Positronium intensity measurement preparation (GBAR)

SNU

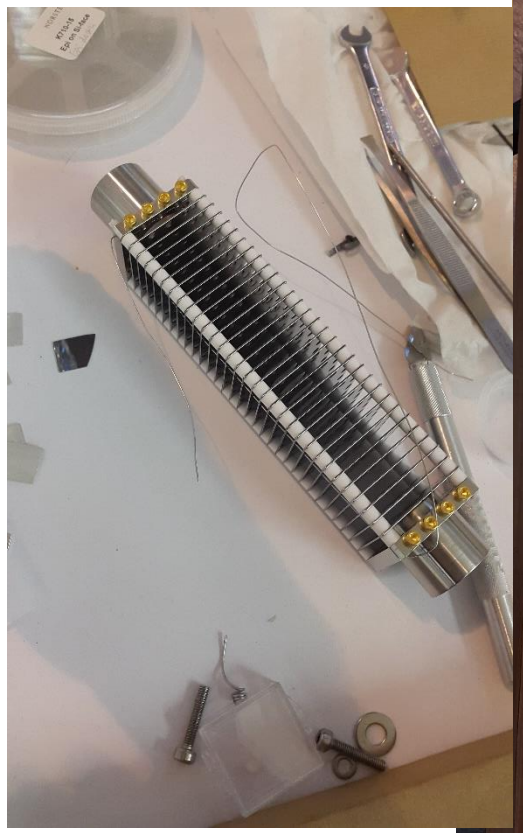
Bongho Kim

Recent status

- I have helped Laszlo to prepare switch of buncher after buffer gas trap
- Saclay linac shows bad performance after changing and moderator will be changed in this week (beam will be usable from next January(?))

Buffer gas trap →Buncher → Electrode → Positronium target

Buncher

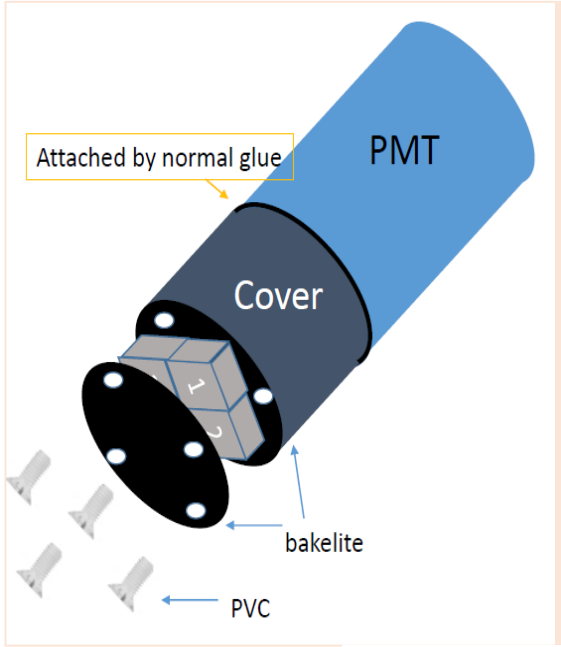


Electrode

At collaboration meeting

- Amelia will talk about recent progress of Antion project which has my positronium simulation inside
- Progress toward H and Ps production (A. Leite)
- I gave two slide (below pages) to Amelia for presentation

