Resolution & Linearity of the Si-W ECal for 2007

Report of an internship

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CALICE Analysis meeting at DESY HH, 30th March 2009

Content

- Test beam 2007 at CERN
- E_{rec} calculation
- Cuts
- Out taken run
- Linearity 2007
- Resolution 2007
- Summery

1. Beam test 2007 at CERN

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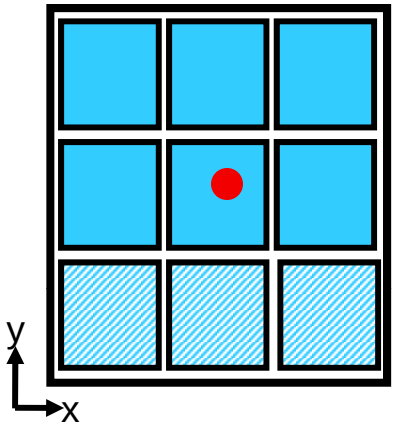
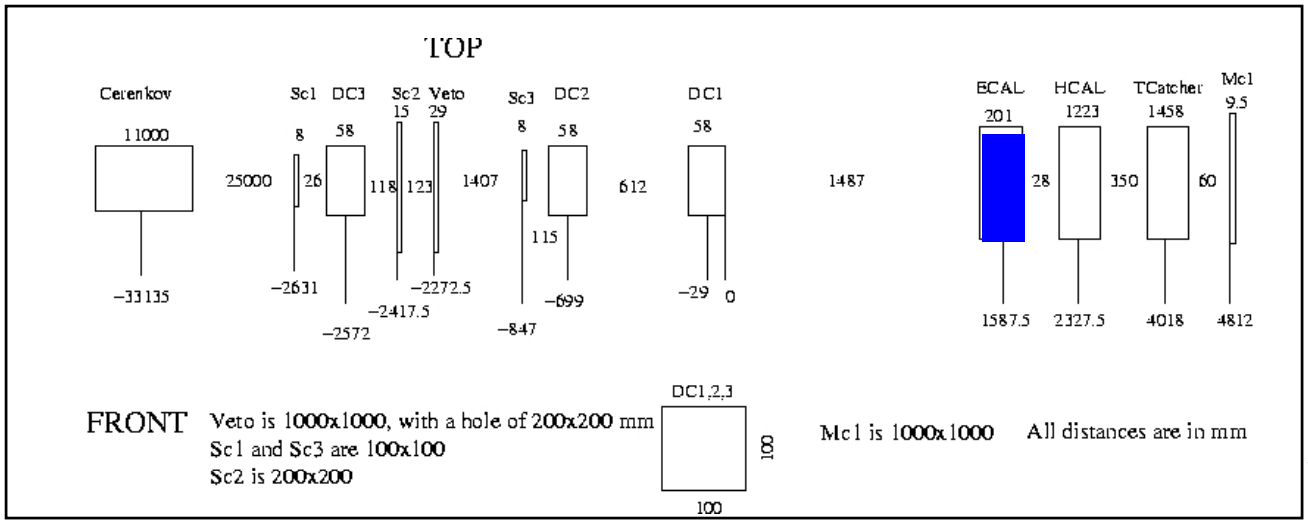
Jun until August 2007, at H6 beam line at CERN

Taken data:

- **just e- runs**
- **centered beam**
- **just 6 wafer per layer**





H6 beam line At CERN in 2007

2. E_{rec} Calculation

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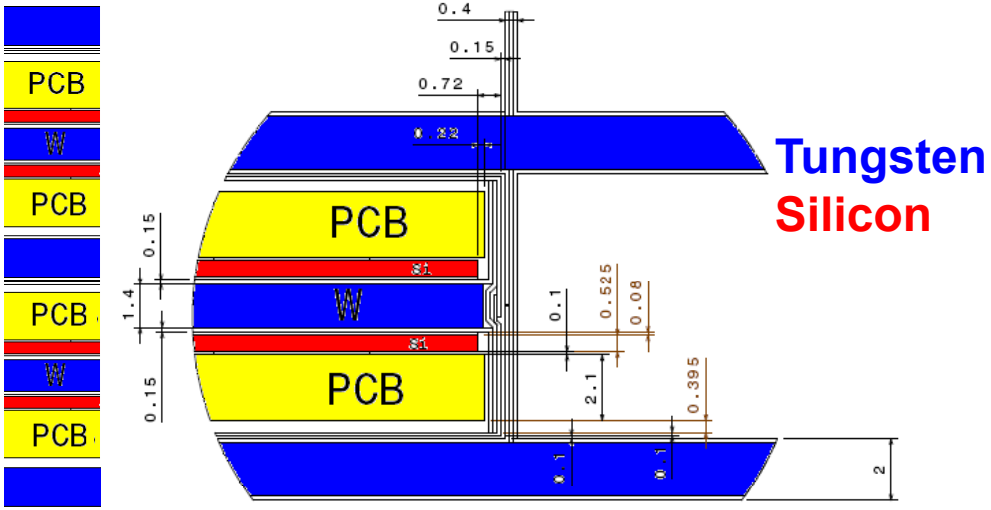
Reconstructed energy:

$$E_{rec} = 1\sum_{i=0}^{9}(1+\eta)E_i + 2\sum_{i=10}^{19}(1+\eta)E_i + 3\sum_{i=20}^{29}(1+\eta)E_i$$

Width of the tungsten thickness



Tungsten
Silicon

$$\eta = \begin{cases} 0.0 & \textit{for odd layers} \\ 0.072 & \textit{for even layers} \end{cases}$$

Difference between odd and even layers

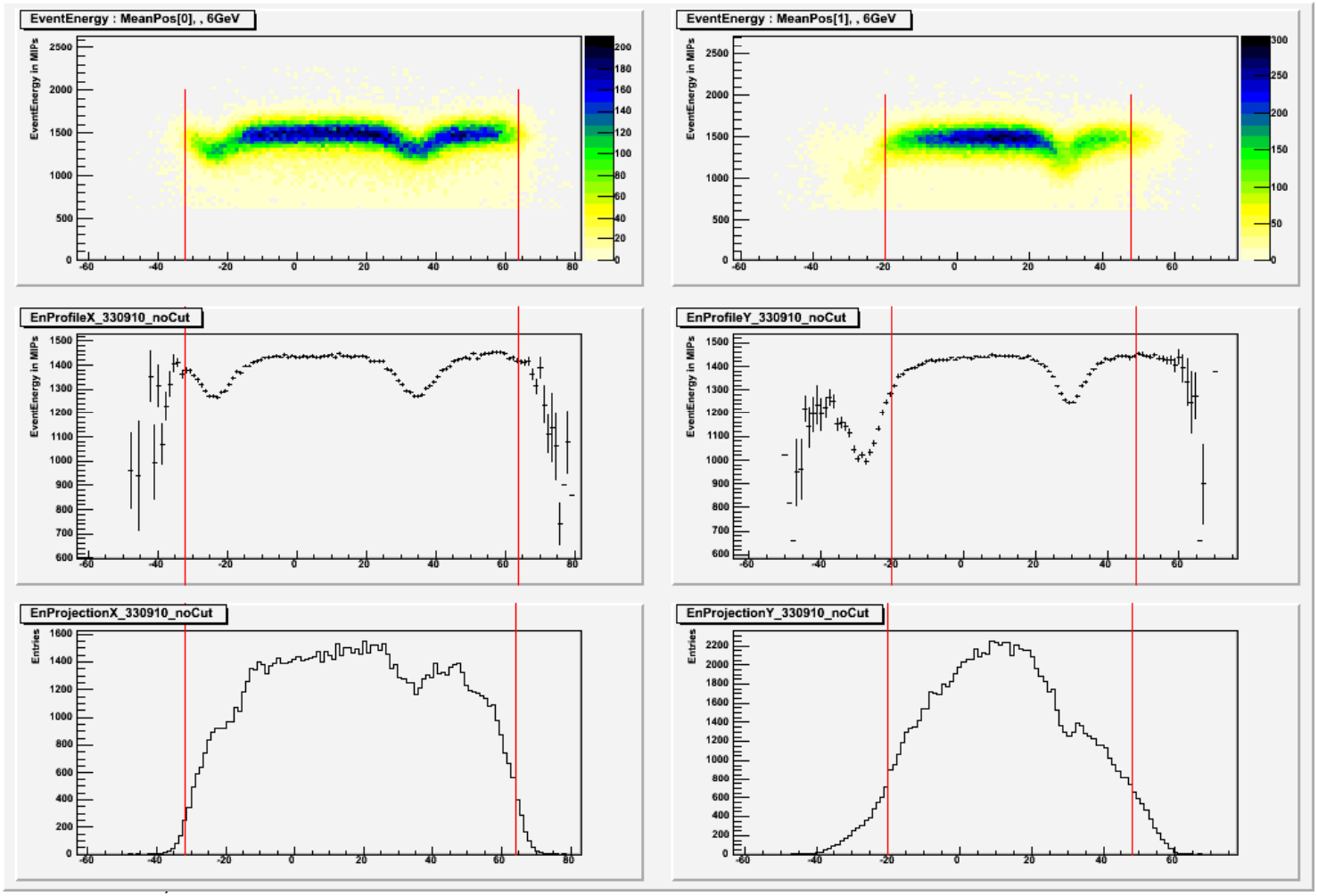
figures by M.F.Giannelli, TIPP09

3. Cuts

3. Cuts

X coordinate

Y coordinate



Rec. Energy : Mean Position

$$(\bar{x};\bar{y}) = \frac{\sum_i (x_i E_i ; y_i E_i)}{\sum_i E_i}$$

Energy profile

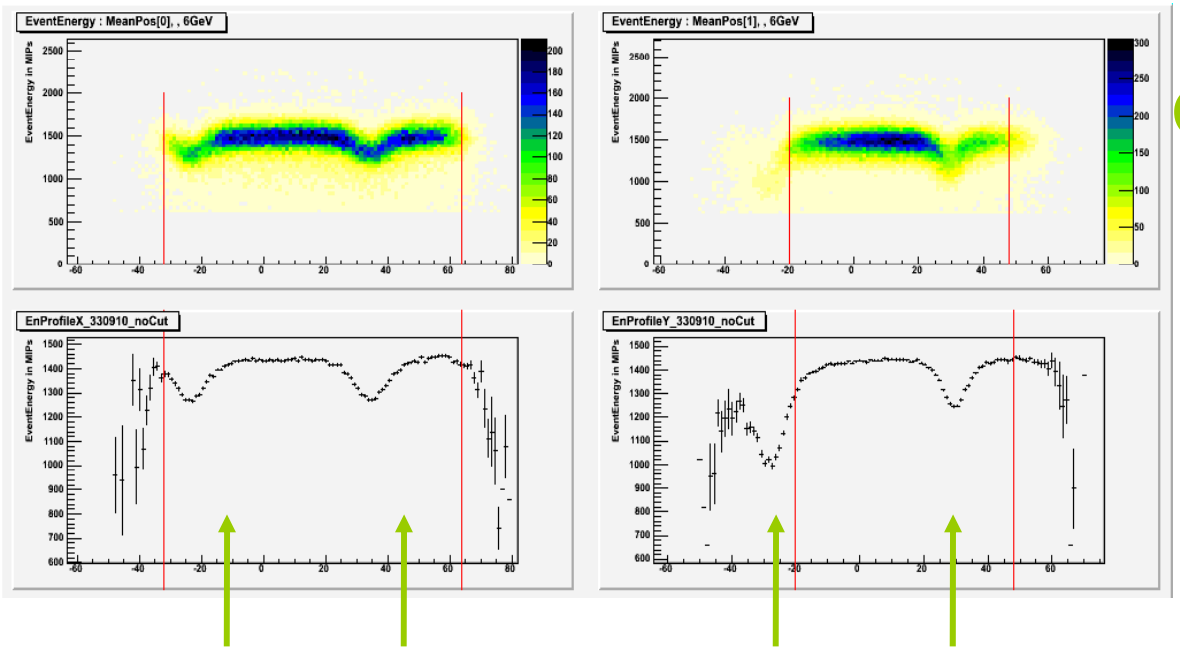
Beam profile

RNr 330910, @ 6GeV

Just to remind you:

X coordinate

Y coordinate

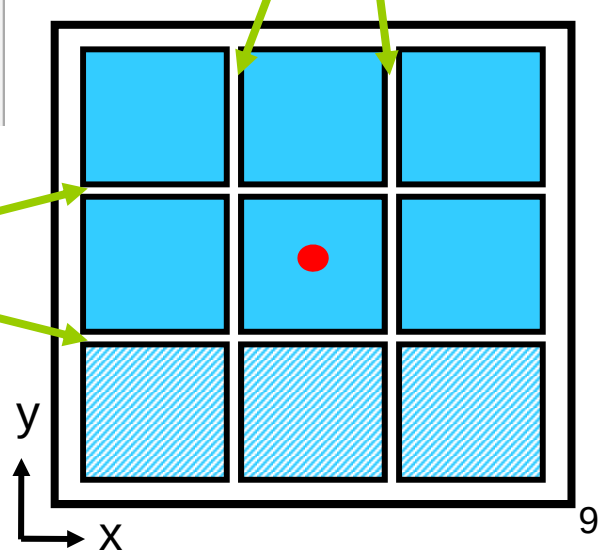


Gaps in X direction

right & left

Gaps in Y direction

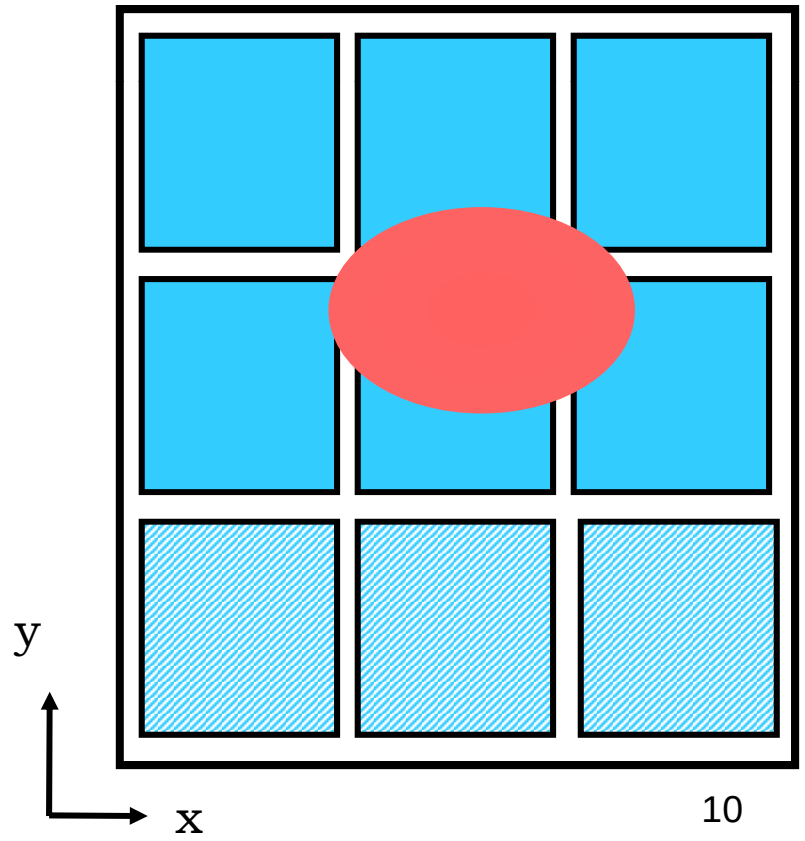
upper & lower



Cuts:

- **Energy:**

$$100 < \frac{E_{rec}[MiP]}{E_{beam}[GeV]} < 375$$

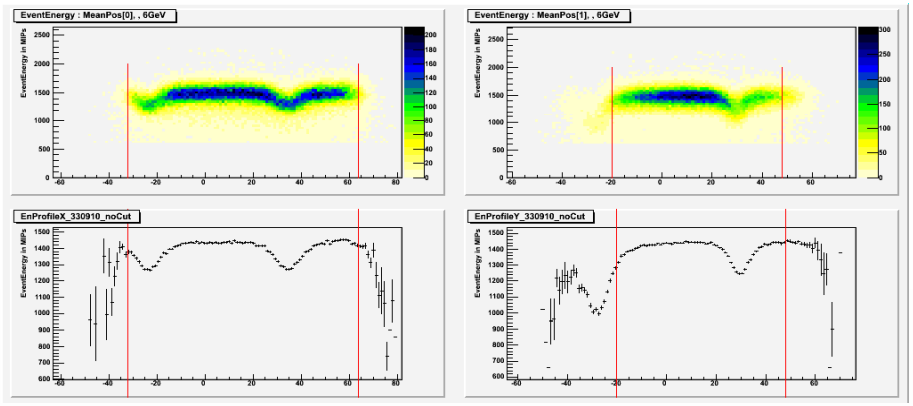


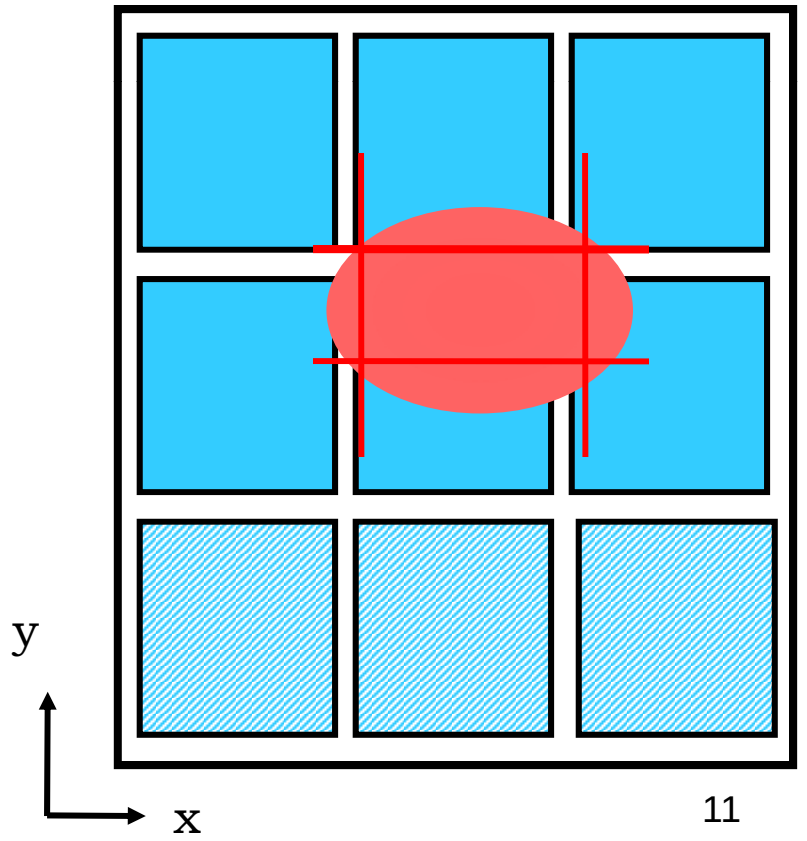
Cuts:

- **Energy:**

$$100 < \frac{E_{rec}[MiP]}{E_{beam}[GeV]} < 375$$

- **Beam halo**
  area of the well defined beam

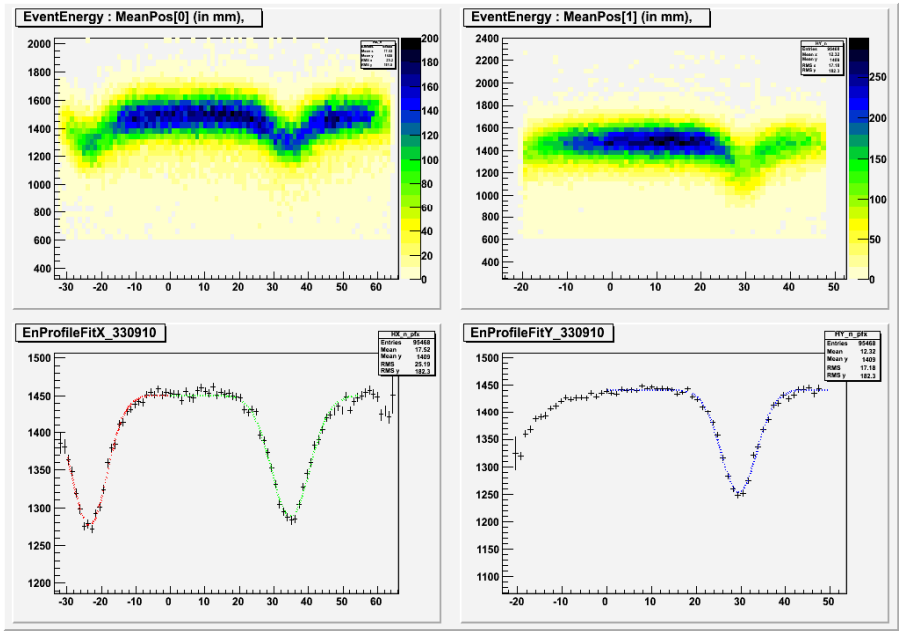




statistic of the gaps:

