Angular resolution with only ECAL information for CALICE TB

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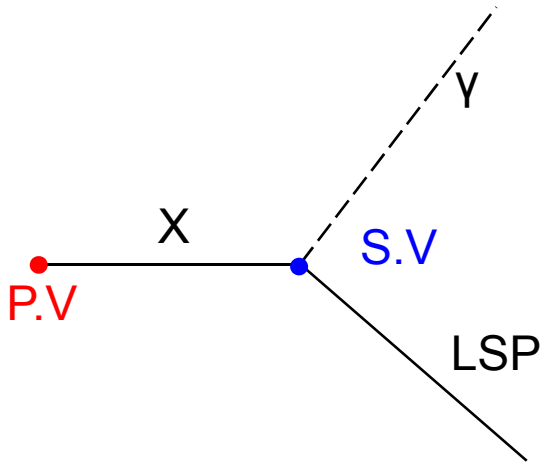
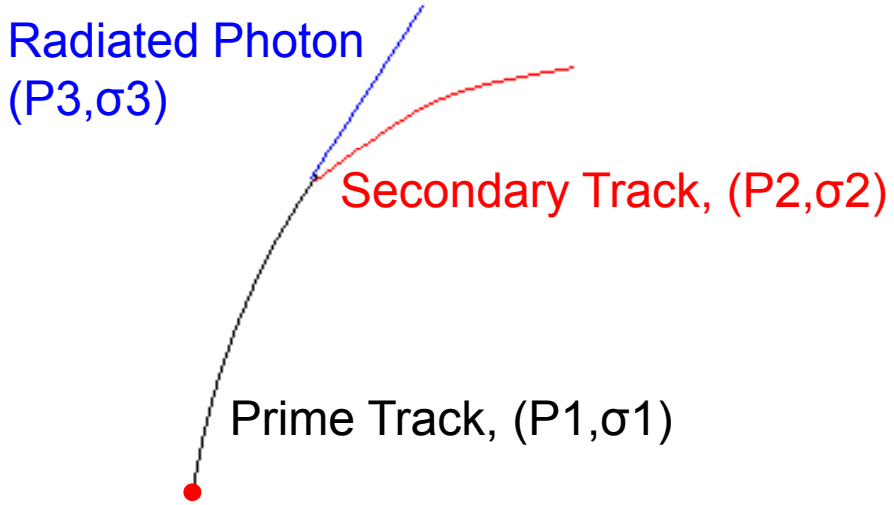
Outline

- Motivation & List of data sample
- Algorithm for ECAL Spatial & Angular resolution
- ECAL Spatial resolution per layer
- ECAL Angular resolution
- Summary

Motivation: Why ECAL only

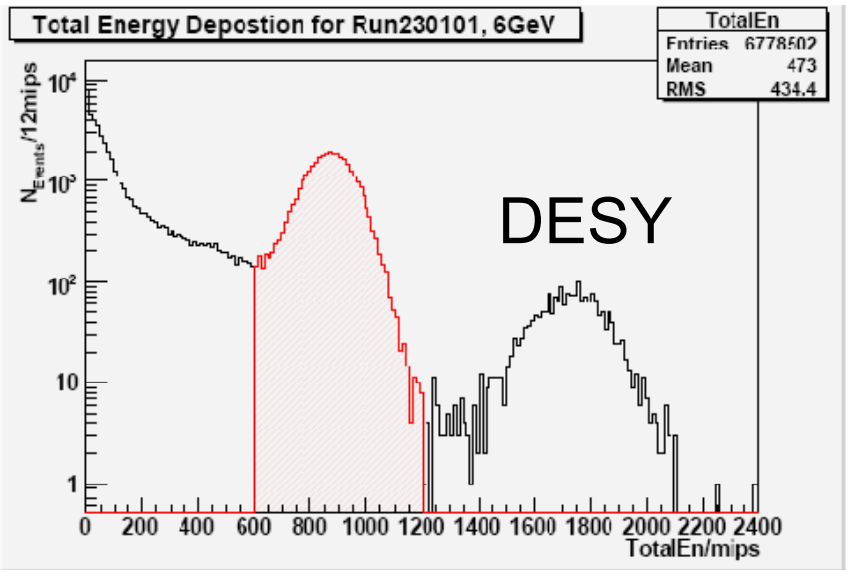
- Photon interact with ECAL samely as electron/positron;
- Could be used to detect a photon from second vertex, like a beyond-SM neutral particle decay into a LSP and a photon;
- Could be used to correct charged track resolution from FSR/radiation

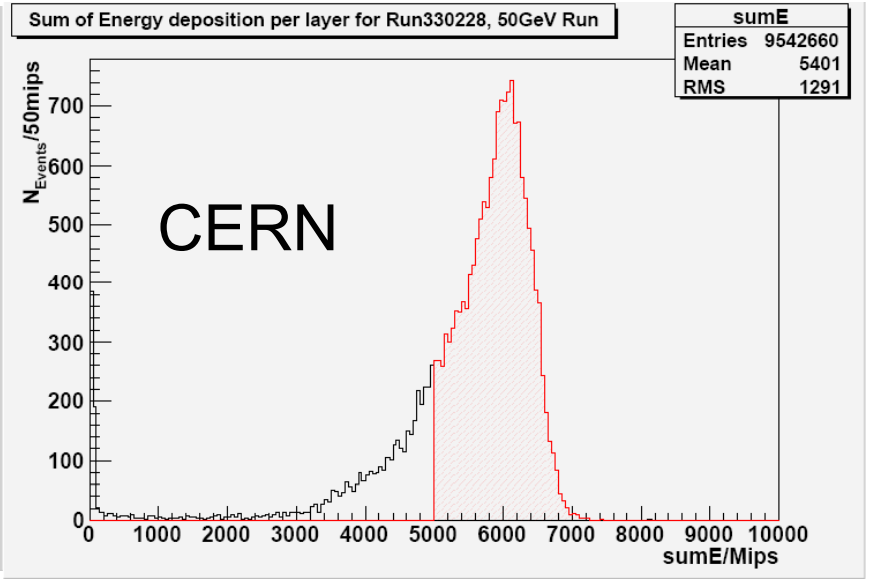




Data & event selection

- Data from DESY test beam at May, 2006: ECAL equipped with 24 layers, the PCB on each layer contains 3*2 wafers, totally 5184 channel;
- Data from CERN test beam at July-August, 2007: ECAL equipped with 30 layers.
- Many double events for DESY Runs, and bump pattern in Total energy spectrum caused by interwafer gaps for CERN Runs: → an Event selection based on cut on sum of energy deposition per layer is applied in our analysis



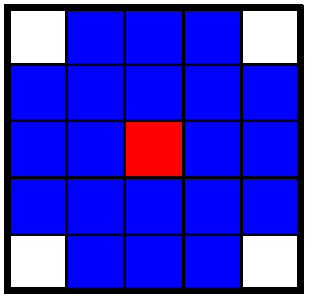


List of electron runs

RunNum	Beam energy	Inject angle	Cut on sumE /mips	RunNum	Beam energy	Inject angle	Cut on sumE /mips
230098	1GeV	0°	90-230	330996	15GeV	10°	1.5k-2.5k
230099	2GeV		150-450	330995	20GeV		1.5k-3.5k
230097	3GeV		300-600	330994	25GeV		2.5k-4.5k
230100	4GeV		400-800	330993	30GeV		3.0k-4.5k
230104	5GeV		500-1.0k	330990	40GeV		3.0k-6.0k
230101	6GeV		600-1.2k	330986	50GeV		5.0k-8.0k
330433	15GeV		1.5k-2.5k	331194	15GeV	20°	1.5k-2.5k
330423	20GeV		1.5k-3.5k	331198	20GeV		1.5k-3.5k
330431	25GeV		2.5k-4.5k	331202	25GeV		2.5k-4.5k
330456	30GeV		3.0k-4.5k	331204	30GeV		3.0k-4.5k
330224	40GeV		3.0k-6.0k	331207	40GeV		3.0k-6.0k
330228	50GeV		5.0k-8.0k	331209	50GeV		5.0k-8.0k

Black: reconstructed with reco_v0406
Blue: reconstructed with monitor-cern07

Method



- First, Apply following cuts to select clean fired cell
  - Energy> threshold (0.6Mip)
  - Not too far away from the most energetic hit in this layer: dis<24mm (only 20 closest cells to the most energetic cell can pass this cut)

- In order to evaluate the spatial resolution (we will not using DC information here as the reference), a straight line fit is performed to the selected cells. The fit is made separately for X and Y direction (assume they are uncorrelated) with χ^2 defined as following, index *i* loop on all the selected hits

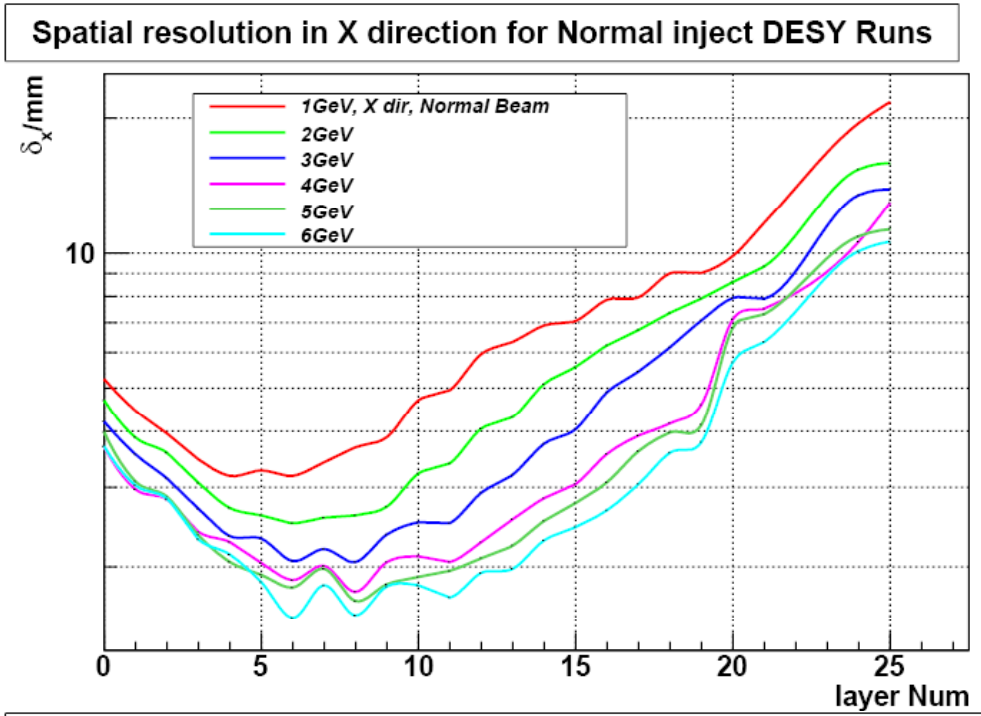
$$\chi^2 = \sum_{i=1}^{n} (x_i - az_i - b)^2 E_i$$

