SuperB detector response to background

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Outline

- Software
- Simulated events
- Geometry
- Event analysis
- Background estimation in sub-detectors and experimental hall
- Conclusions

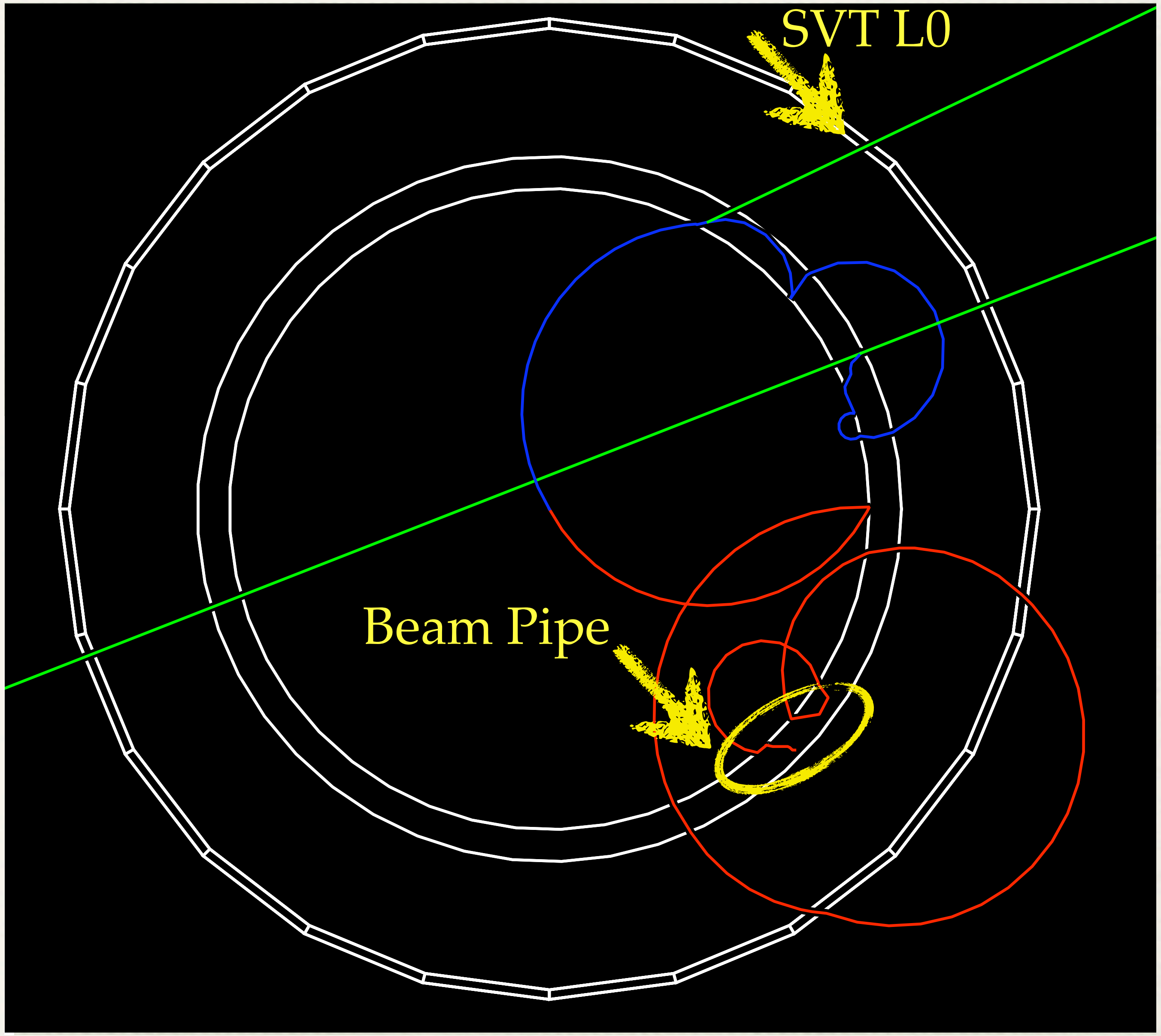
- Acknowledgements: L. Burmistrov, A. Di Simone, S. Germani, D. Lindemann, E. Paoloni, A. Perez, V. Santoro, C. Stella

Simulation software

- Fully customized software based on **Geant4** libraries, version **9.3**
- Input:
  - Method 1: list of particles with defined position and momentum at t=0
  - Method 2: generator code is embedded and particles are generated internally (only for radiative BhaBha background)
- **GDML** geometry (modular files)
- Physics list: **QGSP_BERT_HP** plus optical photons simulation in specific volumes (Cherenkov detector)
- Relevant volumes are made sensitive
- Output: **ROOT** file with non-digitized hits (position, incident and deposited energy) linked to track list. Note: tracks are recorded only if produce a hit or cross an interesting volume

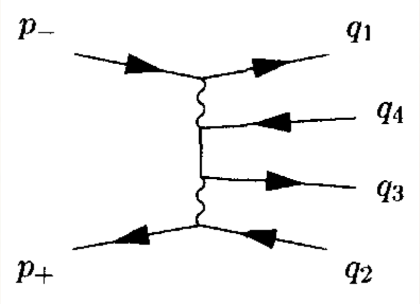
Simulation software (2)

- Interface: basic scripting available in Geant4 (.mac file)
- Options (Geant4 features or plugins):
  - Geometry display with ROOT
  - Tracks display
  - Store truth information for all the tracks

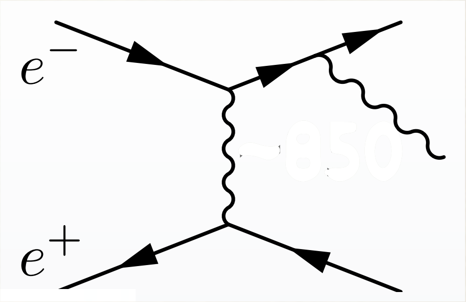


Simulated events

- **Type 1**, 1 evt = 1 bunch crossing (266 MHz), # of tracks depending from luminosity (10^{36} s^{-1} cm^{-2})
  - **2-photon (pairs):** ~100k evts=372us, **Diag36** external generator



  - **Radiative BhaBha:** ~10k evts=37us, **Bbbrem** internal generator, only photons with **E > 10%** of CM energy



- **Type 2**, 1 evt = 1 track with associated frequency
  - **Touschek**: ~84k evts from HER, ~188k from LER provided from Manuela Boscolo
- Processing time is different, radiative BhaBha are much slower

Geometry

- Modular geometry: separate GDML files for final focus, for each sub-detector, for solenoidal magnet, and for experimental hall

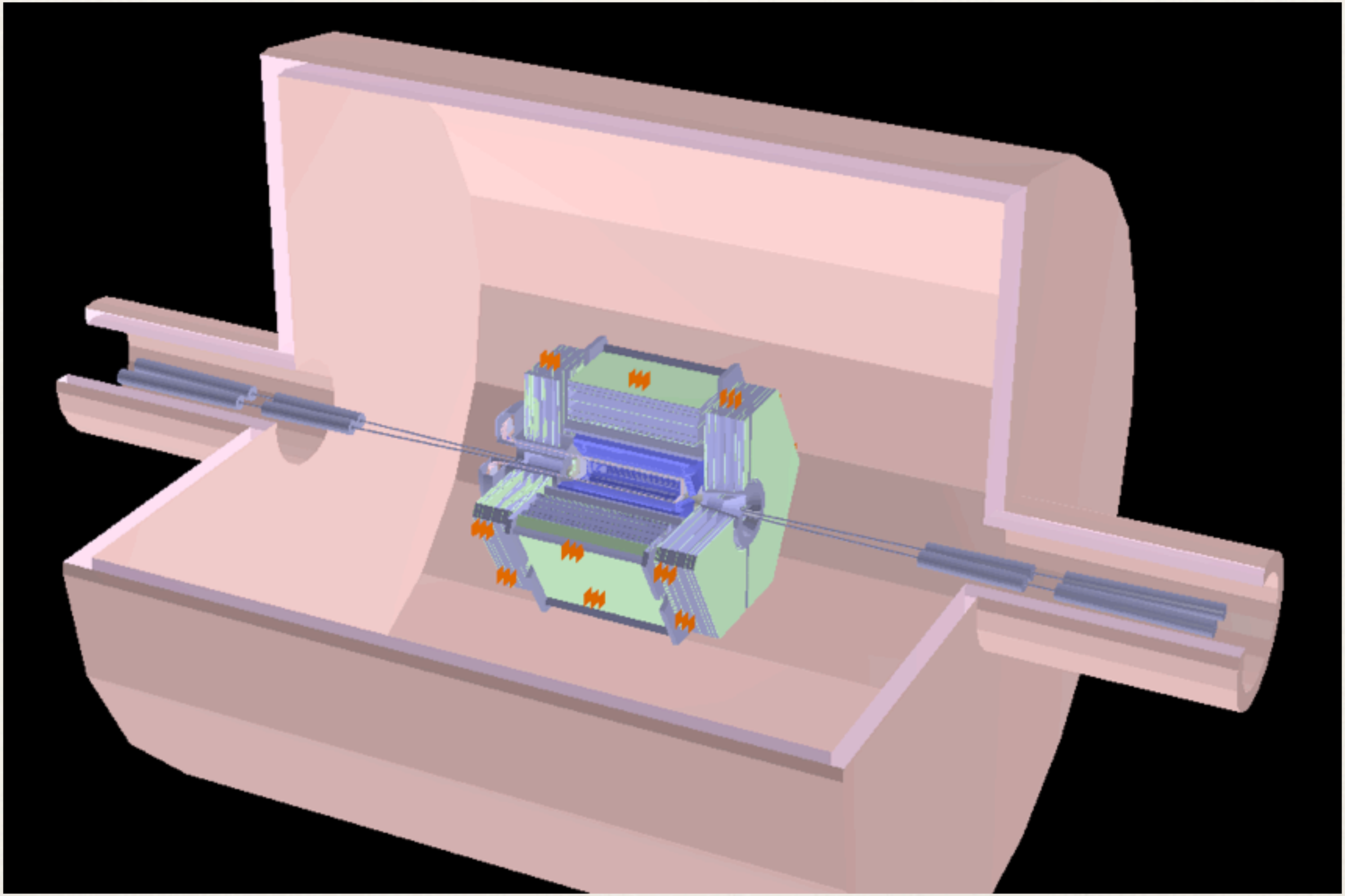
- Implemented geometry is mostly updated to the most recent option

- Magnetic solenoidal field: 1.5 T, everywhere in the detector and limited region of the beam pipe (±40 cm from IP)

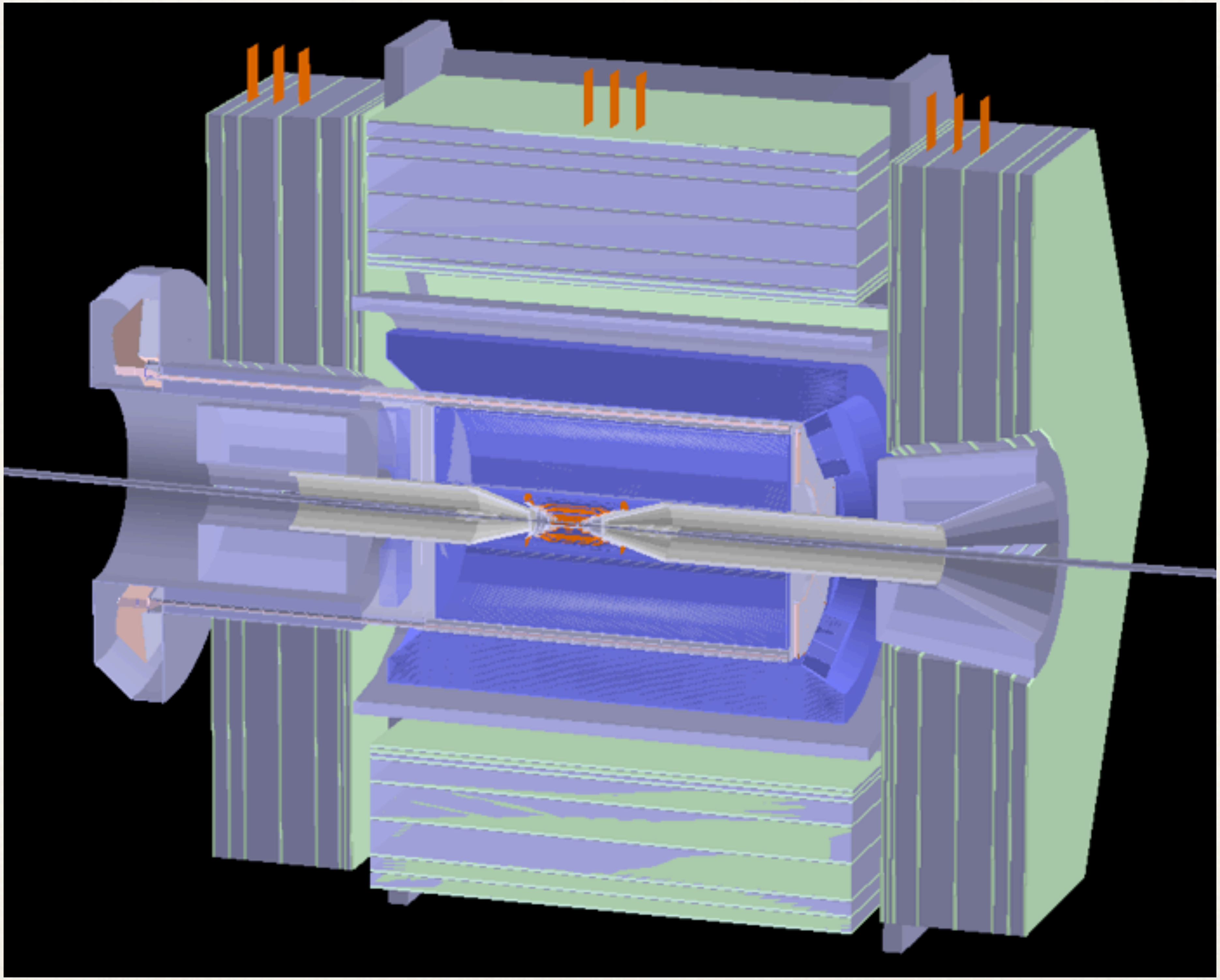
- Final focus fully implemented (materials and magnetic fields) inside the detector and until ±15m from the IP

- Around the detector there are big plates of silicon to monitor the dose in the experimental hall, and a thick concrete wall to represent the external shielding

Geometry



Geometry

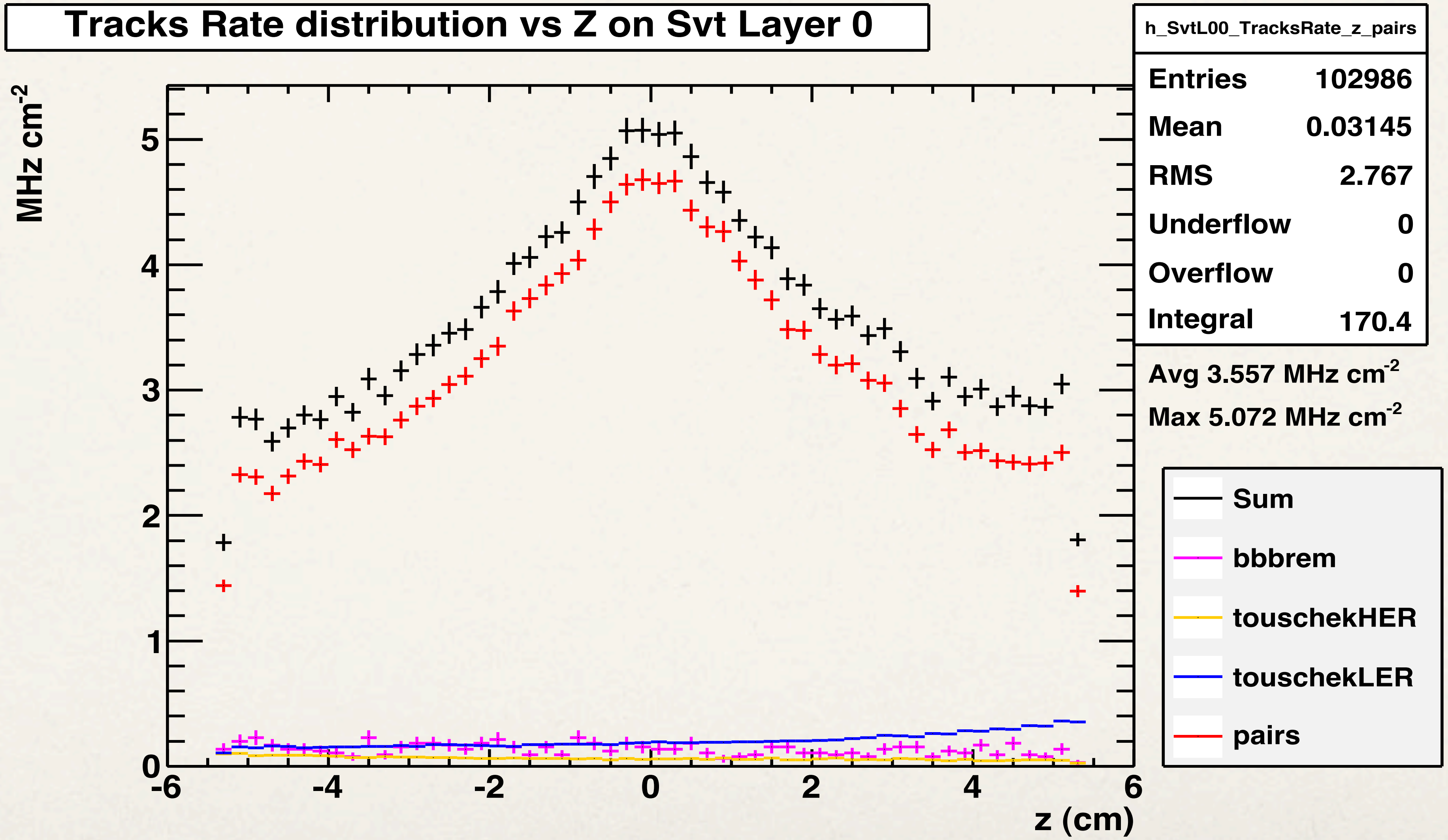


Event analysis

- Output files need to be further processed to obtain plots plus rescaling
- Rates/fluxes: total frequency for a detector (MHz/kHz) or divided by area (MHz/kHz cm^{-2}) for charged or a specific particle
- Doses: Mrad or krad integrated over 10^7 sec (SnowMass Year, SMY)
- Equivalent fluency of 1MeV neutron, [cm^{-2}], integrated over a SnowMass year (each particle is rescaled according its type and momentum)
- Hits information is available for detector material (silicon, gas, crystals, fused silica), but also for front-end electronic boards (FEE, silicon) for most of the sub-systems

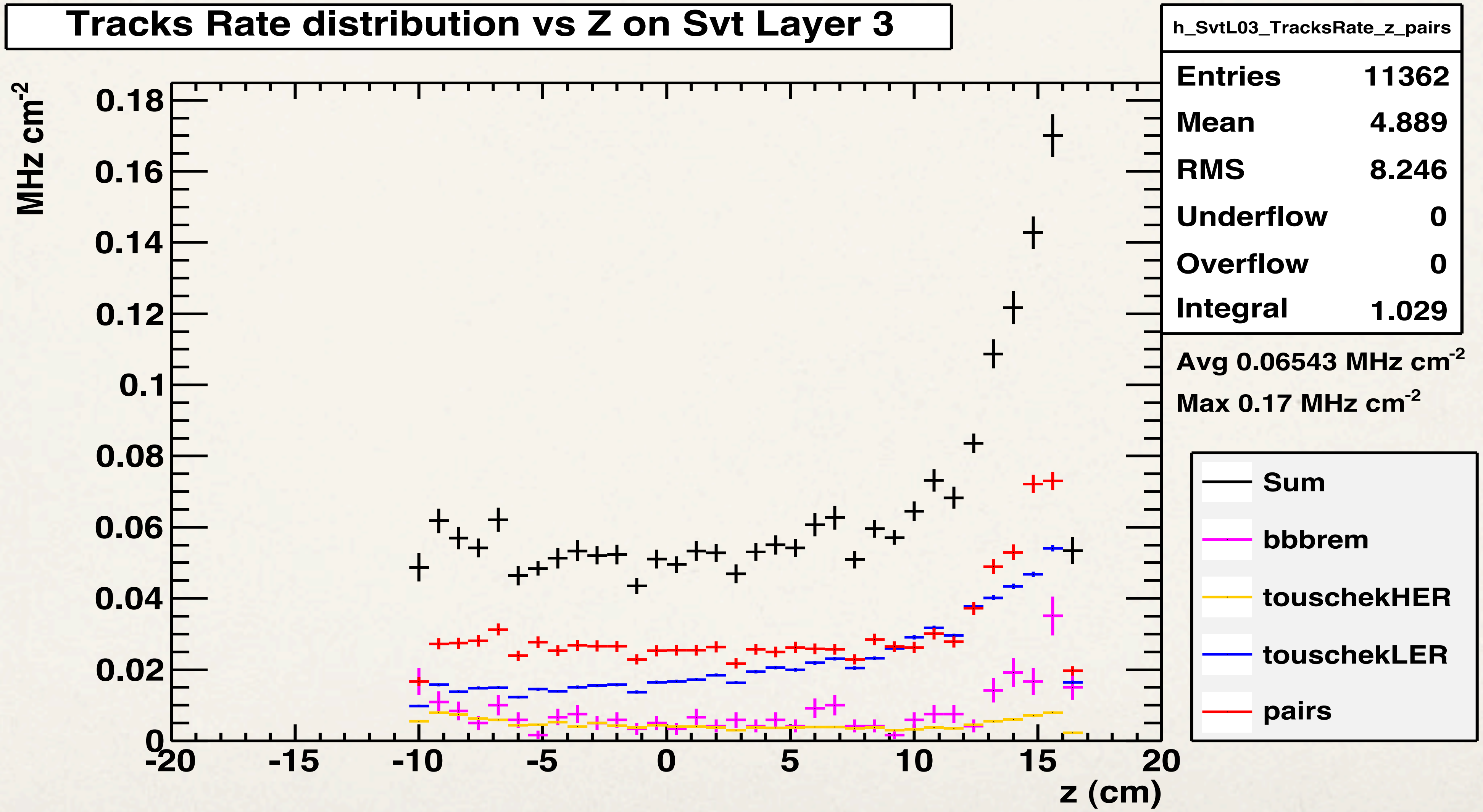
Silicon Vertex Detector (SVT)

