Electromagnetic beam-beam background at SuperB

Joint Belle II & SuperB Background Meeting

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University of Technology, Vienna, Austria

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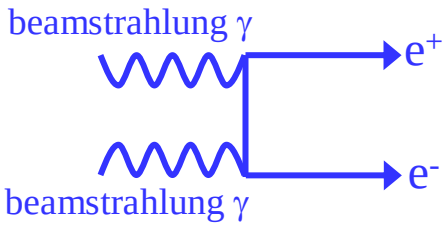
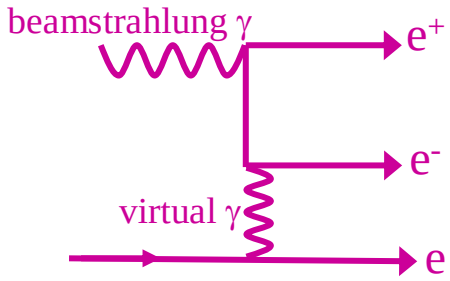
Electromagnetic beam-beam background at SuperB

Tools
BDK tuning
GP++ fast simulation
DIAG36/BDK/GP++ FastSim comparison
GP++ full simulation
Rough estimation of SVT backgrounds
Summary table

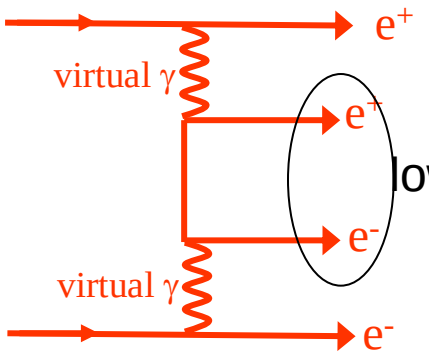
Pairs backgrounds in SuperB



Breit-Wheeler ~ 0



Bethe-Heitler ~ 3%



Landau-Lifshitz ~ 97%

- Purpose: Cross-check of DIAG36 cross-section prediction ➔ 7.28 10^6 nbarn

- Tools:

  - BDK : 4 fermions generator (DELPHI)

F. A. Berends, P. H. Daverveldt, and R. Kleiss, Comput. Phys. Commun. ***40****, 285 (1986).*

  - GUINEA-PIG++: C++ version of beam-beam interaction simulation code written by D. Schulte. LL process estimation using Weizsäcker-Williams approximation

https://trac.lal.in2p3.fr/GuineaPig, versions 1.0.16 & 1.1.1

MC Generators Overview

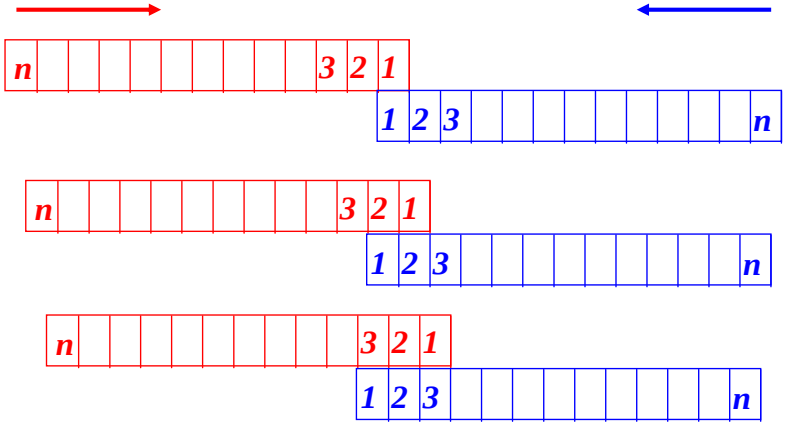
- The generators used in the followings

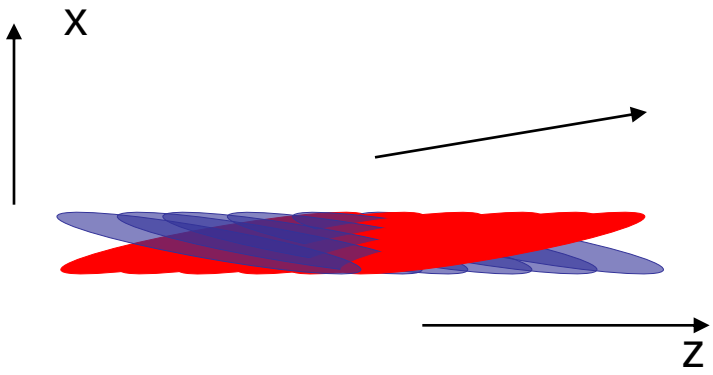
	Diag36	BDK
Authors	F.A. BERENDS, P.H. DAVERVELDT, R. KLEISS	
Last update (known by me)	8/2/1985	28/1/1985
Source	BaBar software repository	Cecile Rimbault (from Delphi software repository)
Features	All the 36 tree QED diagrams are properly taken into account	Photon - Z0 interference, running coupling constant (vacuum polarization)

Beam-Beam interaction simulation

Macro-particles replace particles (can be 10^5 Macro ⇔ 2 10^{10} part)

- Bunches are cut into slices: a slice of one bunch interacts with a slice of the other bunch when they occupy the same transverse plan.
- Slices are moved longitudinally on a 3D grid
- For each slice-slice interaction:
  - Macro-part are distributed on a 3Dim. grid
  - Fields calculation
  - Macro-part are moved according to fields + photons are produced.
  - if photon treatment is asked:
    - photons are distributed and moved on the grid
    - (if asked) pairs are generated and moved....





Approximation: beams are moved along z with a tilted angle

Background in the SVT

- r_{L0} =14mm/30mm, B=1.5T
- Electron travel along helix with a radius of

  $r_0(m)=3.33Pt/B$ (GeV/T)

- Conditions to hit the SVT:

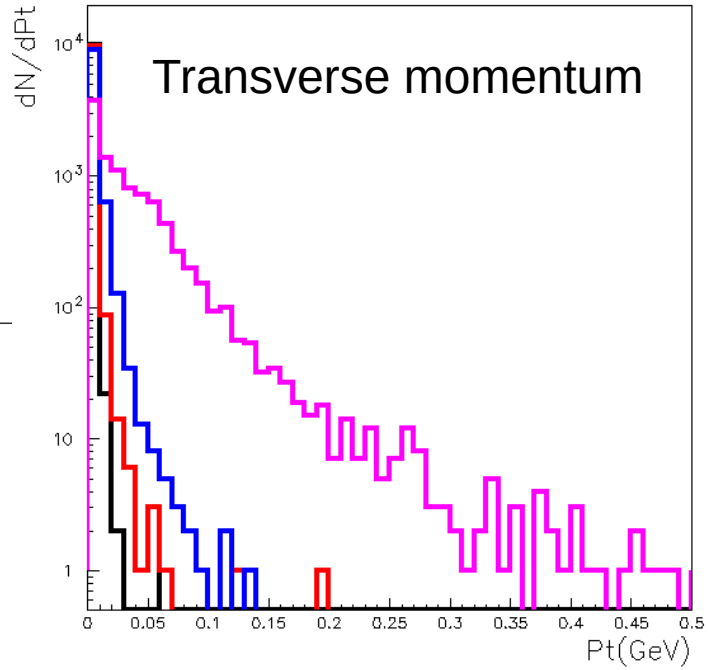
  $r_0 \geq r_{SVT}/2$

  $300mrad<\theta_0<pi-300mrad$

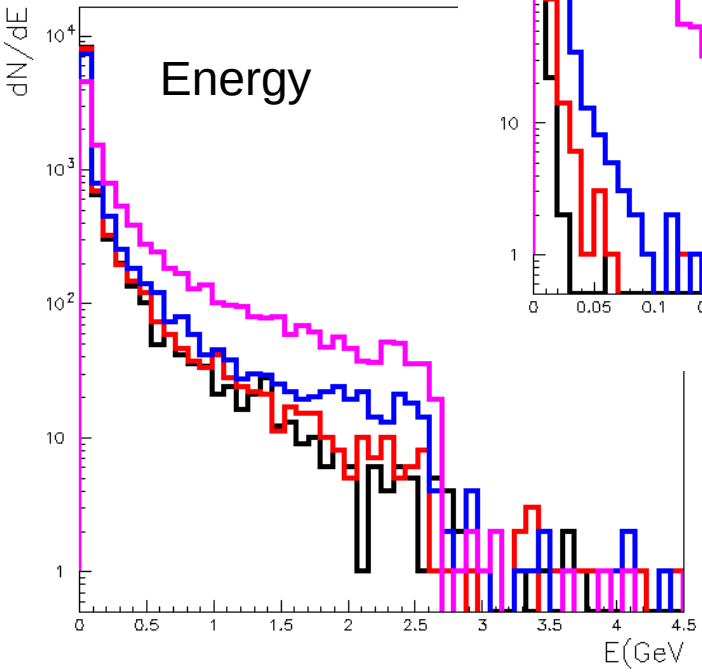
- Comparisons made at the generator level