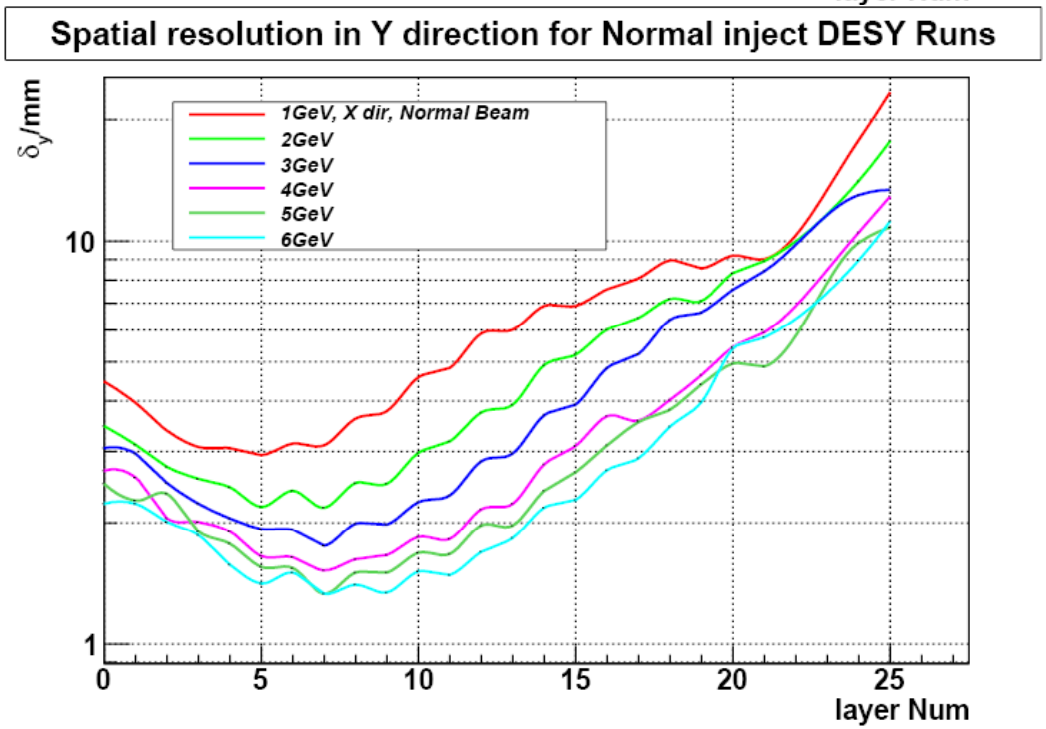
- Third, calculate the spatial resolution for each ECAL layer: calculate the difference between expected position and energy weighted center. The width of this distribution is defined as ECAL spatial resolution per layer, σ_i

- Forth, take into account of the spatial resolution: fit with following χ^2. the arc(tan) value of a is defined as ECAL measured angle.

$$\chi^2 = \sum_{i=1}^{n} (x_i - az_i - b)^2 (E_i / \sigma_i)$$

Spatial resolution per layer for DESY Runs

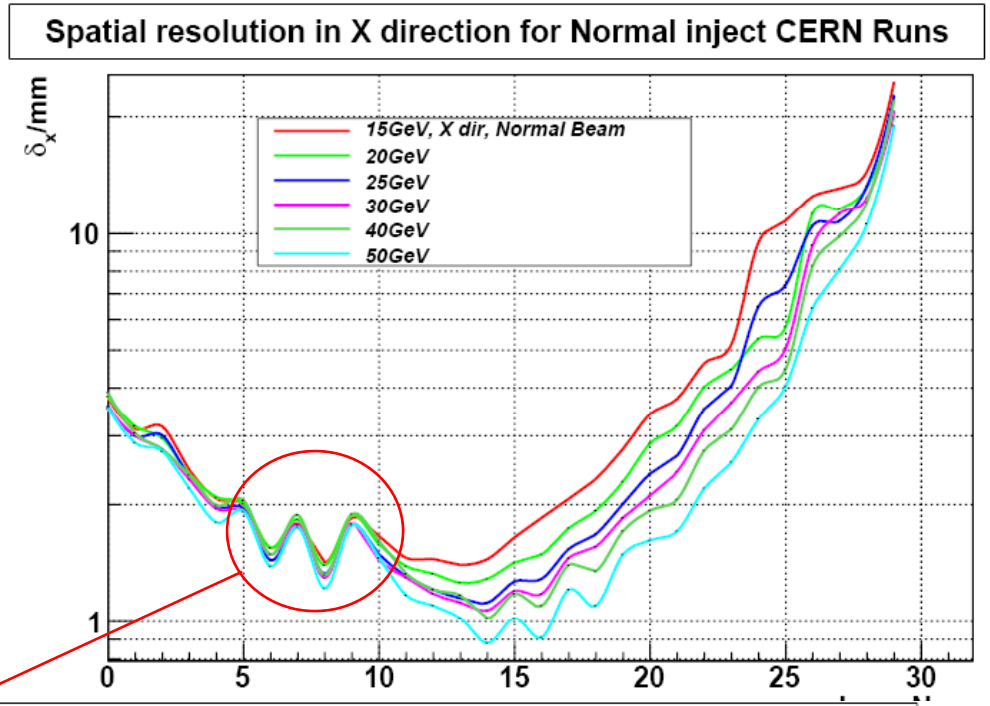


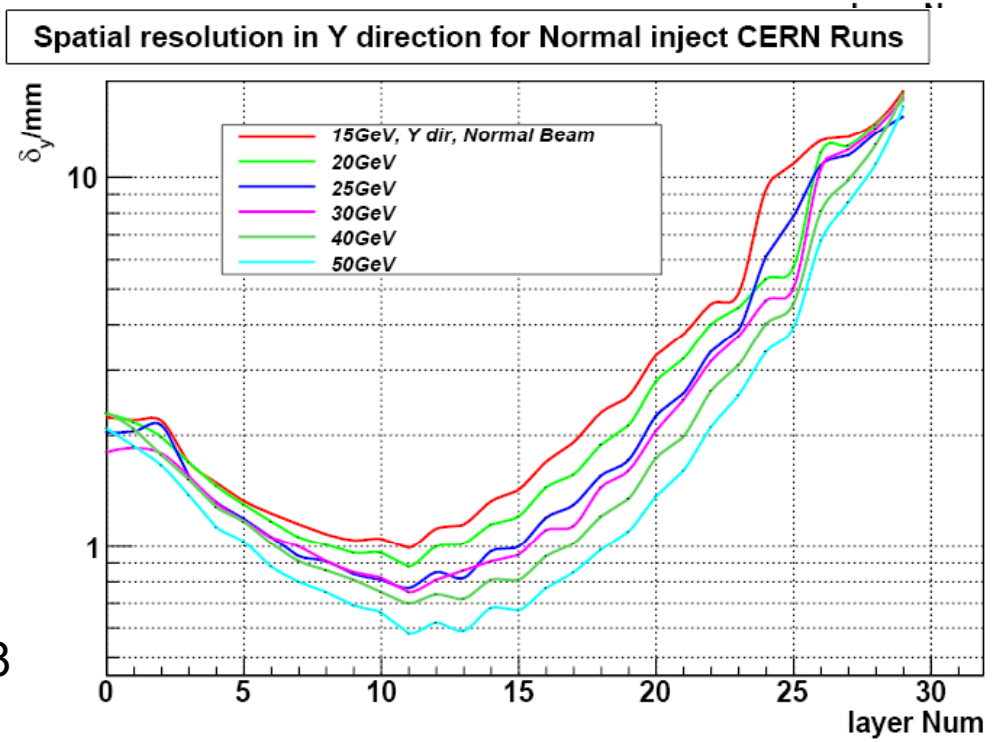


Better spatial resolution achieved For large beam energy.

The spatial resolution is slightly better for Y direction than X direction, presumably due to the shift between odd and even layers on X direction

Spatial resolution per layer for CERN Runs



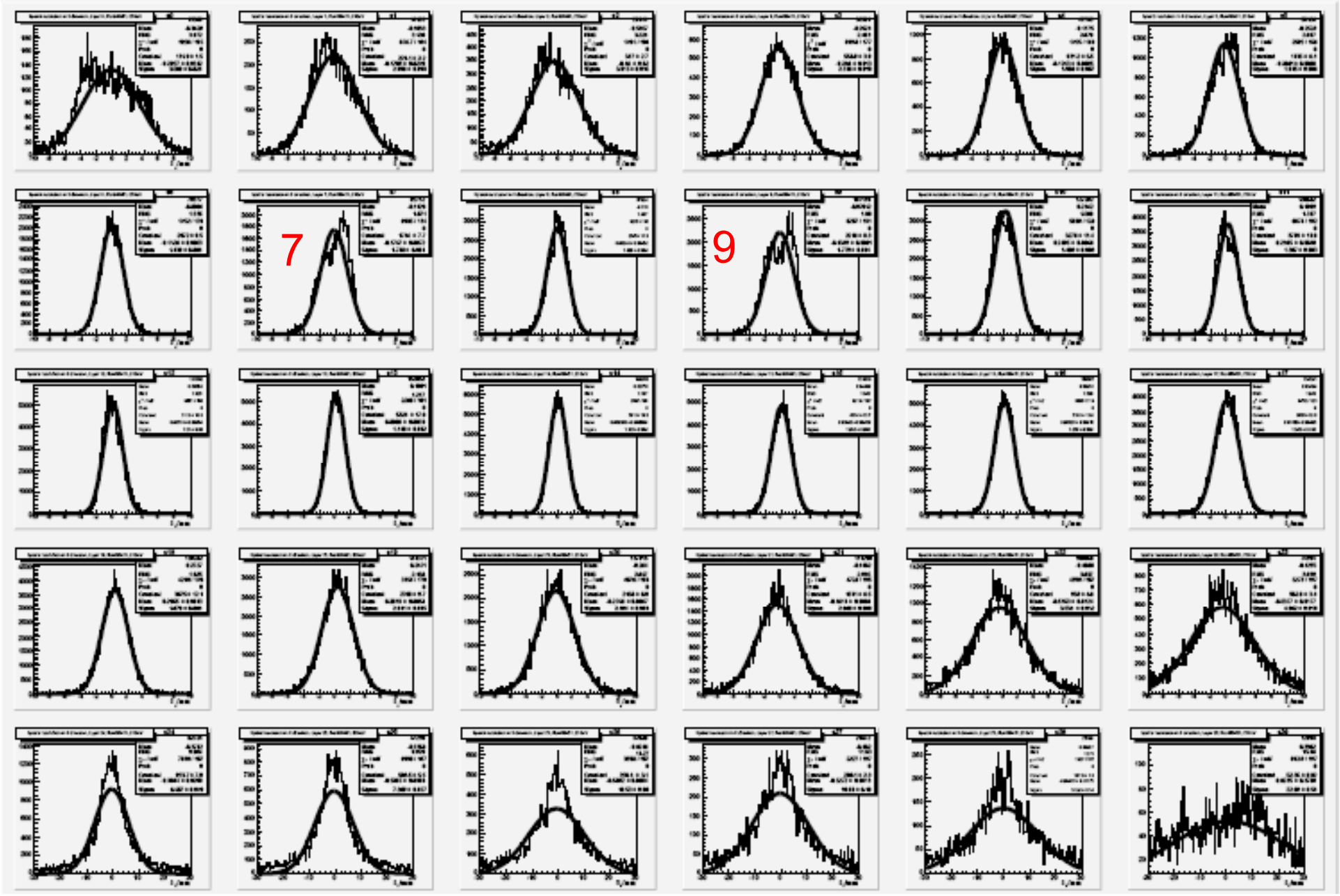


W Shape

Noise? Gap effect?
Wrong alignments between layers?

