Radiative BhaBha background for FTOF detector

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Elba meeting

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Outlook

- Introduction
- Geometry reminder
- Number of background photoelectrons estimation
- Time distribution of the background photoelectrons
- Main source of background
- Absorbed dose by FTOFFEE

Numbers we are using in the following for our calculations

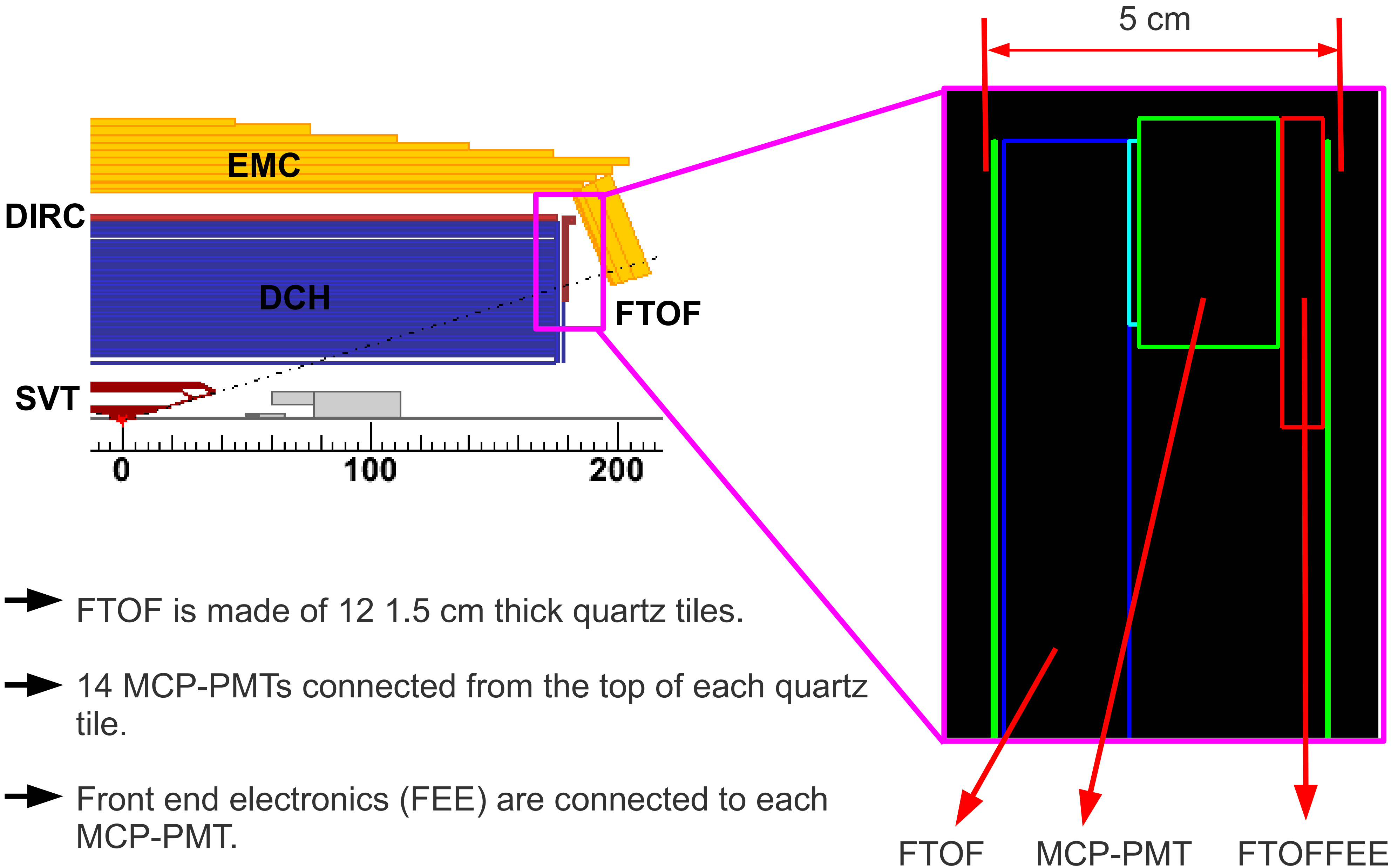
- **Seconds in one data taking year = 2 x 10^7 s (new Snowmass year)**
- **Bunch crossing frequency = 209 MHz**
- **Data taking duration 5 years @ L = 10^{36} cm^{-2} s^{-1}**
- **MCP-PMT SL10**
  - **Total number of PMTs = 168**
  - **Effective area = 2.2 x 2.2 cm^2 ***
  - **Multialkali photocathode**
  - **Collection efficiency = 60%***
- **FTOF surface ~ 1.87 x 10^4 cm^2, mass = 61.7 kg (ρ=2.2g/cm^3) (SiO_2)**
- **FTOFFEE** surface ~ 1.3 x 10^3 cm^2, mass = 1.5 kg (ρ=2.3g/cm^3) (Si)**

*** arXiv:1010.1057v1 (Lifetime-Extended MCP-PMT) T.Jinno et. all.**
http://arxiv.org/abs/1010.1057v1

**** FTOFFEE – FTOF Front End Electronics**

Total number of simulated bunch xing = 19695

FTOF and FTOFFEE geometry reminder



- FTOF is made of 12 1.5 cm thick quartz tiles.
- 14 MCP-PMTs connected from the top of each quartz tile.
- Front end electronics (FEE) are connected to each MCP-PMT.

Productions reminder

Production	Comment	Background rate
Annecy 2010		450kHz/cm^2
Frascati 2011	Bug in Bruno	45kHz/cm^2
Elba 2011	Most precise description of the machine	460kHz/cm^2

In the following we present analysis of the Elba 2011 production

Background photoelectrons estimation

The number of detected photoelectrons can be described with this formula:

$$N_{d.p.e.} = \int E_g E_c N_0 \sin^2(\theta_c)/\lambda^2 \, dx \, d\lambda$$

x - is the length of the track in the radiator

λ - wavelength of the photons

E_g - geometrical efficiency of the photon collection. In general this is a function of the position and direction of the track.

E_c - conversion factor from photons to photoelectrons. This is defined by the quantum efficiency of the photocathode and the collection efficiency of the PMT.

θ_c - Cherenkov angle

Production and propagation of the Cherenkov light is not implemented in Bruno yet for FTOF. Consequently the most precise method to estimate number of detected p.e. is to use a standalone full simulation of the FTOF detector and the information from Bruno about particles entering FTOF as input.

Other method (Proposed by Jerry) is to sum up at each step the number of detected p.e.:

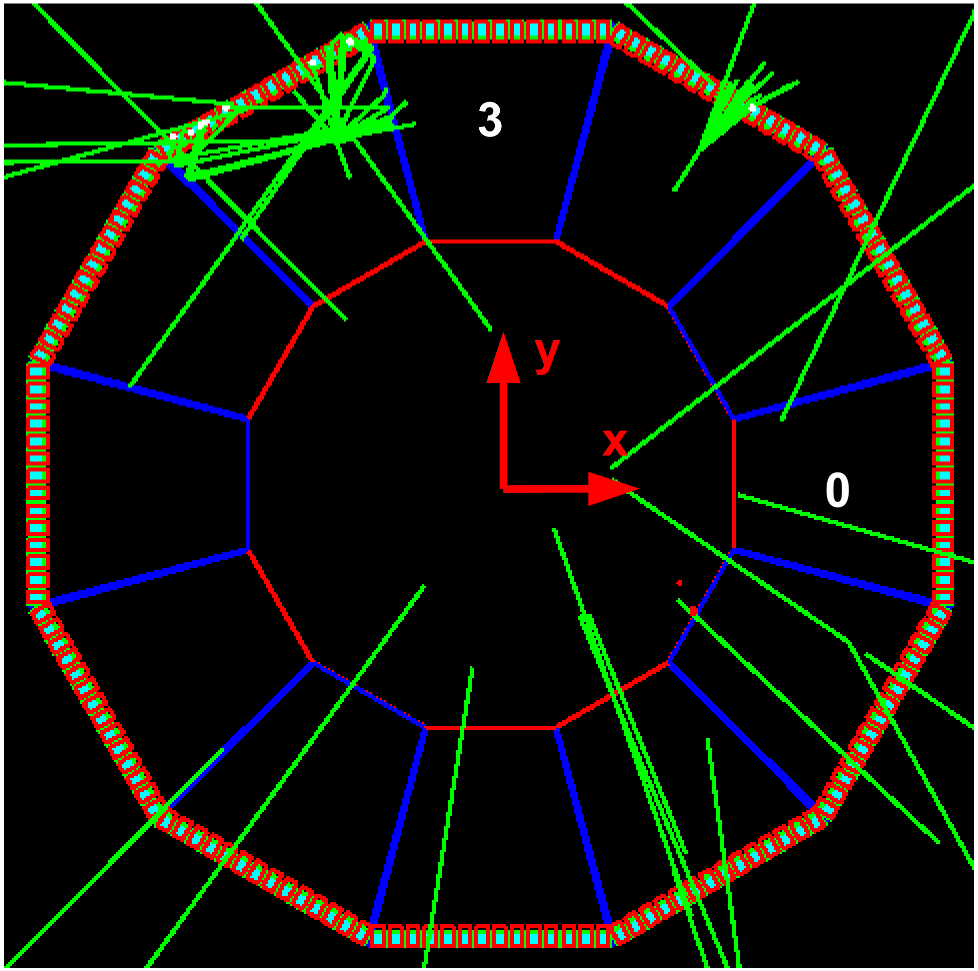
$$N_{d.p.e.} = 26 \sum L_i[cm](1 - 1/n^2/\beta_i^2)$$ L_i, β_i are available in Bruno

