Scaling of Charged Hadron p_T distributions in Au+Au collisions at 200 GeV

Gerrit van Nieuwenhuizen
MIT
for the PHOBOS Collaboration

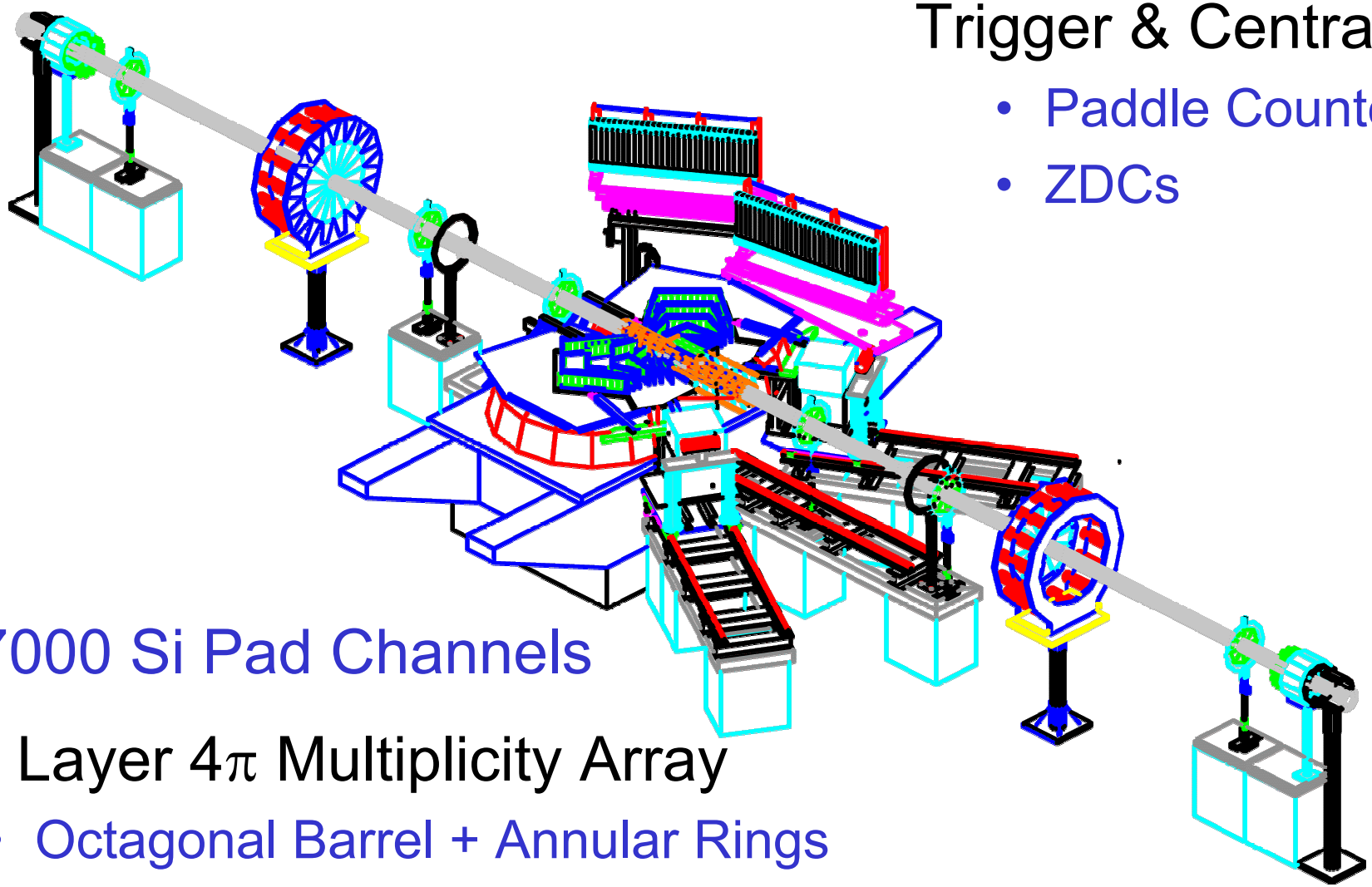
ICHEP 2002
July 24-31, 2002, Amsterdam

PHOBOS Collaboration



ARGONNE NATIONAL LABORATORY	Birger Back, Alan Wuosmaa
BROOKHAVEN NATIONAL LABORATORY	Mark Baker, Donald Barton, Alan Carroll, Nigel George, Stephen Gushue, George Heintzelman, Burt Holzman, Robert Pak, Louis Remsberg, Peter Steinberg, Andrei Sukhanov
INSTITUTE OF NUCLEAR PHYSICS, KRAKOW	Andrzej Budzanowski, Roman Hołyński, Jerzy Michałowski, Andrzej Olszewski, Pawel Sawicki, Marek Stodulski, Adam Trzupek, Barbara Wosiek, Krzysztof Woźniak
MASSACHUSETTS INSTITUTE OF TECHNOLOGY	Maartin Ballintijn, Wit Busza (Spokesperson), Patrick Decowski, Kristjan Gulbrandsen, Conor Henderson, Jay Kane, Judith Katzy, Piotr Kulinich, Jang Woo Lee, Heinz Pernegger, Corey Reed, Christof Roland, Gunther Roland, Leslie Rosenberg, Pradeep Sarin, Stephen Steadman, George Stephans, Carla Vale, Gerrit van Nieuwenhuizen, Gábor Veres, Robin Verdier, Bernard Wadsworth, Bolek Wysłouch
NATIONAL CENTRAL UNIVERSITY, TAIWAN	Chia Ming Kuo, Willis Lin, Jaw-Luen Tang
UNIVERSITY OF ILLINOIS AT CHICAGO	Russell Betts, Edmundo Garcia, Clive Halliwell, David Hofman, Richard Hollis, Aneta Iordanova, Wojtek Kucewicz, Don McLeod, Rachid Nouicer, Michael Reuter, Joe Sagerer
UNIVERSITY OF MARYLAND	Abigail Bickley, Richard Bindel, Alice Mignerey, Marguerite Belt Tonjes
UNIVERSITY OF ROCHESTER	Joshua Hamblen, Erik Johnson, Nazim Khan, Steven Manly, Inkyu Park, Wojtek Skulski, Ray Teng, Frank Wolfs

The PHOBOS Apparatus



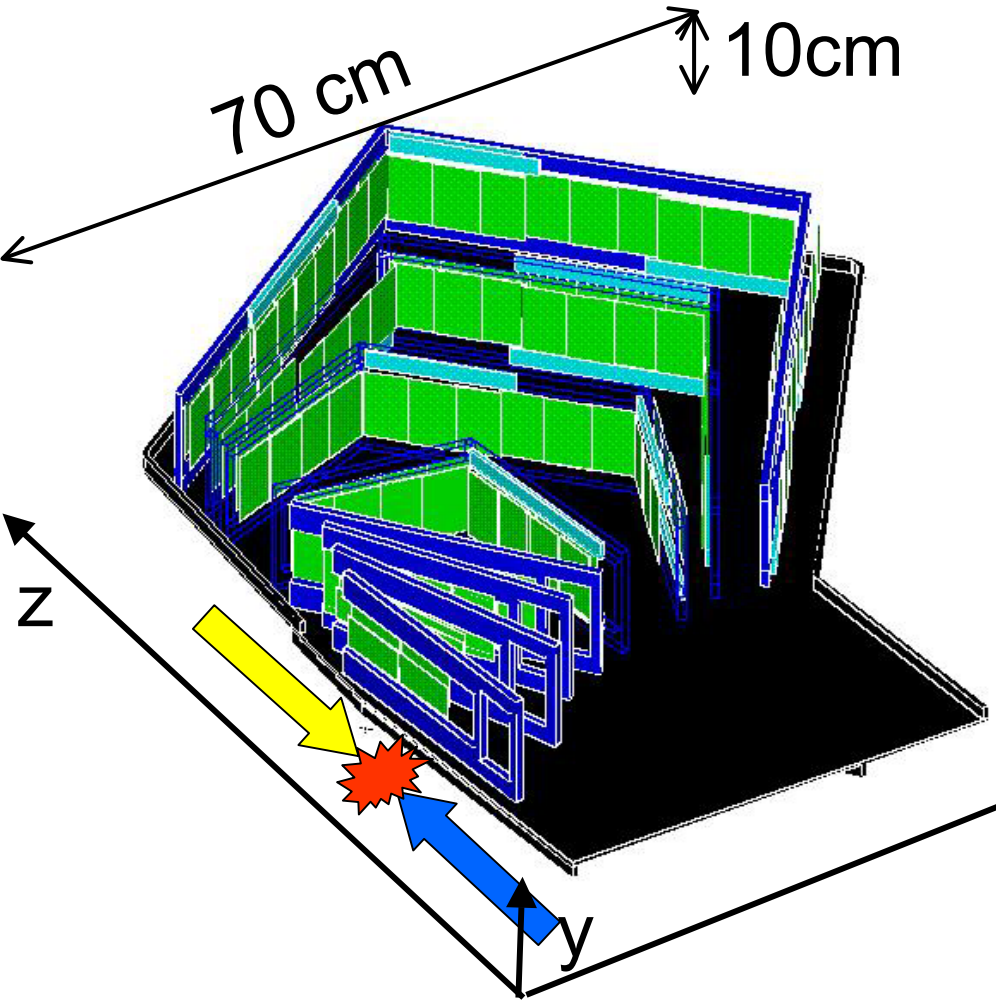
Trigger & Centrality

- Paddle Counters
- ZDCs

137000 Si Pad Channels

- 1 Layer 4π Multiplicity Array
  - Octagonal Barrel + Annular Rings
- 16 Layer 2-Arm Spectrometer

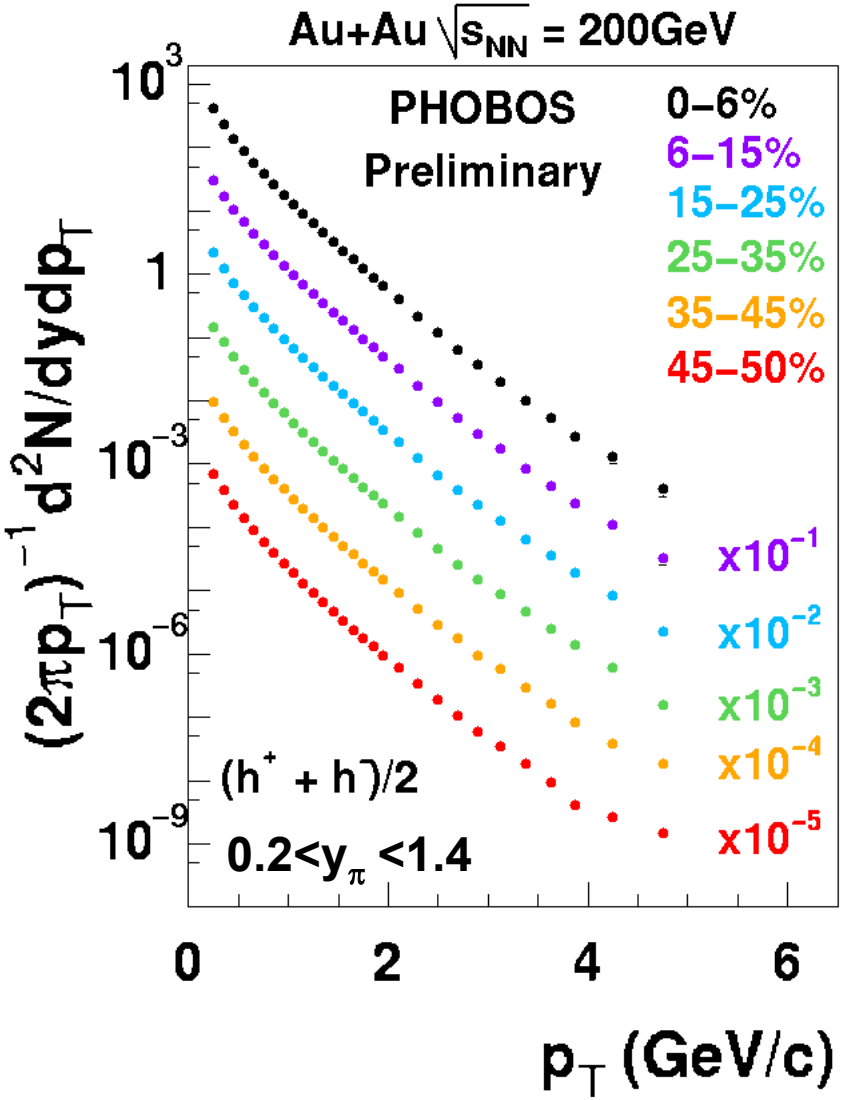
The PHOBOS Spectrometer



- Outer layers situated in 2T magnetic field
- High segmentation in bending direction
- Tracking within 10 cm of interaction point

