Gamma time calibration

Elvis Penghui Li

Motivation for time calibration

Motivation

The gveto and xwall are not calibrated for cable length

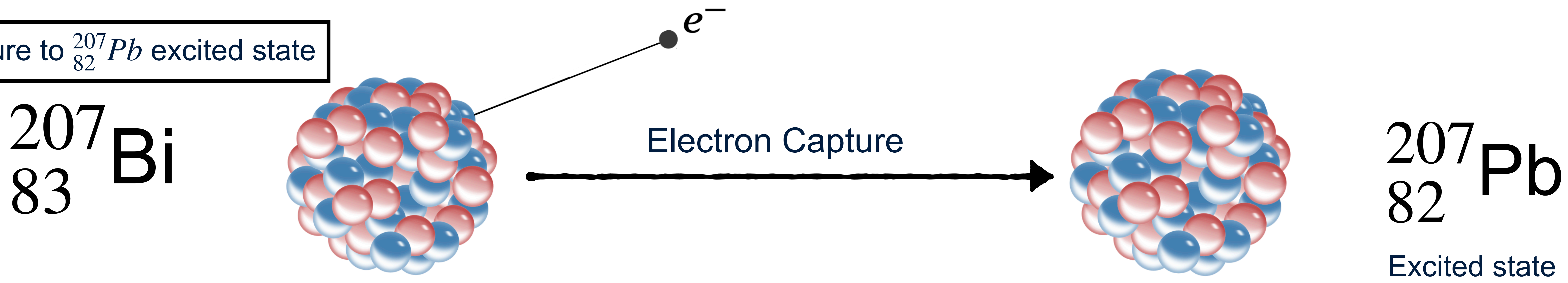
Currently we only have time calibration using electron, is it different for γ?

We have good PMT time resolution, we need to use it

Measuring time resolution with ^{207}Bi

^{207}Bi Decay

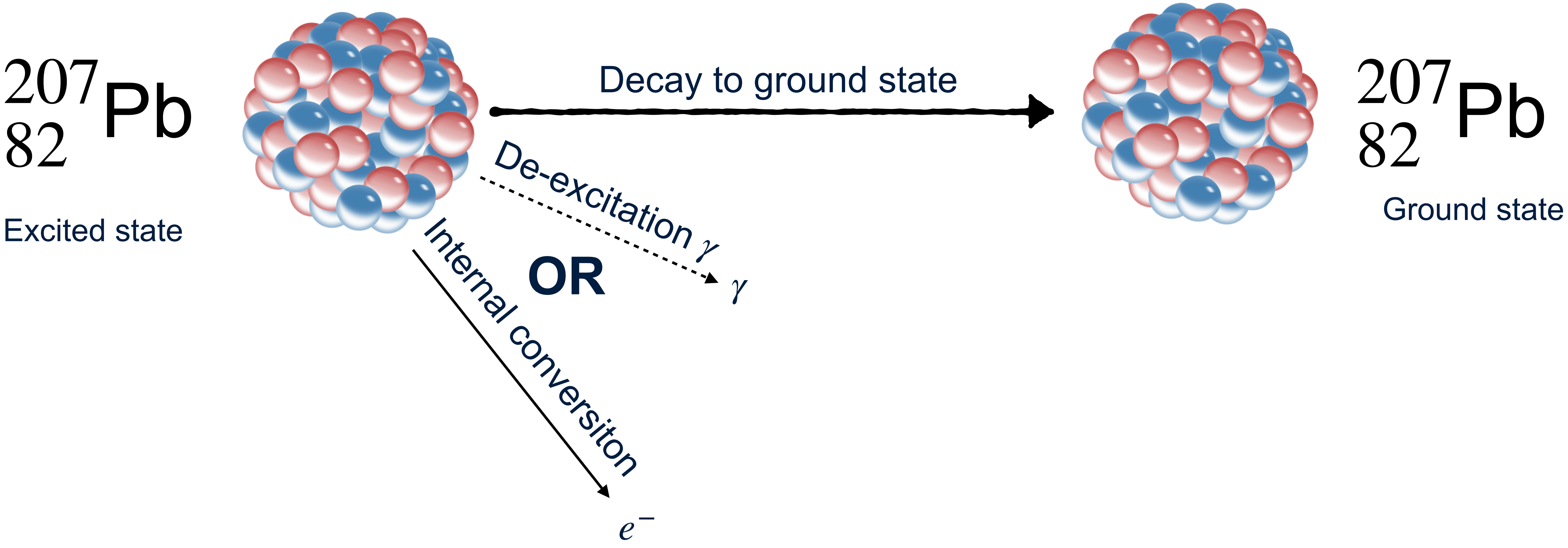
Electron capture to $^{207}_{82}Pb$ excited state



E_{total} = 2339 keV

De-excitation via electron conversion or gamma emission

E_{total} = 2339 keV



^{207}Bi calibration source

Table 1: Decay channels of Bi-207 (De-excitation of Pb-207)

Decay Mode	Decay energy (keV)	Relative Intensity %
Electron Conversion	481.7	1.537%
Electron Conversion	553.8	0.442%
Electron Conversion	565.8	0.111%
Electron Conversion	975.7	7.08%
Electron Conversion	1047.8	1.84%
Electron Conversion	1059.8	0.44%
Electron Conversion	1682.2	0.0238%
Electron Conversion	1754.4	0.0034%
De-excitation Gamma	569.7	97.8%
De-excitation Gamma	1063.66	74.5%
De-excitation Gamma	1770.228	6.87%

1e1γ

E_{total} = 2339 keV

Produce vary e-/γ from 0.5MeV to 1.7MeV.

Characterisation well studied

^{207}Bi calibration source

Why are we interested in those coincident event—gveto cant see electron

1e1γ or
1e2γ

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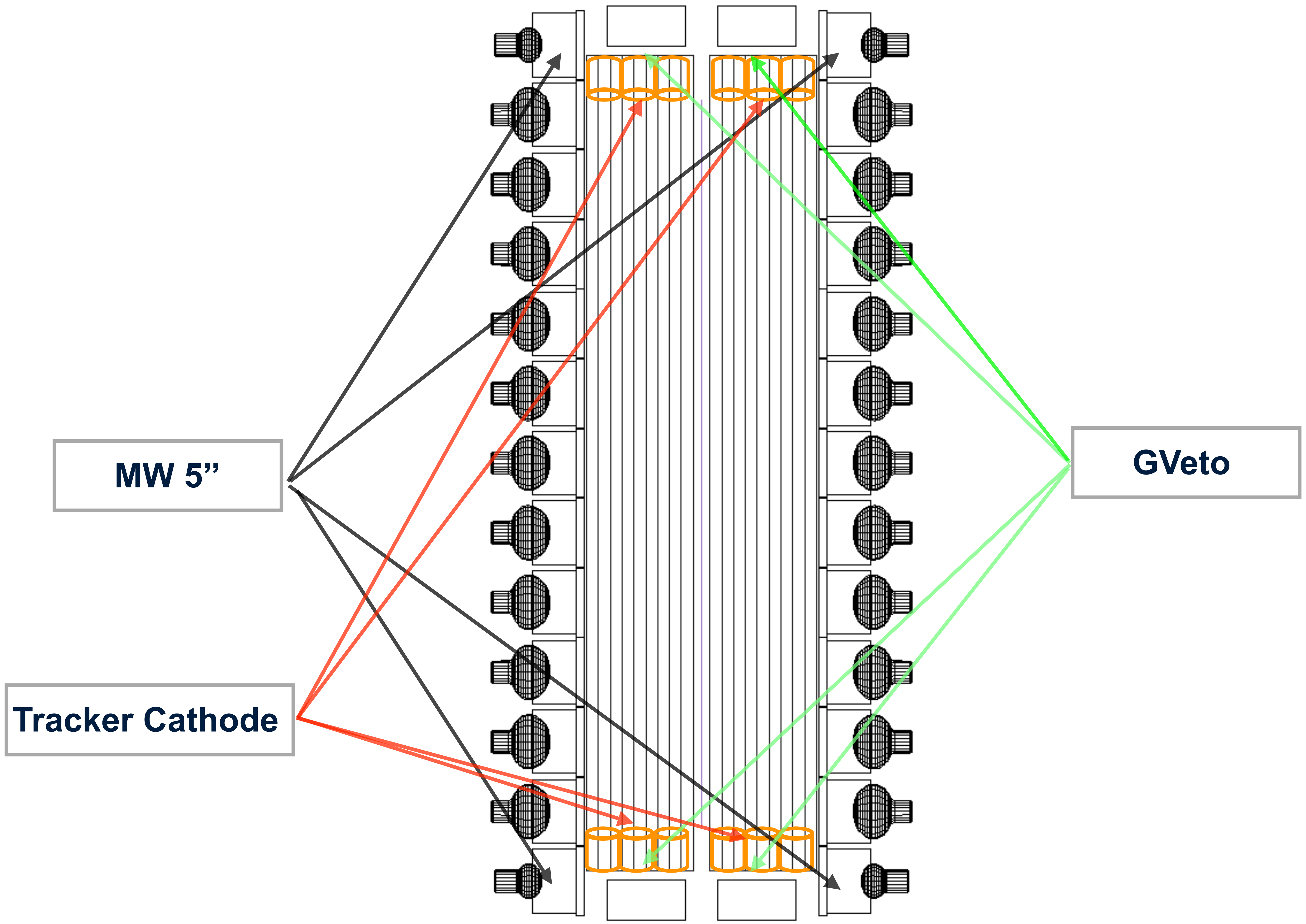
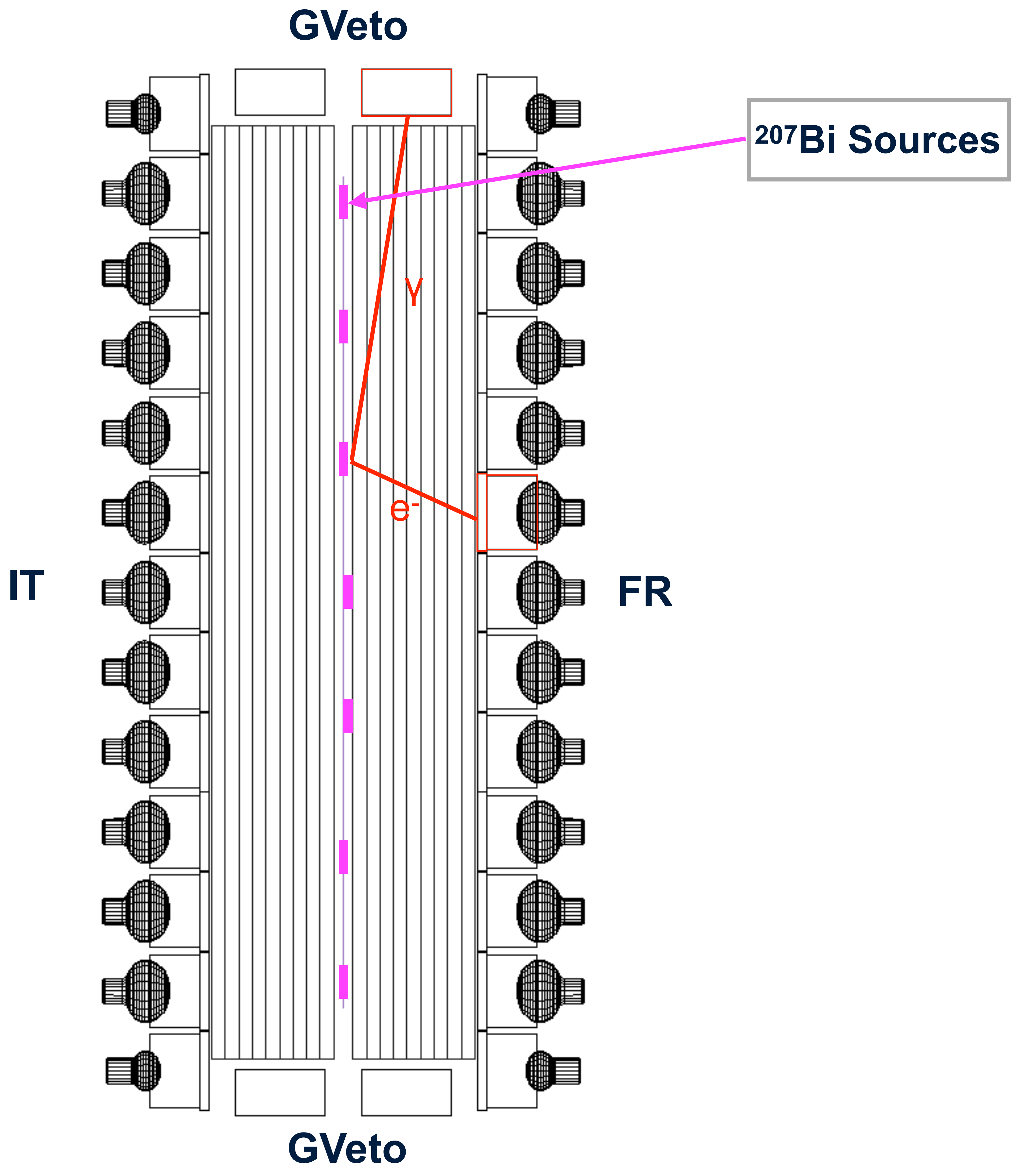
Characterisation well studied

