MEG時間測定

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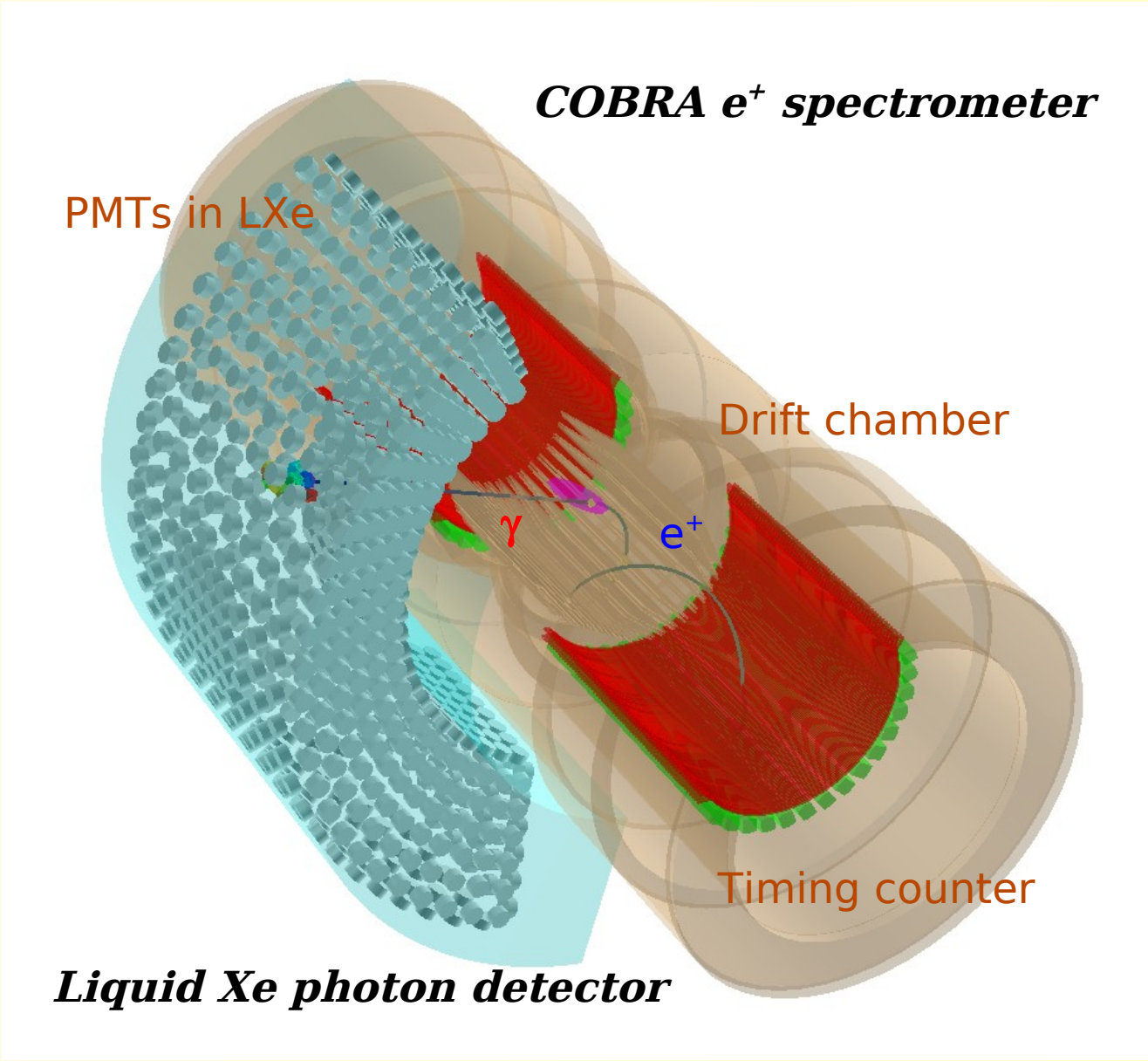
MEG
Mu-E-Gamma Collaboration

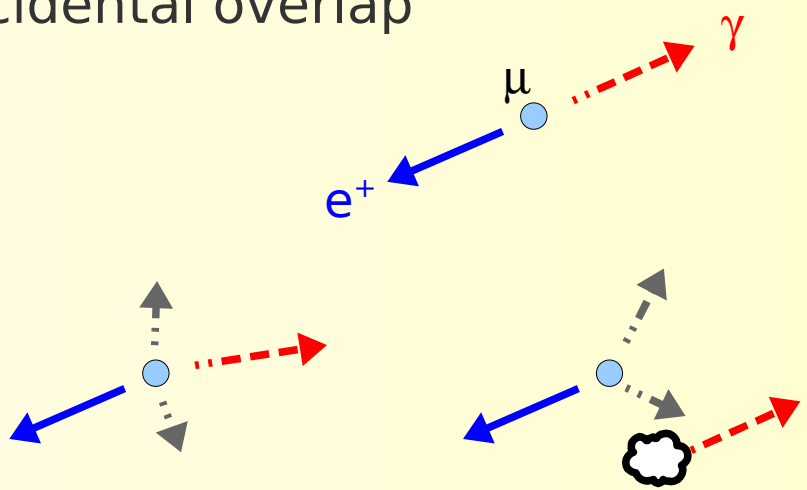
Outline

- Significance
- Photon timing
- Positron timing
- Coincidence events
- Prospect
- Summary



