QED Background Event Generators

- SuperB QED simulations (Frascati workshop): 10MHz/cm^2

  yields 0.5 % occupancy for PXD (inner layer)

- Set of MCs studied:

  → KoralW gives result consitent with SuperB simulations

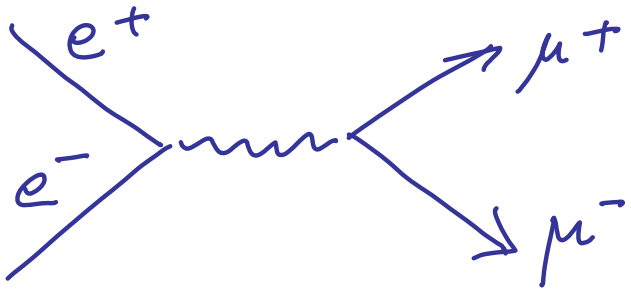
  → difference with BDK is significant (~ order of magnitude!)

- Conclusion of Prague Meeting:

  → contact authors and find out why the differences

QED Processes at SuperKEKB (Belle II)

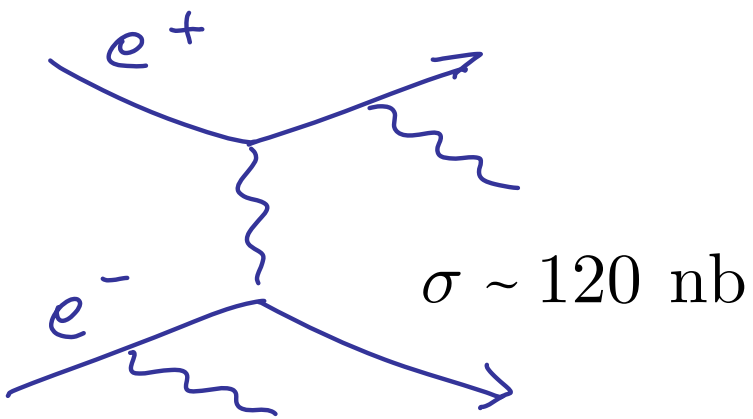
Cross sections for s-channel processes fall like 1/s



Rate ~ 600 ev/s

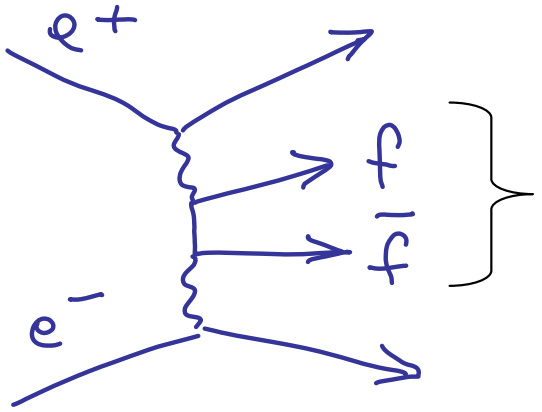
@10^3 / nb s

Cross sections for t-channel processes are largely independent of s



$\sigma \sim 120$ nb

Bhabha scattering



e^+e^- :

$\sigma \sim O(10^7\,\mathrm{nb})$

2-photon-processes

QED Processes of Importance

- 2-photon processes dominate by far

- Several generators:

  Diag36 (Berends-Daverfeldt-Kleiss, 1985)

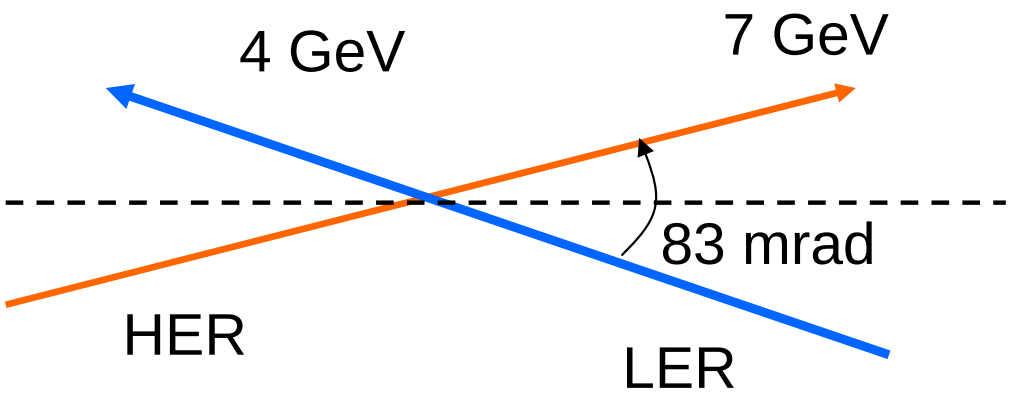
  Grace (J.Fujimoto, et.al. Comp.. Phys. Comm. 100 (1997) 128)

