TIME PERFORMANCES OF THE LIQUID KRYPTON CALORIMETER OF THE NA48 EXPERIMENT

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TIME MEASUREMENT IMPORTANCE IN NA48

- The aim of the NA48 experiment is the measurement of the ratio between **direct** and **indirect** CP violation in the neutral kaon system with a precision of $\approx\ 2.10^{-4}$ through :

$$Re(\frac{\epsilon'}{\epsilon}) = \frac{1}{6}(1 - R)$$

with

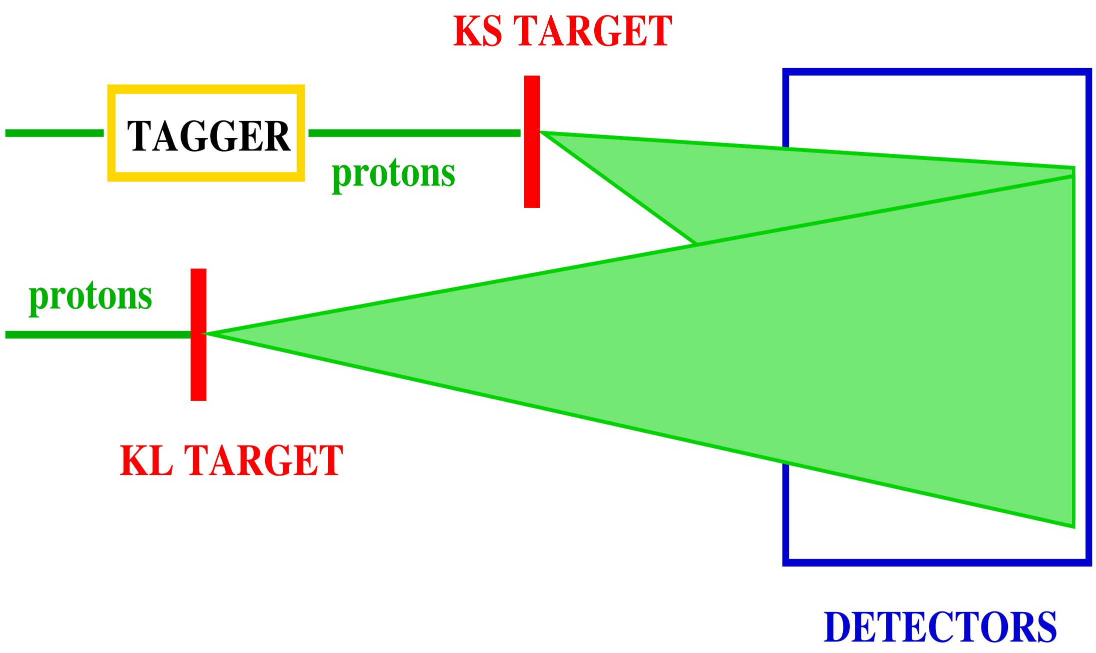
$$R = \frac{N(K_{Long}\to\pi^0\pi^0).N(K_{Short}\to\pi^+\pi^-)}{N(K_{Short}\to\pi^0\pi^0).N(K_{Long}\to\pi^+\pi^-)}$$

- To minimize the systematic effects of this measurement, the NA48 collaboration has chosen to detect concurrently and in the same fiducial volume the four decay modes of the neutral kaons.

$\Longrightarrow$ This implies that we need an accurate method to determine the nature of the kaon which is at the origin of the decay otherwise the measure of R will be biased !

KAON TAGGING

- **Principle**



- **Neutral or charged decays**

  The nature of the kaon can be identified using time coincidences between the tagger and the other detectors.
  Tagger : time of the protons leading to the K_S beam (resolution $\approx$ 200 ps).
  Charged hodoscope and the spectrometer : time of charged modes (hodoscope resolution $\approx$ 250 ps).
  LKr calorimeter and the neutral hodoscope : time of neutral modes (resolution $\approx$ 250 ps).

- **Charged decays**

  For charged decays, the identification of the kaon is also possible using the reconstruction of the vertex by the spectrometer (the two beams are separated vertically by 7 cm).

TIME MEASUREMENT WITH THE LKR CALORIMETER : 1996 RESULTS

Mistagging of kaons :

- K_L taken as K_S : fortuitous coincidences between a proton measured by the tagger and a K_L.
- K_S taken as K_L : detectors inefficiency $\rightarrow$ DANGEROUS, change R : the effect is a priori different for neutral and charged modes.