- Instantaneous rate of charged tracks for SVT vs Z (summed over Phi)
- Layer 0, most of the rate is coming from 2-photon (mostly tracks coming directly from IP)
- Multiple crossing not included



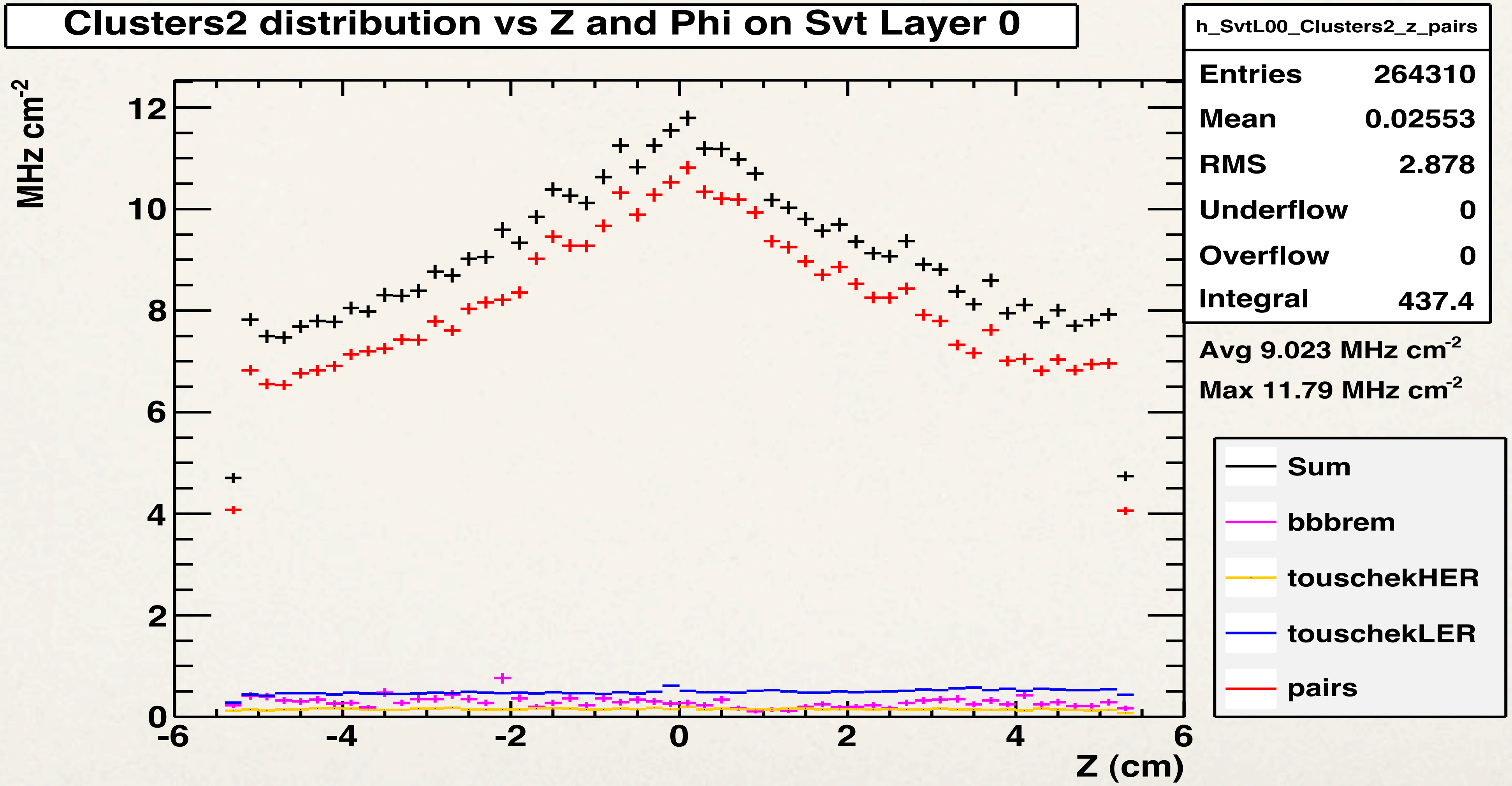
Silicon Vertex Detector (SVT)

- Instantaneous rate of charged tracks for SVT vs Z (summed over Phi)
- Layer 3, Touschek from LER is now comparable with 2-photon
- Multiple crossing not included



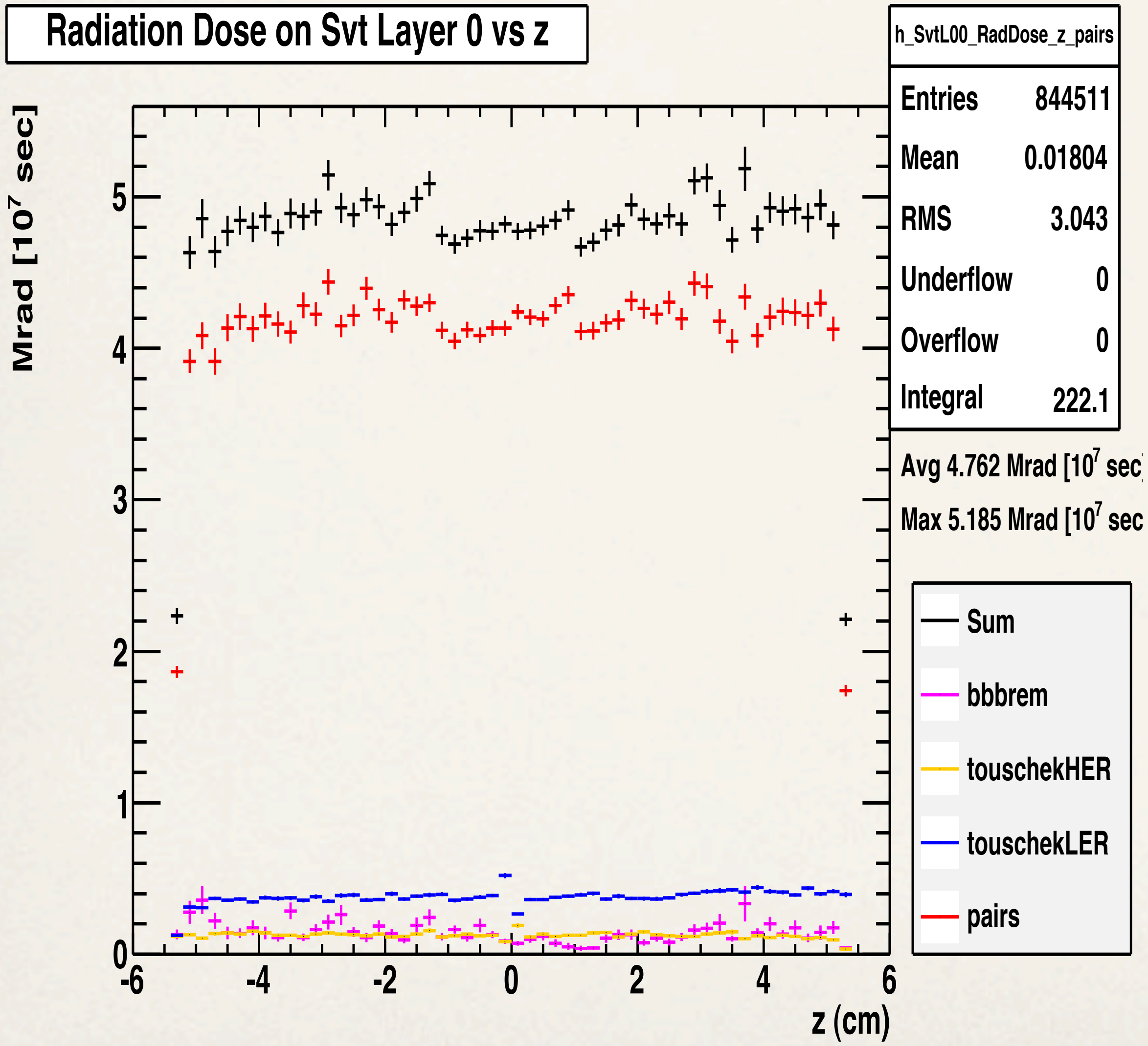
Silicon Vertex Detector (SVT)

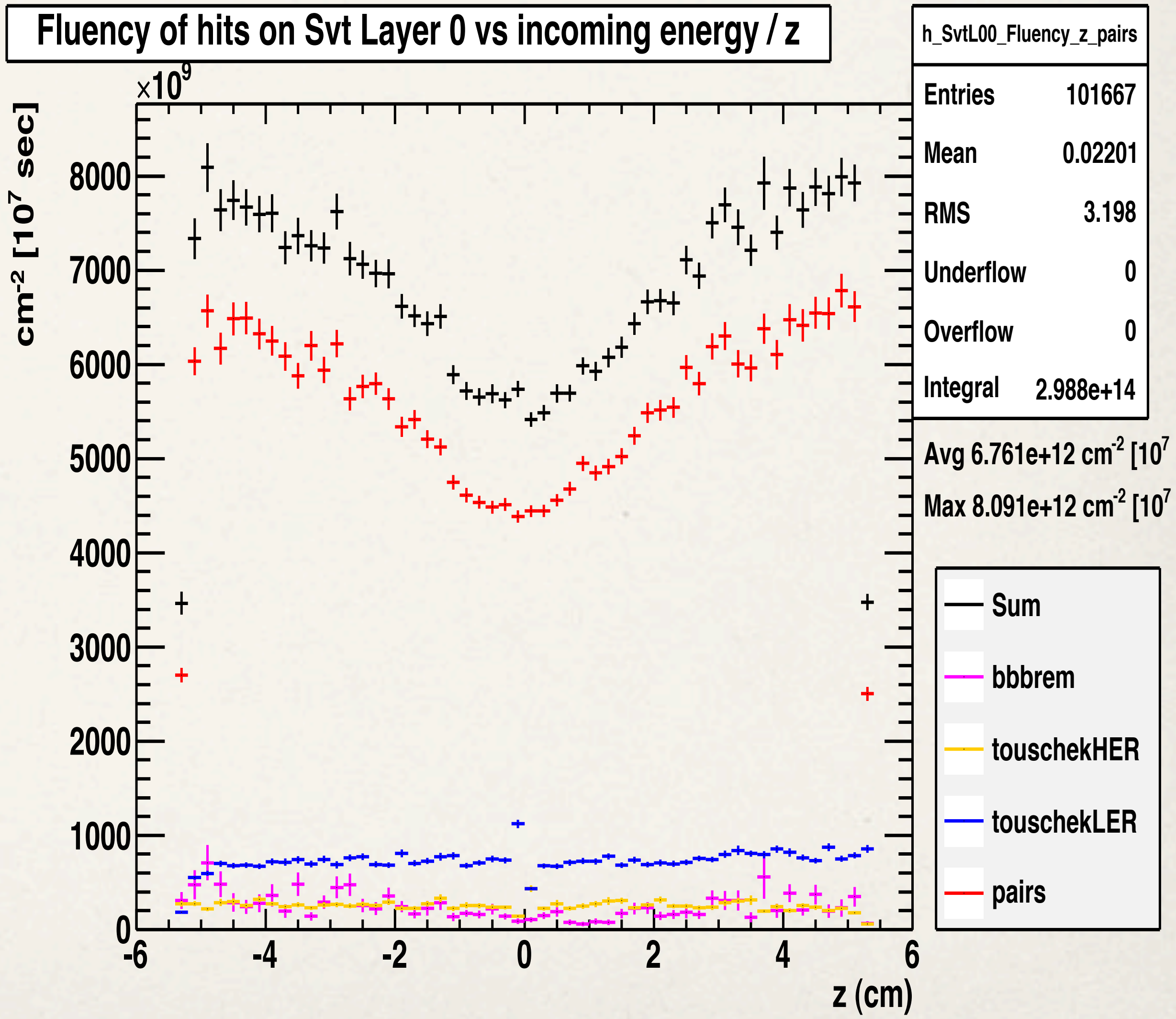
- Instantaneous rate of **clusters=crossing=curlers** for SVT vs Z (summed over Phi)
- Layer 0, similar rate fraction for the different contributions
- Average # of clusters per track: **~2.6**
- Additional factor due to # of hits (pixel/strip) per cluster, pitch/thickness dependent: average up to **~5** (200 um)



Silicon Vertex Detector (SVT)

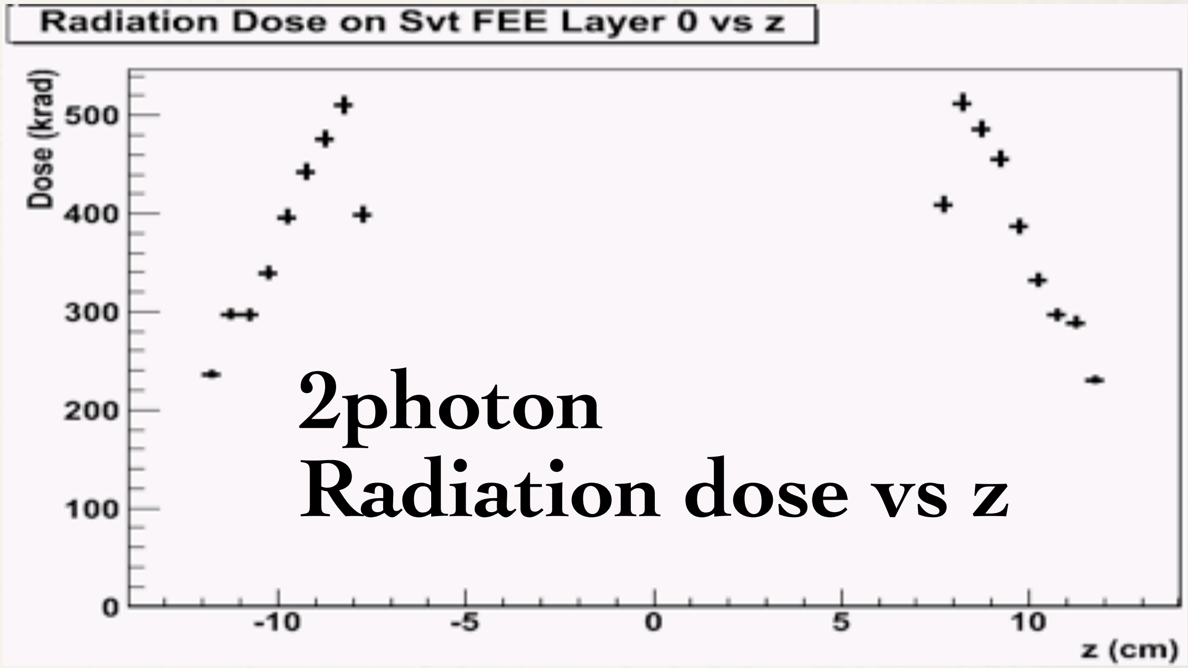
- Integrated dose, Equivalent fluency for Layer 0
- Dose is not dependent from z: less particles at small angles, but longer path in the silicon





Silicon Vertex Detector FEE

- Integrated dose on the SVT FEE
- Wide area tested for L0, small chips for outer layers
- Table shows the max values accumulated in 1 SMy

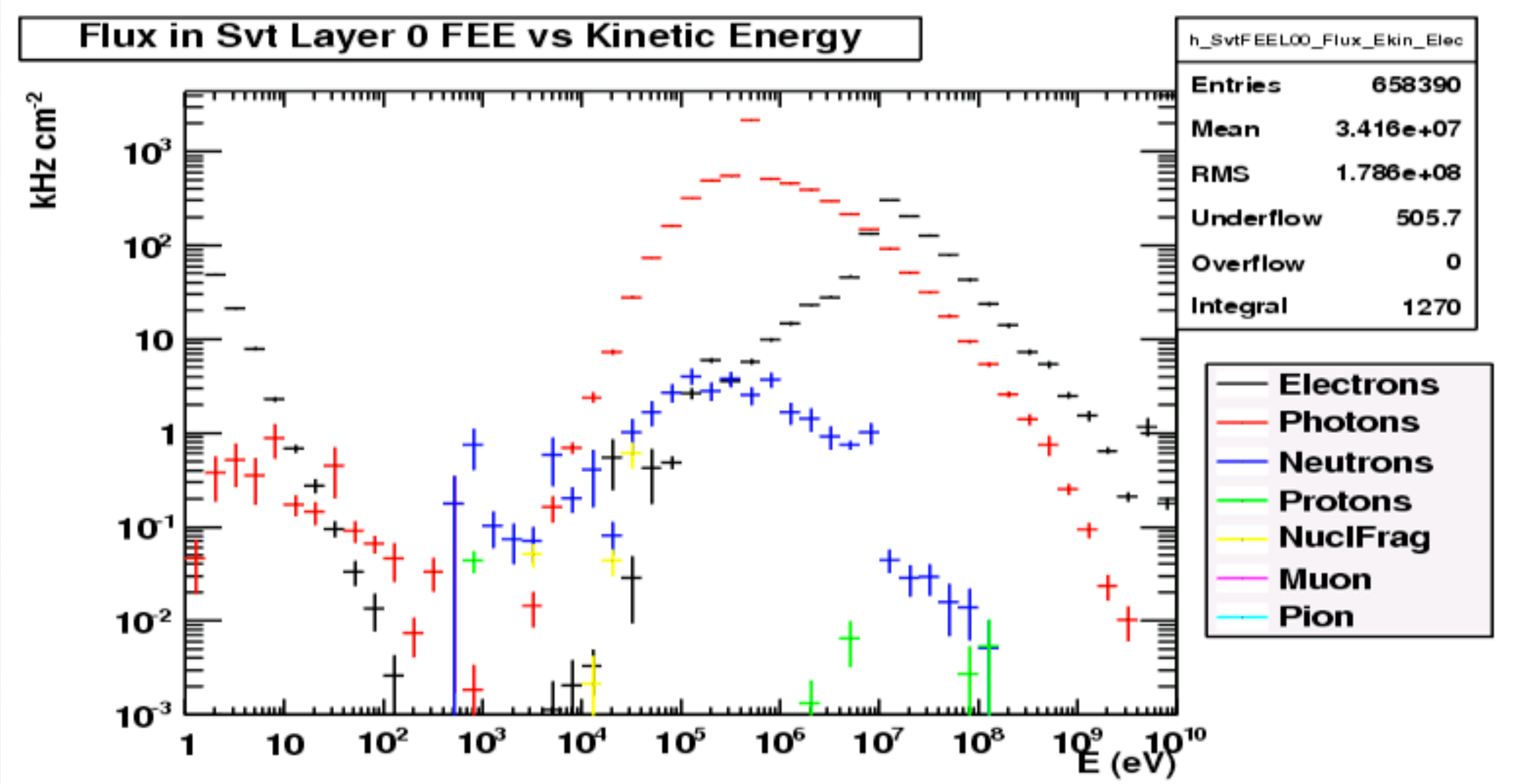


2photon Radiation dose vs z

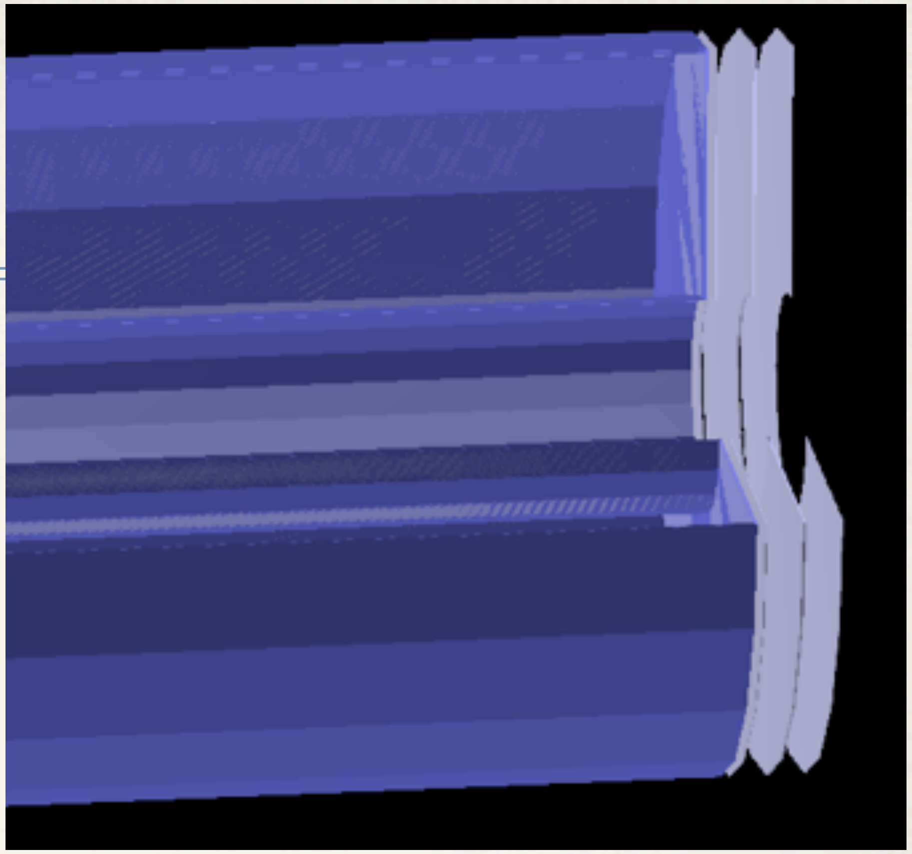
Max. Dose (krad)	0	1	2	3	4	5
Pairs	520	71	85	95	48	8
RadBhabha	95	15	14	22	11	2
Touschek HER	57	12	14	7.5	3	1.2
Touschek LER	180	52	64	29	8.2	3.9
TOTAL	852	150	177	154	70	15

