MC corrections for calculation of differential π^0 production cross section

Ruslan Akhunzyanov

LHEP, JINR

SPD Physics Meeting
July 19, 2022

Goal of study

- To estimate MC corrections for measurement of unpolarized π^0 production cross section at SPD for different momenta and polar angles.

Plan of the talk

- Kinematical distributions of MC π^0.
- Reconstruction procedure
- Estimation of N_{RC} / N_{MC} for different *p* and θ.

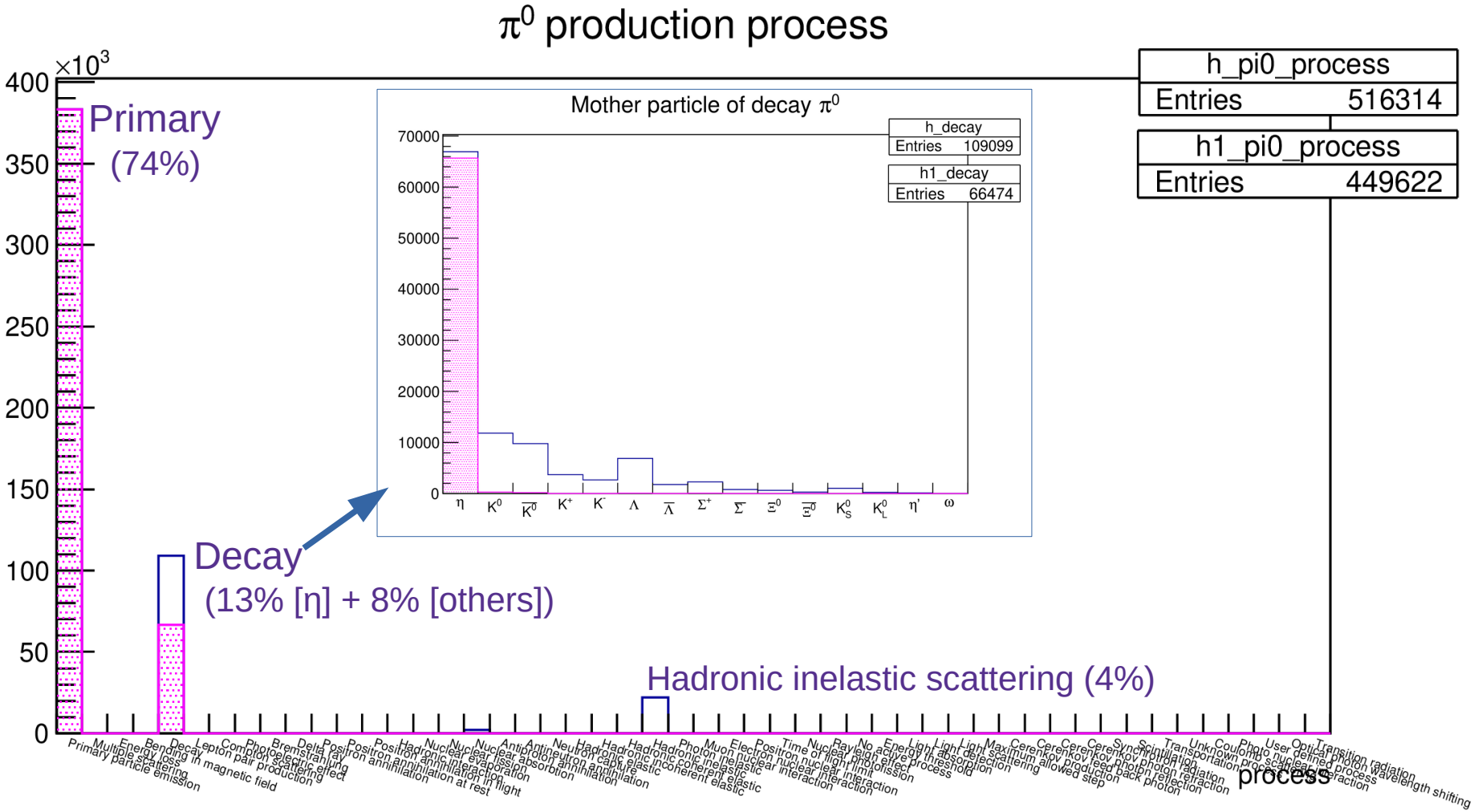
Event sample

- SpdRoot 4.1.4
- Pythia8: SoftQCD (without elastic)
- $\sqrt{s} = 27\,\mathrm{GeV}$
- 99 000 events

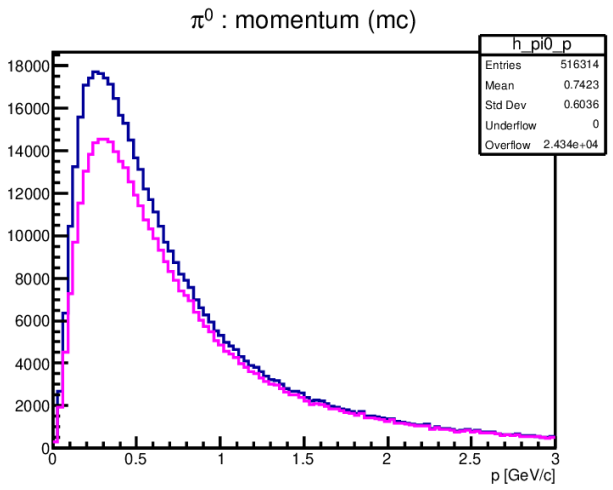
MC π^0: selection

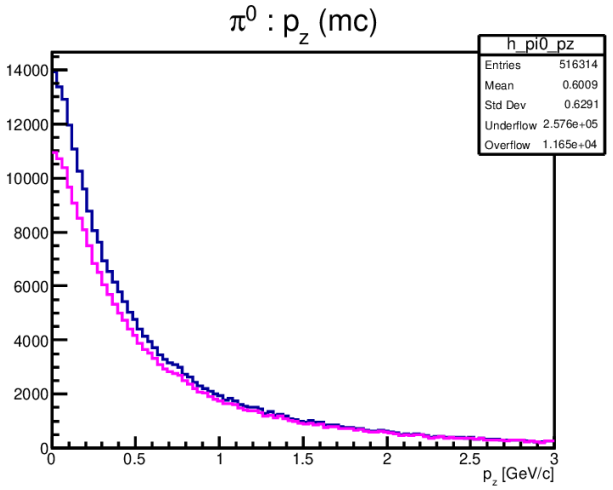
- Simply go through MC particles with pdg code = 111 (π^0).
- Always exclude π^0's that were produced in ECAL or beyond it.
- Optionally, include only π^0's with distance ρ between π^0 production vertex and the primary vertex < 1 mm.

