ADAS data and models for visible tungsten emission

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Tungsten emission in visible region of the spectrum

- Passive emission from the edge plasma.
  - arises from low stages, W I-VI
  - requires excellent atomic structure
  - primary data in *adf04* datasets
- Active (CX) emission driven by neutral beams.
  - arises from highly charged stages across the plasma
  - requires charge exchange cross section data
  - *adf01* is required
- Fine structure M1 from $\mathrm{W}^{+2?}$ stages.
  - *not* considered yet.

Source of data in ADAS

- Passive emission from the edge plasma.
  - baseline generation with ADAS8#1 (Cowan) and ADAS7#1 (AUTOSTRUCTURE).
  - U mons optimization via optional input to ADAS8#1.
  - Vilnius group modified RO with large CI method (data only).
  - Photon emissivity coefficients (and feature PECs) from ADAS810.
- Active (CX) emission driven by neutral beams.
  - universal CX cross section from ADAS315.
  - Active emissivity coefficients from ADAS316.
- Fine structure M1 from $\mathrm{W}^{+2?}$ stages.
  - Possibly ADAS7#1 (AS) or adf04 archiving.
  - Emissivity calculated with ADAS810.

W^{+2} (W III) structure

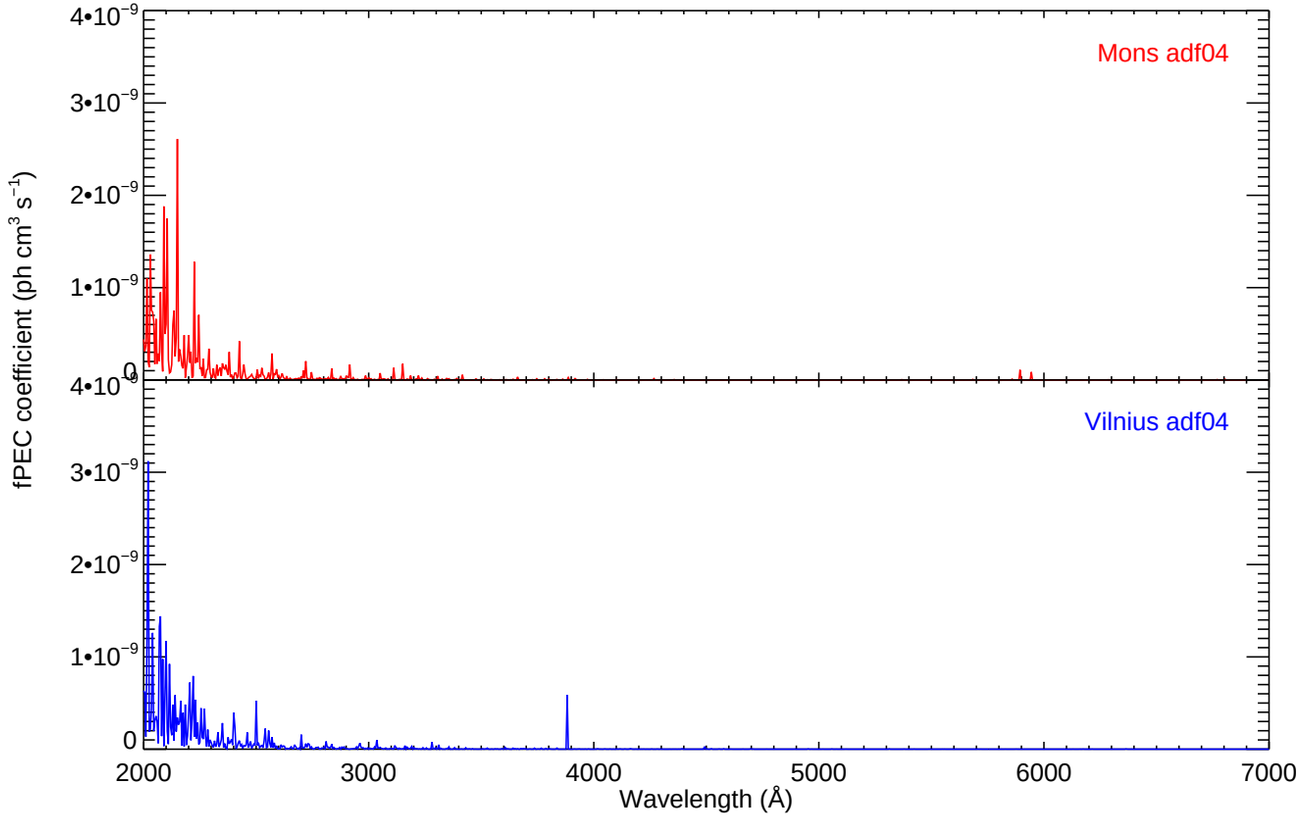
Optimized Cowan (U Mons), modified RO (Vilnius) and NIST:

			Mons	Villnius	NIST
1	4f14 5s2 5p6 5d4	(5)2(0.0)	0.0	0.0000	0.00
2	4f14 5s2 5p6 5d4	(5)2(1.0)	2291.8	2369.8870	2256.20
3	4f14 5s2 5p6 5d4	(5)2(2.0)	4505.3	4690.3922	4461.19
4	4f14 5s2 5p6 5d4	(5)2(3.0)	6280.7	6555.7070	6277.81
5	4f14 5s2 5p6 5d4	(5)2(4.0)	7615.0	7941.9088	7686.68
6	4f14 5s2 5p6 5d4	(3)1(0.0)	10037.4	10538.7325	9904.30
7	4f14 5s2 5p6 5d3 6s1	(5)3(1.0)	10918.1	11536.0252	10968.54
8	4f14 5s2 5p6 5d3 6s1	(5)3(2.0)	12439.1	13020.1126	12427.09
9	4f14 5s2 5p6 5d4	(3)1(1.0)	12949.8	13525.3432	12881.03
10	4f14 5s2 5p6 5d4	(3)5(4.0)	13803.7	14496.7379	13700.95
11	4f14 5s2 5p6 5d4	(3)3(2.0)	14036.1	14751.9869	13992.14
12	4f14 5s2 5p6 5d3 6s1	(5)3(3.0)	14848.0	15332.0583	14899.80
74	4F14 5S2 5P6 5D3 6P1	(5)4(2.0)	57350.5	59663.7379	57231.04

- Optimized Cowan: 463 retained levels.
- Modified RO: 293 levels.

