Amplitude Method – summary results

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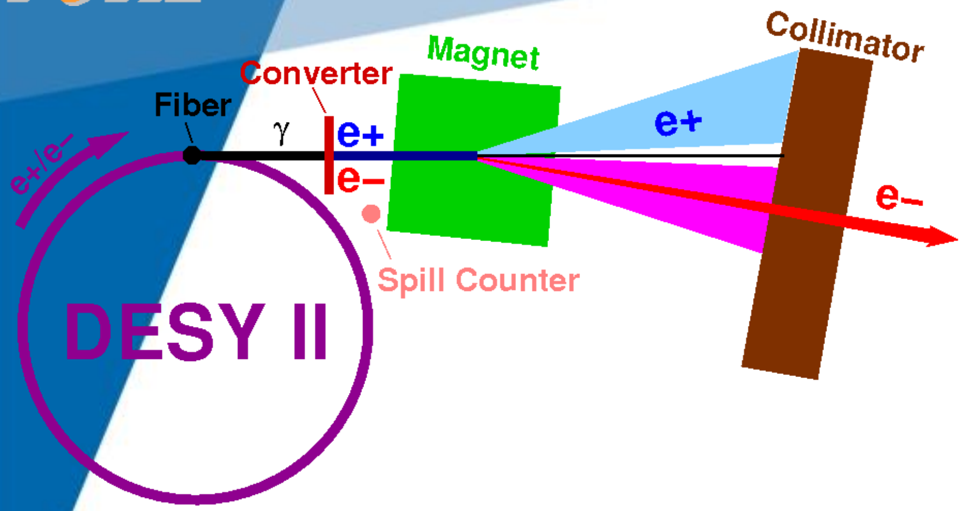
Outline

- ✓ Test Beam set-up
- ✓ Amplitude Method
  - Amplitude algorithm
  - Signal candidates
  - MPV uniformity in space&time
  - Signal to noise ratio
- ✓ Edge effects:
  - Track reconstruction
  - Induced signal in neighboring pads
  - Results
- ✓ Shower analysis
  - Longitudinal & transversal evolution of showers
- ✓ Conclusions

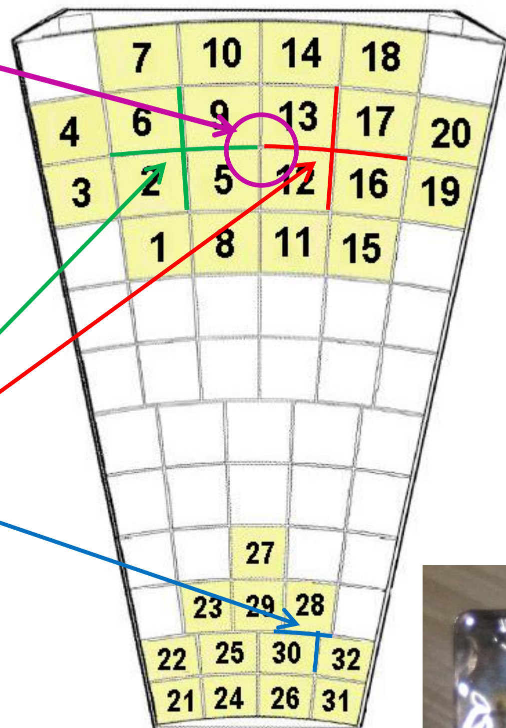
Test Beam DESY II



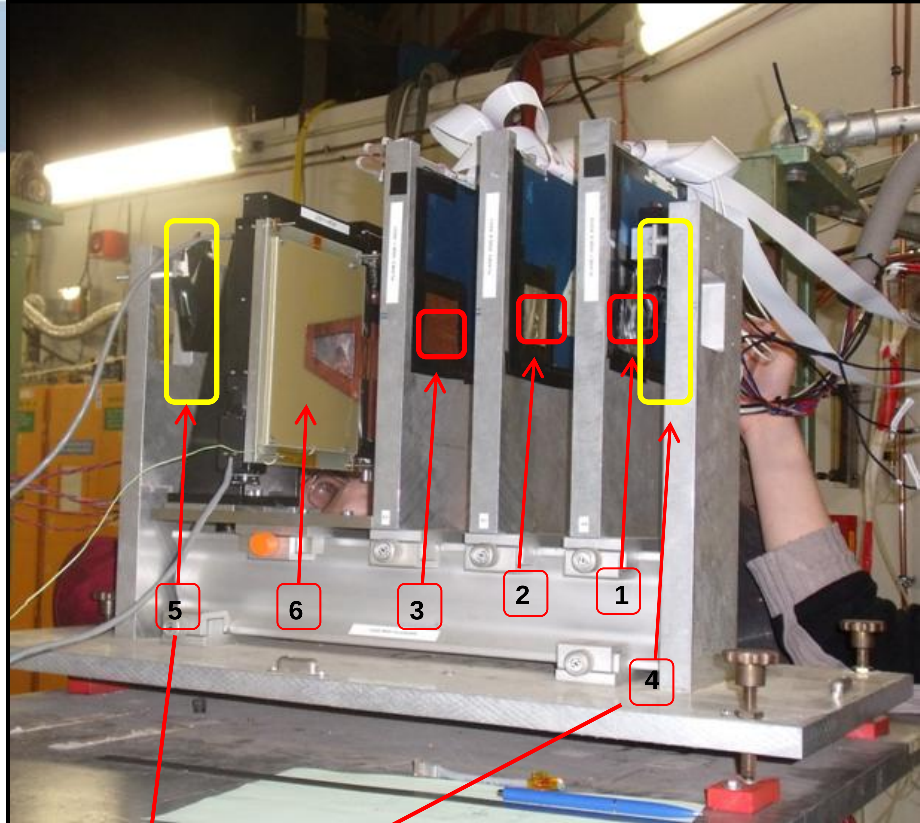
- DESY II Synchrotron provide electrons with up to 1000 particles per cm² and second, energies from 1 to 6 GeV;
- Test Beam took place in beam line 22 of DESY II ring in Hamburg, from 04.11.2011 to 22.11.2011;
- Used 2GeV or 4 GeV electron beams;

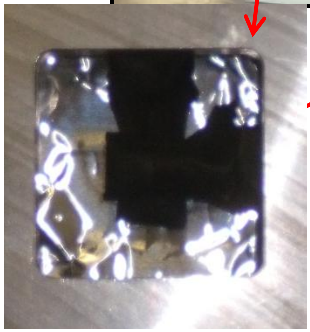
Set-up

Shower analysis

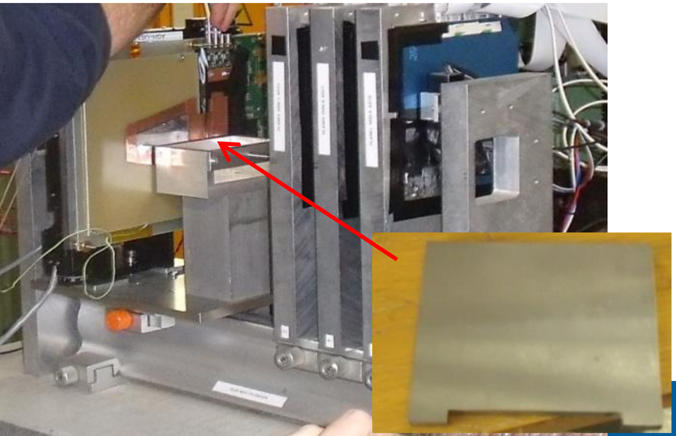


Edges between pads irradiation





- ZEUS telescope planes (1, 2, 3):
  - Si planes: 300 μm thick
  - Active area: 32 x 32mm^2
  - Double perpendicular layers,
  - 640 strip channels (50µm)
- Trigger scintillators (4,5) :
  - Trigger window: 7 x 7mm^2
- BeamCal Sensor (6)
  - GaAs:Cr sensor



