Department of Physics

Quinquennial Review Self-Assessment Document

October 2019

1. Introduction

1.1 Preparation of the Self-Assessment

This document has been compiled by Prof Paul McKenna (Head of Department) with input from the following members of staff:

- Dr Nigel Langford (Director of Teaching until August 2019)
- Dr Brian McNeil (Director of Teaching)
- Dr Alison Yao (Deputy Director of Teaching)
- Prof Thorsten Ackemann (PGT Director)
- Prof Gail McConnell (Director of Research)
- Dr Gordon Robb (PG Tutor)
- Dr Nicolas Laurand (Director of KE)
- Prof Erling Riis (Deputy Head of Department; HoD until August 2018);
- Mrs Gabrielle Weir (Department Manager)

All appendices can be found on Strathcloud. (The link is provided by the Faculty Office).

1.2 Consultation Process

This report was prepared in consultation with the Leadership Team and other members of staff. It was circulated to the Department Committee for comment and will be circulated to all staff ahead of the review date.

1.3 Background and Context

The Department of Physics has continued to grow over the course of this four-year review period and to contribute strongly to the University's Strategic Plan 2015-20. We have benefited from investment in new appointments, across most job categories, amounting to a 16% increase in total staff number.

We teach around 380 undergraduates and around 170 postgraduate students. Over the past four years, the Department has introduced new initiatives to enhance student experience. These include revisions to our UG curriculum to improve alignment of the mathematics and physics content, by bringing mathematics for physicists teaching in-house. This is a significant activity and is being actively rolled out over a three-year period. We have also introduced a new class in computational and physics skills in years 1 and 2 to further develop group working and employability skills, and we have continued to develop our taught Masters programmes as well as PhD programmes. New training opportunities have been introduced via our partnership in SUPA, the Cockcroft Institute and several Centres for Doctoral Training (CDTs), and via the new Strathclyde Doctoral School.

Building on the Department's excellent performance in REF 2014 (1st in the UK for overall research quality as measured by grade point average), we have continued to deliver strongly in terms of research outputs and have increased our research income by more than 40%. Prestigious new grants attracted include an RAEng Chair, Royal Society URFs, two EPSRC Programme grants, two EPSRC Strategic Equipment grants, an EPSRC Prosperity Partnership grant and, jointly with colleagues in the Department of Civil and Environmental Engineering, an EPSRC New Nuclear User Facility (subject to a gateway review), in addition to large responsive mode funding. The Department is also playing a leading role in the UK National Quantum Technologies Programme, being the only university involved in all four hubs during both phases of the programme.

We have also continued to grow our knowledge exchange portfolio. We appointed a KE Associate and secured 2 Innovation/Enterprise fellowship awards. We also secured our first KTP, 6 Innovate UK awards, filed 7 patents, developed a healthy pipeline of 12 invention disclosures at various stages of

translation and worked on growing our spin-out portfolio. We continued to develop our industrially relevant research themes.

The Department renewed its Athena SWAN Bronze award earlier this year, and introduced a new action plan to increase the diversity of our workforce and advance equality across recruitment, promotion and career progression. This includes a renewed Equality and Diversity Committee and two new support groups; the Women in Strathclyde Physics Association (WiSPA) and the Equality, Diversity, Equity and Inclusion group (EDEI).

We have continued to be a key partner in the Scottish Universities Physics Alliance (SUPA) and in other Scottish research pools. During the review period, the Department became a full partner in the Cockcroft Institute, a leading centre for accelerator science and technology. It has also continued strong strategic partnerships with Fraunhofer UK and NPL Scotland, which has led to co-funding and sponsorship of 3 new Chancellor's Fellowship appointments during this period.

The many positive changes in the Department over the review period have been driven by our excellent and committed staff and students. We acknowledge the significant investments that the University has made in Physics in recent years and the role that this has played in shaping our department. We share the ambitions of the University's Vision 2025 strategy and aim to contribute strongly to its delivery, whilst actively promoting the University's values.

2. Learning, Teaching and Assessment

Highlights in Teaching and Learning over the review period include:

- Continued high-level performance in NSS with Faculty and University leading scores for Assessment and Feedback component.
- Introduction of a new MPhys in Physics with Advanced Research course aimed at attracting high achieving applicants.
- Recruitment of students whose average tariff far exceeds our minimum requirement.
- A review of the 1st and 2nd year curriculum, following the opportunity for the Department to teach mathematics to its own students, and the embedding of computational physics as key skill set in these years. A review of the 3rd year curriculum is underway.

2.1 Learning, Teaching and Assessment Strategy, as it reflects the University's Strategic Plan

The Department aims to provide an excellent educational experience, creating opportunities for deep intellectual learning that enables students to realise their full potential. Our LTA strategy is to deliver high quality, research-led programmes of study that introduce students to the latest advances in physics, whilst also covering core physics concepts and developing the skills necessary to work in a variety of professional contexts. This aligns with the University position as a research-intensive and its mission statement of being 'A place of useful learning'. We aim to deliver this in a way that enhances student satisfaction and widening access, reflecting the University's Strategic Plan. The National Student Survey is one metric the Department uses to measure student experience and, in the past few years, it has performed well in this. The opportunities afforded by the Department bringing in-house the teaching of mathematics for physicists in Years 1 and 2 has allowed a strategic reshaping of the undergraduate curriculum.

2.2 Undergraduate and Postgraduate Programmes

Introduction

The Department offers degrees at undergraduate, postgraduate taught and postgraduate research level. The programmes are designed to produce students with the skills sets needed to develop their career in their chosen paths. All the undergraduate degrees at Honours and Integrated Masters level are accredited by the Institute of Physics and as such meet the educational requirements for Chartered Physicist. The BSc Physics with Teaching degree is also accredited by the General Teaching Council Scotland and graduates of this degree are able to enter the teaching profession as probationary teachers.

The next accreditation, by the Institute of Physics, will take place in December 2019 and the Department will be seeking accreditation not only for its undergraduate degrees but also for its postgraduate degrees.

2.2.1. Undergraduate Programmes (UG)

The current undergraduate programmes offered by the Department are:

- MPhys
- MPhys in Physics with Advanced Research (MAR)
- MPhys with Specialisation in …
- BSc (Hons) Physics (BPhys)
- BSc (Hons) Physics with Teaching (Joint with School of Education, HASS) (BPwT)
- BSc (Hons) Mathematics and Physics (Managed by Mathematics and Statistics) (BMP)

2.2.2. Graduate Diploma Programmes (GD)

The Department offers two Graduate Diplomas, one aimed at articulating students on 3+1+1 agreements, the other aimed at international students interested in one of the MSc courses offered by the Department but who do not have an appropriate physics qualification as detailed below:

- Graduate Diploma in Physics
- Graduate Diploma in Physics (Conversion course)

2.2.3. Postgraduate Taught Programmes (PGT)

At present the Department offers four MSc degree courses:

- MSc Applied Physics
- MSc Advanced Physics
- MSc Nanoscience
- MSc Optical Technologies and Applied Physics

Postgraduate Taught (phased out during this review period):

Since the last review in 2015 the Department has phased out both the MSc Photonics and Micro-fabrication of Devices (PMD) and the MSc Industrial Photonics (IP) due to insufficient recruitment (PMD) and lack of engagement, despite promises, from the local Photonics industry (IP).

2.2.4. Postgraduate Research Programmes

MRes

The Department offers two MRes degrees:

- MRes in Physics
- MRes in Physics (in specific research area)

MPhil

Occasionally we get a student enrolling on this degree programme, but it is mainly used as an exit qualification from PhD when attainment of a PhD appears unlikely.

PhD / EngD

Along with the standard PhD programme, the Department also offers PhD opportunities to international students in the Gulf region through the Joint Supervision Scheme. There is also strong engagement with a number of EPSRC-funded CDTs (Centre for Doctoral Training). The Department teaches and offers PhD/EngD projects on the following:

- CDT in Quantum Optics (led by Heriot Watt; University of Glasgow)
- CDT Diamond Science and Technology (led by University of Warwick)
- CDT in Medical Devices (led by Biomedical Engineering at Strathclyde)

The Department offers PhD/EngD projects as part of the:

- CDT in Optical and Photonics Technologies, Photonics and Applied Photonics (led by Heriot Watt, leading to EngD award)
- CDT in Optical Medical Imaging with Healthcare Innovation and Entrepreneurship (led by University of Edinburgh)

2.2.5 Curriculum and Programme Specifications

Details of the curricula and programme specifications undertaken by our students at UG are detailed in T&L Appendix 1 & 2. A key feature of the UG degrees is that the curriculum for the first two years is compulsory and the same for all students. There are a number of benefits of having a compulsory curriculum, including allowing the embedding of computational physics and employability skills. The third year sees the introduction of options and fourth and fifth years allow IM and BPhys students to tailor their learning to the research interests of the Department.

Since the last review the Department has changed the structure of the BPwT degree such that students on this degree follow three years of physics and then in the fourth year of the degree follow the PGDE offered by School of Education. This decision was made to improve the teaching and learning experience of these students. Under the previous arrangement these students often felt that they fell between the two departments in years 3 and 4.

The MSc courses offered by the Department base their teaching on the Level 4 and Level 5 classes offered to the UG students. This allows for the sharing of classes across MSc courses (e.g. Nanoscience and Optical Technologies sharing a module), efficient teaching and minimises the number of classes with small student numbers. Like many science subjects, Physics is a linear subject and the material taught in year 1 provides the foundation for the material taught in year 2 and so on into higher years.

In the case of postgraduate research level teaching, MRes students take a curriculum based on 60 credits of taught material and a 120-credit project. The PhD students are required to satisfy the requirements of both the University's Researcher Development Programme (RDP) and those specified by the Graduate School associated with the Scottish Universities Physics Alliance (SUPA). Our PGR and MRes students can access teaching from the SUPA partners that meets the requirements for RDP.

2.3 Collaborations

2.3.1. Within the Faculty

At Undergraduate Level the Department collaborates with the Department of Mathematics and Statistics in offering the BSc (Hons) Mathematics and Physics degree. Students in the 5th year of the MPhys can choose classes from the Level 5 offering of the Department of Mathematics and Statistics. Given the range of Level 4 classes offered by the Department of Mathematics and Statistics, it is difficult to offer students on this degree the full choice of mathematics and statistics classes and physics classes. To minimise the impact of this on the students there is detailed discussion between the two departments when developing the 4th year timetable.

At the PGT level, the MSc in Nanoscience is delivered jointly with the Department of Pure and Applied Chemistry.

2.3.2. Within the University

The Undergraduate BSc Physics with Teaching degree is a joint degree offered by the Department of Physics and the School of Education. The Department also offers service teaching at Level 1 and Level 2 to both the Department of Pure and Applied Chemistry and the Department of Electronic and Electrical Engineering. Postgraduate students on the MSc Optical Technologies and Applied Physics degree have the opportunity to take classes offered by the Department of Electronic and Electrical Engineering, and one student also did the final project in that department.

2.3.3. With UK/EU/International Partners

At postgraduate level, the Department participates in and contributes to the SUPA Graduate School (GS) along with our partner organisations in this pan-Scotland pooling initiative. The SUPA GS provides postgraduate education and training to our PhD students by offering a choice of 60 courses across seven research themes. These courses include those already being run by member institutions as well as courses that were commissioned and designed specifically for the Scottish Physics community. SUPA GS courses are delivered through a variety of means, ranging from lectures delivered in-person (or via purpose-built video-conferencing suites located in the eight member institutions) to residential and lab-based courses. Online training is also delivered via the My.SUPA Virtual Learning Environment. Students are required to complete 40 hours of technical and 20 hours of core skills courses, with the aim of equipping our PhD students with the full complement of skills required for their future careers.

The SUPA GS has been externally reviewed and is widely felt to be one of the major benefits of the pooling initiative. The courses are valued by students and supervisors alike.

In addition to the SUPA GS, some of our PGR population benefit from the Department being partners in CDT programmes offered by Strathclyde, Heriot Watt, Glasgow, St Andrews, Edinburgh and Warwick. Students enrolled on these courses experience a year of specially-designed taught material delivered by experts in the field.

The Department is engaged in the Postgraduate Institute at NPL, with a number of co-supervised PhD students. This is a primary vehicle for building collaborations with researchers at NPL. The Department also leads, or is a partner in, several Strathclyde-CDT initiatives (mini-CDTs with several students per cohort), supported by a range of external partners, in ultraintense laser-plasma interactions, plasma-based particle and light sources, quantum optics and transformative technologies for nanomedicine characterization.

We are also establishing an International Graduate School for Quantum Technologies, supported by the University and industry. The first students in this new initiative will start in October 2019.

2.4 Off Campus Teaching

We are currently engaged in a small amount of off-campus teaching in Warwick for the CDT in Diamond Science and Technology. We also contribute specialist postgraduate courses at the UK's Cockcroft Institute of Accelerator Science and Technology, in which we became a full partner during the review period. In addition to broadcasting our SUPA GS lectures to students registered across the eight SUPA institutions, we also broadcast some of our courses to our PhD students based externally, e.g. at the Rutherford Appleton Laboratory.

2.5 Examples of Innovation and Best Practice

The excellent teaching provided by the staff in the Department is reflected through the Department's continued high levels of performance in the NSS, recognition by students that the Department reacts to their concerns, and regular TEA awards.

Examples of effective practice include:

- Exam feedback sheets
- Standardised assessment format in all years
- Defined deadlines for submission of 4th and 5th year coursework to try to avoid clashes in hand-in dates
- Development of in-class response systems using mobile phones or other personal response devices.

