Compact Photon Source Conceptual Design for K^0_L Production at Hall D

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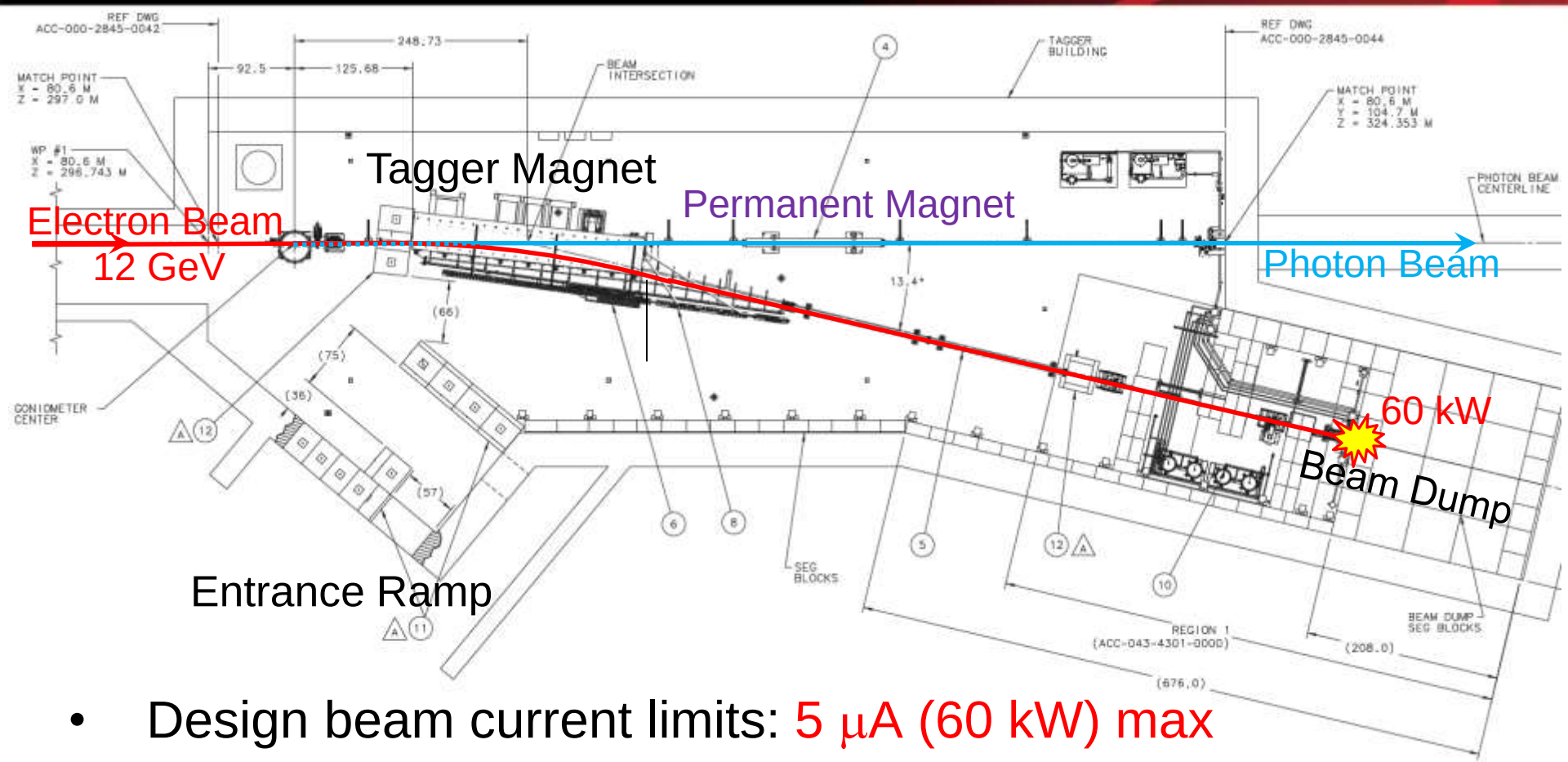
Outline

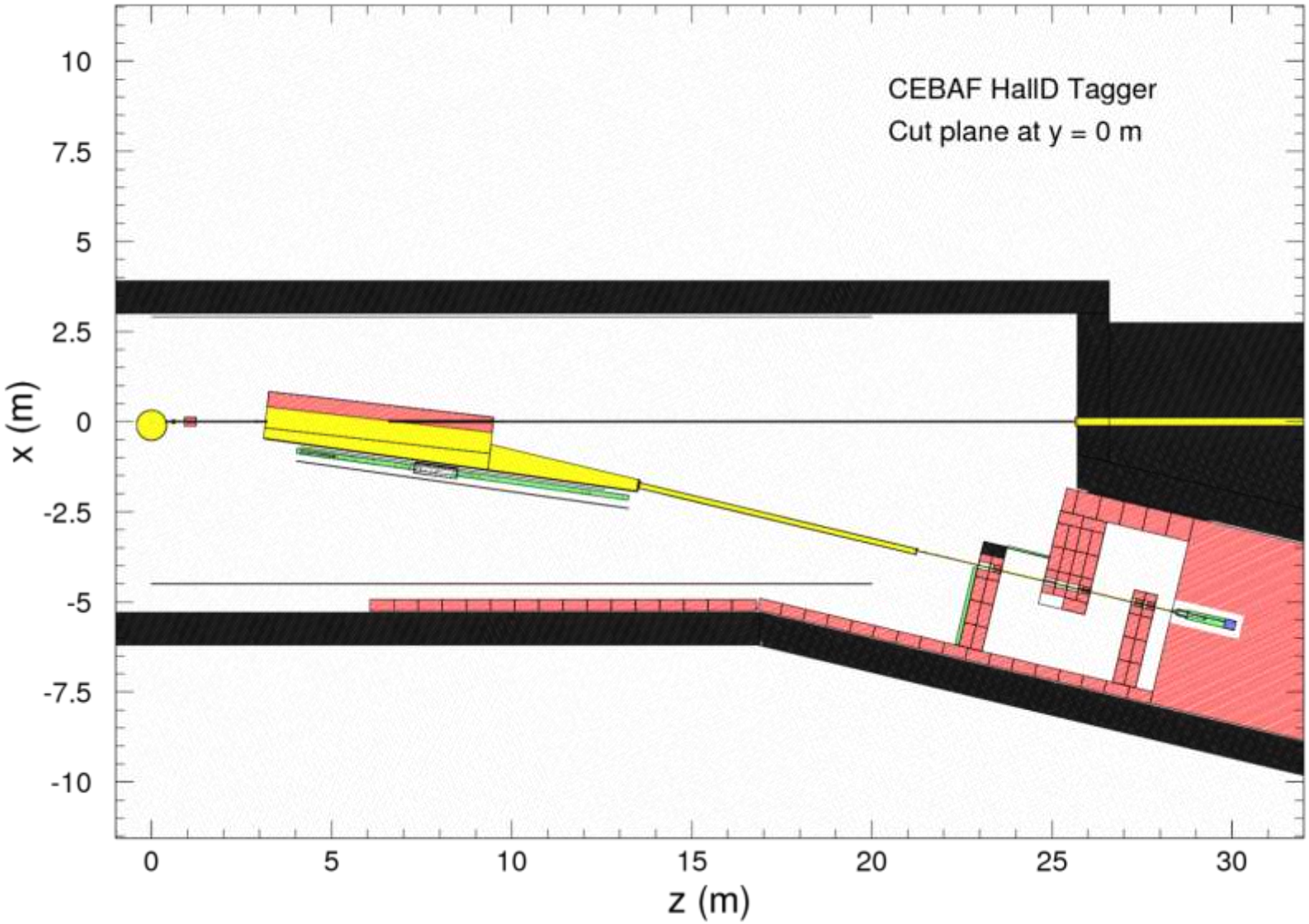
- Intense gamma beam as a pre-requisite for the K^0_L experiments at Hall D
- Available facilities and options at the Tagger Area
- Consequences of intensity increase by “brute force”
- The new “Compact Gamma Source” solution
- Preliminary design parameters and dose rates
- Conclusions

