Impurity Probes on MAST

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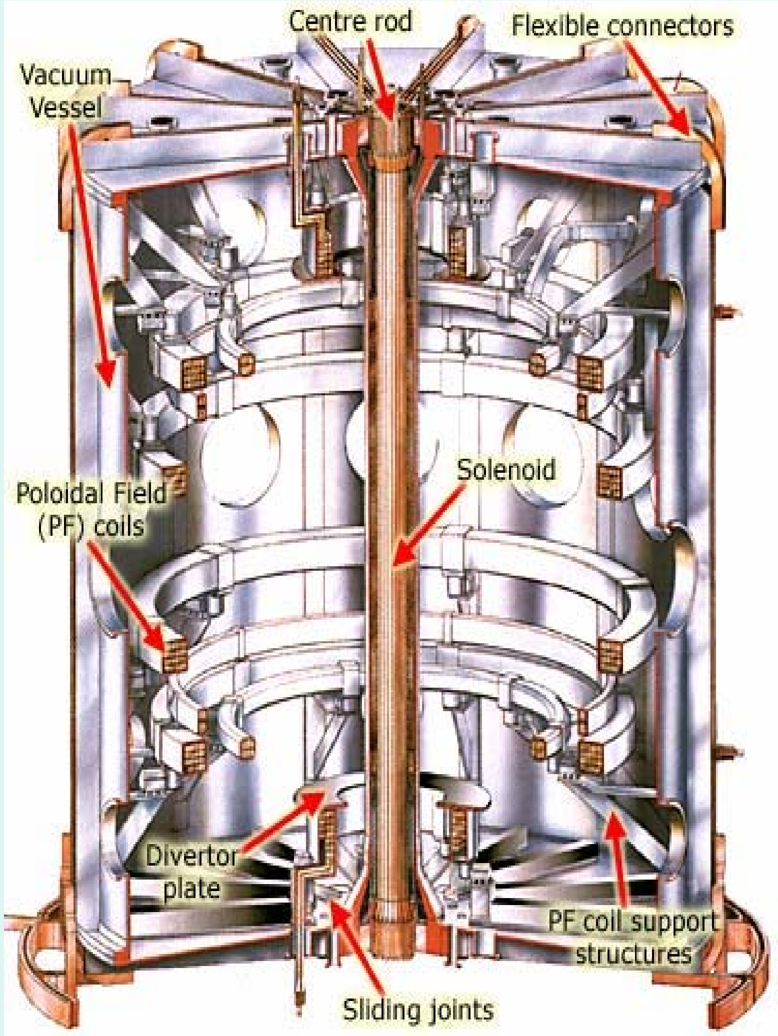
Content

- Introduction to MAST, probe system and spectroscopic coverage.
- Experiments conducted
- Analysis
- Planned improvements

MAST



Mega Ampere Spherical Tokamak

Major radius of 2m

Tin can shape with internal coils: provides excellent diagnostic access

Little/no wall interaction on outboard side

Pulse length ~300-400ms, 100-200ms flattop

Typical core conditions:

T_e = 0.7-2keV, n_e= ~3E^{13}cm^{-3}.

Reciprocating Probe

- Located on the outboard midplane of the vessel
- Can reciprocate up to 10cm in 100ms during shot
- Has replaceable heads, allowing it to be used for a variety of different experiments.
- Materials head has been designed to allow coated samples to be dipped into the SOL of the plasma
- So far have used In and Sn (Z=49,50)
- Domed upper surface maximises impurity exposed without sharp edges, also shields surface from carbon (problem on old designs)
- Includes 2 langmuir probes for local n_e, T_e measurements.