NOTE this formula valid only for BaBar DIRC detector

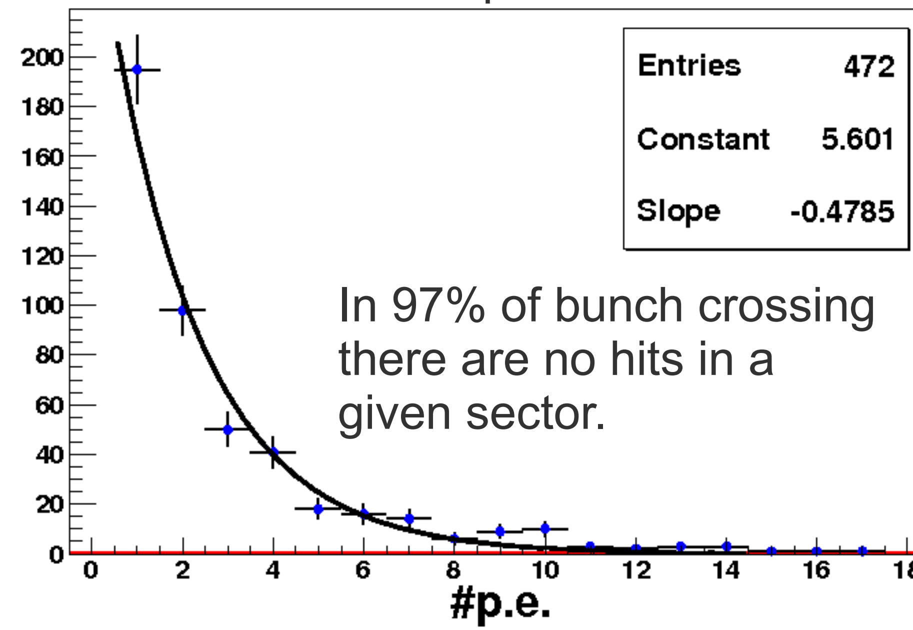
Background photoelectrons estimation

15000 bunch crossing simulated in total

One bunch crossing



Distribution of p.e. in sector 3



In 97% of bunch crossing there are no hits in a given sector.

<u>1.8 p.e. per bunch crossing in whole FTOF</u>

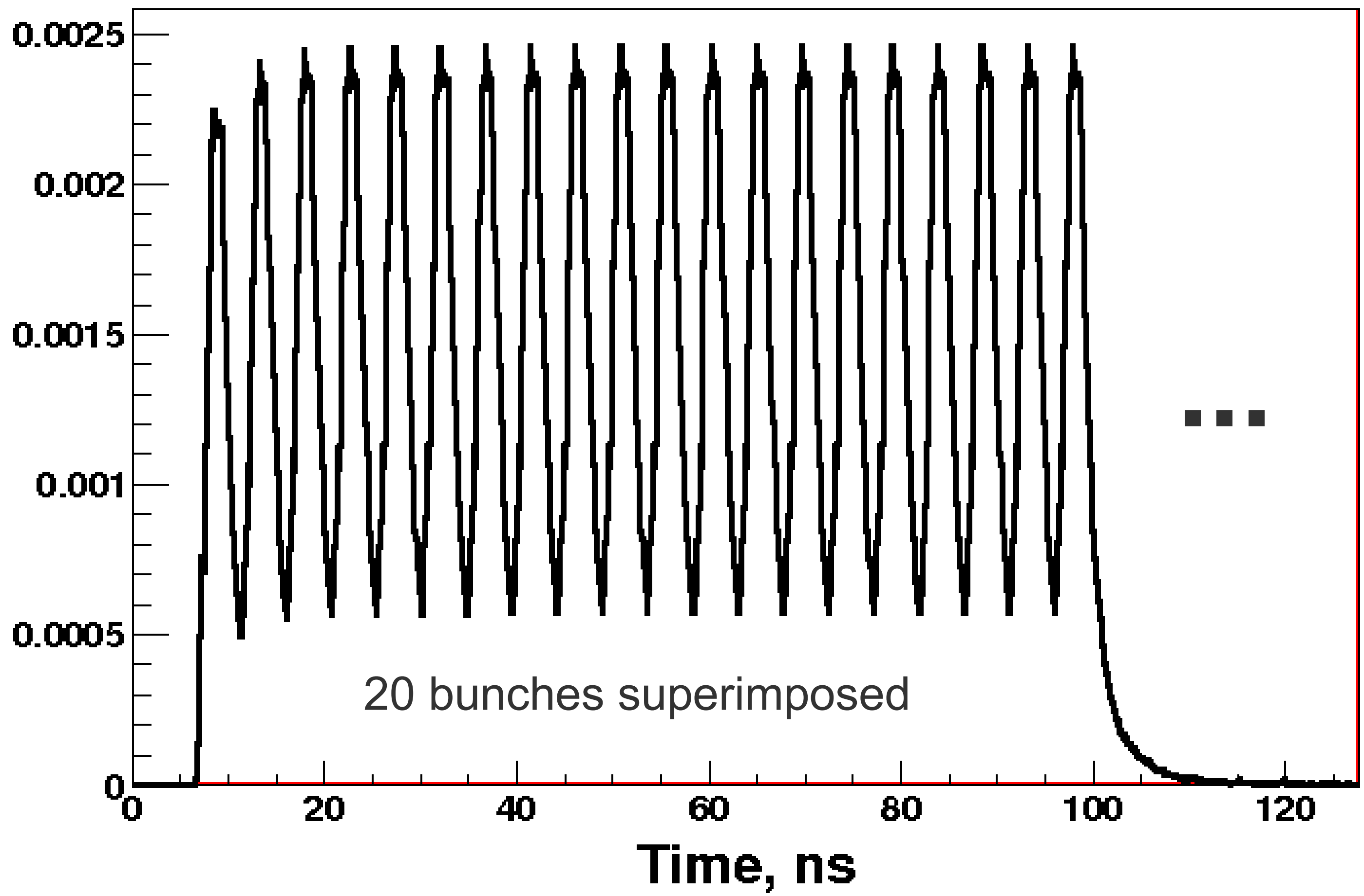
↓

460kHz/cm^2

Using "Jerry method" we get 3.2 p.e. per bunch crossing in whole FTOF detector.

Time distribution of the background photoelectrons

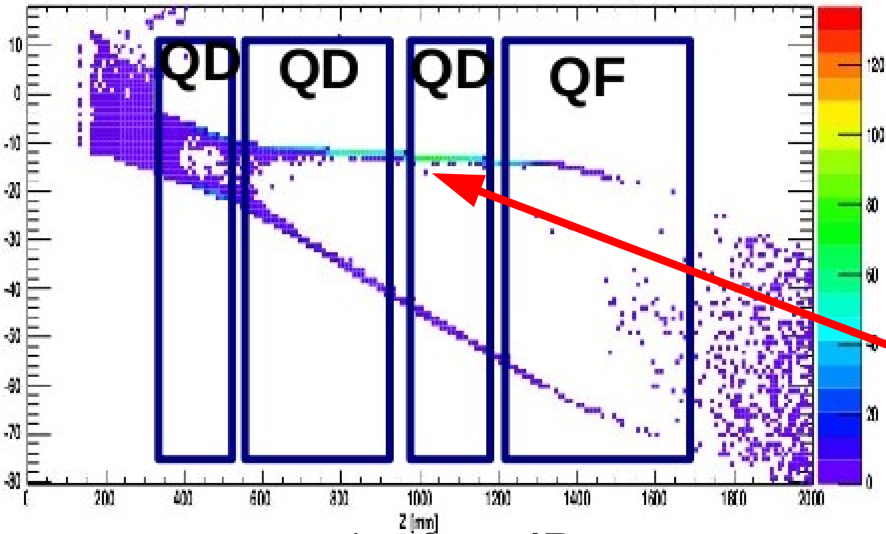
t = 0 corresponds to first bunch crossing



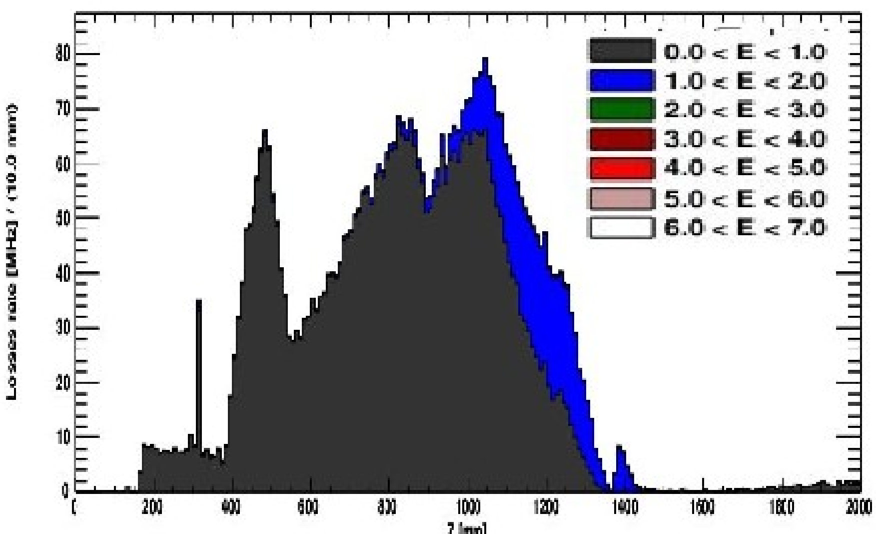
Bunch crossings every ~ 4.7 ns.

