# High Z shields and final doublet doses

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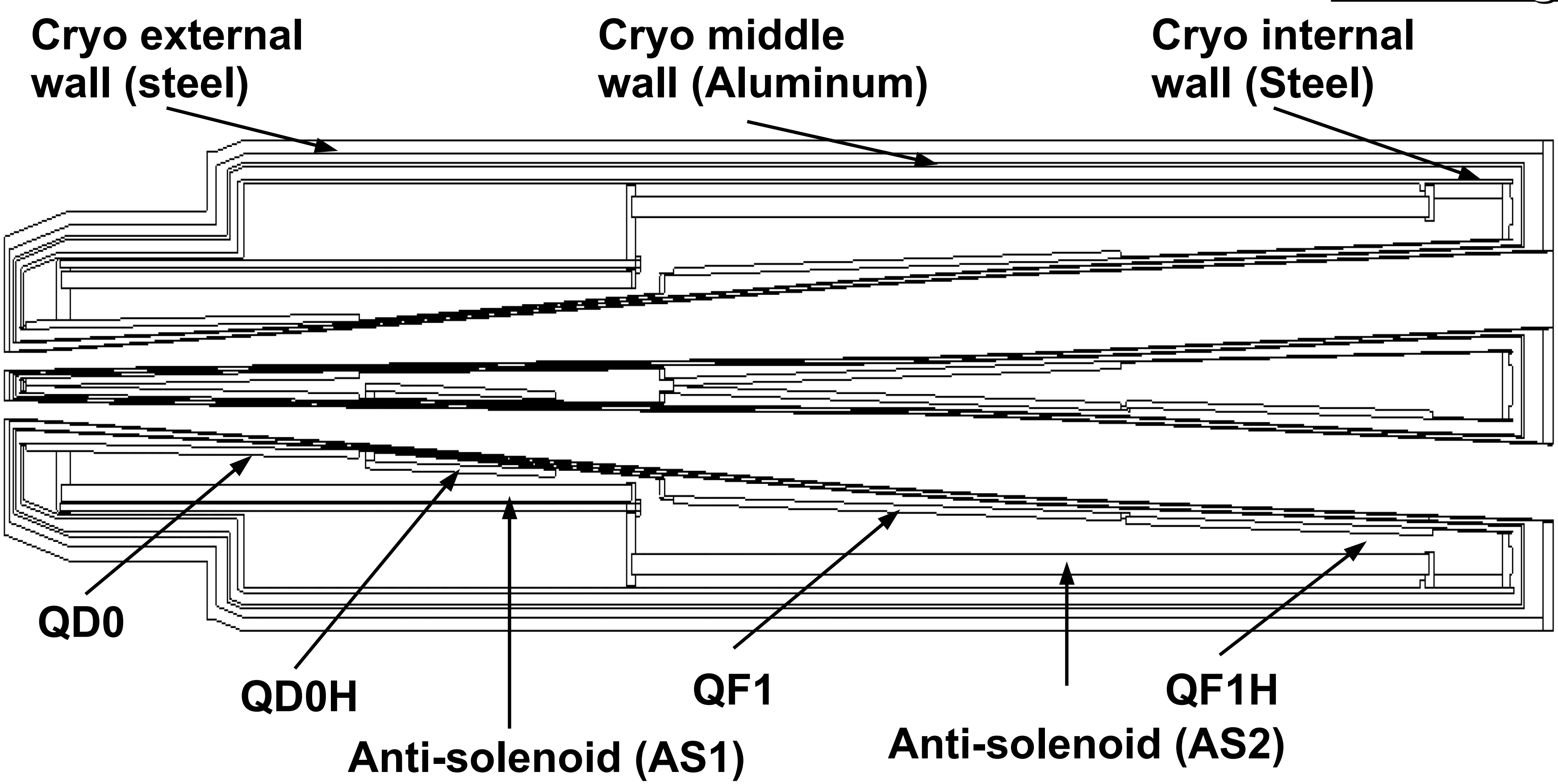
**Elba SuperB Collaboration Meeting**

# Outline

- **Final focus (FF) model**
  - Geometry: Super-conducting magnets and Cryostat
- **High Z**
  - Shield studies strategy: W-shield different thickness and U-shield
  - Results
- **Absorbed doses on the super-conducting magnets**
  - Strategy
  - April 2012 fullsim production
  - Results from latest fullsim production
  - Comparison of doses for aligned/not-aligned magnetic model
- **Summary**

# FF model: Cryostat and Magnets (I)

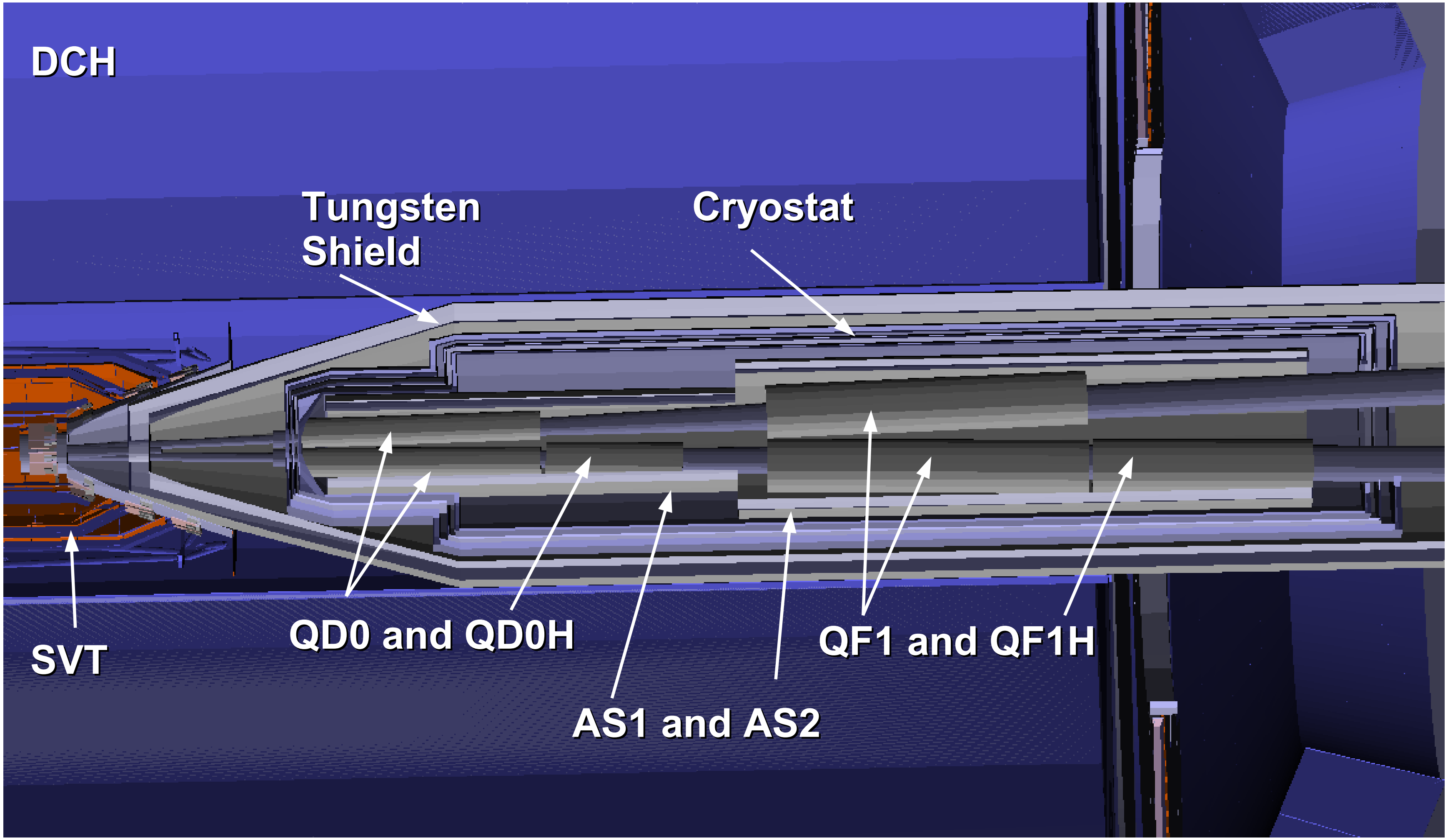
**Filippo Bosi Drawings**



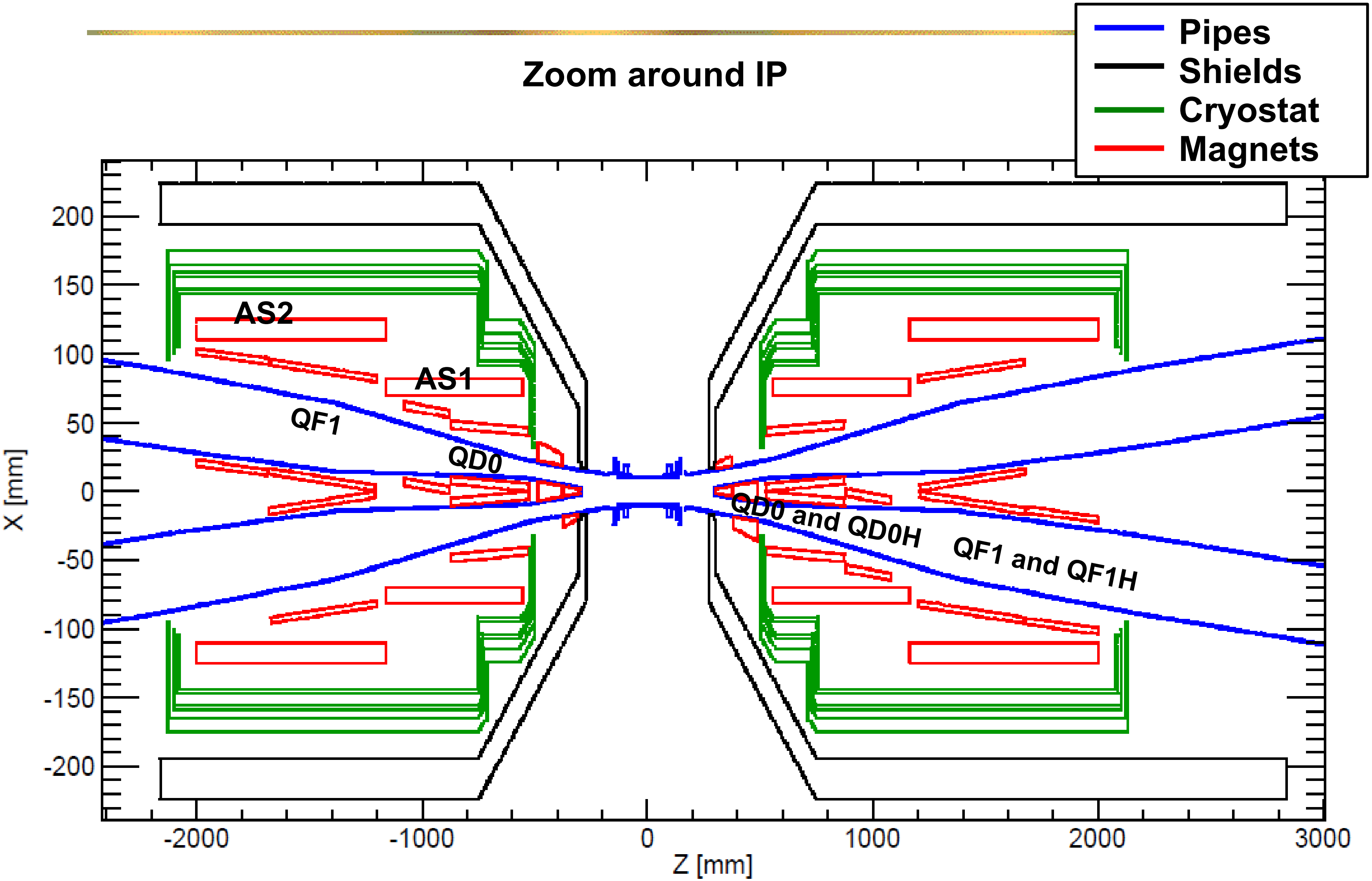

- **All magnetic elements are made of the same material (QD0_mixture):**
  - Density: 3.44 gr/cm$^3$
  - Composition: Nb (0.062), Ti (0.069), Cu (0.206) and Al (0.663)

# FF model: Cryostat and Magnets (II)

## BRN implementation

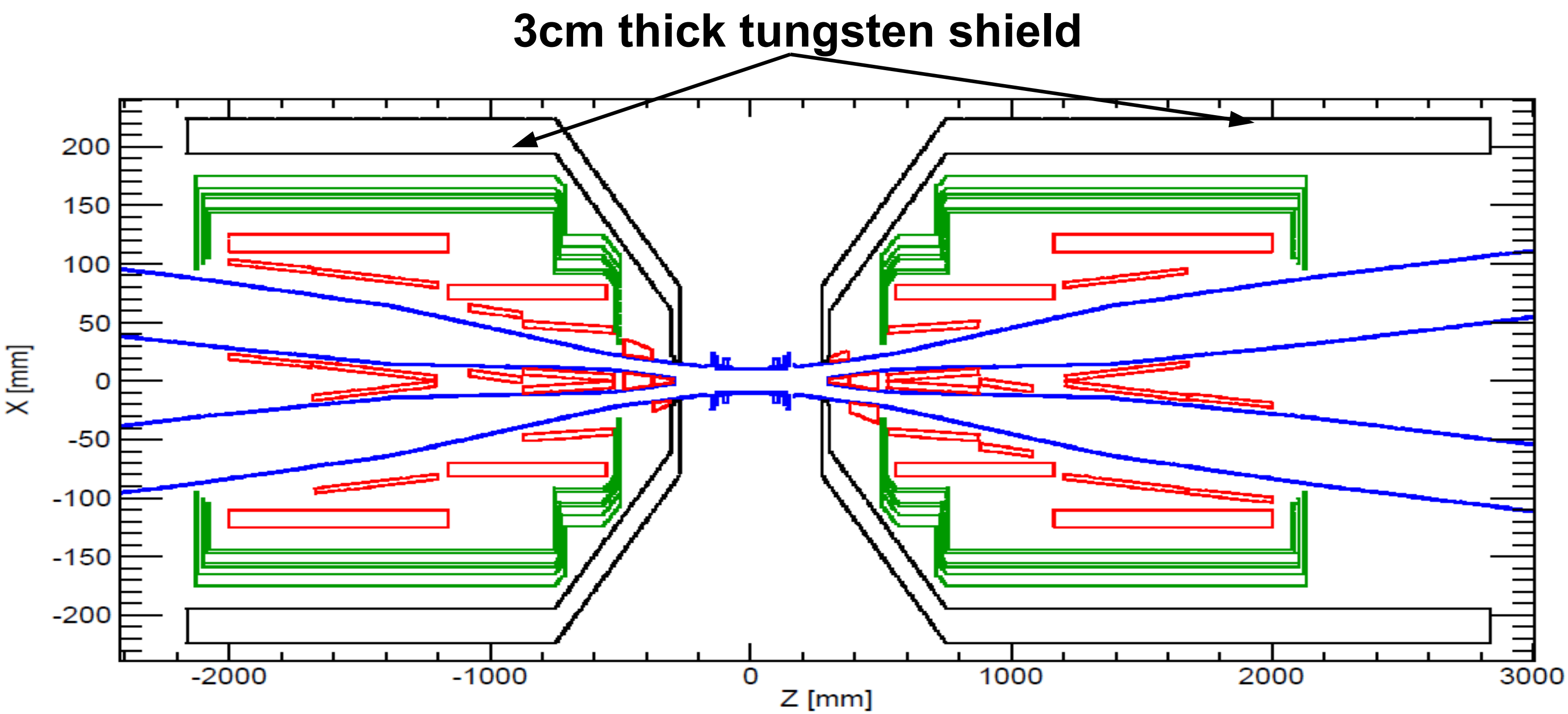


# FF model: Cryostat and Magnets (III)



# Shield studies: current configuration

- **Current shield configuration:** W-shield which is a cone+cylinder 3cm thick going from 27 to 284 cm (-27 to -216 cm) in the Fwd (Bwd)

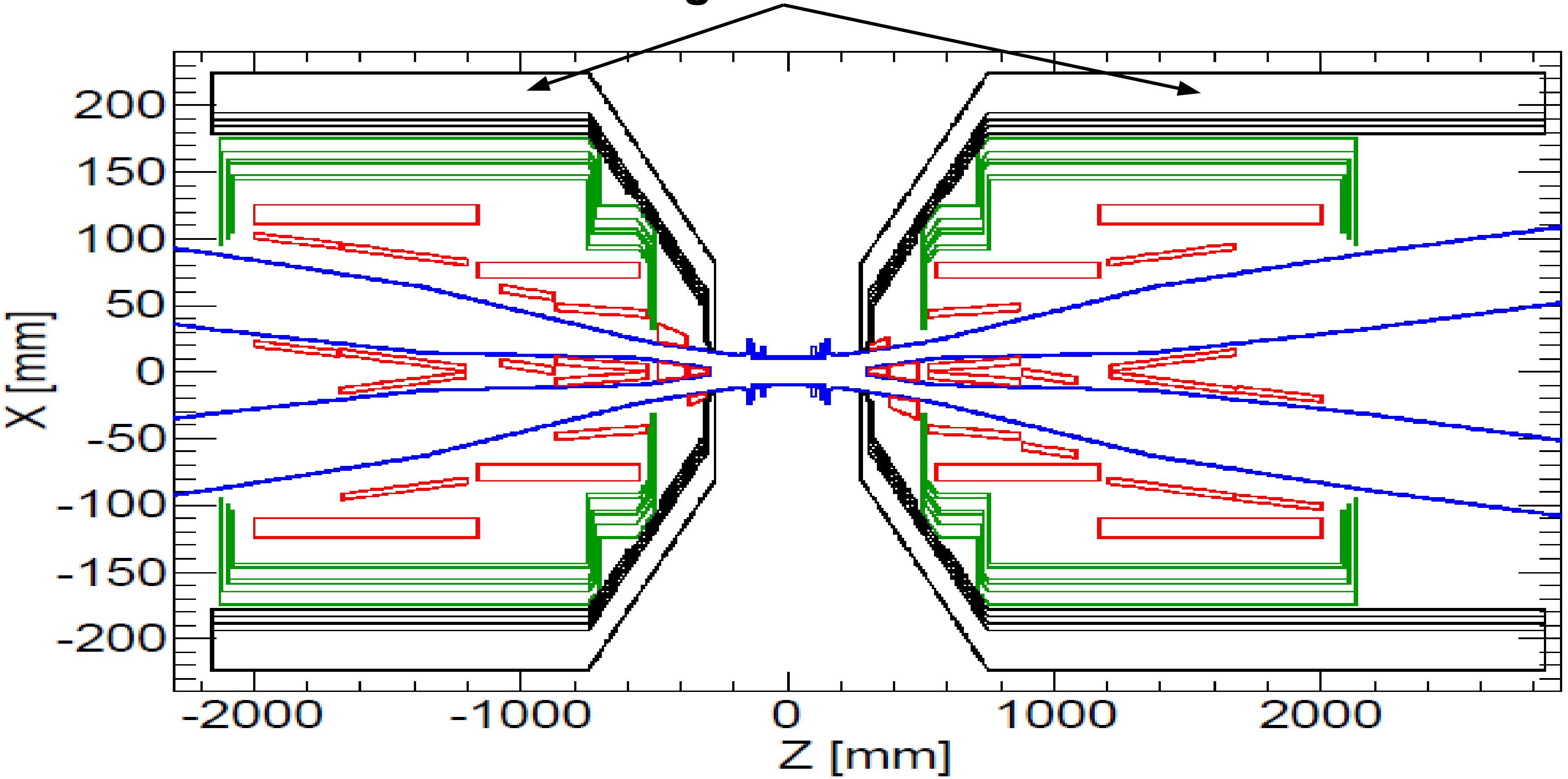



- **Nominal bkg rates seems to be OK. Rates too high when applying safety factor $\times 5$ (not true for all detectors)**
- **If could reduce nominal bkg-rates by a factor of 4-5 $\Rightarrow$ Rates with safety factor should be OK**

