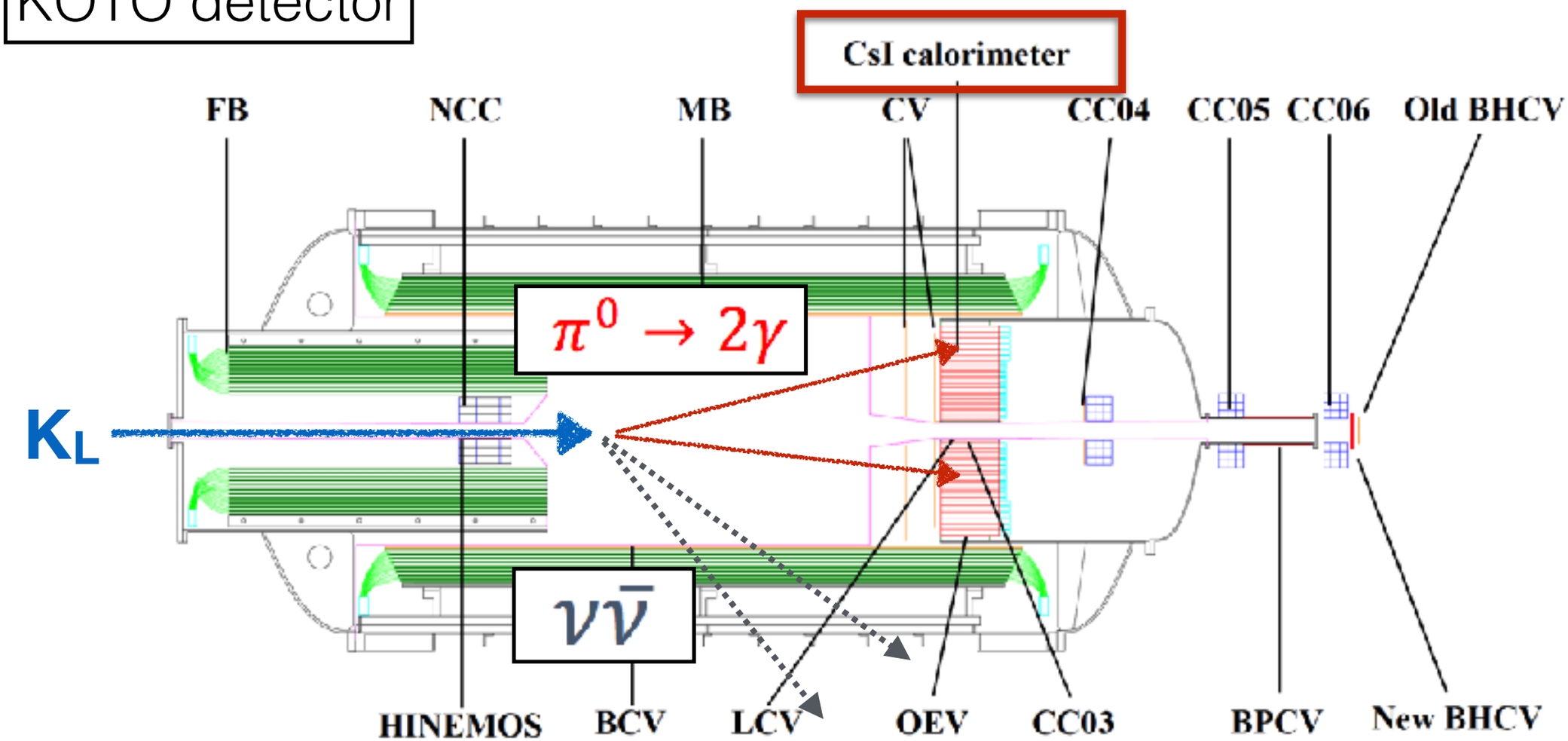
KOTO実験における中性子背景事象削減のためのMPPC読出し用回路の開発

Yamanaka Taku Laboratory
Yuta Sato

- KOTO experiment

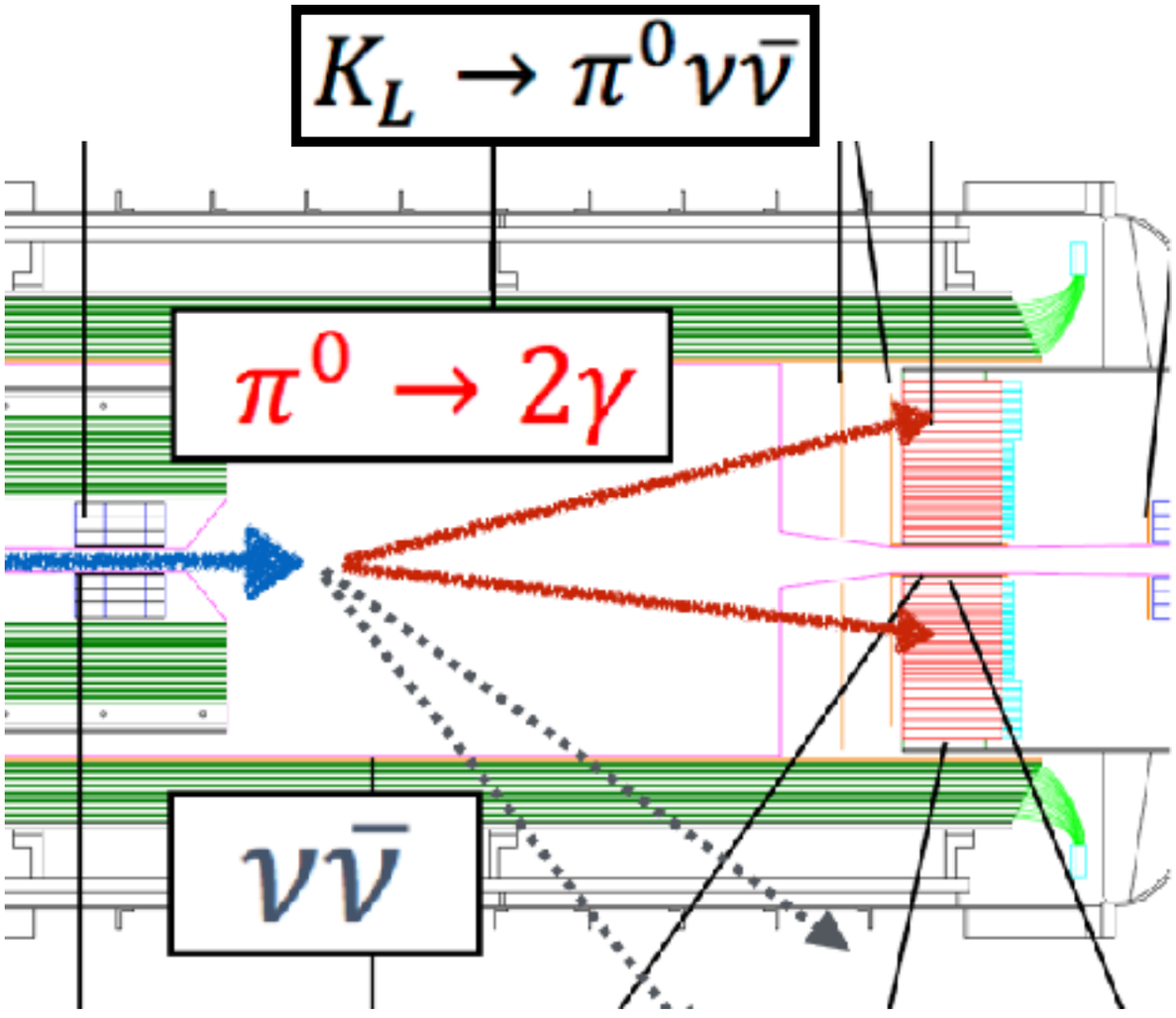
$$K_L \to \pi^0 \nu\bar{\nu} \quad (BR = 3\times10^{-11})$$