Significance of timing measurement

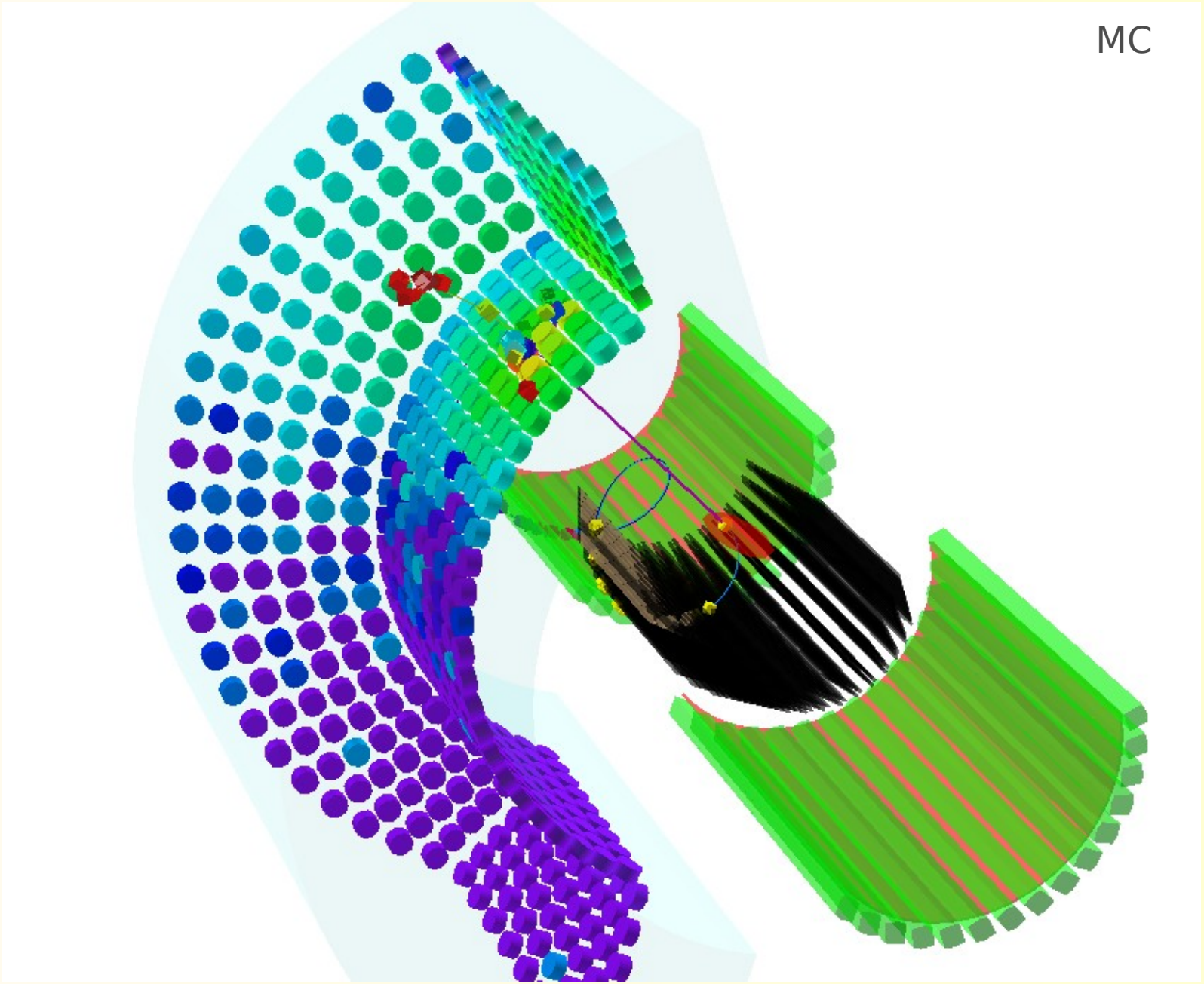
- Background is dominated by accidental overlap
  - Signal : clear 2-body kinematics
  - Two types of backgrounds
    - Radiative decays
    - Accidental overlaps



- Our goal
  - $\Delta T_{e\gamma}$=180ps (FWHM)

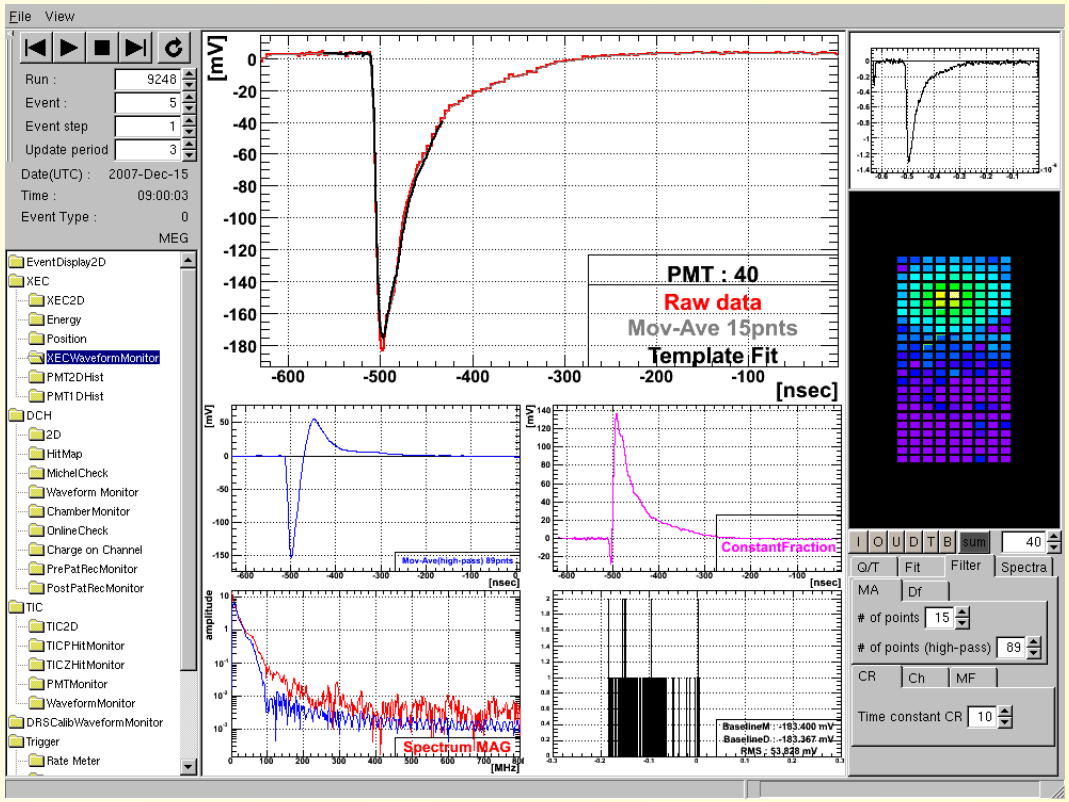
	ΔE_e (%)	ΔE_γ (%)	$\Delta\theta_{e\gamma}$ (mrad)	$\Delta t_{e\gamma}$ (ns)
CrystalBox	8	8	87	1.8
MEGA	1	3.3–5.7	33	1.6
MEG goal	0.8	4.5–5	13	0.18

Photon timing measurement



Photon timing reconstruction1:waveform analysis

- Waveform from every PMT are recorded
  - Digitizer developed for MEG (DRS)
  - Sampling speed : 1.6GHz for RUN2007
  - Ability for Identifying pile-up events
- Pickoff timing by waveform fitting
  - Make template waveform by averaging many pulses