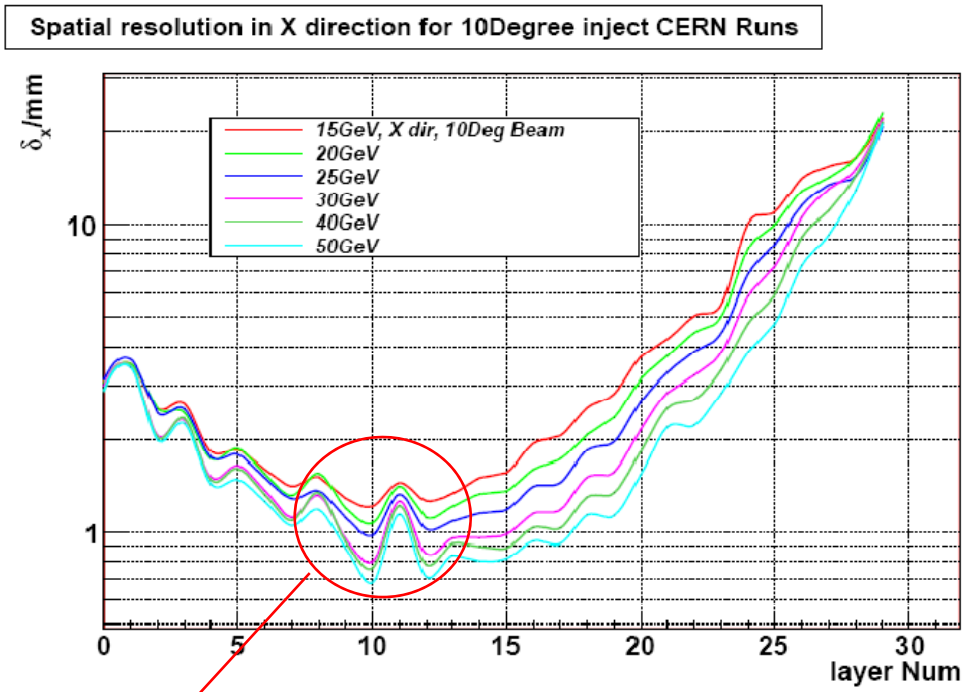
See next page

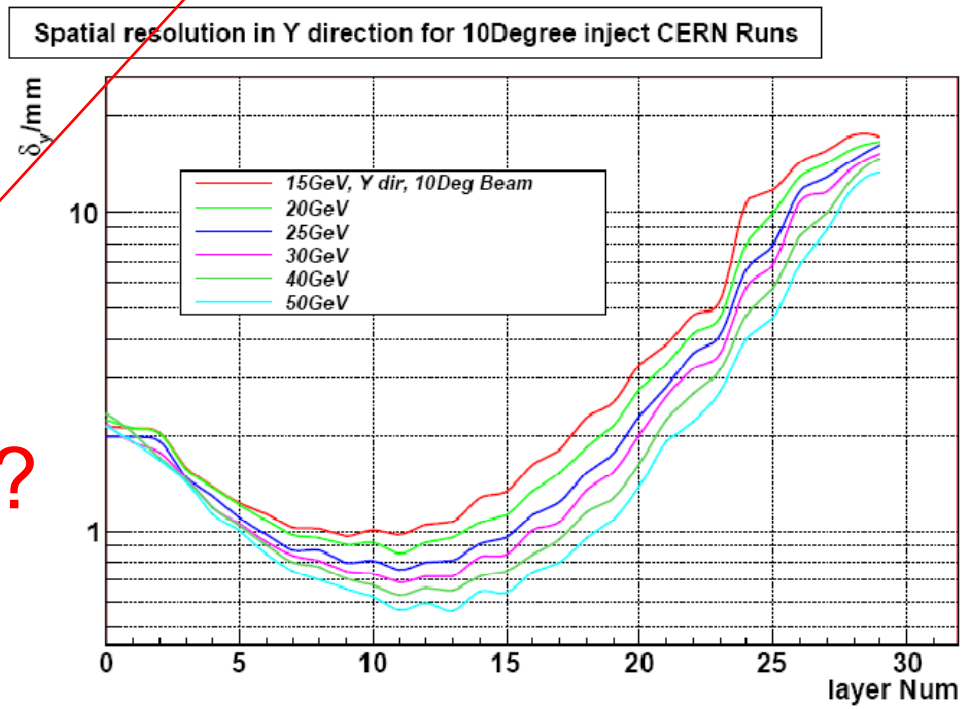
ECAL(EWC) – ECAL (Exp): in X direction, Run330431, 25GeV



Beam inject with Angle:

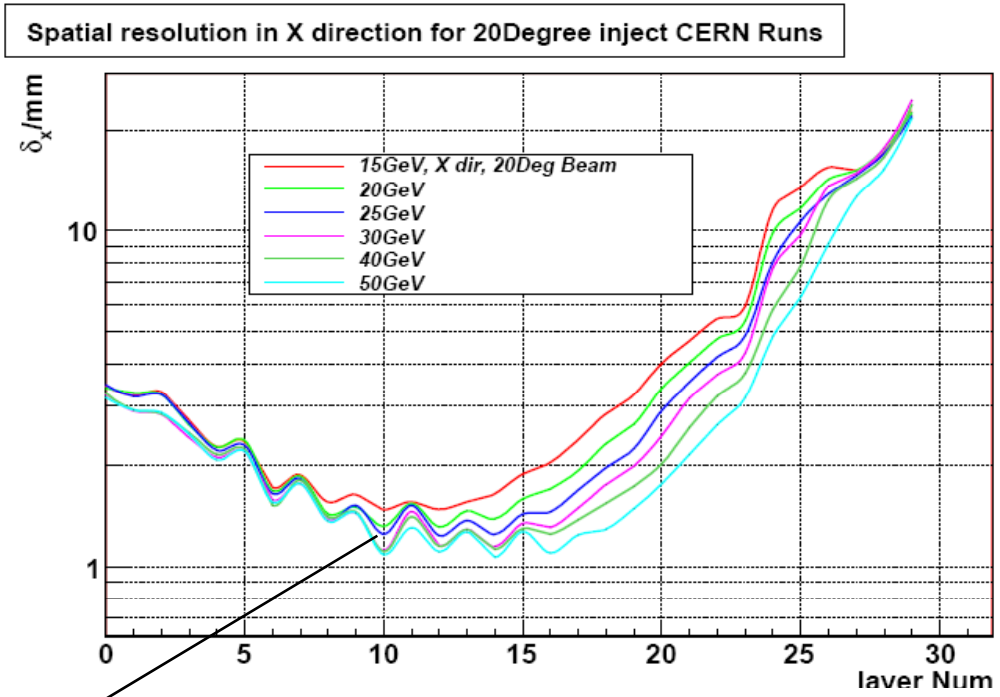
Spatial resolution per layer for 10° inject CERN Runs

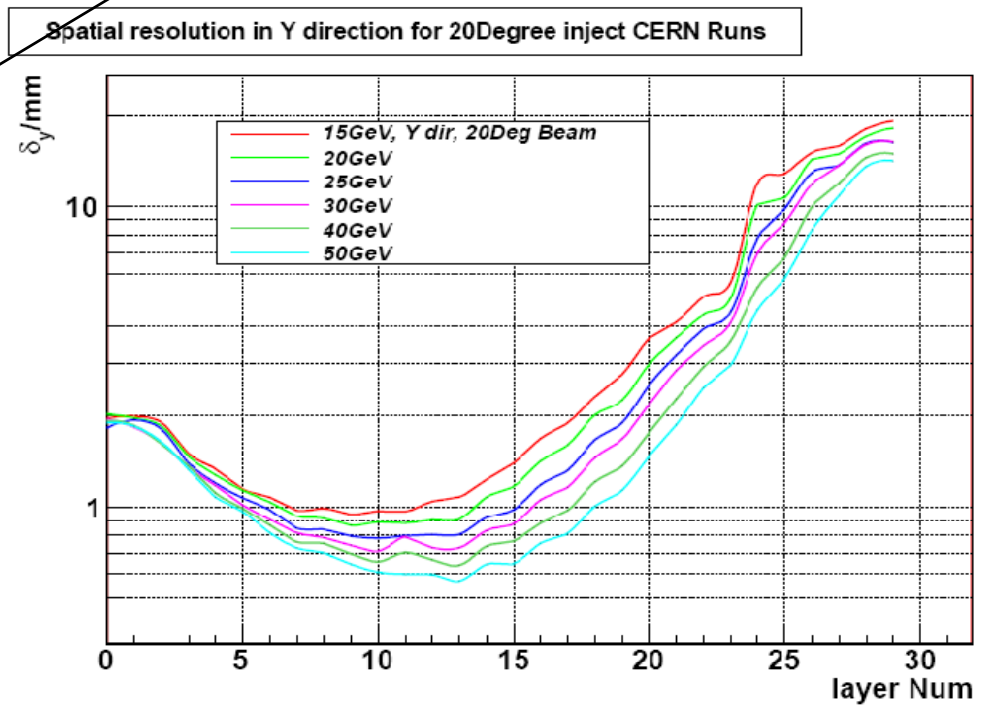




Shift to deeper layers?

