

Electronics for rare event search

- Background rejection
- Electronics can
- CANDLES

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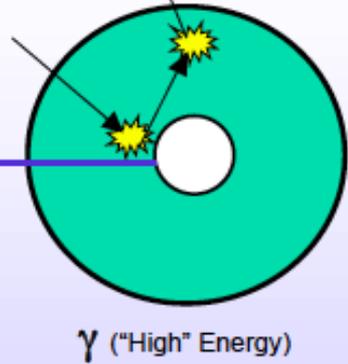
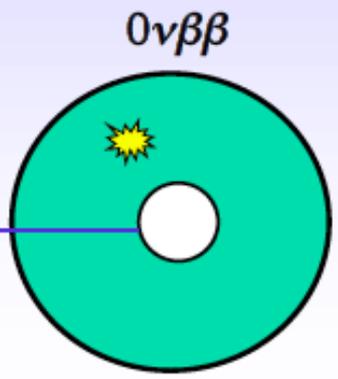
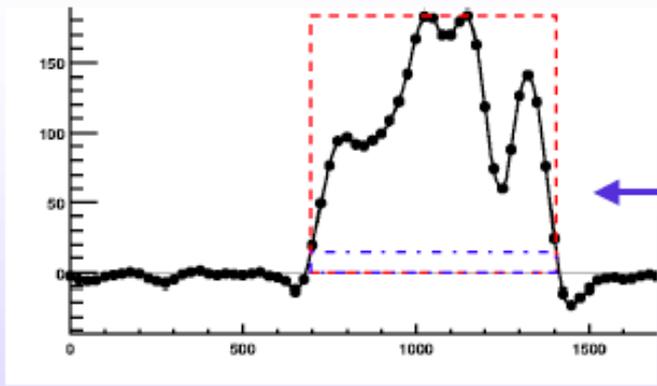
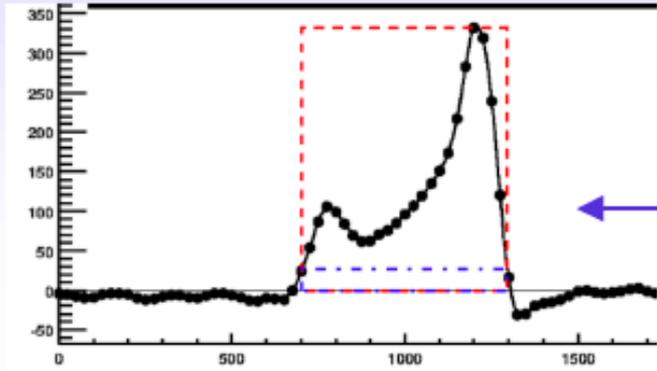
M.Nomachi

@DBD11

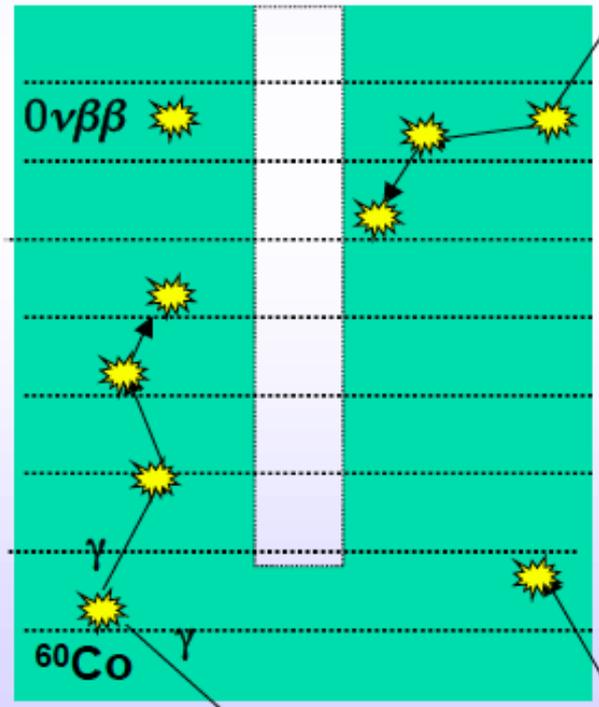
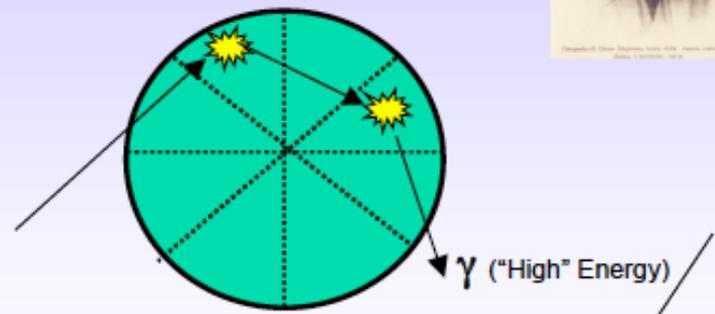
- **Wave form digitization is necessary**



