8th International Workshop on

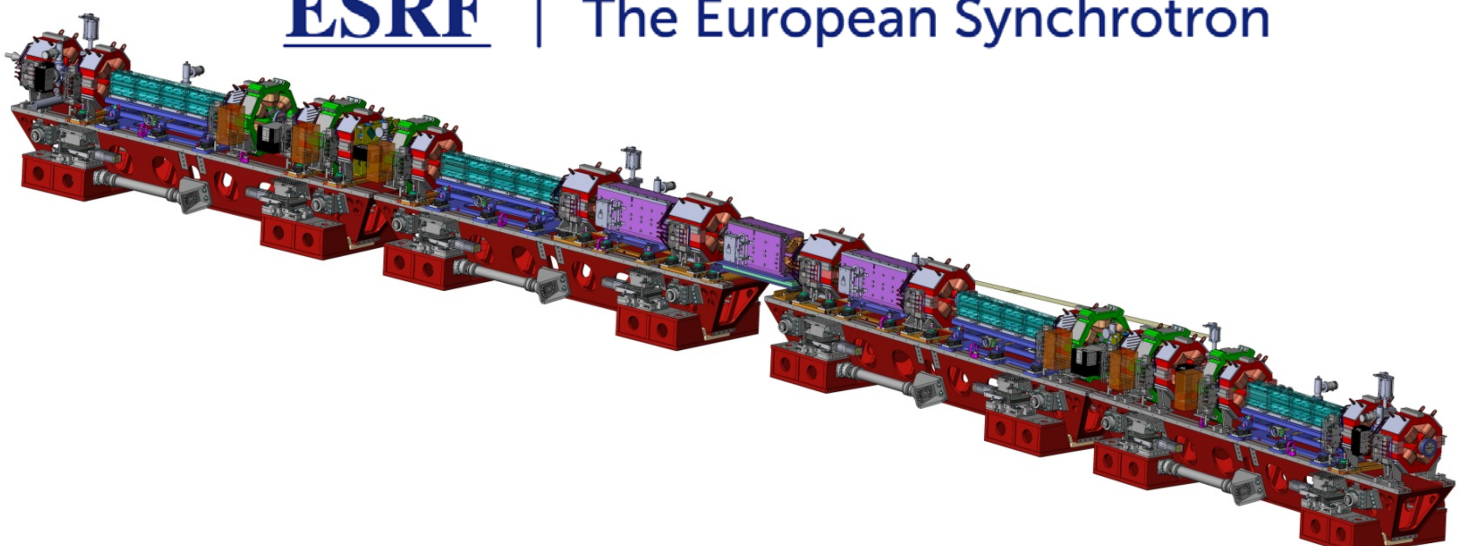
Radiation Safety at Synchrotron Radiation Sources

DESY Hamburg, 3 – 5 June 2015

Preliminary shielding results for the ESRF storage ring upgrade

Paul Berkvens

ESRF | The European Synchrotron



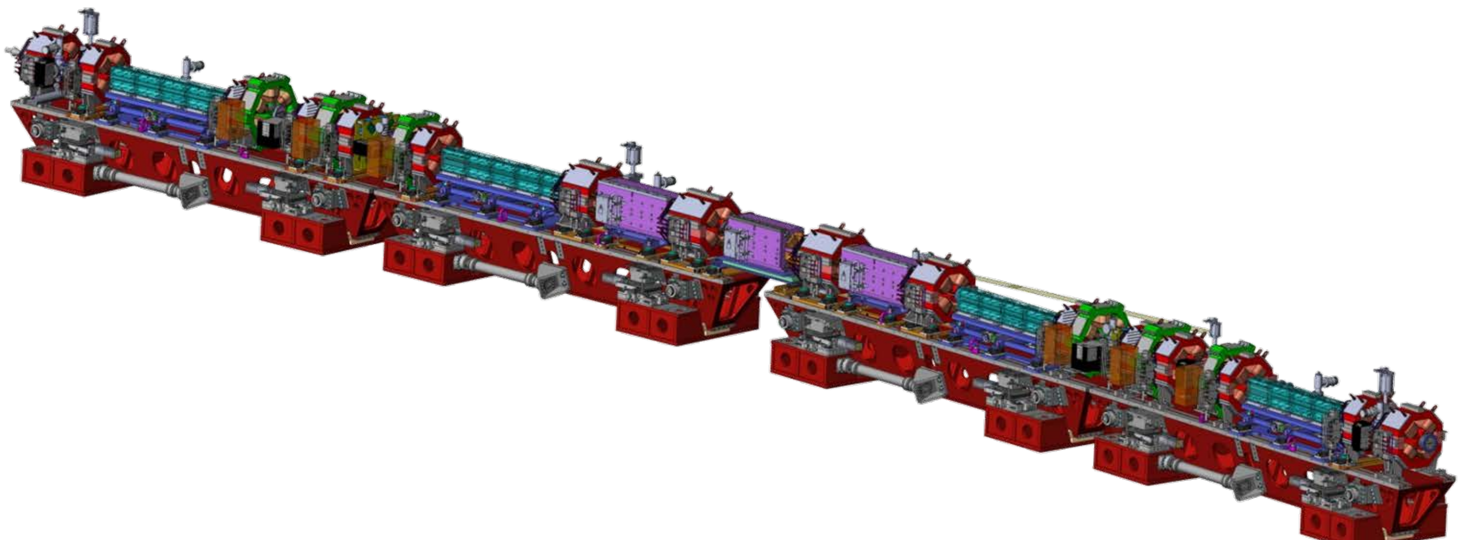
PRELIMINARY SHIELDING RESULTS FOR ESRF STORAGE RING UPGRADE

Phase II of ESRF upgrade program

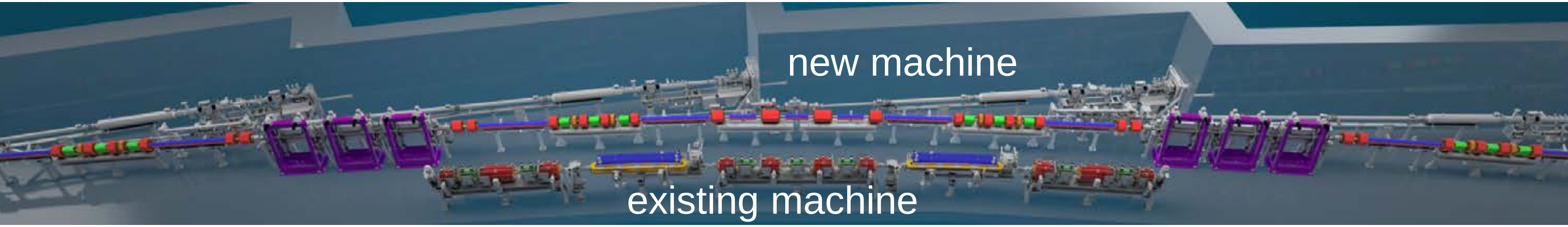
Comparison between existing and future lattice

Distributed losses versus localised losses

Conclusions and next steps



ESRF PHASE II UPGRADE PROGRAM: STORAGE RING UPGRADE



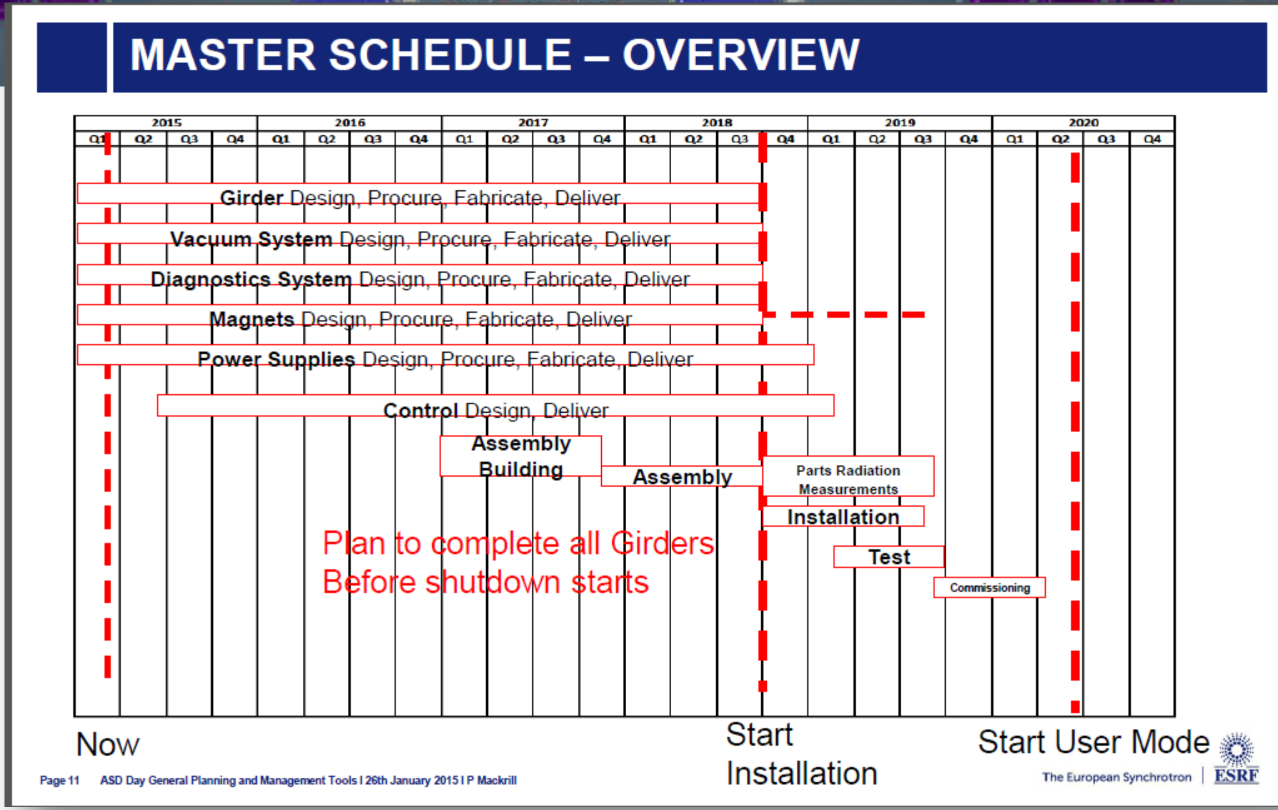
Parameter	Existing Lattice	New Lattice
Energy, *E* [GeV]	6.04	6.04
Circumference, *C* [m]	844	844
RF frequency, *fRF* [MHz]	352	352
Beam current [mA]	200	200
Horizontal Emittance [pm ·rad]	4000	150
Vertical Emittance [pm ·rad]	4	3
Beta at ID center, βx , βy [m]	37.6 , 3.0 (high β) 0.35 , 3.0 (low β)	3.6 , 3.6
Beam size at ID center, σx , σy [μm]	413 , 3.9 (high β) 50 , 3.9 (low β)	24 , 3.3
Beam div. at ID center, $\sigma x'$, $\sigma y'$ [μrad]	10 , 1.3 (high β) 107, 1.3 (low β)	6.4 , 0.91

Constraint: install new storage ring in existing storage ring tunnel

Recall: ESRF radiation protection policy: < 2 μSv/4 hours (1 mSv/year)

Requirement from Regulator: future dose constraint ≤ present one

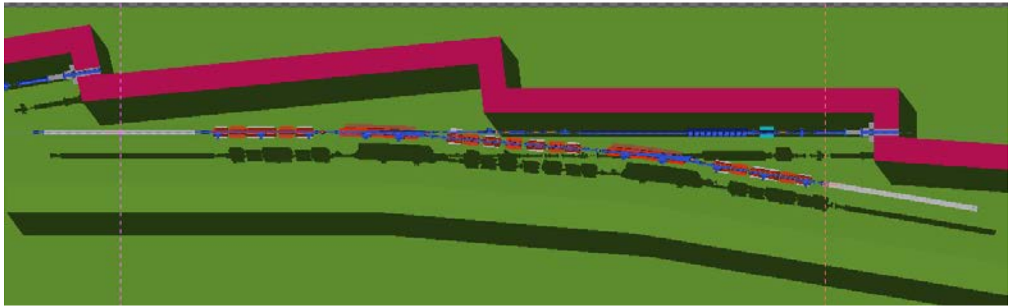
ESRF PHASE II UPGRADE PROGRAM: STORAGE RING UPGRADE



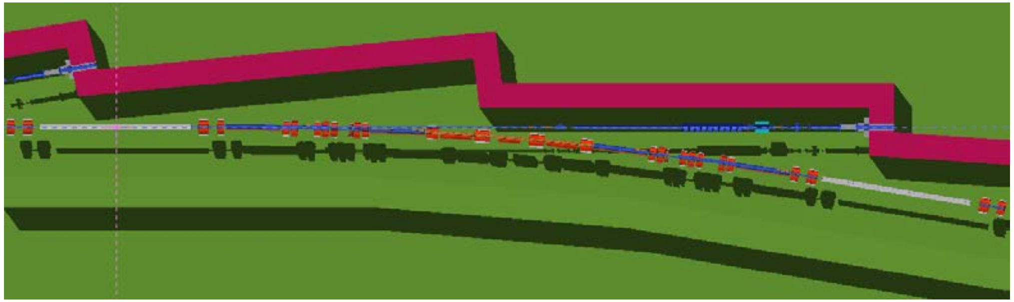
STORAGE RING SHIELDING: COMPARISON NEW AND EXISTING LATTICE

Fluka models of existing lattice and new lattice .