$t = [2X_0 \div 14X_0]$;
step = $2X_0$

Amplitude method (MAX)

1. Data

At each trigger the ADC counts stored in a matrix A = $||A_{i,j}||$, $i \in [0,31]$, $j \in [0, 31]$

$$A = \begin{pmatrix} A_{0,0} & \cdots & A_{0,20} & \cdots & A_{0,31} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ A_{i,0} & \cdots & A_{i,20} & \cdots & A_{i,31} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ A_{31,0} & \cdots & A_{31,20} & \cdots & A_{31,31} \end{pmatrix}$$

where:
- $A_{i,j}$ is the ADC count of the pad (i+1)
- i electronic channel
- j sample number

2. Amplitude method finds for every pad (channel) the maximum of ADC counts for $j \in [20, 31]$

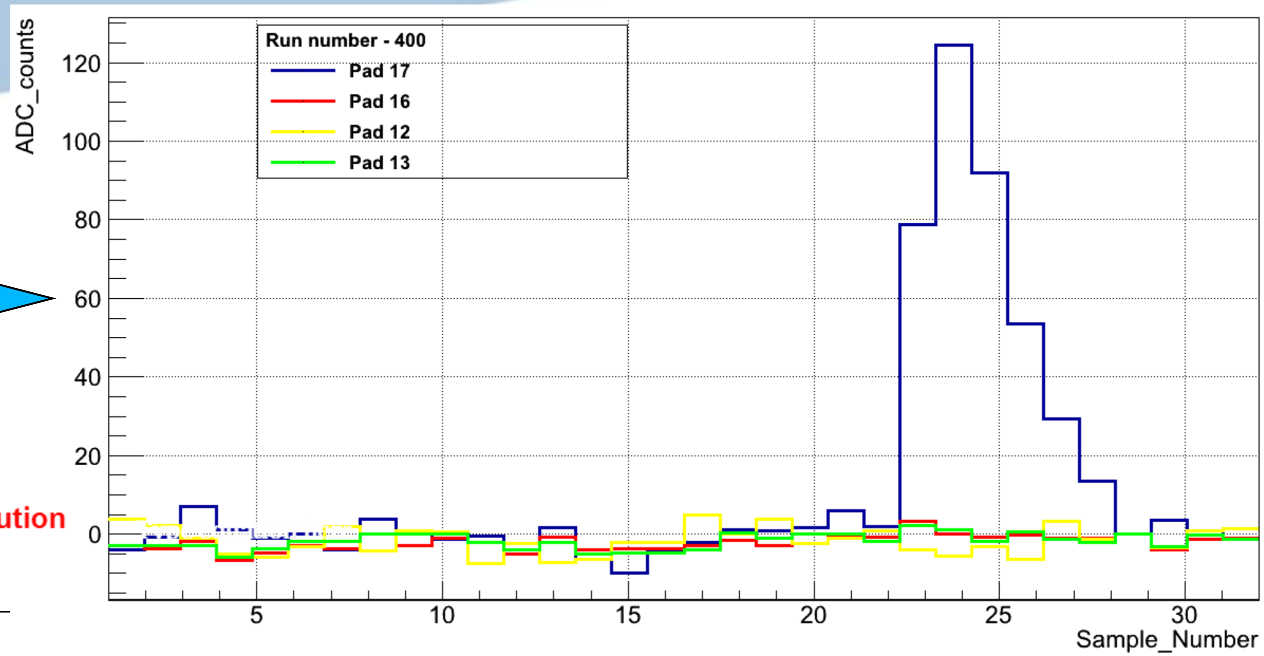
$$\boldsymbol{Amax_i = MAX(A_{i,20}, \dots, A_{i,31})} \longrightarrow \boldsymbol{Amax_i = A_{i,smax}}$$, where *smax* represents the sample corresponding to $Amax_i$

3. Pedestals are computed for every run and every pad (channel) in the sample interval $j \in [0,19]$
Pedestal values are the mean values, P_i, of the $\boldsymbol{f_i(A_{i,0}, \dots, A_{i,19})}$ distributions which have the RMS_i values

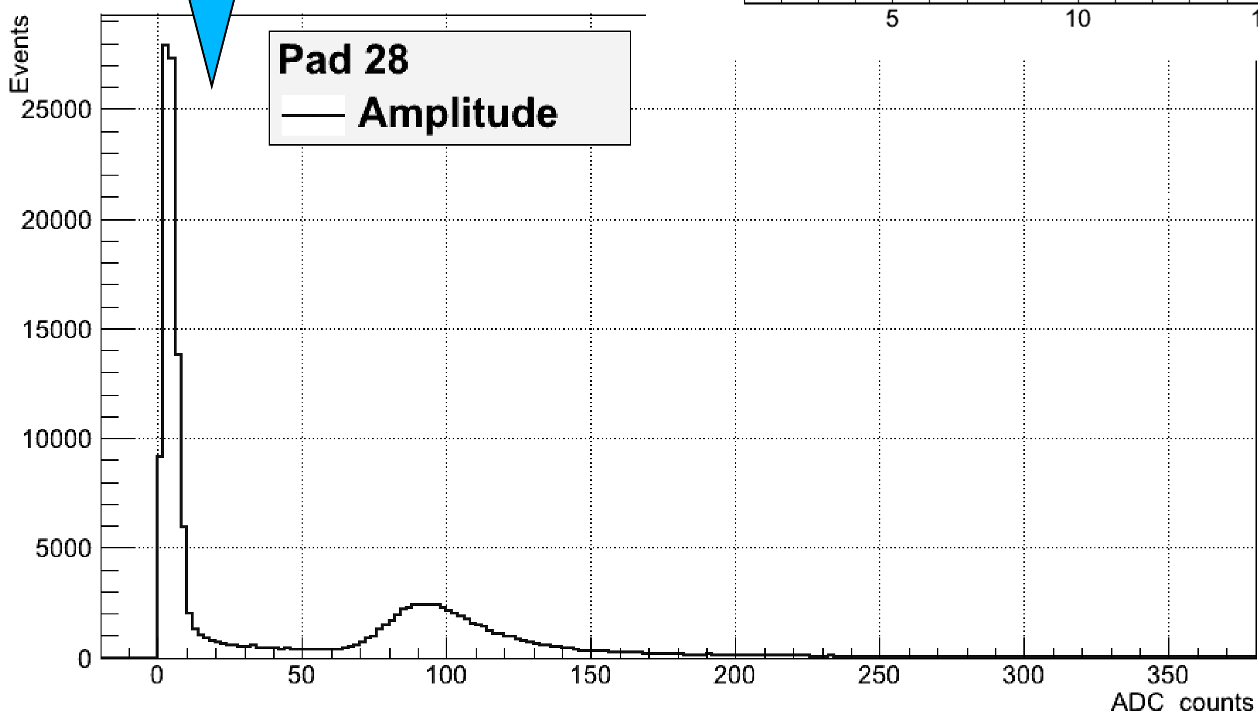
$$\boldsymbol{f_i(A_{i,0}, \dots, A_{i,19}) = f_{i,0}(A_{i,0}) \times \cdots \times f_{i,19}(A_{i,19})}$$, where $i \in [0, 31]$

