



LAMPS START COUNTER R&D STATUS

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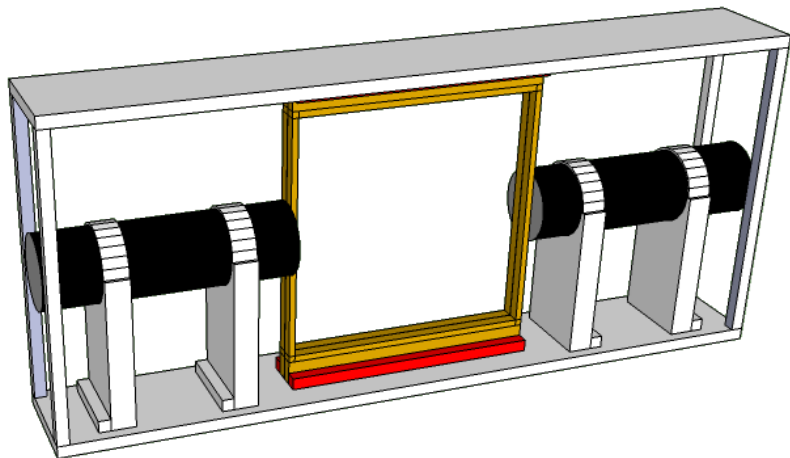
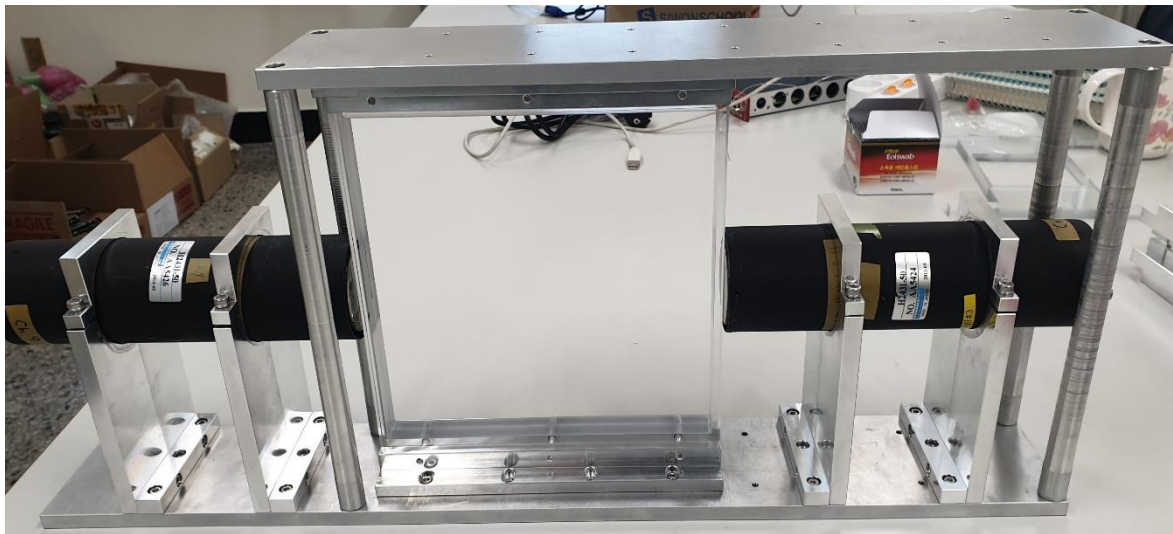
RAON User Workshop
March 6th 2020

Setup status



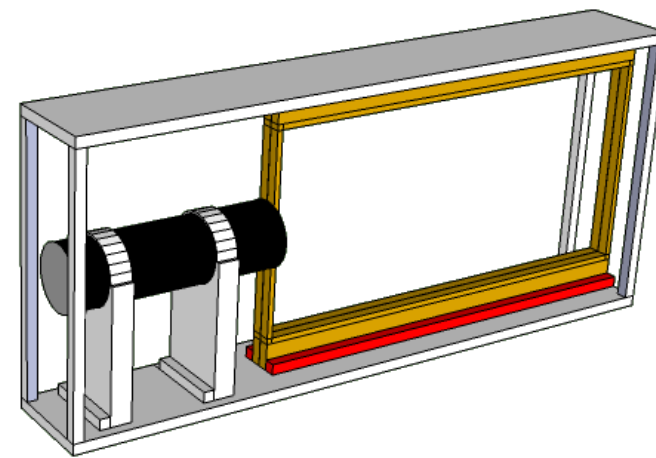
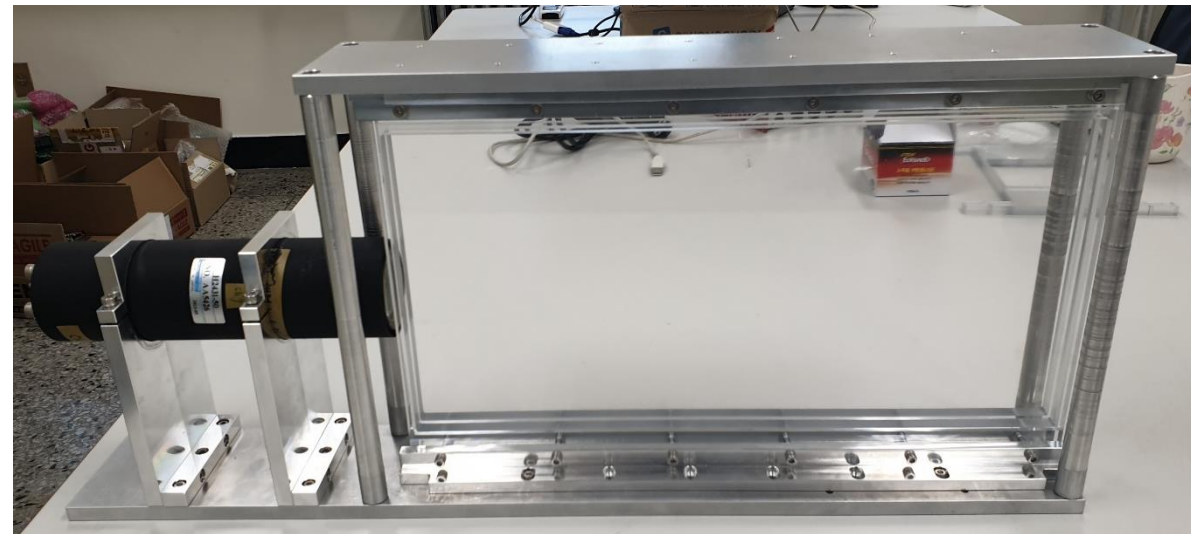
Starting counter

