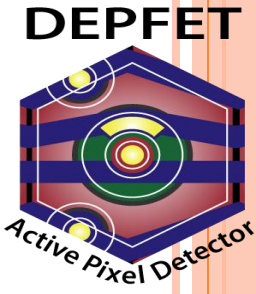
Analysis of Luminosity – Related Background

Elena Nedelkovska, Christian Kiesling, Burkard Reisert
Max – Planck Institute for physics, Munich

- Types of background at BELLE
- Background analysis
- Experiment proposals
- Conclusions

Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)

Different Background Simulations

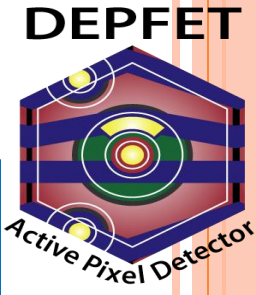


- SuperB QED simulations (BDK generator) :
  - $rate \rightarrow 10 MHz/cm^2$
  - *occupancy for the inner layer of the PXD* $\rightarrow$ 1.3%

close to the "limit" of 2%

- Our MC generators (BDK, KoralW, Grace):
  - KoralW gives result inconsistent with SuperB's
- What to do?
  - do beam tests to find the correct answer

Types of background :



Beam – related background

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

expected increase by a factor of 2

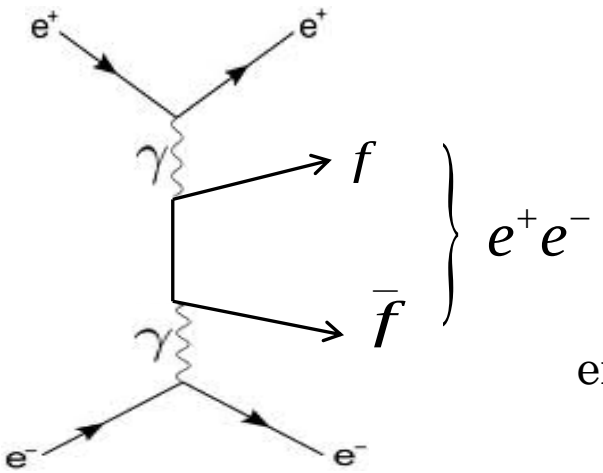
- Radiative Bhabha scattering
- $\gamma\gamma$ reactions

increase by factor of 40

Luminosity – related background

QED Processes – 2 photon process

t – channel processes



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

expected background tracks per event →

Occupancy (inner layer):

BDK : 0.07%
KW : 0.1%

SuperB, Italy
$rate \rightarrow 10 MHz/cm^2$

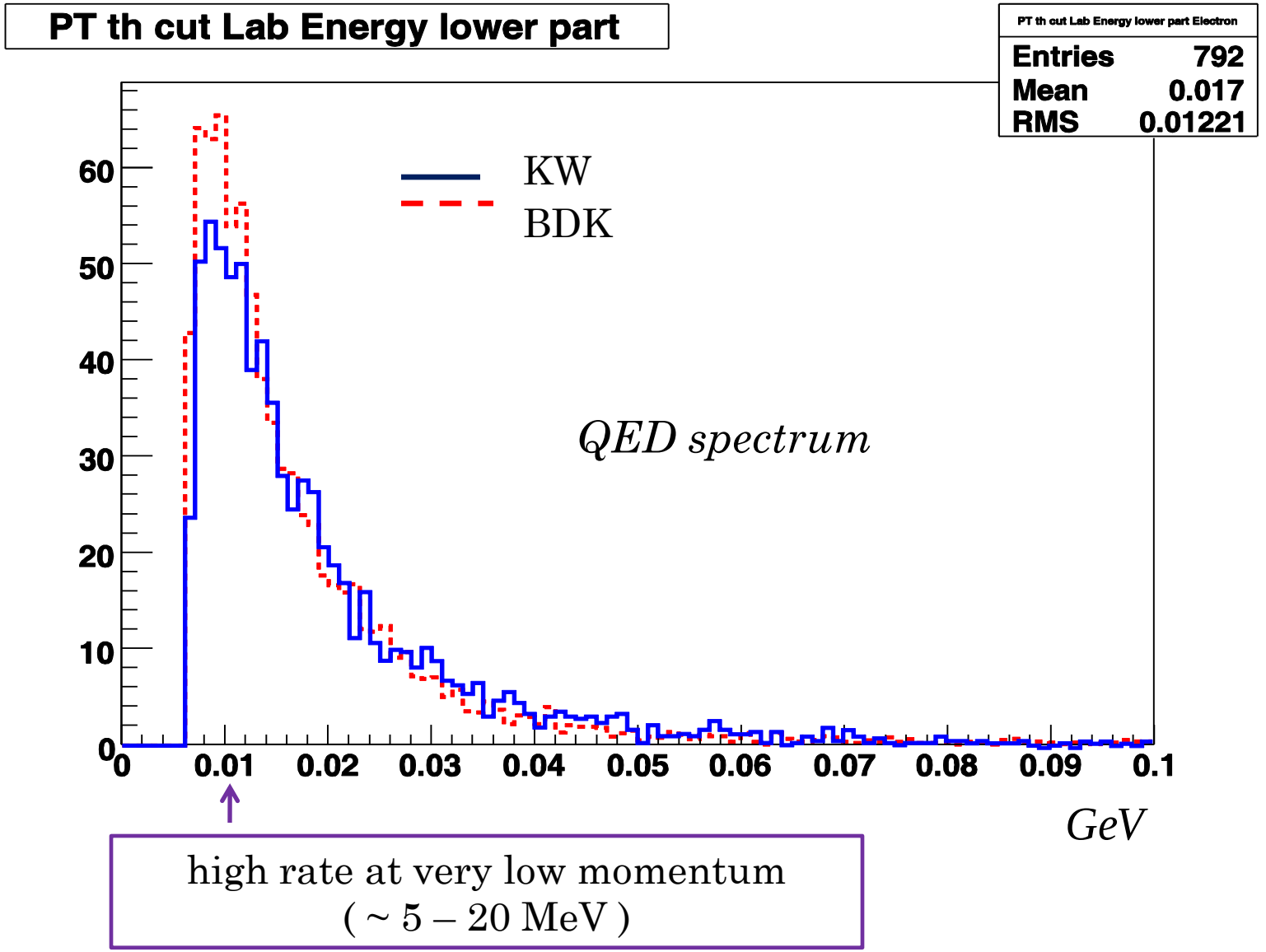
$tracks \rightarrow 13800$

$occupancy \rightarrow 1.3\%$

in strong disagreement with the number form SuperB (a factor of 15 difference)

our three MCs are consistent

QED processes – 2 photon processes



- A few MeV cannot be triggered at Belle

Therefore:

→ Look at real data from Belle

↓

Random Triggers (unbiased background)

