Update on high pt neutral meson production in heavy ion collision

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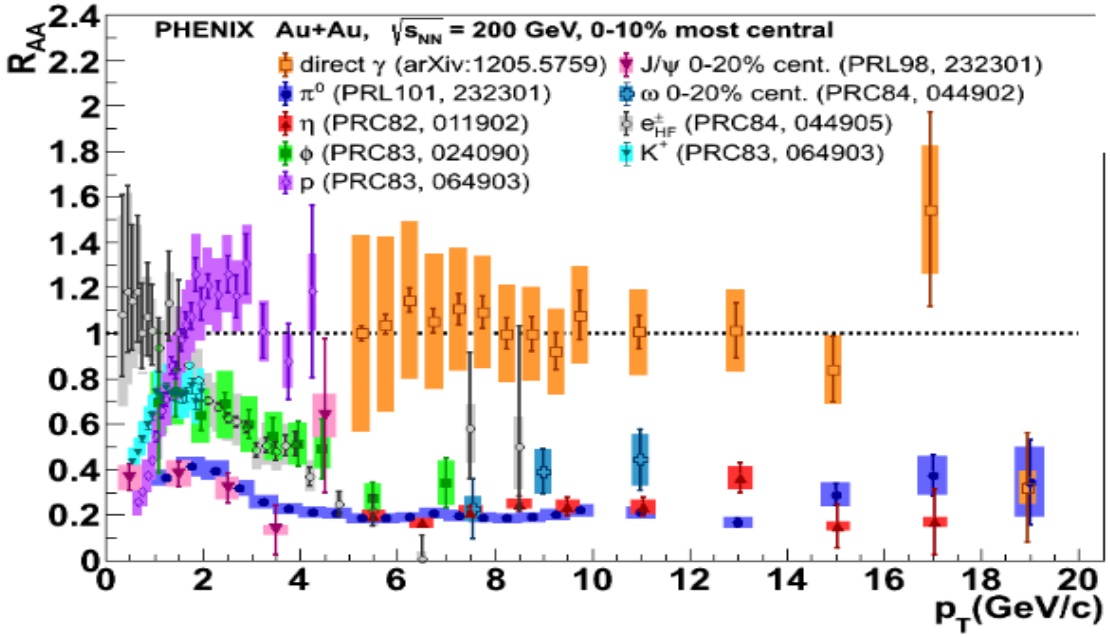
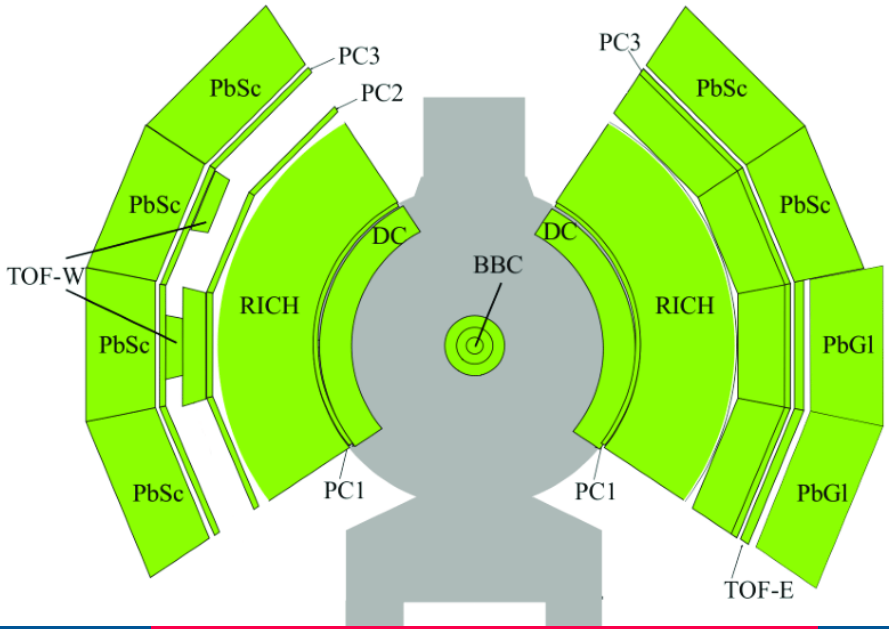
Motivation

- The main particles: π^0, η, $\omega \rightarrow$ have decay channels to γ
- $\pi^0 \rightarrow 2\gamma$ $BR = 98.8\%$ $\parallel$ $\eta \rightarrow 2\gamma$ $BR = 39.5\%$ $\parallel$ $\omega \rightarrow \pi^0 + \gamma$ $BR = 8.34\%$
- The Run16 collected a large amount of data, vastly exceeding the statistics of all similar data taken earlier
- This makes it possible to extend the transverse momentum range + improve the systematic uncertainties



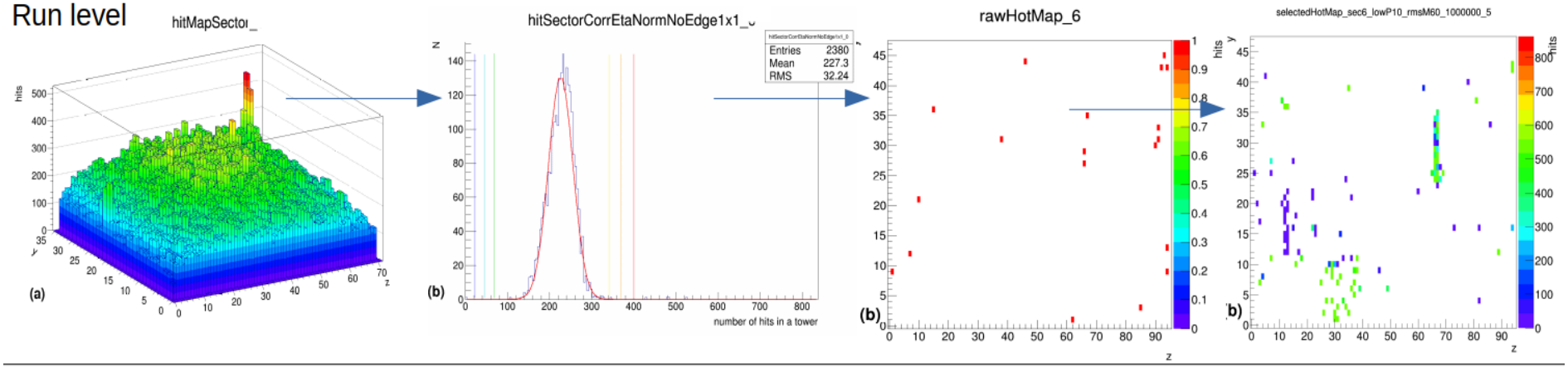
PHENIX Detector

- The η particles also decays into 2γ, like π^0, but the ω decays into 3γ, via a π^0
- The analysis of these particles is same in the sense, that we are searching γ-s
- But the mass differences and the $\omega \to \pi^0 + \gamma$ channel complicates the analysis
- There will be differences in the minimum opening angle too, that means for the 3 cases we need 3 different sector condition

