ECAL data analysis

considering signal time parameters

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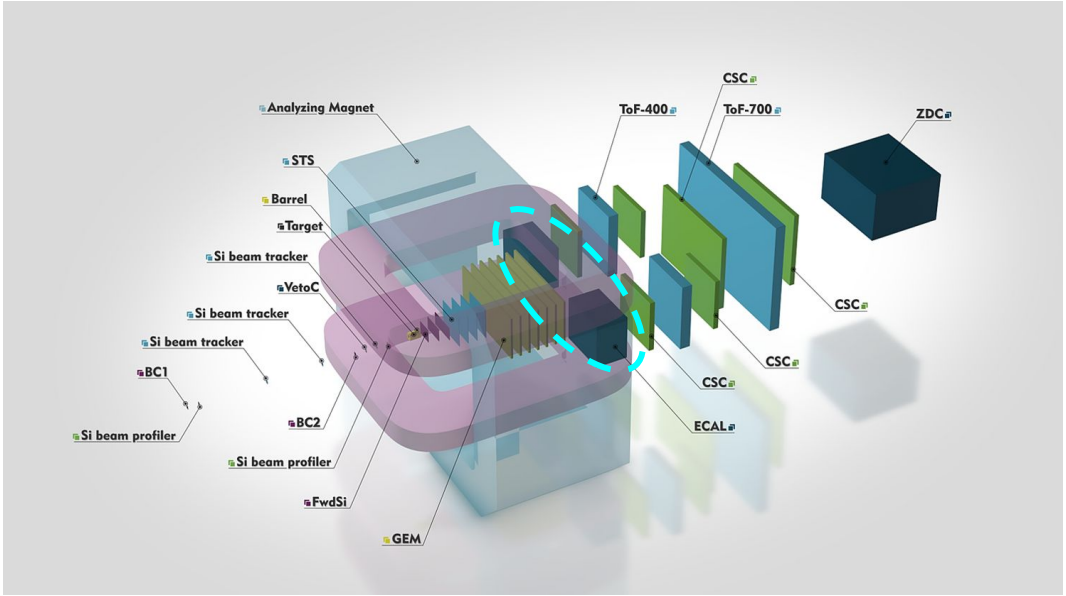
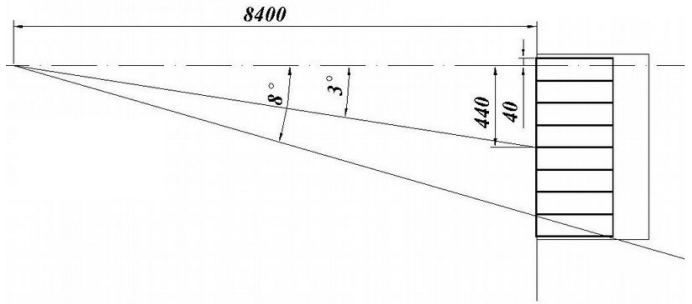
6th Collaboration Meeting of the BM@N Experiment at the NICA Facility
JINR
October 26–27, 2020

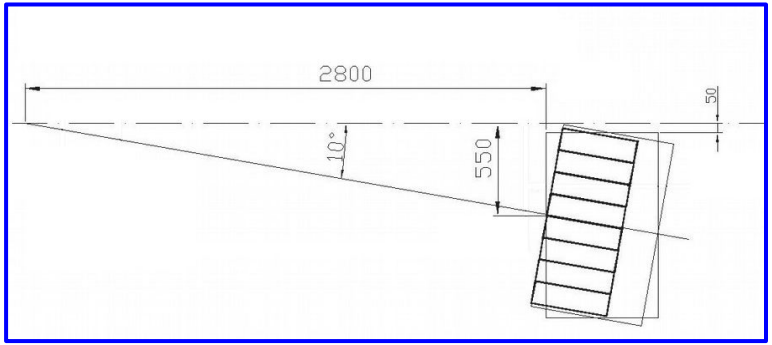
Schematic drawing of the ECAL position in the BM@N setup



Position 1, Run 7 (SRC) ECAL calibration runs
C 3.17 AGeV → Pb, run ids 3503-3511, ~2M ev.



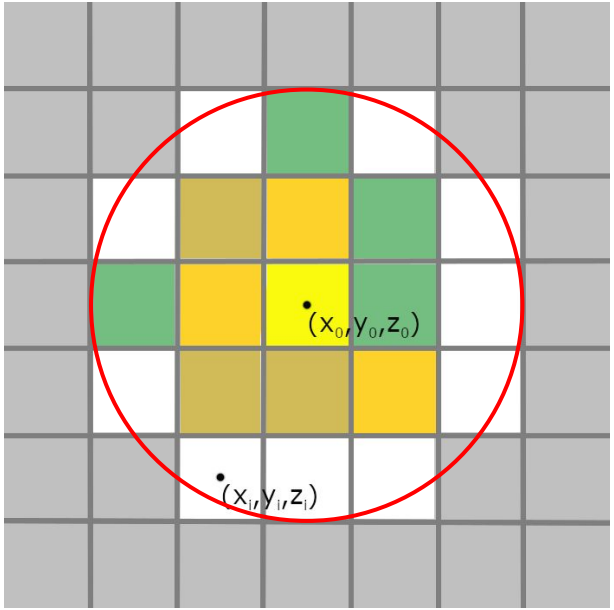
Position 4, Run 7 (BMN) ECAL data analysis
Kr 2.6 AGeV → Sn, run ids 4921-4966, ~5.7M ev.



- **2018 year ECAL setup (run 7)**
  - **one shoulder 7x7 modules, 441 cells**
- New ECAL setup
  - two shoulders of 8x7 modules, 1008 cells

Cluster parameters

- Minimal cell energy is 30 MeV, other cells are ignored
- Cluster radius is 10 cm (21 cells of 5x5 area)
- Cluster parameters are:
  - energy
  - center gravity
  - weighted average time (t_{wa})
  - time spread (t_{sp})
  - normalized moment (M_{norm})

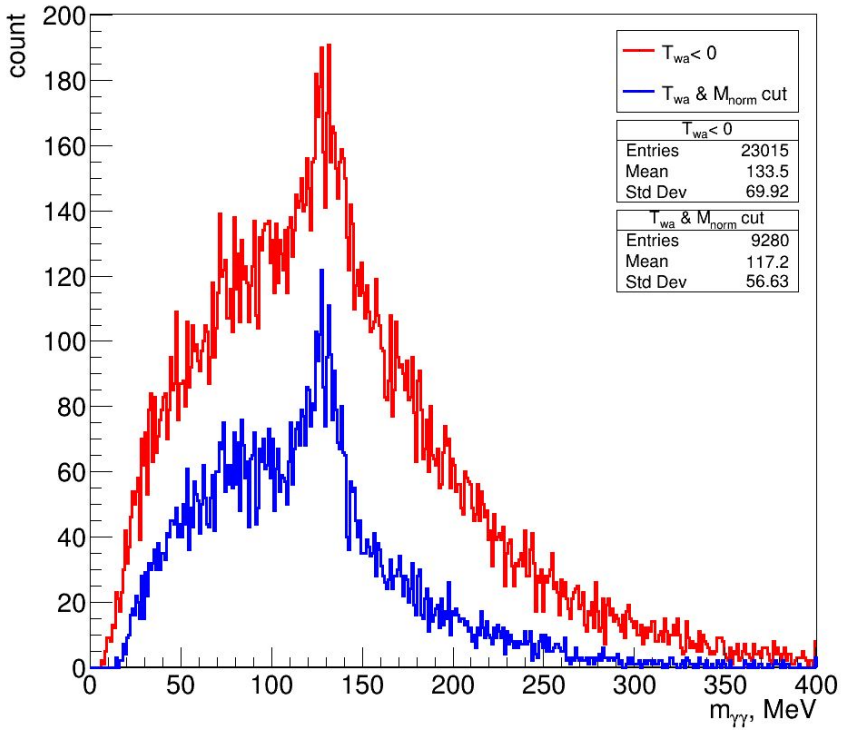


$$t_{wa} = \frac{\sum E_i \cdot t_i}{\sum E_i} \qquad t_{sp} = \frac{\sum E_i \cdot (t_i - t_0)^2}{\sum E_i}$$