  Racoon (A.Denner, S.Dittmaier, M.Roth, D.Wackeroth,
  Comp. Phys. Comm.. 153 (2003) 462)

  KoralW (S. Jadach, W. Placzek, M. Skrzypek, B.F.L. Ward,
  CERN-TH/95-205, Jul 1995, CPC 94 (1996) 216 …)

- all done for symmetric e+e- machines (PETRA, LEP), all tested there!

QED at SuperKEKB



B-field direction

(Belle's symmetry axis)

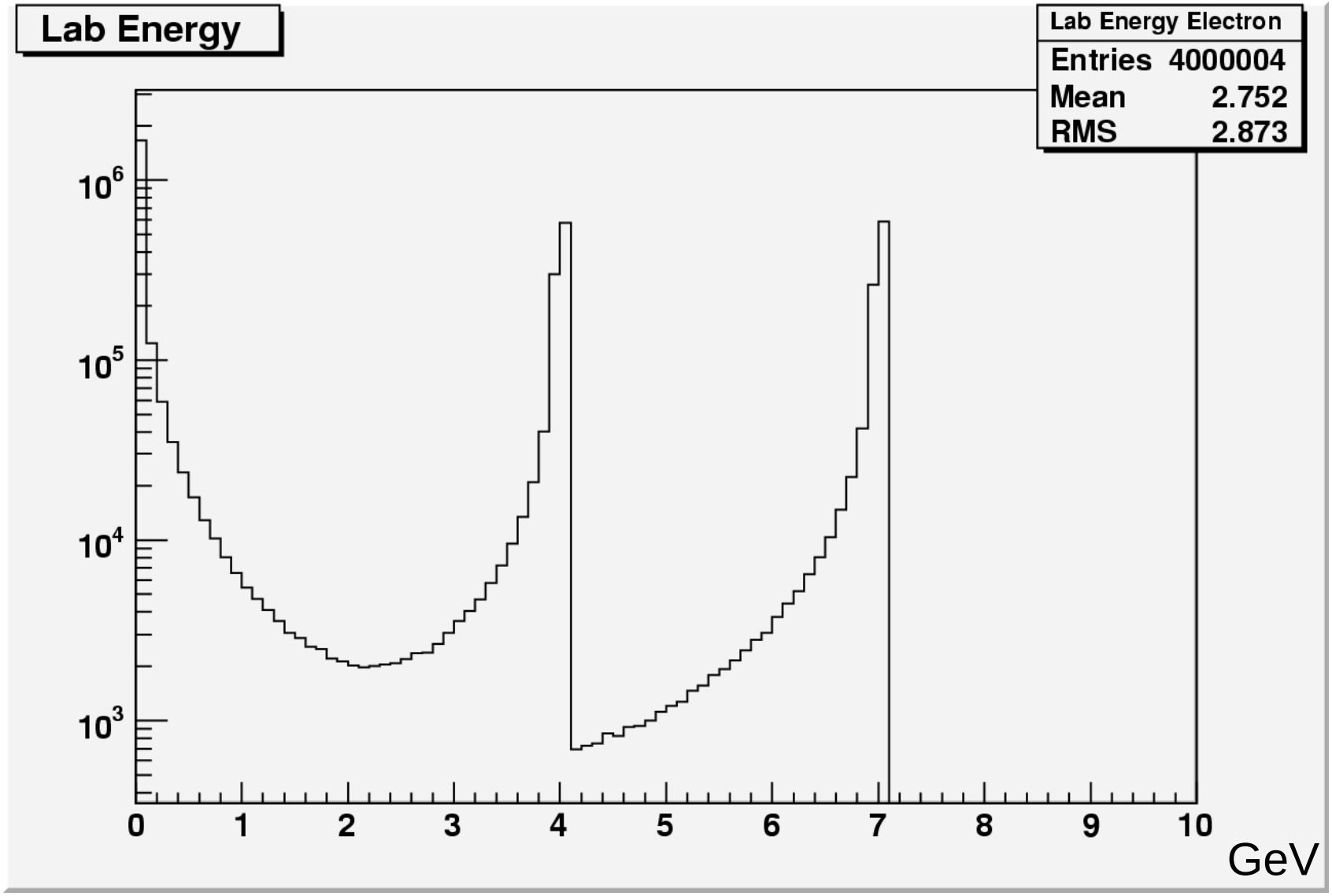
Procedure:

1M events per generator

- generate events in CM system
- calculate boost from lab to CMS (method of Burkard)
- boost CMS to lab
- make acceptance cuts (p_T, θ) in the lab

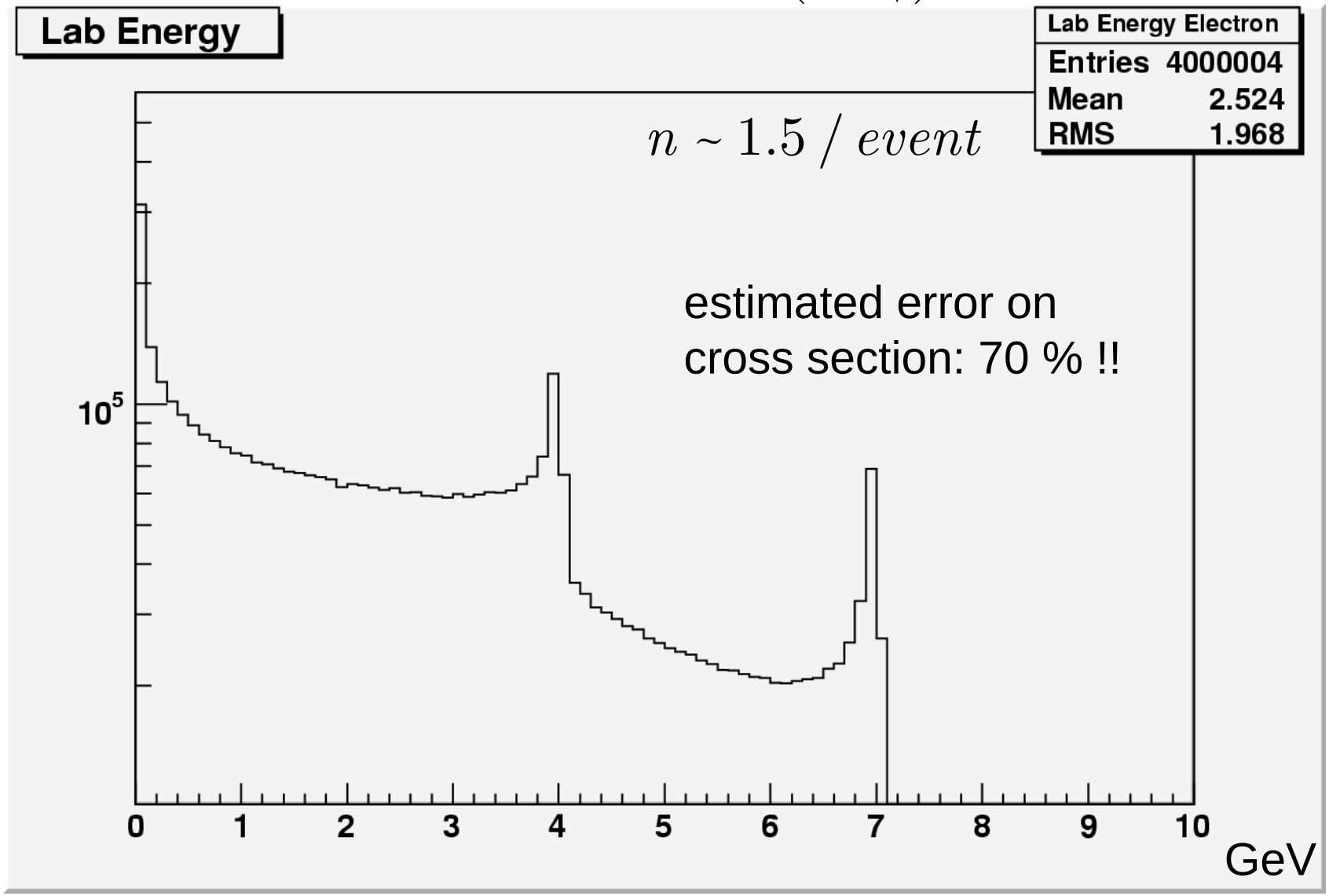
Berends-Daverfeldt-Kleiss (BDK)