Gaussian Fit of the inter-wafer gaps

	Right X-gap	Upper Y-gap
μ	**35.5mm**	**30.2mm**
σ	**5.1mm**	**4.4mm**
Deposit E	**12.3%**	**13.3%**



errors: $\delta\mu < 0.03\%$

$\delta\sigma < 0.3\%$

$\delta E_{dep} < 2\%$

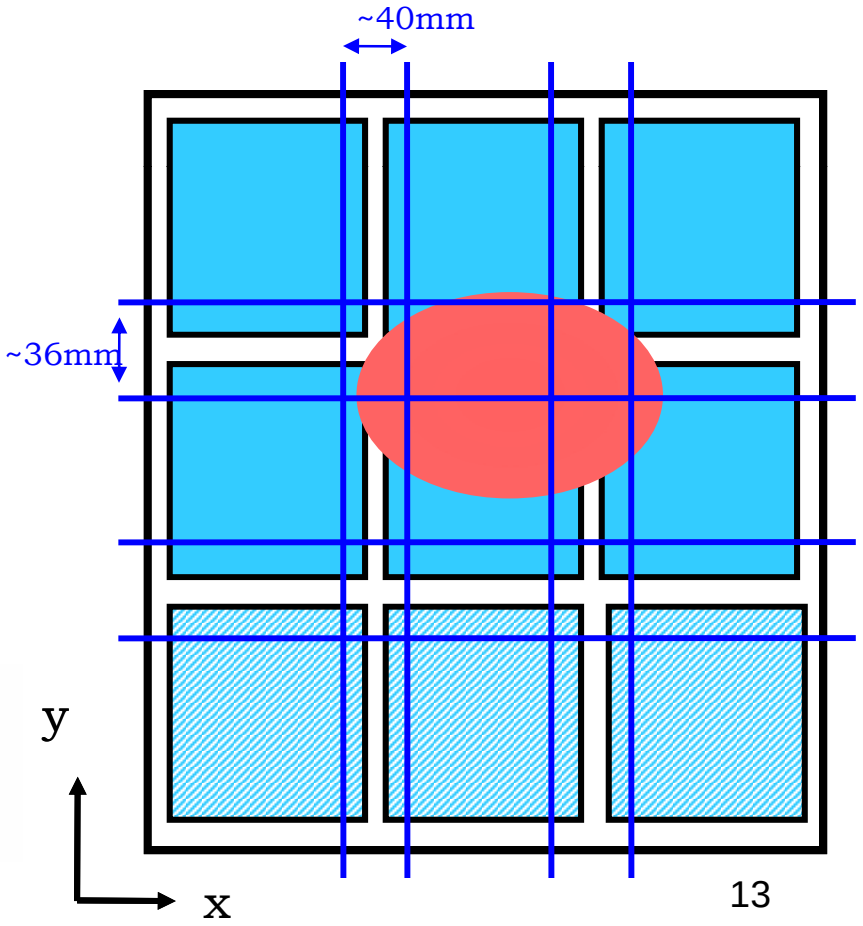
Cuts:

- **Energy:**

$$100 < \frac{E_{rec}[MiP]}{E_{beam}[GeV]} < 375$$

- **Beam halo**
  area of the well defined beam

- **Gaps:**
  mean position of the event is 4*σ far a way from the gap
  while each gap is defined run by run



Cuts:

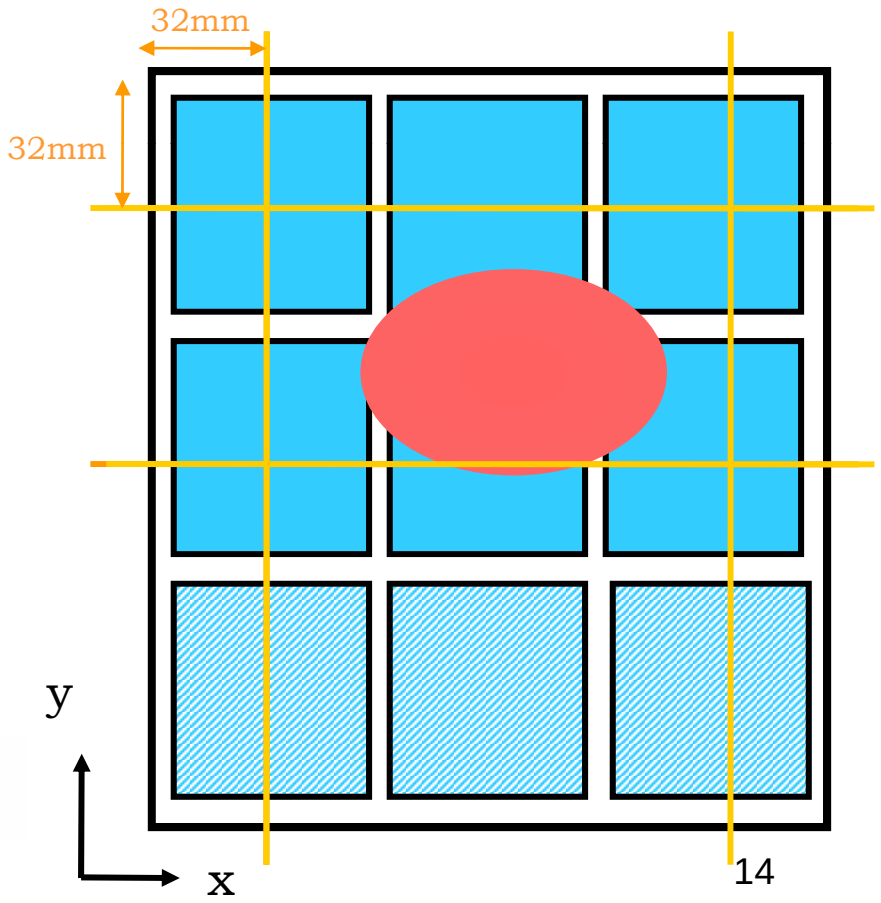
- **Energy tail:**

$$100 < \frac{E_{rec}[MiP]}{E_{beam}[GeV]} < 375$$

- **Beam halo**
  area of the well defined beam

- **Gaps:**
  mean position of the event is 4*σ far a way from the gap
  while each gap is defined run by run

- **Shower position:**
  mean position is more then 32mm far a way from the ECal borders



Cuts:

- **Energy tail:**

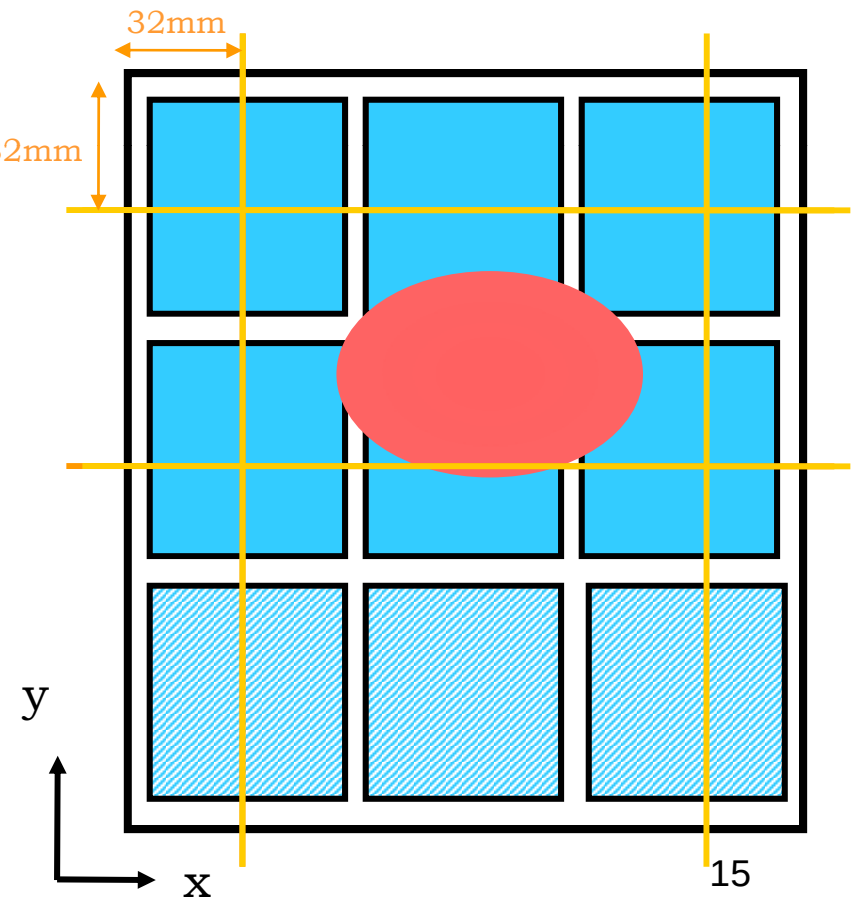
$$100 < \frac{E_{rec}[MiP]}{E_{beam}[GeV]} < 375$$

- **Beam halo**
  area of the well defined beam

- **Gaps:**
  mean position of the event is 4*σ far a way from the gap
  while each gap is defined run by run

- **Shower position:**
  mean position is more then 32mm far a way from the ECal borders

