# The Hermetic Compact Photon Source (HCPS)

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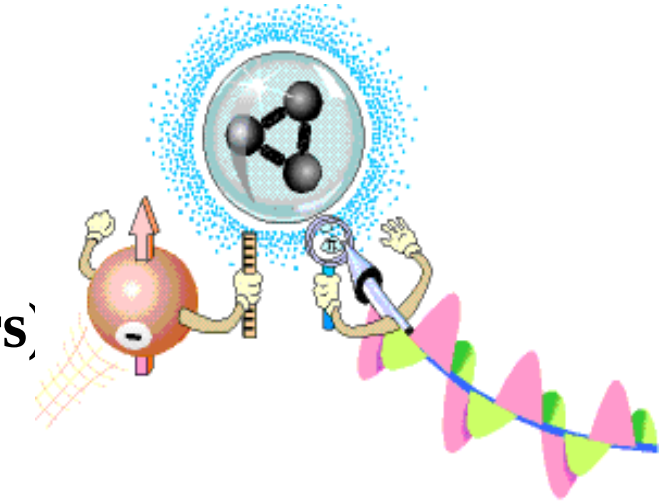
**Outline:**

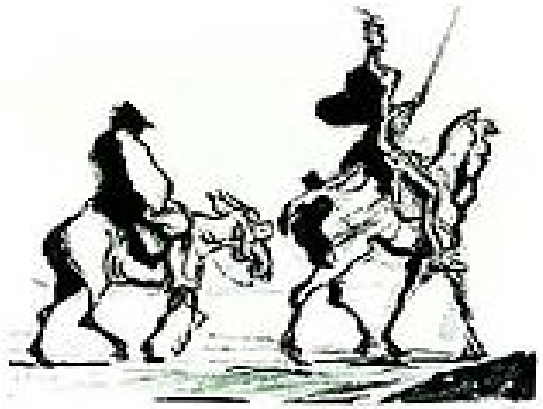
- **(skip) Why photoproduction reactions?**
- **Inventory of photon source options**
- **HCPS design and projected performance**
- **Quo Vadis?**

# Photon Source Options…

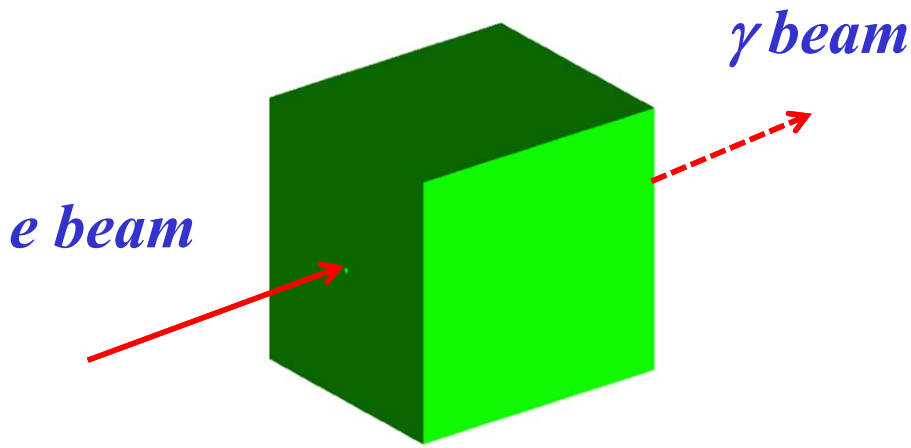


- Natural sources (radioisotopes, cosmic)
- Low intensity options (inverse CS, taggers)
- Bremsstrahlung sources
  - synchrotrons
  - pure (~$10^{10}$ γ/s)
  - mixed beam (~$10^{13}$ γ/s)

- Q: Can one improve on the above?



# Hermetic Compact Photon Source Idea



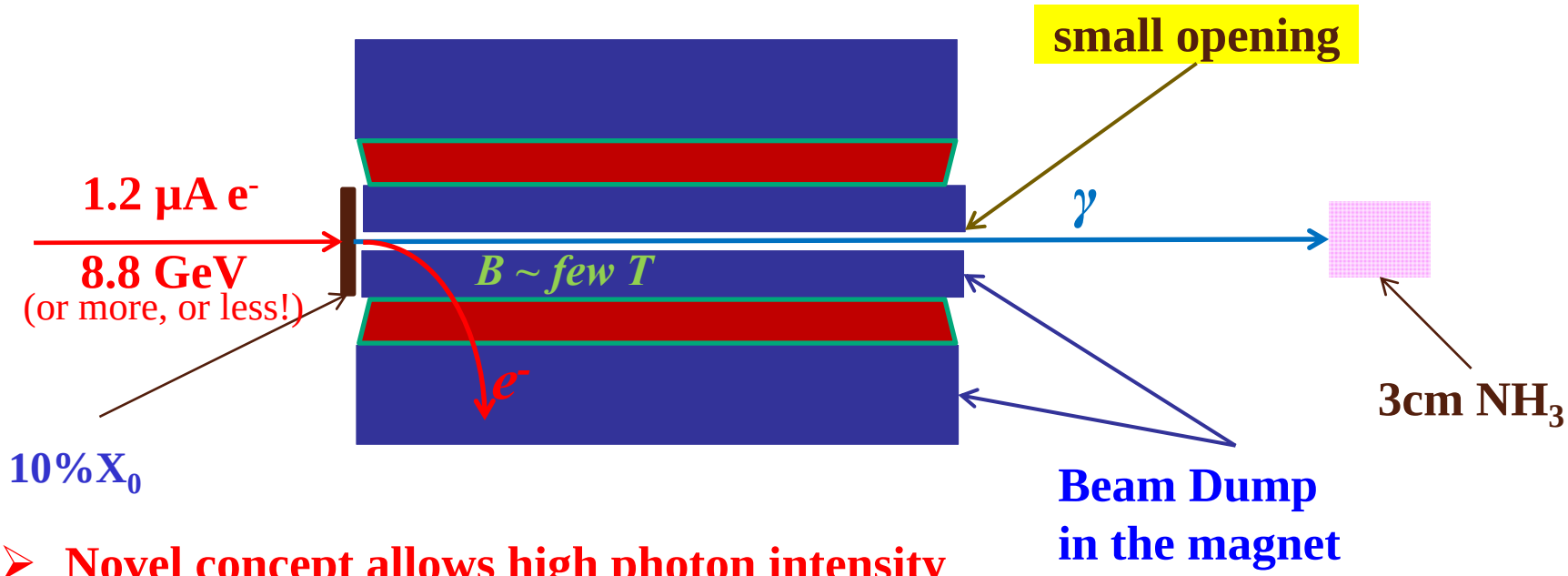

Incident beam has small transverse size
Outgoing photon beam has m/E angular size

} Source could be hermetic!!!

- However, where to send the used electron beam?
- Traditional approach is based on using magnets to get e to a beam dump =>
- large openings => no hermeticity and large radiator-target distance
- Our new approach is using the magnet as a dump => The problem is solved!

# HCPS

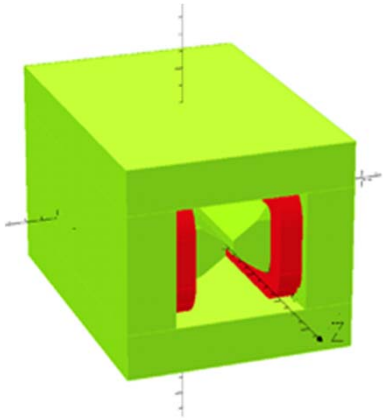
- For the typical JLab application… $\vec{\gamma} + \vec{p} \rightarrow \gamma + p$
- Distance to target ~2 m
- photon beam diameter on the target ~ 0.9 mm!

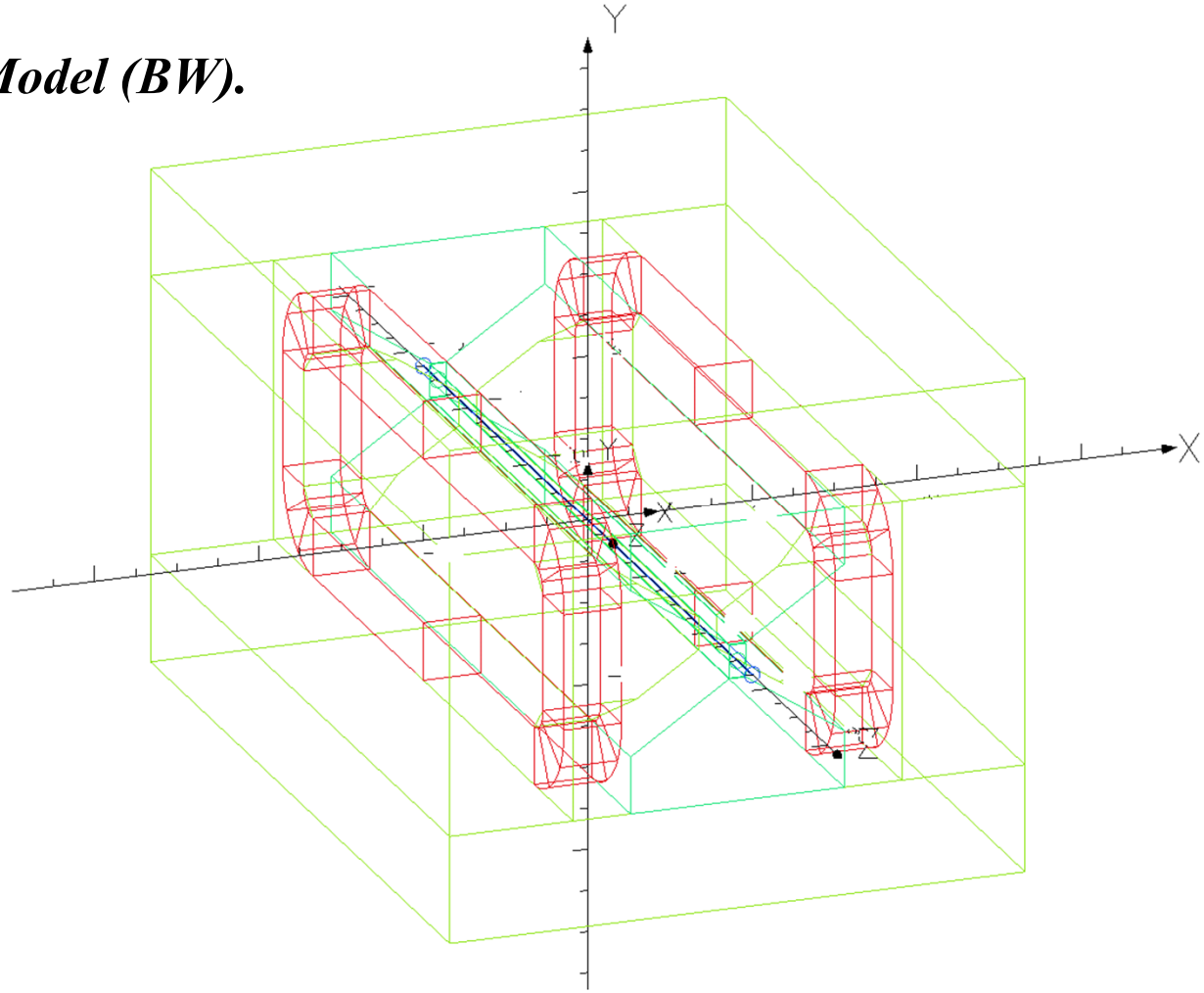



- Novel concept allows high photon intensity and low radiation
- photon flux: $10^{11} – 10^{12}$ γ/s (for JLab energies)

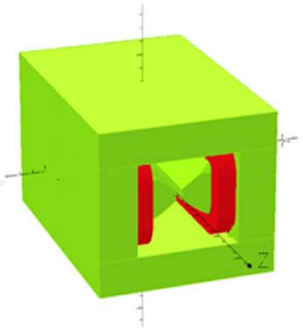
# HCPS Details (I)

