NRC «Kurchatov Institute» – ITEP, Moscow, Russia
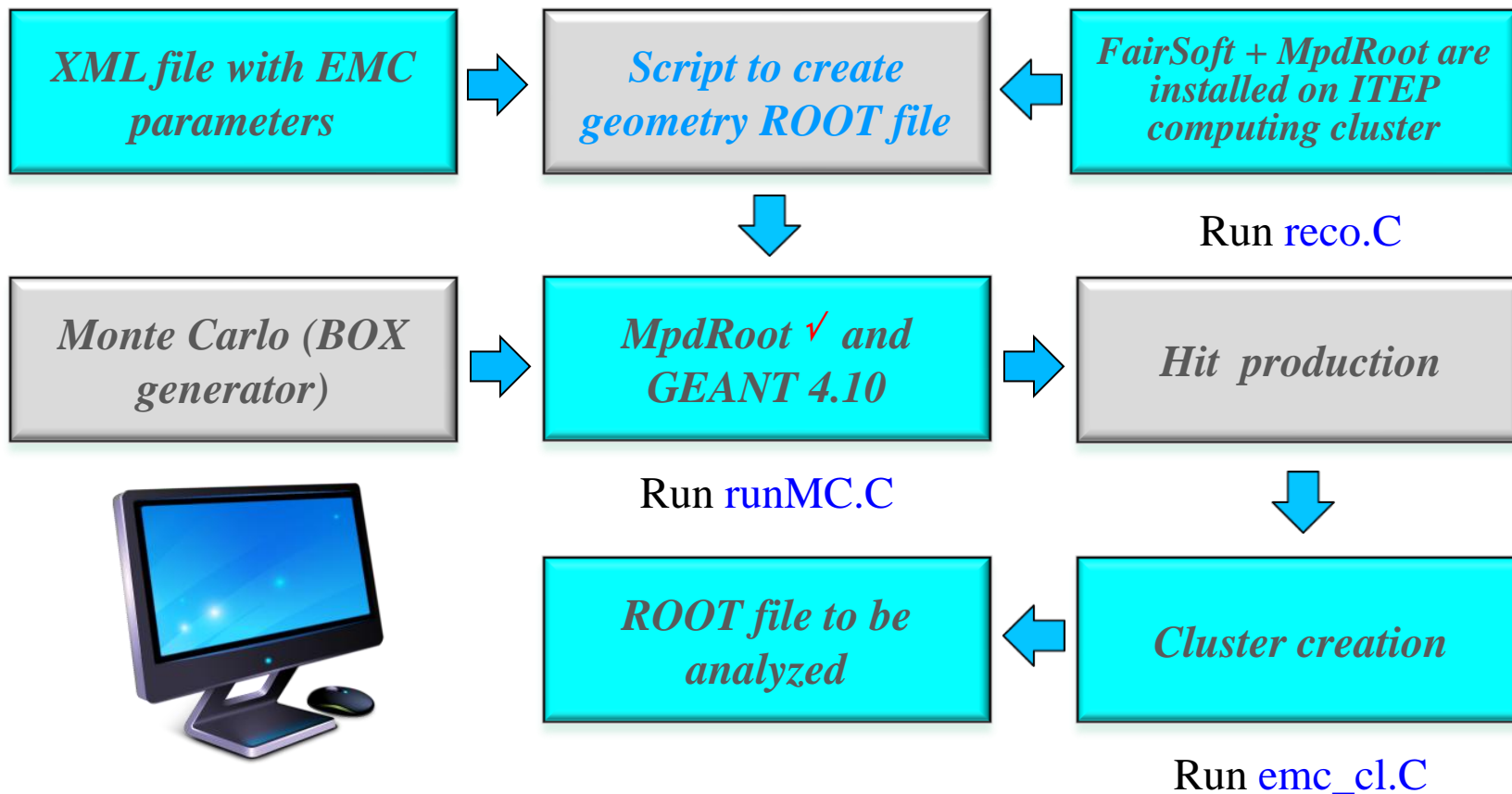
EMC geometry and cluster production for MPD detector

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**The first Collaboration meeting
of the MPD and BM@N experiments
at the NICA Facility**

11 − 13 April 2018, VBLHEP − Dubna

Soft structure

Run create_rootgeom_emc_v2.C

```
┌──────────────────────┐      ┌──────────────────────┐      ┌──────────────────────┐
│  XML file with EMC   │ ──▶  │  Script to create    │ ◀── │ FairSoft + MpdRoot are│
│     parameters       │      │ geometry ROOT file   │      │  installed on ITEP    │
│                      │      │                      │      │  computing cluster    │
└──────────────────────┘      └──────────────────────┘      └──────────────────────┘
                                        │
                                        ▼                      Run reco.C
┌──────────────────────┐      ┌──────────────────────┐      ┌──────────────────────┐
│  Monte Carlo (BOX    │ ──▶  │  MpdRoot ✓ and       │ ──▶  │   Hit production      │
│    generator)        │      │  GEANT 4.10          │      │                       │
└──────────────────────┘      └──────────────────────┘      └──────────────────────┘
                                  Run runMC.C                         │
                                                                      ▼
                              ┌──────────────────────┐      ┌──────────────────────┐
                              │  ROOT file to be     │ ◀── │  Cluster creation     │
                              │     analyzed         │      │                       │
                              └──────────────────────┘      └──────────────────────┘

                                                               Run emc_cl.C
```
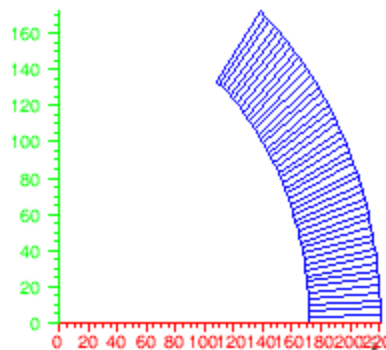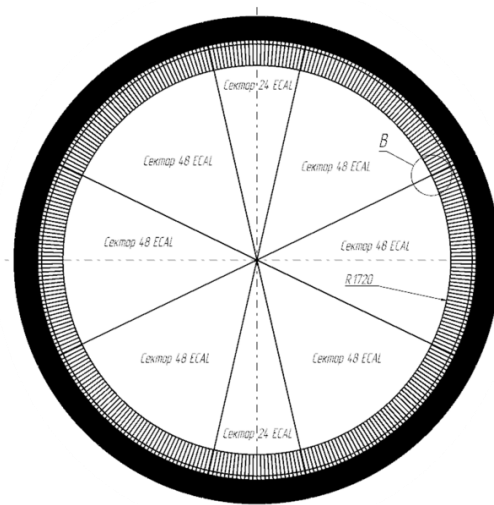
✔ Works with Root5.3x

