time resolution of a long scintillator bar

Hongyu Zhang

(Xiaolong Wang, Xiyang Wang, Weike Liu)

Fudan University

CEPC Physics and Detector Plenary Meeting

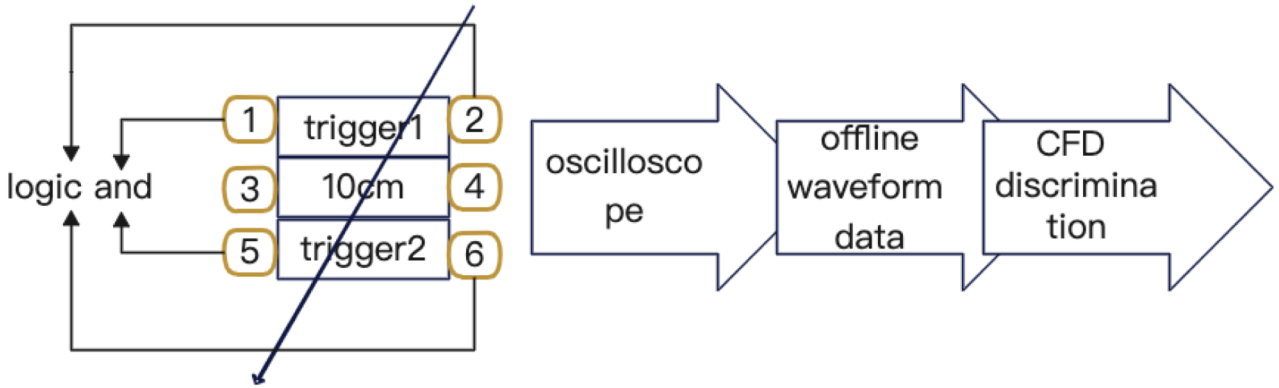
November 23, 2022

Content

01 Set up for time resolution

02 Measurement results : GaoNengKeDi & Saint-Gobain

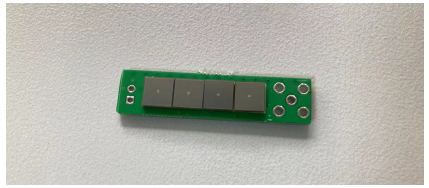
Set up and readout



$\Delta T=(T1+T2+T5+T6)/4-(T3+T4)/2$

Time resolution
Gaus Fit-> $\sigma(\Delta T)$

- 10cm triggers
- Readout from two ends
- 4 SiPMs in parranel



- reduce the hitting position variation of the cosmic ray and the uncertainty of start time of the system.

$\sigma(\Delta T)^2= (\sigma_1^2+ \sigma_2^2 +\sigma_5^2 +\sigma_6^2)/16+ (\sigma_3^2 +\sigma_1^2)/4$