2.6 Recruitment

2.6.1. UG Recruitment

The entry requirements for all our undergraduate programmes and categories of students are detailed in the programme specifications (T&L Appendix 2). Targets and performance against these targets are shown in T&L Appendix 3 for all categories of students. The Department is aware that some applicants apply to several of our degrees. It is evident from T&L Appendix 3 that the Department struggles to meet its UG RUK and Overseas targets and in recent years has not hit its SIMD0-20 and 21-40 targets (SIMD- Scottish Index of Multiple Deprivation). We understand the reasons why: in terms of RUK, there is competition from English universities making unconditional offers to students who have not yet completed A Levels and accepting "far misses" who are holding Strathclyde Physics as conditional insurance. In terms of SIMD0-40, data obtained from the Scottish Government shows that only 10% of the students taking Higher Physics and less than 2% taking Advanced Higher Physics come from SIMD0-40 backgrounds. The pressure on other universities to meet Scottish Government Widening Access targets has seen this population squeezed across Scotland to the extent that some Universities are making unconditional offers to applicants based on National 5 qualifications. The Department also has concerns that under the Curriculum for Excellence pupils are taking only 6 National 5 subjects with only one or two sciences and subjects which are perceived to be difficult, such as physics, are being dropped by the schools. Similarly there is a lack of provision of Advanced Higher in many SIMD0-40 schools and whilst the Department supports the Advanced Higher Physics Hub offered by Glasgow Caledonian University, the number attending this hub cannot make up for the shortfall. In respect of the overseas students, the key driver is the University's overall ranking and the attraction of higher ranked universities in the south of England. The fees are currently set high when taking this into consideration.

The introduction of computational physics into the first three years' curriculum has seen a change in admission policy in that we no longer advertise direct entry to 2nd Year. Despite the best efforts of the Department in advertising the advantages of this route there was little uptake from applicants.

2.6.2. PGT Recruitment

Appendix T&L 4 shows the performance against targets for our various MSc programmes. Up until session 2018/19, the number of international PGT students admitted by the Department was around 10 per year, against a target of 12, corresponding to 6% of the total UK population of international PGT students studying physics. The drop seen in 2018/19 may be due to the fact that the University was removed from the Saudi Arabian approved university list. The main market for PGT in Physics was the Gulf States and this is greatly influenced by Saudi Arabia's actions (see Appendix T&L 5). The number of valid applications (17 on 07/09/2019) and rolled-forward students (19 on 07/09/2019) is looking more promising for 2019/20. The Department's international student recruitment was reviewed in April-June 2019 by the University's Performance Management Group and it is hoped that one outcome of this review will be that more realistic targets are set by the University for the Department. A summary of our strategy and implementation plan presented as part of the review is

available in Appendix T&L 6. We have assigned a senior academic (Prof Kuhr) to take this forward. Our activities include increasing the number of international partnerships that yield results, market intelligence to enhance our understanding of the overseas market and global trends, enhancing our marketing and promotional activities, reviewing scholarship provision, making more effective use of recruitment agencies and working on maximising conversion from applications.

2.6.3 PGR Recruitment

The Department has seen a continuing growth in PGR numbers in recent years, as shown in table 2.1, but the increasing targets set by the University are challenging to meet. There is no strong tradition of self-funding in the discipline and so we are restricted to taking on students for whom we have to raise all or most of the funding. This is progressively more challenging given the other pressures on Departmental budgets. The Department's strong position in terms of its grant income from EPSRC translates into increases in DTP income to the University, though this does not necessarily translate to an increased number of funded PhD studentships in the Department. Staff work hard to identify contributions to REA and SEA studentships, though increasingly potential contributors are now choosing to put their financial contributions towards new CDTs. We are working together to create as many opportunities as possible to increase our PGR numbers and recruit the best possible students. This includes through further engagement with external partners e.g. non-UKRI funding bodies, national laboratories, industrial collaborators and NPL, and through leadership and contribution to CDT bids. We hope to gain additional students through the University's new Doctorates@Work scheme.

	PhD	MPhil	MRes	EngD	PGR total
2018-19	155	2	0	11	**168**
2017-18	130	1	0	13	**144**
2016-17	128	1	0	7	**136**
2015-16	126	3	0	7	**136**
2014-15	109	4	0	5	**118**

Table 2.1 : Physics PGR population per academic year

The markets for self- or government-funded international students in the discipline are traditionally very small, with most selecting the three most well-known English universities. We are working with our international team to explore opportunities for engaging with e.g. institutions in the Middle East to establish in-country supervision of traditional PhD students but also upskilling of partner university staff to doctorate level.

2.6.4. Diversification

In terms of the widening access agenda, the Department makes use of contextual data to make offers to applicants. Typically, this will involve relaxing the grade A requirement for applicants repeating Higher Physics or Higher Mathematics and reducing the expected grade requirement by one or two grades depending on the contextual data flags. Applicants from SIMD0-20 backgrounds are also made an alternative offer of attending and passing the Summer School. The physics provision in FE colleges is poor as very few colleges offer Higher Physics or Advanced Higher and the Department receives 5 – 20 applications per year from college-based applicants taking Higher National qualifications or SWAP Access to Science courses. Any such applicant is asked to attend and pass the Summer School.

Currently about 25% of the Scottish Higher Physics population identify as female and the Department typically recruits 21 – 23% females (see Appendix T&L 7). Whilst there are systemic failings in the Scottish school sector over addressing the number of females studying Higher Physics, which cannot be directly addressed by the HE sector, the Department has been involved in several initiatives to drive

up the number of females taking Higher Physics. In January 2019, the Department hosted a 'Girls into Physics' day for 100 S3 female school pupils, organised by the Institute of Physics. In 2019/20, the Department will focus on events for S1 and S2 school pupils, aimed at girls and schools which cover SIMD0-20 post codes. We are developing more links with schools, particularly through our BSc Physics with Teaching alumni. For example, in September 2019 the Department will host a visit by 8 female pupils from Denny High School who are studying Higher or Advanced Higher Physics with the aim of inspiring them to continue in physics. The pupils will attend a lecture, talk to female PhD students about their research and learn about the UG courses and potential careers.

At PGT level, the percentage of female students is higher, at 35% average over the review period, fluctuating between 26% and 45%.

2.6.5. International Recruitment and Opportunities

On average, less than 2% of the applications that the Department receives through the UCAS process come from overseas applicants. In an attempt to try and bolster this, the Department has, over the review period, established articulation agreements with Harbin Institute of Technology in Weihai, Shanghai Normal University, University of Science and Technology China, Chengdu and maintained links with existing partners such as East China University of Science and Technology, Donghua University, Shanghai and Capital Normal University Beijing. These articulation agreements offer a variety of degree pathways with time splits between the home university and the Department such as 2+2, 3+2 and 3+1+1 years. As these agreements rely on the institutions in China sending students from their own degree programmes the numbers that articulate to the Department through these agreements is small, typically binary. The Department tried a different approach by developing an International Joint Education Programme (IJEP) with Ningbo University, but the fact that the University of Strathclyde already holds 6 IJEPS and a change in policy at Ningbo meant that this approach had to be abandoned.

As mentioned earlier, in 2019, the Department developed a new strategy for international recruitment, and is working on an implementation plan, with the support of the Faculty's Head of International Development and Student Recruitment. An overview is presented in Appendix T&L6. In summary, the new approach aims to:

1. Increase the number of international students
2. Enhance the conversion rate of applications
3. Enhance the experience of our international students
4. Enhance the reputation of Strathclyde Physics

The strategy involves:

1. Market intelligence to enhance understanding of the overseas market and global trends
2. Enhancement of marketing and promotional activities
3. Increase in the number of strategic partnerships that yield results
4. Review of scholarship provision
5. More effective use of recruitment agencies – working with RIO to decide on incentives
6. Review of course titles and content, and revision, if appropriate, to enhance marketability
7. Review of entrance requirements based on market intelligence
8. Maximisation of conversion of applications
9. Continuing provision of high quality support to international students from arrival to graduation, to enhance potential to engage our international alumni

2.7 Student Progression and Retention

Appendix T&L 8 gives a breakdown of the progression and retention statistics for students in the Department. This is typically around the 90% level which is a testament to the care and attention that

staff pay to their teaching duties. A key aspect of this high progression and retention rate is the sense of belonging to the Department engendered by the staff and, more importantly, the Physics Society. The efforts of the student-led Physics Society in building a sense of community are recognised and supported by the Department.

2.8 Student Support

All students are allocated a Personal Development Adviser (PDA) who monitors the academic development of the students. New 1st and 2nd year students meet with their PDAs immediately after the first day talk in welcome week so that they have a point-of-contact from day 1. After each examination diet meetings are arranged between advisers and advisees to discuss progress and to try and identify difficulties. For each academic year there is also an Adviser of Study who is an additional point of contact for students. The Director of Teaching, PGT Director and other teaching staff offer an open-door policy so that students with personal issues can approach staff for help. The Department, through its two disability coordinators (Dr Arnold and Ms Munro), work with Disability Services to provide appropriate support to students with additional support needs. The disability coordinators are identified at the First Day Meetings and on the class information sheets that are issued to students at the start of each class (see Appendix T&L 9). At PGT level, training material and guidance on where to find further training material is co-located in a "Physics PGT community" site on MyPlace. A drop-in session (Wednesday afternoons, 2 hours) run by an experienced postdoc was offered in semester 1 (2018/19) to help international students and students with international background to settle in and will run again in 2019/20. This is mainly to address gaps in IT and other transferable skills, but also helps with gaps in physics knowledge.

2.9 (inc. 2.10) Opportunities for Overseas Study, Student Exchanges, Socrates/Erasmus

Students within the Department are encouraged to take the opportunity to study overseas, be it for a single semester or two semesters. These opportunities are through established programmes such as Socrates/Erasmus exchanges or self-found opportunities. The steady increase in the number of students finding placements (e.g. 3 in 2017/18 and 5 in 2018/19) either overseas or in UK industries has led the Department to introduce two new exit awards – MPhys / BSc Physics with International Placement and MPhys / BSc Physics with Industrial Placement to allow students to show potential employers that they have taken the opportunity to develop their skills outside of the University. MSc students who want to do the project at another research institution are also supported (2018, Paul-Drude-Institut, Berlin).

International collaboration and the use of international facilities is an integral part of the research performed by many of our PhD students. For example, the use of high power laser and accelerator facilities in various European countries, the USA and Japan. The Department is a partner in Laserlab-Europe, which facilitates short-term placements at laser facilities throughout Europe. Other examples of recent PhD research placements include the Kansai Photon Science Institute (KPSI) in Nara (via a JSPS fellowship), Stanford University and NIST in Gaithersburg. The Department has collaborative PhD programmes with DESY Hamburg and Macquarie University in Australia, which have enable students to spend part of their time studying at the partner university. All of these opportunities offer a diverse PGR student experience and enhance research collaborations.

2.11 Graduate Employment

Statistical data supplied by the Careers Service show, for those graduates who complete the 6-month post-graduation employment return, typically, around 80% of our graduates move on to either postgraduate level study or obtain graduate level jobs (see Appendix T&L 10). At PGT level, during the period 2015-17, students reported 75-100% positive outcomes on graduate level with a roughly matching weight of further (PG) study and full time employment. Our own informally obtained

information confirms PhD projects, higher level "lecturer" positions at their home institution, and diverse positions in industry as the major career paths.

3. Quality Assurance and Enhancement of Teaching, Learning and Assessment

3.1 (inc. 3.2) Course and Class Reviews

The Department uses a range of indicators for course and class review, which include pass rate monitoring and cohort performance with an in-house web-based system developed for this, questionnaire monitoring and external syllabus changes. As the curricula of the UG degrees are common for years 1 to 3 the Department reviews its teaching by a thematic approach. Reviews of the teaching of solid state and thermal physics as well as quantum mechanics have been undertaken over the Review Period (see Appendix T&L 11). The UG physics curriculum for years 1 to 3 is defined by the Institute of Physics Core of Physics accreditation requirements and thus the reviews are undertaken with this in mind.

3.3 External Examiners Reports and External Reviews

The reports from the external examiners and the responses to any comments made by the external examiner are given in Appendix T&L 12). The external examiners are very complimentary and supportive of the teaching and assessment practices in the Department. At UG level the reports are scrutinised by the Director of Teaching who drafts a response, which is then agreed by the Teaching Committee. At PGT level the PGT coordinator undertakes a similar role.

3.4 Student Feedback and Responses to Feedback

3.4.1 Course and Class Monitoring Questionnaires

Students are issued with paper-based class questionnaires around week 7 of each semester (see Appendix T&L 13). The questionnaires are designed to reflect the questions that appear on the National Student Survey and also contain sections to allow students to raise issues and identify what they enjoyed about the class. The questionnaires are processed electronically and the responses reviewed by the Departmental Manager who identifies any common issues. The numerical outcomes from the questionnaires are posted on MyPlace. In 2018/19 the department ran several feedback sessions over lunch with UG and PGT students to catch and discuss details difficult to get from questionnaires.

The most recent summary of themes from module feedback forms (2018/19) can be found in Appendix T&L 14. To 'close the loop', teaching staff provided a response to the feedback on their modules, reflecting on what went well and what they will change for next session.

3.4.2. NSS and PTES

Another source of student feedback comes from the NSS and PTES with the NSS performance over the review period shown in Appendix T&L 15. The results from this survey are a testament to the care and attention that the teaching staff in the Department pay to the students. The outcomes from the NSS are standing items for discussion at Teaching Committee, Departmental Committee and Student Staff Committee and PTES results are also discussed by the relevant committees and stakeholders.

3.4.3. Focus Groups

The Department has introduced meetings with each UG year group and PGT students to discuss issues on Teaching and Learning. These are open floor meetings managed by the Director of Teaching, PGT Director and the Departmental Manager.

3.5 Reflections on TESTA Findings

The Department underwent the TESTA process in semester 2 of academic year 2018/19, with strong engagement of staff in the process. The findings were presented, as part of the reflective process, to the Department on 10/05/2019, and largely supported what the Department already knew about its assessment and feedback processes. It did flag some additional issues that we are in the process of addressing – namely, some students see the examinations as memory tests, inconsistencies in laboratory marking, and issues over the provision of past exam paper solutions and the lack of equation sheets from Year 3 onwards. A key feature that was raised by the students was that the Department took their comments seriously and if changes are required, these are considered and, if appropriate, suitable adjustments are made. The TESTA report is included in Appendix T&L 16.

3.6 Student-Staff Committee

Student feedback on the teaching in the Department is also sought through the Student-Staff Committee (SSC). Undergraduate students from all years and postgraduate taught students are represented on this committee, which meets twice a semester and is chaired by a student with support from the Director of Teaching. Although issues can be raised by this committee, students are encouraged to bring any issues to the Director of Teaching before the scheduled committee meetings if they so wish.

