FDIRC Machine Background Estimates from April 2012 Production

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Outline

- **The samples**
- **Latest developments on BRN (reminder)**
- **Analysis strategy (reminder)**
- **Some studies about the FDIRC-shield**

- **FDIRC Machine Backgrounds**
  - Rad-bhabha
  - Pairs
  - Touschek-HER/LER
  - BeamGas-HER/LER

- **FEE dose and Fluency**

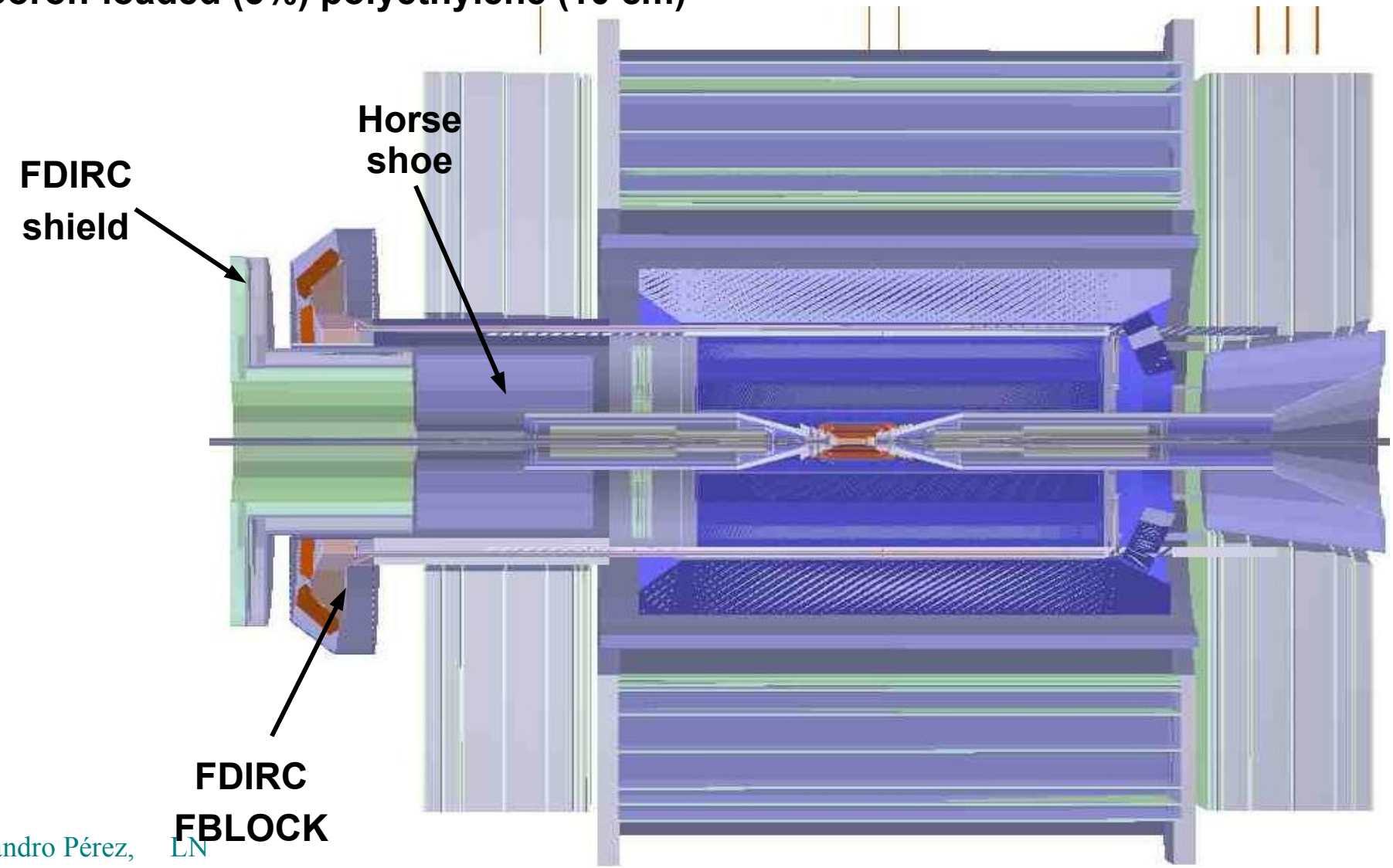
- **Summary**

The Samples

- **In April 2012 were produced several background samples**
  - Rad-bhabha samples for two geometries (which include FDIRC new Lead-steel-polyethylene shield)
    - 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)
  - The other background sources generated with the same geometry: Geometry_CIPE_V00-00-02_Tungsten4.5cm
    - Pairs (2-photon)
    - Touschek HER/LER
    - BeamGas HER/LER

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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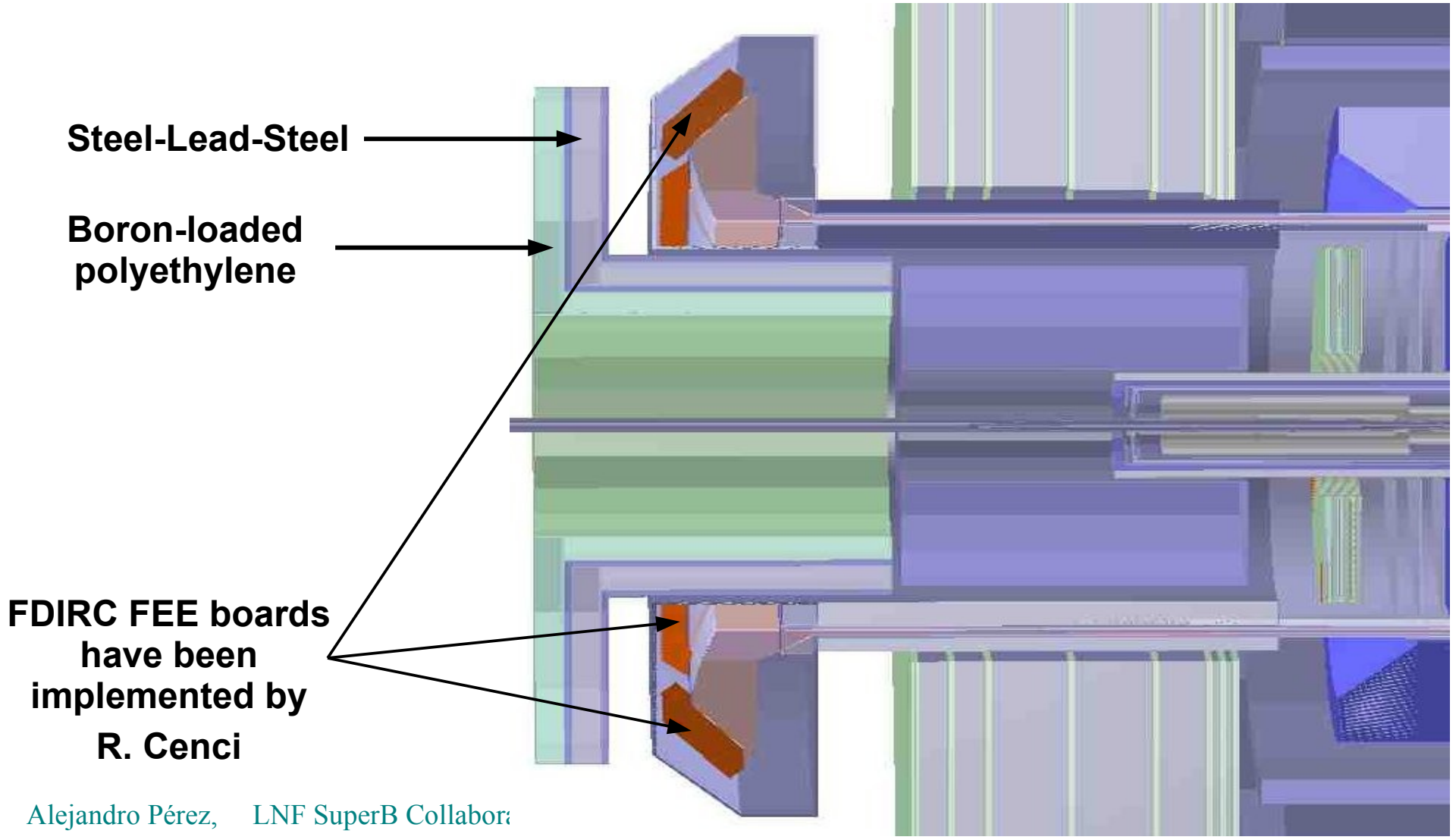
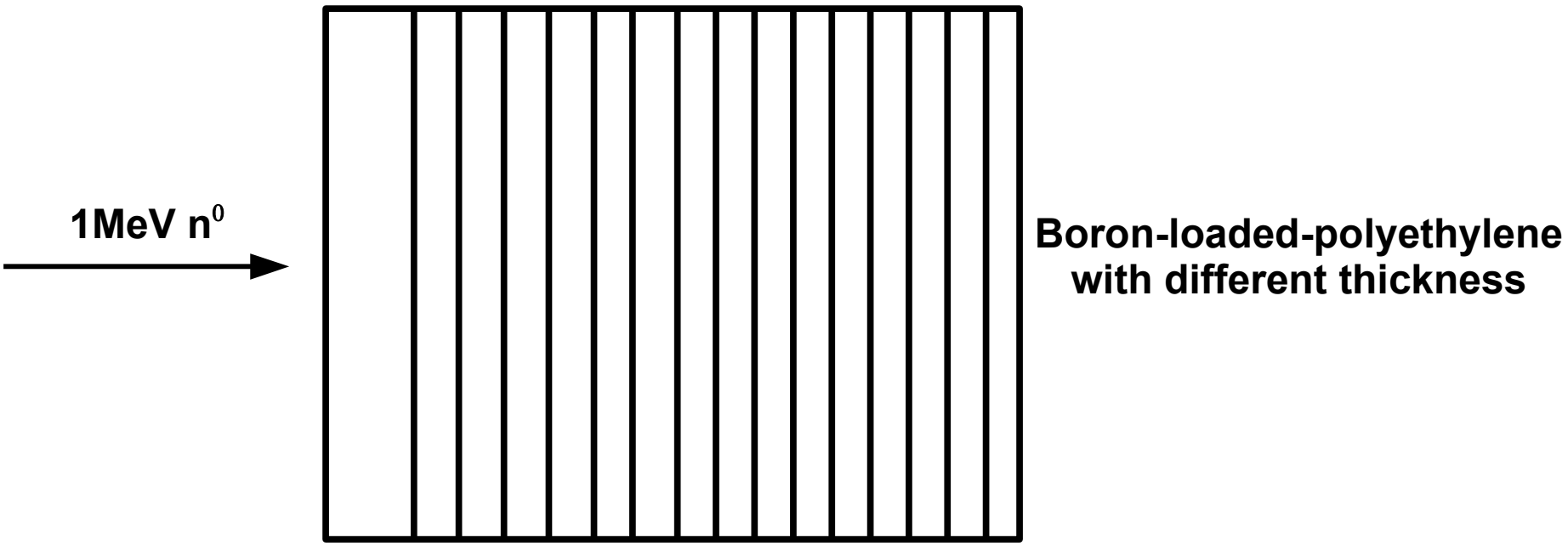
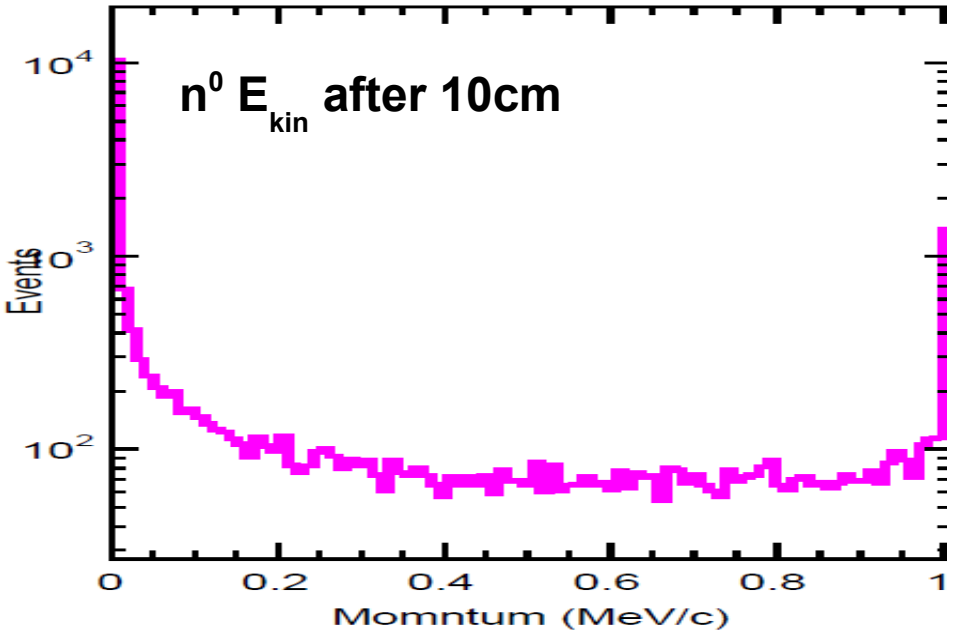


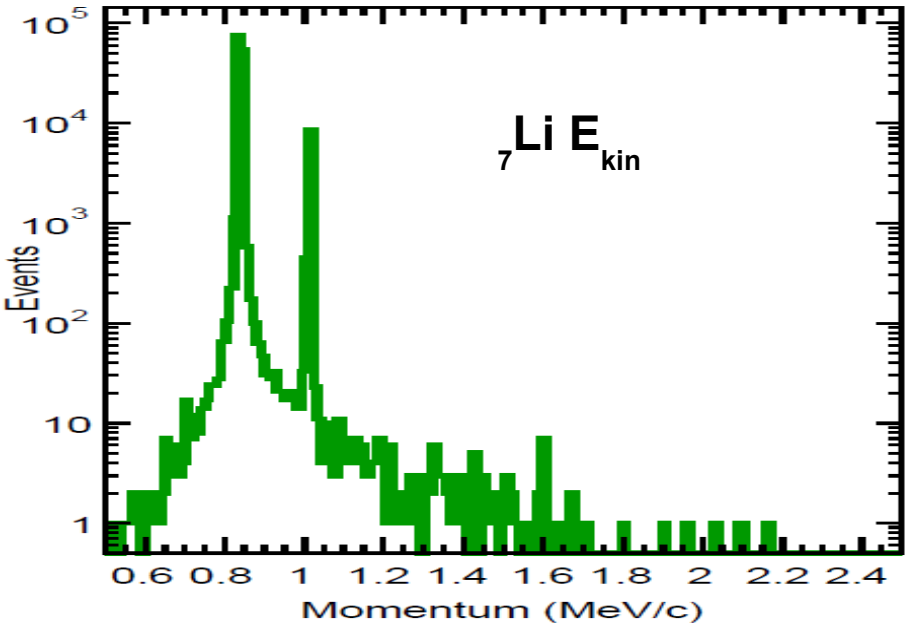
Boron-loaded-polyethylene neutron shield

- **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 slab
  - Different thickness: 1 – 40 cm (1cm steps)
- **Study the particle multiplicity and spectrum at the other end of the shield**