Hot spot caused by Radiative Bhabha effect

Positron losses along beam pipe



z ~1m from IP

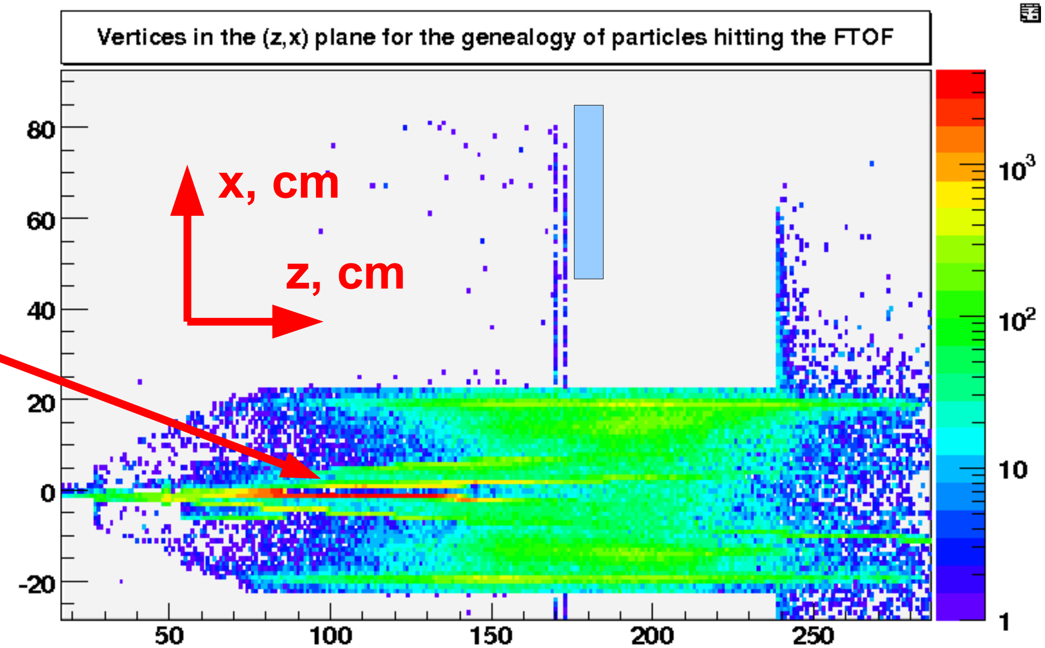


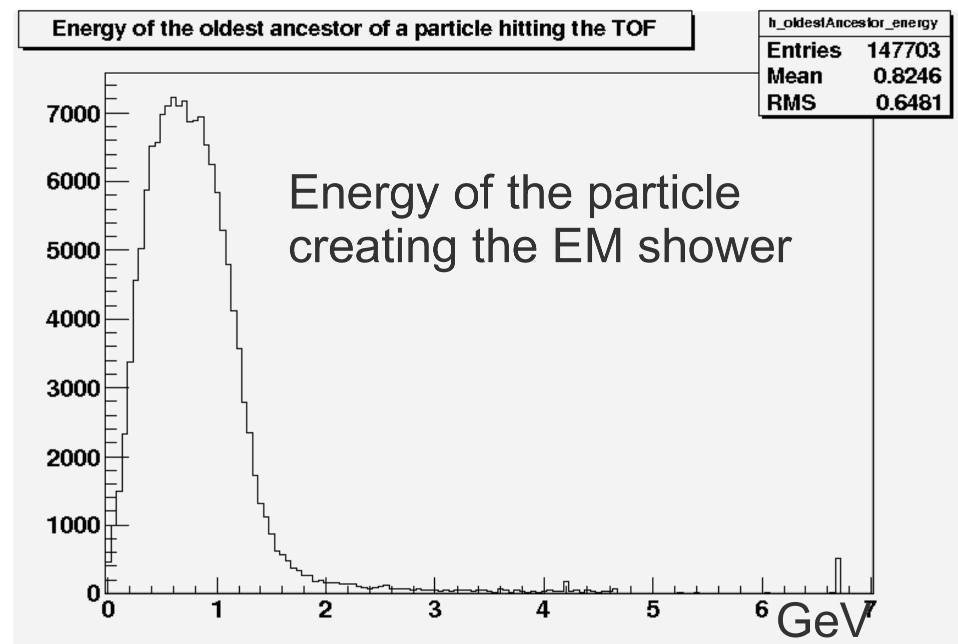
See this presentation (page 7)

http://agenda.infn.it/getFile.py/access?contribId=6&resId=0&materialId=slides&confId=3808