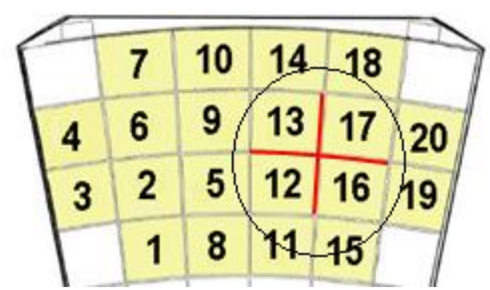
Amplitude method (MAX)

$A_{11,j}, A_{12,j}, A_{15,j}, A_{16,j}$ **dependence on the samples,** $j \in [0,31]$

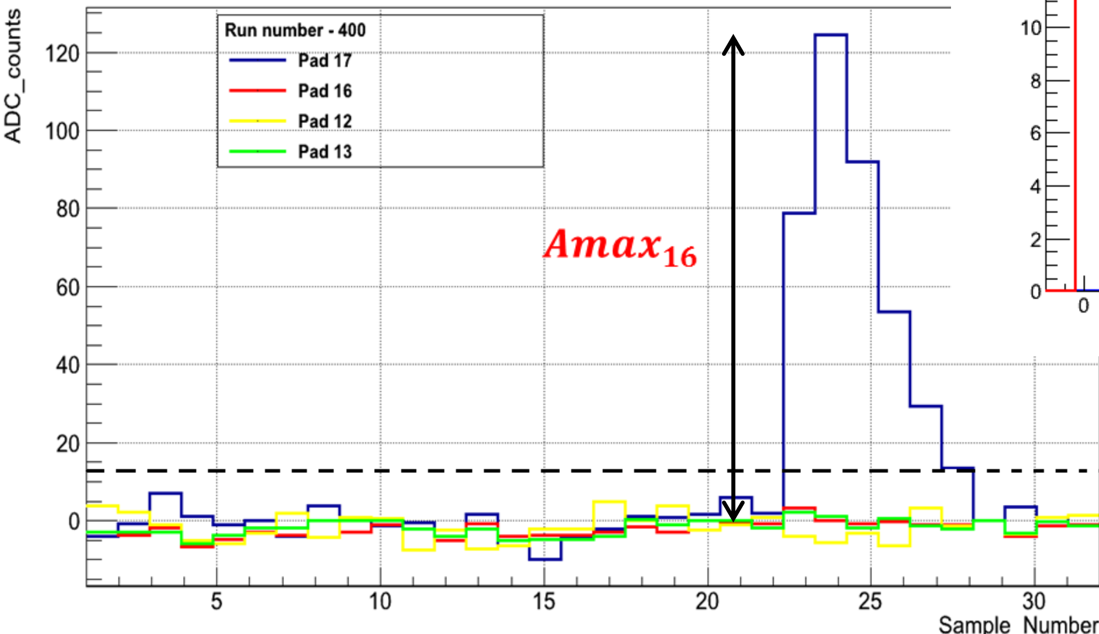


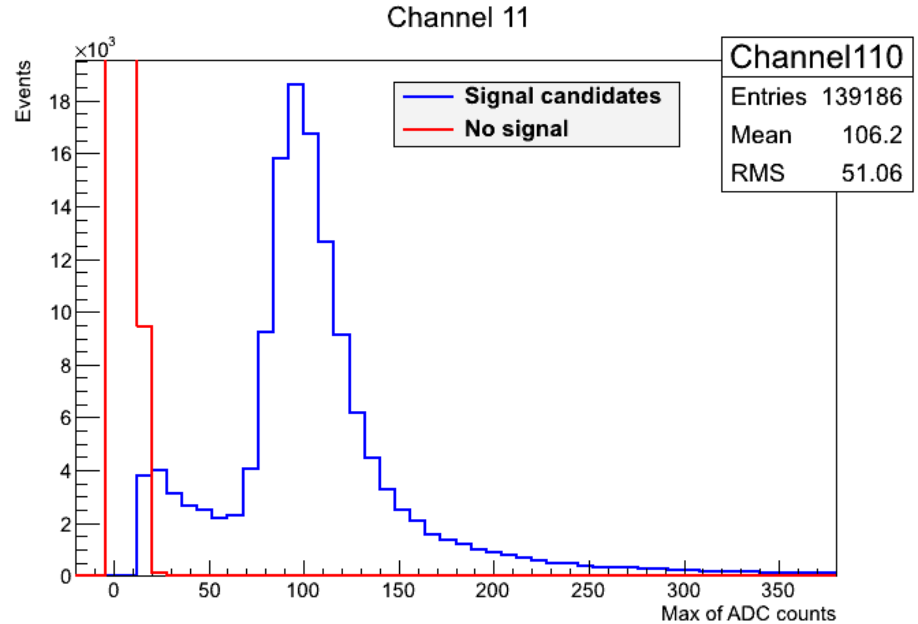
$Amax_{27} = MAX(A_{27,20}, \ldots, A_{27,31})$ **distribution**





Analysis Methodology





$f_i(S_i)$ when (1) and (2) are fulfill

$f_i(Amax_i - P_i)$ when (1) or/and (2) are not fulfill

Conditions for signal:

1. The maximum count has to satisfy:

$$Amax_i \geq P_i + coef \times RMS_i, \text{ we used } coef = 3 \qquad (1)$$

2. At least one of the nearest samples has the count:

$$A_{i,smax-1} \text{ or } A_{i,smax+1} \geq P(i) + coef \times RMS_i \qquad (2)$$

The Signal Amplitude is:

$$S_i = Amax_i - P_i$$

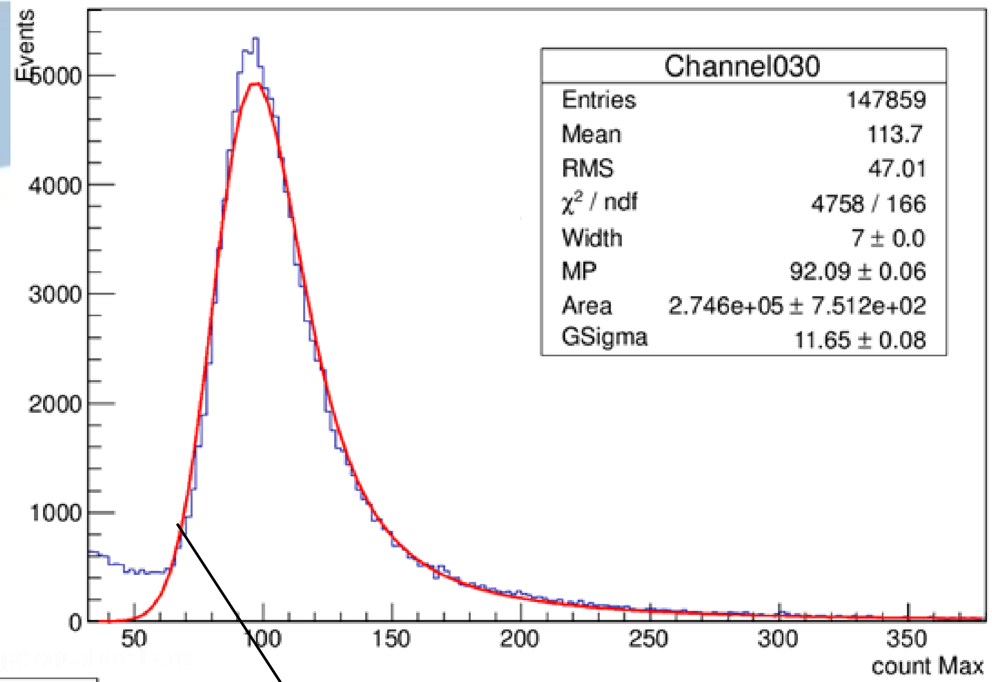
Signal analysis

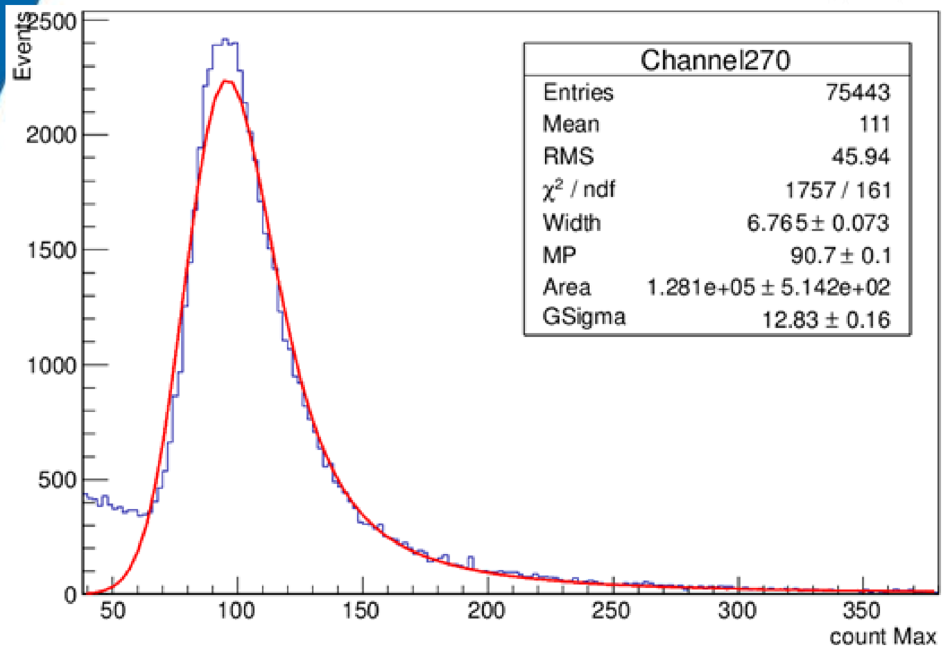
Landau – Gauss Convolution fit

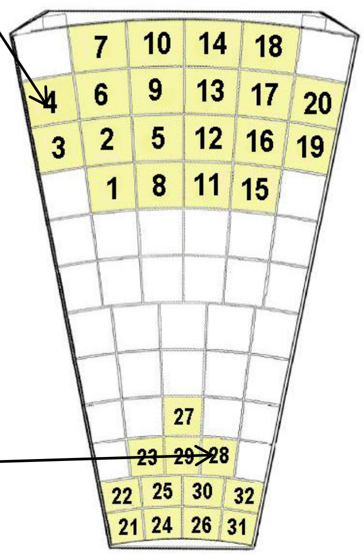
$$L(S) * G = \int_{-\infty}^{+\infty} L(\tau) G(S-\tau) d\tau$$

Where:

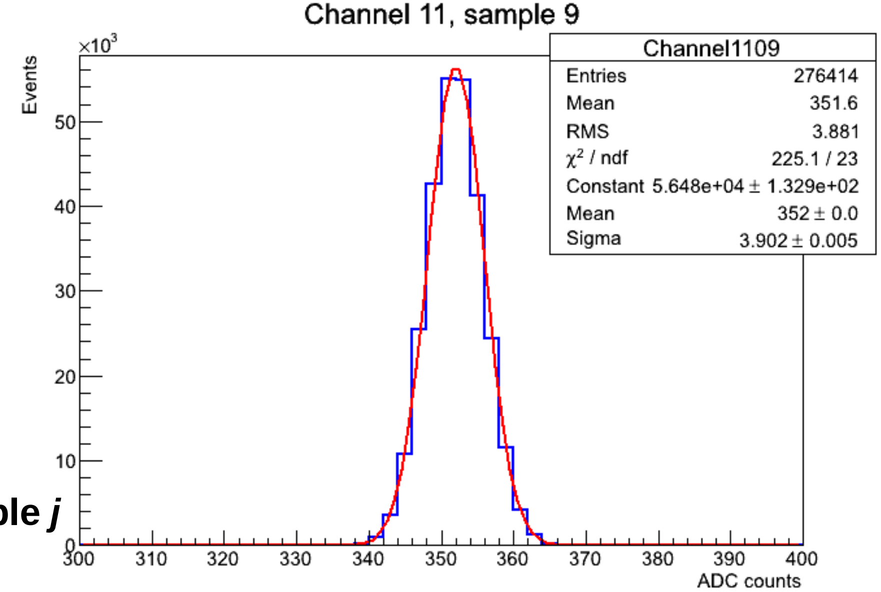
$$\left.\begin{array}{l} L = L(MPV, \Delta) \\ G = G(\sigma) \end{array}\right\} \Longrightarrow MPV, \Delta, \sigma$$







