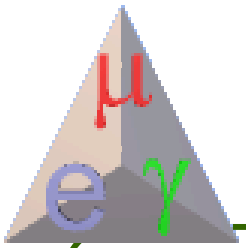

日本物理学会2005年秋季大会 @大阪市立大 2005年9月13日

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 パイルアップ事象の研究

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久松康子, 真木晶弘[B], 三原智, 森俊則, 山下了, 山田秀衛,
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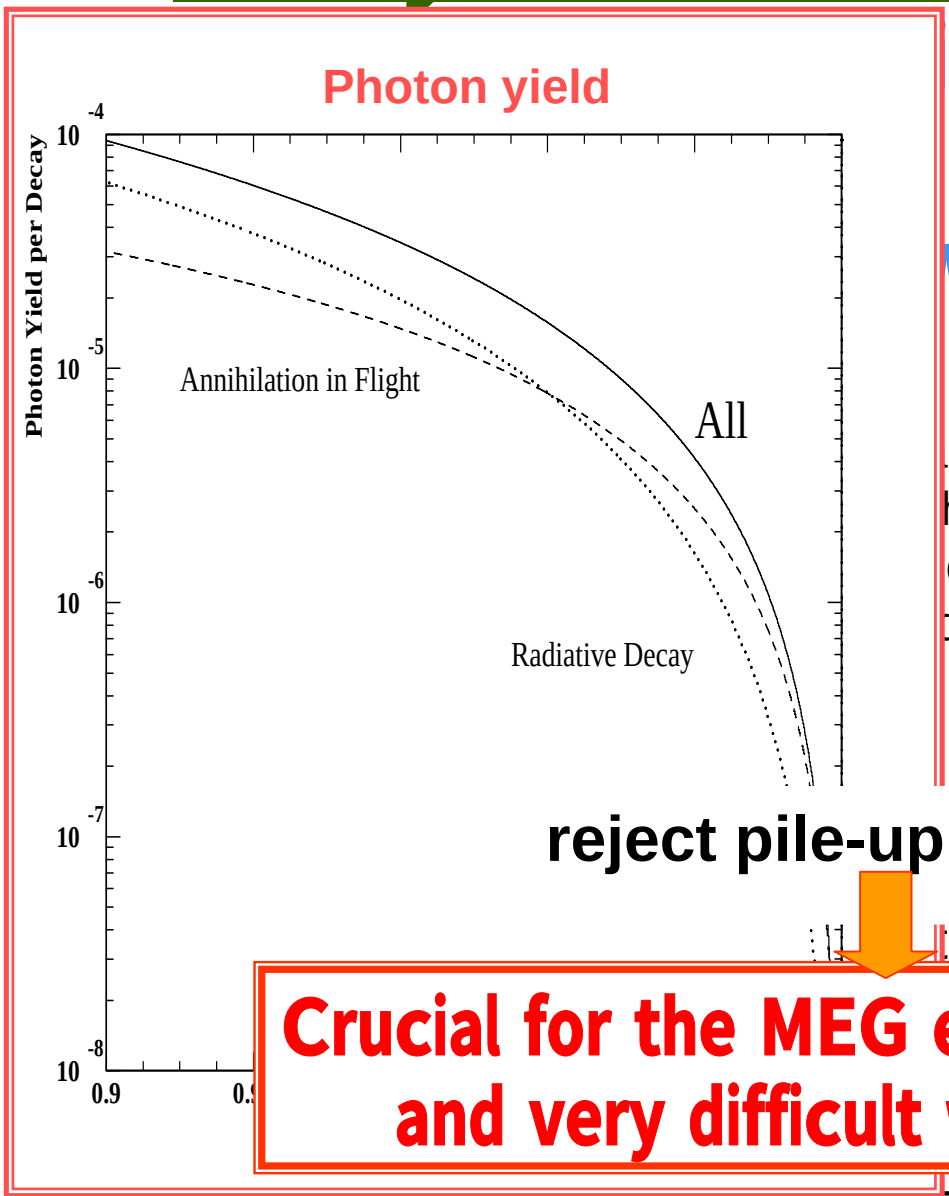
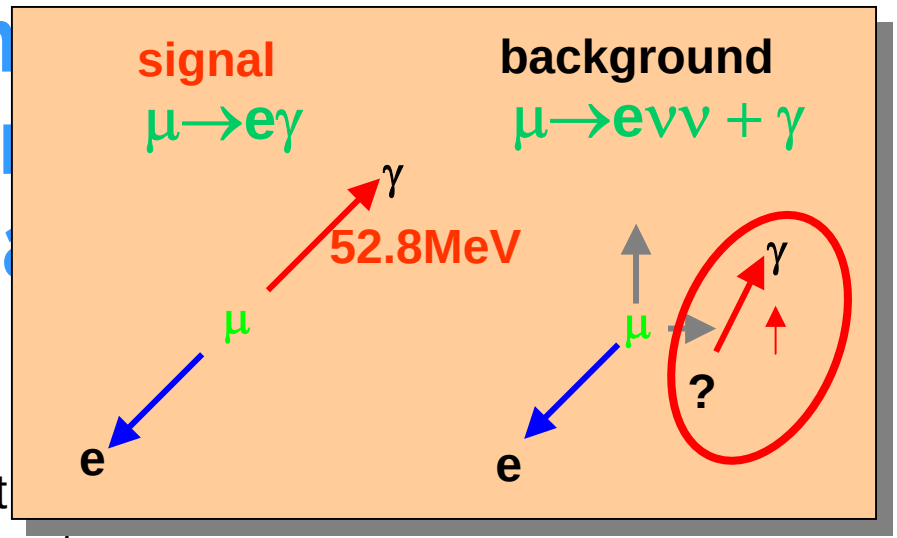
Contents