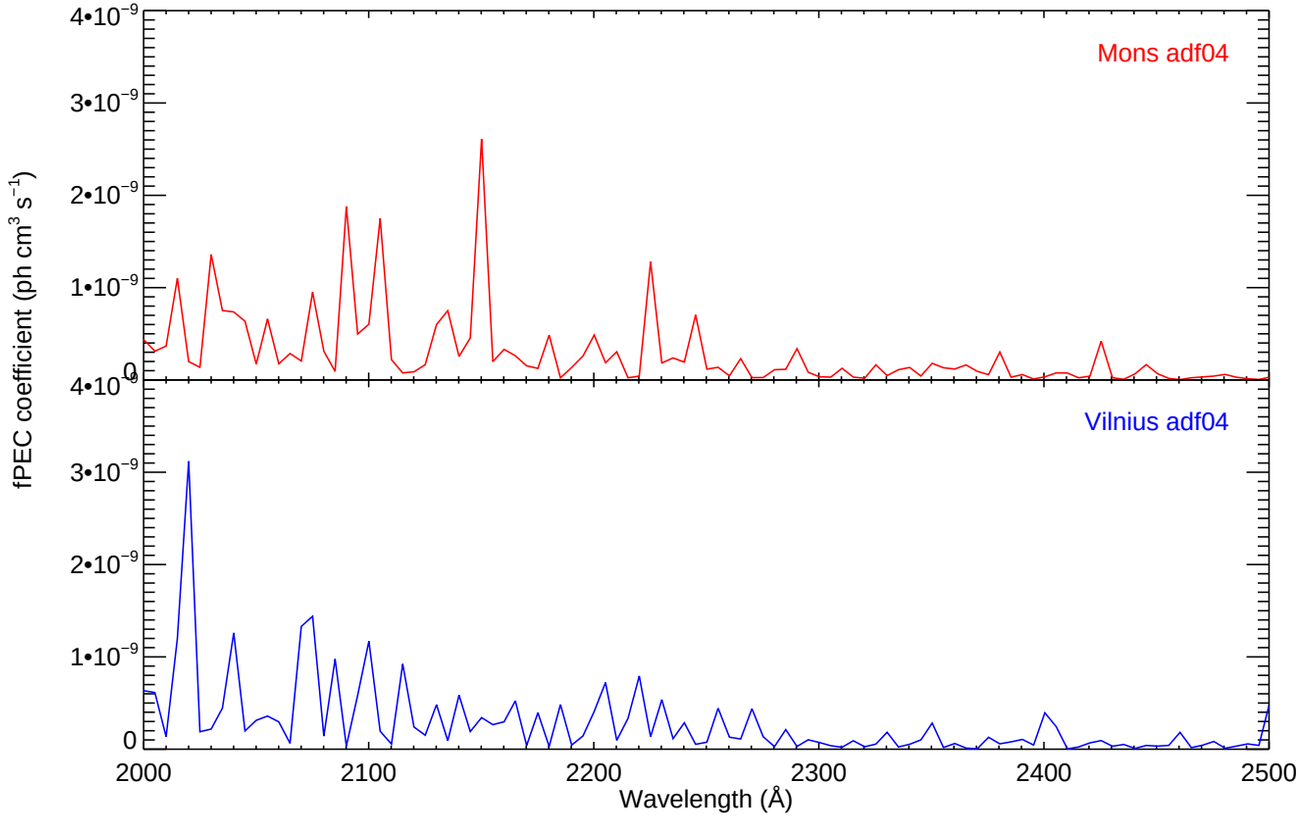
W III spectral emission

- For spectral analysis we need collision data.
- Use Born cross sections.



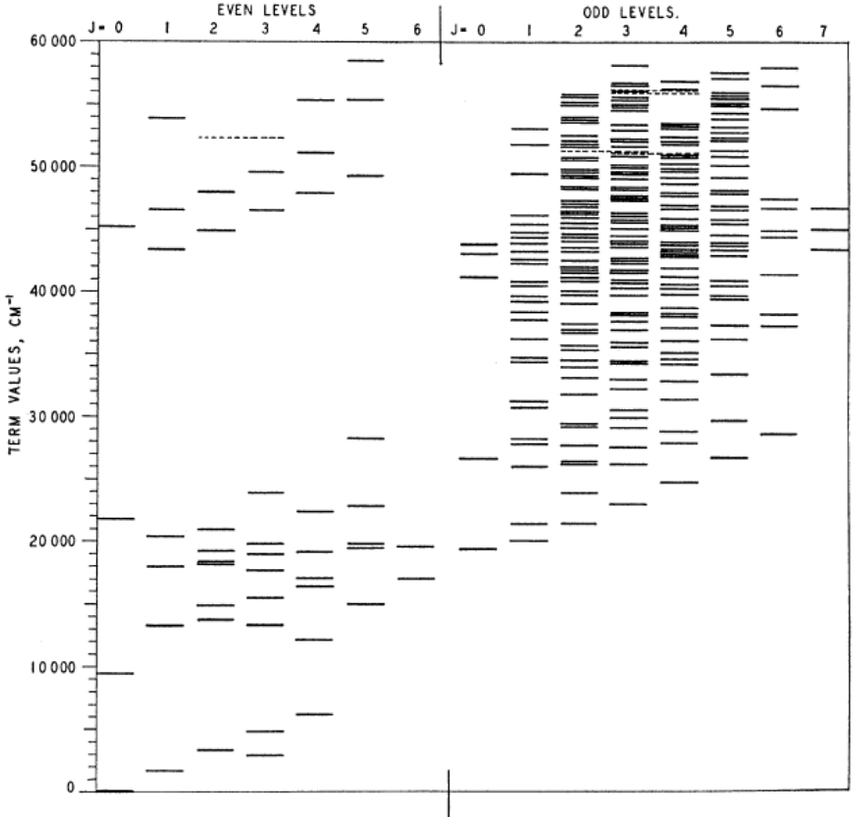
W III spectral emission

- Agree on strongest line: $5d^3\,6s\,{}^5F_1 - 5d^3\,6p\,{}^5G_2$.
- Disagree on wavelength: 215nm vs 208nm



W I neutral

- Important for influx measurement.
- But it has a quite complex structure.



