Positronium simulation

SNU

Bongho Kim

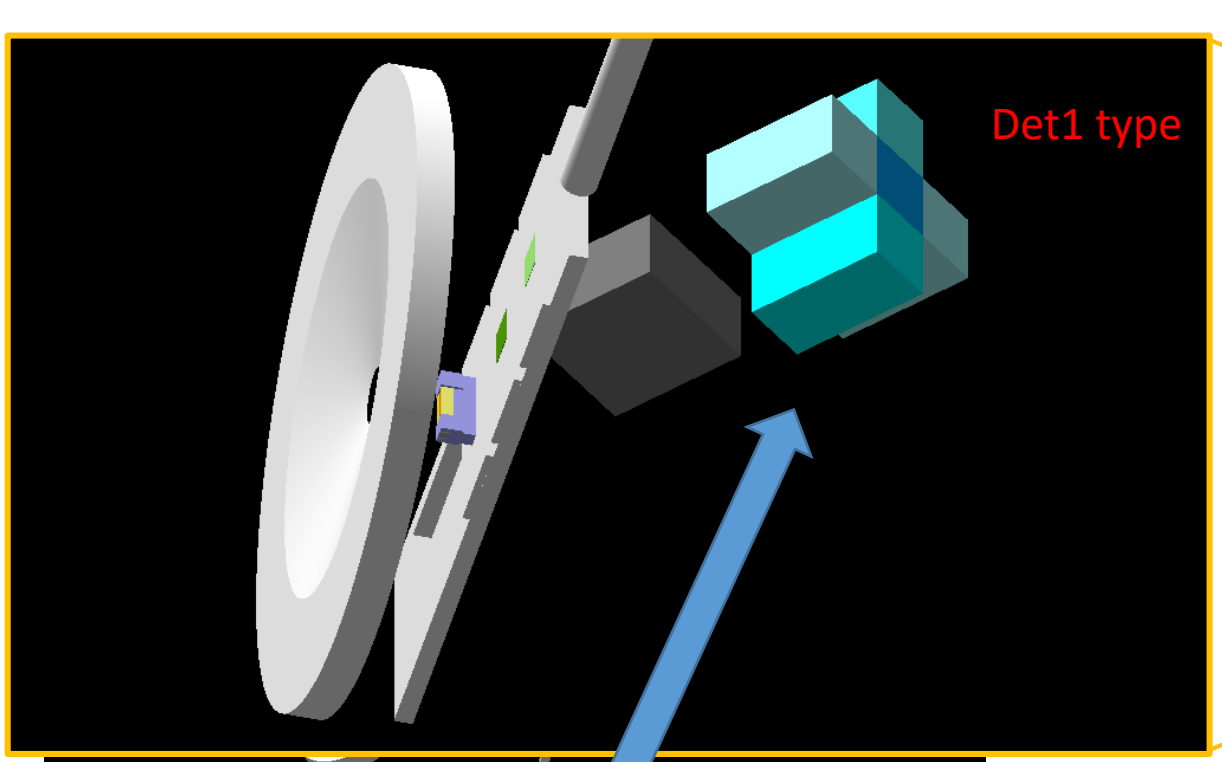
Contents

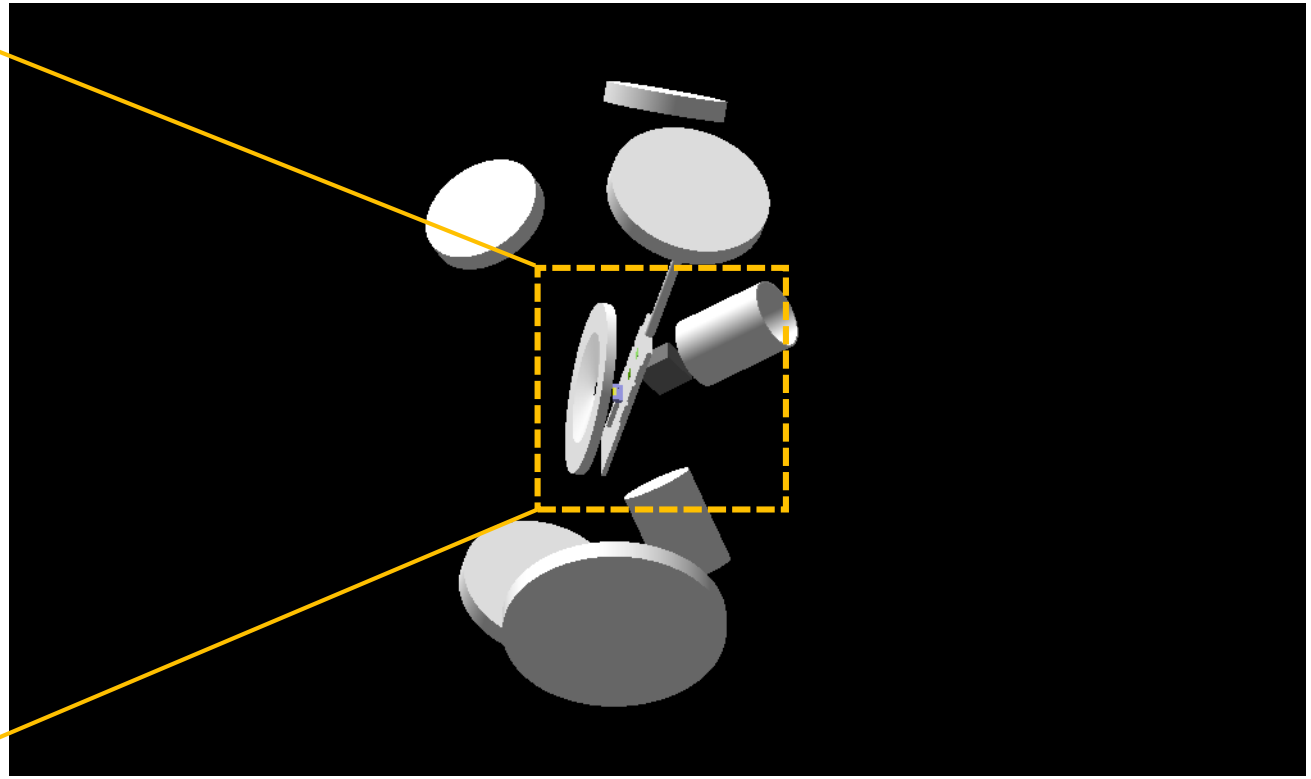
1. Basic information of simulation
2. Positronium spread by reflection and generation angle distribution
3. Detected signal distribution

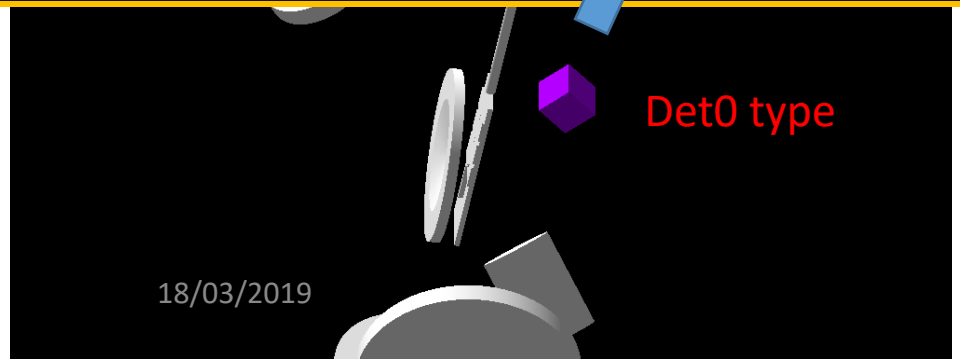
1. Basic information of simulation

- Purpose of this simulation
- Check Compton background effect to measure correct beam intensity.
- Efficiency change by positronium spread (especially flat target)
- Time distribution of positronium for cavity (required for cross-section measurement) ← possible main error
- Find the way to measure positroniuim property to reduce systematic error

Simulation geometry







Simulation

- Geant4.10.3.p01
- Positronium library + Penelope library

 - positronium library (positronium generation, decay and reflection)

 - positronium generation library (o-Ps (142ns; 30% x 100%(or75%)), p-Ps (125ps;10%), thermal positron (10ps; 50%), Ps at pore (74ns; 30% x 0%(or25%)),Bk positron(10%)

 - oPs energy (50meV; Maxwell-Boltzman distribution)

 - Ps generation & reflection direction distribution (cosine or isotropic)

