Update on FDIRC full simulation

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LNF SuperB Collaboration Meeting

Outline

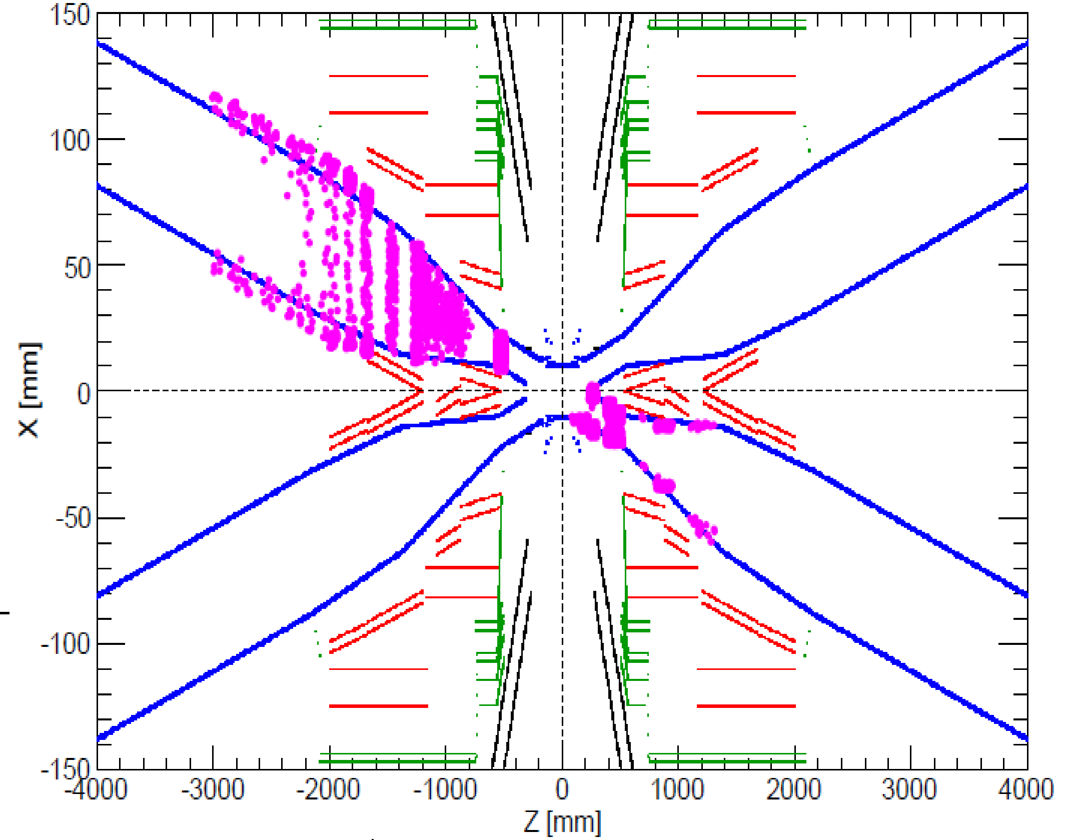
- The new beam-gas sample
- Beam-gas background rates on the FDRIC
- FDIRC shield studies
- Summary

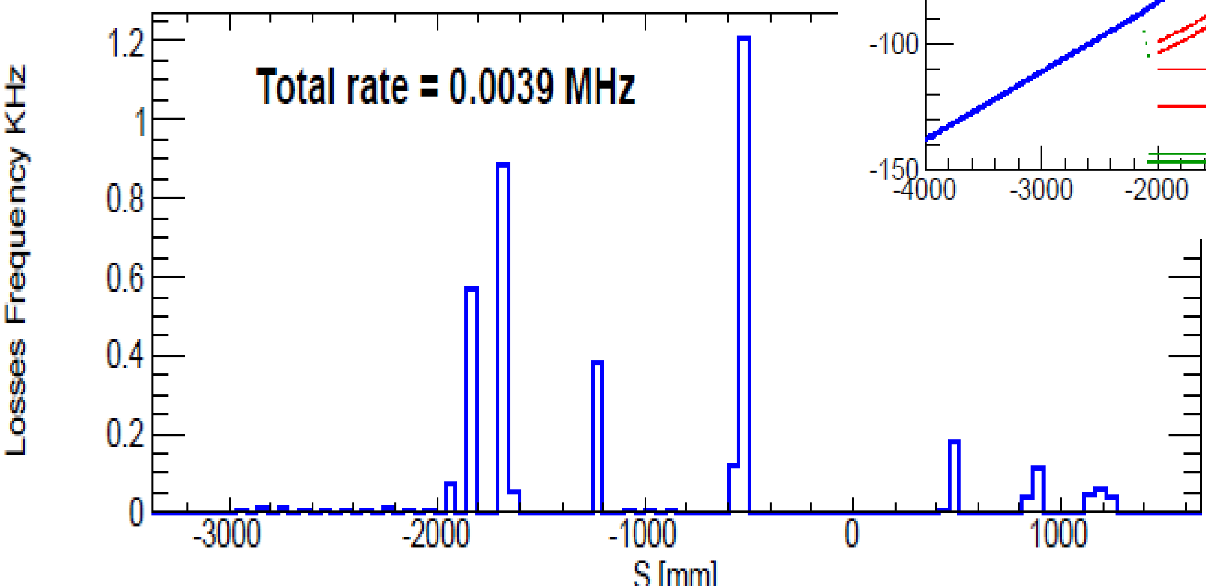
Beam-gas HER sample

- **285k primaries (losses) from beam gas HER backgrounds**
- **Total rate around the IP of 3.8MHz (Touschek-LER 58MHz)**

- **Run this sample with the code used for the Dec Production**

  ⇒ No FDIRC shield is included!

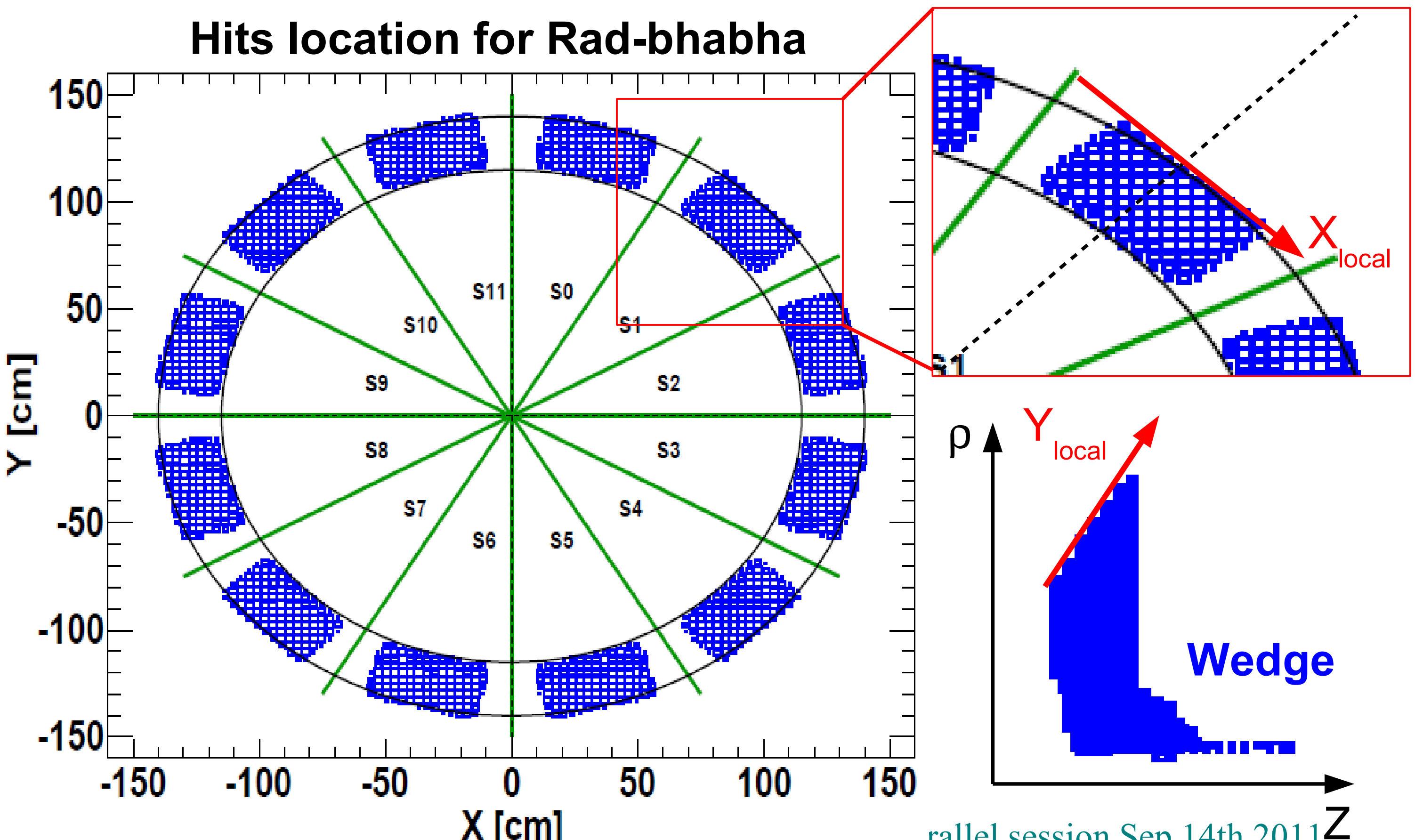




Bkg rates on the FDIRC: Strategy (I)

- **Use same sector labelling as in BABAR**
- **Determine the photo-electron (p.e.) rates per pixel** (see next slide) **for every sector and for all available background sources**
- **Use a “local” coordinate system in the instrumented plane:** X_{local} vs Y_{local}

Hits location for Rad-bhabha



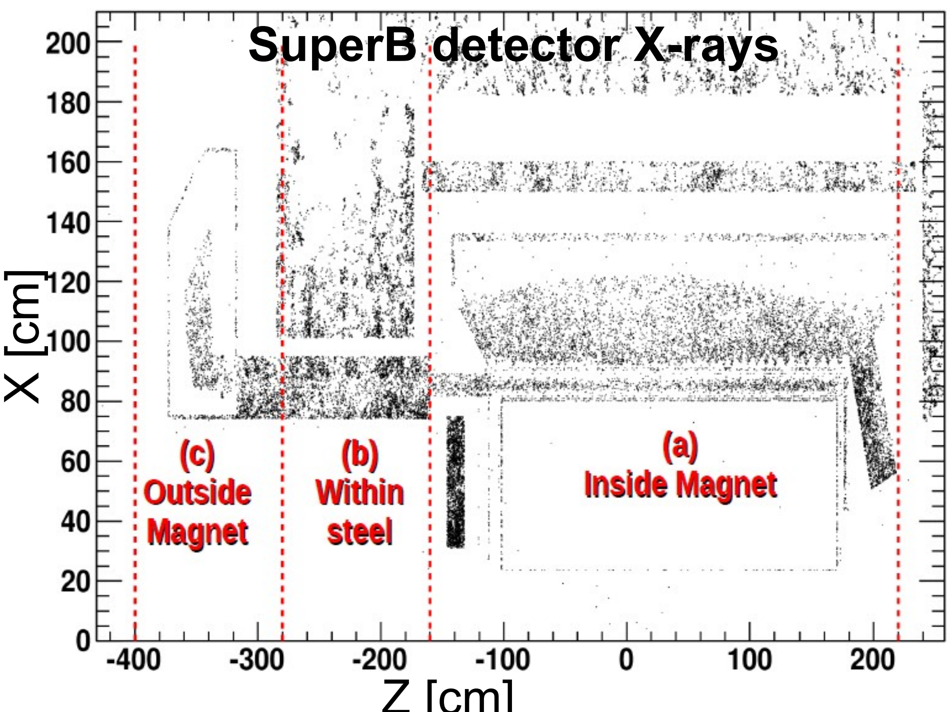
X_{local}:
From -width/2
up to width/2

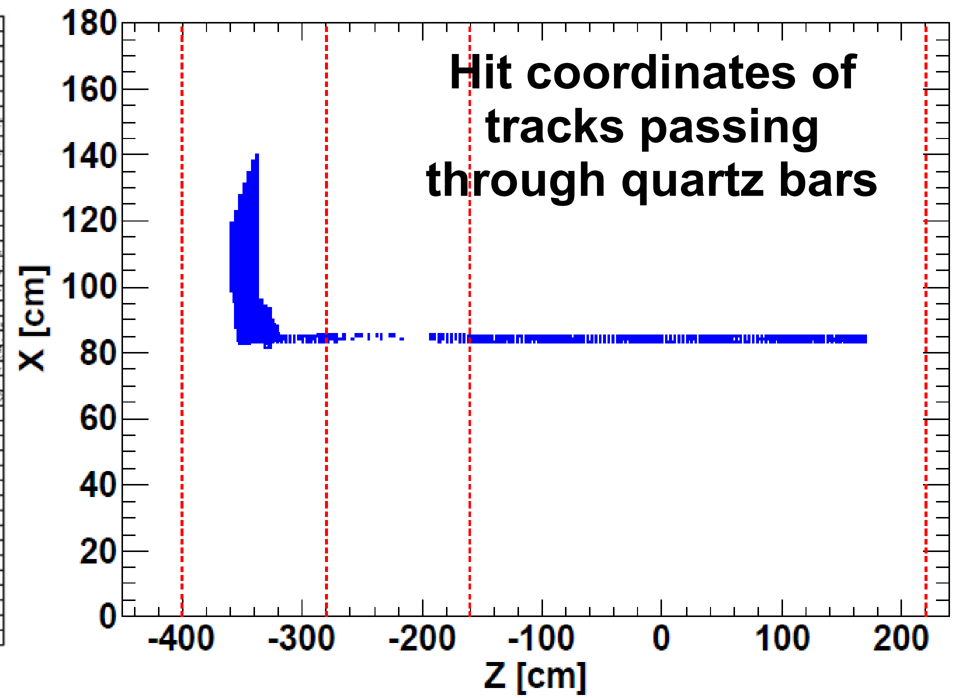
Y_{local}:
From 0.0
up to Length

Bkg rates on the FDIRC: Strategy (II)

- **Study the pixel rate for different regions were the tracks hit the quartz bar:**
  - (a) Inside magnet: -160 < Z < 220 cm
  - (b) Within steel: -280 < Z < -160 cm
  - (c) Outside magnet: -280 < Z < -400 cm
- **If main contribution comes from outside magnet**

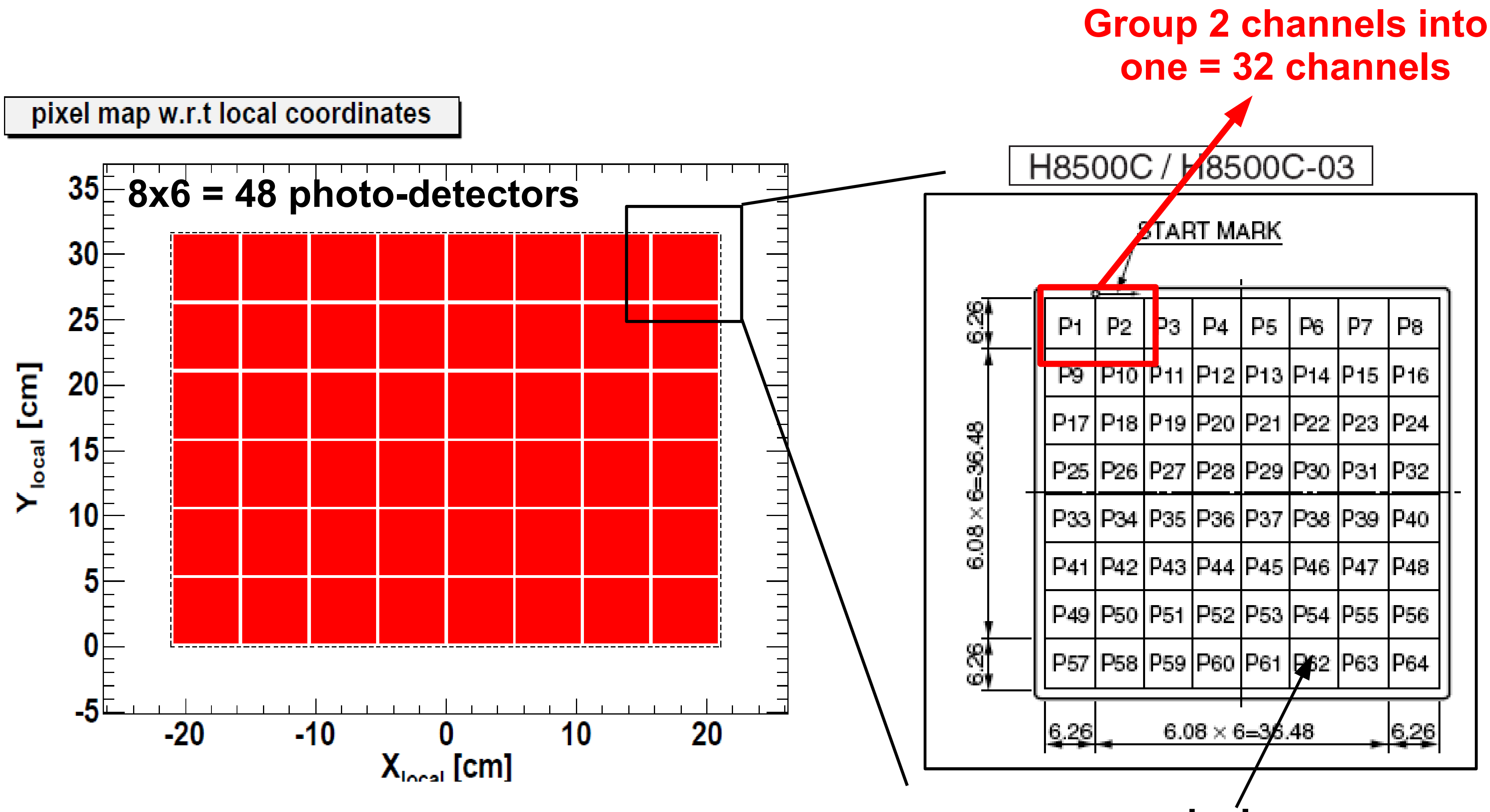
  ⇒ can reduce backgrounds by increasing shields





Bkg rates on the FDIRC: Pixel map

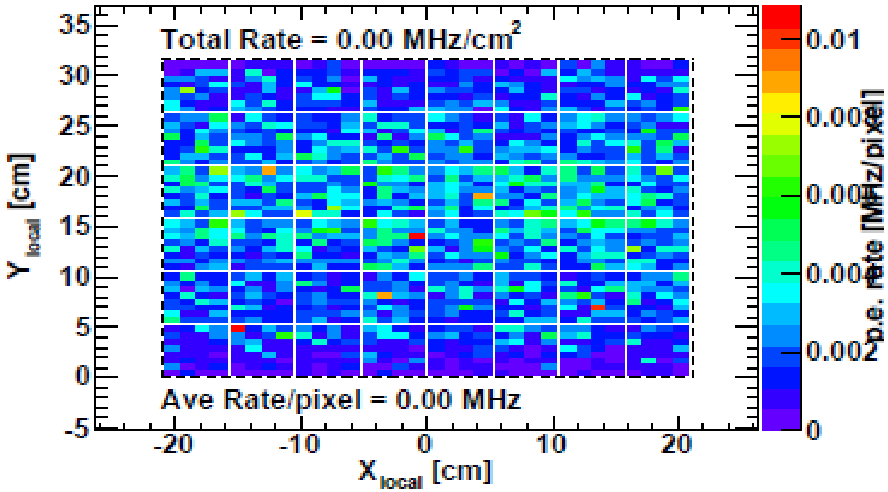
- For each sector have an array 8x6 = 48 photo-detectors
- Each detector is an 8x8 = 64 array of PMTs (pixels) with ~6.08mm pitch



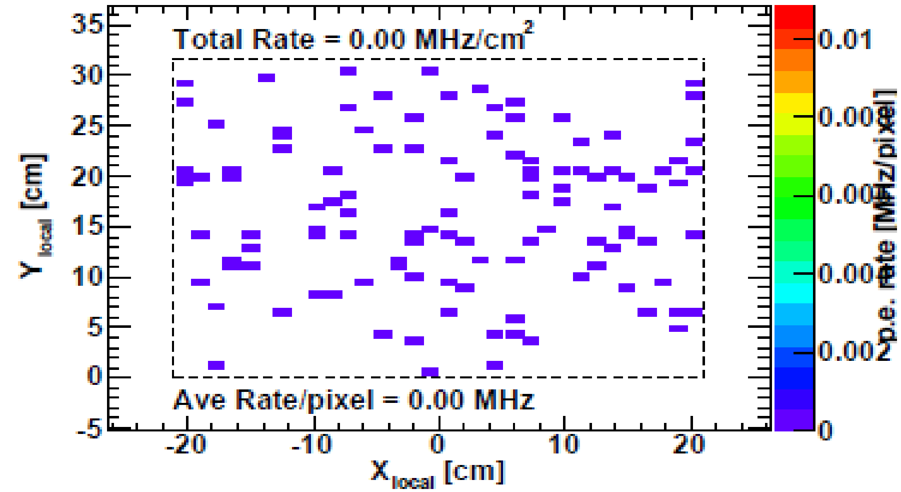
FDIRC Bkg rates from Beam-gas HER (I)