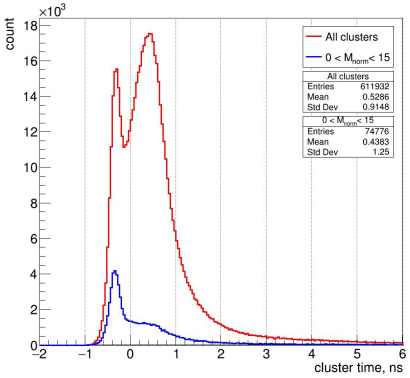
$$M_{norm} = \frac{\sum E_i \times ((x_i - x_0)^2 + (y_i - y_0)^2 + (z_i - z_0)^2)}{\sum E_i}$$

Simulation: GEANT4, DCMQGSM KrSn 2.36AGeV mb, ~2M ev

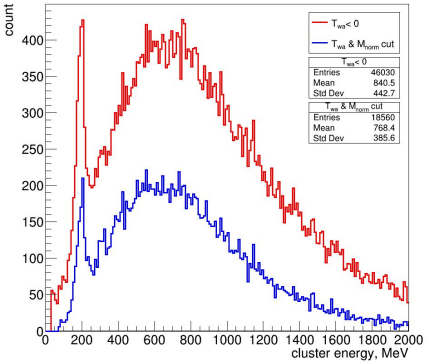
Effective mass spectrum



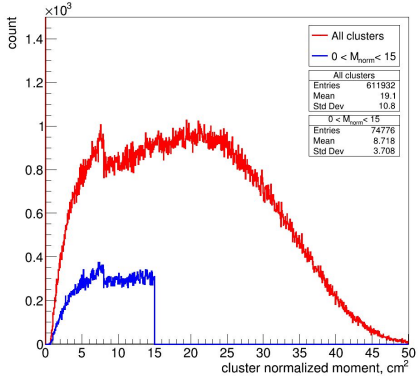
Cluster time



Cluster energy



Normalized moment



$t_{wa} < 0$

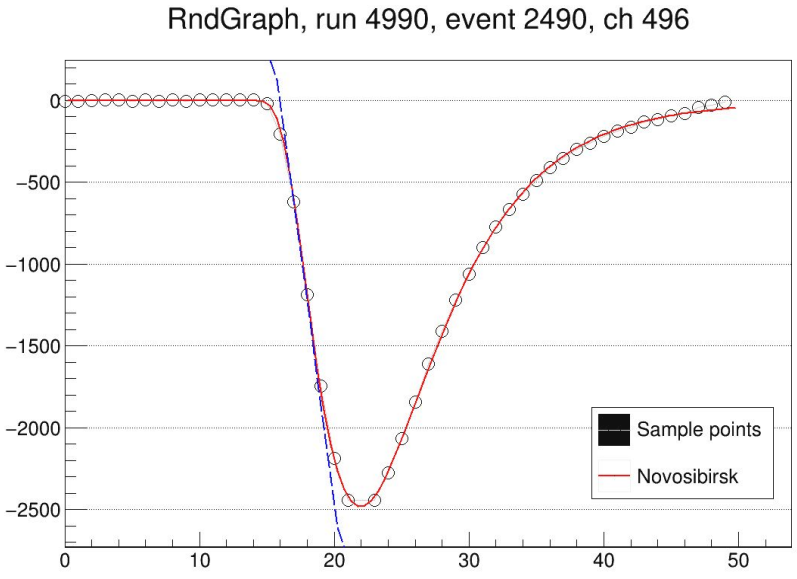
$M_{norm} < 15$

$N_{cells} > 1$

$E_{cluster}$ no cut

ECAL signal raw to digi conversion

1. Pedestal - mean of slices 0..7
2. Novosibirsk fit
3. Peak amplitude $\mathbf{A}_{\mathbf{peak}}$ and time $\mathbf{T}_{\mathbf{peak}}$
4. Cell start time $\mathbf{T}_{\mathbf{cell}}$
5. Amplitude **A** - mean of $T_0 \ldots T_0+20$ slices
6. Get coords from geometry file

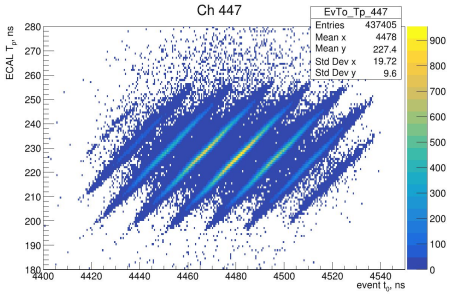


Novosibirsk function:

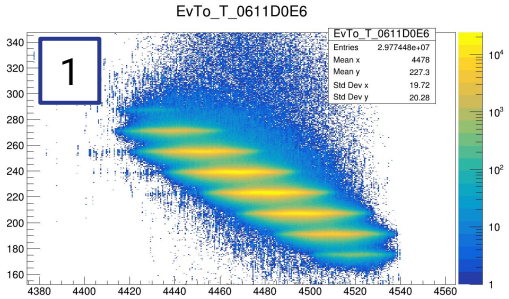
$$f(x) = e^{-\frac{\ln^2 q_y}{2\Lambda^2}+\Lambda^2}, \quad q_y = 1 + \frac{\Lambda(x-x_0)}{\sigma} \times \frac{\sinh\left(\Lambda\sqrt{\ln 4}\right)}{\Lambda\sqrt{\ln 4}}$$

ECAL cells time T_{cell}

T_{cell} vs T_0 (single cell)



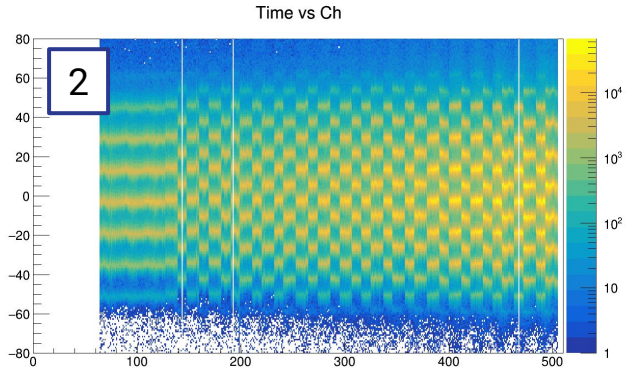
(T_{cell} - T_0) vs T_0 (single ADC)

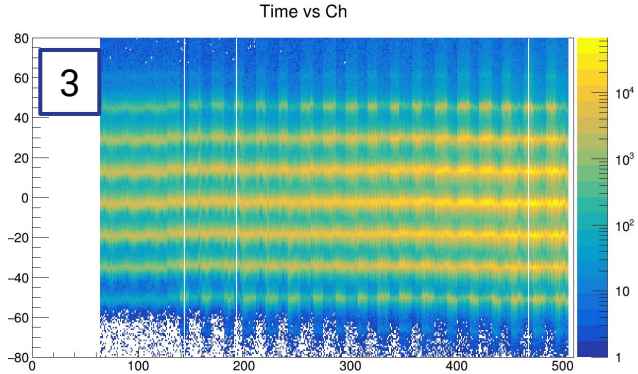


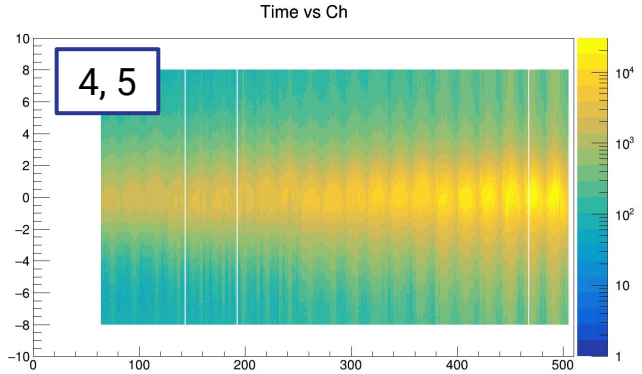
T_{cell} ECAL cell time, ns
T_0 Start time of the event, ns

ECAL cell time reconstruction flow

1. Subtract T0
2. Apply each ADC board mean time
3. Shift some ADC boards by 8 ns
4. Collapse all the slices with 16 ns step
5. Fine tune each channel time by its mean value