Scintillator : EJ-230 / PMT : H2431-50 / 20cm x 20cm x 0.02cm



Veto counter

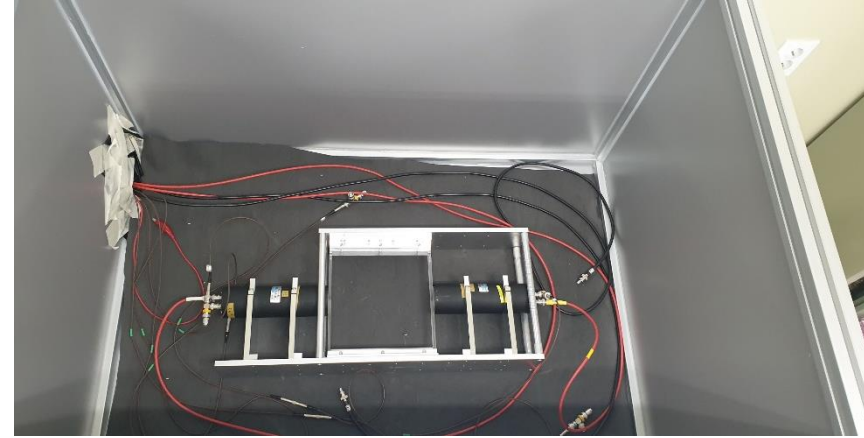
Scintillator : EJ-230 / PMT : H2431-50 / 20cm x 20cm x 0.5cm



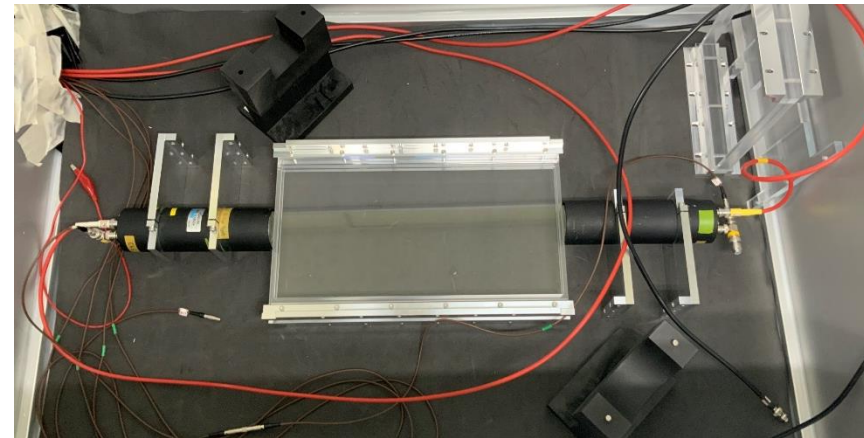
Setup status



Dark box

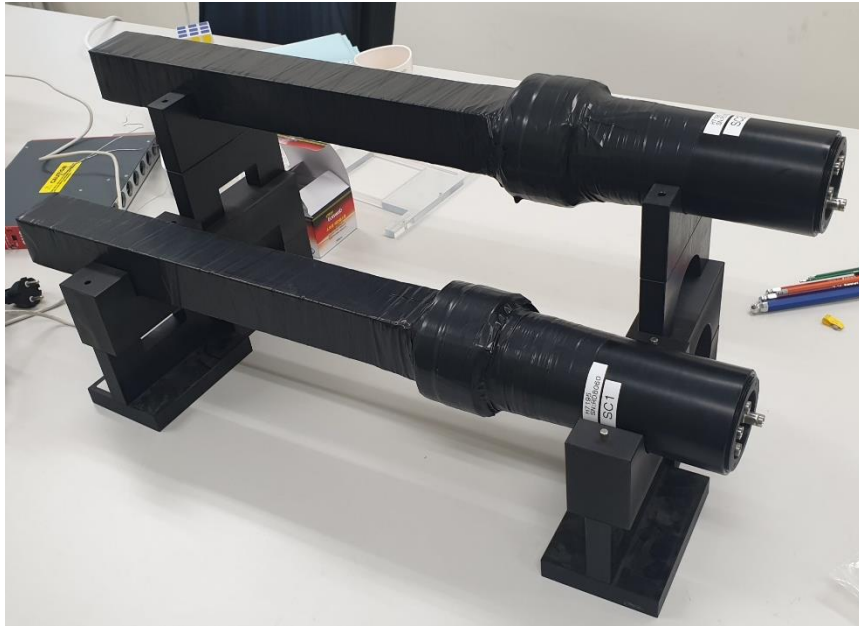


20cm x 20cm setup
(starting counter)



