Some studies on the MC beam divergence (SPS and PS)

1 - Intro; pending questions from last week's presentation

2 - Beam dispersion vs Energy for few electron runs

3 - Beam dispersion in full brems MC run BT-1445

MC Runs used

<u>SPS electron runs (custom simulation)</u>

BT-1922 (282GeV), BT-1885 (197 GeV), BT-1981 (100 GeV), BT-2039 (50 GeV), BT-2082 (20 GeV)

<u>PS electron runs (standard simulation)</u>

BT-1460 (5 GeV), BT-1432 (2.5 GeV)

<u>PS full brems run (standard simulation)</u>

BT-1445 (0-2.5 GeV)

1 - Intro; pending questions from last week's presentation

I could not find G4config proper parameters for runs 2039 (electrons, 50 GeV) and 2082 (electrons, 20 GeV) so that MC beam profile matches the one in the data runs

MC runs have larger:

Beam width

"MaxBeamDivergence"

MC-data differences are small in run 2039, but rather significant in run 2082

Things to be tested:

1.1 Energy dependent increase in MC beam divergence

1.2 Possible relation with Beam Dispersion increase found in full Brems MC runs (reported in Paris meeting)

2 - Beam dispersion vs Energy for few electron runs

MaxBeamDivergence is a variable meant to be used with data runs: it gives an upper limit for the beam divergence, but it is NOT the beam divergence

For event i

cos (MaxBeamDivergence_i) = <Tkr1ZDir>* Tkr1ZDir_i + <Tkr1YDir>* Tkr1YDir_i + <Tkr1XDir>* Tkr1XDir_i

<Tkr1[ZYX]Dir> ~ Incoming direction of the beam

Tkr1[ZYX]Dir_i ~ Incoming direction of the electron i

The resolution of the CU will affect both variables, and consequently the distribution of MaxBeamDivergence does NOT tell us about the true value of the beam divergence

Playing with MC data has the advantage that we know:

a) The exact incoming direction of the beam

b) The exact incoming direction of event i (Mc[ZYX]Dir)

Therefore, we can compute, the following quantities:

Cos(BeamCU_DirErr) = cos(XthetaBeam) Tkr1XDir +*
cos(YthetaBeam) Tkr1YDir +*
cos(ZThetaBeam) Tkr1ZDir*

CU Resolution + BeamDiv *("Measured PSF")*

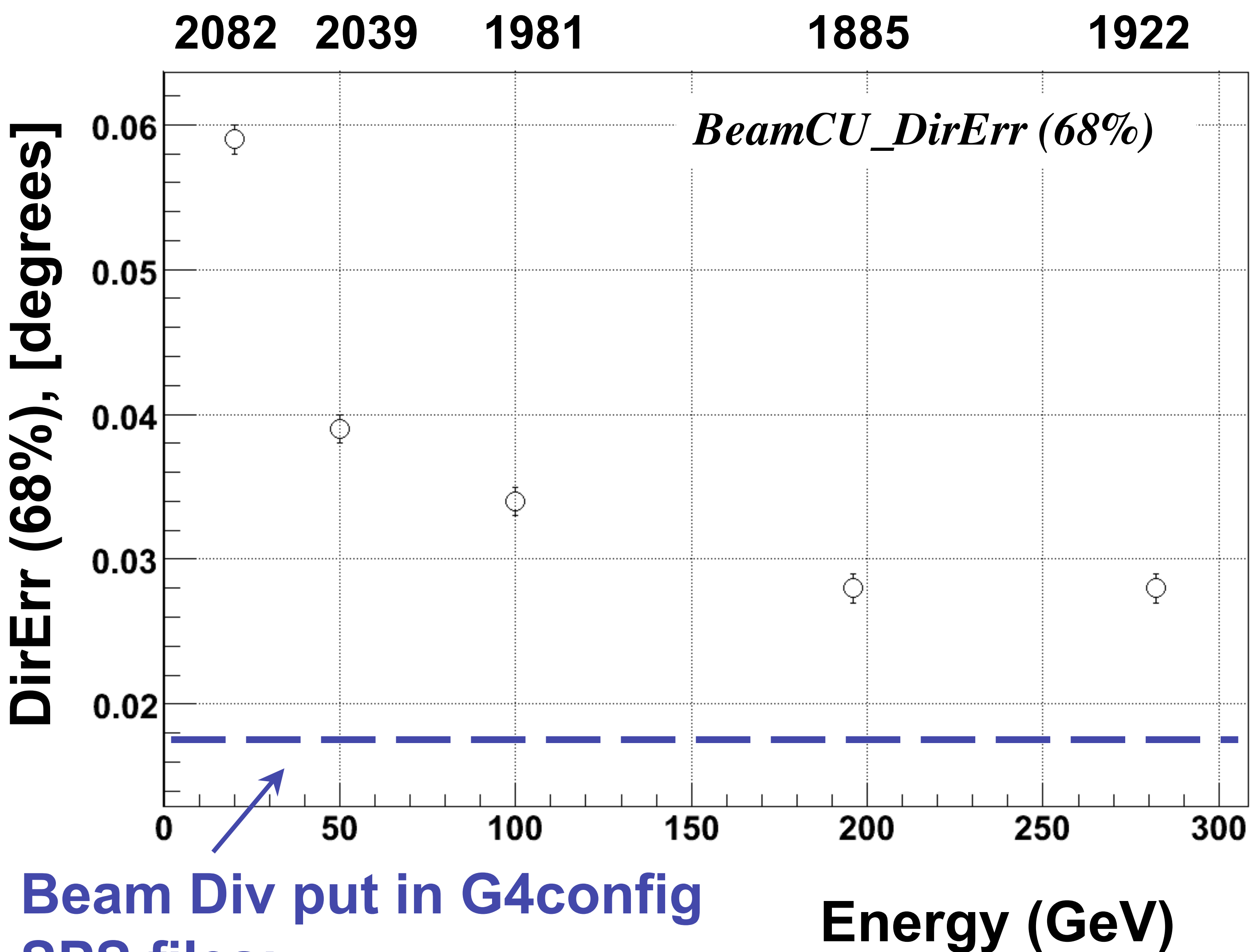
*Cos(CU_DirErr) = McXDir * Tkr1XDir +*
McYDir Tkr1YDir +*
McZDir Tkr1ZDir*

CU Resolution (True PSF)

Cos(BeamCU_DirErr) = cos(XthetaBeam) McXDir +*
cos(YthetaBeam) McYDir +*
cos(ZThetaBeam) McZDir*