# Shield studies: strategy

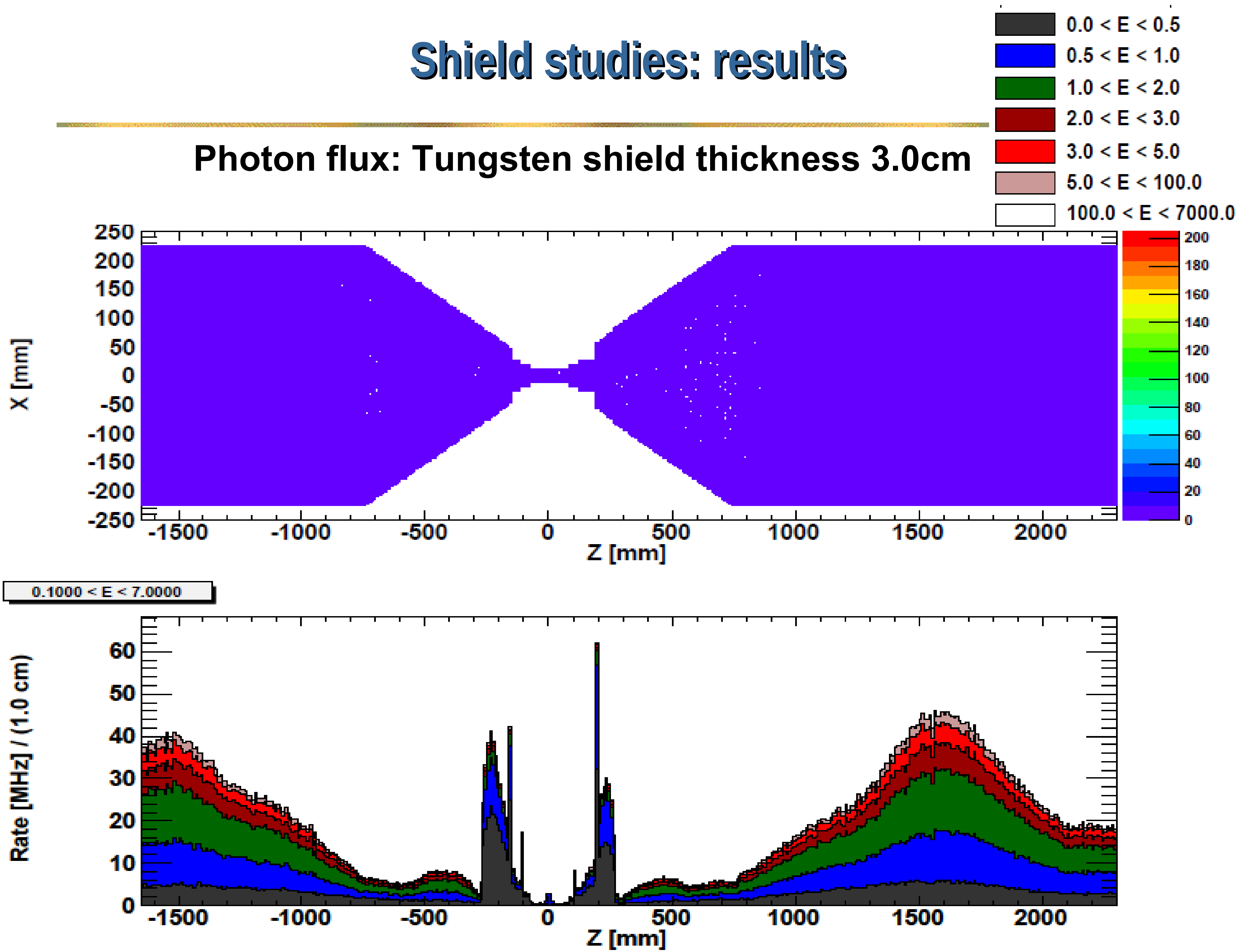
- Study reduction of Rad-bhabha flux of particles escaping the final focus:
  - Different W-shield thickness: 3.0 to 4.5 cm (step 0.5cm)
  - Different shield material: Depleted Uranium of 3cm thick (lower radiation length and higher density)

**Different tungsten shield thickness**



# Shield studies: results

## Photon flux: Tungsten shield thickness 3.0cm

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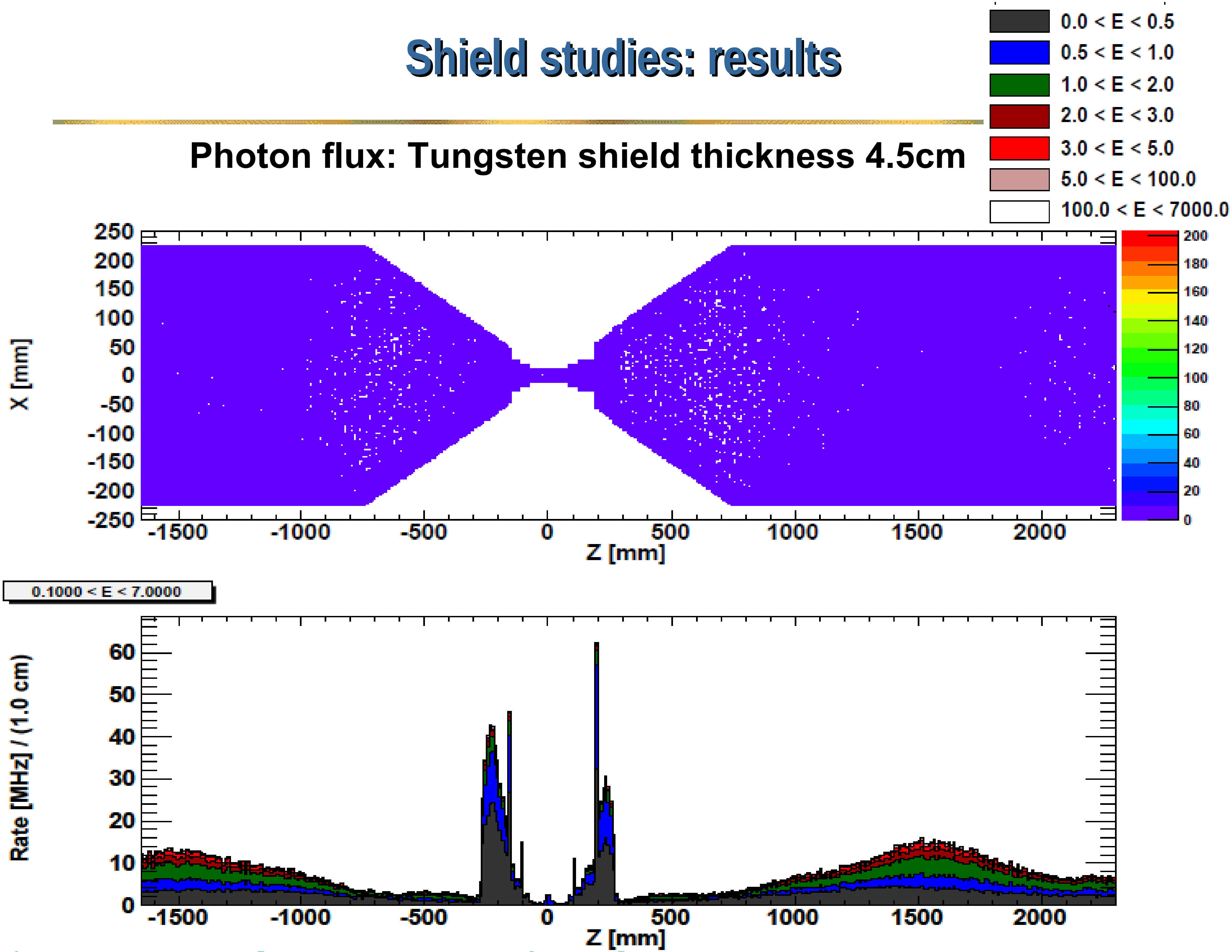
# Shield studies: results

## Photon flux: Tungsten shield thickness 4.5cm

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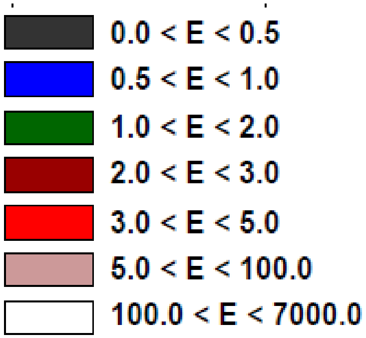
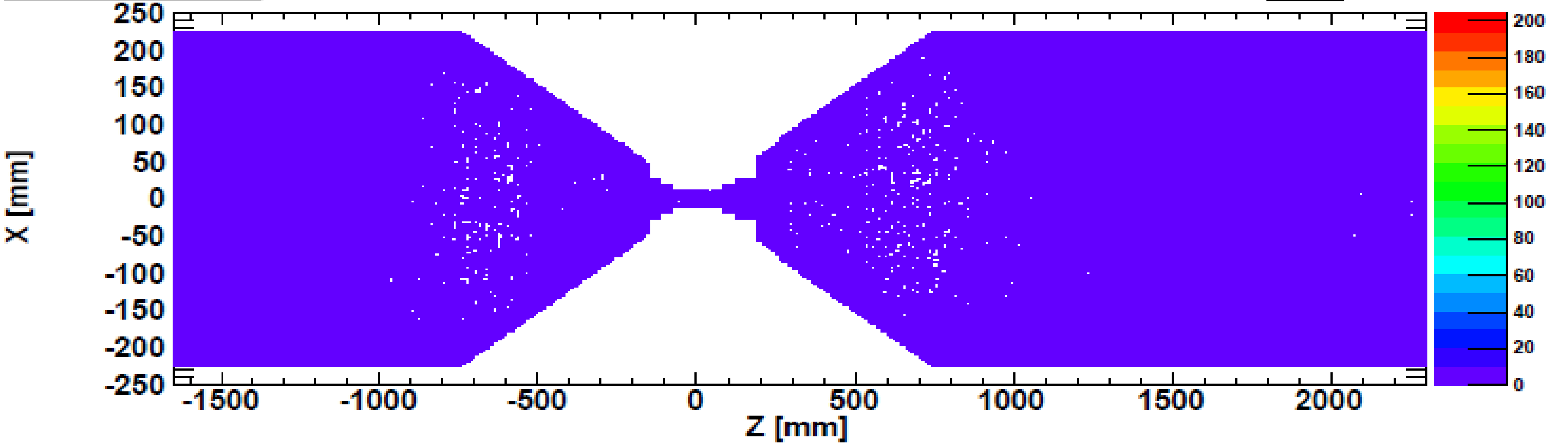
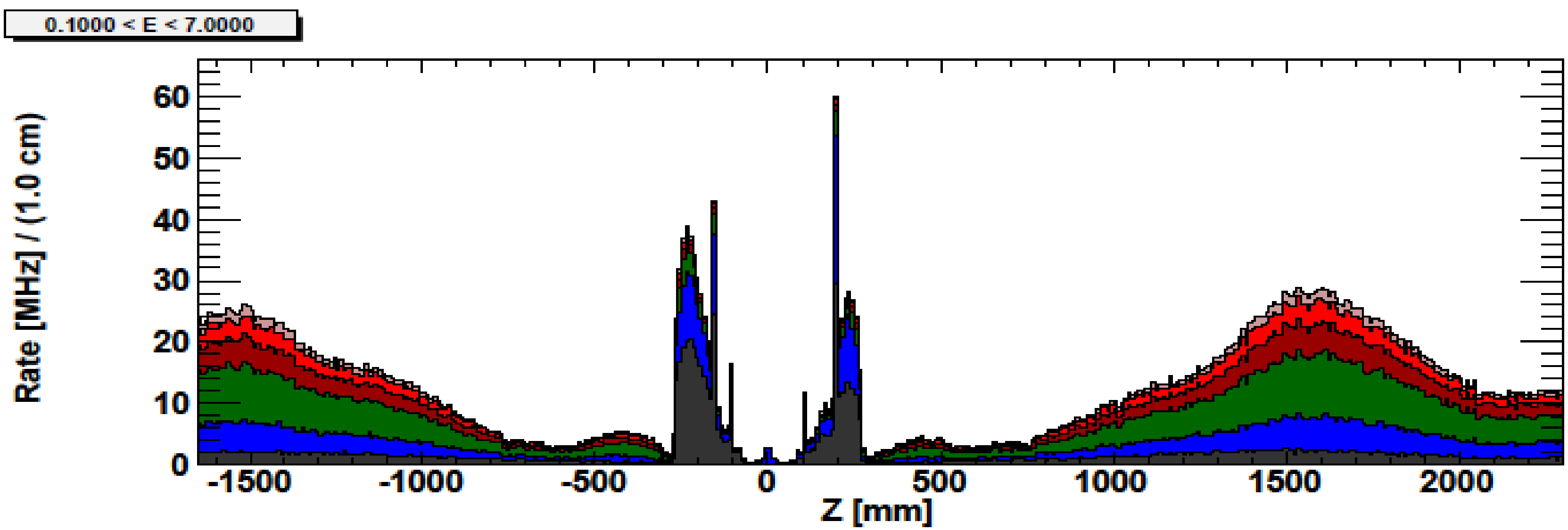
# Shield studies: results

## Photon flux: Depleted U shield thickness 3.0cm

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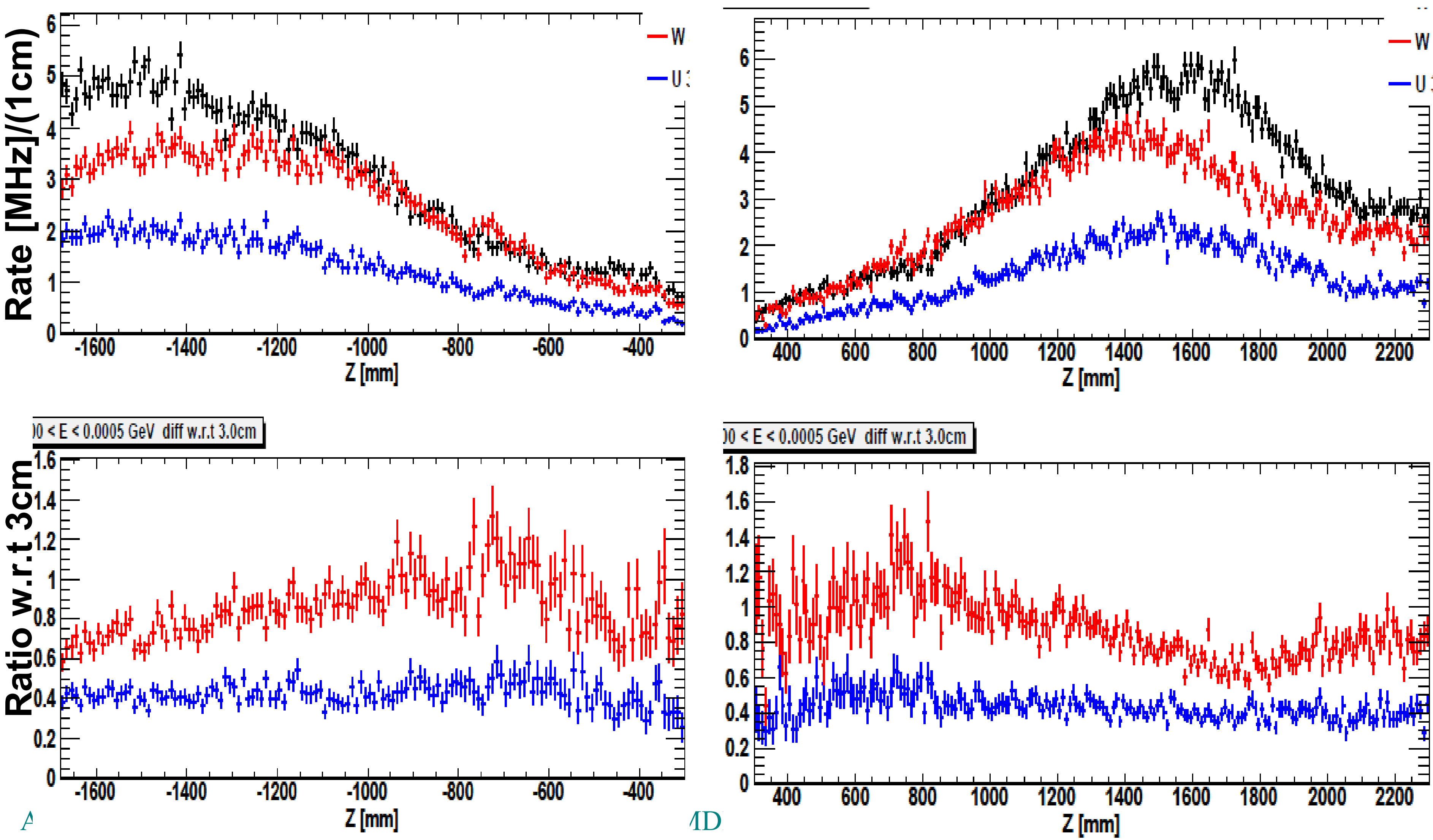
# Shield studies: results