- **Also, if available:**
  Cherenkov Trigger gives just electrons



4. Out taken runs

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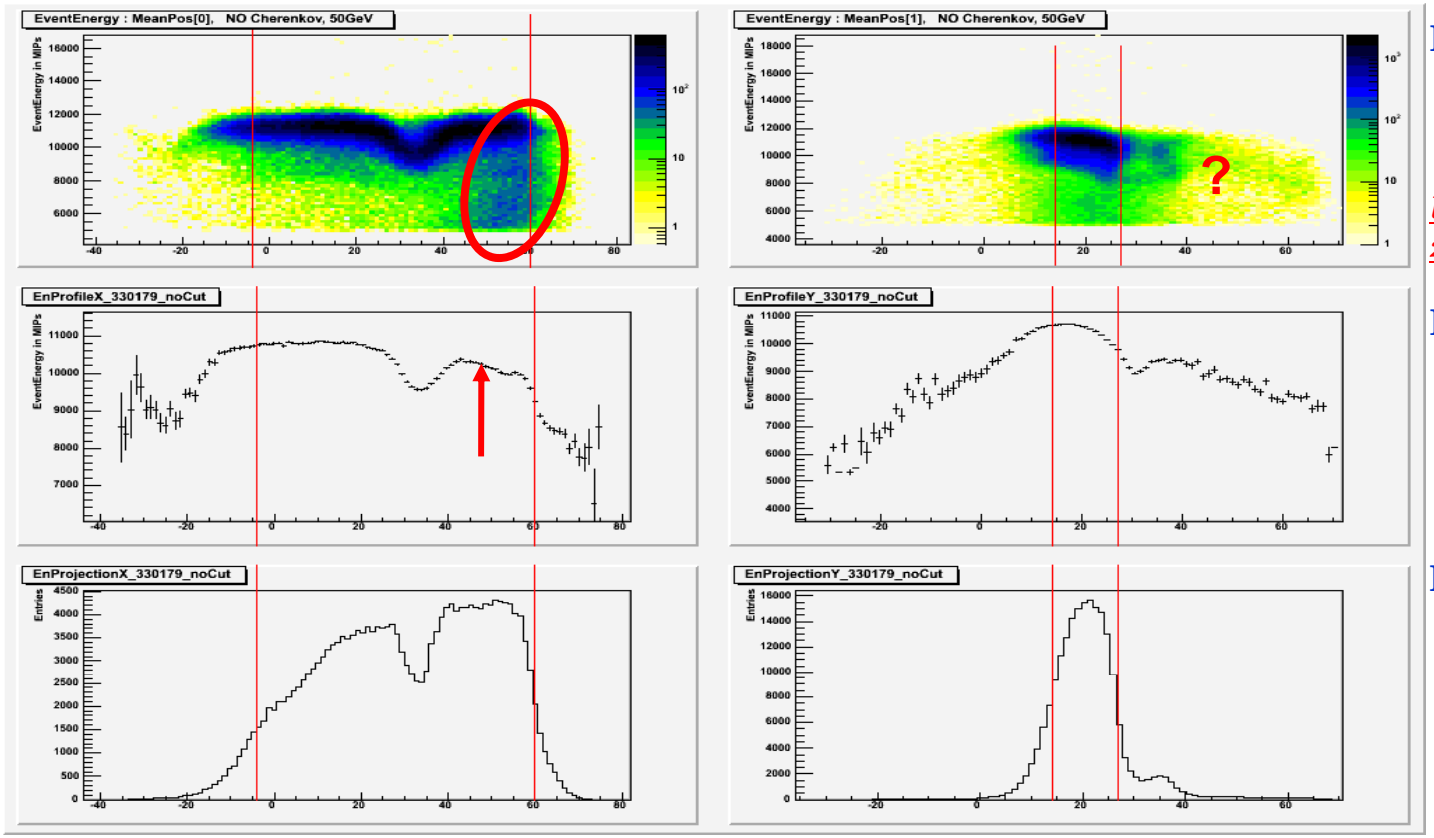
X coordinate

Y coordinate



Event Energy : Mean Position

logarithmic z-axis

Energy profile

Beam profile

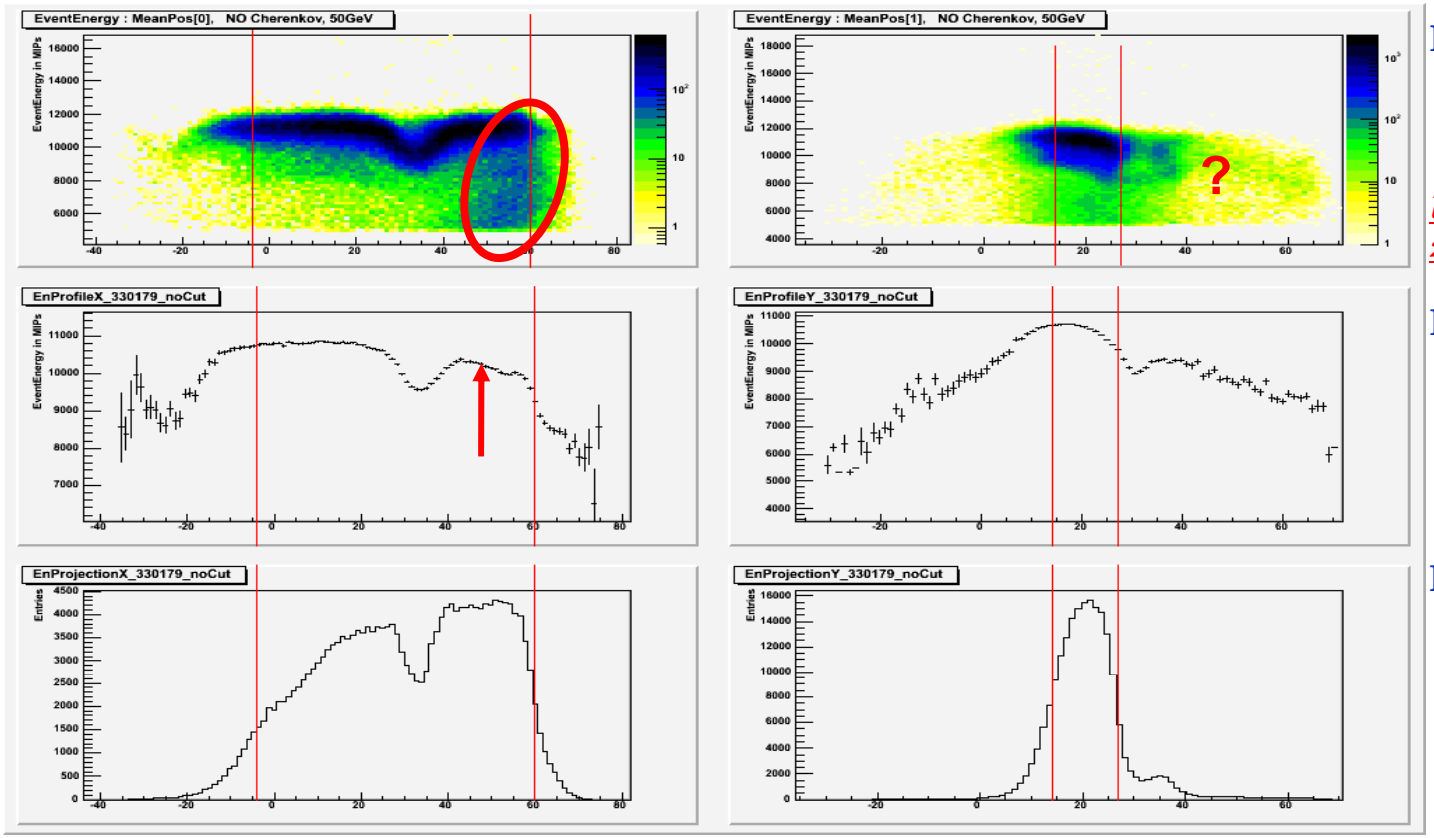
RNr 330179, @ 50GeV

For the following 5 runs similar

4. Out taken runs

X coordinate

Y coordinate



Event Energy : Mean Position

logarithmic z-axis

Energy profile

Beam profile

RNr 330179, @ 50GeV

For the following 5 runs similar

Took them out of the calculation

5. Linearity 2007

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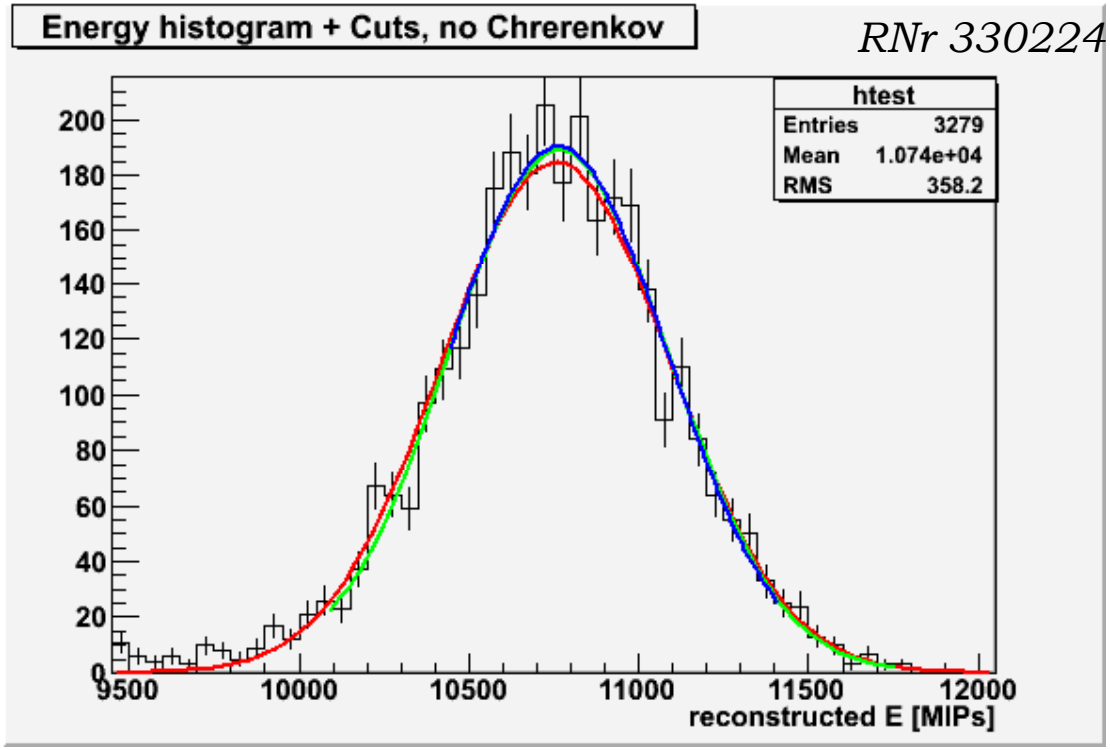
Fitted histograms of E_{rec} in 3 steps:

- **[minEnergy ; maxEnergy]** define run by run
  → get σ and μ
- **[μ-2σ ; μ+3σ]**
  → get σ and μ
- **[μ-σ ; μ+2σ]**



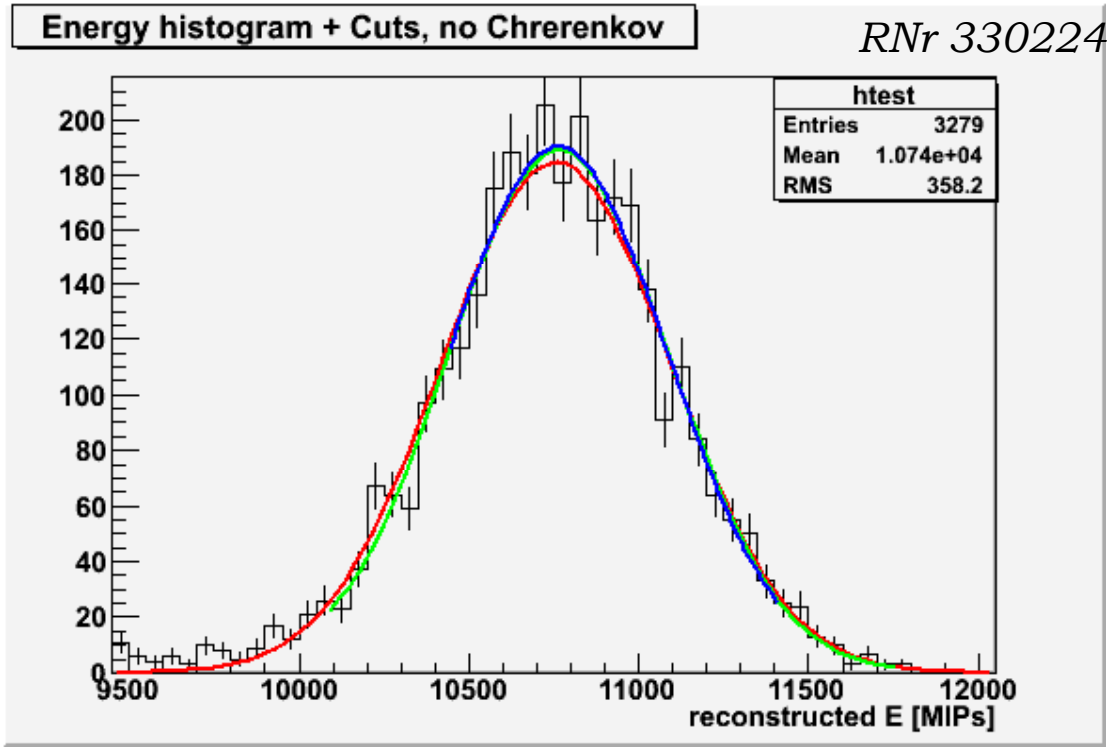
5. Linearity 2007

Fitted histograms of E_{rec} in 3 steps:

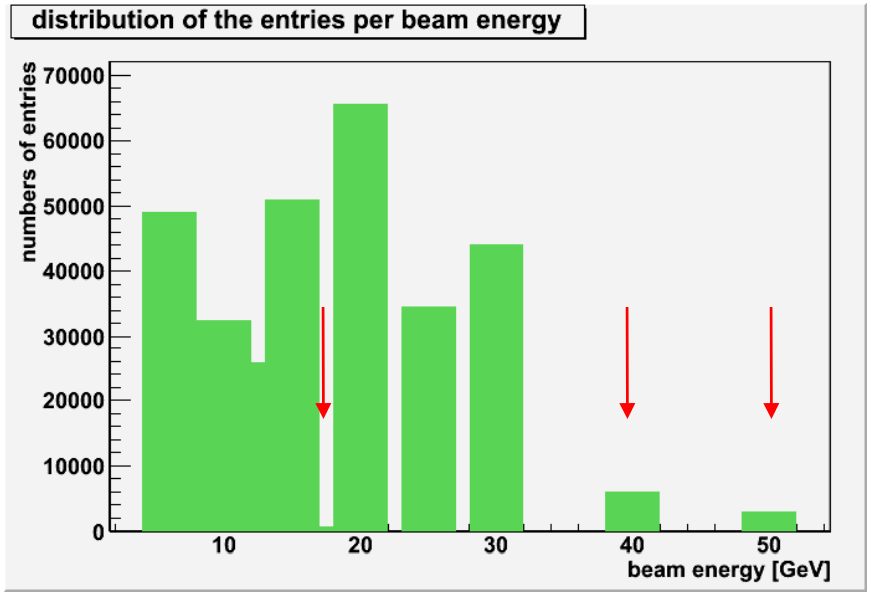
- **[minEnergy ; maxEnergy]** define run by run
  → get σ and μ
- **[μ-2σ ; μ+3σ]**
  → get σ and μ
- **[μ-σ ; μ+2σ]**

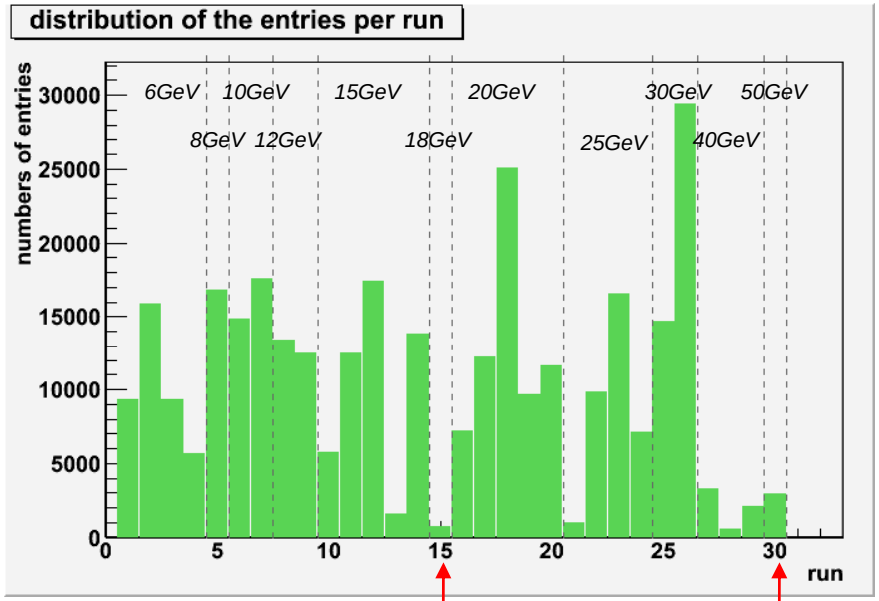
$$E_{meas}^{final} = \mu \pm \delta\mu$$

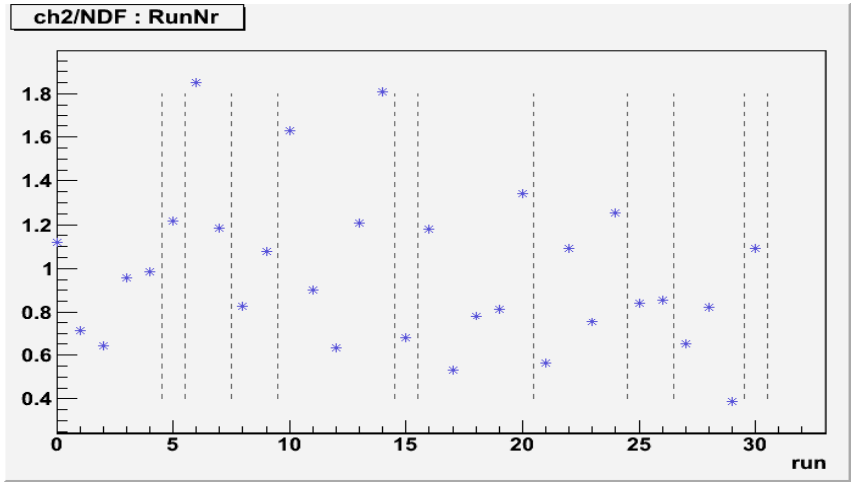
and: σ, δσ, χ^2, ndf



Statistics of the fits:







- Just one run for 18GeV and 50GeV with just a view entries
- Also less entries for 40GeV
- χ^2 is ok → fits are ok

Calculation of the errors:

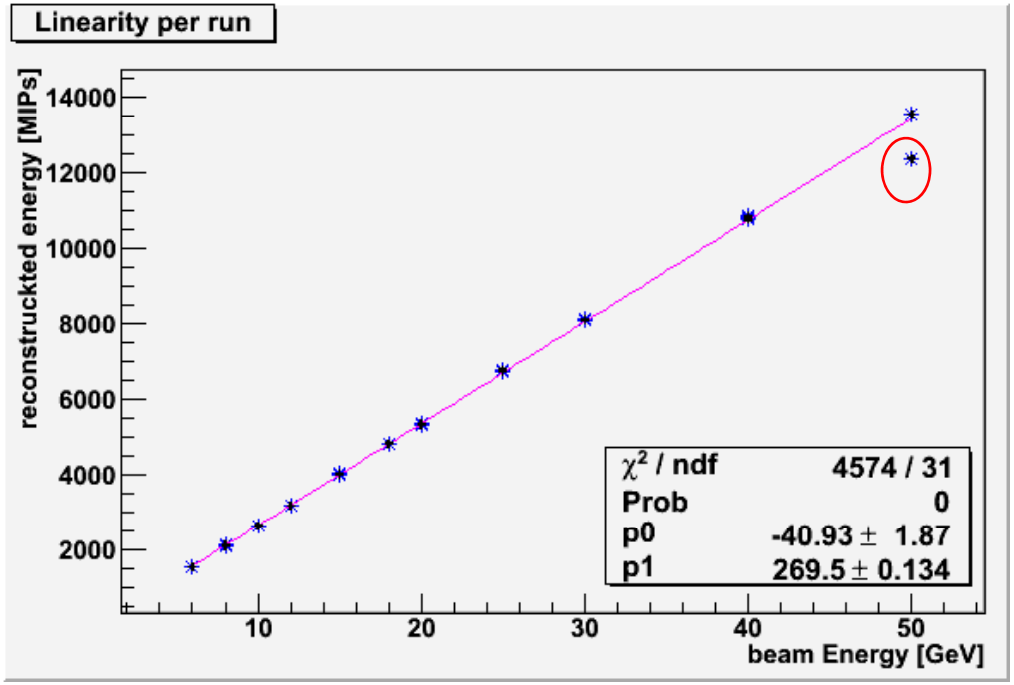
Uncertainty of the beam mean energy calculated by:

$$\frac{\sigma_B(E_{beam})}{E_{beam}} = \frac{0.25\%}{E_{beam}} \oplus 0.5\%$$

Given by CERN

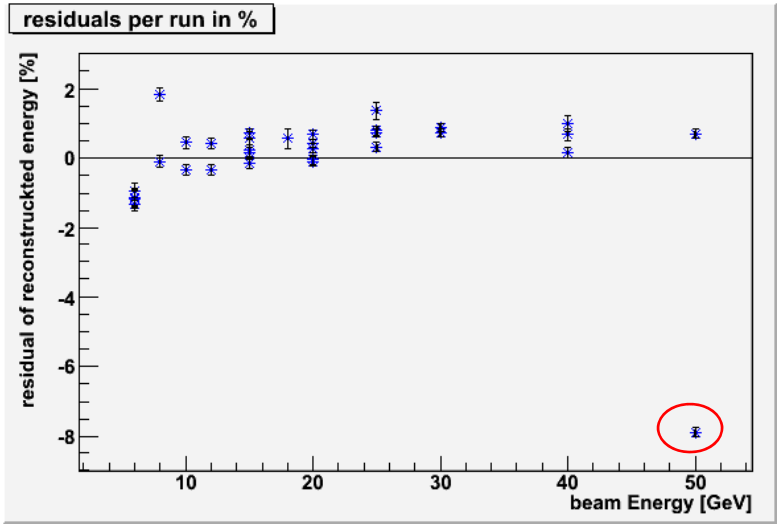
No energy momentum spread available for 2007!