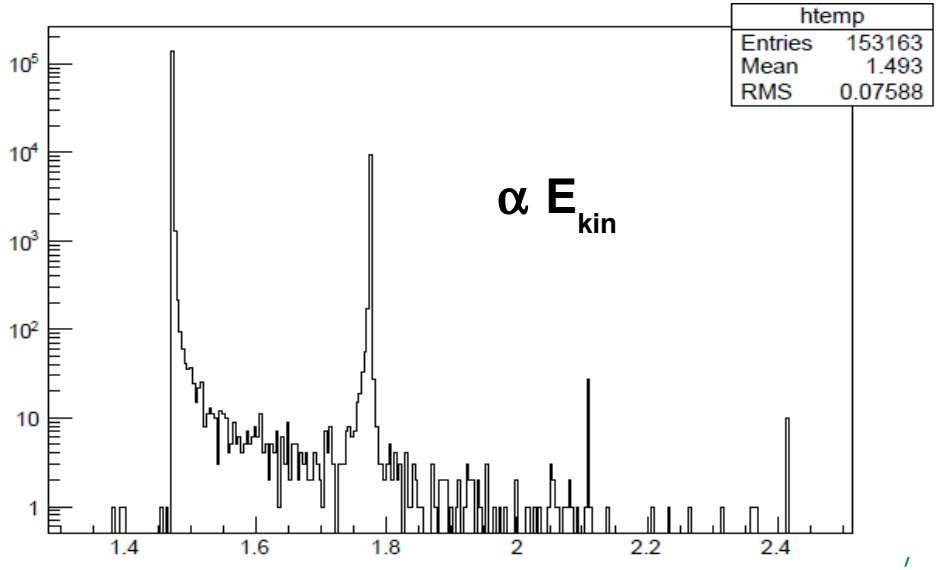


Boron-loaded-polyethylene neutron shield

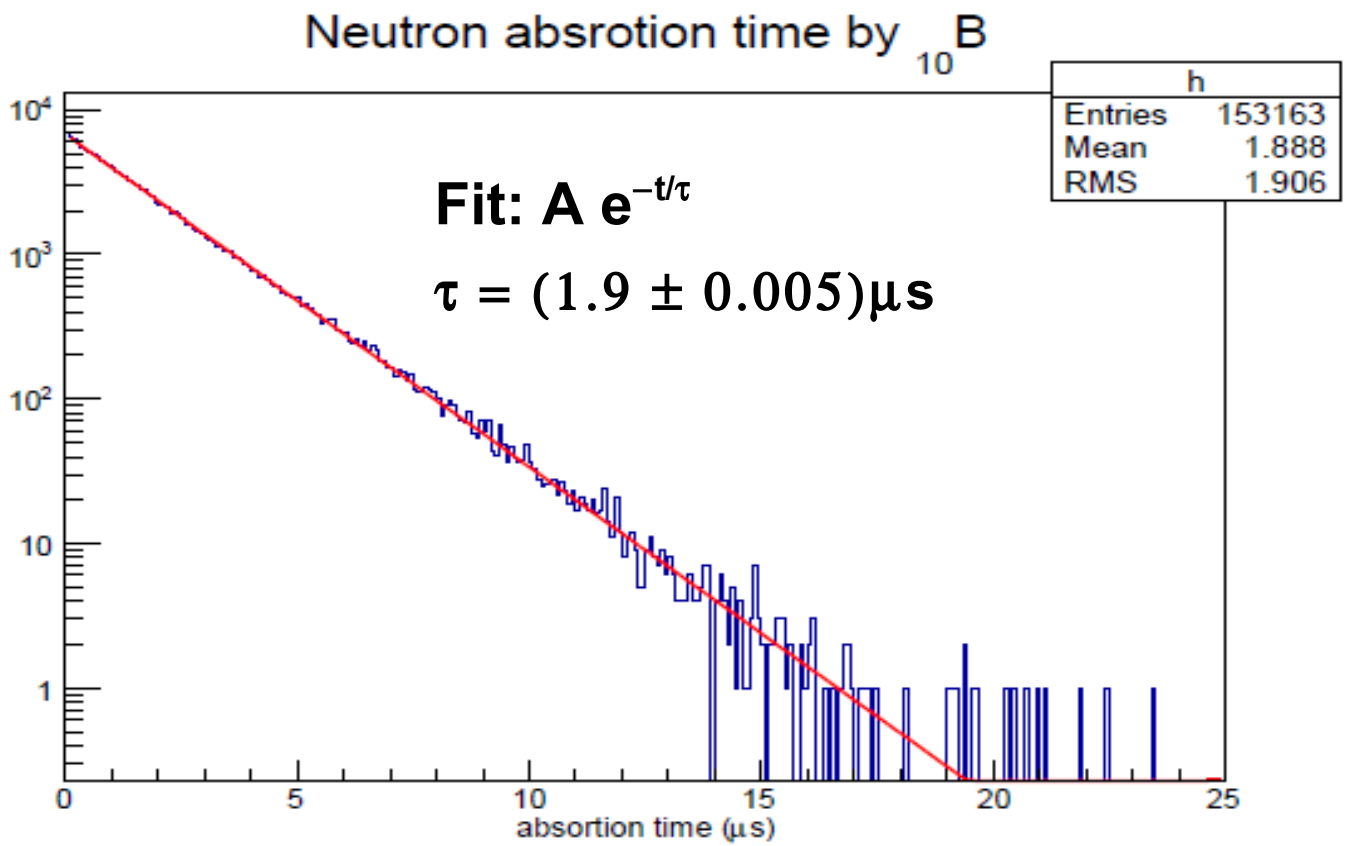




- **After 10cm of Boron-loaded-polyethylene around 92.5% of the neutrons are absorbed**
- **Main absorption mechanism is Boron capture**
  - $_{10}B(n,\alpha)_7Li$
  - $_{10}B(n,\alpha)_7Li^*(\rightarrow_7Li+\gamma)$

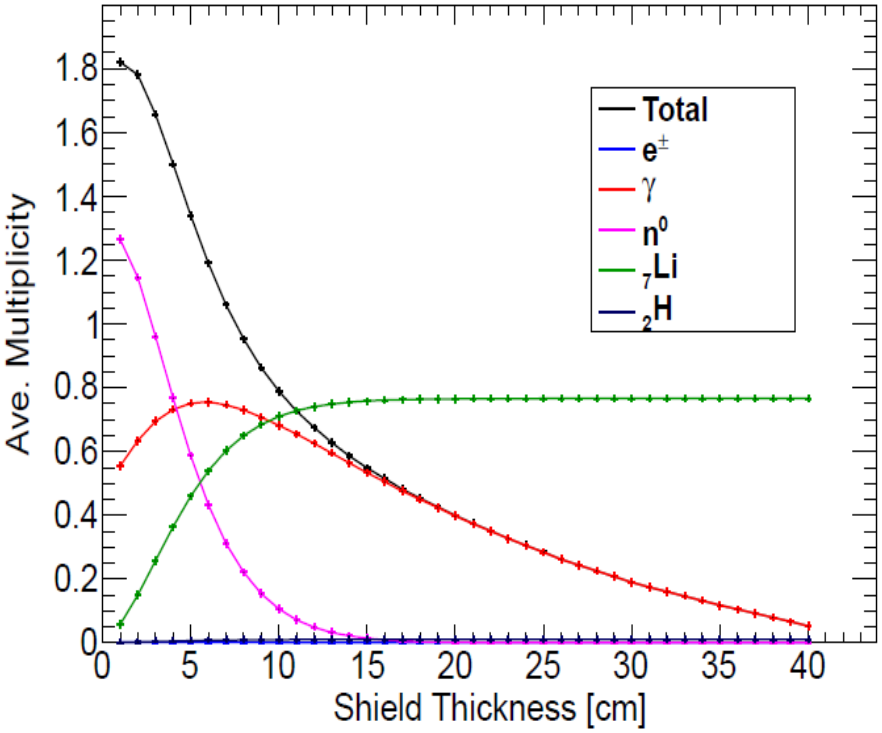


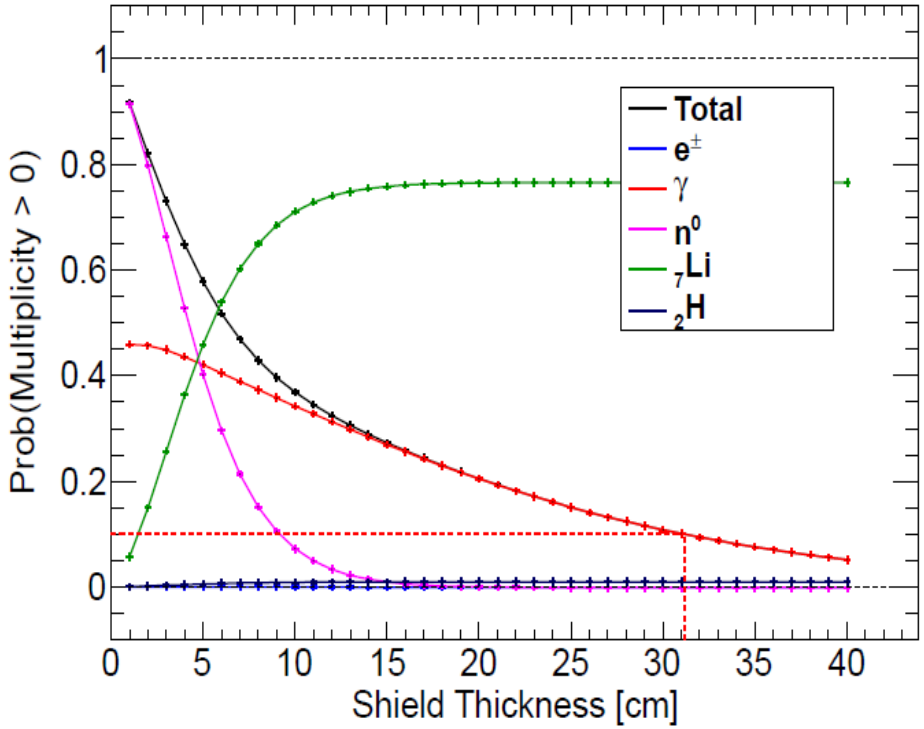
Boron-loaded-polyethylene neutron shield



- 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?

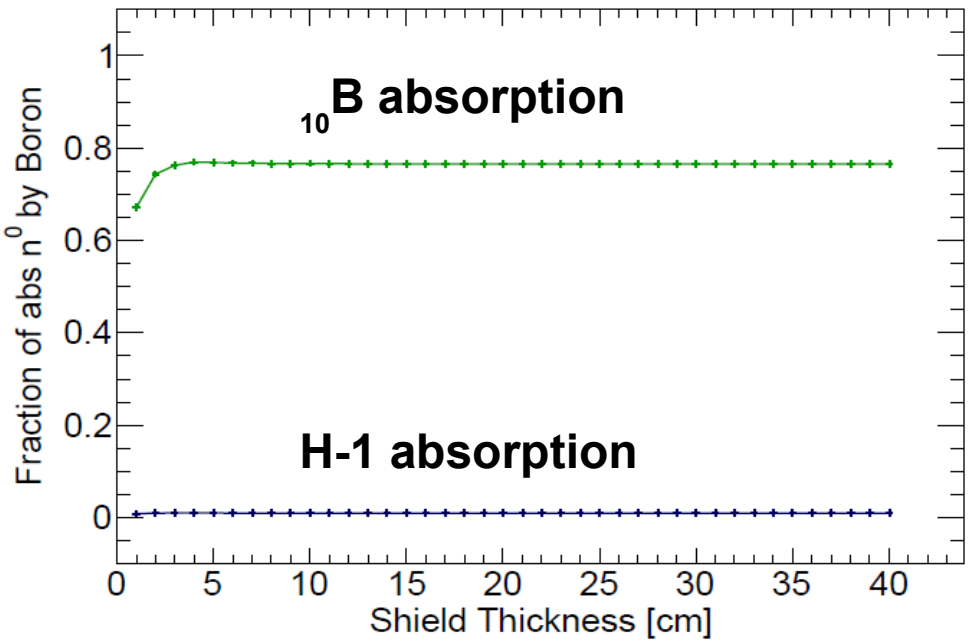
Boron-loaded-polyethylene neutron shield

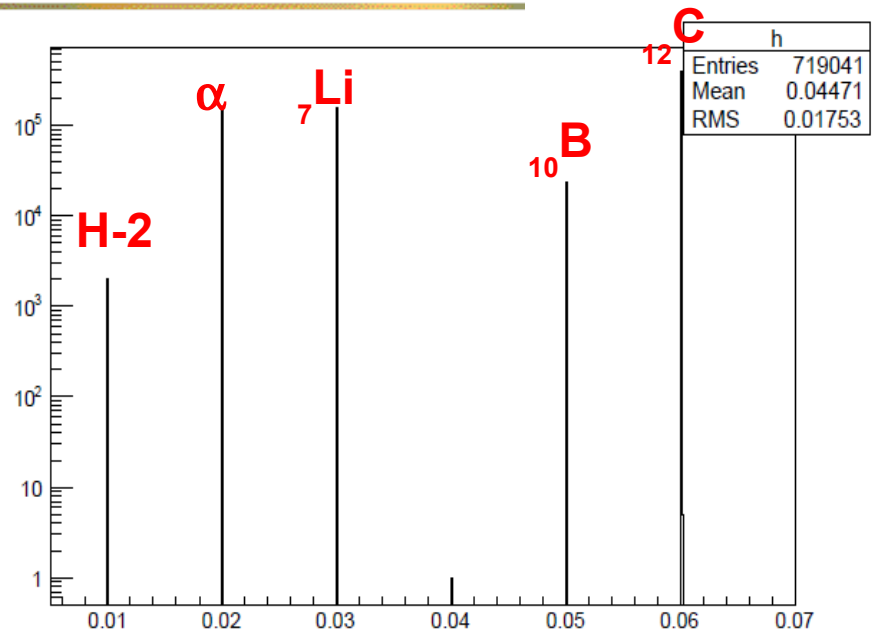




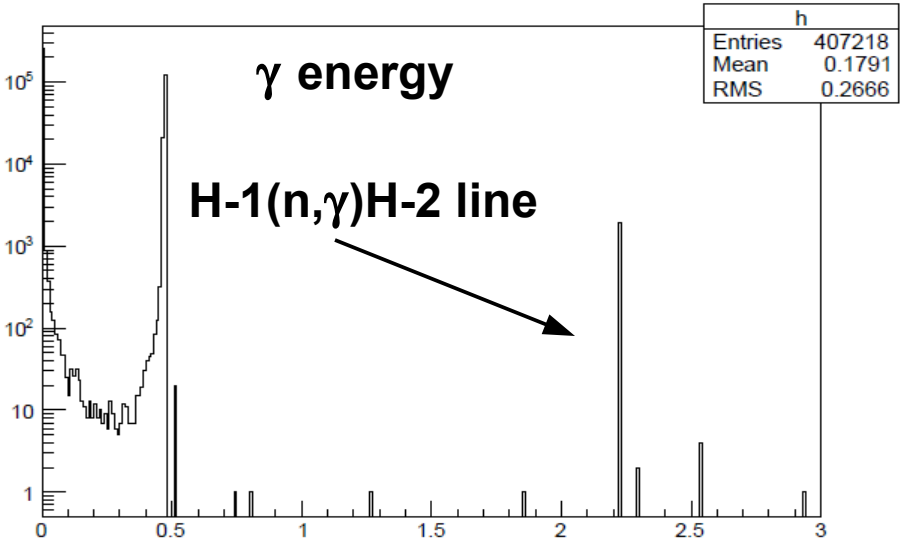
- **Neutron (magenta curve) multiplicity (left plot) get reduced when increasing shield thickness. At 10cm neutron flux is reduced up to 7.5% (right plot)**
- **$_7$Li ion (green curve) multiplicity increases with shield thickness**
- **Not all the absorbed neutrons are due to Boron**

Boron-loaded-polyethylene neutron shield



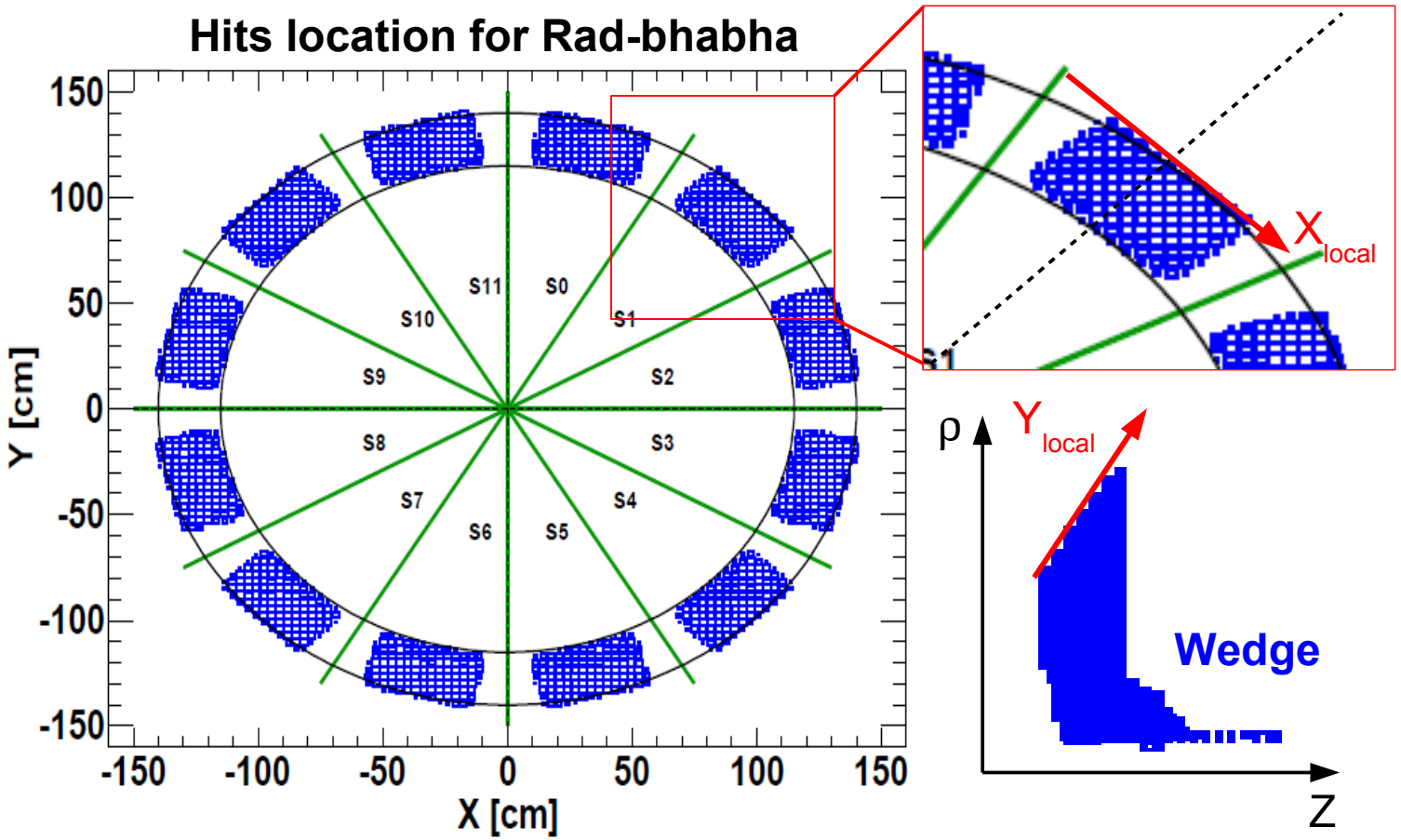


- Around 80% of the absorbed neutrons are due to $_{10}B$
- A small fraction is due to H-1(n,γ)H-2
- Are there any other absorption processes with Carbon, Hydrogen and Boron?