Pulse-shape discrimination



Segmentation



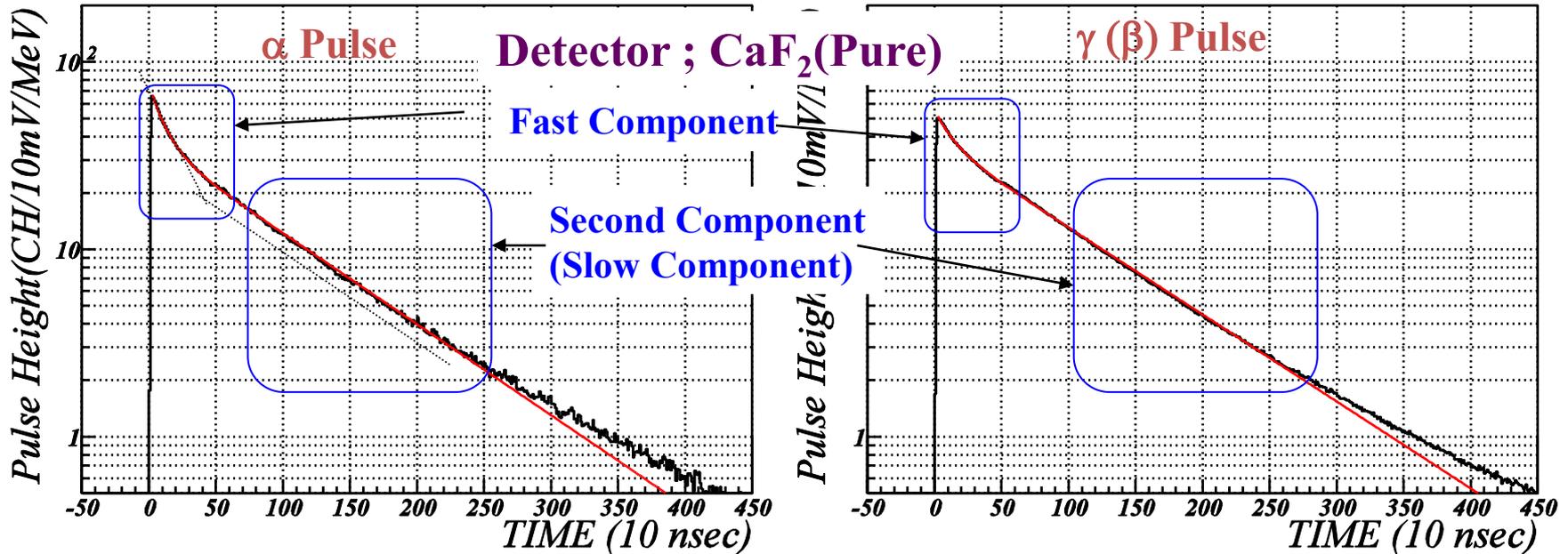
4/16/07

R. Henning -- UNC-CH

γ ('Low' Energy)

Particle identification

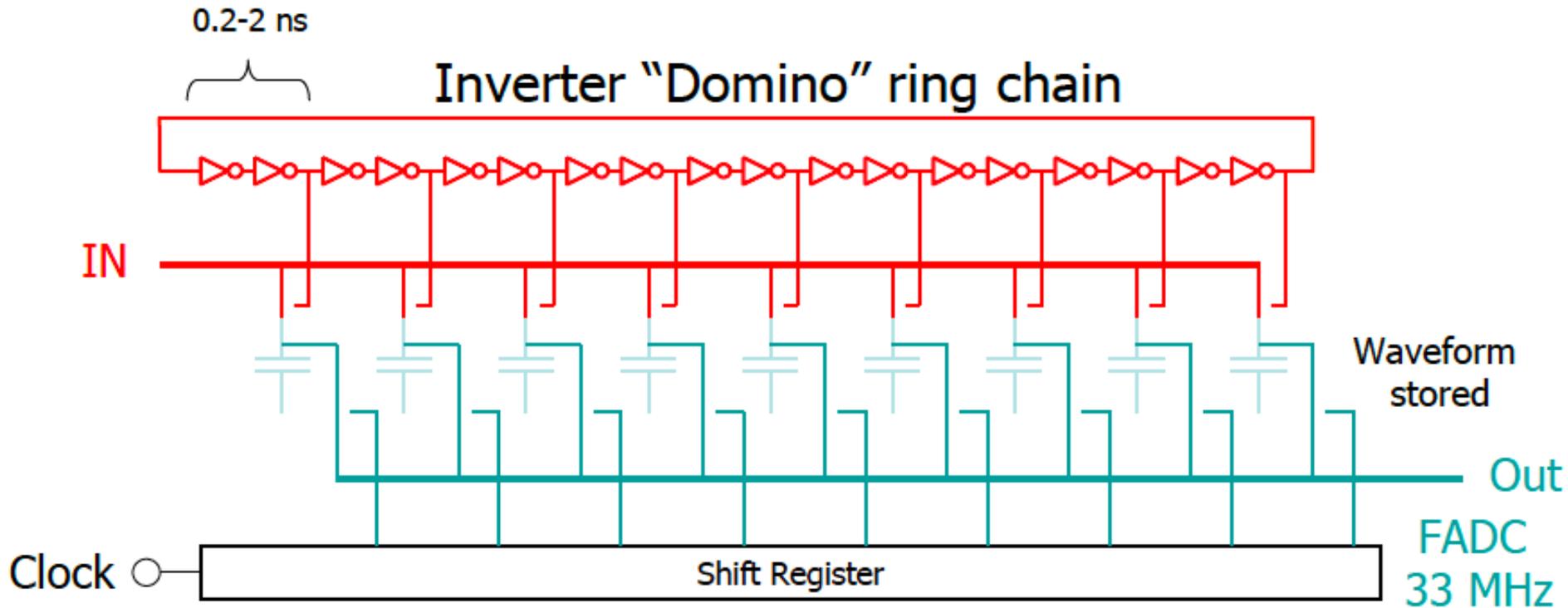
- Pulse shape discrimination is powerful tool
- Need large dynamic range



