Neutral Pion Distributions in PHENIX at RHIC

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for the PHENIX Collaboration

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The Physics Issues

Where is the transition from “soft” to “hard” processes?

Do yields scale with number of collisions?

Pointlike interaction or effects from an extended, dense medium?

Do we observe some deficit at high pT?

Charged vs neutral pions: the analysis perspective

Charged:

- single particles, no combinatorial background
- PID and momentum increasingly difficult with higher pT
- better per-event statistics, need fewer events for same pT range
- sensitive to particle composition

Neutral:

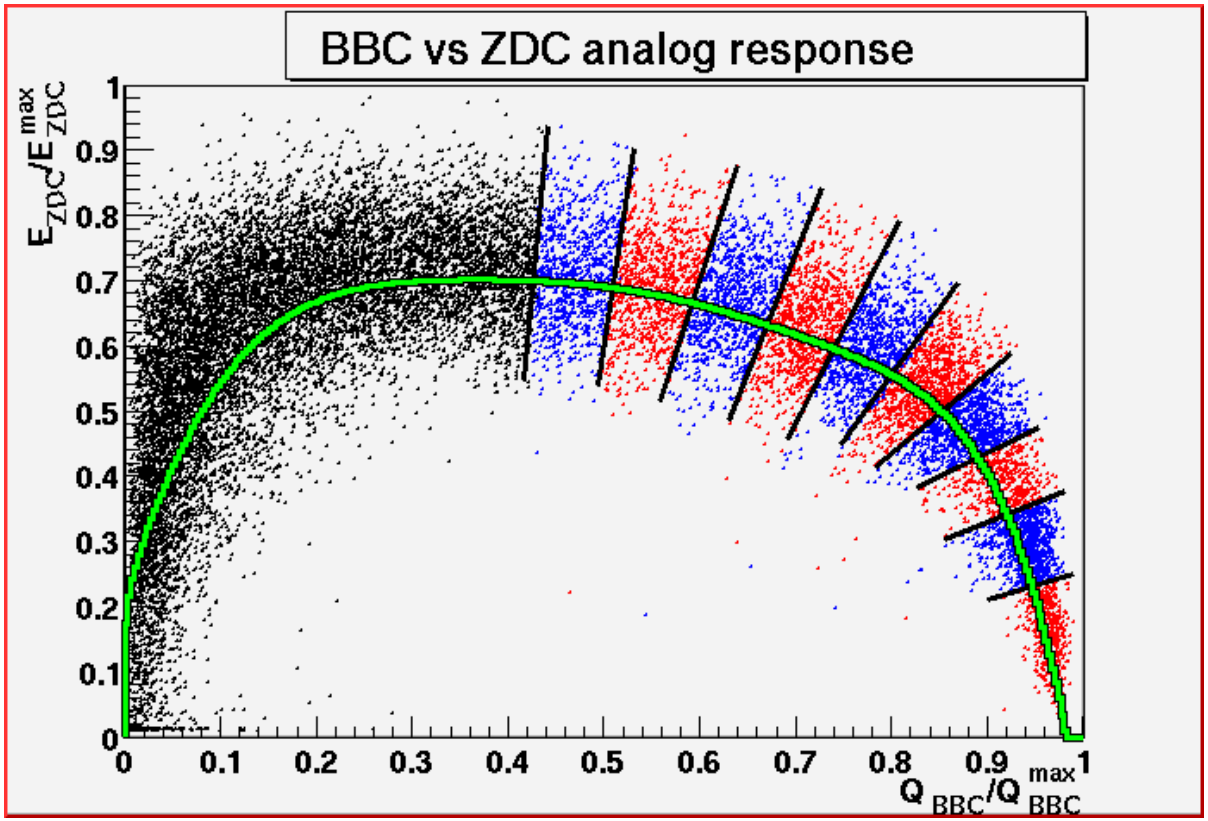
- pair measurement (yields from invariant mass distributions)
- yields extracted statistically – large combinatorial background
- requires many events
- very hard at low pT
- signal to background improves at higher pT
- pT scale "self-calibrating"

Different systematics!

Trigger and Dataset

Centralities defined with Beam-Beam Counter and Zero Degree Calorimeter

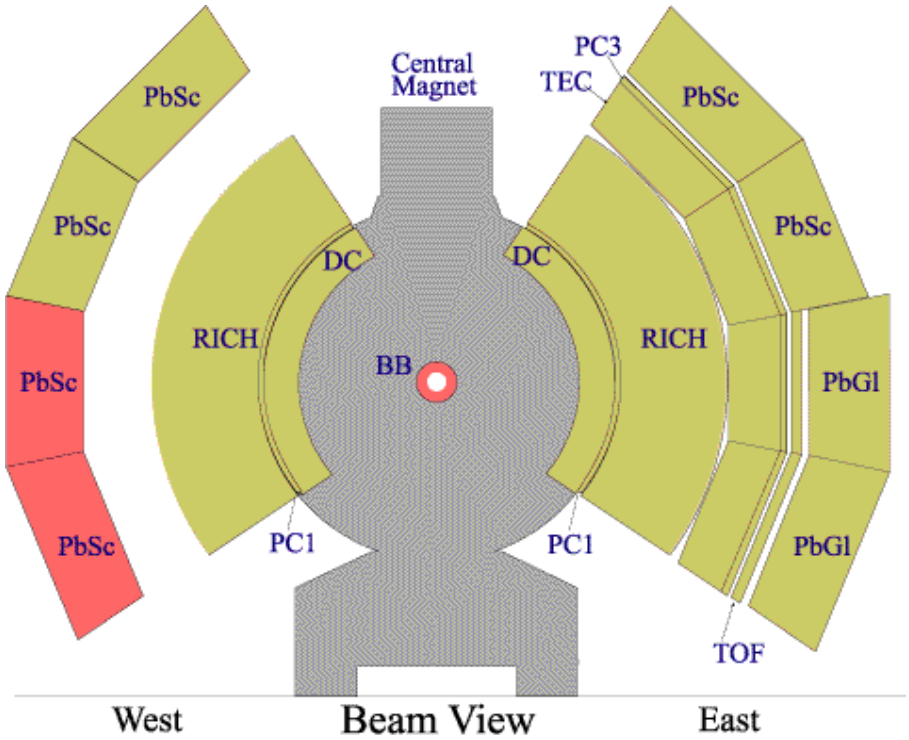
Events in this analysis:
1.17 M min. bias
202 k peripheral
(75-92%)
128 k central
(upper 10%)



Detectors included

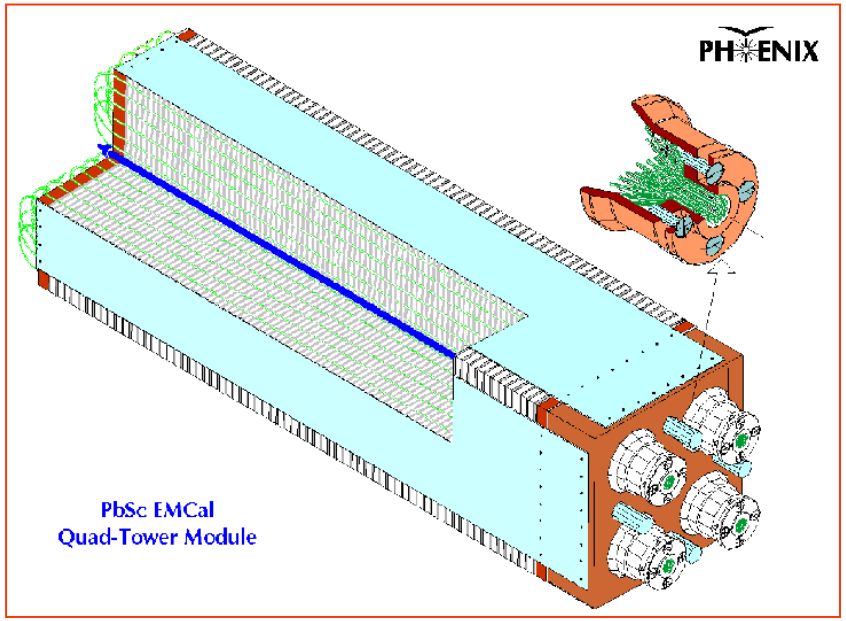
Triggering devices
Two sectors of lead-scintillator calorimeter (PbSc)