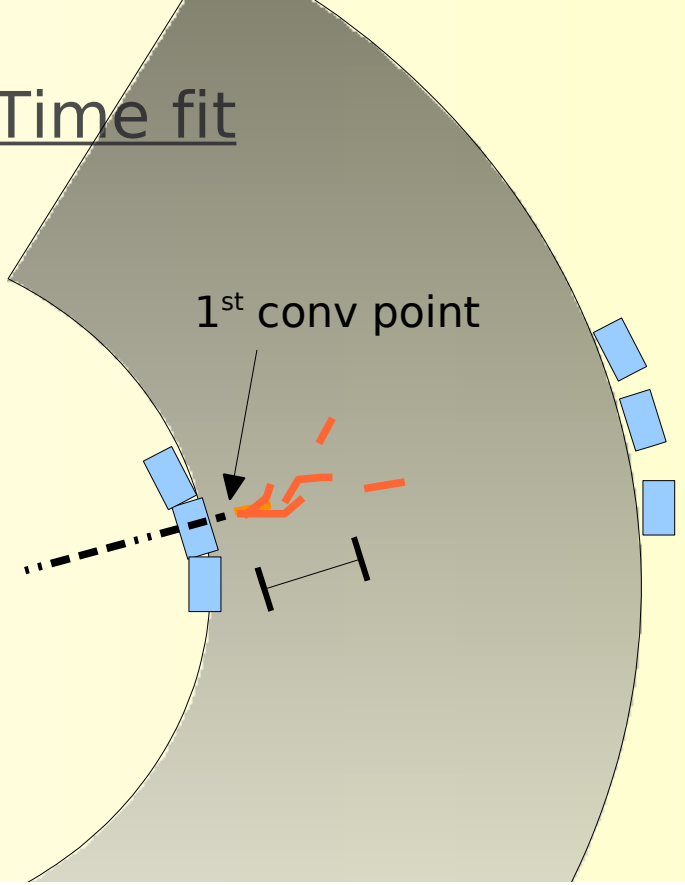
Photon timing reconstruction2:Time fit

- Reconstruction (Time fit)
  - Chisquare fitting taking into account
    - Conversion position
      - Reconstruct with light distribution
    - Shower development
    - Walk effects

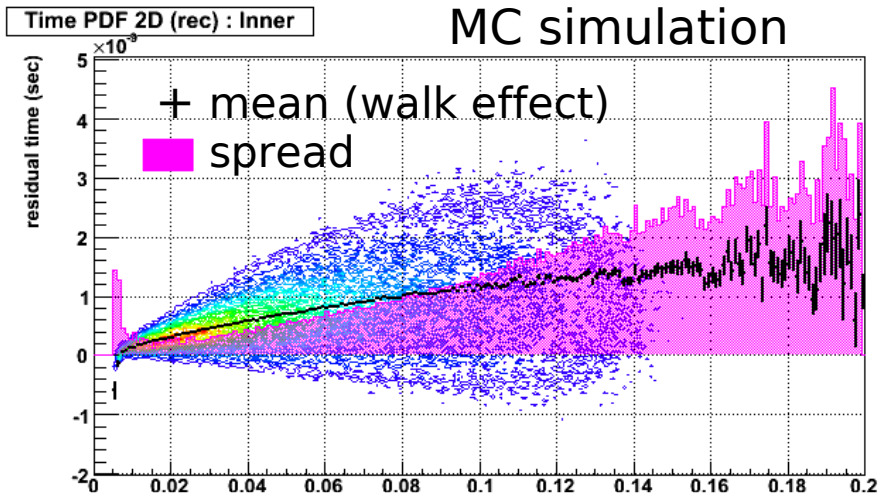
$$T_i = T_{pmt,i} - t_{propa} - t_{walk}$$

$$\sigma T_i \propto 1/\sqrt{Npe} + \text{additional}$$

- ToF subtraction
  - μ decay vertex reconstructed by positron tracking
  - Reconstructed photon conversion point



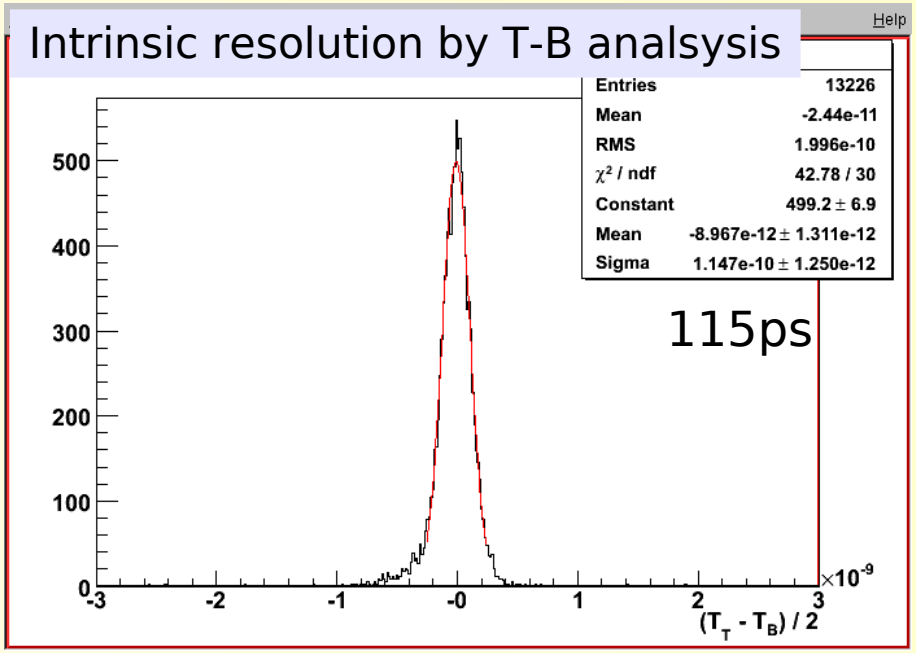
MC simulation



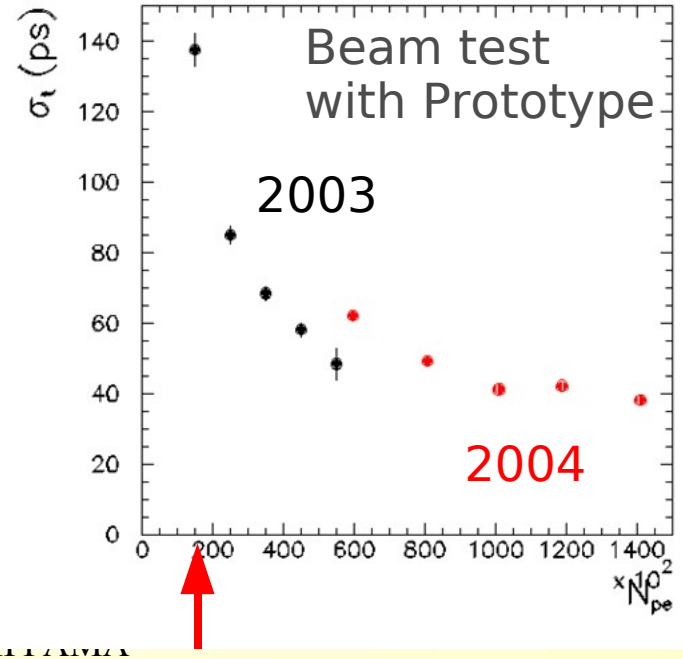
Plot of $T_{pmt,i} - distance/v_{eff}$ as a function of $(Npe)^{-1/2}$

LXe timing resolution

- Pi0 run
- σT_{LXe} = 115ps
- Worse resolution
  - Precise time-offset calibration is necessary
  - Few scintillation photons

