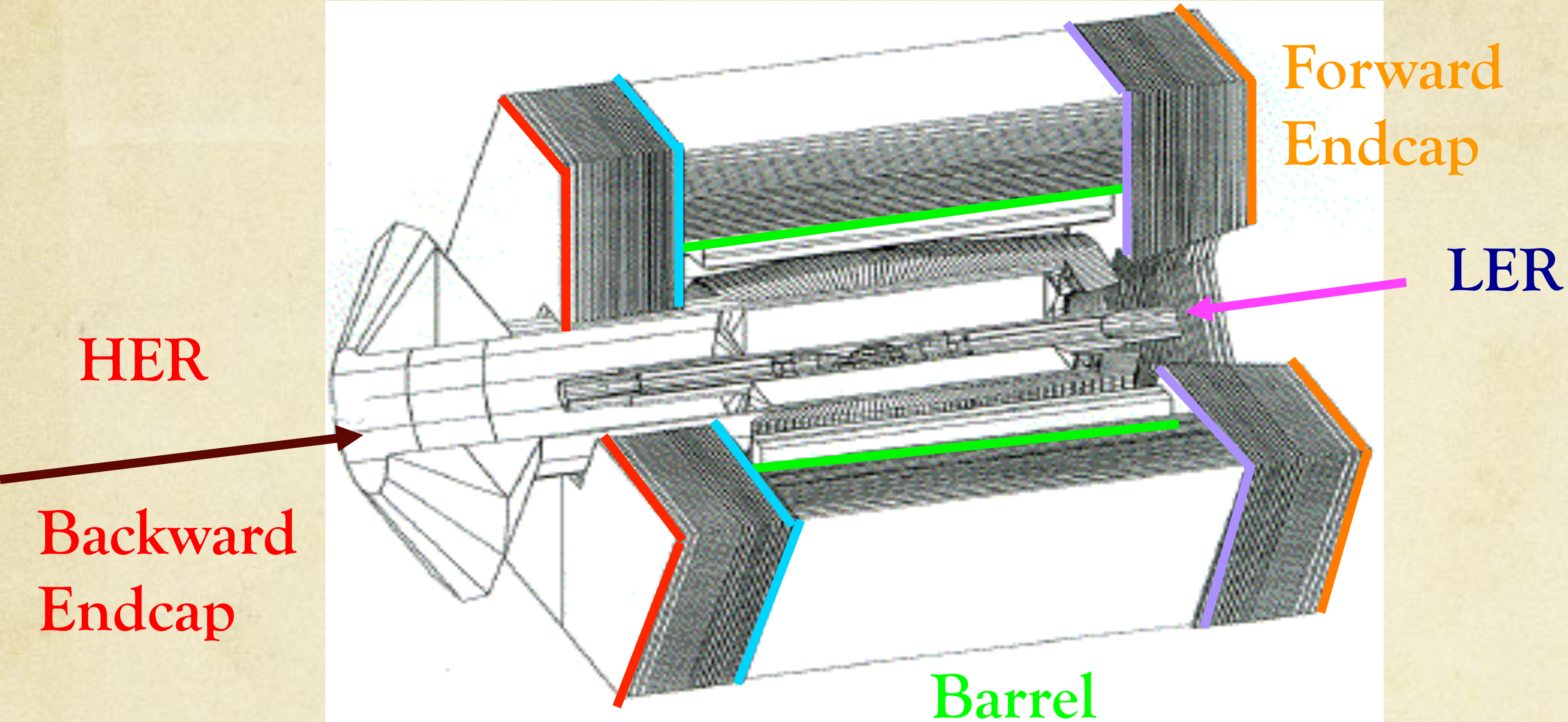
IFR Background Report

Valentina Santoro
INFN Ferrara

03/21/2012

SuperB Collaboration Meeting 21 March 2012

Hot regions



Barrel: innermost layers, mostly neutrons

FWD encaps (hottest region) : inner layers and outer layers (BEAM halo), electron and photons

BWD encaps: inner layers and small radii

What’s new from the Frascati CM Meeting

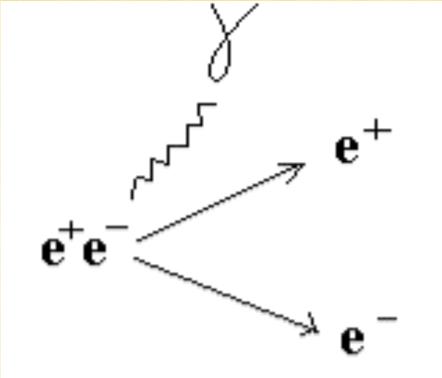
Frascati Dec 2011

- ✓ Beam Composition for the IFR background
- ✓ Radiative BhaBha Background Studies (neutrons, photons and electron)
- ✓ Touschek background (neutrons, photons and electron)
- ✓ Pair background (neutrons, photons and electron)
- ✓ Background Studies and Absorbed dose on our FEEs

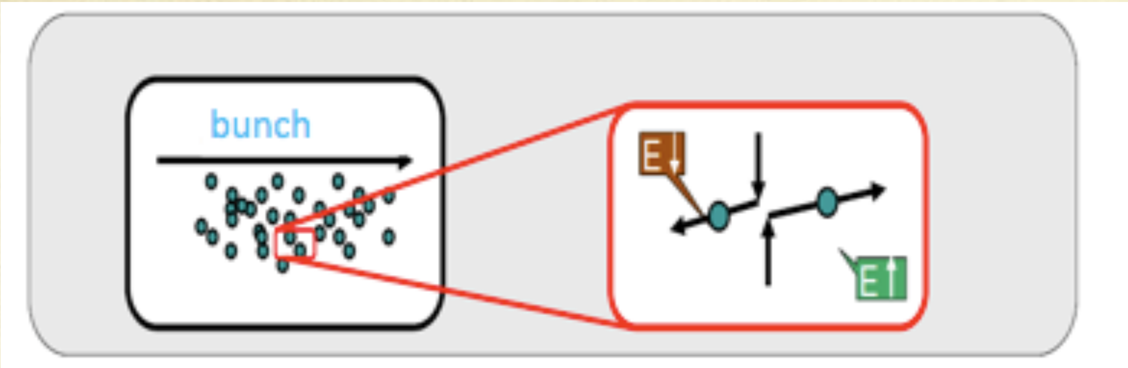
New

- ✓ Proton study
- ✓ FEEs studies improved
- ✓ Beam-Gas Background
- ✓ Neutron Background Shielding
- ✓ Report from Vienna

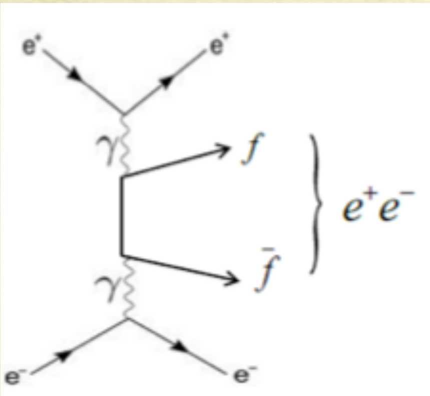
Background sources crossing the IFR detector



Radiative BhaBha



Touschek scattering : results from a Coulomb collision of two relativistic electrons in a particle beam, producing an instantaneous change in particle energy