Pedestal analysis

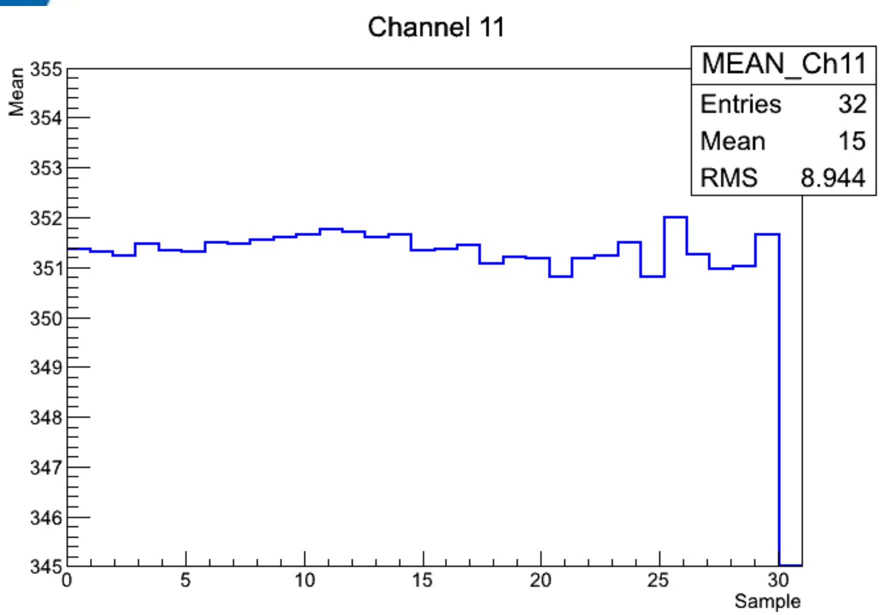


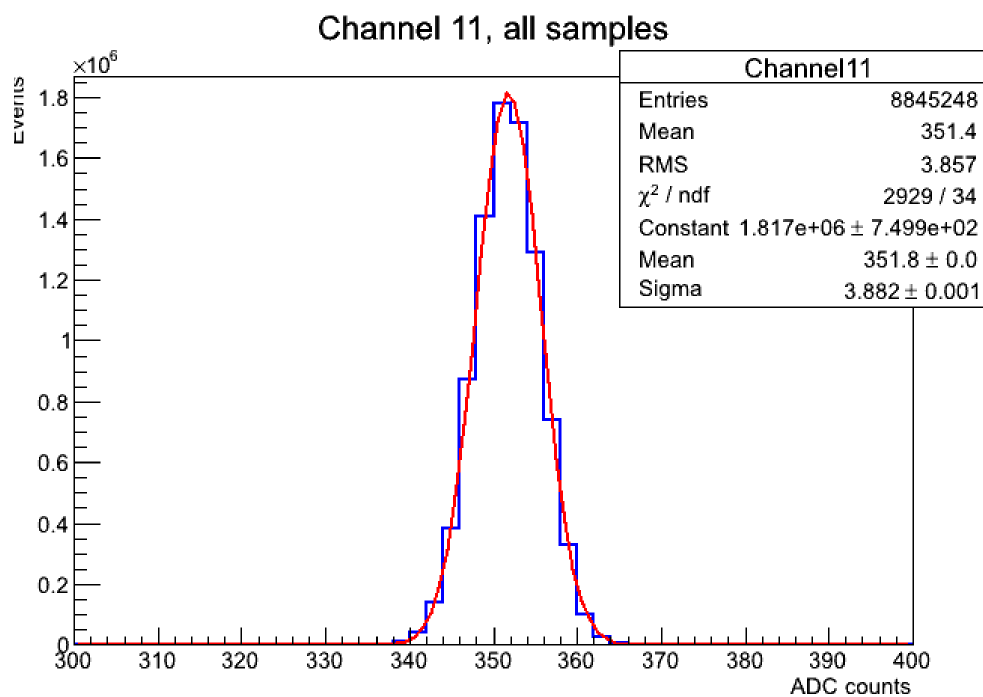
$f_{i,j}$* – pedestal distribution for channel *i* and sample *j

