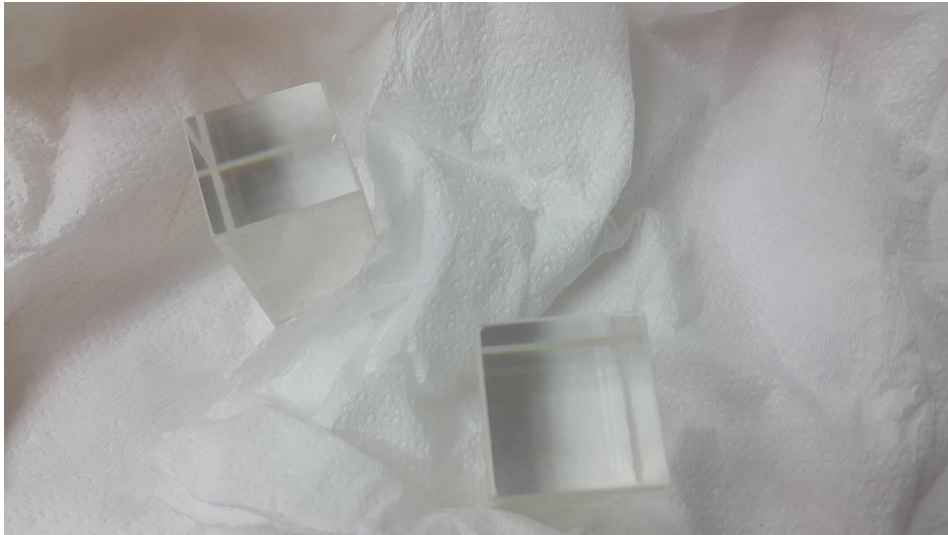


Positronium detector development

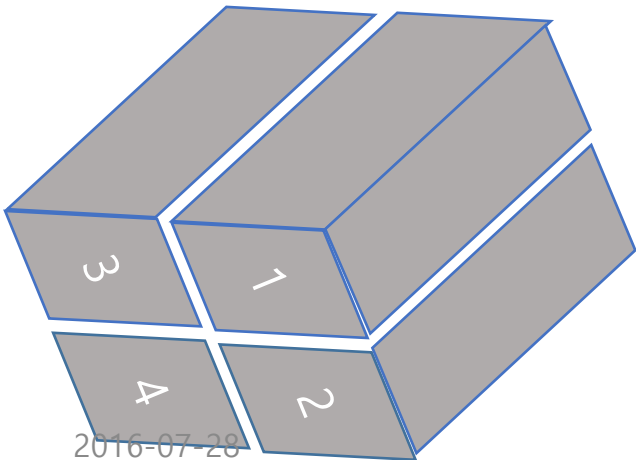
Seoul National Univ.
BongHo Kim

PWO detector preparation

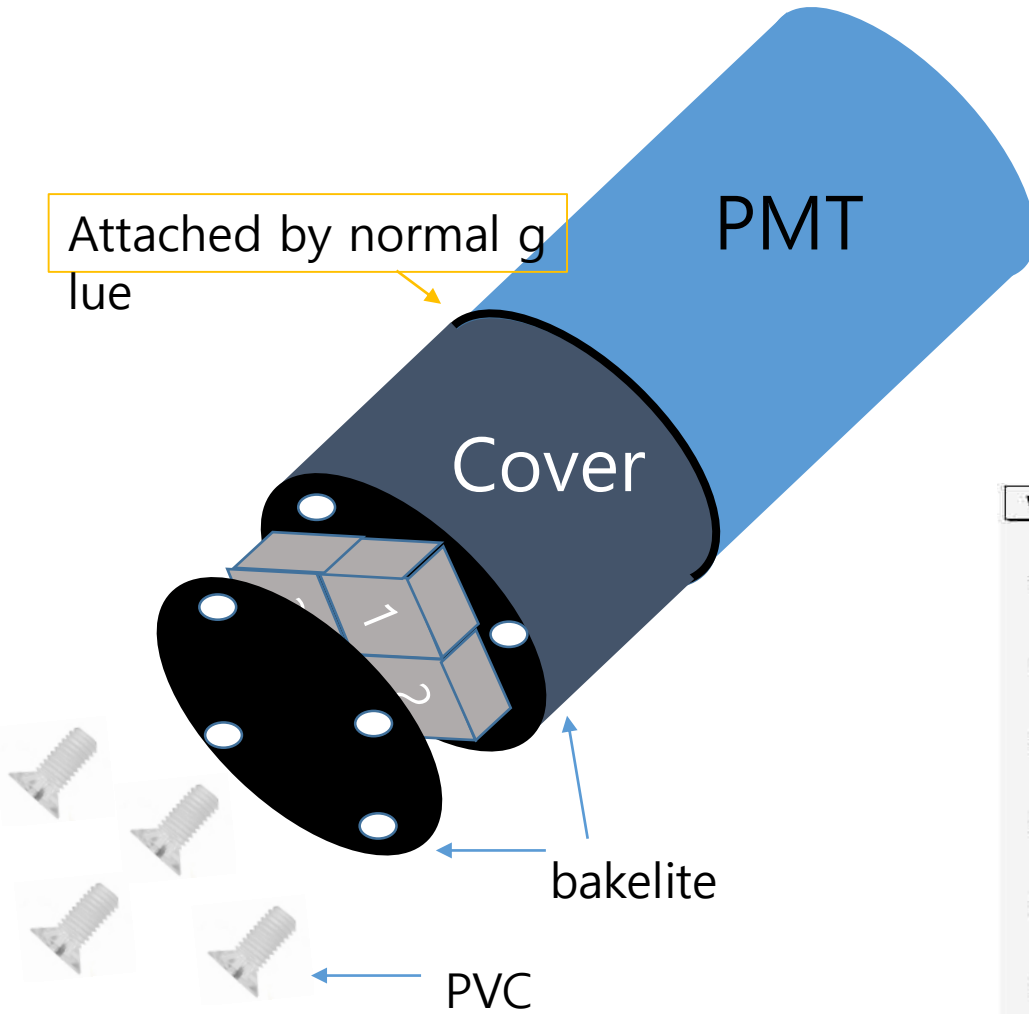
PbWO₄ crystal



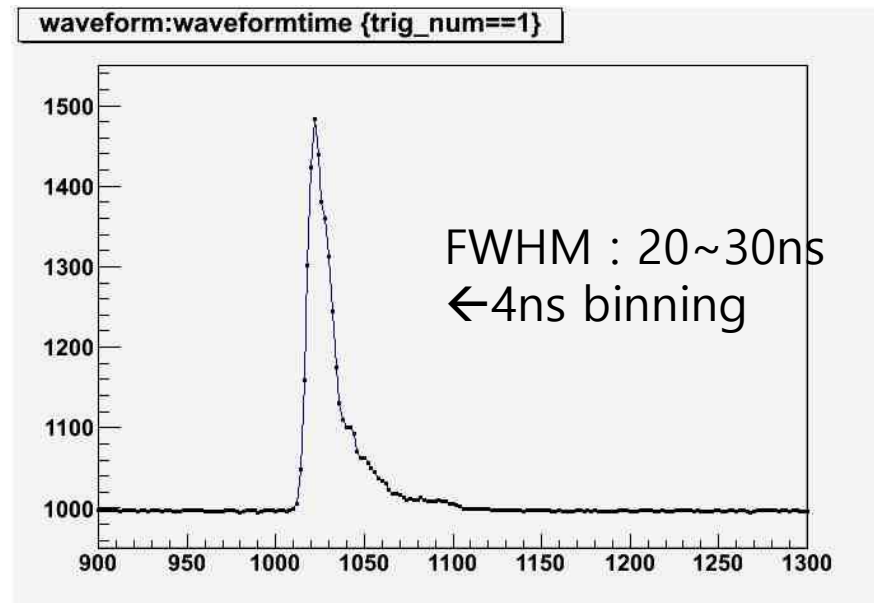
- 1 PMT + 4 PWO Crystal (2x2x3.8cm for each)
 - Yield 0.7~2.6 [p.e./MeV] achieved with ²²Na source before cutting.
 - Density : 8.3g/cm³
 - Radiation length : 0.9cm
 - Decay time : 10~30ns
 - Good for high intensity beam measurement
- Already used many experiments like CMS, Alice, Panda or positronium detections..