Sector 6

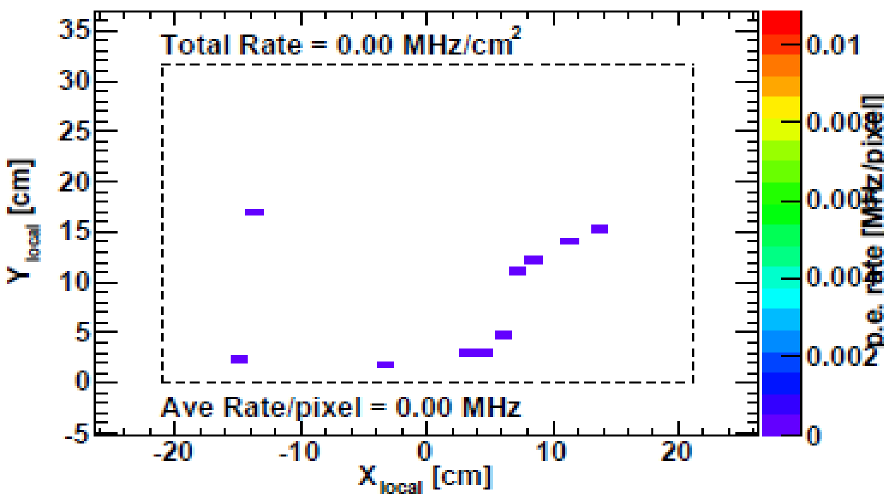
Inside Magnet



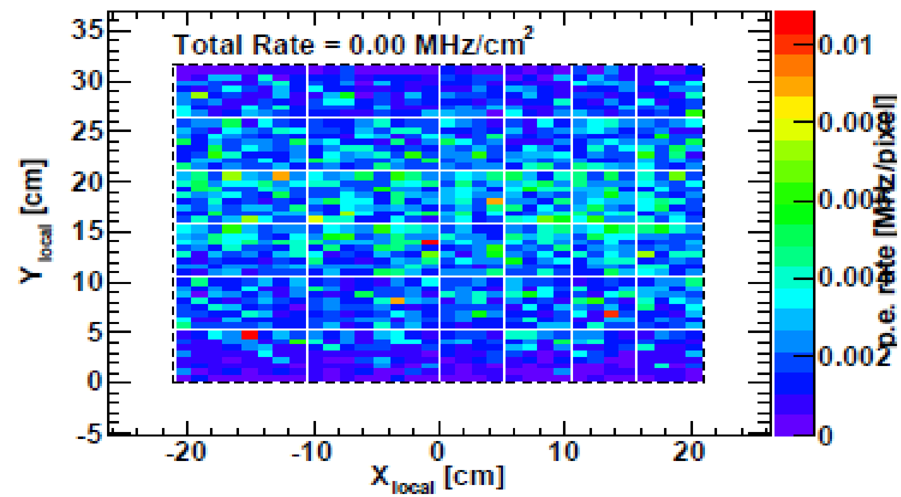
Within Steel



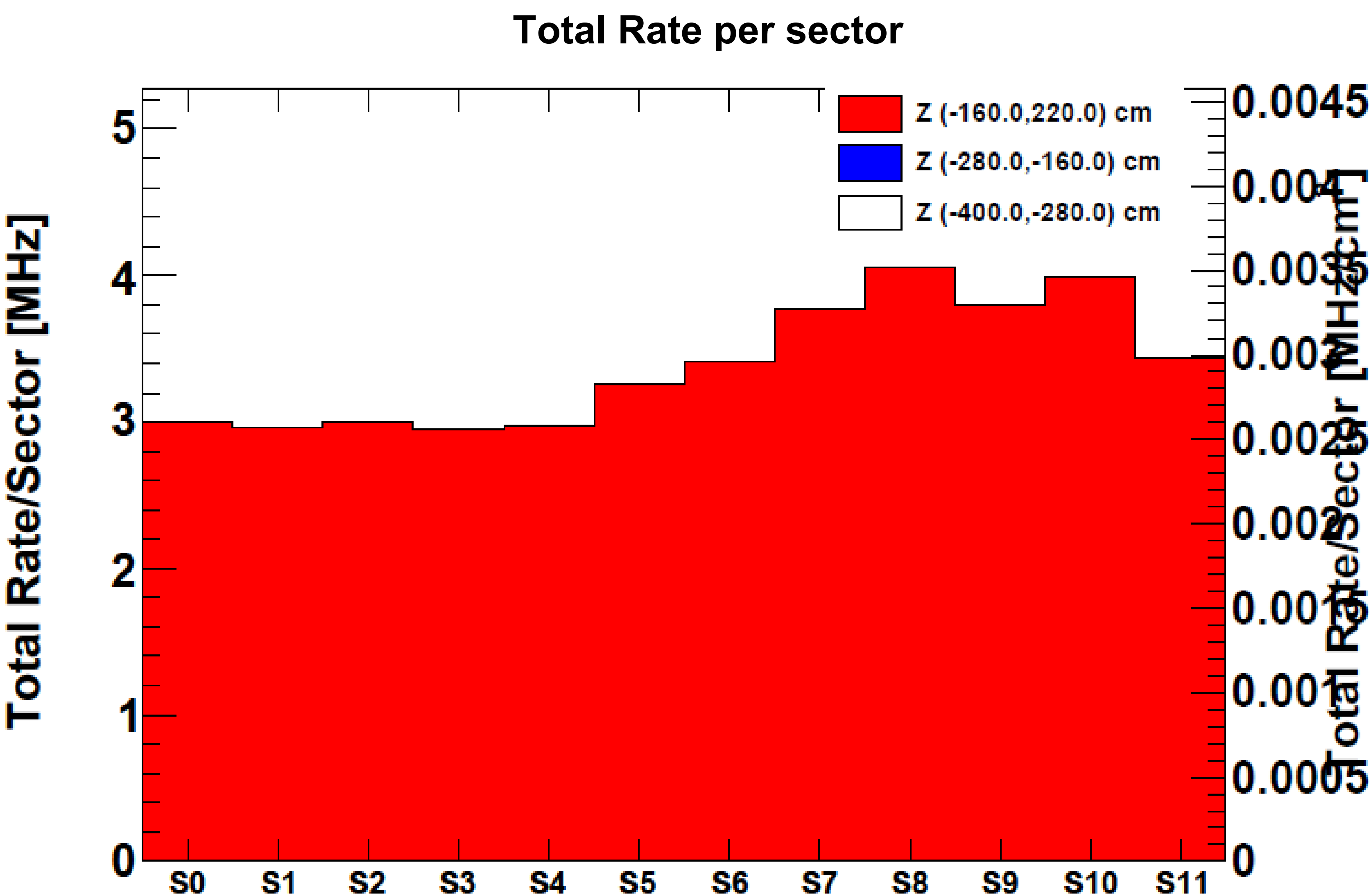
Outside Magnet



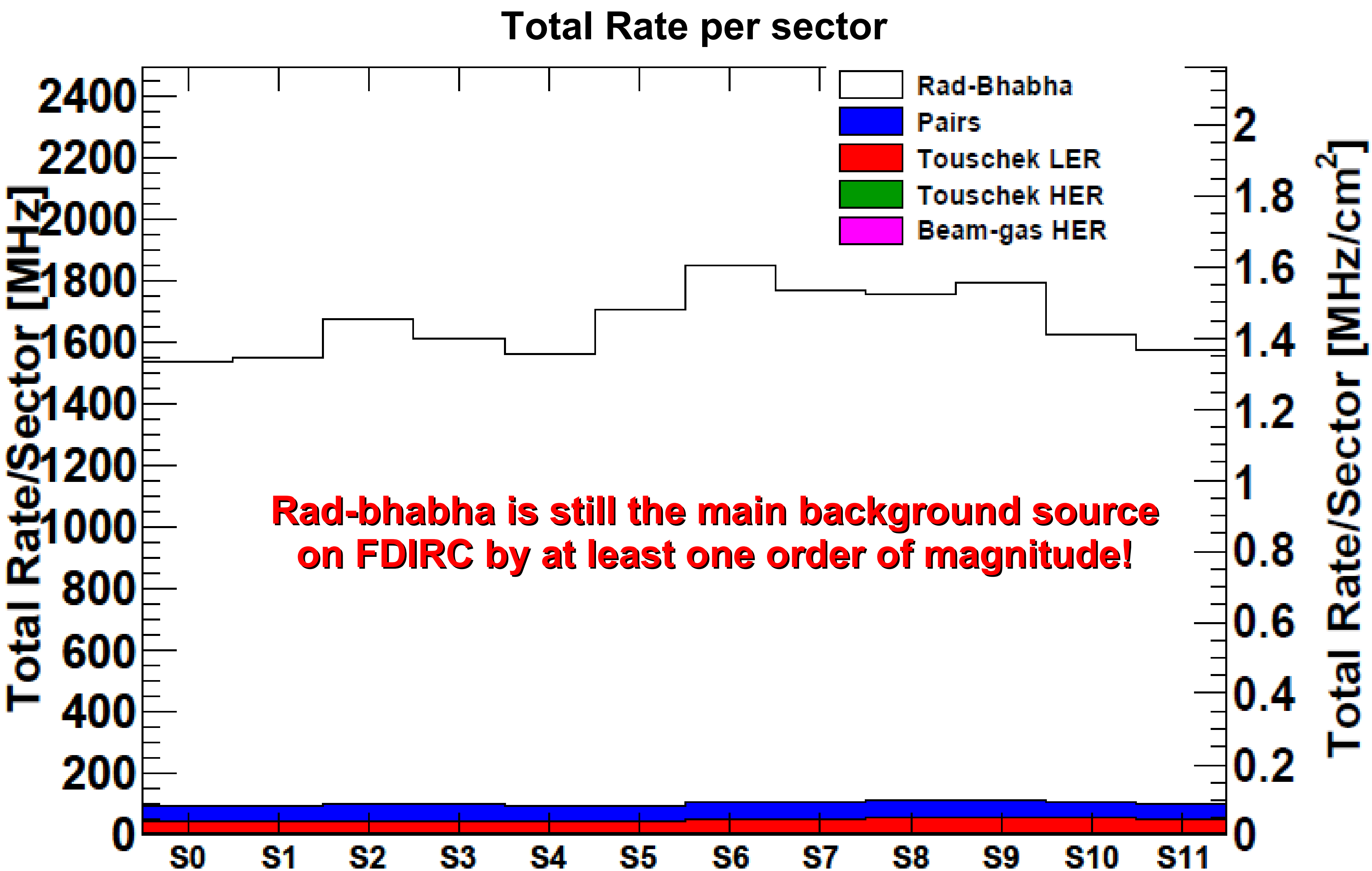
Total Rate



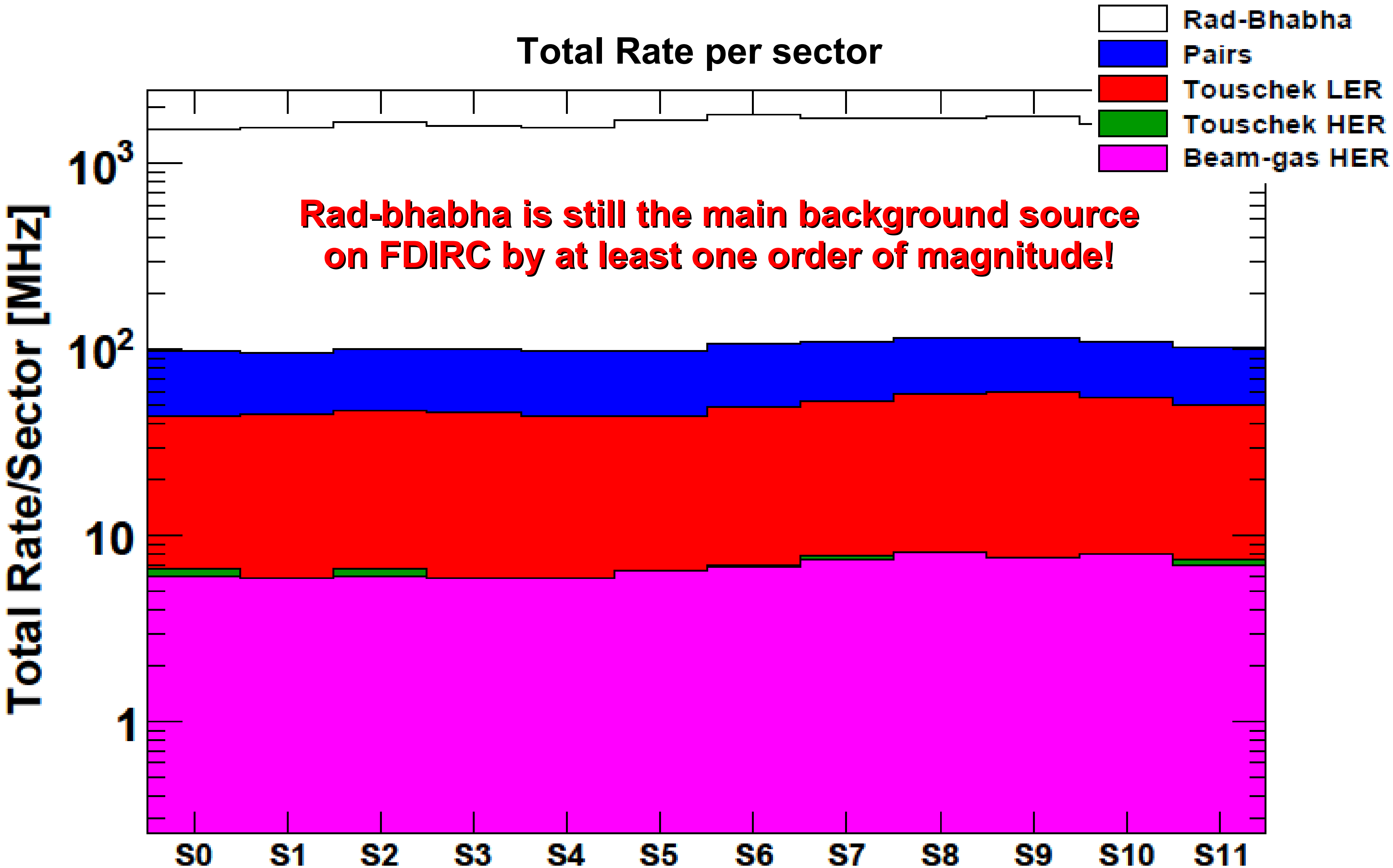
FDIRC Bkg rates from Beam-gas HER (II)