O Laporte and J E Mack, Phys. Rev, 1943

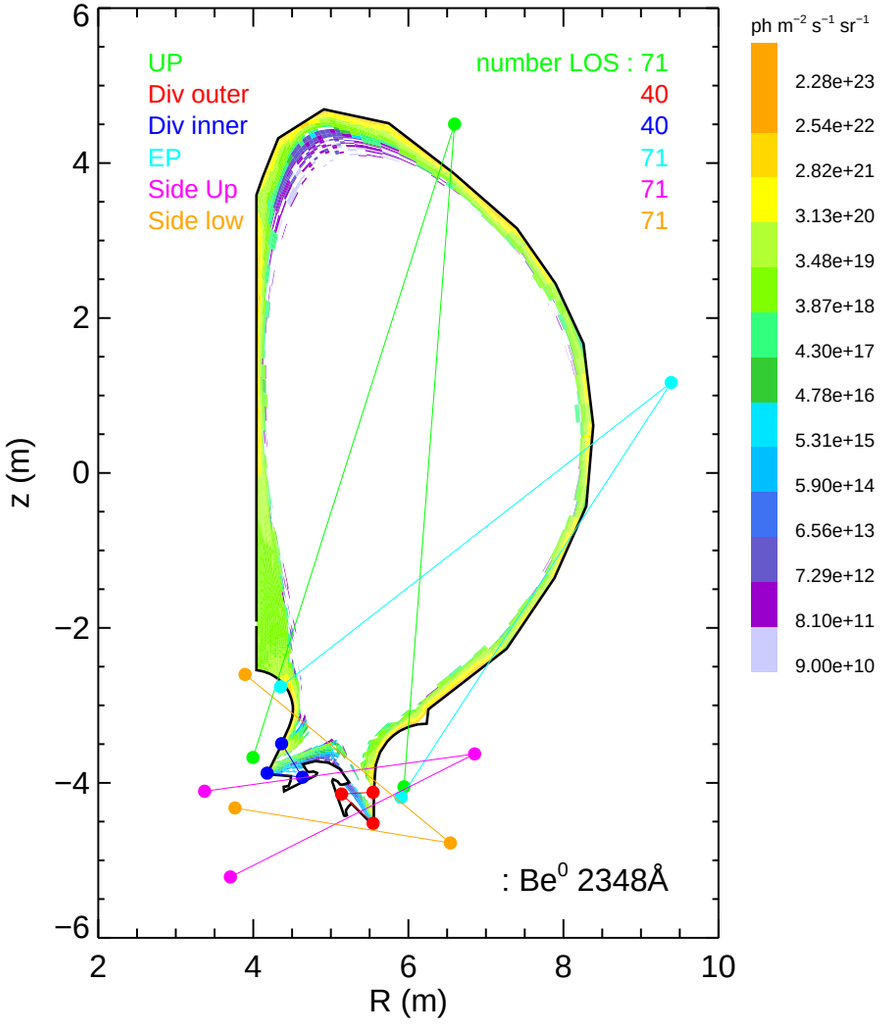
WI energy levels and the most accessible line

