MC simulation results for projective geometry version of MPD ECAL at NICA collider

V.V. Kulikov[1], M.A. Martemianov[1], M.A. Matsyuk[1], B. Dabrowska[2,3], I.A. Tyapkin[2]

1 SRC "Kurchatov institute" - ITEP, Moscow, Russia

2. VBLHEP, JINR, 141980 Dubna, Russia

3. PU"Paisii Hilendarski", Plovdiv, Bulgaria

XXIV INTERNATIONAL BALDIN SEMINAR ON HIGH ENERGY PHYSICS PROBLEMS

17 – 22 September 2018, VBLHEP – JINR, Dubna

MPD, First stage

ECAL(barrel)

Rin = 172 cm, Rout = 221 cm

L = 2 × 314 cm

Modules =43008

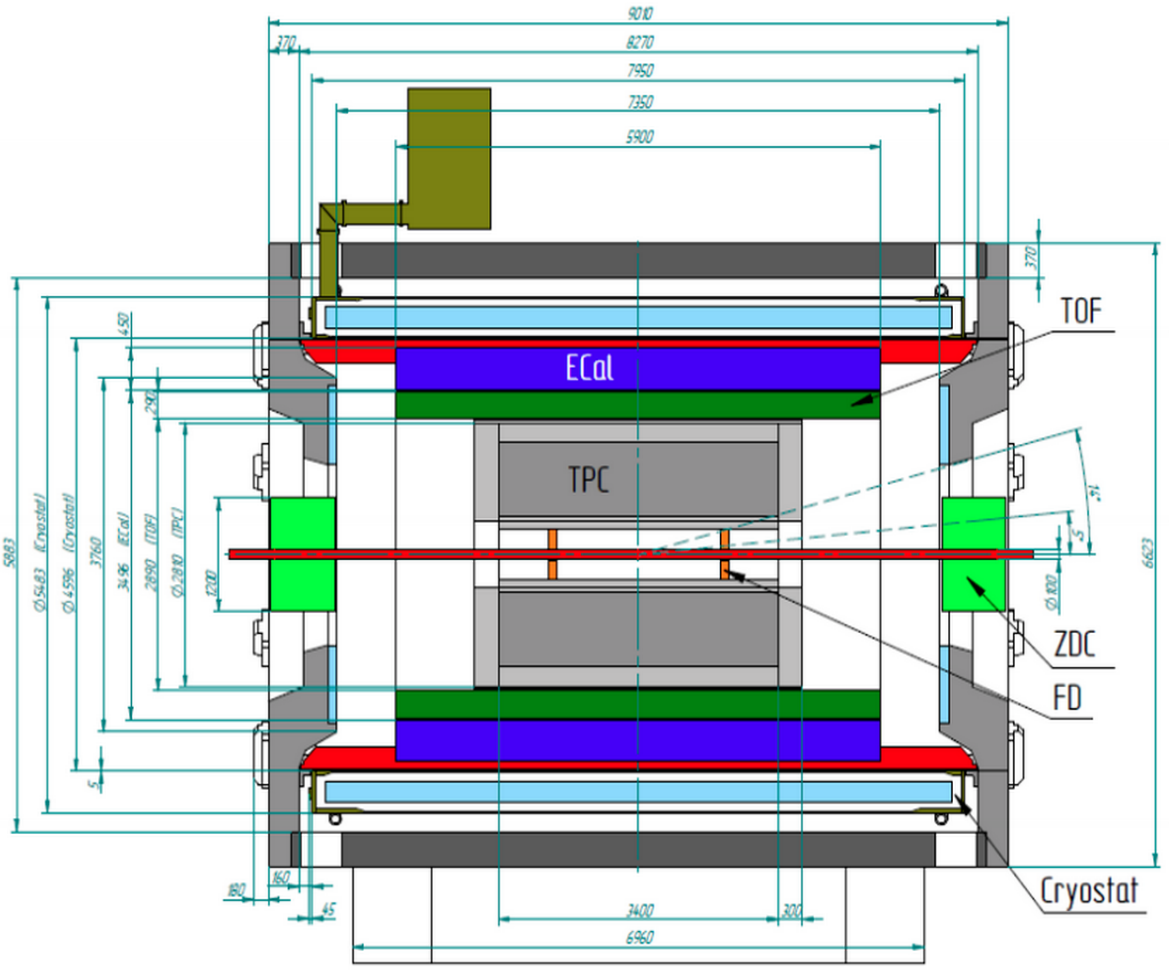
Shashlyk type PbSc

Weight = 60 tons

ECAL team leaders: V.Golovatyuk and I.Tyapkin;

ITEP contribution-

MC software



Soft structure

Run create_rootgeom_emc_v2.C

XML file with ECAL parameters

Script to create geometry ROOT file

FairSoft + MpdRoot are installed on ITEP computing cluster

Run reco.C

Monte Carlo (BOX generator)

MpdRoot and GEANT 4.10

Hit production

Run runMC.C

ROOT file to be analyzed

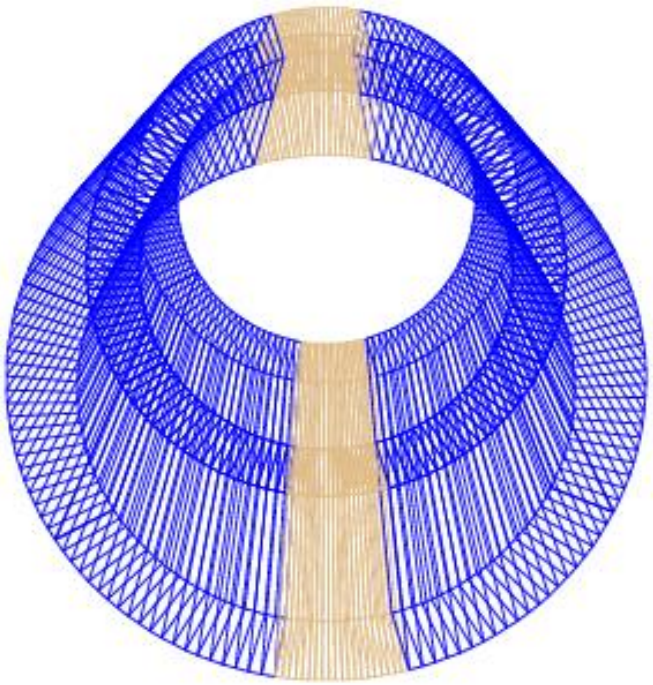
Cluster creation

Run emc_cl.C

✓ Works with Root5.3x

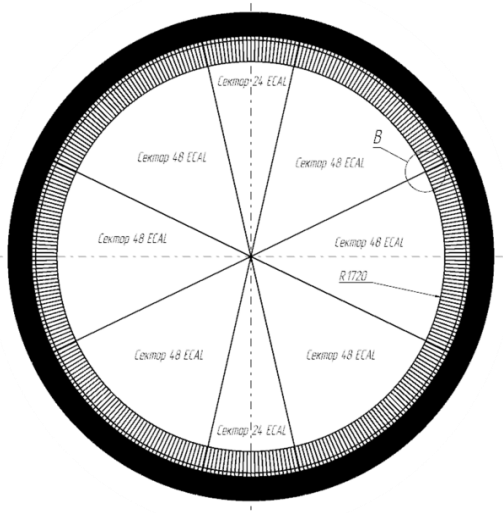
✓ Этот текст здесь не понятен его надо использовать позже Corrected base FairModule.cxx file thanks to A. Zinchenko to suppress track break passing through the segmented cylindrical volumes

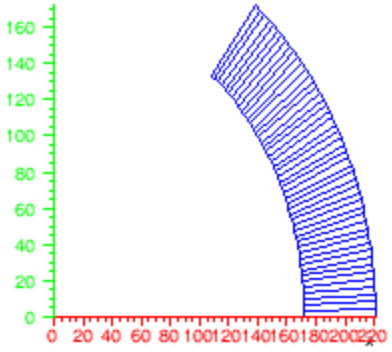
ECAL geometry. Sectors.



