An updated modelling of Be and BeD spectroscopy at JET ILW, W spectroscopy at PSI-2 and ADAS-relevant data

D.Borodin et. al

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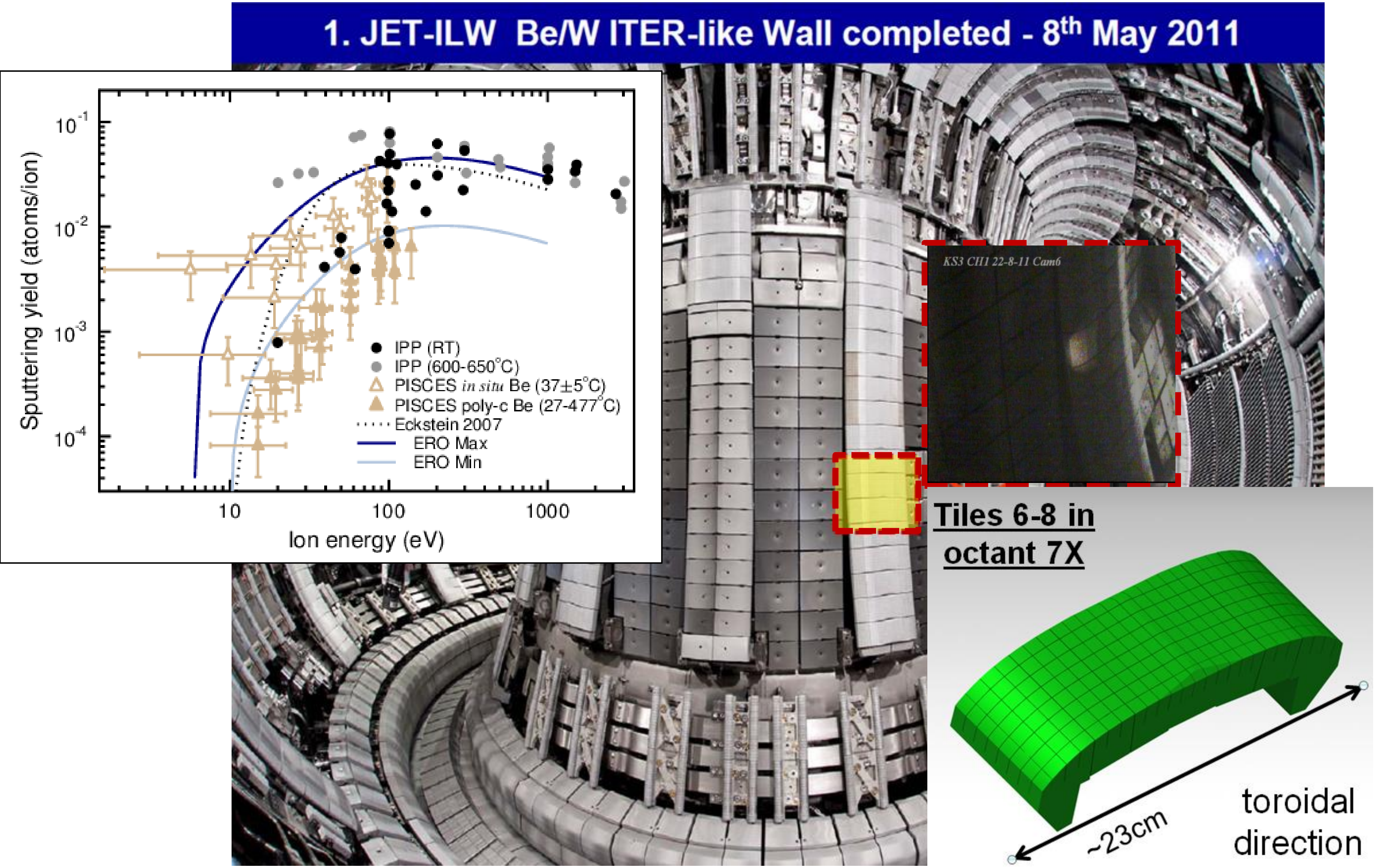
Spectroscopy at inner-wall Be limiter

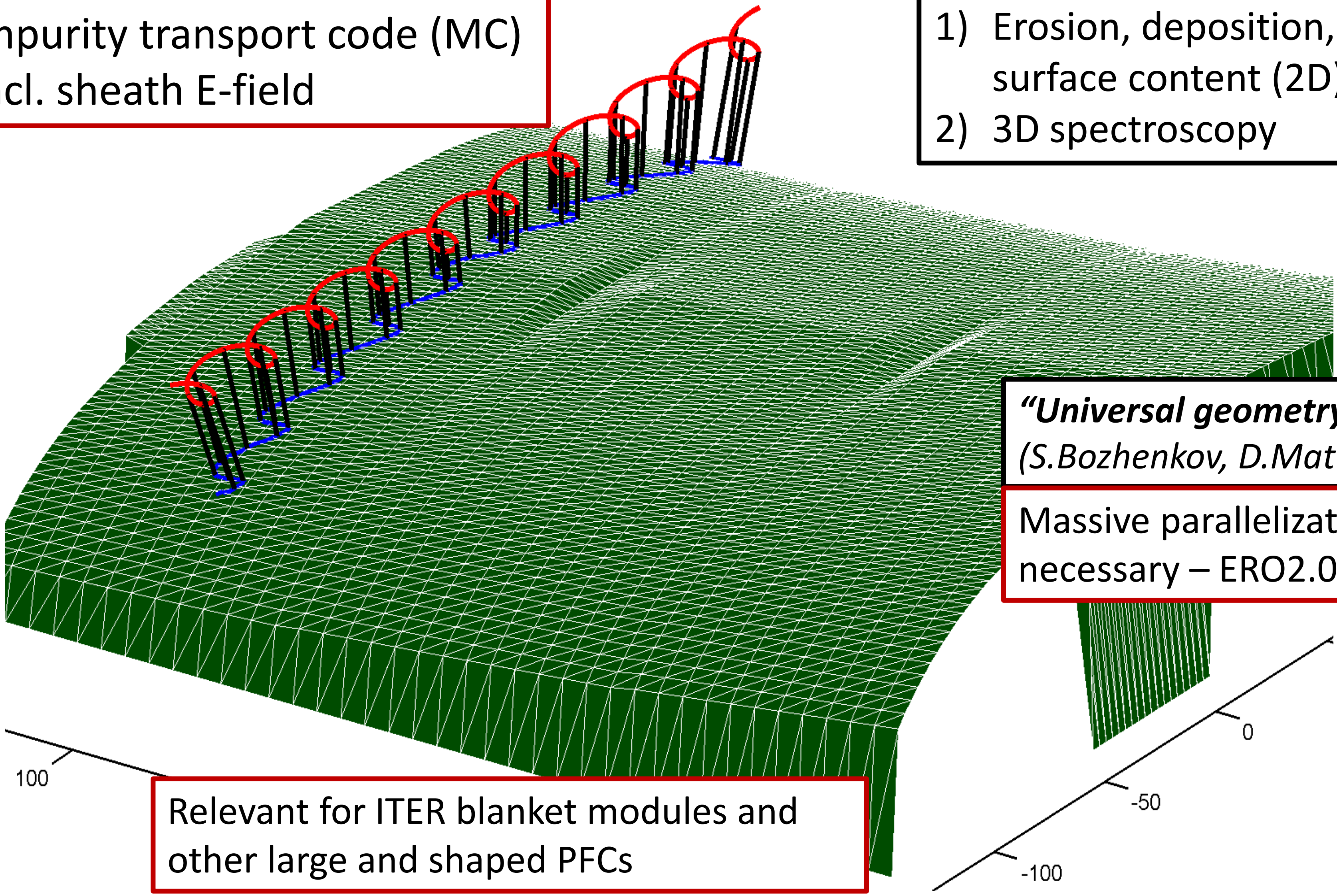


ERO code – gyromotion and PFC shape

ERO is the PSI and 3D local impurity transport code (MC)
Incl. sheath E-field

ERO simulates:

1) Erosion, deposition, surface content (2D)
2) 3D spectroscopy



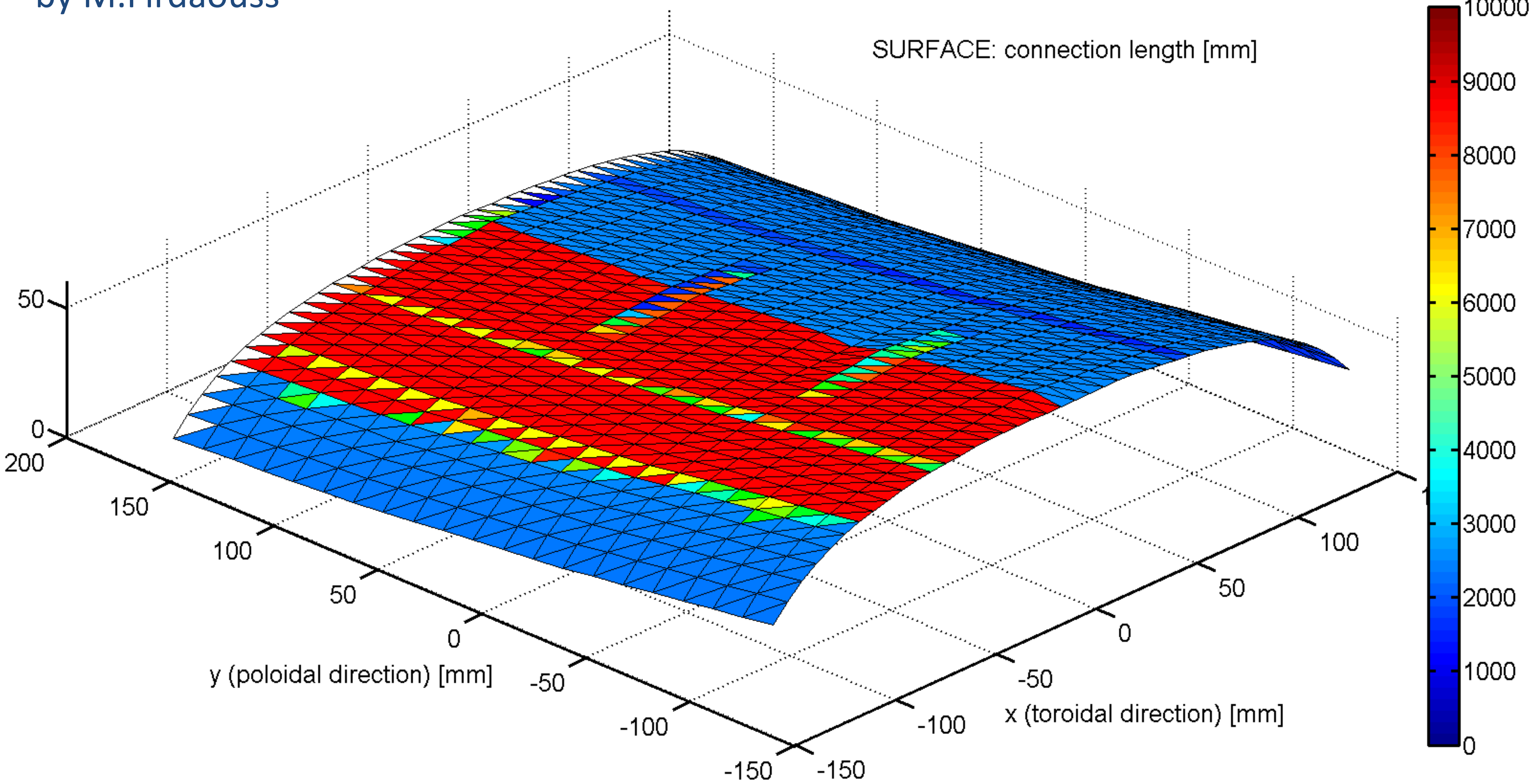
"Universal geometry"
(S.Bozhenkov, D.Matveev)

