Compact Photon Source
Toy Model Studies

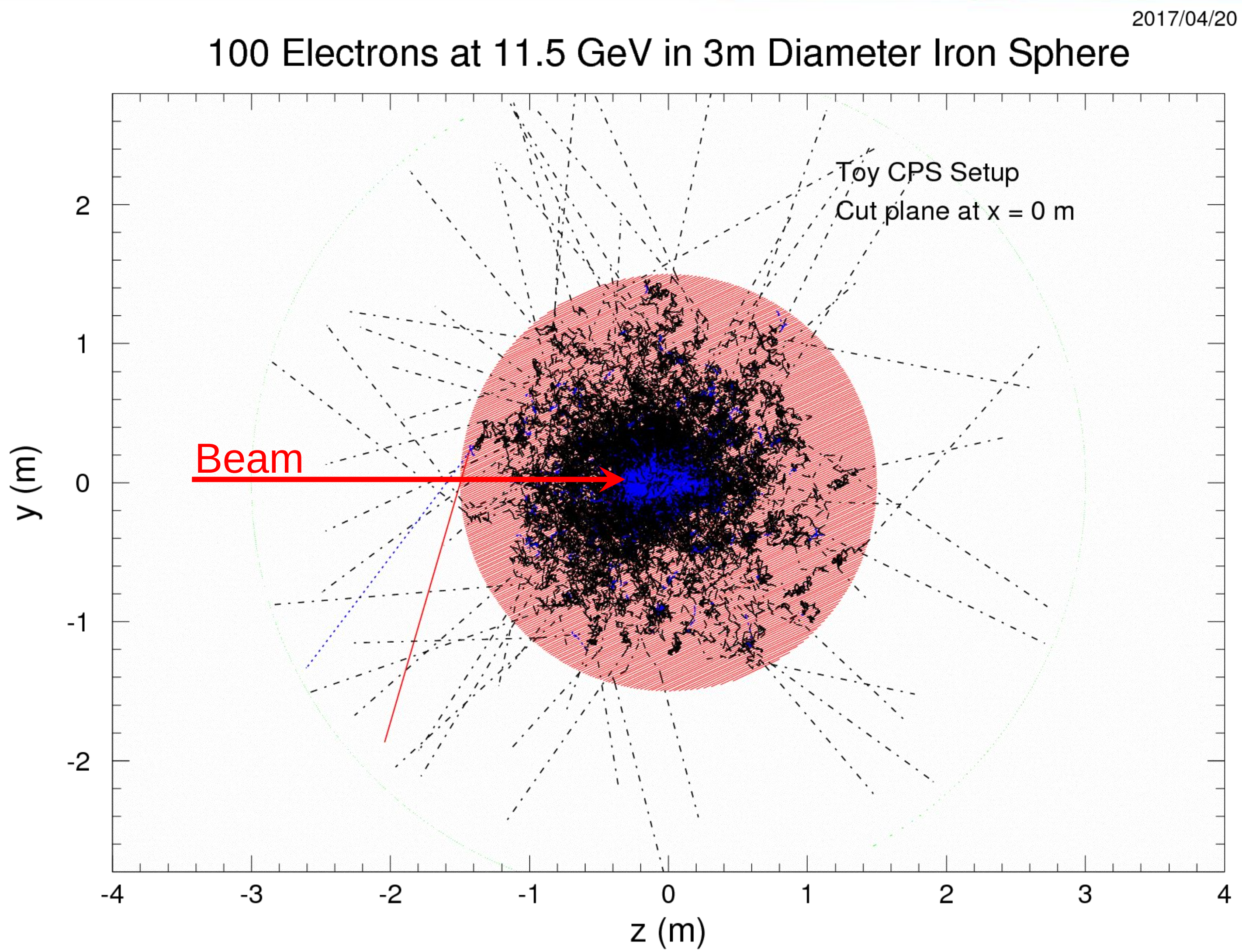
Pavel Degtiarenko
Radiation Physics Group at RadCon