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}



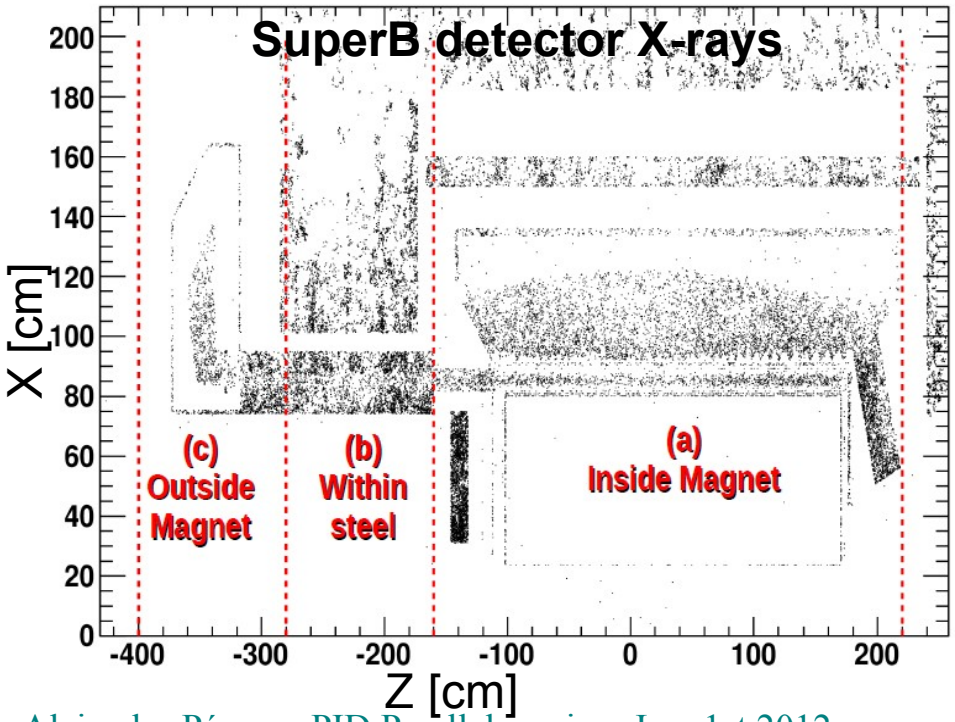
X_{local}:
From -width/2
up to width/2

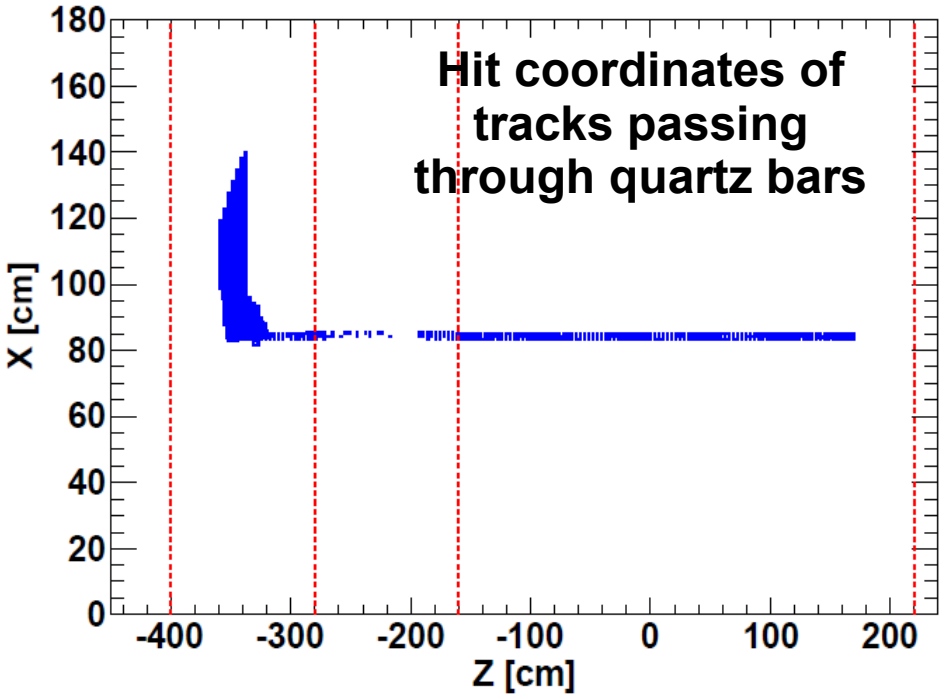
Y_{local}:
From 0.0
up to Length

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

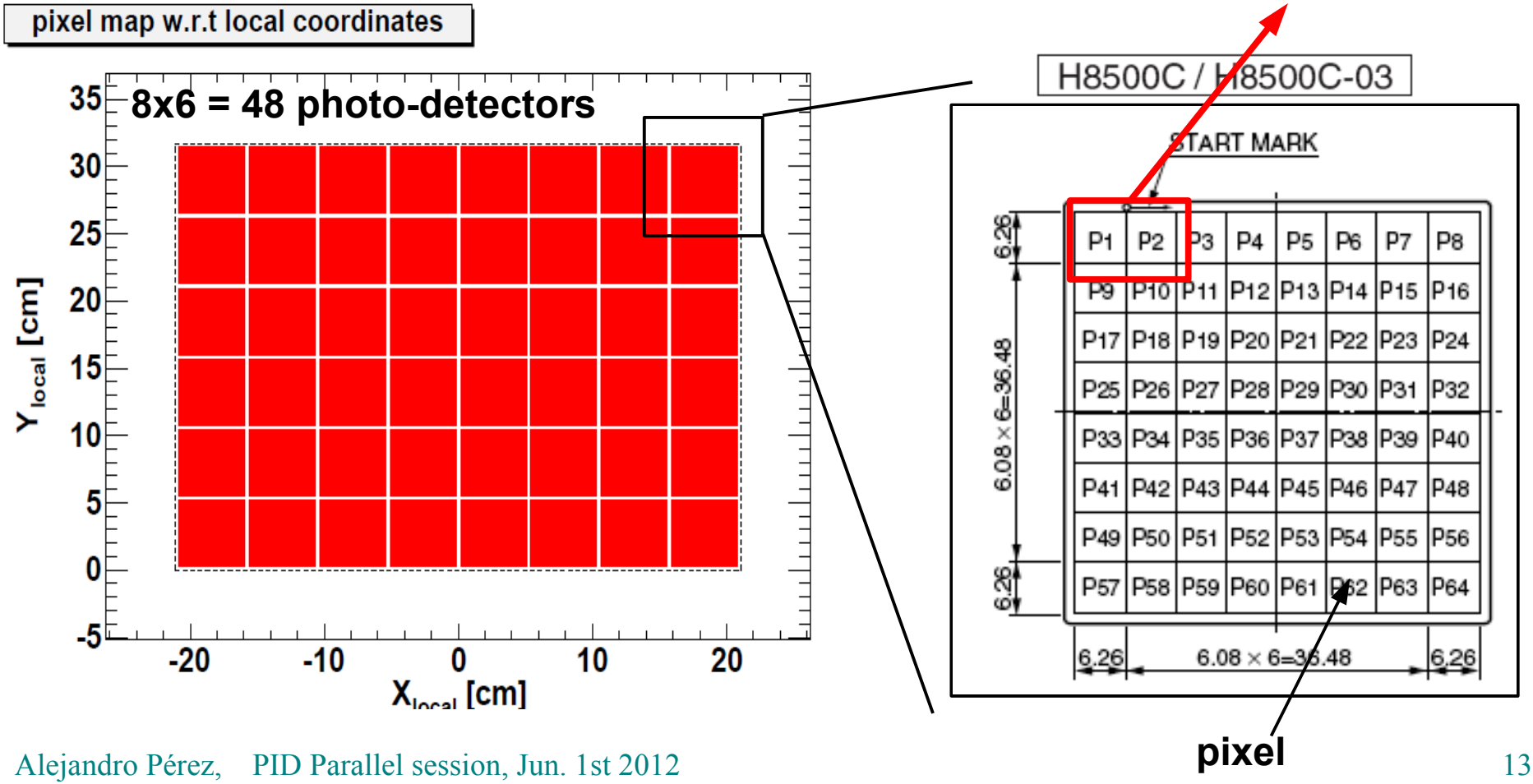




Bkg rates on the FDIRC: Pixel map

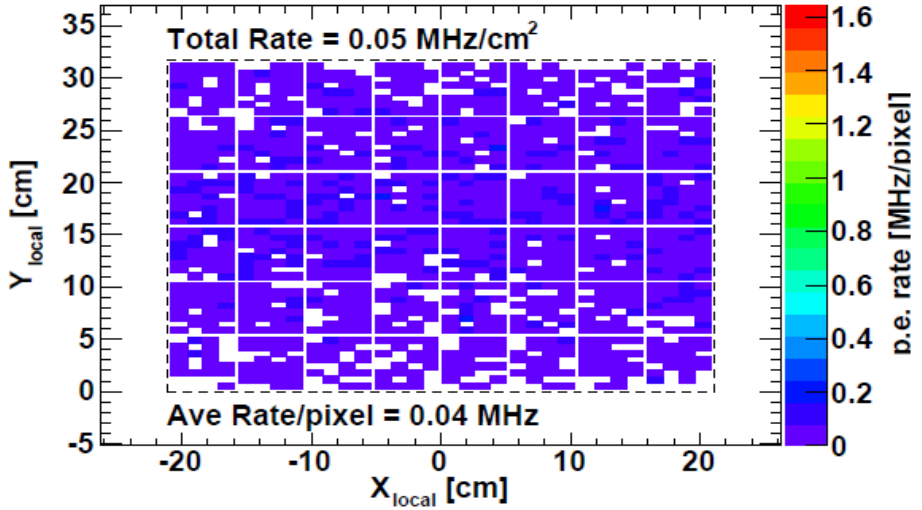
- For each sector have an array 8x6 = 48 photo-detectors
- Each detector is an 8x8 = 64 array of PMTs (pixels) with ~6.08mm pitch