Massive parallelization is necessary – ERO2.0

Relevant for ITER blanket modules and other large and shaped PFCs

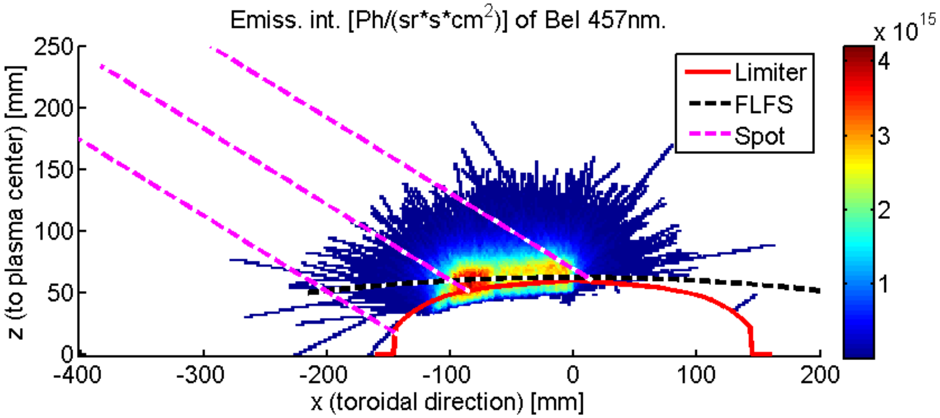
Be limiter surface shadowing

PFCFLUX simulations
by M.Firdaouss

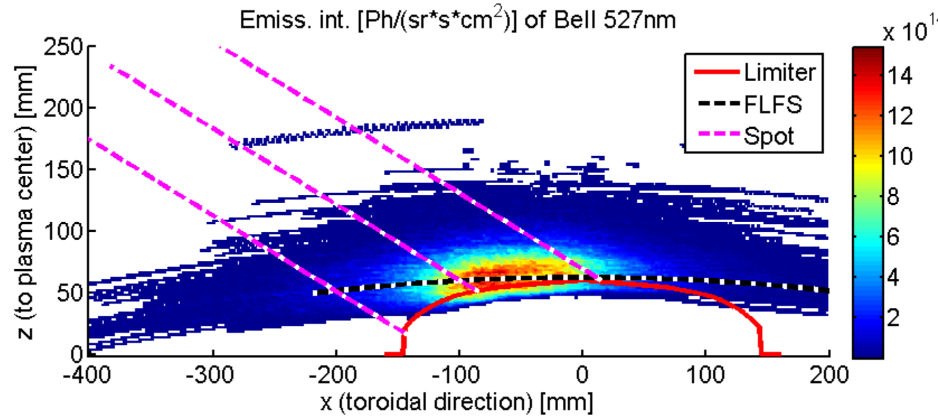


Local Be transport and light emission

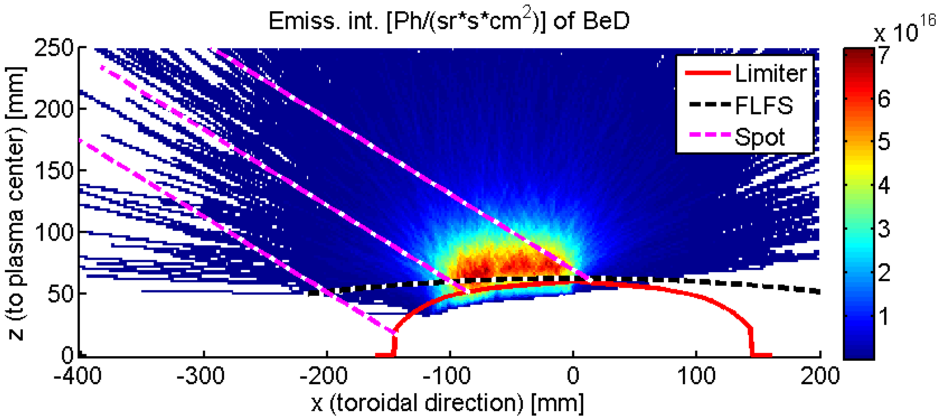
BeI, physically eroded Be



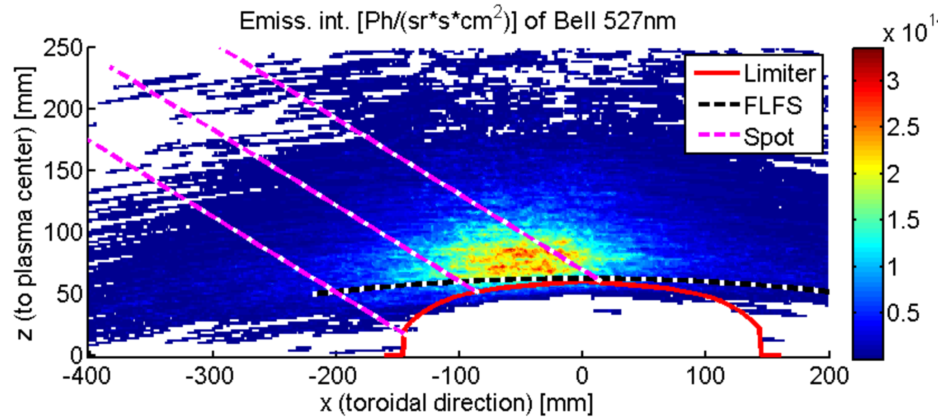
BeII, physically eroded Be



BeD band, chemically eroded Be (BeD)