Beam Divergence

BeamCU_DirErr (68%), *CU_DirErr (68%)* and *Beam_DirErr (68%)* vs Energy



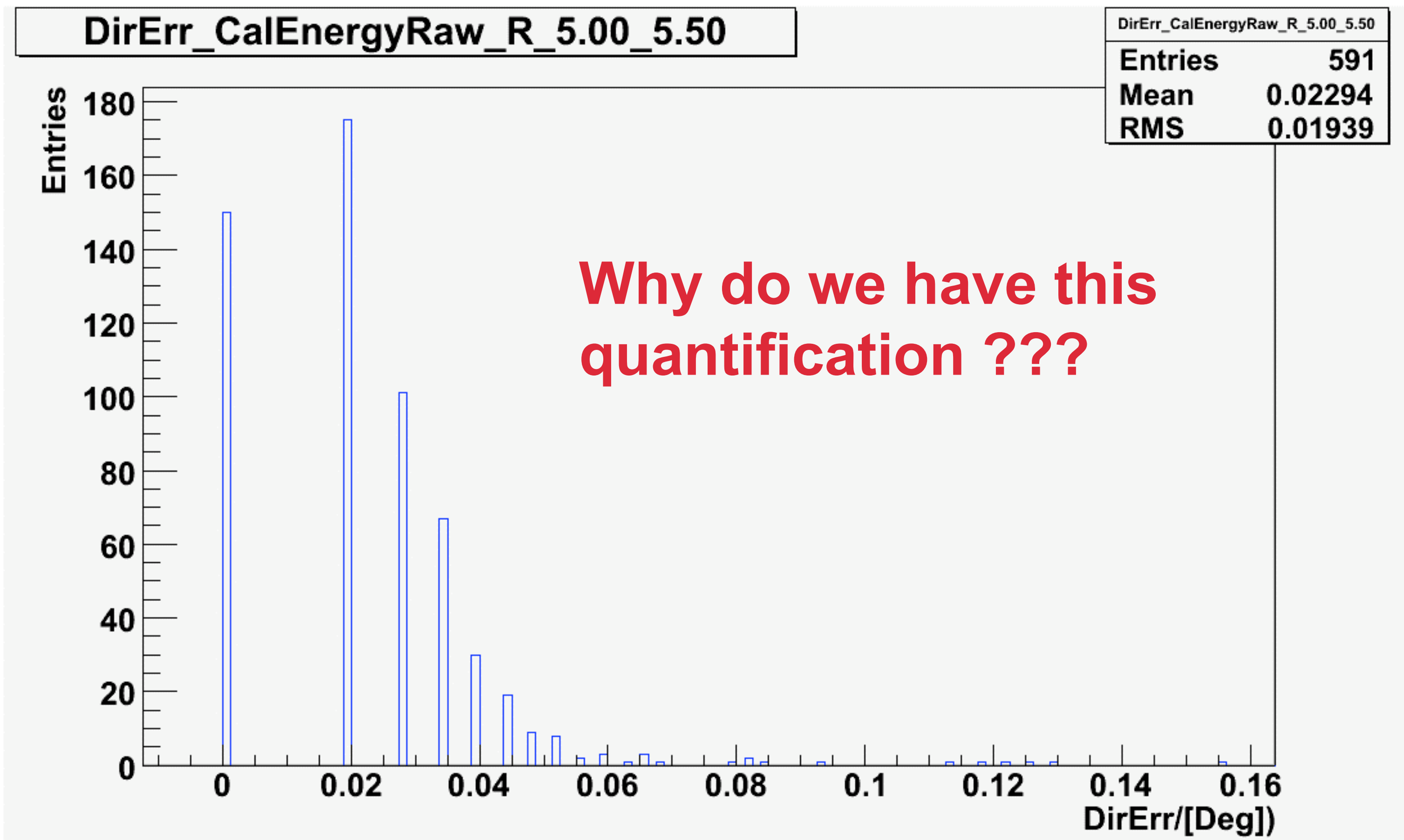
Expected beam divergence

Beam Div put in G4config SPS files:

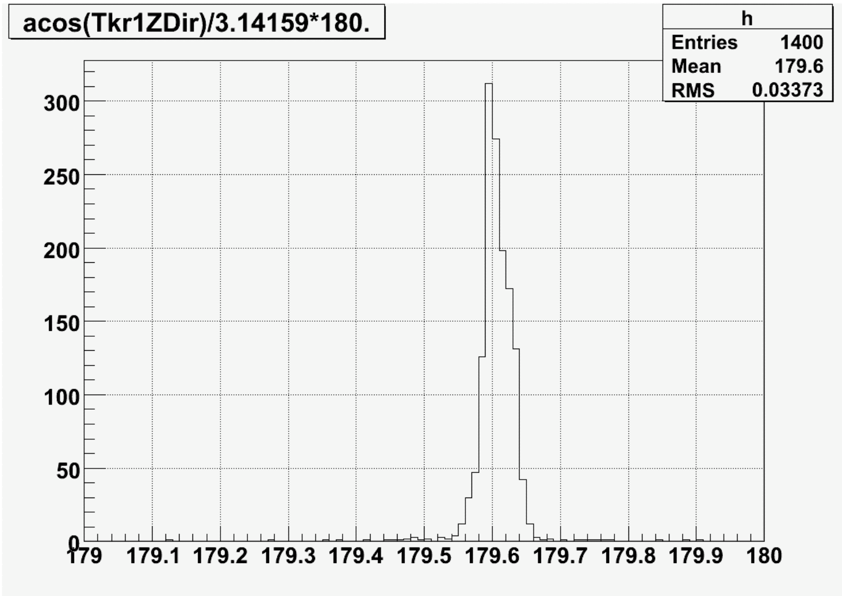
0.25mrad ~ 0.0014 degrees

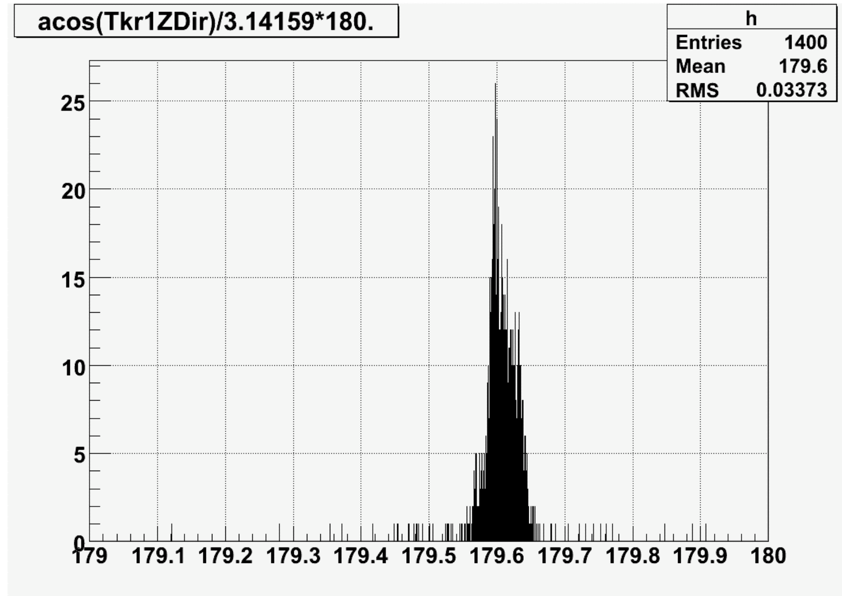
Quantification of these variables

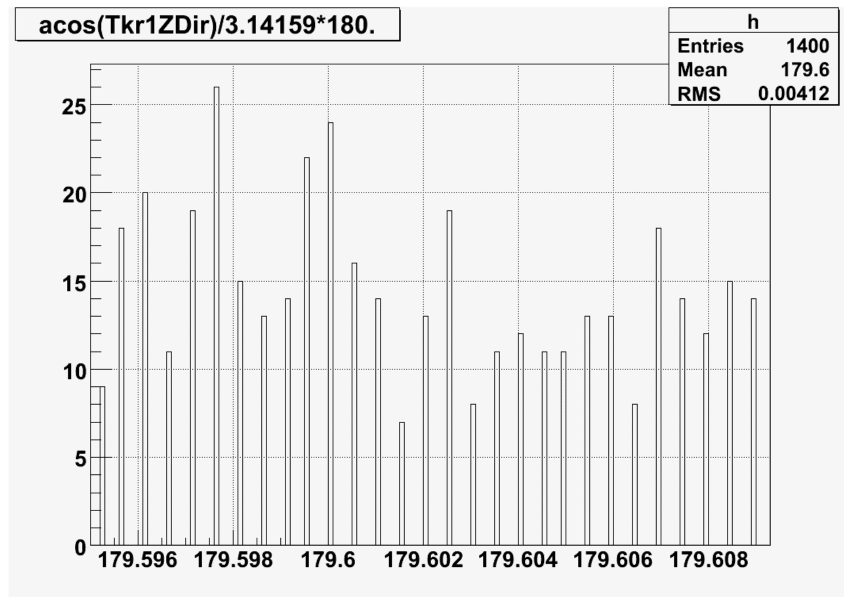
Example: distribution of BeamCU_DirErr for run MC run 1922 (electrons, 280 GeV)



