Tungsten shield and the FDIRC Boron-loaded-polyethylene

Alejandro Pérez
INFN – Sezione di Pisa

INFN Istituto Nazionale di Fisica Nucleare SEZIONE DI PISA

SuperB

Outline

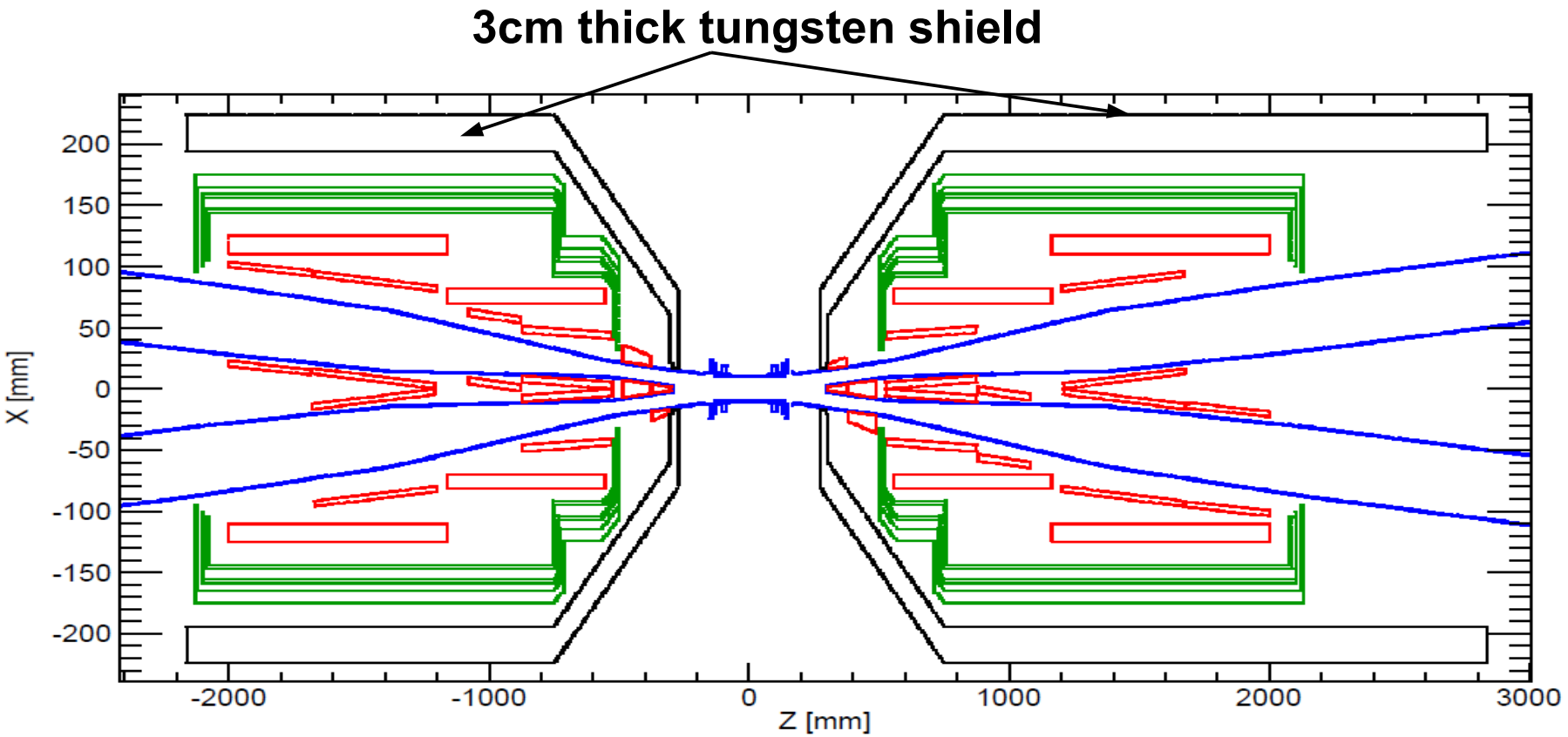
- **Tungsten shield studies**

- **FDIRC neutron shield**
  - Neutron moderation and absorption in Boron-loaded polyethylene shield

Tungsten shield studies (I)

- **Current configuration**

  Cone+cylinder 3cm thick going from 27 to 284 cm (-27 to -216 cm) in the Fwd (Bwd)

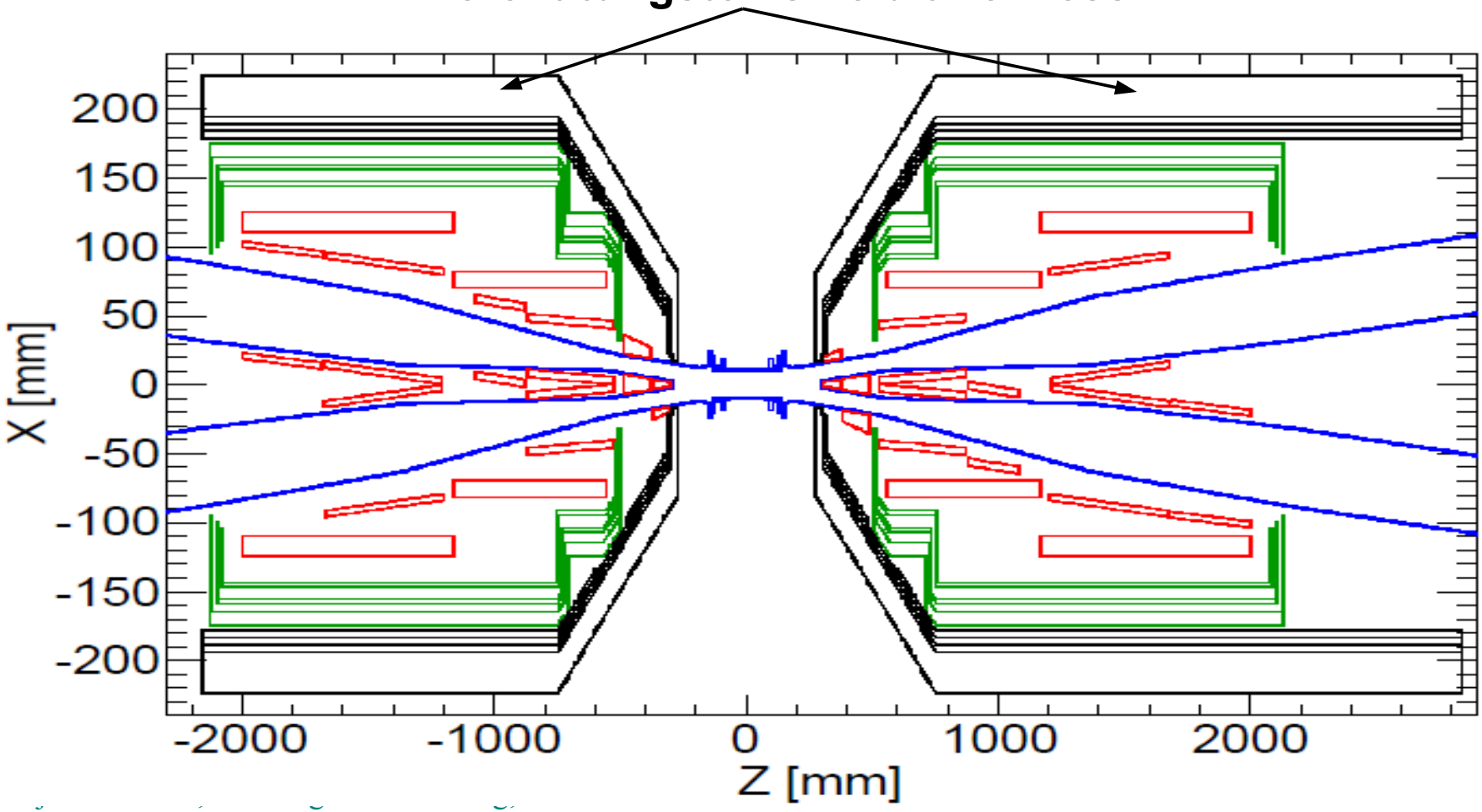


- **Background rates on the detector are too high ⇒ Main contribution is Rad-bhabha**

Tungsten shield studies (II)

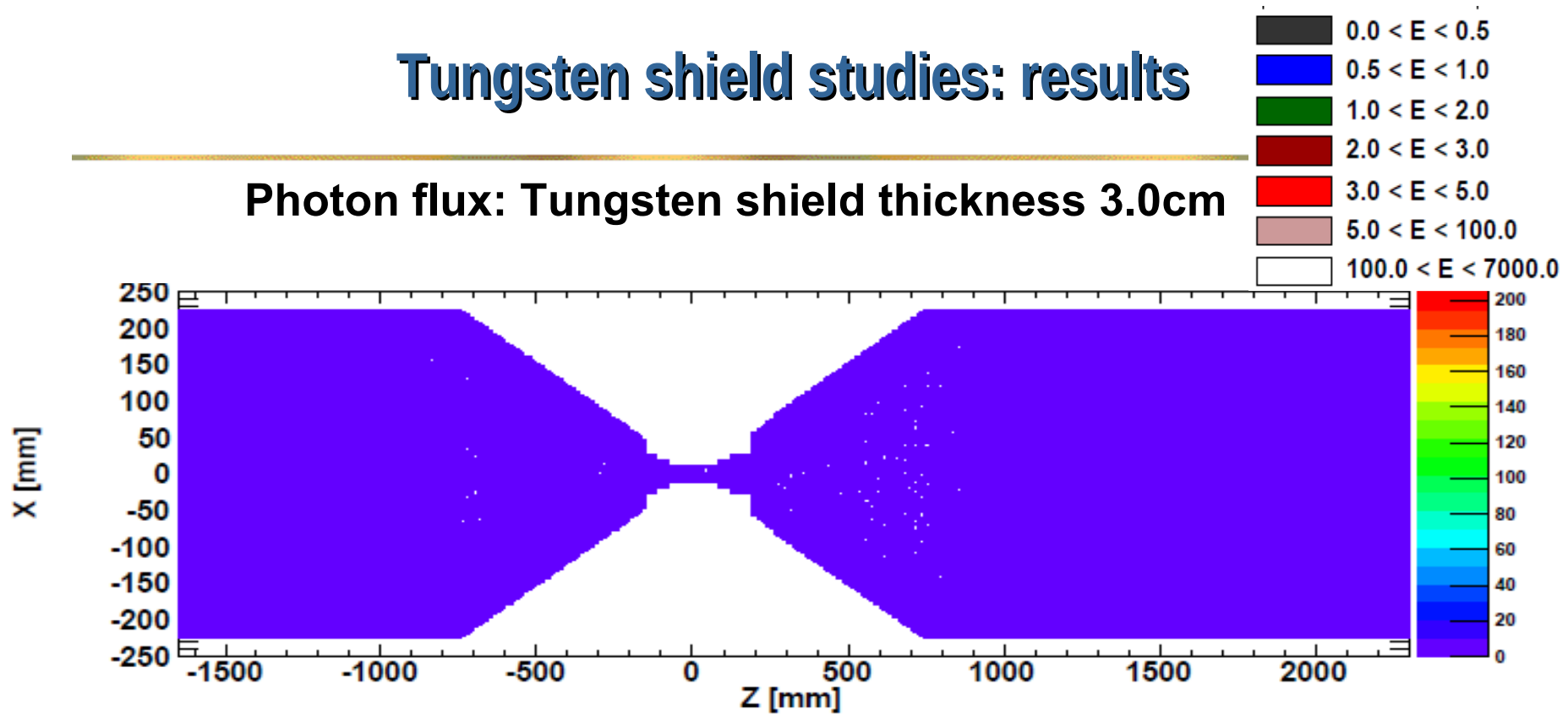
- **Strategy:**
  - Reduction of the particle flux out of the final focus from Rad-bhabha for the different tungsten shield thickness: 3 to 4.5 cm (step 0.5cm)