- *In the beginning…*
- *There was a TOSCA Model (BW).*

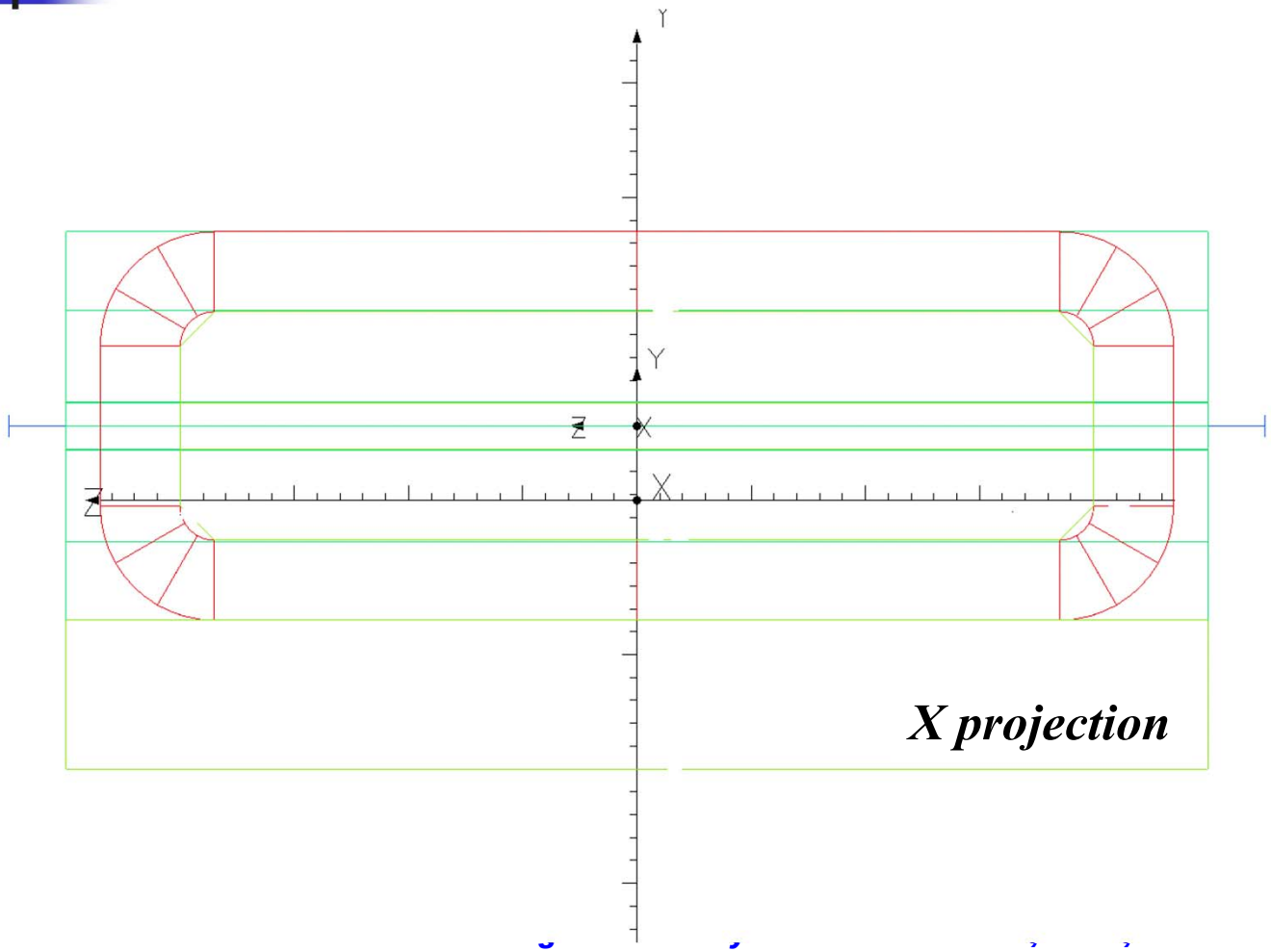




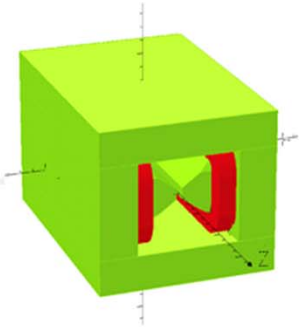
# HCPS Details (II)



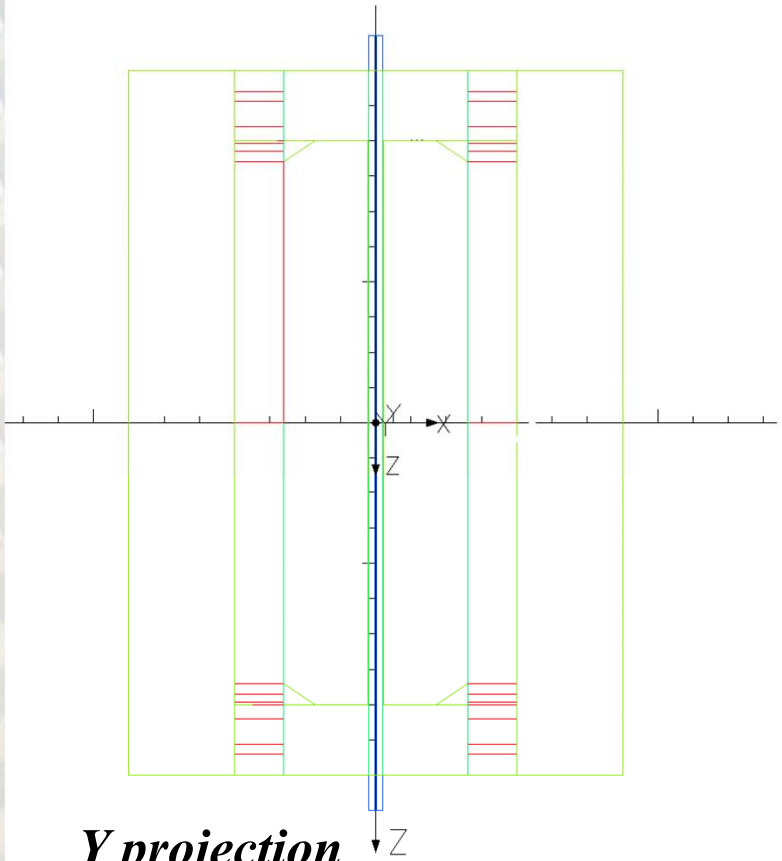
*With projections and everything else…*



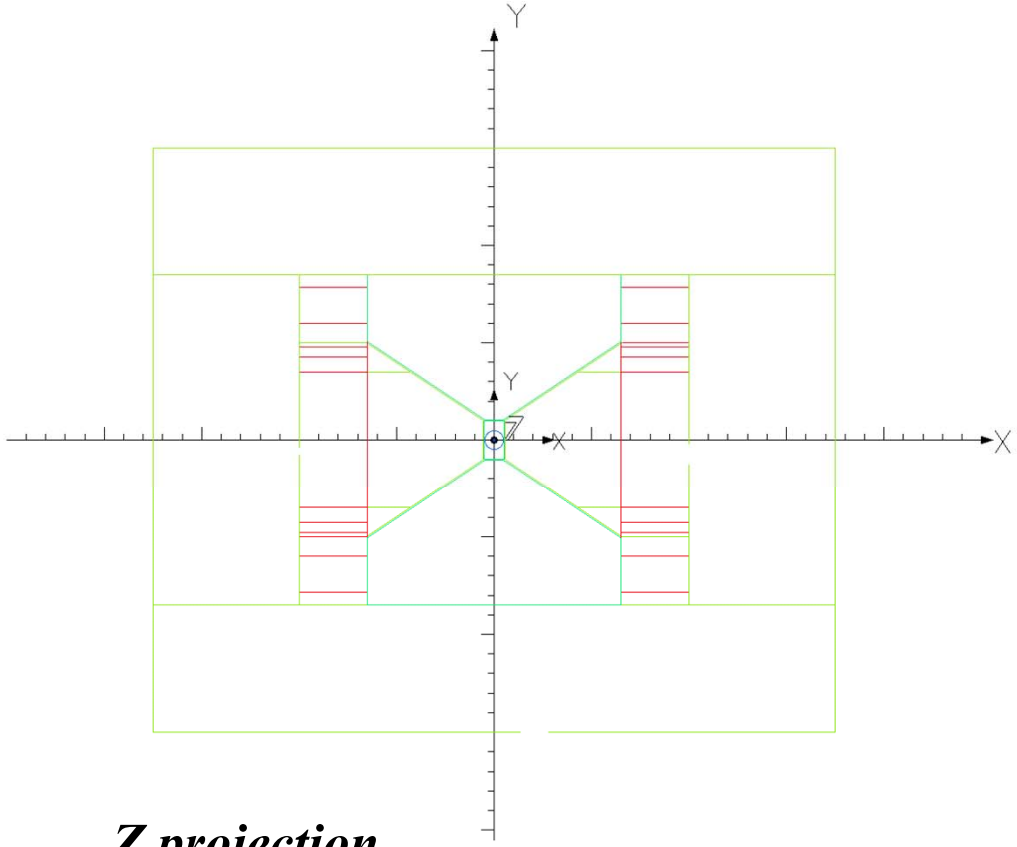
# HCPS Details (III)



*With projections and everything else…*



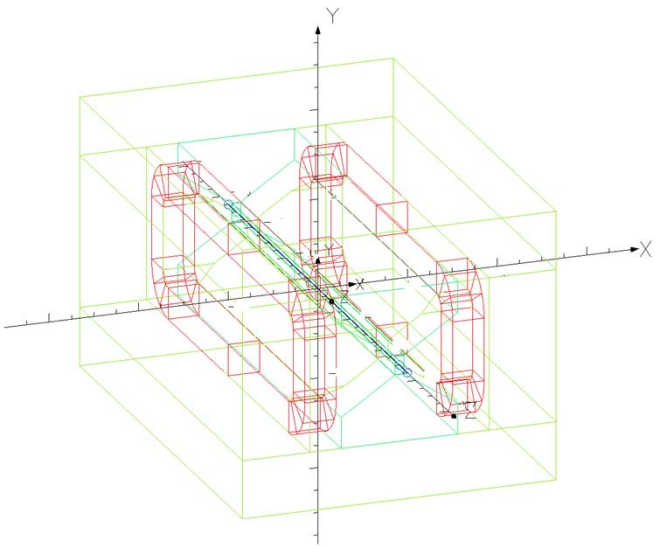

*Y projection*




*Z projection*

# HCPS Details (IV)

- *…and the Model was good!*
- *It also provided a field map to be used in further demiurgic endeavors.*




**x y z Bx By Bz**

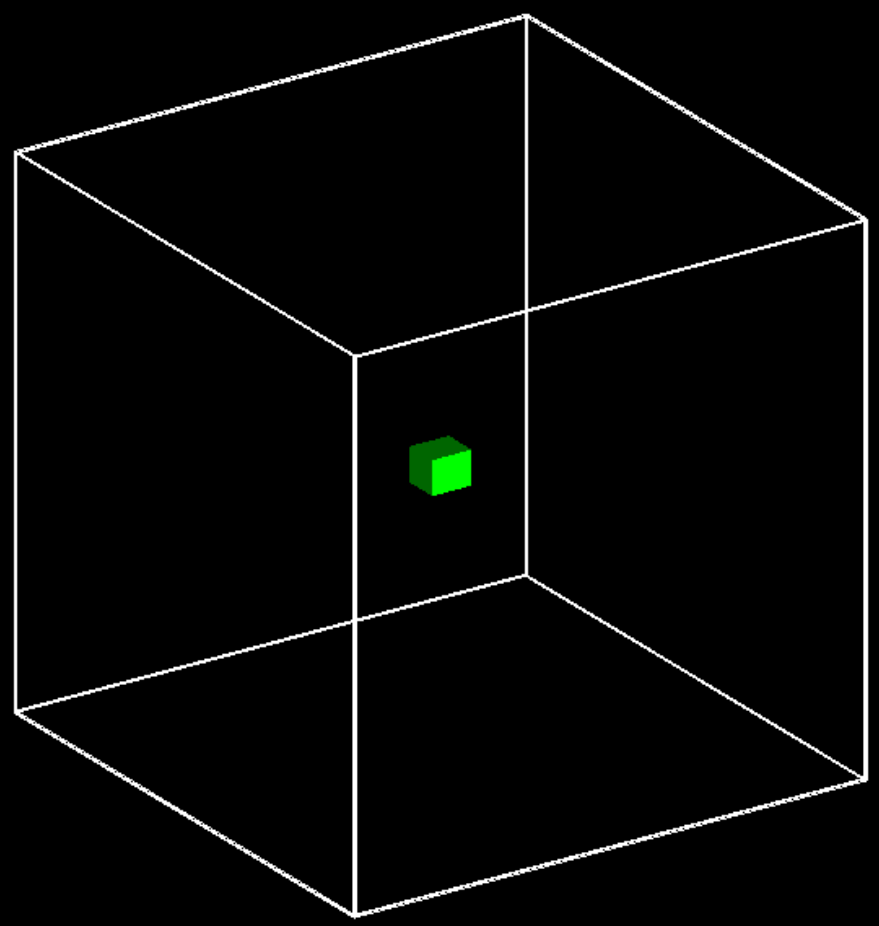
**(lots of ….)**

| | | | | | |
|---|---|---|---|---|---|
| -16.00 | 10.00 | -28.00 | -20207.0815848 | -2891.28109803 | 2077.22205257 |
| -16.00 | 10.00 | -26.00 | -20112.0456011 | -3001.31434030 | 1871.32171785 |
| -16.00 | 10.00 | -24.00 | -20016.6541207 | -3163.17100252 | 1732.77015978 |
| -16.00 | 10.00 | -22.00 | -20003.6508044 | -2938.39724943 | 1467.86133775 |
| -16.00 | 10.00 | -20.00 | -19919.7691780 | -3035.32479900 | 1475.28504489 |
| -16.00 | 10.00 | -18.00 | -19859.7660622 | -3006.62291382 | 1328.28272474 |
| -16.00 | 10.00 | -16.00 | -19808.5031789 | -2947.03168534 | 1028.36804096 |
| -16.00 | 10.00 | -14.00 | -19791.9788166 | -3032.54759551 | 837.072833700 |
| -16.00 | 10.00 | -12.00 | -19786.7264040 | -3054.88818892 | 691.213651030 |
| -16.00 | 10.00 | -10.00 | -19743.6237821 | -3059.58897082 | 739.641982748 |
| -16.00 | 10.00 | -8.00 | -19742.4858056 | -2913.09107628 | 644.992941586 |