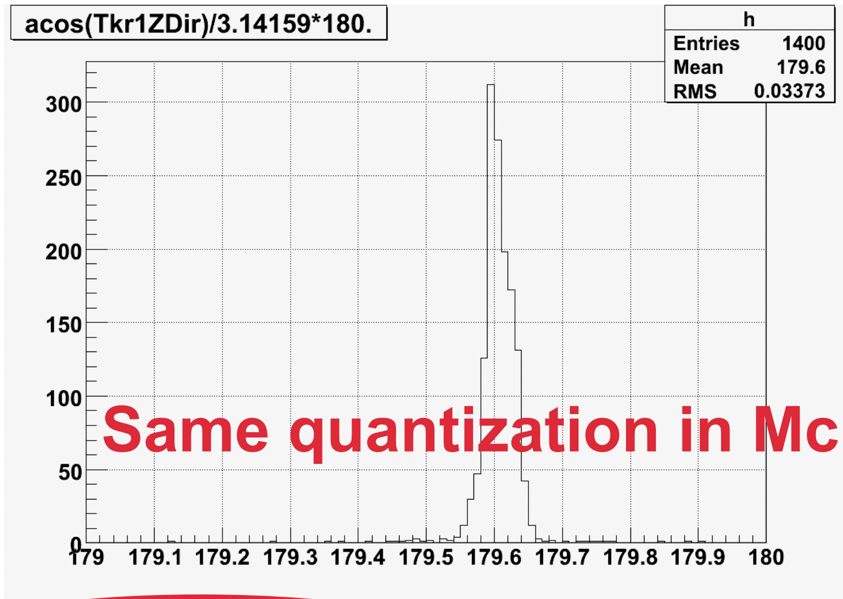
Quantification of variables DirErr in Z direction

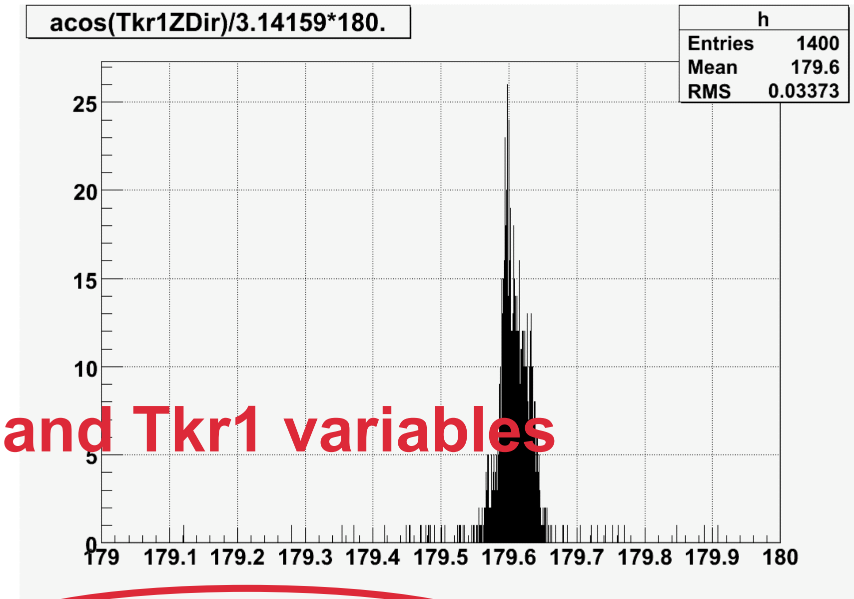




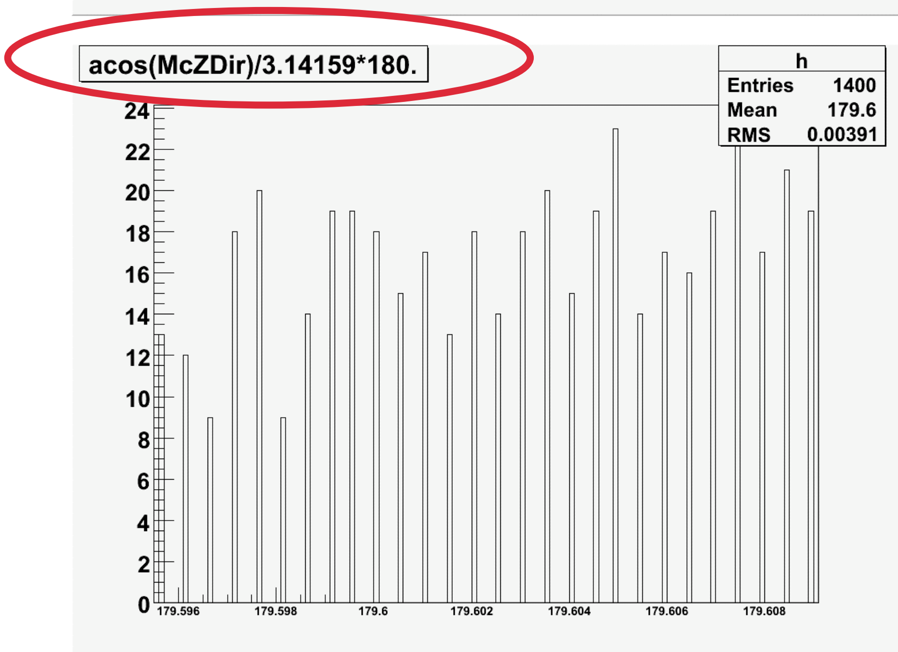


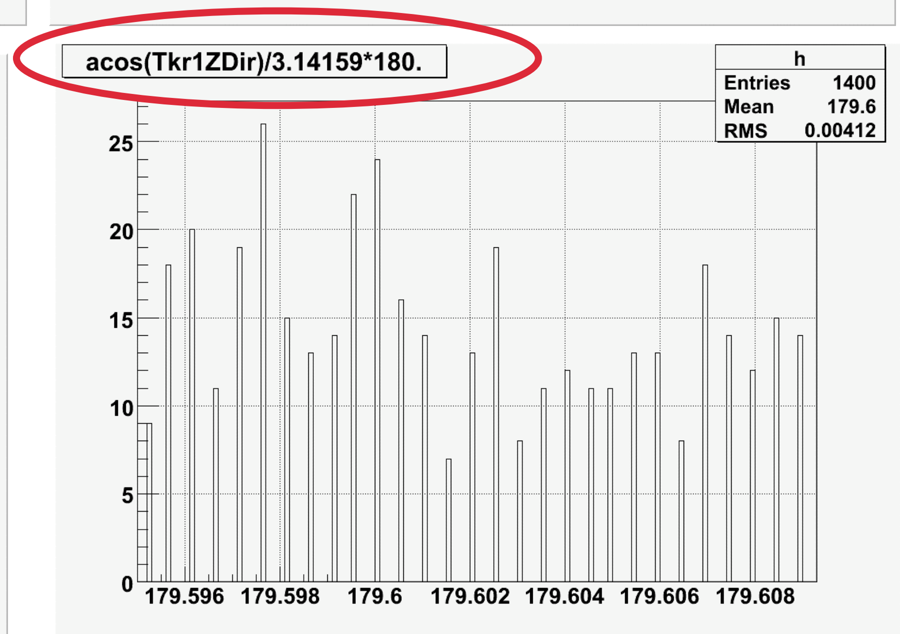
Quantification of variables DirErr in Z direction