Silicon Vertex Detector FEE

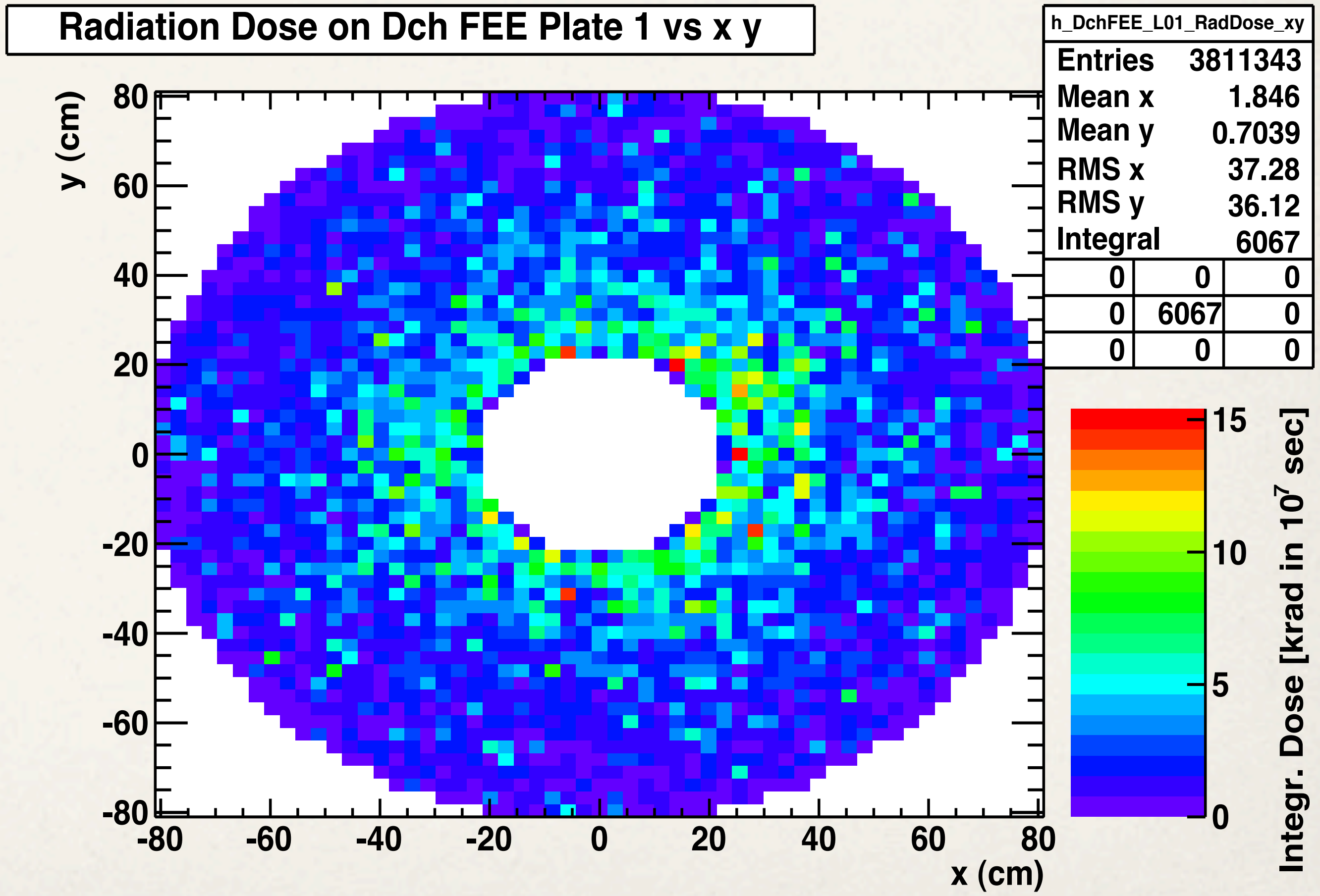
- Particle fluxes on SVT FEE
- Mostly photons, peak at 511 keV for annihilated positrons
- Few neutrons, others are negligible



Drift chamber FEE

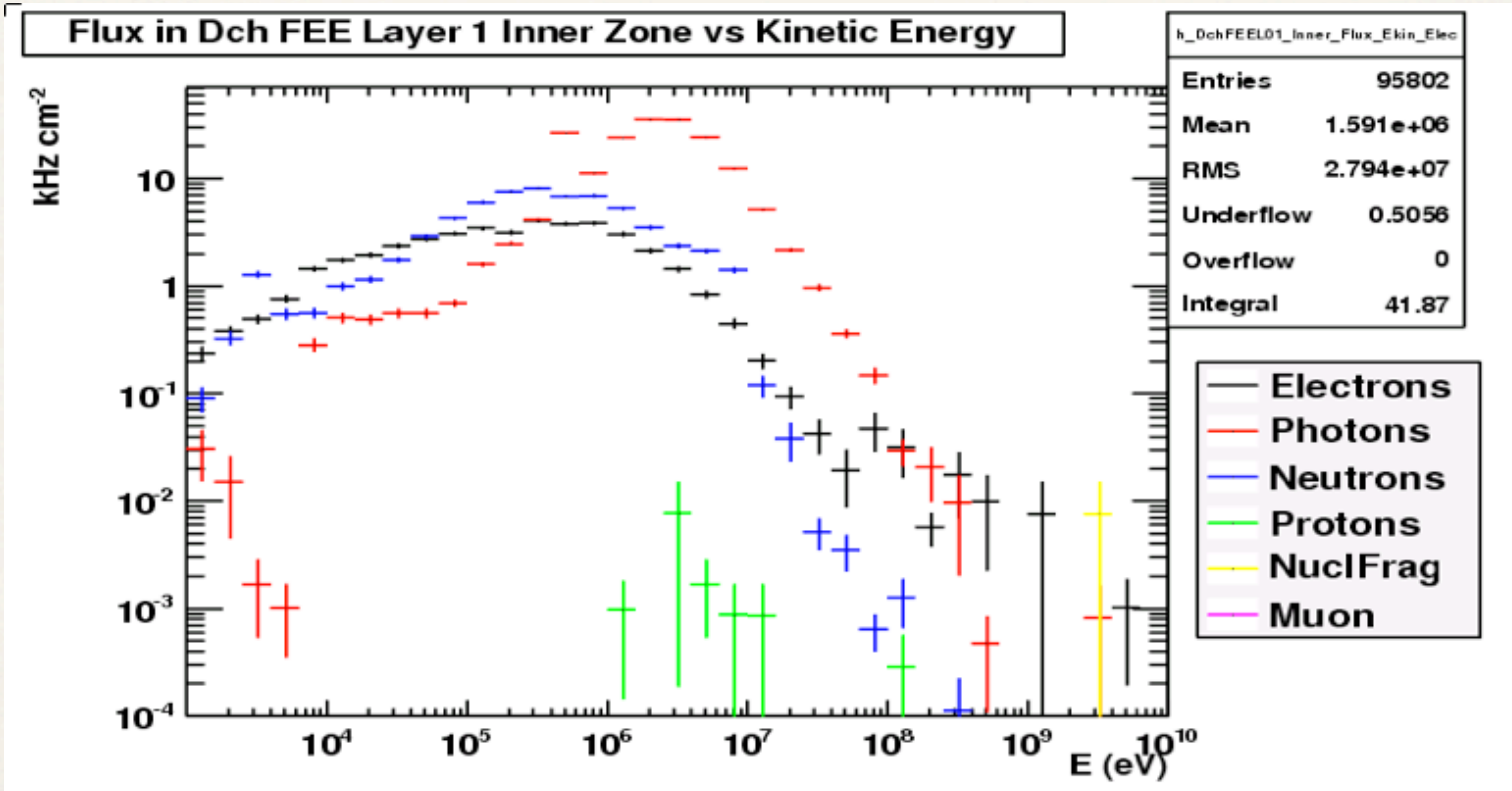


- FEE simulated by 3 silicon plates on the bwd side
- Integrated dose on the second plate (# 1), summed over all the contributions
- Radiative BhaBha is dominant
- Dose looks not so critical



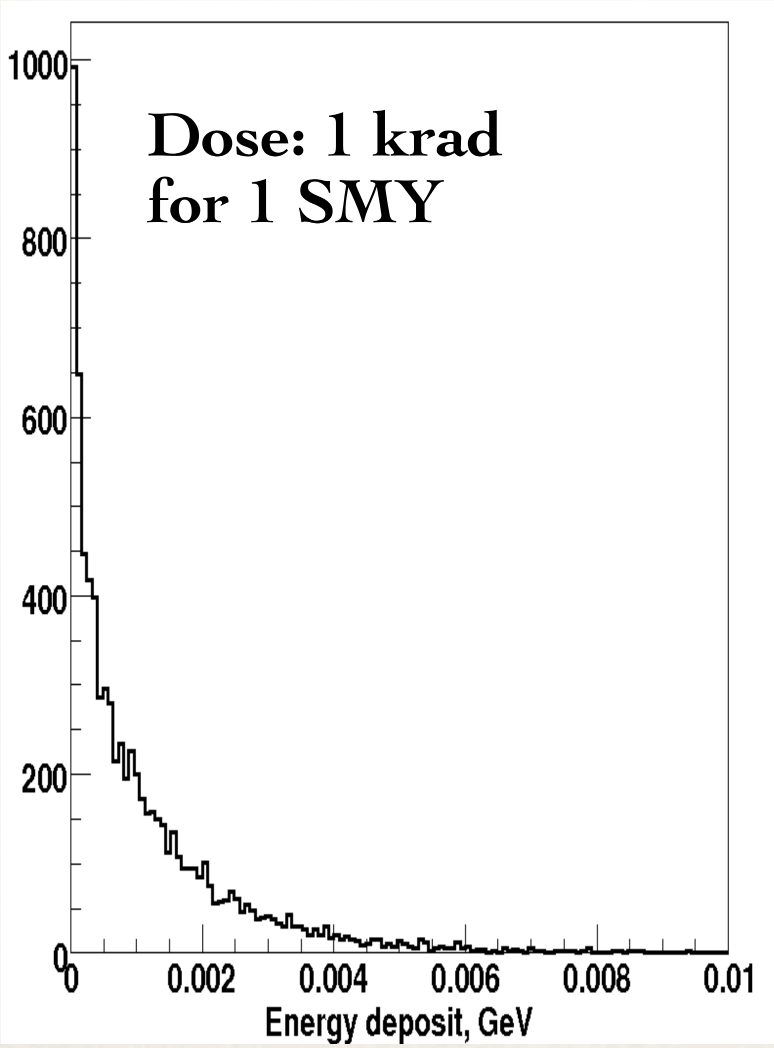
Drift chamber FEE

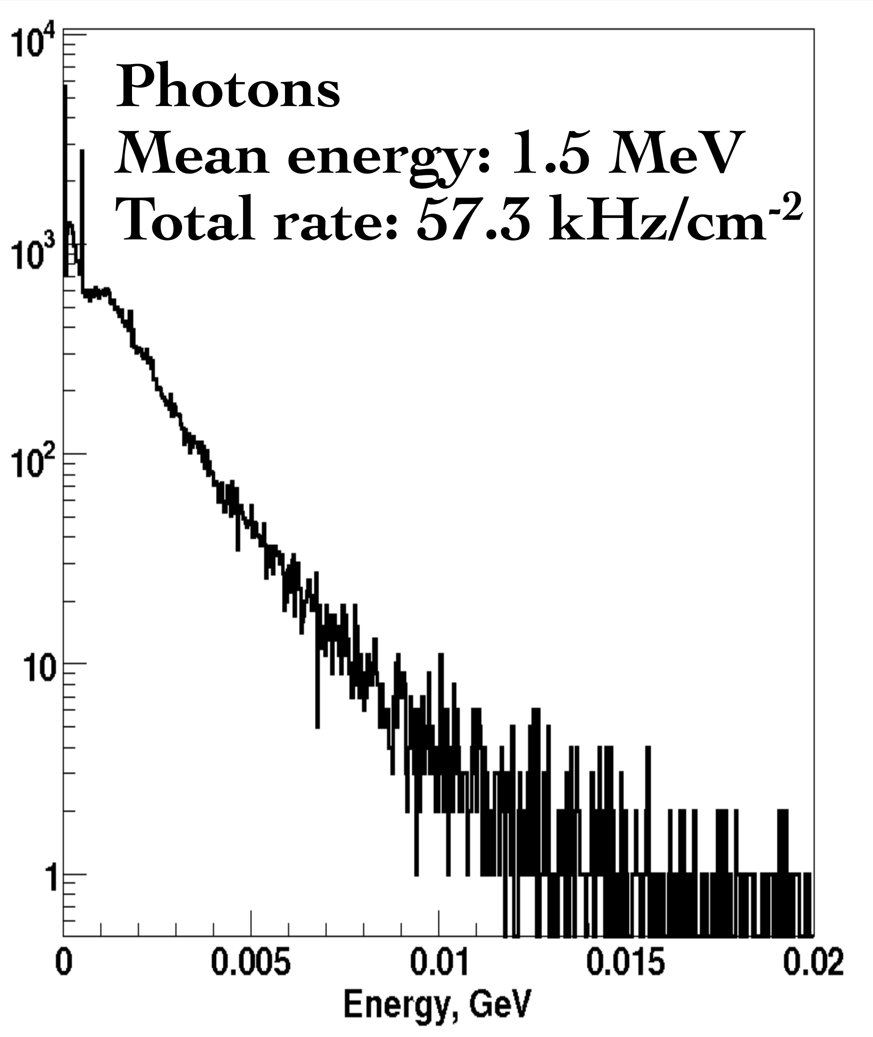
- Particle fluxes on DCH FEE, inner zone (23 < radius < 40 cm)
- Again mostly are photons, peak at 511 keV for annihilated positrons
- Less electron/positron, more neutrons, others are negligible

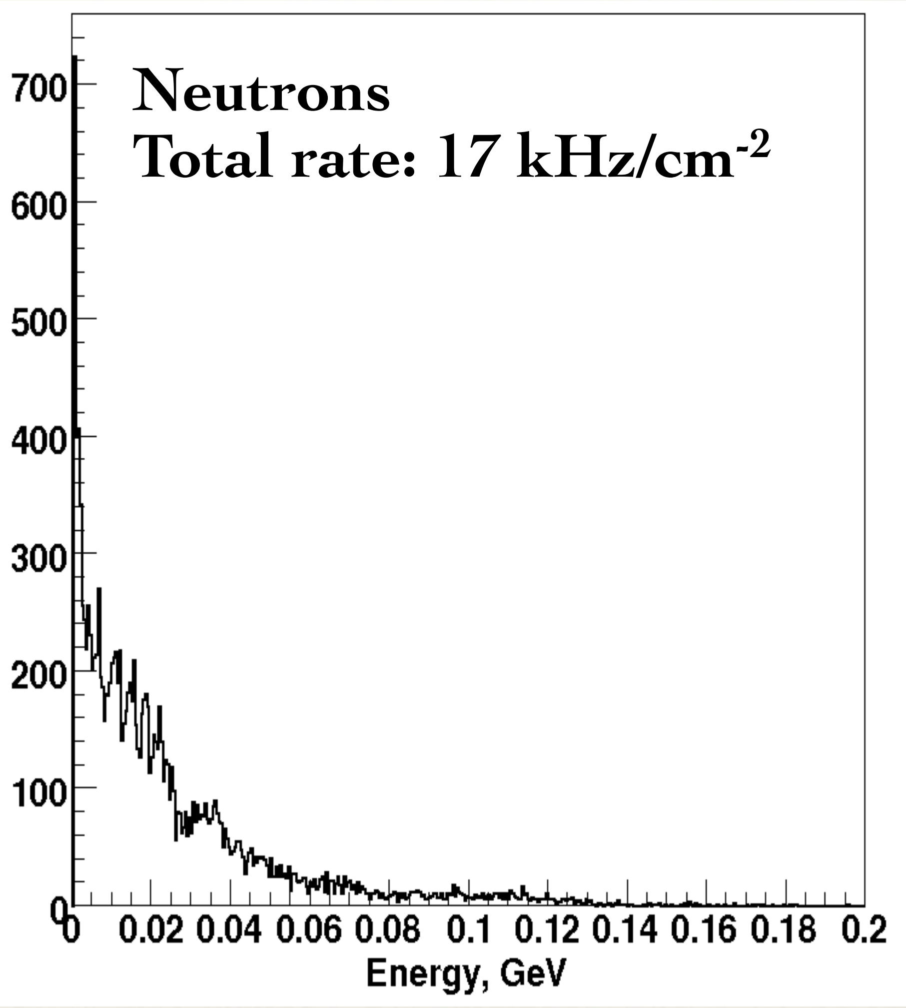


Int. refl. Cherenkov light det. FEE

- Cherenkov detector like BaBar, no estimation yet
- Simple estimation for Forward Cherenkov detector, only radiative BhaBha contribution

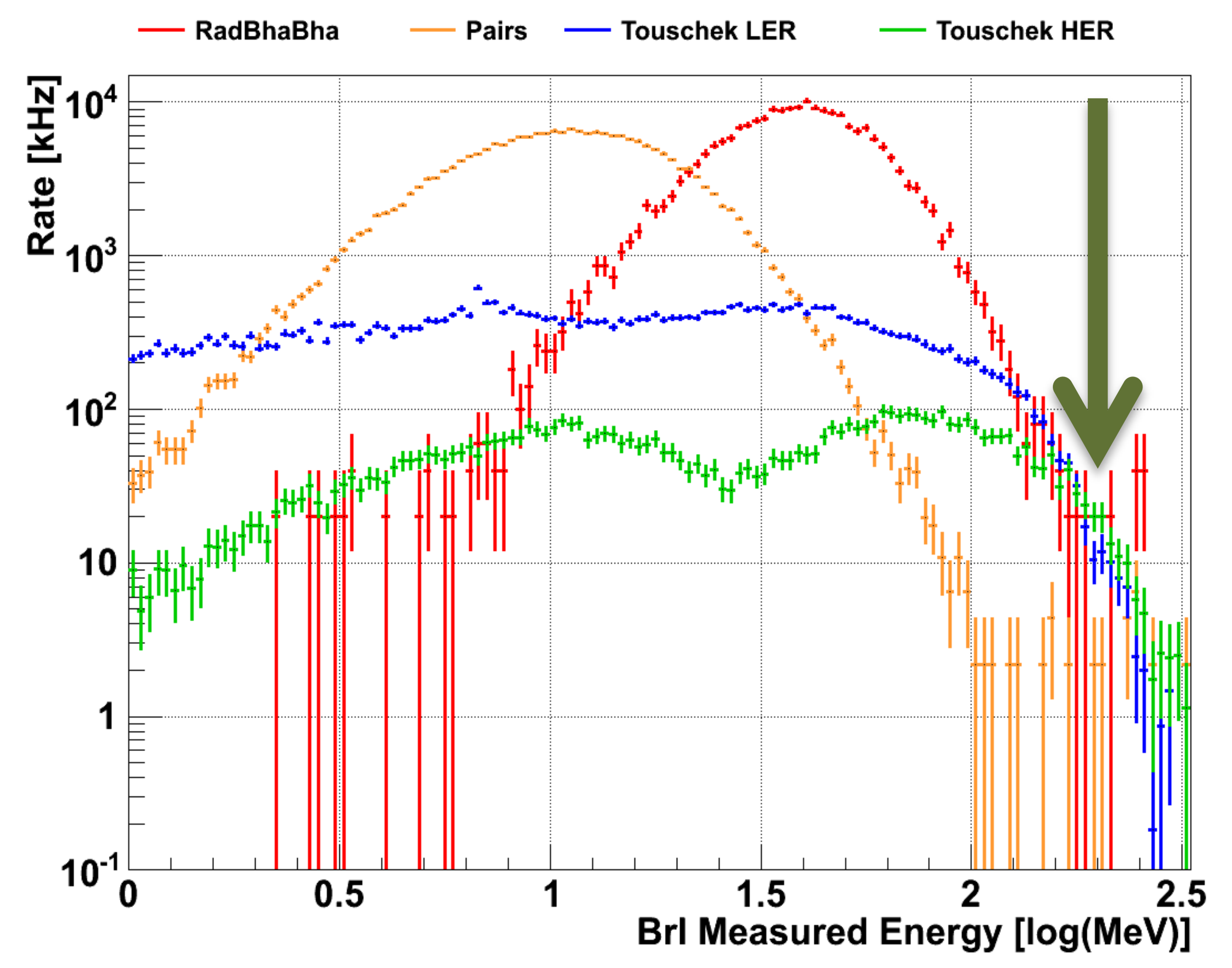

Dose: 1 krad
for 1 SMY

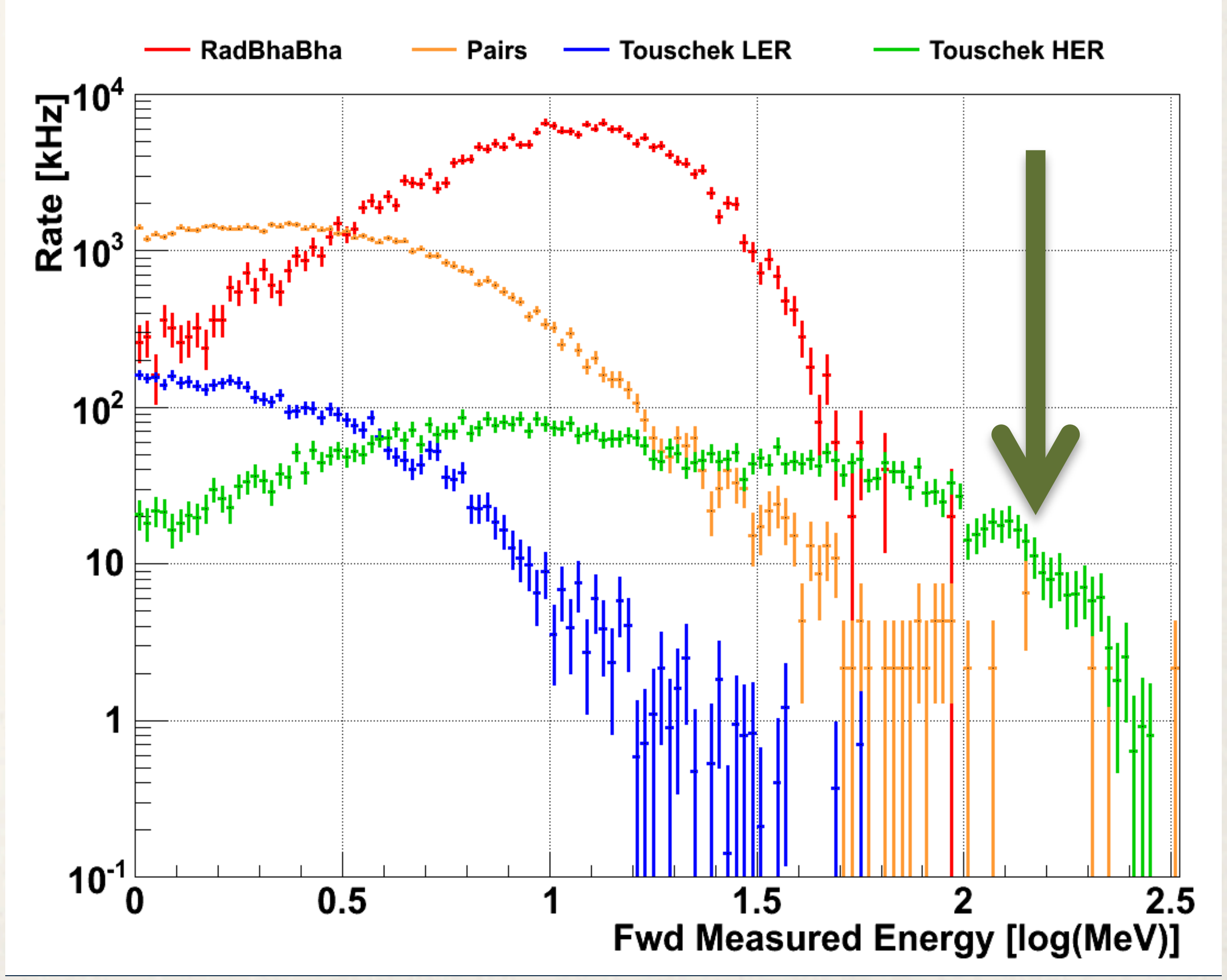

Photons
Mean energy: 1.5 MeV
Total rate: 57.3 kHz/cm^{-2}


Neutrons
Total rate: 17 kHz/cm^{-2}

EM calorimeter (EMC)