✔ Corrected base FairModule.cxx file thanks to A. Zinchenko to suppress track break passing through the segmented cylindrical volumes
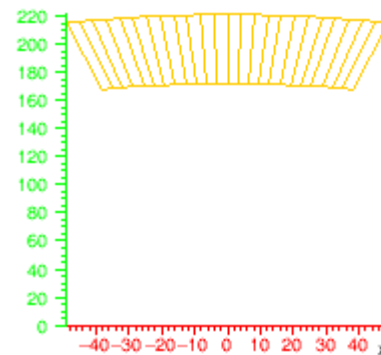
EMC sector geometry
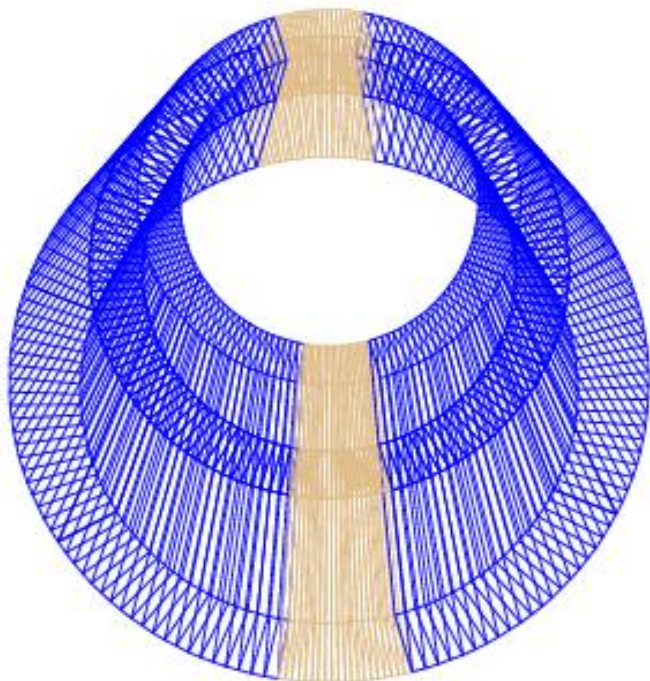
EMC Barrel

- Rin = 172 cm, Rout = 221 cm
- L = 2 × 314 cm
- Division : 8 sectors at + Z and – Z
- Minimal weight : 60 x 10^3 kg
- No specific material implementation (Air)

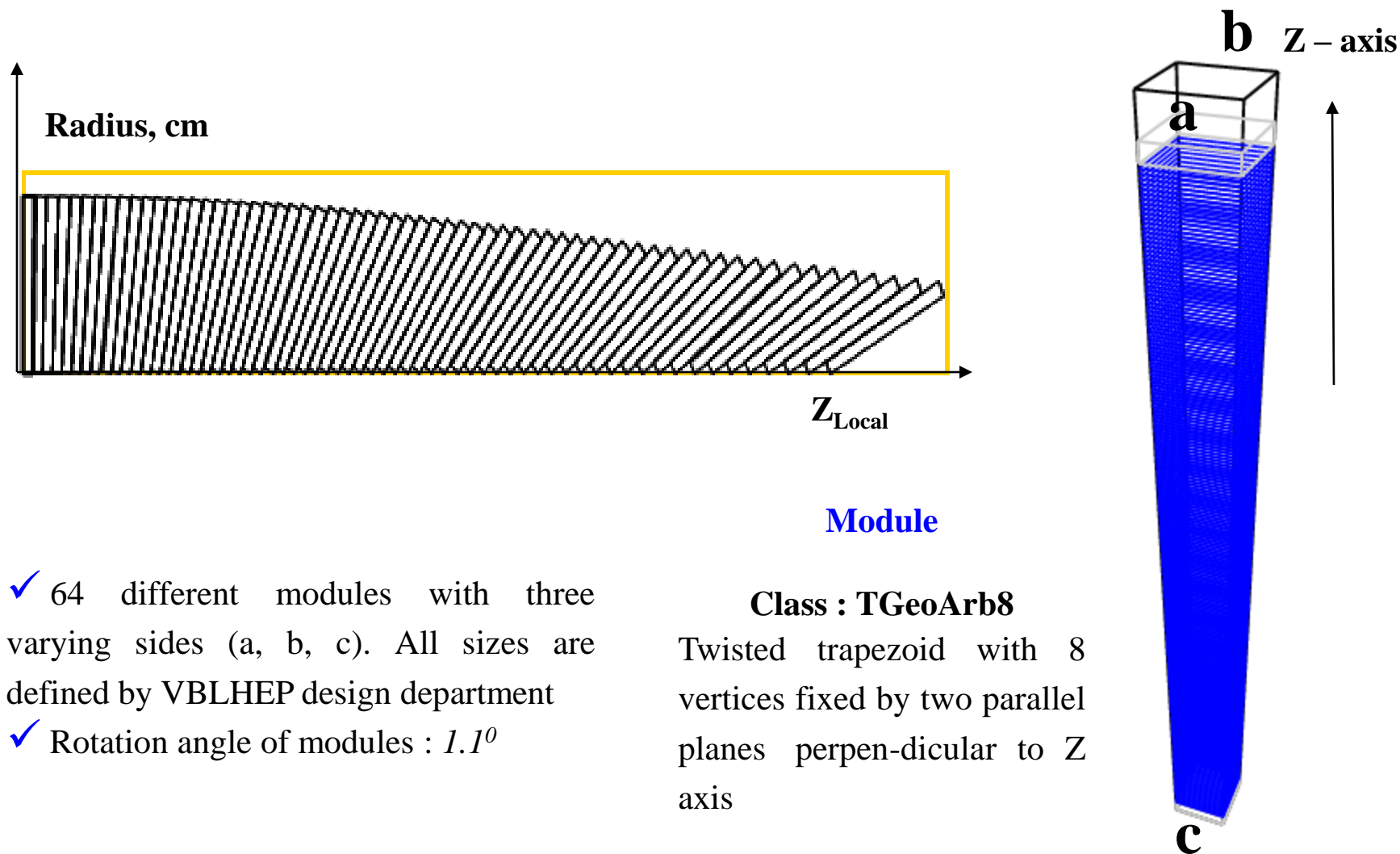### Large sector

- ✓ Number of modules : 48
- ✓ Coverage angle : 51.2^0

Small sector

- ✓ Number of modules : 24
- ✓ Coverage angle : 26.1^0

Radius, cm

Z_{Local}

b Z – axis

a

c

Module

✓ 64 different modules with three varying sides (a, b, c). All sizes are defined by VBLHEP design department

✓ Rotation angle of modules : *1.1⁰*

Class : TGeoArb8

Twisted trapezoid with 8 vertices fixed by two parallel planes perpen-dicular to Z axis

EMC module

✓ Total number of modules : 43008

✓ Longitudinal size : 43.095 cm

✓ Each module has 221 Pb (h = 0.3 mm) plates and 221 (FscScint − C_9H_{10} , h = 1.5 mm)

✓ Module is fixed by two plates on top and bottom (Kapton − $N_2C_{22}H_{10}O_5$, h = 8 mm)