Electronics for wave form recording

- Flash ADC
 - several hundred M sample / second
 - Pipeline processing -> dead-timeless
 - Signal processing on the fly
- Switched capacitor array
 - A few G sample / second
 - Cause dead-time
 - Large dynamic range (Good S/N ratio)

Switched Capacitor Array

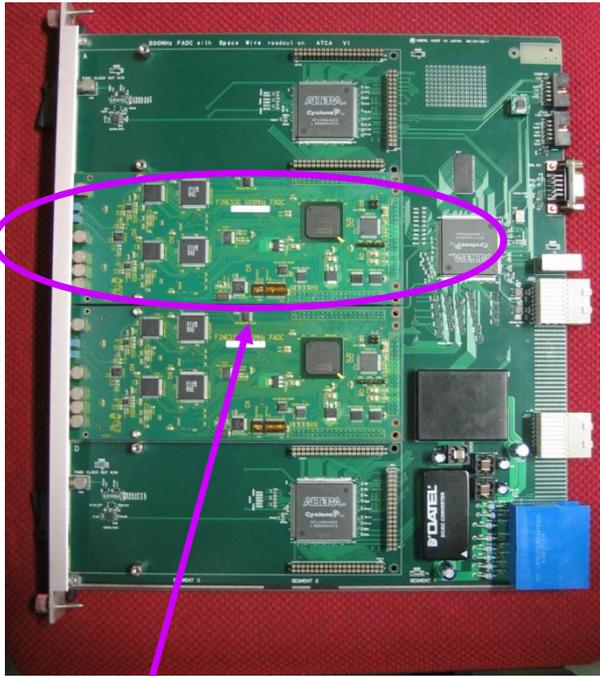


"Time stretcher" GHz \rightarrow MHz

CANDLES

500MHz FADC

Mother Board for FADC



- 500MHz FADC(Finesse board)
: HW is developed at KEK
- FADC board has 2 analog inputs.

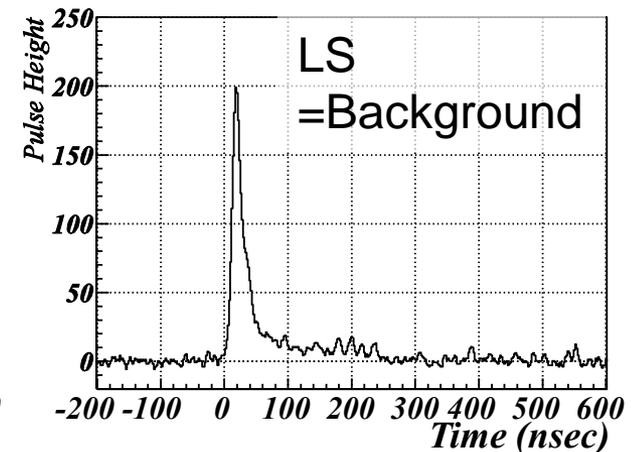
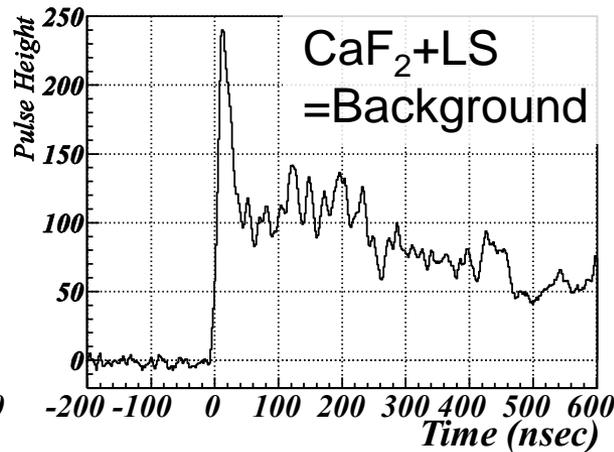
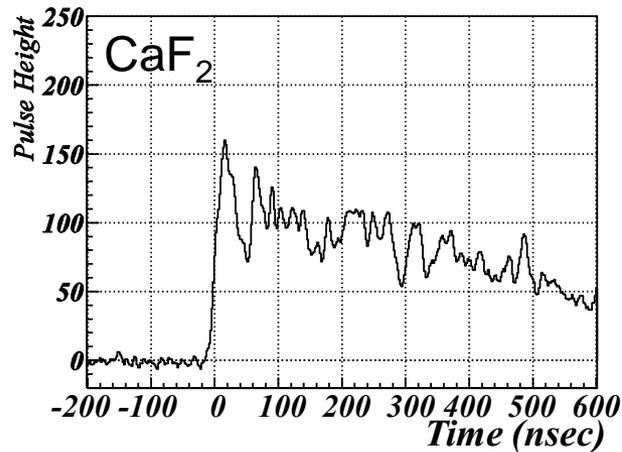
ATCA Subrack