- **Why waveform ?**
- **Waveform data**
- **Waveform simulation**
- **Pile-up rejection**
- **Summary**

Why use waveform data





cay time

diation length

Major background

reject pile-up of γ-rays

rompt background

Accidental background

Crucial for the MEG experiment and very difficult without waveform image

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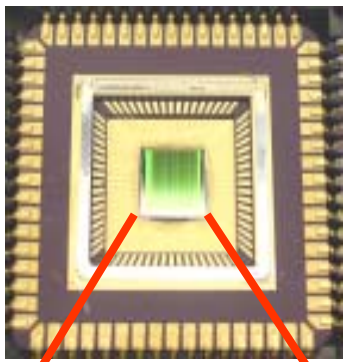
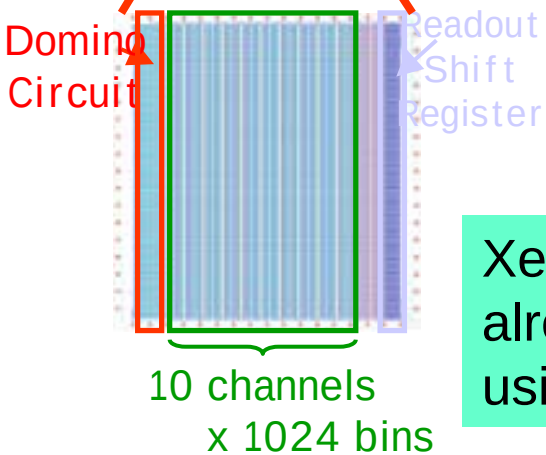
Waveform data

Domino Ring Sampler (DRS)

Developed by **Stefan Ritt**

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

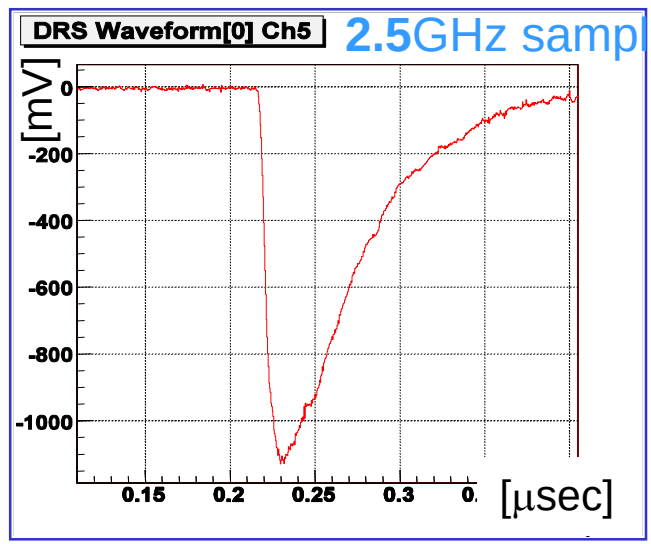




Analog sampling chip, switching capacitor circuits

- Max sampling speed **4.5**GHz (required 2.5GHz)
- 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

Xe waveform data were already taken successfully using prototype detector



Xe scintillation pulse

Data analysis is going on.

I reported at last meeting...

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~¥10,000/chn

13/Sep/2005

Waveform simulation

Waveform

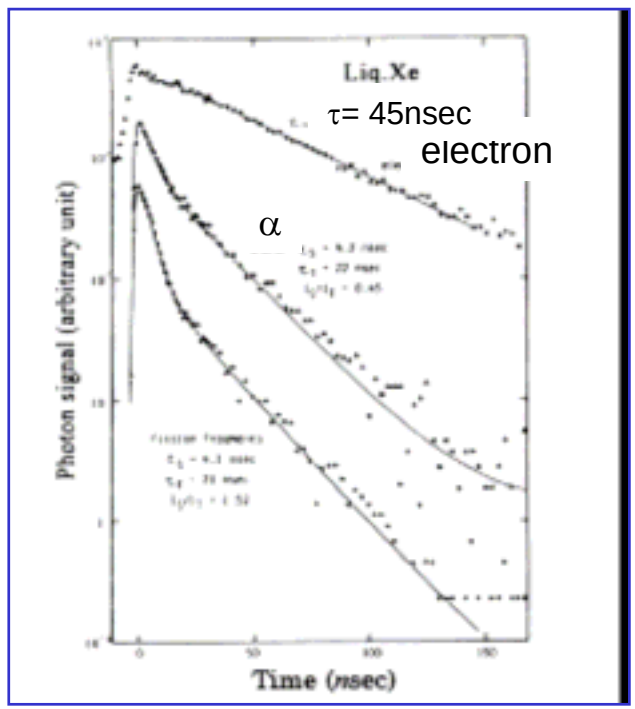
Pulse shape is a consequence of various effects like,

- Scintillation process
- Light transport in the scintillator
- PMT response
- Shaping from circuit
- Cables
- Receiver (DRS)

Xe scintillation process for γ
Decay time 45nsec

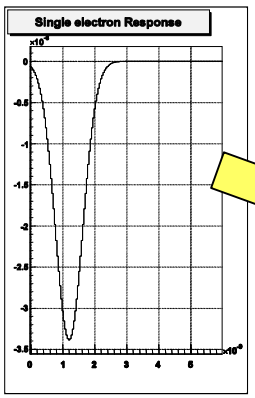
PMT TTS 0.75nsec (Typ.)

