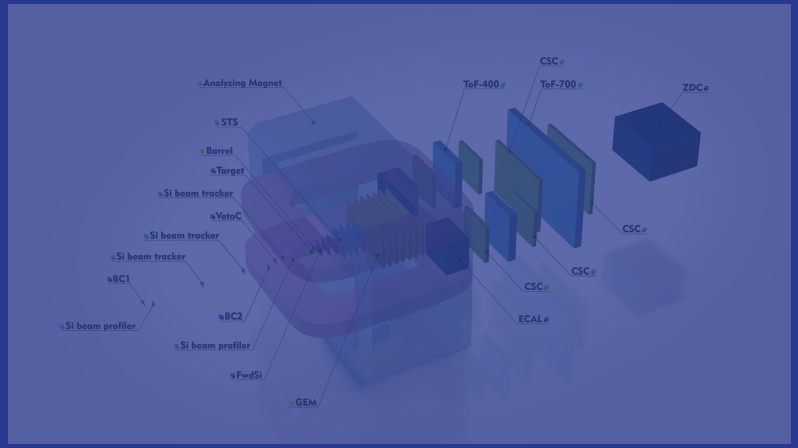
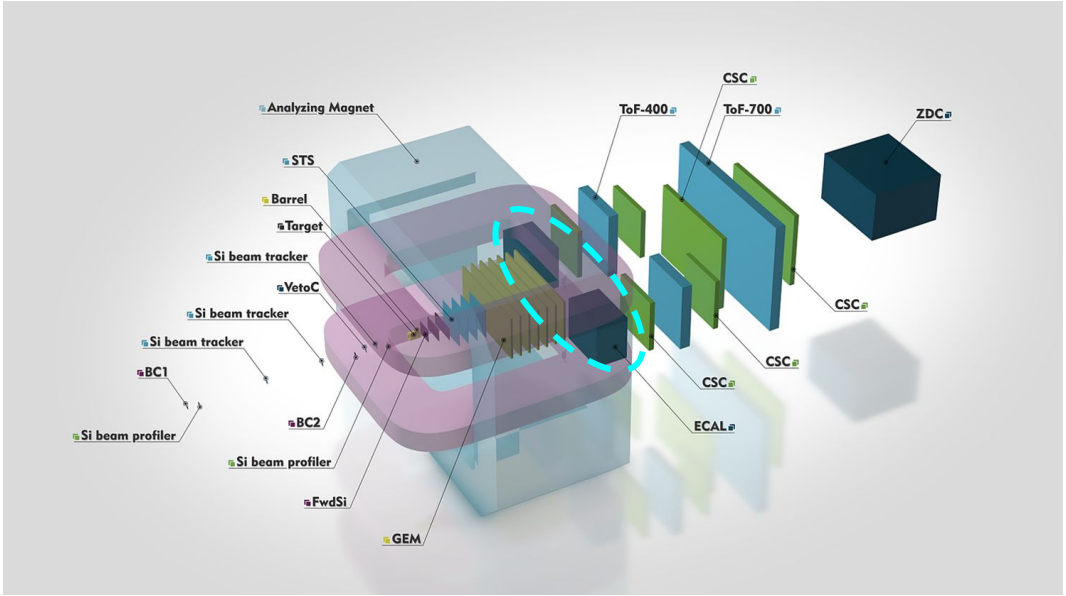


Data selection criteria for gamma-clusters detection in BMN ECAL

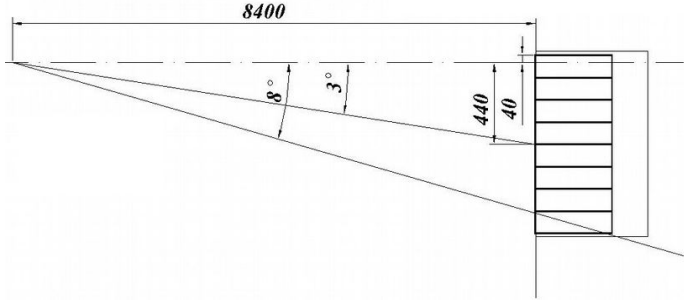
Petr Alekseev on behalf of BMN ECAL group

5th Collaboration Meeting of the BM@N Experiment at the NICA Facility
JINR
April 20–21, 2020

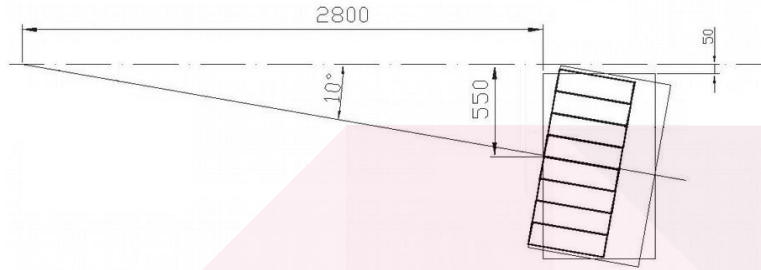
Schematic drawing of the ECAL position in the BM@N setup



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, ~5M ev.