✓ Correction in MpdEmc.cxx : sensitive volume is scintillation plate

✓ A huge number of nodes :

$$444 \times 43000 \sim 19 \times 10^6$$

✓ EMC geometry is stored in ROOT – file (emc_v2.root)
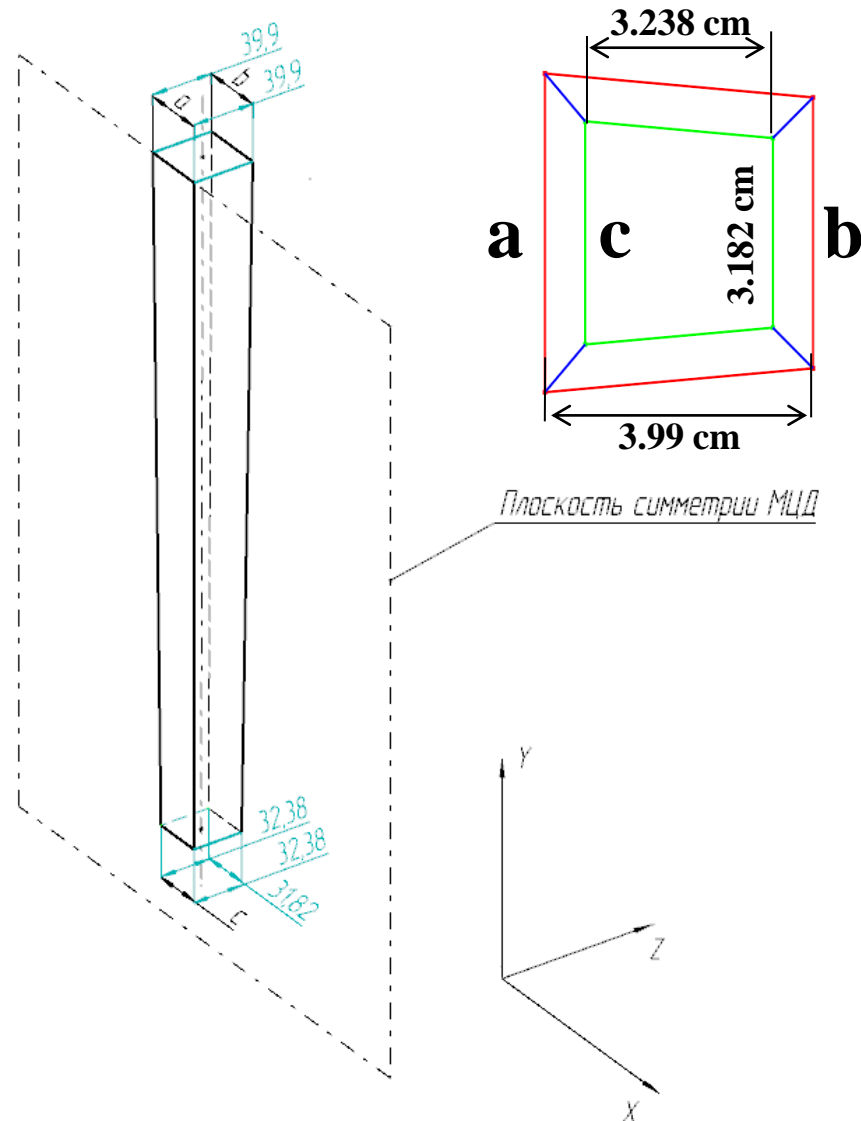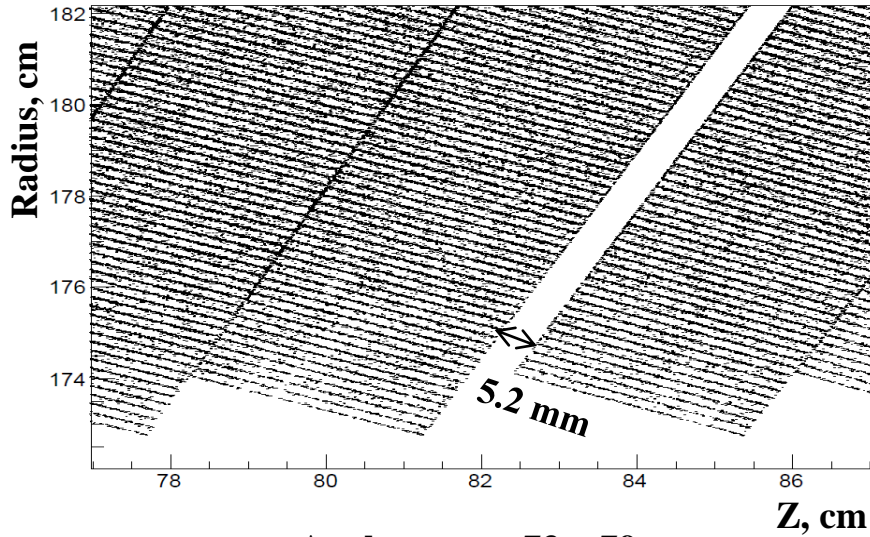
3.238 cm

3.182 cm

a   c   b

3.99 cm

Плоскость симметрии МЦД
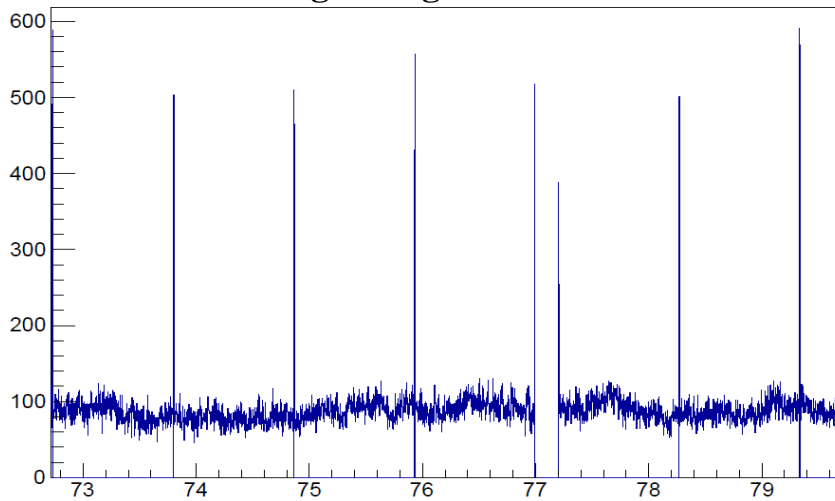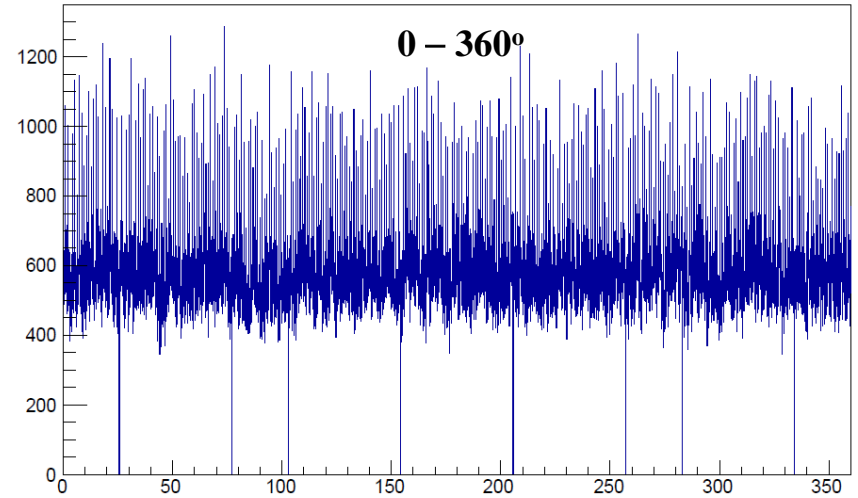
Angle range : 73 − 79°