$\sigma=\sigma_1=\sigma_2 =\sigma_3 =\sigma_4 =\sigma_5 =\sigma_6$

Time resolution of short strip using two end readout

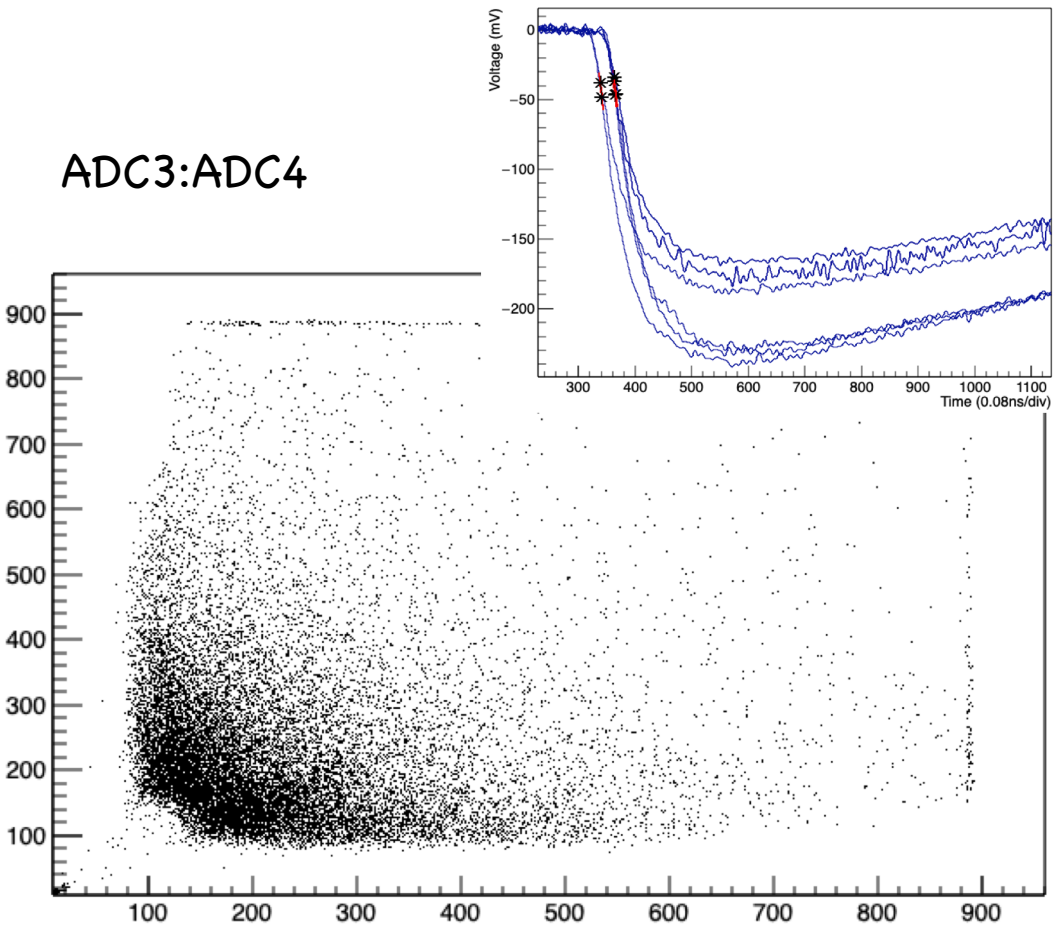
$\sigma_{short}= \sigma /\sqrt{2}$

Time resolution of two triggers

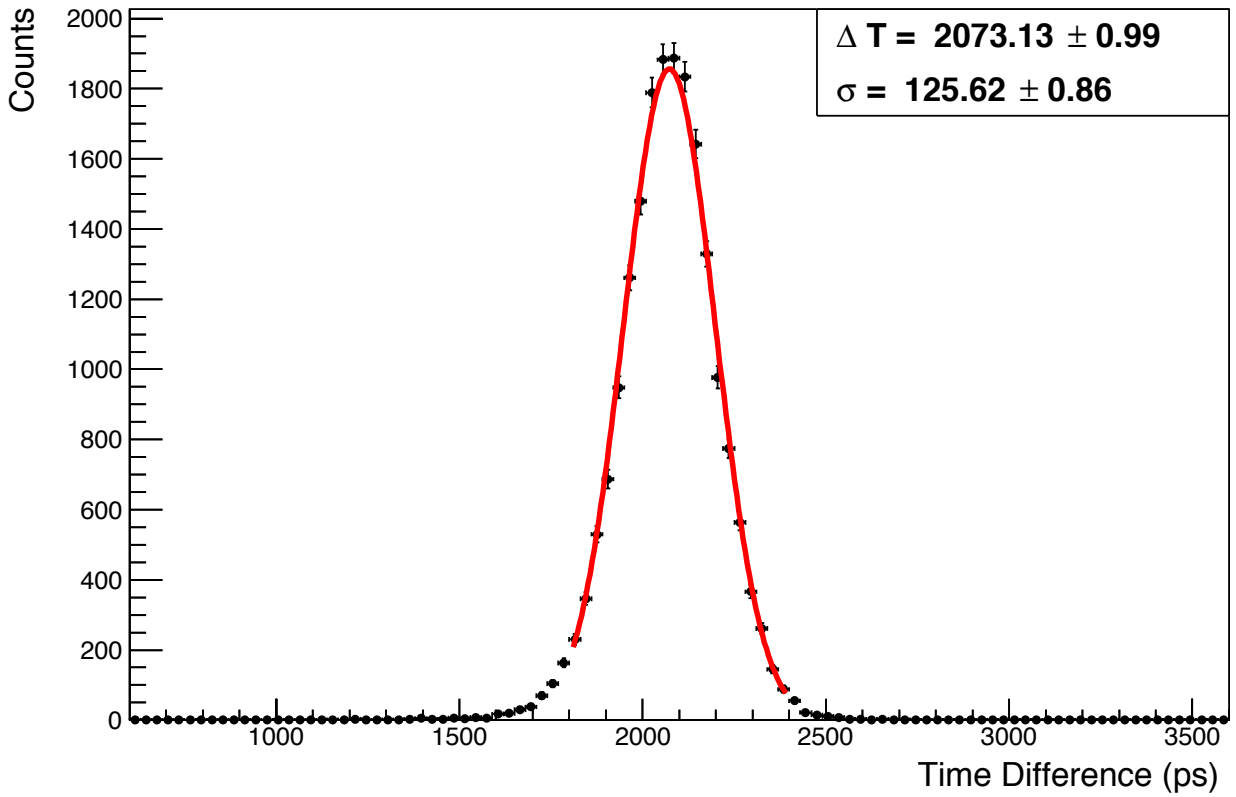
$\sigma_{tri}= \sigma /2$

Time resolution of short strip

ADC3:ADC4



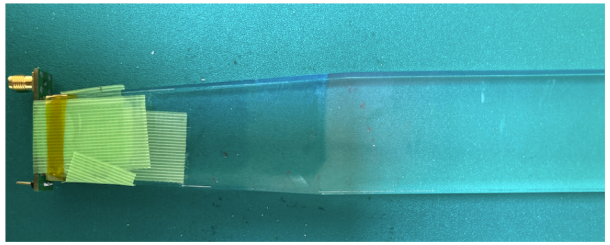
(T1+T2+T5+T6)/4-(3+T4)/2

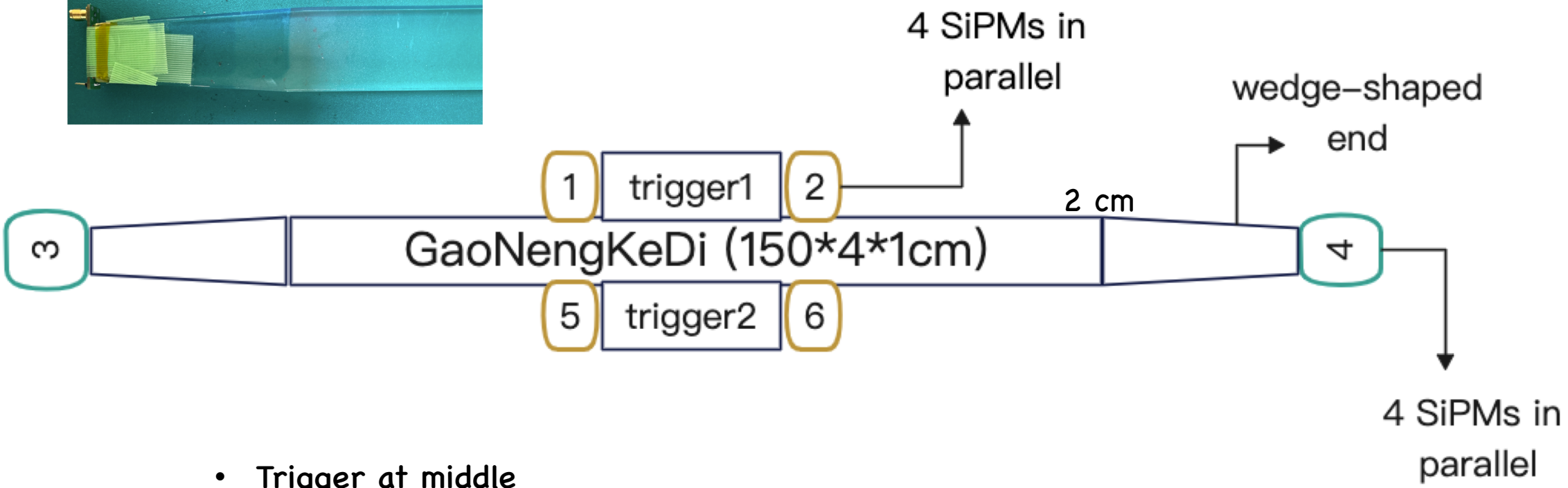


Time resolution of short strip using two end readout σ_{short}=103 ps