- housing 12 mother boards.
(96ch analog inputs)
- Serial backplane

Pulse shape

 Expected pulse shape from CANDLES system



τ of CaF₂ = ~ 1000 nsec
LS = ~ 20 nsec

LS = active shield

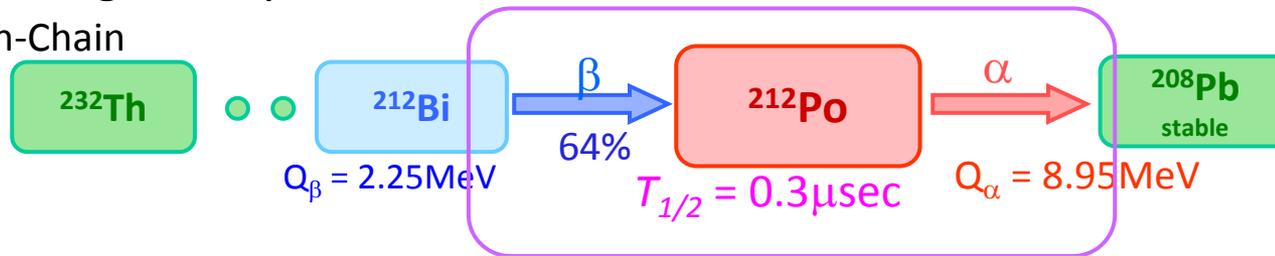
CANDLES

internal Background

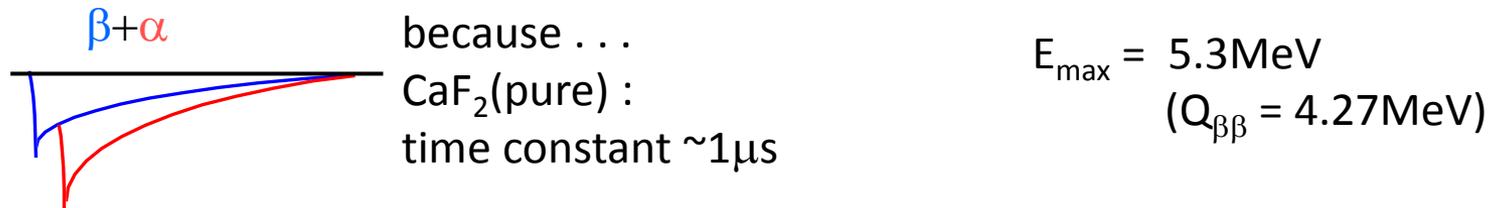
– Radioactive Contamination within CaF₂(pure)

Background process

Th-Chain



Pile-up Event (Sequential Event)



To Identify as pile-up event (background event)
with $\Delta t \sim 10\text{nsec}$...

- Record the pulse shape with high sampling

CANDLES electronics

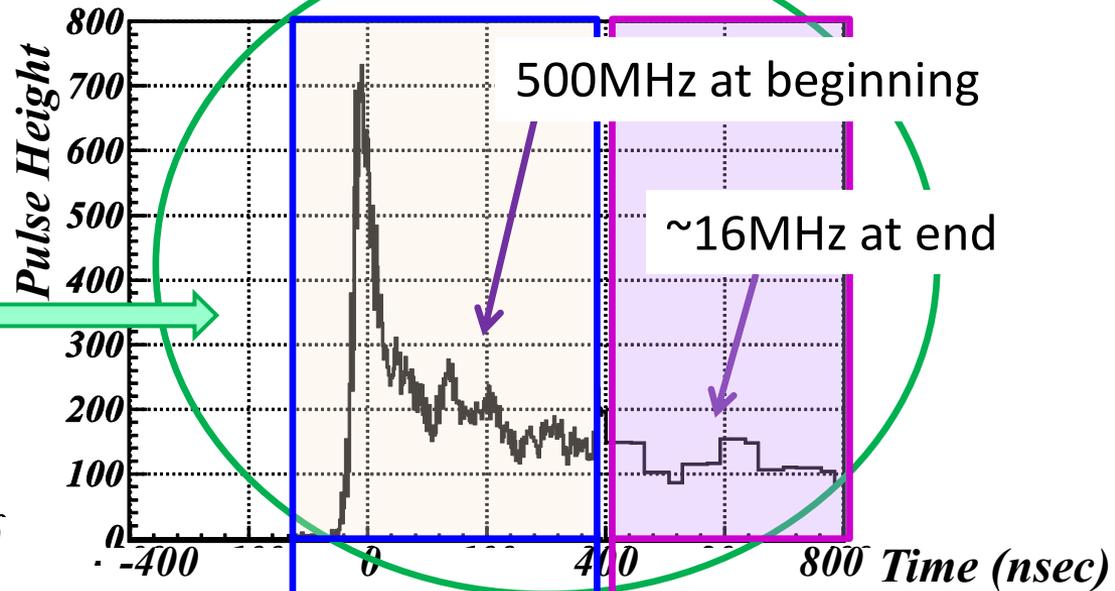
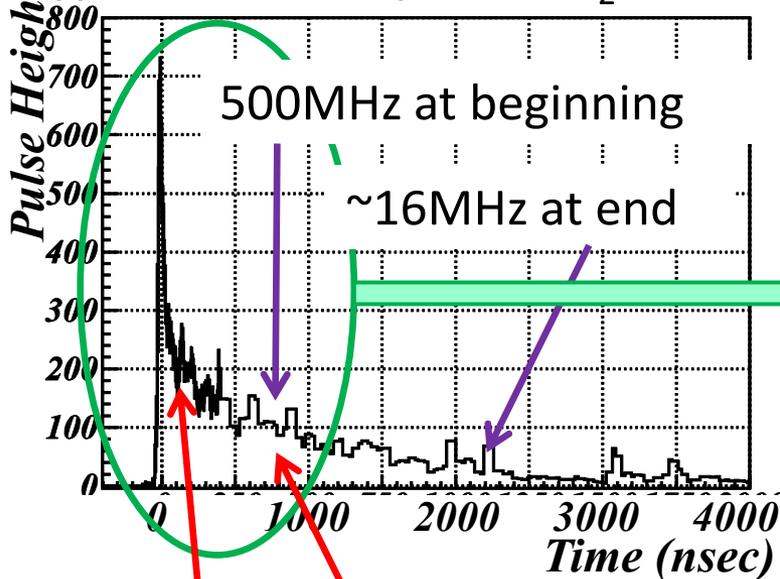
- Wave form digitization
 - Pulse Shape Information (500MHz)
 - For rejection of liquid scintillator events
 - For rejection of sequential events
 - On the other hand, we need to save data size
 - High sampling at the beginning of pulse shape
 - Low sampling at the ending
 - Dead-timeless
 - Recording time is very long
- Trigger : sophisticated event selection
 - High efficiency for CaF_2 signal
 - Low efficiency for liquid scintillator signal