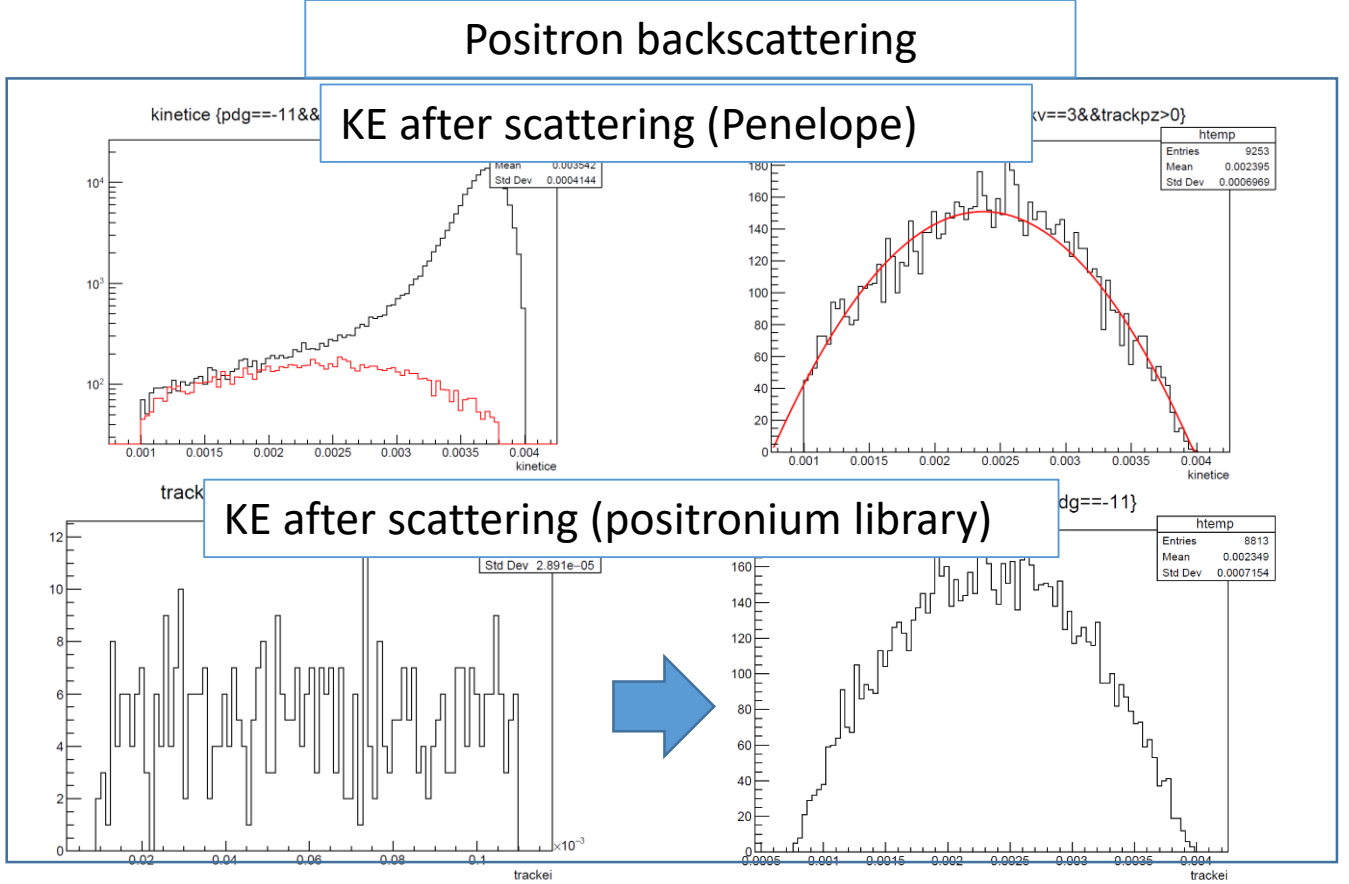
- Positron penetration of 30nm film, reflection angle at target.

Positron library

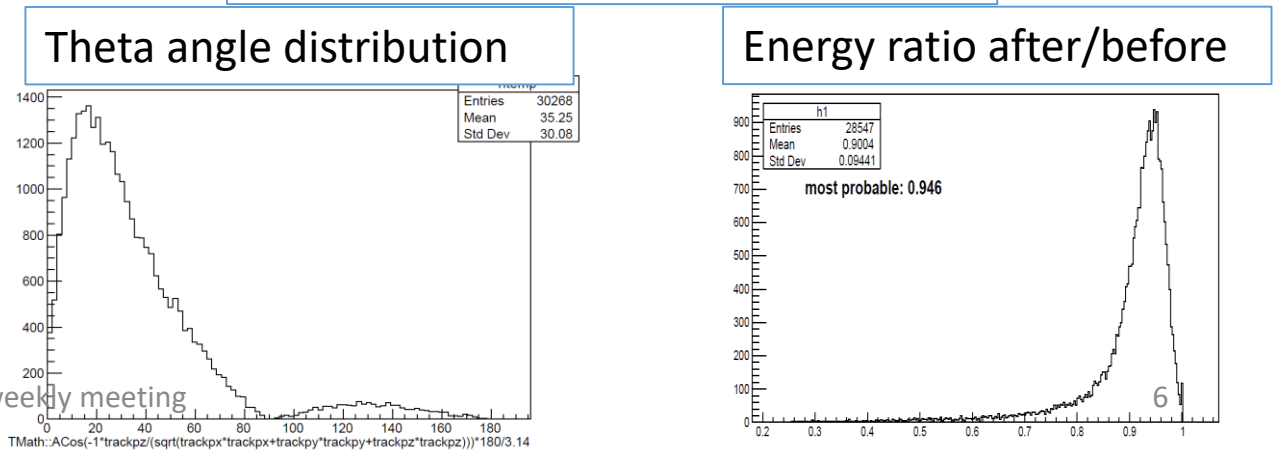
- Positronium deposit energy distribution with back scattering is simulated with Penelope library and the shape is used for positron reflection at the target.

- Theta angle distribution after 30nm window (geant4.10.3p01) is done with Compton scattering (not multiple scattering)

Positron backscattering



Positron penetration

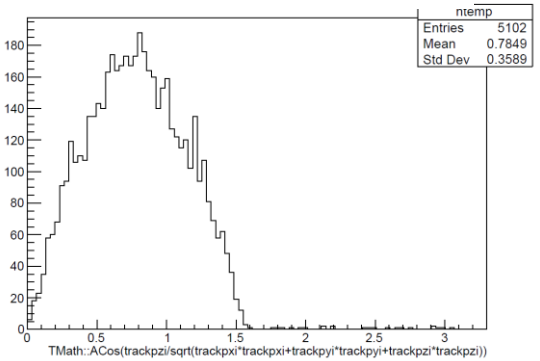


2. Positronium spread

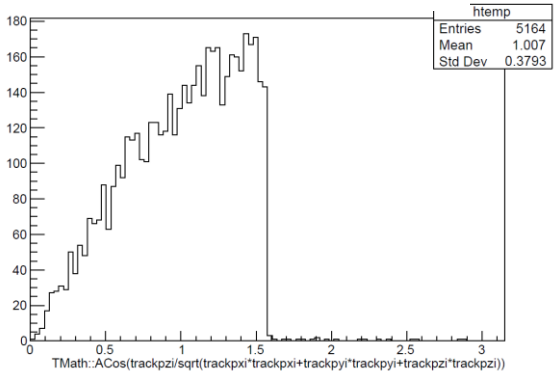
Cosine and isotropic distribution

- Positronium generation and reflection angle distribution
- PRA94, 022716 (2016) insist cosine distribution but not precise.
- Cavity target is more related with reflection distribution and flat target is more related with generation direction distribution