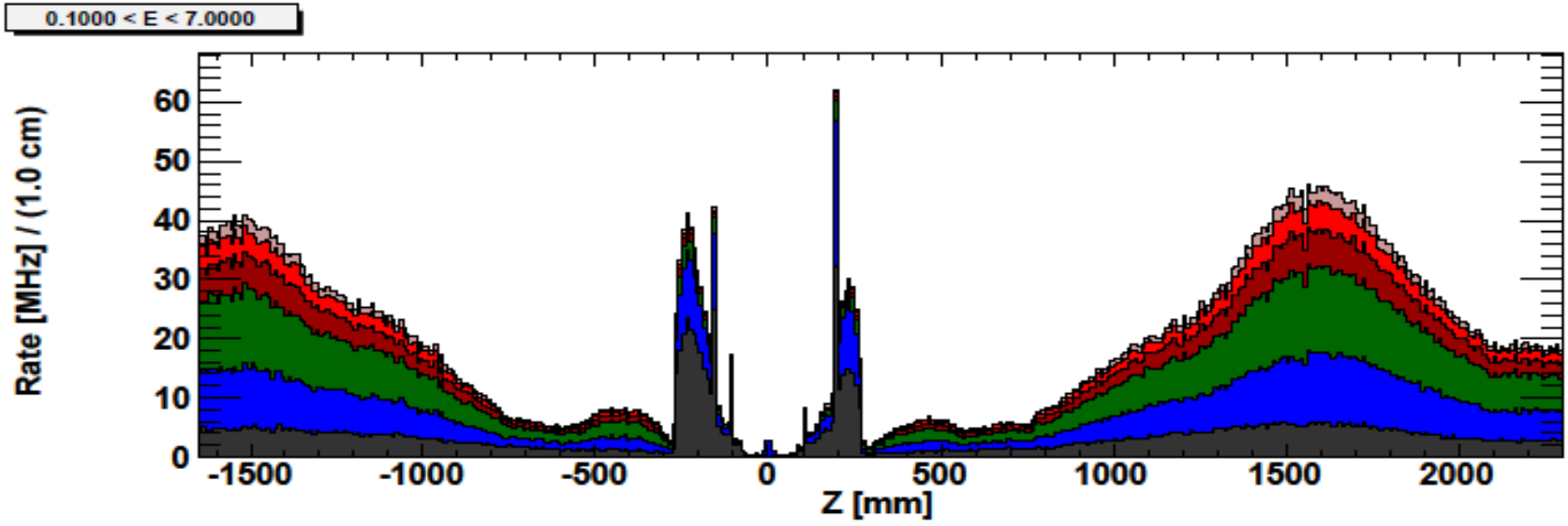
Different tungsten shield thickness



Tungsten shield studies: results

Photon flux: Tungsten shield thickness 3.0cm





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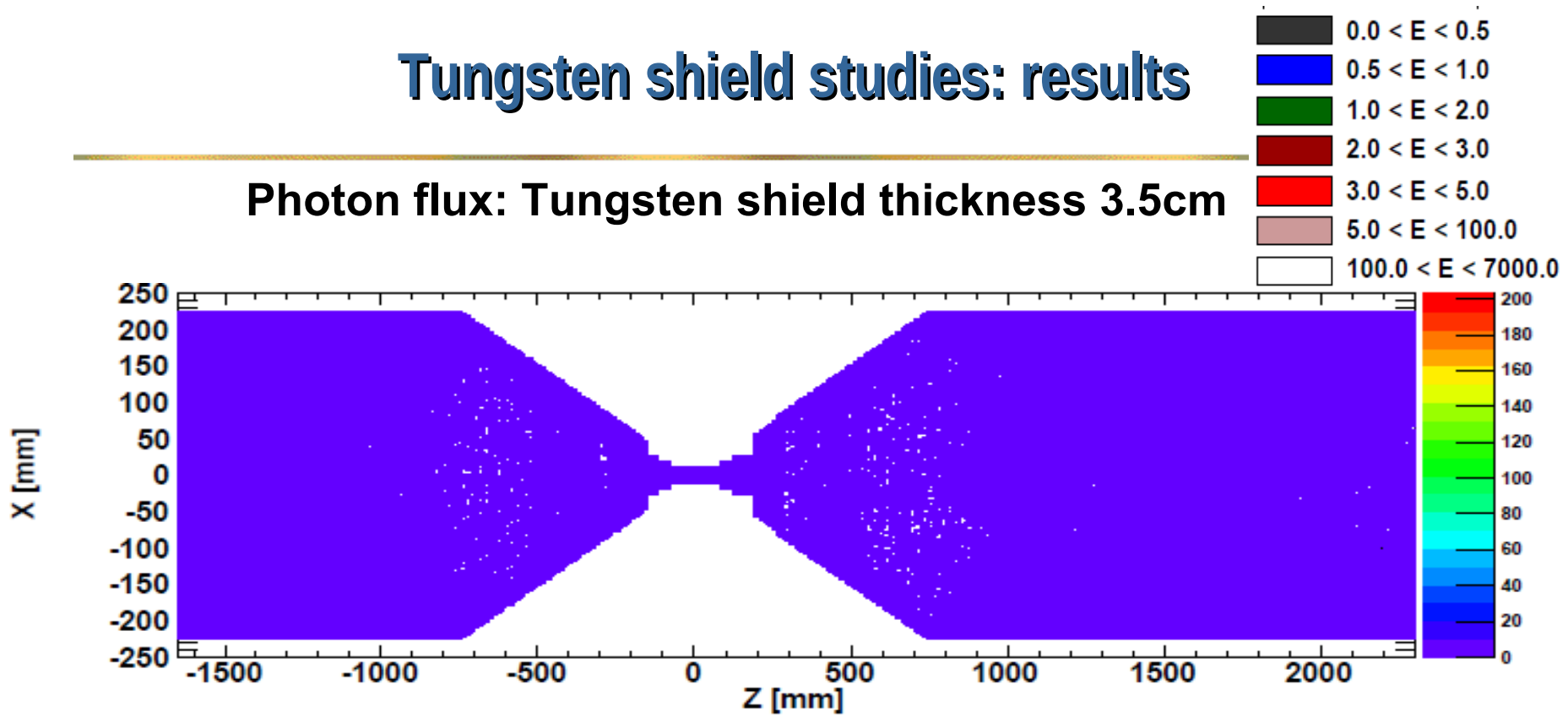
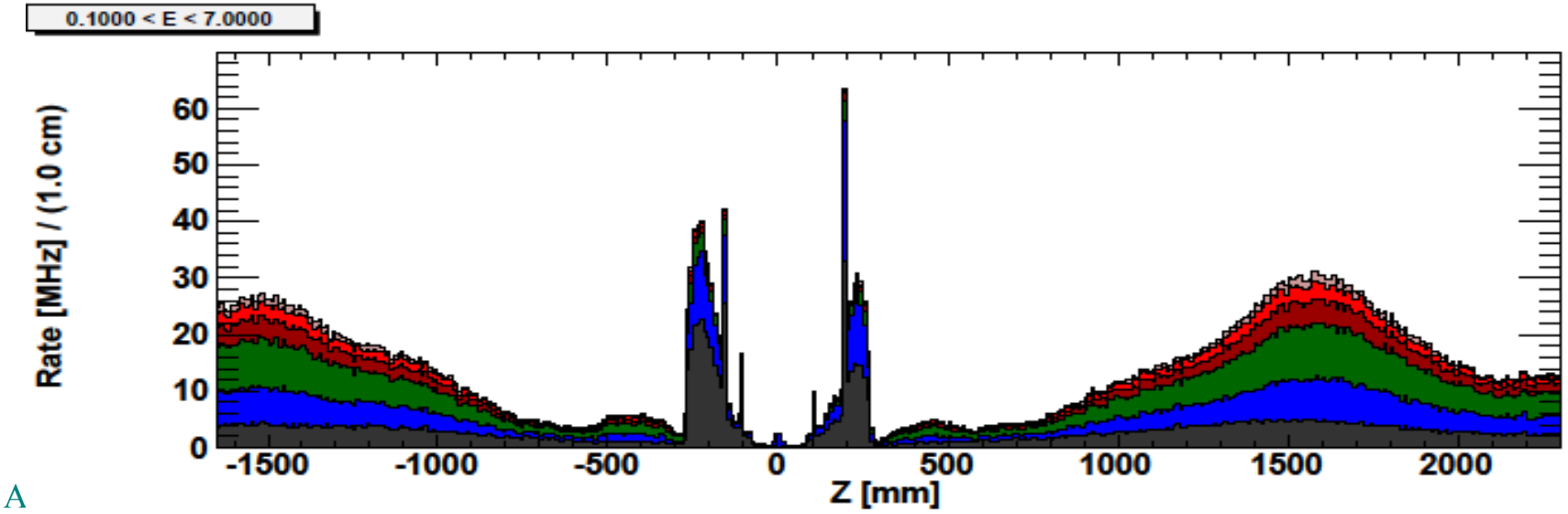
Tungsten shield studies: results

