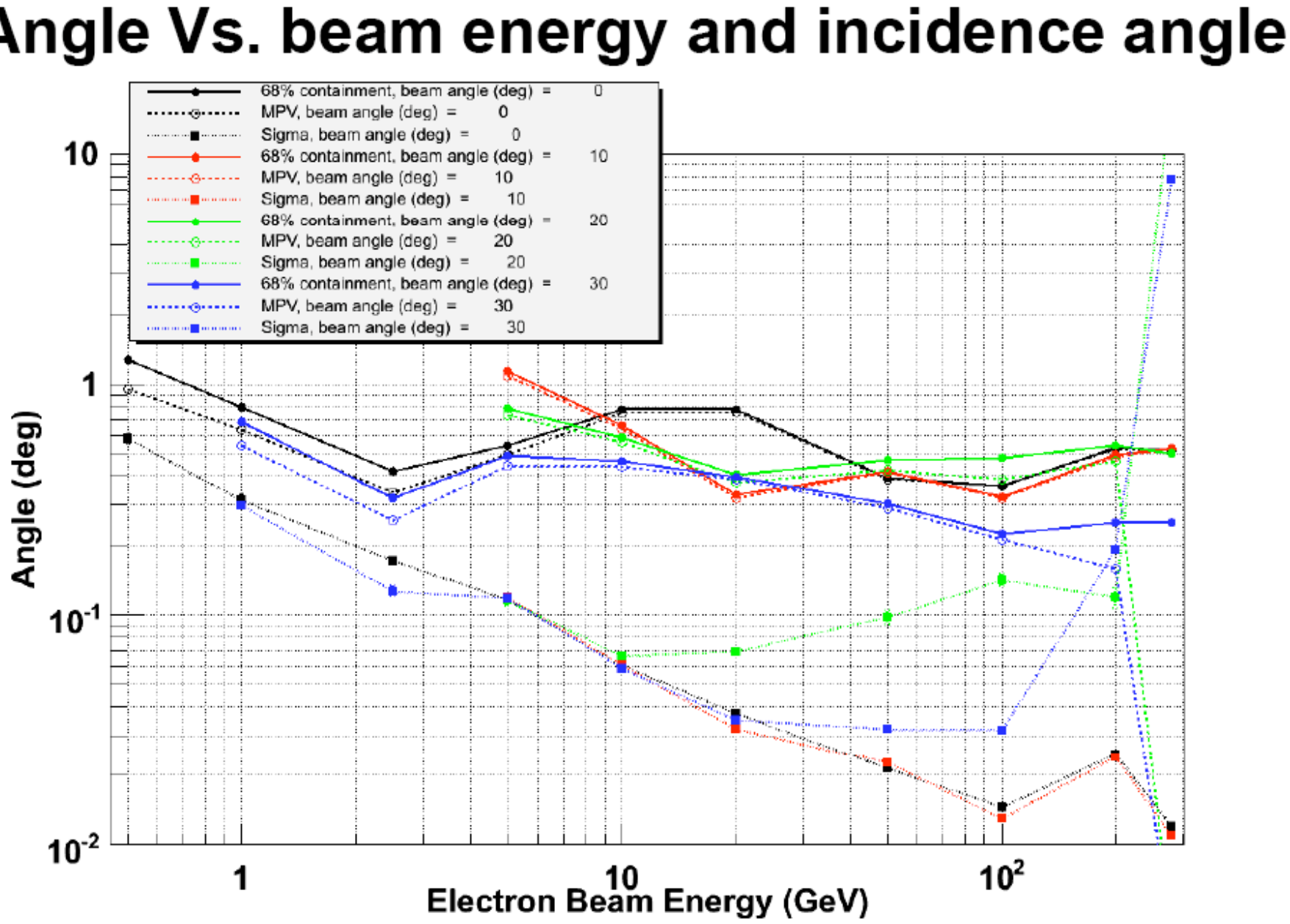
Importance of knowing the accurate beam incoming direction when computing the PSF

0 - Intro; PSF plots presented by Nicola last week

1 - Calculation of the PSF with electrons (short!)

2 - "Improvement" in the computed PSF when using the "true" incoming beam direction

0 - Intro; PSF plots presented by Nicola last week



I suggested that the reason for the relatively large “PSF” is due to fact that Nicola was using the **NOMINAL** beam incoming direction instead of the **TRUE** beam incoming direction into the CU

Example: Data run 1922 (280 GeV, 0 deg)

Incoming direction is defined by cos directors of the first track

Nominal:

Tkr1ZDir = -1.0

Tkr1XDir = 0

Tkr1YDir = 0

RECONSTRUCTED (~ TRUE)

Tkr1ZDir = -0.9999591213 (90 + **89.48 deg**)

Tkr1XDir = 0.006854878802 (90 + **0.39 deg**)

Tkr1YDir = 0.005882297613 (90 + **0.34 deg**)

These uncertainties of fractions of degrees cause an error in the determination of DirErr, and thus on the PSF