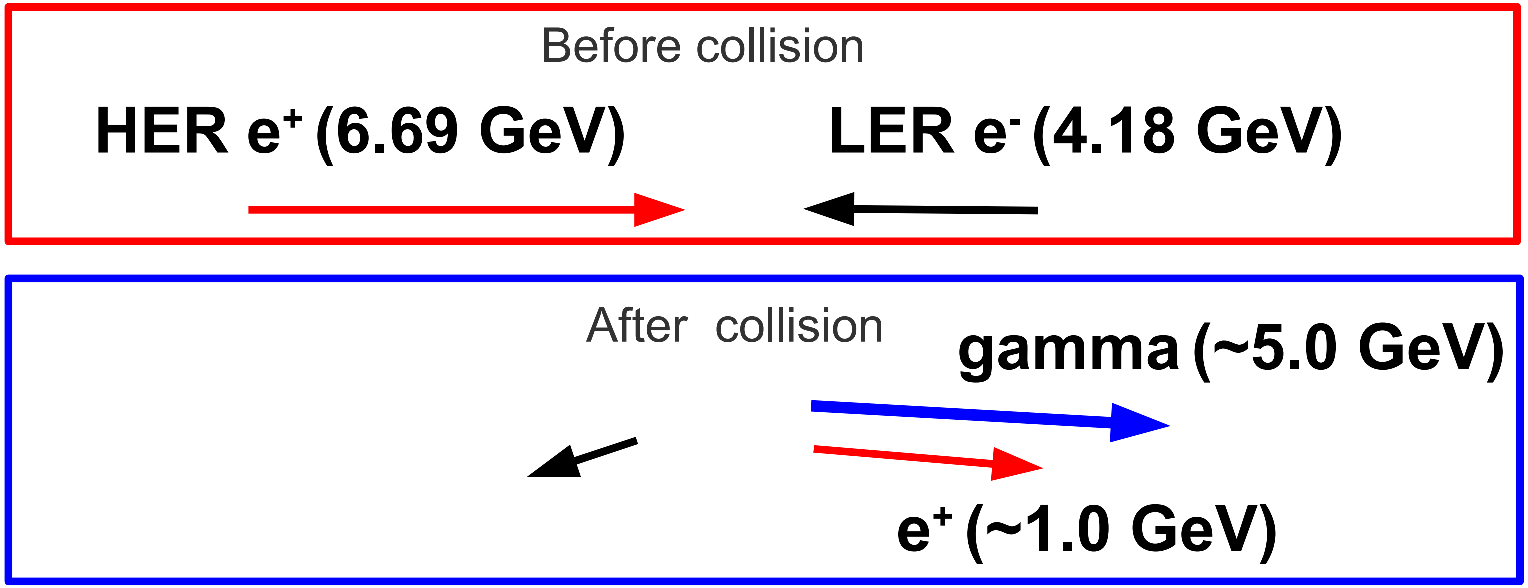
29.05.2011

Vertices of the genealogy of particle hitting the FTOF





Deeper look at the source of background
Final focus (sf11) layout



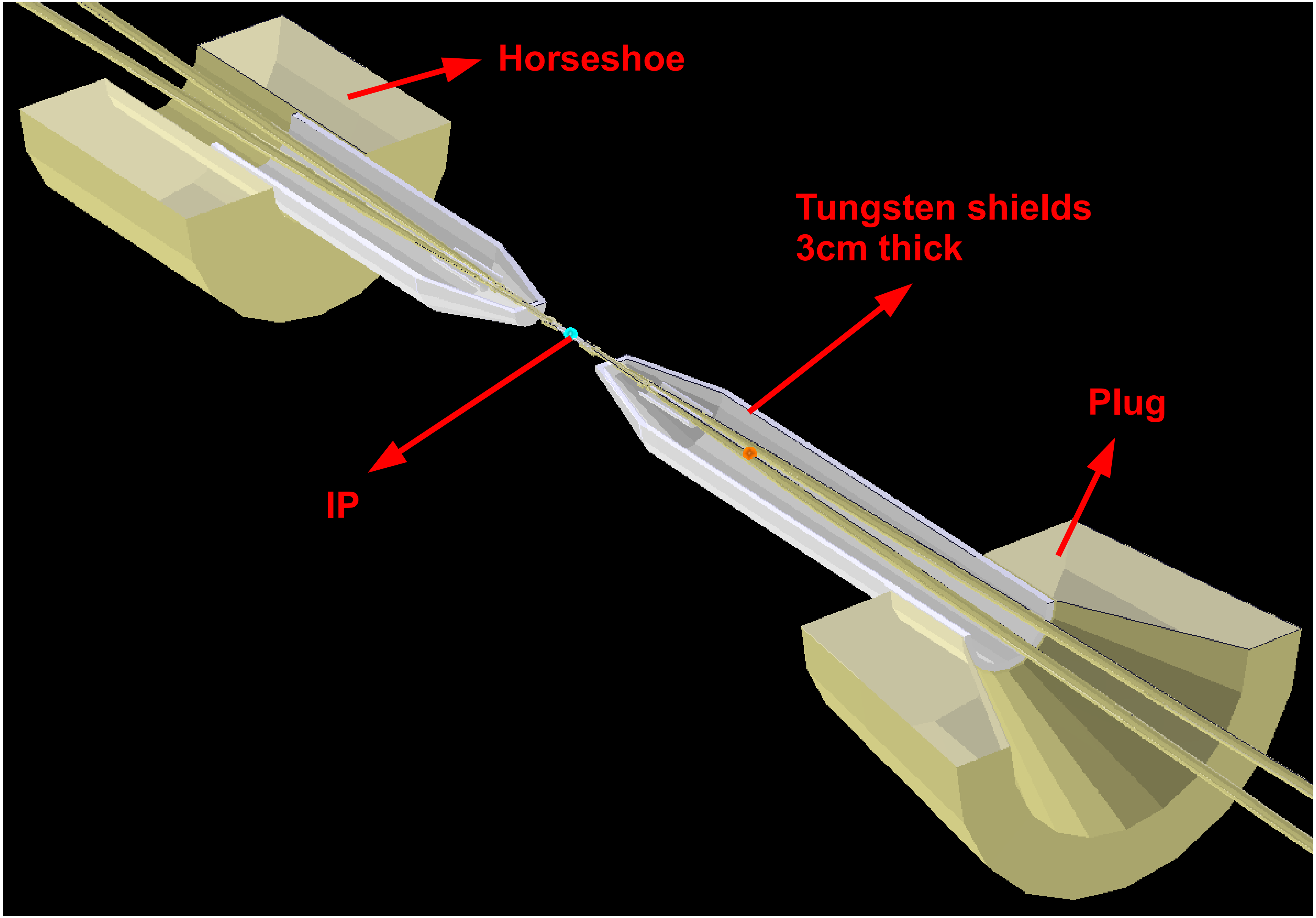
High energy gammas (5 GeV) produced via radiative BhaBha process by positrons go straight and hit the bending magnet ~10m away from IP, while ~ 1 GeV positrons get a kick from the nominal trajectory and hit the beam pipe 1 m away from IP. This create EM showers which then affect the FTOF detector.

~90% of the FTOF background comes from this effect.

Thanks to tungsten shield around beam pipe and 1.5 T magnetic field the charged particles from EM shower will not reach the FTOF.

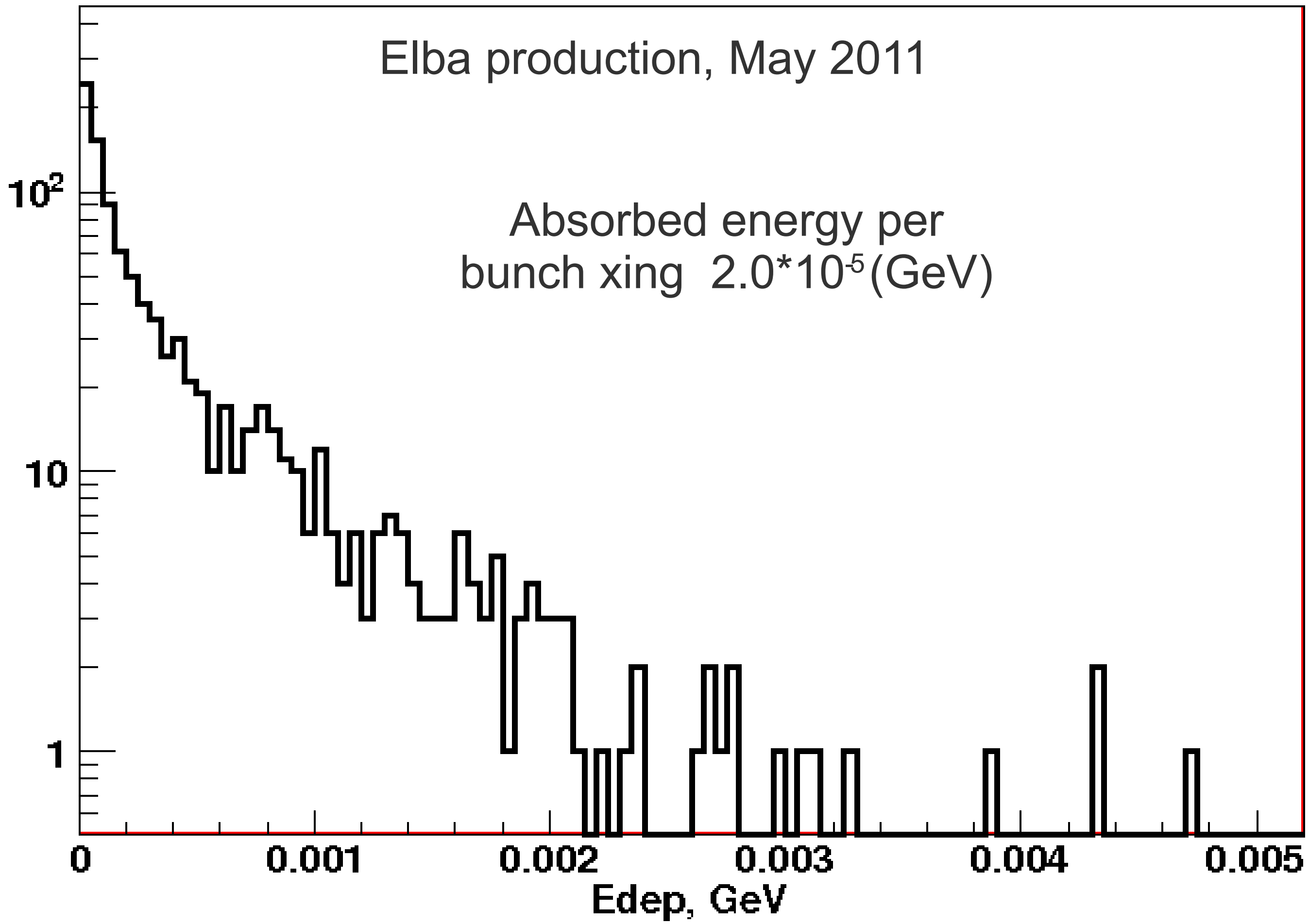
The main particles entering FTOF are gammas ~ (85%) and neutrons (~14%).

Final focus (sf11) layout



We need to increase thickness of the tungsten shield

Absorbed dose by FTOFFEE



Absorbed dose = (Absorbed energy)[J]/(mass[kg]) =

$2.0*10^{7}$(s in one year)*$2.09*10^{8}$(bunch xing/s)*$2.0*10^{-5}$(GeV)*$1.6*10^{-10}$ (J/GeV)/1.5kg

~ 9 (Gy in one year) = 0.9 kRad in one year

This is a small dose.

