Performance Study of Large CsI (TI) Scintillator with MPPC Readout

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We consider nano-satellites for accurate position determination of short duration gamma-ray bursts (SGRBs) by measuring arrival time difference. In order to achieve sufficient photon statistics to precisely measure the arrival time, we plan to use CsI scintillator which has a large area and high light output and multi-pixel photon counter (MPPC) which has a small size and low electricity consumption. We compared light output of two scintillators of different sizes $(150 \times 75 \times 5 \text{ mm}^2, 100 \times 75 \times 5 \text{ mm}^2)$ and found they showed similar light output and archived an energy threshold <10 keV. We also found that the uniformity of light output was improved by using 2 MPPCs for readout.

1. Introduction

Accurate position determination of short duration gamma-ray bursts (SGRBs)

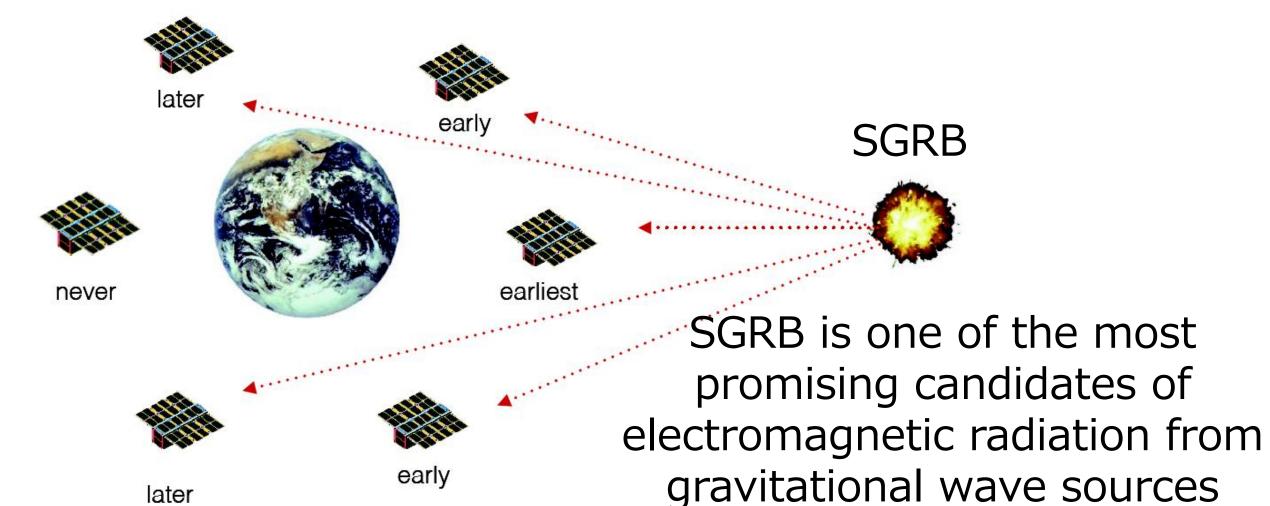
Launch several nano-satellites and measure arrival time difference