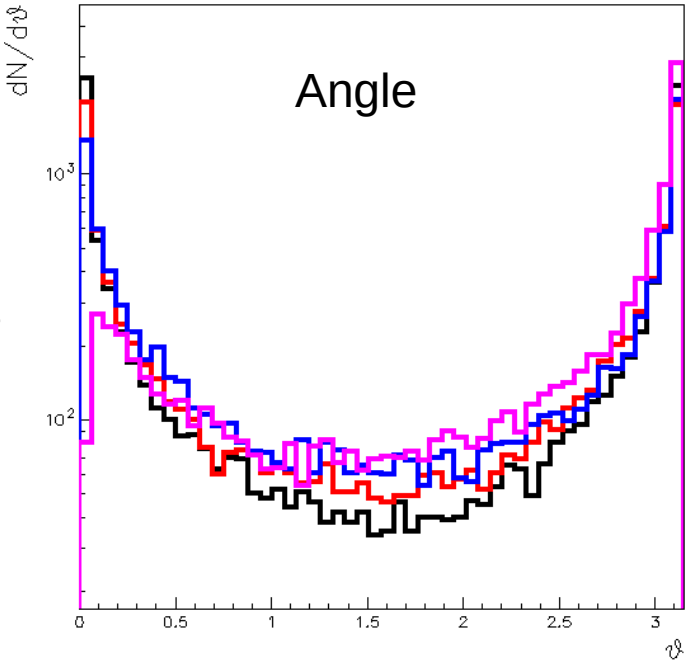
BDK tuning

- Run at 5.3 GeV energy beam, 10K events
- Sensitivity to pair minimal invariant mass square w2min



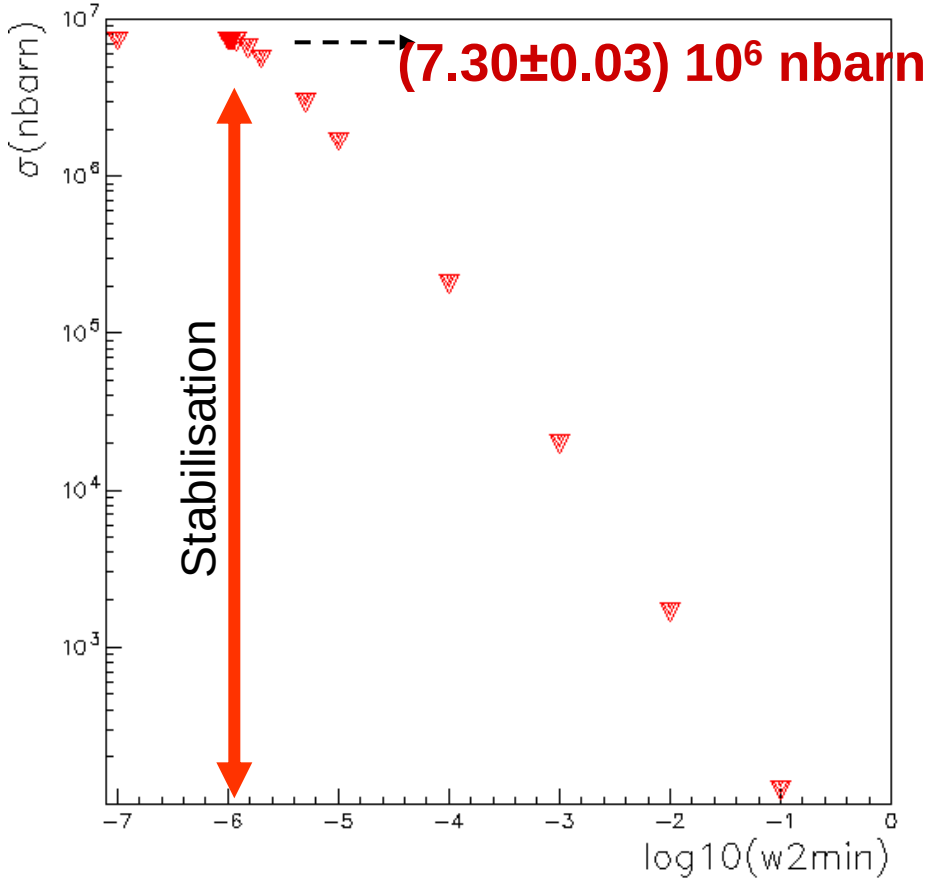
w^2_{min} (GeV^2) = 10^{-2}, 10^{-4}, 10^{-5}, 10^{-6}

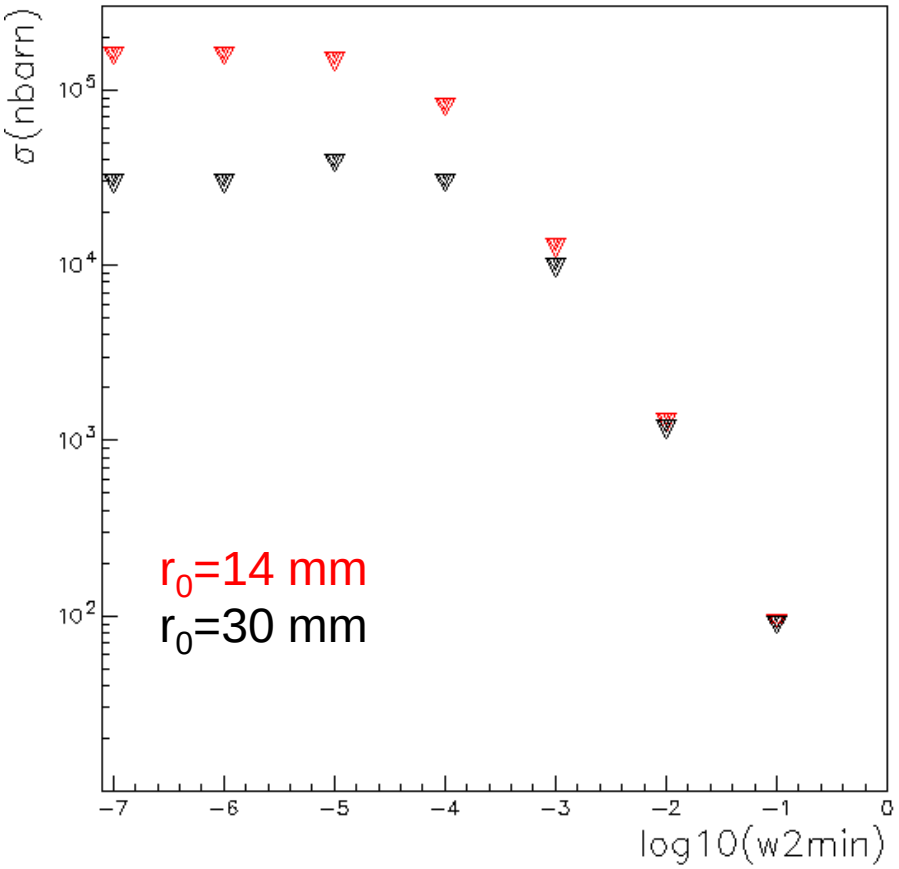




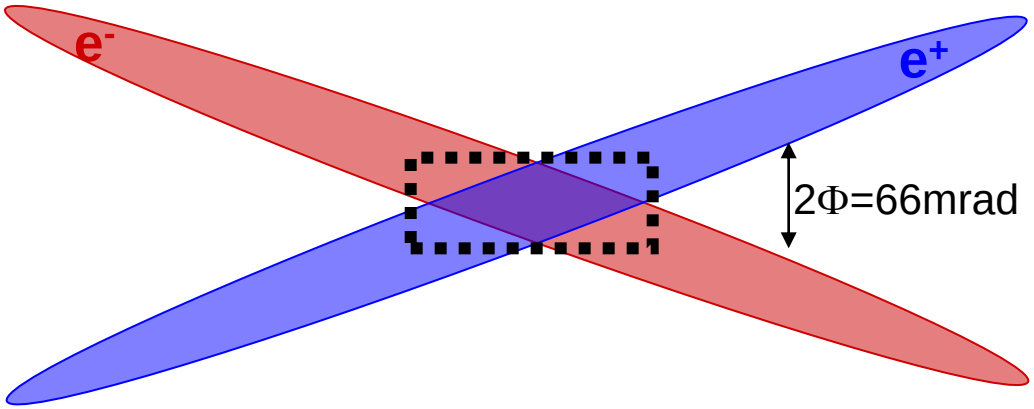
BDK tuning

Cross-section and background in SVT predictions as function of w2min, constant below 10^{-6} GeV2=$4m_e^2$





GP++ fast simulation



Symetrical beams of 5.3 GeV with

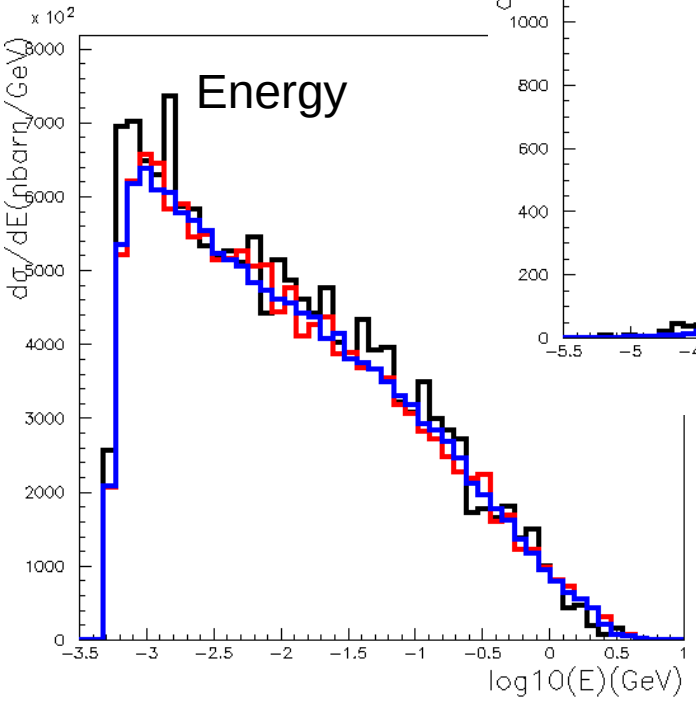
$N=N_B\sigma_x/\sigma_z\Phi=2.6\ 10^9$ particles and