Impurity Spectroscopy on MAST

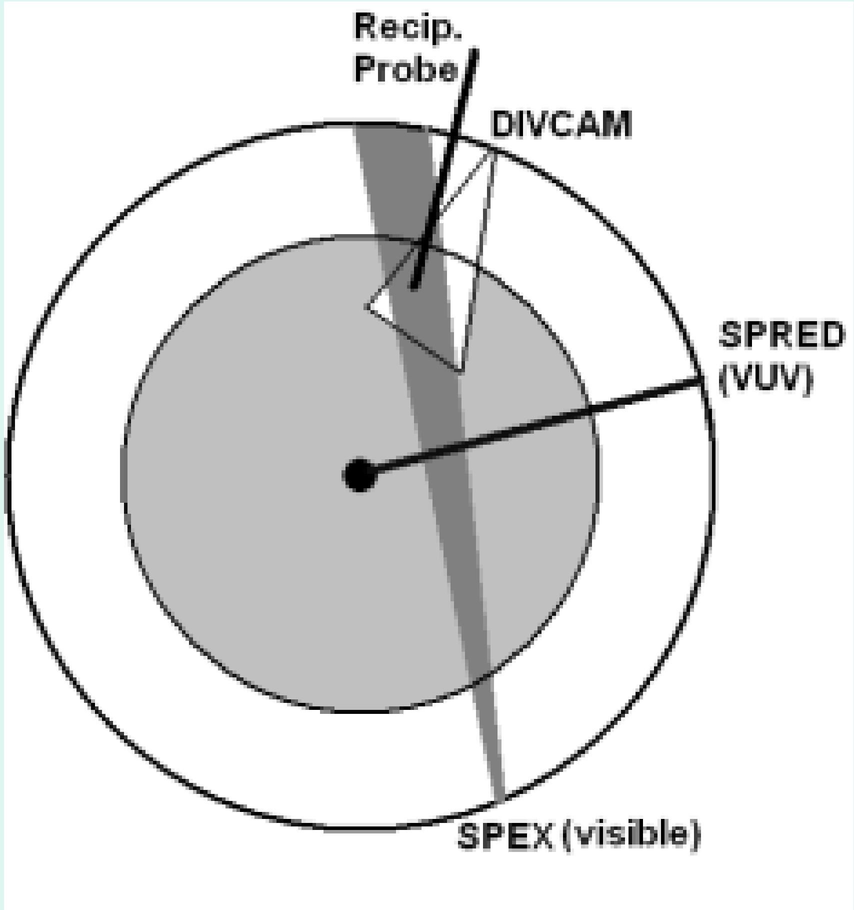
MAST impurity spectroscopic suite:

SPRED: 100-1700A, radial LOS

SPEX: 300A band in visible region

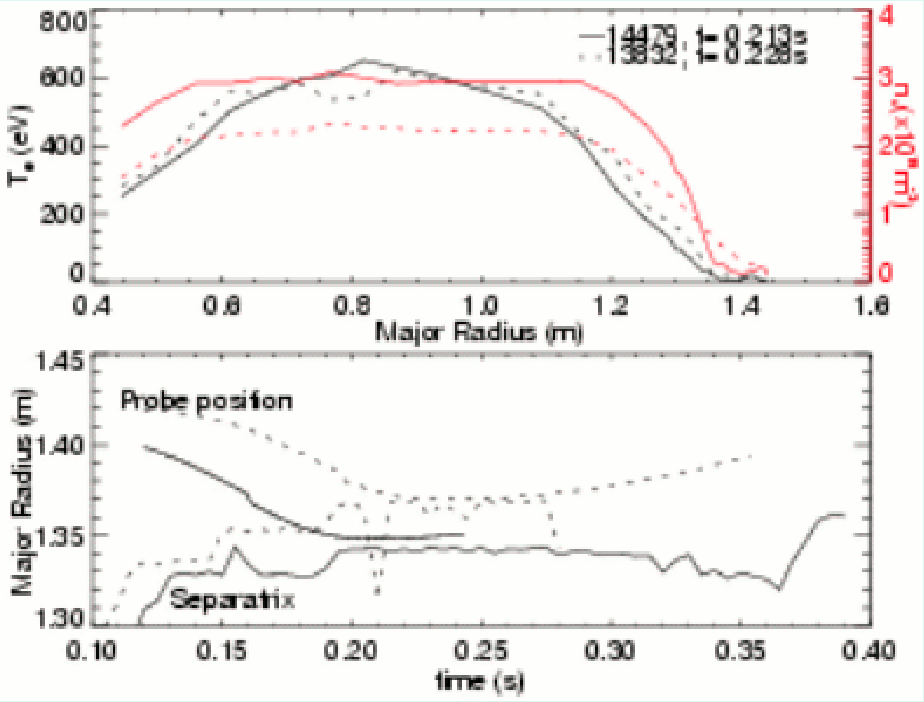
DIVertor CAMera: 2D CCD array with filter to pick out impurity line.

