Multi-Channel SiPM Calibration

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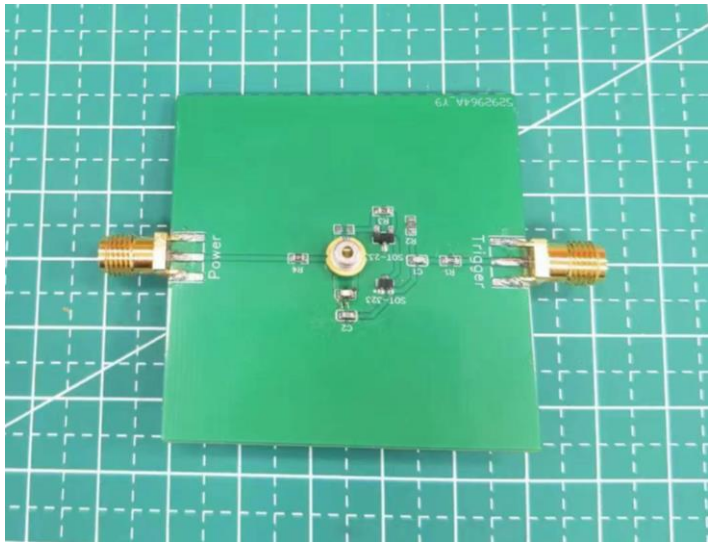
TSUNG-DAO LEE INSTITUTE

Motivation & Method

- Single PE calibration for multi-channel SiPMs in ECAL module
- Laser diode as a light source. The light is divided into multiple channels by optical fibers.
- SiPMs tested: EQR15-11-3030D-S



Laser diode and its driver circuit

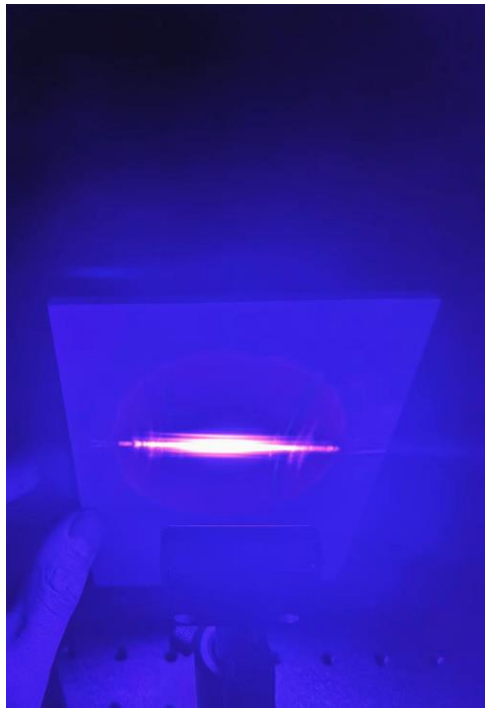
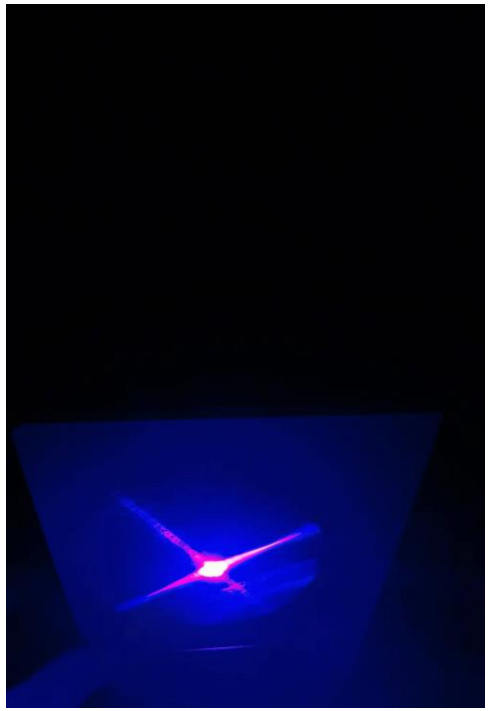
Plastic fiber, Φ 0.5mm

Collimator

Light Spot of Laser Diode

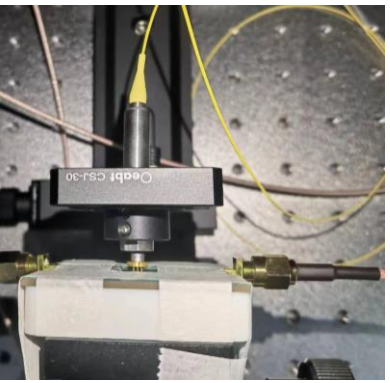
- When the receiver is close enough(<1cm) the to laser diode, the spot can be controlled within 1cm .