Comparative shielding study carried out, assuming electron losses on input taper of insertion device vacuum vessel.

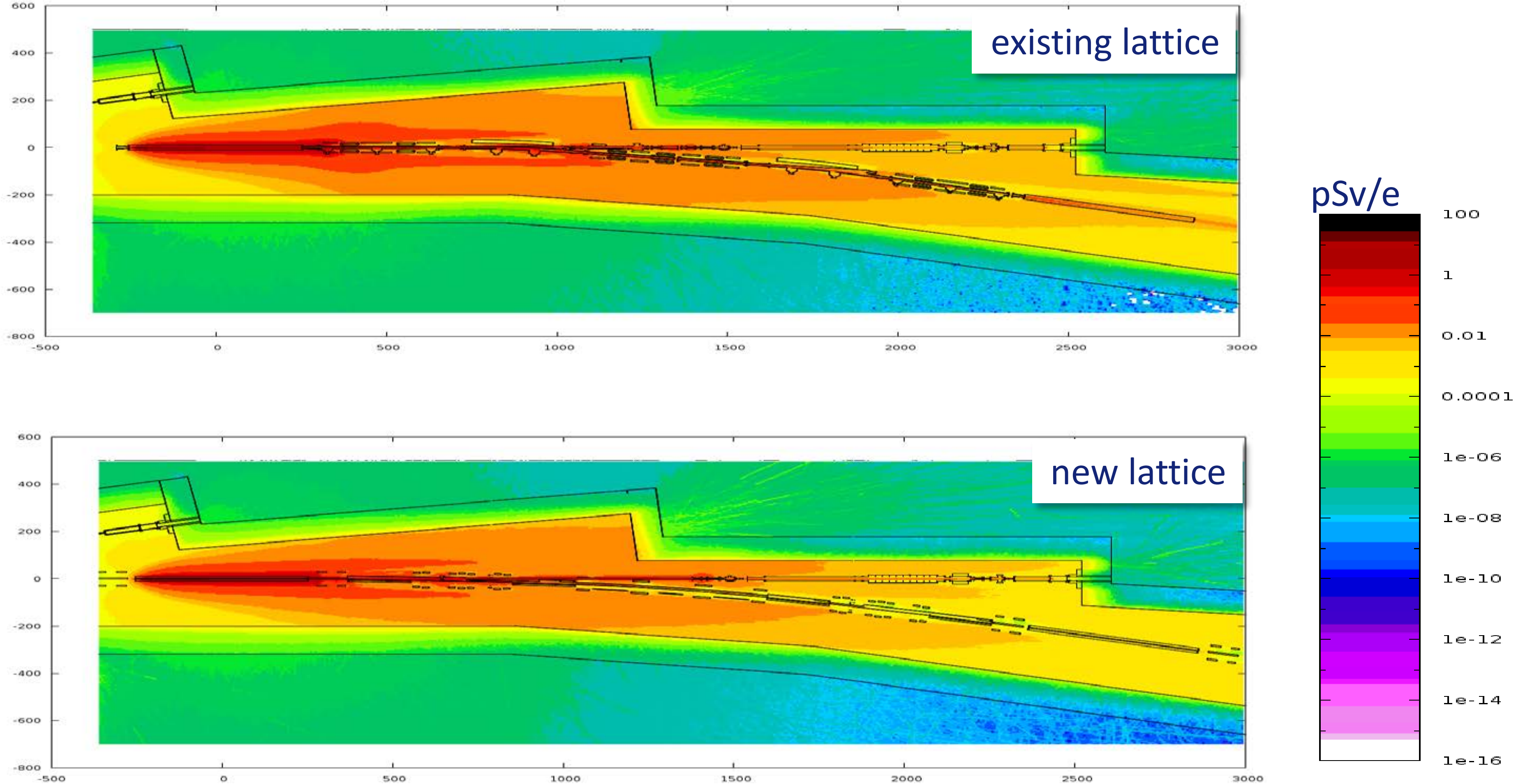


Existing lattice



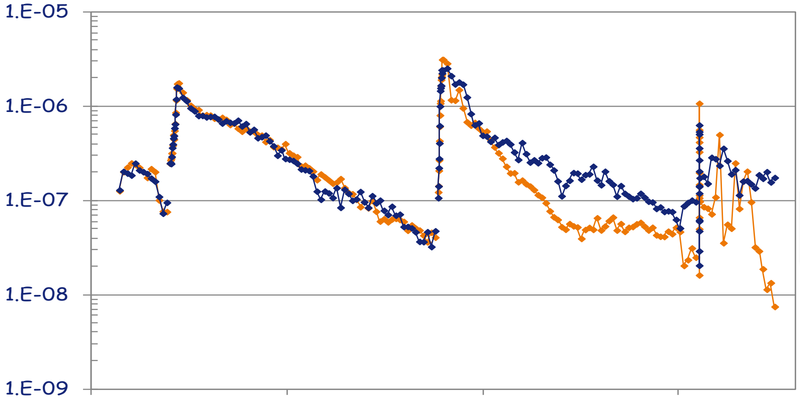
New lattice

STORAGE RING SHIELDING: COMPARISON NEW AND EXISTING LATTICE

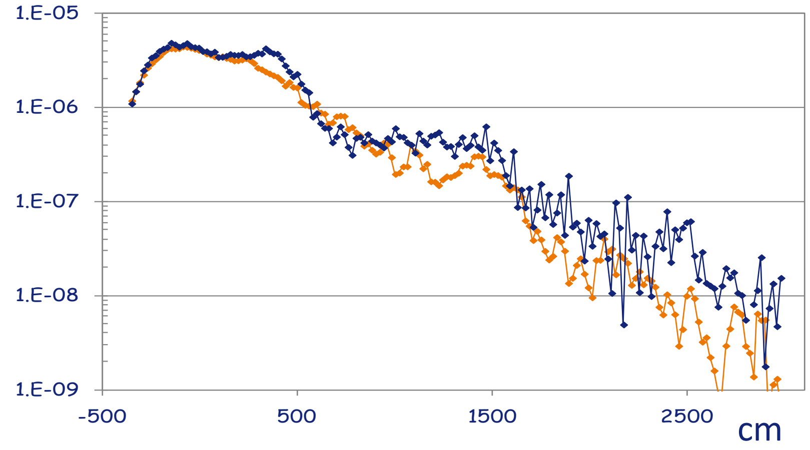


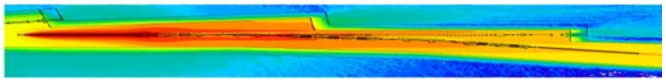
STORAGE RING SHIELDING: COMPARISON NEW AND EXISTING LATTICE

total dose behind outer wall (nSv/e$^-$)

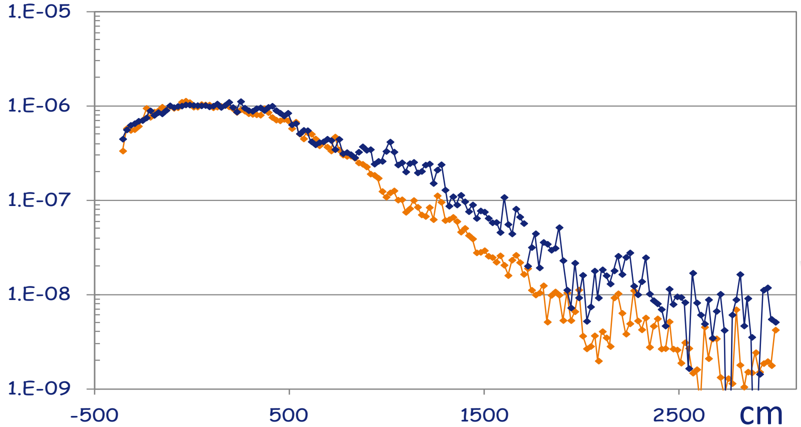


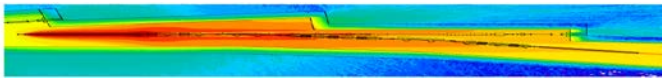
dose above roof along beam axis (nSv/e$^-$)



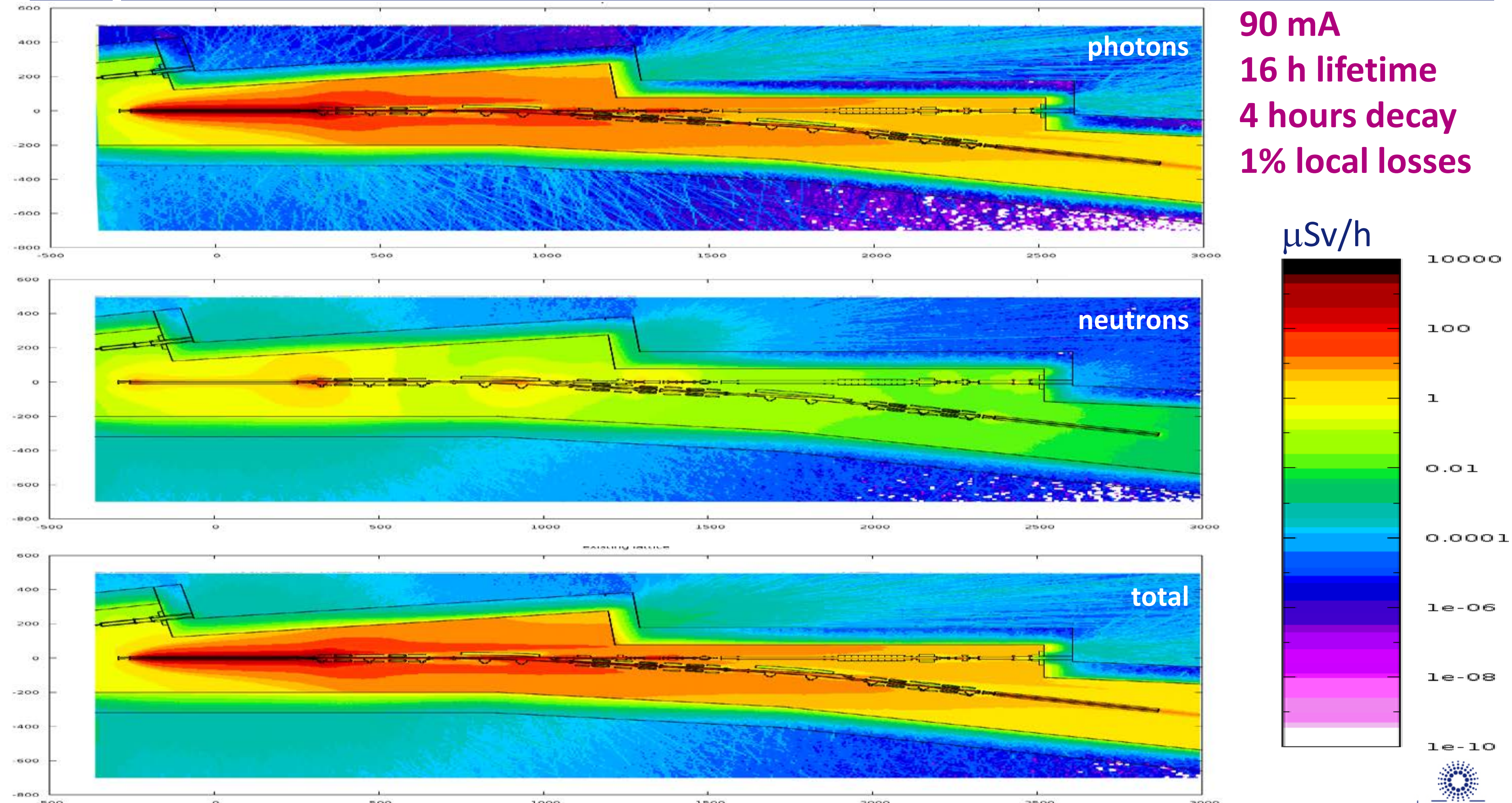


total dose behind inner wall (nSv/e$^-$)



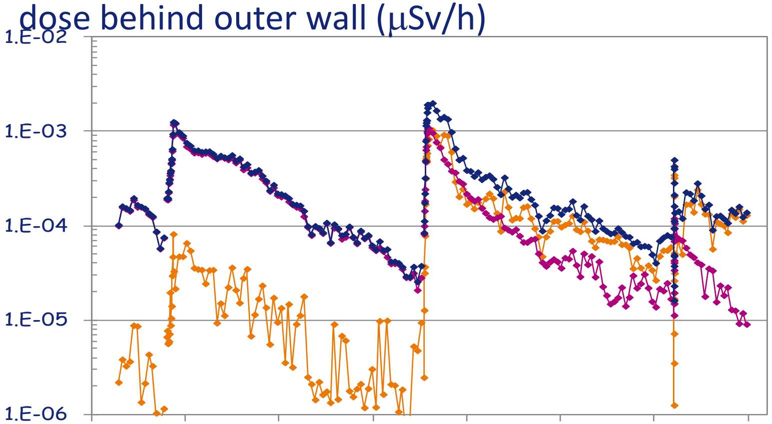


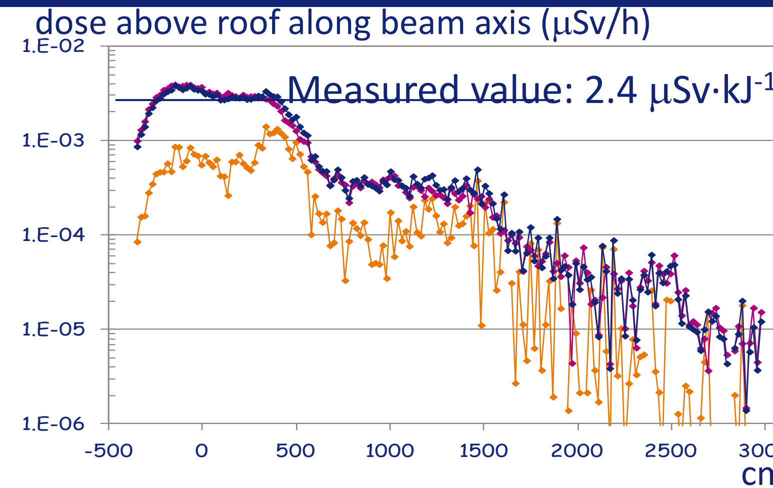
STORAGE RING SHIELDING – EXISTING LATTICE