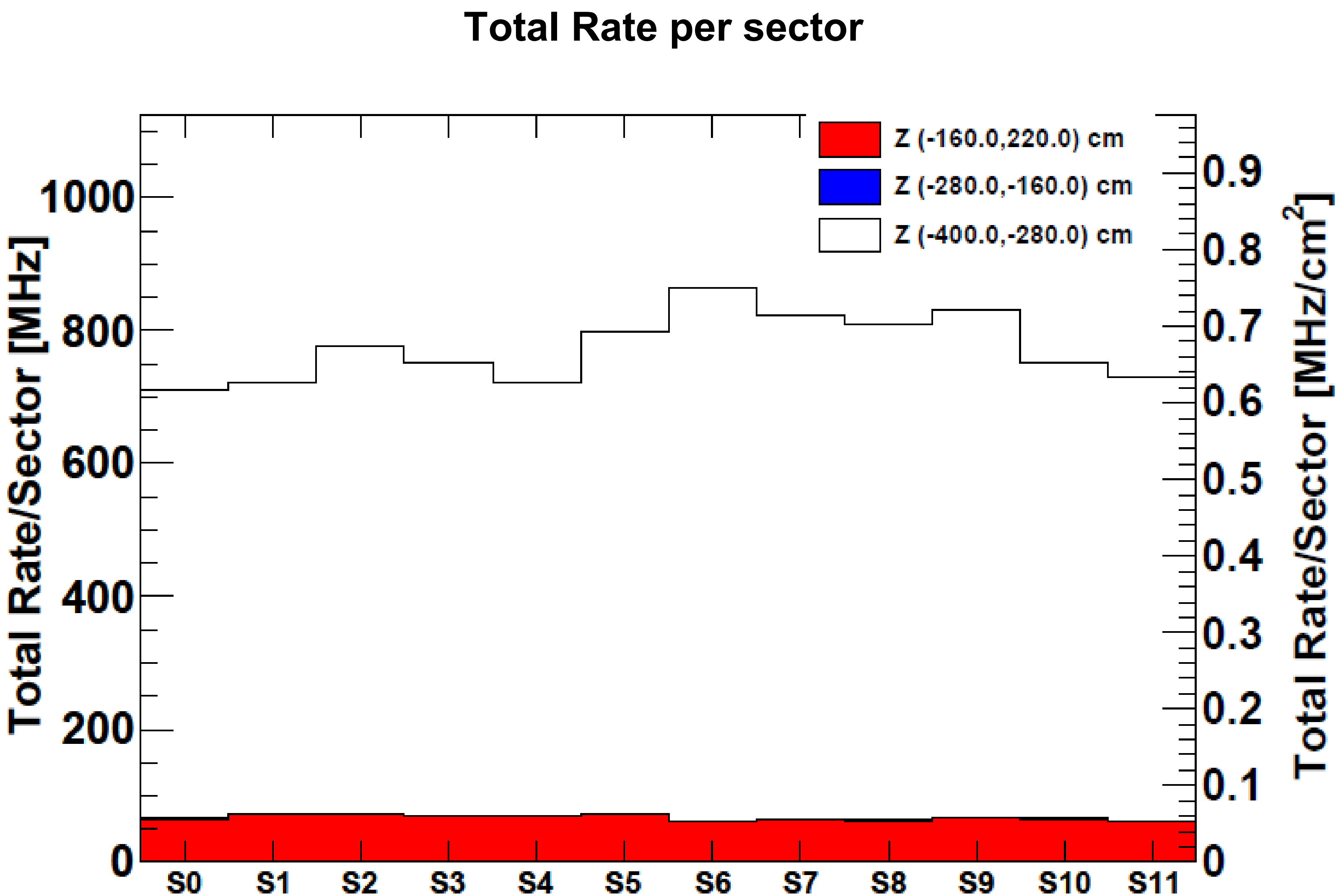
Total bkg rates on FDIRC



Total bkg rates on FDIRC

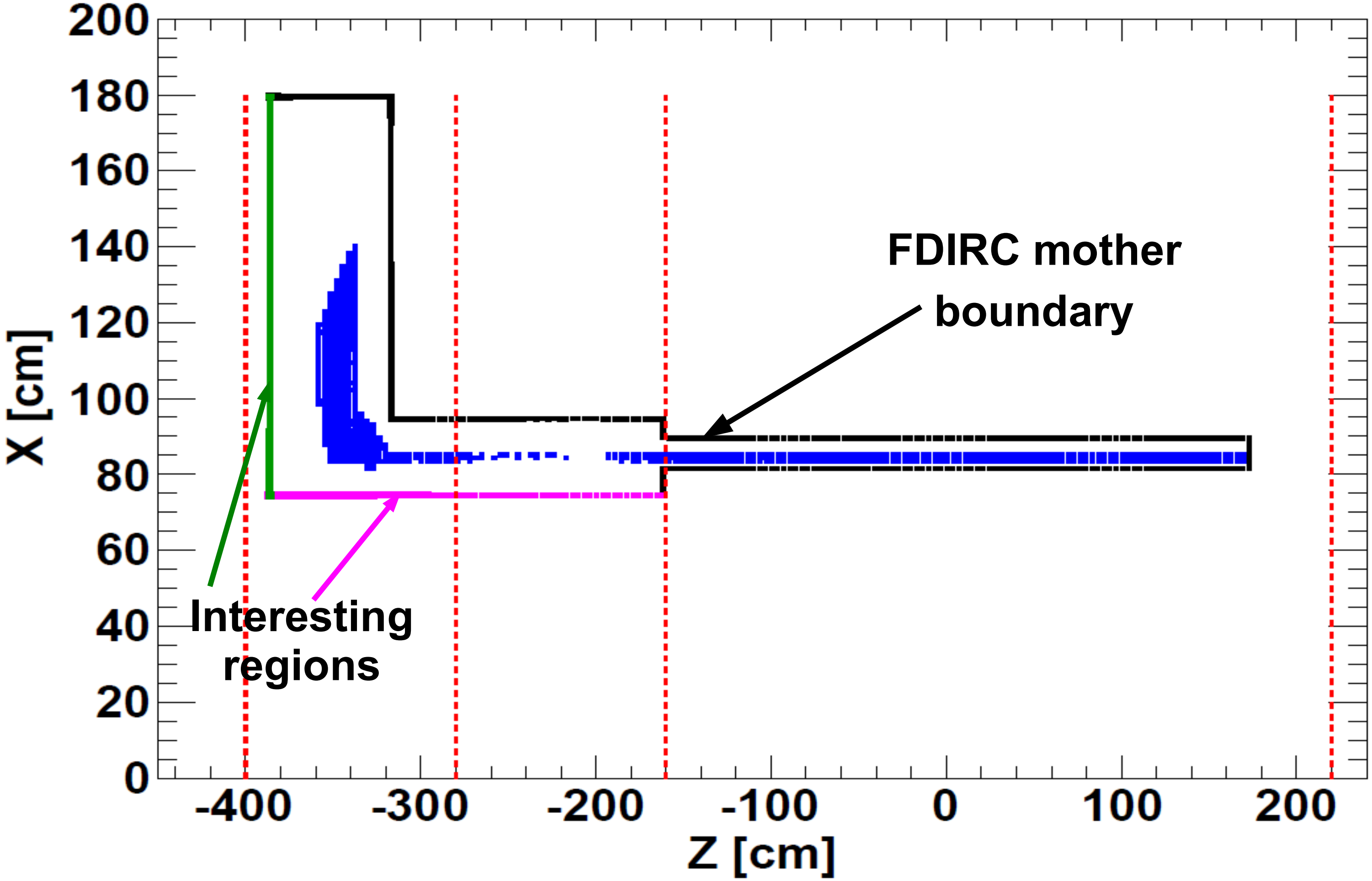


FDIRC Bkg rates from Rad-Bhabha

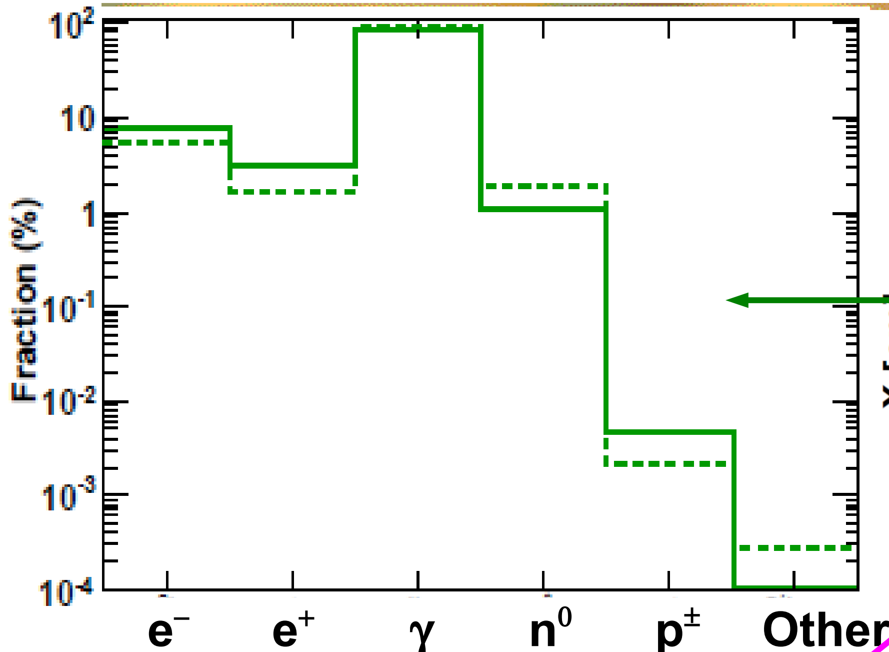


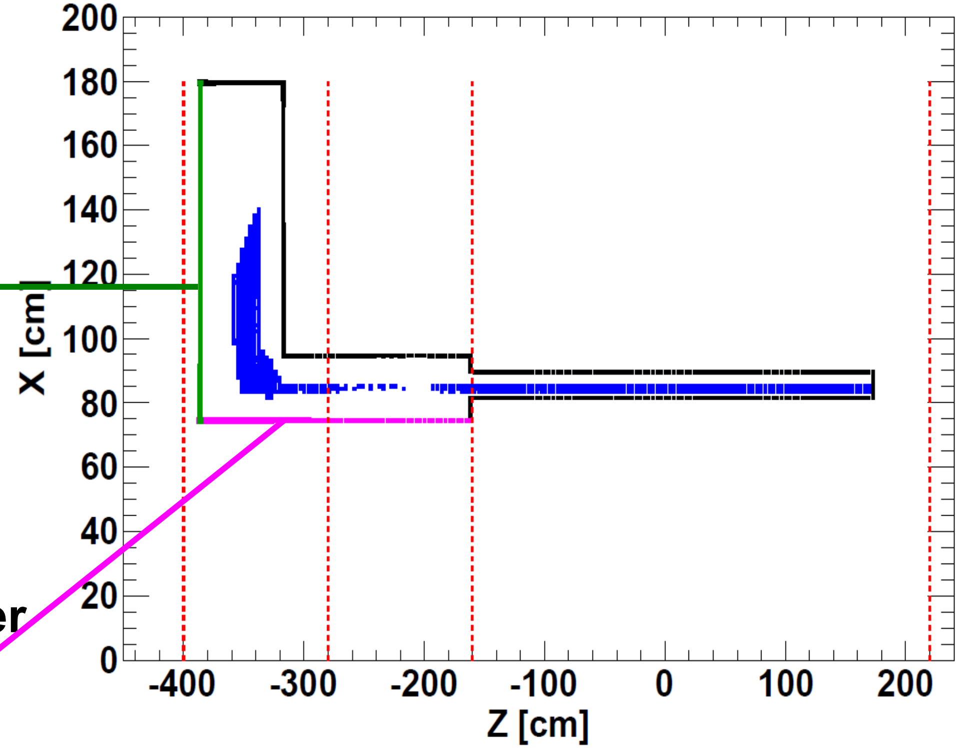
Particle flux studies (I)

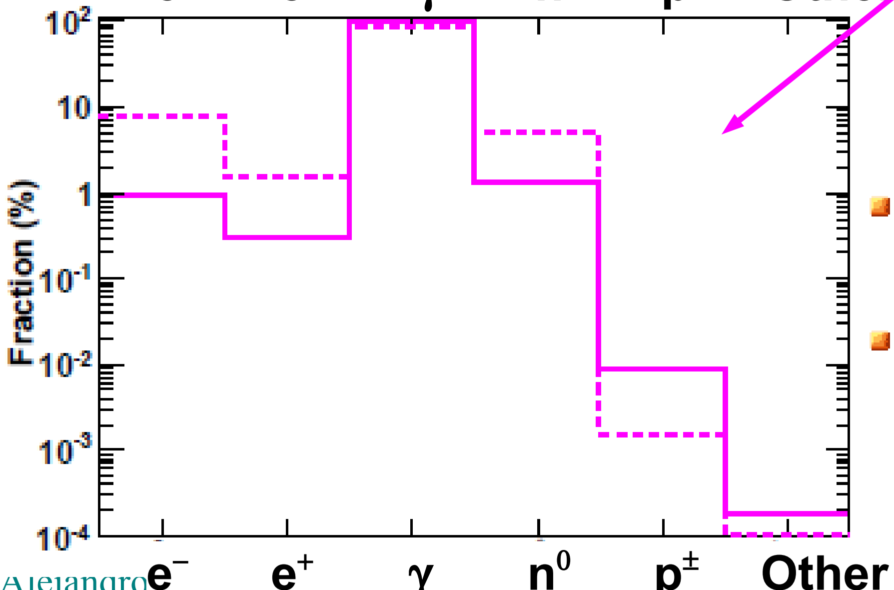
- Study the flux of particles through interesting regions of the the FDIRC mother boundary (magenta and green regions)
- Try to understand the nature of the particles crossing those boundaries (PID and spectrum)



Particle flux studies (II)

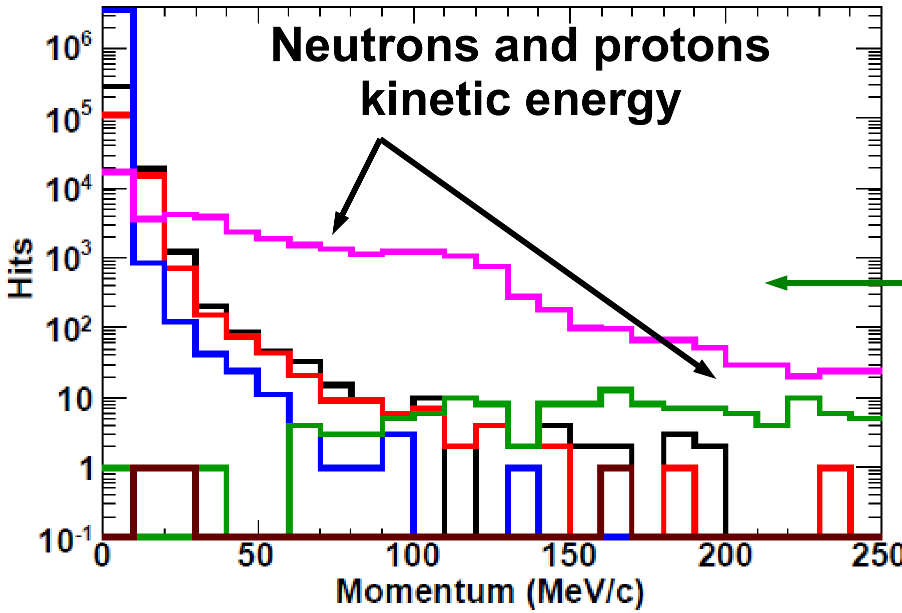


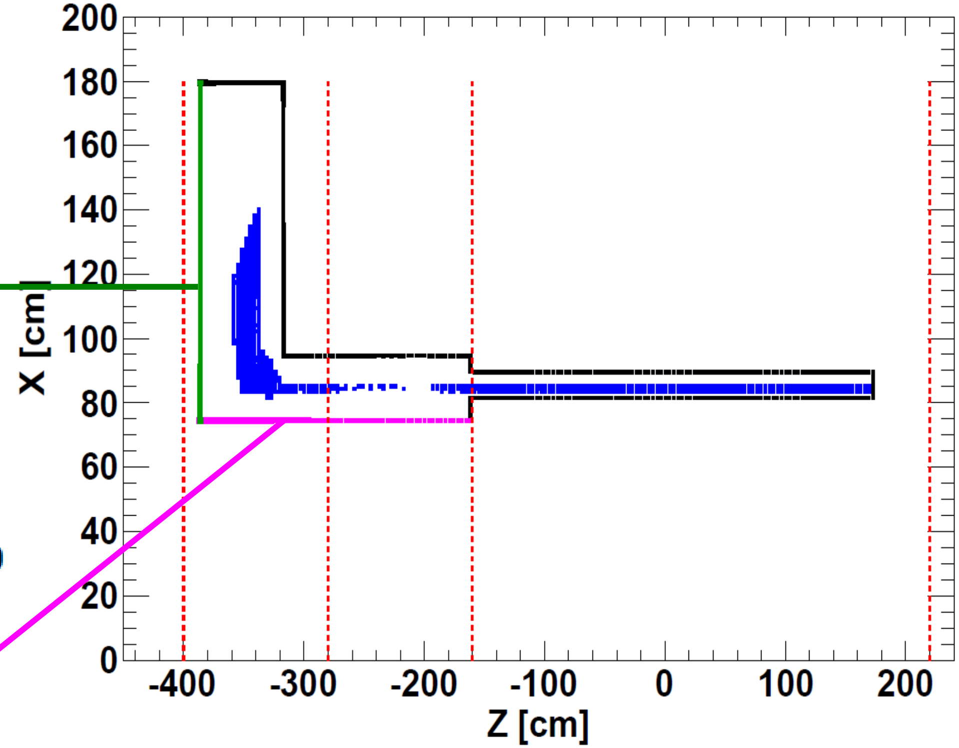


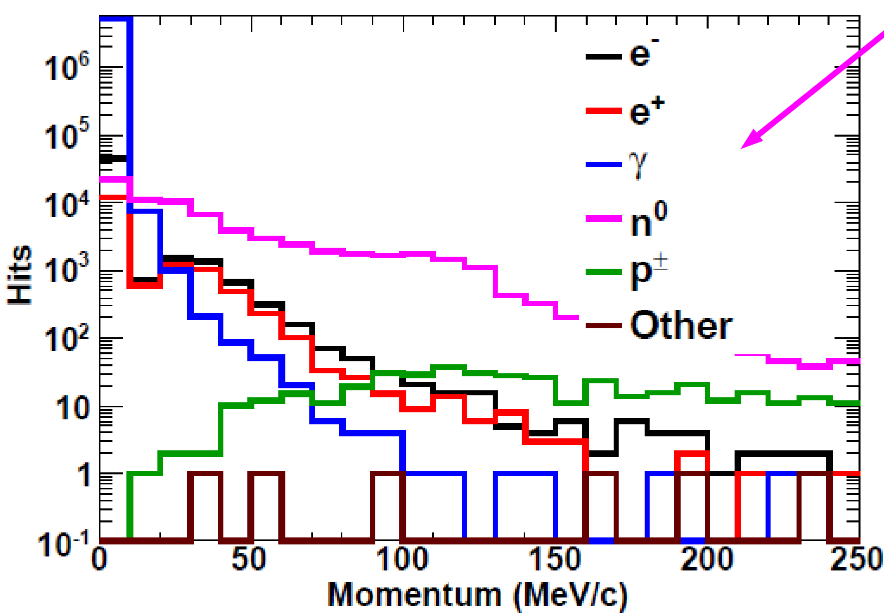


- The main contribution to the flux are γ (~90 – 98%) and $e^\pm$ (1-10%)
- In the second place are neutrons (~1%)

Particle flux studies (III)

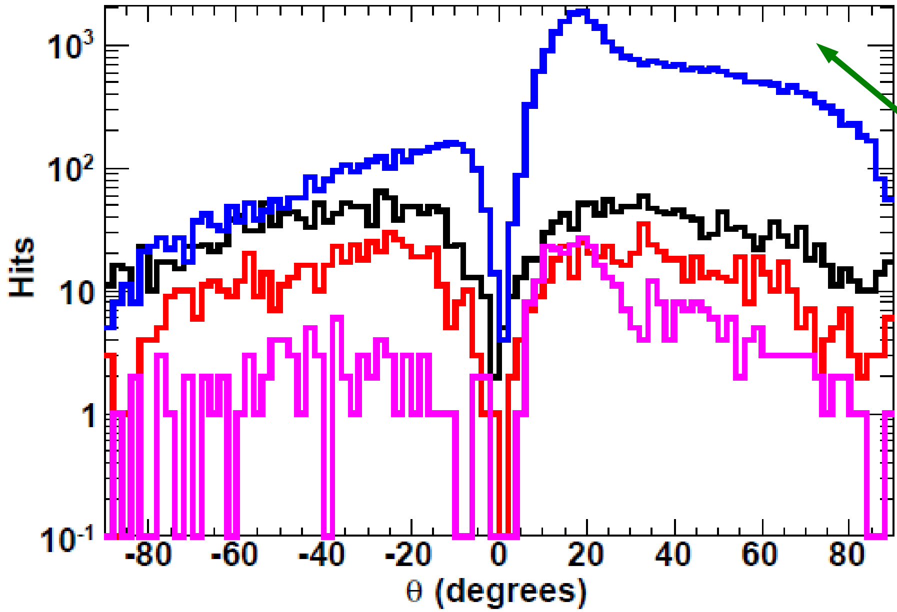


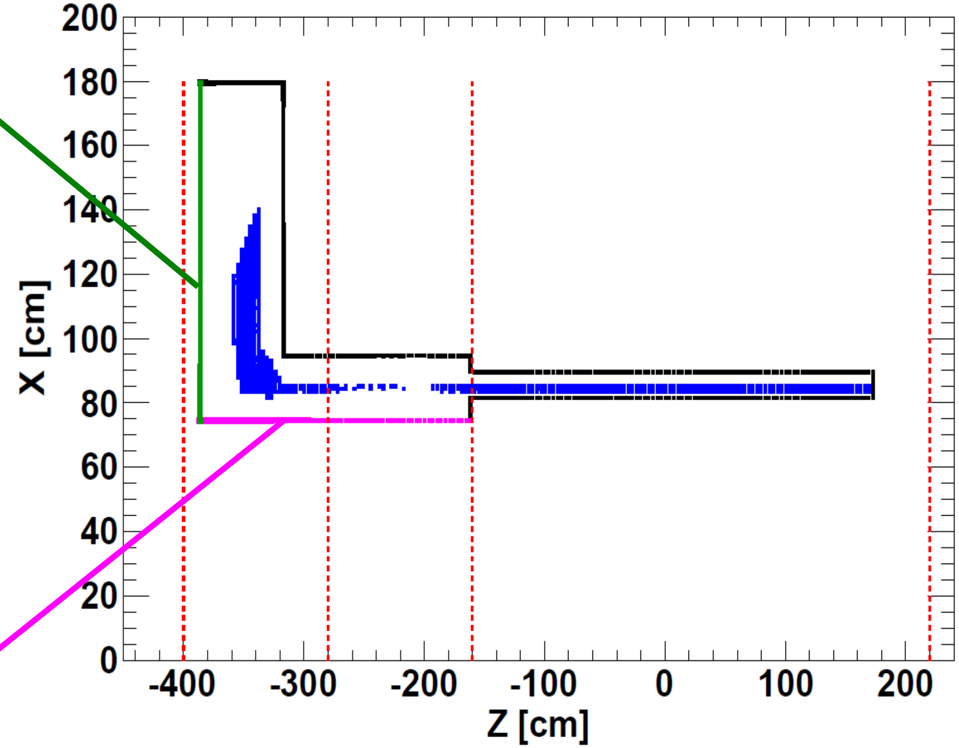


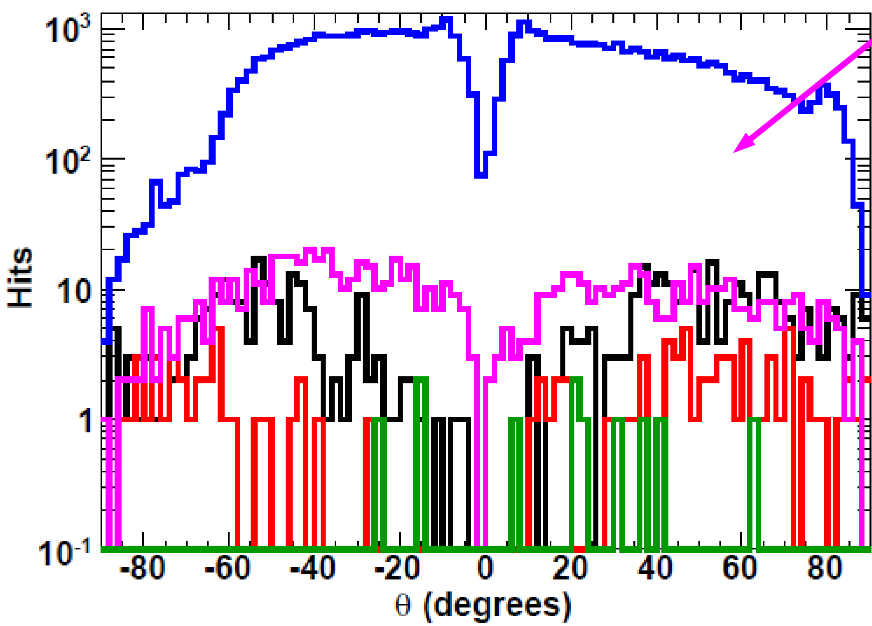


- The main contribution of the flux are γ and $e^\pm$ doesn't with energies below 200 MeV
- Neutrons and protons on the other hand have a harder spectrum (kinetic energy)

Particle flux studies (VI)