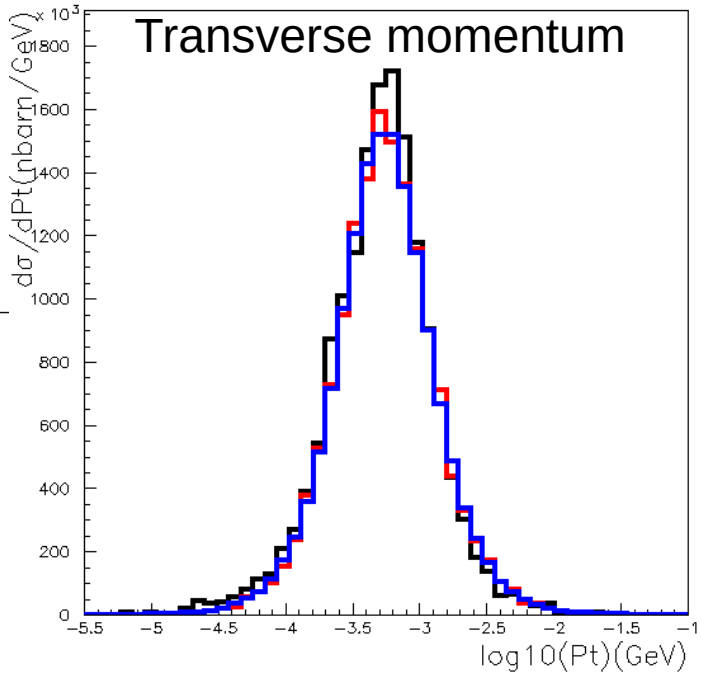
$\sigma_{zeff}=\sigma_x/\Phi=244\mu m$

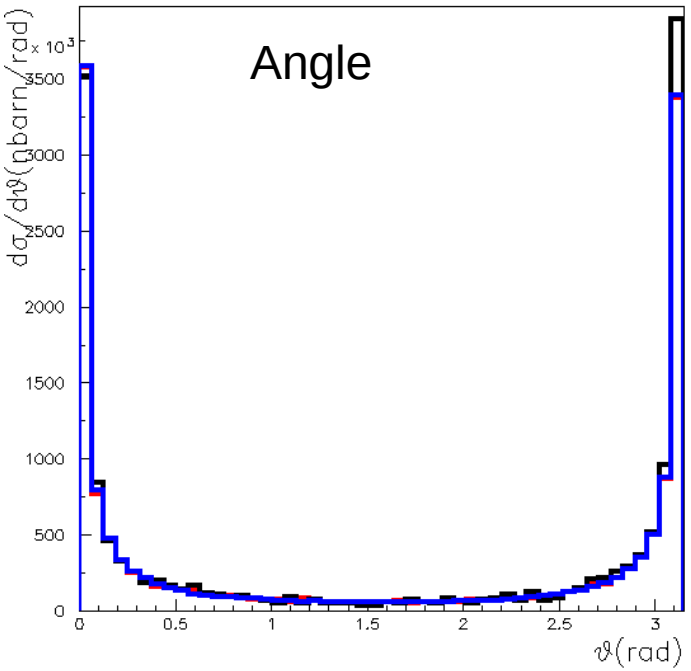
1 slice-slice interaction

2000 runs ➔ $\mathcal{L}=2.66\ 10^{33}\ m^{-2}$ ➔ $\sigma=(7.7\pm0.4)10^6$ nbarn

Comparison
BDK / DIAG36 / GP++FastSim







(7.30±0.03) 10^6 nbarn

(7.7±0.4) 10^6 nbarn

7.28 10^6 nbarn

Good quantitative and qualitative agreement between the 3 simulations

GP++ simulations comparison

- Is the **fast simulation** enough?
  - Fast Sim with asymmetric beam energies (4.18 & 6.7 GeV)
  - Full Simulation: Entire beam-beam interaction at 66mrad

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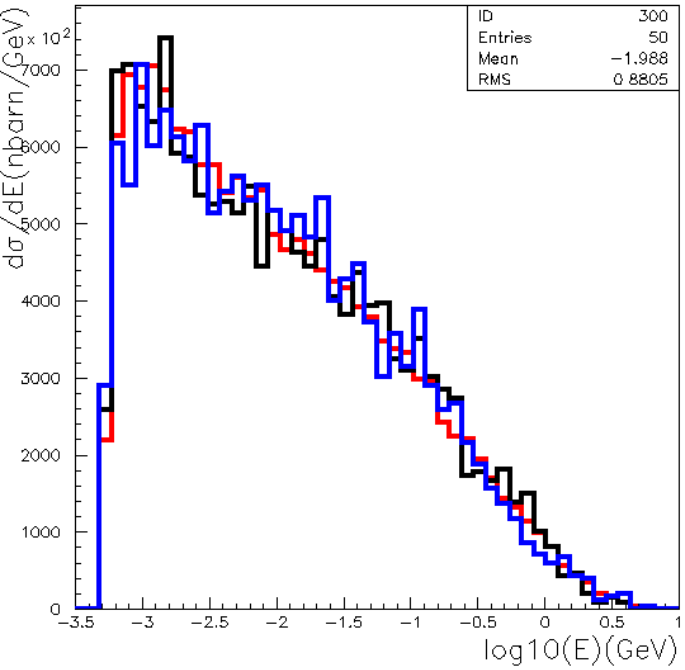

