

BRAHMS *Beam Use Proposal*

RUN-6

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For the BRAHMS collaboration

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Overview

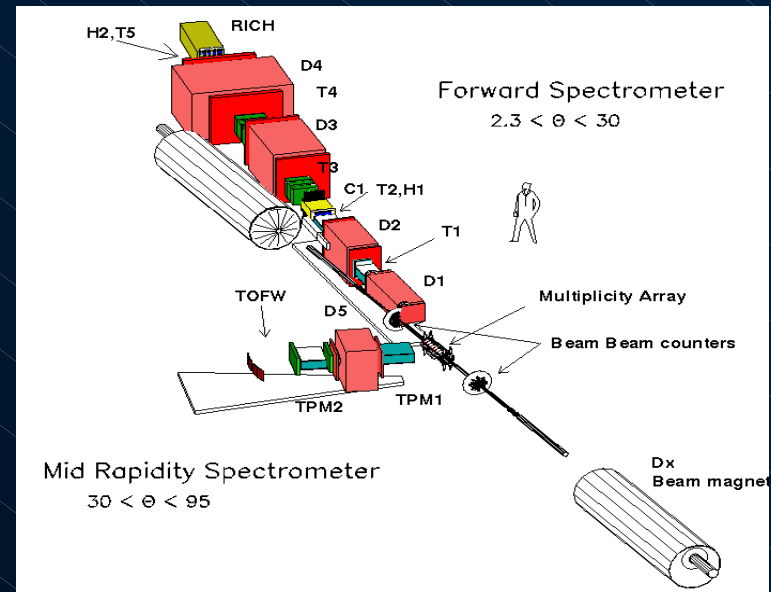
- Introduction
- Accomplishments
- Plans for RUN-6
 - Physics
 - Detailed request
- Possibility for d-Au measurement
- Summary

BRAHMS Experiment and Goals

Physics questions that have been addressed in Run 1 – 5

- How much energy is available for particle production ?
- How do particles flow in the transverse & longitudinal direction?
- What is the chemistry of the system?
- What is the rapidity dependence of jet quenching ?
- What can we learn about the parton distributions in the Au nuclei at small x ?
- What is intrinsic angular momentum in proton?

- The experiment has unique capabilities in terms of precision measurements and particle ID covering a rapidity range of 0-4 and up to moderate high pt (~ 4 GeV/c)



Publications

2000-2005 12 Refereed Journal articles

2000-2005 51 Conference proceedings

2000-2005 100+ Talks at conferences , meetings and workshops

QM05 lenary talk + 4 parallel talks with AuAu and CuCu results

- *Recent Publications*
- "Centrality Dependent Particle Production at $y=0$ and $y \sim 1$ in Au+Au Collisions at $\sqrt{s_{NN}} = 200$ GeV"
Accepted to Phys. Rev. C in 6/3/2005
- "Charged Meson Rapidity Distributions in Central Au+Au Collisions at $\sqrt{s_{NN}} = 200$ GeV"
Phys. Rev. Lett. 94, 162301 (2005) , [nucl-ex/0403050](#)
- "Forward and Midrapidity Like-particle Ratios from p+p Collisions at $\sqrt{s_{NN}} = 200$ GeV"
Phys. Lett. B607, 42-50 (2005)
- "Centrality Dependence of Charged-particle Pseudorapidity Distributions from d+Au Collisions at $\sqrt{s_{NN}} = 200$ GeV" **Phys. Rev. Lett. 94, 032301 (2005)** , [nucl-ex/0401025](#)
- "Quark-gluon plasma and the color glass condensate at RHIC? The perspective from the BRAHMS experiment" **Nucl. Phys. A757 (2005) 1-27**, [nucl-ex/0410020](#)
- "Evolution of the Nuclear Modification Factors with Rapidity and Centrality in d+Au Collisions at $\sqrt{s_{NN}} = 200$ GeV"
Phys. Rev. Lett. 93, 242303 (2004) , [nucl-ex/0403005](#)

Data collected in Run-5

Cu -Cu at 200 GeV

- Brahms recorded $\sim 1.75 \text{ nb}^{-1}$ in the 10 weeks run out of 5.5 nb^{-1} delivered. Recorded data within a $\pm 30 \text{ cm}$ vertex.
- Identified Charged hadrons in $0 < y < 3.8$
- High- p_t studies at $y \sim 1, 2, 3$