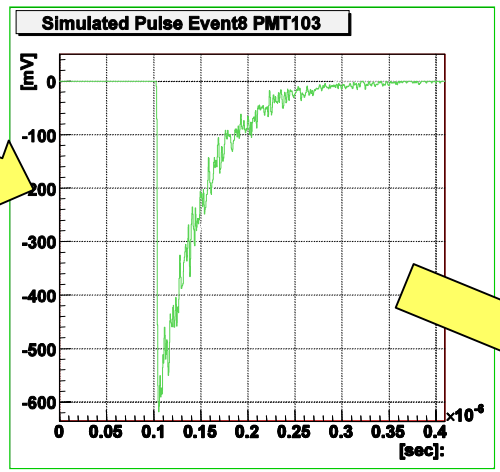
TTS : Transit time spread of PMT
for individual photoelectrons

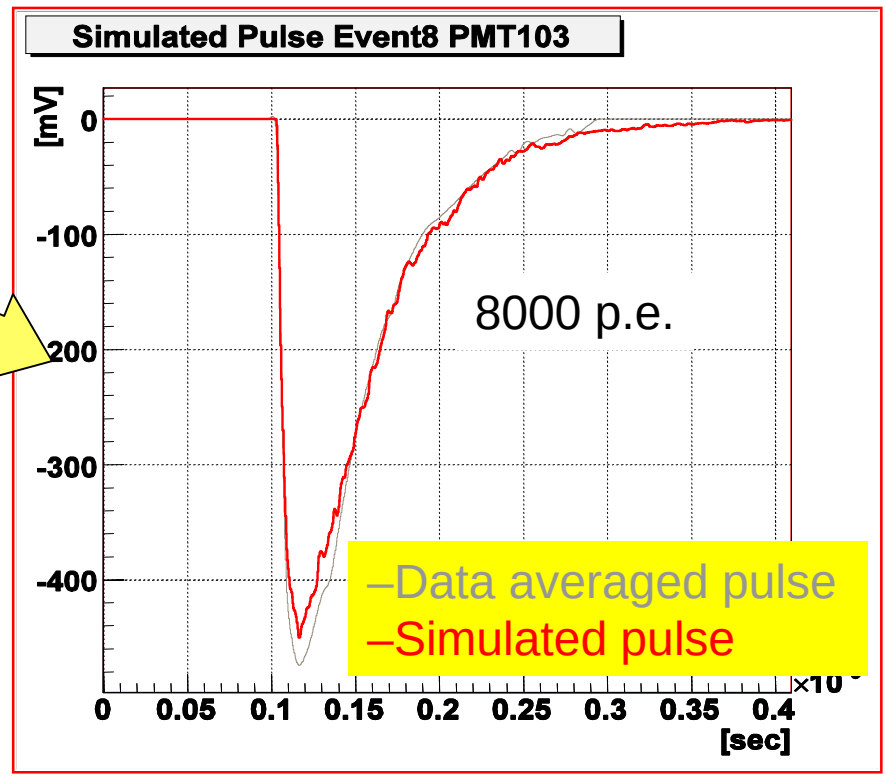


Waveform simulation

1. Sum up single electron pulses for all photoelectrons
   - Single electron response spread by TTS (Gaussian).
   - Arrival time of each scintillation photon tracked by MC simulation.





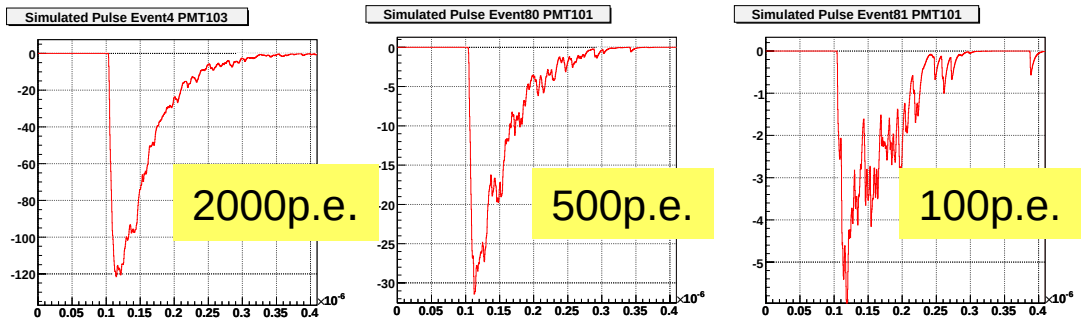


2. Shaped by low pass filter
   - RC shaping (integration circuit)
   - Time constant RC = 5 nsec

Simulated waveform is well fitted to real waveform.

