Energy and centrality dependence of particle production at very low transverse momenta in Au+Au collisions

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PHOBOS

Collaboration

PHOBOS Collaboration



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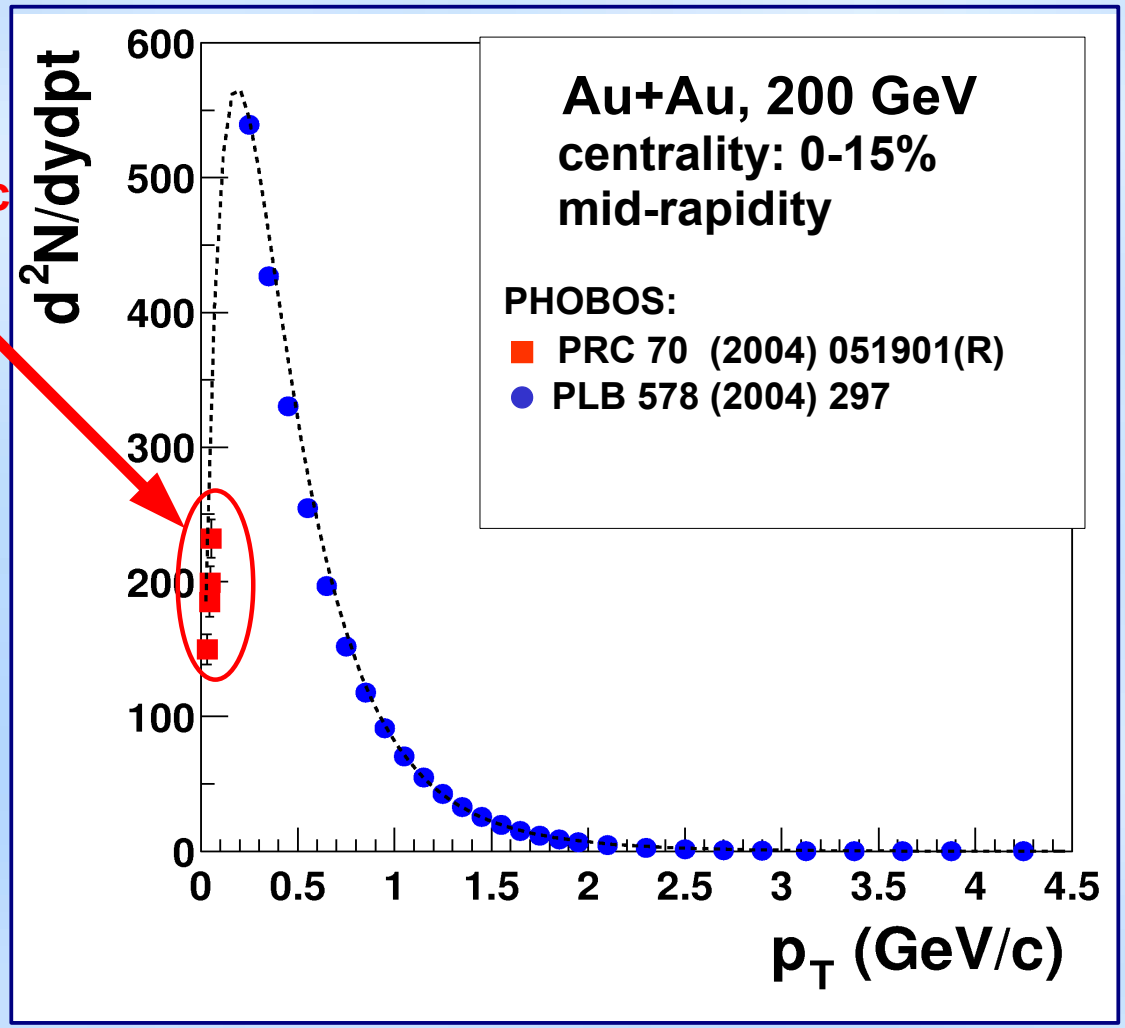
UNIVERSITY OF ROCHESTER

Motivation

The PHOBOS experiment has the capability to measure particles at very low transverse momenta 0.03 - 0.2 GeV/c

Production of low transverse momentum particles may be <u>sensitive to</u>:

- **Collective transverse expansion**
- **NEW long wave-length phenomena**
  may lead to enhanced production
- **Chiral symmetry restoration**
  may change the shapes of pion spectra



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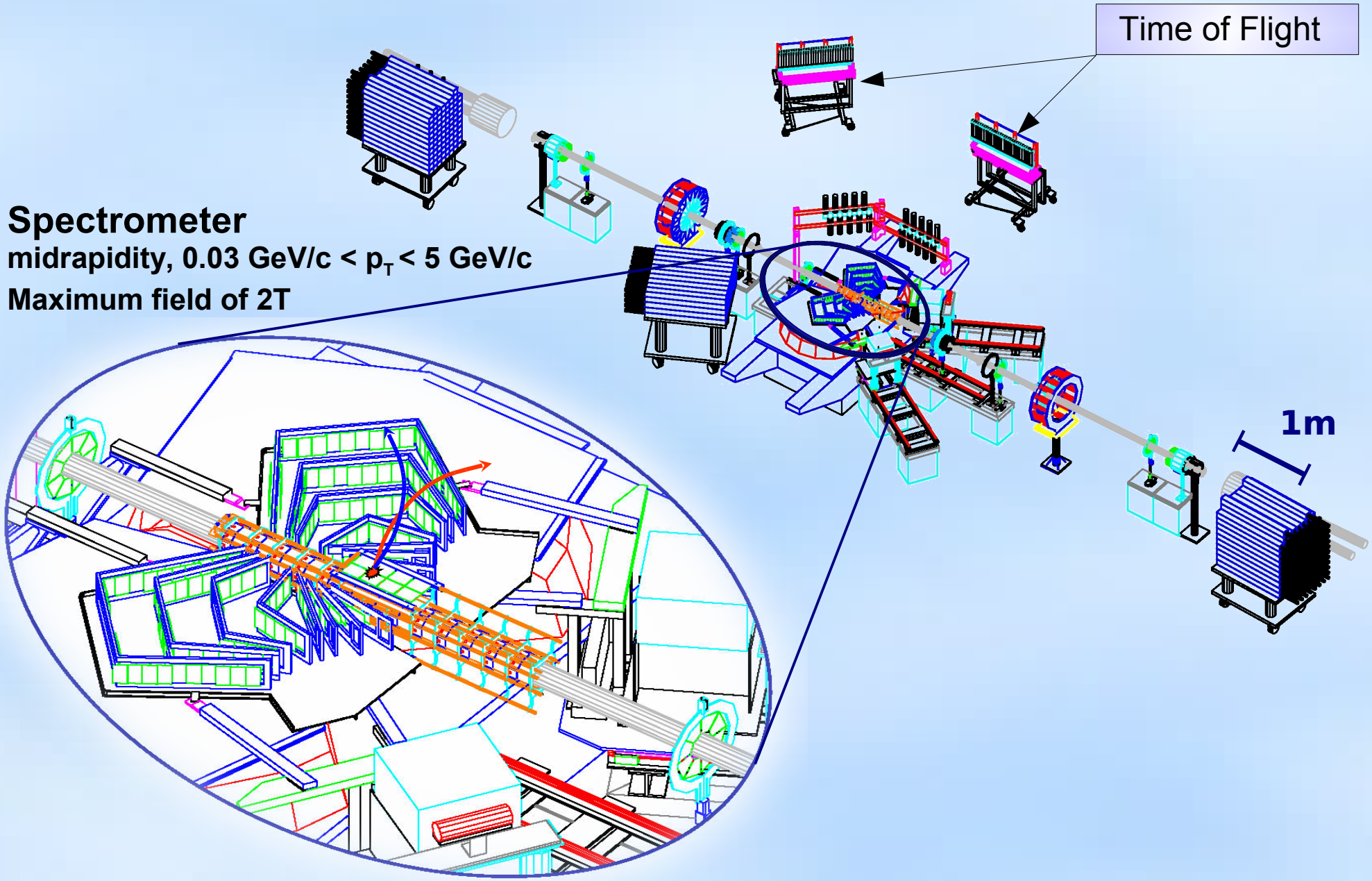
PHOBOS Detector