Hall D Tagger Area

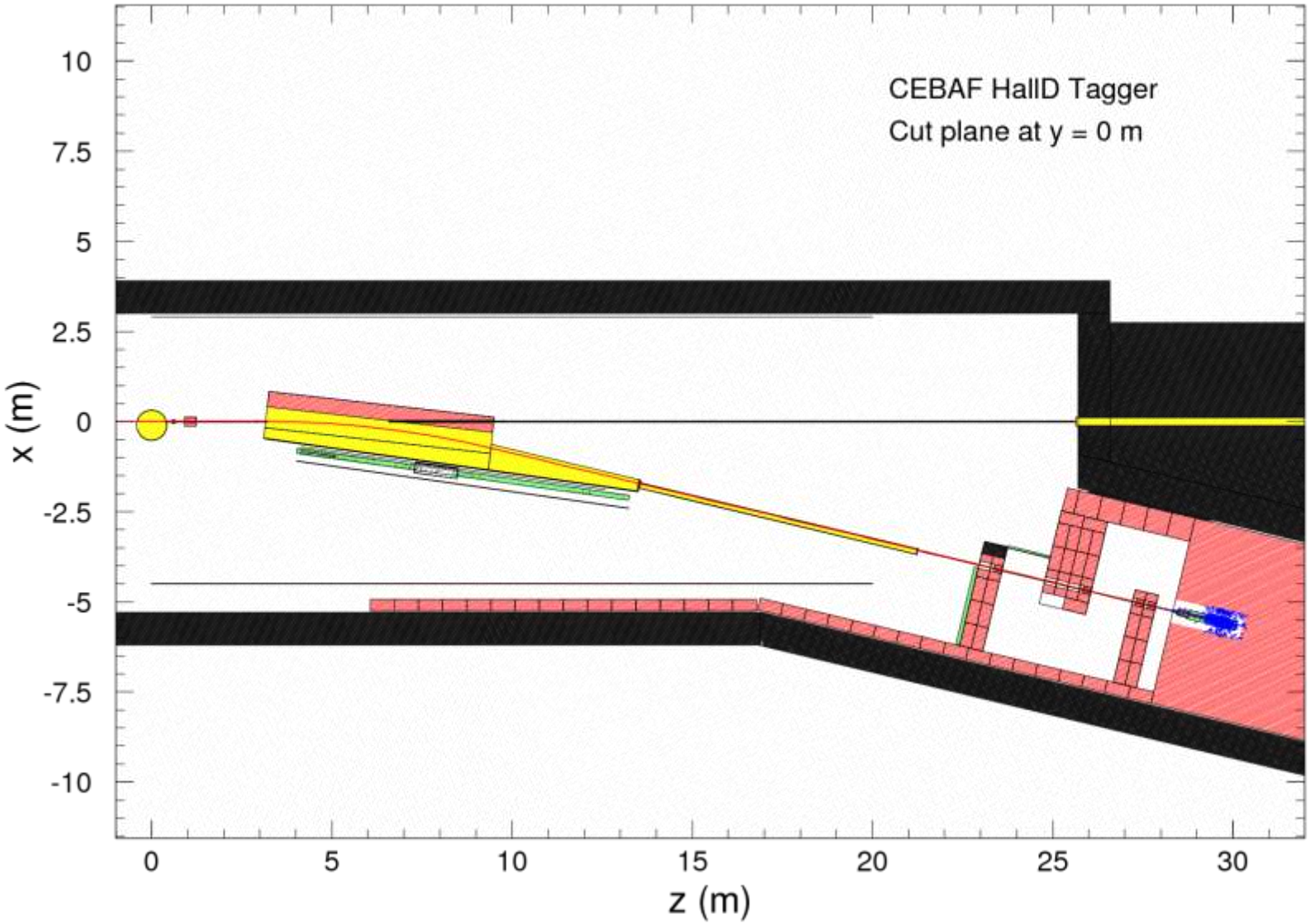


- Design beam current limits: 5 μA (60 kW) max
- Design radiator thickness: ~0.0005 Radiation Lengths max
- Challenge: Increase radiator thickness to 0.05-0.10 R.L.?!

