Positronium intensity measurement preparation (GBAR)

SNU

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Goal of Ortho-Ps measurement

- Measurement of generated total O-Ps amount.
- Measurement of parameters which is required to expect O-Ps amount inside cavity.

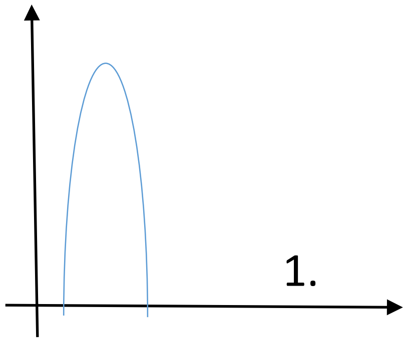
←Still there's no precise measurement for positronium reflection angle.

←No laser now to measure positoronium velocity.

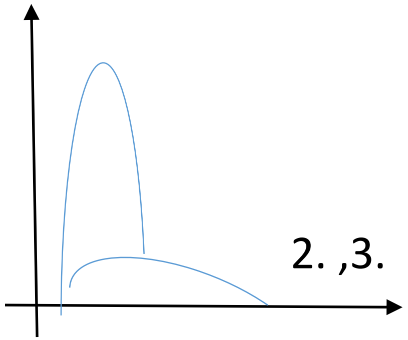
➔ Methodology is almost prepared.

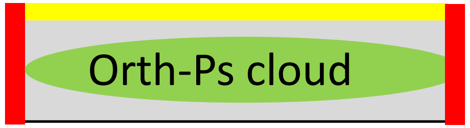
O-Ps measurement plan

- 1. Measure N_{e+} with dummy target



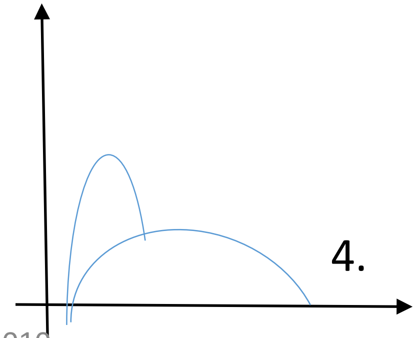
- 2. Measure $N_{O\text{-}Ps}$ with shielded hole cavity target

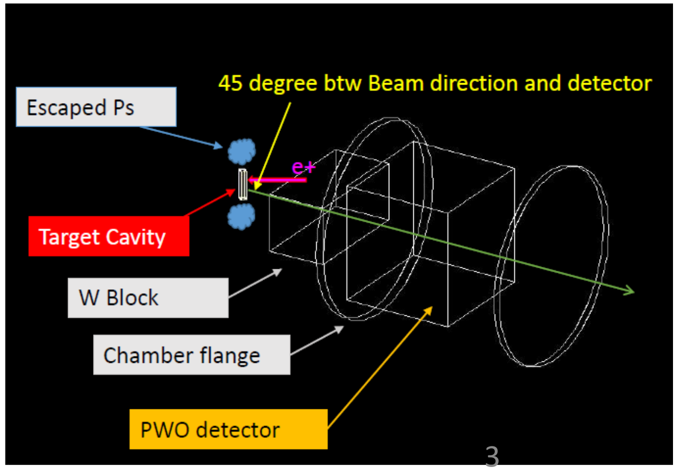




- 3. Measure with cavity target (basically similar with (2). (~5% deiviation?)

- 4. Measure $N_{O\text{-}Ps}$(escaped) with W block in center. (efficiency decrease 30% for escaped Ps (model dependent – Ps KE, reflection angle))



