Test beam shower analysis with GaAs sensor and Tungsten absorber

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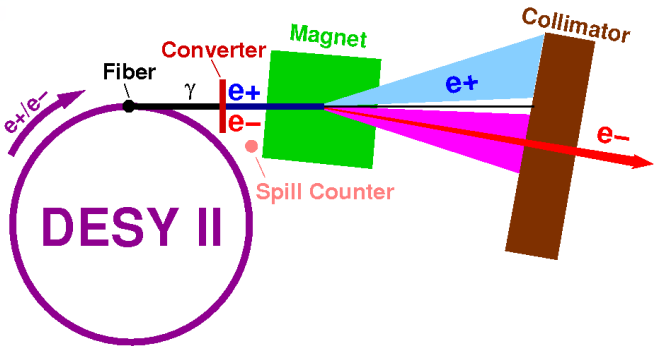
Outline

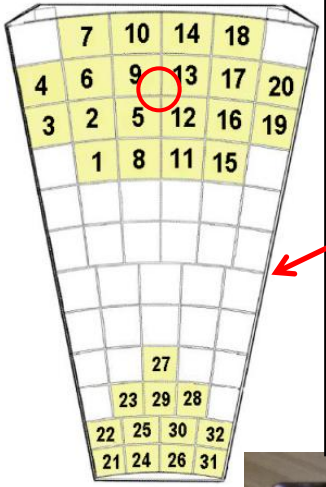
- ✓ **Test Beam set-up**
  - Signal analysis
  - Tracking reconstruction
- ✓ **MC simulation**
- ✓ **Shower analysis**
  - Longitudinal development of EM shower
  - Radial development of EM shower
- ✓ **Conclusions**

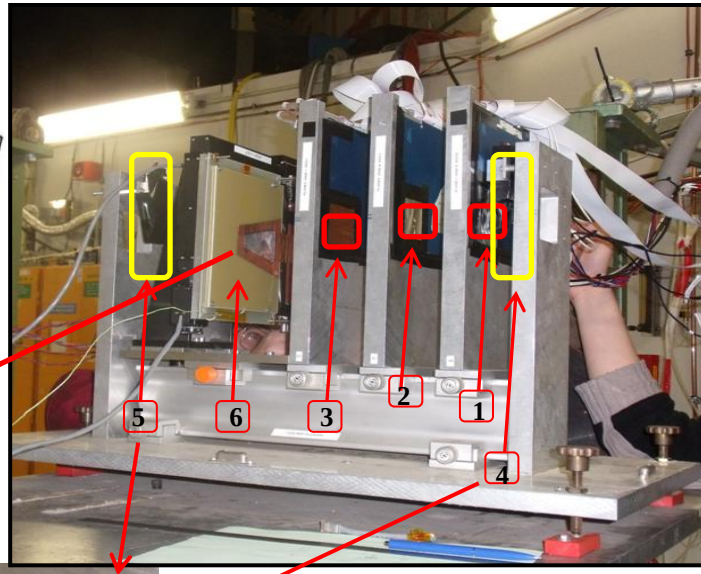
Test beam set-up

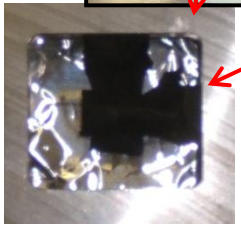


- DESY II Synchrotron provide electrons with up to 1000 particles per cm², energies from 1 to 6 GeV;
- Test Beam took place in beam line 22 of DESY II ring in Hamburg, from 4th to 22nd November 2011;
- Used 4 GeV electron beam for shower measurements;

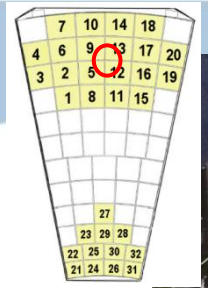
- **ZEUS telescope planes (1, 2, 3):**
  - Si planes: 300 mm thick
  - Active area: 32 x 32mm²
  - Double perpendicular layers,
  - 640 strip channels (50μm)
- **Trigger scintillators (4,5) :**
  - Trigger window: 7 x 7mm²
- **BeamCal Sensor (6)**
  - GaAs:Cr sensor

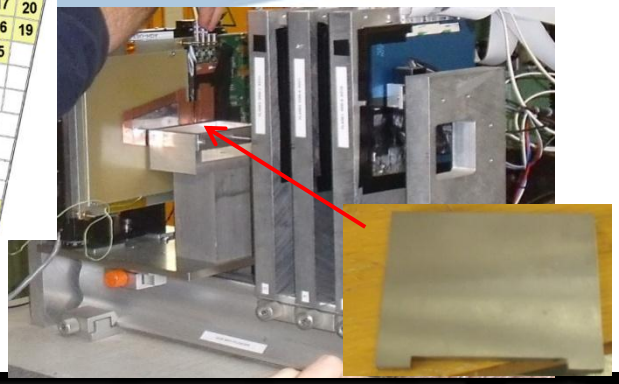




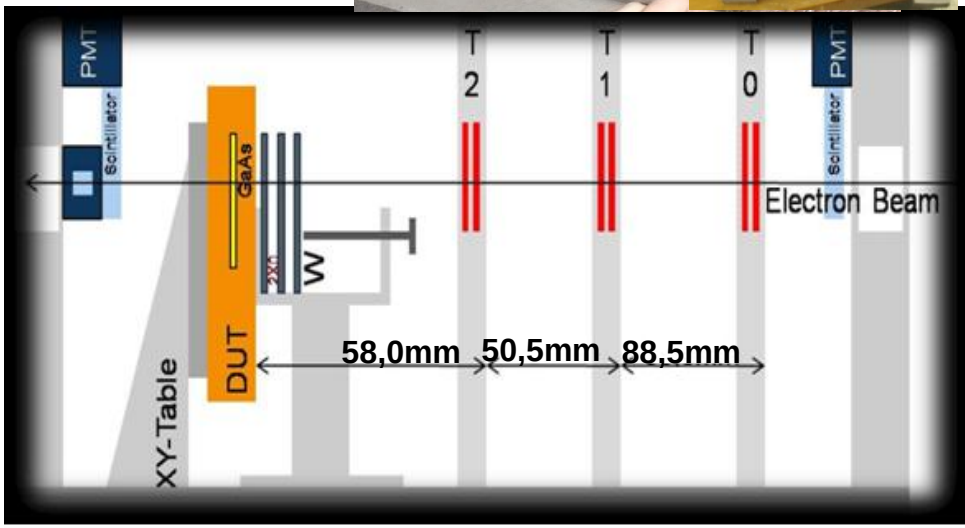


Set-up configuration



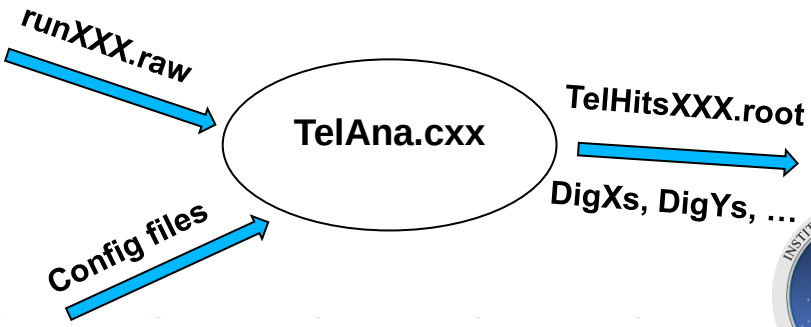


- For **shower measurements** the beam was focused between pads 5, 9, 13, 12;
- ~50k events/run;
- t = [$2X_0 \div 14X_0$]; step = $2X_0$
- X_0 = 0.3504 cm