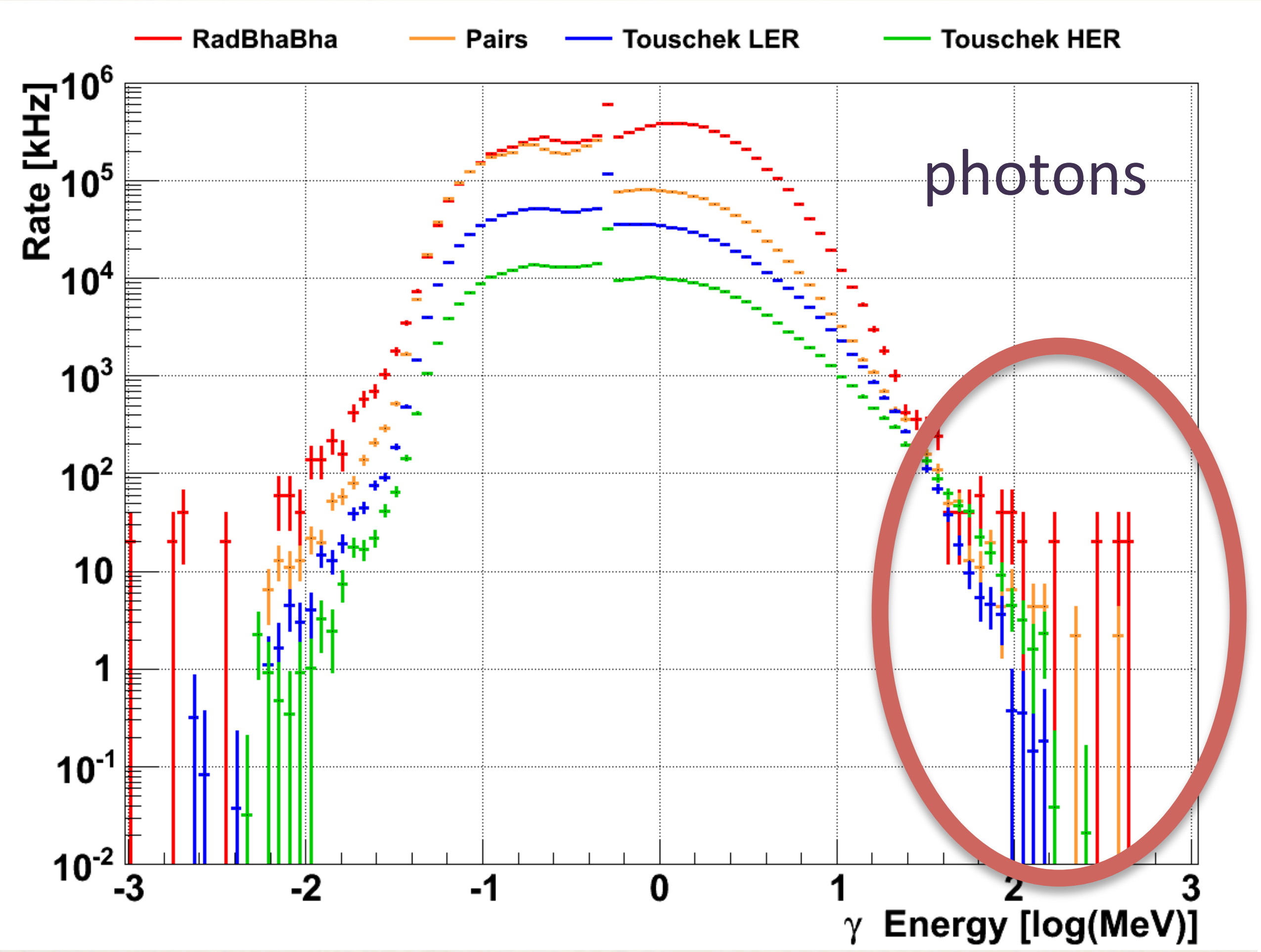
- Rate of energy deposited in the whole Barrel (left) and Forward (right) calorimeter
- Main contribution is from BhaBha, but at high energy, where Touschek from HER is dominant

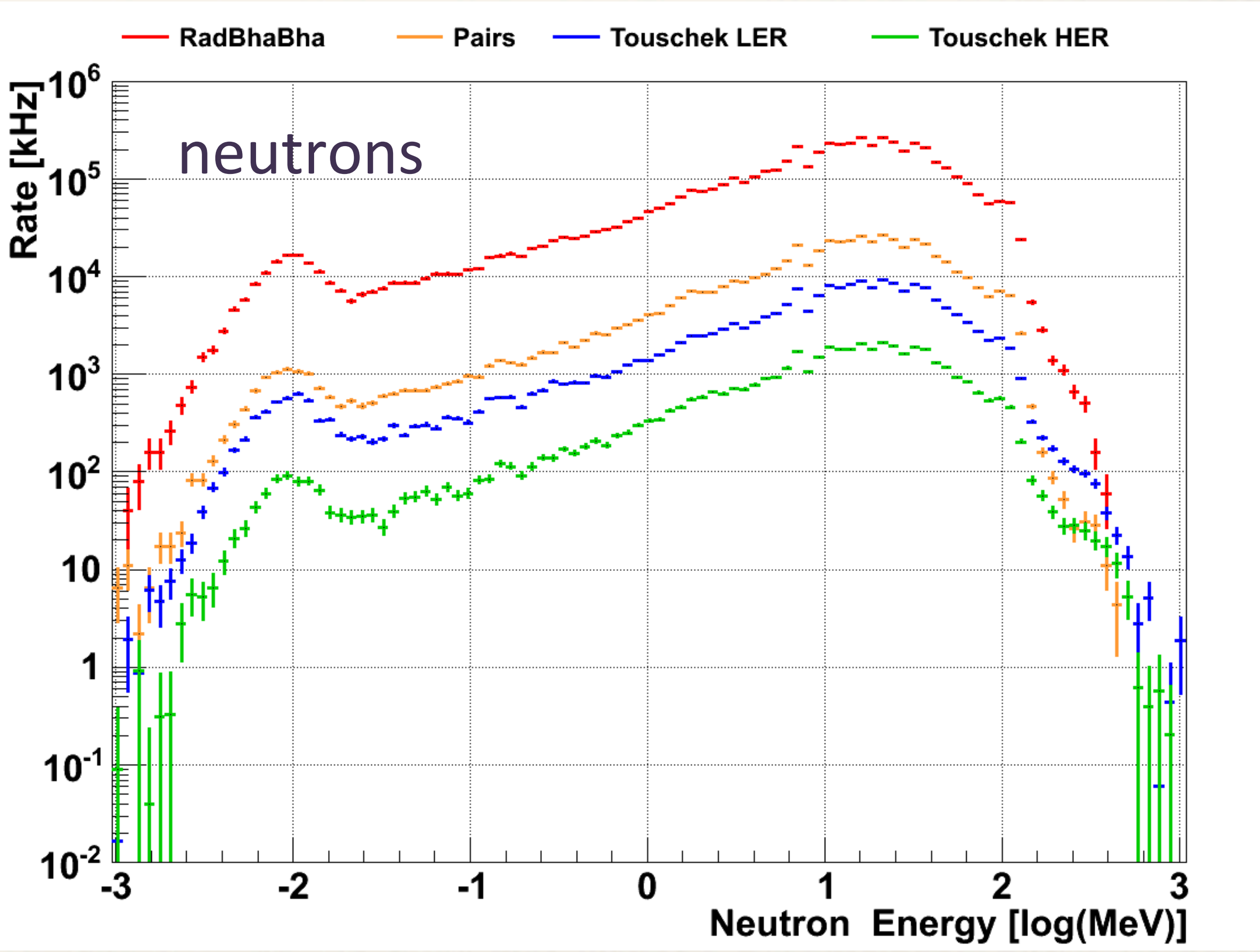




EM calorimeter (EMC)

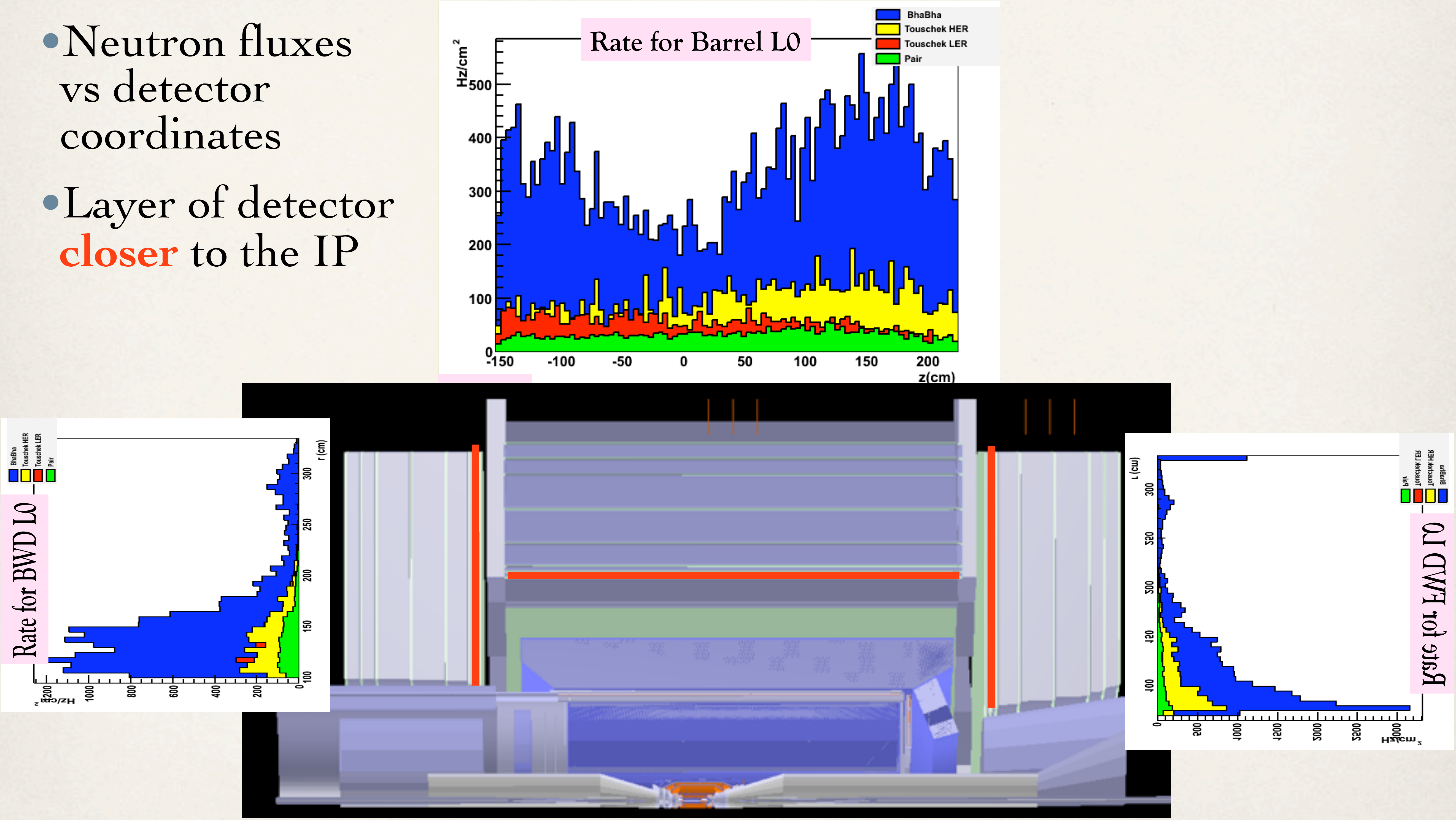
- Total rate for photons and neutrons
- Shape are similar to DCH FEE
- Main contribution is always BhaBha





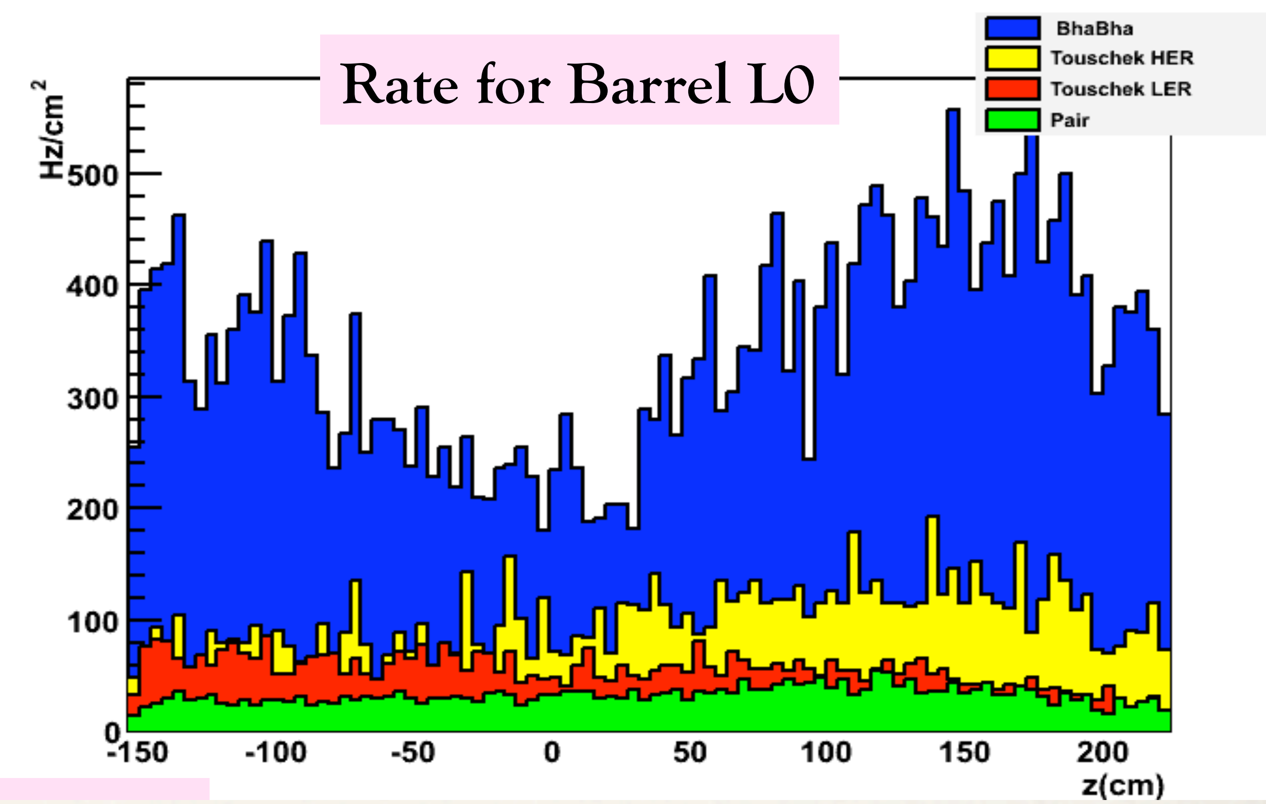
Instrum. flux return (IFR)

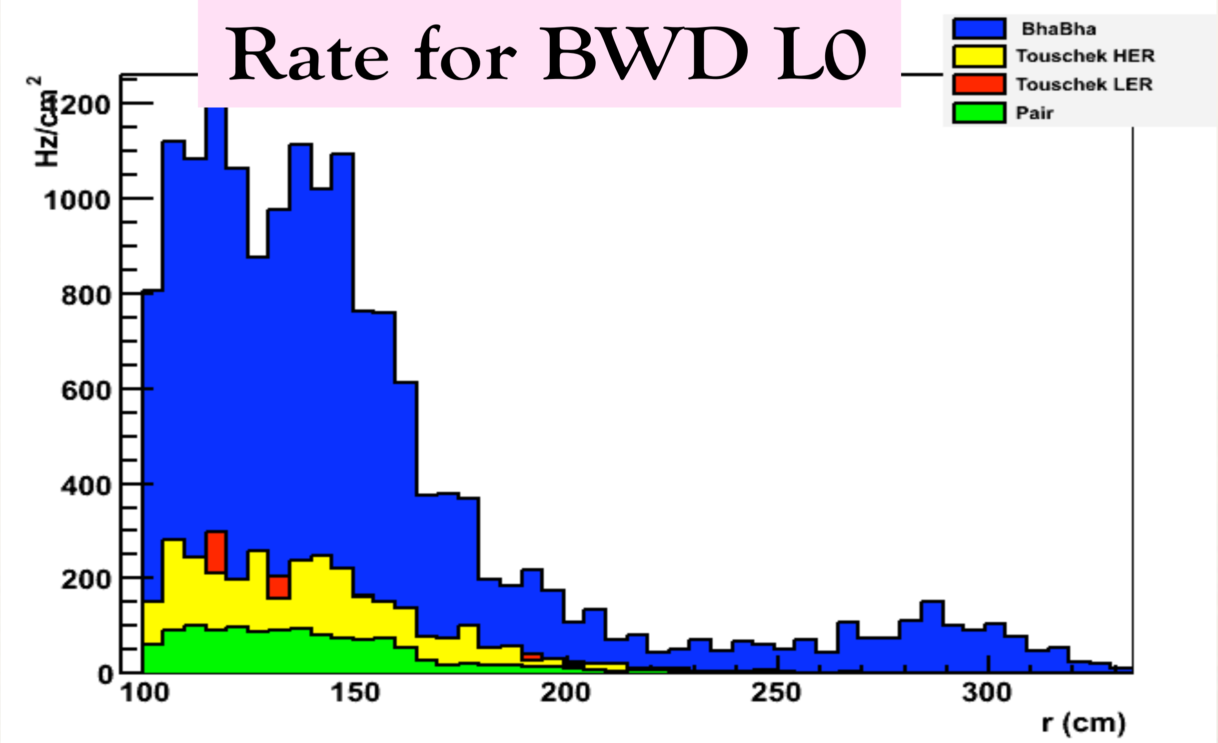
- Neutron fluxes vs detector coordinates
- Layer of detector **closer** to the IP

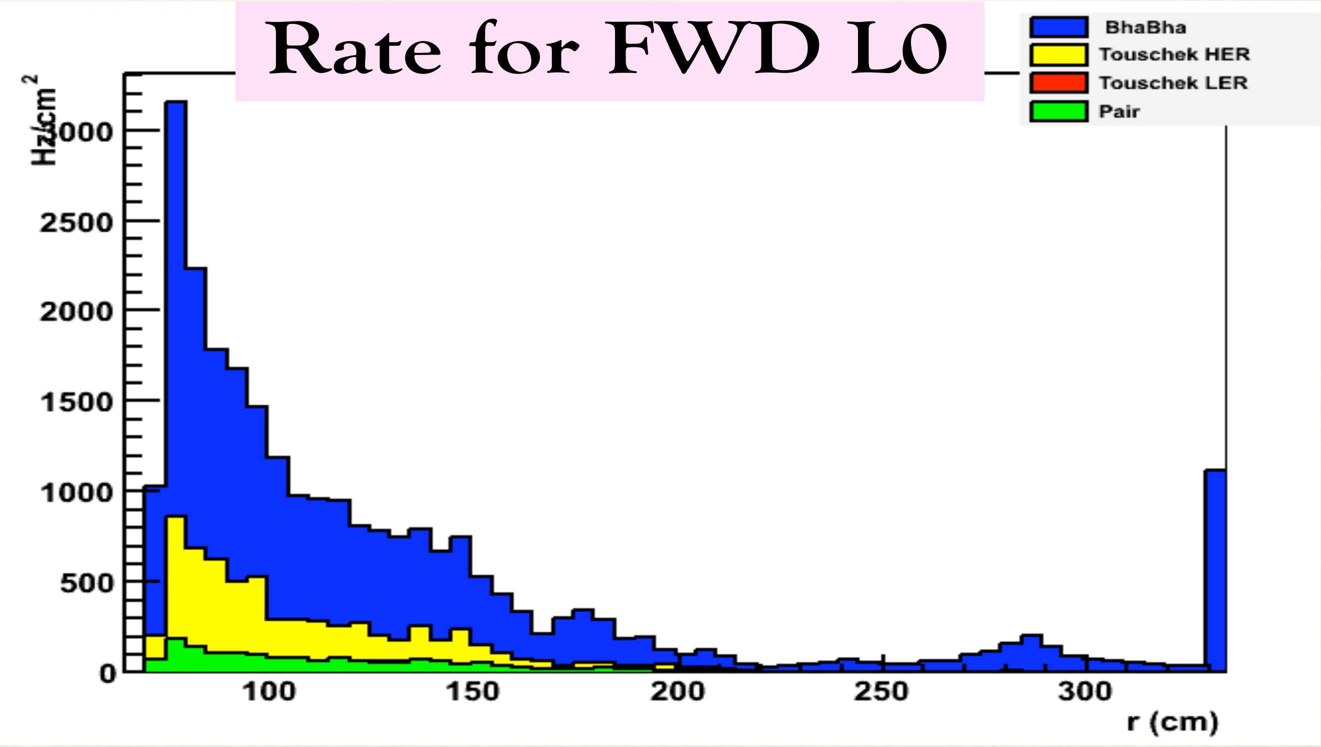


Instrum. flux return (IFR)

- Neutron rates vs detector coordinate for Forward, Barrel and Backward
- Rates are really high in the region close to the pipes
- Main contribution is again from Radiative BhaBha