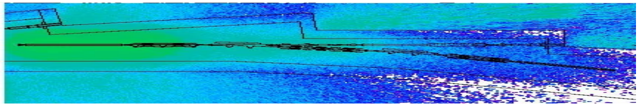


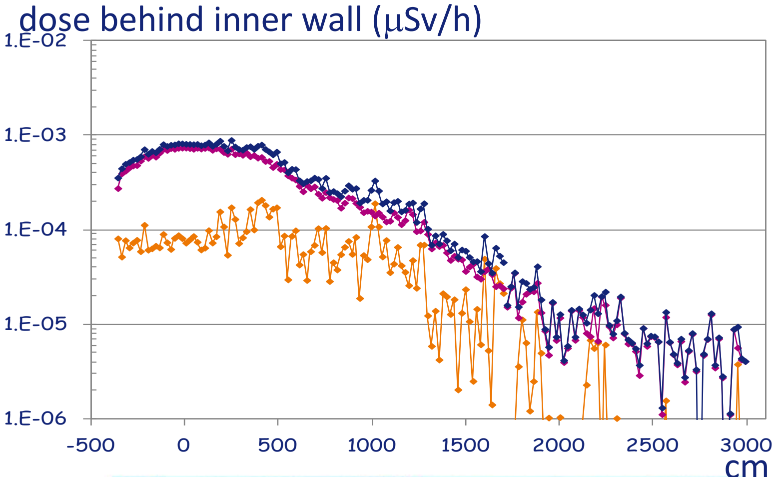
90 mA
16 h lifetime
4 hours decay
1% local losses

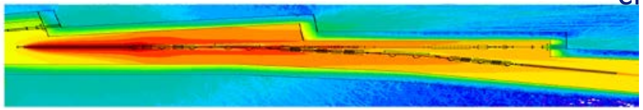
STORAGE RING SHIELDING – EXISTING LATTICE











photons
neutrons
total dose

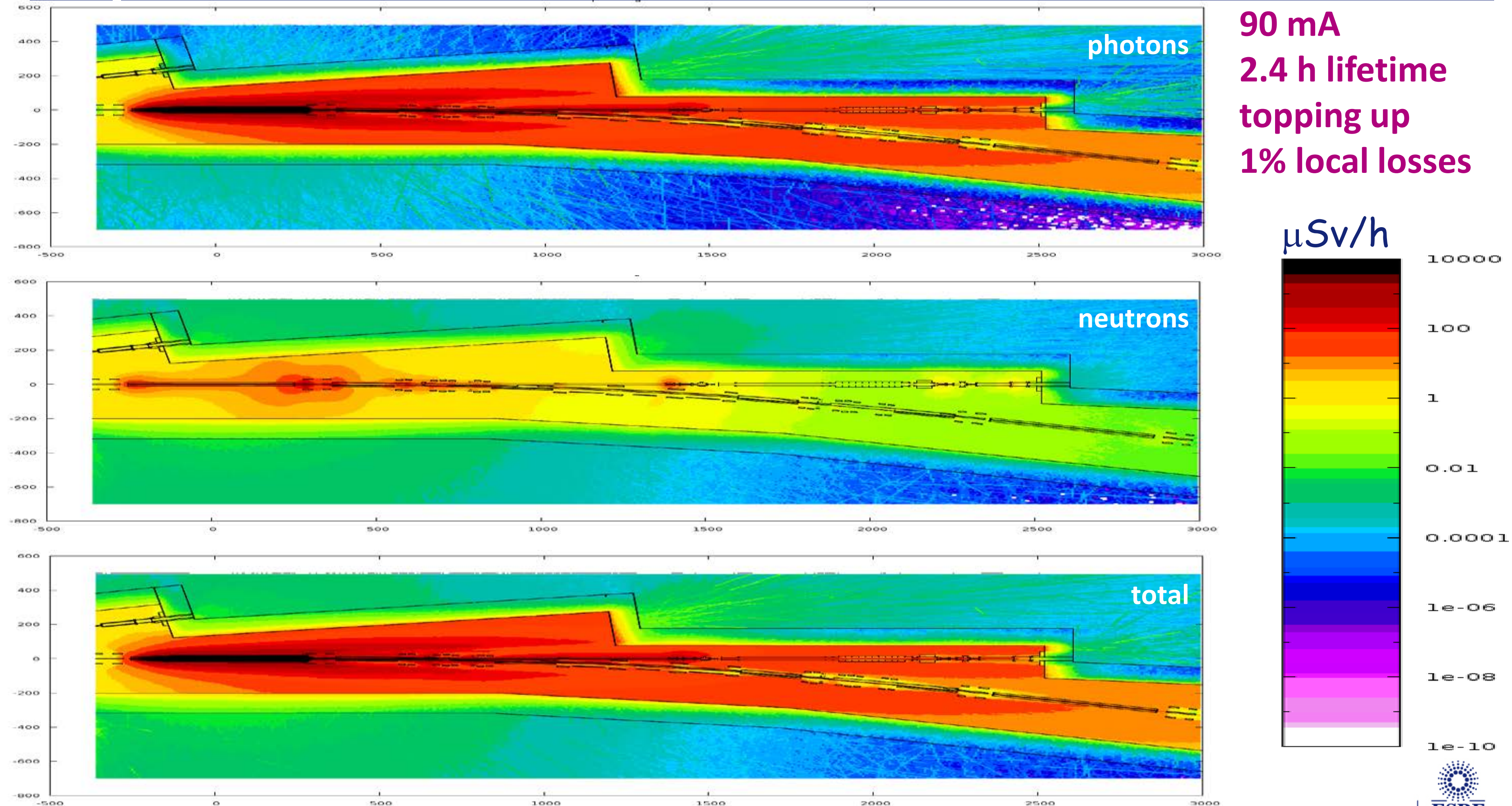
Existing lattice

90 mA – 16 h lifetime

average over 4 hours decay

1% local losses

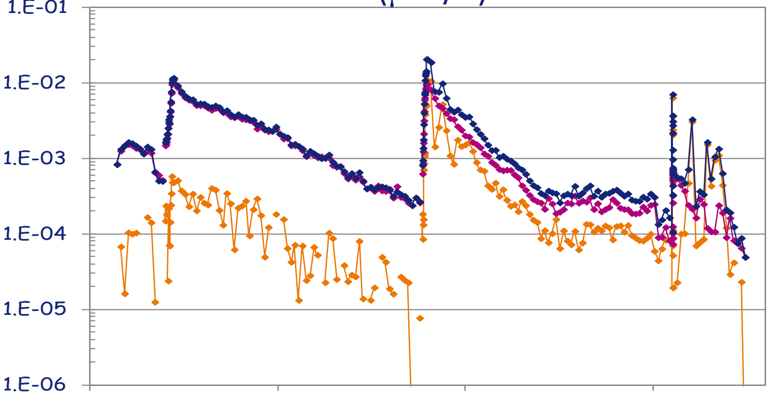
STORAGE RING SHIELDING – NEW LATTICE



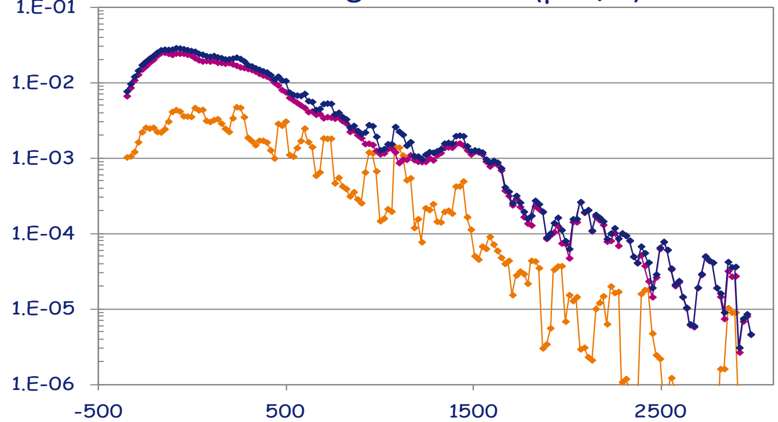
90 mA
2.4 h lifetime
topping up
1% local losses

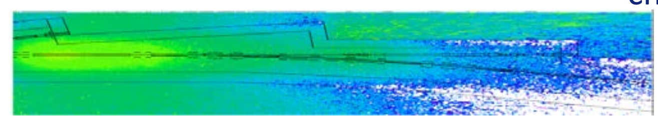
STORAGE RING SHIELDING – NEW LATTICE

dose behind outer wall (μSv/h)

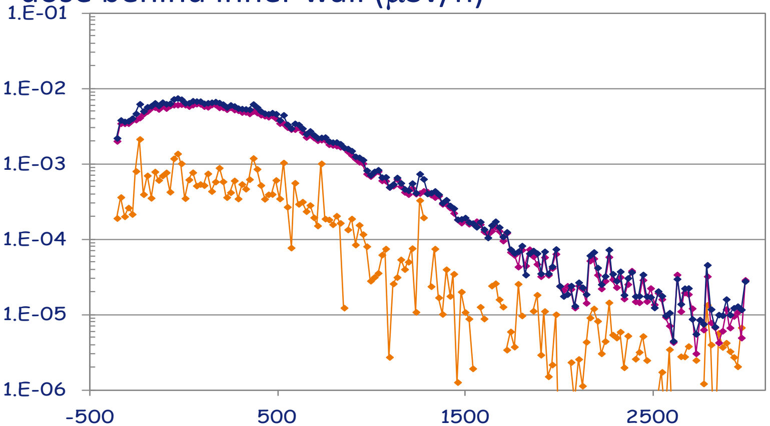


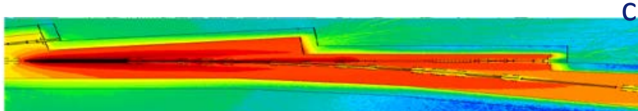
dose above roof along beam axis (μSv/h)

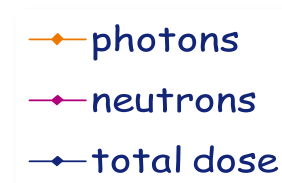




dose behind inner wall (μSv/h)