Also available: bolometer, soft xray camera



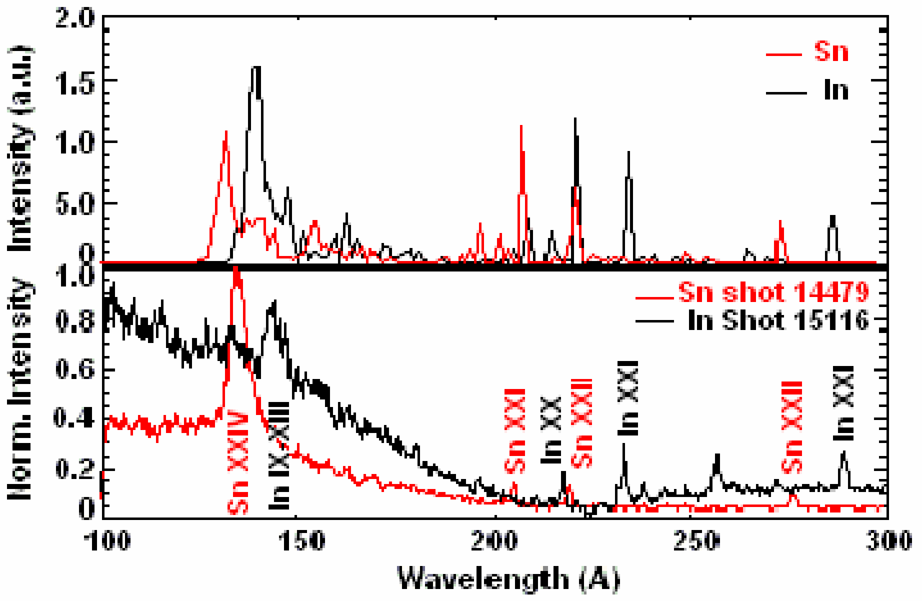
Experiments

- Probe has been reciprocated into single and double null plasmas.
- Tin data will be dealt with here.
- Beam heated plasmas have been tried, however edge proves to be unstable with the probe.



VUV signals

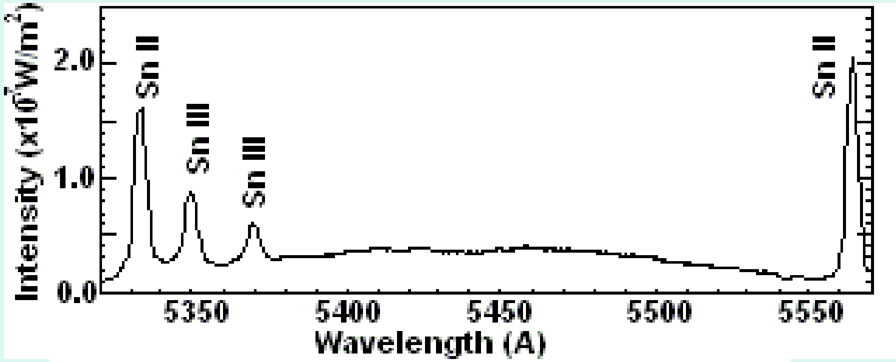
- ADAS baseline calculations along with a variety of other considerations had led to choice of tin and indium.
- Both Sn and In Impurity lines successfully observed in the core and edge plasma
- This information has been used in conjunction with UTC-SANCO to estimate the transport coefficients in the plasma.