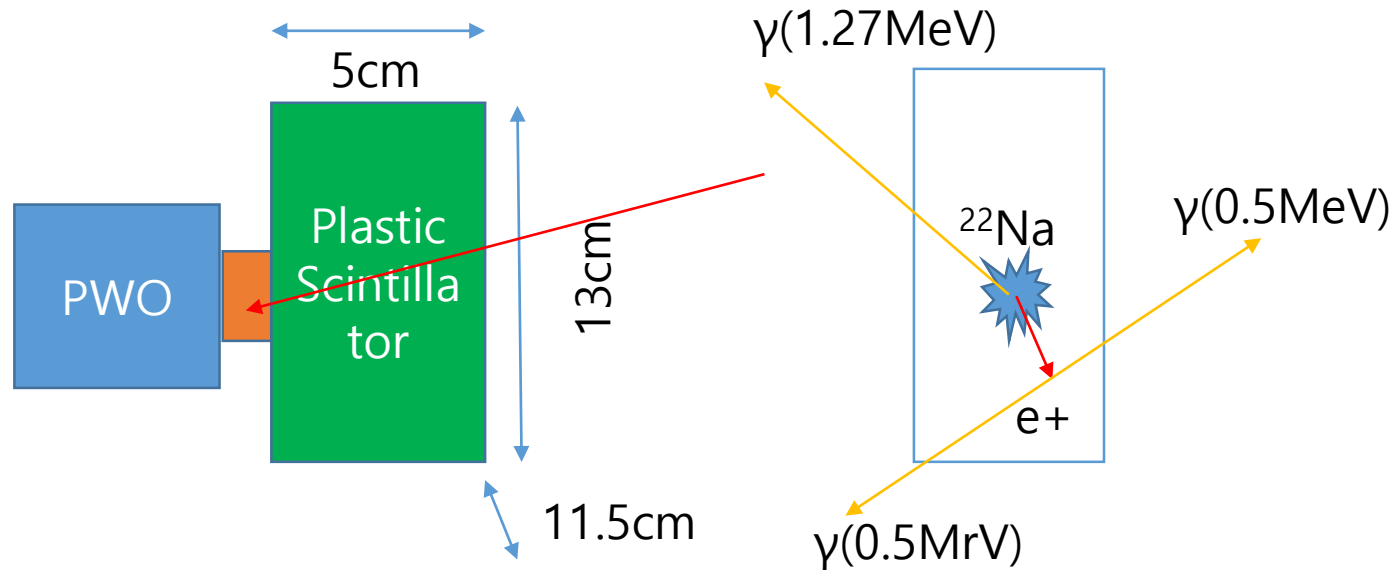
PMT



- H7195 in HAMAMATSU
- Dia : 60mm
- Voltage : $> -2700\text{V}$
- Gain : 3×10^6
- Transit time spread : 1.1ns



Setup for calibration

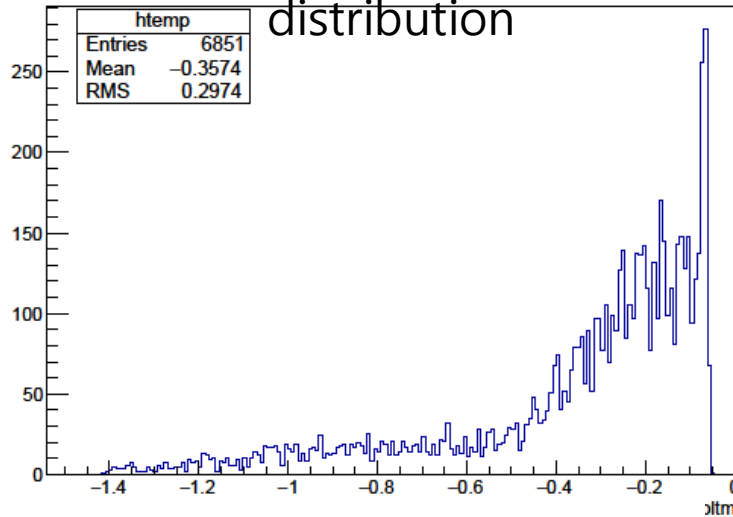


- ^{22}Na source is in center of two scintillation materials
- ^{22}Na decay
 - 1.275MeV gamma(99%),
 - 0.543MeV beta+ (90%) ← will be annihilated inside source or surface of detector