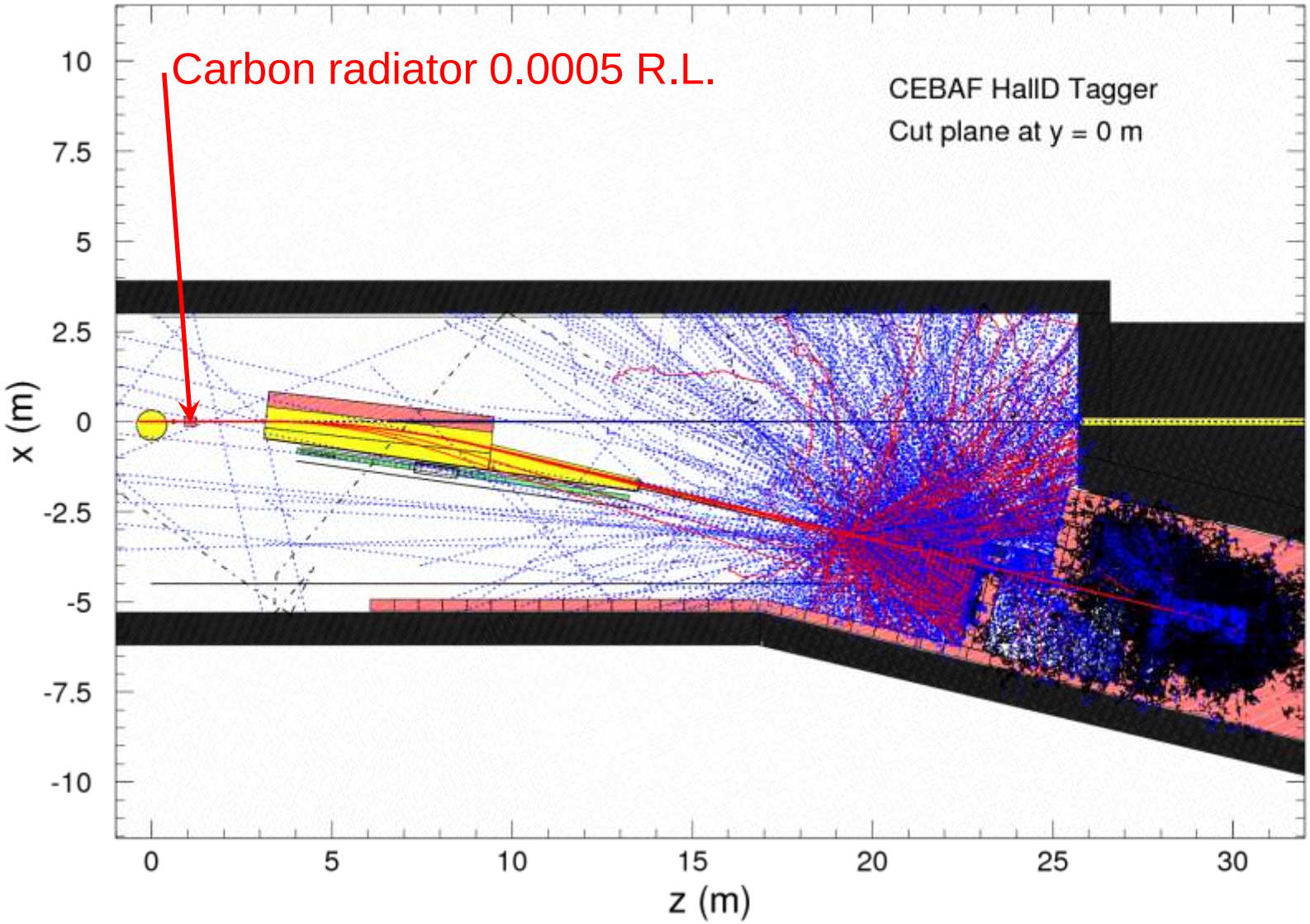
Hall D Tagger Area GEANT3 Model



Tagger Area GEANT3 Model, 1 electron

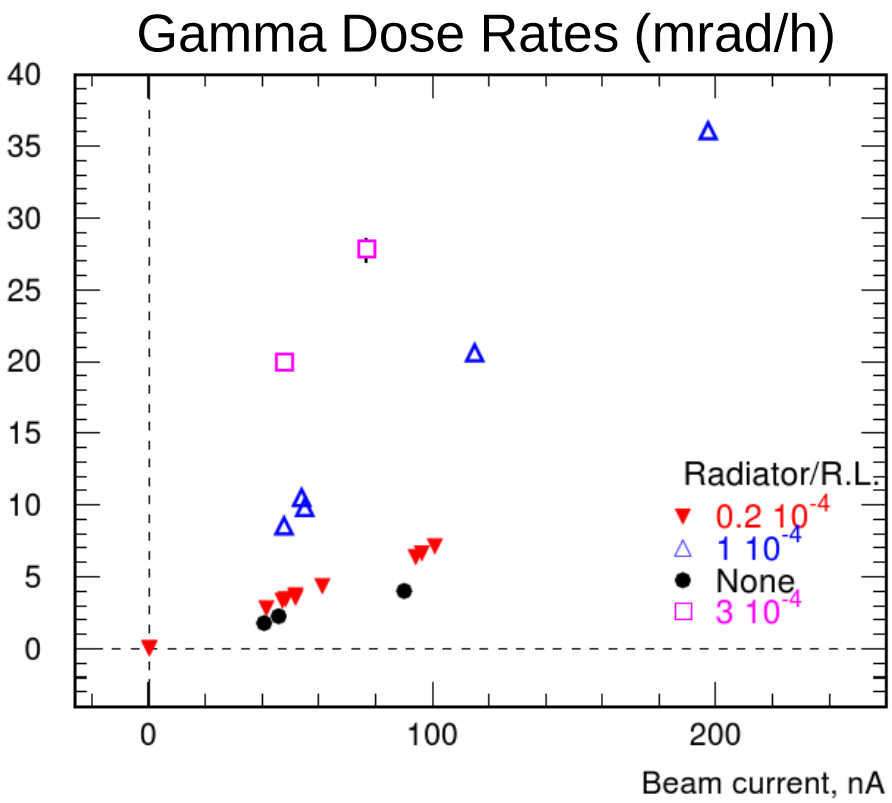


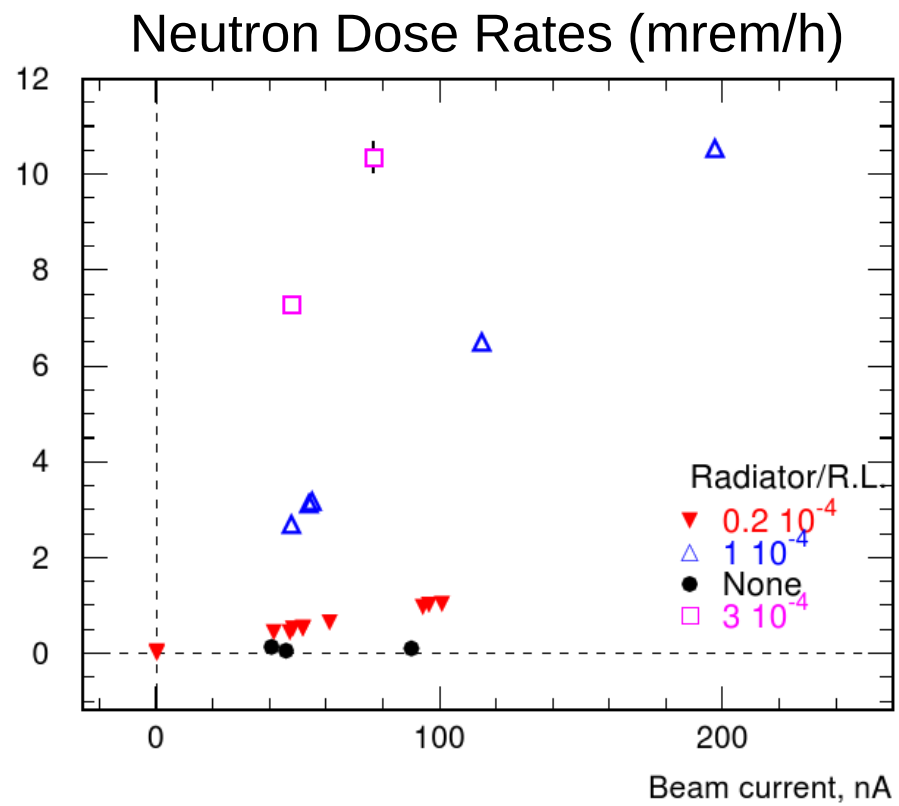
GEANT3 Model, 2000 electrons at 12 GeV



Dose Rates Observed at Tagger Area

Measured dose rates, approx. at the middle of the floor area*





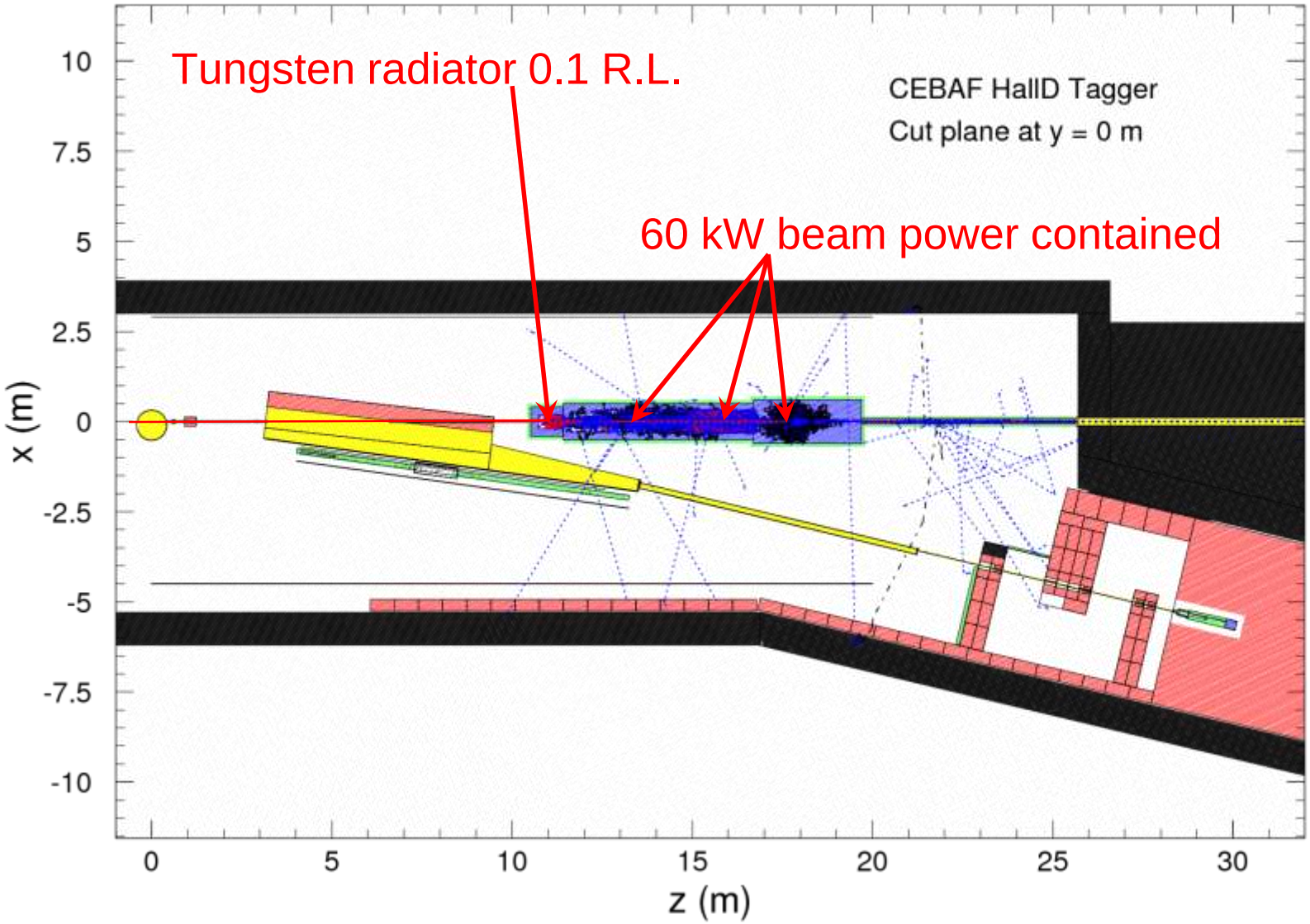
Agreement with calculations is generally good (factor ~2)

*https://logbooks.jlab.org/entry/3308061

“Brute Force” Approach Problematic

- Radiation environment at the Tagger Area measured recently was reasonably close to original calculations
- Simply increasing radiator thickness would make the expected dose rates and activation unacceptable
- Mitigation would include removal of sensitive electronic components, building new temporary shielding walls, disposal of beam line components
- Dose rate and activation evaluation would require complex simulations, quality and reliability control
- Possible, but costly and lots of headaches for all
- Max radiator R.L. may still be below K^0_L beam needs
- We suggest the “Compact Gamma Source” approach