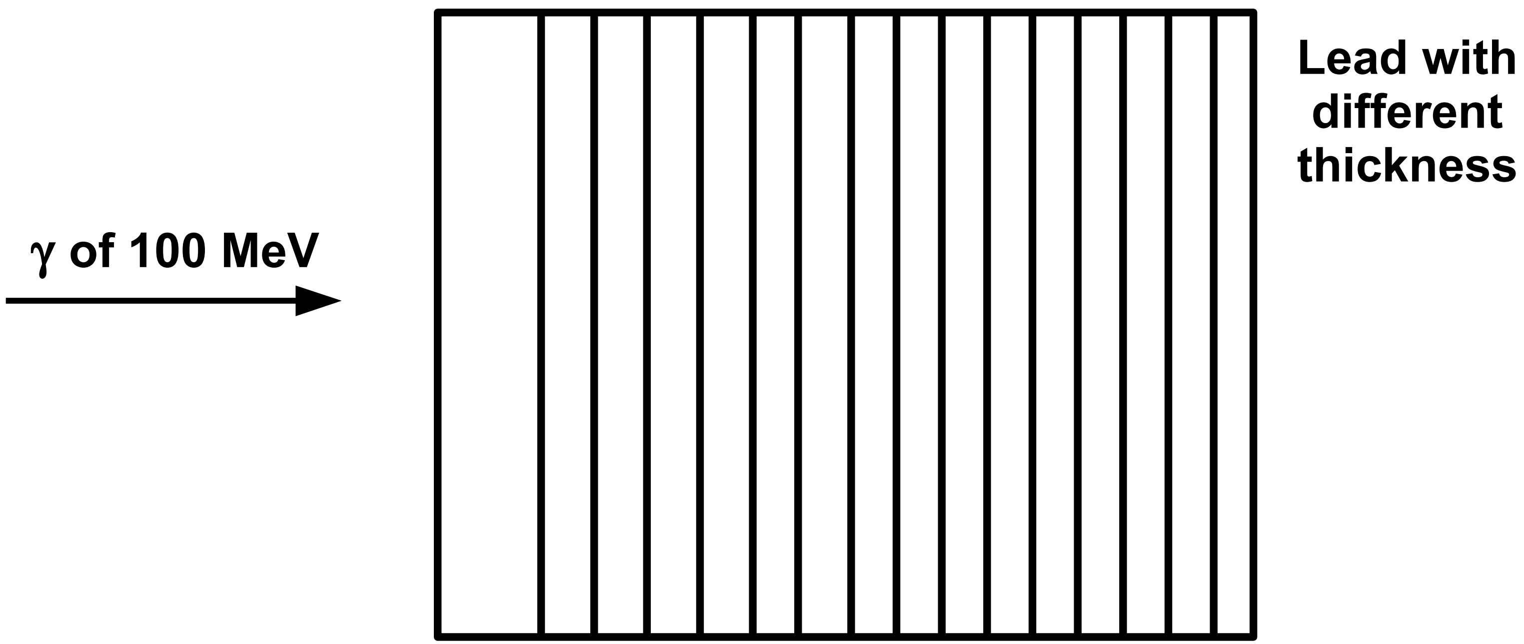


- **Incident angle:**
  - **θ = 0 means normal incidence**
  - **θ > 0 means particles coming more or less from the IP**
- **Most of the particles have a not-normal incidence**

Lead shield optimization studies (I)

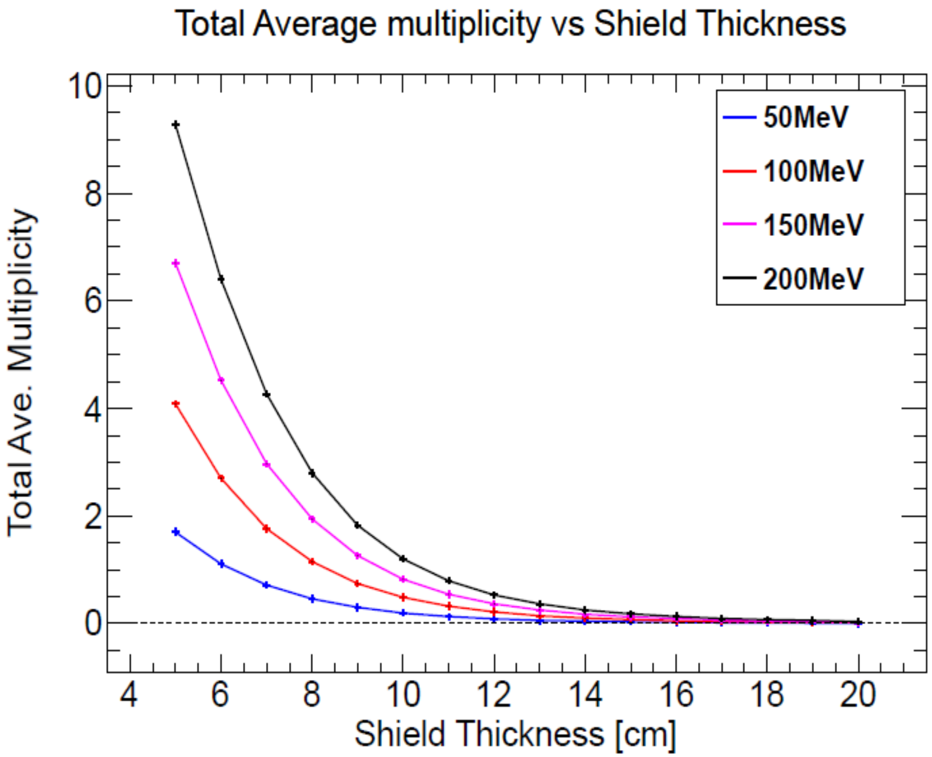
- **Shot particles ($e^{\pm}$, γ, n^0) at normal incidence on Lead for**
  - Different lead thickness: 5 – 20 cm (1cm steps)
  - Different incident energies: 50 – 200 MeV (50MeV steps)
- **Study the particle multiplicity and spectrum at the other end of the shield**
- **Optimization: thickness for which the probability to have more than one particle on the other side of the shield is lower than 10%**

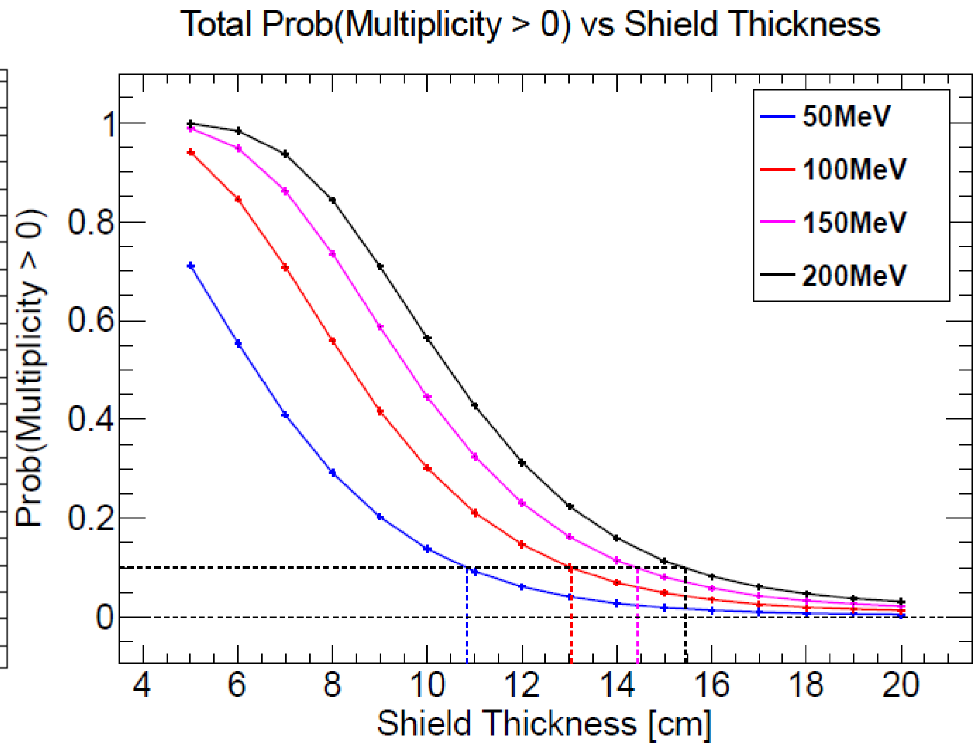
Probability(Multiplicity > 0) ≤ 10%



Lead shield optimization studies (II)

Incident photons

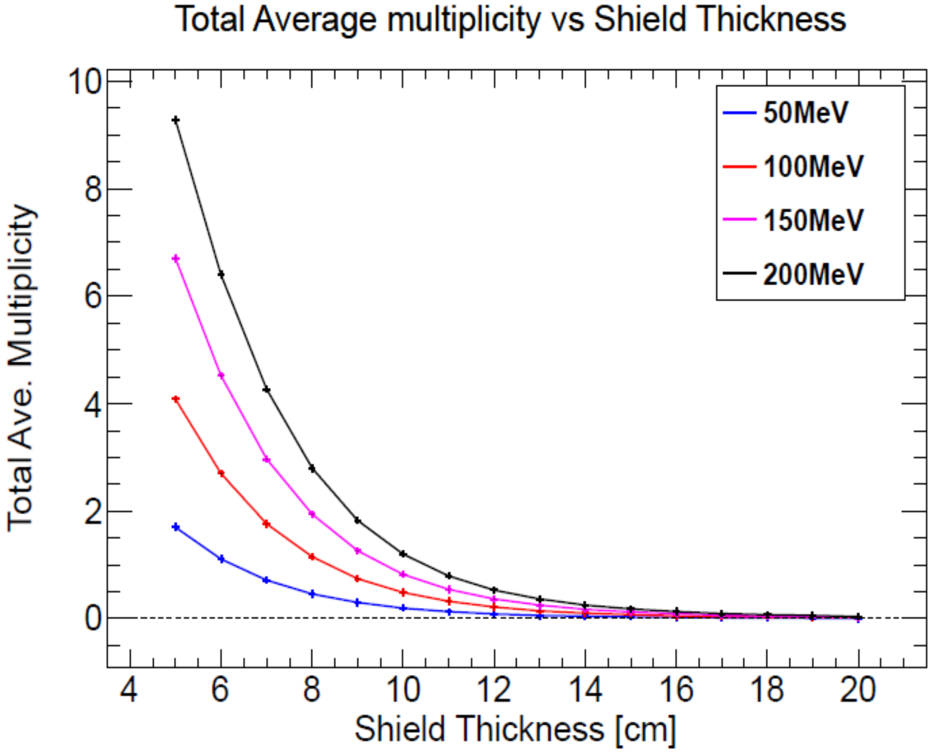


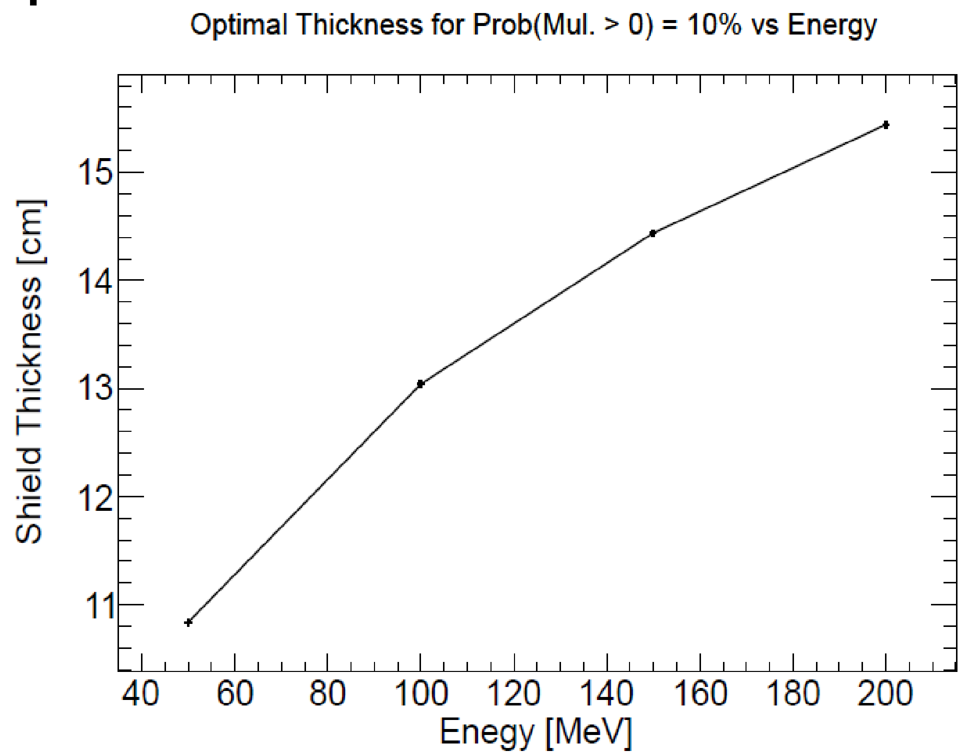


- Multiplicity at the other end of the lead shield due mainly to photons and electrons/positrons (very small contribution from neutrons)
- Higher the energy of the incident photon, thicker must be the lead shield

Lead shield optimization studies (II)

Incident photons

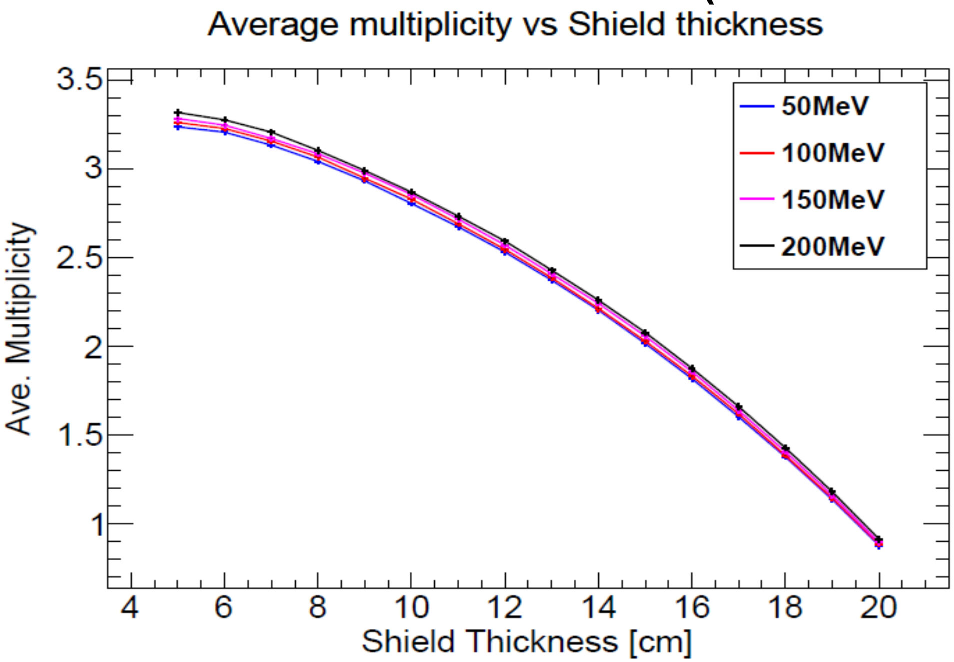


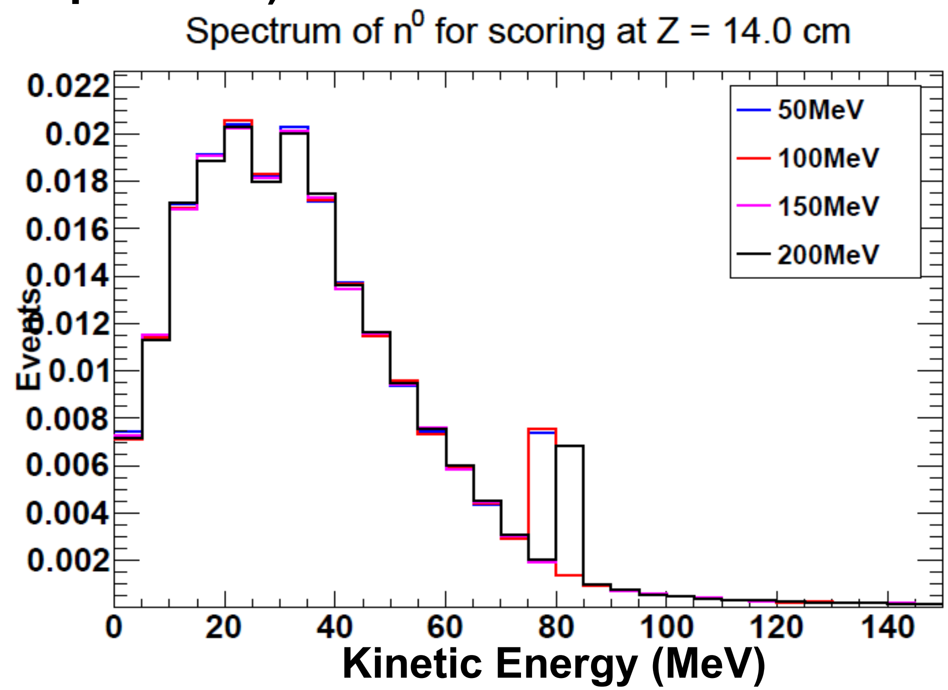


- **Multiplicity at the other end of the lead shield due mainly to photons and electrons/positrons (very small contribution from neutrons)**
- **Higher the energy of the incident photon, thicker must be the lead shield**
- **In order to reduce the photon flux by a factor of 10 for photons up to 150MeV, the lead shield thickness needs to be 14.4cm**

Lead shield optimization studies (III)

Incident neutrons
(neutron multiplication)



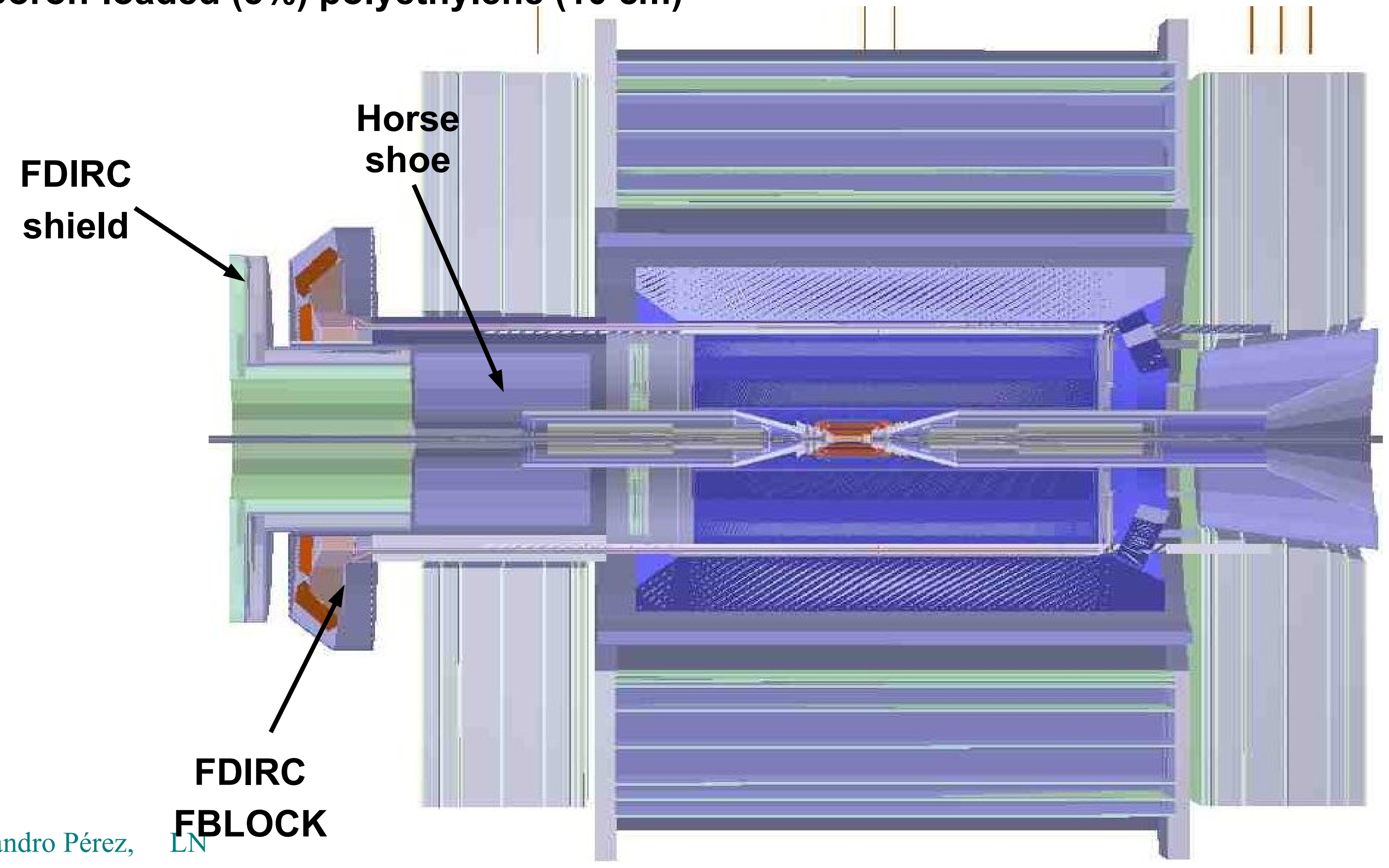


- **Incident neutrons with kinetic energies from 50 to 200 MeV get multiplied by a factor of ~2.3 for lead thickness of 14cm**
- **The kinetic energy spectrum of those neutrons has a slight variation with the incident neutron kinetic energy**
- **Outgoing neutrons have a significant amount of kinetic energy (10 – 70 MeV)**