Simulated waveform

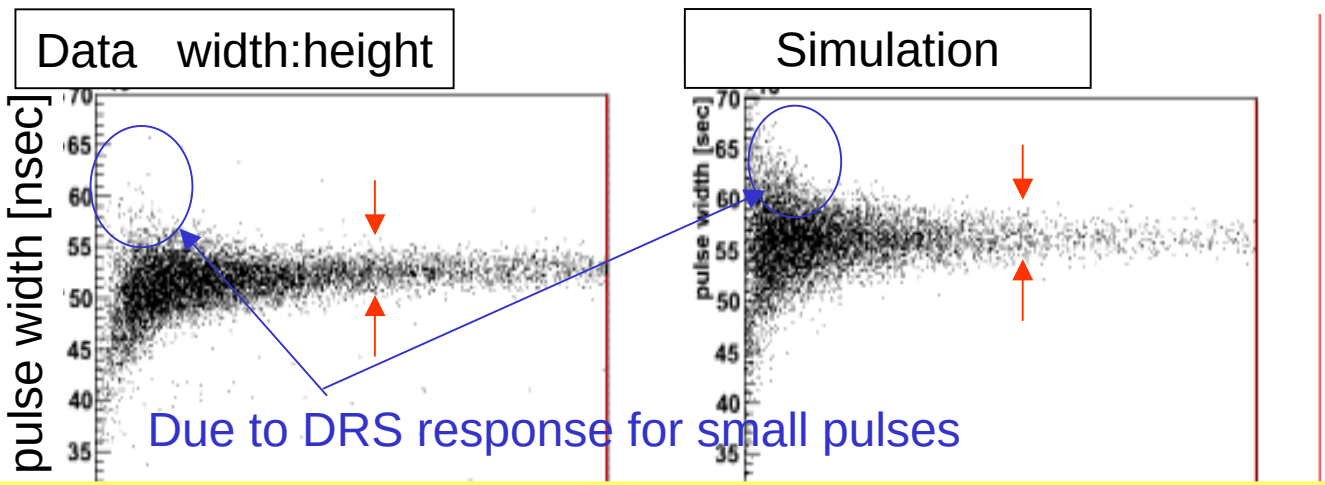
Now we can simulate waveform pulse by pulse.



Pulse shapes are not constant especially for small pulses because of statistics.

Distribution of pulse width

Fluctuation of pulse shape is well simulated

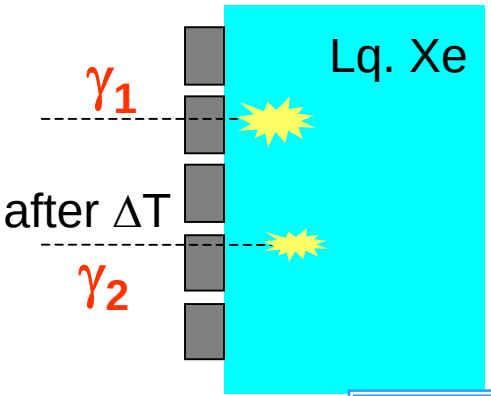


We succeed in simulating pulse shape properly

After this, use these simulated waveform for analysis

Pile-up rejection

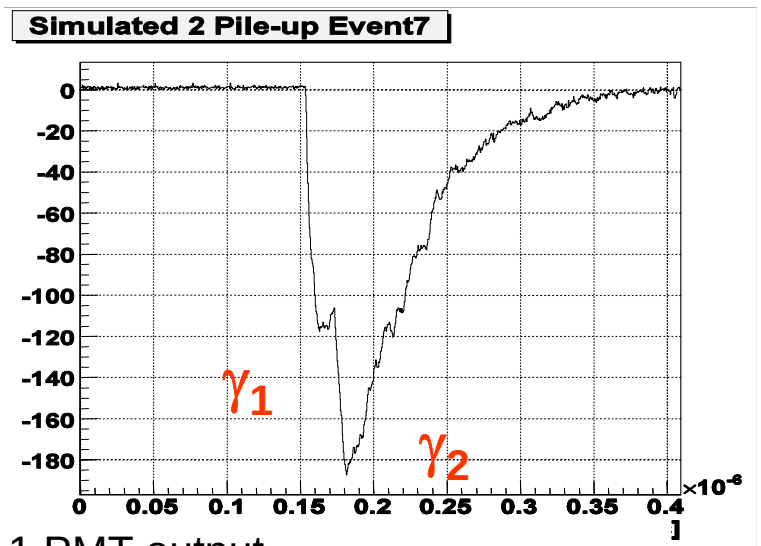
Pile-up event



How to reject pile-ups ?