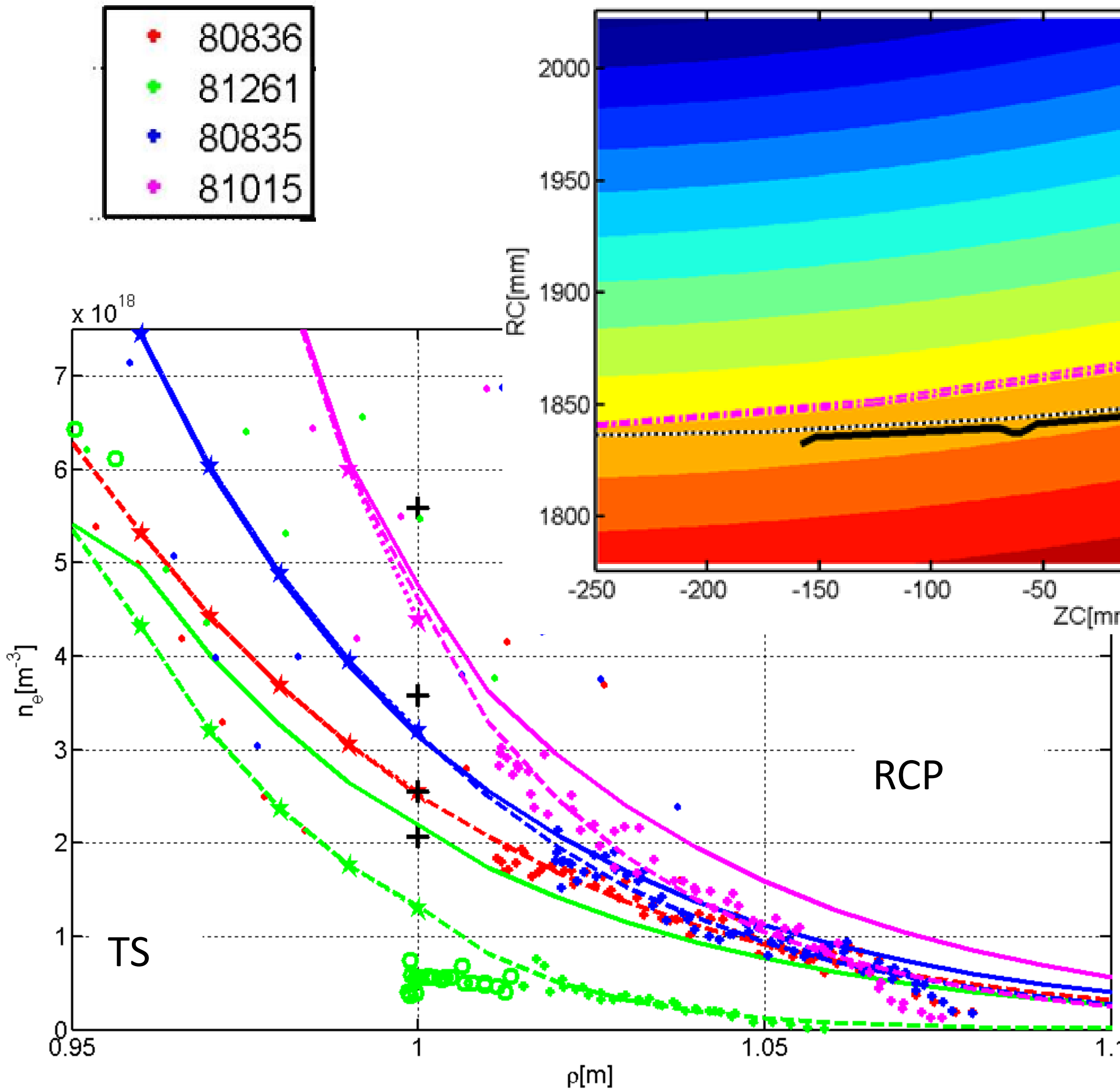


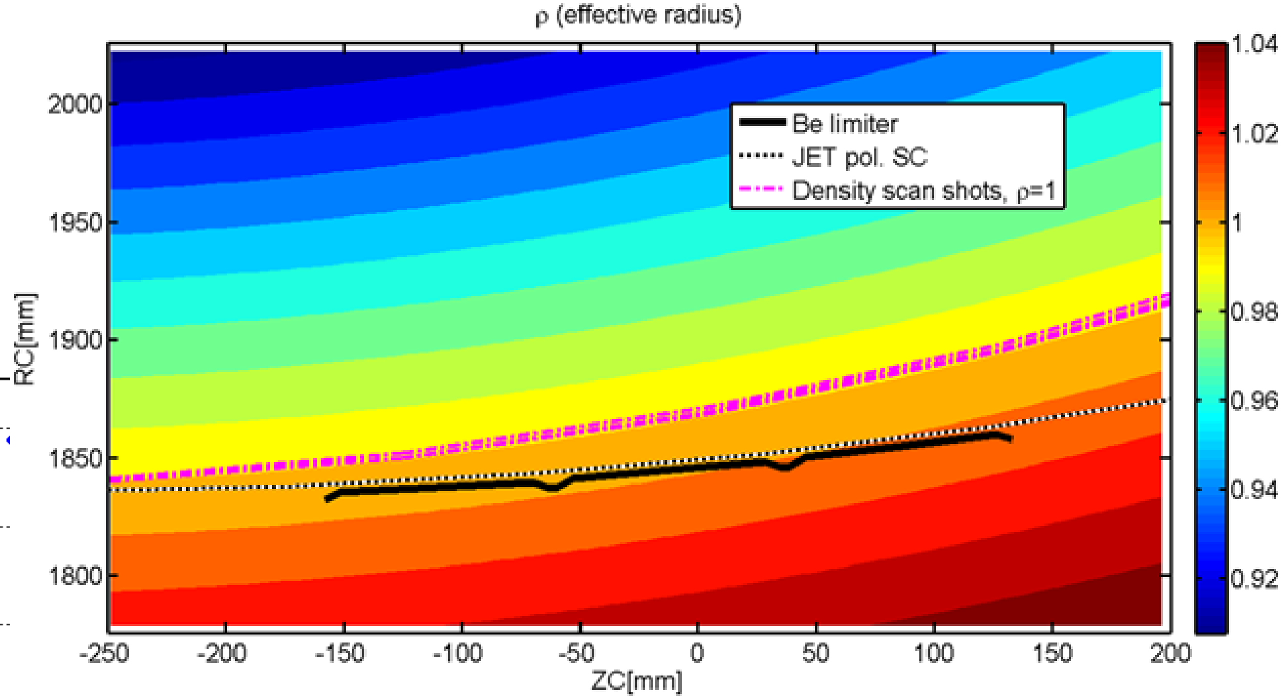
BeII, chemically eroded Be (BeD)



BeII intensity and fraction coming to the observation chord depends on the erosion mechanism

Plasma parameters fitting

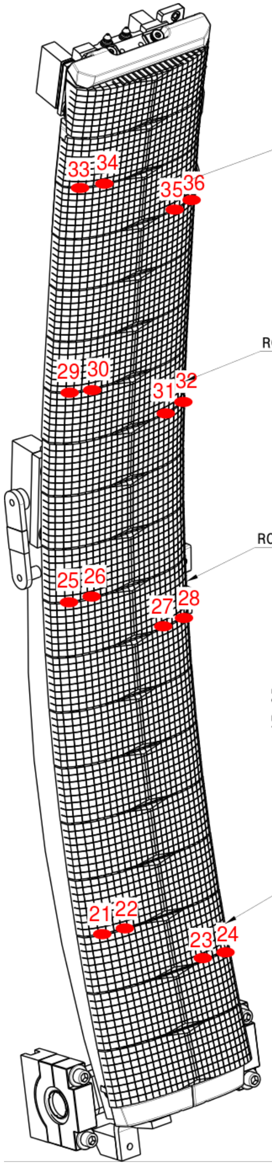


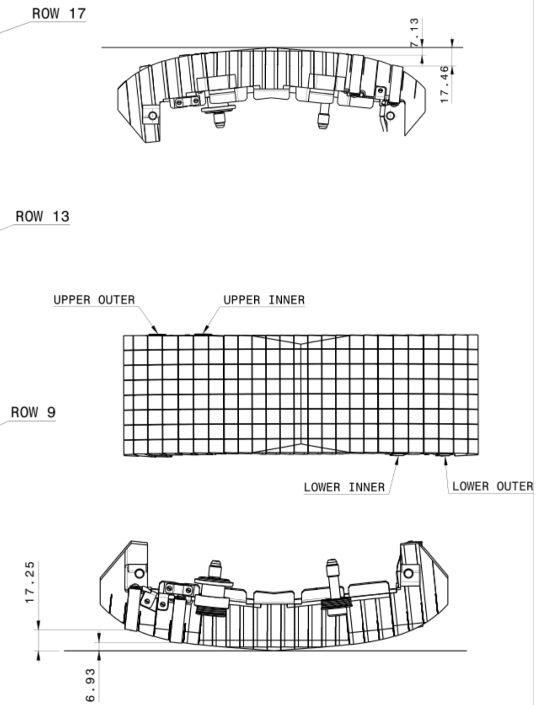


+ Ne scaled so that Ne*Te = const

Dγ/Dβ ratio, embedded probes indicate that T_e is overestimated . . .