Angle range : 77 − 78°
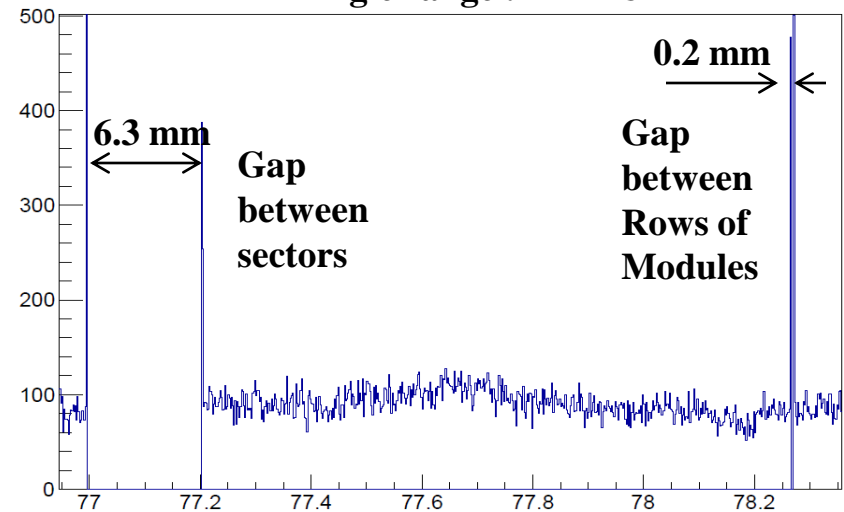
φ, degrees

✓ Class structure :

   MpdEmcGeoParams

   MpdEmcHitCreation / MpdEmcHit

✓ MpdEmcGeoParams defines parameters of the center of each EMC module (fRhoCenter, fZCenter, fPhiCenter, fThetaCenter) directly from ROOT-file

✓ ROOT function FindNode works not correct

✓ Constructed special function which relates point to the corresponding module by minimal angle (in ϕ and θ) between module axis and direction to the point and merges all points in active element to hit

✓ Each hit (MpdEmcHit) is described by geometrical parameters (module center) + special numbers defined this geometry:

   fSecId – sector number

   fRowId – number in XY plane

   fModId – number along 0Z plane

Hit distributions vs module number
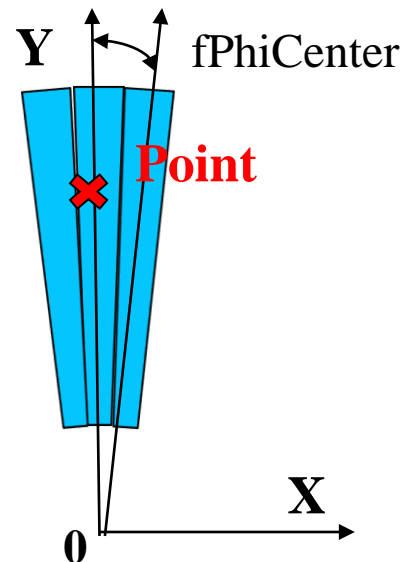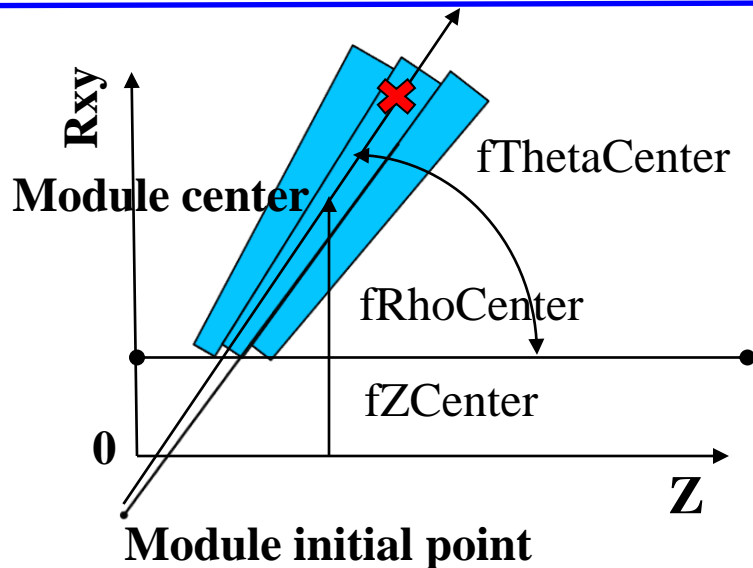
MpdEmcHit.fSecId
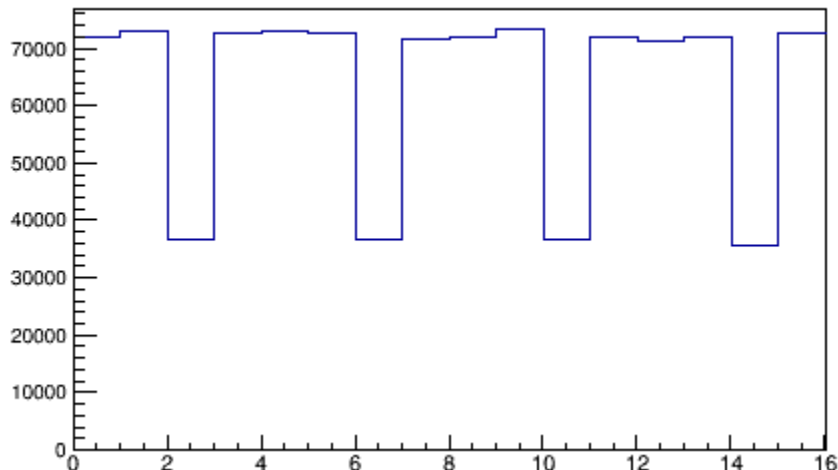
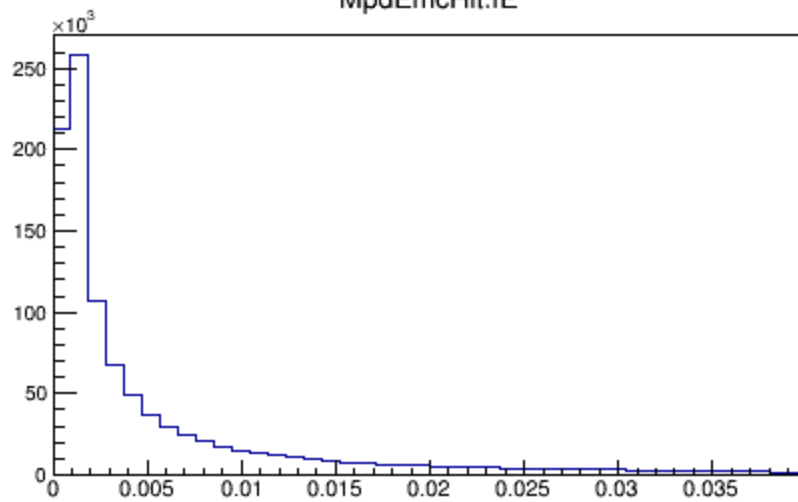Sectors : 0 - 7 at Z > 0 area; 8 - 15 at Z < 0