April, 2017

Feasibility of the CPS

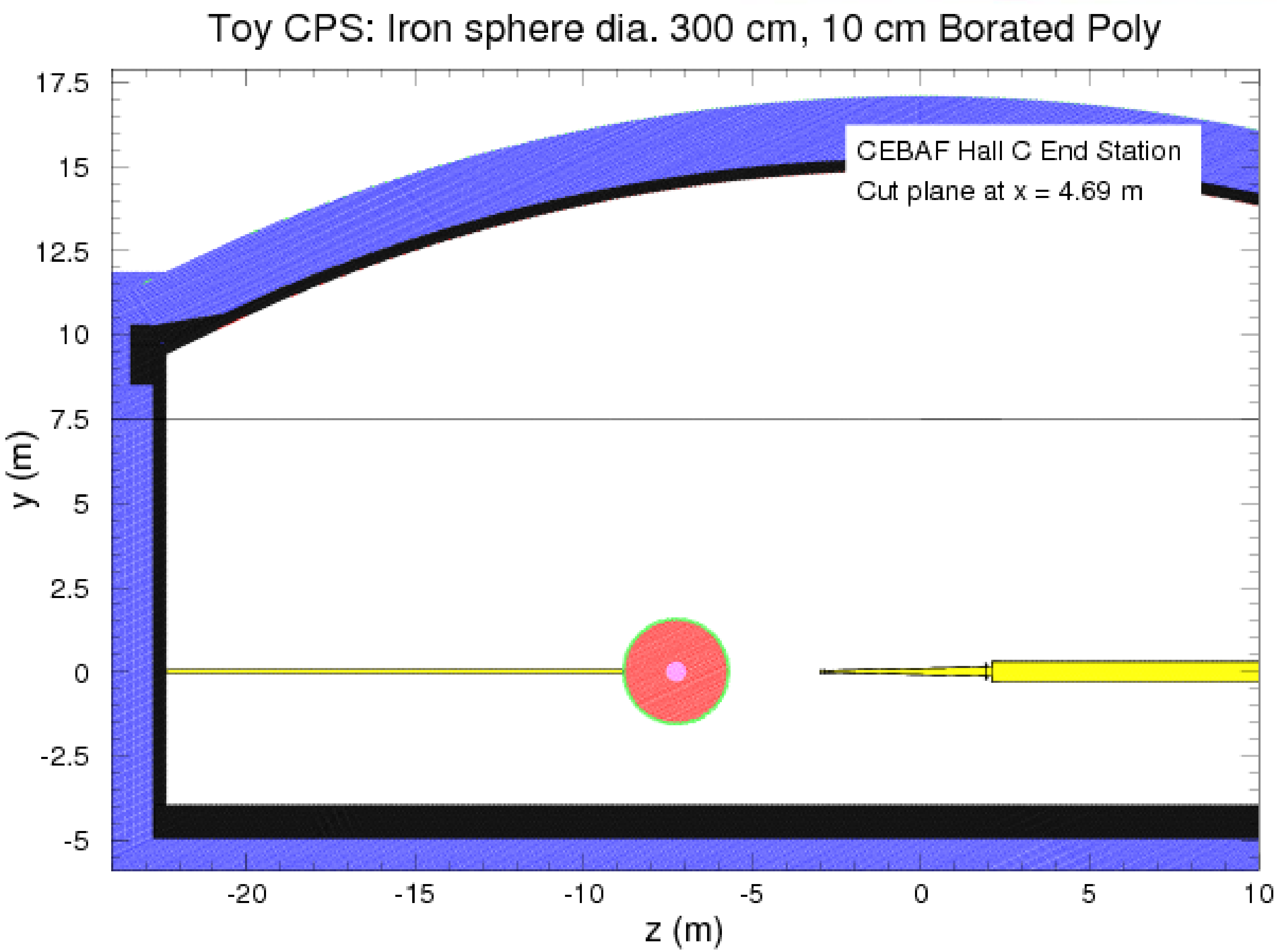
- Compact Photon Source (CPS) setup: a possibility to produce powerful high energy photon beams locally in Halls A & C
  - Beam energies up to 11.5 GeV
  - Up to 30 kW electron beams
  - Photon source as close to the target as reasonably possible
- Main task for the studies: evaluate feasibility of the CPS solution
  - Feasibility parameters
    - Prompt dose rates in the Hall
    - Activation dose rates around the setup after the runs
    - Prompt dose rates at the CEBAF boundary, Radiation Budget
  - Cross-comparison of the simulation models
    - Old GEANT3/DINREG – prompt dose rates (Hall, site boundary)
    - FLUKA – dose rates and activation, site boundary not ready yet
    - MCNPX – prompt dose rates in the Hall
    - Geant4 – prompt dose rates (Hall, site boundary)

