Reconstruction of neutral pions at CBM-RICH detector via conversion *

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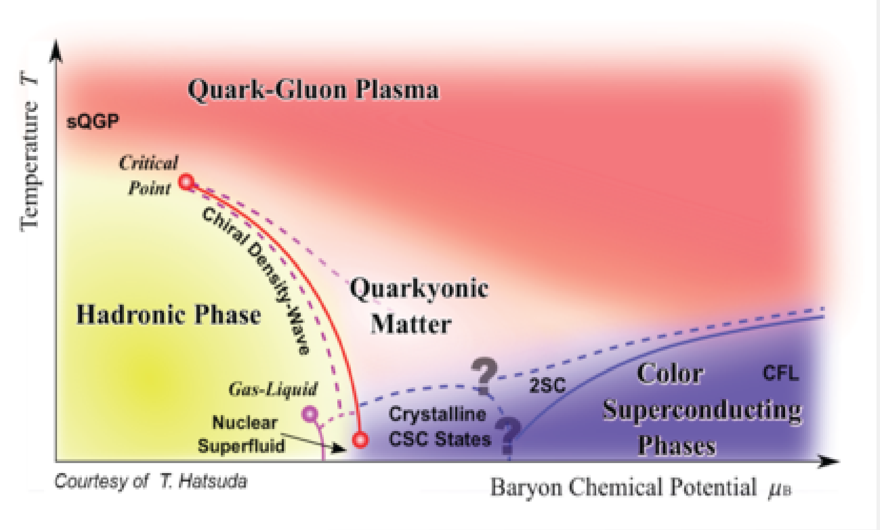
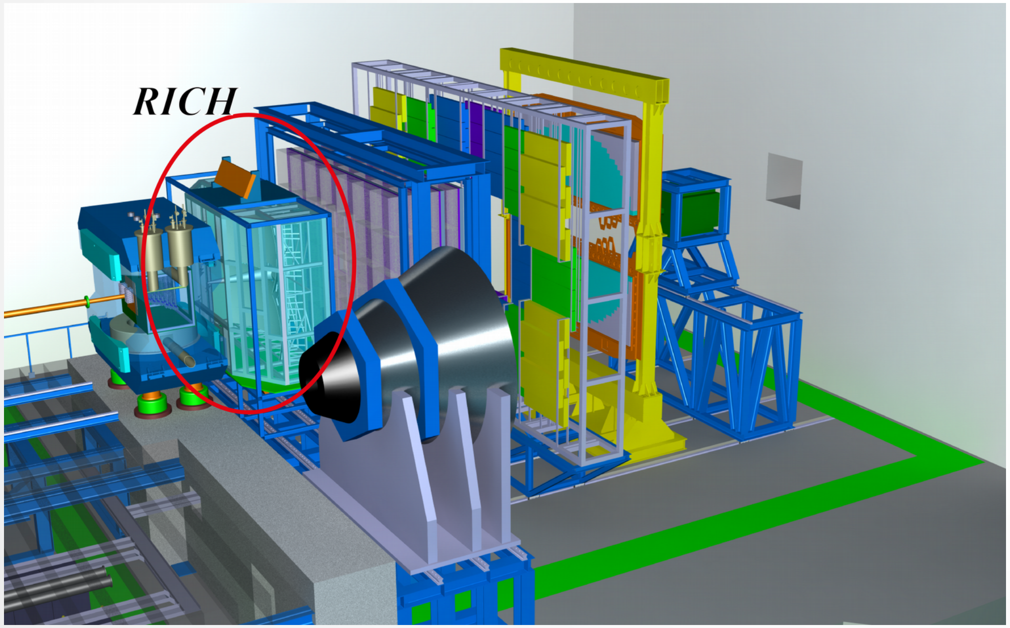
Compressed Baryonic Matter(CBM) experiment at FAIR

At top RHIC and LHC energies, QCD matter is studied at very high temperatures and very low net-baryon densities.

CBM will play a unique role in the exploration of the QCD phase diagram.





For larger net-baryon densities and lower temperatures, it is expected that the QCD phase diagram exhibits:

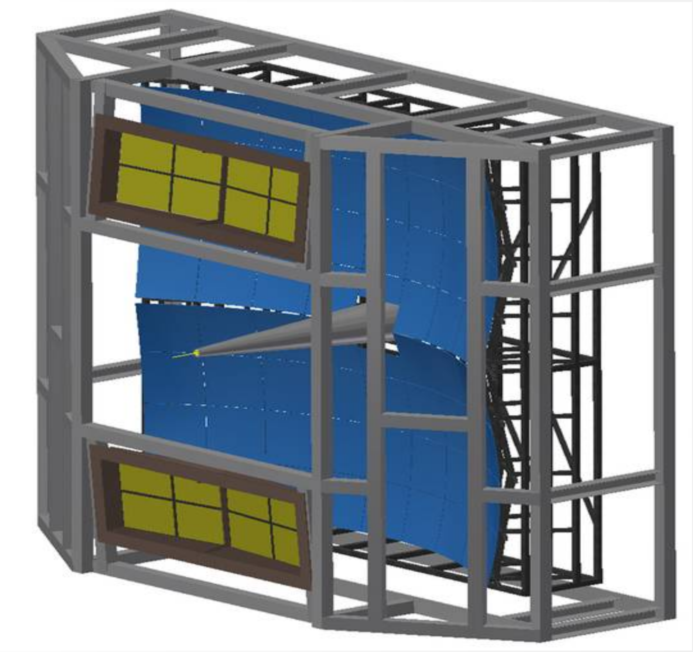
- a rich structure such as a critical point;
- the predicted first order phase transition between hadronic and partonic matter;
- new phases like quarkyonic matter.

CBM-RICH detector

The RICH detector is designed to provide identification of electrons and pions.

CBM-RICH foresees three main parts: CO_2 gaseous radiator, focusing mirror system and photon detector system.

- Detector will be positioned after magnet.
- The gas radiator is 1.7m long.
- The mirror plane is split horizontally into two spherical mirrors (4m x 1.5m), curvature 3m.
- Ring Cherenkov radiation will be projected onto photon detector planes.