Solution: determine the “TRUE” beam incoming angle and re-compute the PSF

I estimated the beam profile (which includes the incoming beam direction) for the data/mc runs that Nicola used

In noric machines (SLAC):

/nfs/farm/g/glast/u33/dpaneque/BeamTestData/EstimateBeamProfileForNicola_2007_07_18/Output/AsciiFiles/

EstimatedBeamCharacteristicsSummaryTable_Data.txt
EstimatedBeamCharacteristicsSummaryTable_MC.txt

I put them as attachments into the BeamTest web page

Nicola did some quick tests last week and saw the improvement. Unluckily he is unavailable this week, so could not finalize the study

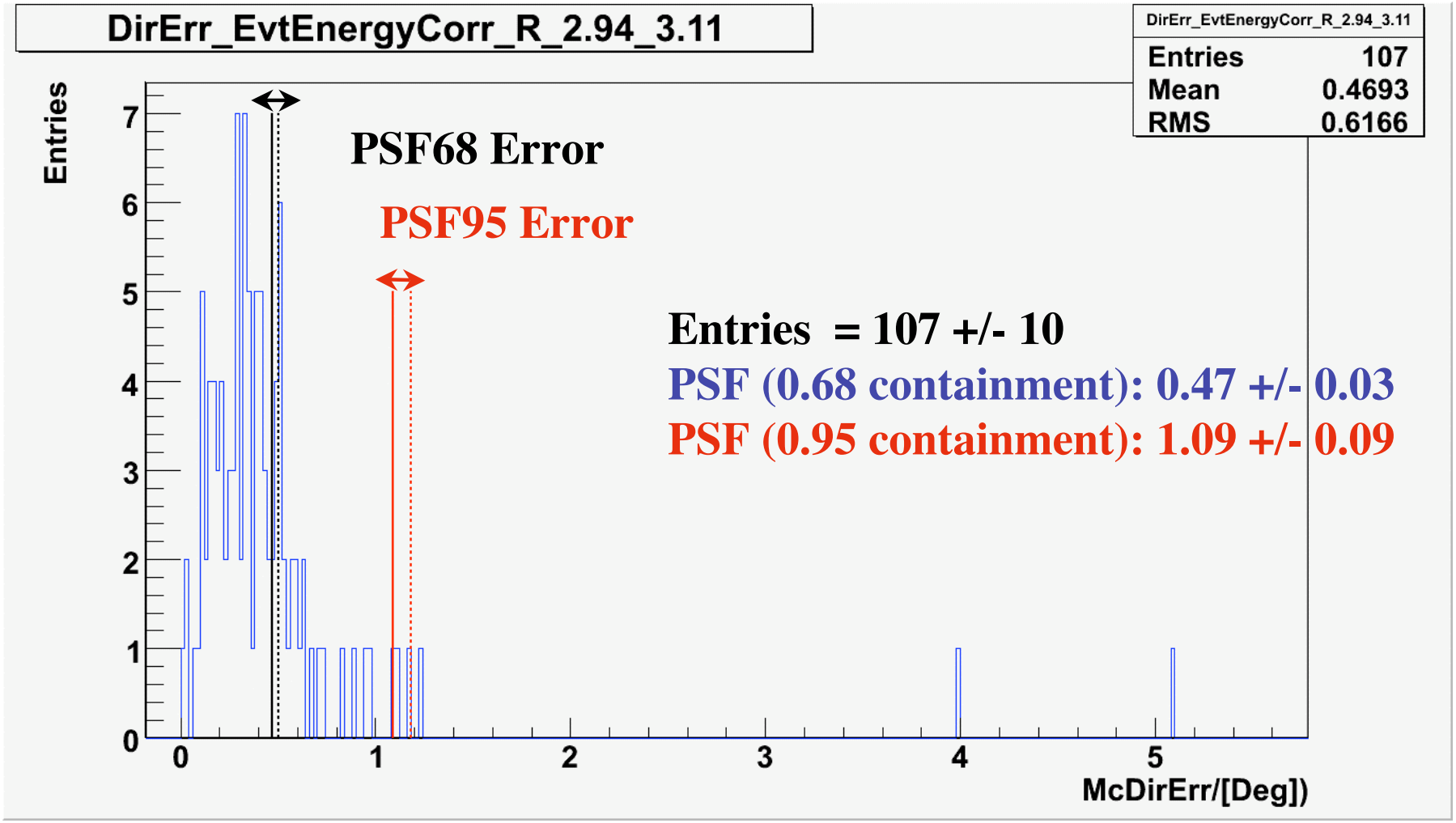
I will show the improvement for one run (highest energy)

I will also show that the precision with which we can determine the beam incoming direction is indeed a limiting factor in the accurate determination of the PSF

CALCULATION OF PSF (using electrons)

$$Cos(BeamCU\_DirErr) = cos(XthetaBeam)* Tkr1XDir + cos(YthetaBeam)* Tkr1YDir + cos(ZThetaBeam)* Tkr1ZDir$$