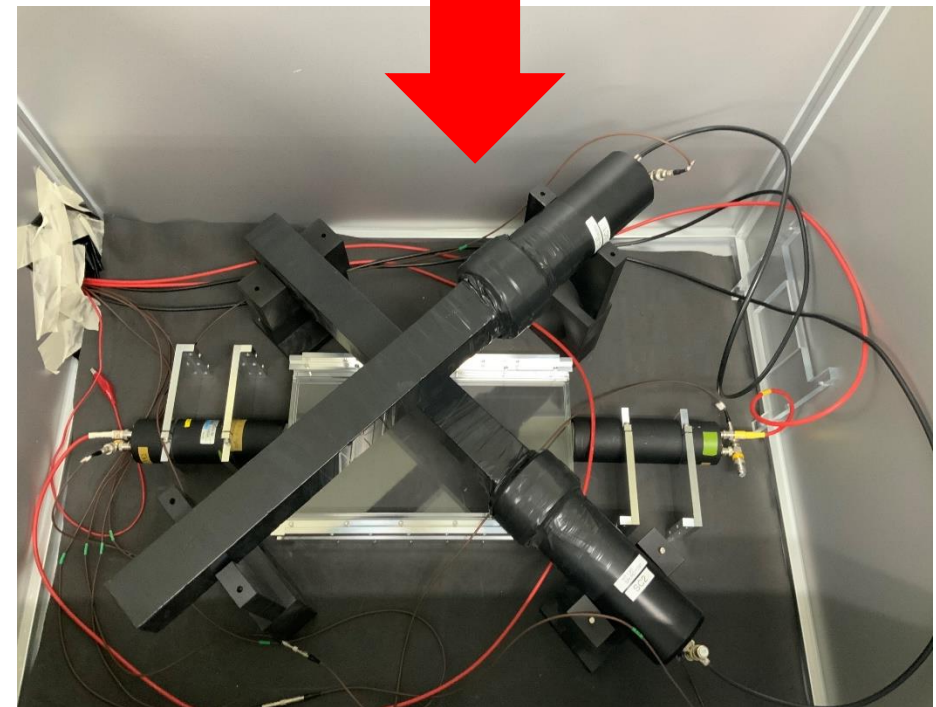
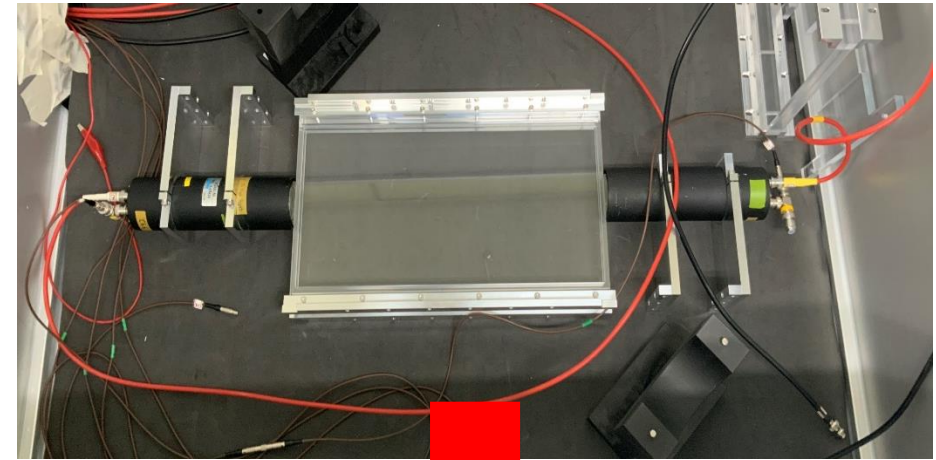
20cm x 40cm setup
(veto counter)

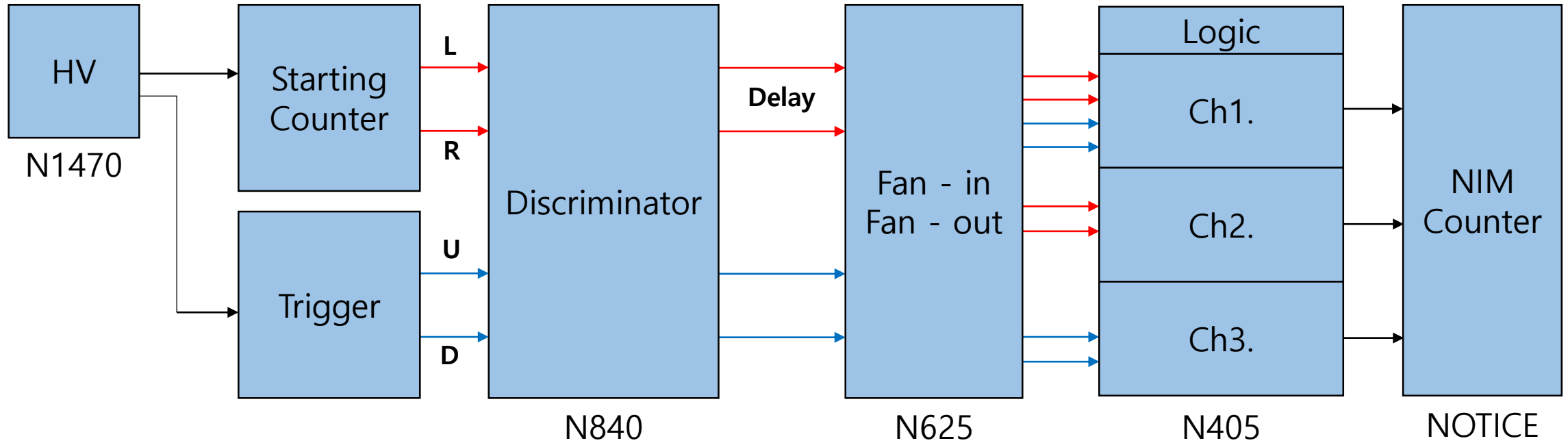
Setup status



Trigger :