Photon flux: Tungsten shield thickness 3.5cm





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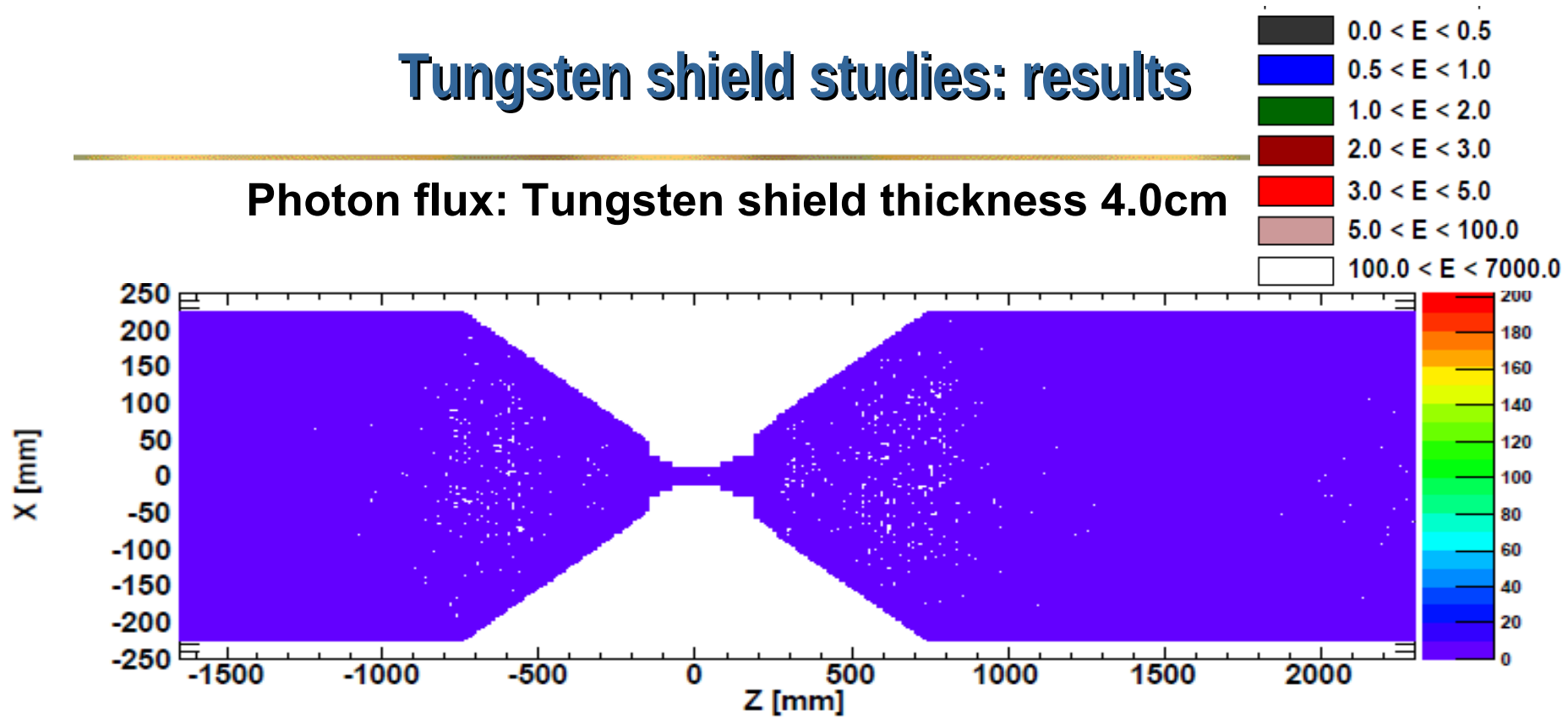
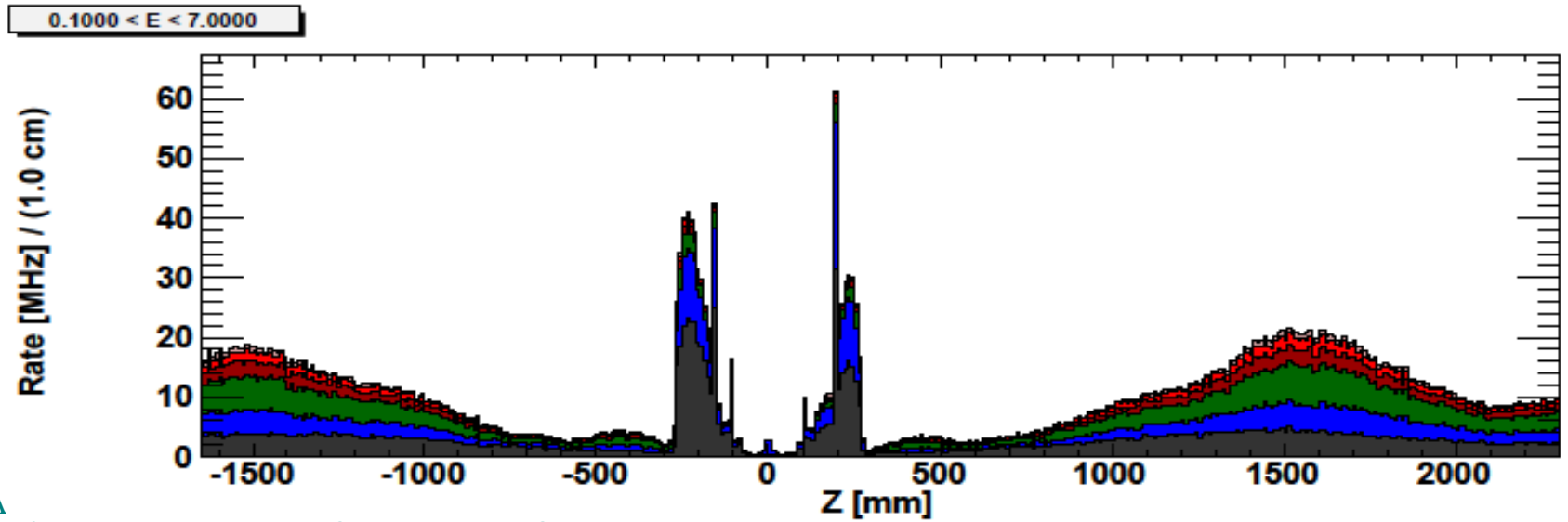
Tungsten shield studies: results

Photon flux: Tungsten shield thickness 4.0cm





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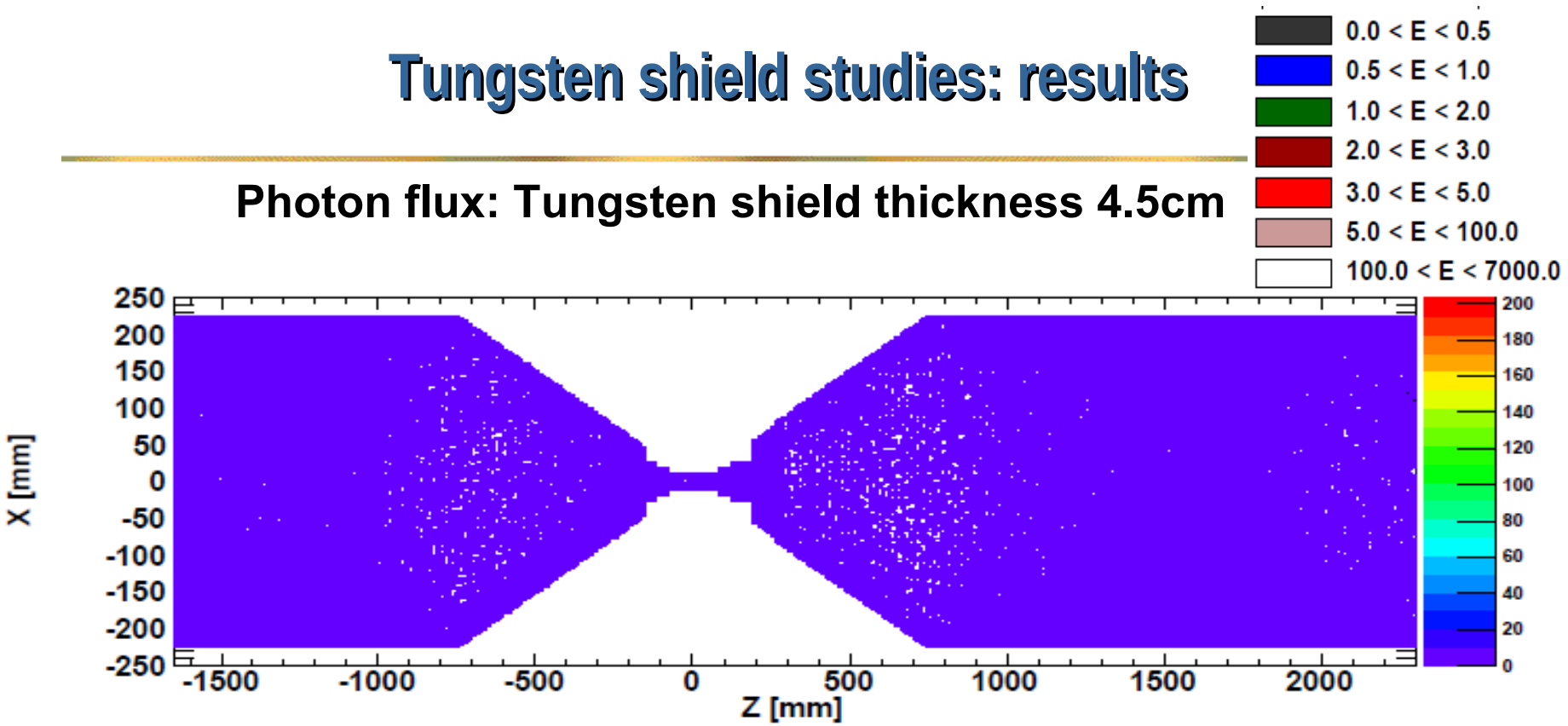
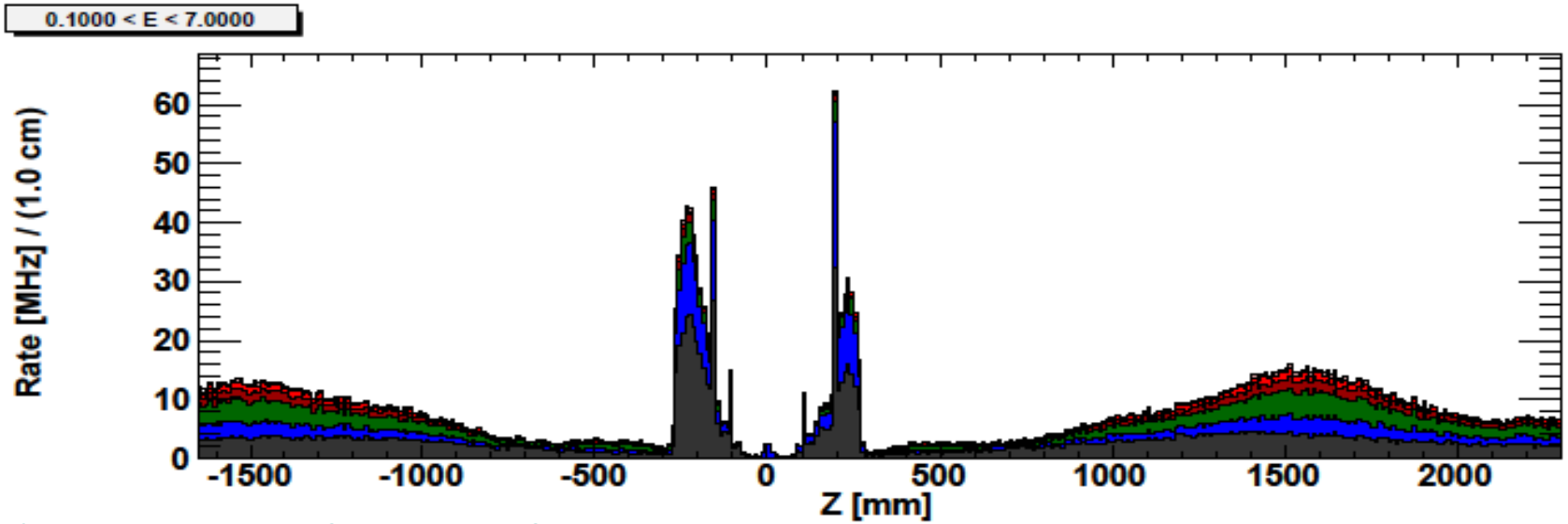
Tungsten shield studies: results