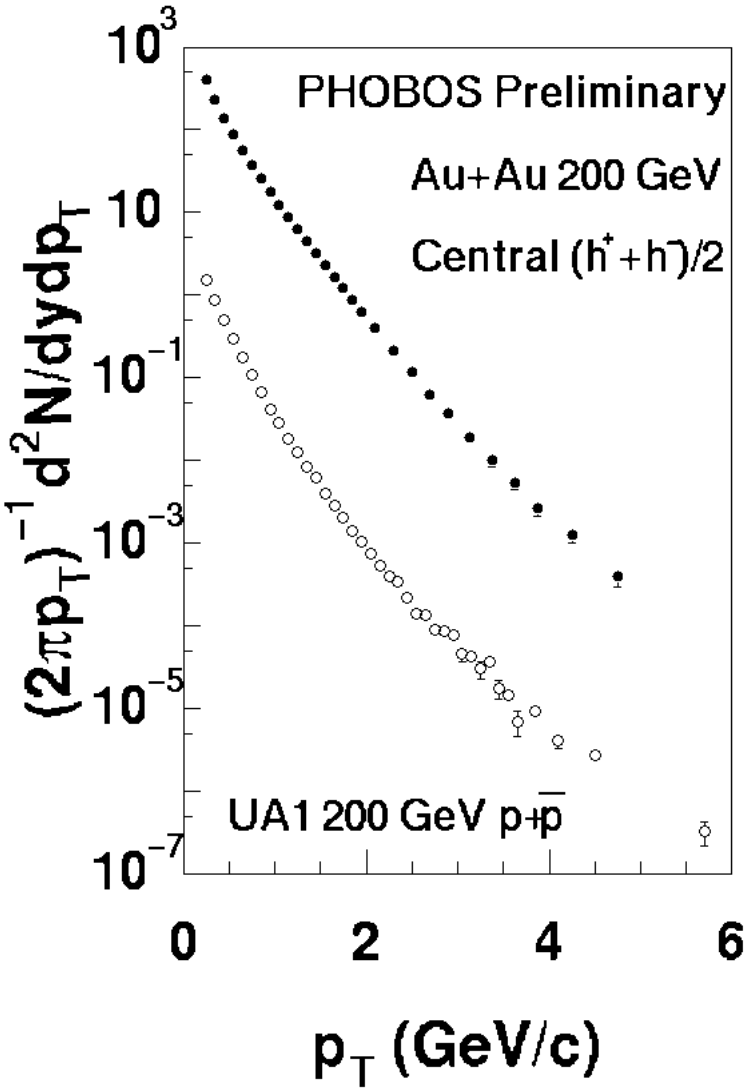
- Coverage near mid-rapidity
- Phi acceptance of 3% per Arm

PHOBOS-Spectra @ 200GeV



- Spectra corrected for
  - Acceptance/Efficiency
  - Ghost Tracks
  - Momentum resolution
  - Variable bin width
  - Secondaries
- At 200 GeV min. bias. $p\bar{p}$ reference data exists

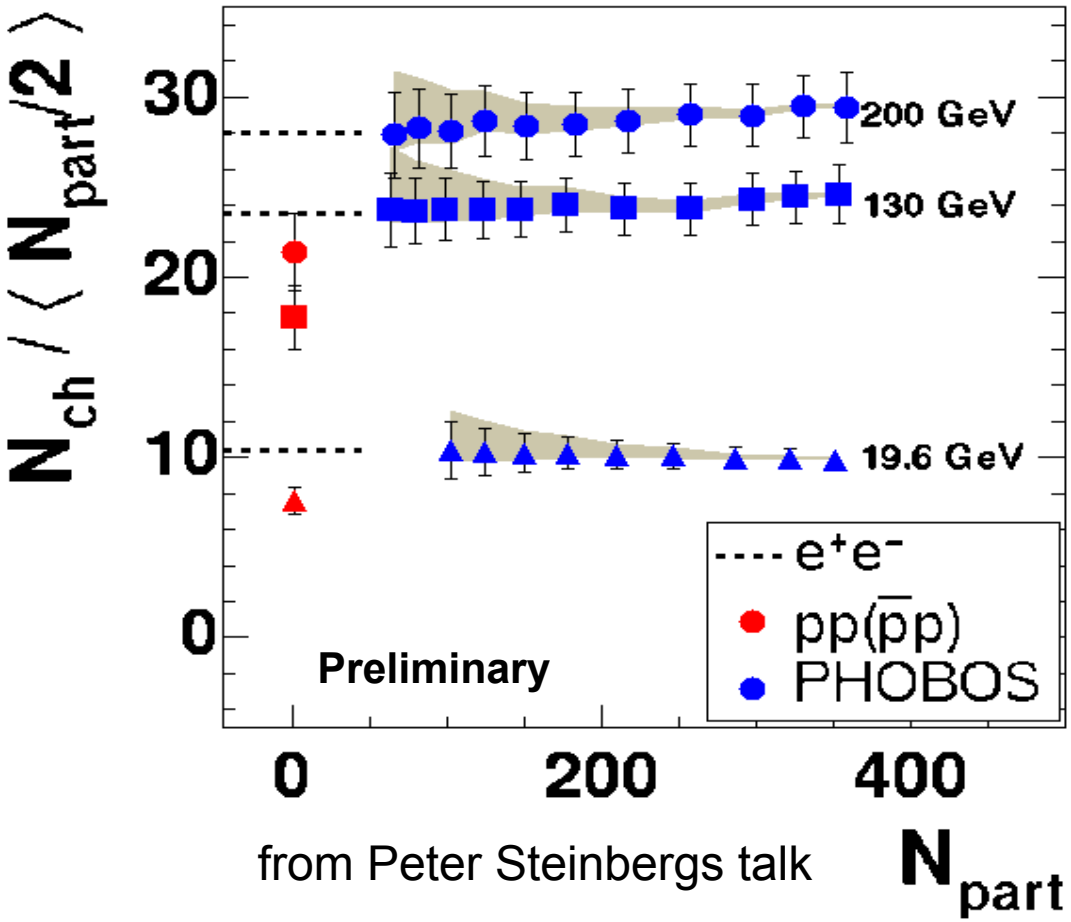
Comparing Au+Au and $p\bar{p}$ Spectra 1



- Production of high p_T particles dominated by hard scattering
- High p_T yield prop. to N_{coll} (binary collision scaling)
- Compare to $p\bar{p}$ spectra scaled up by N_{coll}
- Violation of N_{coll} scaling observed at 130GeV (PHENIX/STAR publications)
- Jet quenching?