**(ditto ….)**

**No, we do not expect the umpthieth decimal figure to be significant!**

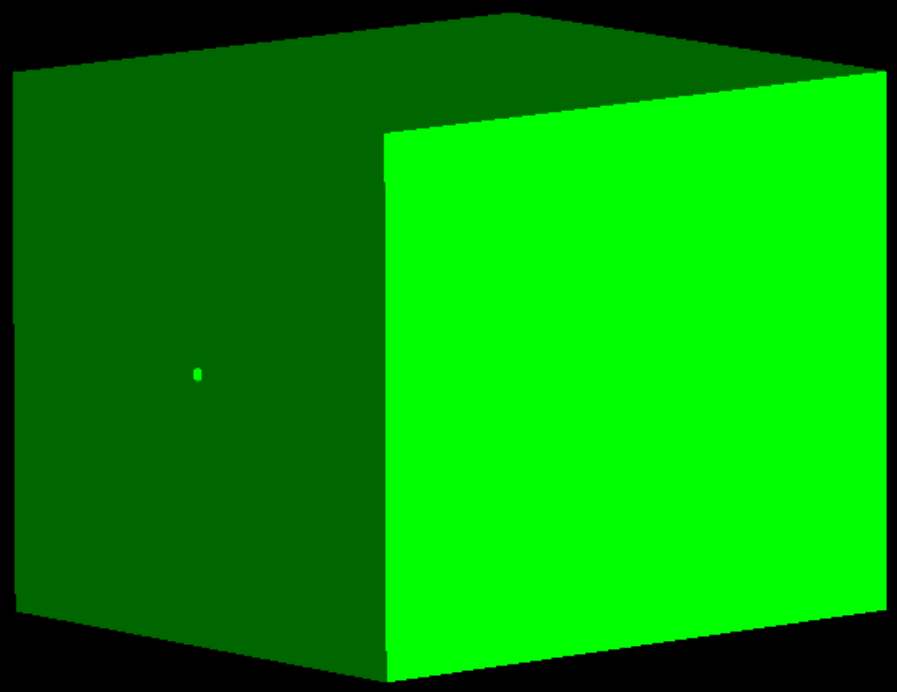
# HCPS Details (V)




- *Next logical step was to simulate the whole thing in GEANT 4 (G4).*
- *FTPQBert, GDML, multi-core, ROOT, openGL*

- *The white "lines" are actually scoring volumes used for dose-rate calculation (more on that later)*
- *They are 15 m from the target*

# HCPS Details (VI)



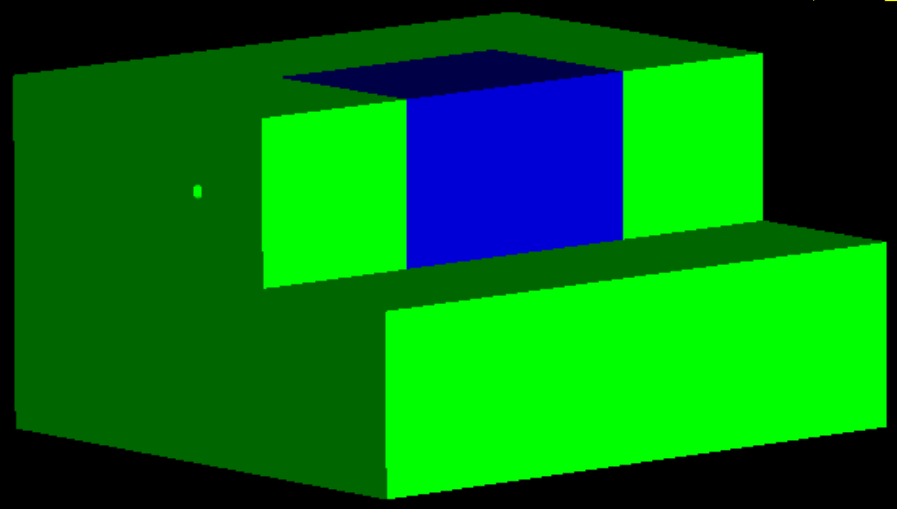
- *Here is just the HCPS itself*
- *Outer/Extra Shielding (Fe and concrete…)*

- *Note the small opening allowing the electron beam in*
- *A matching hole on the other side lets the photon beam out*
- *The whole thing is less than 27 $m^3$*
- *Estimated weight ~ 70 tons*

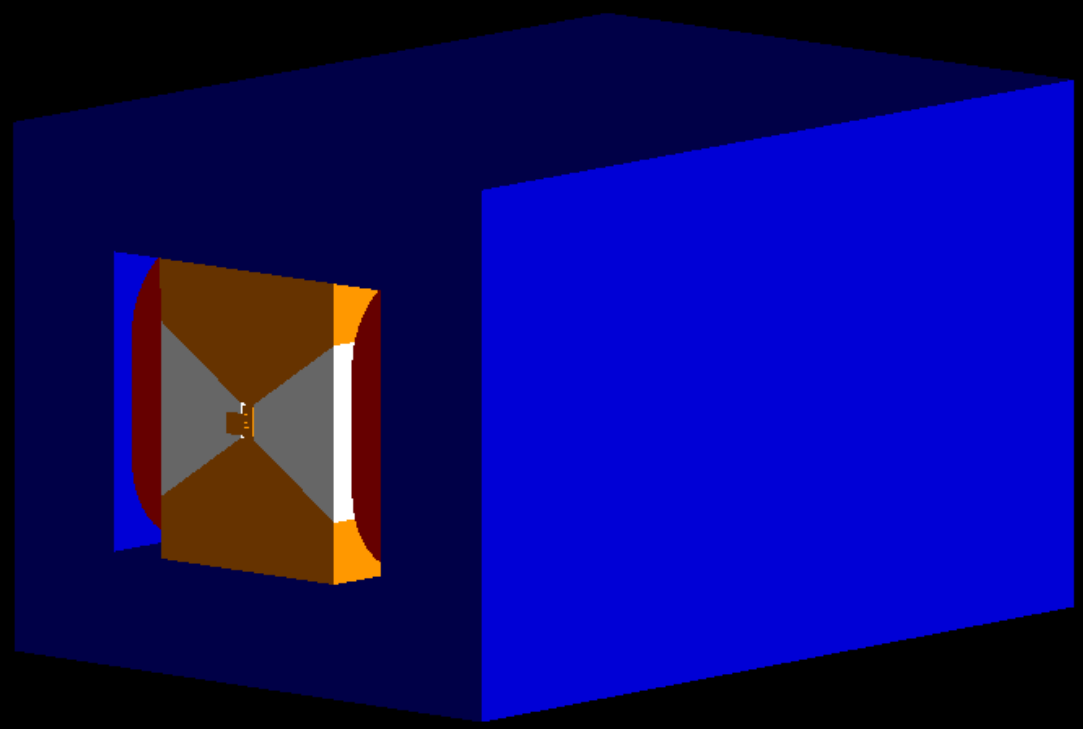
# HCPS Details (VII)

- *Removing some of the outer shielding*
- *Each "block" should be movable by the Hall C crane (or hire contractor)*

- *The magnet itself starts to show (blue)*



# HCPS Details (VIII)



- *Inner HCPS structure*
- *Magnet, inserts, central part*
- *Radiator is also shown*

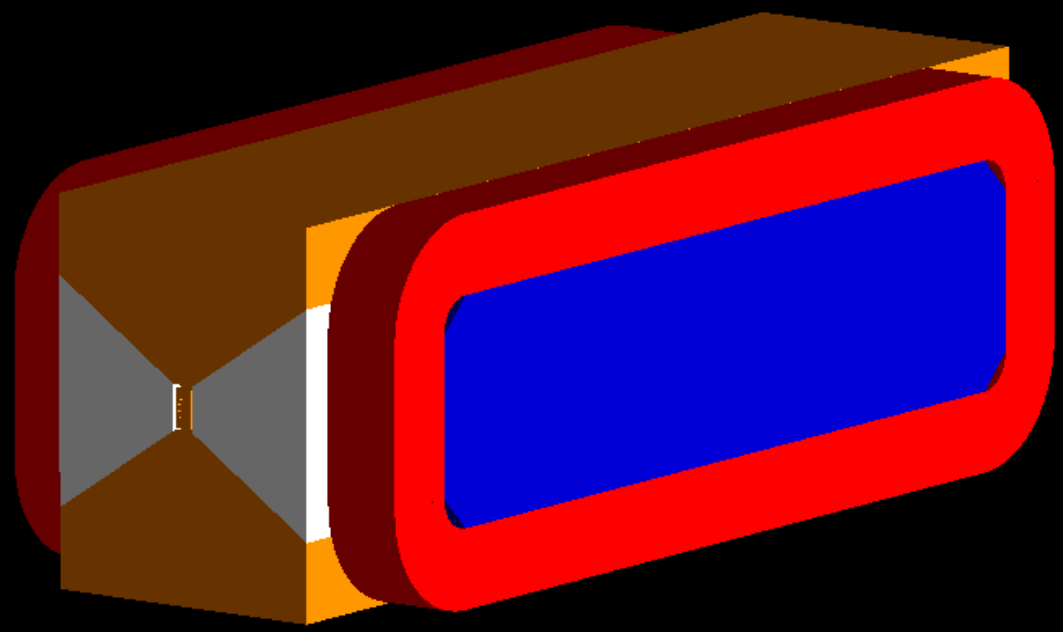
- *NOTE: poles are hidden by the Cu inserts (orange and white blocks)*

- *OBS: To achieve the <u>hermeticity</u> we aim for we need to fill all the inner part of the magnet w/ high Z, non-magnetic material.*

# HCPS Details (IX)

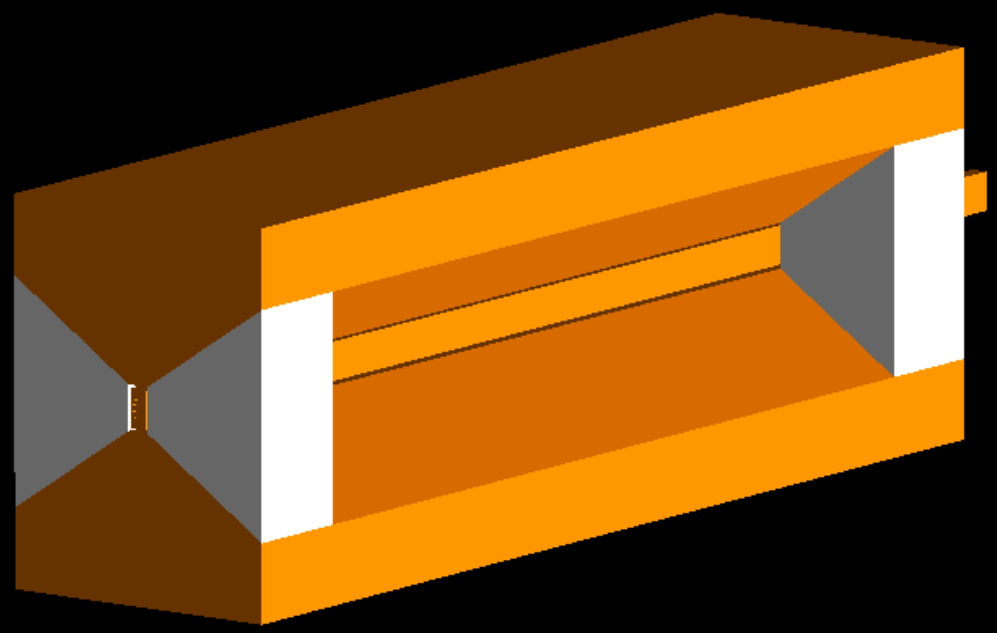
- *Side view to see the radiator position*

# HCPS Details (X)



- *Return iron removed one can see the (backside of the) pole*
- *Coils (red) and*
- *Inserts (orange and white) as well*

