

BRAHMS

Beam Use Proposal

RUN-5

F.Videbæk
For
The BRAHMS collaboration

8 September 2004

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The BRAHMS Collaboration

- 53 people from 12 institutions-

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Overview

- Introduction
- Accomplishments
- Requests for RUN-5
 - Physics
 - Detailed request
- Considerations for RUN-6
- Summary

Physics program for next RHIC runs.

Completion of Baseline program and follow-up on opportunities in high-pt studies, and spin physics including:

- Systematics of intermediate $-p_t$ suppression (1-4 GeV/c)
- Longitudinal collision dynamics via rapidity distributions.
- Collective effects
 - Transverse flow
 - Source sizes (coalescence)
 - Elliptic flow
- Centrality, System size and energy dependence
- Dedicated spin program (A_N)

High- p_t studies.

- Suppression observed in Au-Au relative to pp and d-Au.
- The dense matter suppression effect is thought to be dependent on $\sim \rho \cdot L$
- Interplay of partonic energy loss, Cronin and possible CGC.
- Controlled experiments with systematic change of ρ and L via change in system (L, A), density (rapidity, centrality) and $\sqrt{s_{NN}}$.
- Suppression depends on hadron type.
- P_t dependence of π , p different. $P/\pi \geq 1$ at intermediate p_t .

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Bulk and Collective Properties - longitudinal dynamics

- Development of stopping
 - Projectile and energy dependence
- Integrated 4π yields for identified hadrons
- Collective flow (transverse & elliptic)
 - $\langle p_t \rangle$ vs. centrality and rapidity
- Correlation measurements
 - Coalescence (anti) deuterons.
 - HBT
- Explore particle production at low # $N_{\text{collision}}$, and N_{part} (10-100) by utilizing light projectile

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Some published 200 GeV data

- p_T spectra of pions and kaons ($0 < y < 4$); sub PRL, nucl-ex/0403050
 - Systematic decrease in inverse slopes with increasing y
 - Rapidity distributions are near Gaussian.
 - $\sqrt{s_{NN}}$ dependence of K/π (AGS-SPS-RHIC)
- Net proton Rapidity distributions (PRL 93,102301 (2004))
 - The rapidity loss of protons is estimated to be near 2.0 for central collisions
- High p_T suppression; PRL 91,072305(2003)
 - Au+Au high p_t suppression at $\eta=0$ and $\eta=2$
 - at $\eta=0$ R_{dAu} is consistent with Cronin effect.

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d-Au

Data

- Survey of “soft” physics I.e. rapidity distributions for identified hadrons.
- Selected high- p_t runs at $y \sim 0, 1, 2, 3$

Results

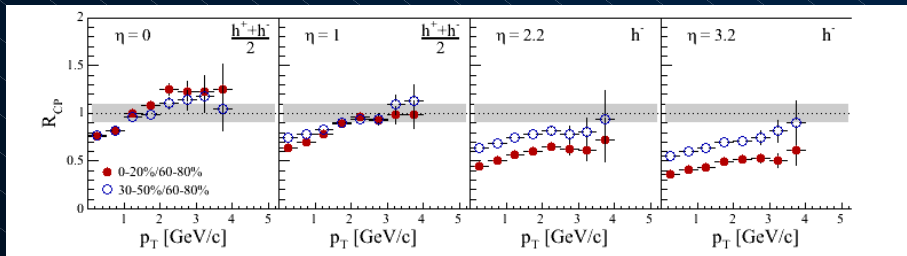
- High- p_t hadron yields, comparison to p-p; observation of no suppression in d-Au at rapidity $y \sim 0$. PRL91,072305
- Suppression of R_{dA} and R_{cp} at $\eta \sim 1, 2$ and 3 (nucl-ex/0403005)
- Centrality dependence of Charged particle multiplicity distributions (nucl-ex/040025)

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Evolution of R_{CP} with rapidity



Cronin like enhancement at $\eta=0$

Clear suppression at $\eta=2.2$ & 3.2
 Decreasing R_{CP} with centrality at large η .
 Interpretation of these data is still ongoing (CGC)

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Data collected in Run-4

Au -Au at 200 GeV

- Brahms recorded $\sim 170 \mu\text{b}^{-1}$ in the 10 weeks run out of $550 \mu\text{b}^{-1}$ delivered. Recorded is within a ± 30 cm vertex. Last years request was for 240 delivered; exceeded expectations.