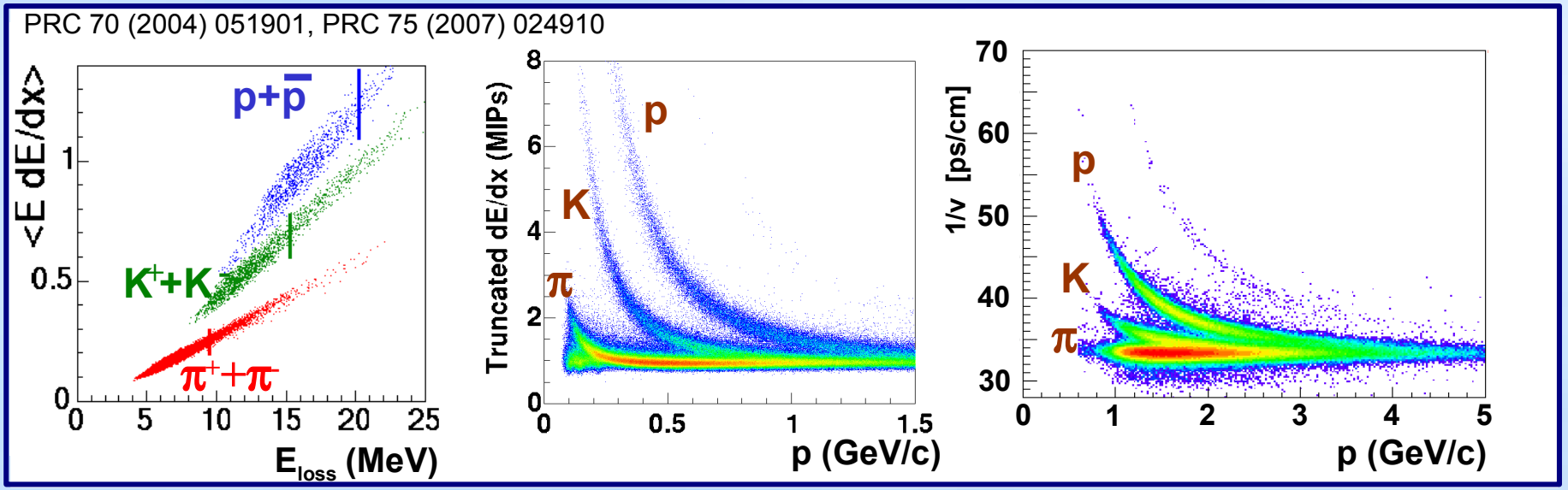


Spectrometer

midrapidity, 0.03 GeV/c < p_T < 5 GeV/c

Maximum field of 2T

PHOBOS Particle Identification



low p_T
Stopping particles

TOF

0.03 0.3 3.0 p_T (GeV/c)

mass **mass + charge**

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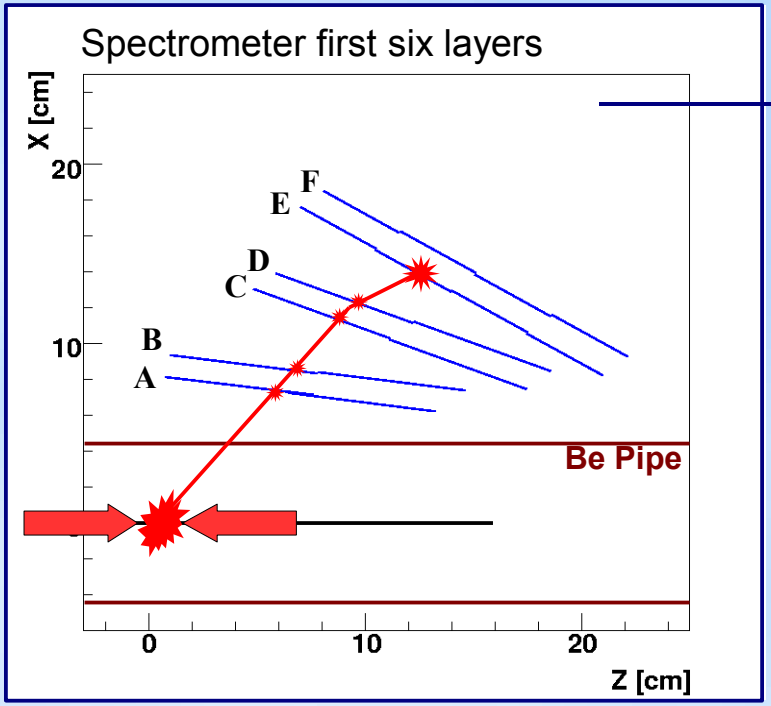
Particle Measurement at very low p_T

PHOBOS Spectrometer features

- 16 layers of silicon wafers
- fine pixelization, precise dE measurement
- very close to collision vertex
- near mid-rapidity coverage
- lack of material between interaction region and first layers

Spectrometer can measure particles at very low transverse momenta 0.03 - 0.2 GeV/c



Search for particles ranging out in the 5th spectrometer plane

B field is negligible at the first layers
No charge identification

Transverse momentum p_T range

Pions	0.031 – 0.053 GeV/c
Kaons	0.105 – 0.128 GeV/c
Protons and antiprotons	0.143 – 0.206 GeV/c

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Low p_T analysis reconstruction

Analysed events ~ 140 Milion
Selected events ~ 25 Milion

Centrality class	Reconstructed pions	Reconstructed kaons	Reconstructed (anti)protons
0-6%	21 511	2 938	1 454
6-15%	25 869	3 614	1 837
15-30%	28 858	4 099	2 219
30-50%	18 979	3 016	1 654
TOTAL	95 217	13 667	7 164

Particle Reconstruction
pions,kaons,(anti)protons

Data Corrections
- Efficiency
  embedding of single tracks
- Acceptance
- Background

Systematic errors
- detector
- reconstruction procedure

ANALYSIS ORDER

First published results obtained from Au+Au collisions at energy 200 GeV and 62.4 GeV were based on **low statistics**.