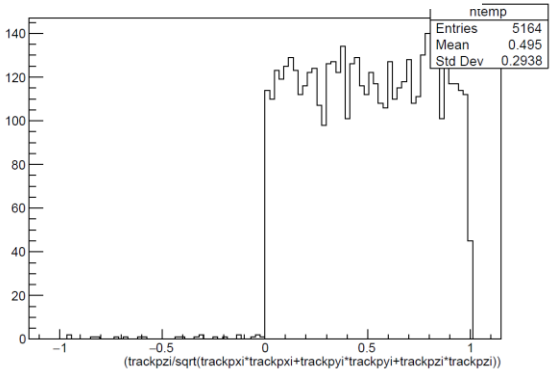
Theta distribution cosine



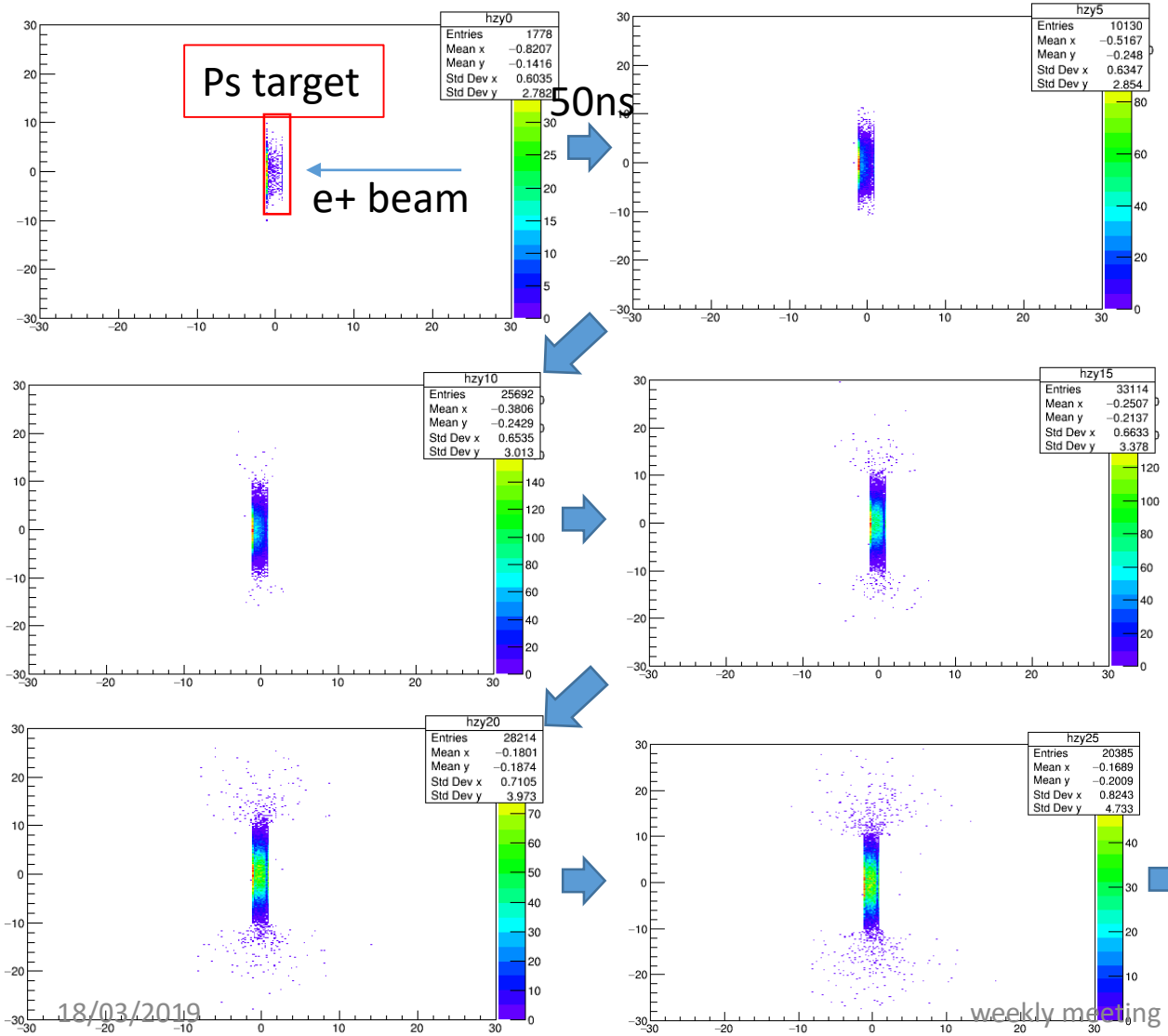
Theta distribution isotropic



phi distribution

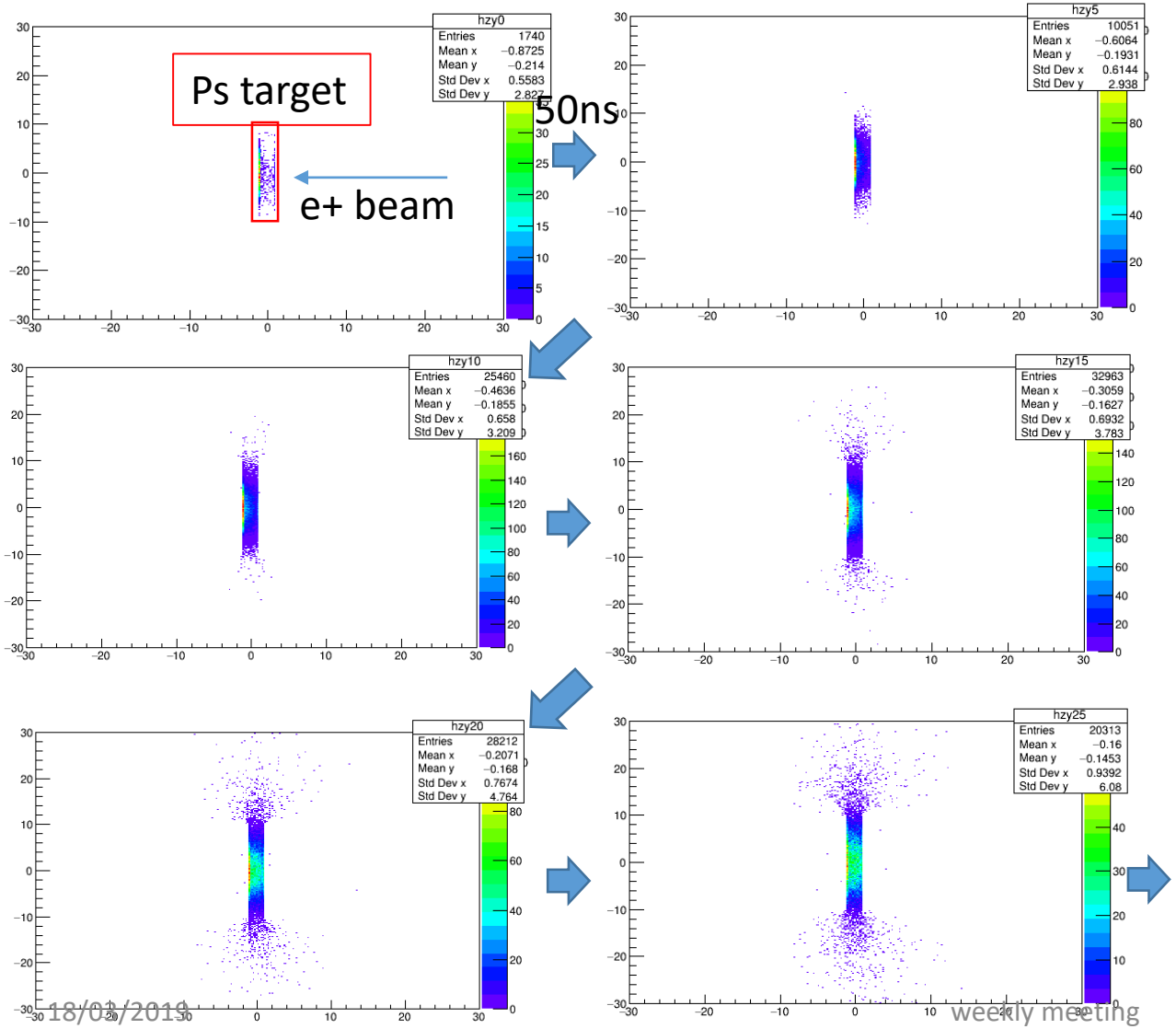


Positronium in the target cavity (cos)



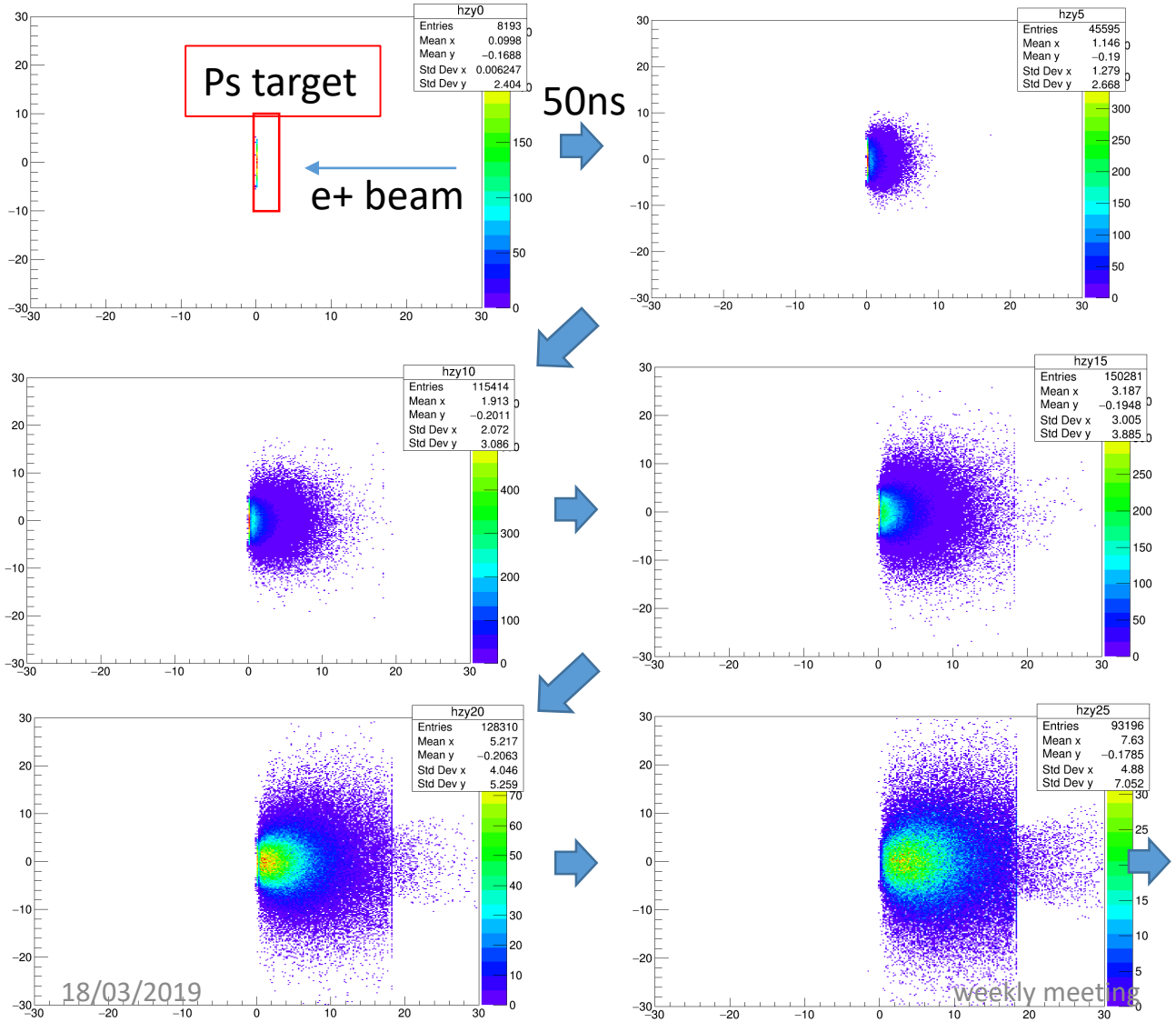
Time	Fraction (in/all)	Total Amount
-100ns	0.987	1779
-50ns	0.992	10132
0ns	0.989	25692
50ns	0.984	33130
100ns	0.970	28226
150ns	0.952	20412
200ns	0.926	14335
250ns	0.893	10135

Positronium in the target cavity (iso)