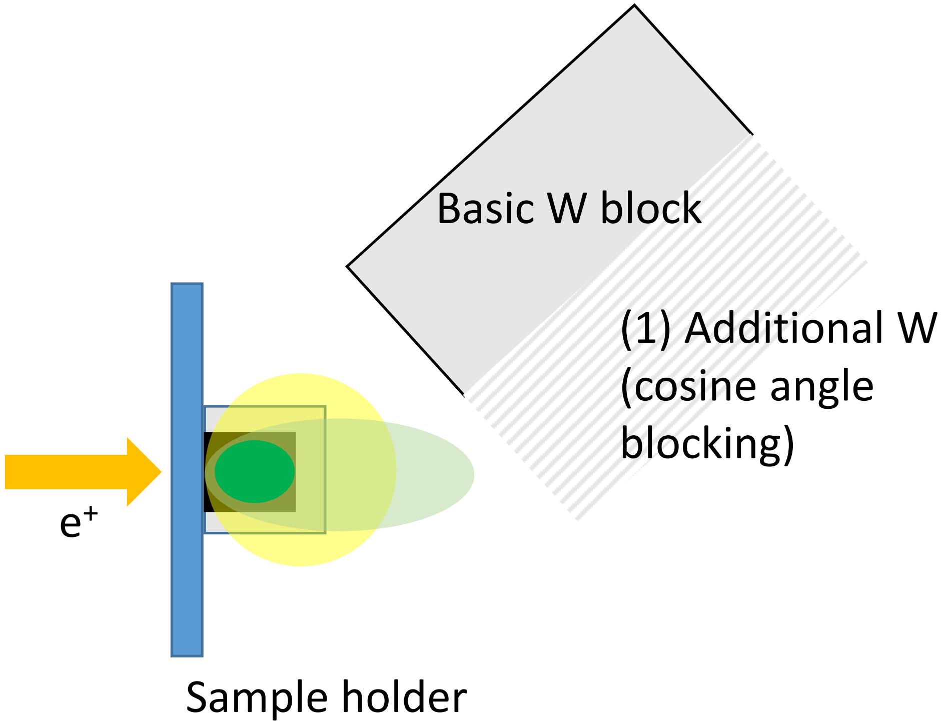


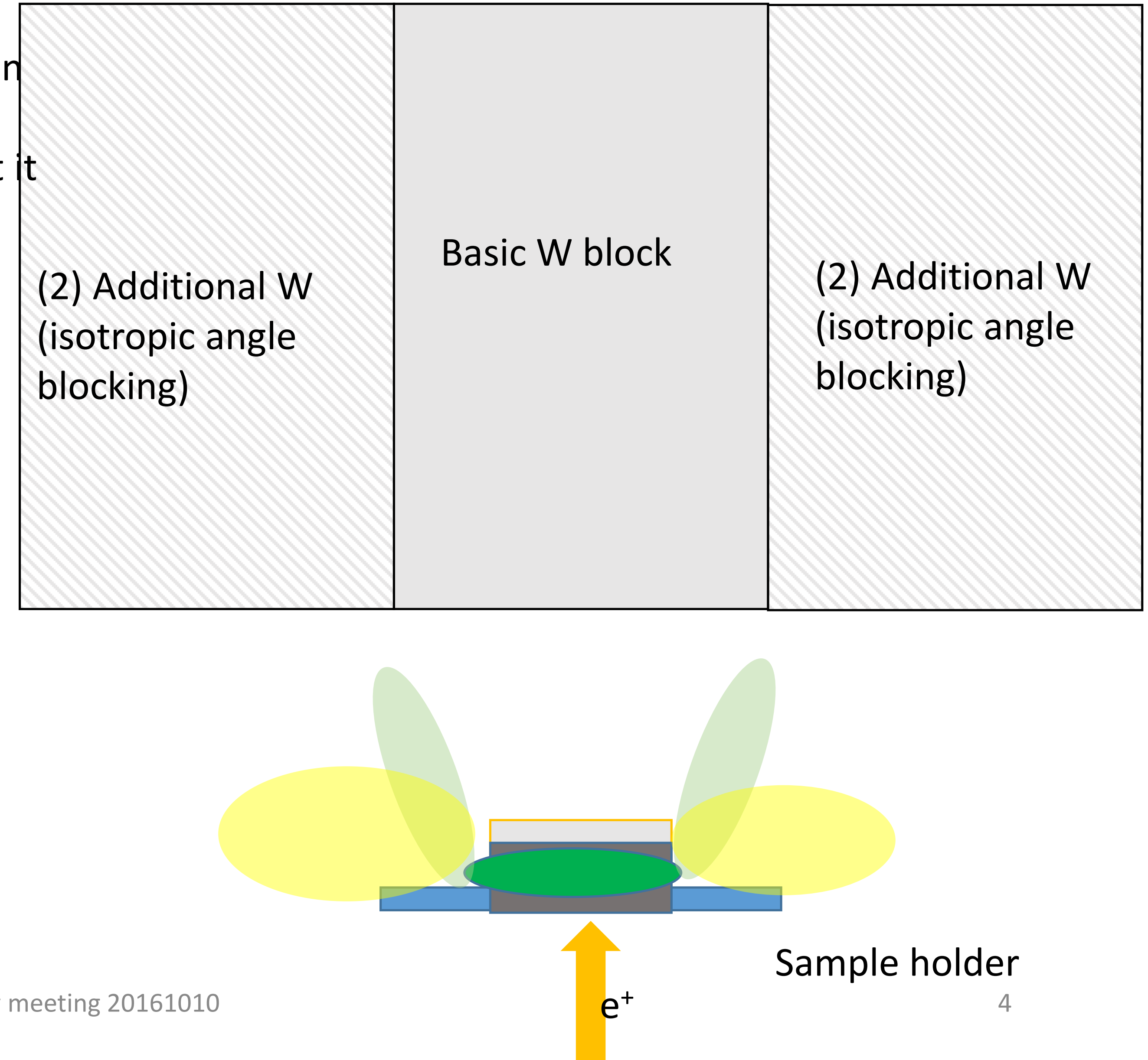
- 5. Measure $N_{O\text{-}Ps}$(escaped) with W blocks (positronium reflection angle measurement by additional W block with basic W block in center)

- Comparision ratio btw (1) and (2)