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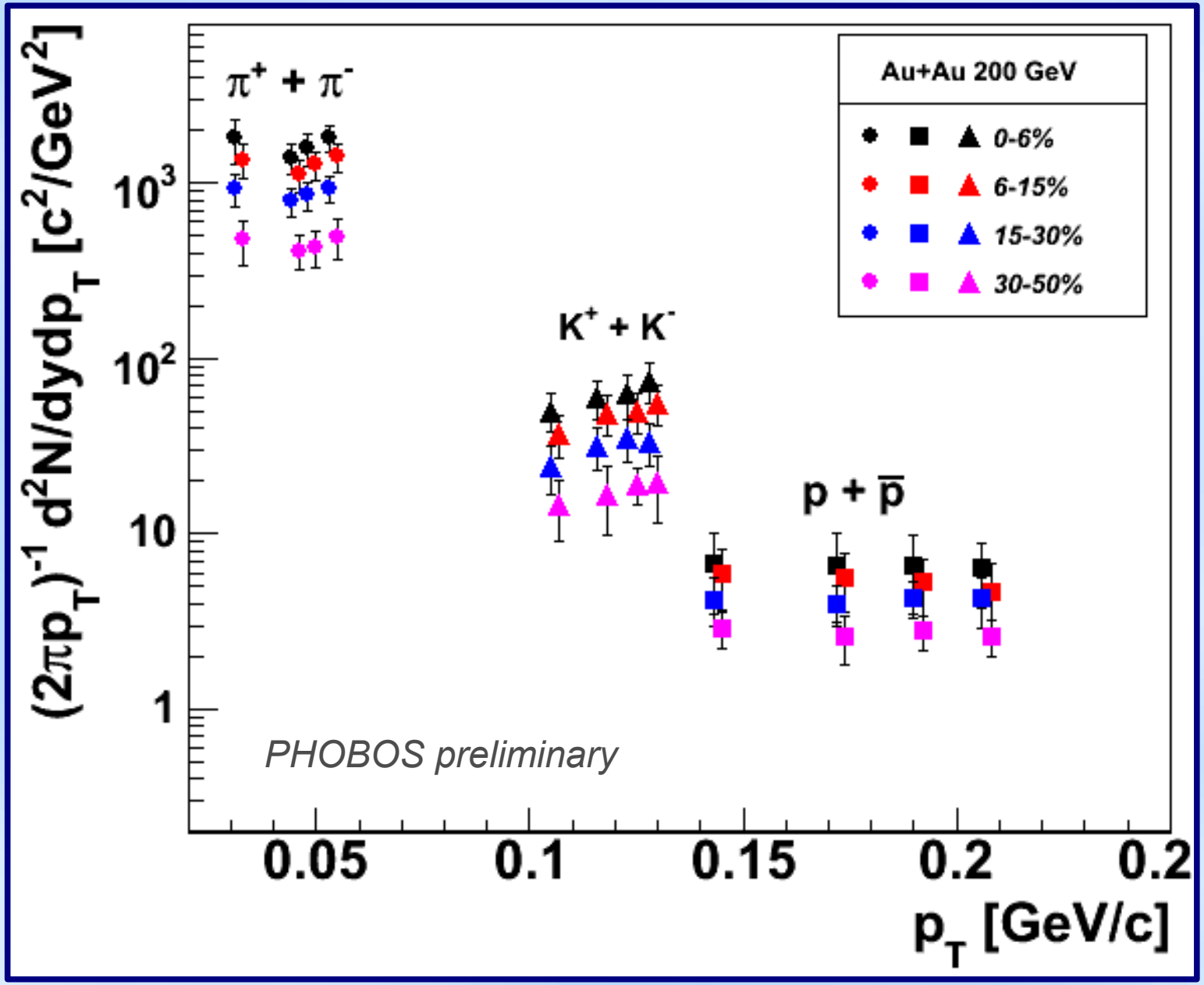
Identified Particle p_T - Spectra, Au+Au at 200 GeV

Average systematic errors

	0-6%	6-15%	15-30%	30-50%
π	14.8%	15.3%	15.2%	21.8%
K	16.7%	19.3%	18.7%	24.5%
p	55.1%	43.8%	31.1%	23.8%

Combined statistical and systematics errors are shown



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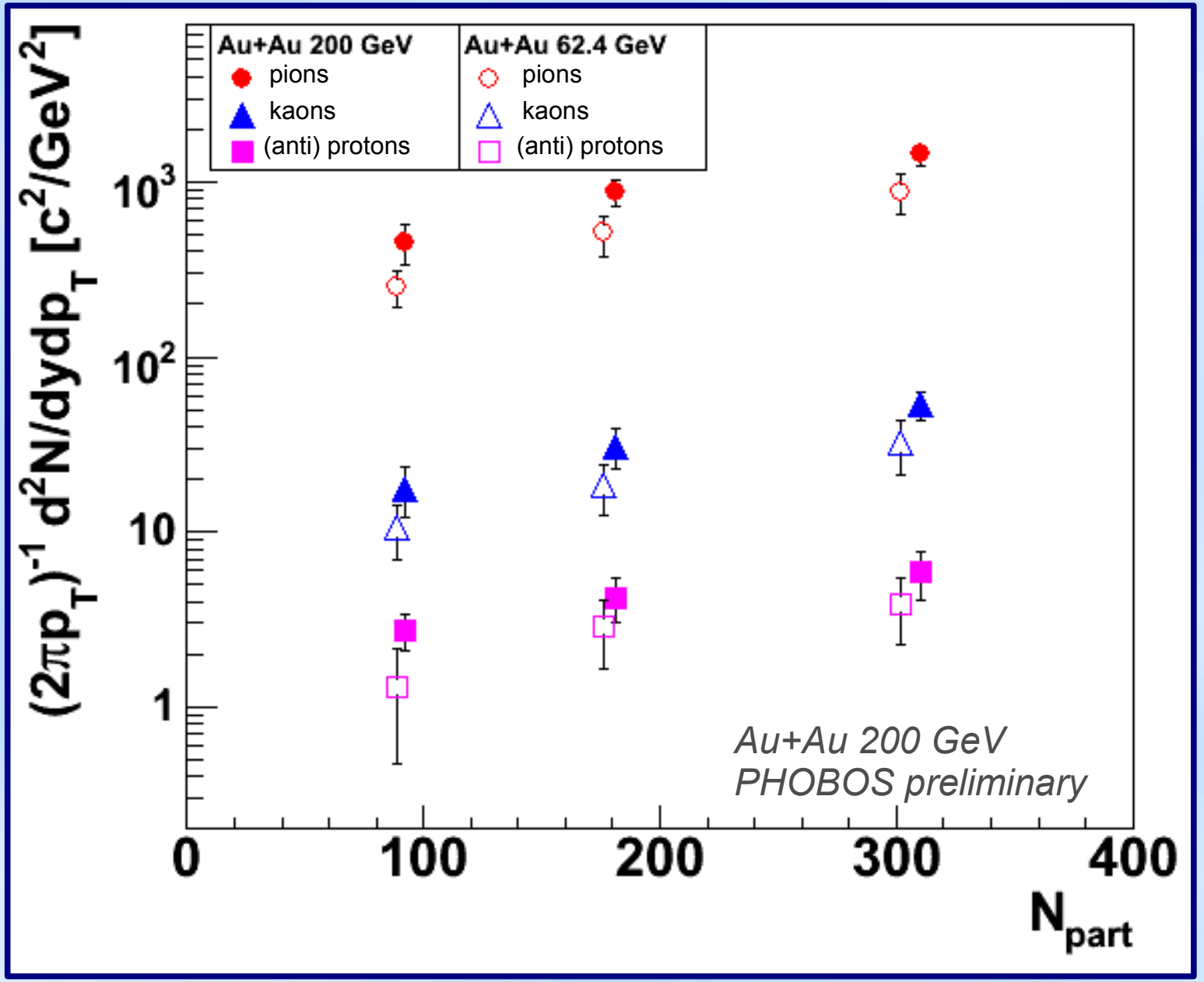
Identified Particle p_T Spectra