$\leadsto$ To measure ϵ'/ϵ with a precision of $\approx 2.10^{-4}$ we need to know the mistagging of the kaons at the 10^{-4} level.

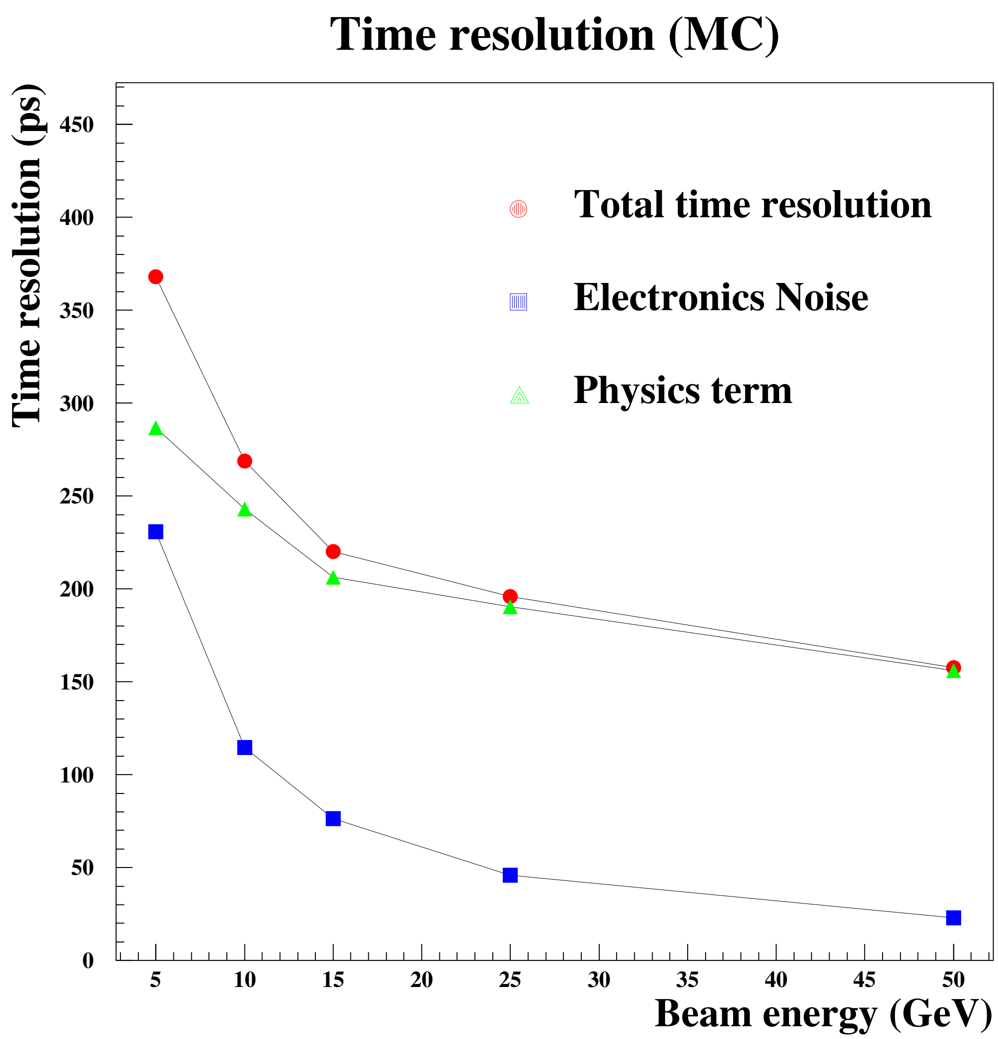
$\Longrightarrow$ We need a **very good time resolution** for our detectors and we need to understand **tails of time distribution at a level of** 10^{-4} to control respectively fortuitous coincidences and detectors inefficiency !!

$\leadsto$ The time study with 50 GeV electrons for the LKr calorimeter is presented here : MC expectations, signal presentation, time measurements and results over 384 cells (/13500) read with final electronics.