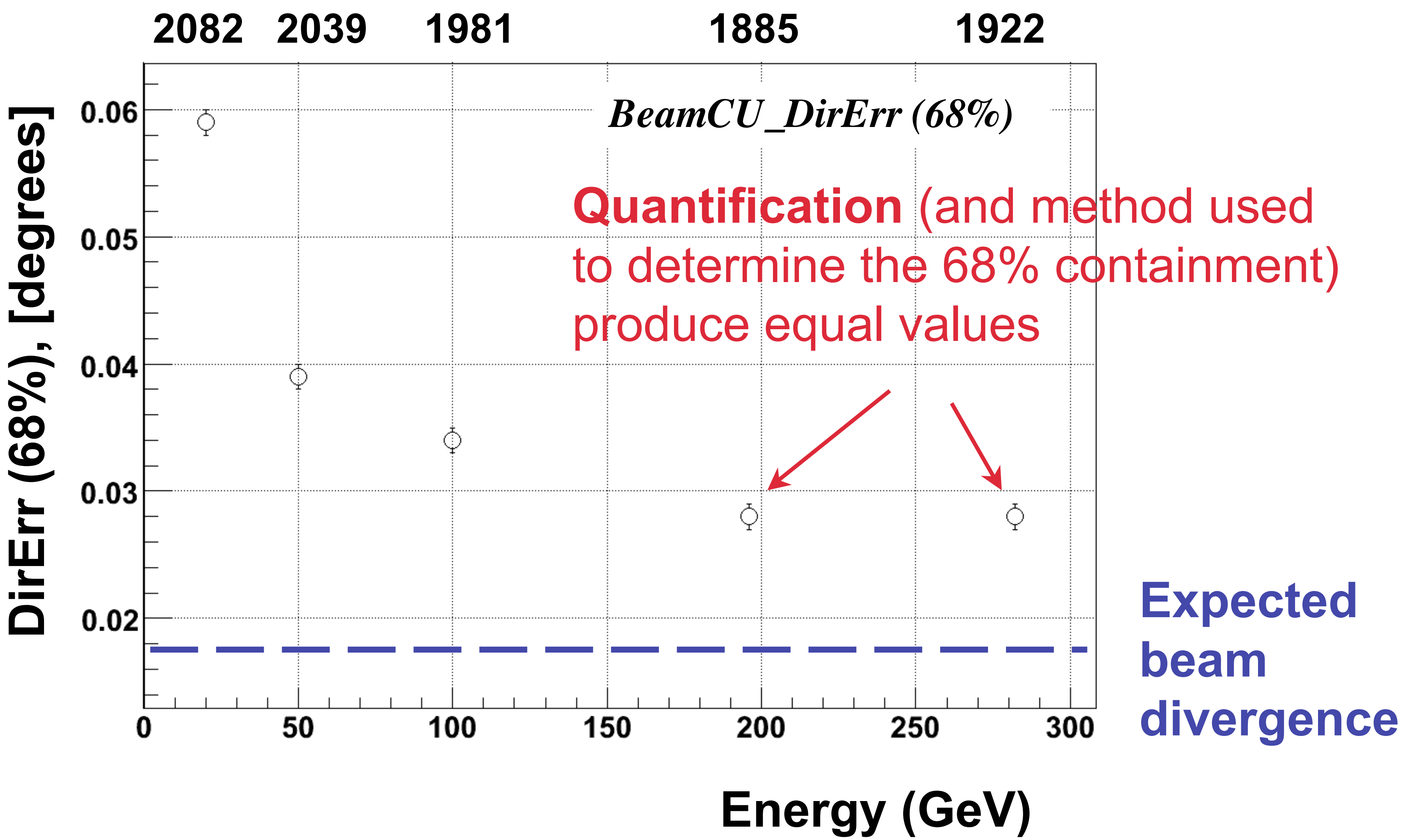


Same quantization in Mc and Tkr1 variables

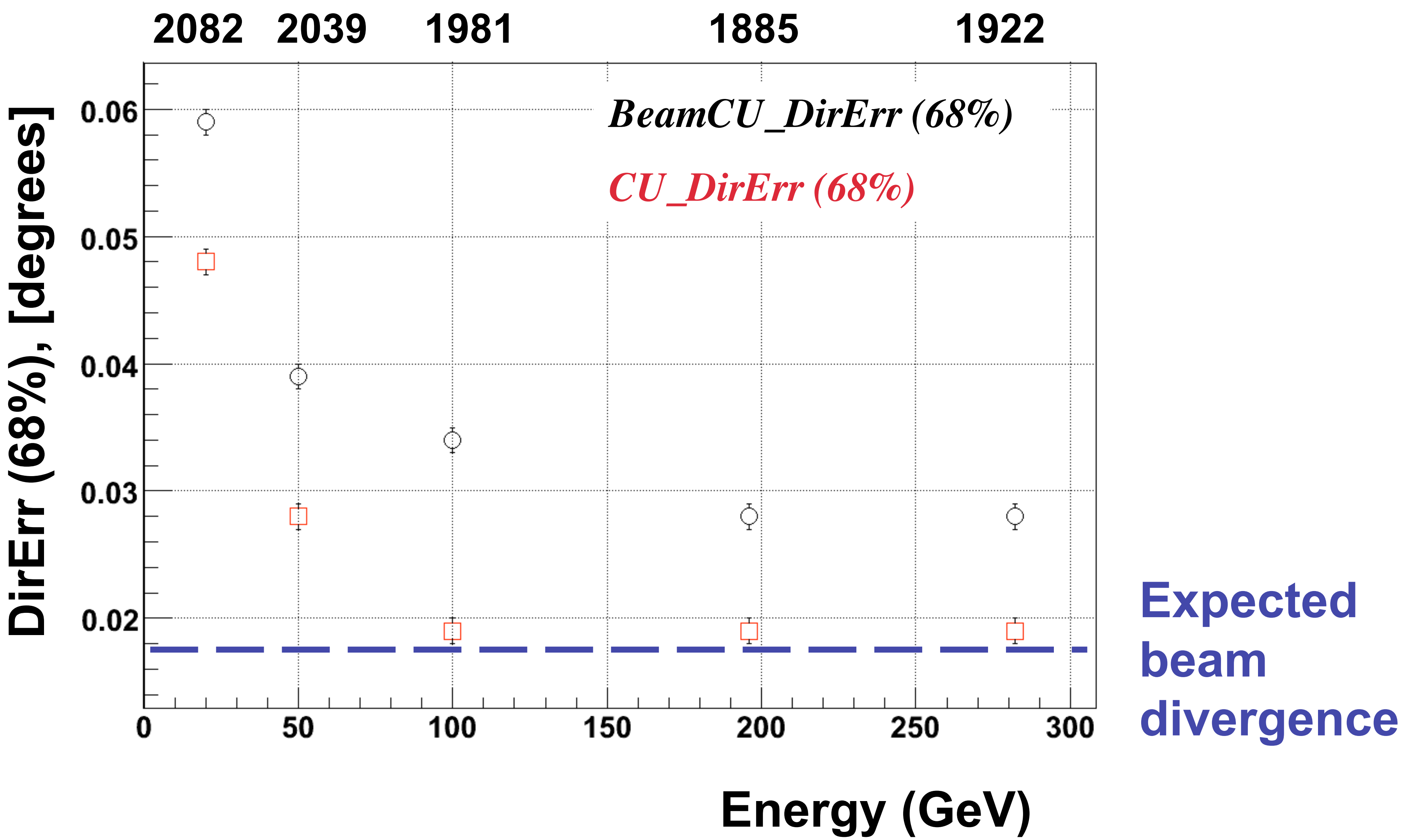




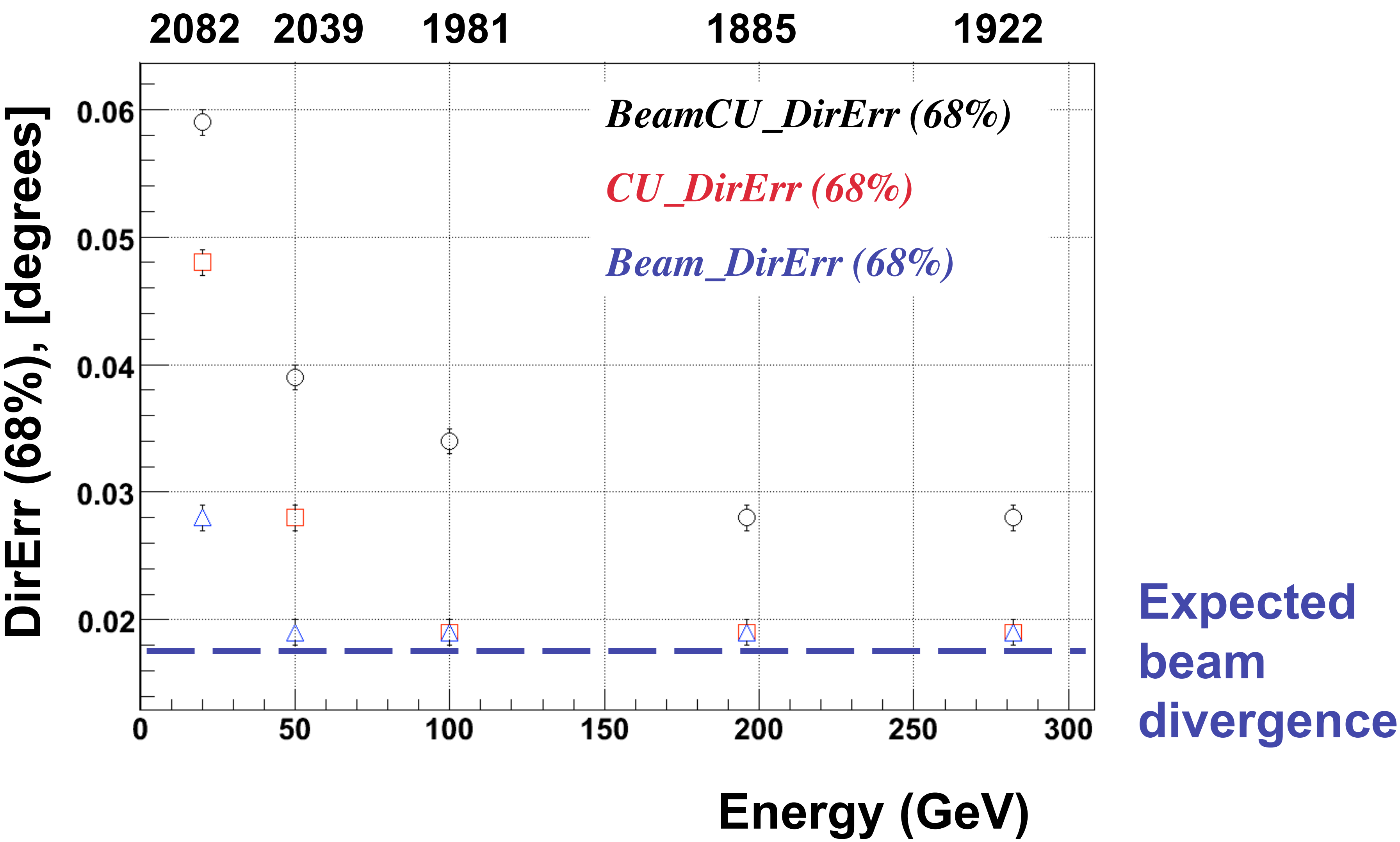