Photon flux: Tungsten shield thickness 4.5cm





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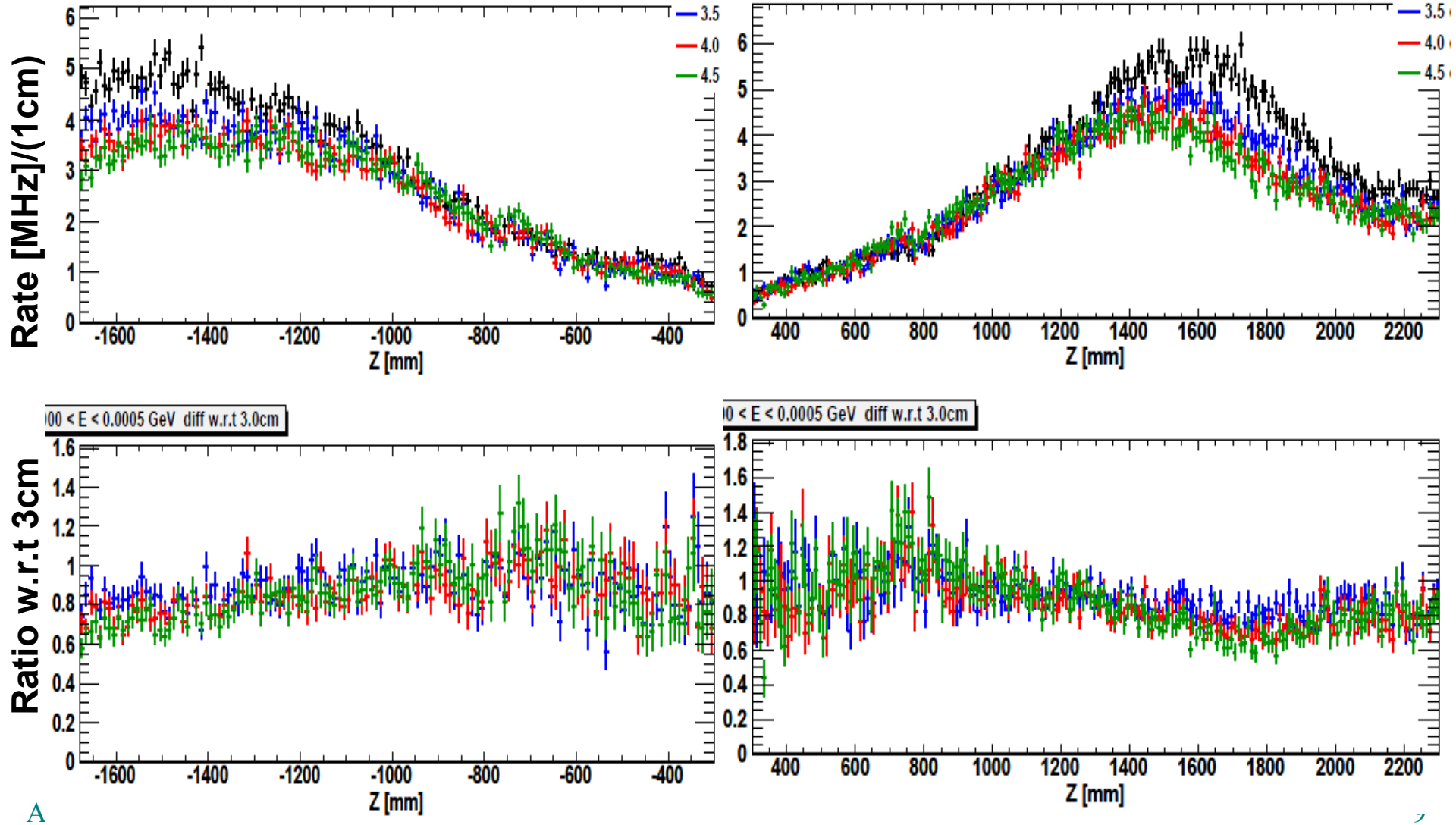
Tungsten shield studies: results

3.0 cm
3.5 cm
4.0 cm
4.5 cm

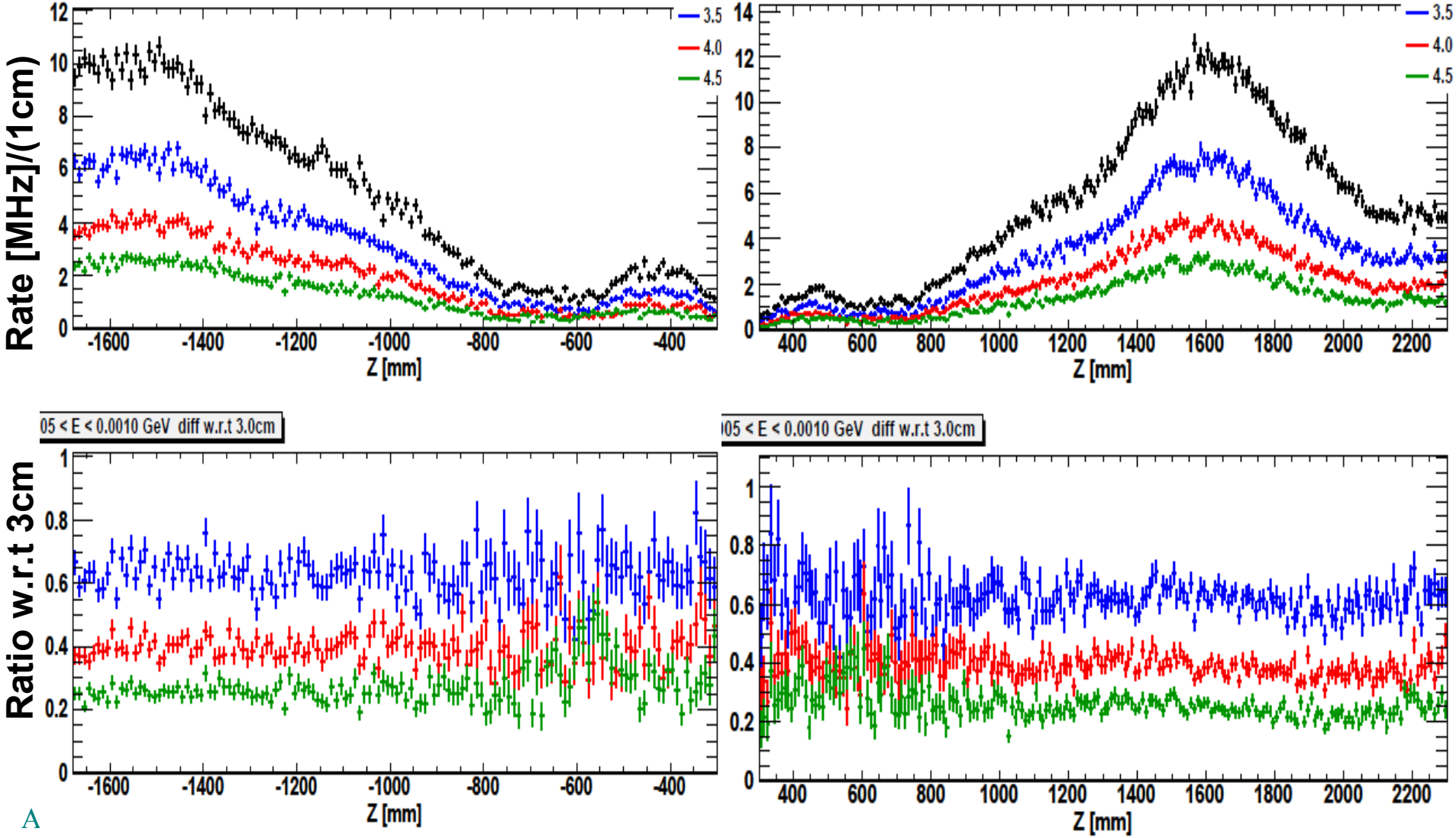
Photon flux comparisons: γ E (0,0.5)MeV



Tungsten shield studies: results

3.0 cm
3.5 cm
4.0 cm
4.5 cm

Photon flux comparisons: γ E (0.5,1.0)MeV



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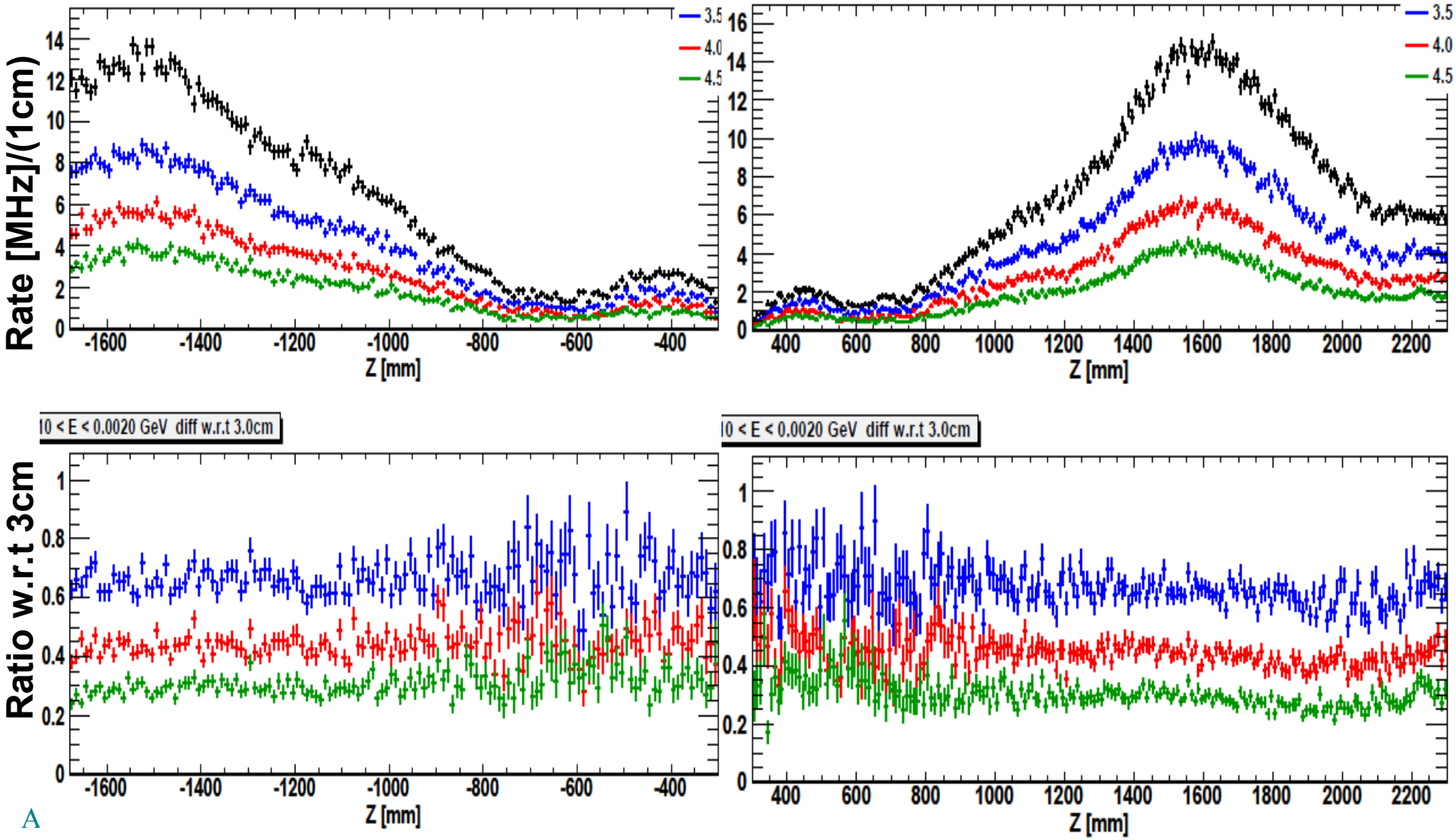
Tungsten shield studies: results