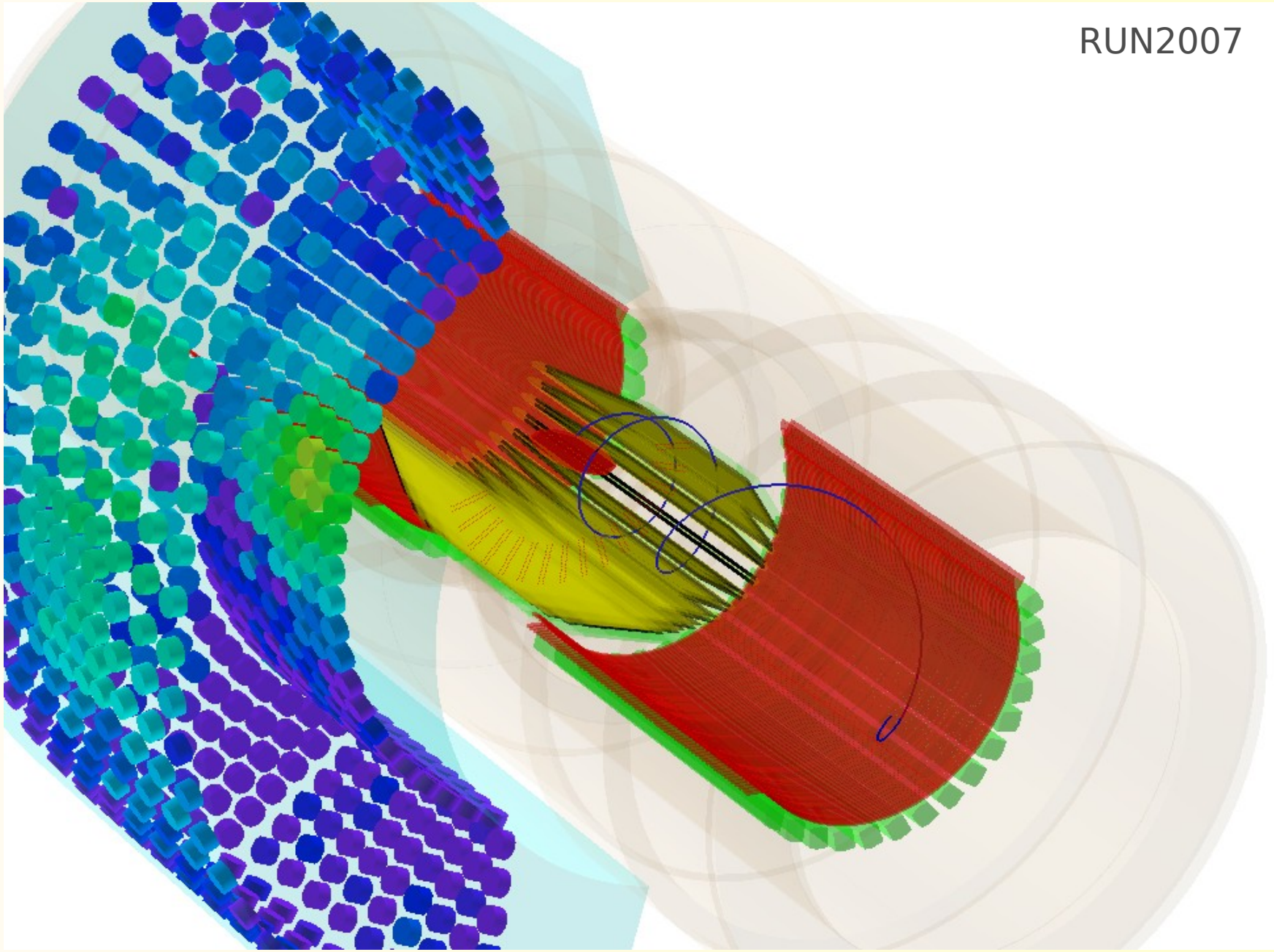


Resolution as a function of #p.e.



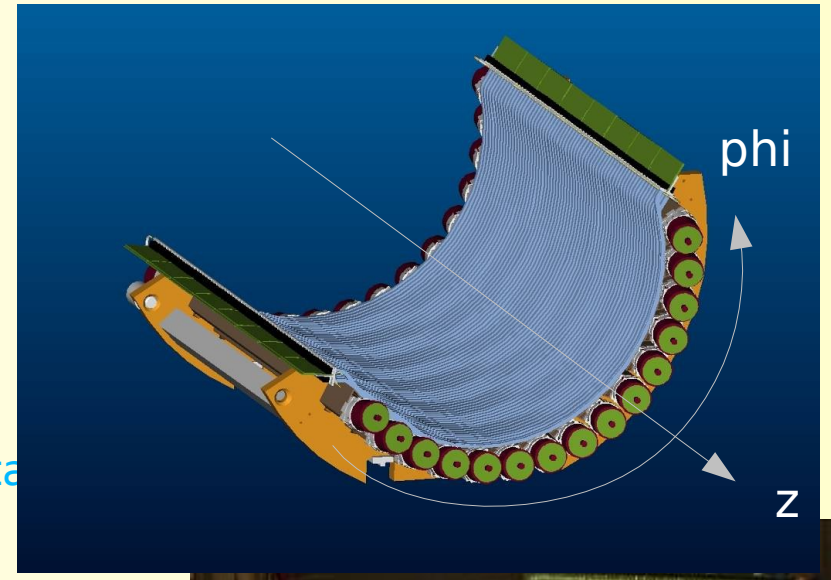
Consistent with prototype result,
if the photoelectron statistics taken into account

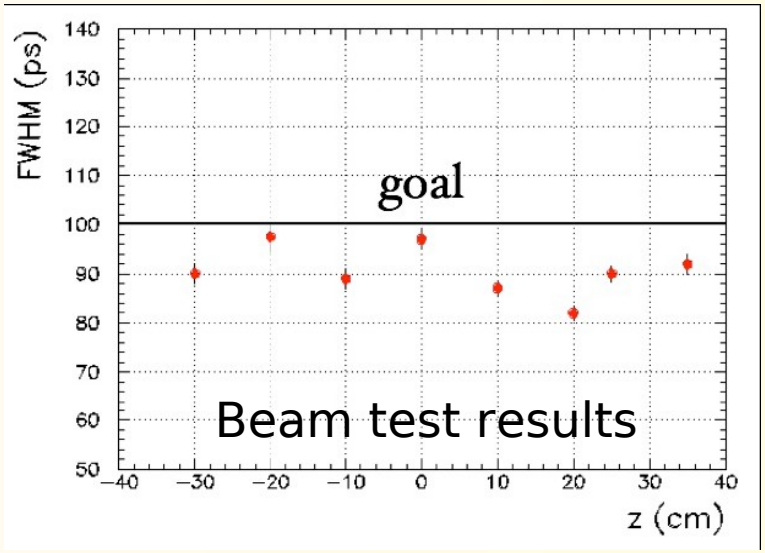
Positron timing measurement



Timing counter

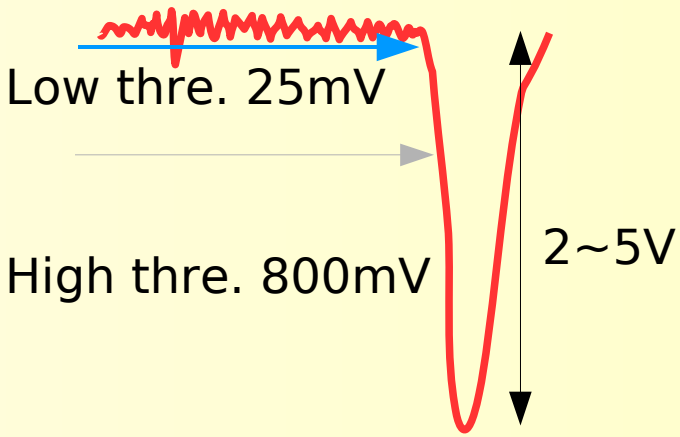
- Two layers of scintillator hodoscope
  - Outer thick bars : timing
  - Inner thin fibers : z measurements
    (Unfortunately couldn't acquire useful data in 2007)
- σ_{TC}=40ps demonstrated at beam test