SuperNEMO Calorimeter



Vertex position

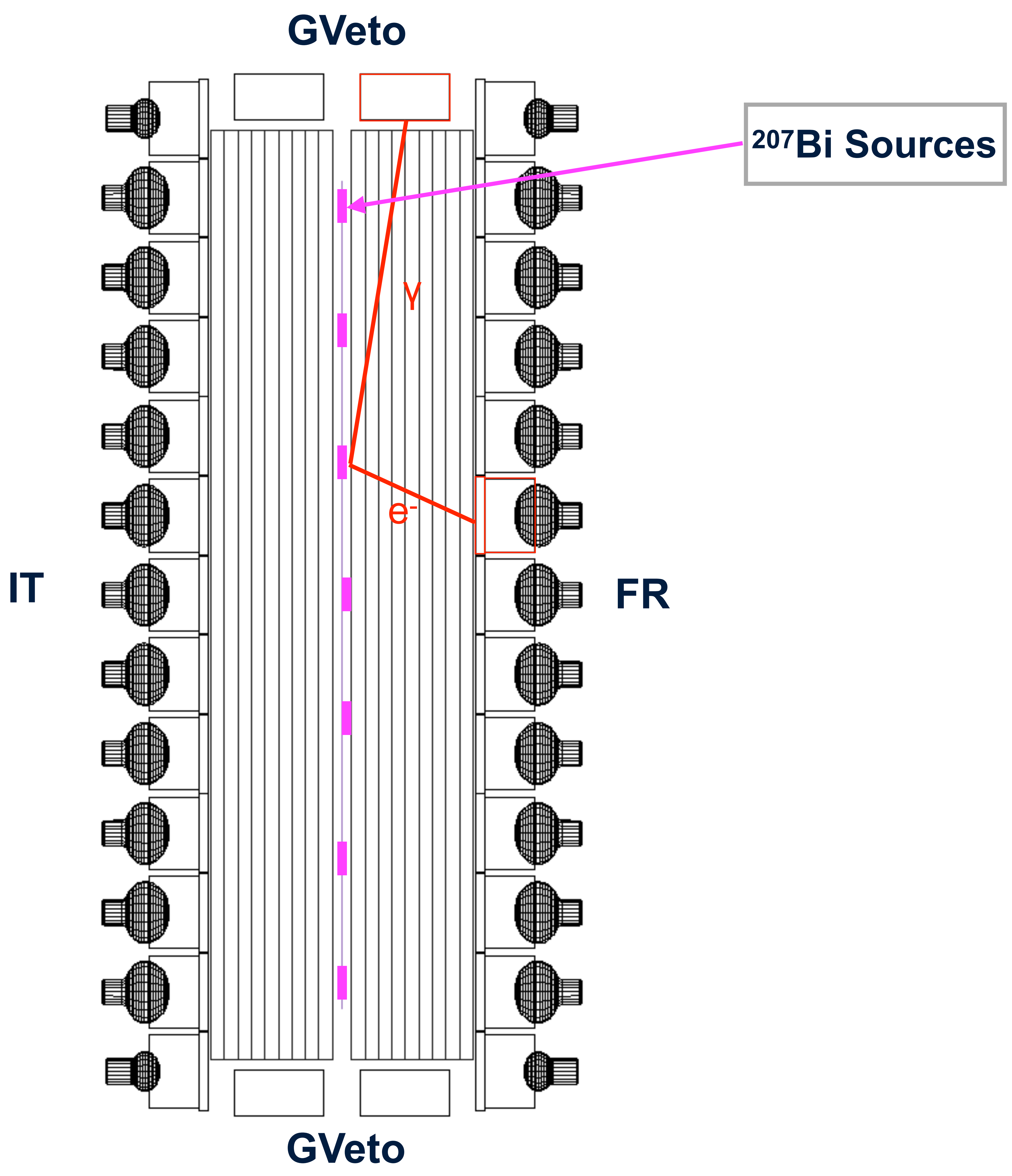
1e1γ coincident event. e⁻ goes to MW, γ goes to GVeto. Trigger on electron



Vertex position

1e1γ coincident event. e⁻ goes to MW, γ goes to GVeto. Trigger on electron

Calculating e⁻ speed from energy and track length



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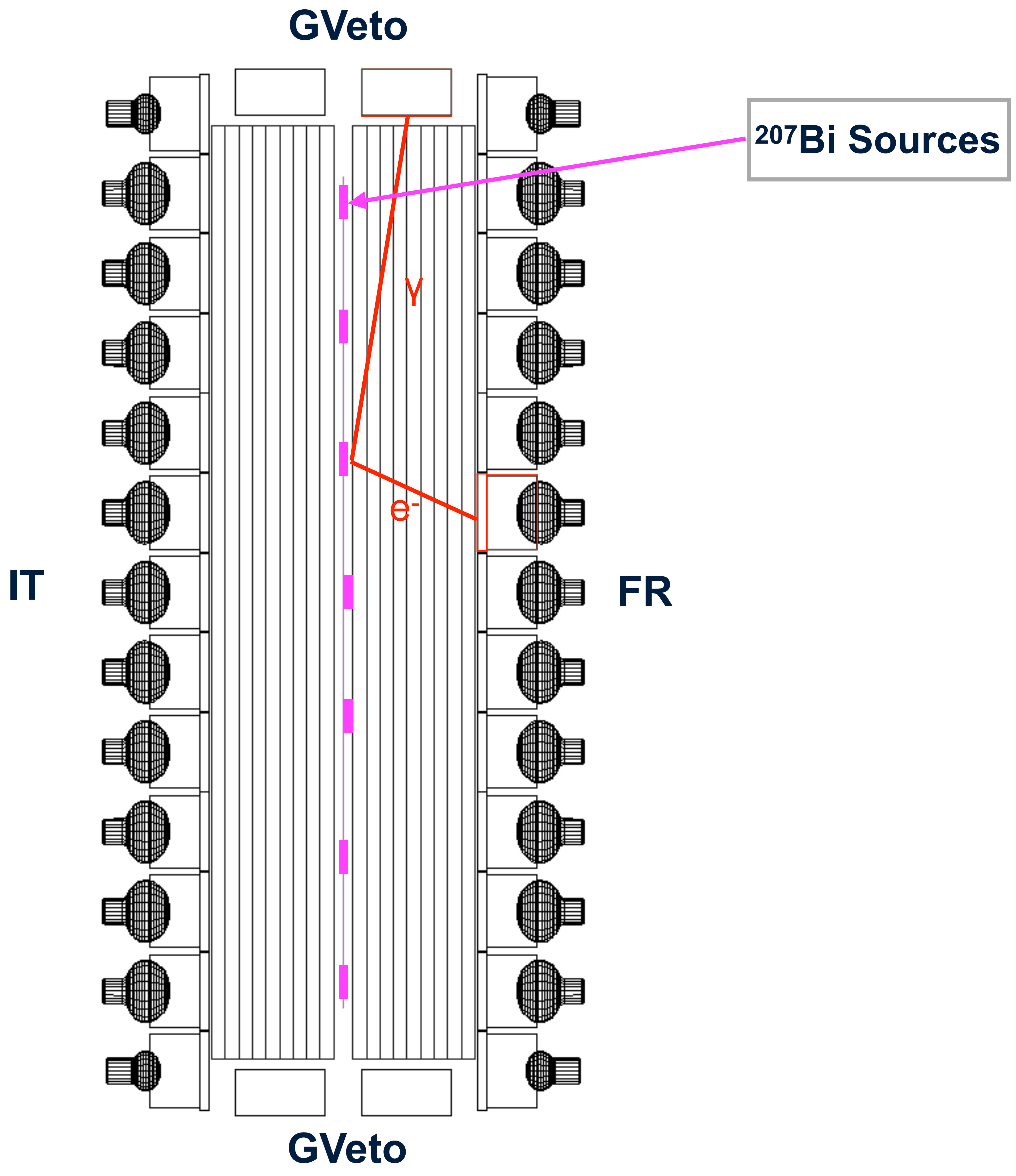
Decay vertex + Decay time



Vertex position

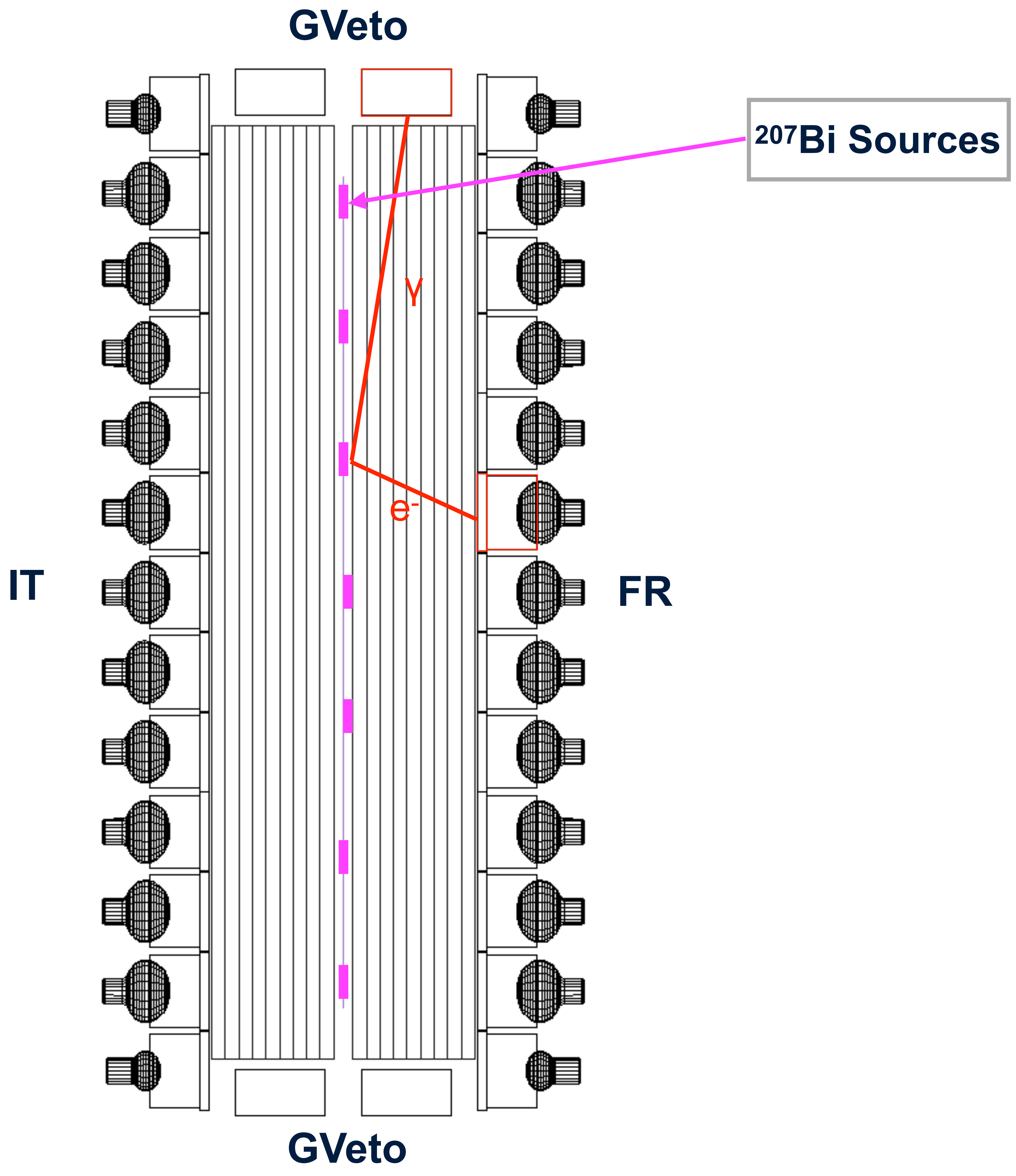
1e1γ coincident event. e⁻ goes to MW, γ goes to GVeto. Trigger on electron