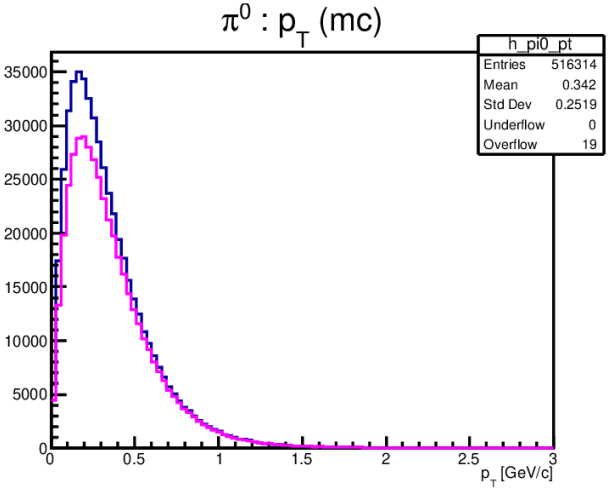
MC π^0: origin

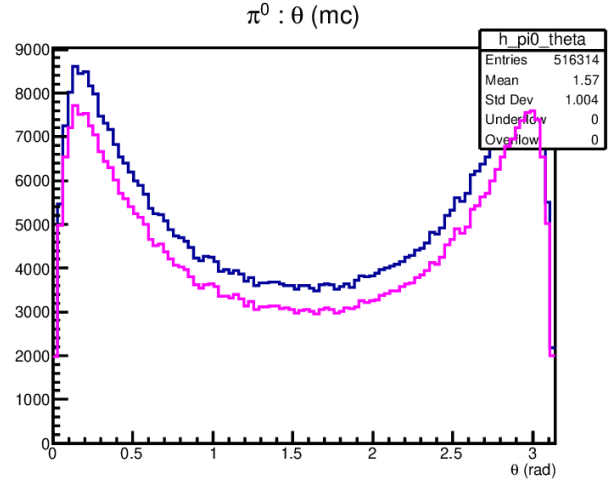


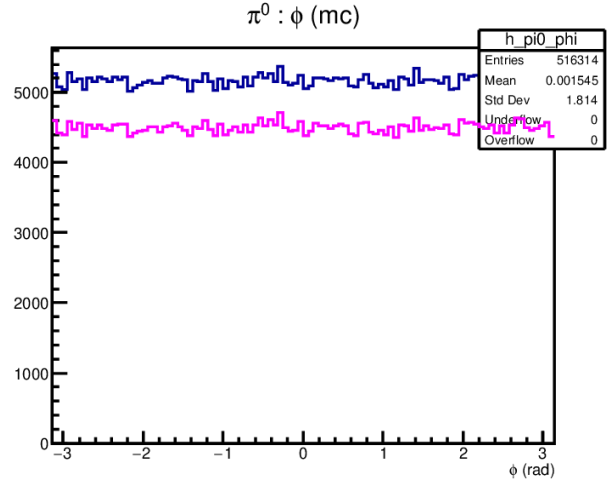
MC π^0: 1D distributions

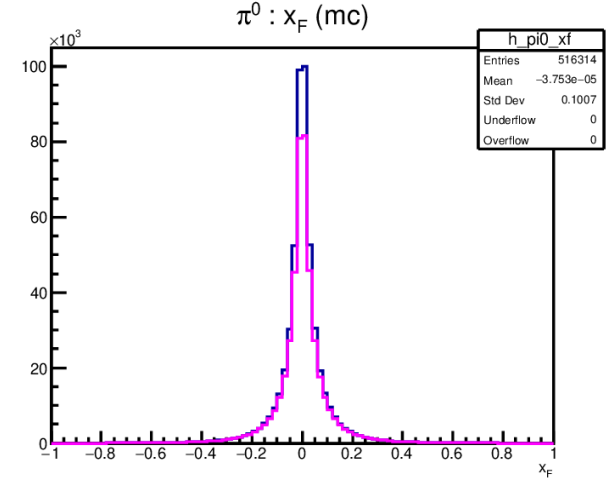




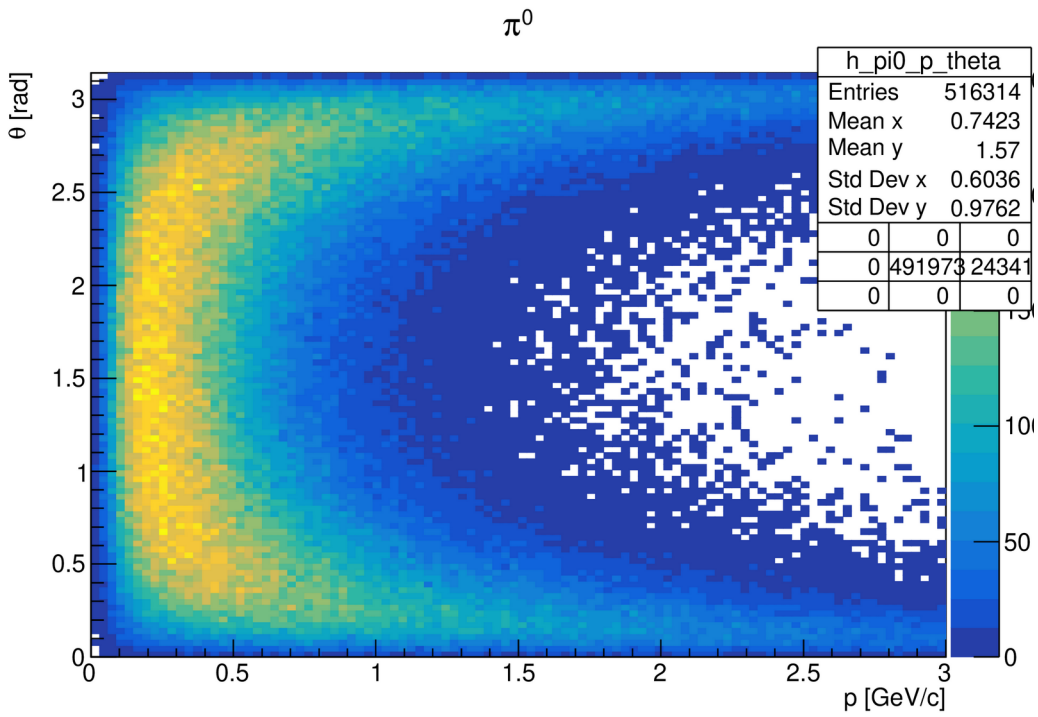


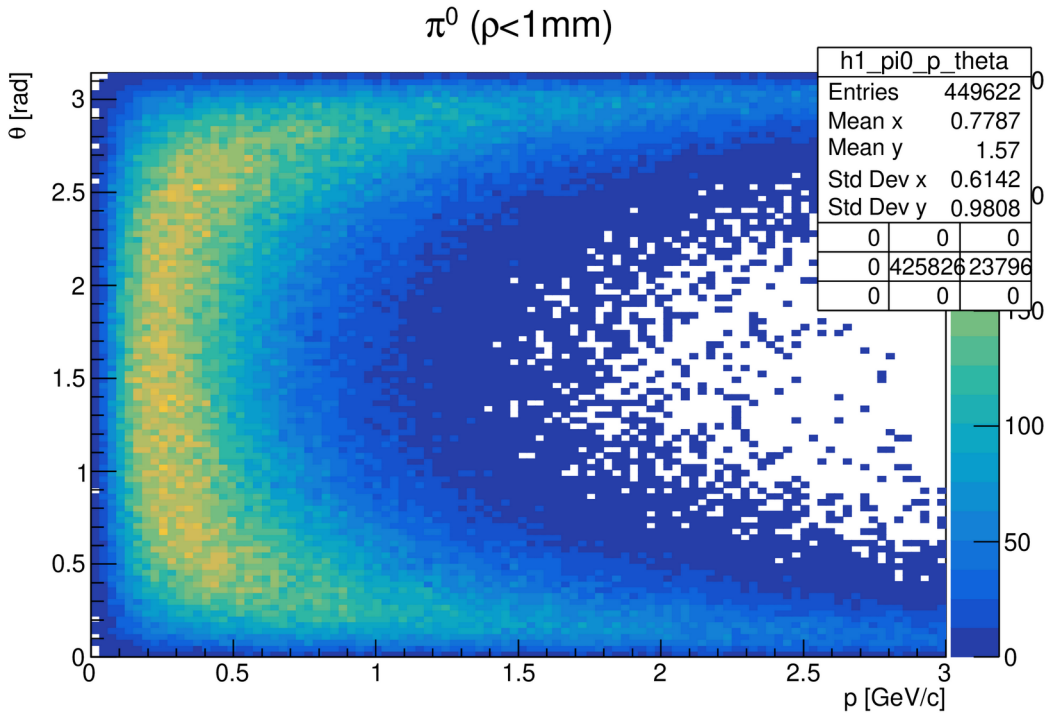




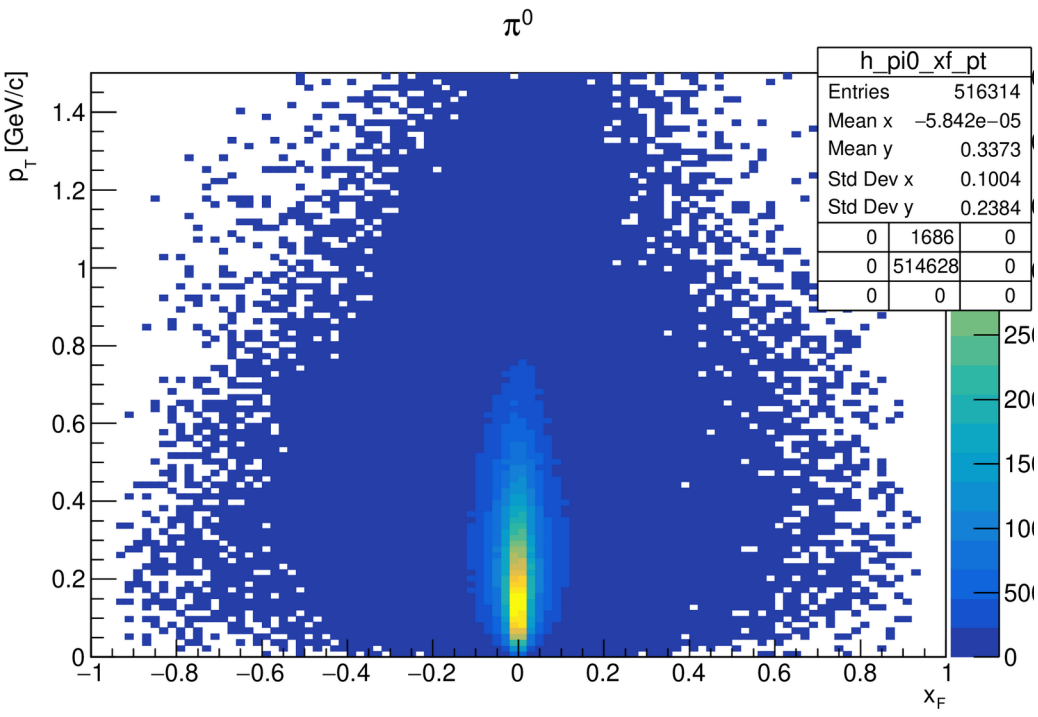


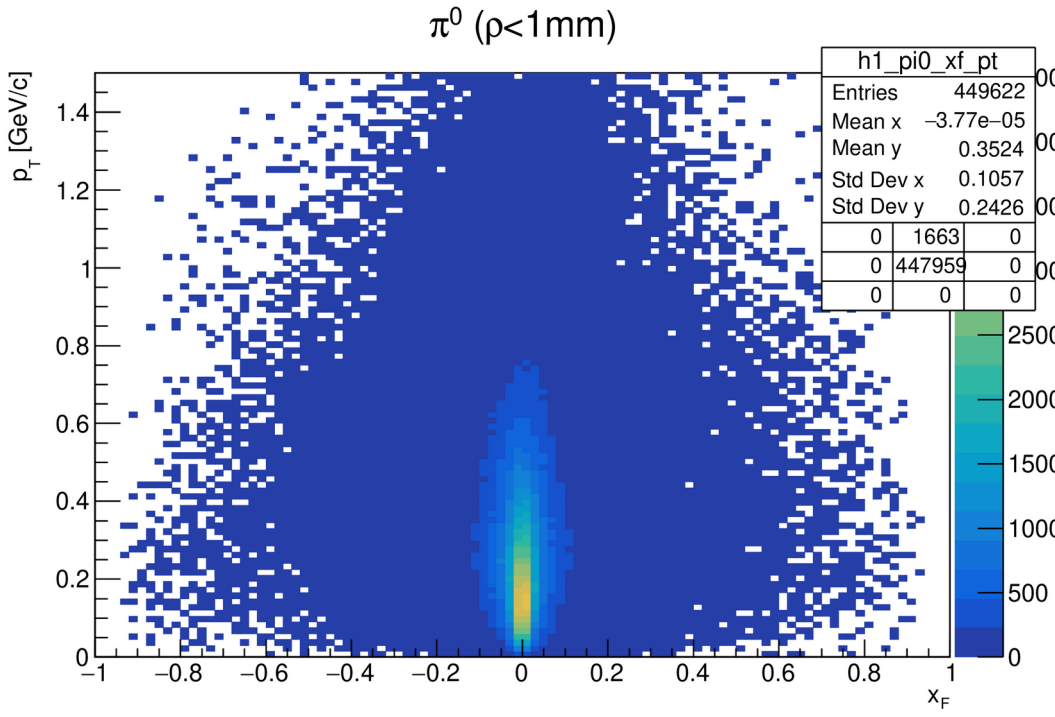
MC π^0: θ vs p


π^0
h_pi0_p_theta
Entries 516314
Mean x 0.7423
Mean y 1.57
Std Dev x 0.6036
Std Dev y 0.9762
0 0 0
0 491973 24341
0 0 0
θ [rad]
p [GeV/c]


π^0 (ρ<1mm)
h1_pi0_p_theta
Entries 449622
Mean x 0.7787
Mean y 1.57
Std Dev x 0.6142
Std Dev y 0.9808
0 0 0
0 425826 23796
0 0 0
θ [rad]
p [GeV/c]