Accurate time information

Sufficient photon statistics

Synchronize time information of each satellite by GPS

Use detector which have a large area and low power consumption



2. Scintillators and Photodetectors

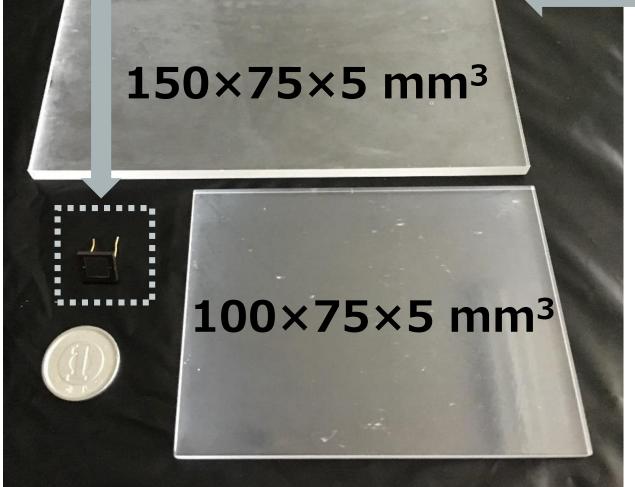
MPPC

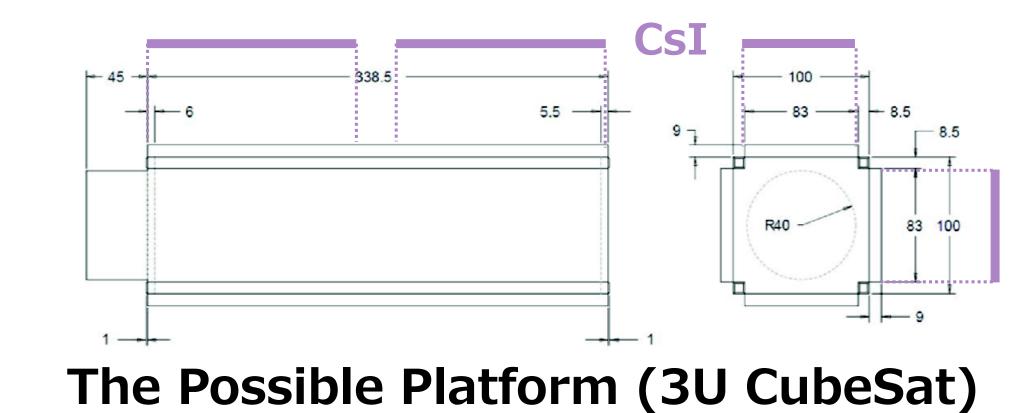
- Low power consumption
- Small size

CsI Scintillator

- Large area
- High light output

We plan to use 2 or 3 scintillators at 2 sides of 3U CubeSat





Multi-Pixel Photon Counter (MPPC)

- □ Photon-counting device using multiple avalanche photodiode
- □ Output charge is proportional to number of detected photons

Use S13360-6050CS by HPK (window size: 6×6 mm²)

We need small and low power consumption photodetectors for nano-satellites

Geiger-mode APD pixel

Quenching resistor

Structure of MPPC

3. Key Parameters

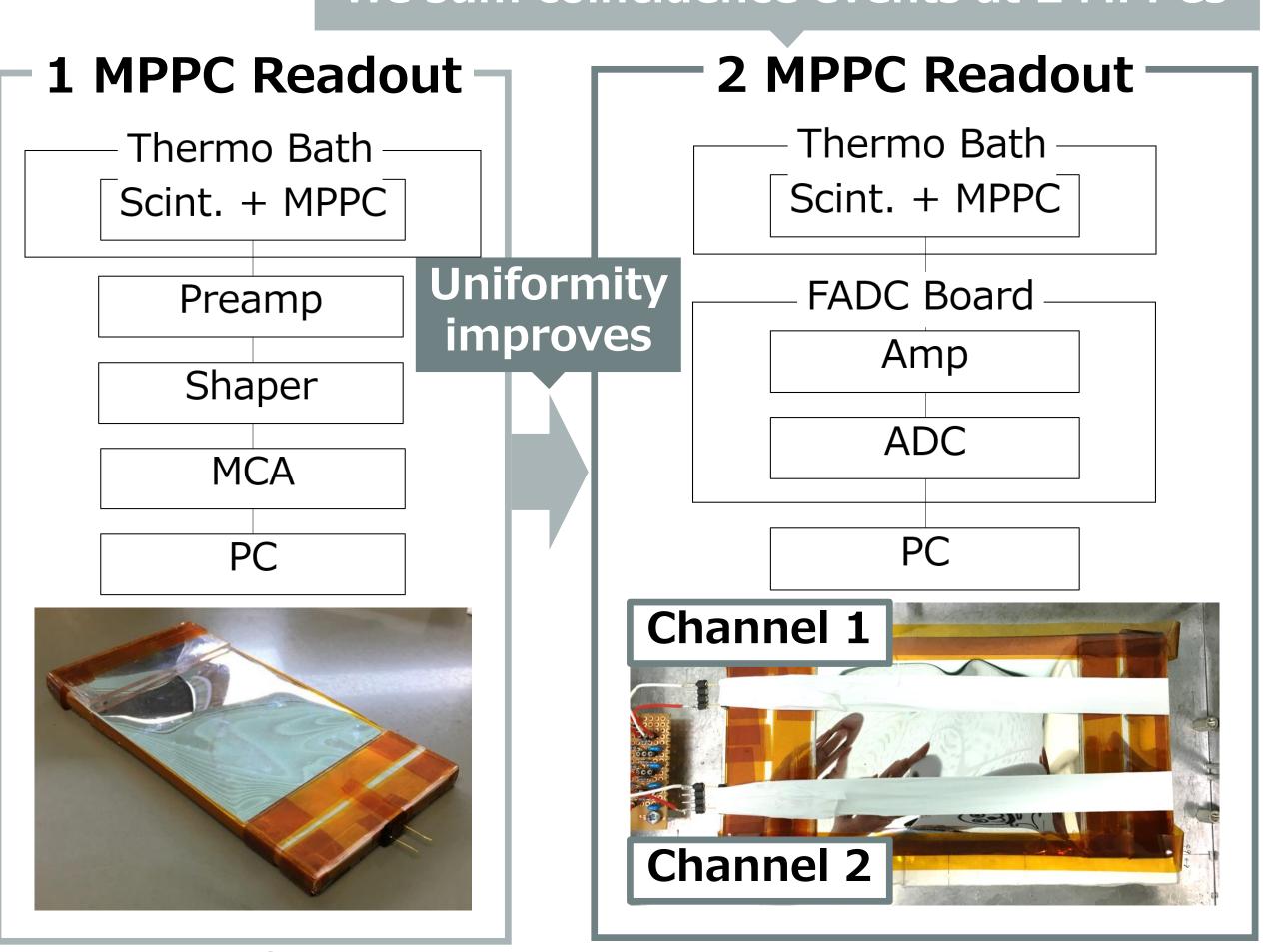
Evaluation of light yield at large CsI scintillator with MPPC readout

