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MEG実験用液体キセノン検出器における デジタル波形処理を用いたガンマ線測定 技術の開発研究

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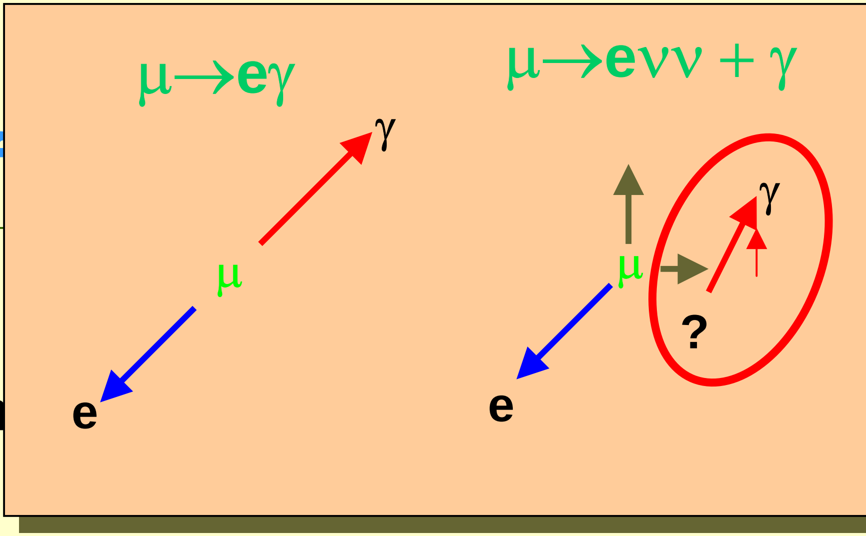
  - Templates and time resolution
  - Pulse Shape Discrimination
  - Pile-up rejection
- Summary

In the MEG experiment
every PMT will be read by
a fast waveform digitizer
for the best use of



- reject pile-up of γ-rays
- timing and energy measuremen
- particle identification

Crucial for the MEG experiment and very difficult without waveform image

Major background
- Prompt background
- Accidental background

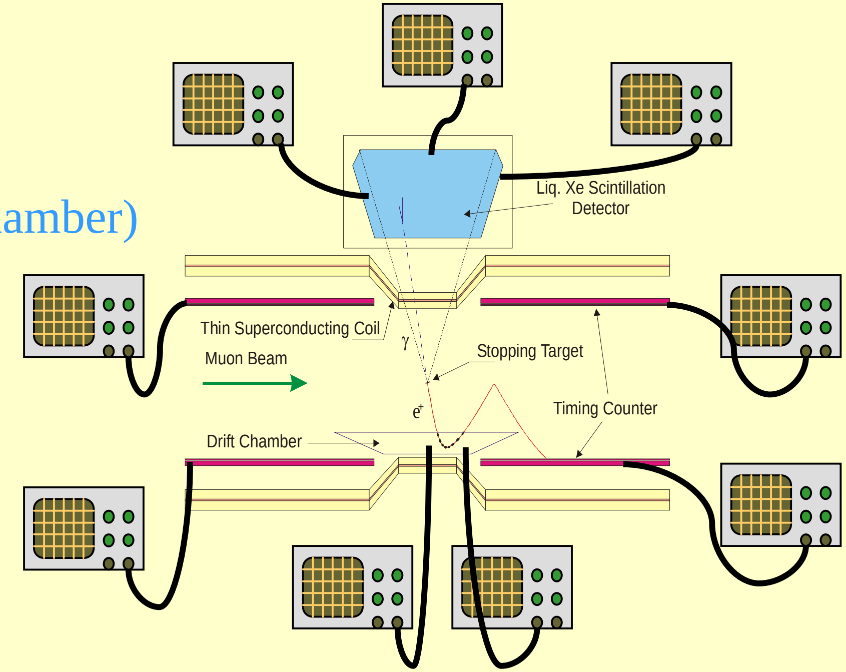
Without waveform separate only spatially if > 2 PMTs apart (15 cm)

pulse shape separation

Requirements

- TDC resolution 40ps ⇨2.5GHz(400ps)
- ADC resolution 12bits
- 3000 channels

(Xe calorimeter, Timing counter, Drift chamber)

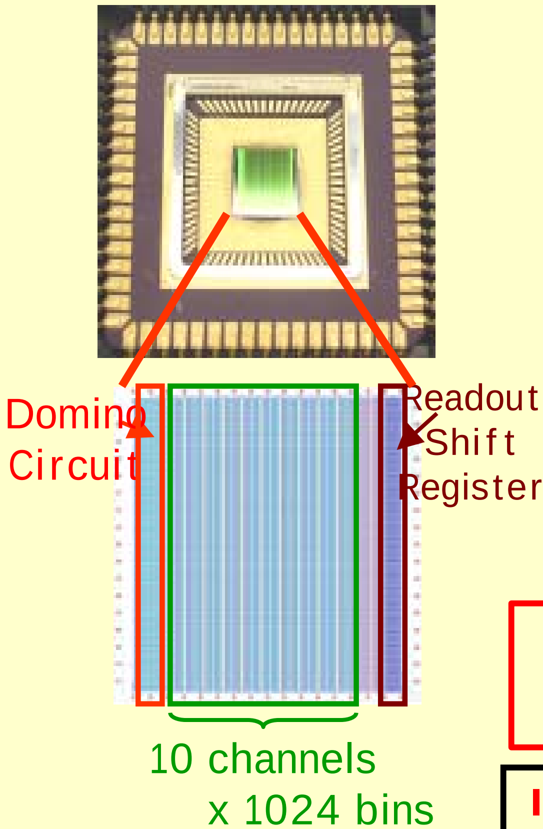


Cheap & fast waveform digitizer

Domino Ring Sampler (DRS)