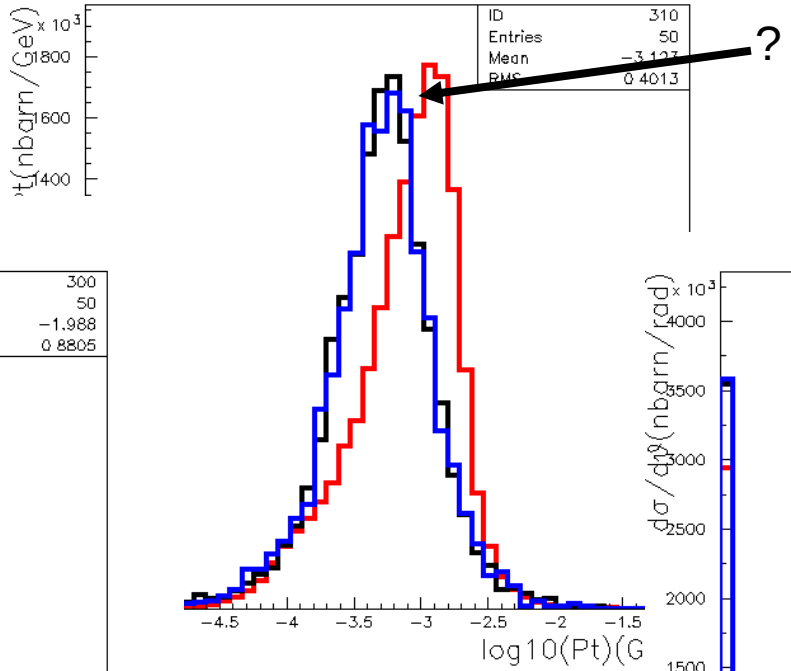

7.7 10^6 nbarn
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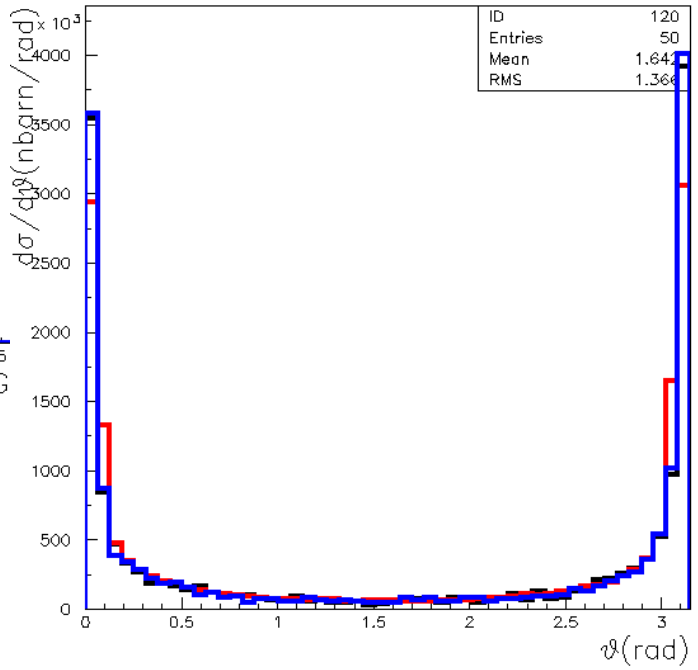
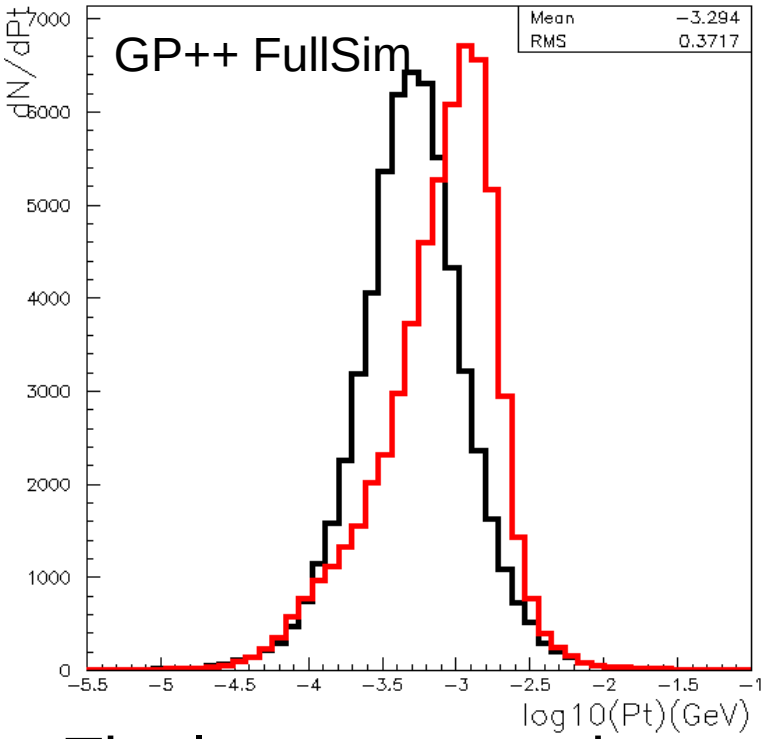
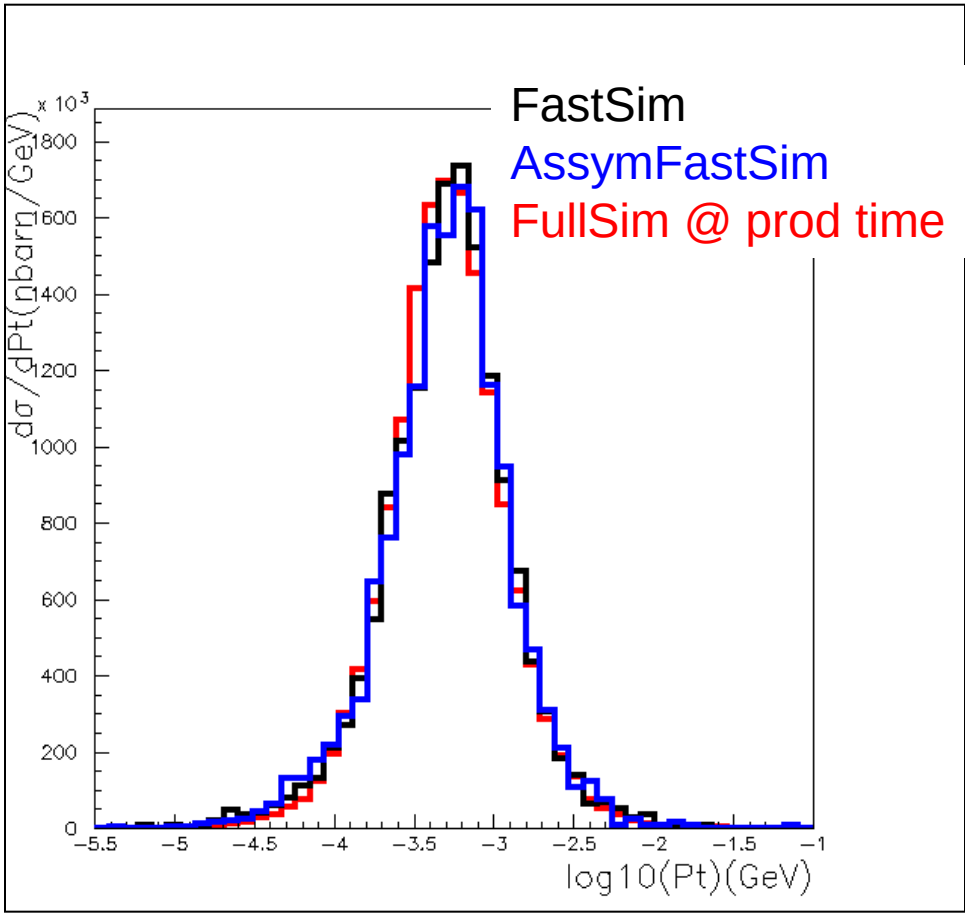


Beam-Beam Deflection

Comparison of the pairs Pt at the production time and after the whole beam-beam interaction



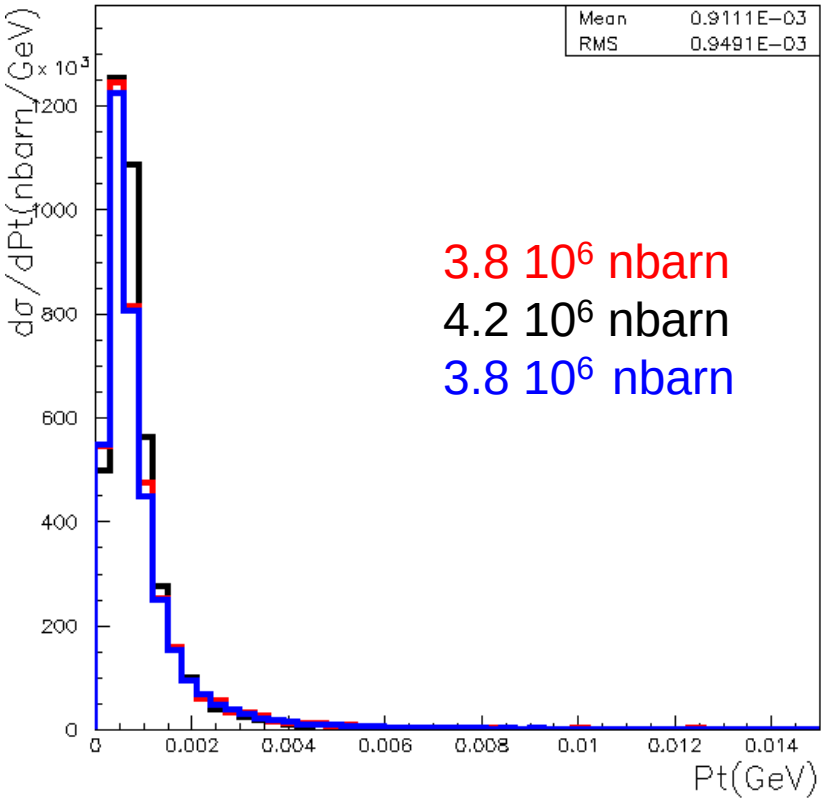


The low energy pairs seem to be deflected by the field of the oncoming beams even at large angle interaction