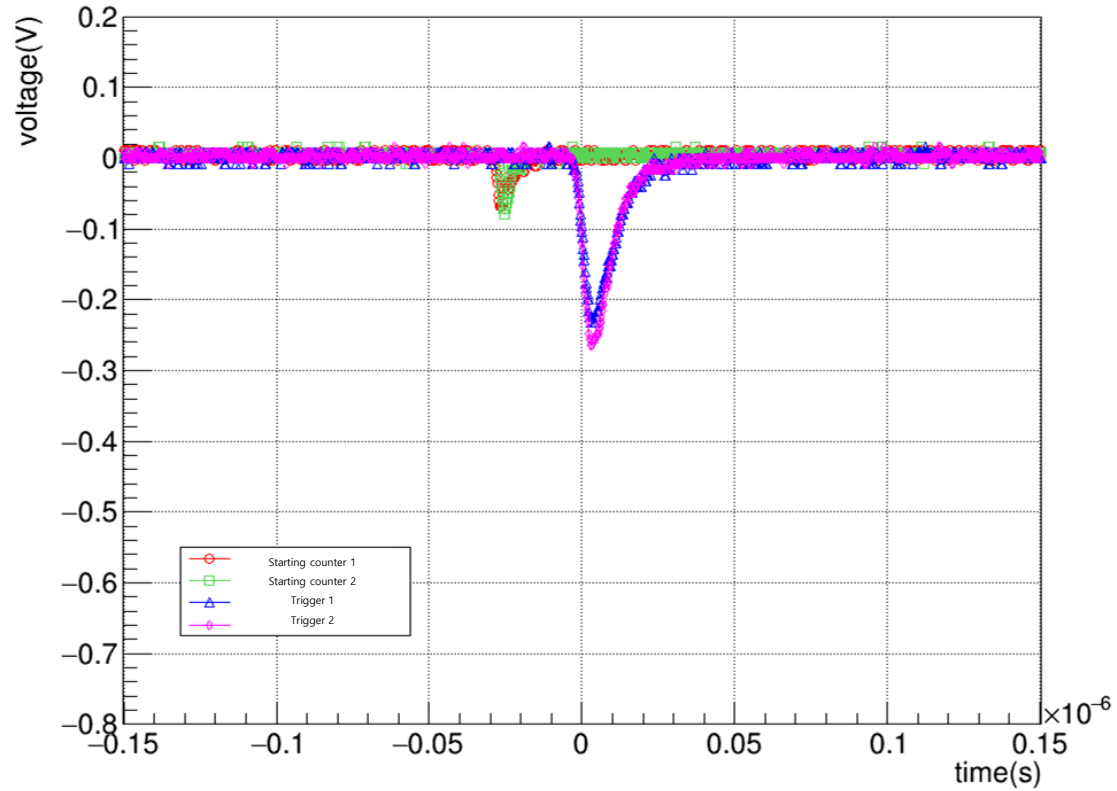
PMT Model	H7195
Base Material	Polystyrene
Density(g/cm ³)	1.05
Refractive Index	1.58
Decay time(ns)	2.4
Wavelength of emission maximum(nm)	415