Cu -Cu at 62.4 GeV

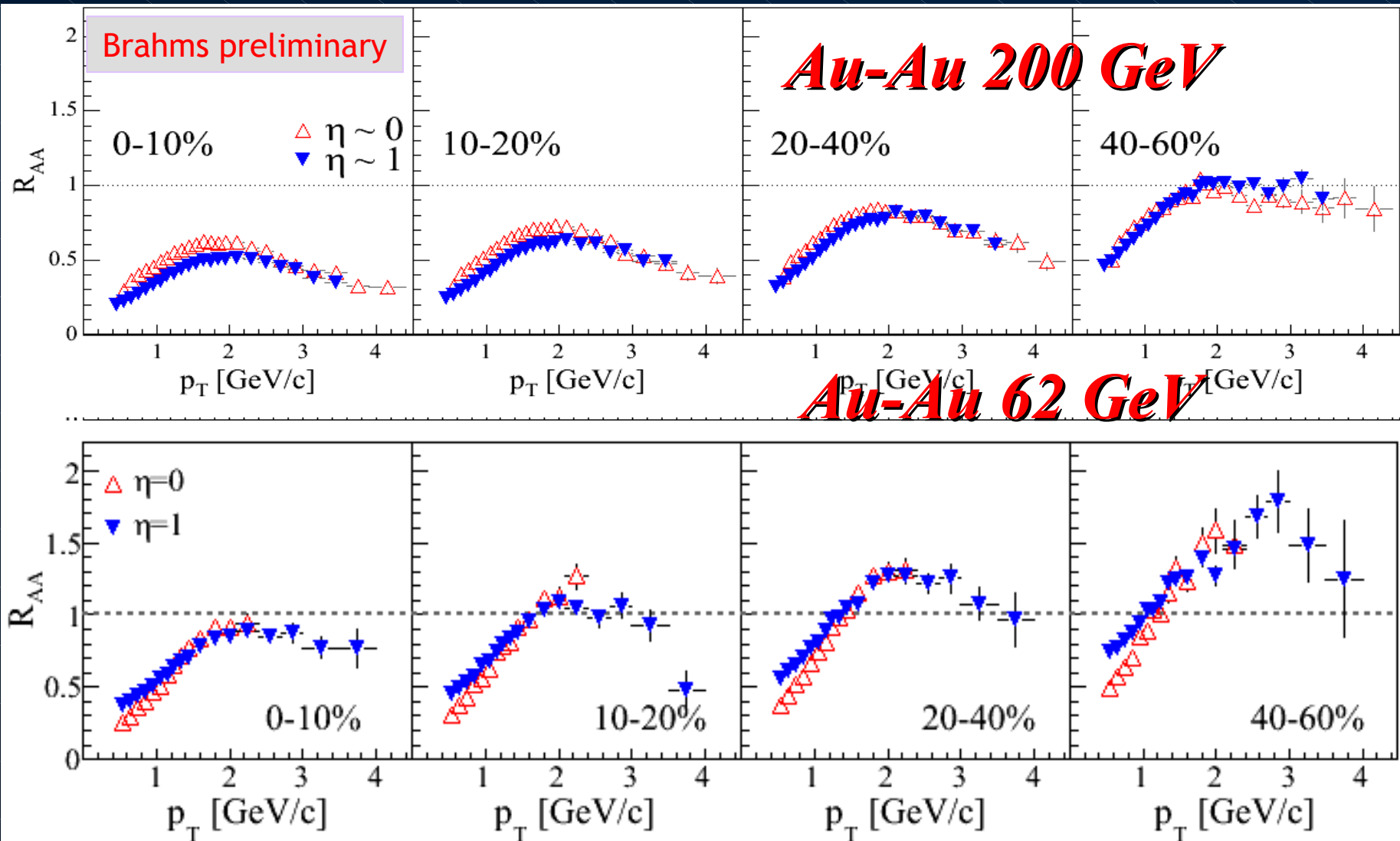
- Brahms recorded $\sim 120 \mu\text{b}^{-1}$. All physics goals were achieved.
- Particle yields in $0 < y < 3$
- High- p_t physics at $y \sim 1$ and $y \sim 2$

p-p at 200 GeV

- $\sim 2.6 \text{ pb}^{-1}$ recorded. Exceeded Physics goal from Beam Use Proposal.
- Physics goals of reference spectra to higher p_t at $y \sim 0-3$ achieved.
- Main goal of single spin asymmetries vs. x_F and p_t accomplished.

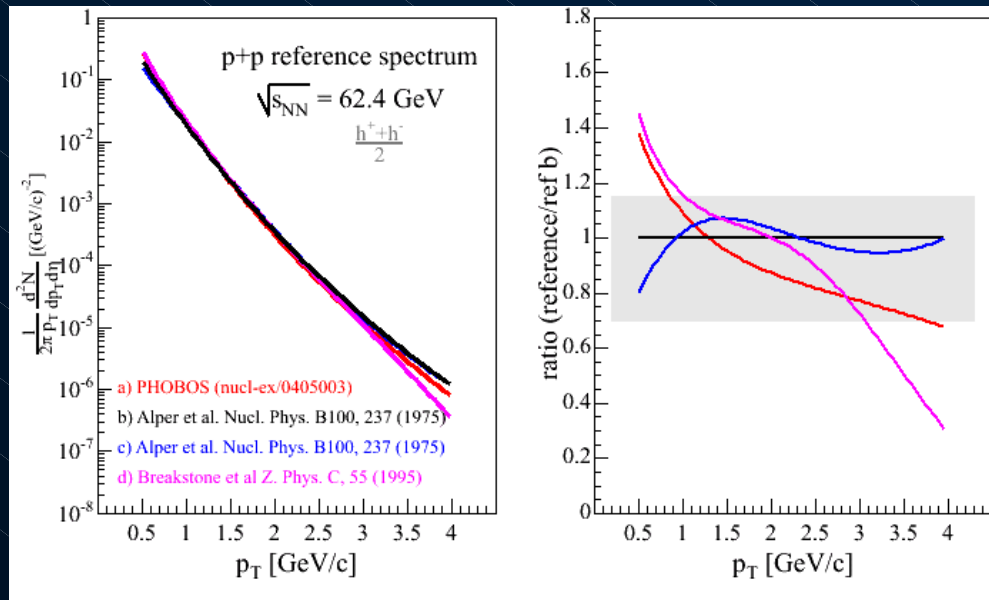


Nuclear modification factor Studies at 200 and 62.4 GeV



pp reference is based on ISR collider data extrapolated to acceptance.