Group 2 channels into one = 32 channels

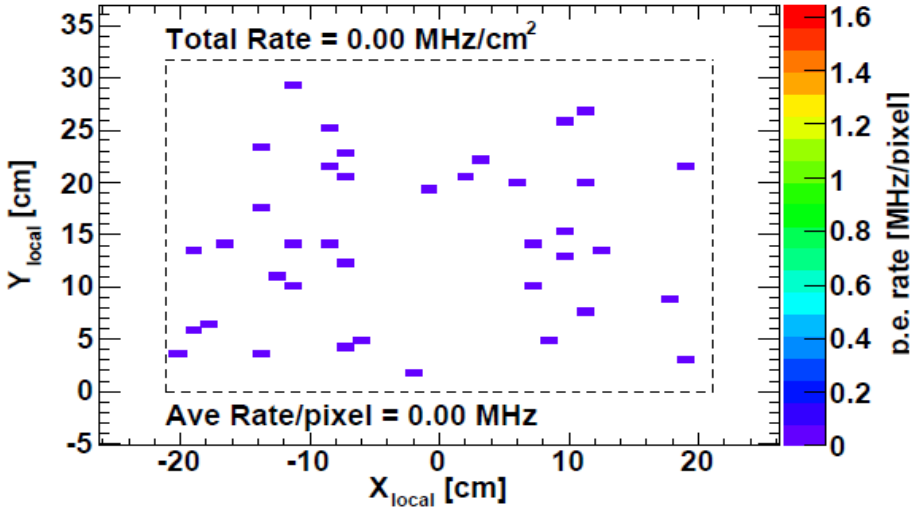


FDIRC Bkg rates from Rad-bhabha
No FDIRC shield

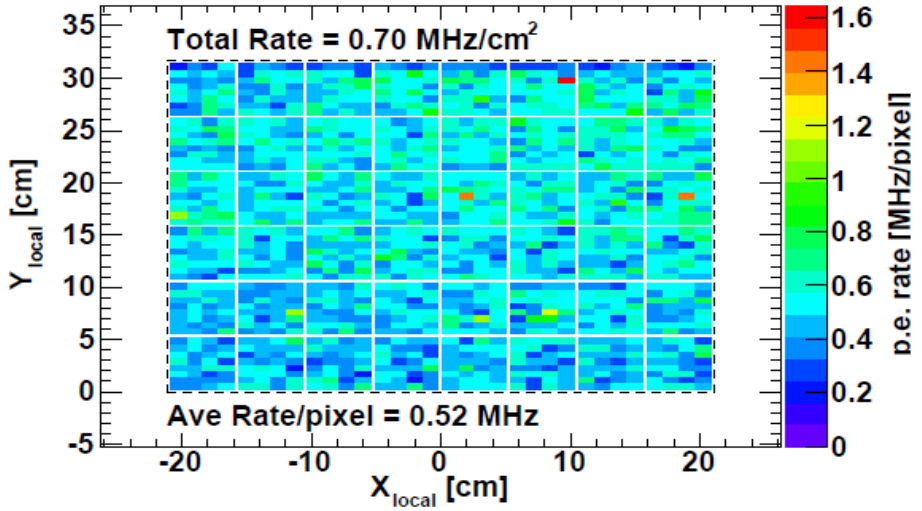
Hits on the quartz bars



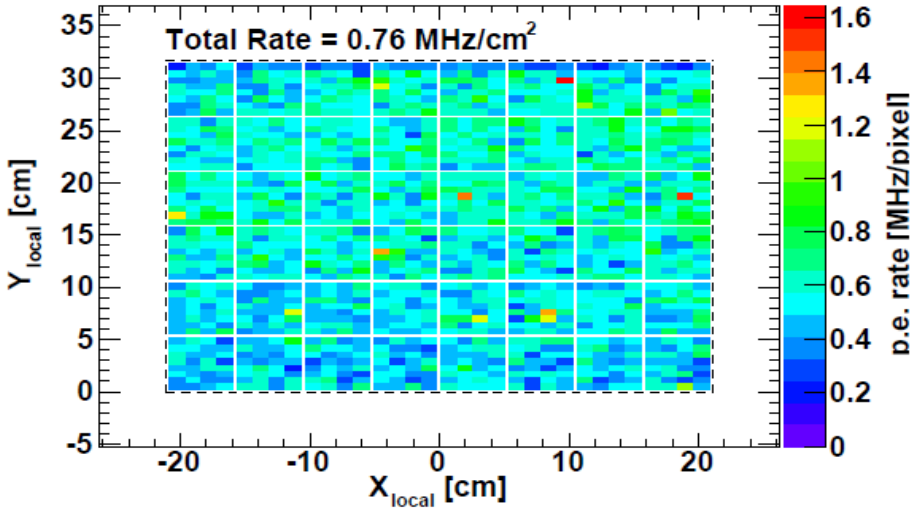
Hits within the horseshoe



Hits on the FBLOCK

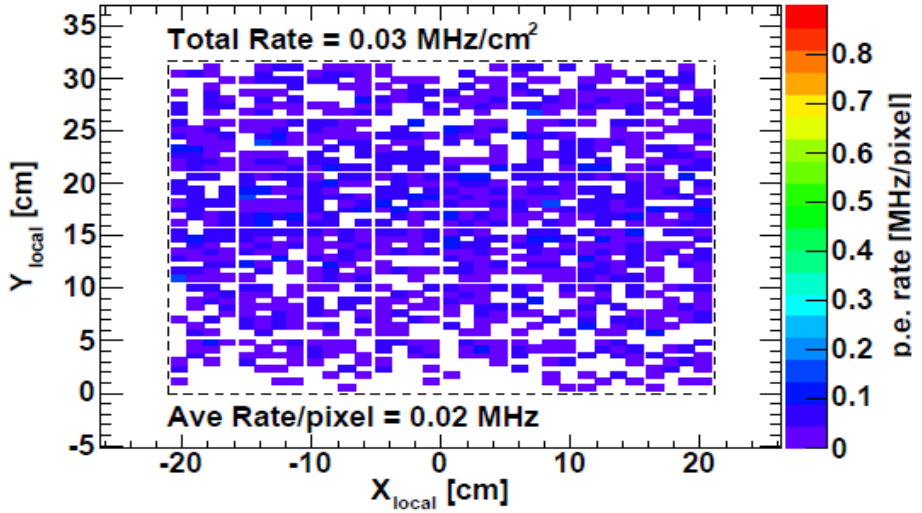


Total rate

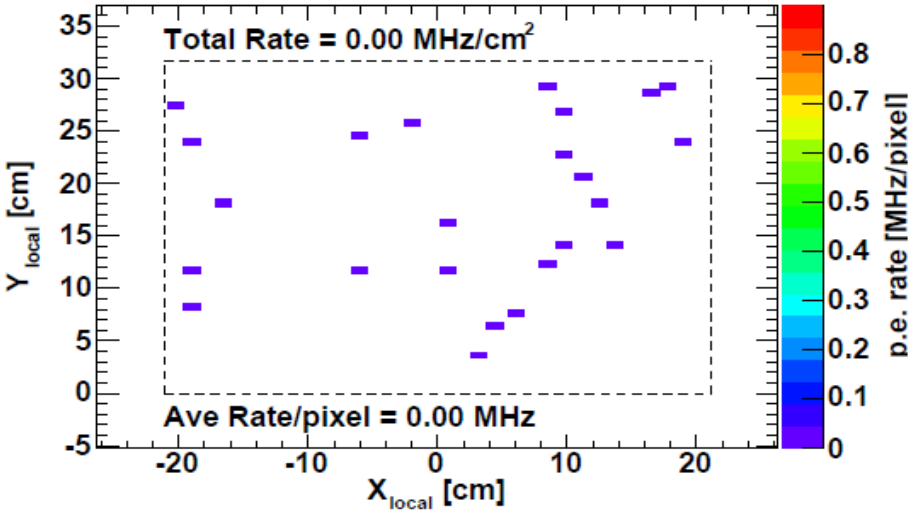


FDIRC Bkg rates from Rad-bhabha new FDIRC shield

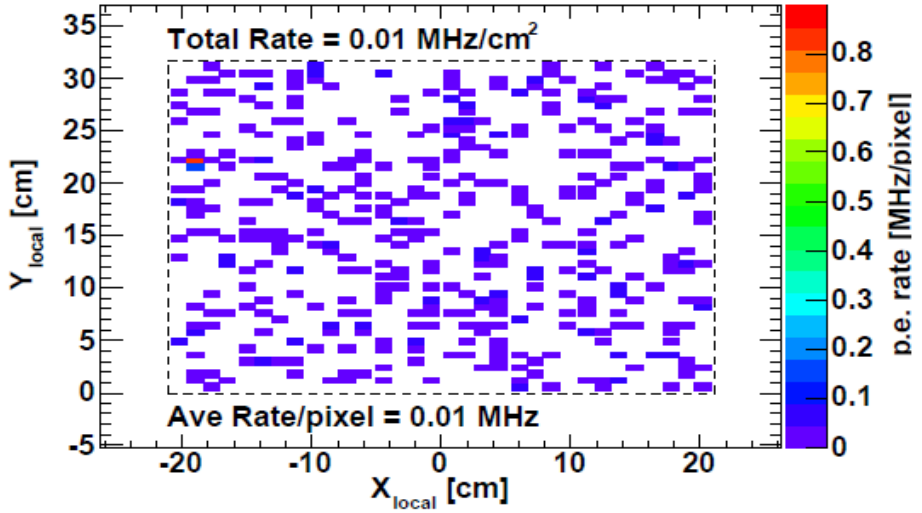
Hits on the quartz bars



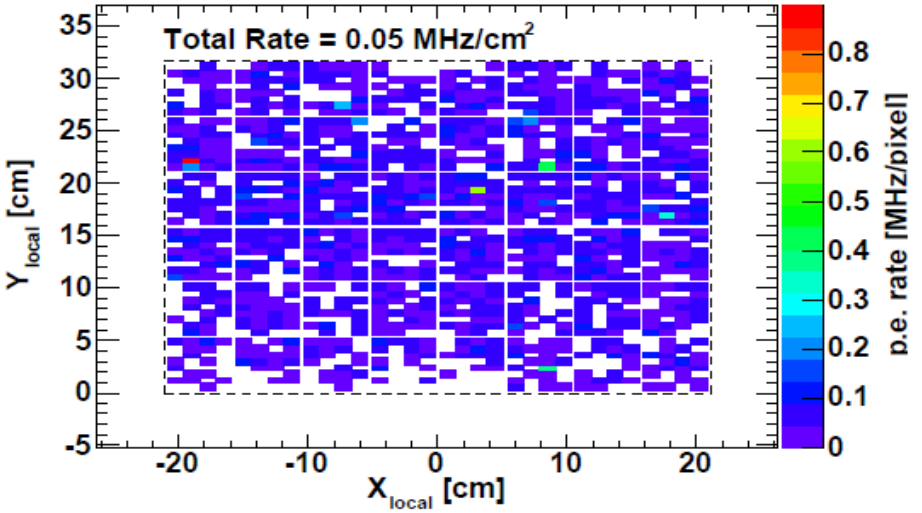
Hits within the horseshoe



Hits on the FBLOCK

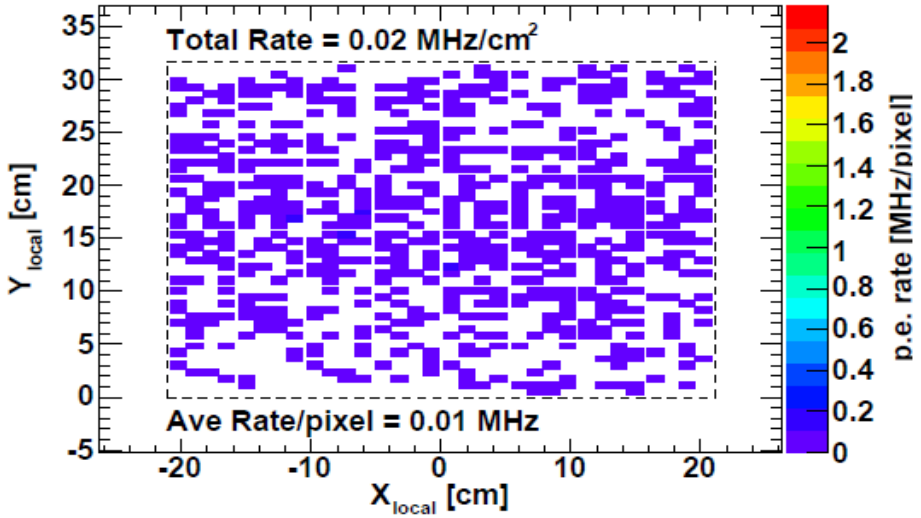


Total rate

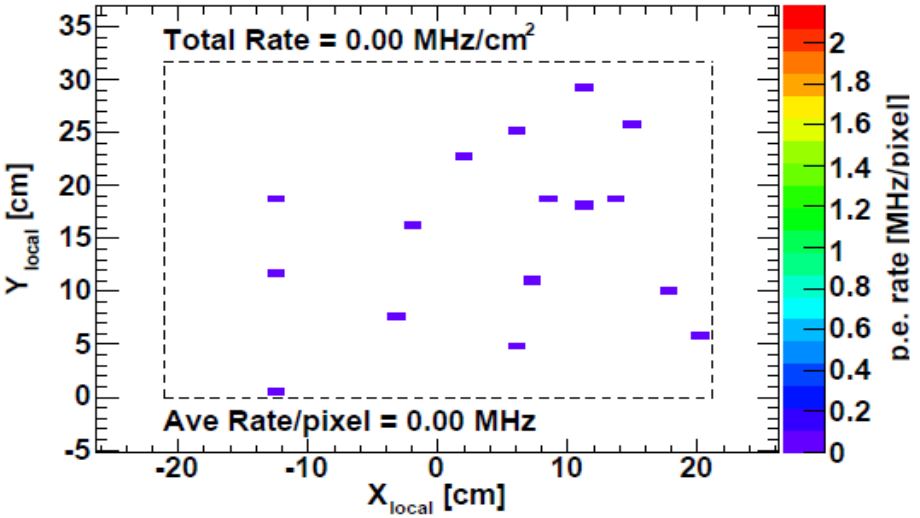


FDIRC Bkg rates from Rad-bhabha new FDIRC shield + Increased W-shield

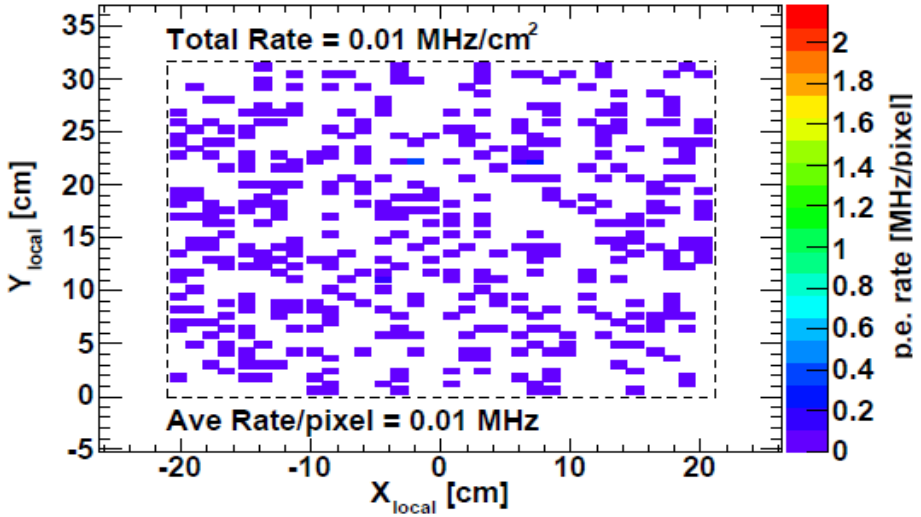
Hits on the quartz bars



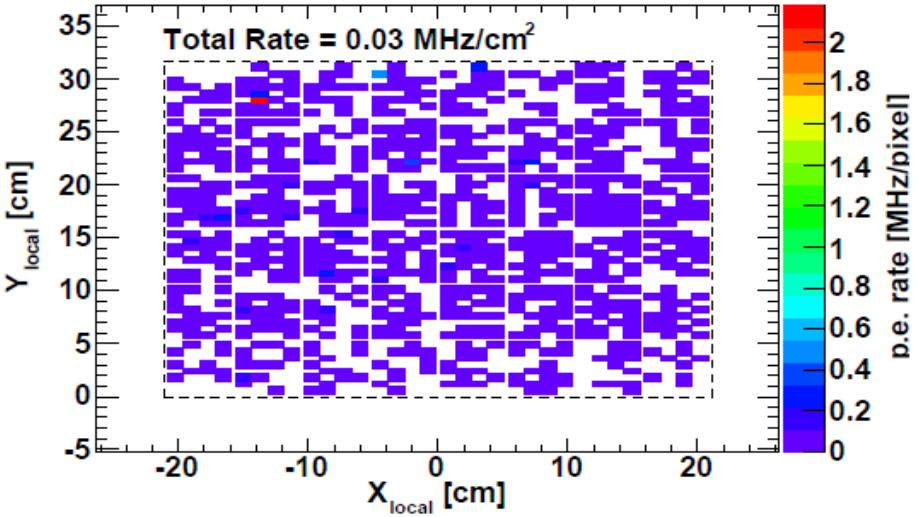
Hits within the horseshoe



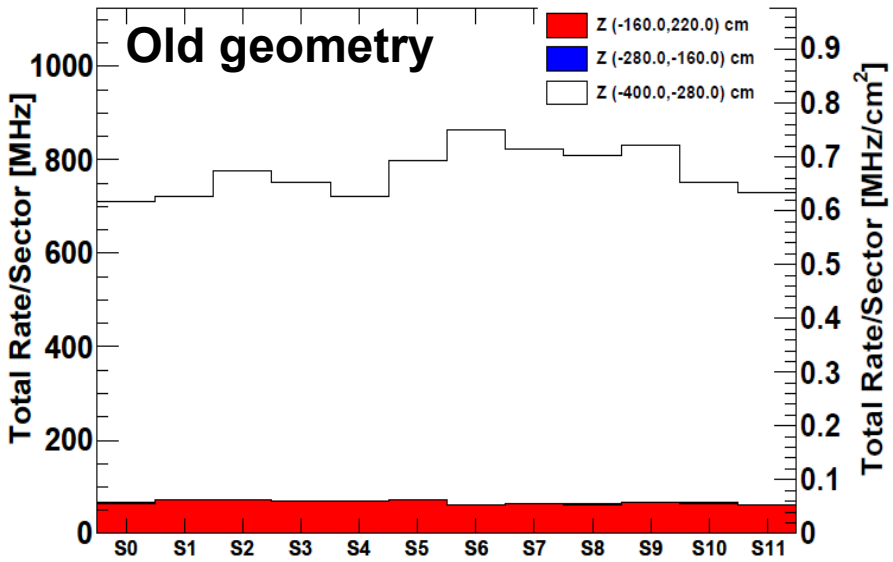
Hits on the FBLOCK

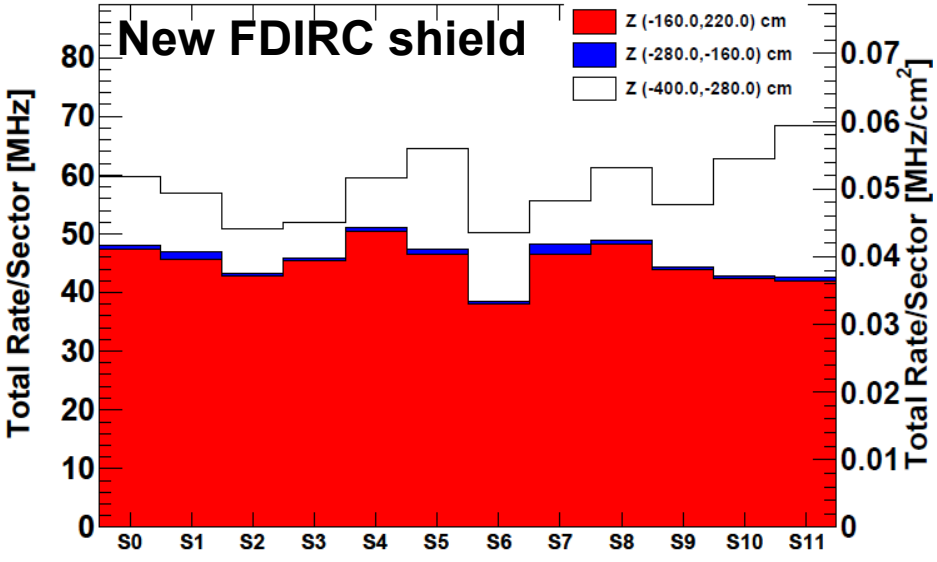


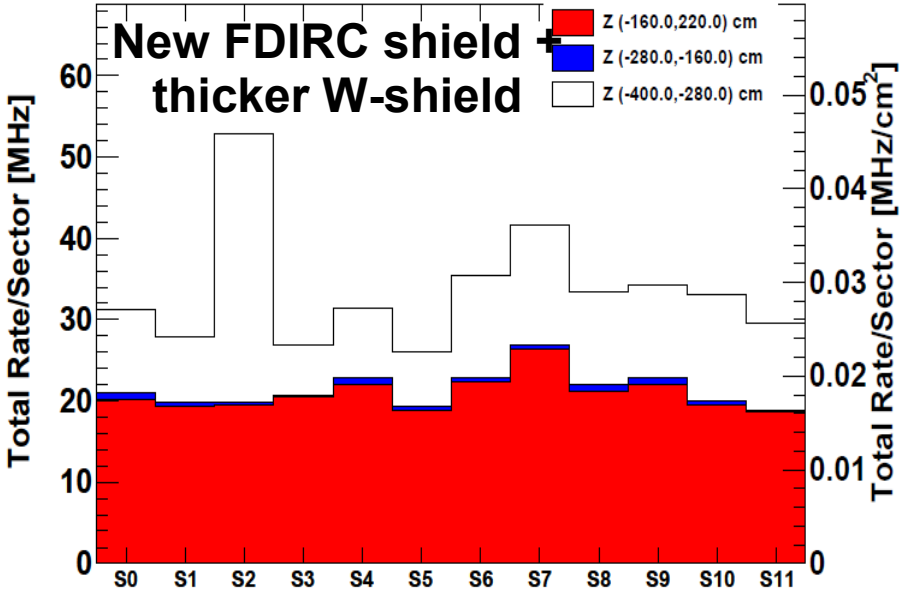
Total rate



FDIRC Bkg rates from Rad-bhabha: total rates



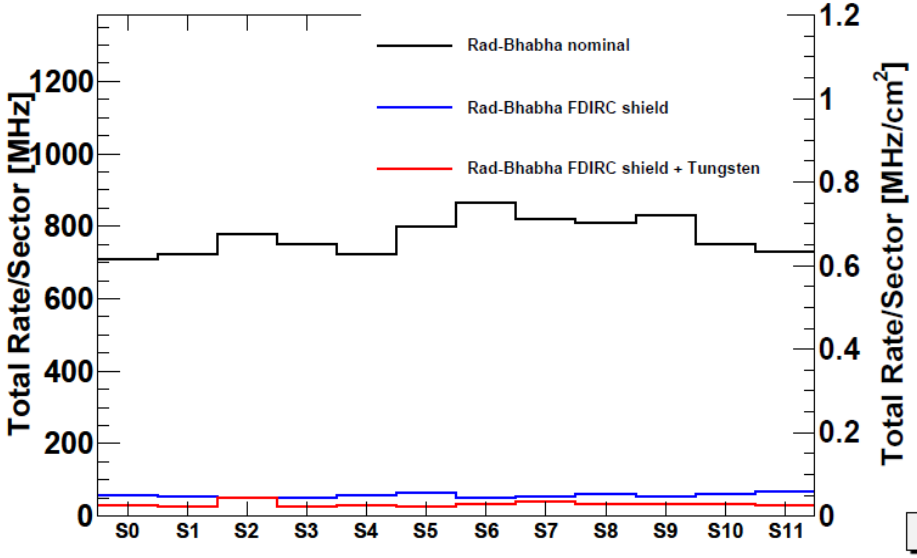


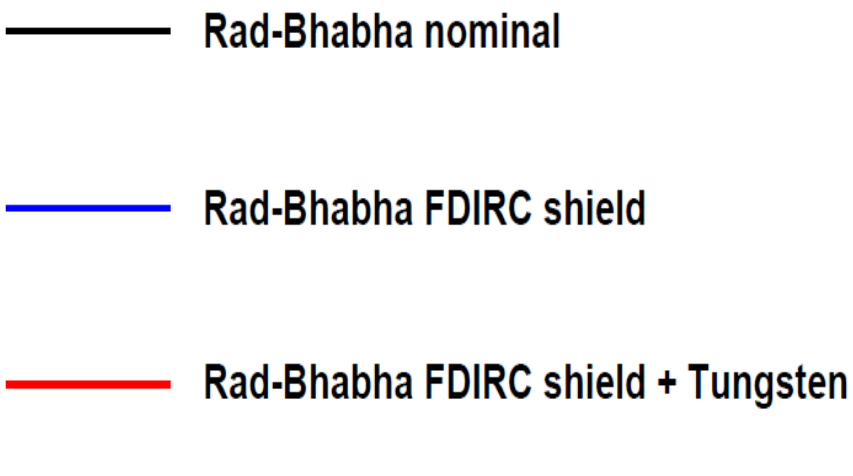


- New FDIRC shield effectively reduces the rates on the FBLOCK regions by a factor of ~10 (expected)
- Additional W-shield thickness reduces rates on the quartz bar region (a factor of ~2.5)