Charged Particle Production

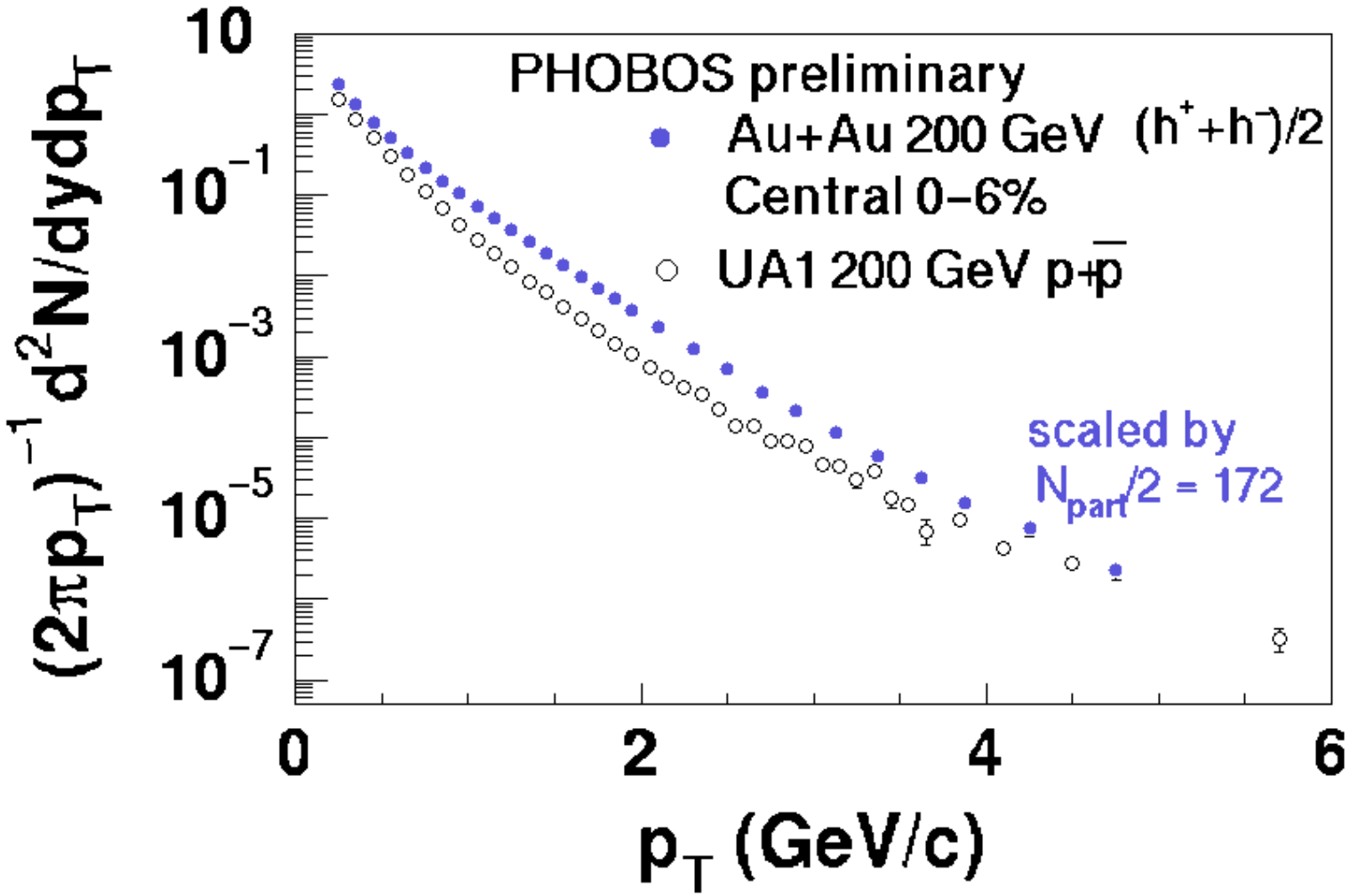
Total Multiplicity



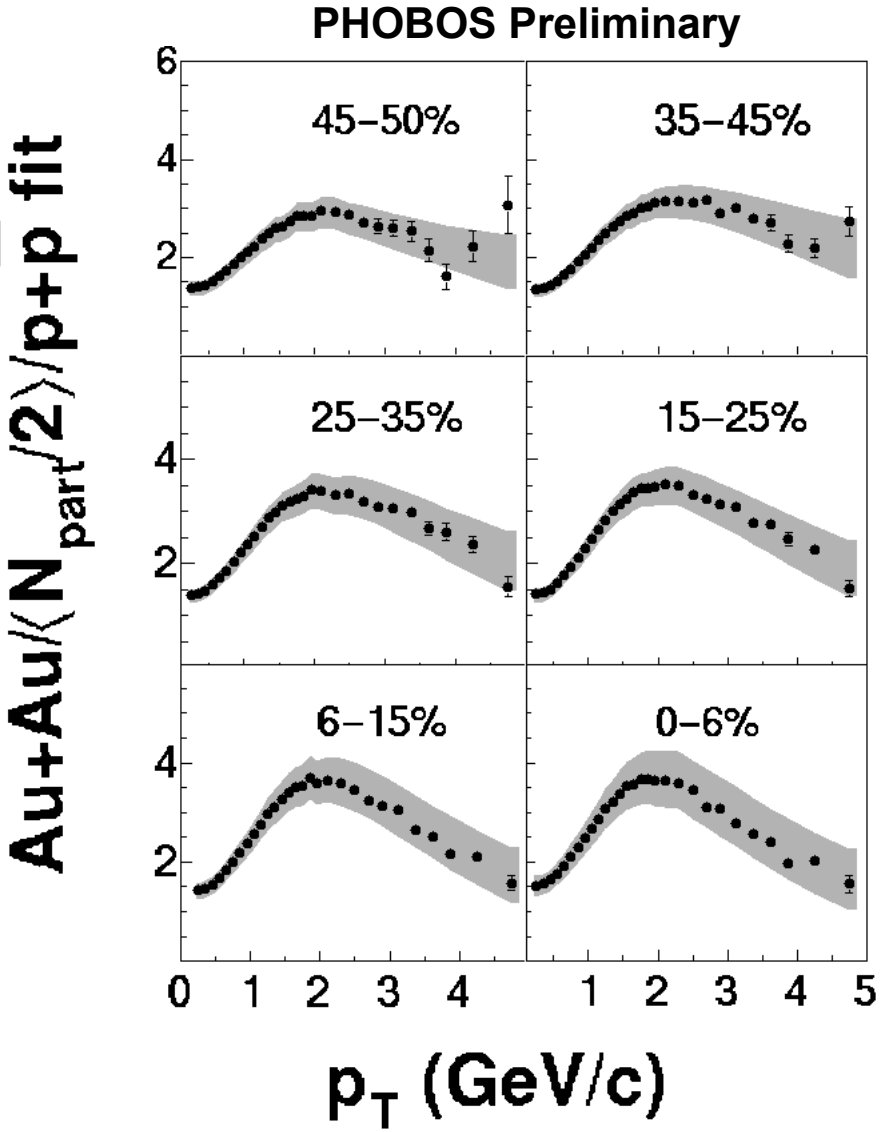
from Peter Steinbergs talk

Total multiplicity scales with N_{part}

Comparing Au+Au and $p\bar{p}$ Spectra 2



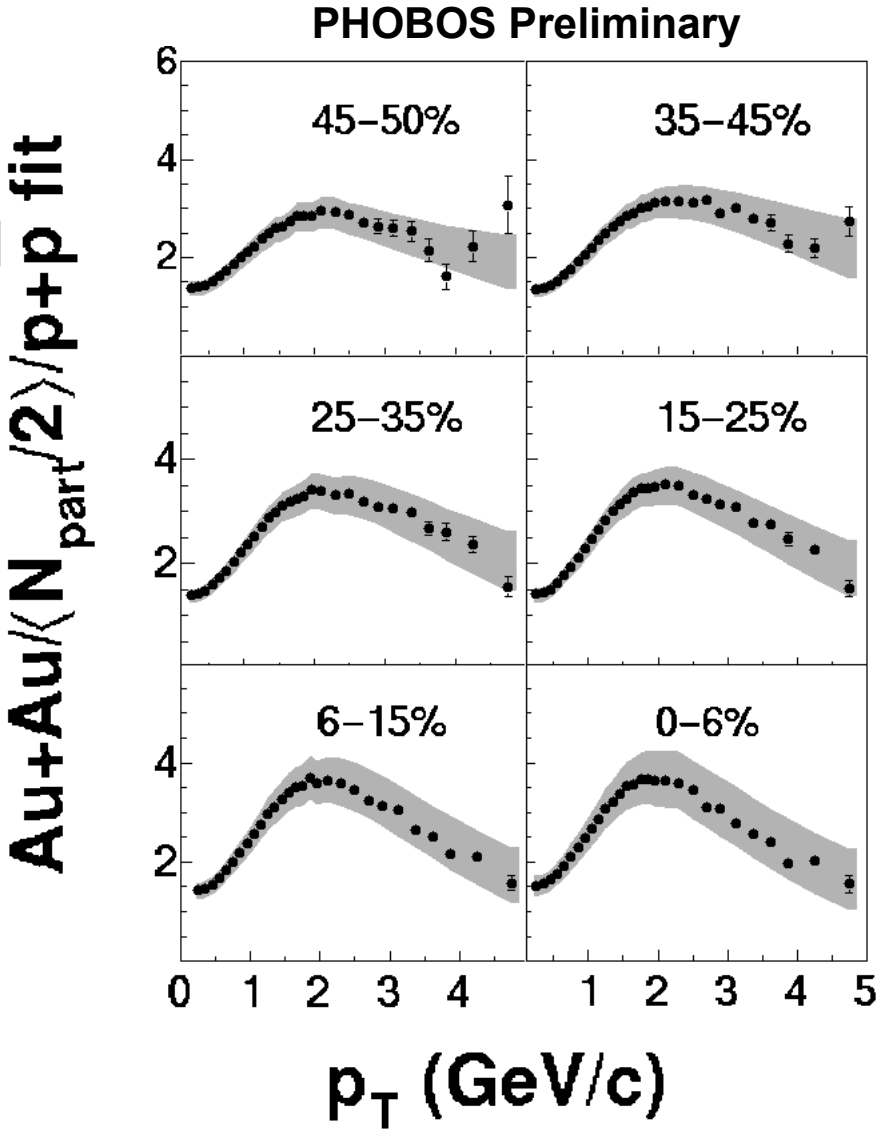
Scaled Spectra / $p\bar{p}$-Fit



Centrality	N_{part}
45-50%	65 ± 4
35-45%	93 ± 5
25-35%	138 ± 6
15-25%	200 ± 8
6-15%	276 ± 9
0-6%	344 ± 12

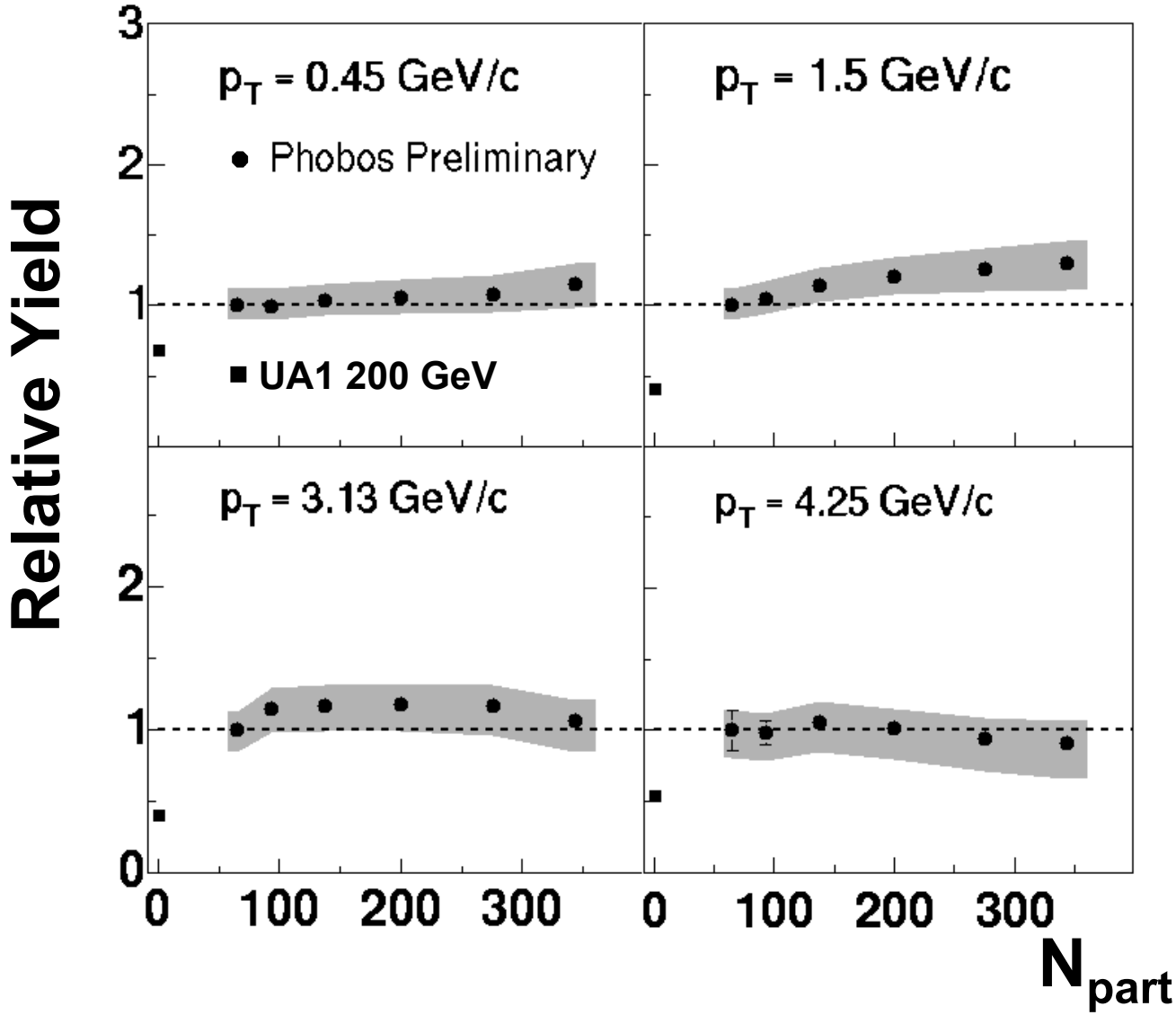
- Centrality range:
  - <b> from 10 to 3 fm
  - <ν> from 3 to 6