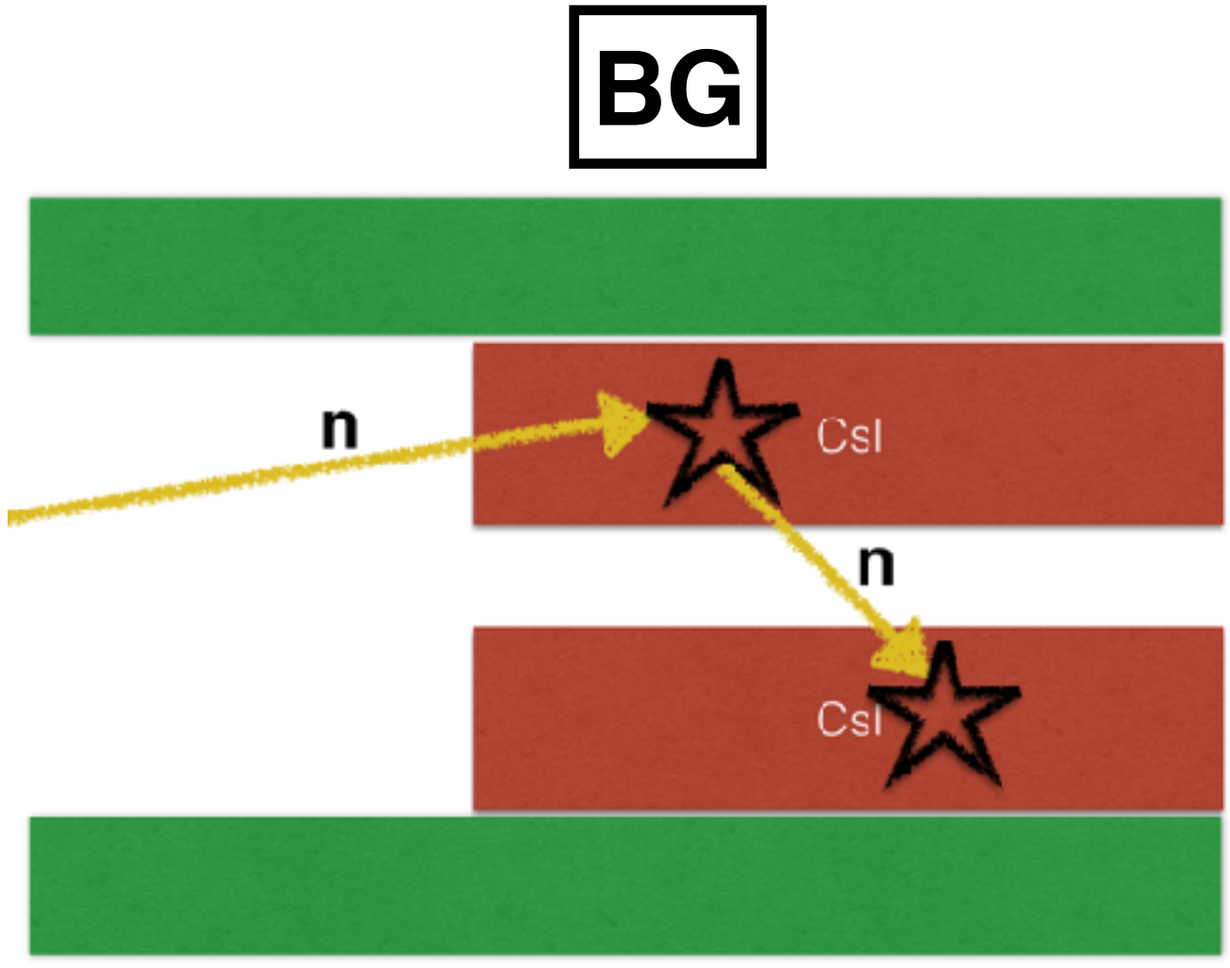
KOTO detector



CsI crystals are placed in vacuum

- Background

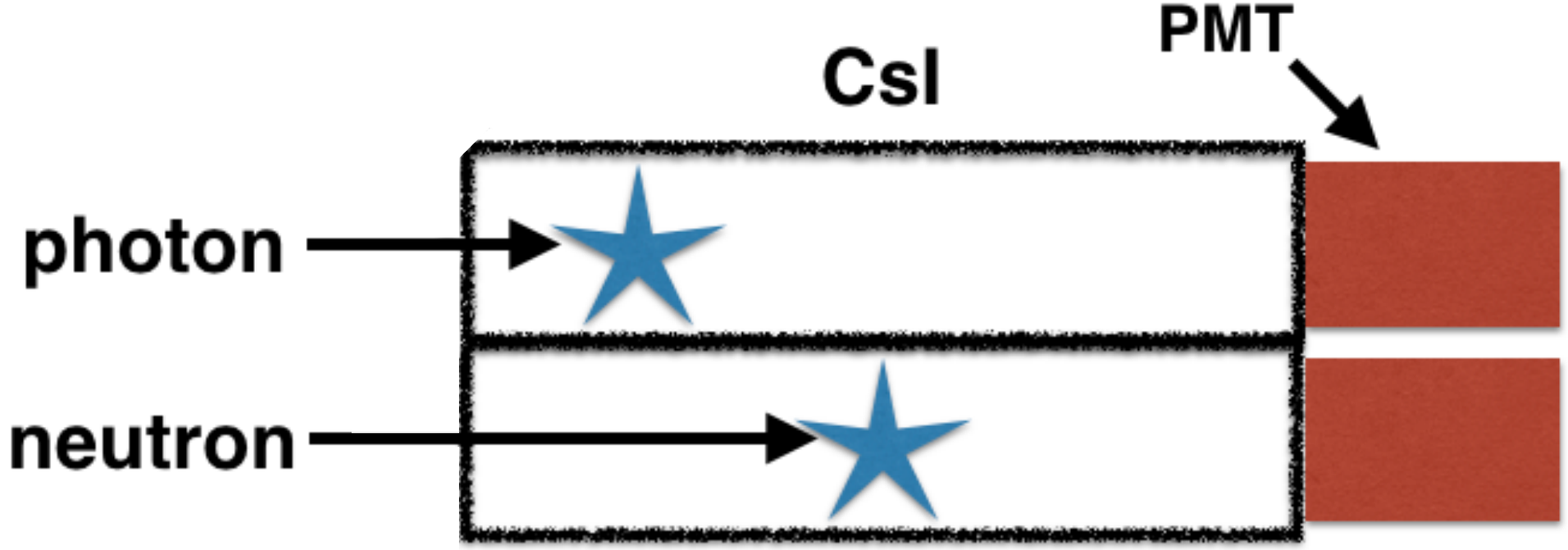




Halo neutrons make 2γ-like events

- Both-end readout of the CsI calorimeter

The depth of the shower made by neutrons and photons are different

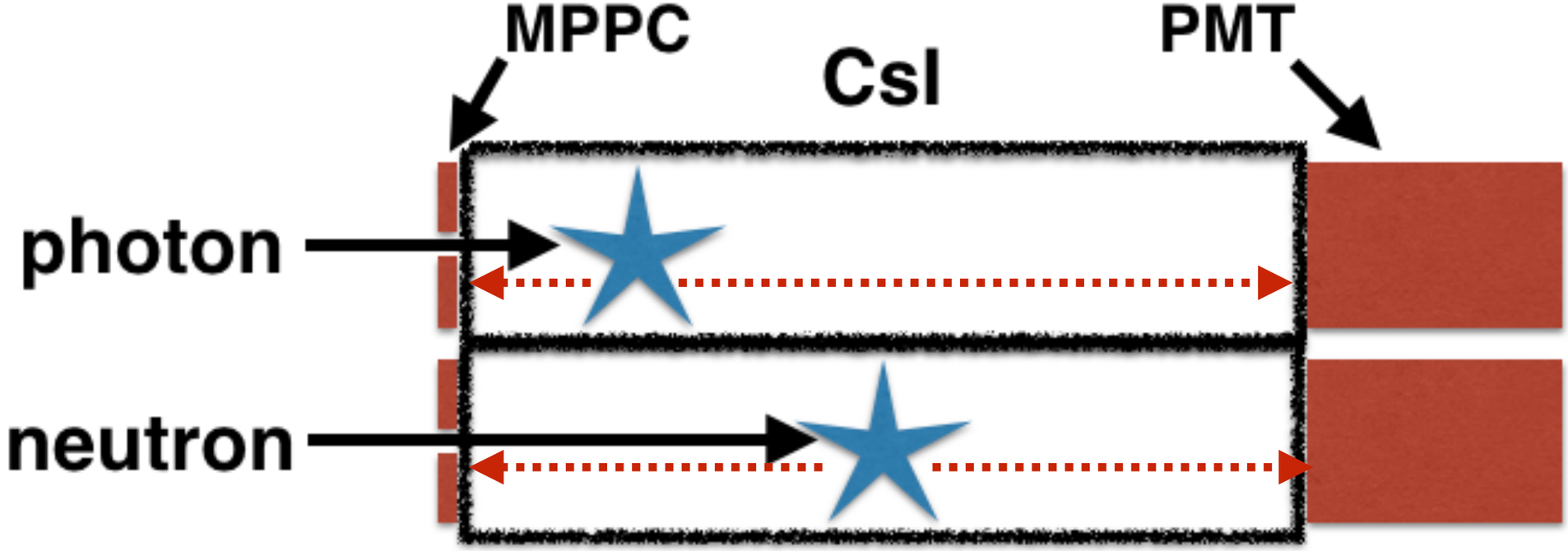


- Both-end readout of the CsI calorimeter

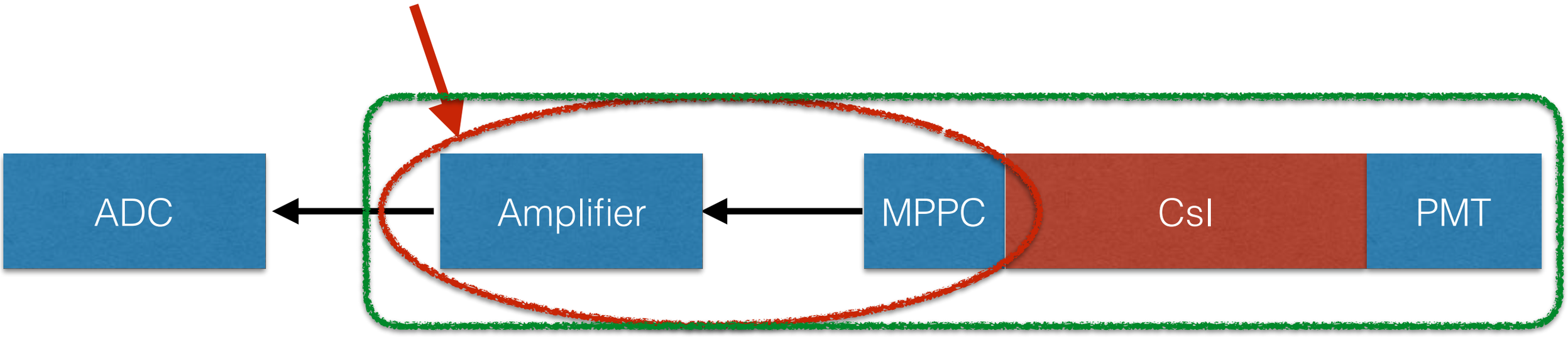
The depth of the shower made by neutrons and photons are different