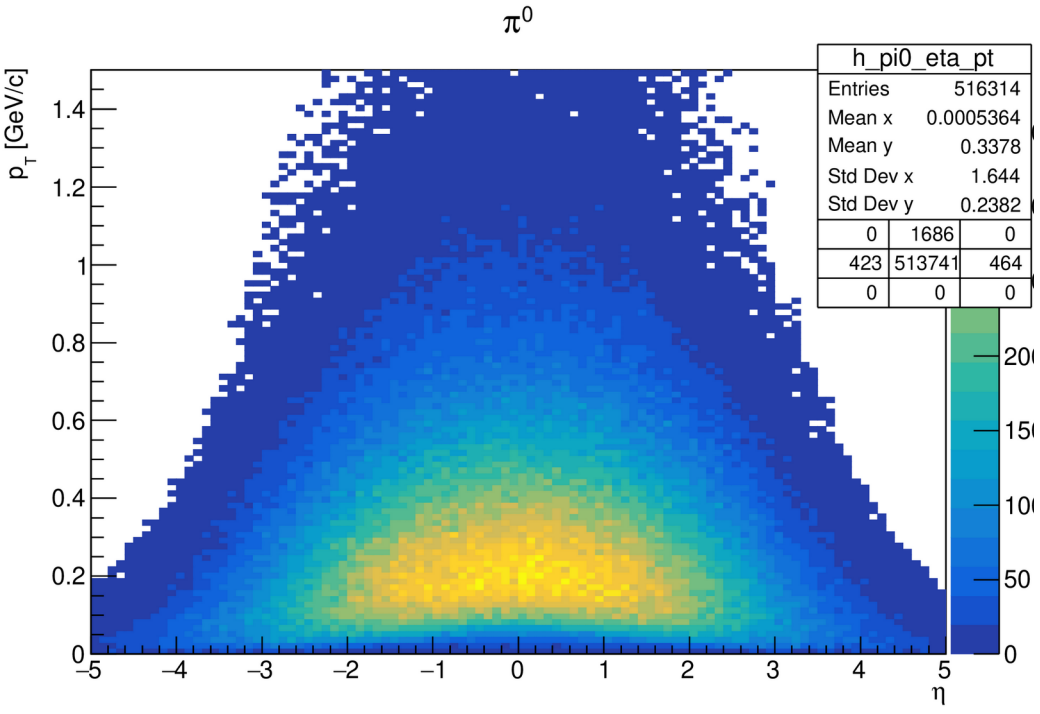
MC π^0: p_T vs x_F

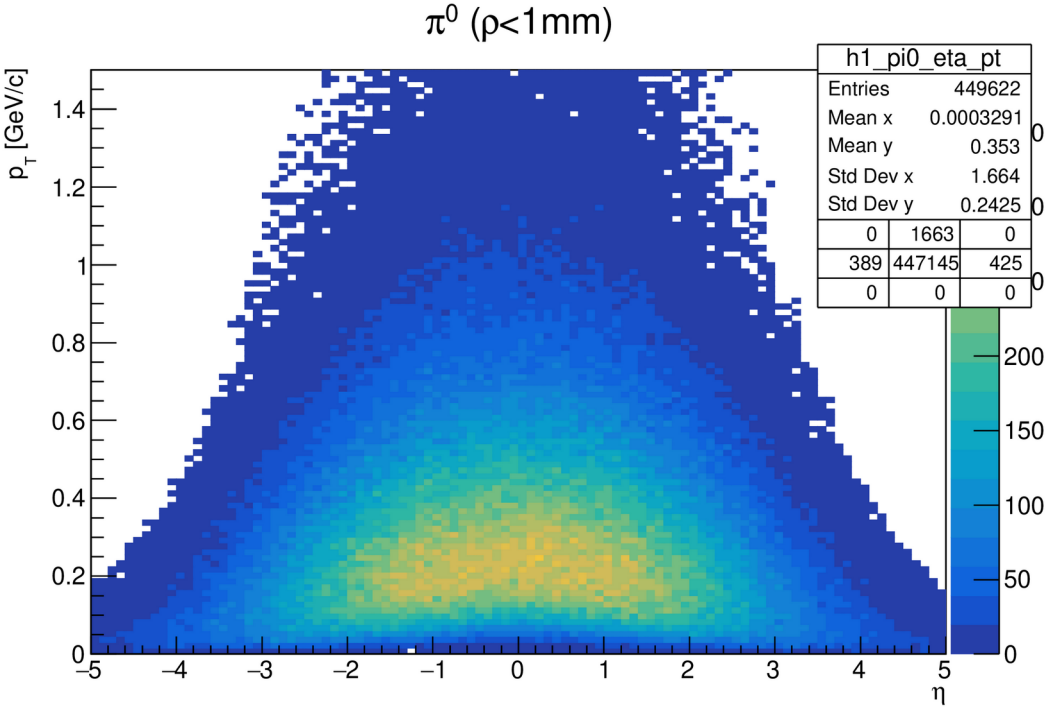




$$x_F = \frac{p_z}{\sqrt{s}/2}$$

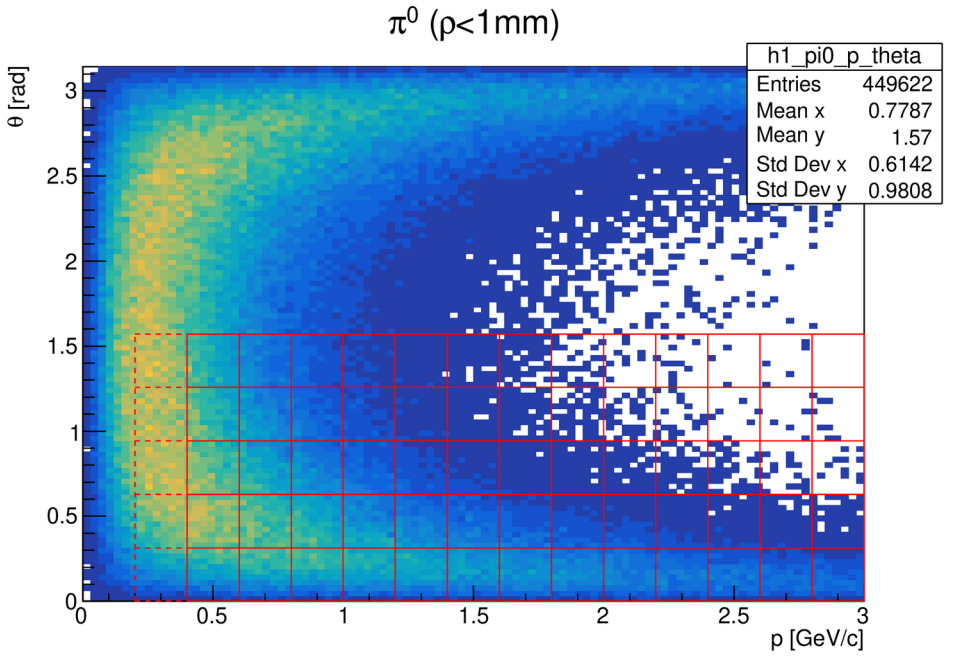
MC π^0: p_T vs η

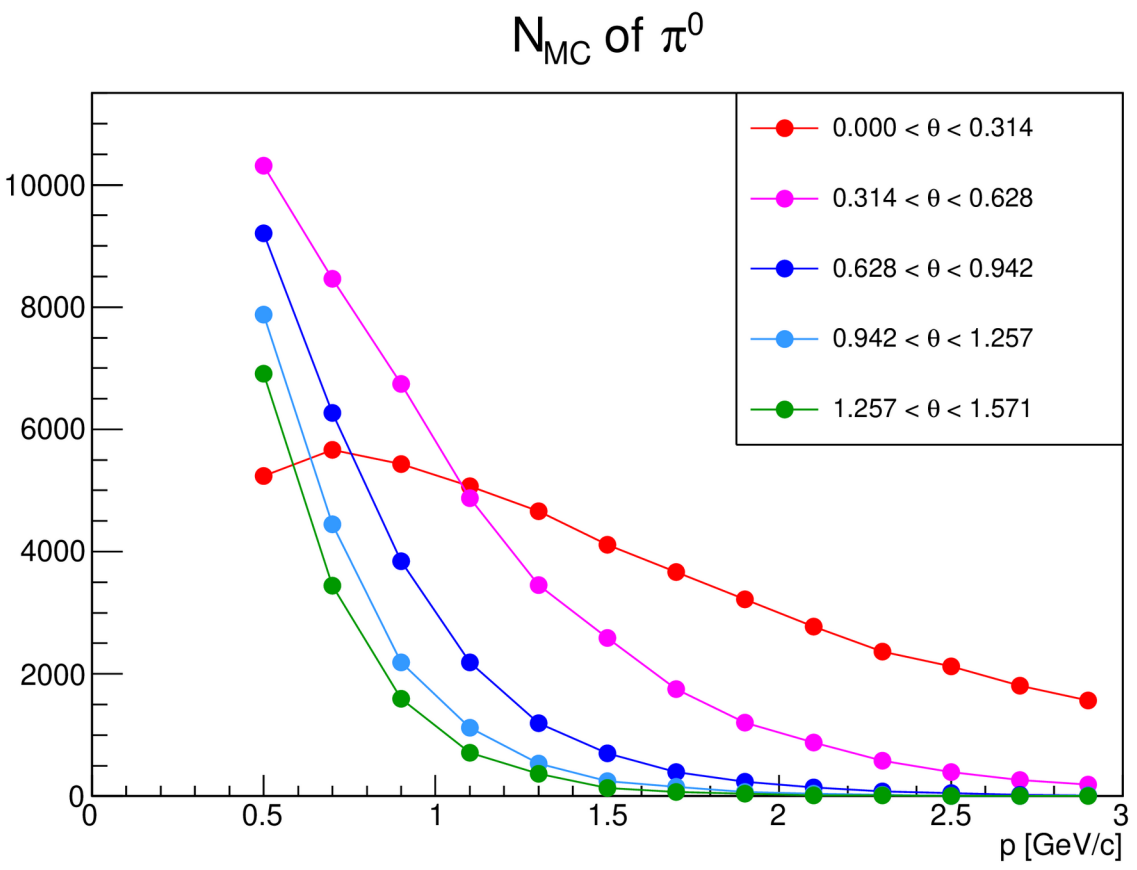




$$\eta = \frac{1}{2}\ln\left(\frac{p+p_L}{p-p_L}\right) = -\ln\left(\tan\frac{\theta}{2}\right)$$

MC π^0: θ vs p (for comparison with RC)