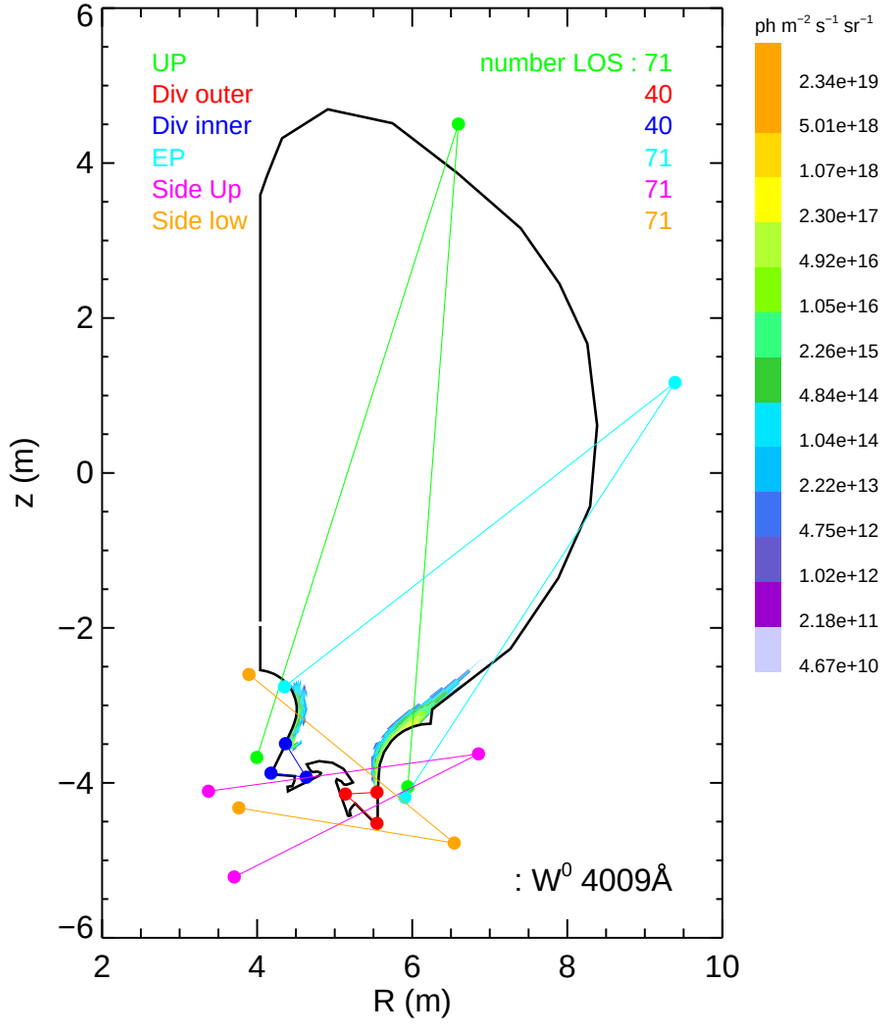
			baseline	Mons	NIST
1	4FE 5D4 6S2	(5)2(0.0)	0.0	0.0	0.00
2	4FE 5D4 6S2	(5)2(1.0)	1467.9	1785.2	1670.29
3	4FE 5D5 6S1	(7)0(3.0)	-	2981.7	2951.29
4	4FE 5D4 6S2	(5)2(2.0)	3189.4	3469.8	3325.53
5	4FE 5D4 6S2	(5)2(3.0)	4863.1	4927.4	4830.00
6	4FE 5D4 6S2	(5)2(4.0)	6404.8	6207.7	6219.33
7	4FE 5D4 6S2	(3)1(0.0)	12950.2	9612.9	9528.06
8	4FE 5D4 6S2	(3)5(4.0)	14044.2	12249.8	12161.96
9	4FE 5D4 6S2	(3)1(1.0)	17084.9	13500.8	13307.10
10	4FE 5D4 6S2	(3)4(3.0)	16981.1	13506.3	13348.56

	NIST	U Mons	*adf04*	
E_{ground}	0.00	-88.0	0.0	$5d^4\,6s^2\ ^5D_0$
E_{lower}	2951.29	2893.0	2981.7	$5d^5\,6s\ ^7S_3$
E_{upper}	27889.68	27815.7	27905.5	$5d^4\,6s\,6p\ ^7P_4$