EXPECTATIONS ON TIME RESOLUTION (MC)

$\rightsquigarrow$ Main contributions to time resolution :

- Electronics noise : 11 MeV
- Physics term (essentially anode effect)



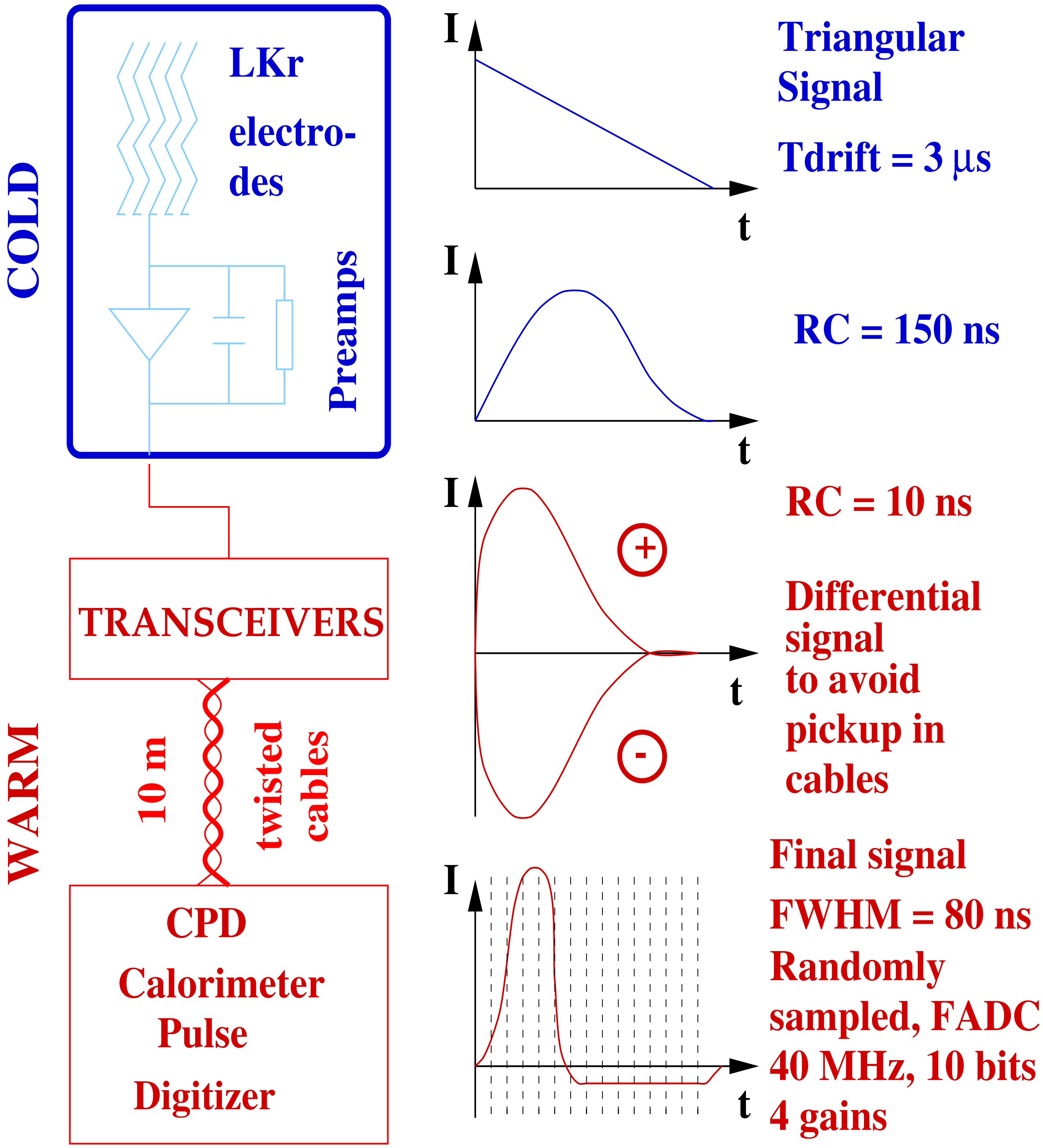
$\rightsquigarrow$ Other effects :

$$Time \approx \frac{5t_{Drift}}{1+\frac{t_{Drift}}{\tau_{Shaping}}} \Longrightarrow \quad \sigma(Time) = 5\left(\frac{\tau_{Shaping}}{t_{Drift}}\right)^2$$