EMC Barrel

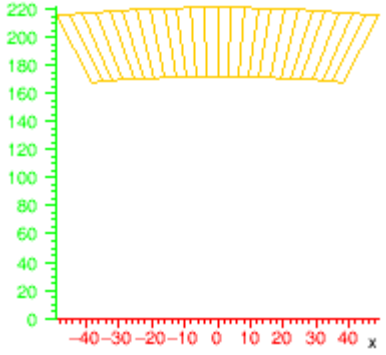
- Rin = 172 cm, Rout = 221 cm
- L = 2 × 314 cm
- Division : 8 sectors at + Z and – Z
- Minimal weight : 60 x 10^3 kg
- No mechanical support structure which is under design yet





6 Large sectors

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

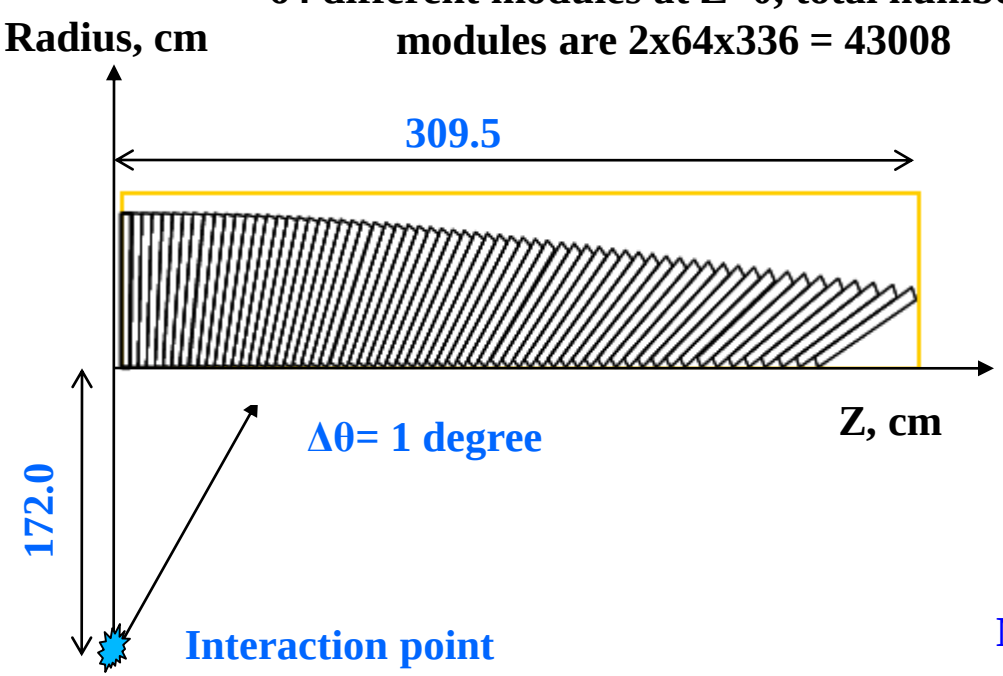


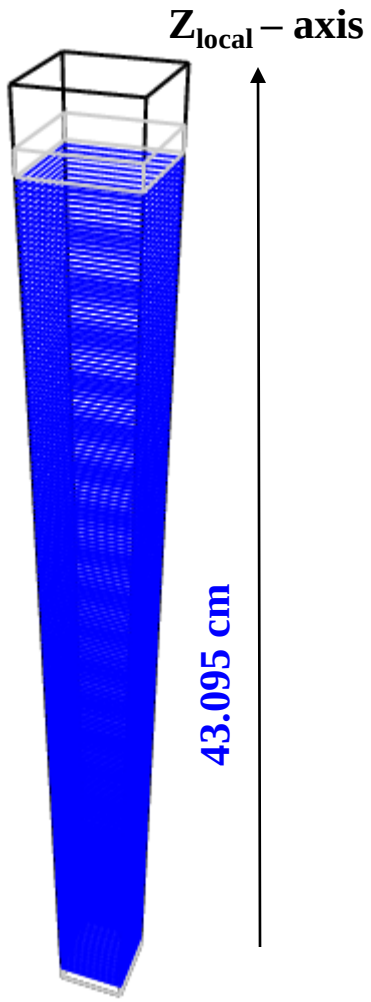
2 Small sector

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

ECAL geometry. Modules.

64 different modules at Z>0, total number of modules are 2x64x336 = 43008





Module

Class : TGeoArb8

Arbitrary trapezoid machined from 4x44x43 cm^3 box.

✓ 64 different modules machined from parallelepiped 4x4x41 cm^3. All sizes are defined by VBLHEP design department with precision slightly better than 0.1 mm

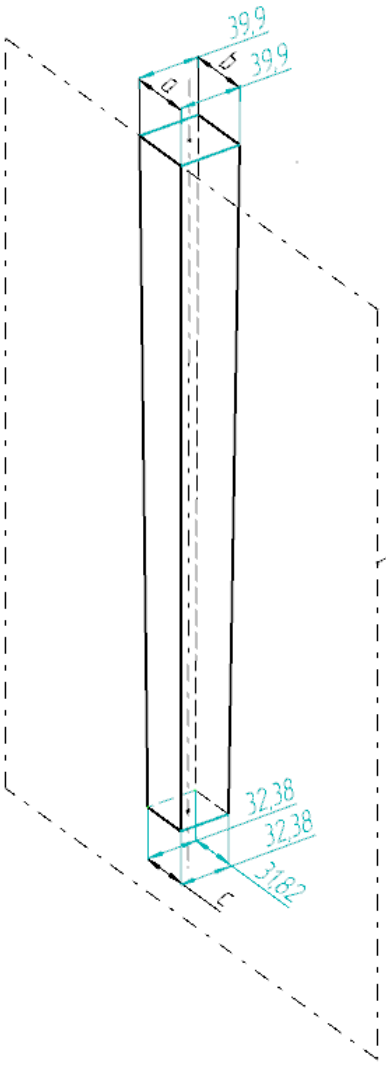
EMC module

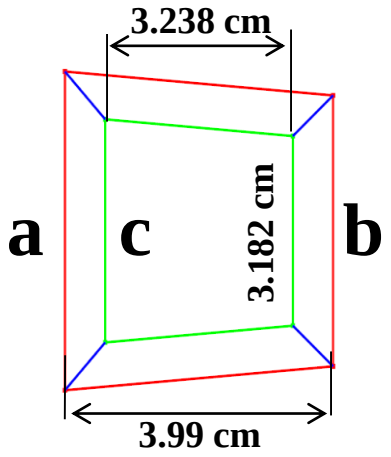
EMC module

- ✓ Total number of modules : 43008
- ✓ Longitudinal size : 43.095 cm
- ✓ Module has 221 Pb (h = 0.3 mm) plates and 221 (FscScint – C_9H_{10} , h = 1.5 mm)
- ✓ WLS-fibers are ignored
- ✓ The plates are fixed by plates on top and bottom (Kapton – $N_2C_{22}H_{10}O_5$, h = 8 mm)
- ✓ A huge number of nodes :

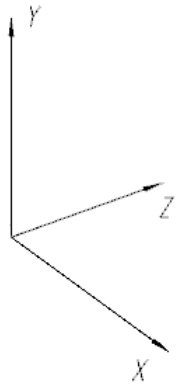
$$444 \times 43000 \sim 19 \times 10^6$$

- ✓ EMC geometry is stored in ROOT – file (emc_v2.root)
- ✓ GEANT4 needs ~5 minutes to digitize geometry infirmation





Плоскость симметрии МЦД



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FairSoft + MpdRoot are installed on ITEP computers

Macro runMC.C

Monte Carlo (BOX generator)