CPS Toy Model

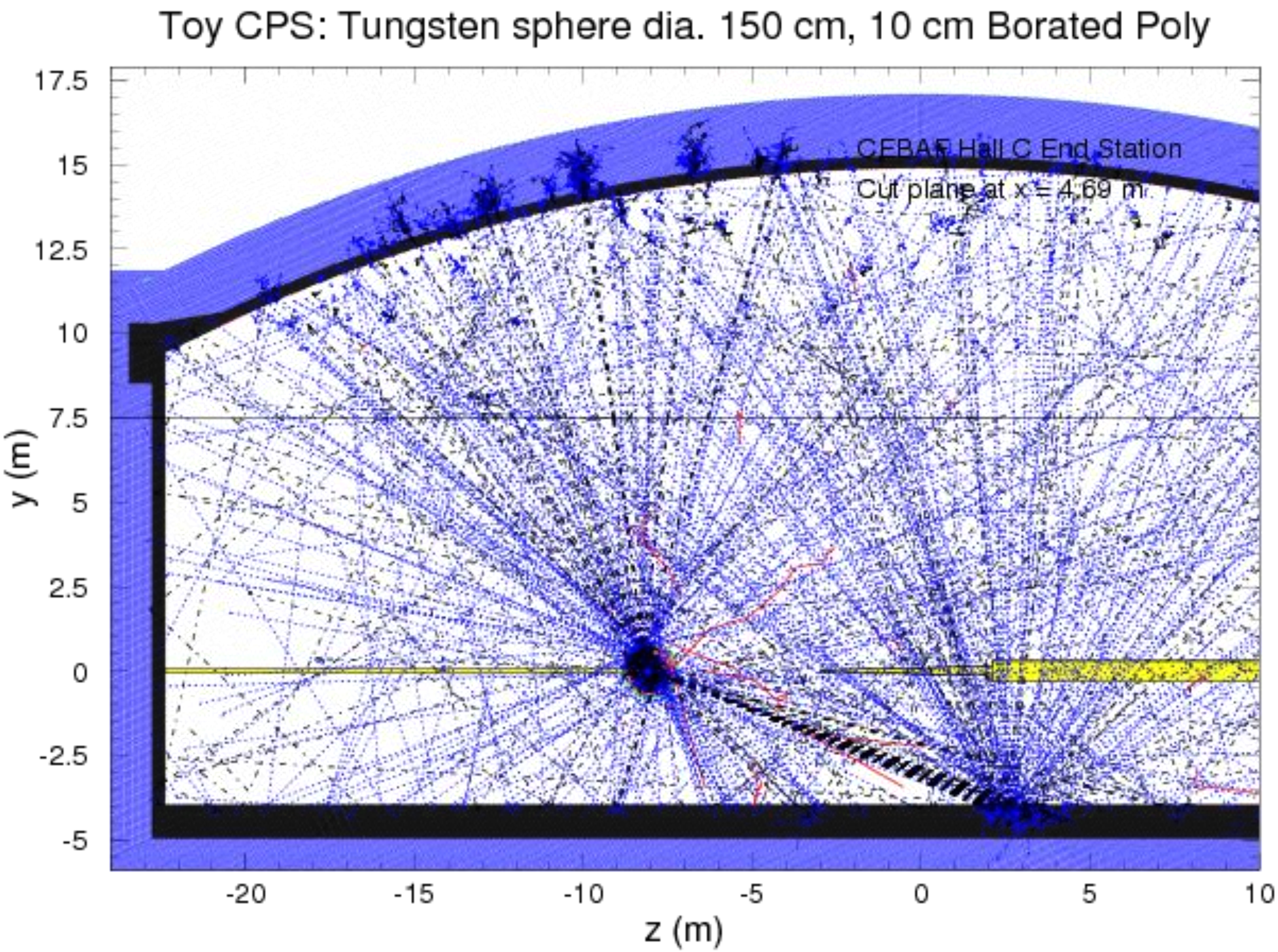


Dose rates scored at a distance of 3 meters from the center

CPS Toy Model in Hall C



CPS Toy Model in Hall C



First Results

Setup \ Score	Only the metal sphere shielding Dose rates in rem/h at 90 degrees 3 m from the beam	Including 10 cm outer Borated Poly layer Dose rates in rem/h at 90 degrees 3 m from the beam	Dose rate estimate in microrem/h RBM-3 Boundary position
Iron 7.8 g/cm^3, 300 cm dia sphere 11.5 GeV, 30 kW beam starting inside, 30 cm upstream from the center	neutrons: 146.0 gamma: 0.44 total: 146.4	neutrons: 0.8 gamma: 2.8 total: 3.6	neutrons: 0.19 gamma: 0.05 total: 0.24
Tungsten 15.6 g/cm^3, 150 cm dia sphere 11.5 GeV, 30 kW beam starting inside, 15 cm upstream from the center	neutrons: 13.0 gamma: 0.06 total: 13.1	neutrons: 2.7 gamma: 0.003 total: 2.7	neutrons: 1.9 gamma: 0.5 total: 2.4

First Model Comparison

Setup \ Model	GEANT3/DINREG	FLUKA by P.D.	MCNP6
	Dose rates in rem/h at 90 degrees, 3 m from the beam	Dose rates in rem/h at 90 degrees, 3 m from the beam	Dose rates in rem/h at 90 degrees, 3 m from the beam
Iron 7.8 g/cm^3, 300 cm dia sphere 11.5 GeV, 30 kW beam starting inside, 30 cm upstream from the center	neutrons: 146.0 gamma: 0.44 total: 146.4	neutrons: 9.5 gamma: – total: 9.5	neutrons: 11.5 gamma: 0.16 total: 11.7
Tungsten 15.6 g/cm^3, 150 cm dia sphere 11.5 GeV, 30 kW beam starting inside, 15 cm upstream from the center	neutrons: 13.0 gamma: 0.06 total: 13.1	neutrons: 8.2 gamma: – total: 8.2	neutrons: 4.4 gamma: 0.05 total: 4.5

First Conclusions

- The reasonably sized compact spherical shielding configuration can be used in the experimental halls at JLab to contain 30 kW electron beams without producing unacceptable radiation levels inside and outside.
