5Y +1Y analysis with Barrels & Study of Barrels with 1Y

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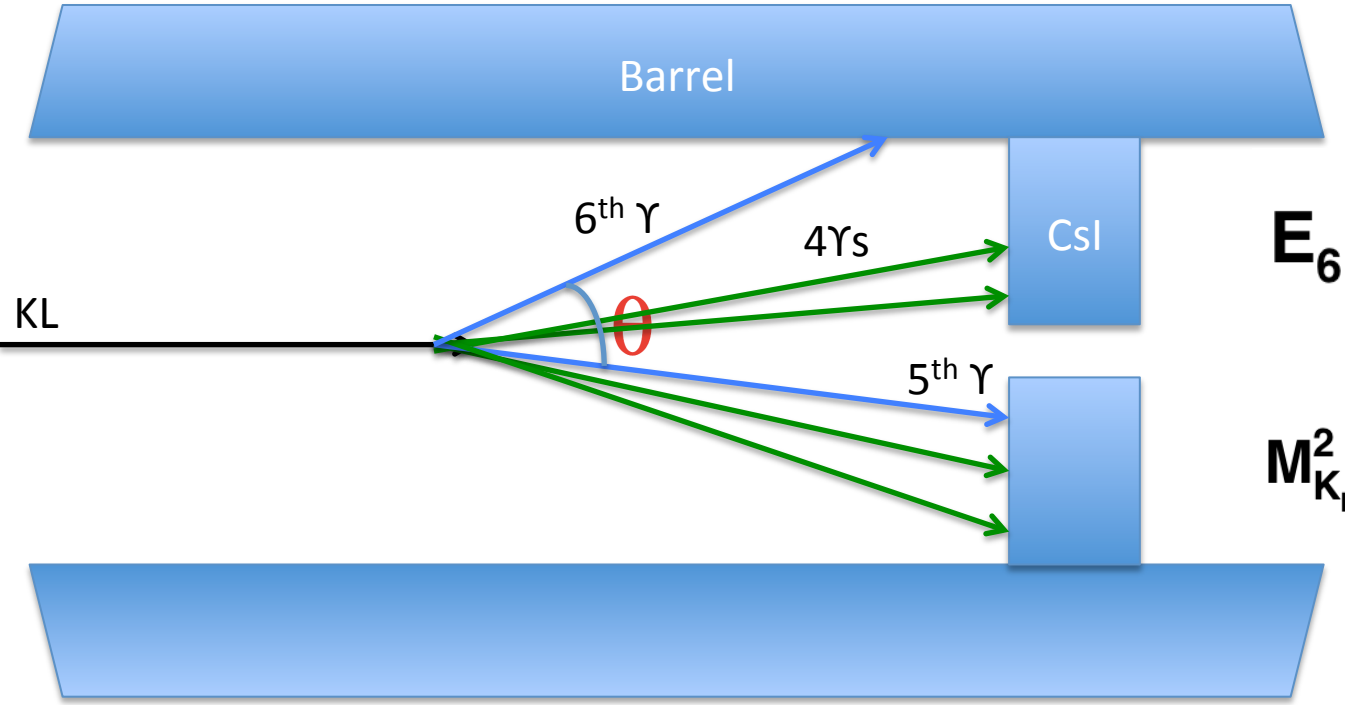
$K_L \to \pi^0\pi^0\pi^0$ Reconstruction Using 5Y on CsI and 1Y on Barrel



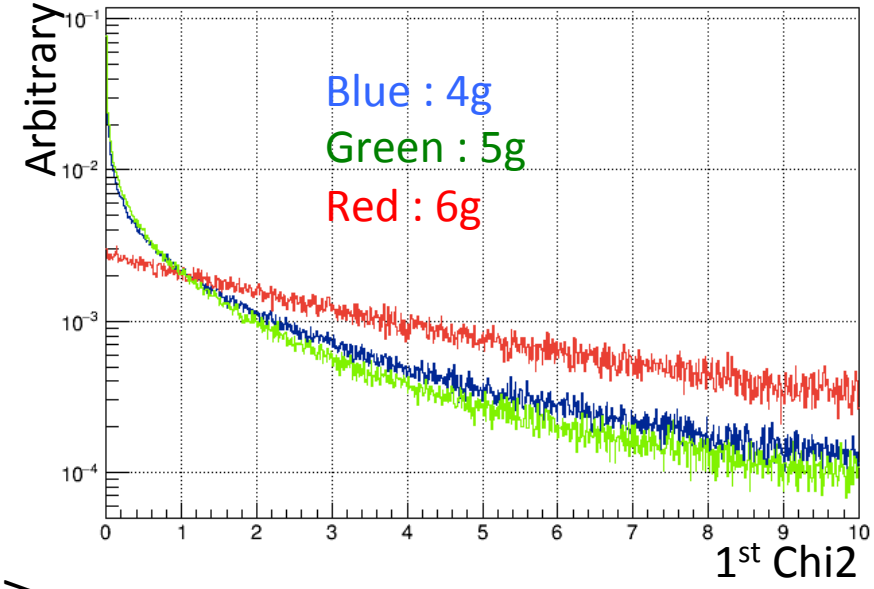
$$E_6 = \frac{M_\pi^2}{2E_5(1-\cos\theta)}$$

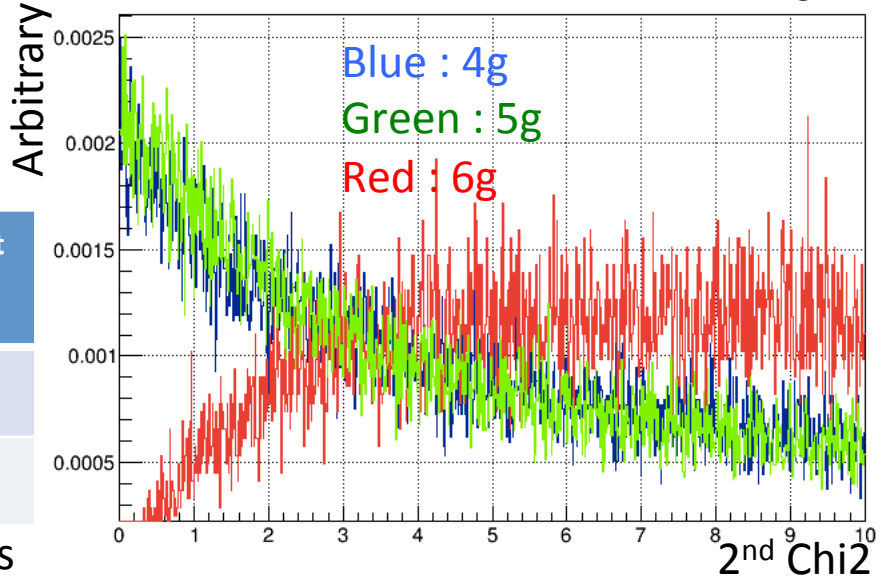
$$M_{K_L}^2 = \left(\sum_{i=1}^{6} E_i\right)^2 - \left(\sum_{i=1}^{6} \vec{p}_i\right)^2$$

- $K_L \to \pi^0\pi^0\pi^0$ decay samples with 5ϒs on CsI and 1ϒ on Barrel
- Reconstruction of $2\pi^0$ from 4ϒs on CsI
- 1ϒ Reconstruction from hit information on Barrel (timing and segment ID)
- Reconstruction of the last π^0 from 1ϒ on CsI and 1ϒ on Barrel

Vertex estimation from 2pi0 Reconstruction

- Behavior of Vertex Chi2 in 5g is same as 4g
- Chi2 Cut in 5g is not so effective as 4g
  - 90% bad pair with 5th γ