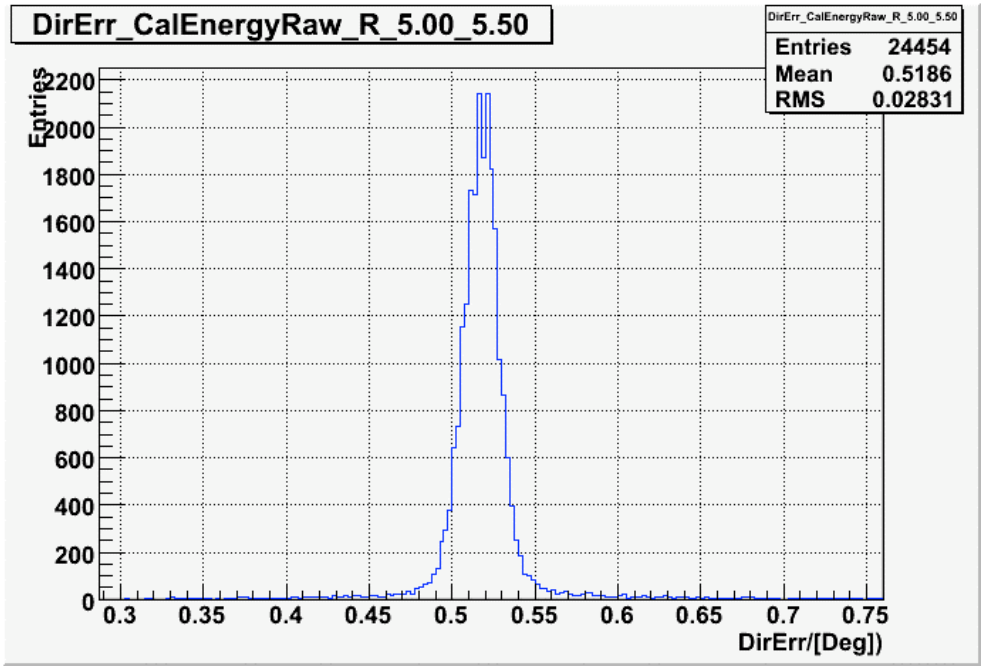
CU Resolution + BeamDiv = *("Measured PSF")*

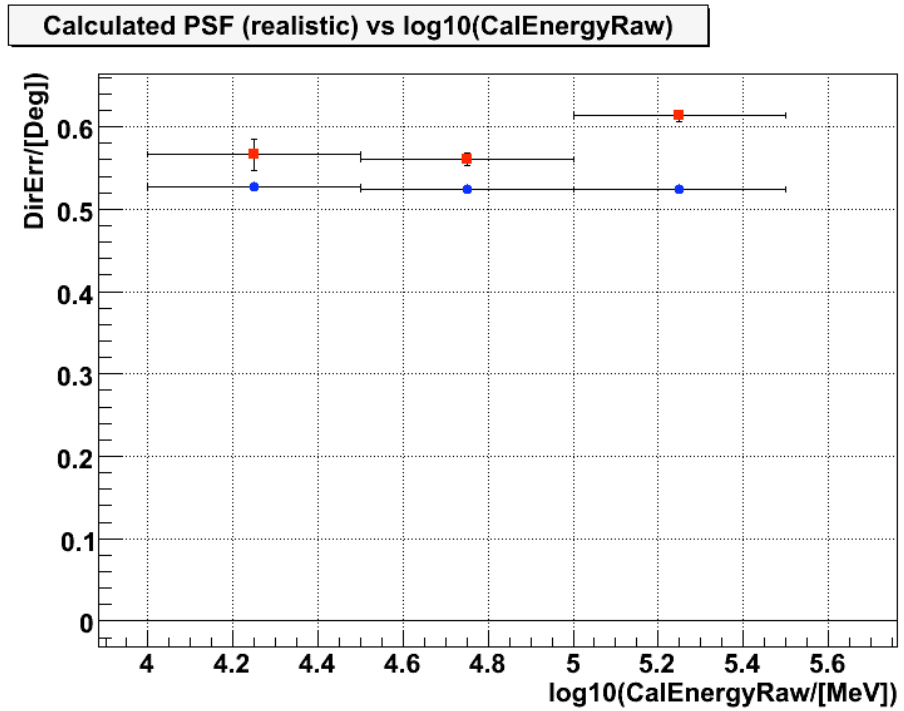


PSF computed for some of Nicola's runs; Nominal beam Dir

Data run 1922; 280 GeV, 0 deg

PSF 68% PSF 95%





PSF calculated for different CalEnergyRaw. Old macro I did to compute PSF with Full Brems photons