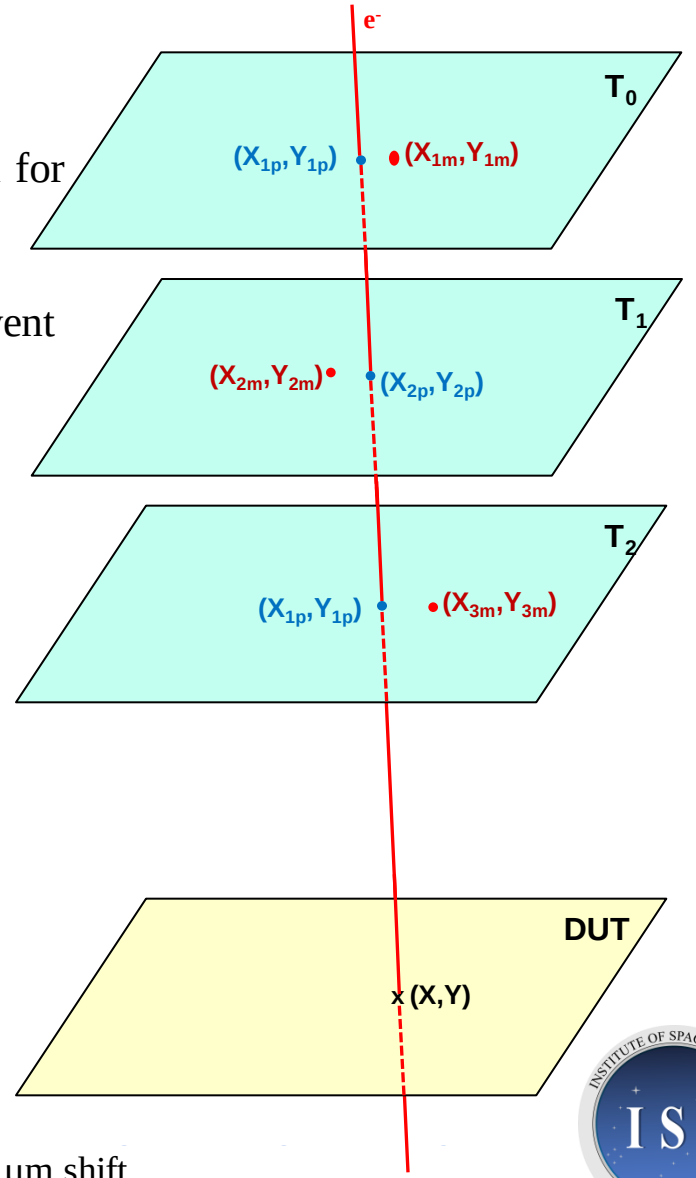

```
# config files for DUT analysis for  all runs
                Energy [MeV] = 4
                  [Telescope 0]
                TELOffsetZ = 0.0
                  [Telescope 1]
              TELOffsetZ = 49500.0
                  [Telescope 2]
              TELOffsetZ = 100000.0

                     [DUT]
              DUTOffsetZ = 197000.0
              DUTThickness = 500.0
//[DUT]= Ni-100µm+GaAS-300µm+Ni-100µm
```



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, $i \in [1, 3]$;

• (X_{im},Y_{im}) = (DigXs, DigYs);

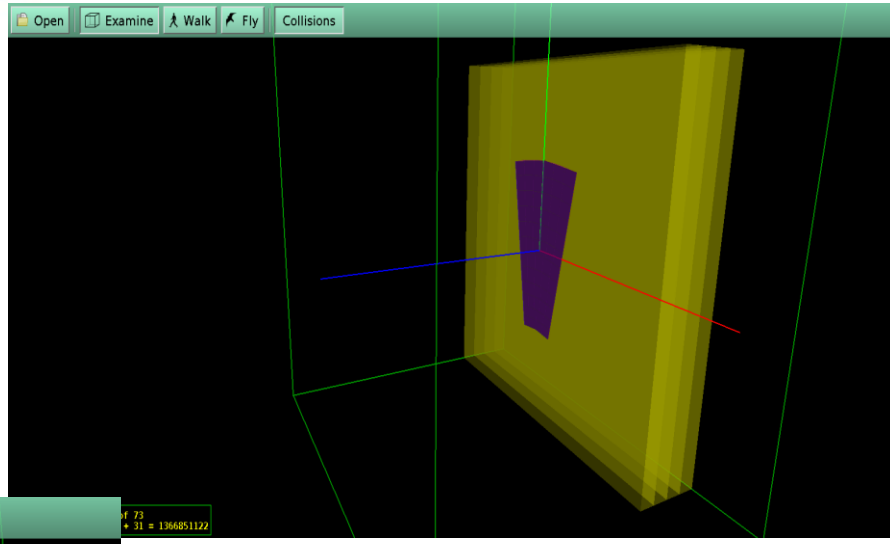
• (X_{ip},Y_{ip}) = predicted coordinates given by line intersection with each telescope plane

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

Spatial resolution:

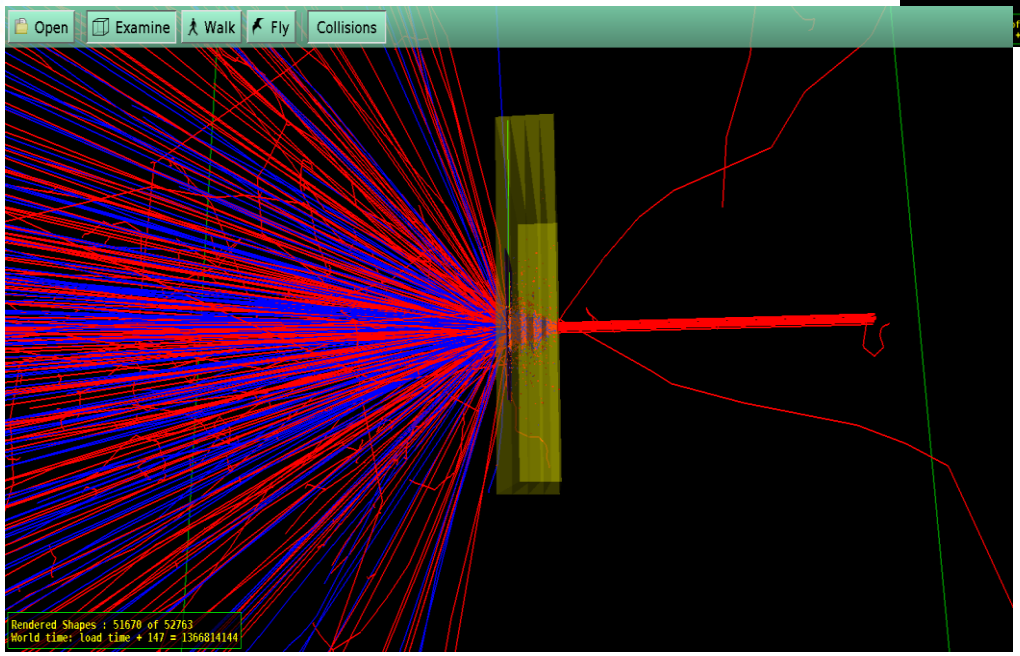
- Sigma from fits are smaller than about 30μm
- The Si chamber alignment was make with a maximum 100 μm shift

MC geometry



Particle Gun definition:

- Incident particles: e^-
- Beam energy: 4GeV
- Gauss distribution of beam with σ = 3 *mm*

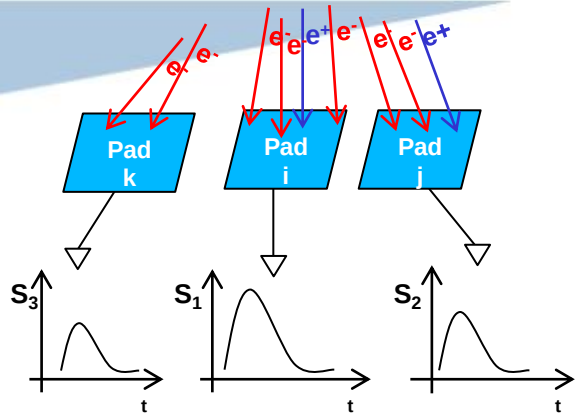


Tracking example for 8 X_0 tungsten

Tracking cuts:

- applied only for GaAs sensor
- ***fStopAndKill*** method was used for stop any gamma particles

Signal management



Signal:

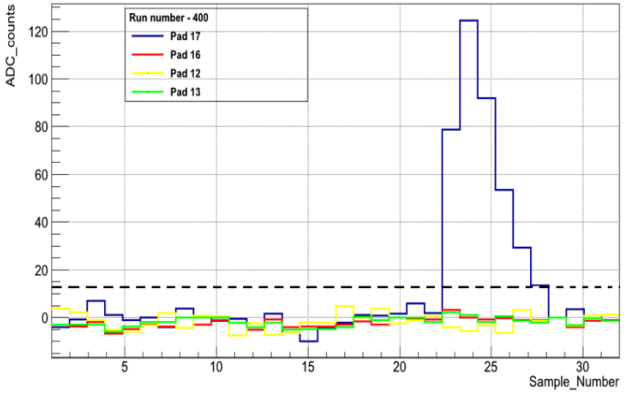
MAXC(pad_nr)>Eped (pad_nr) + coef*RMS(pad_nr), where coef = 3

Active pads in a trigger for one track/event:

PadNo.	#ch1	#ch2	#ch3	…	#chi
SignalValue	S_1	S_2	S_3		S_i

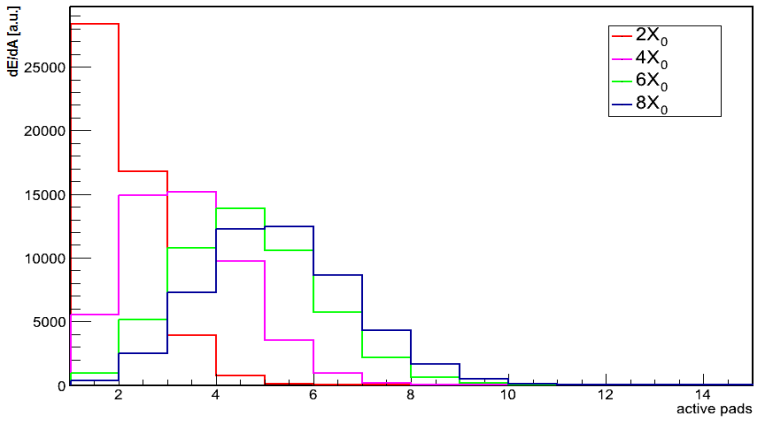
ContainerSignalSize ϵ [1, i], i = no. of active pads

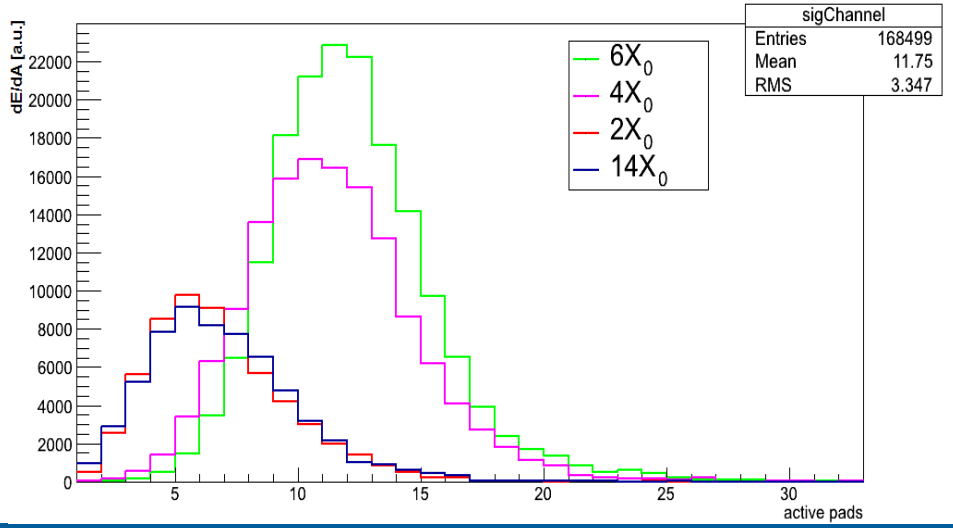
$S_1 \geq S_2 >= S_3$…,



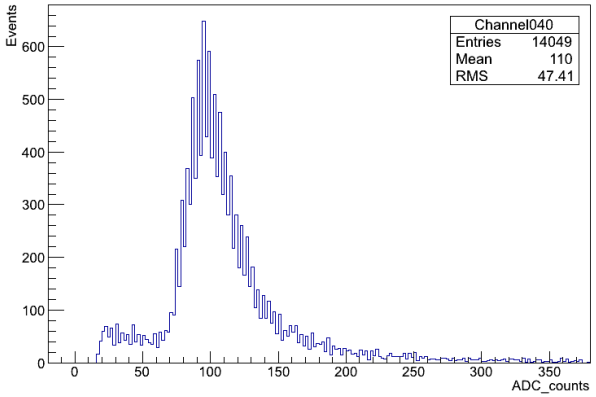
where:

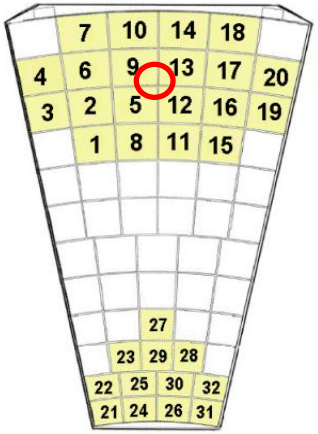
- S_1 is the max signal
- The pad with S_1 represent the shower center

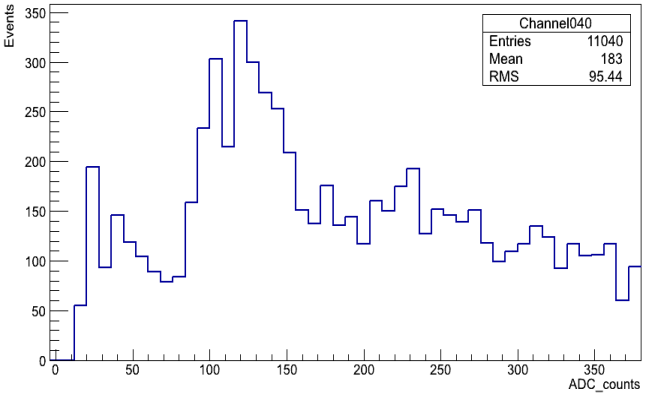


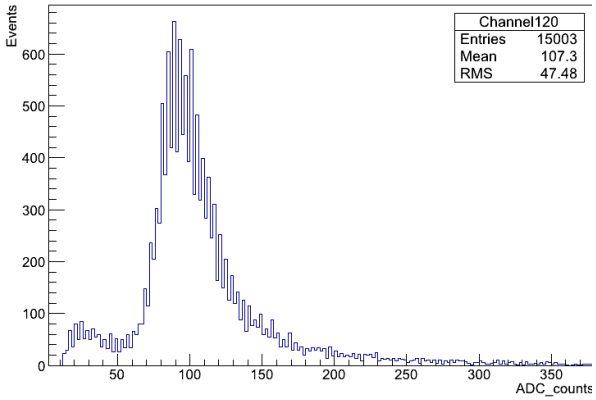


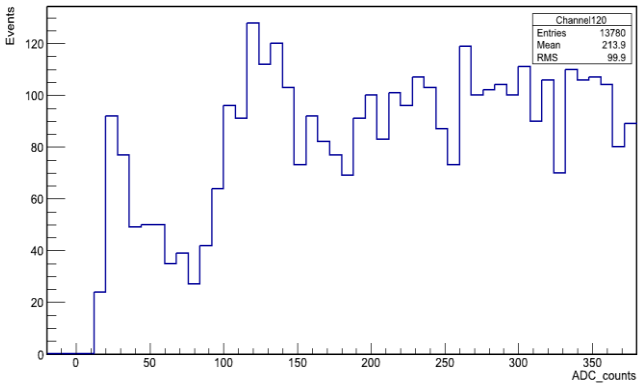
Signal distribution

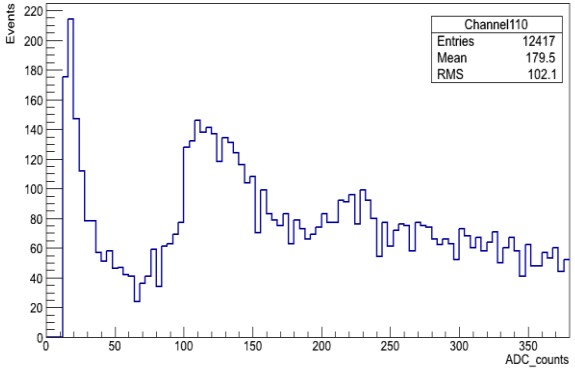








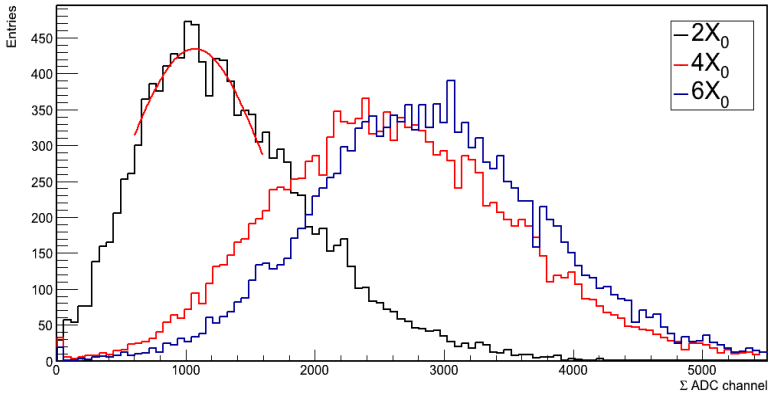




The Signal amplitude from one active pad, run used for uniformity study

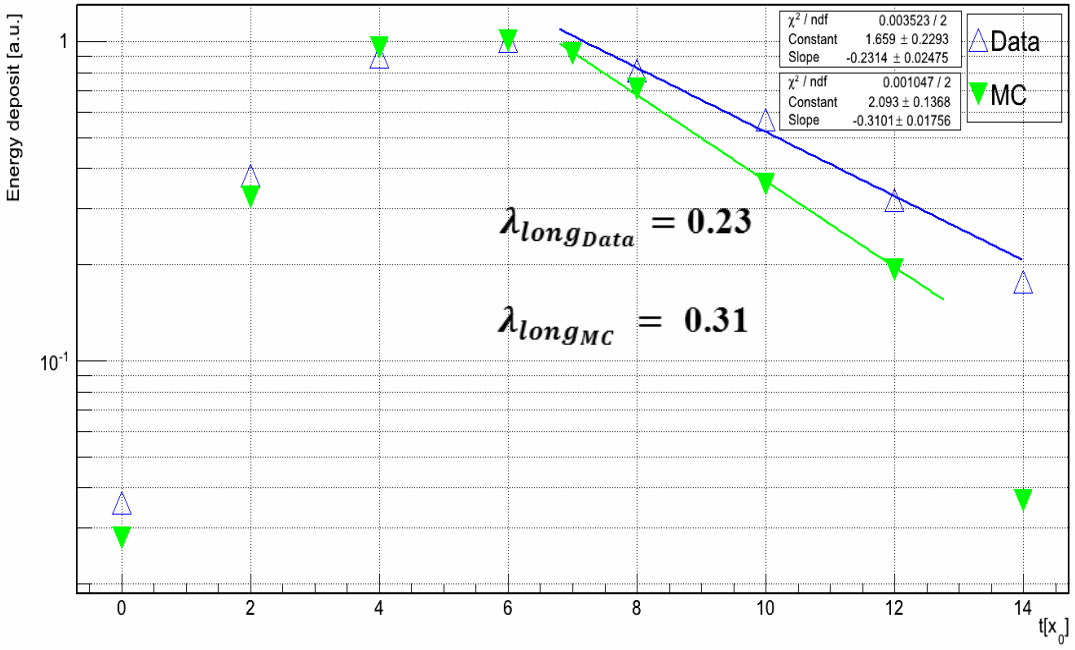
The Signal amplitude from one active pad, run used for shower study, the absorber thickness: $t = 4X_0$