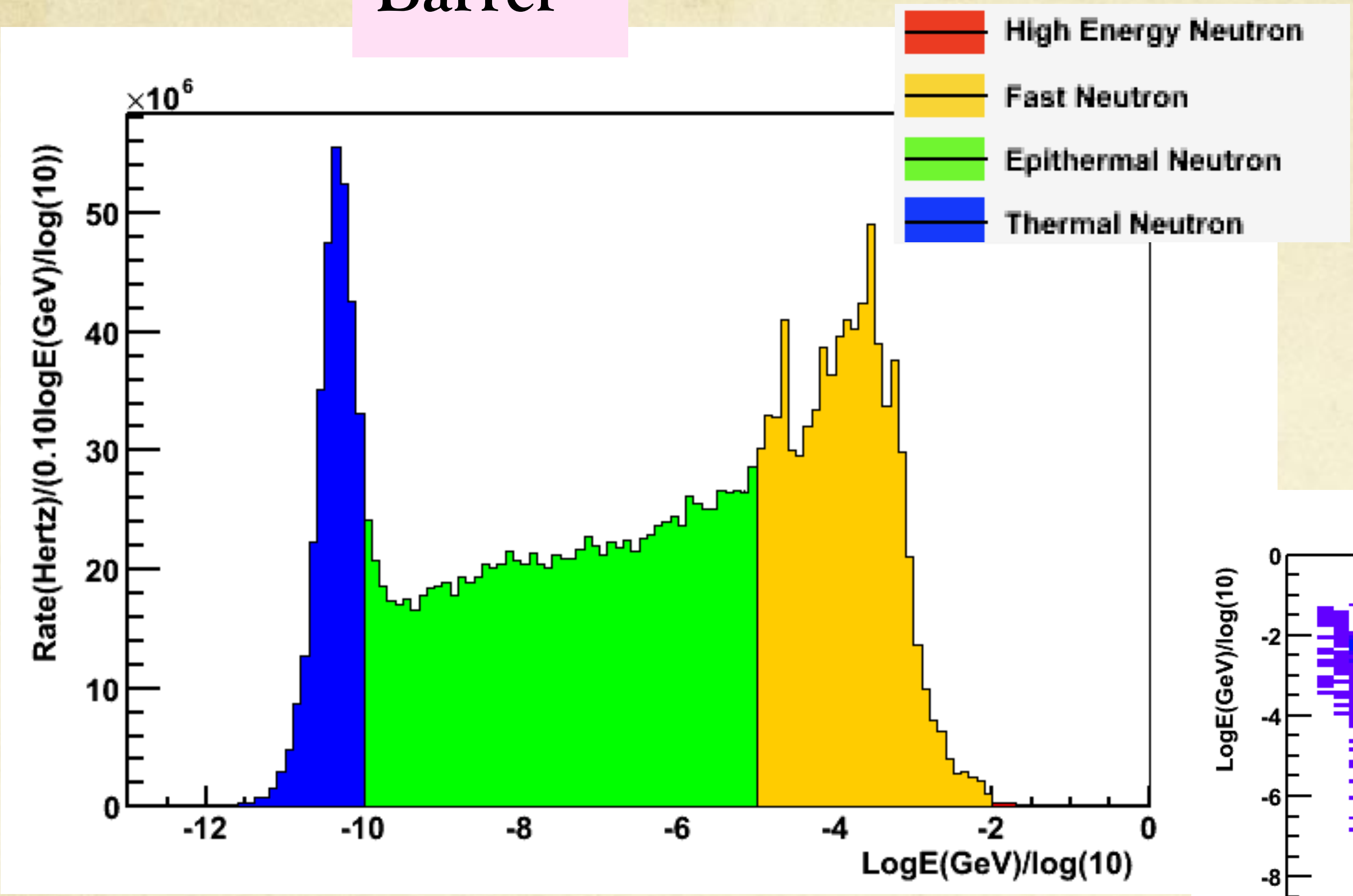
Pair production

$e^+e^- \rightarrow e^+e^-\gamma\gamma \rightarrow e^+e^-e^+e^-$

New **Beam-Gas Scattering**

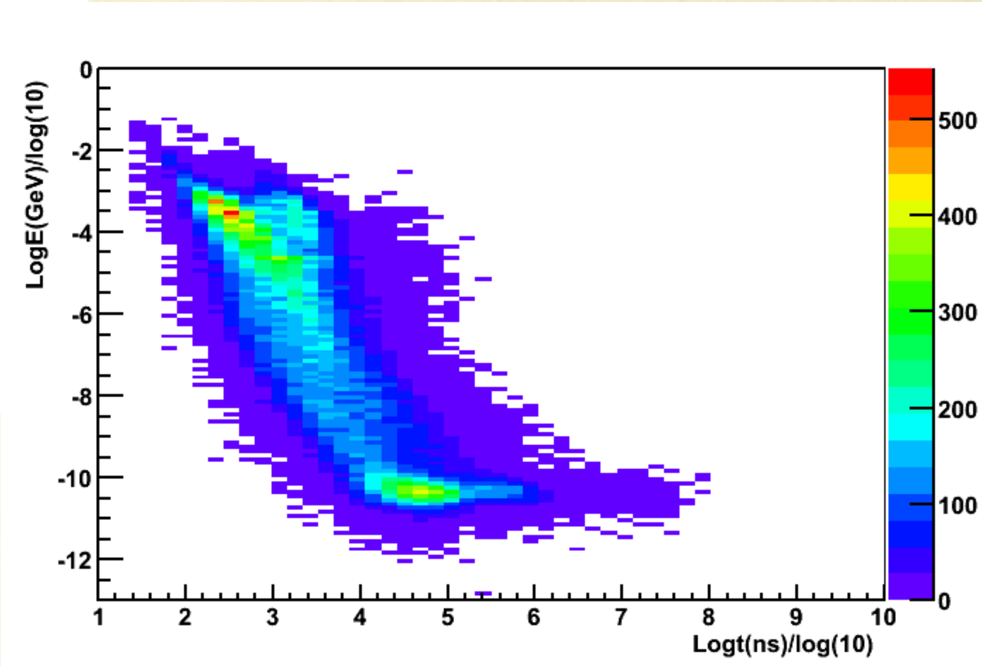
Neutron Energy Distributions for Radiativa BhaBha events

Barrel



Barrel

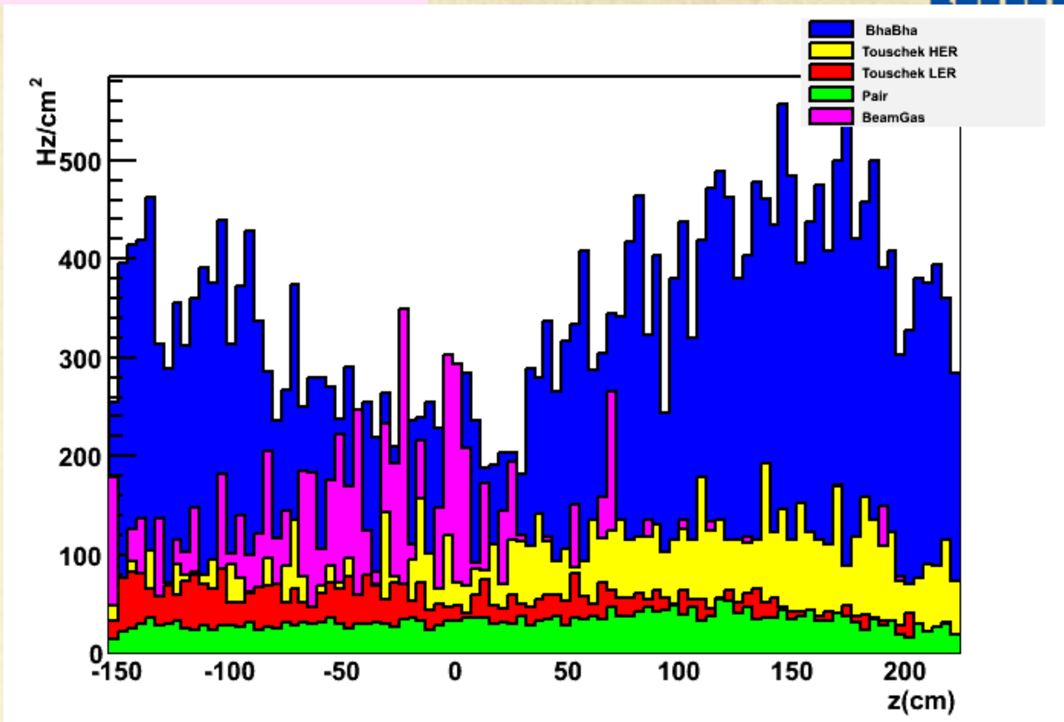
Energy vs time distributions



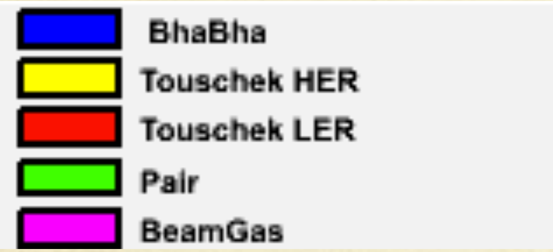
The Energy distribution for FWD and BWD Endcap are similar

Neutron Rates (for different background sources)

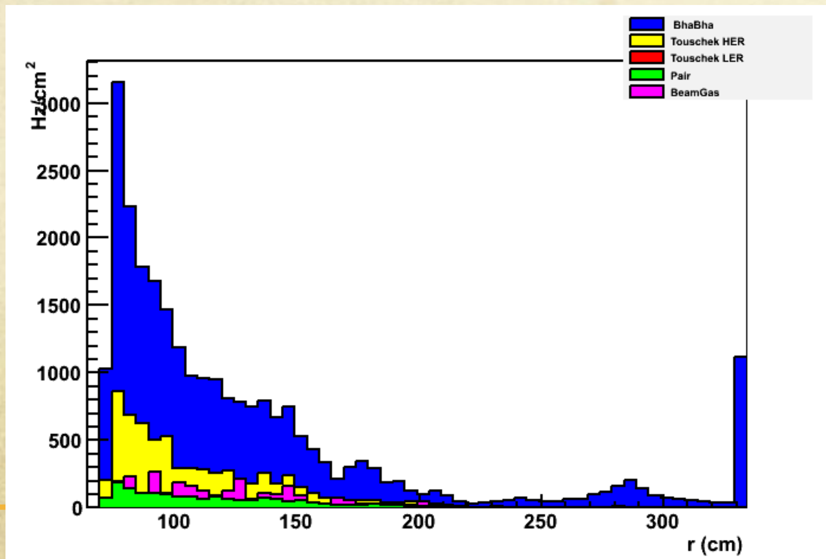
Rate vs Z-coordinate for Barrel



Rate of 450Hz/cm^2 --> about 3x10^9 neutrons/cm^2 for a year



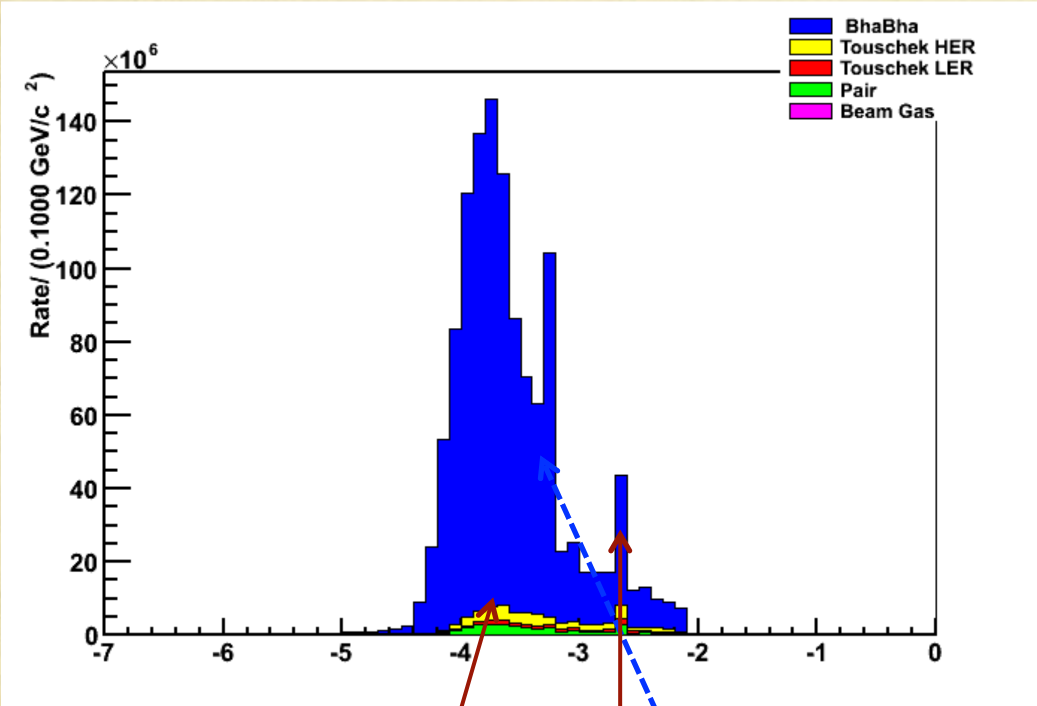
Rate vs radius for FWD Endcap



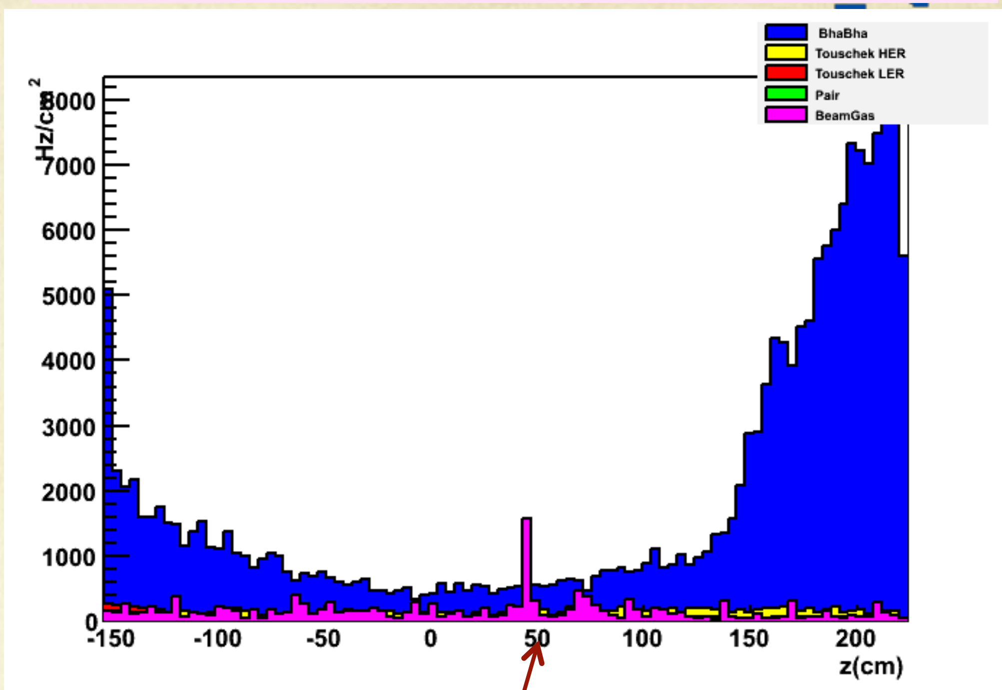
All the rate are normalized to 1MeV energy

