# Readout Electronics of DarkSHINE ECAL

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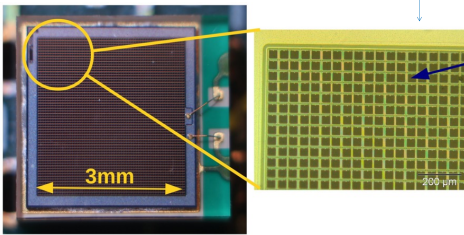
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Introduction

- DarkSHINE
  - Fixed target experiment.
  - Beam: 8 GeV, 10 MHz, single electron beam from SHINE.
  - Detection object: dark photon generated by electron bremsstrahlung.
  - Signal: dark photon can not be detected, resulting in the energy loss of the final state particles.
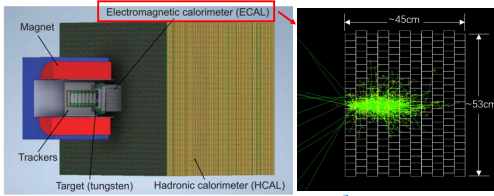
- DarkSHINE ECAL
  - Basic detection unit
    - Crystal: LYSO with high light yield and good radiation hardness
    - SiPM: S14160-3010PS with 90000 pixels and high dynamic range
  - High energy resolution
  - Large dynamic range: 1 MeV – 1 GeV
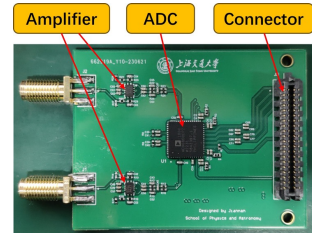 - High event rate: up to 10 MHz

Requirements to the electronics

- High energy resolution
  - Low noise, good SNR of the front-end electronics
- High event rate: 10 MHz
  - SiPM waveform: ~200 ns, shape to 100 ns
  - High speed and high precision digitization
- Large dynamic range
  - 1 MeV – 1 GeV: about 1000x
- SiPM calibration system

Design of the readout electronics

- Pre-amplifier
  - transimpedance amplifier
  - PZC + RCRC filter
  - 2 channel output
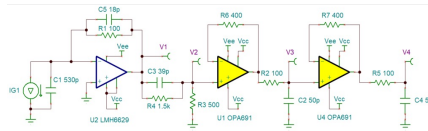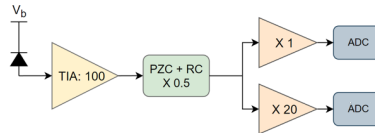
| 沉积能量范围（MeV）	光子数	总跨阻增益（Ω）	输出信号幅度（mV）
1 - 40	100 - 4000	1000	40 - 1600
40 - 1000	4000 - 100000	50	80 - 1400

- Large and small gain dual channels output : large dynamic range

- High speed and high precision ADC
  - ADC: AD9680, 1 GSPS, 14 bit
  - Input driver: differential amplifier
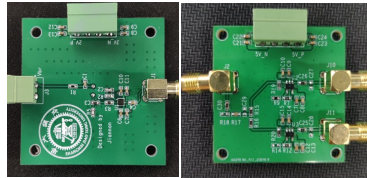 - Output to FPGA to process

  Amplifier ADC Connector

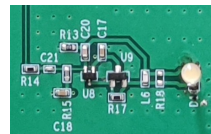- LED calibration system for SiPM
  - LED driver: nanoseconds width and tunable light intensity
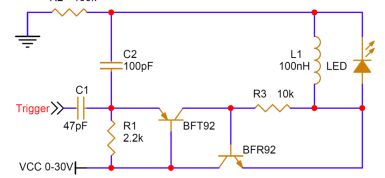
Prototype of the electronics

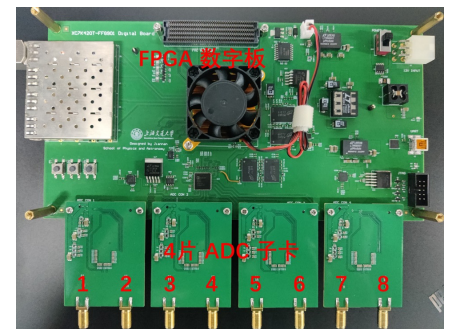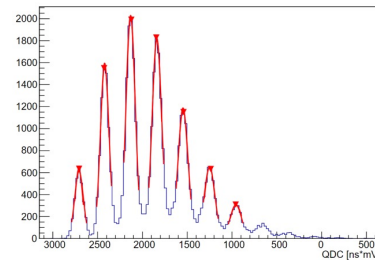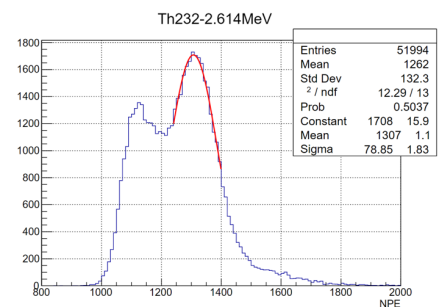- Pre-amplifier and 2 channels output
- LED driver

- 4 ADC card connect to a FPGA board

FPGA 数字板

4片 ADC 子卡

Test results & summary

- Pre-amplifier: low noise, good linearity
- ADC performance
  - SNR ~ 66 dBFS, ENOB ~ 10.6 bit

SPE spectrum of S14160-3010PS

- The Th-232, 2.6MeV γ spectrum

Th232-2.614MeV

Entries	51994
Mean	1262
Std Dev	132.3
χ^2 / ndf	12.29 / 13
Prob	0.5037
Constant	1708 15.9
Mean	1307 1.1
Sigma	78.85 1.83

The energy resolution is ~ 6%.