Embeded probe measurements

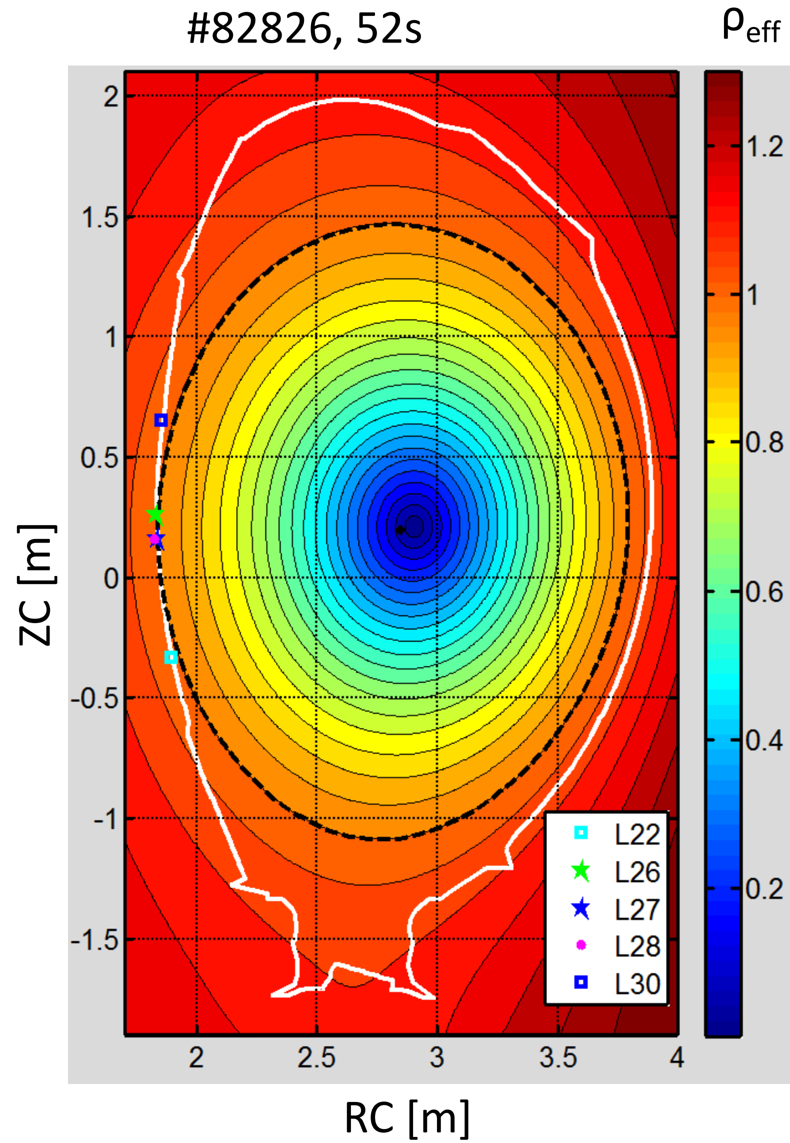




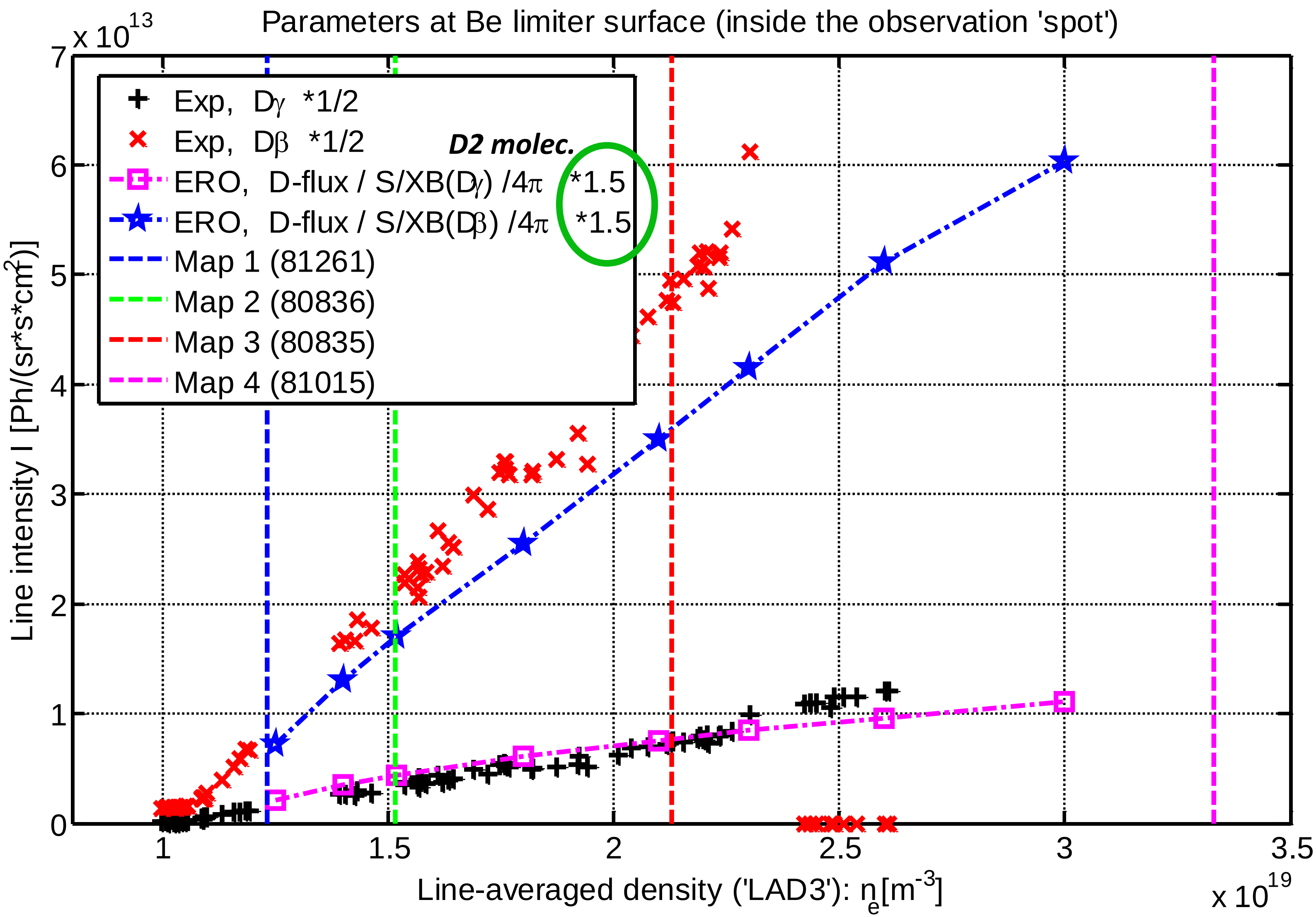
T_e (separatrix) ~ 15eV

#82826, 50.5s

L22: rho=1.013 Te=16.82eV Ne=7.30e+018m^-3
L26: rho=1.004 Te= 4.57eV Ne=1.66e+018m^-3
L27: rho=1.003 Te=14.05eV Ne=5.51e+018m^-3
L28: rho=1.007 Te= 4.06eV Ne=1.41e+018m^-3
L30: rho=1.021 Te= 3.14eV Ne=1.75e+017m^-3



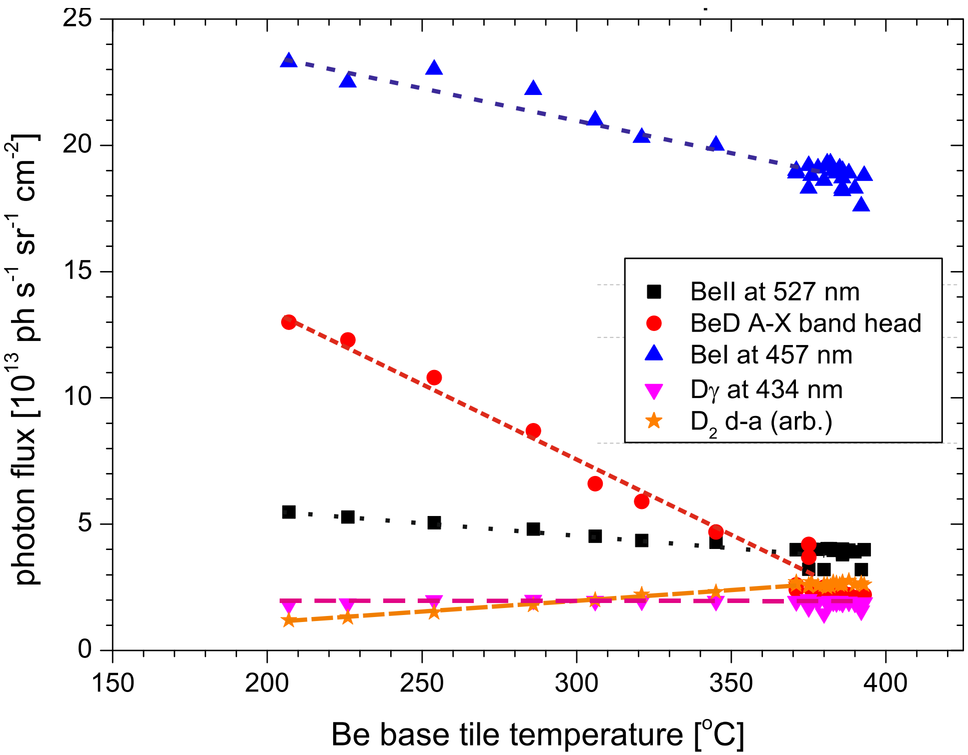
D spectroscopy and recycling flux

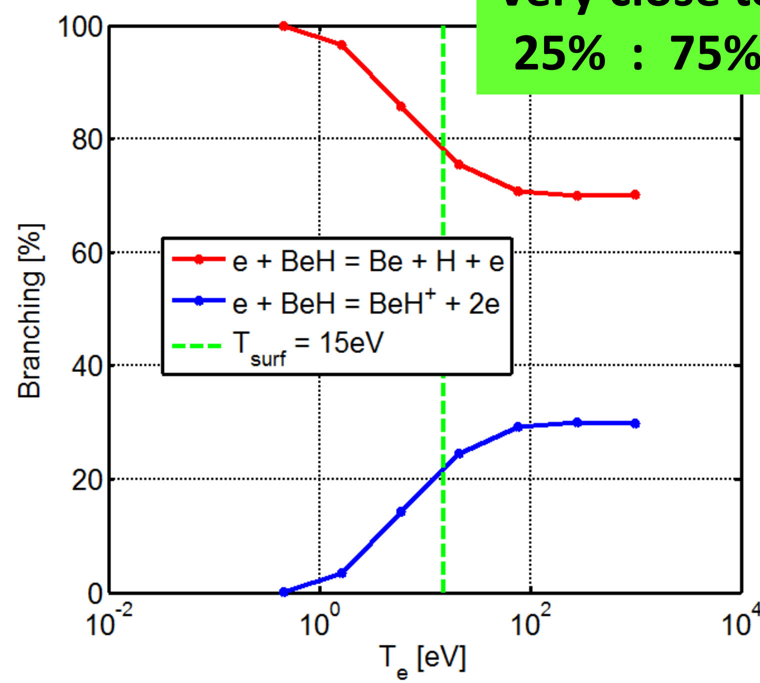


T_{surf} scan: spectroscopic observations:

Spectroscopic observation under otherwise constant plasma conditions:

- Reduction of BeI, BeII and BeD photon flux with increase of surface temperature
- Increase of D_2 photon flux with increase of surface temperature
- Dγ - reflecting recycling flux – remains constant



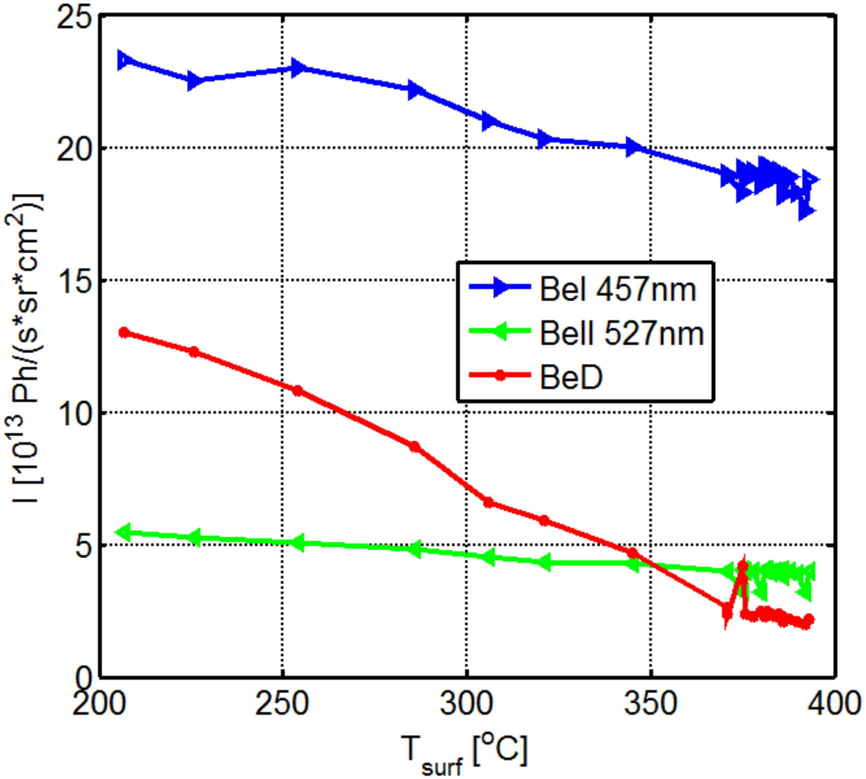


Very close to
25% : 75%

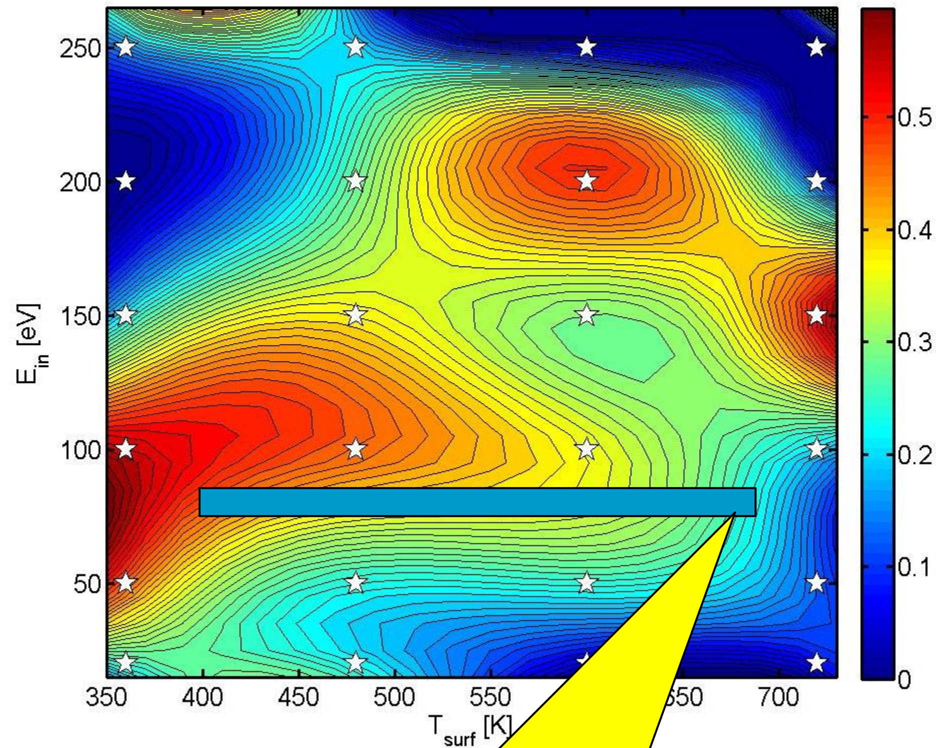
- Comparison of BeD A-X band, BeI and BeII provides information on dissociation path
- Dominant path BeD + e ->Be + D + e (75%) over BeD + e-> BeD^+ + 2e (25%)