Wavelength: 4009.8Å $\leftarrow$ 4012.4Å

Visible emission from beryllium and tungsten



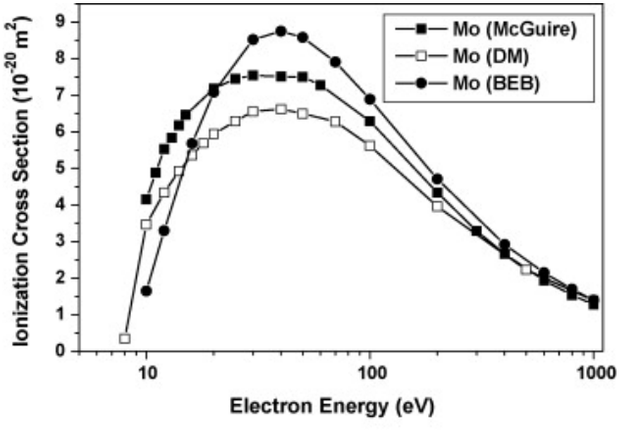


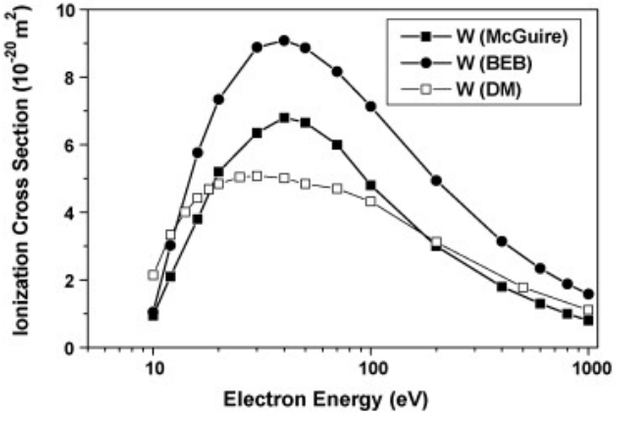
Be^0 2348Å, $2s\,2p\,{}^1P - 2s^2\,{}^1S$

W^0 4009Å, $5d^4\,6s\,6p\,{}^7P_4 - 5d^5\,6s\,{}^7S_3$

Ionisation from neutral W

A few to choose from with no great agreement — use range as uncertainty estimate.