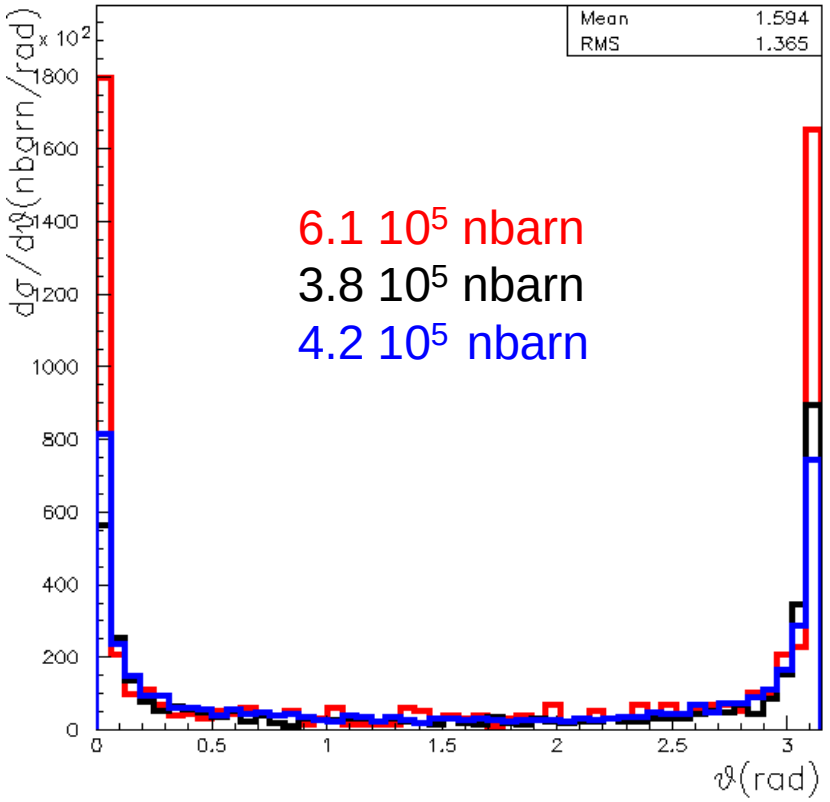
Background in the SVT

BDK / GPFULL / DIAG36 comparison

Pt distribution of the leptons in 300mrad<θ<pi-300mrad



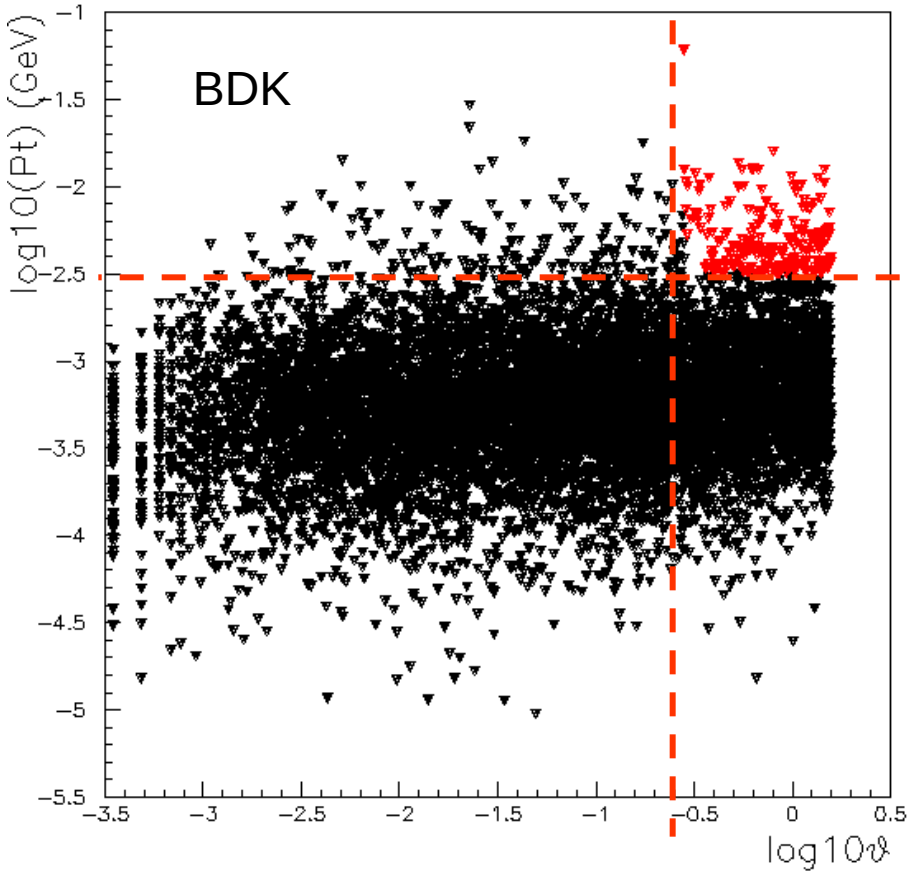
polar angle distribution of the leptons with r_0>1.4cm