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

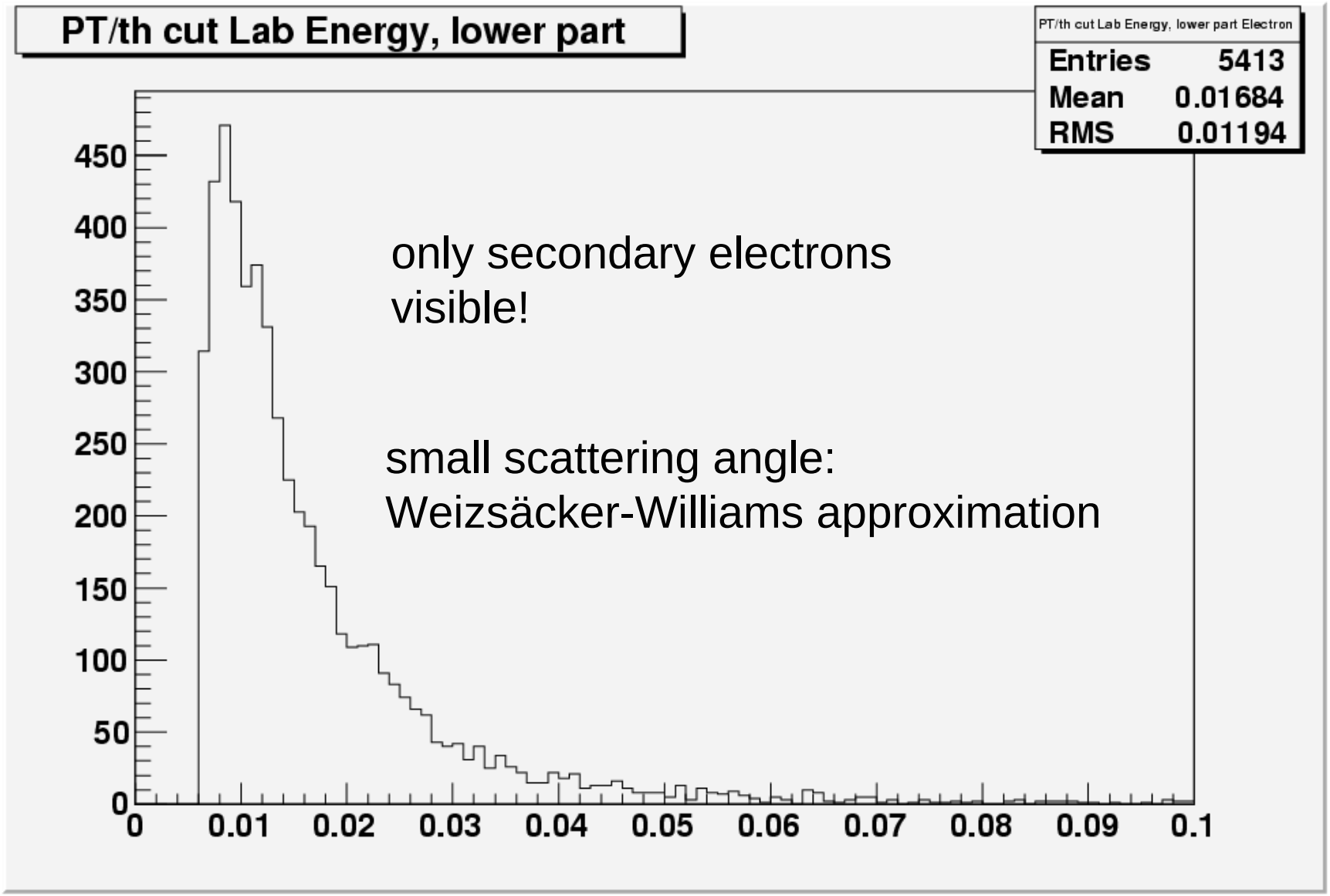


KoralW (KW)