Photon flux comparisons: γ E (1.0,2.0)MeV



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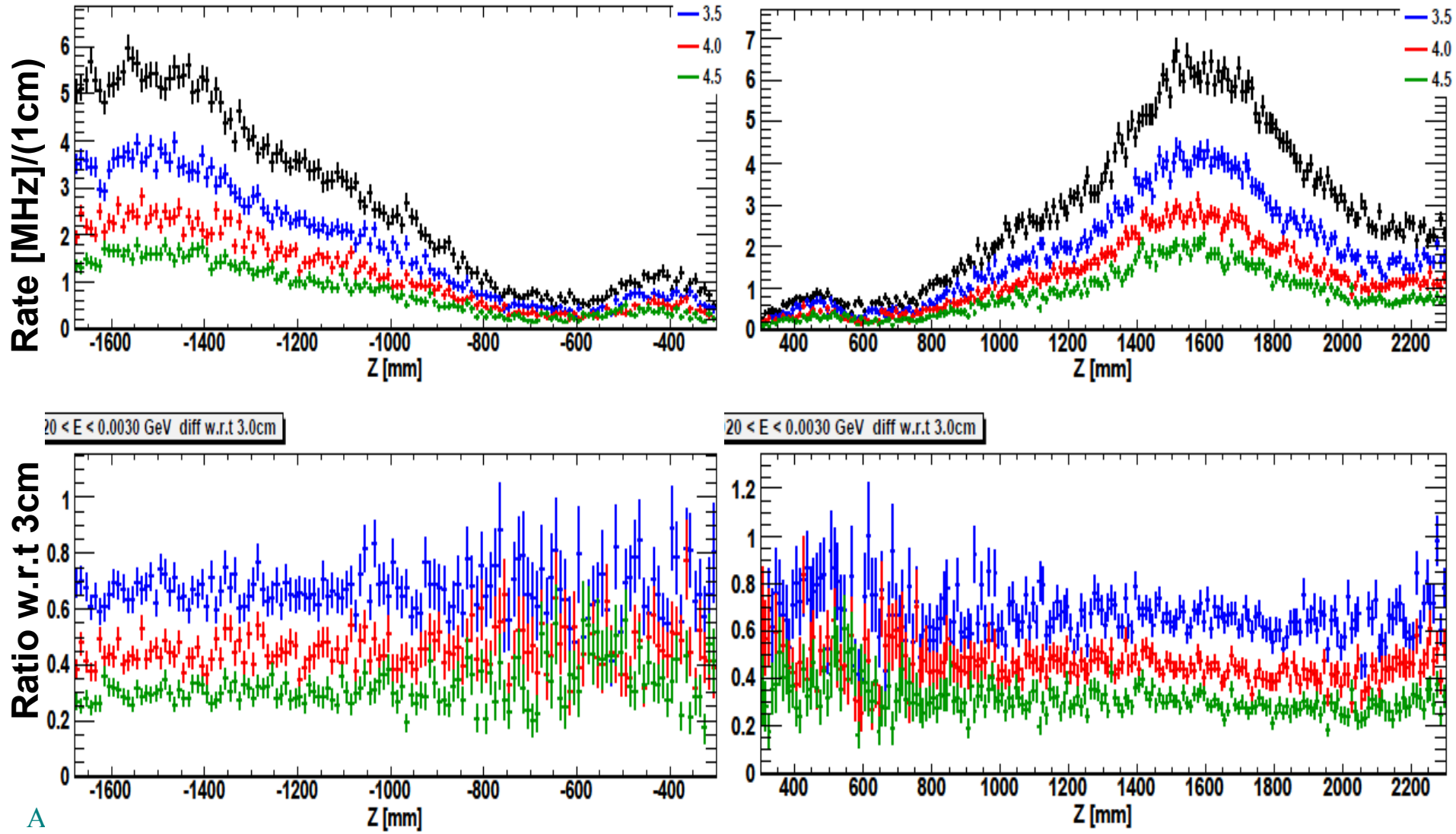
Tungsten shield studies: results

Photon flux comparisons: γ E (2.0,3.0)MeV



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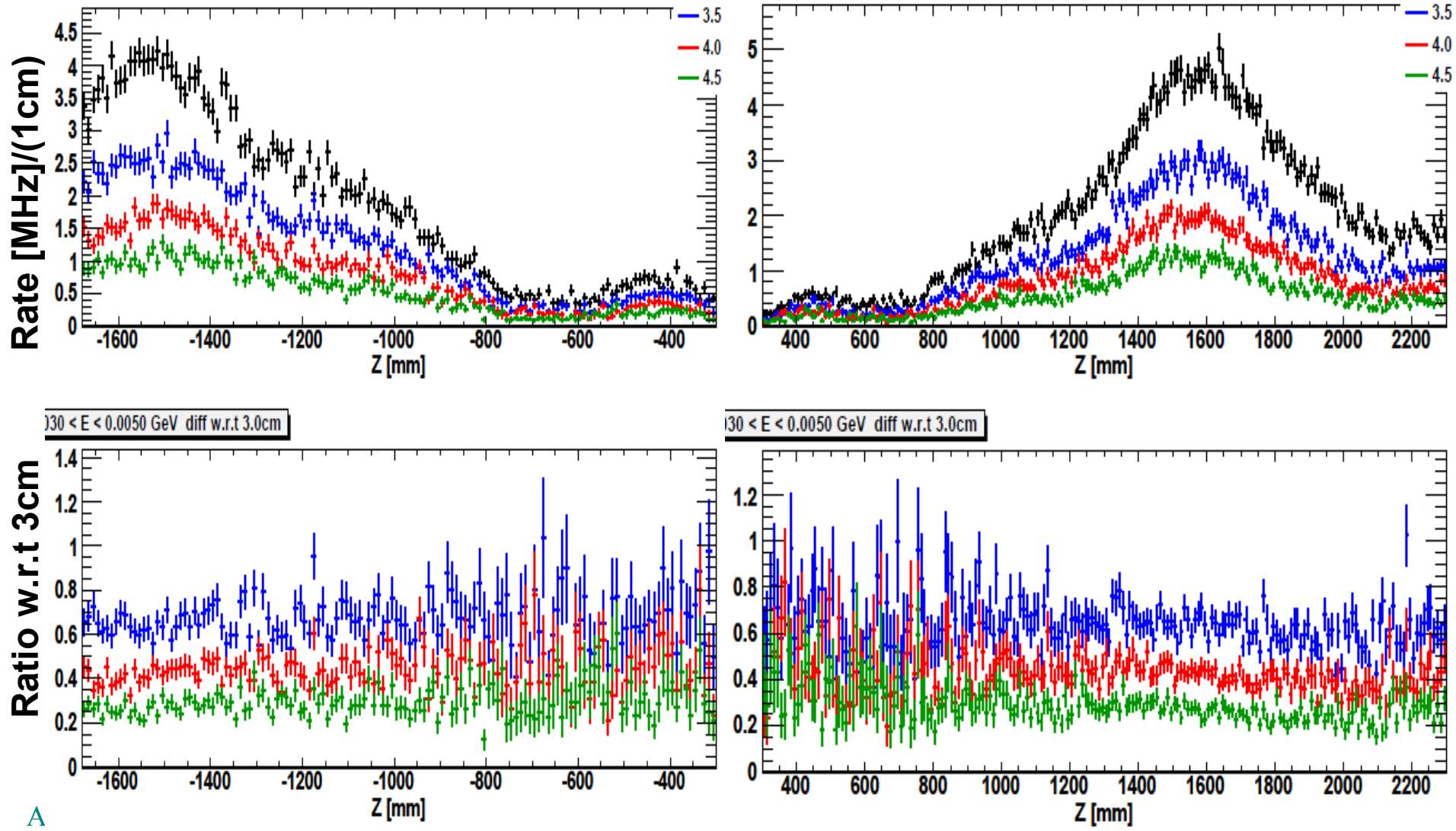
Tungsten shield studies: results

Photon flux comparisons: γ E (3.0,5.0)MeV



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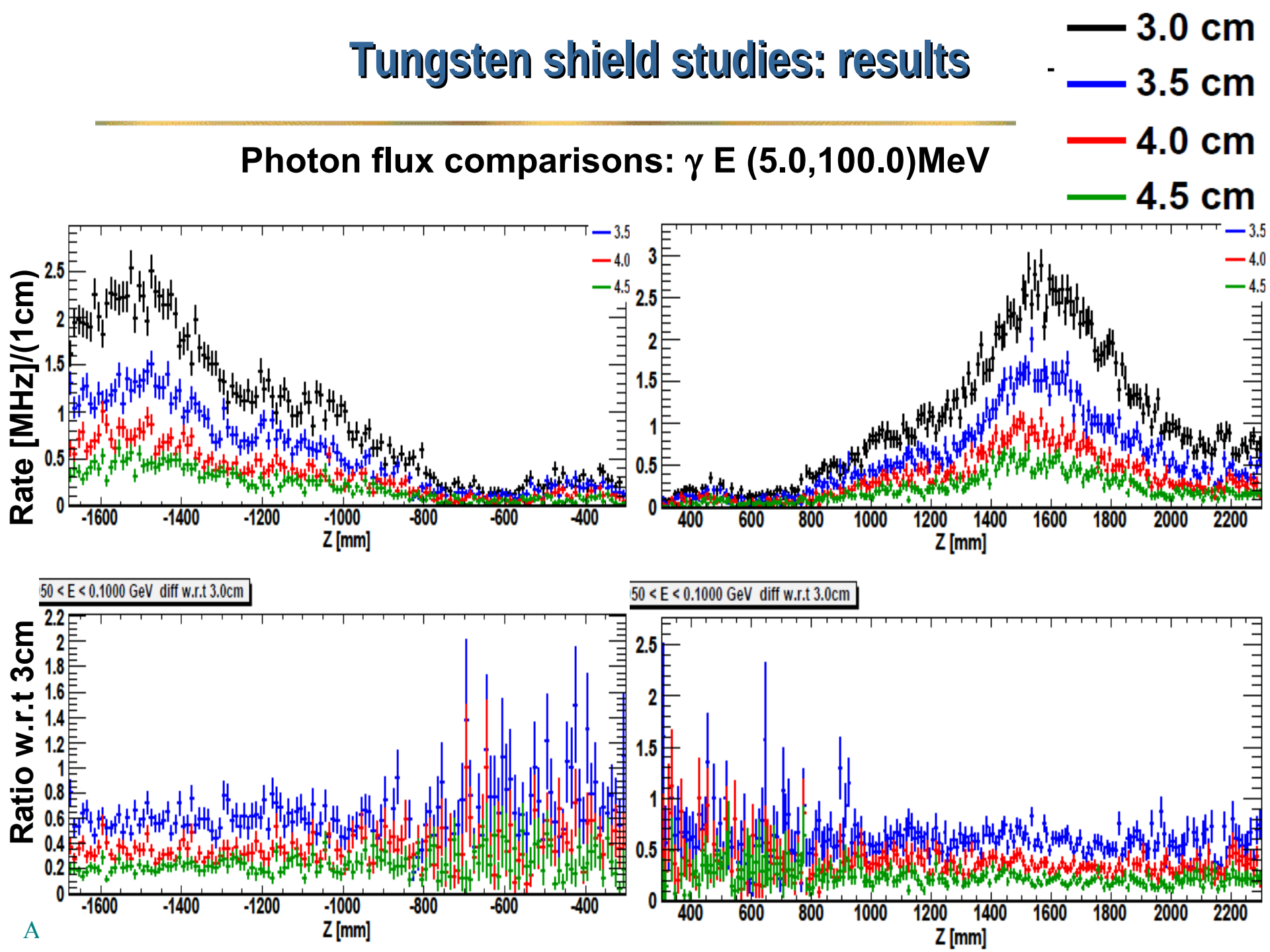
Tungsten shield studies: results