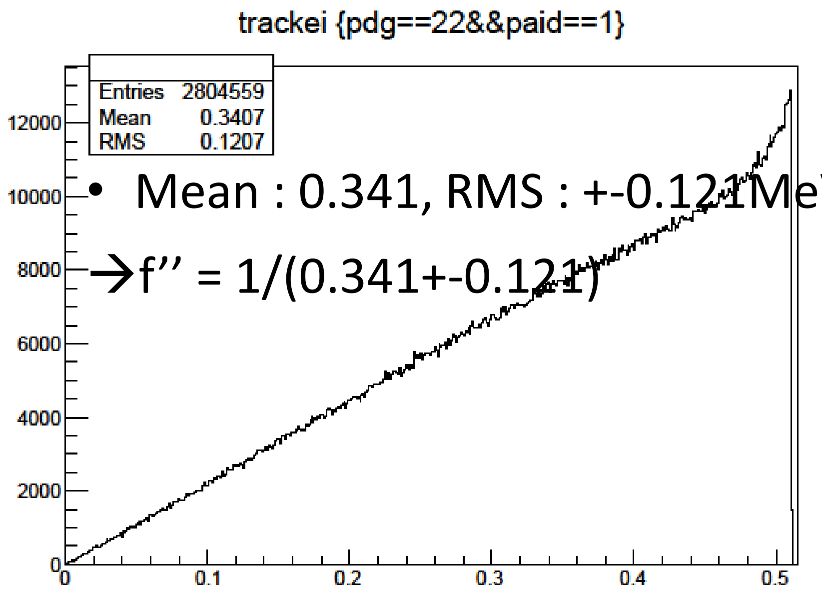
(rough simulation shows about 20% different btw reflection algne model

I need to check momentum dependency by simulation but it would be not to big)



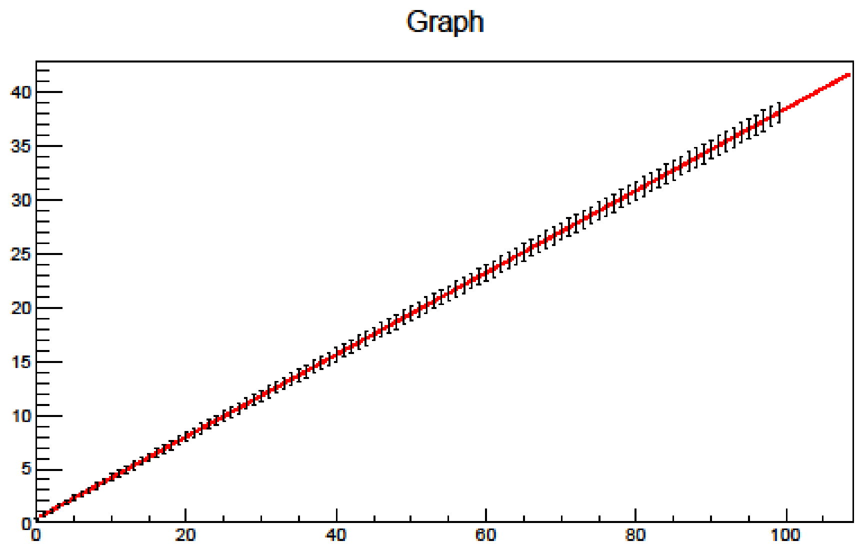


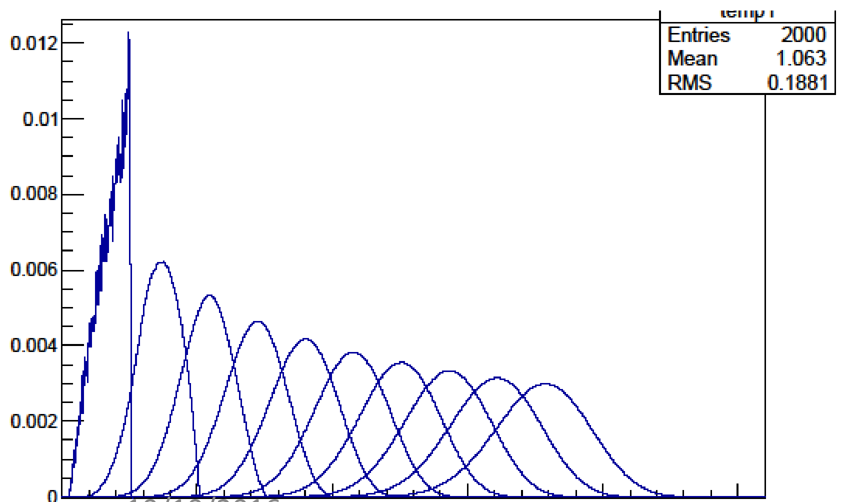
Rough systematic error check (f (MeV/#))



- Mean : 0.341, RMS : +-0.121MeV

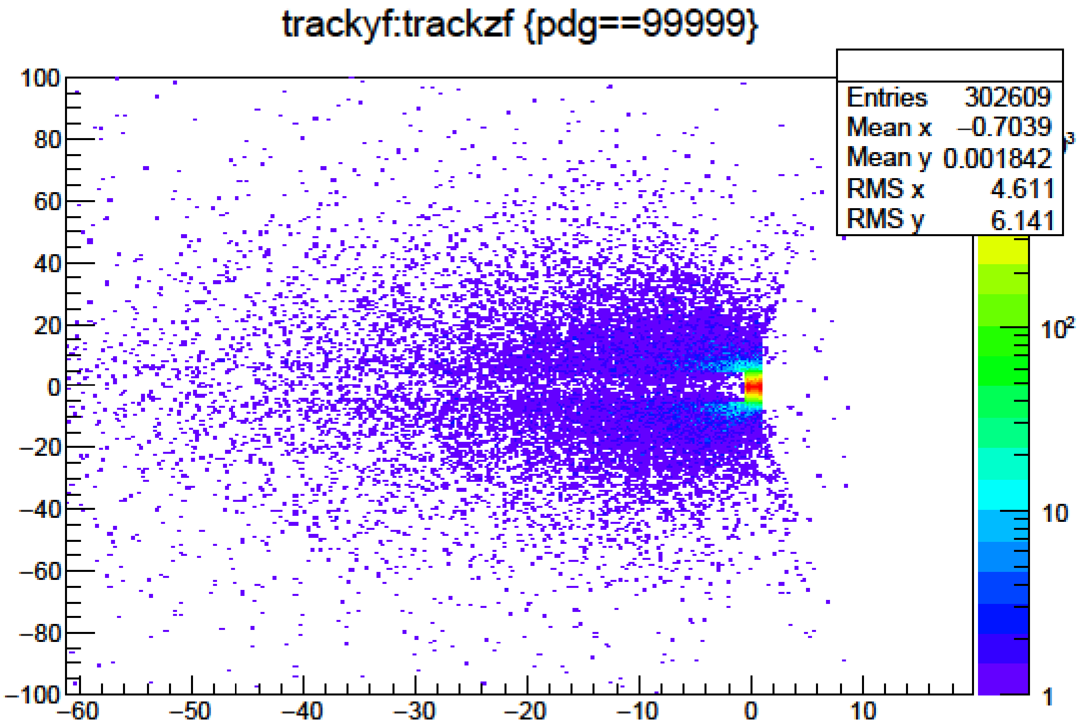
→f'' = 1/(0.341+-0.121)