Total bkg rates on FDIRC

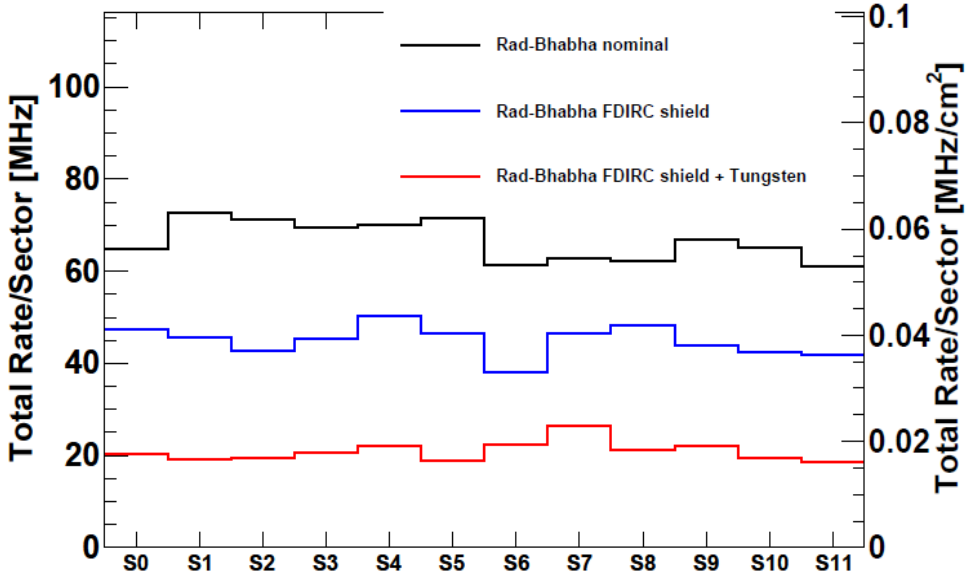
Rates per sector: Total rate



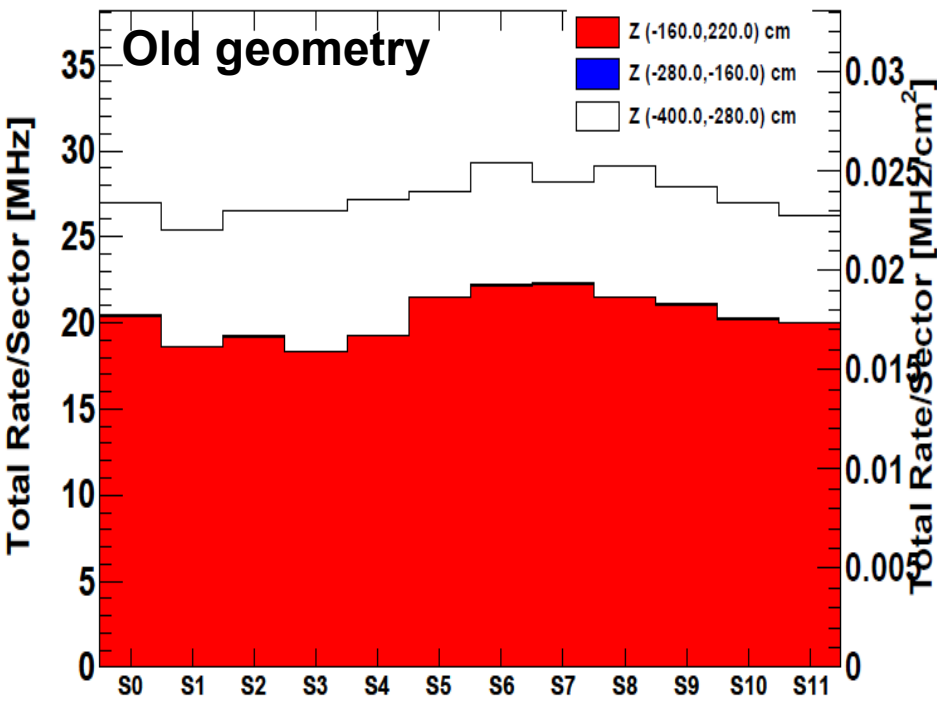


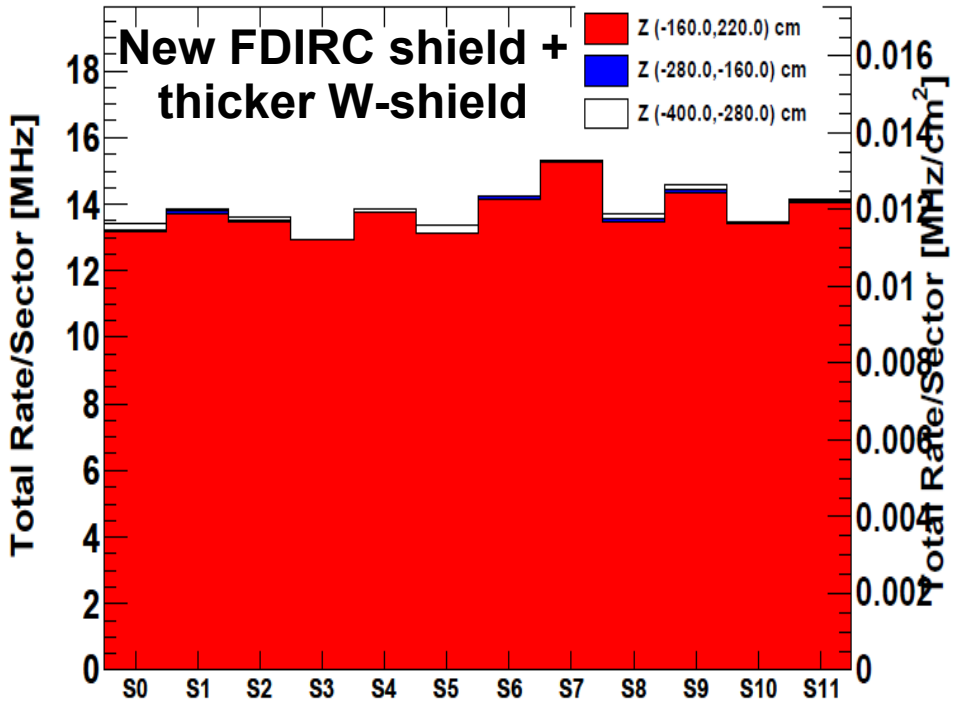
- New FDIRC shield effectively reduces the rates on the FBLOCK regions by a factor of ~10 (expected)
- Additional W-shield thickness reduces rates on the quartz bar region (a factor of ~2.5)

Rates per sector: quartz bar



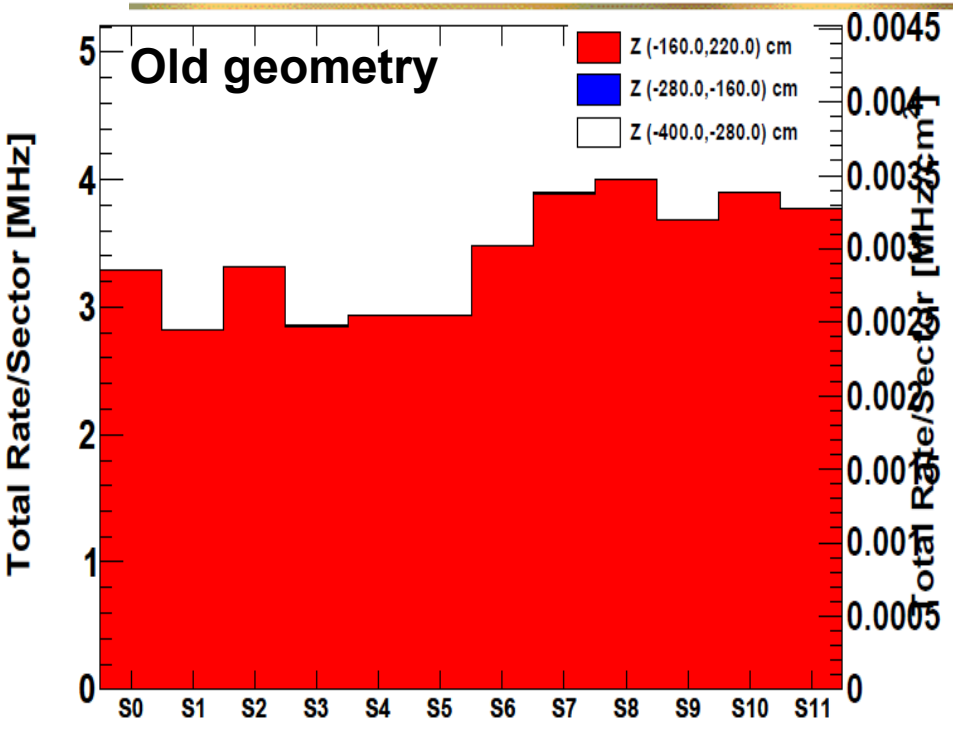
FDIRC Bkg rates from Pairs: total rates

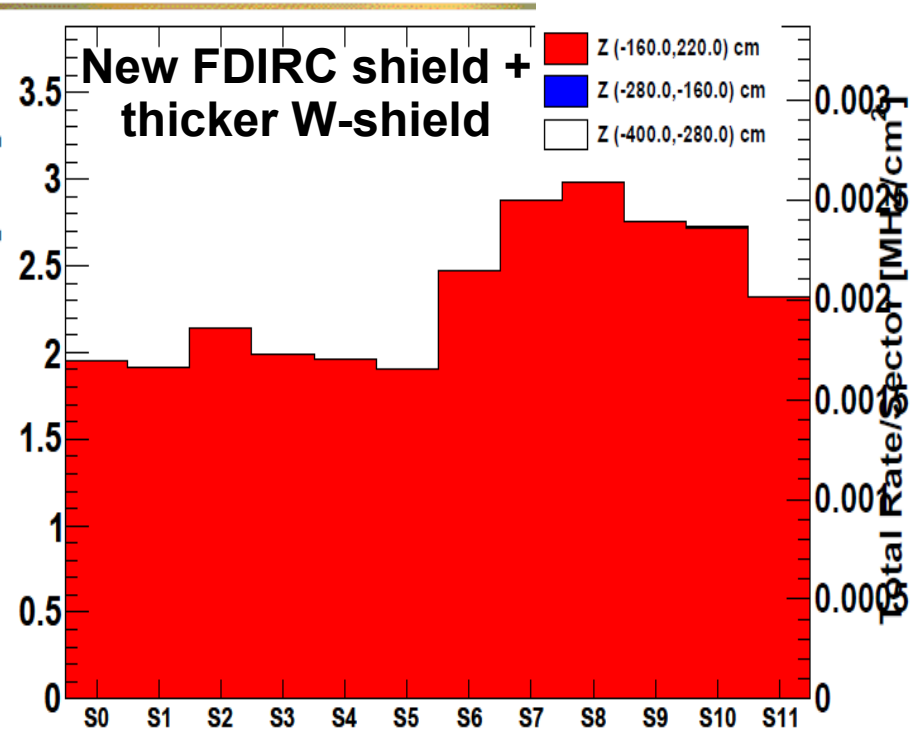




- **New FDIRC shield effectively reduces to almost zero the rates on the FBLOCK region for this background contribution**
- **Additional W-shield thickness reduces rates on the quartz bar region (a factor of ~1.4)**

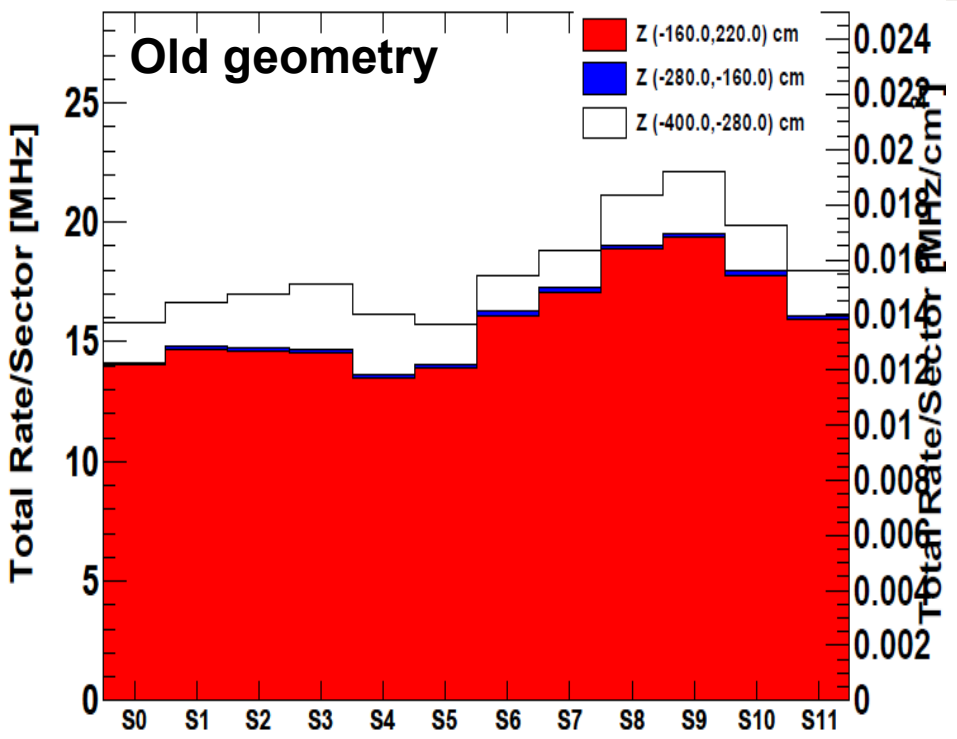
FDIRC Bkg rates from Touschek-HER: total rates