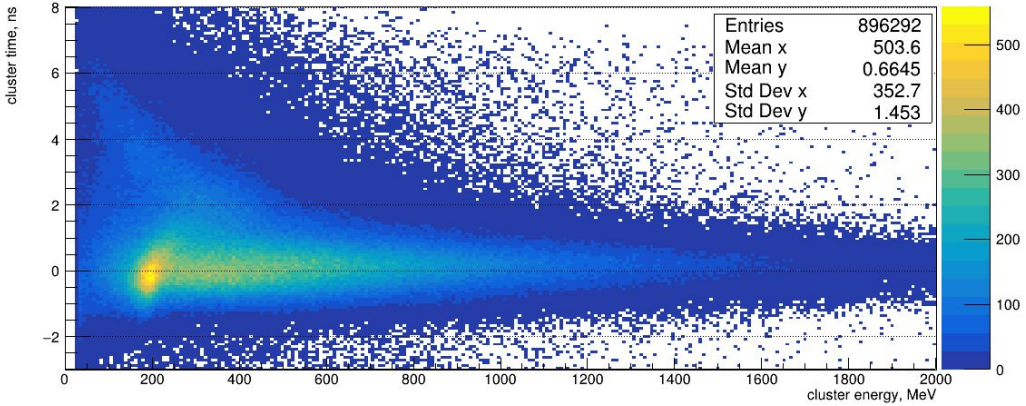


Kr 2.6 AGeV→ Sn (2.57), runs 4921...4966, ~5.7M events

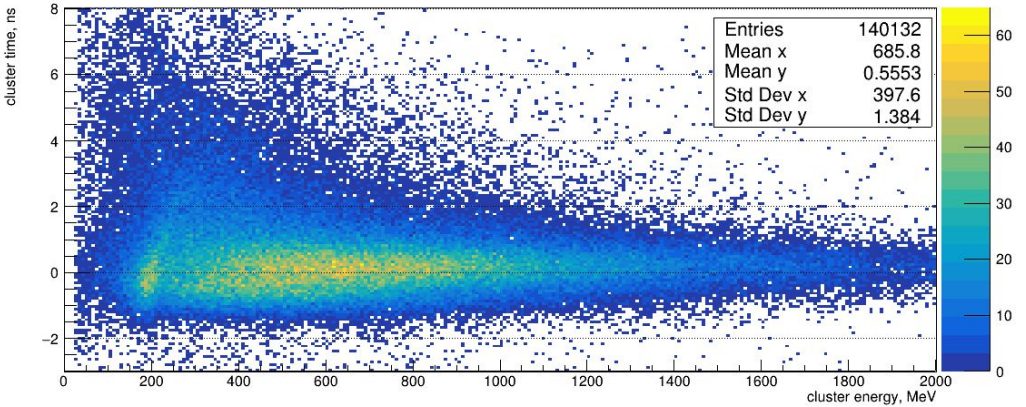
ECAL cluster time vs energy (experiment)

No cut

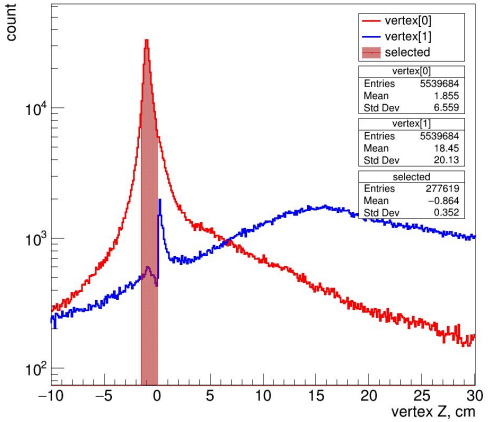
Kr 2.6 AGeV→ Sn (2.57), runs 4921...4966, ~5.7M events



$-1.5 < Z_0 < 0$



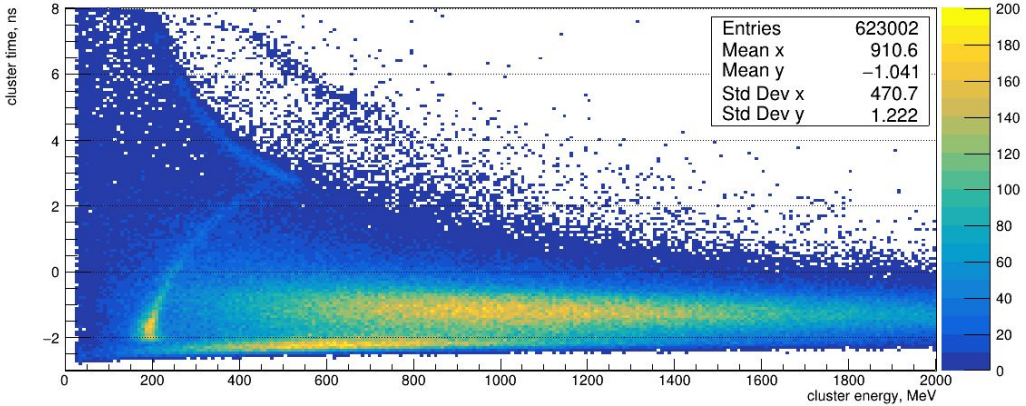
All clusters involved into effective mass calculation



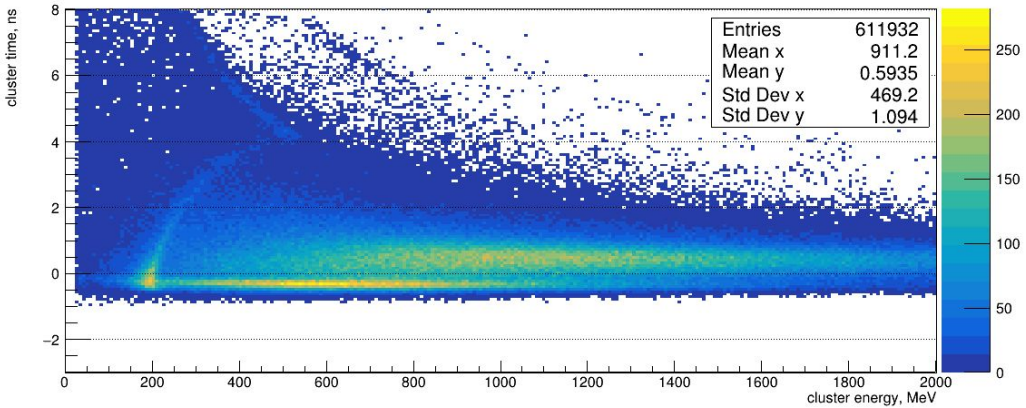
Events selected that has primary vertex found in the range
(using run_reco.bmn.C)

ECAL cluster time vs energy (Monte-Carlo)