MpdRoot and GEANT 4.10

Evetest.root – file with GEANT4 points

Macro reco.C

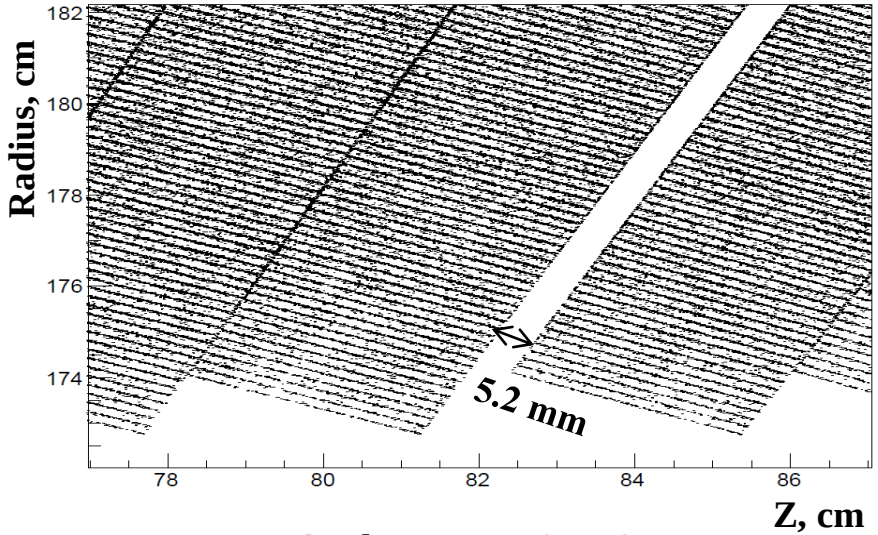
ROOT file to be analyzed by user

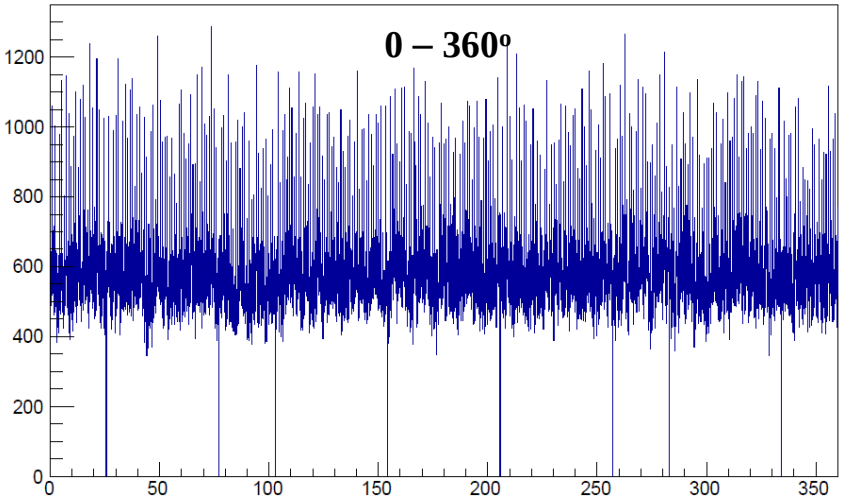
Hits and Clusters production

Run reco.C

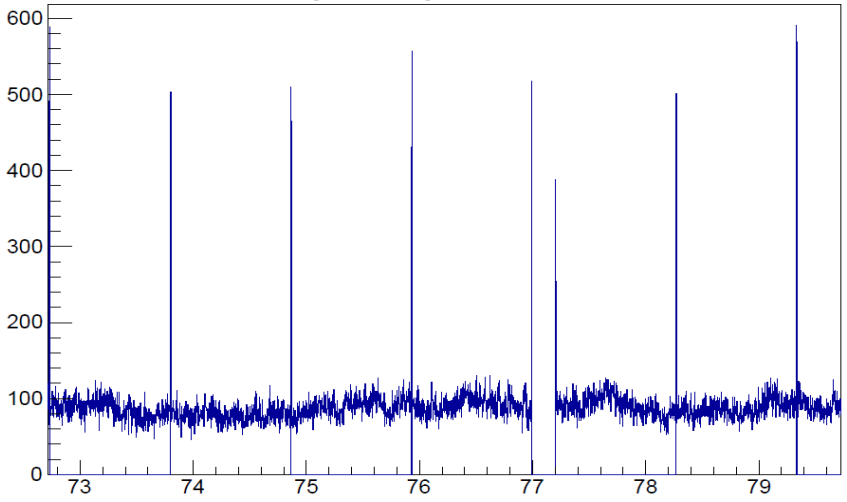
✓ The soft was written in FairSoft/MpdRoot environment which is user-friendly but not free from bugs. We would like to thank A. Zinchenko for his help in fighting the bugs

Geometry check on Geant4 points(X,Y,Z,dE,Tof)

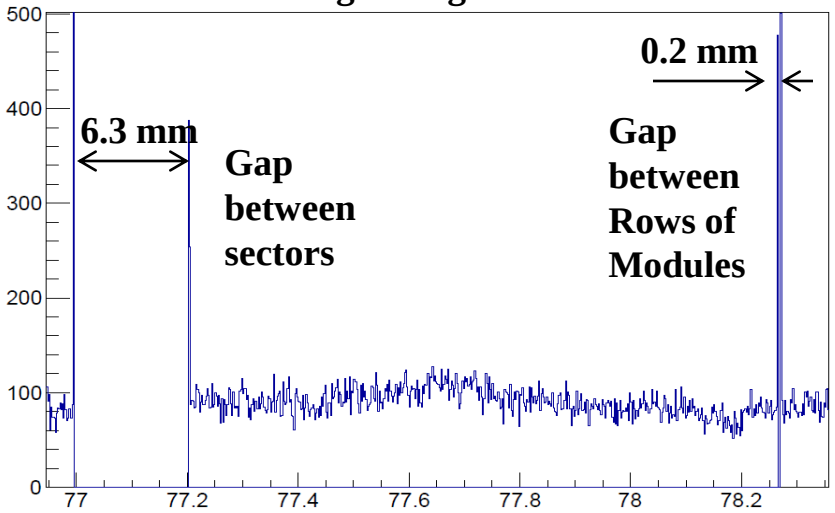




Angle range : 73 – 79º



Angle range : 77 – 78º



φ, degrees

Hit production

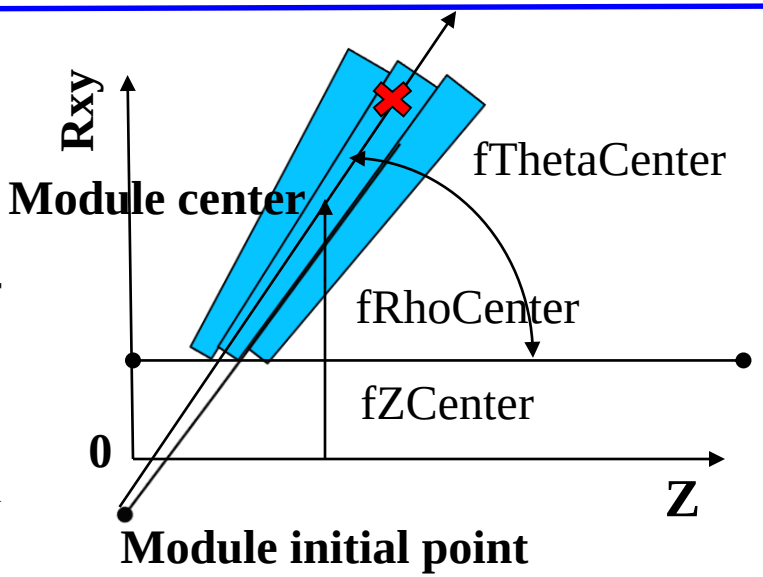
- ✓ Class structure :
  - MpdEmcGeoParams
  - MpdEmcHitCreation / MpdEmcHit
- ✓ MpdEmcGeoParams defines parameters of the center of each EMC module (fRhoCenter, fZCenter, fPhiCenter, fThetaCenter) directly from ROOT-file
- ✓ ROOT function FindNode does not work correctly on few percent level
- ✓ Special function relates point to the corresponding module by closest angle distance to module axis (ϕ and θ) and merges all points in active volumes to a hit
- ✓ Each hit (MpdEmcHit) is characterized by numbers :