W 3.0 cm
W 4.5 cm
U 3.0 cm

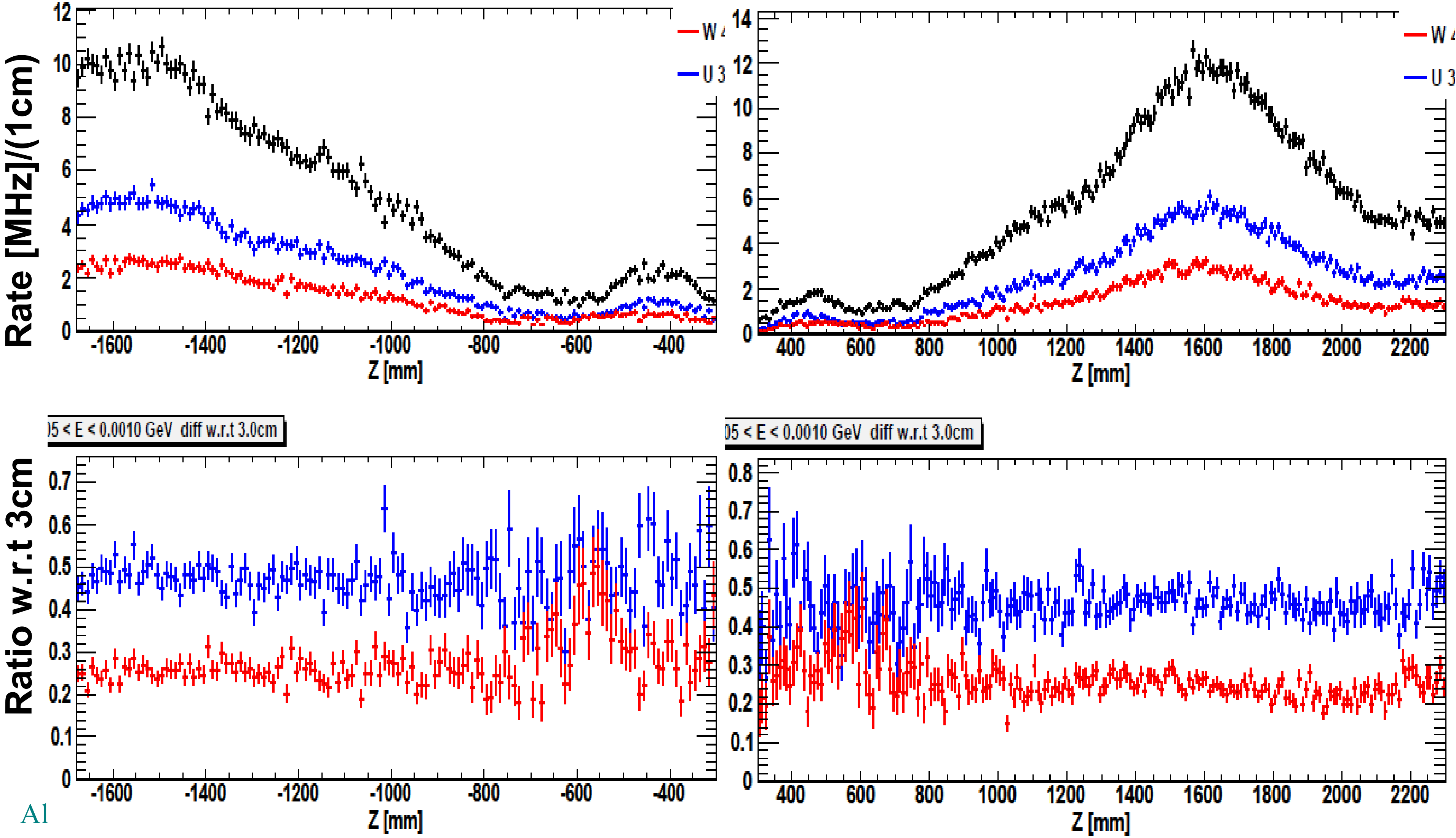
**Photon flux comparisons: γ E (0,0.5)MeV**



# Shield studies: results

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

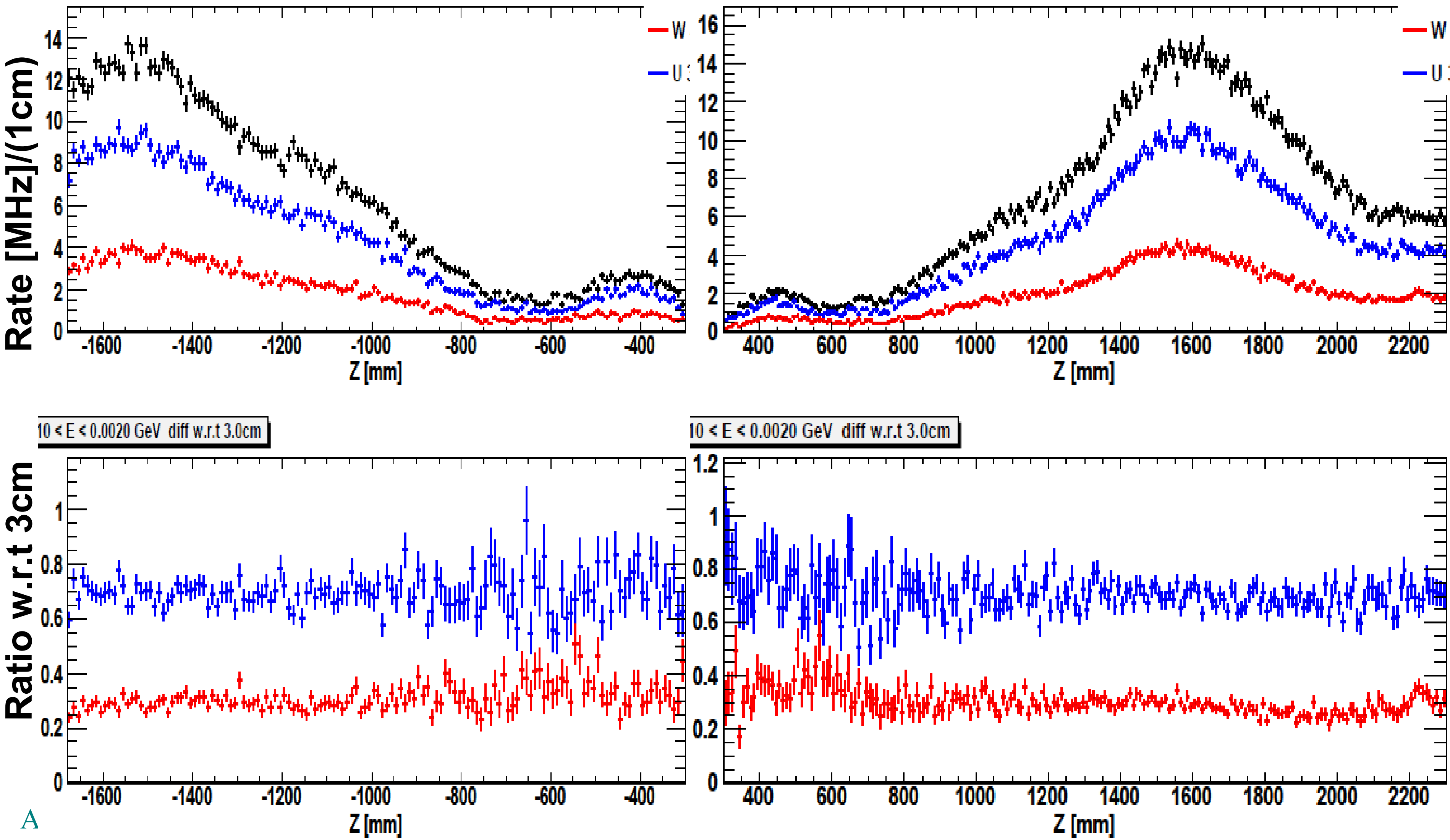
W 3.0 cm
W 4.5 cm
U 3.0 cm



# Shield studies: results

W 3.0 cm
W 4.5 cm
U 3.0 cm

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

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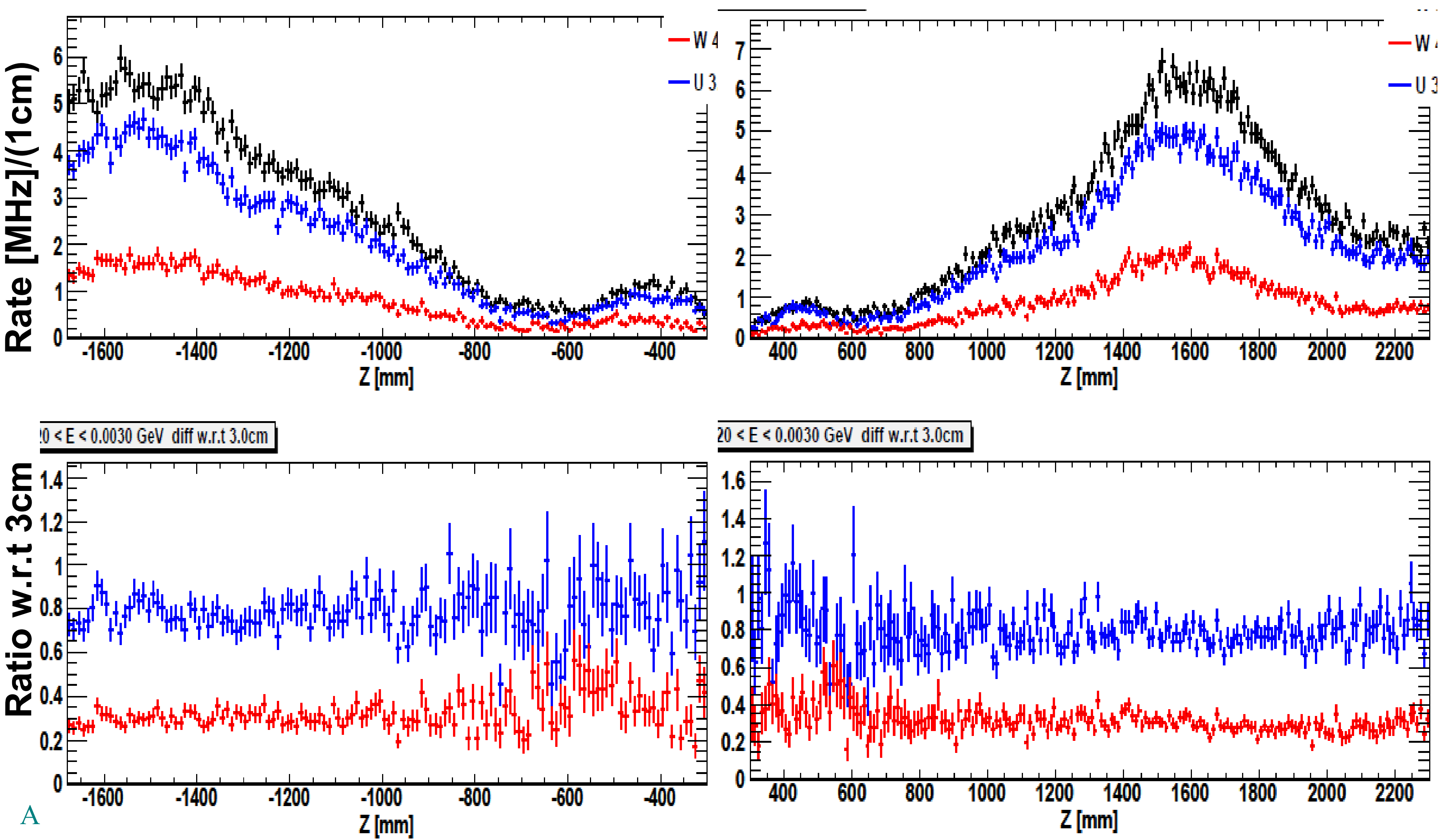
# Shield studies: results

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

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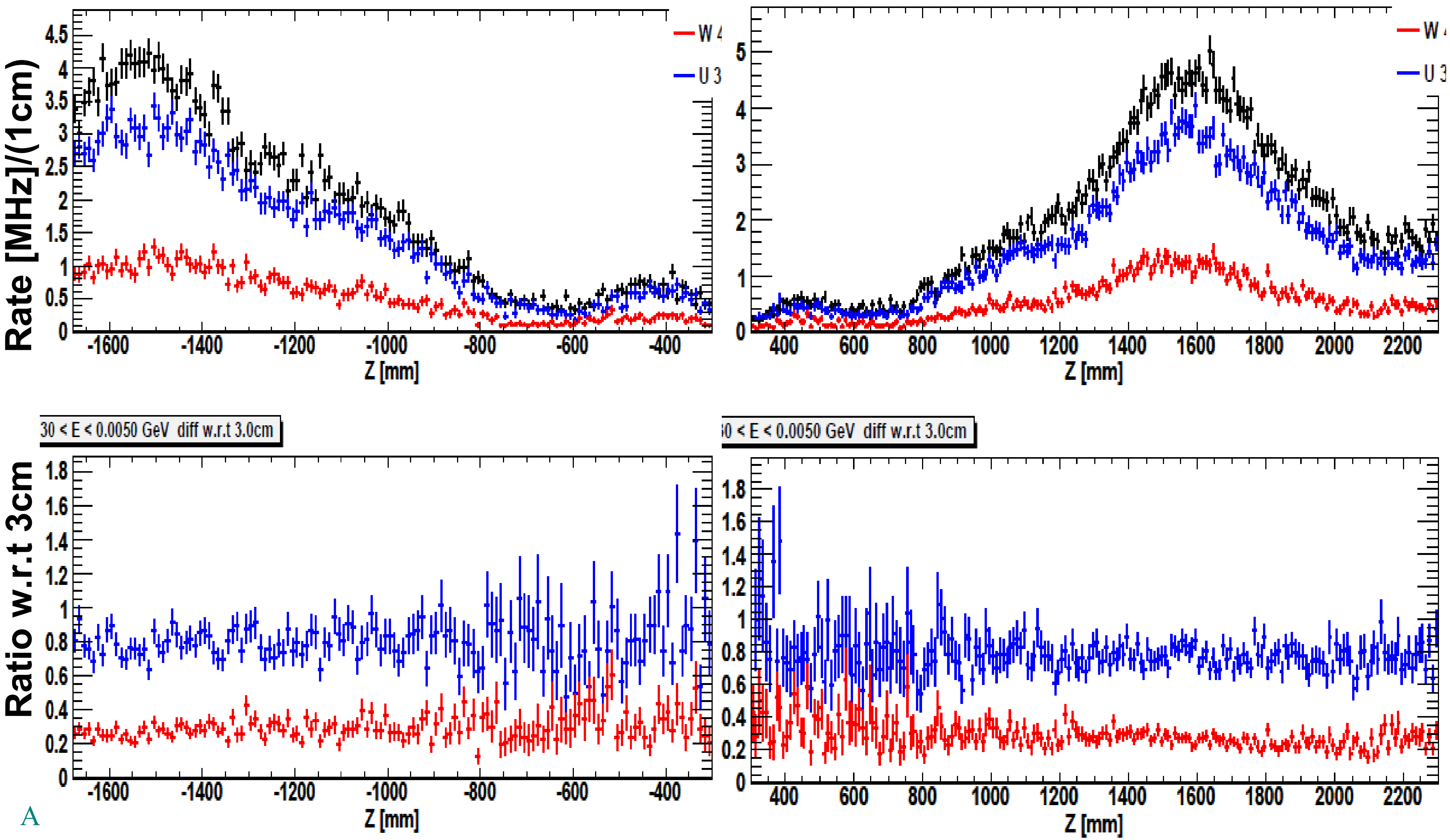
# Shield studies: results

W 3.0 cm
W 4.5 cm
U 3.0 cm

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

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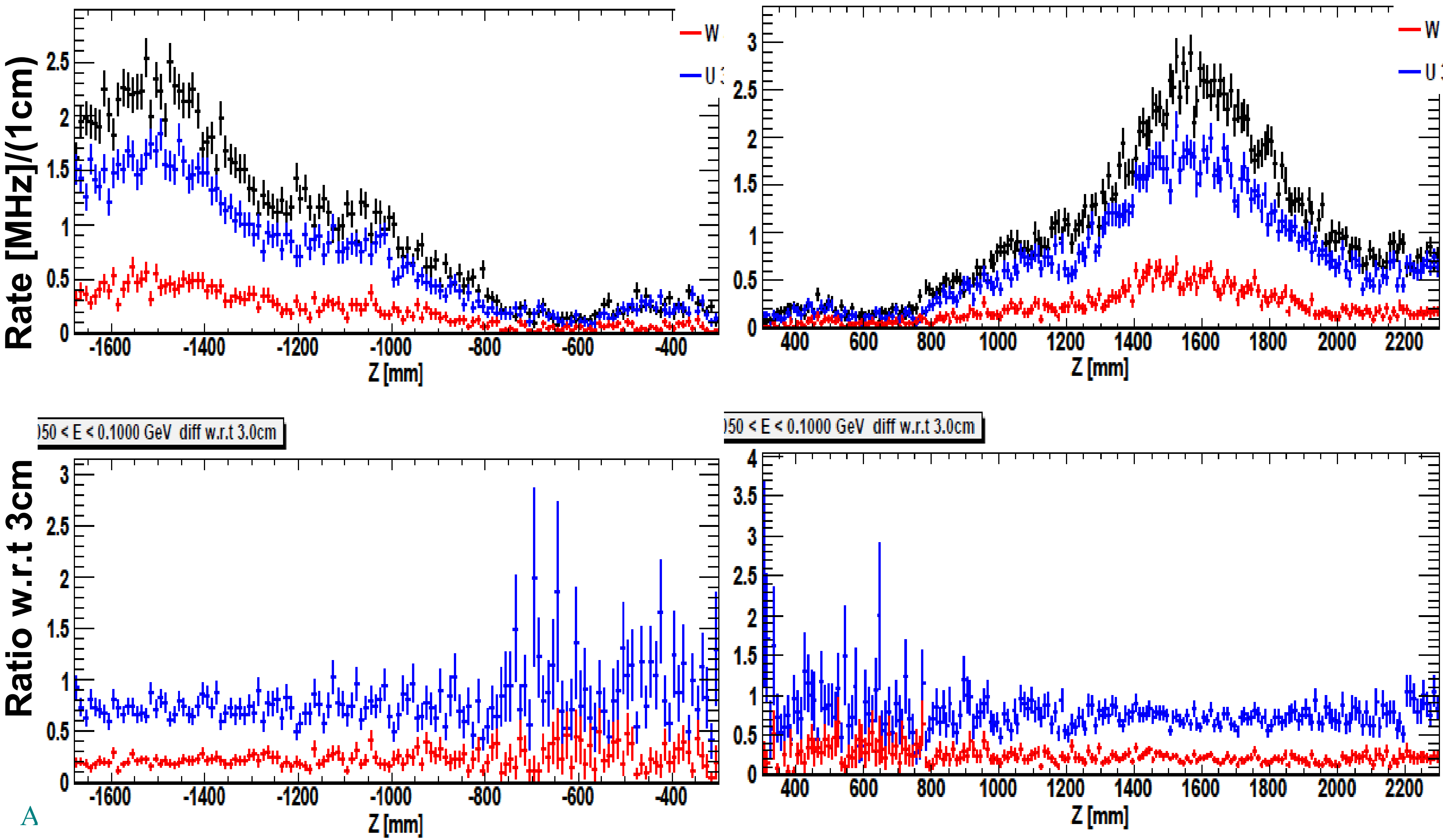
# Shield studies: results