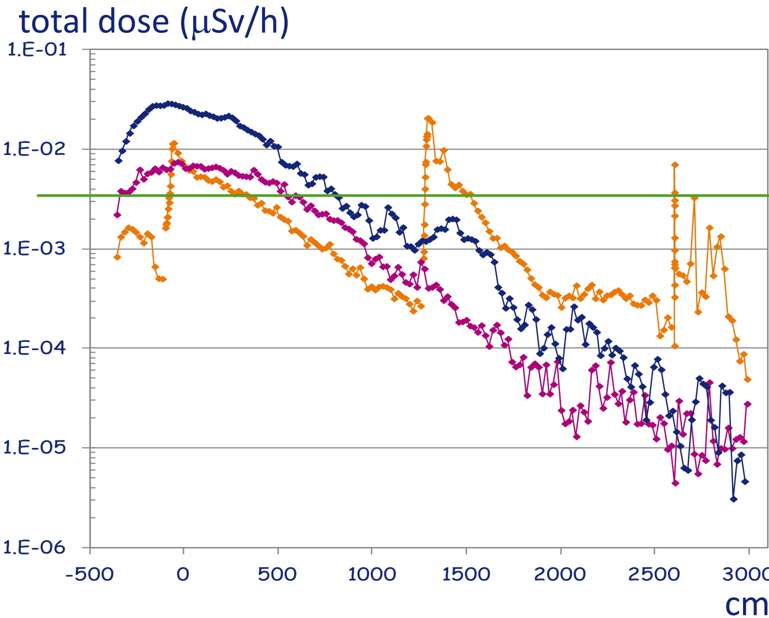
New lattice

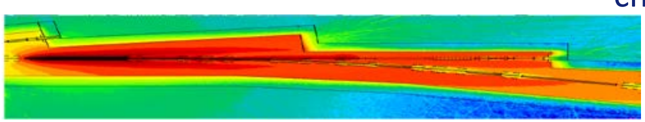
90 mA – 2.4 h lifetime

topping up

1% local losses

STORAGE RING SHIELDING: COMPARISON NEW AND EXISTING LATTICE



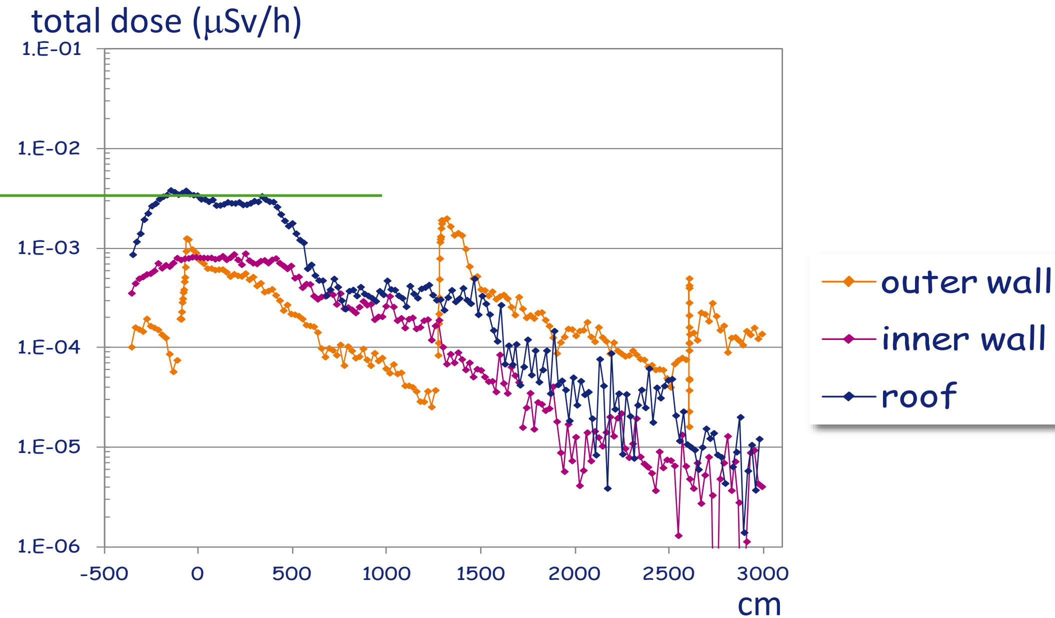


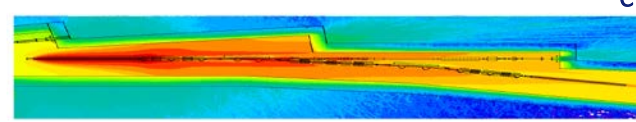
New lattice

90 mA – 2.4 h lifetime

topping up

1% local losses





Existing lattice

90 mA – 16 h lifetime

average over 4 hours decay

1% local losses

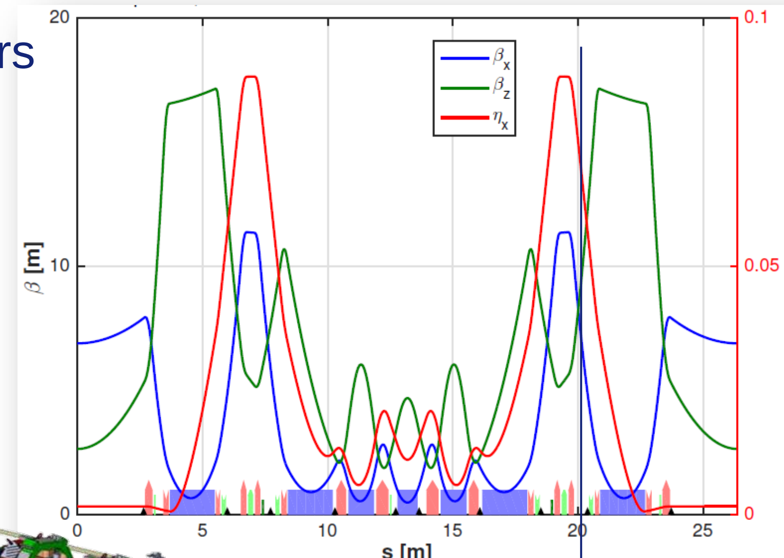
DISTRIBUTED LOSSES VERSUS LOCALISED LOSSES: BEAM LOSS COLLIMATORS

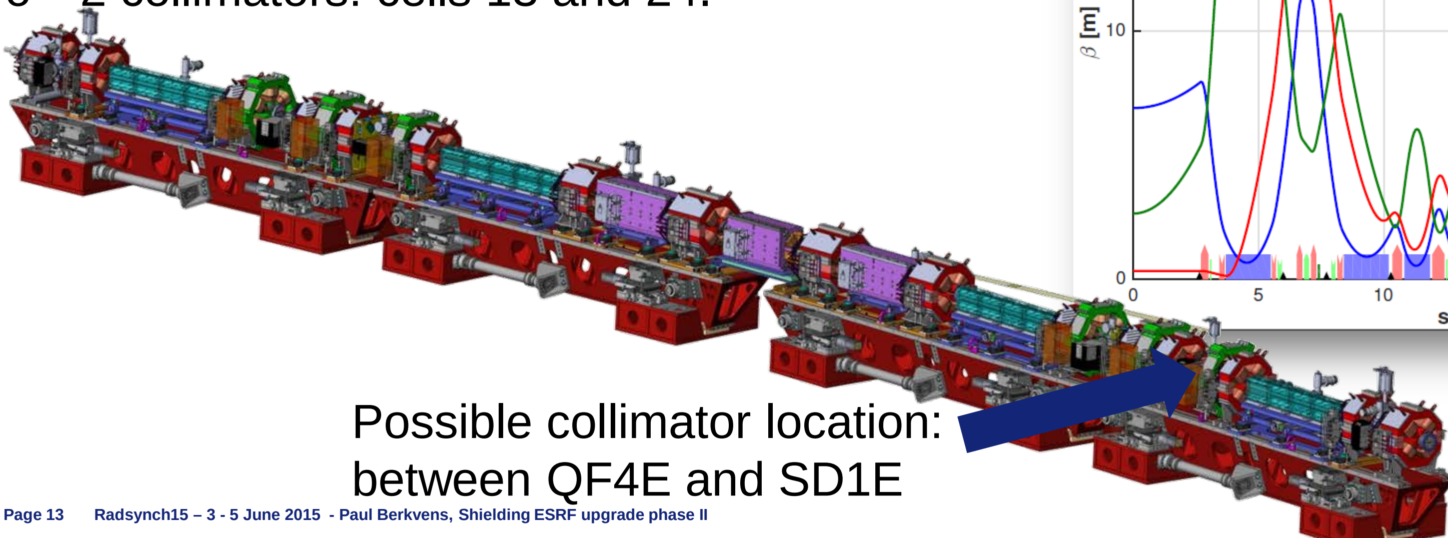
Distributed losses: conclusions

- o Difficult to maintain 2 μSv/4 hours dose constraint if losses per cell ≈ 10 %
- o Losses on input tapers straight sections: possible problems demagnetisation IDs

Localised losses: insertion of beam loss collimators

- o Horizontal collimators (Touschek scattering)
- o 2 collimators: cells 13 and 24.





Possible collimator location: between QF4E and SD1E

COLLIMATION SCHEME FOR THE ESRF UPGRADE

R. Versteegen[*], P. Berkvens, N. Carmignani, L. Farvacque, S.M. Liuzzo, B. Nash, T. Perron, P. Raimondi, S. White, ESRF, Grenoble, France

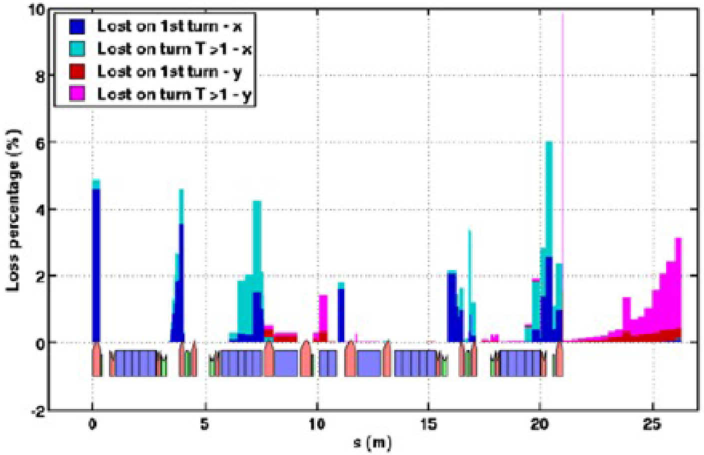


Figure 3: Superimposed losses of the 30 regular cells of the lattice without errors.

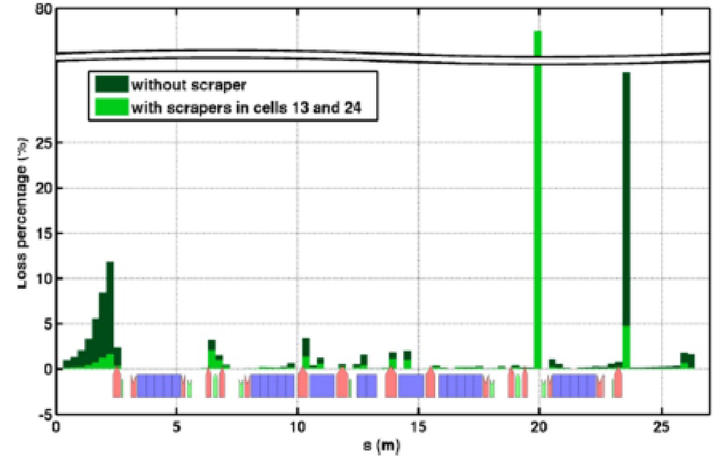


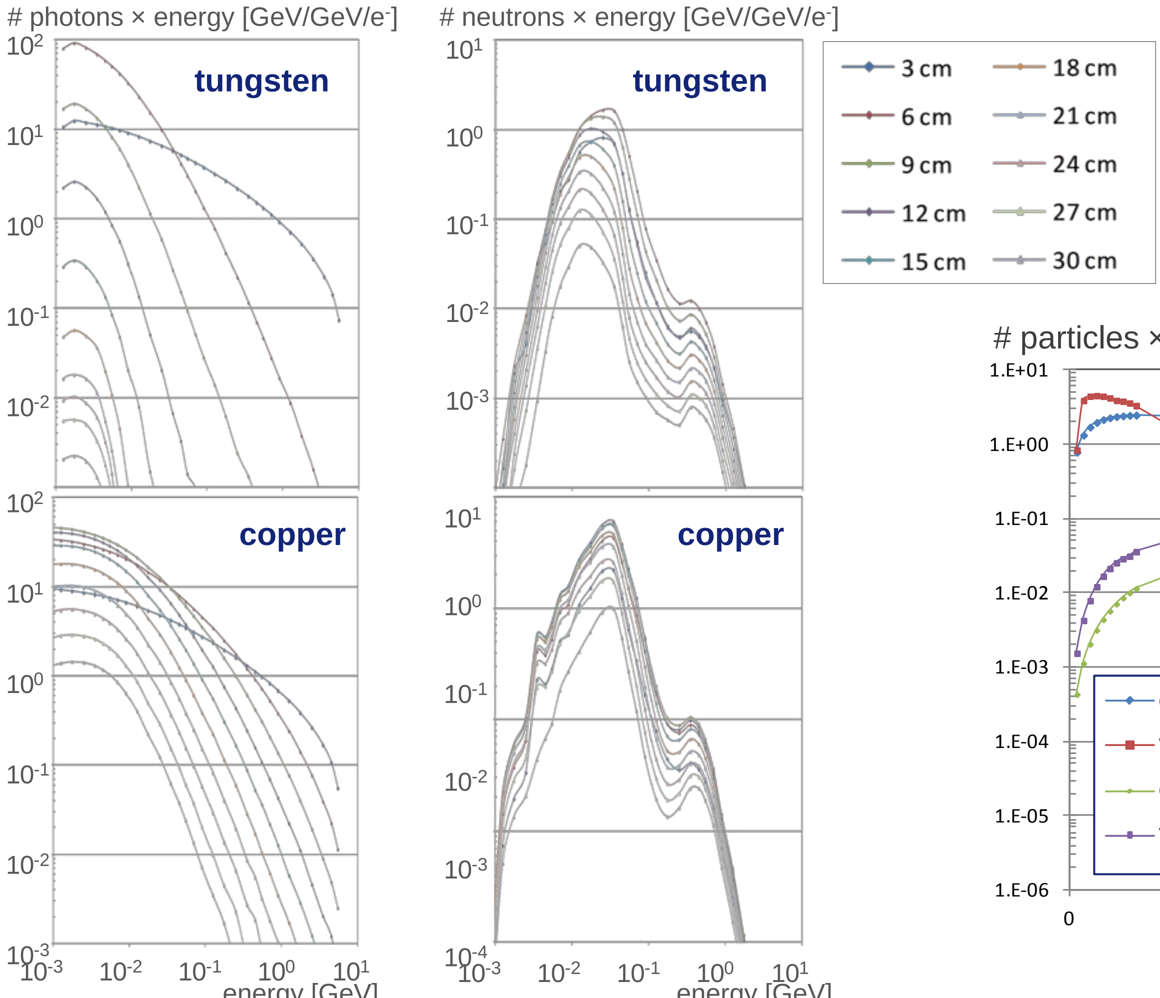
Figure 4: Impact of two horizontal scrapers on the superimposed losses of all 32 cells (lattice with errors, average over 10 seeds of set of random errors).