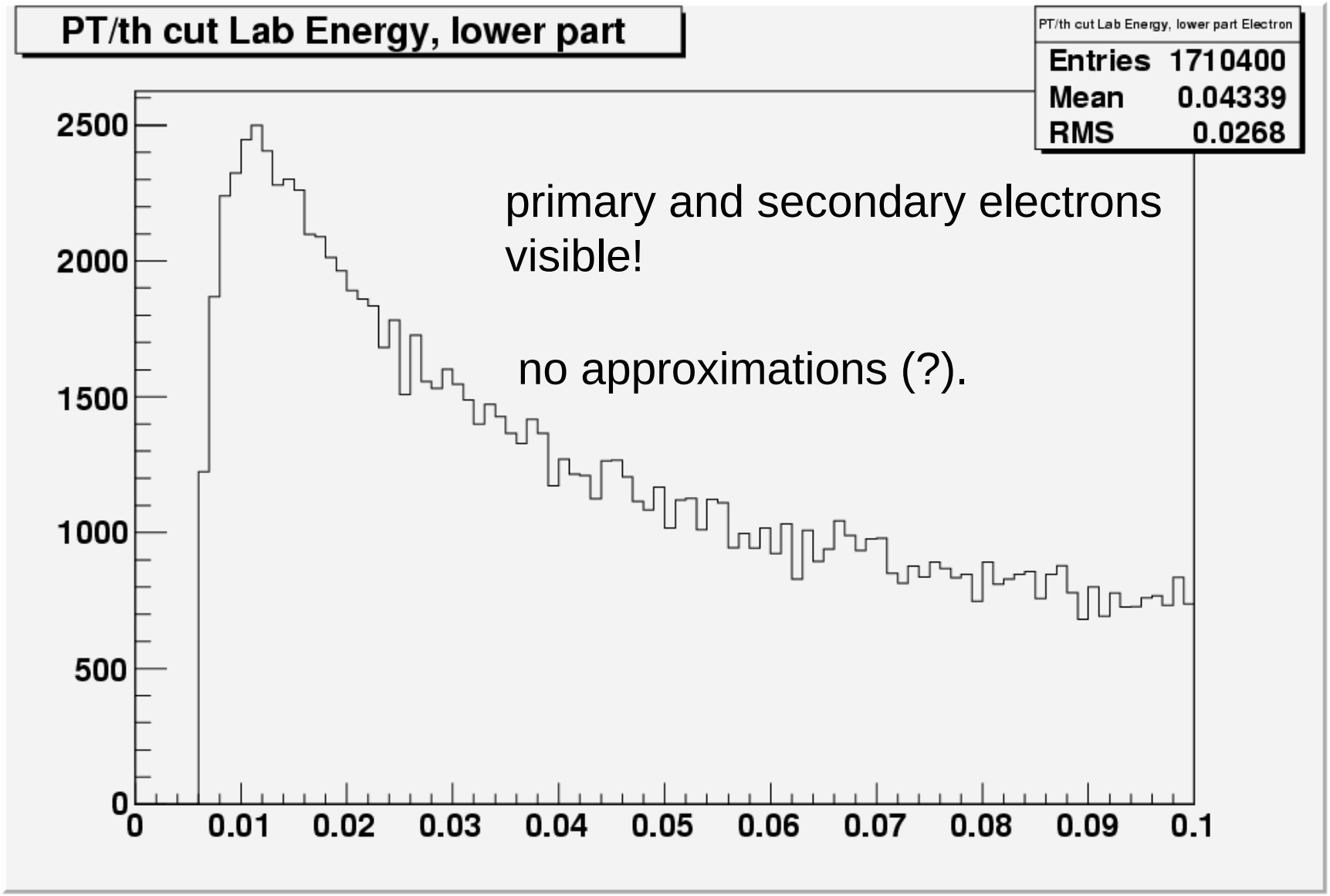
$$e^+e^- \rightarrow e^+e^-e^+e^-(+n\gamma)$$



BDK (after acc. cuts)



KW (after acc. cuts)