Scaled Spectra / $p\bar{p}$-Fit



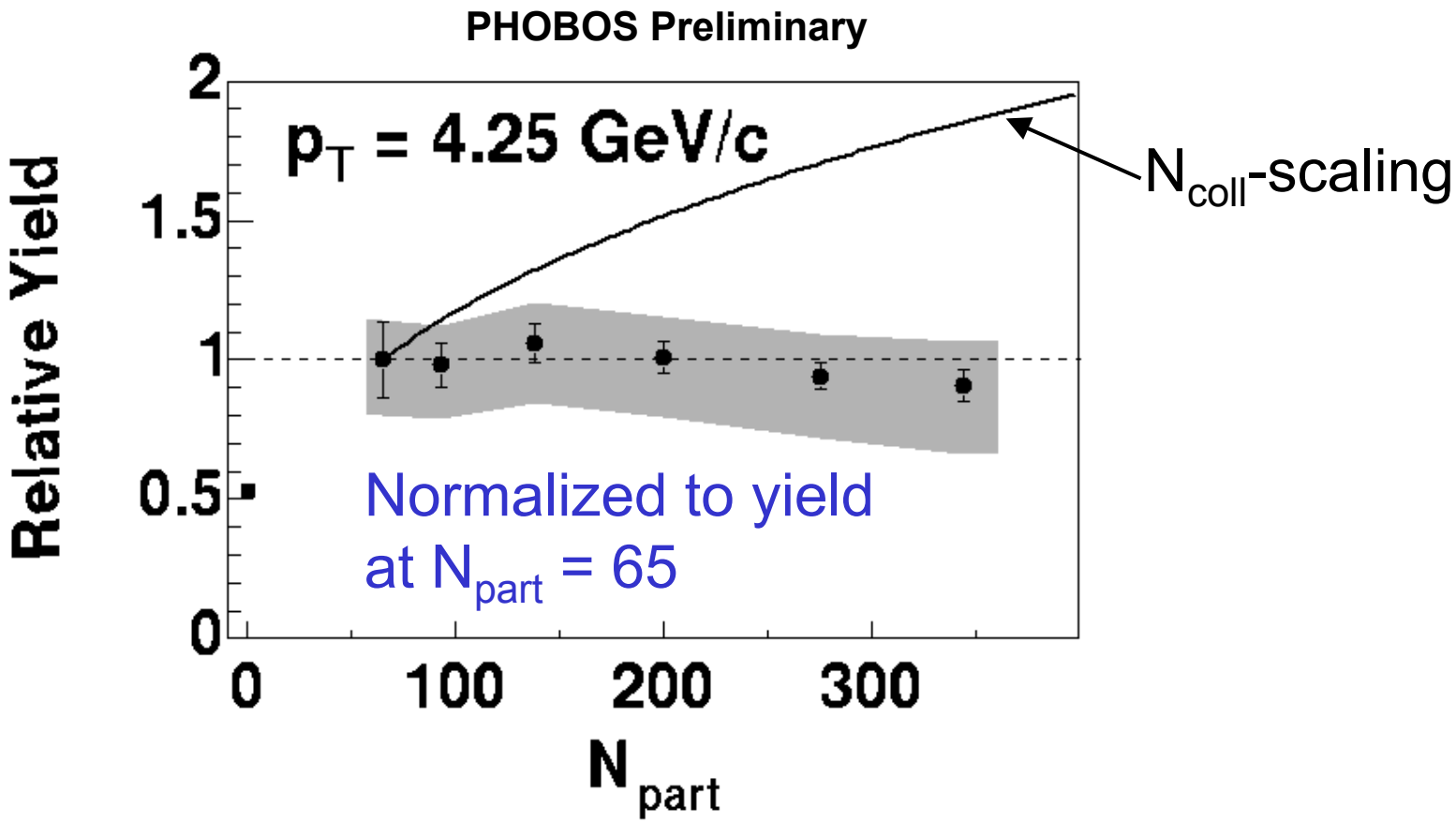
- Shape differs from $p\bar{p}$ already at $N_{part} = 65$
- Moderate change from $N_{part} = 65$ to $N_{part} = 344$

Centrality scaling in p_T bins



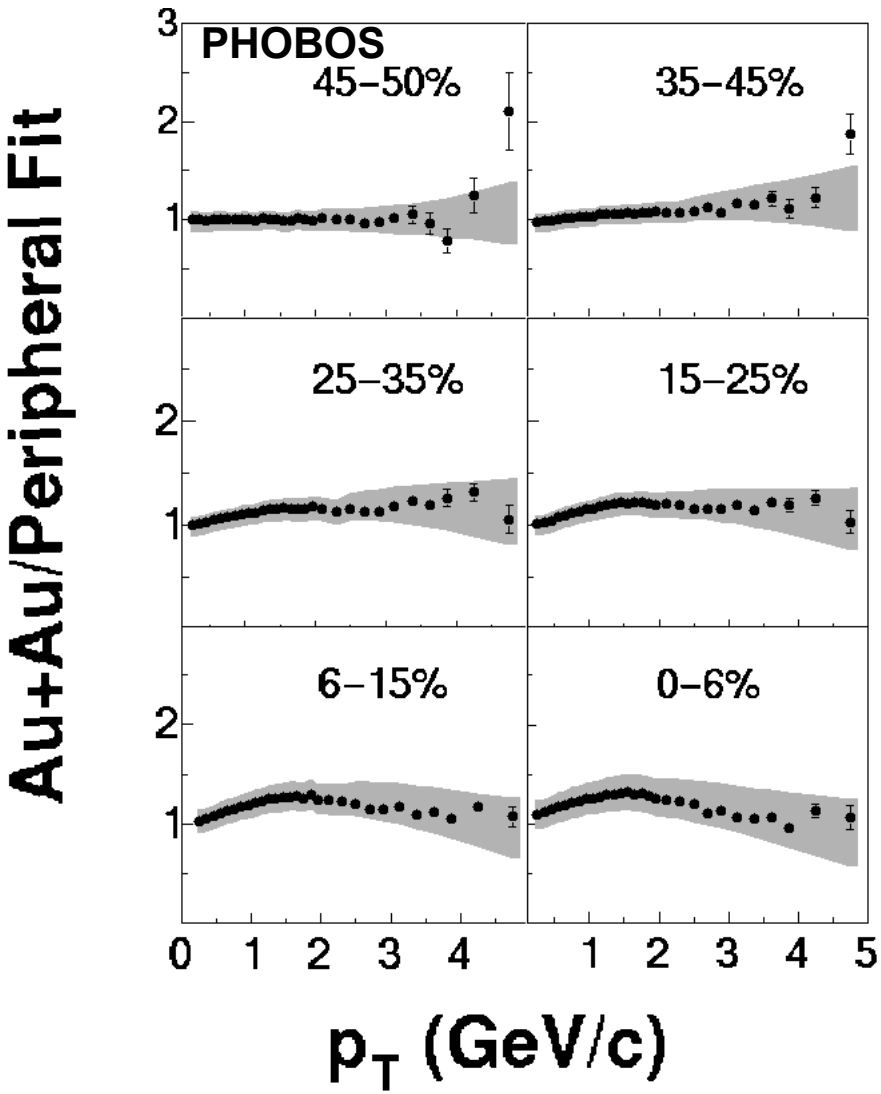
Spectra normalized to yield at $N_{part} = 65$

N_{part} Scaling at high p_T



$\Rightarrow N_{part}$ scaling describes data at p_T = 4.25 GeV/c

Evolution with Centrality



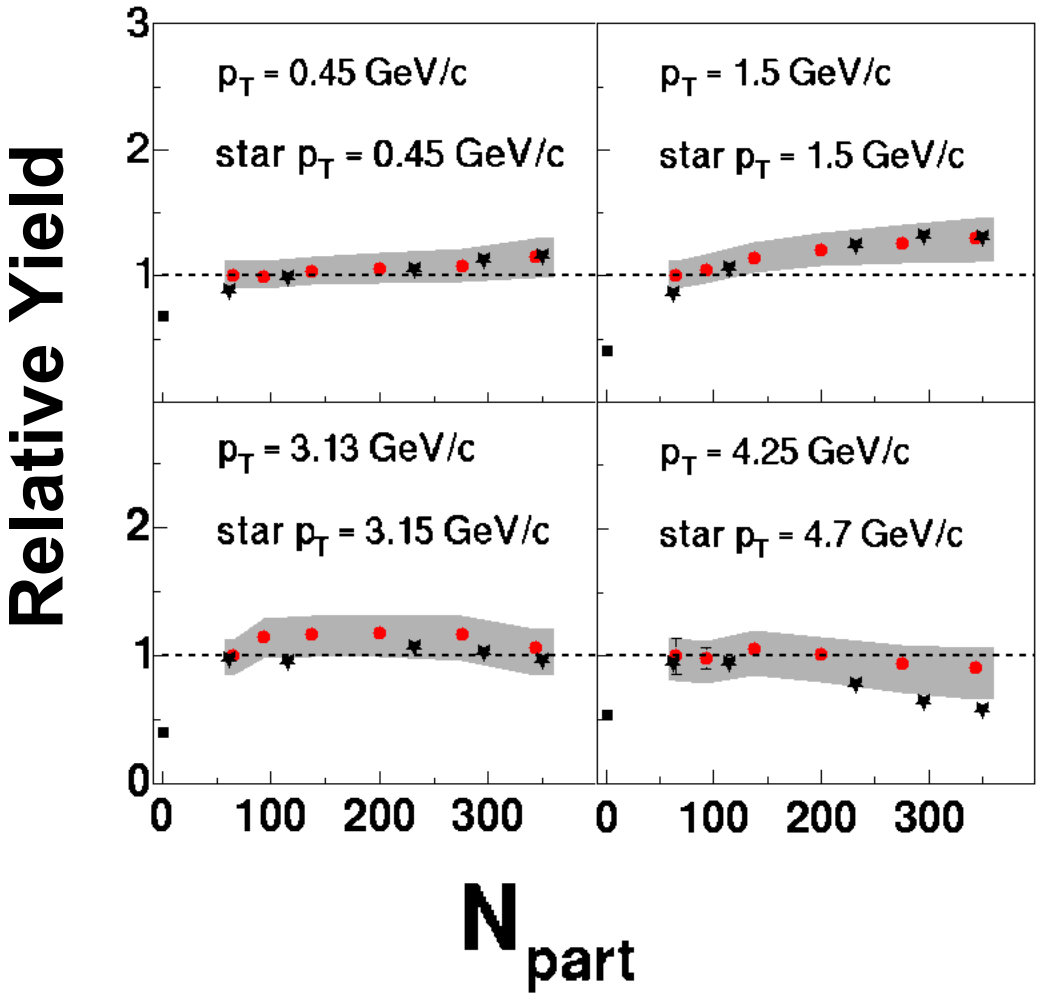
- Follow change of shape vs most peripheral bin
- Dominantly participant scaling
- Violated by about 30% for most central collisions