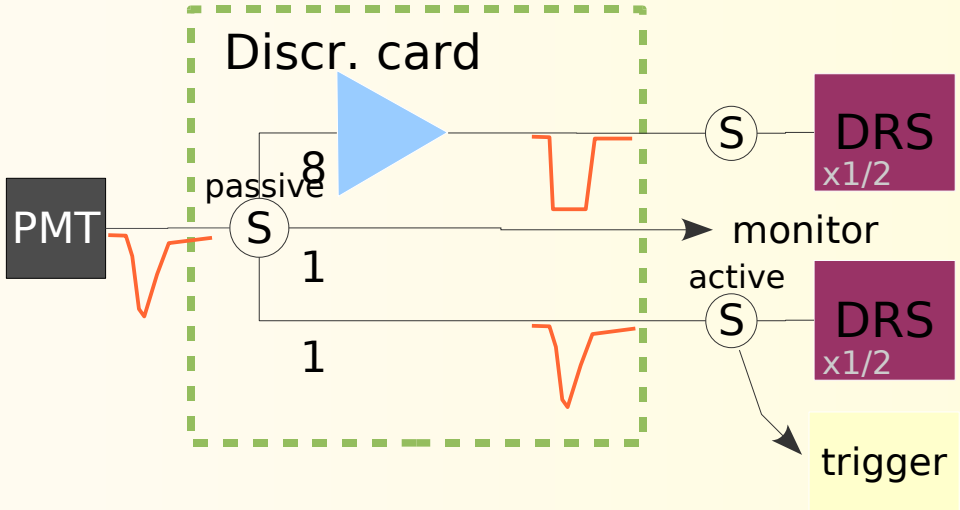


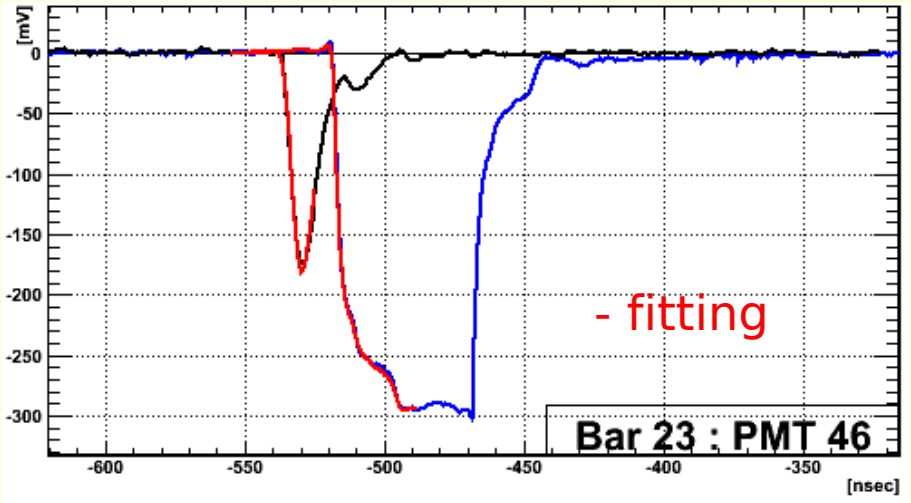


Timing counter electronics & waveform analysis

- Double threshold discriminator
  - Allow to pickoff timing at 1p.e. level
  - Minimize time-walk effect
- Record 2 waveform signals
  - Attenuated PMT pulse
  - NIM pulse from the discriminator
- Template fitting of NIM pulse for precise timing.