Photons for diffent background sources

Barrel: Photon Energy Distribution



Rate vs Z-coordinate for Barrel



The Energy distribution for FWD and BWD Endcap are similar

Photons of energy ~0.512 MeV are from annihilation radiation

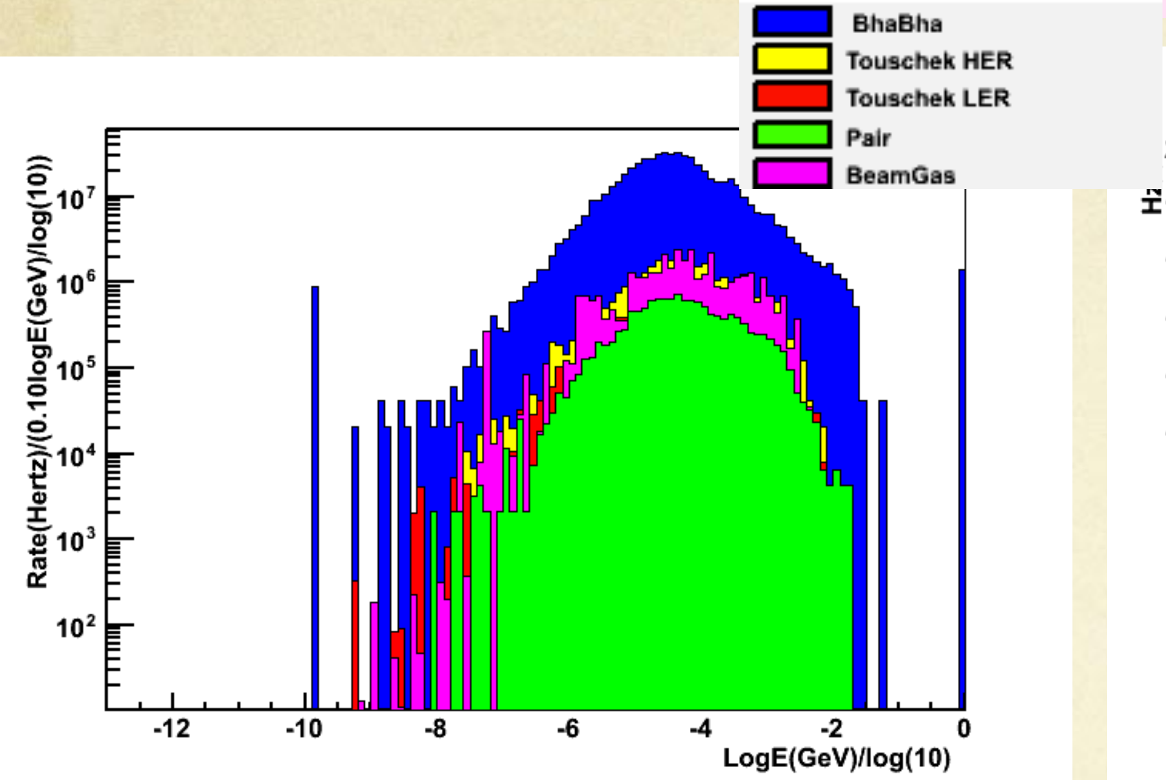
Photons of energy ~0.847 MeV are due from neutron inelastic scattering on Fe^{56}

Hot spots
Located in sextant 1

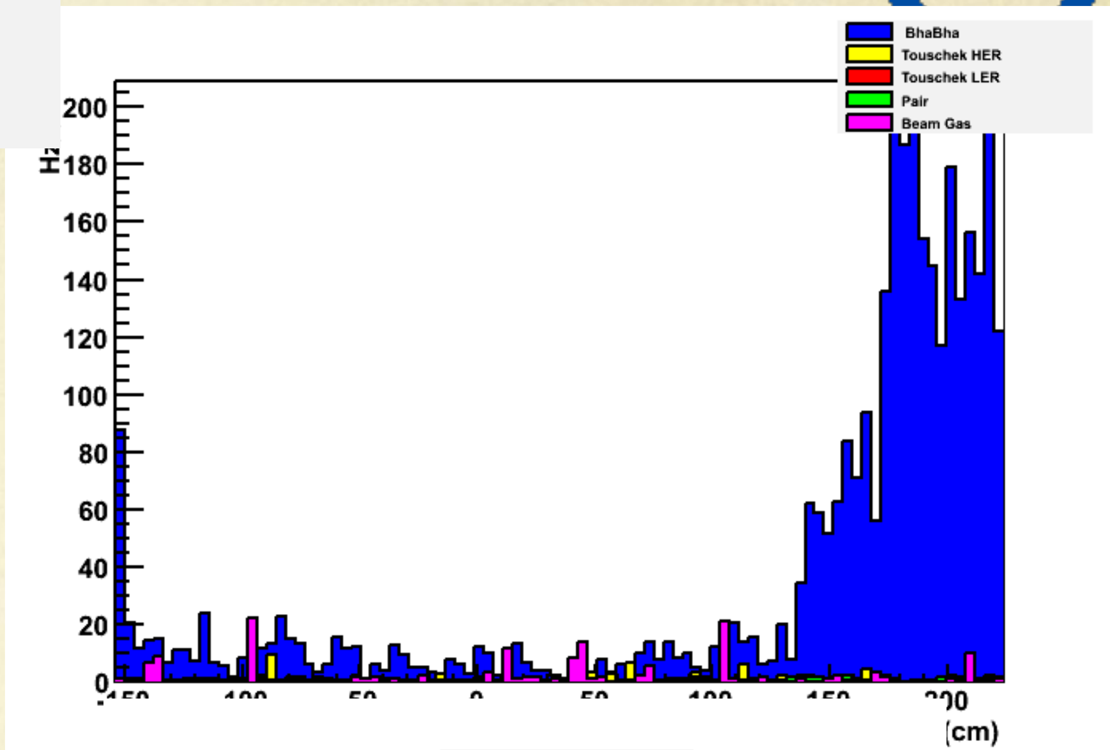
Photons of energy ~2.223 MeV are from neutron capture on Hydrogen