⇒ Add a Boron-loaded (5%) polyethylene shield

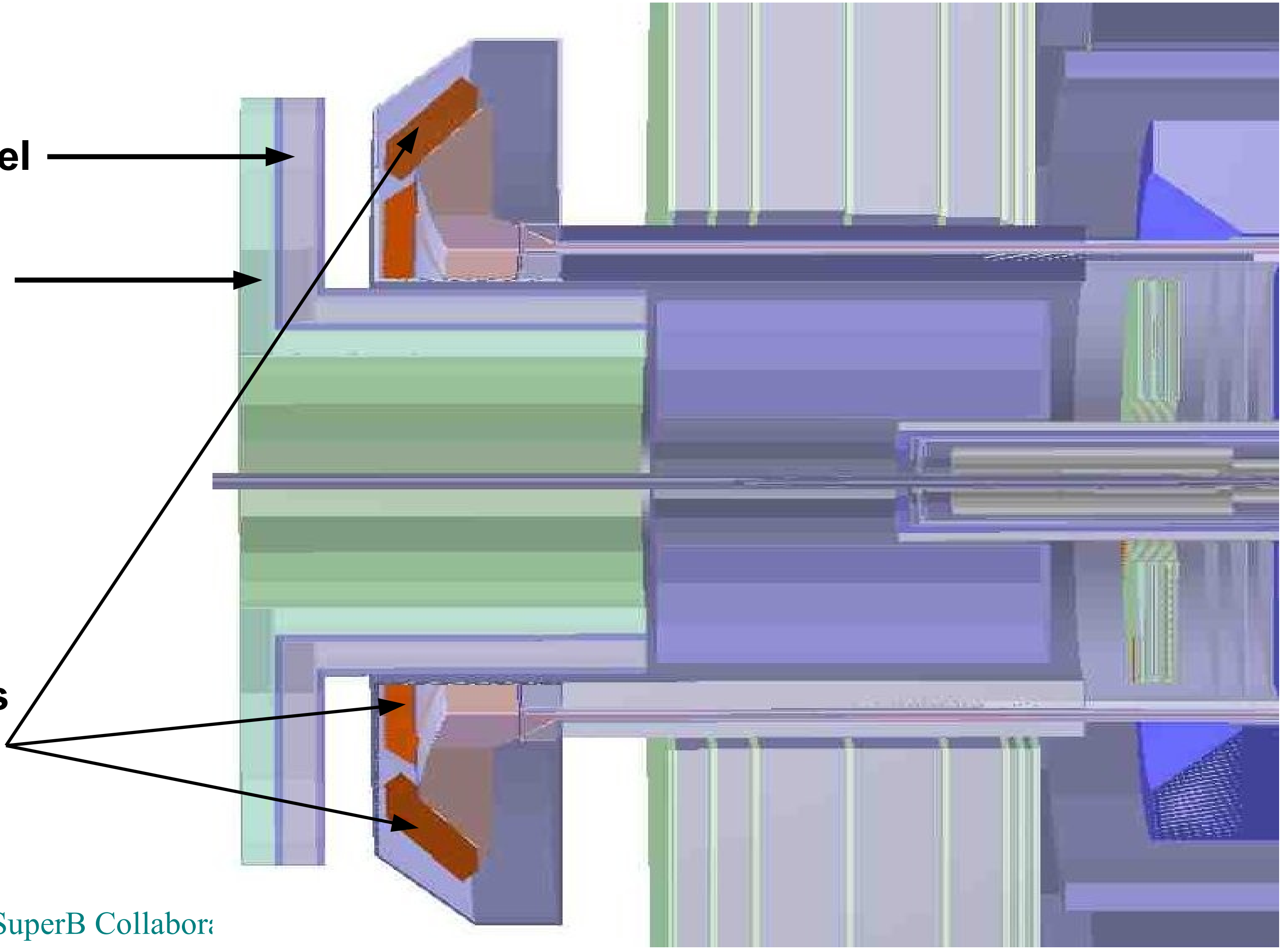
FDIRC shield: BRN implementation

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



FDIRC shield: BRN implementation

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



Summary

- **Beam-gas HER of the same order as Touschek LER**
- **The main machine background contribution on the FDIRC is due to Rad-bhabha, mainly from tracks hitting the quartz bar in the FBLOCK region**
- **Main flux of particles on FBLOCK are photons with energy lower than 200MeV**

- **Shields:**
  - Lead thickness of 14cm can reduce the background by a factor of ~10. Shield BRN implementation: steel-lead-steel (2.5-10-2.5 cm) sandwich
  - **Neutrons:**
    - Neutron multiplication by a factor ~2.2 for lead shield thickness of 14cm
    - Will add a Boron-loaded polyethylene shield (10 cm)
- **FEE:**
  - FEE boards implemented and instrumented by Riccardo
  - Ready to study the doses and neutron fluxes

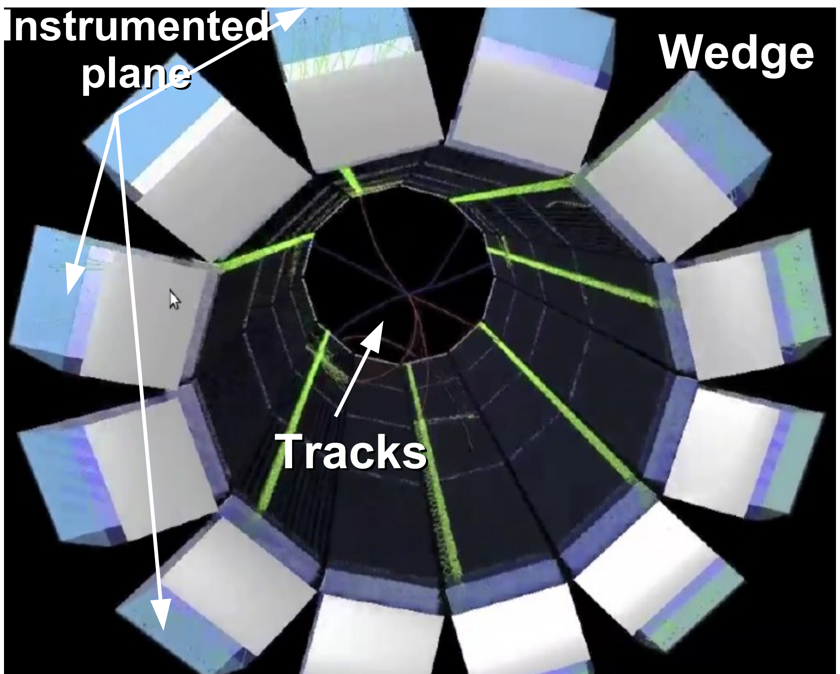
- **FullSim code will freeze in 2 weeks from now.**
- **FullSim production is expected to start in 3 weeks from now.**

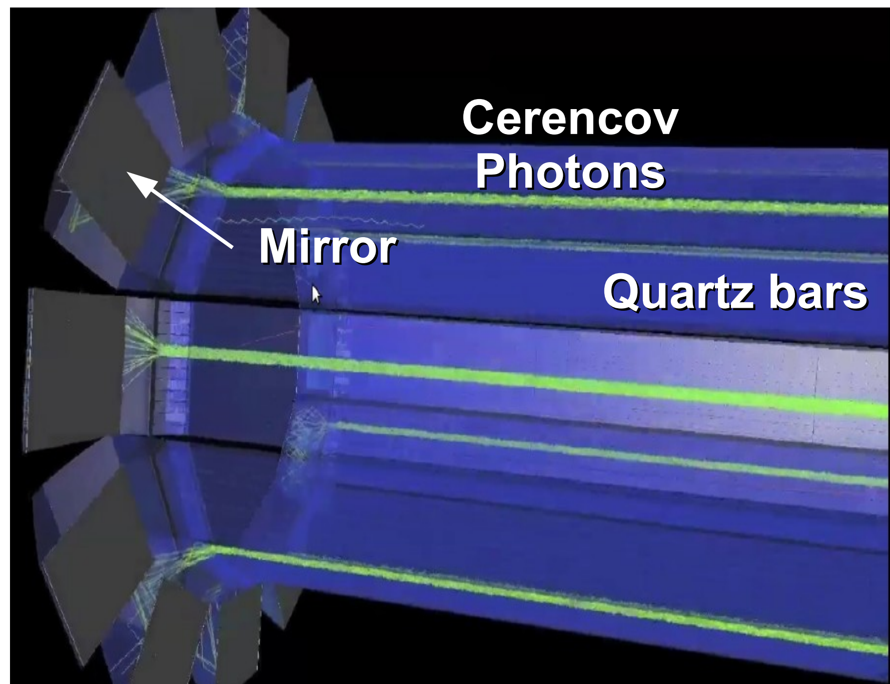
Backup

FDIRC implementation inside BRN (I)

- **Previously:**
  - Only a standalone model of FDIRC (Doug Roberts)
  - In Bruno:
    - Only a model of FDIRC geometry
    - No Cherenkov (optical) photons activated
    - No instrumentation

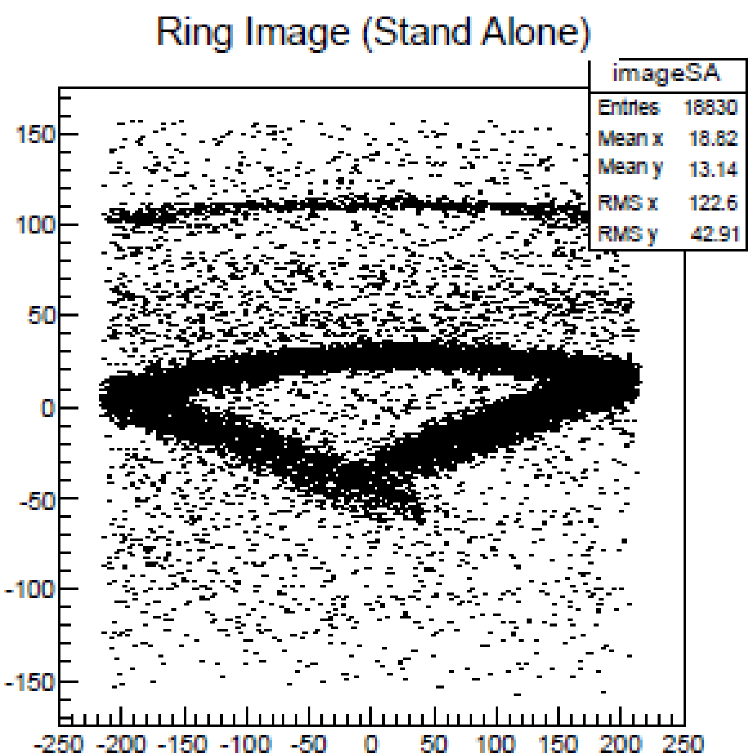
Doug Standalone model of FDIRC

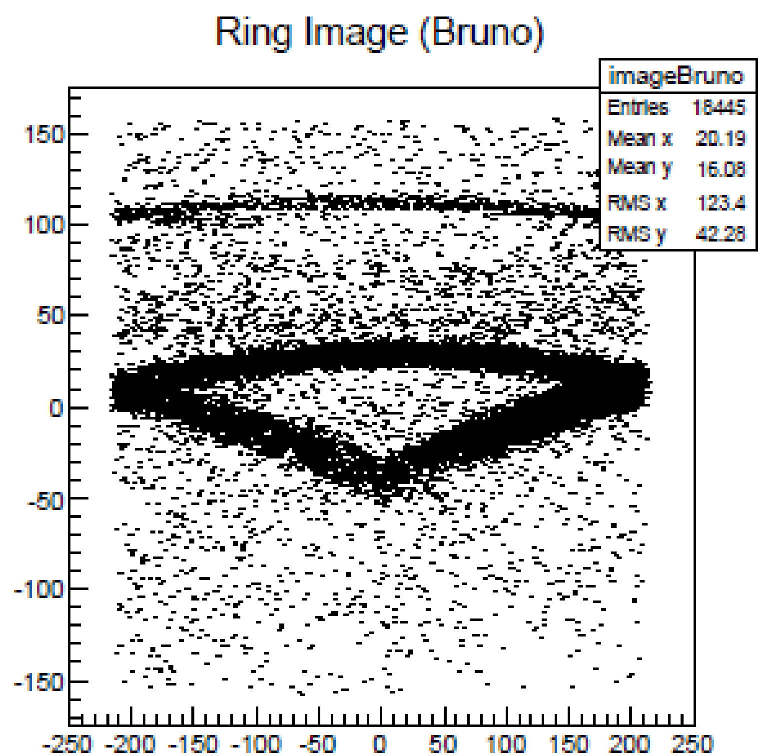




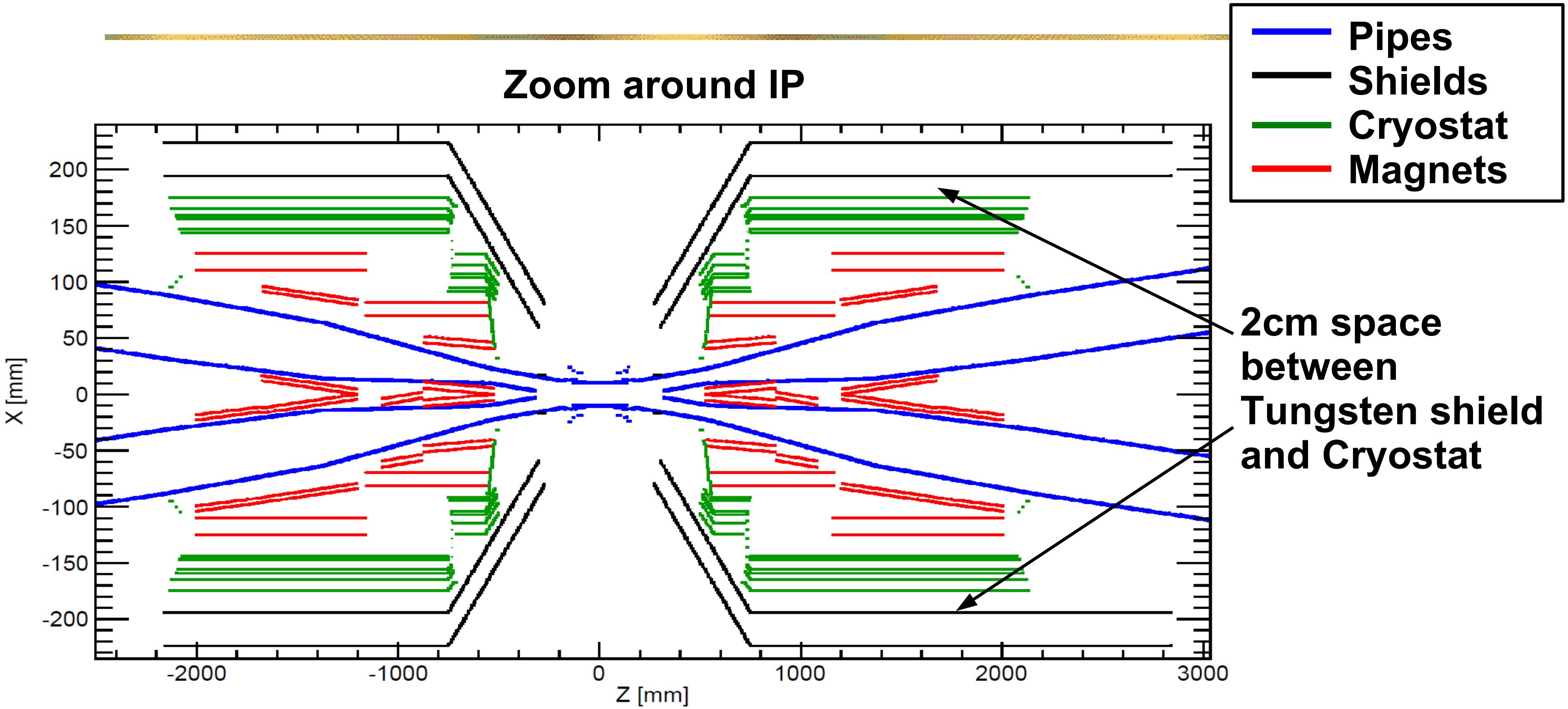
FDIRC implementation inside BRN (II)

- **But now:**
  - Doug and Andrea worked hard to insert standalone model inside Bruno
  - All the required features are in place:
    - Cherenkov photons activated
    - Photo-camera: the whole photo-camera plane is instrumented. Quantum efficiency already taken into account





New FF model: Cryostat and Magnets



- Space free between cryostat and shield will likely be used for SVT cabling and piping
- Space free between shield and DCH likely used as mechanical clearance
- No much room to increase Tungsten shield. Only possibility is to reduce DCH internal radius

New FF model: Magnetic model (I)

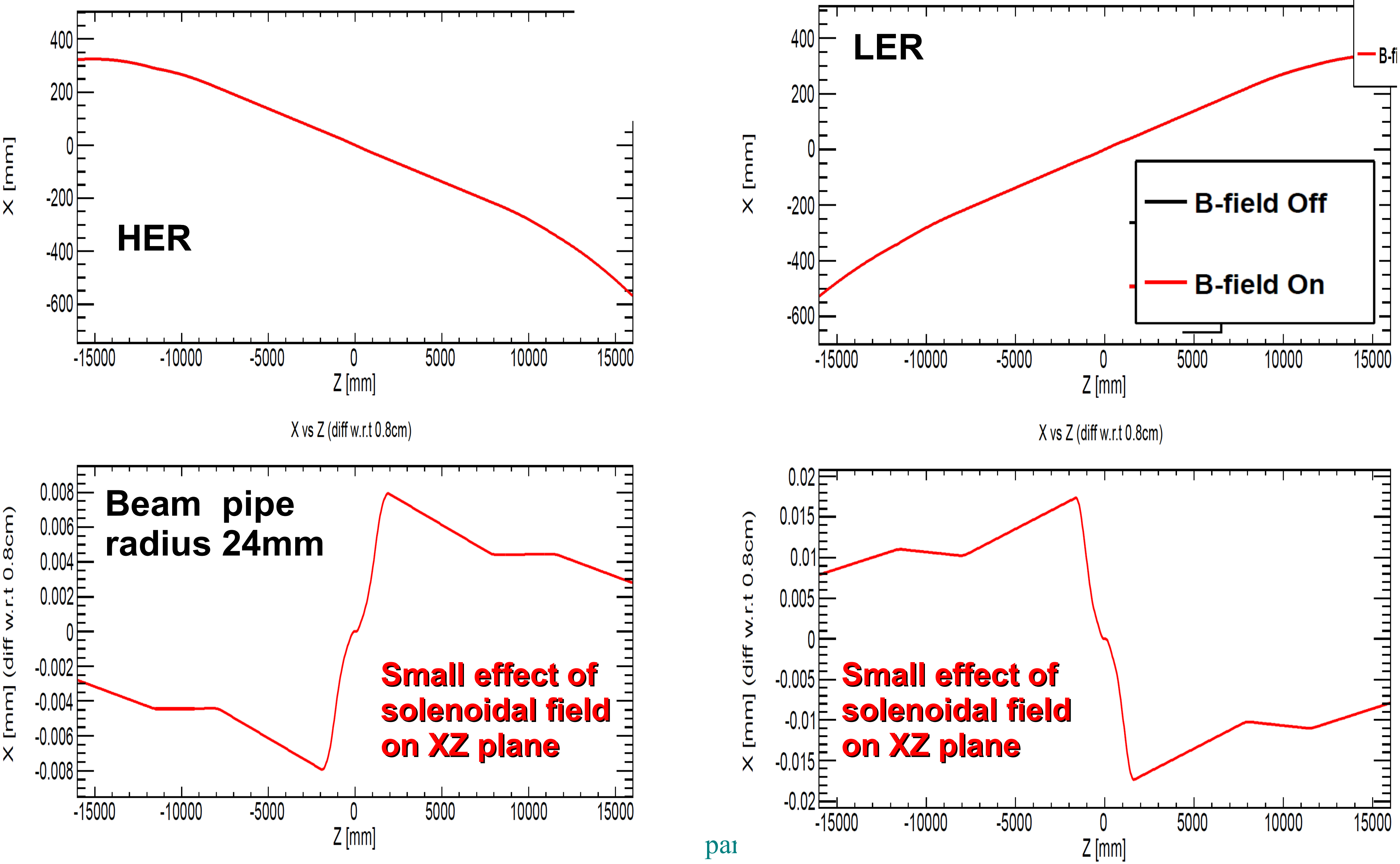
- **Previously:**
  - detector solenoidal field turned off in final focus magnetic model
- **This field is important for an accurate model of two-photon (pairs) backgrounds on SVT. Less important for Rad-Bhaha and Touschek**
- **Implementation:**
  - Magnitud: 1.5 Tesla
  - Direction: Z>0 (0.0,0.0,1.0)
  - Volume: field different from zero only inside a cylinder of length 40cm and radius 40cm.