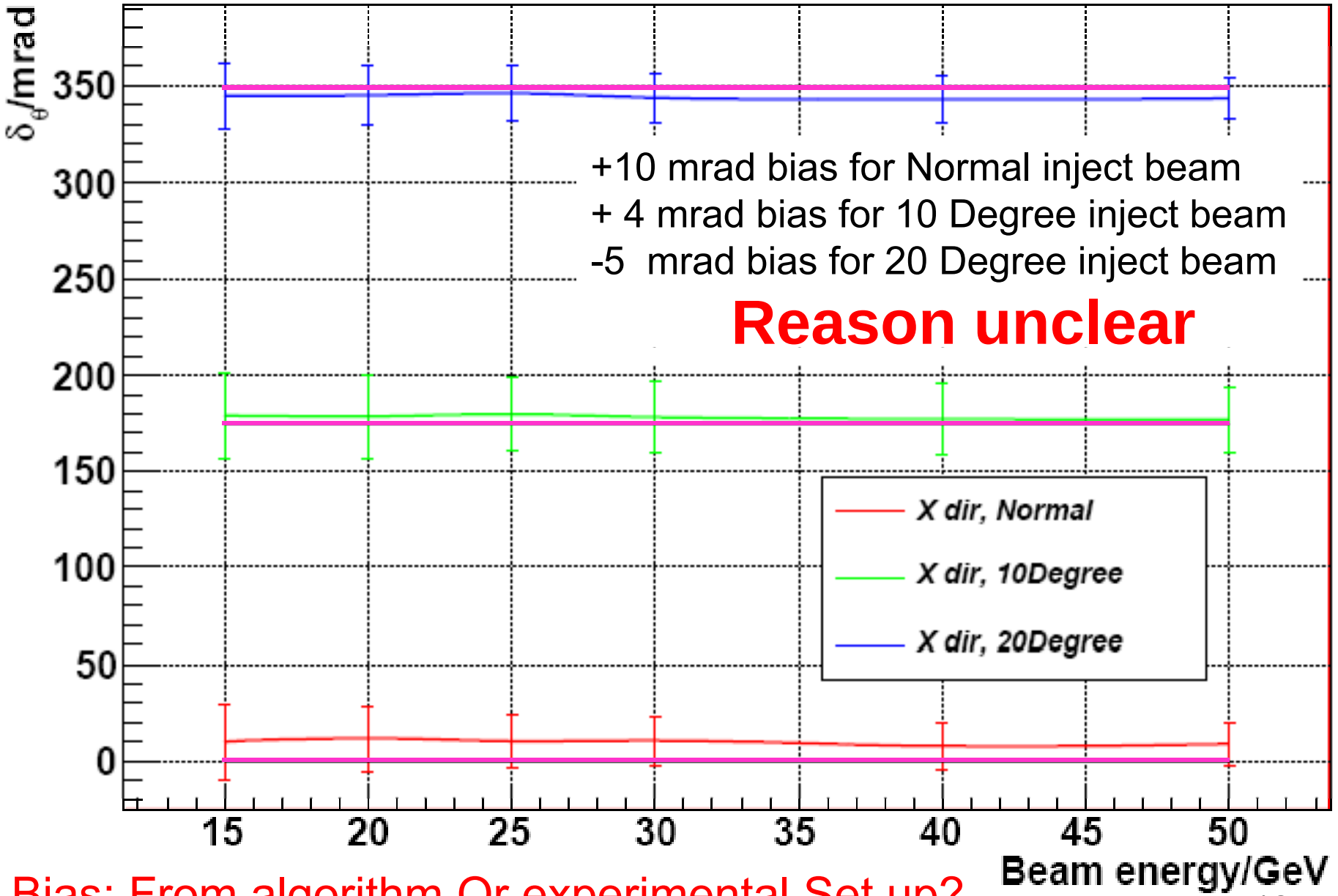
Spatial resolution per layer for 20° inject CERN Runs





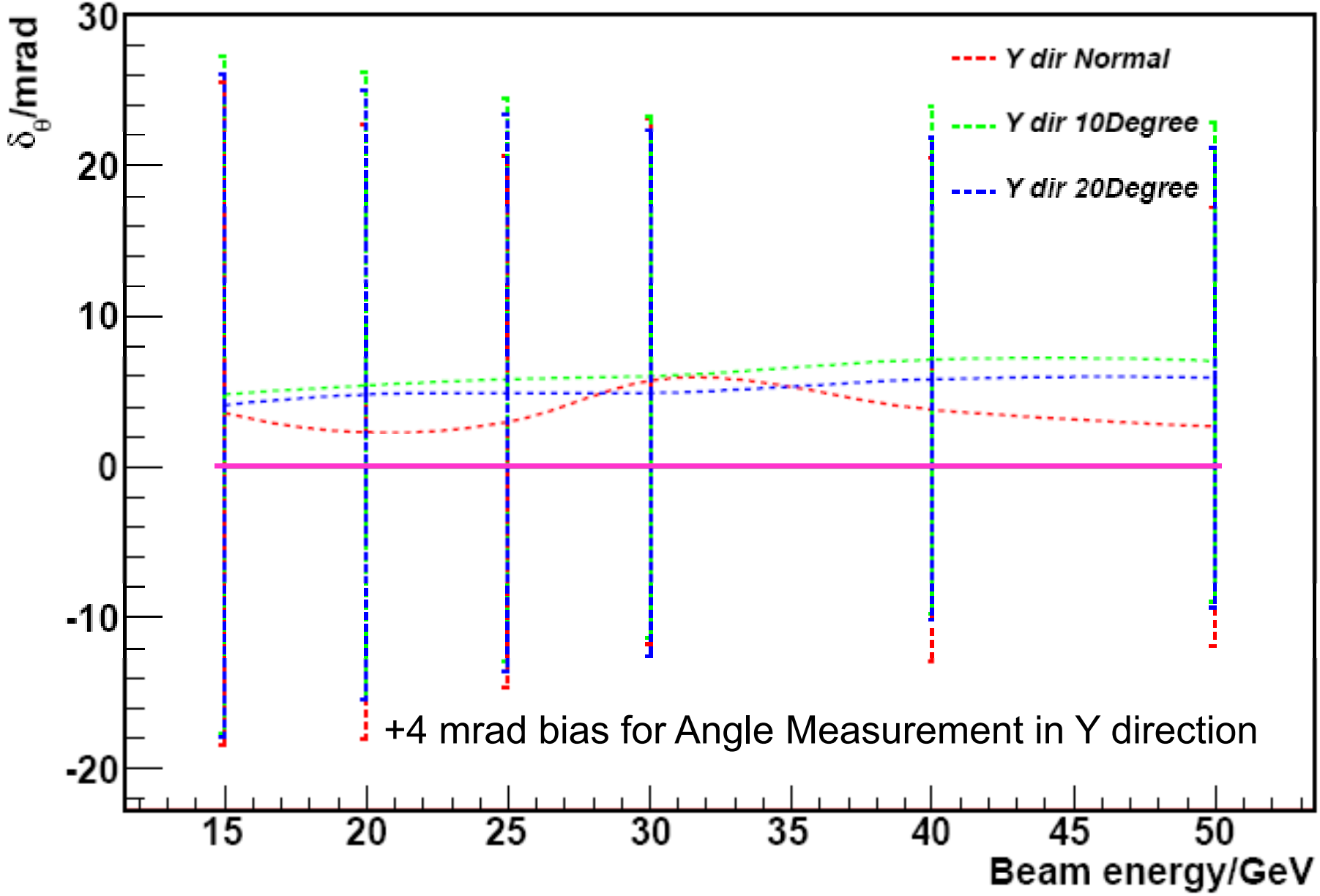
"W" Shape disappears, while odd-even asymmetry become Significant…

Angle Resolution for CERN Runs in X direction



Bias: From algorithm Or experimental Set up?

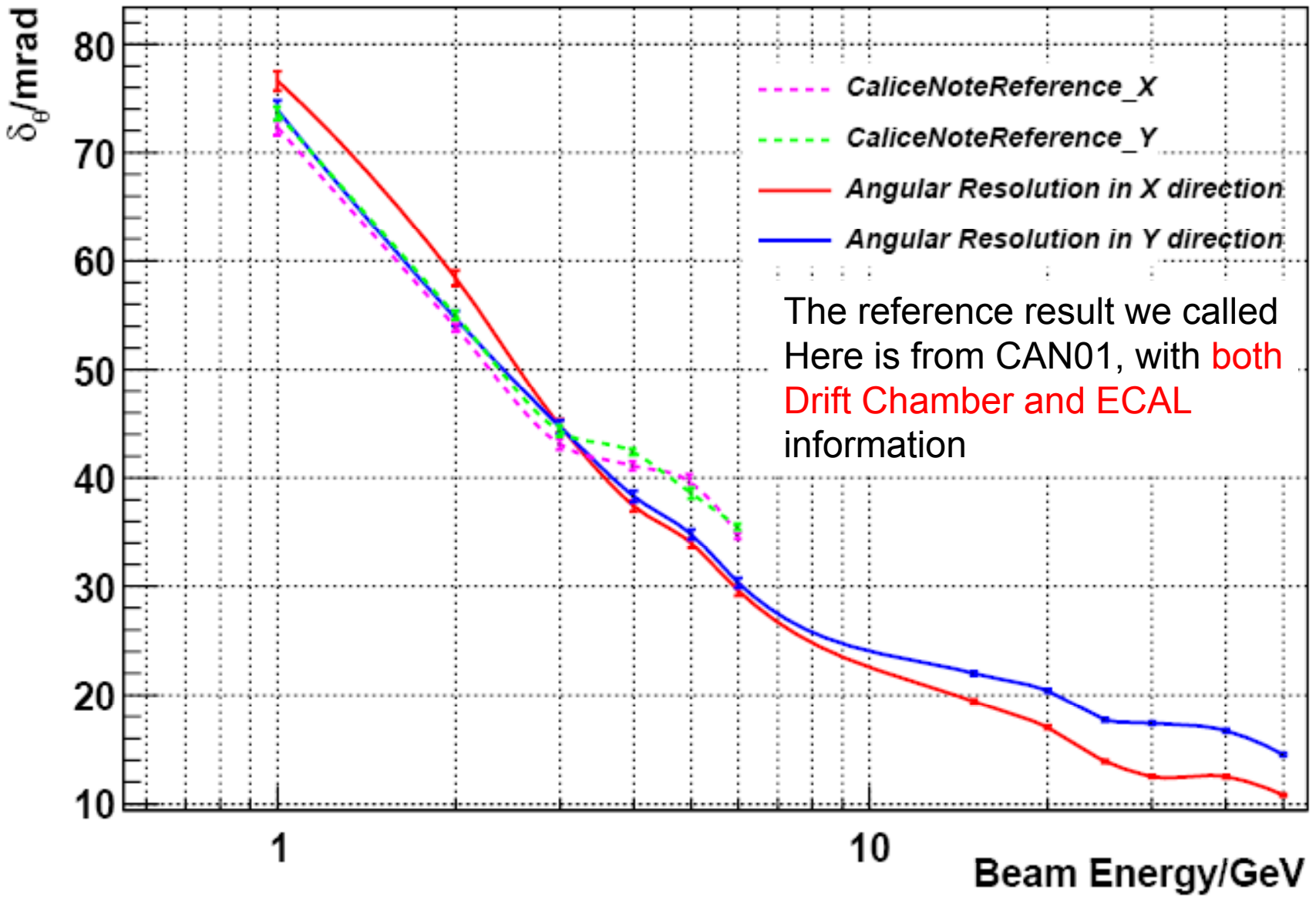
Angle Resolution for CERN Runs in Y direction