- Different simulation models show agreement within about a factor of 15 for the iron shielding material, and within about a factor of 3 for tungsten.
- The estimates for the dose rates at the site boundary show the expected levels to be within the design limits. Only one model is available for that presently (GEANT3/DINREG). It has been tested for years and it did produce conservative predictions when compared to measurements (up to a factor 2-3 differences).
- The present differences between the simulation models are not surprising (with one exception with the case of iron shielding in GEANT3). Different Physics models, sets of the cross sections, code implementations, model setups, etc.
- Thank you to all participants! It was not a test – it was for real!

Looking Forward

- Real design of the CPS would have to combine engineering efforts in building a very compact installation embedding the radiator assembly, a magnet, the channel for exiting photons with the collimation system, the channel for the spent electron beam, a cooled beam dump, and the shielding assembly hermetically covering all of the above, preferably using high-Z and high density materials to save the space and weight – with the efforts of radiation physicists trying to evaluate different aspects of the generated radiation fields.
- The efforts will necessarily have to be iterative.
- Before proceeding, the radiation physicists need to get general understanding of the simulation differences, and select suitable model(s).
- It would be very desirable to have a series of benchmarking measurements done at JLab, in conditions close to real.
- The CPS for the K0 proposal in Hall D has somewhat easier requirements, but it is intended for work at 60 kW at least, so there will be a common interest in the methods of minimizing the prompt dose rates, radiator, magnet, and beam dump designs, etc.