We should compare these numbers with other subsystems

Conclusions

→ **New production**

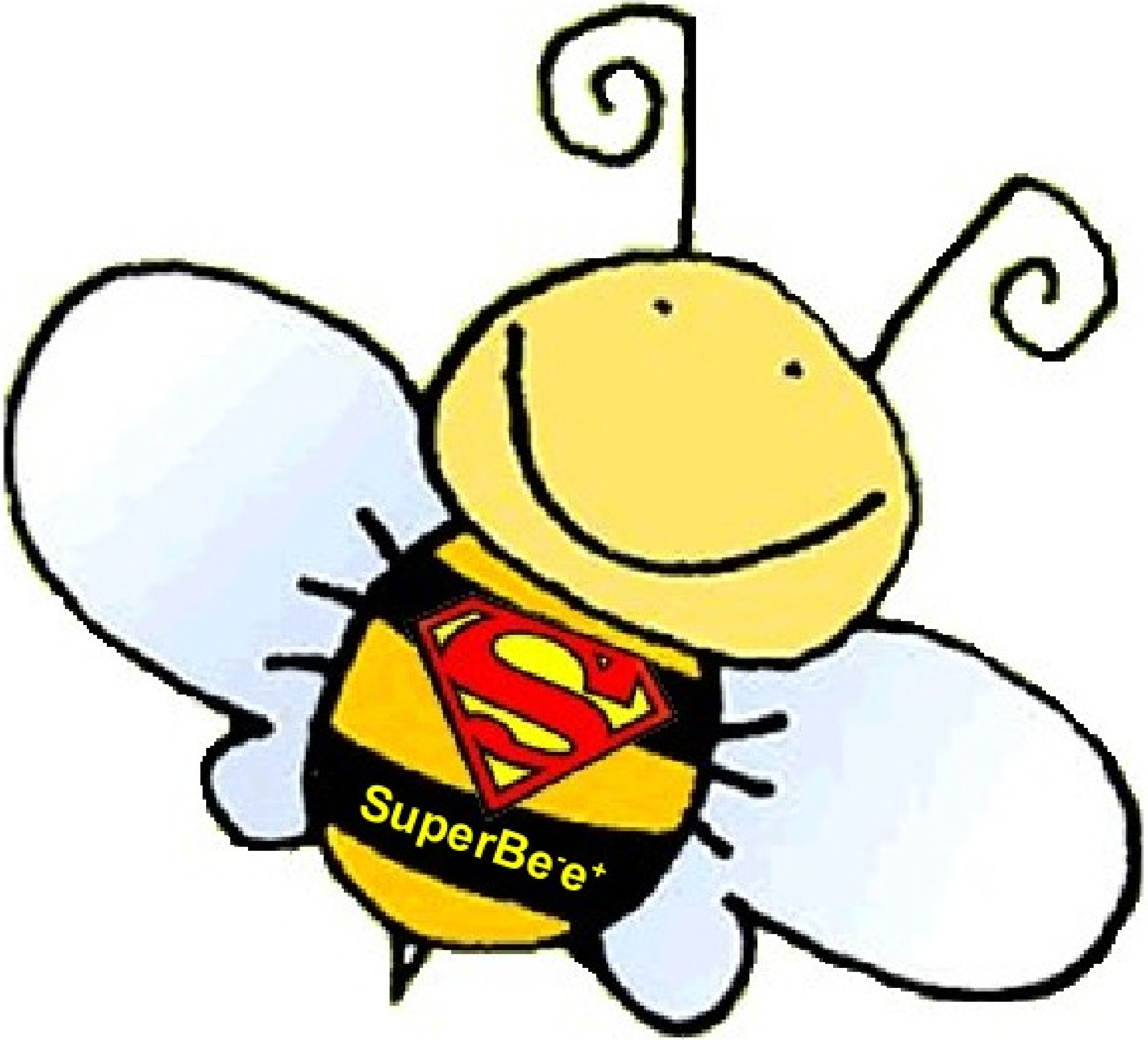
We observe bigger background in forward region caused by ~1 GeV positrons created EM shower ~1 m from IP.

This source situated very close to the FTOF detector and estimated to be the dominant one.

The tungsten shield (3 cm thick) and magnetic field (1.5T) are the main protection from this background but the shielding is currently is not enough.

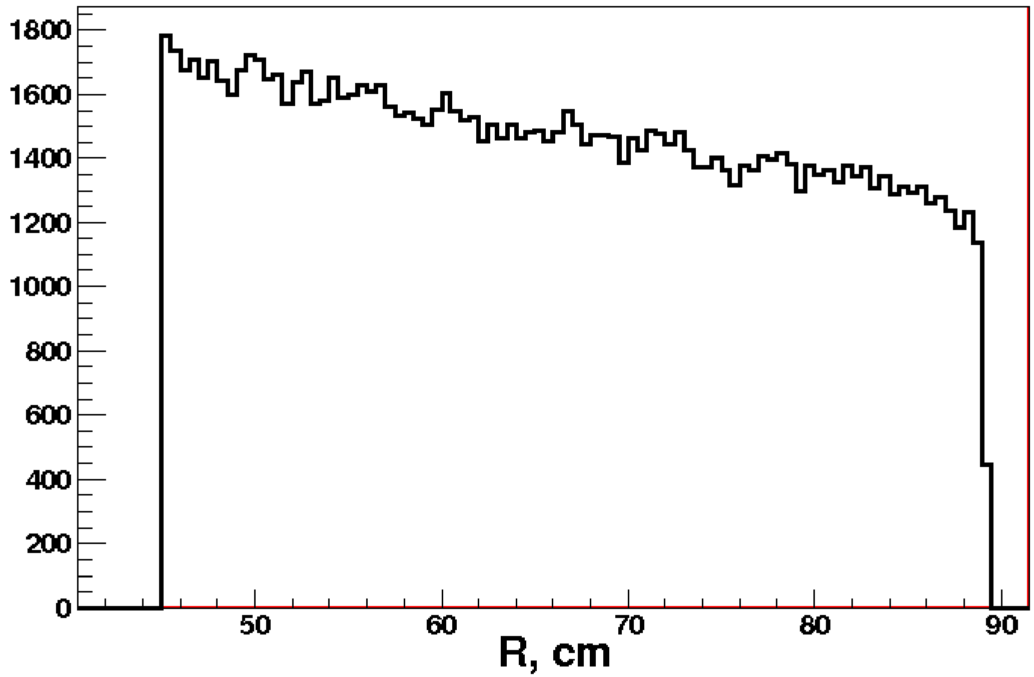
→ **The MCP-PMT rate estimated to be 460kHz/cm^2 which is in agreement using 2 different ways of estimation.**

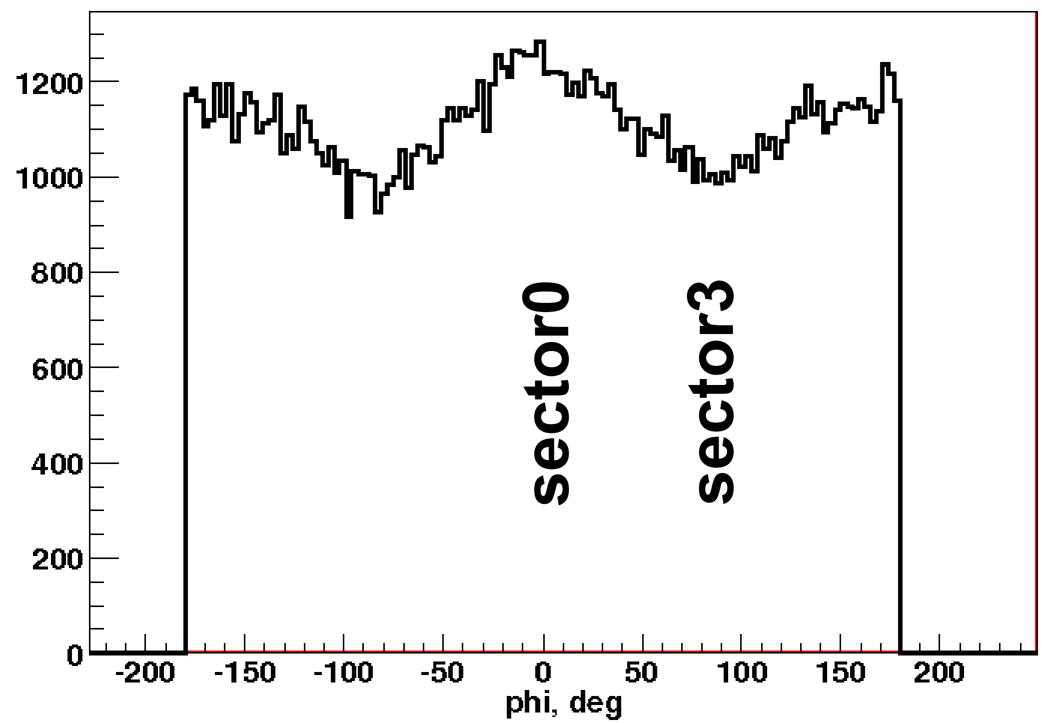
Thank you for your attention!!!