GEANT4, DCMQGSM KrSn 2.36AGeV mb, ~2M events

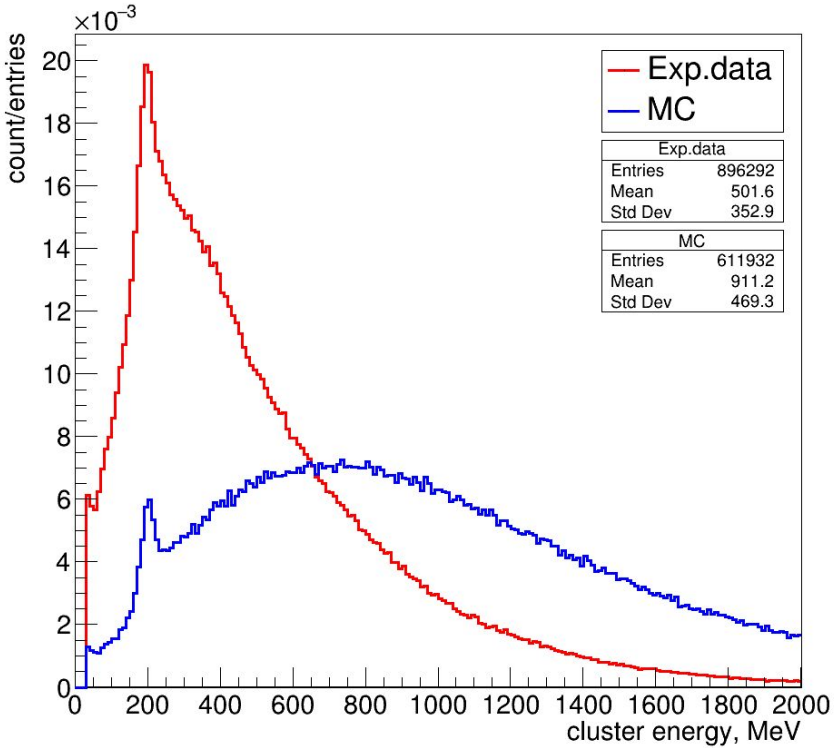


Cell time calculated as weighted average time of MC points

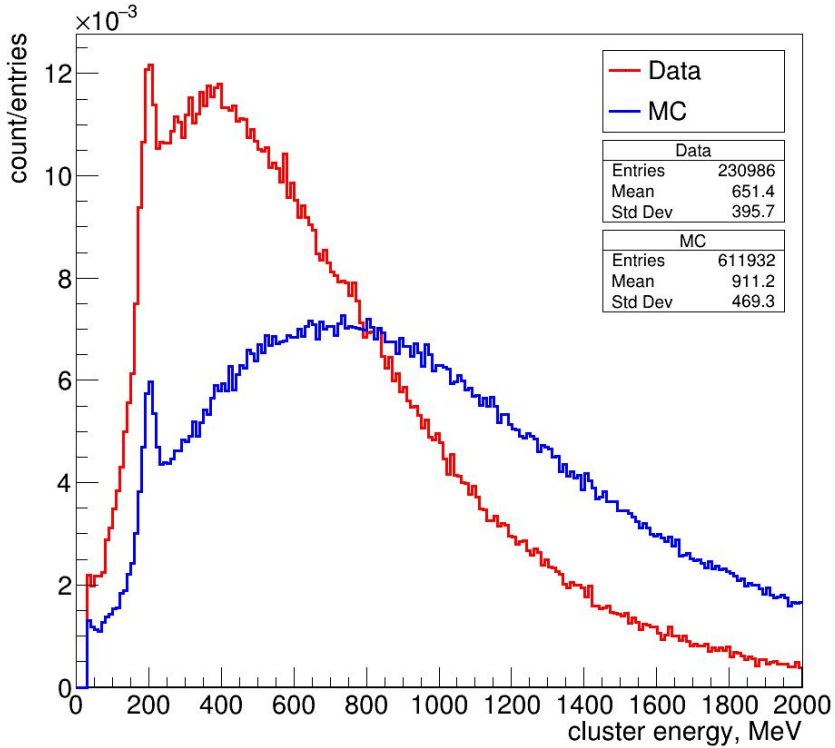


WLS fiber delay considered

ECAL clusters energy spectra



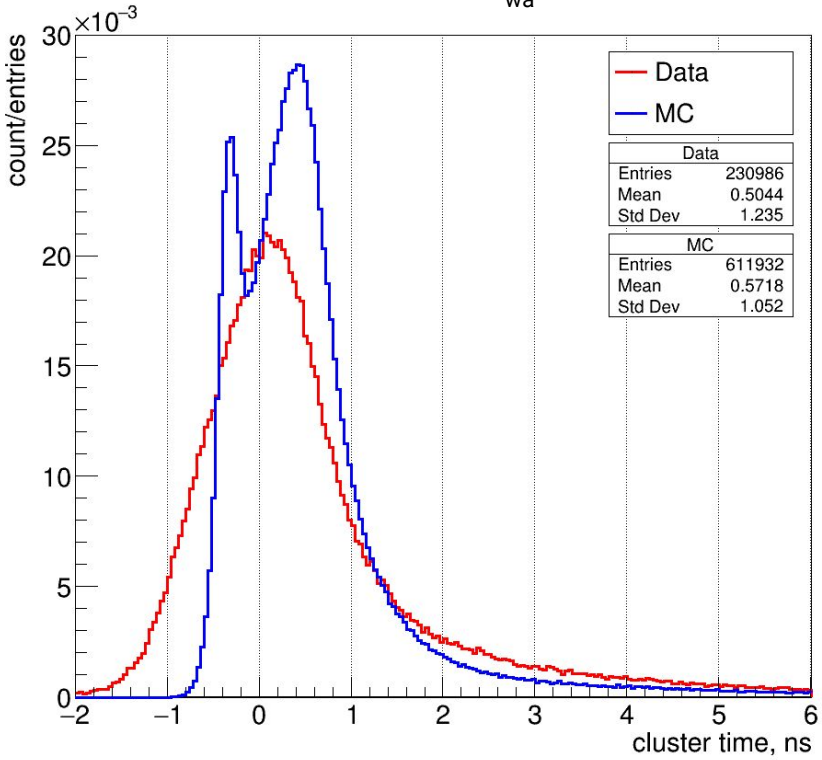
Experimental data spectrum of all clusters involved into effective mass calculation



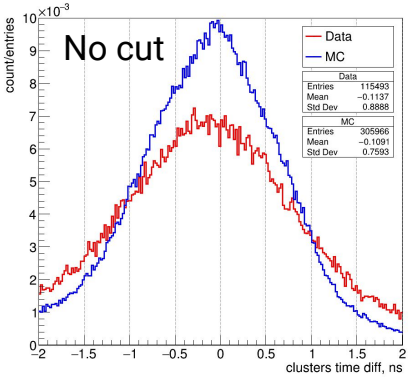
Events selected that has primary vertex found

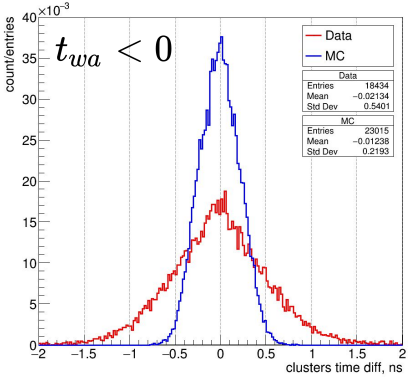
Time parameters of ECAL cells and clusters

Cluster time t_{wa}, ns

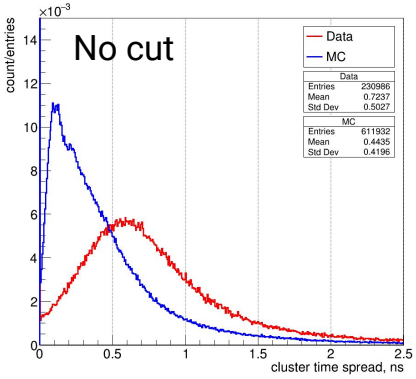


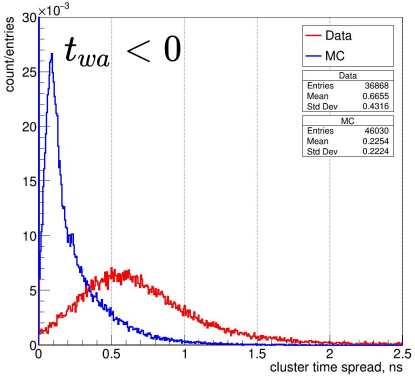
$\Delta t_{wa} = t_{wa1} - t_{wa2}$





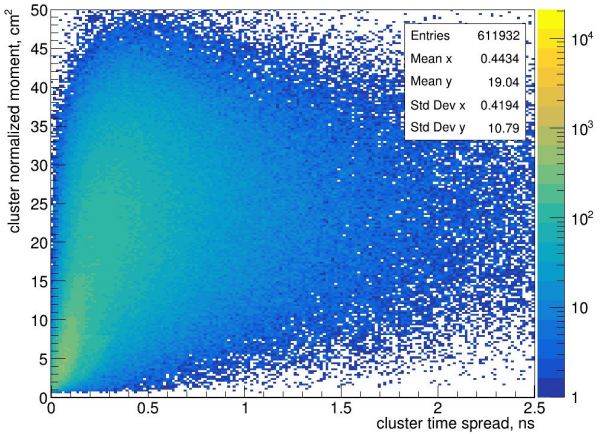
t_{sp}



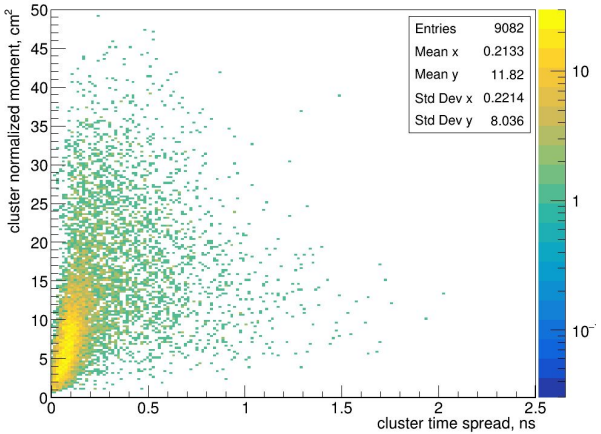


Cluster shape parameters.