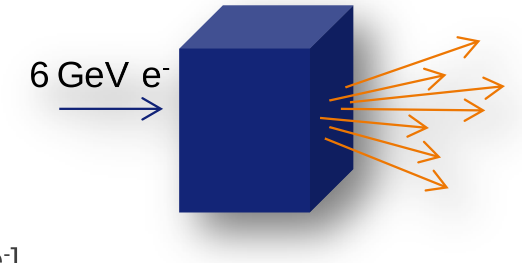
IPAC 2015, Jefferson Lab, 3 – 8 May 2015

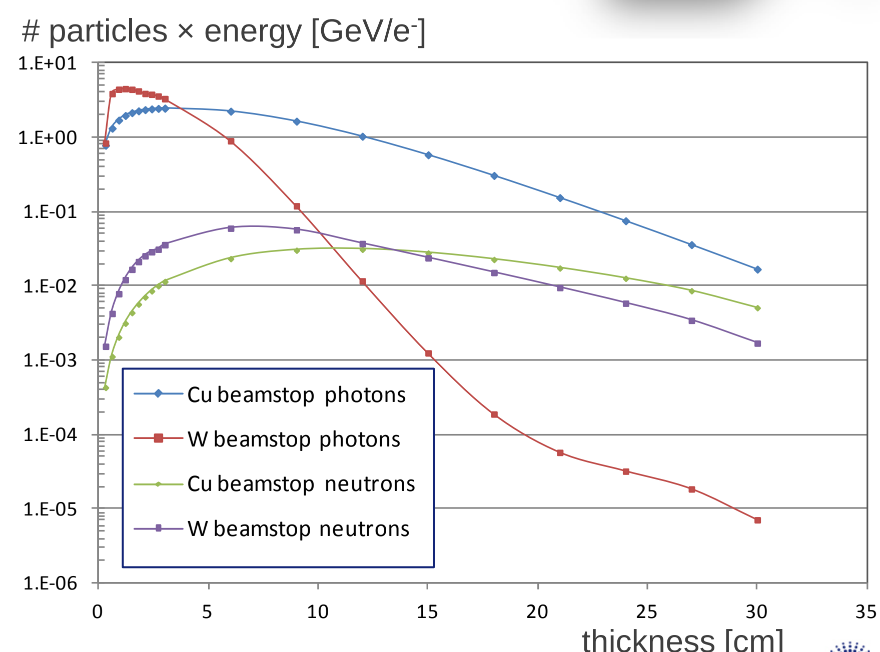
Beam loss collimator design

- Input phase space: R. Versteegen.
- All shielding results for 90 mA, 2.4 h lifetime, 45 % local losses on collimator.

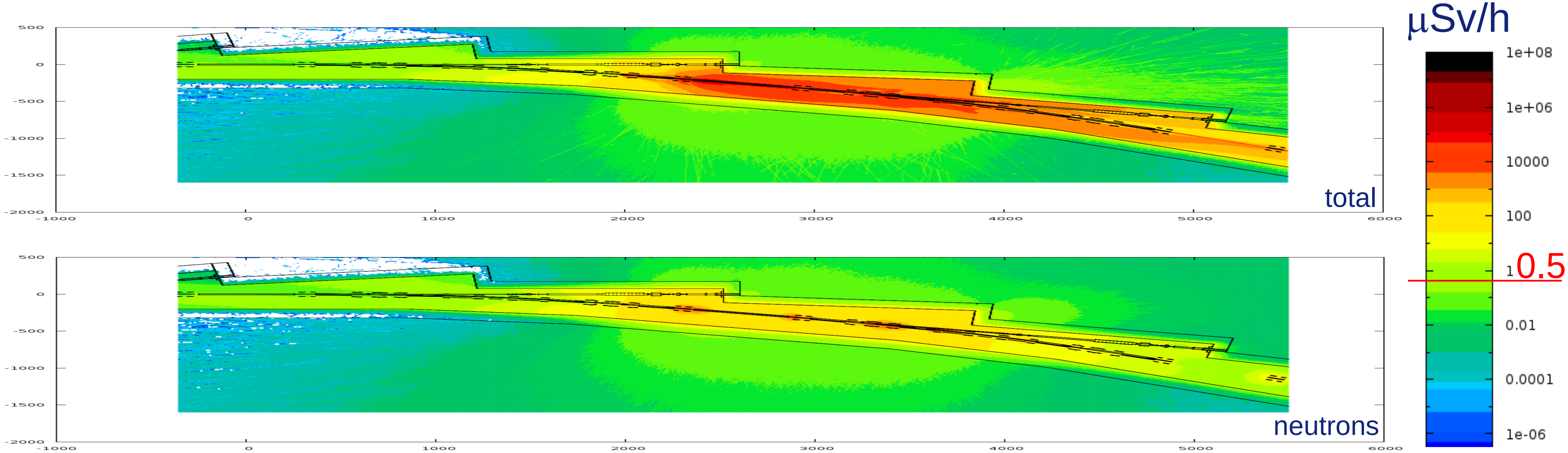
OPTIMISATION OF COLLIMATOR GEOMETRY: THIN SLITS VERSUS THICK SLITS

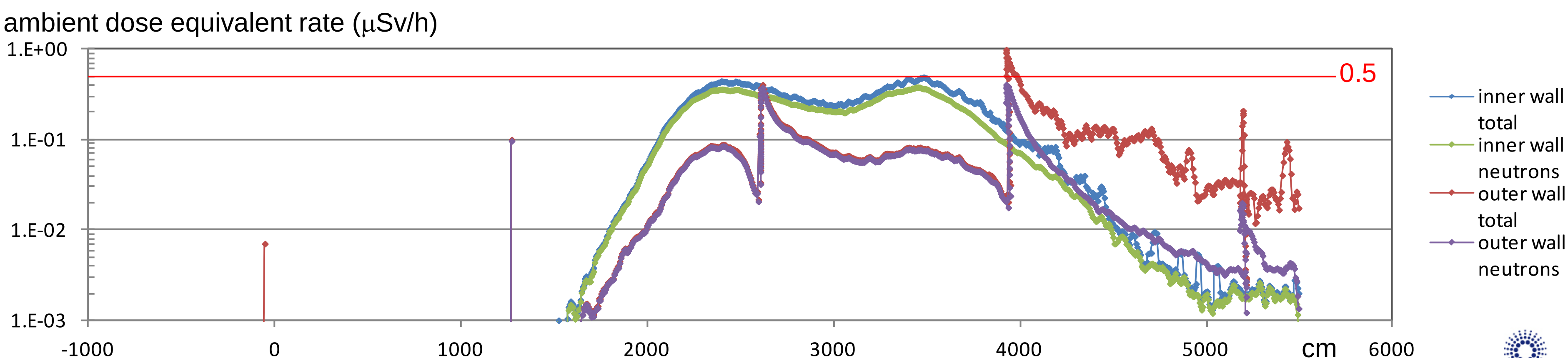




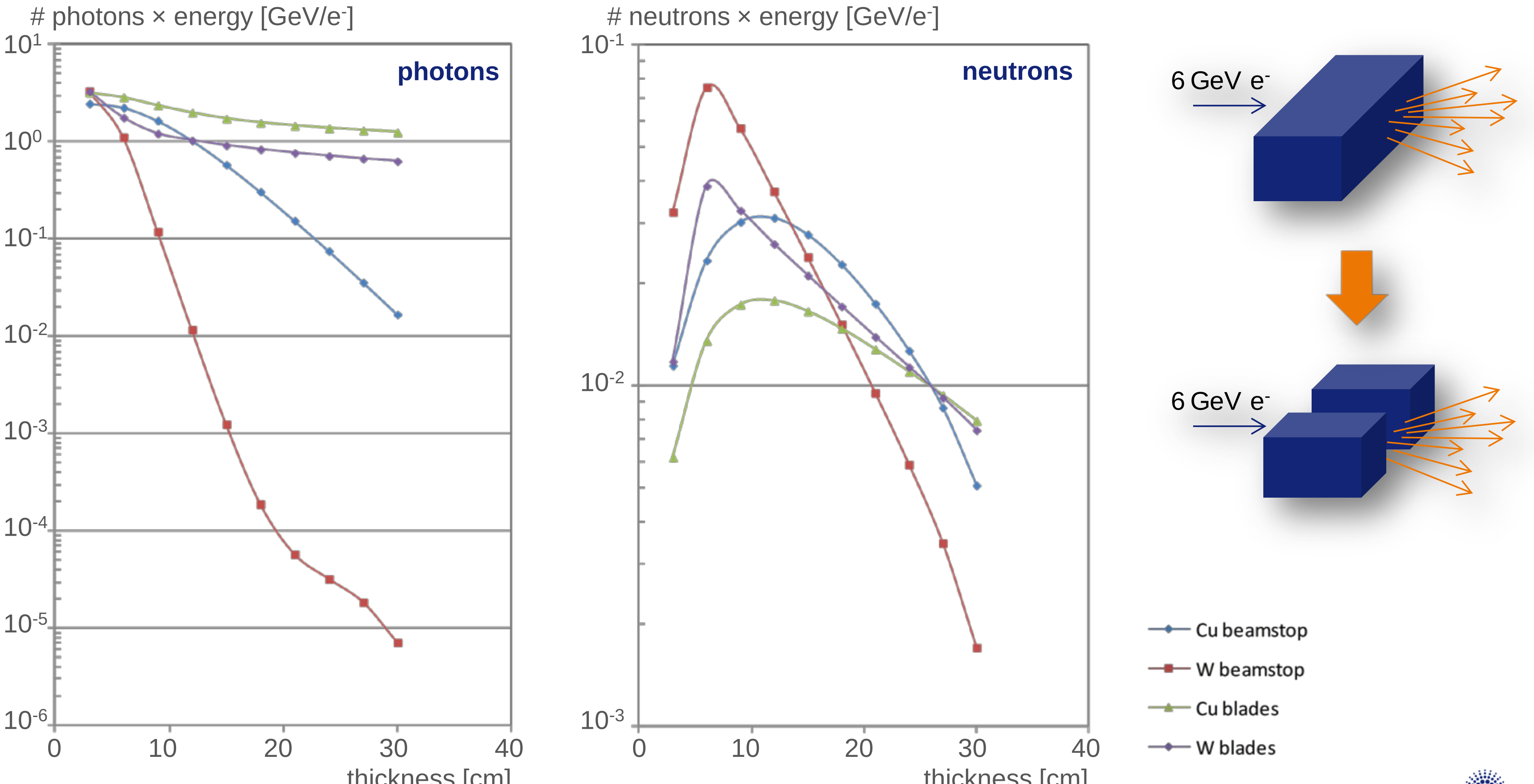


COLLIMATOR SHIELDING THIN SLITS: 1.4 mm Cu (ΔE = 1 %)