- 2018 year ECAL setup (run 7)
  - one shoulder 7x7 modules, 411 cells
- New ECAL setup
  - two shoulders of 8x7 modules, 1008 cells

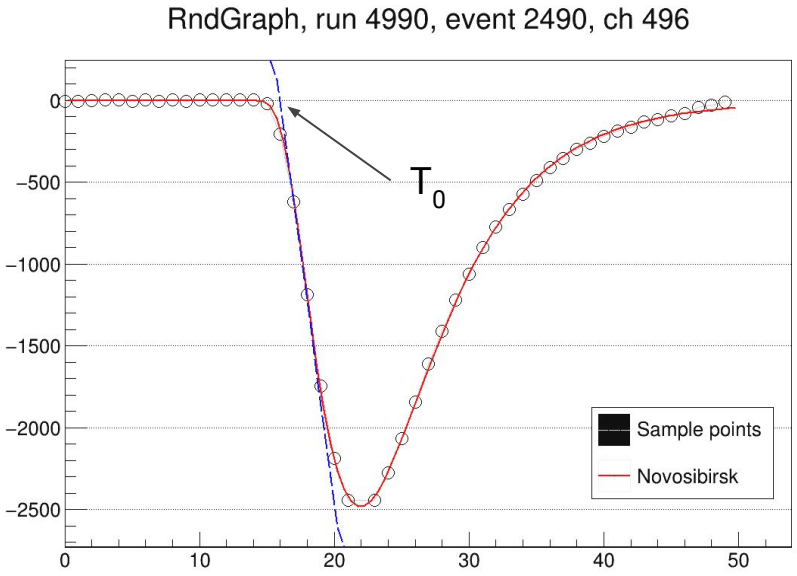
Bmnroot ECAL configuration flies

- ECAL mapping file (`$VMCWORKDIR/input/ECAL_map_period_7.txt`)
  - ADC id & ADC ch → ECAL ch
- ECAL calibration file (`$VMCWORKDIR/parameters/ecal/ECAL_calibration_run7.txt`)
  - ECAL ch → Calibration coeff (MeV)
- ECAL geometry files (`$VMCWORKDIR/geometry/ECAL_v3_run7_pos?.root`)
  - MC simulation (run_sim_bmn.C)
  - MC data digitization (ECAL ch → Ecal(x,y), Lab(x,y,z)*)
  - Exp. data raw to root conversion (ECAL ch → Ecal(x,y), Lab(x,y,z)*)

* ECAL cells coordinates in lab system are written into digi root files so they are fully ready for analysis

ECAL signal raw to digi conversion

1. Pedestal - mean of slices 0..7
2. Novosibirsk fit
3. Peak amplitude $\mathbf{A_p}$ and time $\mathbf{T_p}$
4. Start time $\mathbf{T_0}$
5. Amplitude **A** - mean of $T_0..T_0$+20 slices
6. Get coords from geometry file

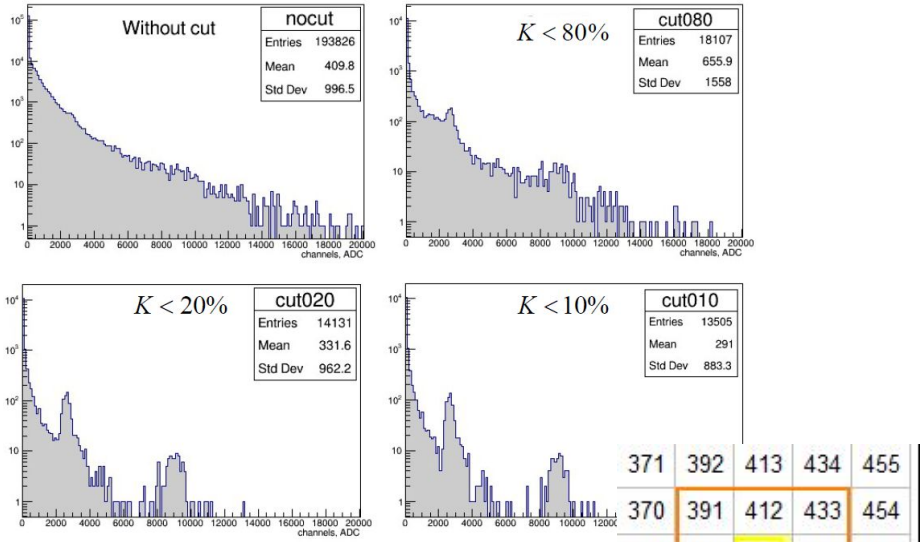


Novosibirsk function:

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

Amplitude calibration by MIP peak

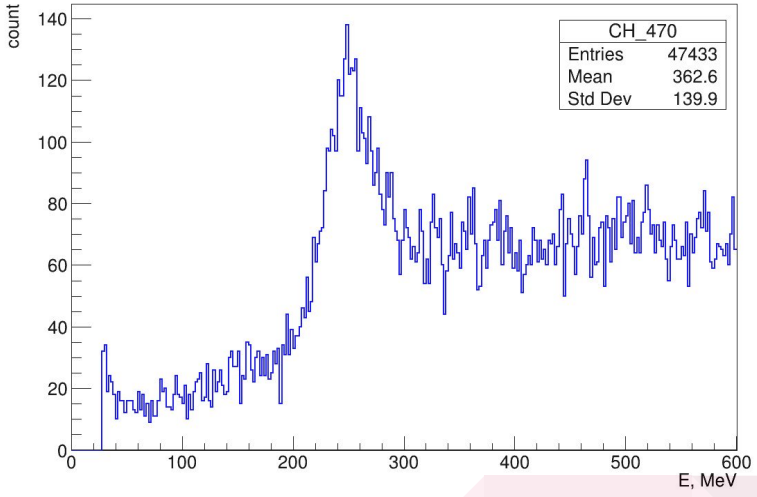
C 3.2 AGeV (3503...3511) ~1.6M ev.
Cell isolation criteria



371	392	413	434	455
370	391	412	433	454
369	390	411	432	453
368	389	410	431	452
367	388	409	430	451