↓

Calculate the position of the interaction by measuring the timing difference

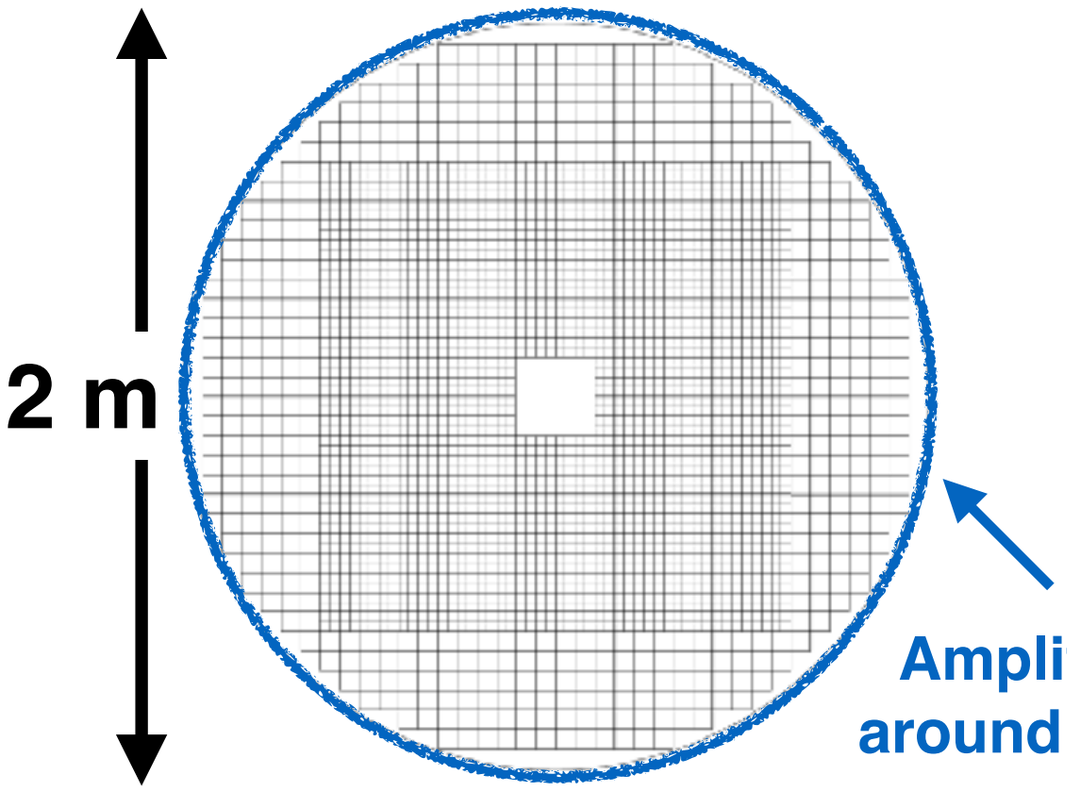


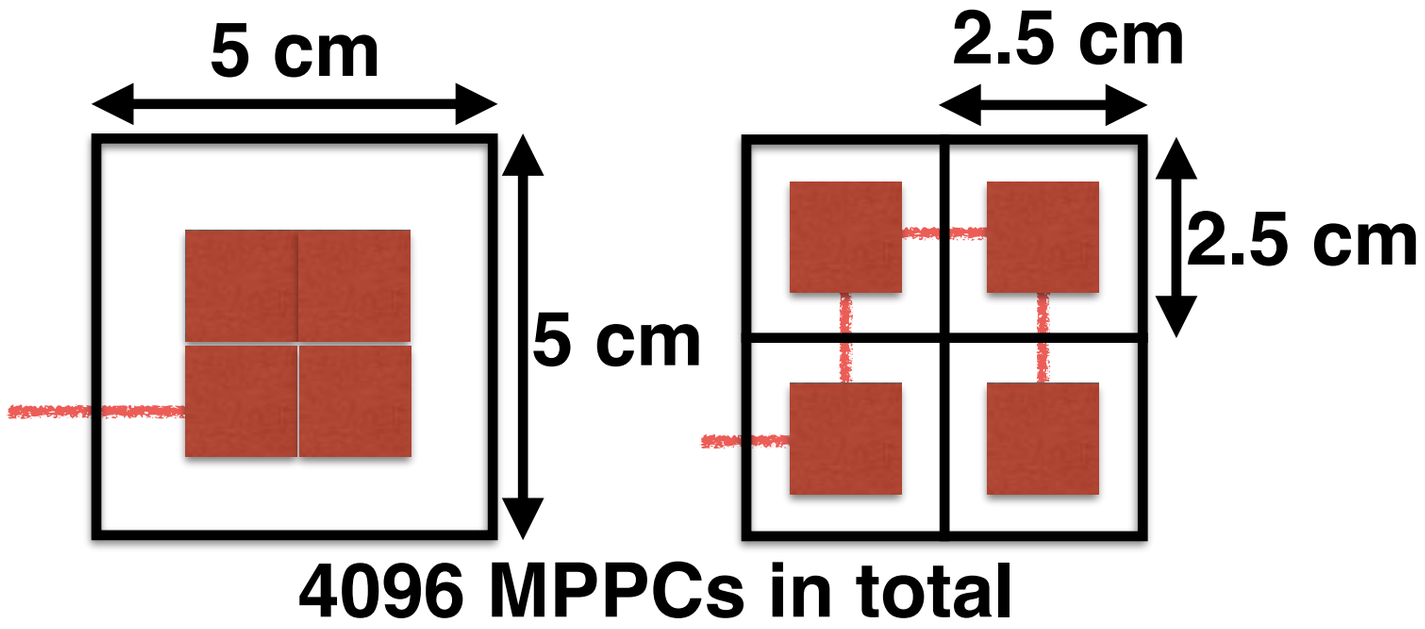
- Purpose
  - **Develop the circuit for the MPPC-side of the both-end readout**



- To develop
  - **Connection between MPPCs ← Today's main topic**
  - **Amplifier circuit**

- Whole schematic of the install





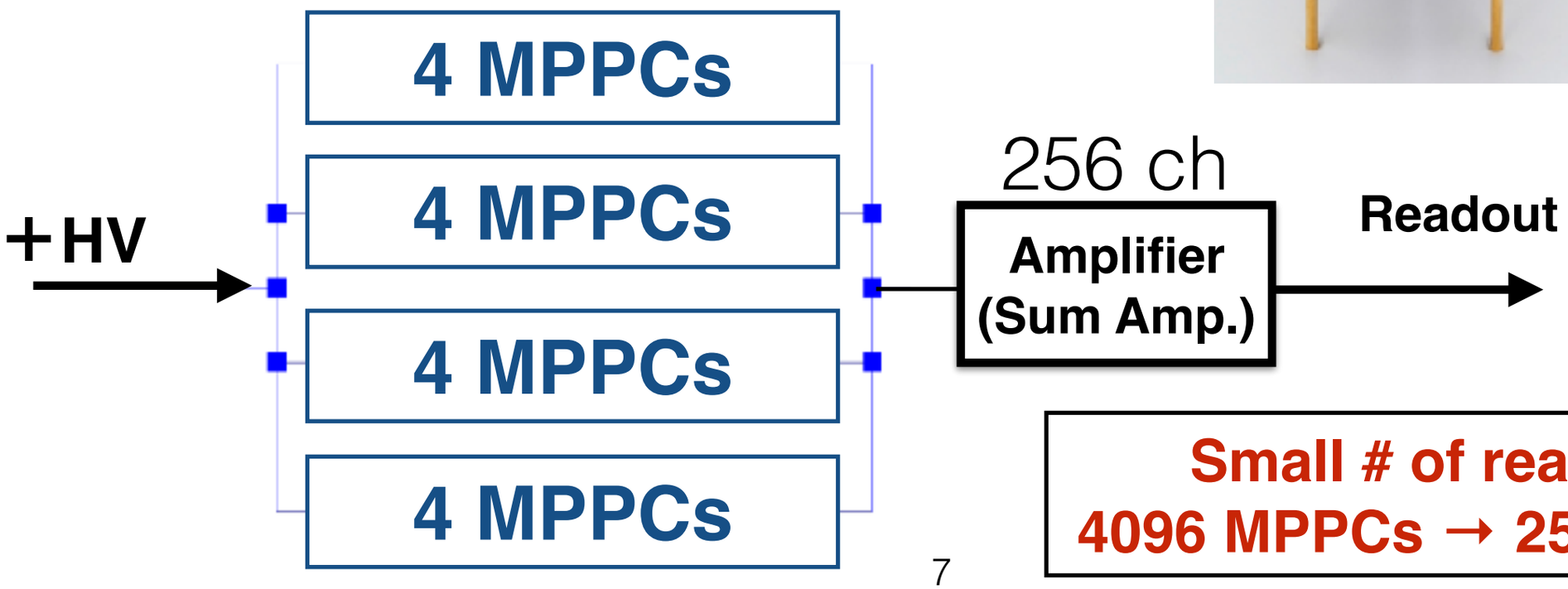
Amplifier boards around CsI crystals

# of CsI Calorimeters:
2240(Small) + 476(Large)

HPK S13360-6050CS

Sensor size：

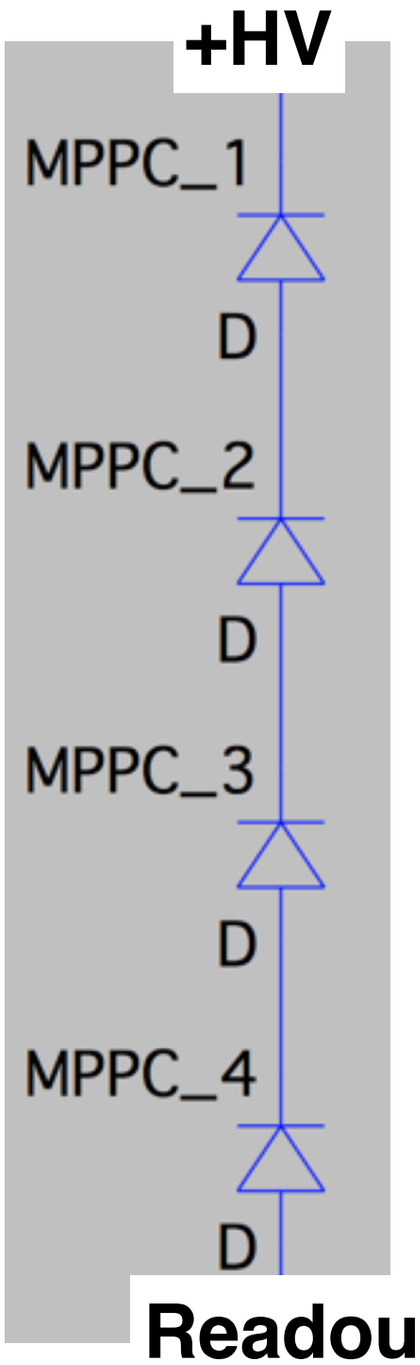
6 mm × 6 mm



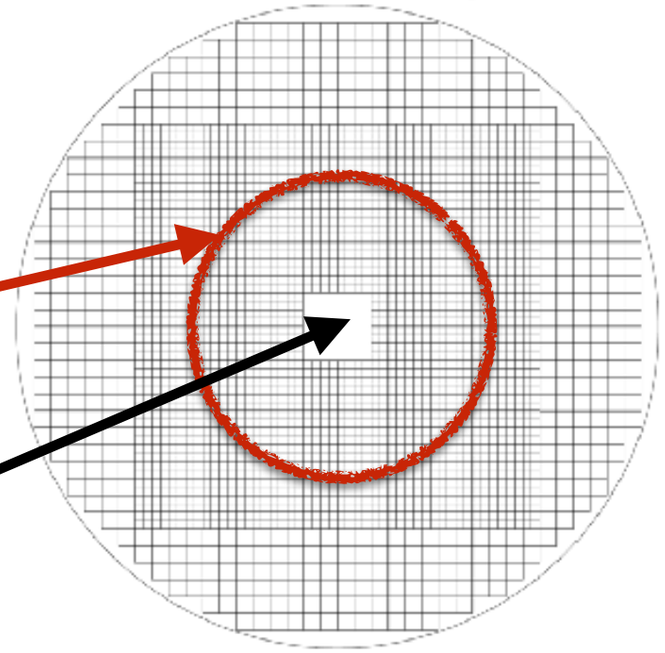
Small # of readout channels
4096 MPPCs → 256 readout channel