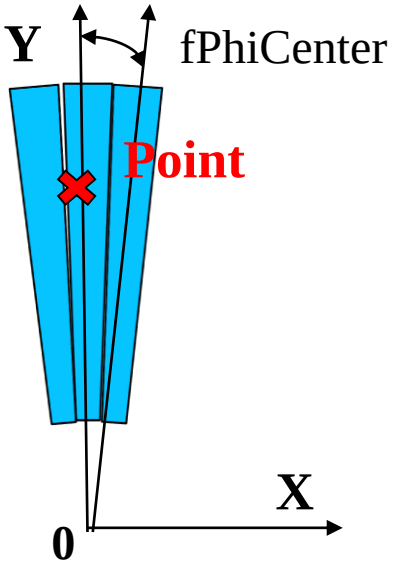
  fSecId – sector number

  fRowId – number in ϕ-angle (0 – 335)

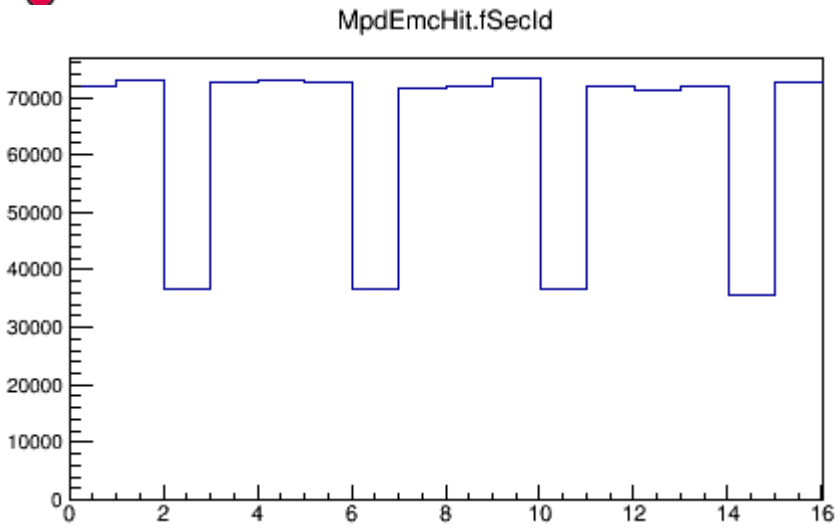
  fModId – number in the Row along Z-axis (0 – 127)

  and total energy deposition and energy weigthed TOF

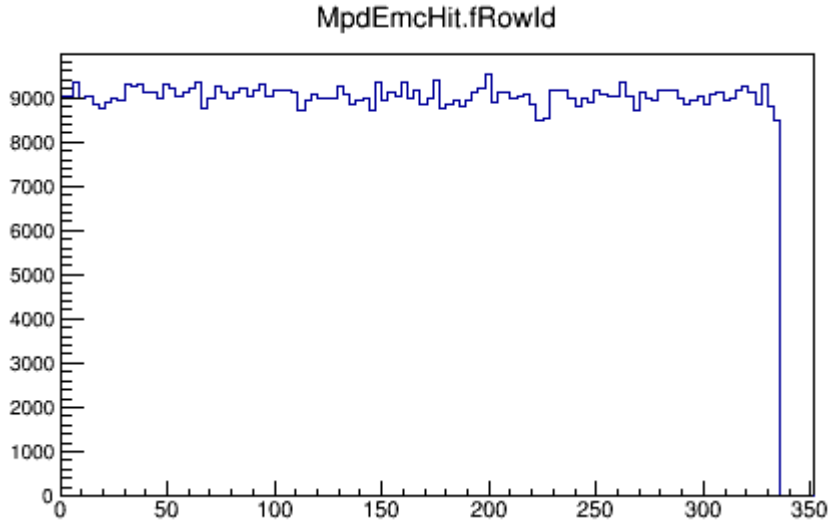




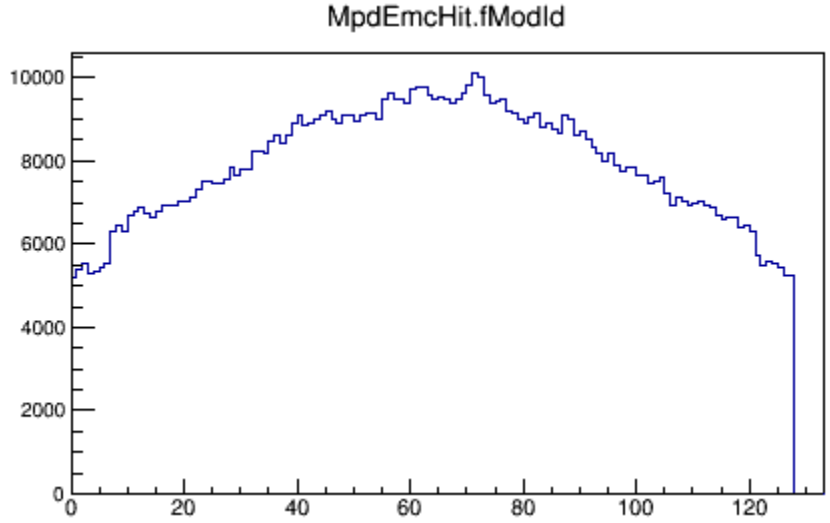
Hit distributions vs module number



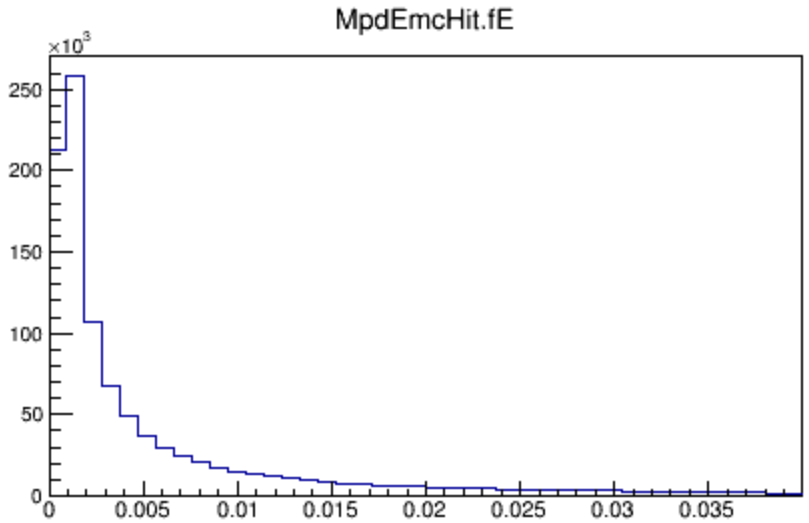
Sectors : 0 - 7 at Z > 0 area; 8 - 15 at Z < 0



Rows : counterclockwise enumeration (0 ÷ 335)



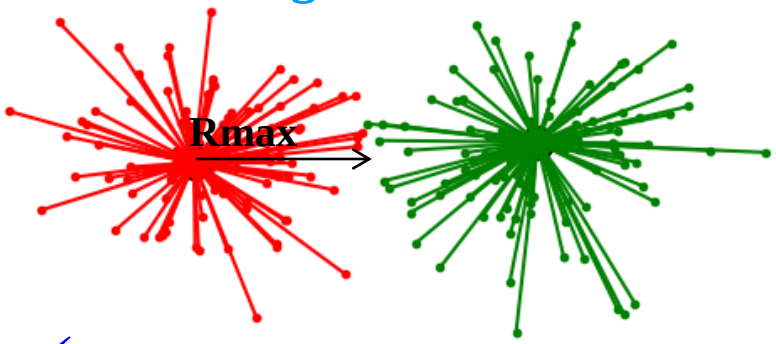
Line : 0 - 63 at Z < 0 area; 64 - 127 at Z > 0