Ortho-Ps measurement preparation

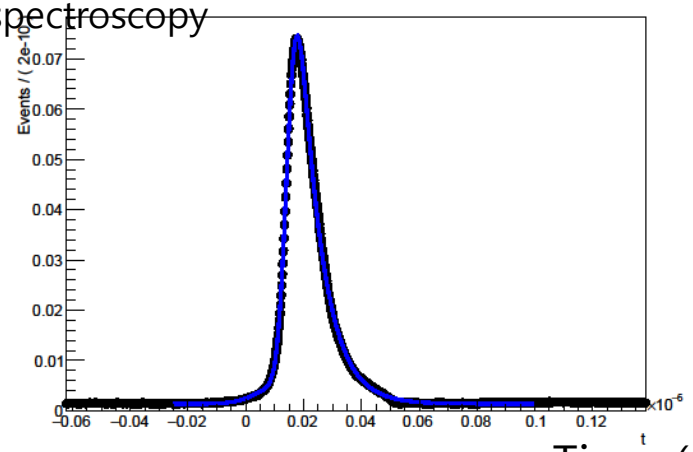


Specification

- 1 PMT + 4 PWO Crystal (2x2x3.8cm for each)
- Yield 0.7~2.6 [p.e./MeV] acheived with ^{22}Na source before cutting.
- Density : 8.3g/cm3
- Radiation length : 0.9cm
- Decay time : 10~30ns
- ~100% efficiency
- Good for high intensity beam measurement ..
- Oscilloscope : 12bit ADC resolution,

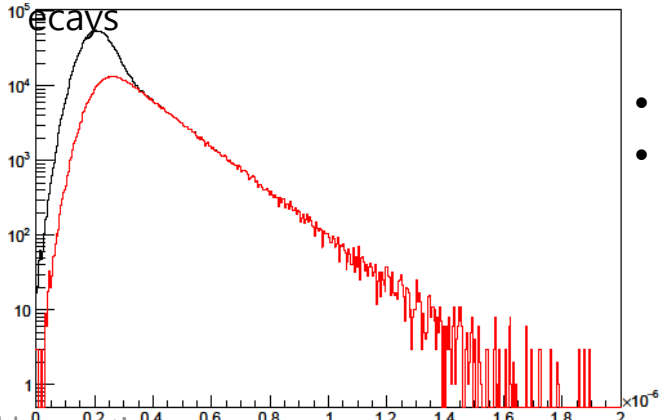
- To measure O-Ps intensity in time, time distribution will be measured by PWO detector.
- Test with ^{22}Na was done and abou t 100% efficiency was achieved.
- Because of 100ns beam width, ad equate estimation will be required

(Averaged) Single 0.511MeV γ time spectroscopy



Time (us)

Simulated time distribution of O-Ps d ecays

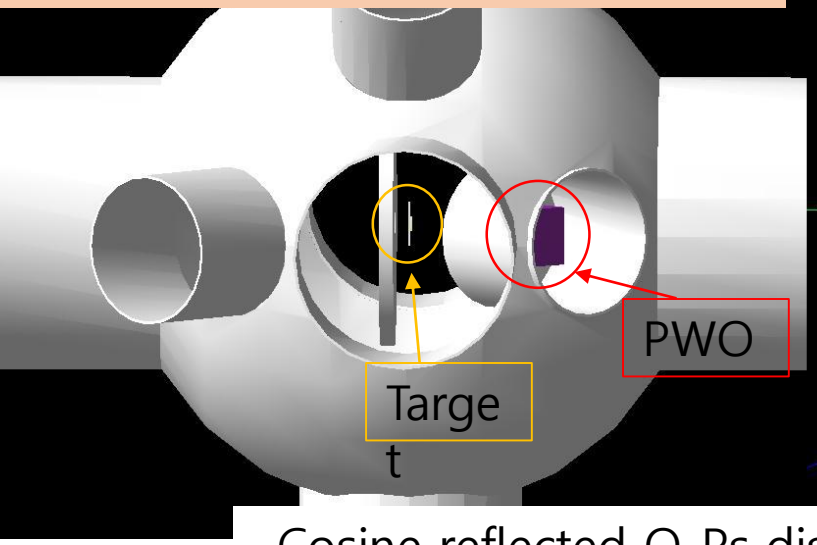


Time (us)