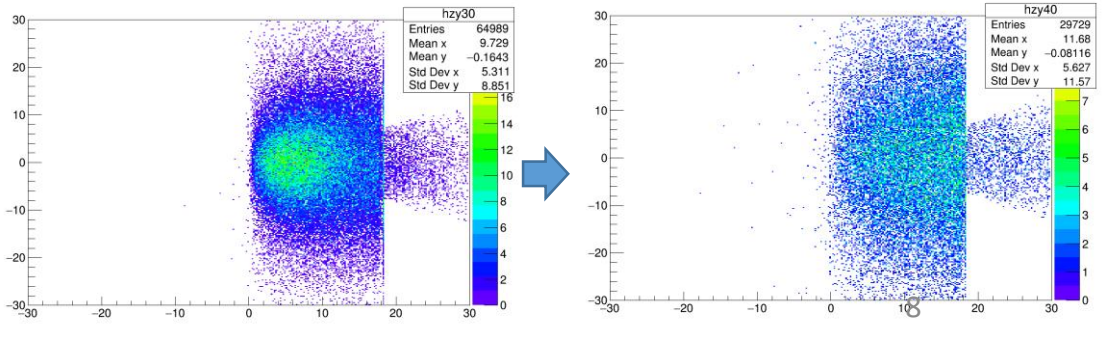


Time	Fraction (in/all)	Total Amount
-100ns	0.99	1742
-50ns	0.989	10054
0ns	0.985	25479
50ns	0.972	32992
100ns	0.948	28247
150ns	0.902	20376
200ns	0.844	14392
250ns	0.782	10137

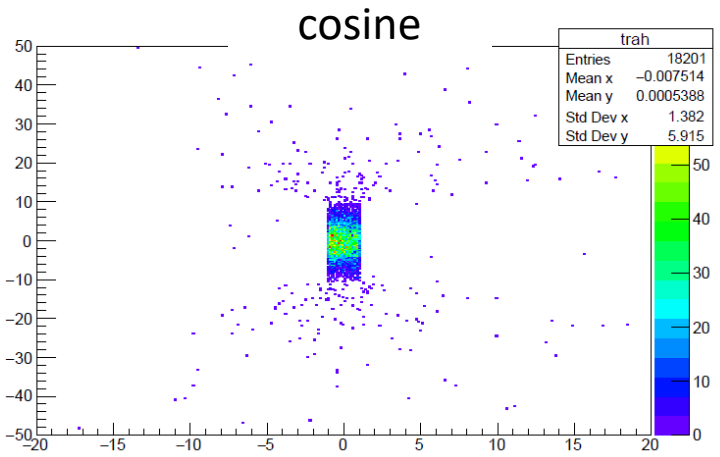
Positronium in the flat target (cos)

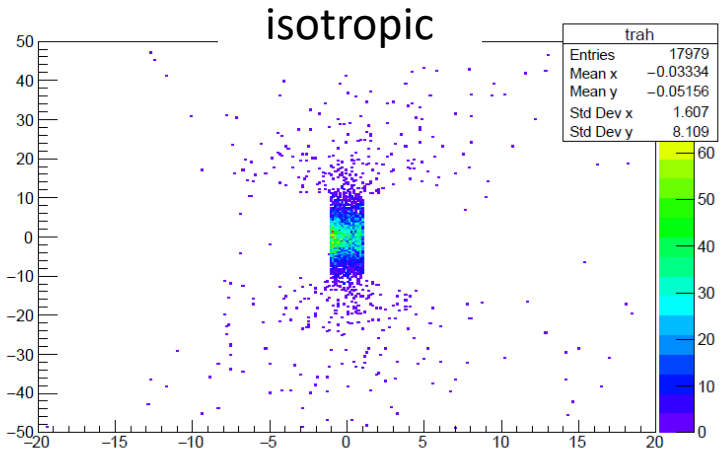


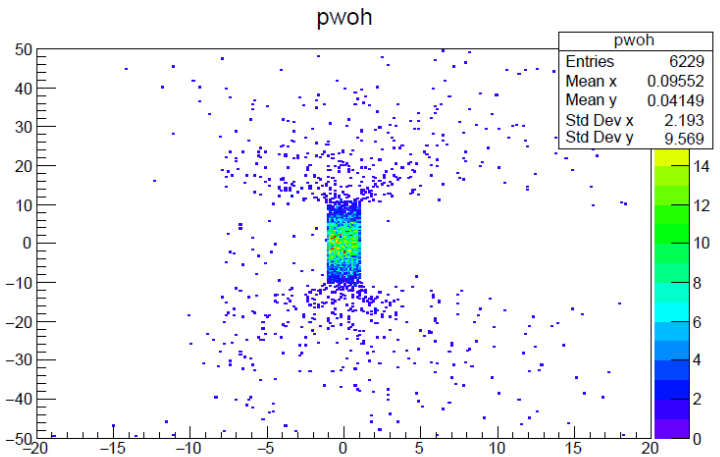
Time	Fraction (in/all)	Total Amount
-100ns	0.385	8195
-50ns	0.199	45595
0ns	0.138	115416
50ns	0.073	150283
100ns	0.025	128374
150ns	0.006	93511
200ns	0.001	66014
250ns	0.001	46462

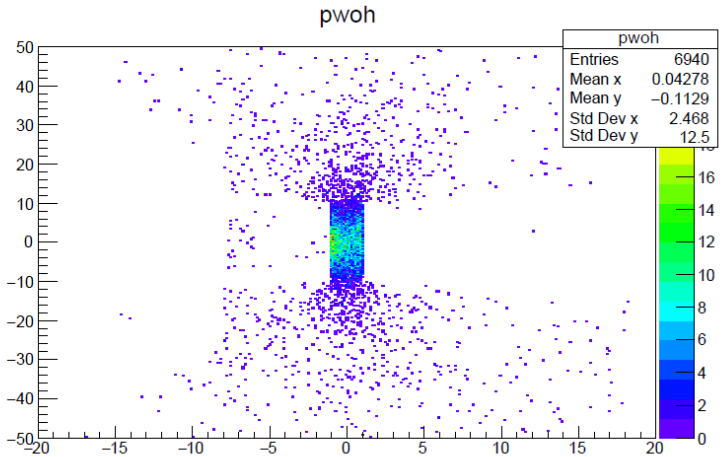


Positronium distribution (dead point) (det0)





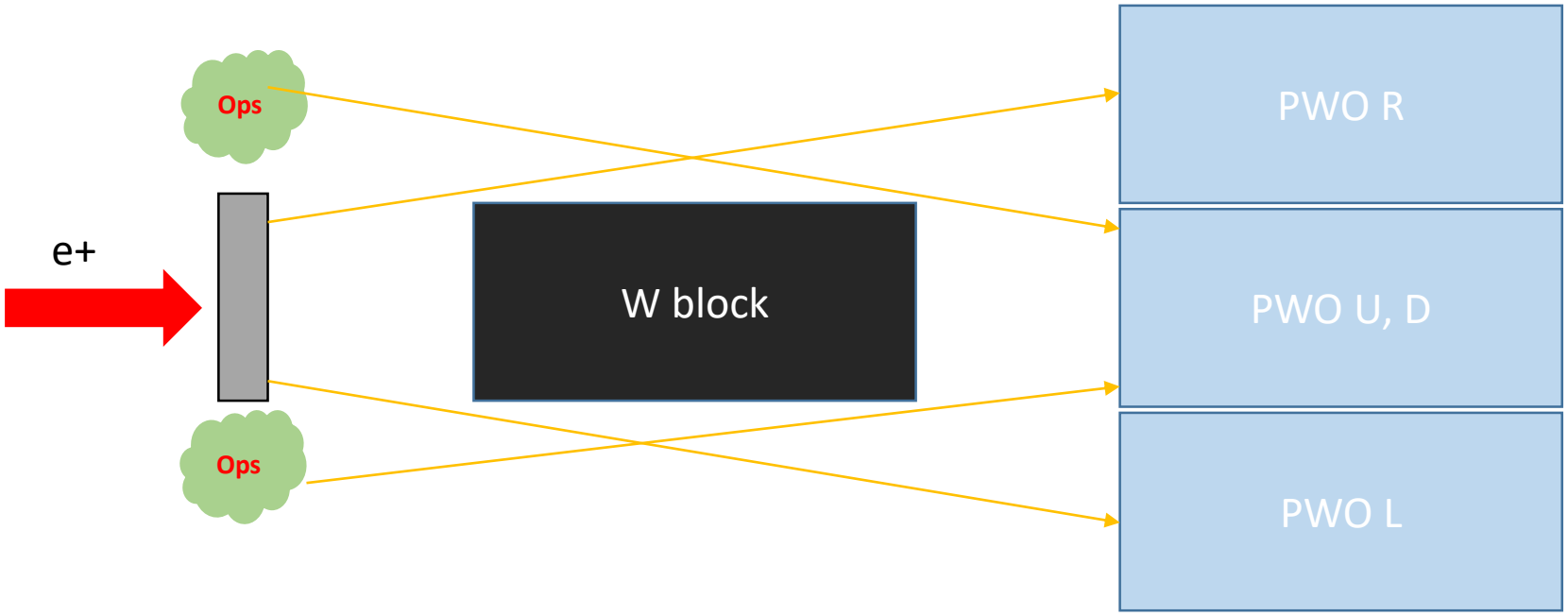




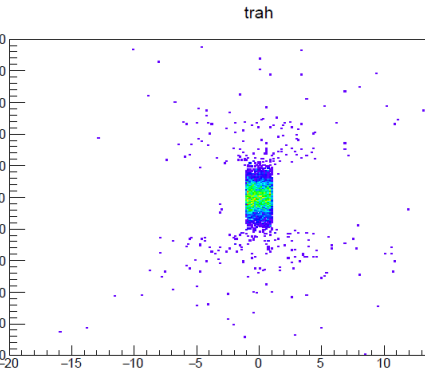
- Upper histograms show annihilation point of Ops
- Lower histograms show detected annihilation point of Ops with W block (2x4x4cm)