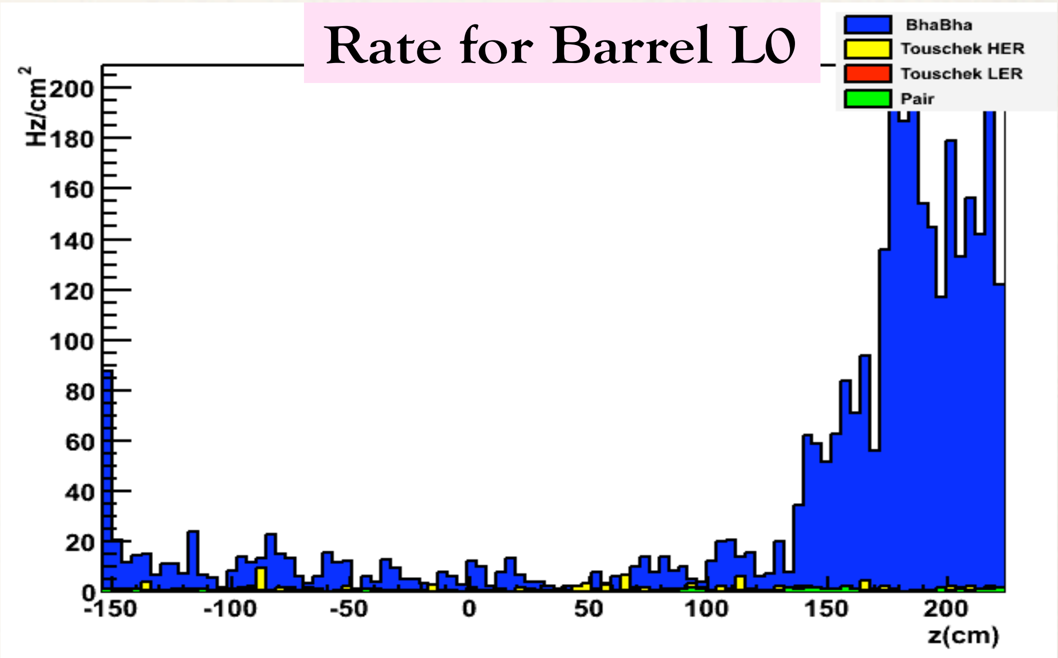

Rate for Barrel L0

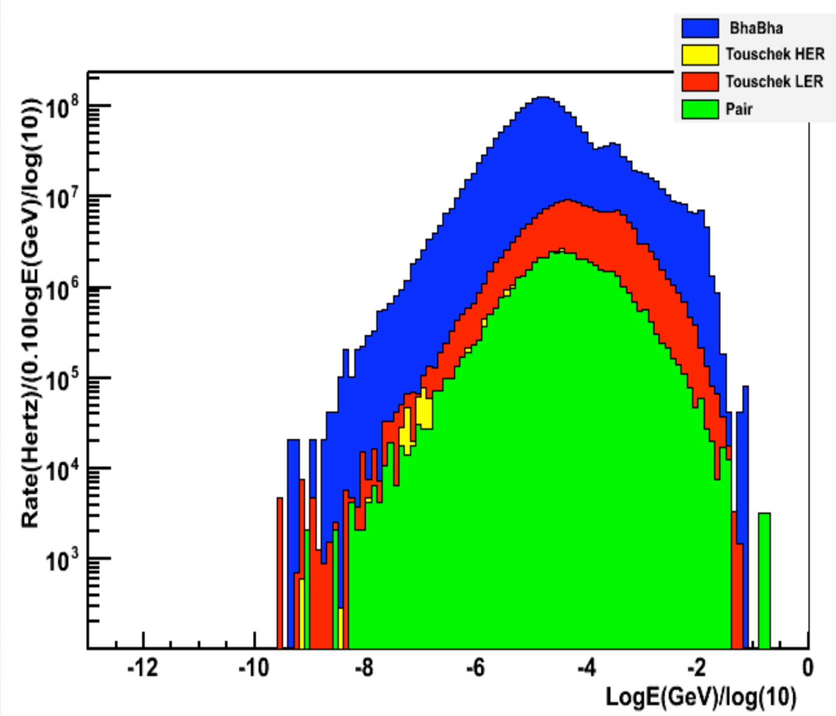

Rate for BWD L0

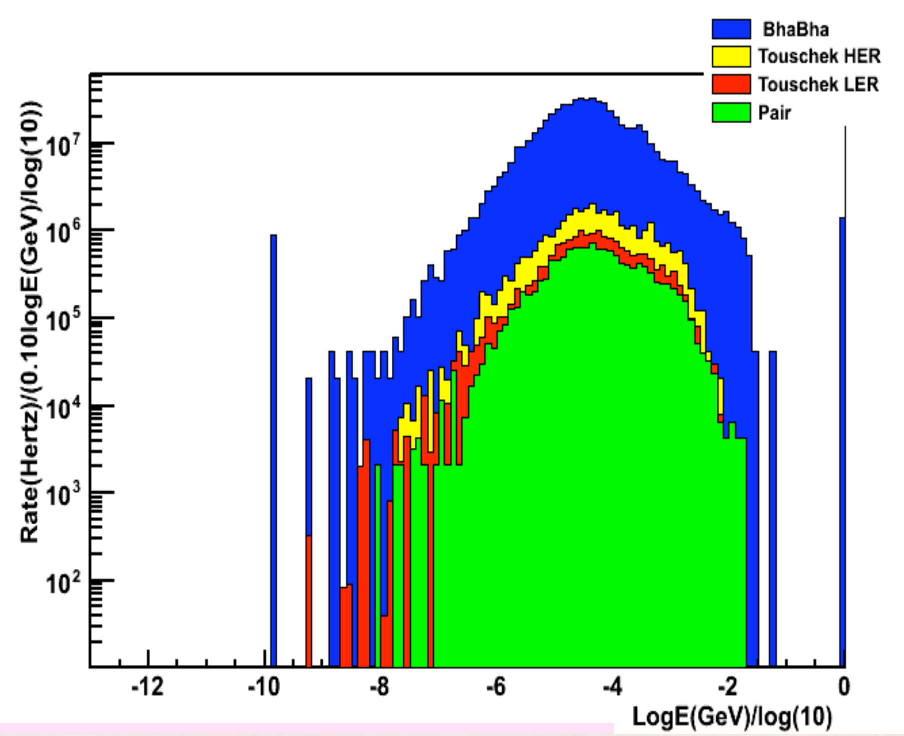

Rate for FWD L0

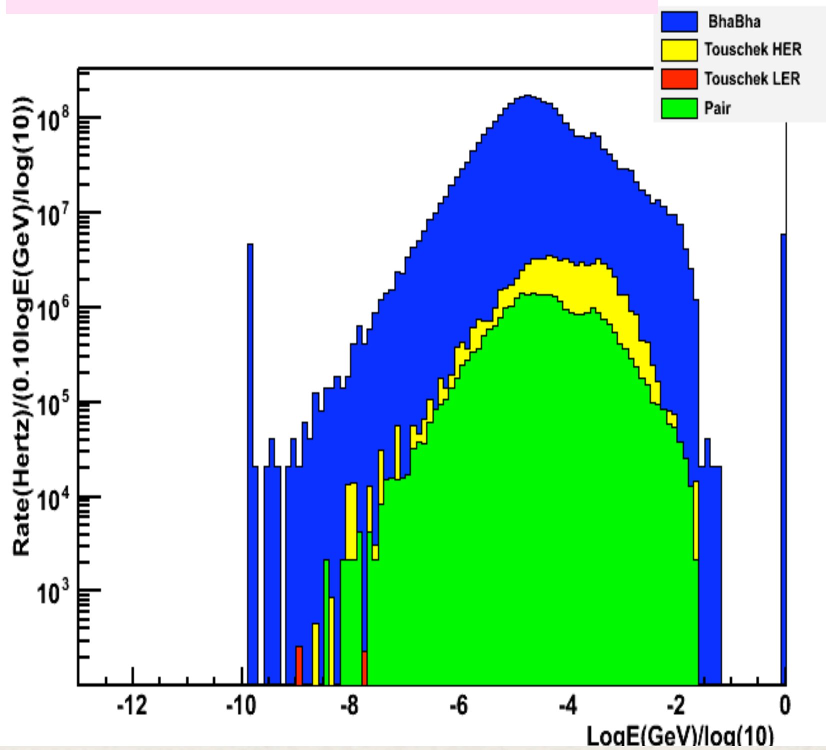
Instrum. flux return (IFR)

- Electron rate per area for barrel vs z coordinate (left)
- Total electron rate vs energy (bottom)
- Main contribution is again from Radiative BhaBha


Rate for Barrel L0

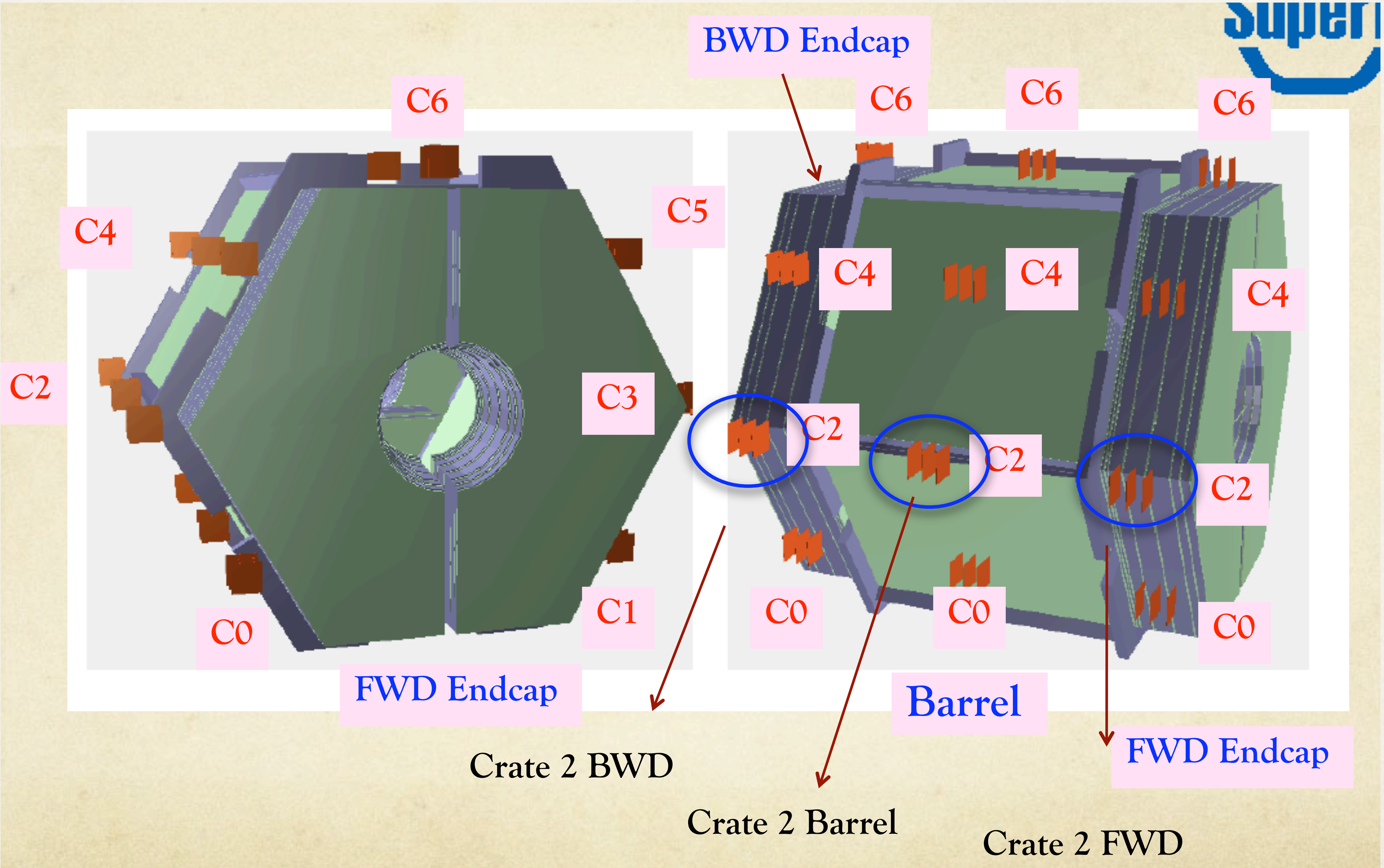

Energy distribution:BWD


Energy distribution:Barrel


Energy distribution:FWD

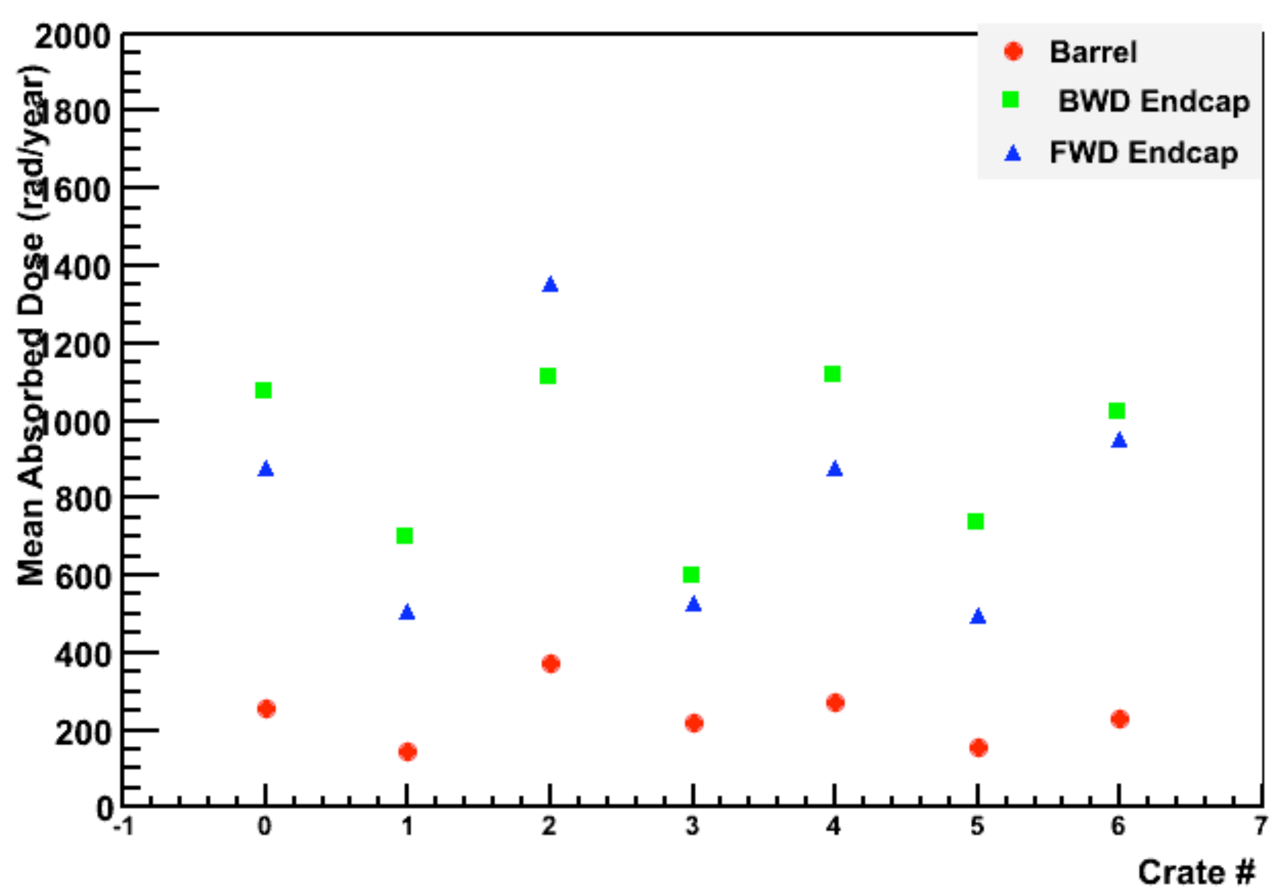
Instrum. flux return FEE

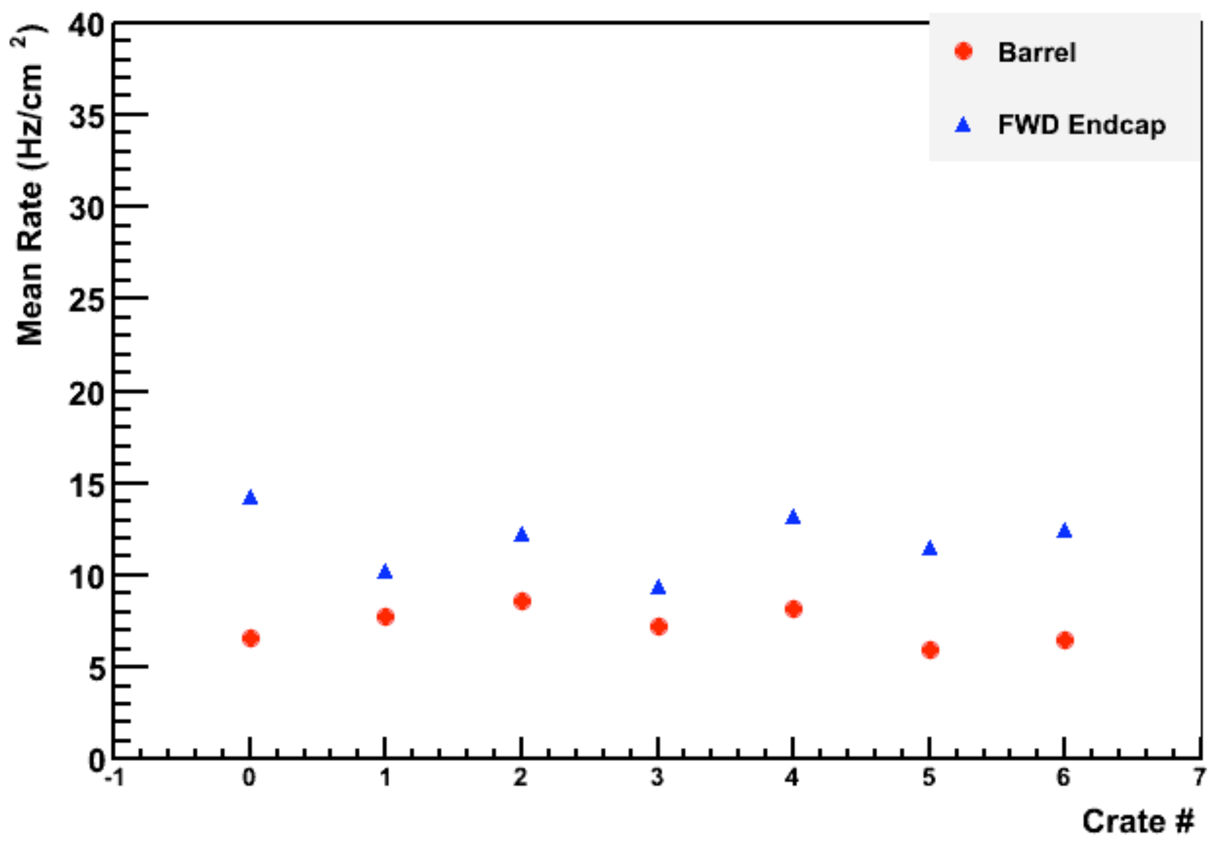
- Silicon board to test electronics crate locations outside the detector



Instrum. flux return FEE

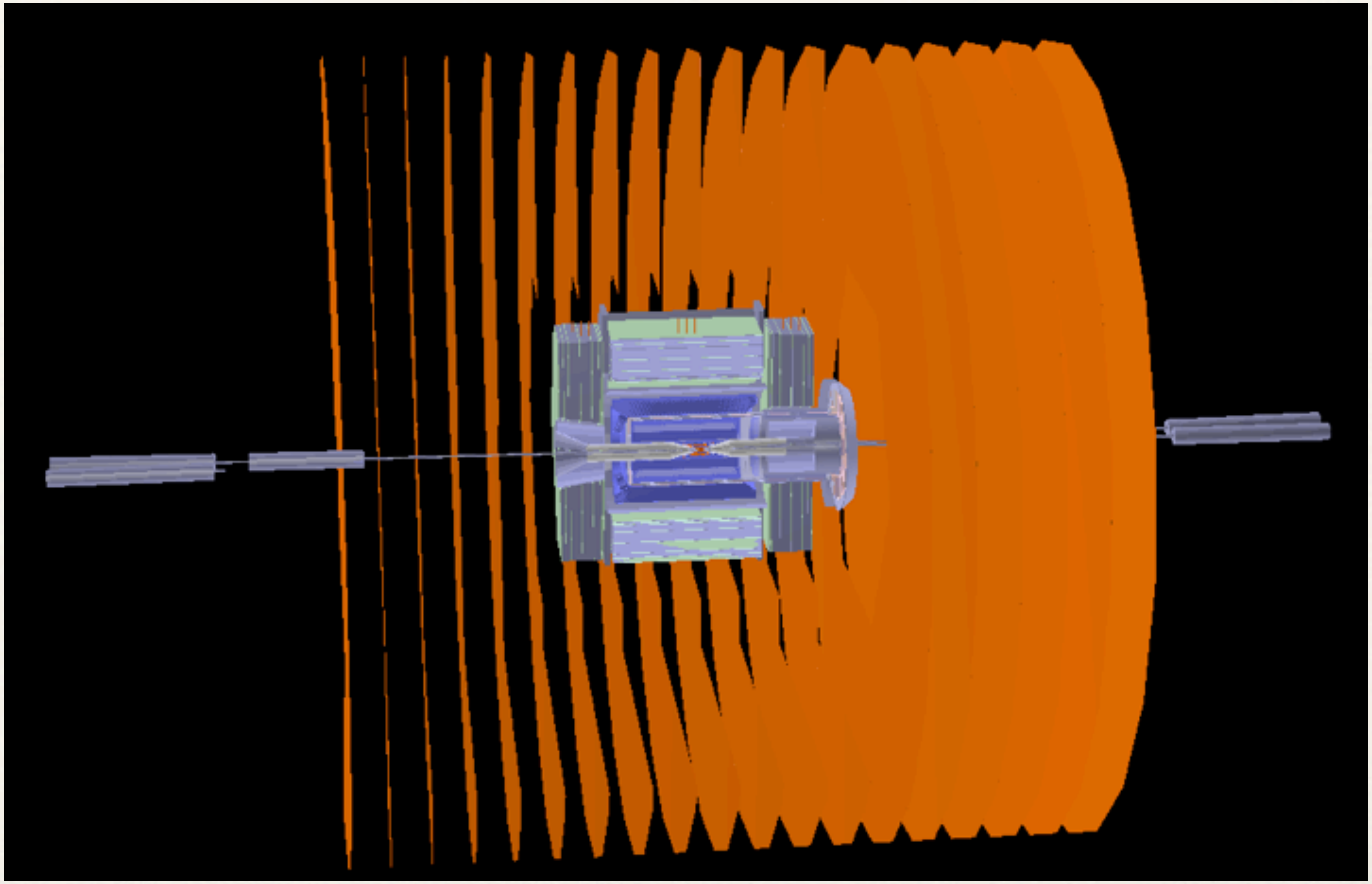
- Only radiative BhaBha contribution
- Integrated dose in 1 SMY (left)
- Neutron rate in FEE (right)
- The barrel locations have always dose and rate lower than the ones for the endcaps