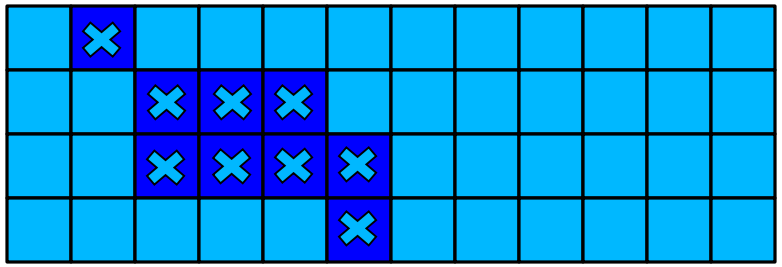
Hit energy from γ's (GeV)

Simple clustering algorithms

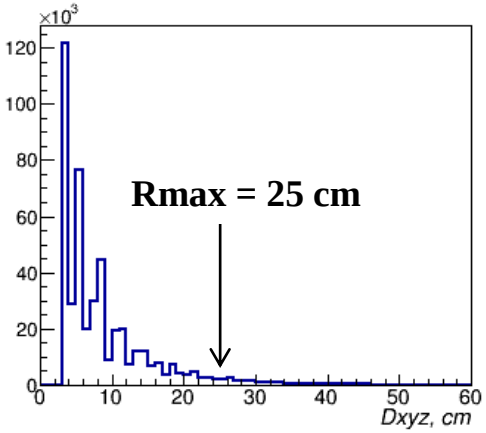
Algorithm 1



Algorithm 2



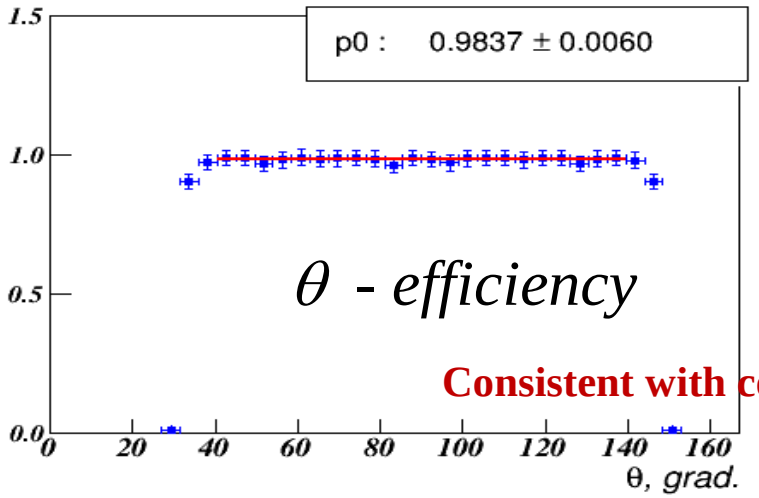
- ✓ Class structure : MpdEmcClusterCreation / MpdEmcCluster
- ✓ MpdEmcClusterCreation *EmcCluster = new MpdEmcClusterCreation();
  - EmcCluster->SetAlgorithmNumber(1); // Algorithm number
  - EmcCluster->SetEnergyThreshold(1.5); // Threshold for each hit (MeV)

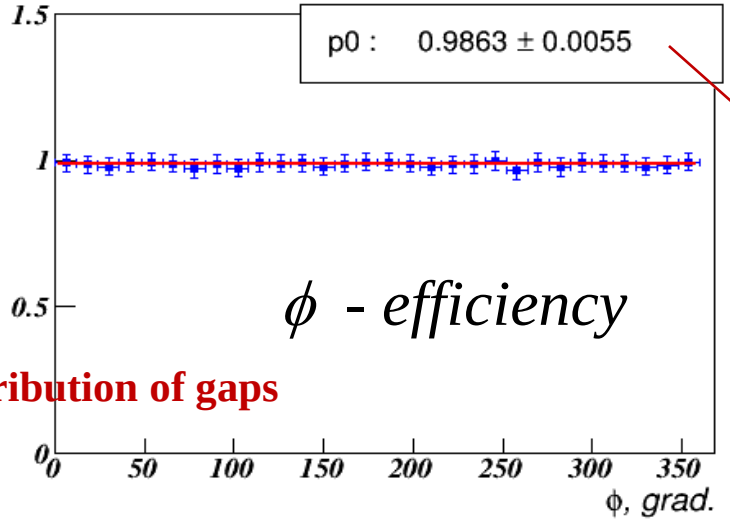


- ✓ Both algorithms are merging hits into cluster around hit with maximal energy
- ✓ First algorithm sums hits inside Dxyz < Rmax:
  - EmcCluster->SetMaxClusterRadius(Rmax)
- ✓ Second algorithm based on a module frame :
  - EmcCluster->SetClusterFrame(nRow, nLine), for analysis we used nRow = 4, nLine = 3
- ✓ No common hits in different clusters

EMC characteristics (no TOF, no TPC)