Calculating e⁻ speed from energy and track length

Decay vertex + Decay time

Calculate expected γ arrival time

$$\Delta t_{\gamma} = t_{\gamma,\text{measured}} - t_{\gamma,\text{calculated}}$$

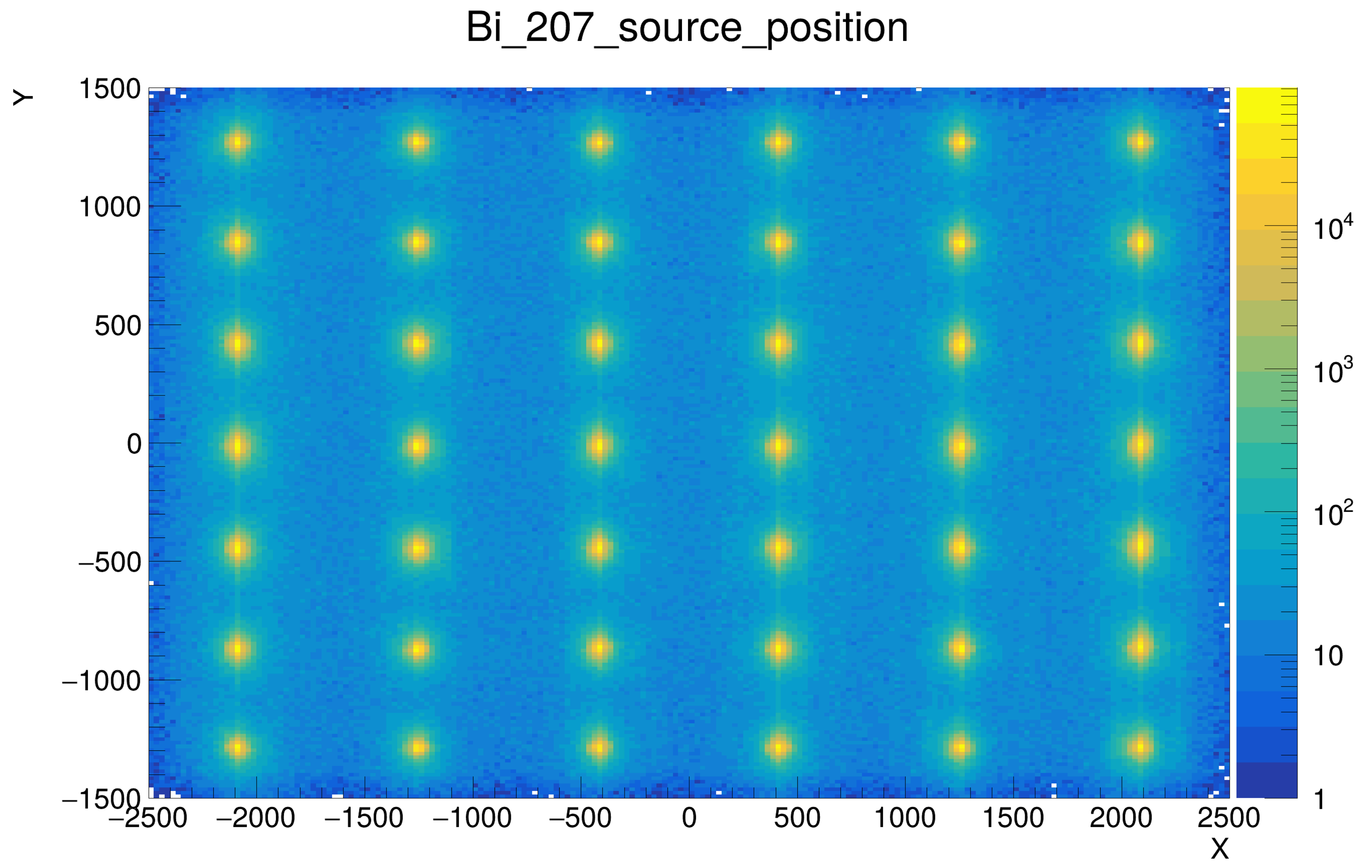


Cuts

Electron cuts

① Cut on 1 e^- event

② Cut on e^- track origin



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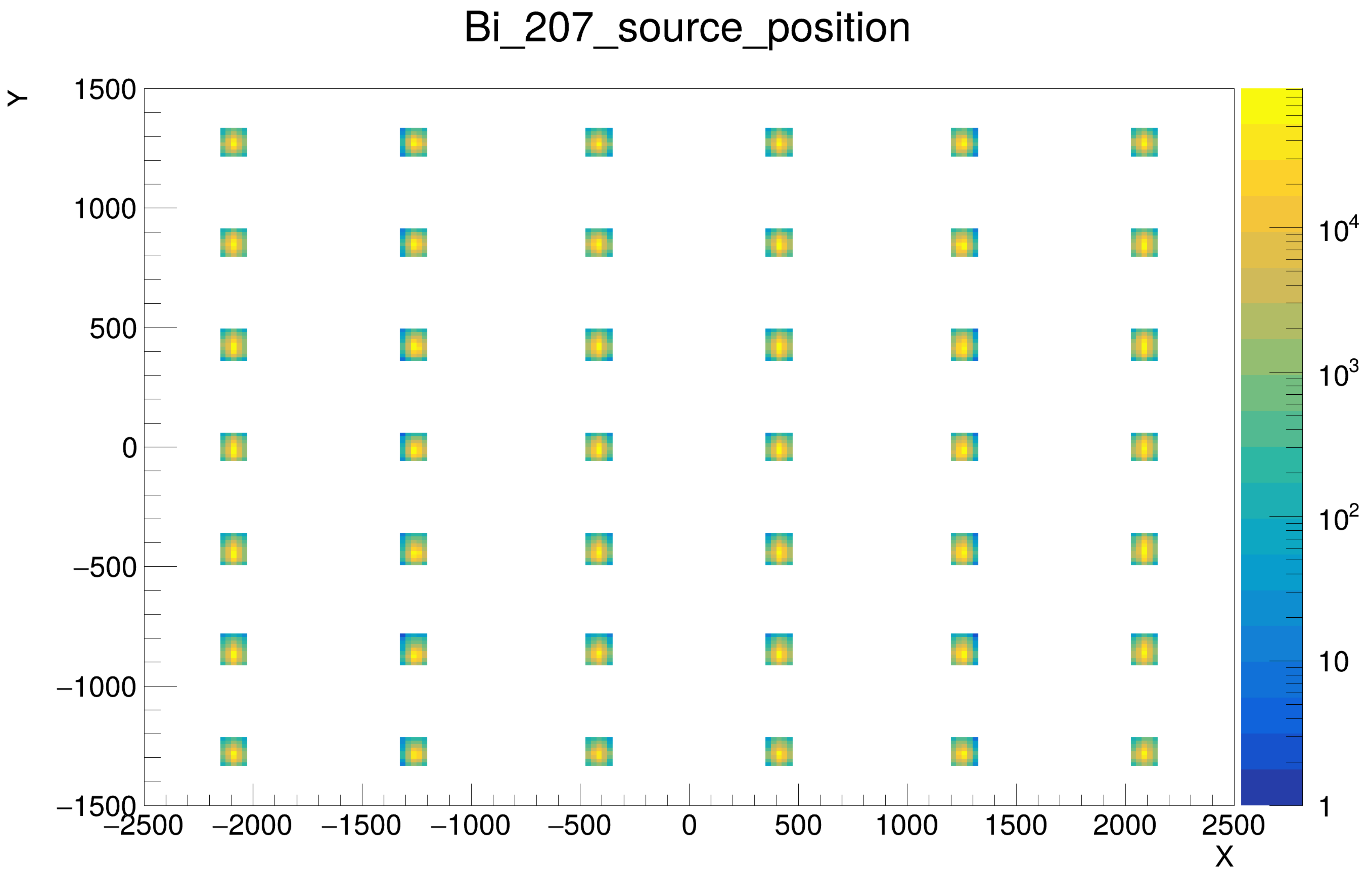

Cuts

Electron cuts

① Cut on 1 e^- event

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③ Cut on e^- track end on MW PMT

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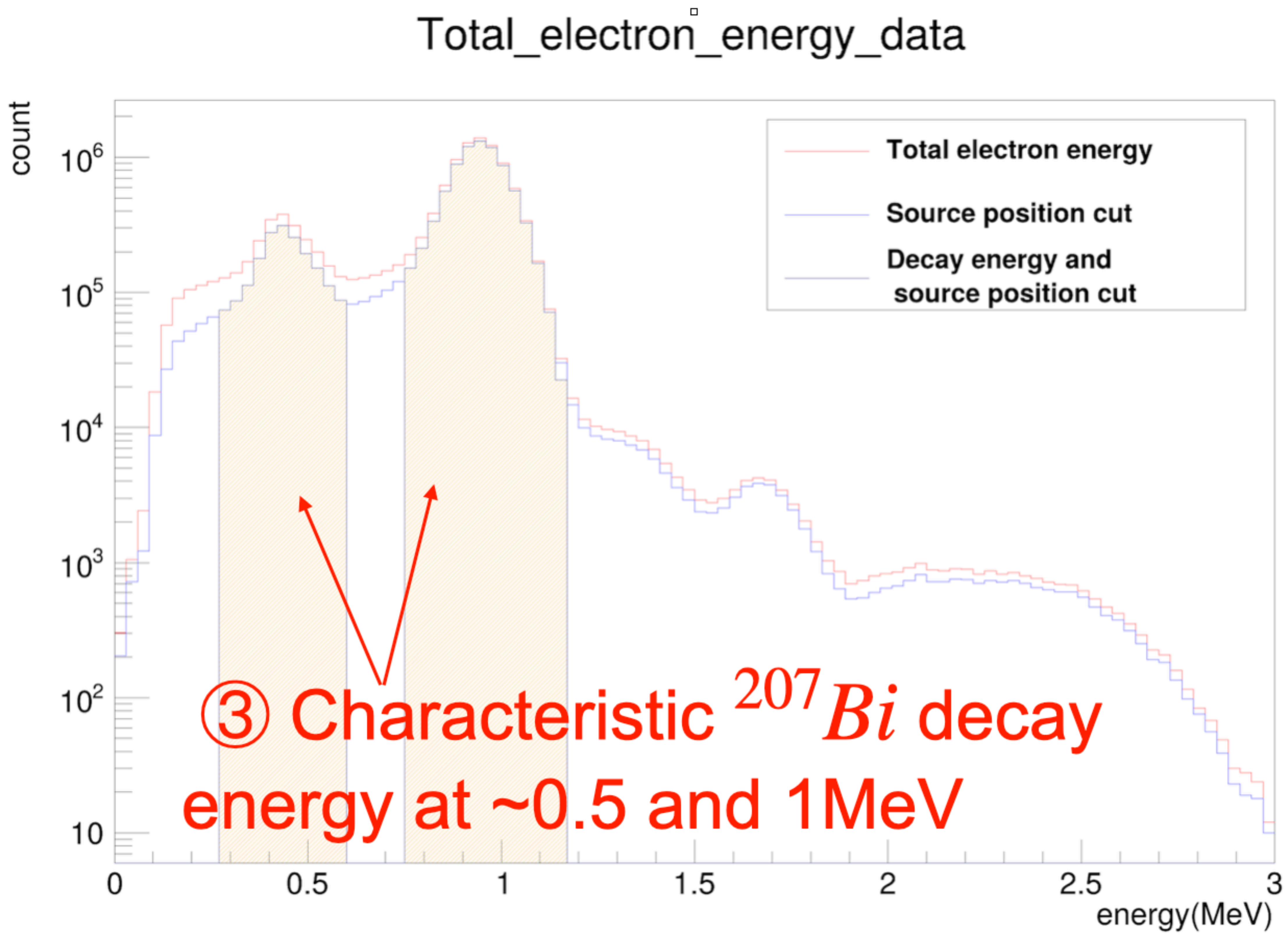
④ Cut e^- energy on ^{207}Bi characteristic energy spectrum