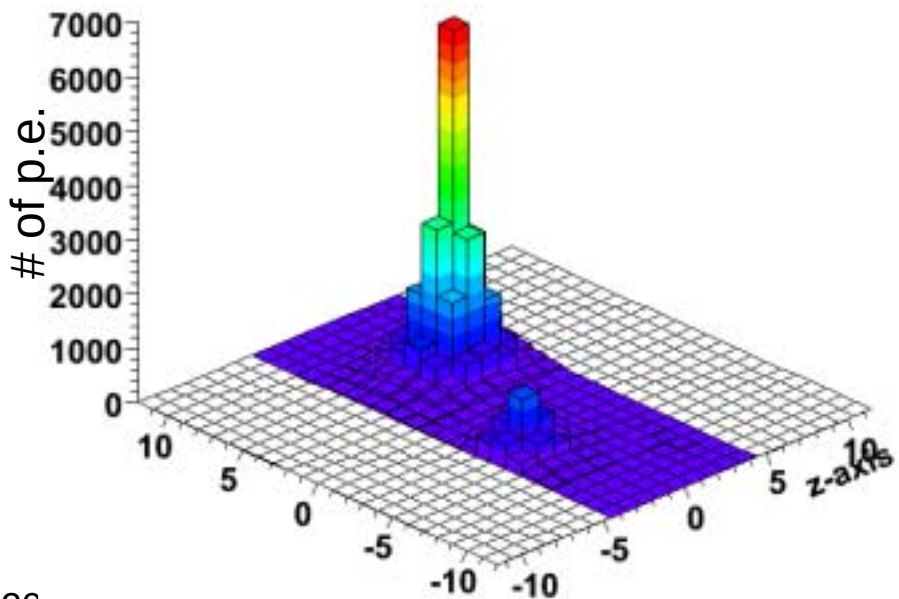
- distribution of PMT output
- pulse shape

- $\Delta T = t_2 - t_1$
- $E_1 + E_2 = 1$ (signal energy)



1 PMT output

2000p.e. + 1600p.e., ΔT = 20nsec



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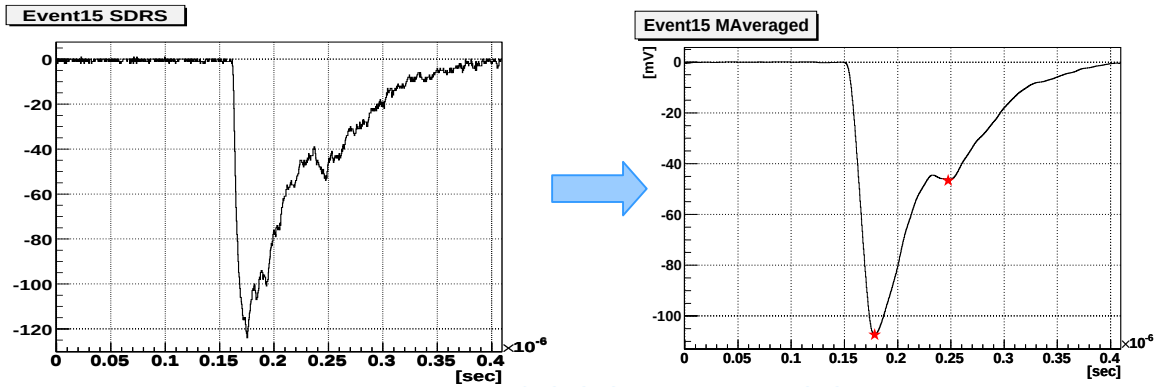
0.8 + 0.2

Pile-up rejection

How to find pile-ups ?

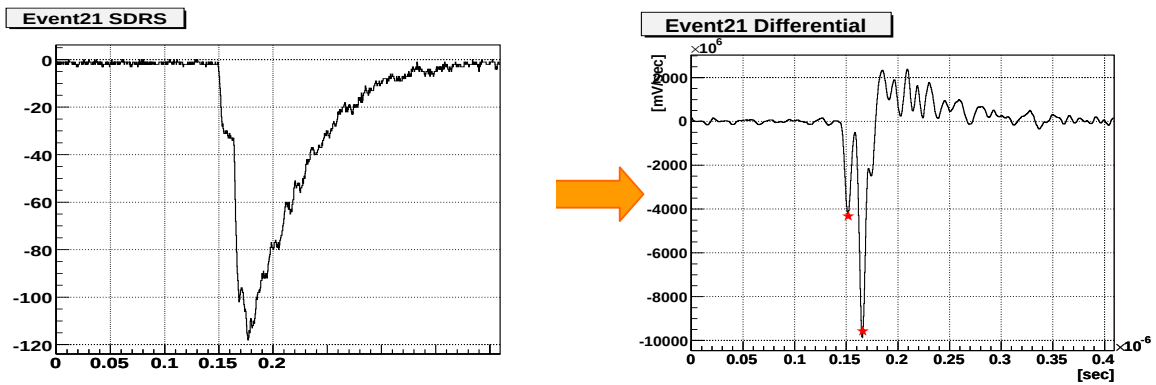
Peak search method simplest way but powerful in case of large ΔT



Take moving average and count peaks

ΔT=75ns, 2000p.e + 400p.e.

Differential method powerful in case of ΔT around rise time



Take differentiation and count its peaks

Set threshold in peak finding with miss-rejection of non-pileup signal

< 0.05%

ΔT=15ns, 600p.e. + 1600p.e.