Motivation

CBM is designed for precision measurements of many observables including particles with very low production cross sections, like:

$\rho \rightarrow e^+ + e^-$

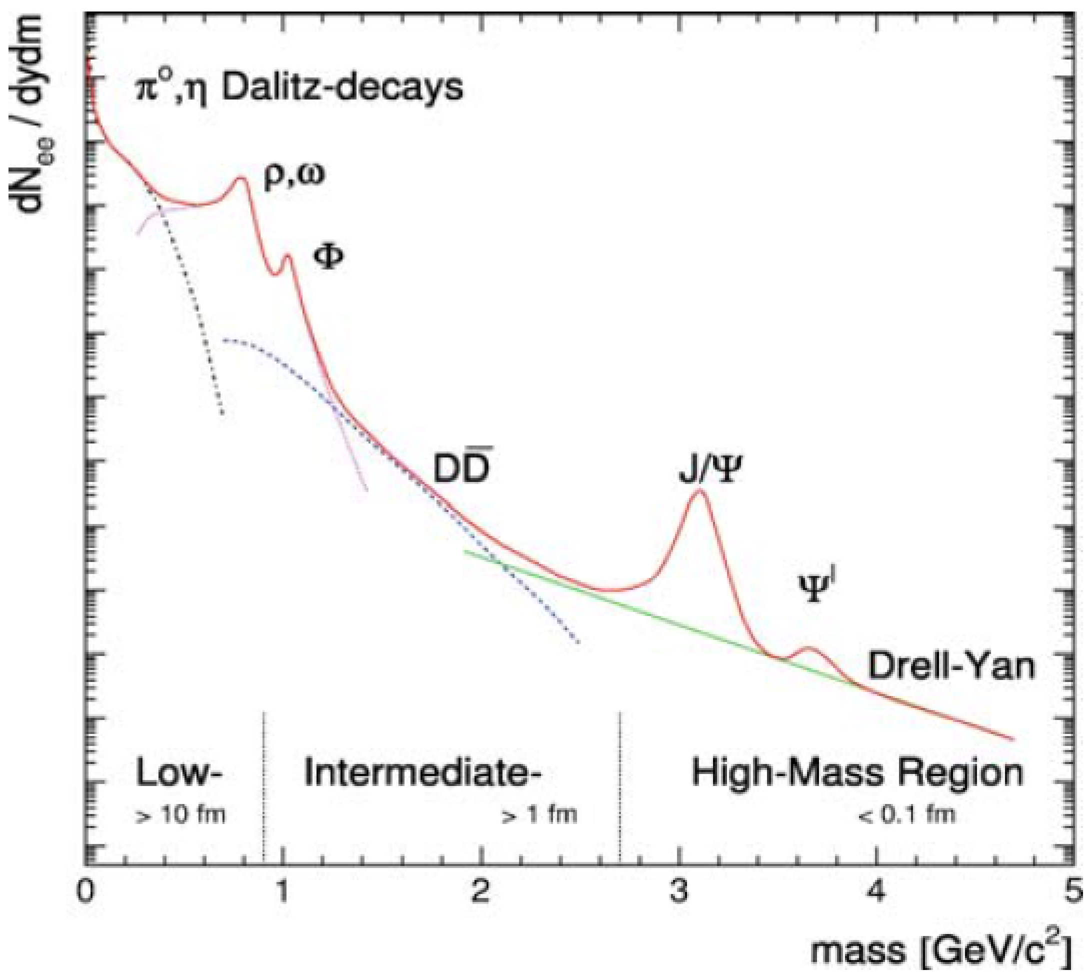
$\omega \rightarrow e^+ + e^-$

$J/\Psi \rightarrow e^+ + e^-$

As leptons are not affected by final-state interactions, the di-leptonic decay offers the possibility to look into the fireball.

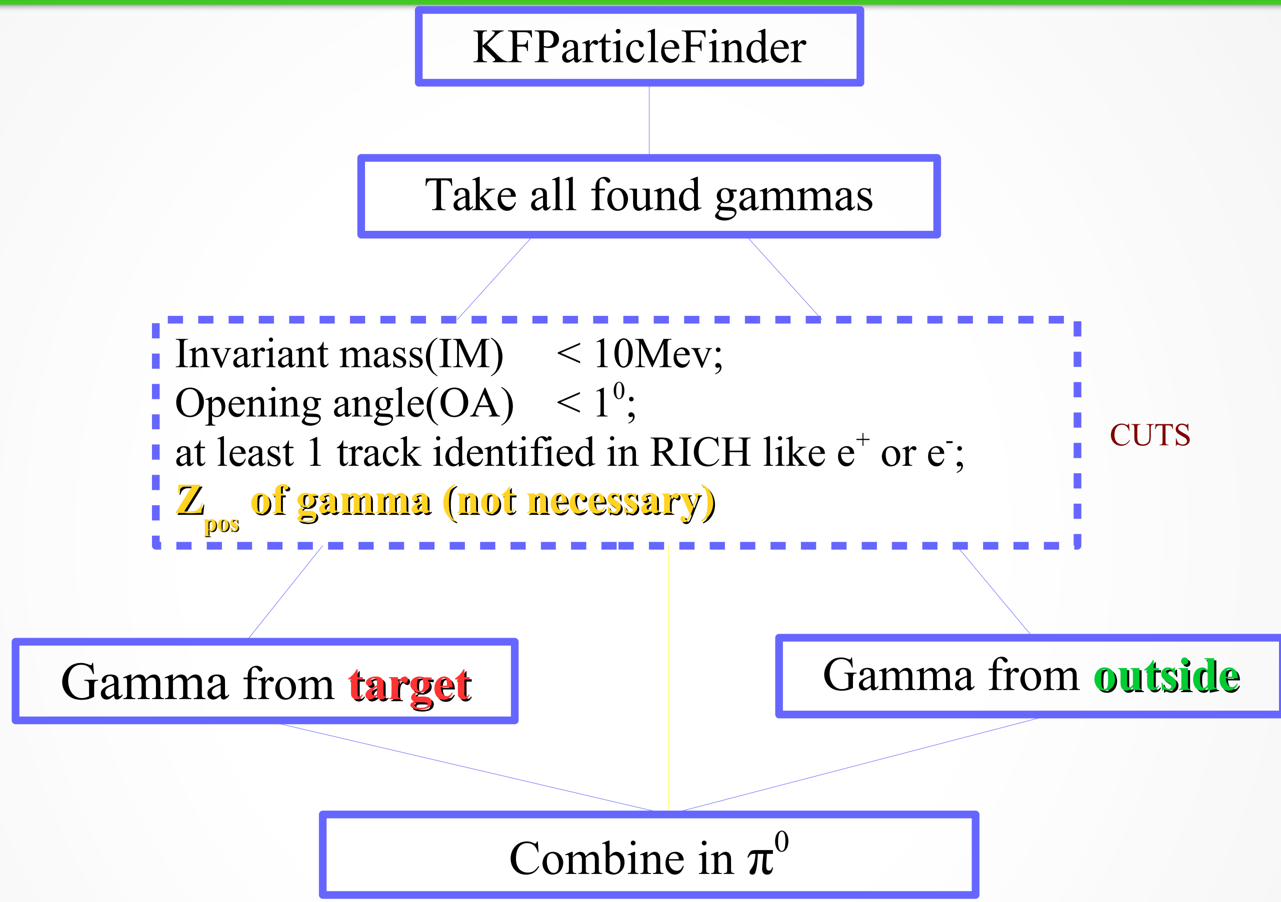
The main background contribution comes from π^0 decays:

$\pi^0 \rightarrow \gamma\gamma \rightarrow (e^+ + e^-) + (e^+ + e^-)$



How accurate one can reconstruct π^0 via double conversion and estimate its background contribution to the dilepton spectrum?