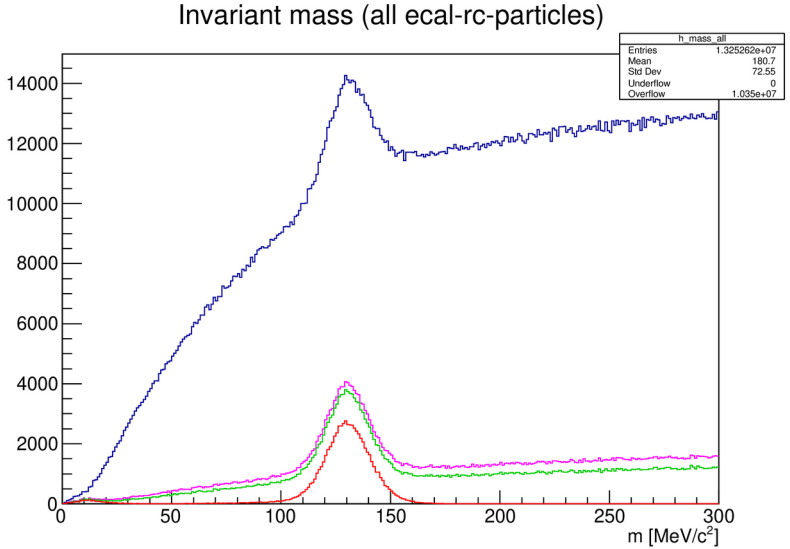


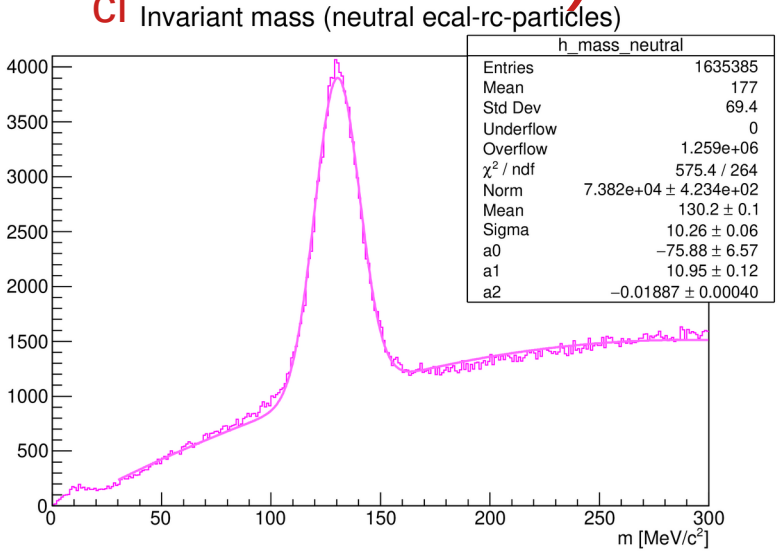


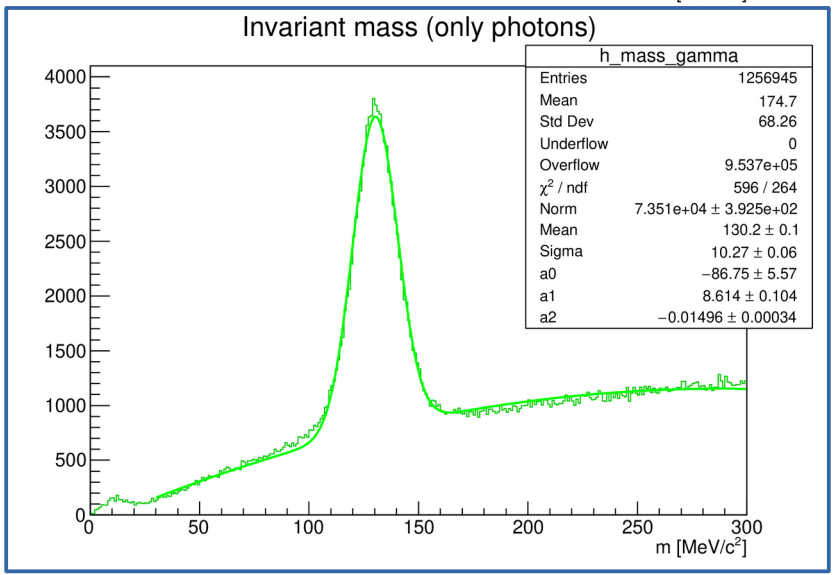
Reconstruction of π^0

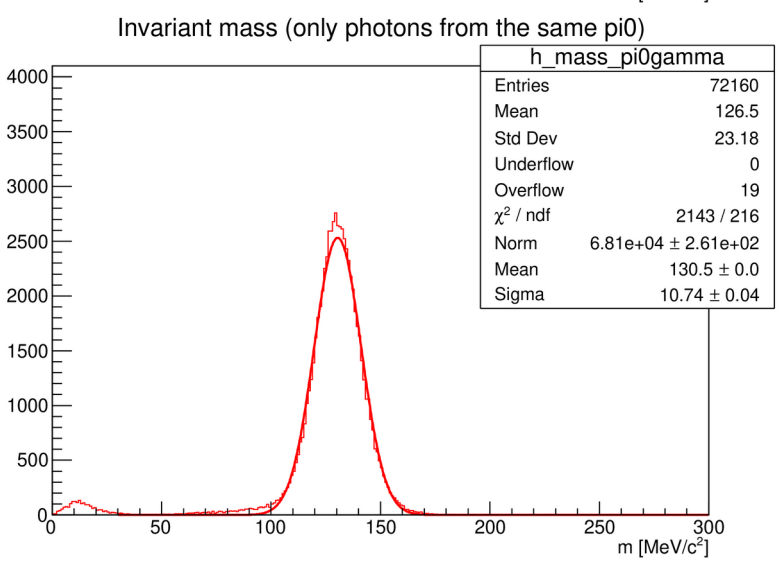
- Loop through `SpdEcalRCParticle` objects, which contain information on reconstructed ECAL cluster energy and position.
- From the corresponding `SpdEcalClusterMCInfo` object obtain information on what MC particle(s) has (have) contributed energy to the cluster.
- For further analysis take only clusters produced by photons.
- Apply cut $E_{cluster} > 200$ MeV (100 MeV) to reduce background.
- Assuming that cluster was produced by a photon going out from the primary vertex, calculate invariant mass for each pair of clusters.

π^0 invariant mass (cut $E_{cl} > 200$ MeV)

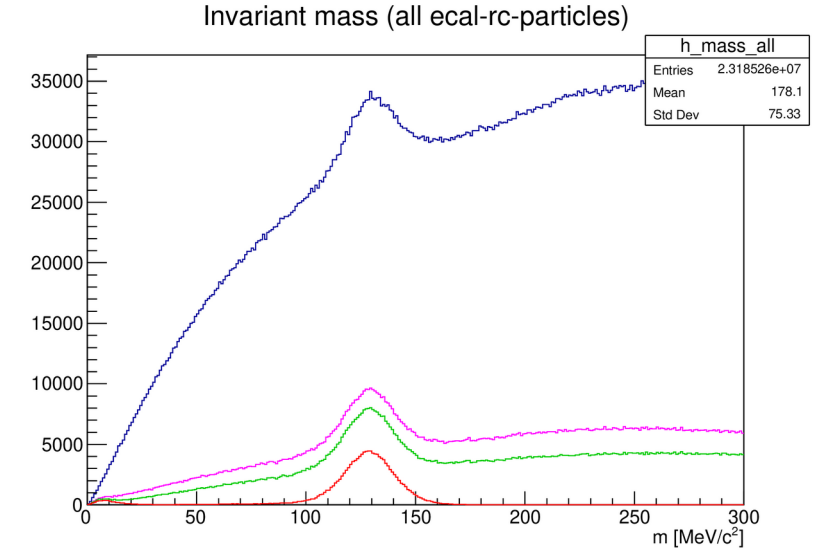


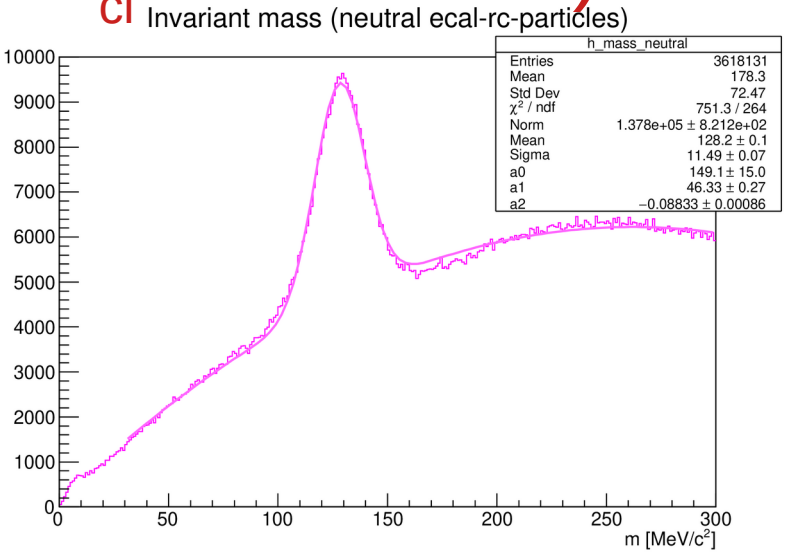


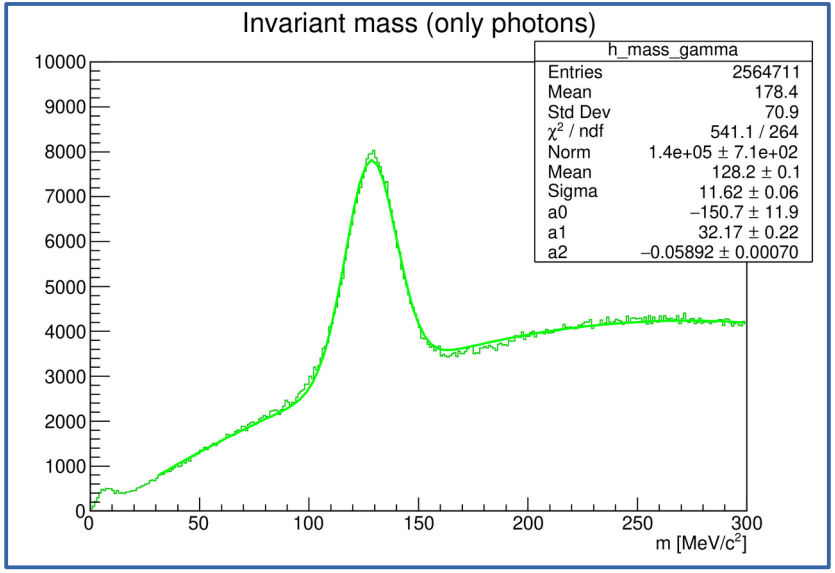


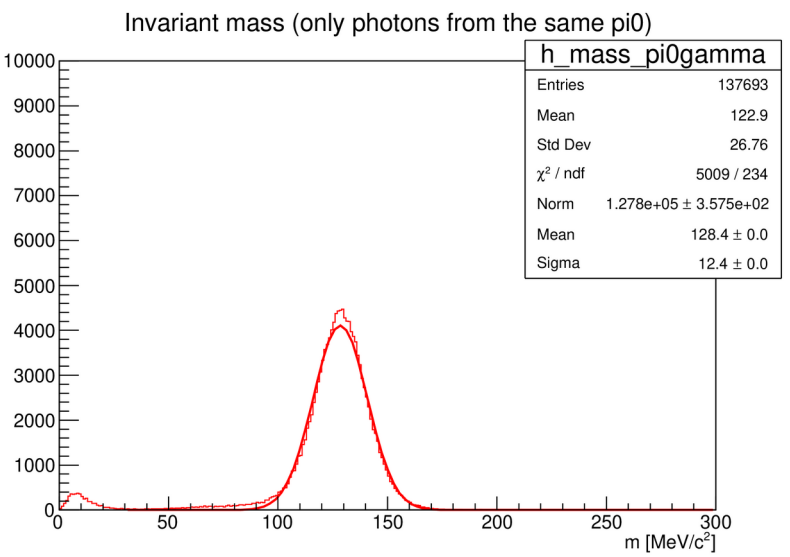


π^0 invariant mass (cut $E_{cl} > 100$ MeV)









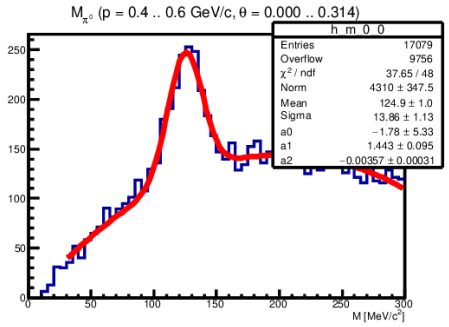
Reconstruction of π^0

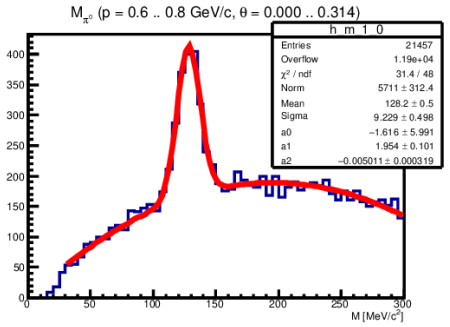
- Invariant mass distribution is fitted by function:

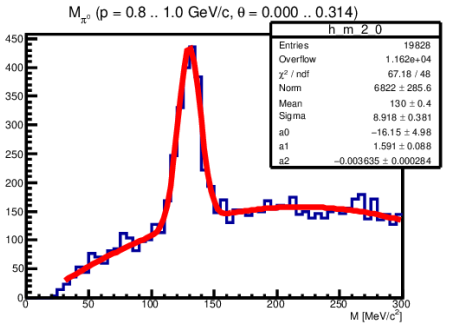
$$f(m) = \frac{I}{\sigma\sqrt{2\pi}}\exp\left[-\frac{(m-\mu)^2}{2\sigma^2}\right] + (a_0 + a_1 m + a_2 m^2)$$

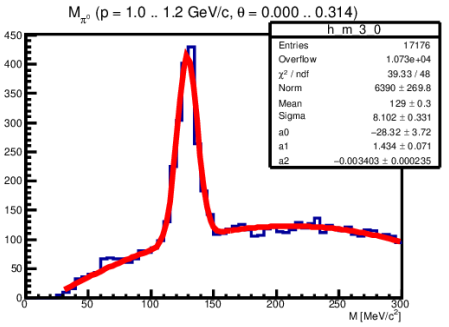
- The procedure described above is applied for each p-θ bin.
- Binning used:
  - p = 0.4 .. 3.0 GeV/c, 13 bins
  - θ = 0 .. 0.5*π, 5 bins

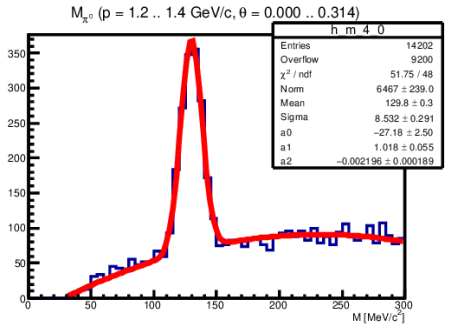
π^0 invariant mass: $0.000 < \theta < 0.314$