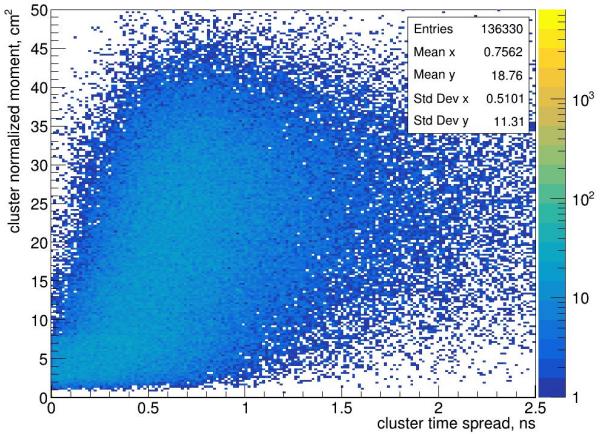
MC data
All events



MC data
t_{wa} cut & π^0 range of ef.mass



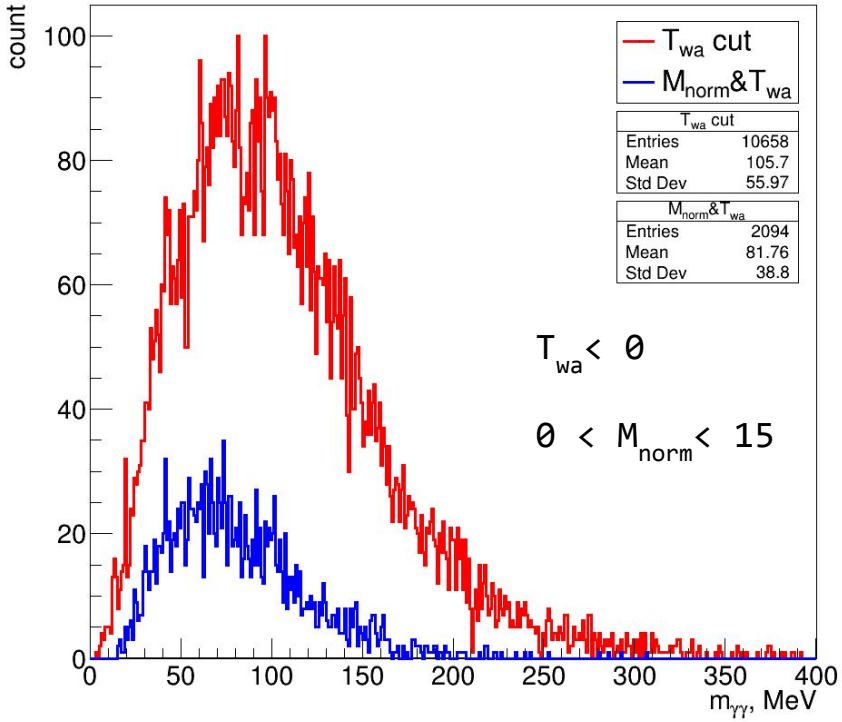
Experimental data
Vertex cut



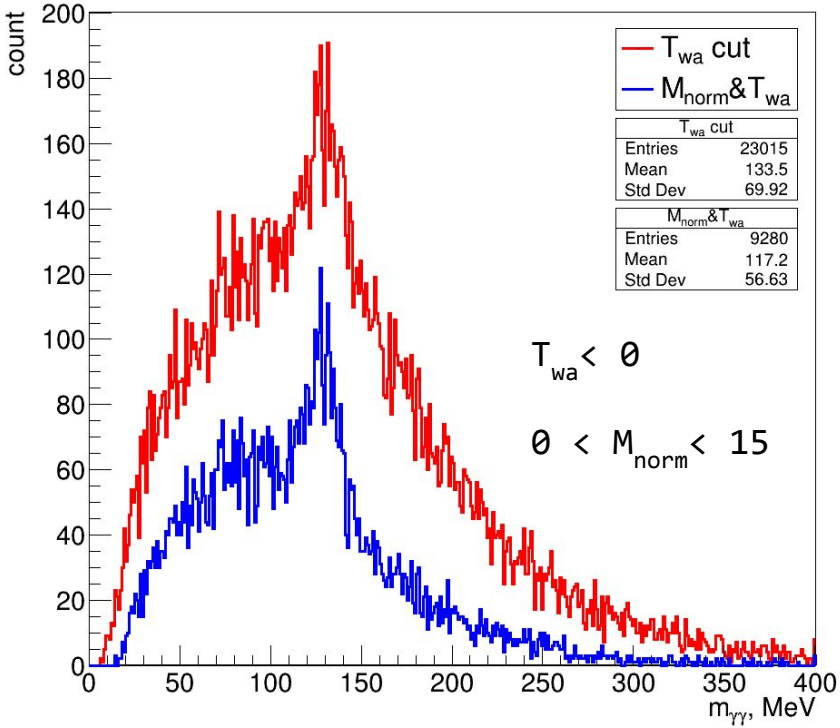
Cluster normalized moment (M_{norm}) vs time spread (t_{sp})