Cuts

Electron cuts

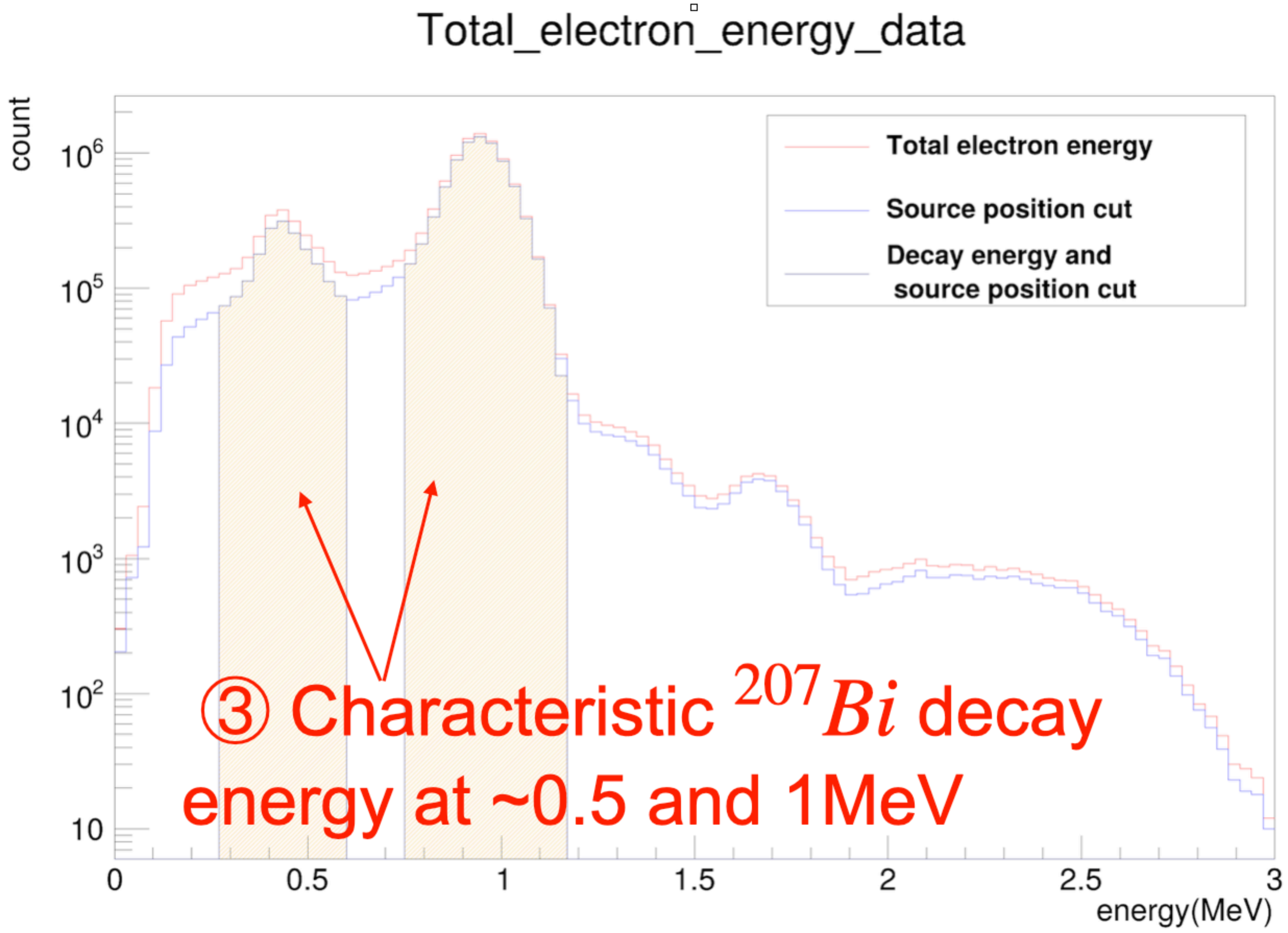
① Cut on 1 e^- event

② Cut on e^- track origin

③ Cut on e^- track end on MW PMT

④ Cut e^- energy on ^{207}Bi characteristic energy spectrum

Currently using full MW



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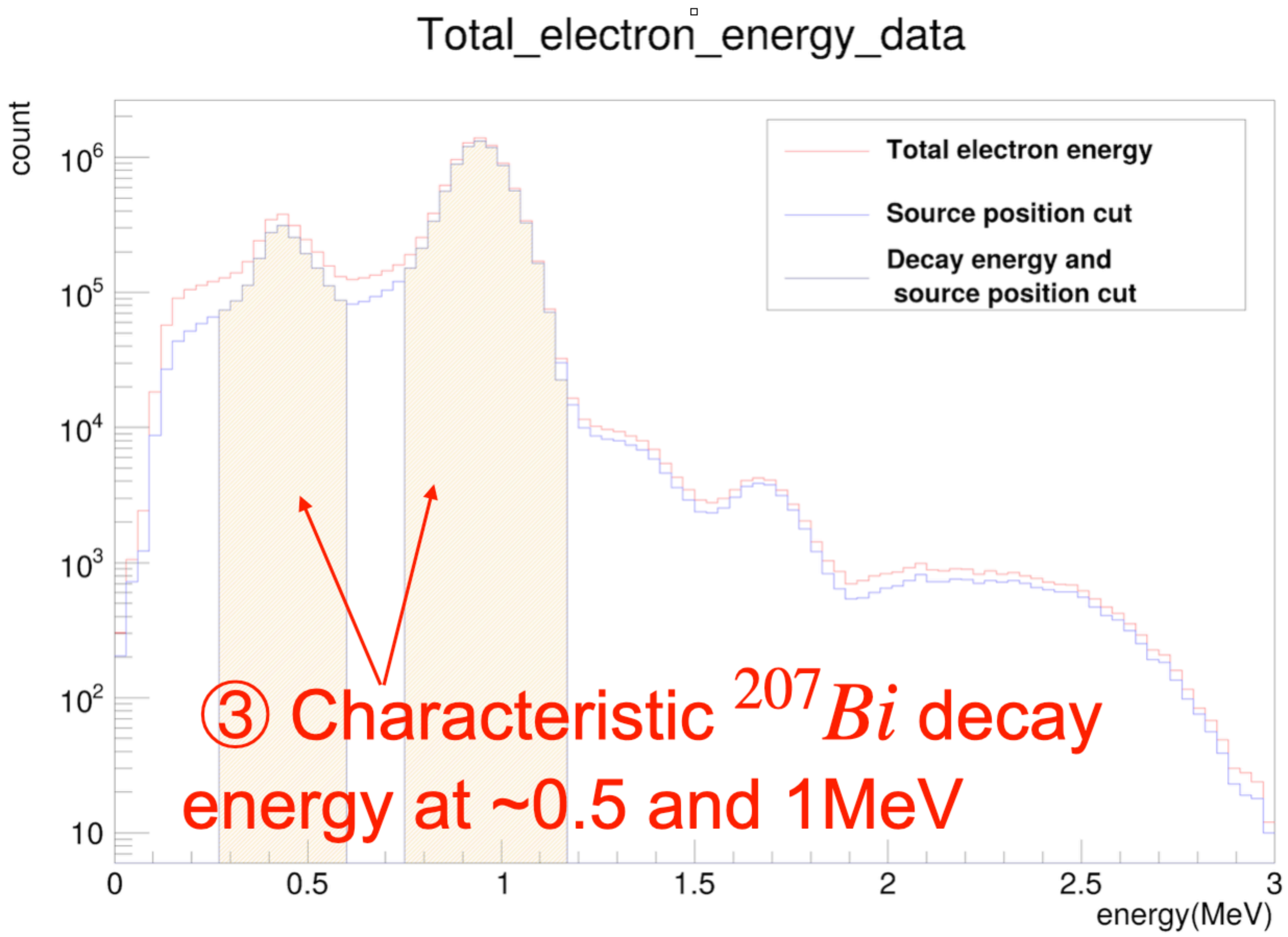


