Luminosity – related background in the Belle II Experiment

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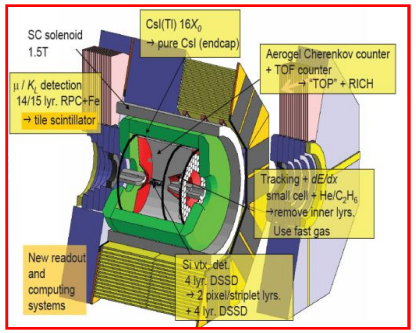
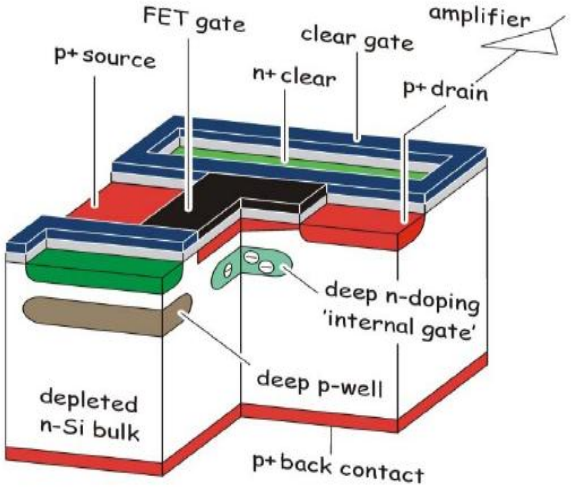
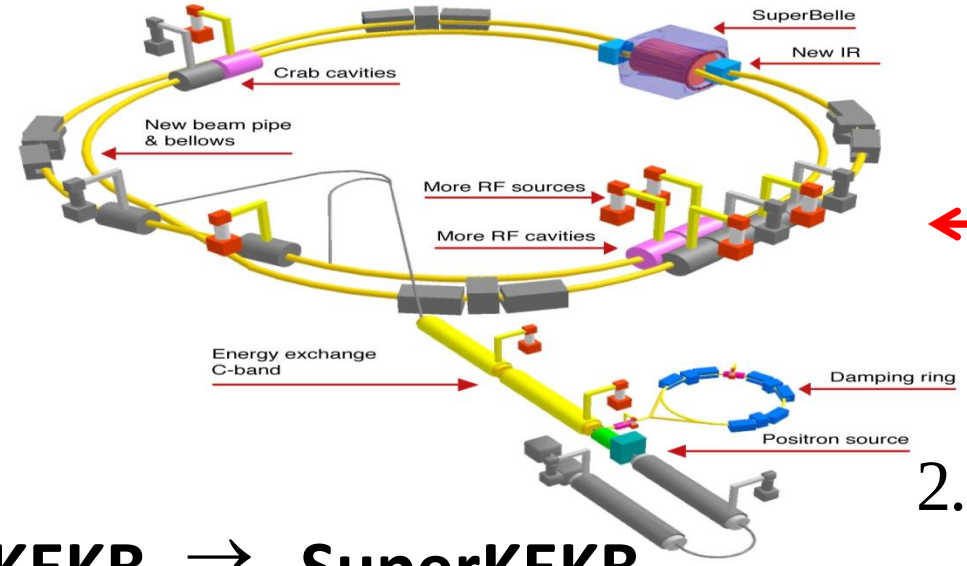
DEPFET Active Pixel Detector

- Upgrade of the BELLE Detector
- Types of background at Belle
- Background analysis
- Conclusions