Developed by **Stefan Ritt**

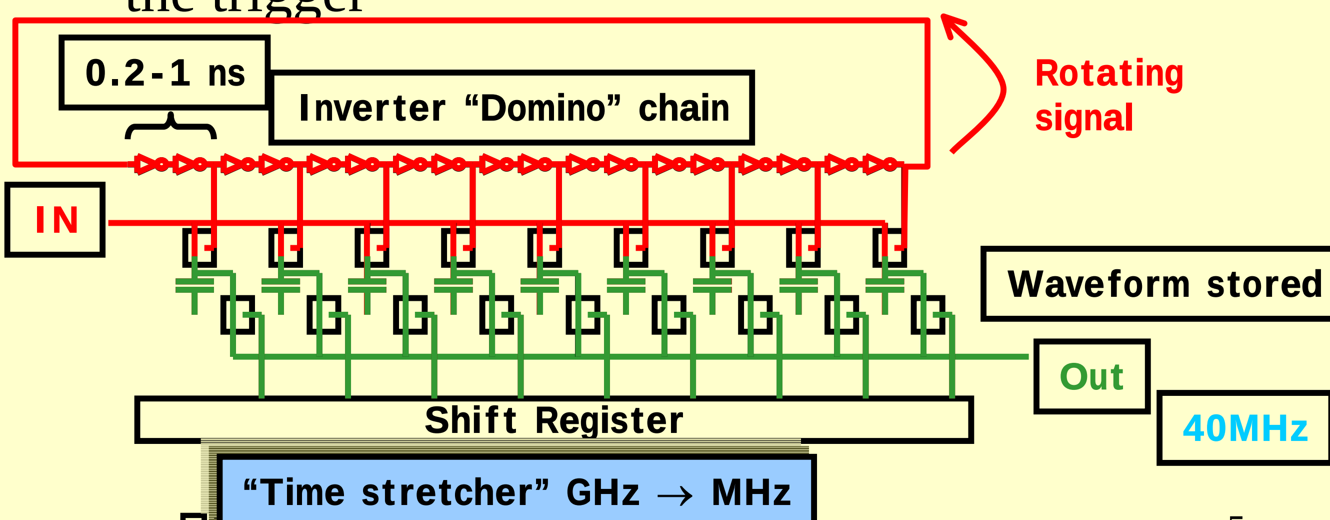
NIM A ***518****(2004) 470*



Analog sampling chip, switching capacitor circuits

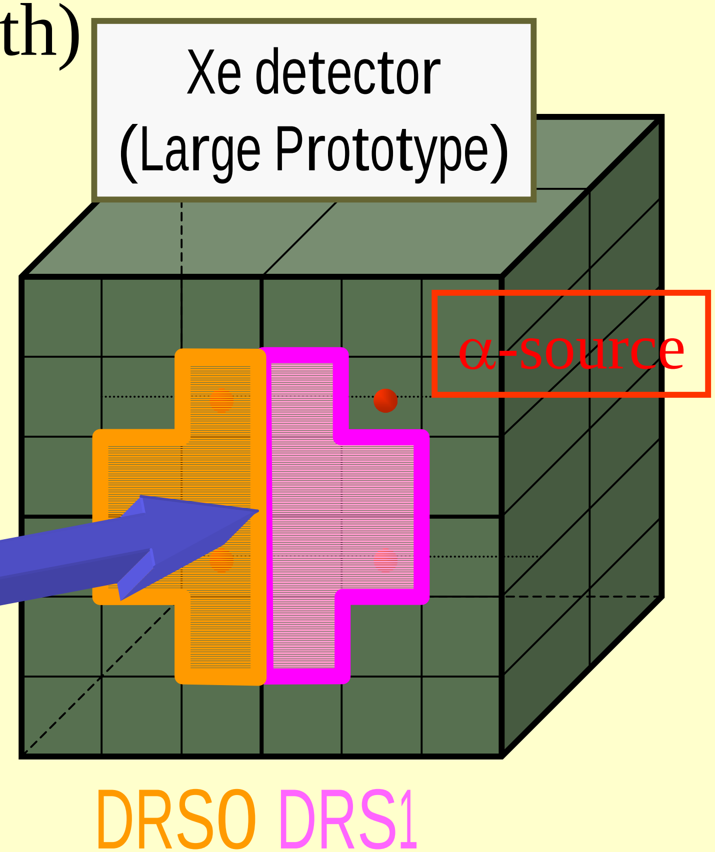
- Max sampling speed **4.5**GHz
- Sampling cells **1024**
- **8** data ch, **2** calibration ch(voltage and time) / chip
- Read out speed **40**MHz, **12**bits
- Domino wave runs continuously, only stopped by the trigger

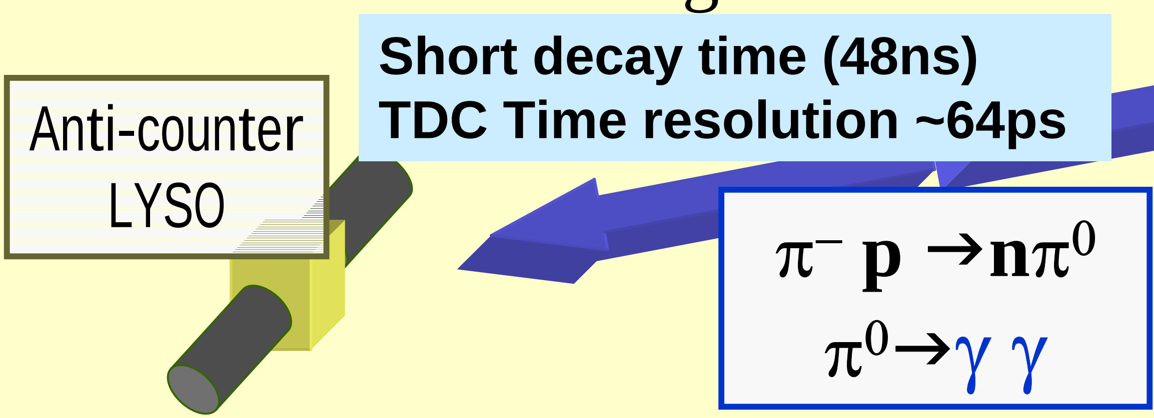
- **~¥10,000/chn**



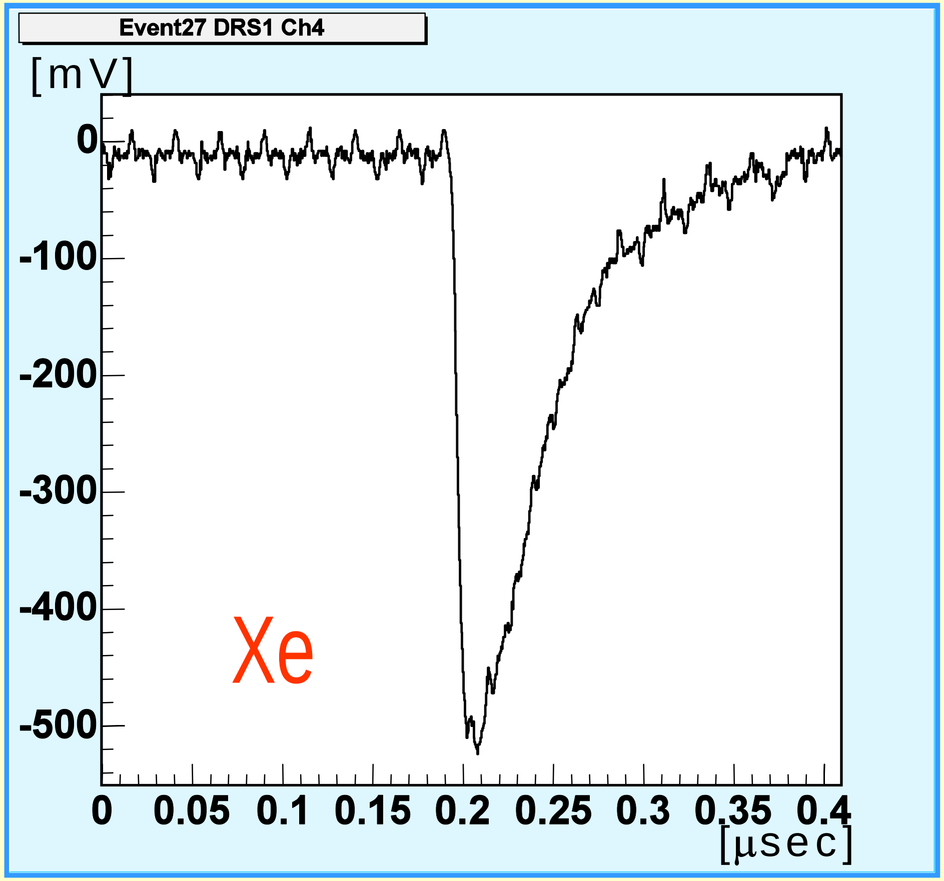
Two DRS chips installed and data taken in the beam test last autumn for the first time