MpdEmcHit.fRowId
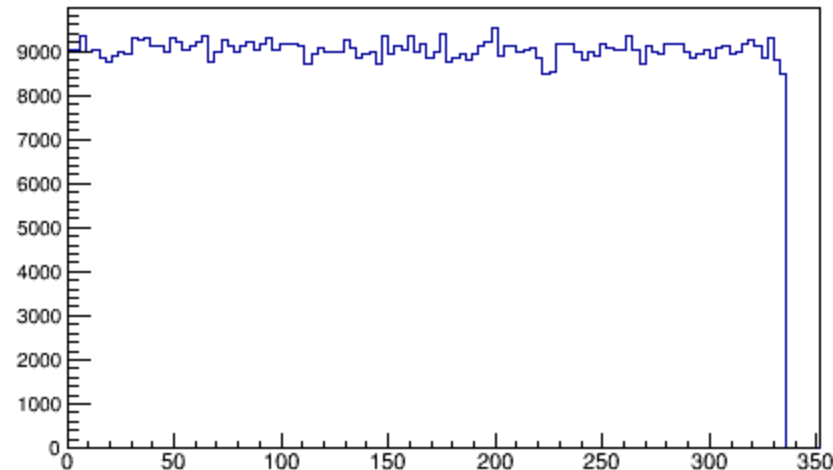
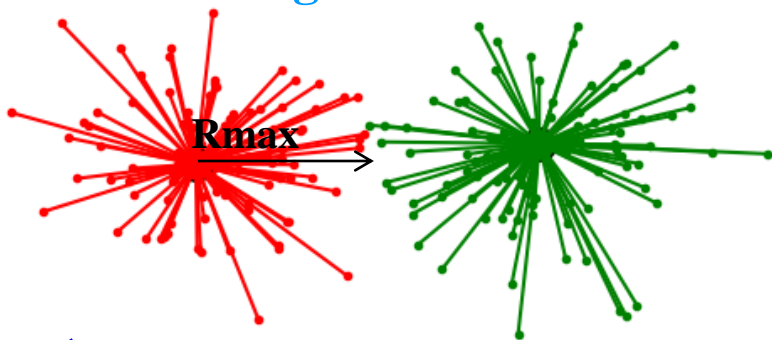Rows : counterclockwise enumeration (0 ÷ 335)

MpdEmcHit.fModId
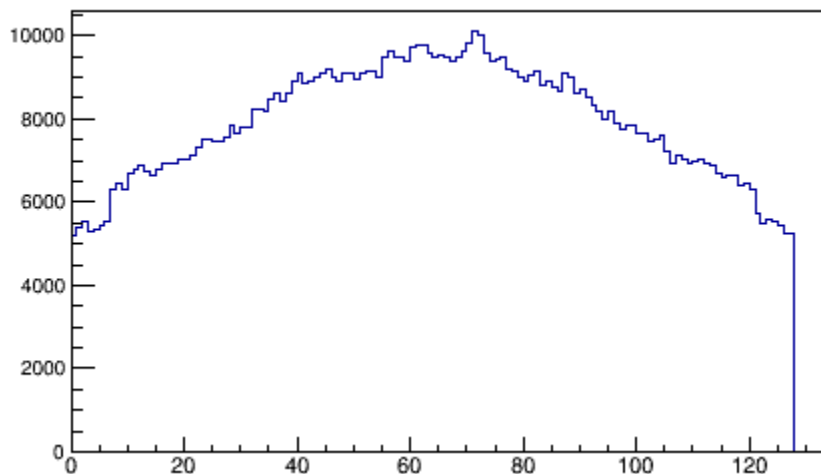
Line : 0 - 63 at Z < 0 area; 64 - 127 at Z > 0
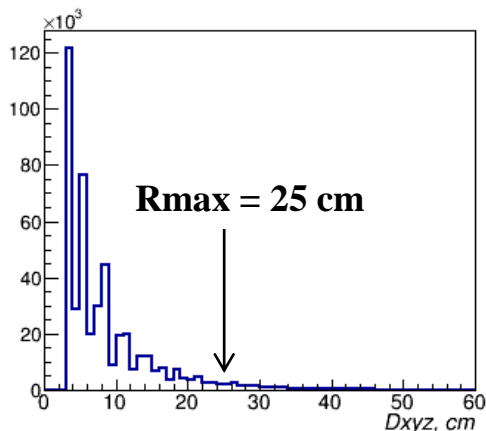
MpdEmcHit.fE

Hit energy from γ's (GeV)

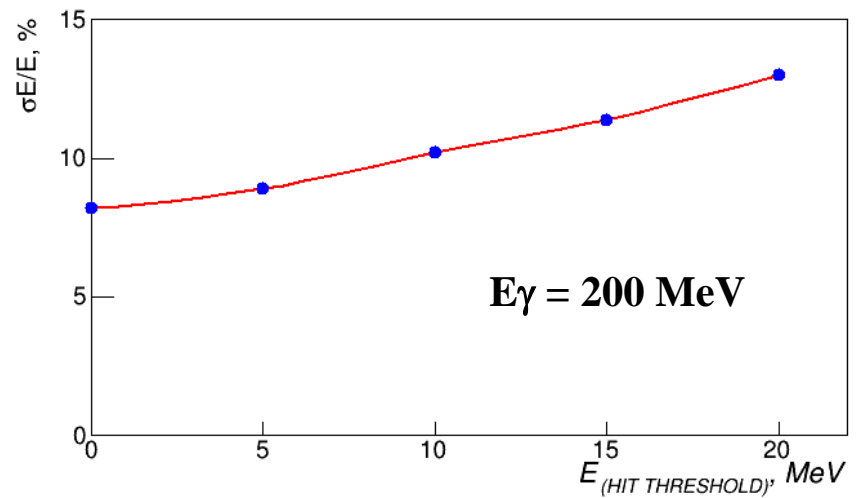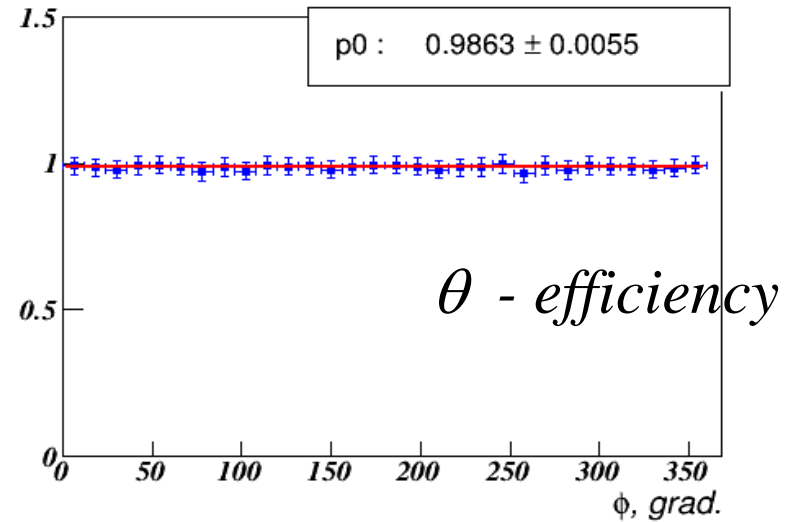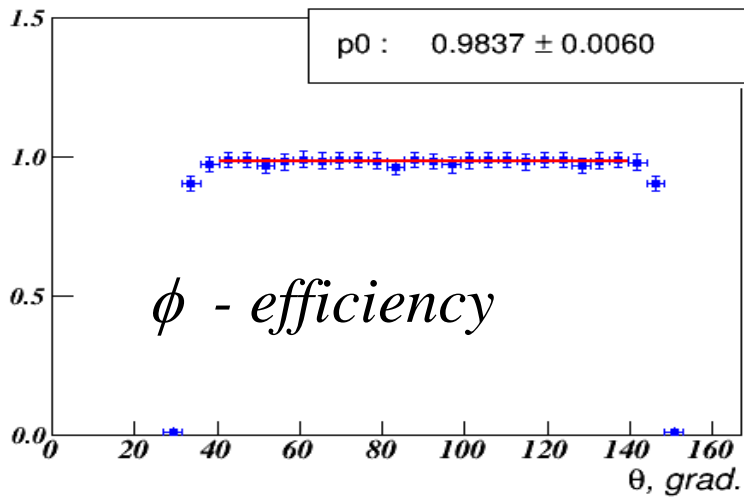# Simple clustering algorithms