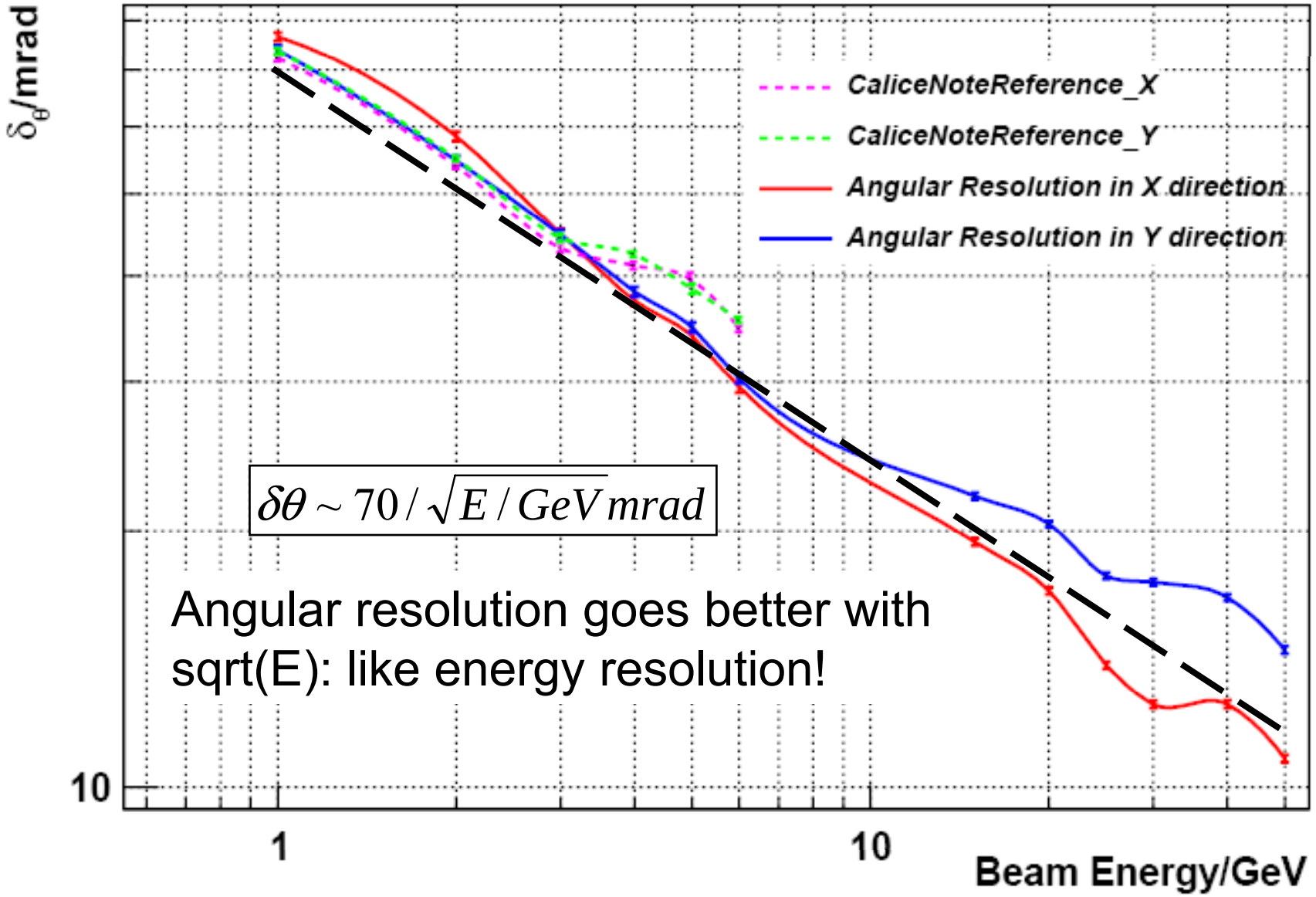
Angular resolution for normal inject beam:

RunNum	Beam energy	Inject angle	Cut on sumE /mips	$\delta\theta_x$ /mrad	$\delta\theta_y$ /mrad
230098	1GeV	0°	90-230	76.6 ± 0.9	73.9 ± 0.9
230099	2GeV		150-450	58.4 ± 0.7	54.7 ± 0.6
230097	3GeV		300-600	44.8 ± 0.6	44.7 ± 0.5
230100	4GeV		400-800	37.4 ± 0.5	38.3 ± 0.5
230104	5GeV		500-1.0k	34.0 ± 0.5	34.8 ± 0.5
230101	6GeV		600-1.2k	29.6 ± 0.5	30.3 ± 0.4
330433	15GeV	0°	1.5k-2.5k	19.4 ± 0.2	22.0 ± 0.2
330423	20GeV		1.5k-3.5k	17.0 ± 0.2	20.4 ± 0.2
330431	25GeV		2.5k-4.5k	14.0 ± 0.1	17.7 ± 0.2
330456	30GeV		3.0k-4.5k	12.5 ± 0.1	17.4 ± 0.1
330224	40GeV		3.0k-6.0k	12.6 ± 0.1	16.7 ± 0.1
330228	50GeV		5.0k-8.0k	10.8 ± 0.1	14.5 ± 0.1

Angle Resolution for CALICE TB, Normal inject Beam



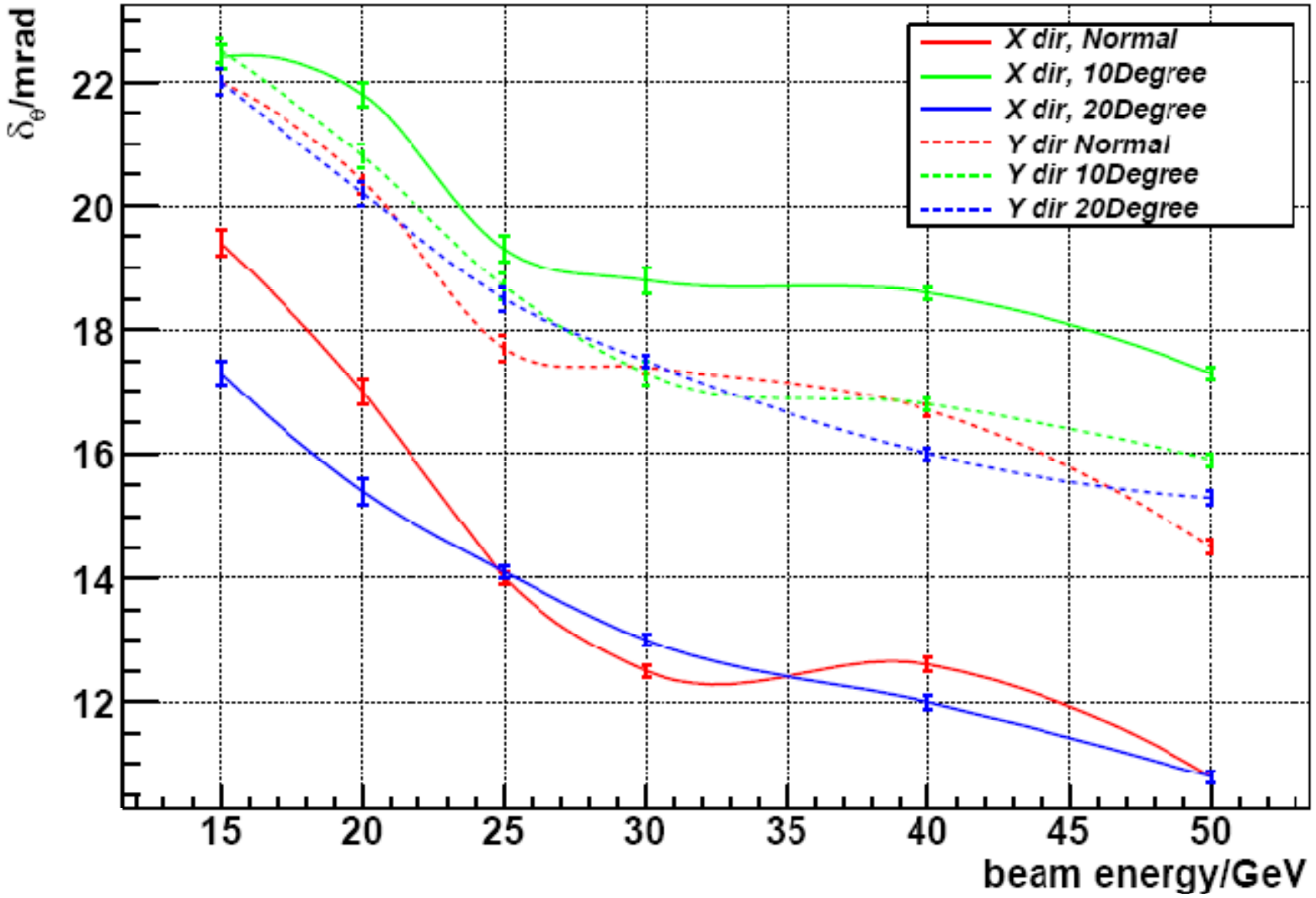
Angle Resolution for CALICE TB, Normal inject Beam



Angular resolution for beam inject with non-zero angle:

RunNum	Beam energy	Inject angle	Cut on sumE /mips	$\delta\theta_x$ /mrad	$\delta\theta_y$ /mrad
330996	15GeV	10°	1.5k-2.5k	22.4 ± 0.2	22.5 ± 0.2
330995	20GeV		1.5k-3.5k	21.8 ± 0.2	20.8 ± 0.2
330994	25GeV		2.5k-4.5k	19.3 ± 0.2	18.7 ± 0.2
330993	30GeV		3.0k-4.5k	18.8 ± 0.2	17.3 ± 0.2
330990	40GeV		3.0k-6.0k	18.6 ± 0.1	16.8 ± 0.1
330986	50GeV		5.0k-8.0k	17.3 ± 0.1	15.9 ± 0.1
331194	15GeV	20°	1.5k-2.5k	17.3 ± 0.2	22.0 ± 0.2
331198	20GeV		1.5k-3.5k	15.4 ± 0.1	20.2 ± 0.2
331202	25GeV		2.5k-4.5k	14.1 ± 0.1	18.5 ± 0.2
331204	30GeV		3.0k-4.5k	13.0 ± 0.1	17.5 ± 0.1
331207	40GeV		3.0k-6.0k	12.0 ± 0.1	16.0 ± 0.1
331209	50GeV		5.0k-8.0k	10.8 ± 0.1	15.3 ± 0.1