W 3.0 cm
W 4.5 cm
U 3.0 cm

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

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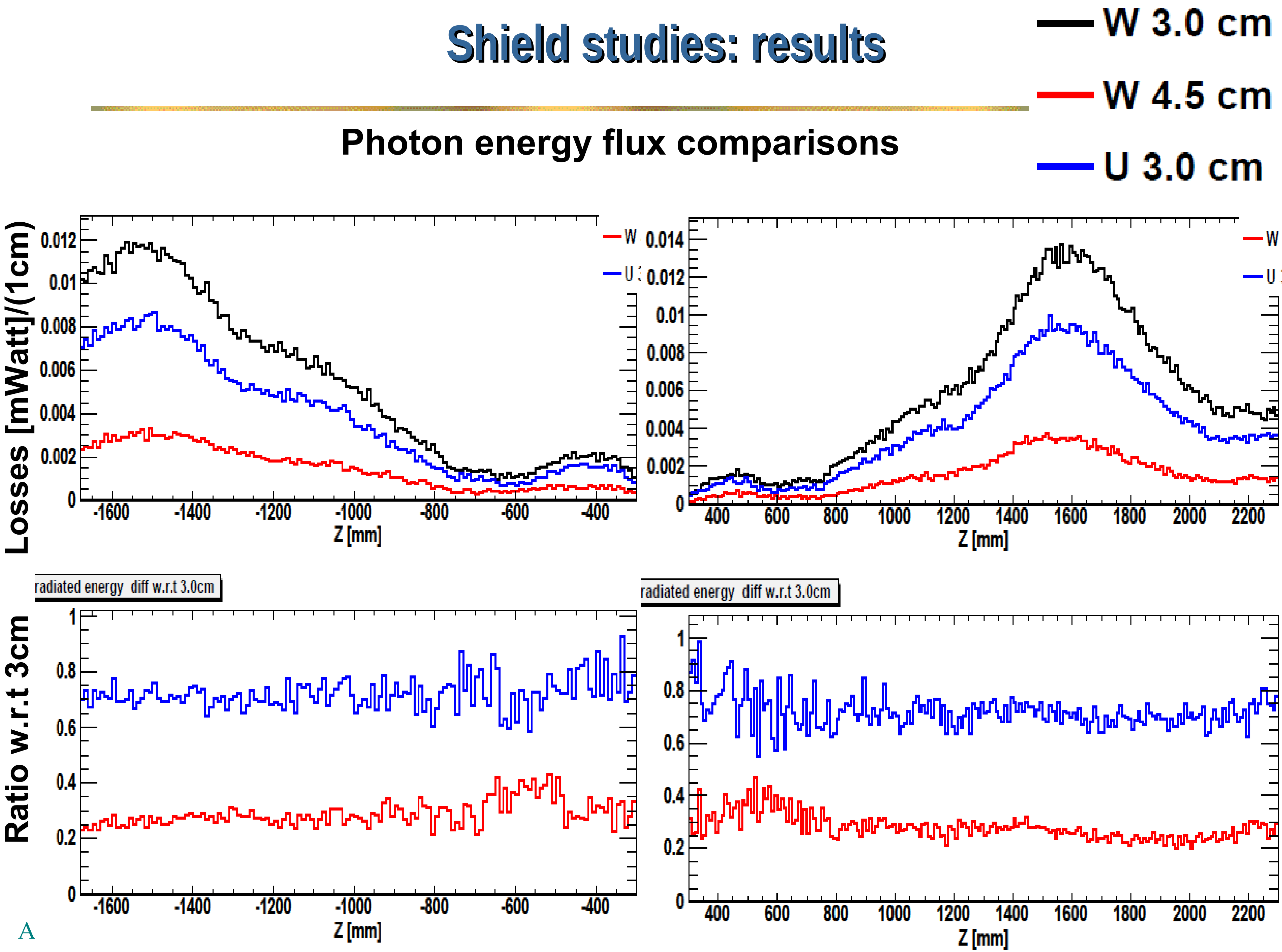
# Shield studies: results

**Photon energy flux comparisons**

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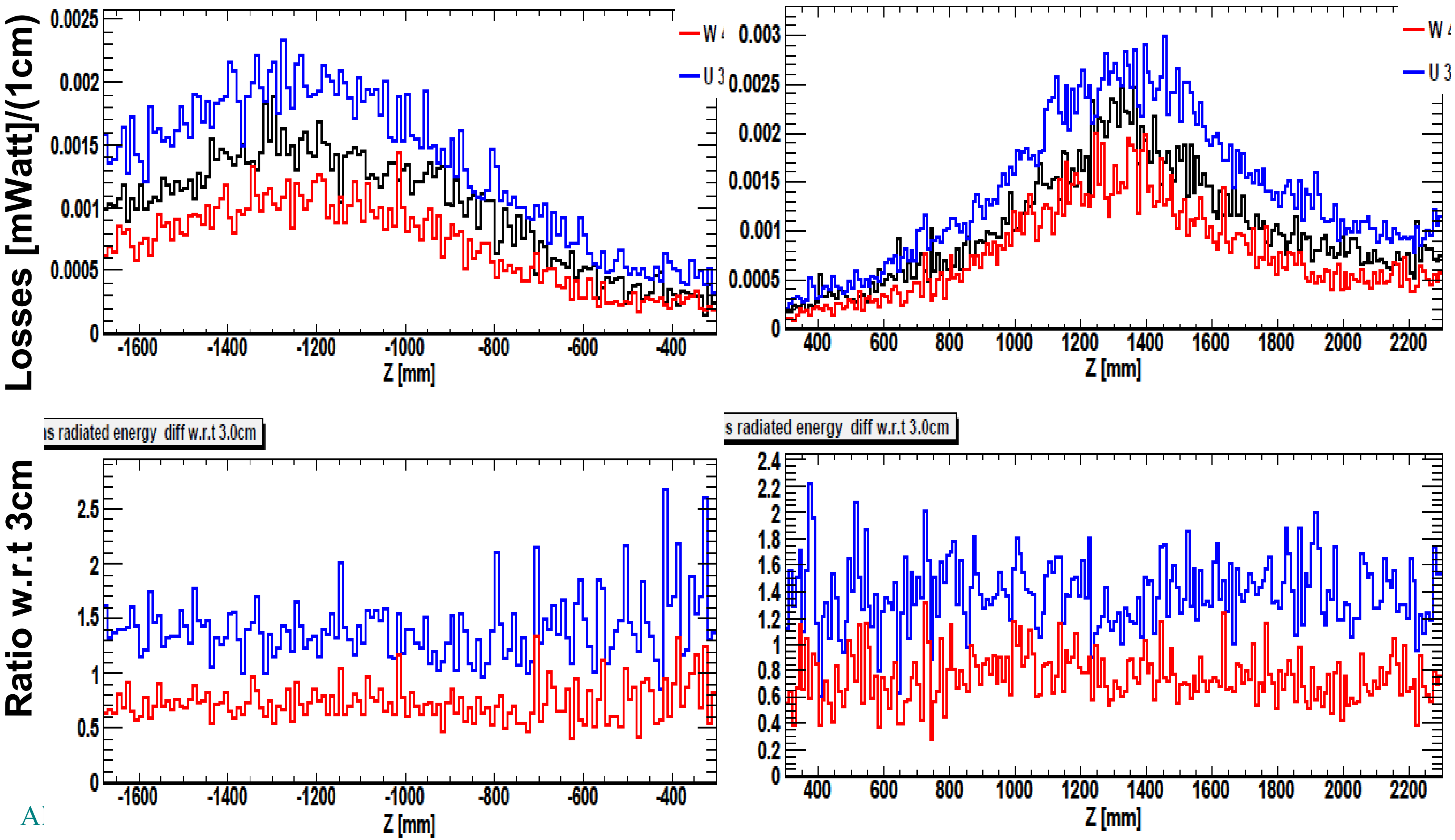
# Shield studies: results

W 3.0 cm
W 4.5 cm
U 3.0 cm

**Neutron kinetic energy flux comparisons**

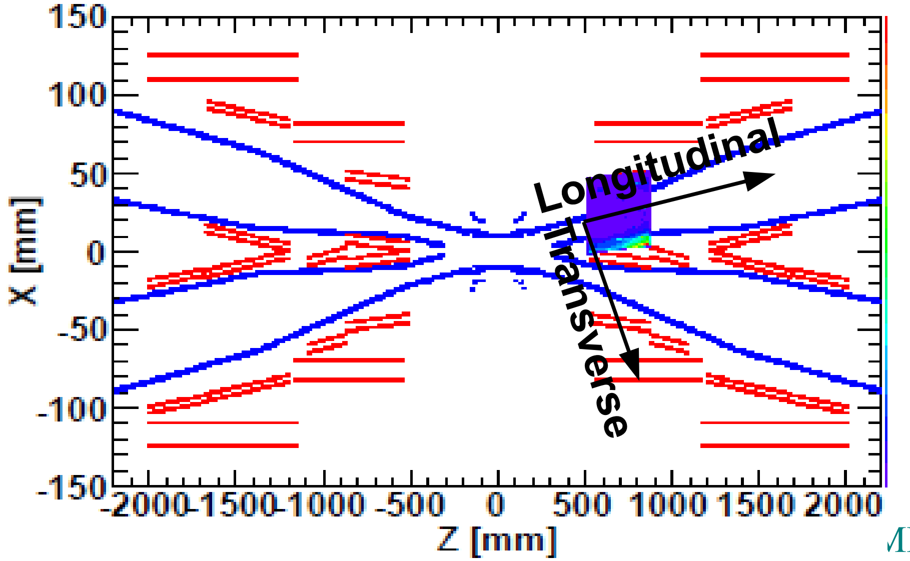


# Shield studies: conclusions

- **W-shield thickness at 4.5cm**
  - Reduces photon flux (dominant component) out of final focus by a factor of ~4-5 depending on photon energy ⇒ **4.5cm thickness is interesting**
  - Neutron flux is similar to W-shield-3.0cm
- **Depleted Uranium shield**
  - Decreases photon/electron flux by about 20% w.r.t W-shield-3.0cm. No as effective as W-shield-4.5cm
  - Increases neutron flux w.r.t W-shield-4.5cm
- **Issues:**
  - In order to increase W-shield thickness in BRN the internal radius of the shield was reduced
  - 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

# Final doublet doses: Strategy

- **Local coordinates:**
  - Longitudinal: axis of the magnetic cylinder and pointing away the IP
  - Angular (ϕ): angle w.r.t. the local (transverse) X-axis on the horizontal plane
    - QD0, QD0H, QF1 and QF1H: local X-axis points to the global Z-axis
    - Anti-solenoids: local X-axis is the same as global X-axis



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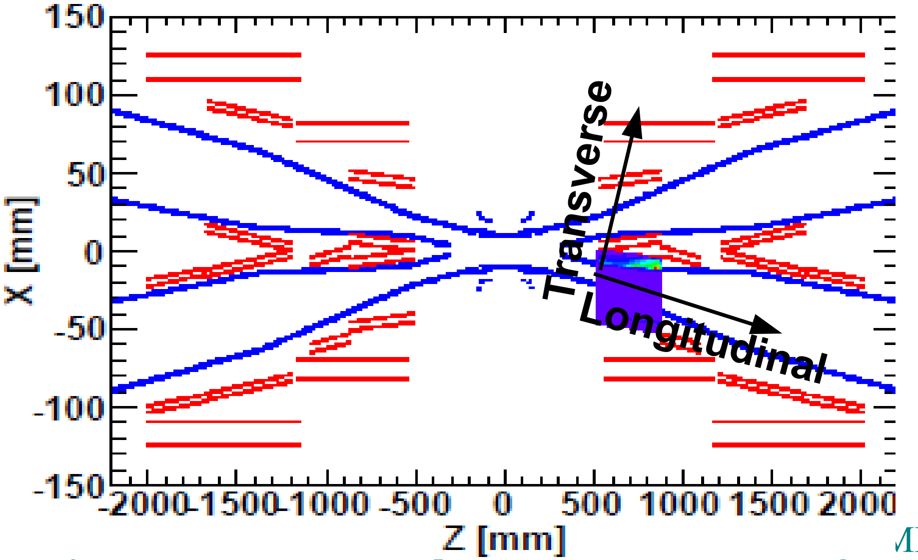

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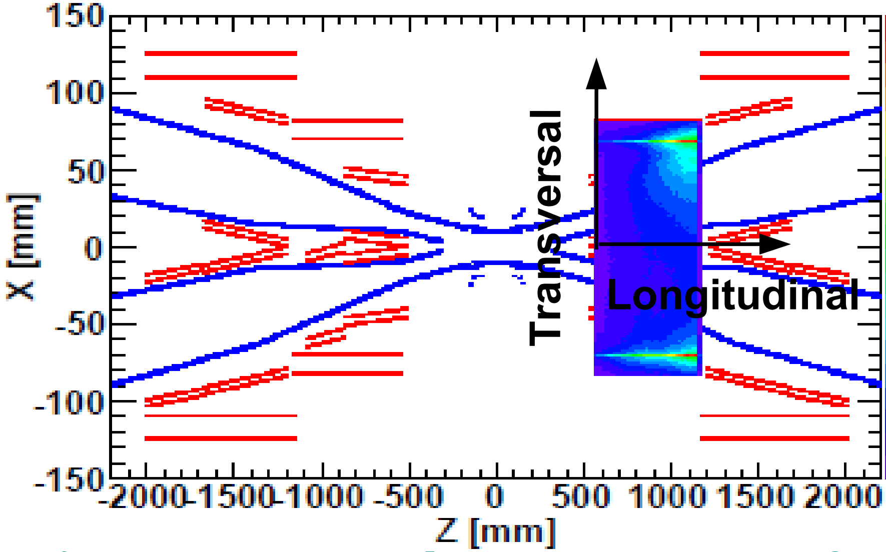
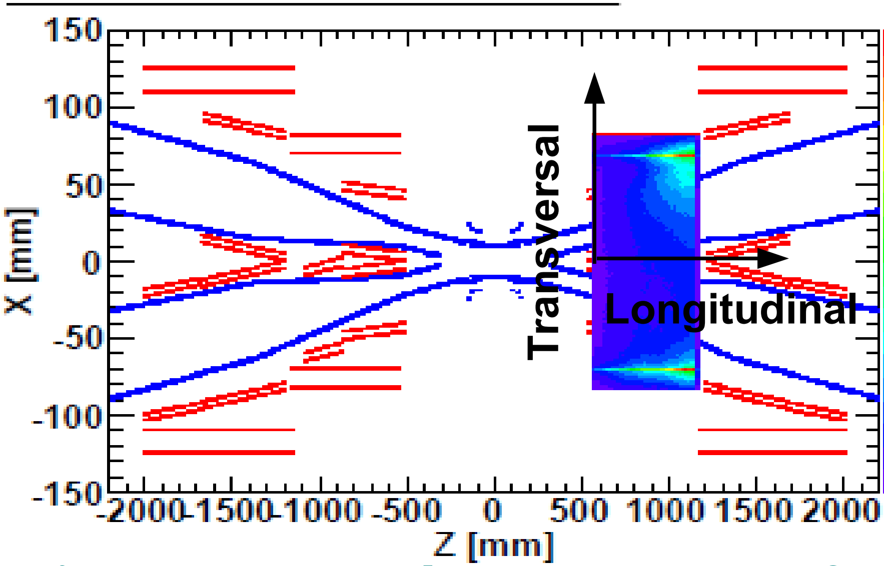
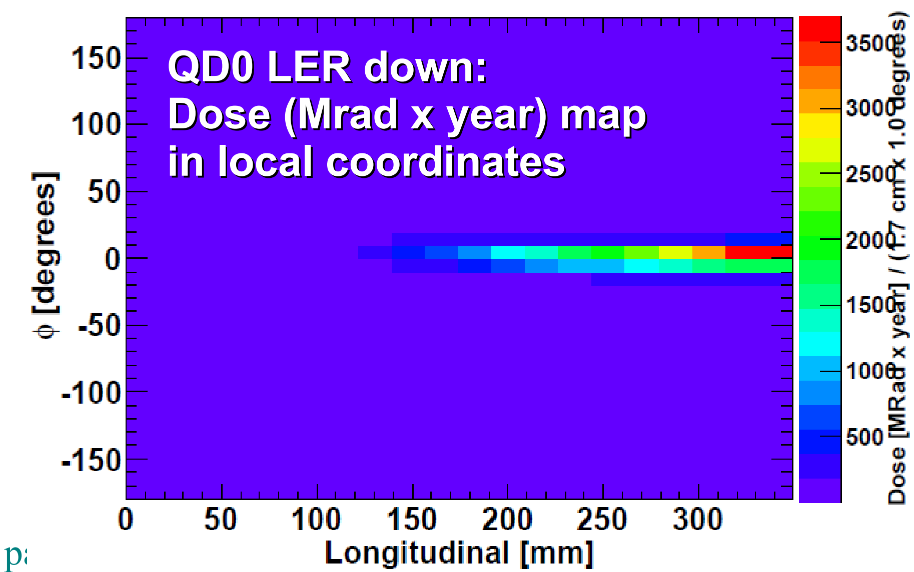


# Final doublet doses: Strategy

- **Local coordinates:**
  - Longitudinal: axis of the magnetic cylinder and pointing away the IP
  - Angular ($\phi$): angle w.r.t. the local (transverse) X-axis on the horizontal plane
    - QD0, QD0H, QF1 and QF1H: local X-axis points to the global Z-axis
    - Anti-solenoids: local X-axis is the same as global X-axis
- **Using the full-sim production samples compute for every magnet:**
  - Absorber power and doses (per year, i.e. 365 days) in bins of longitudinal vs $\phi$ local coordinates
  - Total absorbed power
  - Value of the bin with the maximum absorbed dose



# April 2012 Full-simulation production

- **We produced several samples for machine induced background estimation**
  - Rad-bhabha samples for three geometries (which include new FDIRC Lead-steel-polyethylene shield): 10k bunch crossings
    - Geometry_CIPE_V00-00-02 (nominal W-shield $\Rightarrow$ 3.0cm)
    - Geometry_CIPE_V00-00-02_Tungsten4.5cm (W-shield increased by 1.5cm $\Rightarrow$ 4.5cm total)
    - Geometry_CIPE_V00-00-02_CSI_Tungsten4.5cm (W-shield 4.5cm thick and Fwd-EMC is CsI)
  - The other background sources were generated with the same geometry: Geometry_CIPE_V00-00-02_Tungsten4.5cm (W-shield 4.5cm thick)
    - Pairs (2-photon): 100k bunch crossings
    - Touschek HER/LER: ~250k primary losses
    - BeamGas HER/LER: ~280k primary losses

# Final doublet doses: Results

- **I will show the results for the Rad-bhabha samples for some of the magnets. The results for all the magnets/samples can be seen at the links below**
  - Rad-bhabha:

http://www.slac.stanford.edu/~aperez/SuperB/SuperB_Pisa/Background_Studies/Magnets_Abs_Dose/April_prod_2012/Plots_RadBhabha_background_AbsDose_Geometry_CIPE_V00-00-02_Tungsten4.5cm_full-production.eps

  - Pairs:

http://www.slac.stanford.edu/~aperez/SuperB/SuperB_Pisa/Background_Studies/Magnets_Abs_Dose/April_prod_2012/Plots_Pairs_background_AbsDose_Geometry_CIPE_V00-00-02_Tungsten4.5cm_full-production.eps

  - Touschek HER:

http://www.slac.stanford.edu/~aperez/SuperB/SuperB_Pisa/Background_Studies/Magnets_Abs_Dose/April_prod_2012/Plots_Touschek_HER_background_AbsDose_Geometry_CIPE_V00-00-02_Tungsten4.5cm_full-production.eps