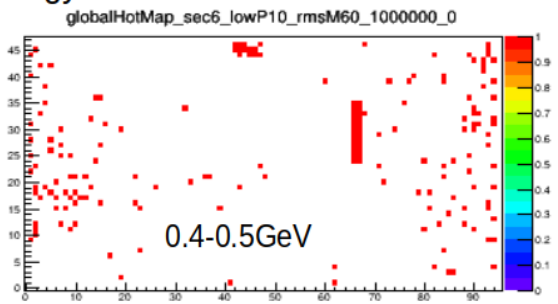


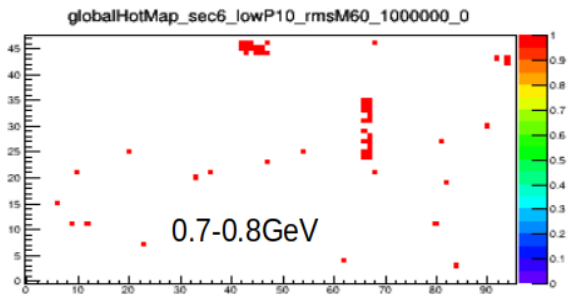
Dead Hot Map Explonation - in short

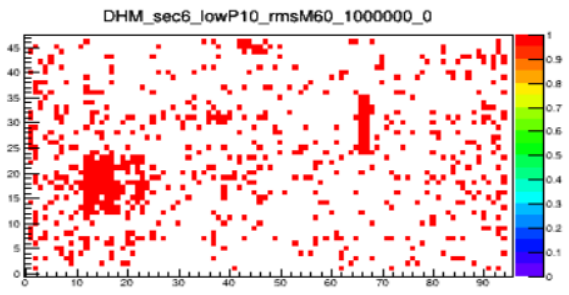
Run level



Energy level



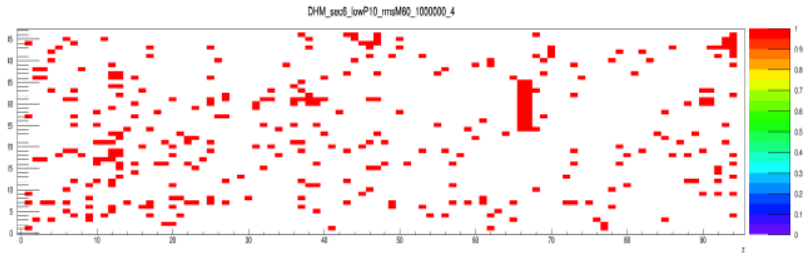




0-30GeV

0.1-2GeV: 20 bin
2-10GeV: 8 bin
10-30GeV: 10 bin

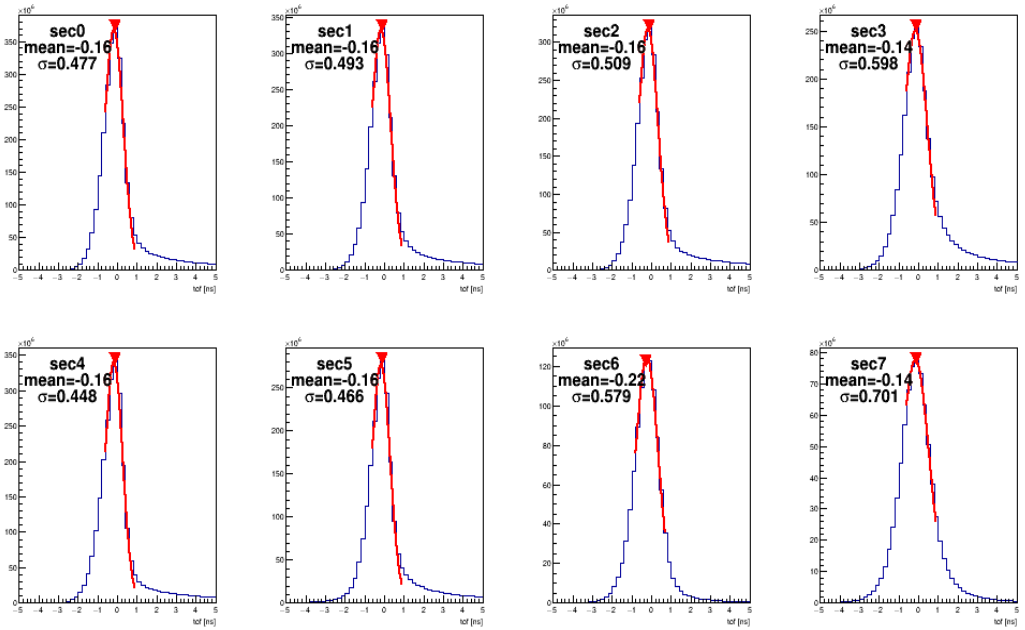
→ Total 38 bin with one more selection →



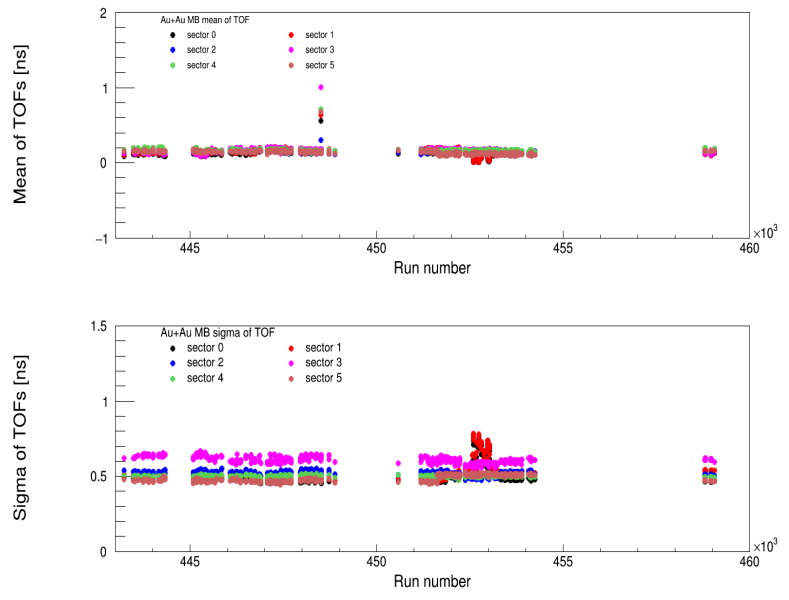
Dead Hot Map and Timing

- Used an energy dependent cut for the DHM
- Every tower which has a signal 5σ or more above the mean, was cutted out from the analysis, total loss was 12%
- We fitted the towers with 5 parameter functions to get the raw TDC
- I get 500 pico sec σ, with energy dependent (slewing corrected) timing

Tof distribution:

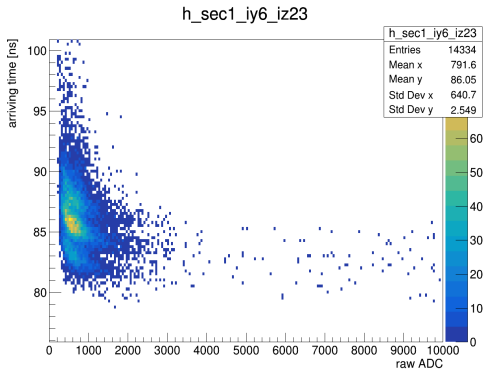


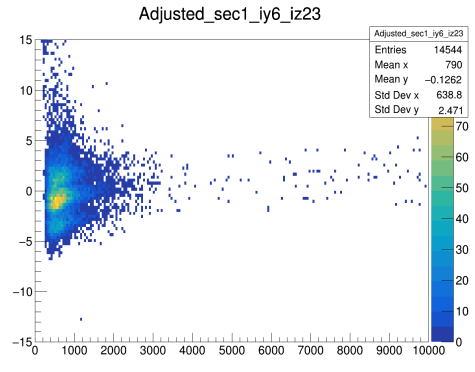
Mean and σ in every runnumber:

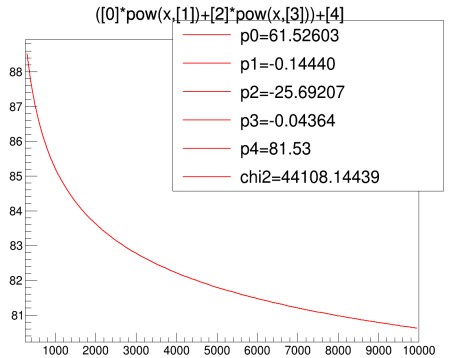


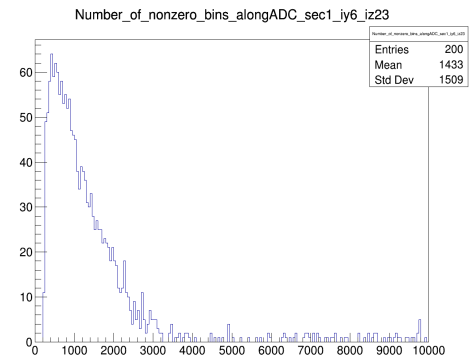
Dead Hot Map and Timing

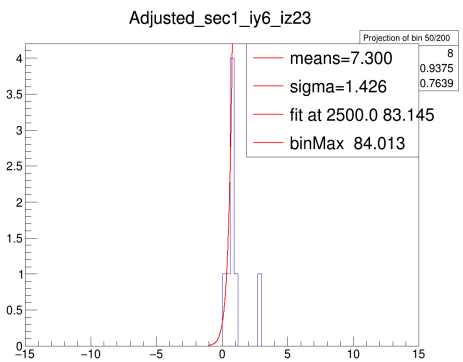
- For some 100 towers, we got results that we could not properly calibrate
- However, there was no need to worry, because we still managed to bring them within 5 ns
- Due to the timing calibration, it was not necessary to exclude additional towers from the analysis
- The fitting function:
  $([0]) * pow(x, [1]) + [2] * pow(x, [3])) + [4]$