FADC for CANDLES

- Data Suppression

- High sampling rate at the beginning, Low sampling at the ending

Typical Pulse Shape of CaF₂+LS



500MHz × 256

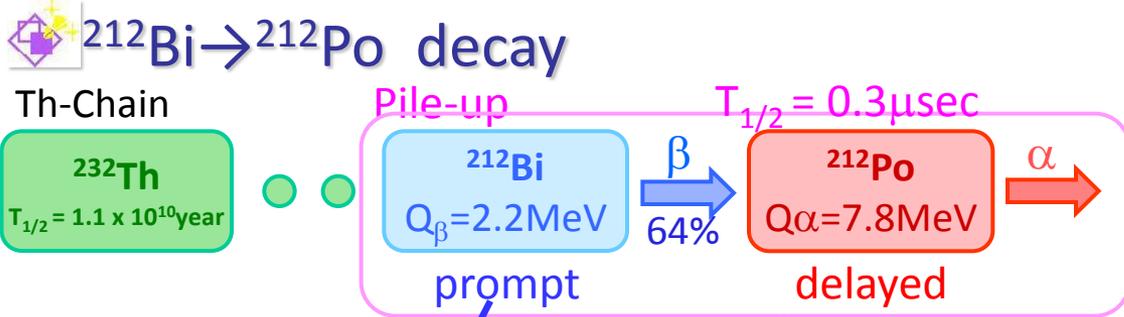
16MHz × 128

(Sum at FPGA)

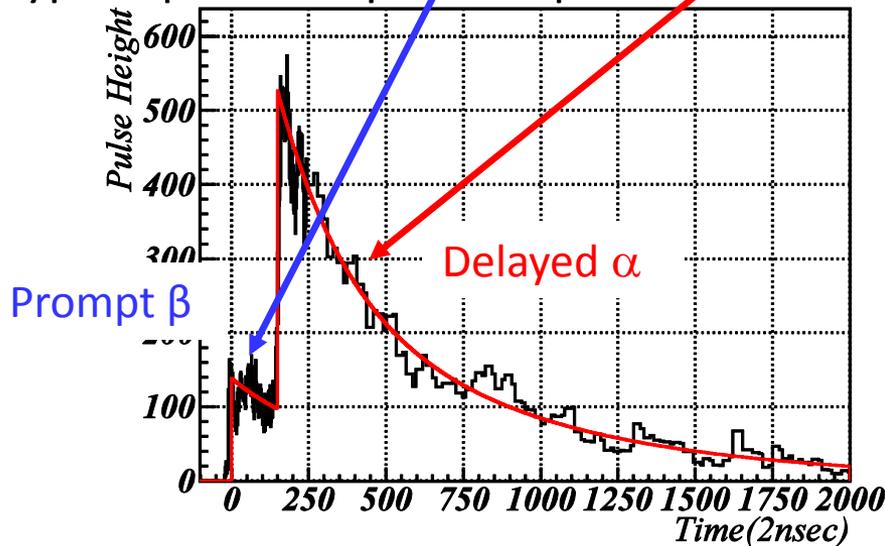
Clear Discrimination between CaF₂ and Liquid scintillators
and Data size is small.