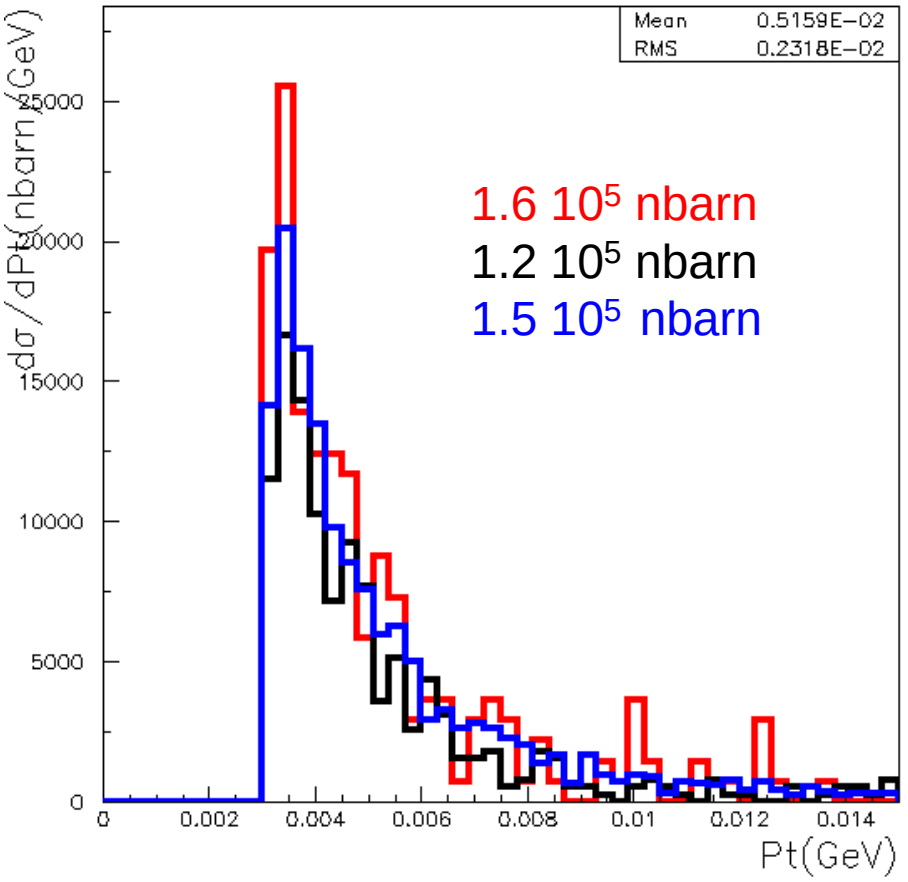


Background in the SVT

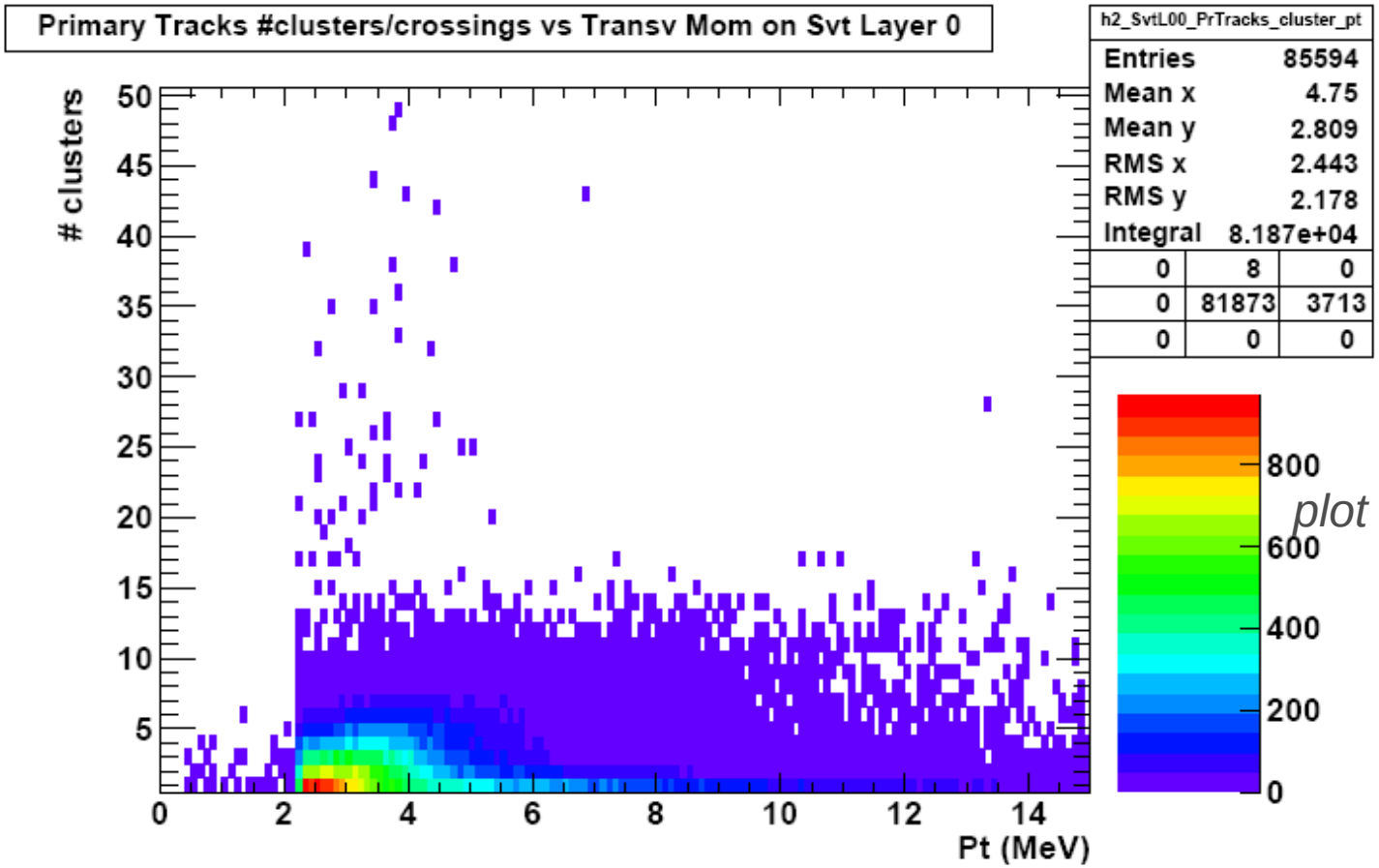
BDK / GPFULL / DIAG36 comparison

Pt distribution of the leptons in
300mrad<θ<pi-300mrad and r_0>1.4cm





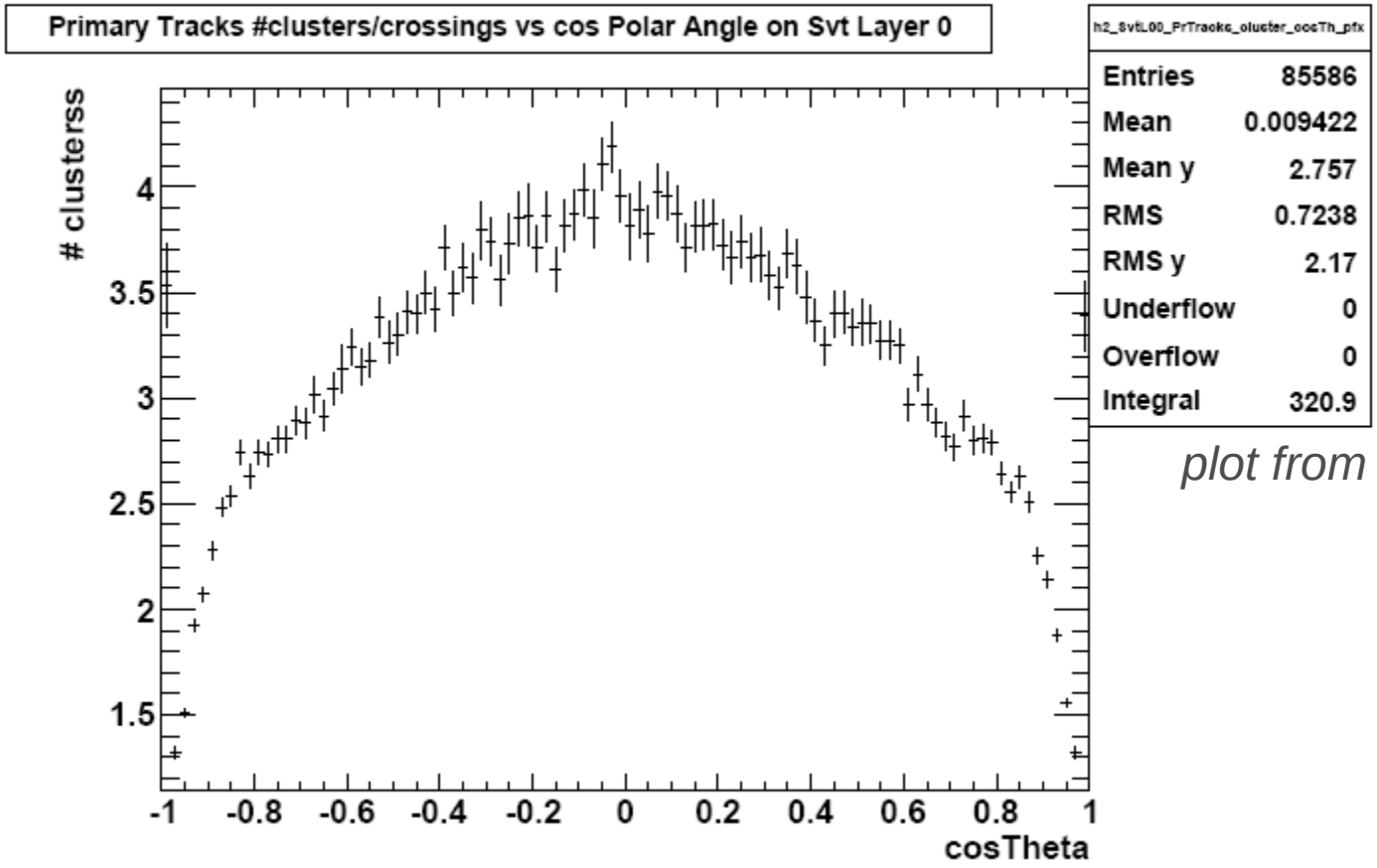
Background in the SVT



plot from R. Cenci

GEANT4 simulation, beam pipe radius=10mm, r_0=14mm, pairs generated with DIAG36

Background in the SVT



plot from R. Cenci

GEANT4 simulation, beam pipe radius=10mm, r_0=14mm, pairs generated with DIAG36

Pair cross-section summary

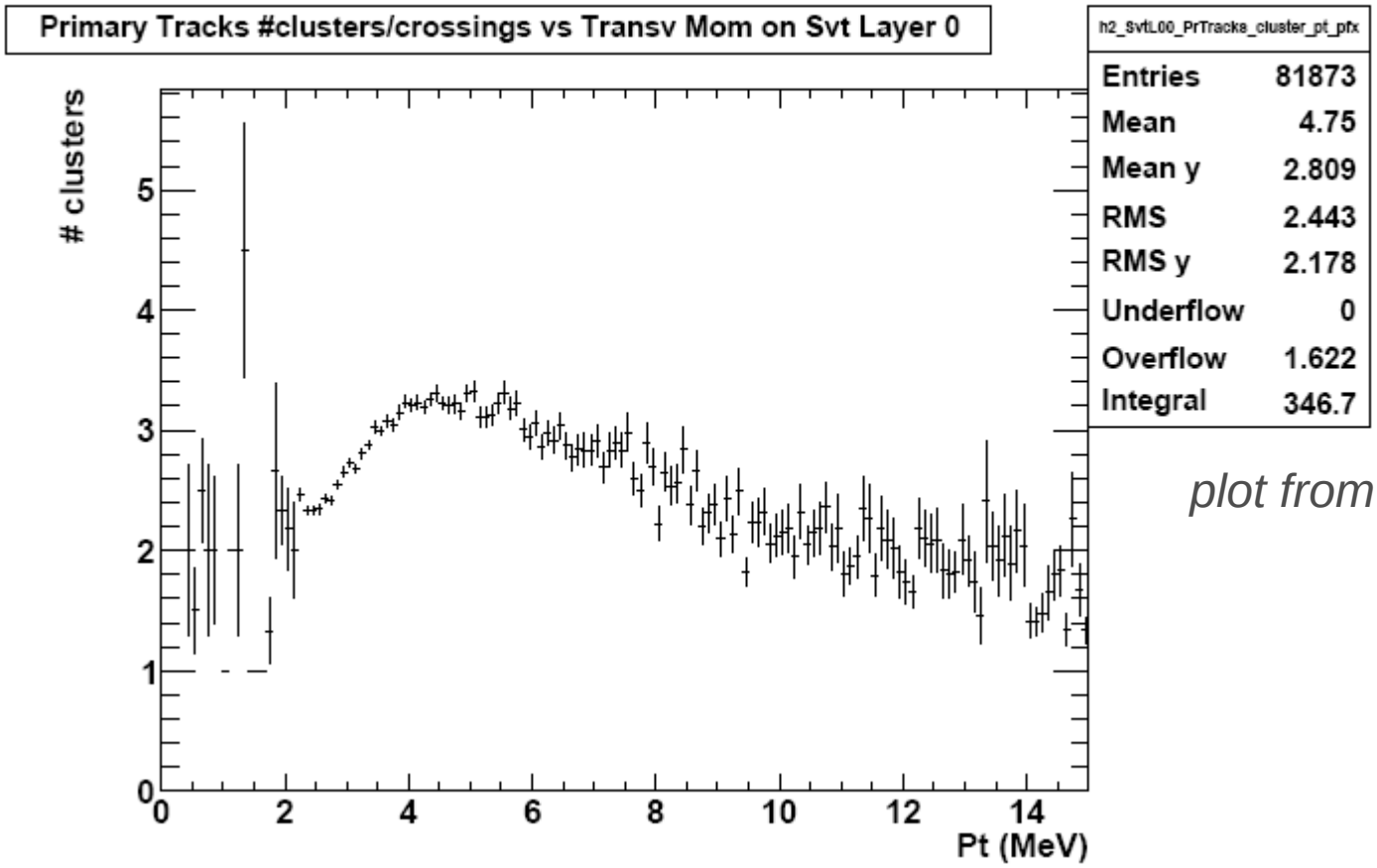
	Pairs σ (μbarn) / MHz A	σ in dθ (μbarn) / MHz (AxC/B)	σ for r_0>1.4cm (μbarn) / MHz (AxC/B)	*Nb pairs* B	*Nb particles in dθ / Pt acceptance* C
BDK	**$7.30\ 10^3$**	**$3.8\ 10^3$**	**$6.1\ 10^2$**	*10000*	*5334 / 838*
DIAG36	**$7.30\ 10^3$**	**$3.8\ 10^3$**	**$4.2\ 10^2$**	*100000*	*52545 / 5810*
GP FullSim @ prod time	**$7.74\ 10^3$**	**$4.0\ 10^3$**	**$2.8\ 10^2$**	*30290*	*15691 / 1096*
GP FullSim after deflection	**$7.74\ 10^3$**	**$4.2\ 10^3$**	**$3.8\ 10^2$**	*30290*	*16586 / 1490*

Pair cross-section summary

	Pairs σ (μbarn) / MHz **A**	L0 σ (μbarn) / MHz **(AxC/B)**	Occupancy, l_0=10cm (MHz/cm²)	$\mathcal{L}$ (10^{34} m^{-2})	Nb pairs **B**	Nb particles hitting SVT **C**
BDK	**7.30 10³**	**1.59 10²** ±0.11 10²	**1.8**	1.37	10000	215
DIAG36	**7.30 10³**	**1.50 10²** ±0.03 10²	**1.7**	13.7	100000	2054
GP FullSim @ prod time	**7.74 10³**	**1.14 10²** ±0.20 10²	**1.3**	3.78	30290	450
GP FullSim after deflection	**7.74 10³**	**1.17 10²** ±0.05 10²	**1.3**	3.78	30290	462