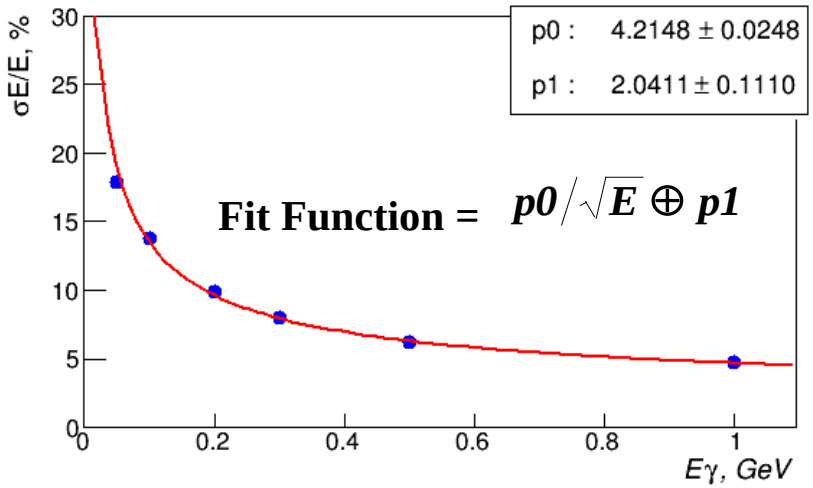
Eγ = 200 MeV

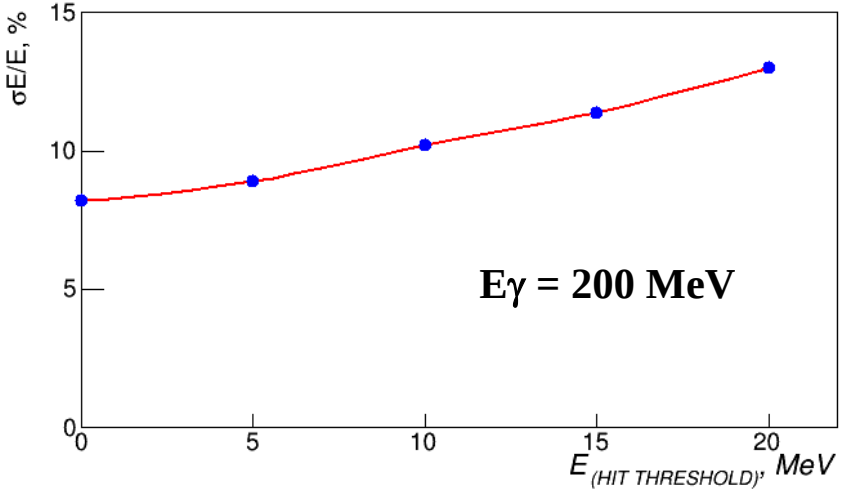




0.92 for TOF and TPC in

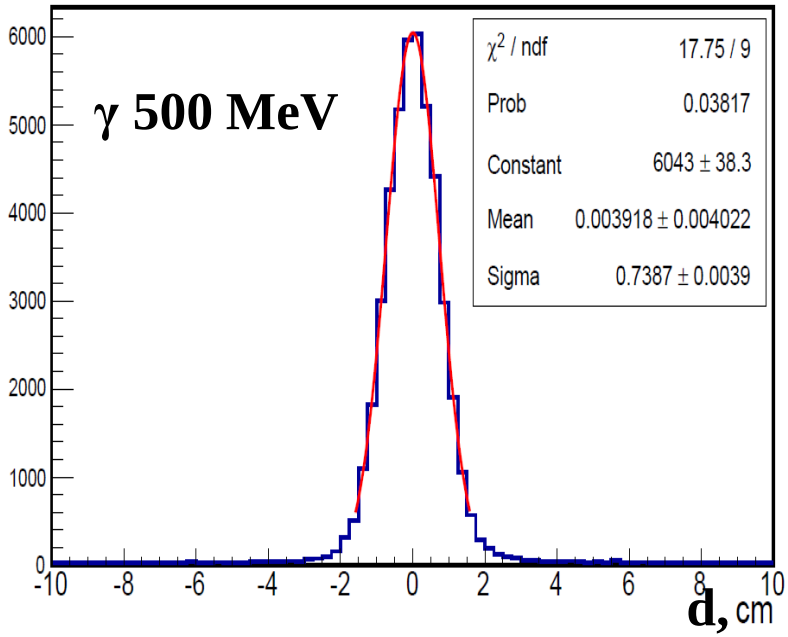
Consistent with contribution of gaps

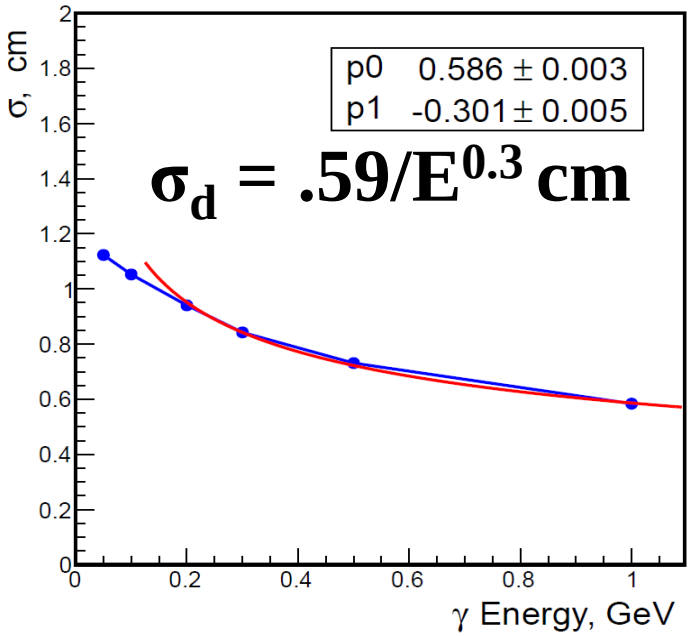




Reasonable agreement with prototype tests at 1 GeV: test->6%, MC->4.6%

Angular resolution



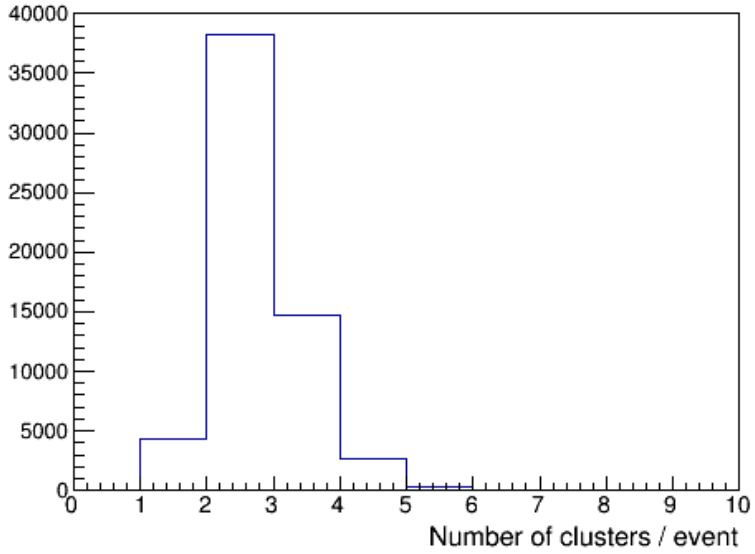


$d = (\theta_{Cluster} - \theta_{\gamma}) * R_{ModuleCenter}$, $\sigma_{\theta} = \sigma_d / R_{ModuleCenter}$

$R_{ModuleCenter}$ = 2-3.5 m

At 1 GeV σ_d =5.9 mm, much less than the half width of the module (~1.75 cm) and **angular resolution σ_{θ} = 0,16 – 0.09 degree**.

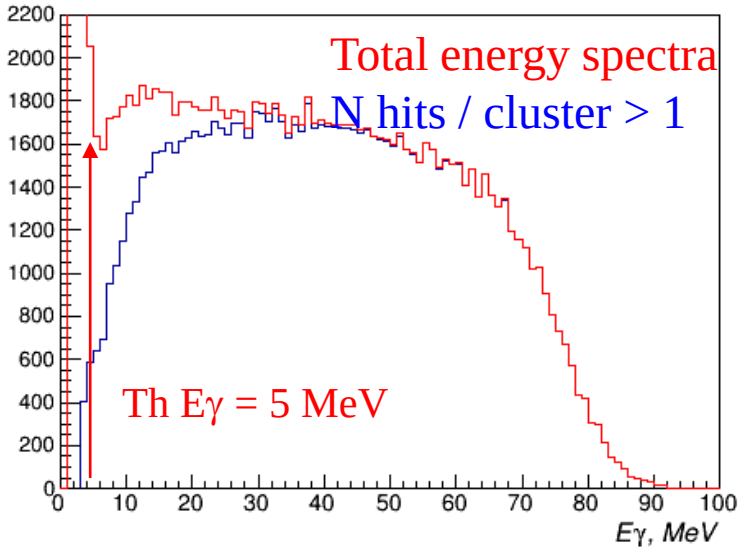
π^0 selection in EMC



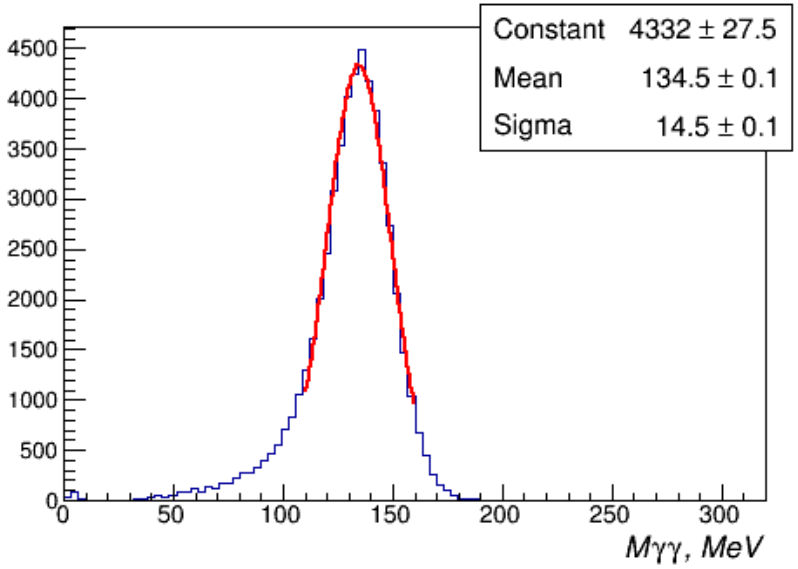
✓ π^0 is produced by BOX – generator at momentum p = 200 MeV/c

✓ 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)