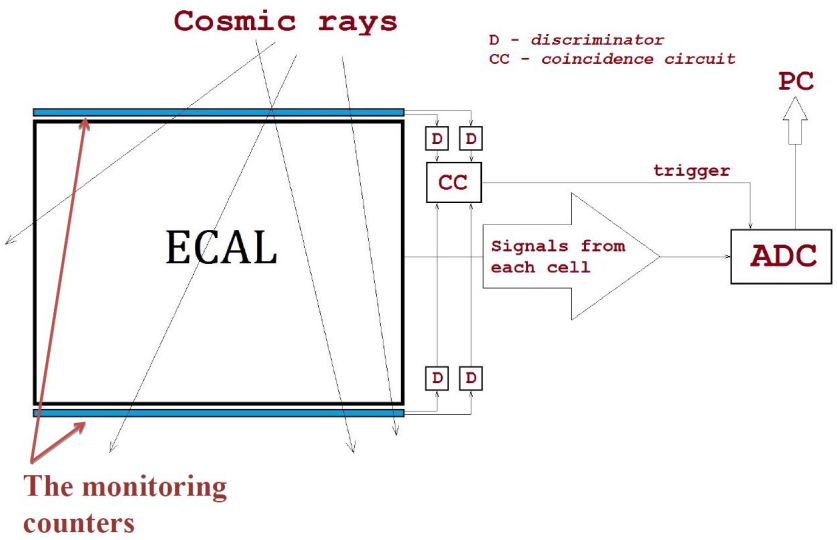
Peak was found in 254 channels

Kr 2.6 AGeV (4921...4966) ~5.7M ev.
Cluster amplitude of most bright cell

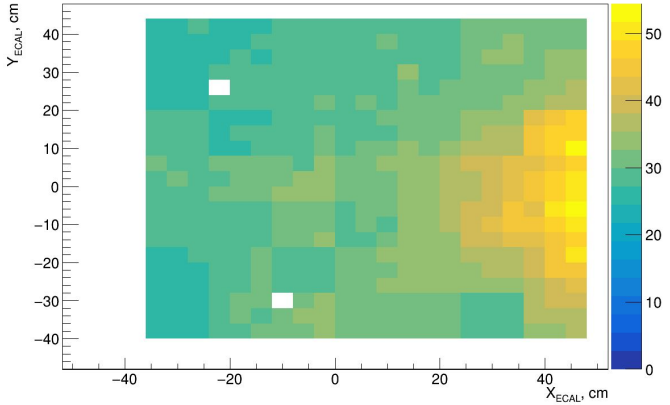


Peak was found in 102 channels

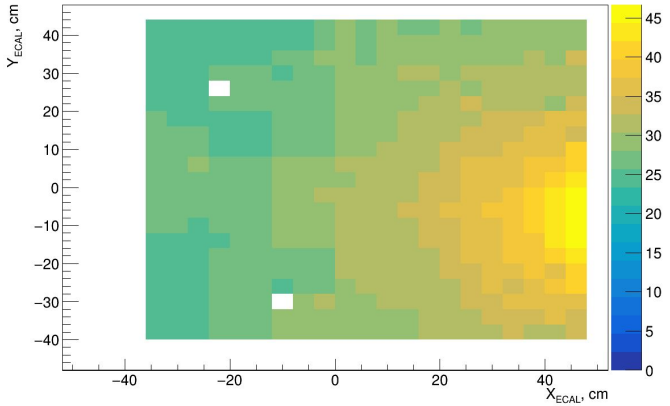
Calibration on cosmic rays



Cosmic calibration only

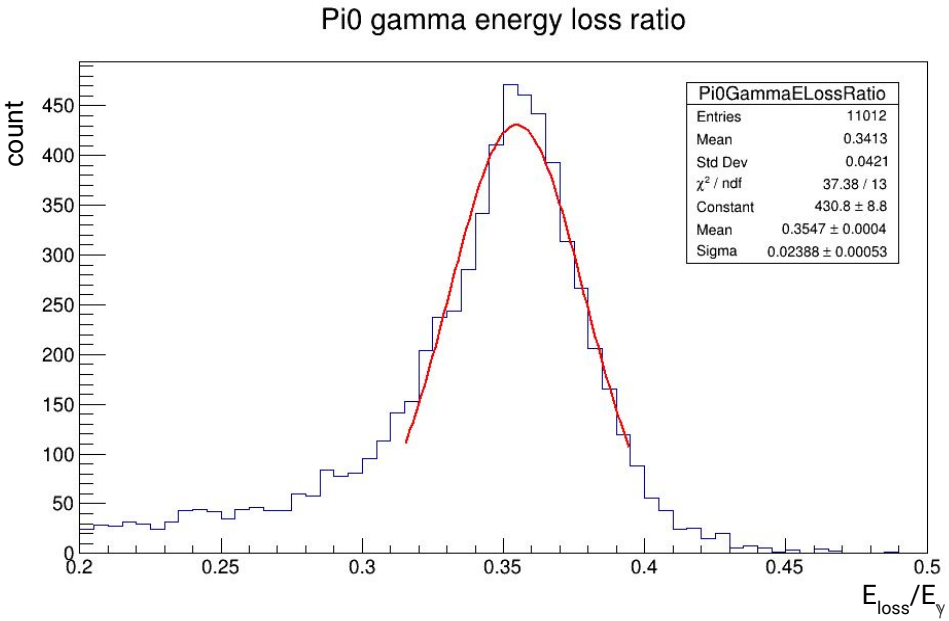


Cosmic + MIP calibration



Calibration coefficients was found for all 441 channels

Cell energy reconstruction

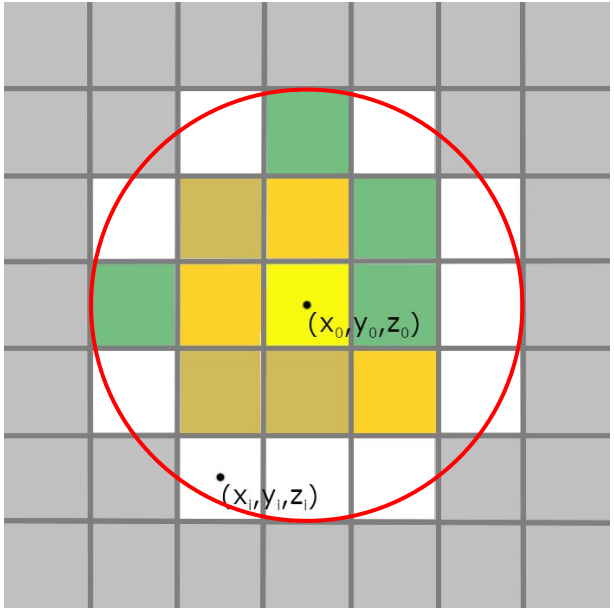


Cell energy scale factor was obtained from simulation

$$K = \frac{E_\gamma}{E_{loss}} = (0.3547)^{-1} = 2.819$$

Cluster parameters

- Minimal cell energy is 10 MeV, other cells are ignored
- Cluster radius is 10 cm (21 cells of 5x5 area)
- Cluster parameters are:
  - energy
  - center gravity
  - weighted average time
  - normalized moment