Summary

- Measured $h^{+,-}$ p_T spectra in 200 GeV Au+Au collisions
  - p_T range: $0.2 < p_T < 5$ GeV/c
  - Rapidity range: $0.2 < y_\pi < 1.4$
  - Centrality range: $65 < N_{part} < 344$
- Data show:
  - Substantial difference in spectral shape between $p\bar{p}$ and peripheral Au+Au ($N_{part} \sim 65$)
  - Minor change from 65 to 344 participants
  - Even at p_T of 4 – 5 GeV/c, N_{part}-scaling from peripheral to central Au+Au

The End

Comparison to Lower Energies



- Data taken at 130GeV shows similar trends
- Shape is consistent with measurements by STAR

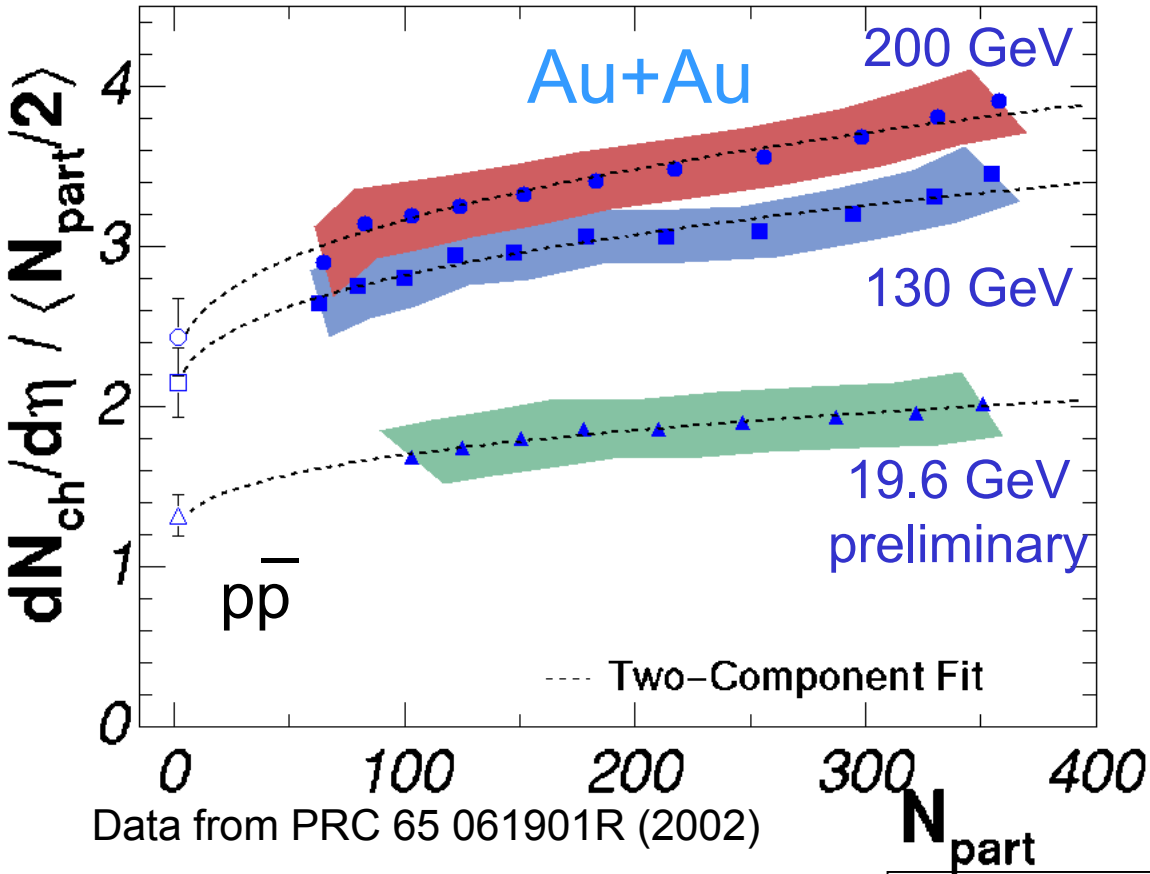
How to compare spectra to $p\bar{p}$?

- Observations:
  - Mid-rapidity multiplicity compatible with two component model
  - Total multiplicity shows N_{part} scaling

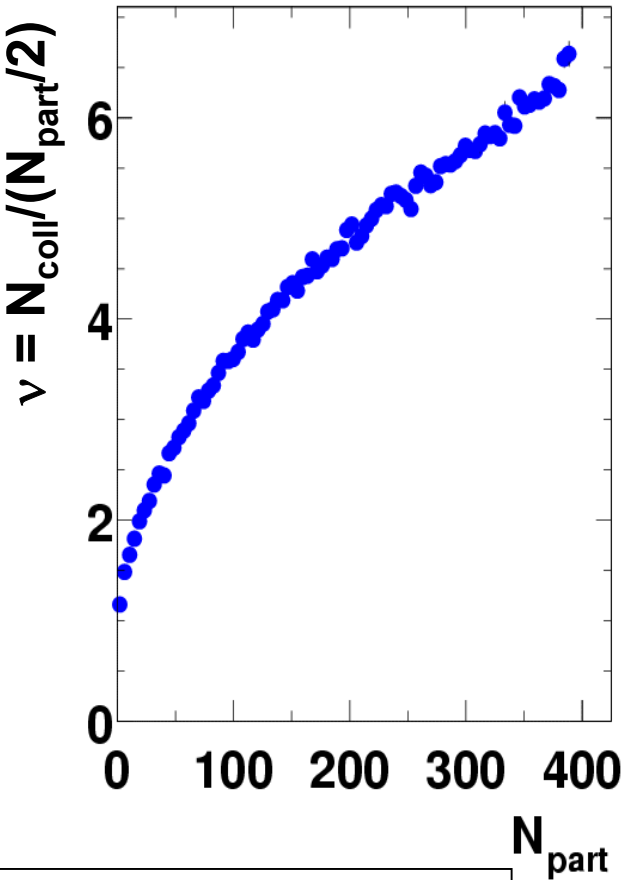
- How do spectra scale with centrality?
  - Does scaling change over the p_T range?
  - Crucial for physics interpretation

Charged Particle Production

Central Density



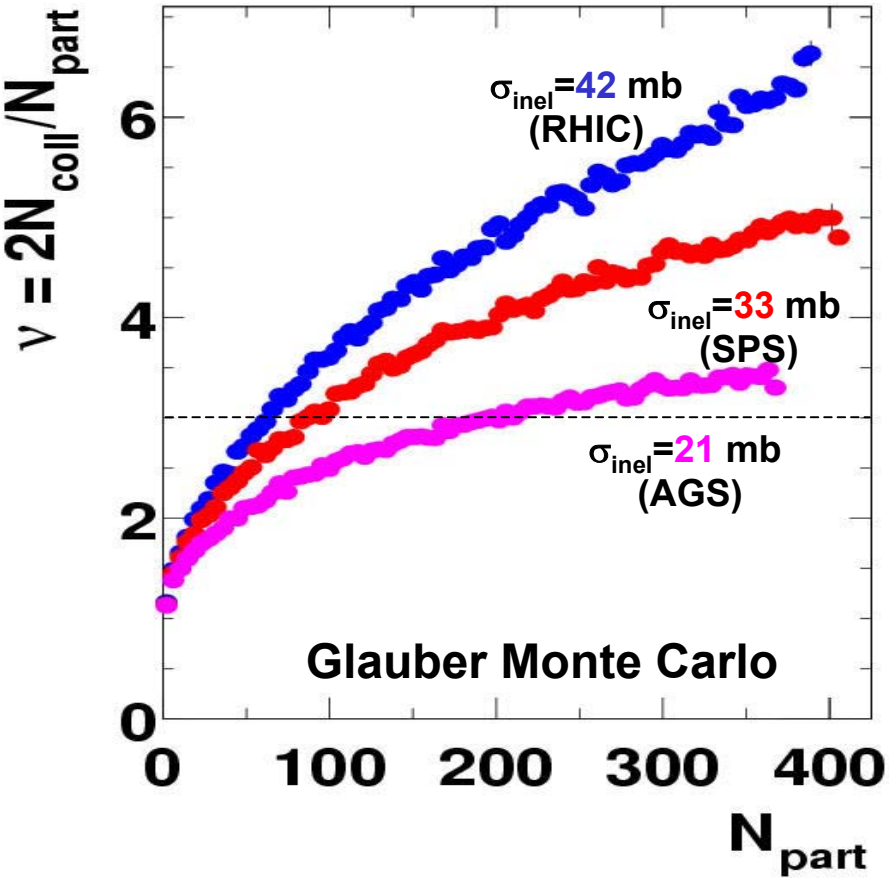
Data from PRC 65 061901R (2002)



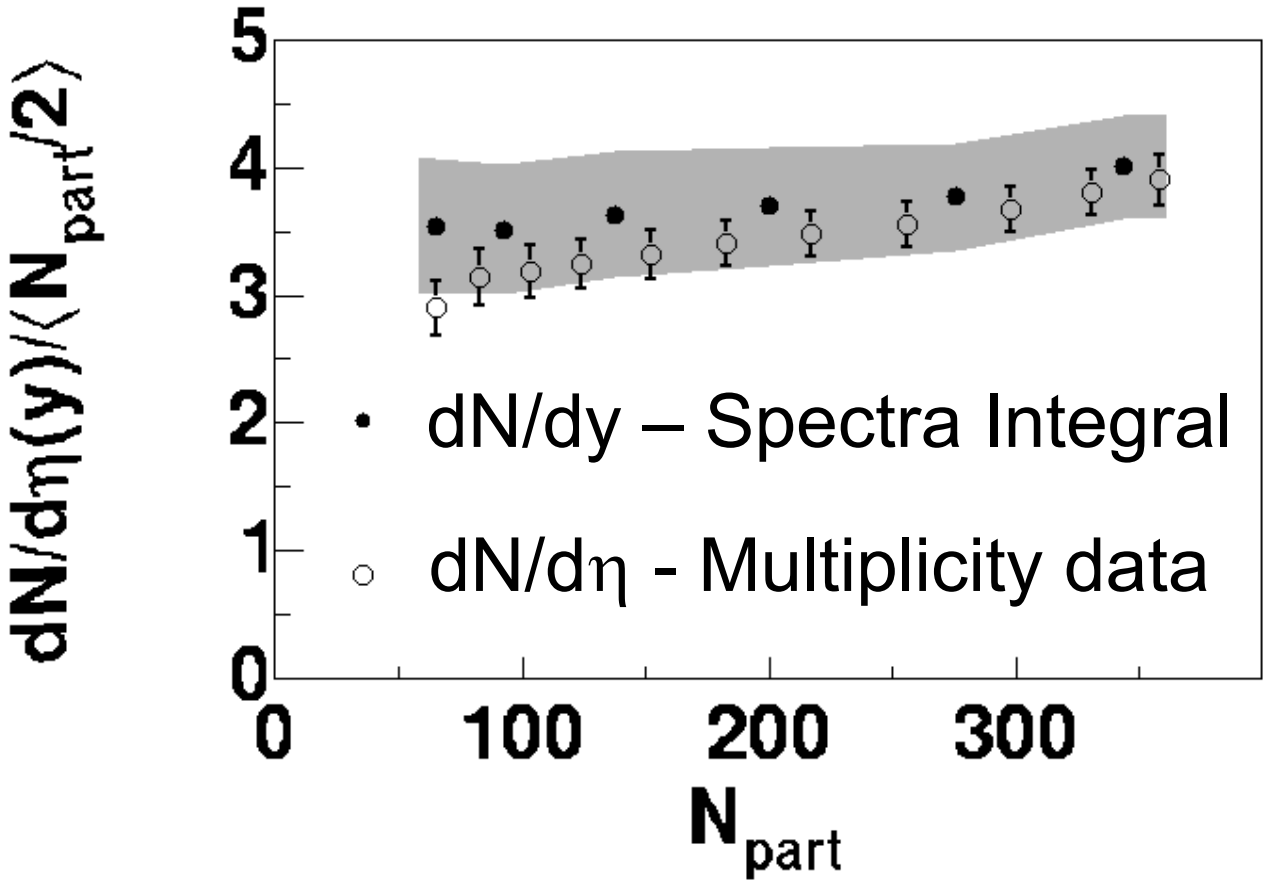
Two Component Model:

$$\frac{dN}{d\eta} = (1-x)n_{pp}N_{part} + xn_{pp}N_{coll}$$

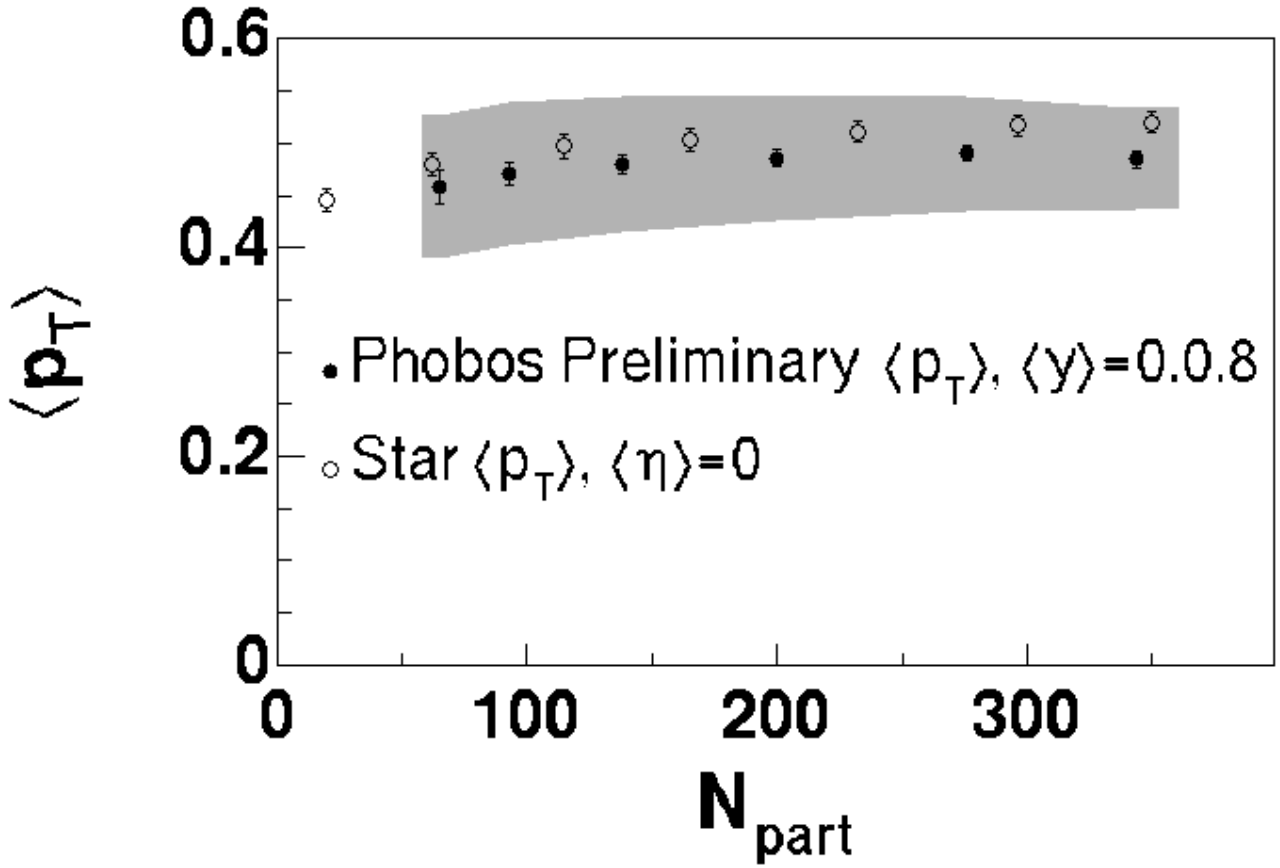
Number of collisions at different Energies