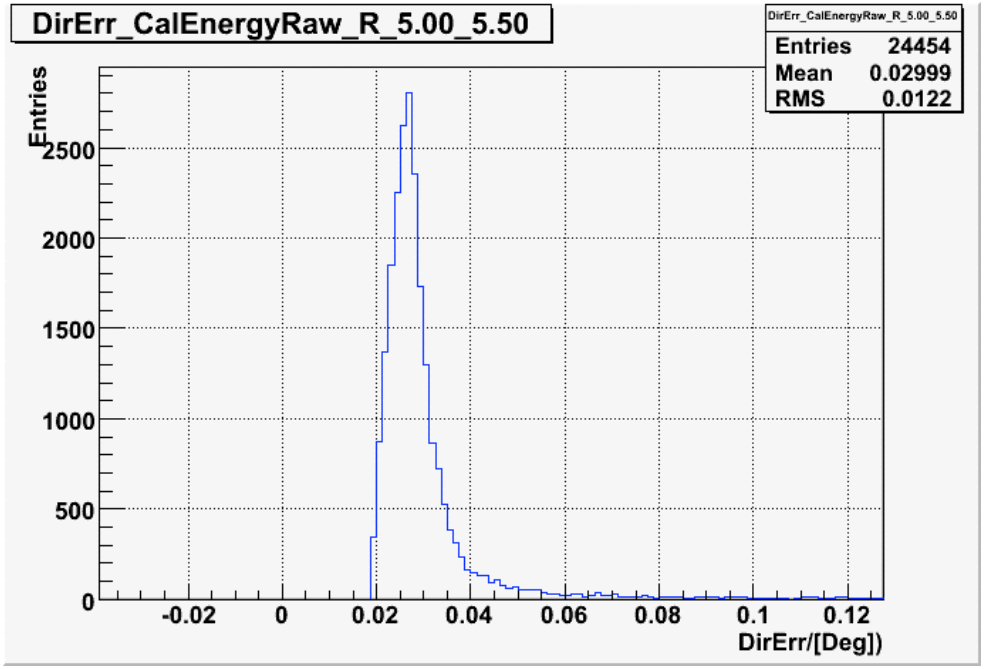
Why it does not start at 0 deg ?

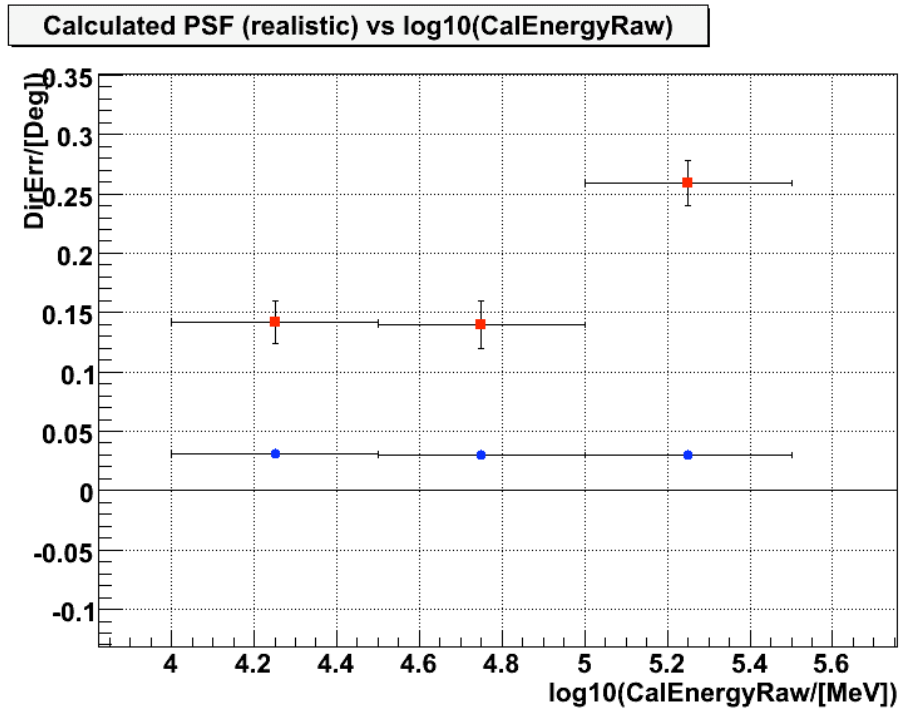
i.e. why, not even by chance, we can reconstruct a single event exactly ?