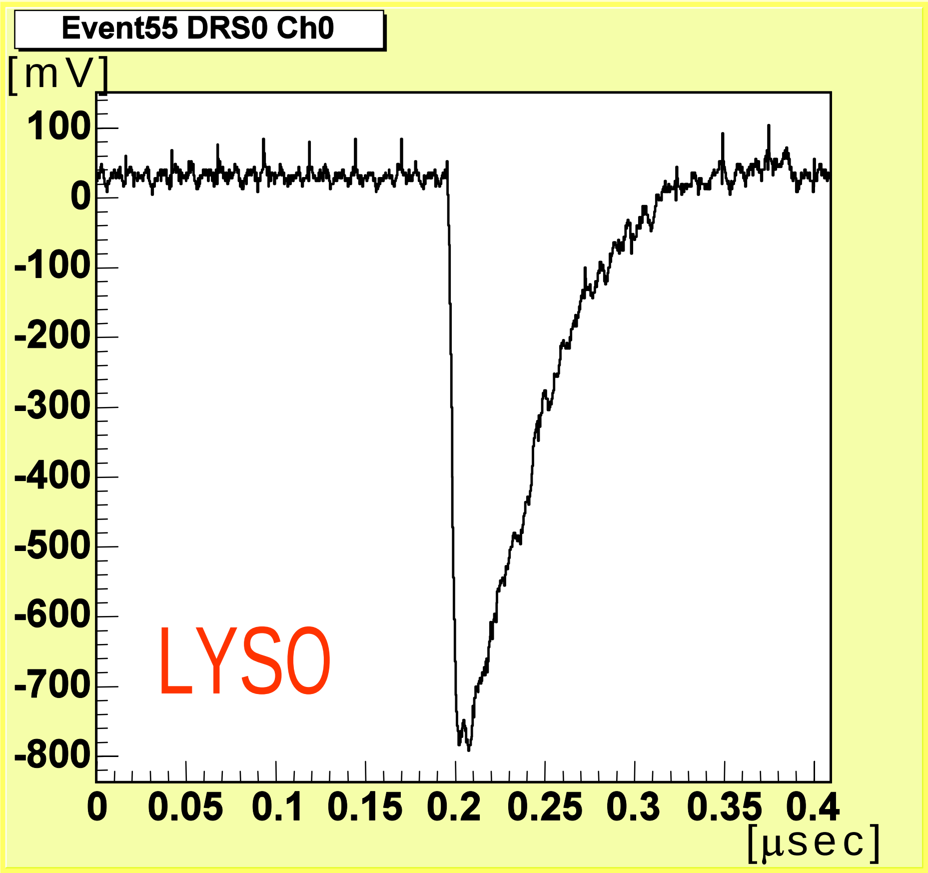
- 2.5GHz sampling (400ps bin width)
- 6×2 ch : Xe detector PMTs
  center 12PMTs on Front Face
- 2×2 ch : LYSO anti-counter
  for timing reference





Waveform





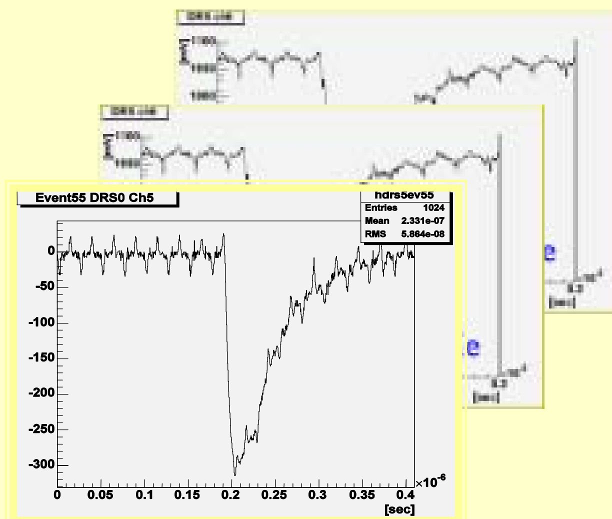
spike noise
related to the reference clock → Can be fixed
Redesign mezzanine board

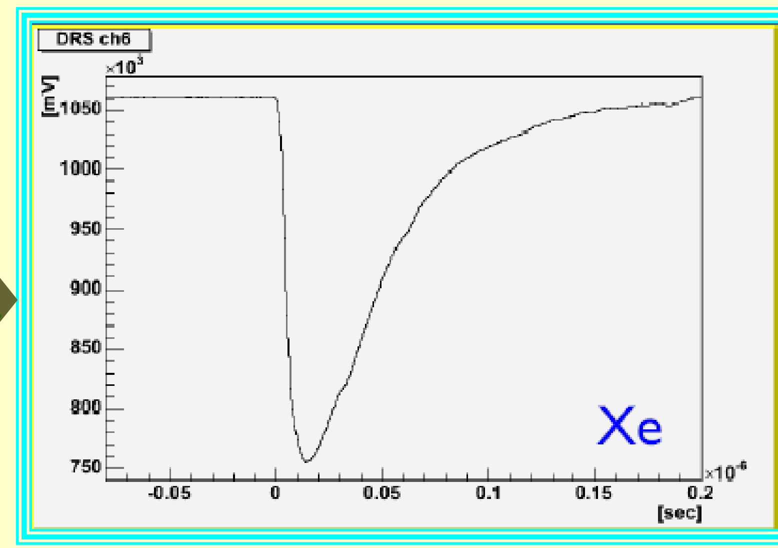
How to analyze these waveforms ?