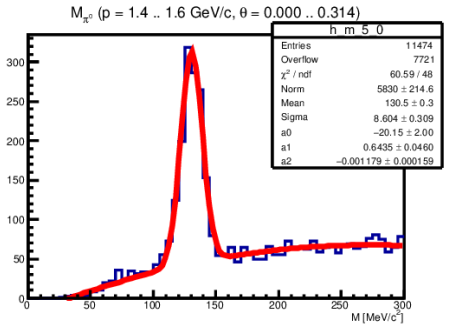


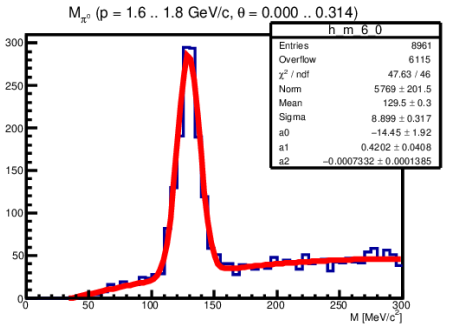


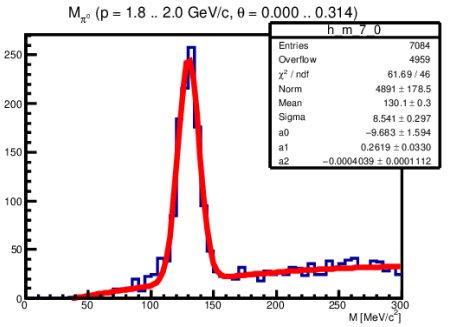


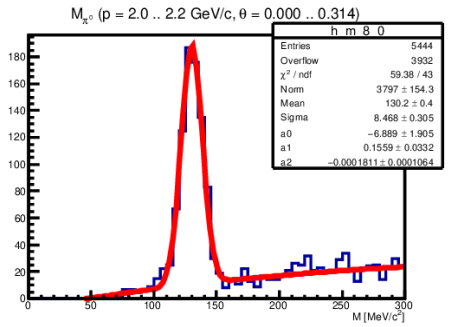


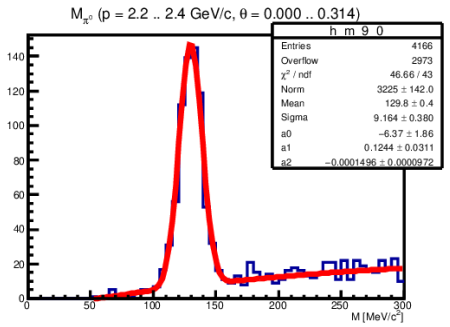


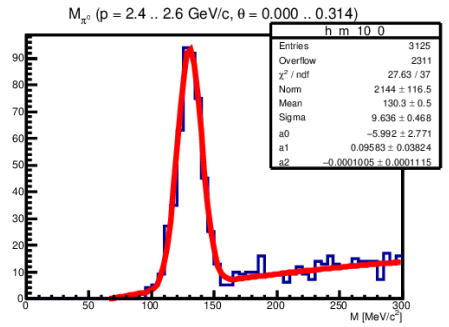


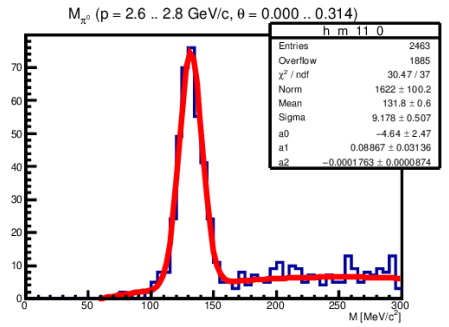




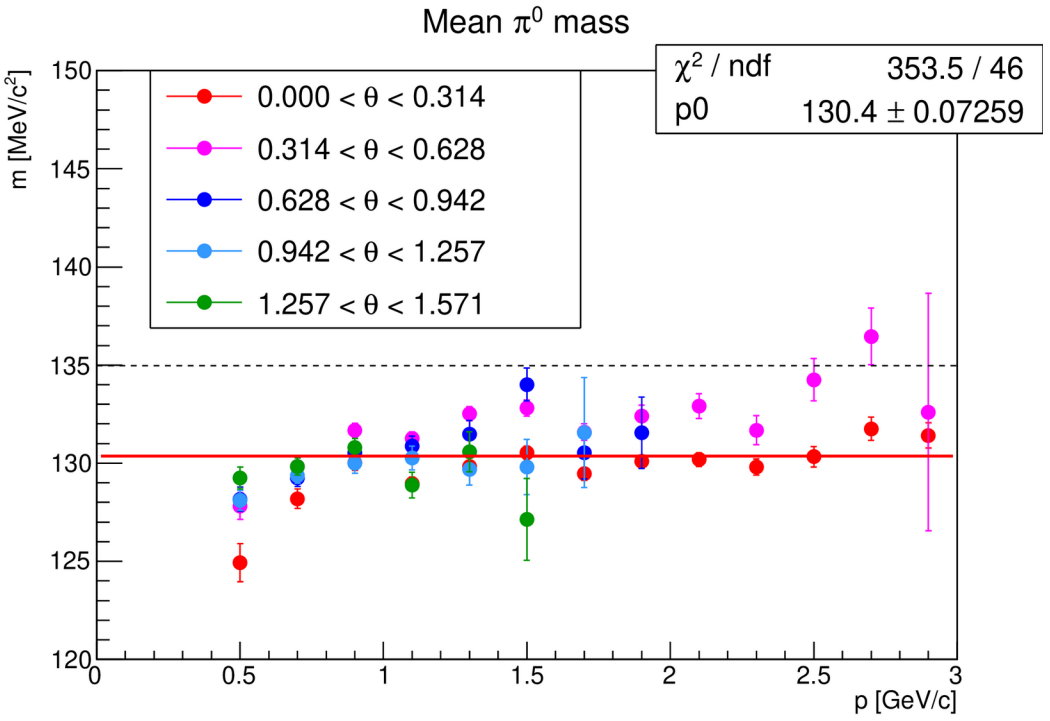


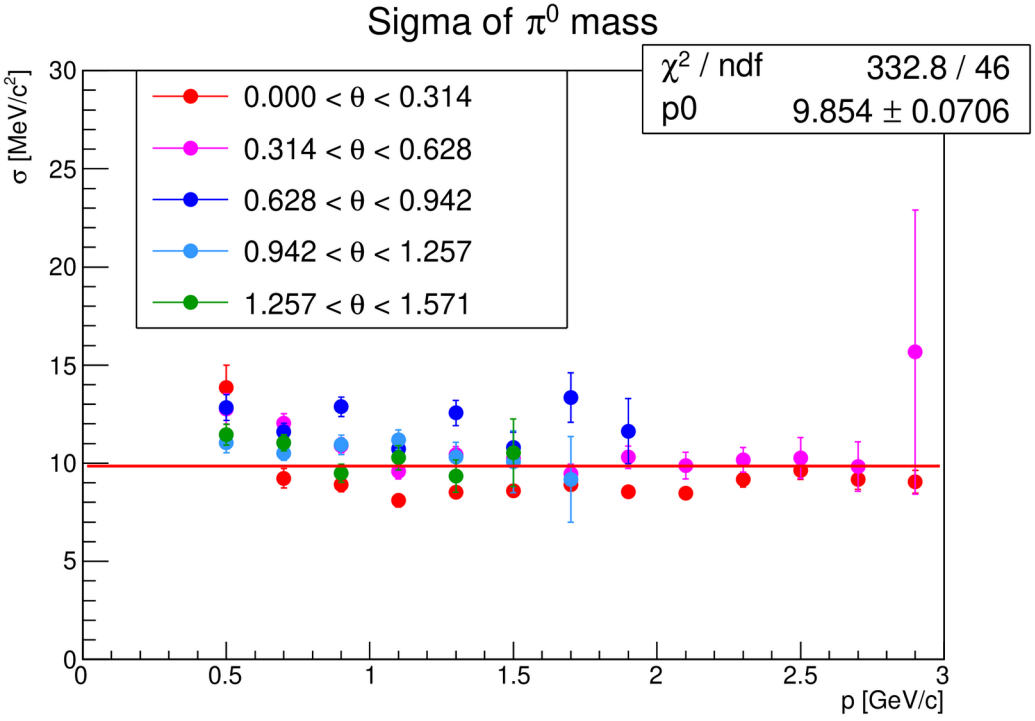




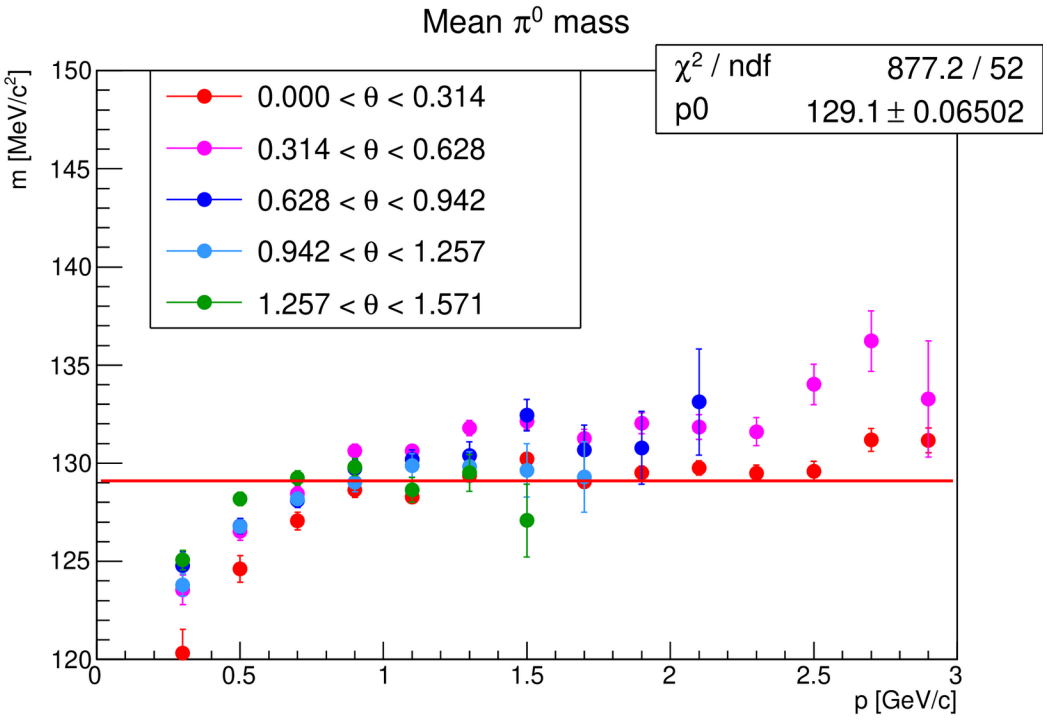


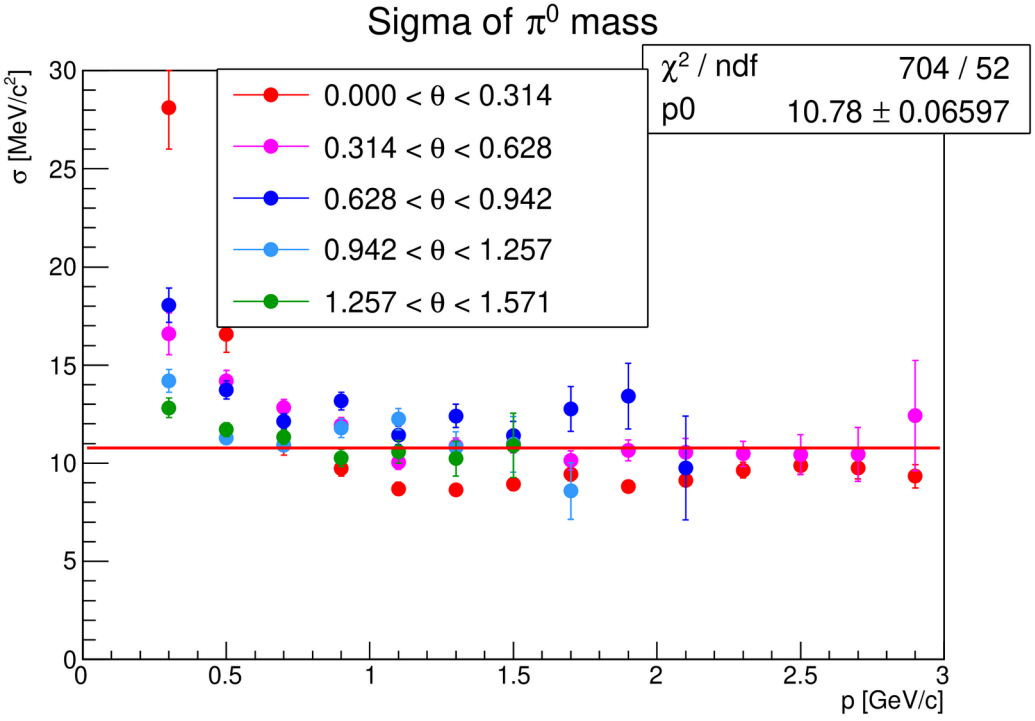
π^0 mean mass and sigma (cut E_{cl}>200 MeV)