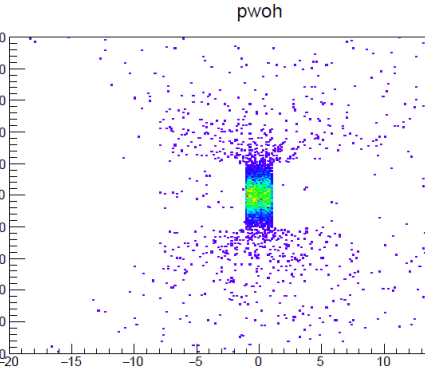
- Efficiency(position) will be updated w & w/o W block

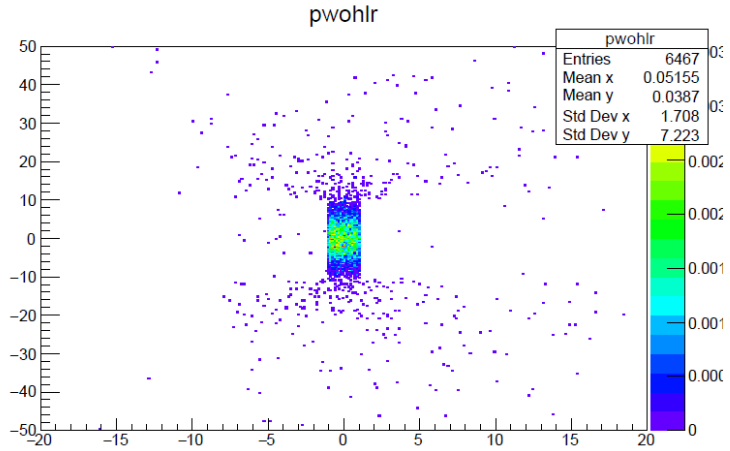
Detector geometry

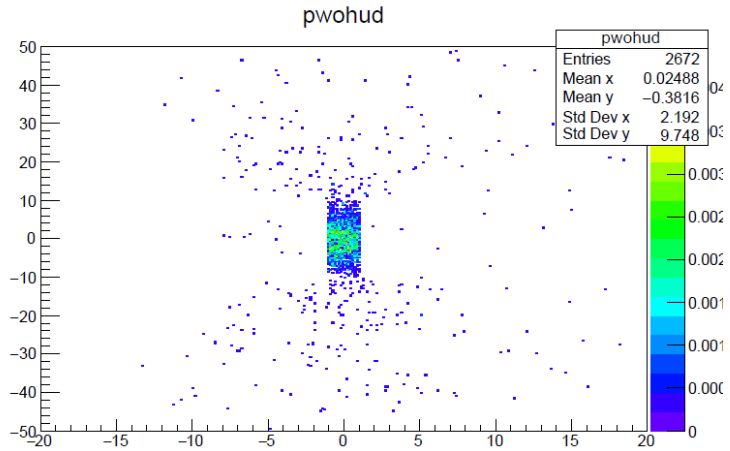


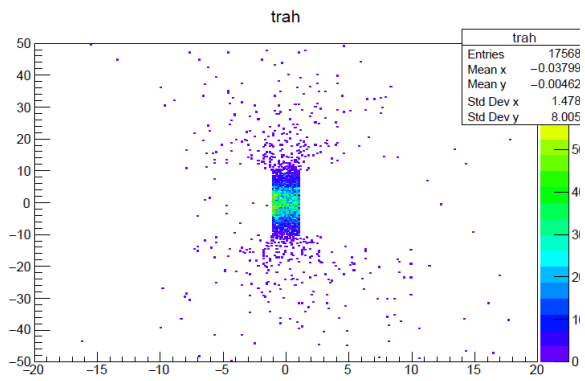
Positronium distribution (dead point) (det1)