Effective mass spectra with cut on cluster time

Exp. data. -1.5 cm < Z_{vertex} < 0 cm

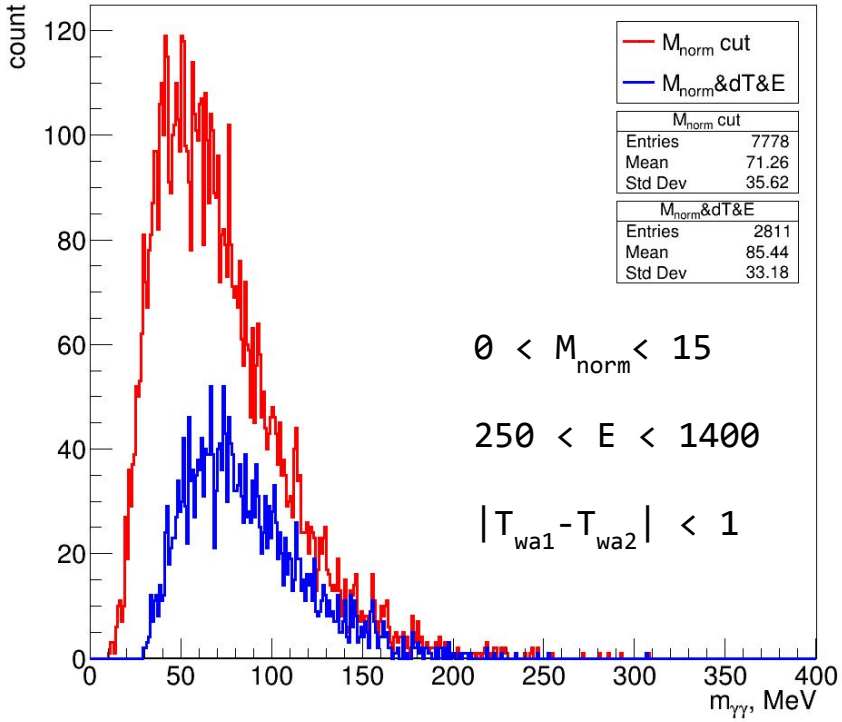


MC

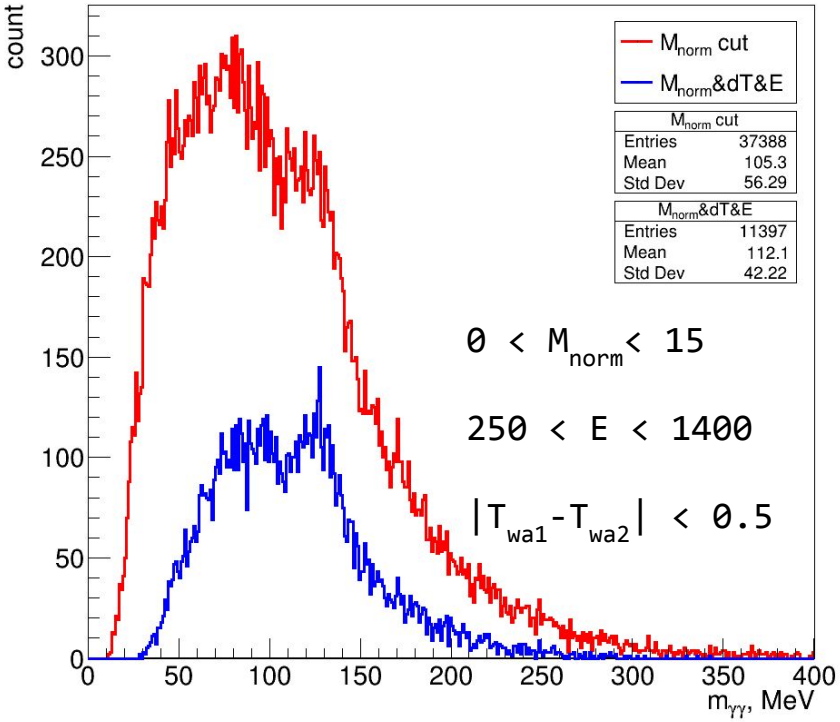


Effective mass spectra without cut on cluster time

Exp. data. -1.5 cm < Z_{vertex} < 0 cm



MC



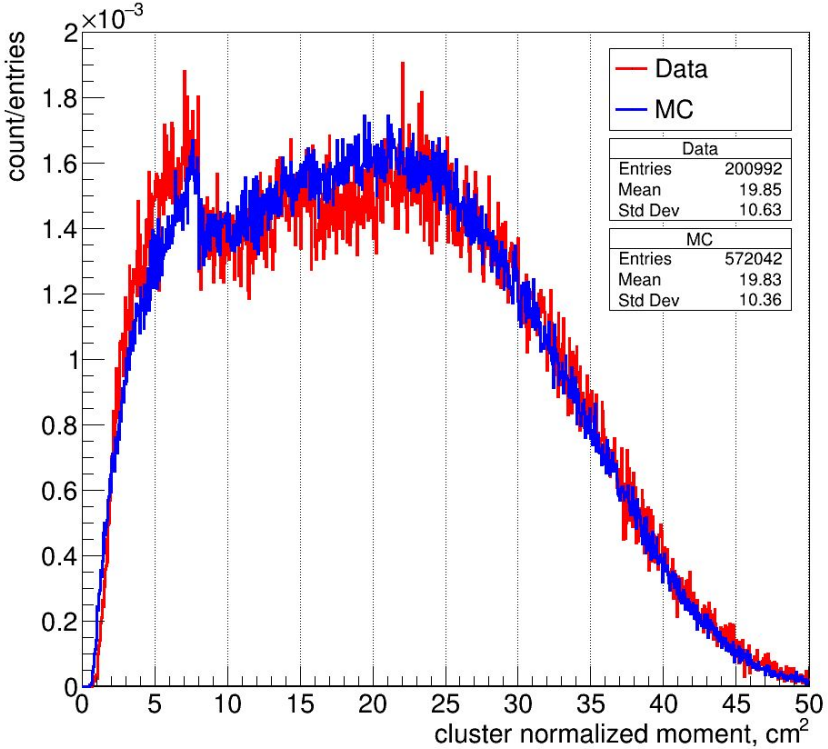
TODO:

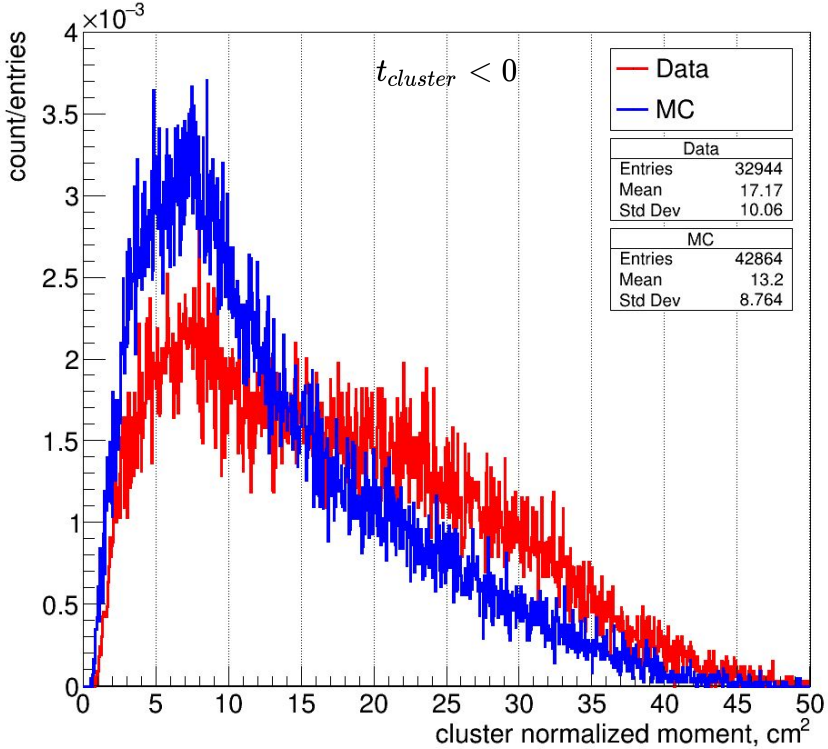
- Hardware
  - Two shoulders ECAL (work in progress)
  - Replace ADC by TQDC

- Software
  - Optimize cut by cluster shape
  - Include other detectors data into the analysis