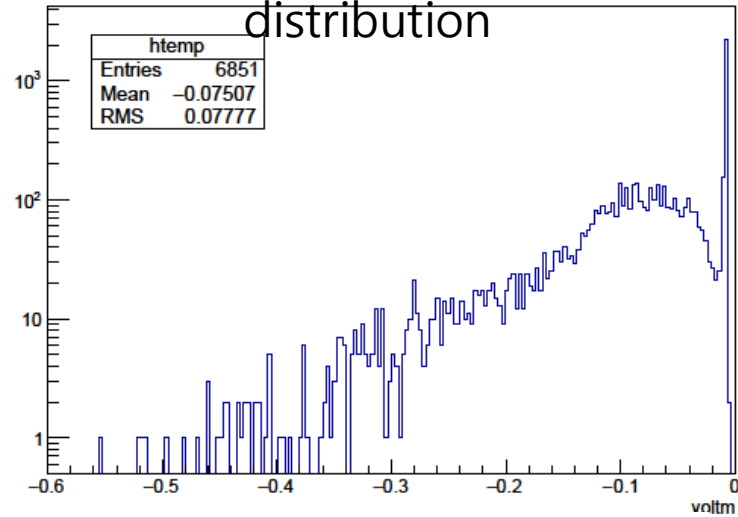


Signal information

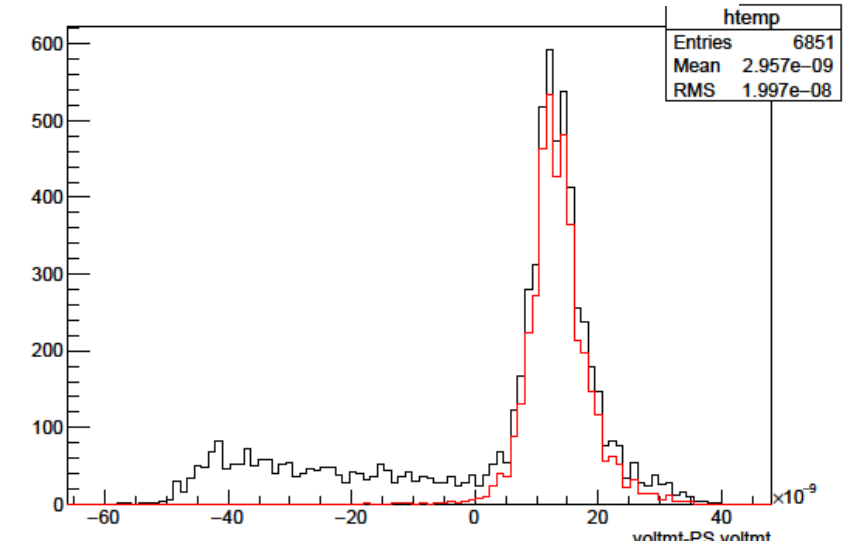
PS peak height
distribution



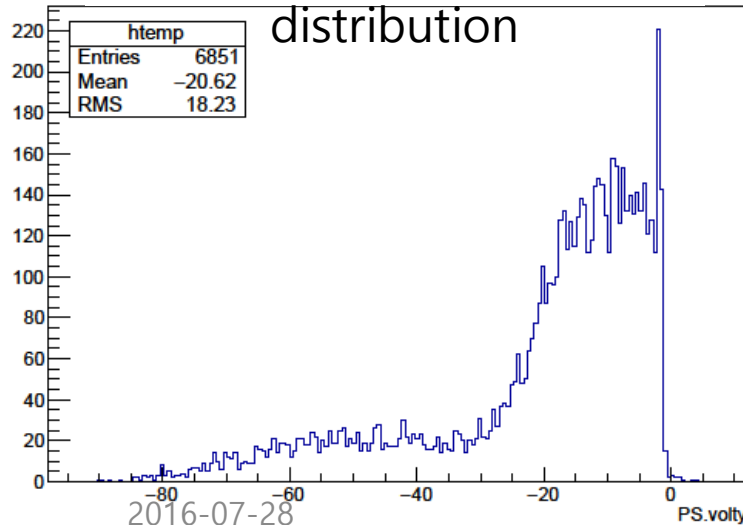
PS charge height
distribution



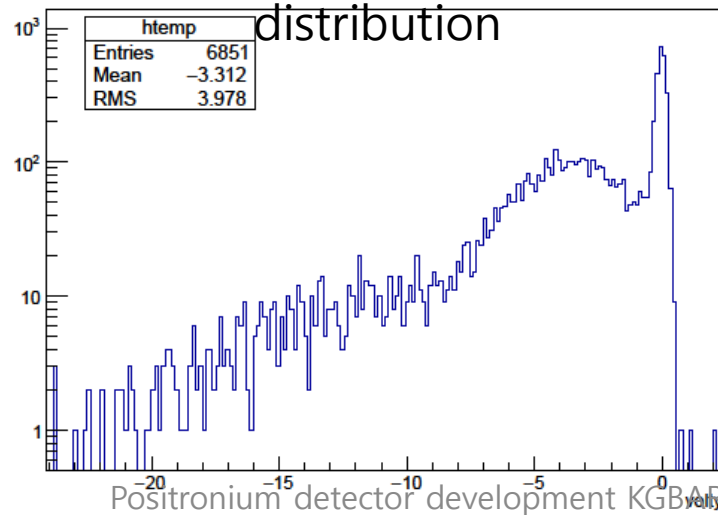
Δt distribution



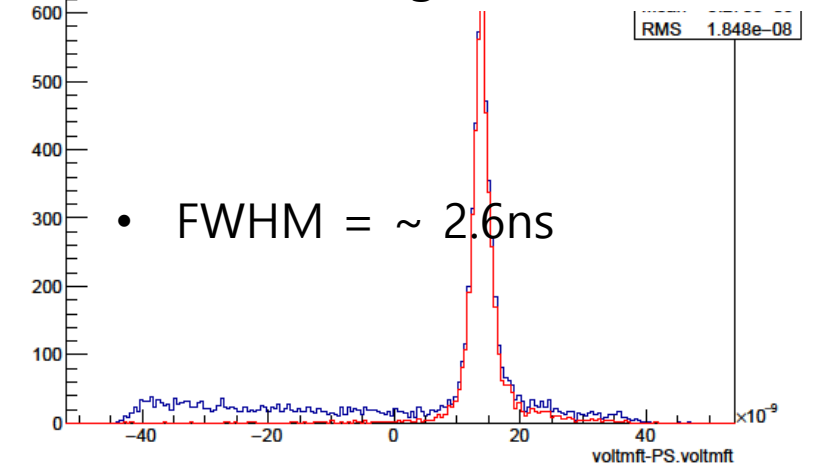
PWO peak height
distribution



PWO charge height
distribution



Select time at 10% height
