Study of LGAD for Timing Measurements in ILC Detectors

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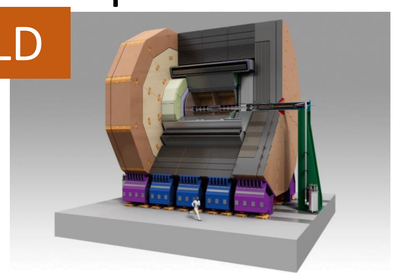
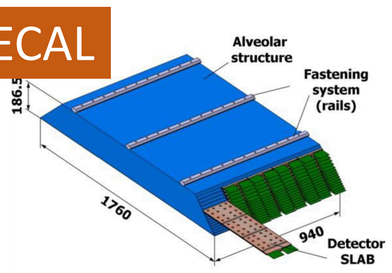
Particle identification in ECAL of ILD

- ILC is a e^+e^- linear collider initial $\sqrt{s} = 250$ GeV
- ILD is one of the detectors to be placed at the collision point of the ILC

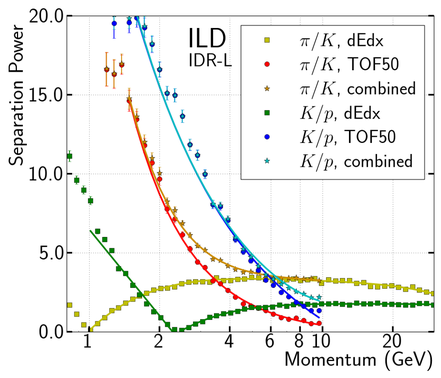
ILD



SiW-ECAL



- dE/dx and momentum measured with TPC
  → identification of charged hadrons
- ToF measurements at ECAL improve particle ID
  → we need timing resolution of a few 10 psec



Sensor with high timing resolution

Low Gain Avalanche Detectors (LGADs)

- silicon sensors with internal avalanche multiplication mechanism
- timing resolution: about 30 psec

Avalanche Photo-Diodes (APDs)

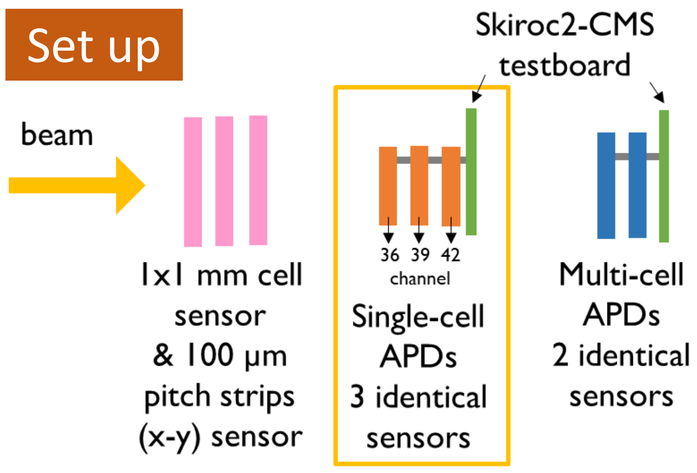
- Sensor used for optical photon measurements have the same structure as LGAD
- The S8664-50K

  - inverse-type APD
  - Single-cell
  - Made by Hamamatsu
  - sensitive area: Ø 5 mm
  - breakdown voltage V_{br}: 430 V

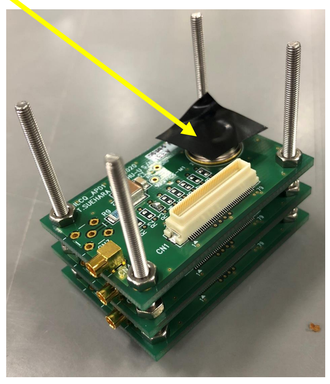
Set up of the test beam

- Test beam at ELPH, Tohoku-University
- 4 days (12 hours/day) with 700 MeV positron beam

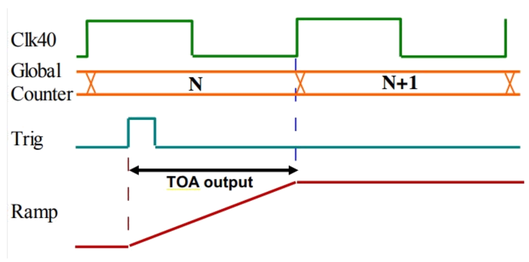
Set up



APDs and boards



- The signals were read out using Skiroc2-CMS ASIC
- Time of Arrival (ToA)
  → The timing information between the triggered time and the next internal clock