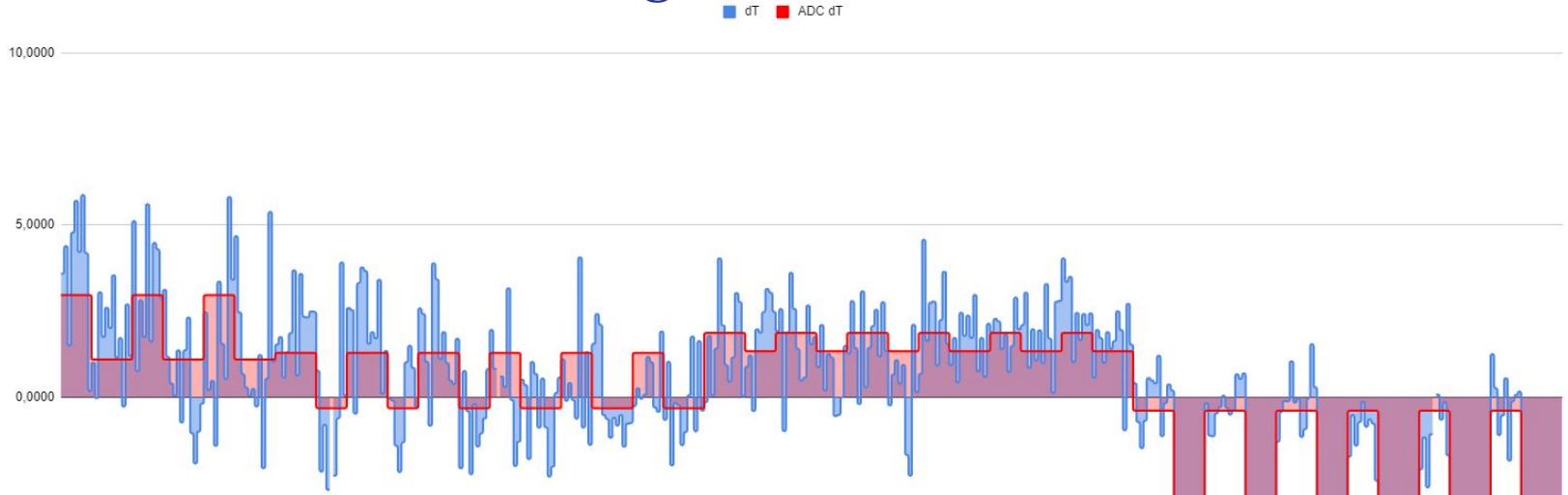
BACKUP

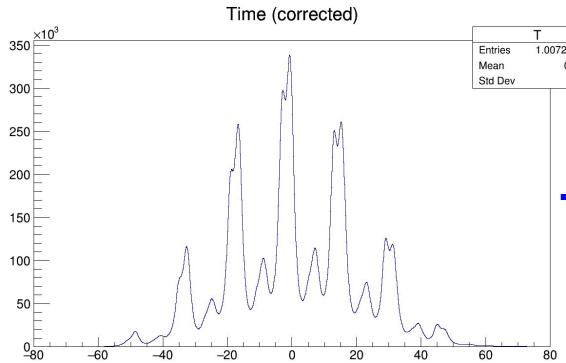
Cluster normalized moment

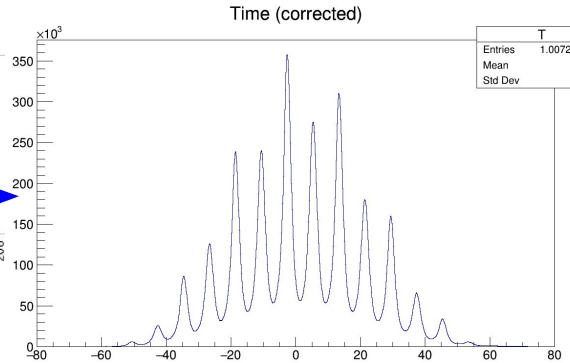




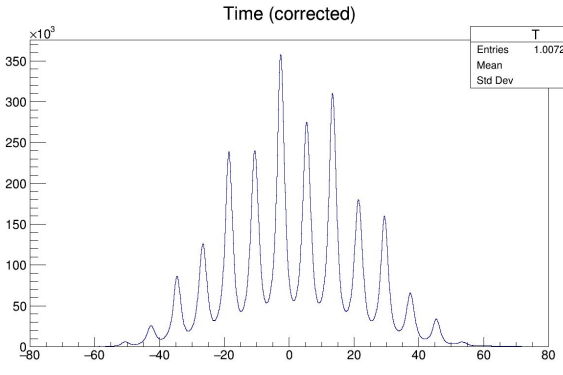
ECAL cells time averaged over the ADC ids

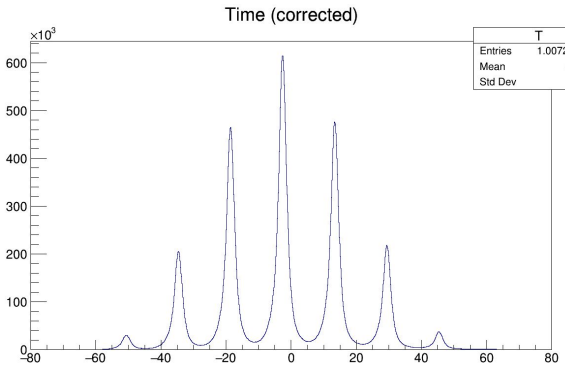


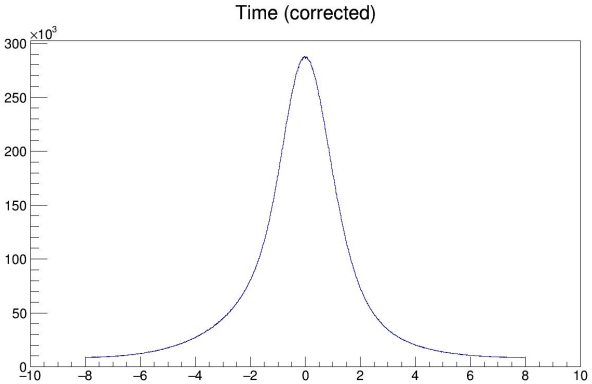




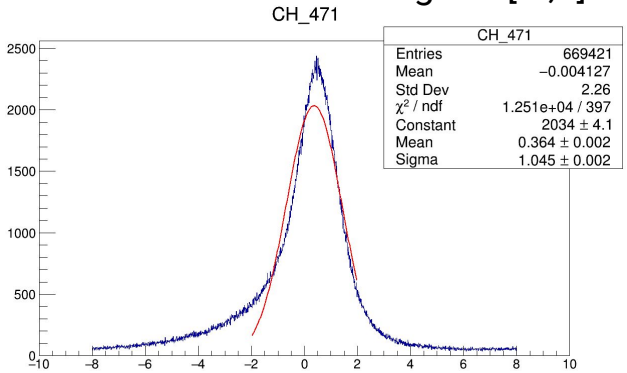
ECAL cell time reconstruction flow



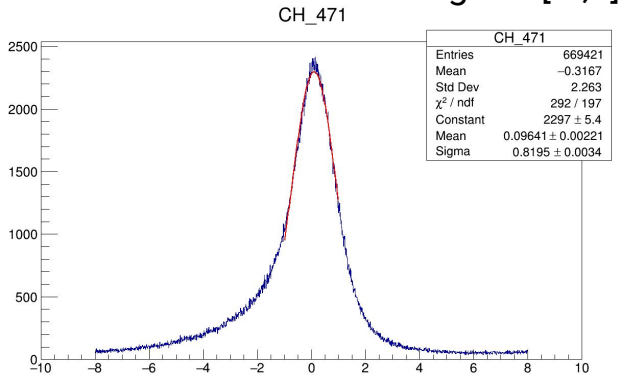




First try
Gaussian fit in the range of [-2,2]

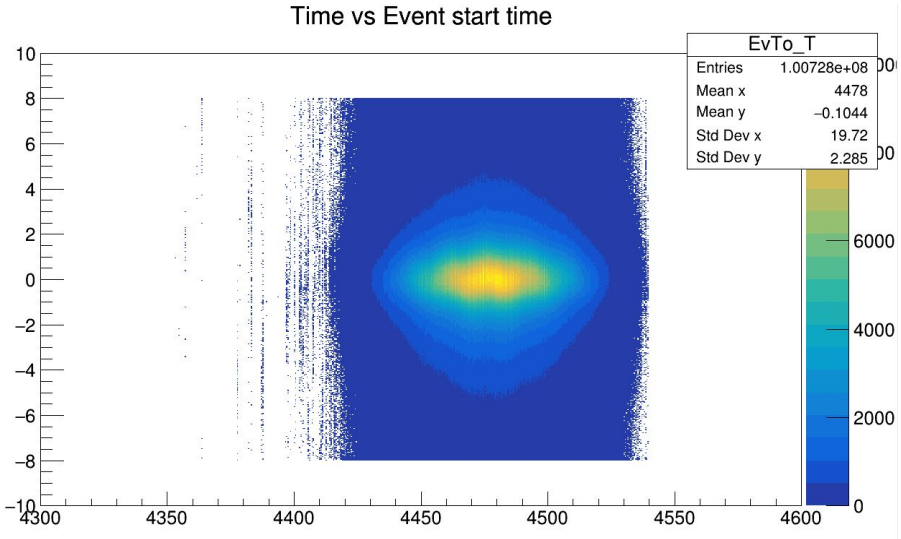


Second try
Gaussian fit in the range of [-1,1]