510 cm from collision point (17 ns)
45 degrees in azimuth
0.7 units in rapidity
high granularity



The Device: PbSc Calorimeter

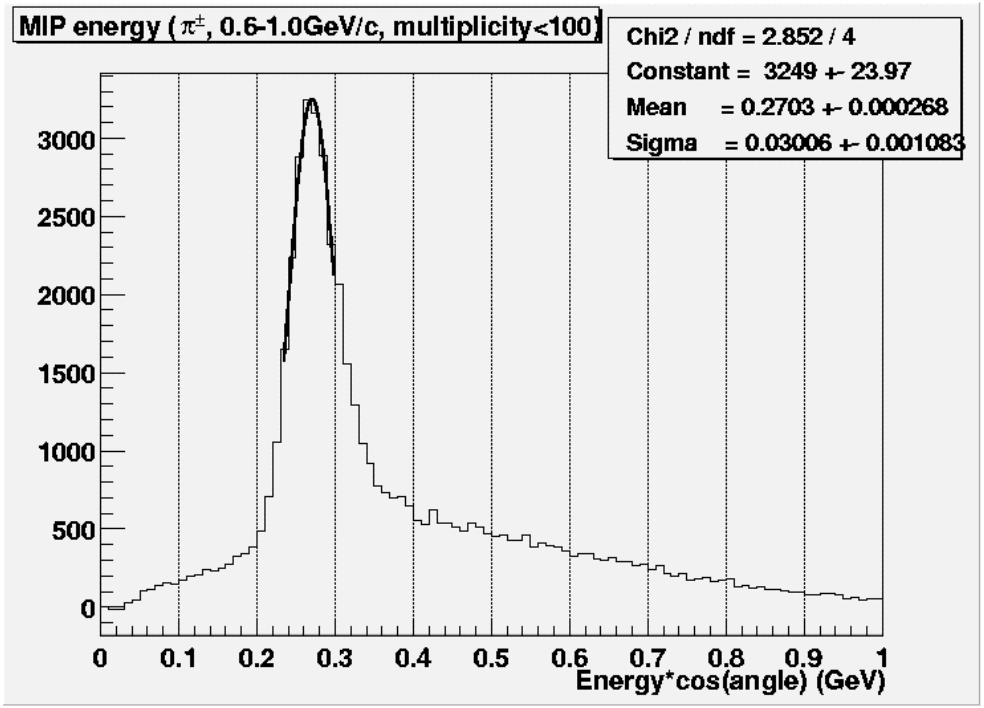
Lead-scintillator sandwich (sampling)
Wavelength-shifting fiber light transport
Photomultiplyer readout
2 sectors (5184 towers) instrumented for Year-1