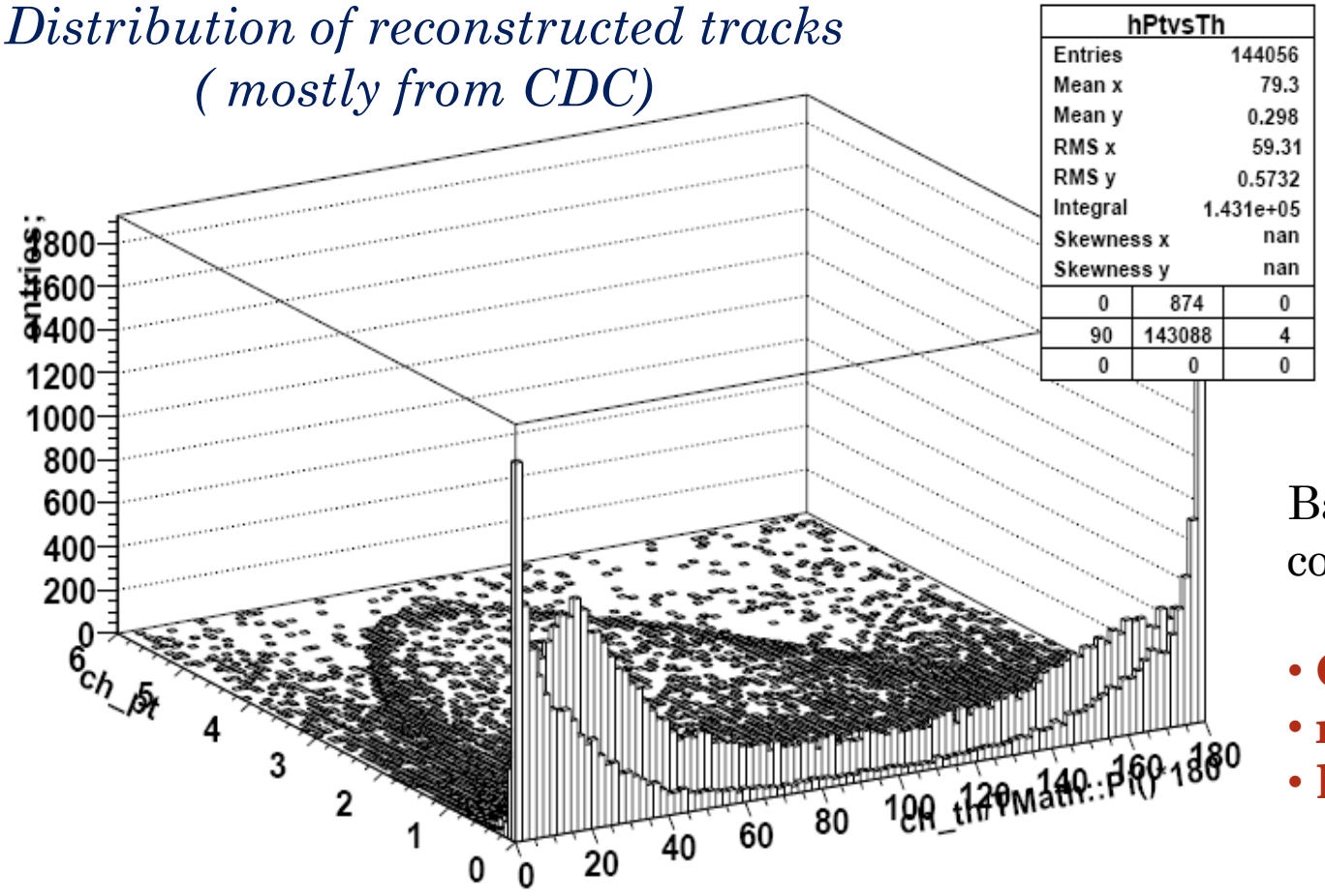
3 types of Random Triggers:

- " Bunch 0 "
- " Physics Random " : physics trigger + 100 μs delay
- " Luminosity Random " : luminosity trigger + 100 μs delay

Study of Random Triggers

Polar angle vs Pt

Distribution of reconstructed tracks (mostly from CDC)



Background components:

- **QED**
- **machine**
- **little bit physics**

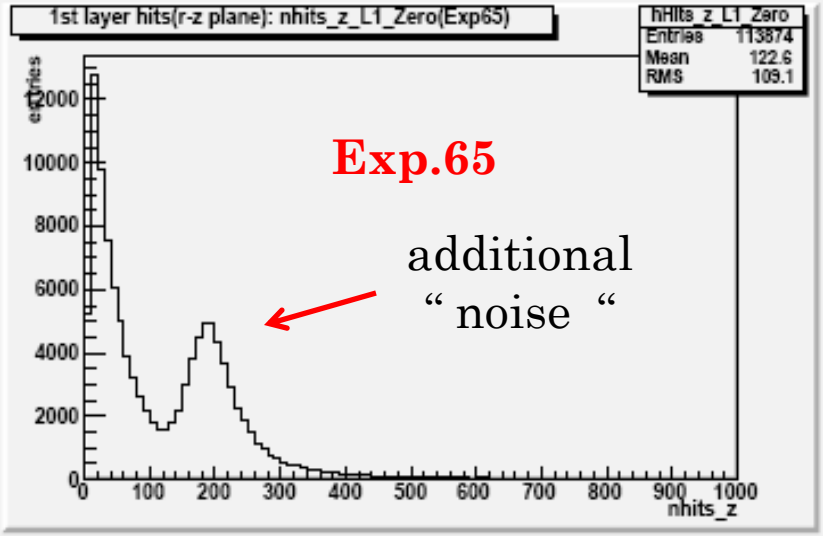
Study of Random Triggers

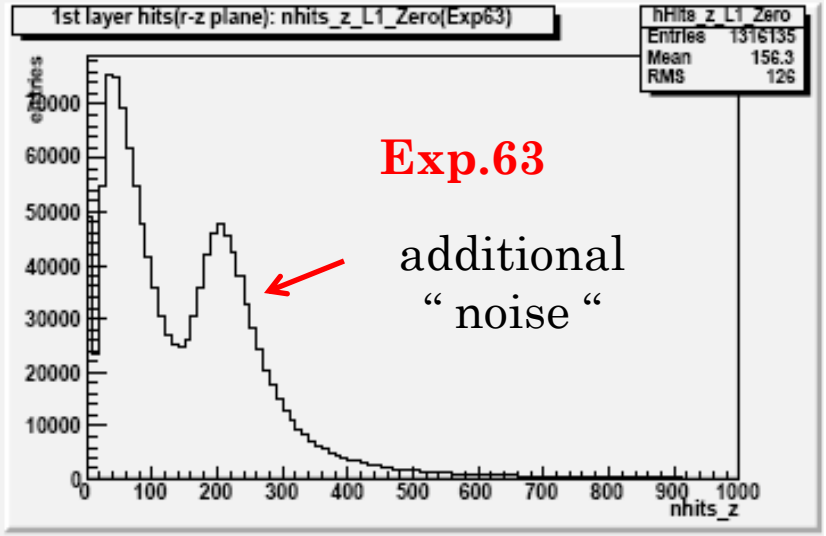
DEPFET

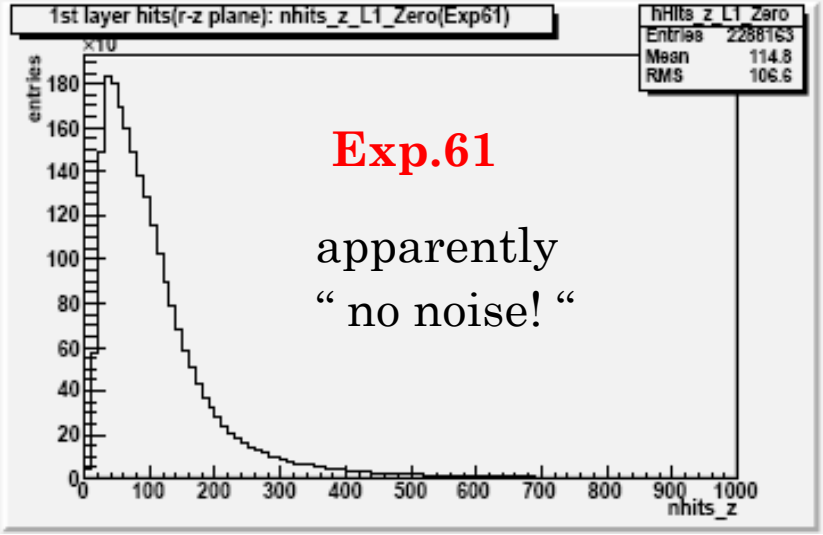
Active Pixel Detector

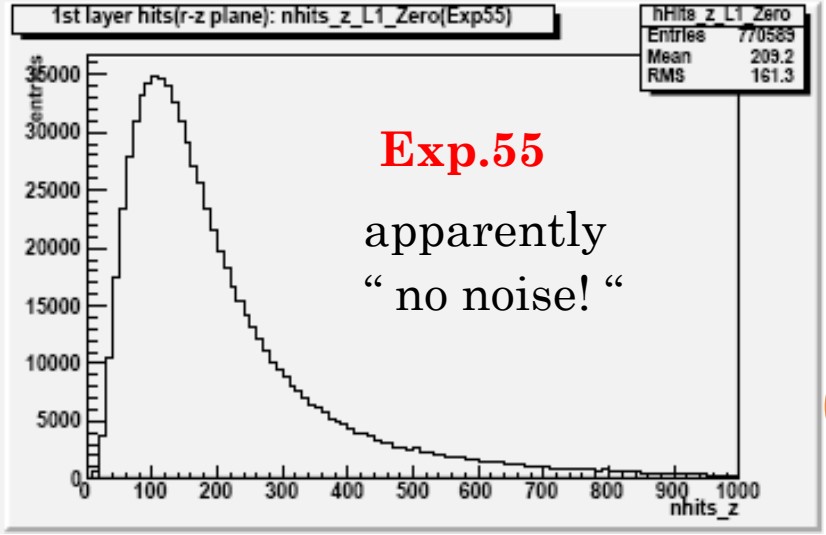
Hit distribution in the 1st layer of SVD2 – zero track events