Use e^- energy and tracking to calculate e^-_{tof} and t_{decay,e^-}

Cuts

Gamma cuts

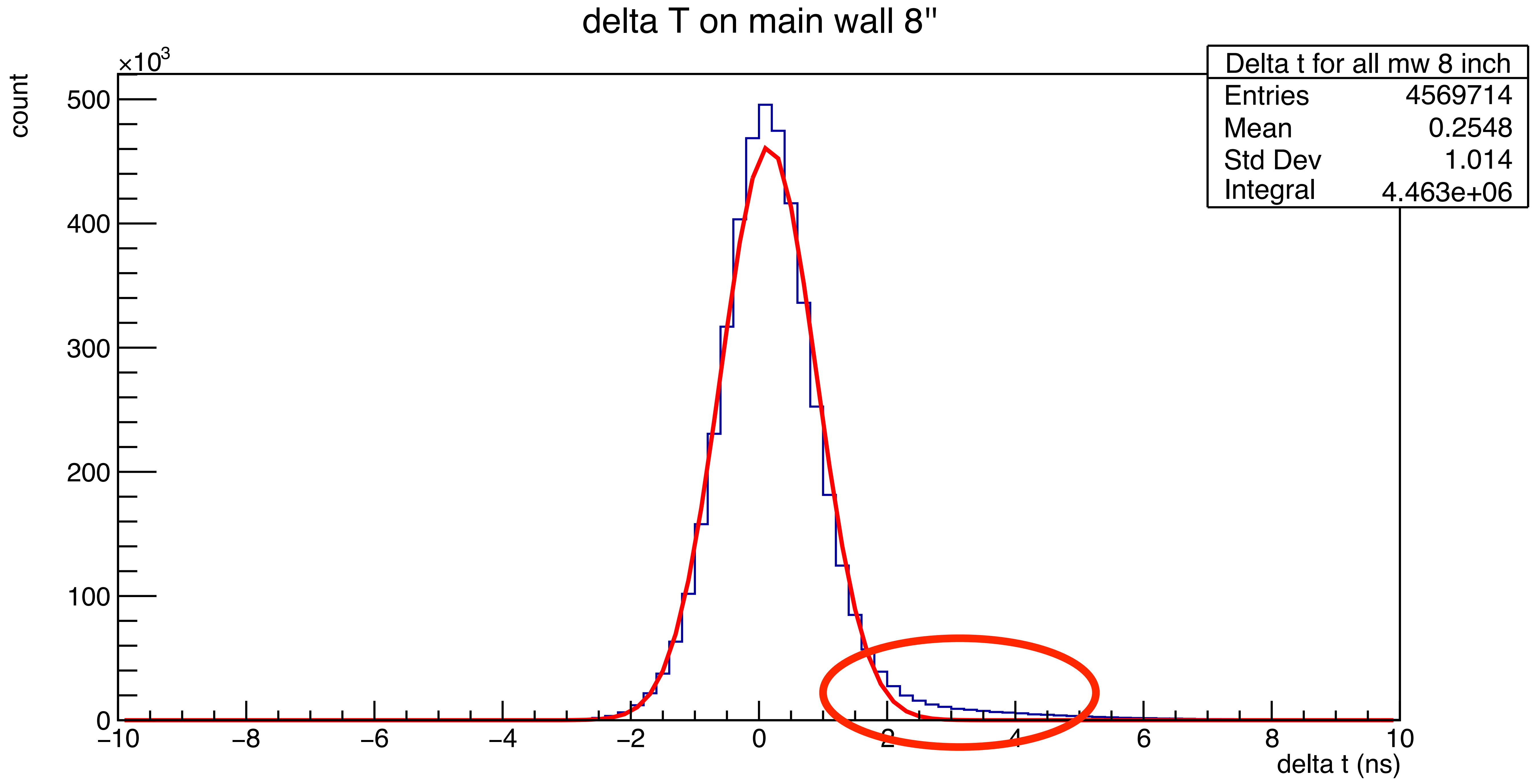
① Cut on 1 γ event

Cuts

Gamma cuts

① Cut on 1 γ event

②Cut on low energy E_γ < 250keV



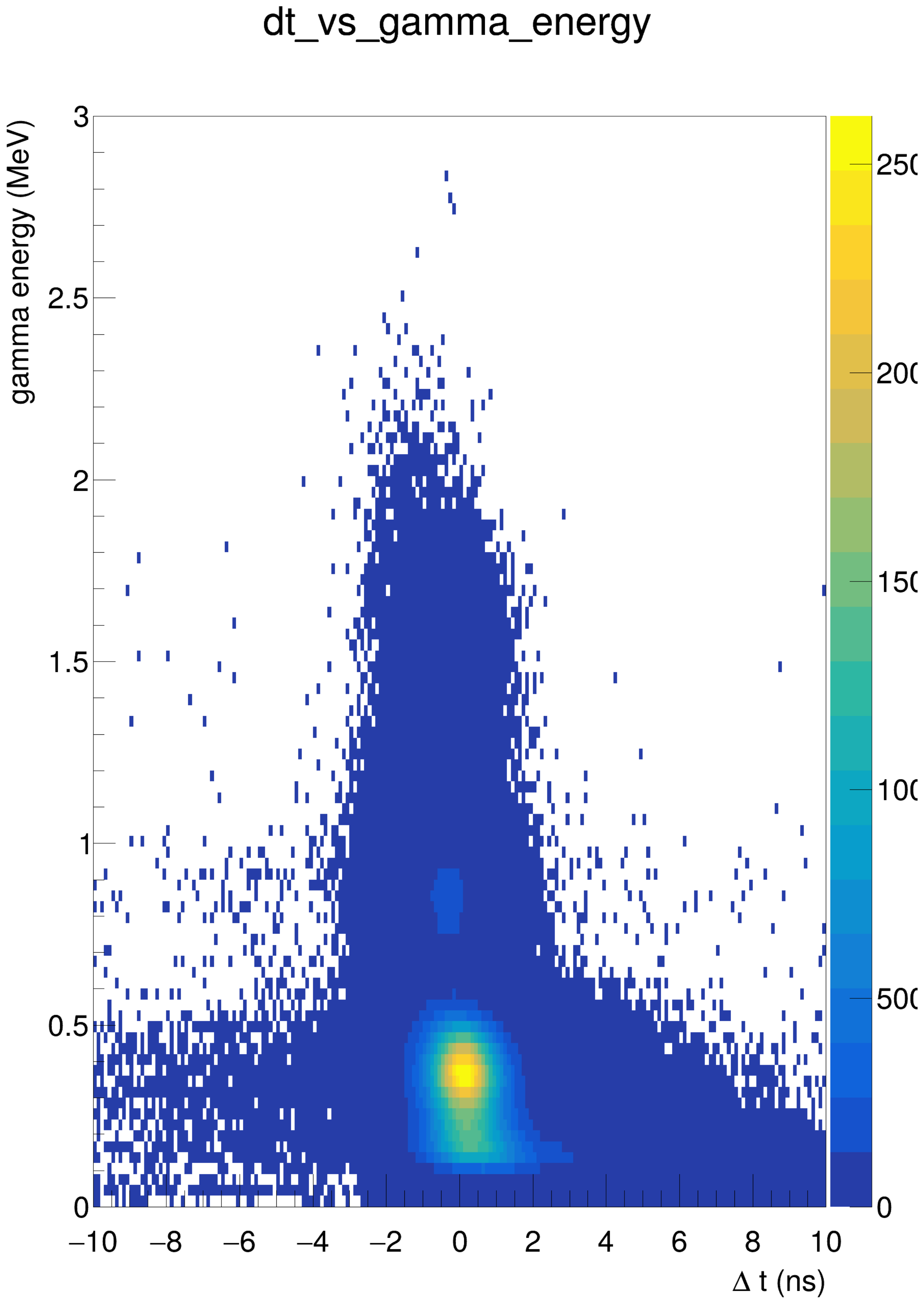
Δt on MW 8'' with a positive bias

Cuts

Gamma cuts

① Cut on 1 γ event

②Cut on low energy E_γ < 250keV



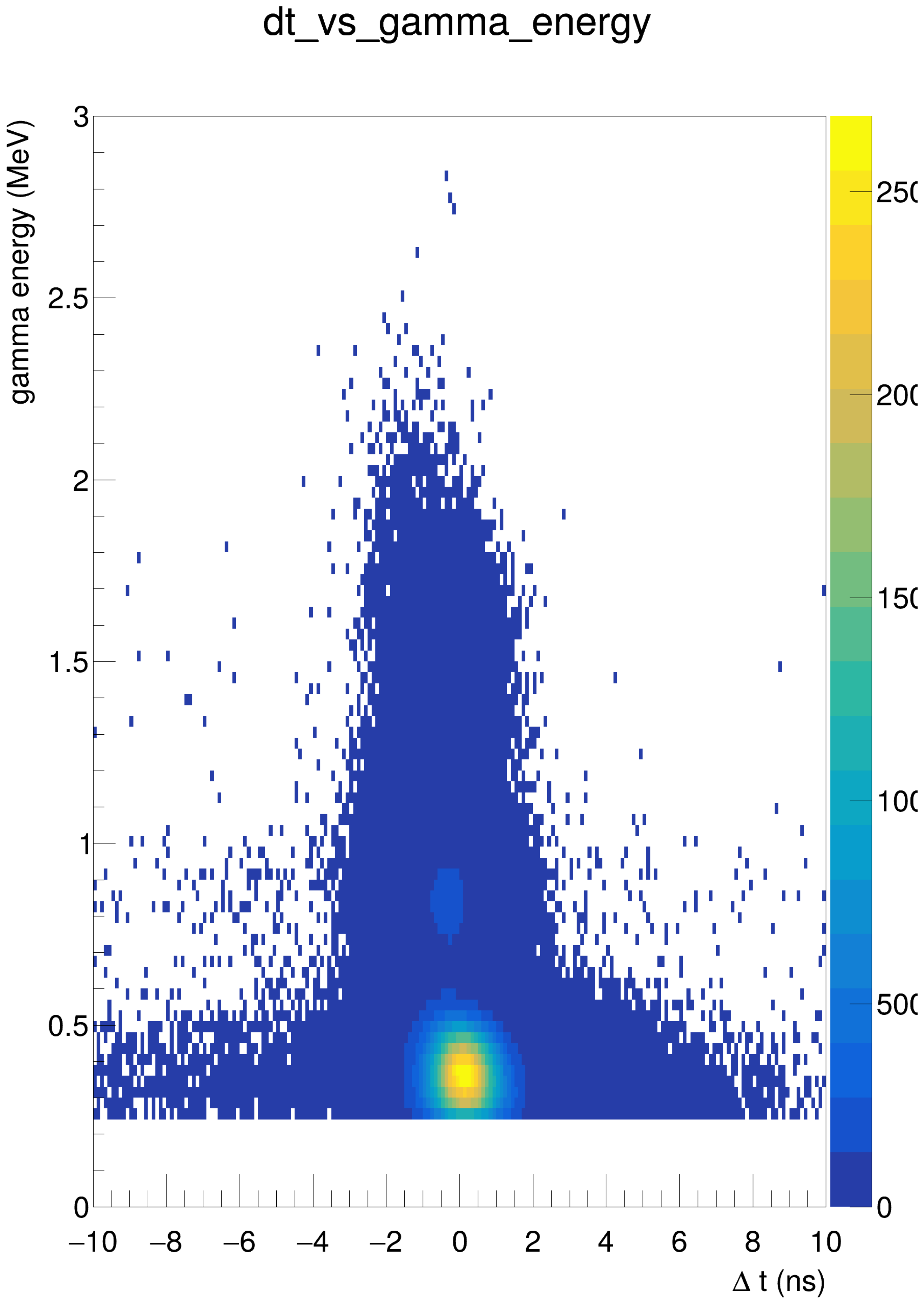
No cut on low energy E_γ < 250keV

Cuts

Gamma cuts

① Cut on 1 γ event

②Cut on low energy E_γ < 250keV



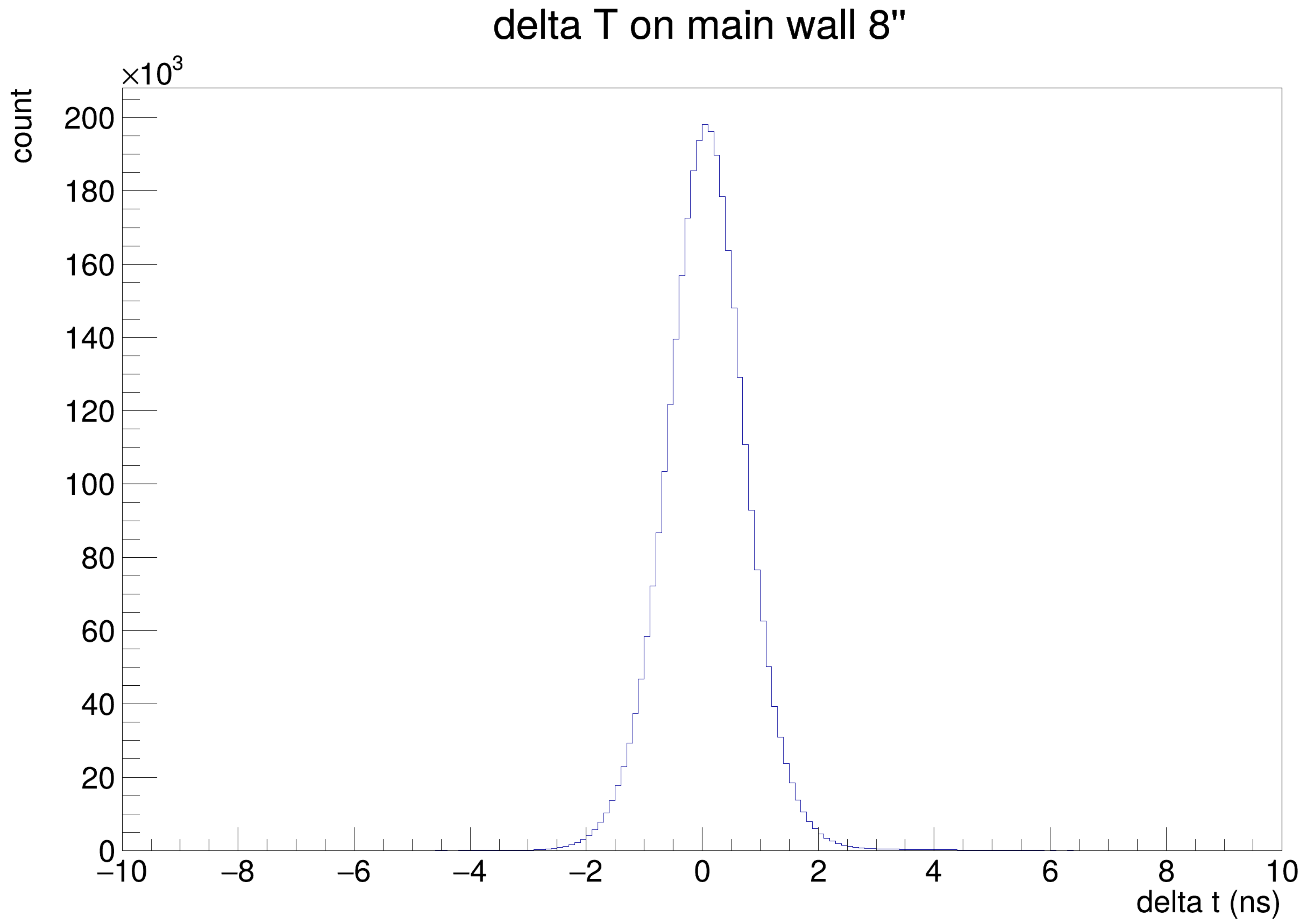
After cut on low energy E_γ < 250keV

Cuts

Gamma cuts

① Cut on 1 γ event

②Cut on low energy E_γ < 250keV



After cut on low energy E_γ < 250keV

Cuts

Gamma cuts

① Cut on 1 γ event

②Cut on low energy E_γ < 250keV

③ Use calo locator, calculate γ_{tof} and select $t_{decay,e^-} - t_{decay,\gamma}$ < 100ns