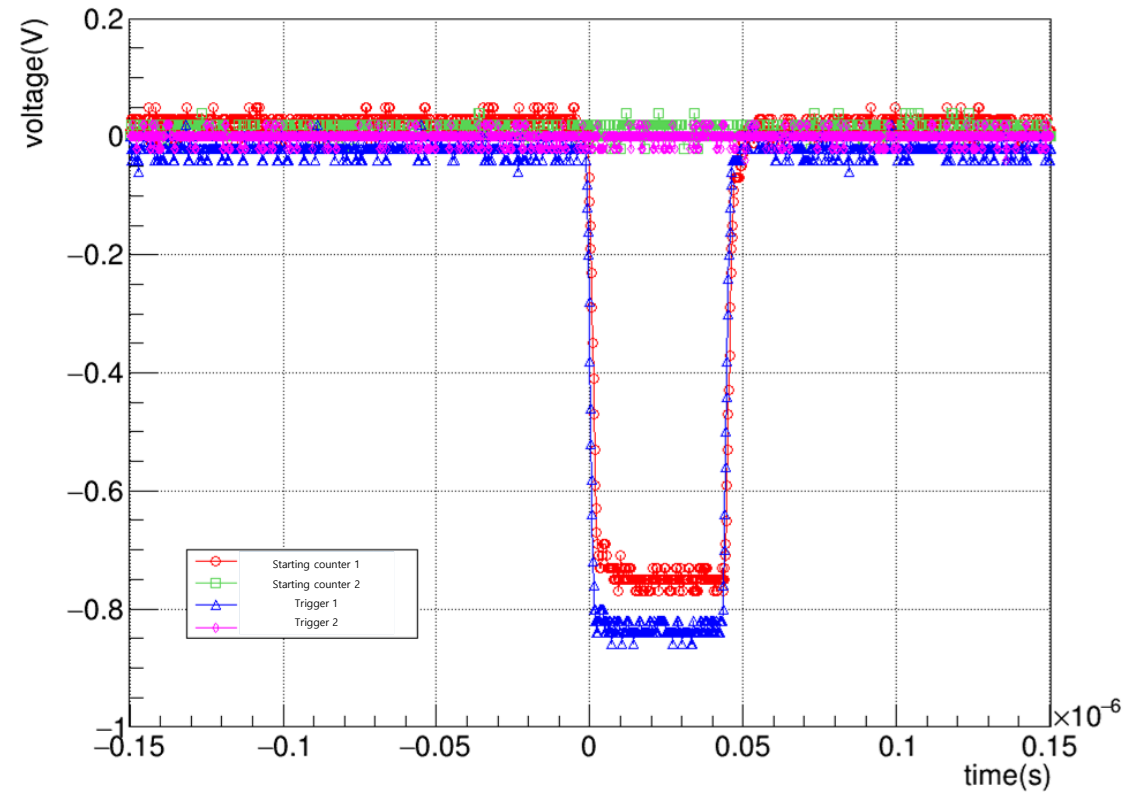


H7195		H2431-50	
[Time Response] Rise Time Typ.	2.7 ns	[Time Response] Rise Time Typ.	0.8 ns
[Time Response] Transit Time Typ.	40 ns	[Time Response] Transit Time Typ.	16 ns
[Time Response] Transit Time Spread Typ.	1.1 ns	[Time Response] Transit Time Spread Typ.	0.37 ns

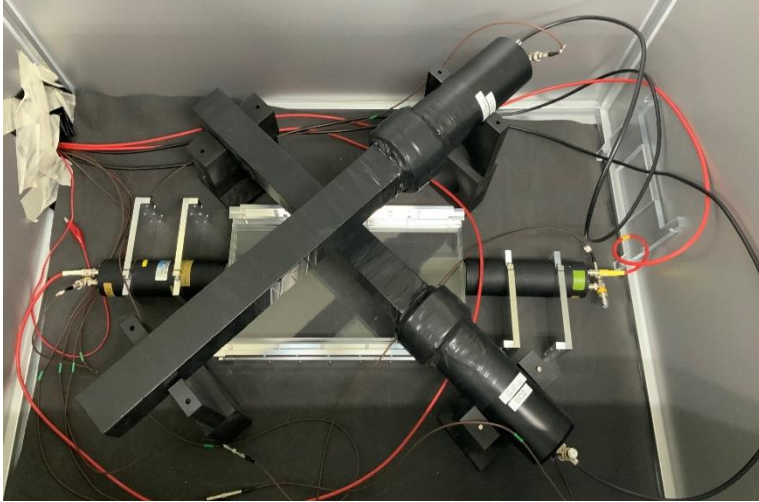
Raw signal



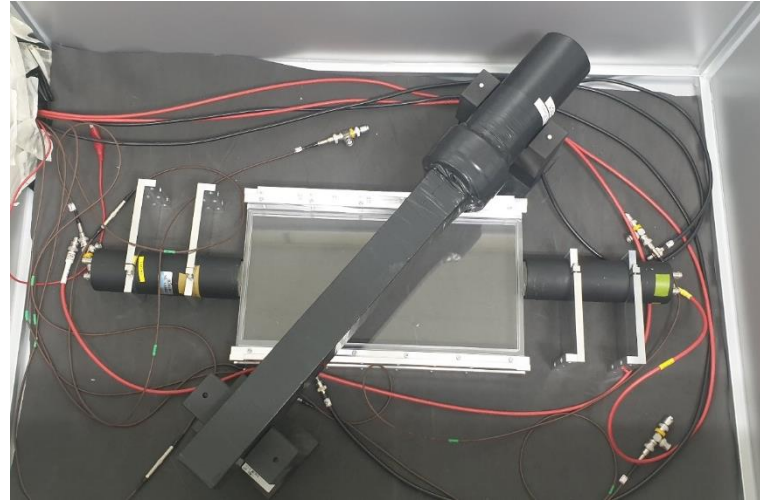
After fan module



Setup 1



Setup 2

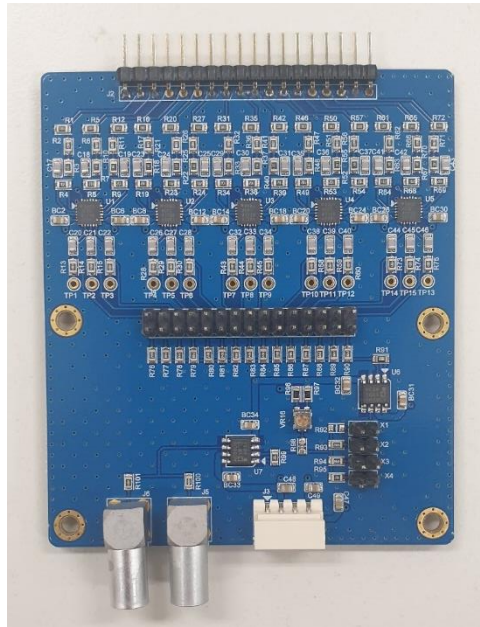


	Signal / 10s
Starting counter 1	148.5
Starting counter 2	128
Trigger 1	42.5
Trigger 2	51.3
Logic Ch.1 (All coin.)	0.3
Logic Ch.2 (Starting coin.)	12.7
Logic Ch.3 (Trigger coin.)	3.4

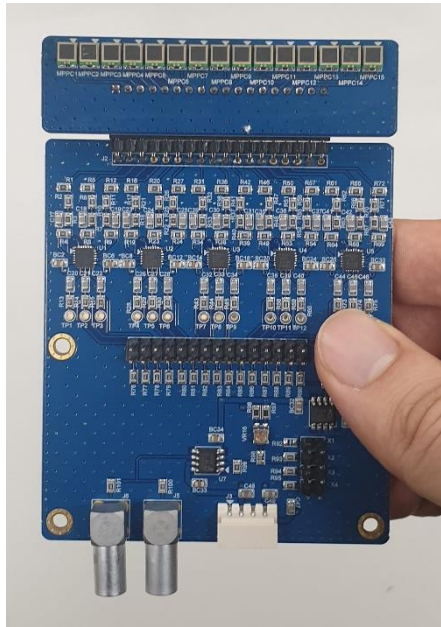
	Signal / 10s
Starting counter 1	125.1
Starting counter 2	95.2
Trigger 1	43.31
Logic Ch.1 (All coin.)	1.315
Logic Ch.2 (Starting coin.)	11.85