Compact γ Source, 2000 electrons

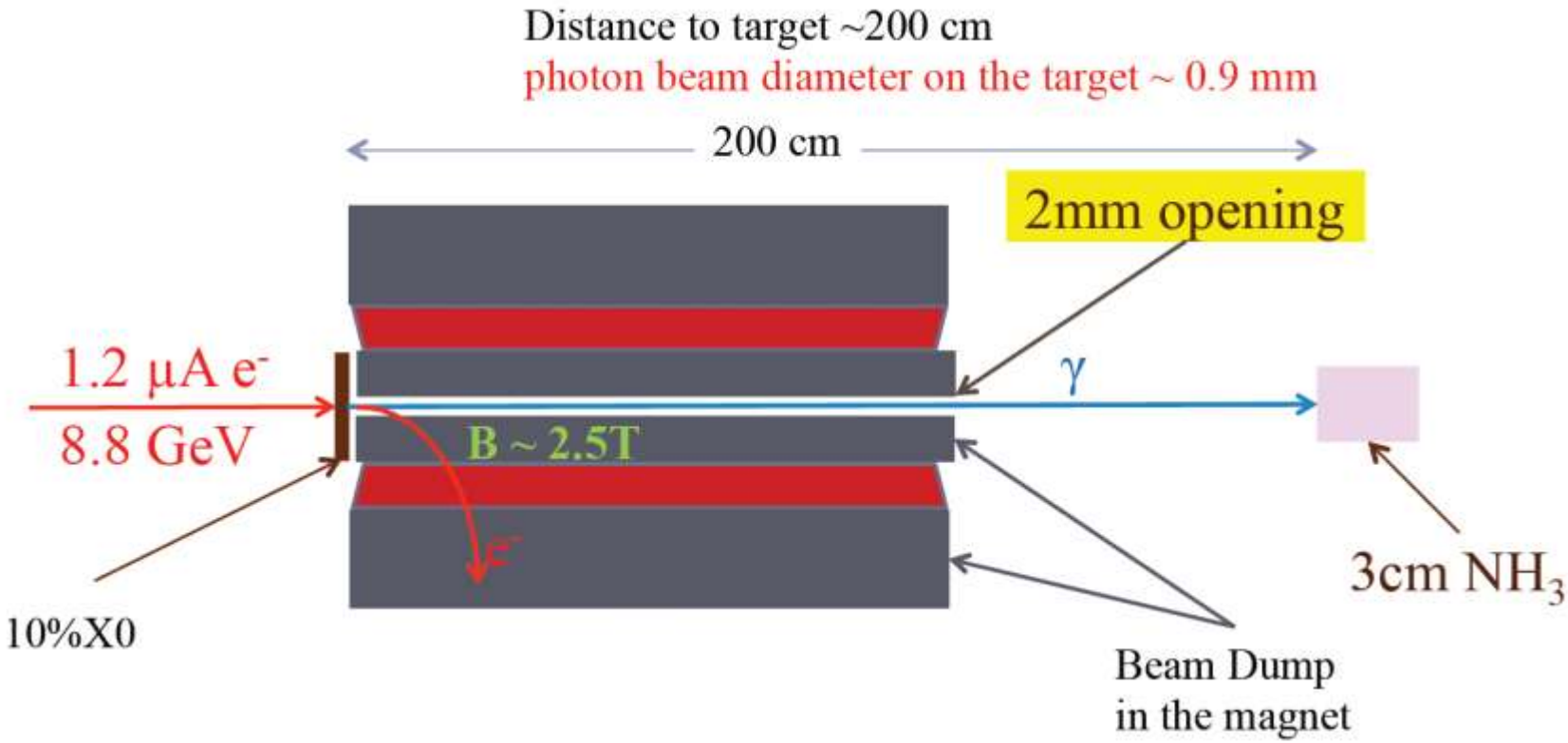


Compact Photon Source Concept

- Strong magnet after radiator deflects exiting electrons
- Long-bore collimator lets photon beam through
- Electron beam dump placed next to the collimator
- Water-cooled Copper core for better heat dissipation
- Hermetic shielding all around and close to the source
- High Z and high density material for bulk shielding
- Borated Poly outer layer for slowing, thermalizing, and absorbing fast neutrons still exiting the bulk shielding
- No need in tagging photons, so the design could be compact, as opposed to the Tagger Magnet concept