Longitudinal shower distribution

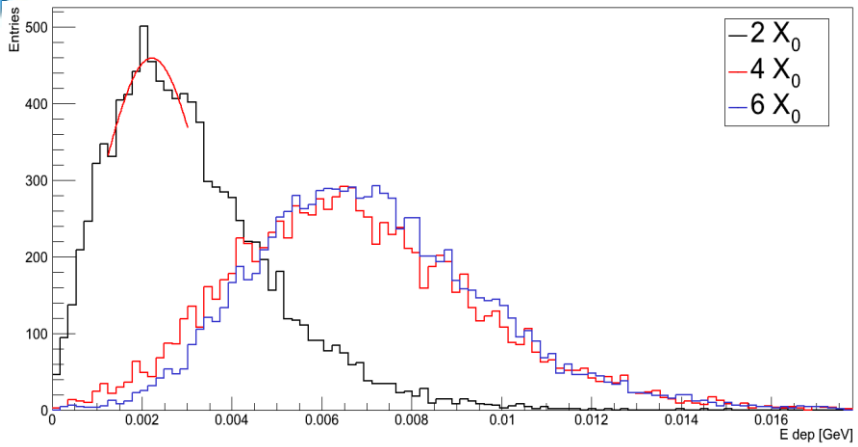


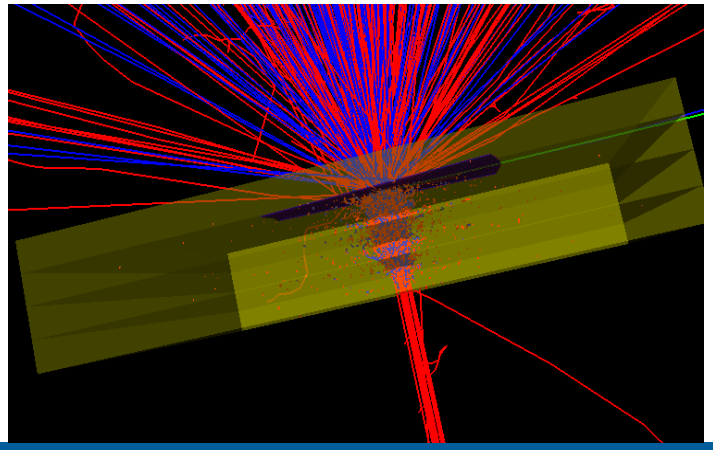
$\mathbf{f}(S_{total}) = \ldots$

$S_{total} = \sum S_i$; where i – active pads

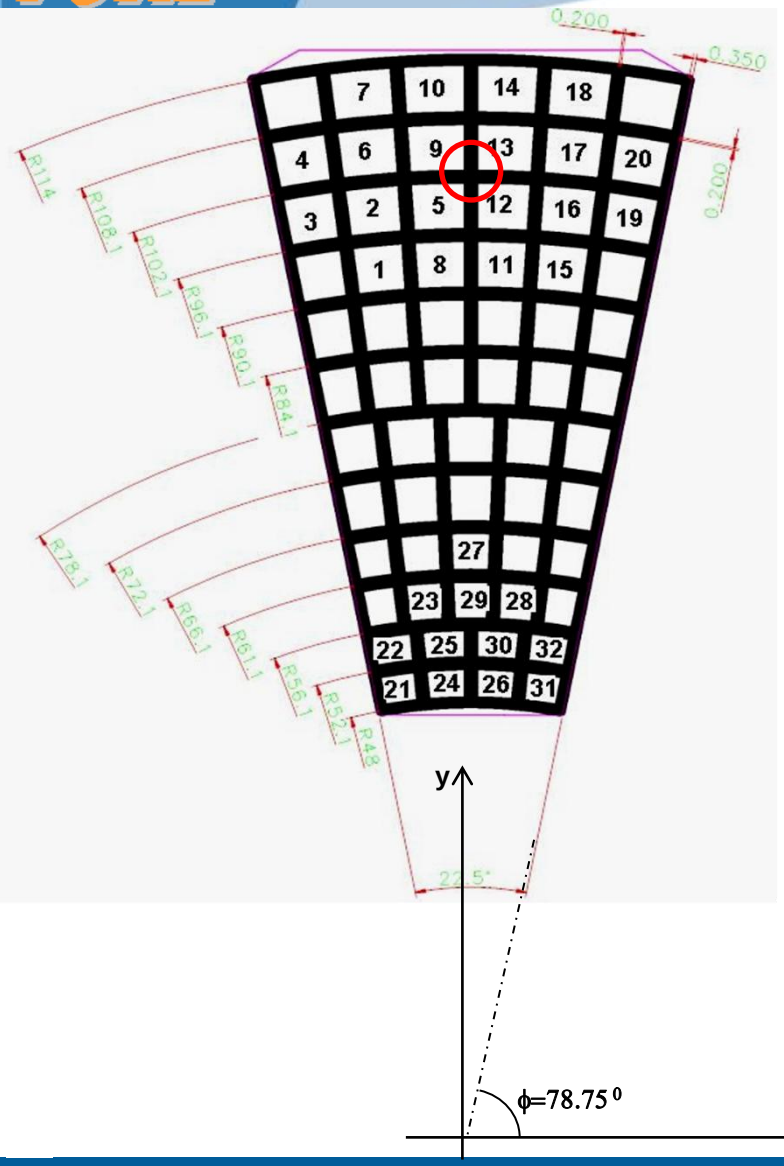


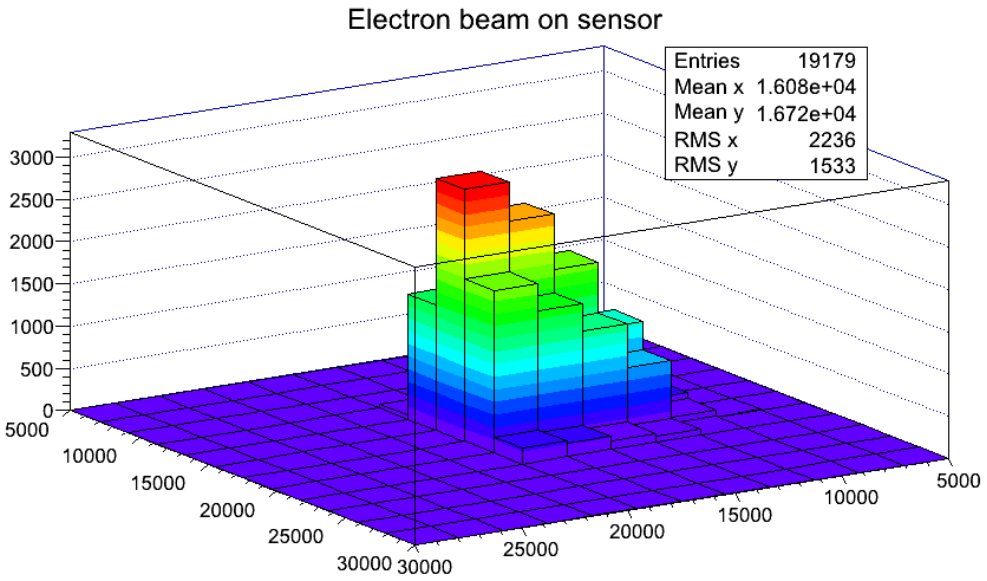
The energy deposited dependence by tungsten radiation lengths for experimental data and MC simulation, respectively