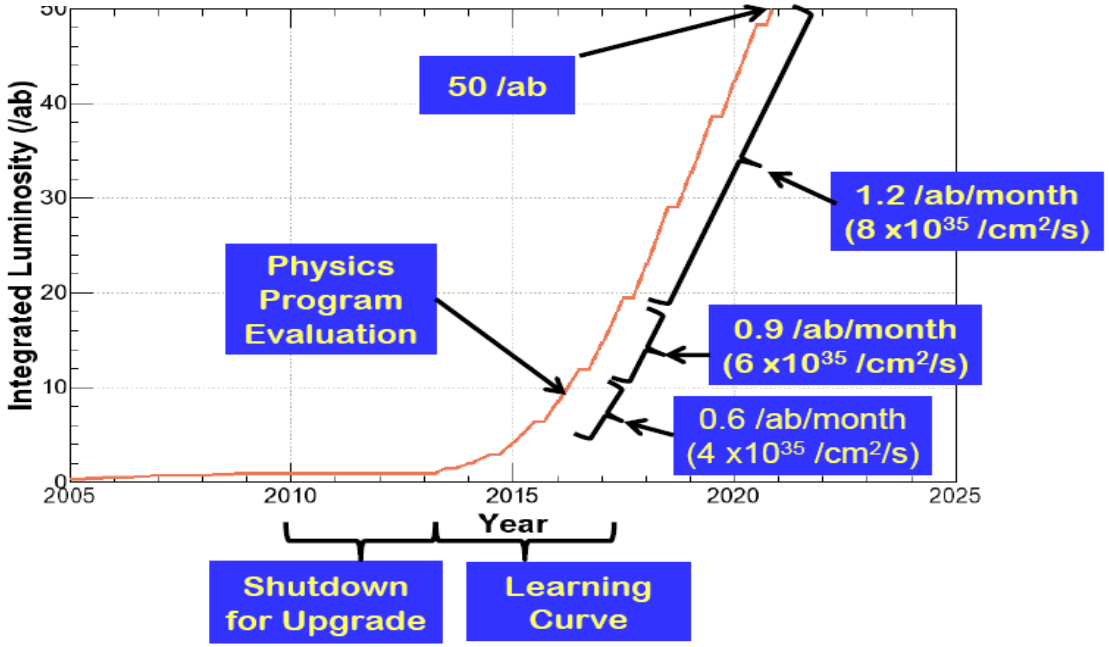


Presently running KEKB collider

$2.1*10^{34} cm^{-2}s^{-1} \rightarrow 8*10^{35} cm^{-2}s^{-1}$

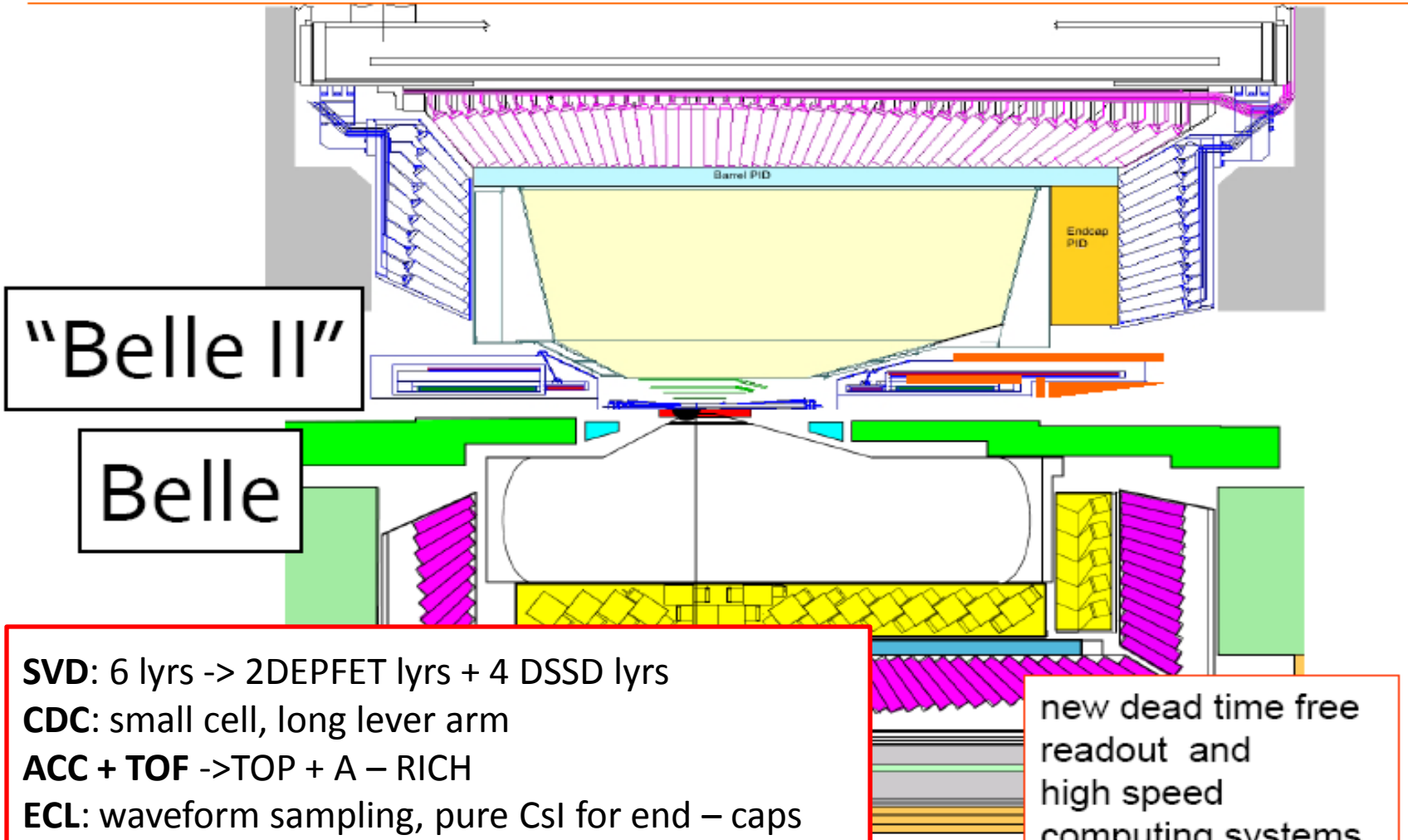
KEKB → SuperKEKB

$$HER(8Gev) \rightarrow HER(7GeV)$$
$$LER(3.5GeV) \rightarrow LER(4GeV)$$



40 *times the luminosity of Belle*

Belle Detector Upgrade

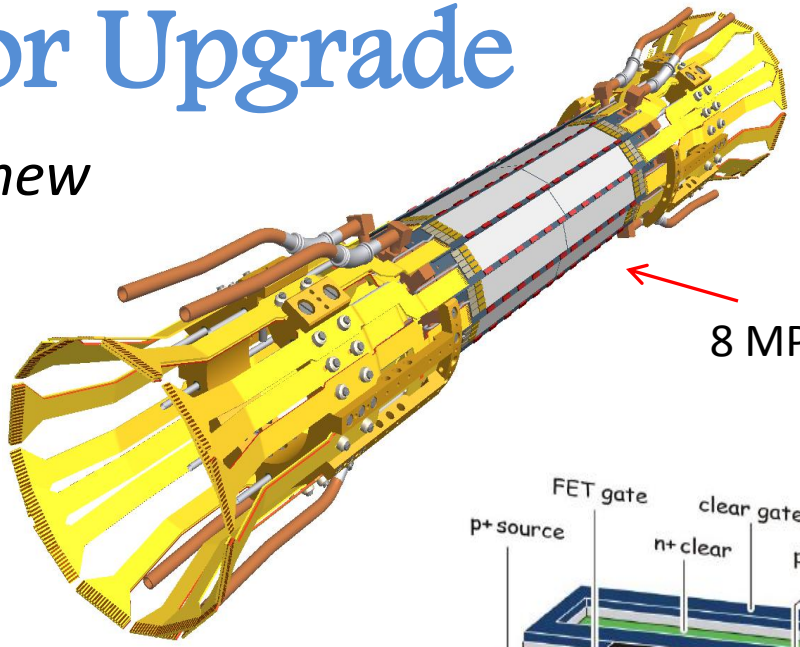


SVD: 6 lyrs -> 2DEPFET lyrs + 4 DSSD lyrs
CDC: small cell, long lever arm
ACC + TOF ->TOP + A – RICH
ECL: waveform sampling, pure CsI for end – caps
KLM: RPC -> Scintillator + SiPM (end – caps)