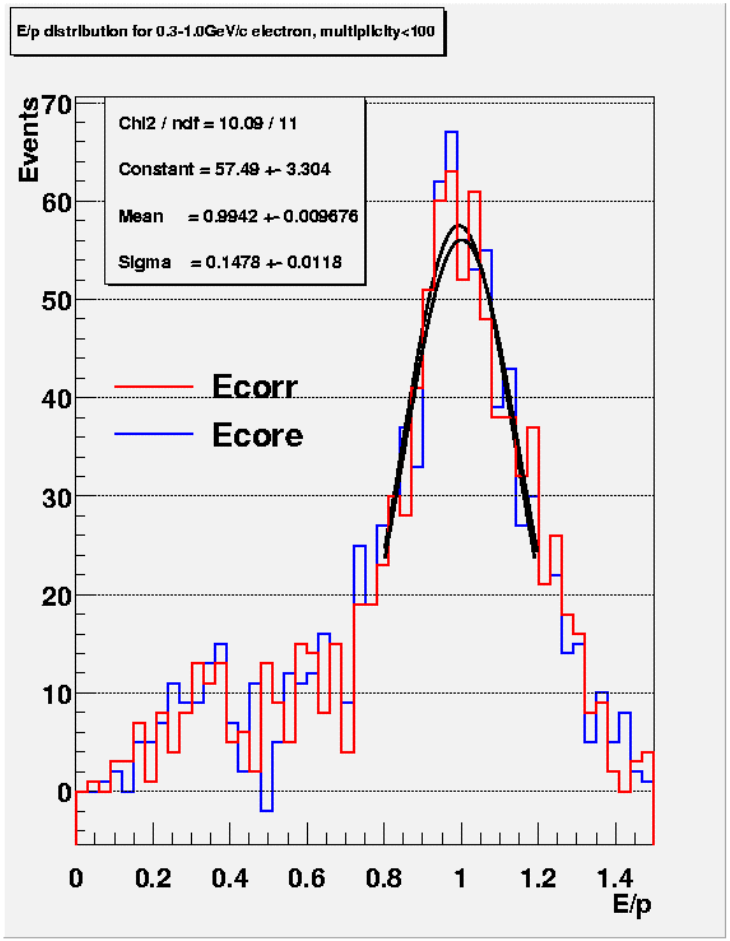


Calorimeter Performance

E/p matching with electrons

Minimum ionization peak
In low multiplicity events





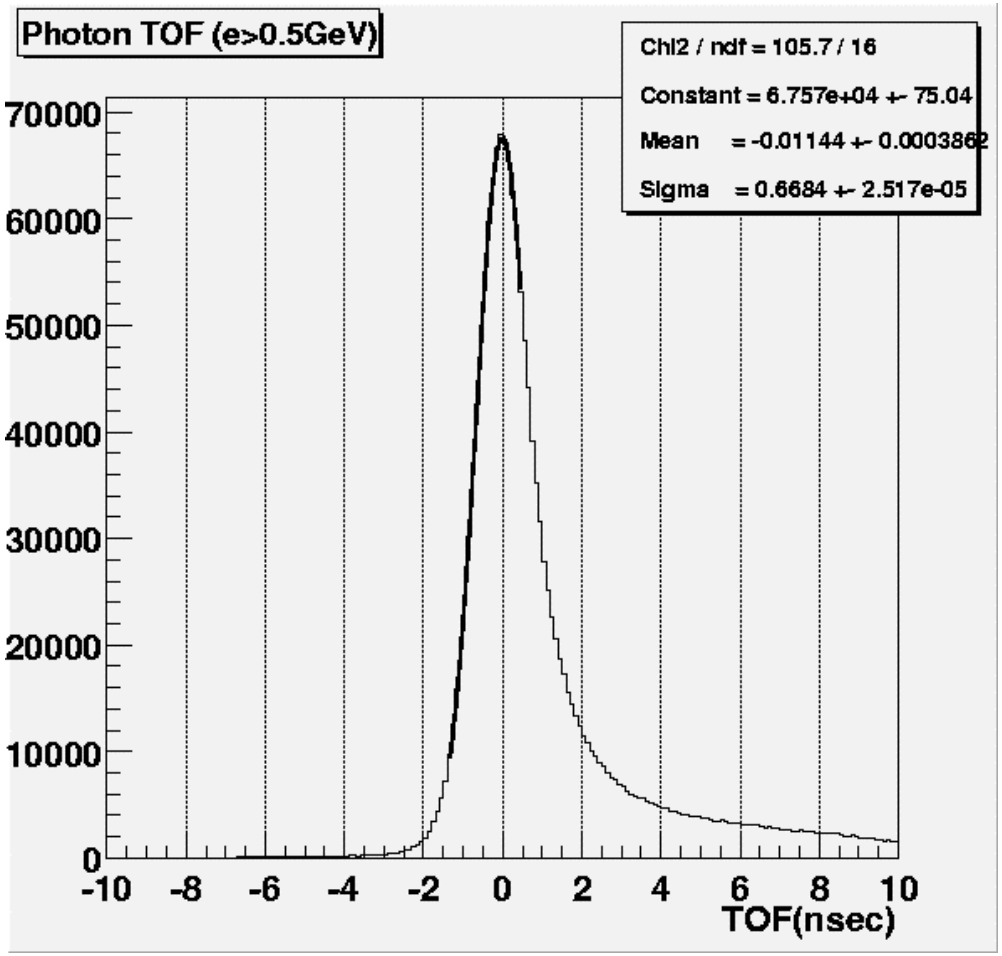
Photon Identification

Neutral pion search does not require a very high quality particle identification (correlation!)

Main tools in Year-1 run:
- time of flight
- cluster shape ("chi2")

Real issue: antibaryons!