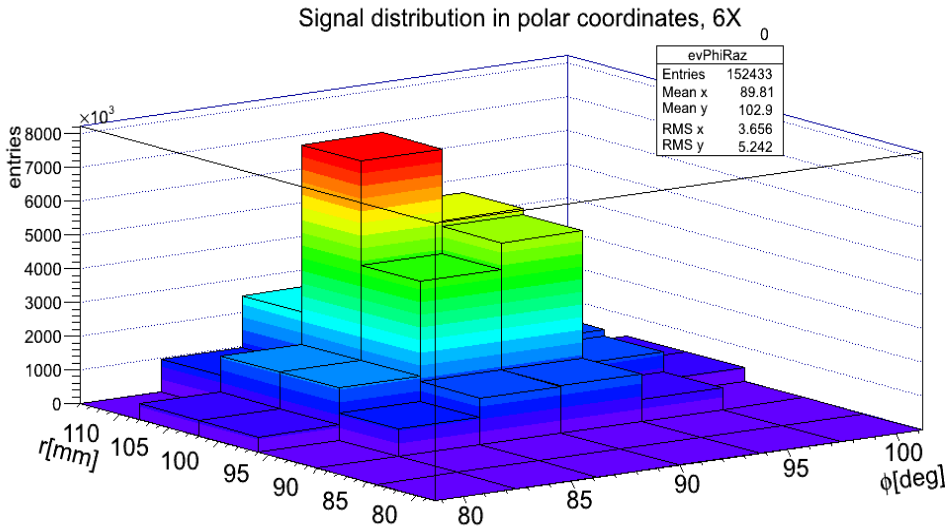




Radial shower distribution

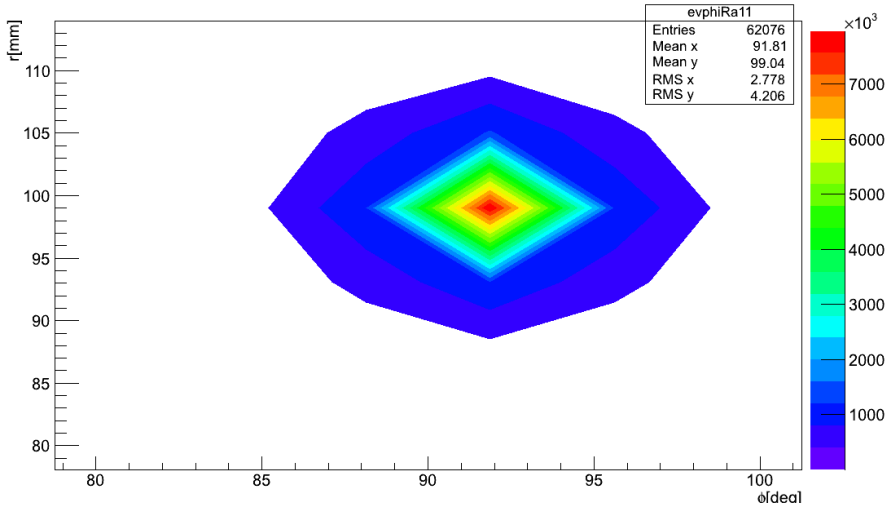


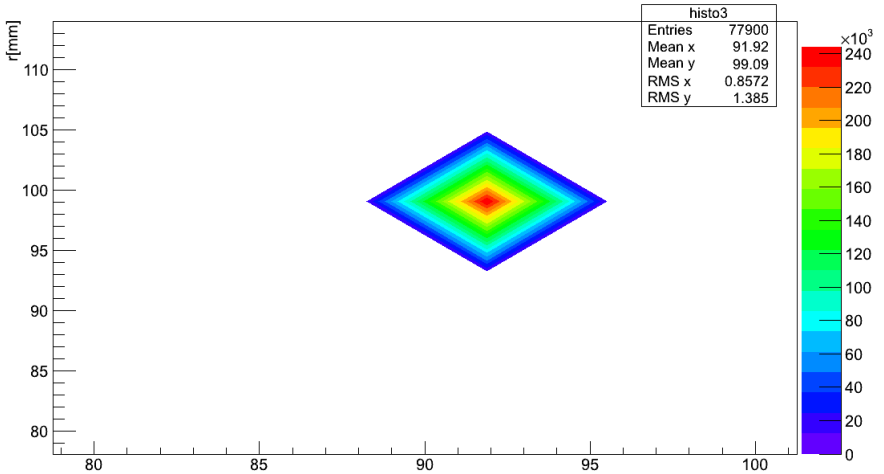


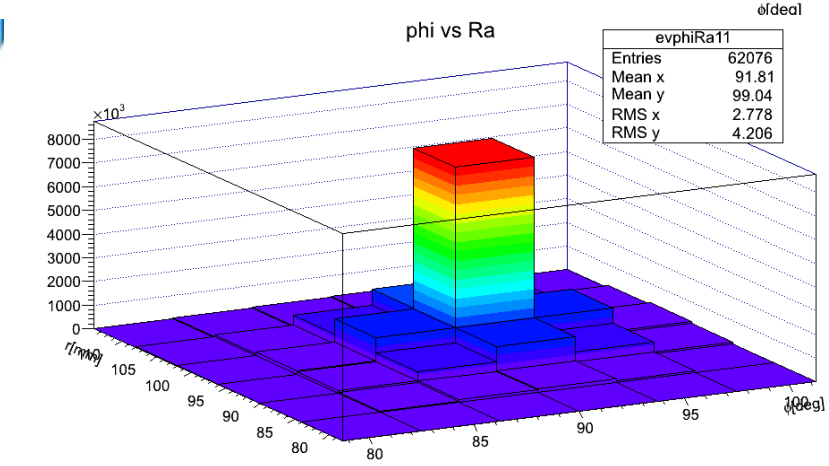


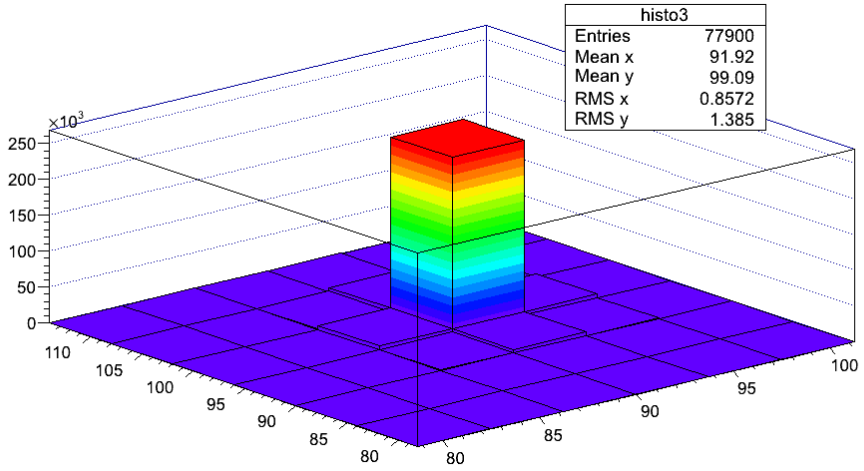
Radial shower distribution

Shower distribution of the experimental data and MC simulation, respectively for $t = 2X_0$ using $R(\Delta r)$ and $T(\Delta\varphi)$