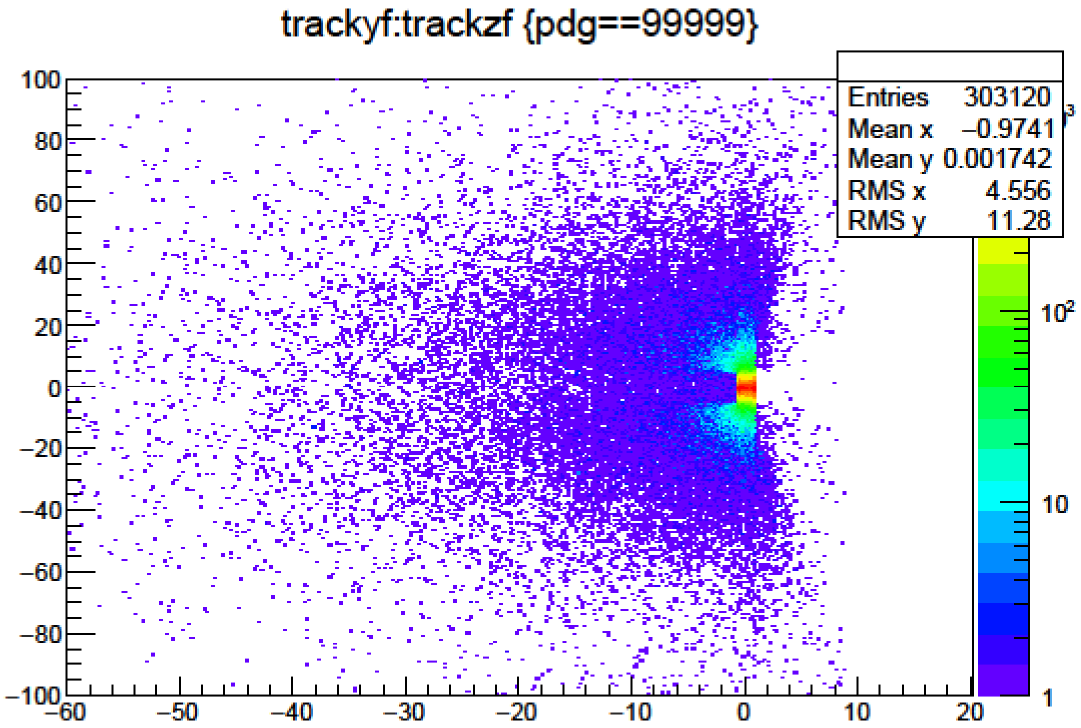




- For one gamma, energy spread is too big.
- In high intensity case, total gamma energy PDF will be convolution of each gamma's energy PDF.
- After 10times convolution, it become like Gaussian, then we can just get as $\sigma_{n\times 100} = \sqrt{n}\sigma_{100}$
- Only few percent from this factor

Positronium decay position (geometry updated)