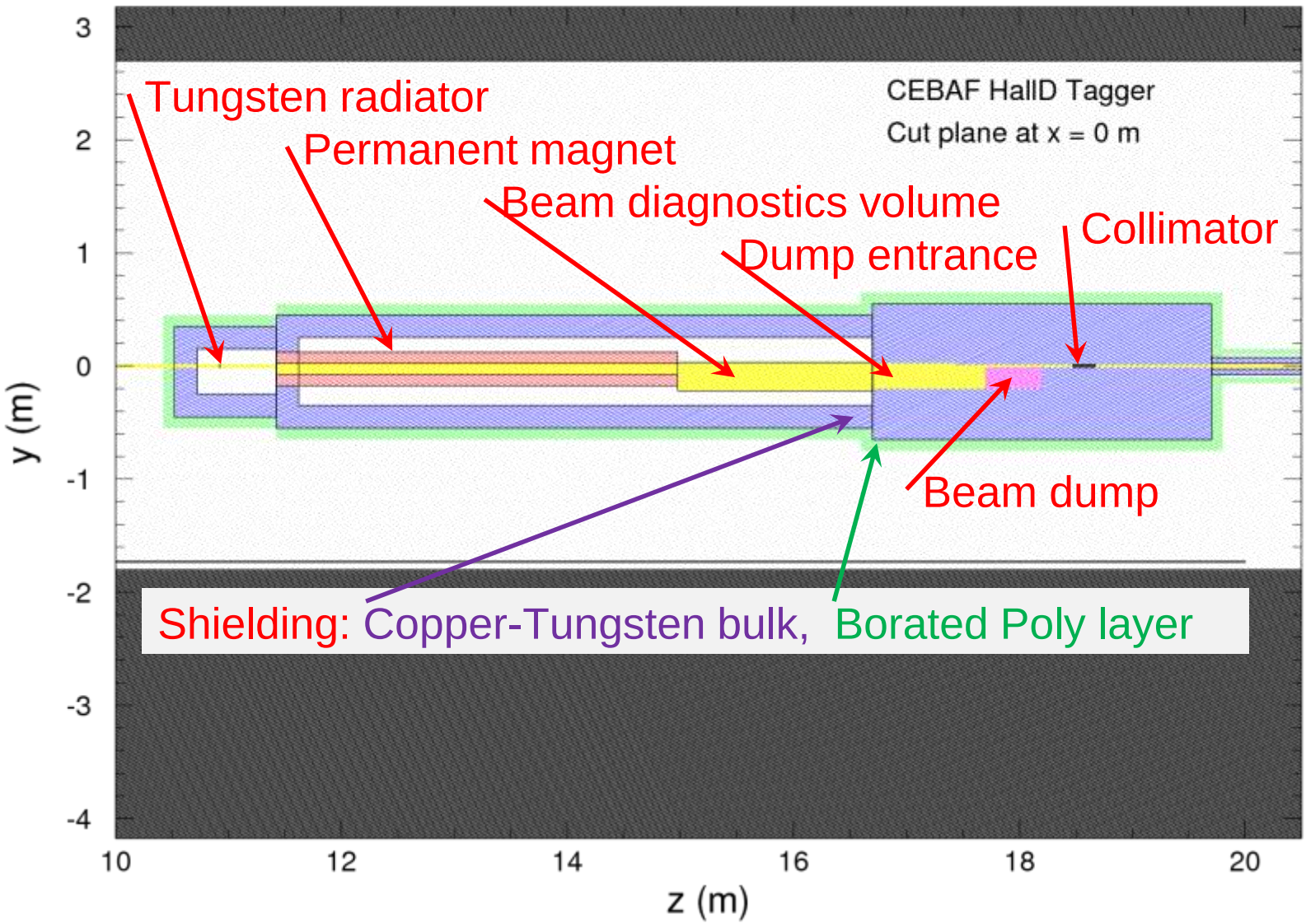
CPS: PR12-15-003 Proposal at JLab

Application example: CPS concept for new experiment in Hall A

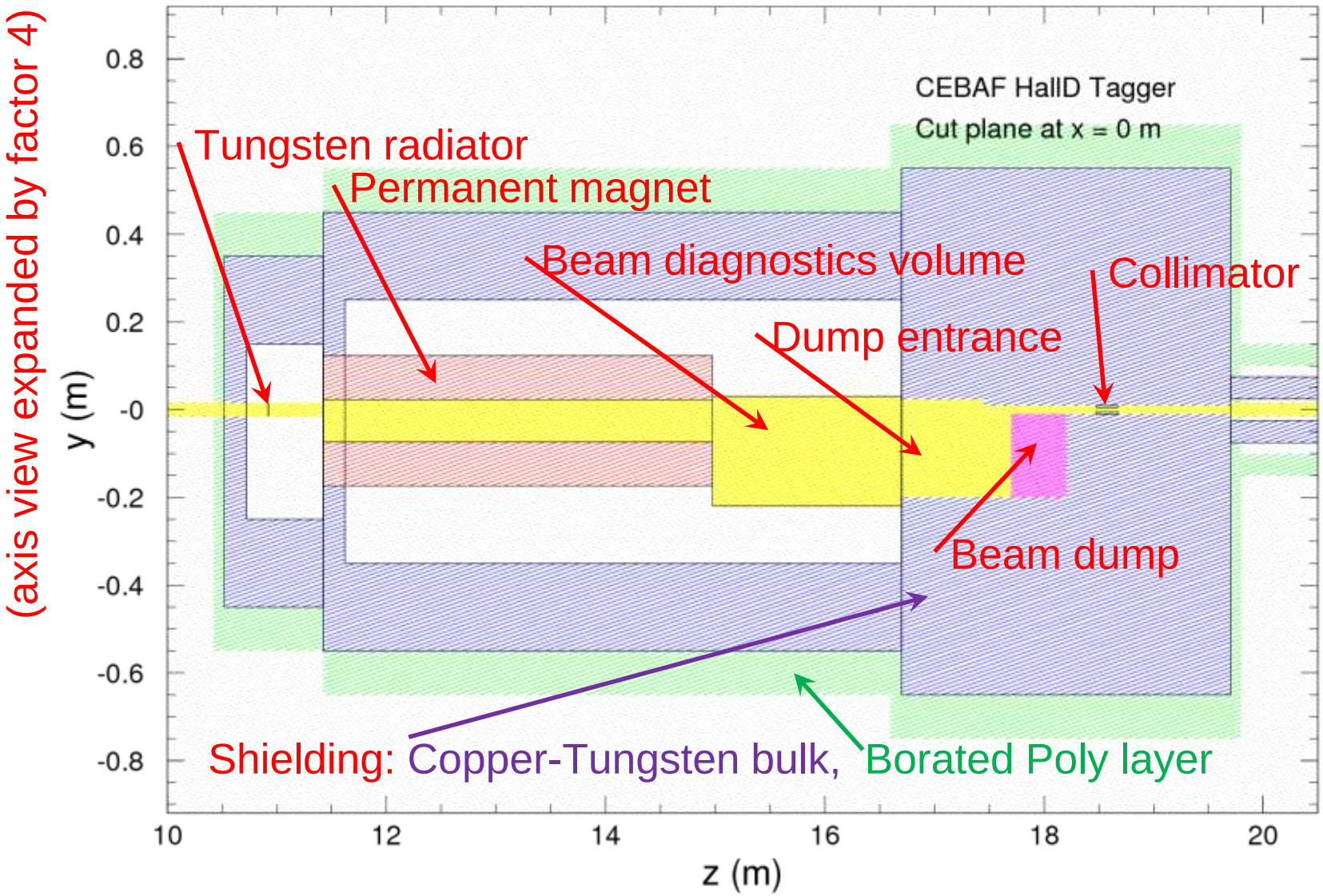


MC simulation and direct calculations show acceptable background rates on SBS and NPS.