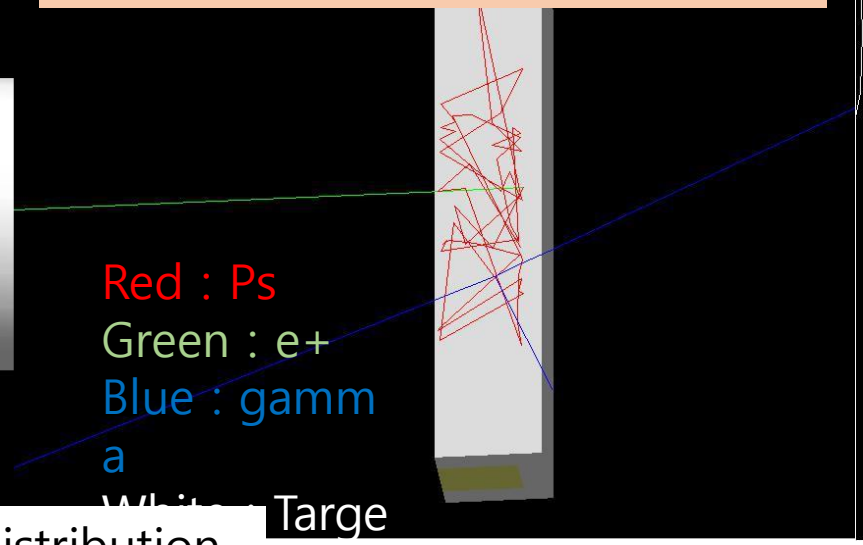
- Beam FWHM ~100ns?
- Fitting or estimation require d to distinguish O-Ps yield and e+e- annihilation

Ortho-Ps measurement preparation

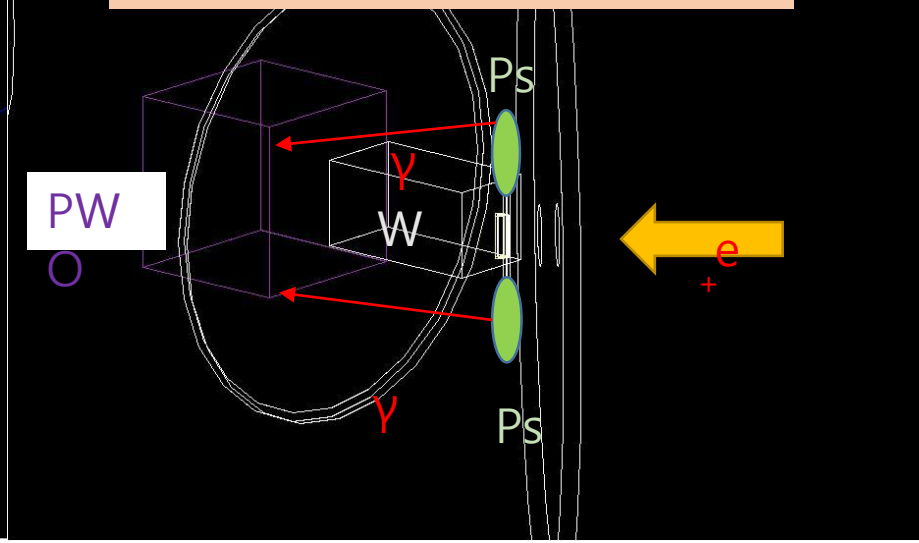
Simulation geometry



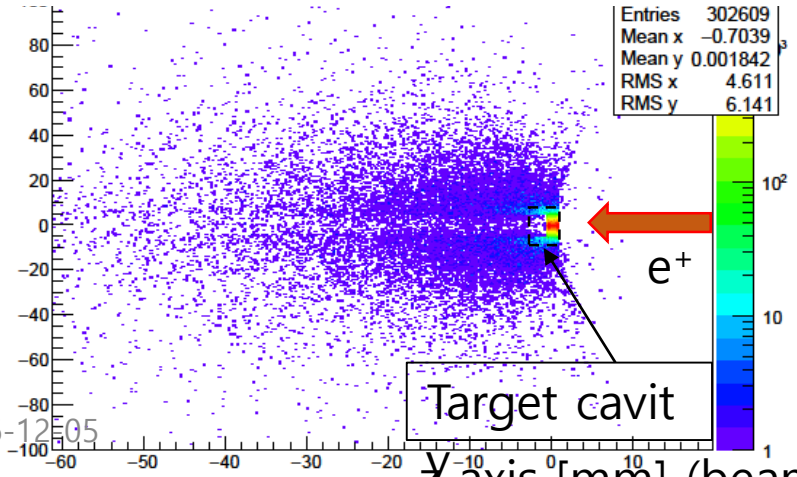
Positronium track example



Tungsten Block option



Cosine reflected O-Ps distribution



- Because of O-Ps reflection and straw shaped tar get, ~20% of positronium will be escaped from t arget region before annihilation.
- We need to get O-Ps yield inside of target to m easure σ (P + O-Ps → H + e^-) cross section preci sely.
- By adding W block in adequate position, we can measure escaped fraction and related informatio ns.