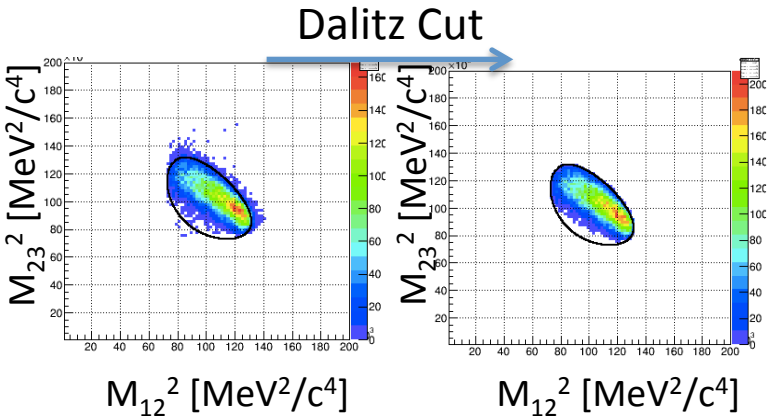


	Bad pair ratio without chi2 cut	Bad pair ratio after 1st chi2 cut(<4)
4g	20%	11%
5g	50%	47%

Without unknown 20% events

Cuts

- Dalitz Cut
  - Graphical cut about phase space of three body decay

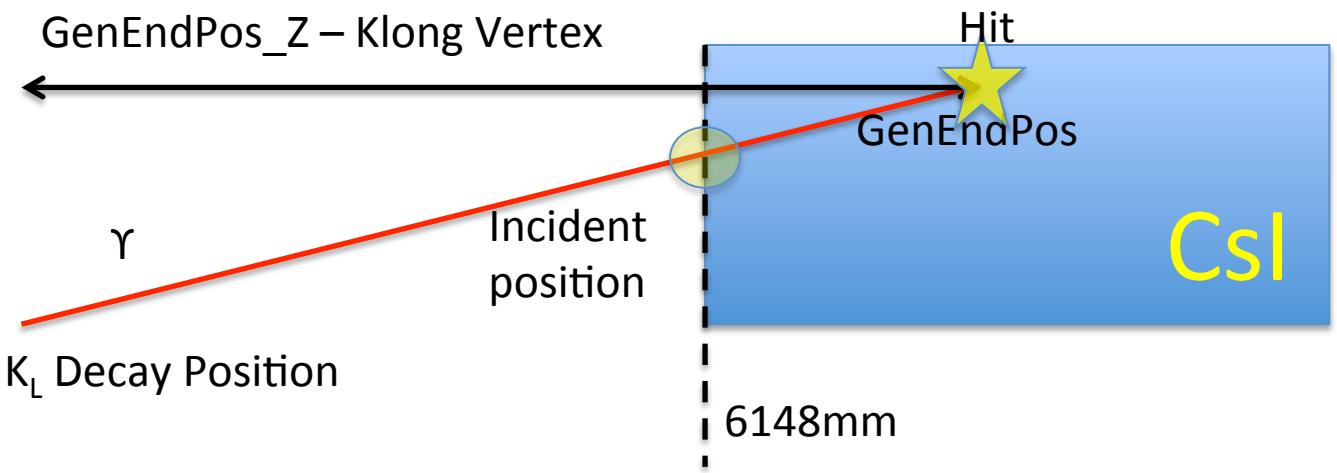


Cut Variables	Selected region
Klong Vertex	2500<VTZ<5000 [mm]
Gamma Energy on CSI	100<e<2000 [MeV]
Distances btw gammas	D>175 [mm]
Fiducial distance	150<r<900[mm]
Chi2_1st	Chi2<4
Chi2_2nd	Chi2>10
ShapeChi2	Chi2<10
Pi0 mass	Mass difference<5MeV
Difference btw 2pi0 mass	Mass difference<5MeV
Klong Pt	Pt<40[MeV/c]
Dalitz Cut	

Bad Pair Ratio

Minimum Cut

Match of ϒ



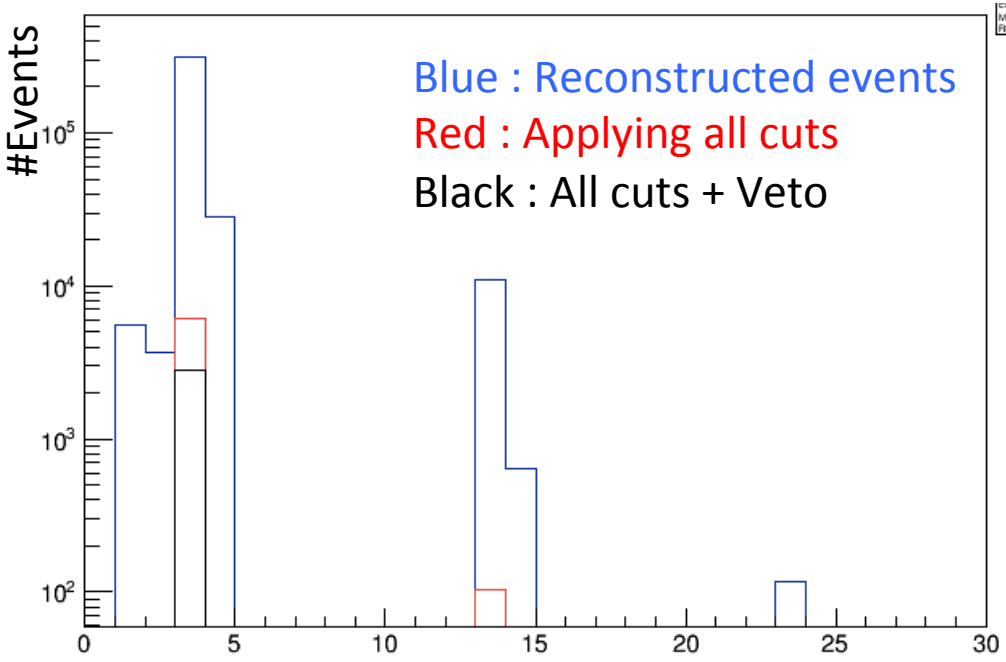
- Calculation of incident position of ϒs
  - IncidentPosition – GammaPos
- One to one match for 5g
  - Match Ratio
  - Match for checking status of pi0 pairing

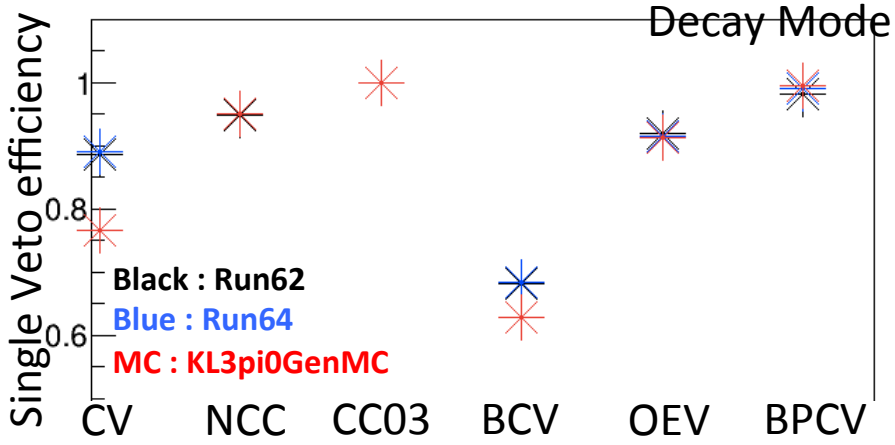
Conditions	Match Ratio	Bad Pair
No cut	79%	50%
Minimum Cut	97.7%	35%
Min. Cut + Pt	98.0%	23%
All Cuts	98.2%	6%