Back-up

Background in the SVT

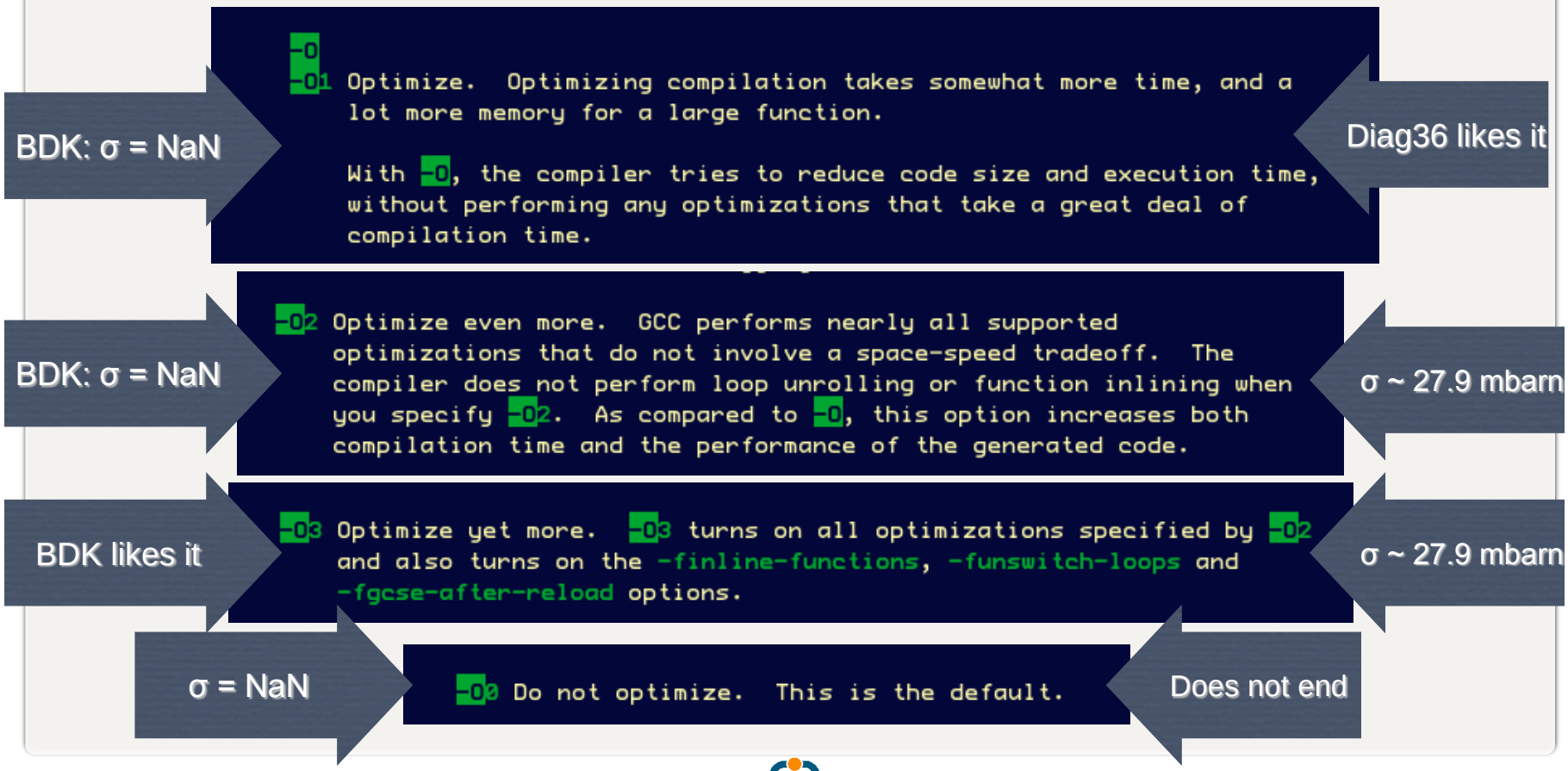


plot from R. Cenci

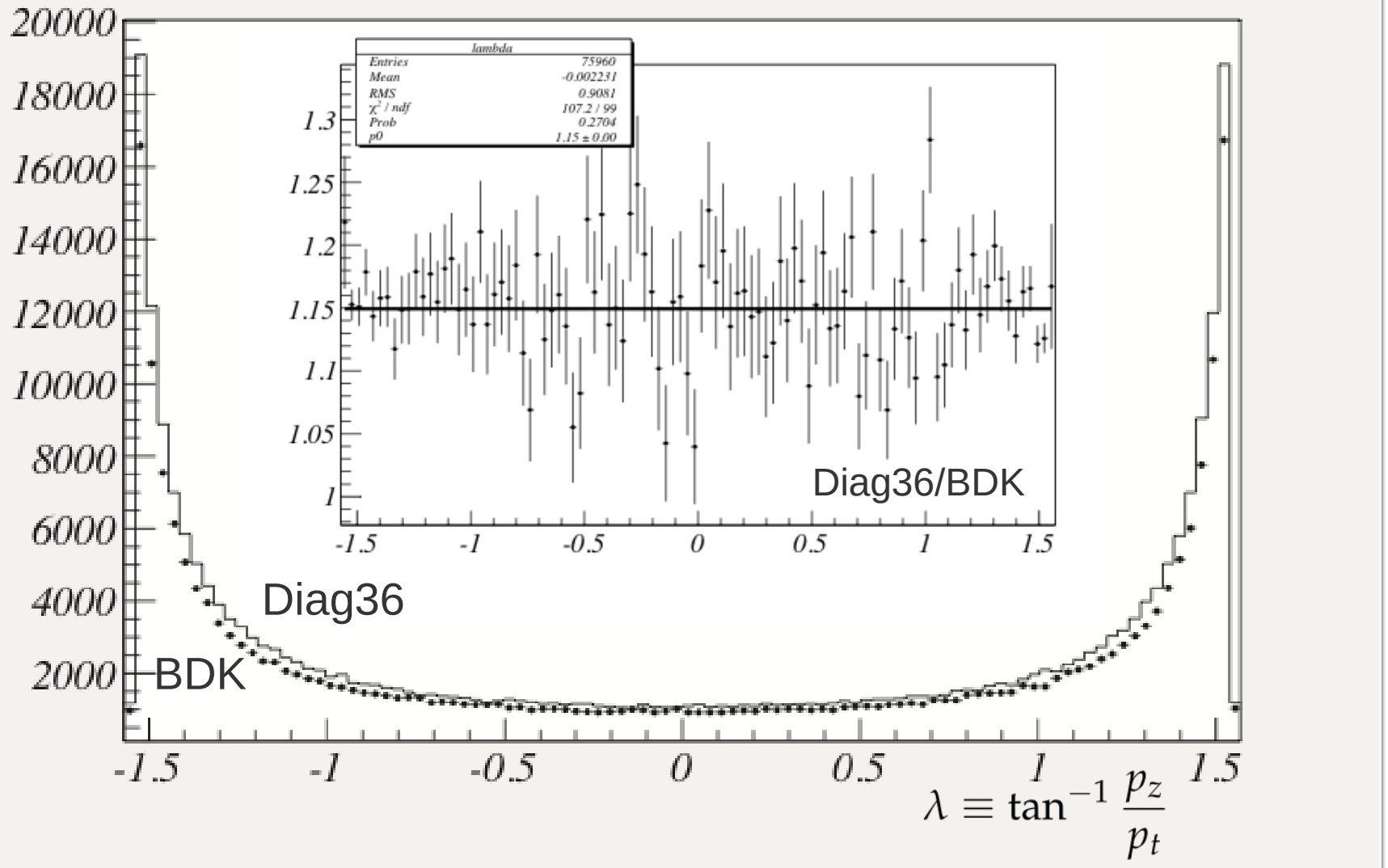
GEANT4 simulation, beam pipe radius=10mm, r_0=14mm, pairs generated with DIAG36

-O: Code Optimization Strategies

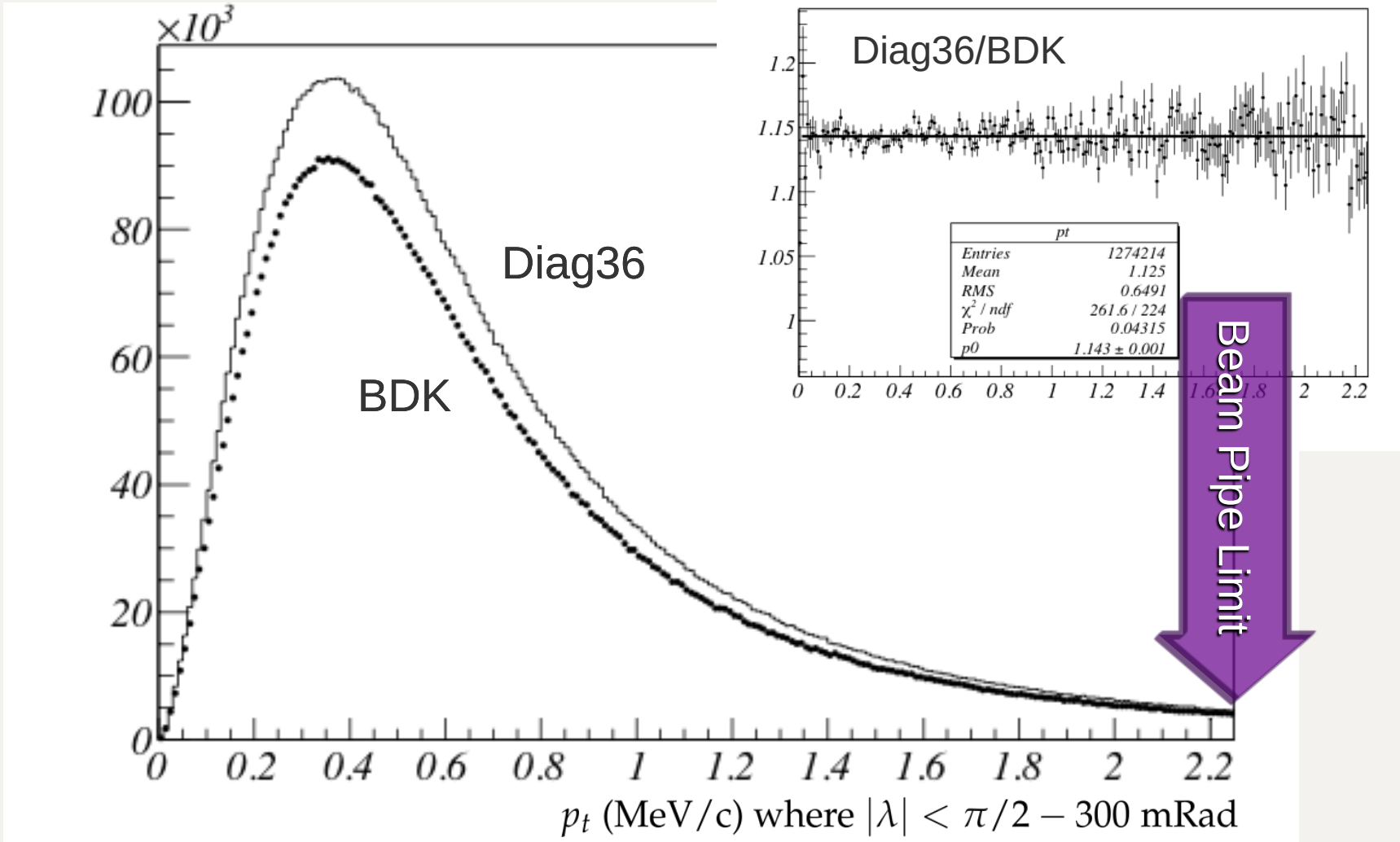
- A correct code should produce results that are independents from the optimization strategy of the compiler: this is not the case. Why?