3.7 Engagement with the Learning Enhancement Events and with University Initiatives to Enhance the Student Experience

The Department engages with the Learning Enhancement advisers on a wide range of topics that are designed to support student learning. Staff are encouraged to attend events organised by LEN. Given the Department's success in NSS, we have offered advice to other departments in the Faculty on improving their NSS scores (Maths & Stats and CIS) and at University forums on NSS, most notably on Assessment and Feedback.

3.8 Engagement with University Initiatives to Enhance the Student Experience

The Department engages with the various initiatives that enhance the student experience as detailed below.

3.8.1 First Year Experience

At the start of welcome week, the Department runs First Day Meetings coordinated by the Advisers of Study for each year group. For the new student intake entering 1st year this is an opportunity to meet the 1st year adviser and to be given information that will allow them to make the transition from school to university as straightforward as possible. This includes relevant points of contact in the department, the requirements for the course, and the different types of support available both within the department and in the wider university. Representatives of the Physics Society, the Careers Service and the Institute of Physics may also attend, depending on availability.

All new students are assigned a Personal Development Adviser (PDA) who remains a constant point of contact for them over the duration of their degree. The students have a short meeting with their PDAs immediately after the welcome talk. This initial meeting is just to ensure that all students know who their PDA is and where to find them. They are also asked to submit a short form that again details what support is available, and allows them to request any support and/or a one-to-one meeting with their PDA to discuss additional support in confidence. The second year adviser of study acts as PDA to the direct entry students. Chinese students who enter via articulation agreements are assigned to Dr Chen, one of our Chinese members of staff.

1st and 2nd year students are assigned workshop tutorial groups, and care is taken to ensure that PDA groupings are from the same tutorial grouping. Typical class sizes are 25-30 students, further broken down into working groups of 5 or 6 students, taking care to ensure that no minority groups feel

isolated. The students are encouraged to work in these small groups across all of their classes, with the exception of the experimental labs.

After the introductory meeting, the PDAs bring all of the 1st year students they are responsible for to a coffee morning that takes place in the staff common room. This gives the students a chance to meet each other and the rest of the academic staff in a less formal environment. Members of the Physics Society also attend the coffee morning, where they give the new students a free re-usable "Physics Society" mug and encourage them to join the society. They also organise a social event for all new students during the first week of semester 1. This year the IoP will also take part in the first day talk and the coffee morning.

At postgraduate taught level the Department also issues a paper based questionnaire that deals with the application process and transition to Strathclyde (see Appendix T&L 17).

3.8.2 Employability

A major strand to the Department's new 1st to 3rd year curriculum is the embedding of transferable skills together with the computational physics. The Department makes full use of the Careers Service and Ms Selwood, Faculty Career Adviser, has been instrumental in developing the curriculum for these classes. Ms Selwood also meets each year group at the First Day Meeting, or early in the semester, and she has input into the teaching at both 1st and 3rd year where employability skills are developed. This year, Ms Selwood and the Department have arranged meetings with each year group to discuss employability issues and the Department actively promotes the Skills Award.

A key part of the Department's training is a 4th year business development class that is taught by a Visiting Professor with expertise in entrepreneurship. We are presently working on developing the 3rd year physics skills class (to be rolled out from 2020) to task students to develop a small workshop suitable for them to present to S1/S2 pupils on outreach days. This will help them to further develop presentation skills gained in the year 1 and 2 skills class.

The Physics Society also play a role in employability by inviting speakers from various industries to discuss career opportunities as well as running alumni lead careers events. As part of the Departmental Open Day, former students are invited to give a potted history of their careers. PGT students are encouraged to attend the career sessions and events, and company visits organised by the PG student chapter SCOPE (the Strathclyde Student Community for Optics, Physics, and Engineering), and are made aware of the opportunity given by the Strathclyde Enterprise Pathway, in particular the Enterprise Footsteps. A dedicated session with Ms Selwood in the development week of semester 2 addresses career questions and CV skills.

3.8.3 Assessment Principles

The assessment principles underpin the design of all classes and the Department revised its policy on assessment and feedback practice based on the recently revised assessment principles (see Appendix T&L 18).

Under the new framework the core (PH181-PH184 & PH281-PH284) 1st and 2nd year classes 40% of the assessment is based on continuous assessment and 60% on an end of year exam.

The continuous assessment is broken down as follows:

- 10%: 5 multiple choice questions (MCQs) per semester consisting of 4 conceptual questions (e.g. "which of the following is a conservative force", "what is the correct equation") randomly allocated throughout lectures to encourage attendance. Marks should follow the rubric 0-1 correct 40%, 2 correct 60%, 3 correct 80%, 4 correct 100% so that the students understand that there is benefit in attending. Questions should be conceptual, such as "which of the following is a conservative force", "what is the correct equation"... rather than formulaic.

- 10%: Longer (10 questions) MCQ class test in December to consolidate 1st semester material
- 10%: Longer (10 questions) MCQ class test in week 6/7 to consolidate 2nd semester material
- 10%: Attendance at tutorial and completion of tutorial questions. Students are asked to indicate which questions they have completed and may be picked at random to present their solution to the class.

PH185 and PH285 (computational and physics skills) are 100% continuous assessment.

3.8.4 Student Representation

The Department fully engages with the USSA Framework on Student Representation. All UG students who serve on the Student Staff Committee are signed up to act as class representatives and are encouraged to attend the training sessions provided by the USSA. Students also serve on a range of departmental committees. Several PGR students act as student representatives on the Department's Postgraduate Committee, which reports to the Departmental Research & Knowledge Exchange committee, and as Strathclyde representatives on the SUPA student committee.

3.9 Engagement with Current and Previous QAA Enhancement Themes

The Department has continued to implement changes based on the Quality Enhancement Framework (QEF) in Scotland enhancement themes, and will review the results of the new enhancement theme 2017-2020 (Evidence for Enhancement: Improving the Student Experience).

Current enhancement themes include:

- Graduates for the 21st Century: The Department has taken the opportunity afforded to it through the revision of its undergraduate curriculum to further embed employability skills in the curriculum. Key features of this are the inclusion of the Python programming language much sought after by employers in year 1 and 2. Group work is embedded in all years to develop team and collaborative working practices. The third year will include further skills development activities with students learning the fundamentals of taking a lab based idea through to commercialisation and developing outreach activities for schools, further developing the communication skills of the students. The compulsory projects in 4th year and 5th year further develop the critical awareness, problem solving and independent thinking aspects that are desired by employers. In 5th year the MPhys students also learn about the process of developing research proposals and seeking funding from public/private bodies. Students also learn about and create their own risk assessments as part of the preparatory work for the 4th year project.
- Integrative Assessment: The department underwent the TESTA process and the outcomes from this are being used to develop the Department's assessment and feedback strategy. For all taught classes in years 1 and 2 the same assessment procedure will be developed and this will allow the redistribution of the assessment load from the final examination to other components of assessment in lectures and tutorials to allow students to fully demonstrate that they have satisfied he learning outcomes for the class.

4 Resources and Planning

4.1 Strategy development / coherence with University strategy

The Department's annual planning statement (Planning Statement 2019/20 Appendix R&P 1) outlines its priorities and targets in all areas of academic activity, in line with the University's Strategic Plan 2015-2020. In addition to continuing to contribute strongly to the delivery of the University and Faculty KPIs and objectives in the final year of the current plan, the Department is strategically planning for the next phase of the University's strategic plan – Vision 2025.

4.2 Priorities and Targets

Our short-to-medium term priorities are to:

- Consolidate, maintain and strategically shape our staff profile. We have been extremely ambitious in growing the Department over the past 5 years, attracting outstanding new academic staff from Chancellor's Fellows to Professors. Now a focus is on ensuring that there is strong support in place for this reshaping of the Department and to ensure new staff members meet their potential. To maintain the recent growth in research and KE activity, we also plan to identify additional candidates in areas that bridge gaps in our portfolio and recruit through the University's Global Talent Attraction Platform (GTAP). In parallel, we will continue to maintain and develop a sustainable level of technical and administrative support, and staff for our research infrastructure and KE activities.
- Achieve sustainable long-term growth of existing grant income from UKRI and other sources, exploit University strategic partnerships (e.g. NPL), extend international collaborations with key partners and expand industrial engagement from PGR support through research and innovation projects to KTP.
- Perform strongly in REF 2021. Our short-term ambitions are to continue to grow our proportion of 3*/4* research outputs and impacts to achieve a strong submission, and our medium term ambition is to make sure there is a healthy impact pipeline for the following REF exercise.
- Grow our Knowledge Exchange portfolio, including KTPs, licence deals and, in the longer term, spin-outs. Our ambition is to have 2-3 KTPs as a sustainable portfolio to fund our KE Associate post; the post-holder is in turn helping to facilitate our industry-linked strategy.
- Attain our SIMD intake targets, supported by participation in school outreach activities, and increase our student numbers at UG and PG levels, including RUK and international, through expansion of international partnerships.
- Enhance our student experience, via improvements in our UG and PG curricula, and maintain our overall strong performances in the NSS and PTES exercises.
- Increase the diversity of our workforce, including maintaining our Bronze Athena SWAN award and working towards achieving Silver in the medium term.

4.3 Staffing Profile

4.3.1 Profile

The Department has 161 members of staff, which includes 48 academic staff, 82 staff on research, teaching or KE contracts, 20 Technical Services staff (including 2 Modern Apprentices; 18.7 FTE), and 10 Administration and Professional Services staff (9.4 FTE). Please see table 4.1 for a summary and Appendix R&P 2 for the full staff list.

There has been a growth of 16% in staff numbers since the last review in 2015, which includes 9% increase in academic staff and 20% increase in the numbers of research staff. This reflects the continuing growth in our research portfolio and income. The Department's first Teaching Fellow post was also created during this period.

This review period has also seen the appointment of a KE Associate, who has secured our first KTP, awarded in summer 2018, and a KTP Associate employed on that project. Our ambition is to have 2-3 KTPs as a sustainable portfolio to resource our KE Associate. A Commercial Business Development Manager, based with RKES and assigned to the Department, moved on in April 2018. This position has since been brought within the University's new Directorate of Industry Engagement and been expanded to include the Faculty of Engineering. It has not yet been filled, but when it is, we will work

with the new appointee to fully capitalise on emerging opportunities and to support the growth of licence deals.

Table 4.1 Staff numbers and FTE

Category	Number at present	FTE	Number in 2015
Professor	20	17.3	20
Reader	9	8.8	9
Senior Lecturer	9	9	7
Lecturer / Chancellor's Fellow (inc. 2 recent appointments starting in January 2020)	12	8	10
Research (inc. Senior Fellows, Fellows, Associates and Assistants)	79	76.2	66
Teaching	1	1	0
Knowledge Exchange	2	1.8	0
Technical Services	20	18.7	17
Administration and Professional Services	10	9.4	11
TOTAL	161	150	140

The post of Department Manager was created and filled in 2018 to support the Department Leadership Team to ensure effective operations across the various academic activities. The role includes coordination of meetings of the various department committees, supporting the preparation of planning documents, handling student complaints and supporting staff in the compliance with university policies and procedures. Despite the overall increases in academic, research, teaching and KE staff, the number of administration staff has decreased. The current administration team is very effective and meets the needs of the Department, ensuring that core activities are supported. However, with an increasing number of academic staff and an increase in the administrative tasks being assigned to the Department at Faculty and University levels, we expect to need to grow the number of support staff in the near future.

The number of technical staff has remained approximately constant over the four years of the review period, and the numbers shown include several Modern Apprentices appointed during this time. Whilst the current structure and level of technical expertise is servicing the needs of the Department at present, factors such as increasing teaching and research requirements, the overall staff profile and likelihood of retirements, together with recent changes in personnel mean that we are facing a number of challenges going forward. We are presently reviewing future technical support requirements and mapping out a revised staffing structure and business case to appoint staff to meet those requirements.

4.3.2 Identifying and nurturing talent/Mentoring Career progression

Newly appointed academic staff with less than 3 years' experience in an academic role at another institution participate in the University's Academic Career Development Framework (ACDF), which was introduced in 2018 to support early career academics in fulfilling the role and the responsibilities of an academic member of staff. The process involves the development and evolution of an individual academic career plan covering the first three years of appointment. The plans and progress attained are reviewed annually by the HoD and at Faculty level, with the overall aim of supporting the academic to achieve a balanced portfolio of research, teaching, knowledge exchange and citizenship by the end of the process. An appropriate mentor (a senior academic in Physics) is appointed by the HoD to support the new staff member to achieve this goal. Newly appointed staff also attend a series of compulsory course offered by the Organisational and Staff Development Unit (OSDU) on advanced academic studies.

Our academic, research and KE staff are encouraged to undertake training provided through the Strathclyde Programme in Research and Leadership (SPIRAL), a suite of activities aimed at developing leadership across Research and Knowledge Exchange. This includes support for activities such as research grant writing and preparation of high-impact publications. At Department level, we operate a policy of pre-review of research proposals by senior academics from the same research area and in the past year have introduced annual 'fellowship workshops', held in the Spring to engage early with researchers to help them shape their fellowship applications in preparation for submissions in the Autumn, and to promote a pipeline of applications for future fellowship rounds. Additional support is also available within research groups and divisions. One of our research staff recently won a Royal Society URF and we have hosted numerous externally funded fellowship positions (including EPSRC, RSE, URF, EU and RAEng) over the Review Period. We also have examples of internal researchers being appointed to a Chancellor's Fellowship following rigorous recruitment processes with applications coming from the UK and overseas.

Career progression for academic, research, teaching and KE staff is facilitated by the University's Academic Professional Appointments Panel (APAP) promotions process. The Department fully engages with this process, which runs twice per year. The readiness of potential cases from within the Department are considered at a meeting of the Physics Professorial Advisory Group (PAG), scheduled in advance of each APAP meeting. Staff considered by the PAG to have a strong enough case to go forward to the Faculty sift panel are invited to complete the APAP application form, with support provided by a senior academic (usually a member of the PAG). We have had 33 members of our staff, including 12 Academic staff and 13 research staff promoted since May 2015, as detailed in Appendix R&P 3. This includes two Chancellor's Fellows who have been promoted to Senior Lecturer.