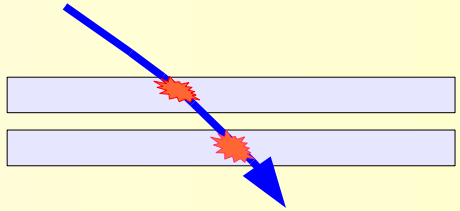


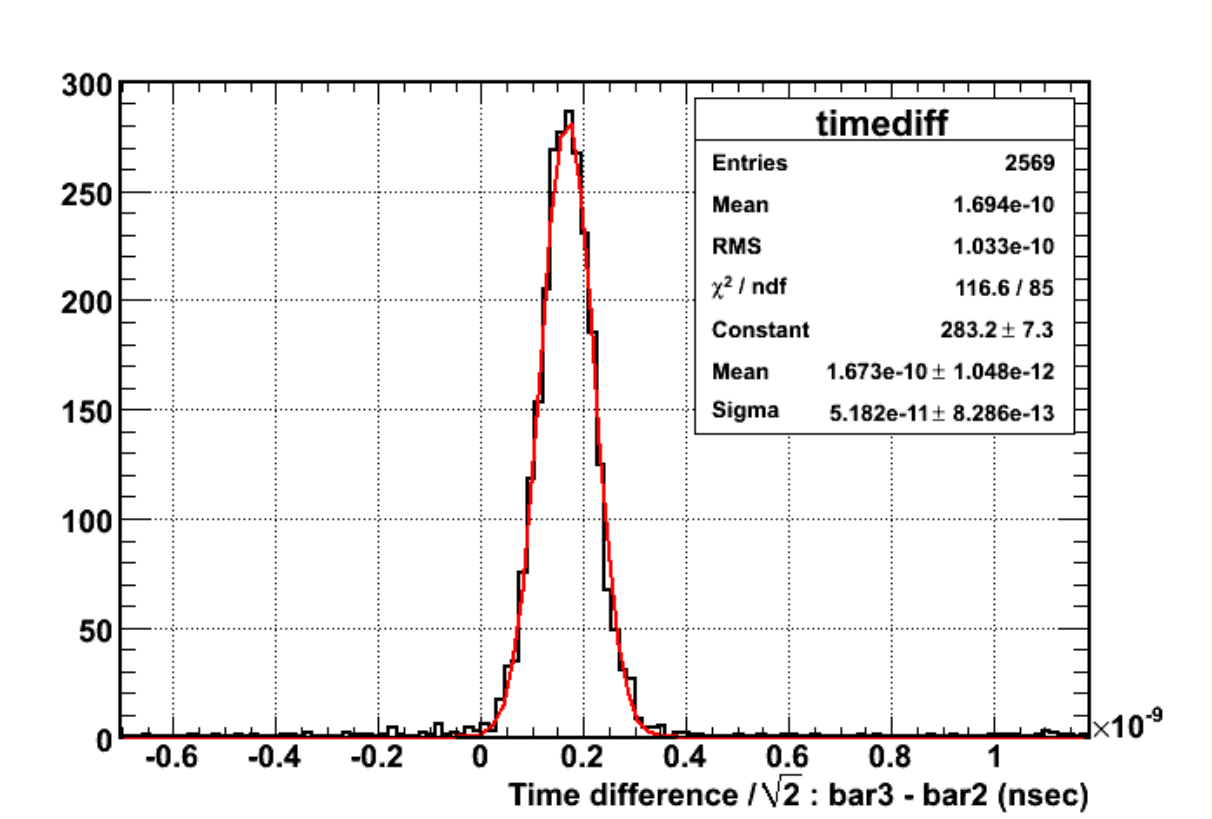




Timing counter resolution

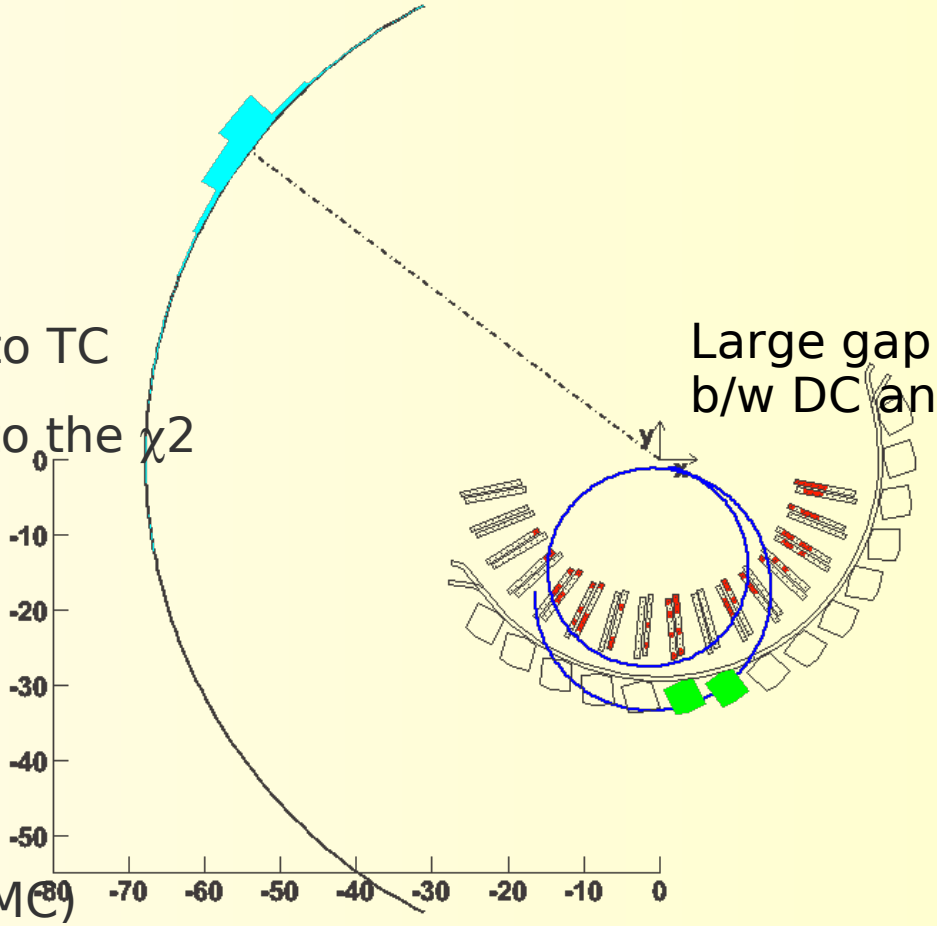
- Estimated TC resolution by using adjacent bar hits
- 1bar resolution : σ_{TC1}=52ps
  - Improved from RUN2006 (75ps)
    - Introduction of DTD and NIM pulse analysis



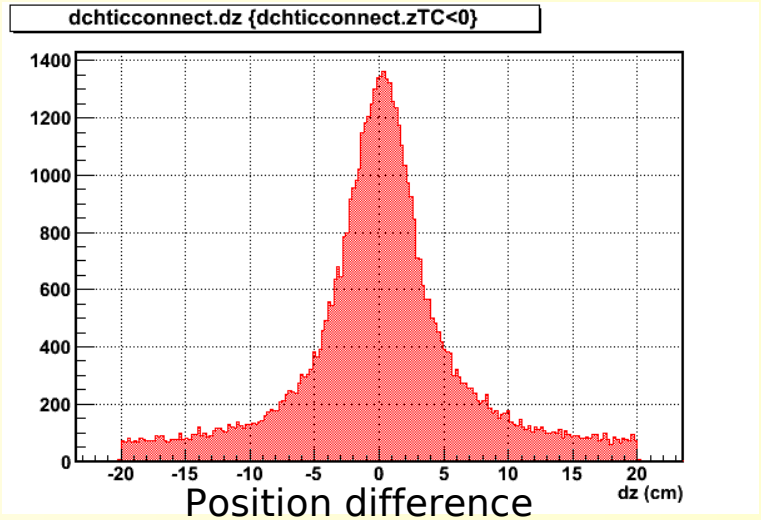


DC-TC interconnection

- ToF correction
  - Extrapolate Kalman track upto TC
  - Match with TC hit according to the χ^2
  - |dZ| should be <4cm
  - σ_{ToF}=32ps (MC, preliminary)
- Combine several TC hits
  - 65% signal e^+ have >2 hits (MC)
  - Achieve σ_{TC}=42ps with 2 adjacent hits (MC)