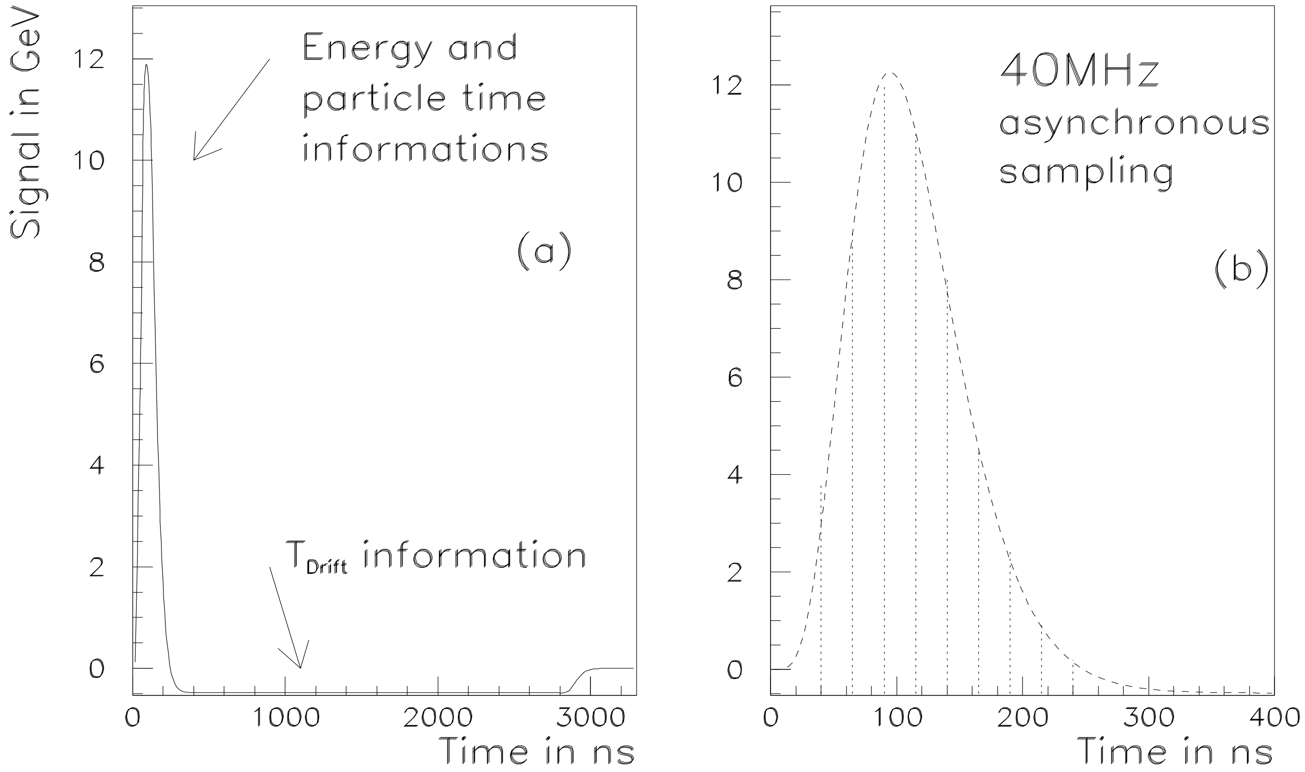
$$\Longrightarrow \quad \tau_{Shaping} \searrow \quad \Rightarrow \quad \sigma(T) \searrow$$

$$\Longrightarrow \quad t_{Drift} \nearrow \quad \Rightarrow \quad \sigma(T) \searrow$$

CALORIMETER ELECTRONICS



READING THE SAMPLED SIGNAL



$\rightsquigarrow$ Energy : maximum of the signal

Time : position of this maximum

$\rightsquigarrow$ As the signal is randomly sampled, its maximum does not correspond in general to a sample.

$\Longrightarrow$ we need a method to reconstruct the maximum and its position.

Method : parabola interpolation

Samples used : max, max+1 and max-1.

Signal not parabolic $\rightarrow$ E and Time measured are biased.

This bias ($\approx 2\ ns$) varies with the phase (= time position of the signal / clock samples).

TIME CORRECTIONS

⇝ The raw time obtained with parabola interpolation needs some corrections (for reconstruction, physics or electronics effects) :