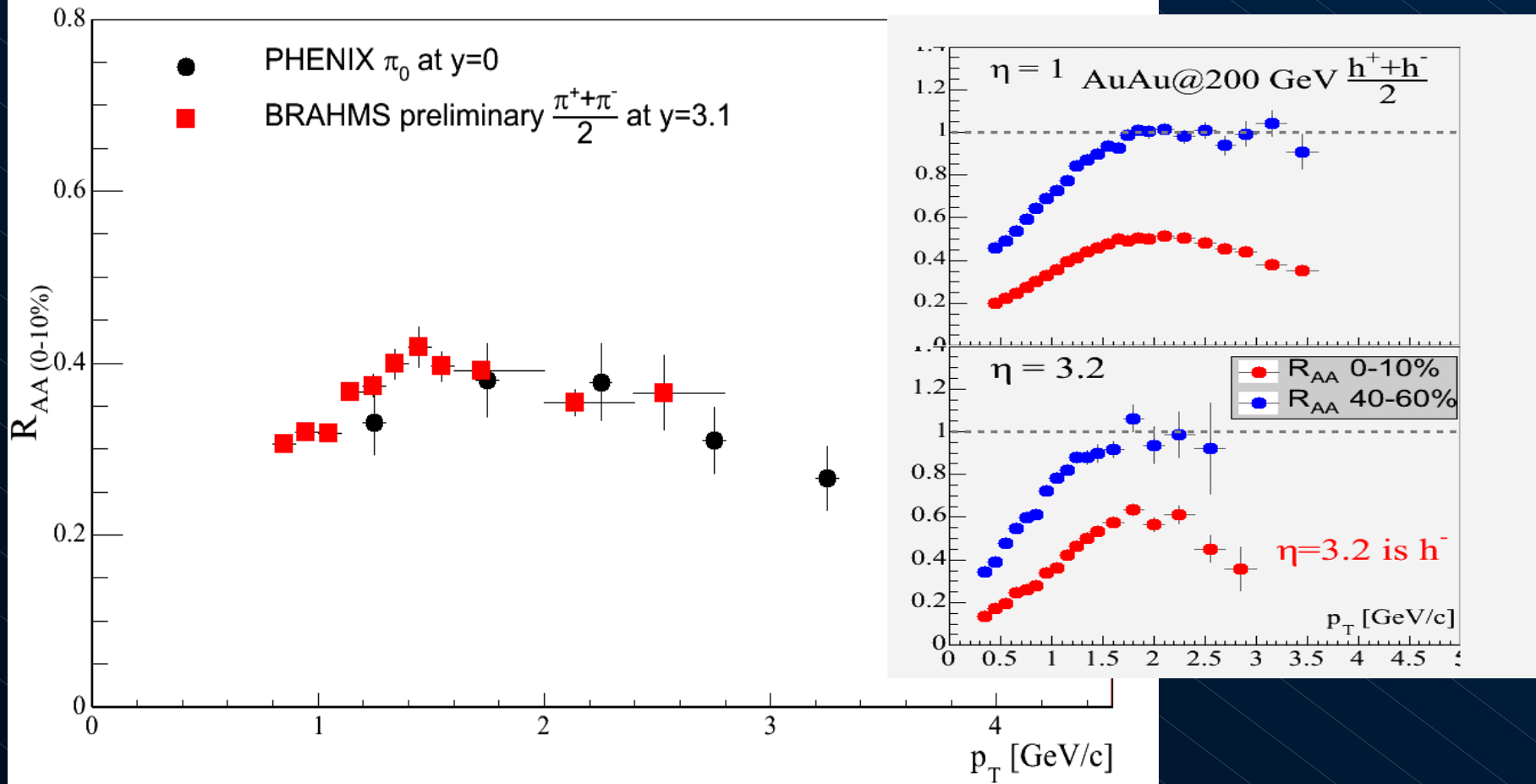
p+p at $\sqrt{s} = 62.4 \text{ GeV}$ comparison between different parameterizations



There is a clear need to have better reference near mid-rapidity. BRAHMS HI mid-rapidity data are mainly at $y \sim 1$. In addition we have significant data sets at high rapidity.