of raw signal



Efficiency check

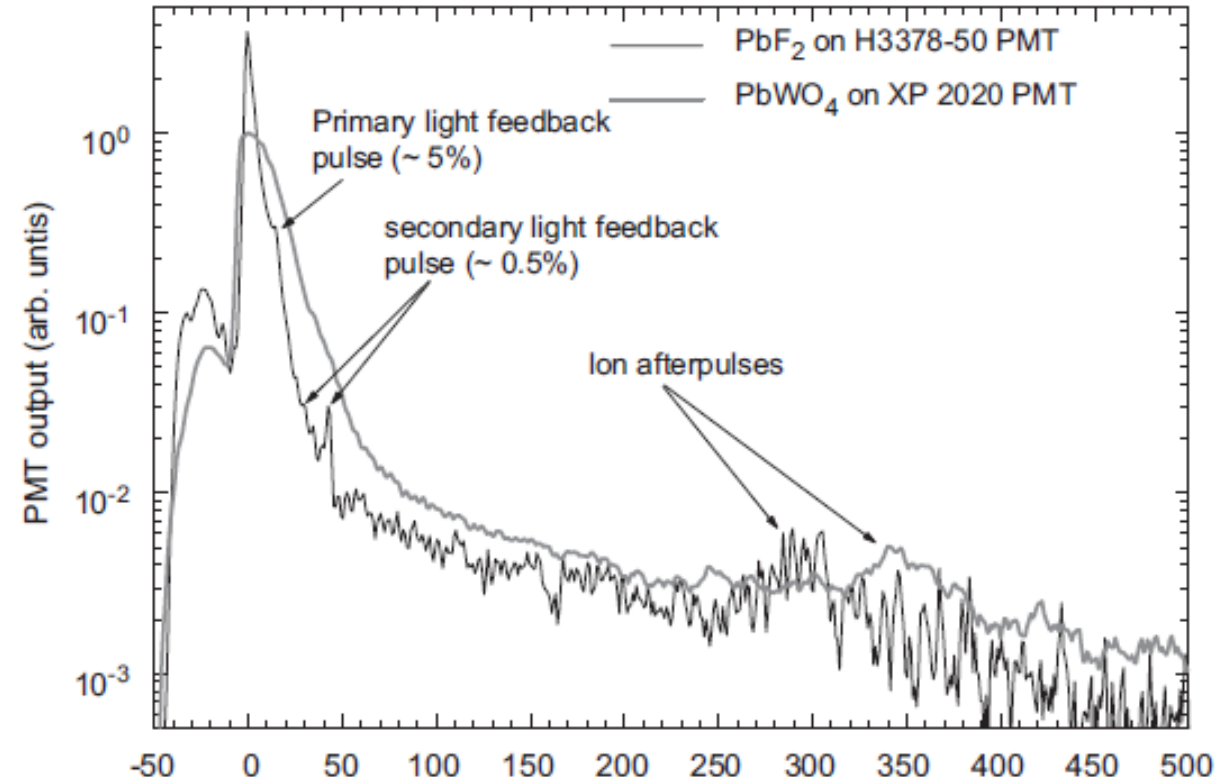
- 2488~2868 gamma(10000 generated) loose their energy at PWO in simulation. ← acceptance check
- Binomial Error

$$\sigma = \text{Sqrt}(N_{\text{det}} * p * q) = \text{Sqrt}(N_{\text{det}}^2 * (N_{\text{gen}} - N_{\text{det}}) / N_{\text{gen}}) = 24.22 \text{ (0.84\%)}$$

$$eff = \frac{\text{det}(PWO\&PS)}{\text{det}(PS) \times accept} = \frac{463. \pm 21.5}{751 \pm 27.4 \times 2 \times (0.2739 \pm 0.002334)} = 1.075 \pm 0.063(stat) \pm 0.009(syst)$$

Positron beam detection

- As a next step, I will measure efficiency with positron beam in CEA Sacaly.
- First, take data with low intensity beam by coincidence with plastic scintillator to measure efficiency and signal signal parameters.
- Next, take data with dense beam to check linearity.