  - Touschek LER:

http://www.slac.stanford.edu/~aperez/SuperB/SuperB_Pisa/Background_Studies/Magnets_Abs_Dose/April_prod_2012/Plots_Touschek_LER_background_AbsDose_Geometry_CIPE_V00-00-02_Tungsten4.5cm_full-production.eps

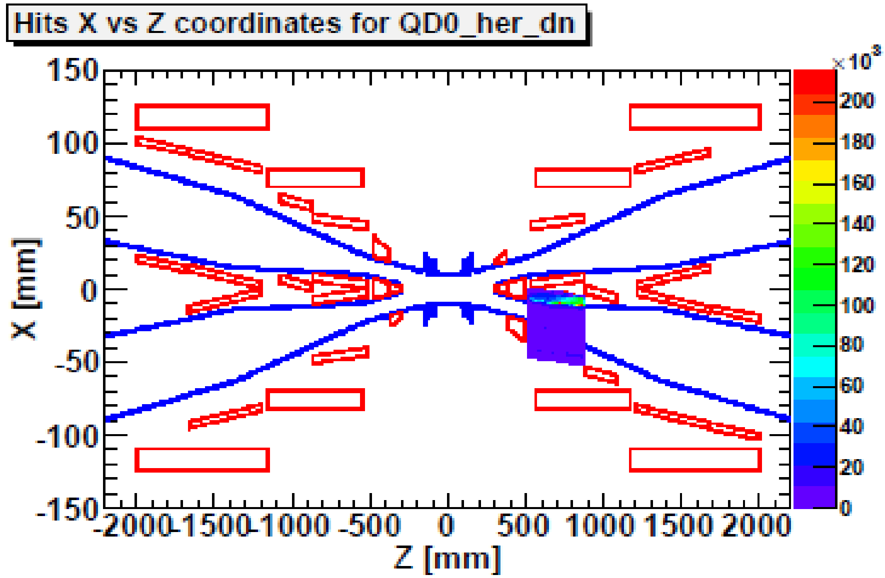
  - Beam-Gas HER:

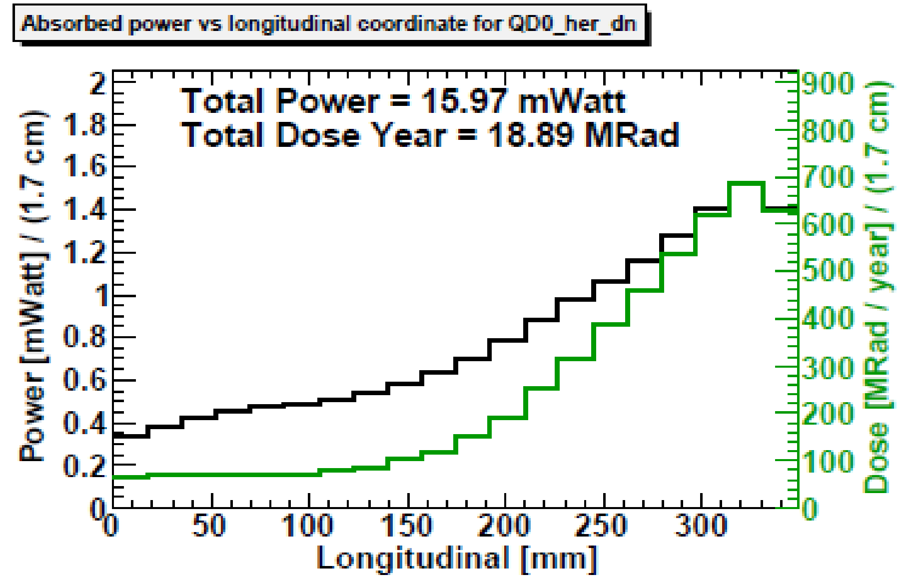
http://www.slac.stanford.edu/~aperez/SuperB/SuperB_Pisa/Background_Studies/Magnets_Abs_Dose/April_prod_2012/Plots_BeamGas_HER_background_AbsDose_Geometry_CIPE_V00-00-02_Tungsten4.5cm_full-production.eps

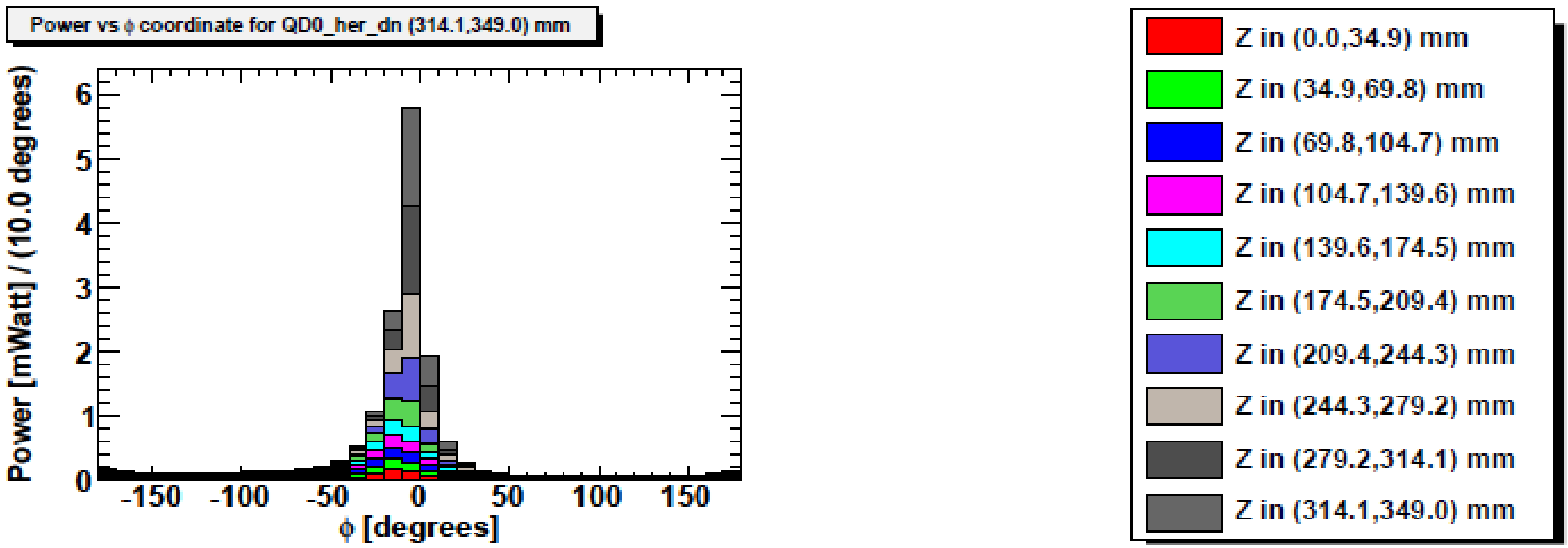
  - Beam-Gas LER:

http://www.slac.stanford.edu/~aperez/SuperB/SuperB_Pisa/Background_Studies/Magnets_Abs_Dose/April_prod_2012/Plots_BeamGas_LER_background_AbsDose_Geometry_CIPE_V00-00-02_Tungsten4.5cm_full-production.eps

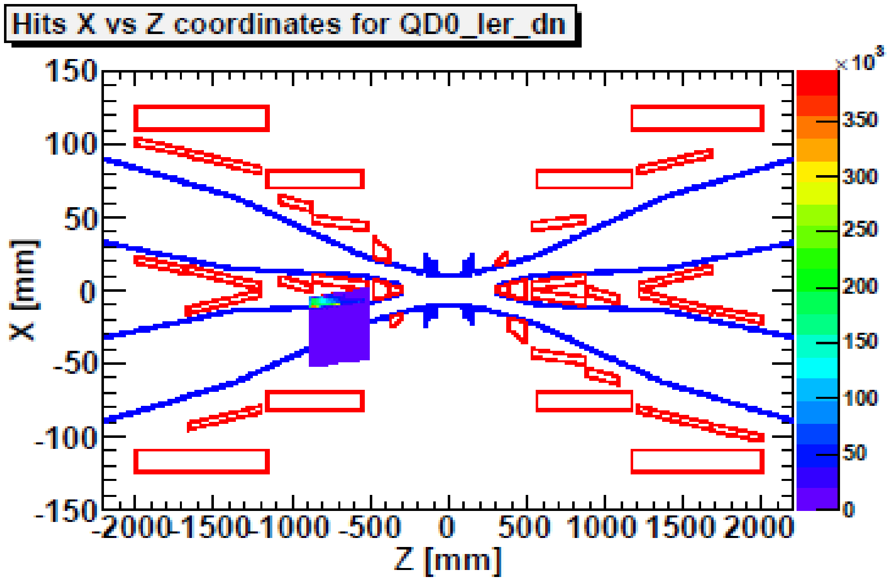
# Final doublet doses: Doses on QD0-HER-down