• 500MHz × 2048data → 500MHz × 256data + 16MHz × 128data

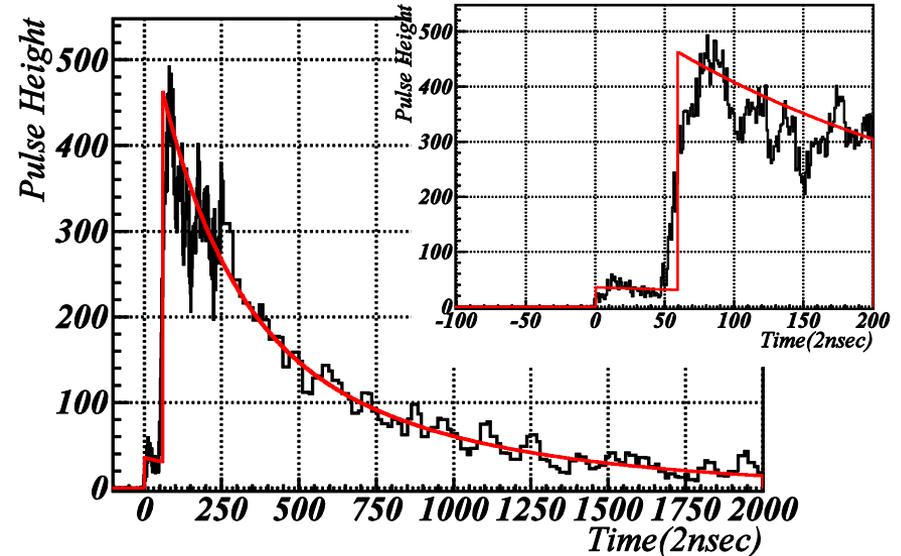
Sequential Events



Typical pulse shape of sequential events



with small Δt

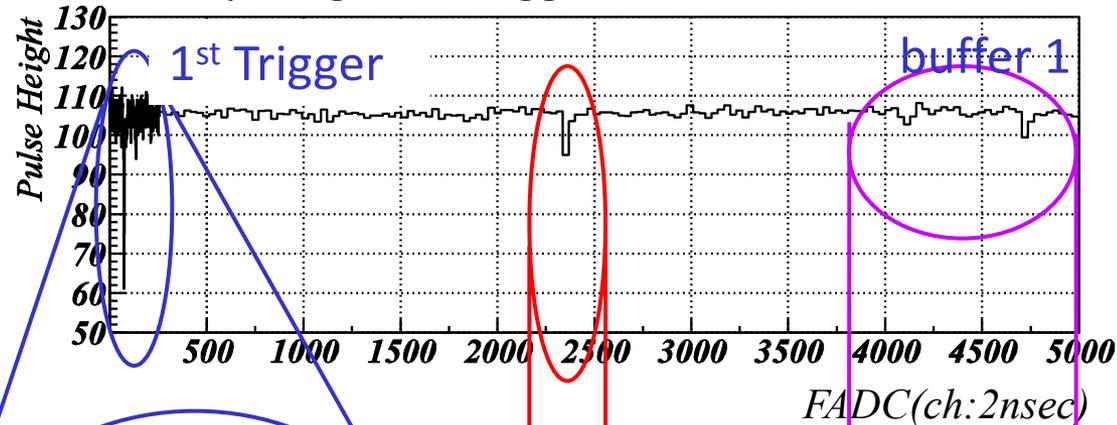


Sum-up signal of 62 PMT

We can identify the sequential events by using the FADC data in offline analysis.