In the case of technical and administrative staff, the University operates a process of regrading the staff member's post, based on the changing needs of the role, and thus possibilities for promotion within these job families are linked to the changing needs of the post. This makes the Department vulnerable to the loss of some of the most valuable members of staff if they seek higher grade positions elsewhere. Five technical staff and three Admin and Professional Services staff have been promoted since May 2015.

4.3.3 Staff development

Staff at all grades are encouraged to develop their leadership and other skills, and thereby enhance their contribution to the Department and wider community through participation in relevant University led and external courses. Academic, research and KE staff are encouraged to develop their external engagements through research collaborations and visits, conference participation and external committee representation. We have numerous examples of staff contributing to shaping the research funding landscape nationally, through scientific advisory roles within UKRI committees. Examples from during the review period are provided in section 6.7. We also value the opportunities for contributing to the life and operation of the University through staff engagement with committees, working groups and panels at Faculty and University level, across all staff categories.

Staff development needs are identified and progress monitored through the University's annual Accountability and Development Review (ADR) process, which includes a one-to-one interview with an appointed ADR reviewer, in which learning and development activities and plans are discussed. The principles and practice of the ADR process is firmly embedded in the culture of the Department. There is commitment across the Department to conducting reviews and implementing personal development plans that are informed by the process.

Over the past year, the Department has introduced the Equality and Diversity Committee (replacing its Athena SWAN Committee) to investigate and address equality, diversity and inclusion matters. In addition, the Department has two new groups to support staff and students: a women's network (Women in Strathclyde Physics Association, or WiSPA), and the Equality, Diversity, Equity and Inclusion

group (EDEI), which organise events on equality and diversity issues, and social get-togethers to promote inclusion and cohesion. These activities reflect the Department's commitment to promoting and advancing equality across recruitment, promotion and career progression.

4.4 Succession Planning

We are continually seeking to involve a broad range of staff in the leadership and management of the Department. Over the review period, the Department Leadership Team has evolved to include staff from the academic, research, teaching and administration job categories. Key roles in the Department performed by non-professorial staff include the Director of Teaching, the Director of Knowledge Exchange, the Postgraduate Tutor, the line manager for technical staff, the examination coordinator and UG admissions. As discussed above, the Department is in the process of developing a succession plan for technical staff, based on the overall staff profile and very recent staff changes such as the departure of the electronics workshop manager.

Over the review period, the Department has reorganised its administration team to ensure that experience and knowledge are shared amongst the team, to avoid an over-reliance on a few individuals. This risk mitigation process was tested in the autumn of 2018 when a key member of the team was off for three months for medical reasons. The fact that academic operations continued smoothly is testament to our approach to good practice and the rest of the administration team that willingly took on the additional work created.

4.5 Physical Resources and Planned Developments

The Department consolidated its academic staff in the John Anderson building at the start of this review period, with the exception of staff in the Institute of Photonics, who moved to new office and laboratory space in the TIC building (due to the industry-facing nature of its research and its strong engagement with the Fraunhofer Centre for Applied Photonics based in the TIC building). Some of our research staff associated with other research activities in the TIC Building (mainly the Atoms, Beams and Plasmas group) are also based there. In addition, some of our research activities in high resolution optical microscopy for bioscience are based in the SIPBS building at present, until they can be moved across to space identified in the John Anderson building. During the review period, there has been a major (£12M) extension and refurbishment of the John Anderson building. This has seen new state-of-the-art laboratory space being created for two flagship SUPA2 projects (SCAPA and Quantum Information) as well as a much-needed refurbishment and modernisation of some of the office space.

Whilst recognising that the University has made significant investments in the John Anderson building, we continue to face a number of ongoing issues with our accommodation. There remain considerable infrastructure challenges that are restricting the research that can be performed. Examples include:

- Electrical noise issues throughout the building when pulsed high current supplies are running in the JA extension. Estates Services are working to find a solution to this problem so that several research groups can progress their research programmes in parallel.
- Teaching laboratories in need of modernisation
- Existing mechanical risers are congested, centralised pumps chillers and mechanical headers are at full capacity
- Growing need to replace heating system, and water ingress around windows, lift shafts and roof

In addition, the John Anderson building is at full capacity in terms of occupancy. We have a pressing need to develop space presently used as centralised teaching provision to create new laboratory space. We have plans drawn up to create the suite of laboratories needed to bring the high resolution optical microscopy equipment that is presently in the SIPBS building across to Physics, and are working with the Faculty and University on routes to achieve this.

The Department is drawing up a strategy for the future of the John Anderson building and its growing research, KE and teaching provision needs. The list of large estates projects awaiting funding opportunities are:

- Creation of a suite of laboratories for high-resolution optical microscopy, to underpin growth in an important area of University research aligned to both the Measurement Science & Enabling Technologies and the Health & Wellbeing strategic themes. The consolidation of our internationally-leading optical microscopic imaging equipment from several laboratories will create new collaboration opportunities and attract internationally leading researchers.
- Refurbishment of Physics undergraduate teaching laboratories to provide a sector-leading student experience that will reflect in recruitment, retention rates and satisfaction.
- Refurbishment of laboratory space for three recently appointed Chancellor's Fellows, and the creation of new laboratories to enable the Department to continue to recruit internationally-leading experimentalists.
- Further extension to the John Anderson building or acquisition of new space in other buildings to facilitate further growth in research and KE activities, attract the best global talent and to contribute to delivering the strategic objectives of the University's Vision for 2025.

The Department is continually seeking to renew and expand our equipment infrastructure and has, for example, been successful in leading successful bids to EPSRC Strategic Equipment calls (£1.7M for beamlines at SCAPA and £2.7M for nanoscale analysis equipment for the SSD group, for installation in the TIC building).

4.6 Financial Position

4.6.1 Background

The Department consistently generates a surplus of direct income over expenditure. Its total income has increased year-on-year from £14.9M in 2015/16 to £17.4M (forecast) in 2019/20. Our direct expenditure over this period increased from £11.8M to £12.8M, and thus our income-less-direct-expenditure increased from just over £3M to £5.3M (Appendix R&P 4). This healthy increase is driven by the substantial University investment in staff in recent years.

The increase in our total income arises due to an increase of more than 40% in our research income, from £6.8M in 2015/16 to £9.6M (forecast) in 2019/20 (i.e. 10% annual growth). By contrast, our income across SFC grants and tuition fees has remained approximately constant over this period, the former at ~£5.7M and the latter at ~£2.2M per annum. The main change in our direct expenditure is an increase in salary costs rising from £3.8M to £4.7M over the review period.

The Department runs a deficit when the allocation of University-wide costs are factored in. Our allocation of these central costs has grown from £4.9M in 2015/16 to £5.9M in 2019/20. Our deficit was £1.3M in 2015/16 and is forecast to be £1.1M in 2019/20.

This data, including those presented in figure 4.1 and included in Appendix R&P 5 and is for the full Department. The Institute of Photonics continues to operate its own cost centre and financial model in which expenditure is offset by income on an annual basis. The IoP finances are reported together with the rest of the Department's finances to the Faculty and University, but in recognising its remit to operate at the interface between industry and academia it retains its financial and a degree of strategic independence, and therefore continues to operate separate budget codes.

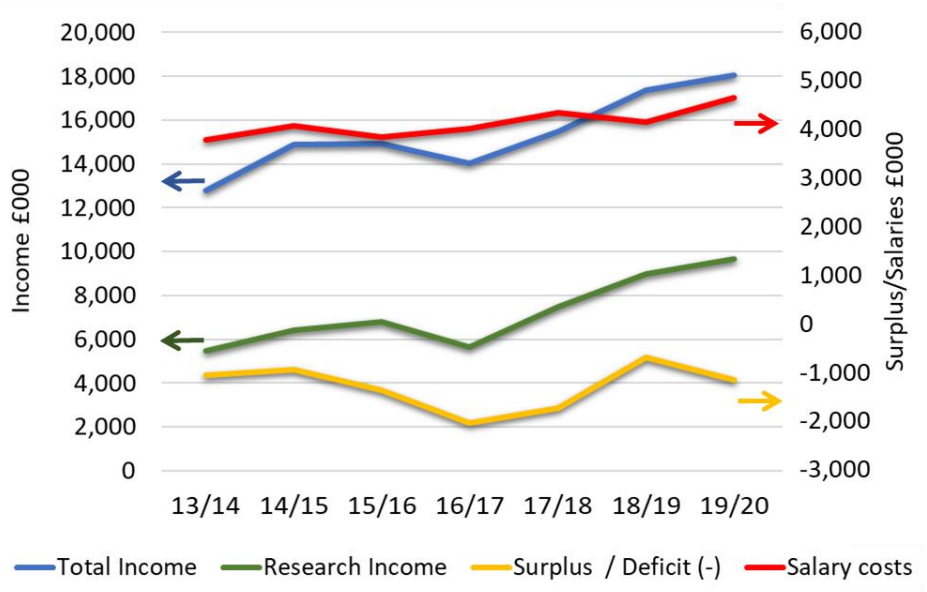

Figure 4.1 Trend analysis of the Department's financial position. The 19/20 figures are based on budgets.

4.6.2 Budget allocations and savings targets

A combined capital and running costs budget is allocated to the Department annually by the Faculty. The Department subsequently allocates the funding as follows:

- 53% of the budget is allocated across research groups based on a staff census produced in October each year (to enable the census to include new PGR arrivals). Any adjustment to the head count is then reflected by amendments to the budget at the end of the first quarter.
- 32% of the budget is allocated to teaching, split across years 1-5 teaching delivery, teaching events and payments for engagement of PhD students in teaching.
- 15% of the budget is allocated to Departmental expenditure such as staff training, safety, printing, photocopying, stationery and furniture costs.

The main pressures on the running costs include increasing Departmental/supervisor contributions to PGR funding (research group budgets and PGR budget) and demonstrating payments for lab support.

The Faculty's financial position has meant a 10% reduction in the running costs budget allocation in 2018/19, in addition to challenging savings targets imposed on the Department in 2017/18 and 2018/19 (~£500k in total). Salary savings were made when a member of the professoriate retired, one academic staff member left and another took an extended a leave of absence. In addition, unrealised income in the form of SCAPA access fees was identified. Part of the SCAPA fees contribute to core salary expenditure (the SCAPA Manager, laser scientists and mechanical technicians).

4.6.3 Environment and Forecasts

The Department aims to achieve sustainable long-term growth in grant income, in line with the University Strategic Plan 2015-20 and Vision 2025. SFC grant allocations are not anticipated to grow over this period, leaving tuition fees and research grant income as the possible vehicles for growth.

During 2018/19, the Department reviewed its international recruitment strategy, supported by the Faculty, the Recruitment and International Office (RIO) and the Deputy Associate Principal (International), with a view to increasing non-EU and RUK fee income. A summary of our strategy and implementation plan is available in Appendix T&L 6. We have assigned a senior academic (Prof Kuhr) to take this forward and to develop and put in place our implementation plan. Our activities include: increasing the number of international partnerships that yield results; market intelligence to enhance our understanding of the overseas market and global trends; enhancing our marketing and

promotional activities; reviewing scholarship provision; making more effective use of recruitment agencies; working on maximising conversion from applications; and, reviewing and revising course content and titles. The small market in overseas students coming to the UK to study physics is, however, a fundamental problem (the numbers for the whole of the UK in 2016, for example, were only: UG: 415; PGT: 165; and PGR: 210). Thus, international tuition fee income cannot be the primary route for the Department to deliver strongly to the University's income growth targets as outlined in Vision 2025.

In order to achieve the levels of growth required, the Department will continue to focus on research and KE income. As outlined in sections 6 and 7, we are working to increase our research grant and KE income through active encouragement and support mechanisms. These include encouraging staff to participate in the Grant Writing Challenge and holding biannual meetings between staff needing extra support and the HoD and Director of Research. We are also providing additional support (e.g. mentoring) to our Chancellors Fellows. We have introduced workshops to engage early with researchers to help them shape fellowship applications and to promote a future pipeline of applications. The level of growth required means intensifying our research through further investments in star appointments (via the University's GTAP platform). We will maintain and strategically shape our team of internationally leading researchers. The Department has a track record in attracting outstanding new academic staff from Chancellor's Fellows to Professors. We will continue to identify additional candidates in areas that bridge gaps in our portfolio. As noted above, the John Anderson building is at capacity in terms of office and laboratory space, and thus our ambitious expansion plans are dependent on enhancing and expanding our existing accommodation.

5 Management and Organisation

5.1 Departmental Committees

The Department committee structure is shown in figure 5.1, with the remits and memberships for the committees in Appendix M&O 1. The main committees and sub-committees meet frequently and the meeting dates for 2018/19 and 2019/20 are available in Appendix M&O 2.

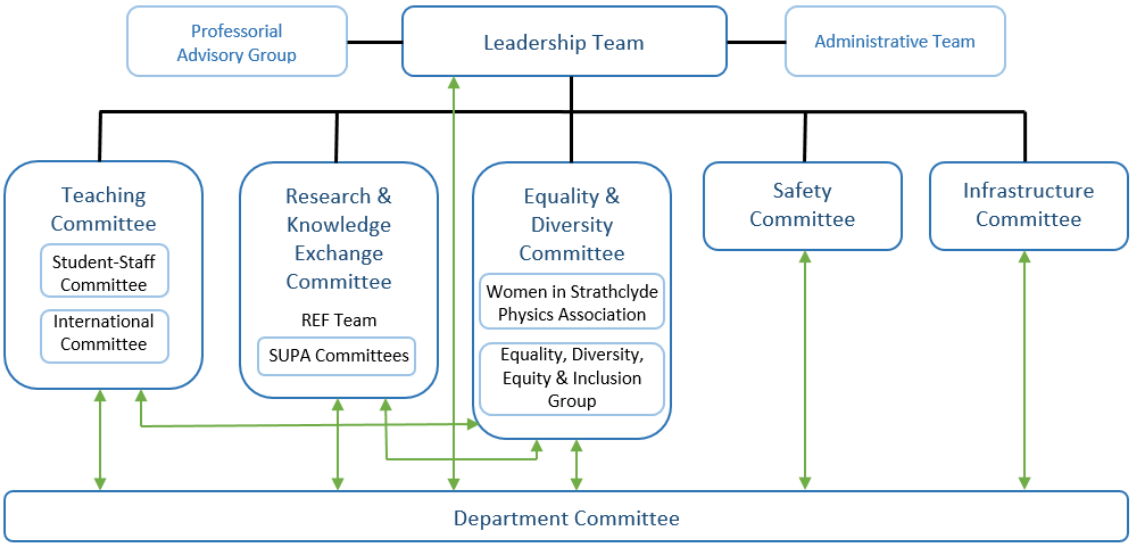

Figure 5.1 The Departmental committee structure. The green arrows correspond to direct lines of communication and reporting.