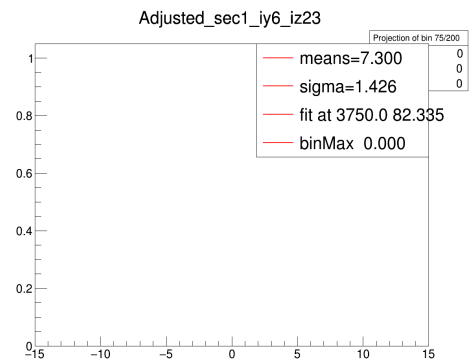










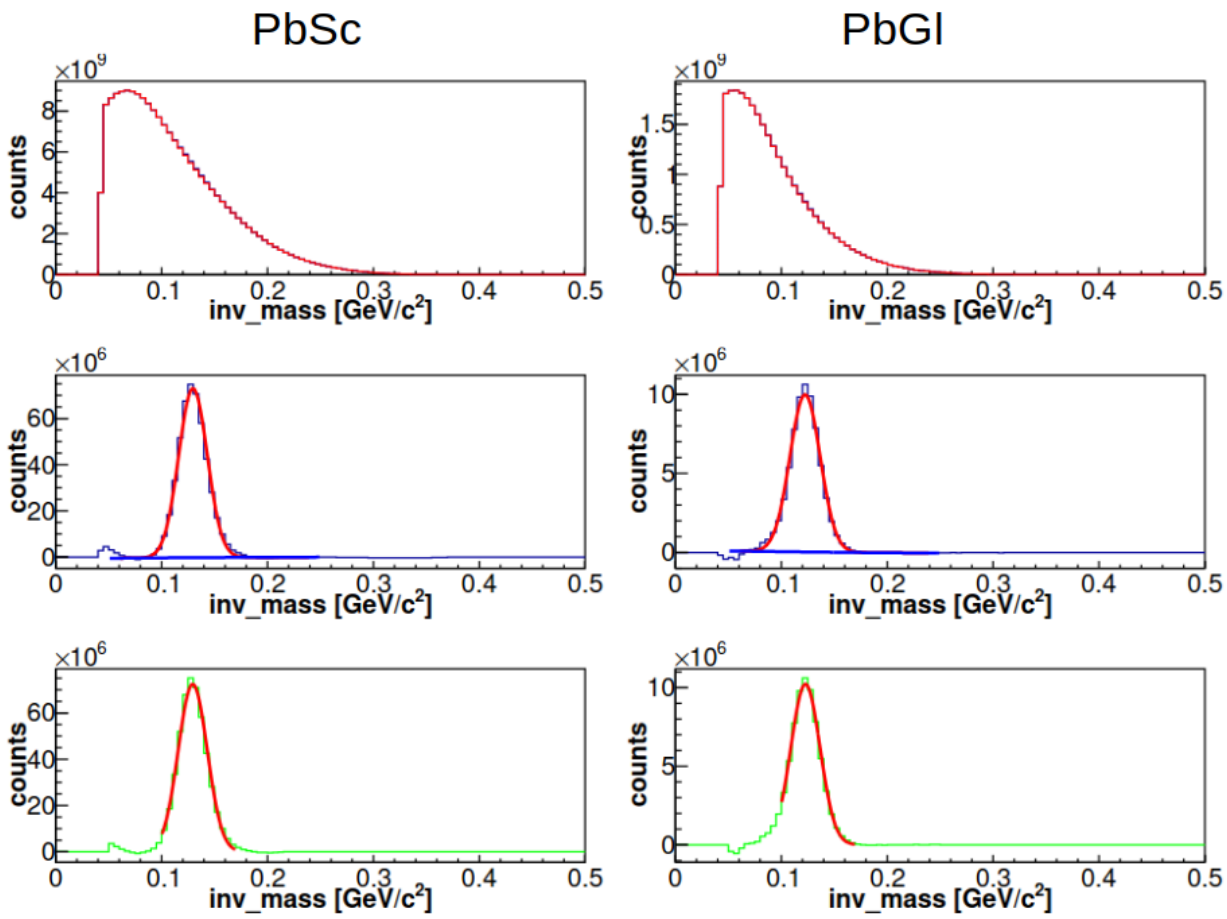


PHENIX Trigger system

- PHENIX level 1 trigger: Minimum Bias (MB)
- The MB trigger works on the Beam-Beam Counter (BBC)
- The BBC looks for coincidence signal in both its north and south detector to establish a flag to denote that this trigger threshold has been met
- At Run16 two subcategories were active on z_{vtx}:
  - MB no vertex cut: no cut on vertex of collision
  - MB narrow vertex cut: vertex cut of ± 10 cm
- PHENIX level 2 trigger: EMCal/RHIC Trigger(ERT)
  - The total energy is calculated by online summing from a 4×4 tower grid $\rightarrow$ large local energy deposit, probably from a single particle
  - Because of different energy threshold, 3 labeling: ERT4x4a, ERT4x4b, ERT4x4c
  - In Run16 only, the ERT4x4b was used

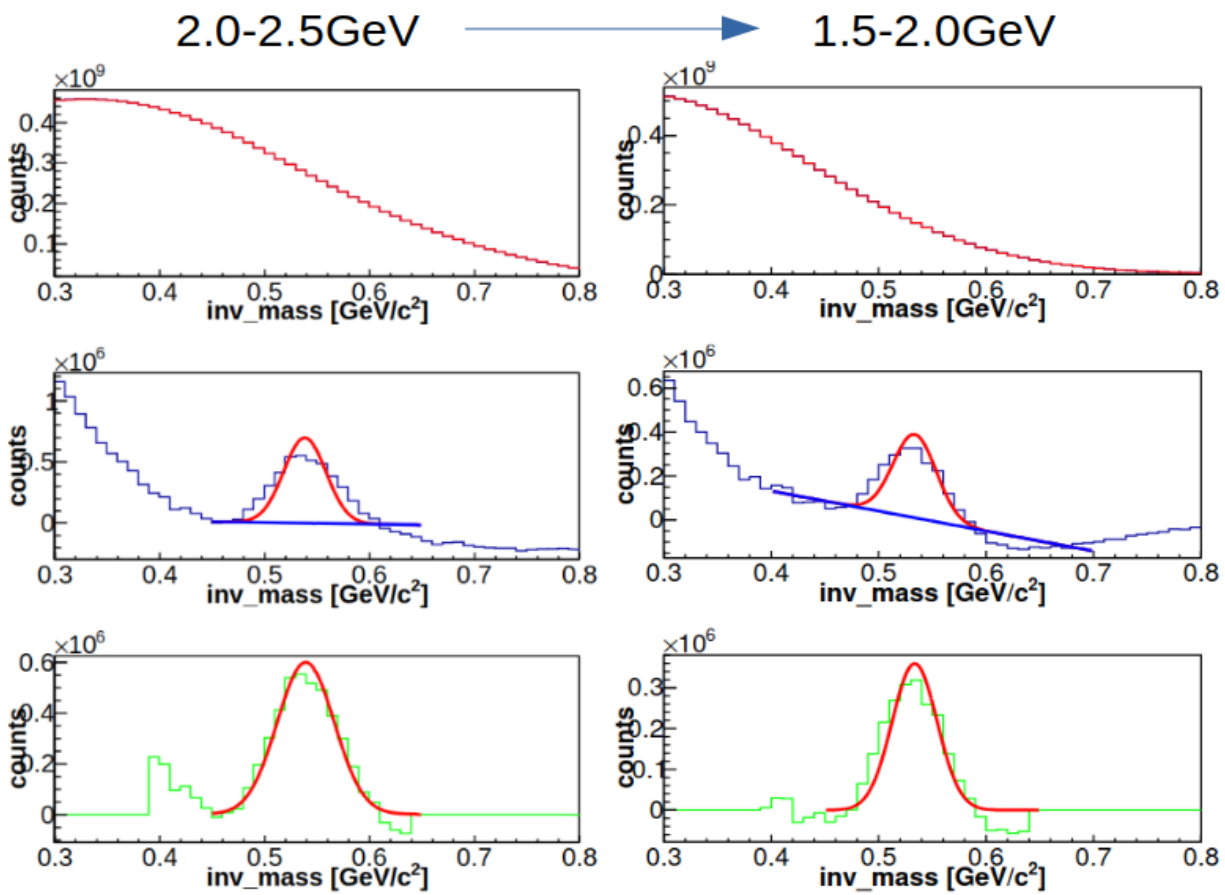
Raw invariant mass for π^0

- Mixed event subtraction
- 0.5-1.0GeV
- 5ns tof cut
- No pid cut
- MB trigger (BBCLL1 > 0 narrowvertex)
- MB centrality $0 - 100\%$