BeamCU_DirErr (68%), CU_DirErr (68%) and Beam_DirErr (68%) vs Energy



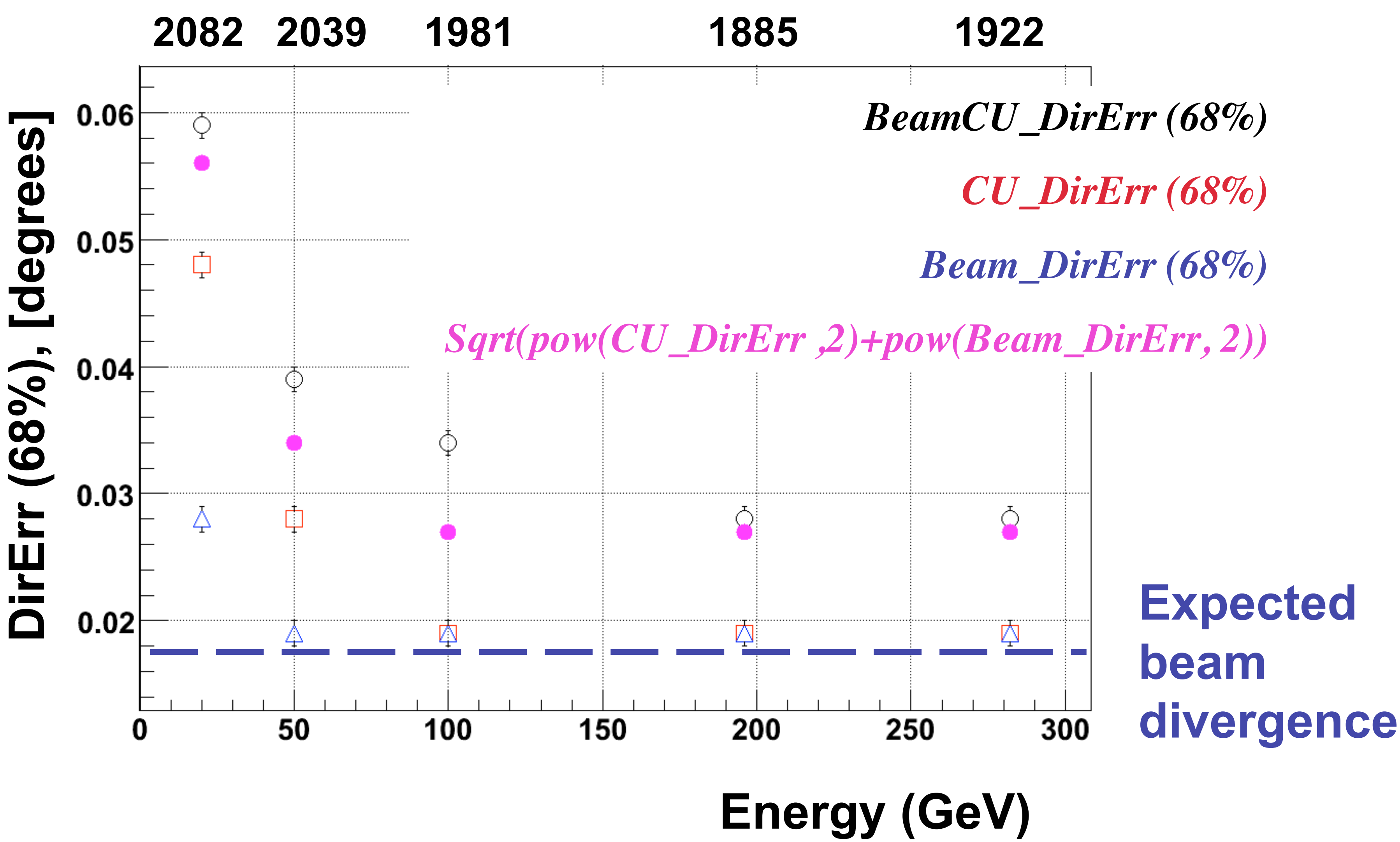
BeamCU_DirErr (68%), *CU_DirErr (68%)* and *Beam_DirErr (68%)* vs Energy