BeD release – T_{surf} scan

JET ILW surface density scan



BeD/Be released



Clear drop at $E=75eV=2T_i+3kT_e$

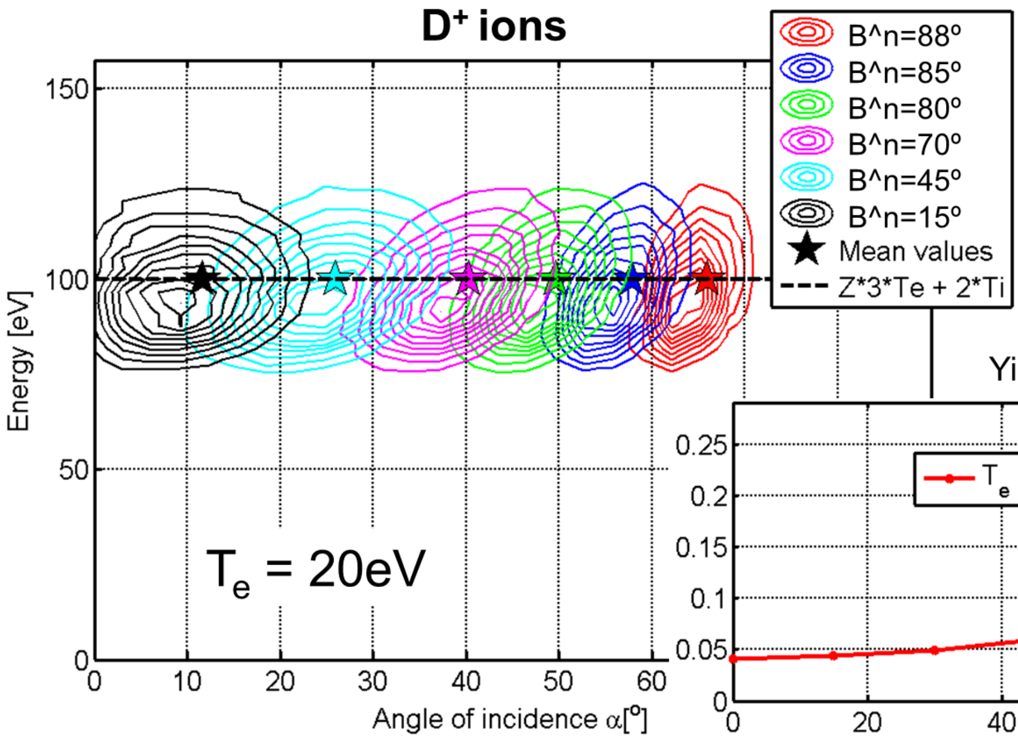
ERO simulations
ongoing . . .

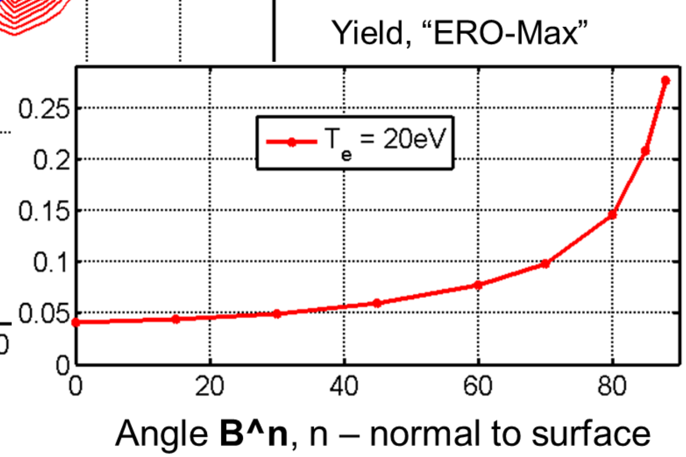
A.Lasa et al, recent cumulative simulations (normal incidence, 1500 impacts . . .)

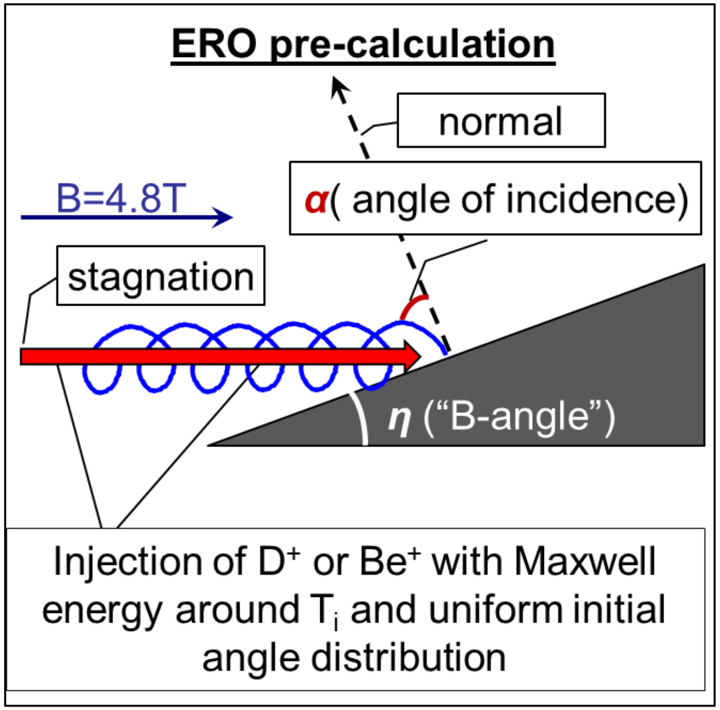
Treating angular part in sputtering yield

$Y(E_{in}, \alpha_{in}) = Y(E_{in}, 0) * \mathbf{A(E_{in}, \alpha_{in})}$

Preliminary ERO runs . . .
"Integration" produces effective sputter yields:







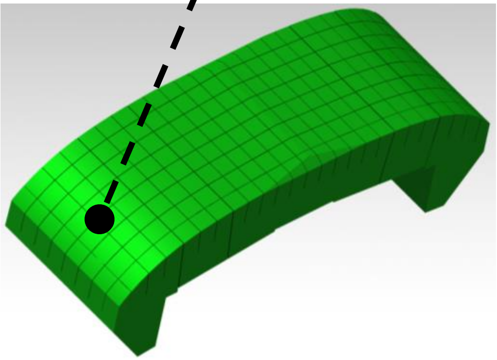
Very recent: analytic solution by I.Borodkina (MEPhI, RF)

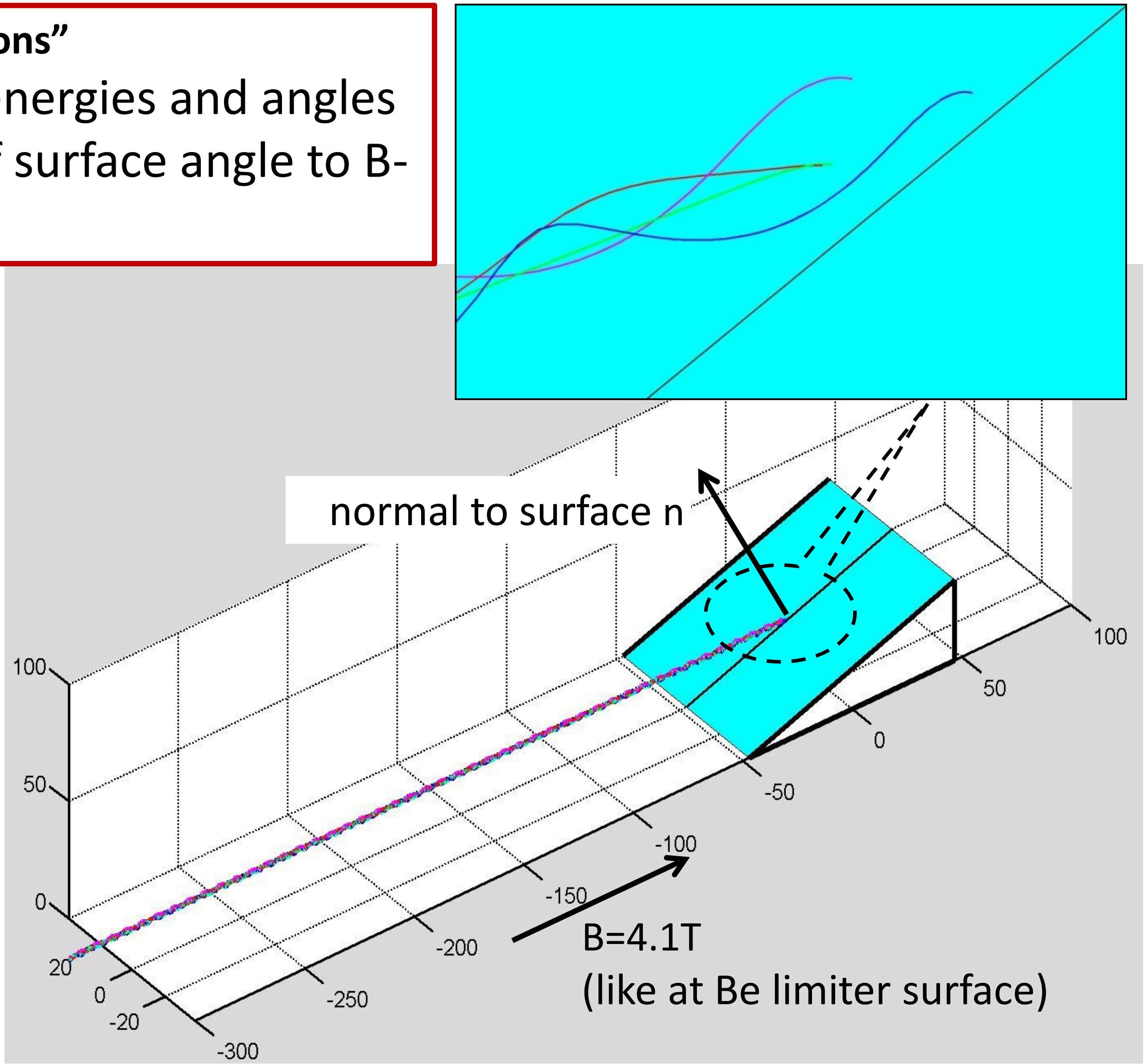
Numeric simulation of the distributions on impact

Series of **ERO "Pre-simulations"**

To get distributions of energies and angles on impact as a factor of surface angle to B-field and plasma T_e . . .