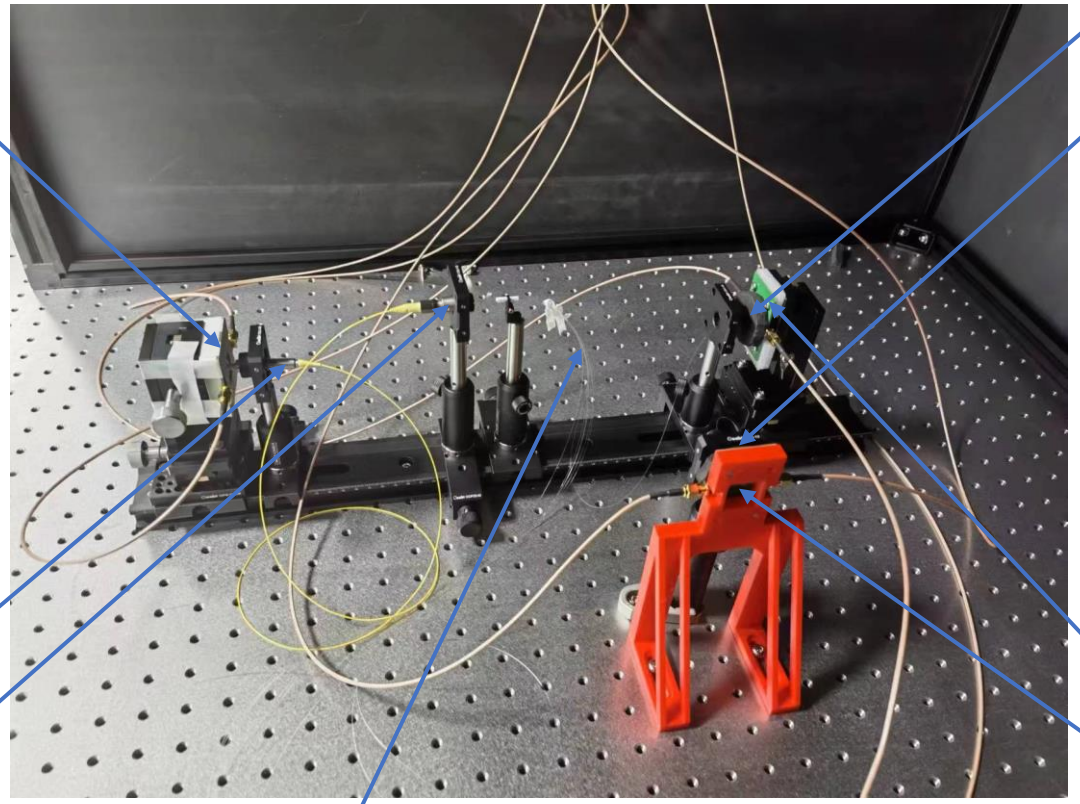



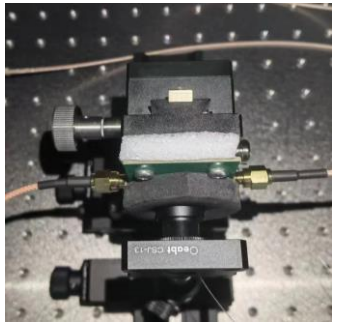
Setup

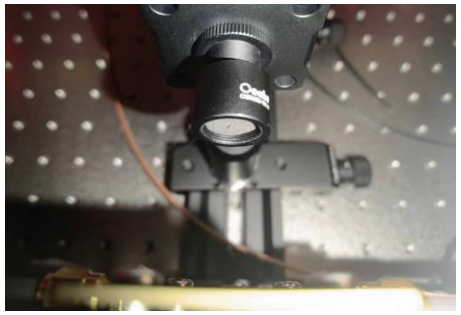
Shield Tube



Laser Diode

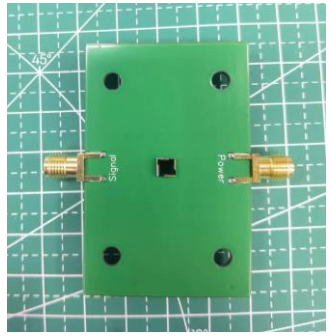




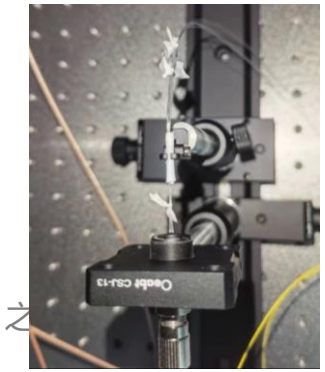


Collimator
532/550 nm

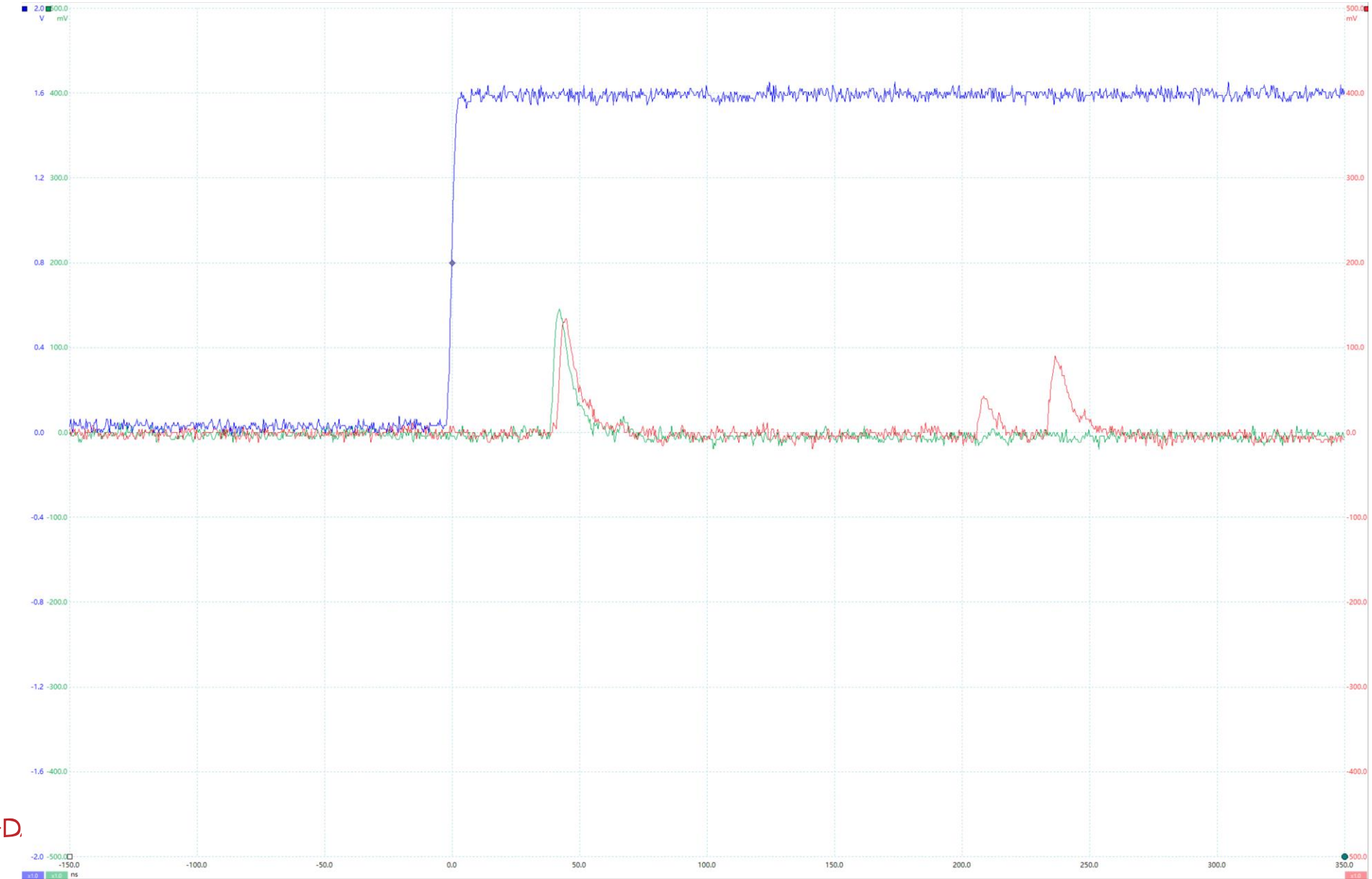
SiPMs



Fiber
650 nm



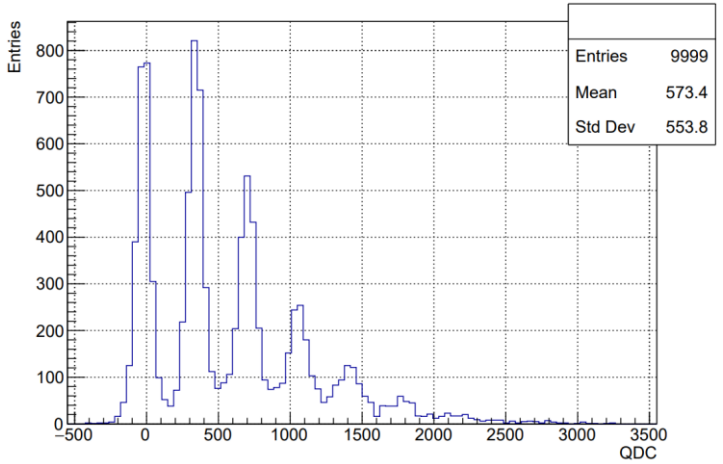
Waveform


2.0 500.0
V mV
1.6 400.0
1.2 300.0
0.8 200.0
0.4 100.0
0.0 0.0
-0.4 -100.0
-0.8 -200.0
-1.2 -300.0
-1.6 -400.0
-2.0 -500.0
500.0
mV
400.0
300.0
200.0
100.0
0.0
-100.0
-200.0
-300.0
-400.0
500.0
-150.0
-100.0
-50.0
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
ns