$P_{i,j}$* – pedestal value for channel *i* and sample *j

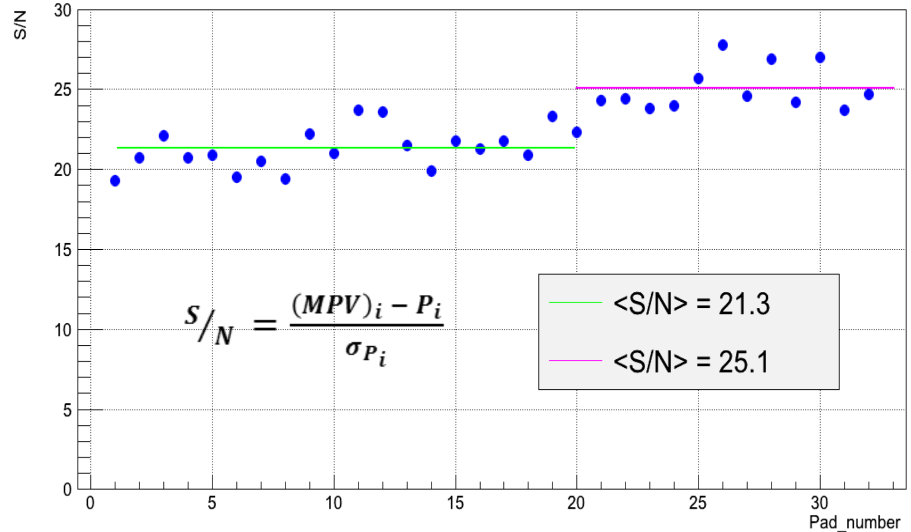
$f_i \sim f_{i,j}$

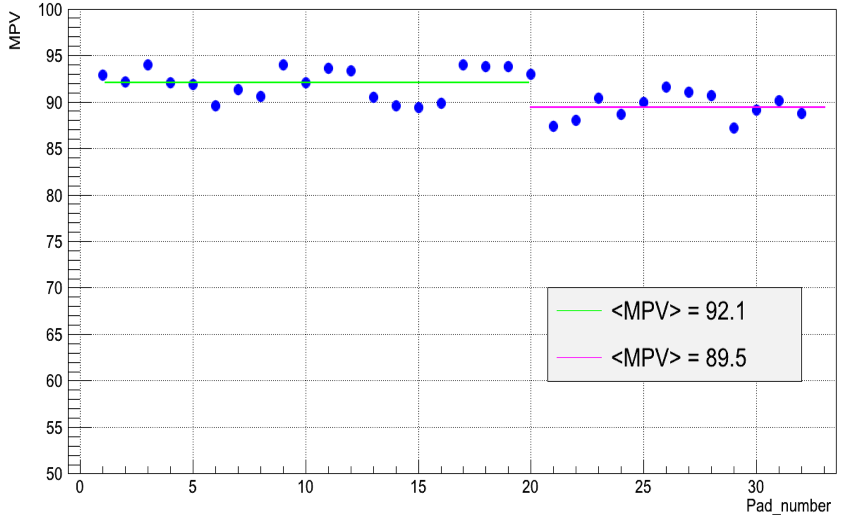
$P_i = P_{i,j}$ for every sample *j*

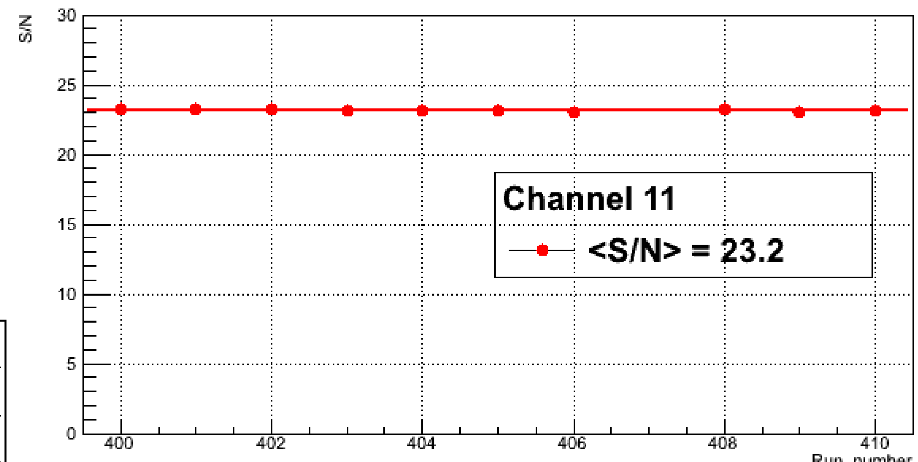


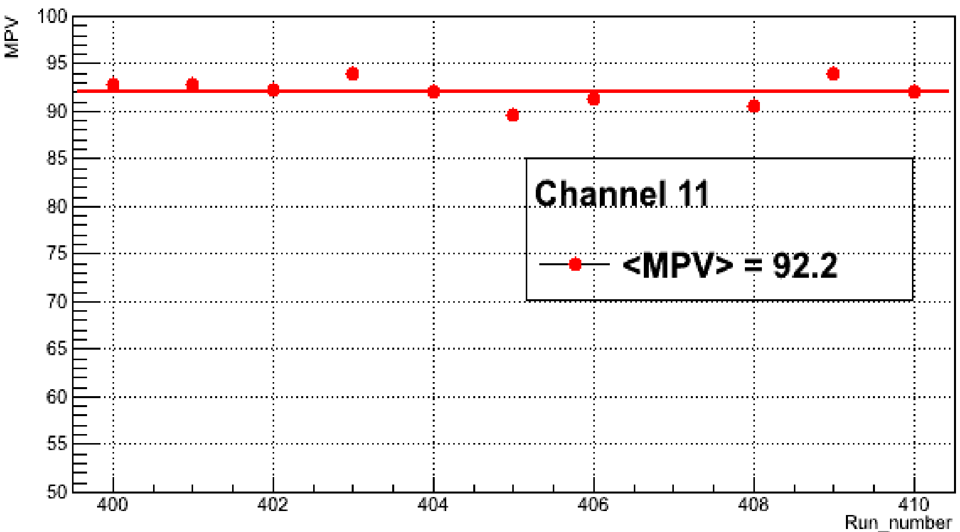


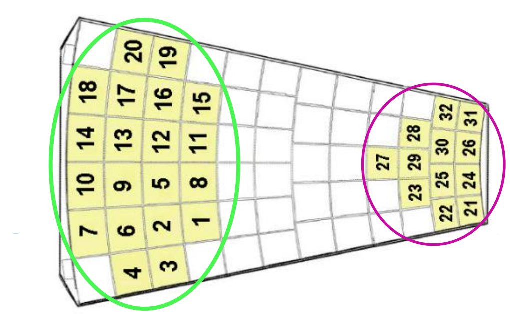
Uniformity analysis











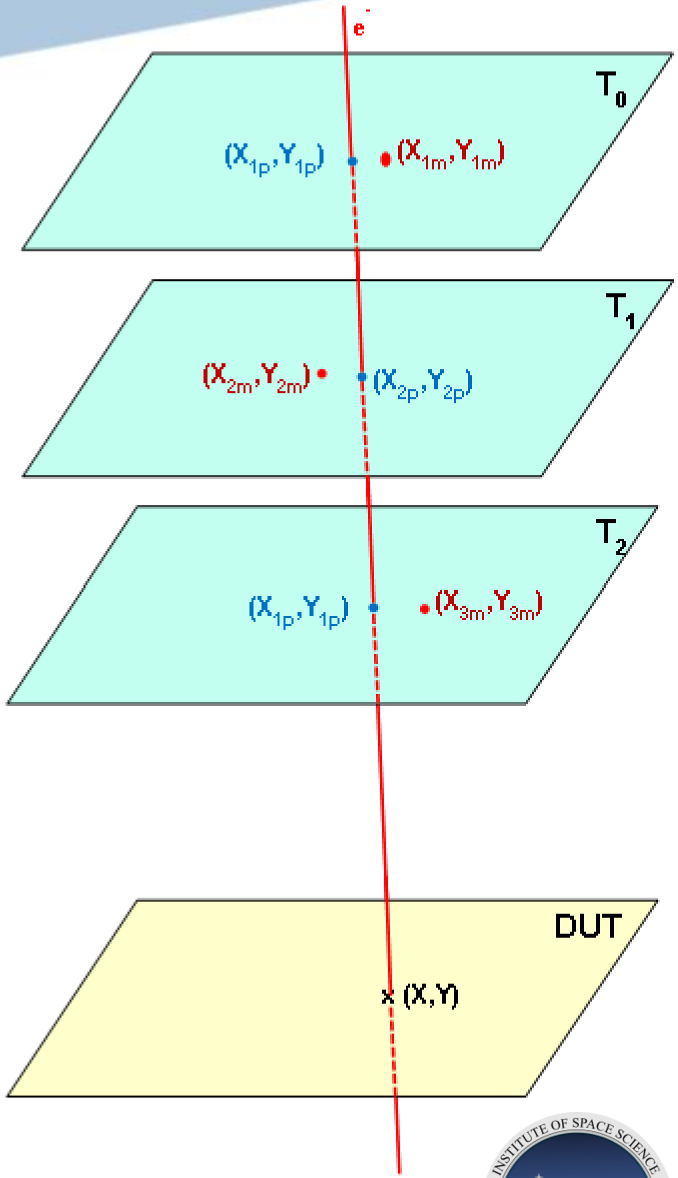
Track reconstruction method

- DigXs and DigYs coordinates have been took for all telescope planes;
- Hits number/plane = 1 → one EM shower/event

where:

- (X_{im},Y_{im}) = measured coordinates or given coordinates by TelAna, i Є [1, 3] ;
- (X_{im},Y_{im}) = (DigXs, DigYs);
- (X_{ip},Y_{ip}) = predicted coordinates given by line intersection with each telescope plane

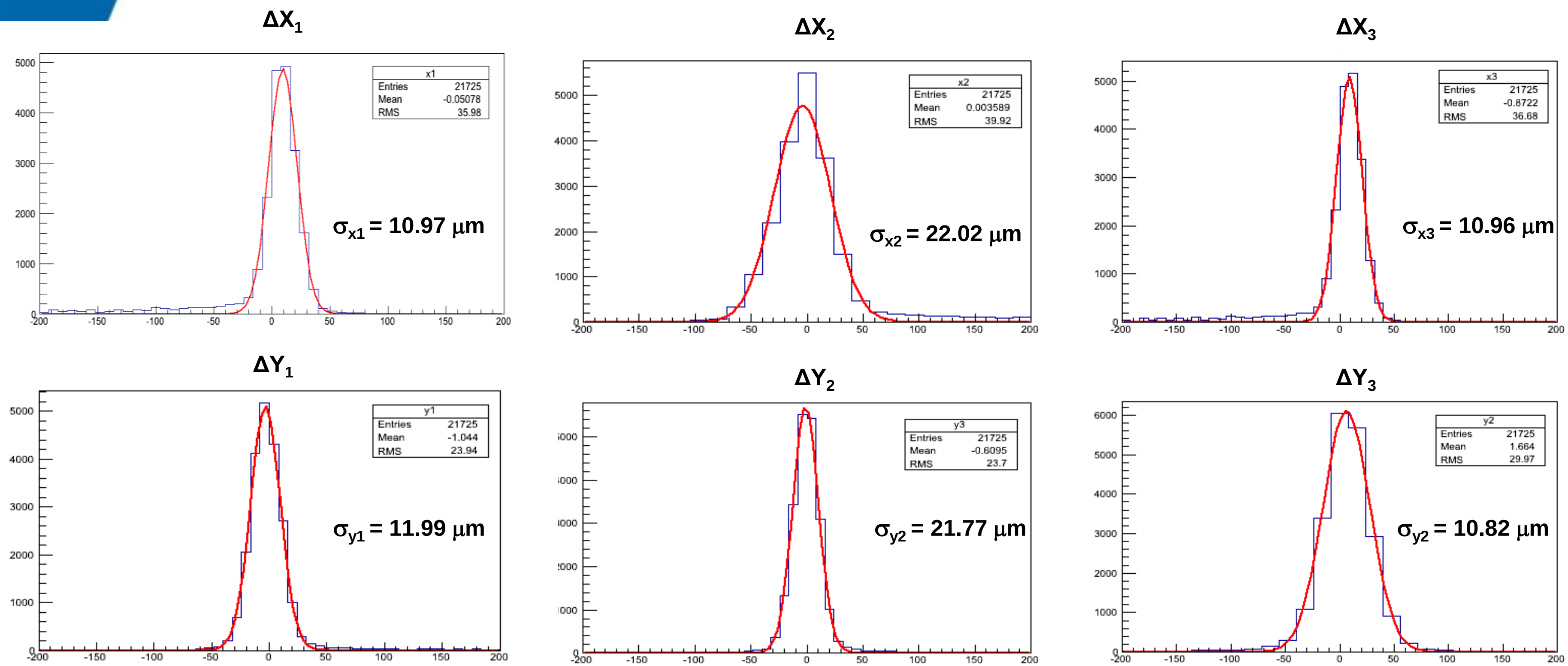
$$Min\,(d^2) = Min\left(\sum_{i=1}^{3}\left(\left(x_{ip}-x_{im}\right)^2+\left(y_{ip}-y_{im}\right)^2\right)\right)$$