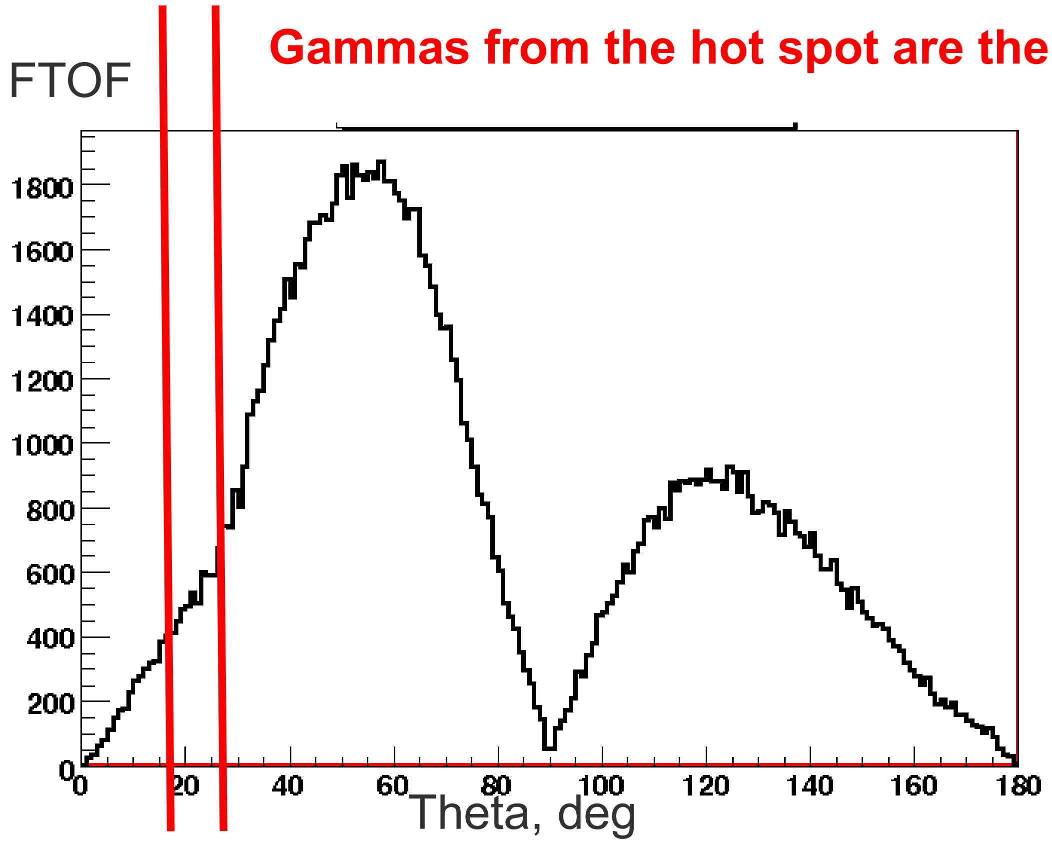
Backup

R and phi distribution of the hits in the FTOF detector





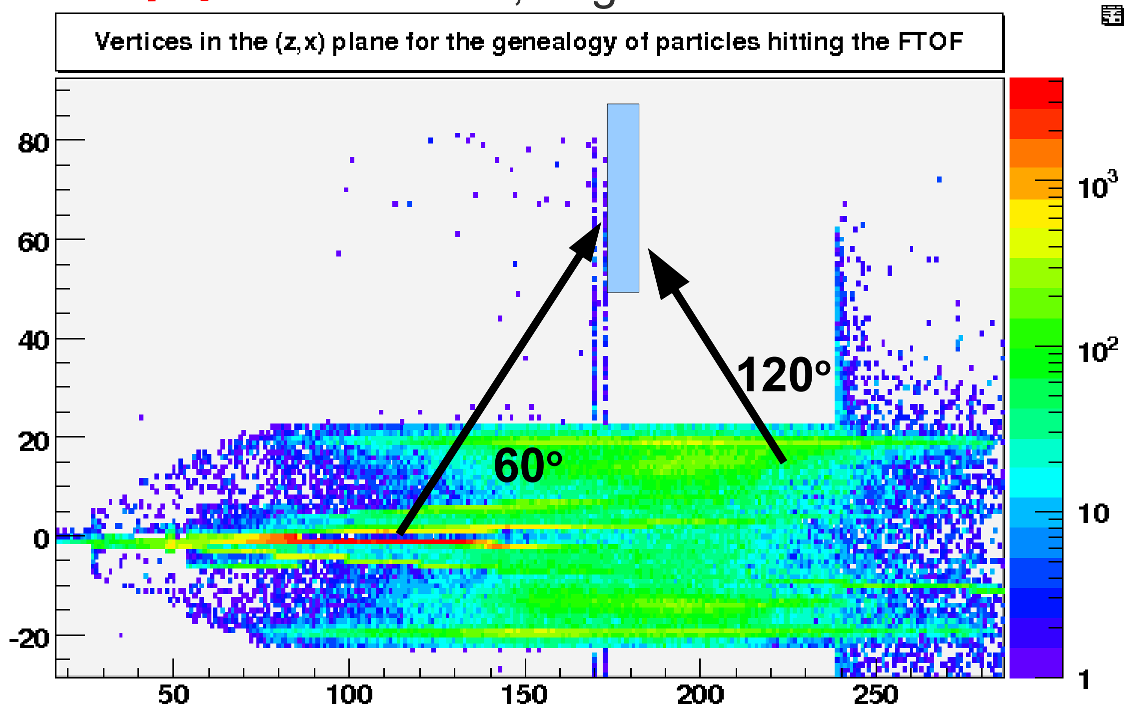
Gammas from the hot spot are the main source of the FTOF background



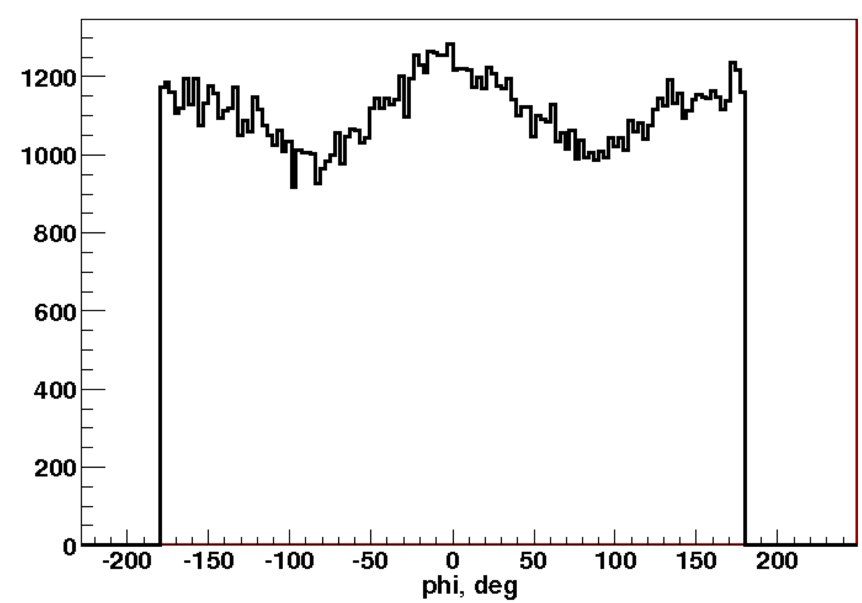
1) The dominant particle entering FTOF detector are gammas (~85 %) and neutrons (~13%)

2) Gammas do not comes directly from IP. But from the hot spot 1 m away from IP

3) The phi distribution shows slight non uniformity. But we can consider it flat for our studies.



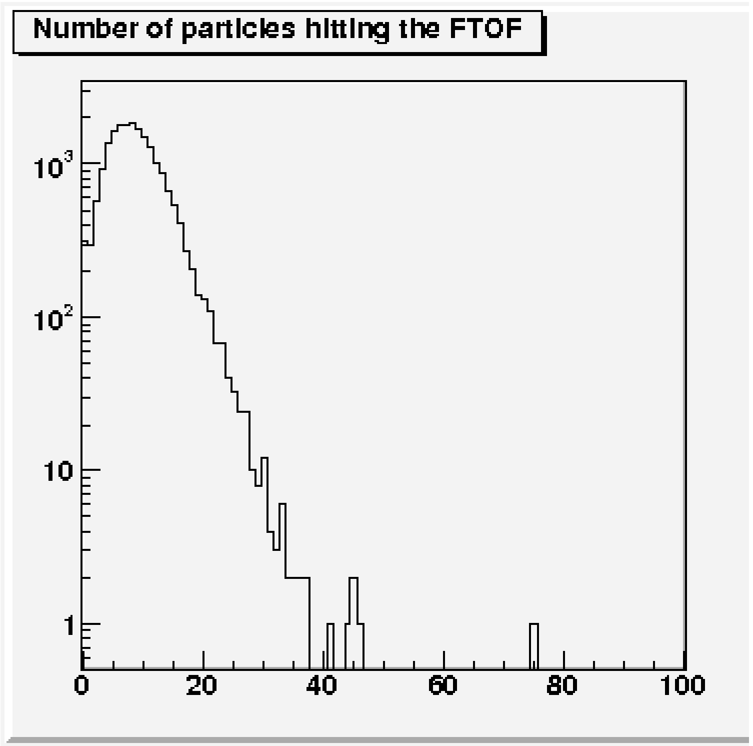
Phi distribution of the gammas entering FTOF

