BRAHMS Beam Use Proposal
RUN–6

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For the BRAHMS collaboration

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November 3, 2005 Brahms Beam use proposal
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  51 Conference proceedings
2000–2005  100+ Talks at conferences, meetings and workshops

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

- Recent Publications
  - "Centrality Dependent Particle Production at y=0 and y<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"
  - "Centrality Dependence of Charged-particle Pseudorapidity Distributions from d+Au Collisions at sqrt(s_{NN})=200 GeV"
  - "Quark-gluon plasma and the color glass condensate at RHIC? The perspective from the BRAHMS experiment"
  - "Evolution of the Nuclear Modification Factors with Rapidity and Centrality in d+Au Collisions at sqrt(s_{NN})=200 GeV"
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 \( \text{nb}^{-1} \) 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 \( \sim 120 \text{ \mu b}^{-1} \). 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
   - \( \sim 2.6 \text{ \mu b}^{-1} \) 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.
Au-Au 200 GeV

Au-Au 62 GeV

pp reference is based on ISR collider data extrapolated to acceptance.
p+p at $\sqrt{s} = 62.4$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 \( \eta \) for AuAu 200 GeV and 62.4 GeV**

The 62.4 GeV data show similar trend weak \( \eta \) dependence at 200 GeV... but greater suppression approaching beam rapidity at 62.4 GeV.

Reference spectrum is needed to clarify relevance of
- suppression due to medium
- Change in underlying pp spectrum
- Entrance channel effects.
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.

  Flavor dependent correlation between the proton spin, momentum and transverse momentum of the un-polarized partons inside the proton.

- **Collins effect** [Nucl Phys B396 (1993) 161]
  Correlation between the quark spin, momentum and transverse momentum of the pion.

  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
Measurements at 2.3 and 4 degrees. New result.
Summary of $p_T$ dependence

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

Systematic errors from online polarization is (presently estimated at ~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.
- Bourrelly 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 $\sim 50\%$.
- 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 $\sim 1.6\, pb^{-1}$, or $\sim 16$ 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 $\pi^+$
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 $\sim$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 \(y\sim1.0\) and \(y\sim3.0\).
  - Obtain a measurement of \(A_N\) for \(\pi^+\) and \(\pi^-\) 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 \(~50\%\) 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.