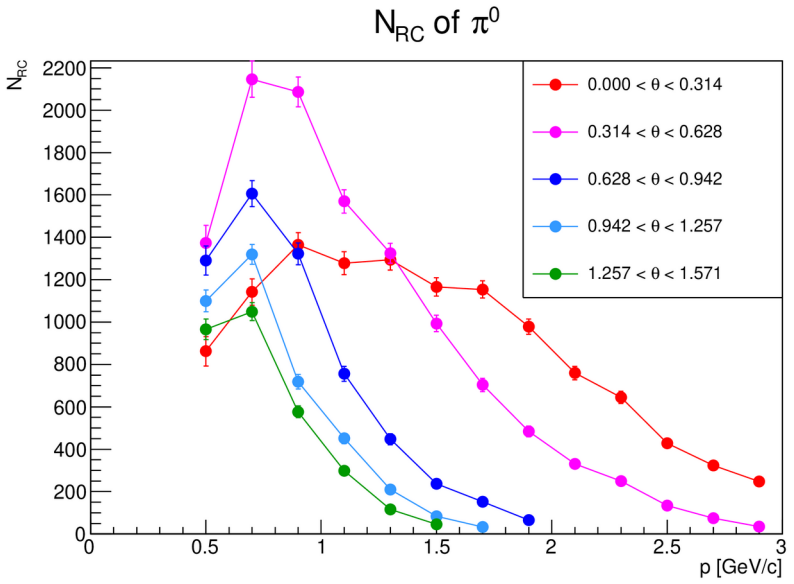


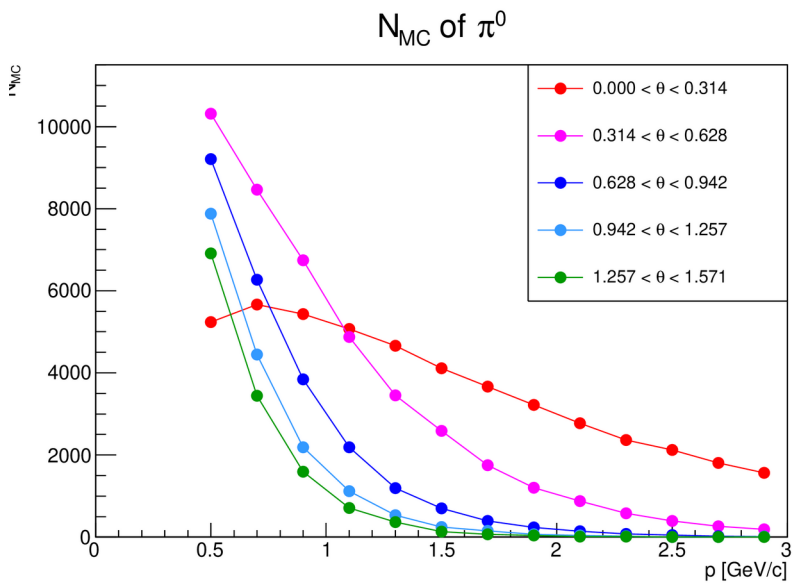
π^0 mean mass and sigma (cut E_{cl}>100 MeV)

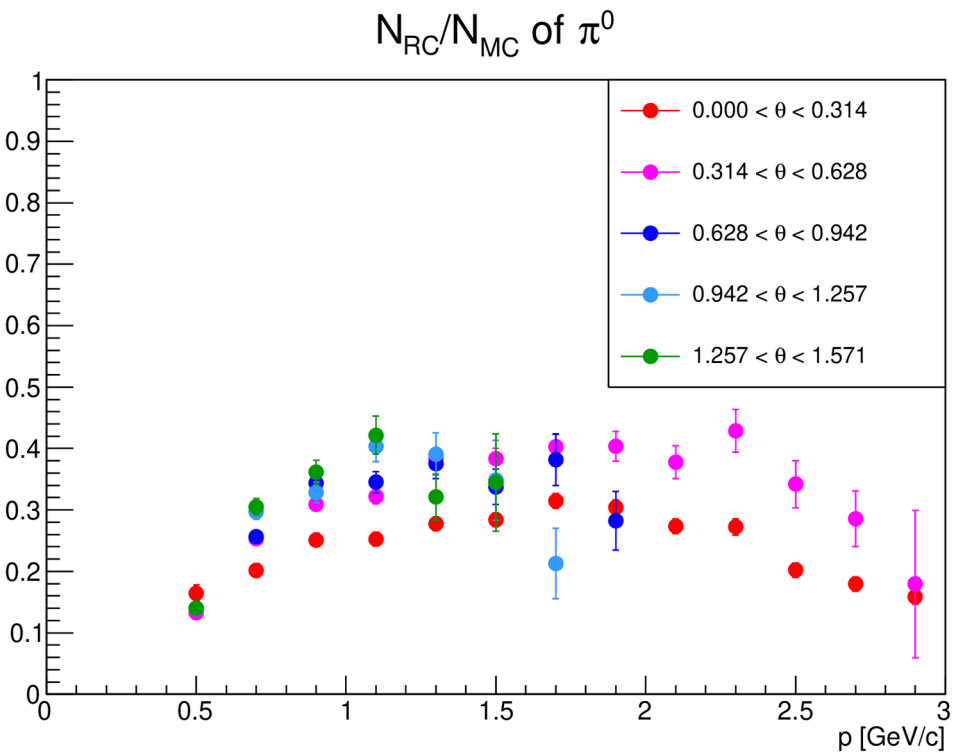




π^0 acceptance (cut E_{cl} > 200 MeV)

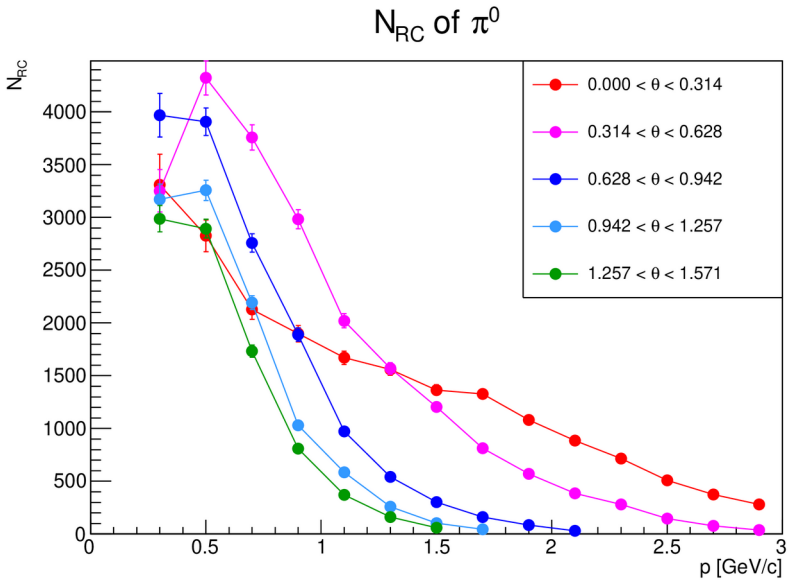


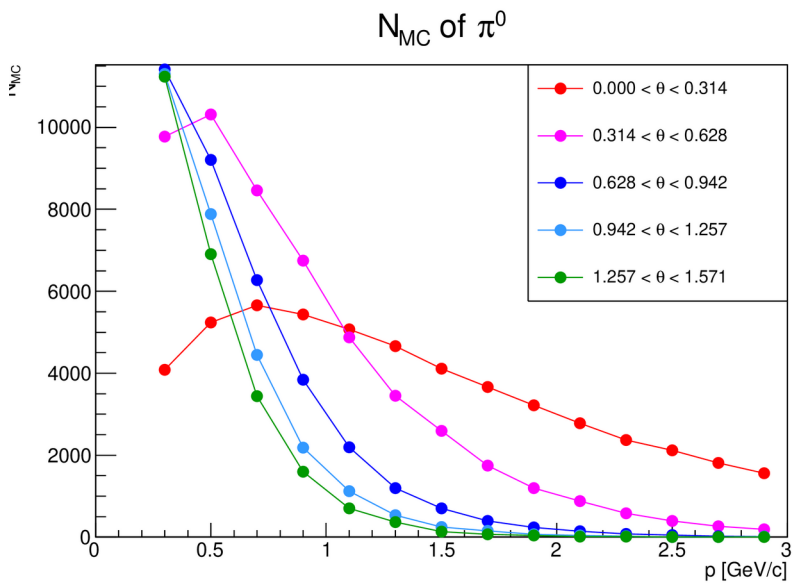


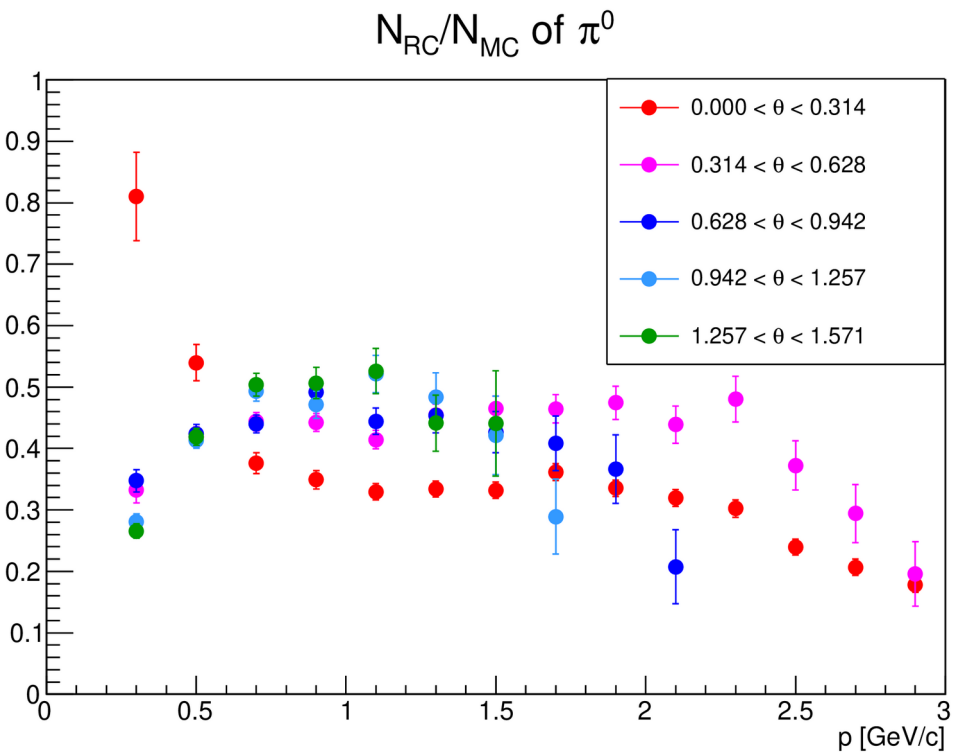


min = 13%, max = 43%

π^0 acceptance (cut E_{cl} > 100 MeV)