Large gap b/w DC and TC



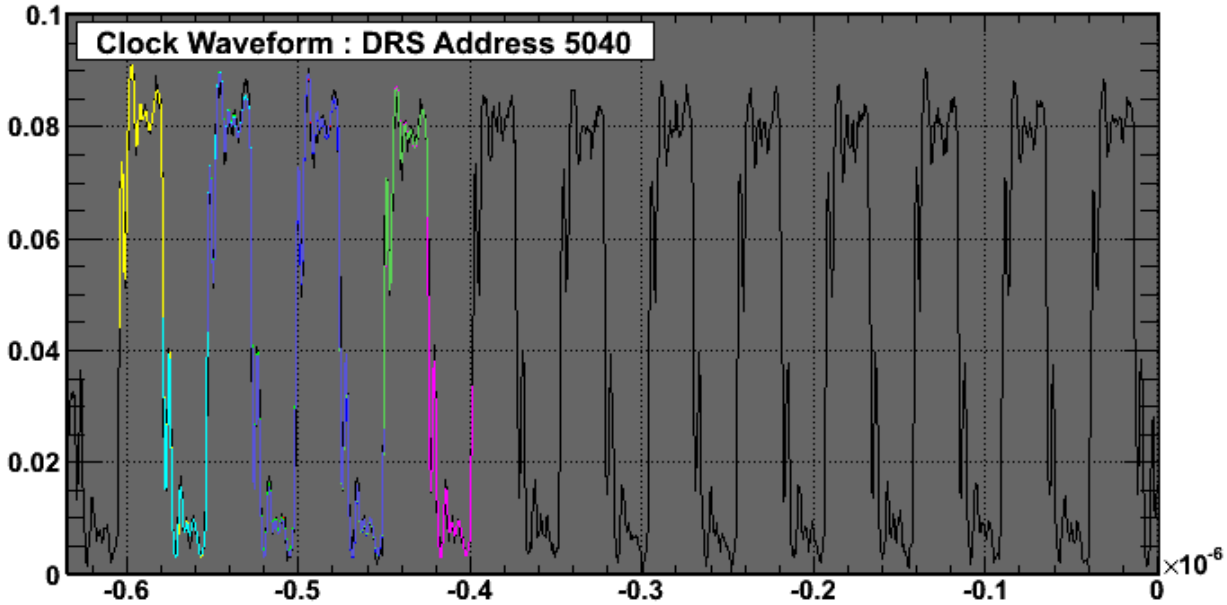
Position difference b/w track prediction and TC measurement

Synchronization of timing measurements

- Clock signal for the time reference over the experiment
- Distributed to every chip and recorded
- Time calibration is done offline
  - Calibrate sampling frequency
  - Synchronize clock phase
- Resolution evaluated by the TC adjacent bar hits over different chips
  - σ_{clock} = 110ps

Bad clock quality
- Clock signal itself is high quality
- Distorted in DRS chip

20MHz clock



→will be improved with new version digitizer (DRS4)

Synchronization of timing measurements

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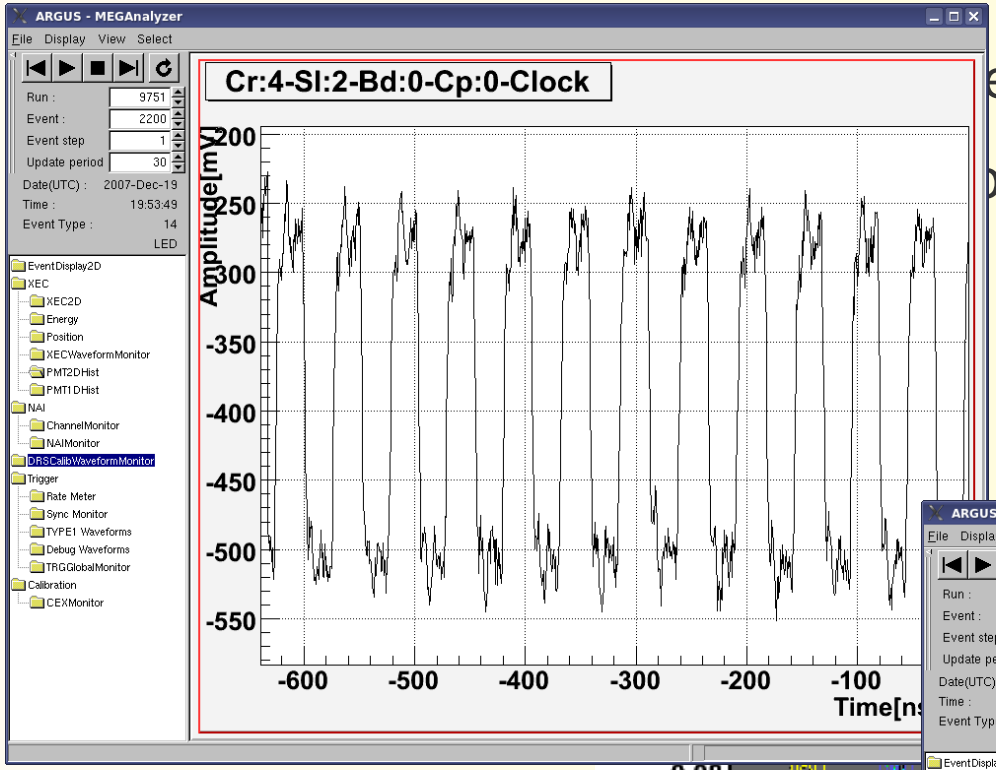