- Connection methods for MPPCs

Series connection



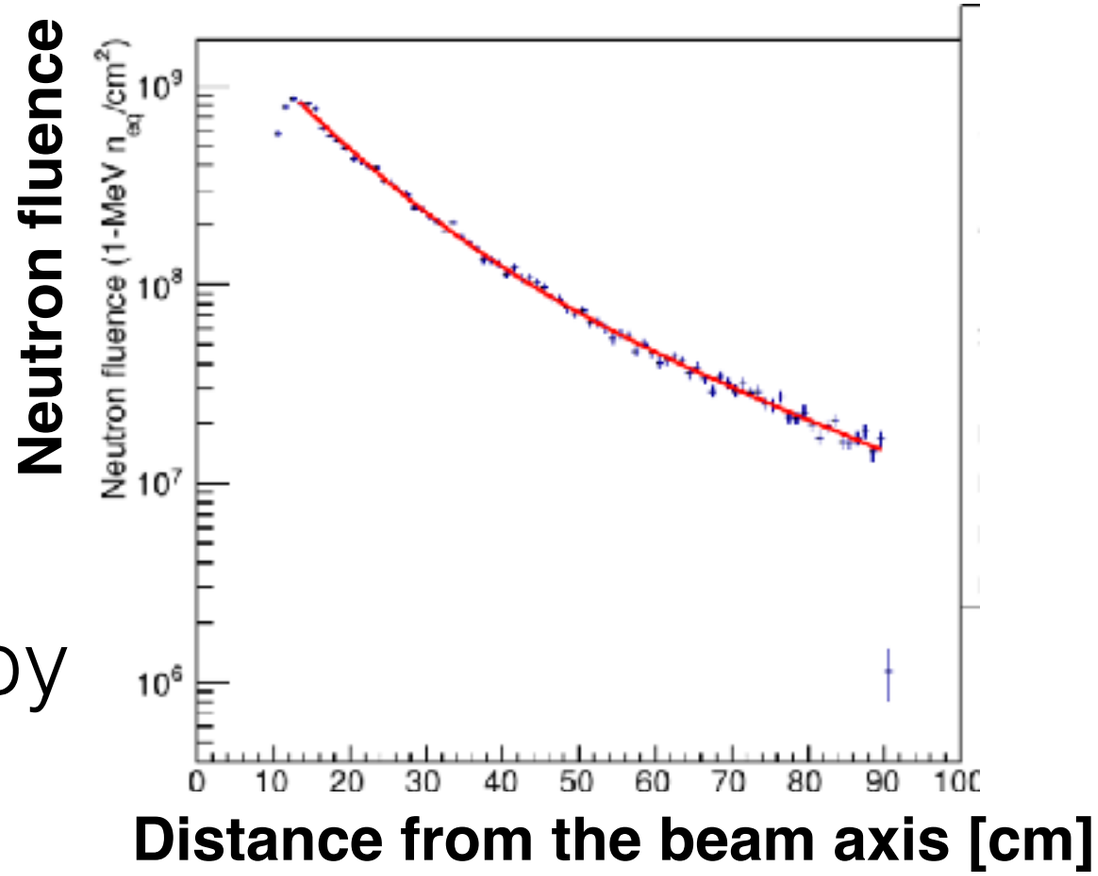
Stacked CsI crystals



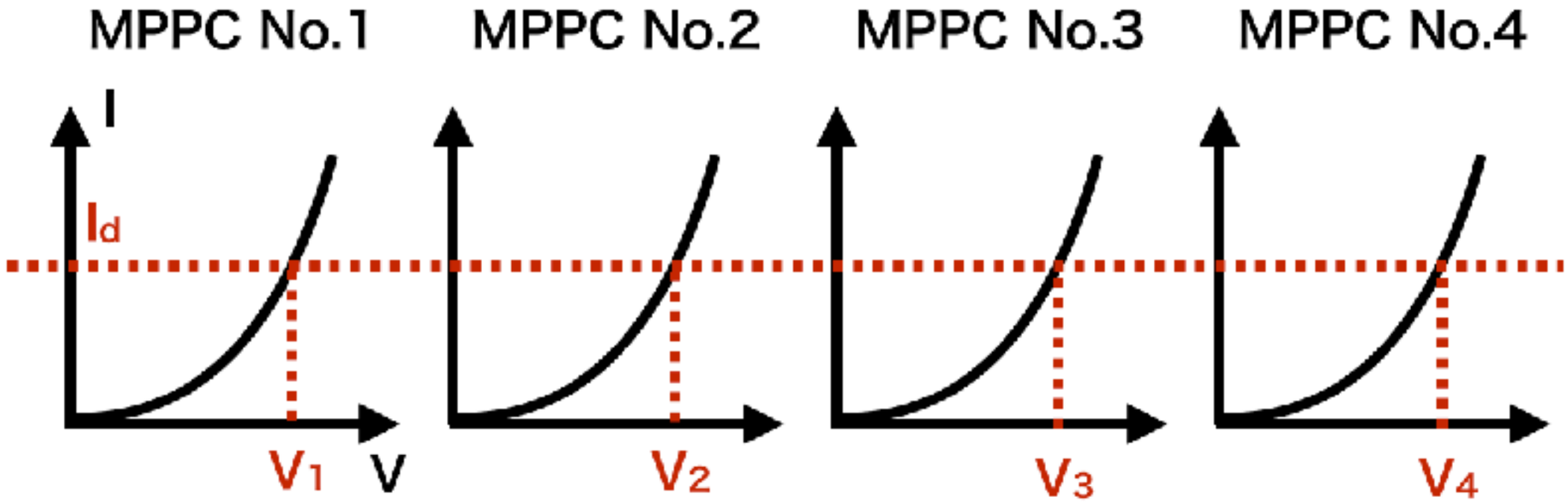
High radiation dose

Beam hole

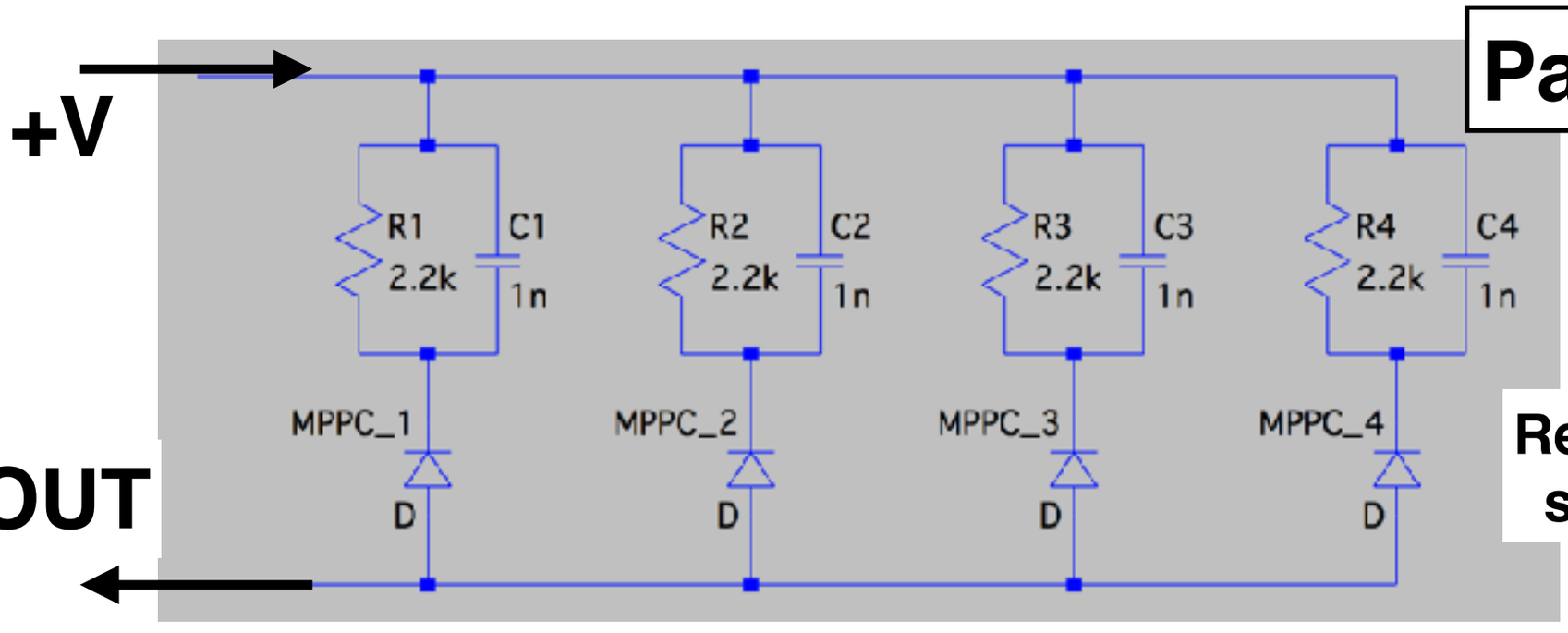
Simulated by
H. Nanjo



- Connection methods for MPPCs

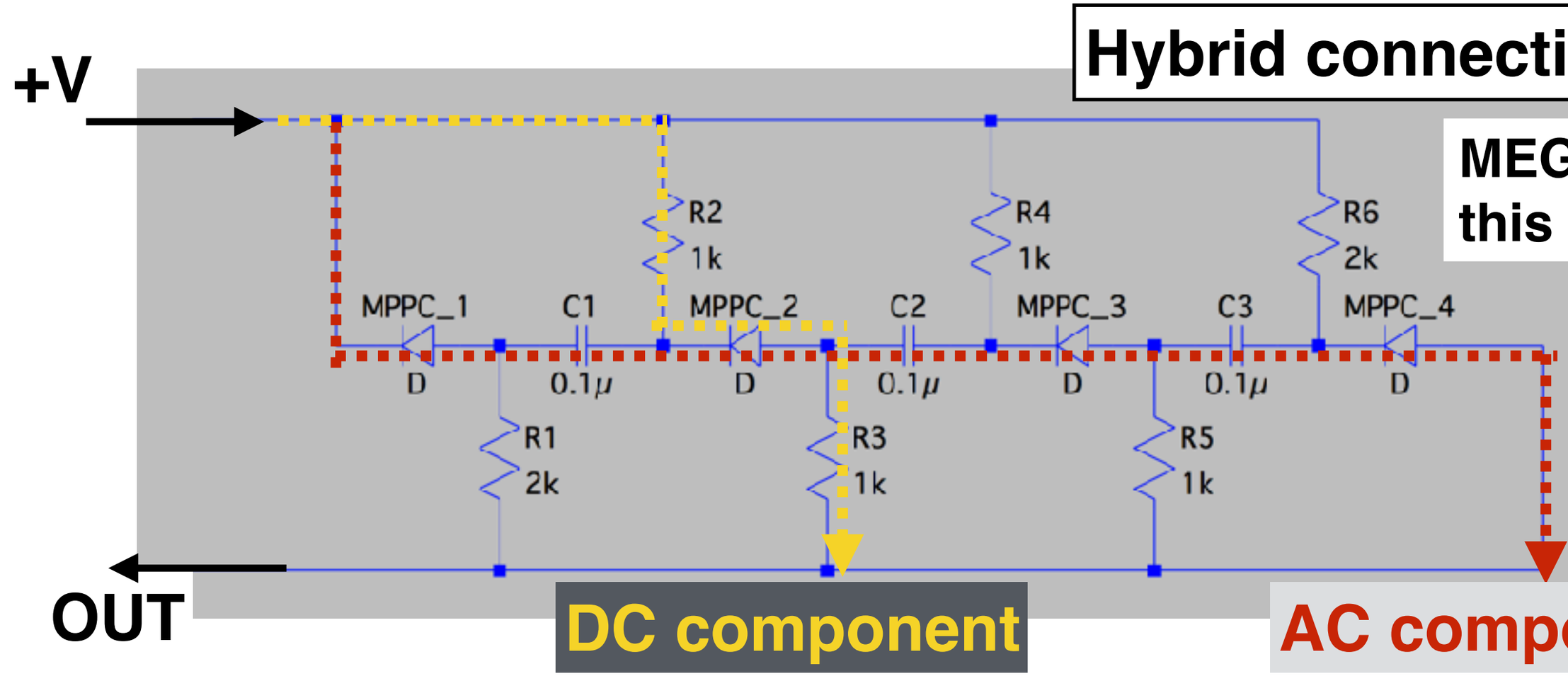