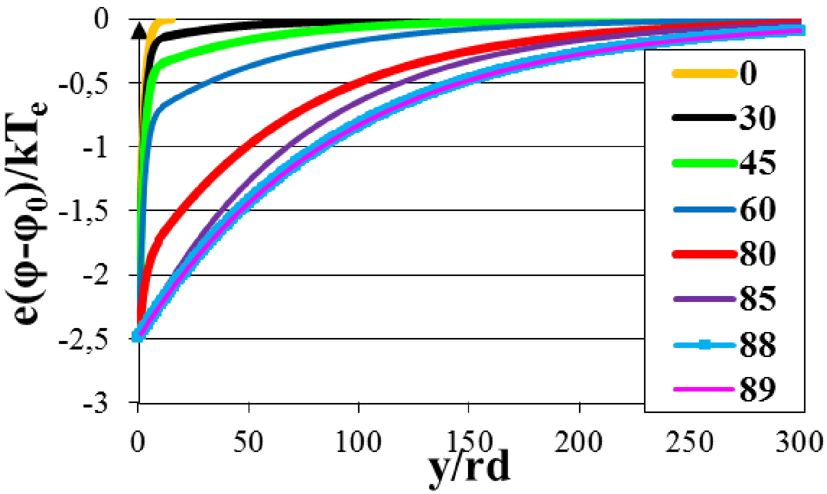
$\{E_{imp}, \alpha_{imp}\}$?..



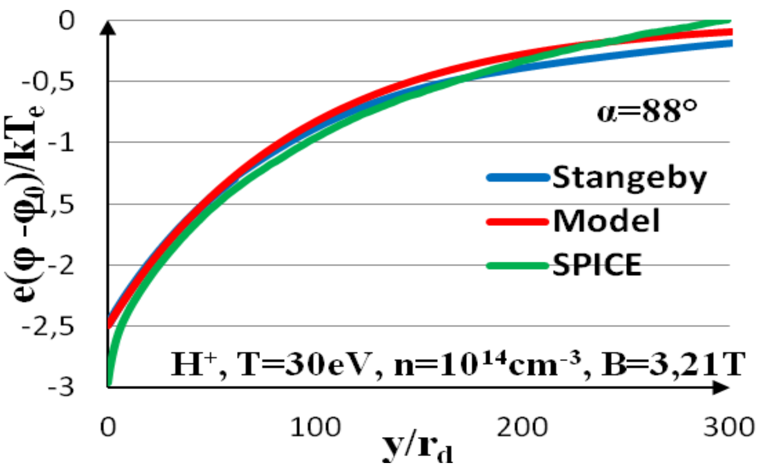


Analytical approach

1) Sheath potential approximation

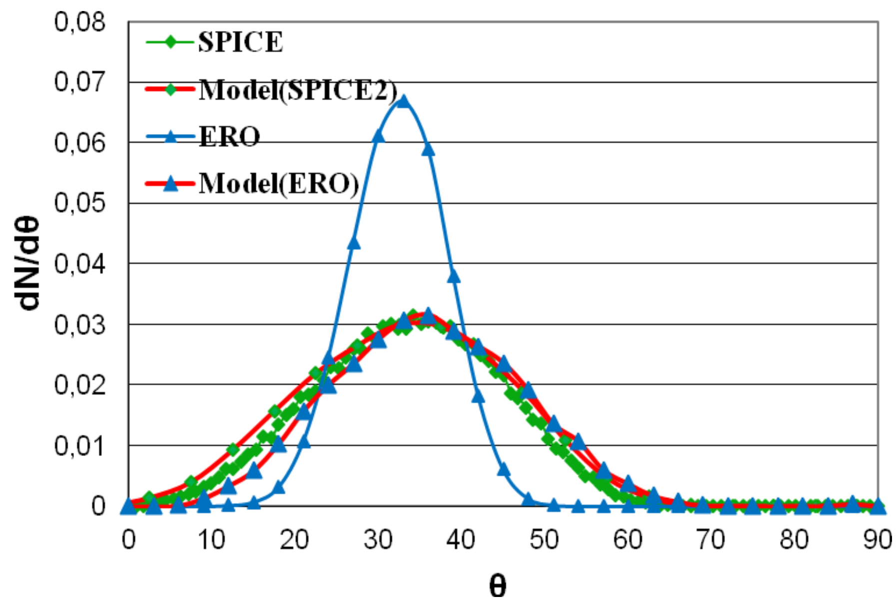


The expression benchmarked with another analytics and simulations



2) Formula for velocity at the part of trajectory just before the impact

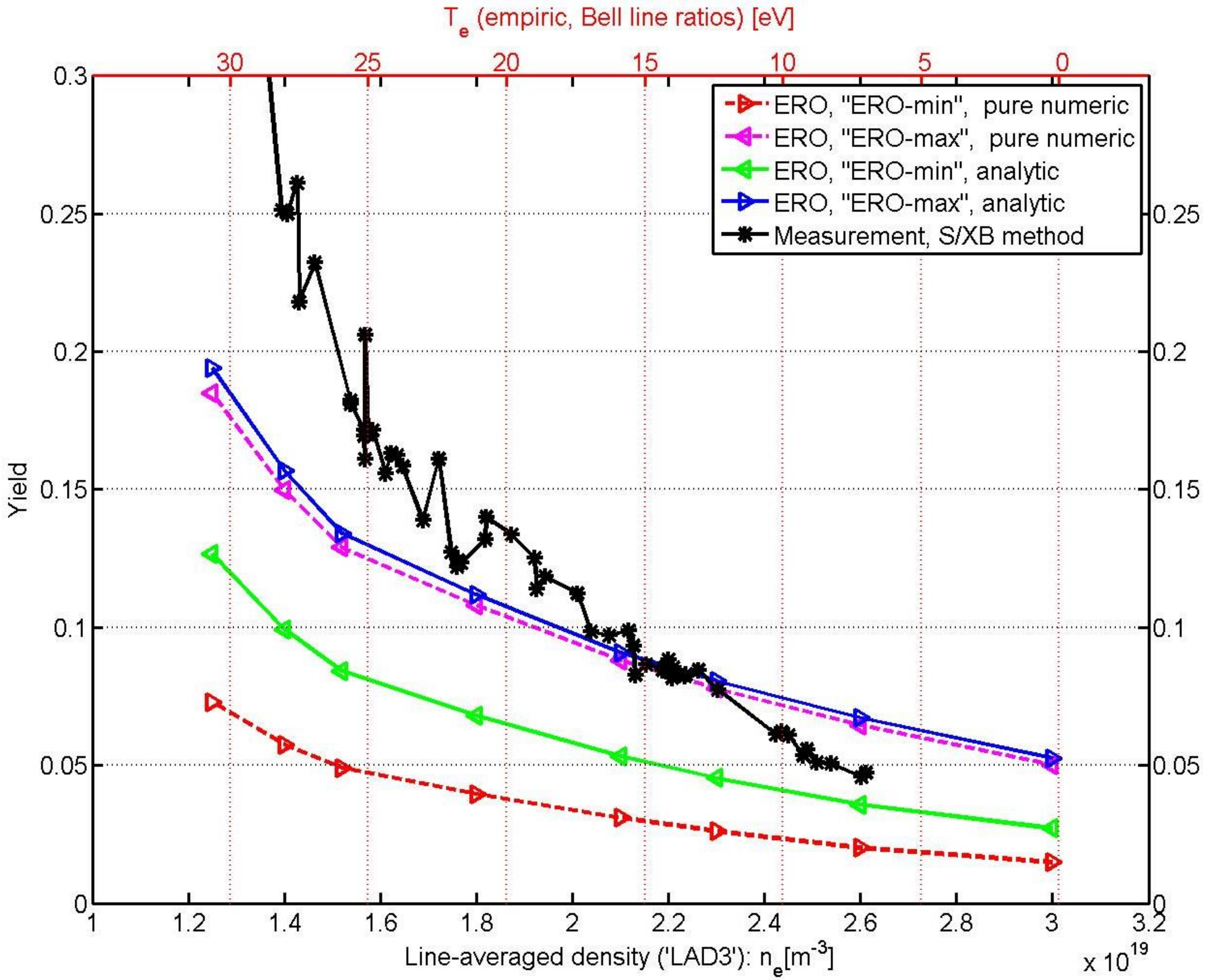
- *Energy distribution on impact quite similar to the numeric one.*
- *Angular distribution in ERO pre-runs seems to be too peaked:*