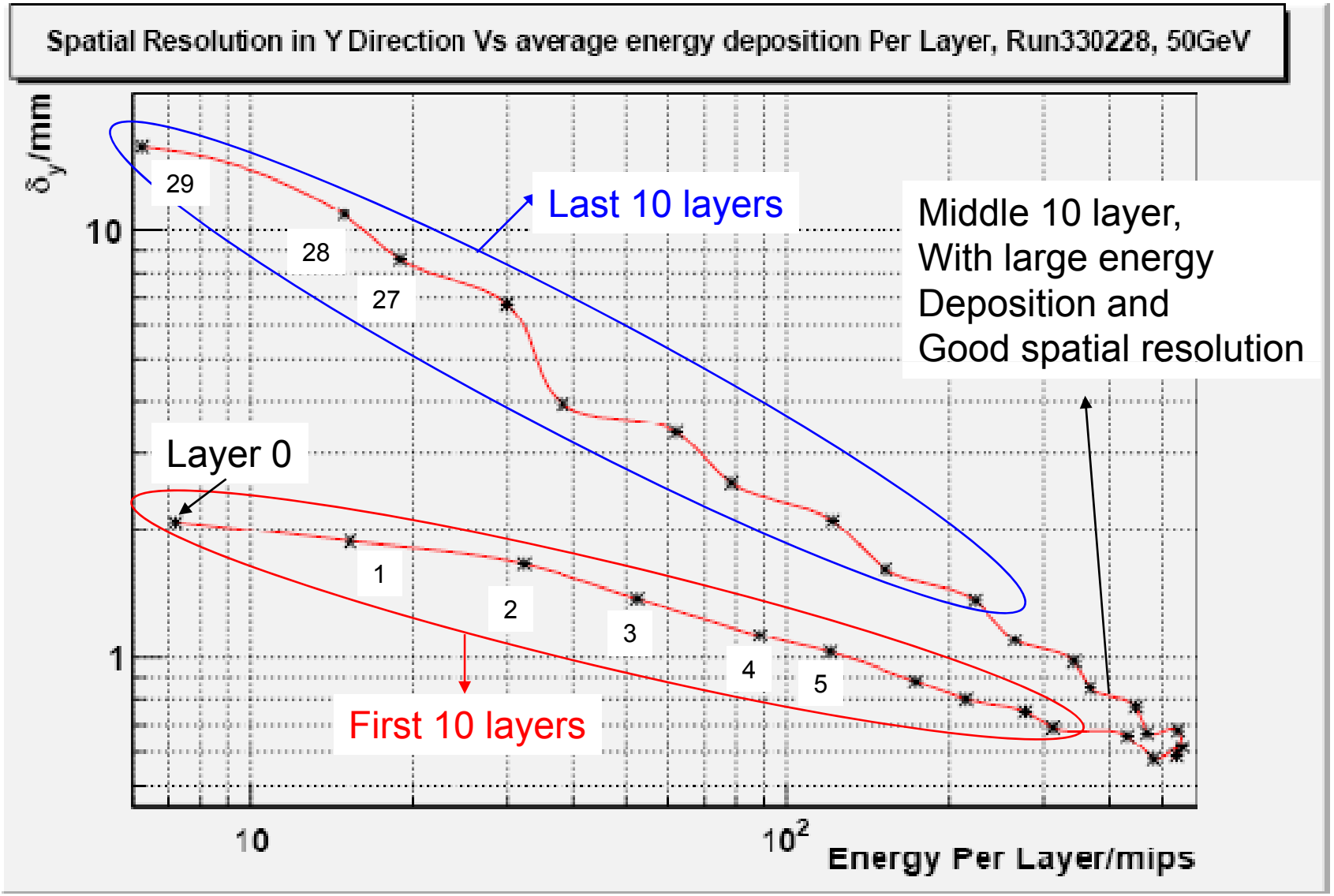
Angle Resolution for CERN Runs



Δθy is comparable for all 3 inject angle,

Δθx get much wider for 10^o inject beam → reason unknown

Correlation between spatial resolution and energy deposition



 Spatial resolution explodes after shower maximal

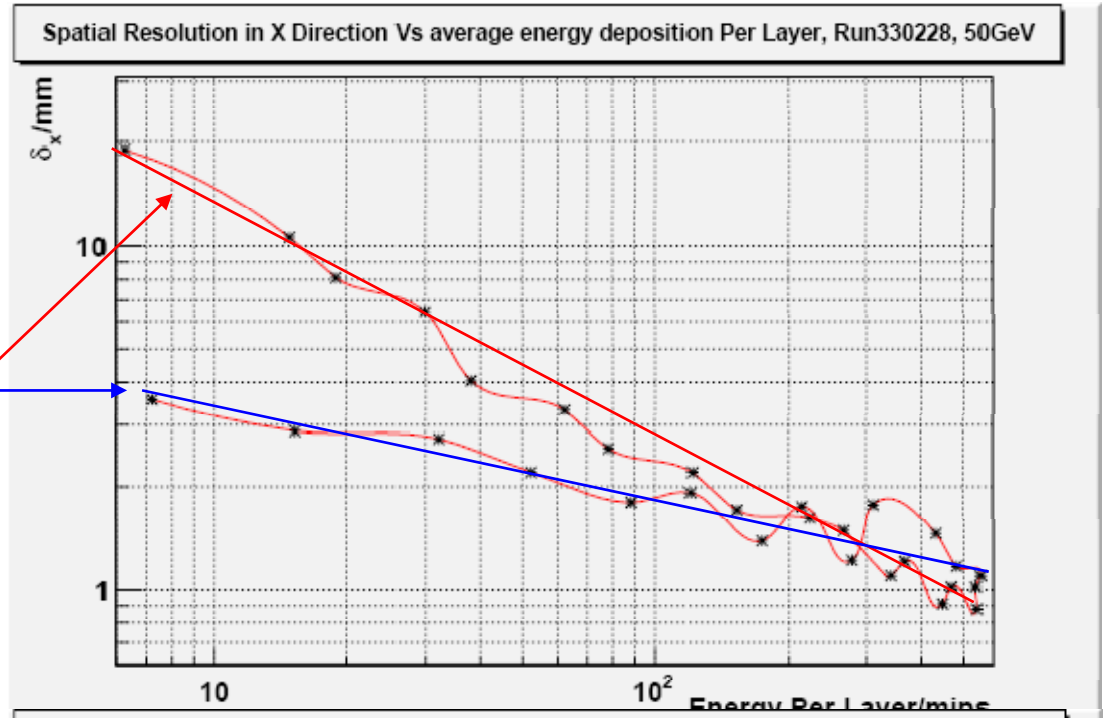
Power relation between Spatial resolution and energy deposition

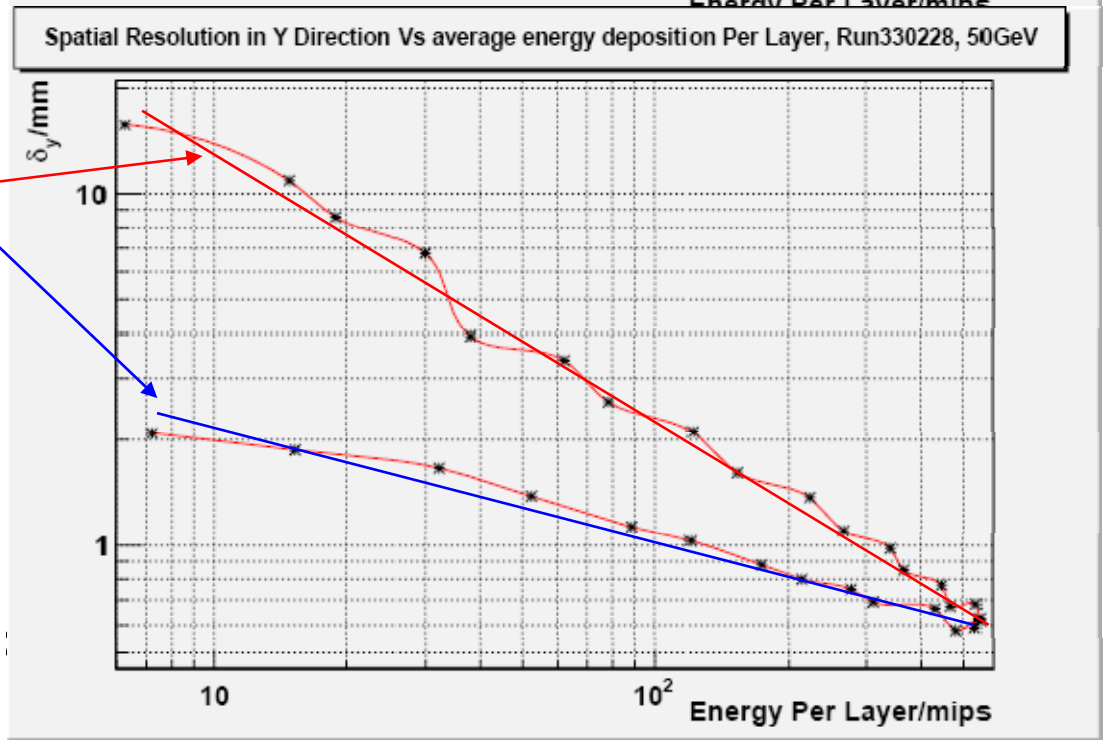
$$\delta x(1) \sim 6.5 \times E^{-0.3}$$