N_{part} dependence



Pions range
0.020 - 0.060 GeV/c
Kaons range
0.060 - 0.138 GeV/c
Protons range
0.105 - 0.225 GeV/c

For each centrality bin the invariant yield was averaged over four p_T points

Bose-Einstein and Blast Wave Parameterizations

Bose-Einstein (B-E)

- Extrapolation based only on PHENIX data at high p_T
- Fit parameters T_{pions} , T_{kaons} , $T_{protons}$

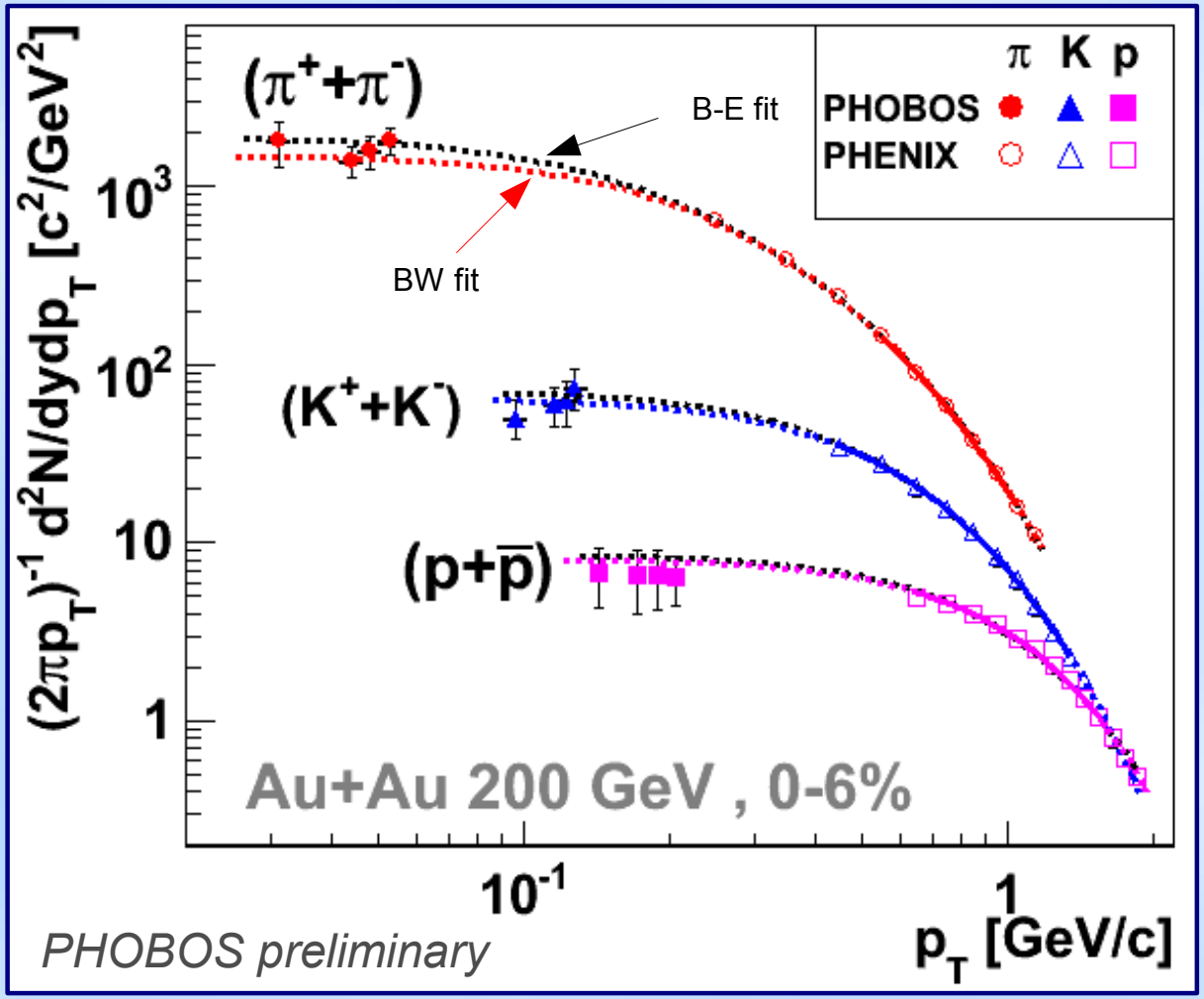
$$\frac{1}{2\pi}\frac{1}{m_T}\frac{d^2N}{dydm_T} = A\left[\, e^{m_T / T} \pm 1 \,\right]^{-1}$$

$$m_T = \sqrt{p_T + m_h}$$

Blast Wave (BW)

- Extrapolation based only on PHENIX data at high p_T
- Fit parameters β_T , T_{fo}

$$\frac{1}{2\pi}\frac{1}{m_T}\frac{d^2N}{dydm_T} = F(\,\beta_T\ ,\ T_{fo}\,)$$



B-E and BW parameterization agree with low p_T data

No enhancement in low p_T yields for pions is observed

Flattening of $(p+\bar{p})$ spectra down to very low p_T is consistent with transverse expansion of the system