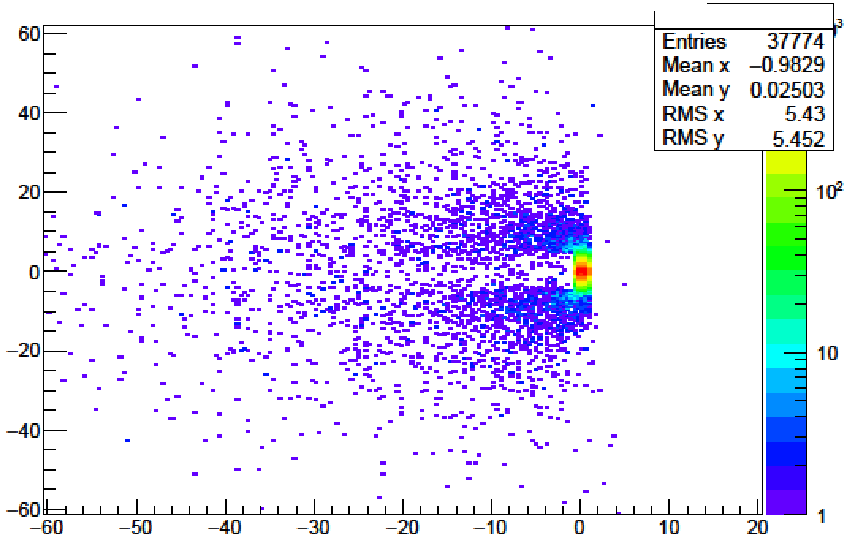




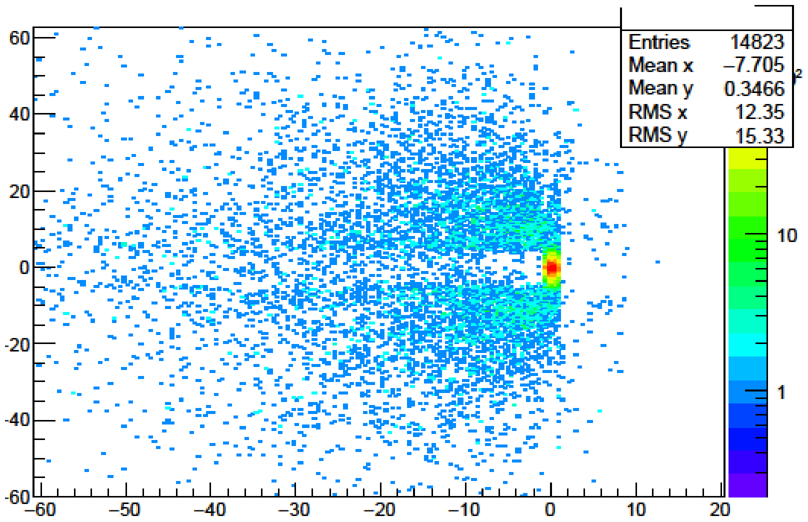
- Lambert(reflection) case : 89.6% of positroniums are remained in cavity before decayed
- Isotropic case(reflection) : 72.7% of positronium remain in cavity before decayed
- Quite big difference

W block effect (Cosine reflection case)