$$t_{wa} = \frac{\sum E_i \cdot t_i}{\sum E_i}$$

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

Clusters selection for effective mass calculation

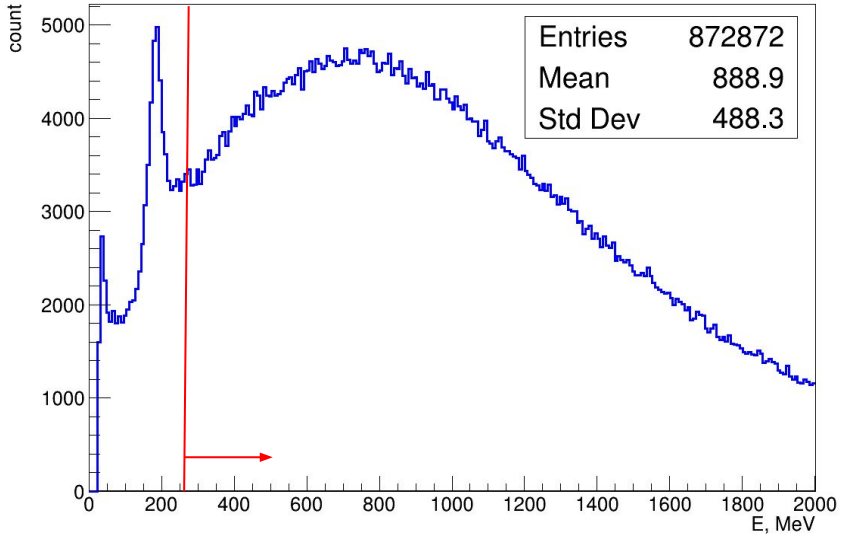
1. Find most bright cell in the event (max(E_i)). It's the center of first cluster.
2. All the cells which are close enough to that cell is the cells of the first cluster (R_i < 10 cm).
3. Find most bright cell in the event which is outside of the first cluster. It’s the center of the second cluster.
4. All the cells which are close enough to that cell is the cells of the second cluster.
5. All the other cells in the event are ignored.

Cluster energy cut

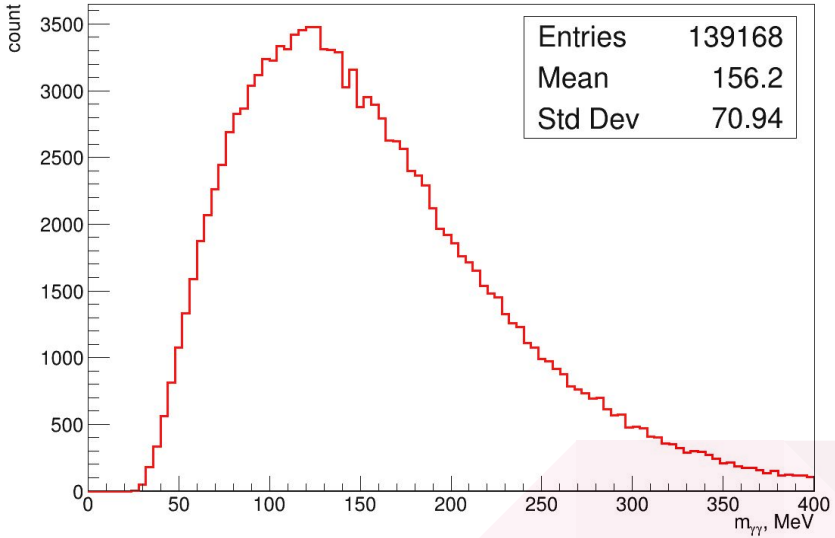
Monte-Carlo simulation. GEANT4, DCMQGSM KrSn 2.36AGeV mb, ~1M ev.