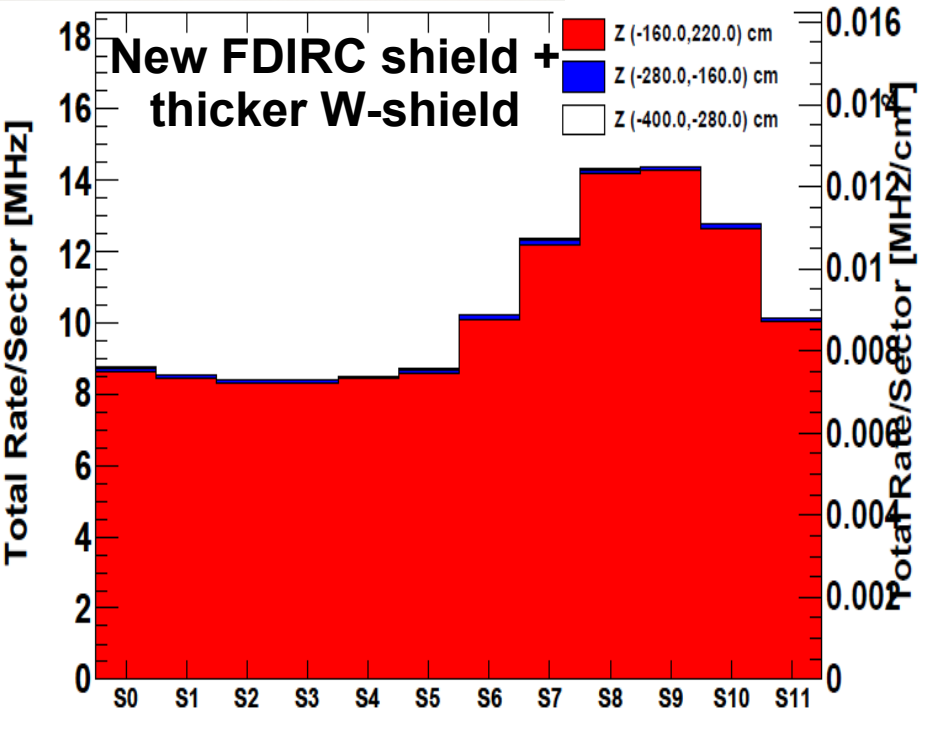




- No rates on the FBLOCK region for this background contribution
- Additional W-shield thickness reduces rates on the quartz bar region (a factor of ~1.5)

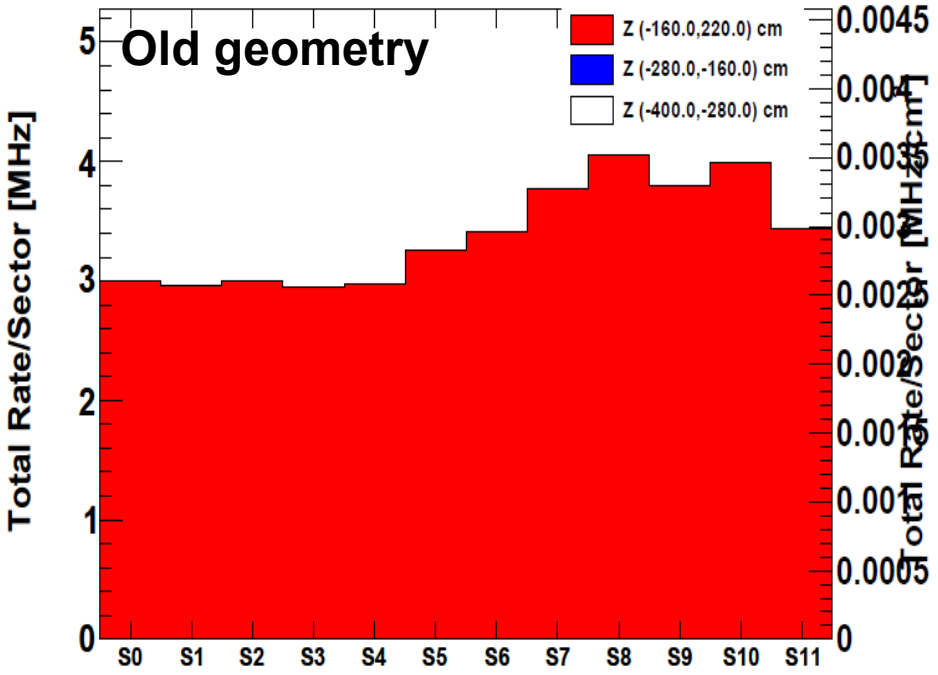
FDIRC Bkg rates from Touschek-LER: total rates

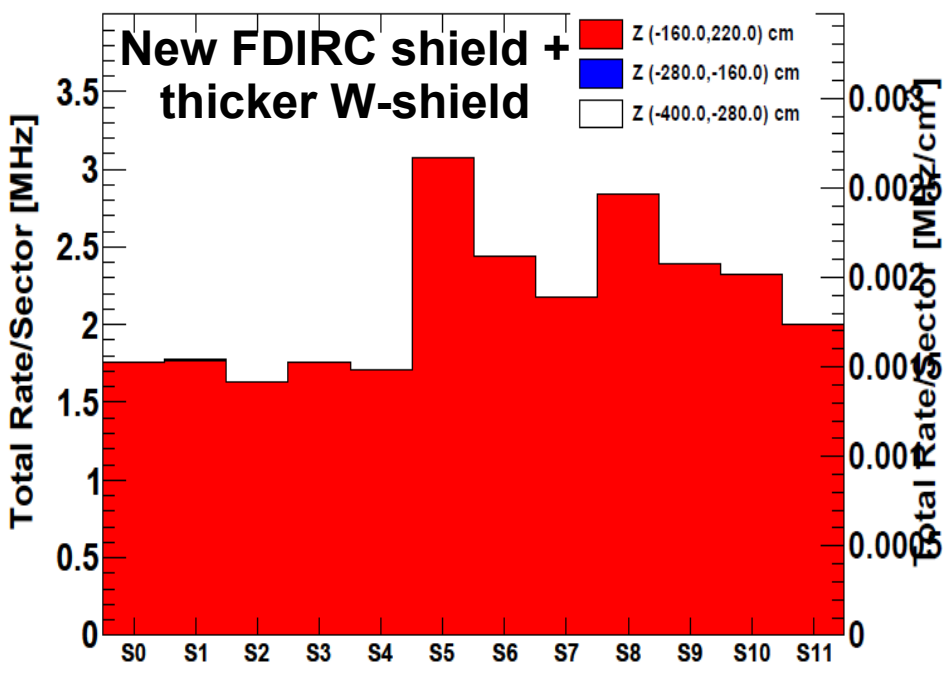




- New FDIRC shield effectively reduces to almost zero the rates on the FBLOCK region for this background contribution
- Additional W-shield thickness reduces rates on the quartz bar region (a factor of ~1.4)

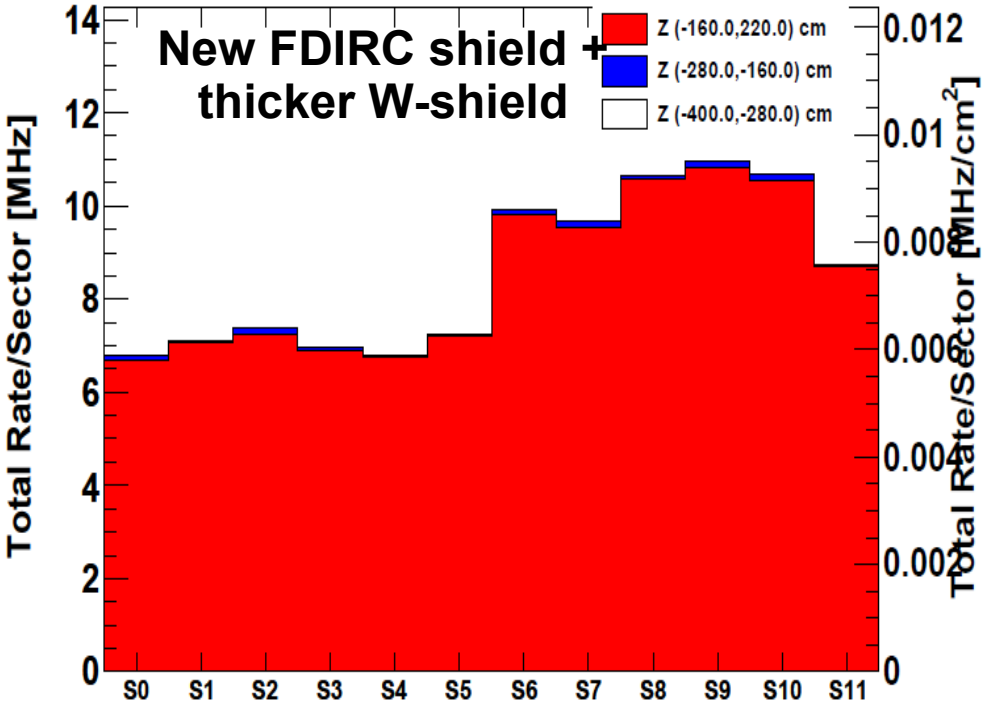
FDIRC Bkg rates from BeamGas-HER: total rates





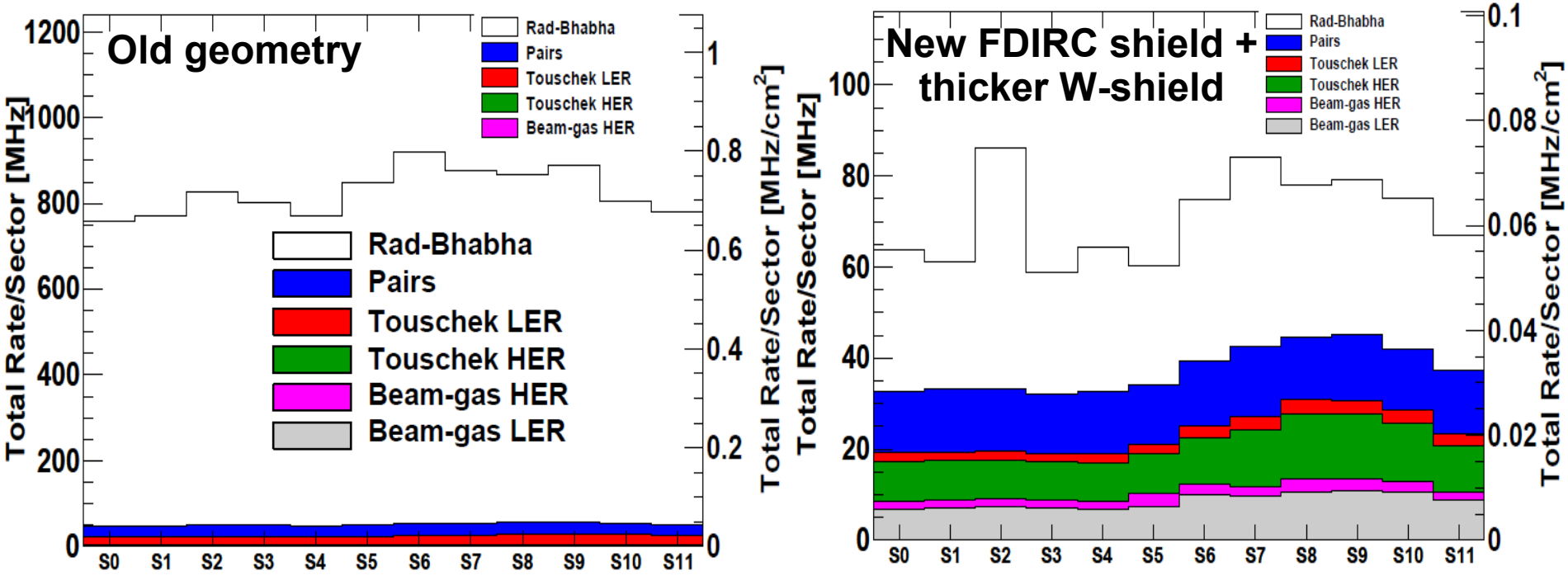
- No rates on the FBLOCK region for this background contribution
- Additional W-shield thickness reduces rates on the quartz bar region (a factor of ~1.5)

FDIRC Bkg rates from BeamGas-LER: total rates



- First time that the Beam-gas-LER is available
- Background rates comparable with Touschek-LER

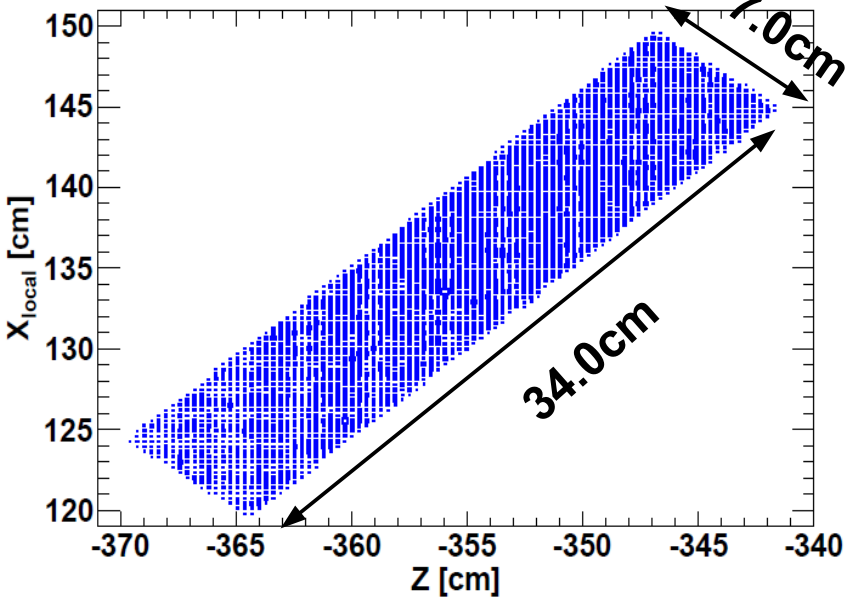
Total bkg rates on FDIRC

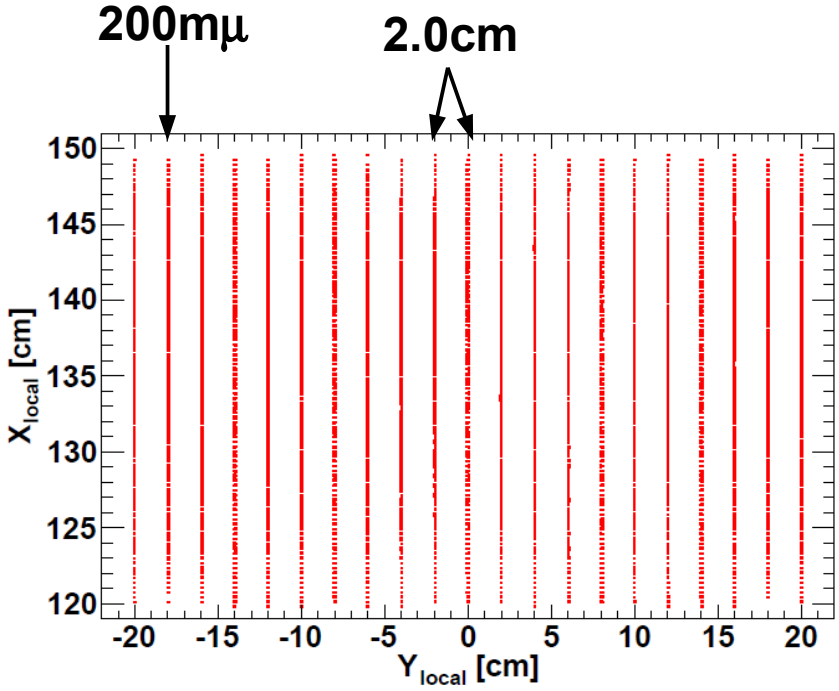


- **Previously:**
  - Rad-bhabha main background source on the FDIRC
  - Other sources negligible
- **Currently:**
  - Significant reduction of Rad-bhabha contribution (a factor of ~10)
  - All background sources give similar contributions to the total rate

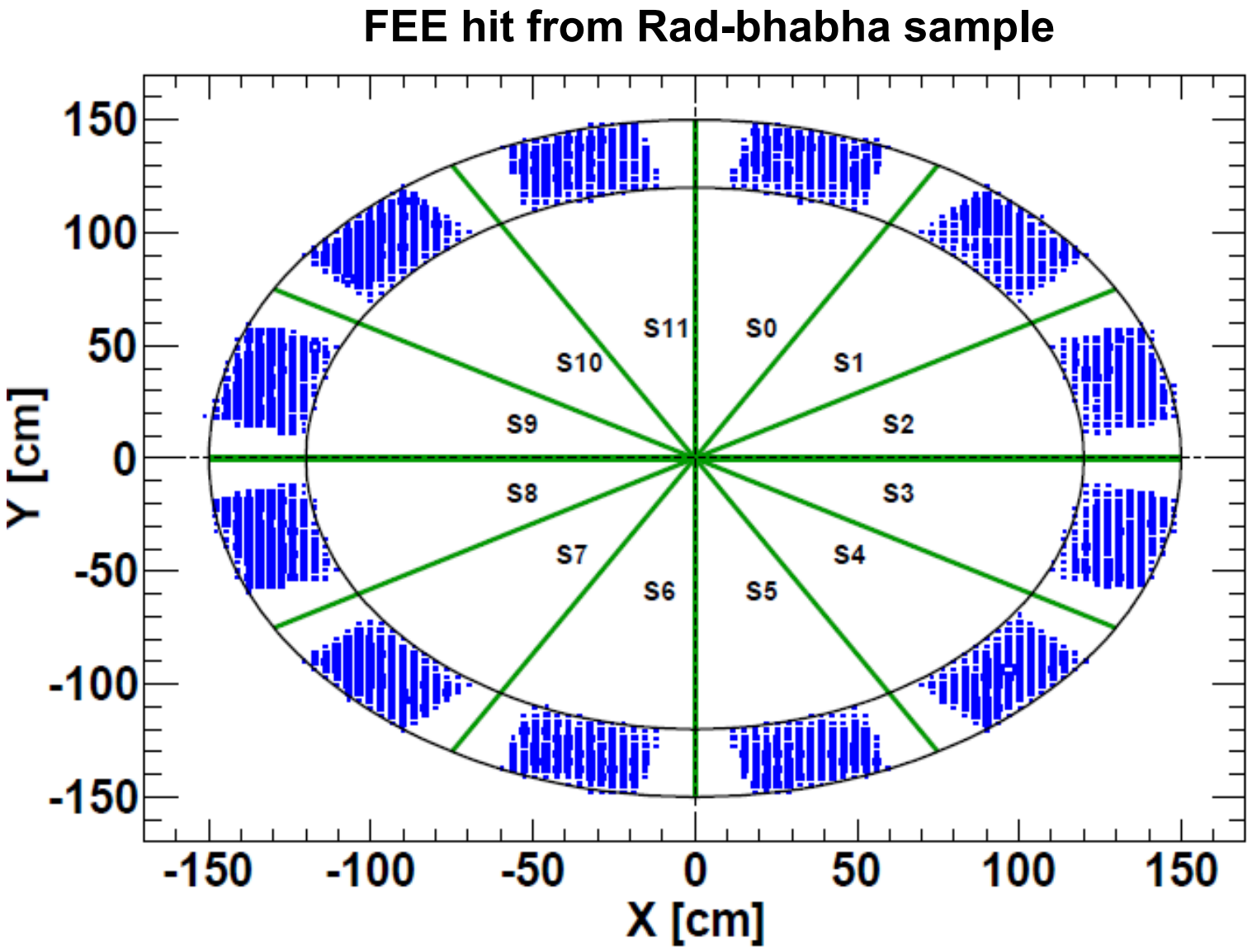
FEE Dose and fluency: geometric model and strategy