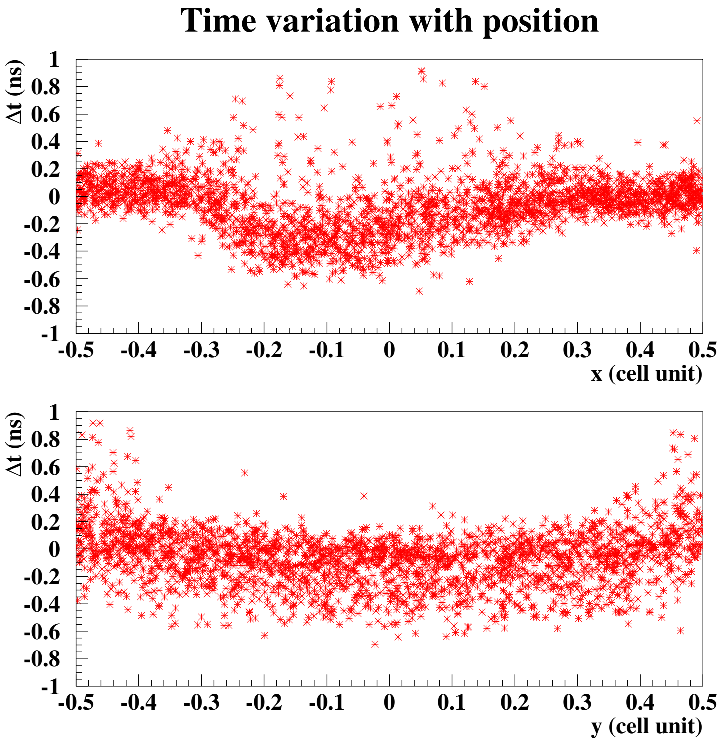
Note : Time resolution calculated on (to cancel the 25 ns phase incertitude) :
time (most energetic cell) - time(most energetic lateral cell).

Alignment :
Spread (≈ 3 %) of electronics components $\rightarrow$ need of time calibration. Alignment made from cell to cell.

Correction of the parabola bias :
The bias due to the parabola method is computed using calibration data.

Correction of the anode effect :

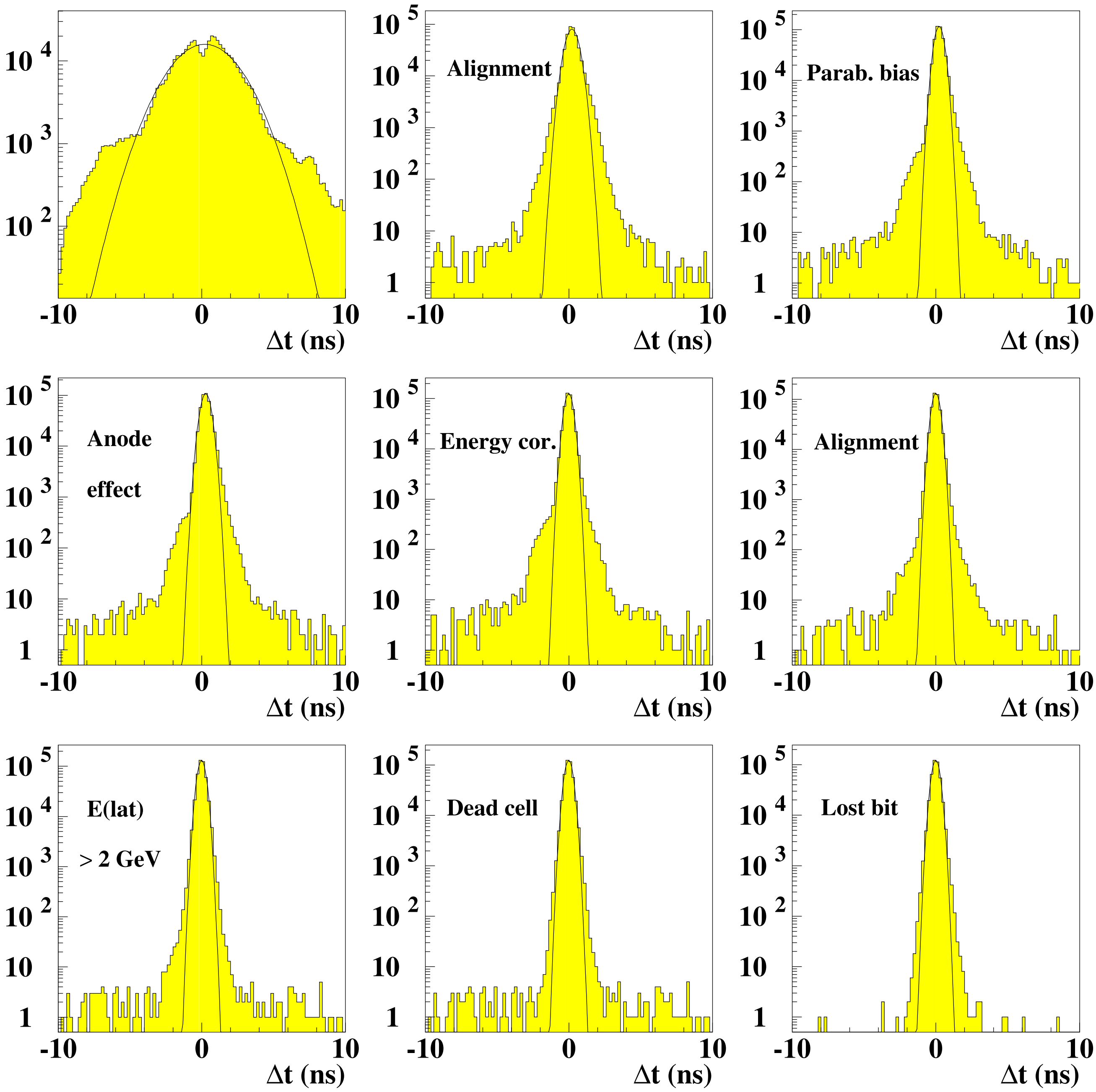
When a particle develops a shower near the anode, the shaping time could be larger than the drift time of some electrons. The signal is then distorted so that the reconstructed time decreases.



