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

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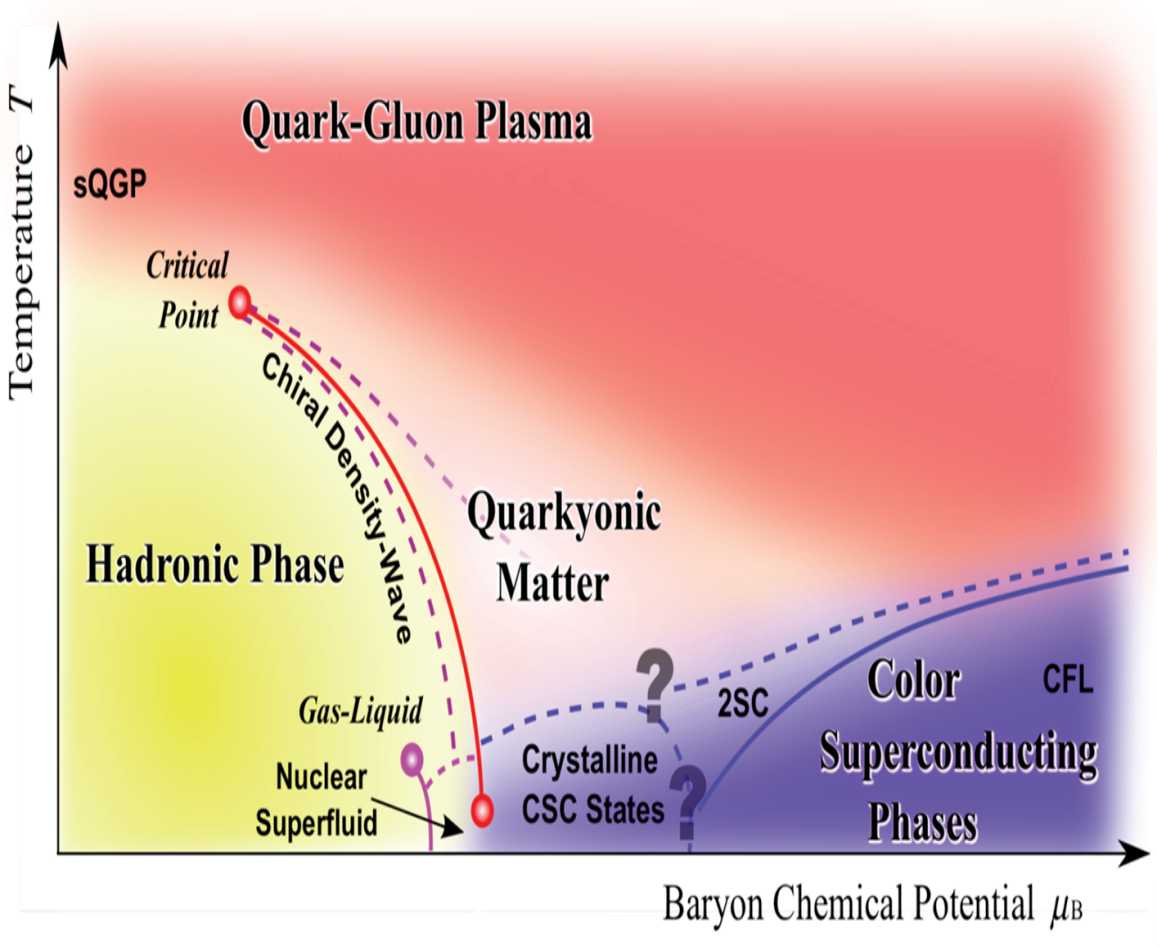
Compressed Baryonic Matter(CBM) experiment at FAIR



CBM conditions:

- High net-baryon densities
- Moderate temperatures

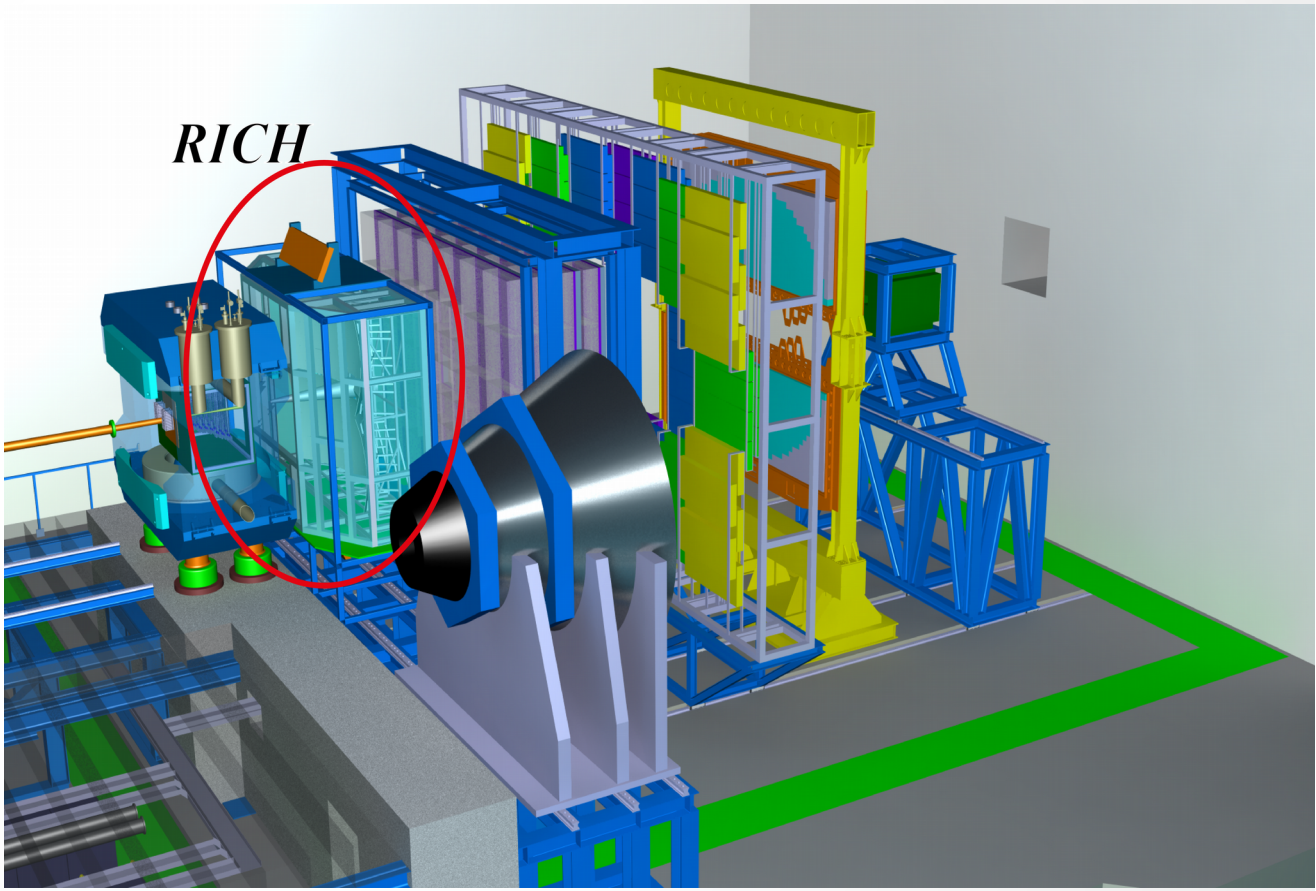
Possible features of the QCD phase diagram:

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

Experimental setup

Detectors:

- Micro Vertex Detector (MVD)
- Silicon Tracking System (STS)
- Ring-Imaging Cherenkov (RICH) detector
- Muon Chamber
- Transition Radiation Detector (TRD)
- Time-of-Flight detector (TOF)
- Projectile Spectator Detector (PSD)



Motivation

CBM is designed for precise measurements of many observables including particles with very small branching ratio and low production cross section, like:

$\rho \rightarrow e^+ + e^-$ $(4.72*10^{-5}\ \%)$

$\omega \rightarrow e^+ + e^-$ $(7.28*10^{-5}\ \%)$

$J/\Psi \rightarrow e^+ + e^-$ $(5.94\ \%)$

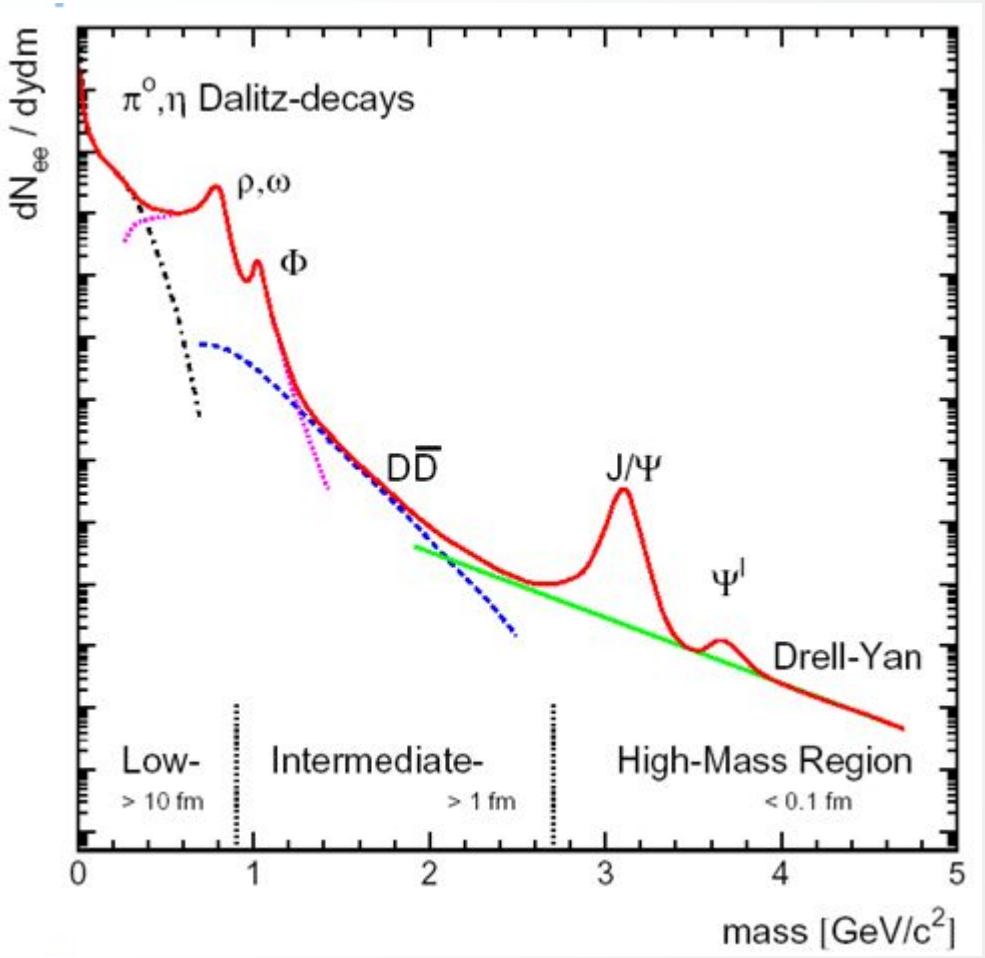
$\varphi \rightarrow e^+ + e^-$ $(2.95*10^{-4}\ \%)$