$R_{cluster}$ = 10 cm, E_{cell} > 10 MeV, Θ > 6°, **$E_{cluster}$ > 250 MeV**

Clusters energy spectra



Effective mass spectra

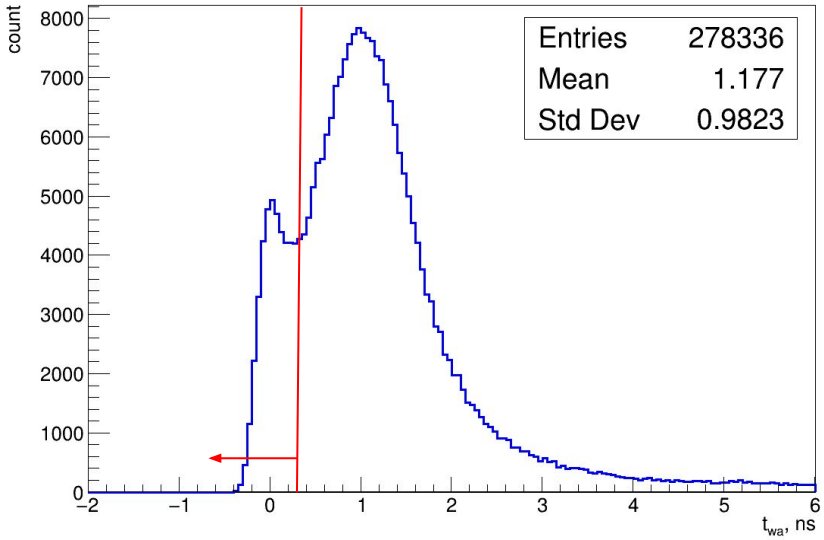


Cluster time cut

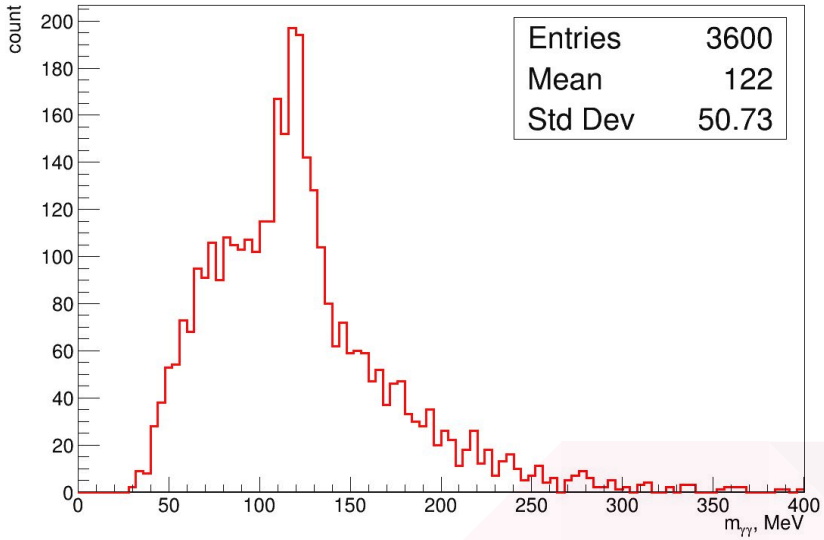
Monte-Carlo simulation. GEANT4, DCMQGSM KrSn 2.36AGeV mb, ~1M ev.

$R_{cluster}$ = 10 cm, E_{cell} > 10 MeV, Θ > 6°, $E_{cluster}$ > 250 MeV, **t_{wa} < 0.3 ns**

Clusters time



Effective mass spectra

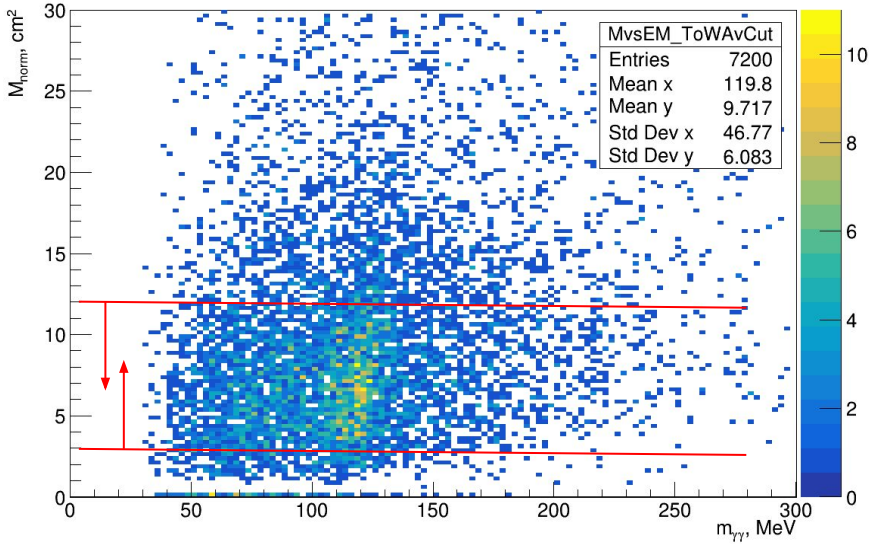


Cluster moment cut

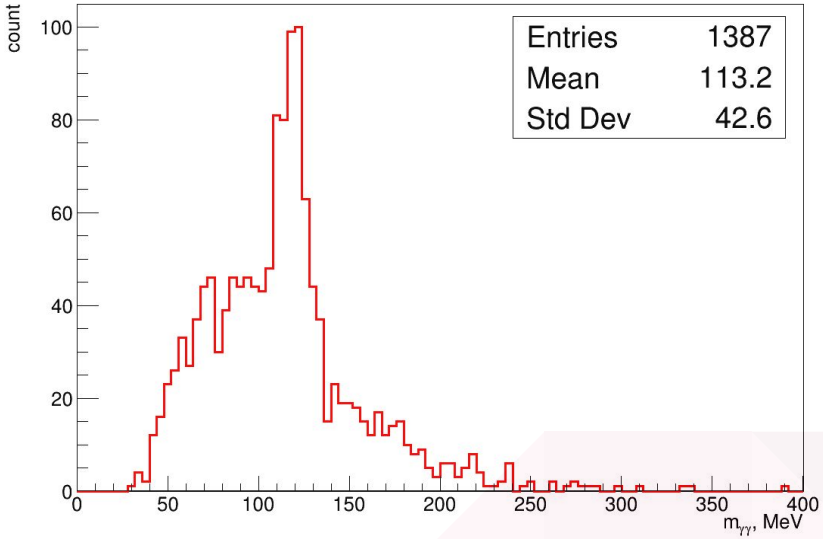
Monte-Carlo simulation. GEANT4, DCMQGSM KrSn 2.36AGeV mb, ~1M ev.