Algorithm 1

Algorithm 2
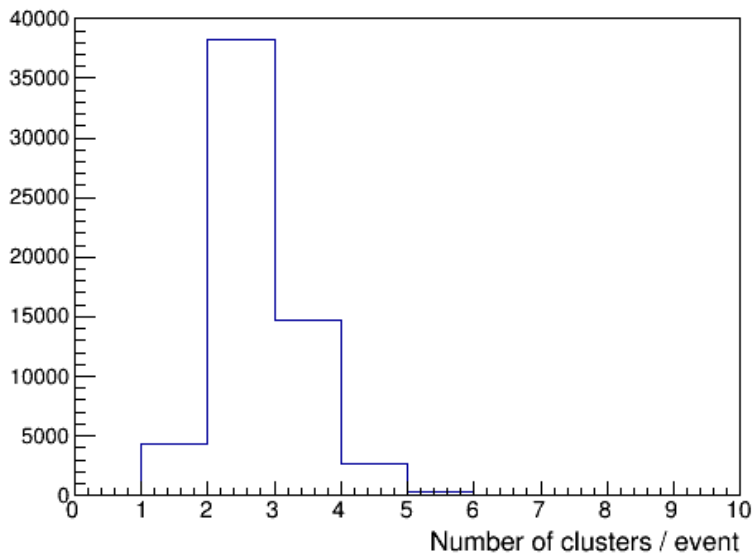

✓ Class structure : MpdEmcClusterCreation / MpdEmcCluster

✓ MpdEmcClusterCreation *EmcCluster = new MpdEmcClusterCreation();

- EmcCluster->SetAlgorithmNumber(1); // Algorithm number
- EmcCluster->SetEnergyThreshold(1.5); // Threshold for each hit (MeV)

Rmax = 25 cm

✓ Both algorithms are merging hits into cluster around hit with maximal energy

✓ First algorithm sums hits inside $Dxyz < Rmax$:
  - EmcCluster->SetMaxClusterRadius(Rmax)

✓ Second algorithm based on a module frame :
  - EmcCluster->SetClusterFrame(nRow, nLine), for analysis we used nRow = 4, nLine = 3

✓ No common hits in different clusters

Eγ = 200 MeV

ϕ - efficiency

p0 : 0.9837 ± 0.0060

θ - efficiency

p0 : 0.9863 ± 0.0055

Fit Function = $p0/\sqrt{E} \oplus p1$

p0 : 4.2148 ± 0.0248

p1 : 2.0411 ± 0.1110

Eγ = 200 MeV

π^0 **selection in EMC**
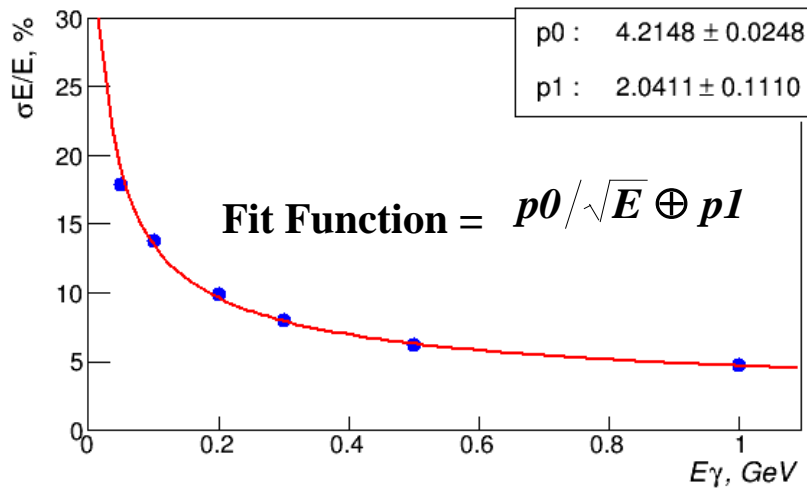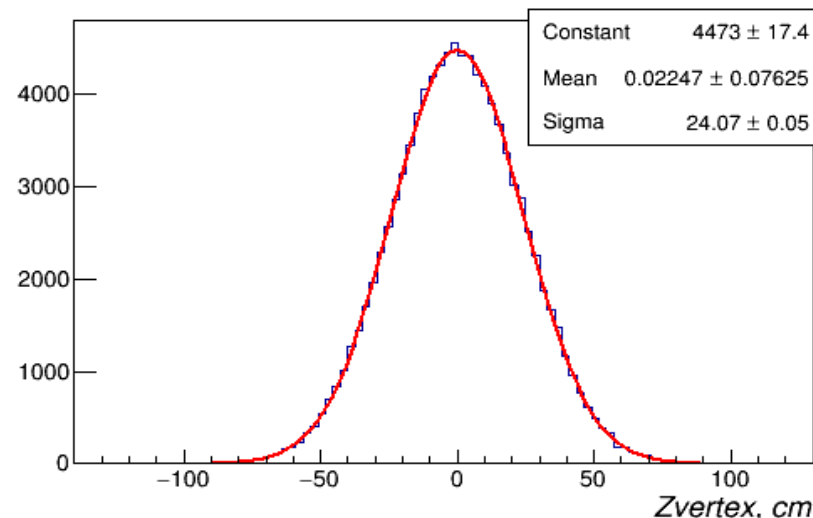

✔ π^0 is produced by BOX – generator at momentum p = 200 MeV/c

✔ To obtain π^0 we asked two neutral clusters in EMC giving mass close to it's nominal

✔ π^0 invariant mass can be used for EMC energy calibration (calibration coefficient ~ 2.96)

