# NaI(Tl) crystal characteristics with temperature dependence

CHOI JaeJin* [1], YU Gyunho [2], HA Chang Hyon [3], ADHIKARI Govinda [4]

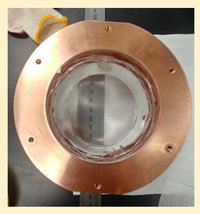
[1]Department of Physics and Astronomy, Seoul National University,
[2]Department of Physics, Sungkyunkwan University ,
[3]Center for Underground Physics, Institute for Basic Science(IBS),
[4]Department of Physics, Sejong University
**On behalf of the COSINE-100 collaboration**

## 1. Introduction

- For a direct dark matter detection experiment with NaI(Tl) crystals, two major characteristics of the crystals are a high light output and a good pulse shape discrimination(PSD) power among different particles. We installed a 1.2kg test NaI(Tl) crystal in a freezer whose temperature can go down to −35 degree Celsius. Energy resolution of the crystal is measured to be 16% at 59.54keV gamma emission from Am-241 with light yield of 10.04±0.24 photoelectron/keV. PSD-separator alpha activity is 0.73±0.16 mBq/kg. Measurements of light yields and PSD powers of the NaI(Tl) crystal in different temperatures will be presented.

- SETUP


Refrigerator(−33℃)



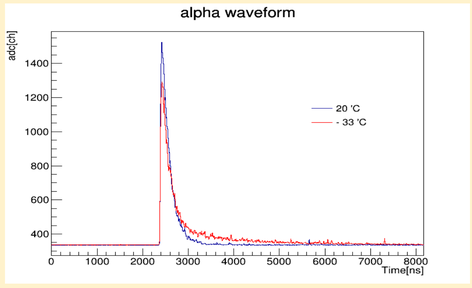
NaI crystal

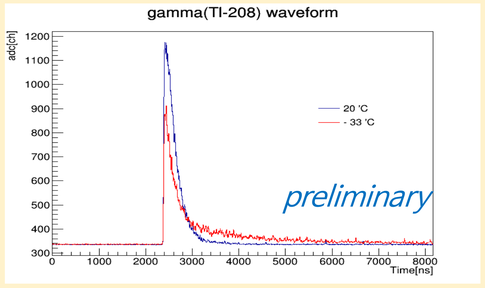
- Diameter: 75mm
- Height: 75mm
- Weight: 1.2 ±0.12 kg
- Alpha Activity : 0.73 ± 0.16 mBq/kg

- We took data at 20℃ and −33℃

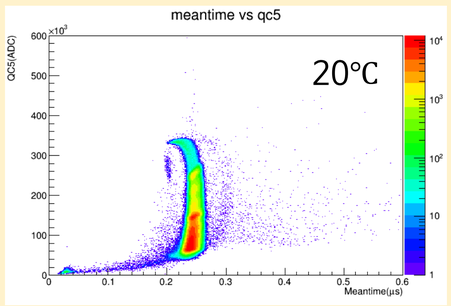
## 2. PSD(Pulse Shape Discrimination) Analysis

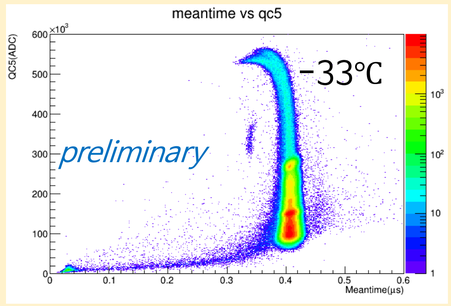
- Alpha Pulse Shape Discrimination Power
  - Raw Waveform