PSF computed for some of Nicola's runs; "TRUE" beam Dir

Data run 1922; 280 GeV, 0 deg

PSF 68% PSF 95%



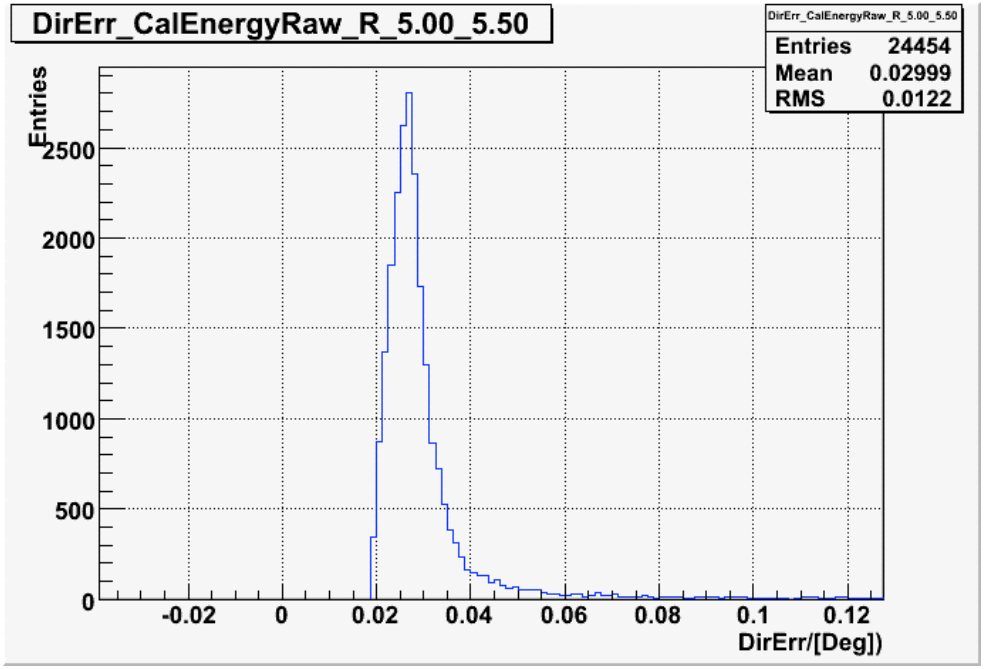


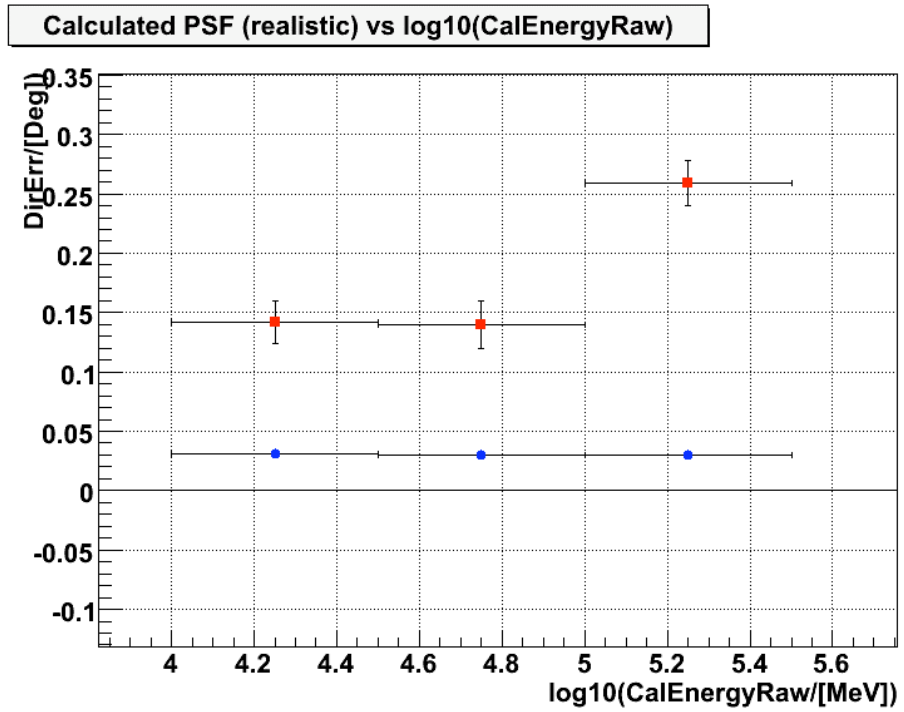
Substantial improvement in PSF: For this run, PSF 68 gets reduced by almost a factor 20

PSF computed for some of Nicola's runs; "TRUE" beam Dir

Data run 1922; 280 GeV, 0 deg

PSF 68% PSF 95%





Substantial improvement in PSF: For this run, PSF 68 gets reduced by almost a factor 20