GBAR simulation framework

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What is this topic?

- Before real experiment start, we need to share information an d make concrete simulation to estimate signal and backgroun d by adequate geometry, etc..

- There's simulation from tracker group, paul trap group, CEA a nd SNU separately developed.

- Before real experiment start, we need to make and converge all information which will affect to our measurement in free-f all area.

- Which will be helpful to understand minor systematics.

Why we need to do? For example

- 1$\bar{H}$ #/100s (?)→0.46 $\bar{H}$ #/100s (after trap) → 0.05$\bar{H}$ #/100s (two pi on(TB) in TOF) →>0.02$\bar{H}$ #/100s(Tracker) : about 90 day to make 1 500 measurement : We need to check real efficiency with required track numbers for (TOF + MM)
- Pion decay angle from anti-proton is not symmetry in Geant4

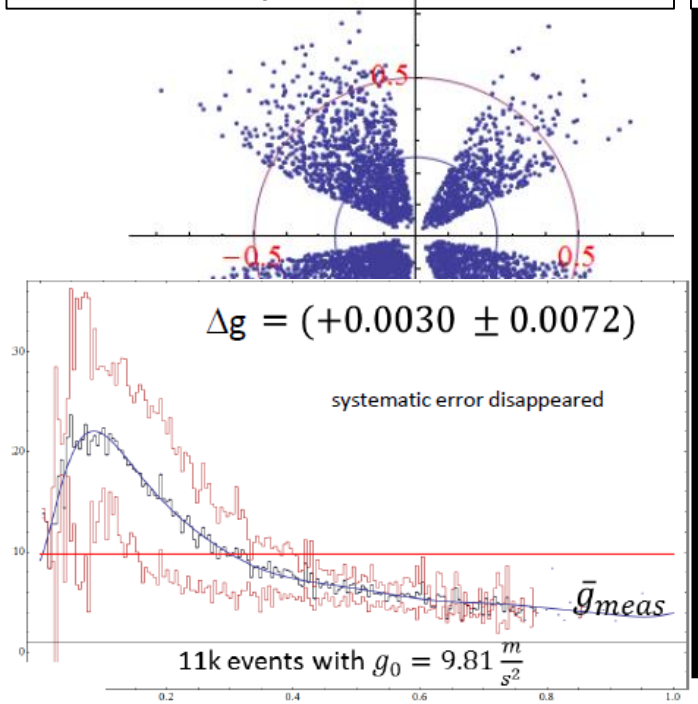
→ There's problem of $\bar{H}$ decay angle in Geant4 and A.Mattia and J. Hwang figured out separately because we didn't share information..

How we can share information?

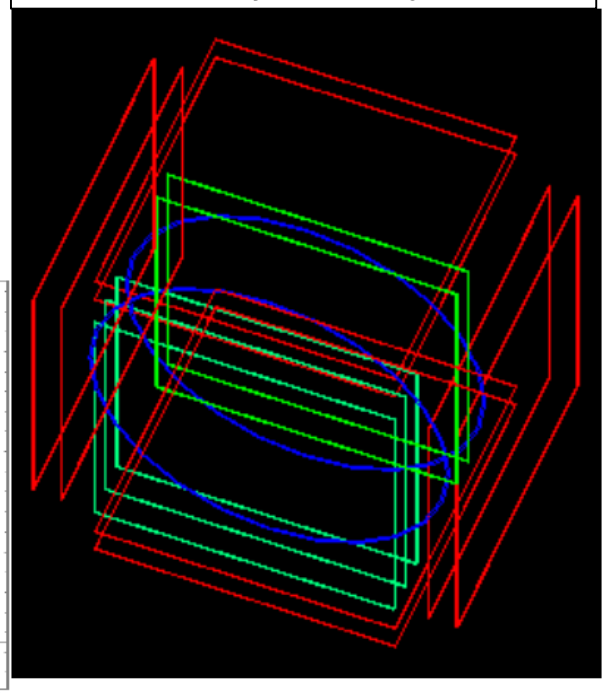
- P.Crivelli kindly suggested to use GIT for sharing information ☺
- If possible, we can use some area in web-page to share infor mation like floor-plan of chamber, detector, etc.
- We don’t need to spend time to do same thing againg which is already checked by others! We can play game together.