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:

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

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



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

Working conditions

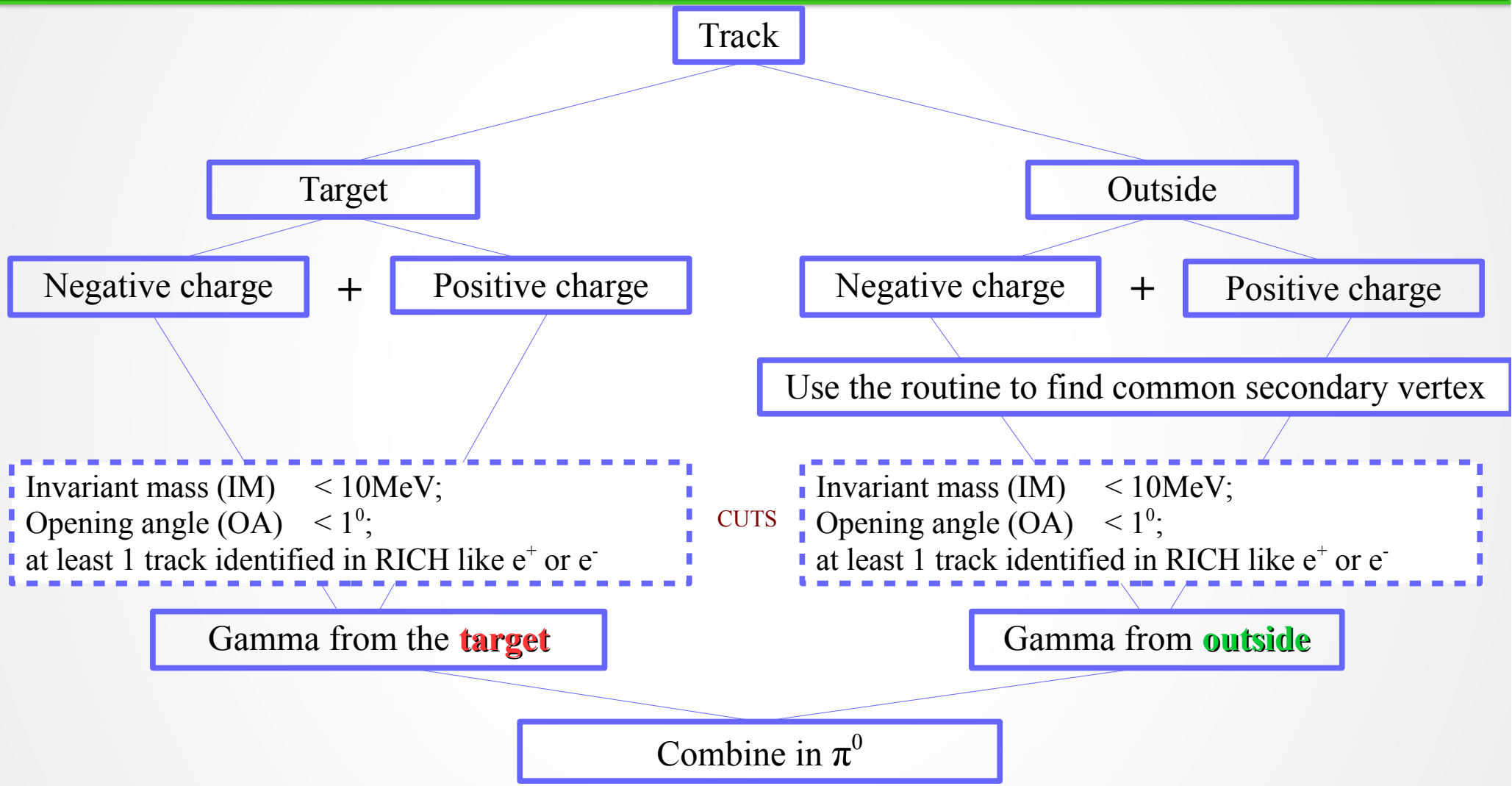
Simulation information

- The results shown here are based on $5*10^6$ simulated central Au+Au events at beam energy of 8 AGeV;
- As a generator in the simulation the Ultrarelativistic Quantum Molecular Dynamics model (UrQMD version 3.4) was used.