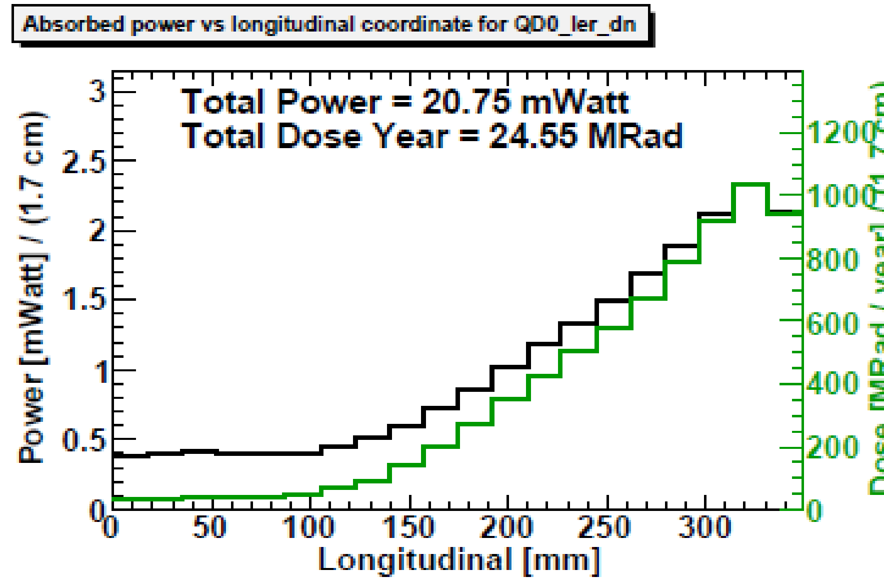


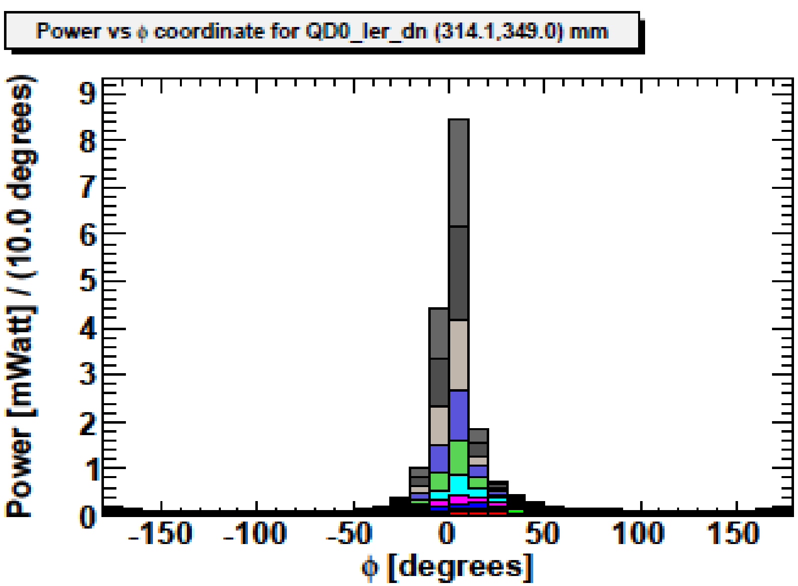



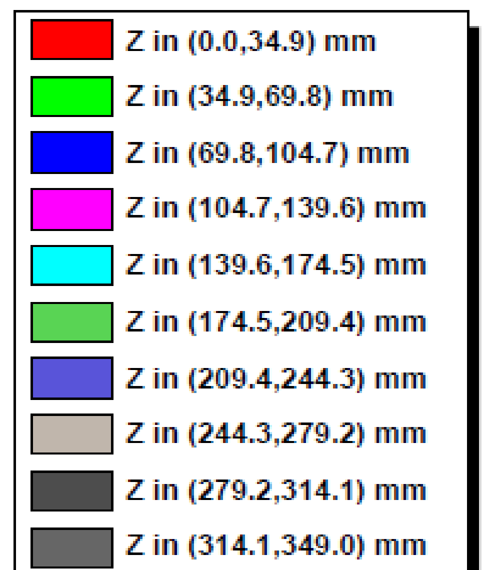



# Final doublet doses: Doses on QD0-LER-down

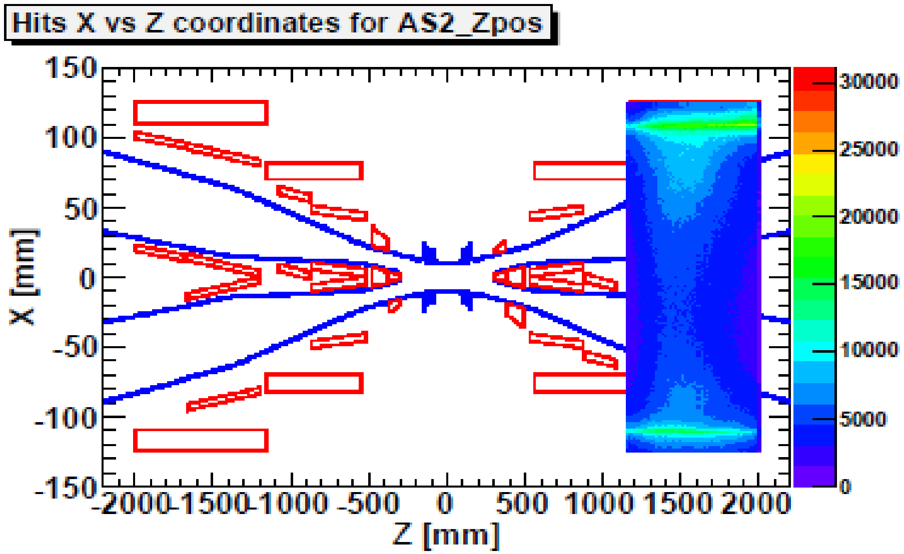


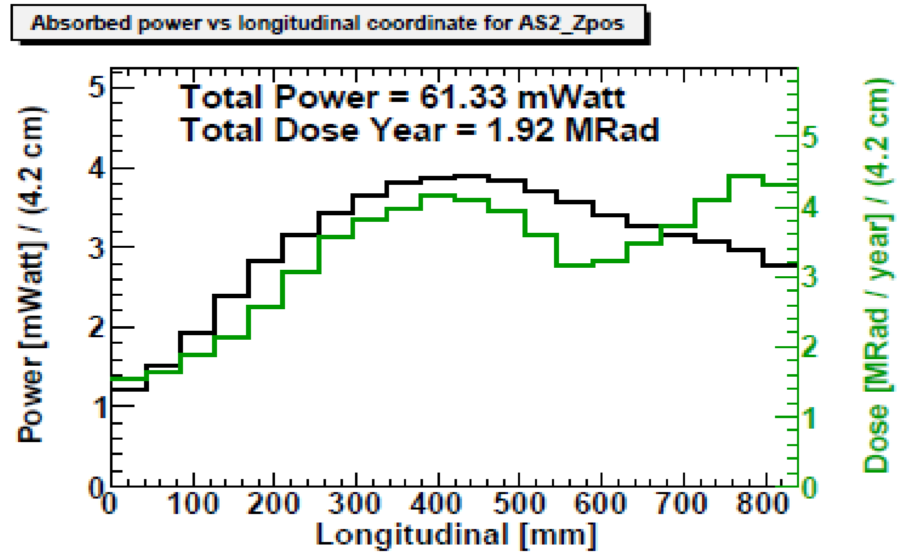



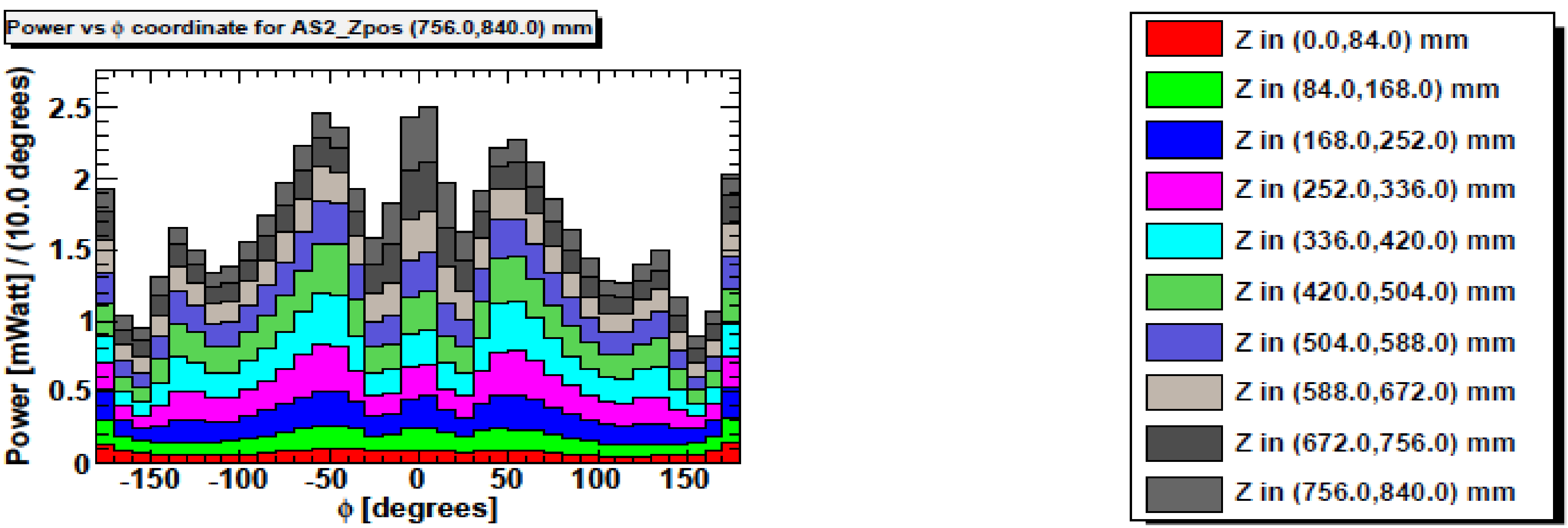



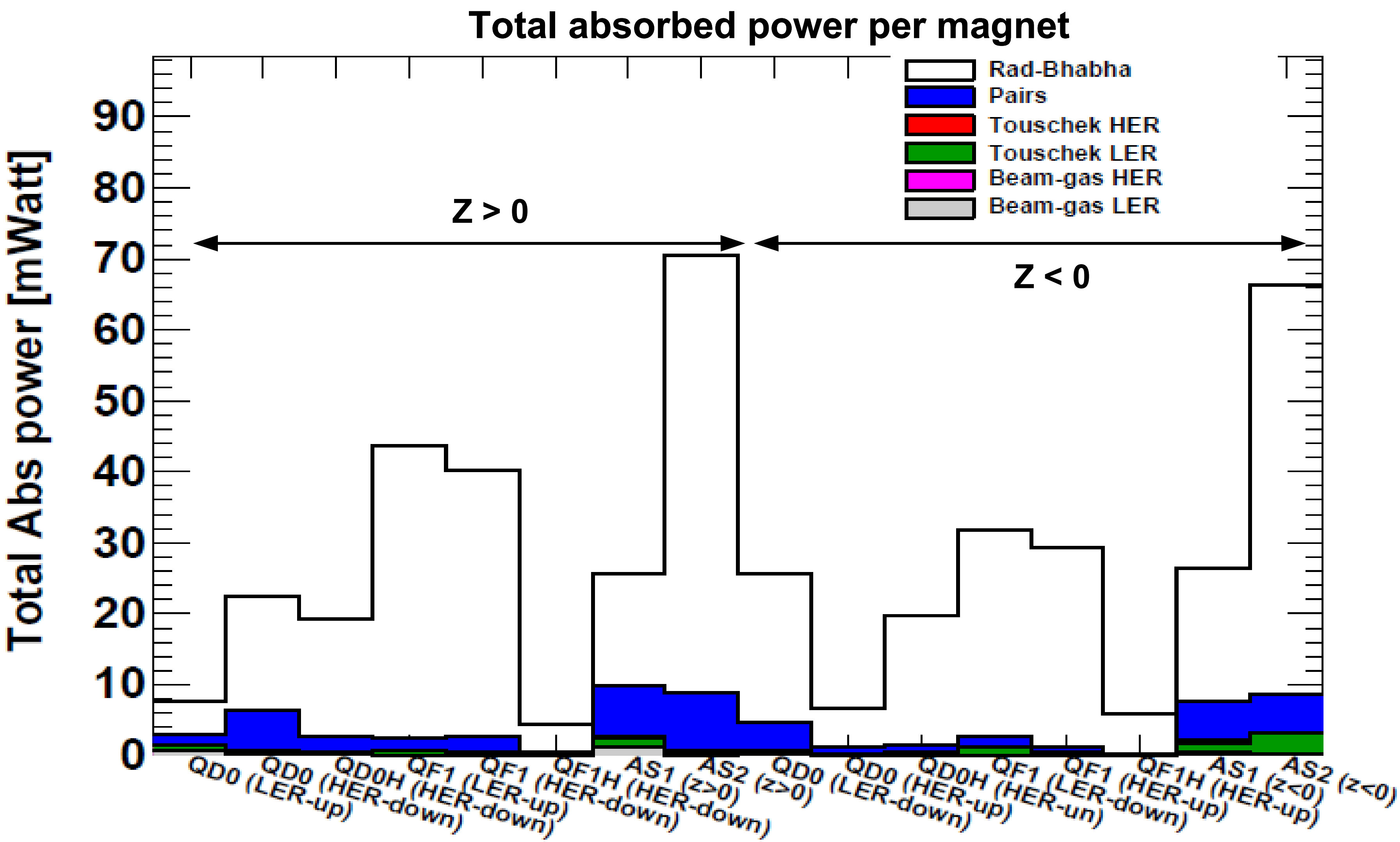
# Final doublet doses: Doses on AS2 (Z>0)



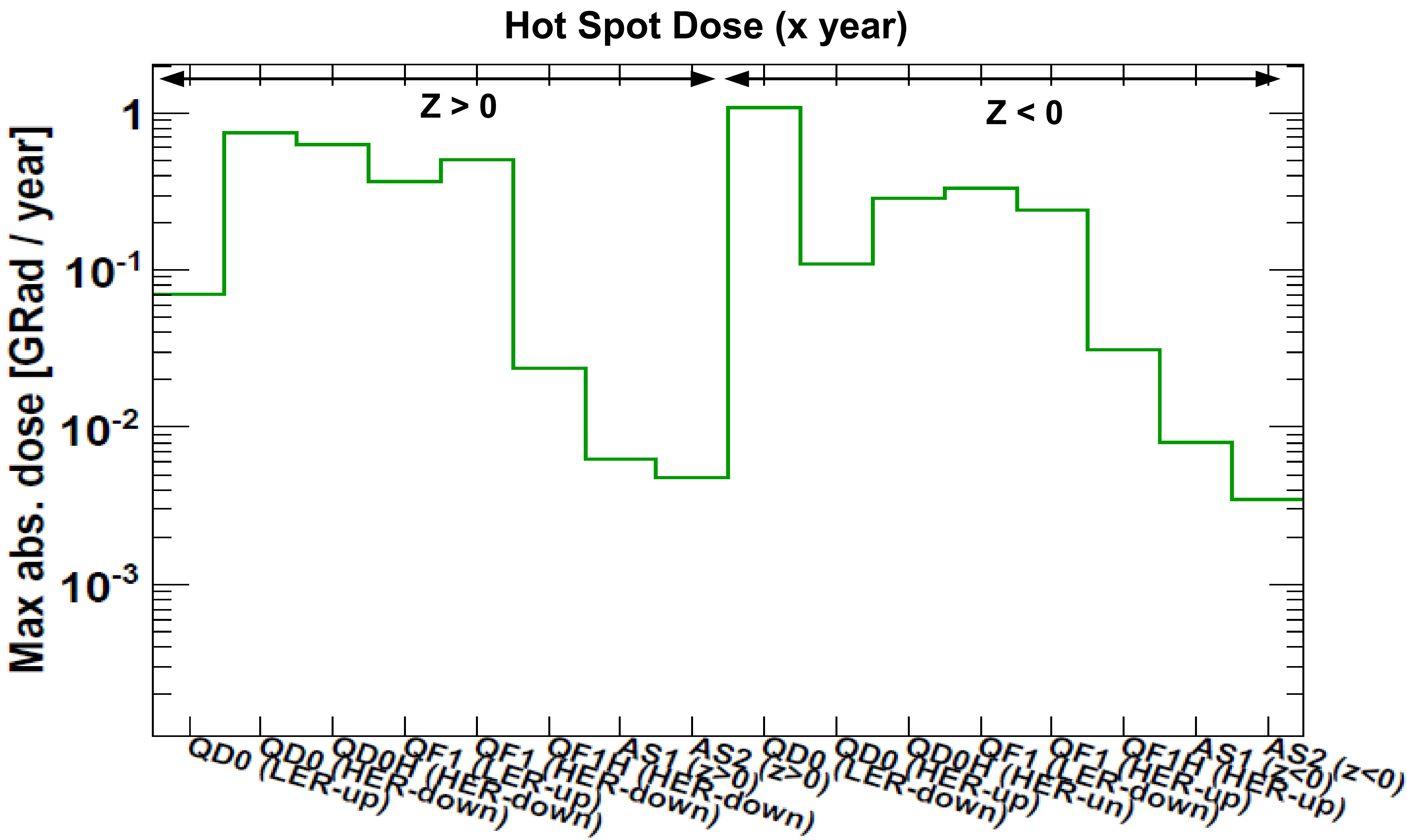



# Final doublet doses: Total absorbed power

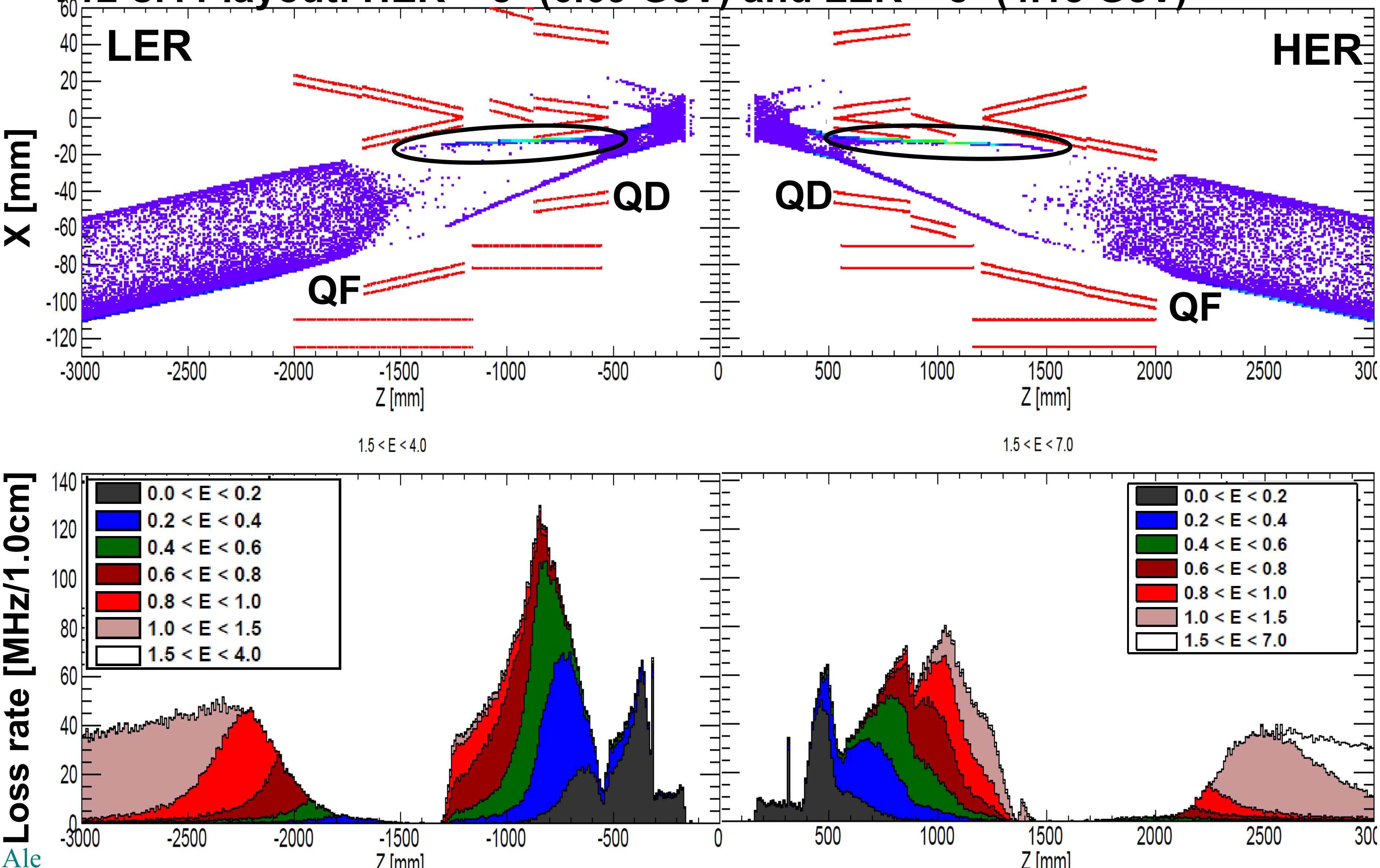


# Final doublet doses: Maximum absorbed dose



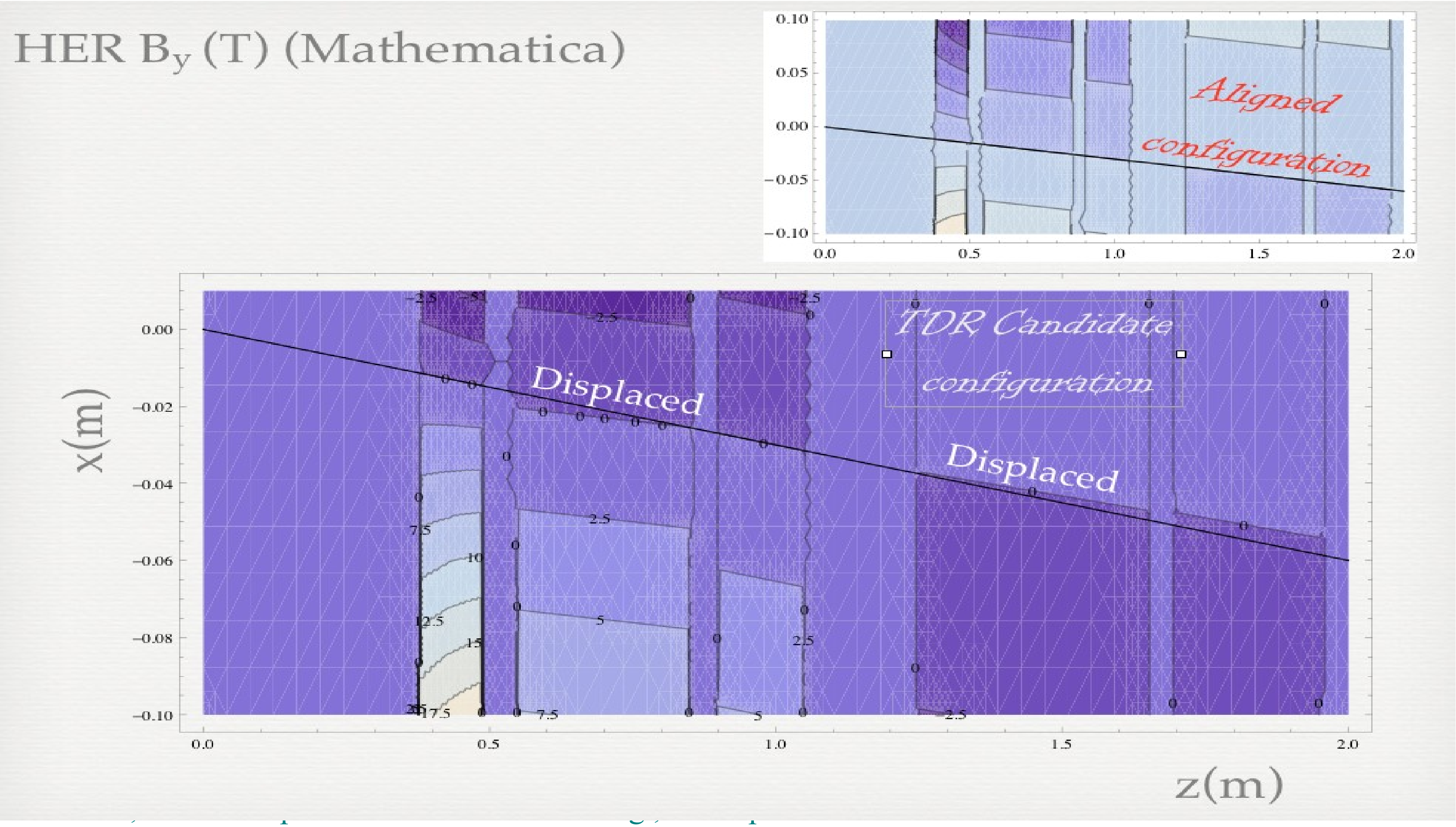
# Rad-Bhabha Losses at the Beam-pipe: $e^+e^-$

- V12-sf11 layout: HER = $e^+$ (6.69 GeV) and LER = $e^-$ (4.18 GeV)

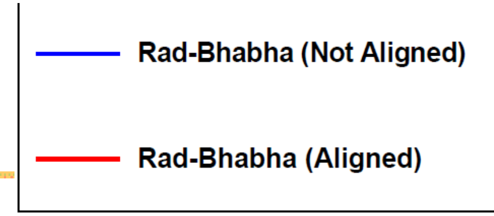


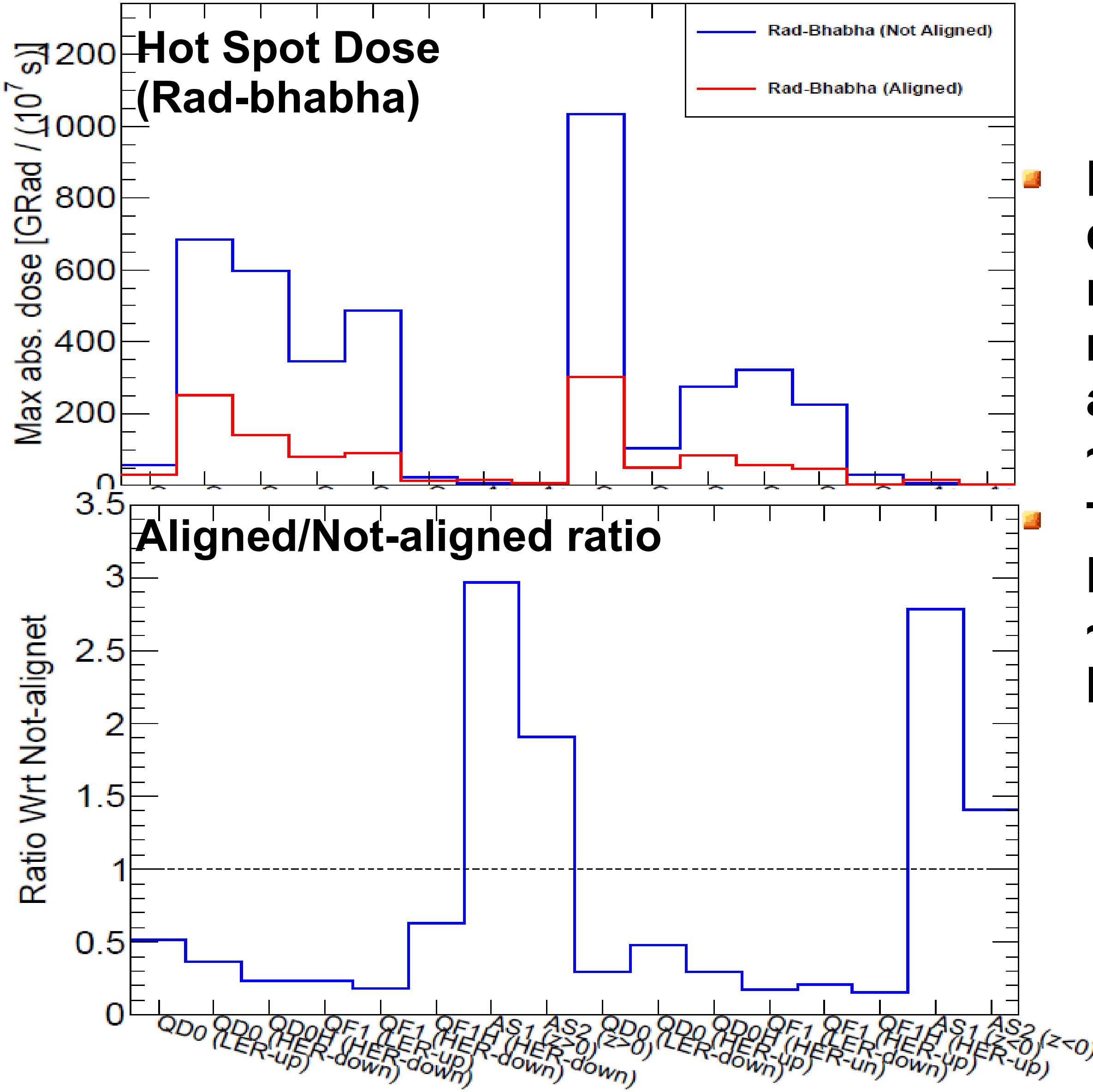
# Aligned vs Not Aligned Magnetic elements