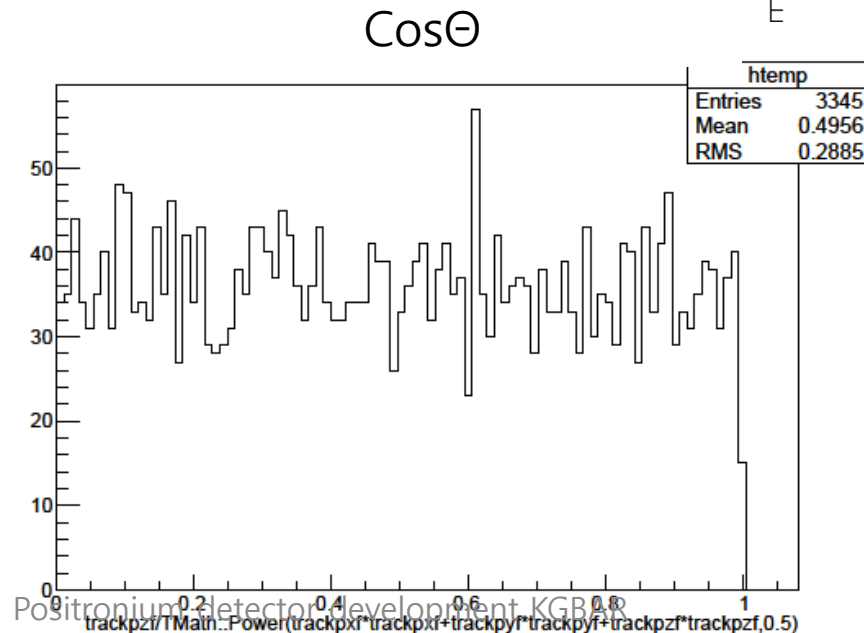
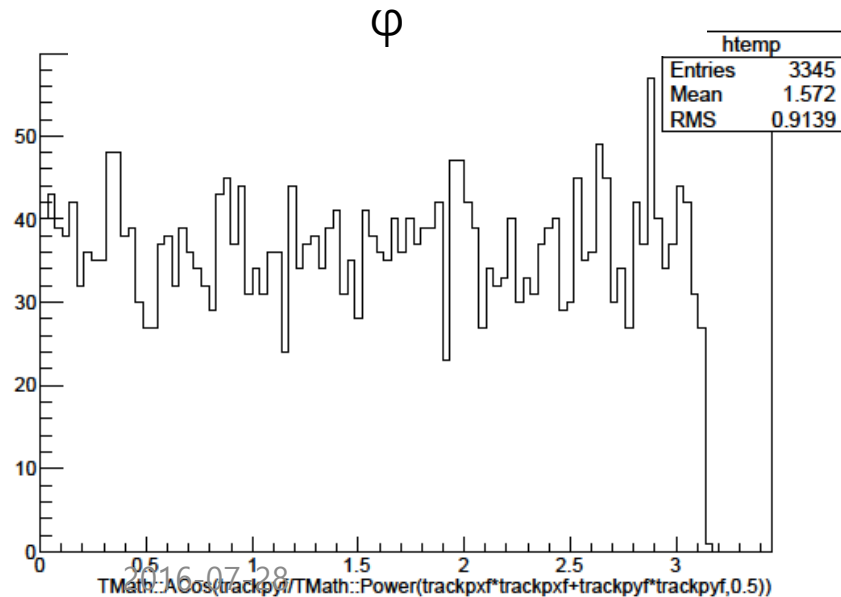
Eventually, we can get like this smooth line
(NIM A 580 (2007) 1338)

Simulation preparation

Check positronium simulation

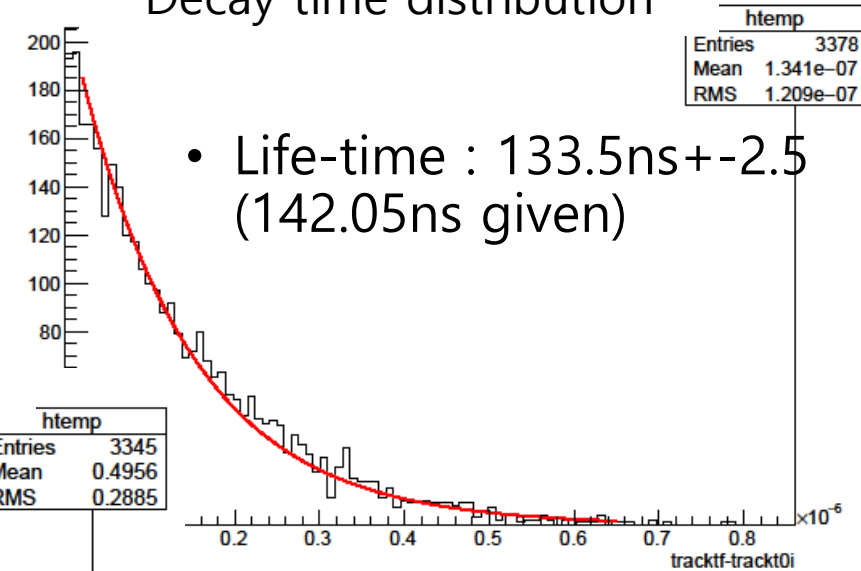
Check list

- Positronium fraction (o)
 - 33.78% (30% given)
- Positronium decay (life time) (o)
- Positronium direction(isotropic) (o)
- Positronium Energy(maxwell-boltzman)(on-going)