CPS at the Hall D Tagger Area

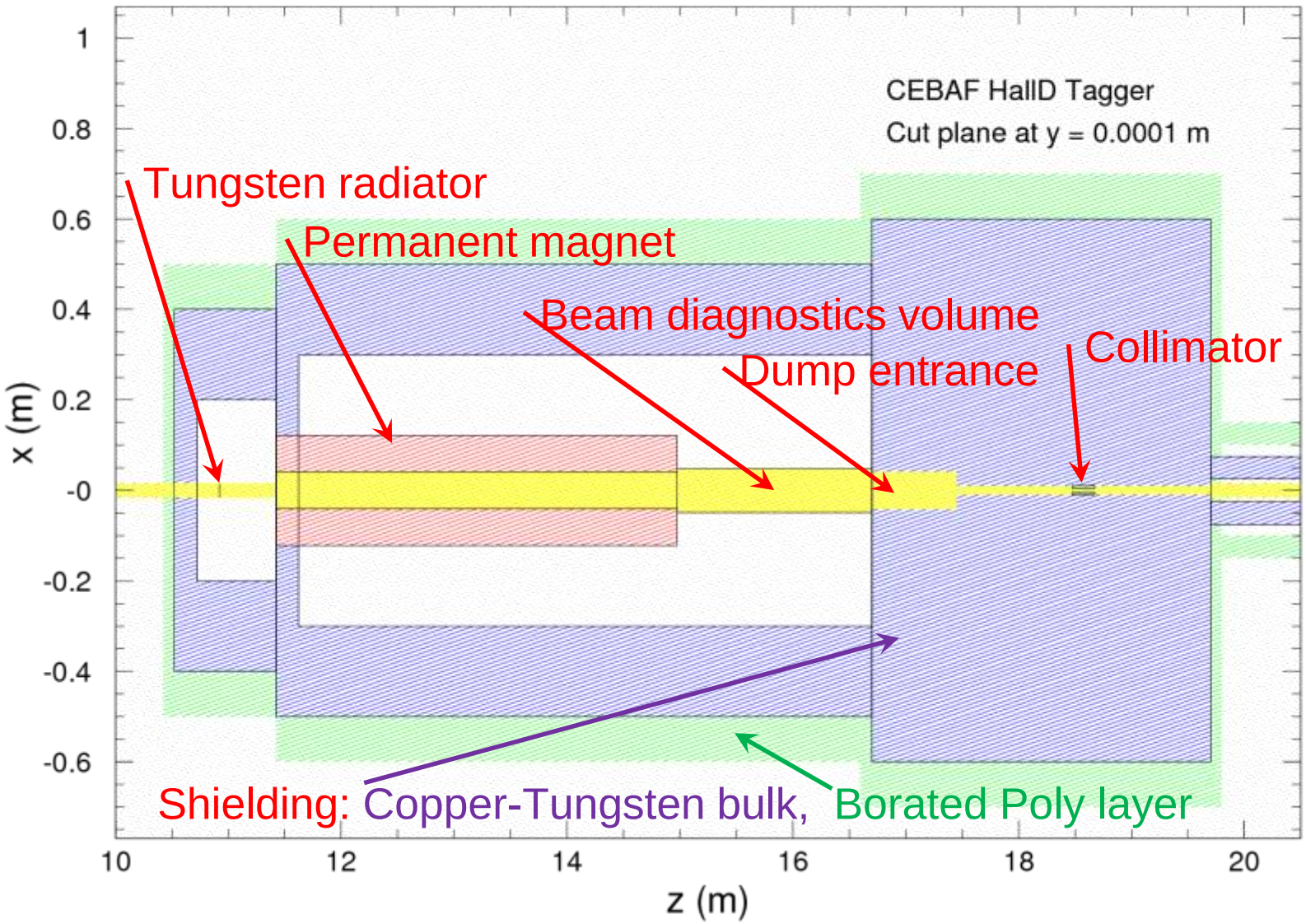


CPS, vertical plane cut



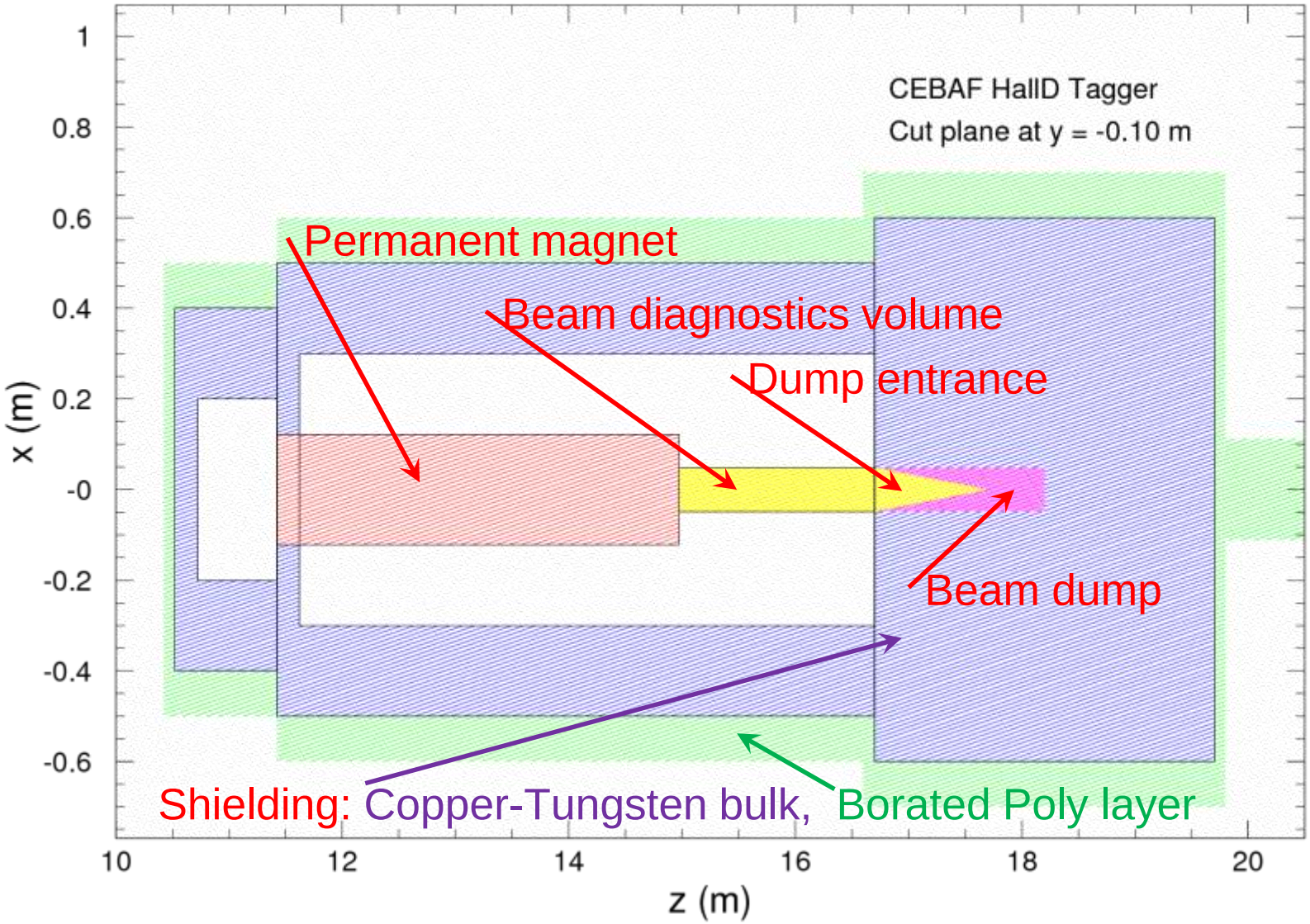
CPS, horizontal plane (1)

(axis view expanded by factor 4)

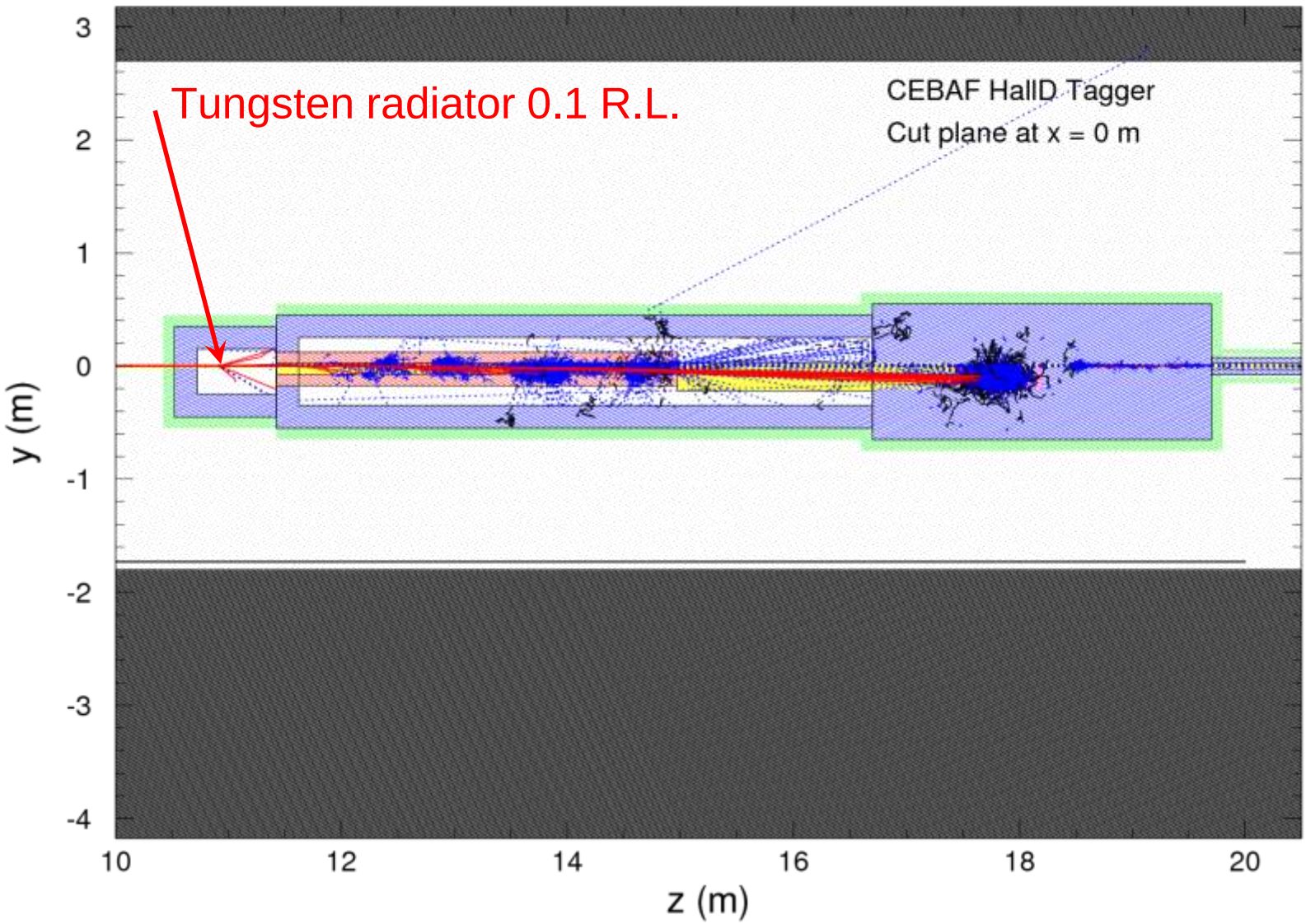


CPS, horizontal plane (2)