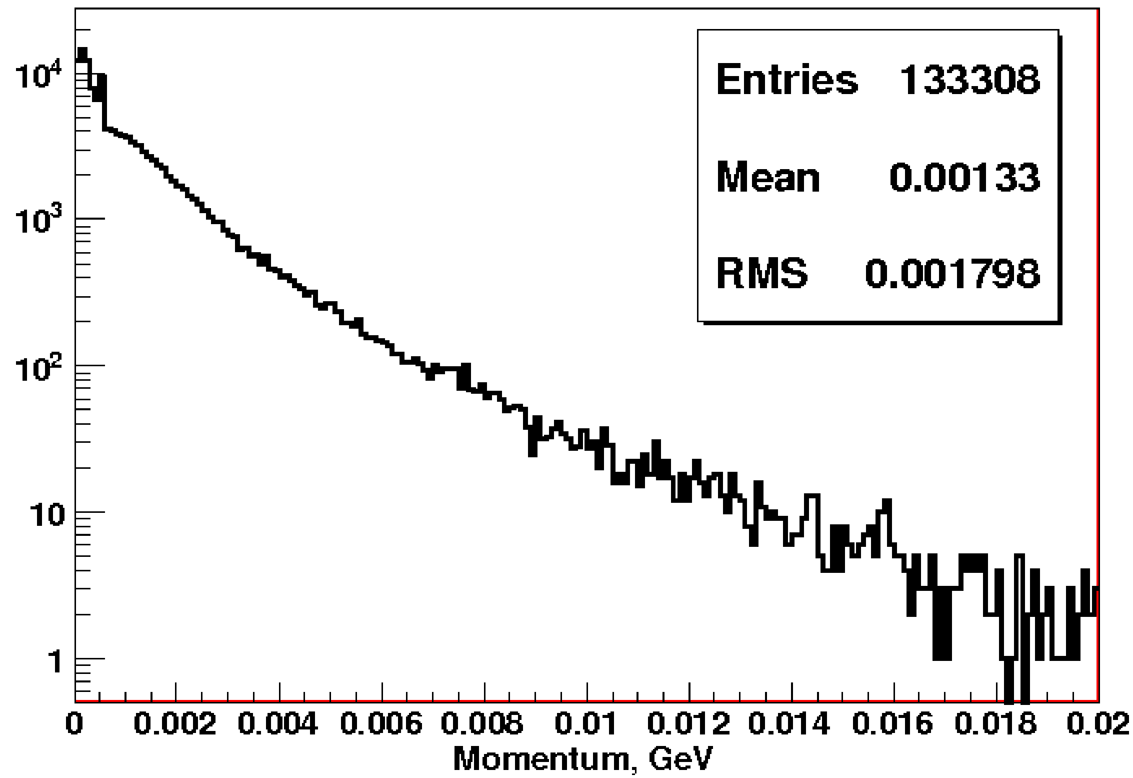


Gammas from the hot spot are the main source of the FTOF background

1) around 10 gammas enter FTOF each bunch xing

2) Average momentum of the gammas is 1.3 MeV

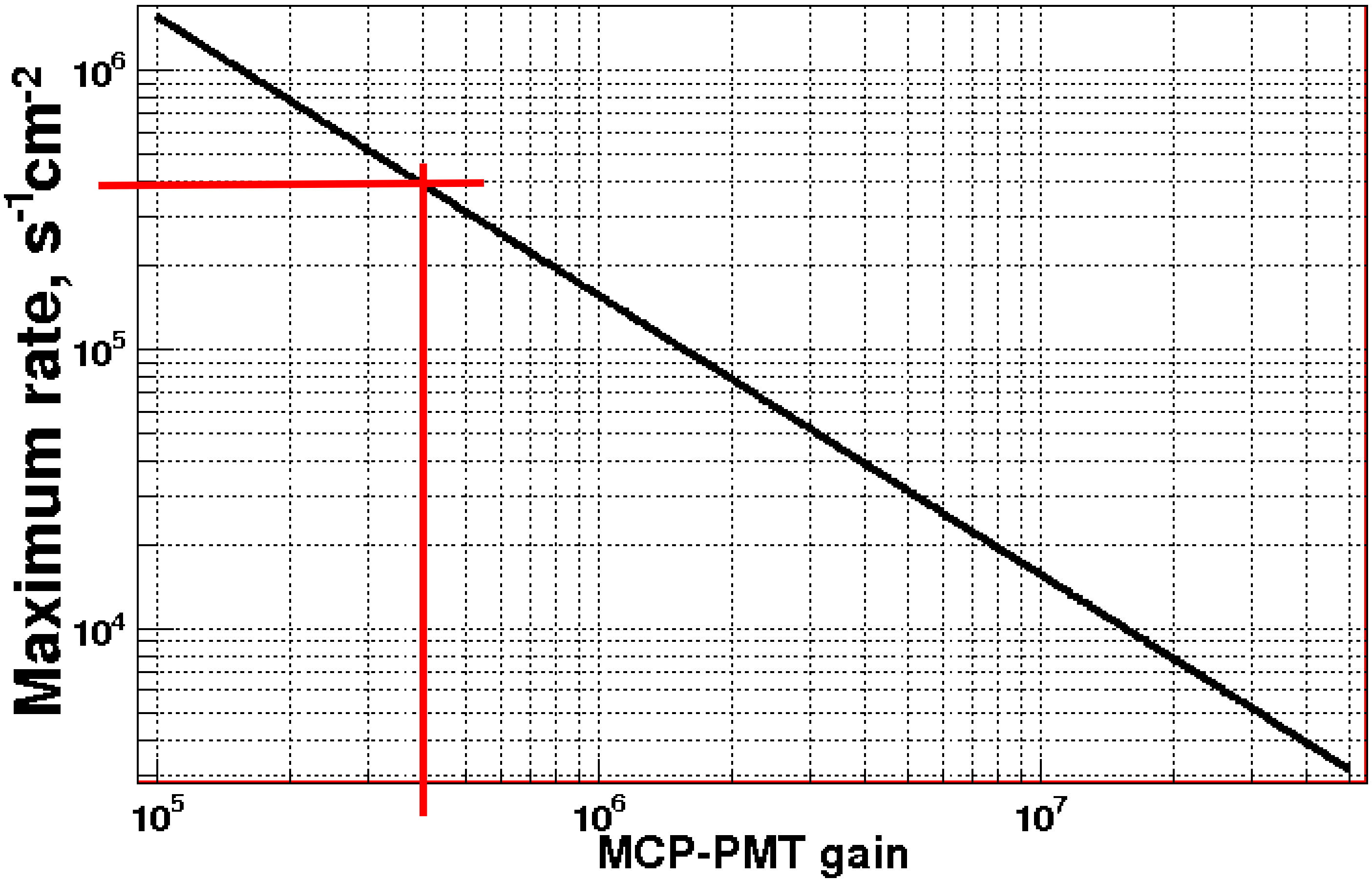




3) Mainly the gammas will interact with FTOF via Compton effect.

4) The Compton electrons will create a light which can be detected by PMT

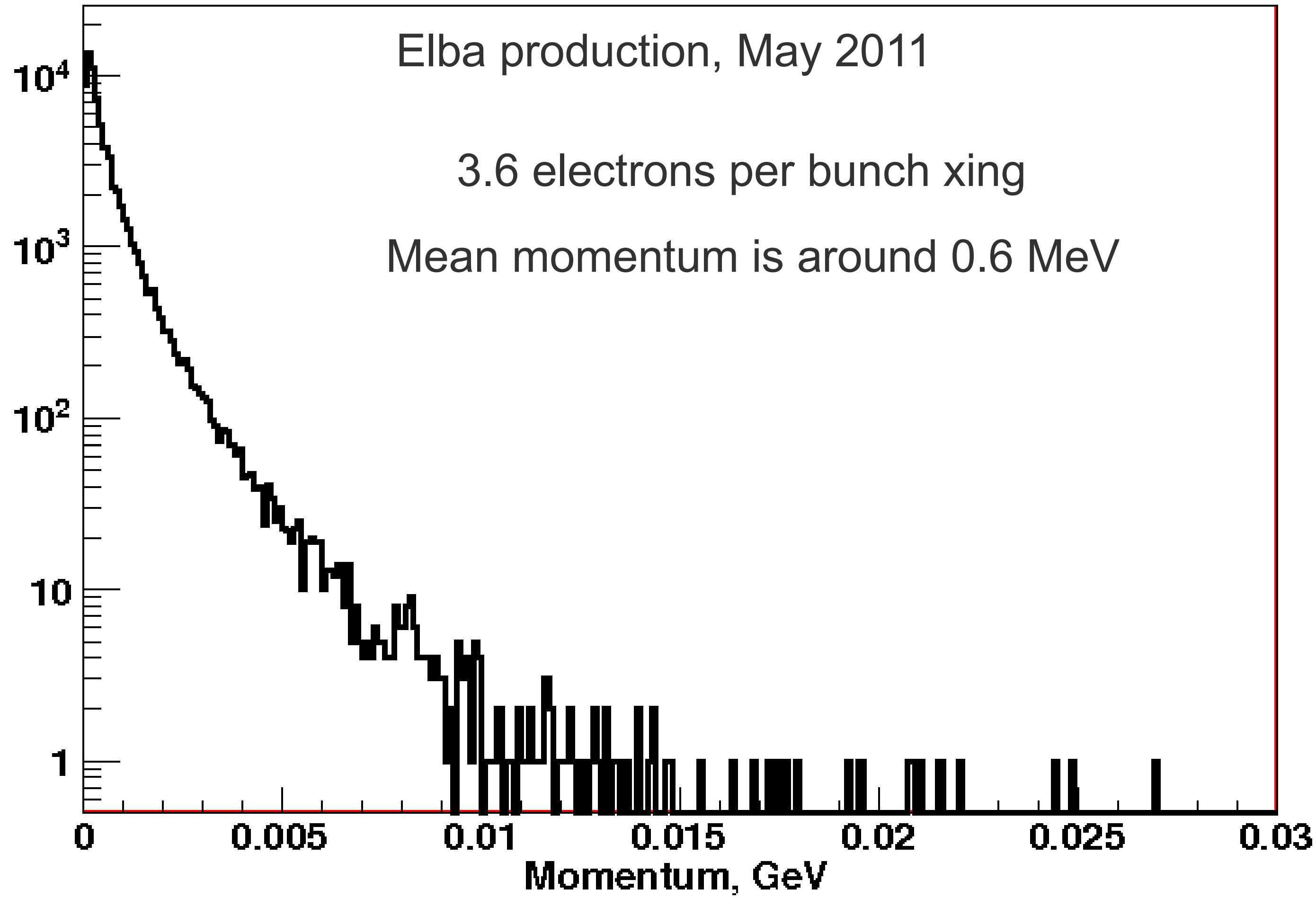
MCP-PMT life time



We can run tubes @ gain 4 $*10^5$
The study of the TTS of the SL10 at low gain is in progress at LAL test bunch.