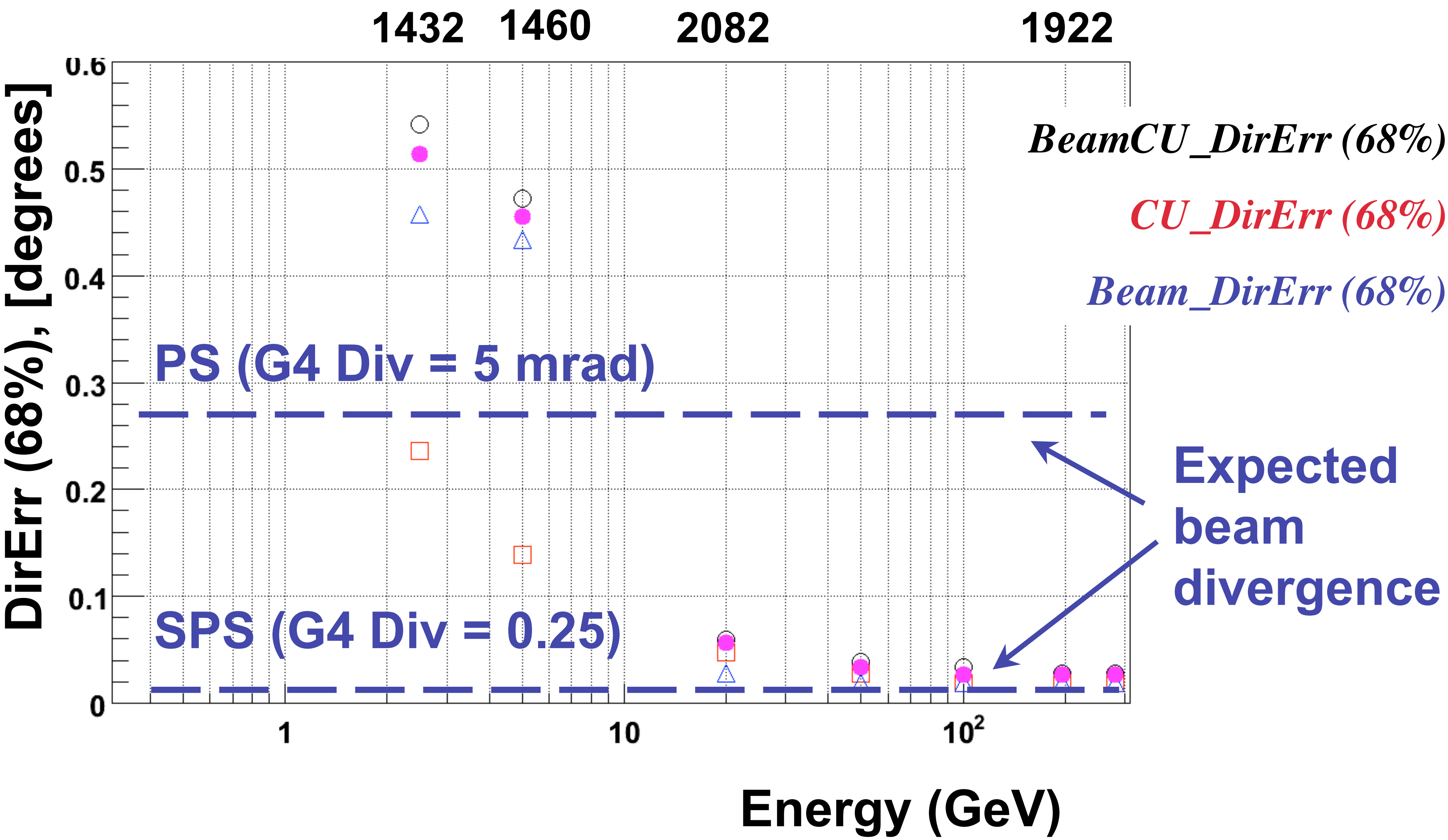
BeamCU_DirErr (68%), *CU_DirErr (68%)* and *Beam_DirErr (68%)* vs Energy