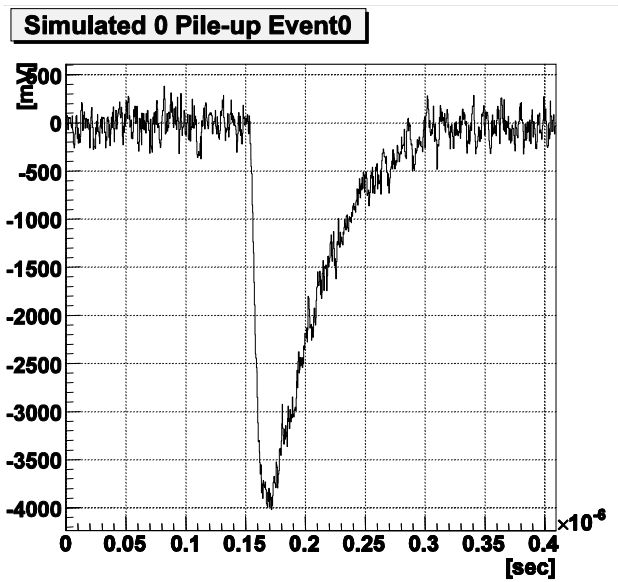
Pile-up rejection

Difficult to find pile-up by looking at individual PMT output.

- # of photons for each PMT is small
- # of PMTs which can observe event as a pulse is small
- Noise such as microstructure in pulse shape for small signal

Take sum of PMT outputs

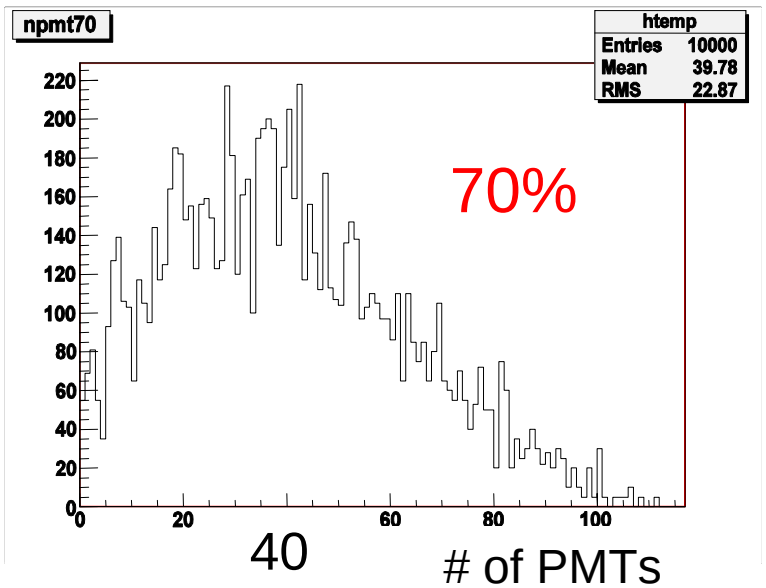
- Larger pulse
- Microstructure in pulse shape disappear

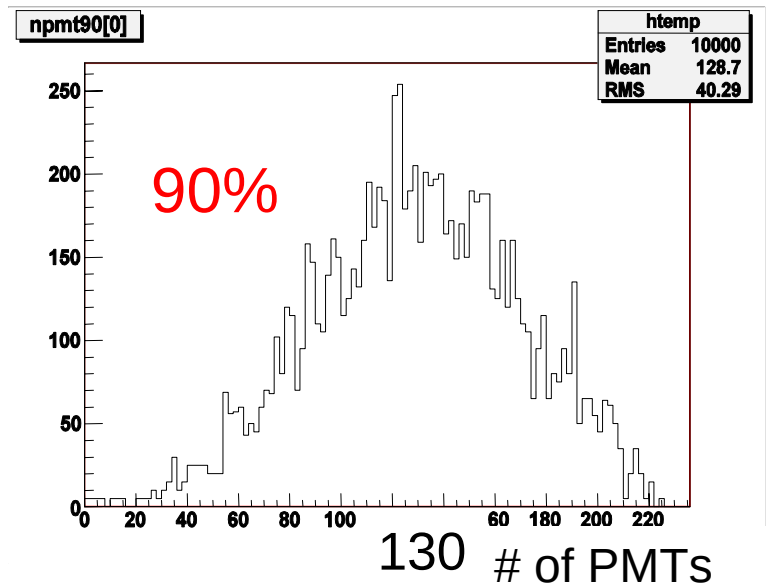


Sum of all PMTs for signal γ

Pile-up rejection

- Taking all PMTs sum is not good from S/N viewpoint.
- Sum in order of PMT output
- How many PMTs to be summed ?