Analysis requirements

- The conversion should happen before the RICH detector;
- Lepton track should have at least 3 hits in Tracking System to reconstruct the particle momentum;
- At least one lepton from the converted photon should be identified within the RICH;
- Number of hits to reconstruct the Cherenkov ring should be > 5 hits;
- Invariant mass of reconstructed photons should be < 10 MeV;
- Opening angle of reconstructed photons should be $< 1^0$.

How to get invariant mass spectrum of π^0

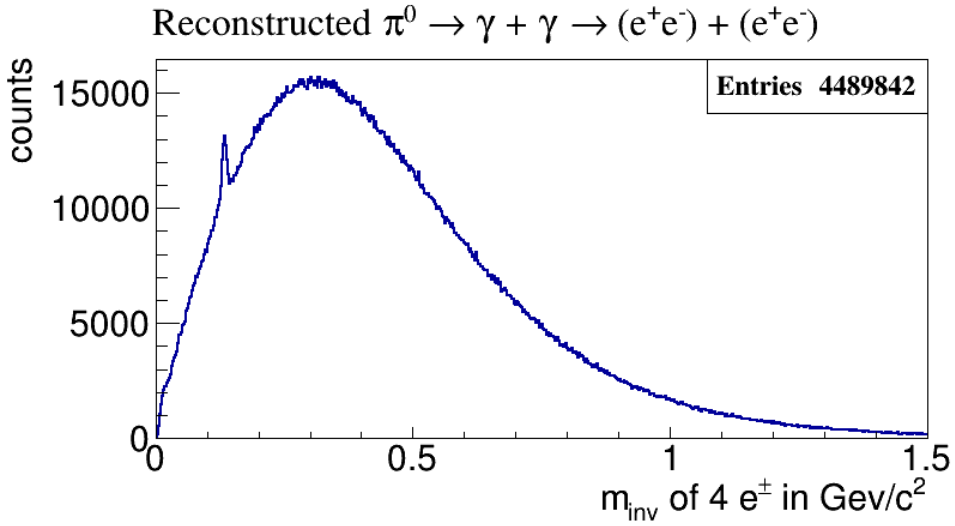


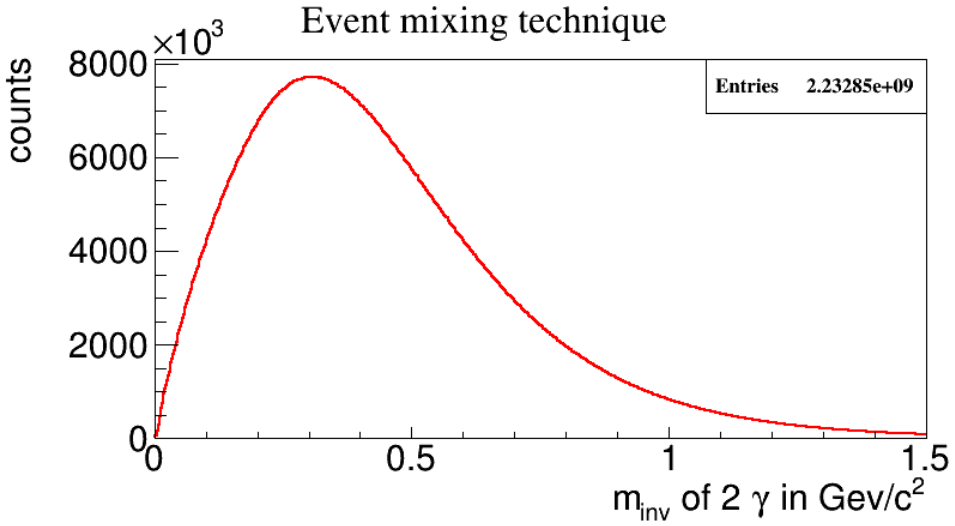
Gamma from the **target** + Gamma from the **target** = π^0

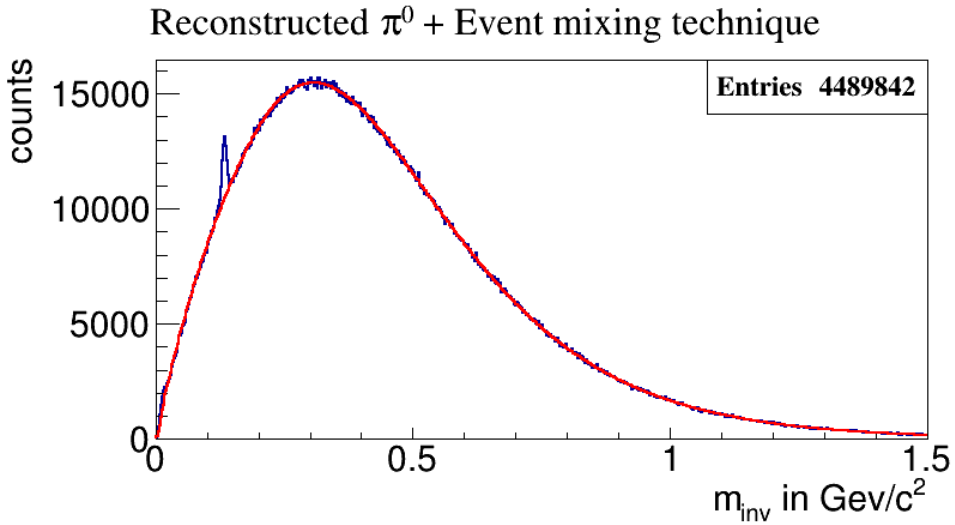
Gamma from the **target** + Gamma from **outside** = π^0