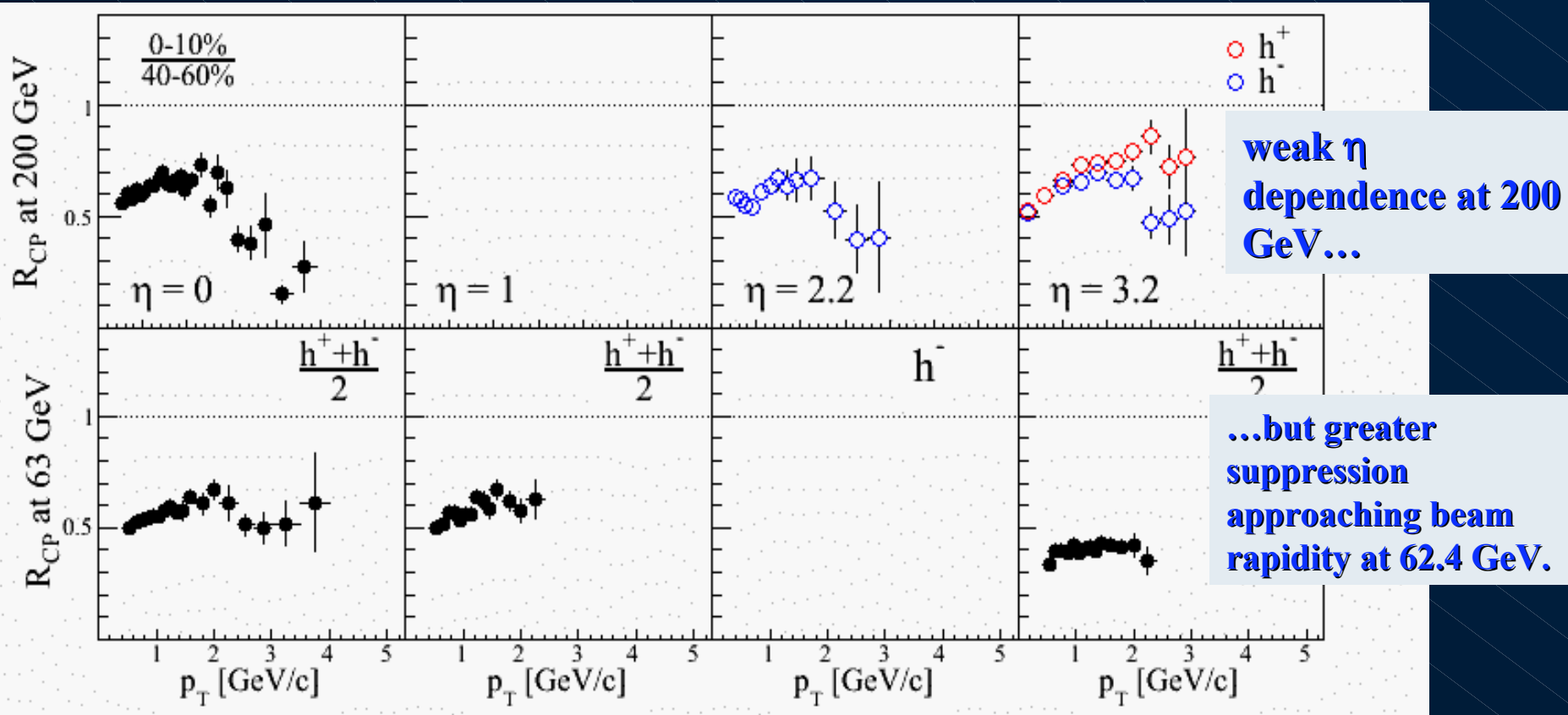
R_{AA} rapidity dependence for Au+Au @200GeV

Nearly identical suppression at $y \sim 0$ and $y \sim 3$



R_{CP} dependence on η for AuAu 200 GeV and 62.4 GeV

The 62.4 GeV data show similar trend



Reference spectrum is needed to clarify relevance of

- suppression due to medium
- Change in underlying pp spectrum
- Entrance channel effects.