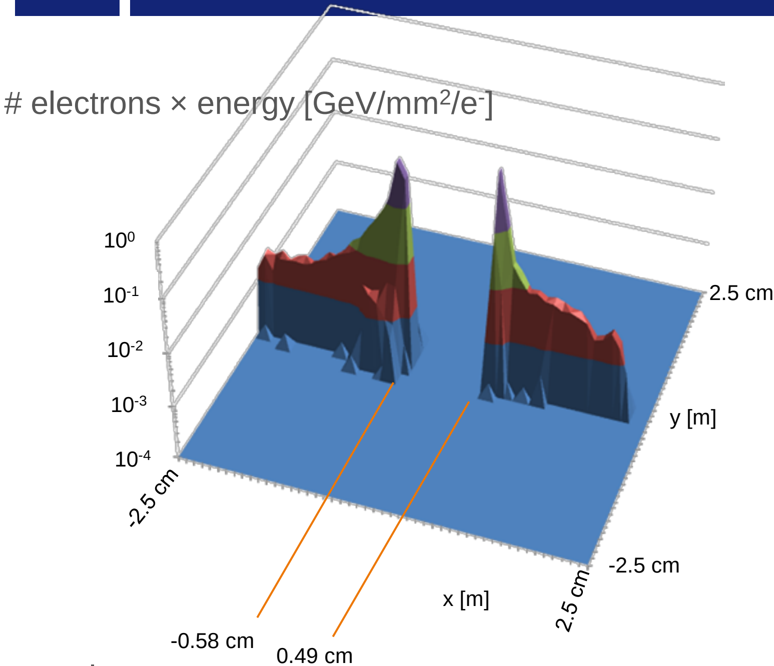


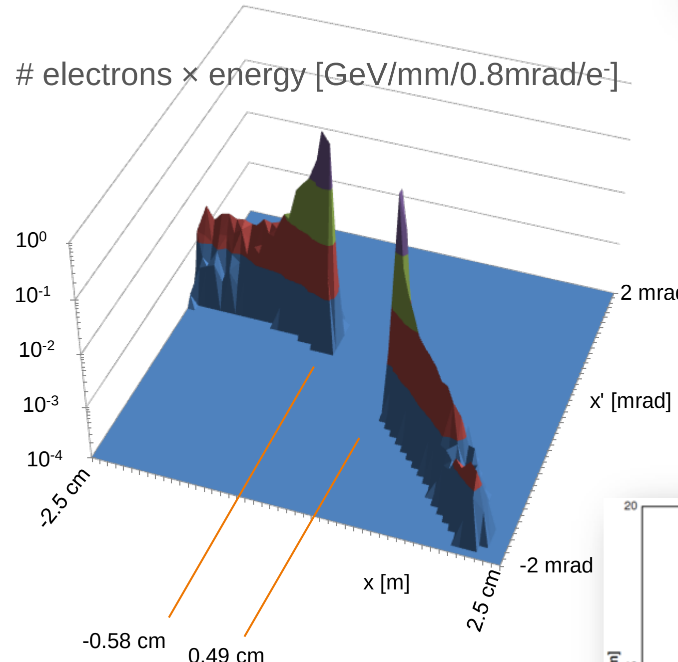


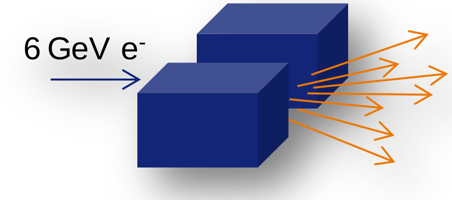
COLLIMATOR: RECTANGULAR BLADES

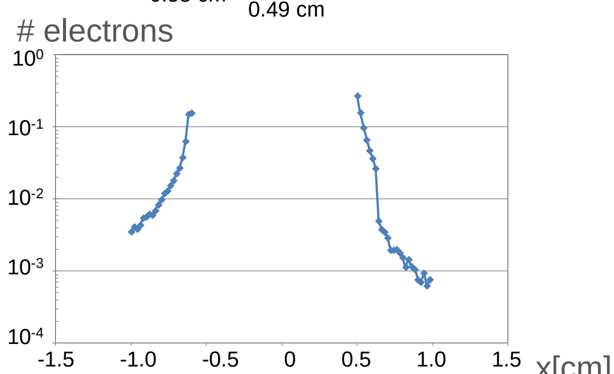


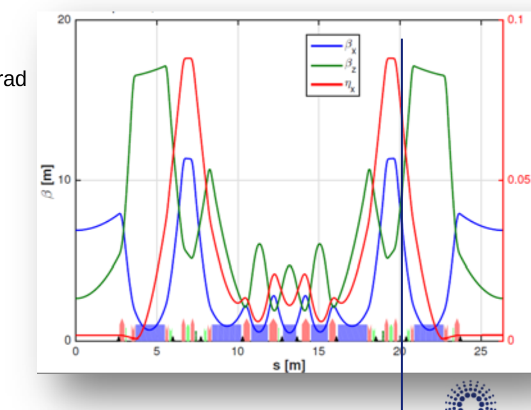
COLLIMATOR: RECTANGULAR BLADES ELECTRONS HITTING COLLIMATOR



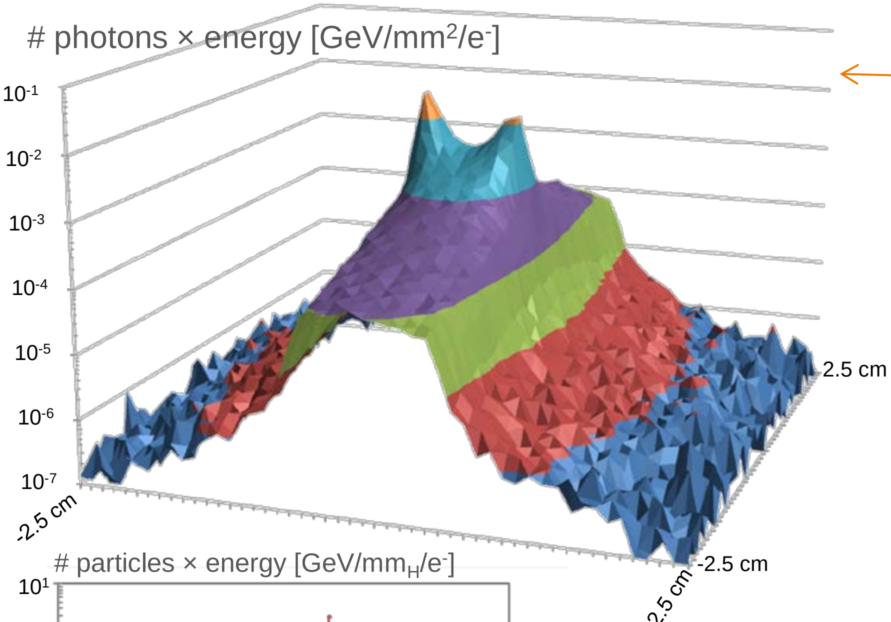


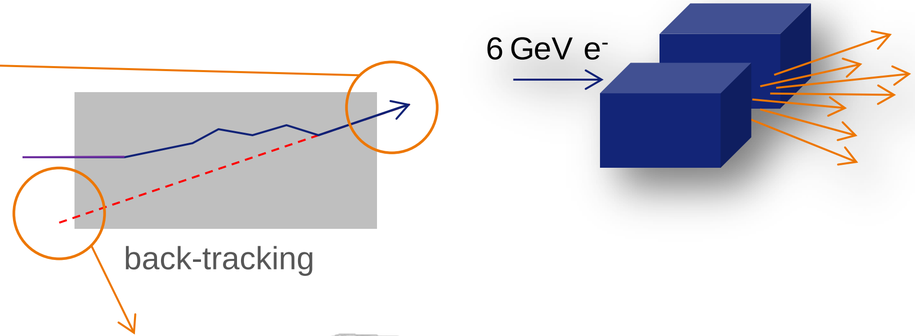


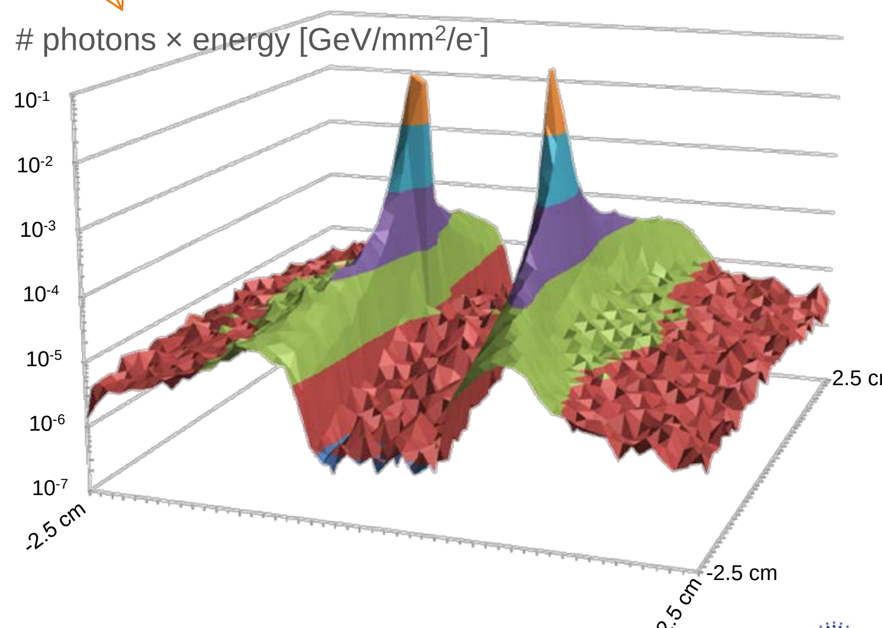


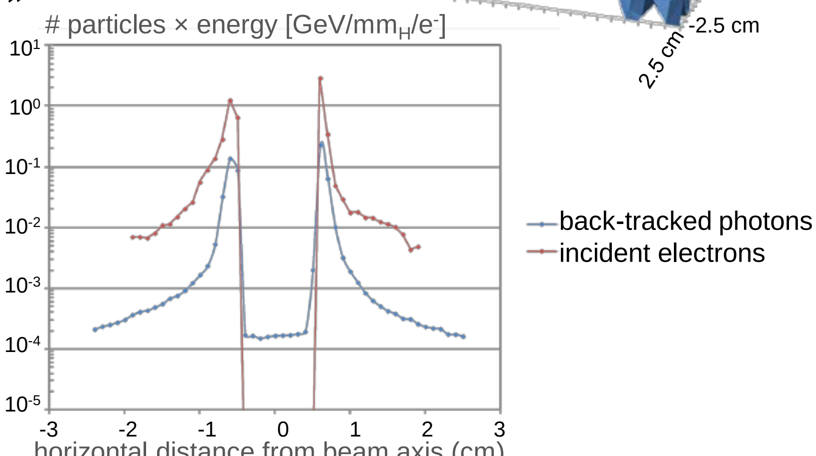


COLLIMATOR: RECTANGULAR BLADES (30 cm W)