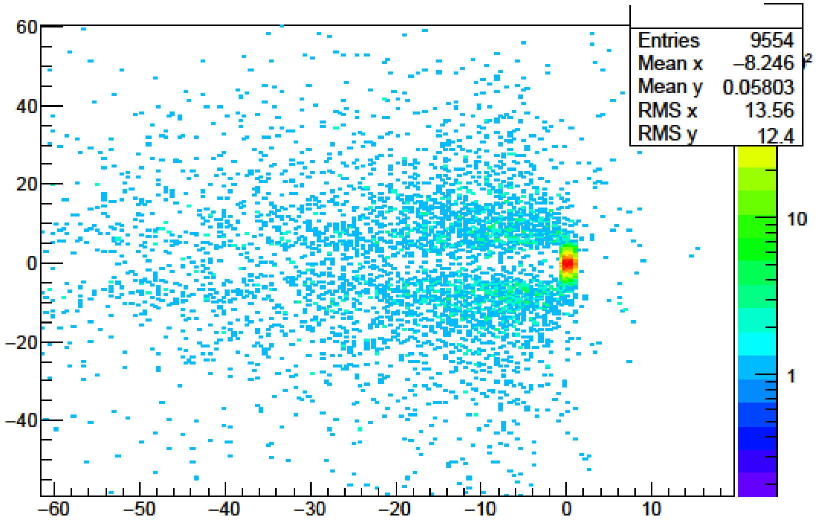
W block in center



W block in center and bottom

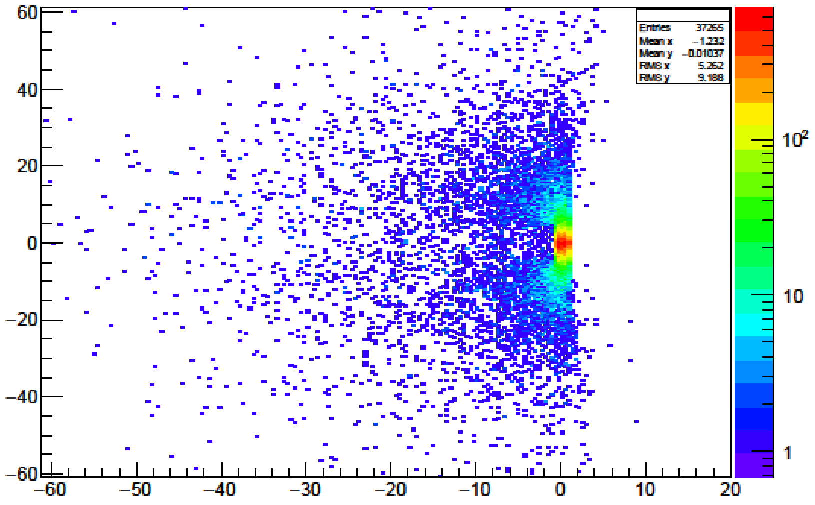


W block in center and side

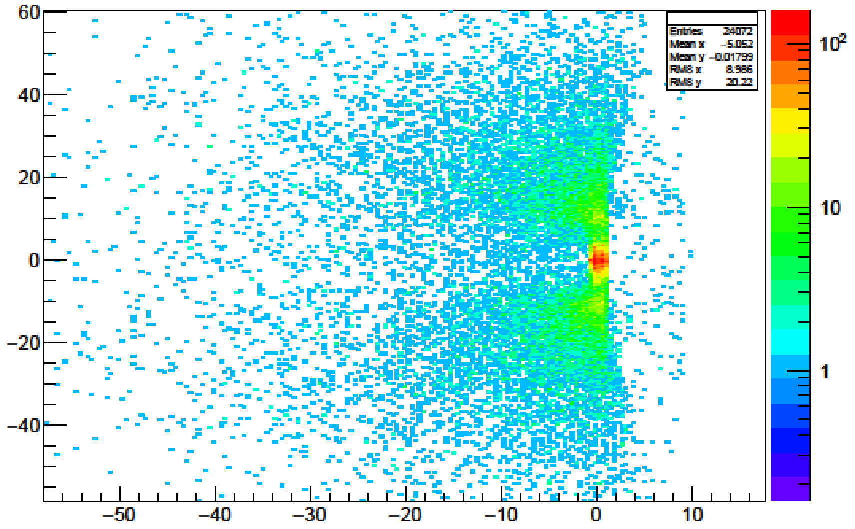


W block effect (isotropic reflection case)