Photon flux comparisons: γ E (5.0,100.0)MeV



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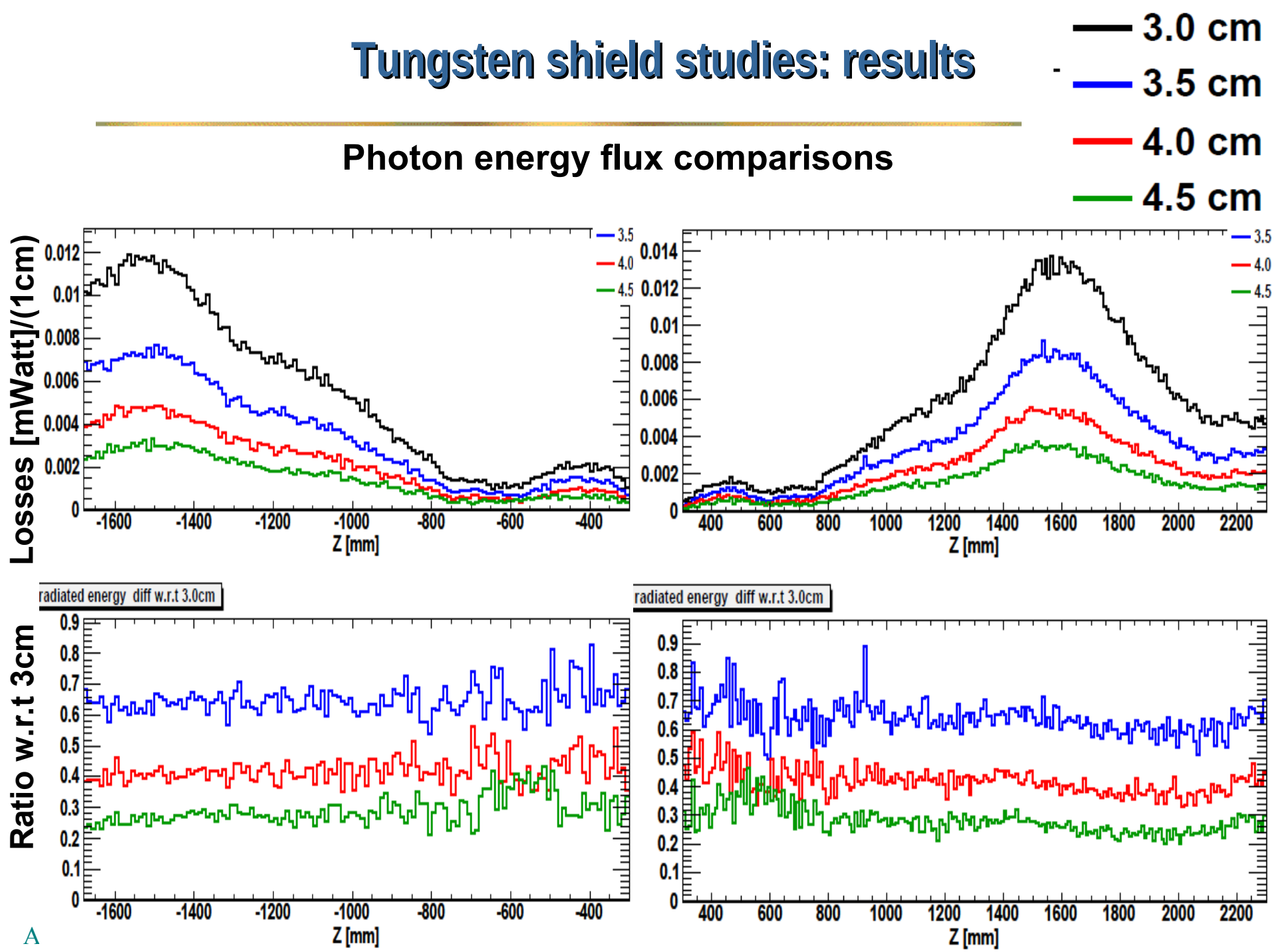
Tungsten shield studies: results

Photon energy flux comparisons



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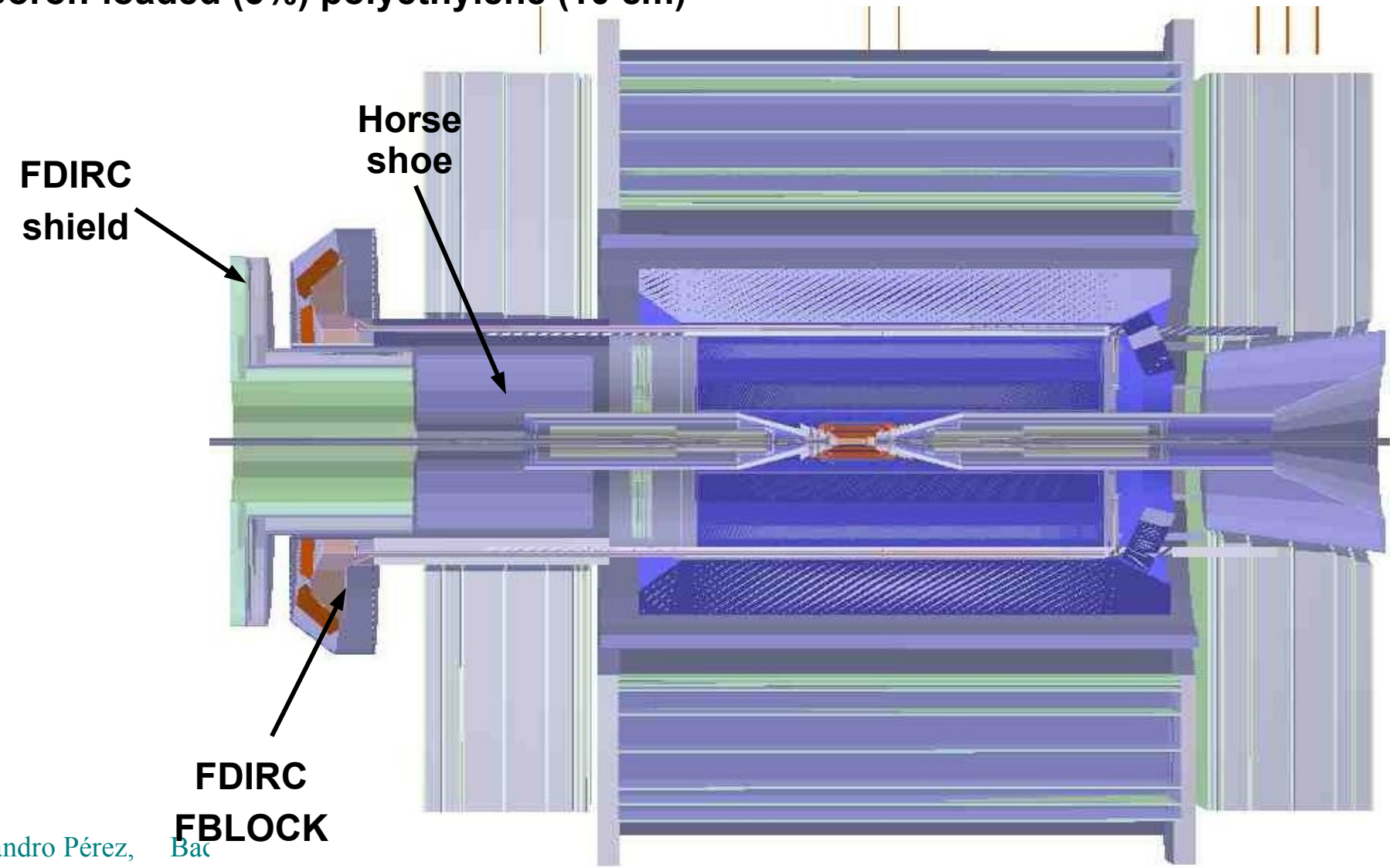
Tungsten shield studies: conclusions

- **Current bkg levels + safety factor gives too high rates on the detector**
- **Wants to reduce bkg levels by a factor of 4-5**
- **Tungsten shield thickness of 4.5cm reduces photon flux (dominant) out of final focus by a factor of ~4-5 ⇒ 4.5cm thickness is the interesting one**
- **The plan for next production is:**
  - Produce Rad-bhabha samples for the tungsten shield thickness of 3.0 (nominal) and 4.5 cm
  - Evaluate the reduction on the bkg rates
- **Issues:**
  - In order to increase tungsten shield thickness reduced the shield internal radius
  - In real life there is no space for doing this ⇒ will need to increase tungsten shield external radius
  - How this affects the DCH? For sure will need to increase DCH internal radius

FDIRC shield: BRN implementation

- Steel-lead-steel sandwich (2.5-10-2.5 cm)
- Boron-loaded (5%) polyethylene (10 cm)



FDIRC shield: BRN implementation

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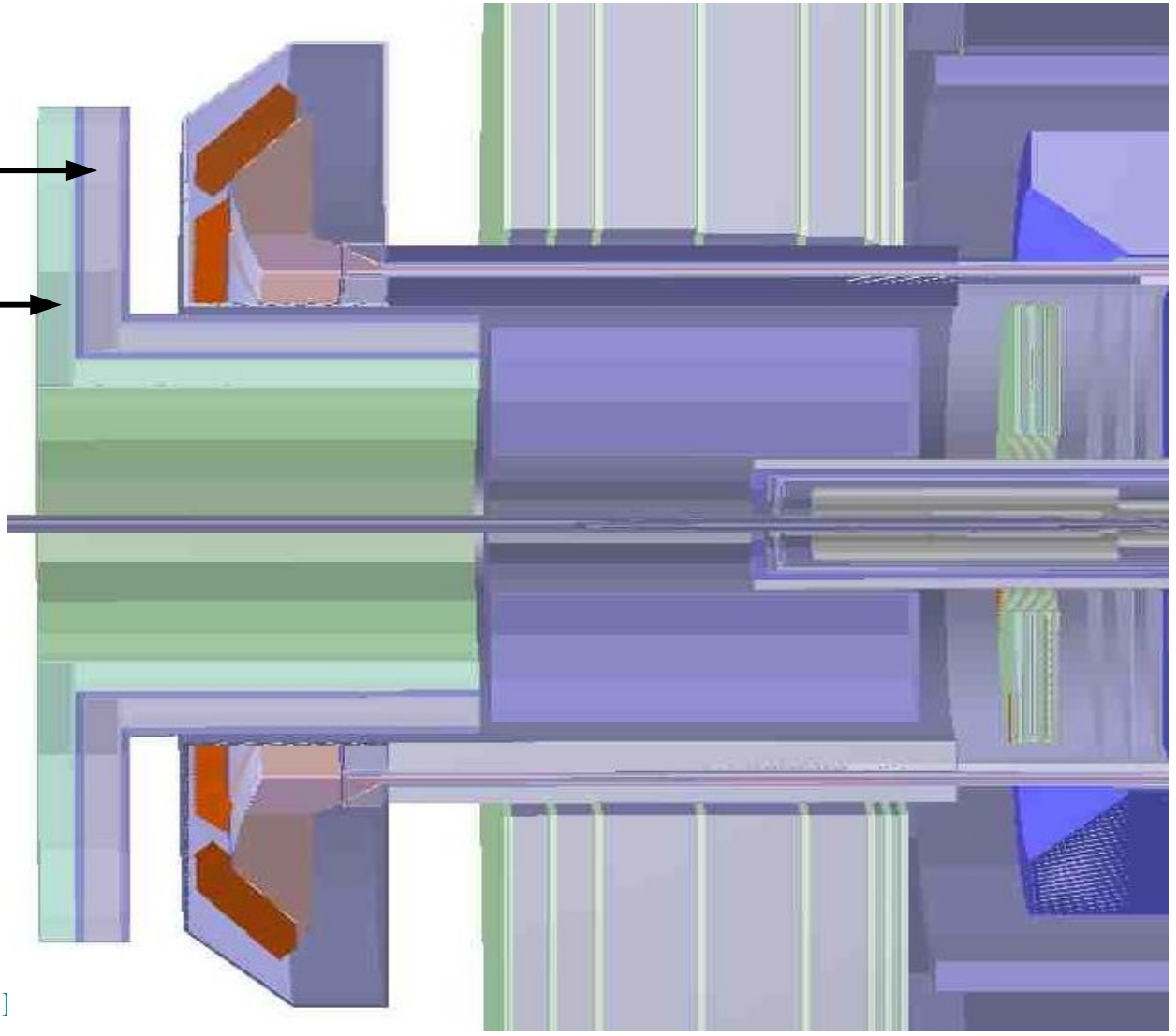
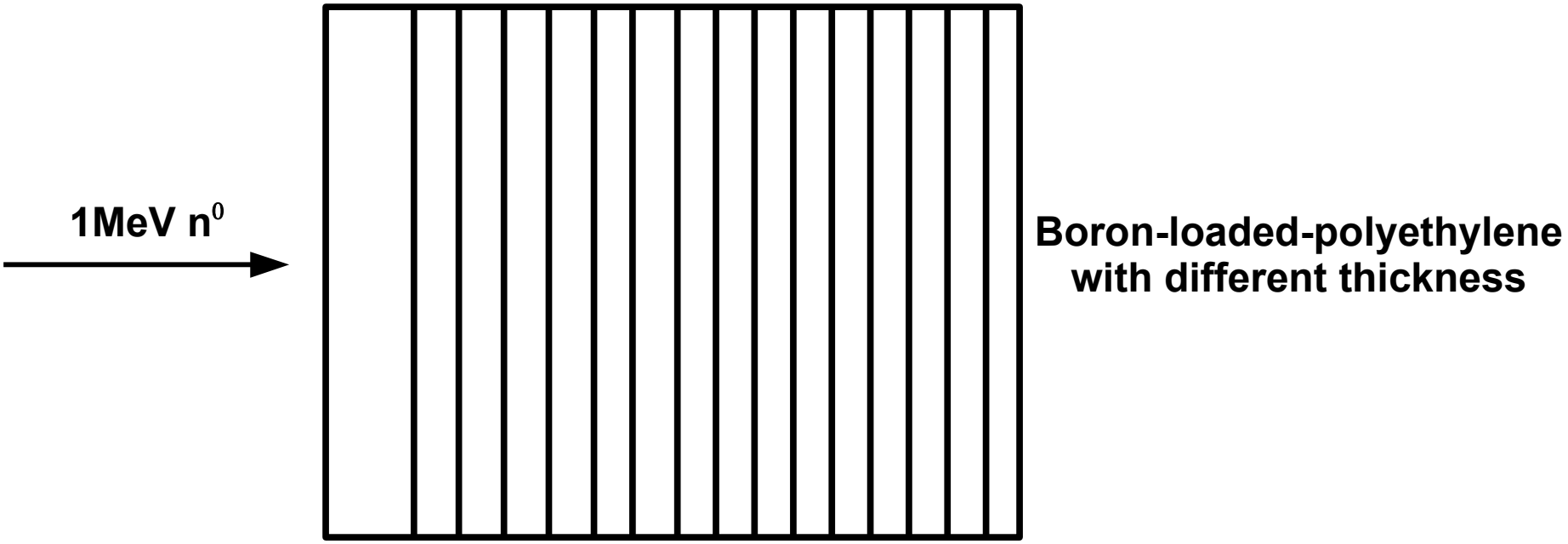
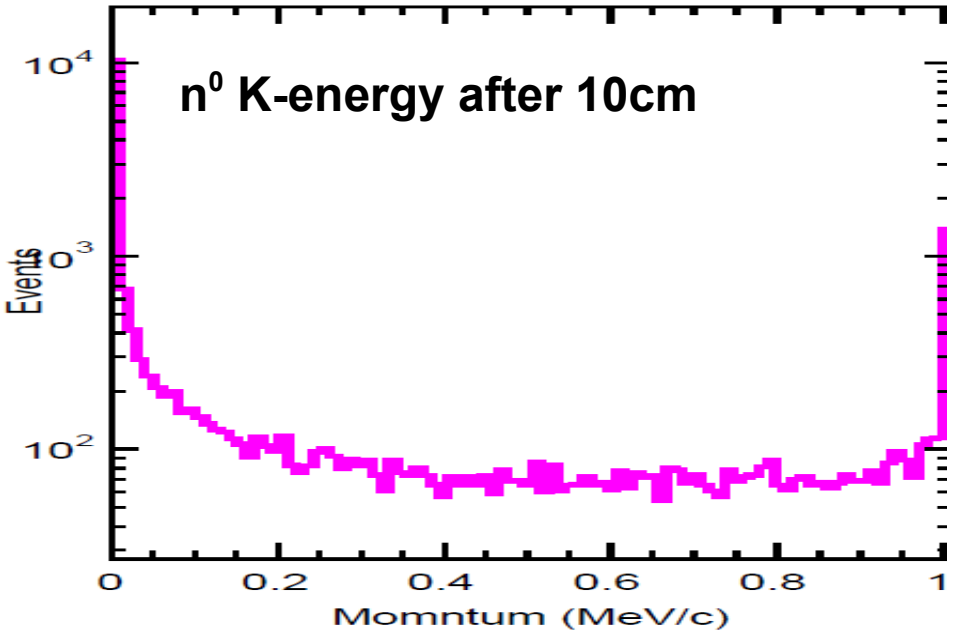