- *Analytic result is in a good agreement with various of PIC simulations give*

I.Borodkina et. al., PET-2015, submitted to CPP

S/XB approach – ERO and experiment

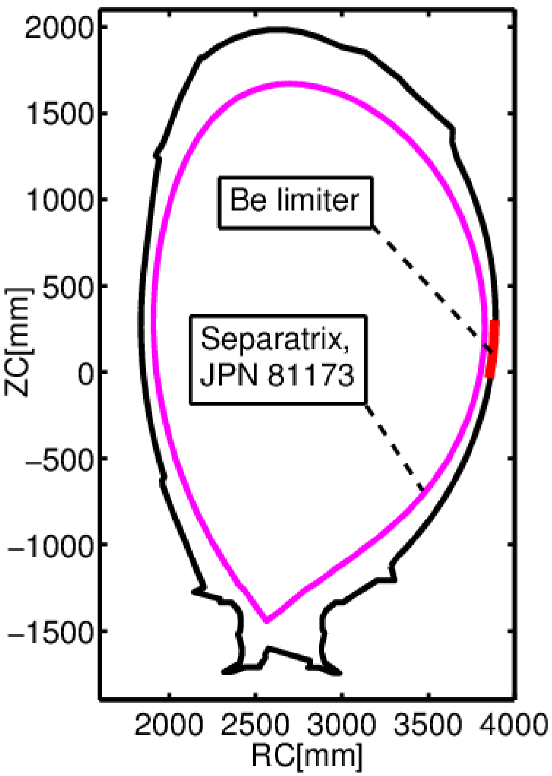


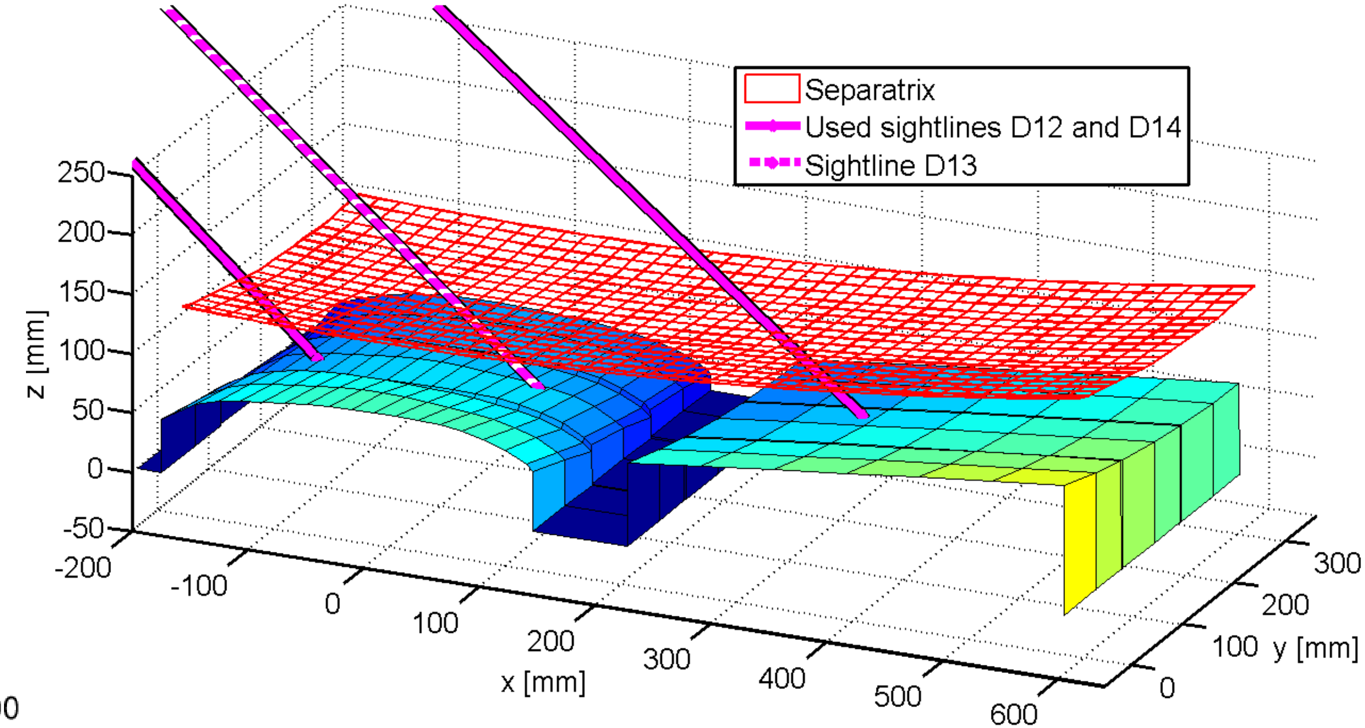
Corrections:

+10%
for 'ERO-min'

+30%
for 'ERO-max'

JET OW: Be limiter near ICRH antenna

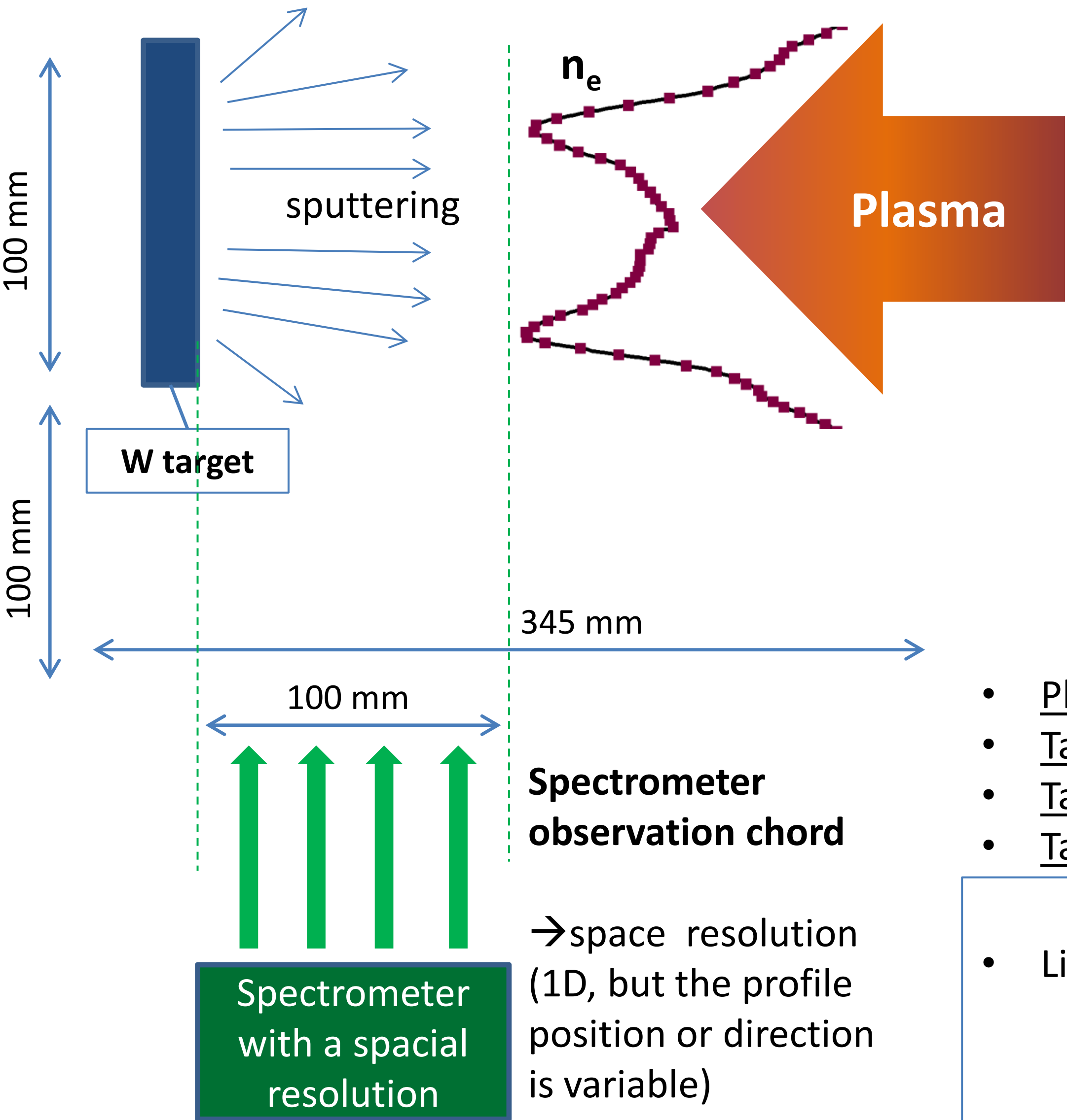


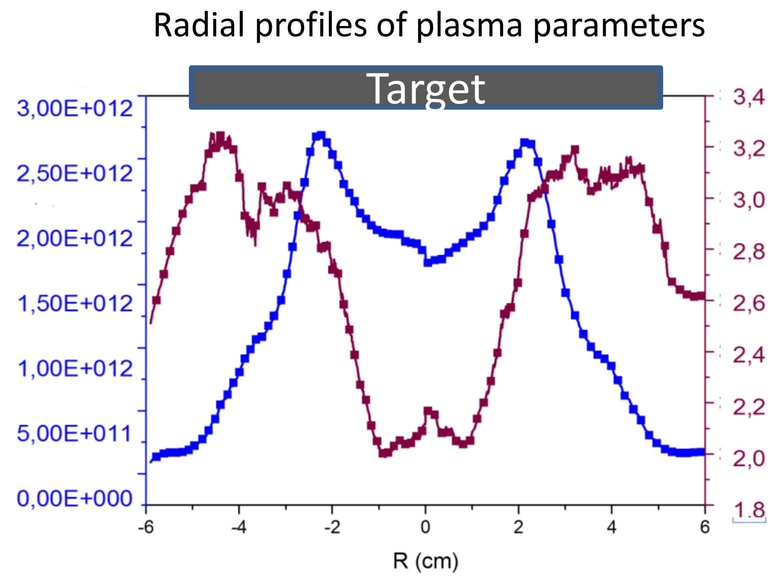


- It was shown that the variation of the Be line intensities up to factor 3 due to the ICRH antena can be explained by am additional biasing.
- Reading of Edge2D data for the plasma BG was provided with proper interpolation and extrapolation to far SOL.

Ch.Klepper et. al., PFMC-2015, accepted to Phys. Scripta.