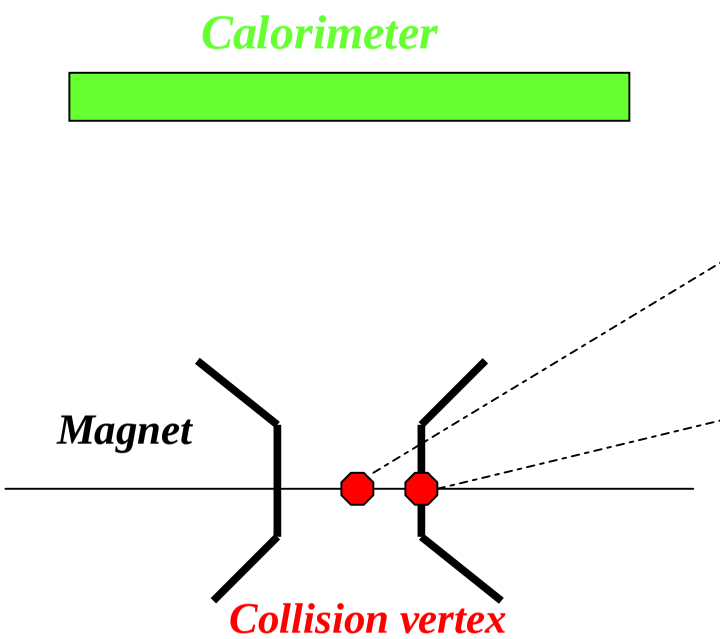
Future:
- charge particle rejection

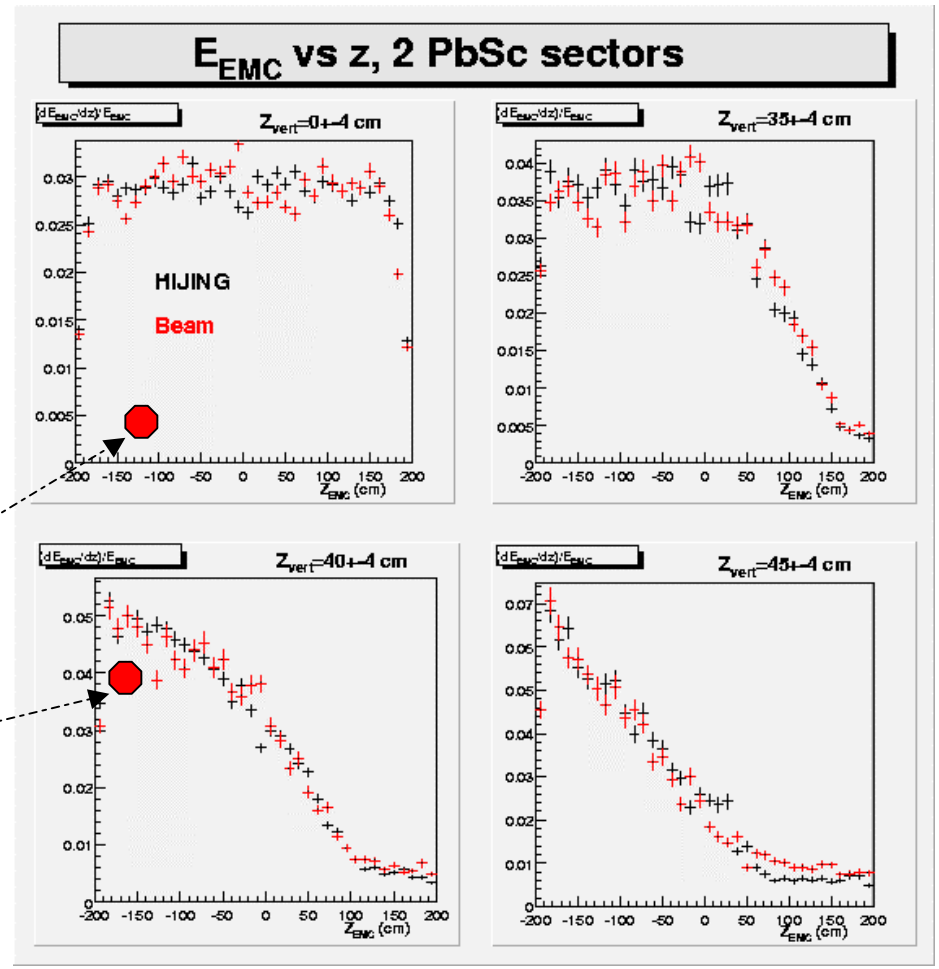


Verification of the simulations / 1

We – as most other analyses – rely heavily on simulations

Substantial background from
- magnet pole
- structural elements



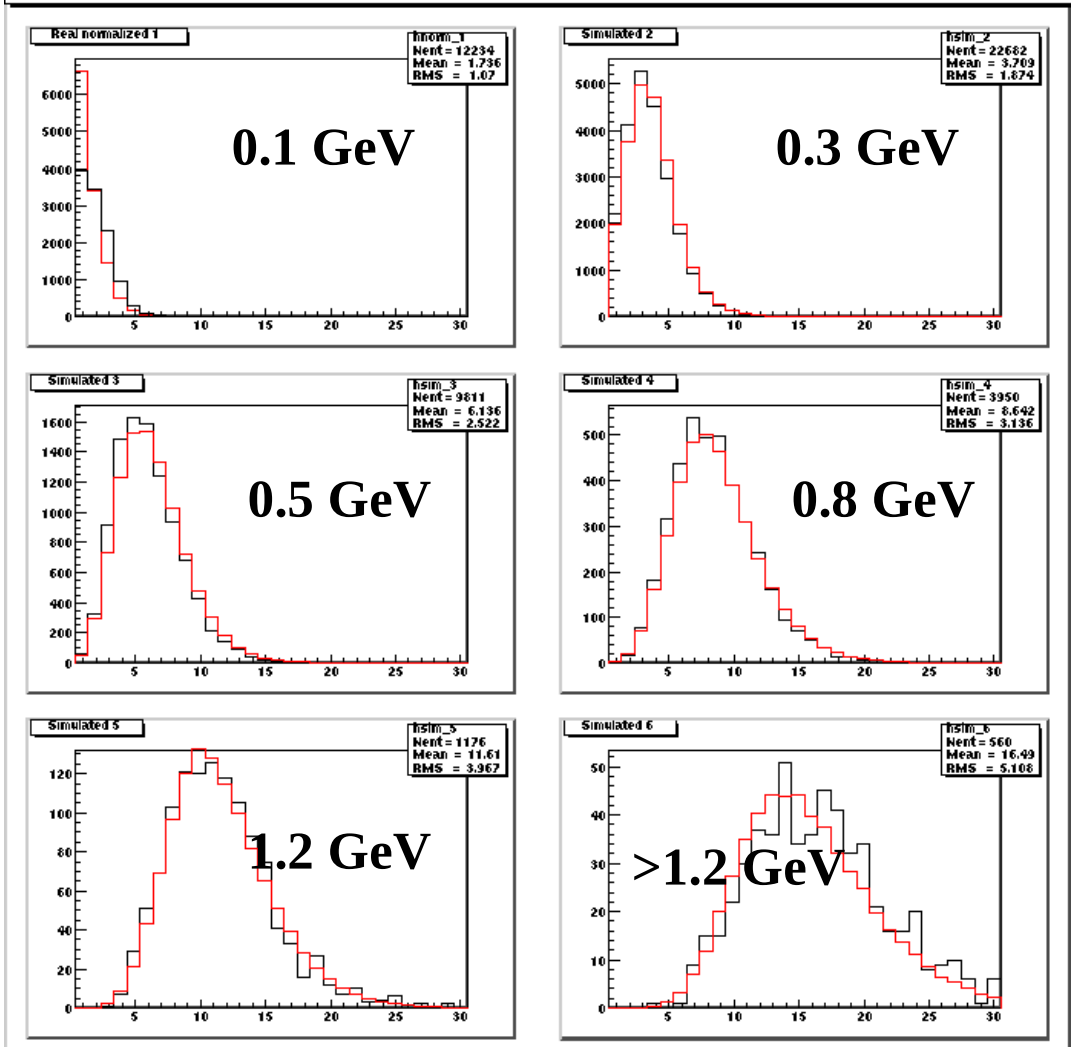


Verification of the simulations / 2

Description of showers
- shape (PID)
- overlaps (efficiency)
- has to work in 3D

Example:
- towers in a cluster
- different energy bins
- edge of the calorimeter
- sensitive to depth!

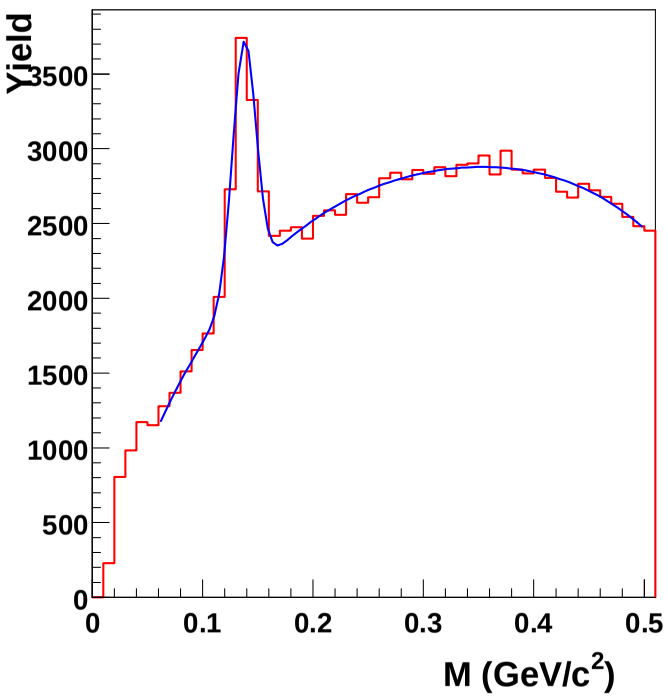
Cluster sizes at the edge of EMCal: sim (black) data (red)