Time resolution of two trigger σ_{tri}=73ps

Set up and readout



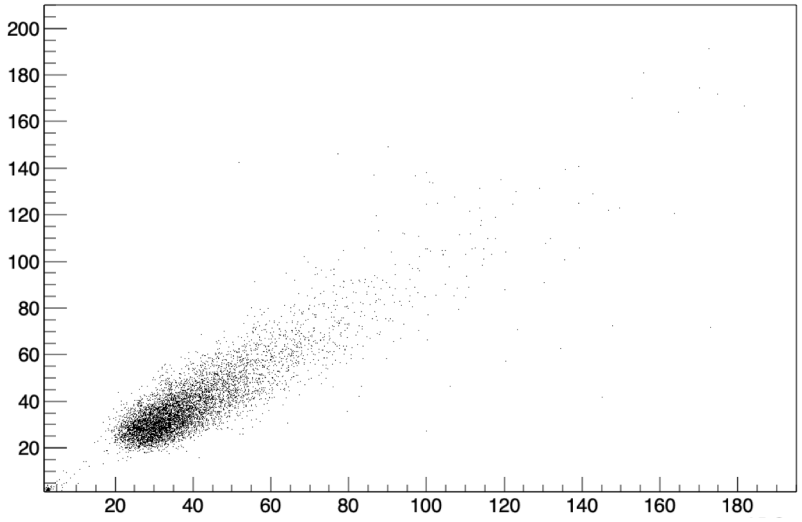


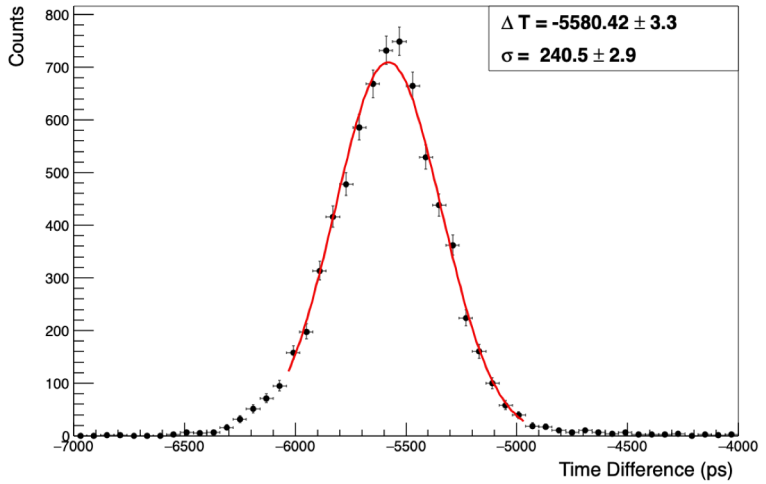
- Trigger at middle
- signals generated from the middle of the bar would give out the worst time resolution.

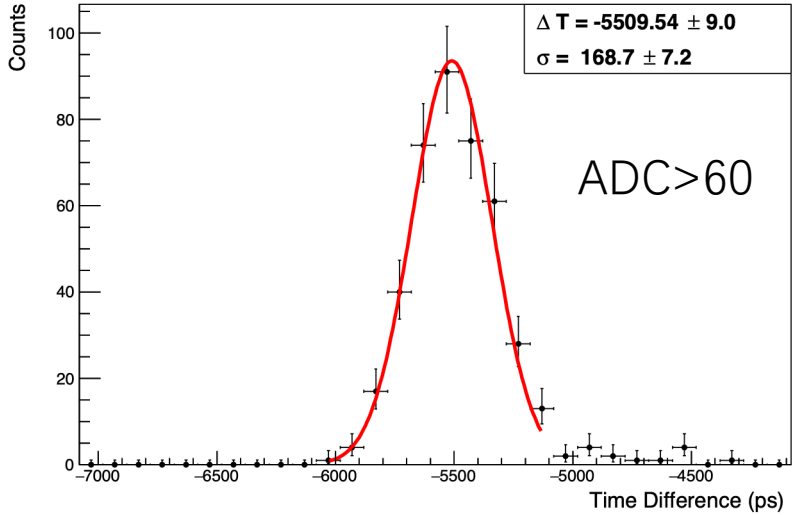
Result of long scintillator : GaoNengKeDi

ADC3:ADC4

(T1+T2+T5+T6)/4 - (T3+T4)/2







σ_{tri}=73ps

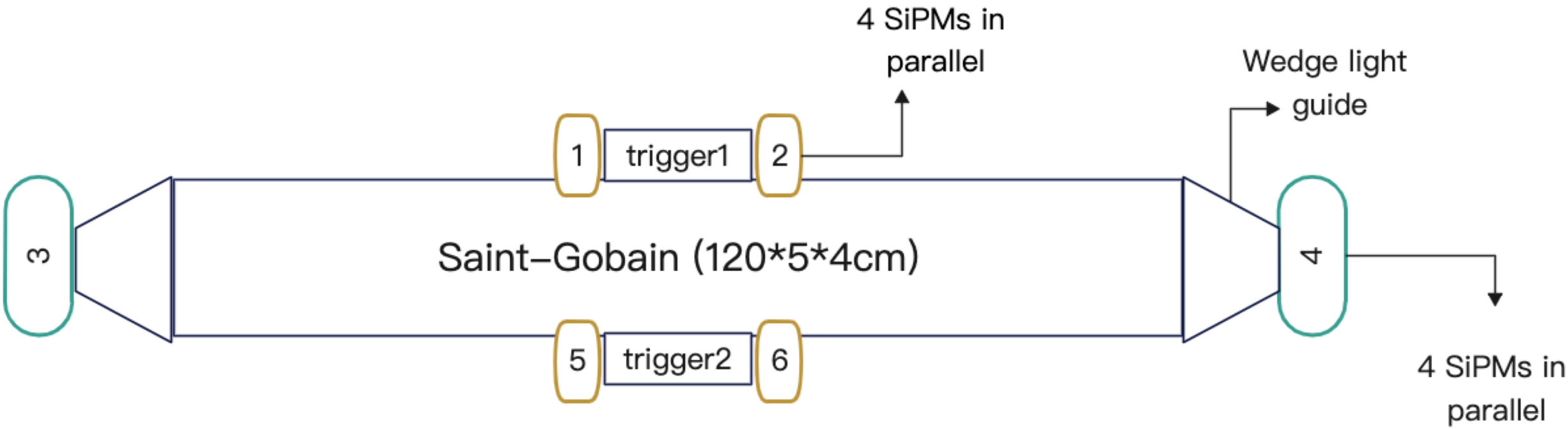
Time resolution of long strip using two end readout