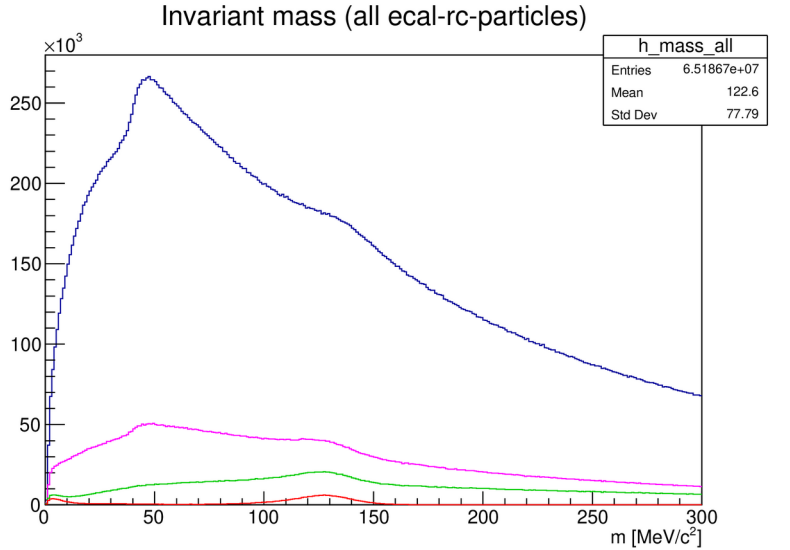


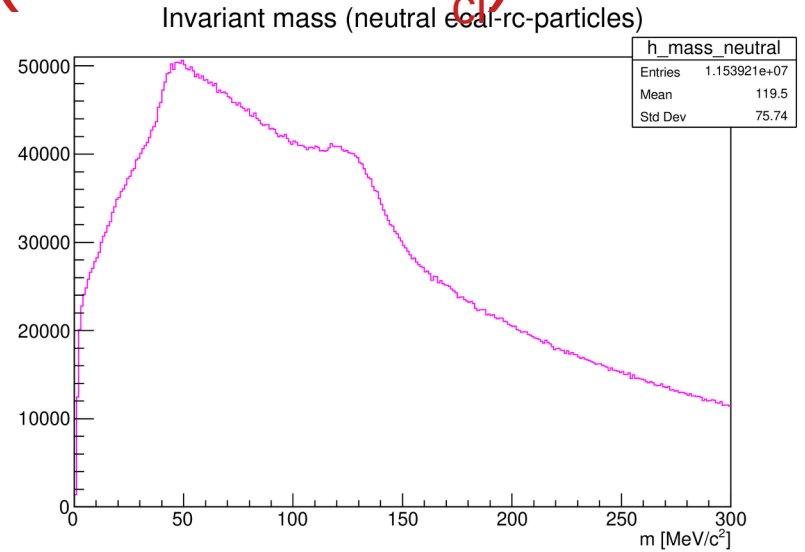
TODO

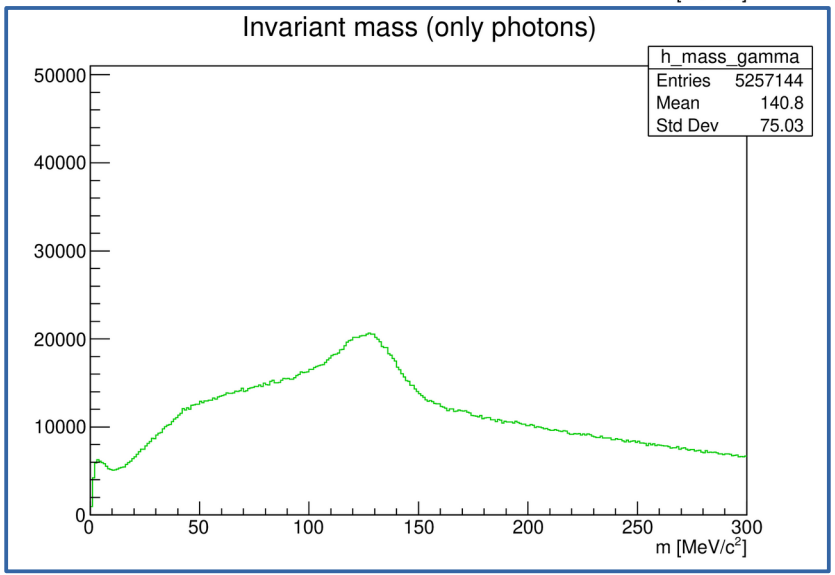
- To apply more realistical procedure for $\pi 0$ reconstruction.
- Further refine this procedure.
- To estimate contribution of different factors (energy cut, geometry, …) to the acceptance.

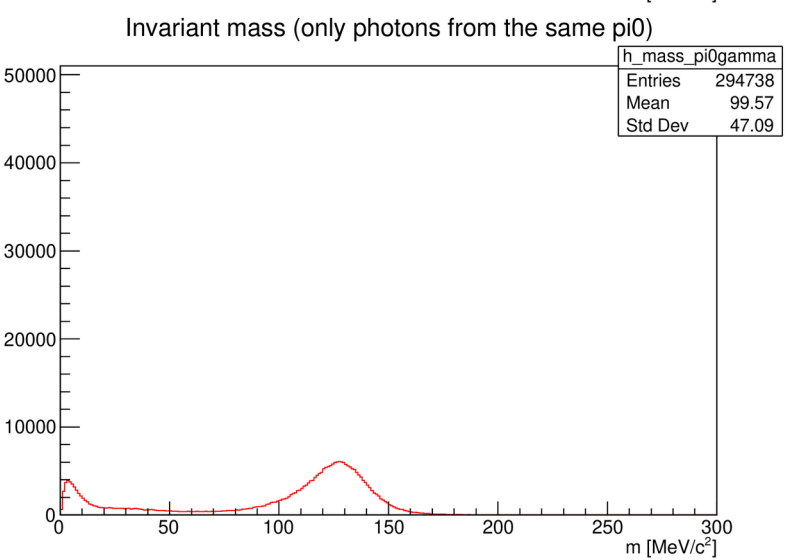
backup slides

π^0 invariant mass (no cut on E_{cl})

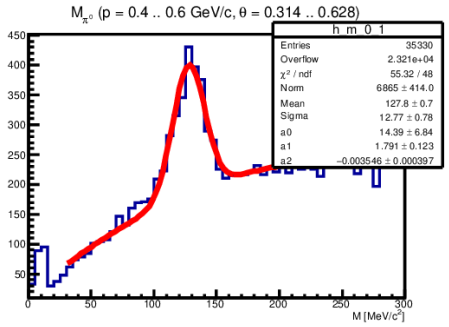


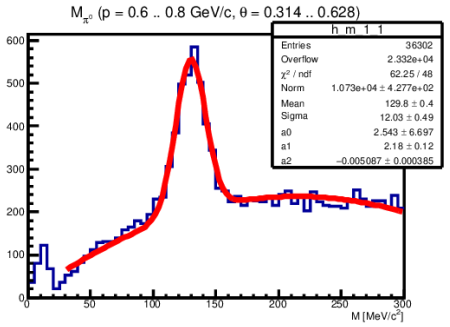


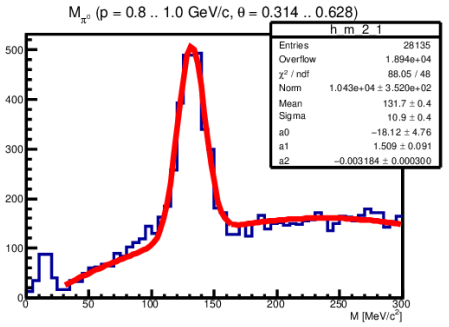


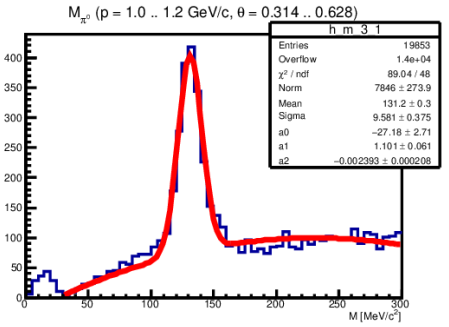


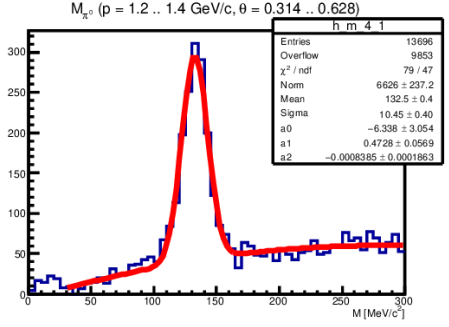
π^0 invariant mass: $0.314 < \theta < 0.628$