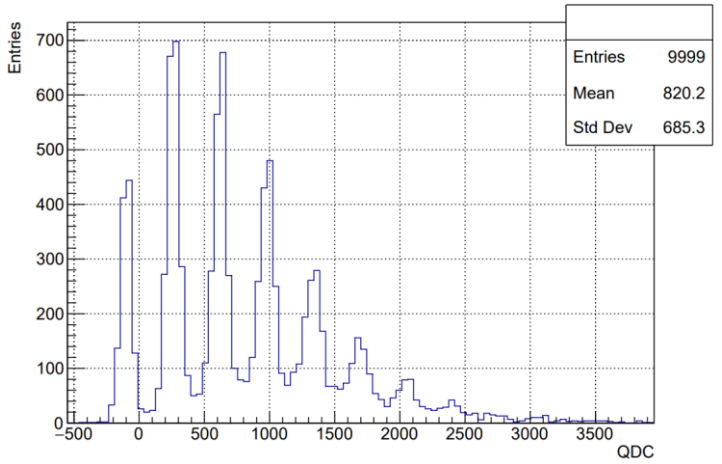
Calibration Result of 2 Channels

- The light uniformity of different channels looks not bad. But the number of detected photons of channel 1 is a little smaller than that of channel 2.

EQR15-1

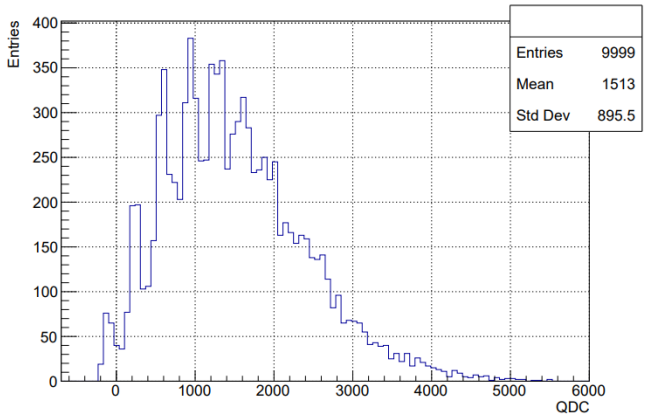


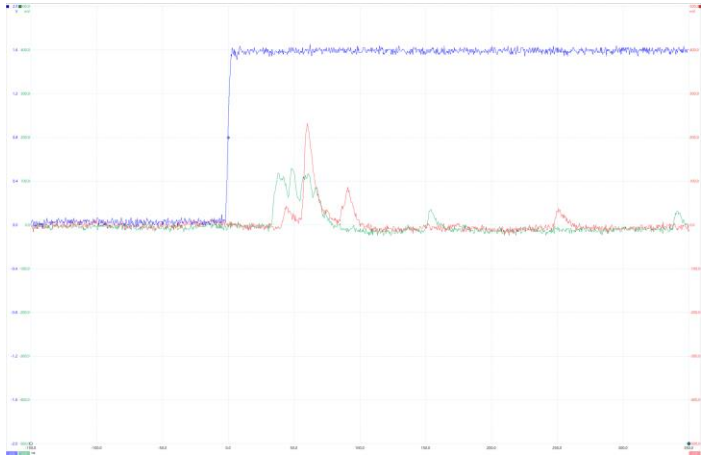
EQR15-2



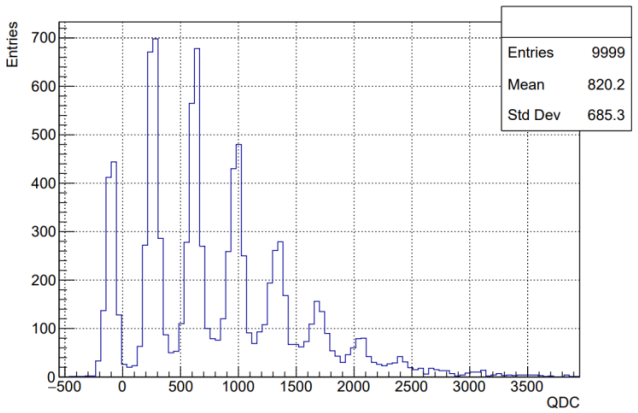
Impact of Collimator

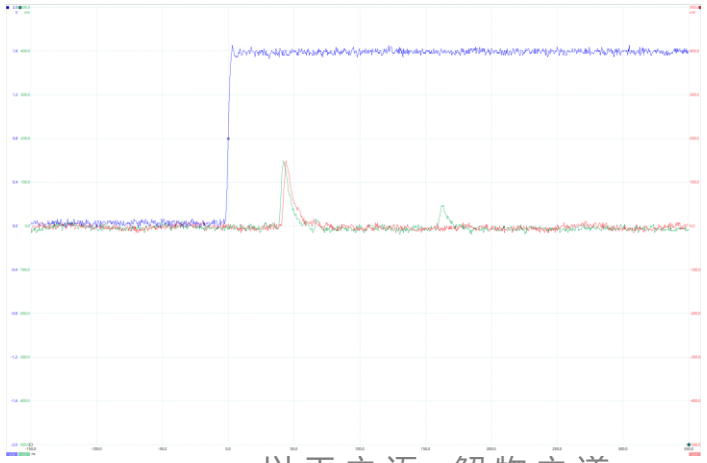
Ch1- w/o Collimator





Ch1 - w/ Collimator

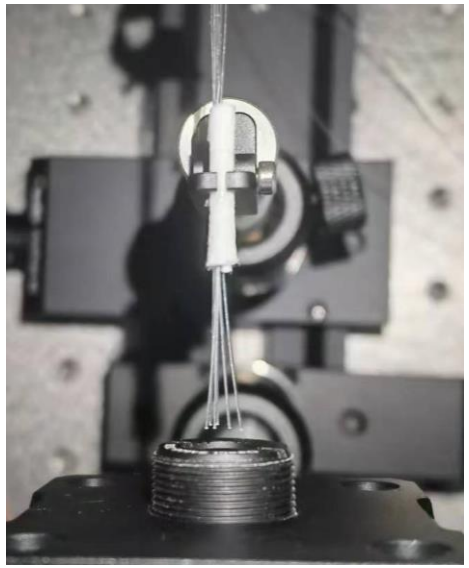




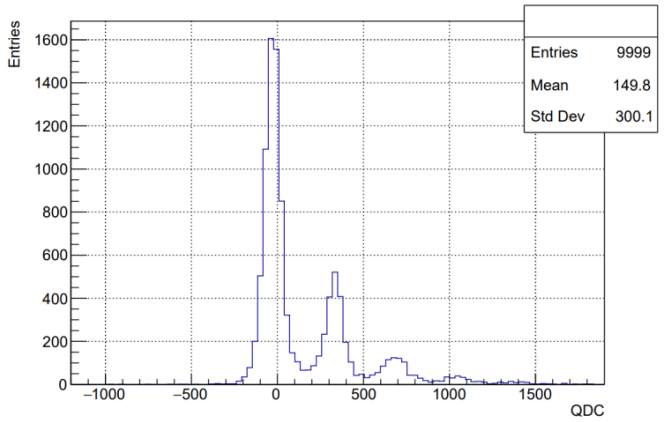
- It seems that there is light leakage without collimator.