Eroded W spectroscopy at PSI-2





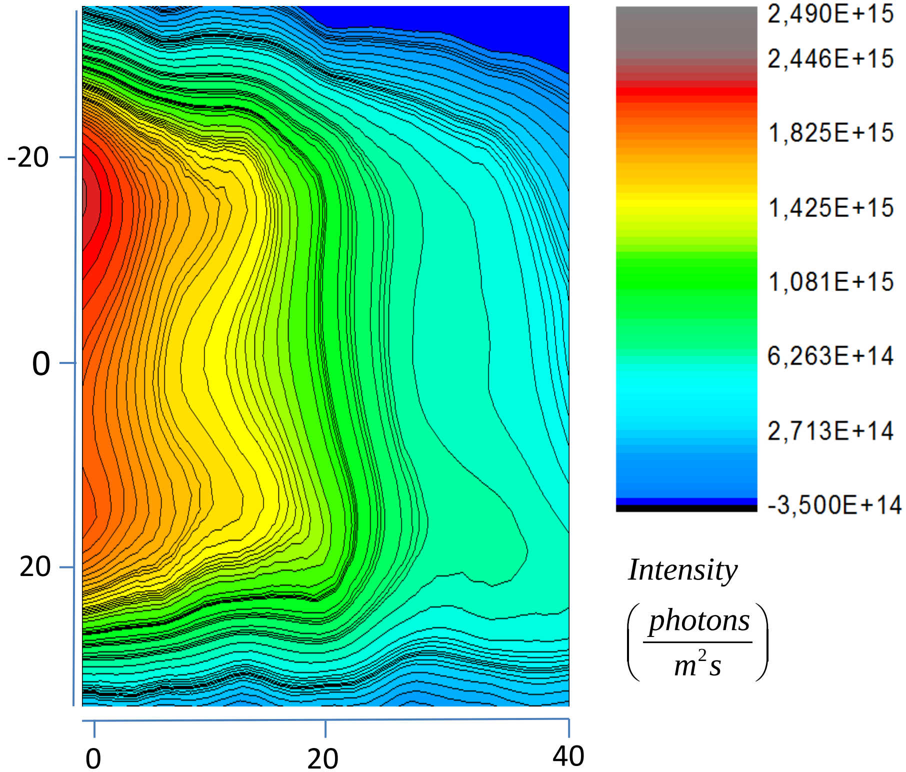
Series of experiments on W sputtering:

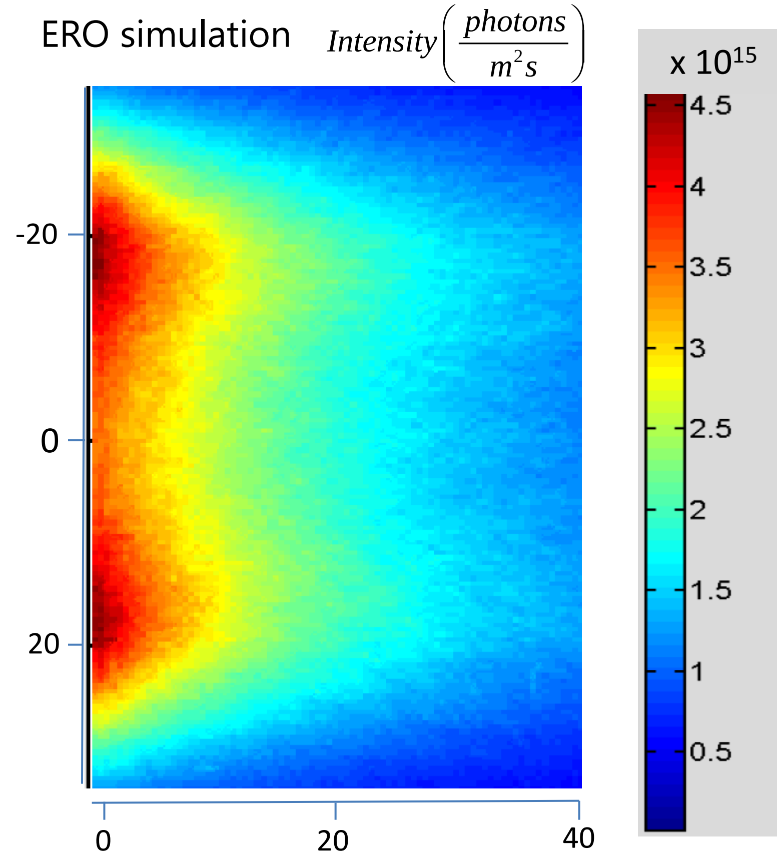
- Plasma: Ar
- Target: W
- Target bias voltages: U_b = 50 – 150 V
- Target: 100 x 80 mm, a line of mass loss samples

Measurements:

- Line intensity profiles (4009 A):
  1. Along z (device axis)
  2. Perpendicularly to z (installation) axis at several z-positions

2D patterns based on multiple profiles taken





$I_{max\_ERO} \approx 4.5*10^{15}$ ph/(m^2*s)

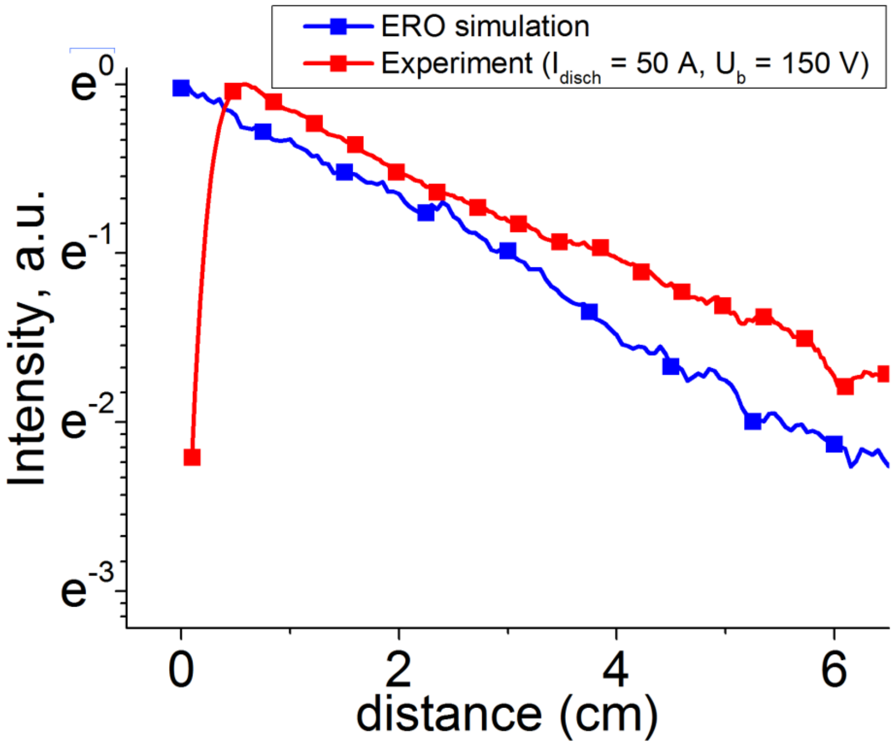
$I_{max\_experiment} \approx 2.4*10^{15}$ ph/(m^2*s)

2 more independent measurements:

1) weight loss (with space resolution) and 2) QMB as a witness plate.

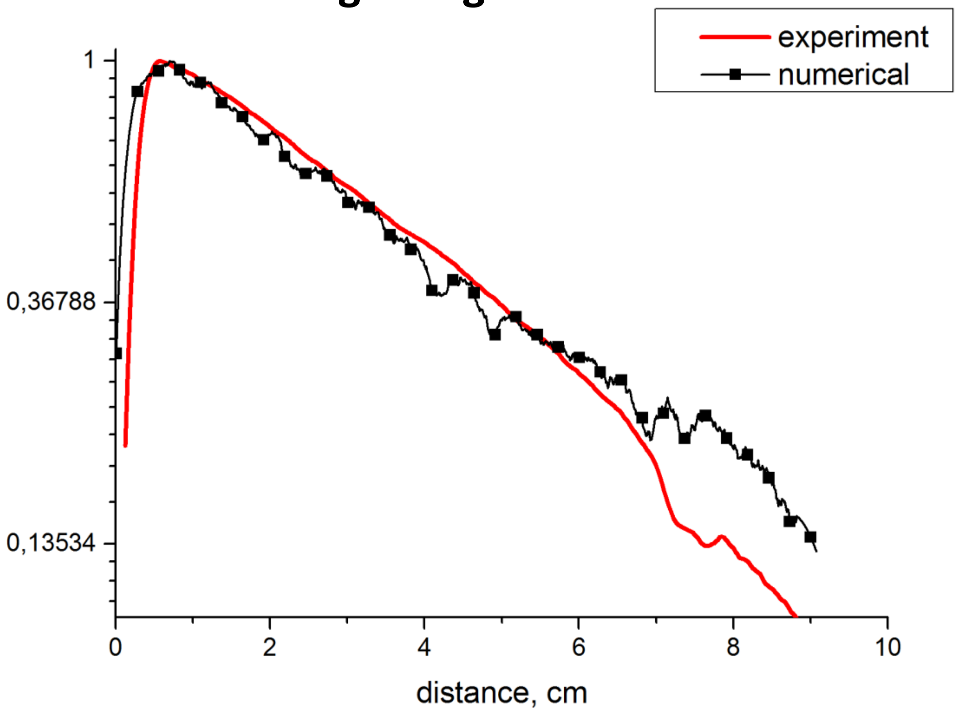
WI axial profile simulation

ERO (3D MC), no MS tracking



Experimental and ERO simulated dependence of neutral W radiation intensity on the distance from the target surface. ERO simulation doesn't give us maximum from the experiment

Simplified 1D model tracking a single MS



Assumed parameters:

- Angular distribution – from ERO
- $V_{10} = V_{10} \approx 1*10^4\ s^{-1}$ (electron impact (de)excitation coefficient)
- PEC $\approx 2*10^5\ s^{-1}$
- $S_{ion} \approx 3*10^4\ s^{-1}$ (electron impact ionization coefficient)

ADAS data needed for PSI studies

W – JET divertor

PEC and ionization for WI and WII. UV spectroscopy for WIII is also expected. For many experimental applications S/XB can suffice as a first approach.

W – PSI-2 experiments.

Basic needs are same as for JET. However, the simple geometry and continues operation allow us to go into more detail. We can observe MS effects and need resolved adf11 (‘scd’, ‘acd’, ‘qcd’) data. Some effort from FZJ side is considerable.

Be – JET ILW, PISCES

we find it quite good covered for now by the ‘96’ package. Only checking and additional questions are to consider. E.g.: do we need to track MS in BeII?

Ar, N and Ne – important as seeding impurities.

Ar is used to increase sputter efficiency in PSI-2, experiments with N and Ne are under discussion. We need ionization data and PECs for neutrals and +1 and +2 ions. Purpose: BG plasma, impurity concentration control etc.

Al and Mg as a proxy for Be

Some experiments are already done for Al. Mg is complicated because of the vapor pressure. We need any data for Al. MS resolved data for Mg can motivate related experiments.

Thanks for the attention!

Spectroscopy at inner-wall Be limiter

1) Same density scan as for Be sputtering – surface temperature T_{surf} varying with “memory effect”. IR camera data not yet interpreted . . .

2) T_{surf} variation (**S.Brezinsek**) at constant plasma T_e=15ev, LAD3=2.2e19m^{-3}