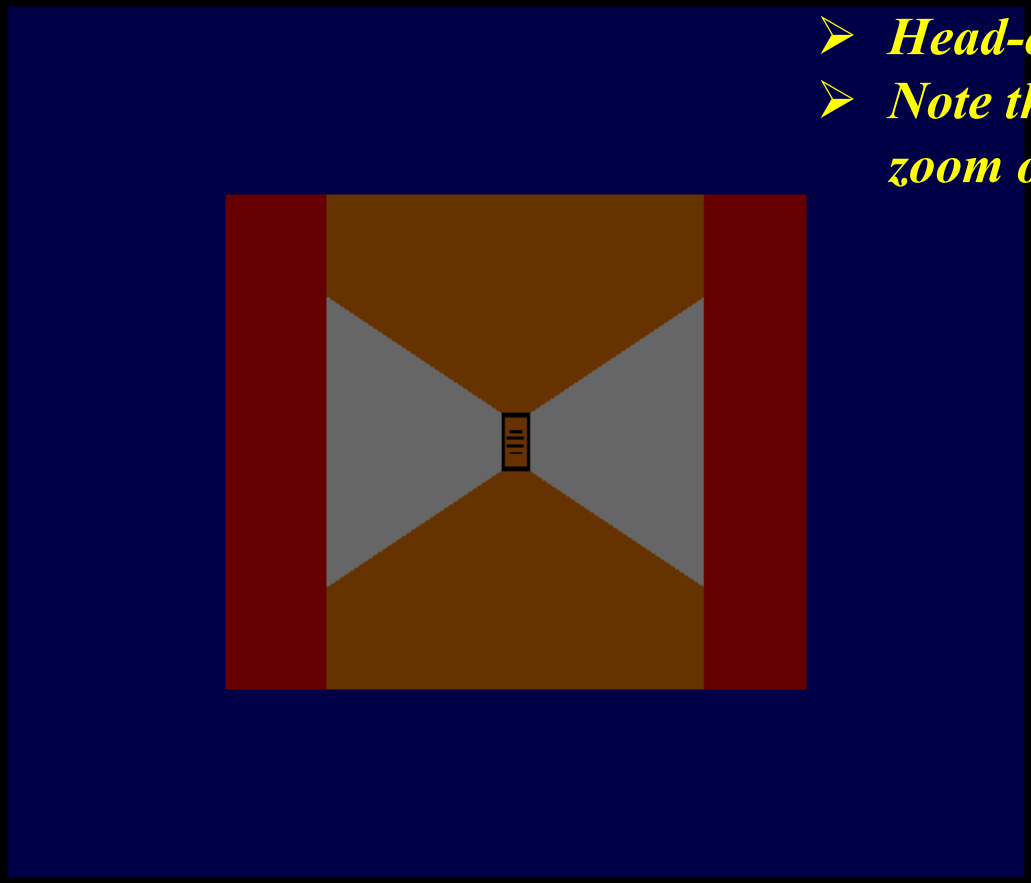
# HCPS Details (XI)



- *Just the inserts and the central piece left*
- *Yes, there is a small gap in the central region (see next slides)*

# HCPS Details (XII)

– do you really want me to continue numbering these in latin?



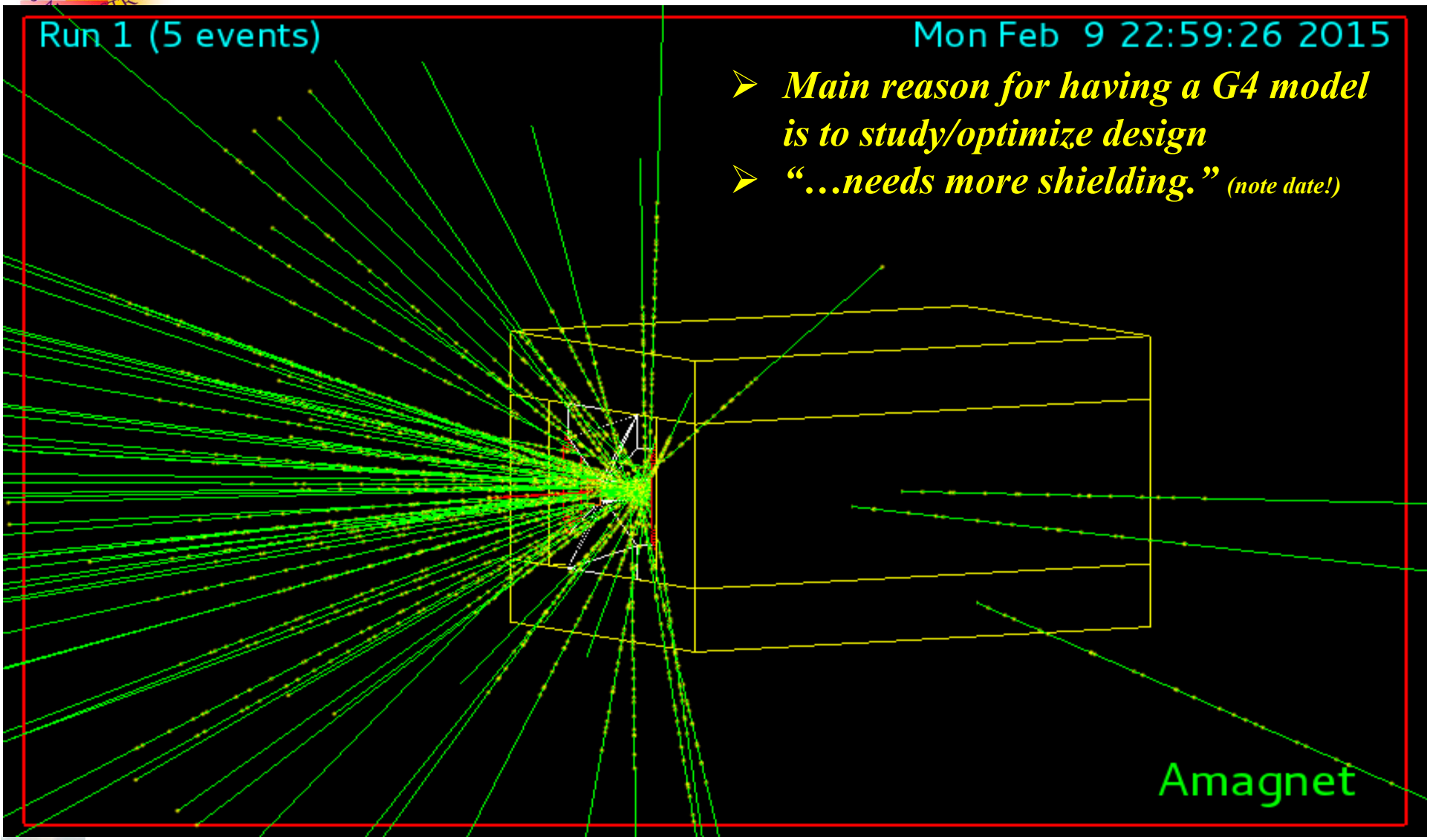
- *Head-on view of the magnet*
- *Note the central region (we'll zoom on it next)*

# HCPS Details (XIII)

– you do.

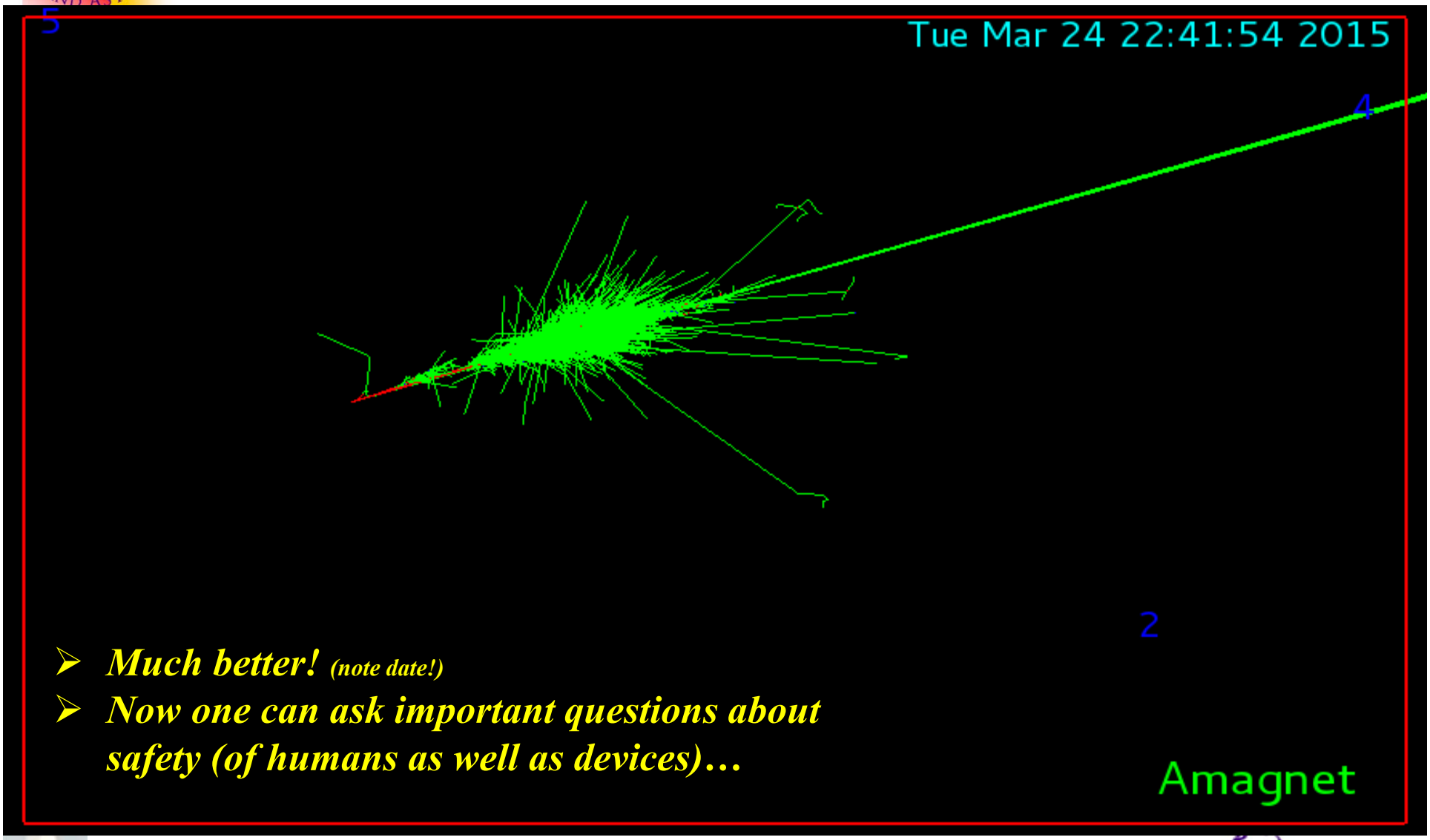
- *HCPS central piece*
- *"heavy metal" W-Cu alloy*
- *Cooled. Identified vendor for suitable bellows.*
- *Thin (2mm) slits that help define the photon beam*
- *Space (top/bottom) allows it to act as "mechanical raster" (~60 Hz)*

# HCPS Performance (I)



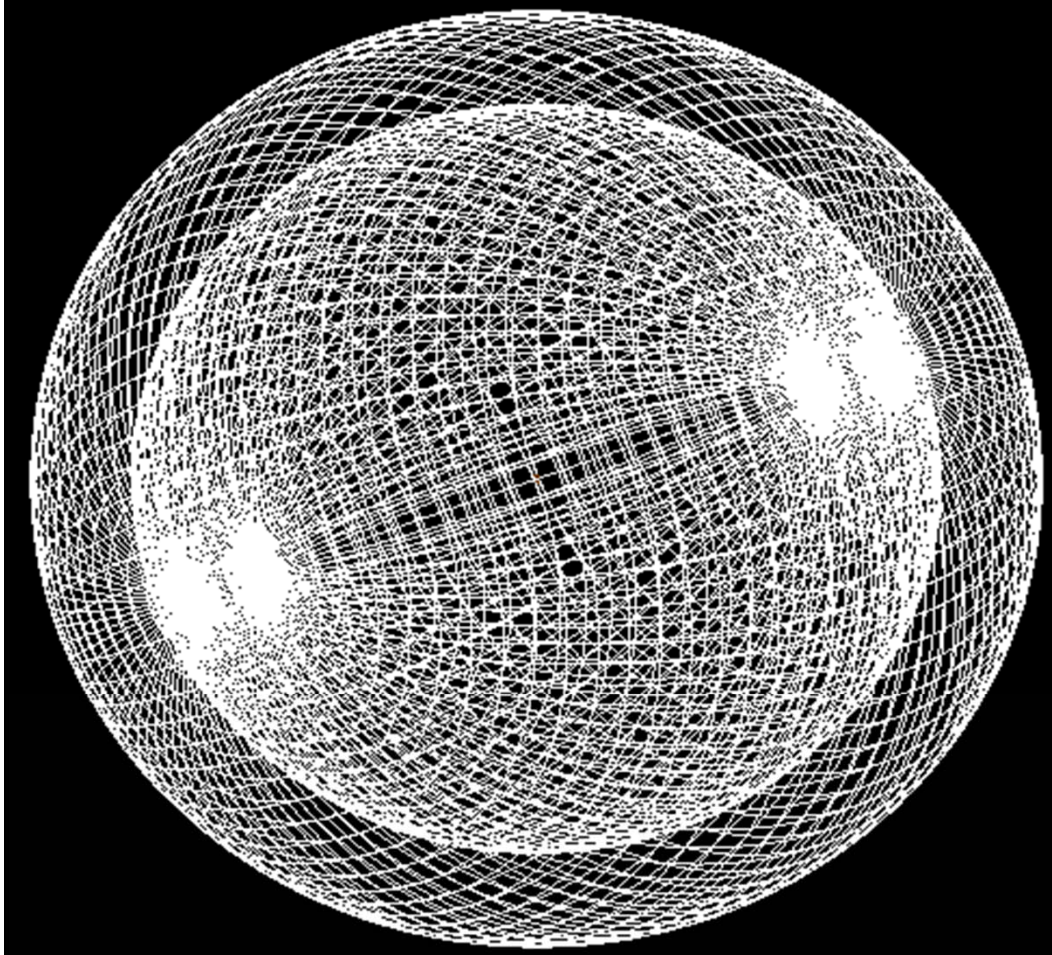

- *Main reason for having a G4 model is to study/optimize design*
- *"…needs more shielding."* *(note date!)*