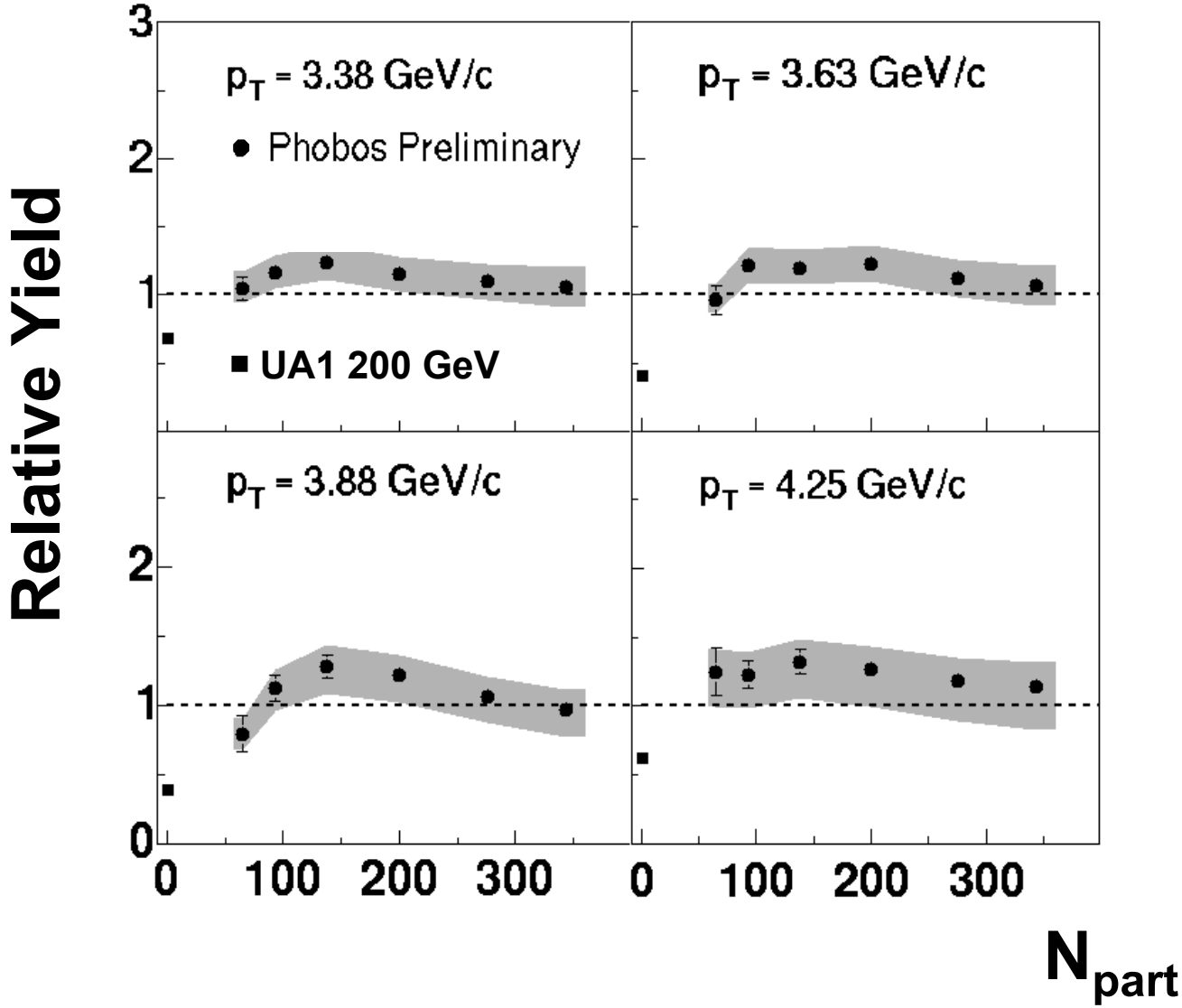
Integrated Yields vs Centrality



Mean p_T vs centrality

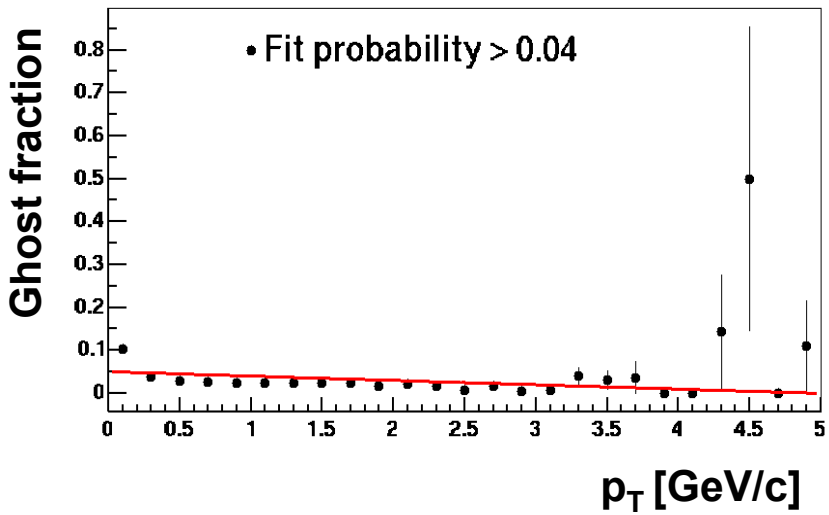


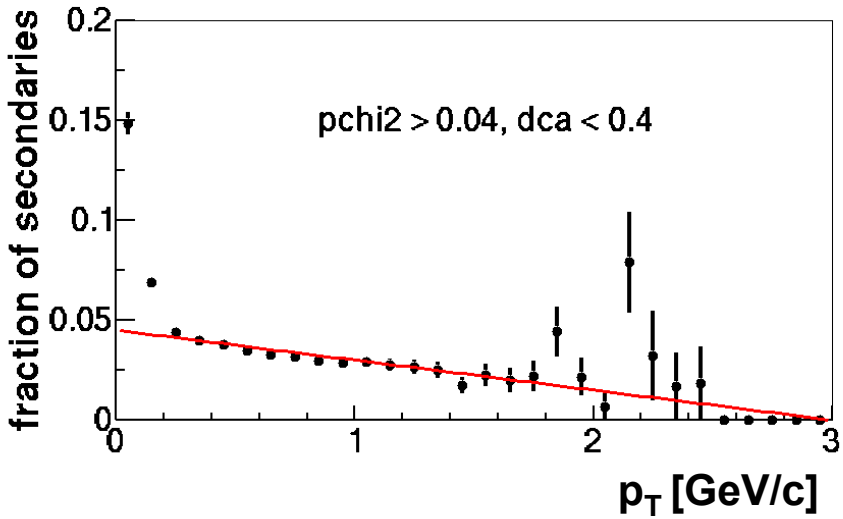
Centrality scaling in p_T bins

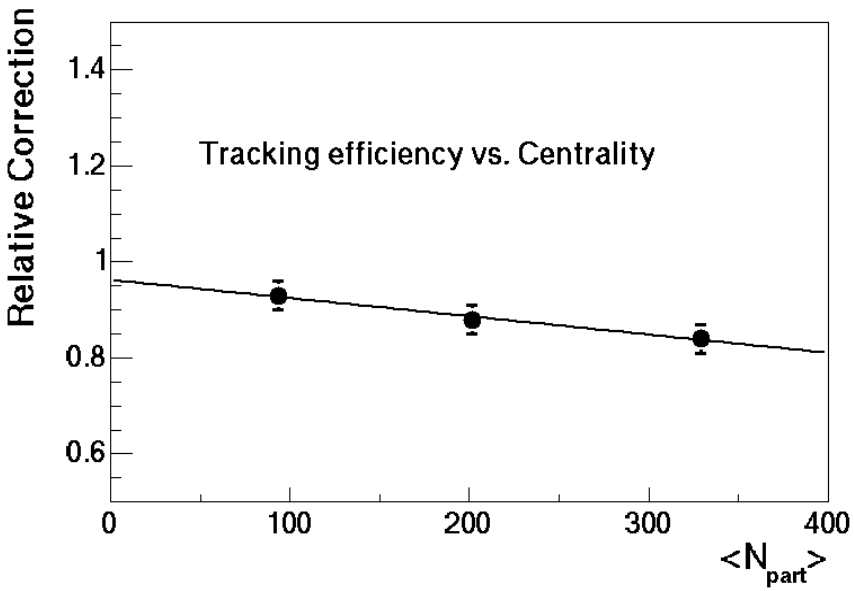


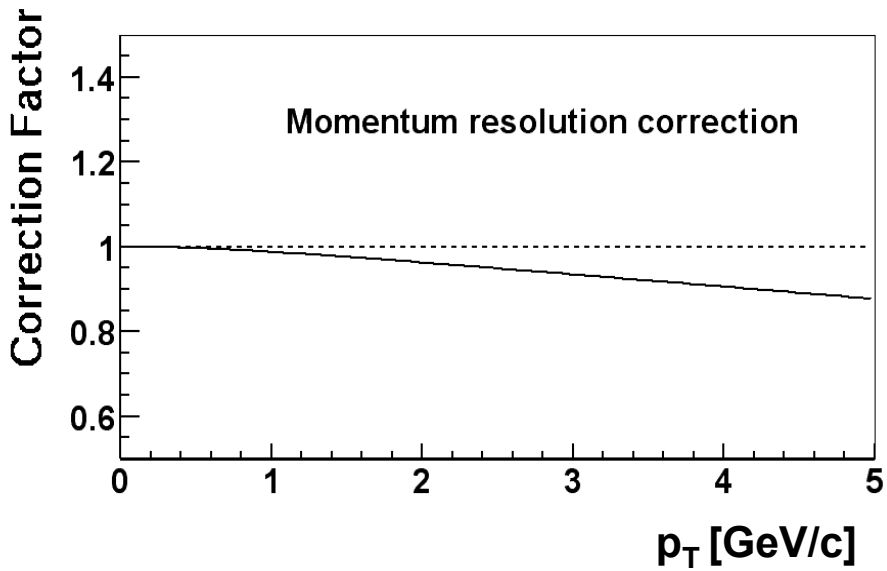
Spectra normalized to FIT to yield at N_{part} = 65