Cuts

Gamma cuts

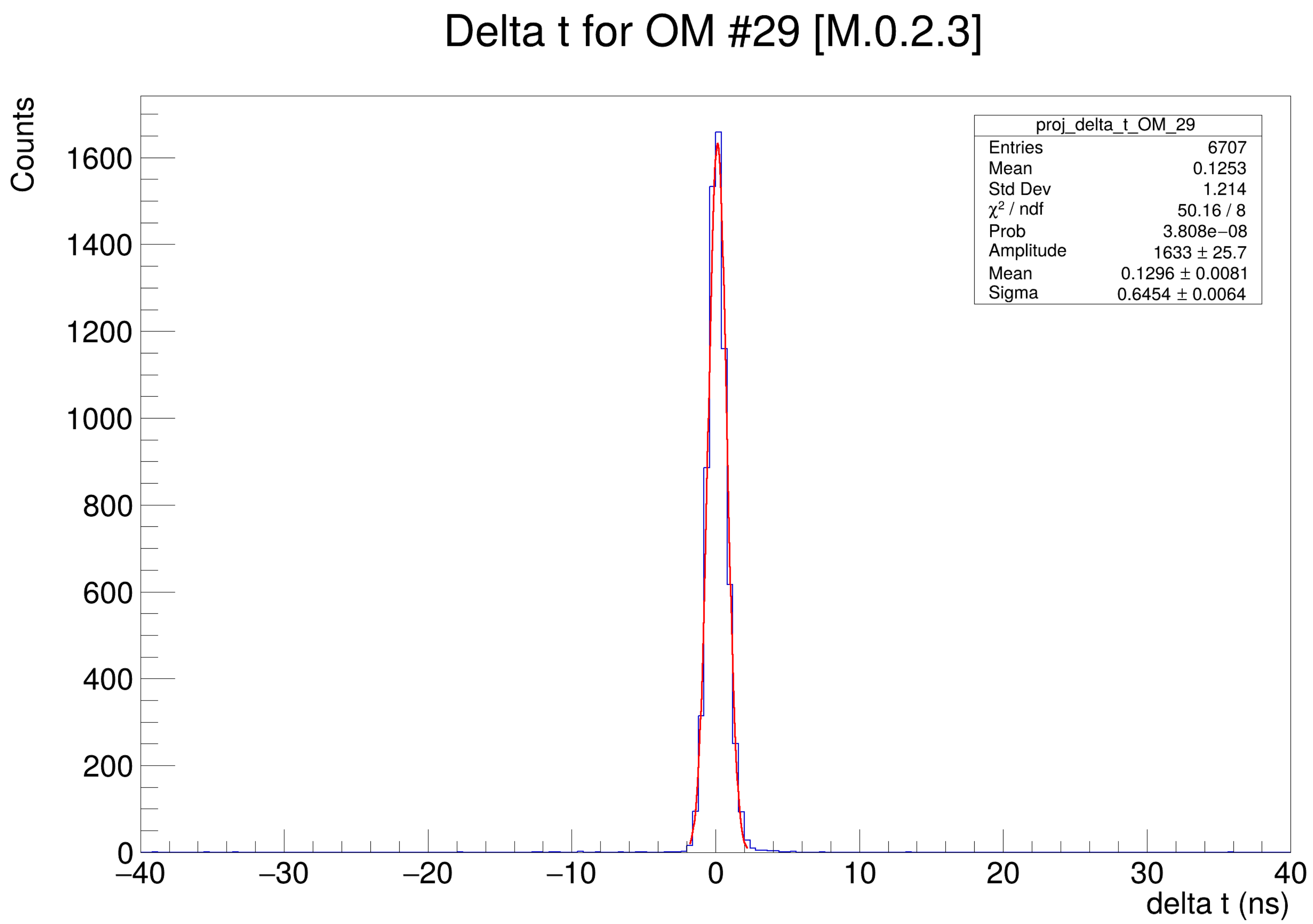
① Cut on 1 γ event

②Cut on low energy E_γ < 250keV

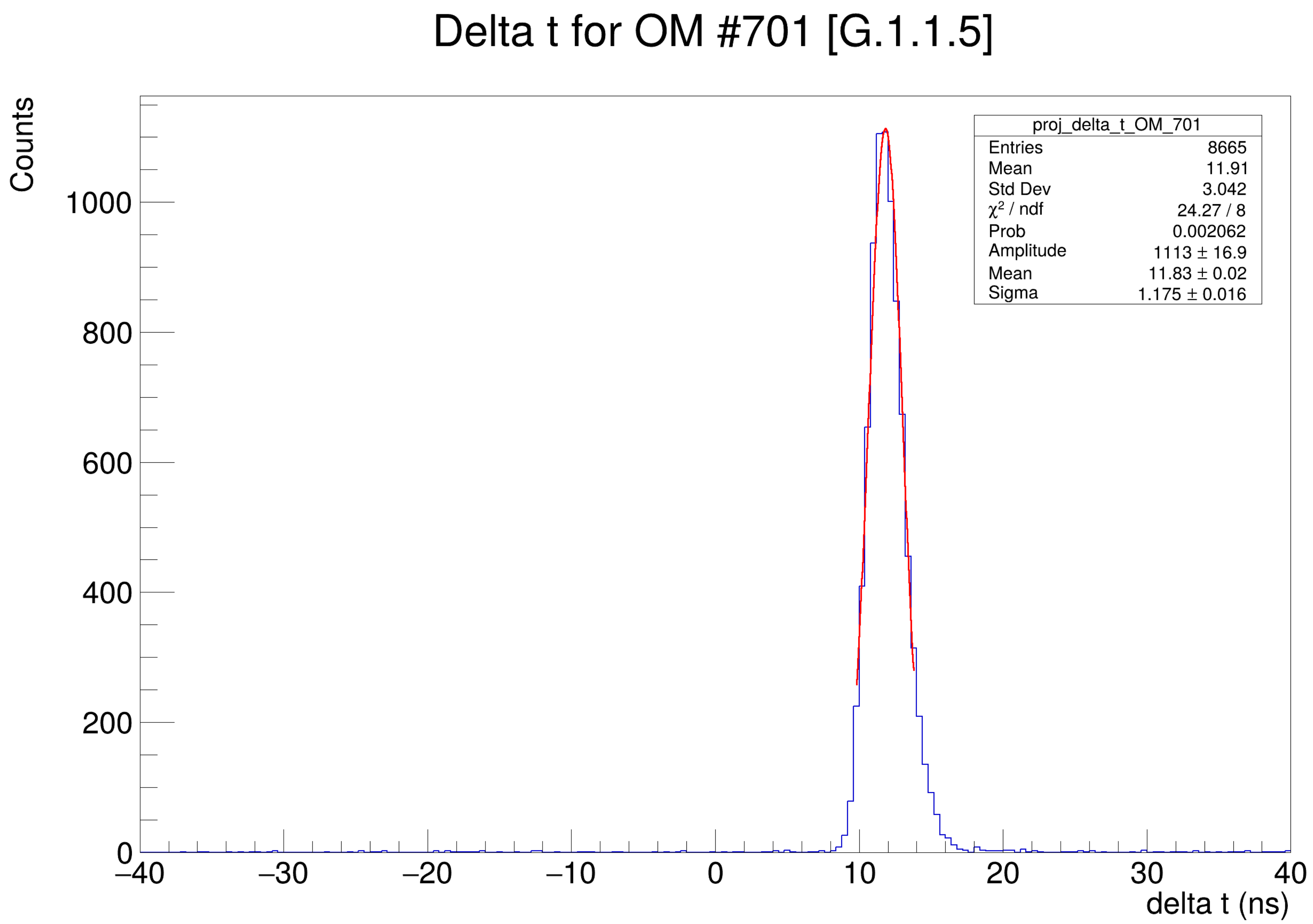
③ Use calo locator, calculate γ_{tof} and select $t_{decay,e^-} - t_{decay,\gamma}$ < 100ns