new dead time free readout and high speed computing systems

Belle Detector Upgrade

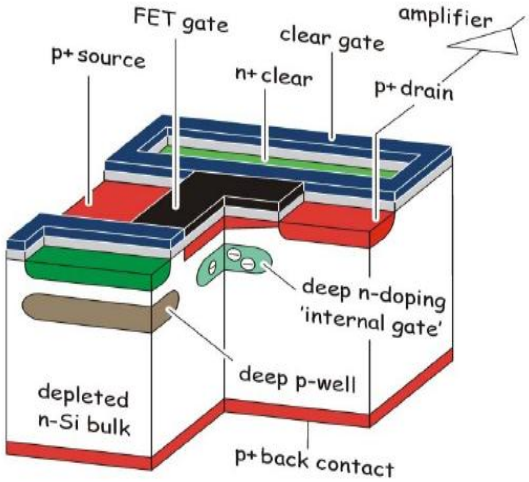
Belle II will be upgraded with a new pixel vertex detector (PXD)



Very close to the beam pipe

DEPFET Technology

Has to stand a high background at full luminosity



Time between two clear pulses

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$20\,\mu s$

DEPFET matrix : array of pixel cells

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Readout concept :
reading -> clear pulse

Types of backgrounds :

Beam – related background

- *Beam – Gas scattering (bremsstrahlung and Coulomb scattering)*
- *Touschek effect (intra - bunch scattering)*
- *Synchrotron Radiation*

expected increase by a factor of 2

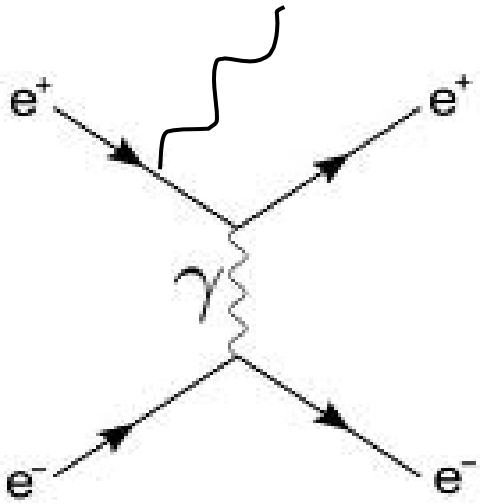
- *Radiative Bhabha scattering*
- *$\gamma\gamma$ reactions*