Veto Detectors

Veto Conditions

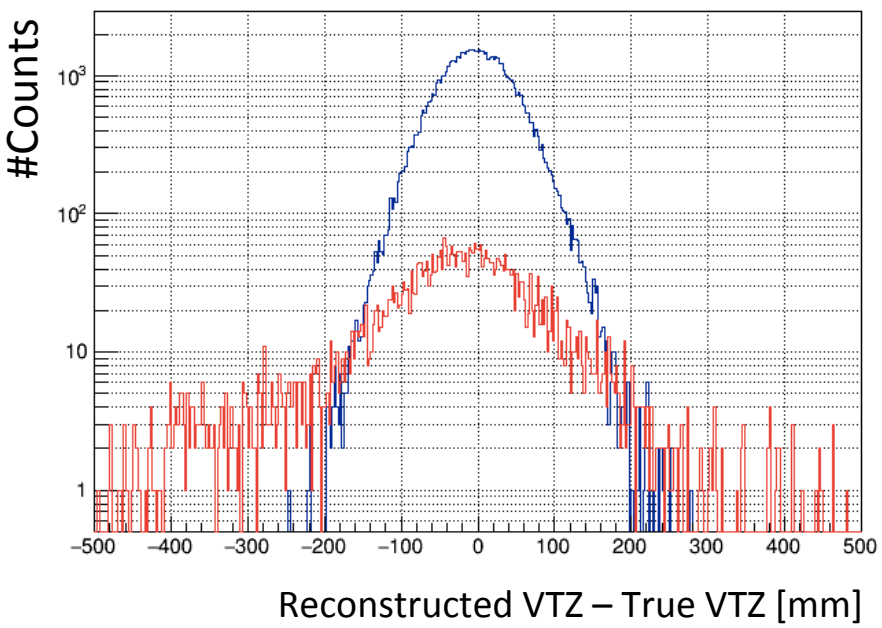
Detector	Time window	threshold
CV	30ns	0.25 [MeV]
NCC	40ns	2 [MeV]
CC03	40ns	3 [MeV]
BCV	50ns	0.5 [MeV]
OEV	70ns	2 [MeV]
BPCV	30ns	2 [MeV]

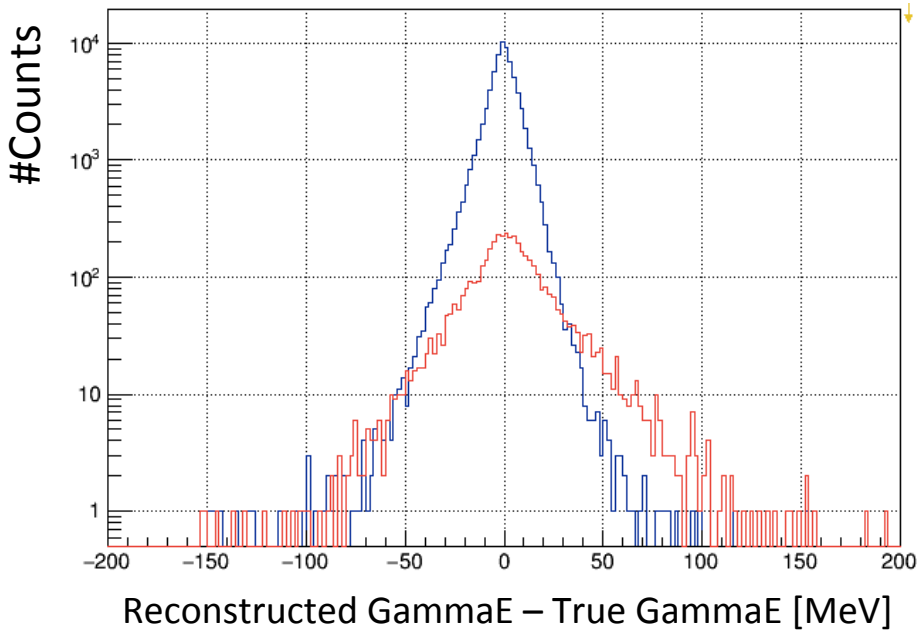




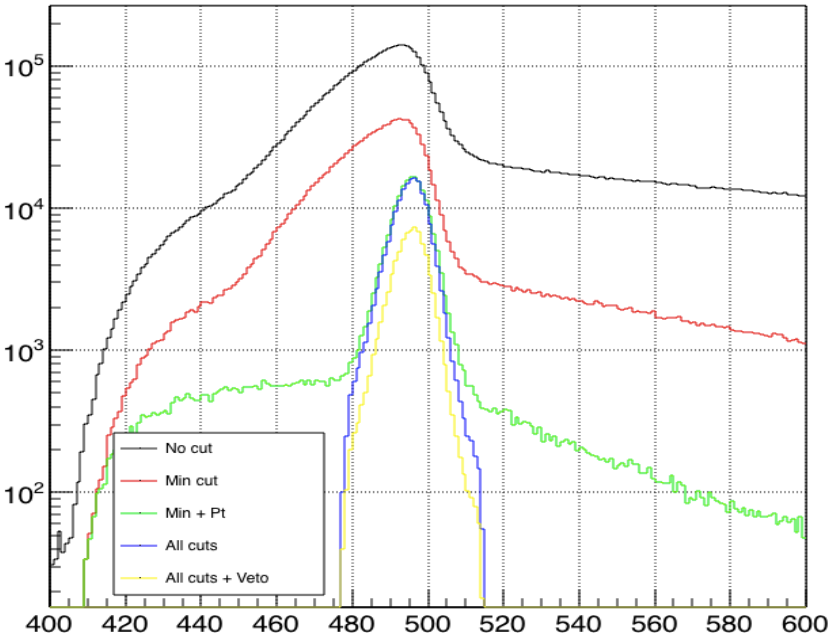
- After applying all Cuts,
  - ~1% Dalitz Decay Event $\mathbf{K_L} \to \pi^0\pi^0\pi^0$ remain.
- After using Detector Veto,
  - Only $\mathbf{K_L} \to \pi^0\pi^0\pi^0$ events remain. (Decay Mode = 3)