- Connection methods for MPPCs



Parallel connection

Resistance and capacitance shorten the time constant



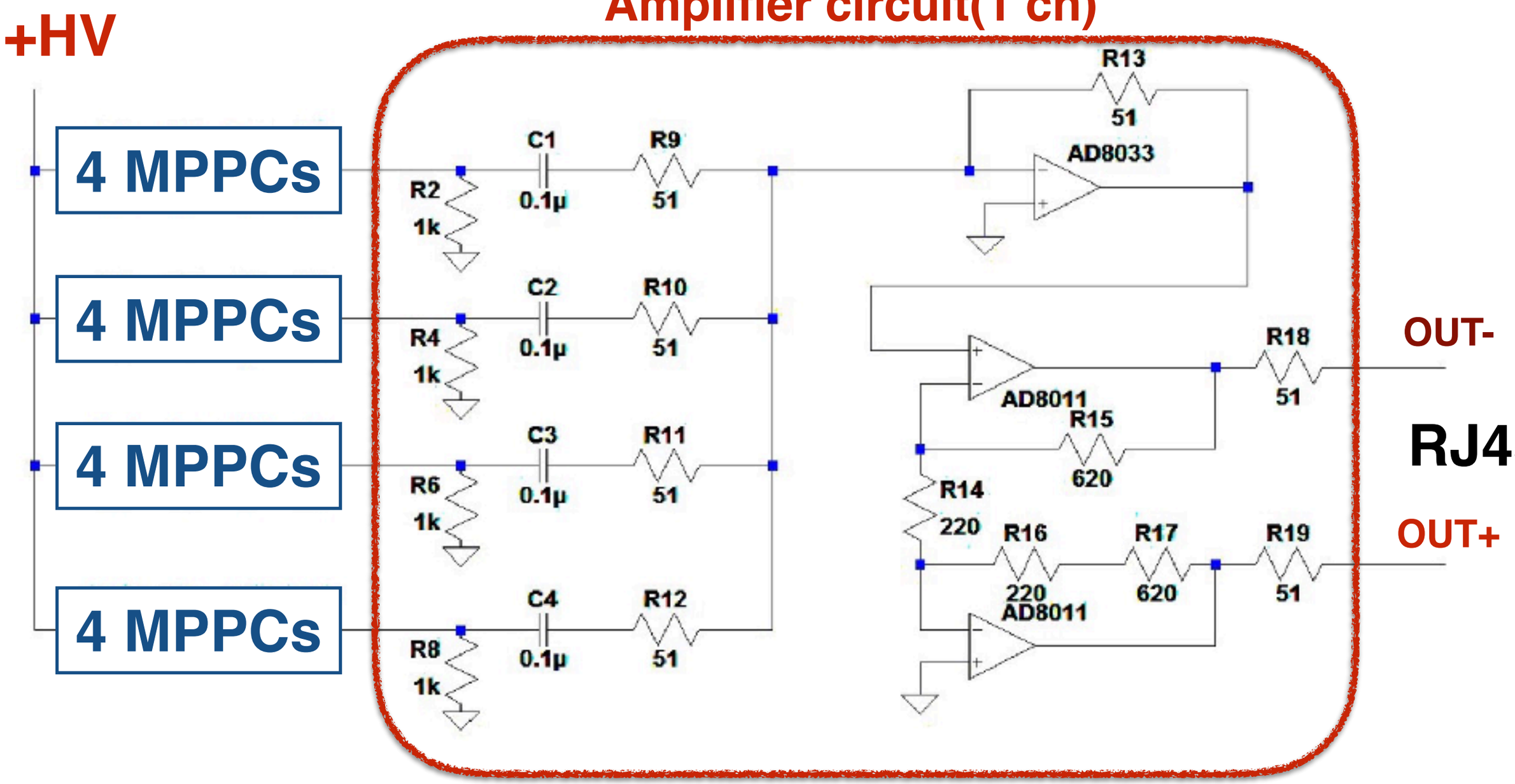
Hybrid connection

MEG II uses this method

DC component

AC component

- Readout circuit

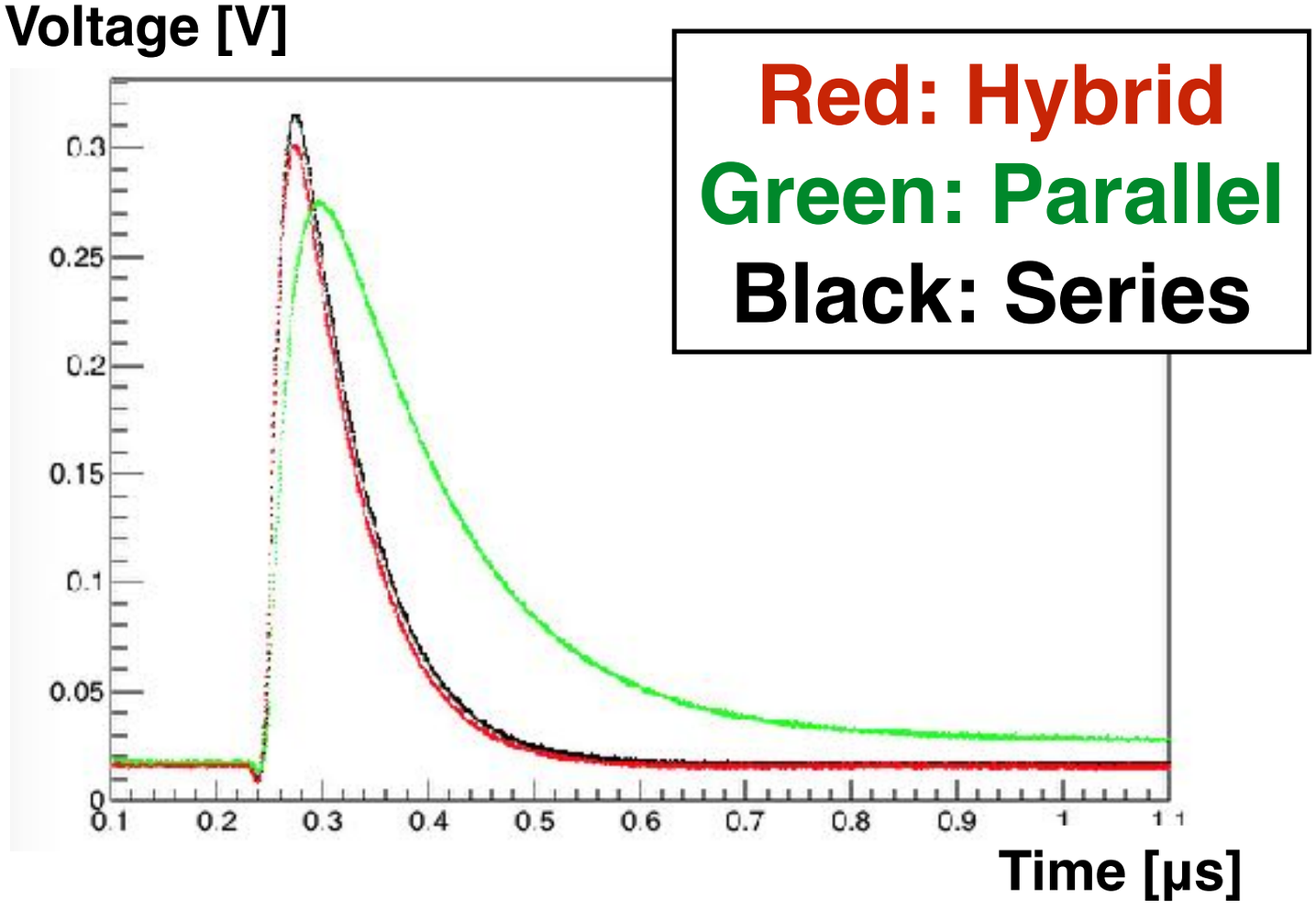


Power consumption：55 mW / ch

→ 14 W in total (256 ch)