Luminosity – related background

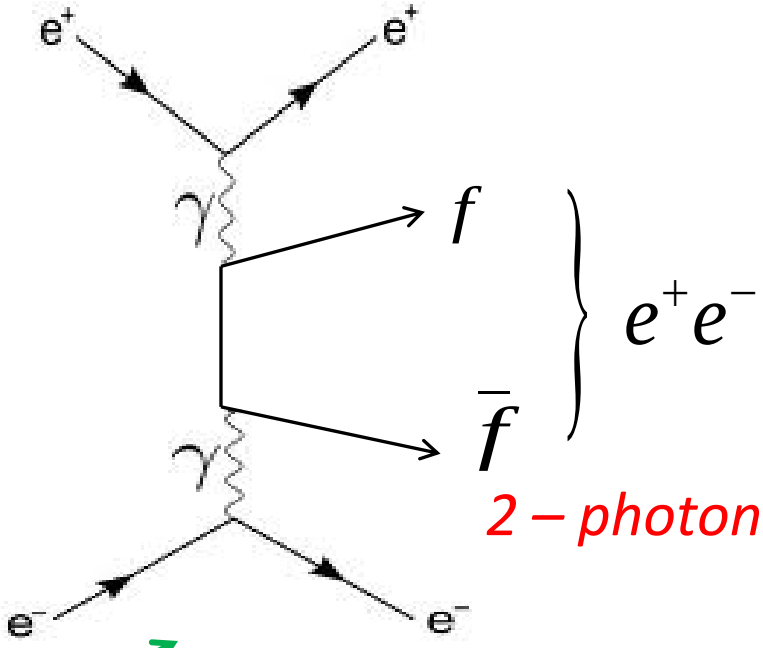
increase by factor of **40**

Important QED processes

t-channel processes



Bhabha scattering



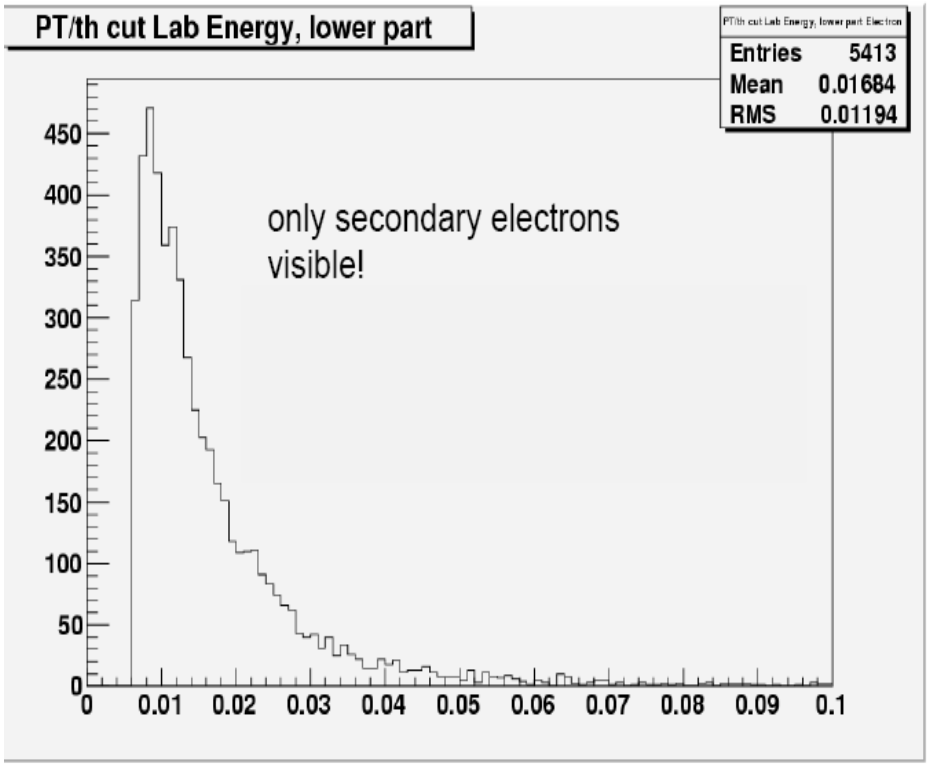
2 – photon processes

SuperB in Italy

$rate \rightarrow 10 MHz/cm^2$

$tracks \rightarrow 5000$

$occupancy \rightarrow 0.5\%$



- *Berends – Daverfeldt – Kleiss (BDK)*
- *S.Jadach et al. (KW)*
- *J.Fujimoto et al. (Grace)*

Expected background : tracks per event

$$BDK: \quad N_{tr}^{acc}(bg) = 790$$

$$KW: \quad N_{tr}^{acc}(bg) = 910$$

Occupancy :

BDK: 0.07%

KW: 0.1%

Number of pixels :

$$250 * 1600 * 8 = 3.2 * 10^6$$

(assume each track lights up 3 pixels)

in strong disagreement with the number from SuperB

3 MCs -> consistent
(all tested at high Pt)

How to find out which MC is right?

→ *Look at real data from Belle*

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Random triggers (unbiased background)

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Beam - gas | QED

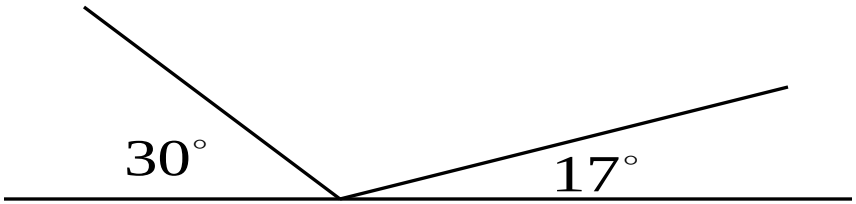
How to separate QED from beam gas?

* colliding beams (QED + beam gas)

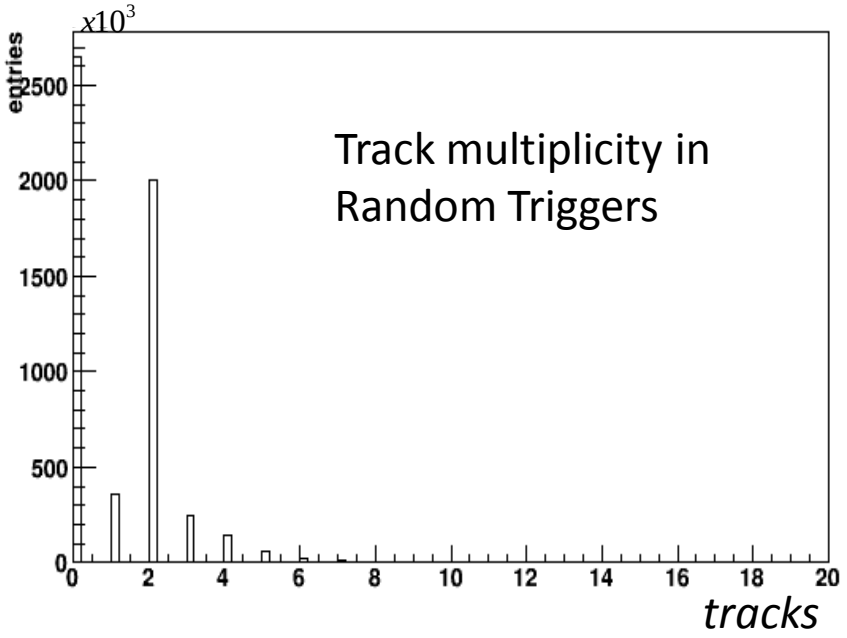
* separated beams (only beam gas)