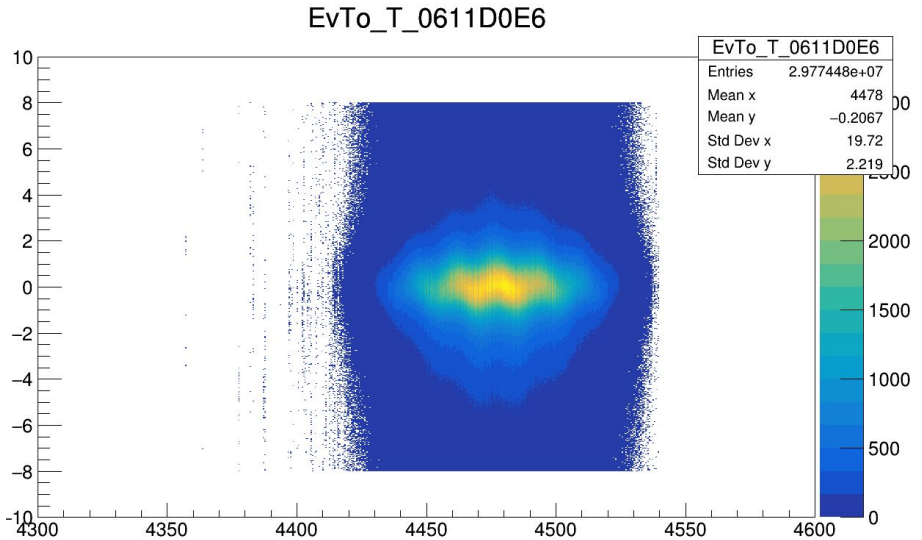


Syne-like distortion (in the final result also)

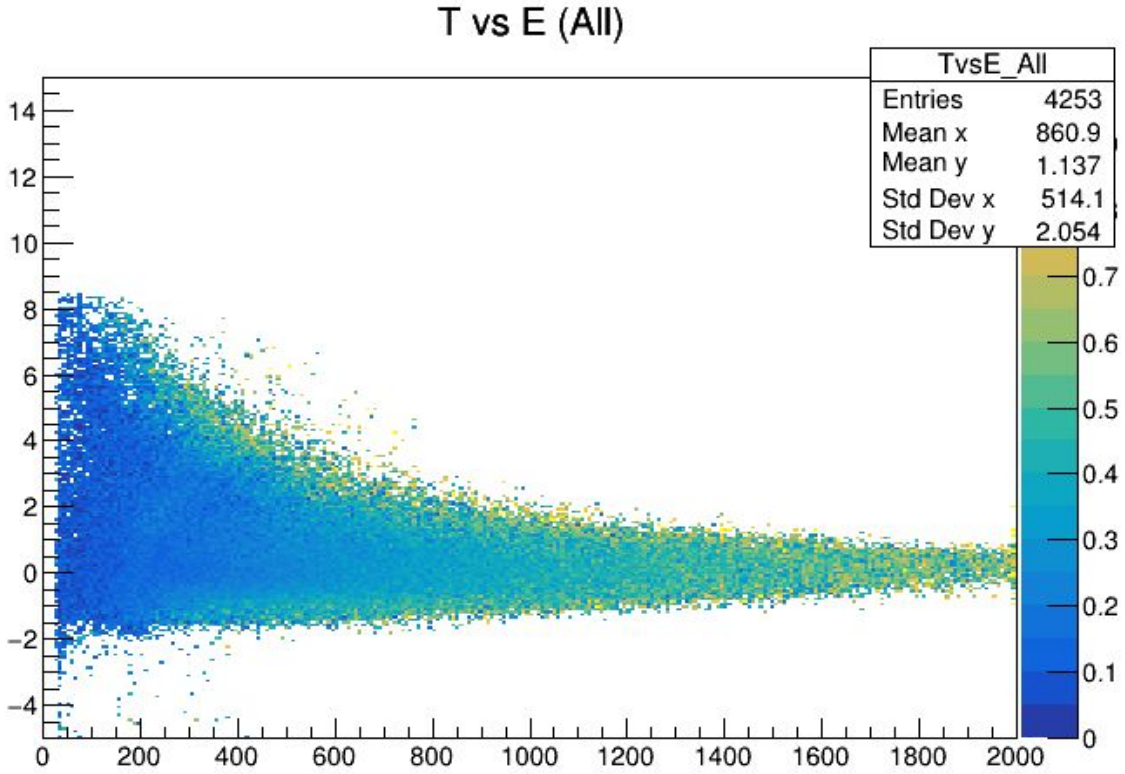
All channels together

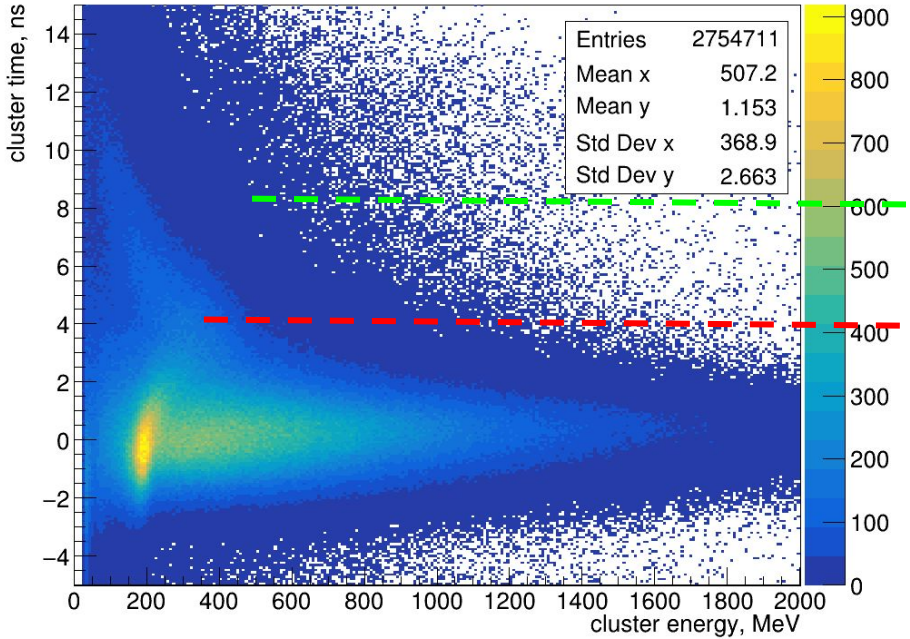


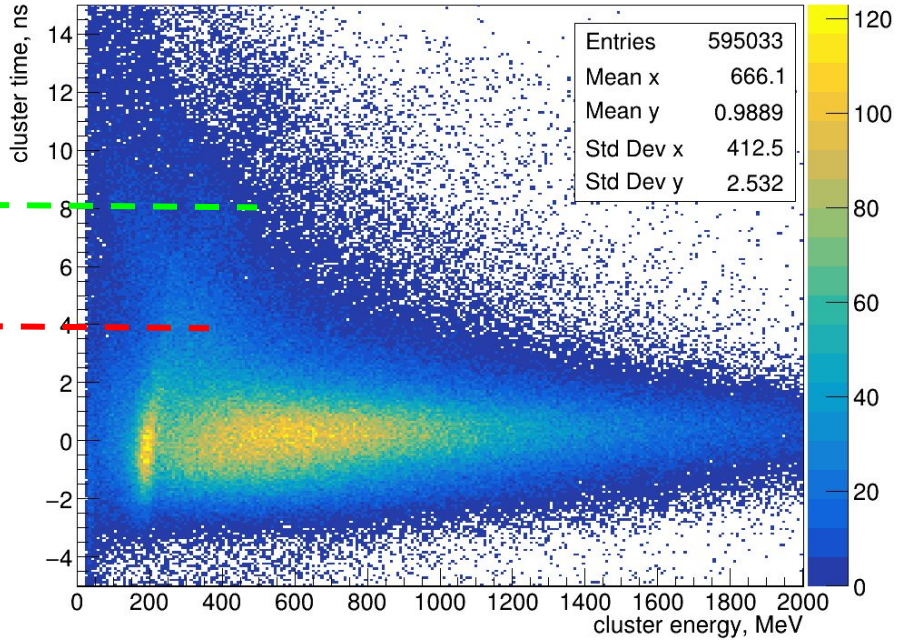
Single ADC



TvsE_Vertex / TvsE_All (bin >= 5)




Entries 2754711
Mean x 507.2
Mean y 1.153
Std Dev x 368.9
Std Dev y 2.663
cluster time, ns
cluster energy, MeV


Entries 595033
Mean x 666.1
Mean y 0.9889
Std Dev x 412.5
Std Dev y 2.532
cluster time, ns
cluster energy, MeV