Fitting takes so much CPU-time
Need some kind of devised way or different fast method

Averaged waveform

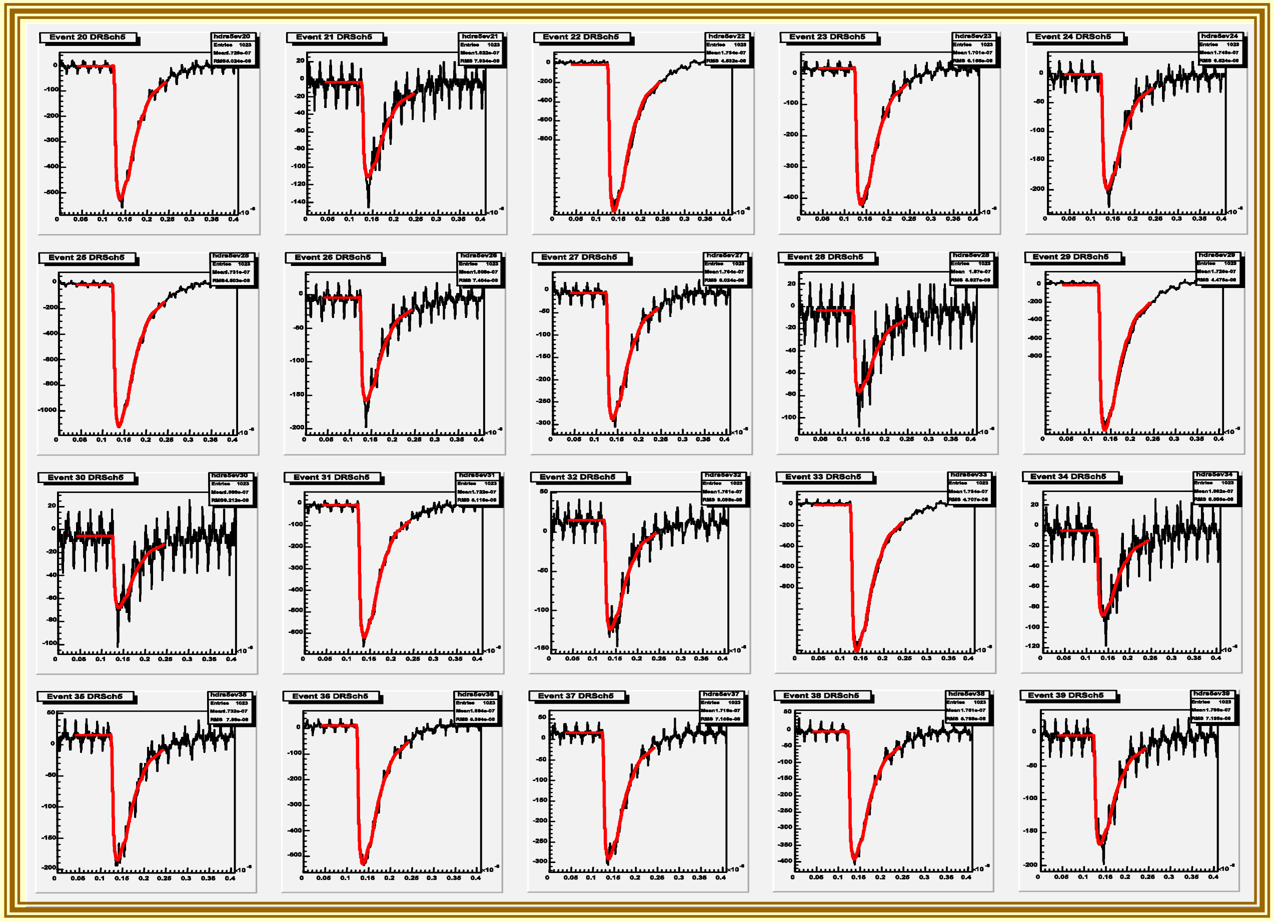
Assuming constant pulse shape





Now, able to use this template for fitting, for testing algorithm and for simulating pile-up