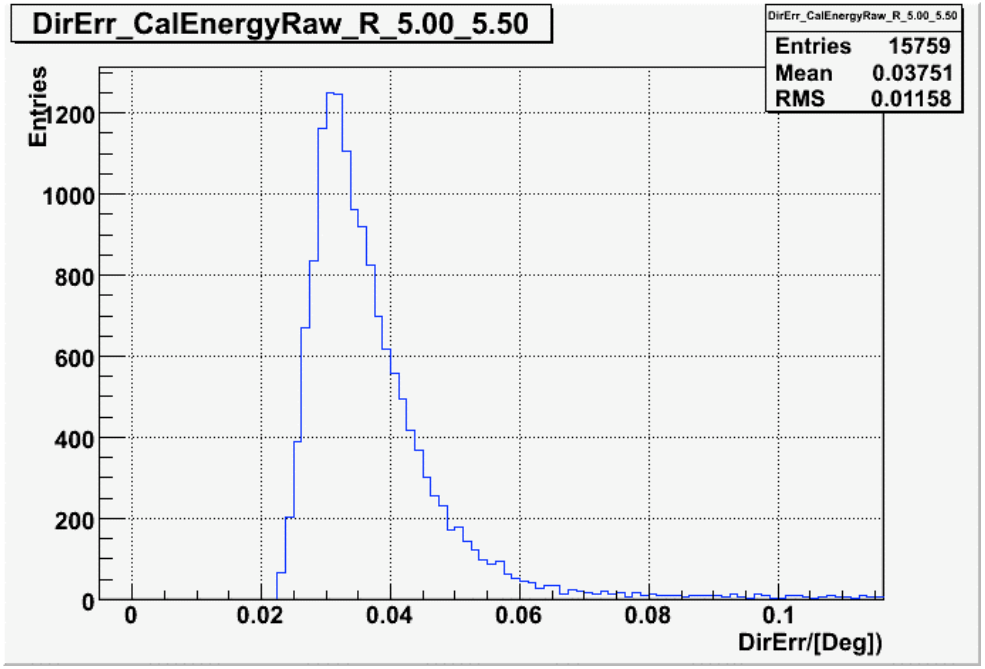
But DirErr still does not go through zero…

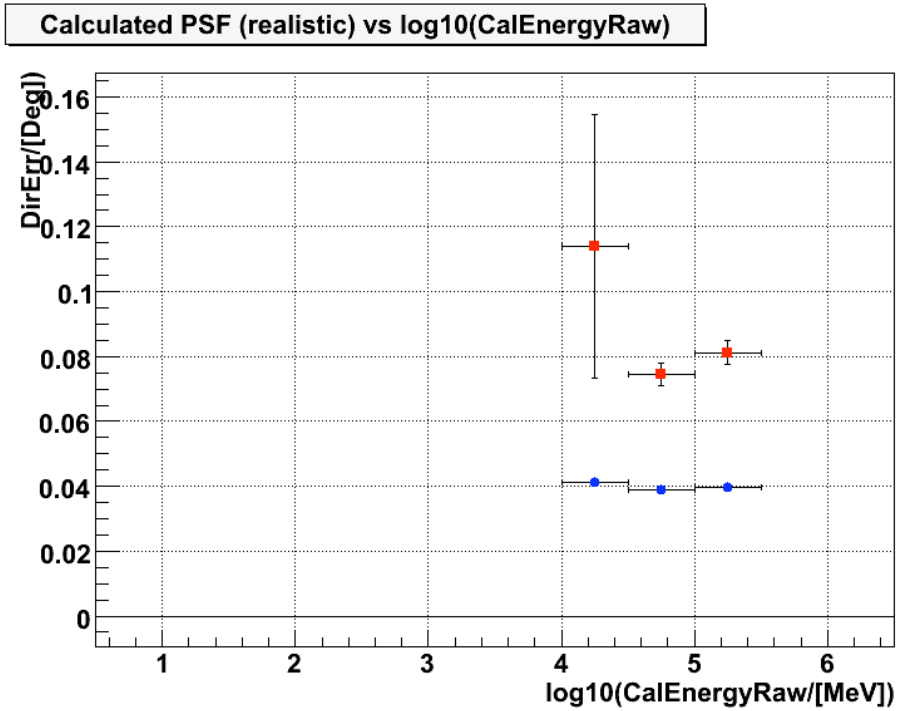
i.e. why, not even by chance, we can reconstruct a single event exactly ?

Let's have a look at the MC runs

MC run BT-1922; 280 GeV, 0 deg (using reconstructed Beam dir computed in the same way as in DATA)

(produced on demand by Johan, 2007/06





Does not start at 0 degrees either

CALCULATION OF PSF (using electrons)

When MC data is being used, additional info is available:

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")*

$$Cos(CU\_DirErr) = McXDir * Tkr1XDir + McYDir* Tkr1YDir + McZDir* Tkr1ZDir$$

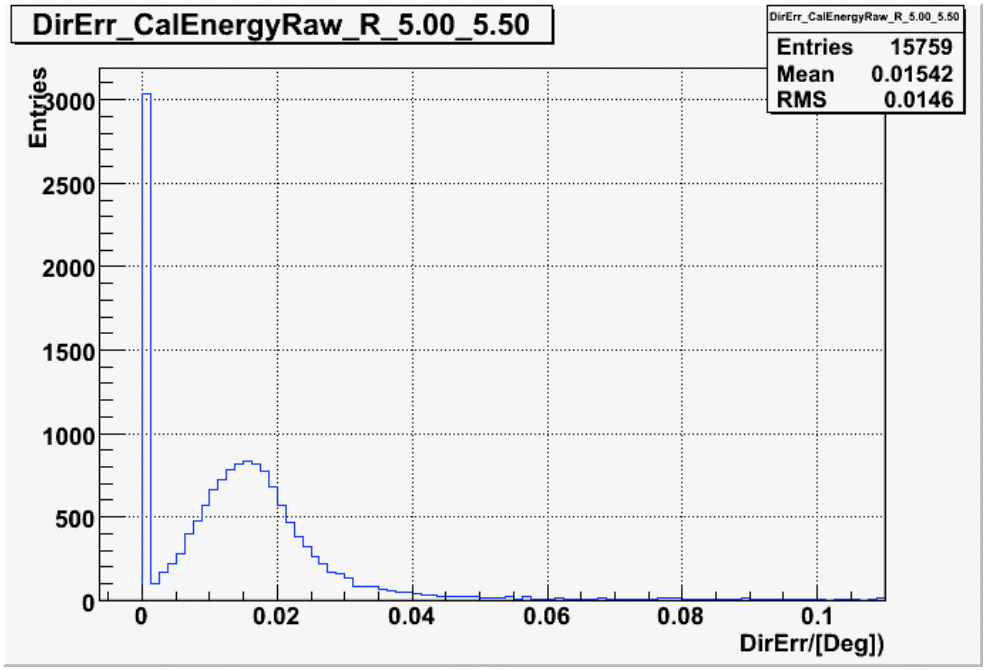
CU Resolution (True PSF)

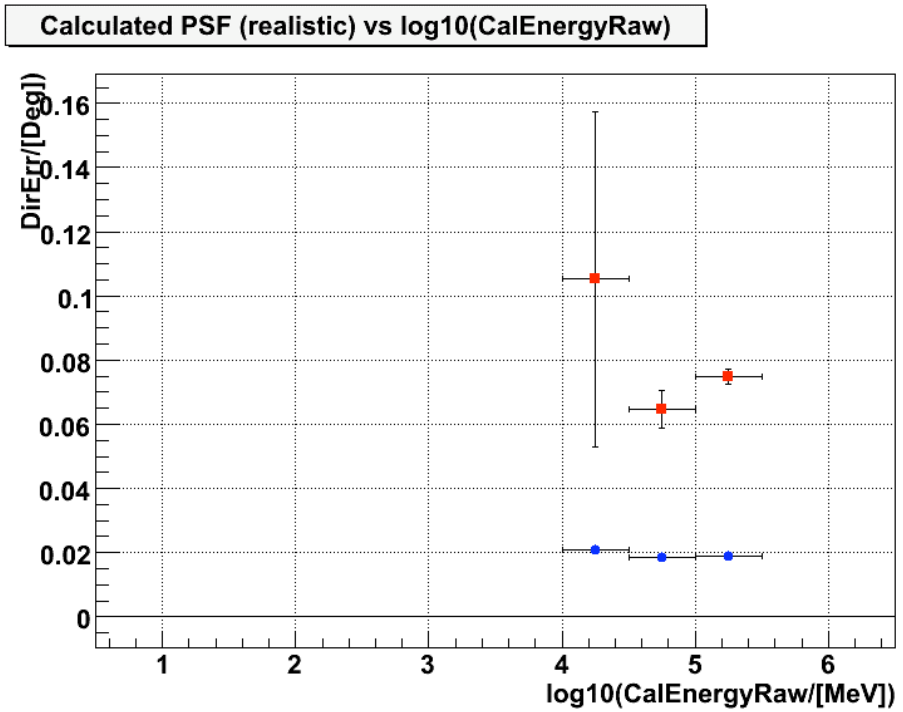
$$Cos(BeamCU\_DirErr) = cos(XthetaBeam)* McXDir + cos(YthetaBeam)* McYDir + cos(ZThetaBeam)* McZDir$$

Beam Divergence

This has nothing to do with the resolution of the CU to reconstruct events

CU Resolution for MC run BT-1922; 280 GeV, 0 deg





Values at exactly DirErr = 0 deg are set manually when, because of numerical imprecisions, 1.0 < |cosDirErr| < 1.001

$$Cos(CU\_DirErr) = McXDir * Tkr1XDir + McYDir * Tkr1YDir + McZDir * Tkr1ZDir$$

CU Resolution (True PSF)

The reason is the "precision/imprecision" with which the incoming direction is determined. This can be studied with the MC runs

MC run BT-1922; 280 GeV, 0 deg

Output from the macro:

RECONSTRUCTED Beam incoming direction (cosinus directors):

Tkr1ZDir = -0.9999601523 (90 + 89.488657 deg)

Tkr1XDir = 0.006804791685 (90 + 0.389965 deg)

Tkr1YDir = 0.005759525823 (90 + 0.3299226 deg)

Nominal (True for MC) beam direction:

Tkr1ZDir = -0.9999602458537 9 (ratio with recons. Val= 1.000000094)