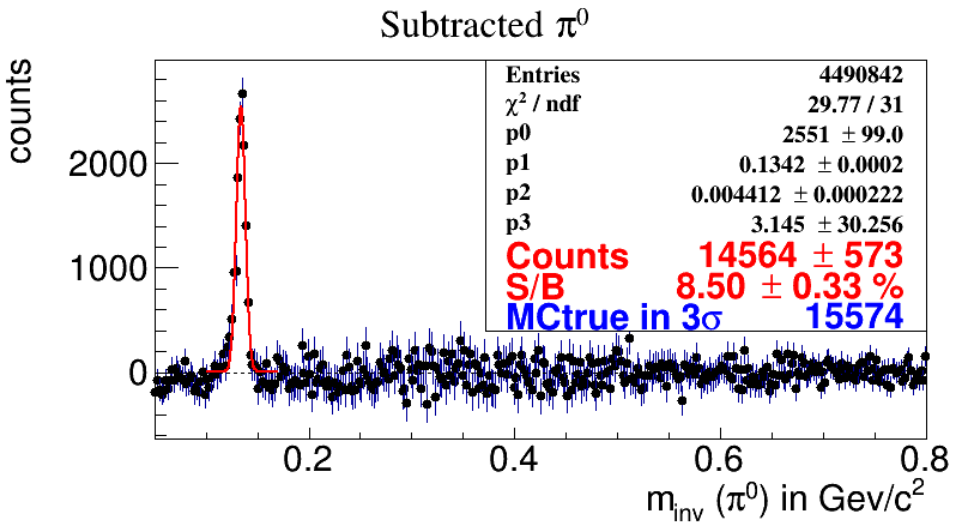
Gamma from **outside** + Gamma from **outside** = π^0