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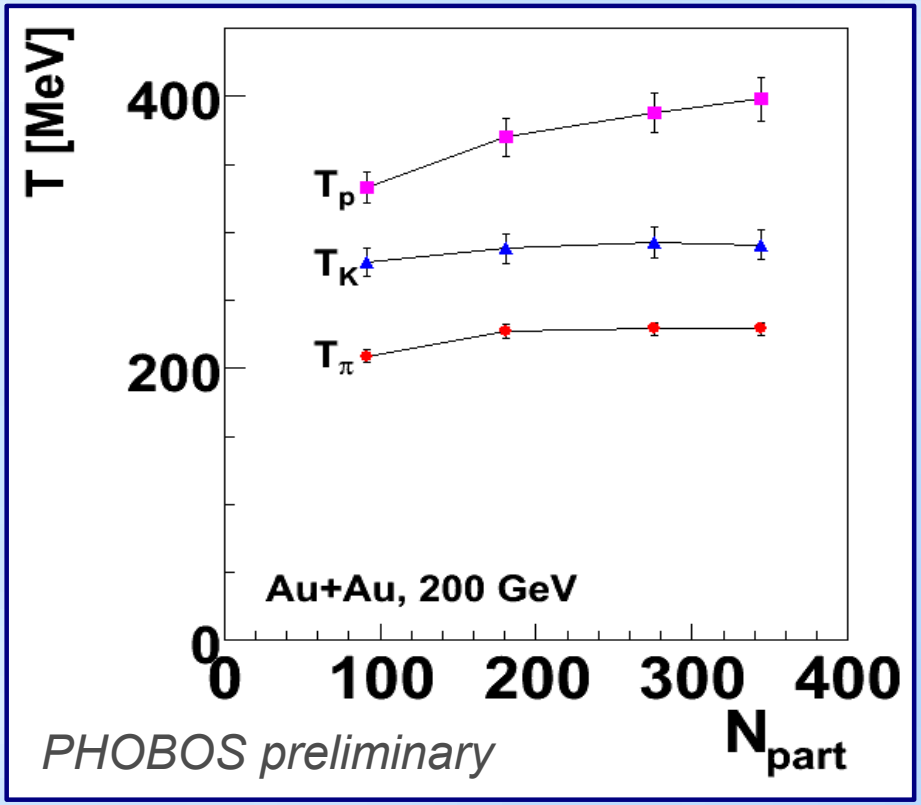
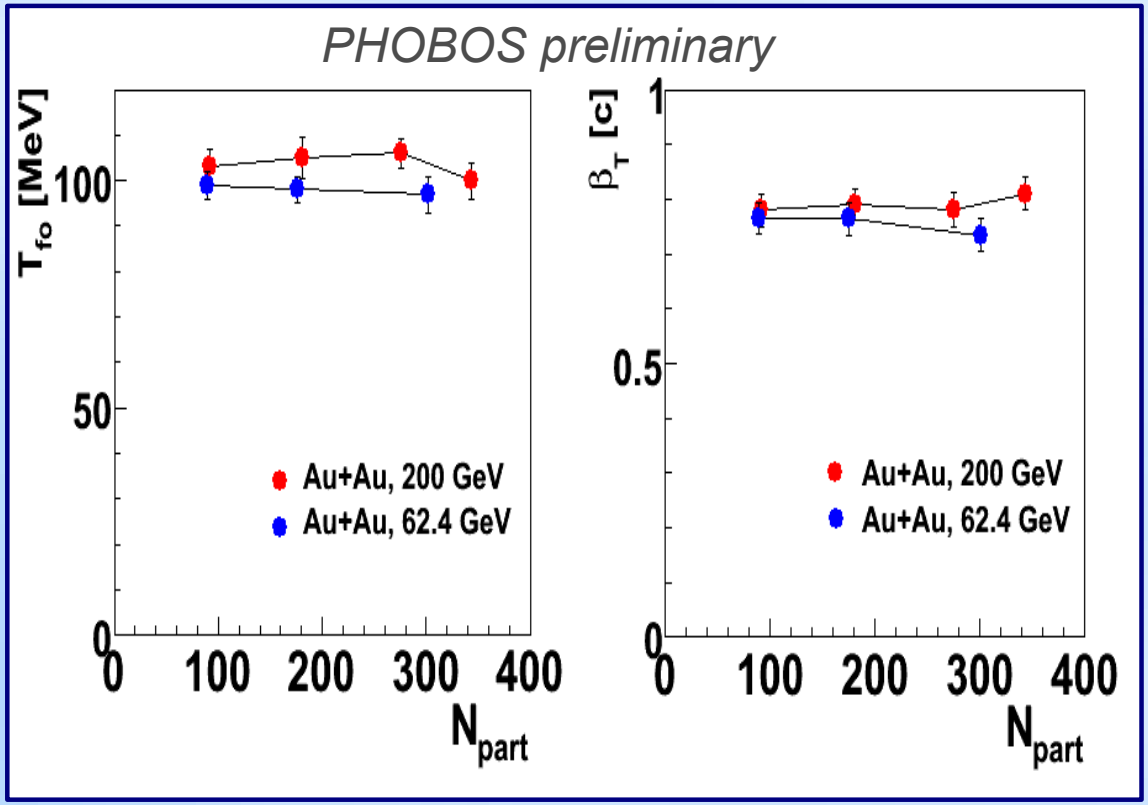
Bose-Einstein and Blast Wave parameterization