# HCPS Performance (II)



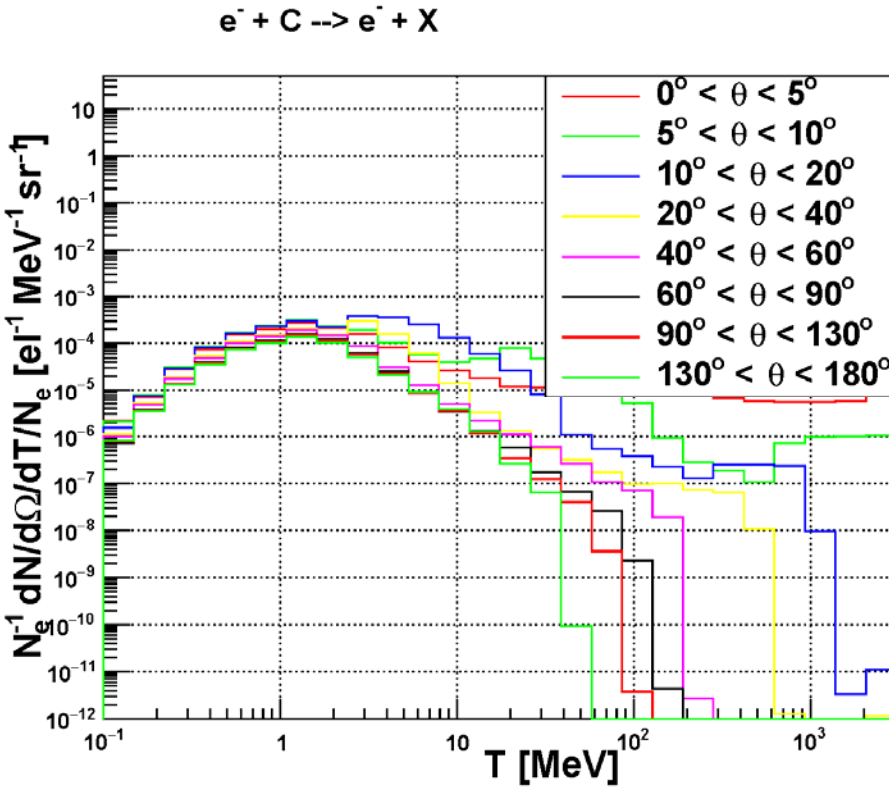

- *Much better! (note date!)*
- *Now one can ask important questions about safety (of humans as well as devices)…*

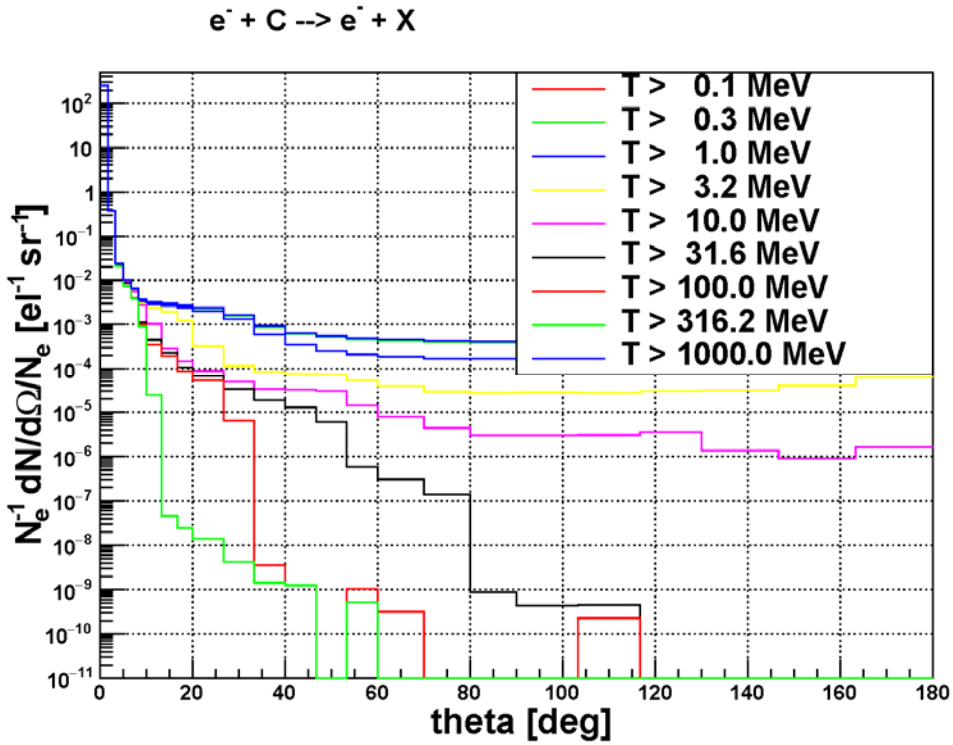
# HCPS Validation (I)



- *To validate the event generation algorithm..*
- *Strip down geometry to bare minimum (gdml…)*
- *Generate lots (~few x $10^9$) of events compare with expectations*
- *e- + C → …*

# HCPS Validation (II)



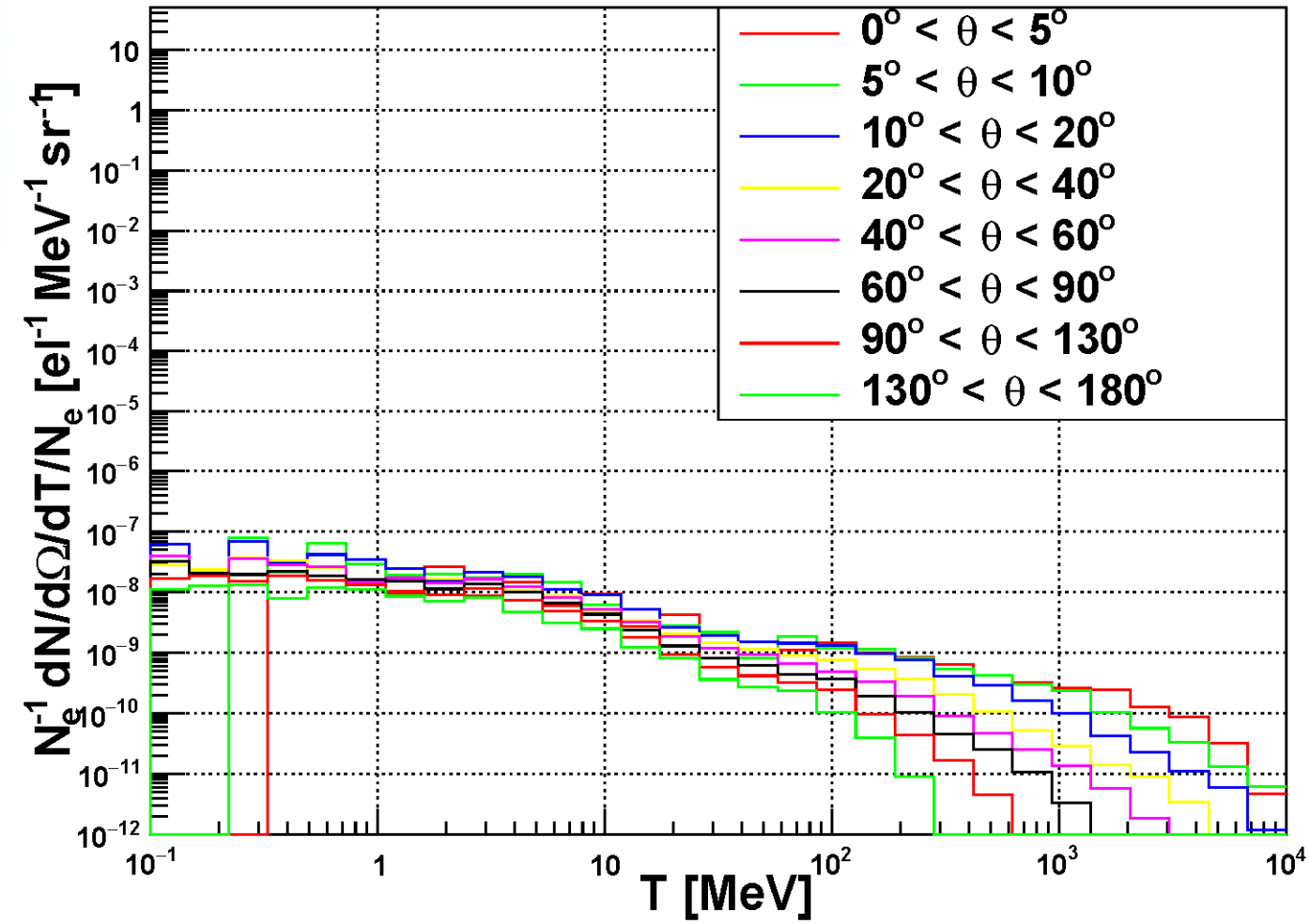




*3120 M Events*

- *Similar distributions for photons, positrons, pi+, pi-, and neutrons*
- *All checked against accepted standards (PD)*