	Gain
Starting counter 1	2400V
Starting counter 2	2400V
Trigger 1	1350V
Trigger 2	1300V

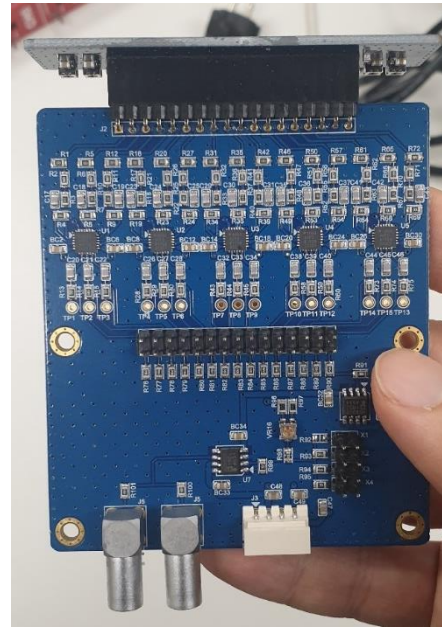
Threshold	-100mV
Signal size	~50ns



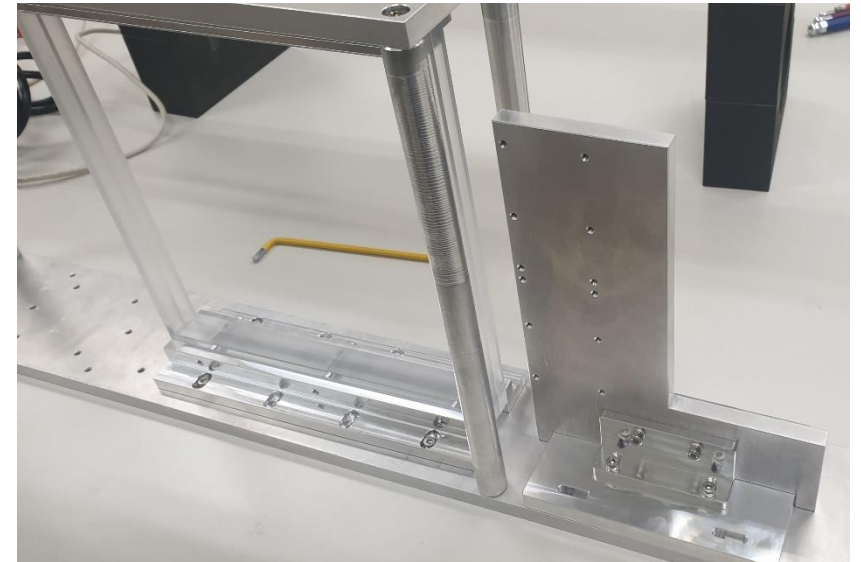
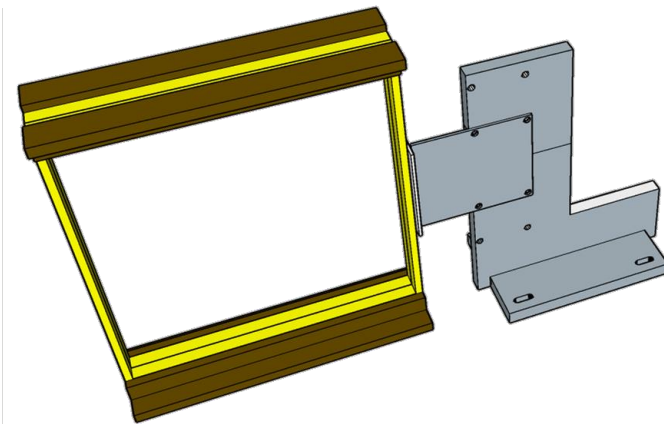
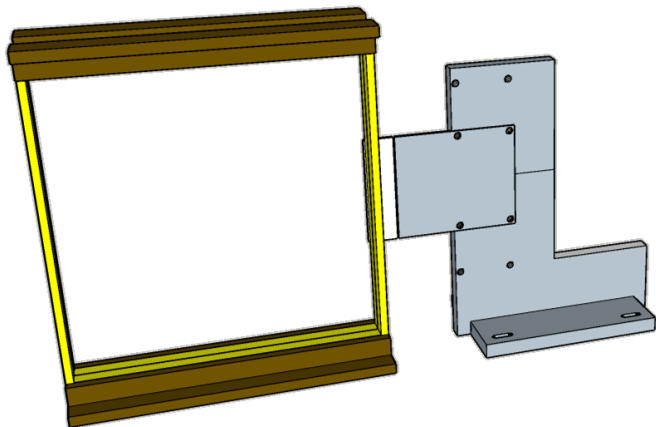
Main board



Flat ver.



Bending ver.



- MPPC Test : 3월 중순부터 진행 가능
- Am-241를 통한 signal Test : 3월 내 진행 가능, electric noise와 signal 구분
- DAQ : 1. FADC signal analysis : 적절한 PMT gain 과 Threshold 정량적인 분석 가능
2. TDC : timing resolution 분석 가능.