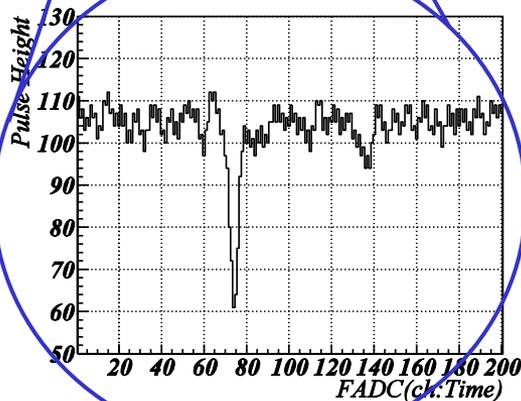
Dead time less measurement

Sample signal of triggers with short Δt

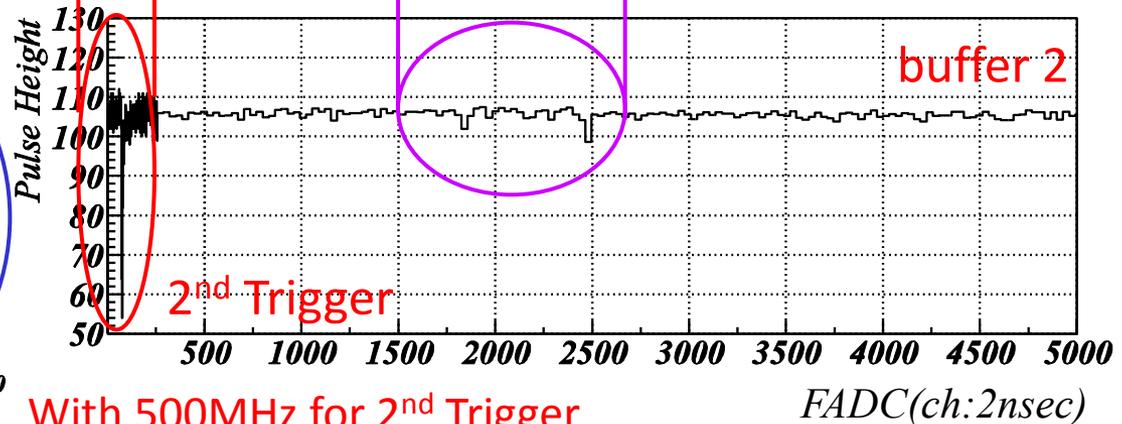


FADC has 3 buffers
for data memory
→ dead time less

Identify as the same event
With time stamp



With 500MHz for 1st Trigger



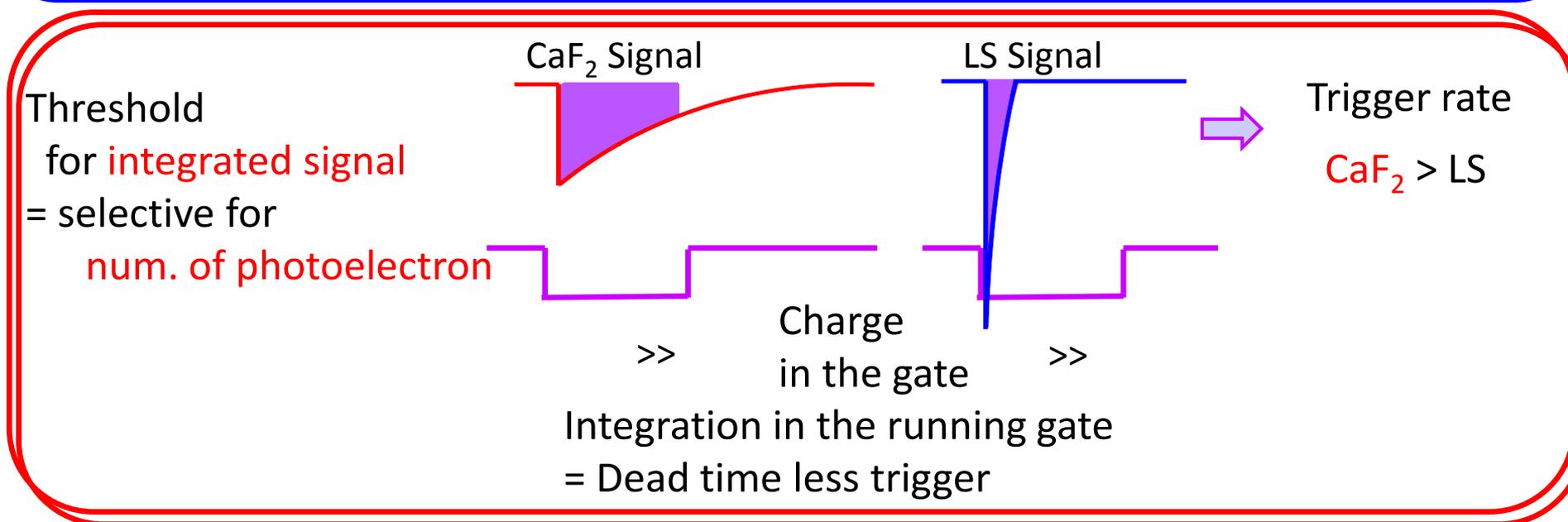
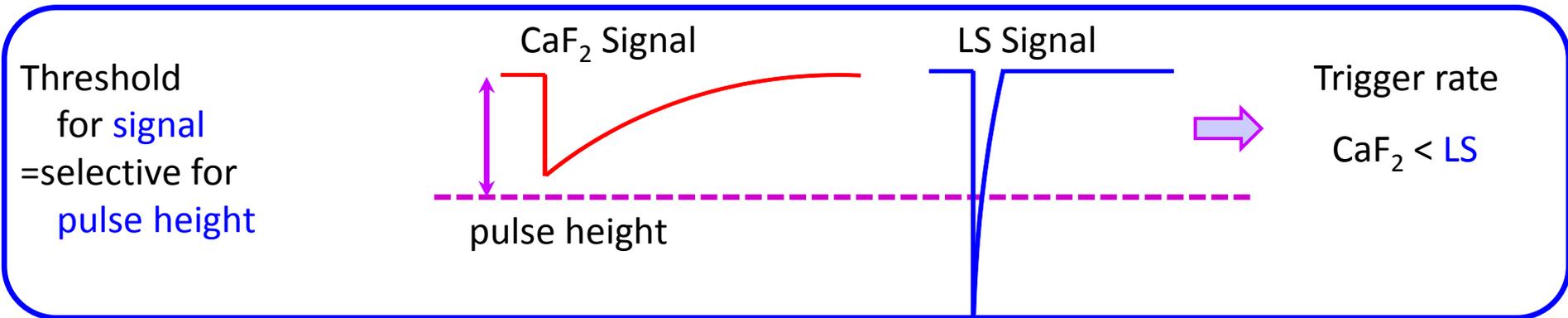
With 500MHz for 2nd Trigger

CANDLES electronics

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 - For rejection of sequential events
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 - Low efficiency for liquid scintillator signal