sensitive to very low momentum







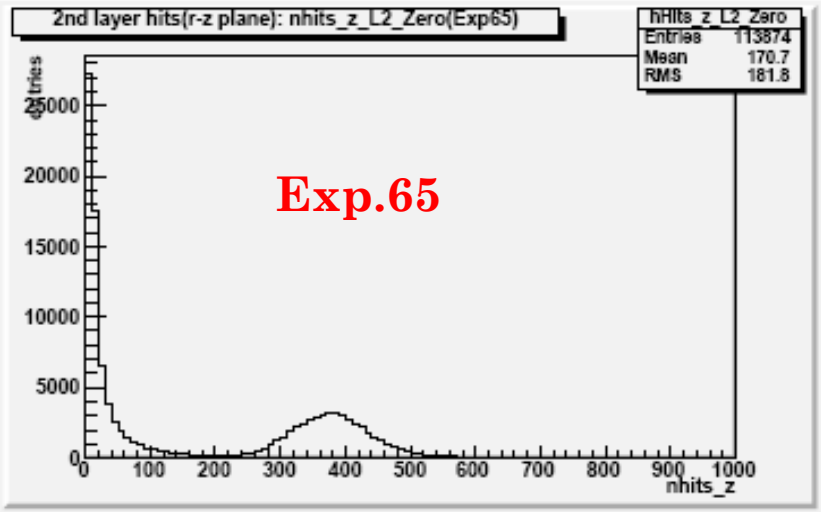


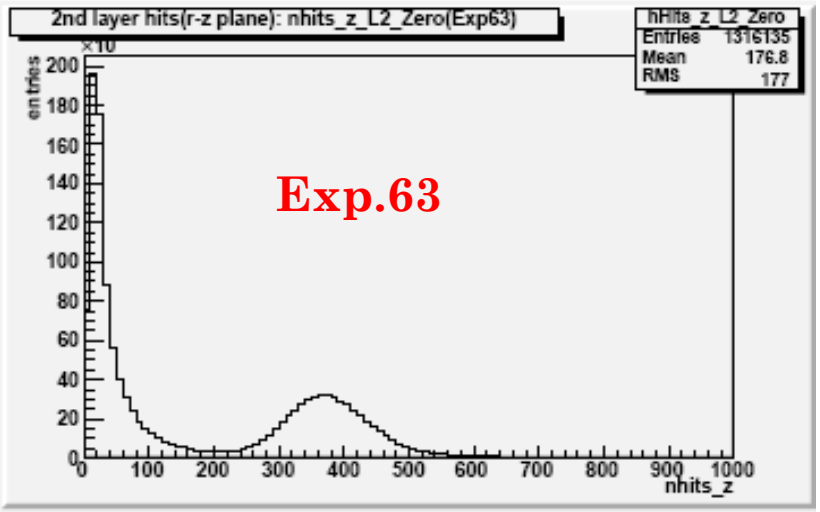
Study of Random Triggers

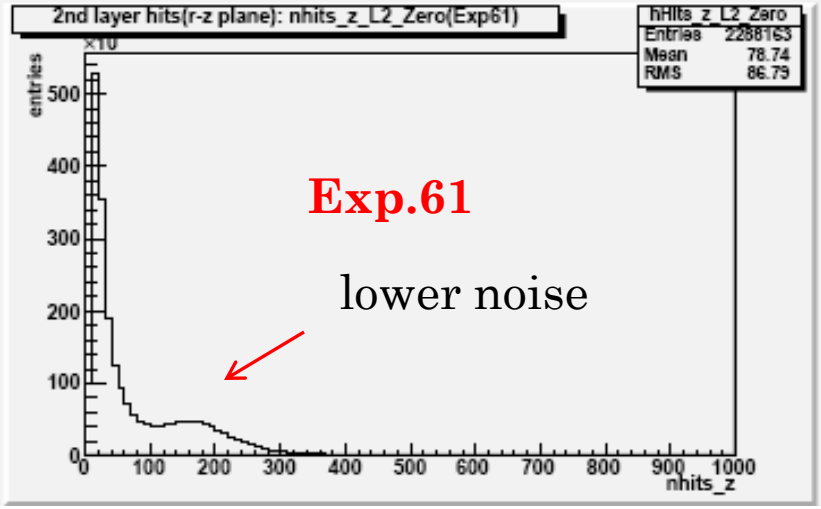
DEPFET

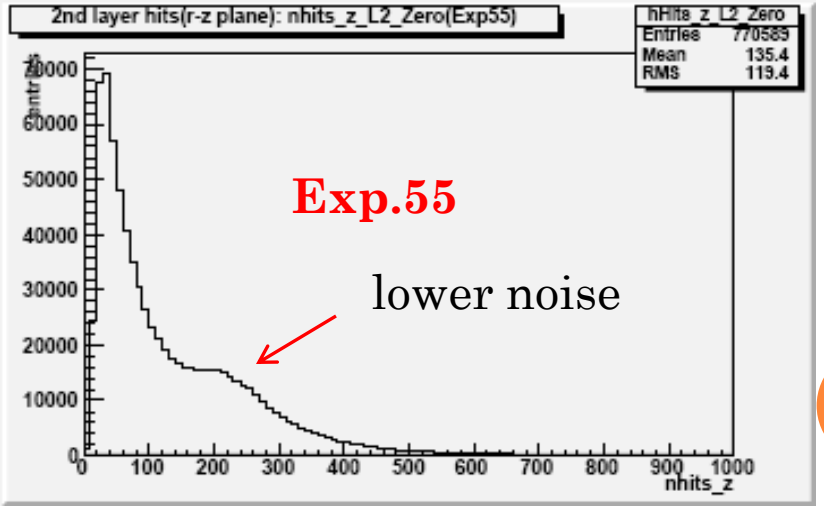
Active Pixel Detector

Hit distribution in the 2nd layer of SVD2-zero track events





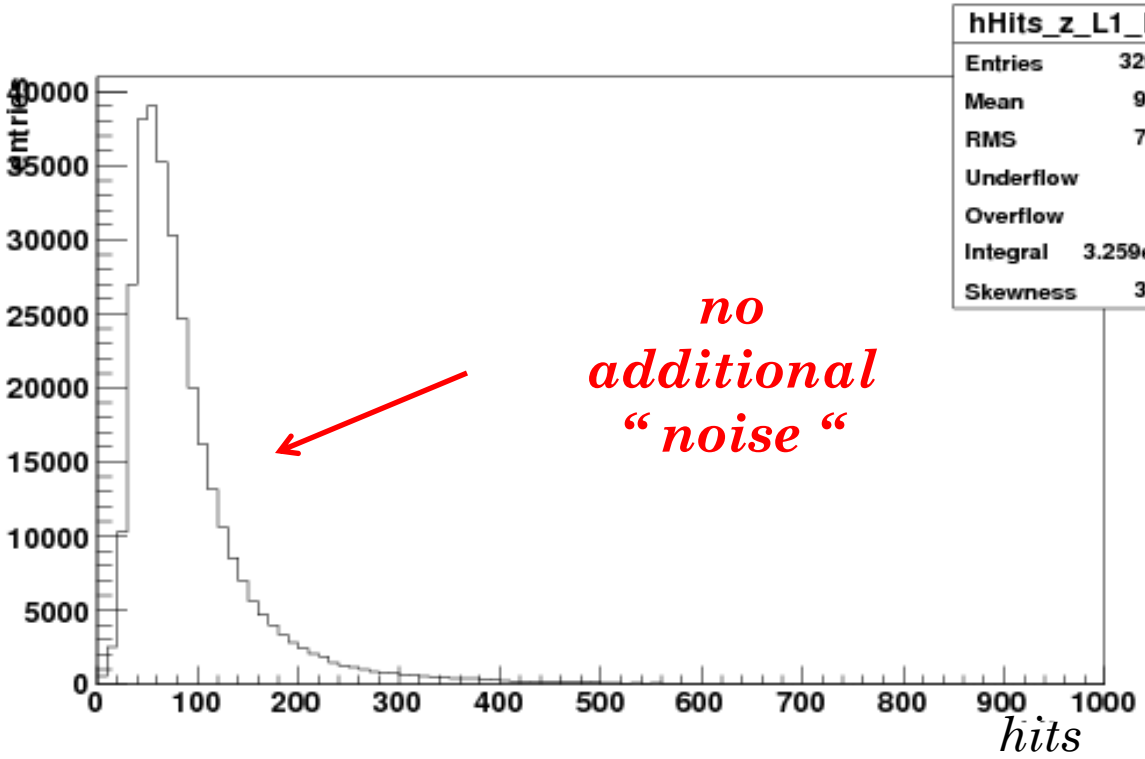




Study of Random Triggers

Such additional noise is not seen in physics events !