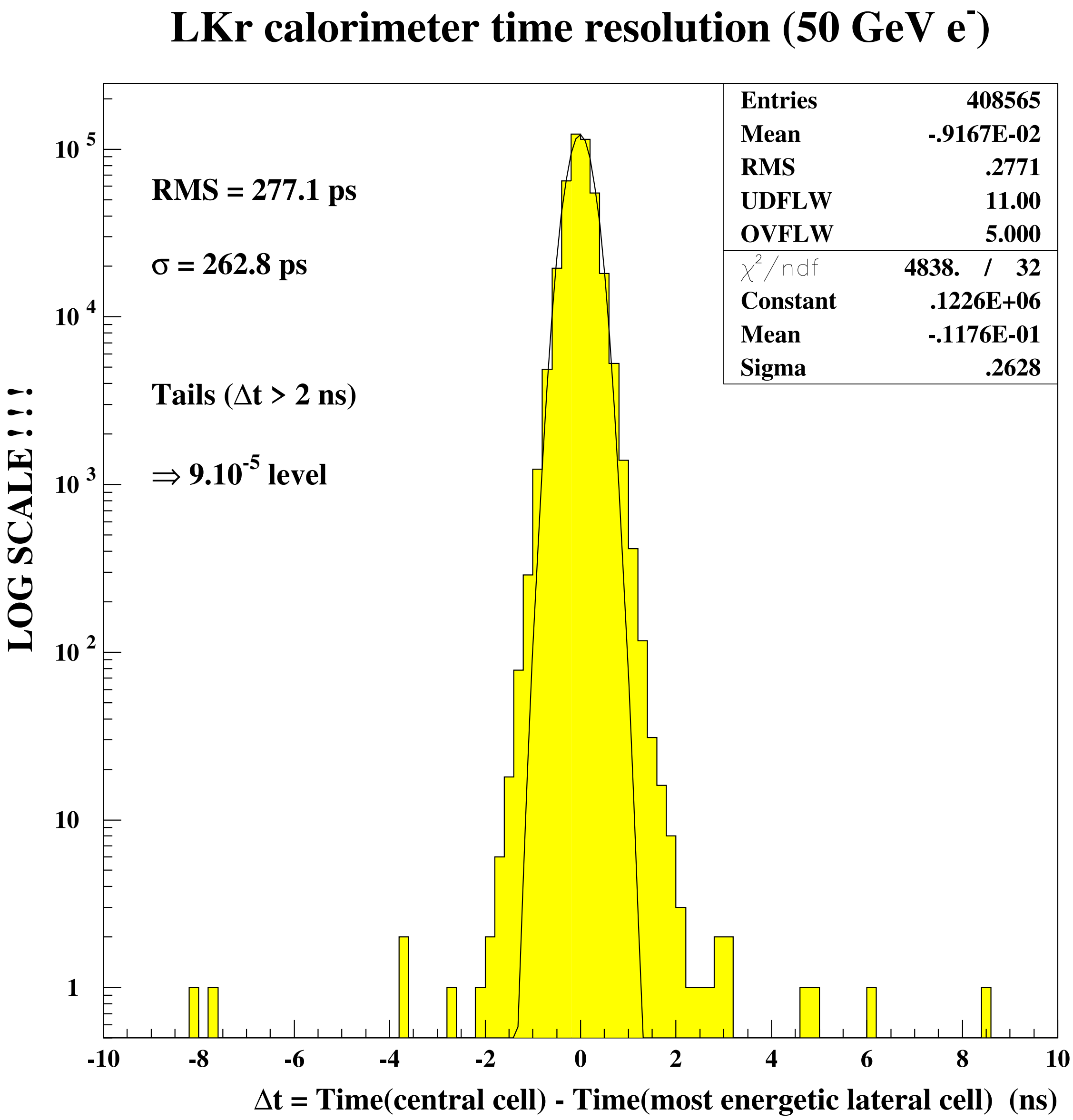
EVOLUTION OF THE TIME RESOLUTION AND TAILS

- Previously described corrections.
- Phenomenological correction as a function of energy has been applied.
- Alignment iteration, and particular electronics problems like dead cell or lost bits are taken into account.