BeamCU_DirErr (68%), CU_DirErr (68%) and Beam_DirErr (68%) vs Energy

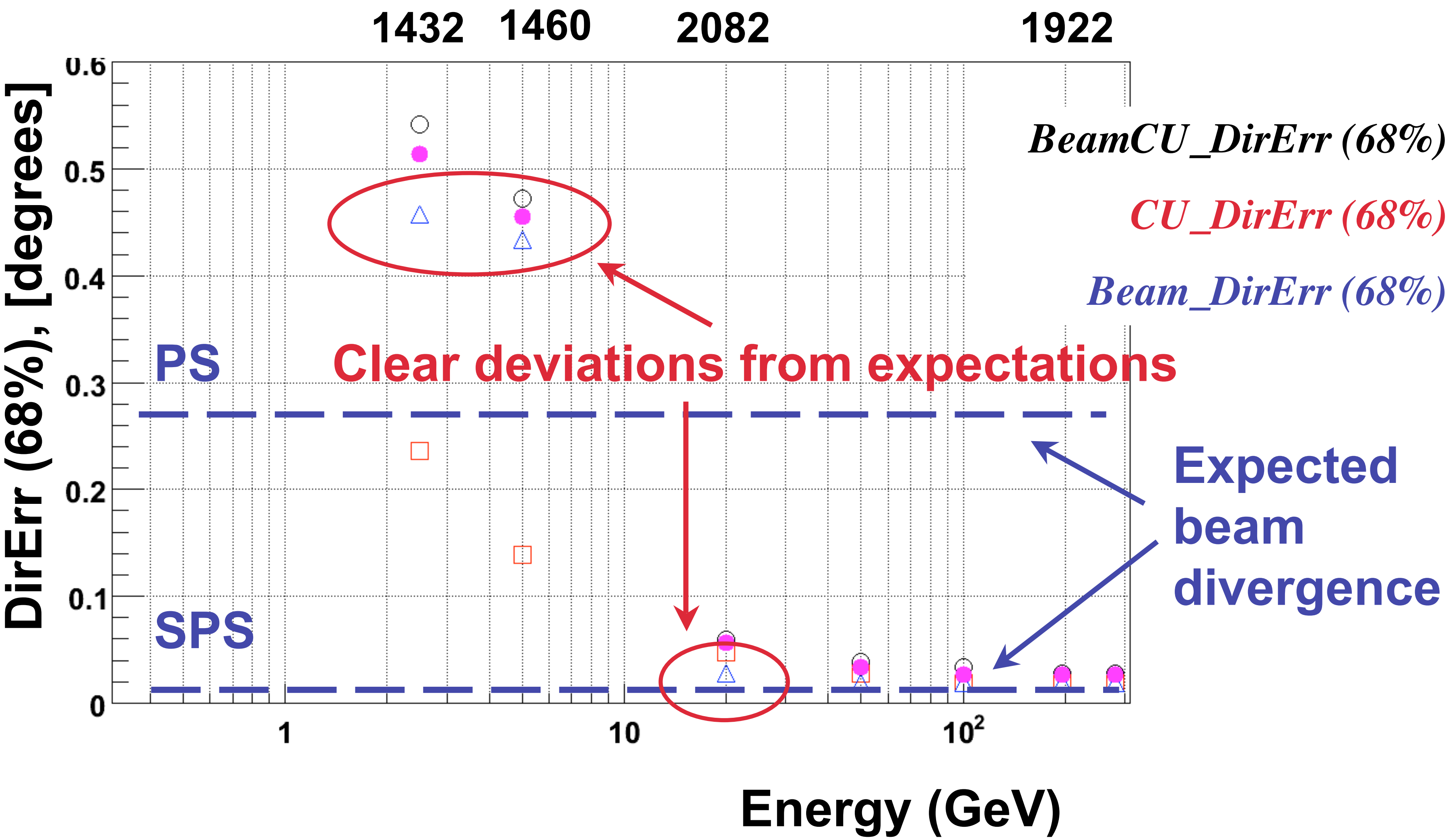


BeamCU_DirErr (68%), CU_DirErr (68%) and Beam_DirErr (68%) vs Energy



In PS runs, beam divergence > CU resolution

BeamCU_DirErr (68%), CU_DirErr (68%) and Beam_DirErr (68%) vs Energy



Conclusion from Test 1

There is an unknown contribution to the Beam divergence in the MC generation

This “additional increase” depends on the energy of the electrons

There is a quantification of the values McZDir and Tkr1ZDir (**??**)

3 - Beam dispersion in full brems MC run BT-1445

Same formulae as before, replacing Tkr1 for Vtx

Logarithmic binning used for energy split: **23 bins in range 0.120-4.170**

Bin width increases by 50 %

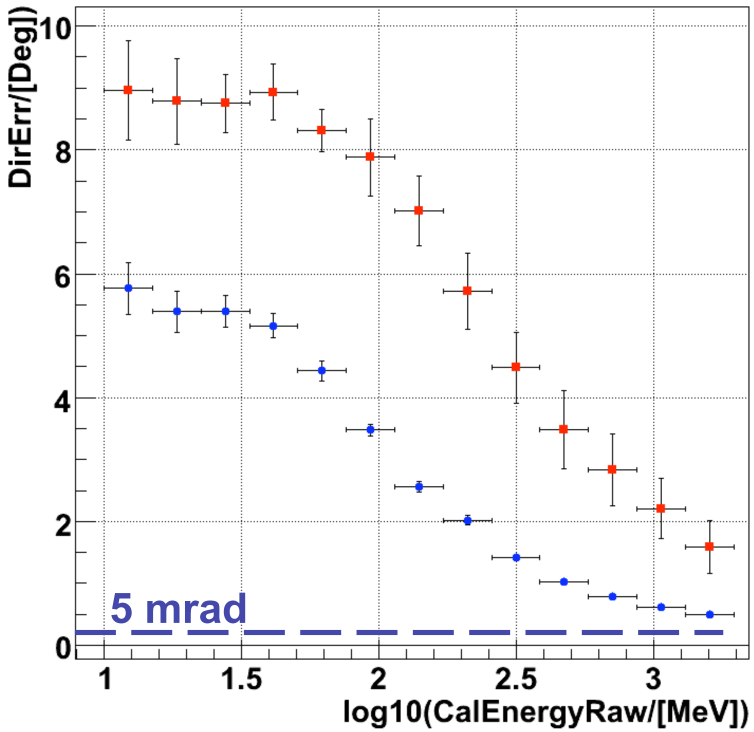
```
bin  1; 1.31687 - 1.97531 : Bin Width = 0.658436
bin  2; 1.97531 - 2.96296 : Bin Width = 0.987654
bin  3; 2.96296 - 4.44444 : Bin Width = 1.48148
bin  4; 4.44444 - 6.66667 : Bin Width = 2.22222
bin  5; 6.66667 -      10 : Bin Width = 3.33333
bin  6;      10 -      15 : Bin Width =       5
bin  7;      15 -    22.5 : Bin Width =     7.5
bin  8;    22.5 -   33.75 : Bin Width = 11.25
bin  9; 33.75 - 50.625 : Bin Width = 16.875
bin 10; 50.625 - 75.9375 : Bin Width = 25.3125
bin 11; 75.9375 - 113.906 : Bin Width = 37.9687
bin 12; 113.906 - 170.859 : Bin Width = 56.9531
bin 13; 170.859 - 256.289 : Bin Width = 85.4297
bin 14; 256.289 - 384.434 : Bin Width = 128.145
bin 15; 384.434 - 576.65 : Bin Width = 192.217
bin 16; 576.65 - 864.976 : Bin Width = 288.325
bin 17; 864.976 - 1297.46 : Bin Width = 432.488
bin 18; 1297.46 - 1946.2 : Bin Width = 648.732
bin 19; 1946.2 - 2919.29 : Bin Width = 973.098
bin 20; 2919.29 - 4378.94 : Bin Width = 1459.65
bin 21; 4378.94 - 6568.41 : Bin Width = 2189.47
bin 22; 6568.41 - 9852.61 : Bin Width = 3284.2
bin 23; 9852.61 - 14778.9 : Bin Width = 4926.31
```

Selection of events applied

TkrNumTracks == 2 && CalEnergyRaw >10 && Tkr1SSDVeto>3 && TkrBlankHits > 3

3 - Beam dispersion in full brems MC run BT-1445

BeamCU_DirErr 68% and 95%



BeamCU_DirErr increases with decreasing energy, as expected for the PSF

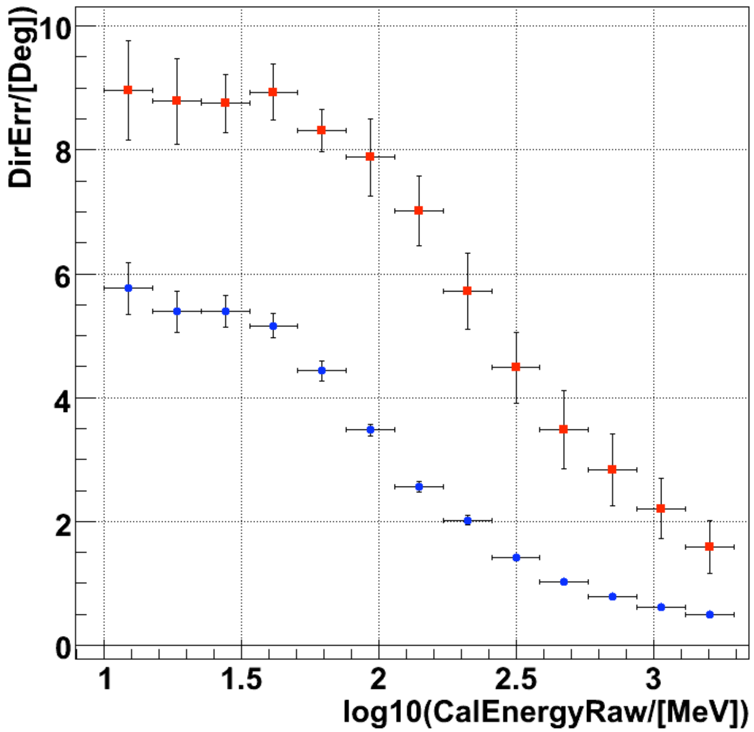
Something “strange” below 30 MeV; perhaps a selection effect (I could not investigate properly this issue…)