Impact of Fiber Dispersion

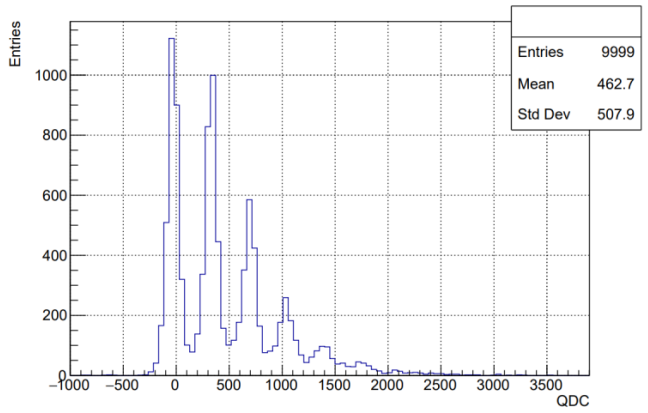
- The light in the bundle with denser fibers is more uniform.



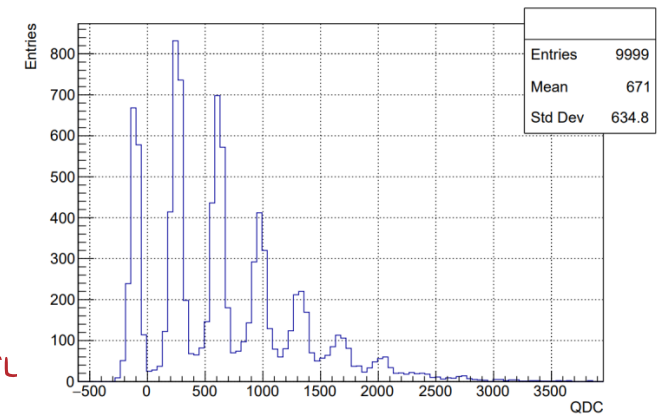
Ch1, w/ Collimator, dispersive fibers



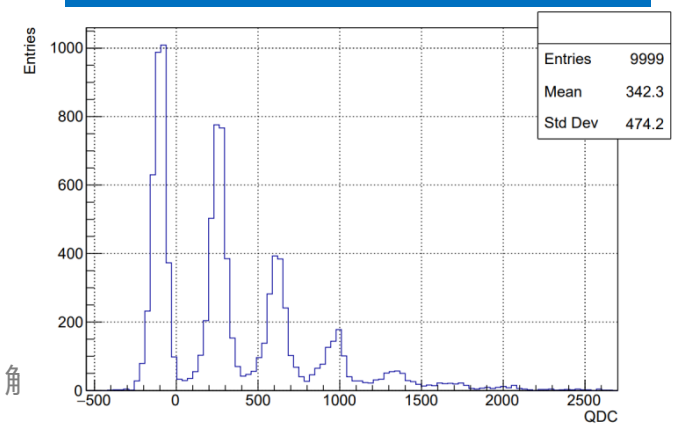
Ch1, w/ Collimator, concentrated fibers

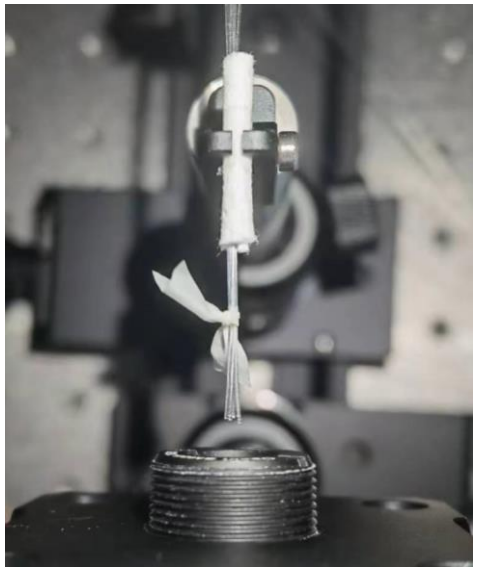


Ch2, w/ Collimator, dispersive fibers



Ch2, w/ Collimator, concentrated fibers





Impact of Distance Between Collimator and Fiber

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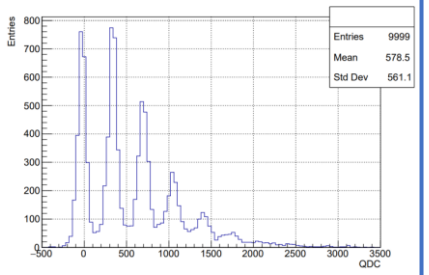
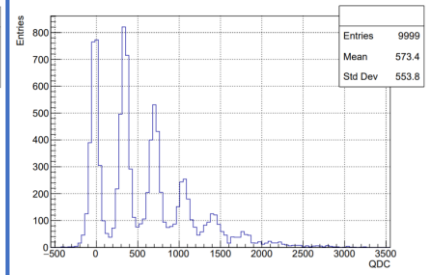
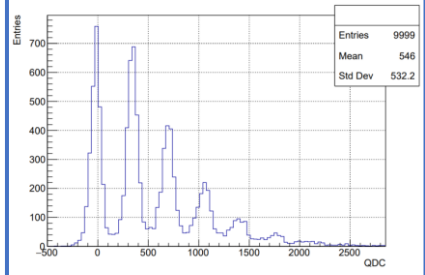
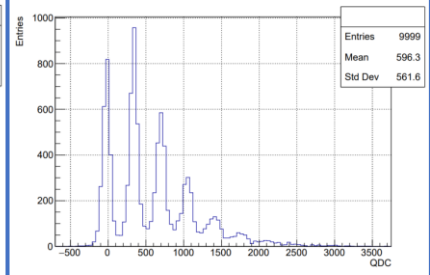