Fitting by the Template

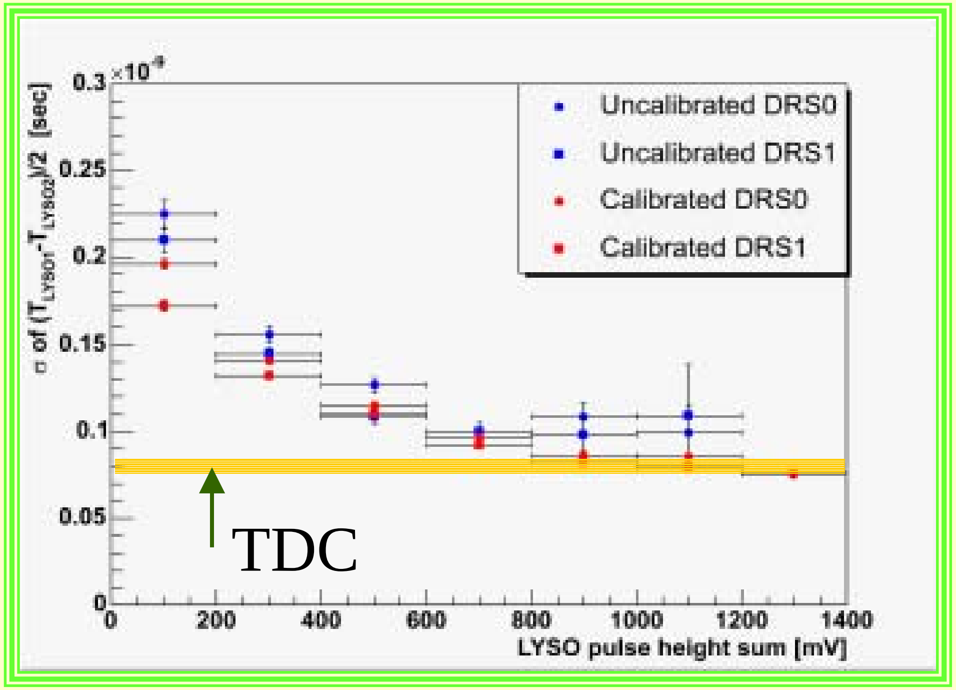


Well fitted
Constant Pulse shape

Time resolution

- **LYSO time resolution obtained by waveform fitting**

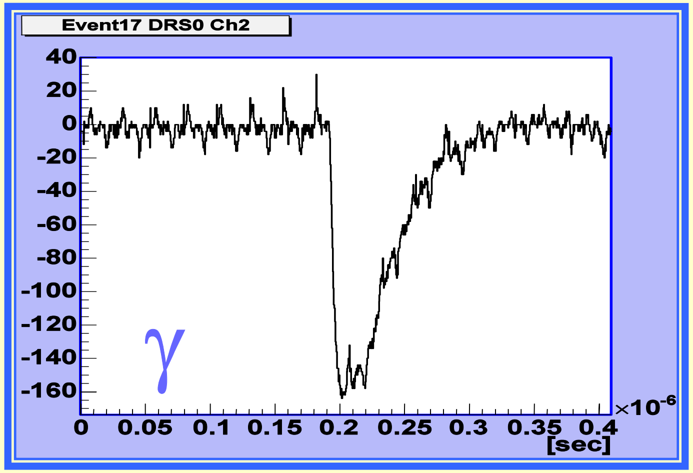
No time-walk correction is needed

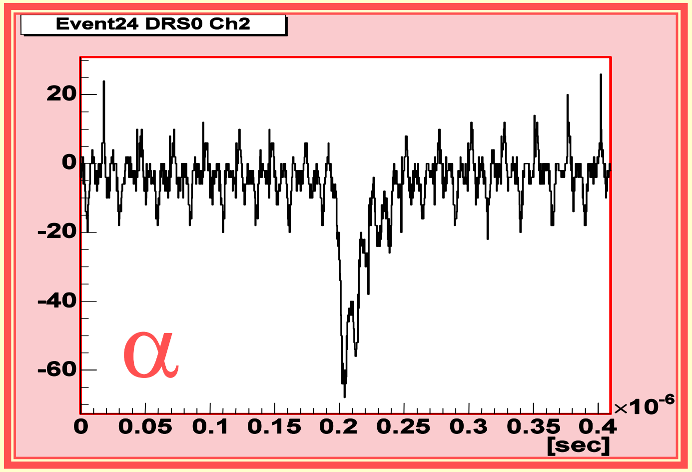


- LYSO time resolution is comparable to TDC analysis

Pulse Shape Discrimination

Decay time of scintillation light depend on the incident particle because of the difference in interaction way



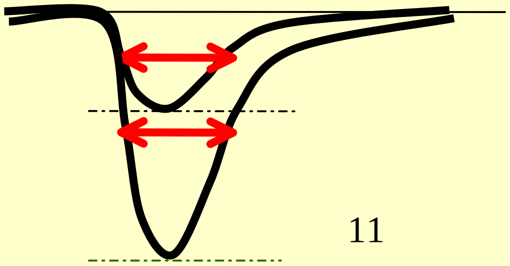


Pulse shape of alpha is much sharper

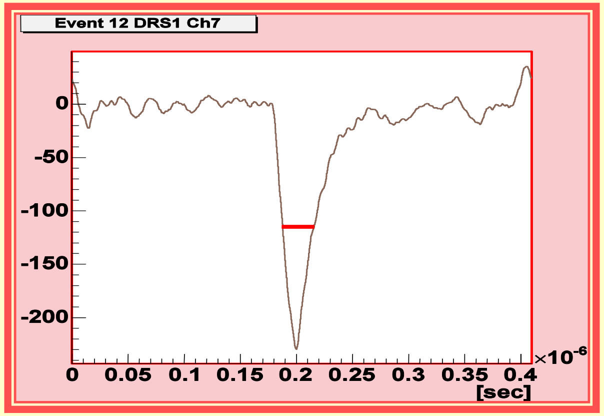
Decay time 45ns

Decay time 4.2ns, 22ns

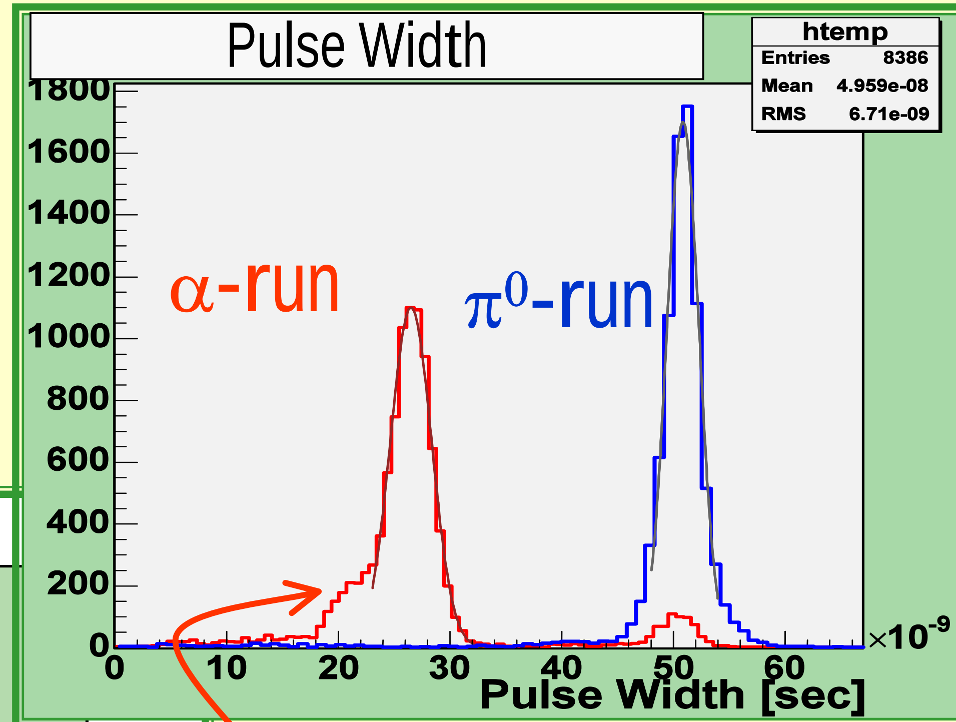
- **Adopt Pulse Width method for PSD**
  - simply measure time width at the half maximum of the pulse height.