How to get invariant mass spectrum of π^0. First way:

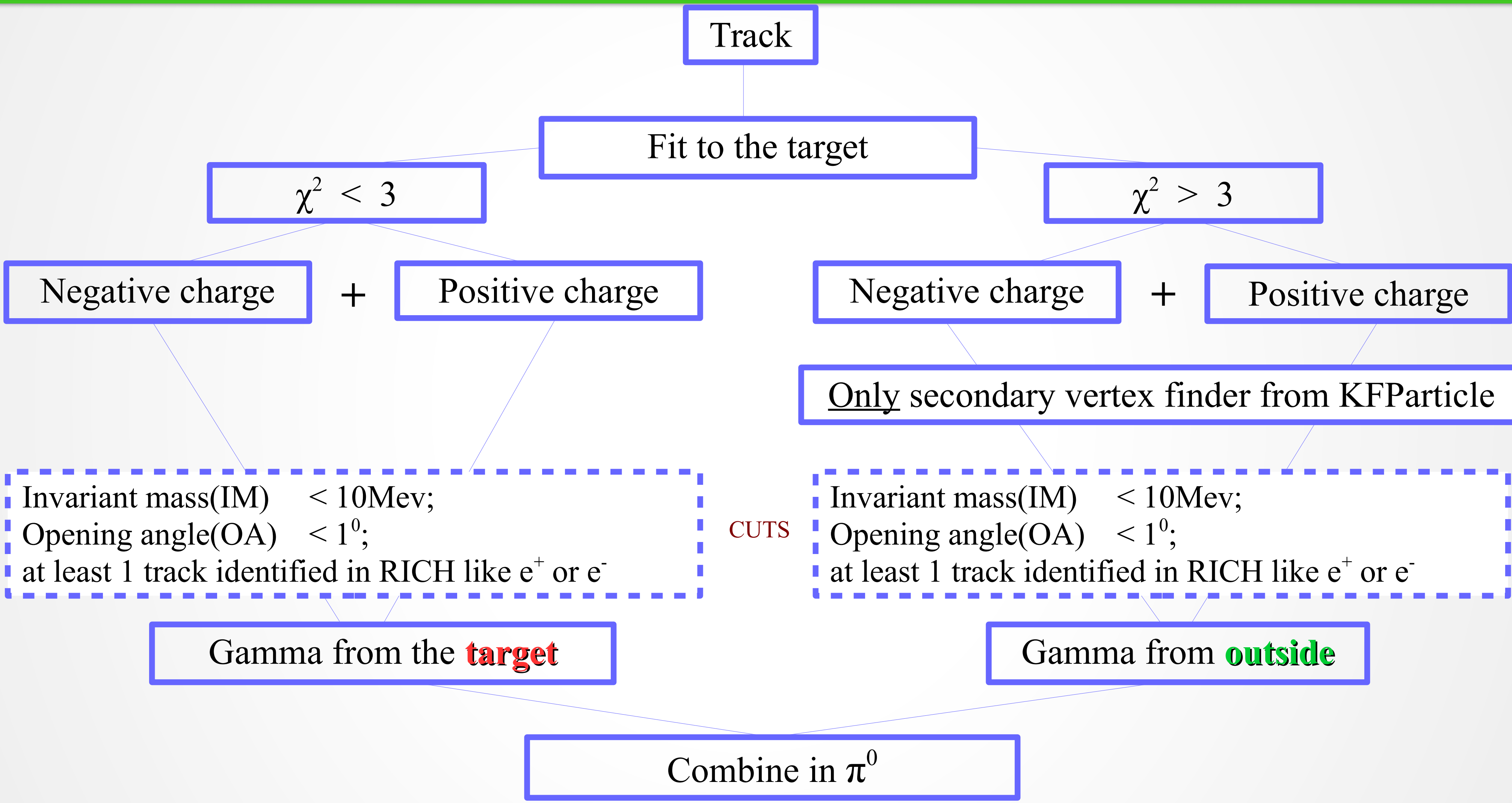


Gamma from **target** + Gamma from **target** = π^0

Gamma from **target** + Gamma from **outside** = π^0

Gamma from **outside** + Gamma from **outside** = π^0

How to get invariant mass spectrum of π^0. Second way:

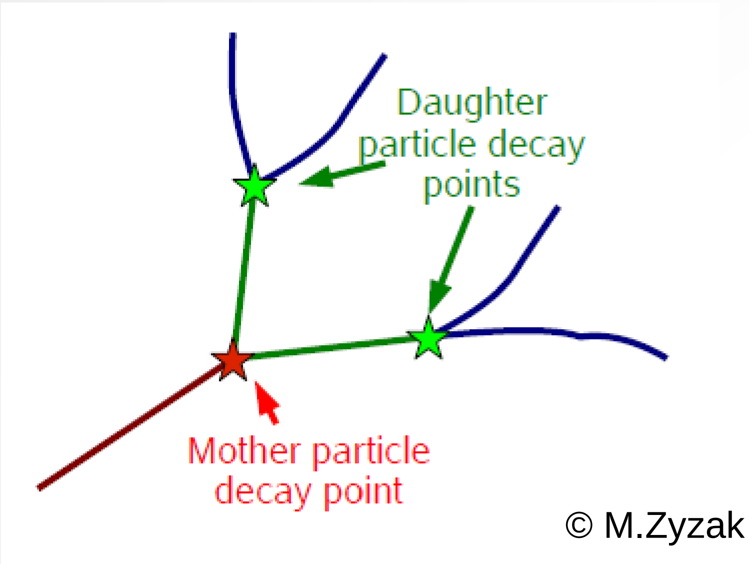


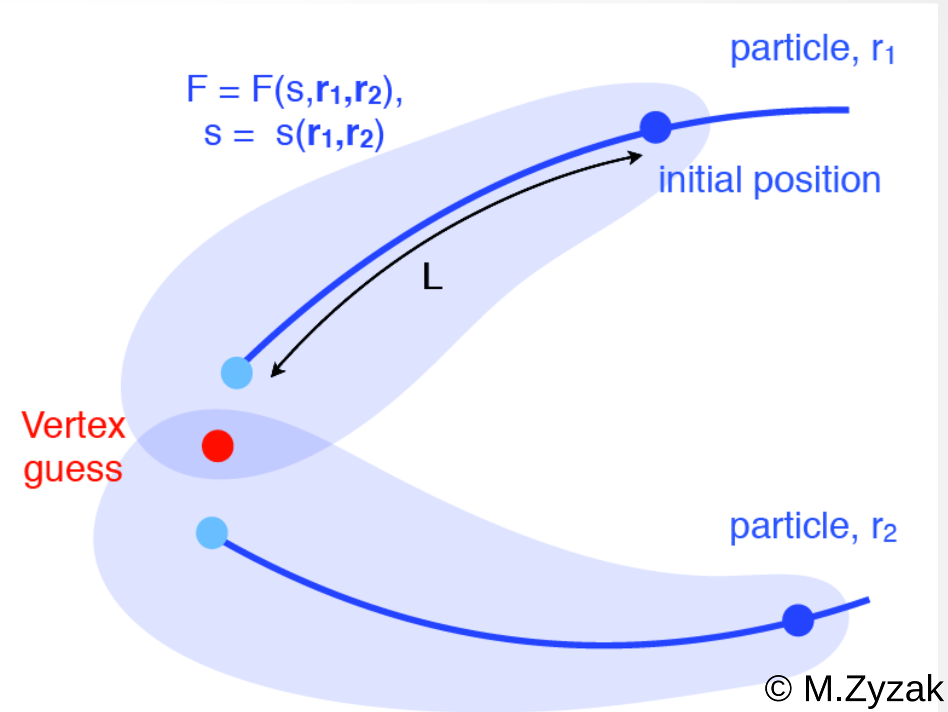
Gamma from the **target** + Gamma from the **target** = π^0

Gamma from the **target** + Gamma from **outside** = π^0

Gamma from **outside** + Gamma from **outside** = π^0

Use of secondary vertex finder from KFParticle to combine and fit tracks outside the target





$\pi^0 \rightarrow \gamma\gamma \rightarrow (e^+ + e^-) + (e^+ + e^-)$

Put two tracks into KFParticle and extract their common intersection point.

r_1 and r_2 may be any particles. It is based on pure geometrical searching. Only one necessary condition is required – particles should have different charges (one +, second –).

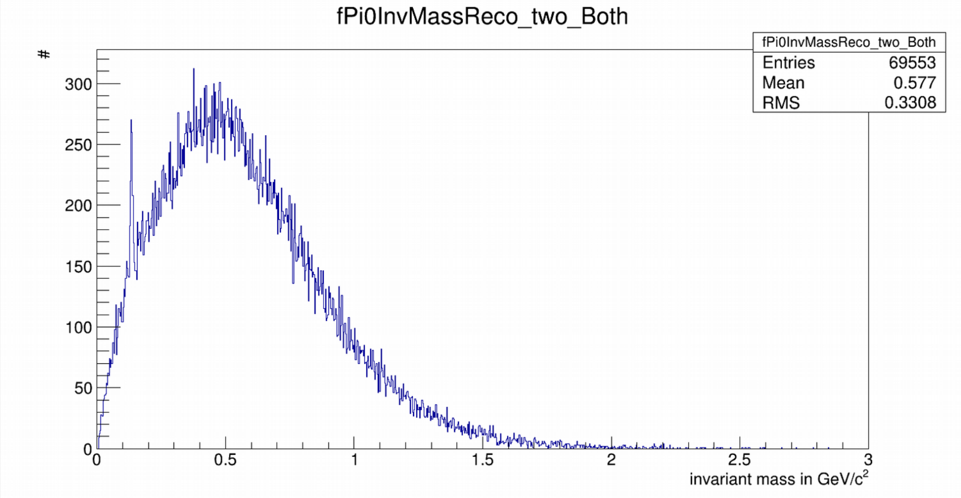
False gammas reconstructed from: $\rightarrow \pi^- + e^+$; $\rightarrow \pi^+ + e^-$; $\rightarrow p + e^-$

Both / >=1 track required in the RICH

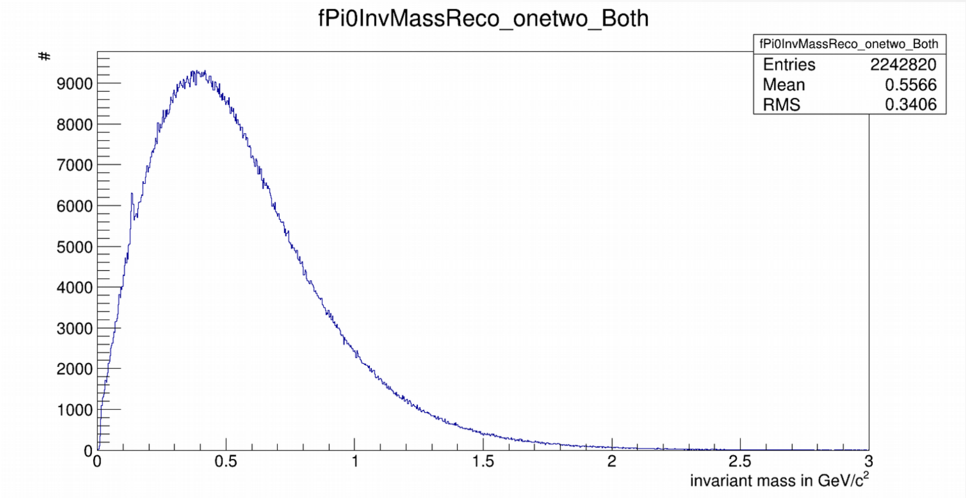
After gamma conversion it is very improbable, that both e^+e^- will hit the RICH. More probably it will be a case, that only one particle hit the RICH, and second will not.