- **Current magnetic some elements (QD0, QD0H, QF1 and QF1H) are not aligned with nominal trajectory**
- **Try a model in which all magnetic elements are aligned ⇒ expect reduction on the doses**



# Aligned vs Not Aligned: results




- **Hot spots dose on the doublets are significantly reduced for the aligned model w.r.t. the Not-aligned one (a factor of ~2 reduction)**
- **The anti-solenoids have hot spot dose a factor of ~3 increase but still in the limits radiation hardness**

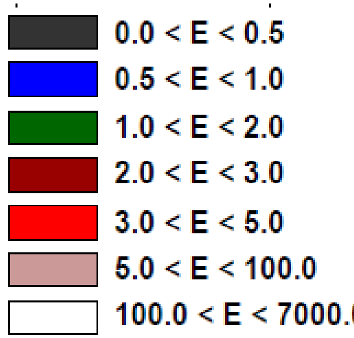
# Final doublet doses: Summary

- **Performed the analysis with all the full-sim production samples (Rad-bhabha, Pairs, Touschek, BeamGas)**
  - Main background contribution from Rad-bhabha by around one order of magnitude
  - Absorbed power are from 10 to 70 mWatts
  - Hot spot doses are about 1Grad/($10^6$sec)

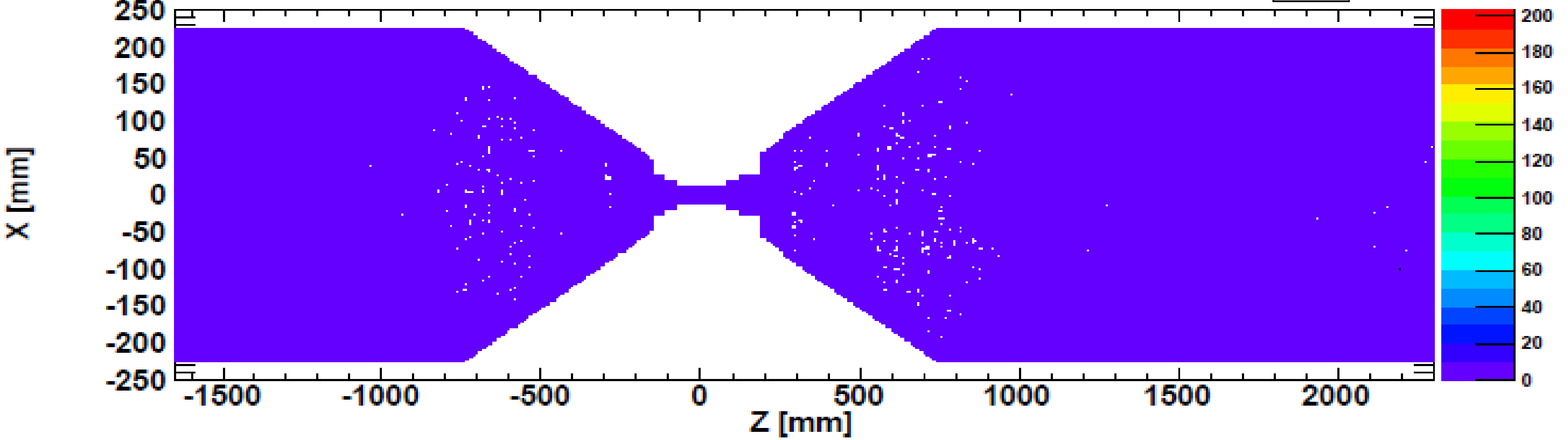
- **Aligned vs Not-aligned model**
  - Absorbed power on magnets gets reduced from 20-80% (depending on the magnet) when using aligned model
  - Hot spot dose reduces by a factor of ~2 for almost all magnetic elements, only increases for anti-solenoids (a factor of ~3) but still within the safety limits

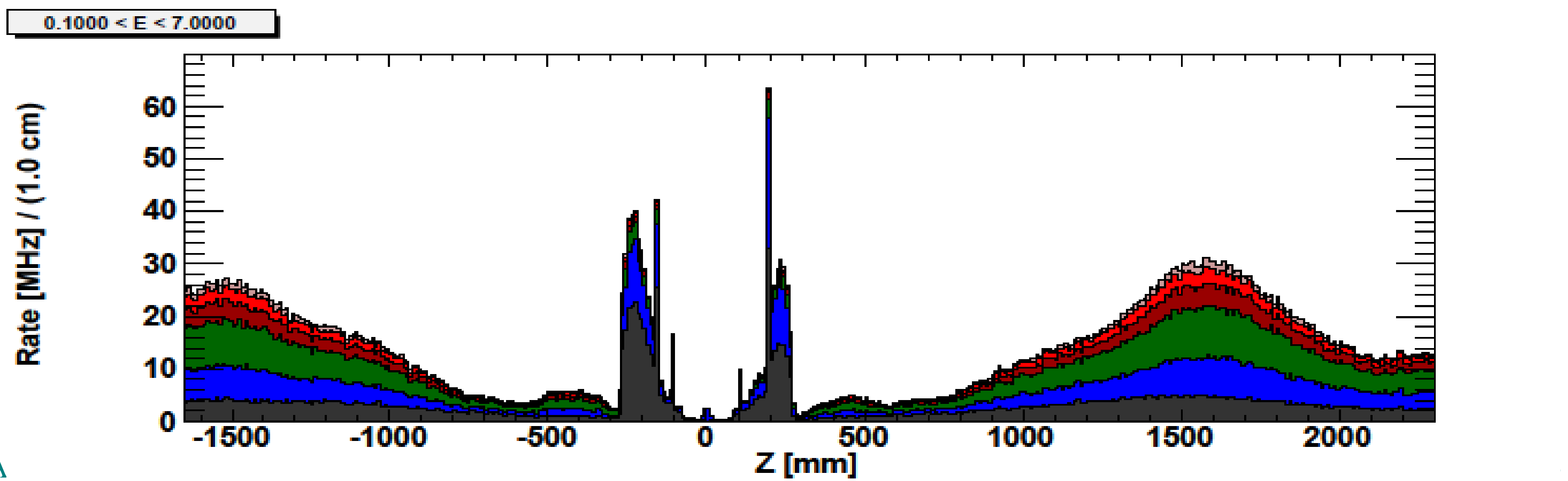
# Backup

# Tungsten shield studies: results




## Photon flux: Tungsten shield thickness 3.5cm

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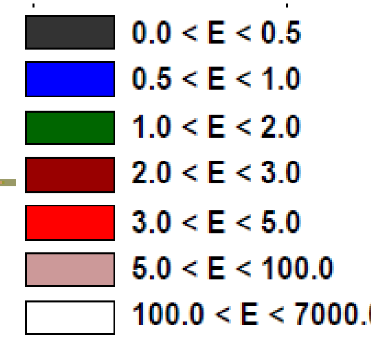
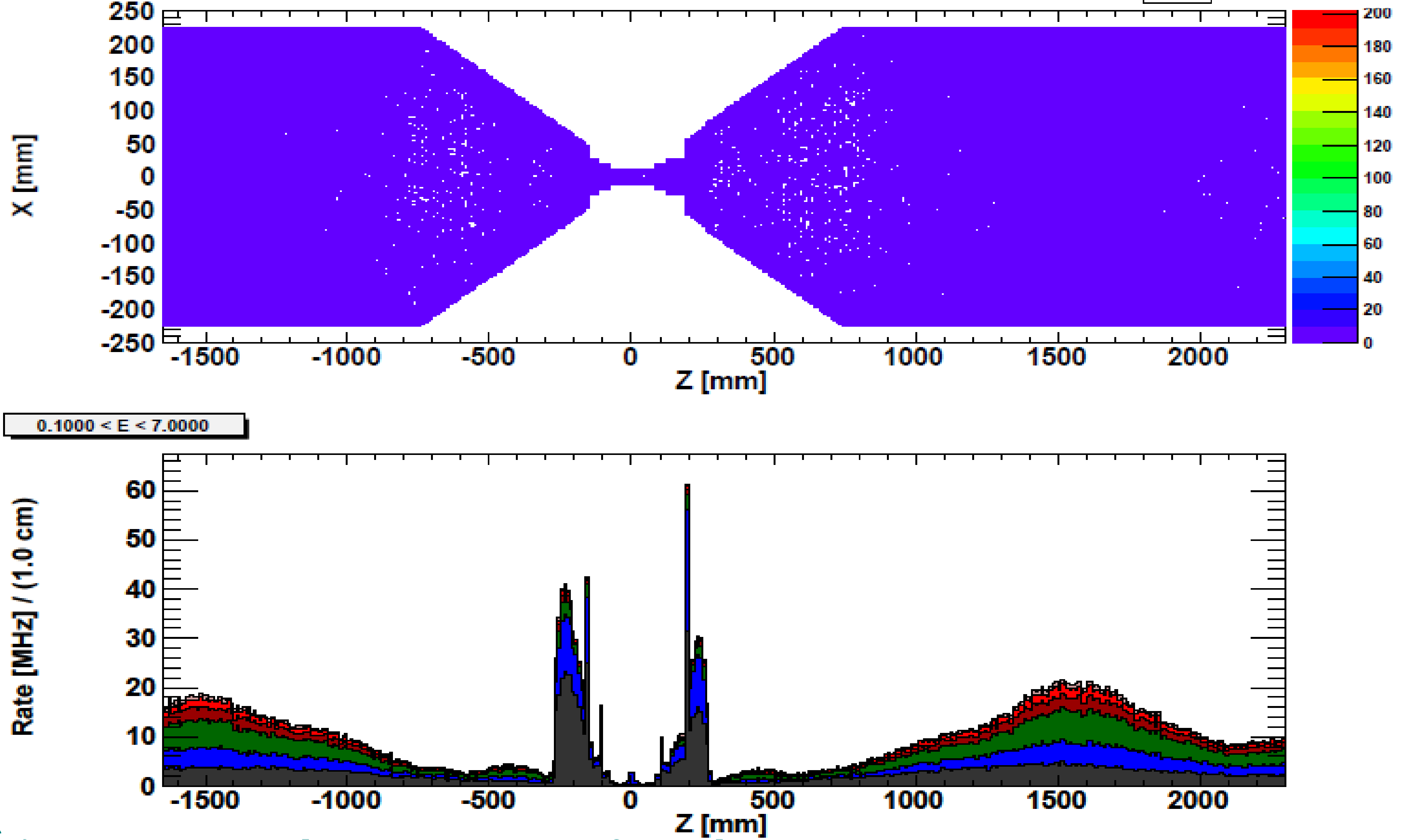
# Tungsten shield studies: results




**Photon flux: Tungsten shield thickness 4.0cm**

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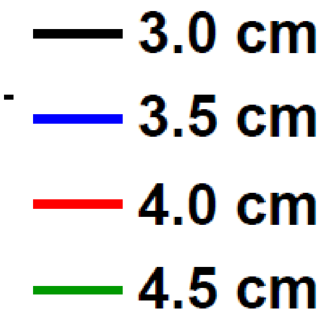
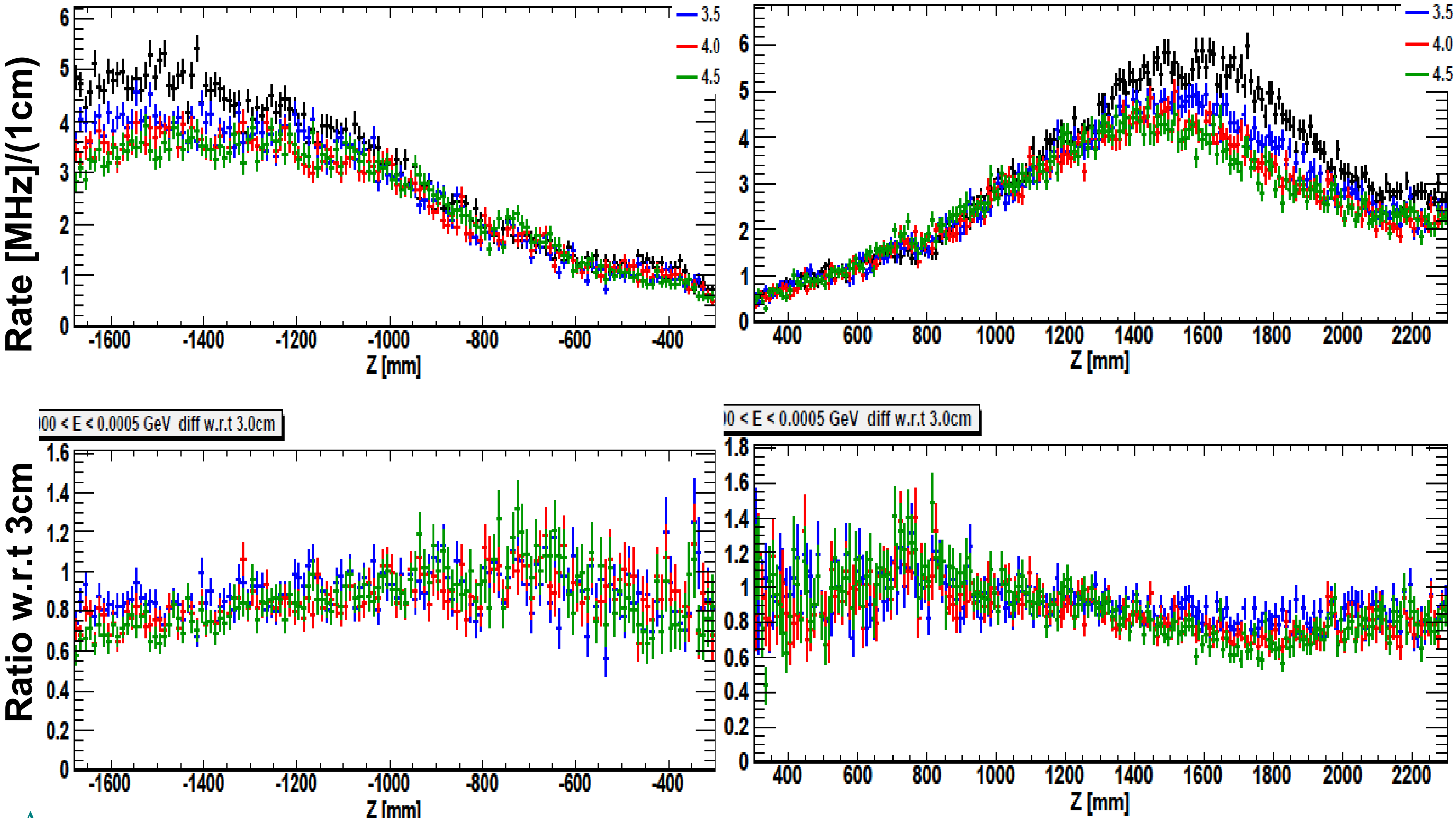
# Tungsten shield studies: results