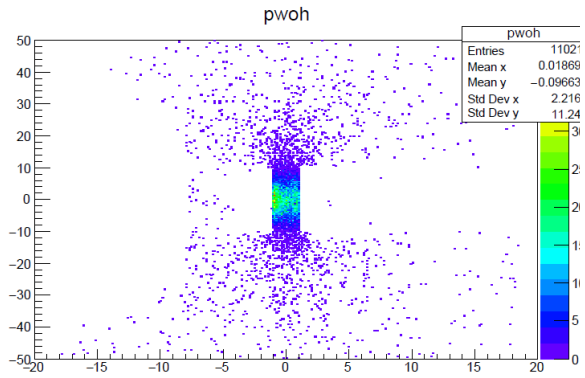


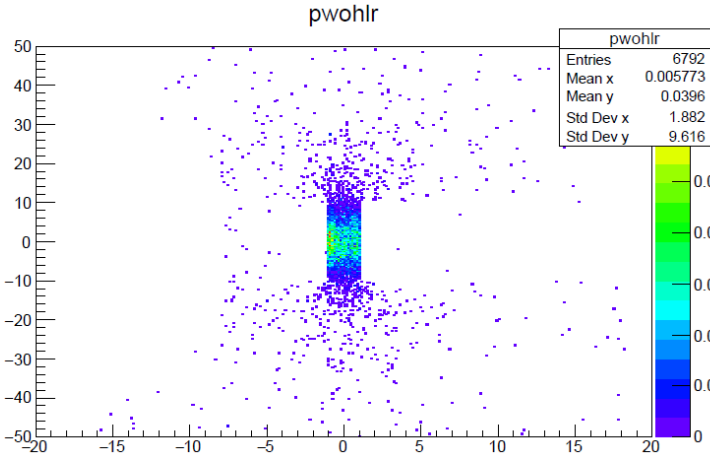


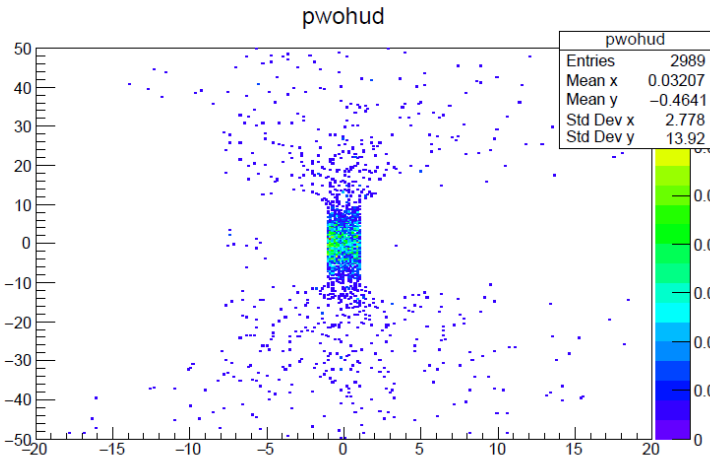








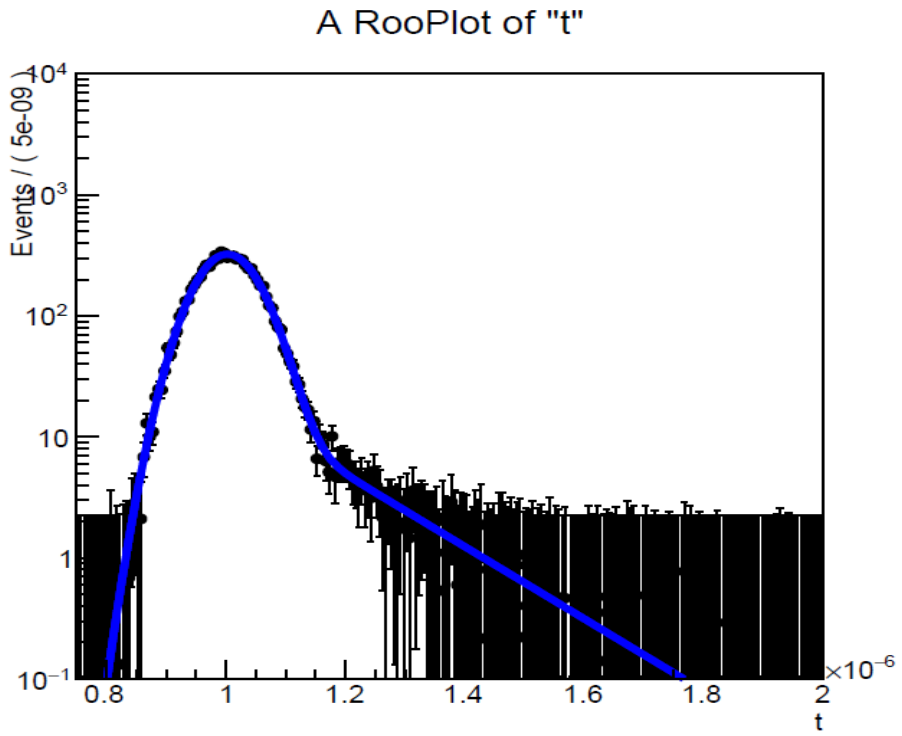


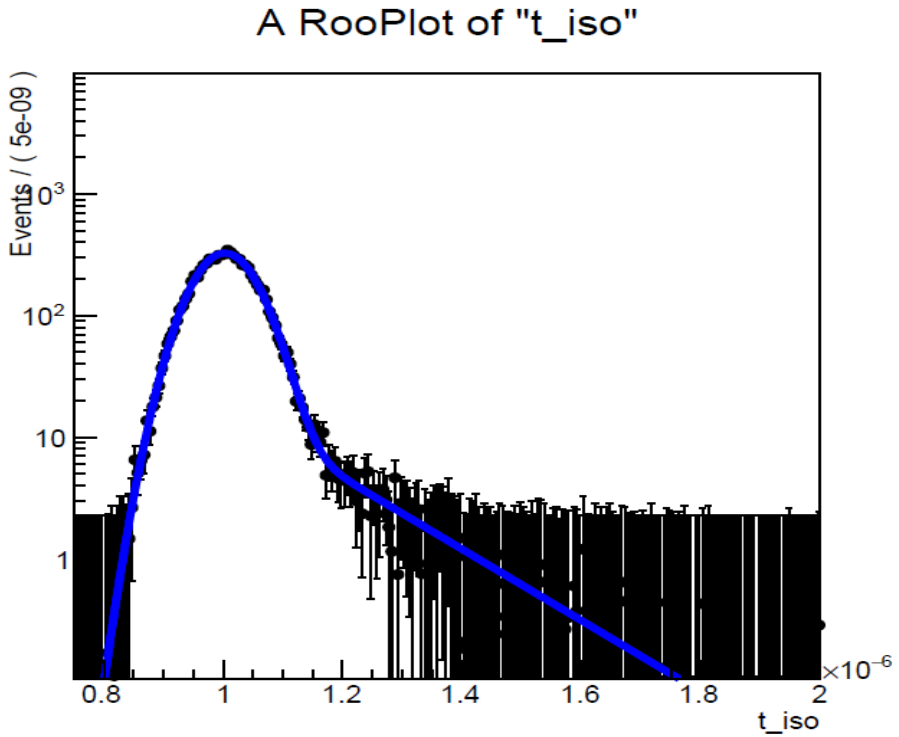


- Efficiency(position) will be updated w & w/o W block

3. Detected signal distribution

Time distribution at PWO detector (det0)





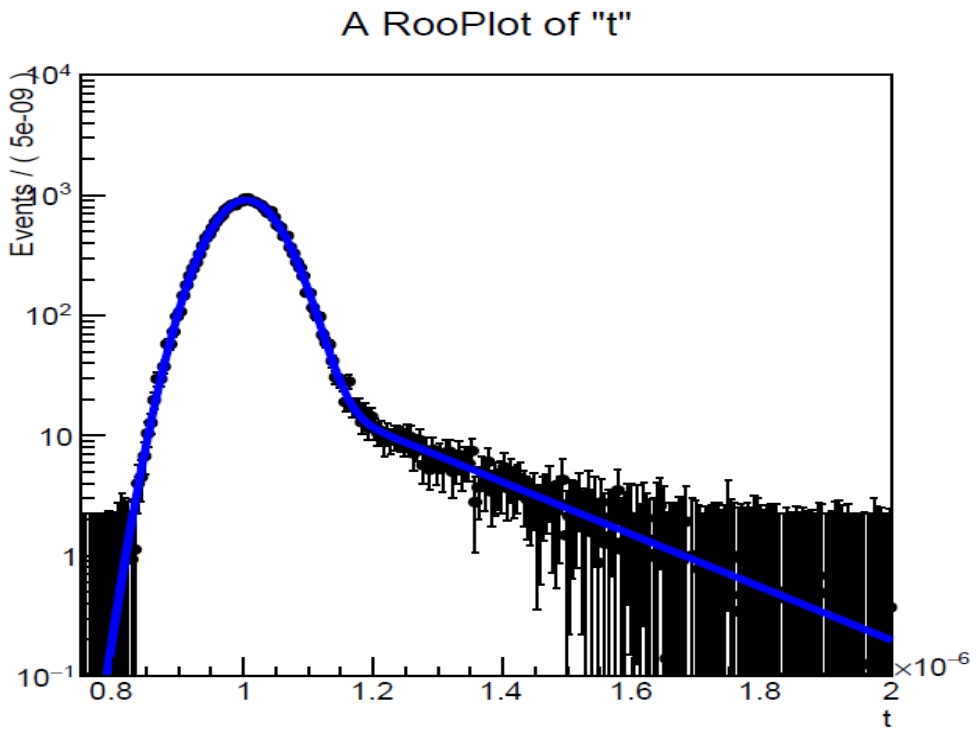
Error should be reduced (error is given with mean depE as 0.5MeV)

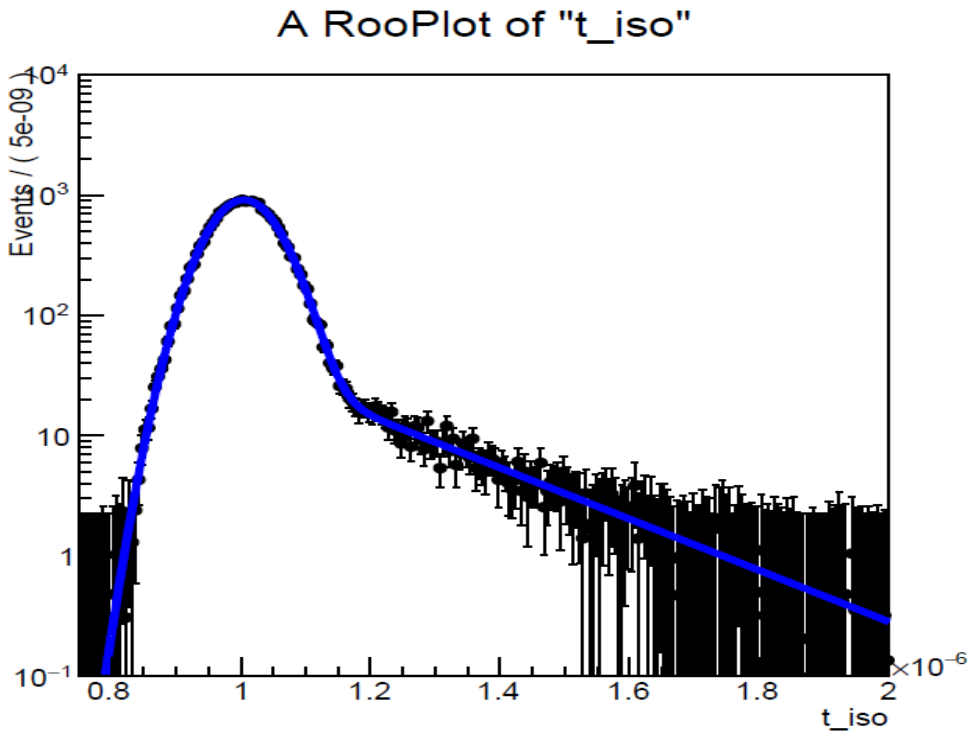
σ_t = 50ns; σ_x = 2mm; σ_y = 3mm ,# =1,000,000

Left) chi2 = 0.37; tau = (1.46 +-0.21)e-7

Right) chi2 = 0.13; tau = (1.48 +-0.22)e-7

Time distribution at PWO detector (det0 +W)





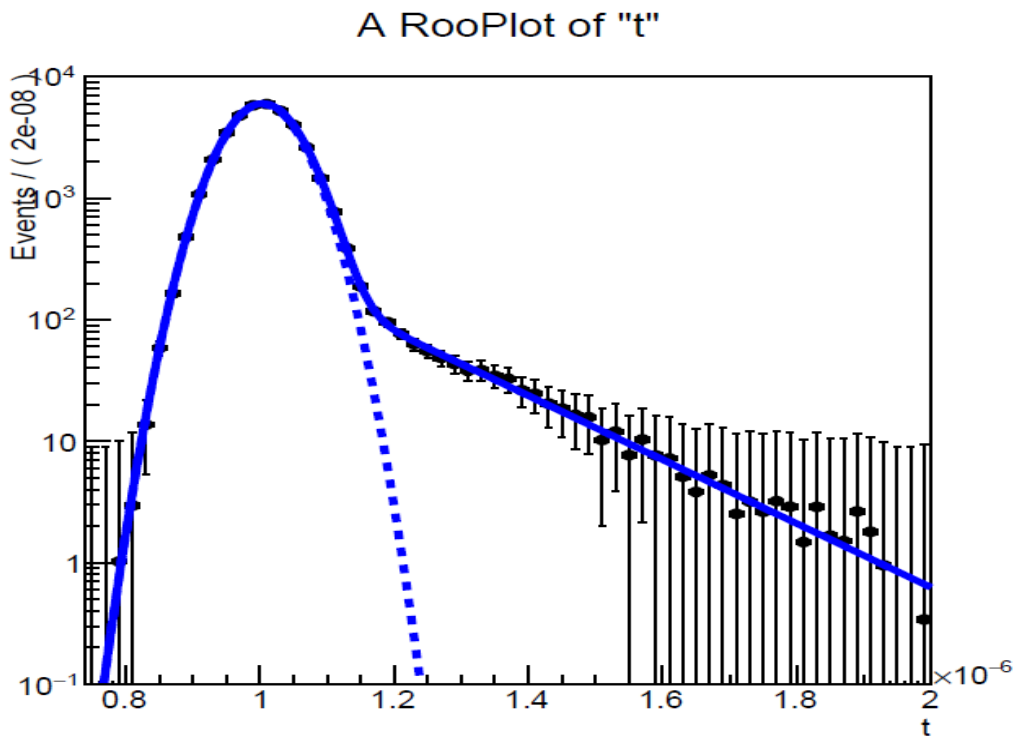
Error should be reduced (error is given with mean depE as 0.5MeV)