Energy threshold

Uniformity of the light output

4. Setup

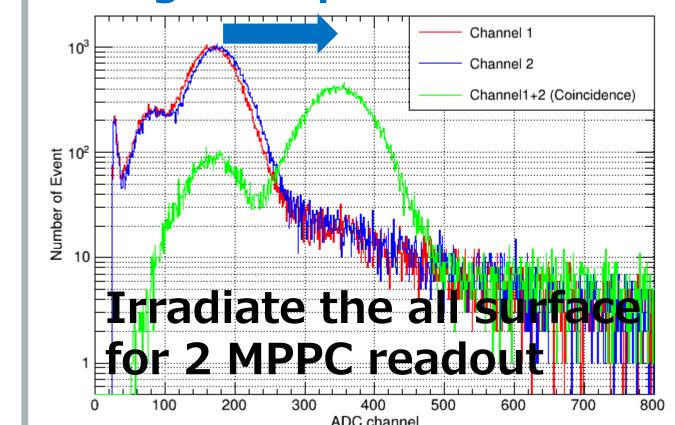
We sum coincidence events at 2 MPPCs



Configurations

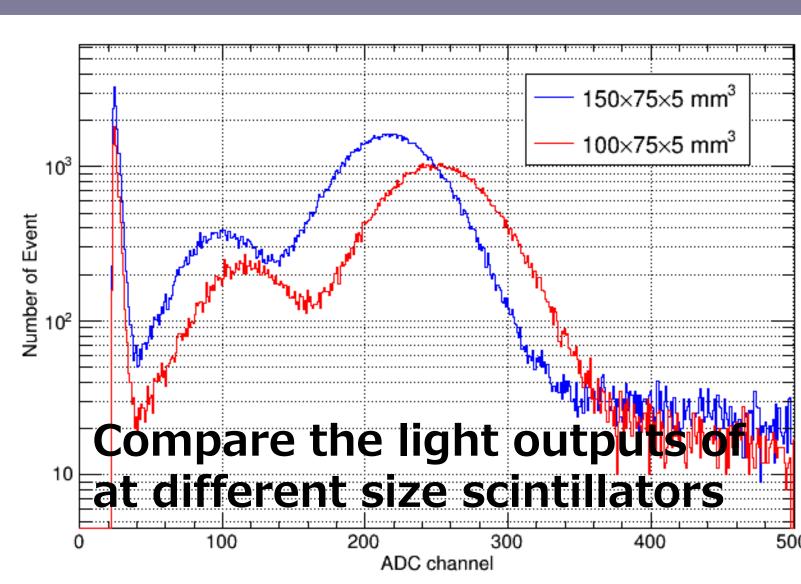
- Shaping time:
 1 μs (1 MPPC readout),
 2.2 μs (2 MPPC readout)
- Temperature: 25 °C
- Operational voltage: 53.4 V
- Breakdown voltage: 50.87 V, 50.82 V
- Radiation source: ²⁴¹Am (59.5 keV)