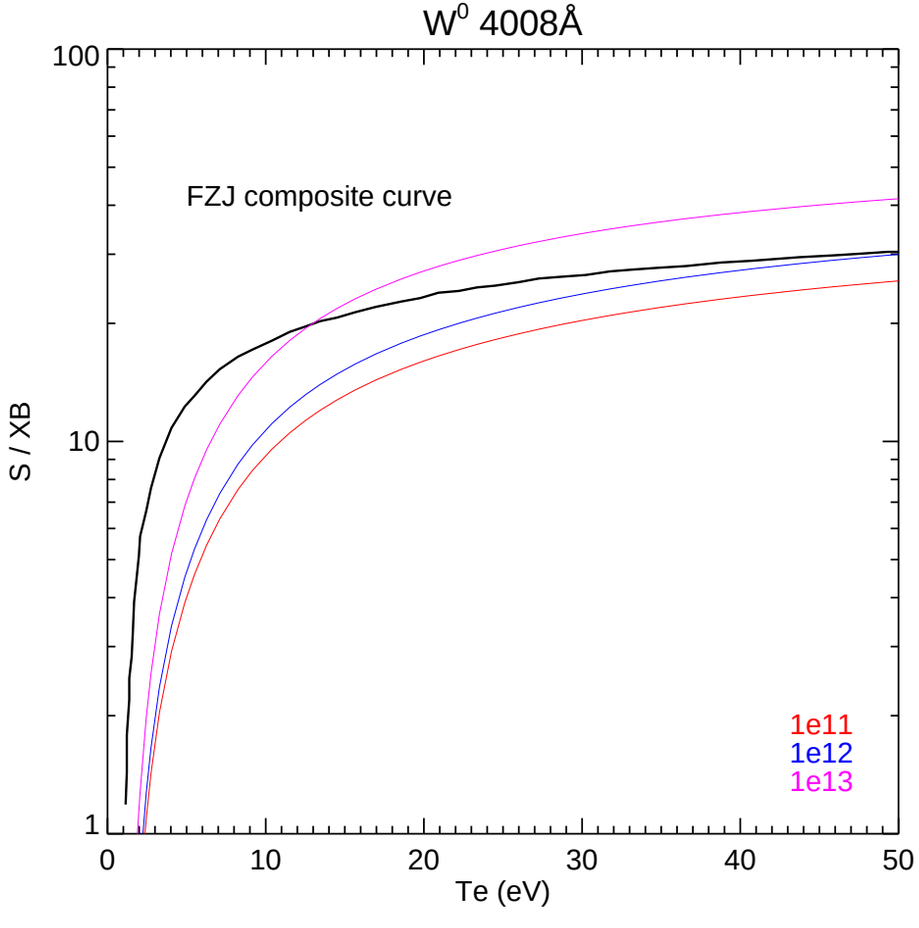




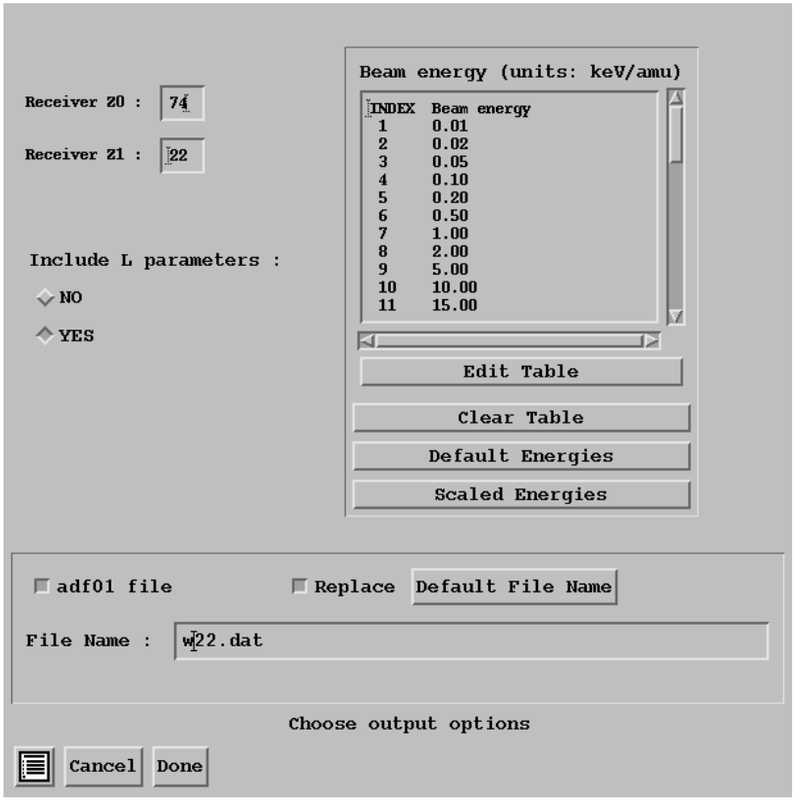
Deutsch et al, Int. J. Mass Spect., 2008