Variables after all cuts

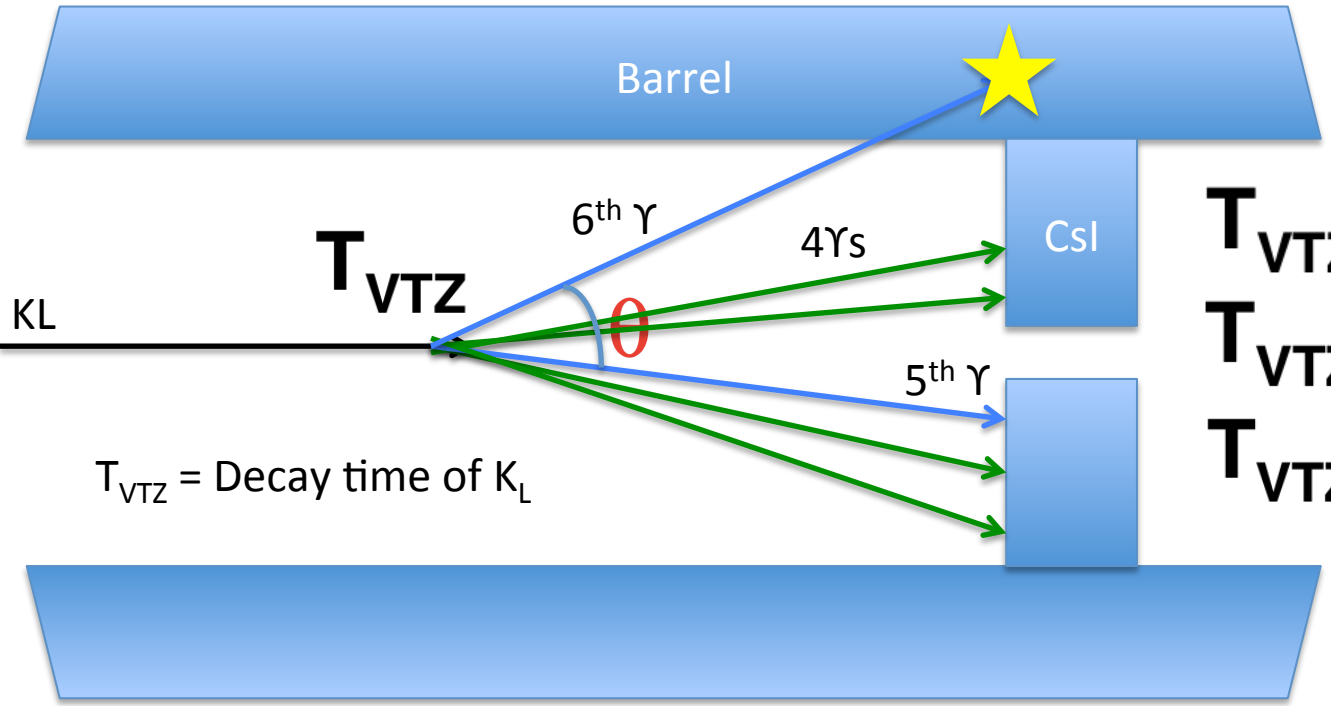




- Reduced bad pair ratio to the 6% level.
  - With ignored 1.8% data
- Clean Mass distribution
- Clean selection of ϒ which goes to Barrel



K_L Vertex Time



$$ToF = \frac{L}{c}$$

L : path length of photons

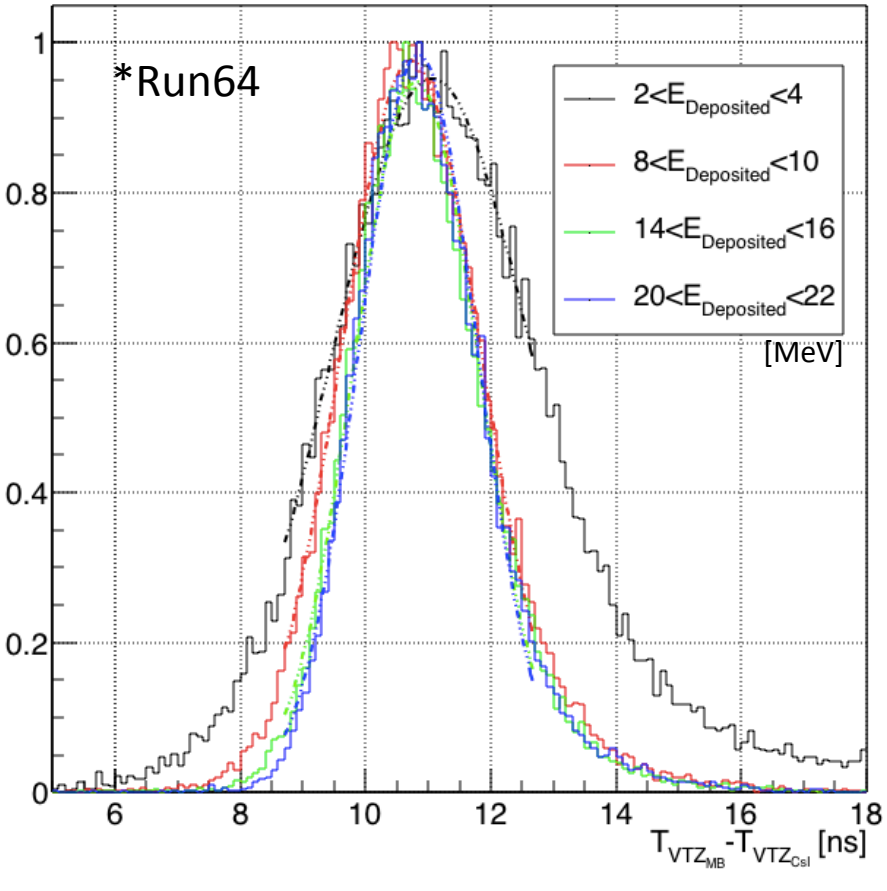
$$T_{VTZ_B} = T_{Barrel} - ToF$$

$$T_{VTZ_C} = T_{CsI} - ToF$$

$$T_{VTZ_B} = T_{VTZ_C}$$

- Estimation of decay time of K_L using Barrel Detector and CsI Detector independently
  - With clean ϒ going to Barrel

Spectra. & Fitting



Entries	27426
Mean	11.36
RMS	1.953
χ^2 / ndf	0.05763 / 37
Prob	1
Constant	0.9522 ± 0.2389
Mean	11.06 ± 0.53
Sigma	1.617 ± 0.711

Entries	32418
Mean	10.86
RMS	1.298
χ^2 / ndf	0.05593 / 37
Prob	1
Constant	0.9767 ± 0.2610
Mean	10.73 ± 0.27
Sigma	1.113 ± 0.287

Entries	31757
Mean	10.94
RMS	1.181
χ^2 / ndf	0.1342 / 37
Prob	1
Constant	0.9481 ± 0.2623
Mean	10.81 ± 0.25
Sigma	0.9944 ± 0.2316

Entries	26230
Mean	10.99
RMS	1.139
χ^2 / ndf	0.1437 / 37
Prob	1
Constant	0.9842 ± 0.2691
Mean	10.84 ± 0.23
Sigma	0.9409 ± 0.2025

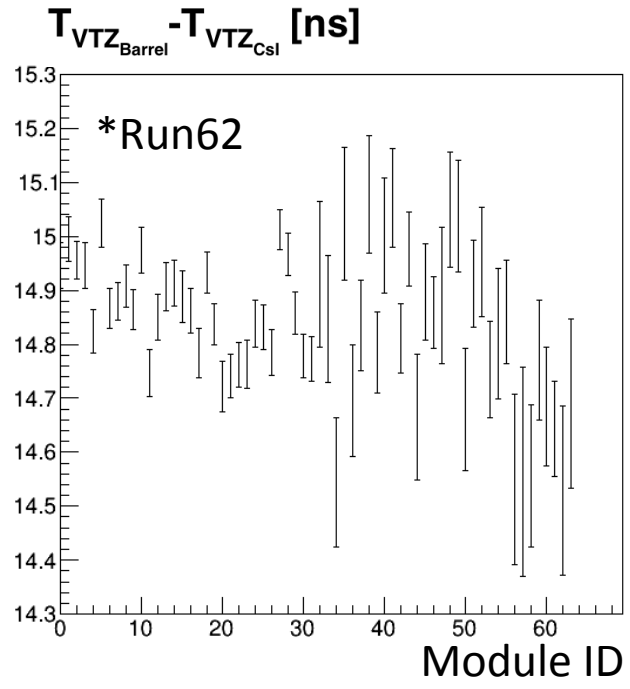
- Fitted with Gaussian
  - Mean : Offset
  - Sigma : Time Resolution affected by CsI and Barrel