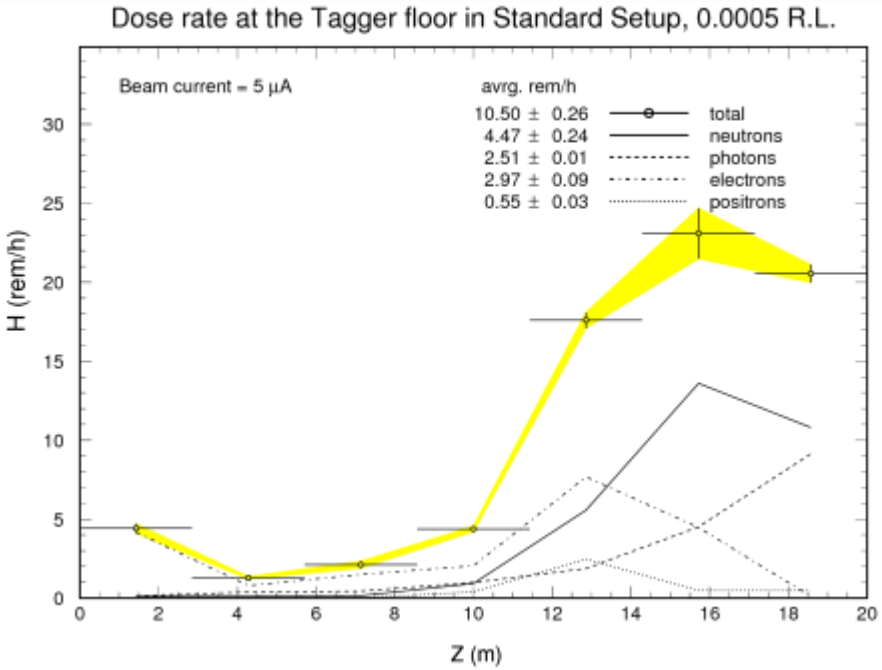
(axis view expanded by factor 4)

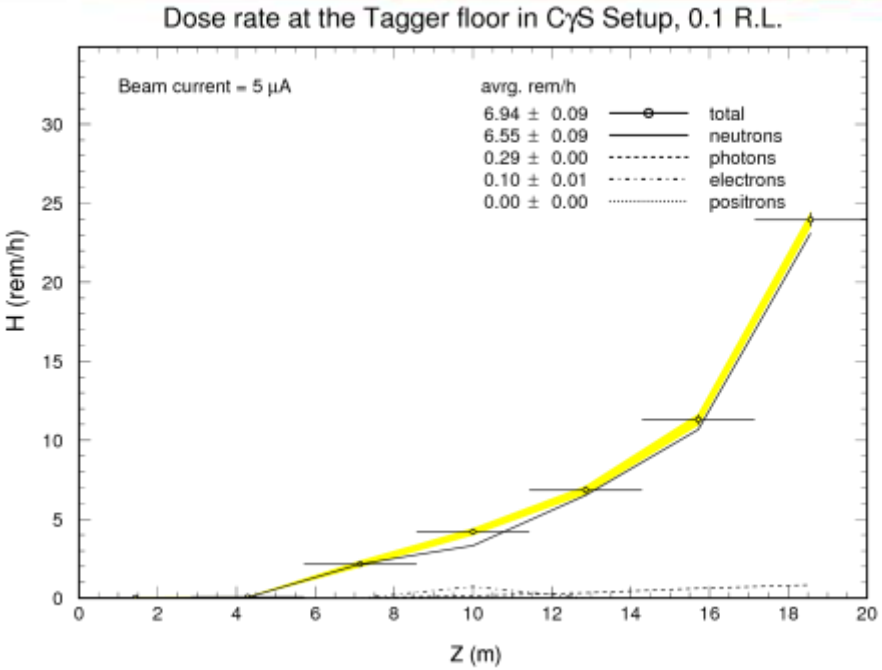


CPS, 50 electrons at 12 GeV



Dose Rate Evaluation and Comparison





- The dose rates in the Tagger vault for the CPS setup with 10% R.L. radiator are close to Standard XD ops
- The radiation spectral composition is different; most of the contribution in the CPS setup is from higher energy neutrons

Dose Rate Evaluation and Comparison

- The plots show comparison of dose rate estimates in the Tagger Area in two conditions: (1) nominal Hall D operation with the standard amorphous radiator at 0.0005 R.L., - with (2) radiator at 0.1 R.L., used as part of the Compact Photon Source setup.
- The comparison indicates that at equal beam currents, gamma radiation dose rates are much smaller for the CPS run (~order of magnitude), and neutron dose rates in the area are comparable.
- Design and shielding optimization may improve the comparison further in favor of the CPS solution

Implementation Advantages

- Most of all present Tagger Area equipment stays in place; CPS is assembled around the gamma line
- Re-use of the available permanent magnet (pending thermal engineering analysis, <~1.5 kW to dissipate)
- Re-use of the dump cooling system (max 60 kW)
- No extra prompt irradiation or extra beam line activation for existing structures in the area
- No problem switching between the two modes of Hall D operations: low intensity tagged photon beam, and high intensity photon beam from CPS
- Disassembly and decommissioning could be postponed until radioactive isotopes decay inside to manageable levels (self-shielded in place)

Detailed Design and Cost Estimate

- We do not see show-stoppers for implementation of the CPS concept in the experiment.
- 60 kW Copper-core dump will have characteristics close to the one installed already
- To make long and narrow photon beam collimation we propose to build the core using two symmetric flat plates, left and right, and make matching grooves in them for the beam entry cones, beam line, and the aperture collimator
- Cost would include detailed iterative modeling and simulation to optimize operation parameters, design, engineering and production, plus the choice and cost of bulk shielding material
- Crude cost expectation: within $0.5M

Conclusions

- Compared to the alternative, the proposed CPS solution presents several advantages, including much less disturbance of the available infrastructure at the Tagger Area, and better flexibility in achieving high-intensity photon beam delivery to the Hall D
- The proposed CPS solution will satisfy proposed K^0_L beam production parameters
- We do not envision big technical or organizational difficulties in the implementation of the conceptual design

Extras