First look at the linearity:



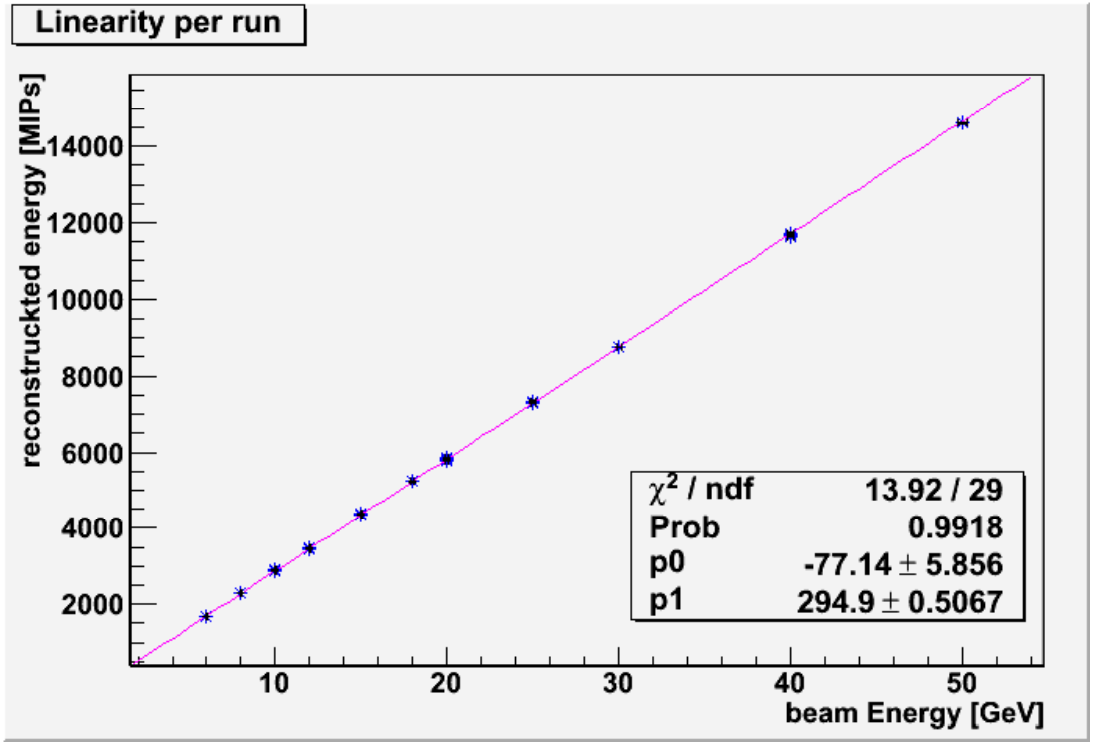
Strange run 330428 @ 50GeV

But everything seems fine



→ **TOOK IT OUT**

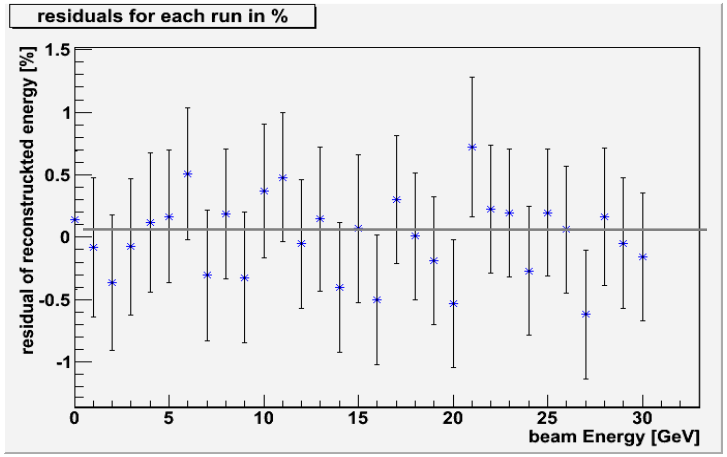
Linearity 2007



Linearity per run

$$f_{Fit}(E_{beam}) = p_0 + p_1 \cdot E_{beam}$$

With the "global MIP to GeV calibration factor"
p1 [MIP/GeV]



6. Resolution 2007

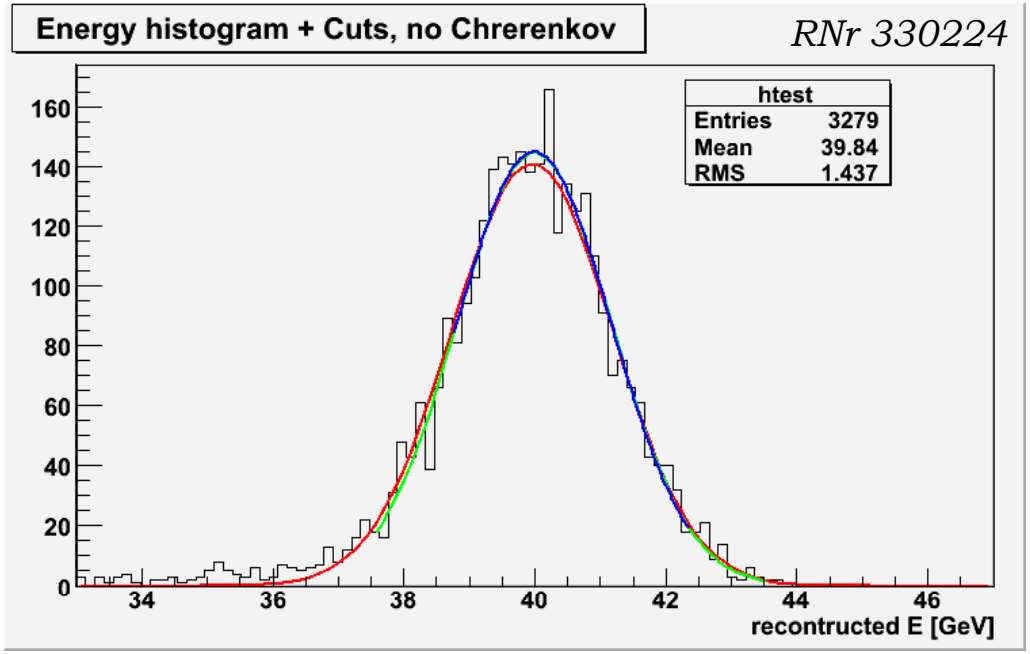
Conversion MIPs to GeV:

→ **conversion of the reconstructed energy**

$$E_{rec}[GeV] = \frac{E_{rec}[MIP] - p_0}{p_1}$$

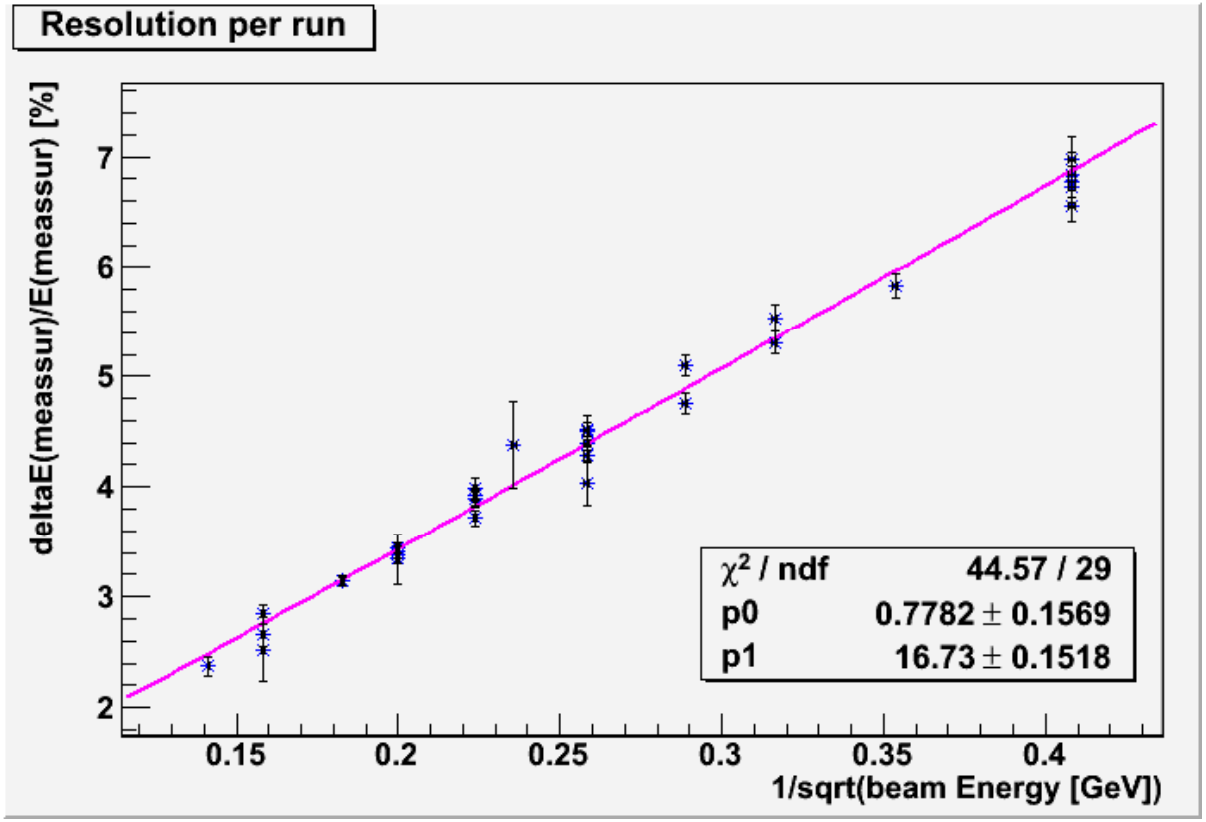
→ **drawing as histograms**
(cuts like before)

Took μ & σ



Resolution 2007

σ / μ

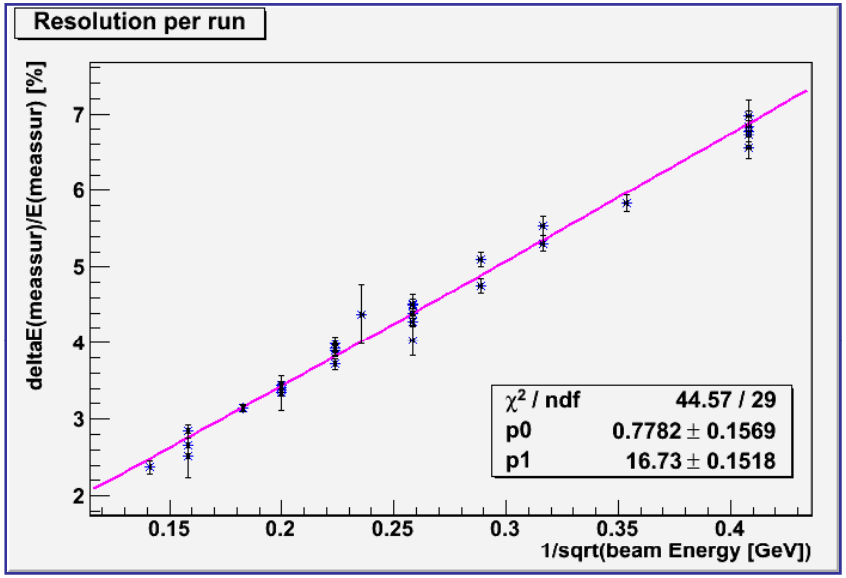


$$f_{Fit}(E_{beam}) = p_0 \oplus \frac{p_1}{\sqrt{E_{beam}}}$$

With the constant term p0 [%]