New FF model: Magnetic model (II)

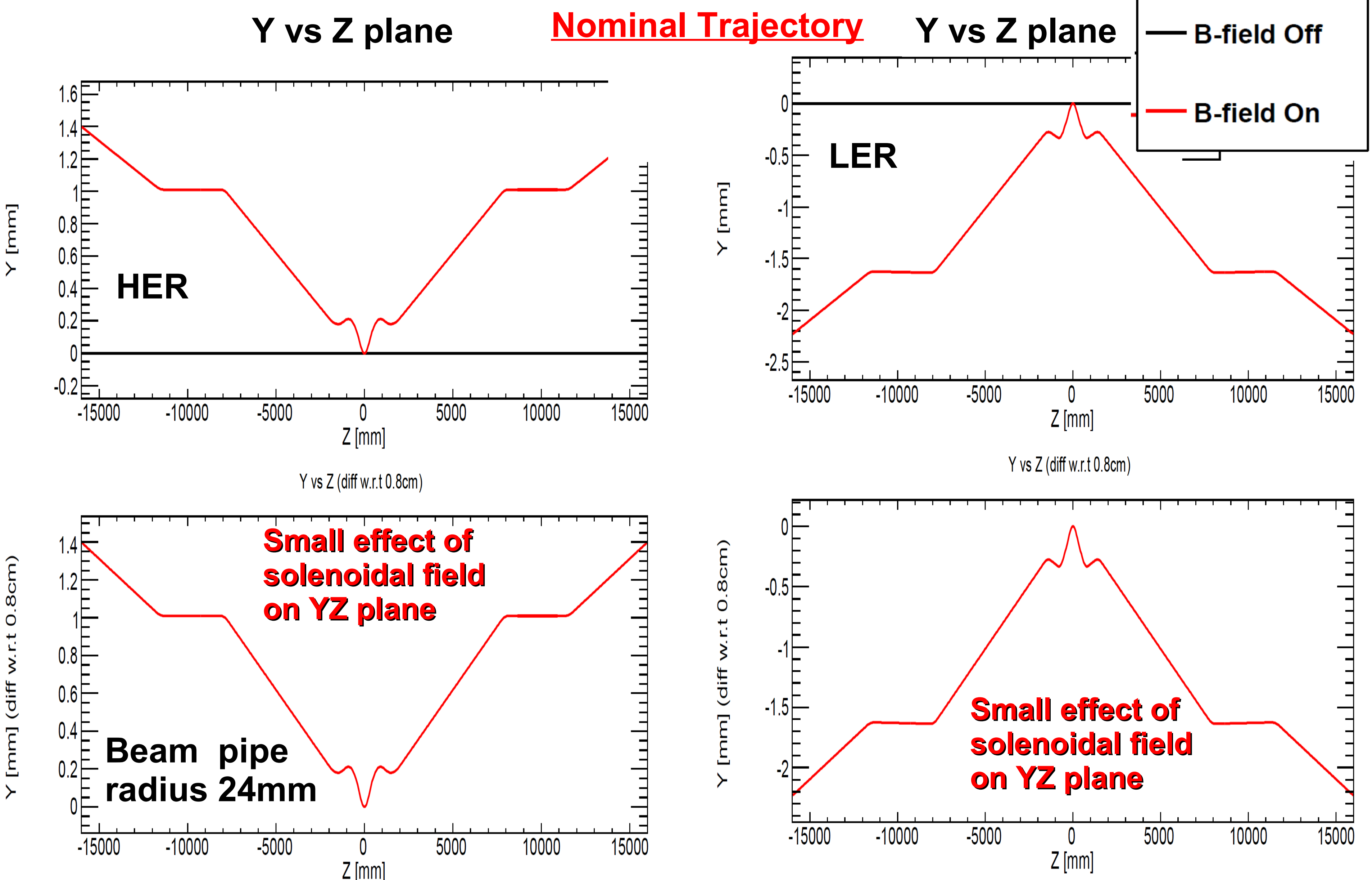
X vs Z plane

Nominal Trajectory

X vs Z plane

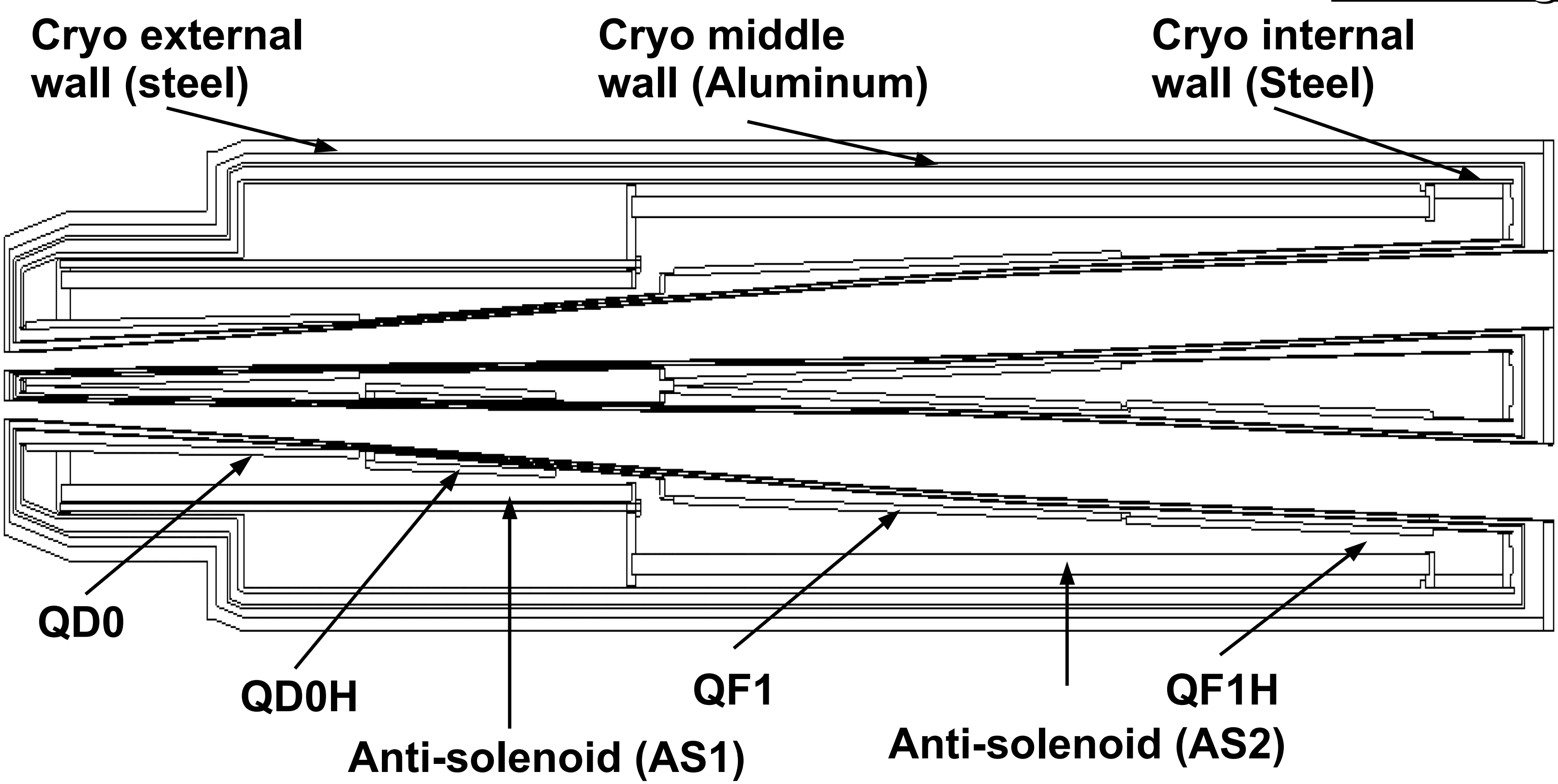


New FF model: Magnetic model (III)



New FF model: Cryostat and Magnets (I)

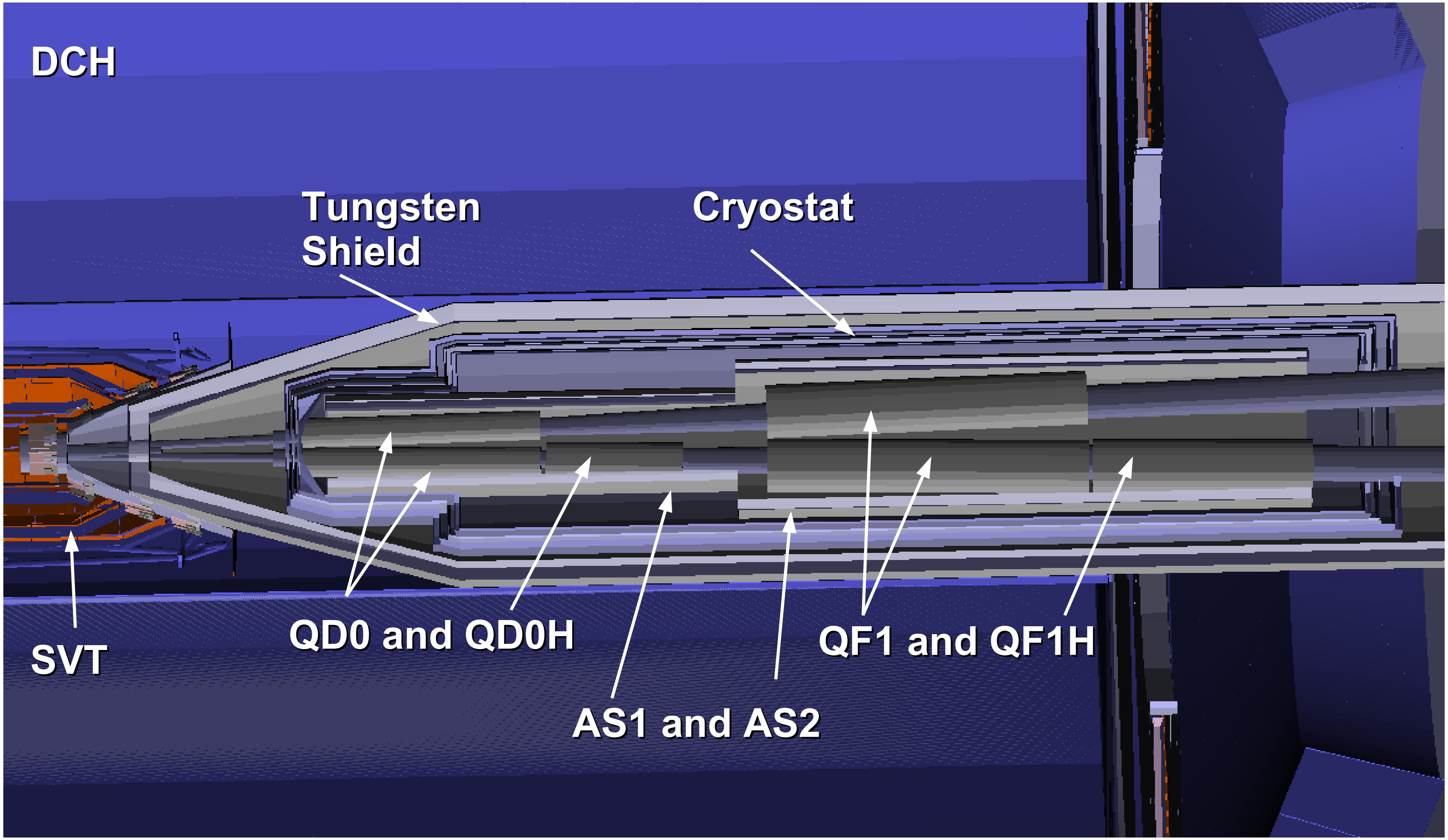
Filippo Bosi Drawings



- **All magnetic elements are made of the same material (QD0_mixture):**
  - Density: 7.57 gr/cm^3
  - Composition: Niobium (0.106), Titanium (0.119), Cooper (0.347) and Iron (0.428)

New FF model: Cryostat and Magnets (II)

BRN implementation



Results

- **Will show the results for one representative FDIRC sector (sector 6) only just to show the format**
- **The full set of plots can be found at the web,**
  - Rad-bhabha:

http://www.slac.stanford.edu/~aperez/SuperB/SuperB_Pisa/FDIRC_Bkg_Studies/Plots_RadBhabha_background_FDIRC.pdf

  - Pairs:

http://www.slac.stanford.edu/~aperez/SuperB/SuperB_Pisa/FDIRC_Bkg_Studies/Plots_Pairs_background_FDIRC.pdf

  - Touschek LER:

http://www.slac.stanford.edu/~aperez/SuperB/SuperB_Pisa/FDIRC_Bkg_Studies/Plots_Touschek_LER_background_FDIRC.pdf

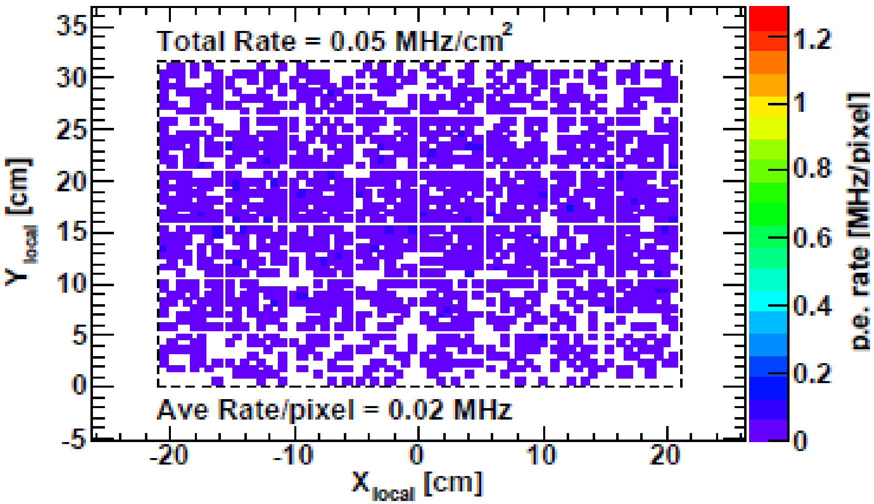
  - Touschek HER:

http://www.slac.stanford.edu/~aperez/SuperB/SuperB_Pisa/FDIRC_Bkg_Studies/Plots_Touschek_HER_background_FDIRC.pdf

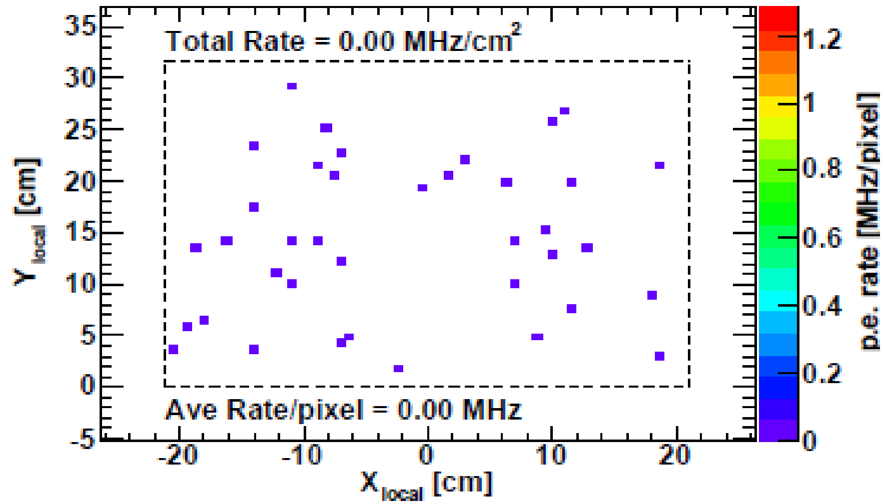
Results: FDIRC Bkg rates from Rad-Bhabha (I)

Sector 6

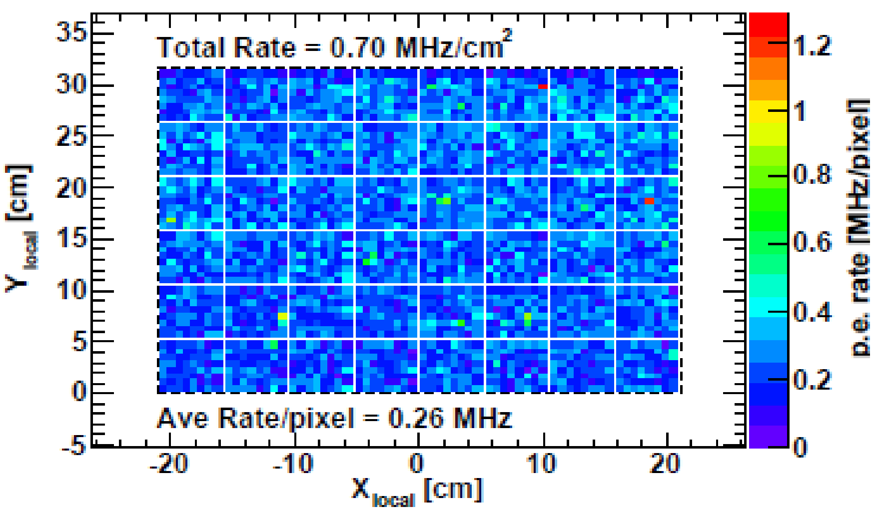
Inside Magnet



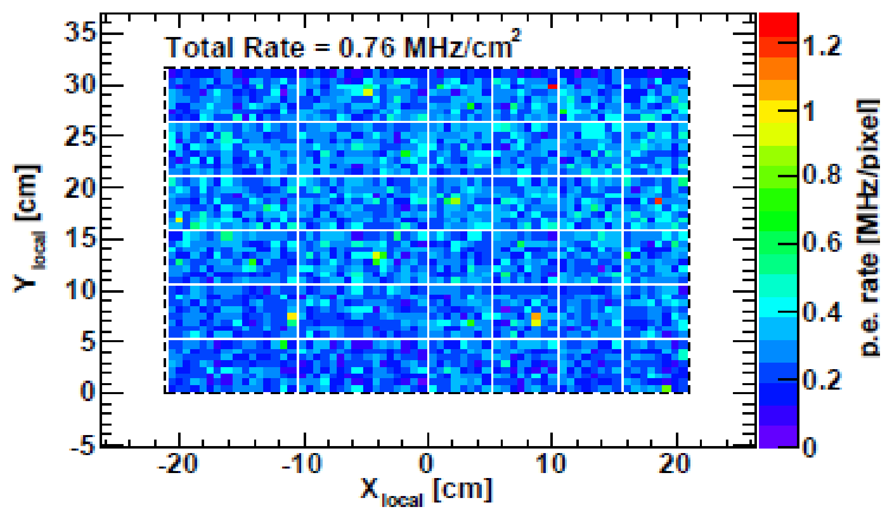
Within Steel



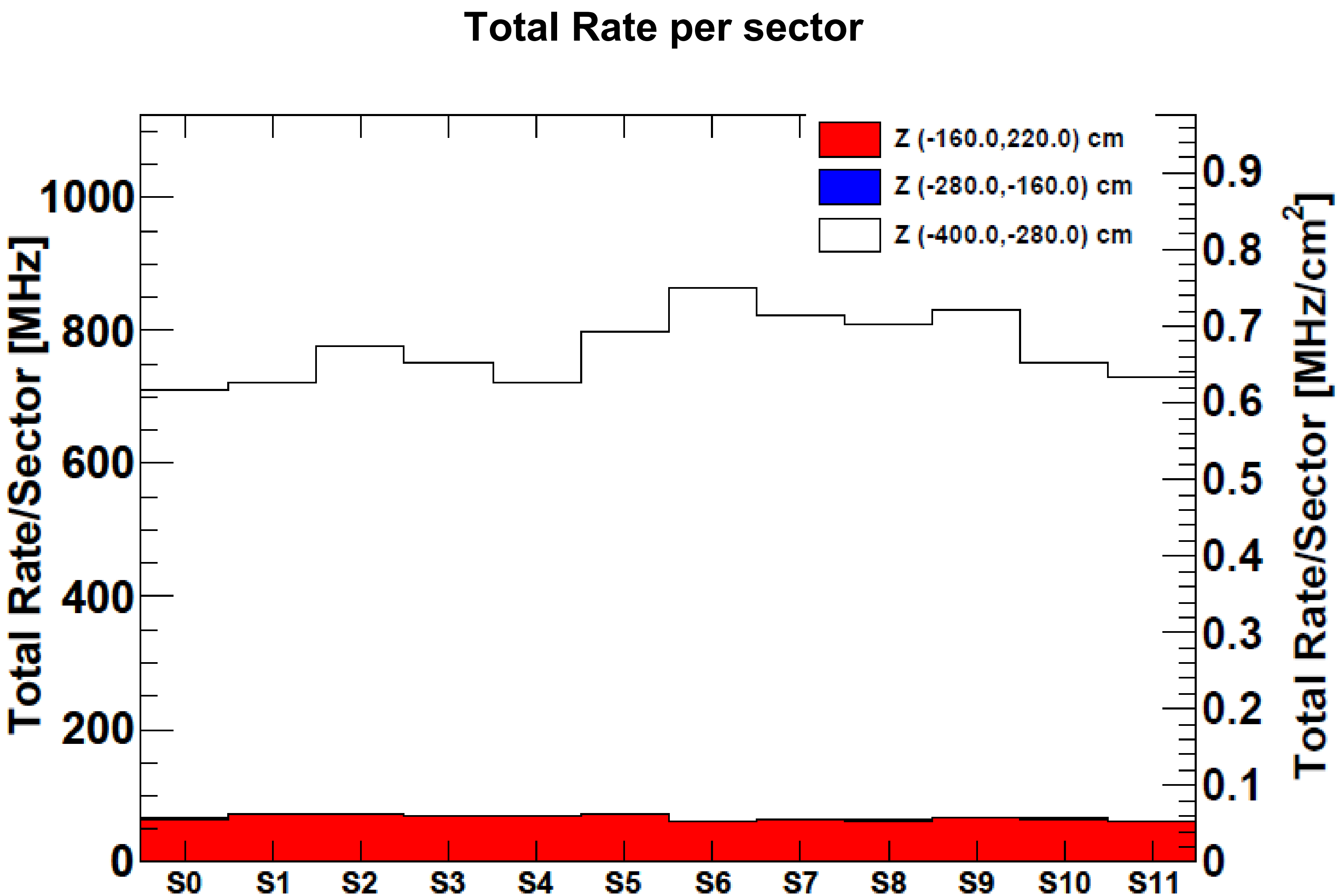
Outside Magnet



Total Rate



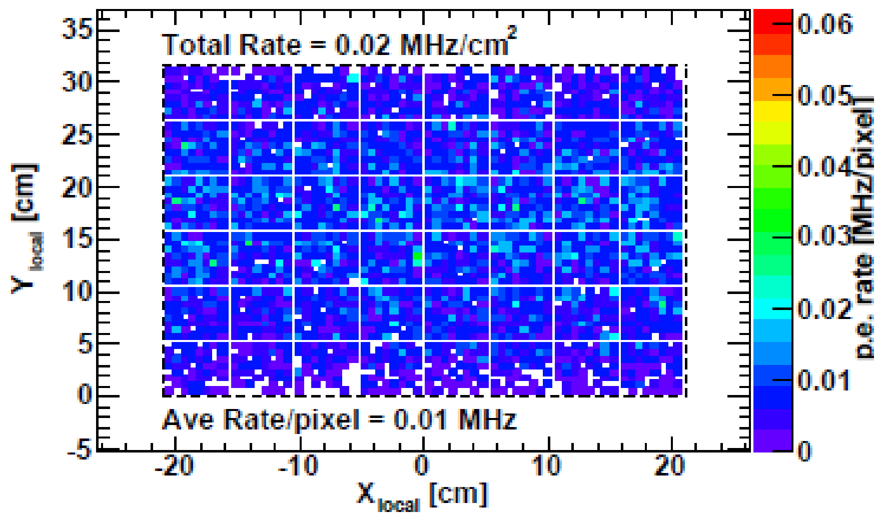
Results: FDIRC Bkg rates from Rad-Bhabha (II)