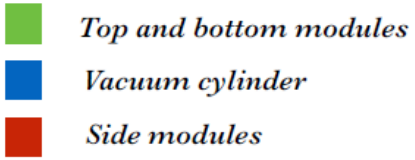
Current simulation status

From Mainz by S.Wolf(2014)

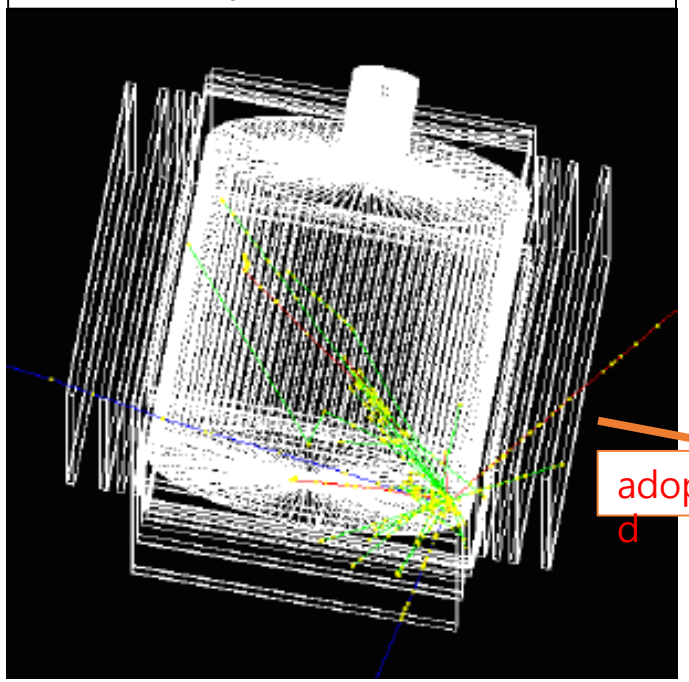


From ETHZ by D.Banerjee (2016

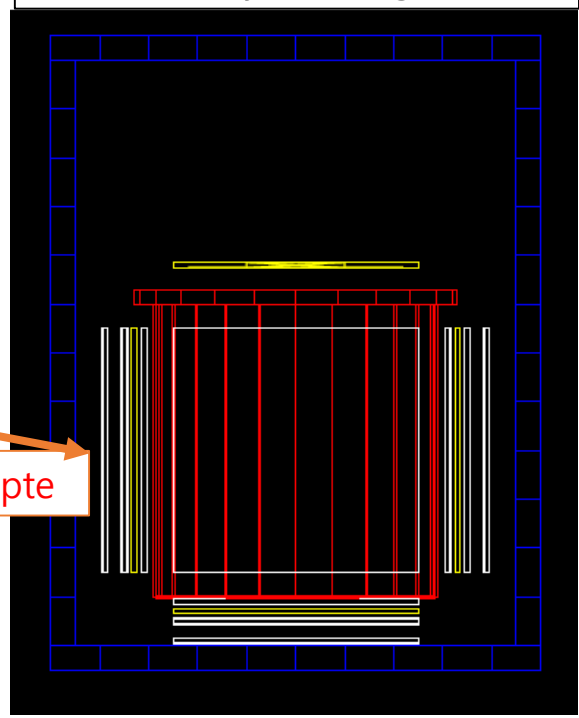




From CEA by A.Mattia (2016)