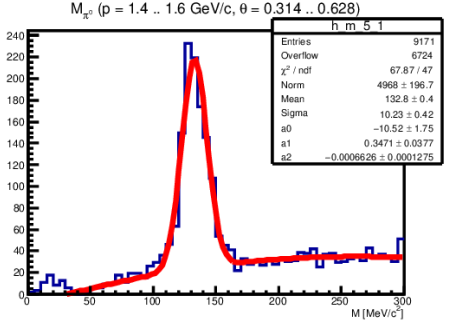


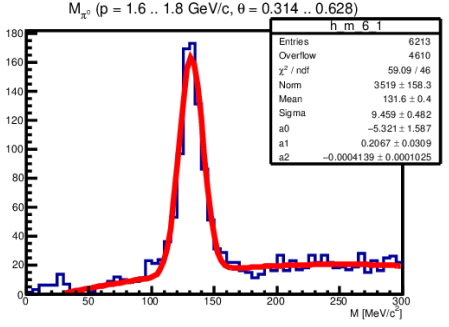


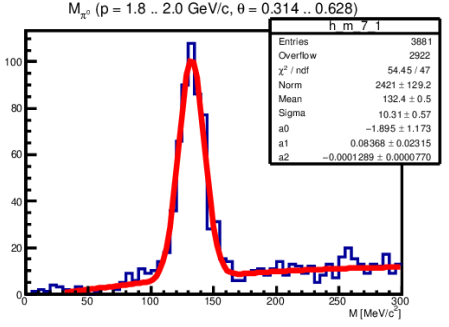


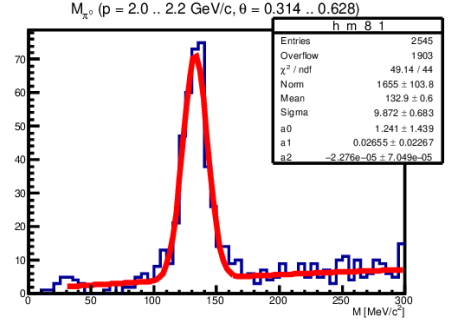


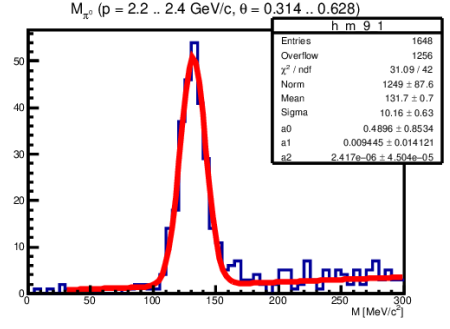


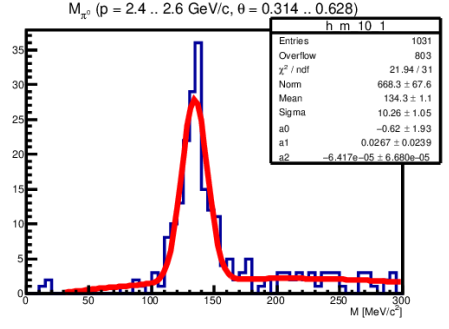


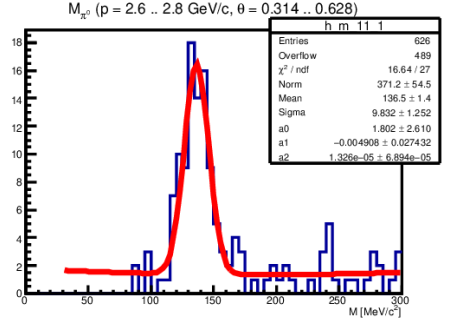




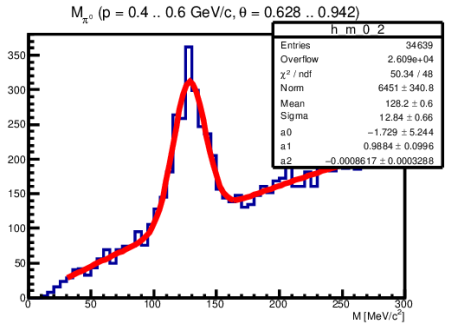


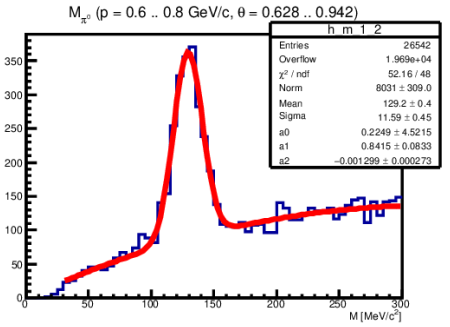


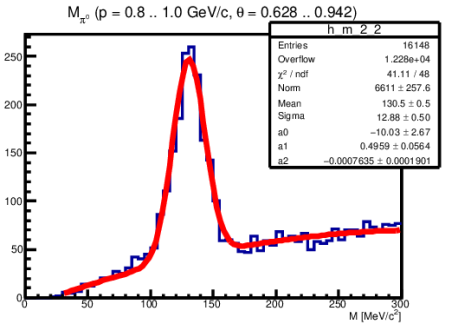


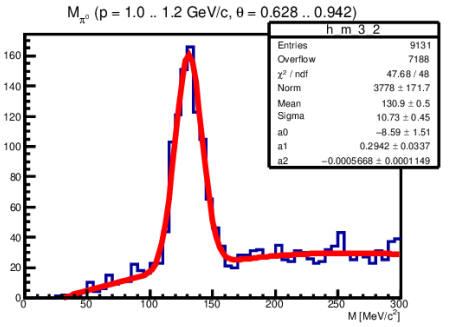


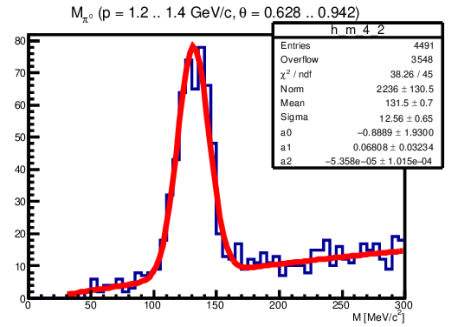
π^0 invariant mass: $0.628 < \theta < 0.942$

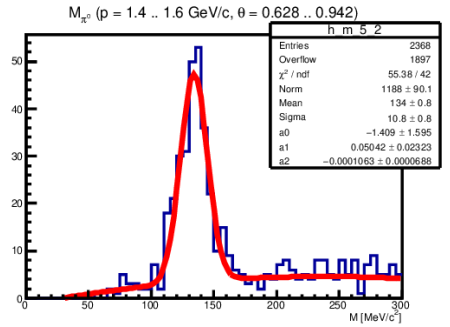


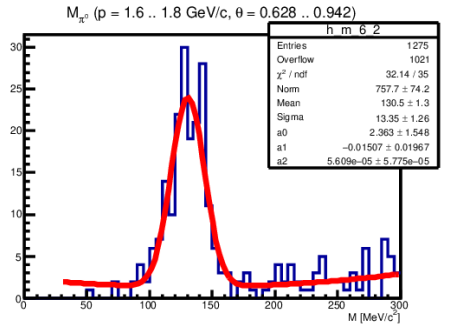


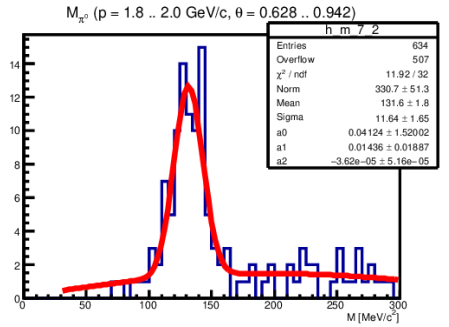


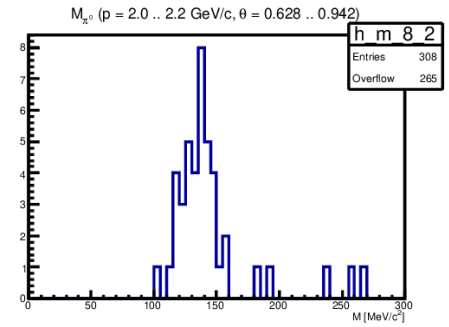


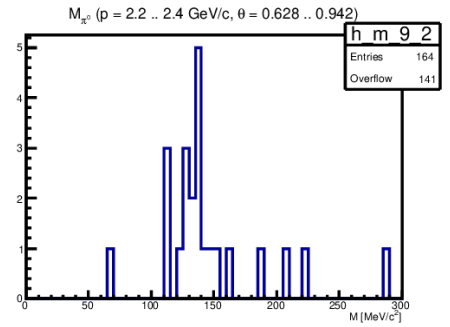


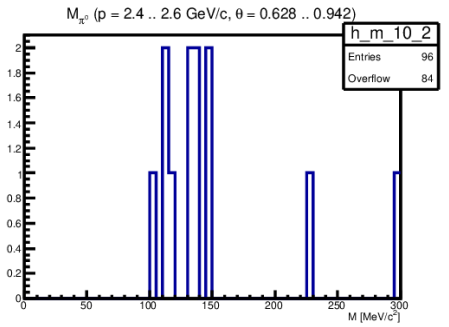


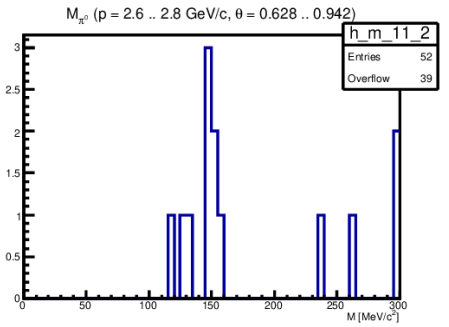




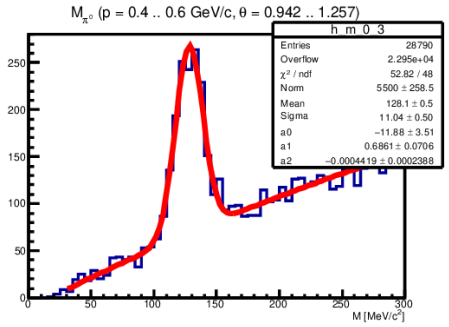


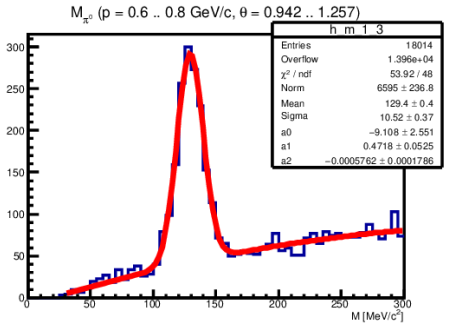


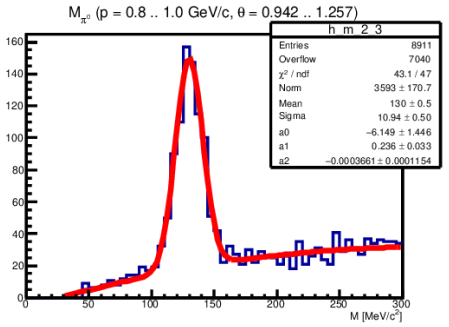


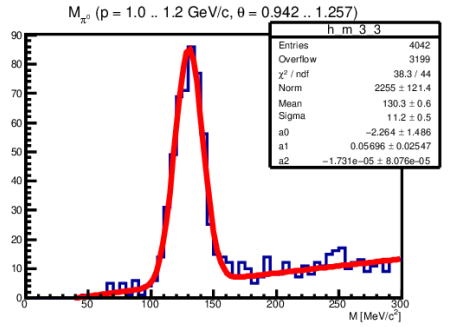


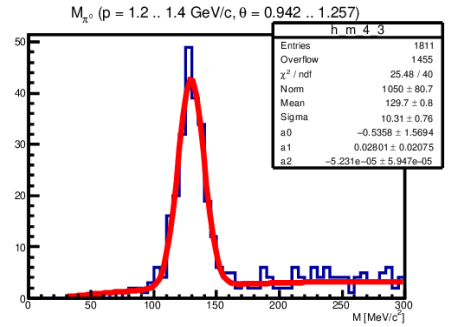
π^0 invariant mass: $0.942 < \theta < 1.257$

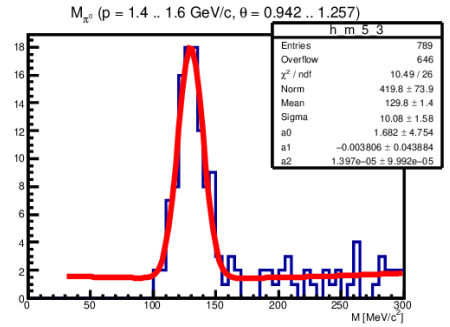


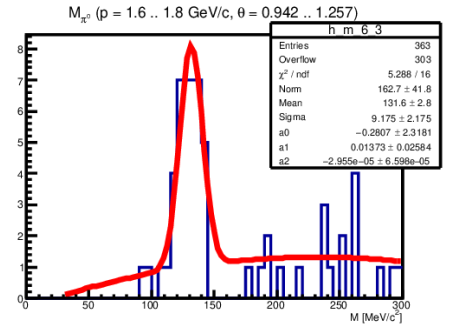


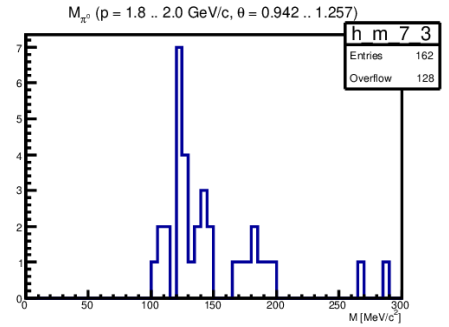


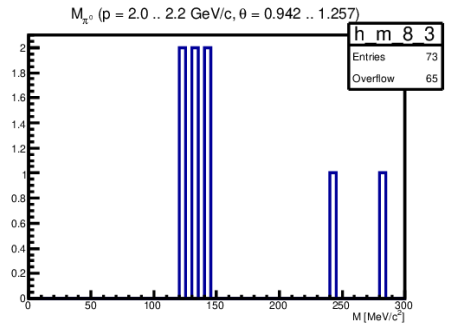


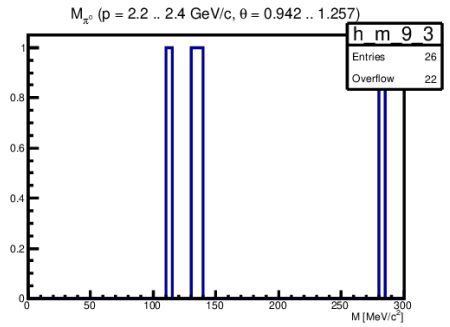


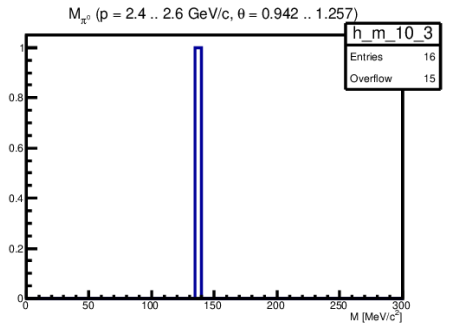


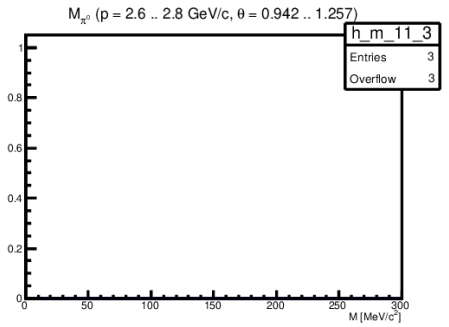












π^0 invariant mass: $1.257 < \theta < 1.571$