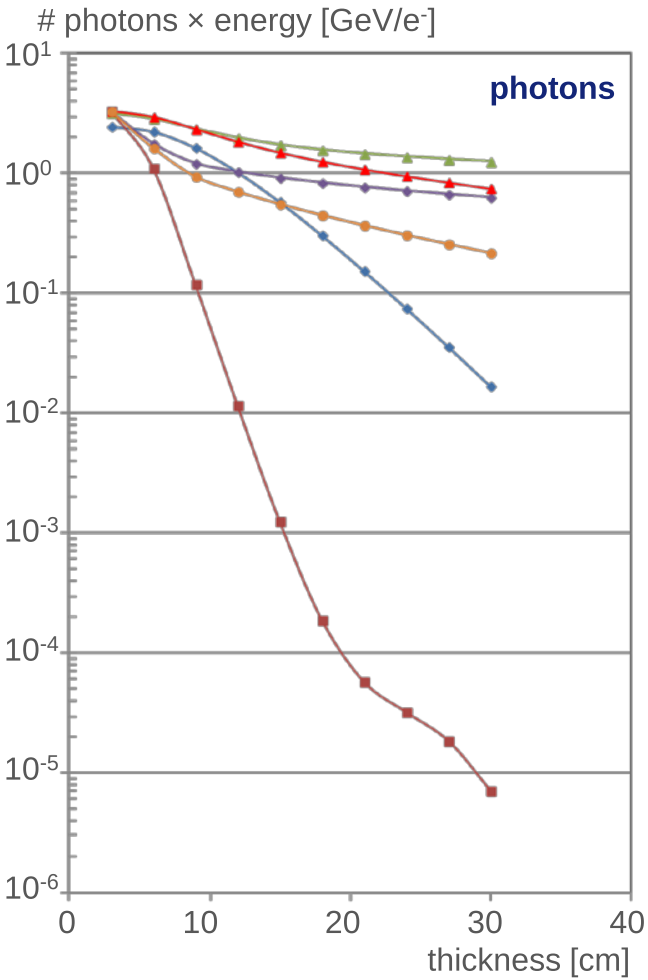


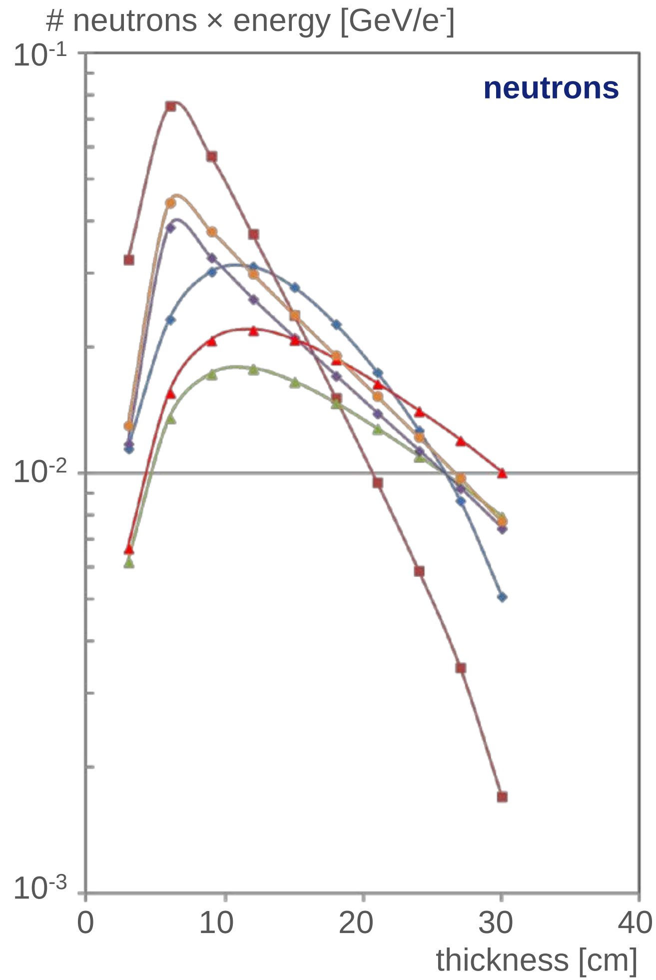


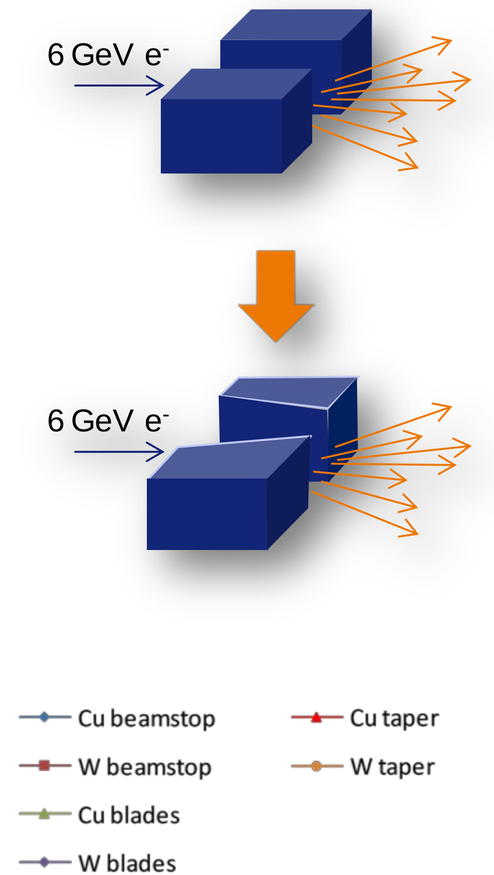




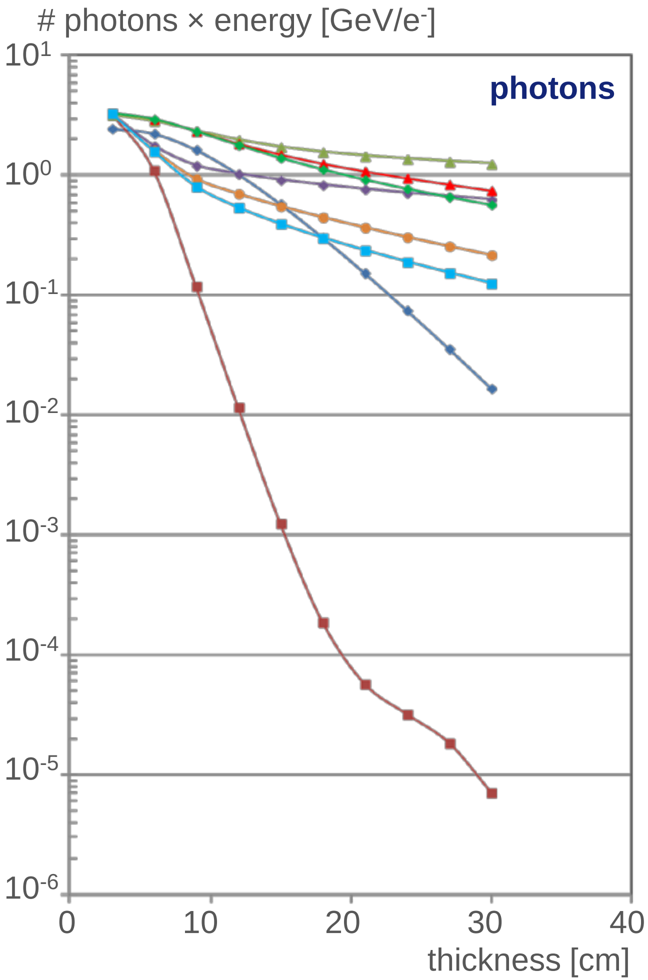
COLLIMATOR: TAPERED BLADES

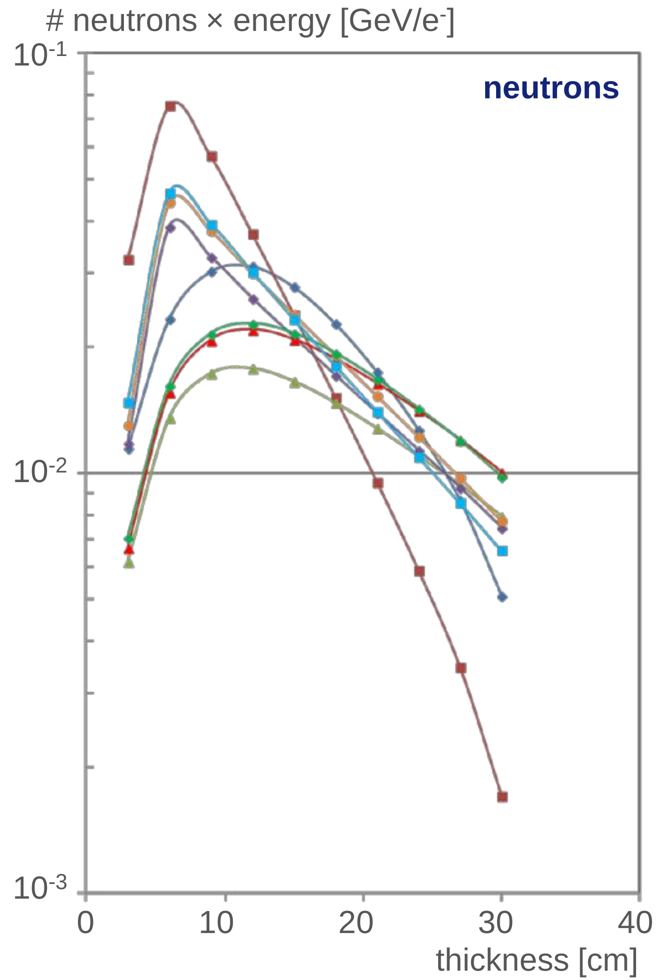


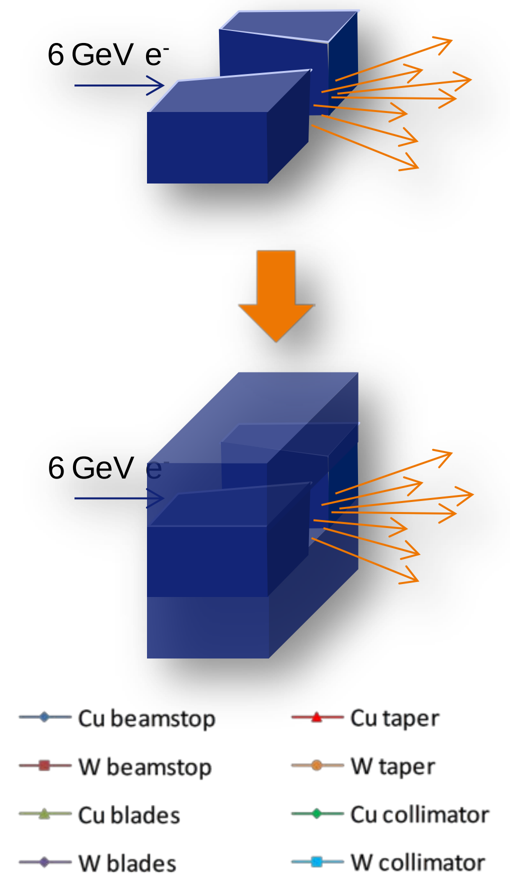




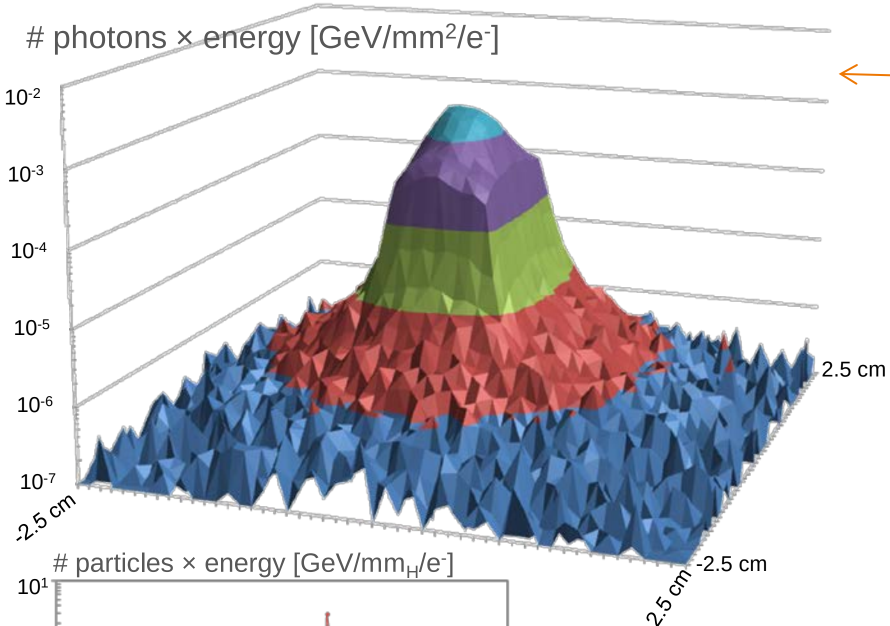
FULL COLLIMATOR

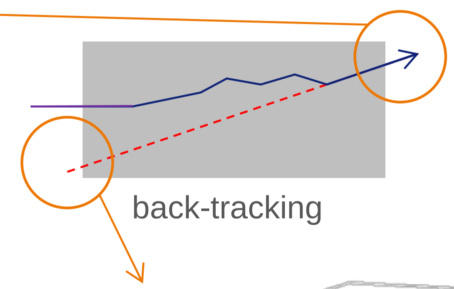


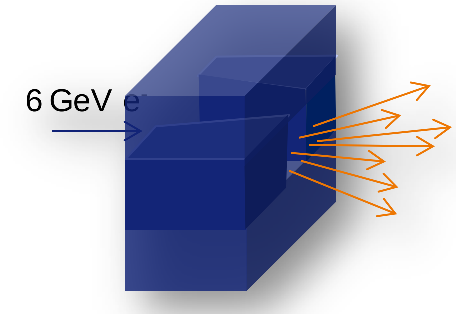


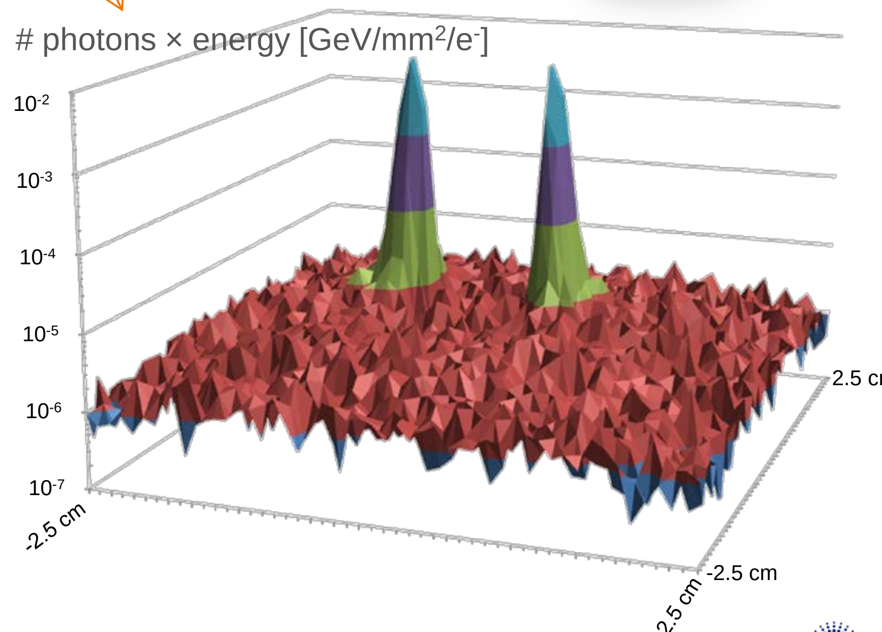


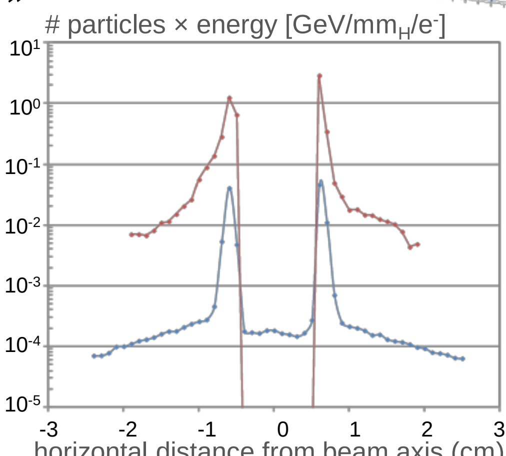
FULL COLLIMATOR (30 cm W)