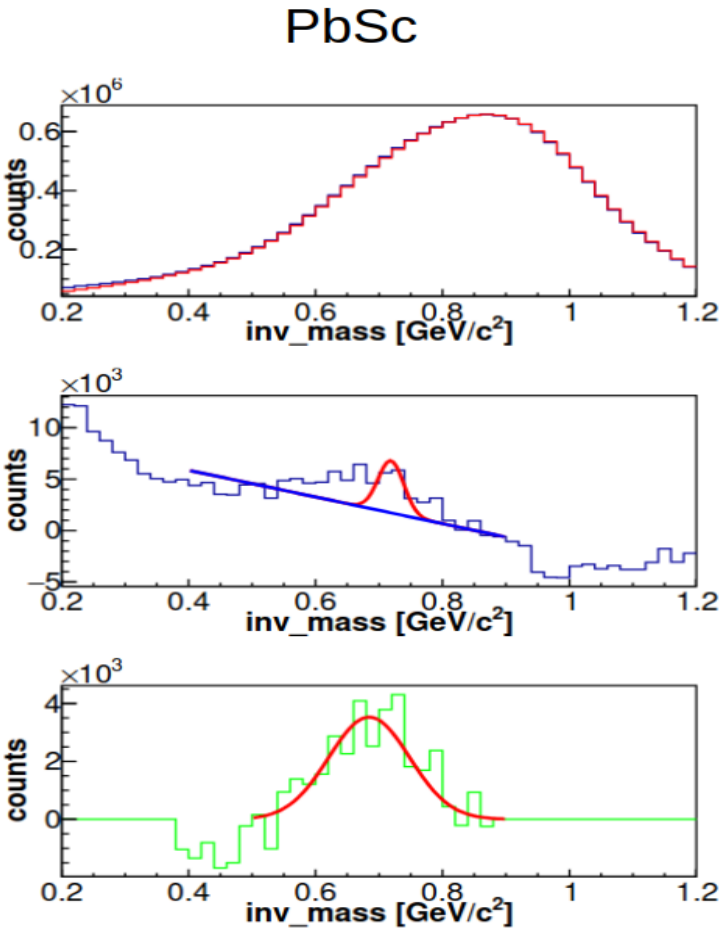
Improved Raw invariant mass for η

- Mixed event subtraction
- PbSc
- 5ns tof cut
- No pid cut
- MB trigger (BBCLL1 > 0 narrow vertex)
- MB centrality $0 - 100\%$



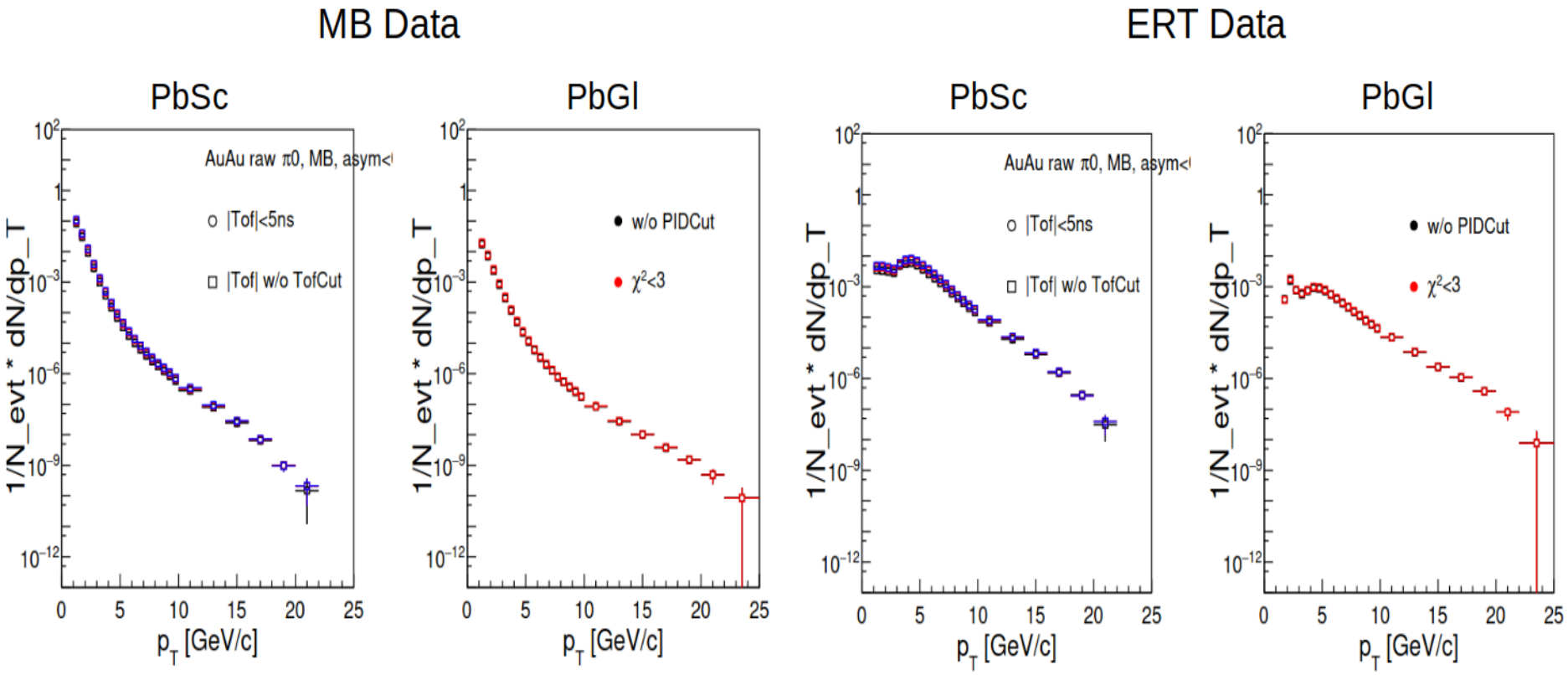
Raw invariant mass for ω

- Mixed event subtraction
- 1.0-3.0GeV
- 5ns tof cut
- No pid
- MB trigger
- MB centrality $0 - 100\%$



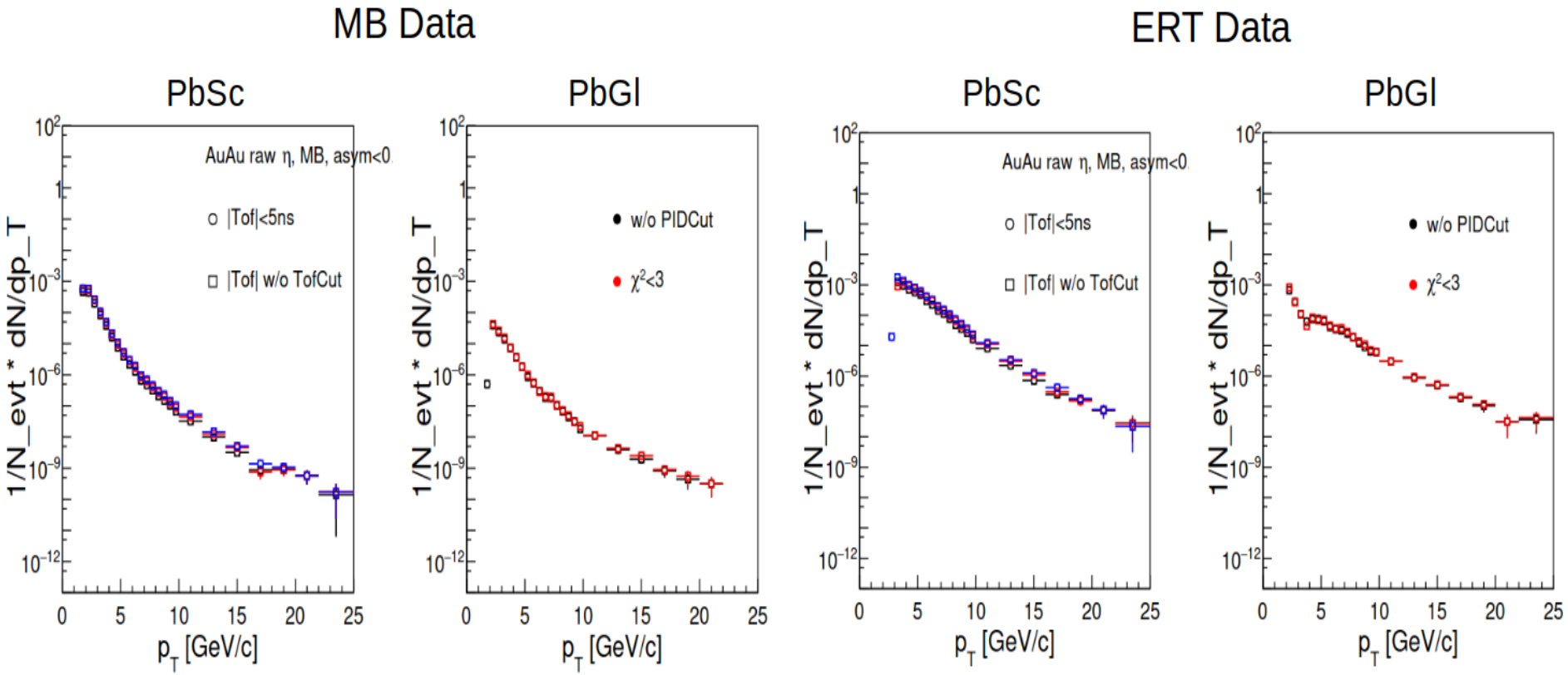
From Invariant mass to Raw MB and ERT spectra for π^0