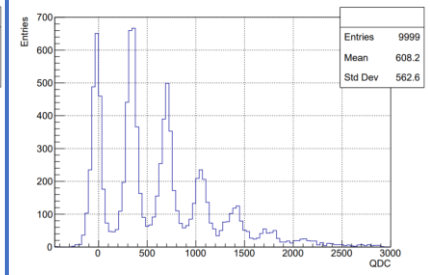
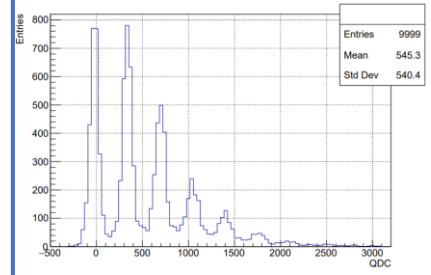
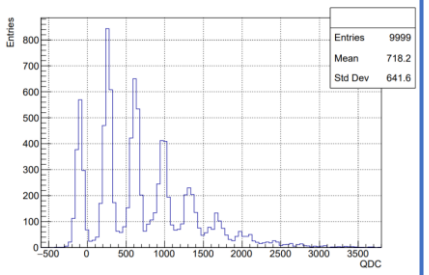
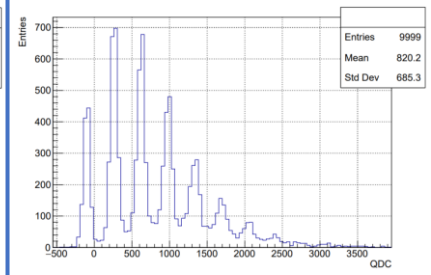
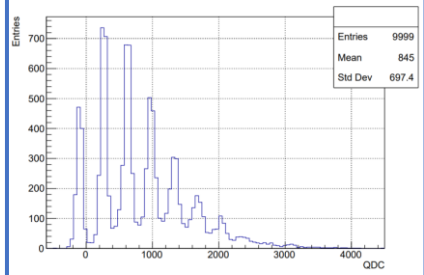
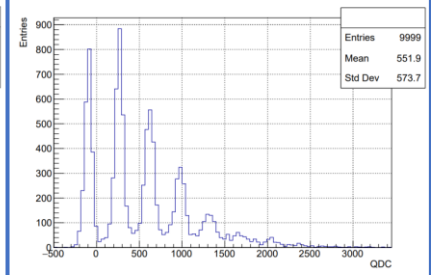
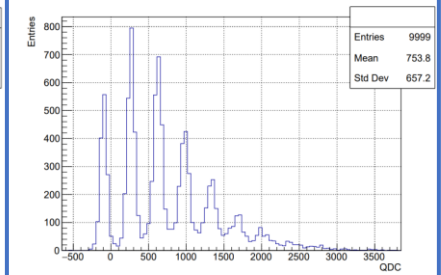
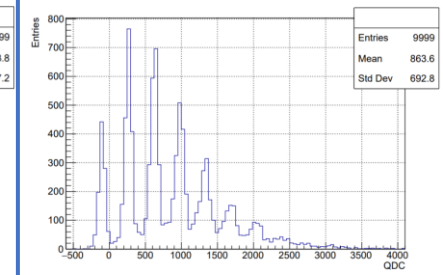
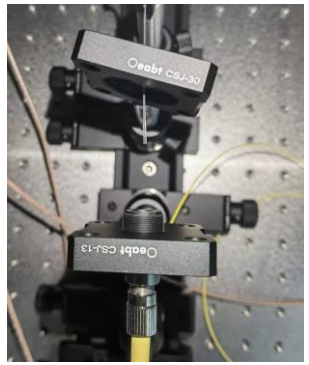
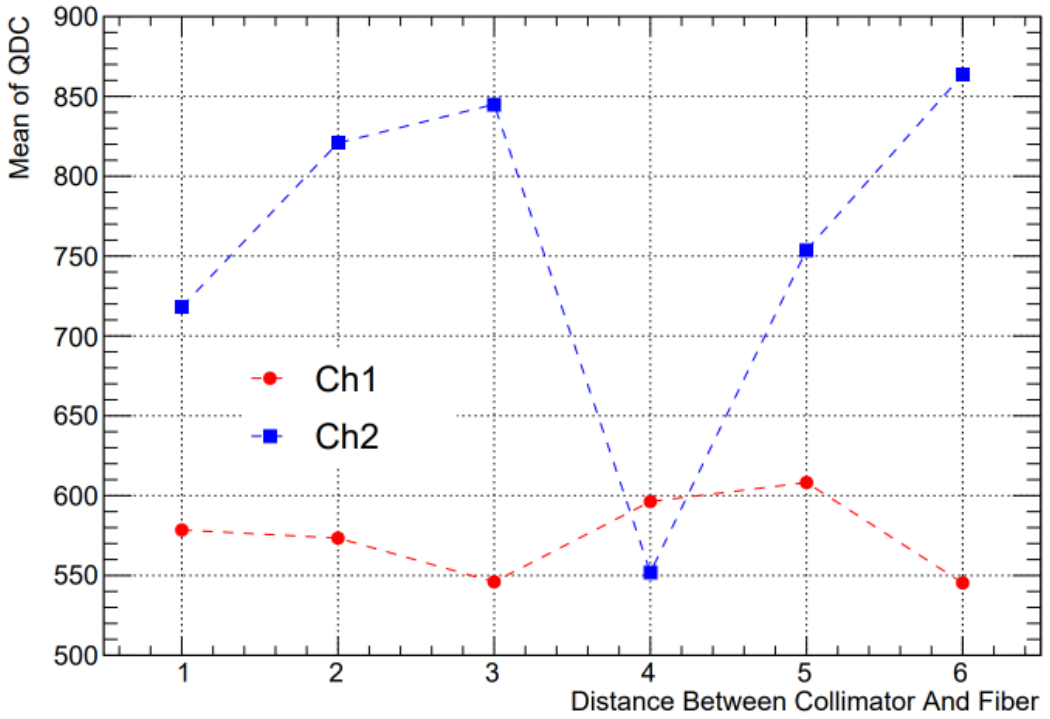
Ch1	Ch1	Ch1	Ch1	Ch1	Ch1
					
Ch2	**Ch2**	**Ch2**	**Ch2**	**Ch2**	**Ch2**
					
					

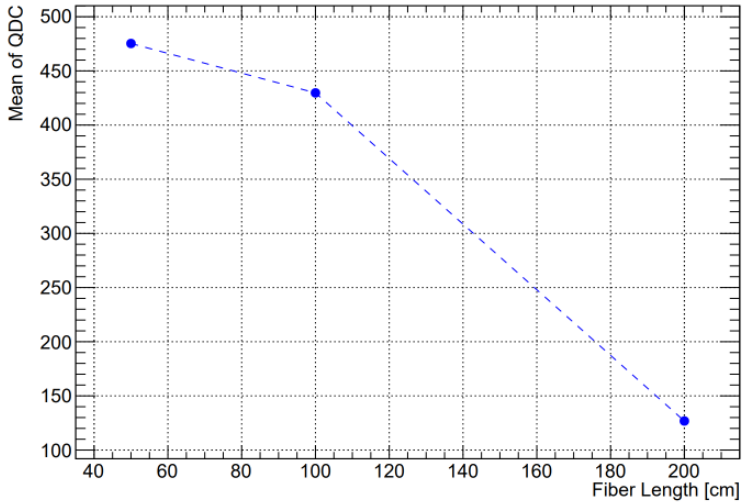
Farther →

Impact of Distance Between Collimator and Fiber

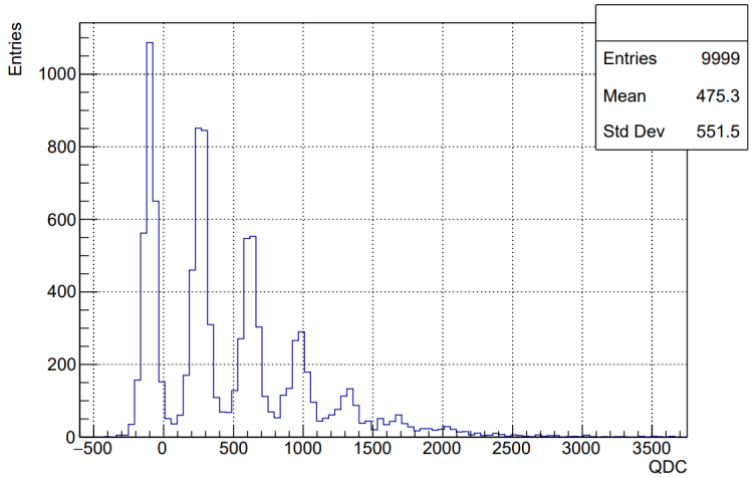


- There is no obvious dependence between light intensity and distance.