Low power

- Waveforms (all MPPCs are viewing photons from LED)

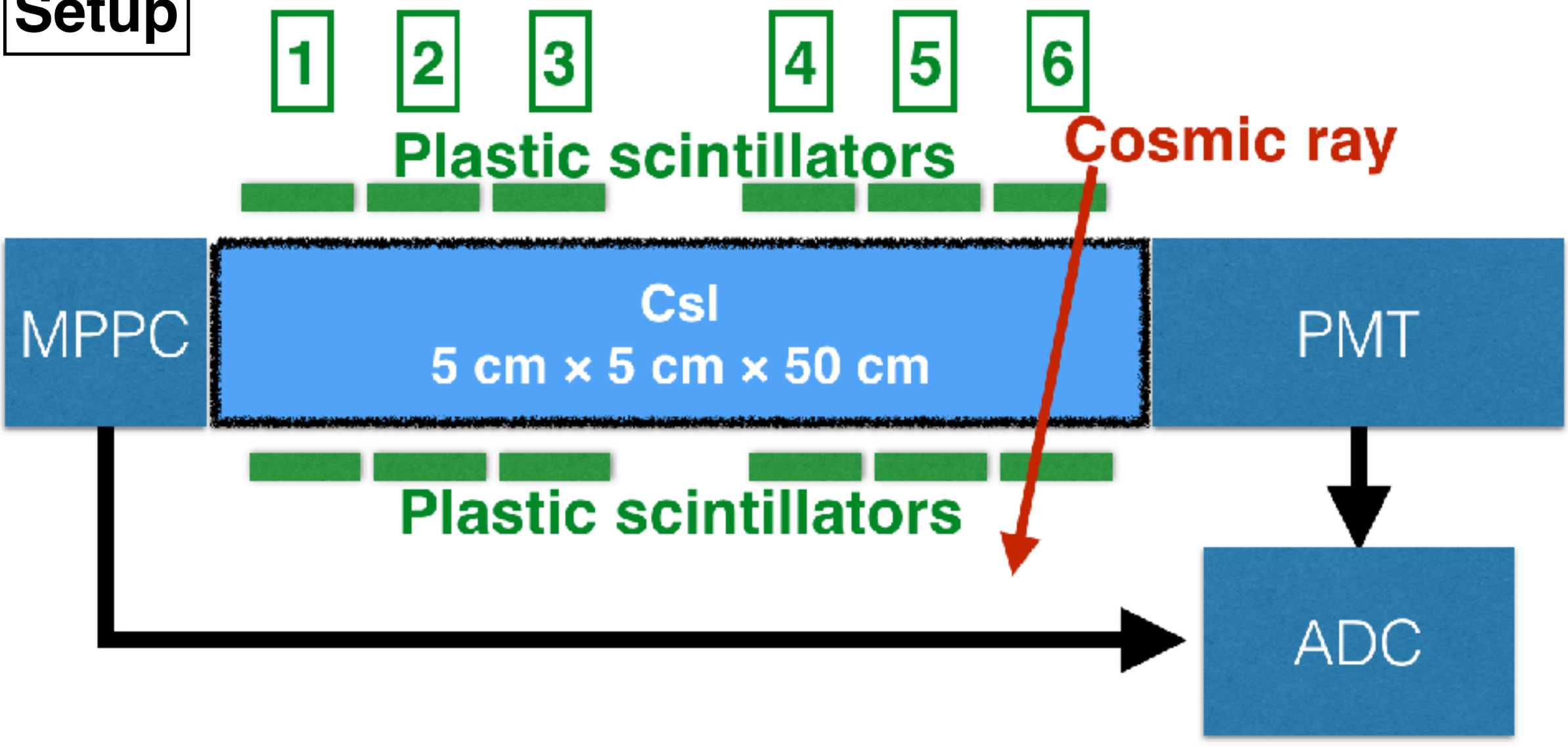


Time constant: Series ~ Hybrid < Parallel
Pulse height: Series ~ Hybrid > Parallel