- Extract the peak content from every invariant mass peak all the 0-30GeV $\rightarrow$ got the Raw spectra



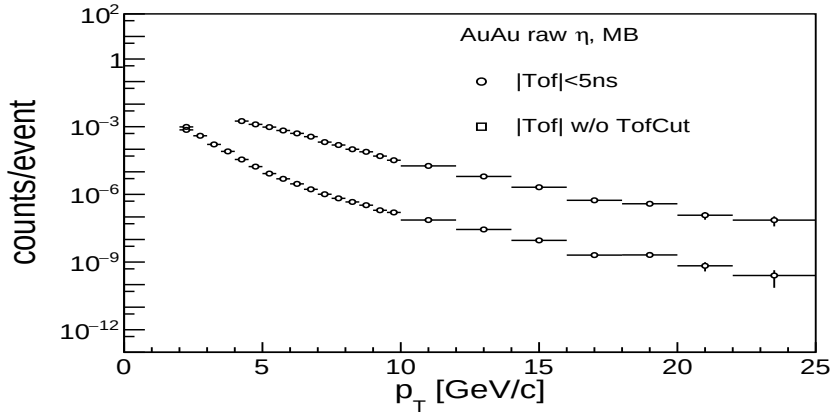
From Invariant mass to Raw MB and ERT spectra for η

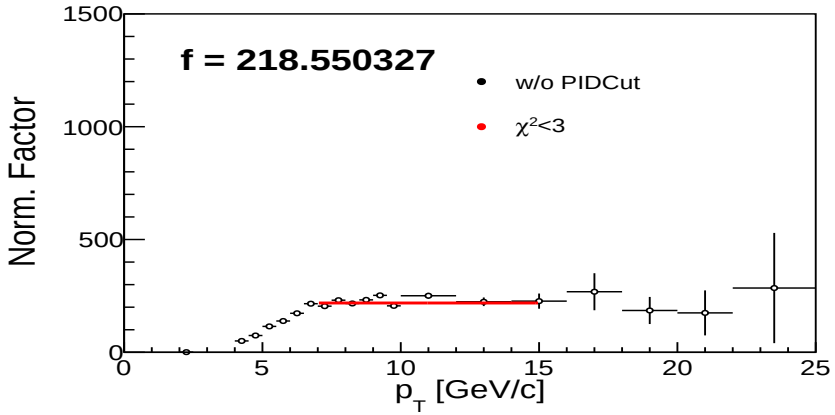
- Extract the peak content from every invariant mass peak all the 0-30GeV $\rightarrow$ got the Raw spectra

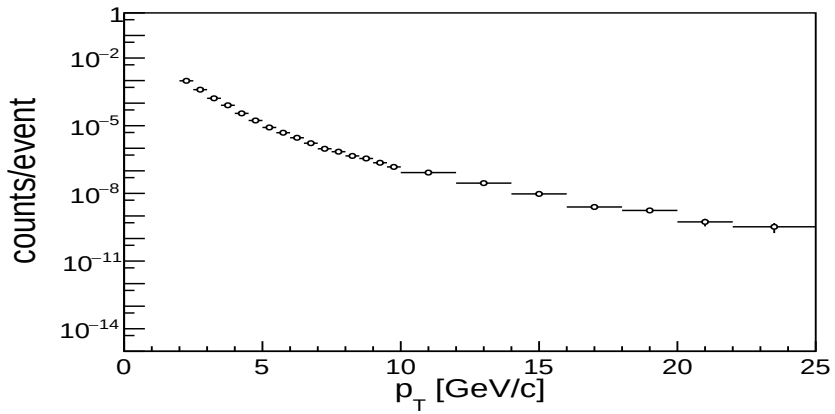


Normalization

- Examine the MB and ERT spectra
- Normalization factor: $\frac{ERT}{MB}$
- With this ratio we correct the yield per triggered events to the yield per collision
- $\rightarrow$ Take the MB spectra until 7.5GeV, and above that take the ERT spectra
- $\rightarrow$ Have better statistics in the high energy region
- In case of π^0 the change between the MB and ERT was at 9GeV