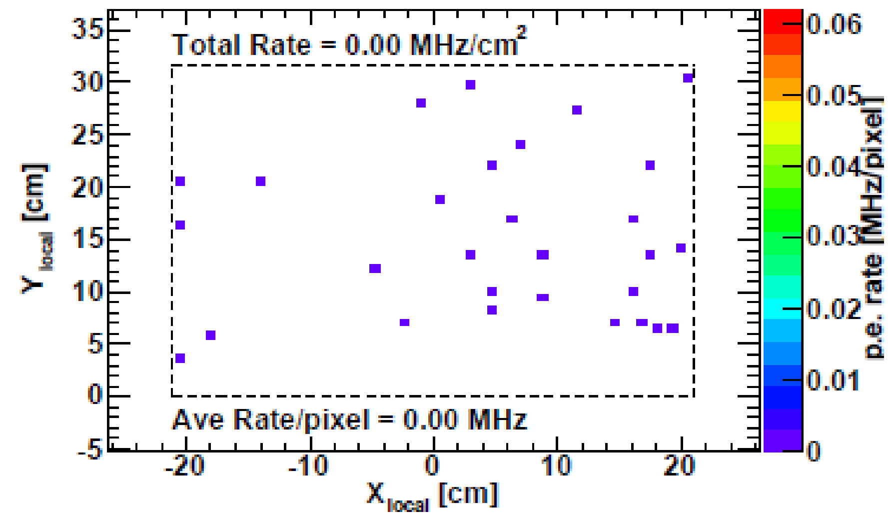
Results: FDIRC Bkg rates from Pairs (I)

Sector 6

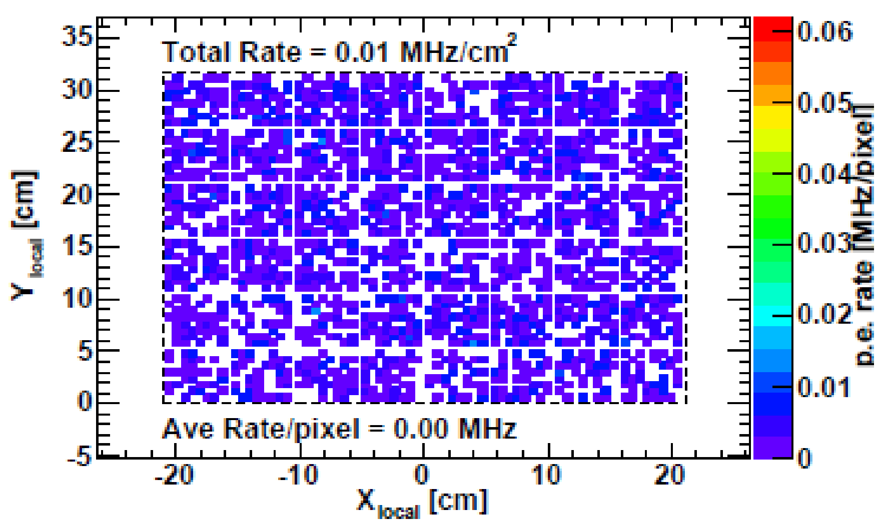
Inside Magnet



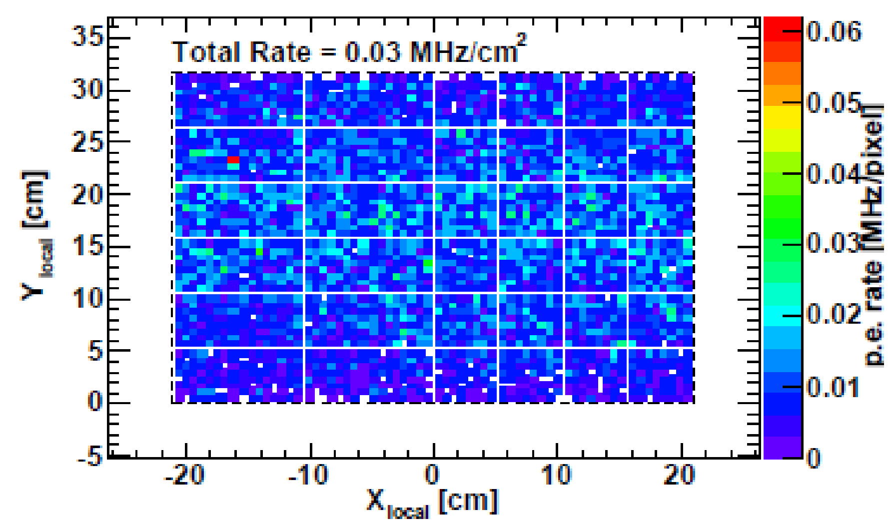
Within Steel



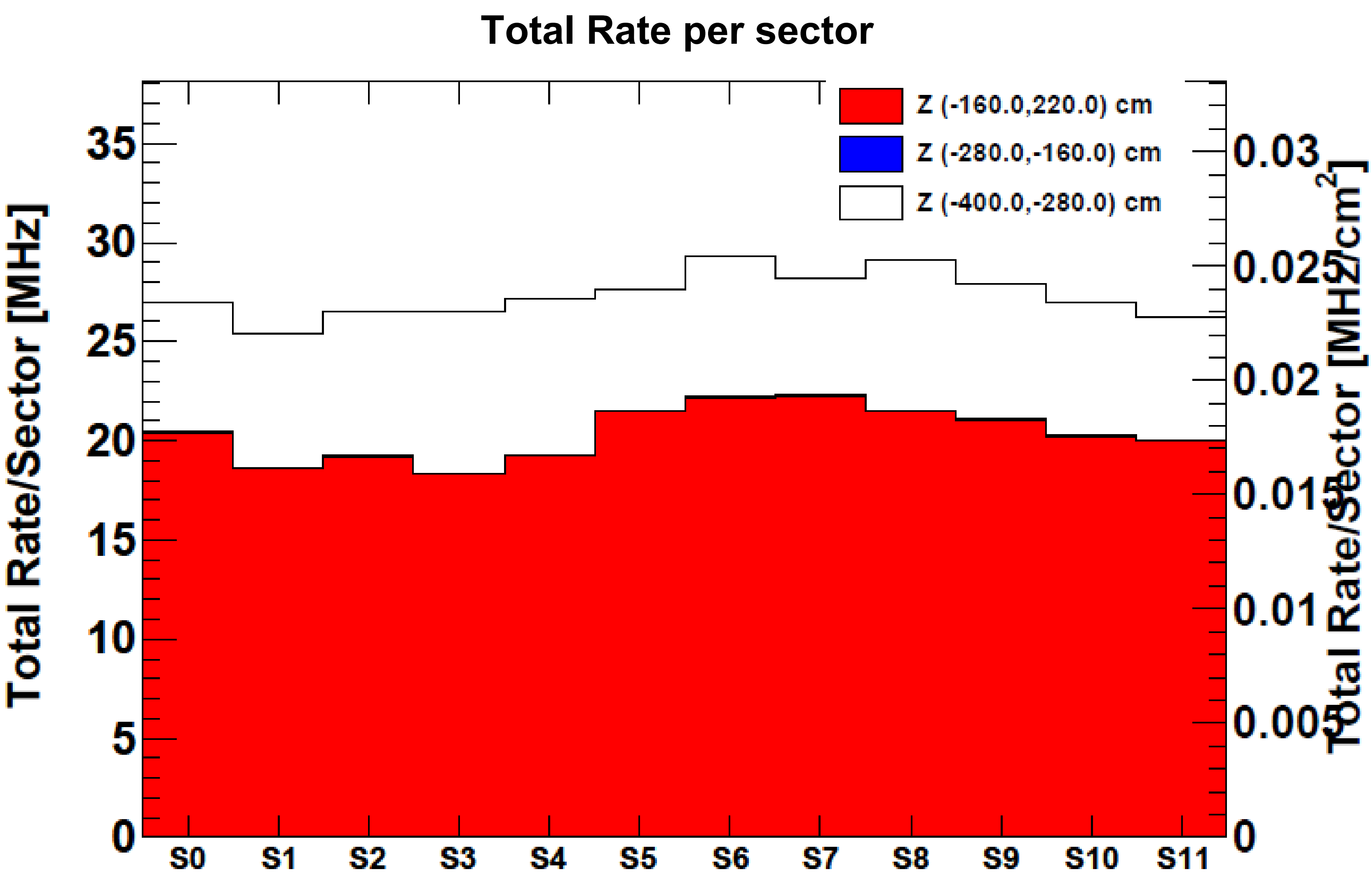
Outside Magnet



Total Rate



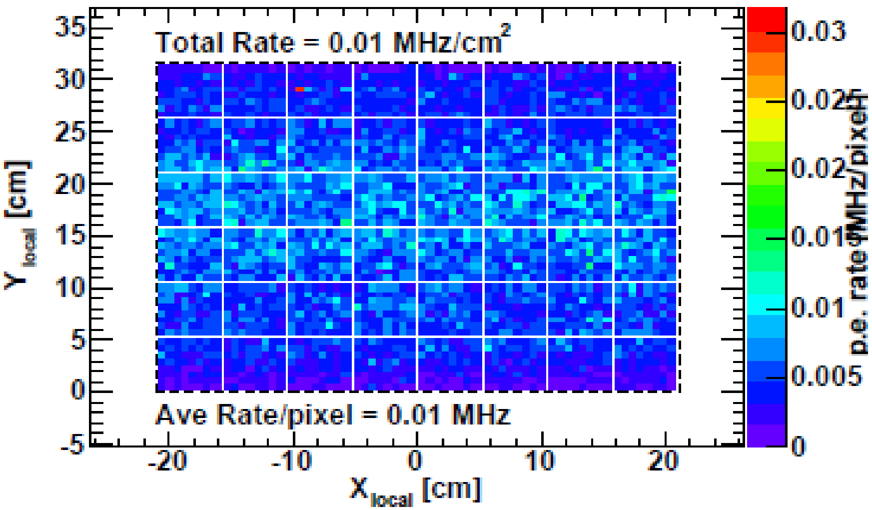
Results: FDIRC Bkg rates from Pairs (II)



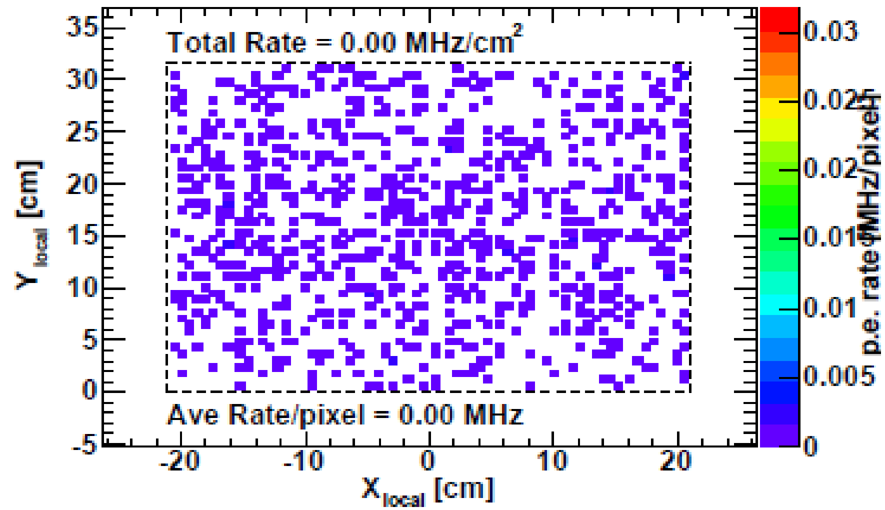
Results: FDIRC Bkg rates from Touschek LER (I)

Sector 6

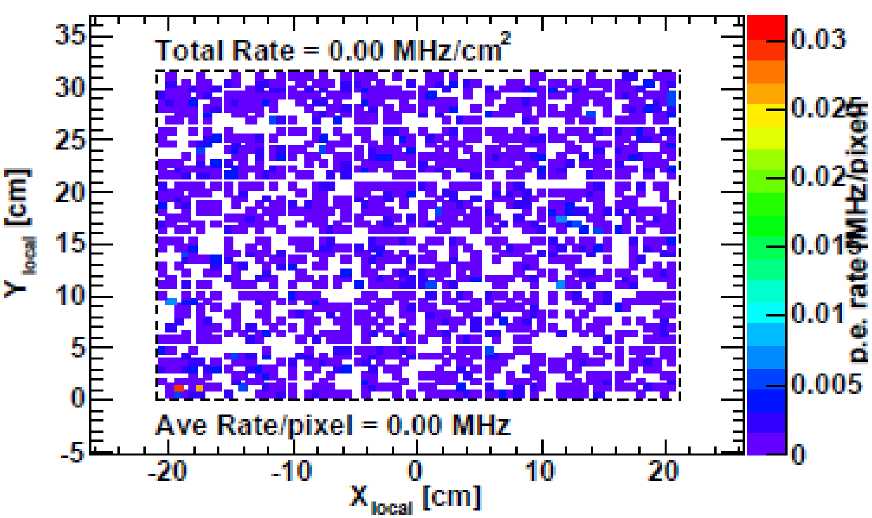
Inside Magnet



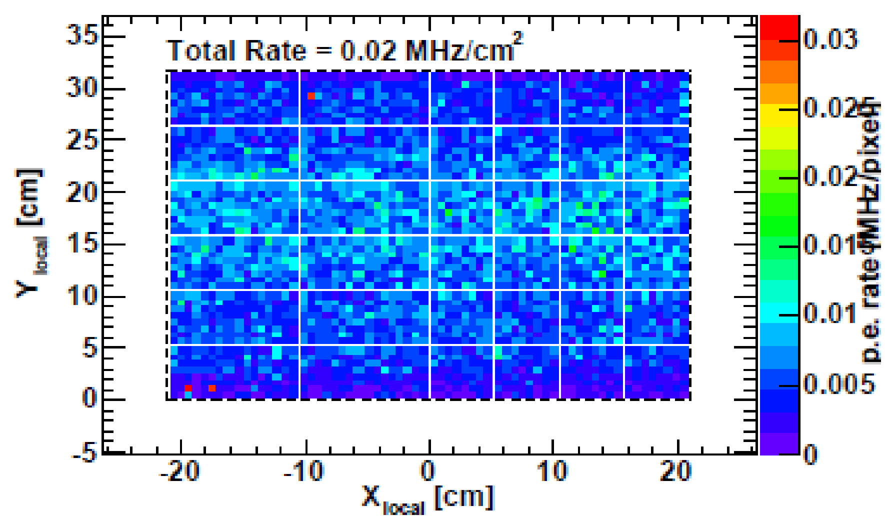
Within Steel



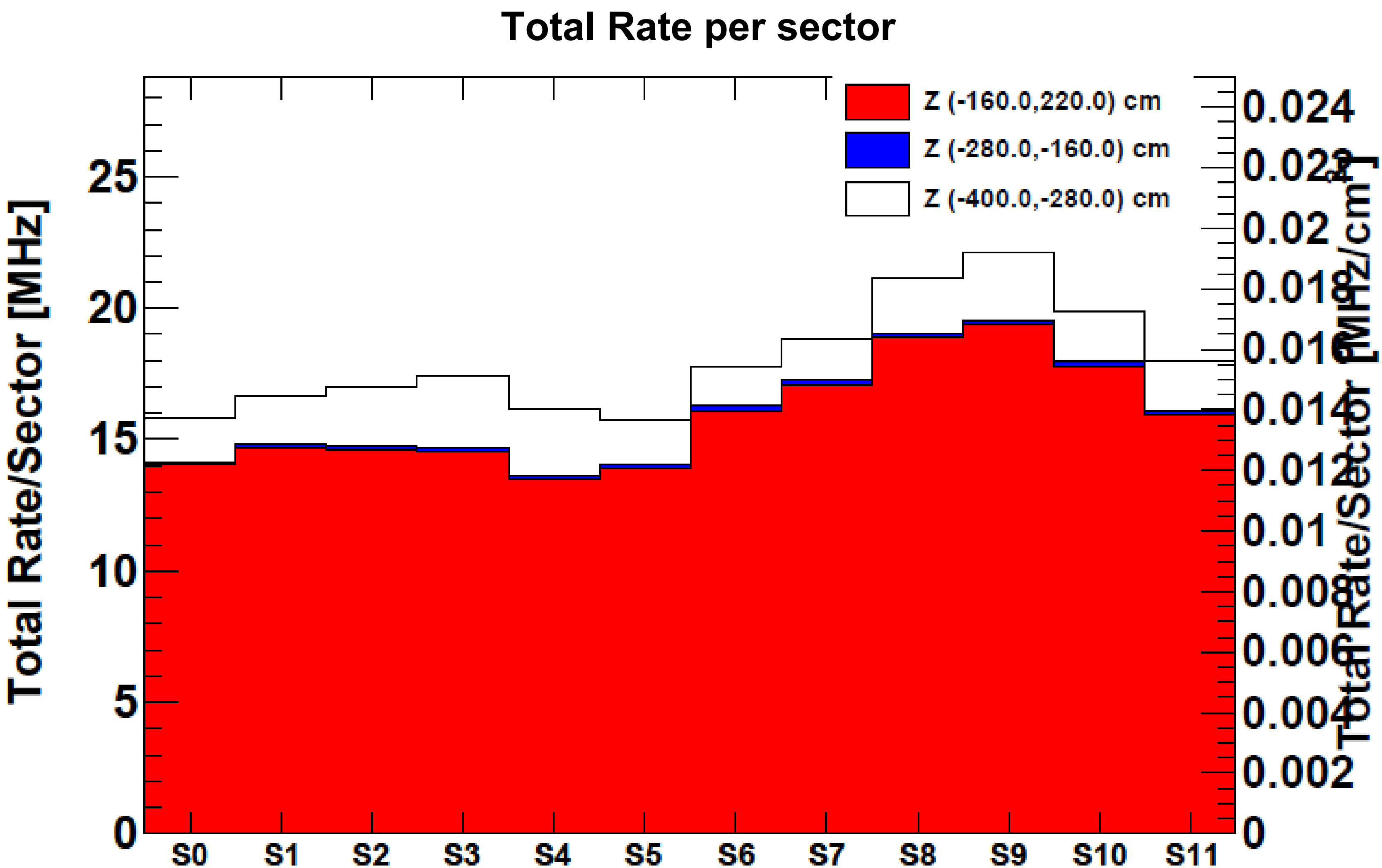
Outside Magnet



Total Rate



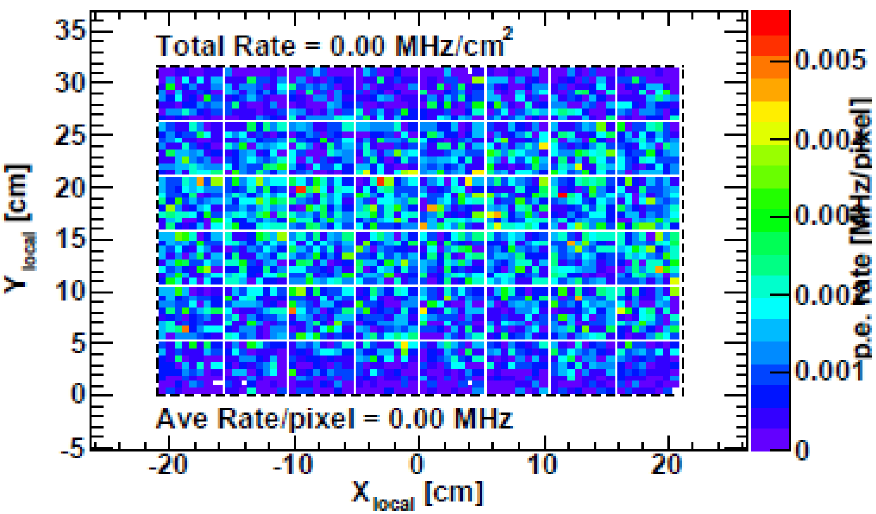
Results: FDIRC Bkg rates from Touschek LER (II)