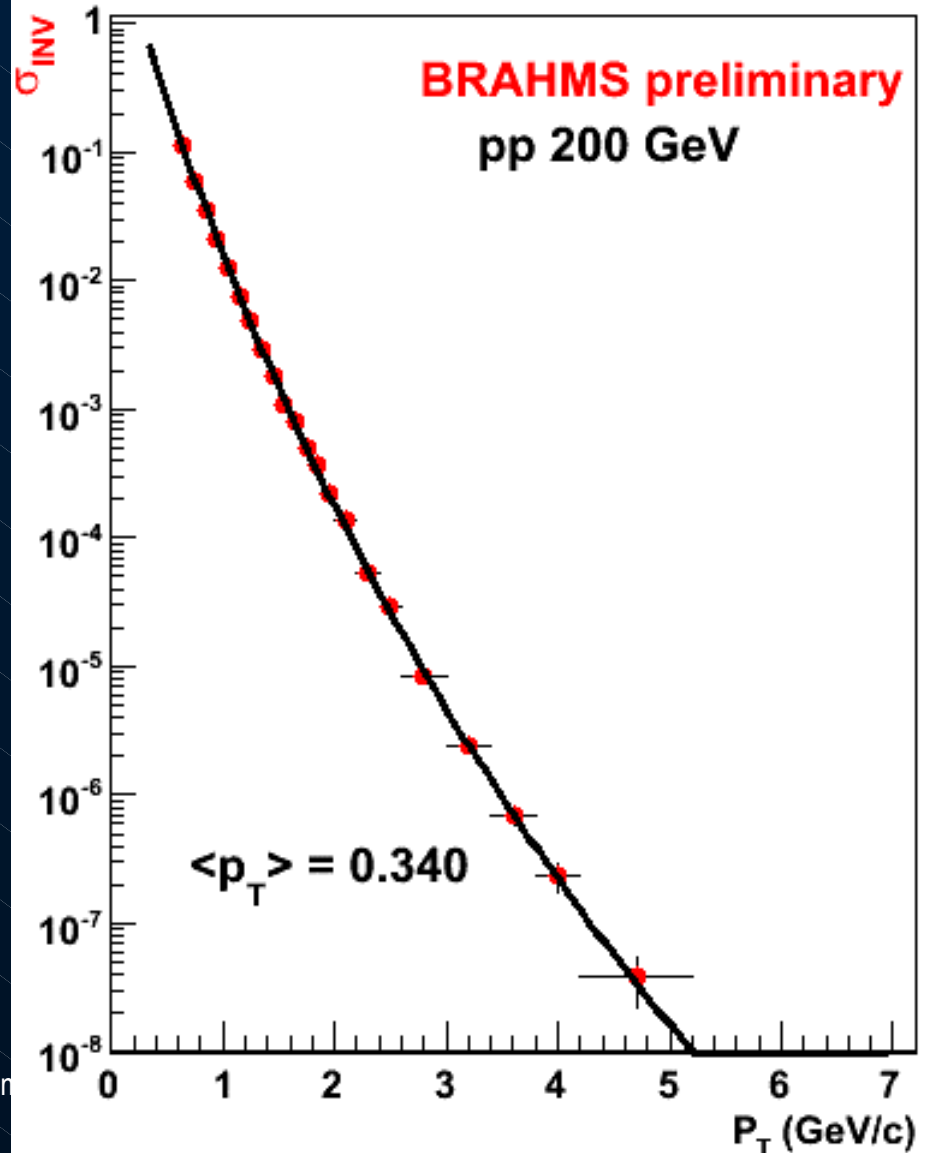
BRAHMS Spin Program

- In RUN-4 and in RUN-5 BRAHMS embarked on a program of measuring transverse Single Spin Asymmetry (SSA/ A_n).
- These require Spin Flip Amplitude and phase difference in intrinsic states
- Such studies may clarify properties of transverse quark structure of the nucleon
 - **Sivers effect** [*Phys Rev D*41 (1990) 83; 43 (1991) 261]
Flavor dependent correlation between the proton spin, momentum and transverse momentum of the un-polarized partons inside the proton.
 - **Collins effect** [*Nucl Phys B*396 (1993) 161]
Correlation between the quark spin, momentum and transverse momentum of the pion.
 - **Qui & Sterman** [*Phys.Rev D*59 (1998) 014064]
Twist-3 pQCD effects

Hadron Spectra

- Example of outcome of the long pp 200 GeV run-5.
- $pp \rightarrow \pi^-$ spectrum over 7 orders of magnitude
- Spectra for other charged hadrons are forthcoming
- Such spectra will provide a testing ground for pQCD