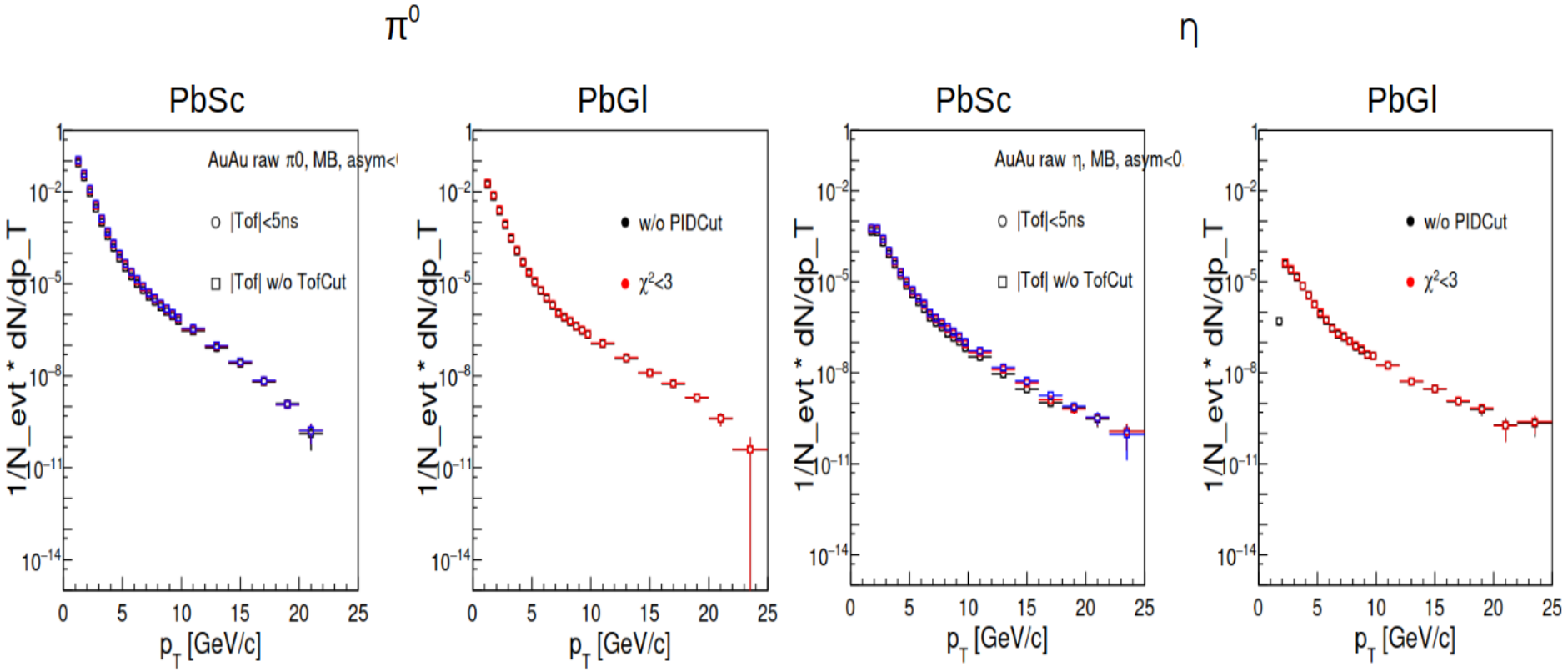






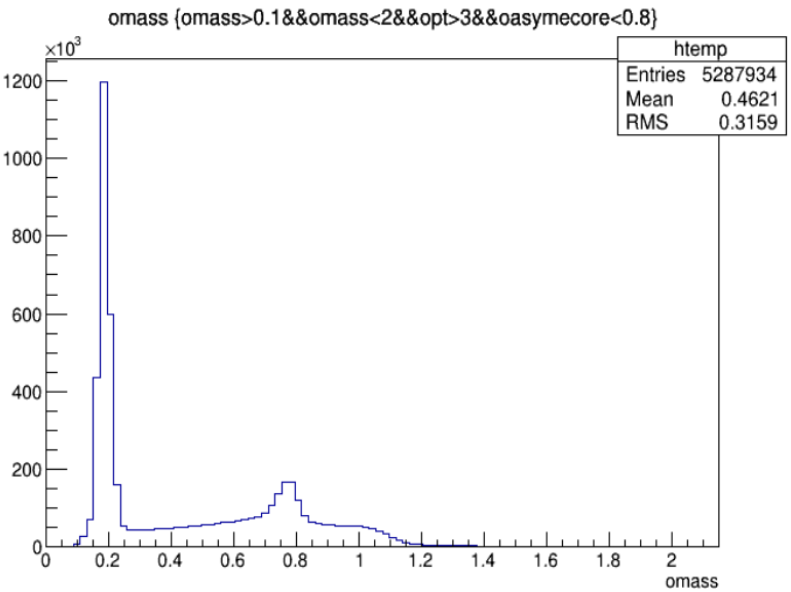
Raw Combined spectra for π^0 and η

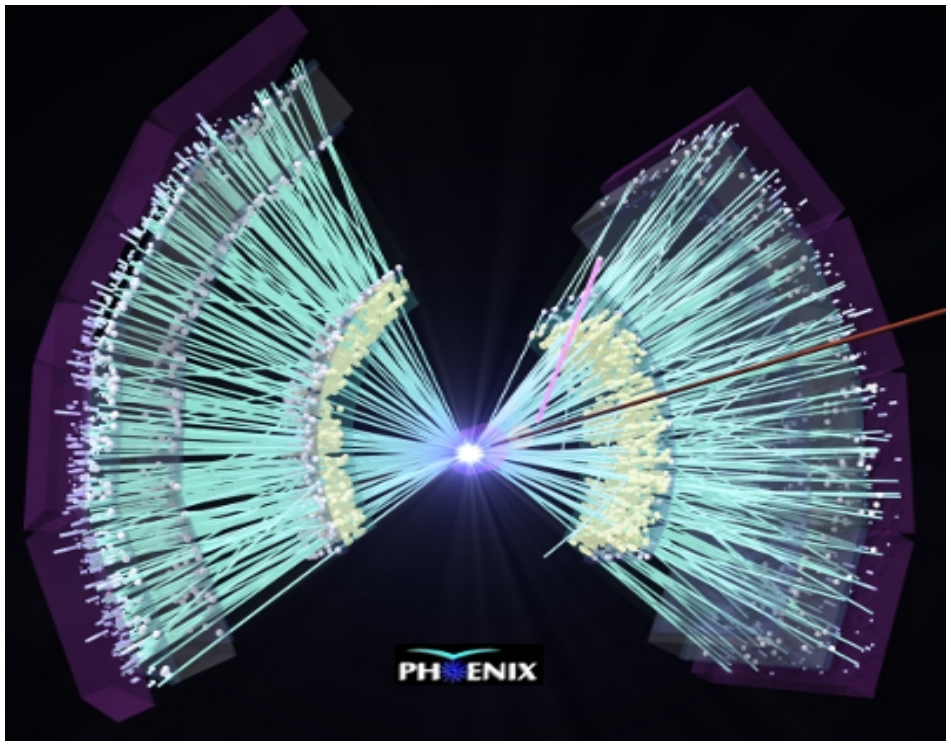
- For π^0 the efficiency decrees fast above 10-15GeV $\rightarrow$ we have an inflection point because of the mergeing effect
- In case of η we have bigger opening angle $\rightarrow$ the merging effect does not affect the shape of the power low in the raw spectra



PISA Simulation

- PISA stands for PHENIX Integrated Simulation Application
- What does it do? $\rightarrow$ PHENIX's GEANT3 based simulation package for geometry and event particle tracking software
- I used this simulation to create the simulated data and getting a 2D response matrix

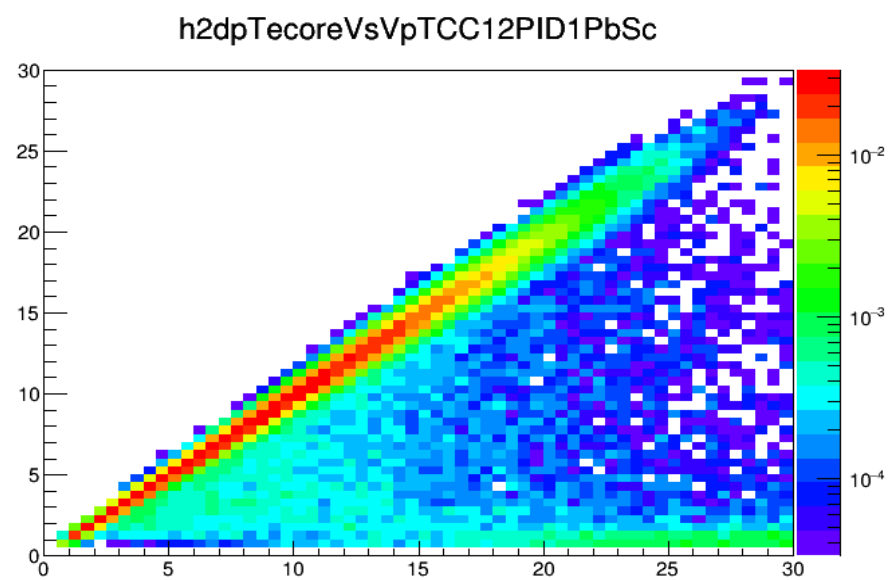




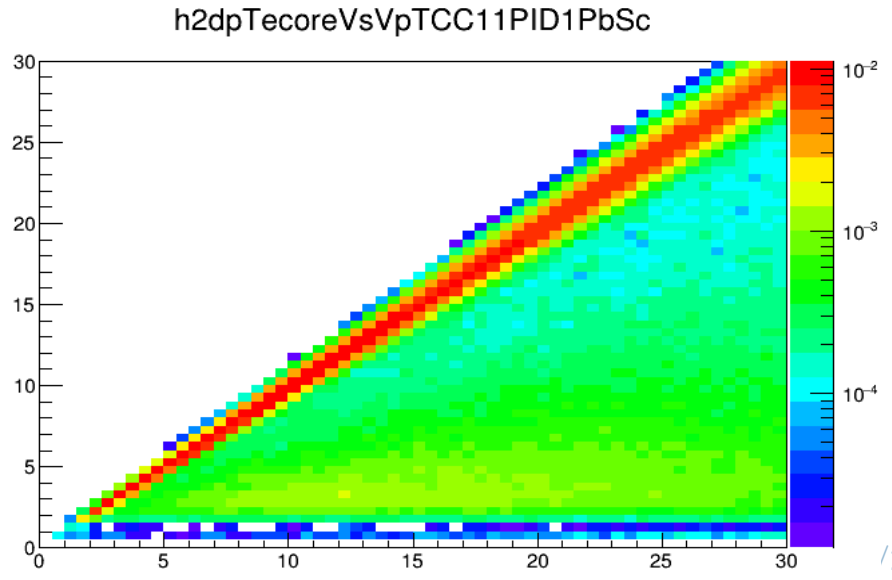
2D response Matrix

- The response matrix describes the probability that a true value x is reconstructed at value y, where y belongs to the set of all possibilities
- A two dimensional matrix is created with the x axis as the generated Pt and the y axis as measured or reconstructed Pt
- This takes care in one single step of the acceptance, reconstruction efficiency and energy smearing.

π^0:

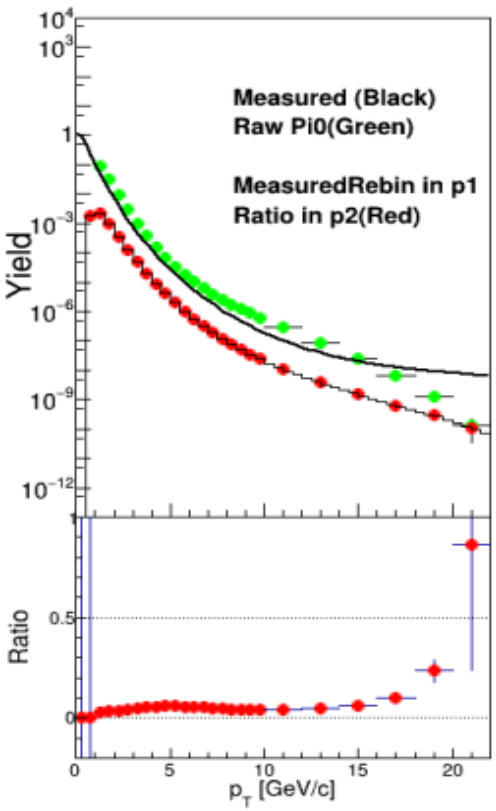


η:

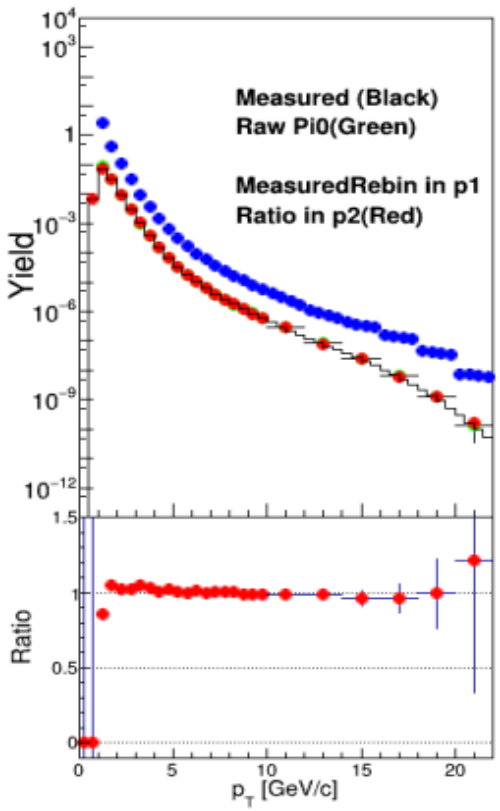


Unfolding for π^0 - some technical plot

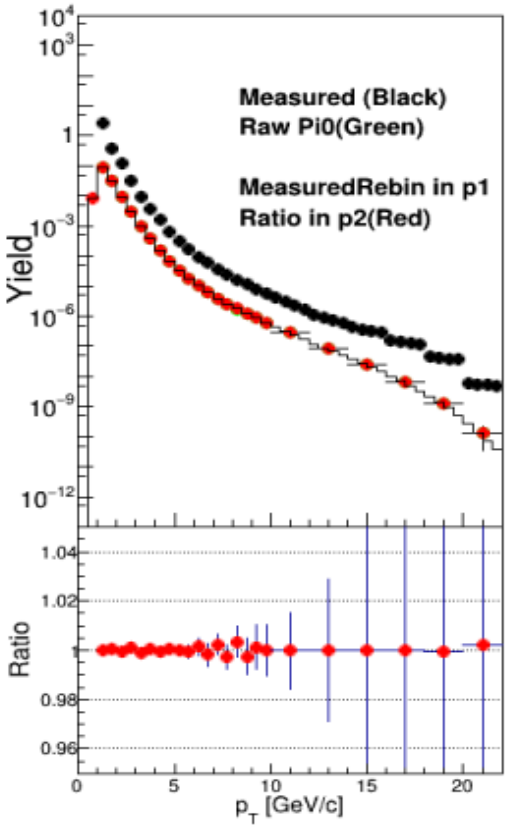
1. Iteration



2. Iteration

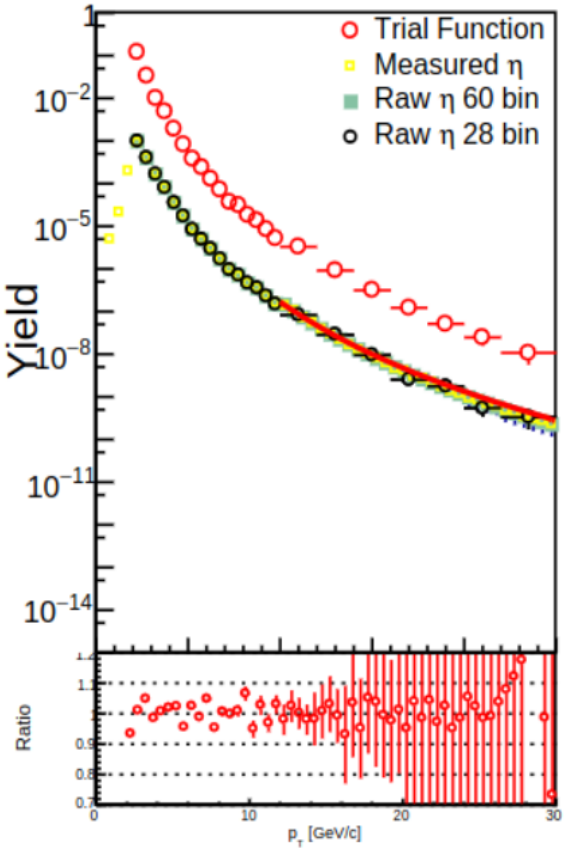


Last Iteration

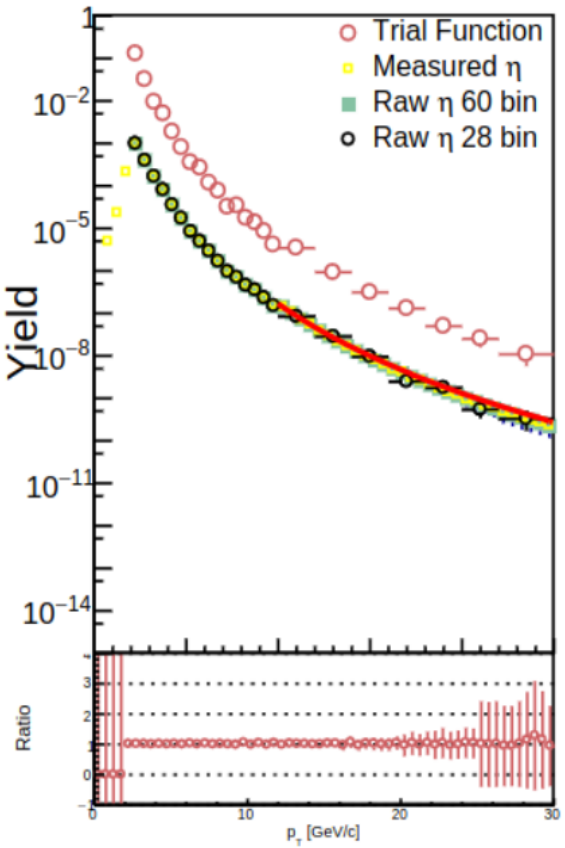


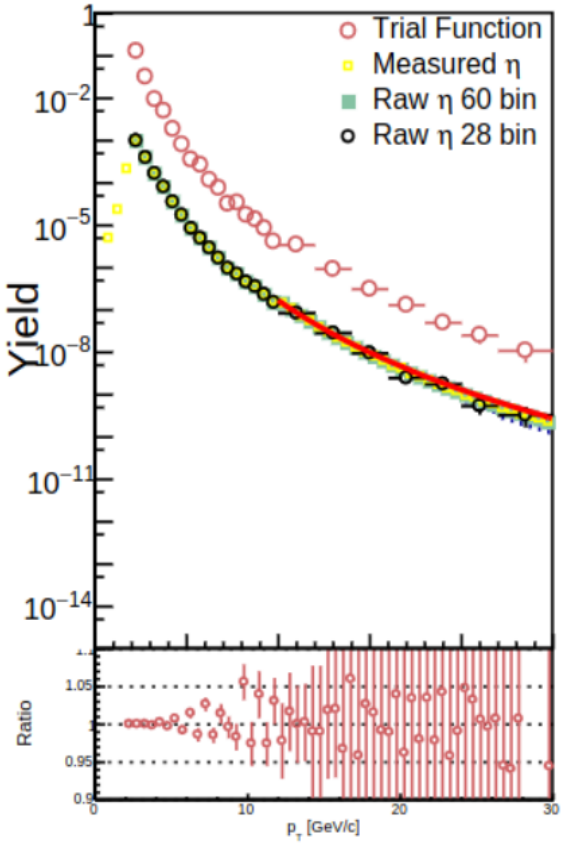
Unfolding for η - some technical plot

1. Iteration



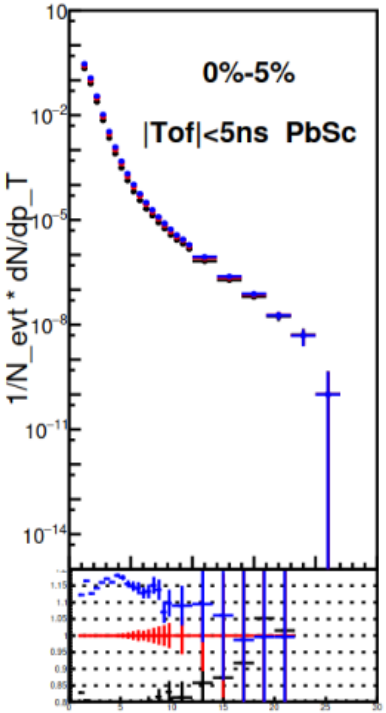
Last Iteration

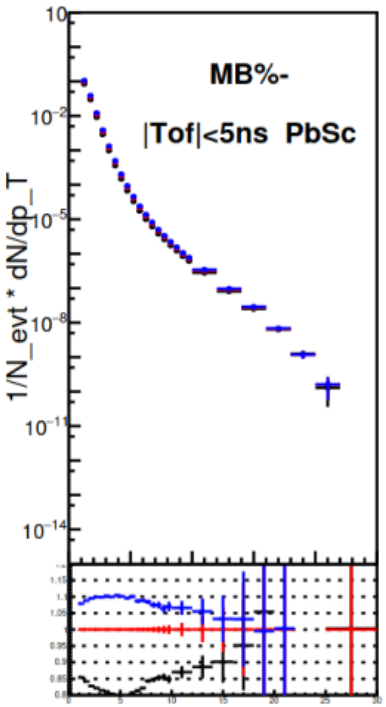




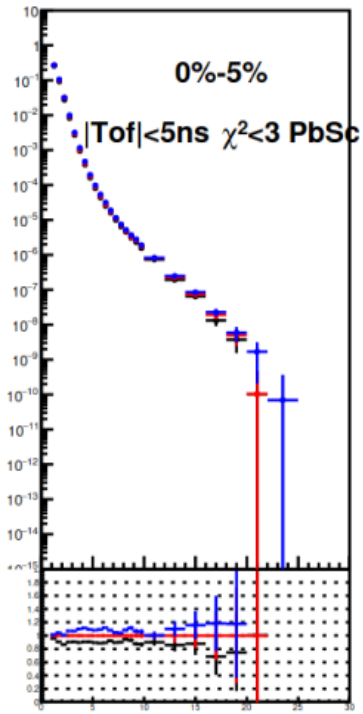
Systematical uncertainties for π^0 - Raw spectra

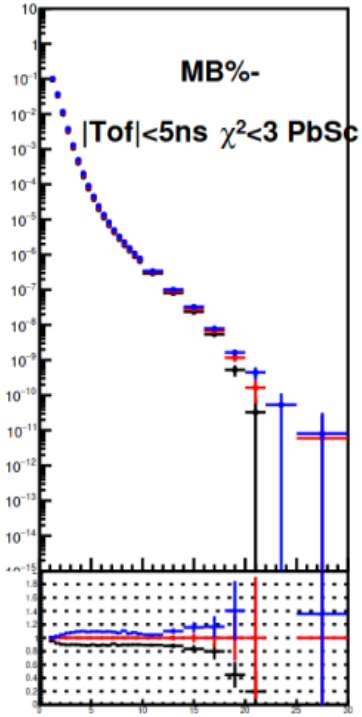
Asym=0.8





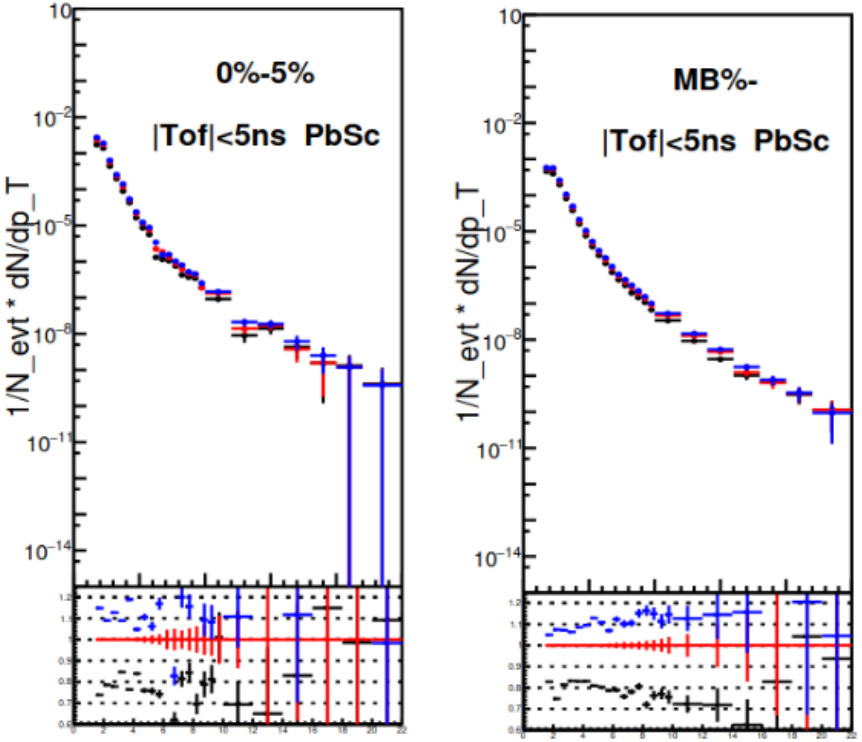
$\chi^2 < 3$





Systematical uncertainties for η - Raw spectra

Asym=0.8



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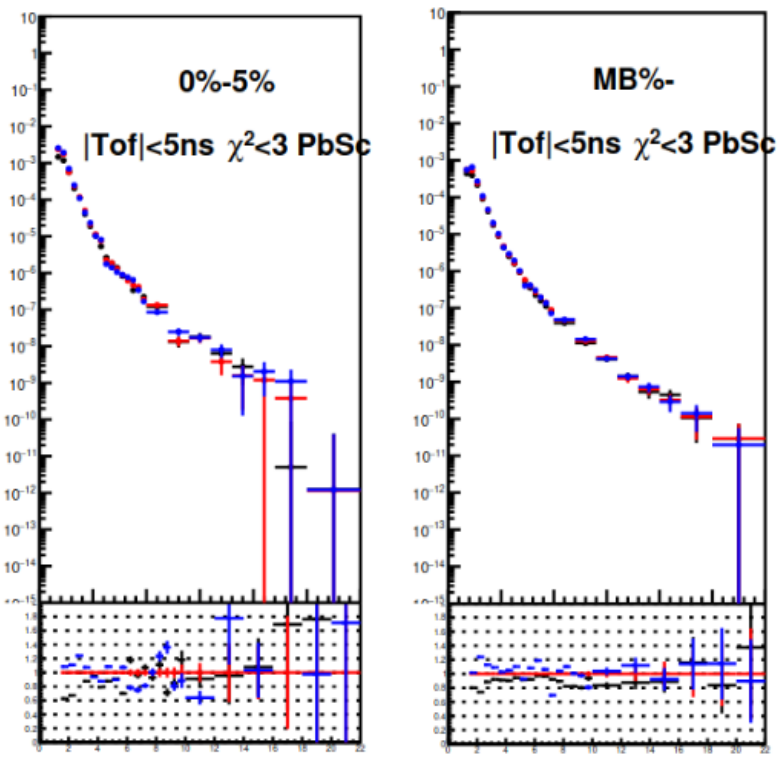

Summary and Outlook

- Light meson analysis for search the direct photon in different decay channels
- With the Dead Hot Map and Timing calibration we exclude out all malfunctioning towers
- Reconstructed raw invariant mass $\rightarrow$ Normalization $\rightarrow$ Combined (MB+ERT) spectra
- PISA Simulation $\rightarrow$ 2D Response Matrix $\rightarrow$ Unfolding $\rightarrow$ Study the uncertainties