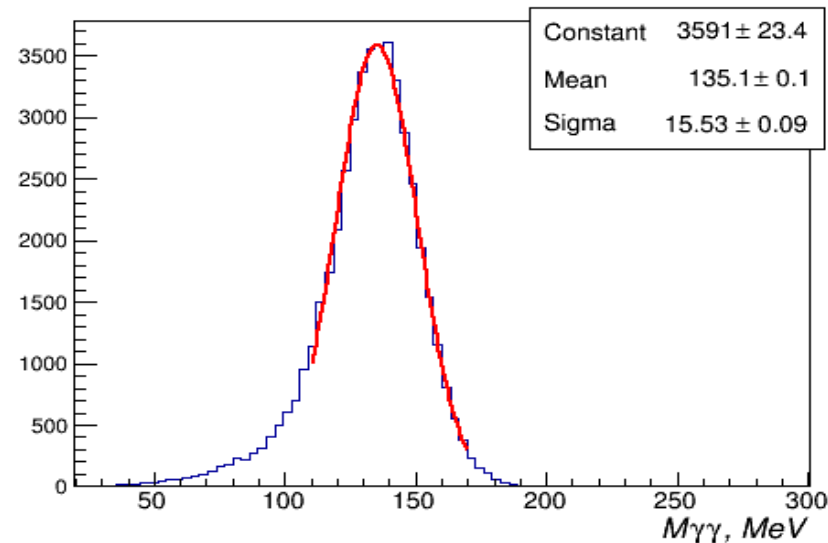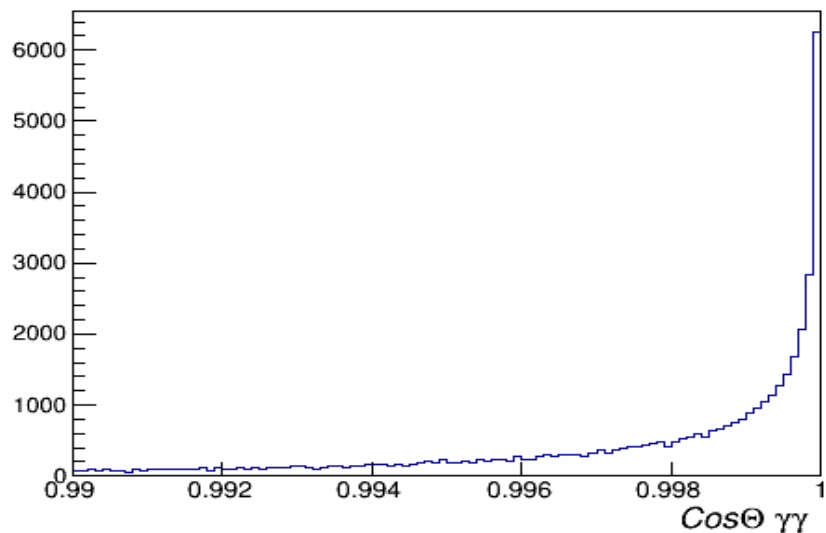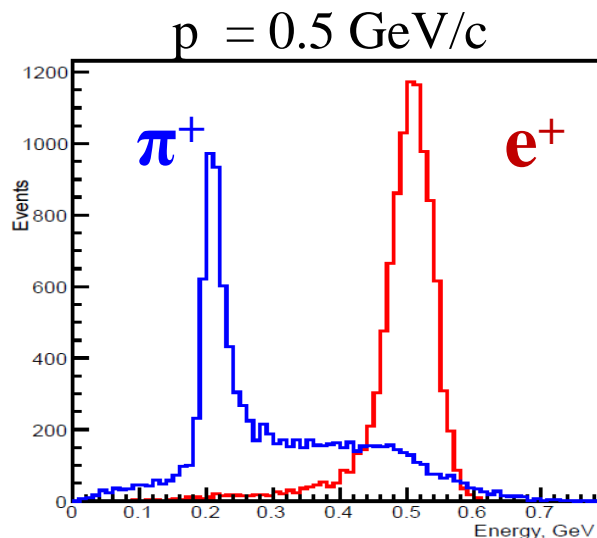$\sigma M\gamma\gamma / M\gamma\gamma$ ~ 10.8 %, Eγ > 5 MeV
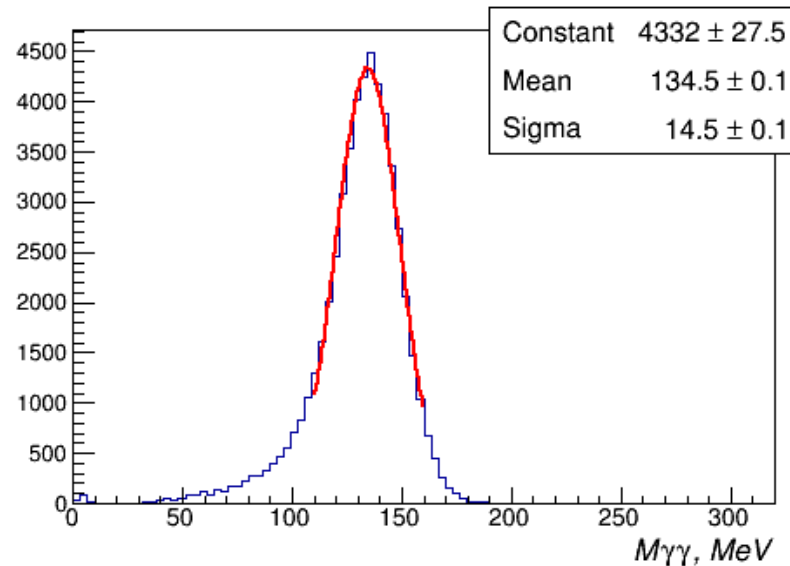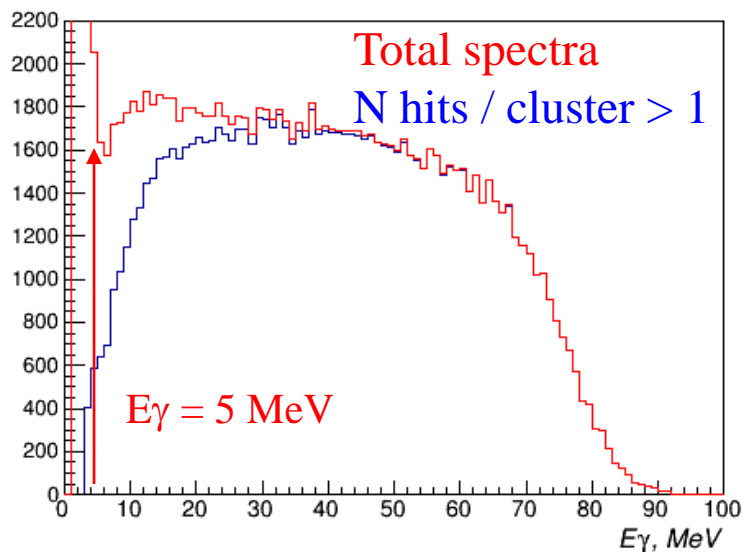
- ➢ NICA collider rings :

    Rms Z (at bunch length 60 cm) : 24 cm

- ➢ Rms X = Rms Y = 0.0 cm

- ➢ Gaussian smearing of π^0 vertex along

    Z - axis

Cos θ γγ - angle between cluster and real
    γ directions

Constant	4473 ± 17.4
Mean	0.02247 ± 0.07625
Sigma	24.07 ± 0.05

σMγγ / Mγγ ~ 11.5 %, Eγ > 5 MeV

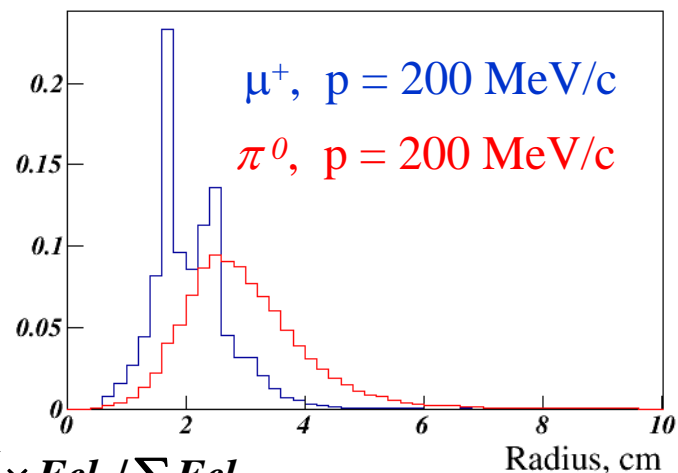| Constant | 3591 ± 23.4 |
| Mean | 135.1 ± 0.1 |
| Sigma | 15.53 ± 0.09 |