(e+e-)(e+e-) invariant mass

Both leptons of each pair identified in the RICH



>=1 lepton of each pair identified

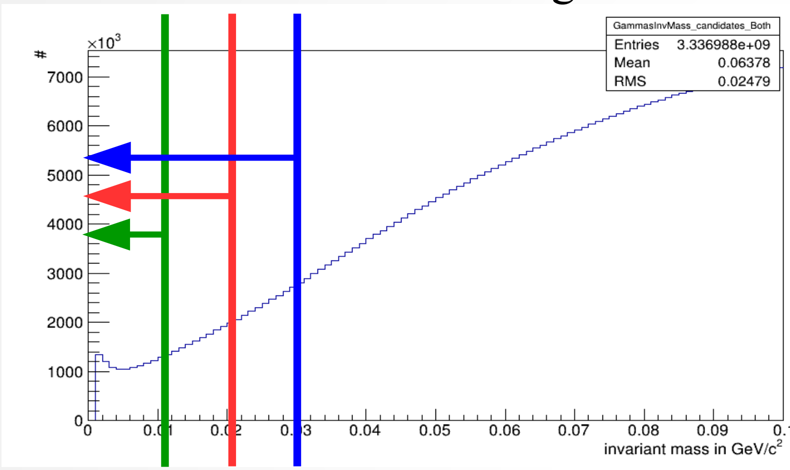


This approach helps to reconstruct ~10 times more π^0, than when one requires both e^+e^- from gamma conversion to be registered in the RICH.

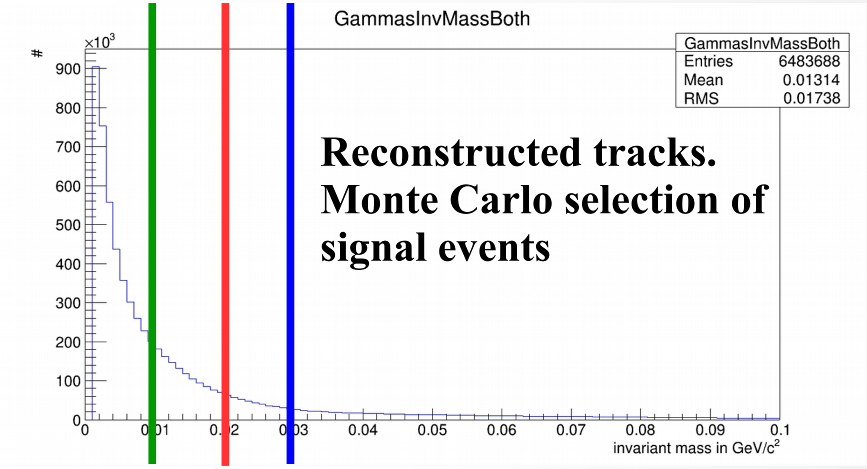
Of course it will also increase amount of background.

Comparison between gamma candidates and signal gamma

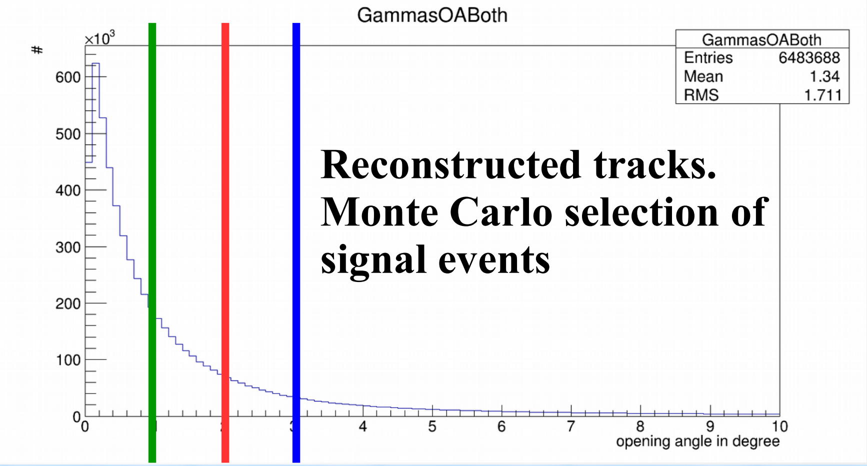
Invariant mass spectrum of all reconstructed candidates on gamma



Invariant mass spectrum of reconstructed signal gammas (from π^0)



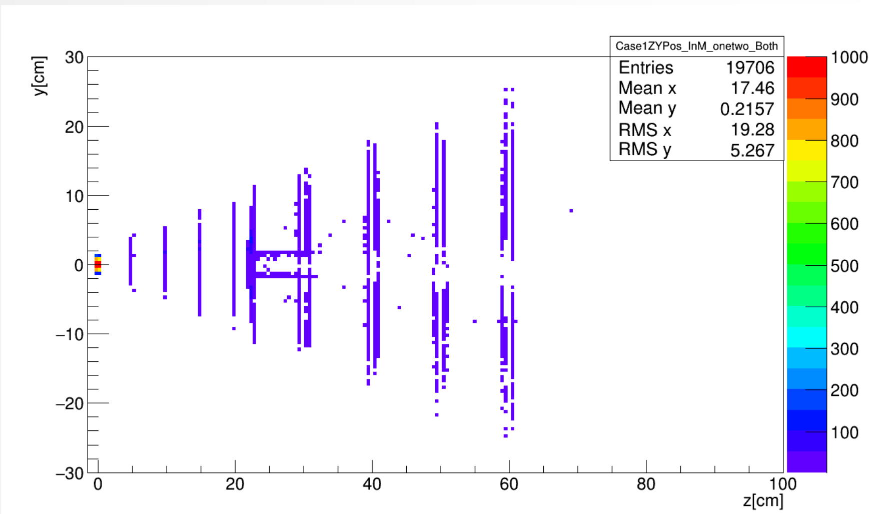
Opening angle spectrum of reconstructed signal gammas (from π^0)

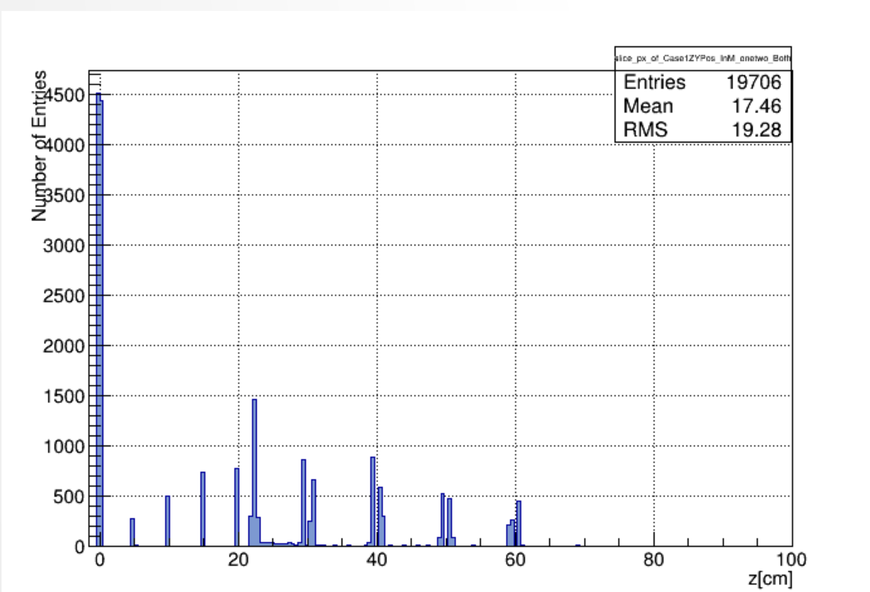


Cuts:

Opening angle:	Invariant mass:
$< 1^0$	< 10 MeV
$< 2^0$	< 20 MeV
$< 3^0$	< 30 MeV

Reconstructed points of conversion

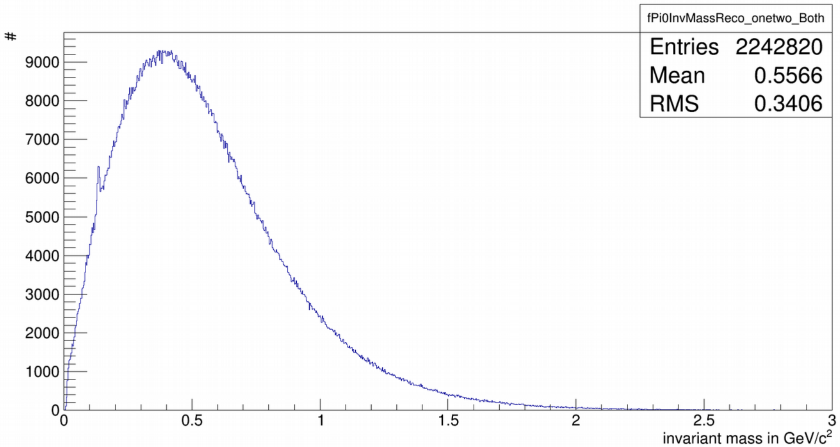


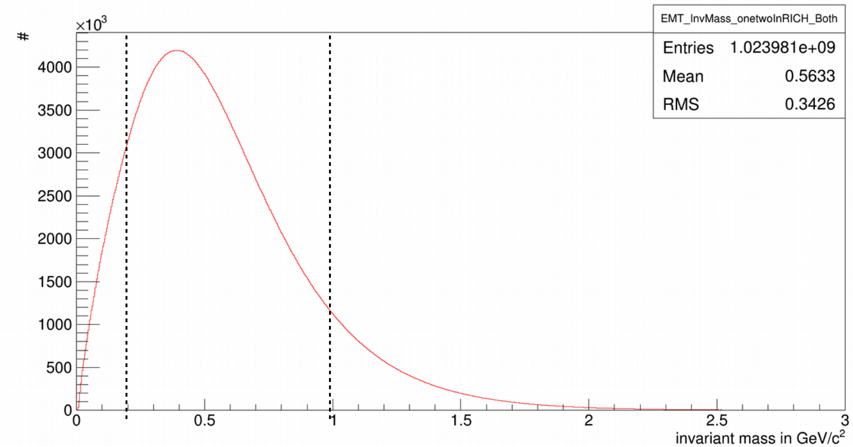


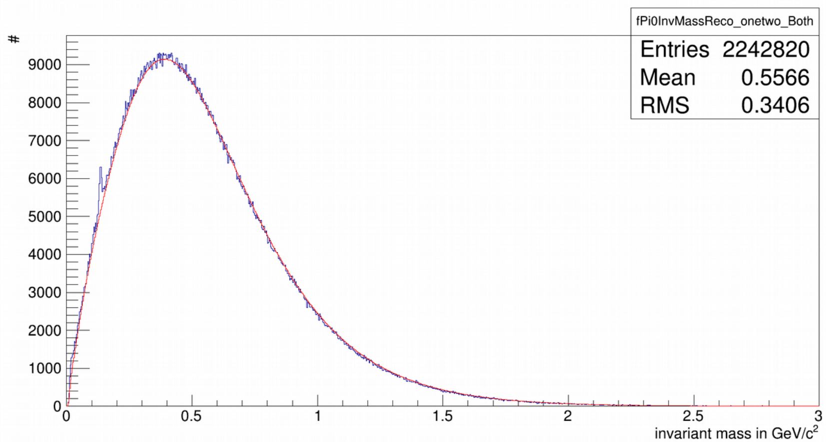
For $\pi^0 \rightarrow \gamma\gamma \rightarrow (e^+ + e^-) + (e^+ + e^-)$ the probability:

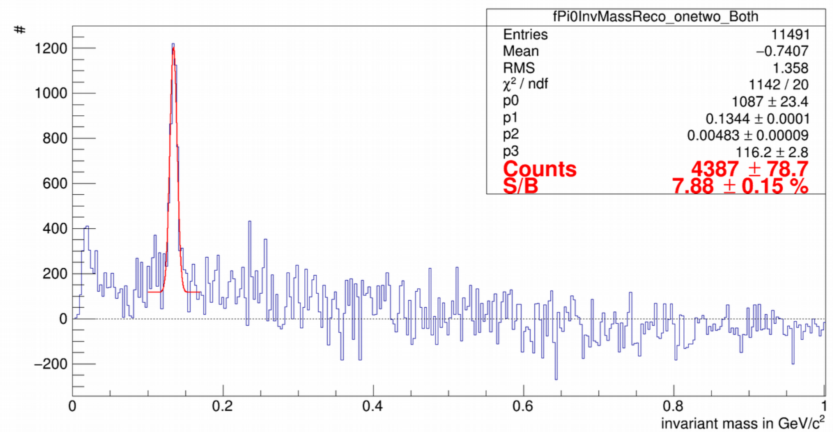
- 25%: both γ have conversion in the target,
- 25%: both γ have conversion in the detector material,
- 50%: 1 γ convert in the target and 1 γ convert outside.