Light output 2x



Red and blue are outputs from each MPPC
Green is sum of them

5. Result



Scintillator size ratio: 33 %
Difference in the light output: 13 %

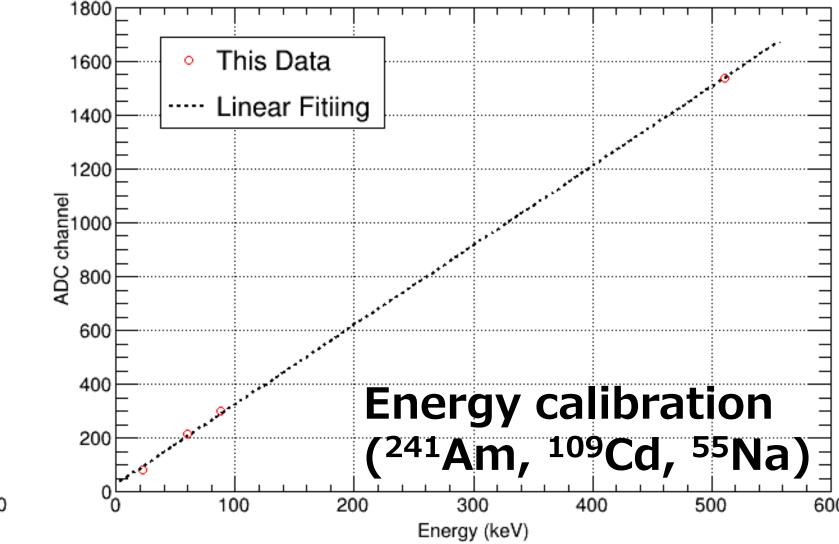
→ Use bigger one

9 mm

Pb 1 mm

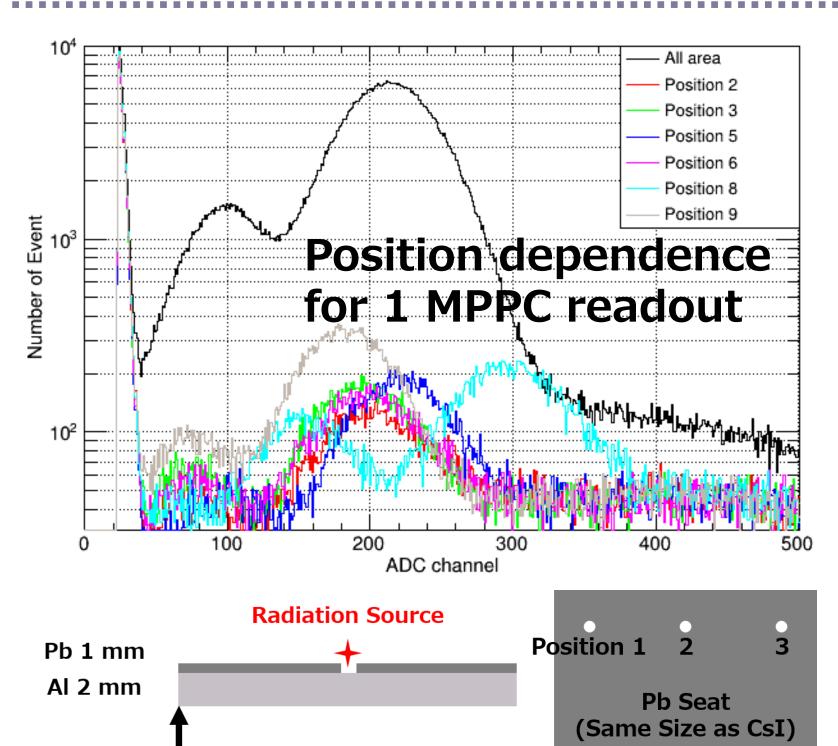
Spacer 1 mm

CsI 5 mm



Energy threshold: <10 keV
Target value: ~100 keV

→ Achieved low energy threshold



Hole Diameter 1 mm

Position 2
Position 5
Position 8
Position 9
Position dependence

Torac MPPC readout

ADC channel

To reduce noise rate, we increased the trigger thresholds and summed signals of 2 MPPCs

Peak-to-peak difference of light outputs in 9 positions:

- □ 40 % for 1 MPPC readout
- □ 15 % for 2 MPPC readout
- → Uniformity improved

Conclusion and Future Works

MPPC

- Achieved low energy threshold <10 keV
- Uniformity improved for 2 MPPC readout
- Detailed measurement of non-uniformity
- Evaluate the energy threshold for 2 MPPC readout (considering noise)