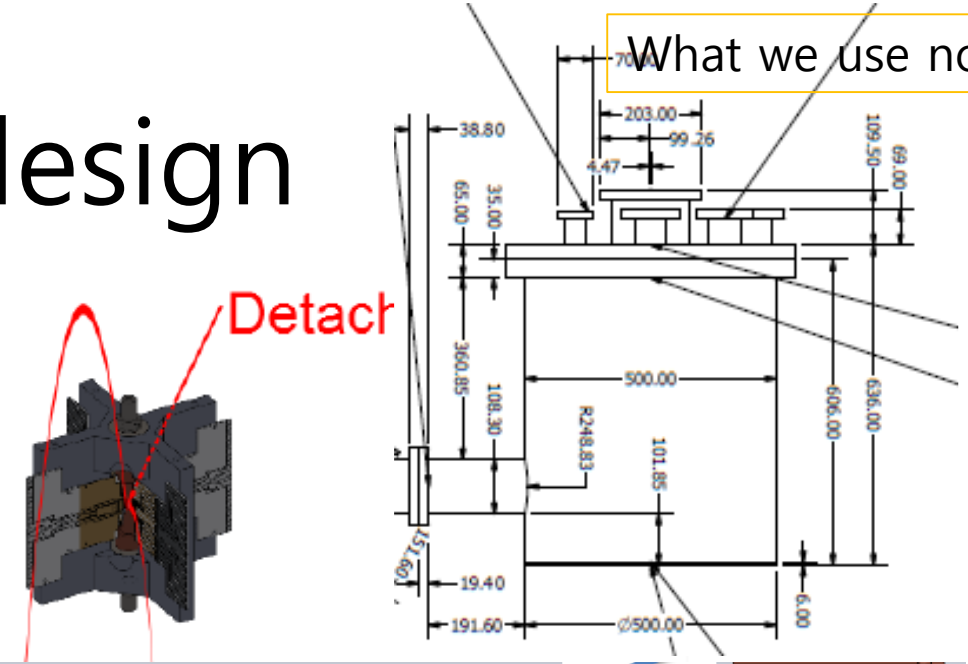
From SNU by J.Hwang



- Many free-fall simulation has been prepared but no official information sharing or complete si mulation for all parts.

Paul trap and chamber design

What we use now



- (2014. S.Wolf)

- Annihilation at trap : 46.2%

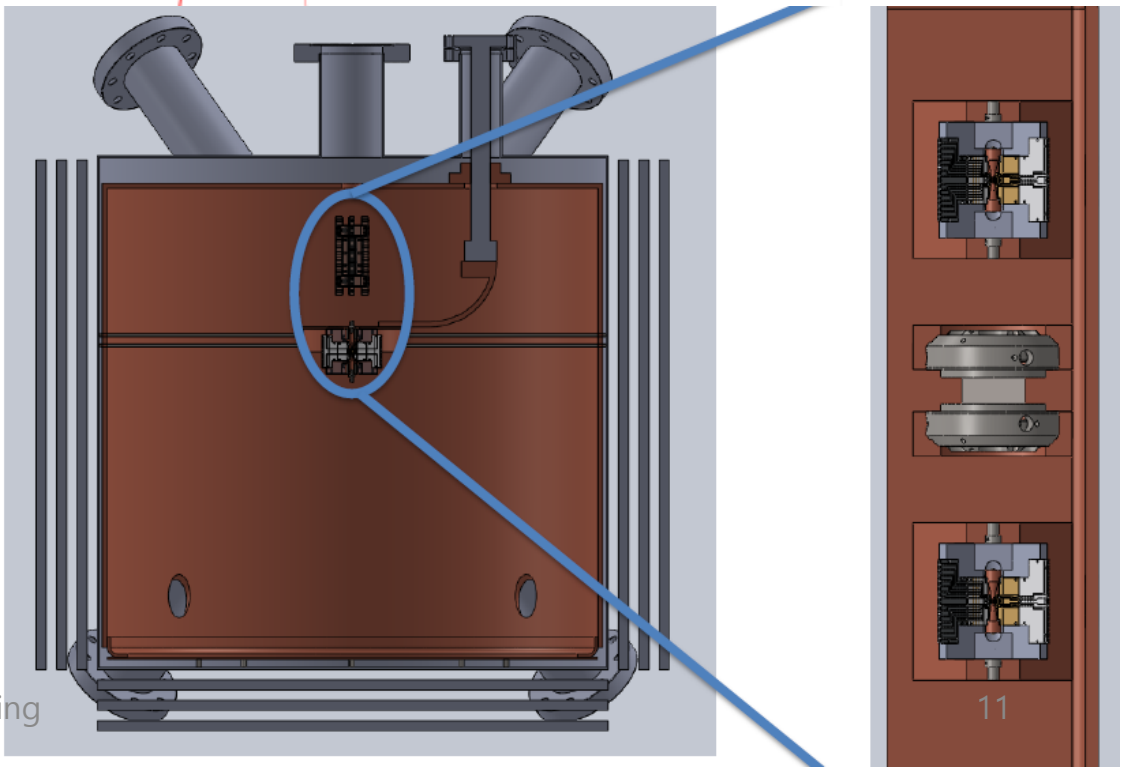
(acceptance angle?)