Study of Random Triggers

5.5 Million events
(real data from Belle)

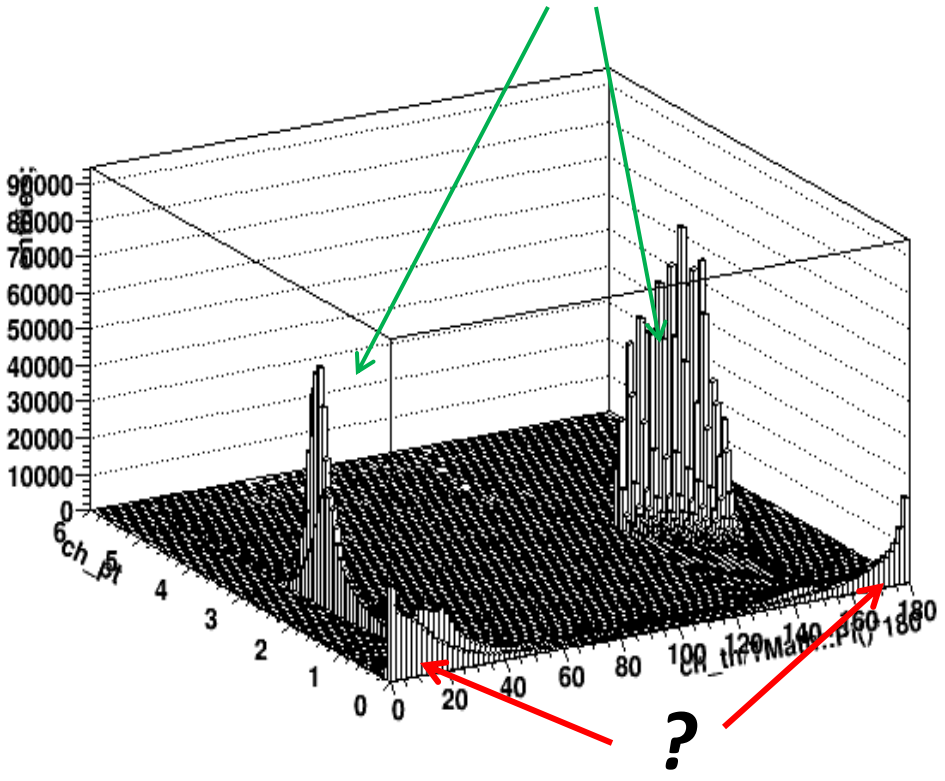


$$17^\circ < \theta < 150^\circ$$



Track multiplicity in Random Triggers

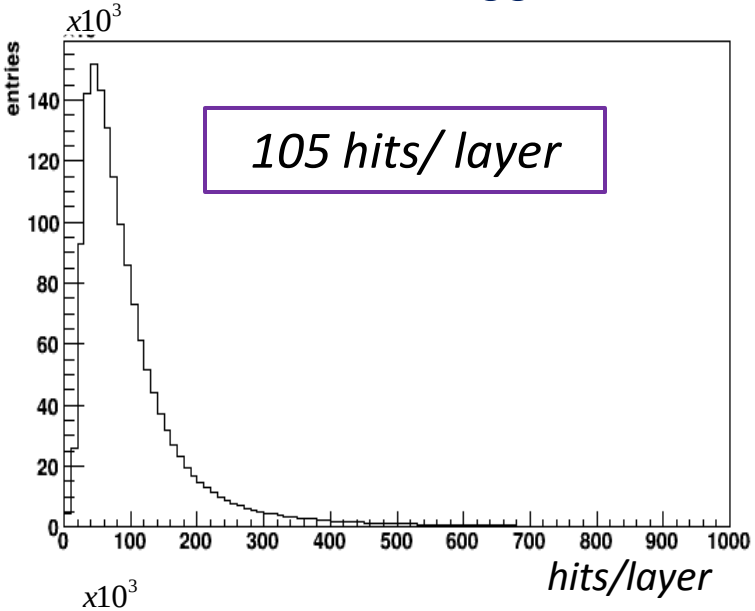
Bhabha scattering

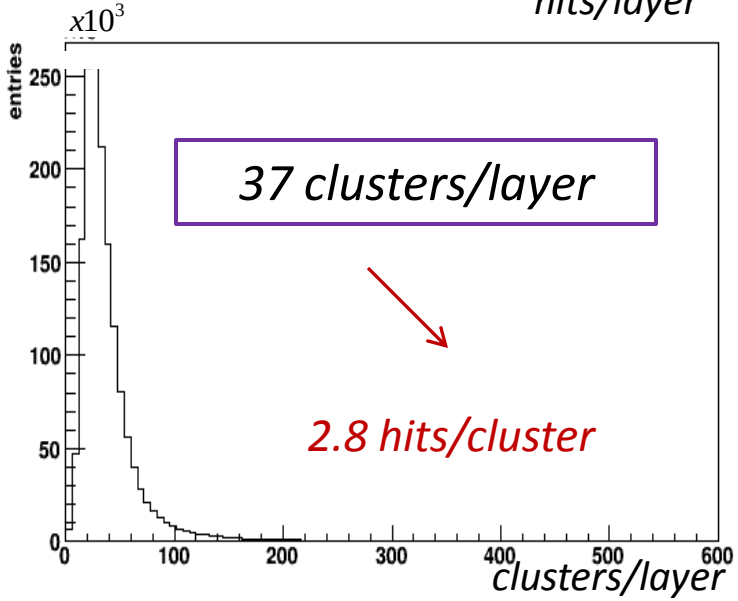


Event Classification :

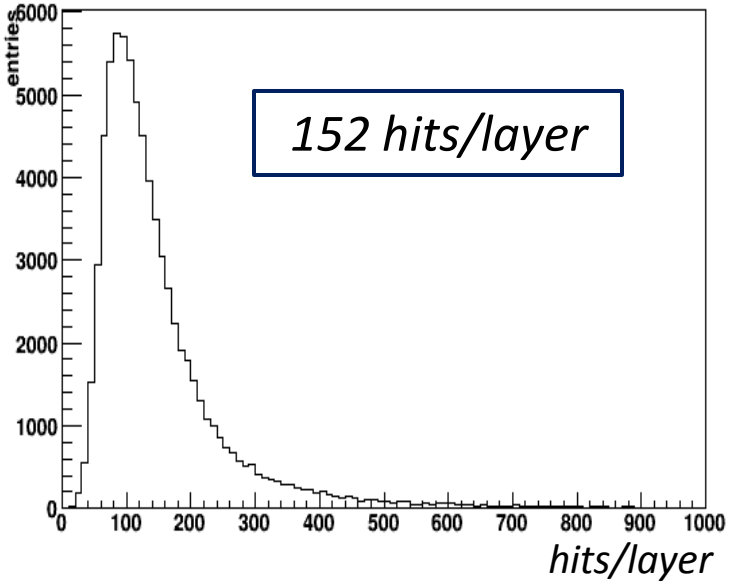
- ***Bhabha*** ***(2 tracks, Pt>1GeV)***
- ***"Half Bhabha"*** ***(1 track, Pt >1GeV)***
- ***Multi Track Event*** ***(3 and more tracks)***