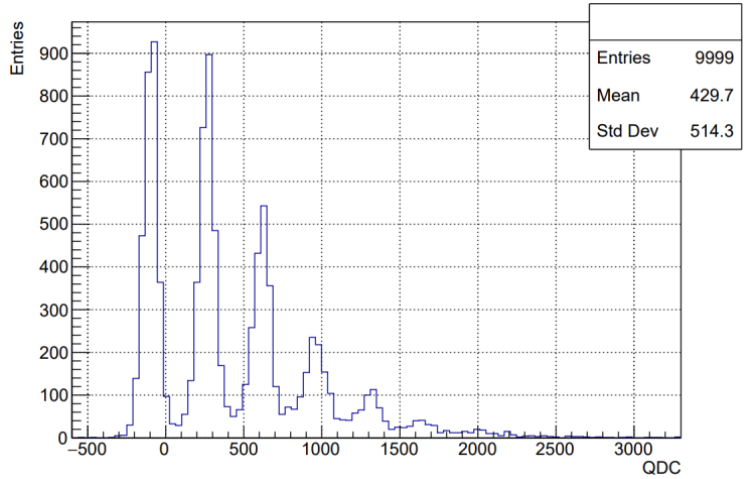
Impact of Fiber Length



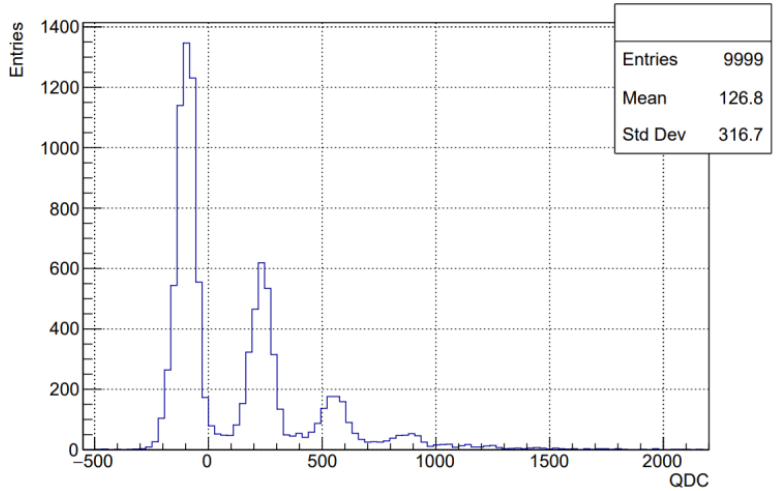
Ch2, 50cm fiber



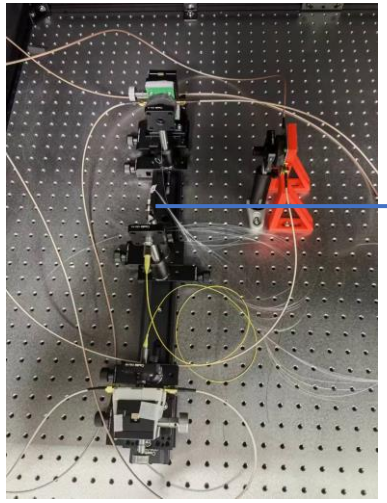
Ch2, 100cm fiber



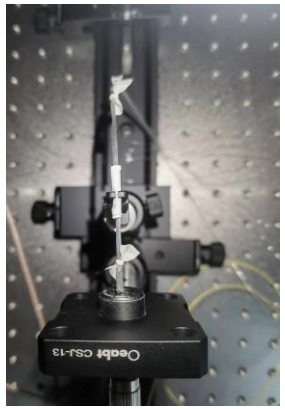
Ch2, 200cm fiber

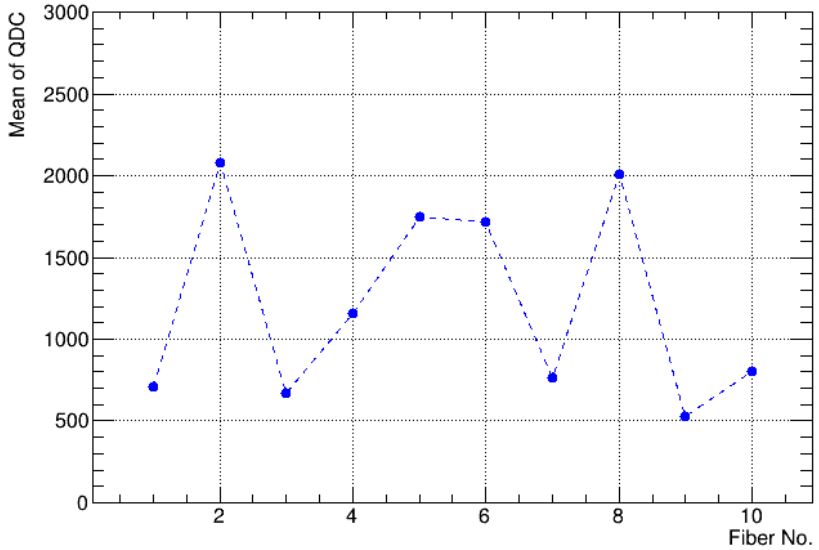


Uniformity Among Fiber Bundle

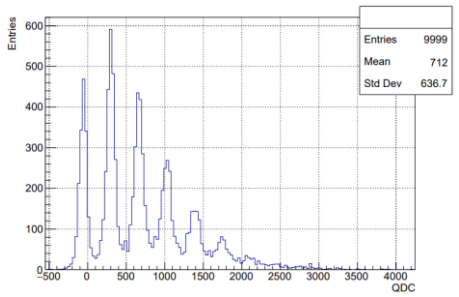


21 fibers with 100cm length

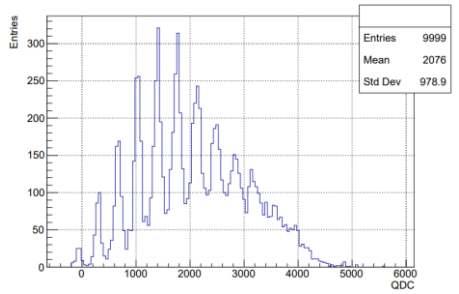




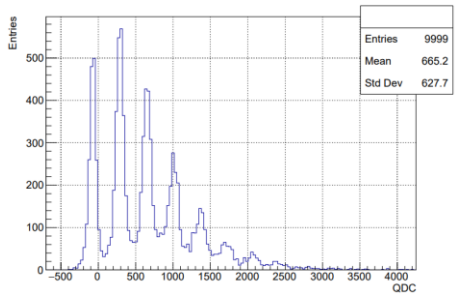
Fiber 1



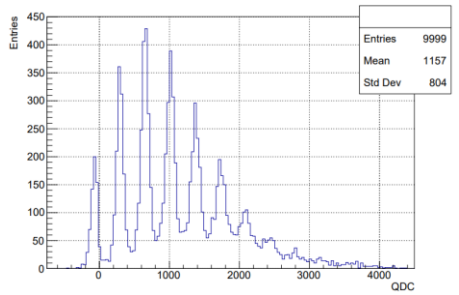
Fiber 2



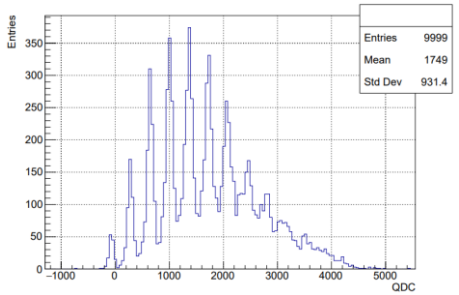
Fiber 3



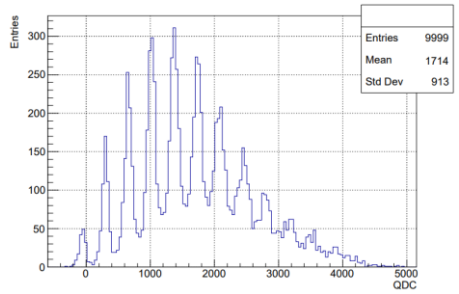