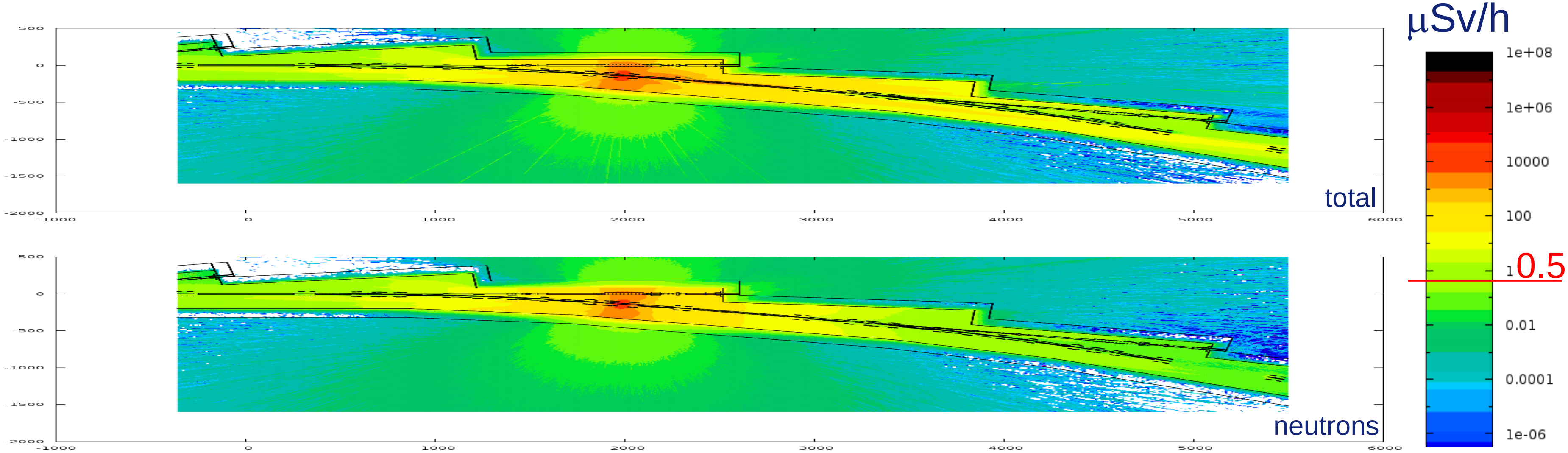


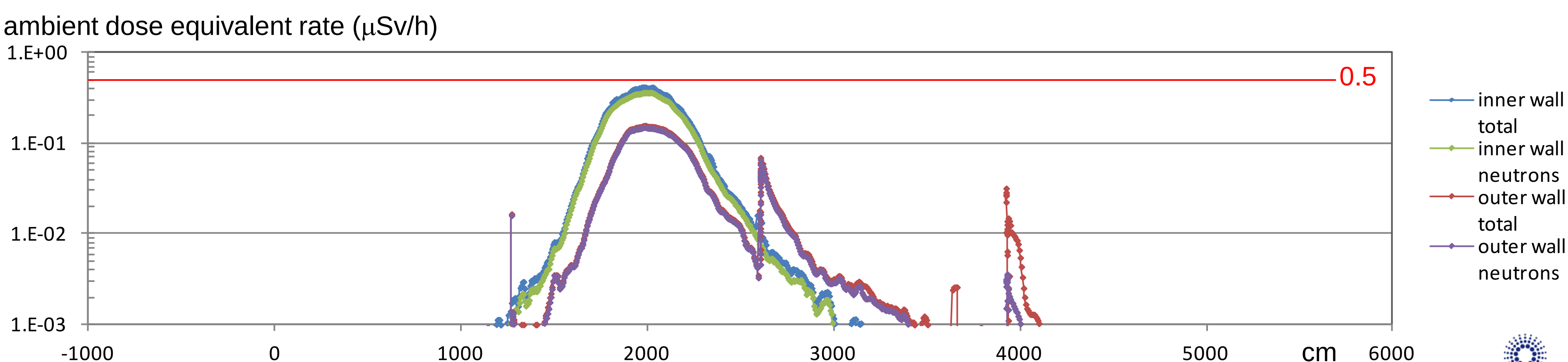


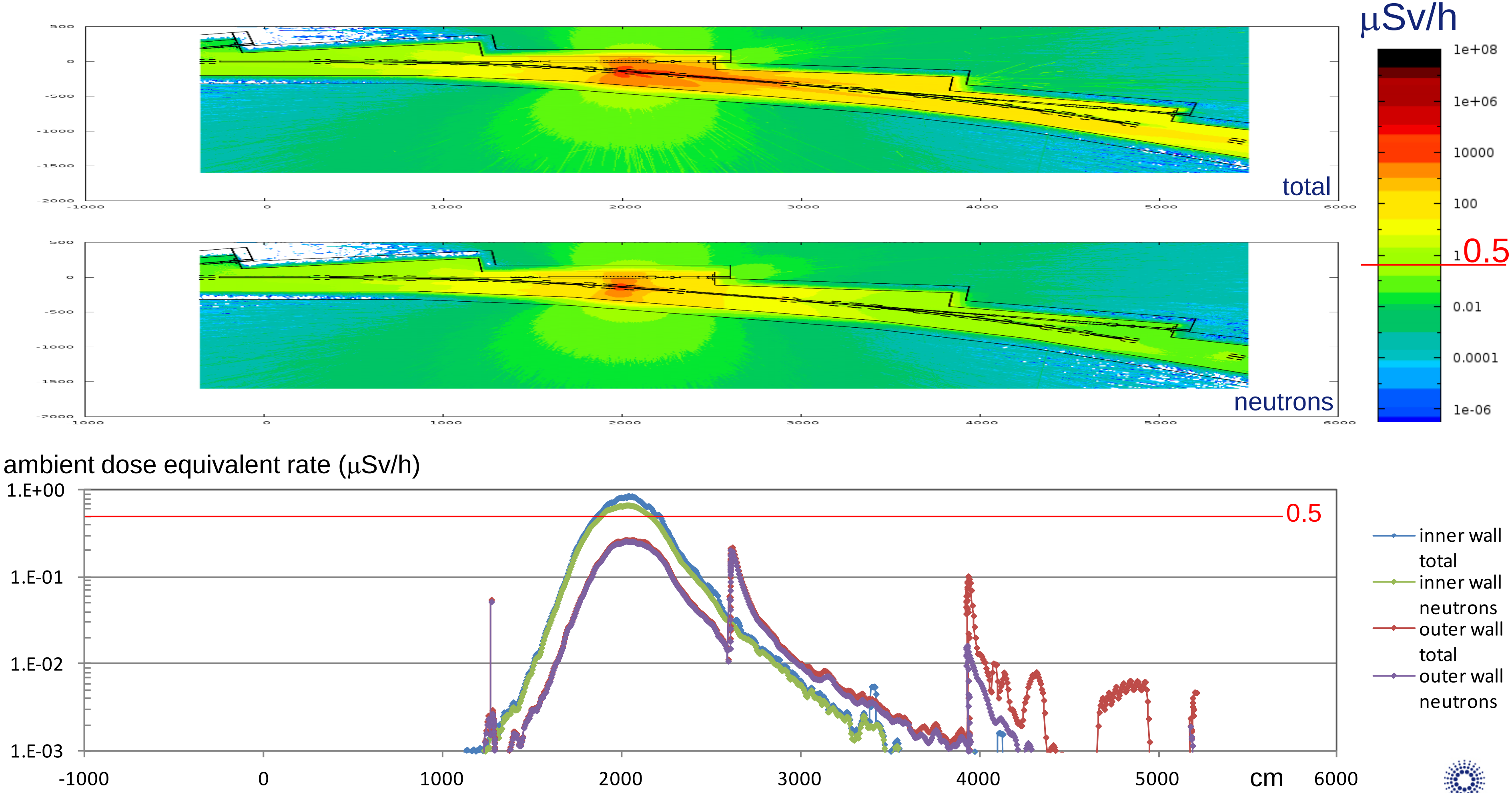


back-tracked photons
incident electrons

TUNGSTEN COLLIMATOR

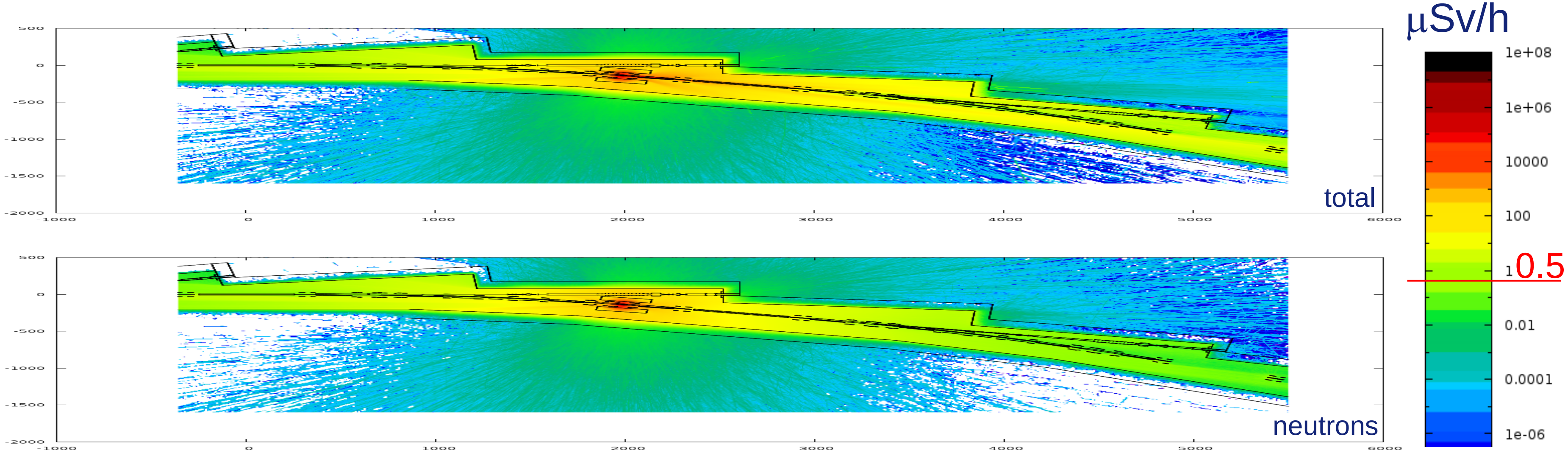


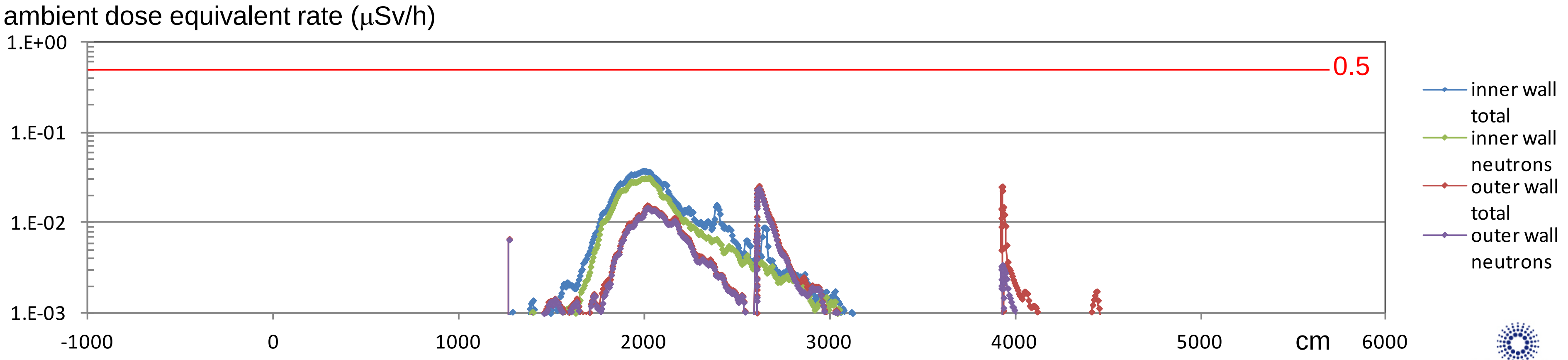




µSv/h
1e+08
1e+06
10000
100
1
0.5
0.01
0.0001
1e-06
total
neutrons
ambient dose equivalent rate (µSv/h)
1.E+00
1.E-01
1.E-02
1.E-03
-1000
0
1000
2000
3000
4000
5000
6000
cm
inner wall total
inner wall neutrons
outer wall total
outer wall neutrons

50 CM STEEL LOCAL SHIELDING





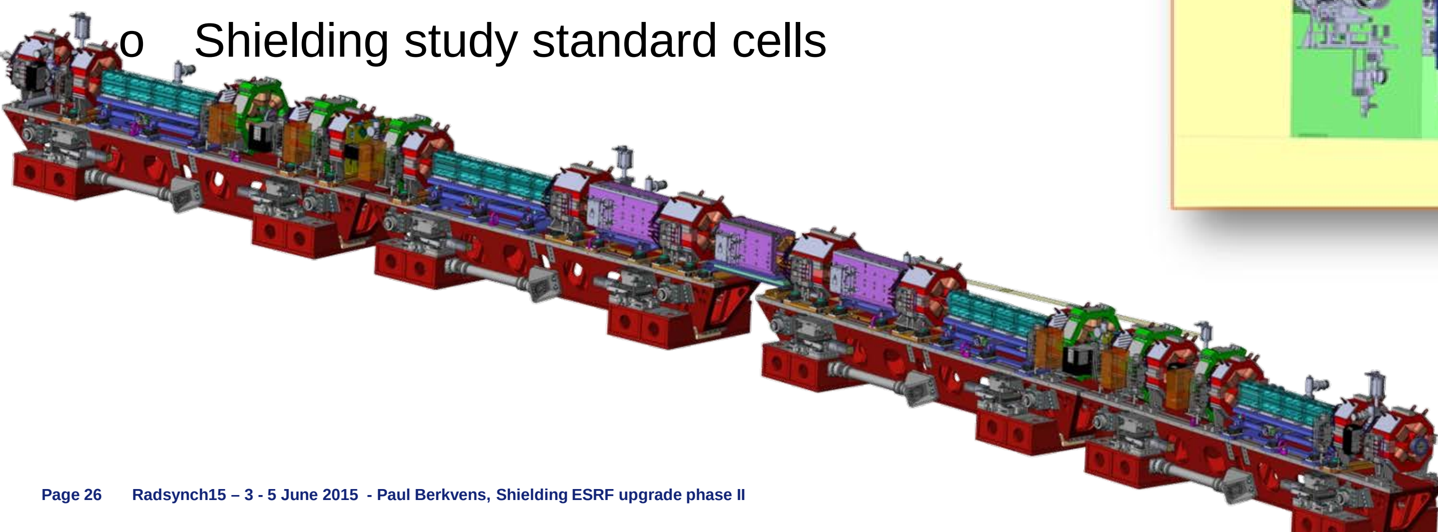
COLLIMATOR SHIELDING: CONCLUSIONS

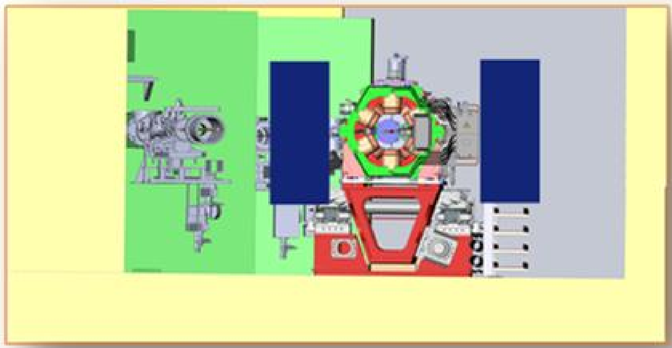
- Collimator geometry optimised: full, horizontally tapered collimator
- 50 cm steel shielding → dose rates outside shield walls < 0.5 μSv/h

  → Proposed dose constraint: 800 μSv/an → 0.4 μSv/h

Next steps

- Engineering design collimator + shielding
- Neutron fluences at downstream magnets
- Shielding study standard cells





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