In addition to the formal committee structure, the Department has a number of groups:

- The Women in Strathclyde Physics Association (WiSPA) – see section 5.3.
- The Equality, Diversity, Equity and Inclusion Group (EDEI) – see section 5.3.
- The Strathclyde Physics Society, which is a USSA-registered organisation for any student with an interest in physics or astronomy. It organises social events and course-related talks and trips for the benefit of its members.

Key roles and responsibilities are shown in figure 5.2.

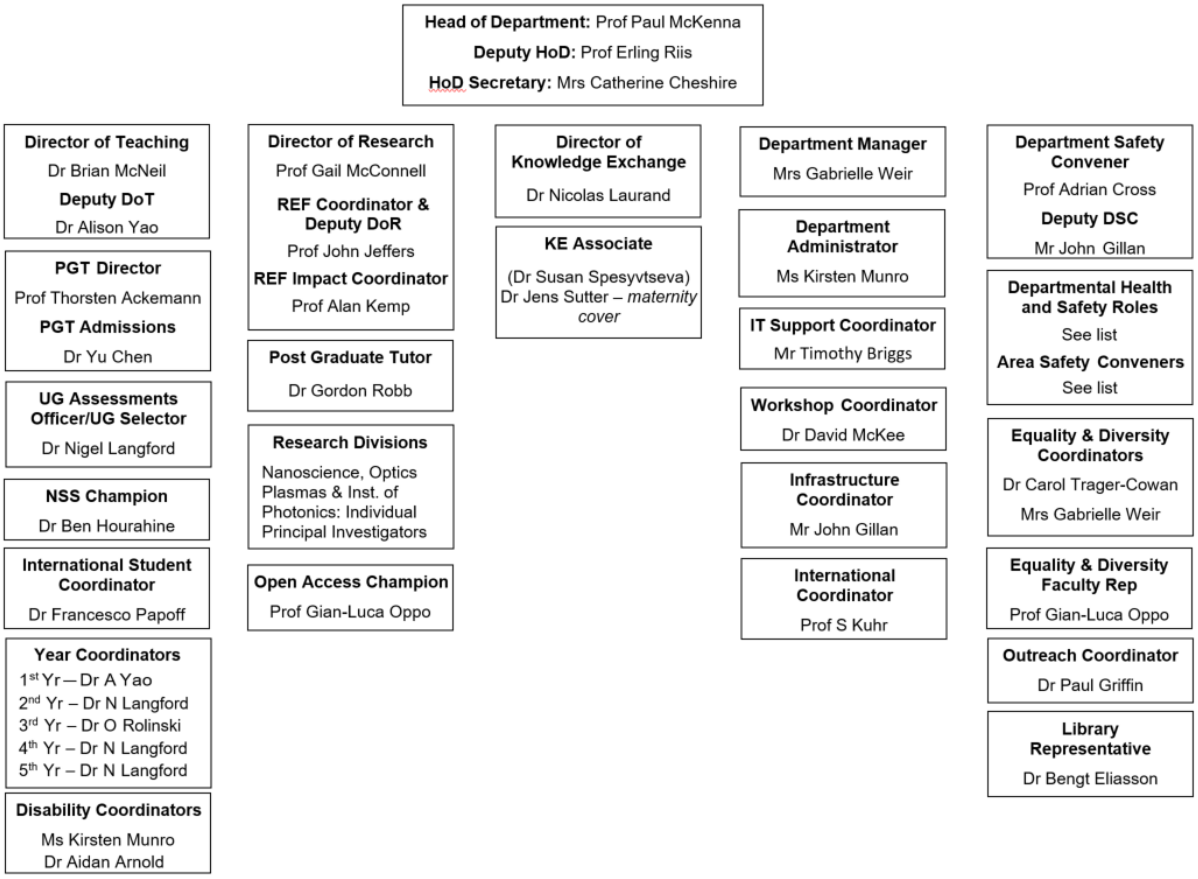

Figure 5.2 Key department roles and responsibilities

5.2 Department Academic Workload Model

The workload model applies to all academic staff in the Department. All staff undertake teaching, research, and administrative/citizenship duties in varying proportions. The model has evolved during the review period to reflect changes in effort required for duties and further updates including allocations for outreach activities are under discussion as part of our Athena SWAN action plan.

The workload model aims to ensure:

- a fair and reasonable distribution of activity among all academic staff;
- that an appropriate balance of activities are assigned to staff, taking into account career stage and other factors;
- a transparent process to inform staff of workload allocations;
- staff are encouraged to manage their workload in a way that is effective for them and in support of the strategic priorities of the Department, Faculty and University.

Details of the workload model time allocations, including anonymised workload data for 2019, are in Appendix M&O 3.

5.3 Equality and Diversity compliance

The Department is committed to providing a supportive working and study environment for all staff and students, and is committed to achieving and promoting equality, diversity and inclusion. Our Equality & Diversity Committee is chaired by the Head of Department.

It is well known that, as a discipline, physics has one of the largest gender gaps in the STEM subjects, and like many physics departments throughout the UK we are working to address this. The percentage of female academic staff in the Department has improved over the review period, from 7% in 2015/16 to 15% in 2019/20, and the Department welcomed its first female professor in 2017. These percentages are, however, still below the UK average of 19% and are lower for research staff, highlighting that further work is required to improve this. To improve the gender balance of our student population, we will run a 'Girls-into-Physics' workshop and ensure good female representation in our open days and outreach activities.

Compared to four years ago, we now have a higher number of female staff role models in leadership positions, including three of the eight members of the Department Leadership Team and two of the seven research theme leaders in the Scottish Universities Physics Alliance. One of our researchers has secured a place in the Homeward Bound Female Leadership Initiative and we now have male and female staff who are also carers taking advantage of support to enable them to work part-time. We have also improved our facilities by providing a dedicated room for nursing mothers.

The Department renewed its Athena SWAN Bronze Award earlier this year and aims to progress towards Silver at the next point of application, in three years time. A range of new initiatives are being put in place via our Athena SWAN action plan – see Appendix M&O 4,

To help promote a positive and inclusive culture, the Department has the following support groups:

- The Women in Strathclyde Physics Association (WiSPA) was set up to provide additional support for female staff and students across all levels (from undergraduate students to senior staff), with the aim of encouraging them to remain in STEM. It provides support on issues relating to gender equality, dignity and respect, in a department where female staff and students are in the minority (15% of academic staff, 9% of research and ~25% of students are female). There are associated (members only) Facebook and Twitter accounts.
- The Equality, Diversity, Equity and Inclusion Group (EDEI) includes volunteers from across the Department who organise social events and a series of equality and diversity themed events with the aim of encouraging a friendly and welcoming environment, and providing opportunities to consider and discuss issues such as diversity in Science, resilience and wellbeing, and mental health.

5.4 Staff Development

Staff development is discussed in section 4.3.

5.5 Integration of the Institute of Photonics

On the 1st of August 2014, the Department entered into a new arrangement with the Institute of Photonics (IoP), joining together with the aim of avoiding duplication of operational aspects and strengthening the working arrangement between the IoP and Physics. The IoP became a Research Division of the Department, alongside the Department's three existing Divisions. Historically the IoP has had a different remit from departments within the Faculty of Science in terms of increased emphasis on applied research and industrial engagement and as a result had been involved in little or no undergraduate teaching. A different model of financial accounting therefore facilitated the IoP operation. Under the new arrangements, which continued to emphasise excellence in applied research, the IoP maintains a degree of strategic independence.

This new arrangement has worked extremely well, allowing the IoP to operate successfully with a reduced management team and allowing the Department to widen its remit and expand its undergraduate teaching pool. The IoP is now closely involved in leadership roles within the Department and makes strong contributions to research income, publications, KE and teaching.

Staff have embraced the new operational arrangements, which is working to everyone's benefit. For example, the role of Knowledge Exchange Director has been held by IoP staff since 2015 (K. Mathieson and now N. Laurand). This position supports the Department's KE activities and reports to Department and Faculty on performance. This period has seen expansion of the Department's IP portfolio and the recruitment of a dedicated KE Fellow. The KE Director also sits on the Physics Leadership Team, making an IoP staff member central to the formation of departmental strategy.

IoP professors have also been welcomed on to the Department's Professorial Advisory Group (PAG), giving the opportunity to support career progression of departmental staff. Over this period the IoP has seen several successful promotion cases, all strongly supported by the PAG (1 to Professor, 1 to Reader, 2 to Senior Lecturer, 1 to Senior Research Fellow and 1 to Research Fellow). This has been enhanced by the IoP recruiting 2 Chancellor's Fellows, a process which is handled at the departmental level.

A marked change in terms of IoP operating has been the translation of the core staff from the research job family to the academic family. Eight of the ten IoP principle investigators are now academics and teach undergraduate courses (with the exception of those who have secured external funds to buy out their time at 100% - Mathieson, Dawson and Kemp). This has helped integrate staff within the departmental structure, but presents some challenges with respect to workload and sustaining a significant industrial engagement.

The joint operational structure has helped encourage combined research opportunities. The Quantum Technology awards are a good example of this. The involvement of Strathclyde Physics in the EPSRC-funded Hubs has been a combined effort from staff across the Department and IoP, with leadership roles split between the two. Both parties have gained from offering a wider range of expertise to these multi-million-pound research hubs.

6 Research

The priority for the Department in terms of research throughout this review period has been to build on our strong performance in the REF 2014 exercise and consolidate our internationally leading position across a range of increasingly diverse research fields, in order to achieve a strong position in the imminent REF 2021 exercise. Key activities include:

- Action to increase the quality of our research output. The Department is deemed to have a high number of top-level papers, as assessed via the University's annual research audit exercise. We regularly monitor changes to our research output profile.
- Focusing on developing several strong REF Impact Case Studies and gaining evidence of impact.
- Recruitment of new rising-star academic staff with ambitious research programmes in strategic areas for growth. See section 6.2/6.3.
- Securing prestigious research Chair and fellowship successes – see section 6.7
- Continuing to develop our research links to NPL, via joint studentships and projects, and most notably, via the joint appointment of Dr Alessandro Rossi. Dr. Rossi is based at NPL for much of early part of his Chancellor's Fellowship.
- Continuing to grow our PGR population: the PGR population has risen steadily, from 88 students in 2014/15 to 138 students in 2018/19.

6.1 Research Strategy

The Department aims to continuously develop and grow its internationally leading research, which ranges from fundamental through to applied physics. Over the review period, we continued to strategically shape our portfolio by making new appointments in areas that bridge gaps (e.g. in physics for life sciences, and at the interface of quantum optics and condensed matter) and to strengthen areas in which there is a national strategy for substantive growth and investment (e.g. quantum technology and photonics), as noted above.

We continued to develop our research infrastructure, including state-of-the-art facilities (e.g. the Scottish Centre for the Applications of Plasma Accelerators (SCAPA)) and the establishment of new laboratories for our GTAP and Chancellor's Fellows appointments. We aim to create a research environment that enables researchers to strive for excellence.

The Department continues to deliver on the University's investments via high quality research output and impact. We are working to increase our research grant income through active encouragement and support mechanisms. These include encouraging staff to participate in the Grant Writing Challenge and holding meetings between staff needing extra support and the HoD and Director of Research. We are also providing additional support (e.g. mentoring) to our early career academics. We have also introduced workshops to engage early with researchers to help them shape fellowship applications and to promote a pipeline of future applications

In preparation for REF, we are communicating performance expectations via multiple channels, including Departmental Committee meetings and focused meetings with staff who do not have at least one output that is definitely at least at the 3* level (per academic). We are making those in this category aware of what needs to be done to address this in the remaining time to submission. We are monitoring our output on an on-going basis to inform this process, whilst also working up compelling Impact case studies.

The Department is committed to delivering world-class training for postgraduate students. We are working together to create as many opportunities as possible to increase our PGR numbers and recruit the best possible students. This includes through further engagement with external partners e.g. non-RCUK funding bodies, industrial collaborators and NPL, and through contributions to CDTs. We have also minimised the time between application and offer to enhance conversion rates.

The Departmental Plan for 2019/20 provides further details on the strategy going forward and is included in Appendix R1.

6.2 (inc 6.3) Research Organisation and Portfolio

Research activity in Physics is organised into four Divisions: Nanoscience, Optics, Plasmas and the Institute of Photonics. Each Division is further organised into research groups as shown in Table 6.1.

Research division	Research group
Nanoscience	Biomolecular and Chemical Physics (BCP)
	Semiconductor Spectroscopy and Devices (SSD)
Optics	Computational Nonlinear and Quantum Optics (CNQO)
	Experimental Quantum Optics and Photonics (EQOP)
Plasmas	Atoms Beams and Plasmas (ABP)
	Strathclyde Intense Laser Interaction Studies (SILIS)
Institute of Photonics (IoP)	Photonic Materials and Devices
	Neurophotonics
	Advanced Lasers

Table 6.1 Divisional and Group Structure

Research Divisions, Groups and Facilities

Each Division covers a range of activities in cognate areas with both experimental and theoretical/modelling activities. All have benefitted from significant investments over the review period with the main strategic developments outlined below.

Nanoscience Division: The Department has traditionally had a strong research effort in the interdisciplinary area of Nanoscience, and this has grown considerably in the Review Period.

Prof McConnell transferred from SIPBS to Physics in 2017, joining BCP to bring new expertise in optical mesoscopy and cell biophysics to the Department. Three Chancellor's Fellows were also recruited to BCP. Dr Sebastian van de Linde was recruited from the University of Würzburg in 2016, and he has secured research funding from AMS/Wellcome, which is a new income stream to the Department. Dr Brian Patton, also appointed as a Chancellor's Fellow in 2016 from the University of Oxford, brought a Royal Society URF to the Department. Dr Oliver Henrich, recruited via the Chancellor's Fellow programme from the University of Edinburgh in 2017, who brings expertise in molecular simulations to the Department, completes the new appointments in BCP during the review period.