σ_{long}=229 ps

σ_{long}=152 ps

Improve photon collection is effective

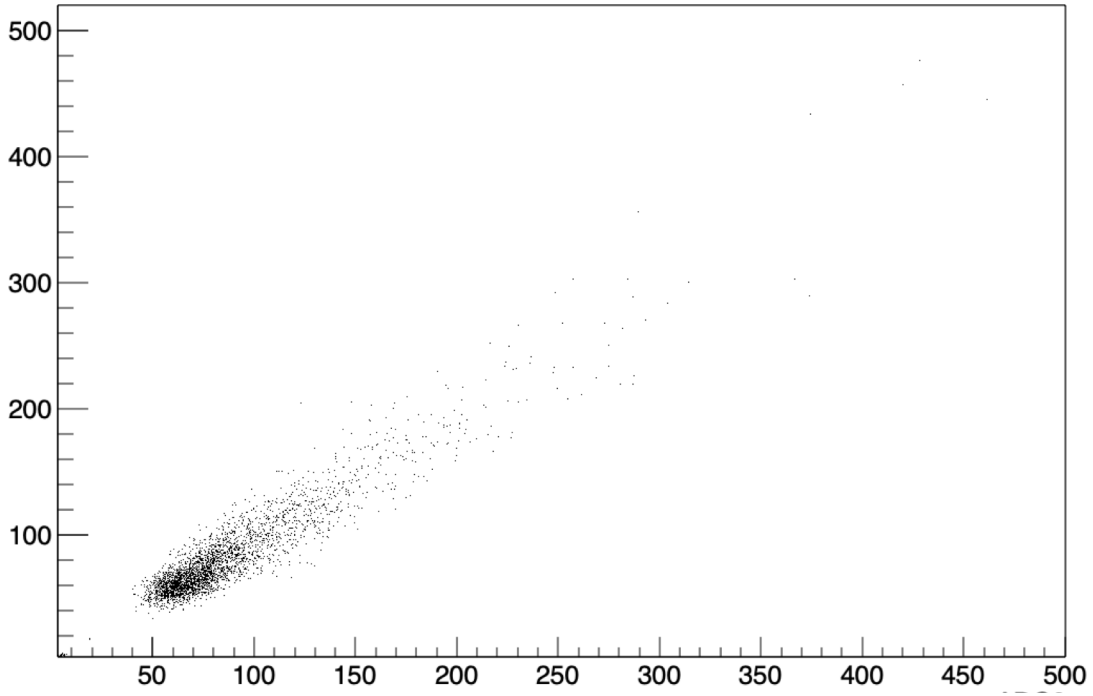
Set up and readout



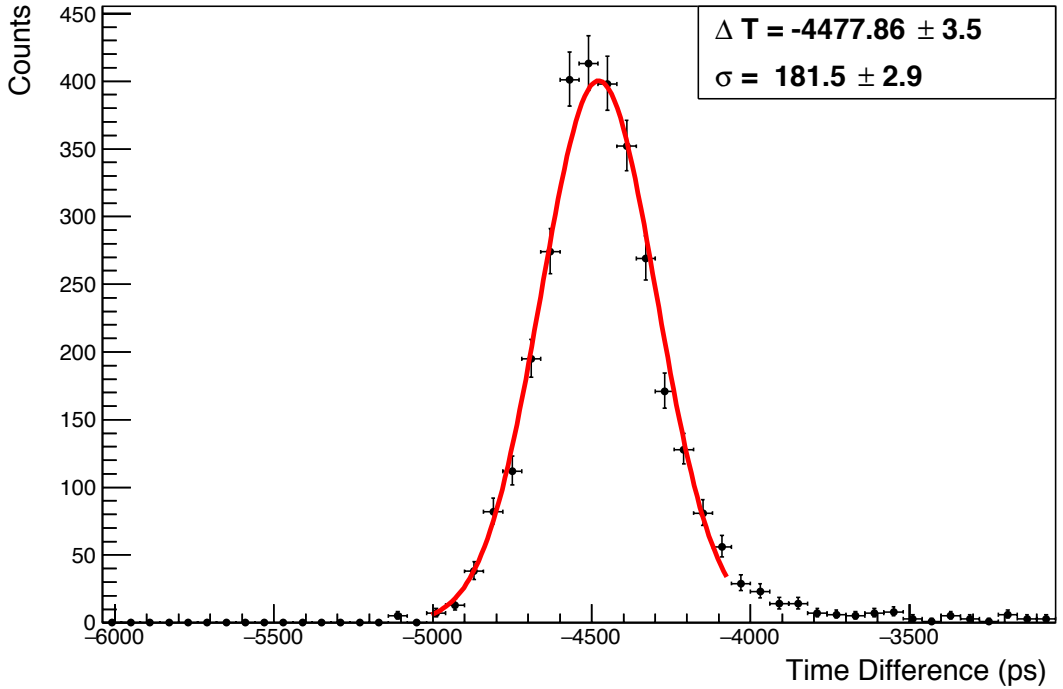
SAINT-GOBAIN: BC420
Long attenuation length