Bose Einstein parameters

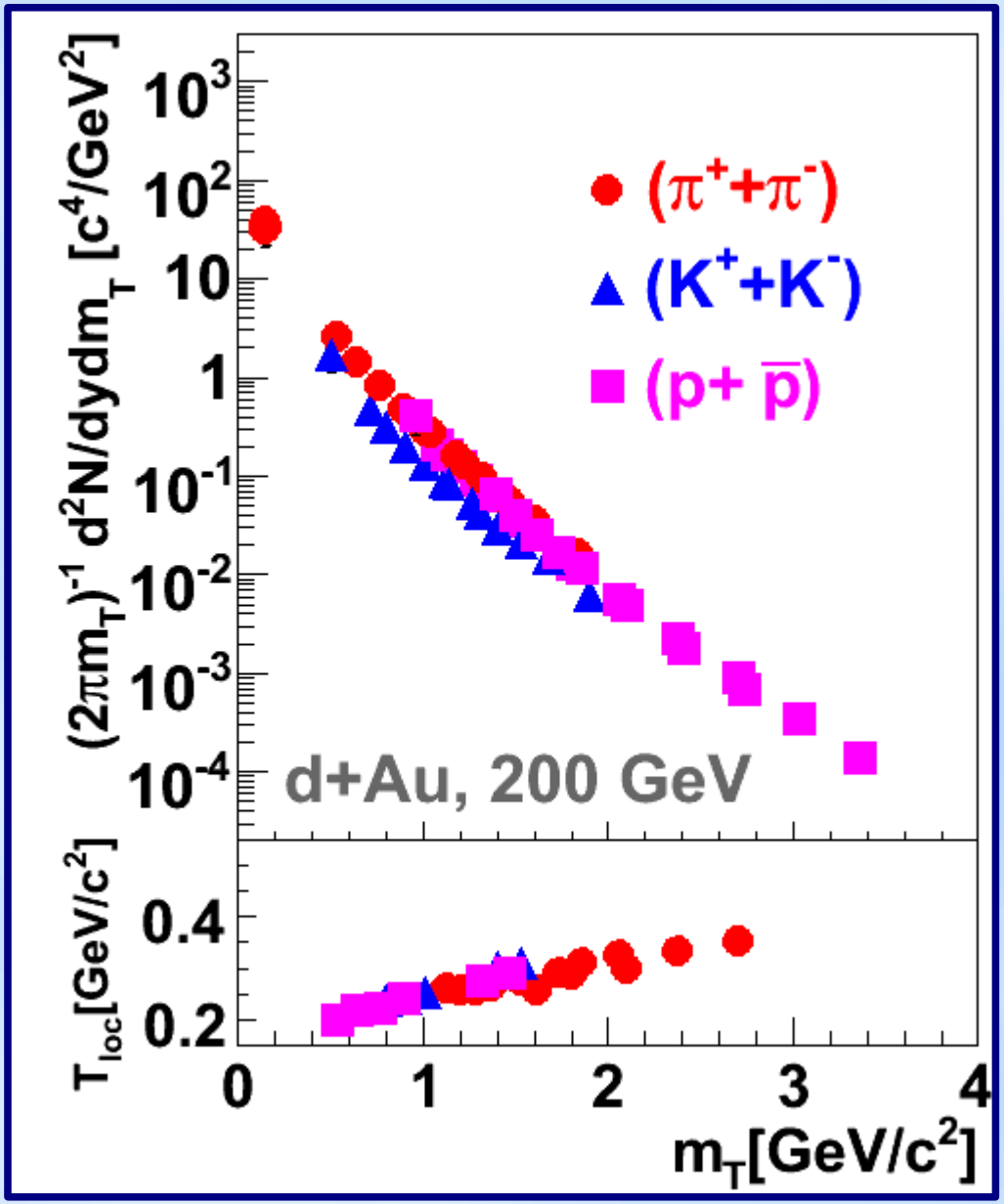


Blast Wave parameters



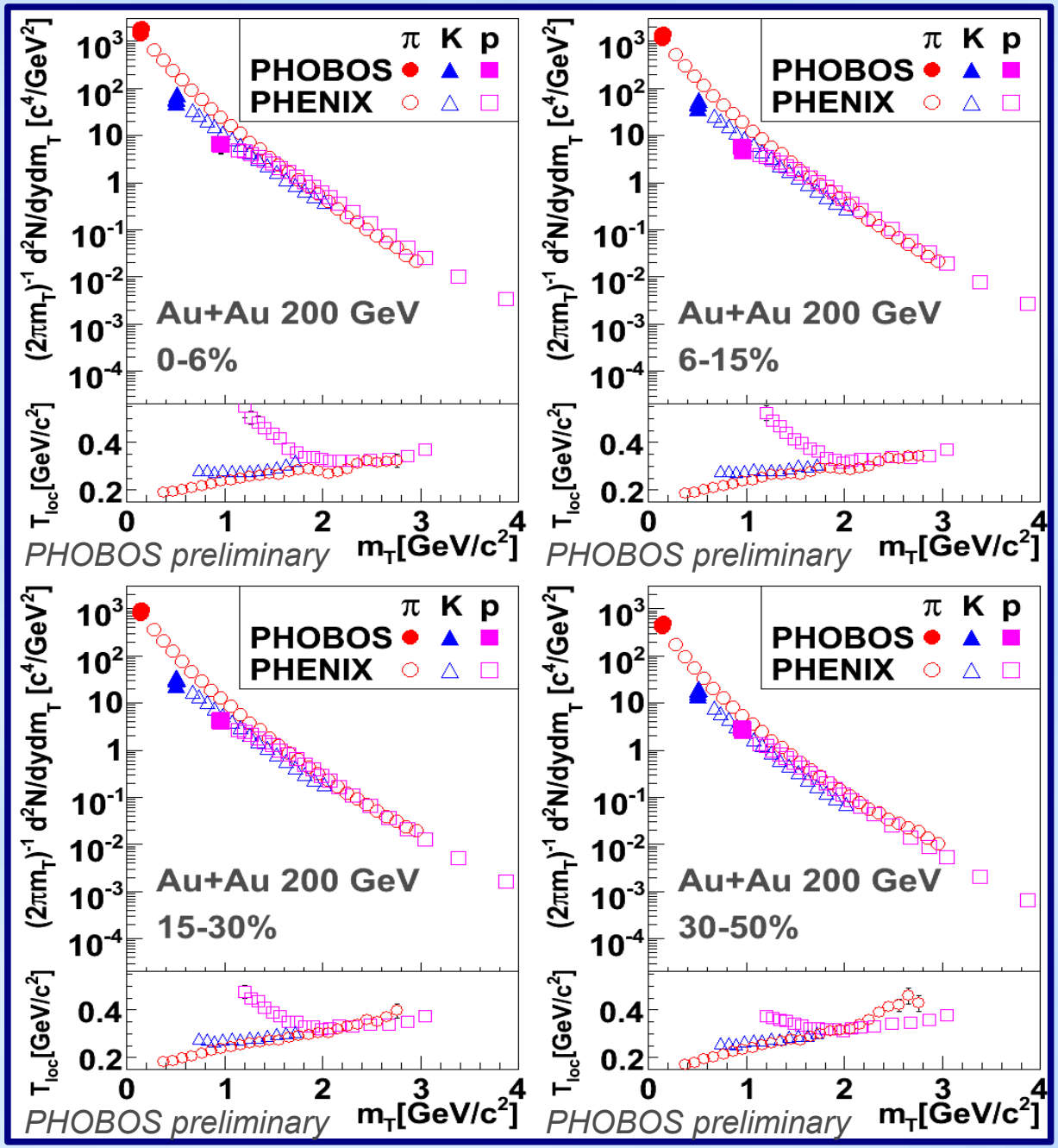
Centrality dependence of fit parameters for Bose Eintstein parameterization