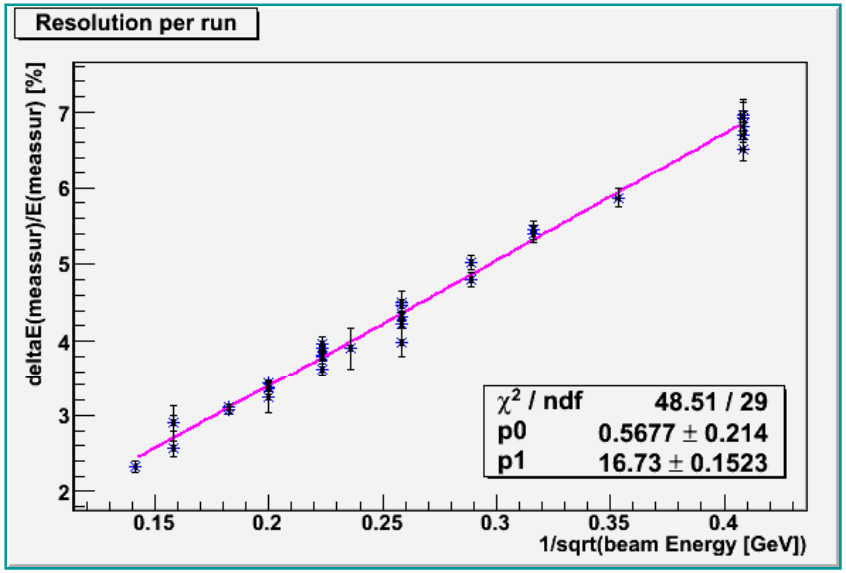
And the statistic term p1 [%/ GeV]

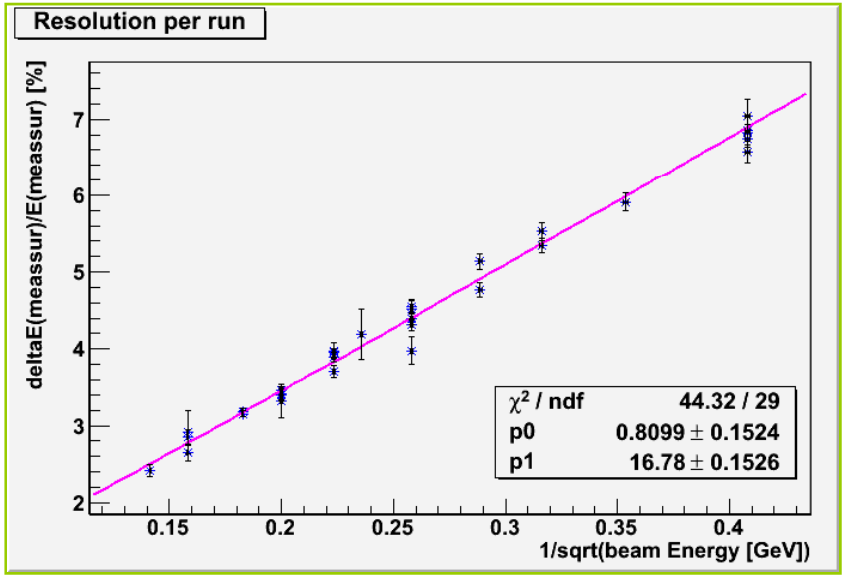
Comparison of the weights:



$$E_{rec} = 1\sum_{i=0}^{9}(1+\eta)E_i + 2\sum_{i=10}^{19}(1+\eta)E_i + 3\sum_{i=20}^{29}(1+\eta)E_i$$

Paper for 2006:	1.0, 2.0, 3.0
V. Bartsch:	1.0, 1.83, 2.7
CALICE analysis Note 001:	1.1, 2.0, 2.7





7. Summary

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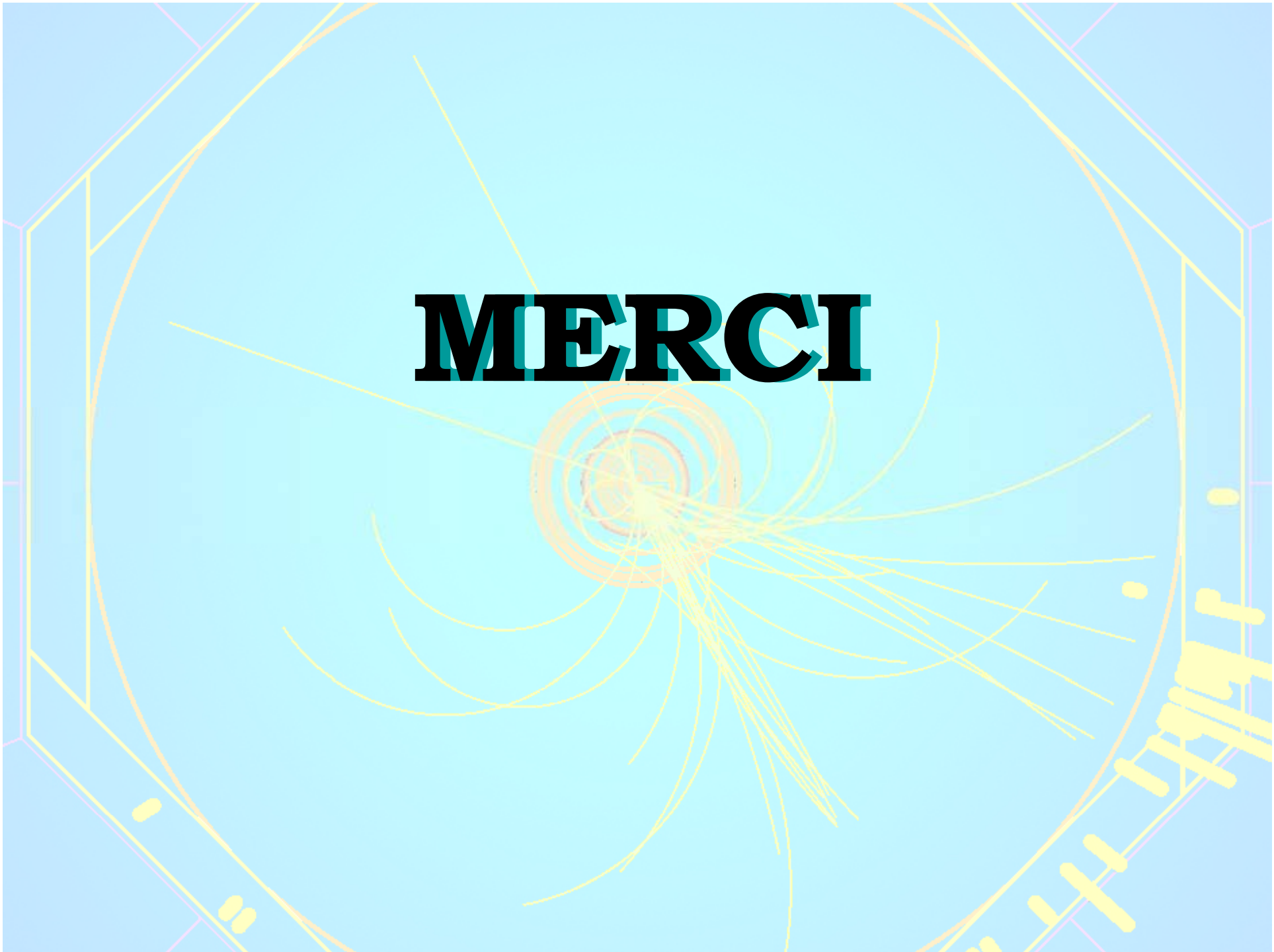
	Data 2006	Data 2007
α [MIPs]	**96.25** ± 11.13	**-77.14** ± 5.86
β [MIPs/GeV]	**266.25** ± 0.48	**294.4** ± 0.5
Chi2 / ndf	**17.64 / 32**	**13.9 / 29**
Residuals		**< 1.5 %**
Constant term [%]	**1.05** ± 0.07	**0.81** ± 0.15
Statistic term [%/GeV]	**16.59** ± 0.14	**16.78** ± 0.15
Chi2 / ndf	**19.65 / 32**	**44.32 / 29**
Residuals		**< 0.5 %**