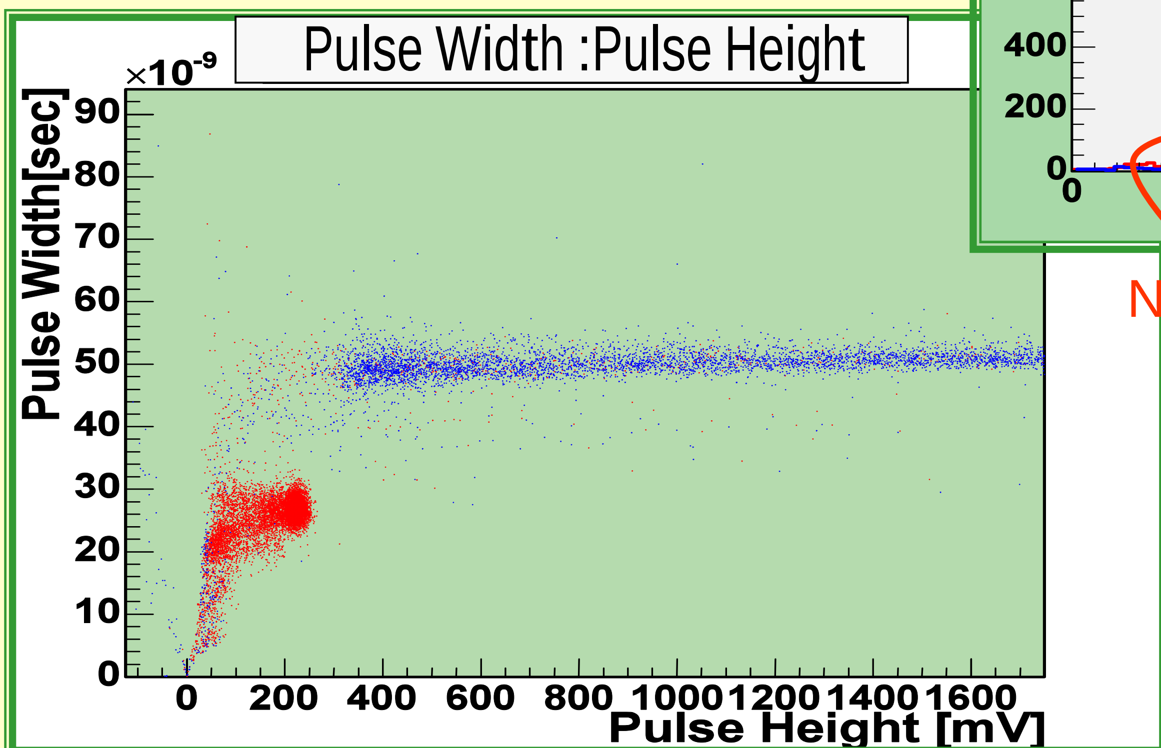
Pulse Width



Noise reduced
Take sum over all Xe channels



Noise infection for small signal



Possible to use for
Trigger(100MHz)

Pile-up rejection

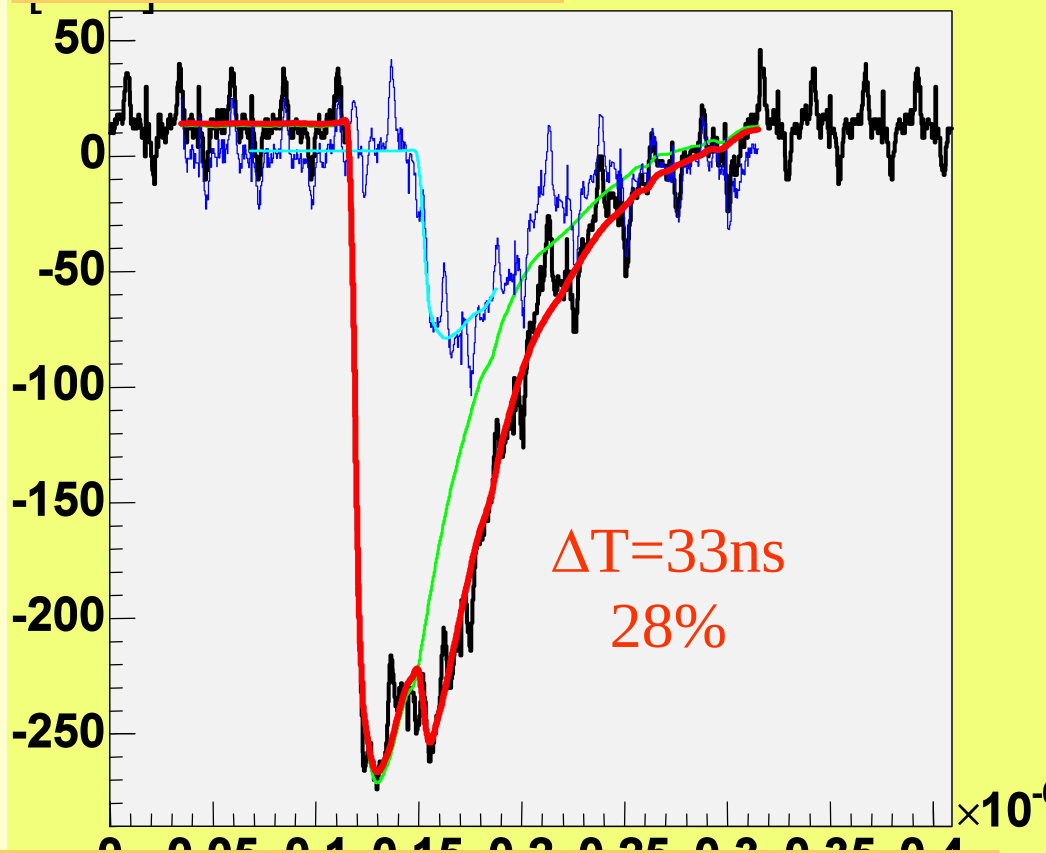
Previous study by MC

2γ, >2.5MeV, >10nsec

Now, real data are available

- Fitting by superposition of two templates
- Able to separate two γ

For example ..



To what time difference and energy 2γ's can be reconstructed ?

Studying by simulation using template and real baseline

Summary

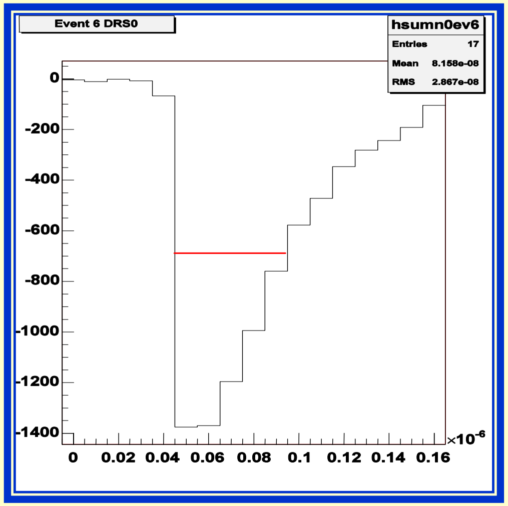
- In the MEG experiment, all PMTs will be read out by waveform digitizer
- Waveform data were successfully taken with DRS in π^- beam test @ PSI autumn '04
- Analyses have been made in several way
  - Make template
  - Comparable time resolution to TDC
  - Succeed in fast powerful PSD
  - Study for pile-up rejection now started