$R_{cluster}$ = 10 cm, E_{cell} > 10 MeV, Θ > 6°, $E_{cluster}$ > 250 MeV, t_{wa} < 0.3 ns, **$2 < M_{norm} < 12$**

Clusters normalized moment



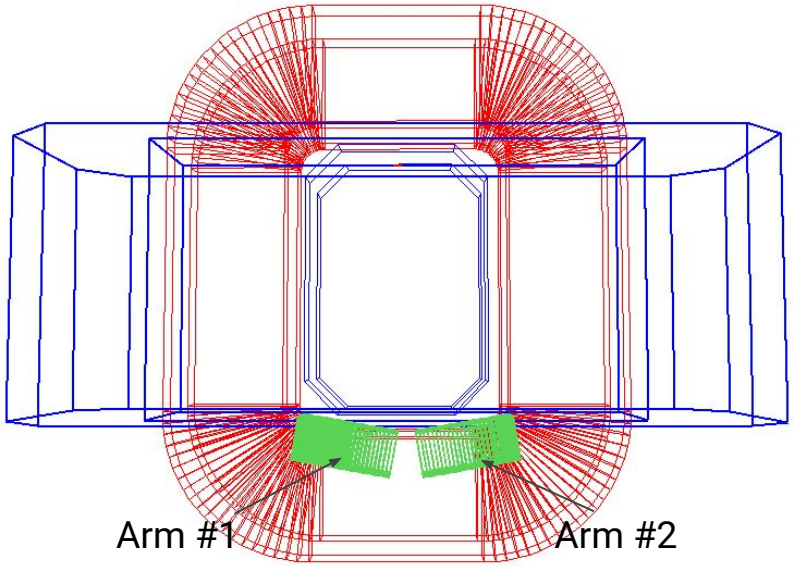
Effective mass spectra



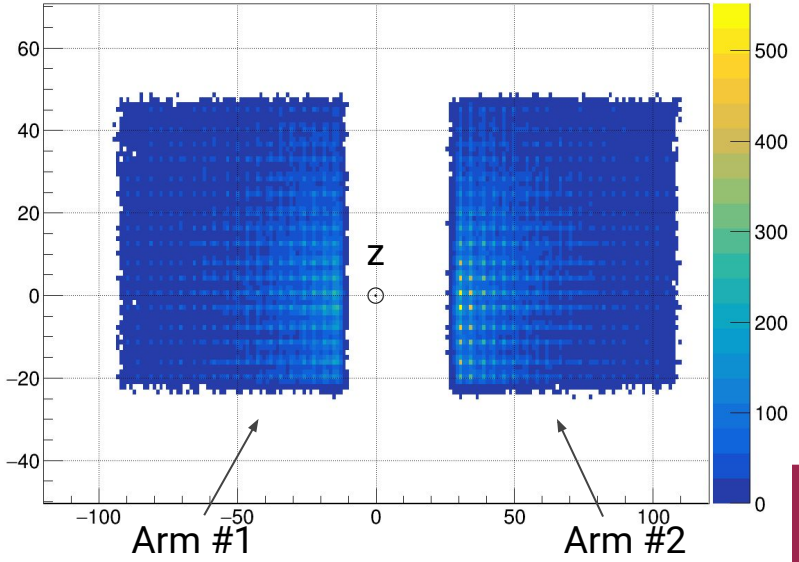
Two arms ECAL

Monte-Carlo simulation. GEANT4, LAQGSM CC 4AGeV mb, 300k ev.

ECAL position in the simulation



Clusters center gravity (lab coords)

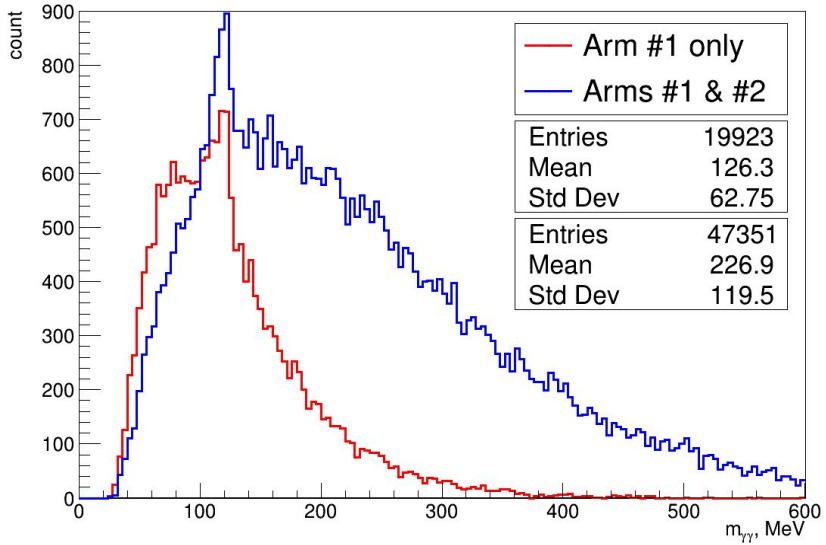


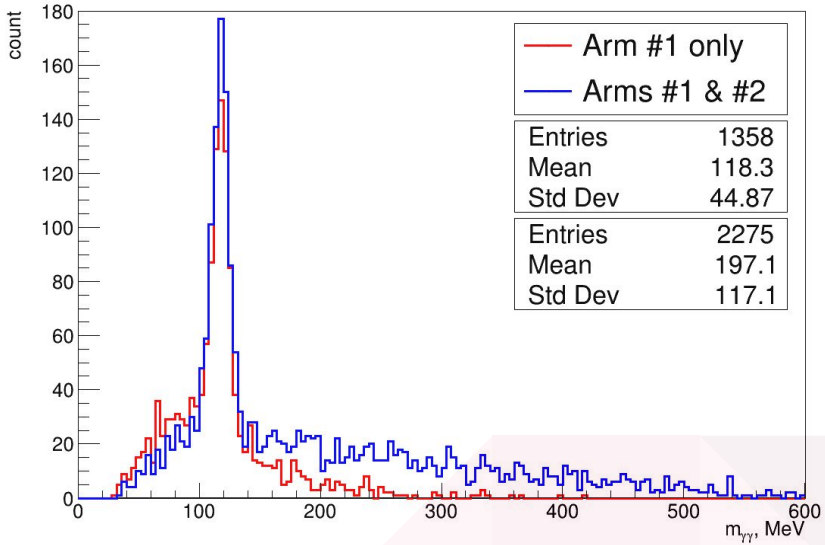
Two arms ECAL

Monte-Carlo simulation. GEANT4, LAQGSM CC 4AGeV mb, 300k ev.