Reconstruction of π^0



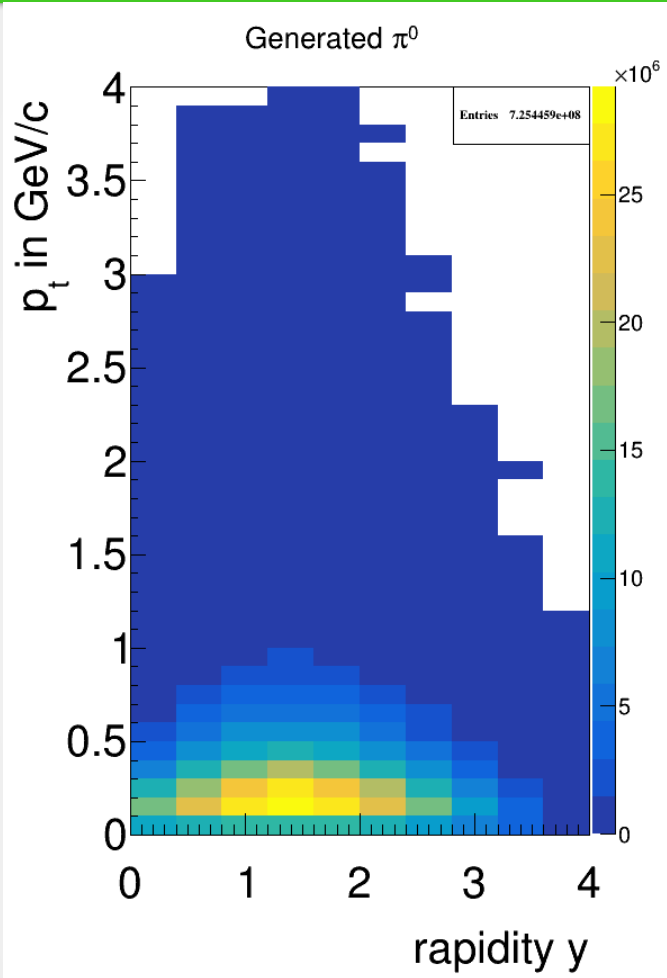


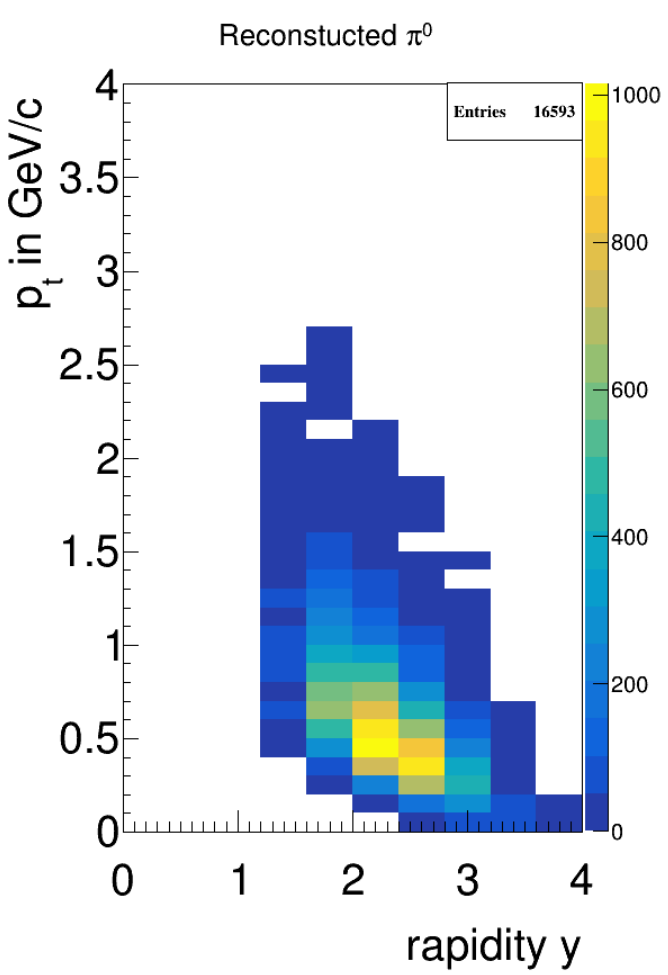


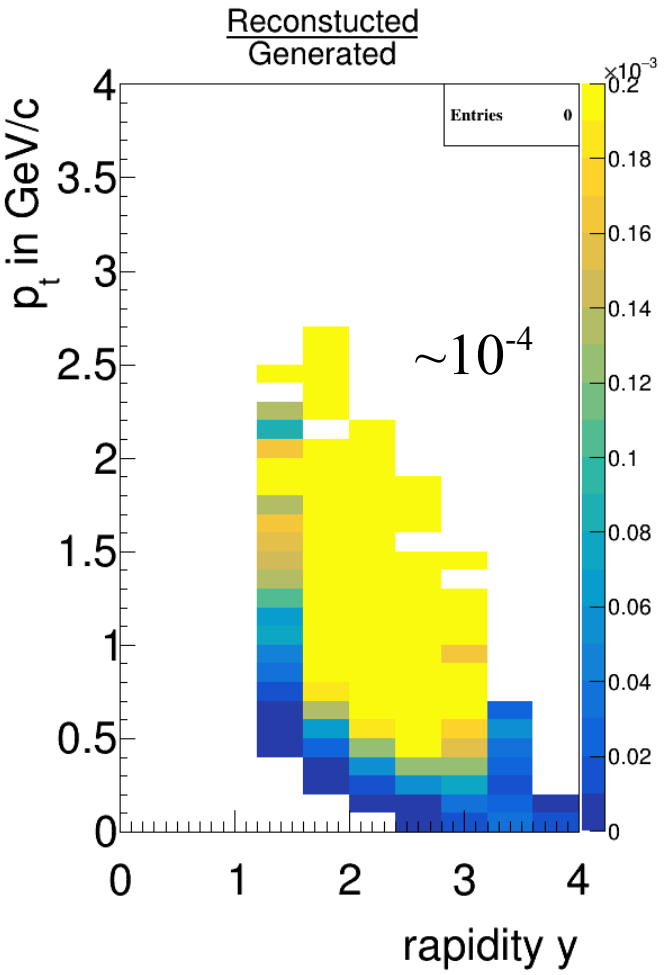


Combine e^+e^- to form photons (with cuts: invariant mass < 10 MeV and opening angle < 1^0);
Combine photons to form π^0.