Evolution of resolution and tails



FINAL TIME RESOLUTION AND TAILS

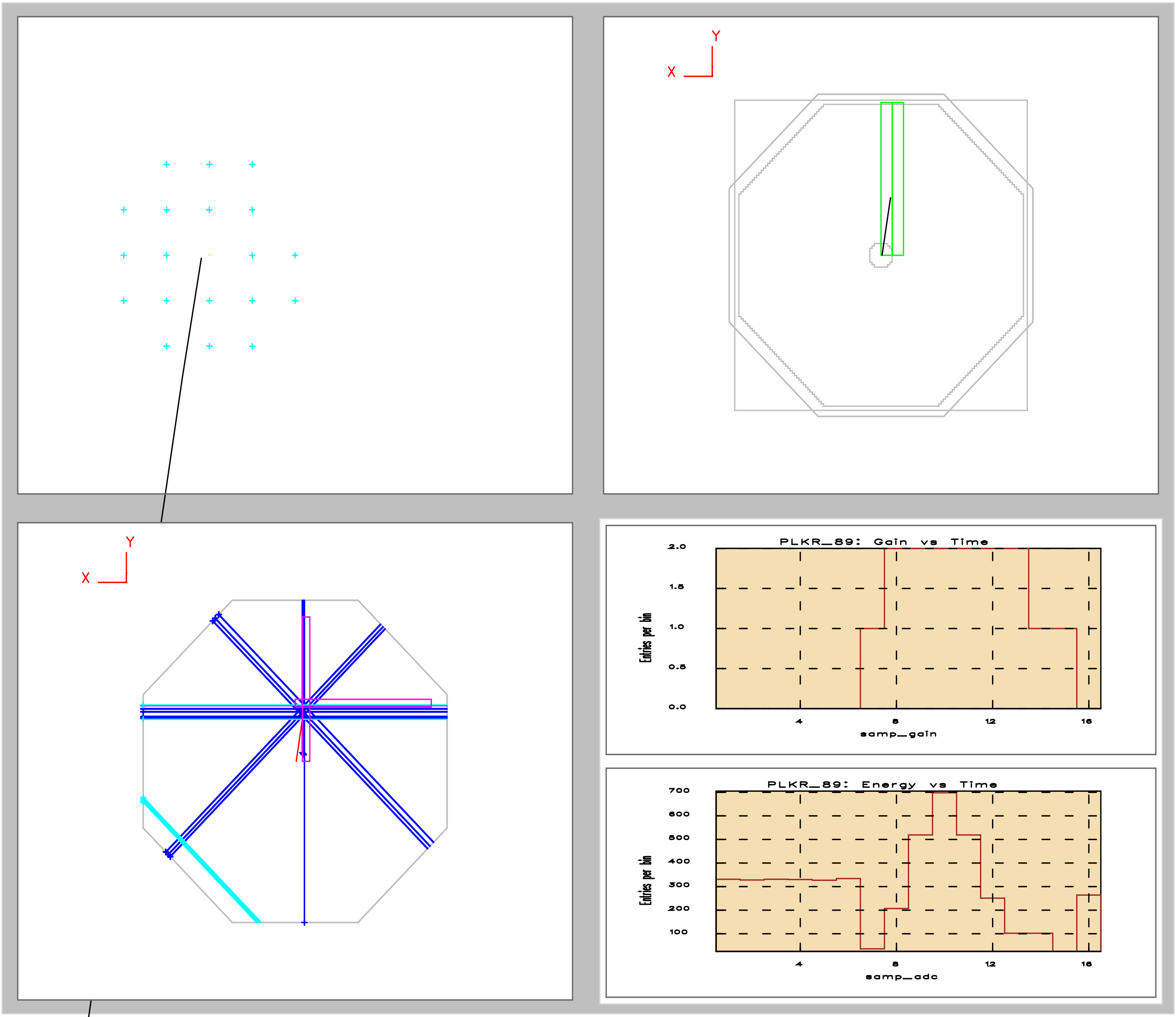


- A resolution of less than 300 ps has been obtained for the time difference between two cells (not independent). 300 cells have been taken into account.