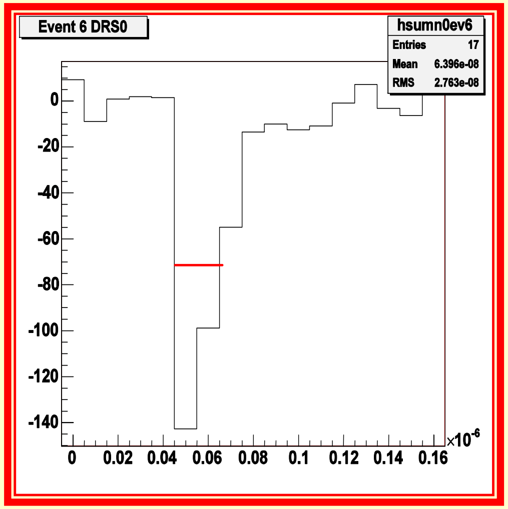
END OF SLIDE

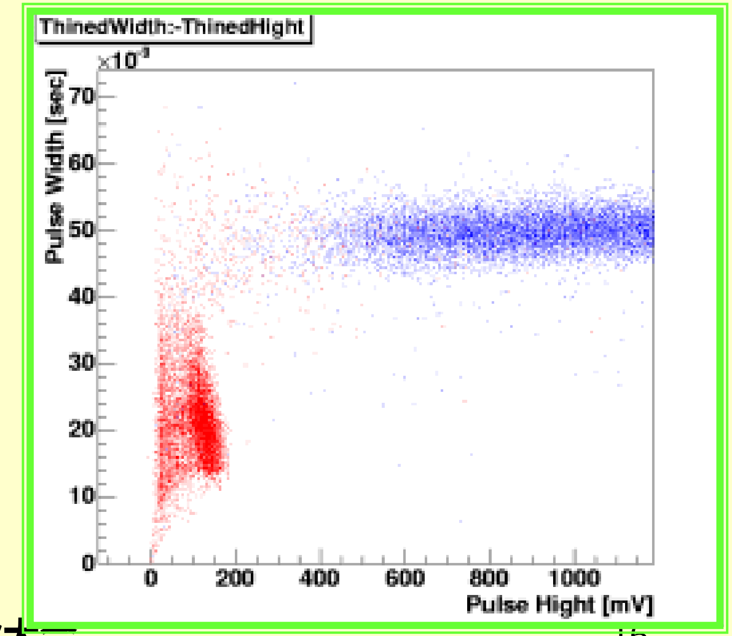
Apply Pulse Width Method for Trigger

- Thinned data point 10ns apart (one point every 25points).

→ "Virtual" FADC Data (100MHz)



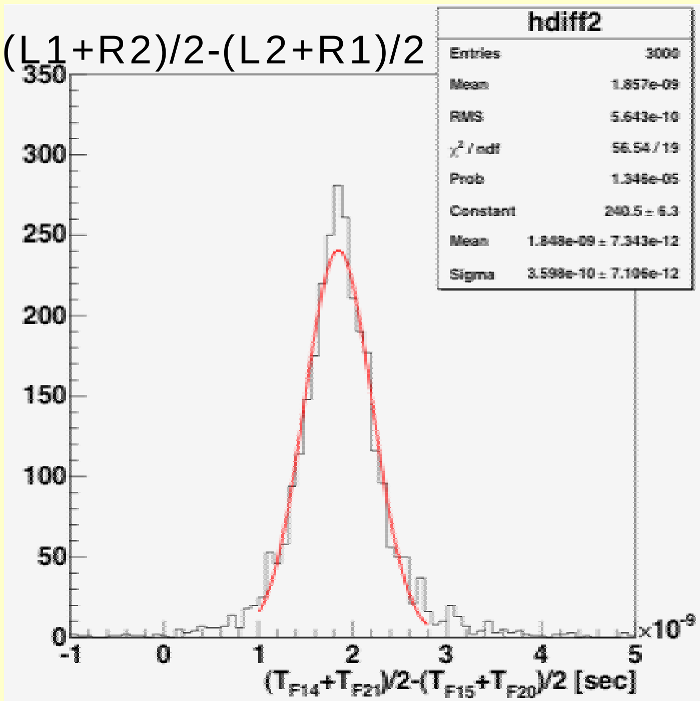




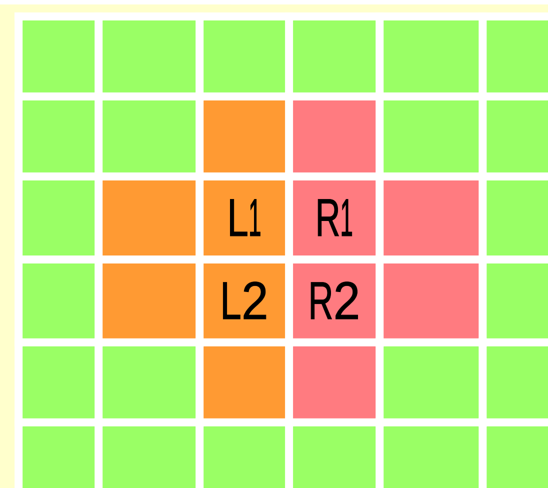
Look still separated enough.

Xe time resolution

Xe time resolution measured by waveform fitting
No cut and no correction

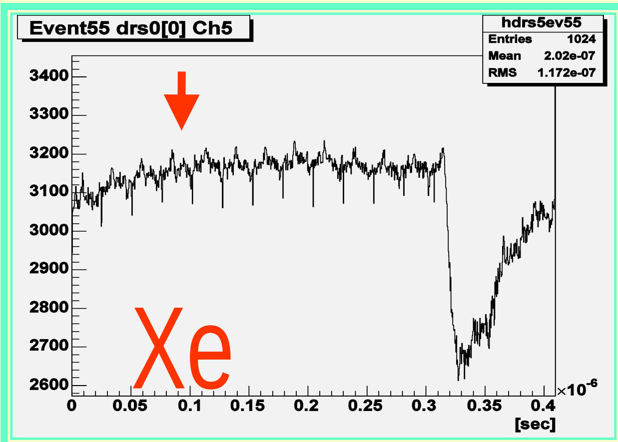


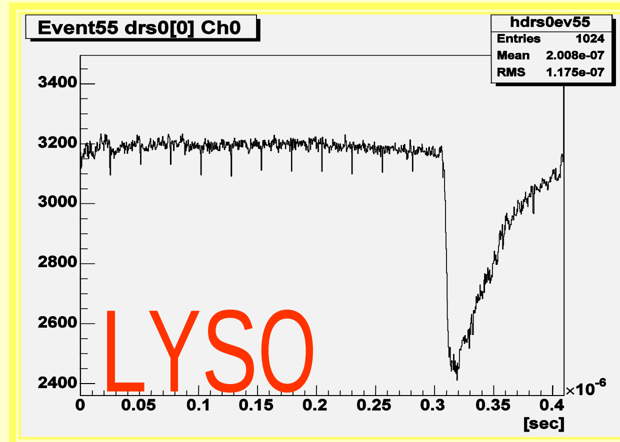
	Waveform	TDC
R1	420psec	-
(L1+R1-L2-R2)/4	190psec	193psec
(L1+R2-L2-R1)/4	180psec	140psec