④ $\Delta t_\gamma = t_{\gamma,measured} - t_{\gamma,calculated}$

Δt graph

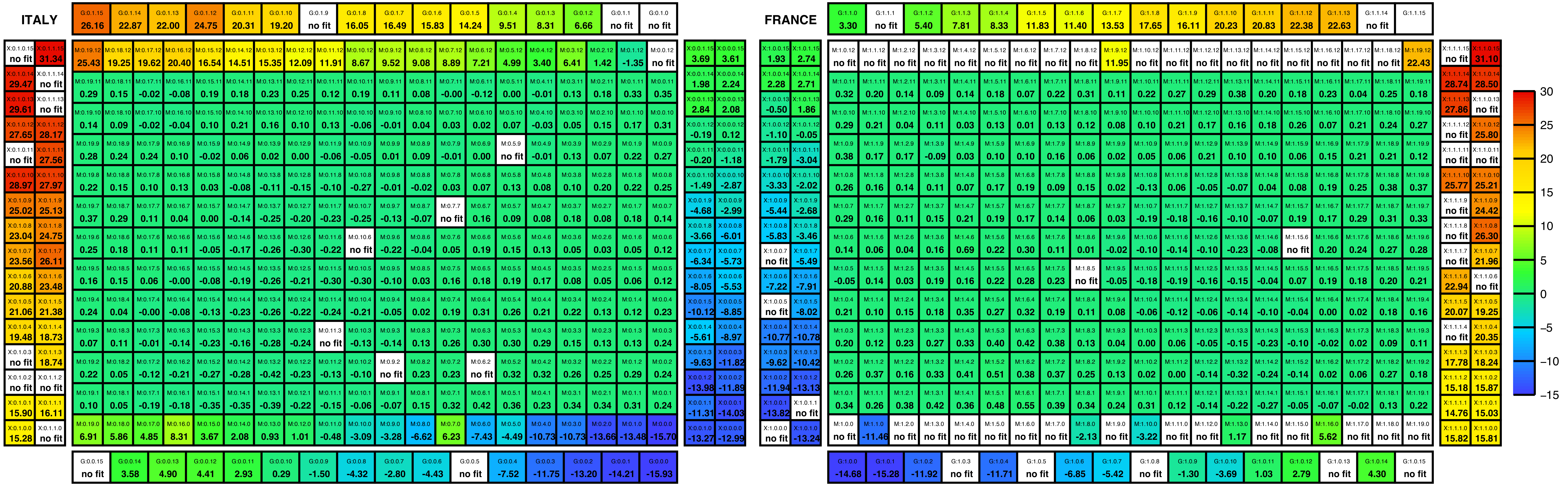


Δt a MW calo



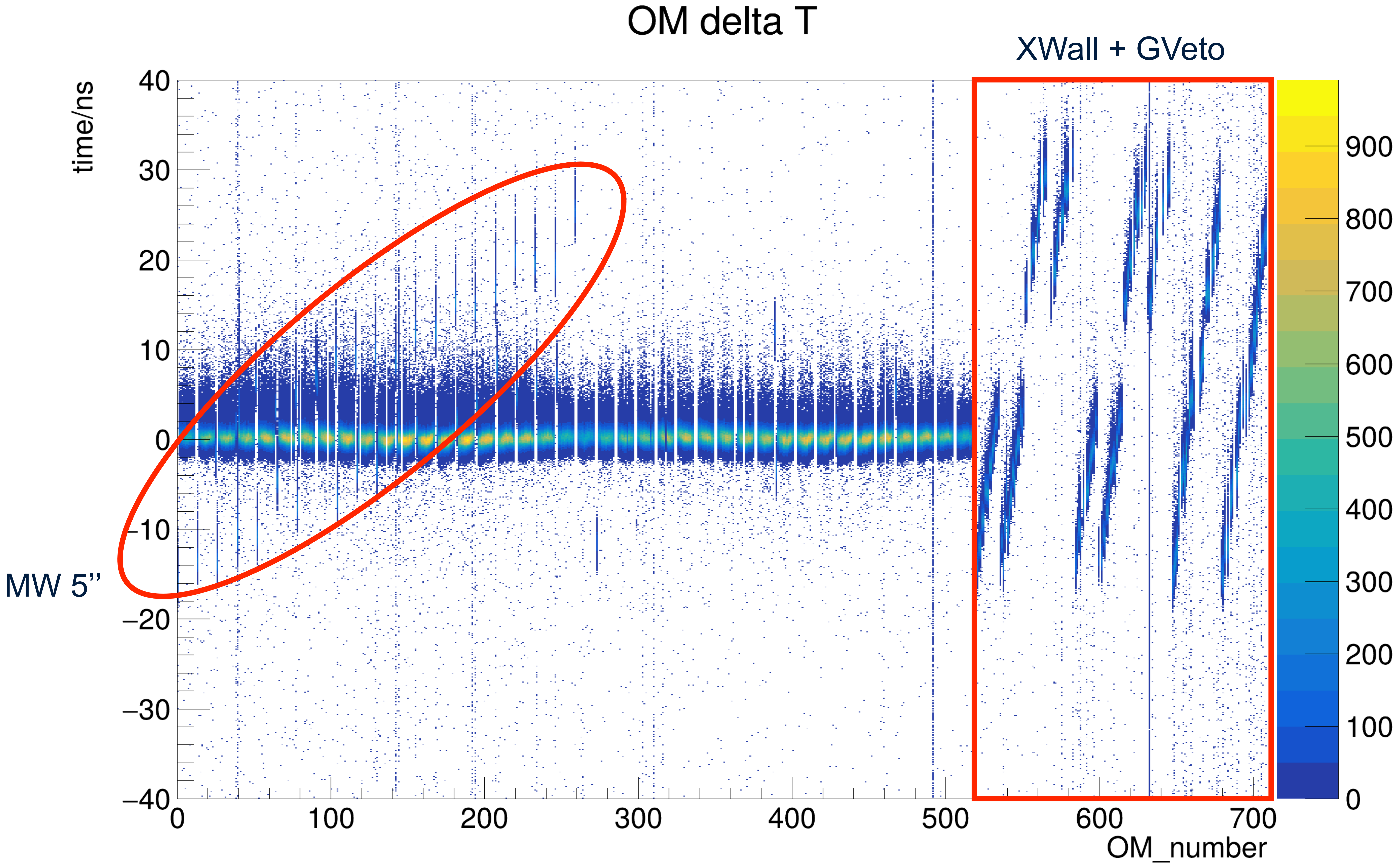
Δt a GVeto calo (wider)

Δt trend



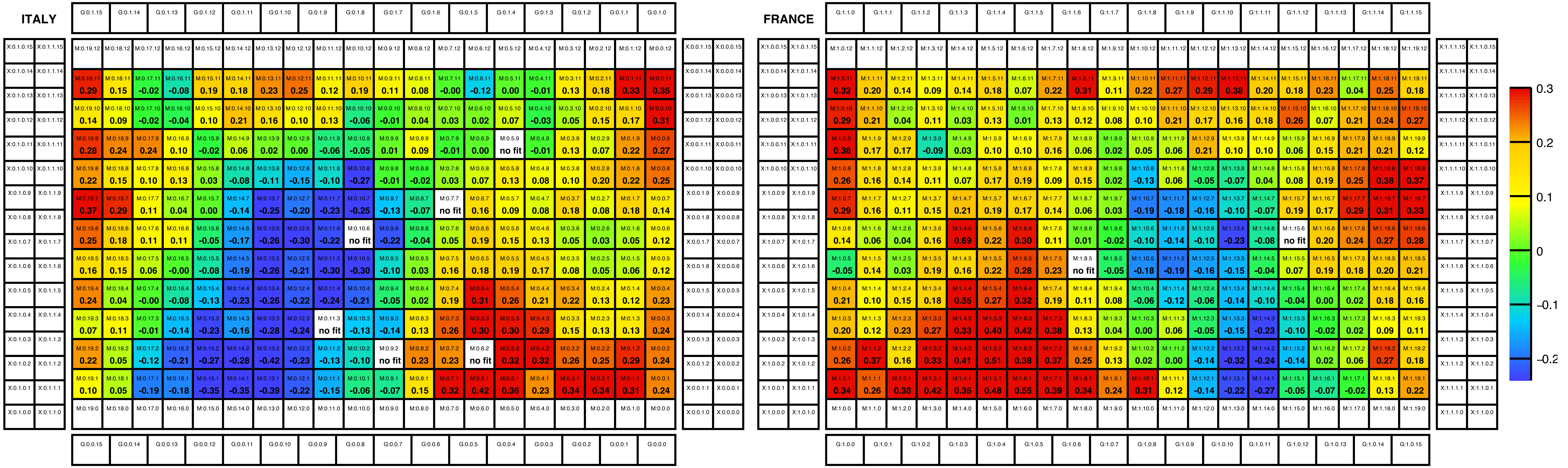
Δt for all calos in μs for all OMs

Δt trend



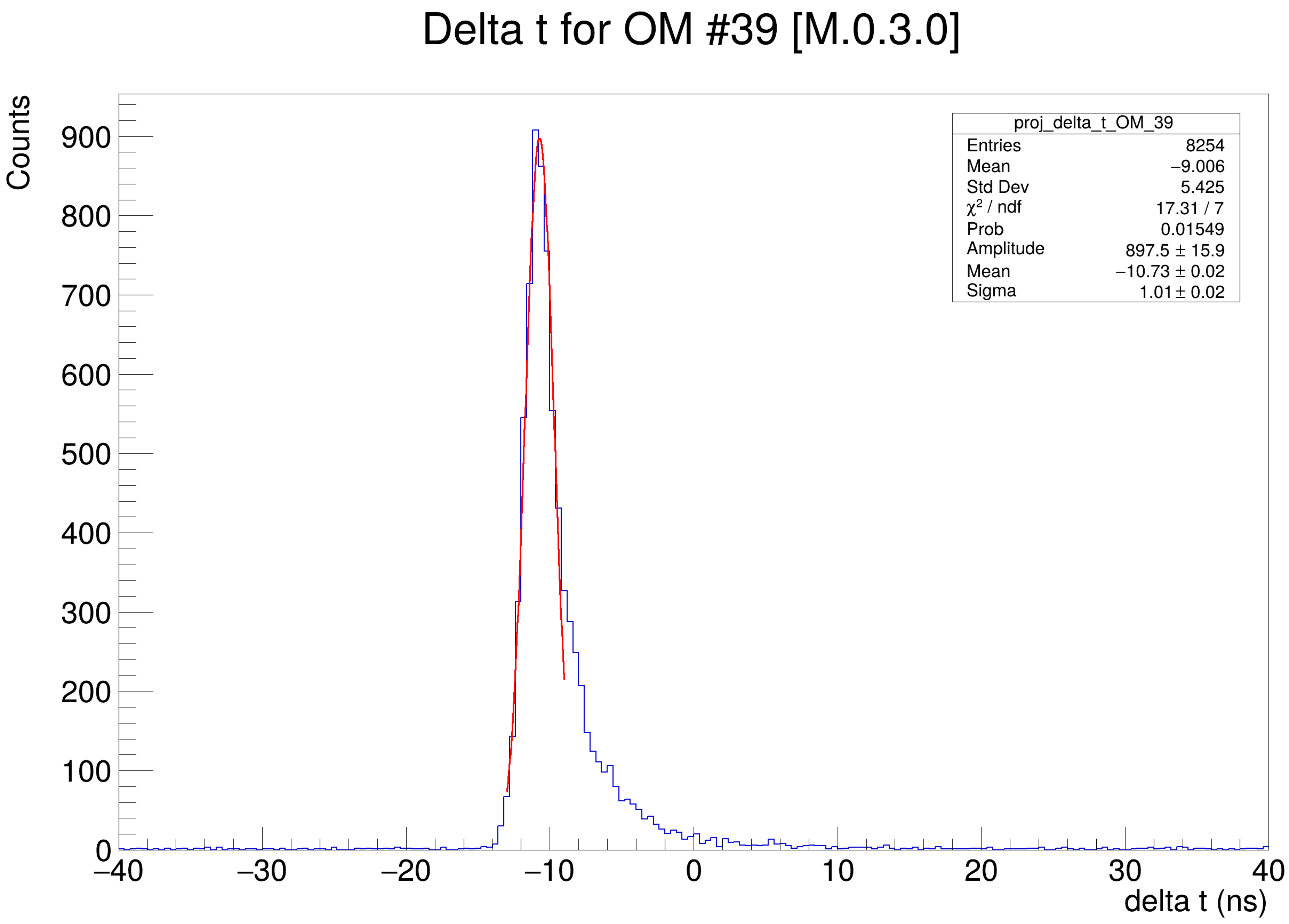
![supernemo collaboration logo]

Time variation for MW 8”

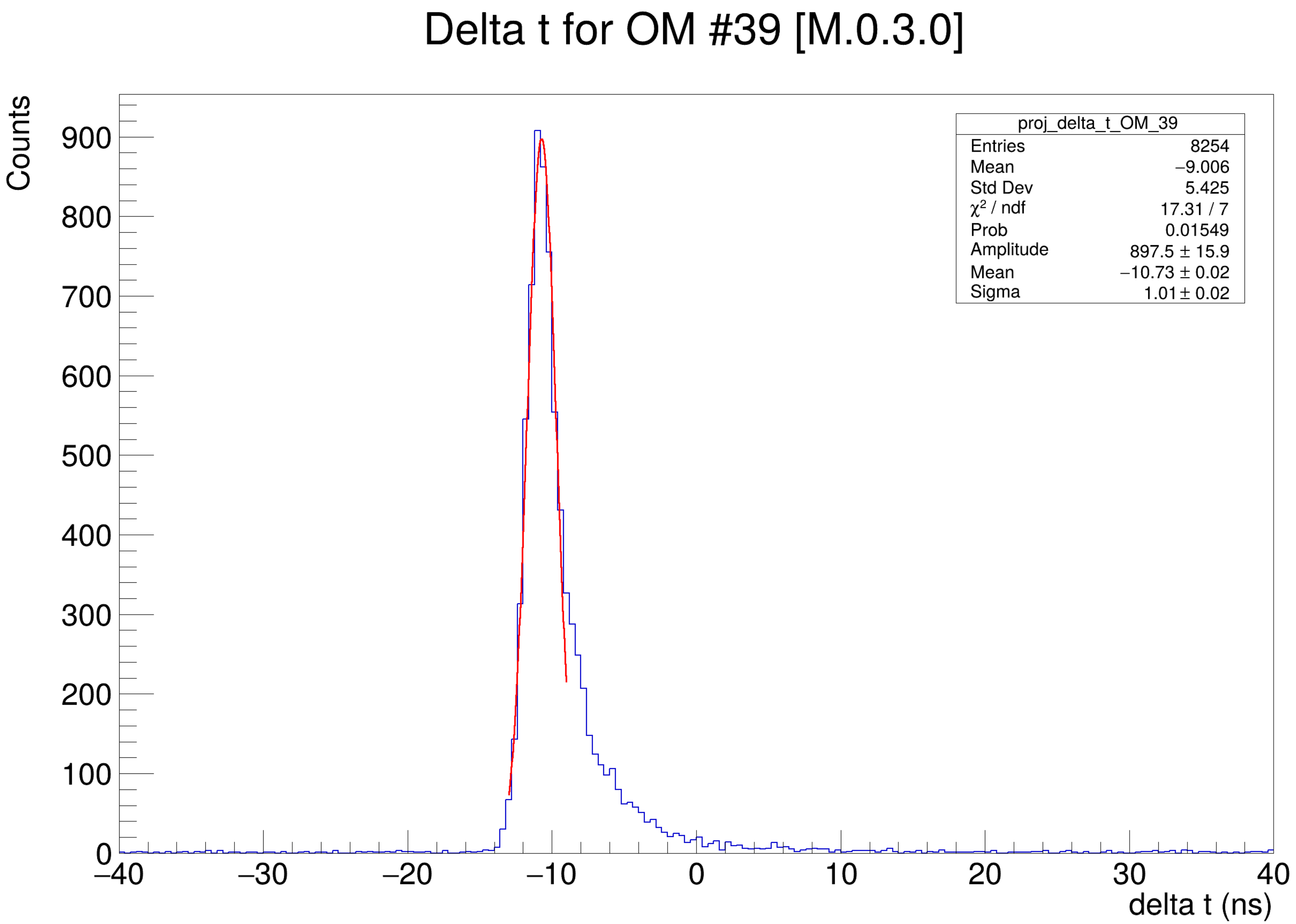


Δt for MW calos in μs

Still some weird ones



Still some weird ones



Maybe we should fine tune them?