Generator Level Comparison



Generator Level Comparison



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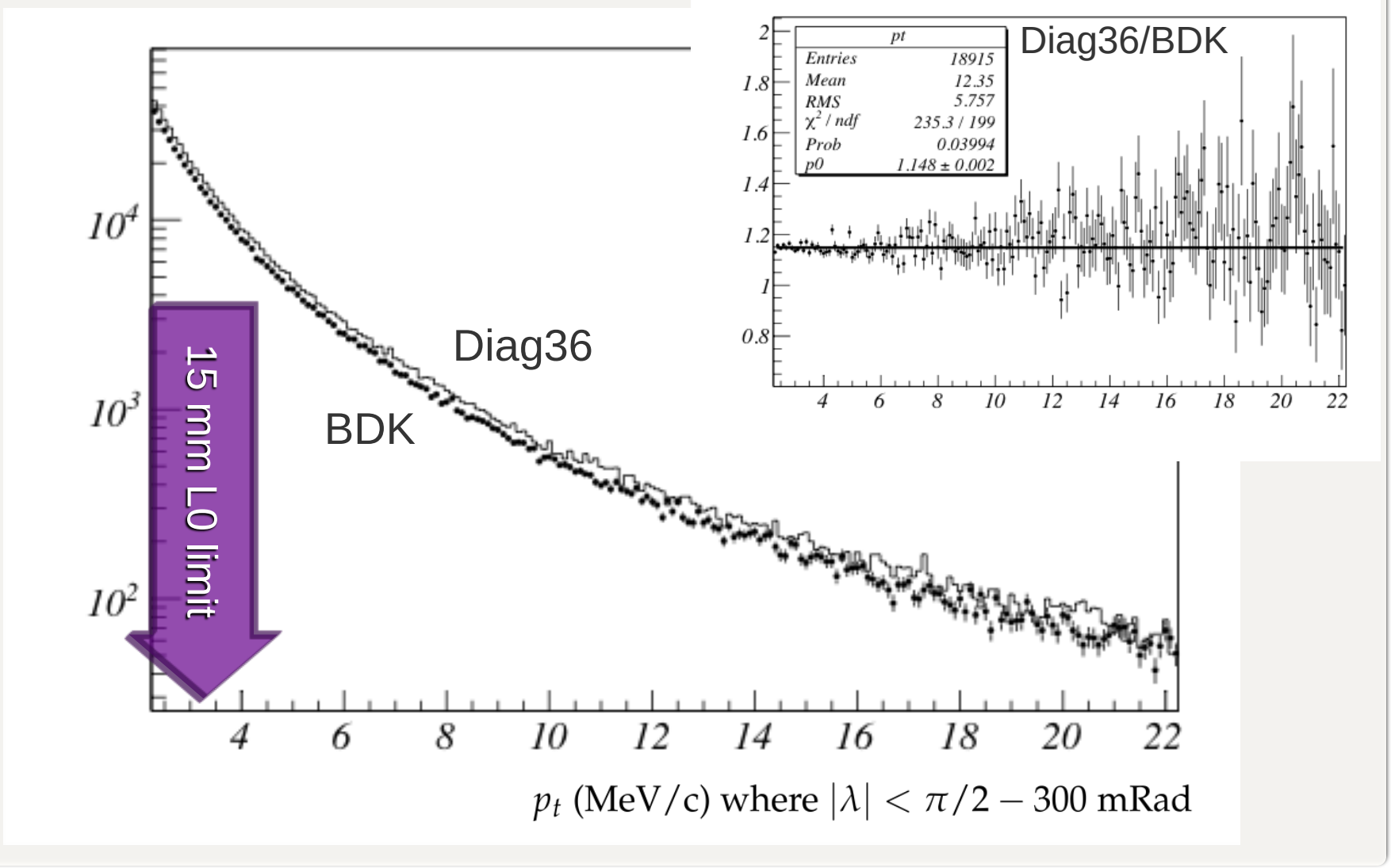

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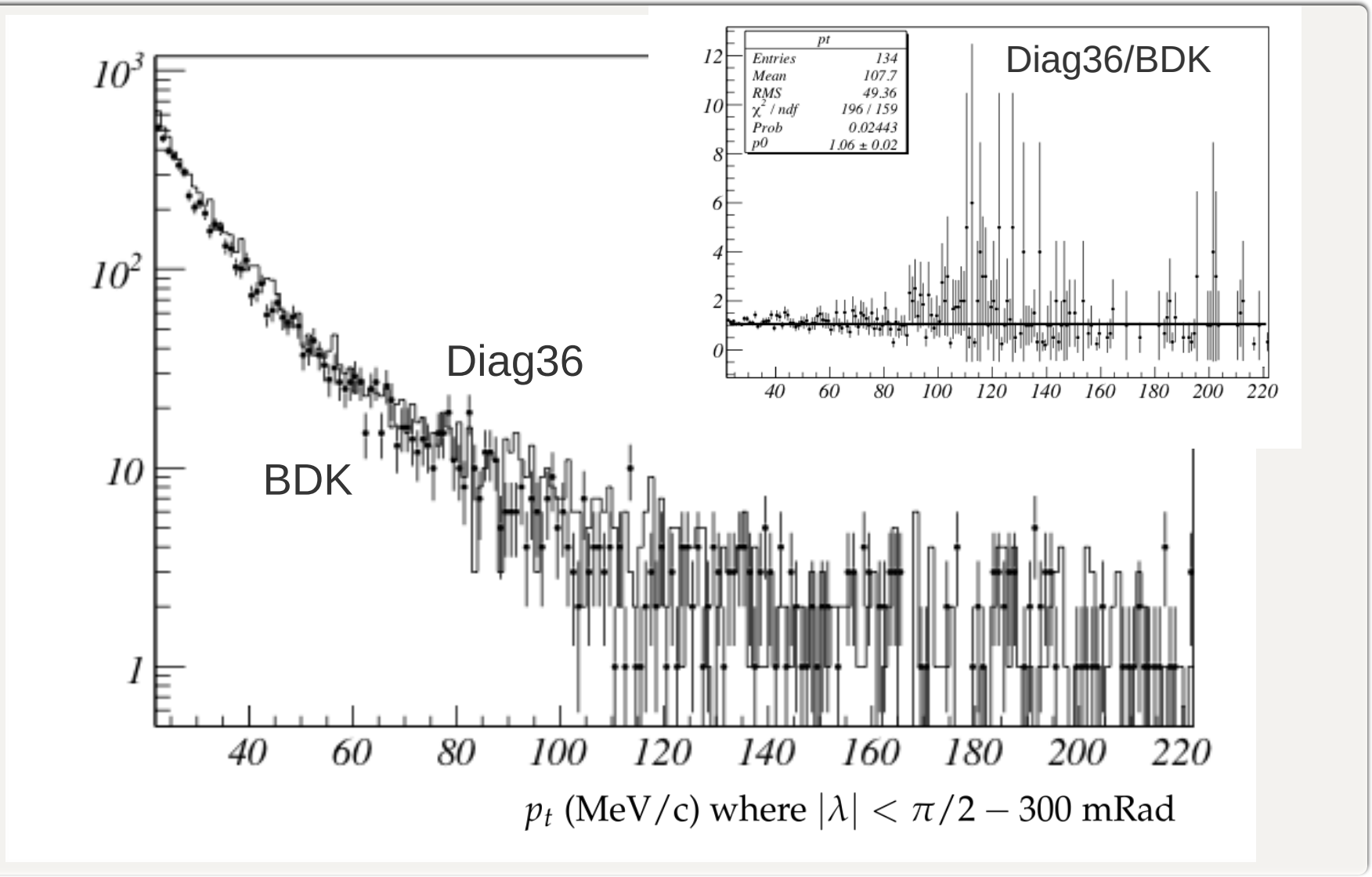

Generator Level Comparison

- Caveat: different optimization strategies produce very different results.
  - The total cross section predictions by BDK and by Diag36 are at 0.6 per mille agreement among them
  - The differential cross section inside the geometrical acceptance of the detector predicted by Diag36 is 15% larger than that predicted by BDK
  - Work in progress to validate these results against the Guinea Pig ++ code (C++, virtual photon approximation)