Extraction of Neutral Pion Yields / 1

Example of a two-particle Invariant mass distribution

Example of some human faces behind this analysis



π0's

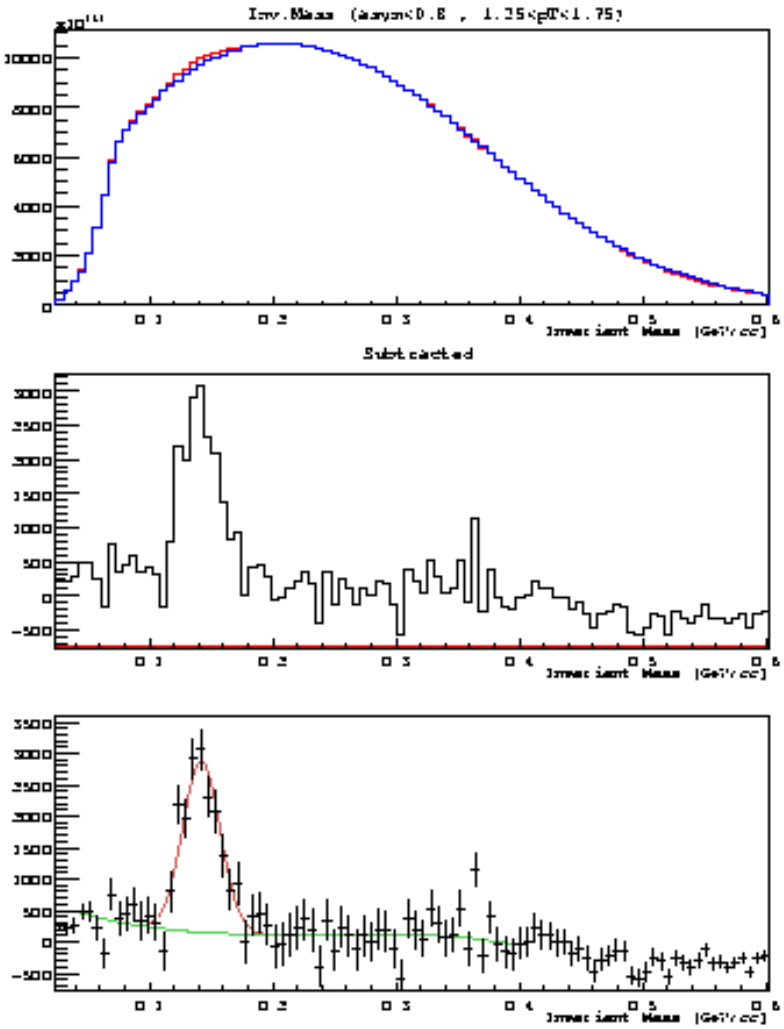
p_t>2 GeV, asym<0.8

m=136.7 MeV/c^2

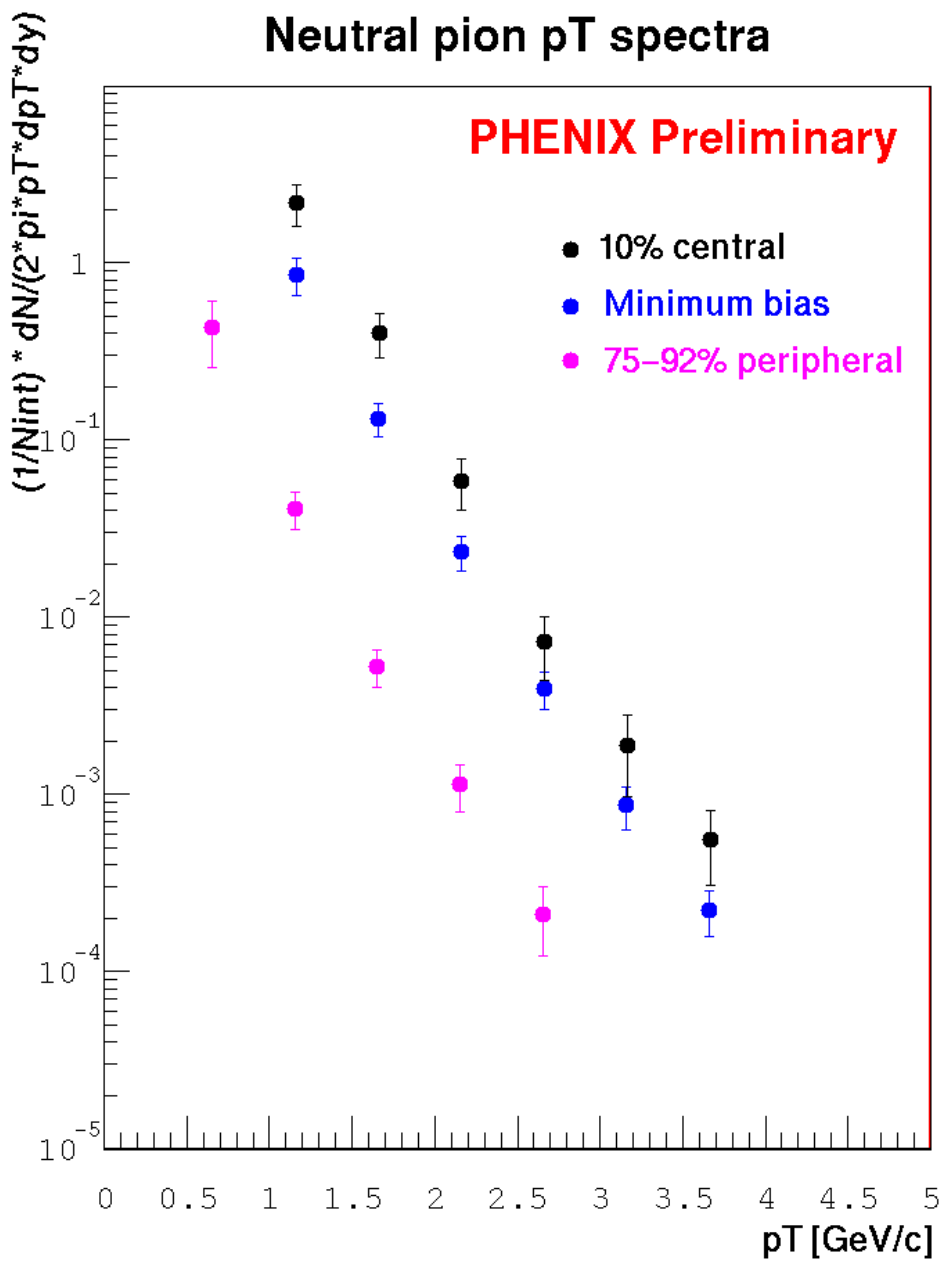
Extraction of Neutral Pion Yields / 2

A harder case:

- *central collisions, pT=1.5 GeV/c*
- *loose particle ID*
- *red: pair invariant mass distribution*
- *blue: combinatorial from mixed events*
- *second panel: subtracted distribution*
- *third panel:*
- *- Gaussian fit to the peak*
- *- polynomial fit to the background*
- *peak at 141 MeV, 15 MeV wide*



Spectra



Systematic errors included

Main sources:

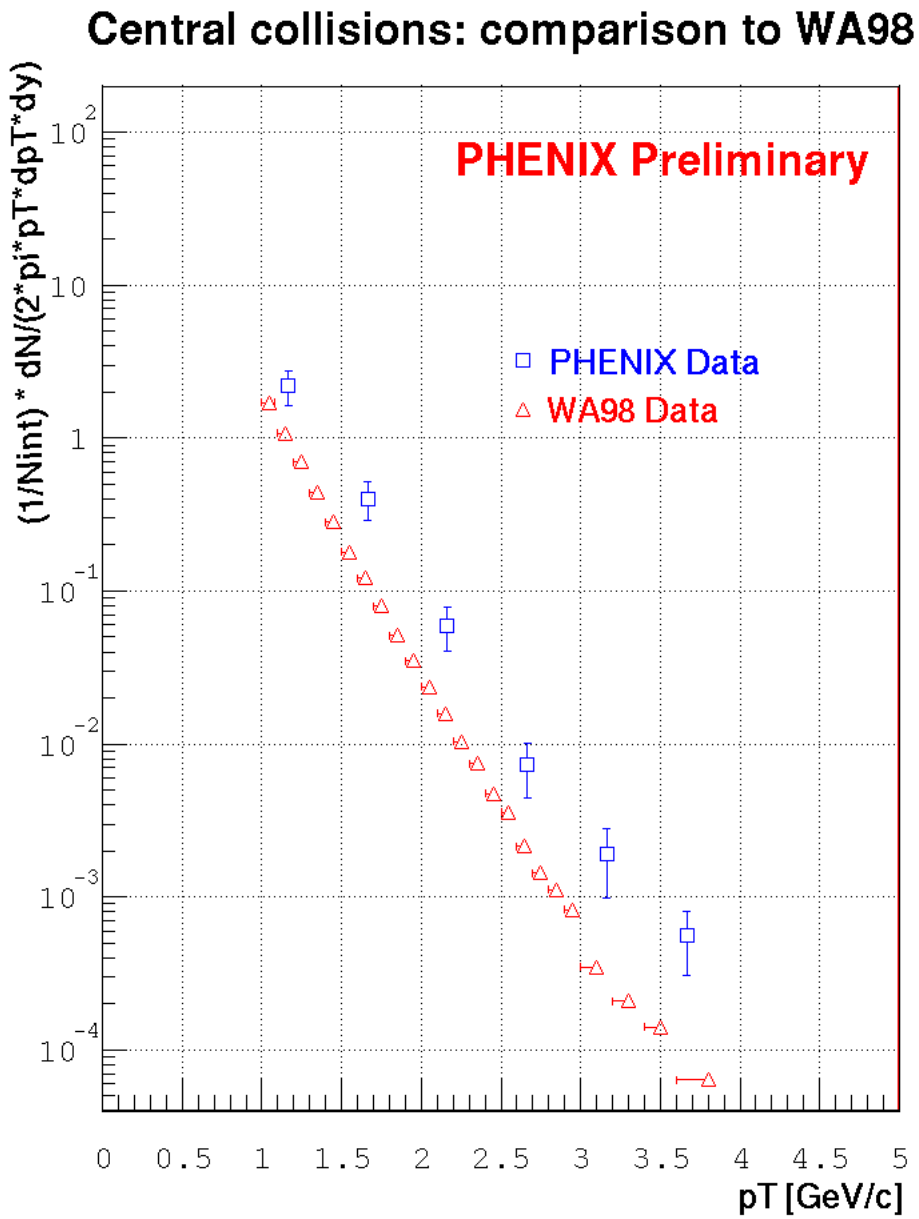
- *peak extraction*
- *PID loss*
- *efficiency calculations*
- *non-vertex pions*
- *pT scale*