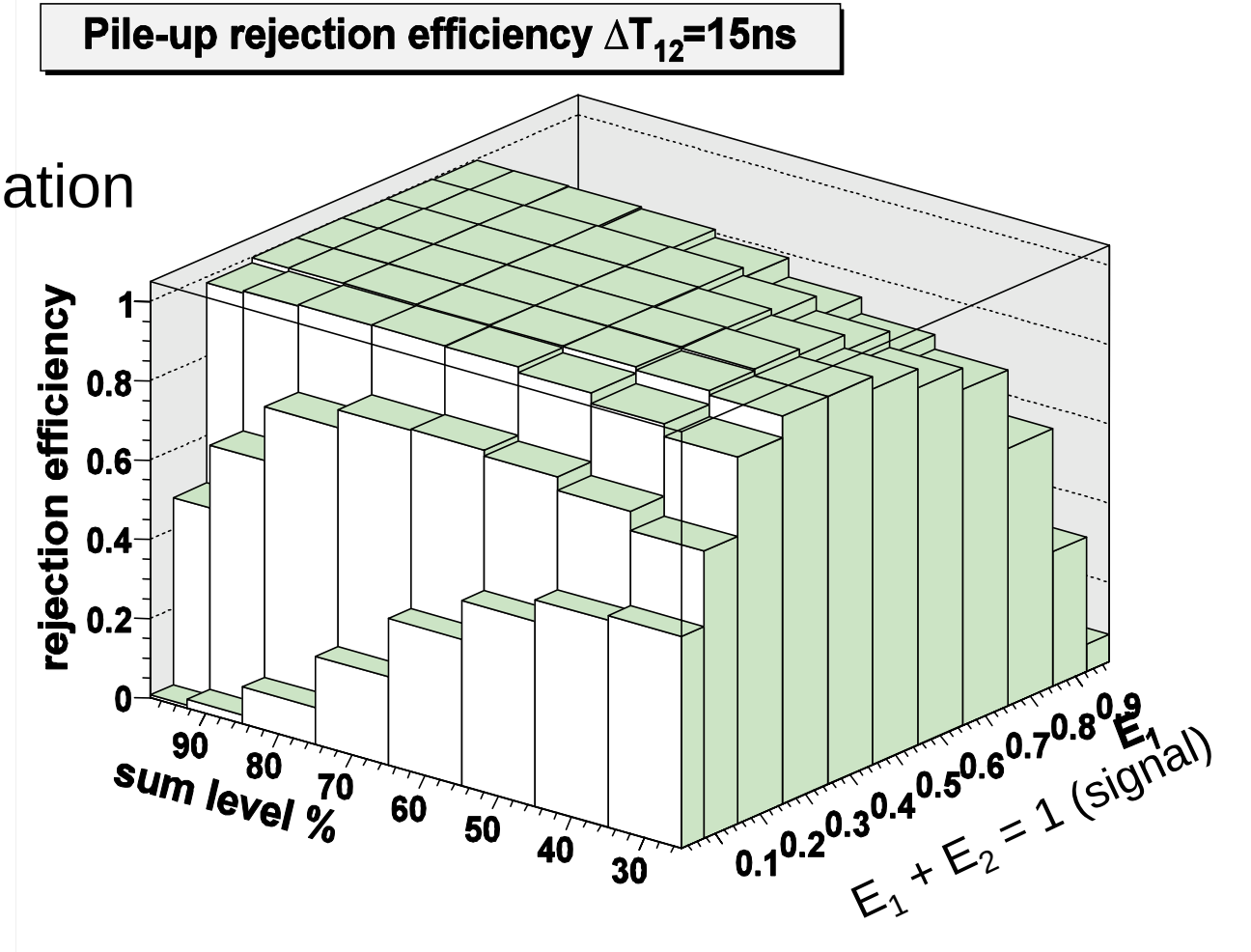




S/N can be improved considerably

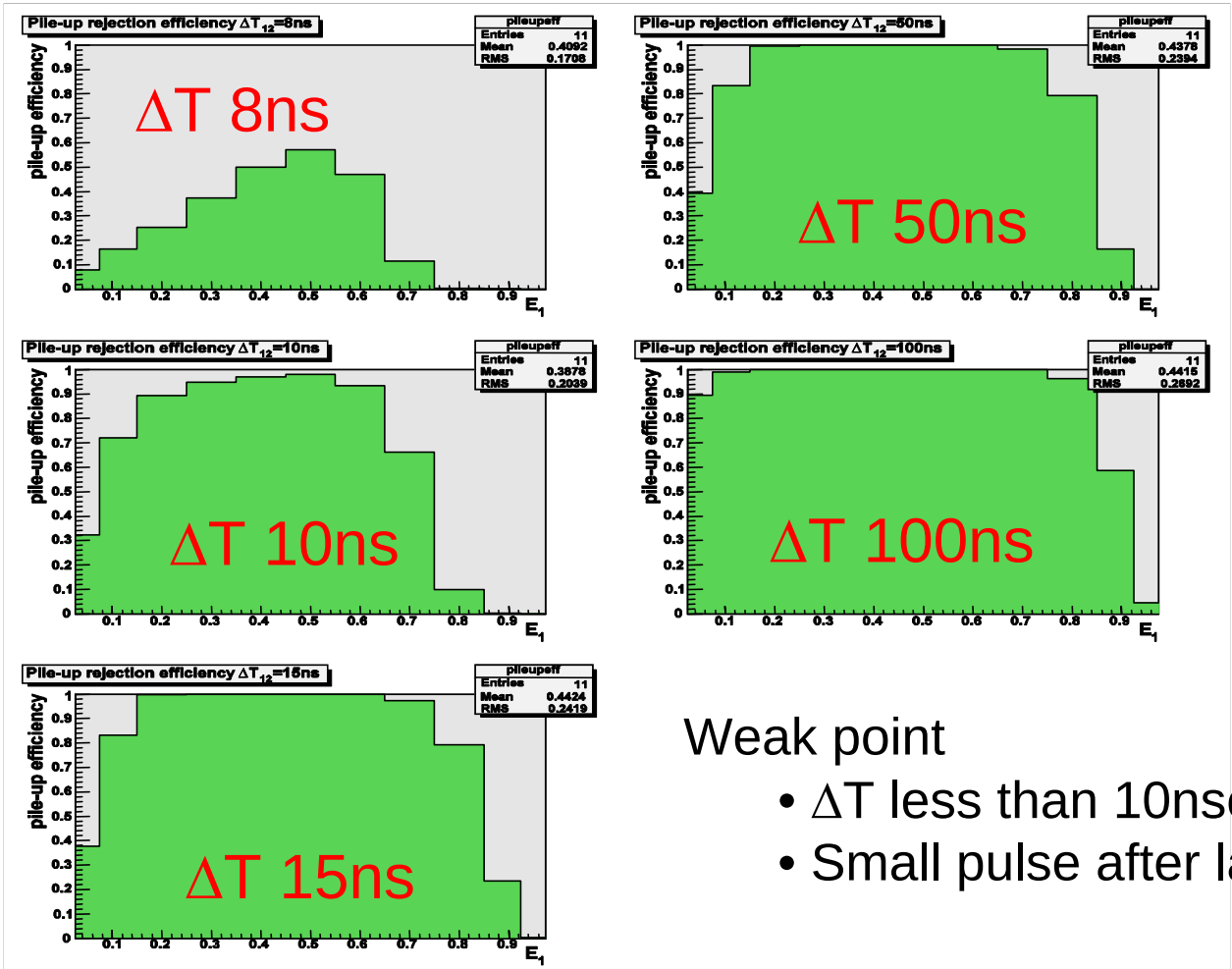
Rejection efficiency

optimization



Rejection efficiency

60%



Weak point

- ΔT less than 10nsec
- Small pulse after large one

Summary

- We Succeed in simulating waveform from LXe detector.
- It indicates the detector response is well understood.