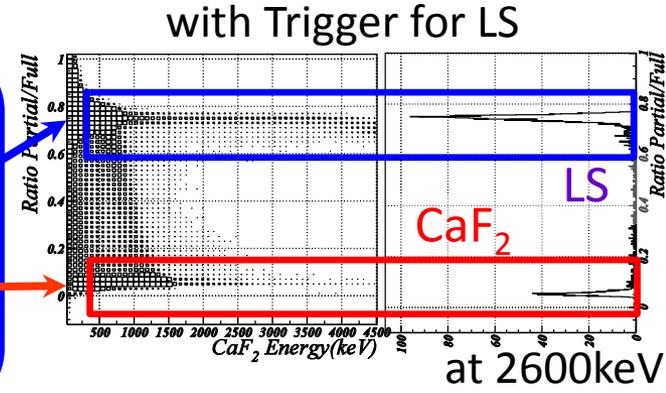
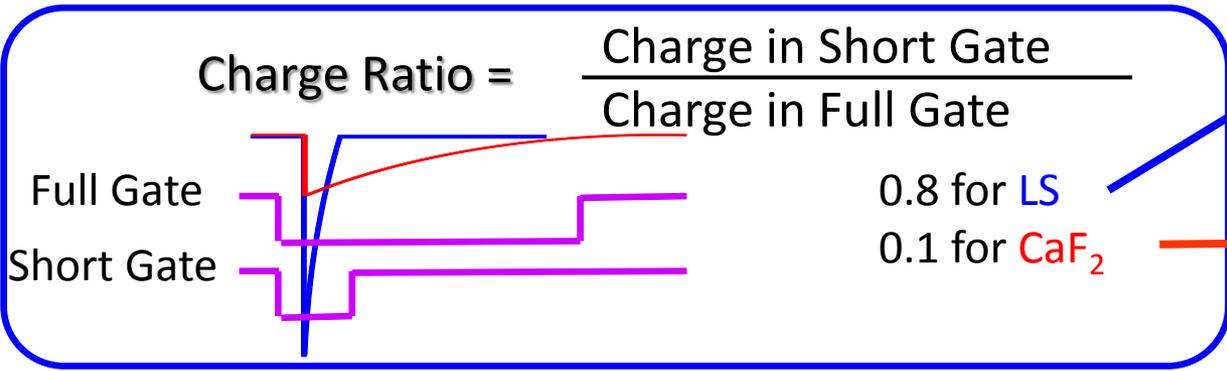
Trigger

- Threshold for Integrated Signal
 - CaF_2 : $\tau = 1\mu\text{sec}$, LS : $\tau = \text{a few } 10\text{nsec}$



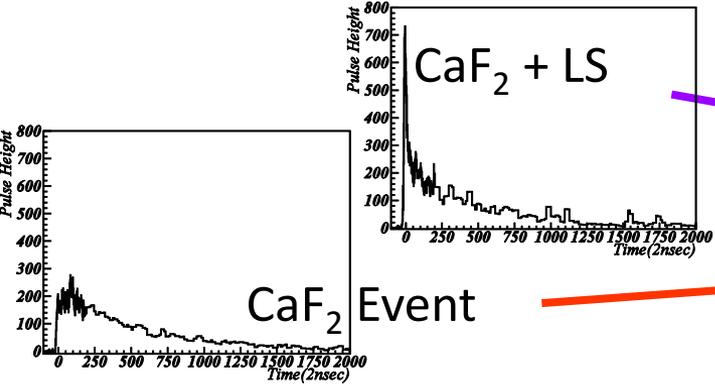
Trigger

- Charge ratio distribution

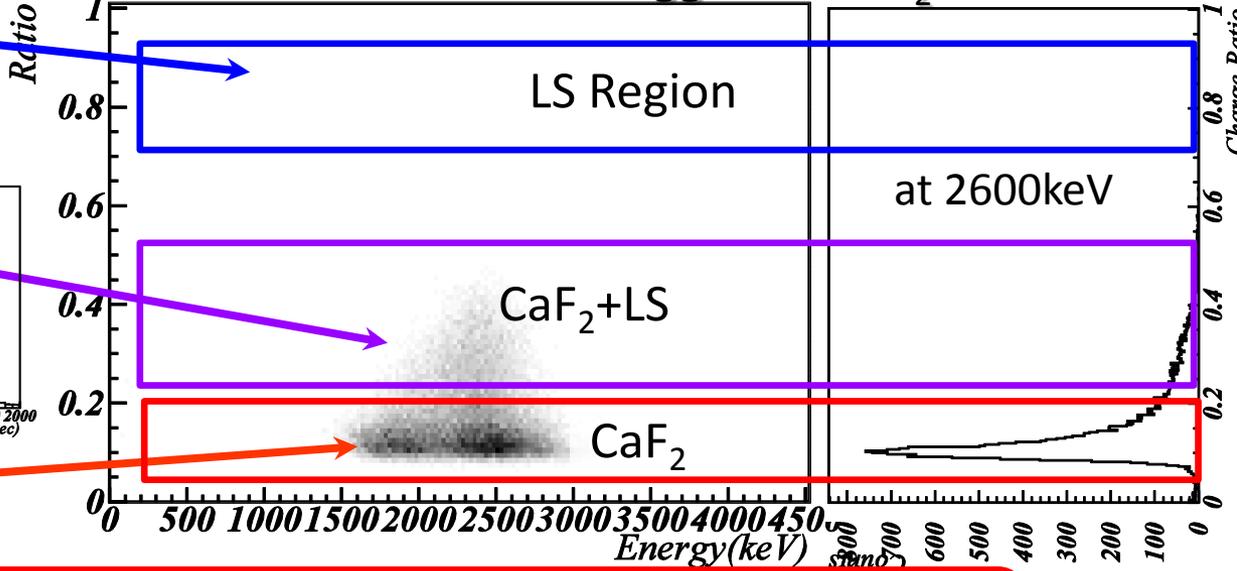


No LS Events

Threshold for integrated signal well works.



Event Distribution with Trigger for CaF₂



We obtained ...

- High efficiency for CaF₂ Scintillator, Low efficiency for LS

Summary

- Wave form measurement is a key for background rejection
- FADC for CANDLES
 - High sampling rate at the beginning of pulse shape
 - Low sampling rate at the ending of pulse shape
 - Threshold for integrated ADC signal
 - Dead time less data processing for trigger at FPGA