- **BRN implementation of FDIRC FEE**
  - FEE boards are silicon boxes of 7.0cm x 34.0cm x 200μ
  - 21 boards per sector separated 2cm
- **The FEE boards are instrumented**
  - Incident particle information (4-p, position, time, particle type): fluency
  - Deposited energy: doses
- **As a first approach will consider all the board in a sector as a single element and will estimate doses and fluences**





FEE Dose and fluency: FEE hits

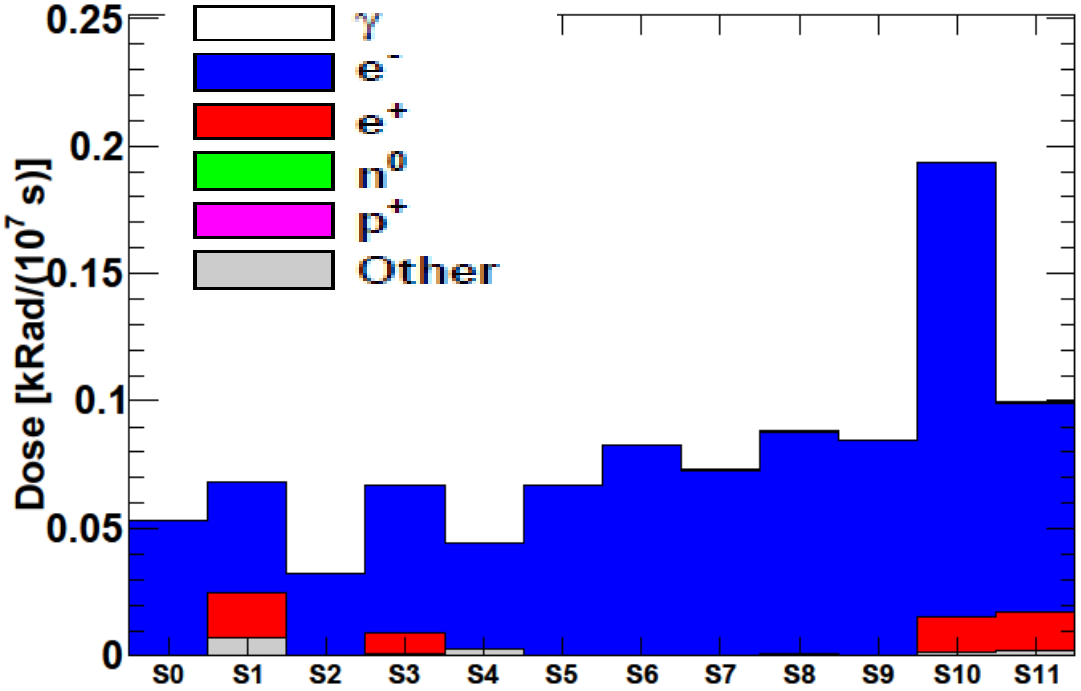


FEE Dose and fluency: The Dose

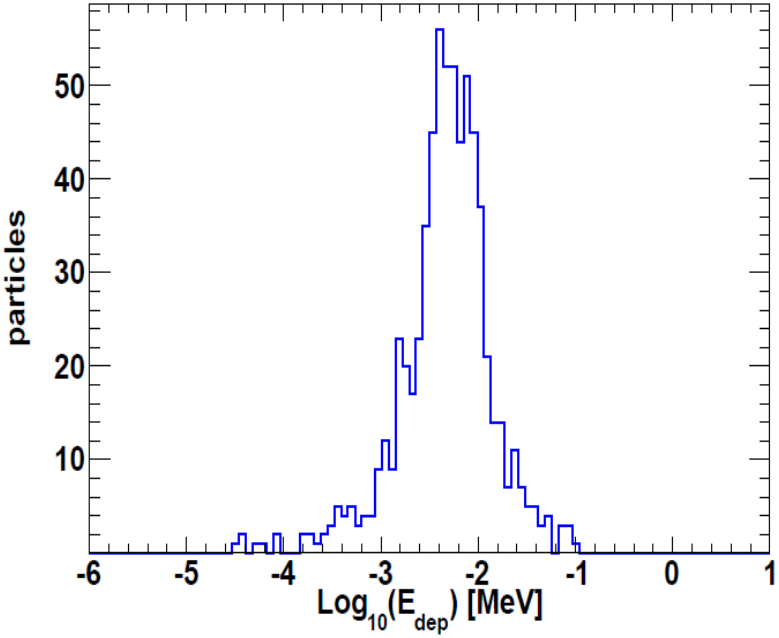
- **Doses:** (total deposited energy on FEE per sector)/(total mass per sector)

  Quoted doses are for 10^7s $\Rightarrow$ 10ab^{-1} integrated luminosity
- **Main doses on FEE are due to electrons/positrons (ionization) and some heavy ions (very minor component)**
- **Main source of doses are Rad-bhabha, other sources are negligible (a factor of 100 smaller, see backup slides)**

Rad-bhabha: Total dose per sector on FEE



Rad-Bhabha: deposited energy on FEE-sector6 from all particle types

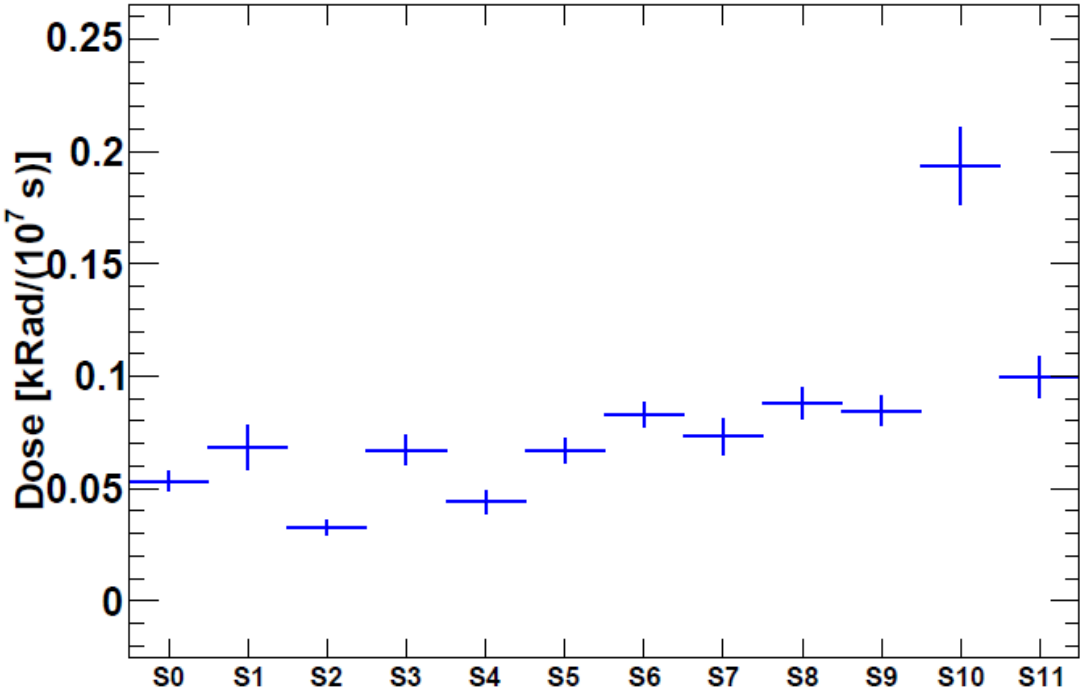


FEE Dose and fluency: The Dose

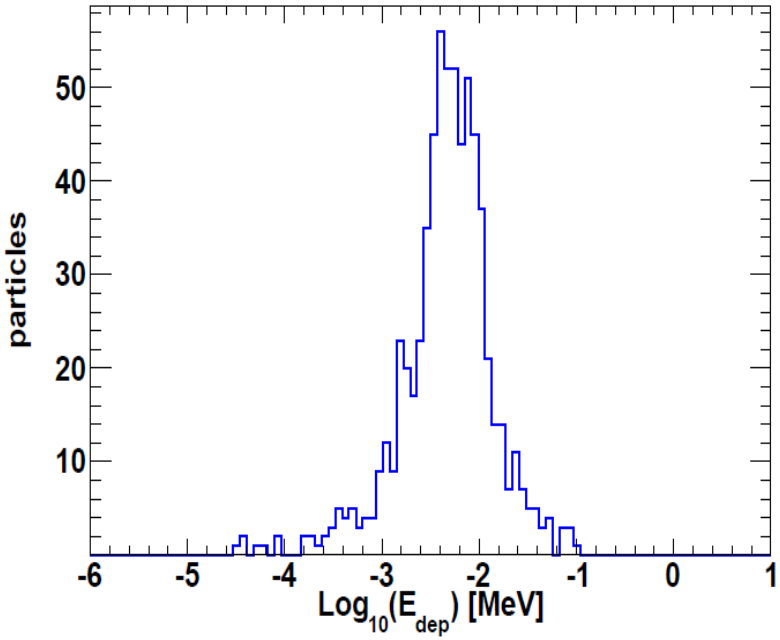
- **Doses:** (total deposited energy on FEE per sector)/(total mass per sector)

  Quoted doses are for 10^7s $\Rightarrow$ 10ab^{-1} integrated luminosity
- **Main doses on FEE are due to electrons/positrons (ionization) and some heavy ions (very minor component)**
- **Main source of doses are Rad-bhabha, other sources are negligible (a factor of 100 smaller, see backup slides)**

Rad-bhabha: Total dose per sector on FEE



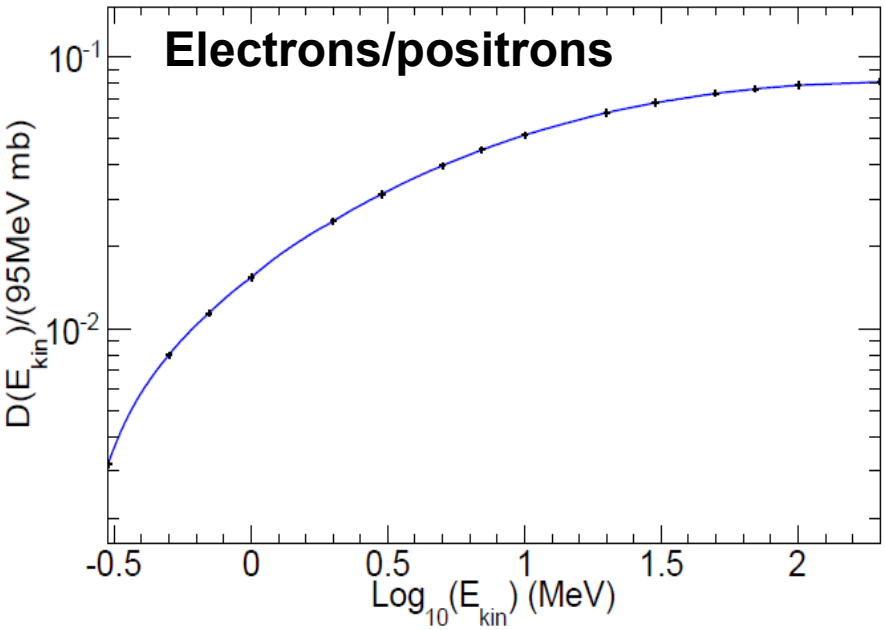
Rad-Bhabha: deposited energy on FEE-sector6 from all particle types

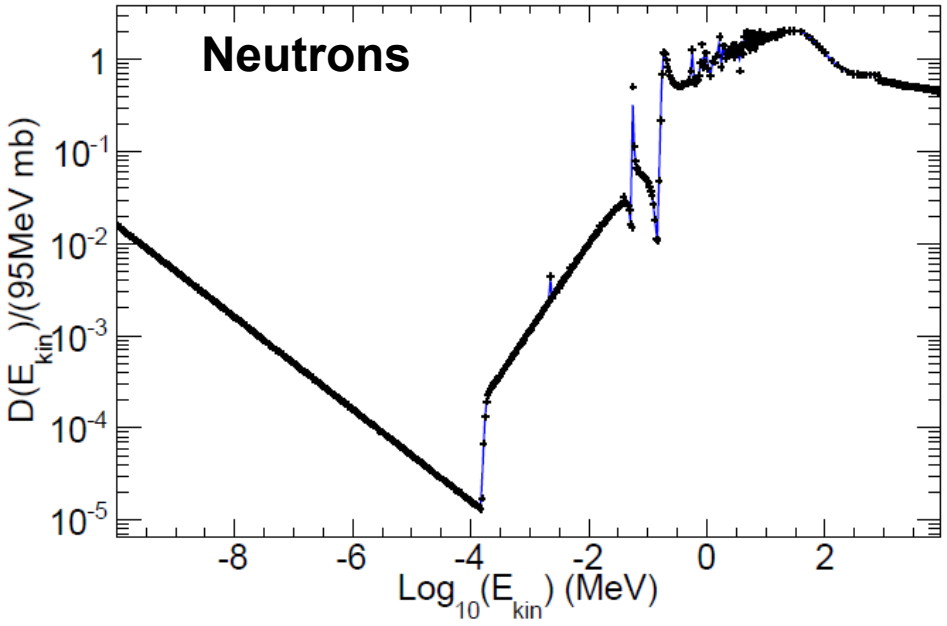


FEE Dose and fluency: The Fluency

- Estimate the 1MeV neutron equivalent fluency per sector
- Particle fluxes are scales by the damage function relative to 1MeV neutrons: $D(E_{kin})/(95MeV\ mb)$. Different damage function for different particles types
- Quoted fluency per sector are for $10^7 s \Rightarrow 10 ab^{-1}$ integrated luminosity