Spectra

10% most central collisions

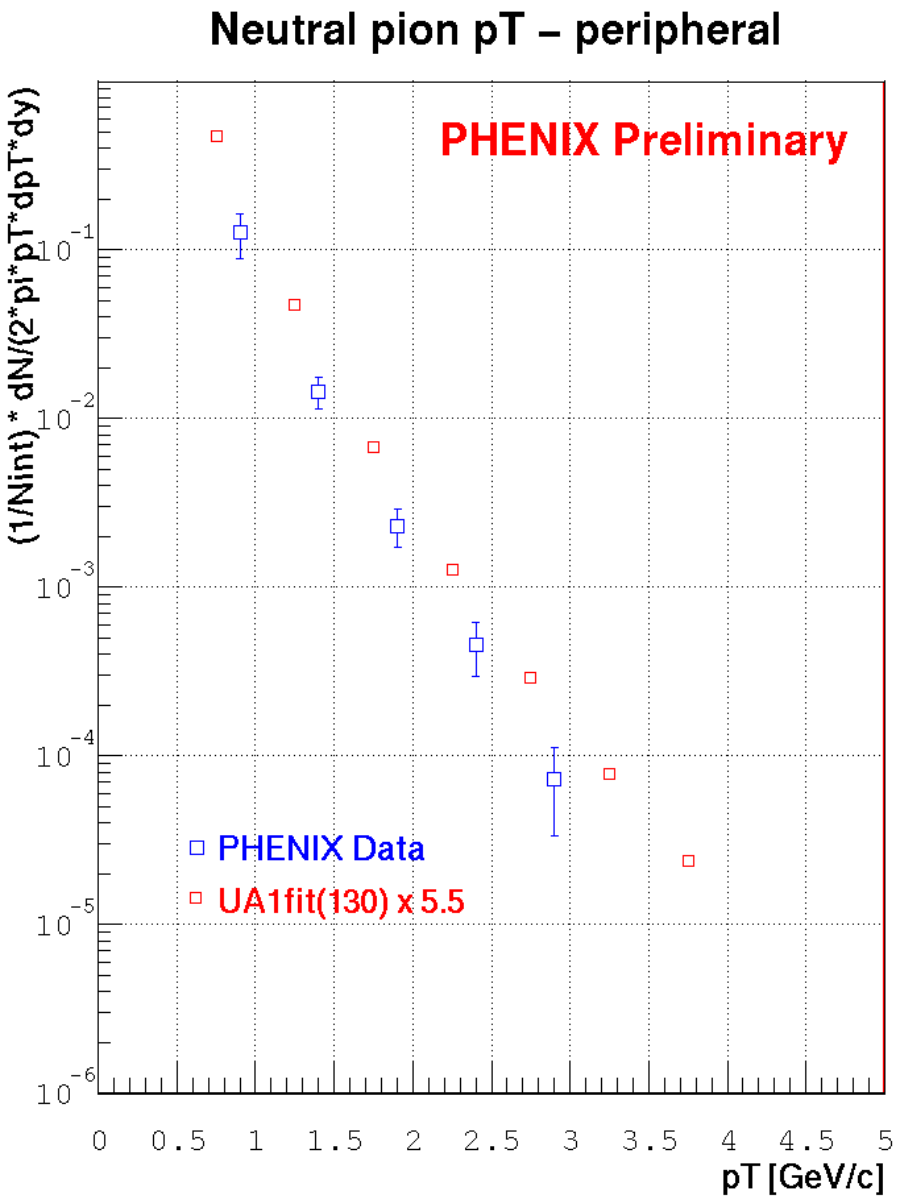
Reached upper pT limit of WA98 already in Year-1

Significant difference in the slope

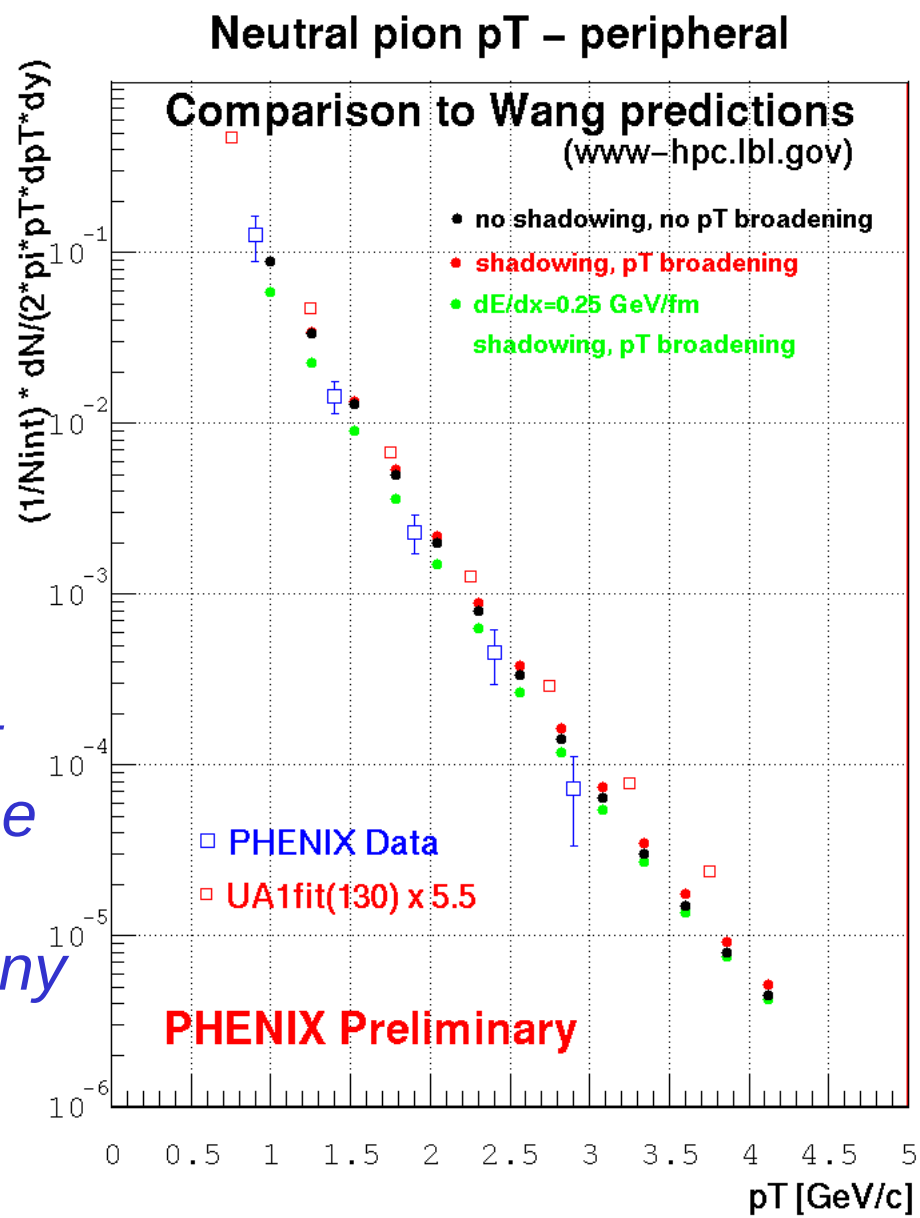


Spectra

75-92% most peripheral
Compared to UA1 fit (charged!)
Estimated number of binary collisions is 5.5
Clear deficit particularly at higher pT



Spectra



Data: 75-92% peripheral, 5.5 binary collisions/event

Theory: not exactly the same cut, but close (2.7/event)