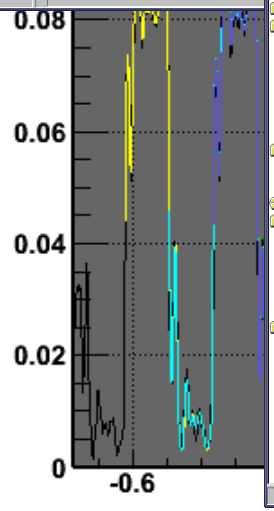

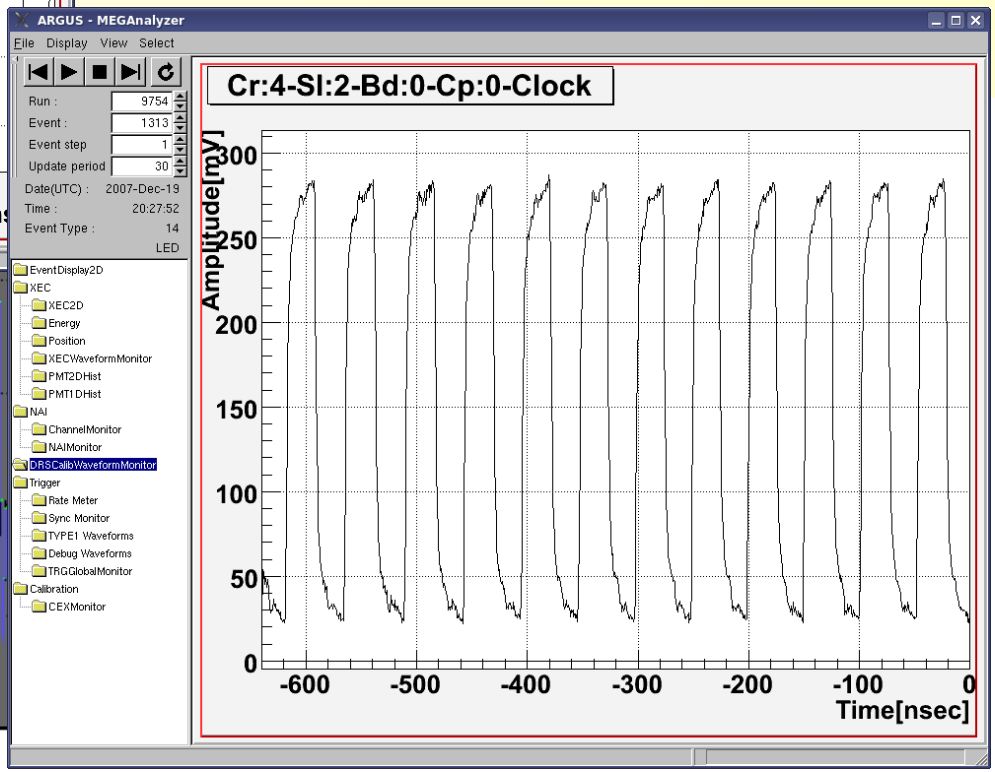

Bad clock quality

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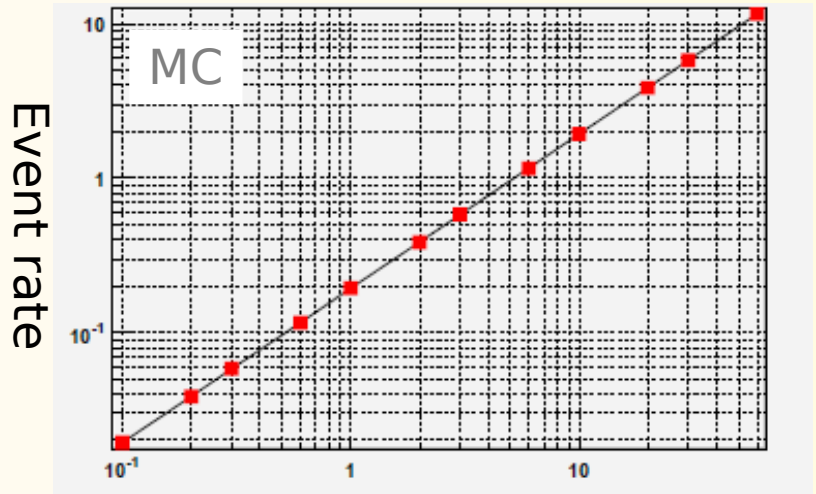
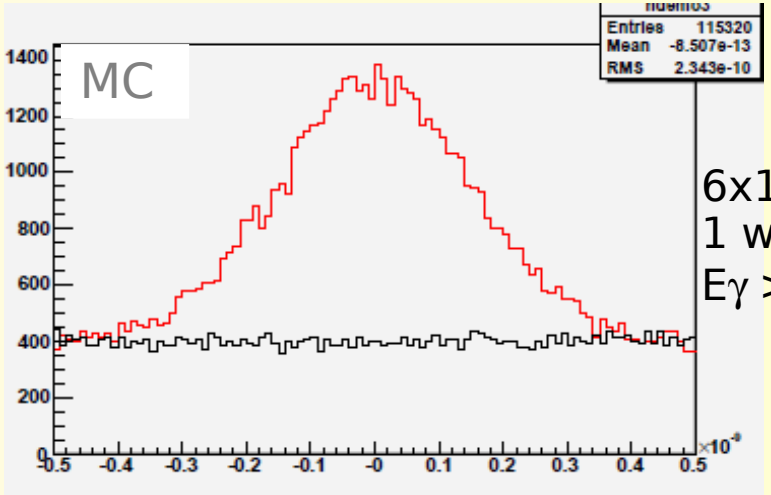
→will be improved with new version digitizer (DRS4)

Calibration with coincident events

- Calibration of photon-positron relative timing
  - Radiative decays
    - Able to evaluate whole reconstruction performance
    - Low rate
      - Require dedicated run (reduce beam rate)
      - Difficult to collect good statistics around signal region
    - Not enough data in 2007



μ stopping rate

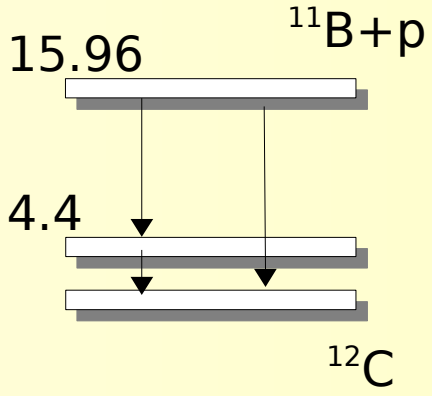


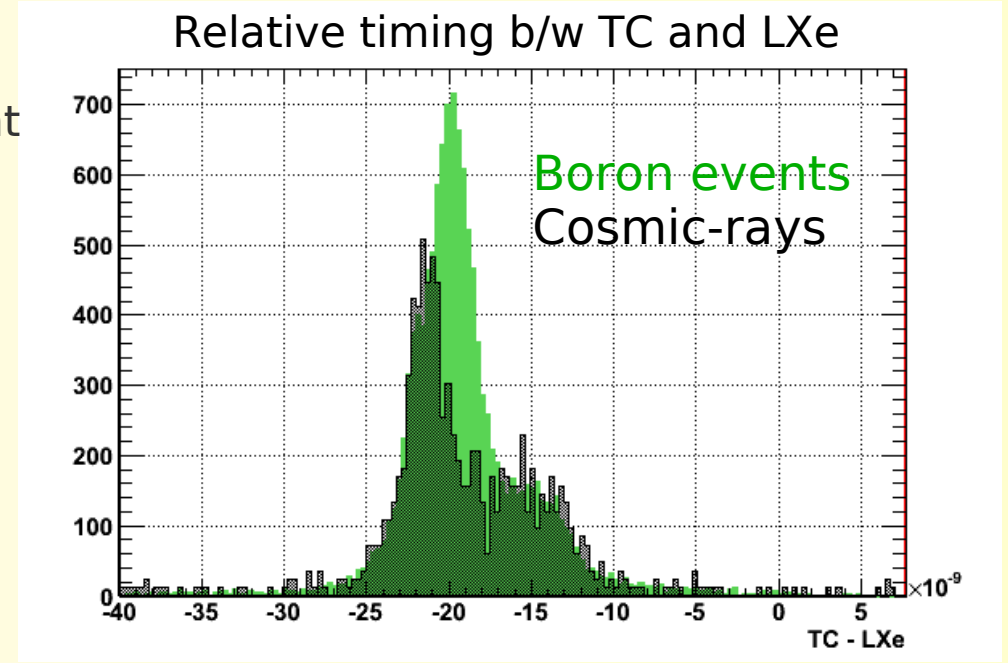
6×10^6 μ
1 week
Eγ > 10MeV

Teγ

Calibration with coincident events

- Calibration of photon-positron relative timing
  - Cosmic rays
  - 2γ from boron target
    - Proton beam from CW accelerator with boron target
    - 11.7MeV emission always associated with 4.4MeV line
    - Able to calibrate with high rate
      - ~10kHz → 20Hz
        efficiency
    - Used for trigger time adjustment





Summary

- Full reconstruction procedure is performed
- Couldn't achieve required resolution yet
  - The main issues
    - Photon timing (low light yield, offset calibration, reconstruction algorithm)
    - Synchronization b/w different chips (bad clock quality)
  - Some treatments will be performed on both issues in 2008