Data per run

Linearity

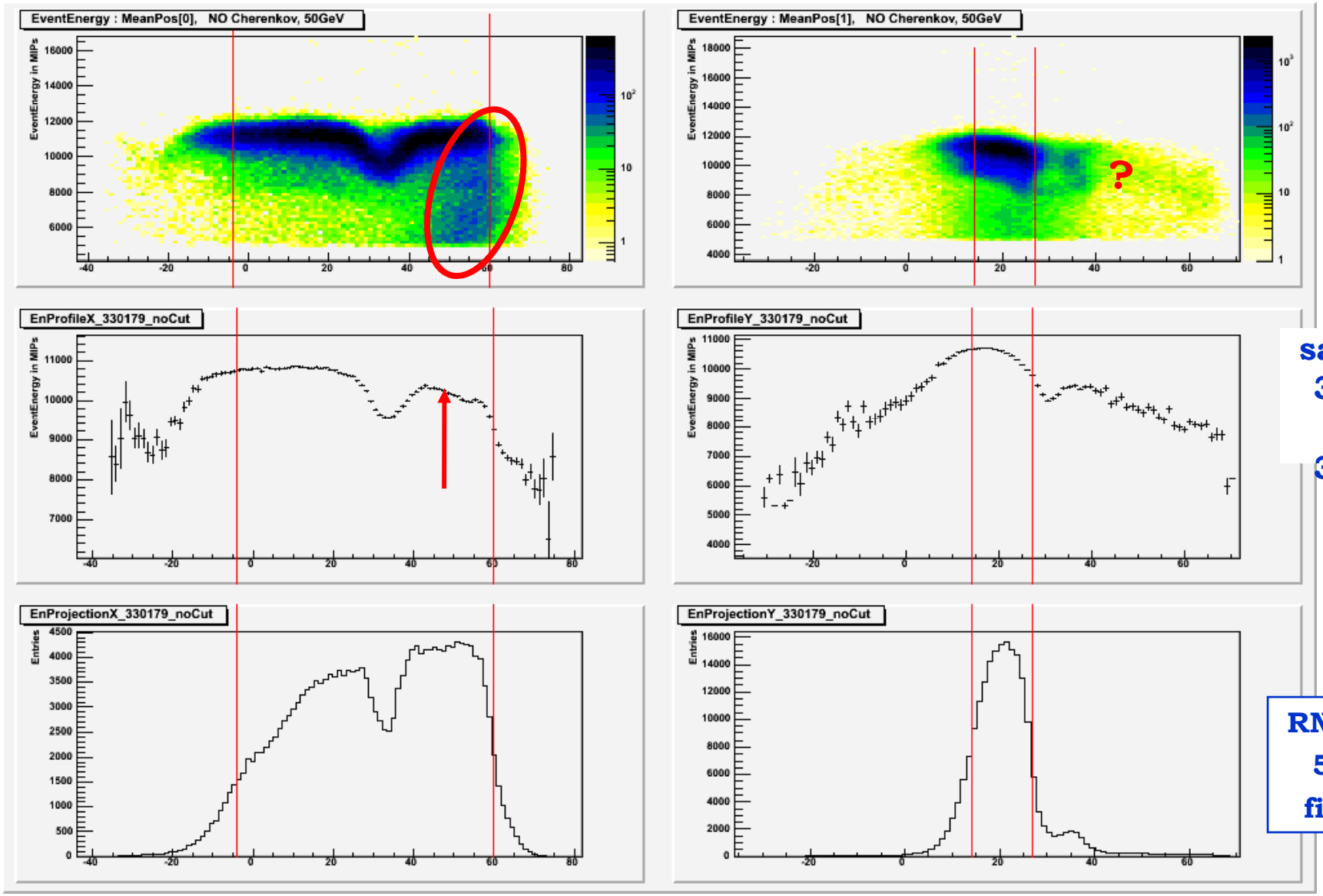
Resolution

paper 2006, CALICE group


MERCI

Additional slides

Strange beam?

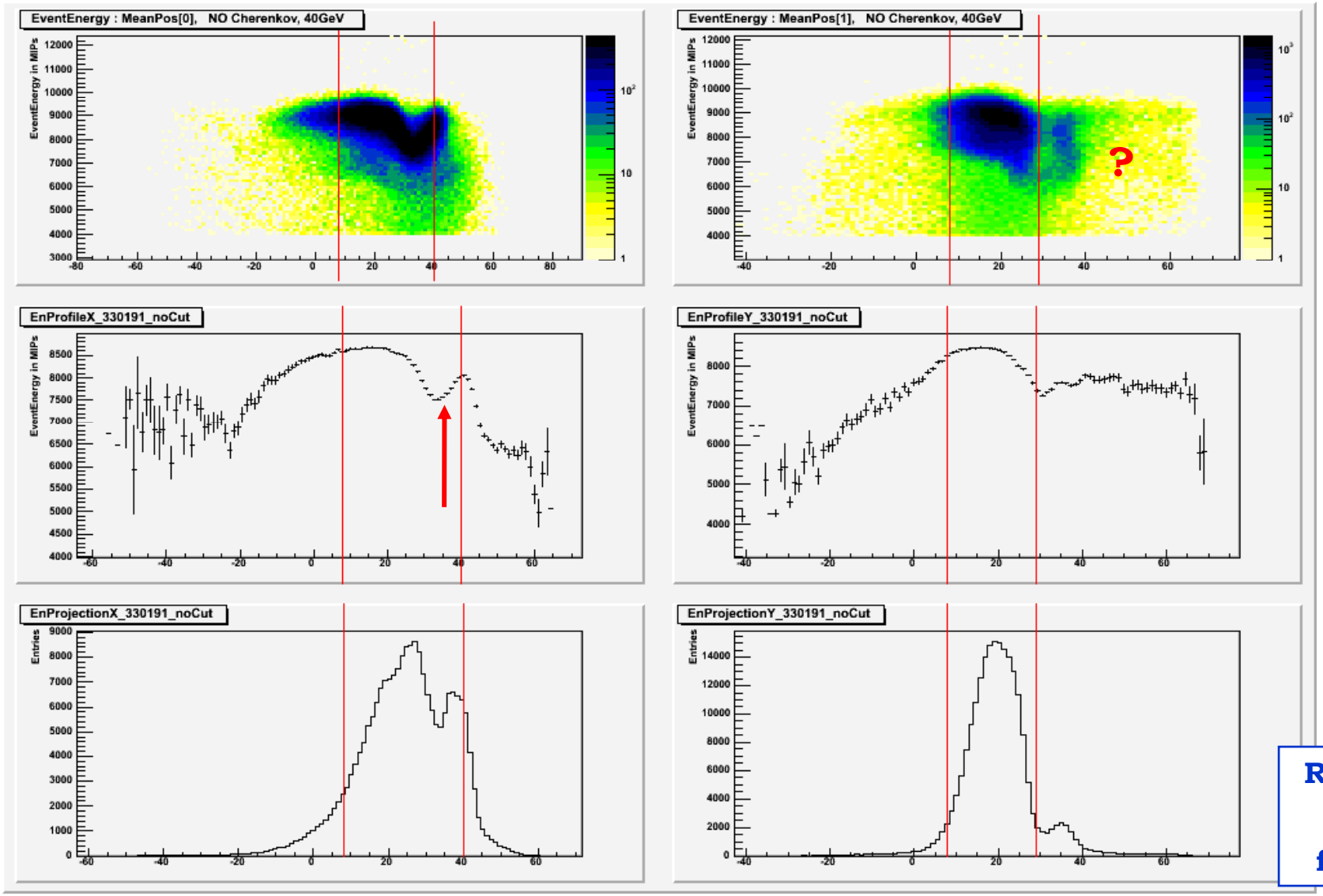


in LogZ

same for: 330180 & 330199

RNr 330179, 50GeV, first day

Strange beam?



in LogZ

same for:
330203
&
330210

RNr 330191
50GeV,
first day

Strange beam?

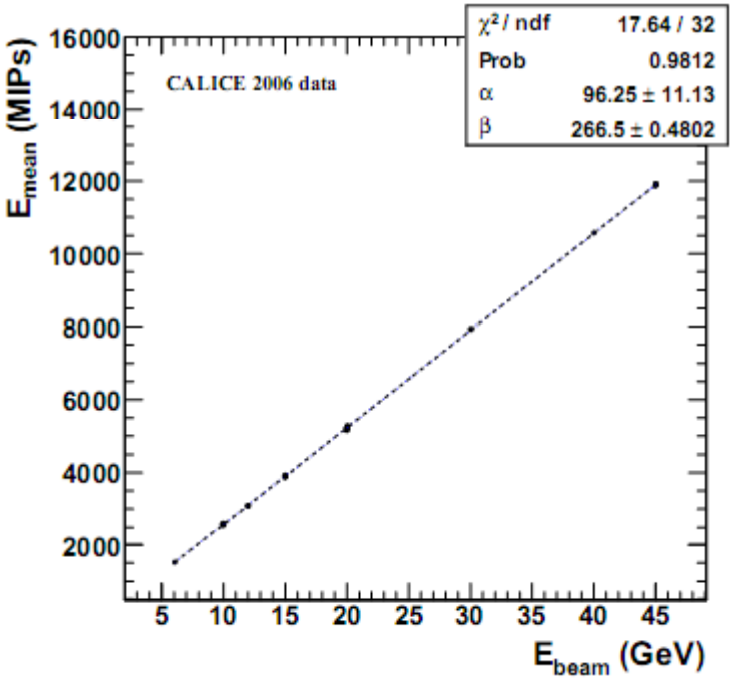
eLogbook:

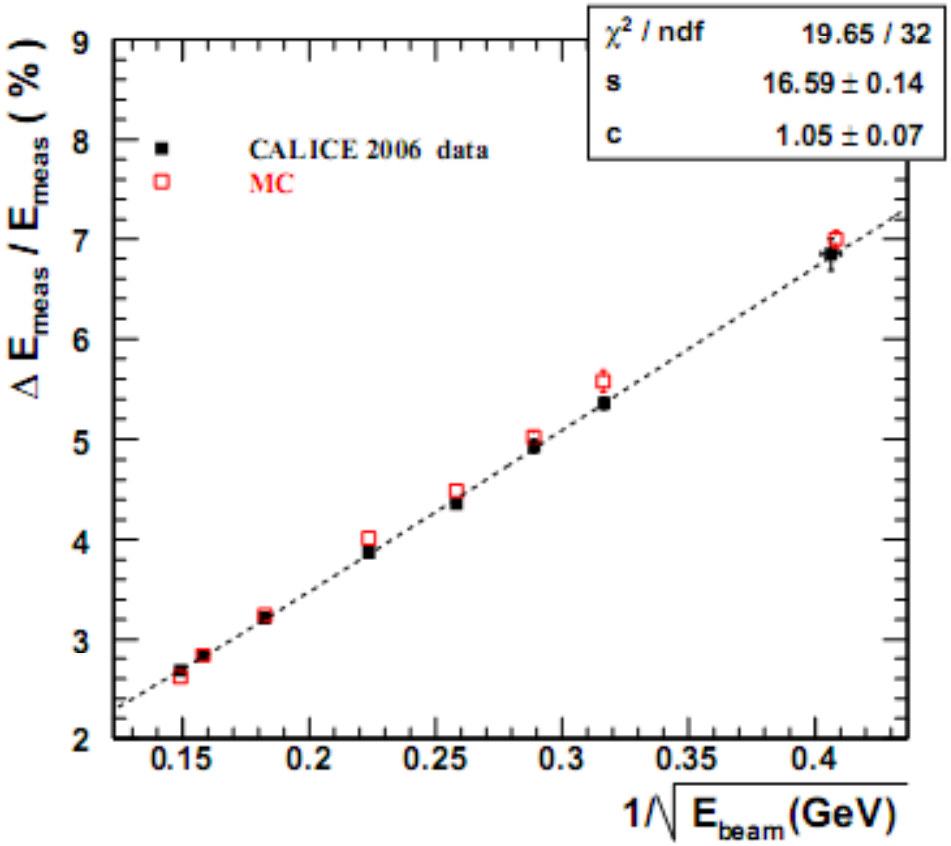
**"… dropped because beam is too board in the x direction.
put collimators in x direction more closer. … "**

08.07.2007 19:32

-> take them out of calculations

Official data 2006:





	position (mm)	σ (mm)	a
x direction	-30.0	4.3	0.143
y direction	-8.4	3.2	0.198

Table 1: Gaussian parametrisation of the inter-wafer gaps.

From: CALICE group, "Response of the CALICE Si-W Electromagnetic Calorimeter Physics Prototype to Electrons"