# HCPS Validation (III)

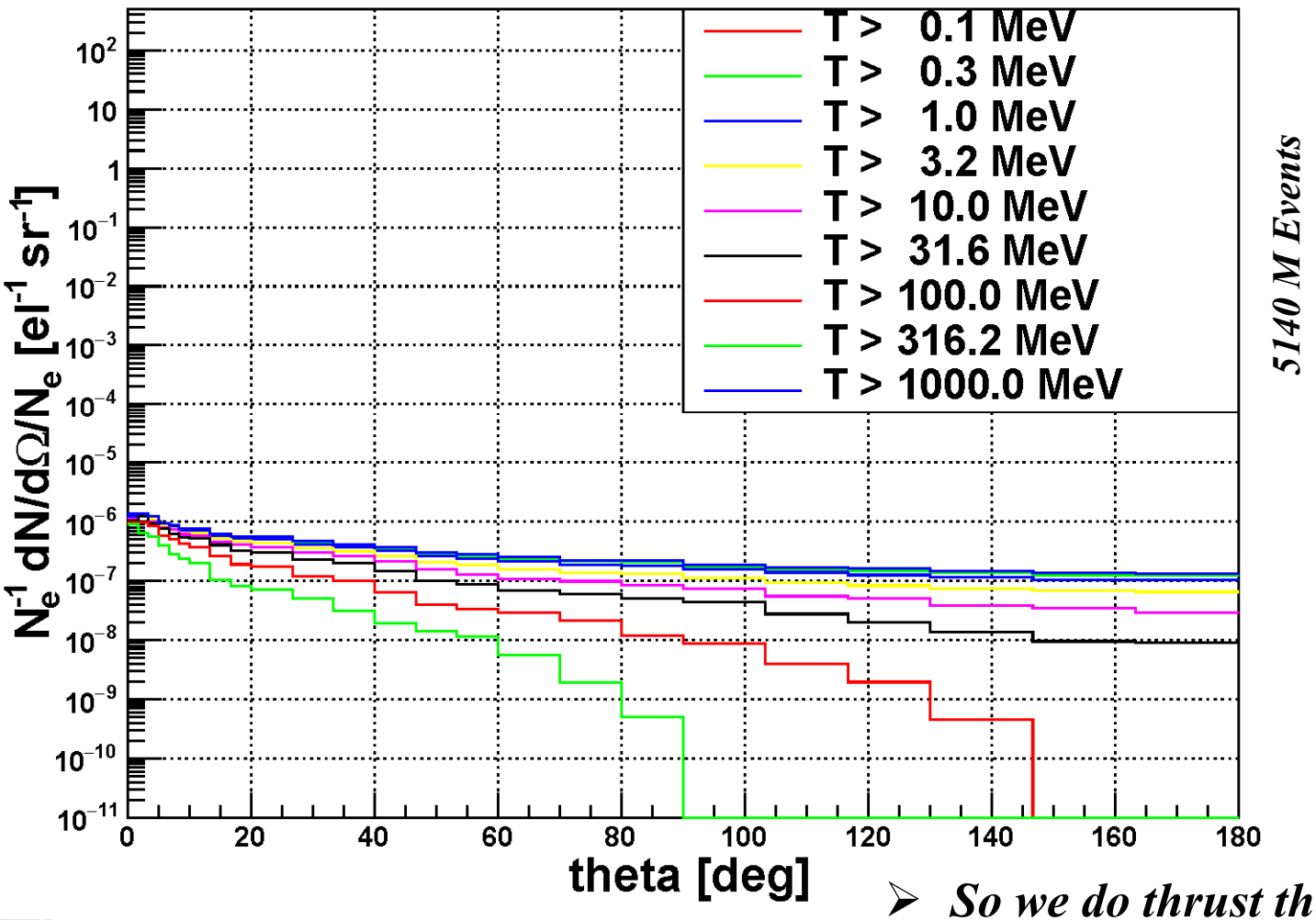
$e^- + C \rightarrow n + X$




- *Multicore…*

# HCPS Validation (IIIb)

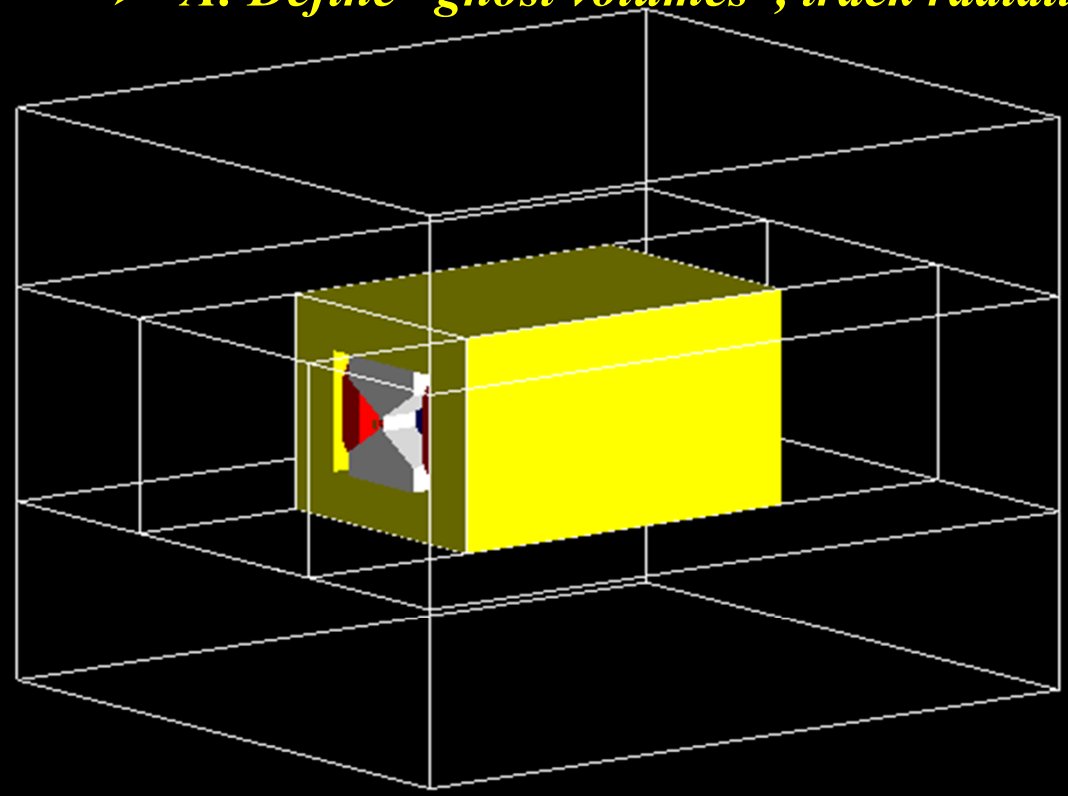
$e^- + C \rightarrow n + X$



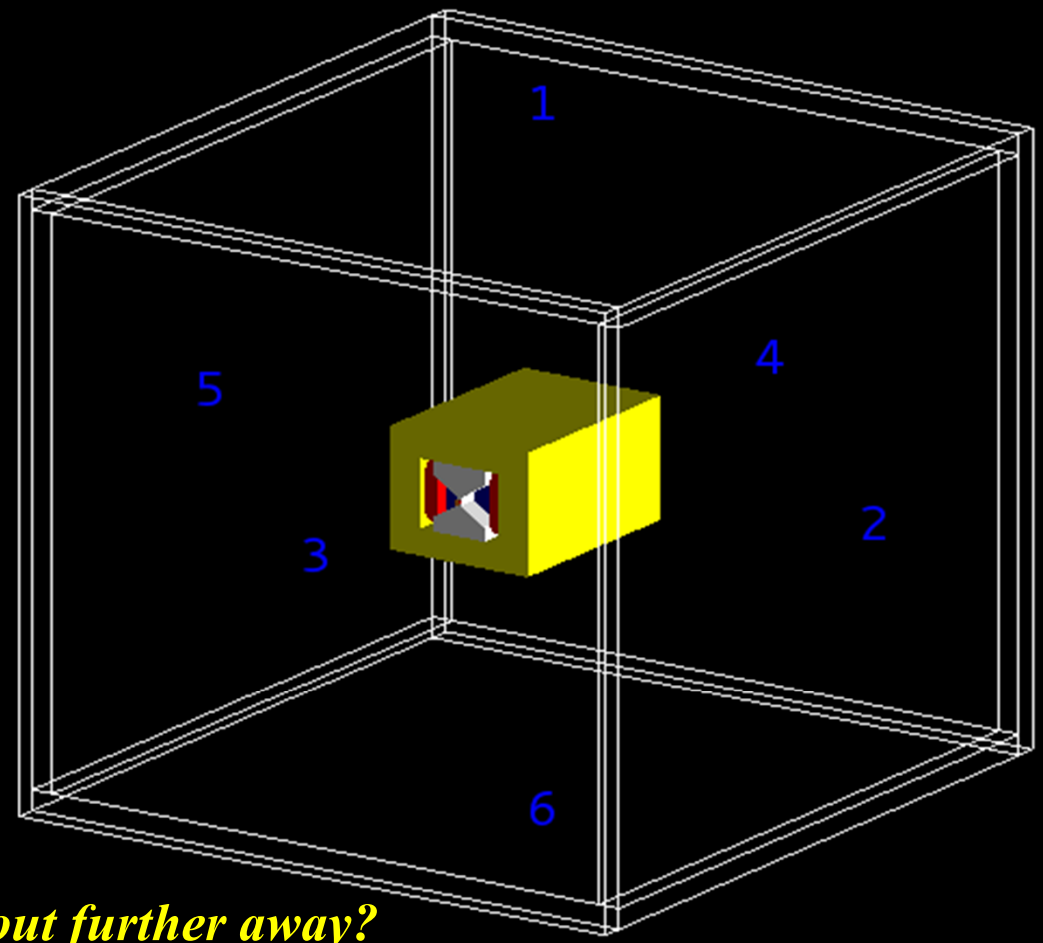

- *So we do thrust the event generator!*

# HCPS Performance (III)

- *Q: How much radiation is there next to the magnet?*
- *A: Define "ghost volumes", track radiation through them…*



# HCPS Performance (IV)

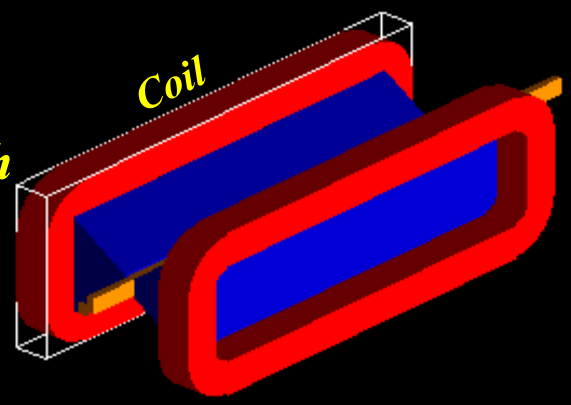


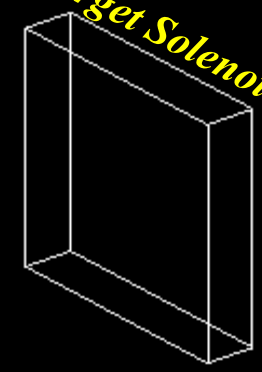

- *Q: How about further away?*
- *A: redefine/reuse volumes…*

Amagnet

# HCPS Performance (IV)

- *Q: How about on the coils? (so one can identify the epoxies that might be used when building the coils!)*
- *Q: How much radiation in the area where the target more sensitive components might be?*




- *Speaking of coils…*

RUSSIAN ACADEMY OF SCIENCES
BUDKER INSTITUTE OF NUCLEAR PHYSICS
SIBERIAN BRANCH

V.V. Petrov, Yu.A. Pupkov

BINP TESTING
OF RADIATION RESISTANCE
OF THE MATERIALS USED FOR PRODUCTION
OF ACCELERATOR MAGNETIC SYSTEMS

NOVOSIBIRSK
2011

**Contents**



2

- ***Identifying radiation-hard materials for coil building…***

- ***Identifying radiation-hard materials for coil building…***

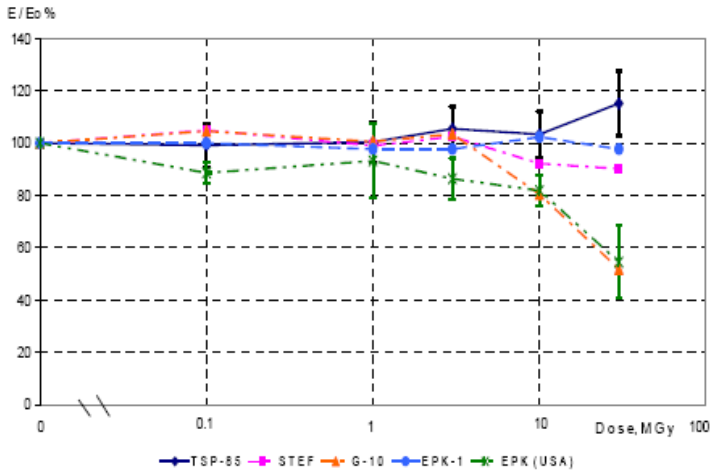



Fig. 2. Relative change in modulus of elasticity vs the dose.

***fiberglass and expoxy mat.***

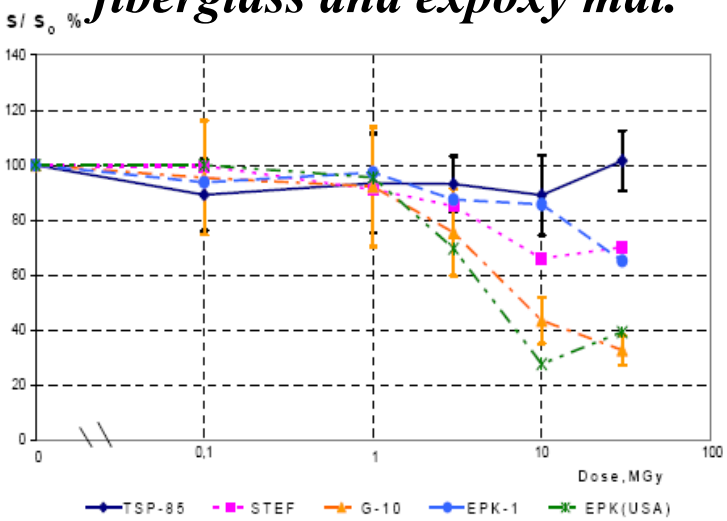



Fig. 3. Relative change in strength vs the dose.