Au -Au at 62.4 GeV

- Brahms recorded $\sim 6 \mu\text{b}^{-1}$ whereas the request was $\sim 15 \mu\text{b}^{-1}$
- A total of 140m FS triggers for high rapidity survey and 90 m MRS mainly at $\eta \sim 1$ (45deg.)

p-p at 200 GeV

- The pp running period was intended for machine development but turned into a ~ 1 week of physics running, determined very late.
- Brahms collected a first sample of data at 2.3 deg to study single spin asymmetries at moderate x_F .

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Analysis from Run-4

- The run-4 dataset is very large (~18Tb)
 - First reconstruction, calibrations done for ~50% of dataset.
 - 62.4 GeV data in physics analysis stage.
- Analysis goals and strategy
 - Au-Au 62.4 GeV
 - Net-Protons; stopping and rapidity dependence of chemical potentials.
 - High-pt suppression at $\eta \sim 1$
 - pp transverse spin asymmetries
 - Au-Au 200 GeV
 - Suppression studies at large y
 - Centrality dependence of identified particle production at largest rapidity range 2.3-90 deg.
 - Correlations.

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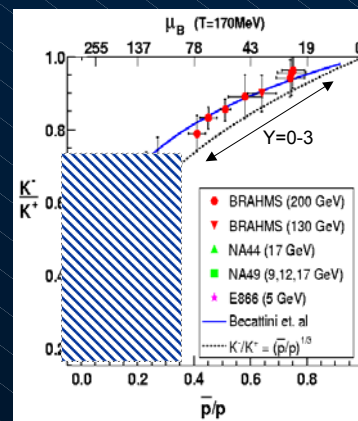
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Expected results from 62.4 GeV

Explore low μ_B region. This may be equivalent to lower energy data.

The 62.4 GeV with $y_{\text{Beam}} \sim 4.1$ Will allow to exploration of the complete rapidity range and fragmentation region well.



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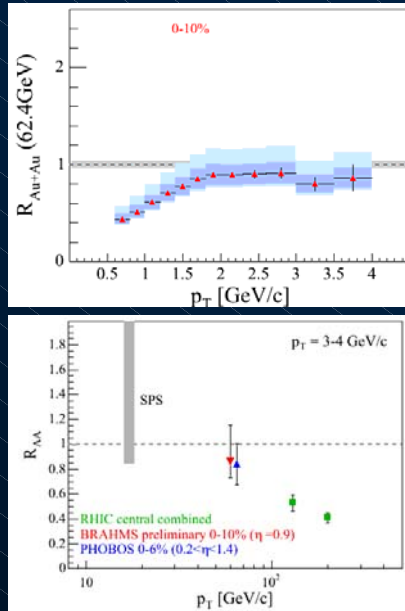
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62.4 GeV Au-Au

Brahms preliminary data for charged hadron suppression at $\eta \sim 1$.

Confirms that suppression has set in at lower energies.

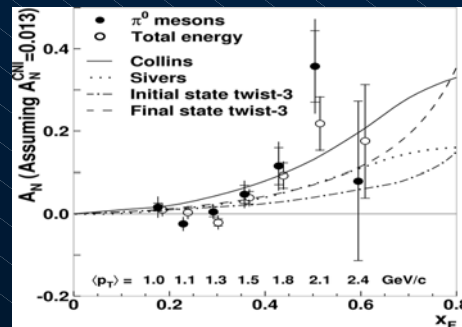
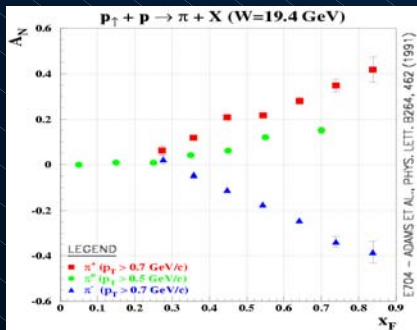


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Transverse Single-Spin Asymmetries



Low energy data (FNAL) show clear differences between π^{+-} and π^0 . At higher energies the models used to describe the data differ. Large spin effects reported for π^0 by STAR for $\sqrt{s} = 200$ GeV pp collisions

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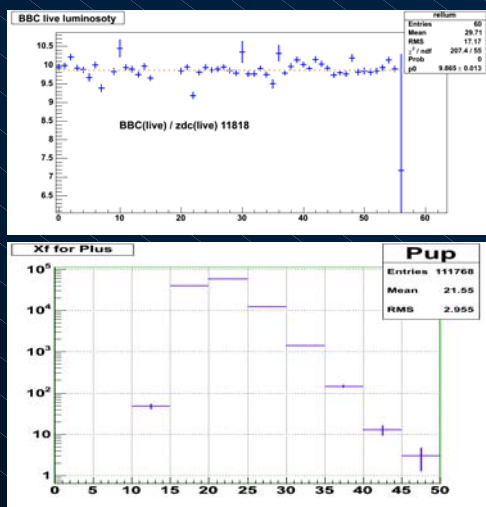
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Analysis Status

Data are from ~5 shifts of pp during run-4.