Trip to Krakow last week

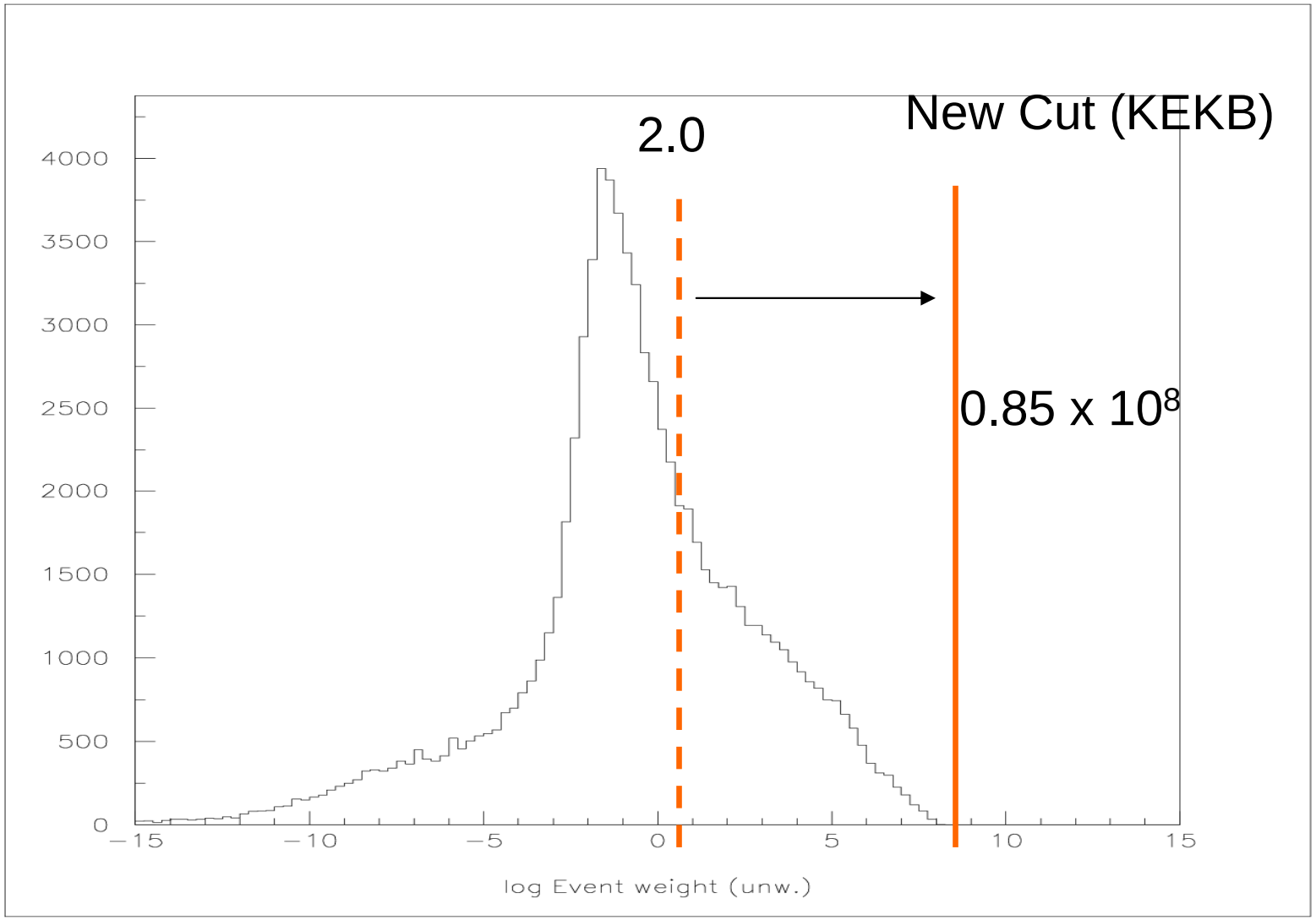
- Direct contact with authors for almost 2 days
- Many tests of the program at large (LEP) and small (KEKB) energies studying the various cutoffs (using WEIGHTED events, fast, recommended by the authors)
- Conclusions:

  to the surprise of the authors, the program seems to behave well even at very small cutoffs.

  When turning to the UNWEIGHTED events, however, a problem‘ was dicovered with the maximum weight