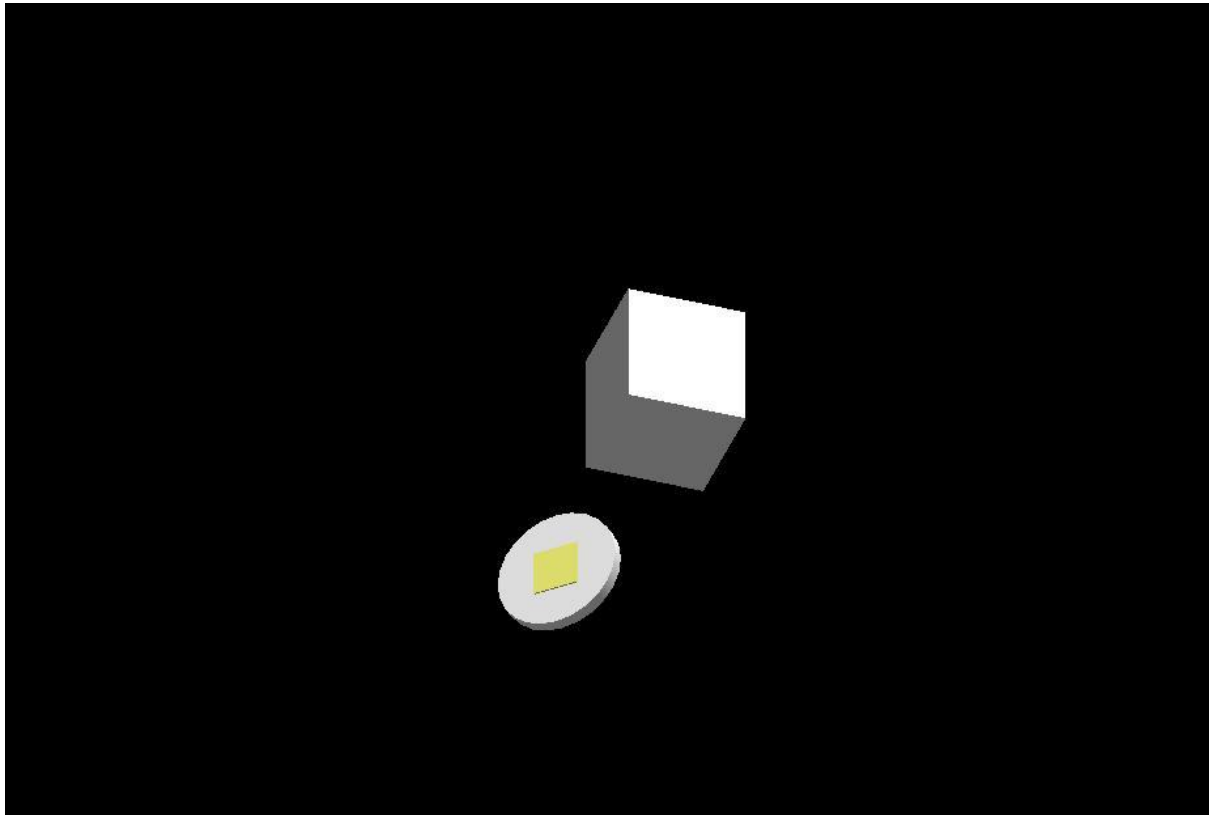


Decay time distribution

- Life-time : $133.5\text{ns} \pm 2.5$ (142.05ns given)



Simulation preparation



- Preparation is ongoing
- Target (yellow) will be changed as rectangular cavity at the end.
- After adding one layer in front of the target, I will check reflection of positronium first.
- Then try to check positron distribution inside of cavity
- Ortho-positronium has 1~2eV reemission energy with 142.05ns lifetime. It means that it will hit cavity wall several times before decay.

To do list

- PWO detector calibration with positron beam
- Positronium simulation development for reflection of positronium.