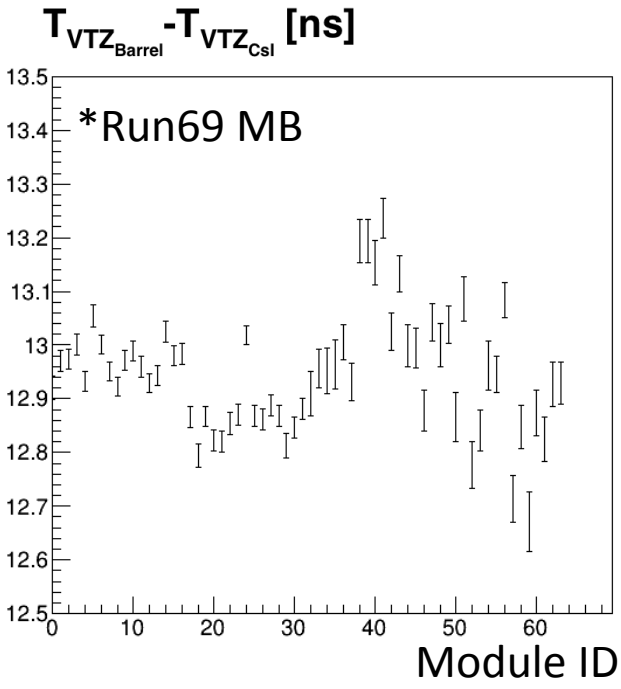
$$T_{VTZ_B} - T_{VTZ_C} = \text{Offset}$$

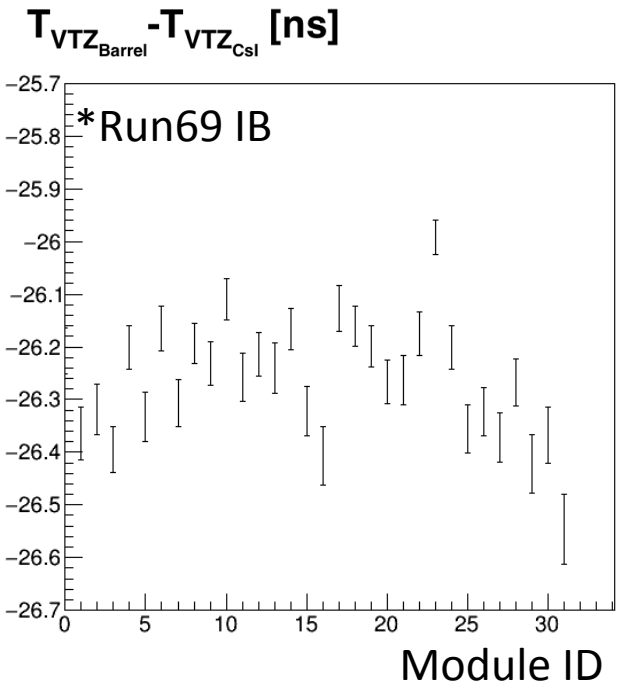
$$\delta(\text{Offset}) = \sqrt{\delta T^2_{VTZ_B} + \delta T^2_{VTZ_C}}$$

- All modules are integrated
- Deposited energy on Barrel affects Vertex Time Difference distribution

Module consistency

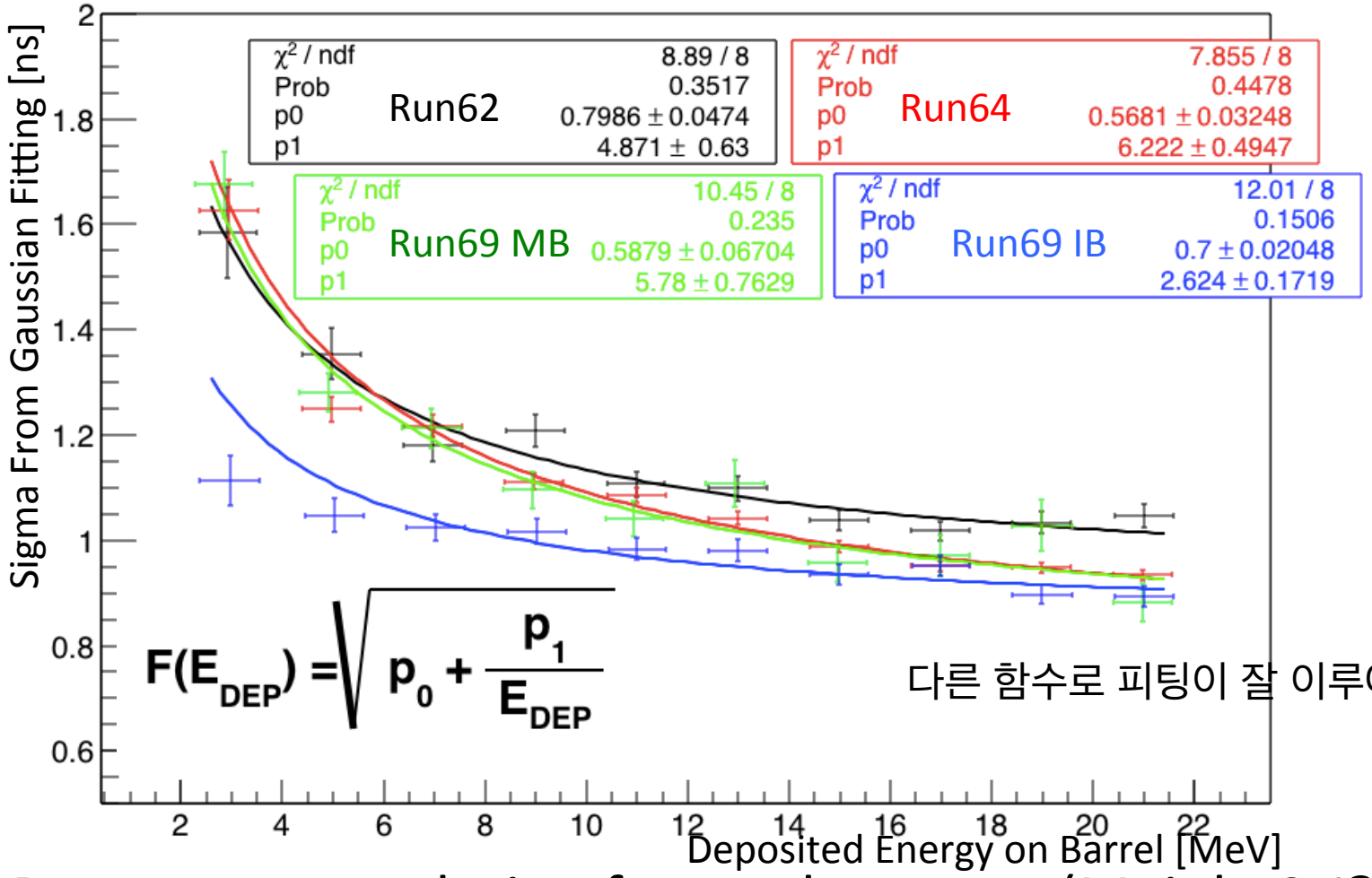






- Evaluation of Barrel Calibration from Fitting of Vertex Time Difference distributions
- Outer Main Barrel has worse quality calibration
  - Modification using this Vertex Time Difference?