Electrons for diffent background sources

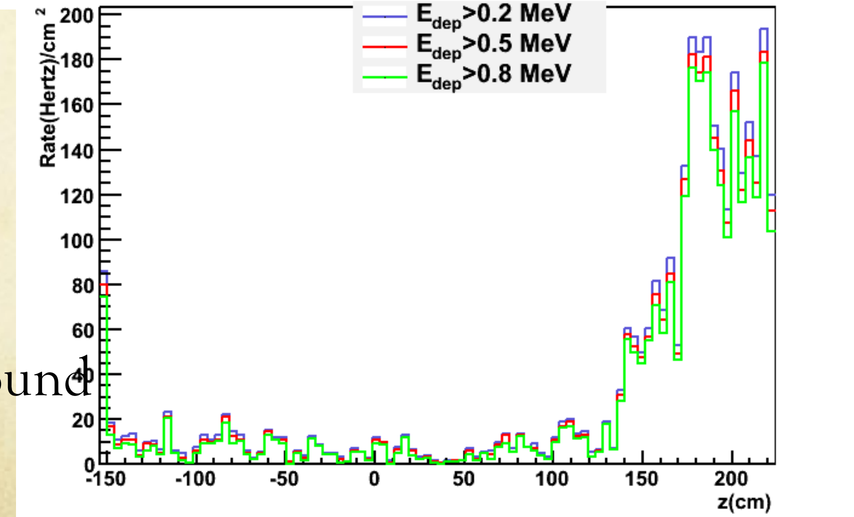
Barrel: Electron Energy Distribution



Rate Layer 0 vs Z-coordinate for Barrel



Rate Layer 0 vs Z-coordinate for Barrel with different cut on deposited Energy

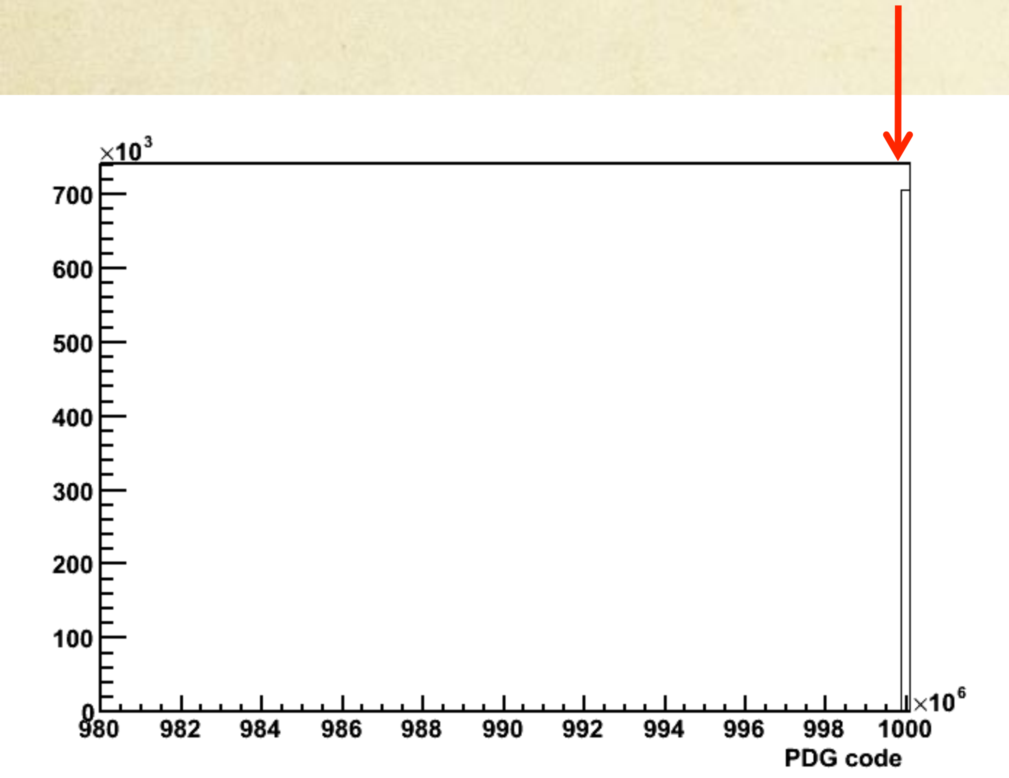


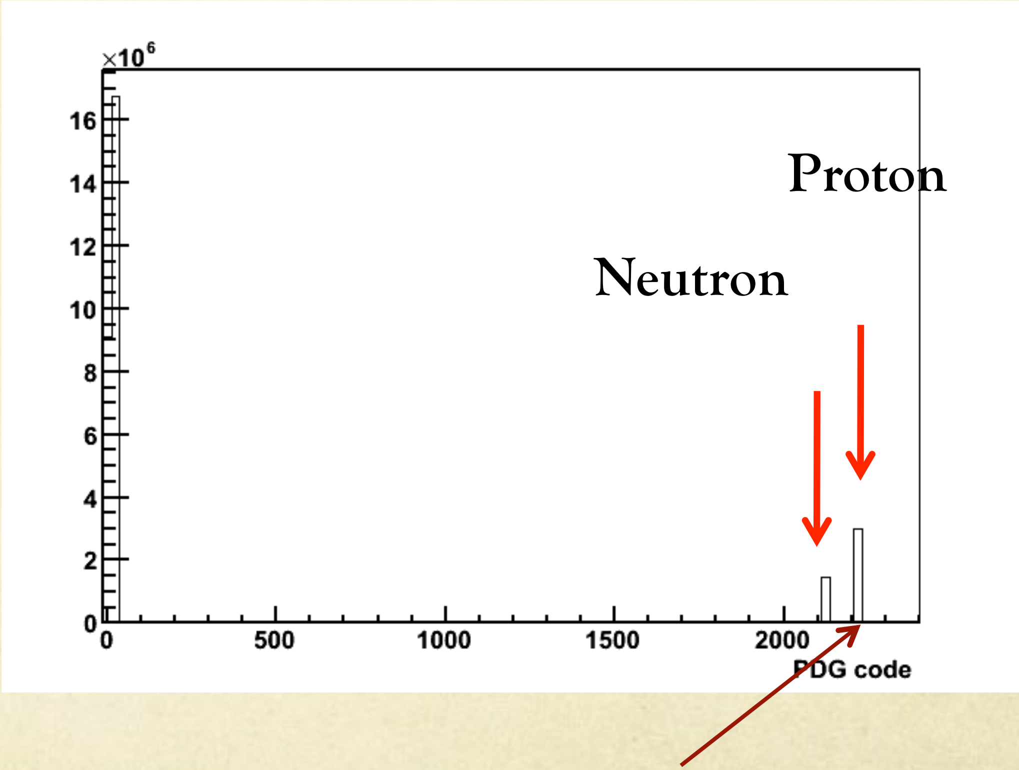
The impact of the electron rates due to the background must be considered on the muon id

Particle composition of the IFR background

For BhaBha, Touschek Pair, BeamGas events the particle crossing the IFR are photons, electron, protons, neutrons and heavy nuclei

Carbon ion



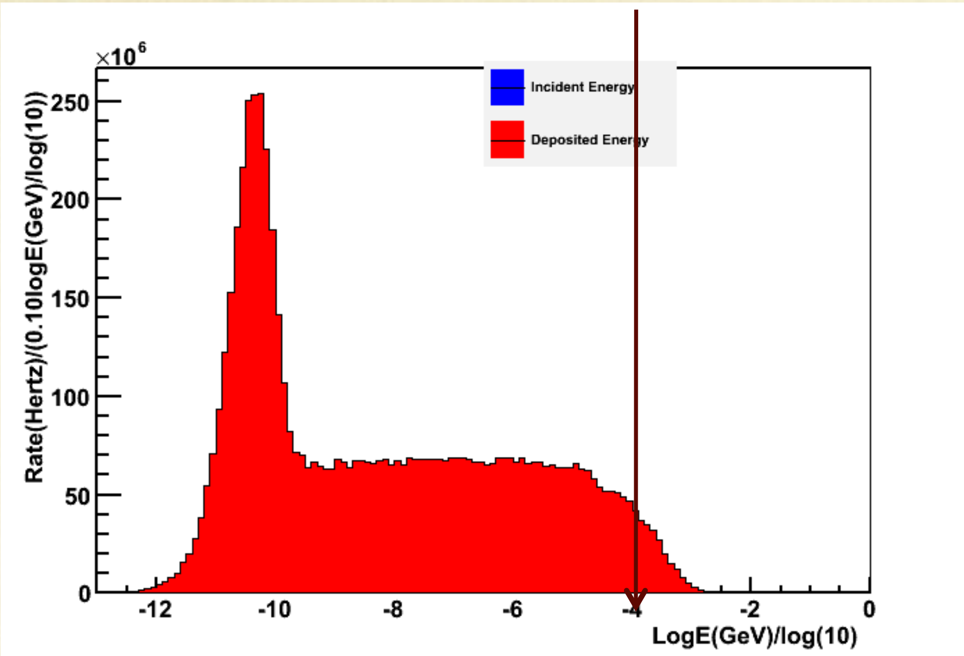


We have a higher number of protons than neutrons

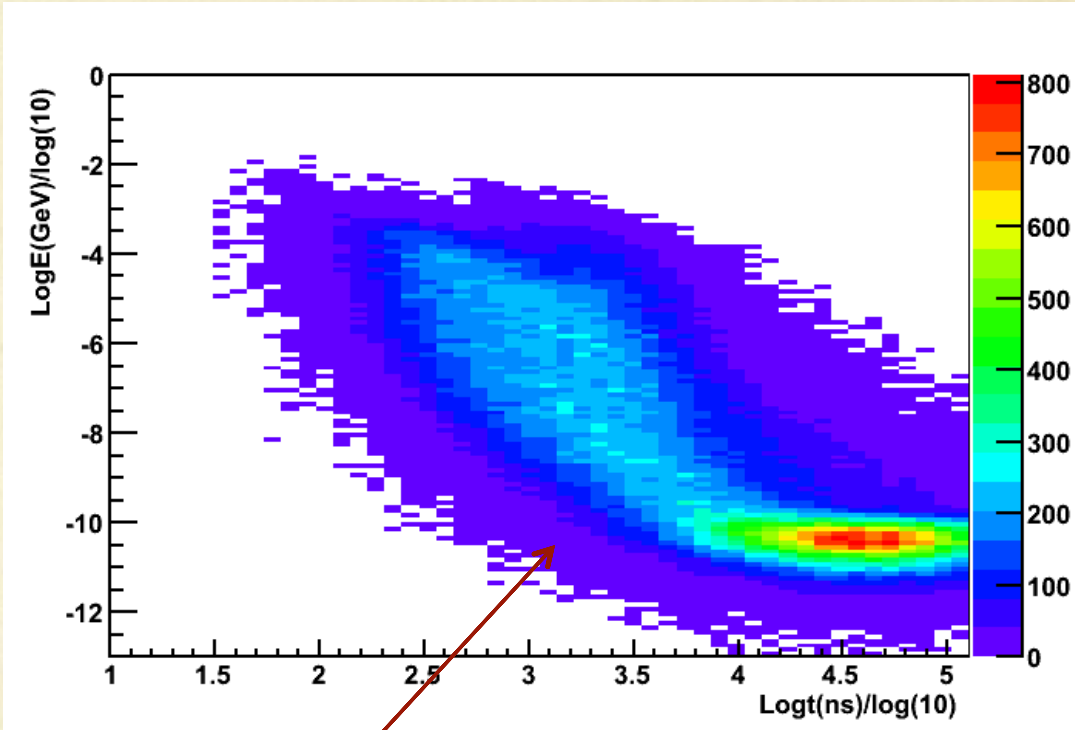
Where are these protons from? (1)

- These protons are not present in the boundaries -> they are produced inside the IFR

Proton Energy



Proton Energy vs time distributions



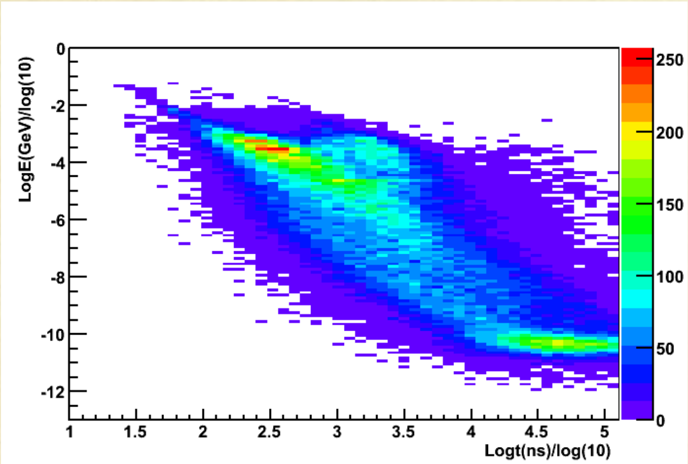
Even if the energy of the proton is very low there is a small fraction of protons that can have energy enought to be considered in the range of charge particle detected in the IFR

They time evolution of these protons is very peculiar

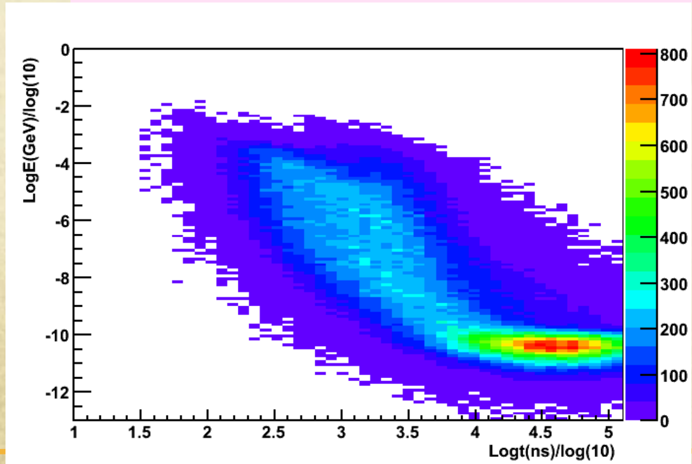
Where are these protons from? (2)