Invariant mass spectrum and Event Mixing Technique







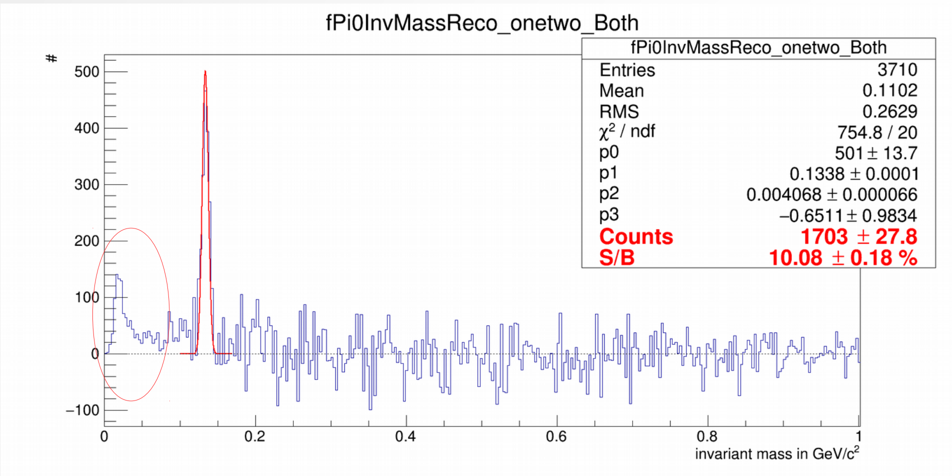


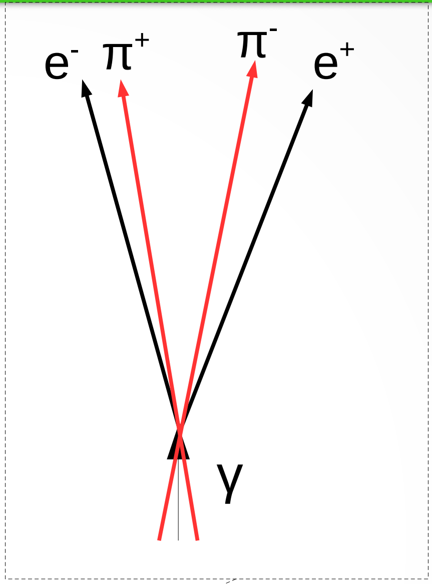
EMT spectrum:

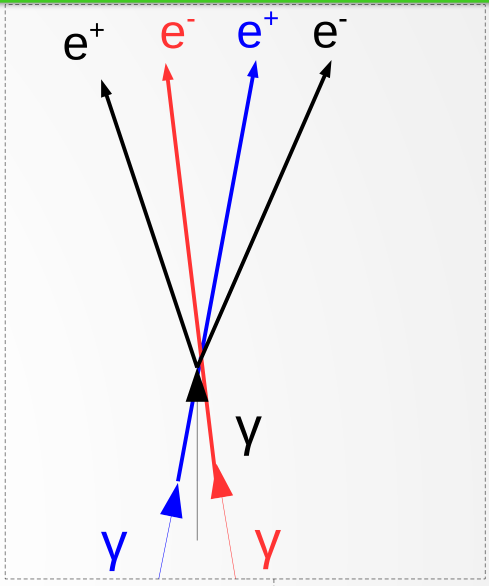
1) Save all gammas after cuts from the last 500 events.
2) Mix them together into π^0 with only one condition → gammas should be from different events.

Normalize spectrum from EMT (I choose the range 0.2-1.0 GeV/c) and then subtract it from invariant mass spectrum.

Peak at low mass

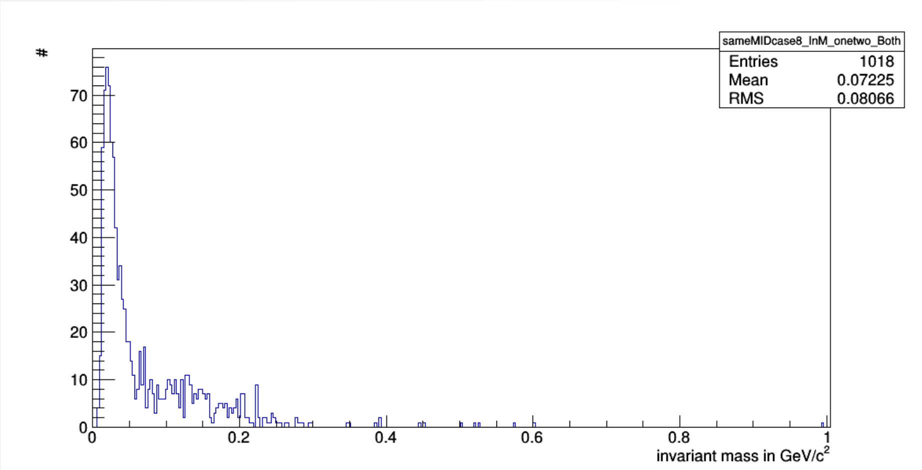


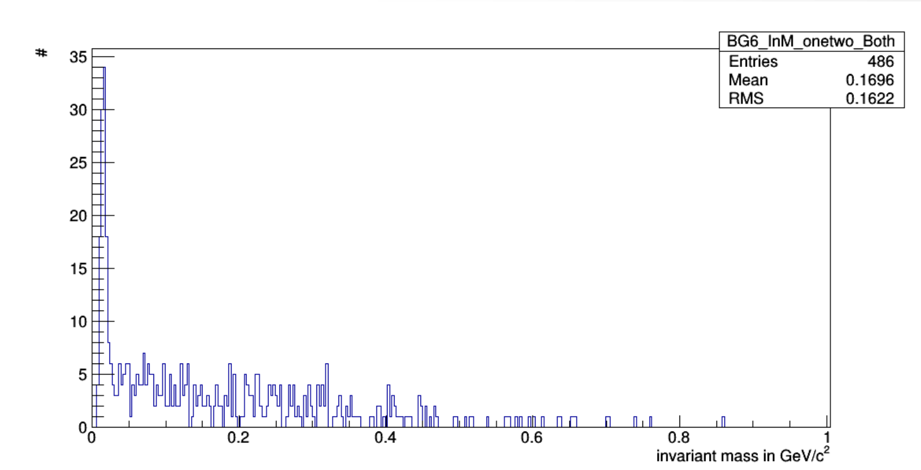




After separation of background for some different subgroups, it was found, that this peak comes from special case:

- γ are wrongly combined;
- Those $\pi^+ \pi^-$ come from the target.