$p = 0.5$ GeV/c
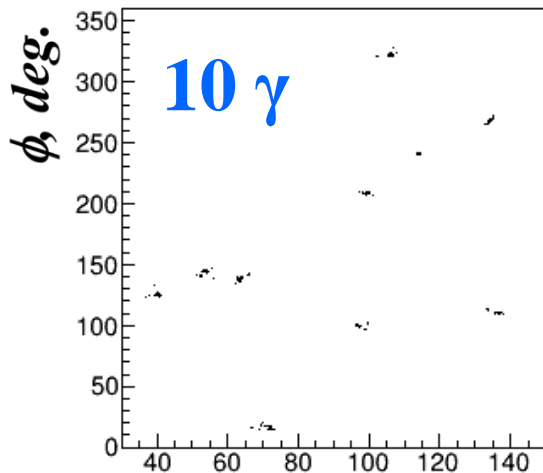
$p = 1.0$ GeV/c

π^+ contamination in $e^+ - 15\%$
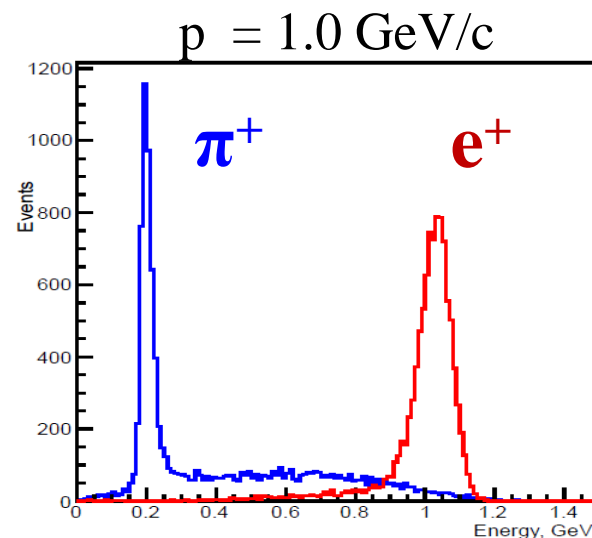
π^+ contamination in $e^+ - 5\%$

✓ Cluster weighted radius (in Root file)

✓ Defined for cluster with hit number > 1
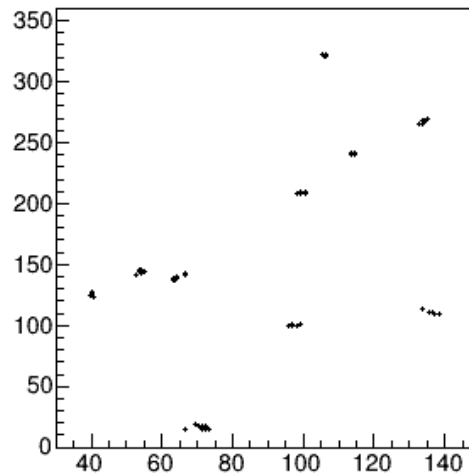
✓ Possible way to select different particles

μ^+, p = 200 MeV/c

π^0, p = 200 MeV/c

$$Rcl = \sum_i \sqrt{Rcl\_xyz \times (\theta_i - \theta\,cl)^2 + Rcl\_xy \times (\phi_i - \phi\,cl)} \times Ecl_i / \sum_i Ecl_i$$
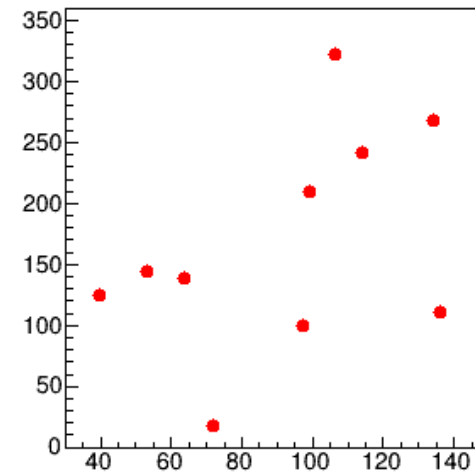
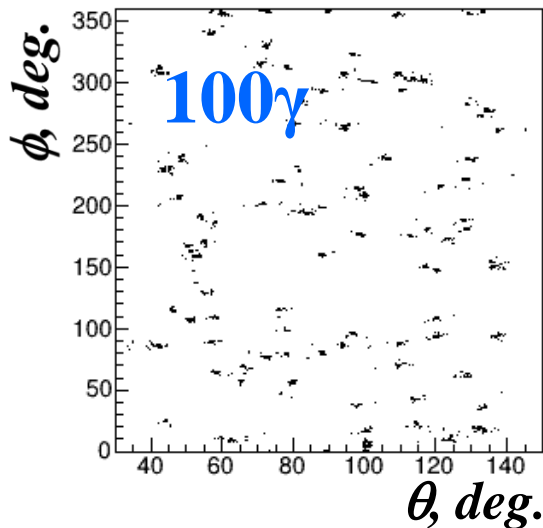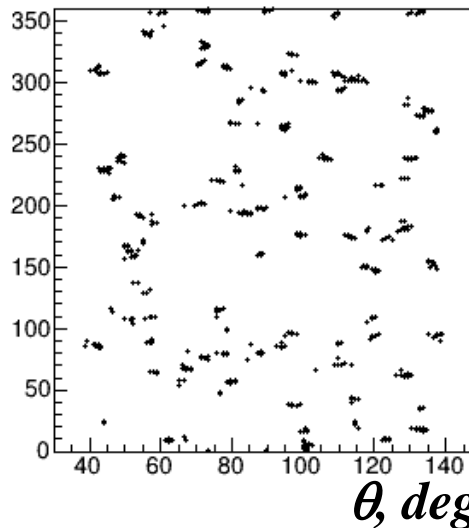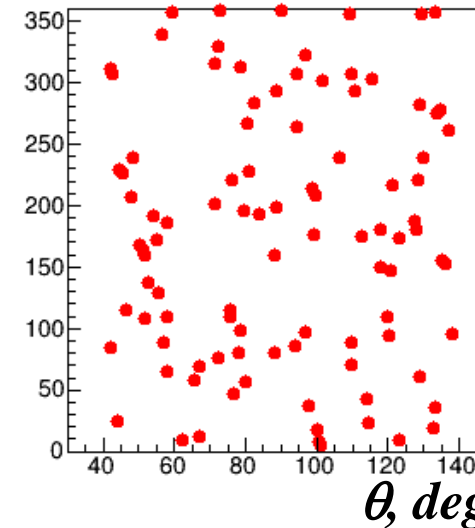**GEANT points – 1623**   **Hits – 63**   **Clusters – 10**

GEANT points – 16042   **Hits – 537**   **Clusters – 97**

① Quasi-spherical ROOT - geometry is implemented to MpdRoot software. Addition soft for hit and cluster production are created and tested with simple MC generator. Installation of FairSoft and MpdRoot at ITEP computer server allowed us to work independently. Despite this, our software is transferred on nc2.jinr.ru (VBLHEP)

② Current EMC geometry is proposed by the VBLHEP Design Department. Also, there is an other offer from Progresstech – Dubna engineering consulting services (more number of modules: 43264, more spherical geometry, other module design, etc.)

③ Other important work, which must be done: more sophisticated algorithm for clustering; implement new / existed algorithm of track to cluster association procedure and etc.

④ For simple MC calculations and software adjustment it is possible to use ITEP computer server. But real future physical event (Au Au interaction / QGSM – model) we need more powerful farms, which we did not used yet

⑤ A lot of other organization work should be done: cooperation with analysis groups in MC study for MPD / NICA physics; search of support from «Kucrhctov Institute» / ITEP / JINR (till now this activity is not in plans)

Thank You