Result of long scintillator : Saint-Gobain

ADC3:ADC4



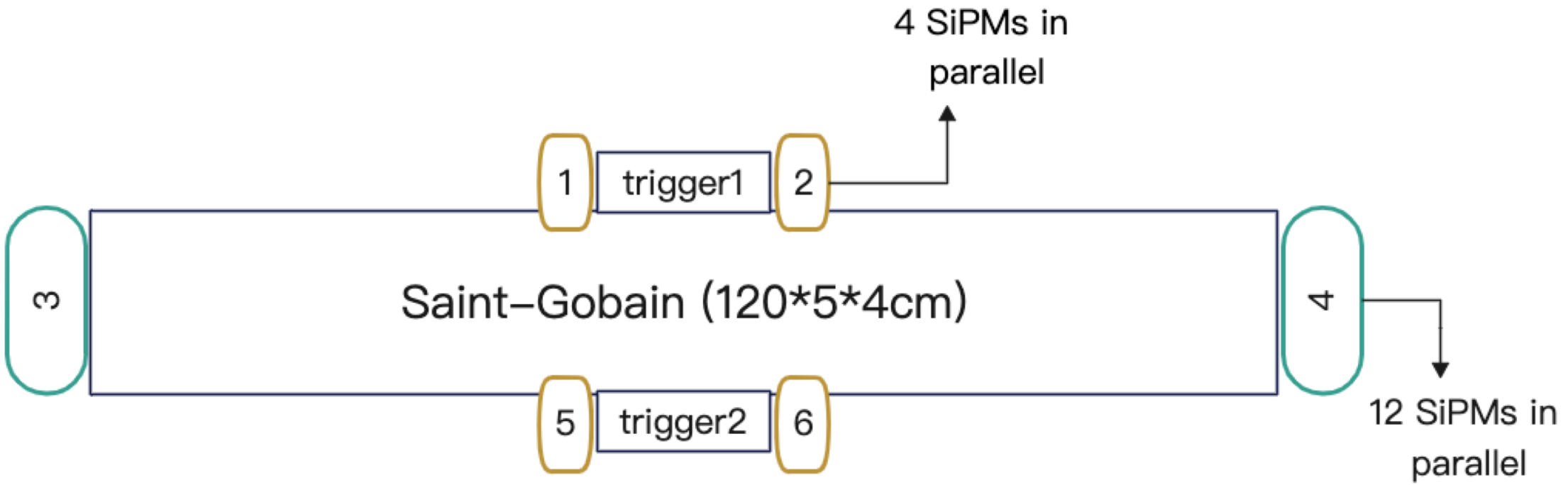
(T1+T2+T5+T6)/4-(T3+T4)/2

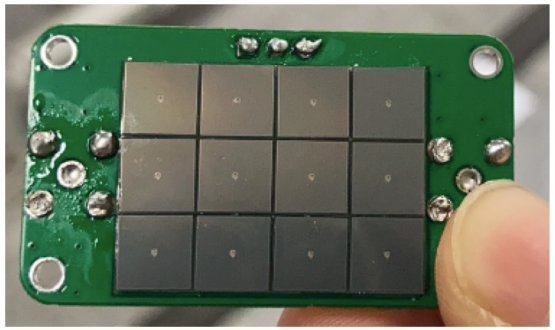


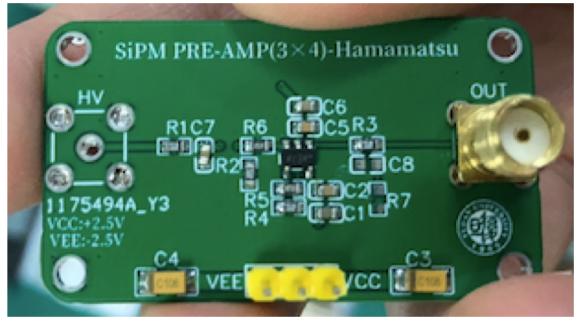
Time resolution of long strip using two end readout