Maximum integrated anode charge for SL10-XM0027 : 2.5 C* (QE drop by 20%)

Electrons produced by gammas which interact with FTOF

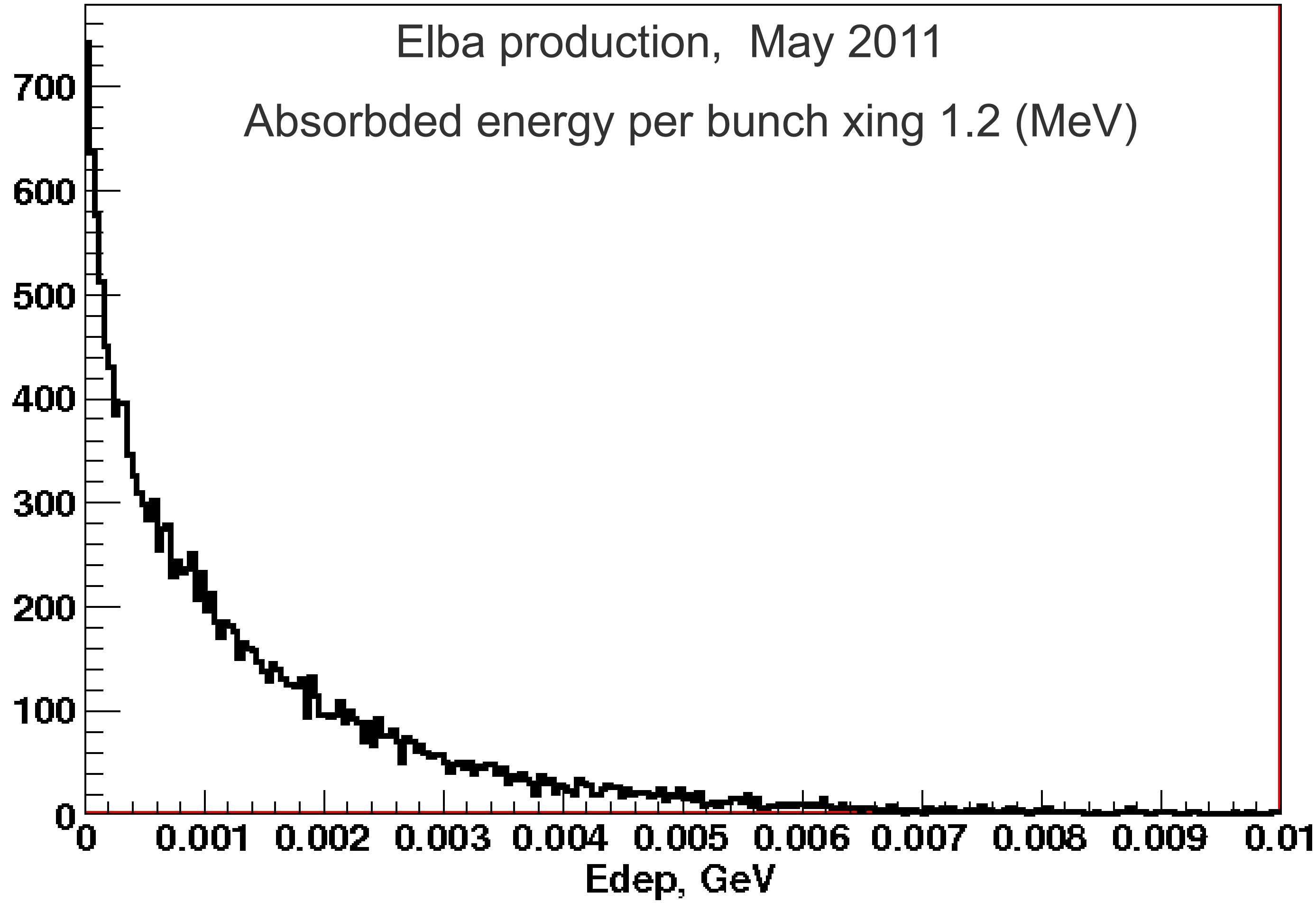


Electron rate =
(Average number of particles per bunch xing) $*2.09*10^8$(bunch xing/s)/($1.87*10^4$cm^2) =
$3.6*2.09*10^8/(1.87*10^4 cm^2)$ = 40kHz/cm^2

(Frascati production, April 2011) electron rate = 1 kHz/cm^2
(there was a bug in Bruno)

Absorbed dose by FTOF: method 1

Use dedx information from Bruno



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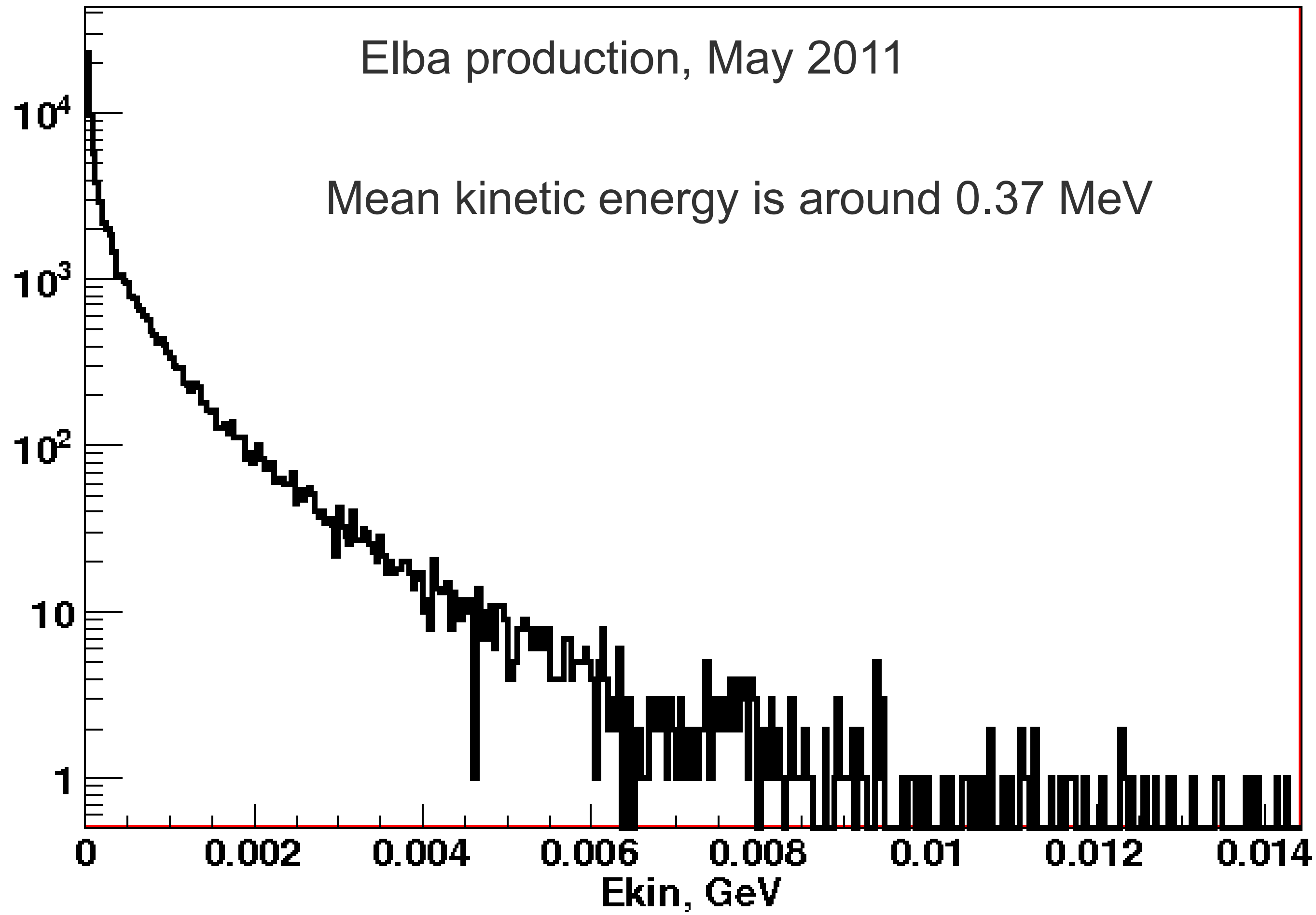
~ 13 (Gy in one year) = 1.3 kRad in one year

Absorbed dose by FTOF: method 2



The electrons will leave all kinetic energy in the FTOF, knowing that we have 3.6 electrons / per bunch xing we can estimate deposit energy:

(3.6 electrons per bunch xing) * (0.37MeV)
= 1.4 MeV/ per bunch xing

Absorbded energy per bunch xing 1.2 (MeV) from Method 2

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