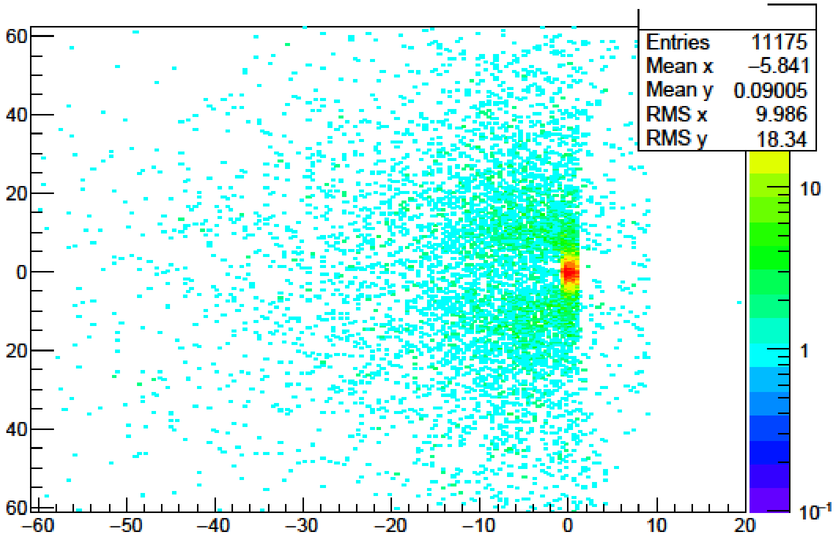
W block in center



W block in center and bottom

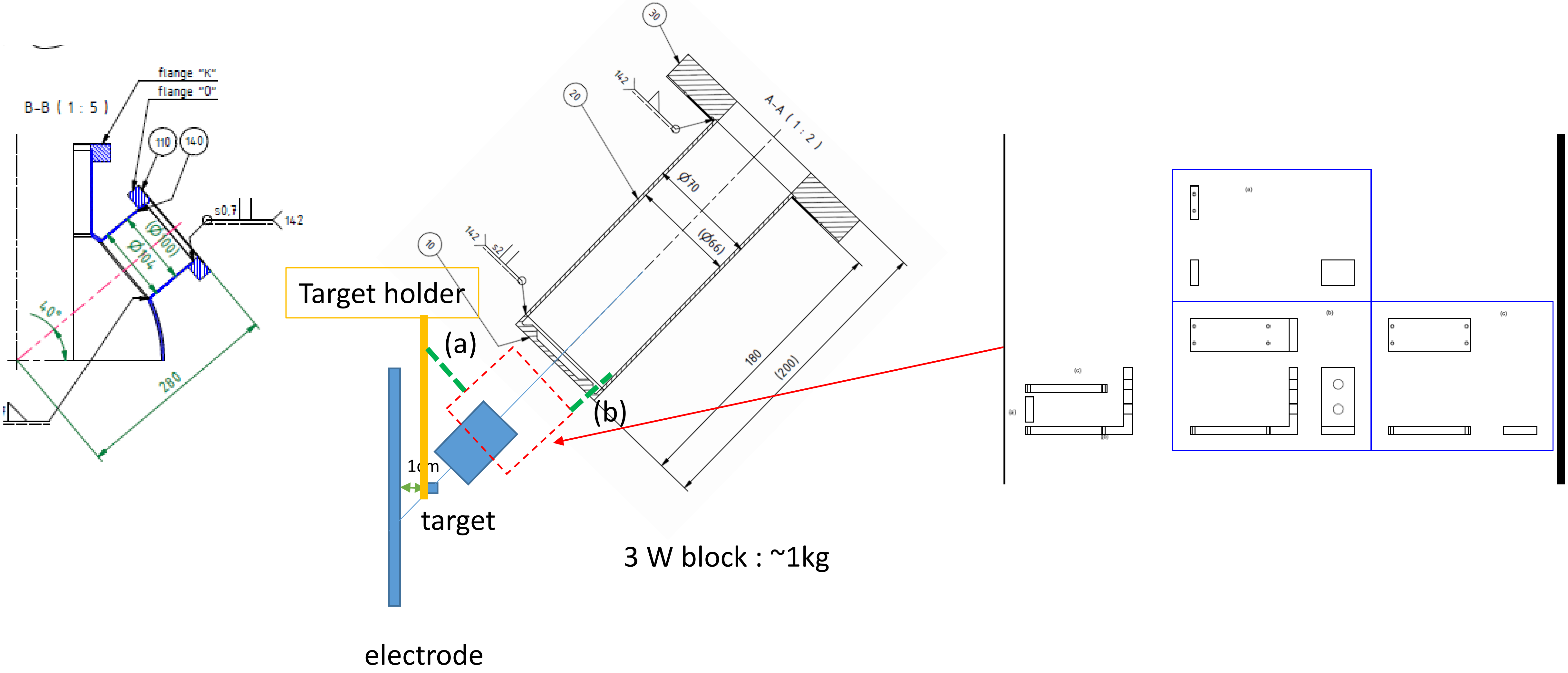


W block in center and side



- Ratio btw second and third panel for cosine reflection and isotropic reflection is different.
- By this fraction, we can prove which reflection model is right in our case.

W holder design



To do list

- I’m trying to help to install electrode for positron beam focusing just before target.
- I will talk about W block holder with Laszlo in this week.
- Distance btw target & PWO is 10cm but used value in simulation is 5cm, I will check with changed distance.

→Statistics can be low for W block cases : Do we need to use FADC?

Appendix

Let's make concrete what we want to measure

α_{corr}= x ns cut correction
ε_{accep} = PWO acceptance
f : unit transfer factor
ε_{trig} = trigger efficiency

What we want to measure

- #(Total Ortho-Ps), #(escaped Ortho-Ps)

What we can measure

- Singleshot Time spectroscopy

$Integ(V_{det}) = \int_{x\,ns}^{1us} Vdt = V_{det}s,\ V_{det}S = E_{dep} \times f\left(\frac{Vs}{MeV}\right) \times \alpha_{corr} = \#_{det}(= \#_{gen}\times \varepsilon_{accep}) \times f\left(\frac{MeV}{\#}\right) \times f\left(\frac{Vs}{MeV}\right) \times \alpha_{corr}$

→ $\#_{O-Ps} = \frac{\int_{200ns}^{1us} Vdt}{\varepsilon_{accep}\times f\left(\frac{MeV}{\#}\right)\times f\left(\frac{Vs}{MeV}\right)\times\alpha_{corr}}$

→ Not good for intensity mesurement but good for fraction measurement (f canceled)

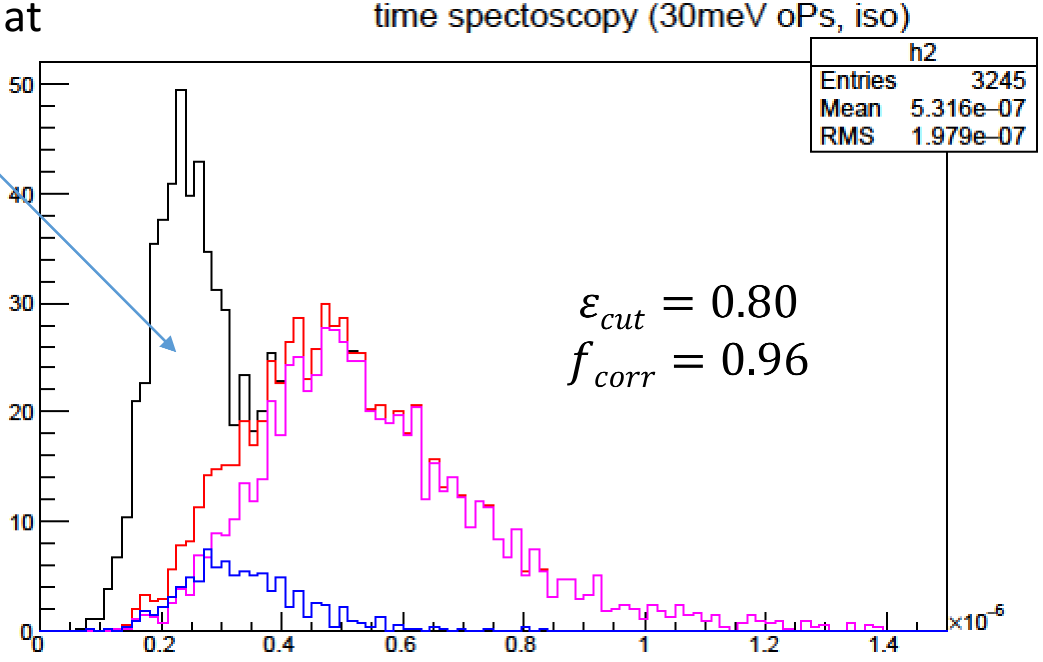
- Gamma counting(?) by low intensity (if we have beam trigger)