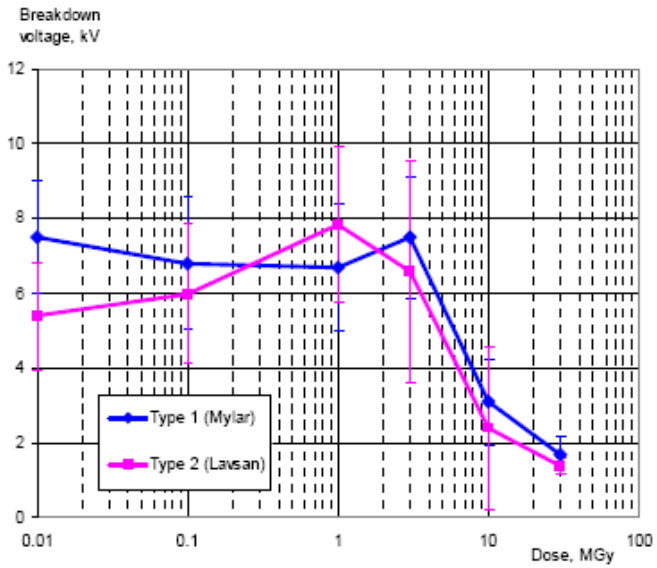



Fig. 7. The breakdown voltage of Mylar and Lavsan vs absorbed dose (average value of 12 samples).

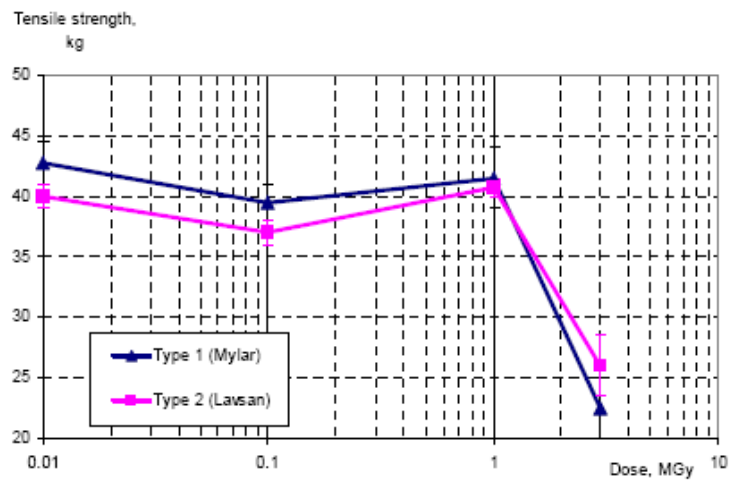
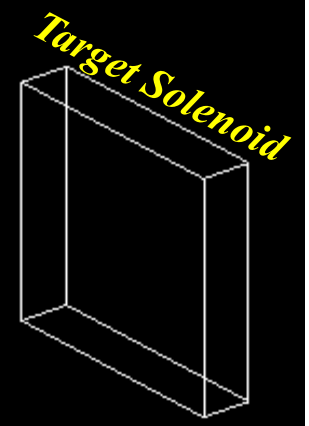


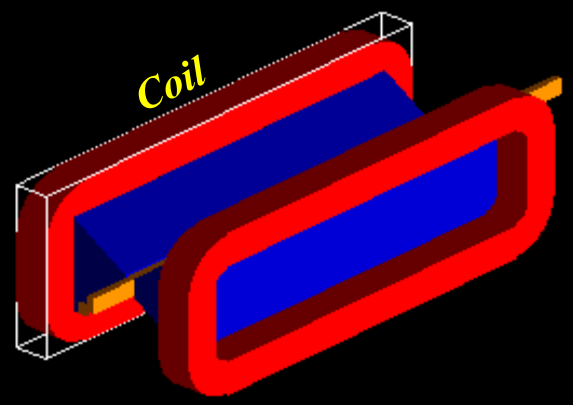

Fig. 8. Tensile strength of Mylar and Lavsan vs absorbed dose.

# HCPS Performance (IV)

- *So based on the G4 simulation and a conservative (!) dose of 2 MGy before breakdown (also 1 rad = 0.01 Gy)…*

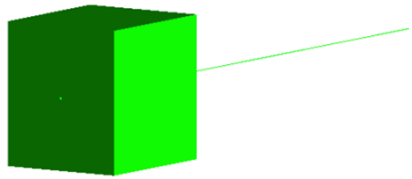


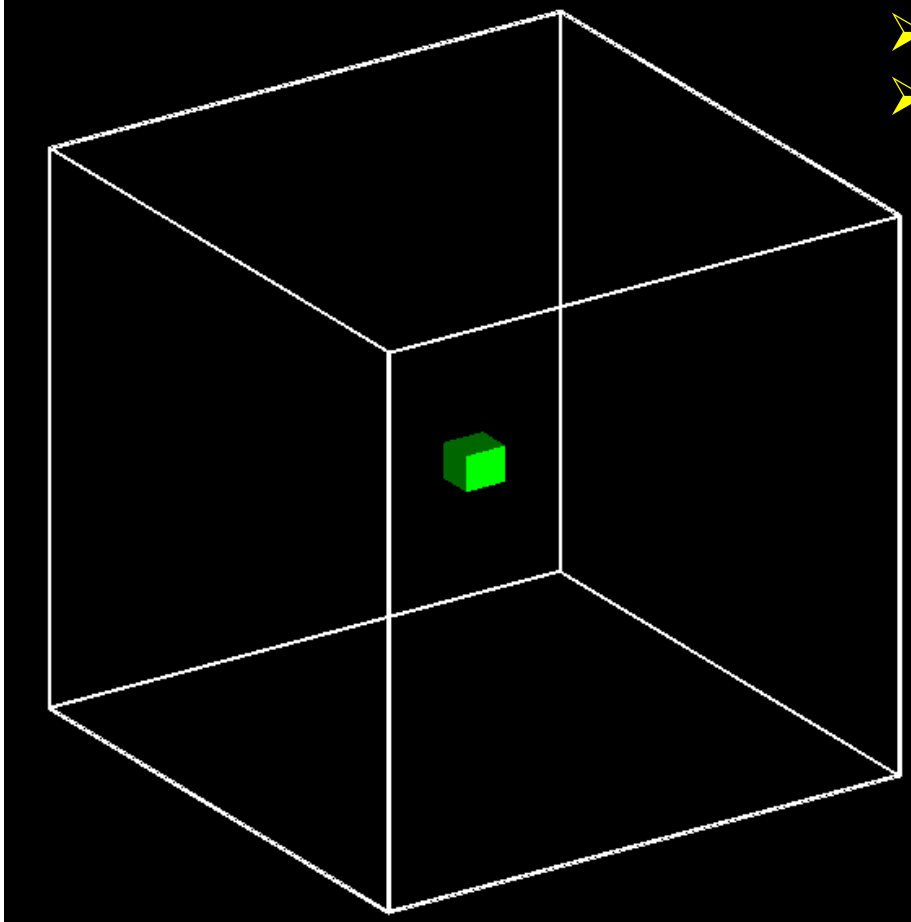

*~2500 h*




*Not a problem as far as solenoid is concerned*

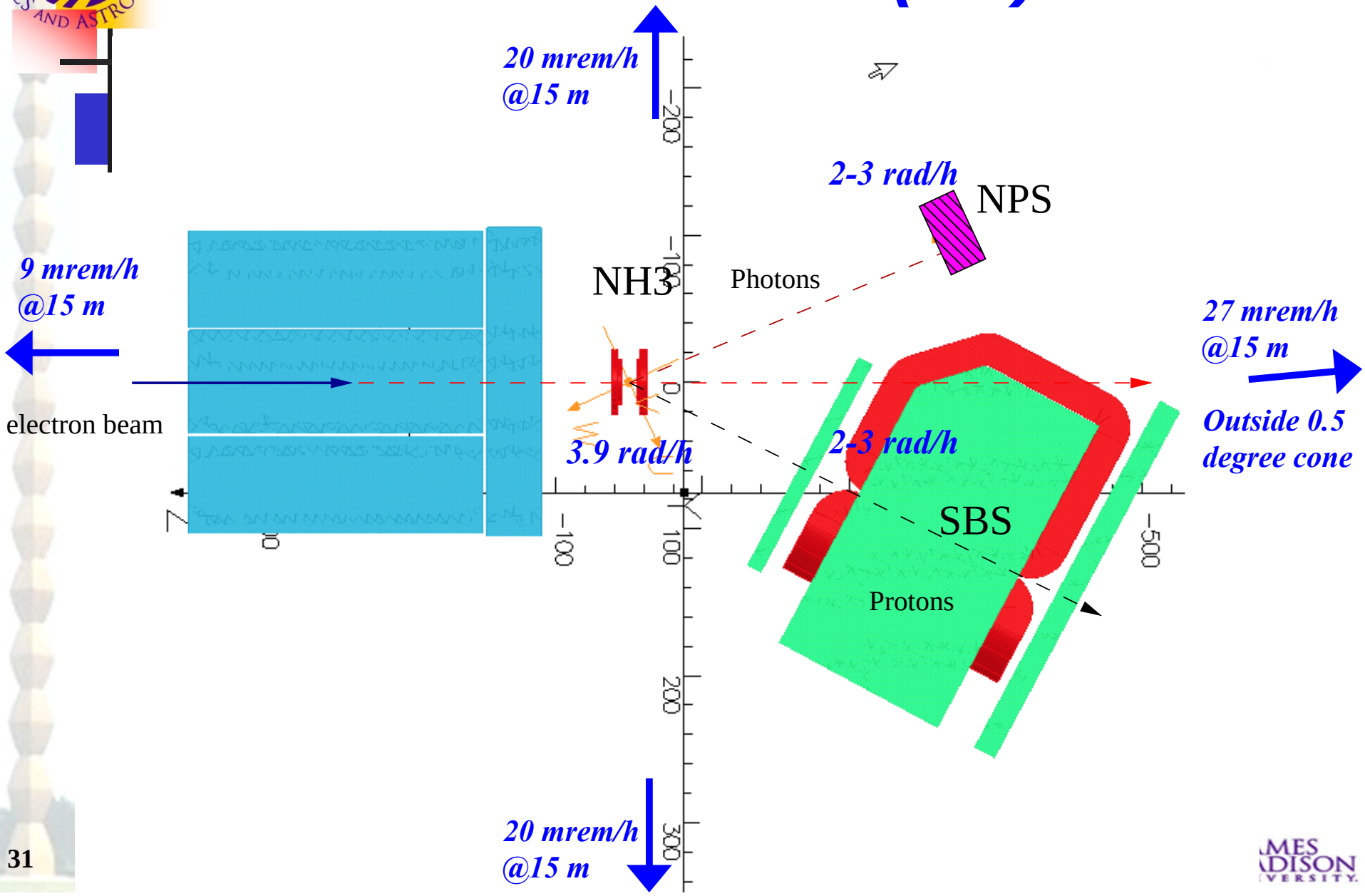
# HCPS Performance (V)