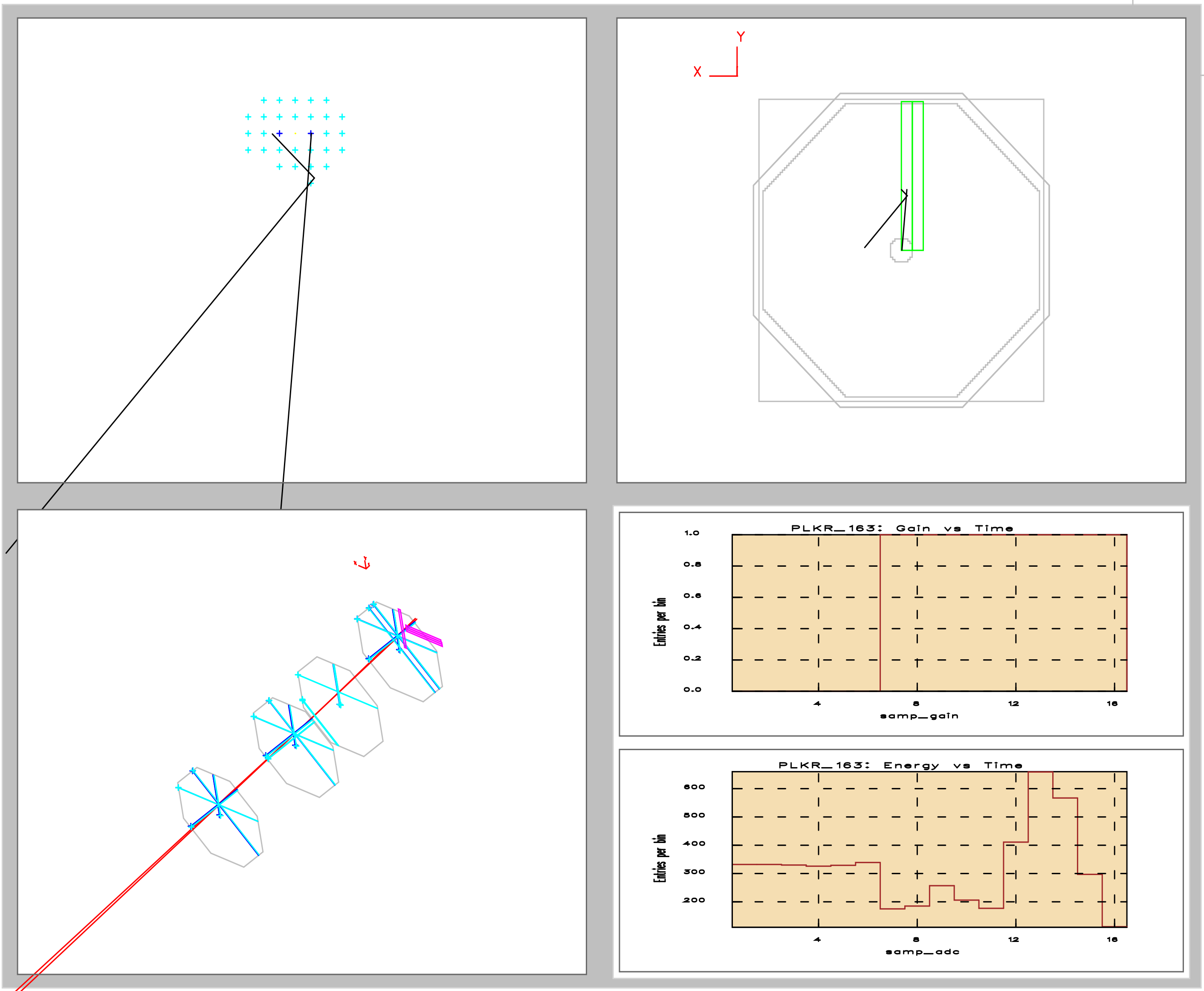
- Tails (9.10^{-5}) level : mainly accidentals and some remaining known electronics problems (lost bit ...).

$\Rightarrow$ NO TAILS LEFT !!!

EXAMPLE OF A GOOD EVENT



EXAMPLE OF AN ACCIDENTAL EVENT



CONCLUSION

Time performances of the LKr calorimeter:

- Time resolution : better than 260 ps measured on : time(hit cell) - time(lateral cell)

- Tails : $< 10^{-4}$ level $\rightarrow$ understood : mainly accidentals.

$\Longrightarrow$ The time performances of our calorimeter correspond nicely to our expectations !

WAITING FOR NEXT DATA TAKING !