E_{cell} > 10 MeV, $R_{cluster}$= 10 cm,
$E_{cluster}$> 250 MeV, Θ>6°

2 cm^2 < M_{norm} < 12 cm^2,
T_{wa} < 0.3 ns





ECAL experimental data of run 7 (spring 2018)

- C-beam,, Pb-target, ECAL position 1 (calibration runs)
- Kr-beam, different targets, ECAL positions 4 and 5

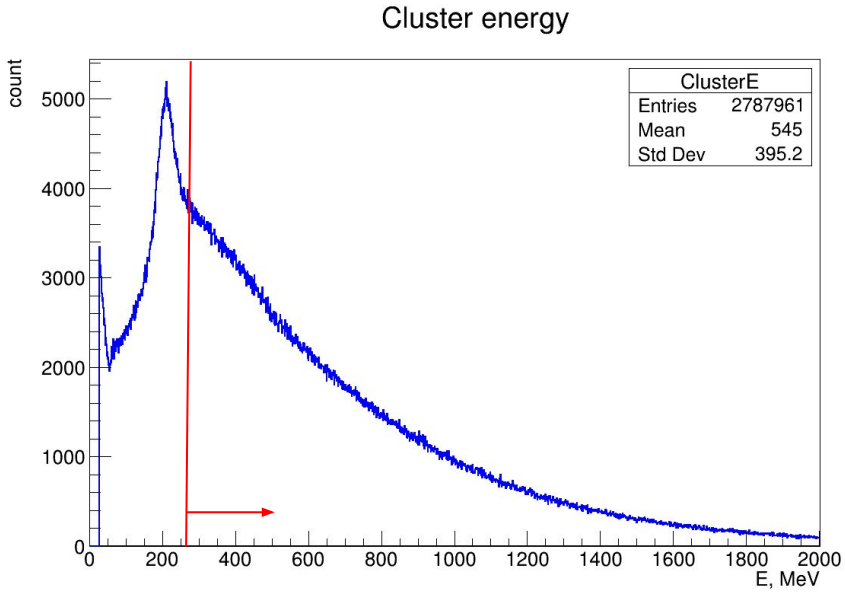
ECAL position 4, SP-1 1150A

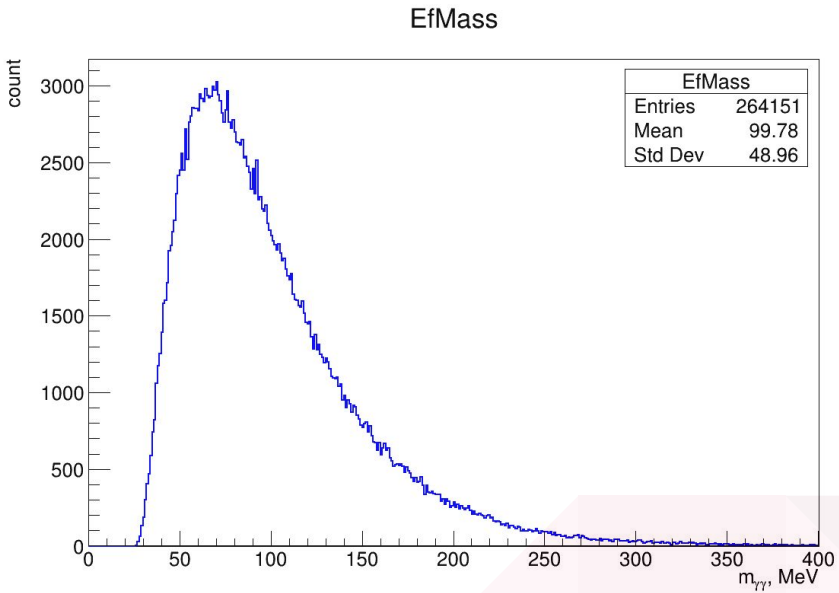
- Kr → Al runs 4906...4912 ~200k events
- Kr → Su runs 4921...4966 ~5.7M events
- Kr → Cu runs 4969...4972 ~800k events

Cluster energy

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

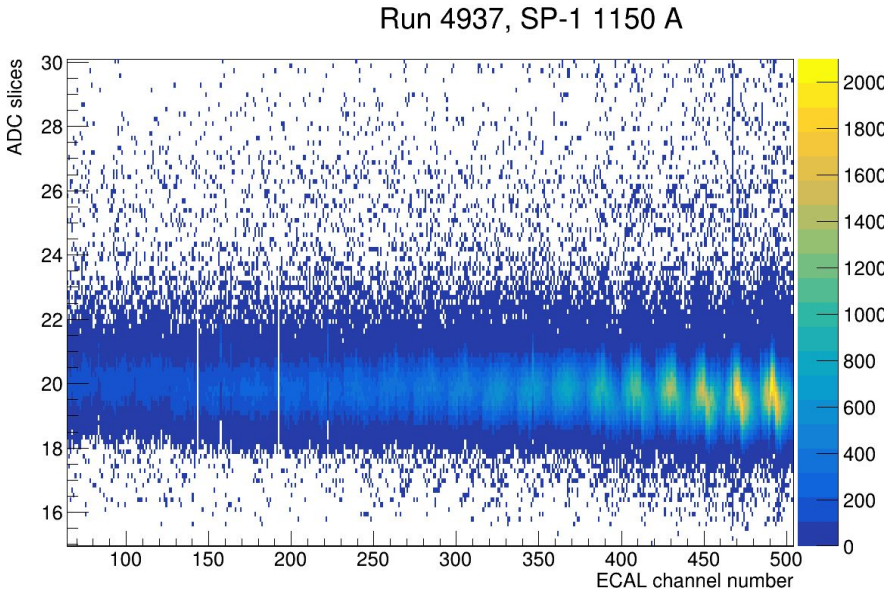
$R_{cluster}$ = 10 cm, E_{cell} > 10 MeV, Θ > 6°, **$E_{cluster}$ > 250 MeV**