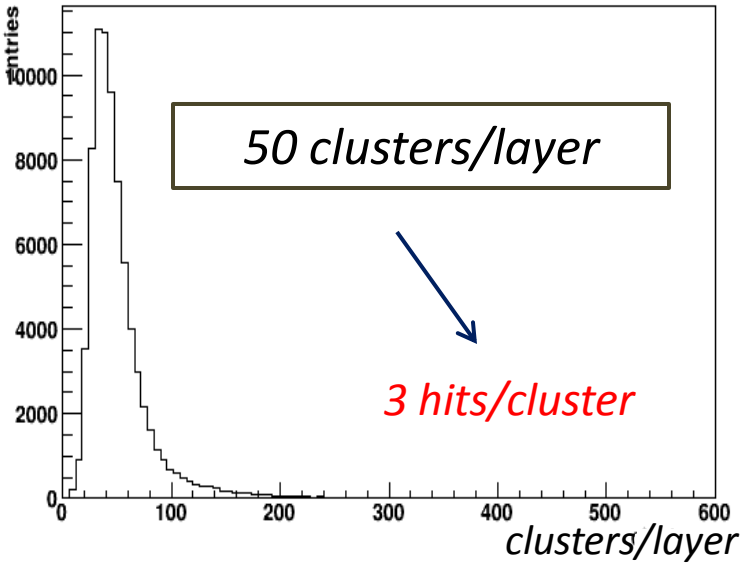
Bhabha events taken with Random Triggers





Control Sample: Real Multi Hadrons





Two extreme assumptions

only QED background

$$105*10*40 = 40000\,hits$$

- Number of hits in the first layer
- SVD -> PXD memory time
- KEKB->SuperKEKB

$\Rightarrow$ leads to 1.3% occupancy in the inner layer of the detector

$$occupancy = \frac{Nhits(layer)}{Nstrips(layer)}$$

only beam gas background

$$105*10*2 = 2000\,hits$$

- Number of hits in the first layer
- SVD -> PXD memory time
- *current increase*

2000 hits $\Longrightarrow$ 0.2 % occupancy

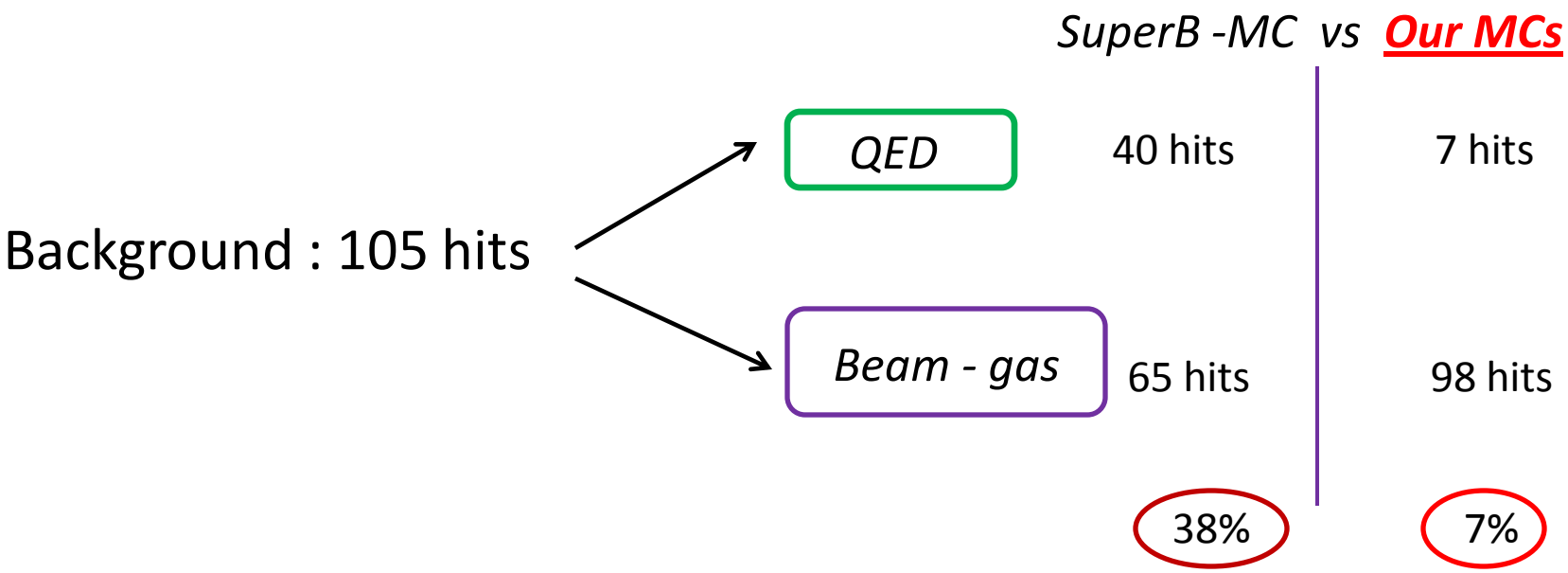
QED Predictions

Belle | **Belle II**

3 hits/track

5000 * 3 = 15000 hits
1500 / (40 * 10) ~ 40 hits ← 5000 tracks -> 0.5 % occupancy

910 * 3 = 2700 hits
2700 / (40 * 10) ~ 7 hits ← 910 tracks -> 0.1 % occupancy



Conclusions :

- Expected Background at Belle II for the new PXD

  - increase by a factor of 2 (current)
  - increase by a factor of 40 (luminosity)

- Physics sources of luminosity – related background
- SuperB and our analysis give very different answers
- Looking at random triggered events in order to determine the low – energy QED

  - colliding beams (collects QED and beam gas)
  - separated beams (collects only beam gas)