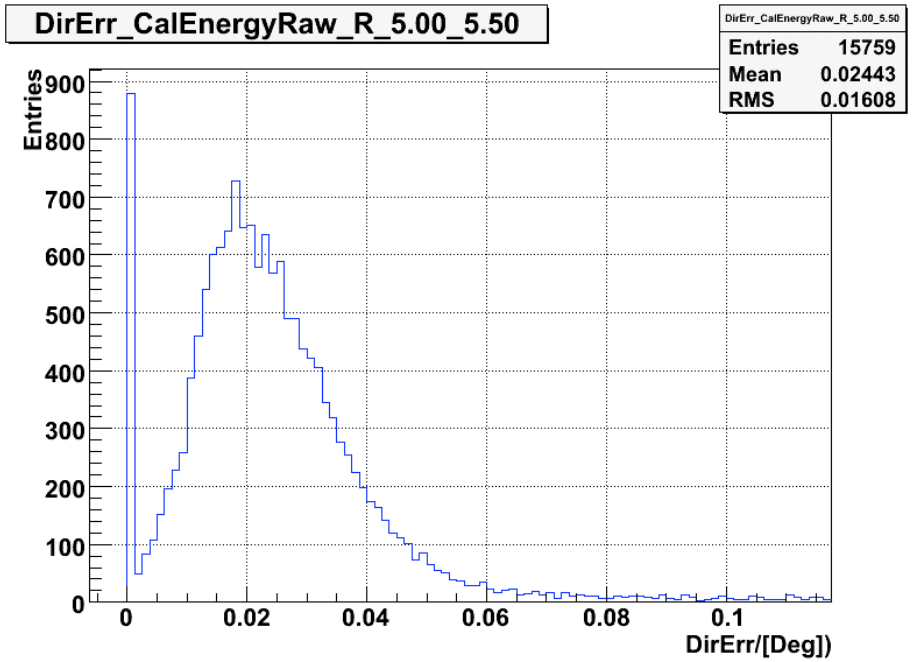
Tkr1XDir = 0.0068080525354 (ratio with recons. Val= 1.000479)

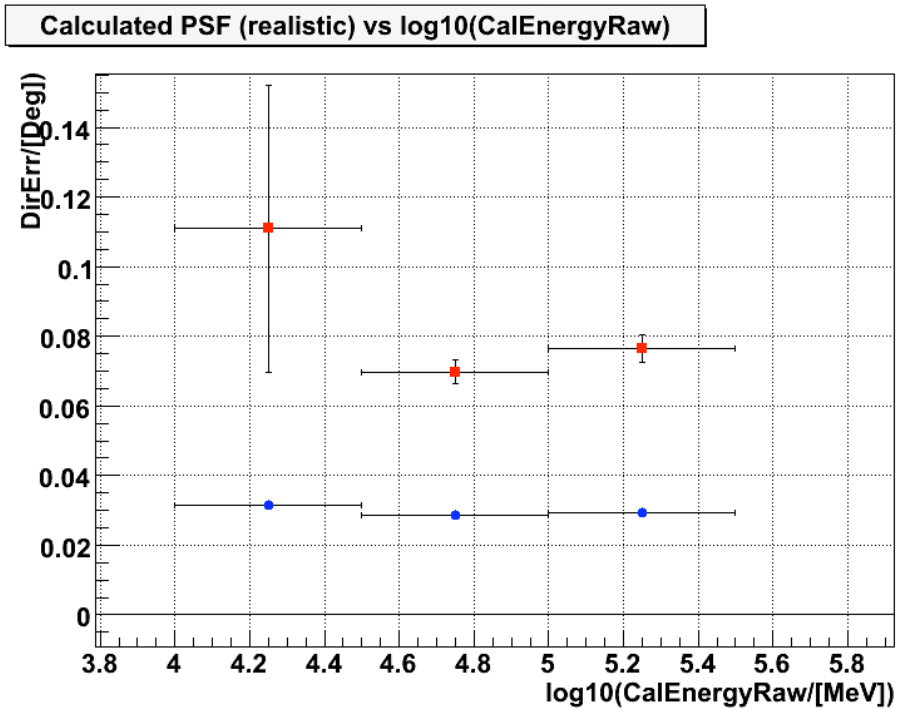
Tkr1YDir = 0.0057582230502675 71 (ratio with recons Val = 0.99977)

Those tiny decimals have a significant impact !!!

Let's have a look at the MC runs

MC run BT-1922; 280 GeV, 0 deg (using **nominal beam direction**, extracted from the config files Johan used to produce these data)





Now distribution DOES start at zero (besides the the events put at zero due to numerical imprecisions in calculations…)

Computed PSF improves from ~0.04 to ~0.03 (~25%).

Conclusions

When computing the PSF we should use the "TRUE" beam incoming angle.

This is particularly important when dealing with very high energies, when the CU resolution to reconstruct directions is a small fraction of a degree.

At the highest energies the PSF improves by more than one order of magnitude

Among other things, a limiting factor in the determination of the PSF at the highest energies is the precision in the determination of the incoming direction of the beam of particles (electrons/photons)