Next step

Compare with older/newer data to see the time affect of the calibration

Do calibration per run / per OM

Summary

We have time calibration — only for MW and only use electron

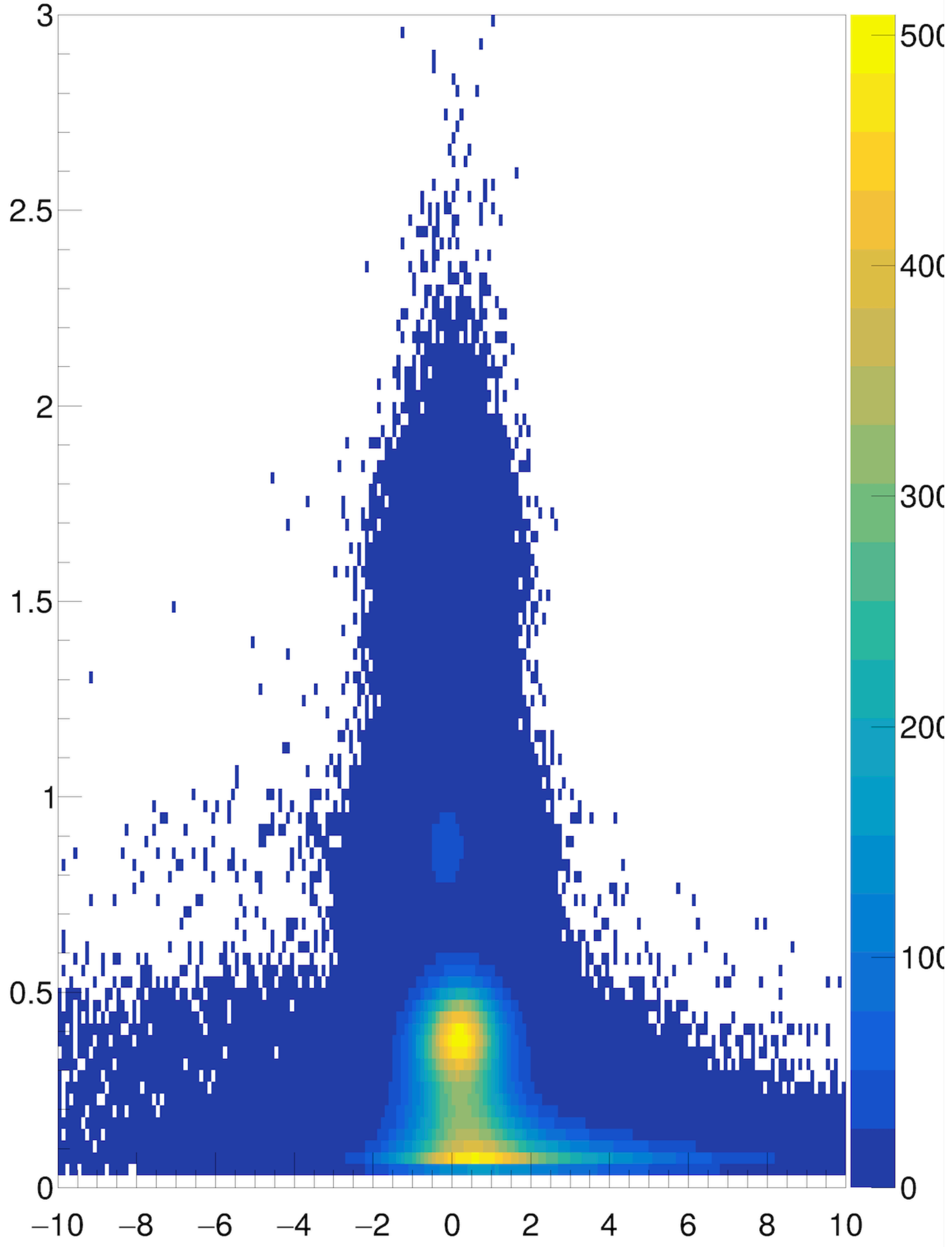
GVeto and Xwall are not calibrated for cable length

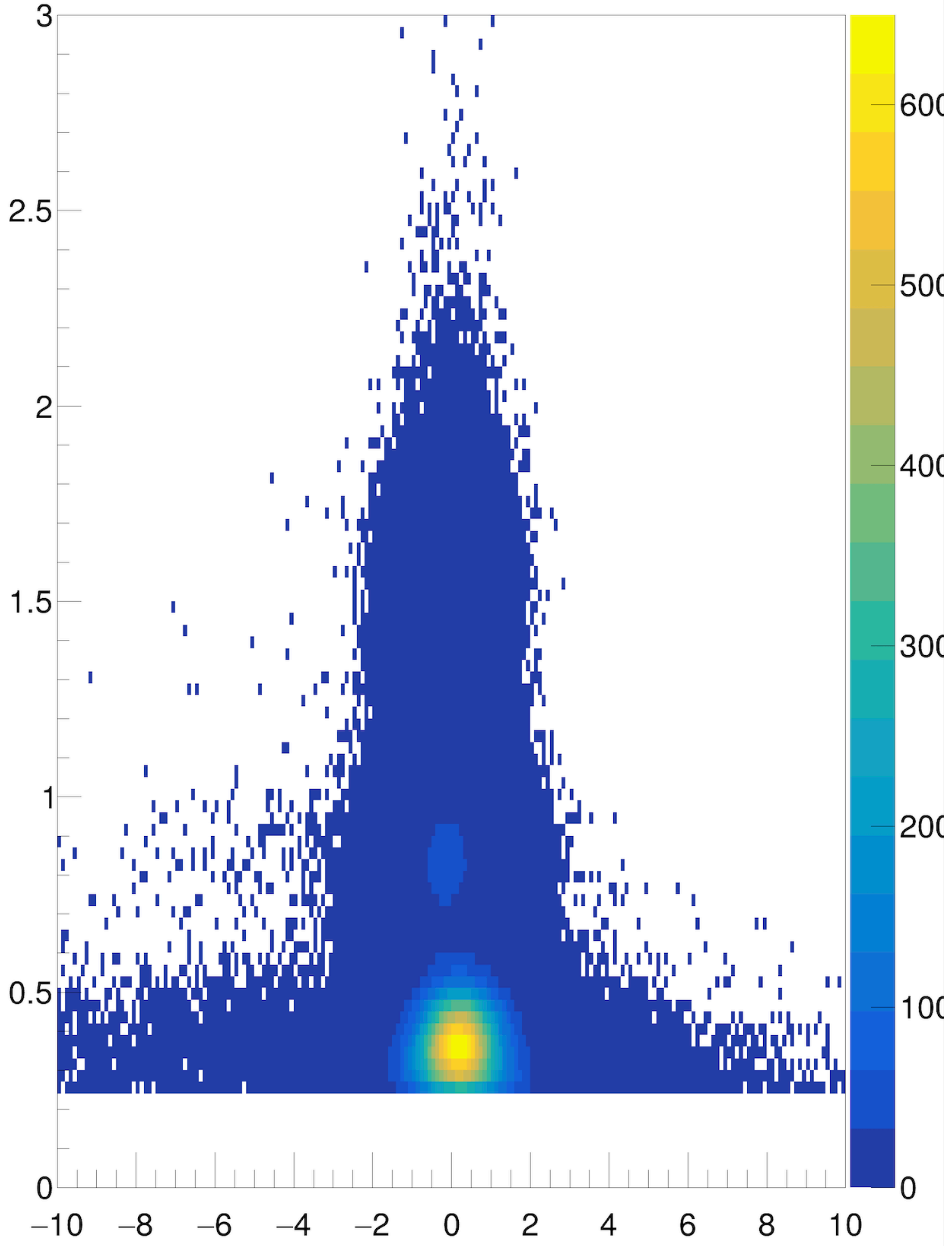
We get primilary Δt value using $1e1\gamma$ channel of ^{207}Bi

Trying to fine tune our result — per run/per OM

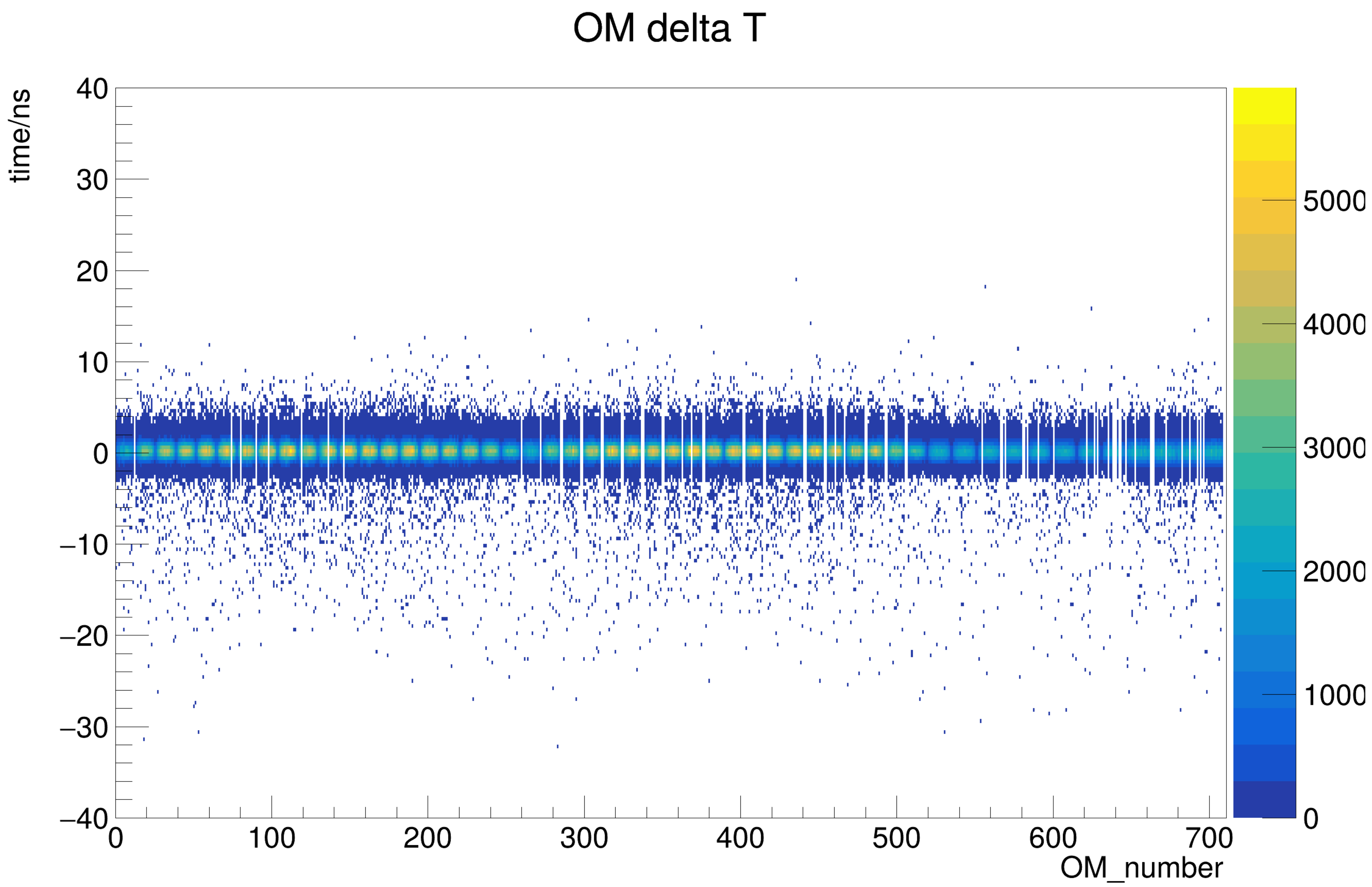
Compare with old/new data to see if there is time dependence

Back up


3
2.5
2
1.5
1
0.5
0
−10 −8 −6 −4 −2 0 2 4 6 8 10
0
100
200
300
400
500


3
2.5
2
1.5
1
0.5
0
−10 −8 −6 −4 −2 0 2 4 6 8 10
0
100
200
300
400
500
600

Back up


OM delta T
time/ns
40
30
20
10
0
−10
−20
−30
−40
0
100
200
300
400
500
600
700
OM_number
5000
4000
3000
2000
1000
0