- Algorithm for pile-up rejection is studied and is being optimized.
- Pile-ups can be separated if ,

$E\gamma$: >5MeV, ΔT: >10ns

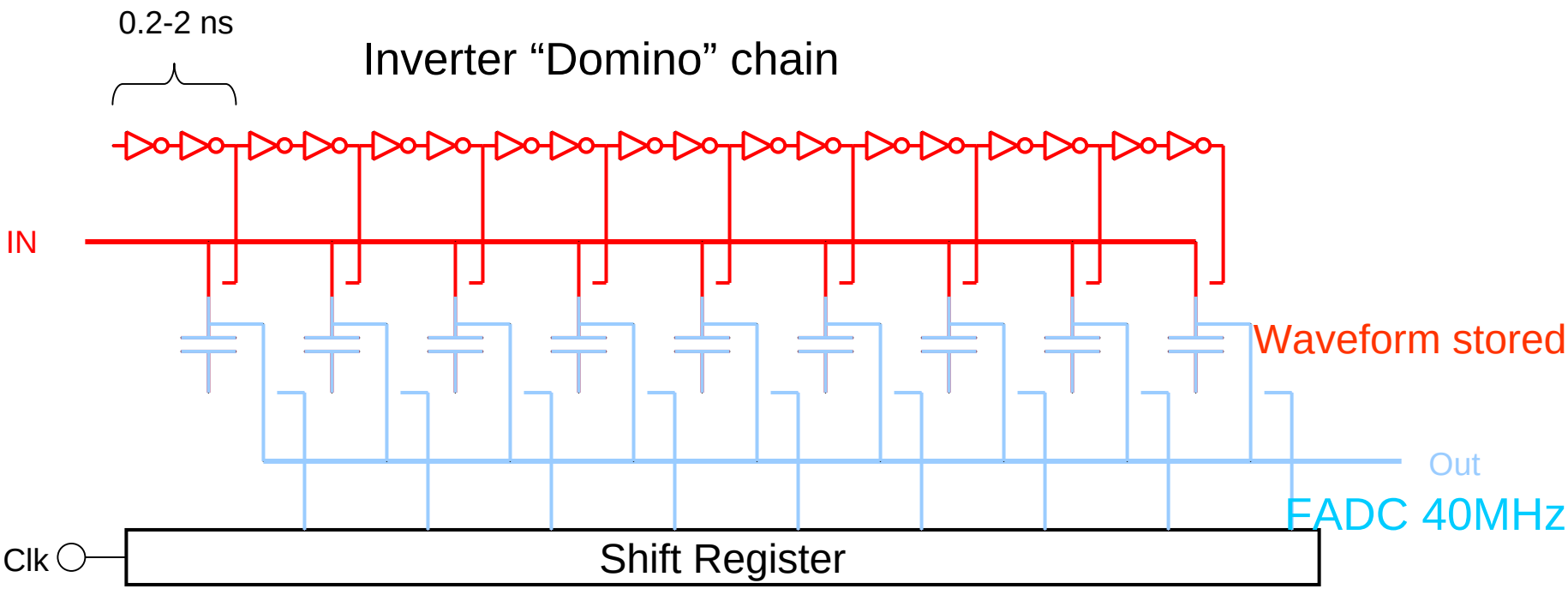
Next step

- Rejection spatially separated pile-up using distribution of PMT outputs
- Rejection efficiency against

$\mu \rightarrow e\gamma$ background

End of slides

DRS principle



“Time stretcher” GHz → MHz