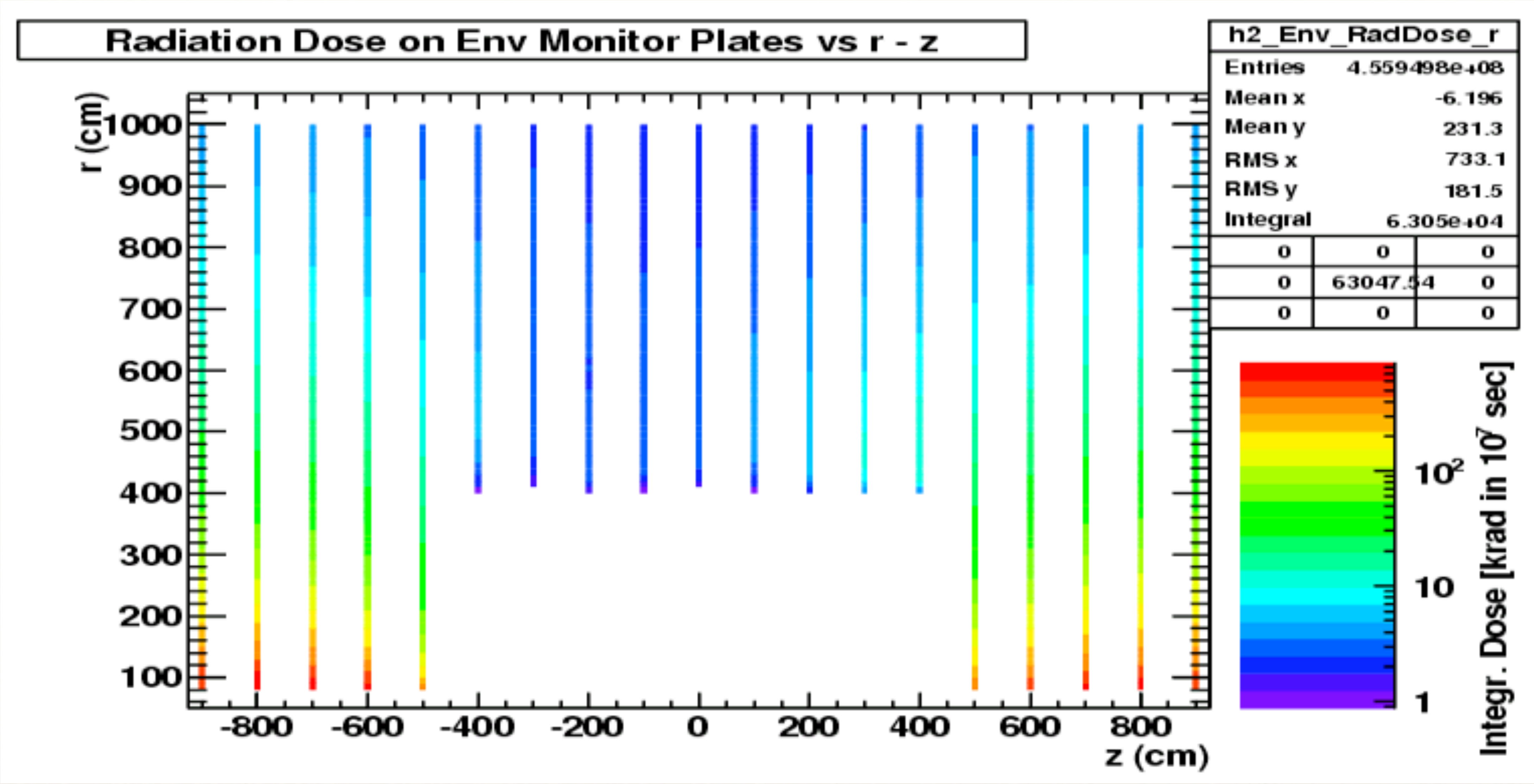
Experimental hall

- For testing other crates position inside the experimental hall we add thin silicon plates to span the whole room



Experimental hall

- Integrated dose in 1 SMY, integrated over Phi
- Most activity is in the region close to the beam
- Areas above **100 kRad** should be avoided
- Radiative BhaBha is the main contribution, others are smaller than a factor 50

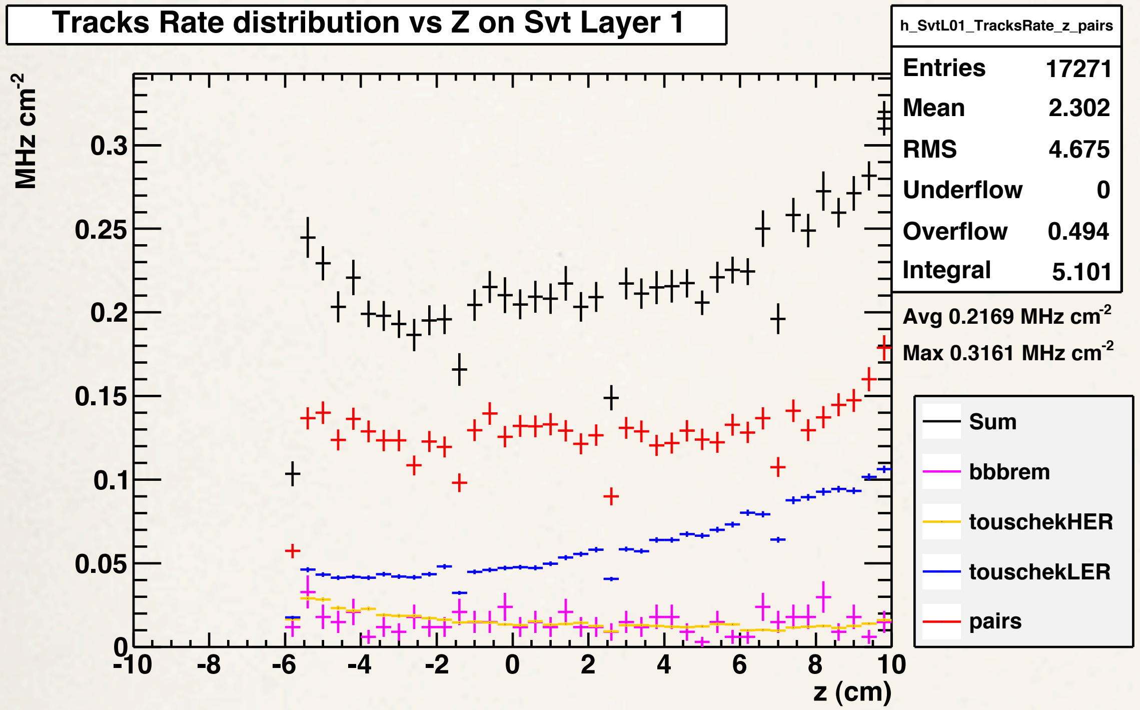


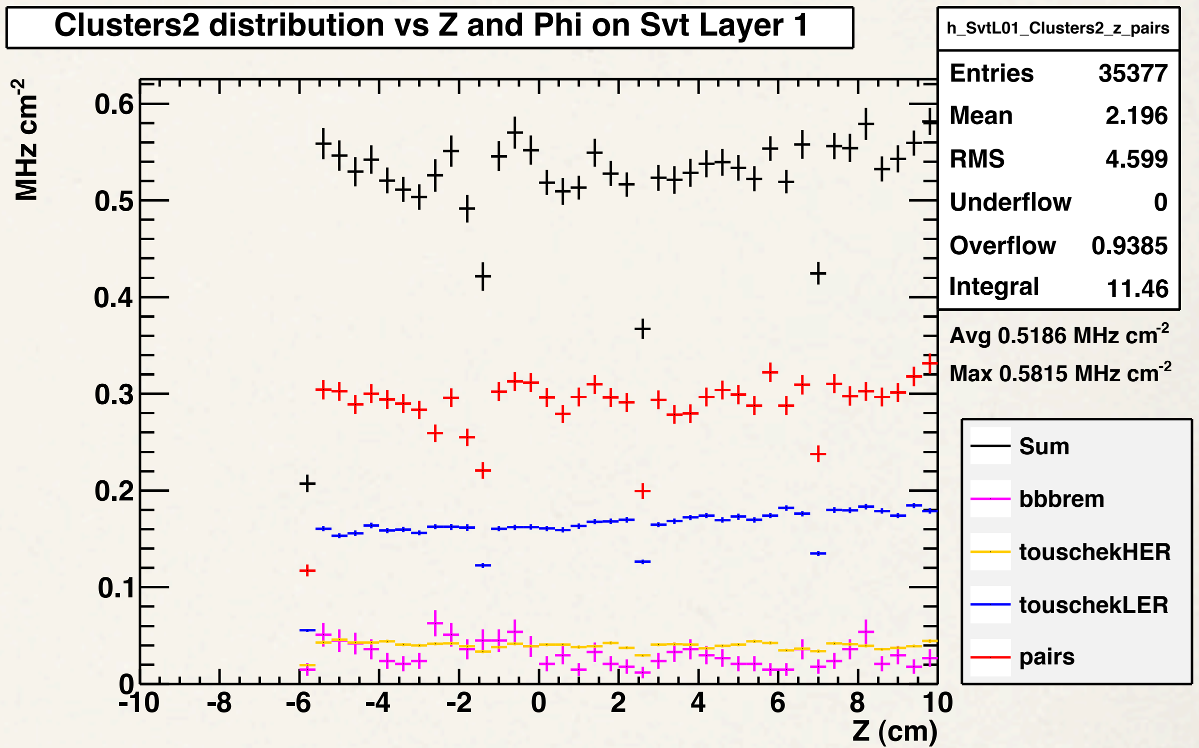
Conclusions

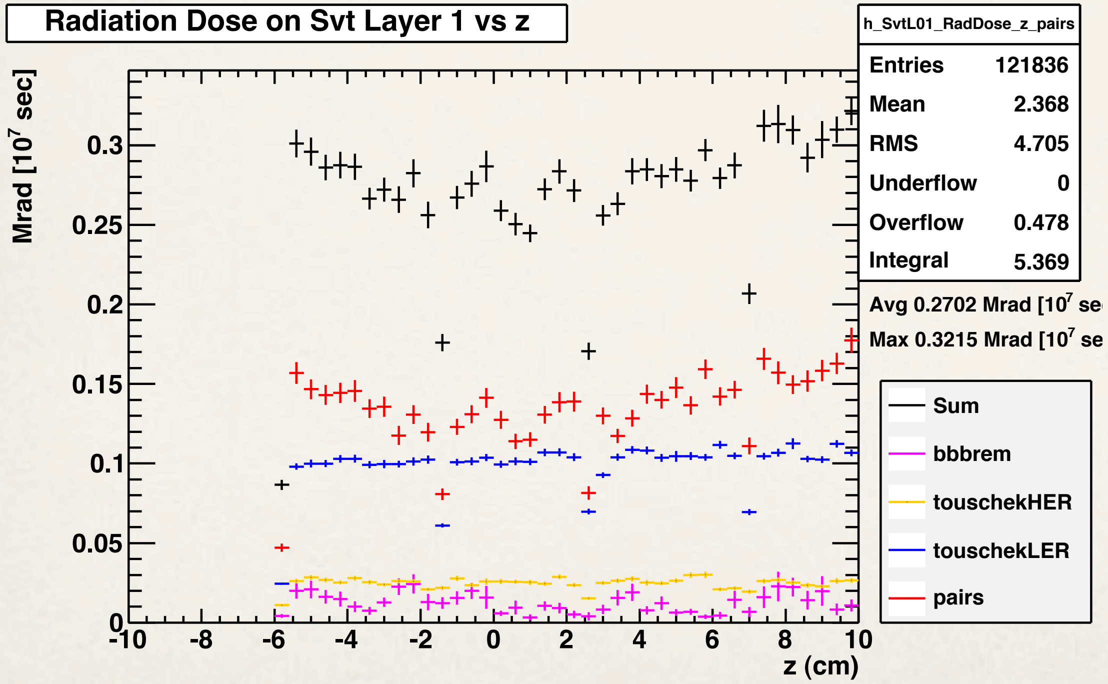
- Short summary of a very complex work started addressing many requests from sub-detector designer
- Radiative BhaBha is the dominant contribution for many sub-systems, but SVT inner layers, where the main one is 2-photon
- Full simulation confirmed to be an extremely useful tool for:
  - estimating many data to be used when finalizing the design
  - optimizing passive material placements
  - corroborate out-of-the-envelope estimations
- Additional doses, rates, and Cherenkov optical photons simulation are in the pipeline, results are coming soon
- Do not forget: some contributions are still missing (beam-gas, SR), expected to be smaller (if no surprise)

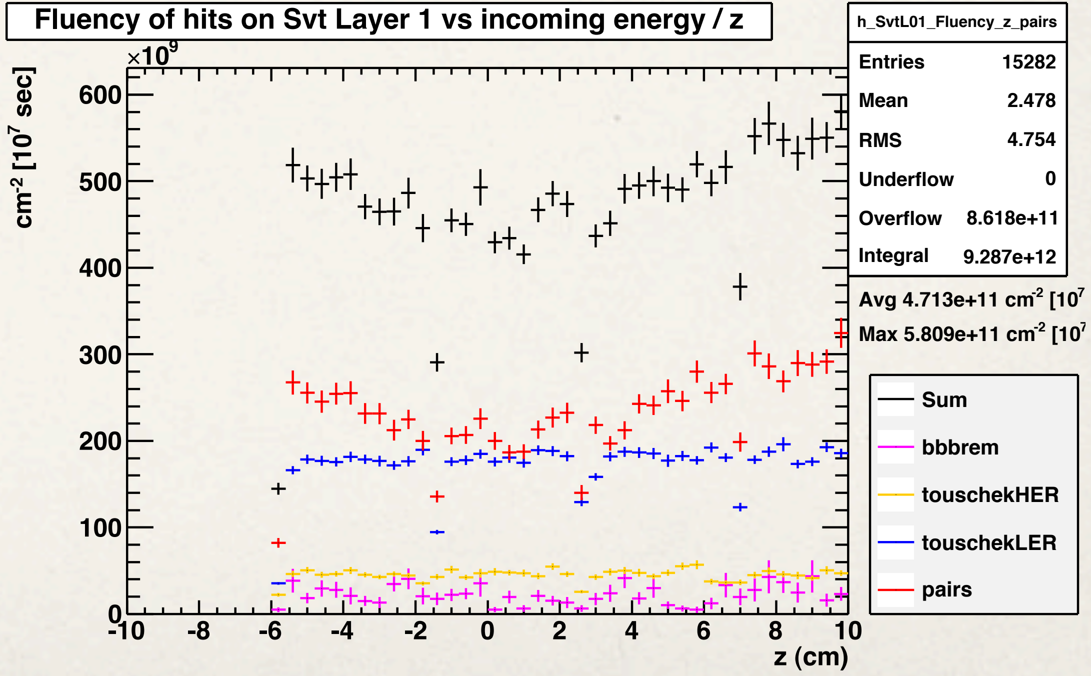
Silicon Vertex Detector (SVT)