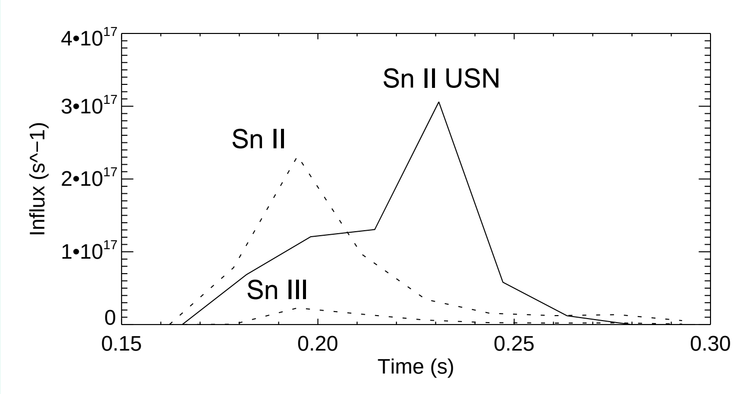


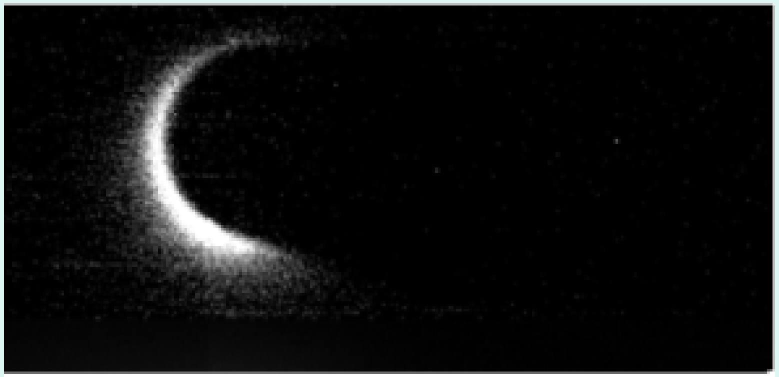
λ (Å)	Species	Transition
135	Sn X-XIV	unresolved
205	Sn XXI	$4s4p\ ^1P_1 \rightarrow 4s^2\ ^1S_0$
219	Sn XXII	$4p\ ^2P_{3/2} \rightarrow 4s\ ^2S_{1/2}$
276	Sn XXII	$4p\ ^2P_{1/2} \rightarrow 4s\ ^2S_{1/2}$

Visible Region

- A very useful set of Sn II and III lines was observed on SPEX.
- Sn II lines have been used to provide an estimate of influx.