Track reconstruction method

Spatial resolution:

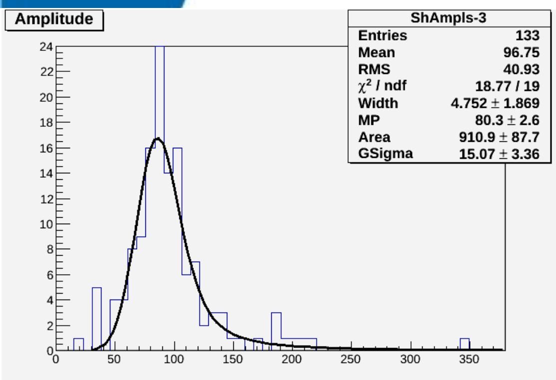
- Sigma from fits are smaller than about 30μm
- The Si chamber alignment was make with a maximum 100 μm shift



Edge effects analysis

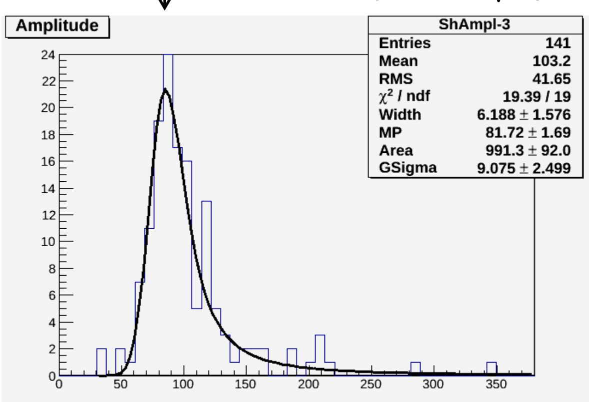
$f_d(S_1)$ = amplitude distribution function

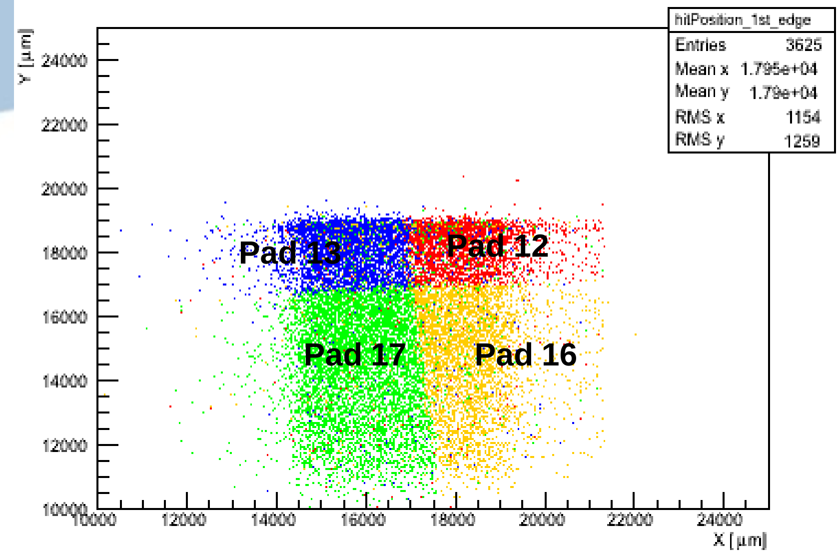
Pad13, d = - 300µm,



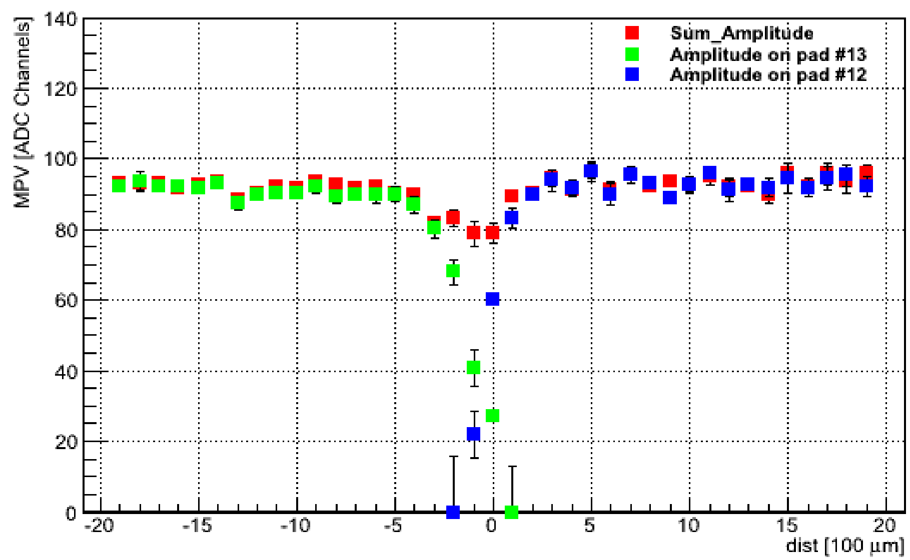
$f_d(S_1 + S_2)$ = amplitude distribution function