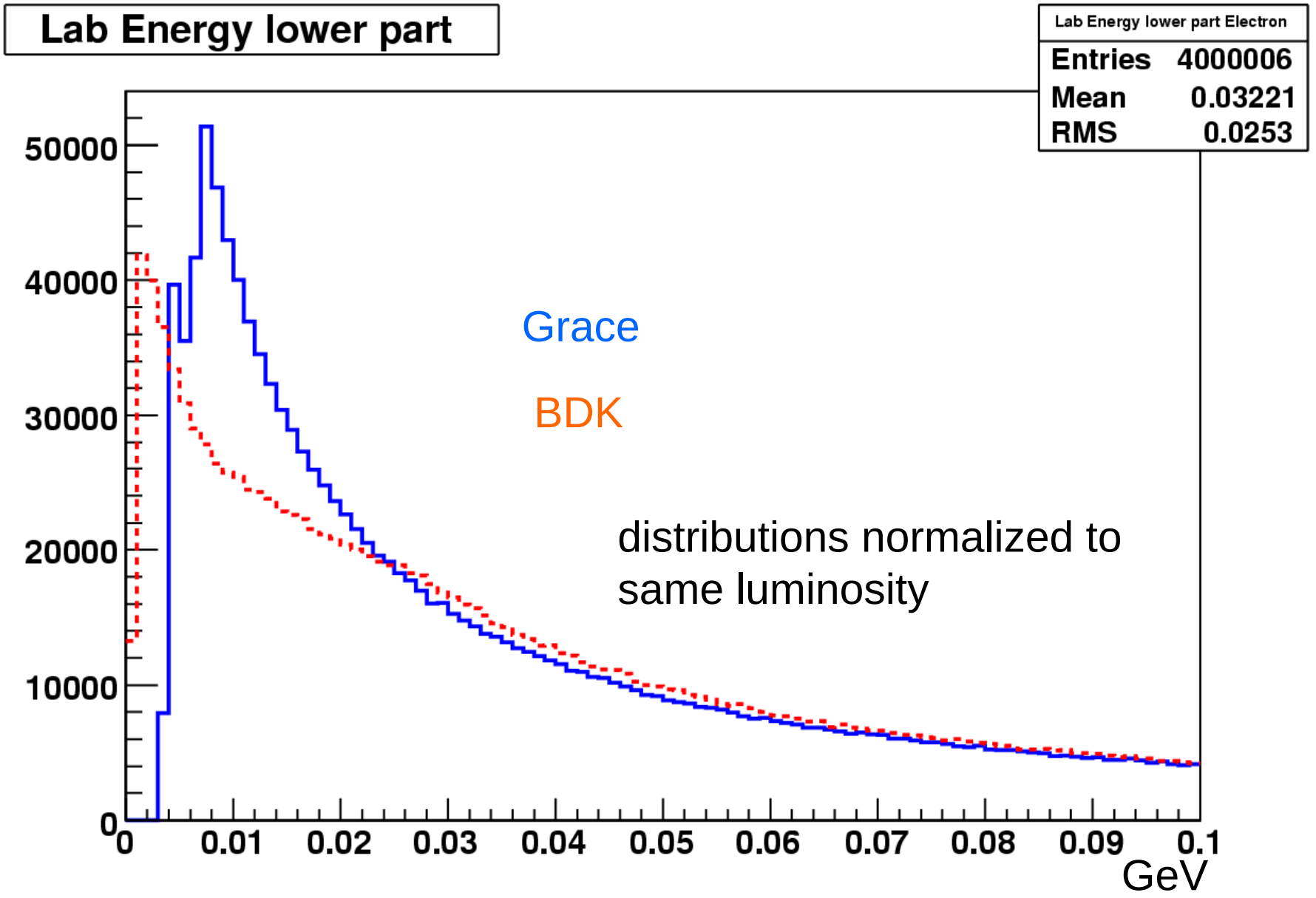
  this needed to be adjusted for the new energies!