m_T scaling in d+Au



m_T scaling is observed in d+Au collisions

m_T scaling in Au+Au



m_T scaling is not observed in Au+Au collisions

data is inconsistent with saturation model predictions

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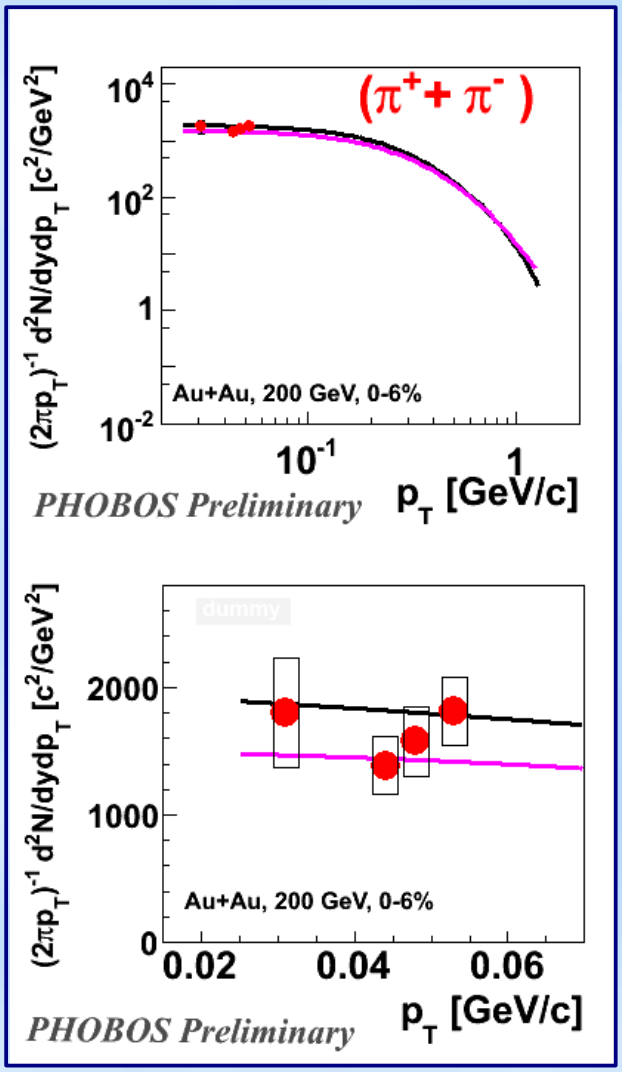
Model Comparisons



HIJING model

Single freeze-out model
W.Florkowski, W.Broniowski nucl-th/0212052
Generated from Therminator (nuc-th/0504047)

HIJING overestimates protons spectra
Good agreement with single freeze-out model prediction

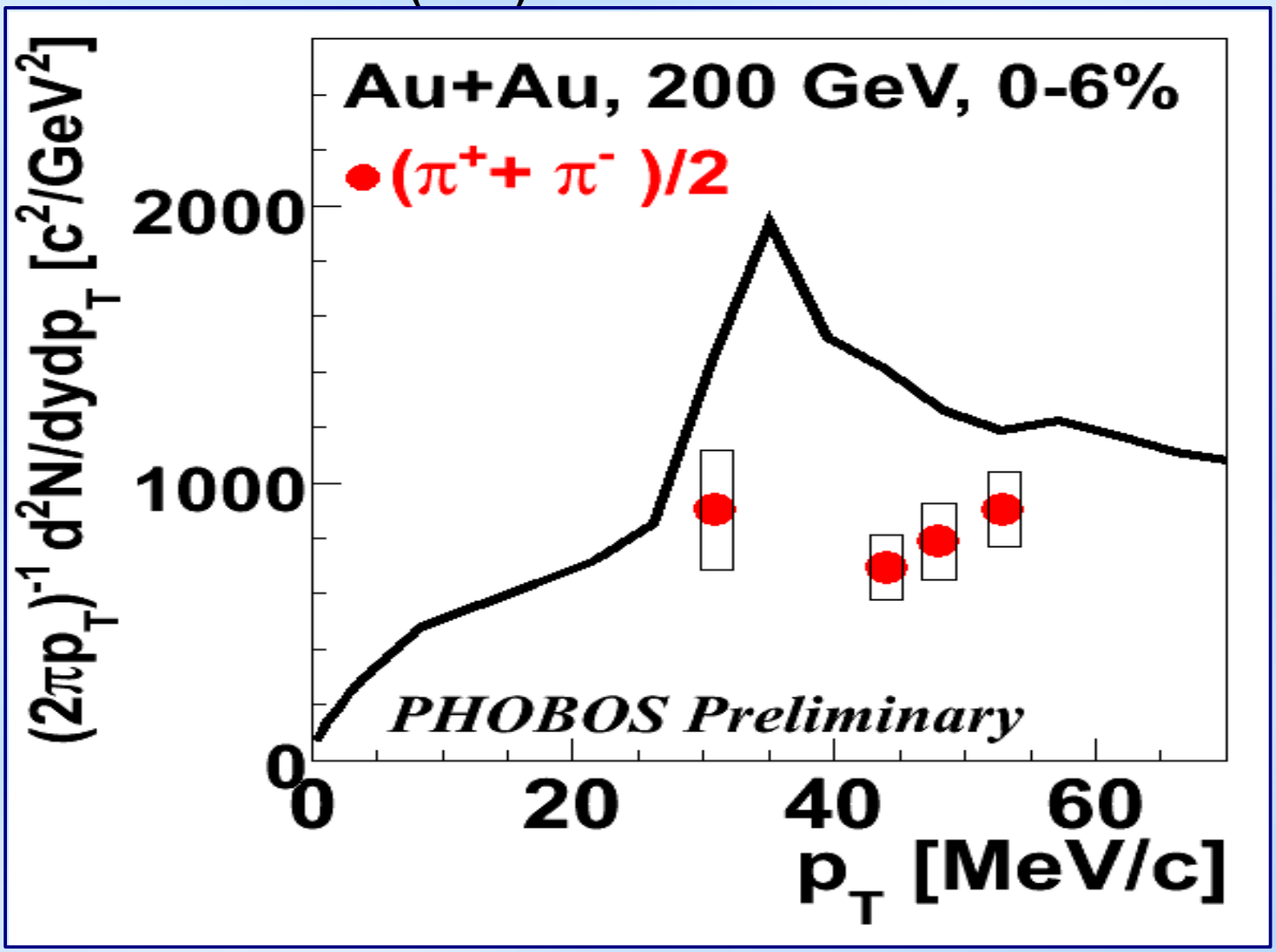
Summary

- New high statistics data on particle production at very low p_T in Au+Au collisions at 200 GeV have been presented
- Low p_T invariant yields increase with energy and centrality
- No anomalous enhancement in low p_T yields for pions is observed for all centralities
- No m_T scaling is observed at very low pt
- B-E and BW parameterizations describe well very low p_T yields
- Low p_T yields are consistent with the single freeze-out model