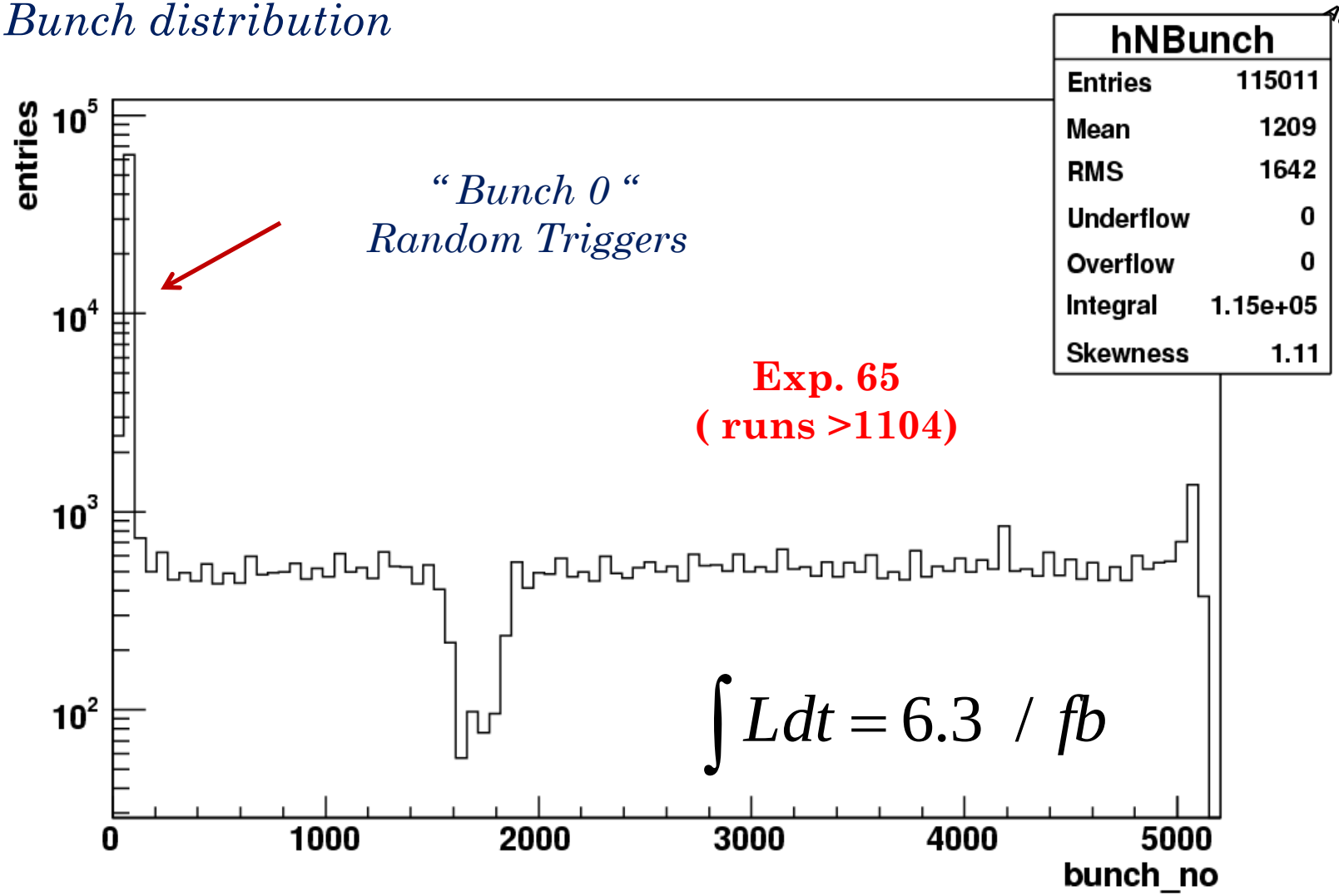
Control Sample : real multi hadrons



Hit distribution in the 1st layer of SVD2

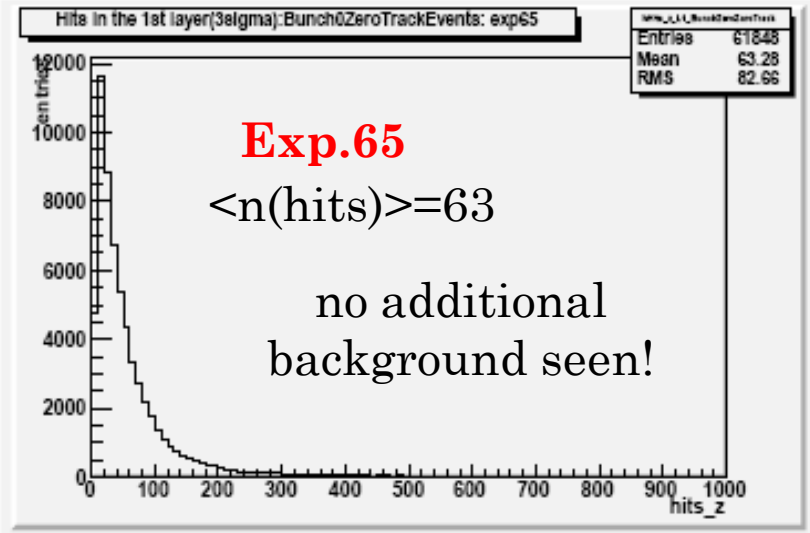
Bunch 0 Random Triggers

Bunch distribution



Bunch 0 Random Triggers

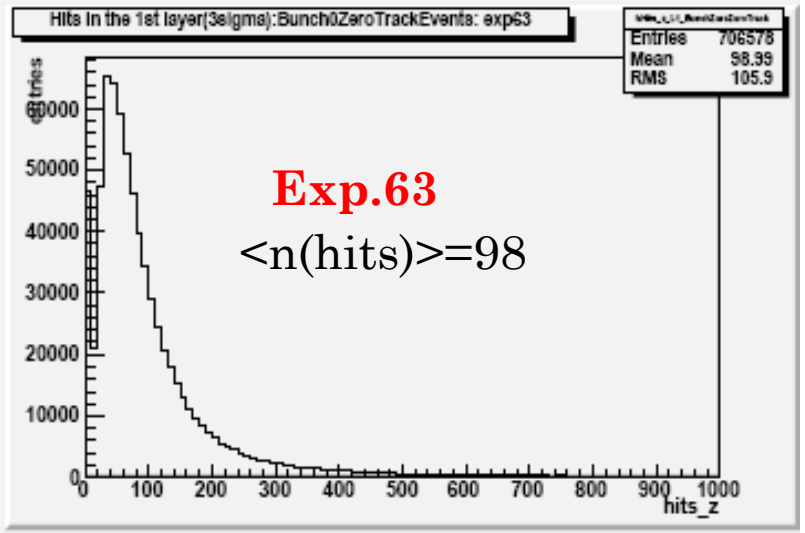
1st layer hit distribution - zero track events



Exp.65

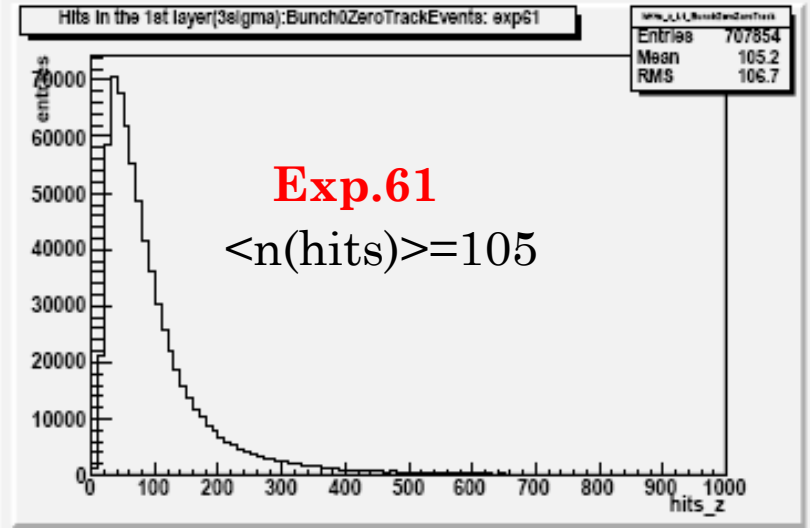
<n(hits)>=63

no additional background seen!