Comparable to TDC analysis

Raw data

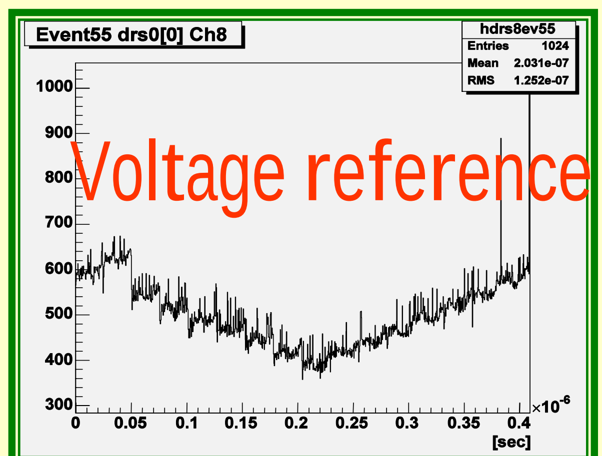


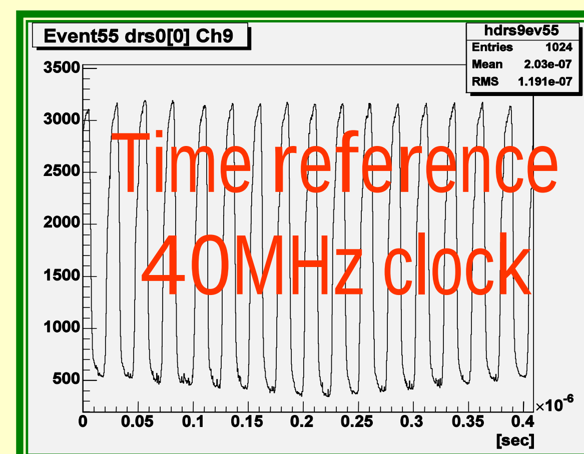


- Random start point
- Non-flat response
- Spike noise

Need Calibration

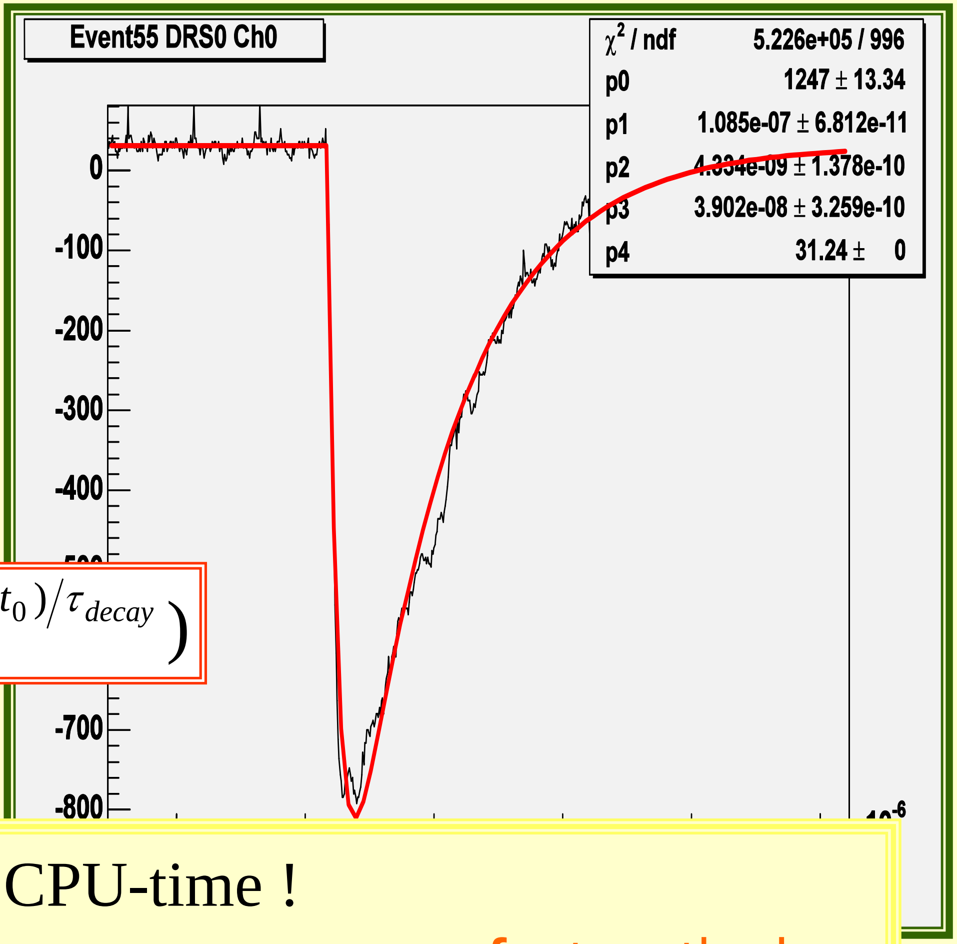
- Global calibration
- Gain calibration on each cell
- Time calibration





Simple fitting

- Fitting
  - Powerful and almighty way

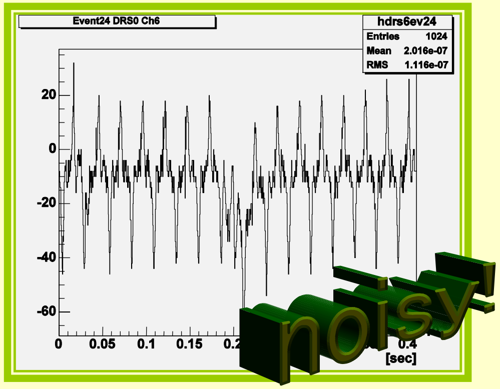


Simple double exponential function seem to good

$$V(t) = A(e^{-(t-t_0)/\tau_{rise}} - e^{-(t-t_0)/\tau_{decay}})$$

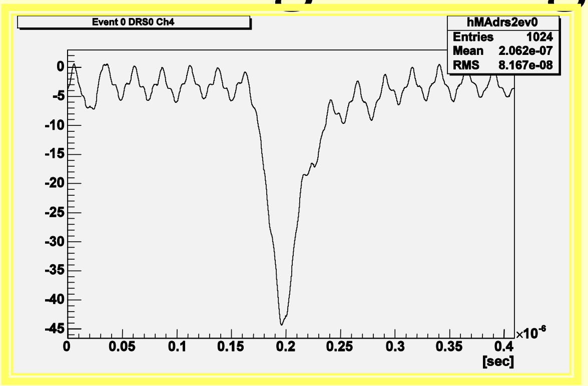
But fitting takes so much CPU-time !
Need some kind of devised way or different fast method

Noise Reduction



- Still noisy after calibrated.
- We have to reduce noise by means of some kind.

Moving Average



Each 50cells (correspond to 20ns) taken average

spike removal