Backup Slides

Model Constrains

J.Cramer, et al.,
PRL 94 (2005) 102302



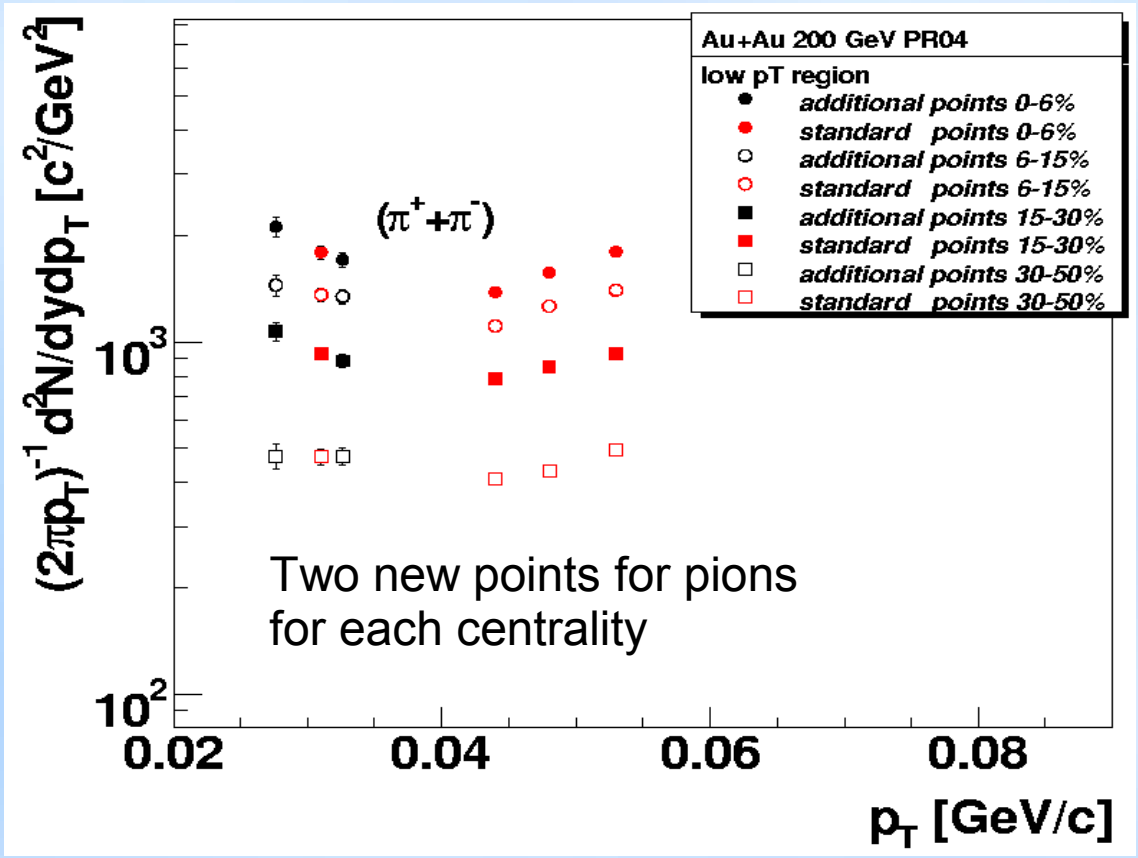
All models (except Cramer) do not predict any structure

Identified Particle p_T -Spectra, Au+Au at 200 GeV

Modified Space Region for pions

New p_T points		
$\langle p_T \rangle$	Δy	ΔZ_{vert}
0.0276	0.35 ÷ 0.4	−7 ÷ −1
0.0326	0.3 ÷ 0.35	−7 ÷ −1
Standard p_T point		
$\langle p_T \rangle$	Δy	ΔZ_{vert}
0.031	0.3 ÷ 0.4	−7 ÷ −1

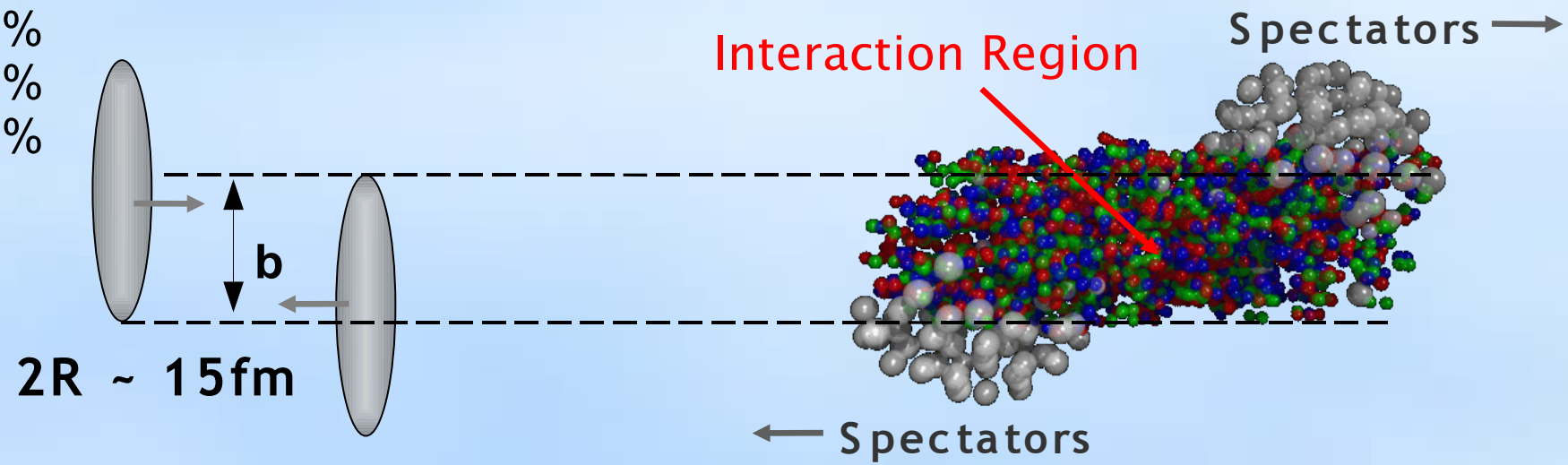
Focus on lowest pT region



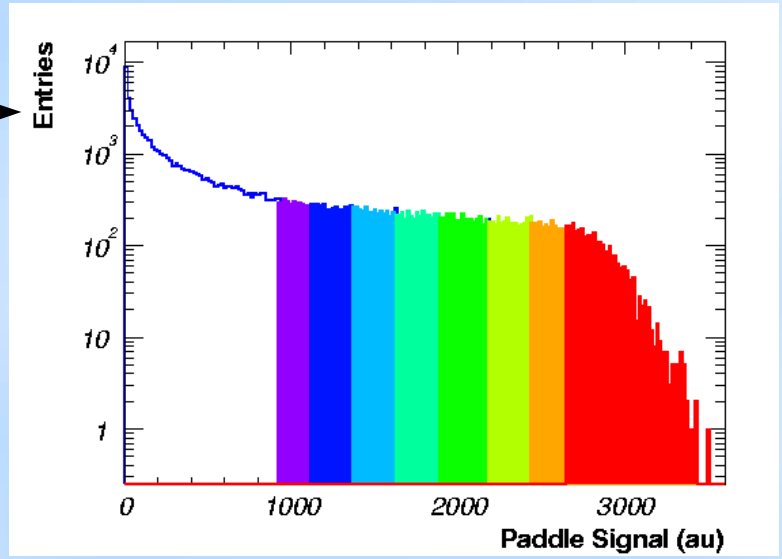
The lowest p_T standard pion point was divided into two points by changing space regions.

Centrality Determination

Centrality (4 class)
- 0-6 % most central
- 6-15 %
- 15-30 %
- 30-50 %



Centrality determination
- Based on number of registered particles
- Npart , Ncoll + GEANT



N_{part}	number of participants
N_{coll}	number of collisions