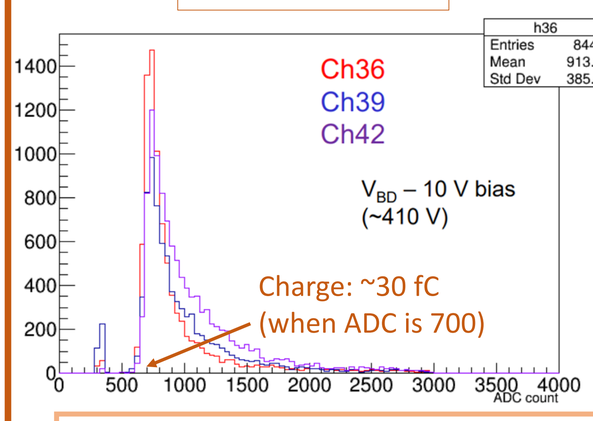


- Three single-cell APDs are connected to a Skiroc2-CMS at channels 36, 39 and 42

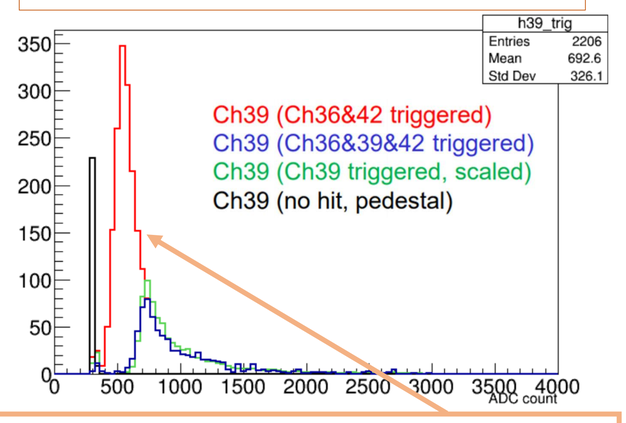
Result of test beam

ADC distribution

each channel



channel 39 for various selections



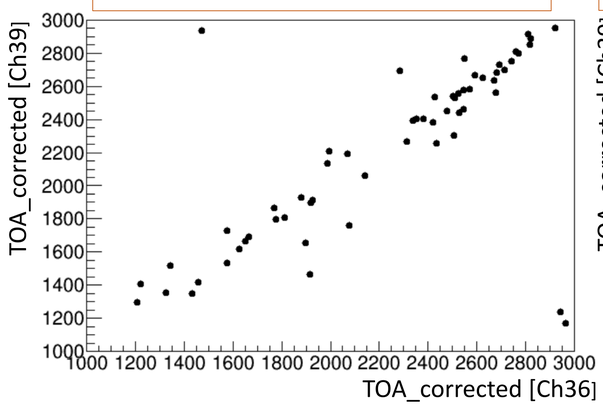
red is clearly separated from the pedestal (black)
→ ~100% of the signal hits cause detectable signal

- trigger threshold is higher than average signal
  → need to reduce the noise to lower the threshold

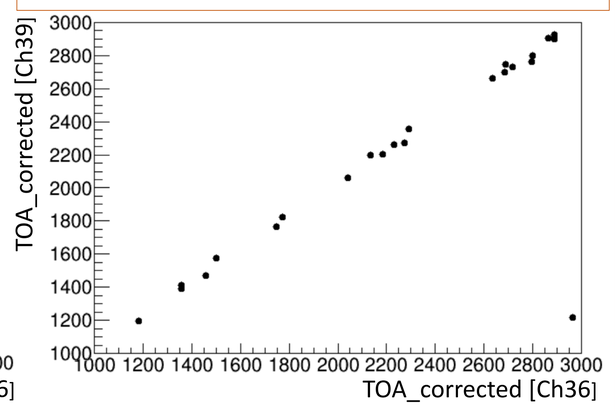
Timing correlation of two APDs

correlation corresponds to 217 psec in sigma
timing resolution of a single sensor: 153 psec
(approximate ratio: 0.1 ToA count/psec)

with 800 < ADC < 900



ADC > 900 and ADC difference < 50



- Jitters of Skiroc2-CMS are large in the lower signal strength (jitter is ~200 ps with 75 fC charge of signal)
  → electronics with small jitter is in preparation

Summary

- We study APDs with charged particles to investigate an application of LGADs to SiW-ECAL in the ILD.
- S8664-50K are measured with positron beam, and the first result of timing resolution is 153 psec.