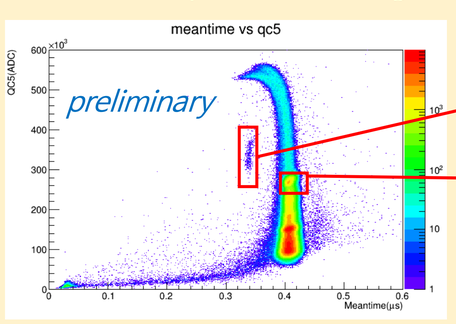



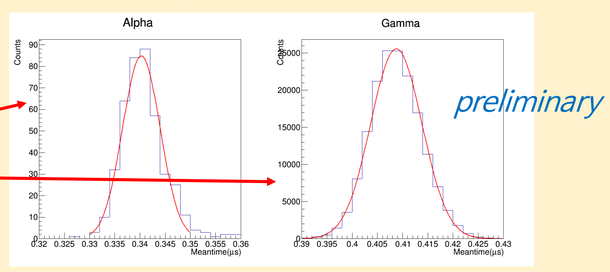

- height at room temperature is higher than height at low temperature
- wave decay time at room temperature is faster than wave decay time at low temperature




- integration[start to 1.5us] meantime vs adc sum[start to 5us]
  - PSD from alpha events and gamma events using meantime variable




- FoM formula : $\frac{Mean_{gamma} - Mean_{alpha}}{\sqrt{{\sigma_{alpha}}^2 + {\sigma_{gamma}}^2}}$
  - Alpha events from Po-210
  - Gamma peak from Tl-208 gamma decay(2614 KeV)

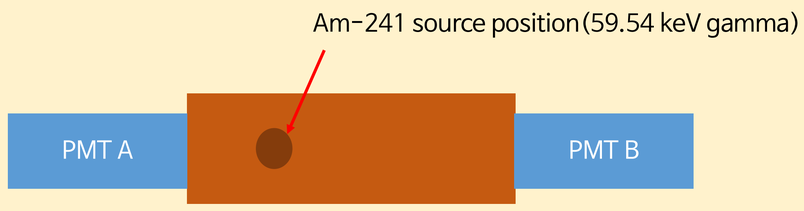
- Result

| temp | FoM of PSD(alpha, gamma) | | |
|---|---|---|---|
| | Integration meantime [start to 1us] | Integration meantime [start to 1.5us] | Integration meantime [start to 2us] |
| 20℃ | 5.82±0.26 | 6.06±0.27 | 5.53±0.32 |
| −33℃ | 6.03±0.25 | 7.76±0.36 | 6.92±0.34 |

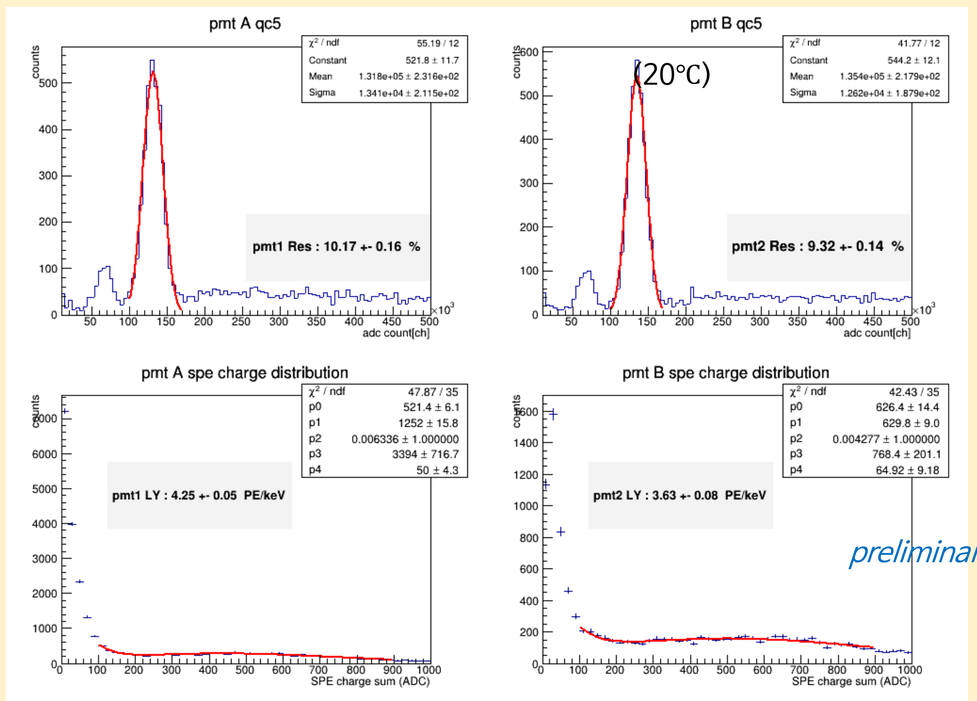
- PSD power at low temperature is better than PSD power at room temperature
- **28±0.01 % increased**