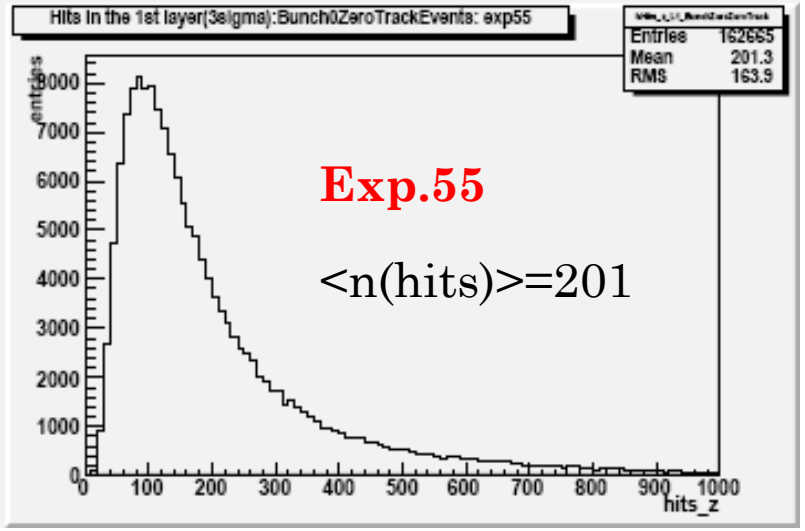
Exp.63

<n(hits)>=98



Exp.61

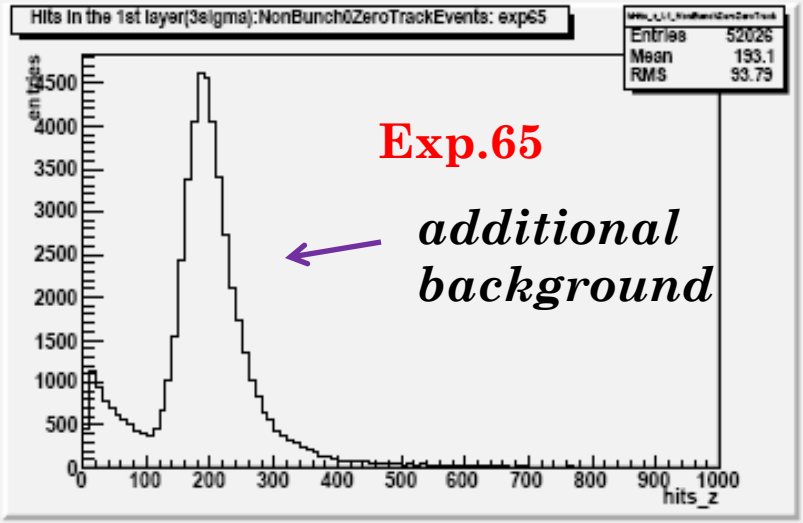
<n(hits)>=105

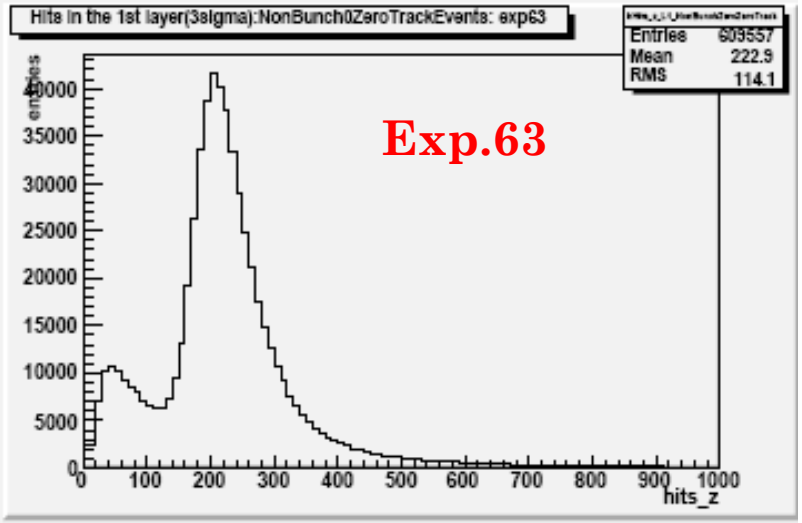


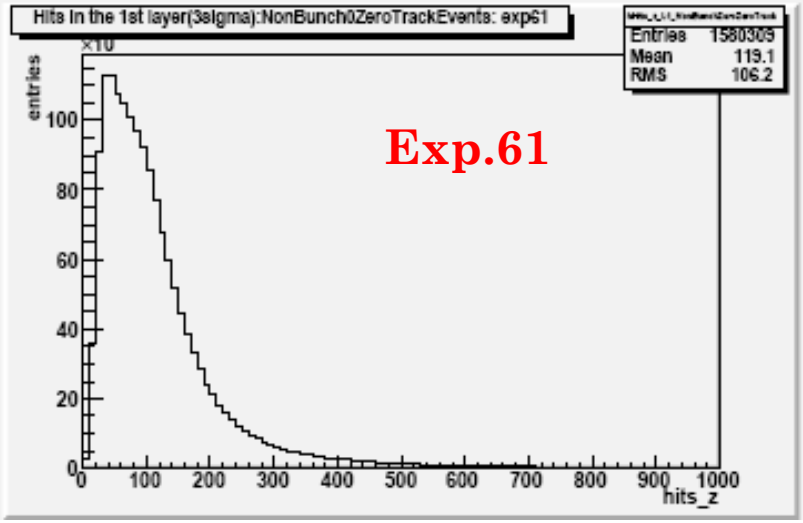
Exp.55

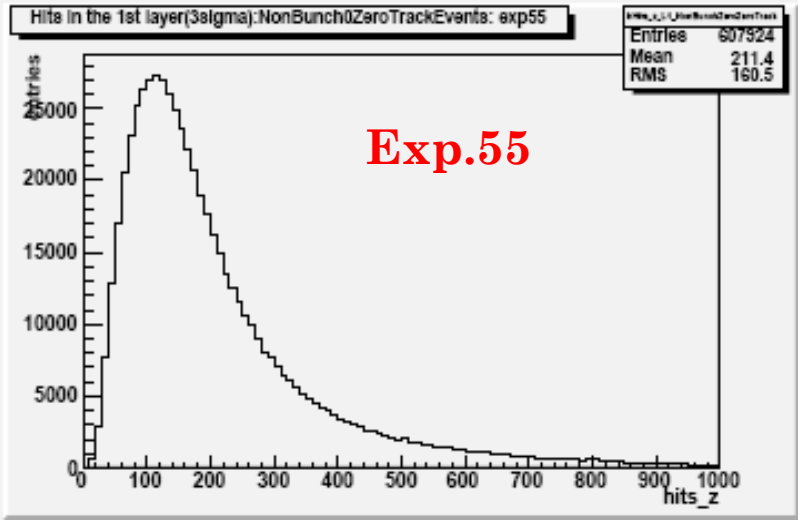
<n(hits)>=201

Non Bunch 0 Random Triggers









Comparison on various experiments at Belle

DEPFET

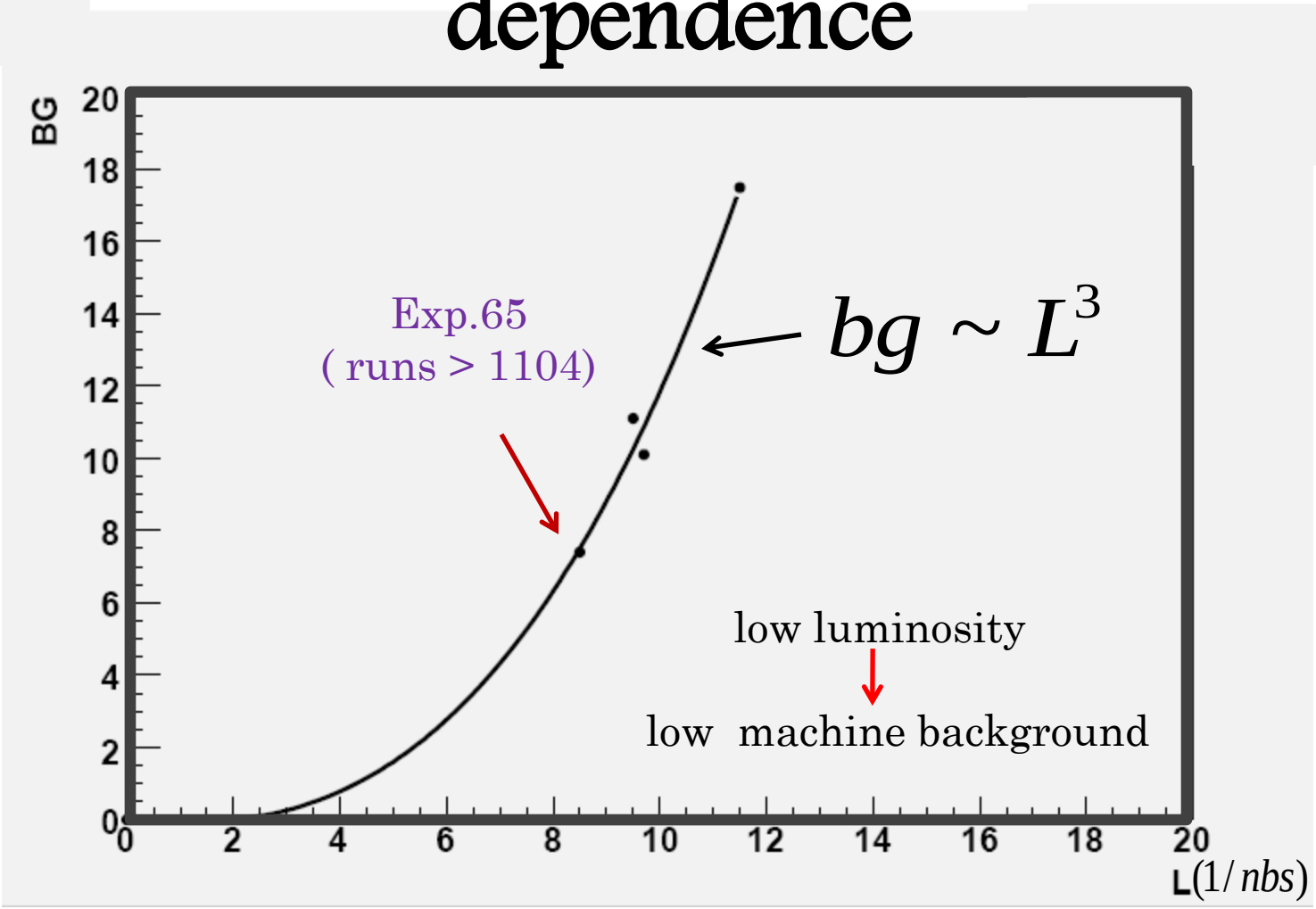
Active Pixel Detector

Exp. Nr.	55(4S)	61(4S)	63(4S)	65(3S)
L (1/fb)	31.2	18.1	26.4	6.3
Time (10^6 s)	2.72	1.91	2.71	0.74
Tr. Rate(1/s)	0.29	1.22	0.97	0.16
# of Bhabha	508	1271	707000**	63
Bhabha σ*	**56.1**	**57.6**		**62.5**
L (1/nbs)	11.5	9.5	9.7	8.5
<hits> (0)	201	105	98	63
<hits> (0)/L	**17.5**	**11.1**	**10.1**	**7.4**

* $\sigma = \frac{N}{L * R * \tau}$

** delay did not work

Background – Luminosity dependence



Random Trigger Runs

DEPFET

Active Pixel Detector

Proposals for estimating the QED Background :