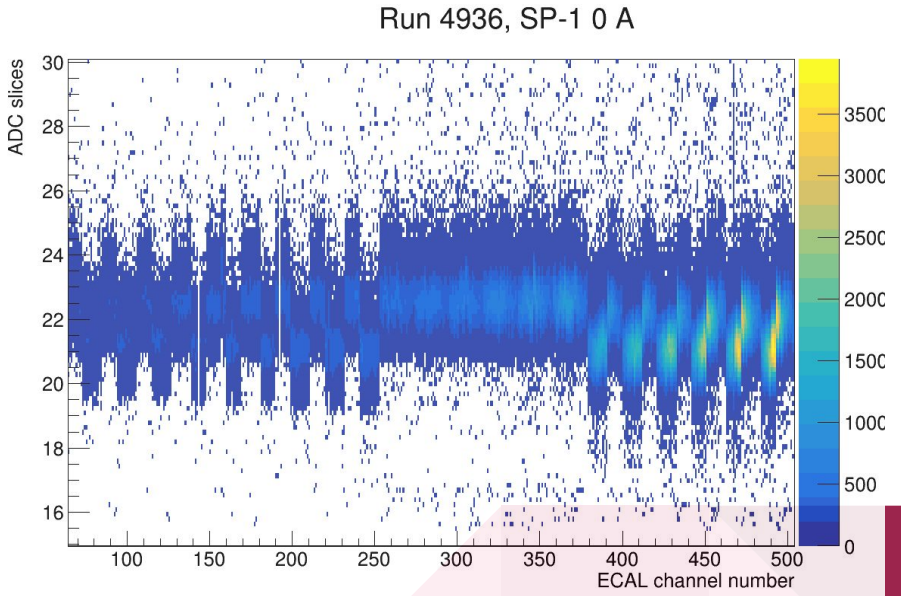




ECAL channels signal time

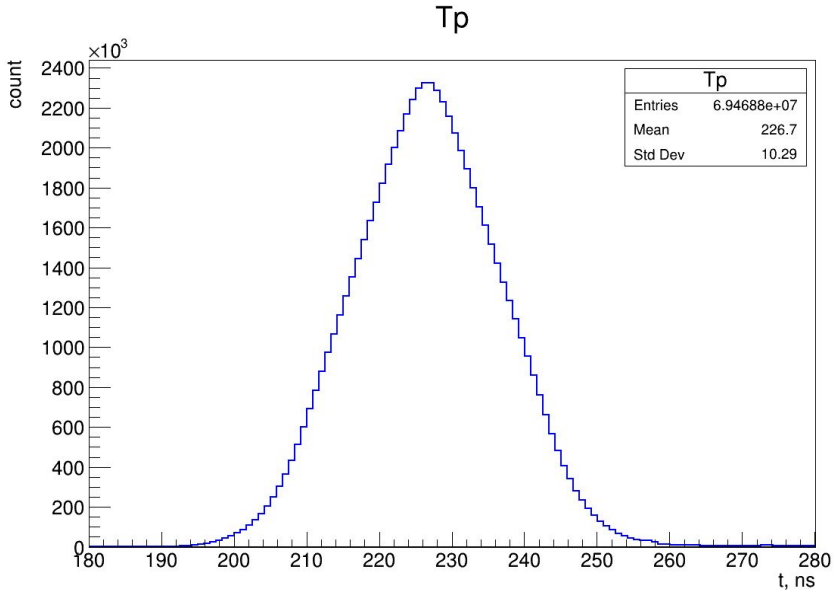
Kr 2.6 AGeV→ Su (2.57)

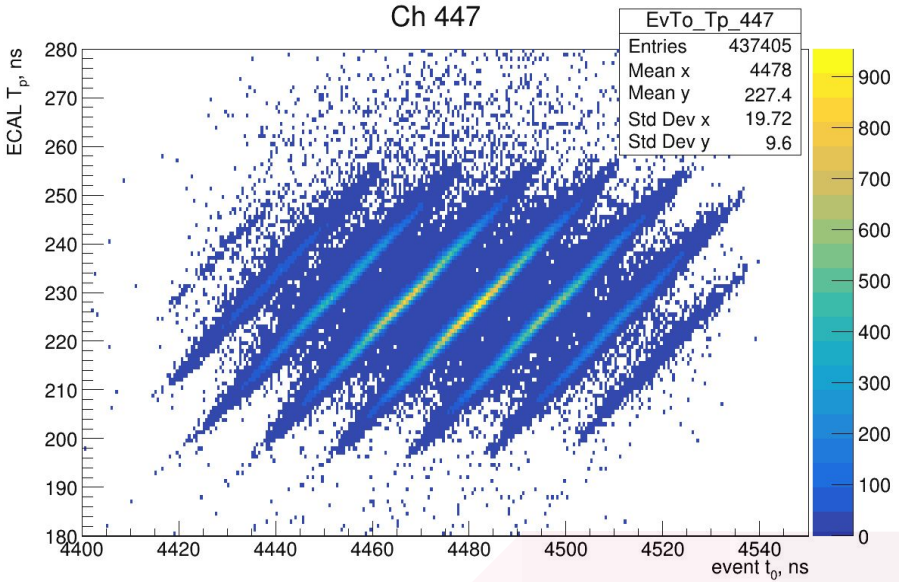




ECAL channels signal time and event start time T_0

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





Thanks for your attention

Schematic and general view of a single cell of the calorimeter