σ_{long}=165 ps

Set up and readout

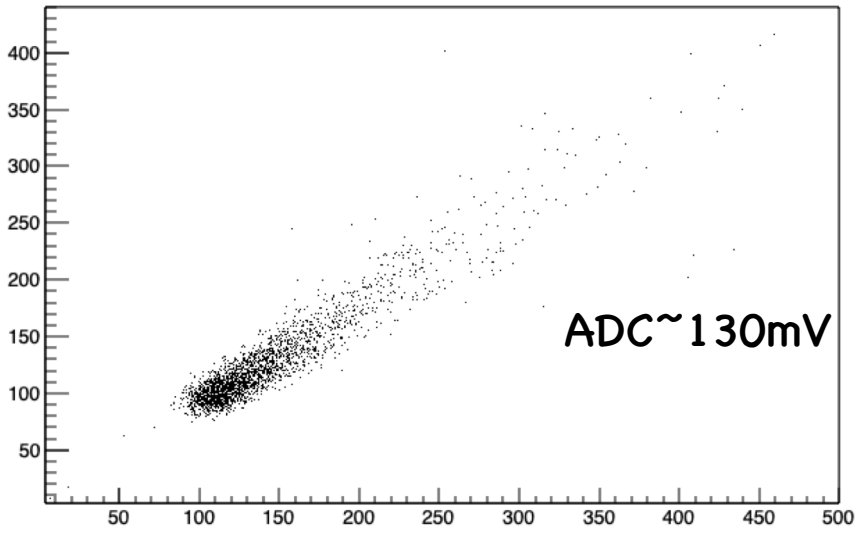




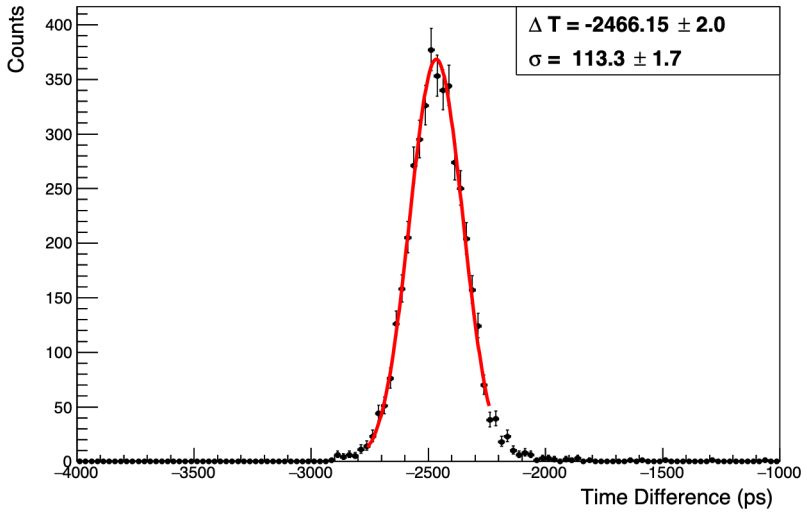


Result of long scintillator : Saint-Gobain

ADC3:ADC4 With Tin foil

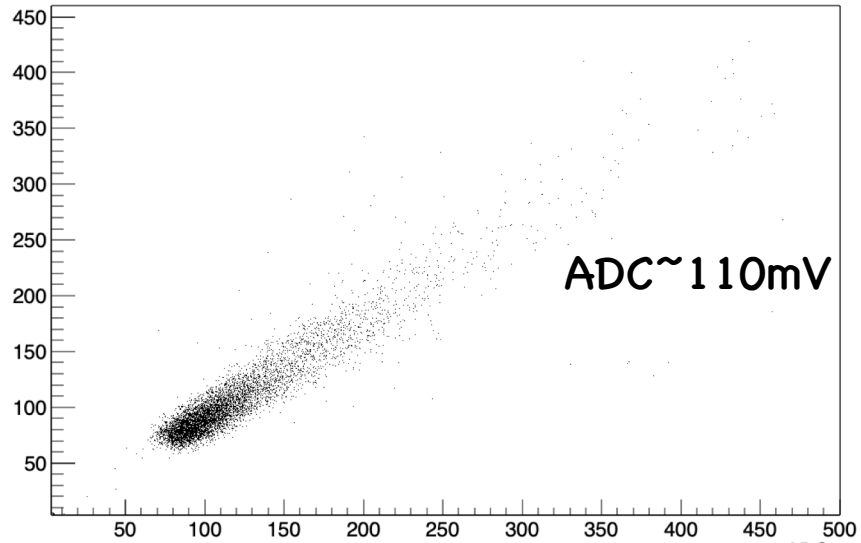


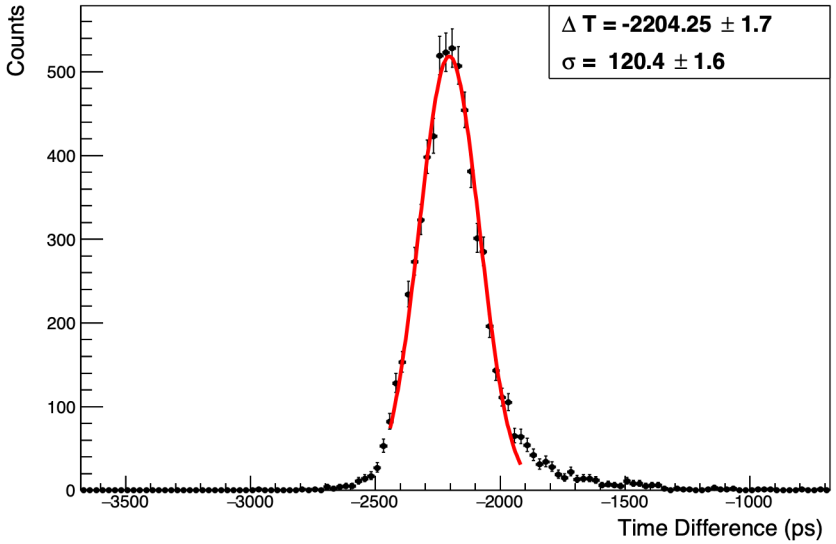
(T1+T2+T5+T6)/4-(T3+T4)/2



σ_{long}=87 ps

Without Tin foil





σ_{long}=96 ps

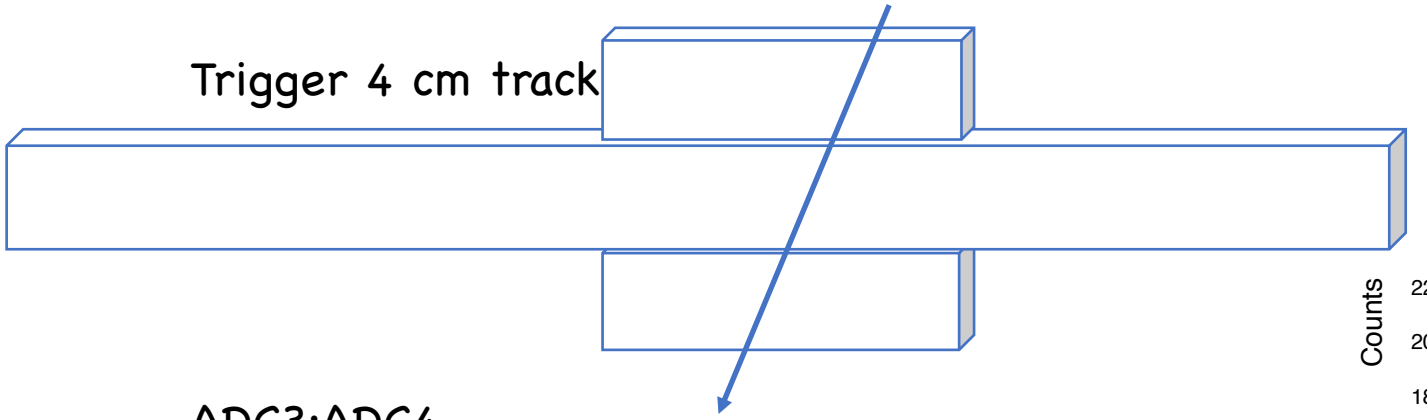
Summary

- Time resolution of two 10cm triggers using two-ends readout : 73ps
- Time resolution of long scintillator bar:
  - GaoNengKeDi(150cm) + 4 SiPMs : 229ps
  - Saint-Gobain(120cm) + 12SiPMs : 87ps