- The time evolution of the protons remaind that one of the neutrons

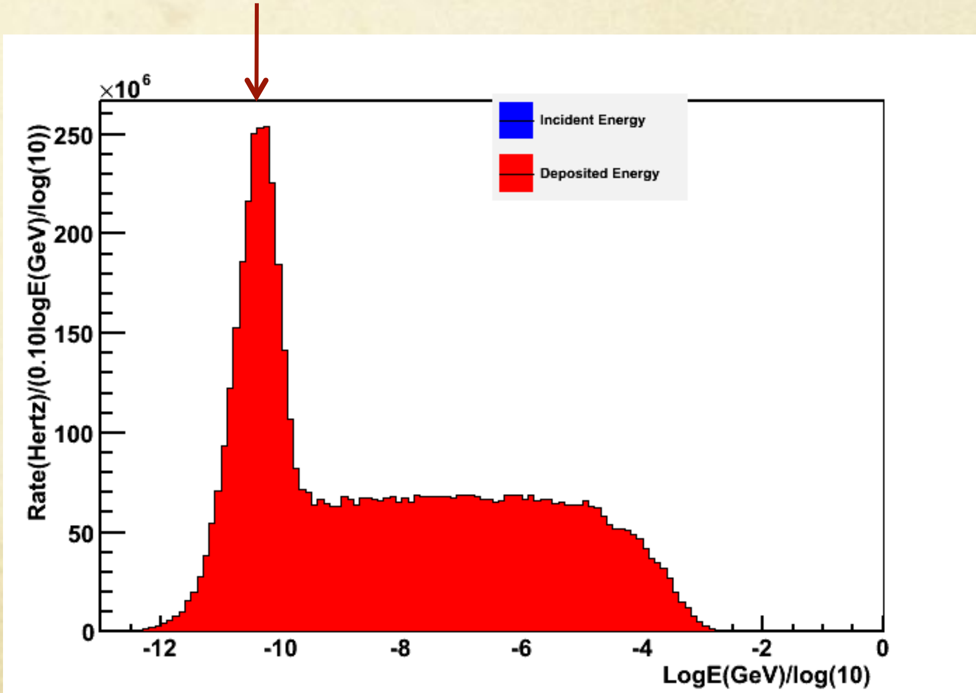
Neutron Energy vs time distributions



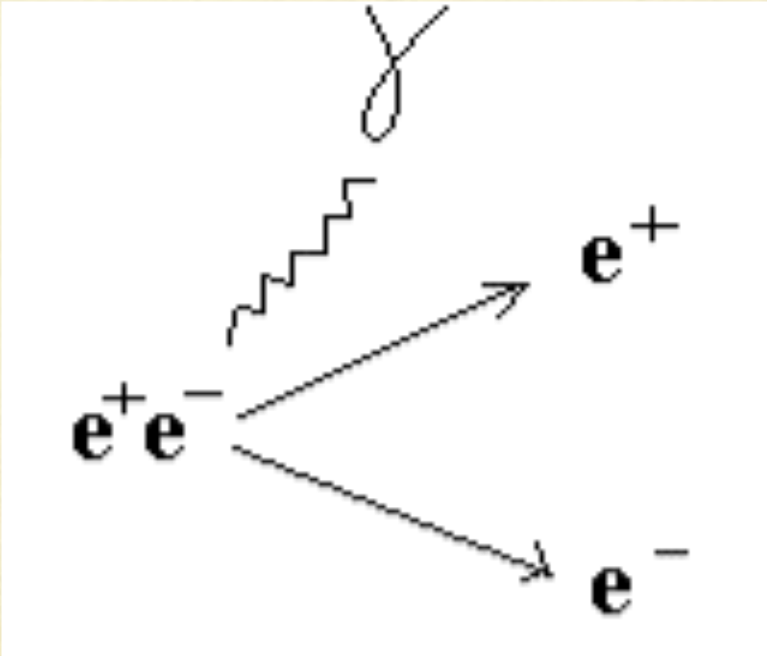
Proton Energy vs time distributions



This means that they are produced by the neutrons throught the following process (n,p) in which the Neutron is captured and a proton is emitted
The cross section for this process falls as 1/v so it Is more likely to happen when the neutron has low energy. This is the reason for the big peak at low proton energy.

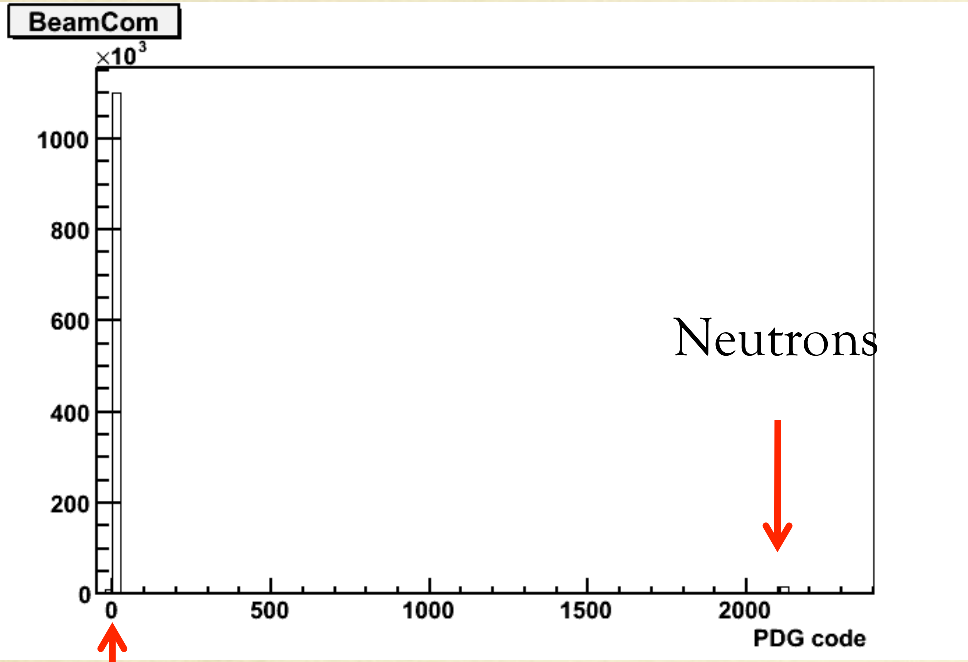


Radiative BhaBha background crossing the IFR FEE boards

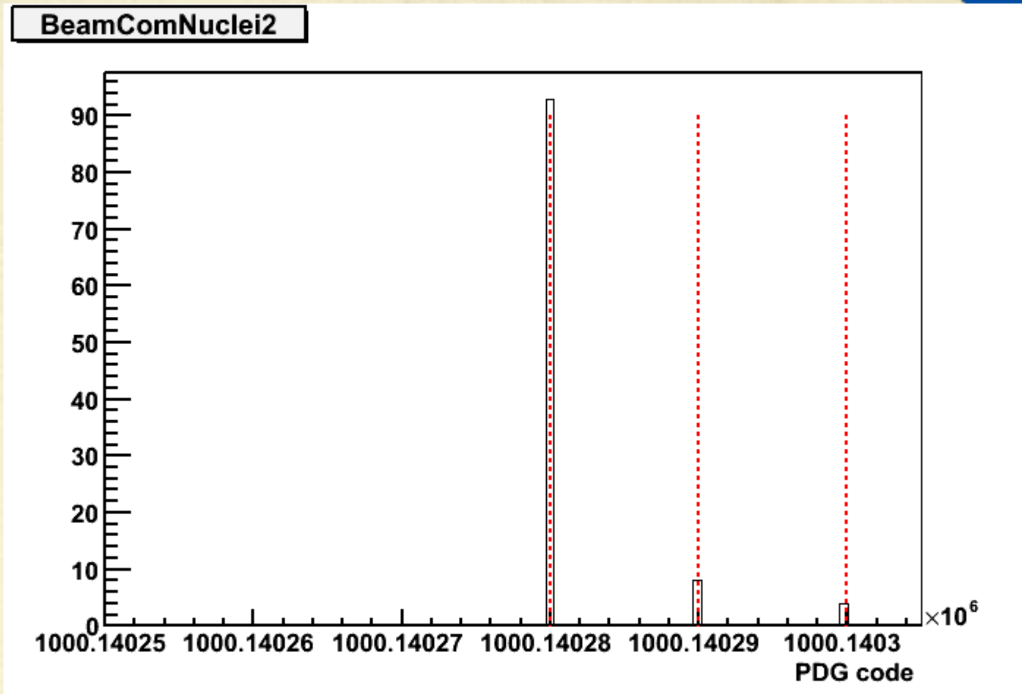


Beam Compositions for FEE electronics

- For BhaBha, Touschek and Pair events the particle crossing the FEE are photons, electron, protons, neutrons and heavy nuclei

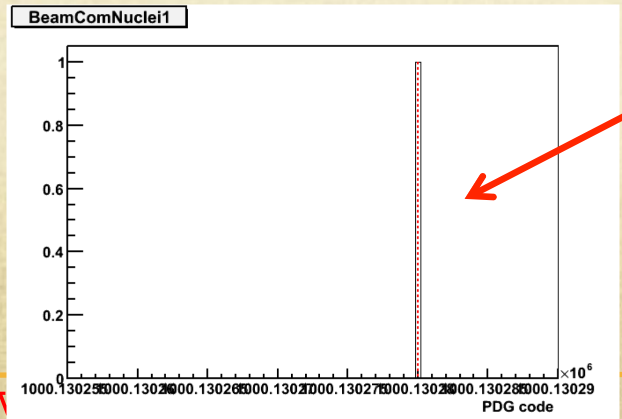


Photons, electrons



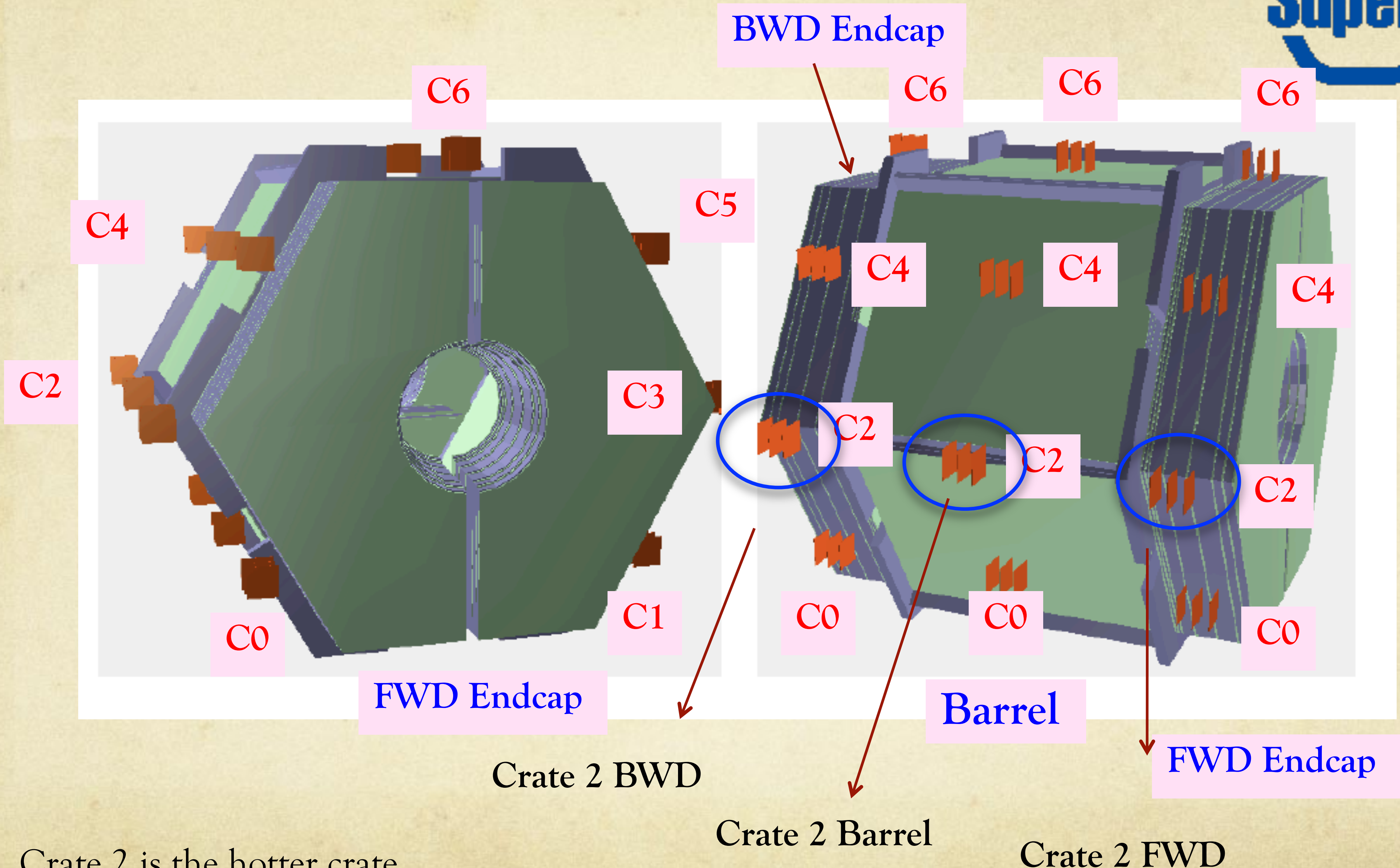
These 3 peaks are Si^{28}, Si^{29}, Si^{30} ions