The SSD group continues to hold a sizeable EPSRC portfolio over the review period. This includes two Programme Grants (current one led by the IoP, previous one with the Department of Pure and Applied Chemistry (PAC)), a Platform grant (with IoP), leadership of a £2.7M Strategic Equipment grant that brought nanoscale analysis equipment for the SSD group, plus colleagues in PAC and in CMAC (Continuous Manufacturing & Crystallisation). SSD and the related area of quantum condensed matter has experienced considerable growth. Dr Konstantinos Lagoudakis was recruited in 2018 from Stanford University to a Readership via the Global Talent Attraction Platform, and is leading the effort in the development of hybrid quantum technologies. Dr Alessandro Rossi was recruited from Cambridge University to a Chancellor's Fellowship, as a joint appointment with NPL, and is developing a research programme in quantum metrology. Both of these appointments strengthen cross-disciplinary research activity with the Optics Division. The 2018/19 round of Chancellor's Fellow recruitment has also resulted in the appointment of Dr Fabien Massabuau from Cambridge University and Dr Iman Roqan from KAUST, to complement and strengthen the electron microscopy and materials expertise.

Optics Division: The Department is strong in quantum optics and quantum technologies, which is covered by the CNQO (theory) and EQOP (experiment) groups. Dr Haller had just started his Chancellor's Fellowship position at the time of the last review. In April 2015, we appointed Dr Paul Griffin to advance cold-atom quantum technologies and atom interferometry. Dr Griffin was promoted to Senior Lecturer in 2018. Dr Luca Tagliacozzo (presently on leave of absence at the University of Barcelona) was hired in 2015 and Dr Peter Kirton (starts January 2020) in 2019, both as Chancellor's Fellows within the CNQO group, work in on various aspects of the theory of many-body quantum systems. Dr Jonathan Pritchard, who won an EPSRC Quantum Technology Fellowship to develop hybrid quantum technologies exploiting atoms coupled to superconducting circuits, was hired in July 2015, and will transfer to an academic appointment in 2020 after his fellowship. Dr Robert Cameron, working as a theorist on the interaction of light with chiral orbital angular momentum molecules, has recently been awarded a Royal Society URF, starting October 2019.

Researchers in the Optics division are involved in all four UK Quantum Technology Hubs, which have been recently renewed with a total grant income to Strathclyde (including the Institute of Photonics) in excess of £6M. New large Strathclyde-led collaborative research grants secured during the review period include the EPSRC Programme Grant "DesOEQ" (PI: Daley), £5.8M total, with £2.7M for Strathclyde, an EPSRC Prosperity Partnership grant, £5M (PI: Pritchard) and the H2020 ETN "ColOpt" (PI: Ackemann), €3.9M total, £802k for Strathclyde; and the project "CMSIN-II" for satellite quantum key distribution (PI: Oi), funded by the UK Space Agency (£899k).

Plasma Division: The Department is also strong in plasma physics. A key activity over the review period for the SILIS group has been the establishment of the Scottish Centre for the Application of Plasma-based Accelerators (SCAPA; Director: Jaroszynski). The Department has an internationally-leading track record in the development of laser-driven particle accelerators and the SCAPA centre is established to develop these novel, potentially compact, sources towards wide-ranging applications in science, industry, medicine and security. The first electron beam was produced at SCAPA earlier this year. An EPSRC Strategic Equipment grant (£1.7M; PI: McKenna) was secured in 2017 to establish three beamlines at SCAPA and funding was committed via our partnership in the Cockcroft Institute in 2019 to establish another beamline (with other contributions from SUPA and other grant funding). Other significant new grant funding in this area securing during the review period includes large EPSRC responsive mode grants; Lab in a bubble (PI: Jaroszynski; £4.4M); relativistically transparent plasmas (PI: McKenna; £1.1M), and an STFC grant on plasma wakefield acceleration-free electron laser programme (PI: Hidding; £600k). The group also secured substantial indirect funding via access time on larger, national and international, laser and accelerator research facilities.

The ABP group have transferred their research laboratories to the Technology and Innovation Centre (TIC) building during the review period. They have also contributed significantly to the international STFC Muon Ionisation Cooling Experiment (MICE) that demonstrated a key technique required for future lepton accelerators and for neutrino factories. Significant EPSRC grant funding was secured by the group for research into multi-wave interactions in plasma (PI: Ronald; £762k), high power THz radiation (PI: Cross; £361k) and tokamak plasma science via a Programme grant led by the University of York (CoI: Ronald and Phelps). Other significant grants include an AFOSR programme linking dispersive pulse compressors with fast wave amplifiers (PI: Ronald; $625). The group also secured significant KE funding, including a €450k programme funded by ESA (PI: Ronald). In April 2017, the University became a full member of the Cockcroft Institute (a research pooling partnership between the Universities of Lancaster, Liverpool, Manchester, Strathclyde, and the STFC). Many of the academics within SILIS and ABP, and a member of staff from CNQO, became members of the Cockcroft Institute.

Institute of Photonics: The IoP has grown to the level of 60 staff and PGR students, and to a Principal Investigator cohort of 9.6 FTE. Dr Lucia Caspani was recruited at a Chancellor's Fellow in 2018 and is developing a research group, QuaSAp (Quantum Sources and Applications), devoted to the development of compact sources of quantum states of light for quantum metrology, computing and communication. Dr Johannes Herrnsdorf was appointed in a Chancellor's Fellowship in June 2019, having previously secured an EPSRC UKRI Innovation Fellowship, to work on structured illumination and digital lighting at the few-photon level. Notably, earlier this year Prof Mathieson was awarded a prestigious RAEng Chair in Emerging Technologies to develop neural interfaces for the understanding and treatment of neurodegenerative conditions (£2.6M, 2019-2029). The IoP currently holds 20 competitively won research grants totalling £10.4M. Other research highlights over the period include the 2016 IEEE Aron Kressel Award and 2016 Institute of Physics Gabor Medal to Prof Dawson.

The IoP's research activities are strategically focused to ensure academic excellence is combined with strong industrial engagement. Its key objective is to bridge the gap between academic research and industrial applications and development in the area of photonics. Knowledge exchange highlighted from the review period include the 2017 sale of spin-out company mLED Ltd. to Facebook and Dr Gábor Várkonyi securing a Royal Society of Edinburgh Enterprise Fellowship in 2018 to translate some patent-protected IP (working towards a future spin-out) on data transmission using visible light communication. The IoP has 12 photonics laboratories and a clean room microfabrication facility, totalling over 1000m^2 in the TIC building. Members of the IoP helped form and collaborate with the Fraunhofer Centre for Applied Photonics, which is led by Prof. Dawson and also based in the TIC building.

6.3.1 The Portfolio REF documentation - REF submission

Assessed by the UoA 9 panel, the Department was ranked first in REF2014 for overall research quality, based on the grade point average metric. We were ranked second for Impact. 96% of our overall research profile rated as 3* or 4*, up from 40% in RAE2008 (Table 6.2).

*Table 6.2 REF 2014 Quality Profile for Strathclyde Physics **

	4*	3*	2*	1*
Overall**	40(5)	56 (35)	3(50)	1(10)
Outputs**	27	66.7	5.4	0.9
Impact	80.0	20	0.0	0
Environment	40.0	60	0.0	0

**27.0 FTE category A staff submitted **(2008 comparison in brackets)*

Impact was not assessed in the 2008 RAE and there were significant differences in how Environment was assessed. Hence, a comparison with results from the previous rankings is only carried out for the Overall and the Outputs profiles.

6.4 Collaborations – internal and external

The Department has a strong culture of collaboration and has established itself as a central participant of several ground-breaking research collaborations. Examples are given below.

Within the Faculty

The Department has strong research links across the Faculty of Science, for example in Pure and Applied Chemistry (Nanometrology), SIPBS (Microbiology, Neuroscience, Neurophotonics) and Mathematics and Statistics (MASTS).

Within the University

The Department features centrally in the University's Strategic Themes including Health and Wellbeing, Measurement Science and Enabling Technology, and Ocean, Air and Space. Physics staff (Chen, Laurand, Kuhr, McConnell) are leading sub-themes. There are also numerous example of cross-Faculty collaboration.

Nationally

The Department plays a significant role through its involvement in national centres. These include:

- The ongoing engagement with the National Physical Laboratory (NPL).
- The new partnership (as a full member) of the Cockcroft Institute.
- Renewed involvement in the EPSRC-funded Quantum Technology Hubs (only institution involved in all four QT Hubs in both phases 1 and 2).
- Hosting the ARCHIE-WeSt Supercomputer, which has been upgraded in 2019.
- Housing the flagship SUPA initiative of SCAPA.
- Researchers from the Department frequently leading experiments in national research facilities (Central Laser Facility, Diamond Daresbury Laboratory etc.).

Internationally

The Department plays a key role in a number of international centres, collaborations and project. The following is a list of examples:

- The International Max Planck Partnership in Measurement and Observation at the Quantum Limit.
- Fraunhofer Centre for Applied Photonics

- SU2P – A Strathclyde-led partnership between our Scottish partners (St Andrews, Heriot-Watt, Glasgow) and Stanford and Caltech in the area of photonics.
- Laserlab-Europe – a consortium of 30 leading organisations in laser-based inter-disciplinary research from 16 countries.
- Extreme Light Infrastructure (ELI) – the first international users facility for high power lasers. The Department is involved in all three pillars of ELI.
- The international Muon Ionization Cooling Experiment (MICE)
- The Advanced Proton Driven Plasma Wakefield Acceleration Experiment (AWAKE) is an accelerator R&D project based at CERN.
- SLAC's Facility for Advanced Accelerator Experimental Tests, or FACET

6.5 Research Pooling Activity

The Department is involved in four Scottish research pools: SUPA, SULSA, SINAPSE and MASTS.

- We are a key partner in the Scottish Universities Physics Alliance (SUPA). For more than a decade, SUPA has successfully stimulated pan-Scotland collaborations between Physics departments and further widening of interactions within the changing landscape of SUPA remains a mainstay of our collective strategy in the coming five years. During the review period, four of the seven SUPA themes were led by academics from the Department: Physics & Life Sciences (McConnell); Photonics (Hastie); Nuclear and Plasma Physics (Jaroszynski); and, Energy (McKenna).
- We are involved in the Marine Alliance for Science and Technology Scotland (MASTS), which is an SFC funded research pooling initiative in marine science involving nine founding consortium members spread across Scottish HEIs and a further four Associate members. Dr. McKee leads the Department's involvement.
- Collaborative links exist between SUPA and the SULSA life sciences pooling initiative, for example through funded research collaboration on biofilm architecture (McConnell and Allen, University of Edinburgh).

6.6 Comparison with Benchmark Departments and Institutions

Comparing research data with benchmark departments is difficult, given that we are five years on from the previous REF cycle. We achieved a sector-leading performance in REF 2014 in terms of overall research quality and also scored very highly on impact. In terms of international rankings, the QS Top Universities Guide 2019 ranks the department in bracket 201-250 from a total of 602 institutions. Our ranking in 2018 and 2019 increased over that in previous years. This is the same bracket as physics departments at Heriot-Watt University, Queen's University Belfast, and the Universities of York, Leeds and Surrey. It puts us ahead of UK institutions such as Lancaster, Newcastle, Swansea and Cardiff, but behind institutions with considerably larger physics departments, such as the University of Durham and Imperial College London. Internationally, we are on a par with University of Milano-Bicocca, University of Bern, University Ulm and Ghent University, and ahead of the University of Jena, University of Bordeaux, University of Salamanca, University of Düsseldorf, KAUST and Beijing Normal University. Table 6.3 provides a comparison of publication rates and citation rates for example UK benchmark institutions.

The international quality of our research and our international standing are strongly reflected in the range of EU consortia and international projects in which we are collaborating with other leading physics departments worldwide.

Table 6.3 Comparison of research outputs for Physics and Astronomy against national and international benchmark institutions over the period 2015-19.

Institution	Number of Acad. staff	QSTU 2019 ranking	REF2014 GPA rank	Ave. pubs. Per year (2015-19)[#]	Pubs/year/ academic staff[#]	Ave. cites /article (2015-19)	h-index (2015-19)[#]
Strathclyde	41	201-250	3.35	338	8.3	17.4	62
Heriot-Watt	33*	201-250	3.15	413	12.5	9.5	48
QUB (School of Maths and Physics)	62*	201-250	3.11	357	5.8	12.8	56
York	68*	201-250	2.93	262	3.9	15.1	46
Lancaster	58*	251-300	3.04	427	7.4	20.2	81
Durham	87*	51-100	3.27	548	6.3	16.2	78
Imperial	134*	11	3.26	1182	8.8	19.3	120

Notes: *2019 estimates based on staff lists on the institution web site; [#]Based on Web of Science citation analysis

6.7 Indicators of Esteem

Tangible recognition of the quality of our academic staff has come through different honours and awards, prizes and appointments to national leadership roles. Key highlights include:

- Learned Societies roles: Appointments to Fellow of The Royal Society of Edinburgh (McConnell in 2019 and Jaroszynski in 2015); Institute of Physics Particle Accelerators and Beams Group Chair (McNeil) and Large Facilities Forum representative (McKenna); Royal Society's International Networks Committee (Dawson); Vice President Conferences for the IEEE Photonics Society (Dawson)
- Prizes and Medals: 2016 IEEE Aron Kressel Award (Dawson); 2016 Institute of Physics Gabor Medal (Dawson); 2017 IEEE Plasma Science and Applications Award (Phelps); The Optical Society's 2019 Robert E Hopkins Leadership Award (Ferguson).
- UKRI leadership roles: STFC Science Board (McKenna); EPSRC Capital and Equipment Strategic Advisory Team (McKenna); EPSRC Quantum Technology SAT/SAN working group (Dawson); STFC Accelerator Strategy Board (Hidding; Jaroszynski until 2015); Member of STFC High Power Laser Facility Access Panel (Hidding; McKenna until 2016)
- National Centre and Programmes: Head of Fraunhofer CAP (Dawson); Technical Advisory Group for the UK's National Quantum Computing Centre (Dawson);
- Research Pool Leadership roles: SUPA Physics & Life Sciences Theme Leader (McConnell), SUPA Nuclear and Plasma Physics Theme Leader (Jaroszynski, until 2018), SUPA Photonics Theme Leader (Hastie) and SUPA Energy Theme Leader (McKenna, until 2018); Energy Technology Partnership Directorate (McKenna, until 2018)
- National Reviews: 2017 BEIS Review of National Large Facilities at Harwell (McKenna); House of Commons Select Committee report on Quantum Technology (Riis and Dawson)
- Advisory Committees for international facilities: APOLLON 10-Petawatt laser in France (McKenna); Extreme Light Infrastructure)-Nuclear Physics facility in Romania (Jaroszynski and McKenna); HIBEF project at the European XFEL in Germany (McKenna)