- Cosmic ray test at J-PARC

- **Compare the timing resolution between parallel and hybrid connection**

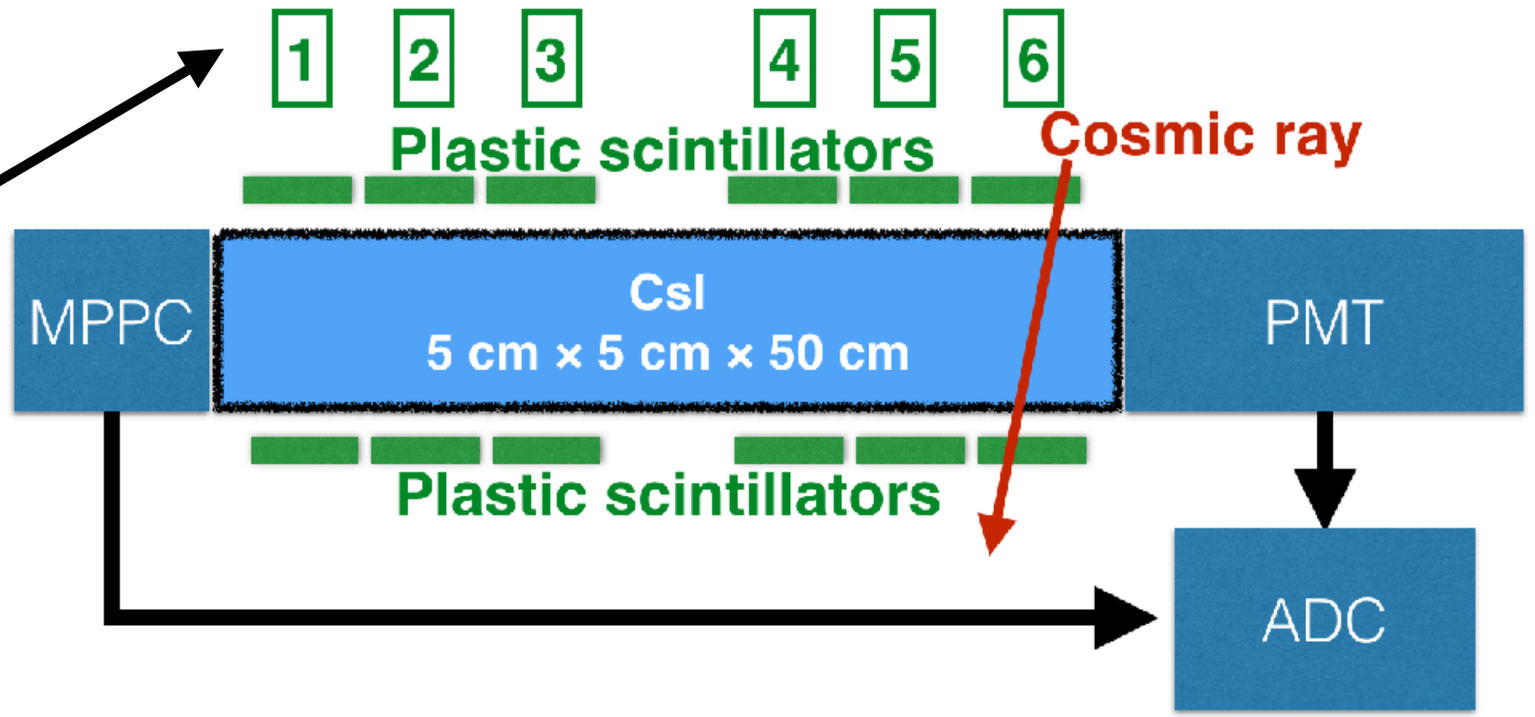
Setup



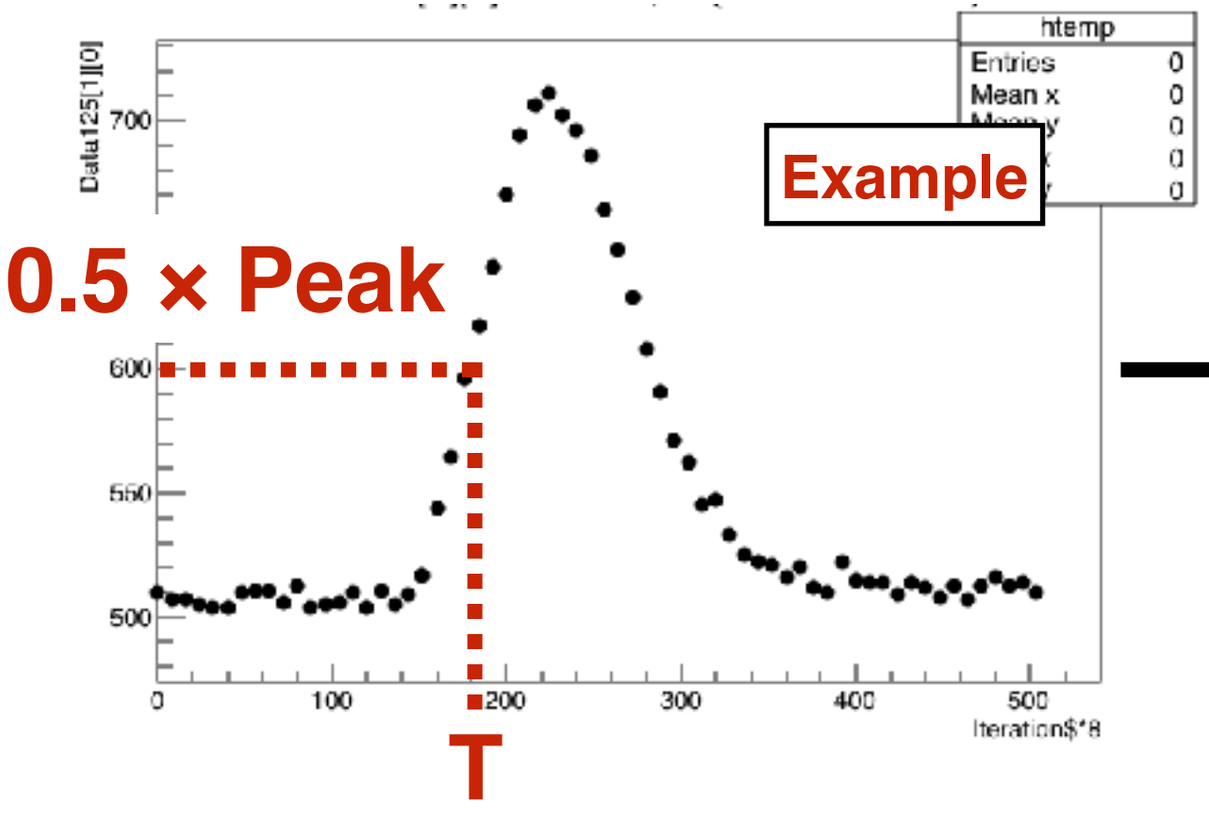
- Cosmic ray test at J-PARC

Timing difference

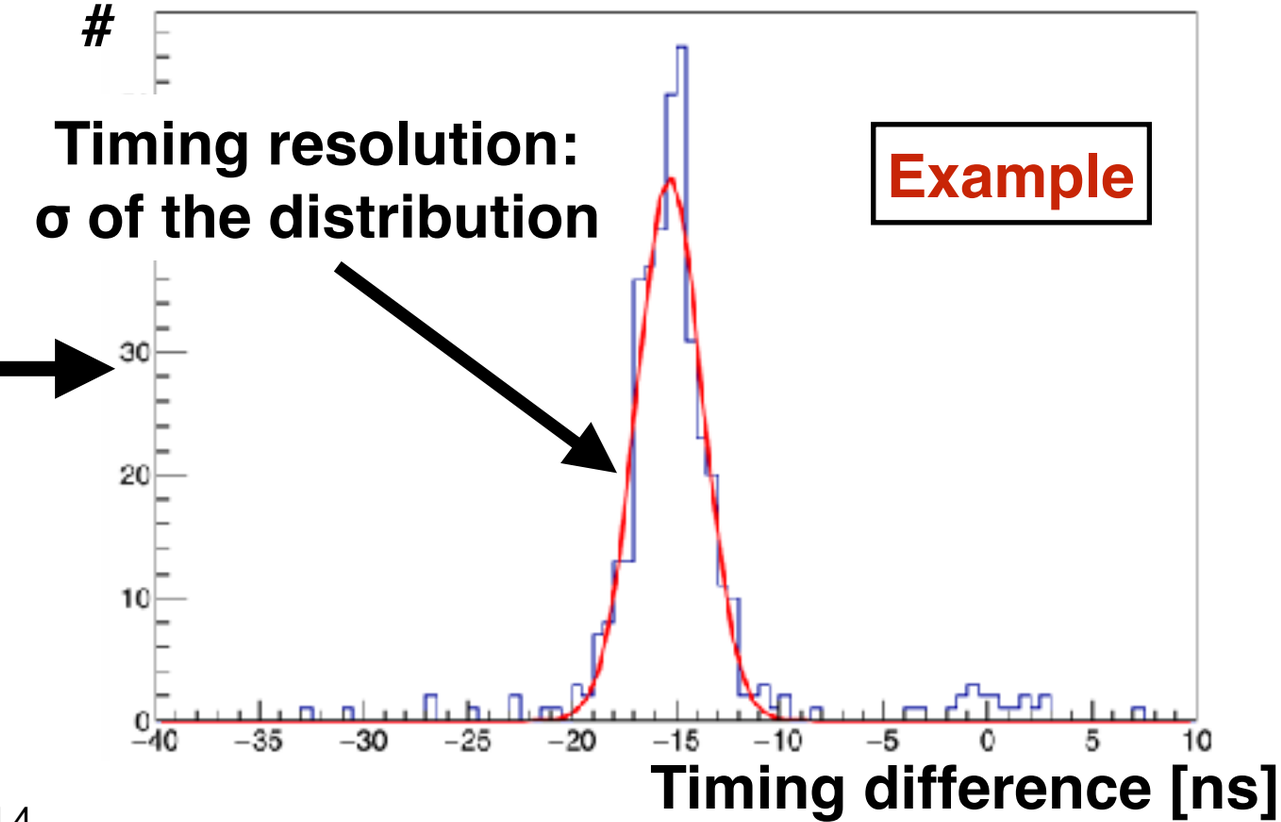
Trigger position



Waveform (MPPC)



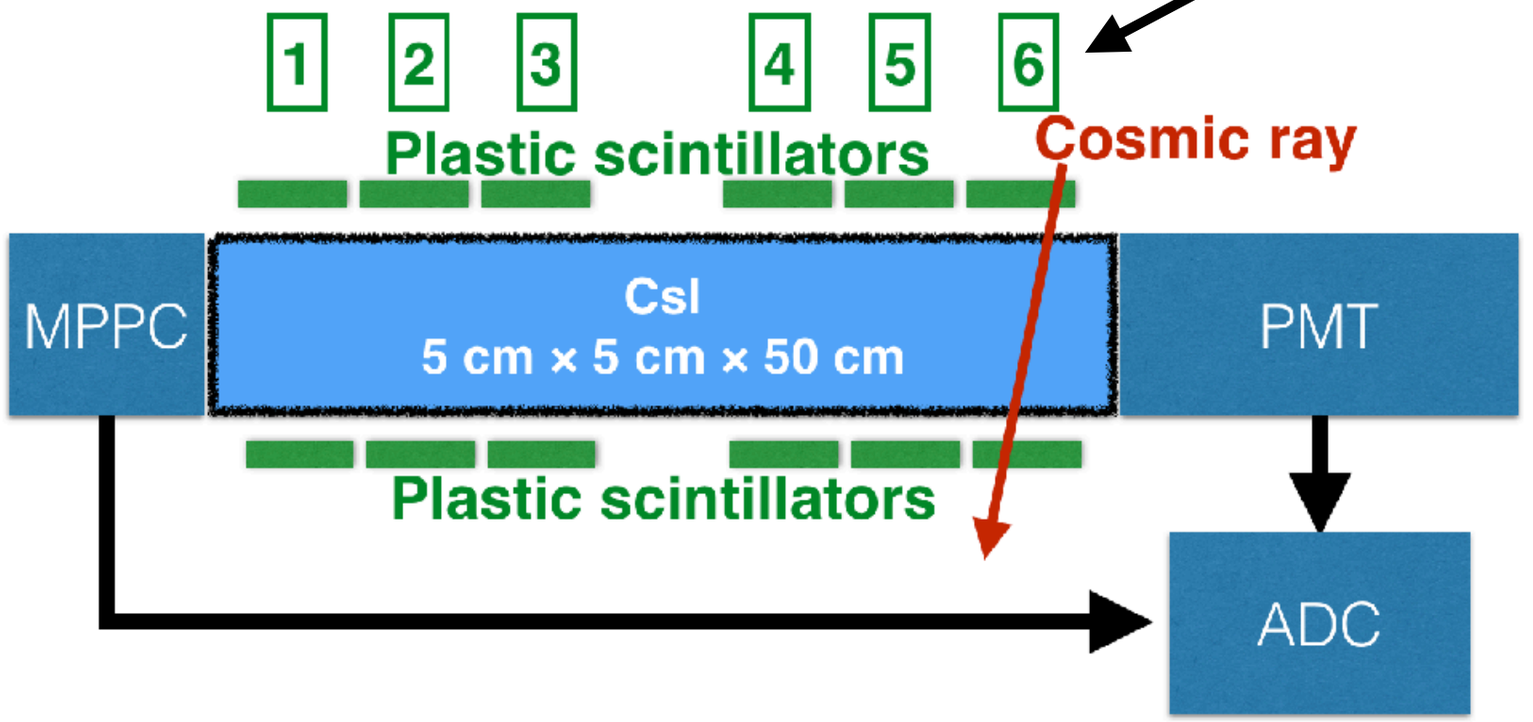
T(MPPC) - T(PMT)