These are the 3 isotopes that form the natural Silicon that we have in our FEEs



There are also Al^{28} this comes from the reaction Si^{28}(n,p) Al^{28} , Al^{28} is a radioactive aluminium Isotope that decay to Si^{28}

Present layout of the IFR crates



Crate 2 is the hotter crate

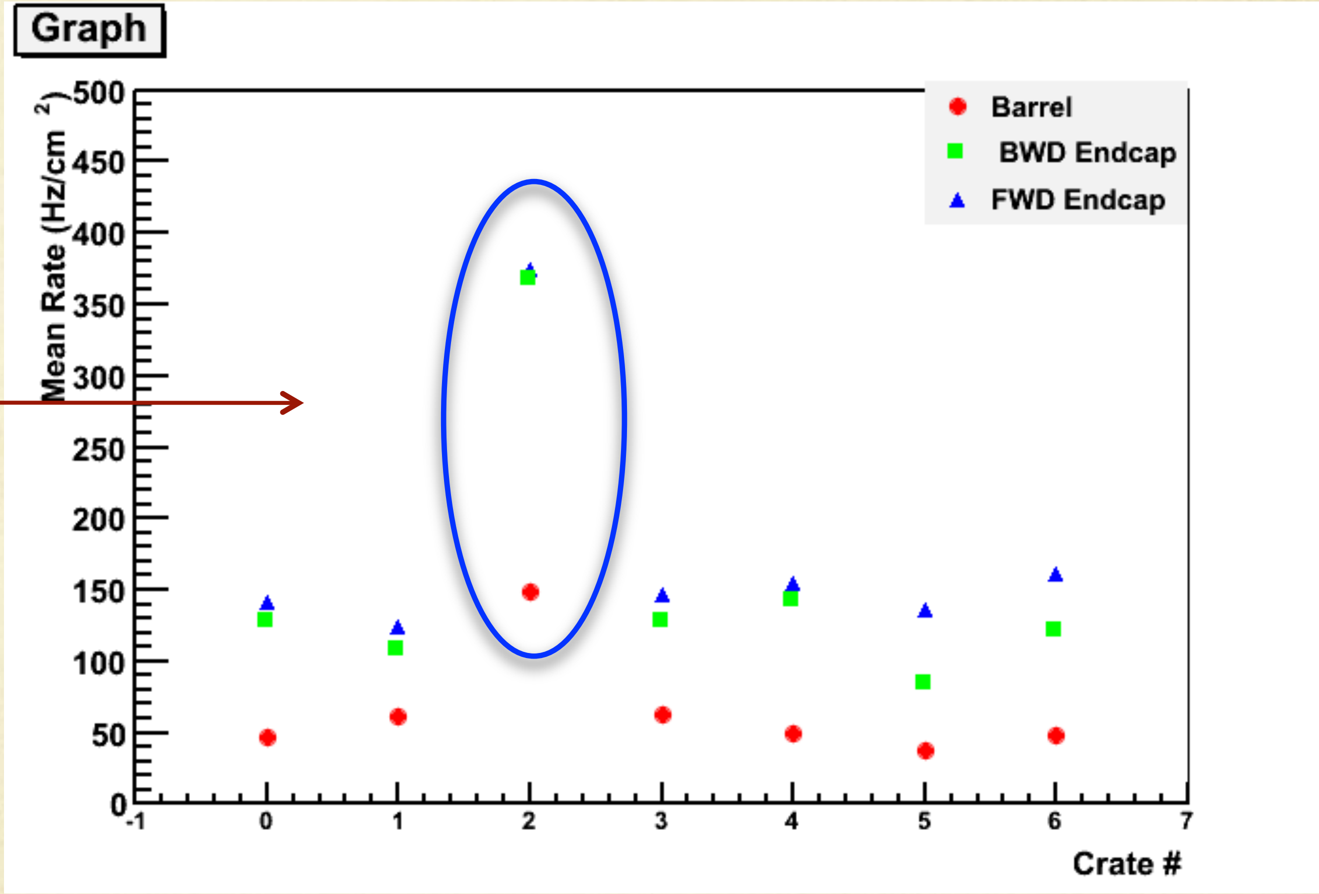
Neutron Rates for FEEs Electronics

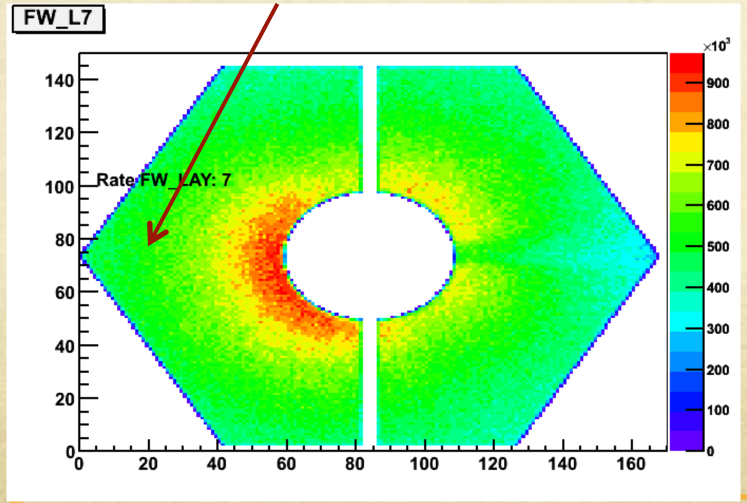
- Rate on electronics comparable to that one on the last IFR layer)

Mean Rate for each FEE in different Crates

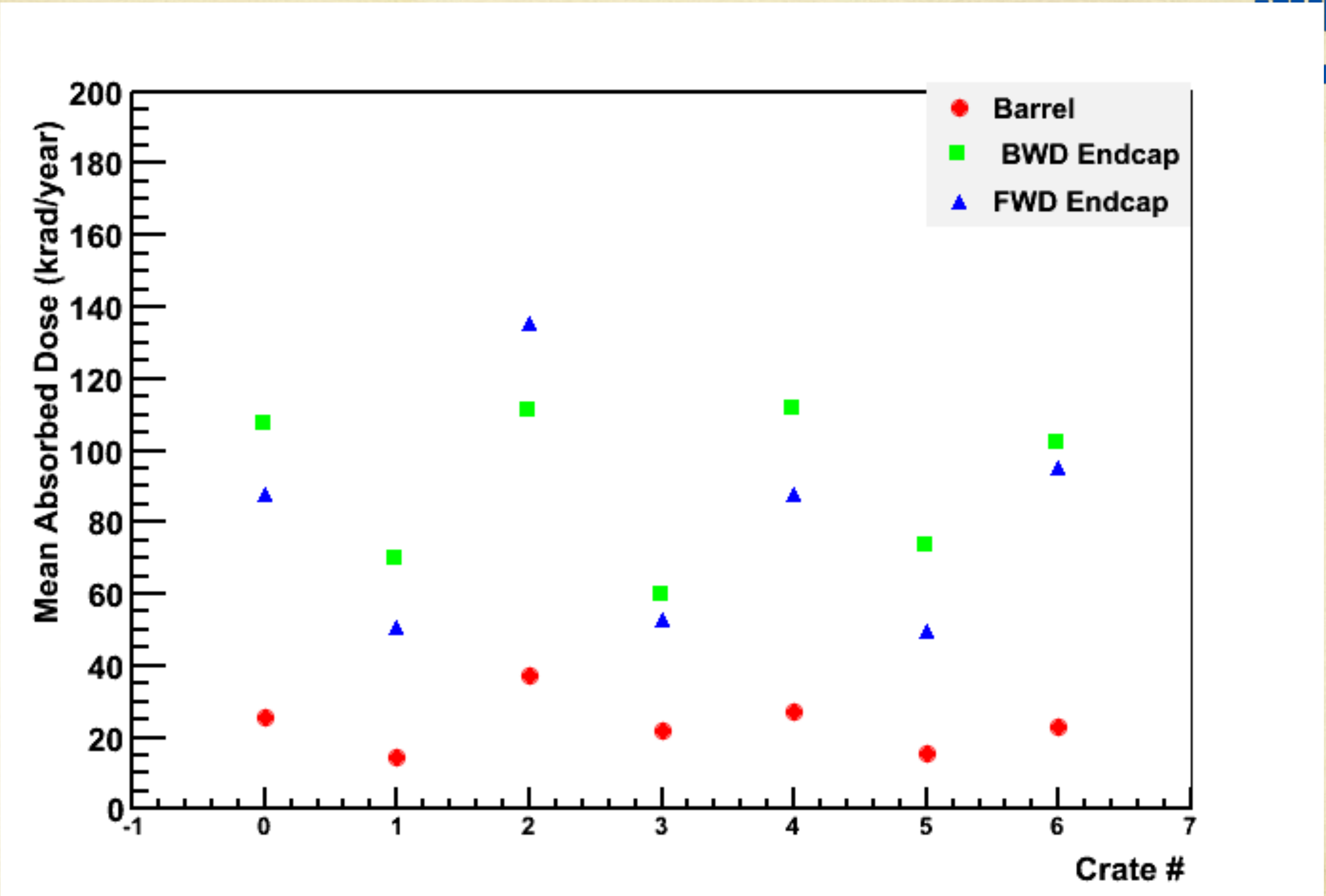
Crates located in the FWD have systematically higher rates compared to that one in the Barrel

Crate 2 very hot compared to other one the crate 2 is located on beam plane negative X