Resolution of Time Vertex Difference & Evaluation of Barrel Time Resolution



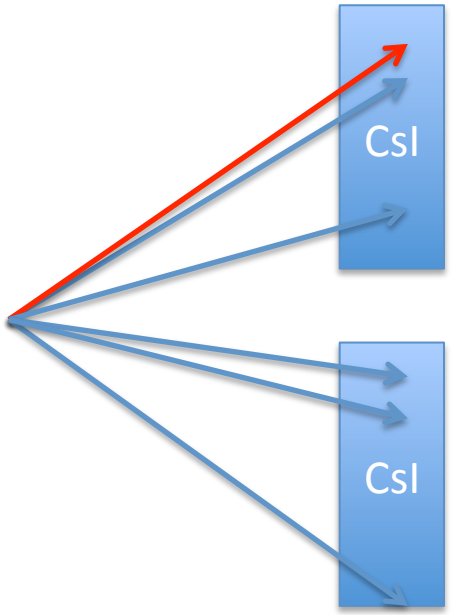
다른 함수로 피팅이 잘 이루어지지 않음

- P_0 presents resolution from other terms(Mainly CsI?)
- P_1 presents resolution of Barrel with $\sigma_{Barrel} \sim \frac{1}{\sqrt{E_{DEP}}}$

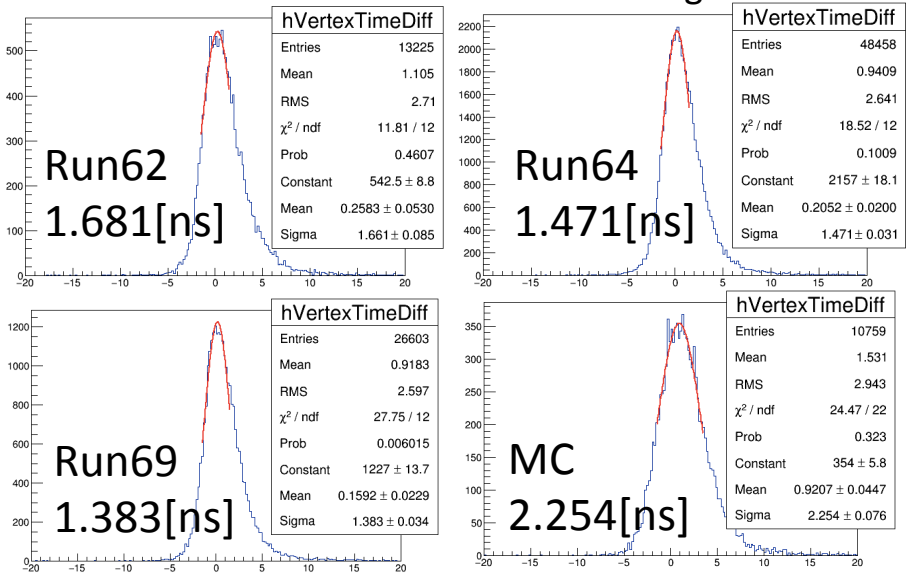
Vertex Time Difference at g6 Analysis

- As 5g+1g analysis, Vertex time differences could be calculated at g6 analysis.
  - Gamma which has highest energy among 6 gammas is selected as 6th gamma

Highest energy selection (Red Cross)



Data Set
Sigma of Gaussian

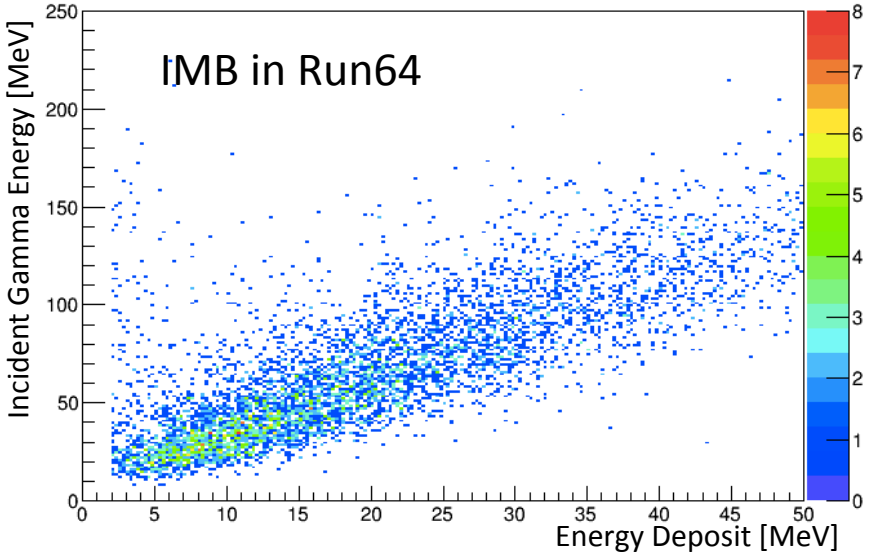


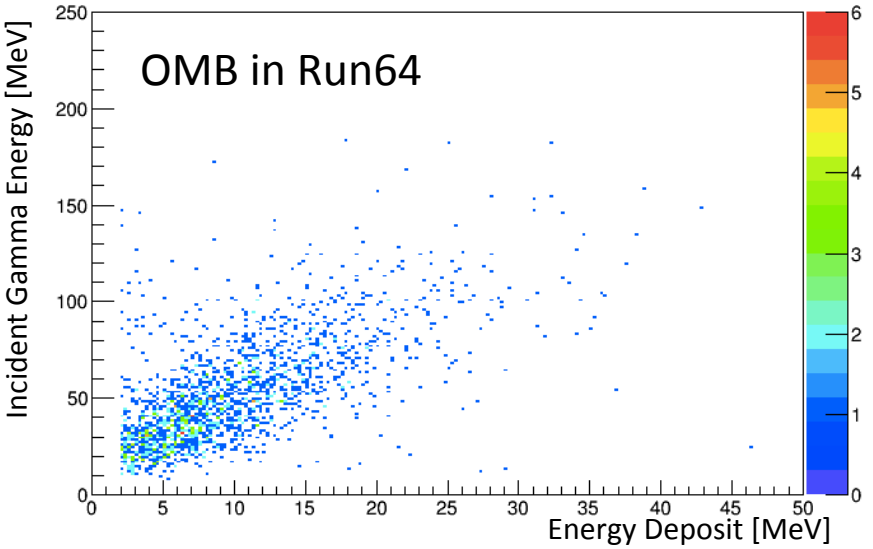
$T_{VTZ_B} - T_{VTZ_C} = \text{Offset}$

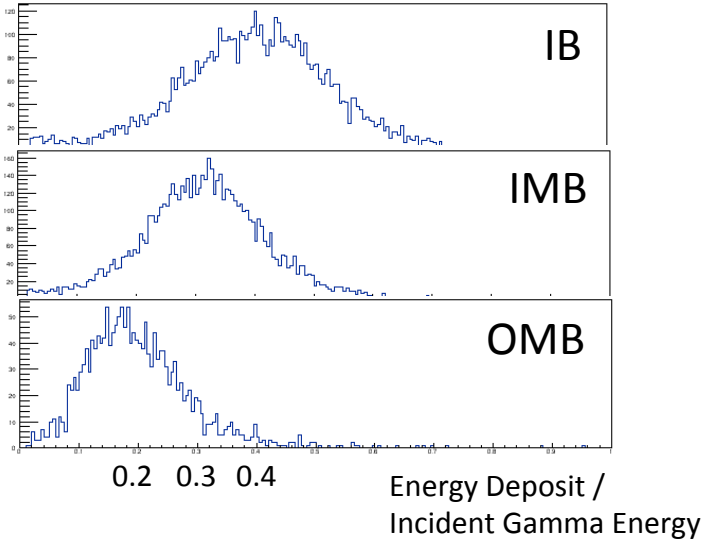
$T_{VTZ_{6^{th}}} - T_{VTZ_C} = \text{Offset}$

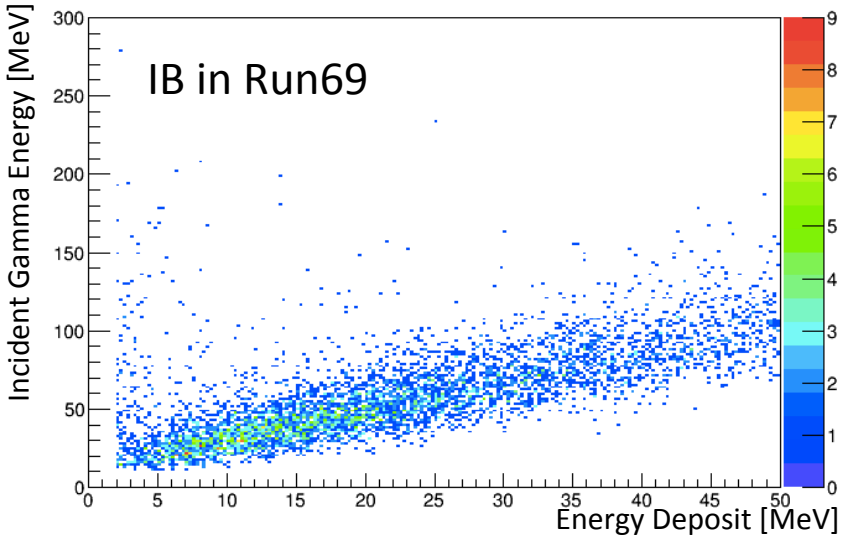
- Is it relate to fit parameter 'P_0'?