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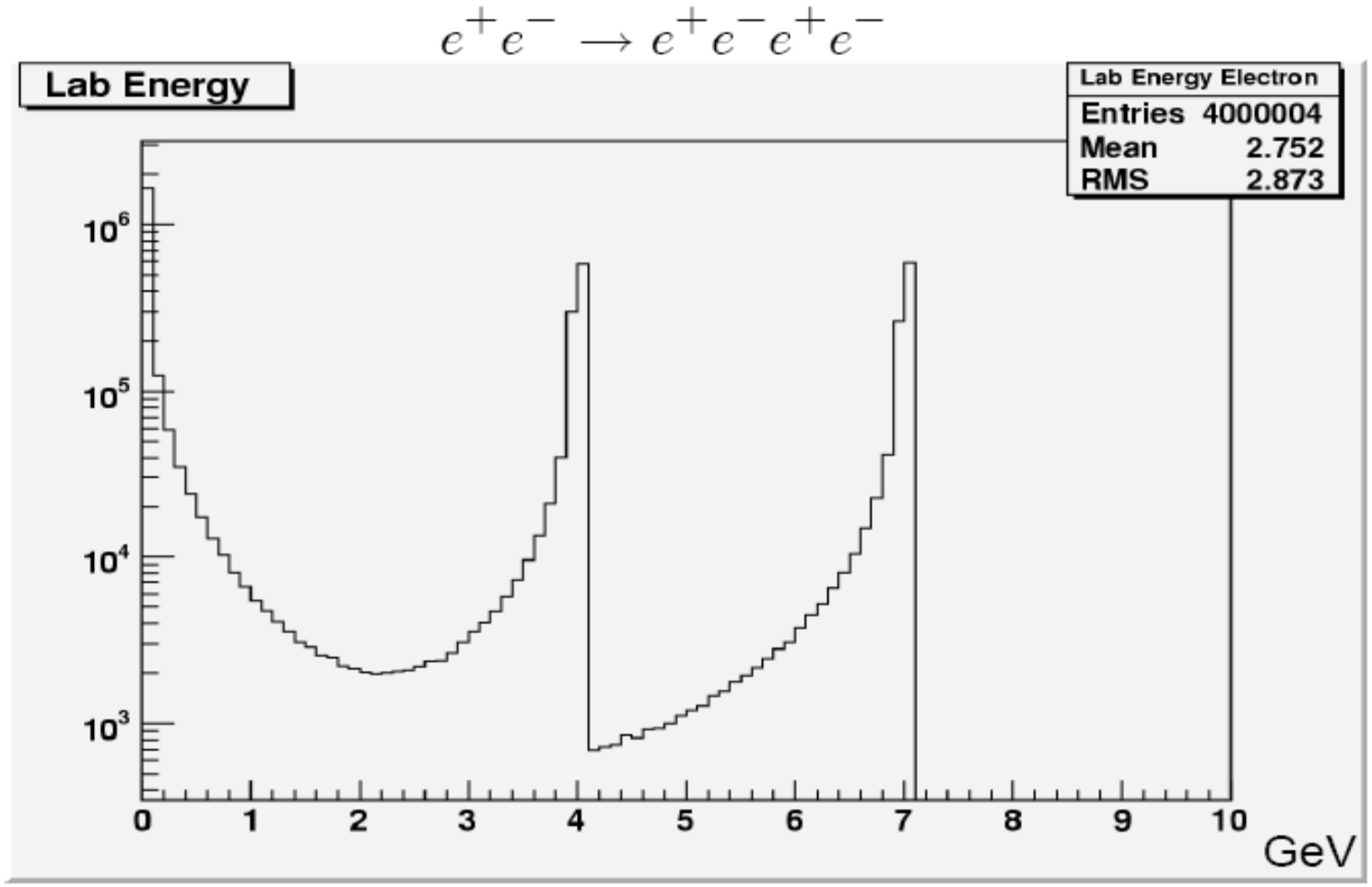
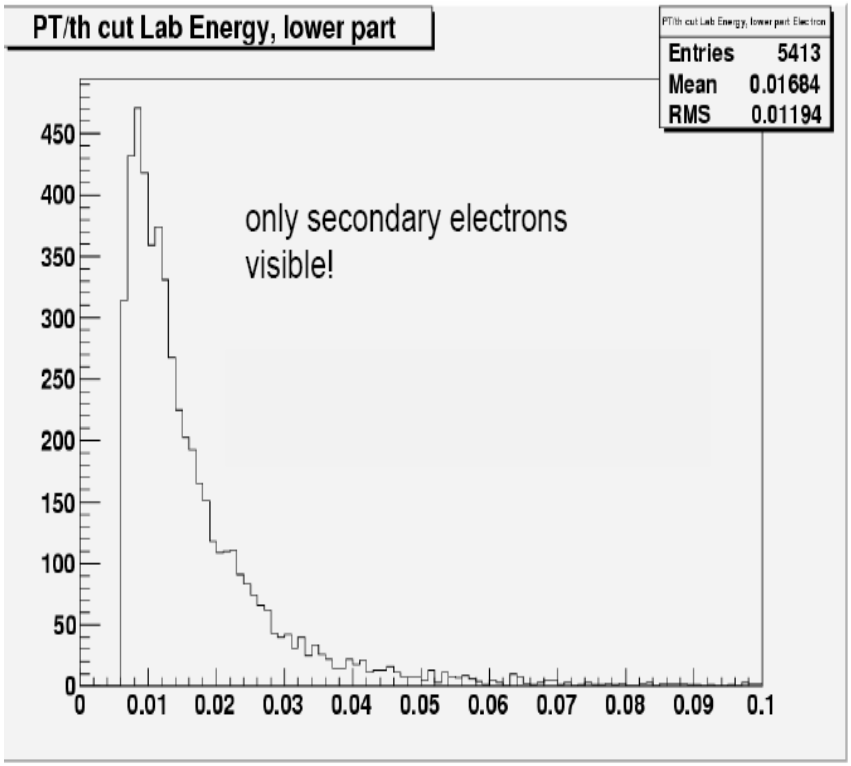
runs to be taken in May/June 2010

Back Up

Berends – Daverfeldt – Kleiss (BDK)





$$BDK: \quad \sigma = 7.3*10^{6}[nb] \qquad \varepsilon = 0.146$$

$$KW: \quad \sigma = 4.5*10^{5}[nb] \qquad \varepsilon = 0.52$$

$$N_{\mathrm{tr}}(\mathrm{bg}) = N_{\mathrm{tr}}^{\mathrm{acc}}(\mathrm{MC}) \cdot \frac{\sigma_{\mathrm{QED}} \cdot L}{N_{\mathrm{ev}}(\mathrm{MC})} \qquad \varepsilon$$