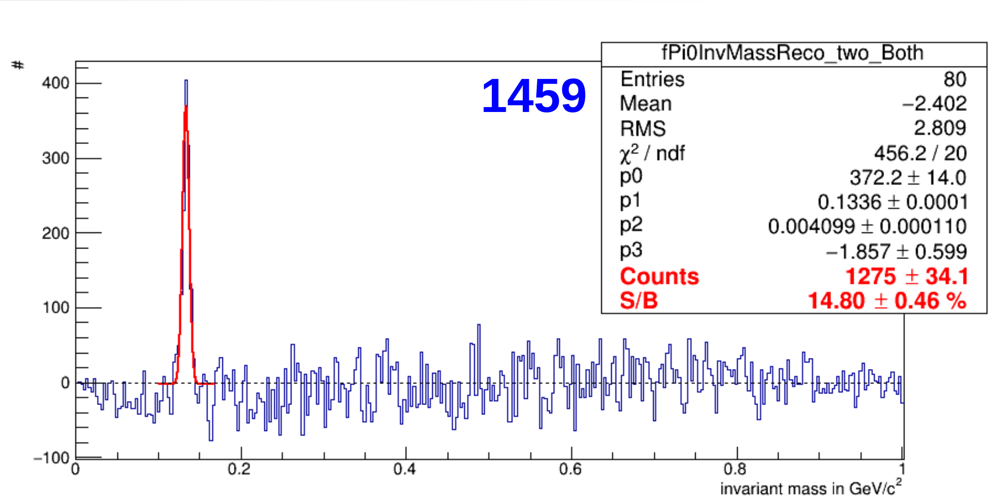


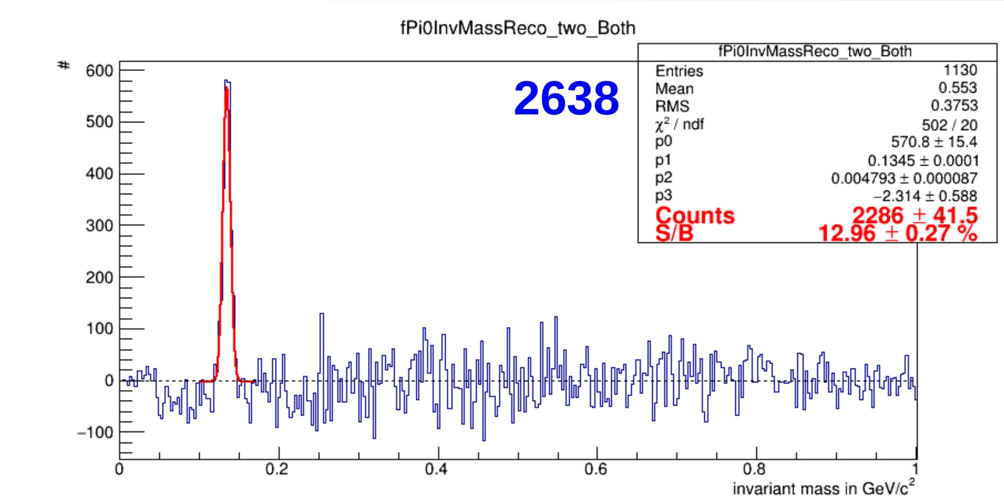
Optimized cuts:
5 Mio events; UrQMD 8 AGeV; Magnetic Field 70%;

OA < 1^0; IM < 10 MeV

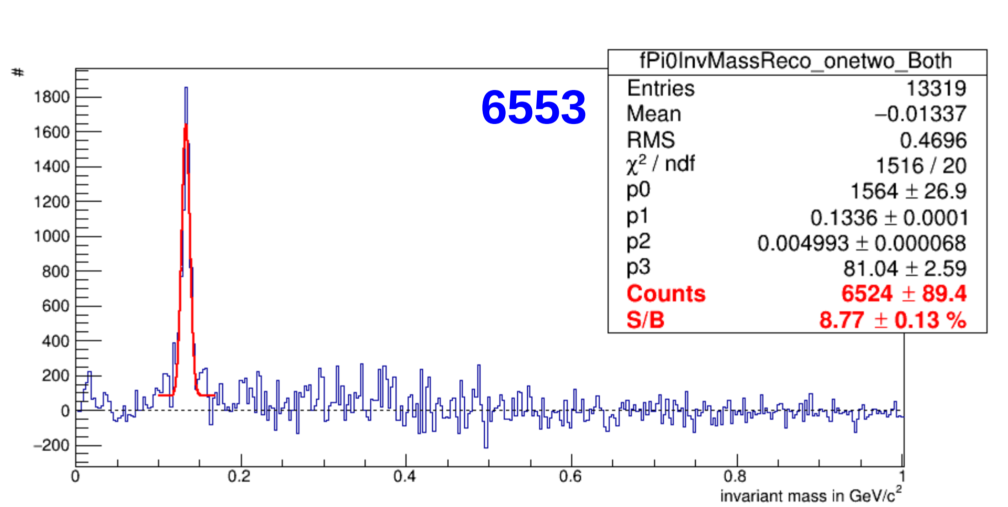
OA < 2^0; IM < 20 MeV

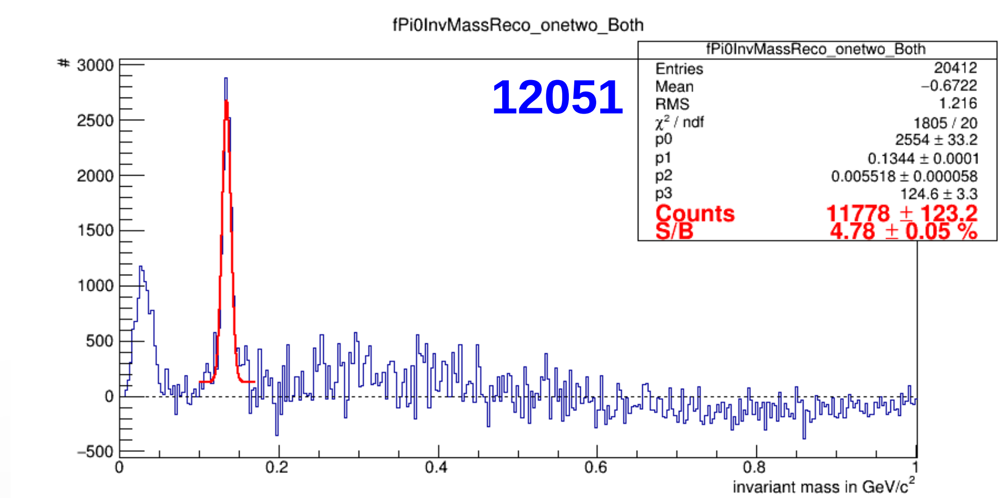
Two in RICH





At least one in RICH





Summary

- Reconstruction of π^0 include conversion of gamma inside and outside the target.
- Three different requirements for particle identification were studied: ==2 / >=1 / >=0 leptons for gamma identification.
- For optimized cuts the UrQMD simulation with 5Mio events central Au+Au collision was done and number of reconstructed π^0 together with their signal to background ratio were calculated.