Corrections

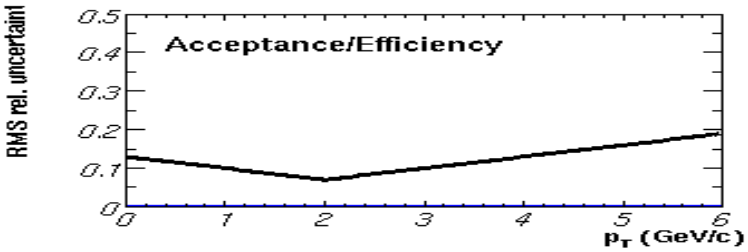


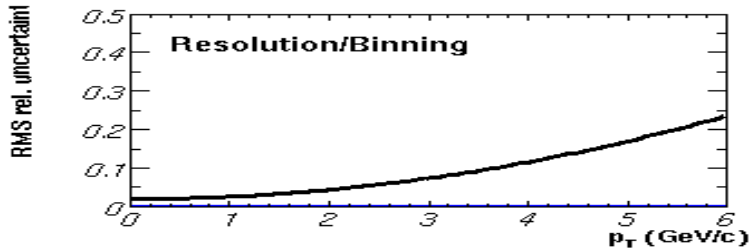


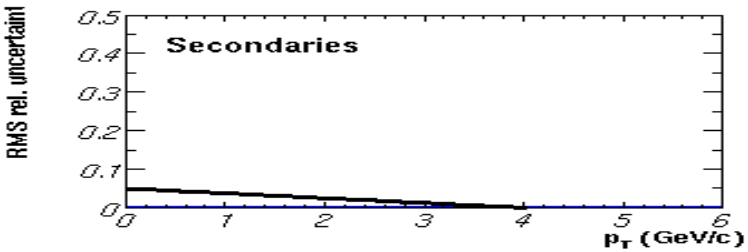


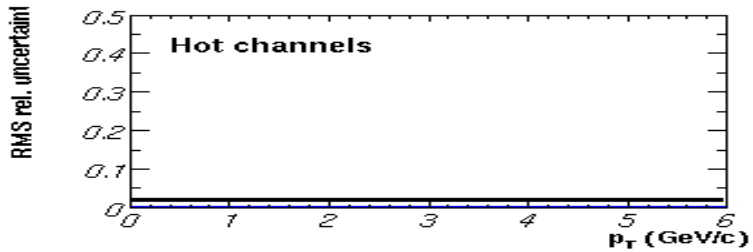


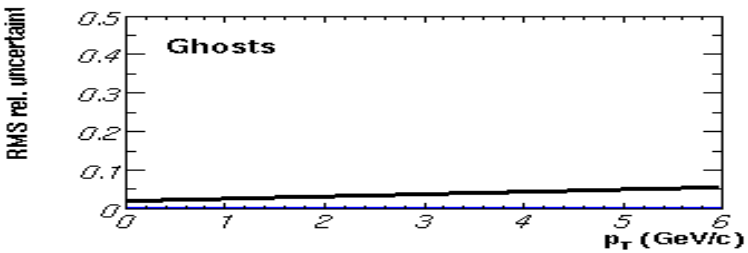
Systematic Errors

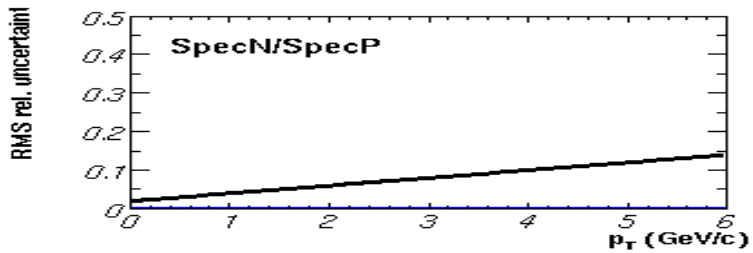


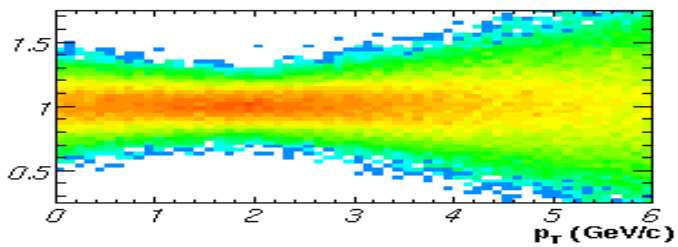


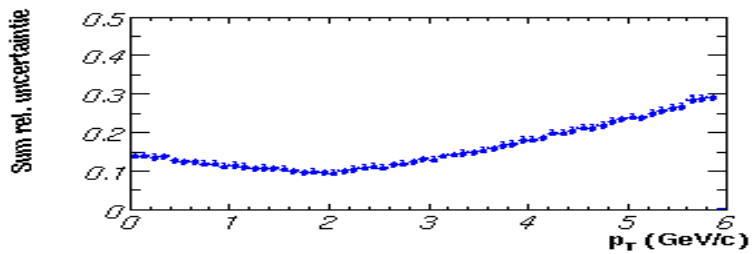




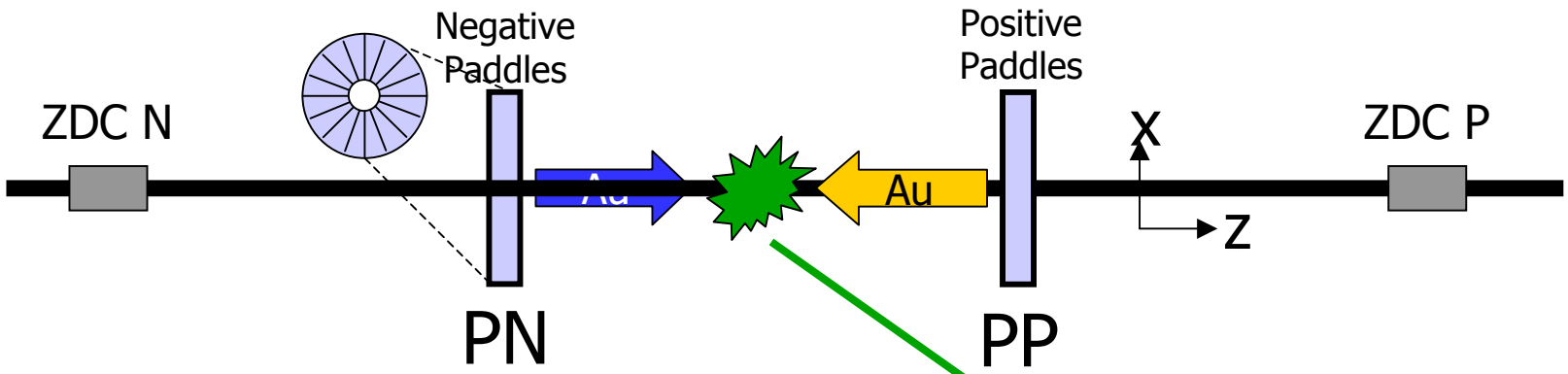




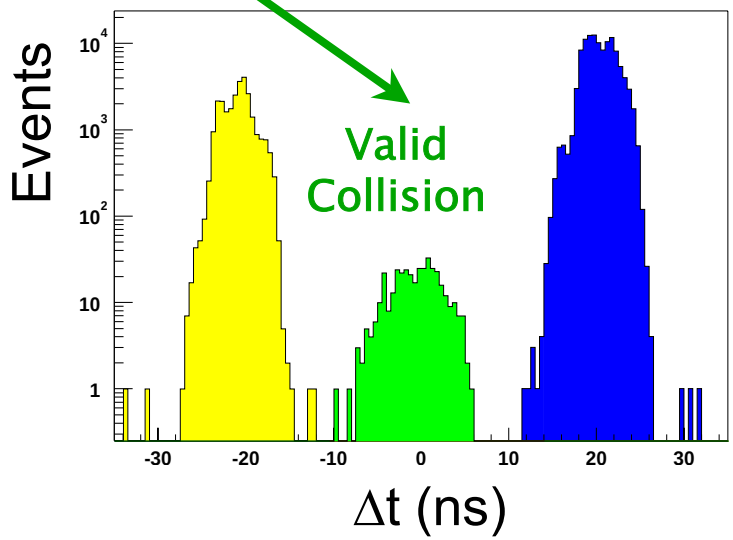




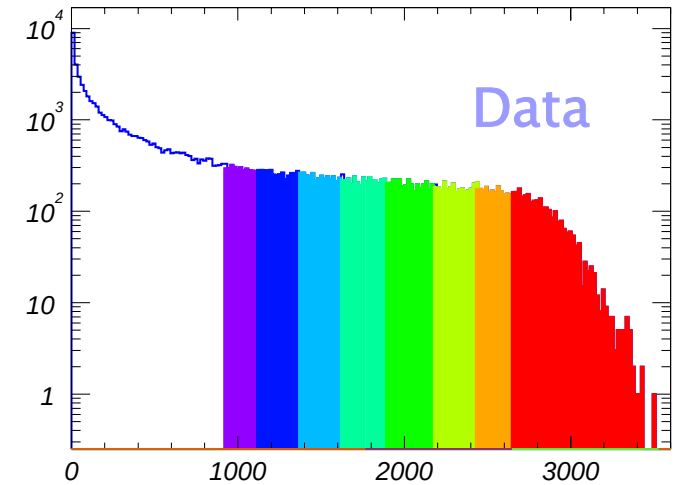
Triggering on Interactions

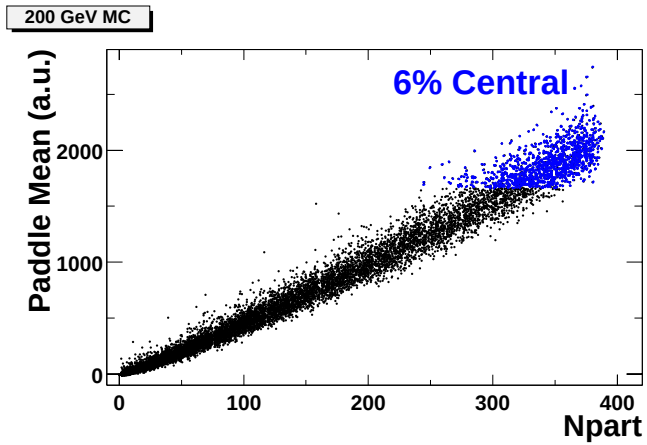


- **Coincidence between Paddle counters**
- **Paddle + ZDC timing reject background**

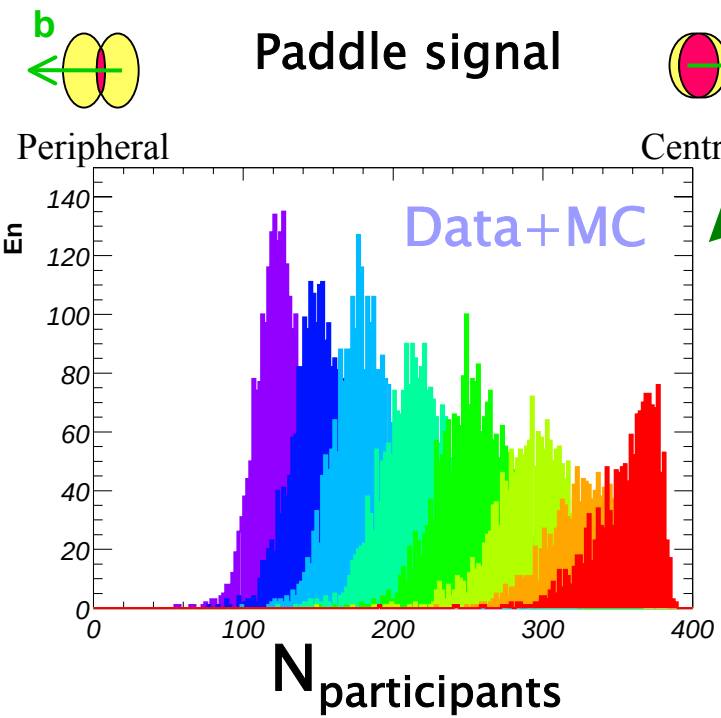


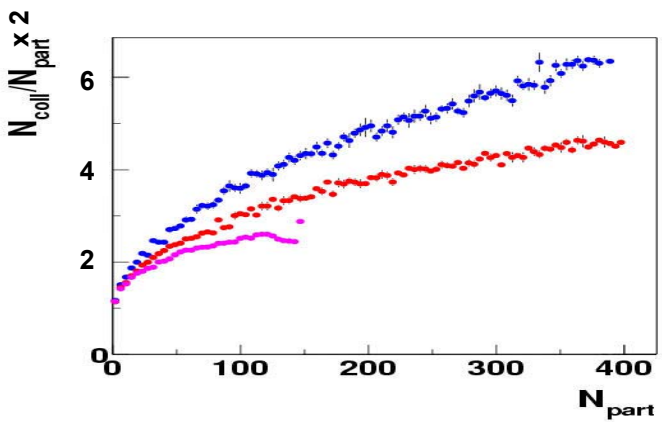
Centrality Determination



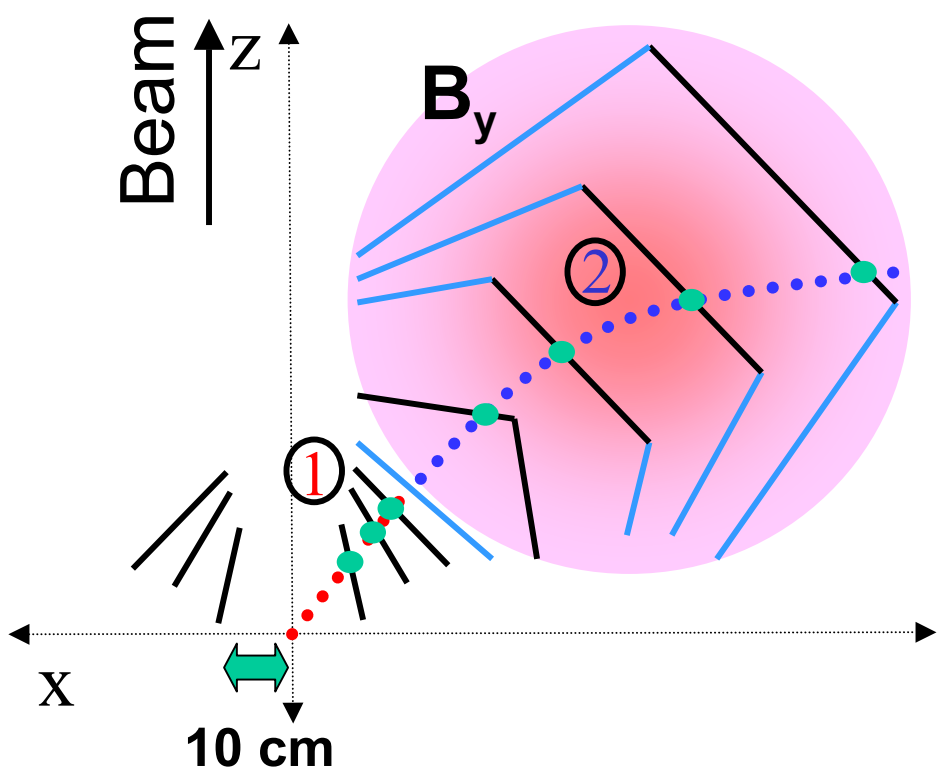


HIJING +GEANT
Glauber calculation
Model of paddle trigger





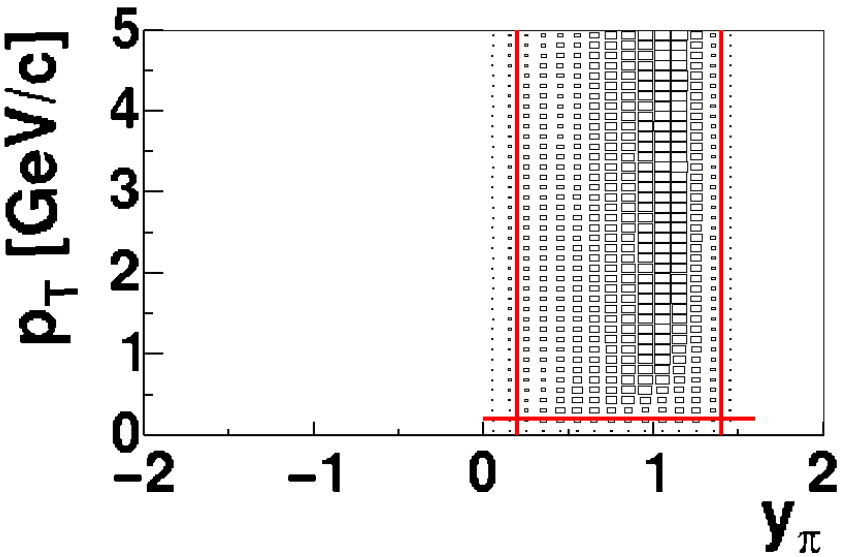
Particle Tracking In Spectrometer



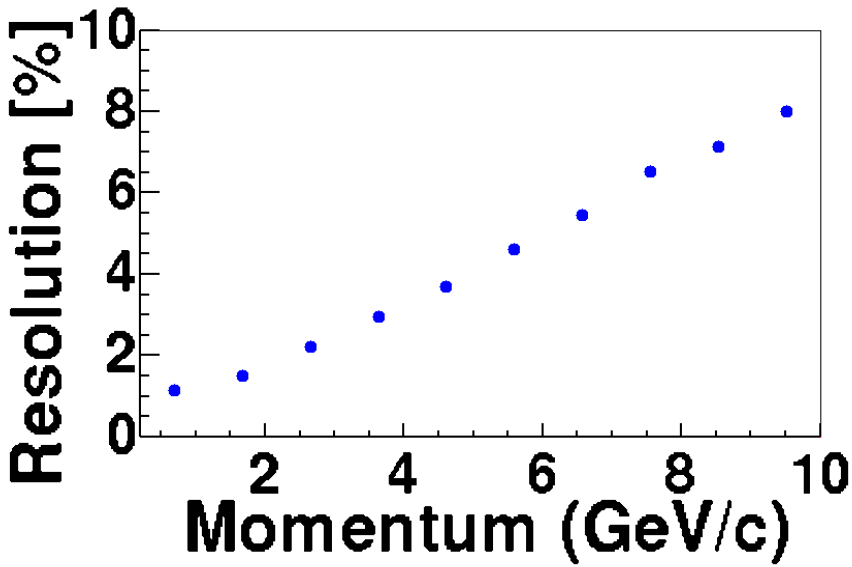
1. Road-following algorithm finds straight tracks in field-free region
2. The curved tracks in B-field found by clusters in (1/p, θ) space
3. Find match of straight and curved by θ, consistency in dE/dx and fit in yz-plane
4. Covariance matrix track fit for momentum reconstruction and ghost rejection

Spectrometer Performance

Acceptance



Momentum Resolution



Data Sample Production Run 2001(200 GeV)

- 7.8 M Au+Au Events, Min. Bias Trigger
- 32 M reconstructed particles