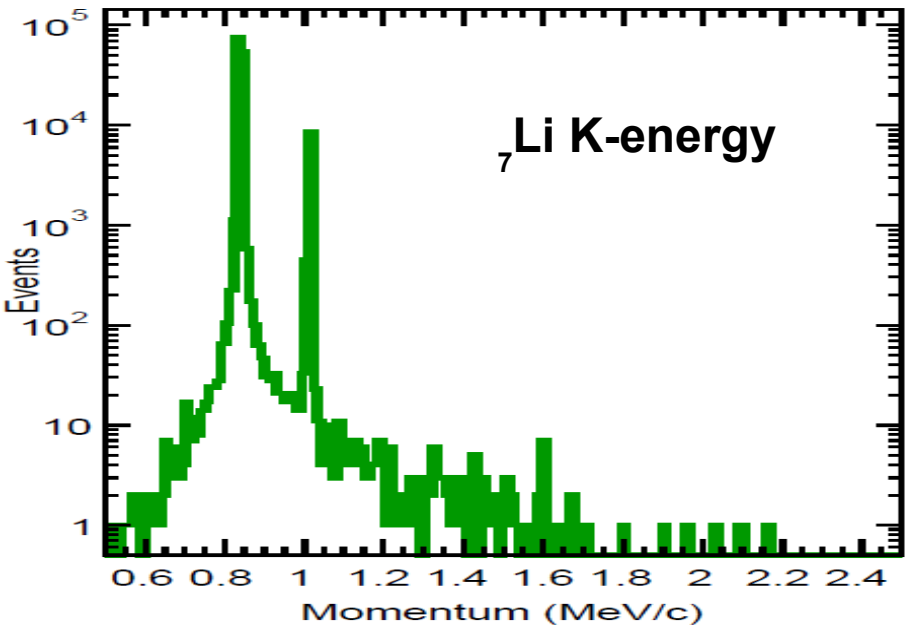
Boron-loaded-polyethylene neutron shield

- **Wants to test if Geant4 is able to correctly simulate the neutron moderation by polyethylene (thermalization of 1μs) and absorption by Boron-10**
- **Strategy:**
  - Shot 1MeV neutrons at normal incidence on boron-loaded-polyethylene
  - Different thickness: 1 – 40 cm (1cm steps)
- **Study the particle multiplicity and spectrum at the other end of the shield**

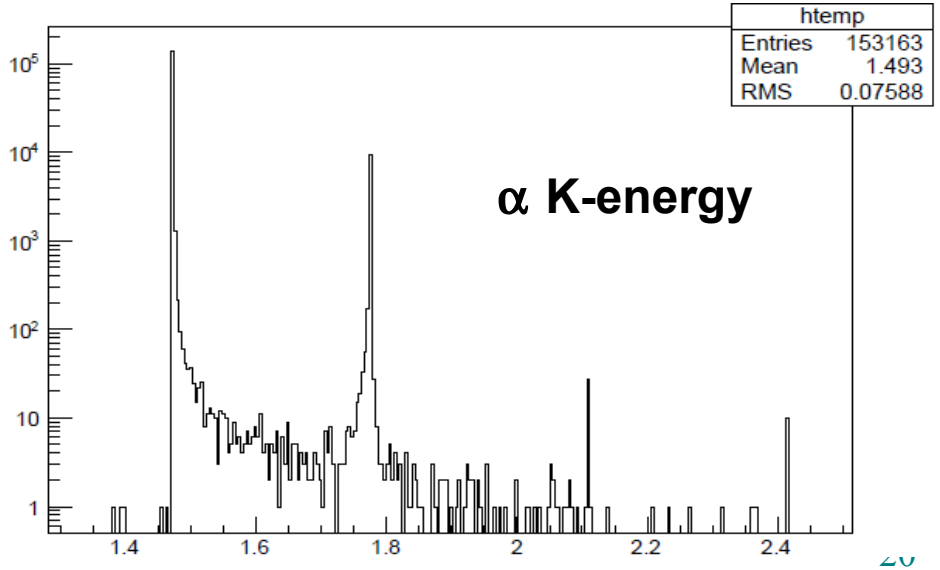


Boron-loaded-polyethylene neutron shield

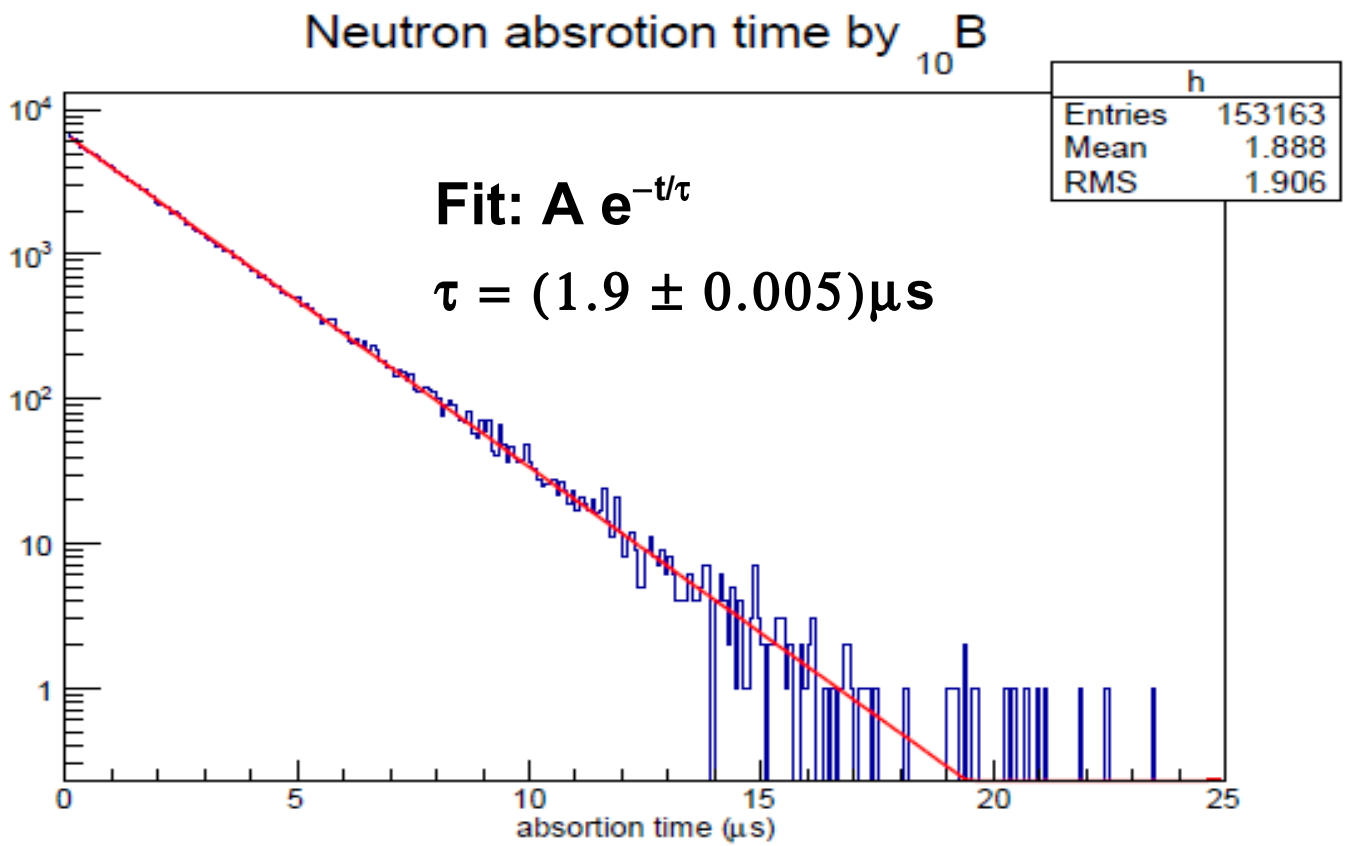




- After 10cm of Boron-loaded-polyethylene around 92.5% of the neutrons are absorbed
- Main absorption mechanism is Boron capture
  - $_{10}B(n,\alpha)_7Li$
  - $_{10}B(n,\alpha)_7Li^*(\rightarrow{}_7Li+\gamma)$