Absorbed Dose for each FEE Crates



Radiation Shielding

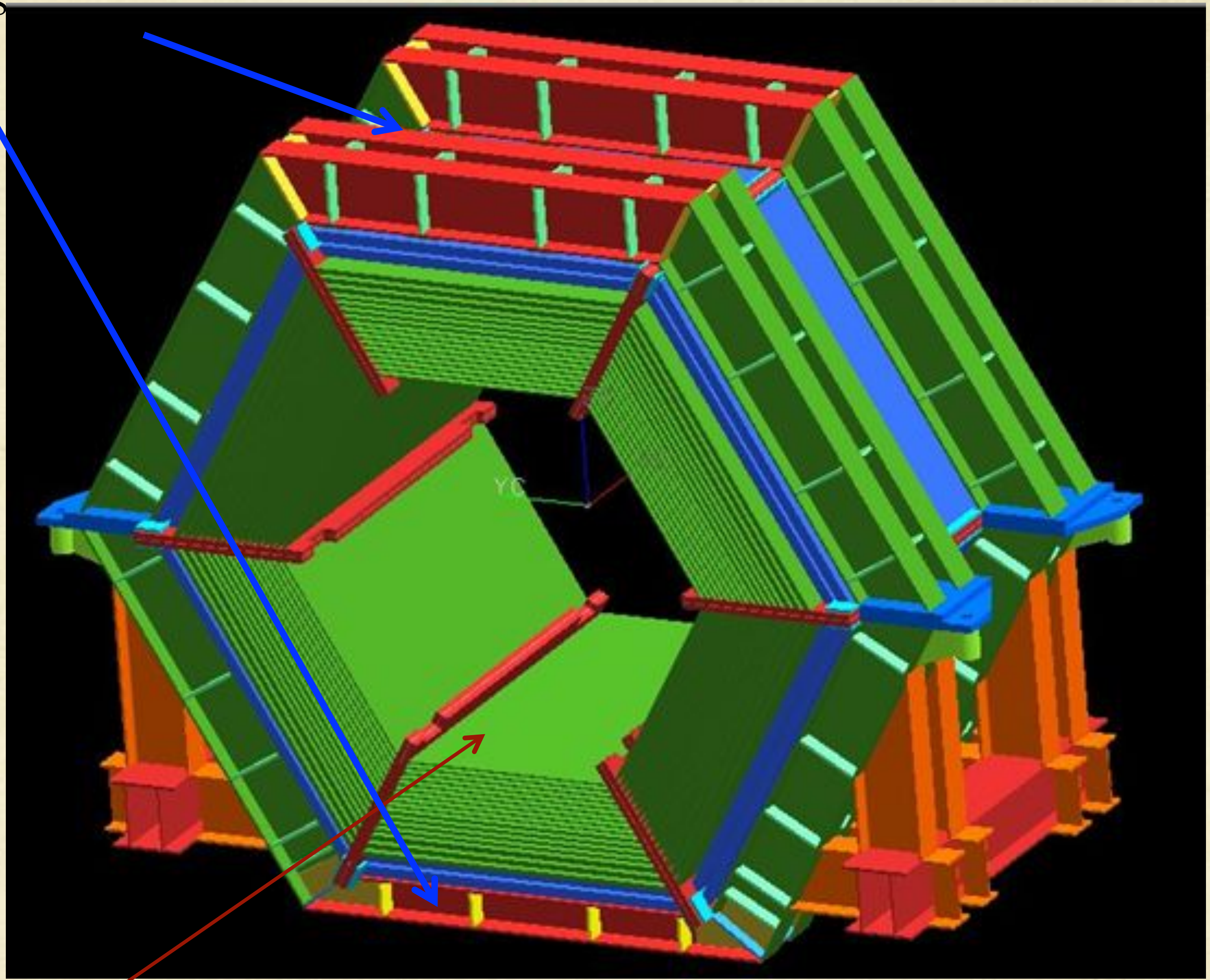
IFR-Shielding Strategy(1)

- We would like to implement some Boron-loaded polyethylene, shield for neutrons:
  - A shield between the IFR barrel and the magnet (50mm)
  - Add a shield between the EMC and magnet (21mm available)
  - Add a shield at small raadius for the Endcap
- Add the IRON Structures around the IFR envelope (It will shield charged tracks and photons coming from the beam)

Thanks to Massimo for the information on the IFR structure

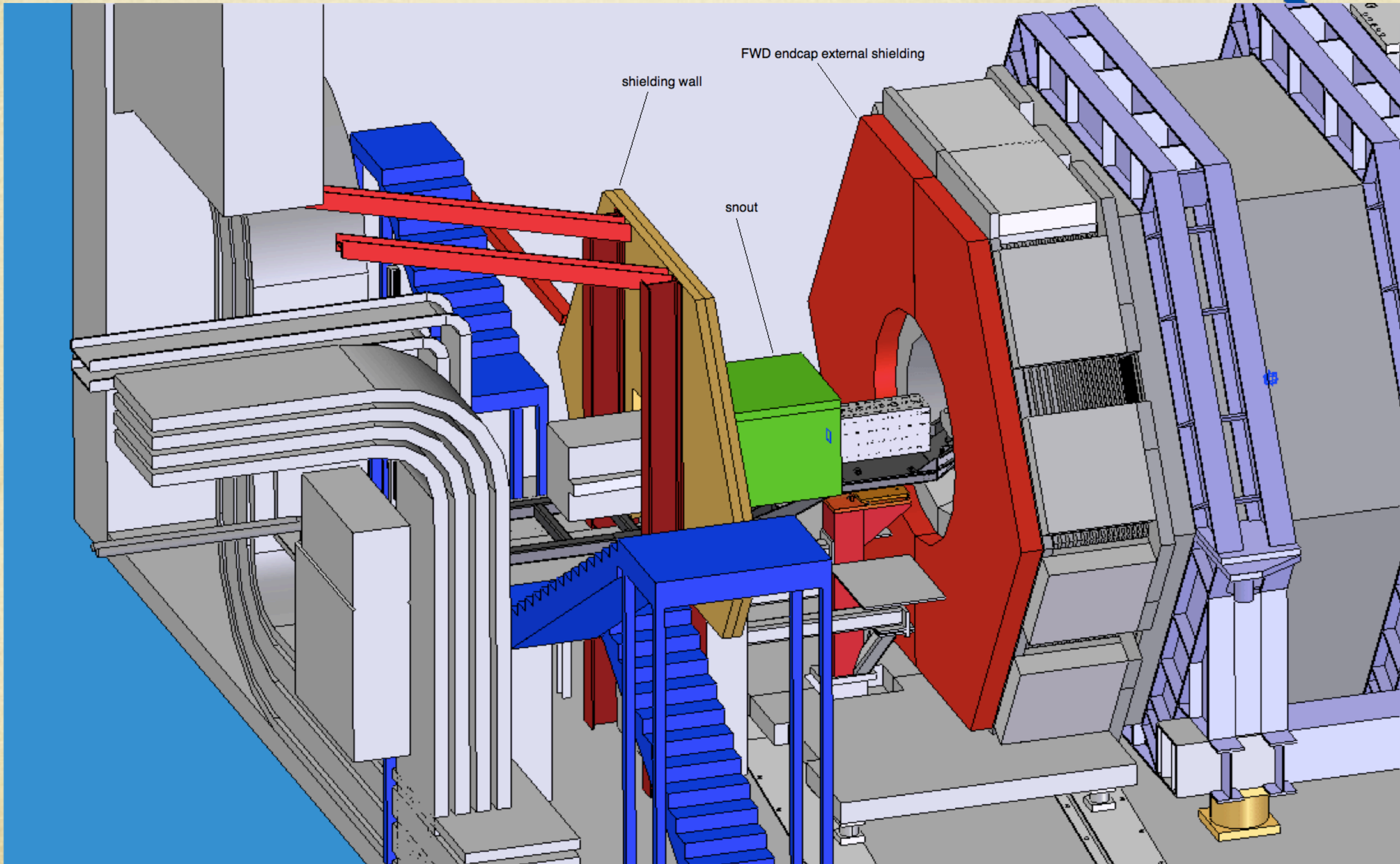
IFR-Shielding Strategy(2)

We have to implement these external structures

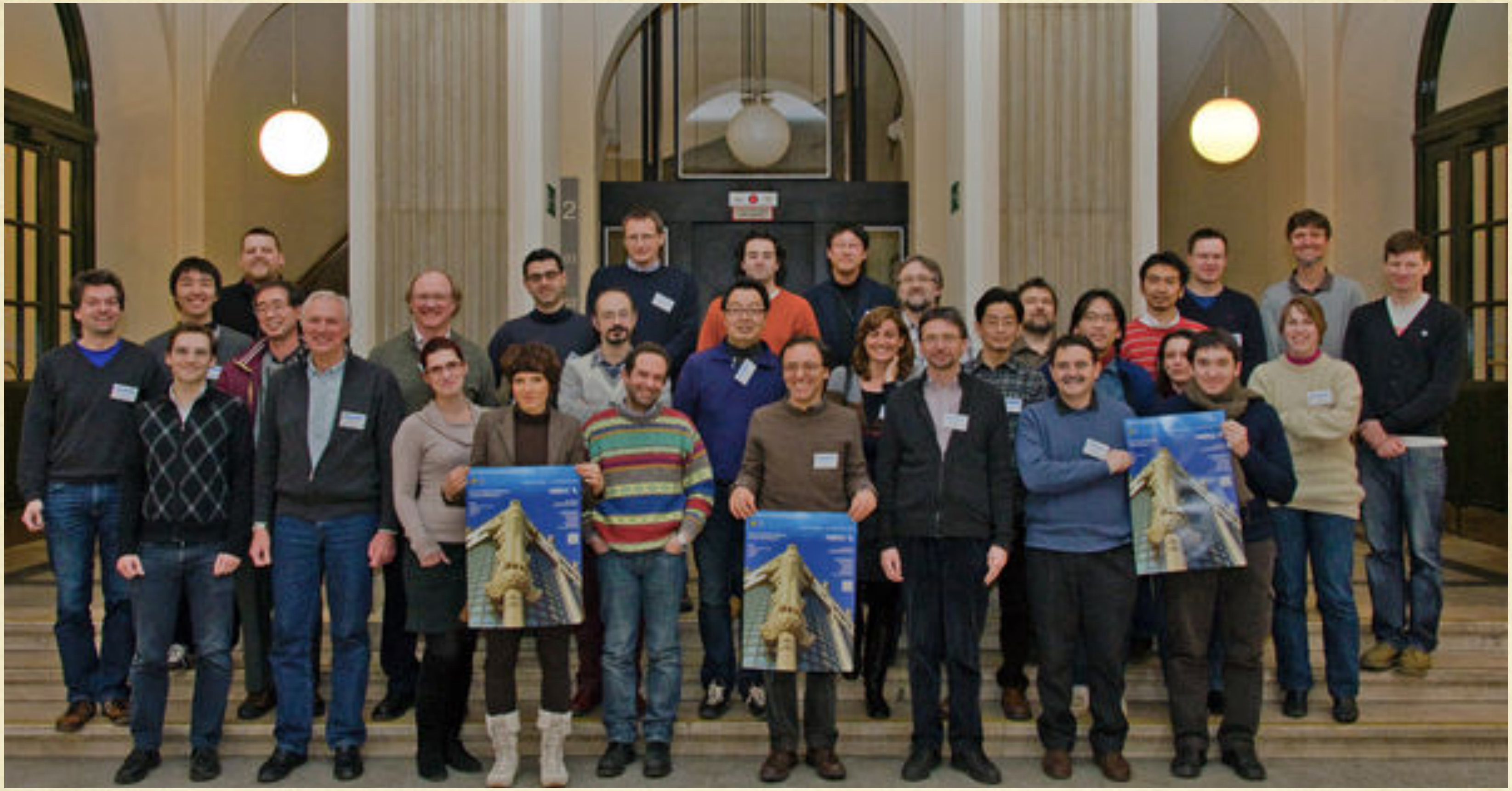


Shield between magnet and Barrel will go in that location

BaBar Shields



Report from Joint Belle2 and SuperB Meeting



41 participants, several talk , several discussion …
We now agree on the main source of background ->Radiativa BhaBha
Some additional discrepancy seems now fixed