Pad13 + Pad 12, d = - 300µm,



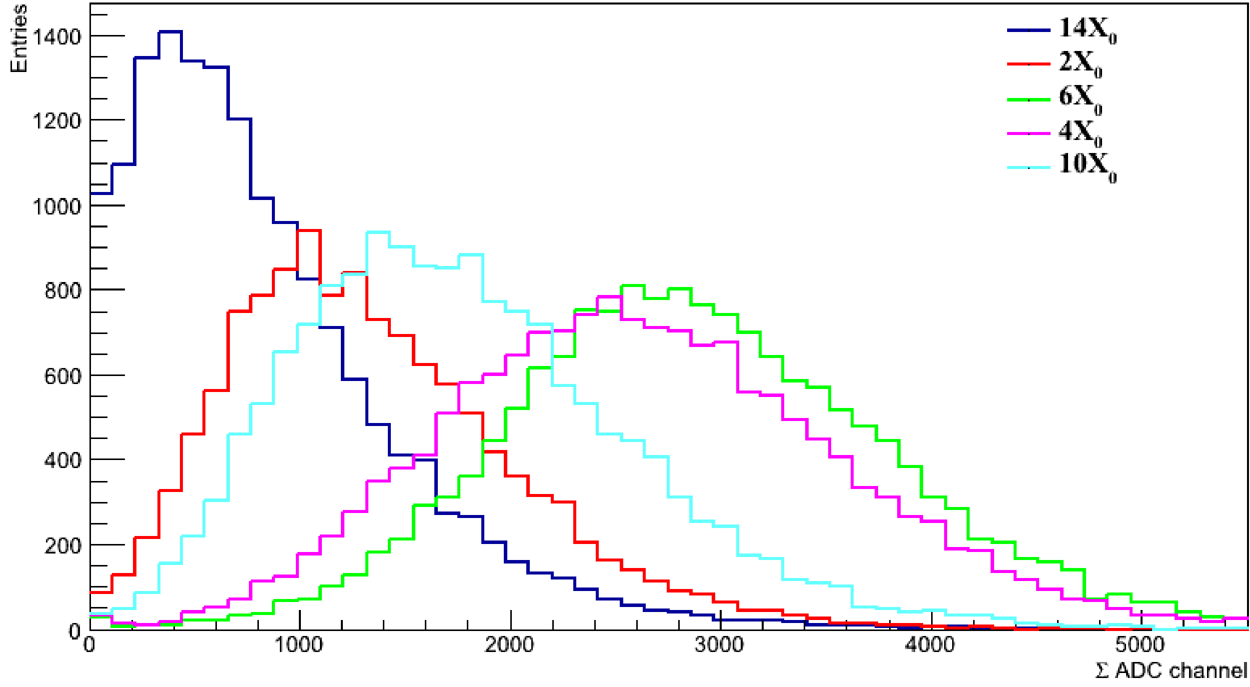


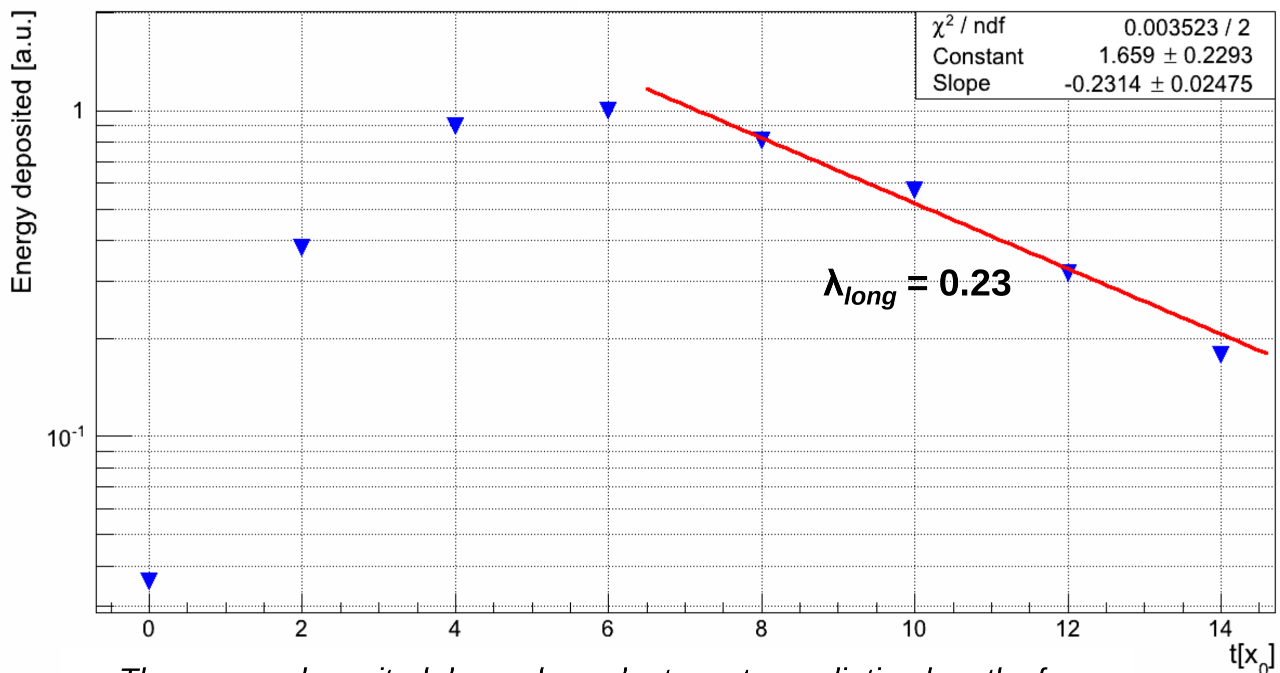
The hits distribution on a fully instrumented BeamCal sensor



Amplitude dependence on the hit position on the pad

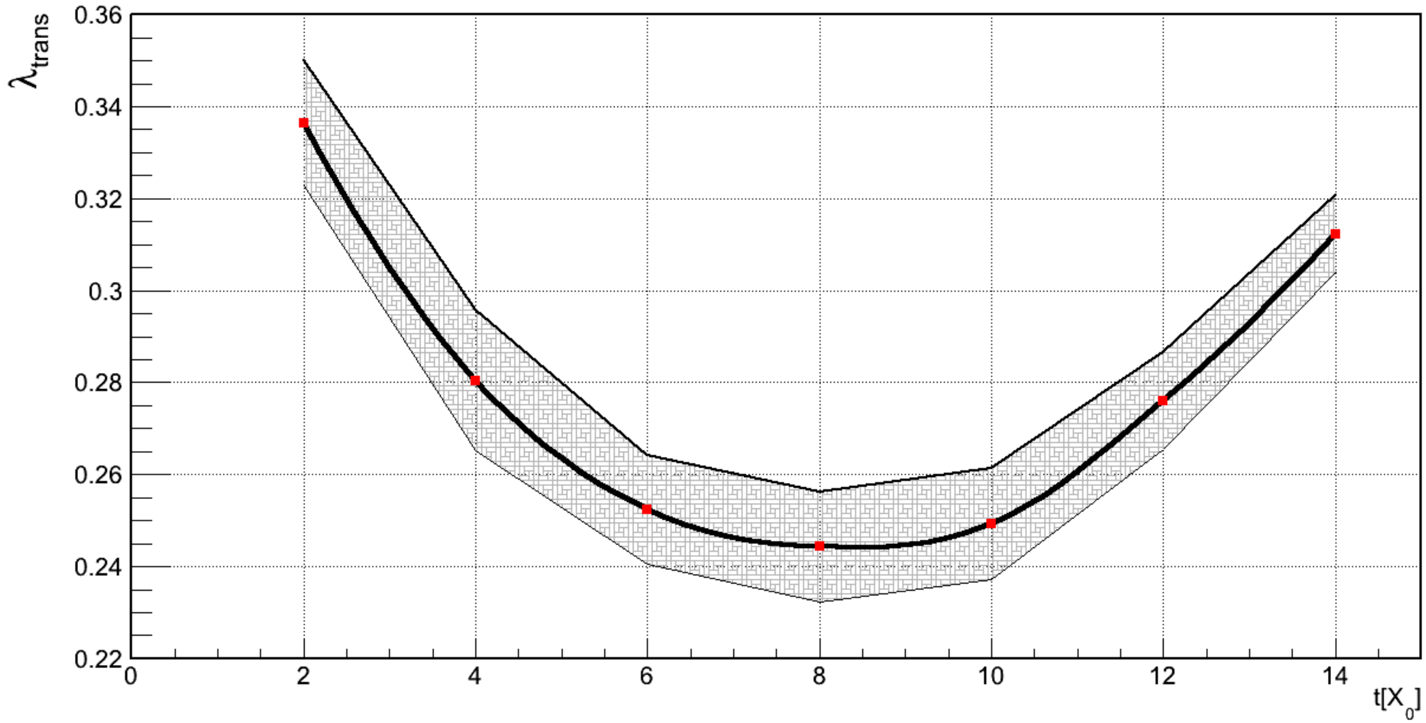
Shower analysis





The energy deposited dependence by tungsten radiation lengths for experimental data

Shower analysis



Conclusions

In the paper could be included:

- **Amplitude method**
  - Algorithm
  - Results (uniformity, S/N)
- **Edge effect**
  - Track reconstruction
  - Results