Fiber 4



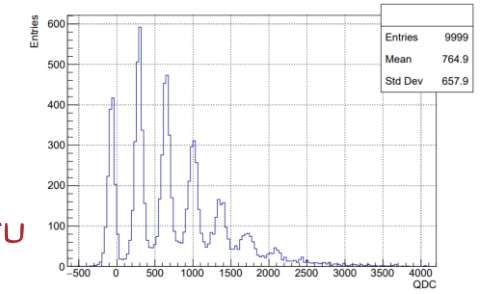
Fiber 5



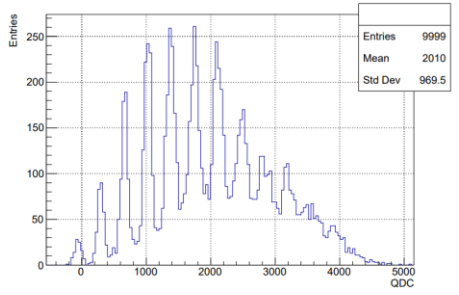
Fiber 6



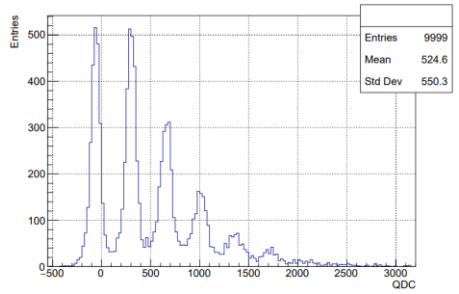
Fiber 7



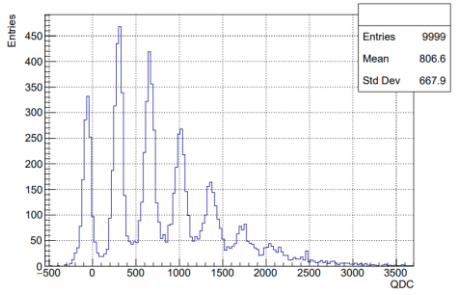
Fiber 8



Fiber 9

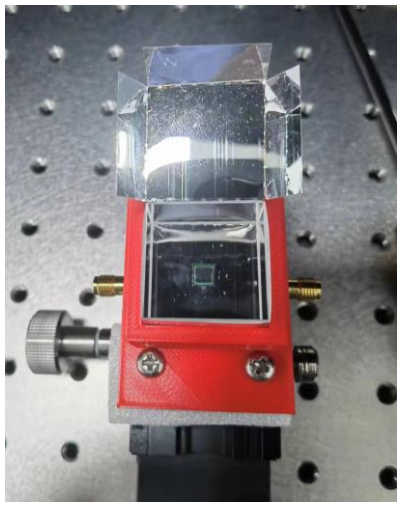


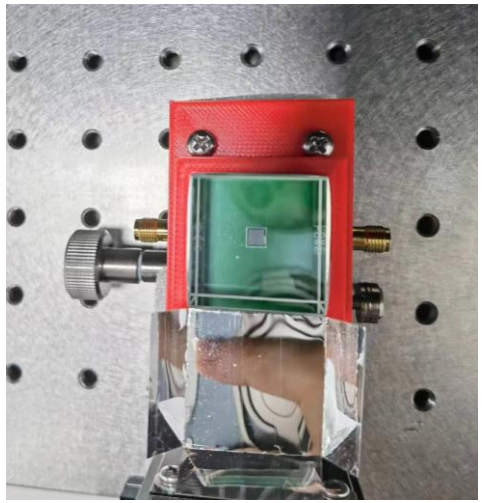
Fiber 10

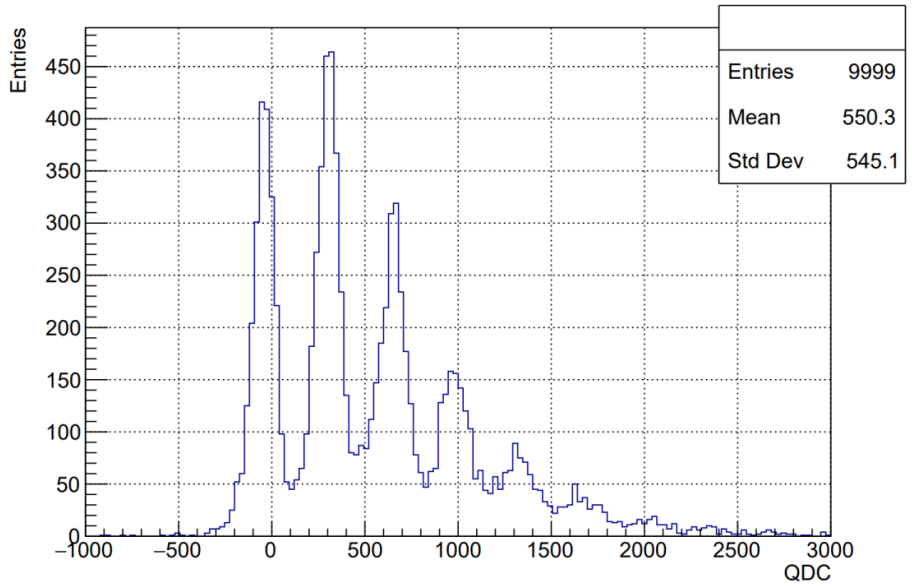


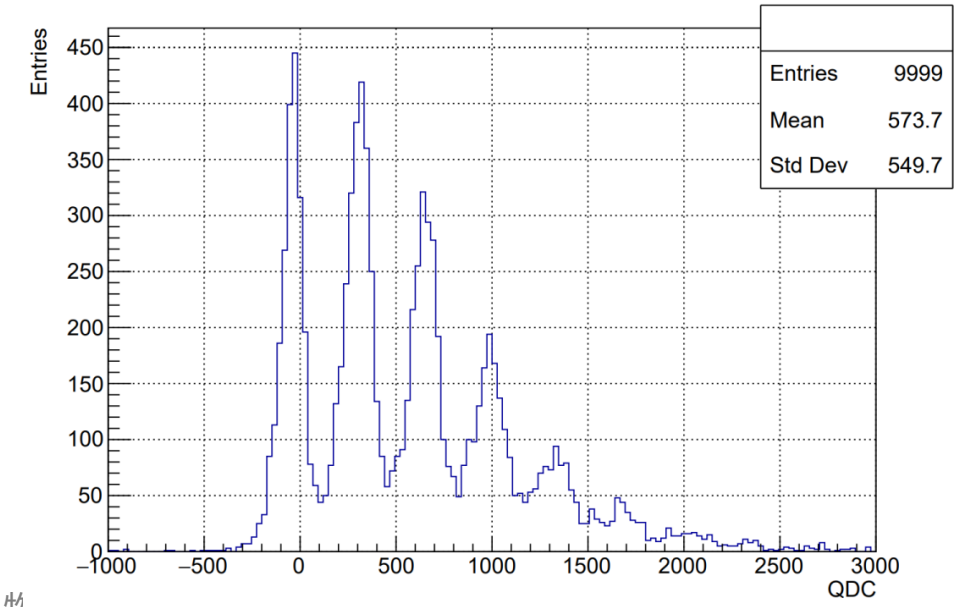
ITU

Calibration Through Crystal





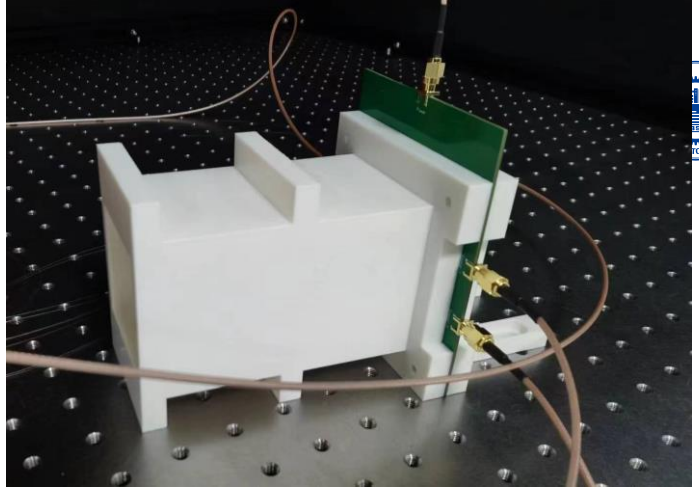


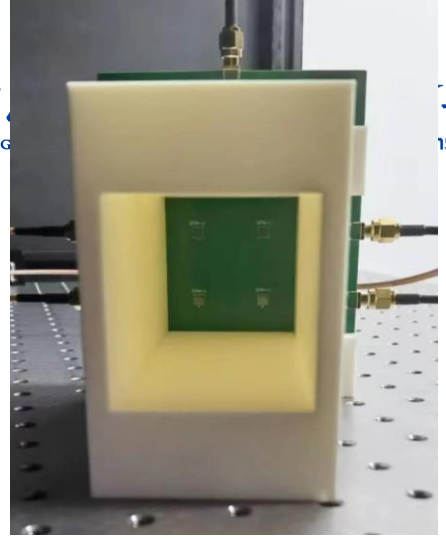


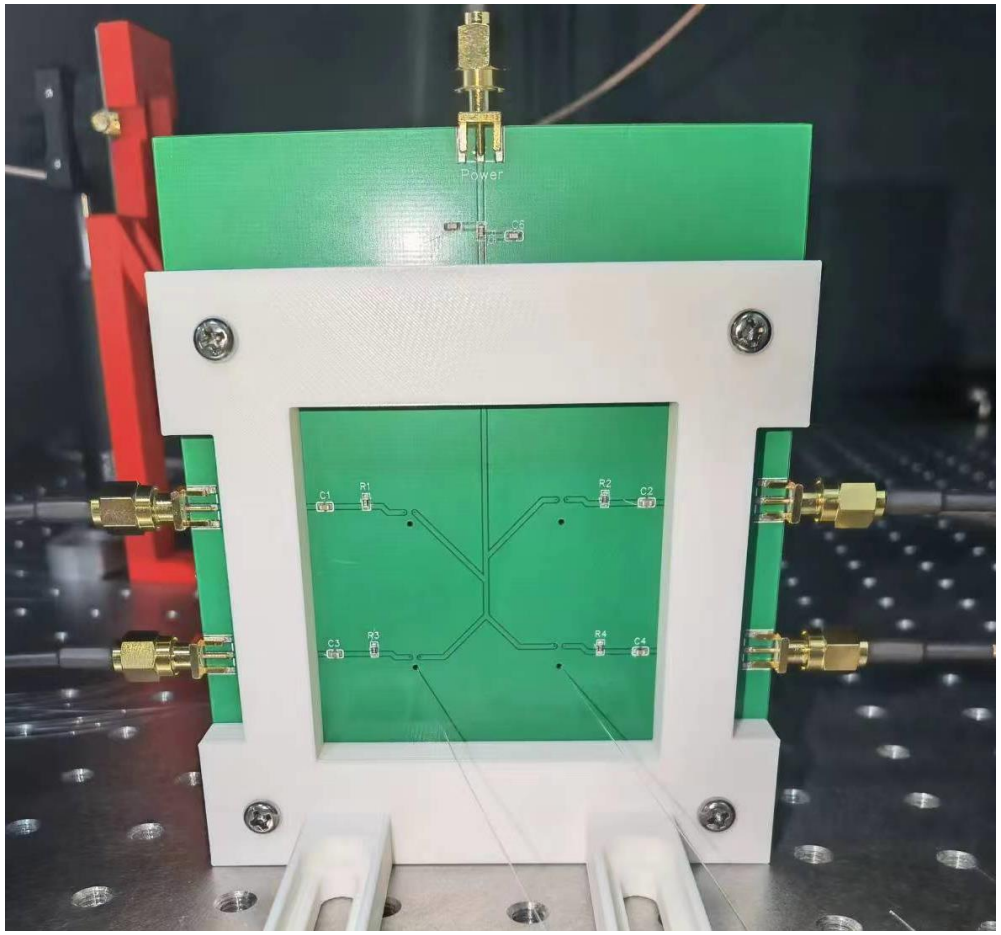
$2.5 \times 2.5 \times 2.5 cm^3$ $LYSO$

30V for driver circuit

Module Test







Summary

- Collimator is nessessary.
- The more concentrated the fiber is in the central area, the more uniform the light within different fibers
- The light intensity hardly changes with the distance from the collimator to the fiber bundle.
- When the fiber length is less than 100cm, the attenuation of light is not obvious.
- The light output is uniform among 21 fibers.
- SiPM can be calibrated with fiber connected to the end of a $\mathbf{2.5 \times 2.5 \times 2.5}\boldsymbol{cm}^{\mathbf{3}}$ crystal. But crystals with longer sizes, verification is also required.