- *Q: How about far (15m) from the target*?*
- *Very good question!*

# HCPS Performance (Vb)



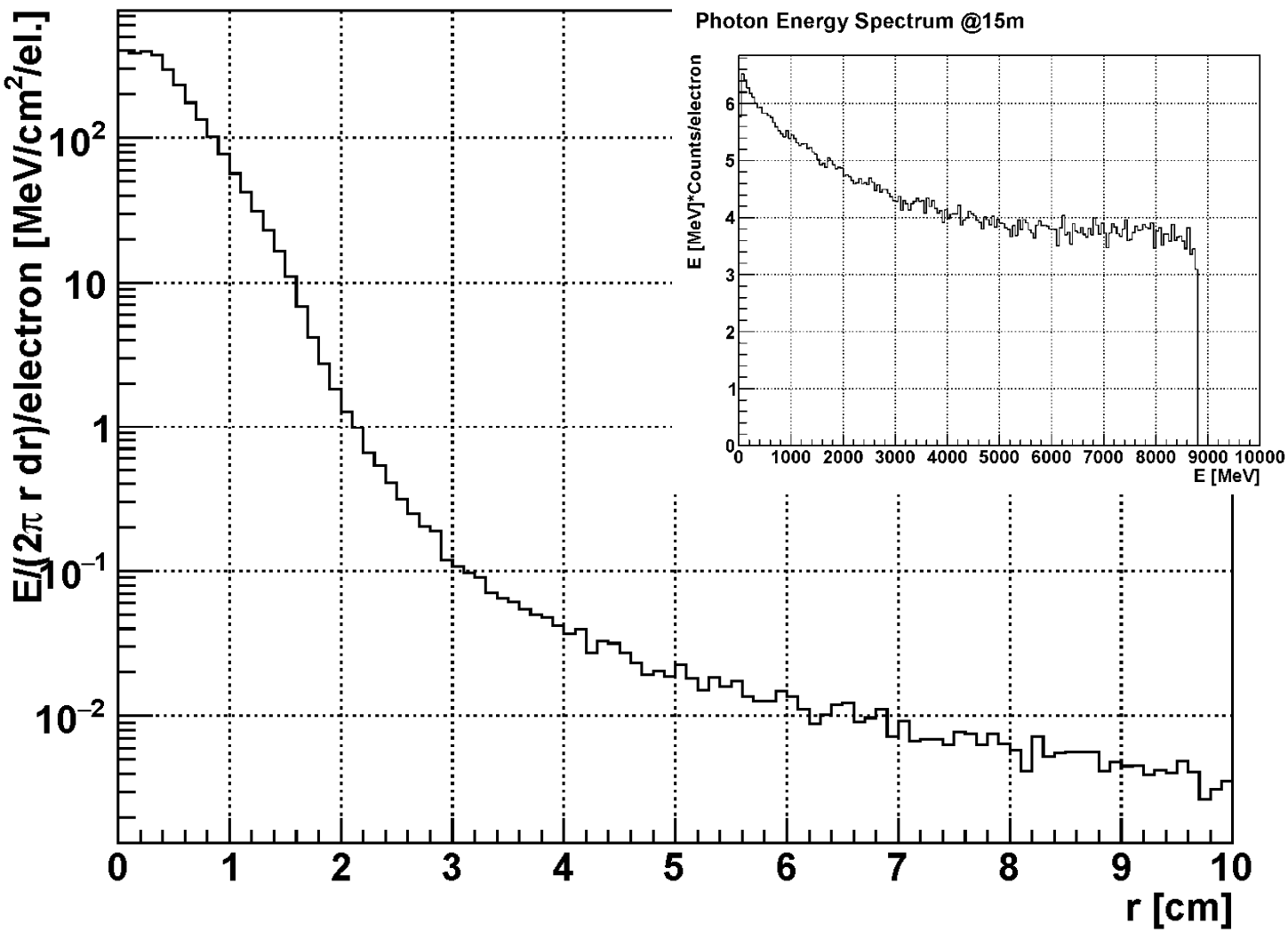
# Radiation summary

- *For the beam of 1.2 μA x 8.8 GeV:*

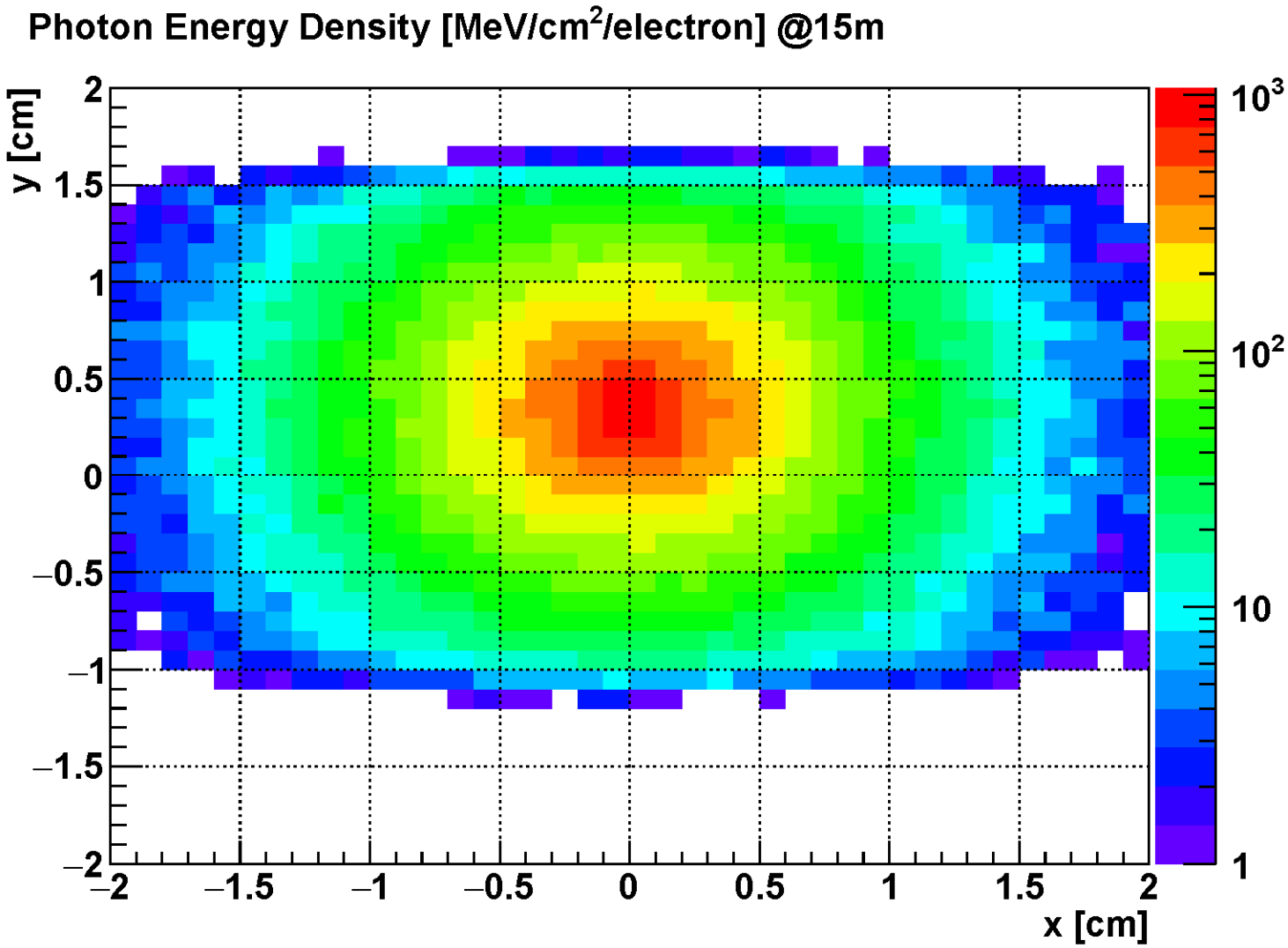
- *Just outside HCPS:*
  - *Forward: 7.5 Rad/h*
  - *Bwd: 14 Rad/h*
  - *Sides: 3.9 Rad/h*
- *@15 m (back of the Hall):*
  - *Forward: 27 mrem/h (outside 0.5 deg cone)*
  - *Bwd:9 mrem/h*
  - *Sides: 15-20 mrem/h*
- *Other:*
  - *Target solenoid: 3.9 Rad/h (~1.8 m)*
  - *SBS/NPS: 2-3 Rad/h (~ 4-5 m)*
  - *Dipole Coils: 80 kRad/h (~0.5 m, inside HCPS)*

# HCPS Performance (VI)

## Photon Energy Density vs radius @15m

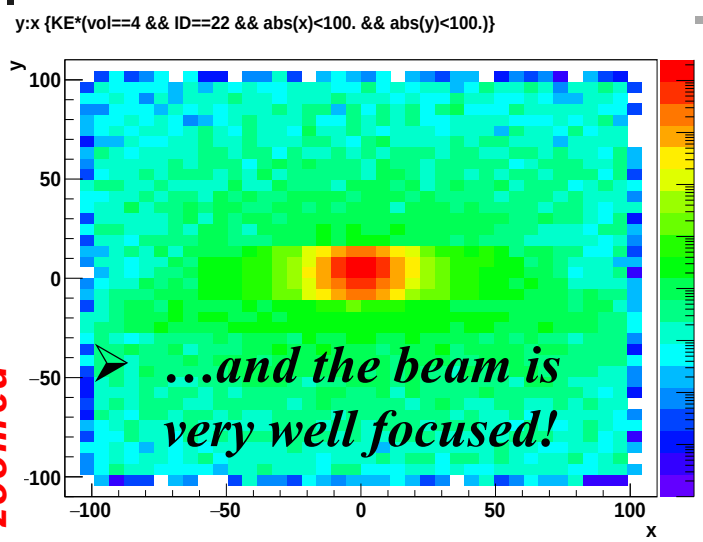


# HCPS Performance (VI)



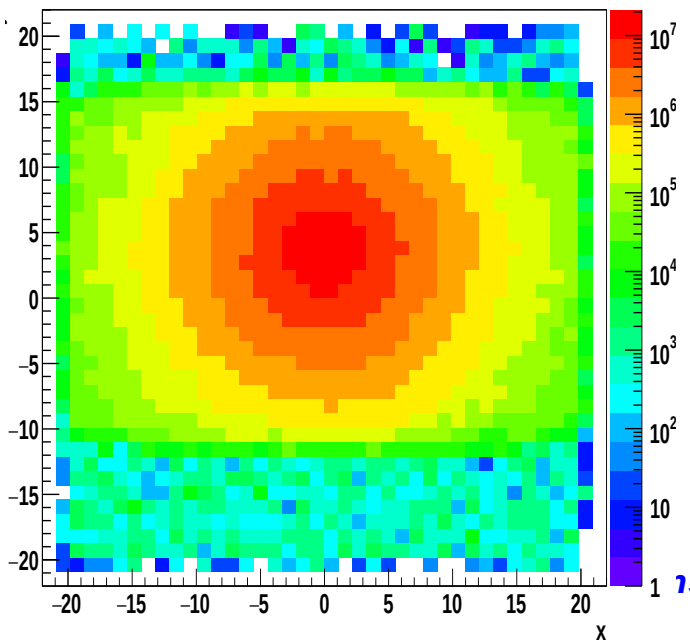

- *the beam spot size is indeed ~0.9mm!!!*

# HCPS Performance (VII)

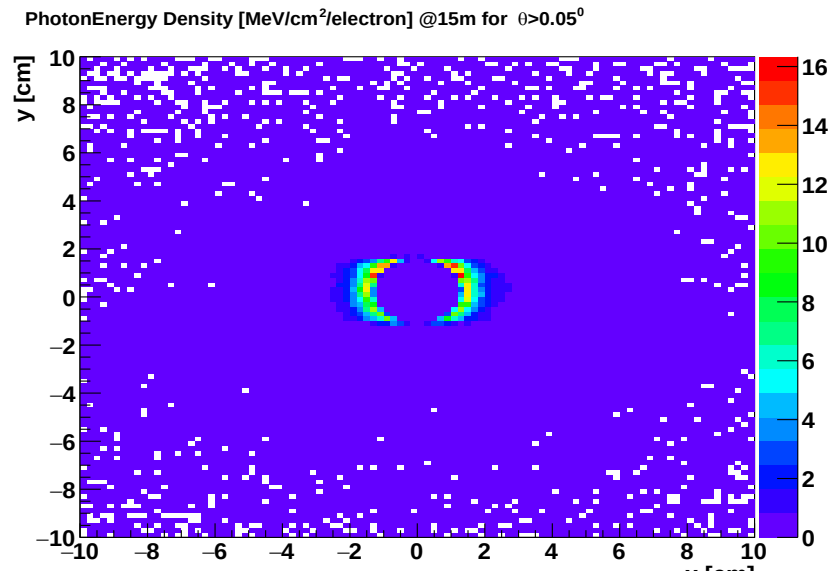


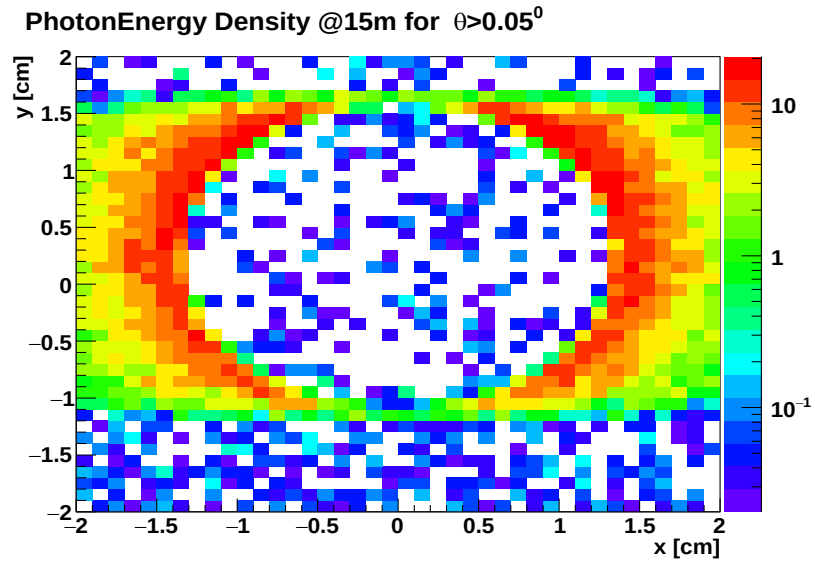

➢ *…and the beam is very well focused!*

Photons, zoomed




Photons, zoomed. exclude 0.05 deg.




9 out of 920 Watt

# Quo Vadis?

- **Novel Hermetic Compact Photon Source capable of delivering a clean, narrow photon beam ~$10^{11}$ γ/s (or more). Not a CONCEPT, a *PROJECT!***
- **Uses existing technology (~250k$). Many fabrication details (technology, materials, industry partners) identified/prototyped.**
- **Ideally suited (100x better than current or proposed technology) for polarized target experiments (WACS, π production, time-like DVCS, etc.)**
- **Concept easily scalable and adaptable to higher/lower energies, potentially appealing to other fields (materials, medical fields, defense).**
- **Looking forward to help build (at least) one!**
- ***Thank you!***