- (2016. S.Wolf)

- w_{ax} = 0.1MHz →v_v = 0.14m/s (v_h=0.42m/s(?))

- We need geometry for chamber and obstacles

→ Many obstacles are shown inside chamber not only copper cryo setup but also cooling material and devices. (As D.Banerjee said, material can change track)



Paul trap and chamber design

- Chamber information (Are these value right?)

- Chamber thickness = 2~3mm (side), 30mm(top), 6mm(bottom)

- Chamber pressure = 1.e-11mb

- Magnetic field gradient

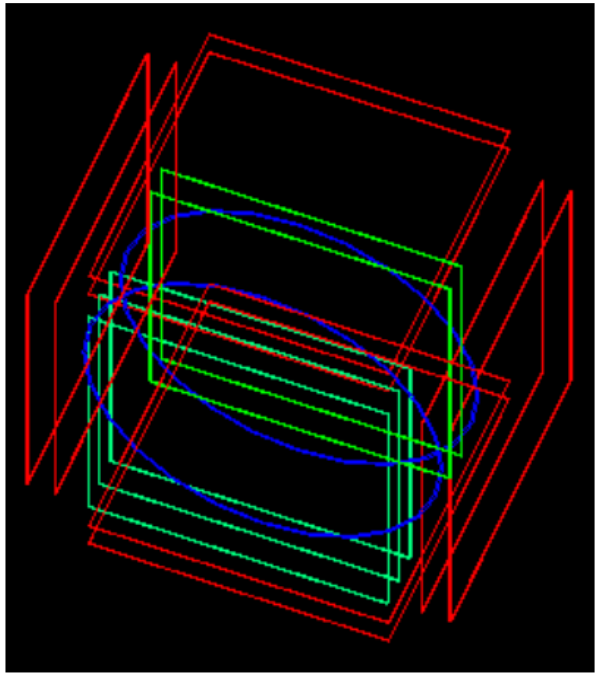
→Field from outside of Mu metal shielding (<0.2g/m expected)

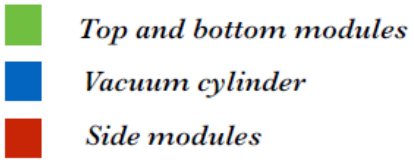
→Inside : Paul trap, Capture trap (can we ignore this?)

MicroMegas tracker

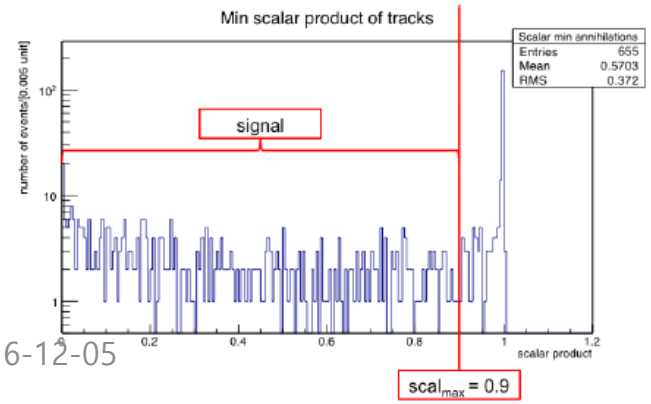
- ~100um resolution
- 3(top),2(side),2(bottom)
- Acceptance : ~66% (from 96% for at least one track)
  → design fixed?
- 50ns sample size(20MHz band width)