- Track rate, Cluster rate, Integrated dose, Equivalent fluency for Layer 1



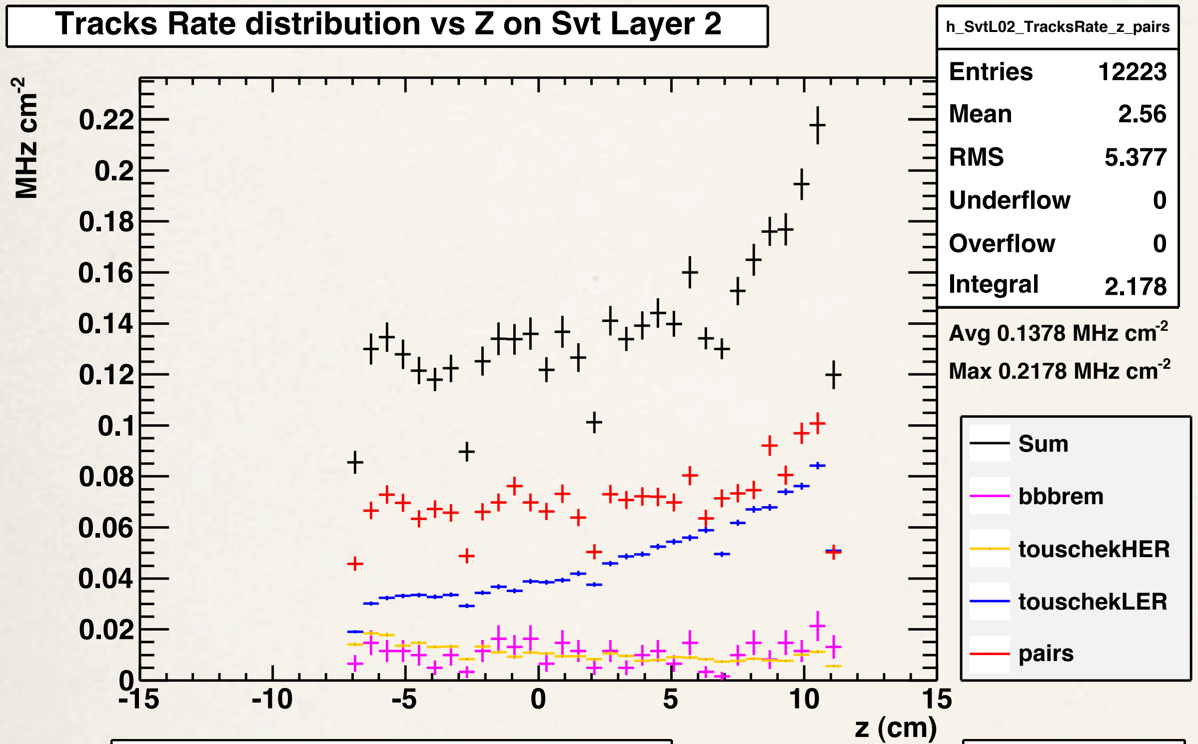


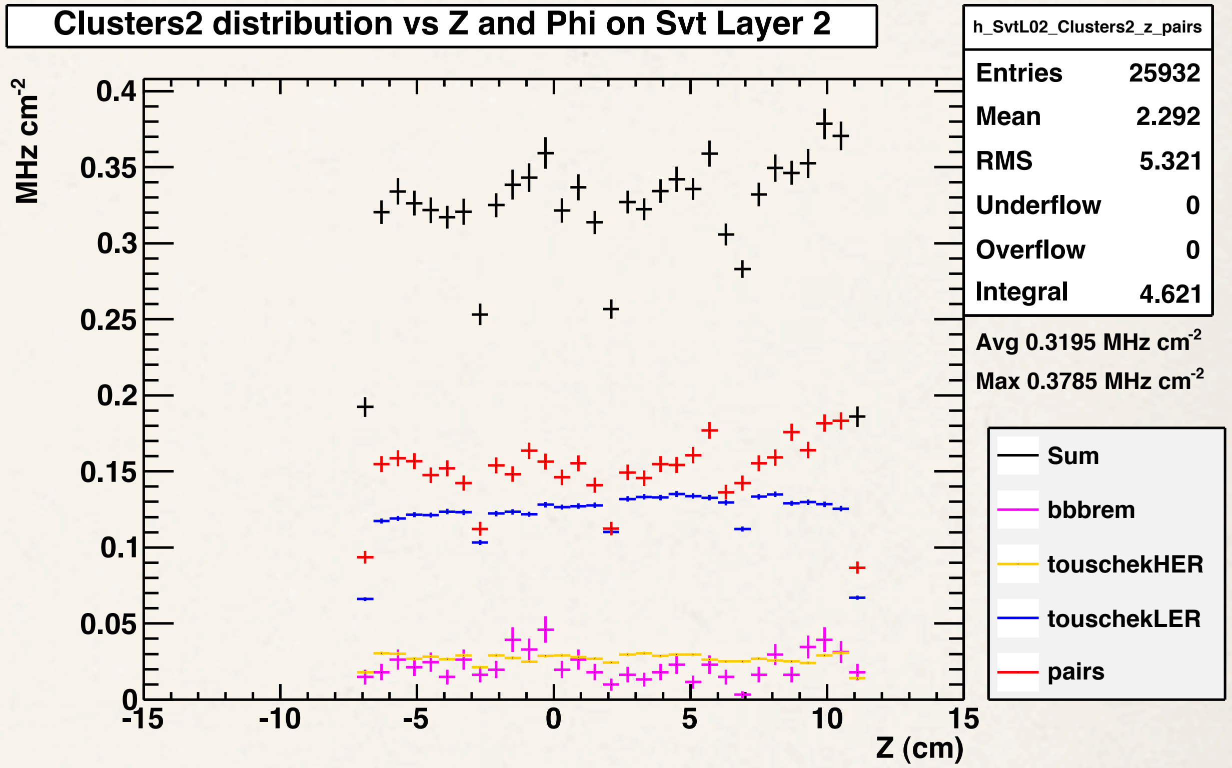


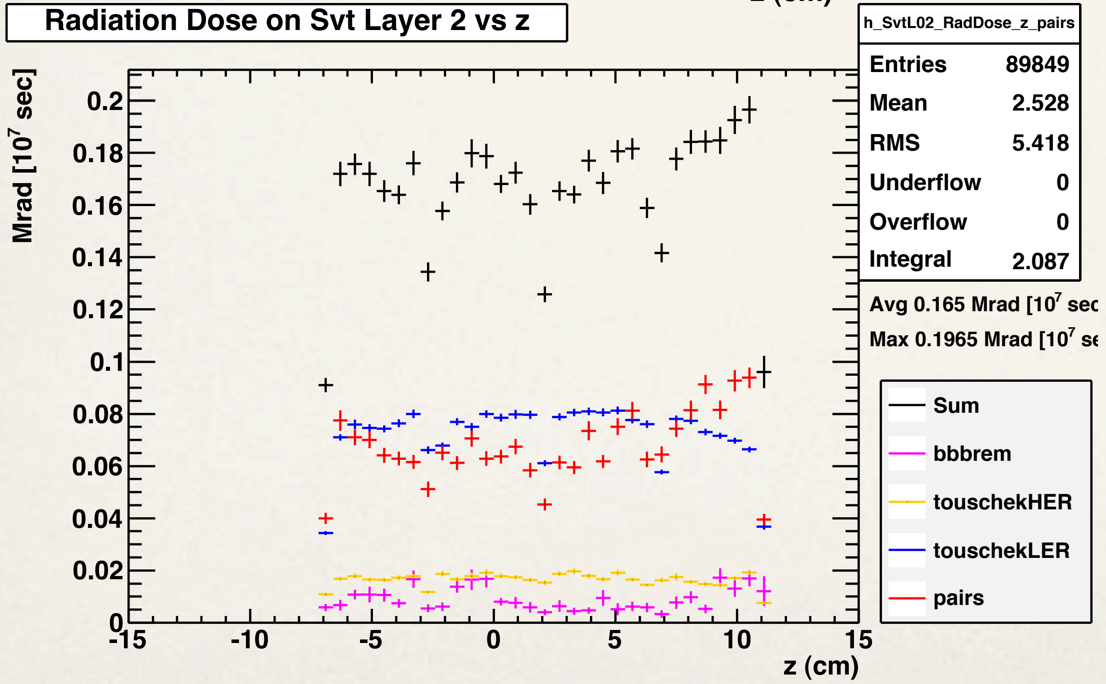


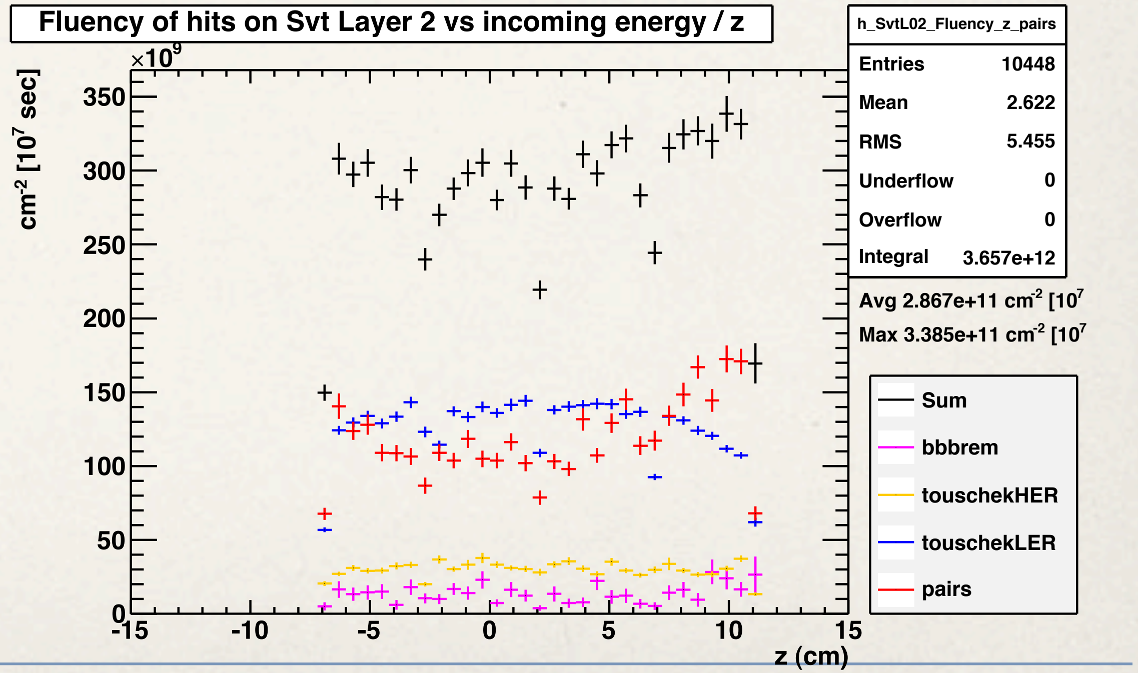
Silicon Vertex Detector (SVT)

- Track rate, Cluster rate, Integrated dose, Equivalent fluency for Layer 2


Tracks Rate distribution vs Z on Svt Layer 2

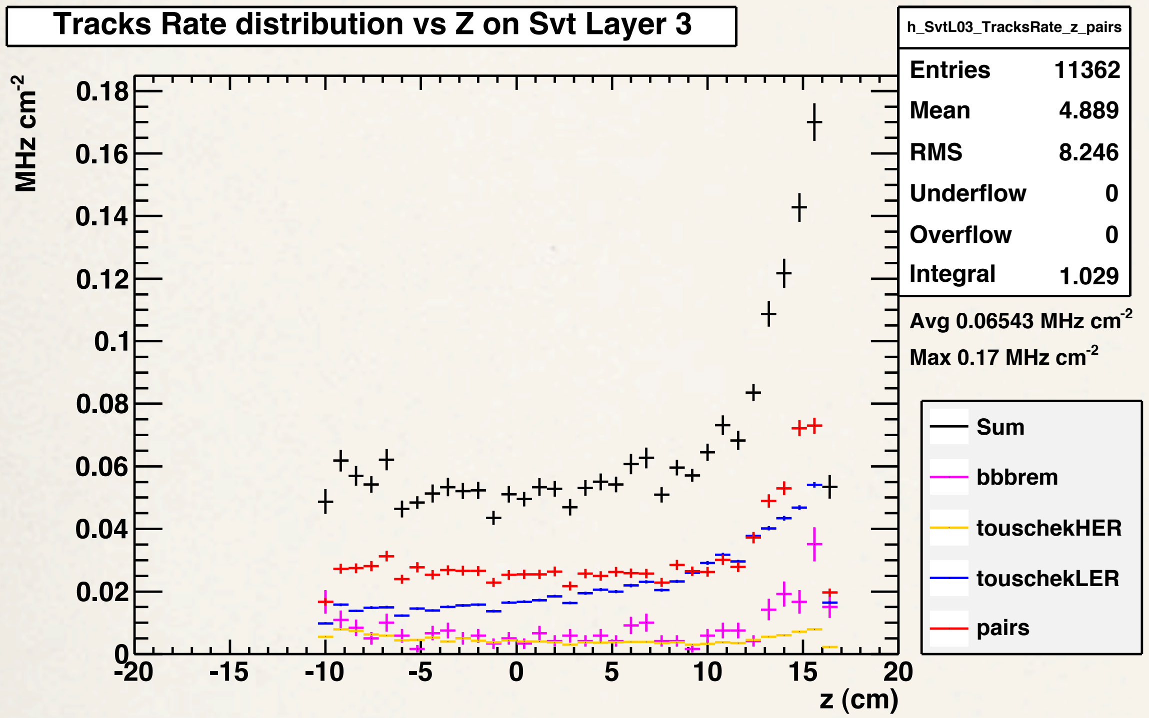

Clusters2 distribution vs Z and Phi on Svt Layer 2

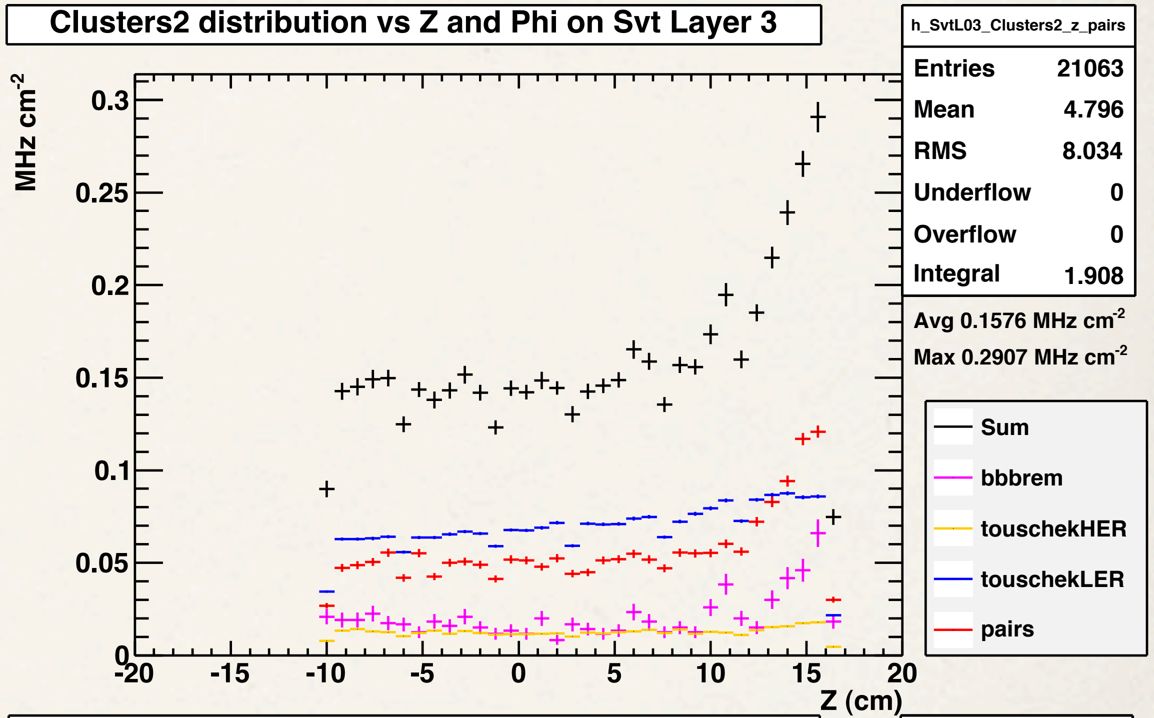

Radiation Dose on Svt Layer 2 vs z

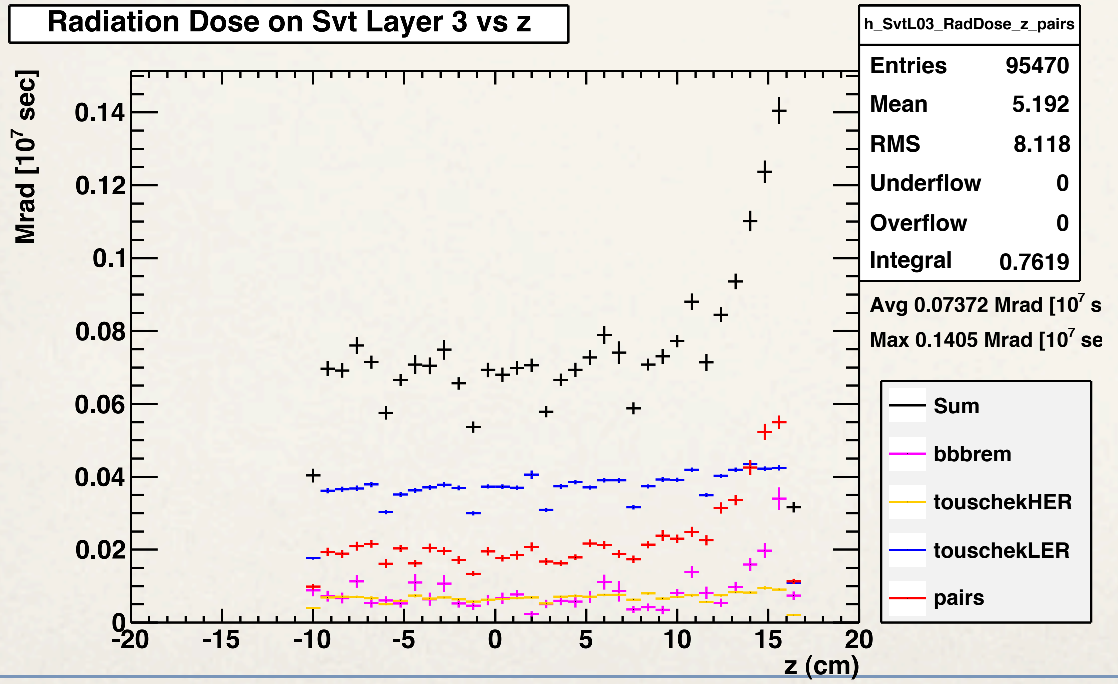

Fluency of hits on Svt Layer 2 vs incoming energy / z

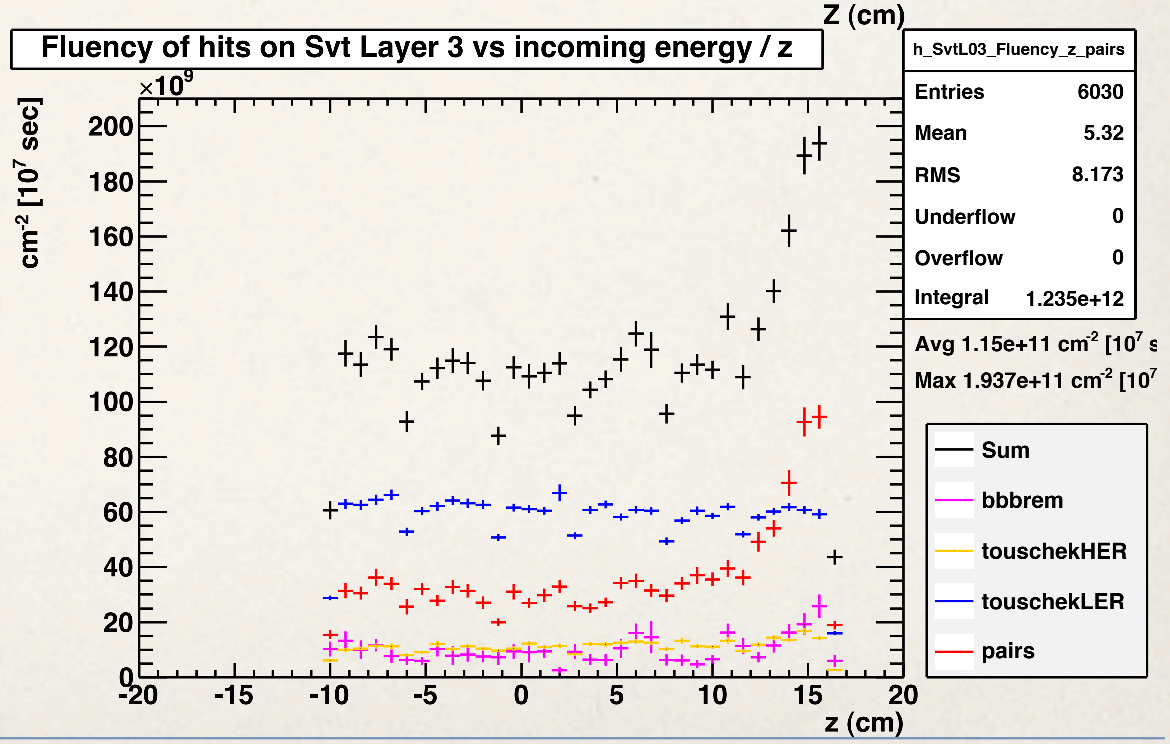
Silicon Vertex Detector (SVT)