## 3. Light Yield Analysis

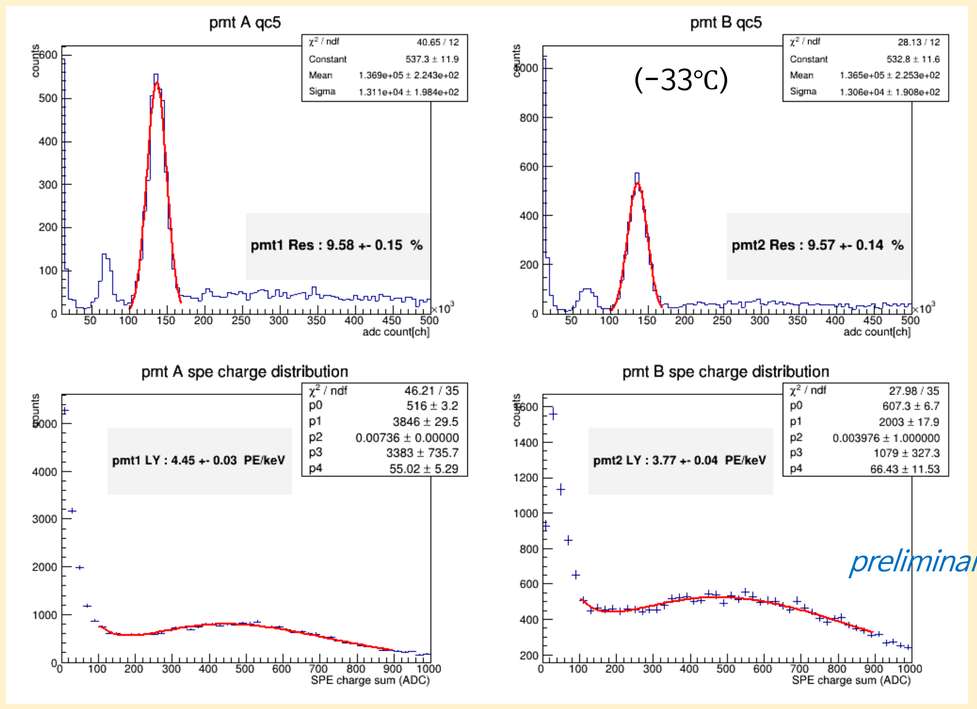
- Using Am-241 source to calculate light yield




- Light Yield[PE/keV] = gamma charge sum / single photoelectron(spe) charge sum/59.54
  - Room temperature energy resolution and light yield




  - Low temperature energy resolution and light yield




- Single photoelectron(SPE) fitting used exponential decay plus poisson distribution

| temp | Light yield using Am-241 [spe/keV] | | |
|---|---|---|---|
| | PMT 1 | PMT 2 | Total |
| 20℃ | 4.25±0.05 | 3.63±0.08 | 7.88±0.09 |
| −33℃ | 4.45±0.03 | 3.77±0.04 | 8.22±0.05 |

- Light yield in low temperature is higher than light yield in room temperature
- Resolution is similar each other

## 4. Summary

- Alpha PSD power at low temperature is better than PSD power at room temperature
- Neutron PSD power would be studied
- Light yield in low temperature is higher than light yield in room temperature