Data not inconsistent with any of the scenarios

Spectra

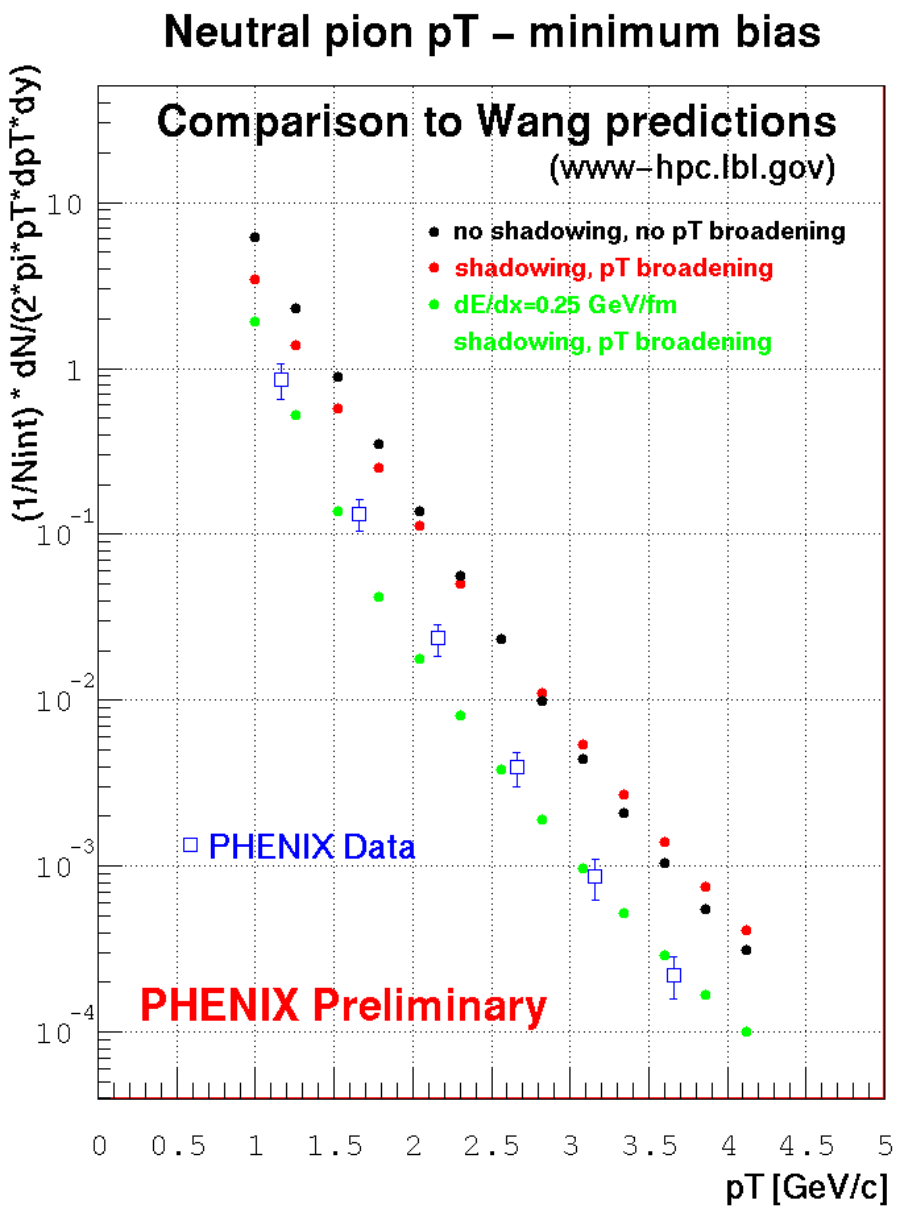
I would like to emphasize, that these were really predictions!

Data: mean number of collisions is 220

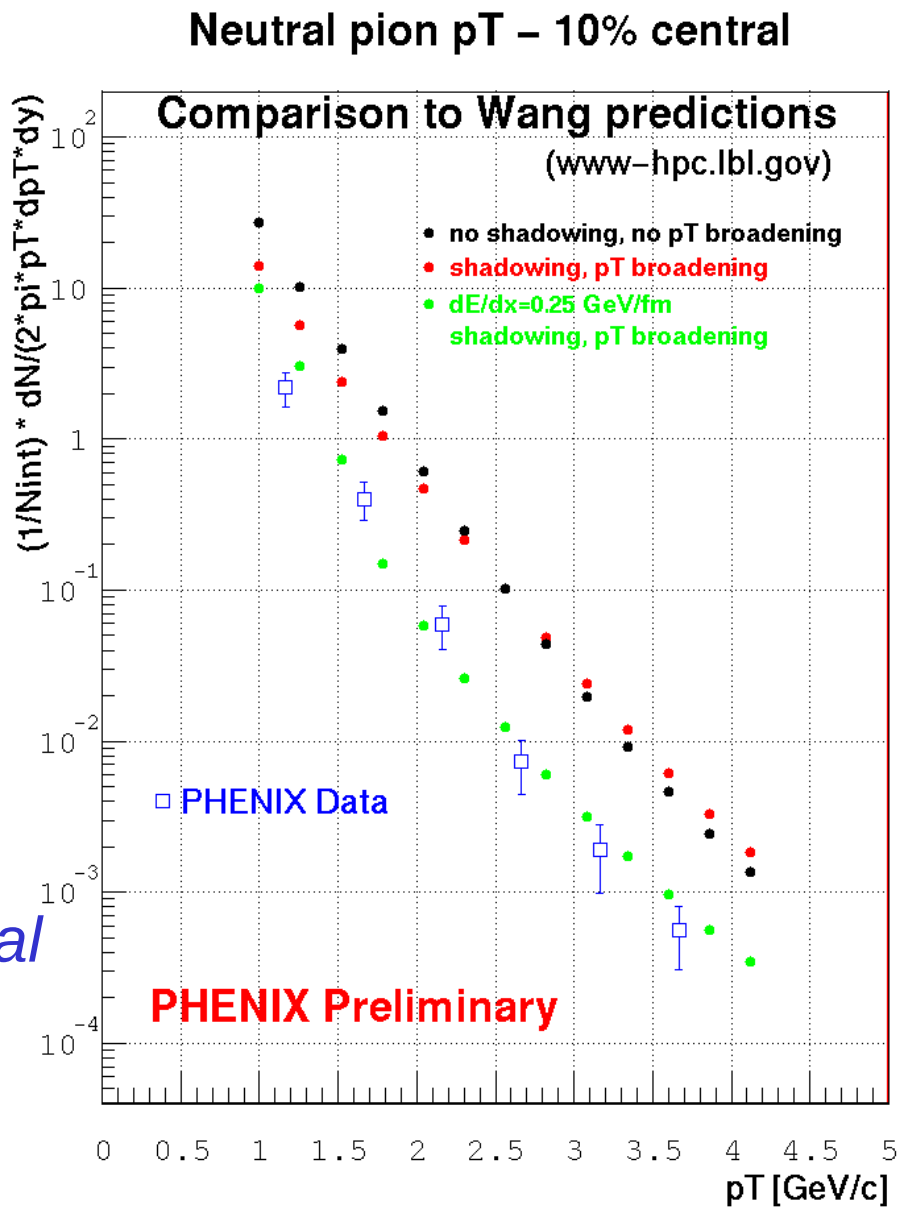
Inconsistent with scenarios without dE/dx loss