σMγγ / Mγγ ~ 10.8 %, th Eγ = 5 MeV

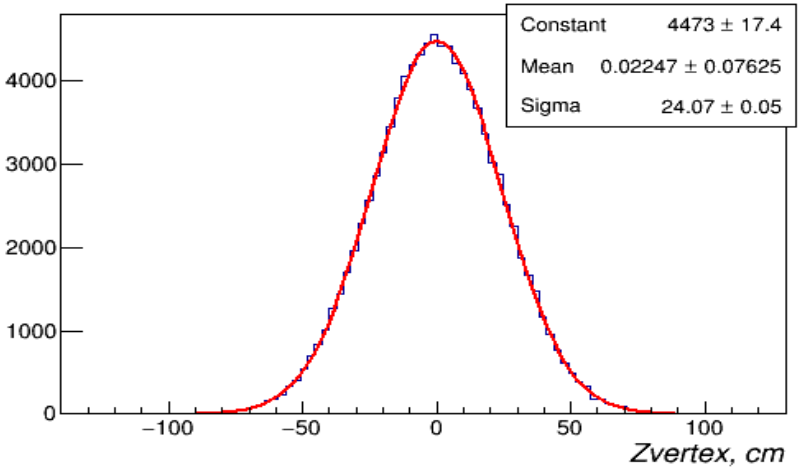


Vertex spread

- NICA collider rings :

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

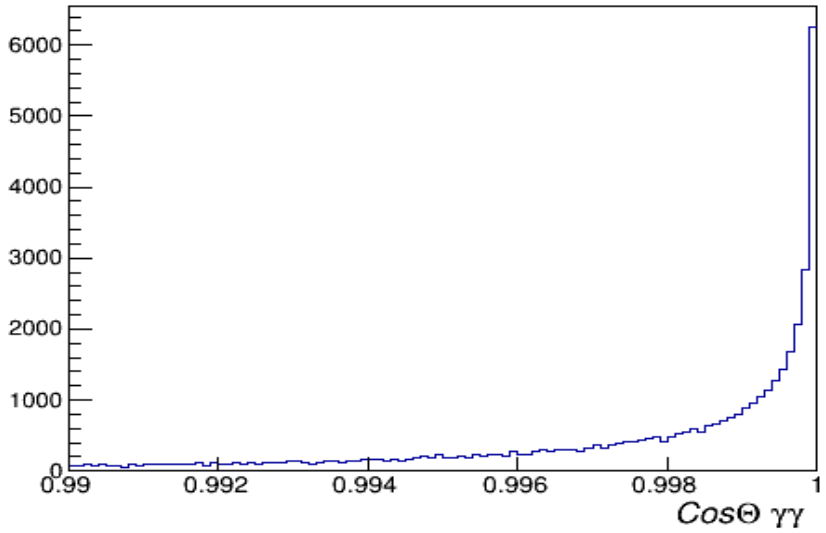
- Rms X = Rms Y = 0.0 cm
- Gaussian smearing of π^0 vertex along Z - axis

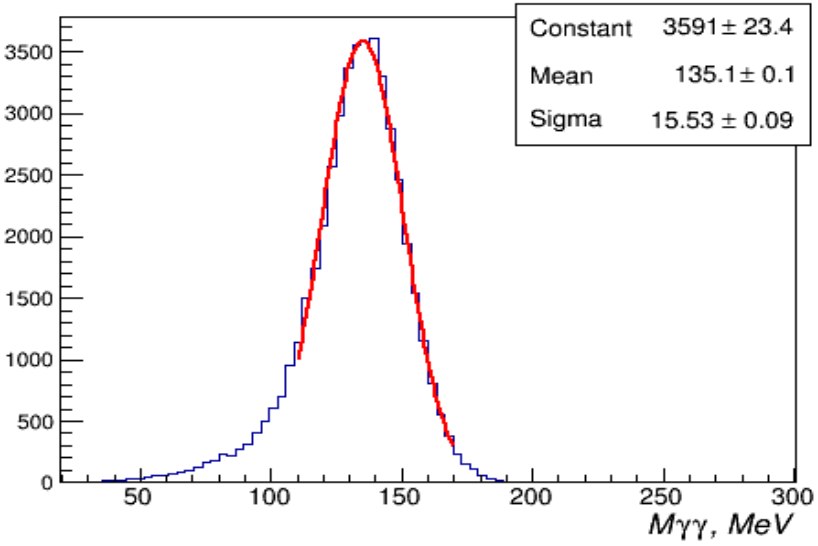


σMγγ / Mγγ ~ 11.5 %, Eγ > 5 MeV

10.8% with no vertex smearing

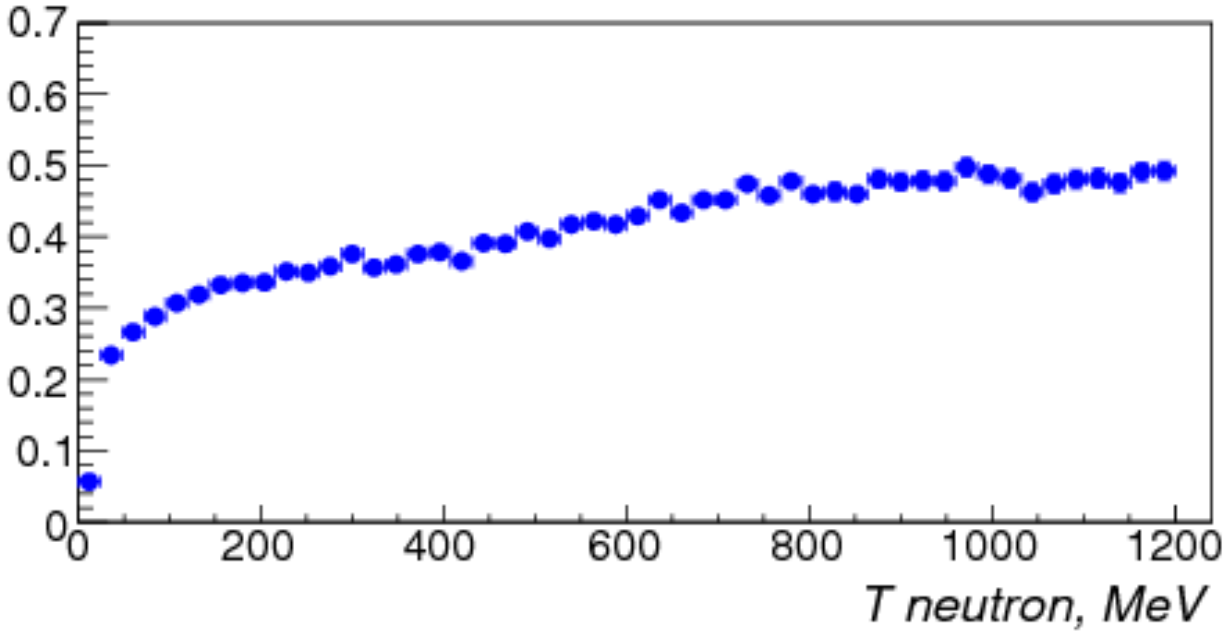
$Cos\ \theta_{\gamma\gamma}$ - angle between cluster and real γ directions





ECAL neutron detection efficiency

Detection efficiency

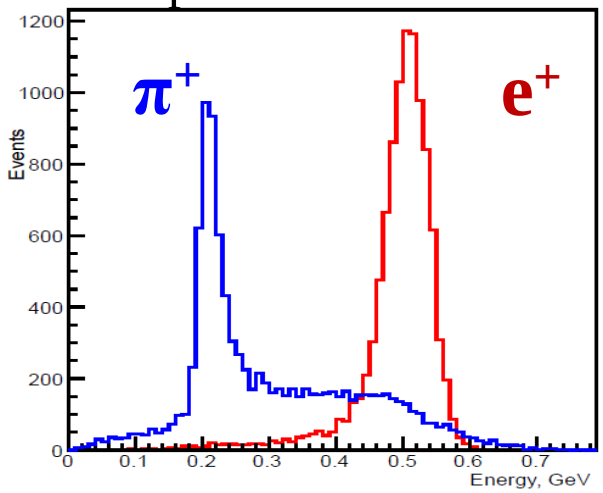


It is good, neutron can be registered with 30-50% efficiency.