$$\delta x(2) \sim 70 \times E^{-0.7}$$

$$\delta y(1) \sim 4 \times E^{-0.3}$$

$$\delta y(2) \sim 70 \times E^{-0.7}$$



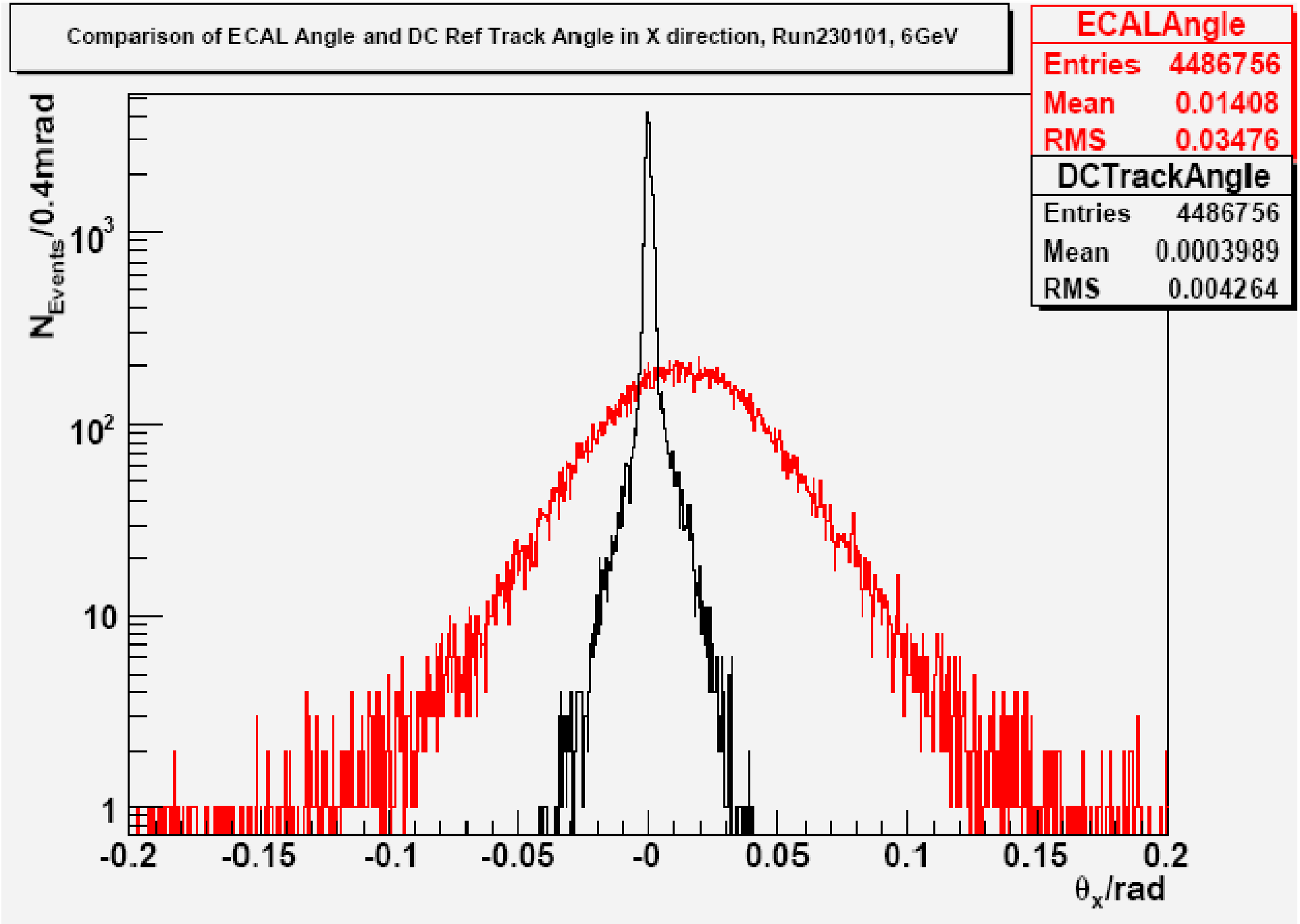


Summary

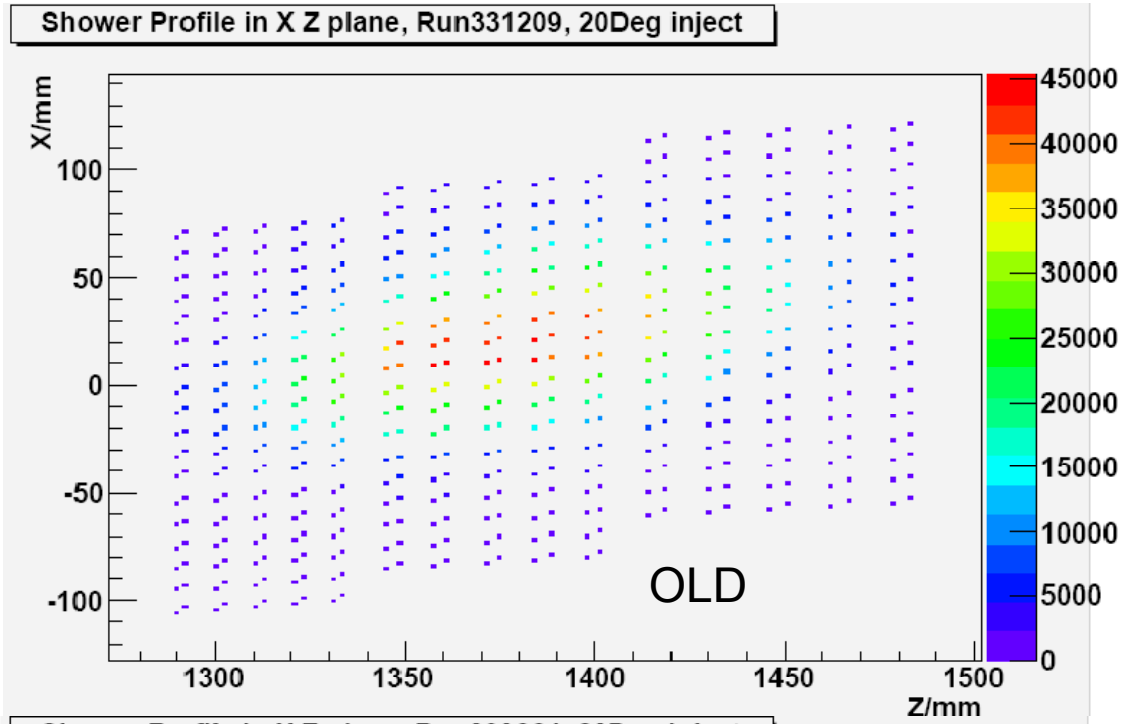
- An angular resolution method based on only ECAL information have been developed. The result is compared with result using both tracking chambers and ECAL

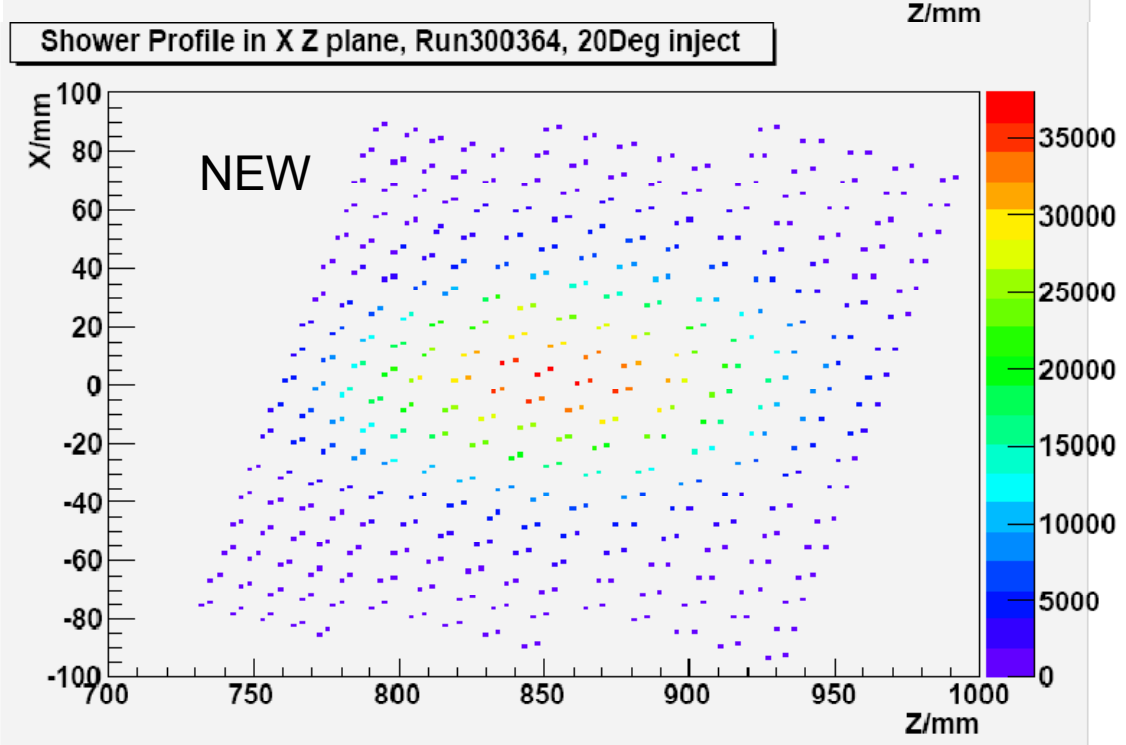
- Many things not yet understood: need to process to MC Simulation & Comparing with other angular resolution algorithm

BackUp


Comparison of ECAL Angle and DC Ref Track Angle in X direction, Run230101, 6GeV
ECALAngle
Entries 4486756
Mean 0.01408
RMS 0.03476
DCTrackAngle
Entries 4486756
Mean 0.0003989
RMS 0.004264
N_Events/0.4mrad
10^3
10^2
10
1
-0.2
-0.15
-0.1
-0.05
-0
0.05
0.1
0.15
0.2
θ_x/rad

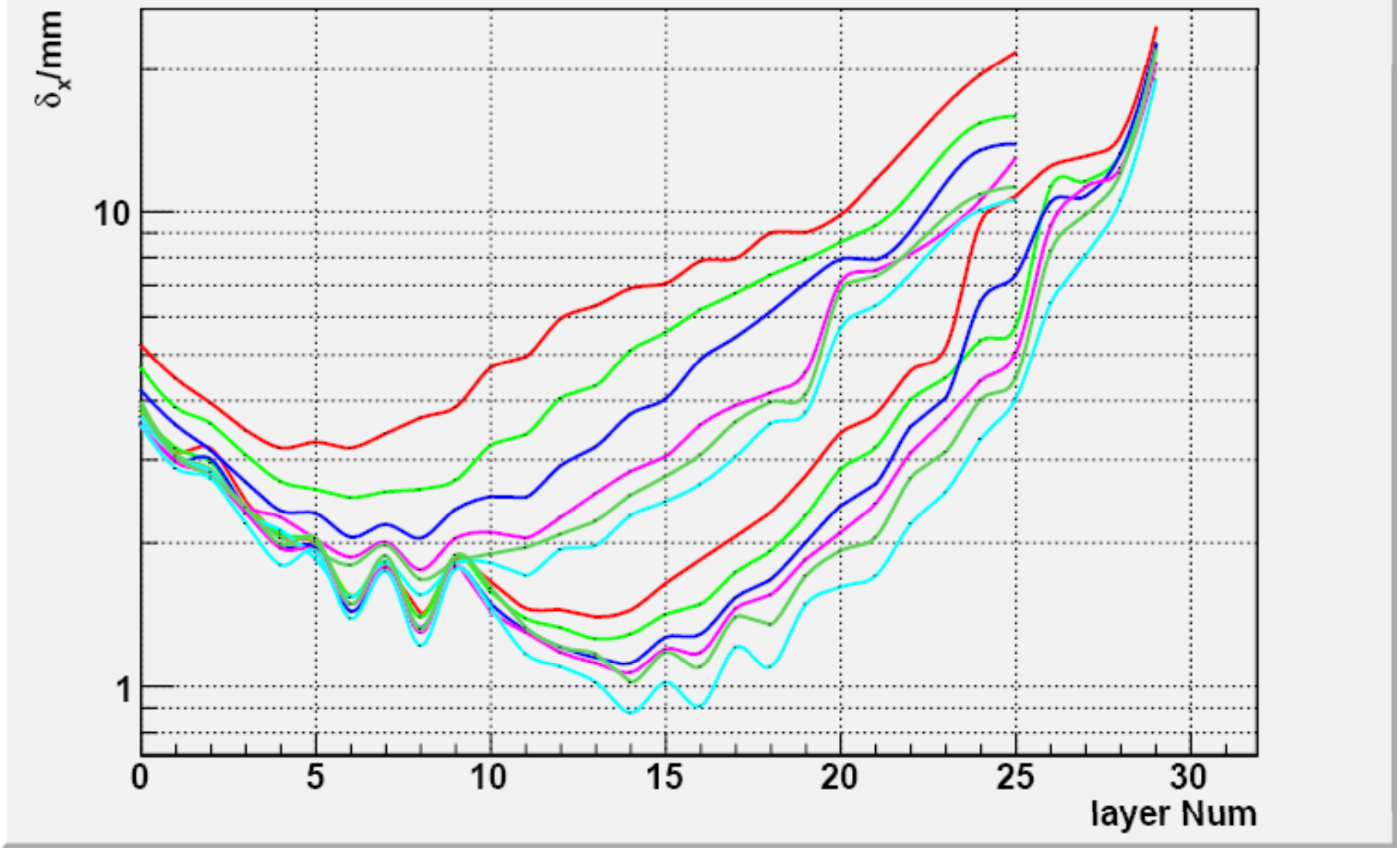
Comparison for old
And new coordinate system