π^- $2.9 < y < 3.0$

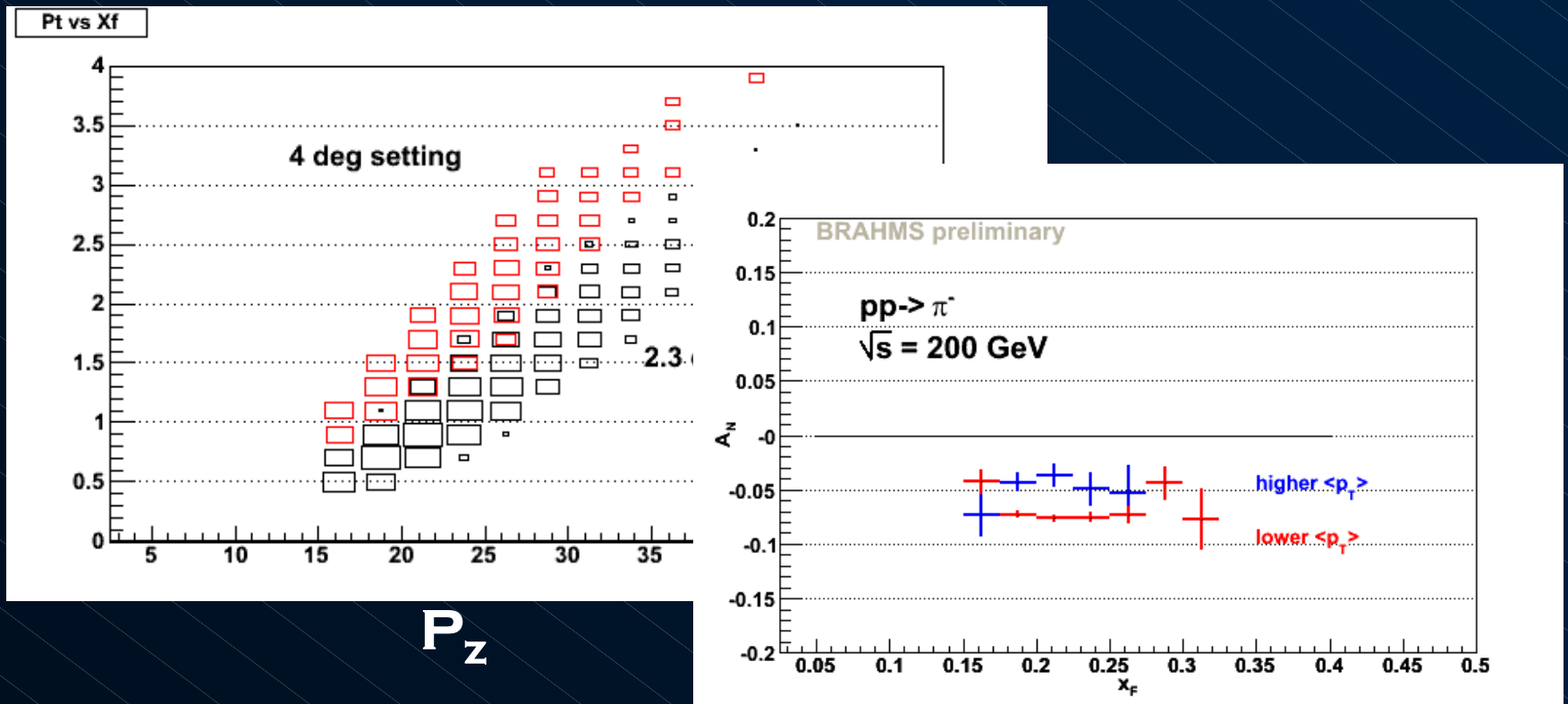


November 3, 2005

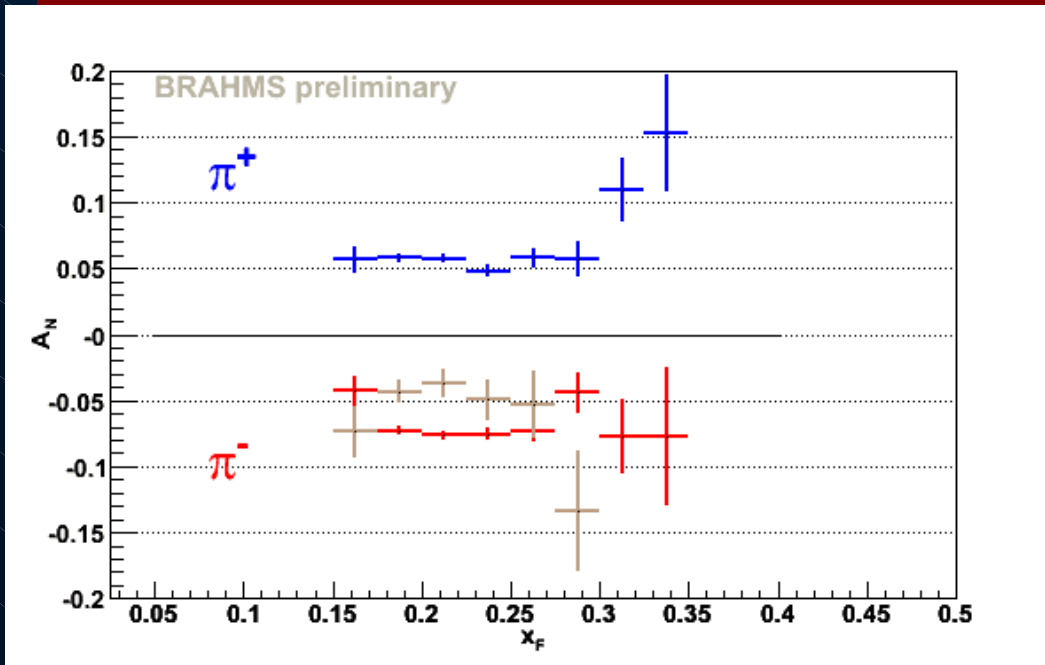
Brahms

A_N measurements for π^-

Measurements at 2.3 and 4 degrees.
New result.



Summary of p_T dependence

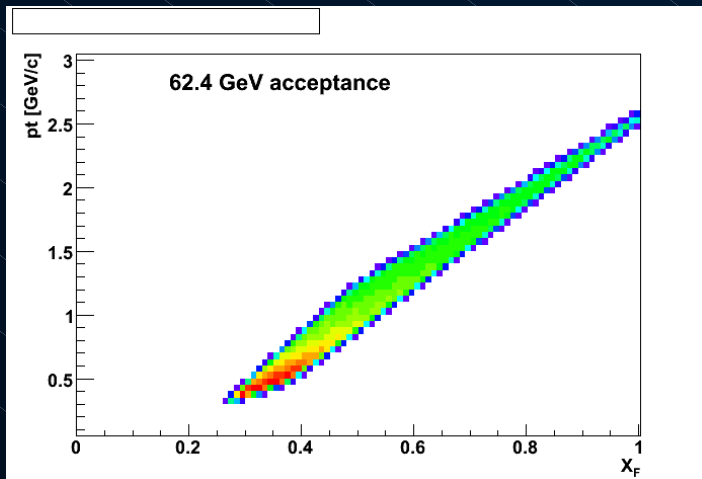


- 0.15–0.30 in x_F
 - $A_N(\pi^-)$ 0.078 \pm 0.002 low p_T
 - $A_N(\pi^-)$ 0.045 \pm 0.003 higher p_T
 - $A_N(\pi^+)$ 0.066 \pm 0.002 low p_T