- separated and colliding beams

  colliding beams : QED + beam –gas
  separated beams : only beam – gas

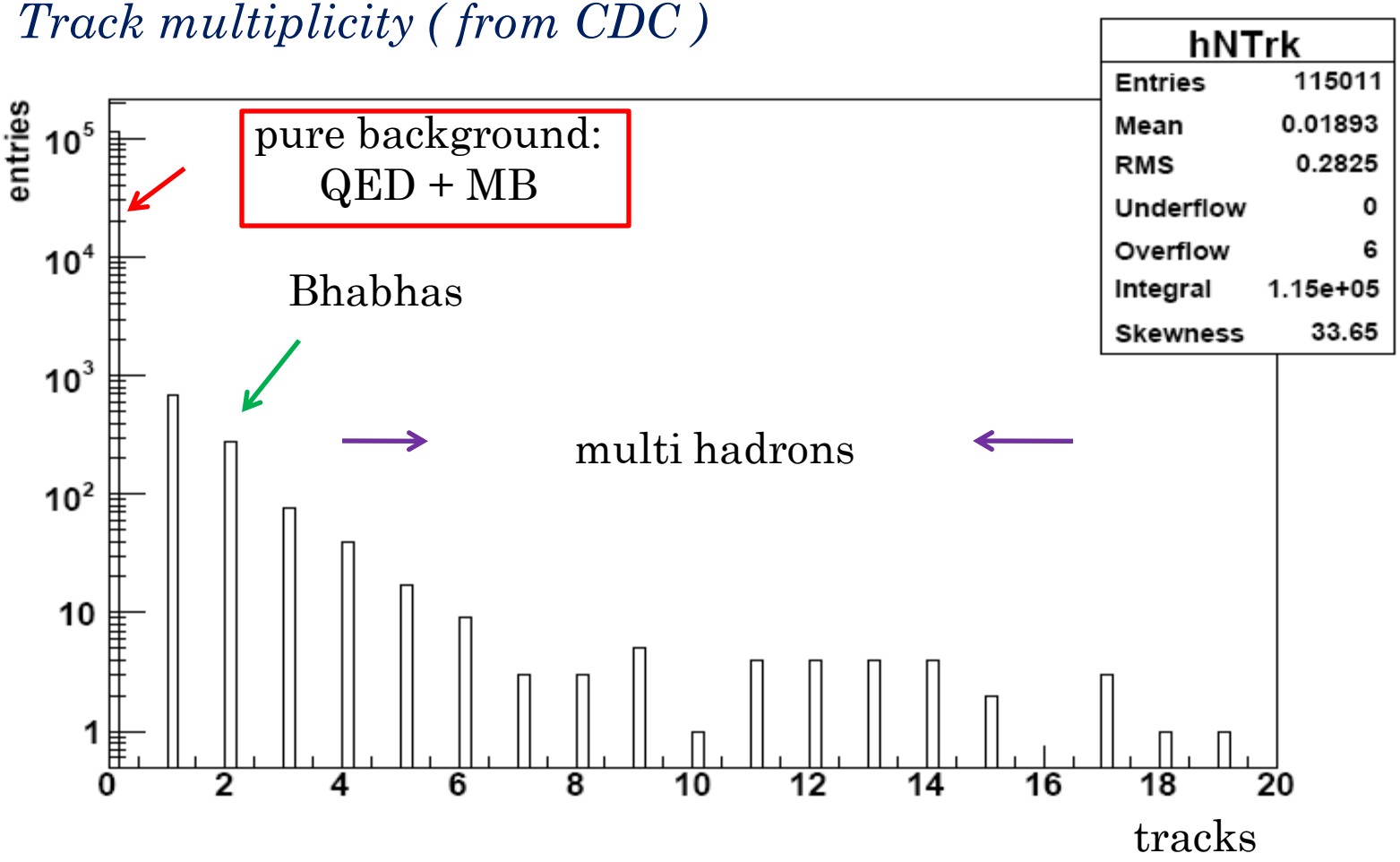
- changed beam size

- changed beam currents

  (***warning from the machine experts*** :
  this will change the vacuum and therefore machine background)

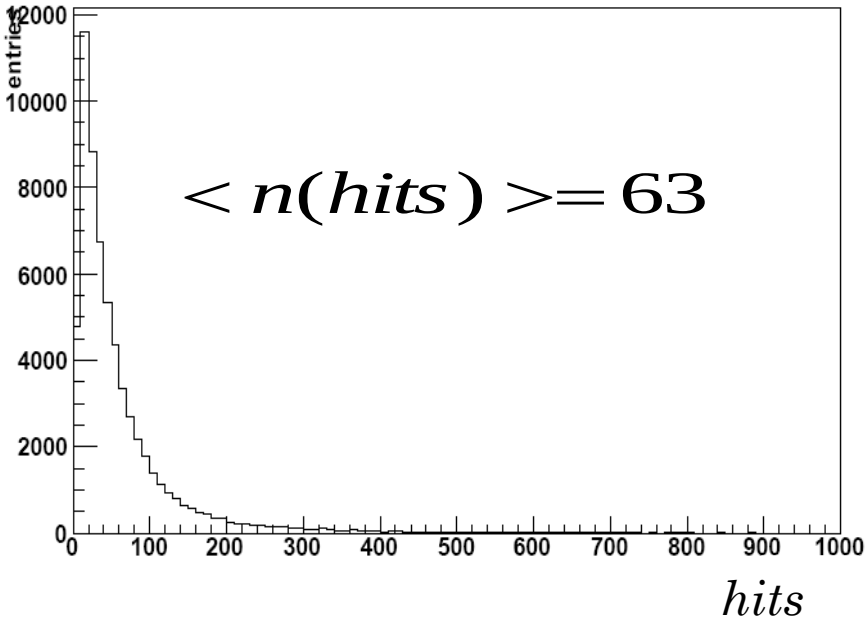
Background analysis : Exp.65

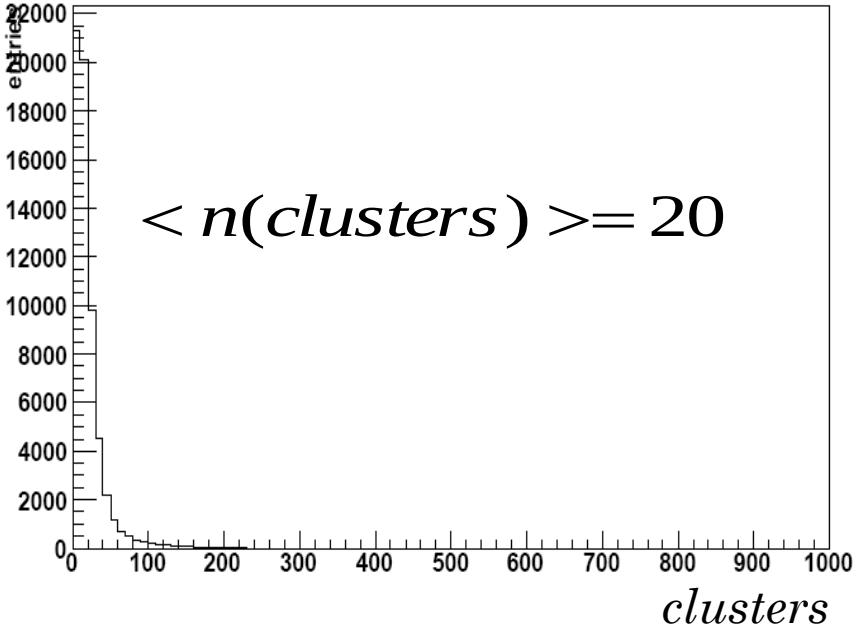
Track multiplicity (from CDC)



Bunch 0 hit and cluster distribution Exp 65

1st layer SVD2 – zero track events (because of the pure background)





3 hits/cluster

Two extreme assumptions

DEPFET

only QED background

Radius dependence

$$63*10*94*2 = 118440 hits$$

Number of hits in the 1st layer

KEKB → SuperKEKB

SVD → PXD memory time

$occupancy \rightarrow 3.7\%$

only machine background

Radius dependence

$$63*10*2*2 = 2520 hits$$

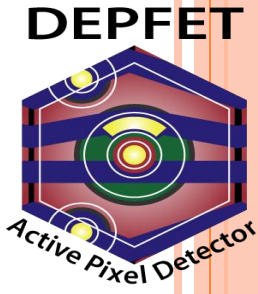
Number of hits in the 1st layer

current increase

SVD → PXD memory time

$occupancy \rightarrow 0.08\%$

QED Predictions for Random Trigger Runs



Belle **Belle II**

SuperB MC : 3 hits/track

13800 * 3 = 41400 hits

41400 / (94 * 10 * 2) ~ 22 hits ← expected hits in layer 1 SVD

Our MC :

910 * 3 = 2730 hits

2730 / (94 * 10 * 2) ~ 1.5 hits ← expected hits in layer 1 SVD

Background : 63 hits

Monte Carlo	*SuperB*	*KoralW(our's)*
QED BG	22	1.5
Machine BG	41	61.5
QED Fraction	34.9%	2.3%

Conclusions :

- MCs give us very different answers for the QED background
- 3 experiments proposed for the runs to be taken end of May to settle the question
  - Colliding and separated beams
  - Changing beam size
  - Changing the beam current (number of bunches)
- Random triggers are not random!
- Belle needs to provide random triggers
- Go to Japan 1 week before Data Taking to set up triggers and online analysis