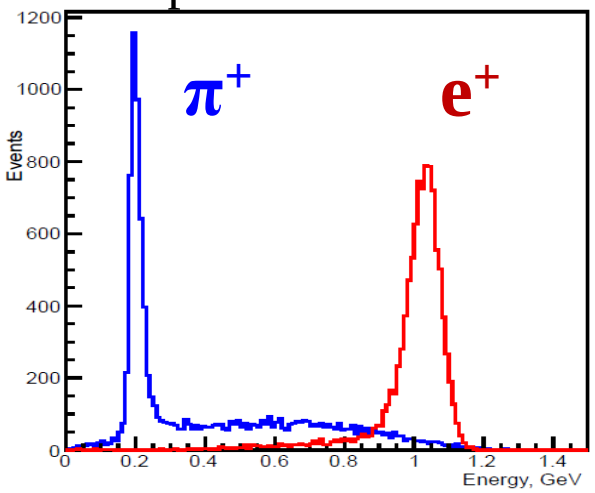
It is bad, copiously produced neutrons give large background, for example for neutral pion detection.

Particle separation by ECAL

p = 0.5 GeV/c



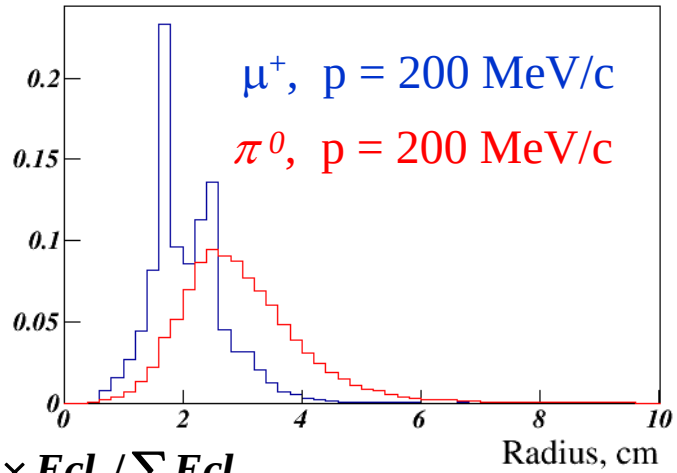
p = 1.0 GeV/c



π^+ contamination in e^+ – 15%

π^+ contamination in e^+ – 5%

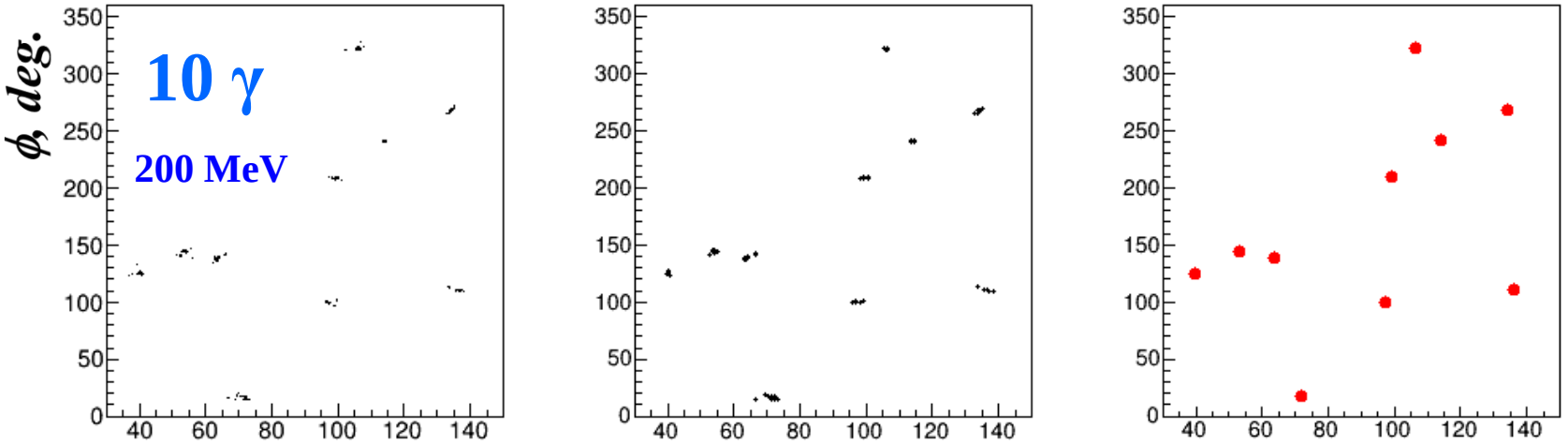
- ✓ Cluster weighted radius (in Root file)
- ✓ Defined for cluster with hit number > 1
- ✓ Possible way to select different particles



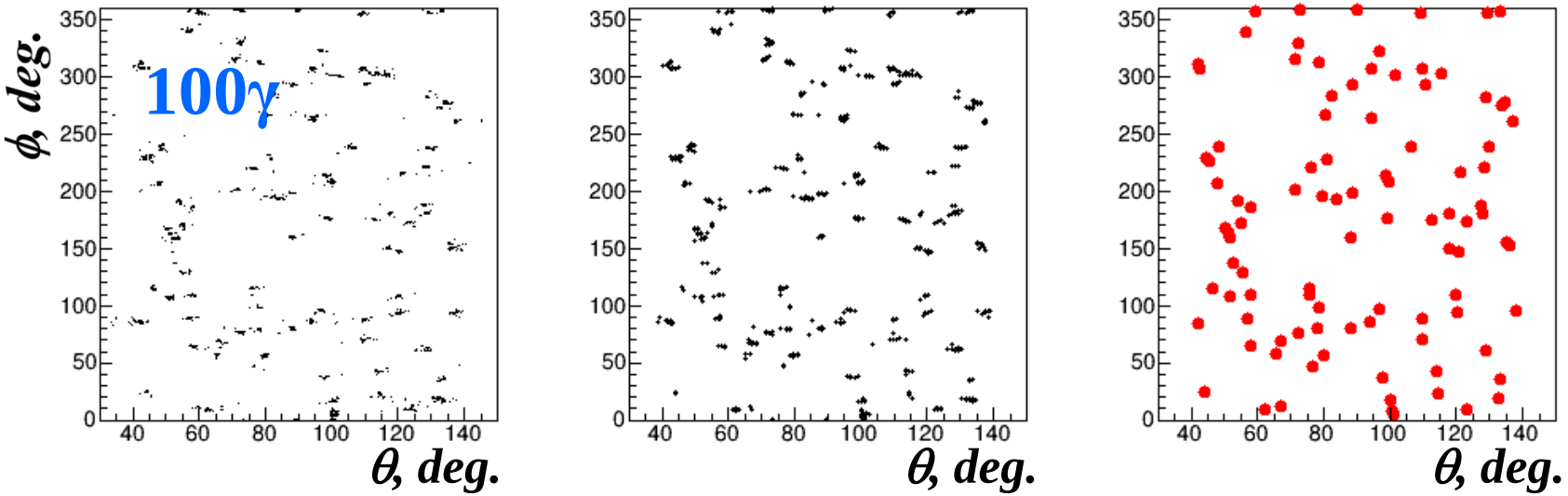
$$Rcl = \sum_i \sqrt{Rcl\_xyz \times (\theta_i - \theta\, cl)^2 + Rcl\_xy \times (\phi_i - \phi\, cl)} \times Ecl_i / \sum_i Ecl_i$$

Cluster search test

GEANT points – 1623 | **Hits – 63** | **Clusters – 10**



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



Conclusion

1. **Projective (quasi-spherical) geometry is implemented for MPD EMC MC**

2. **Programs for Hit and Cluster production have been developed in mpdroot environment and available at git**

3. **Programs have been tested and are ready for physics analysis**

4. **ITEP group plans for near future:**
   a) **Mechanical support structure of 60T EMC is under development and modification of calorimeter geometry has to be done.**
   b) **Cooperation with analysis groups in MC study of MPD NICA physics**

Thank You

Soft structure