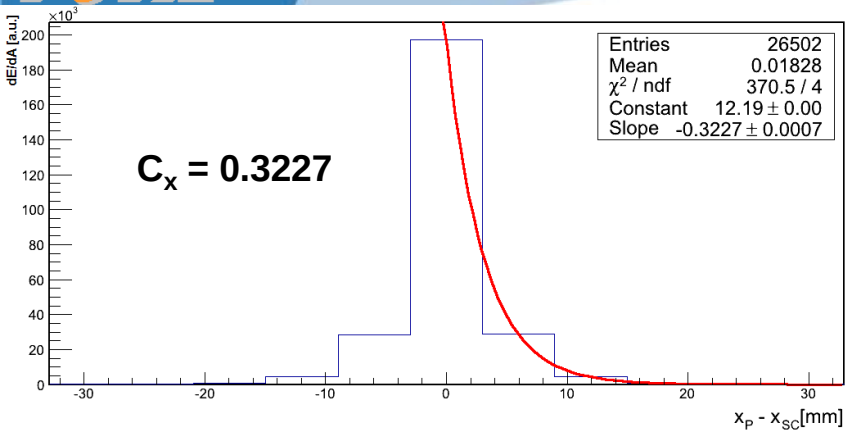






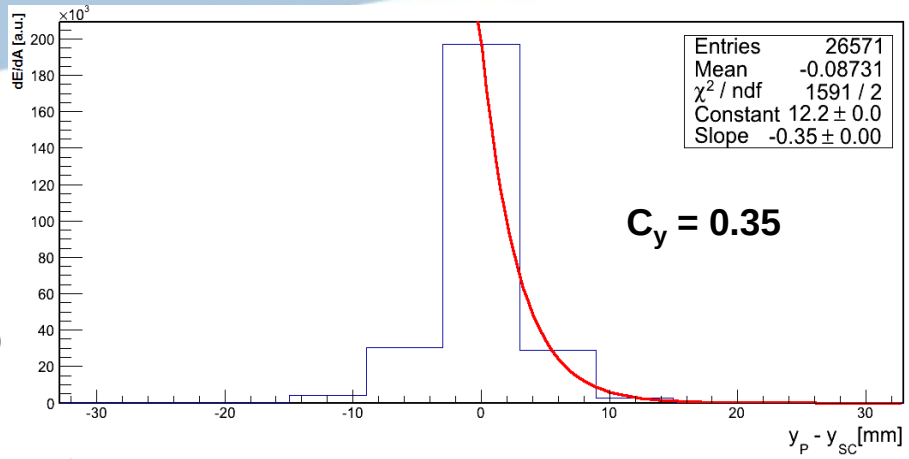


X and Y intensity shower distribution

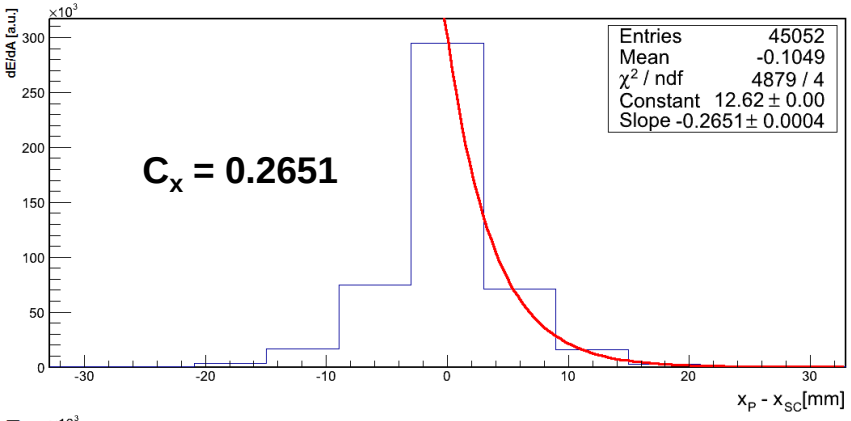


$C_x = 0.3227$

$t = 2X_0$

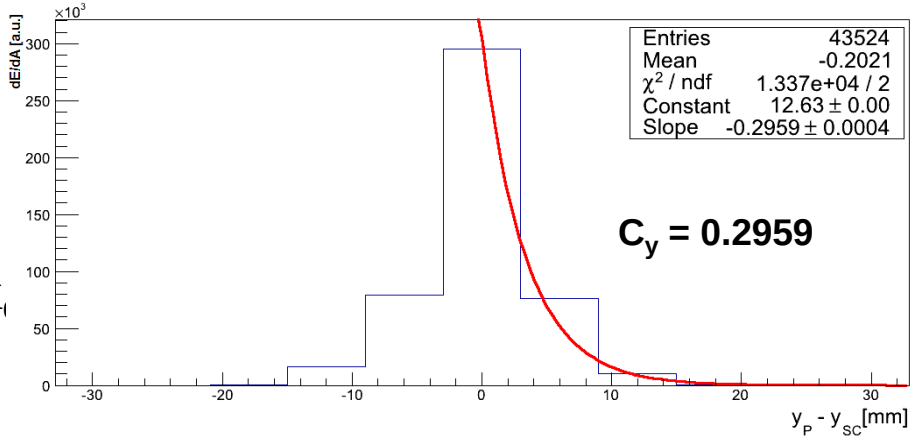


$C_y = 0.35$

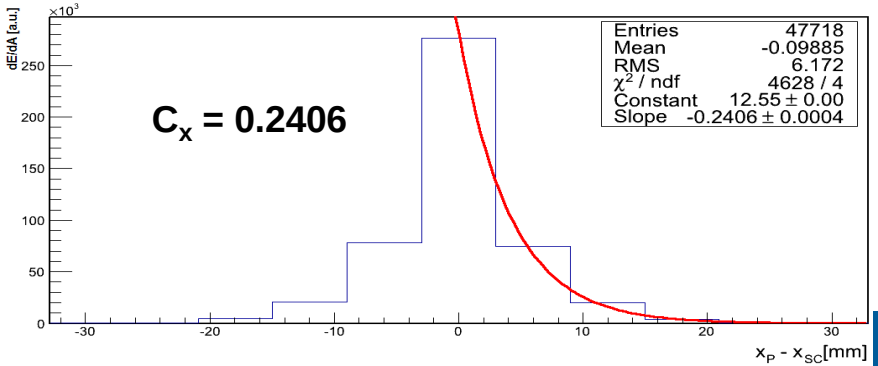


$C_x = 0.2651$

$t = 4X_0$

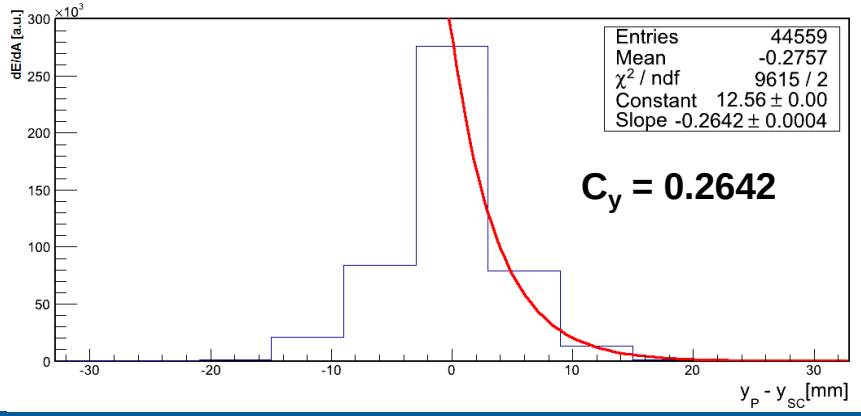


$C_y = 0.2959$



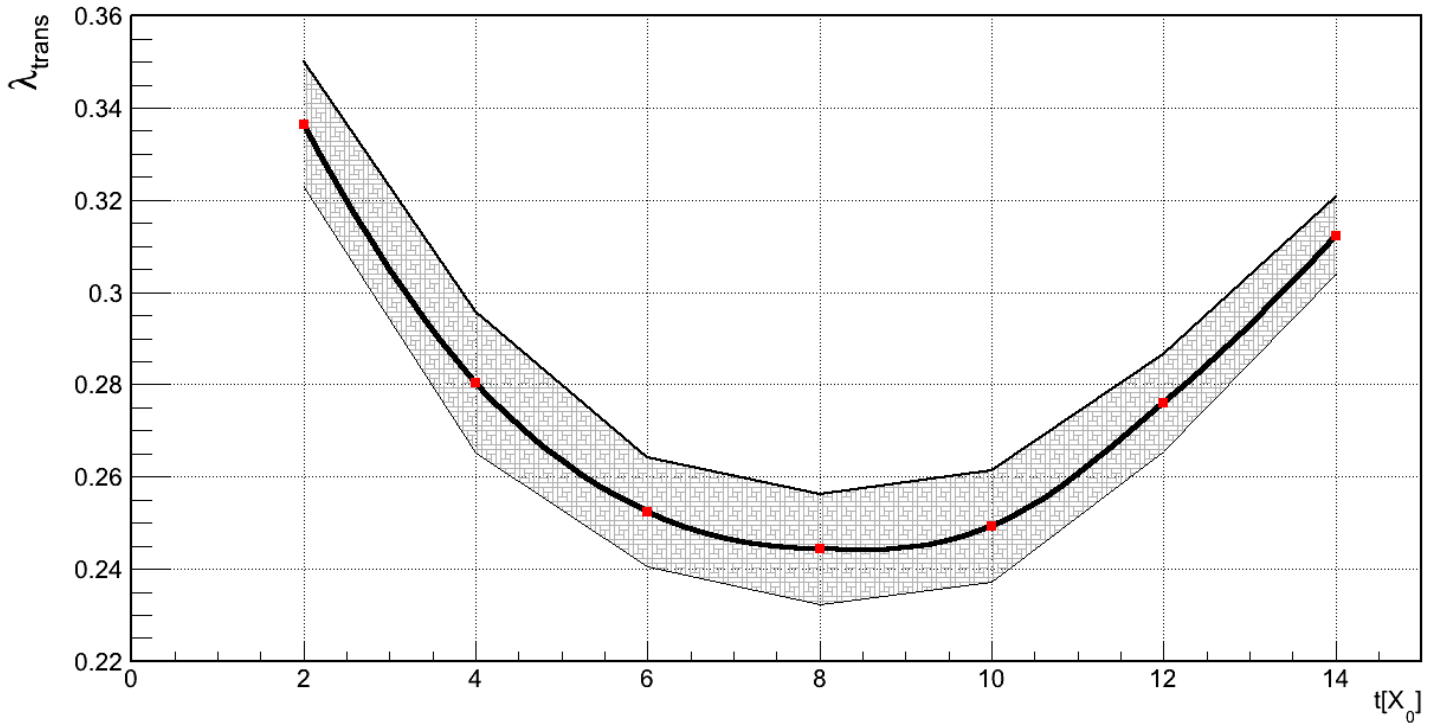
$C_x = 0.2406$

$t = 6X_0$



$C_y = 0.2642$

Radial attenuation coefficient



The transversal EM shower coefficient (λ_{trans}) for experimental data vs tungsten radiation lengths

Conclusion

✓ It was developed the methodology for the shower data analysis;

✓ For Signal management was used the same algorithm like in previously analysis;

✓ Longitudinal and radial EM showers dependence in tungsten with thickness between $2X_0$ to $14X_0$ were studied ;

✓ Longitudinal and radial EM shower attenuation coefficients were evaluated;

✓ Experimental data results were compared with a very preliminary MC simulation. This comparison has suggested that a cross effects on sensor have a big influences;

✓ New testbeam with layers of Tungsten, more GaAs sensors and more beam particles energies are needed;

THANK YOU FOR ATTENTION!