	3월 2 nd week	3 rd week	4 th week	5 th week	4월 1 st week	2 nd week	
Starting counter with PMT	→						
MPPC Test		→					
Am-241 source Test			→				
DAQ analysis	FADC →				TDC →		



Thank you for attention

The average muon energy on surface $\sim 4\text{GeV} = 4000\text{MeV}$

The mass of muon $\sim 105.3\text{MeV}/c^2 \sim 100\text{MeV}/c^2$

$$E^2 = p^2c^2 + m_0^2c^4 \quad \therefore p = \sqrt{\left(\frac{E^2}{c^2} - \frac{m_0^2c^4}{c^2}\right)}$$

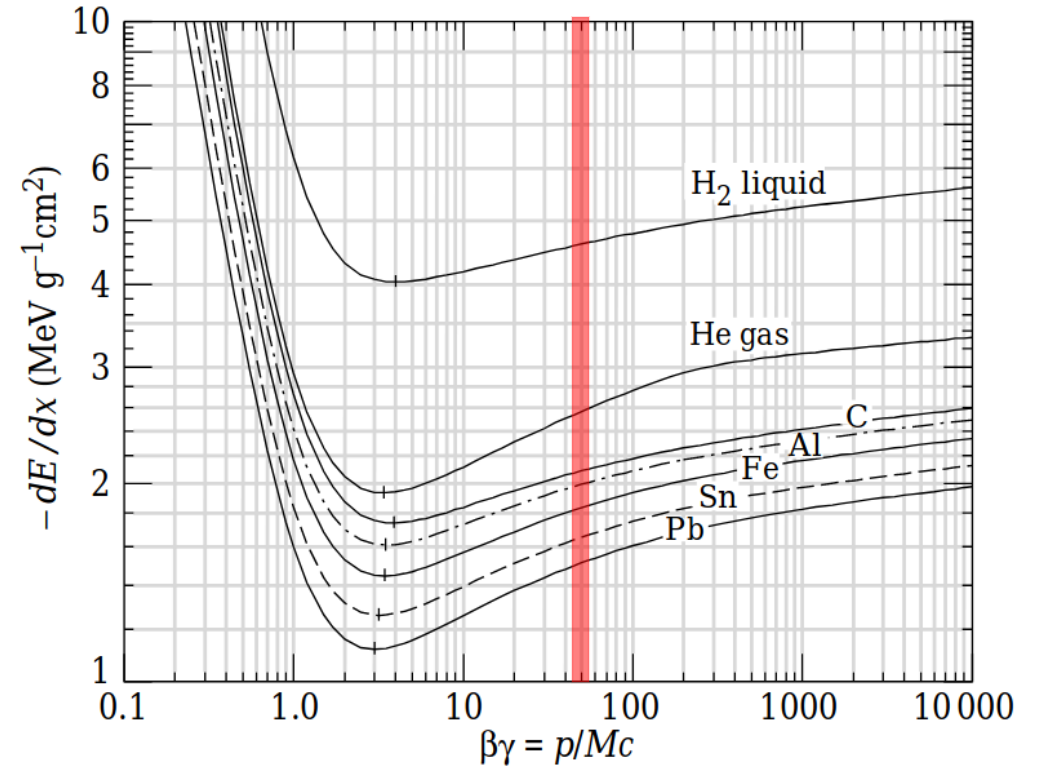
$$\therefore p \sim \sqrt{\frac{4000^2}{c^2} - \frac{100^2}{c^2}} \sim 3998\text{MeV}/c$$

$$\beta\gamma \sim \frac{p}{Mc} \sim \frac{3998}{100} \sim 40$$

$$\left\langle -\frac{dE}{dx} \right\rangle (40) \sim 2.5\text{MeV} \cdot \text{cm}^2/\text{g} \text{ (average value)}$$

$$\therefore \frac{\Delta E}{\Delta x} = \left\langle -\frac{dE}{dx} \right\rangle \cdot 1.023\text{g}/\text{cm}^3 \sim 2.5\text{MeV}/\text{cm}$$

$$\therefore \Delta E = 2.5\text{MeV}/\text{cm} \cdot 0.02\text{cm} = 0.05\text{MeV}$$

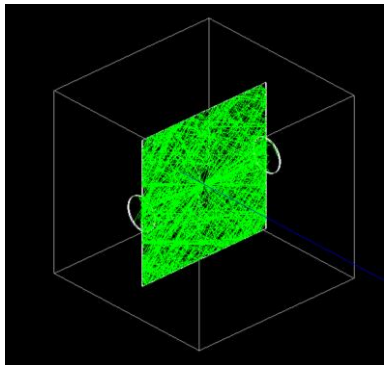


▶ Consider the scintillation efficiency :

PROPERTIES	EJ-228	EJ-230
Light Output (% Anthracene)	67	64
Scintillation Efficiency (photons/1 MeV e ⁻)	10,200	9,700
Wavelength of Maximum Emission (nm)	391	391
Light Attenuation Length (cm)	-	120

▶ The Number of created photon is :
 $9,700 \text{ photons/MeV} \cdot 0.05 \text{ MeV} \sim 500 \text{ photons}$

▶ at Geant4 simulation :