Acceptance



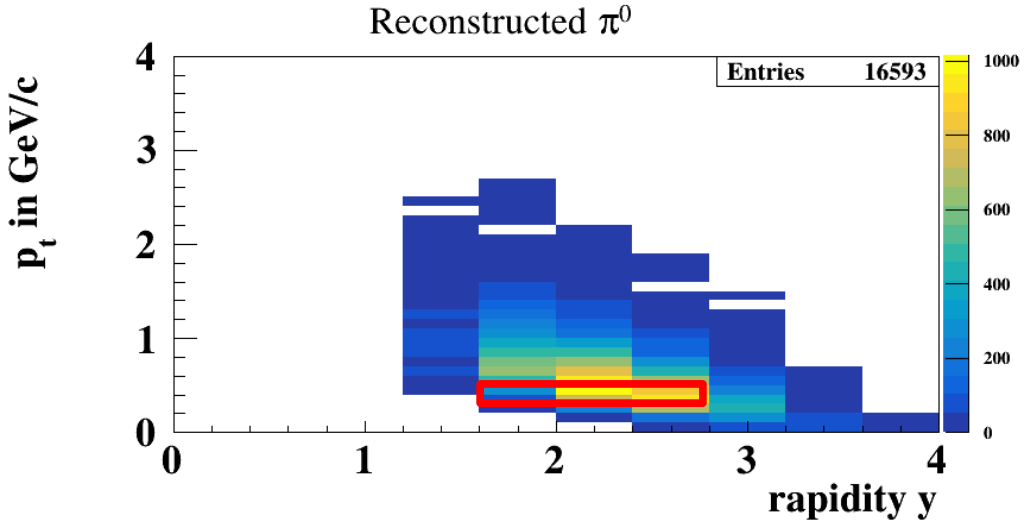


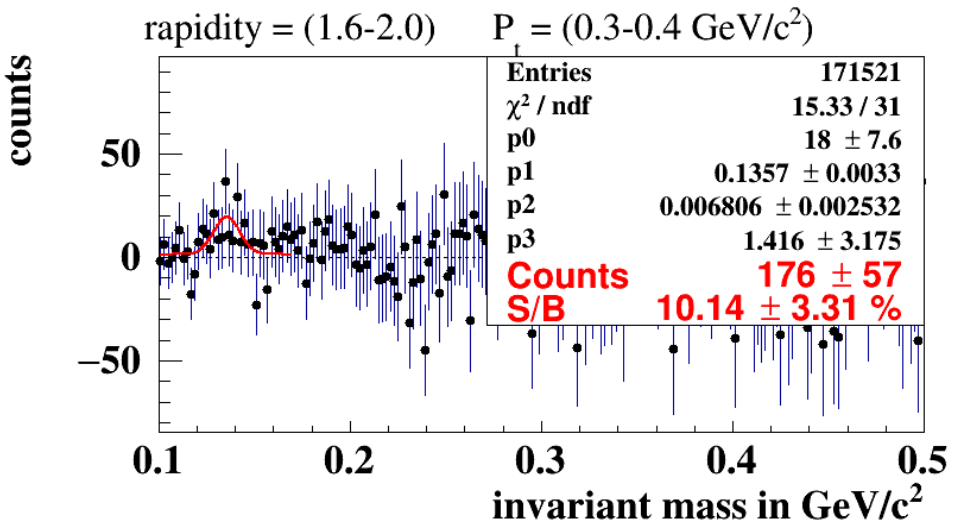


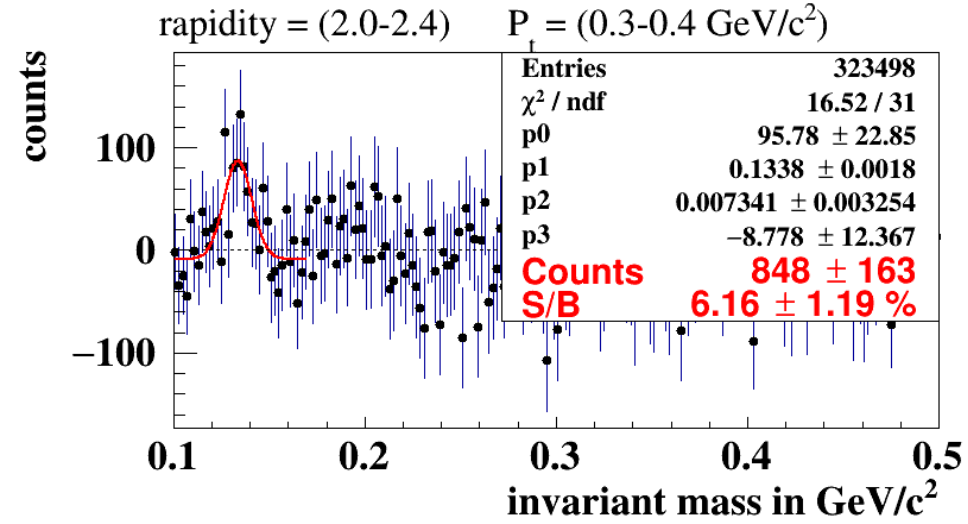
p_t in the range 0.0 – 2.7 ==> 27 bins with a step 0.1 GeV/c.

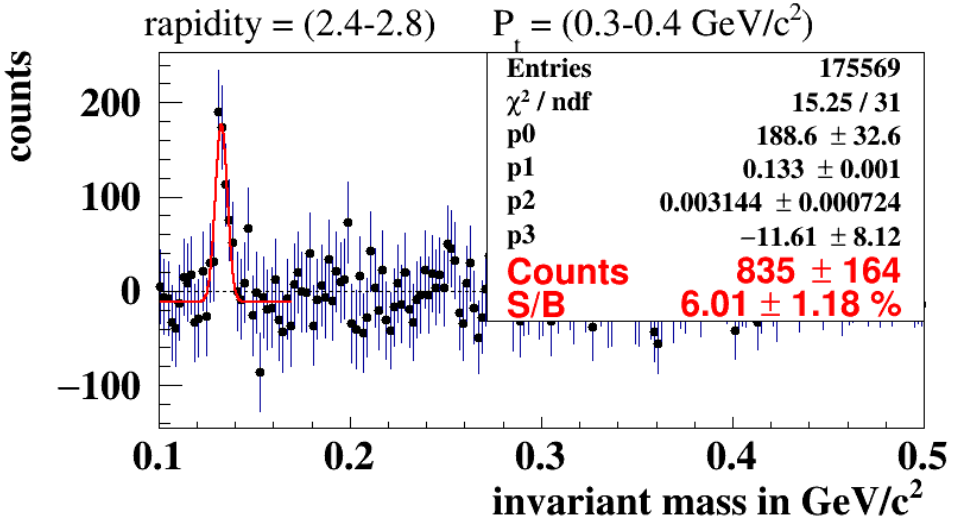
Rapidity range 1.2 – 4.0 ==> 7 bins with a step 0.4.