Prestigious research Chair and fellowship successes won during the review period:

- Prof. Keith Mathieson - RAEng Chair in Emerging Technologies in 2019
- Dr Robert Cameron - Royal Society University Research Fellowship in 2019
- Dr Brian Patton - Extended his Royal Society University Research Fellowship in 2018
- Dr Gábor Várkonyi - Royal Society of Edinburgh Enterprise Fellowship in 2018
- Dr Johannes Herrnsdorf - EPSRC UKRI Innovation Fellowship in 2018
- Dr Luca Tagliacozzo - Ramon y Cajal Fellowship from the Spanish Ministry of Science and innovation in 2018
- Dr Jonathan Pritchard - EPSRC Quantum Technology Fellowship in 2015

Other prestigious research Chair and fellowships held or transferred during the review period:

- Prof Alan Kemp – RAEng Research Chair (2014-19)
- Prof. Paul McKenna – EPSRC (Senior) Leadership Fellowship (2012-17)
- Dr Brian Patton - Royal Society University Research Fellowship (2013-)
- Dr Oliver Henrich – EPSRC Research Software Engineer Fellowship (2016-21)
- Dr Remi Capdessus – EPSRC (Postdoctoral) Fellowship (2017-20)

6.8 Contract Researchers

The research activities of the Department depend crucially on the efforts of the growing population of contract research staff. We feel a strong responsibility to support our colleagues in their efforts to establish a research career in academia or industry. The same type of support in terms of mentoring and grant writing that is available to early career academics and described below, is also extended to research staff. The immediate line manager and the research group leader play a crucial role here, as well as in the more formal ADR process. Contract researchers are encouraged to take on limited duties in undergraduate teaching in order to develop their skills in this area. Most of them would also naturally be involved in supervision of postgraduate students and undergraduate final-year project students.

Contract research staff are particularly encouraged and supported in seeking fellowship funding as a launch-pad for an independent research career. We have been particularly successful in achieving this through a number of fellowships from e.g. Royal Society URF, EPSRC and the RAEng. We have put in place supporting measures to mentor fellowship applicants through the process, and in 2019 we organised an information session / workshop to prime applicants for future calls. Our intention is to make this an annual event.

6.9 Research Students

We currently have 168 registered PGR students (155 PhD, 11 EngD, 2 MPhil), which includes those who are writing up.

Supervision

The Department operates the traditional two-supervisor system, with further supervisors assigned as required (e.g. with EPSRC iCASE students, a third industrial supervisor is appointed to support learning outcomes). A personal development advisor/counsellor from outside the student's group is also arranged, should independent advice be needed. There is an annual assessment of student progress with presentations (oral in first year, poster in second year) and an annual formal viva. In addition to this, student progress is monitored through the Faculty's online system, SPIDER. This supervision and monitoring scheme has been shown to be effective in terms of providing support and guidance when required and needs no changes.

Research Skills Training Opportunities

Strathclyde Physics PhD students are members of the SUPA Graduate School, which provides over 50 advanced specialist and professional development courses, corresponding to over 800 hours of lectures, delivered annually via a network of video classrooms distributed among the 8 SUPA partner institutions. In addition to SUPA Graduate School courses, some students enrol in courses provided by other research pools e.g. MASTS, SINAPSE, Cockcroft Institute, and the Strathclyde Researcher Development Programme.

EngD students are part of the CDT in Applied Photonics, based at Heriot-Watt University. As part of the CDT, students attend training courses at Strathclyde, Heriot-Watt and St-Andrews.

External Scholarships/Studentships

Centres for Doctoral Training (CDT) have been an important source of project studentships. Participation in the Diamond CDT with the University of Warwick, the Optima CDT with the University of Edinburgh, the Quantum Technologies Hub in Sensors and Metrology at the University of Birmingham, the CDT in Next Generation Accelerators, and the CDT in Delivering Quantum Technologies at UCL and the CDT in Applied Photonics at Heriot-Watt, which has been renewed, have resulted in many UKRI funded studentships. We also seek to make a strong submission to the prestigious Carnegie Studentship competition. In addition, as referred to earlier, the Department also leads or is a partner in several Strathclyde-CDT initiatives (mini-CDTs with several students per cohort) that are supported by a range of external partners. We are also establishing an International Graduate School for Quantum Technologies, supported by the University and industry. The first students in this new initiative will start in October 2019.

The NPL Postgraduate Institute has also supported studentships. Fraunhofer CAP is already supporting several PhD and EngD studentships. We also have several PhD students jointly supervised by international partners e.g. DESY (Deutsches Elektronen-Synchrotron) in Hamburg and the Universite Cote d'Azur in Nice.

Success Rate (applications to awards) and Completion Data

Data has been compiled showing the numbers of applications received per academic year and the numbers of applicants who rolled forward to registration per year (Figure 6.1).

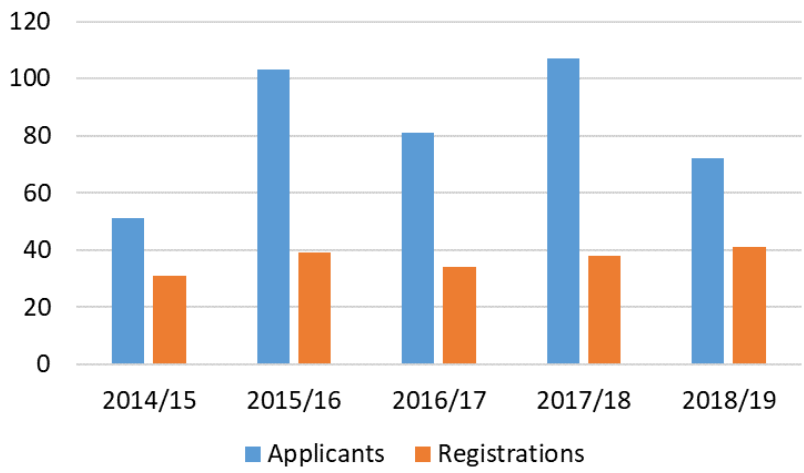

Figure 6.1 Information on applicants, conversion and completion for PGR students in Physics

PGR applications have varied considerably over the review period, with large peaks in 2015/16 and 2017/18. The high number of applications in 2015/16 could have been due in part to the 2014 REF results, but the reason for the large variations in the years following is not clear. As for PGT, a contributing factor to the low number of applications in 2018/19 could be the fact that the University was removed from the Saudi Arabian approved university list. We have made efforts to minimise the time between application and offer in order to enhance conversion rates, in accordance with the University's turnaround policy on applications.

Numbers Supervised by Individual Members of Academic Staff

The mean number of PGR students per academic is 3.62 (45 Staff supervising 163 PGR students). The group size, based on First Supervisor, ranges from 0 to 11 students, as shown in table 6.4. Of the four staff who currently supervise no students as 1st / primary supervisor, two are recent appointments and two act as secondary supervisors.

Table 6.4 Student supervision (as primary supervisor) by staff in Physics

Number of staff	4	8	8	6	6	3	3	1	2	1	1	2
Students supervised (as First Supervisor)	0	1	2	3	4	5	6	7	8	9	10	11

6.10 Research Funding

The Strathclyde Awarded Value of Research Grants and Contract Reports (Table 6.5) was taken from SUnBIRD. Both the value and the diversity of the income streams have increased over the review period. The Department is consistently one of the major physics research grant earners at EPSRC (typically in the top 20 Physics Departments) and in recent years its funding profile has included grants from BBSRC, STFC, the Leverhulme Trust, the Royal Society, the Royal Academy of Engineering, DARPA, EOARD and the Fraunhofer Society. We also have significant industrial research income, particularly in the Plasma Division and more recently in the Optics Division. The Department has a strong track record of funding from the EU, and we have already obtained several awards from Horizon 2020, including participation in Marie-Curie initiatives.

Table 6.5 Research grant income (Strathclyde awarded value)

Source	2015-16	2016-17	2017-18	2018-19	Success rate
UK Research Councils	4,184,313	3,801,977	5,241,671	5,672,920	34%
Non-EU Industry	23,807	96,276	25,124	106,850	100%
Non-EU Other	232,182	134,922	283,903	504,599	100%
UK Other	12,641	134,136	62,227	63,366	25%
UK Charities	189,366	194,572	228,965	322,544	34%
UK Government	142,978	203,330	107,398	54,801	30%
UK Industry	423,916	199,185	118,265	31,737	100%
EC + EU Government	831,530	381,242	392,854	478,568	24%
EU Industry	71,265	21,567	20,256	21,211	100%
EU Other	…	26,470	224,728	156,189	50%
Grand Total	**6,111,998**	**5,193,677**	**6,705,391**	**7,412,785**	**Overall: 38%**

The success rate for the Department, calculated as the Number of Awards / Number of Applications from the data available on SUnBIRD, over the previous four-year period is 38%.

Almost all of our academic staff and a number of our senior researchers are PIs on research grants (our total number of PIs is 61). While emphasising the PI status of the individual researchers, we recognise the value of co-investigators, especially in large grants where it is advantageous to present a larger consortium headed by a senior professor. At the same time, we are encouraging ECRs to apply for personal fellowships in order to better establish their independent research careers.

6.11 Research Facilities

Over the review period, the Department has continued to receive significant investment in its research facilities from the University and external sources, including UKRI funding. Our research facilities include:

- An electron microscope facility, which is run by the SSD group, and is one of the University's central research facilities and used by a large number (approx. 20) of groups.
- The SCAPA high power laser-plasma radiation sources facility was established in a suite of new state-of-the-art laboratories in an extension to the John Anderson building. The investments include equipment funding from EPSRC and STFC-CI, as noted above. The facility is open to users on a fee-based access model. A new initiative is also underway in partnership with colleagues in the Department of Civil and Environmental Engineering, to establish a nuclear users facility at SCAPA.
- The IoP operates an industry-standard cleanroom suite, totalling over 1000m^2 in the TIC building. It comprises fabrication and test equipment for the manufacture of micro-scale optoelectronic and photonic devices. All of this equipment is available for external access on a hands-on or serviced basis to both academic and industry partners.
- The Department has played a key role in the ARCHIE-WeST high performance computing facility, which is hosted by the University. Dr Henrich is one of two Operational Directors and the ARCHIE-WeST Manager and support team are based in the Department.

7 Knowledge Exchange

Highlights from the review period:

- £1.7M income from industrial research since 2015 (not including 18/19)
- >£2M income from licensing, CPD and consultancy
- The sale of the spin-out of mLED Ltd, the biggest of its kind for the University
- 1 KTP awarded (2018)
- 7 patents filed and 12 others in the pipeline of invention disclosures
- 12 recent translational awards

Working from a strong base at the time of the last review, the Department has further invested in its knowledge exchange activities. In 2017 the Department hired a 0.8 FTE KE Associate to develop external engagements and support academics and researchers in undertaking KE related activities through e.g. short to medium-term projects with industrial partners and CPD activities. The role was taken up by Dr Susan Spesyvtseva in April 2017, currently being substituted by Dr Jens Sutter. During most of the review period, the Department's KE team has been led by Prof Mathieson. Dr Laurand has recently (April 2019) taken over the role of KE Director following Prof Mathieson's award of a RAEng Chair in Emerging Technologies. The Department's position was further strengthened in September 2018 with the appointment of Prof Jeremy Ward as Professor of Industrial Practice bringing expertise in Technology and Requirements Management. Prof Ward's work encompasses the generation of impact from the Department's exceptionally strong involvement in the UK National Quantum Technology Hub and the upcoming Quantum Hub II.

The KE team organises monthly drop-in information sessions for staff, and the first Business Breakfast event aimed at strategically engaging with industry was held in June 2019. In collaboration with Fraunhofer UK, the team also held in September 2019 a colloquium on the subject of "Engineering Innovation" given by Dr Tom Baer, Executive Director of the Stanford Photonics Research Center. The KE team meets weekly to discuss updates and priorities. The KE Director reports to the Head of Department at the Department's Leadership Team and Research & KE Committee meetings, and to all staff at the Departmental Committee meetings.

7.1 Commercialisation

7.1.1 Spin-out companies

The Department has enjoyed significant spin-out success over the review period (and historically as well), most recently through the sale of the spin-out of mLED Ltd, the biggest of its kind for the University. mLED Ltd resulted from research at the Institute of Photonics into micron-scale LED devices through sustained EPSRC funding over more than 10 years. The company had secured several rounds of investment, totalling over £1M, before being bought. The initial return to Physics this year was £1,431,823. A residual payment of £253k is expected next year.

Other successes in recent years providing impact include:

- The first UK research centre of Fraunhofer, which was set in Glasgow in the area of applied photonics (Fraunhofer-CAP) in 2012. As noted in the last review, the Institute of Photonics in combination with Coherent, M-Squared Lasers and Thales, were critical in the decision of the Fraunhofer Society to create FCAP. It received a further £5 million funding in 2018, and has now grown to 27 researchers, supporting industry and partners, and securing £12.7M in competitively won funding and direct research contracts, with £8.7M of new project cash generated for R&D expenditure in Scottish industrial partners. Fraunhofer continues to be viewed as a key vehicle in harnessing KE opportunities in the Department.
- Strathclyde's Photophysics Group contributed to the University spin-out company IBH (Birch), and its successful merger with the £1bn multinational company Horiba. Strong collaboration between the group and Horiba continues with research in nanobioparticles for diagnosis, improved understanding of melanin's unknown structure and cancer radiotherapy.
- Cutting-edge research on diamond technology and its applications in collaboration with Element 6.
- Cascade Technologies, which manufactures gas sensors for environmental, security and process monitoring is based on Department research on infrared photonics. Cascade is now part of US-based firm Emerson.
- Technologies from the Atoms, Beams and Plasmas group (microwave and mm-wave sources and amplifiers) are also being exploited commercially by UK industry and public sectors such as security, defence, health and the environment.