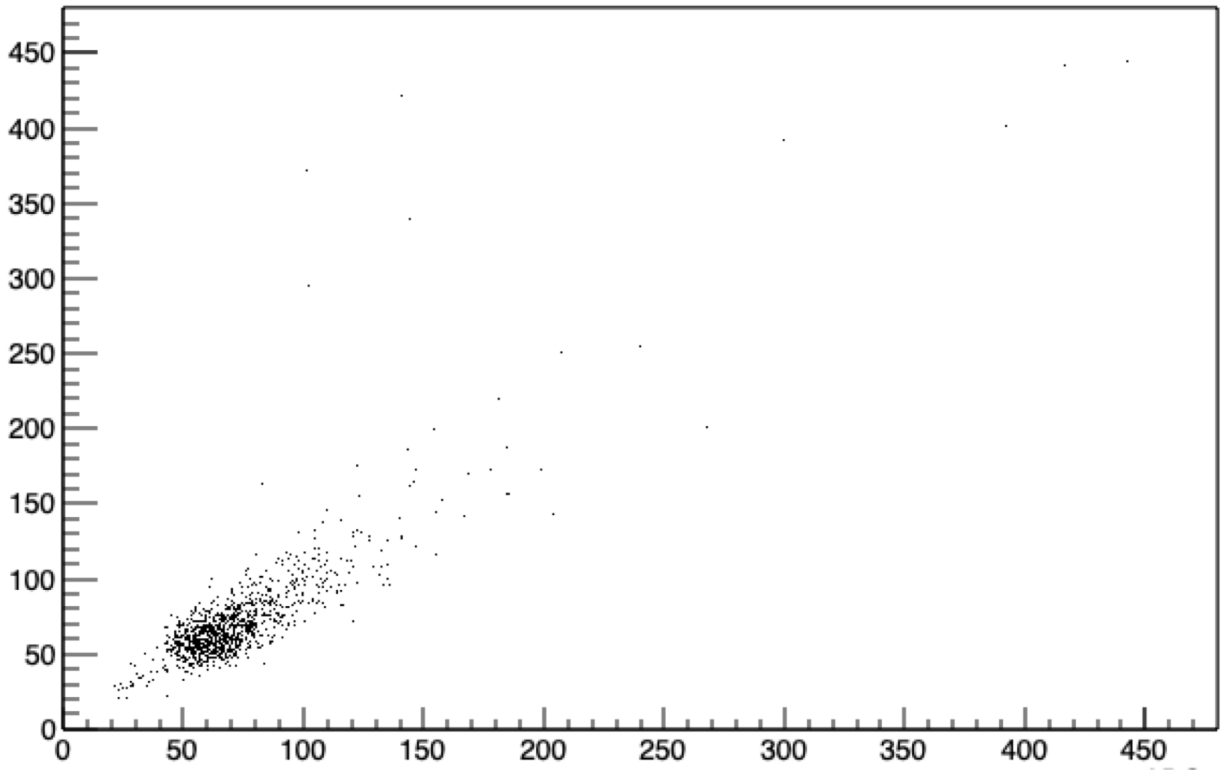
Thank you!

Back up

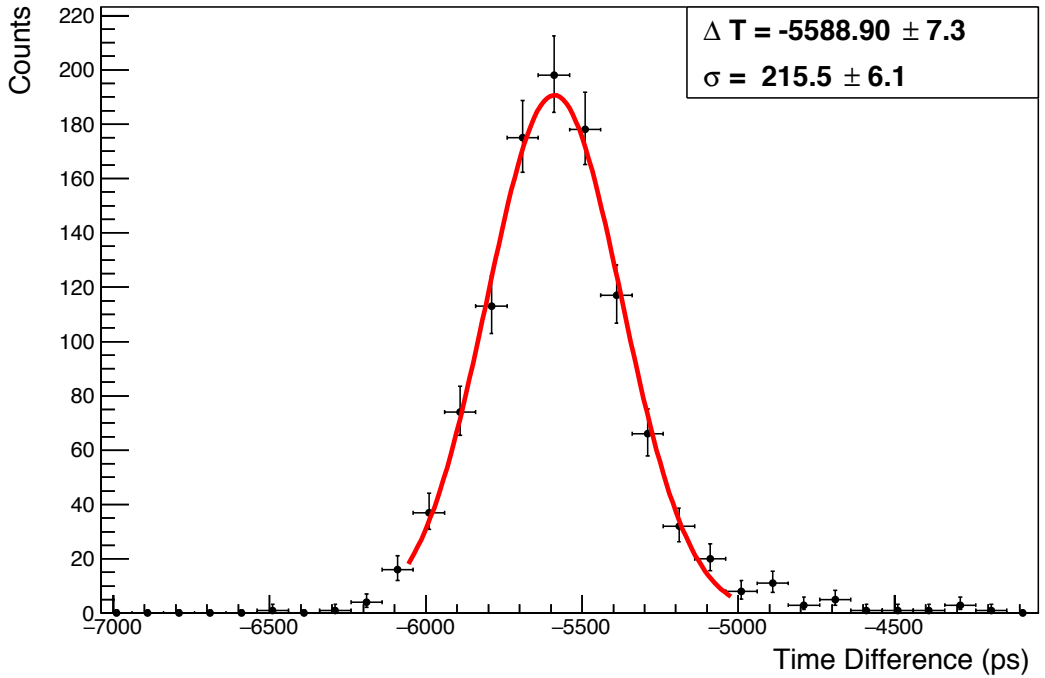
Result of long scintillator : GaoNengKeDi