Full simulation

- GEANT4-based ("QGSP_BERT_HP")
- Whole detector implemented
- No beam line elements |z|>4m (further geometry is urgent)
  - No showers/neutrons from tunnel!
- Input:
  – Track particles by SAD until they hit beam pipe wall, record position and momentum, then pass that information to GEANT4 (Touschek/Beam-gas)
  – BBBrem particles are tracked from IP by SAD until they hit beam pipe wall, record position and momentum, then pass that information to GEANT4 (RBB)
  – Use KoralW output directry in GEANT4 (2photon)

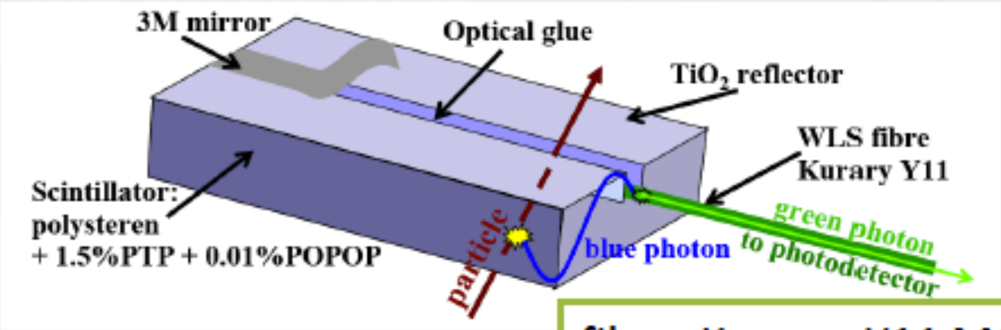
- First campaign was in Dec. 2011
  - 0.9GHz Touschek LER /2-photon
- Second Campaign in Feb. 2012 (coming soon)
  - Touschek/Beam-gas/Rad. Bhabha/2-photon

We need to check:

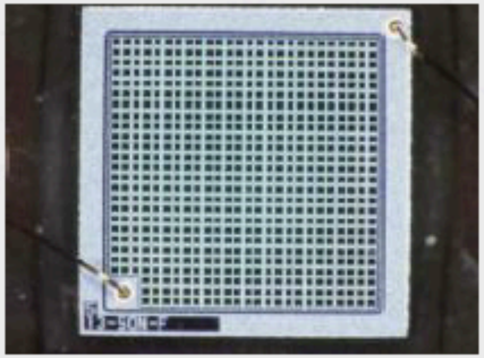
-True event signals are not hidden by fake background hits?
-Our detectors/readout electronics are not severely damaged by radiation or neutrons?

KLM

RPC → Scintillator bar + MPPC for endcap and innermost n layers in barrel

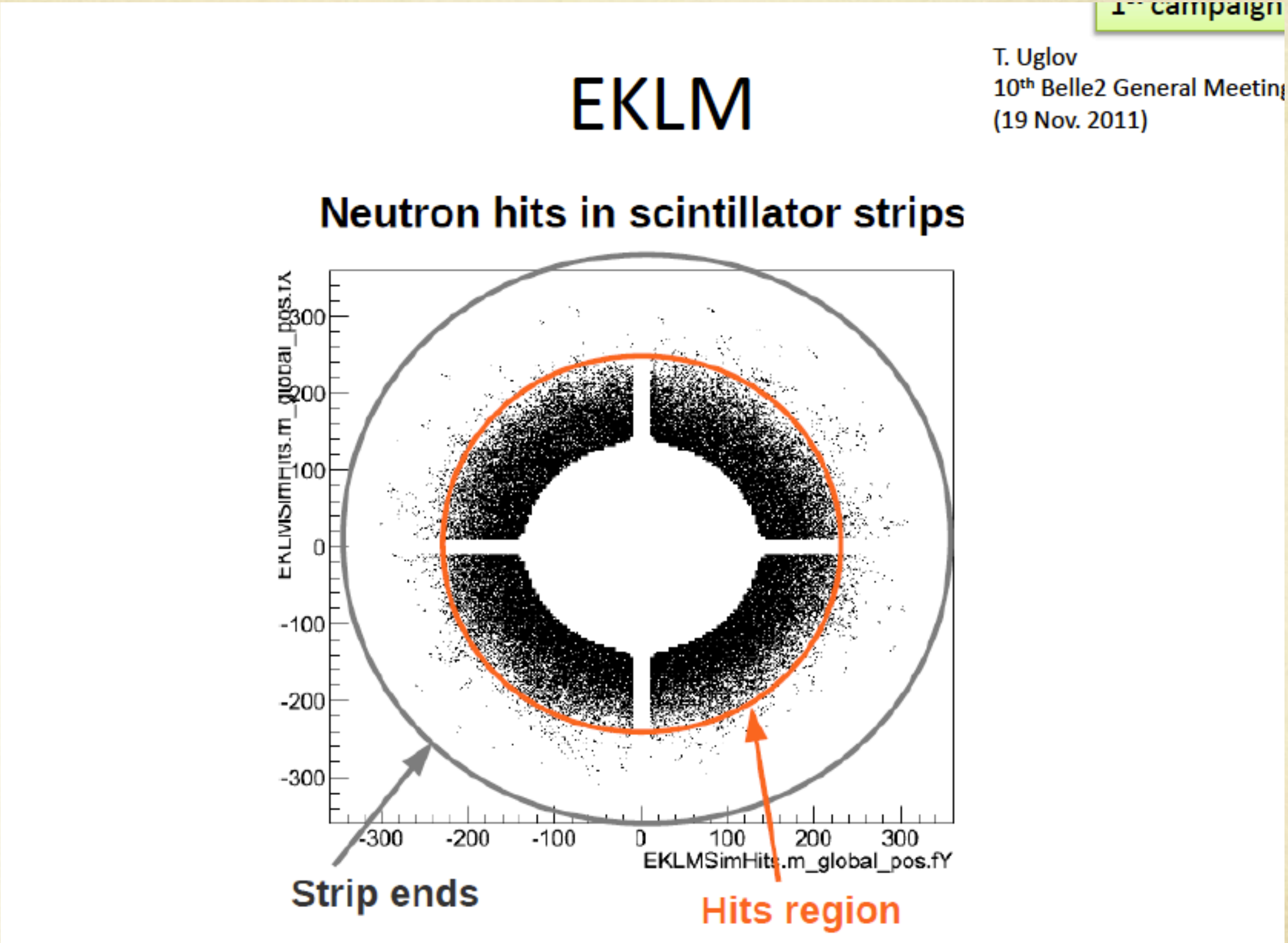


fiber: Kuraray Y11 MC



MPPC: Hamamatsu
1.3×1.3 mm 667 pixels
(used in T2K ND)

Belle-II background situation on IFR (Endcap)



BELLE-II IFR Background

- Detector design was started assuming 20 times more background (the best knowledge at that time based on extrapolation)
  - 10^{12}n/cm2/10 years@endcap
  - 100-1000Gy/10 years @endcap
- Background simulation studies post-validate the extrapolations

Neutron rates on BKLM

Simulation

Layer	Neutron flux (Hz/cm^2)	Hit rate (Hz/cm^2)	Efficiency
0	2407	17.3	0.13
1	1762	12.7	0.36
2	1221	8.8	0.55
3	785	5.6	0.71
4	504	3.6	0.81
5	293	2.1	0.89

LER Touschek only

Hit rate (Hz/cm^2)	Efficiency
—	1.00
—	1.00
2.3	0.88
1.4	0.92
1.0	0.94
0.6	0.96

Extrapolation

		ext.	replace L00	replace L00/01	twice rate
L00	rate(Hz/cm^2)	7.5	7.5	7.5	15
	eff.	0.38	1	1	1
L01	rate(Hz/cm^2)	4	2.7	2.7	5.4
	eff.	0.67	0.78	1	1
L02	rate(Hz/cm^2)	2	1.3	0.9	1.8
	eff.	0.83	0.89	0.93	0.85

replaced by scintillator

Estimated neutron rates on BKLM roughly matches to the extrapolation from KEKB data; still acceptable after replacing 2 inner layers. Neutrons from radiative Bhabha to be checked.

1st campaign

Neutron flux

1MeV equivalent rate

1 year = 10^7 sec

	Region	Simulation (Touschek BG)	Assumption used for R&D	Life time by irradiation test based on the assumption
PXD	Sensors, readout	2×10^{11}/cm2/year (+0.7×10^{11} from 2-photon)	10^{12} /cm2/year	OK for at least 10 years (10^{13} n/cm2)
SVD	Sensors, chips	3×10^{11}/cm2/year	-	...ould be OK ...ted in ATLAS/CMS)
CDC	Readout Boards	~1×10^{10}/cm2/year	10^{11} /c...	...PGA) is OK for at least 2(5)
TOP	Readout electronics	~ 5×10^{10}/cm2/year		...e tested
ARICH	HAPD/ASIC	~7×10^{10}/c...	.../year	OK for at least 4 years
ECL	Diodes	...	...0^{11} /cm2/year	OK for at least 40 years
EKLM	SiPMs	<... - up... ...served no hits - not ... neutrons which travel ...ore than 10us	10^9/cm2/year	OK for at least 10 years
BKLM	SiPMs	2~8×10^9/cm2/year	2×10^{10}/cm2/year	OK for at least 10 years

Should be updated in 2nd campaign

Summary and Future Plans

- ✓ Radiative BhaBha, Touschek,Pair and Beam-Gas backgrounds have been studied in details.
- ✓ The effect of these backgrounds have been also studied on our FEEs
- ✓ IFR TDR background on writing

- ☐ We have to add shielding between EMC and solenoid and between solenoid and IFR layer 0 to moderate neutrons
- ☐ We need to add the external iron structure for neutrons and charged tracks
- ☐ The effect of background on PID will be studied in details with FullSim
- ☐ All the numbers that you have seen in this presentation do not include the safety factor (x5) that must be included to have the final background estimation

BACK-UP SLIDES