We are fostering the culture of KE, and all of the divisions of the Department are conducting research with impact in mind. The recent award of two innovation fellowships (RSE and EPSRC), held within the Institute of Photonics, is expected to maximise commercial opportunities associated with some of our cutting-edge research in Photonics. In particular, the RSE fellowship awardee (Varkonyi) is translating one patent (stemming from research of Prof Mathieson's team) through the spin-out route. A recent application to the high-growth Spinout Programme of Scottish Enterprise has been submitted based on our IP (Savistky).

7.1.2 Licences

One of the Department's IP has recently been approved for licensing to Radiabeam Technologies (Hidding). The EPSRC innovation fellowship awardee (Herrnsdorf), who has also been appointed as a Chancellor's Fellow in the Department as of June 2019, is considering licensing options for 2 patents and 3 invention disclosures in the area of smart lighting applications, based on extensive research conducted at the Institute of Photonics. Some of the patents in our portfolio are currently unlicensed, presenting opportunities for further industry engagement and licensing. Our KE strategy is to expand this area by capitalising on the newly established Innovation and Engagement Directorate, with which we are actively engaging. We will also benefit from the recruitment of a Business Development Manager, a position shared with the Faculty of Engineering, for targeting companies and enhancing our licensing portfolio.

7.1.3 Intellectual Property

The Department is proactive in increasing activity in IP protection, commercialisation, and licensing. The Department currently holds 7 patents in addition to a healthy pipeline of 12 additional invention disclosures spread across all divisions of the Department at various stages of the commercialisation process, presenting substantial opportunities for industry engagement, and generation of licensing and future spin-out income. As mentioned above, the recent award of two prestigious innovation fellowships will maximise opportunities associated with several of these patents.

7.2 Knowledge Transfer Grants

There have been 12 recent KT awards in the Department since the last review. Examples include a Health and Technology Acceleration Fund Confidence in Commercialisation award for Laurand (£43K), 2 AFRC Route to Impact for Jaroszynski and Dawson/Strain (£30k and £17.5k, respectively), and several Quantum Technology Hub awards.

The Department continues to be highly successful in engaging with industry through the latter Quantum and Photonics activities, winning in excess of £1M in related innovation funding. The Chancellor announced in his autumn 2018 statement that the total funding of the 2nd phase of the National Quantum programme will be approximately £315M over 5 years, which includes up to £70M from the Industrial Strategy Challenge Fund. This funding is likely to present significant opportunities for new industrial research contracts in the Quantum and Photonics areas. We will therefore capitalise on our success and on these substantial upcoming opportunities to grow our income in this strategic area – in particular through targeted applications to the Industrial Strategy Challenge Fund competitions.

Collaboration with industry through Innovate UK research has significantly increased in the last few years. Related income has increased to £390k in 17/18 compared to £60k in 16/17 and 15/16. The current Innovate UK portfolio has 6 live projects totalling £575k.

To increase the resilience of the Departmental KE income against possible future shifts in funding the KE team will endeavour to diversify this income stream across the Department. We are fully aware of other opportunities (particularly in Space and 5G) in the context of University strategic themes emerging within TIC2. Besides Quantum we expect Physics to have a presence in Space, 5G and MedTech with additional funding opportunities in Defence.

Knowledge Transfer Partnerships

KTPs are currently a main focus of the University's knowledge exchange activities. The University of Strathclyde is positioned 6th in the UK in numbers of KTPs held and is aiming to reach 5th position increasing the overall KTP portfolio from currently 29 to about 35. The Department has joined in these efforts, recently gaining a KTP on the development of a miniaturized atom-cooling platform with TMD Technologies. Further KTP options have been identified and are being explored with Optos PLC, Craft Prospect, Morgan Stanley, DesignLED, Enocell, and Optocap. One of our key targets is to convert two of these opportunities near term.

7.3 Internal Funding Opportunities

Six awards from the Impact Acceleration Account have been made to Department staff (Savitski, Roberston, Mathieson, Chen, Jaroszynski, Kemp, Riis) with industrial partners including Arctos, TMD Technologies, Leonardo, Thales, Elforlight. These awards are to maximize the commercial impact of EPSRC-funded research.

7.4 Engagement in Agenda Setting

Government, Policy Makers/Advisory Bodies/Contributions to the Discipline

Staff within the Department sit on high-level advisory panels for funding councils and engage at the Scottish and UK government levels, helping shape research strategy and future directions. Examples include:

- STFC Science Board (McKenna, since 2017)
- EPSRC Capital and Equipment Strategic Advisory Team (McKenna, since 2018)
- EPSRC Quantum Technology SAT/SAN working group (Dawson)
- STFC Accelerator Strategy Board (Hidding since 2015; Jaroszynski until 2015)
- STFC High Power Laser Facility Access Panel (Hidding since 2018; McKenna until 2016)
- Advisory roles on EPSRC CDTs (Mathieson - Chair External Advisory Board to Imperial College's CDT in Neurotechnology)
- Advisory Board for EPSRC Prosperity Partnership grants and Programme Grants (Dawson - Engineering Photonic Quantum Technologies)
- Institute of Physics Large Facilities Forum (McKenna)
- Witnesses on Quantum Technologies to the House of Commons Select Committee 2018 (Riis and Dawson)
- Invited speaker at the Scottish Parliament (Dawson – 2017 launch of the Institute of Physics report on 'The Role of Physics in Supporting Economic Growth and National Productivity in Scotland')

7.5 Consultancy

Several of our academics act in the capacity of consultants, to provide added value to companies and other bodies. Current consultancy activities include the engagement of Prof Dawson with Fraunhofer, Prof Phelps with defence contractors, Prof Mathieson with Stanford, Dr He with ATTOBahn, and Dr Oi with PwC Luxemburg. Income for these activities were £285k (16/17) and £485k(17/18). The amount for the first half of 18/19 is at £172k for a forecast of £320k.

The Institute of Photonics also generate income through the TIC clean room facility. The main non-academic users are currently Evince Technology, Oxsensis, CST Global, and FCAP, who together amounts to £30k annually (£28k for 2017-2018) – an amount that is remaining stable over the years.

7.6 Continuing Professional Development

The Department twice ran courses by the Institute of Photonics serving the lasers community: "Introduction to Lasers" and "Advanced Lasers" during the review period. These courses provide an excellent mechanism to strategically connect with laser companies, and the last time it was run for employees of Coherent Scotland in 2018, it generated £11,150. The Nanoscience group has been active in CPD for teachers with the delivery a recent course on semiconductor physics. A new module (20 credits) on FPGA programming is being developed by Dr Herrnsdorf that could be integrated into the Faculty's Advanced Science Masters.

The Department's CPD activity also encompasses the organisation of international workshops, conferences and summer schools. A summer school on Frontiers in Quantum Dynamics & Quantum Optics under the highly regarded brand of Scottish Universities Summer School in Physics (SUSSP) was held in 2015. The last SU2P conference was held in TIC on 22-23 May 2018 and included a Business Masterclass on spin-out technologies from the academic sector. SU2P is a collaborative programme with Stanford University and industry to sustain economic impact in Photonics in the UK and California. It funds pilot projects involving Department staff, linking them with SMEs and Stanford collaborators, and runs workshops and events for industry and academia. Optogen2018, a workshop on technologies for Optogenetics and Neurophotonics (Prof Mathieson as programme chair), was held in TIC on 4-5 December 2018, and had a strong industry focus.

7.7 Outreach/Press Coverage

The Department has built up a strong and steady stream of outreach and public engagement. We regularly contribute to Science Festivals, with a strong presence at the annual Glasgow Science Festival, and activities at the Scottish launch of the International Year of Light at the Royal Society of Edinburgh in February 2015, the Dundee Science Festival in 2016, the Institute of Physics Festival of Physics at Edinburgh's Dynamic Earth in September 2018, the British Science Festival, Kinning Park in March 2019, or the Moss Fest hosted by the Moss Pieratt Foundation in Glasgow in September 2018. In July 2017 the Department hosted Prof William Phillips, winner of the 1997 Nobel Prize in Physics, to give a public lecture to over 300 attendees at the Technology and Innovation Centre. The event was followed by a reception with number of hands-on activities from the Department and liquid-nitrogen ice-cream.

The Department is present at career events like the Technical Careers Fair at City of Glasgow College in September 2018, a stand each year at the Glasgow STEMfest, held at Glasgow Science Centre, and hosting a day of Physics activities for eight high schools as part of Science@Strathclyde. Staff and students lead numerous school visits to primary, secondary, and additional-needs schools, with the most recent ones to Lockerbie Academy, St Margaret's High School in Airdrie and to King Edward VI in Birmingham. We have strong links with the Glasgow Science Centre for the Meet the Expert Series.

The Department uses dedicated international conferences to convene experts from academic research and industry to specific fields. In November 2017 the Ross Priory Workshop on Atomic Clocks, hosted by Experimental Quantum Optics and Photonics group, gathering international leaders from industry and research into a focussed conference. The Strathclyde Innovation Symposium on Optically Pumped Magnetometry at Ross Priory in September 2018 followed this successful strategy, bringing all the leading companies and research labs active in the area to the Ross Priory estate for a 2-day meeting. In August 2019, a successful workshop from the Scottish Centre for Innovation in Quantum Computing and Simulation with industrial attendees (M2, Morgan Stanley…) was organised and hosted by the Department. A Ross Priory Clocks Workshop hosted by Experimental Quantum Optics and Photonics will take place in November 2019.

8. Summary

8.1 Strengths

Physics is a department with an outstanding reputation for excellence in research and knowledge exchange, which delivers high quality undergraduate education and postgraduate training. Our key strengths are:

- Our staff. We have excellent staff across the various job categories, who work to deliver lasting results in all of our academic activities. This includes international research leaders, supported by teams of dedicated researchers, technicians and administrative and professional services staff, working within and across our four research divisions.
- Our research quality (outputs and impact) as measured by REF 2014. We have a vibrant and internationally leading research programme that covers fundamental and applied physics, supporting multidisciplinary collaborations and fostering the development of new fields.
- Our strong national and international profile, via our engagement in all four quantum hubs, with UKRI, as users of large scale facilities on the Harwell campus and internationally, and through strategic partnerships such as Fraunhofer CAP, the International Max Planck Partnership (IMPP), SU2P and many more.
- A consistently high research grant income for the physics discipline and state-of-the-art research facilities (e.g. SCAPA, atom traps, super resolution microscopes, clean-room facilities,…).
- Our track record and continuous achievements in generating spin-out, patents and licencing, and generally our relationships with our industrial partners.

- Our graduate programmes and our approach to teaching and student engagement. We typically score highly in terms of student experience and satisfaction in surveys such as the NSS.
- Our staff have won a number of Teaching Excellence awards. Examples in the review period include Strathclyde Student Union's Teaching Excellence Awards for Dr Yao (Best in Faculty 2019), Prof Kuhr (Best in Faculty), Prof Oppo (Most Enthusiastic Teacher 2015), and Dr Yao won the first annual Faculty of Science Teaching Excellence Award (2019) in the category of Teaching Impact.
- Our commitment to providing a stimulating, inclusive and respectful environment in which staff and students are supported to realise their full potential.

8.2 Examples of Best Practice

The Department aspires to deliver excellence in all aspects of academic life. Some examples of this include:

- Providing a variety of forums for student engagement and feedback, and acting on that feedback to enhance student experience.
- Working to increase our research grant income through active encouragement and support mechanisms. These include encouraging staff to participate in the Grant Writing Challenge and holding meetings with staff needing extra support.
- Workshops in the Spring to engage early with researchers to help them shape fellowship applications for the Autumn competitions and to promote a pipeline of future competitive fellowship applications.
- Our outreach and public engagement activities, including the David Elder Public Lectures series in partnership with the Glasgow Science Centre, Exploratron, schools outreach lectures, Raspberry-PI workshops, Girls-into-Physics event and more.

8.3 Challenges

The key challenges facing the Department are:

- The quality of the infrastructure in our research laboratories, which affects our ability to recruit and retain research talent. The University has made significant investments in the John Anderson building, but there remain considerable infrastructure challenges that are restricting our research ambitions.
- The infrastructure in our teaching laboratories. We aim to meet our growing recruitment targets, but are seeing more competition across all markets. To succeed, we focus on our core strengths, which means quality of learning and student experience. The quality of our laboratory teaching infrastructure is a key part of this, as practical work is an integral part of our degree programmes. We need to invest in modernising our undergraduate teaching laboratories to provide a sector-leading student experience that will be reflected in recruitment, retention rates and satisfaction.
- We are also reaching capacity in the JA building and so a key challenge going forward is to devise a strategy and implementation plan for a further extension to the building or to move selected research activities to alternative accommodation. This would enable the Department to continue to contribute to the University's recruitment ambitions as part of the Vision 2025 strategy.
- Funding for PhD studentships remains challenging. In particular, it can be difficult for potential supervisors to resource the top-up contribution needed for a REA, SEA or JARA studentship.
- Our targets for overseas student numbers, and in particular PGT, are high. We are working hard to attract overseas students, but there is a limited market available and our fees are high. The University ranking in some league tables is also a factor.

8.4 Areas for Improvement

The Department is actively addressing a number of areas for improvement, as listed below.

- Our research and teaching infrastructure. We are working on several projects in partnership with members of the University's Estates Services and Estates Development Group.
- Increasing the number of UG entrants from SIMD0-40 areas. We are working in close partnership with the Widening Access team to achieve this, but note that for 2018, only 10% of those school pupils who take Higher Physics come from the SIM0-40 grouping (Data from Scottish Government August 2018).
- Our PGR intake has flat-lined, against a target for growth. A student intake of around 30 represents an annual commitment to PGR students in excess of £2M, which is challenging to grow. We are exploiting every opportunity to overcome this.
- The gender imbalance in the Departmental staff profile is a concern (female percentage: Academic =15%; Research = 8%; PGR = 23%). We are taking action to address this, e.g. through development and implementation of our Athena SWAN action plan and via initiatives such as Women in Strathclyde Physics Association.