Deposited energy & Incident gamma energy









Comparison with MC
Vertex Time Difference

Module consistency

Energy distribution vs time resolution

Comparison with MC
Sampling Fraction check

No Reflector in MC

Summary

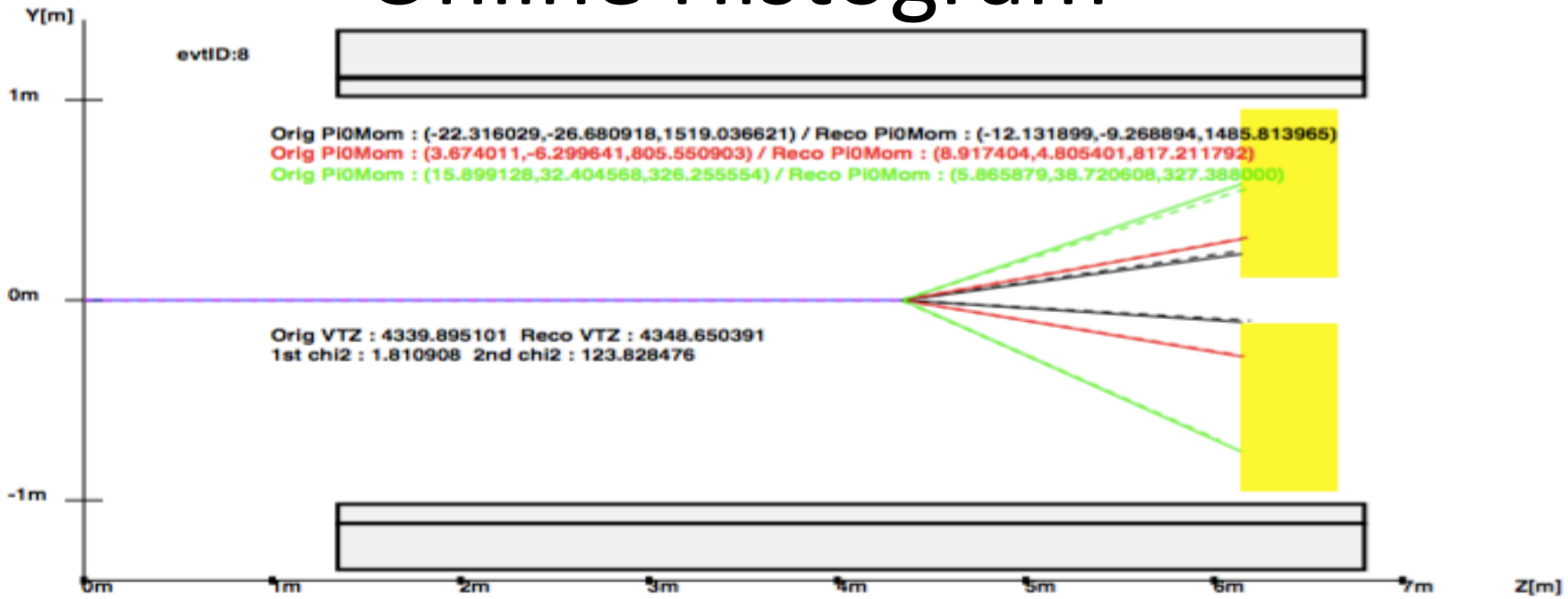
- 5g+1g analysis is done with ~6% mis-pairing of pi0s
  - We can choose gamma incident barrel events
- Time Resolution of Barrel with the function of energy deposit is firstly evaluated
  - The energy-independent term of Barrel time resolution is ignored

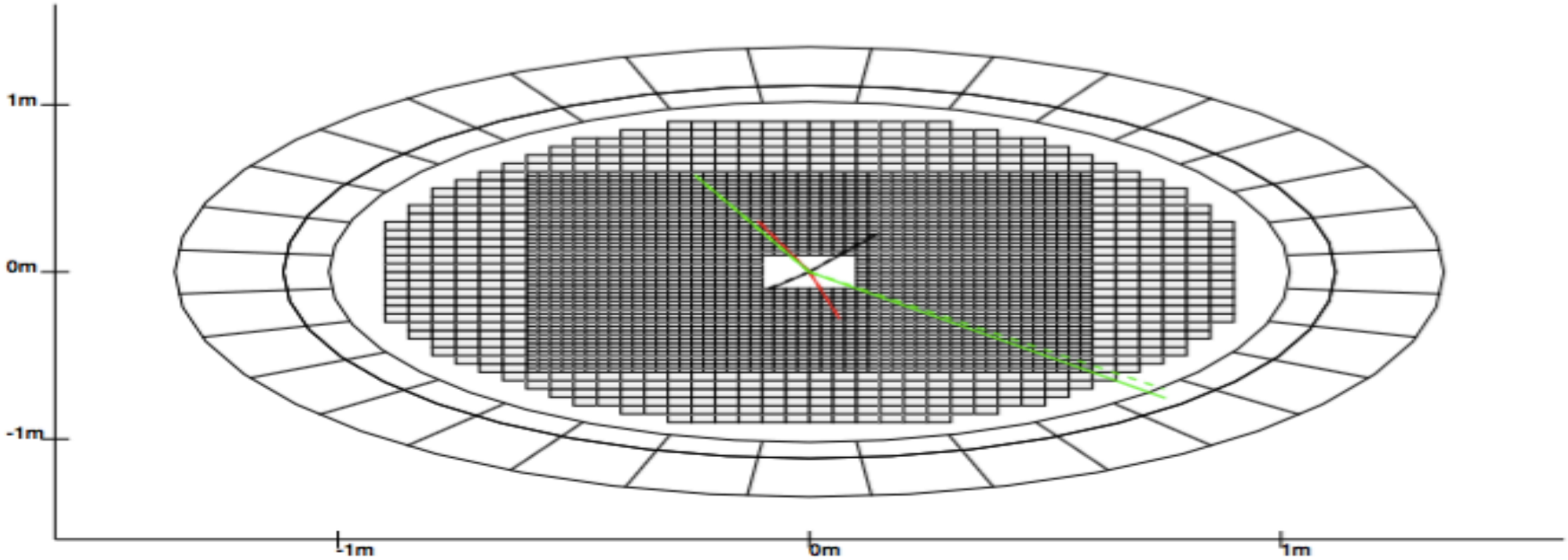
$$\sigma_{Barrel} = P_1 + \frac{P_2}{\sqrt{E_{dep}}}$$

  - We can check Quality of Barrel Calibrations through 6^{th} gamma.
- Sampling Fraction