$D(E_{kin})/(95MeV\ mb)$ vs $Log_{10}(E_{kin})$

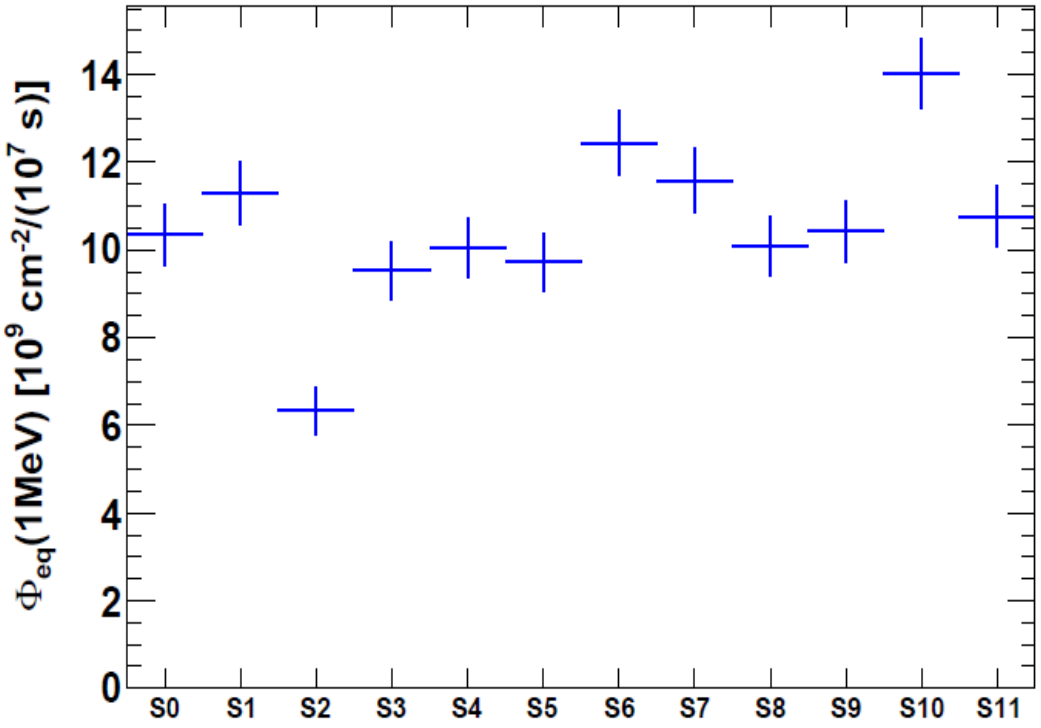




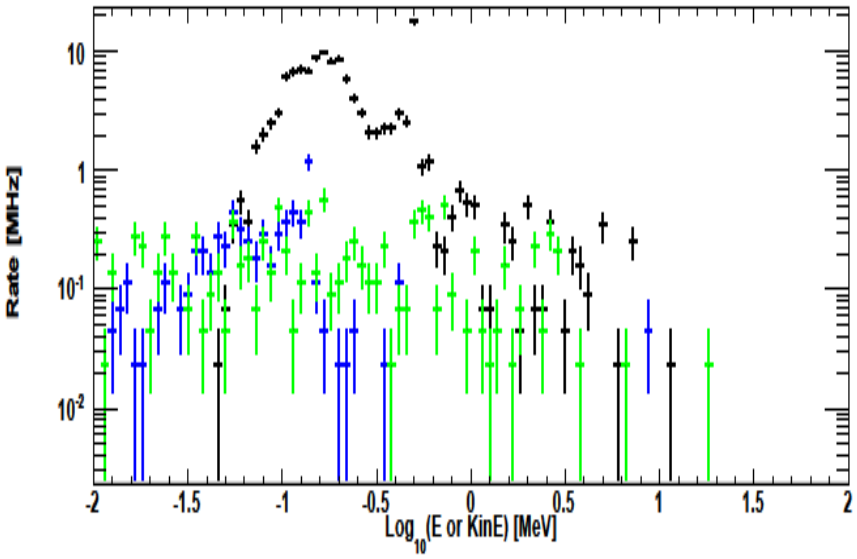
FEE Dose and fluency: The Fluency

- Main 1MeV neutron eq. Fluency is from Rad-bhabha, other sources give negligible contributions (see backup slides)

Rad-bhabha: 1MeV neutron eq. fluency per sector on FEE



Rad-Bhabha: FEE-sector6 particles fluxes vs E_{kin}



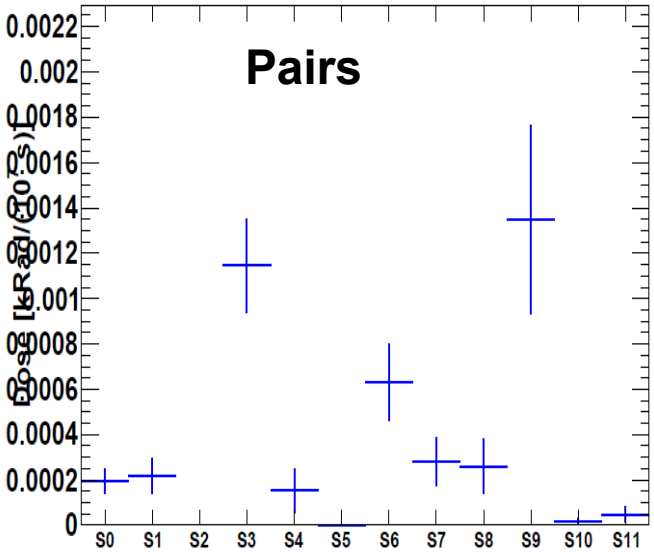
Summary

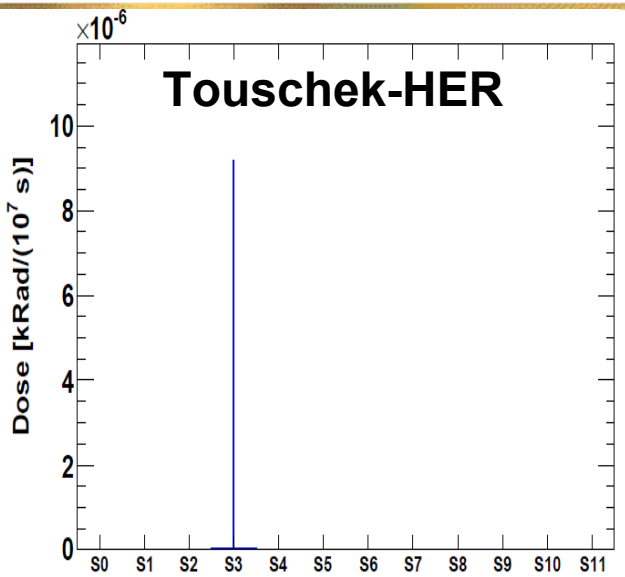
- **Many developments of reduce machine induced backgrounds on the FDIRC**
  - New lead-steel-polyethylene shield on the FBLOCK regions of FDIRC
  - Thicker W-shield (from 30 to 45 mm)
- **A very complete set of background samples have been analysed**
  - Rad-bhabha
  - Pairs
  - Touschek and BeamGas (HER/LER)
- **With the new geometry configuration (additional shield) get a reduction of a factor of ~10 on the total rates (mainly due a reduction on Rad-bhabha rates on FBLOCK region)**

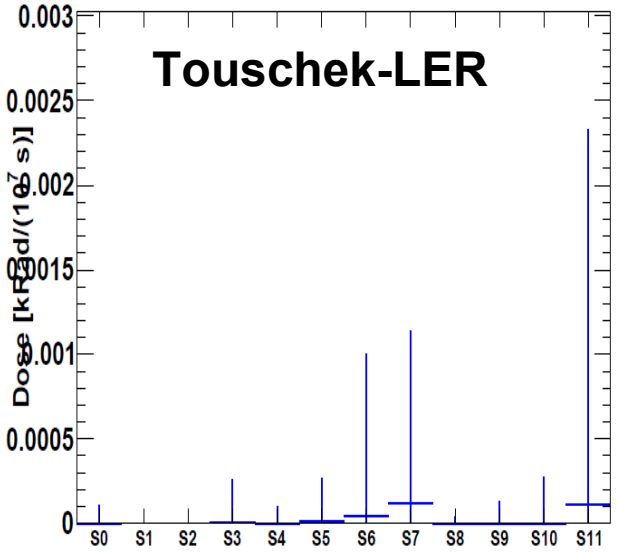
- **FEE dose and fluency**
  - First look at dose and fluency on electronics
  - Quoted numbers are average over a whole sector
  - Are the quoted numbers enough?

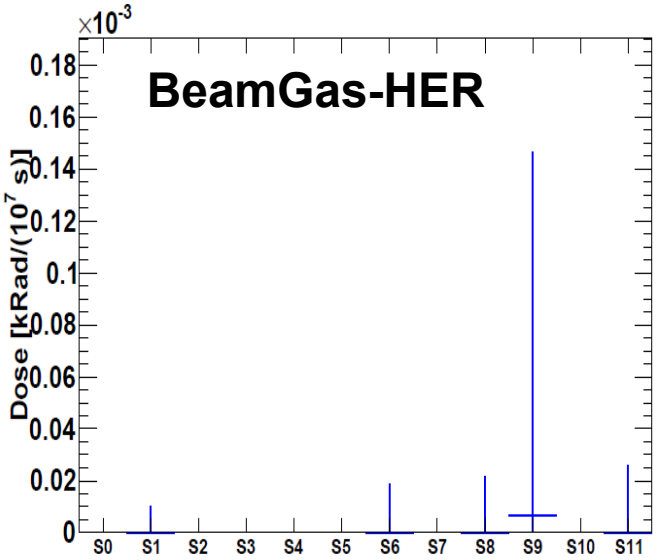

Backup

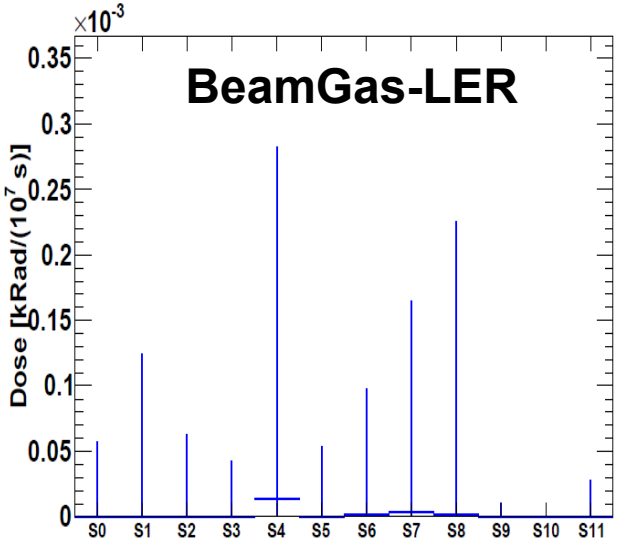
FEE Dose and fluency: Dose





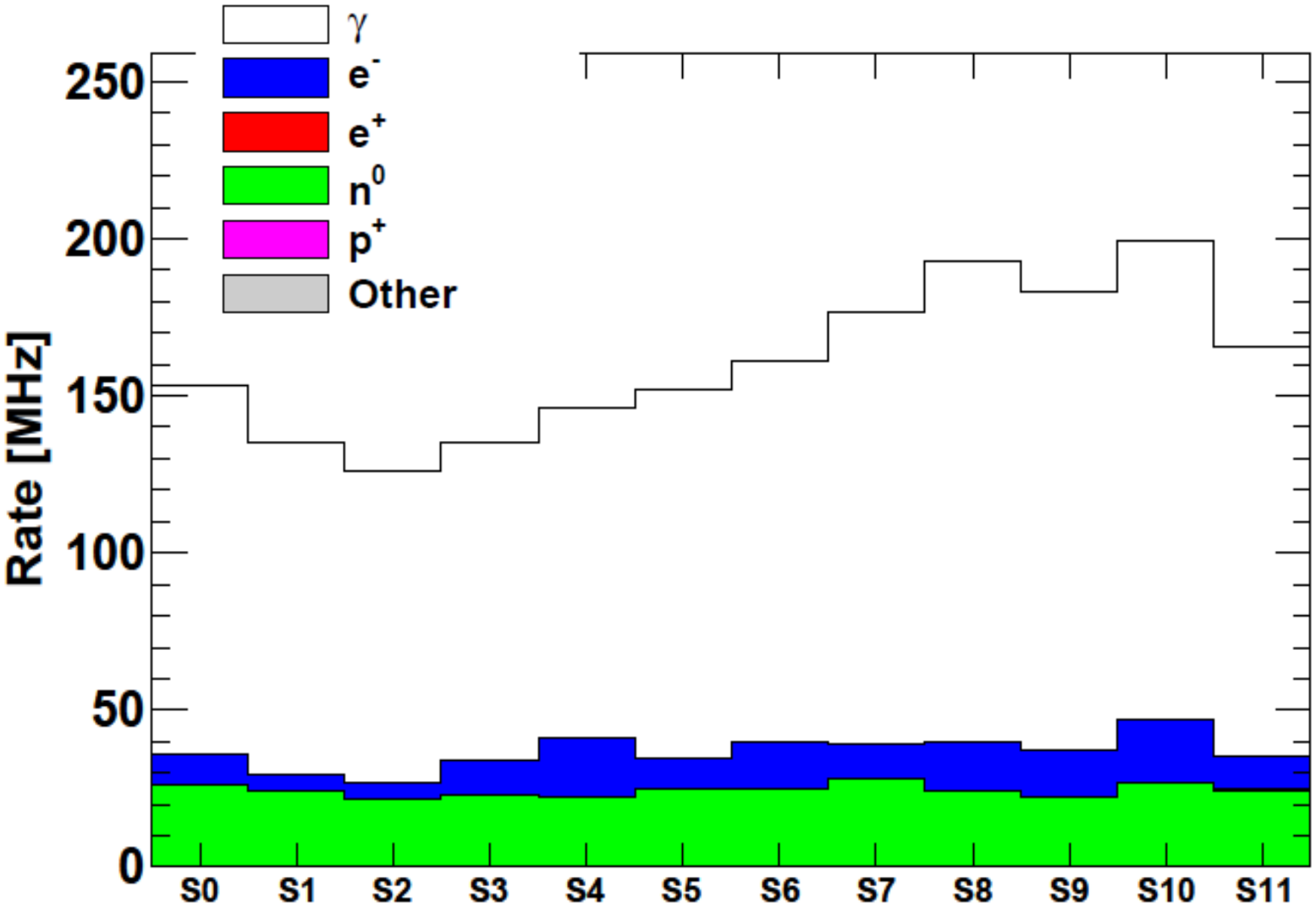






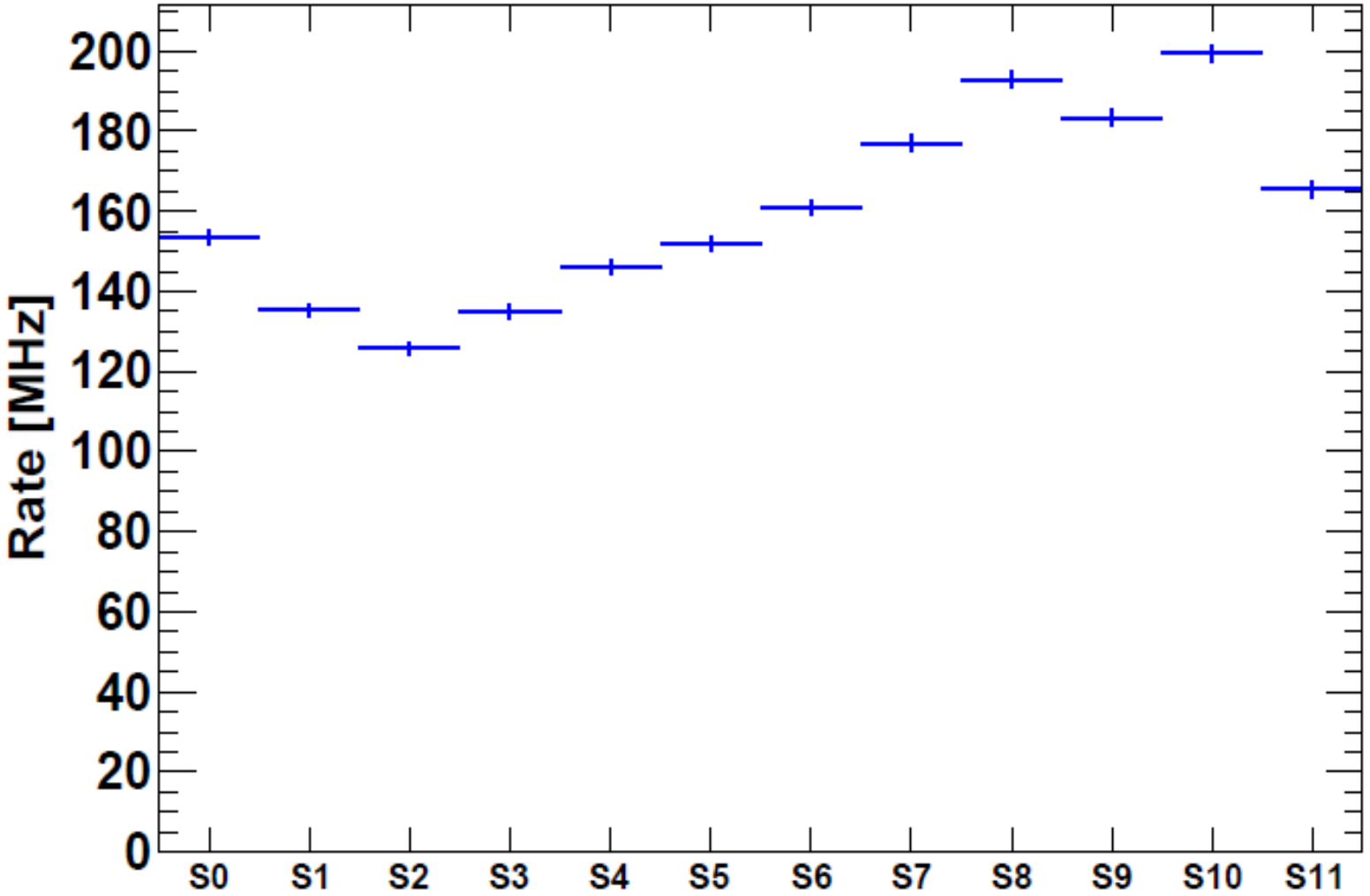
FEE Dose and fluency: Rates

Rad-bhabha: Total particle rate on FEE per sector



FEE Dose and fluency: Rates

Rad-bhabha: Total particle rate on FEE per sector



FEE Dose and fluency: Fluences