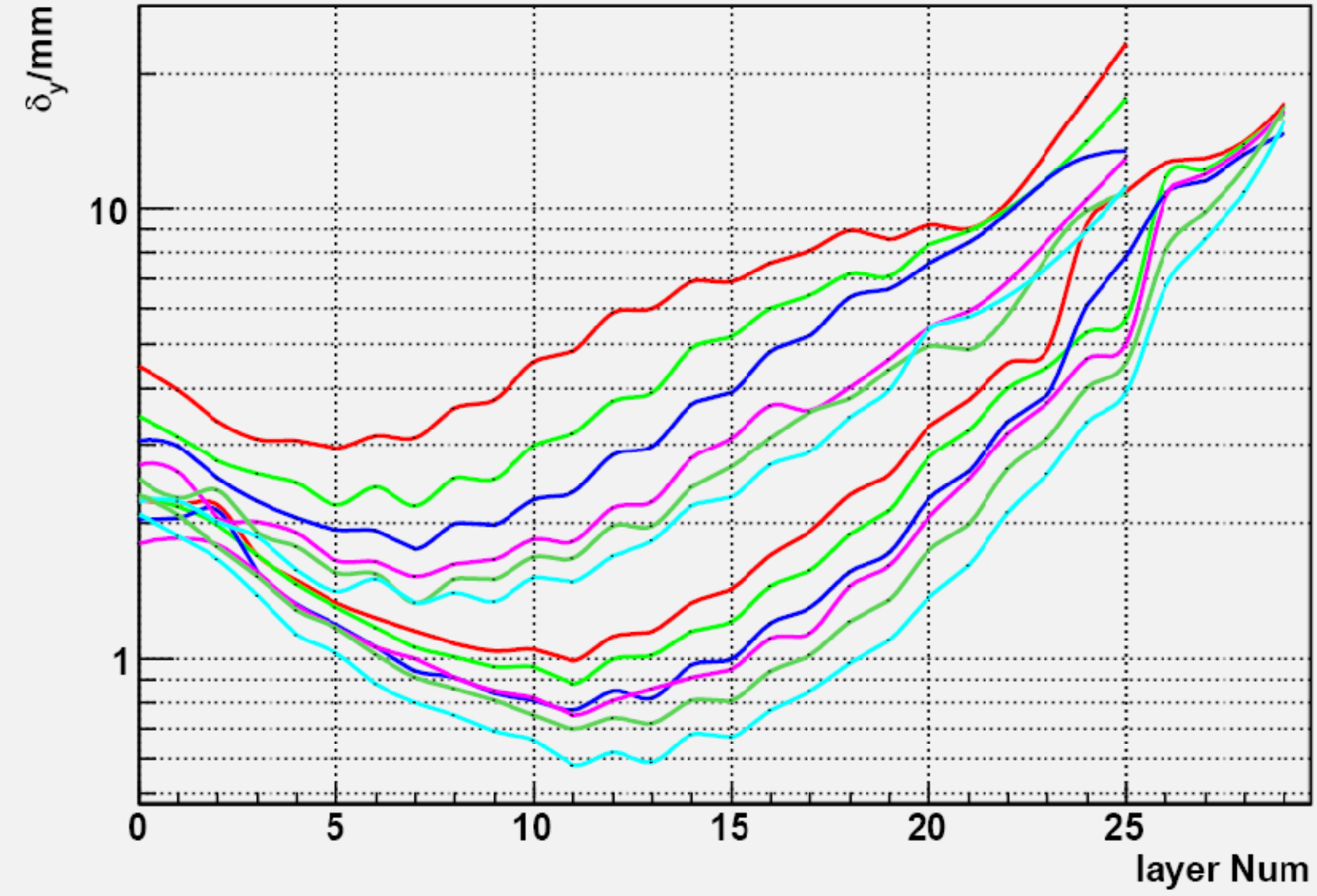


19/03/2008

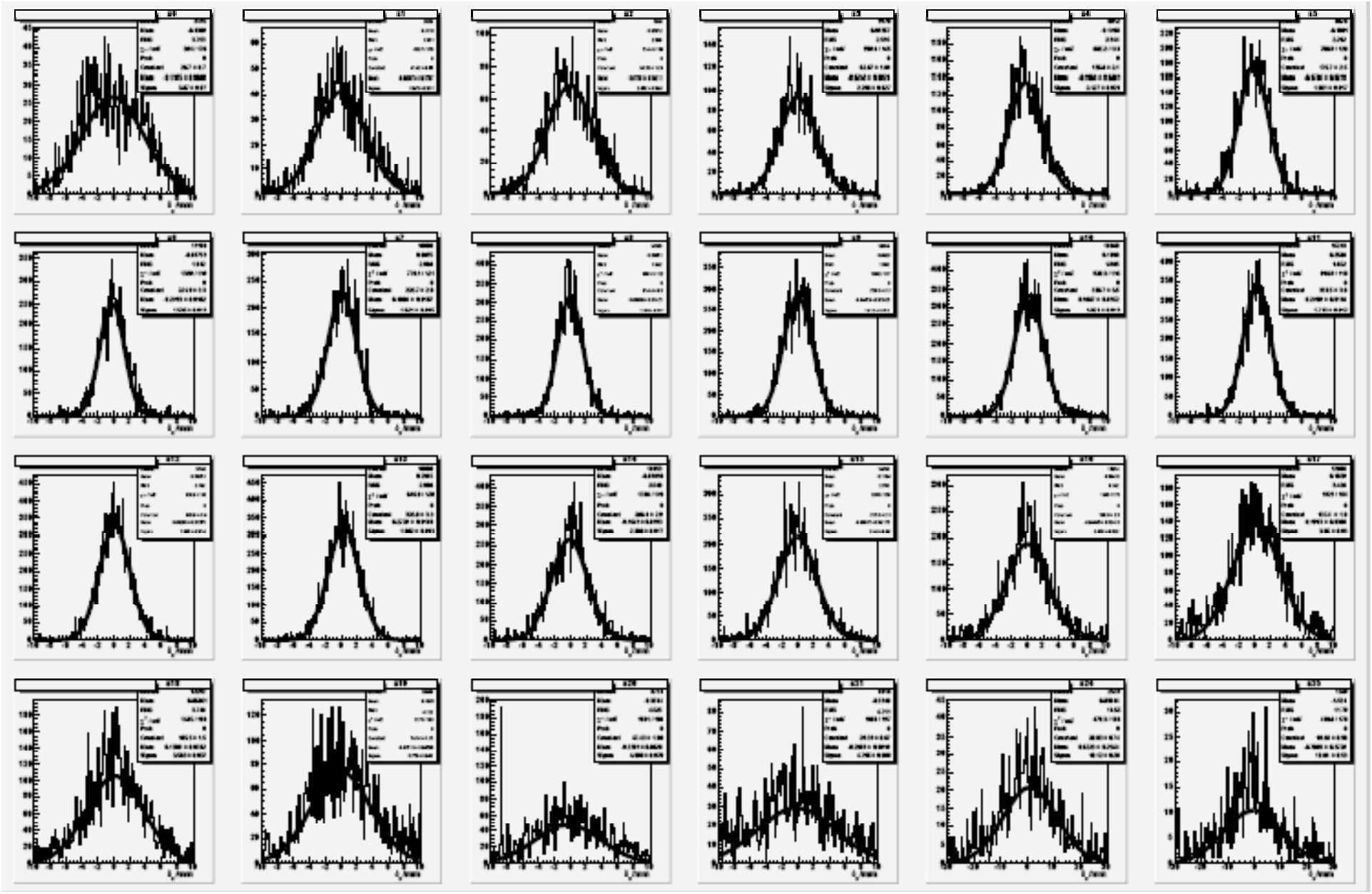
Spatial resolution in X direction for Normal inject Runs



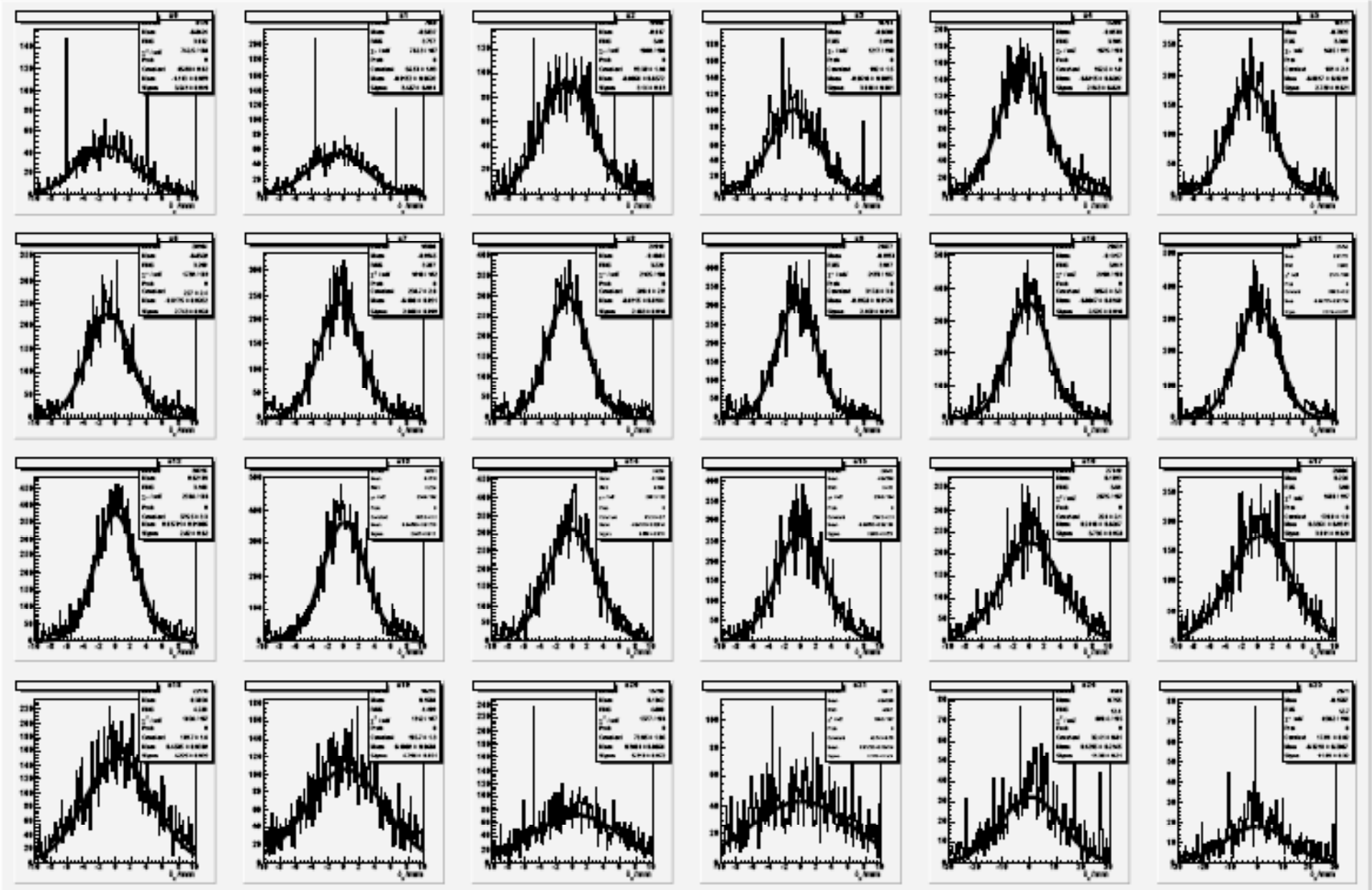
Spatial resolution in Y direction for Normal inject Runs



ECAL(EWC) – ECAL (Exp): in X direction, Run230101, 6GeV



ECAL(EWC) – DC (Exp): in X direction, Run230101, 6GeV



ECAL measured angular distribution for 50GeV CERN run: with 10^o or 20^o inject