Beam Divergence put in G4config PS files:

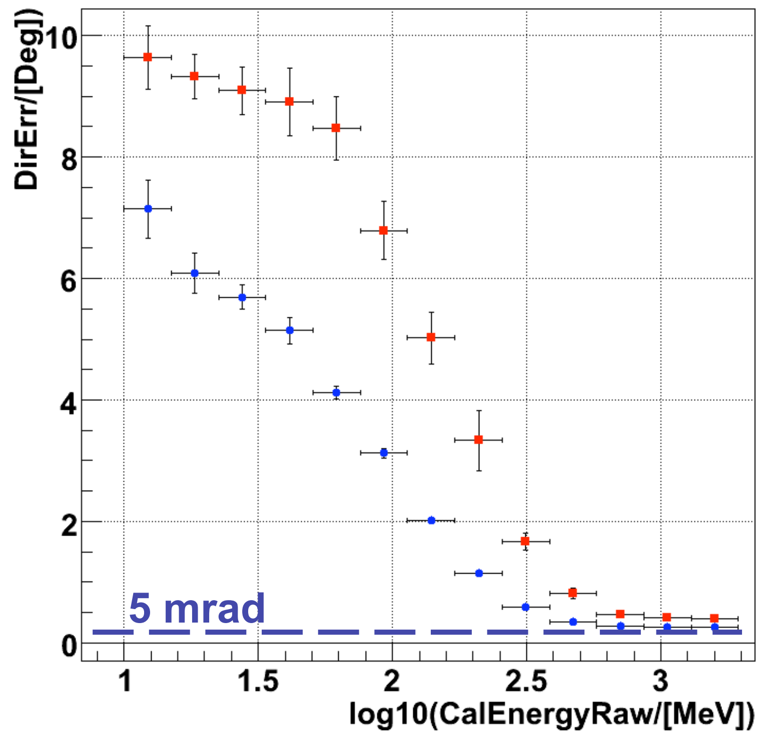
5mrad ~ 0.28 degrees

3 - Beam dispersion in full brems MC run BT-1445

BeamCU_DirErr 68% and 95%



Beam_DirErr 68% and 95%



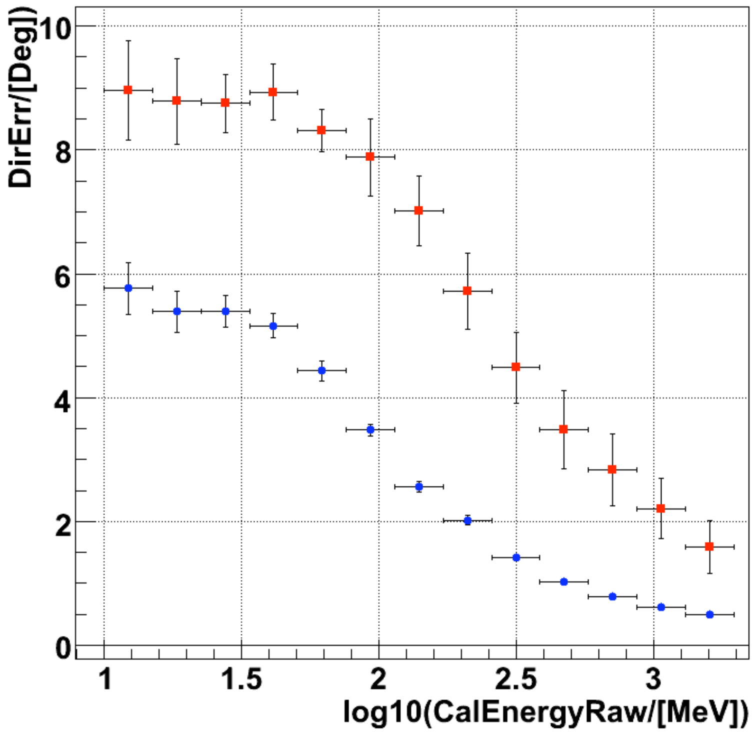
Beam divergence increases with decreasing Energy

Beam divergence is a big fraction of BeamCU_DirErr above 30 MeV

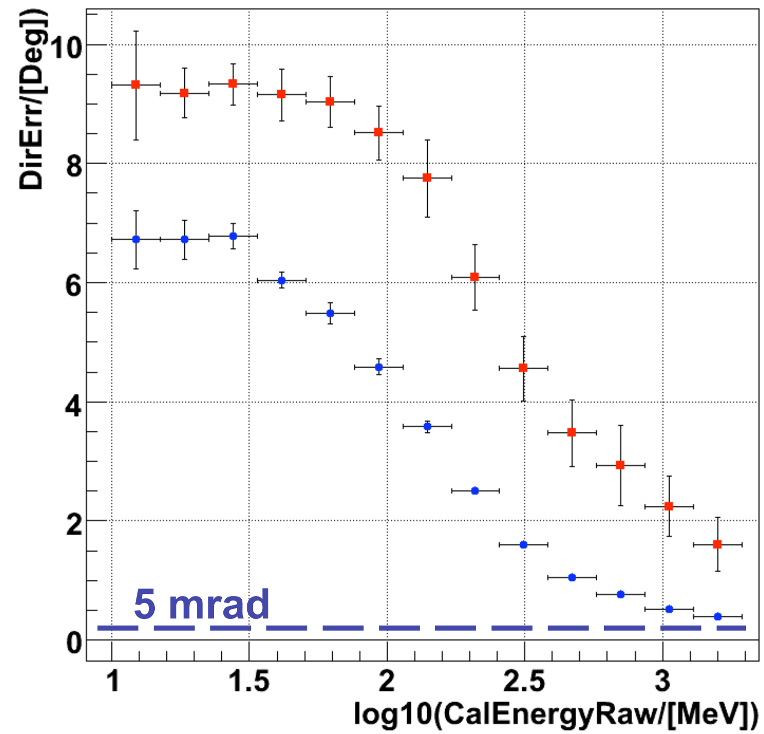
Below 30 MeV, Beam divergence > BeamCU_DirErr (???)

3 - Beam dispersion in full brems MC run BT-1445

BeamCU_DirErr 68% and 95%



CU_DirErr 68% and 95%



Below 300 MeV, CU_DirErr > BeamCU_DirErr (???)

I guess there is an error in the calculation of the variables Mc[ZYX]Dir; this error has a larger effect at the lower energies.

Conclusion from Test 2

Calculated beam divergence increases with decreasing photon energy, and it should not

It might happen that there is an error in the variables Mc[ZYX]Dir, which would make the calculus of beam divergence meaningless

Concerning whether the effect is the same in Full brems runs and electron runs: in electron runs (PS and SPS), the numbers are more consistent… but I cannot exclude that the problem is there, with a smaller effect (due to the larger energies…)

Ideas ? Suggestions ?