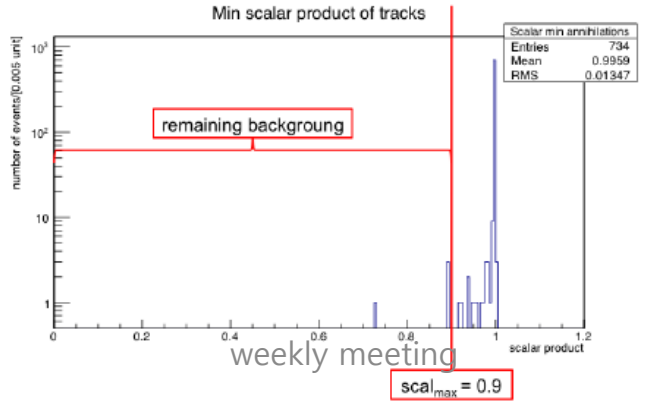
Gap is shown which is quite big





- Can we recon trajectory by two MM tracker?
- Cosmic ray veto technique (two track's similarity)



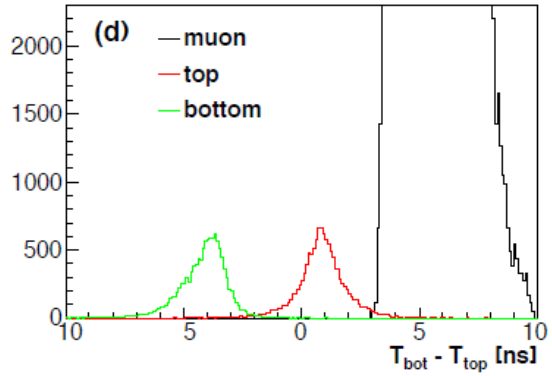


TOF information

- time resolution(<0.2ns).
- Spatial resolution : 1.5cm(x,z), 2.9cm(y)

→combining tracker's trajectory with TOF (x,y,z,t) will be helpful

- Cosmic veto technique : Δt (top and bottom detector asymmetry)→ combining also good
- Efficiency (TB) ~ only 10%
- $\bar{g}$ = L/2t^2← t = <t_{tof}> - L_{track}/c (small correction)



TOF + MM tracker

- In TOF, we need “two tracks from Top and Bottom” or at least “three tracks” to get usable information.
- In MM tracker, we may need to gather “three tracks” to make correct annihilation point (2 is too small because of pion momentum change in chamber)
- If we add information from TOF and MM, we may use measurement even with 1 (TOF&MM) + 1 extra(MM only) →efficiency increase

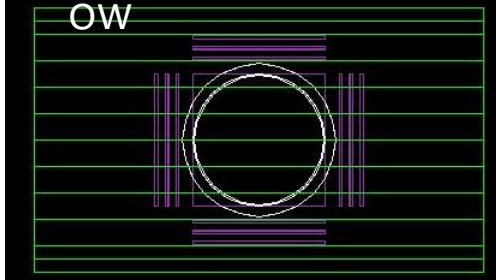
: How we can do this together?

Additional question

- If the gap btw tracker is big I wonder which one is better

Tob view of detect or

Detector design n ow



Cover more area
Less TOF bars

More coincidenc e expected

So

- If we can gather updated information (Design, parameters an d errors of chamber, paul trap, tracker and TOF), we can simul ate expected signal what we achieve.

Appendix

Source of error or bias

Main source

- H-bar kinetic energy
- Start time and position
- Time, spatial resolution and tracking algorithm

Extra

- Fringe field (magnetic), electric field?,
- Vibration, pressure, temp, reflection
- Annihilation in extra obstables

Track change by chamber