DEPFET readout time

$$L = \int \mathcal{L}\, dt = \mathcal{L} \cdot \Delta t = 10^{3} \left[\frac{1}{nb\, s}\right] \times 2 \times 10^{-5} [s]$$

$$BDK: \quad N_{tr}^{acc}(MC) = 5413$$

$$KW: \quad N_{tr}^{acc}(MC) = 1675$$

3 MCs -> consistent

Expected number of background tracks per event

$$BDK: \quad N_{tr}^{acc}(bg) = 790$$

$$KW: \quad N_{tr}^{acc}(bg) = 910$$

Number of pixels :

$$250*1600*8 = 3.2*10^{6}$$

(assume each track lights up 3 pixels)

Occupancy :

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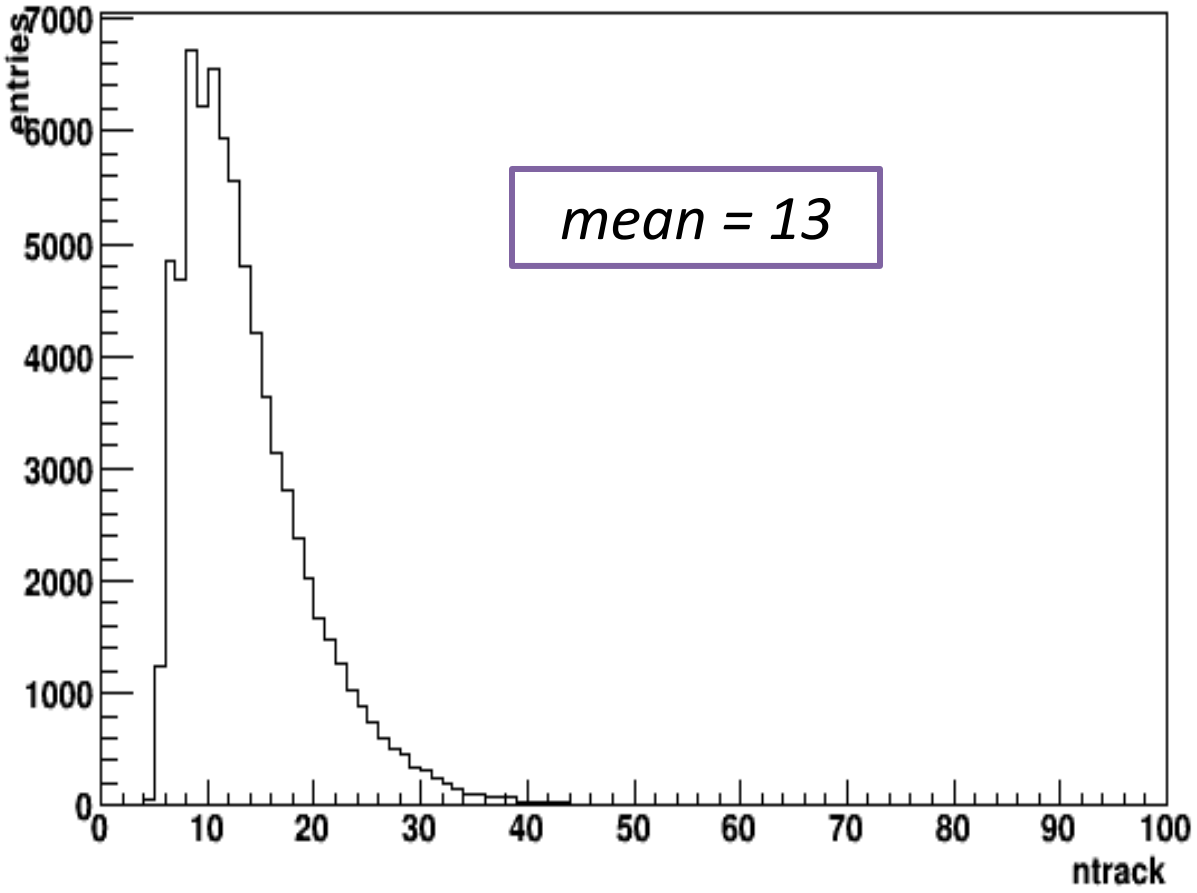
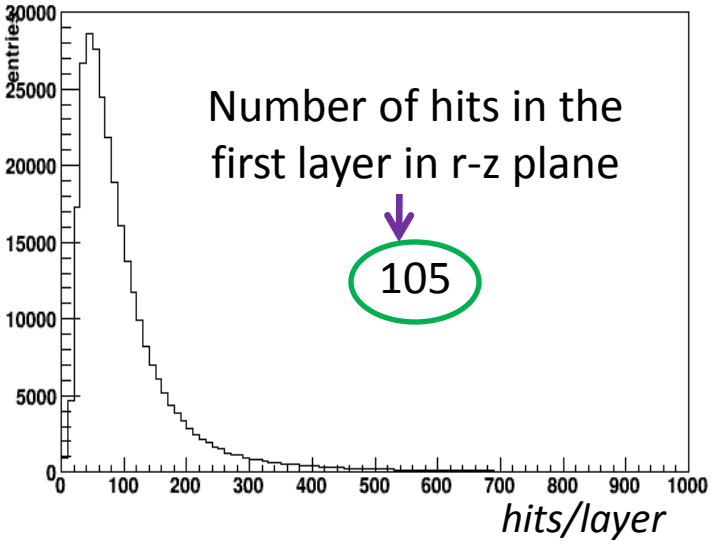
KW: 0.1%

Track multiplicity for the Control Sample with Hadrons



Events classified as ***HalfBhaha***
(Random Triggers)



Multi Track Events
(Random Triggers)