Systematic errors from online polarization is (presently estimated at $\sim 20\%$ [scale])

Spin Status and Plans

- The 200 GeV measurements are complete. It will be difficult to significantly increase reach in x_F and p_T .
- Measurements at 62.4 GeV offers an opportunity to address an intermediate energy (RHIC–FNAL) to clarify to what degree the SSA are describable by PQCD, or is a 'soft' physics effect.
- Bourrely and Soffer concluded that the mechanism at 200 GeV are distinctly different from the 19 GeV.



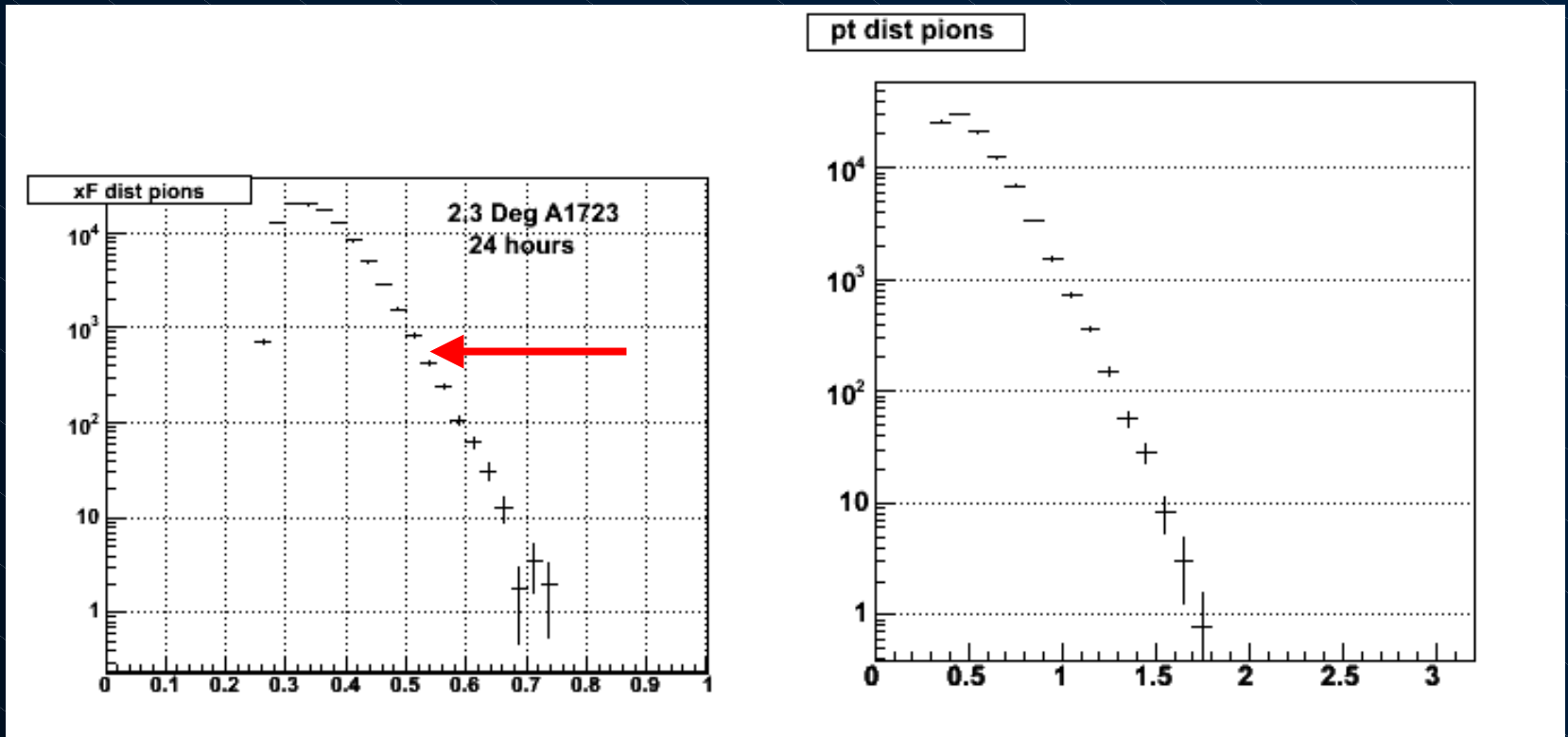
Request for 62.4 GeV polarized pp

- Assumed $\beta^*=3.5$ as in RUN-5 and took CA-D guidance.
- Assumed polarization will be ~50 %.
- Key measurements
 - Reference spectra
 - 4 deg : 3 field settings, 2 polarities
 - 8 deg : 1 field setting, 2 polarities
 - SSA measurements
 - 2.3 deg: 1 field setting 2 polarities
 - Simultaneous reference measurements at $\eta \sim 1$
- This translates into $\sim 1.6 \text{ pb}^{-1}$, or ~ 16 days with nominal machine and experiment uptime.