Not inconsistent with dE/dx=0.25 GeV/fm

Suggests some difference in the shapes



Spectra



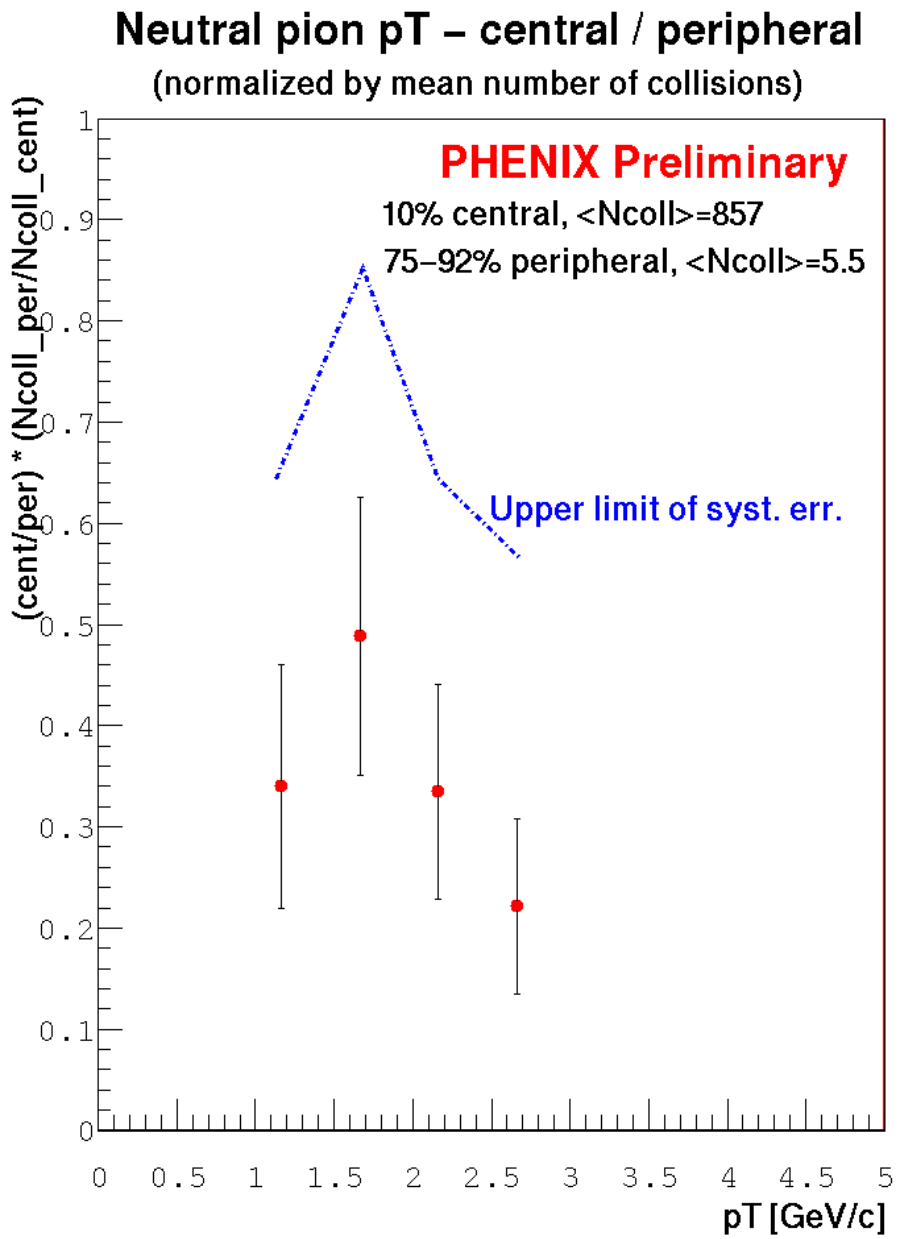
Data: mean number of collisions is 857

Inconsistent with scenarios without dE/dx loss

Not inconsistent with dE/dx=0.25 GeV/fm

Data are closer to exponential than theory

Ratios



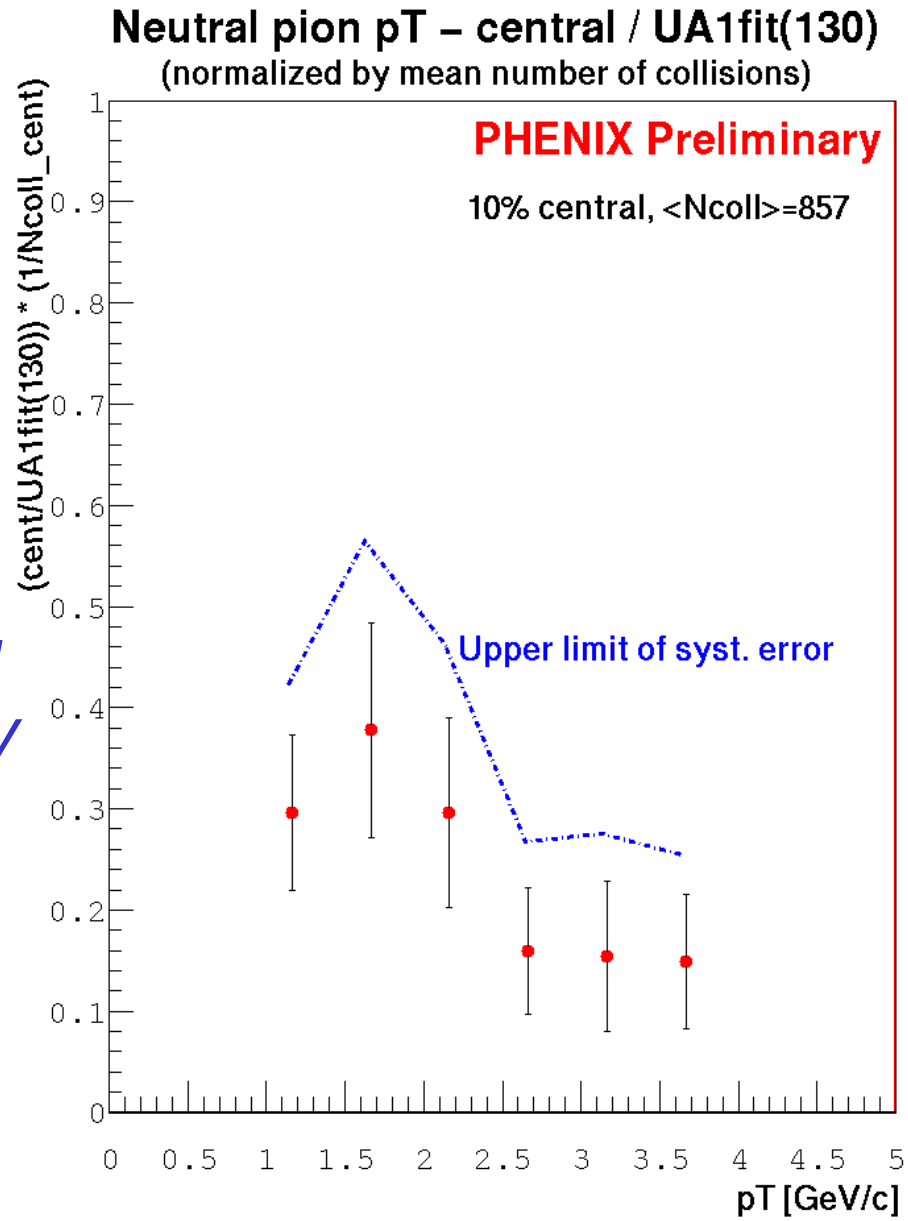
Ratios of per-collision yields (central/peripheral)

Main systematic error: Ncoll in peripheral

pT limited by peripheral data

There is a clear deficit, particularly at higher pT

Ratios



Ratio of per-collision central yield to UA1 fit at 130 GeV

Systematic error small

The deficit observed in central/peripheral is significant

Inconsistent with pointlike interaction

Summary

PHENIX measured neutral pion pT spectra between 1-4 GeV/c

This measurement is unique at RHIC

Results inconsistent with straightforward scaling with binary collisions: we observe a substantial deficit

Results are not inconsistent with strong effects from the dense medium

The deficit is even more pronounced than for charged particles