The Weight Problem

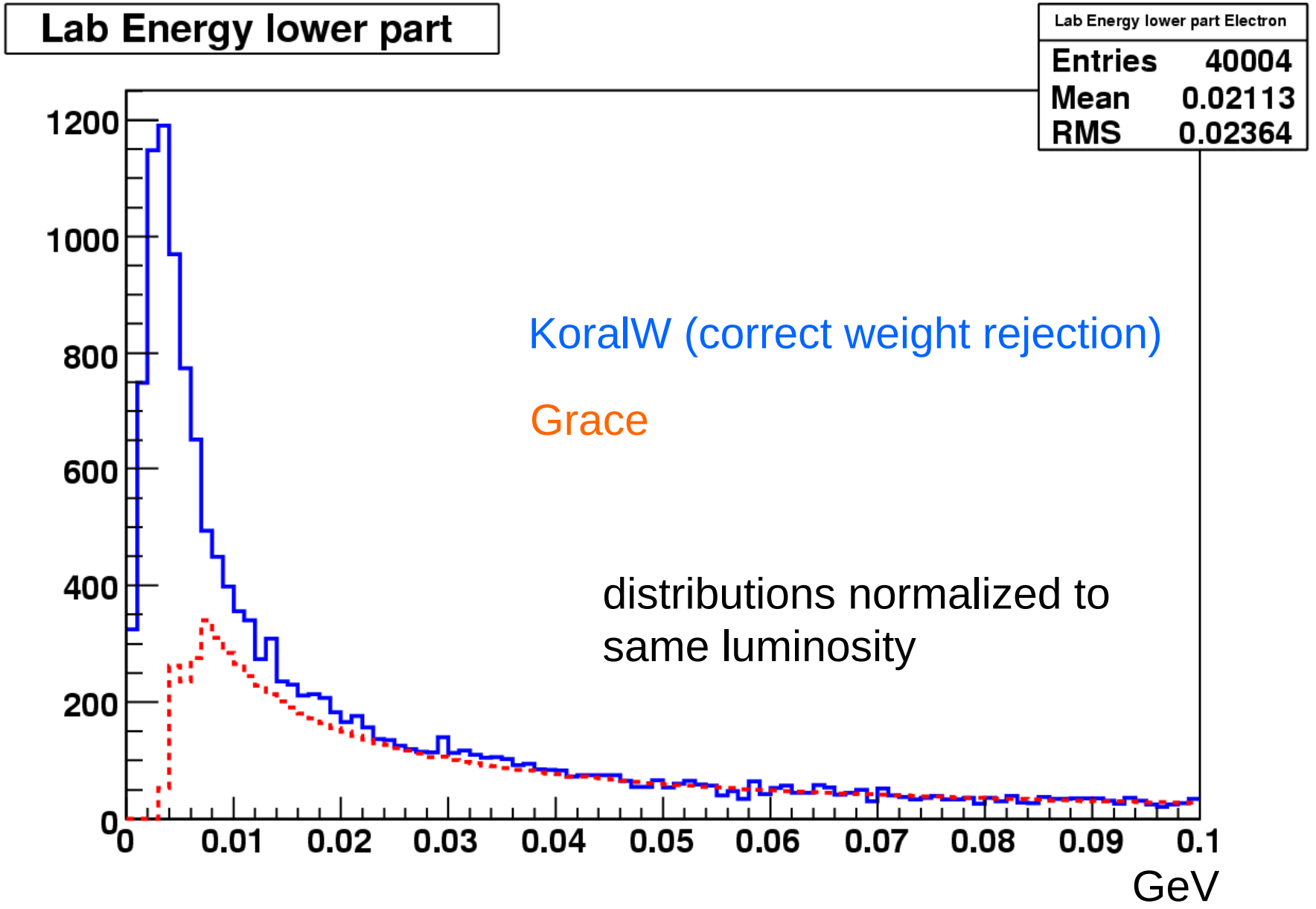


Old Cut (OK for LEP)

Compare BDK to Grace



Compare Grace to unweighted KoralW



Estimates for expected QED rates (I)

BDK: $\sigma = 7.3 \times 10^6 \left[\mathrm{nb}\right]$

KWc: $\sigma = 4.5 \times 10^5 \left[\mathrm{nb}\right]$ (3 MeV cut)

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

ε

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

DEPFET readout time

$$N_{\mathrm{ev}}(\mathrm{MC}) = 10^6$$

BDK: $\varepsilon = 0.146$

KWc: $\varepsilon = 0.52$

Estimates for expected QED rates (II)

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

KWc: $N_{\mathrm{tr}}^{\mathrm{acc}}(\mathrm{MC}) = 1675$

Expected number of background tracks per event:

Occupancy (inner layer):

BDK: $N_{\mathrm{tr}}^{\mathrm{bg}} = 790$ $\quad 0.07\,\%$

KW: $N_{\mathrm{tr}}^{\mathrm{bg}} = 870$ $\quad 0.1\,\%$

enough „room“
„limit“ of 1 %

Nr of pixels: $250 \times 1600 \times 8 = 3.2 \times 10^6$
(assume each track lights up 3 pixels)

QED at low momentum transfers (II)

- A word of caution:

  → We now get consistent results from 2 different MCs,

  BUT:

  → the SuperB number has not been revised (still 0.5 %)

  → Masako also gets 0.5 % occupancy from another program

- Need to measure now:

  Take random triggers with Belle (this year last chance)
  with colliding and separated beams in May/June

  Positive replies from Belle authorities …

Conclusions

- SuperKEKB: Current will rise by factor 2, lumi by factor 40
- Our calculations now indicate that background is NOT likely to be dominated by QED (2 photon reactions) (in contrast to the conclusion of the SuperB colleagues)
- Generators BDK, Grace (used by Belle?) and KoralW, now give similar results
- Present estimate of bg rate in physics event seems manageable (occupancy ~0.1% from QED at full lumi)
- Further study needed and ongoing (contact with SUperB authors as well as KEKB (Masako-san, Uehara-san)
- Study of random trigger ongoing (Elena) Put to a test with special runs with Belle this year