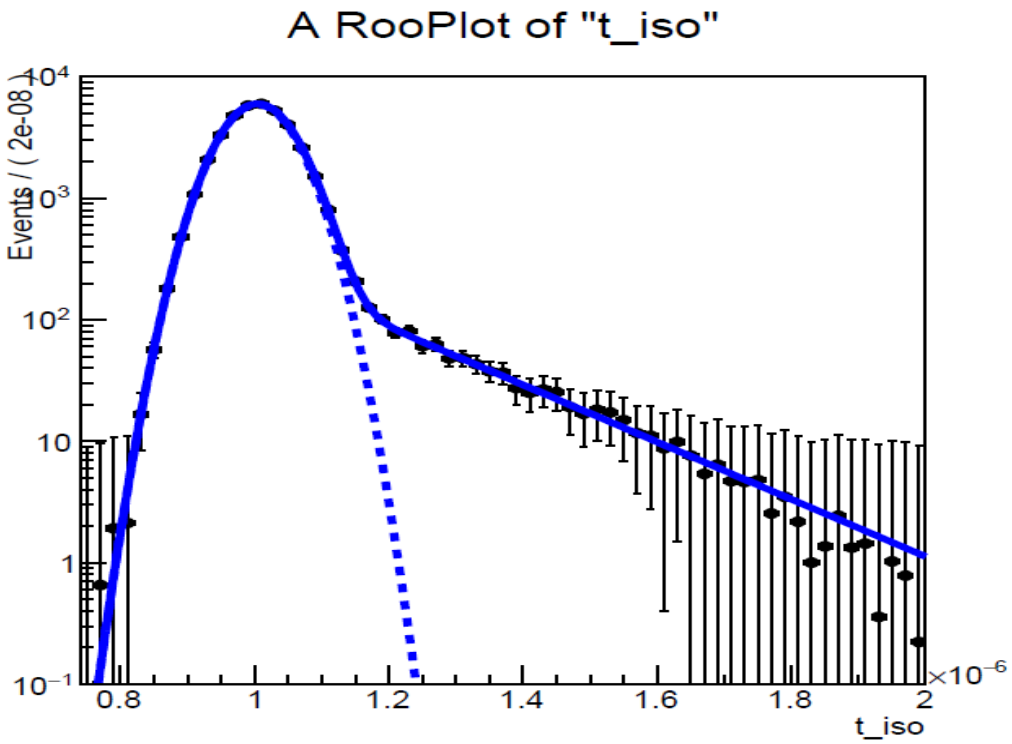
σ_t = 50ns; σ_x = 2mm; σ_y = 3mm,# =20,000,000

Left) chi2 = 0.39; tau = (1.98 +-0.13)e-7

Right) chi2 = 0.39; tau = (2.03 +-0.11)e-7

Time distribution at PWO detector (det1 +W)



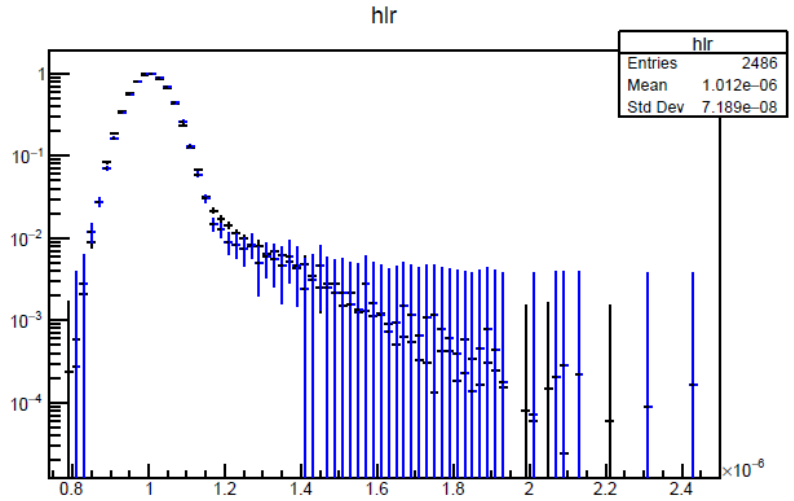


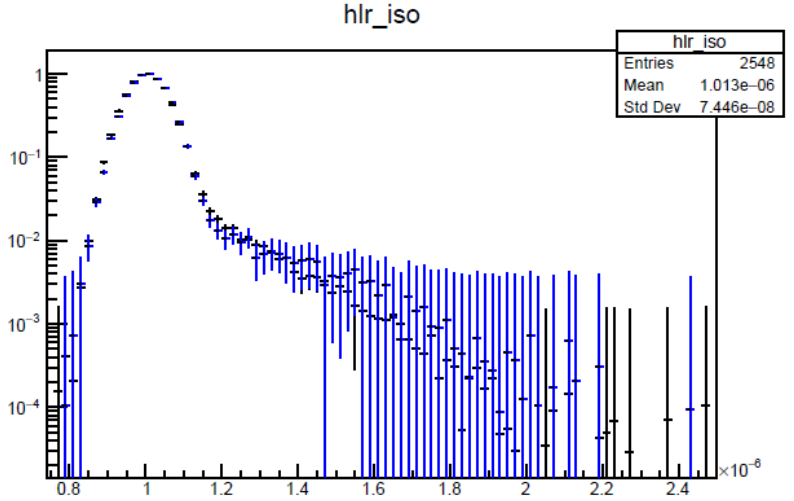
Showing with reduced bin number(1/4) ,# =20,000,000

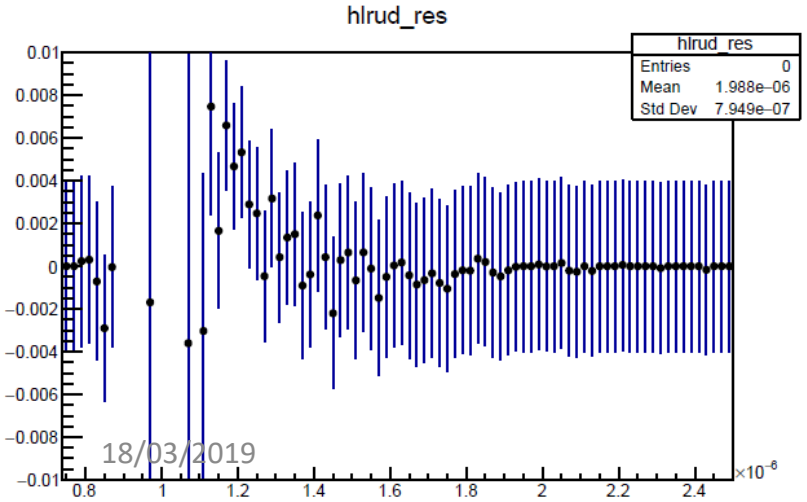
Left) chi2 = 0.26; tau = (1.67 +-0.12)e-7

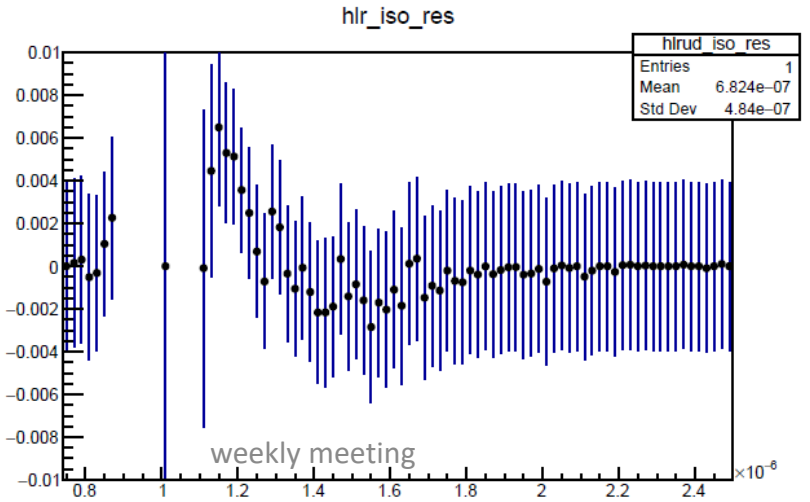
Right) chi2 = 0.26; tau = (1.85 +-0.12)e-7

Det1 signal



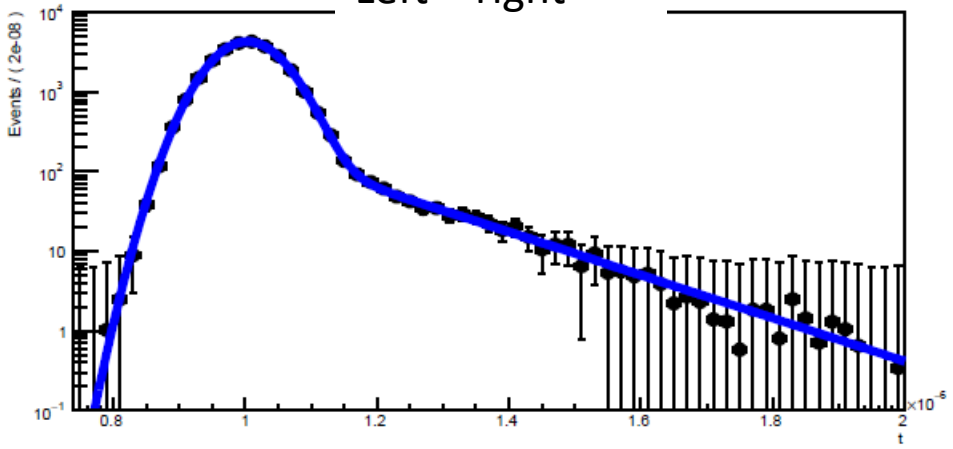




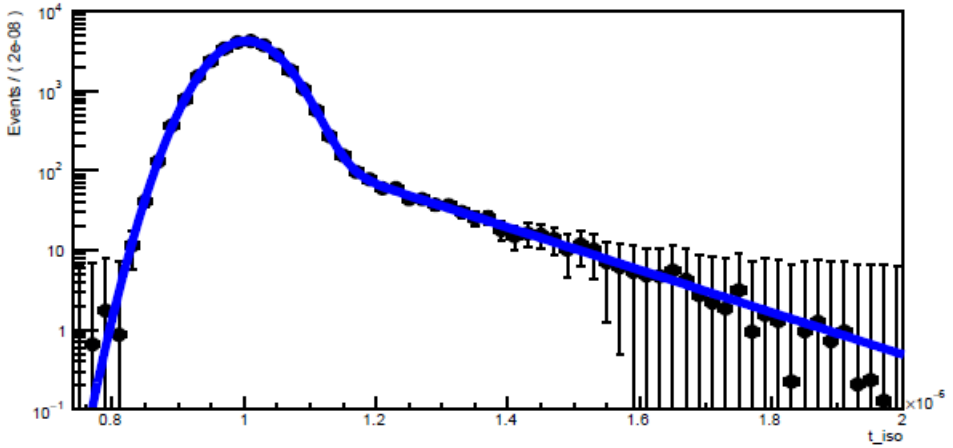


- Upper black : left + right
- Upper blue : up + down
- Lower plots : residual after scaling