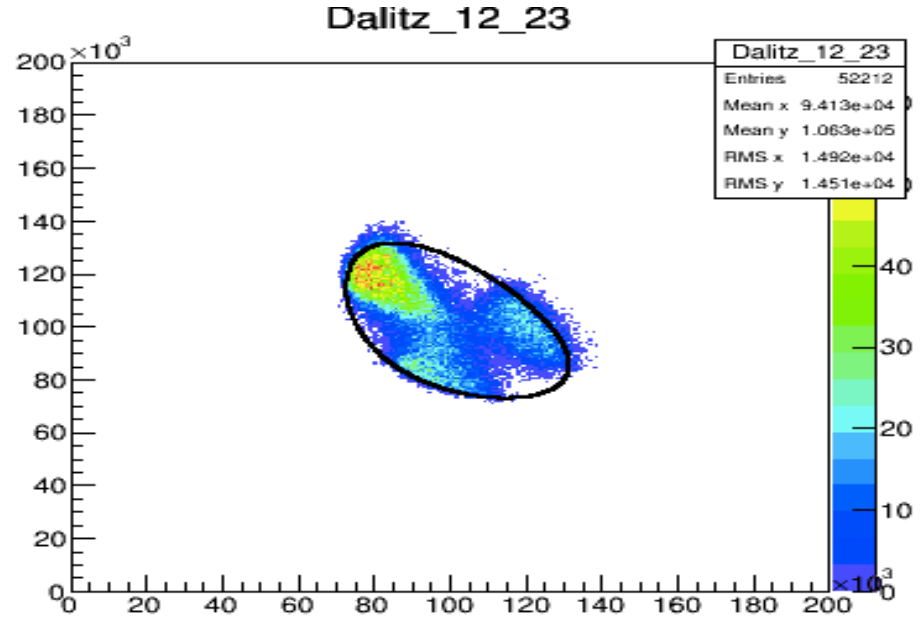
Back up

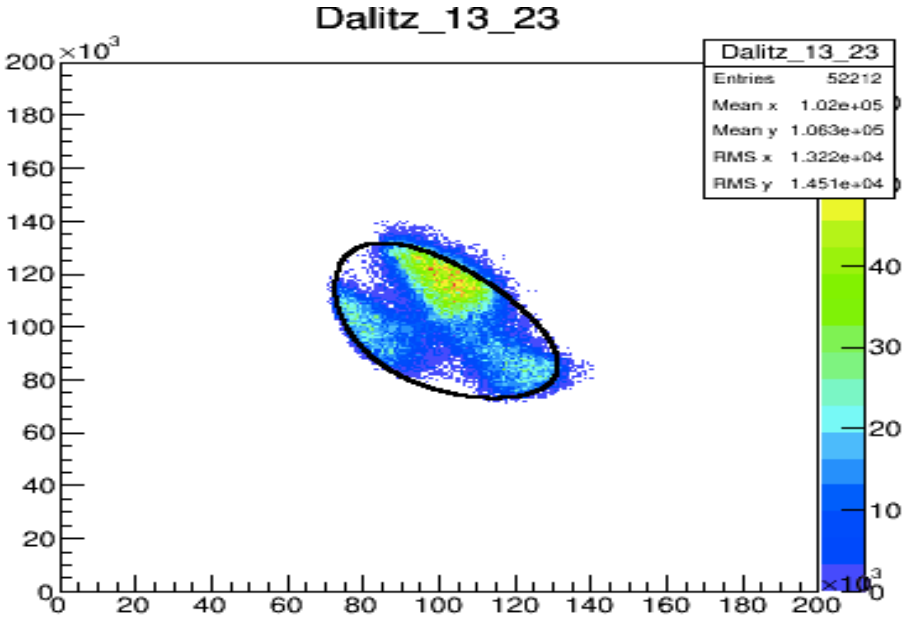
Online Histogram

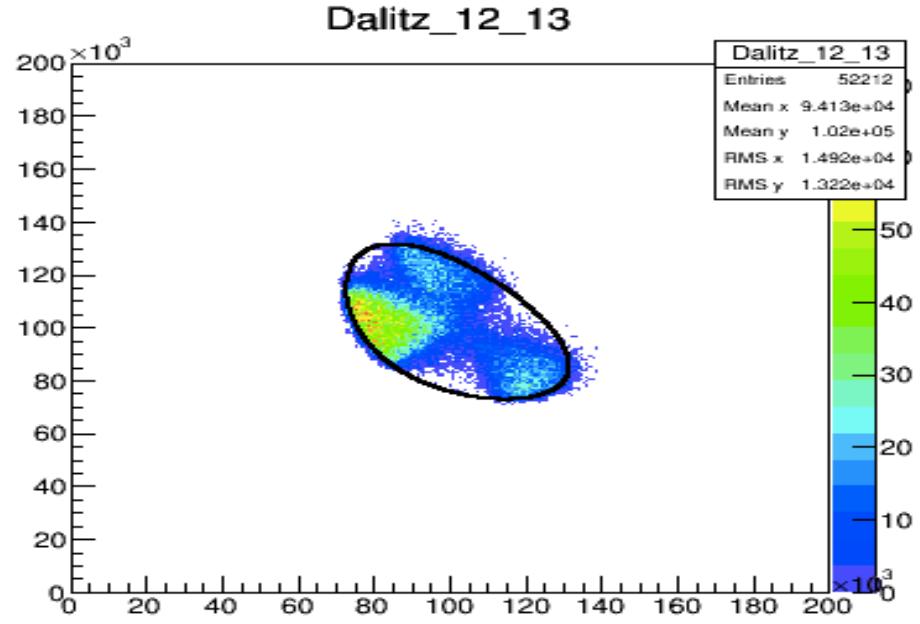


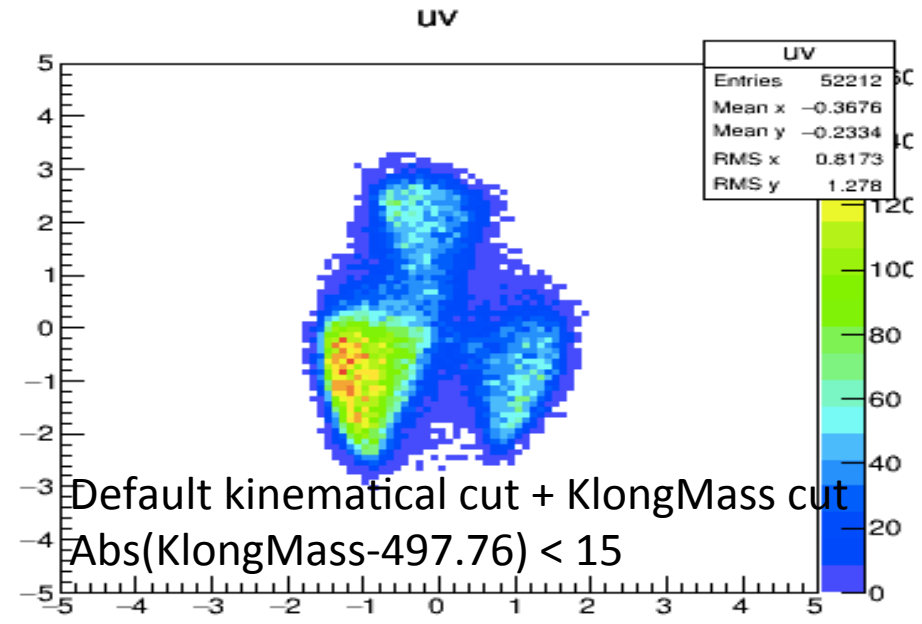


Phase space in 6g









Default kinematical cut + KlongMass cut

Abs(KlongMass-497.76) < 15

6g Vertex Time difference