- Consistency between results with various cuts studied
- Finish the systematic uncertainties
- Continue the ω analysis

Thank you for your attention!

Melinda Orosz

Back Up slides

Unfolding

$$\begin{bmatrix} R_{11} & R_{21} & \bullet & R_{n1} \\ R_{12} & \bullet & \bullet & \\ & & & \\ R_{1n} & & & R_{nn} \end{bmatrix} \begin{bmatrix} T_1 \\ T_2 \\ \\ T_n \end{bmatrix} = \begin{bmatrix} O_1 \\ O_2 \\ \\ O_n \end{bmatrix}$$

Measured pion Pt

Generated pion Pt

Response Matrix

Trial yield (generated)

Measured yield (that which is expected from trial function

Compare with yield measured from data

$$\begin{bmatrix} O_1 \\ O_2 \\ \\ O_n \end{bmatrix} \quad \begin{bmatrix} M_1 \\ M_2 \\ \\ M_n \end{bmatrix}$$

Yield from trial function Yield from data

$$\frac{\begin{bmatrix} M \end{bmatrix}}{\begin{bmatrix} O \end{bmatrix}} = \begin{bmatrix} M_1/O_1 \\ M_2/O_2 \\ \\ M_n/O_n \end{bmatrix}$$

$$\begin{bmatrix} R_{11} & R_{21} & \bullet & R_{n1} \\ R_{12} & \bullet & \bullet & \\ & & & \\ R_{1n} & & & R_{nn} \end{bmatrix} \begin{bmatrix} M_1/O_1 T_1 \\ M_2/O_2 T_2 \\ \\ M_n/O_n T_n \end{bmatrix} = \begin{bmatrix} O'_1 \\ O'_2 \\ \\ O'_n \end{bmatrix}$$