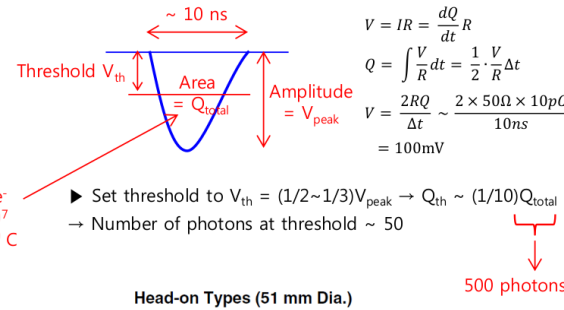
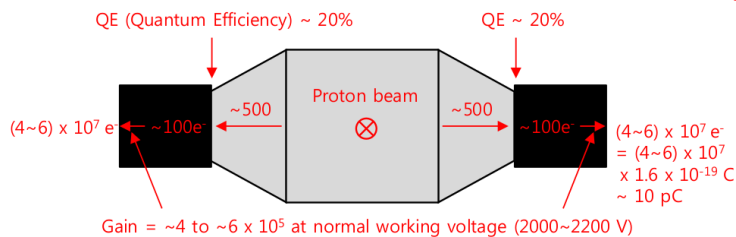


```

hj0521@hj0521: ~/Geant4Example/examples/extended/optical/LXe
File Edit View Search Terminal Help
G4WT0 > ==> Primary particle / energy = mu- / 4000 MeV
G4WT1 > Thread-local run terminated.
G4WT1 > Run Summary
G4WT1 > Number of events processed : 0
G4WT1 > User=0s Real=0s Sys=0s
G4WT0 > ---> Efficiency = 149/409 = 0.364303
G4WT0 > PMT 0 hit count = 70 at 0
G4WT0 > PMT 1 hit count = 79 at 0
G4WT0 > Thread-local run terminated.
G4WT0 > Run Summary
G4WT0 > Number of events processed : 1
G4WT0 > User=1.64s Real=1.52s Sys=0.04s
    
```

▶ The Number of created photon is :
 $\sim 409 \text{ photons}$

- Time resolution obtained from the simulation results
 - Proton beam @ 20 MeV / 12C beam @ 30 MeV/u (event number = 500)
 - Average number of photons detected at each PMT after production at the scintillator $\sim 500 / 1500$



$$V = IR = \frac{dQ}{dt} R$$

$$Q = \int \frac{V}{R} dt = \frac{1}{2} \cdot \frac{V}{R} \Delta t$$

$$V = \frac{2RQ}{\Delta t} \sim \frac{2 \times 50 \Omega \times 10 \text{ pC}}{10 \text{ ns}} = 100 \text{ mV}$$

▶ the Average number of photons detected at each PMT : ~ 75

▶ signal height : 20mV \rightarrow 4mV ..(?)

- ▶ A definition of rise time / fall time / transit time :

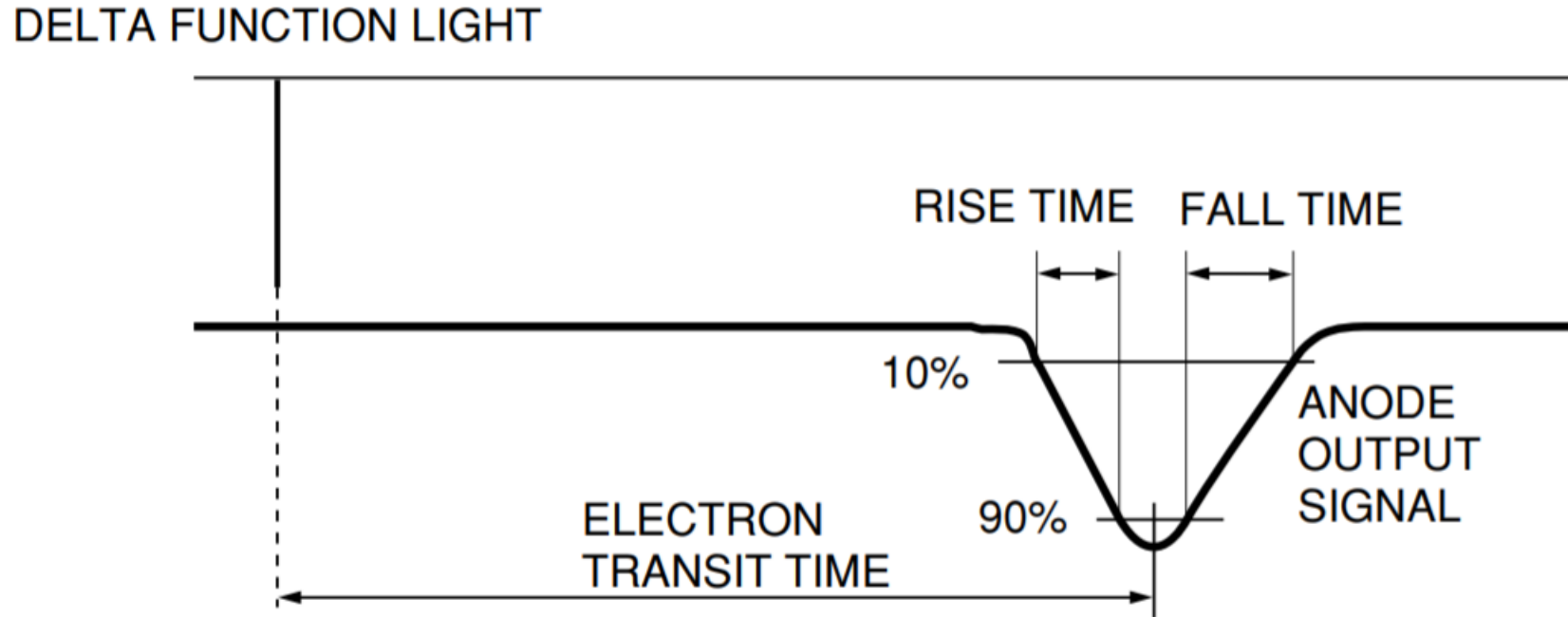


Figure 4-16: Definitions of rise/fall times and electron transit time