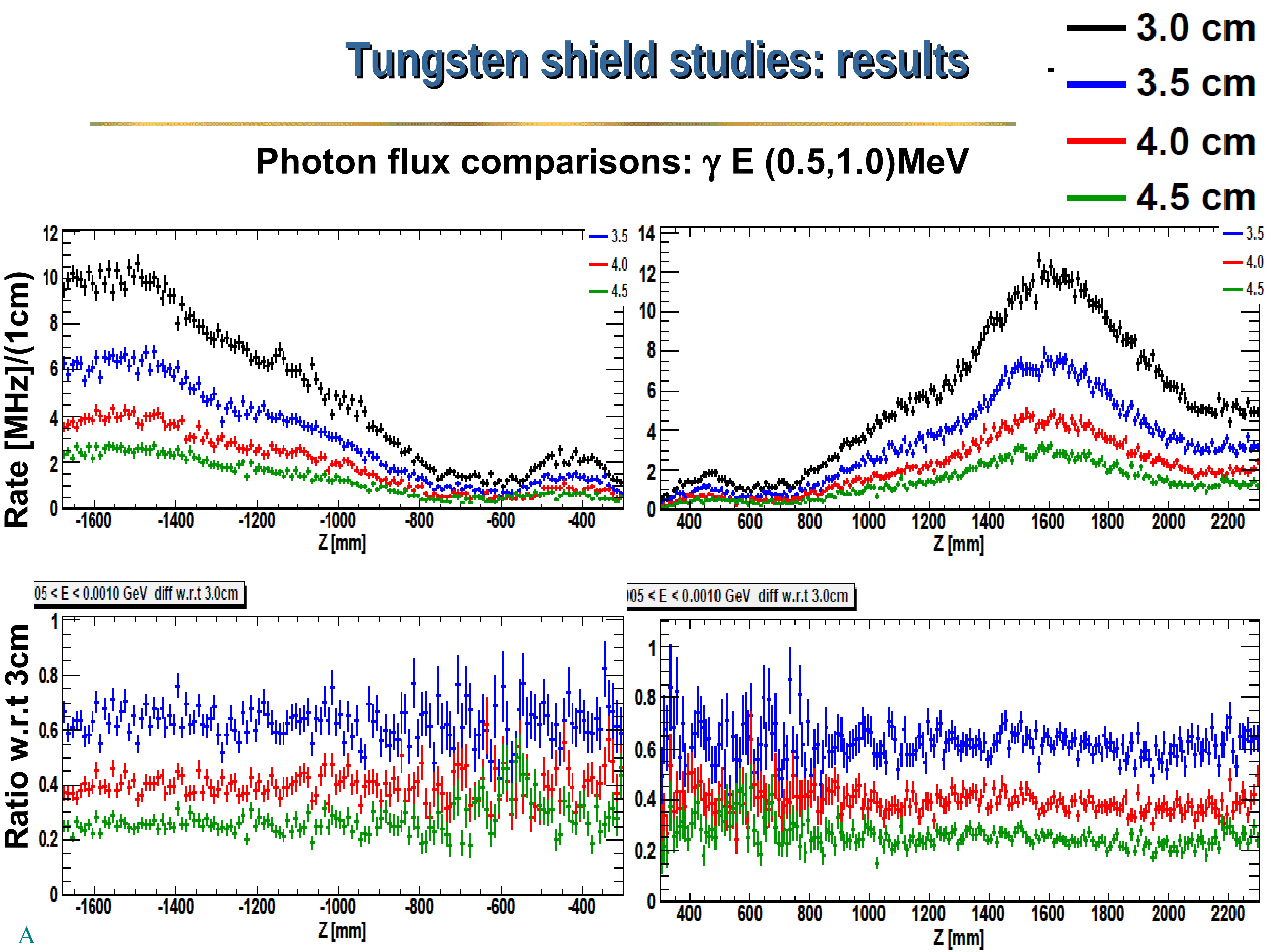



**Photon flux comparisons: γ E (0,0.5)MeV**



# Tungsten shield studies: results

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

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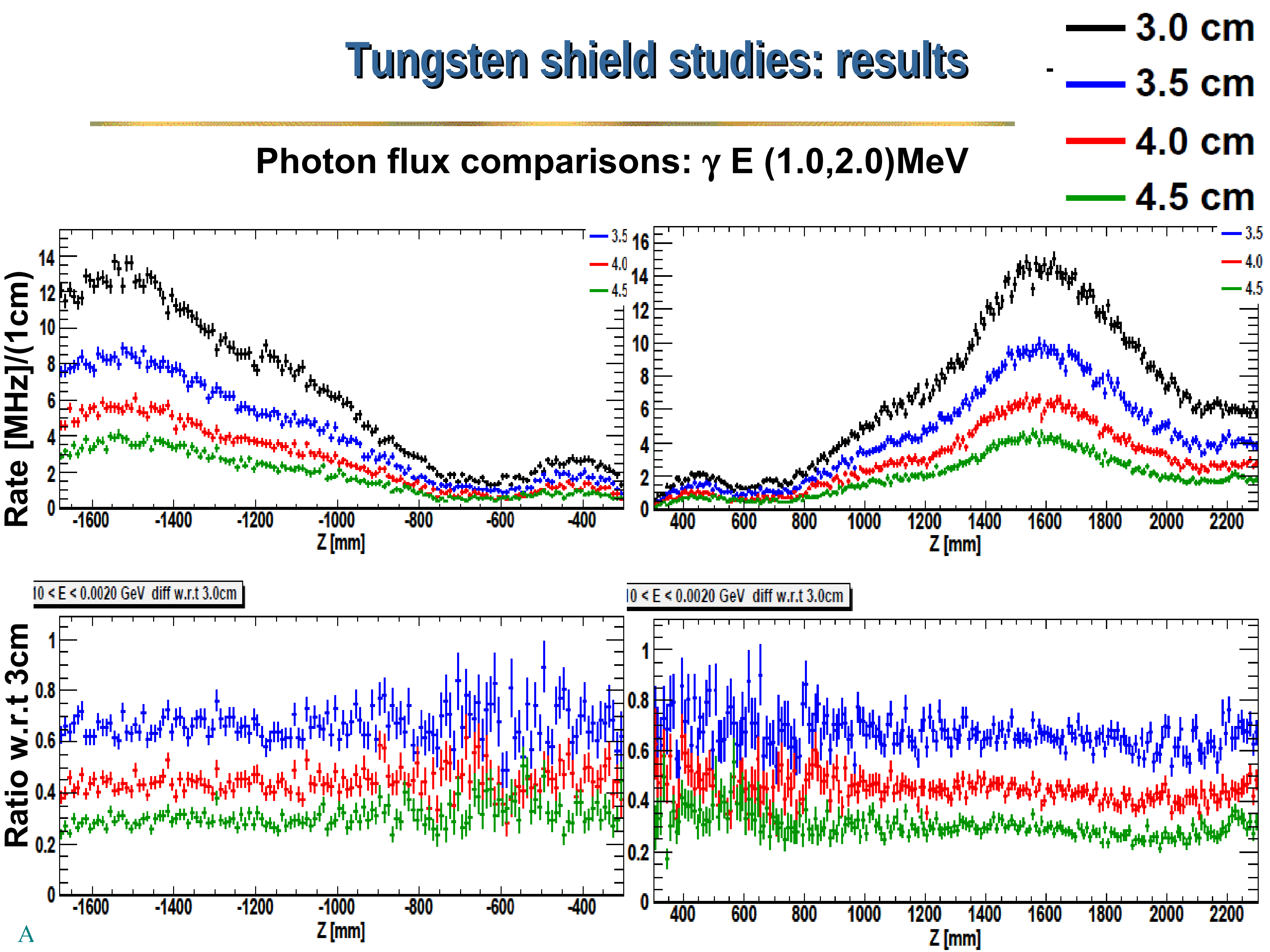
# Tungsten shield studies: results

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

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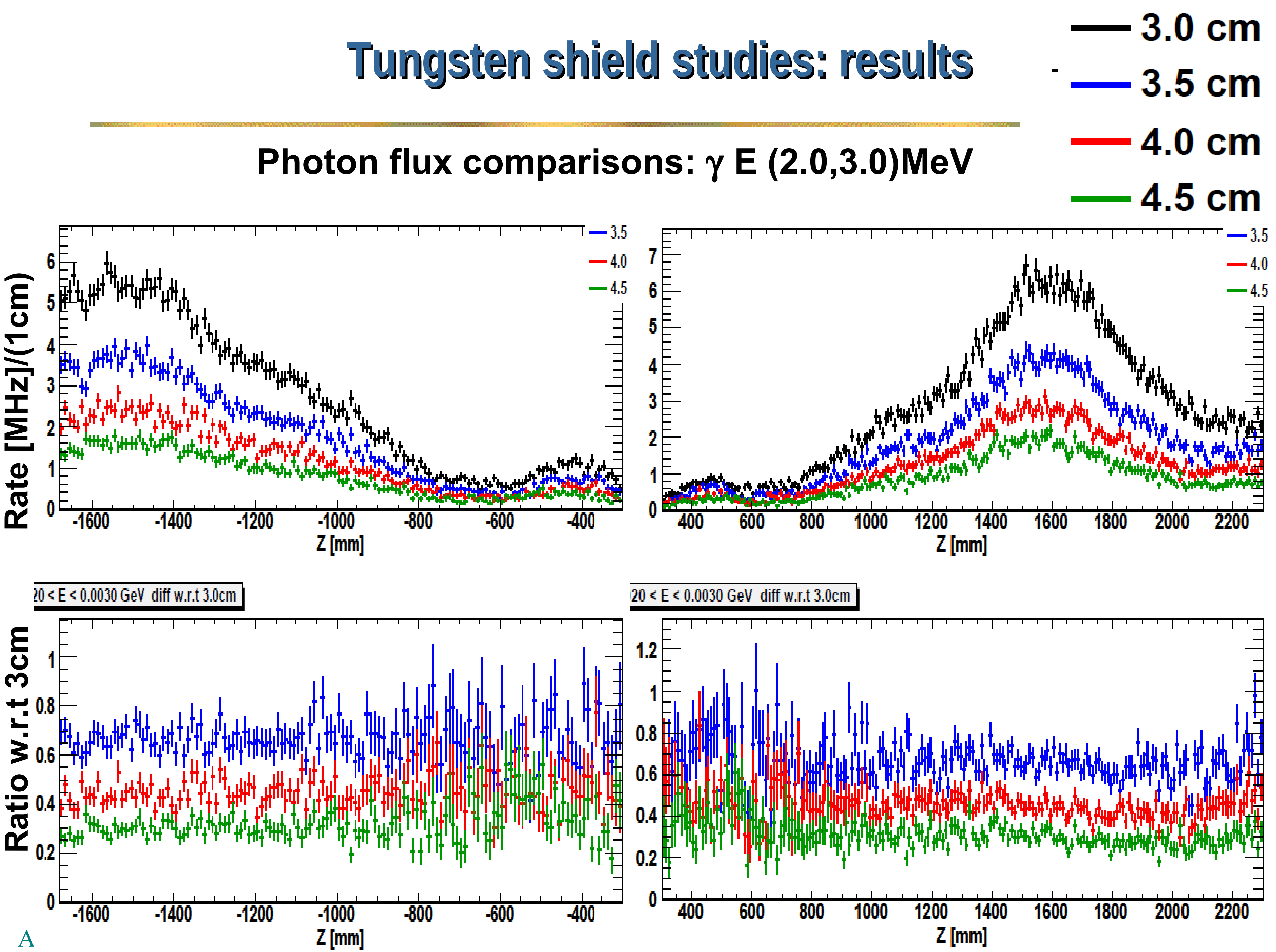
# Tungsten shield studies: results

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

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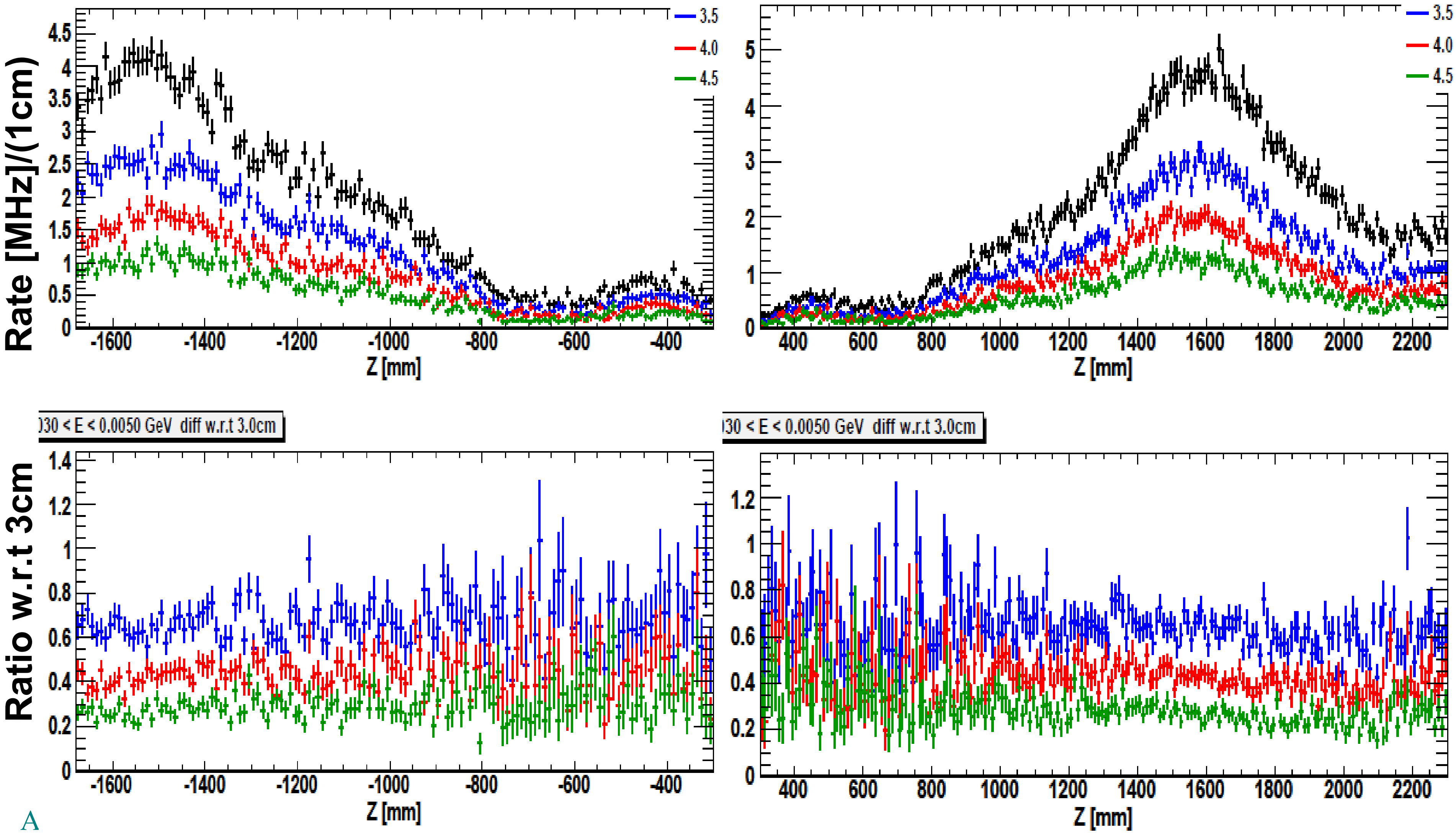
# Tungsten shield studies: results



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

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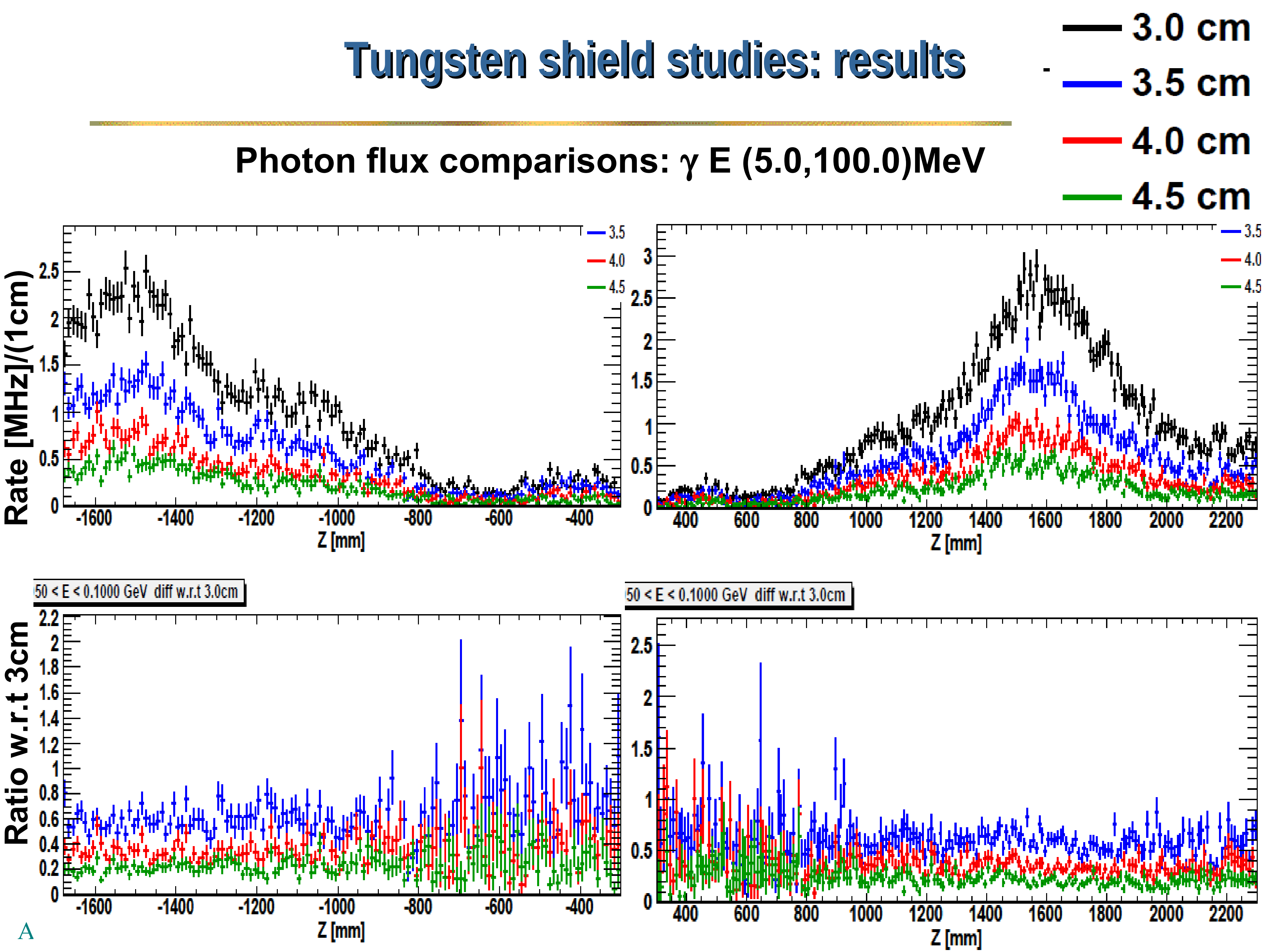
# Tungsten shield studies: results

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

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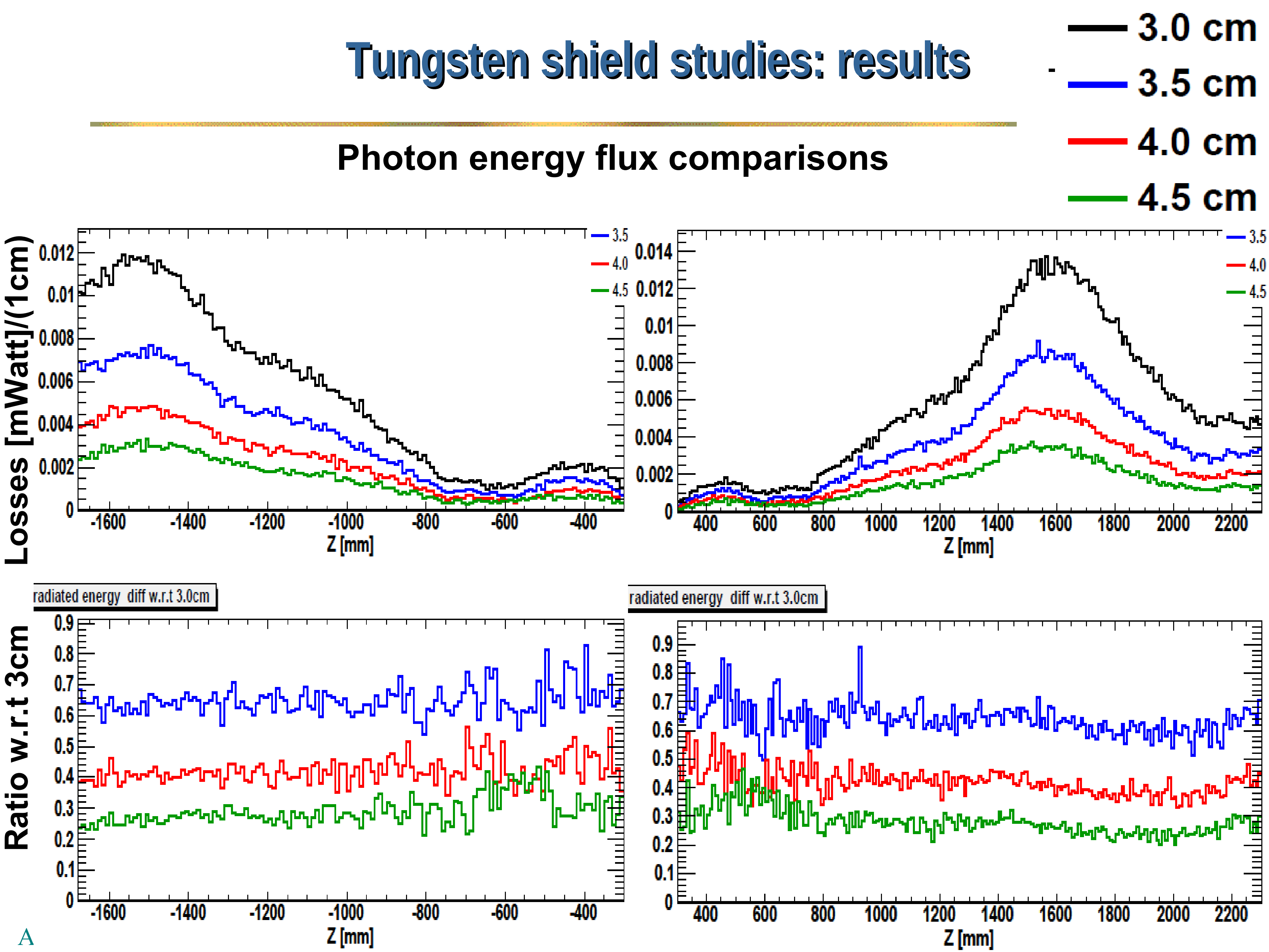
# Tungsten shield studies: results

## Photon energy flux comparisons

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