ADC3:ADC4



(T1+T2+T5+T6)/4-(T3+T4)/2



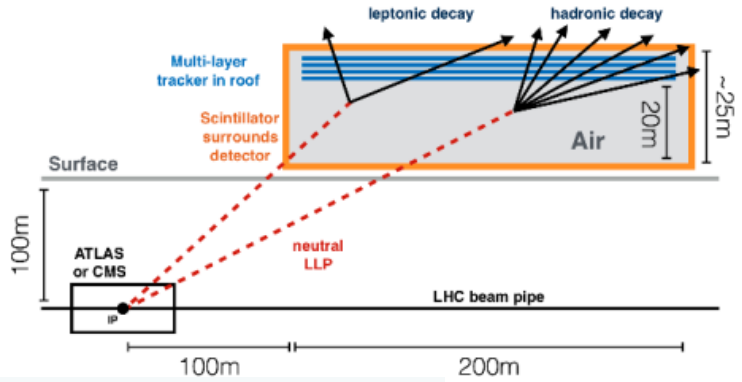
$\sigma_{(T1+T2)/2-(T5+T6)/2}$ =178 ps

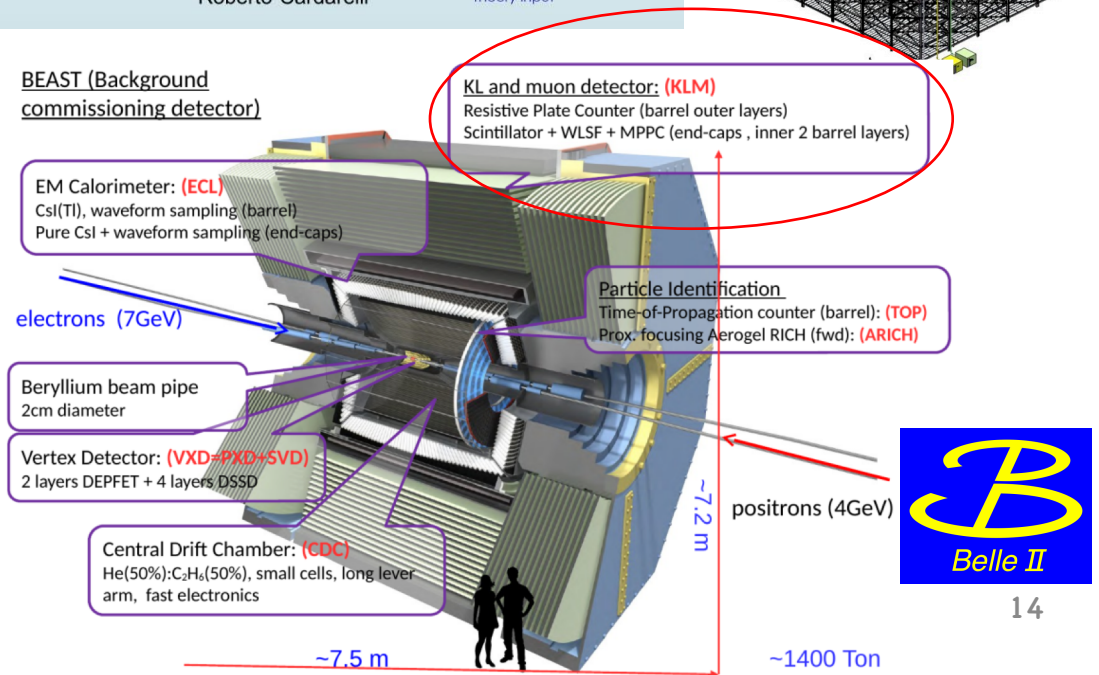
σ_{long}=195 ps

For reference

Scinti + SiPM

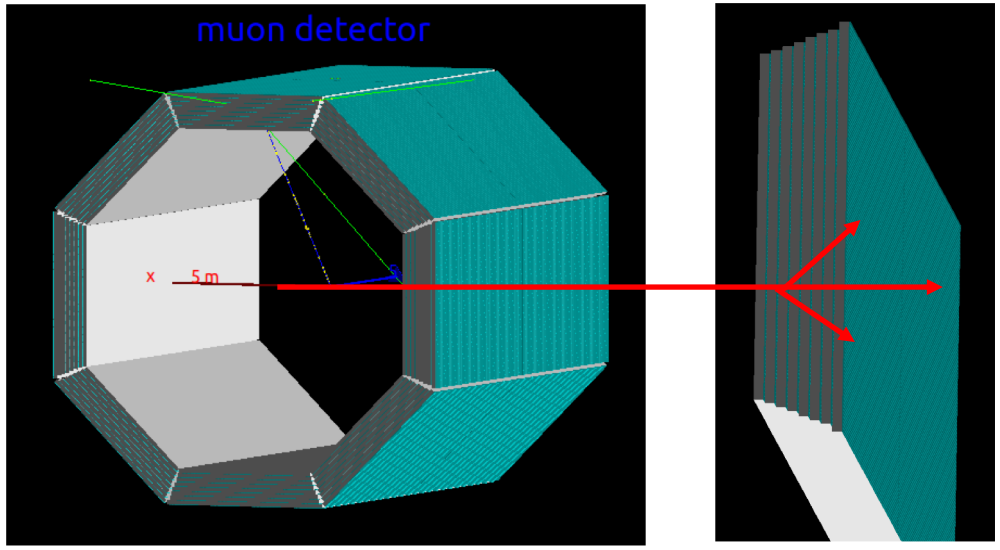
- MUTHUSLA experiment
  - Large size detector based on scintillator to search for long-live particle
  - Institutions: SLAC, Fermilab…
- Belle II experiment: L = 10^{36} $cm^{-2}s^{-1}$
  - Belle II started physics running on 11/3/2019
  - Endcap and inner 2 barrel layers: RPC → Scintillator
  - Good performance achieved
  - Belle II is considering the upgrade: all the barrel RPC → scintillator; new readout system
  - Institutions: Fudan U., U of Hawaii, Virginia Tech, …
- Helpful for R&D, testing, production, price…
- SiPM is becoming popular

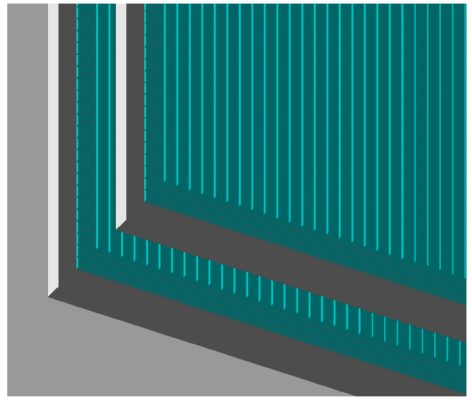




How about implementing timing?

- Two options of scintillator detector:
  - A. Cheap scintillator+WLS fibre+small SiPM, low cost for large size
  - B. Excellent scintillator+large SiPMs, reasonable cost with good timing
- We can combine them for LLP search, to extend the study area of CEPC
  - One sector far away from IP,
  - Measure the tracks with good spatial resolution,
  - Measure the TOF of tracks (and charge?) for velocity (and dEdx?).
  - The distance between layers can be tuned.





LLP decay

MATHUSLA

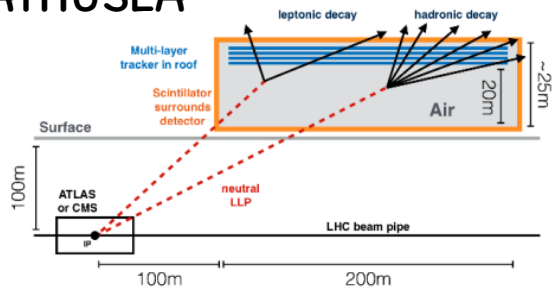


Fig. 1: Simplified detector layout showing the position of the 200 m × 200 m × 20 m LLP decay volume used for physics studies. The tracking planes in the roof detect charged particles, allowing for the reconstruction of displaced vertices in the air-filled decay volume. The scintillator surrounding the volume provides vetoing capability against charged particles entering the detector.