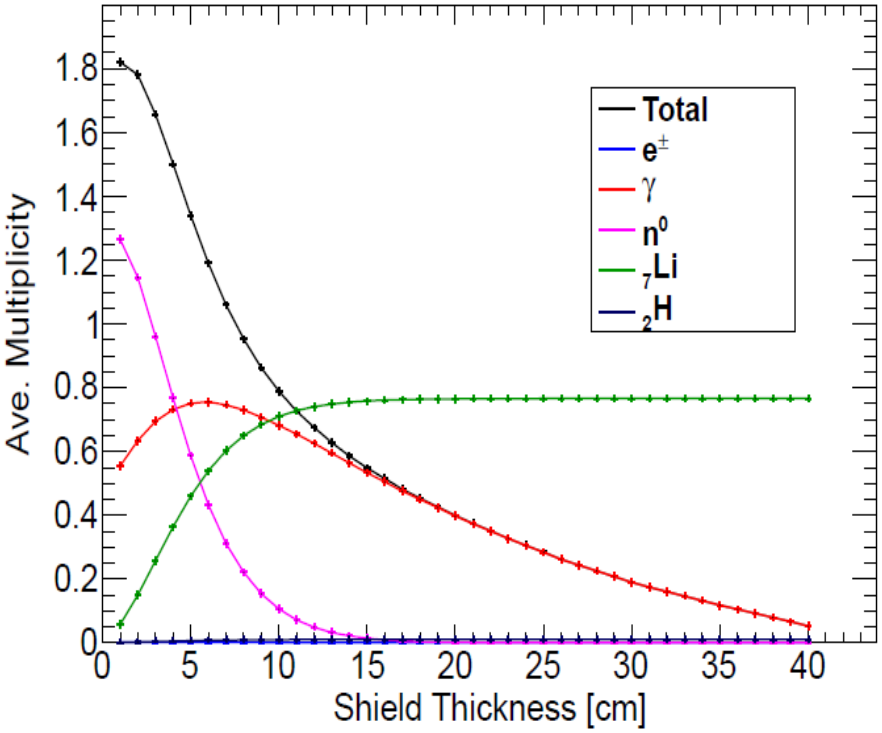


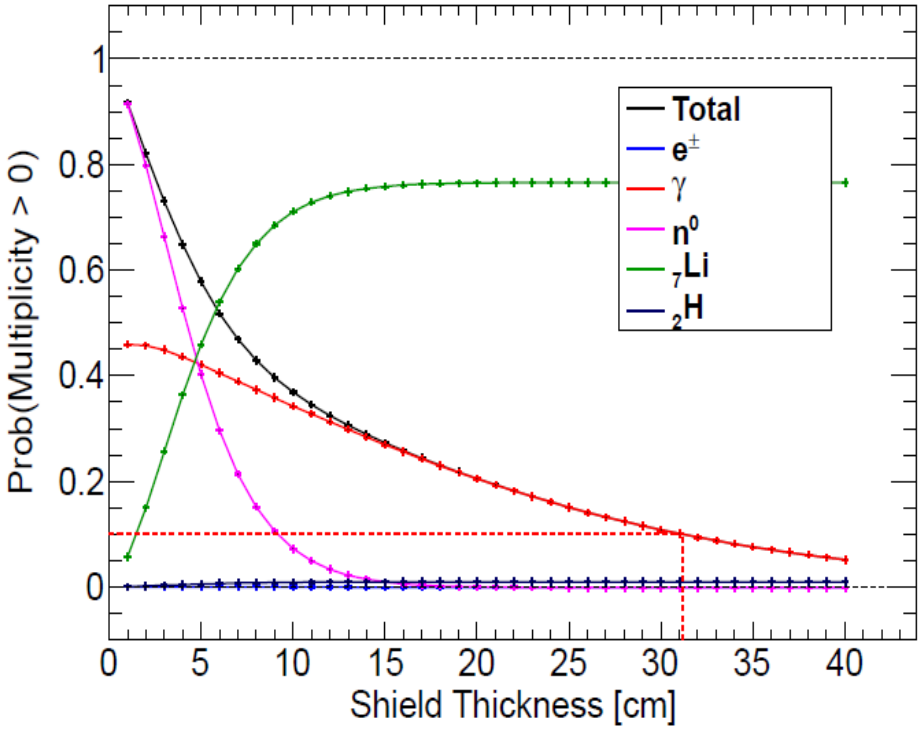
Boron-loaded-polyethylene neutron shield



- The time of neutron absorption by $_{10}$B is an exponential with mean time 1.9μs
- Neutron thermalization time in polyethylene is 1μs
- Is the absorption time of 1.9μs reasonable?

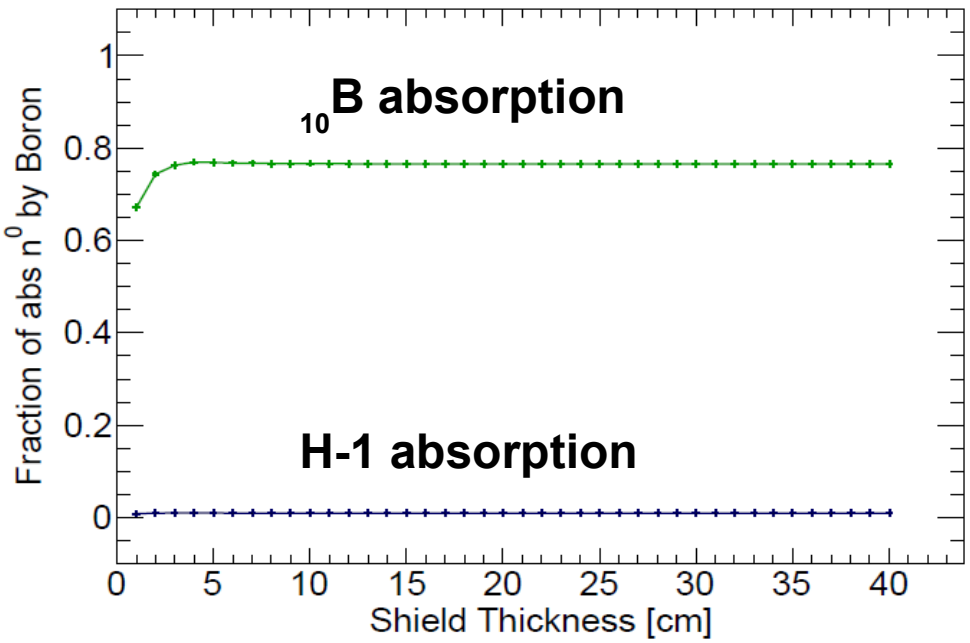
Boron-loaded-polyethylene neutron shield

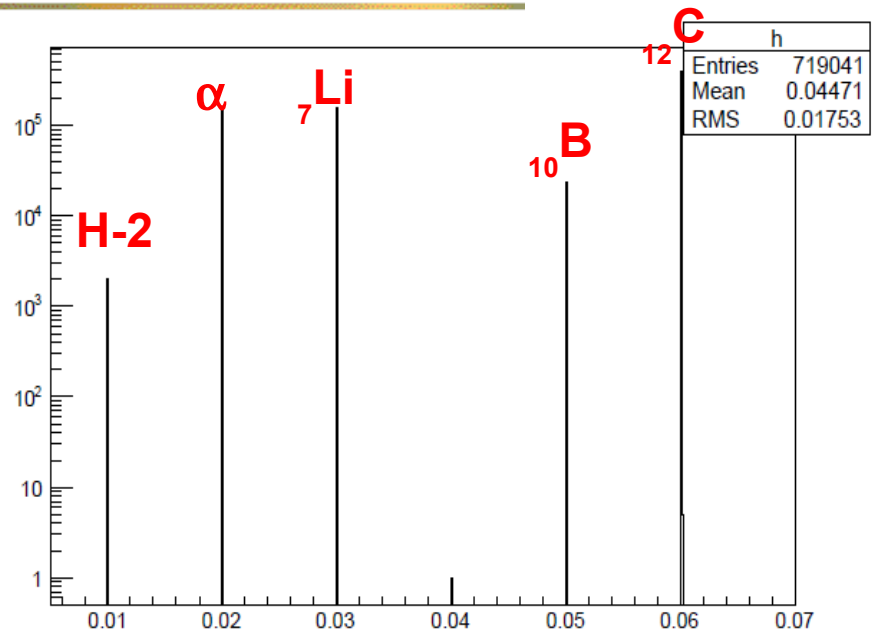




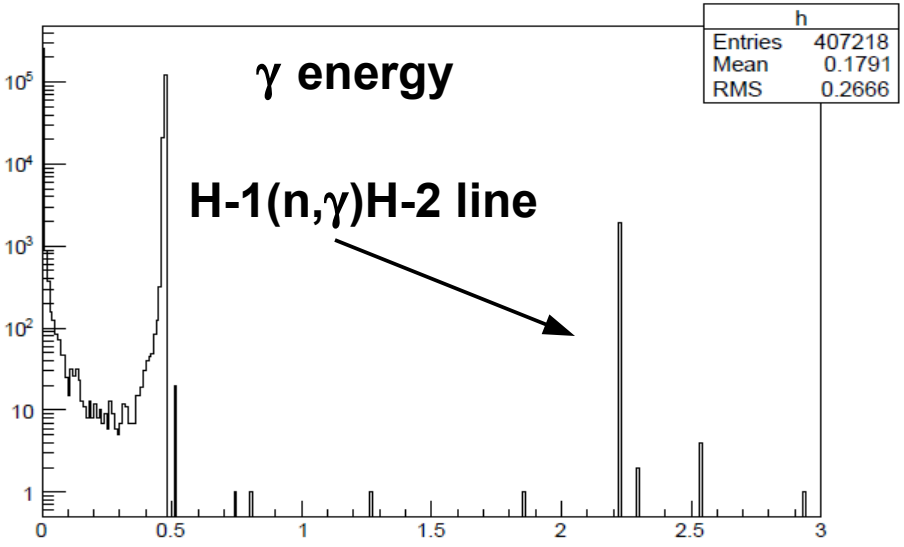
- **Neutron (magenta curve) multiplicity (left plot) get reduced when increasing shield thickness. At 10cm neutron flux is reduced up to 7.5% (right plot)**
- **$_7$Li ion (green curve) multiplicity increases with shield thickness**
- **Not all the absorbed neutrons are due to Boron**

Boron-loaded-polyethylene neutron shield





- Around 80% of the absorbed neutrons are due to $_{10}B$
- A small fraction is due to H-1(n,γ)H-2
- Are there any other absorption processes with Carbon, Hydrogen and Boron?



Boron-loaded-polyethylene neutron shield: conclusions

- **Geant4 seems to simulation correctly the neutron thermalization and capture on Boron-loaded-polyethylene**
- **Not all the capture neutrons are due to $_{10}$B capture (~80%)**
- **Want to understand the capture process. Any hits?**

- **Jerry Va'vra Suggested and additional exercise to test for Geant4 neutron production**
  - Shot 5GeV electrons on a Copper slab
  - Compare the outgoing neutron flux with FLUKA results


Backup