Reconstructed spectra for some rapidity-p_t bins



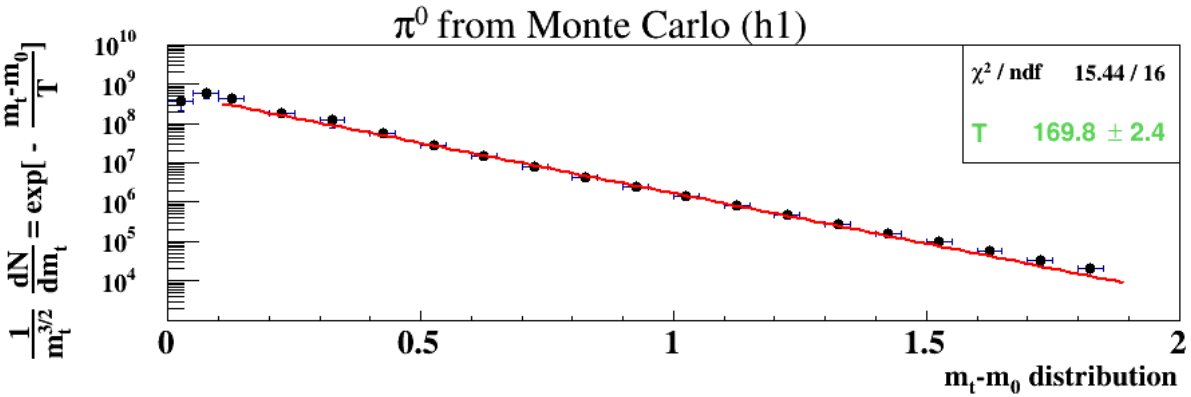


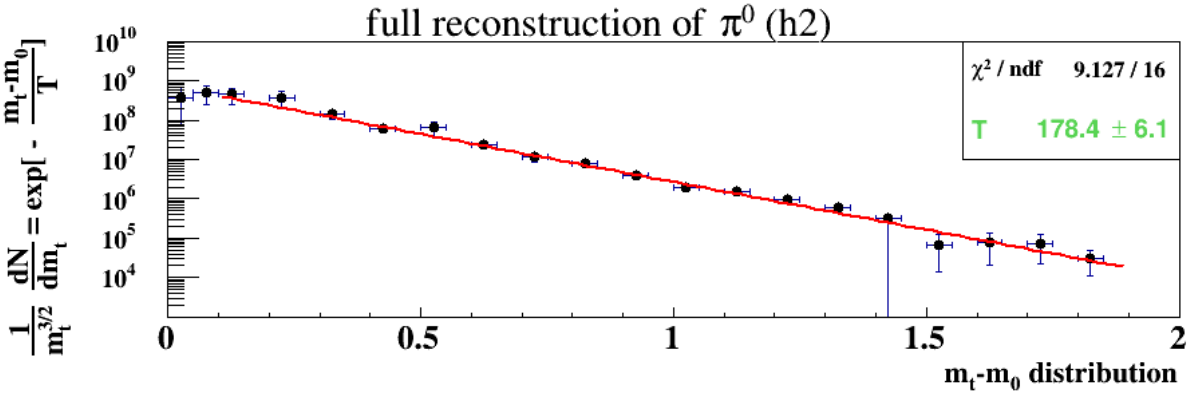


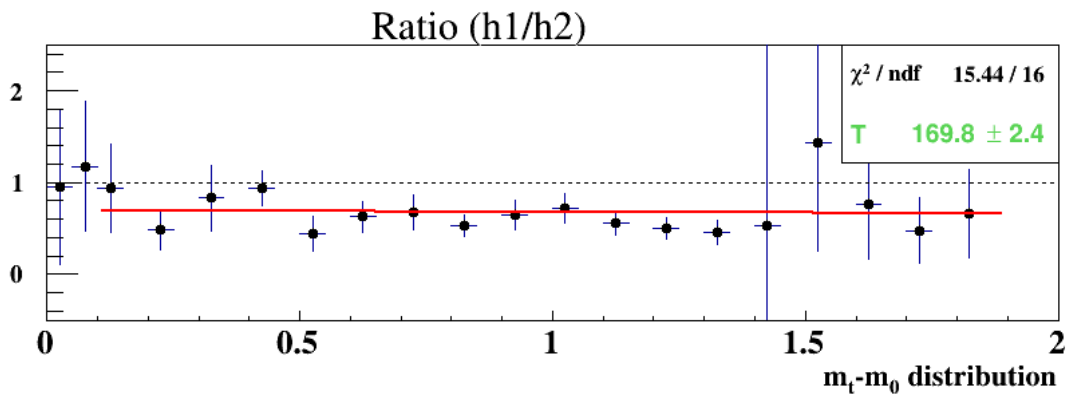


Several examples of background free spectra for phase space region, marked with a red rectangle on the top-left figure.

Input - Output - Ratio







1-dimensional p_t spectrum can be fitted with a formula :

$$\frac{1}{m_t^{3/2}} \frac{d\sigma}{dm_t} = C \exp\left[-\frac{(m_t - m_0)}{T}\right]$$

where

- m_0 is a particle mass;
- $m_t = \sqrt{p_t^2 - m_0^2}$ is transverse mass;
- T is the inverse slope parameter, commonly called ”temperature” of emitting source.
- $m_0(\pi^0) = 134.97$ MeV/c^2

Summary

- Double photon conversion analysis of π^0 allows to
  - estimate its background contribution to the dilepton spectrum.
  - extract inverse slope parameter T for neutral pions.

- Single photon conversion analysis could be applied to
  - reconstruct direct photons (analysis procedure is in progress).

Thank you for your attention !

Backup

CBM-RICH

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

CBM-RICH foresees three main parts: CO2 gaseous radiator, focussing 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), curvuture 3m.
- Ring Cherenkov radiation will be projected onto two photon detector planes (1m x 0.6m)