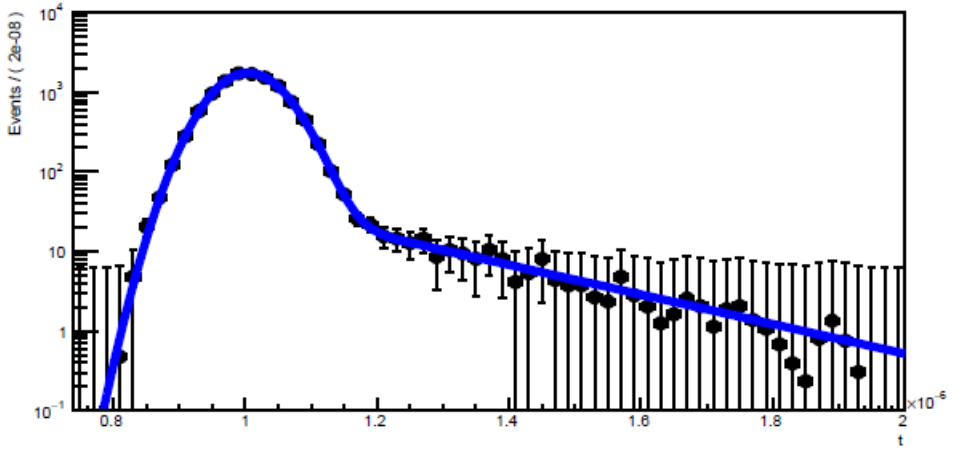
Left + right



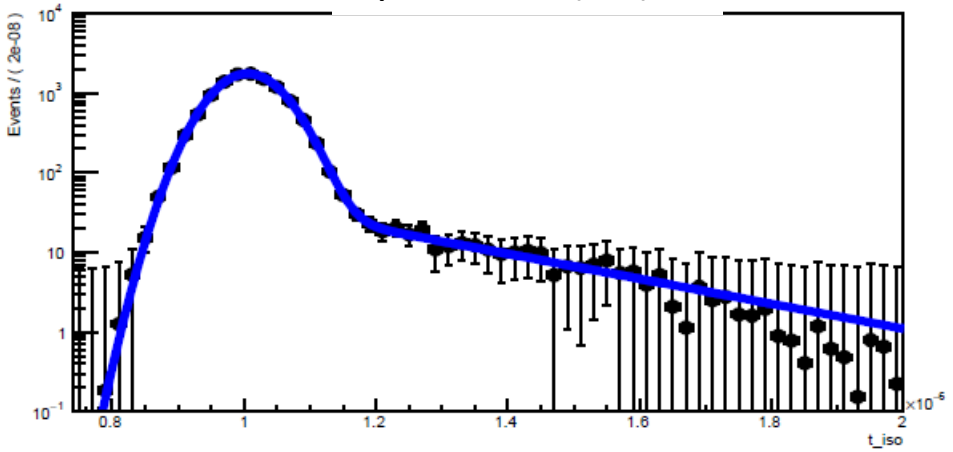
Left + right (iso)



up + down



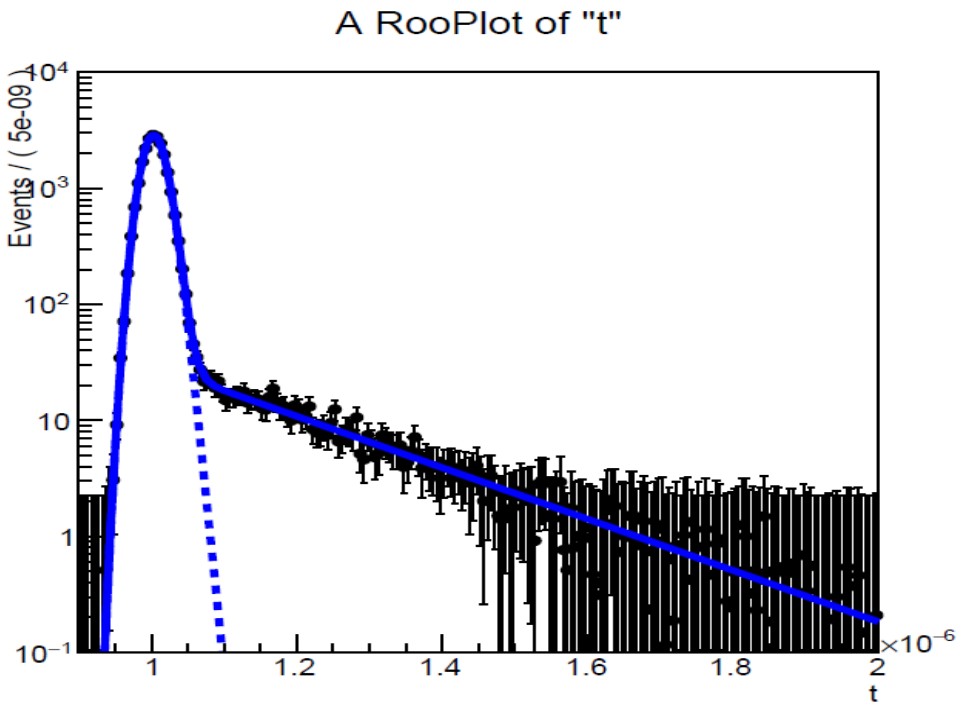
up + down (iso)

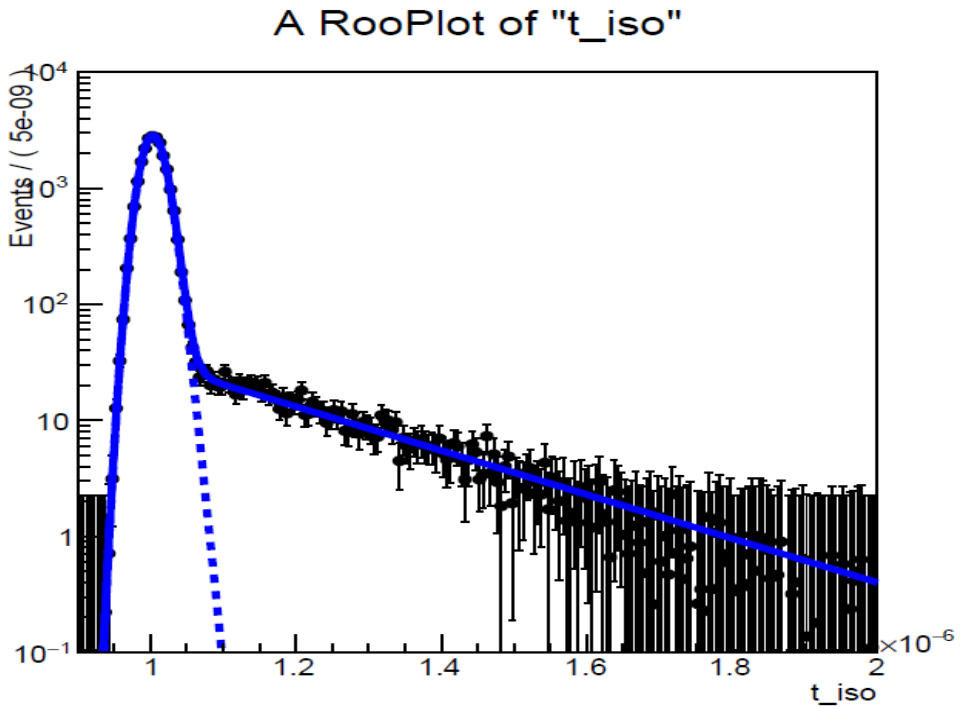


- Tau_lr = 1.63+-0.13e-7, tau_ud = 2.35+0.55e-7
- Tau_lr_iso = 1.63+-0.10e-7, tau_ud_iso = 2.91+-0.53e-7

backup

Time distribution at PWO detector (det0 +W)





Error should be reduced (error is given with mean depE as 0.5MeV)

σ_t = 15ns; σ_x = 2mm; σ_y = 3mm

Left) chi2 = 0.28; tau = (1.96 +-0.08)e-7

Right) chi2 = 0.53; tau = (2.29 +-0.08)e-7

Time distribution at PWO detector (det1 +W)

σ_t = 15ns; σ_x = 2mm; σ_y = 3mm

Showing with reduced bin number(1/4)

Left) chi2 = 0.20; tau = (1.57 +-0.07)e-7

Right) chi2 = 0.29; tau = (1.78 +-0.07)e-7