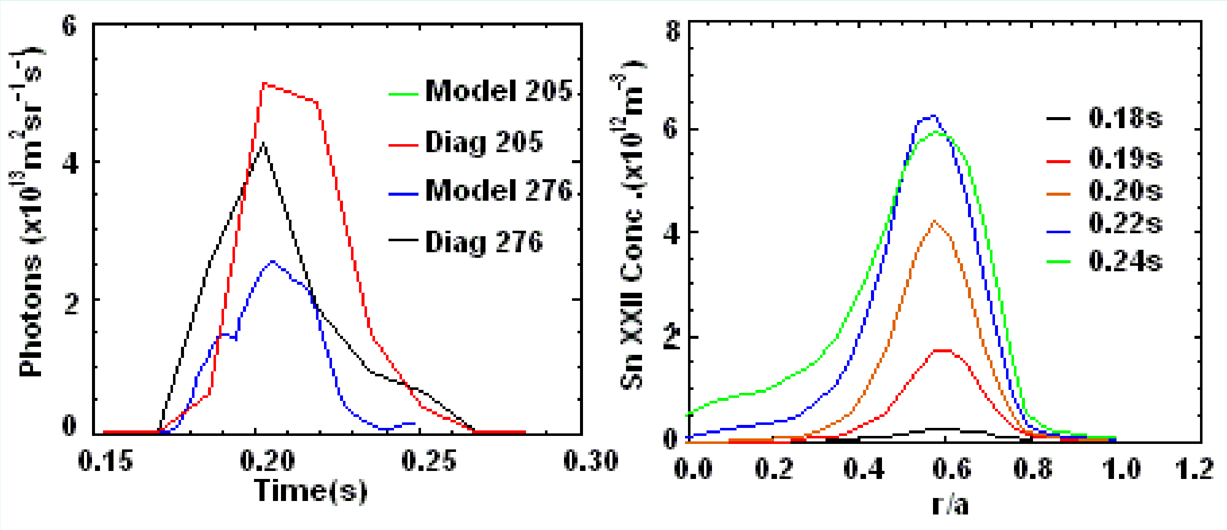






Erosion rate agrees with TRIM calculations to within 30%

Core UTC-SANCO modelling

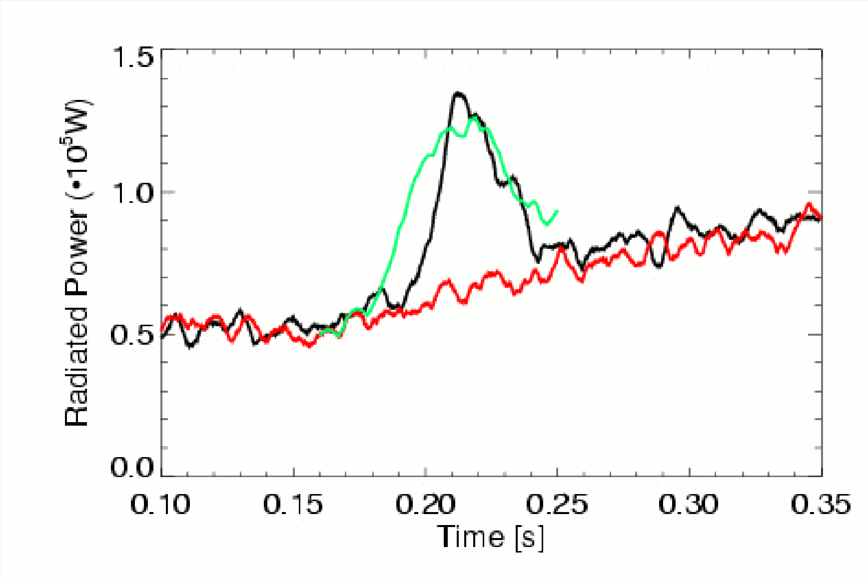


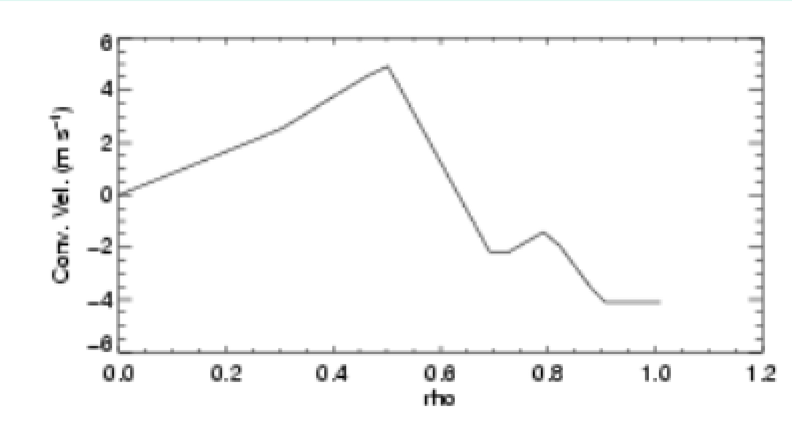
- Ni-like stage is primarily exposed at near edge of plasma – r/a > 0.5
- Due to lack of emission from higher stages, no central core impurity could be observed

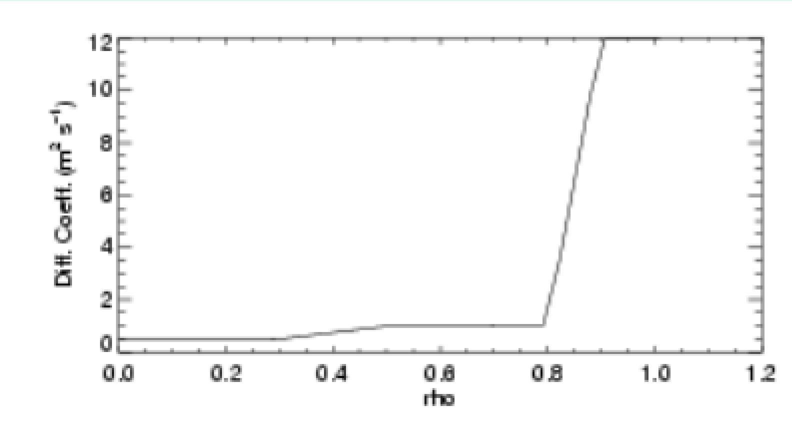
- Only one set of adjacent lines, not a good spread of stages to study.
- However influx was tied down by the visible measurements so not completely free fit

Implications

- Large change (doubling) in total radiated power clearly observed, despite low impurity concentration present ($5x10^{13}m^{-3}$ or ~0.0002% of n_e)
- Indicates that small fractions of impurity will be readily observable in the core.







Future Improvements

Find more visible lines – heavy species CX?

Change element to lighter element.

Improve spatial and wavelength coverage of visible spectrometers.

Addition of new divertor impurity probe.

Use edge modelling codes (e.g. DIVertor IMPurity code) to model motion of impurities in edge plasma.

Conclusion

The materials probe on MAST has been used to introduce heavy elements successfully into the plasma, and observe their emission.

Hot plasmas have been found to be temperamental with the probe, but cool ones have allowed good observations.

Work is ongoing to find ways of optimising the experiment and its modelling, of most interest of these at the moment is the prospect of CX lines for heavy elements.

Spectroscopic upgrades and a new divertor probe will be ready for the next experimental campaign (January)