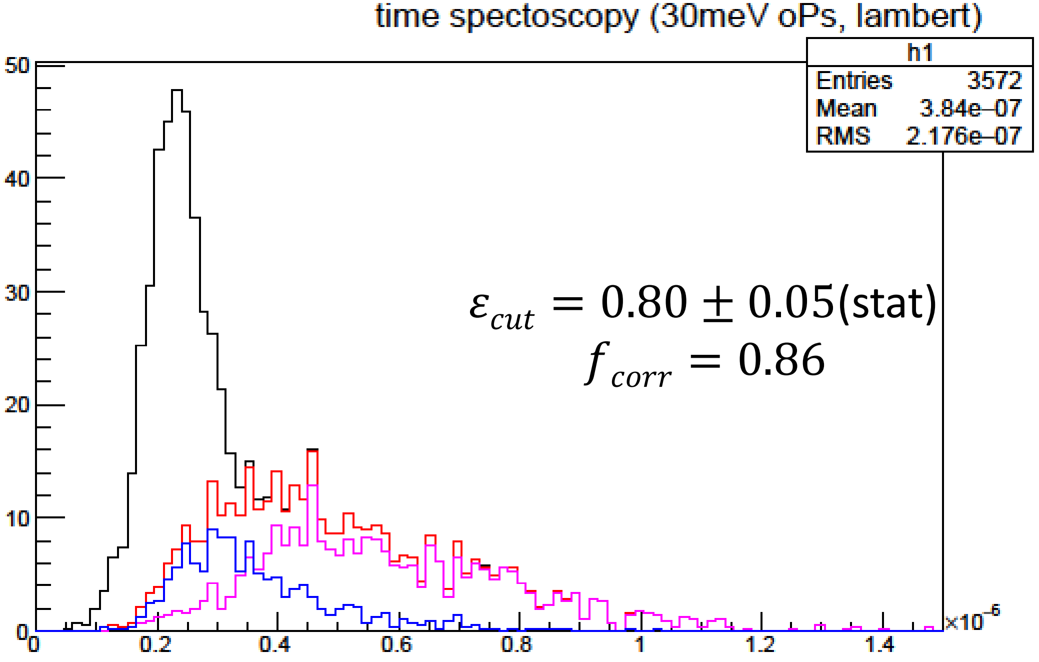
$\#_{det} = \#_{gen} \times \varepsilon_{accep} \times \varepsilon_{trig}$

→ $\#_{O-Ps} = \frac{\#_{det}}{\varepsilon_{accep}\times\varepsilon_{trig}}$

Rough systematic error check (α_{corr})

Compton scattering at electrode





- σ(Time cut + lefted Ps error) <~20%

Other paper for muonium escape rate

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Spatial confinement of muonium atoms

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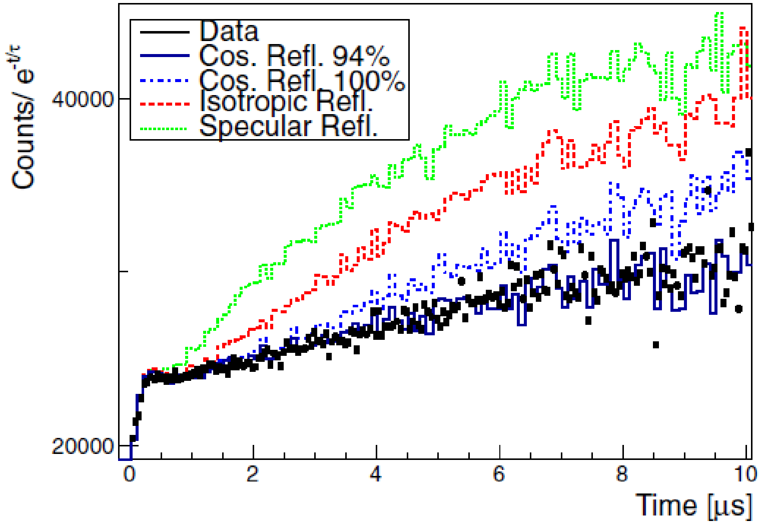

FIG. 6. The points are the data at 250 K for a distance between the SiO_2 target and the SiN window of $h = 1$ mm. The lines are the simulated time spectra for different reflection scenarios (see text for more details).

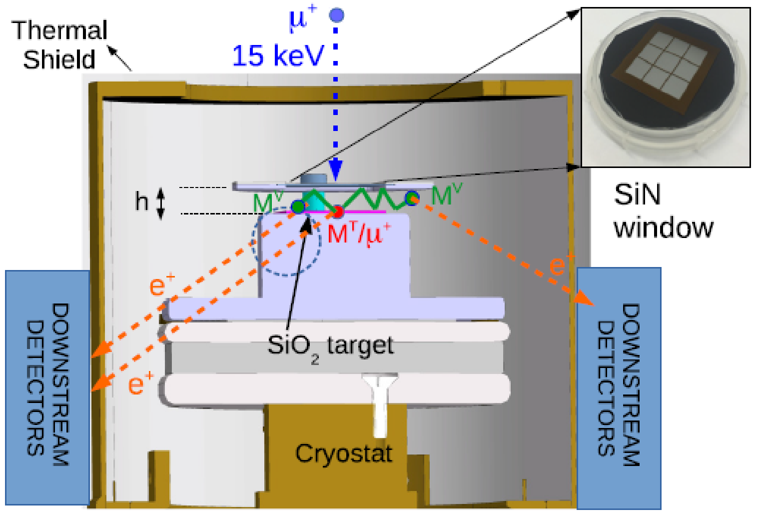

FIG. 2. Confinement of muonium between two surfaces. Sketch of the experimental setup and principle of the positron shielding technique technique. After crossing the thin SiN entrance window (shown in the inset) the 15-keV μ^+ stop in the mesoporous SiO_2 thin film. Positrons from muons or muonium (M^T) decaying in the target have a constant detection probability. Mu exiting the target into the vacuum (M^V) have an increased and time-dependent detection probability because of the shielding/shadowing effect of the copper sample holder [shown as a dotted (blue) circle].