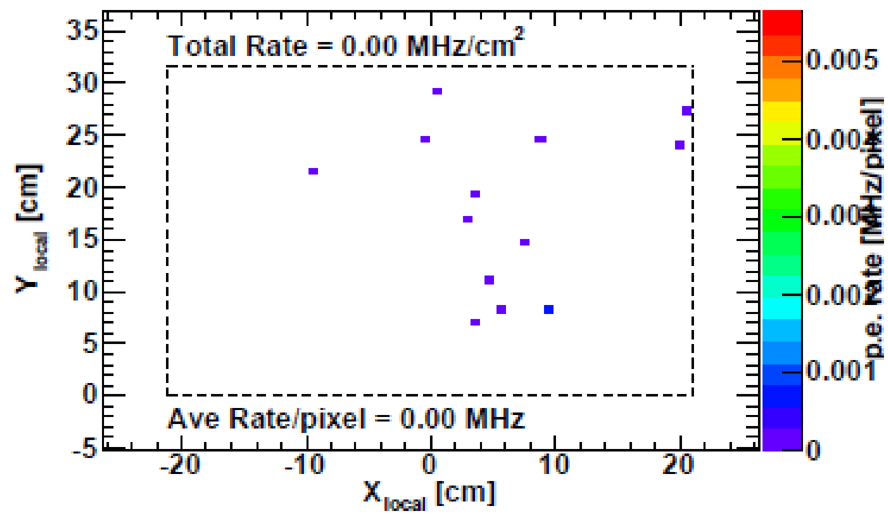
Results: FDIRC Bkg rates from Touschek HER (I)

Sector 6

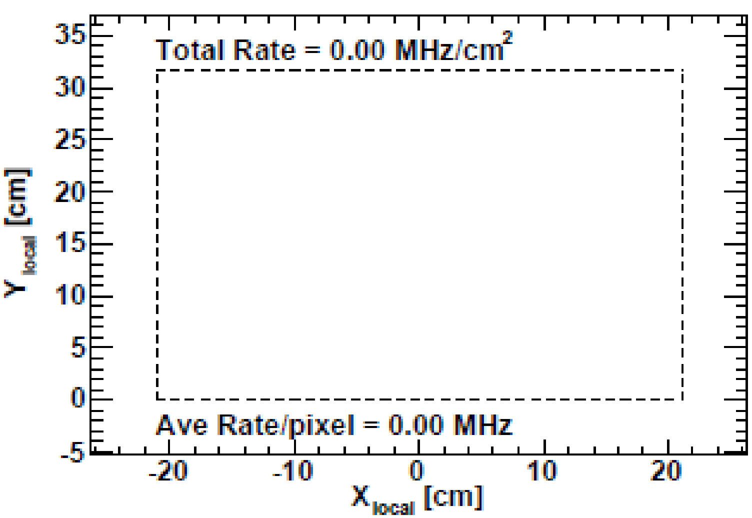
Inside Magnet



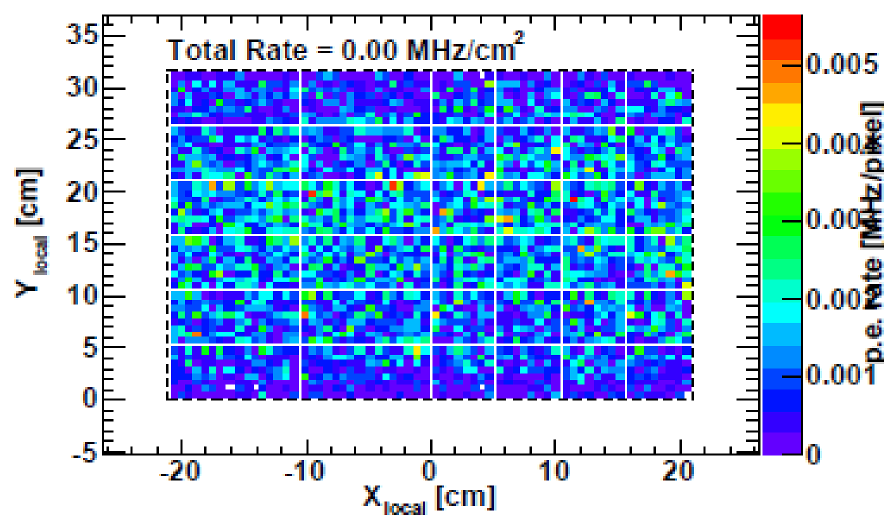
Within Steel



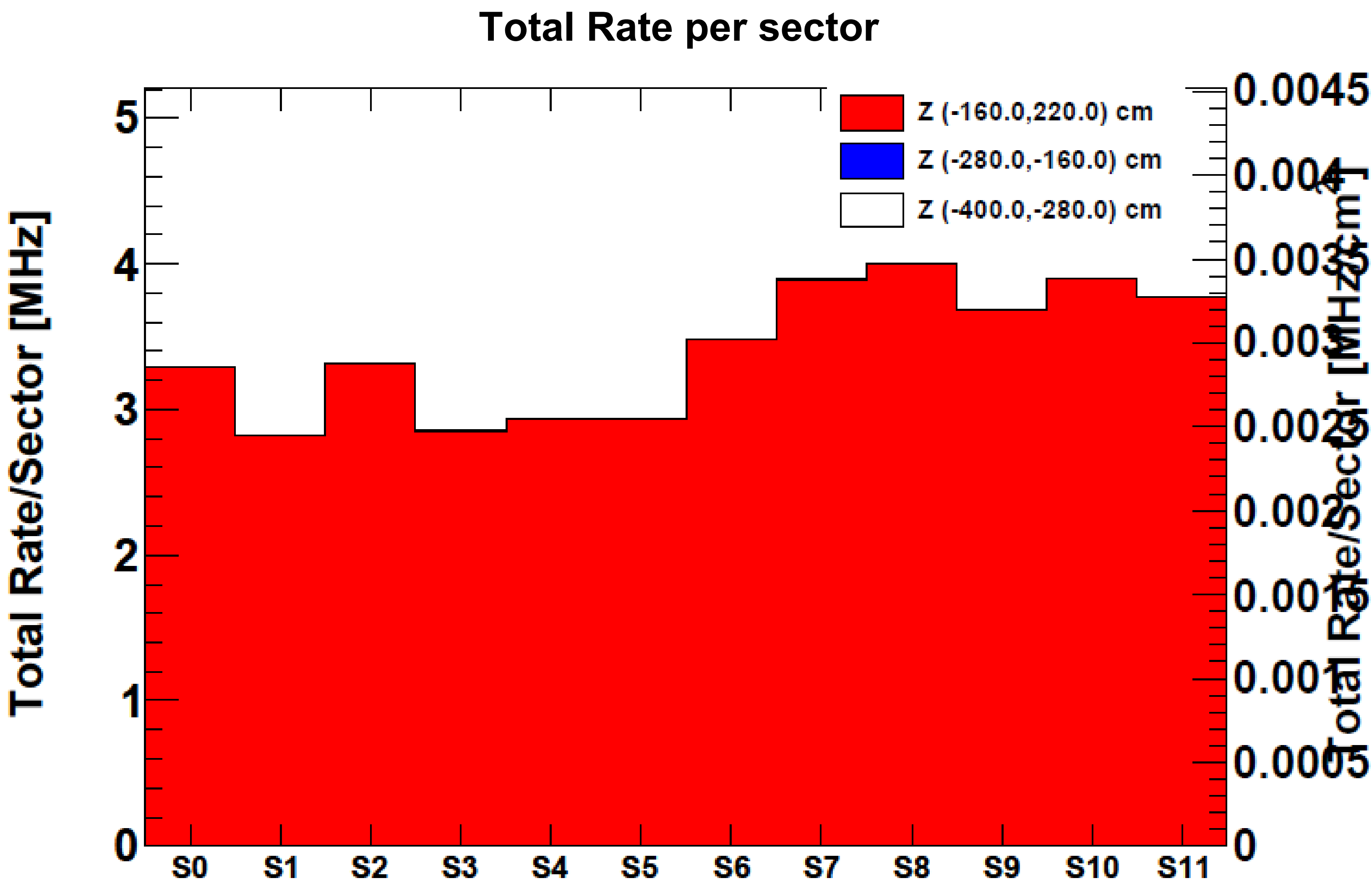
Outside Magnet



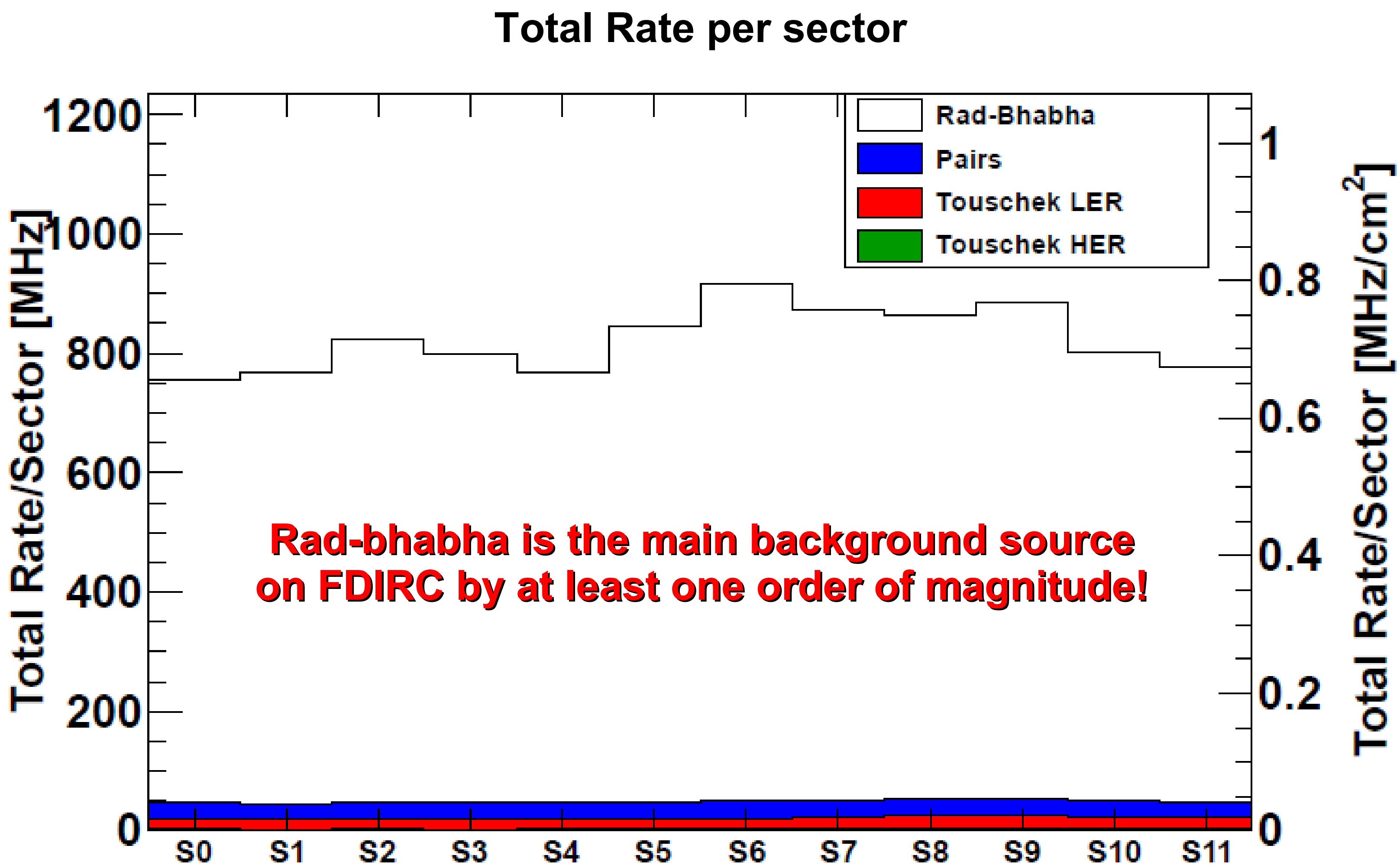
Total Rate



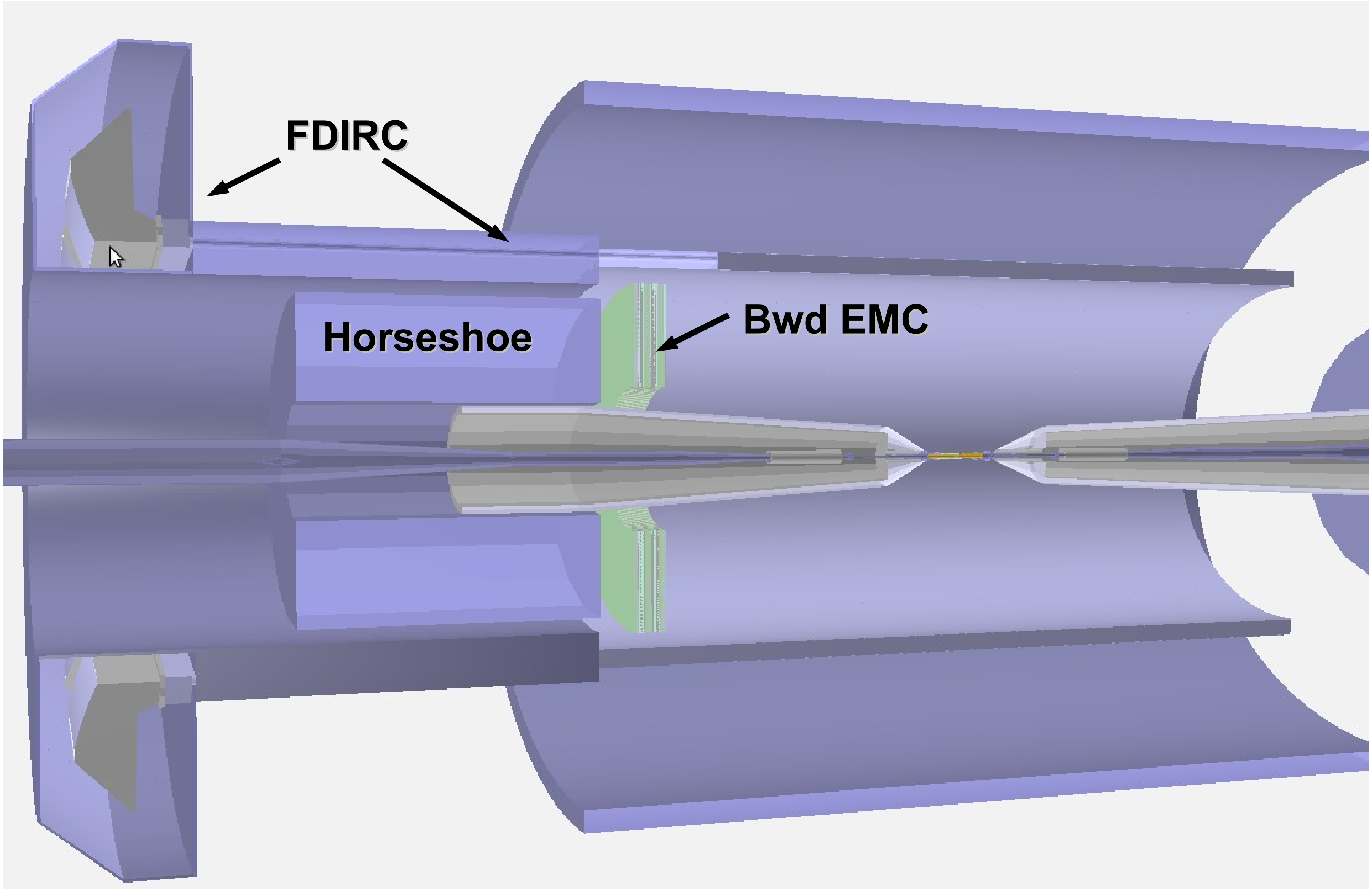
Results: FDIRC Bkg rates from Touschek HER (II)



Results: total bkg rates on FDIRC

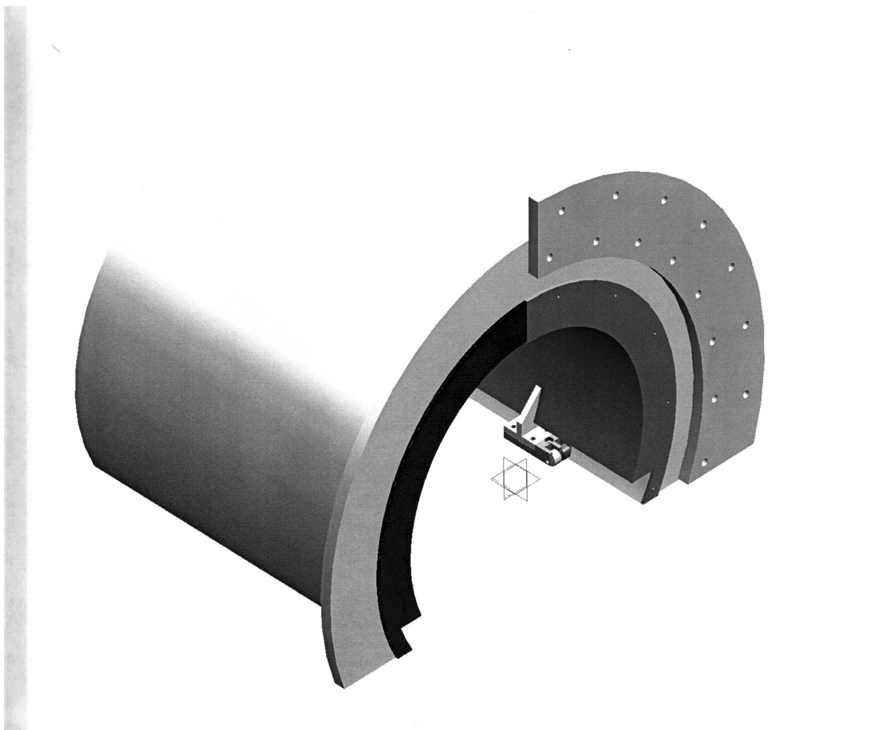


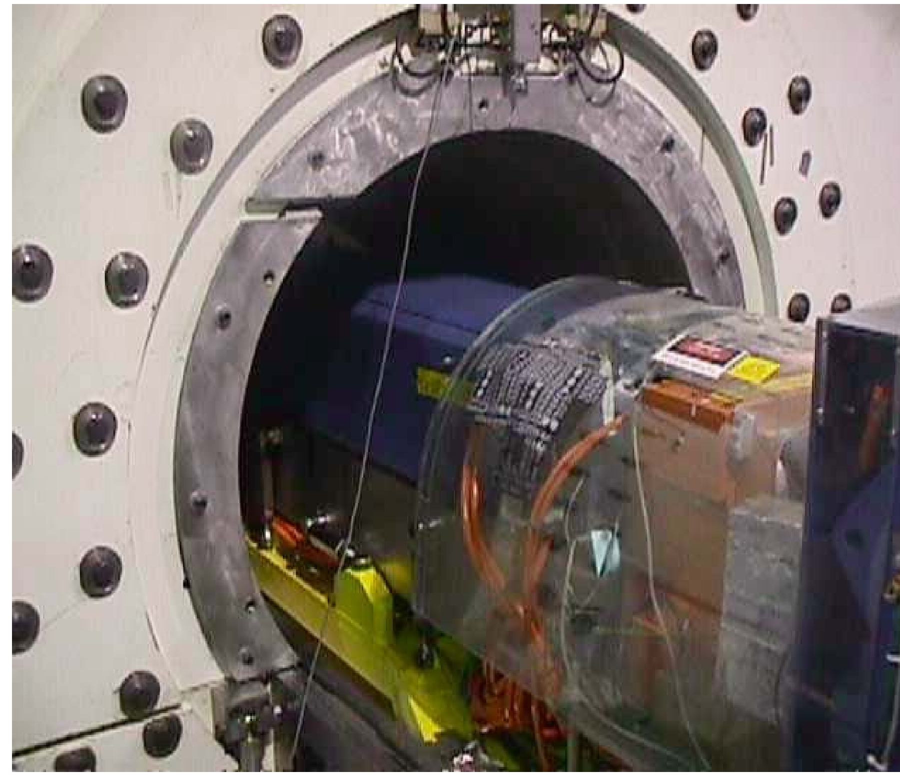
Bwd Horseshoe BRN implementation



Additional shield under photo-camera

Additional shield at BABAR





- **Need the characteristics of this shield**
  - Material
  - Dimensions