- Track rate, Cluster rate, Integrated dose, Equivalent fluency for Layer 3


Tracks Rate distribution vs Z on Svt Layer 3

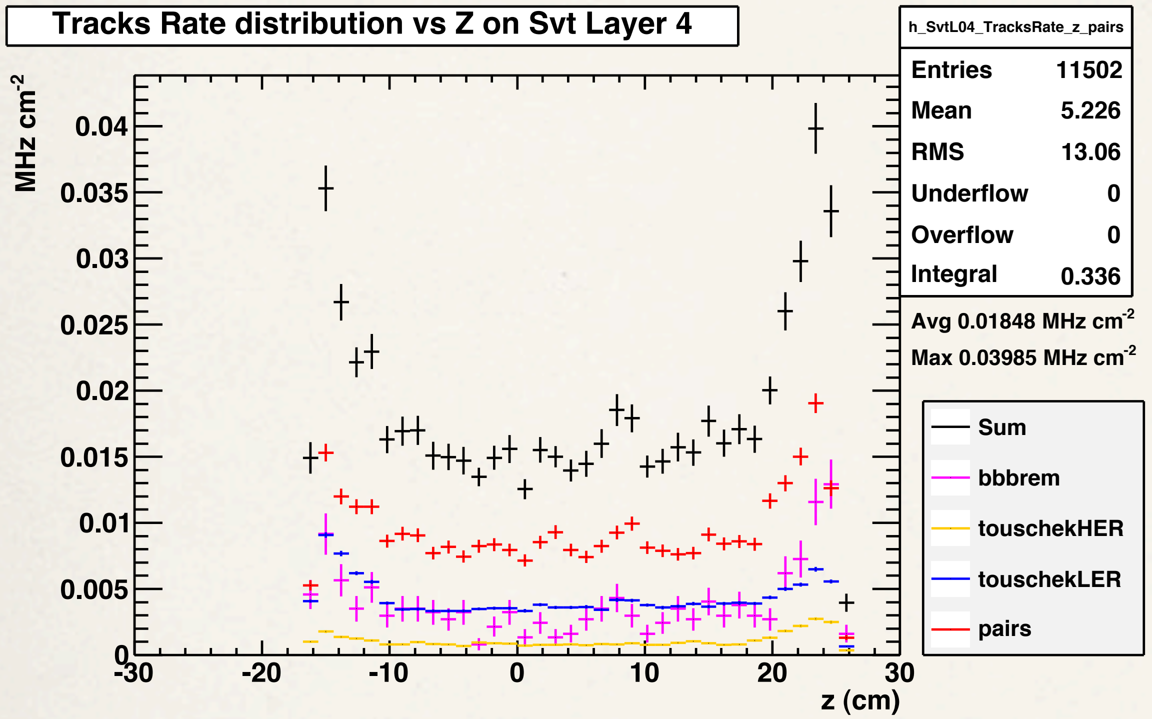

Clusters2 distribution vs Z and Phi on Svt Layer 3

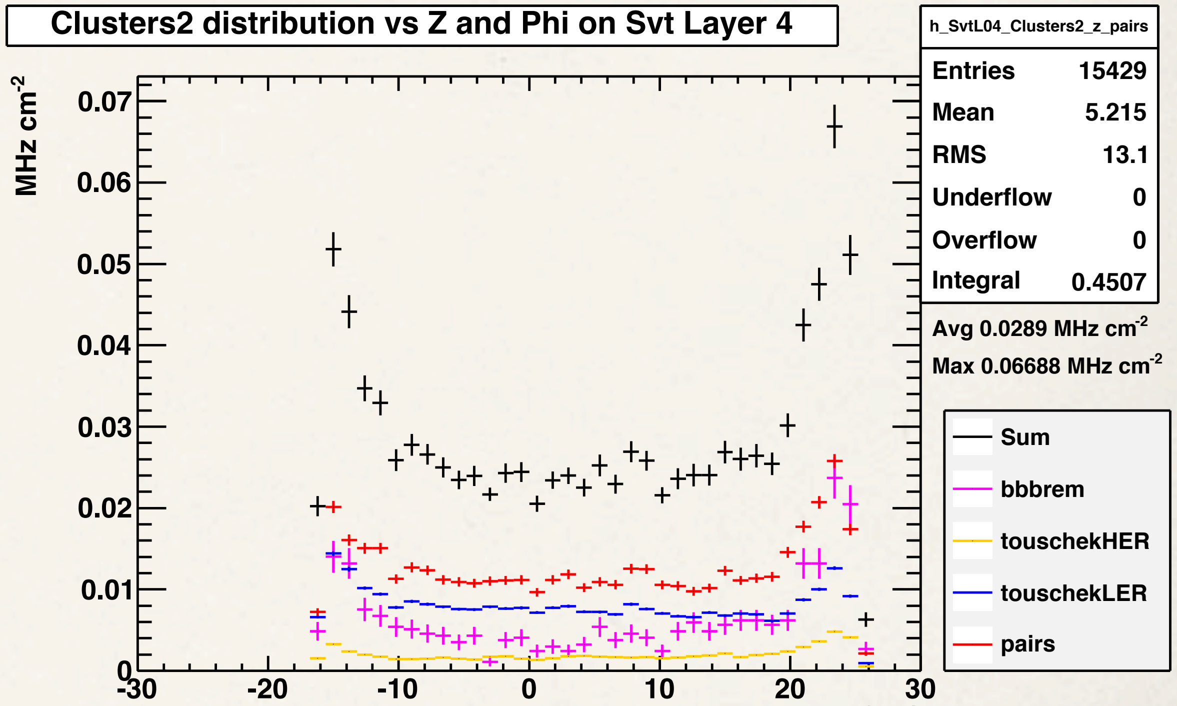

Radiation Dose on Svt Layer 3 vs z

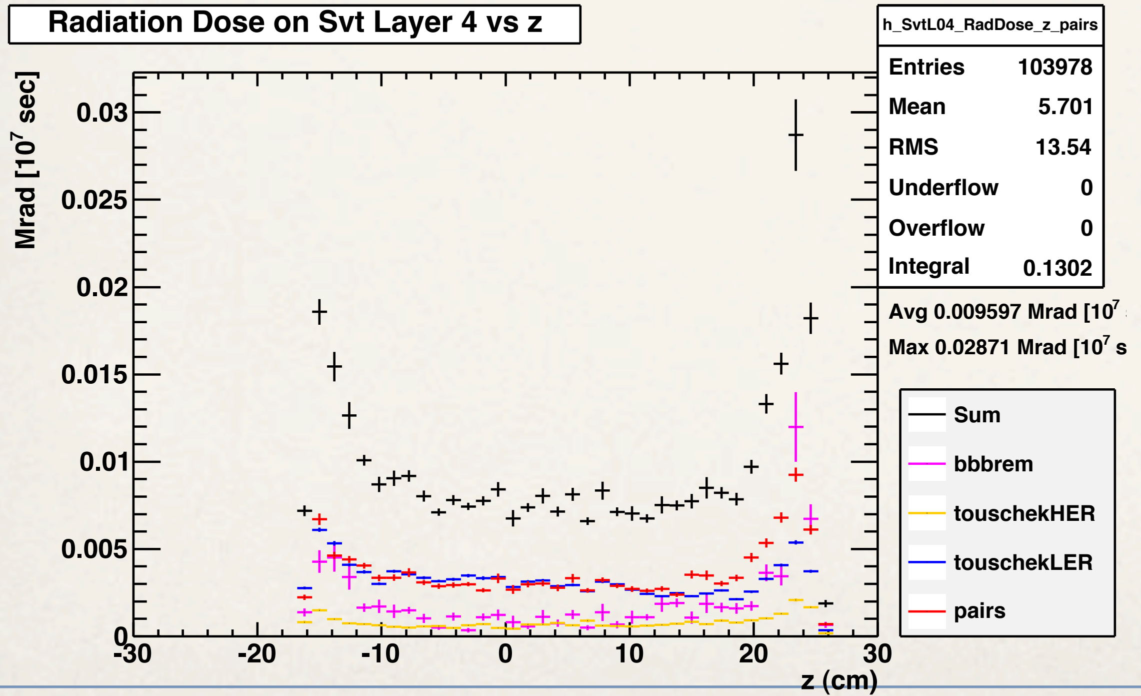

Fluency of hits on Svt Layer 3 vs incoming energy / z

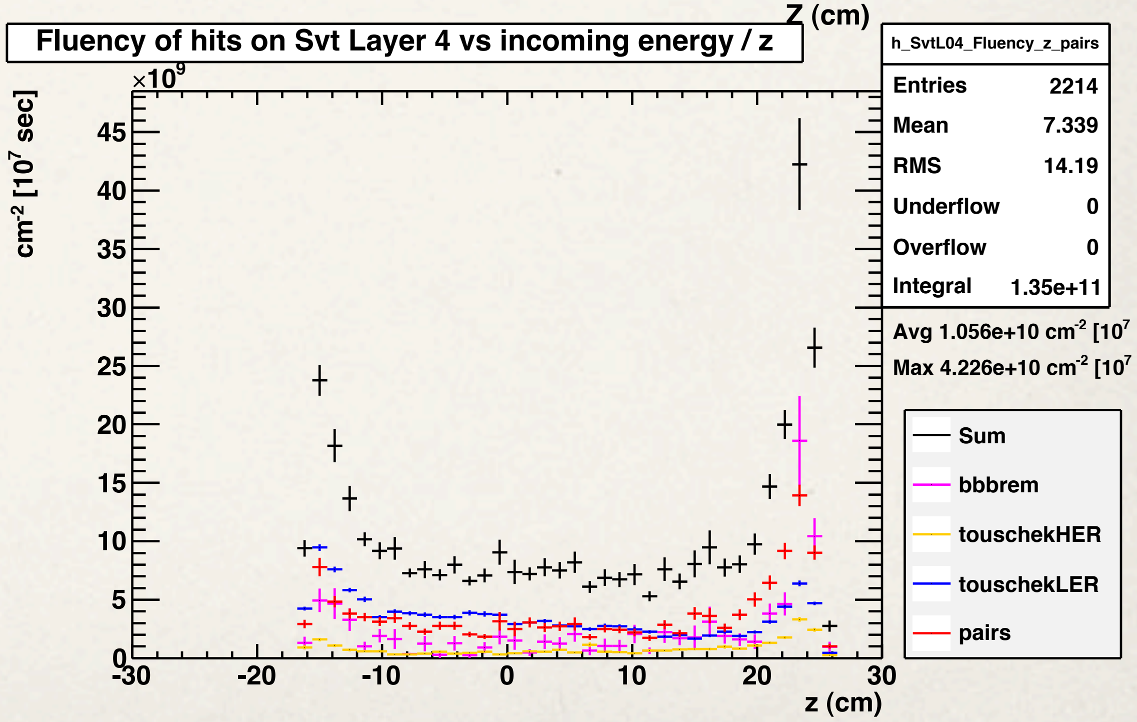
Silicon Vertex Detector (SVT)

- Track rate, Cluster rate, Integrated dose, Equivalent fluency for Layer 4



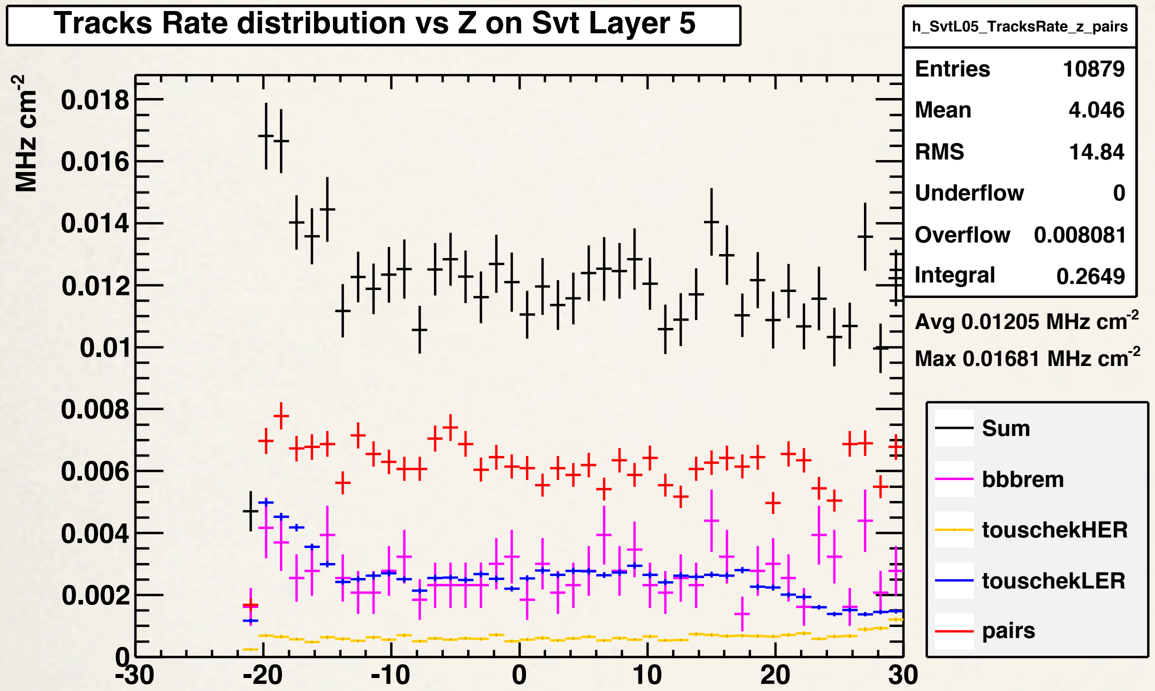


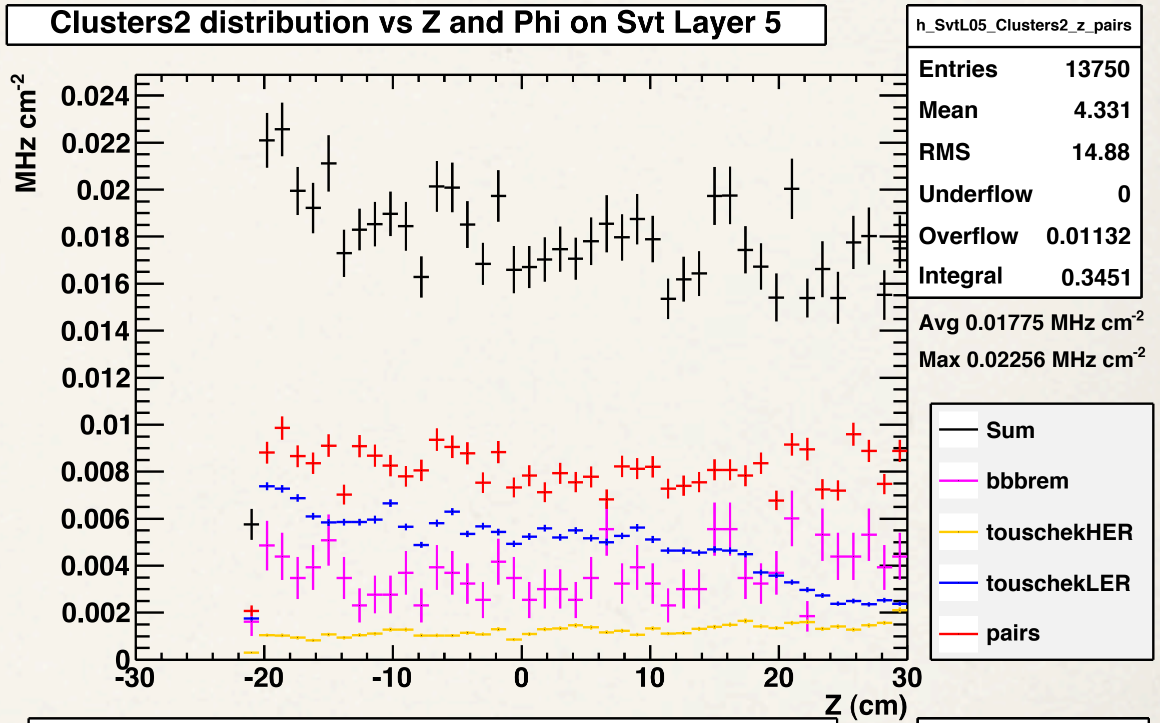


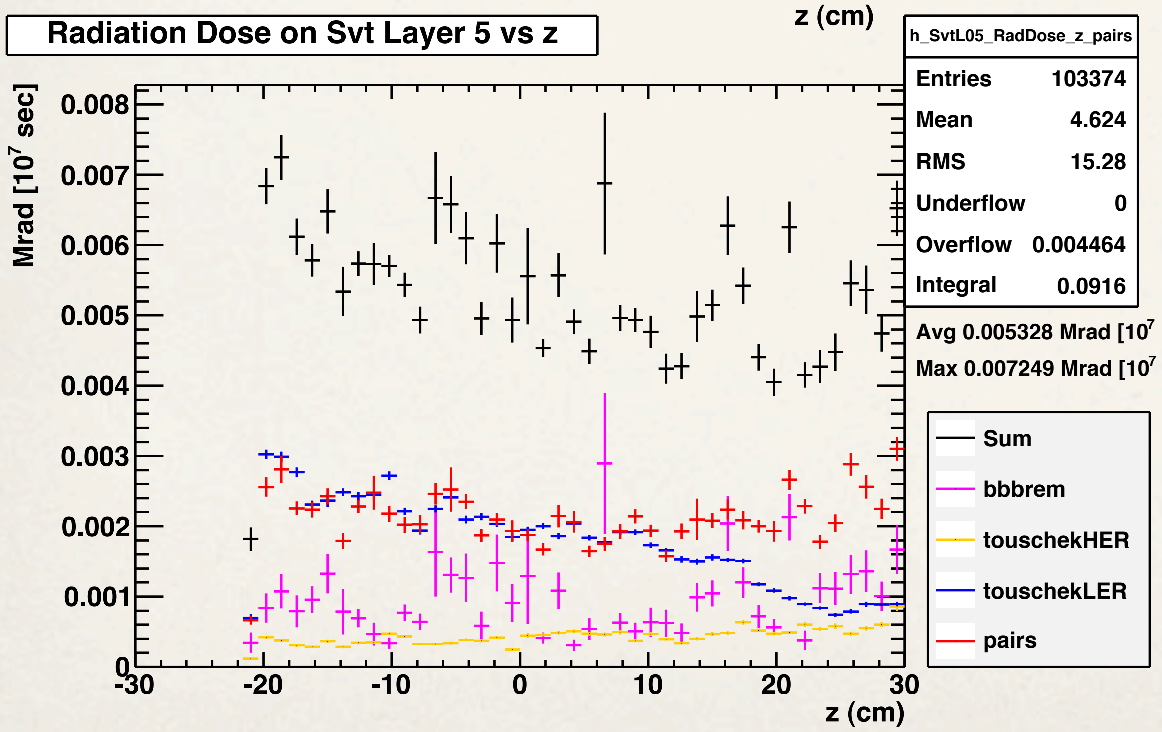


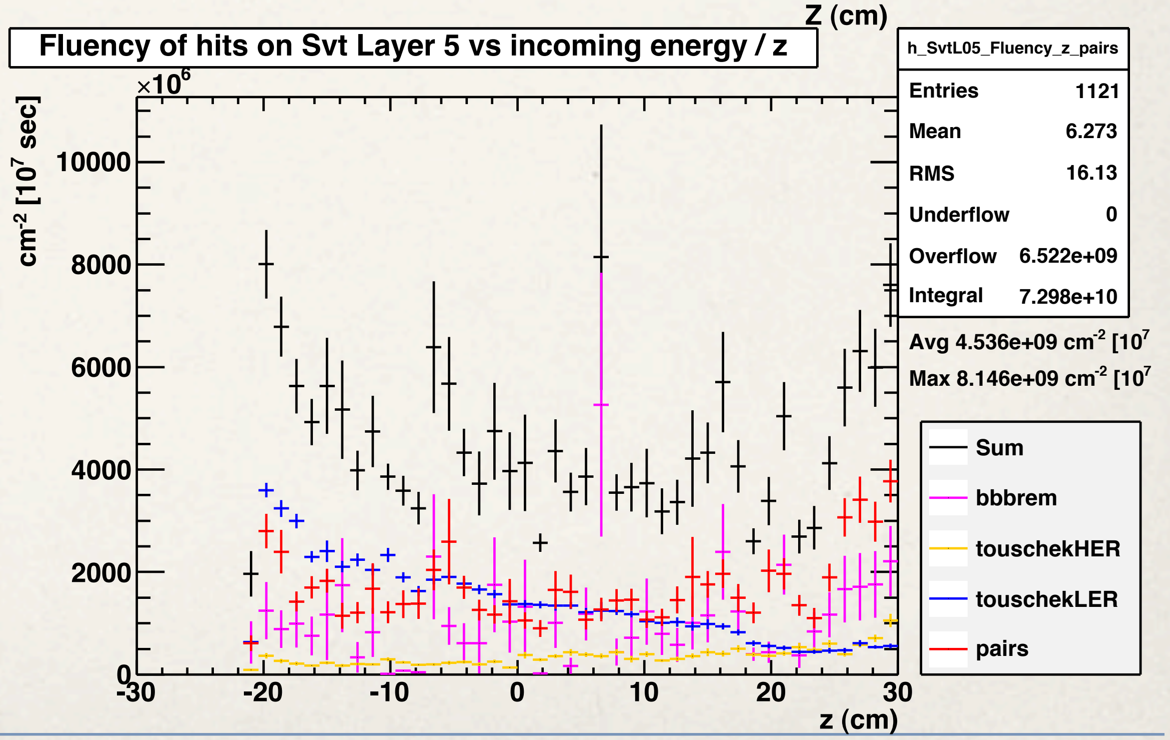
Silicon Vertex Detector (SVT)

- Track rate, Cluster rate, Integrated dose, Equivalent fluency for Layer 5


Tracks Rate distribution vs Z on Svt Layer 5

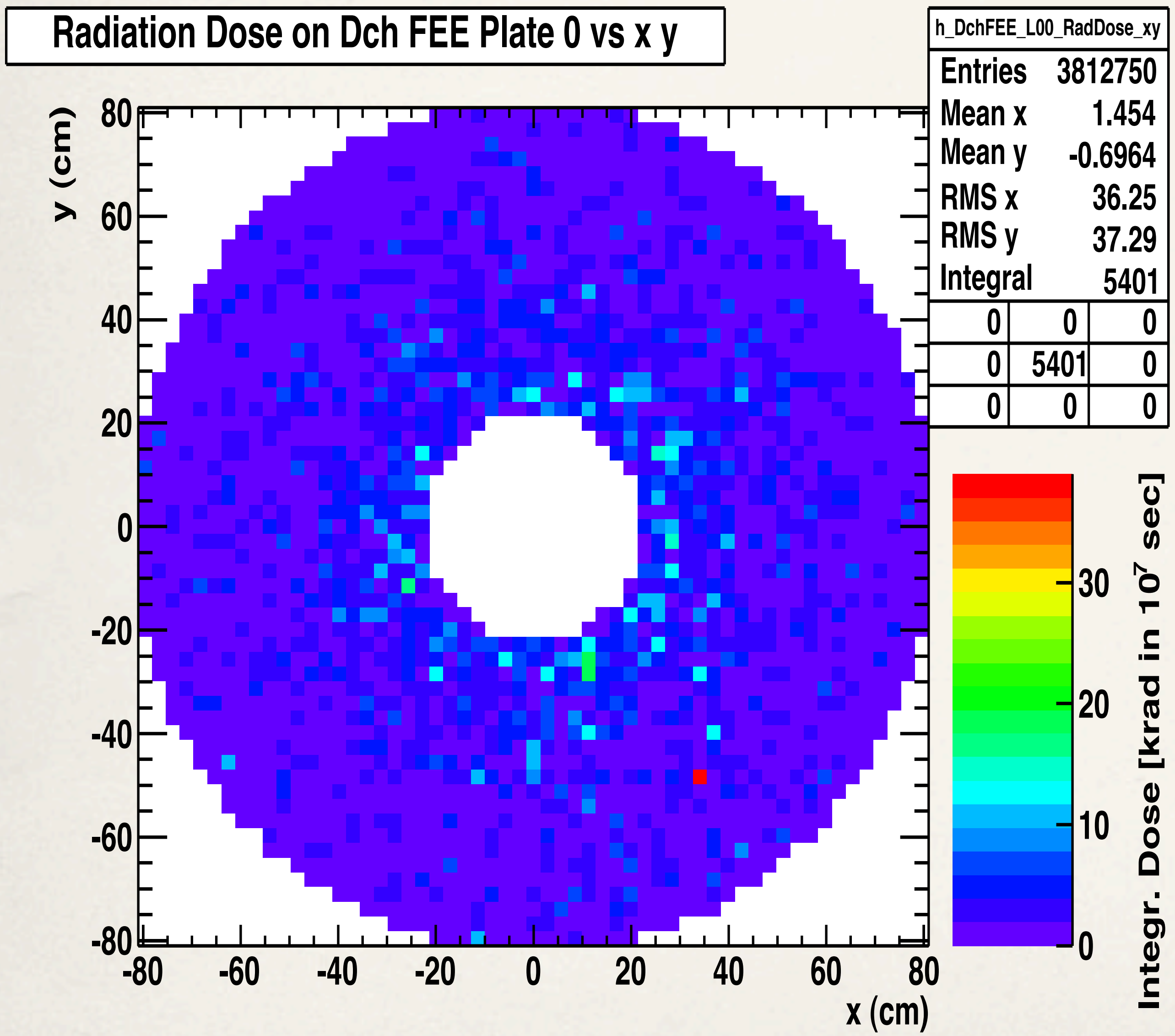

Clusters2 distribution vs Z and Phi on Svt Layer 5

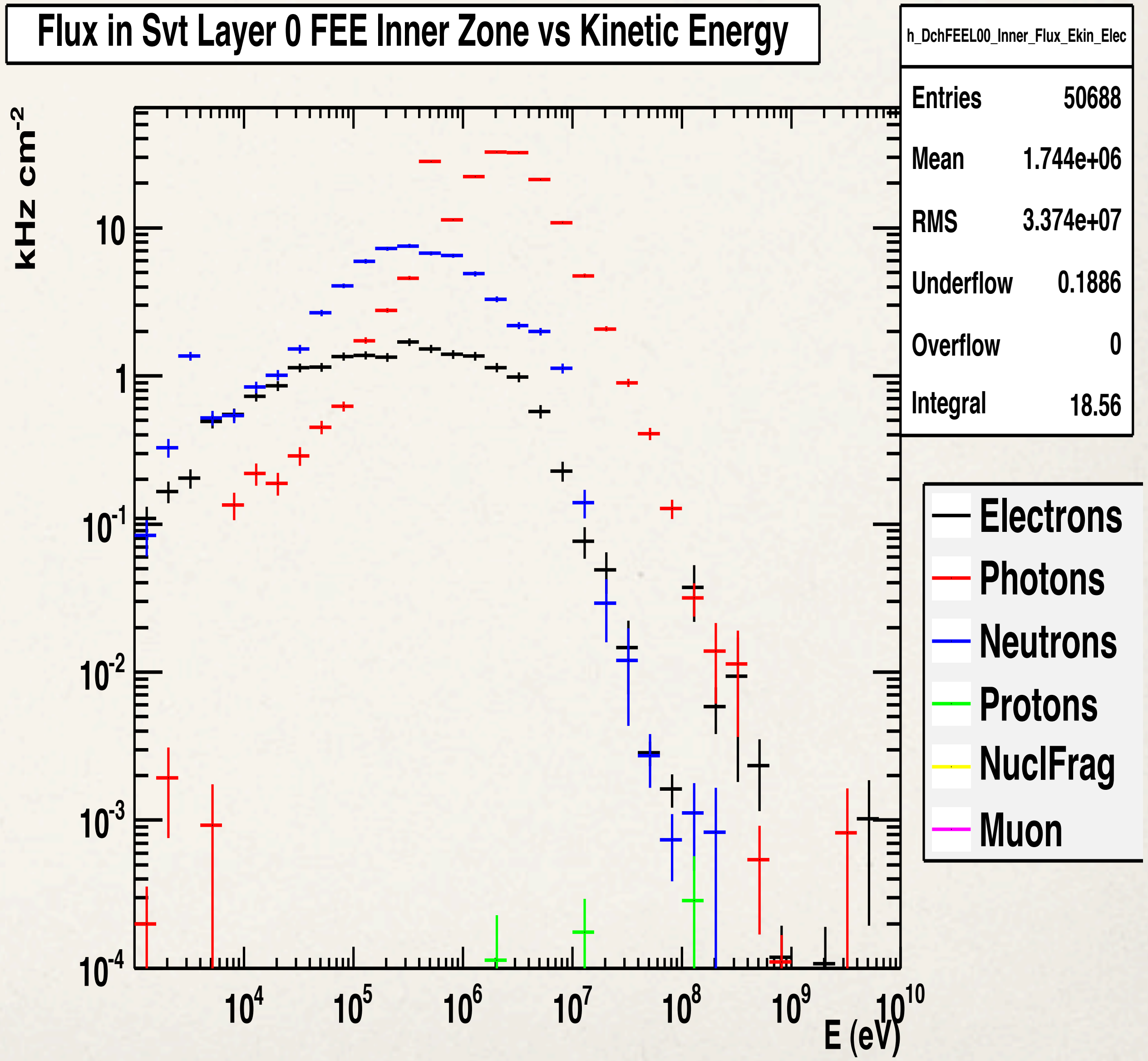

Radiation Dose on Svt Layer 5 vs z


Fluency of hits on Svt Layer 5 vs incoming energy / z

Drift chamber FEE

- Integrated dose and particle fluxes on the first plate (# 0), summed over all the contributions





Drift chamber FEE

- Integrated dose and particle fluxes on the third plate (# 2), summed over all the contributions