Acceptance and expected rates

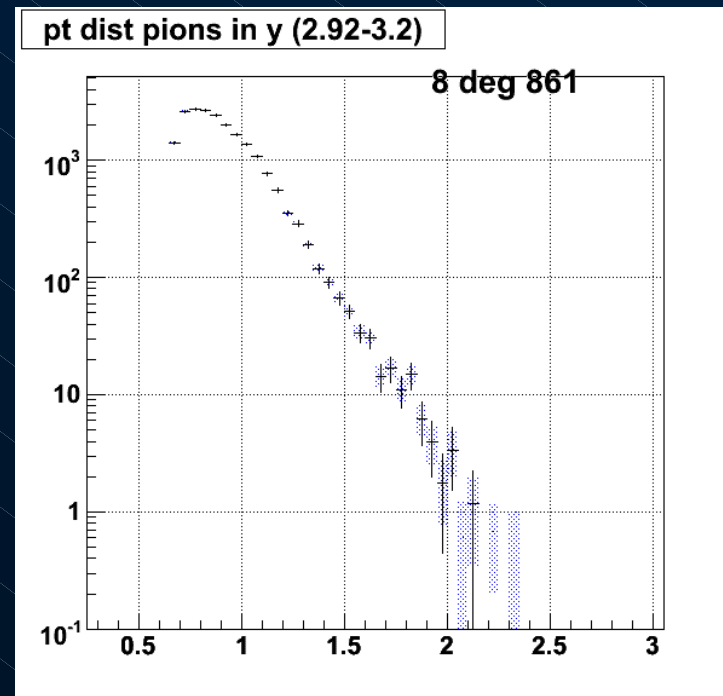
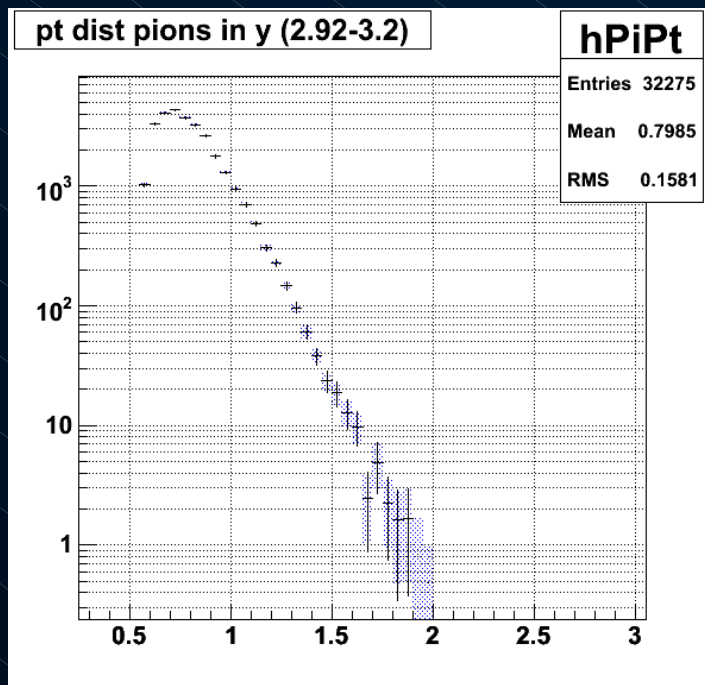
Charged pions at $x_F \sim 0.2-0.6$

Expect asymmetry in order of 5-30% for π^+



Reference spectra

- Typical reach in p_T is ~ 2 GeV/c
- This matches measurements at 62.4 GeV in Au–Au and Cu–Cu at forward rapidities



d+Au collisions in 2007

Present Forward spectrometer data have generated renewed interest in Forward Physics but--

Interpretation is limited by statistics, systematics and p_T coverage.

Nuclear modification factors, R_{dAu} & R_{cp} , above ~ 3 GeV/c help differentiate between descriptions of pA collisions at high energies.

Plans at forward rapidities include:

- Improved statistics and systematics
- Increased p_T coverage
- Fully identified charged particles

Such a run in FY07 is consistent with run plans of PHENIX and STAR

Summary

- BRAHMS requests a short run of **pp at 62.4 GeV** to
 - Obtain reference pp spectra at $y \sim 1, 0$ and $y \sim 3$.
 - Obtain a measurement of A_N for π^+ and π^- in a large range of x_F .
- The requested 'delivered luminosity' is 1.6 pb⁻¹, taking into account typical BRAHMS efficiency factors. (16 days)
- The polarization of the Blue beam should be $\sim 50\%$ or better.
- We request the 62.4 GeV run follow the 200 GeV pp run. A period for setup and commissioning is needed with collisions at 200 GeV at 2 o'clock.
 - This is in accordance with the PHENIX proposal which also requests a short run at 62.4 GeV. The main difference is our request is for transversely polarized beam.
 - Apart from the setup BRAHMS is not requesting pp at 200 GeV.
- The collaboration has dedicated the necessary resources to make this a successful run.