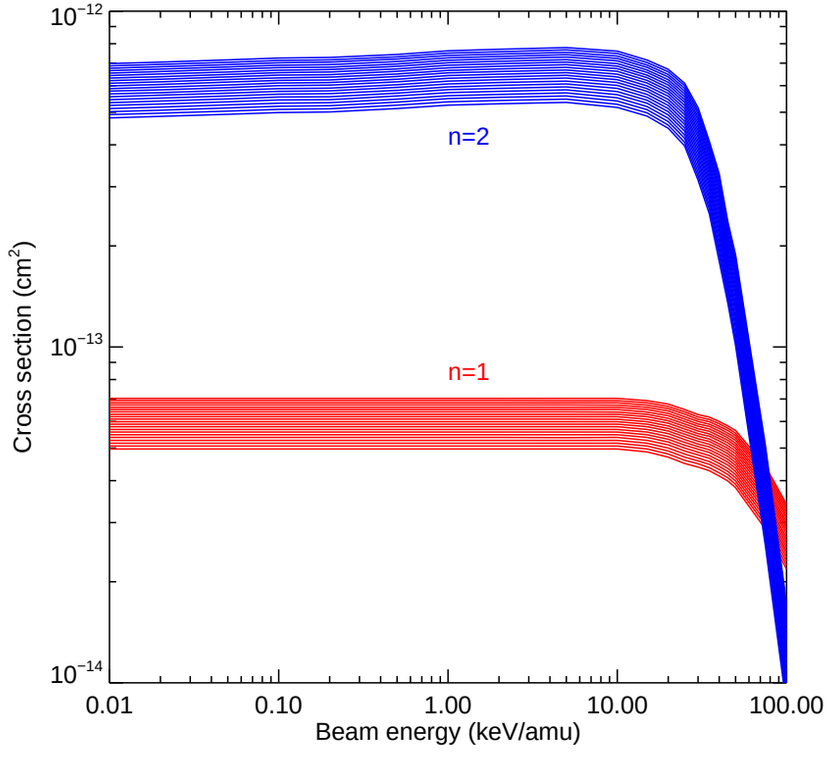
S/XB

If we take Mons *adf04* and CADW *adf07* we get....

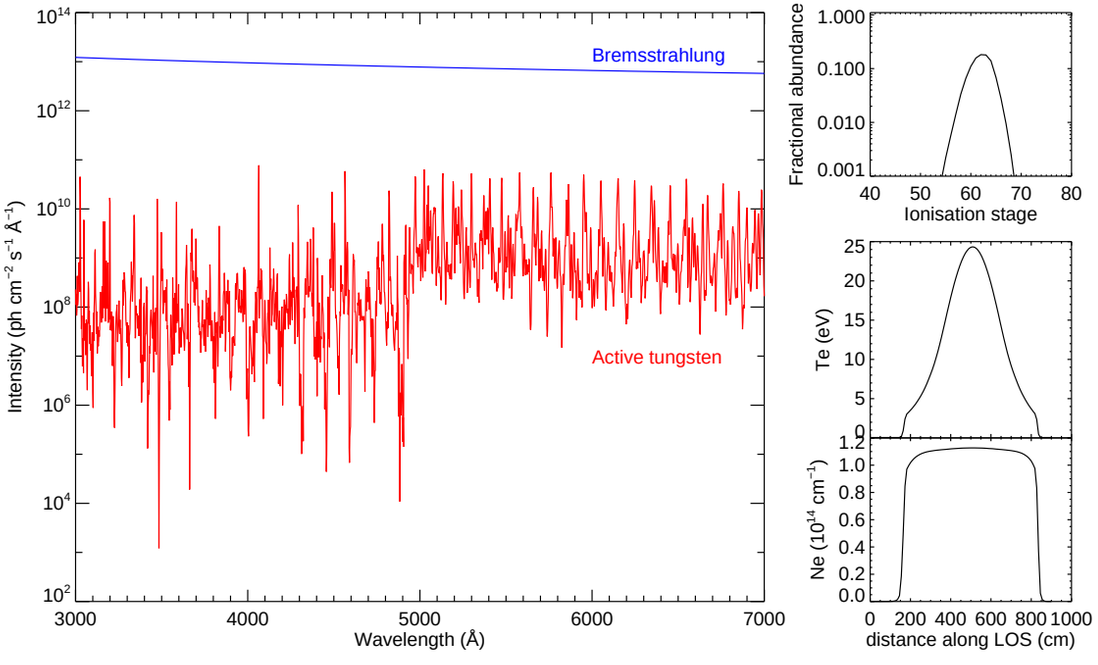


Active emission — fundamental data input





Active emission — applied to ITER-like situation



- 50 keV/amu D beam (diagnostic NB), JNBI=300A/m2, INBI=60A
- Using ITER scenario 2 (Te=24keV core, Ne=1x1014cm-3)
- No transport steady state ionisation balance
- Assume looking vertically down on the beam at the core.
- No beam attenuation effects taken into account.