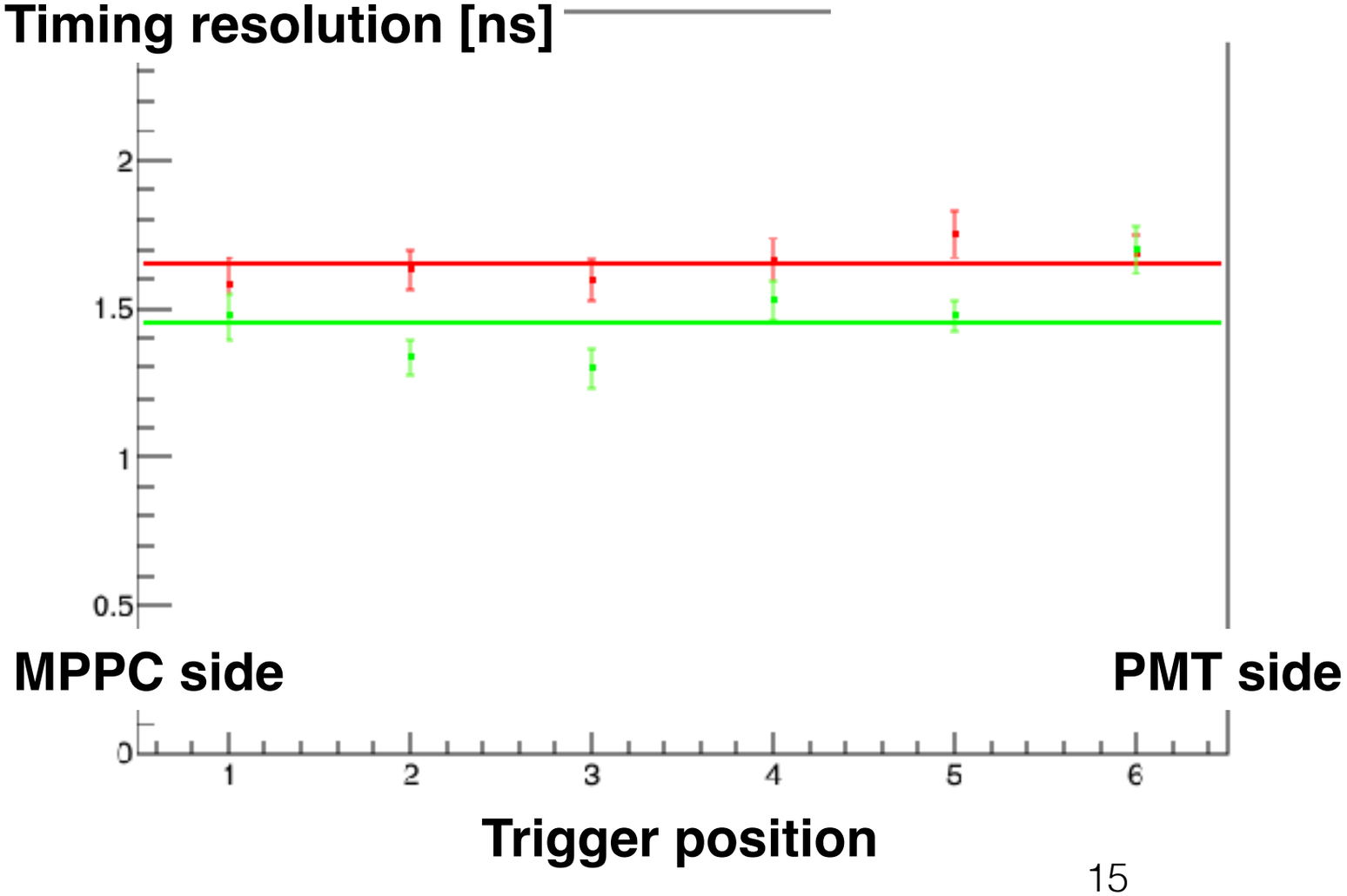


- Cosmic ray test at J-PARC

Timing resolution

<1.7 ns required





Red：Parallel

Green：Hybrid

＜Timing resolution＞

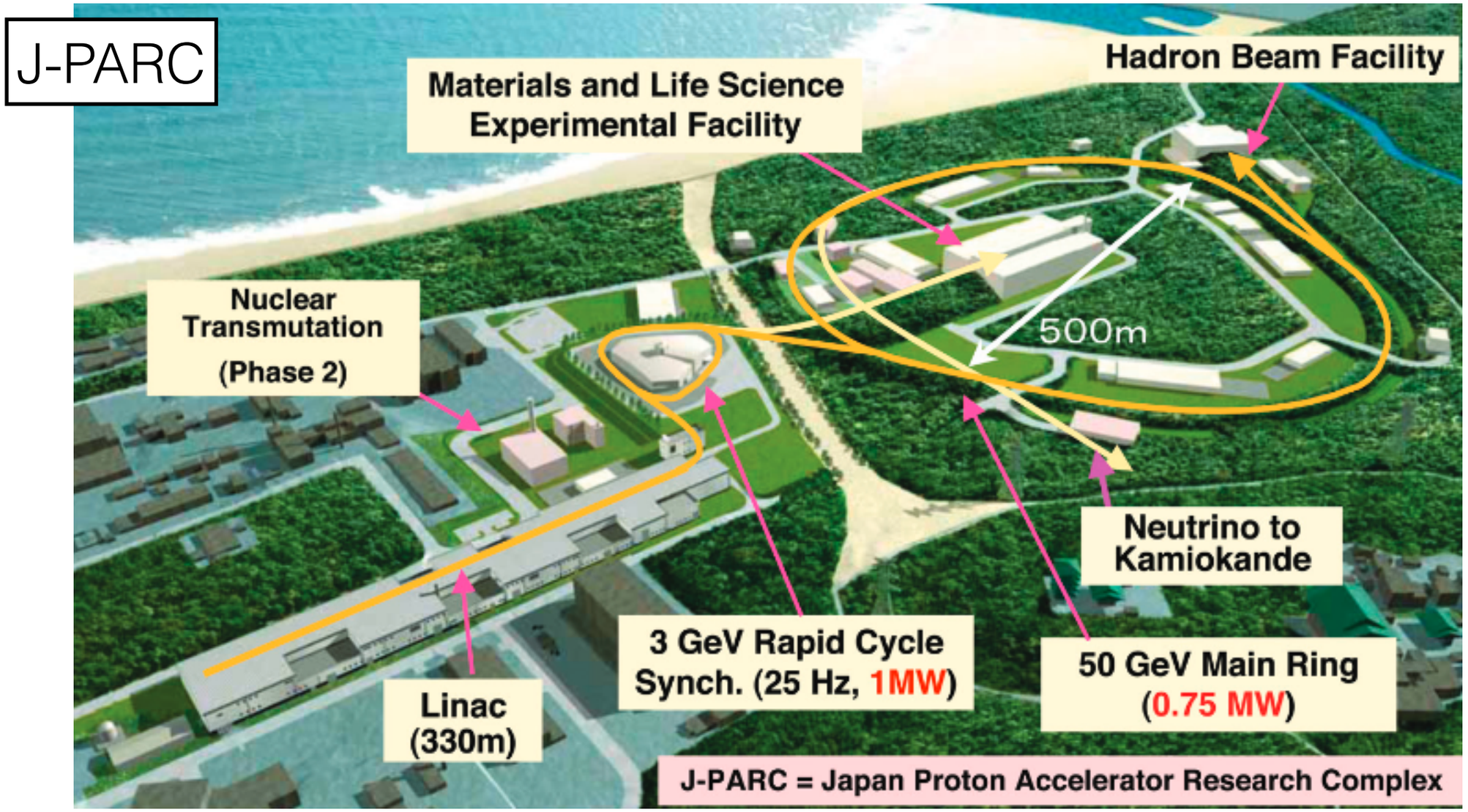
Parallel：(1.65 ± 0.03) ns

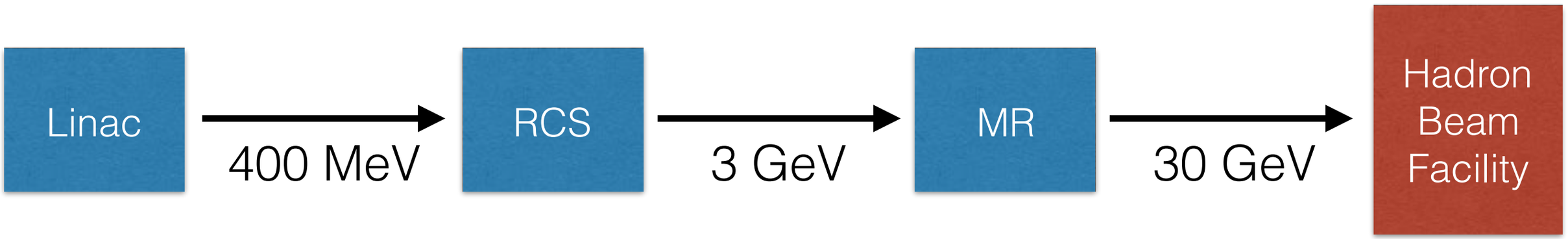
Hybrid：(1.45 ± 0.03) ns

- Summary
  - Evaluating the performance of two connection methods for 4-MPPCs
  - Developed the amplifier board to readout signals from MPPCs
  - Timing resolution of the readout system satisfies the requirement
- Prospects
  - Understand and solve the problems found during the beamtest

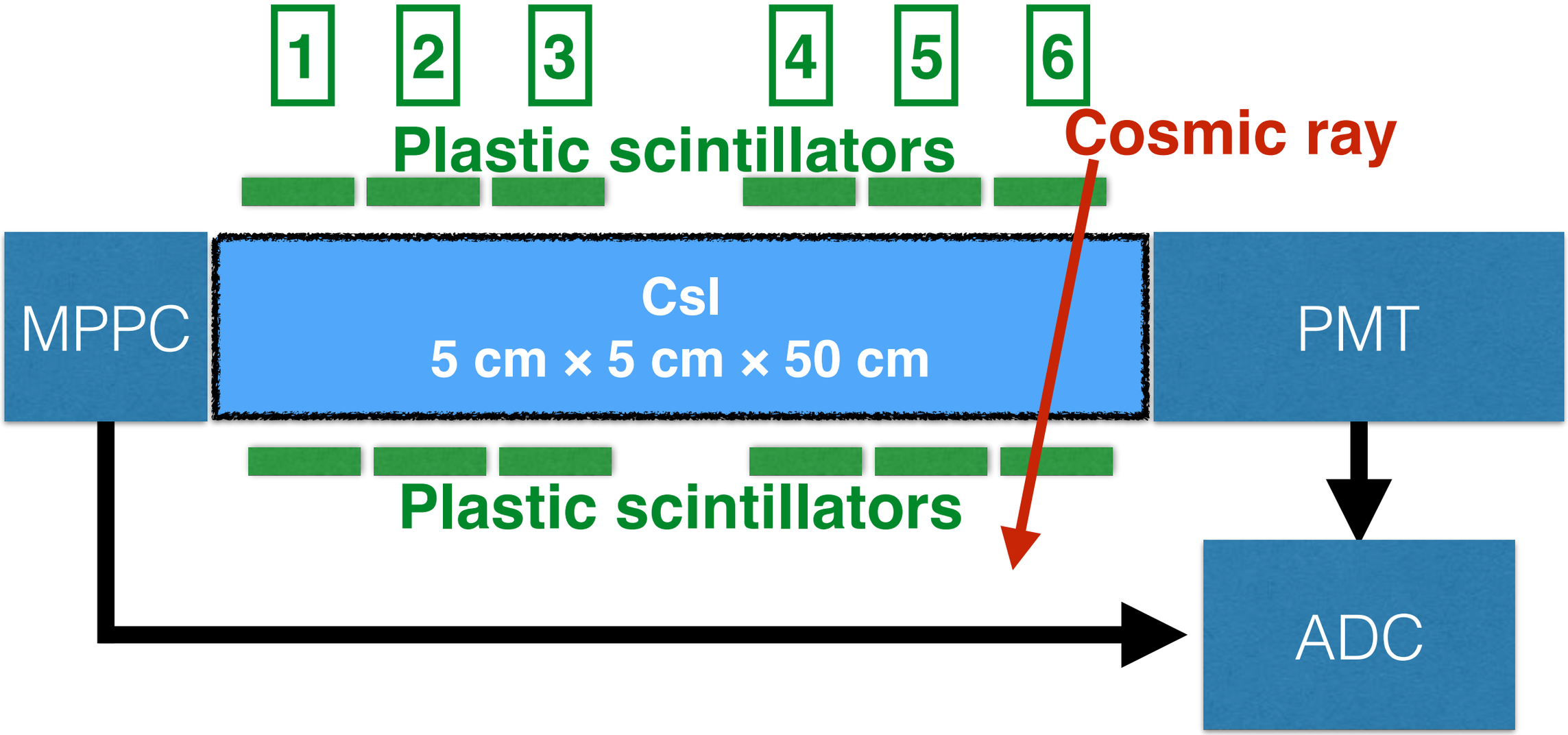
Backup

- KOTO Experiment





Figures


1
2
3
4
5
6
Plastic scintillators
Cosmic ray
MPPC
CsI
5 cm × 5 cm × 50 cm
PMT
Plastic scintillators
ADC