Normalization accuracy ~0.3%.

This sample will give stat. accuracy of ~ 1% at $x_F = .25$. 10-20* statistics will be sufficient for a measurement of π^+ an π^- up to $\sim .35$; Data from Run-4 should be available at DNP meeting.



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Considerations for request

- Assumed 2 running modes (Cu-Cu and pp) leaving a total of ~21 physics weeks (out of 31). Alternate 17 weeks under a reduced funding scenario.
- Assumed $\beta^* = 3$ for RUN-4. With the routinely achieved high luminosities delivered, this is satisfactory, albeit for some high field setting Brahms is luminosity limited.
- Assumed the Cu-Cu at full energy likely to achieve better than minimum projection from CA-D.

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Cu-Cu at 200 GeV

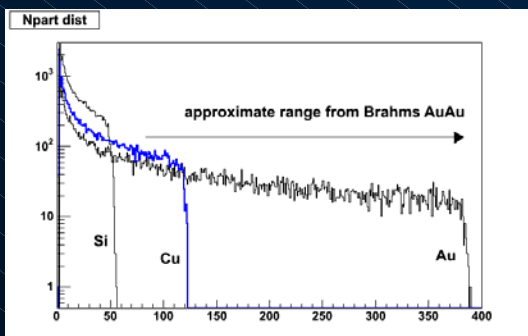
- The focus will be on measuring the higher p_t region of identified particles at $y \sim 1$ and $y \sim 2-3$. This will help in disentangling the importance of medium size vs. energy density experimentally, leading to a greater understanding of the phenomena observed with Au-Au at 200 and 130 GeV. ($R_{Fe} \sim 2/3 R_{Au}$)
- The choice of $A \sim 60$ allows for overlap with peripheral Au-Au in terms of N_{part} .
- Identified charged hadrons in the high- p_t region (2-5) at $y \sim 1$ and 2.5. (4 nb^{-1})
- Complete rapidity distribution for net-protons (baryons), particle composition, and Kaon production vs. rapidity. (2 nb^{-1})

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Centrality coverage



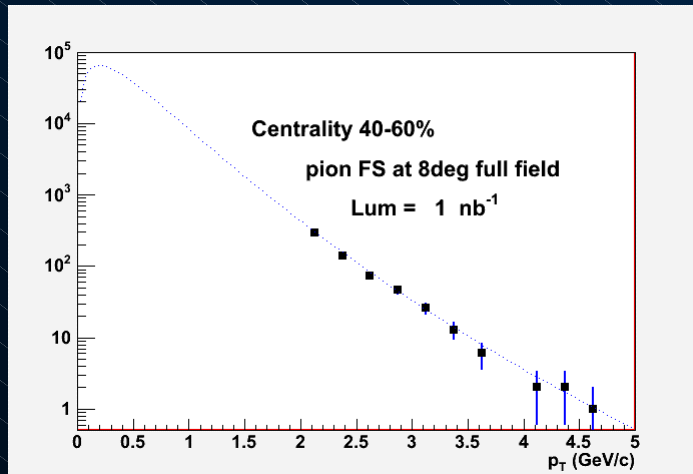
The choice of $A \sim 60$ is based on
Extending N_{part} , N_{coll} range from peripheral Au-Au and down
Maintain good centrality determination with Brahms detector system

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Sample expected Cu-Cu spectrum



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Transverse Spin in BRAHMS

Charged pions at $x_f \sim 0.2-0.4$

Expect asymmetry in order of 1-10% for π^+

Requires good control of systematic error (< 0.3% with 40% beam polarization.)

- Run-3 measurement $\sim 0.15\%$

Under Run-4 Conditions, 6 (2) weeks to make a significant first measurement.

• $\pi^+ \pi^-$ at $x_f \sim 0.4$ (requires $\sim 2 \text{ pb}^{-1}$)

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Consideration for Run-6

- From the BUPs last year some remaining components from the program will be
 - Completion of Au-Au at 62.4 GeV
 - The 03 request was for two simultaneous measurements of
 1. High- p_t measurement at $y \sim 1$. ($10 \mu\text{b}^{-1}$) (MRS)
 2. Survey of net-proton, kaon and π distributions utilizing the FS. ($10 \mu\text{b}^{-1}$)
 - Albeit partially done the measurements lacks in
 - Rapidity coverage between 1.2- 2
 - High p_t studies at large y
 - The BRAHMS data at large η in d-Au has spurred extensive discussion in terms of an interpretation of the CGC.
 - We have realized that a modest run period of d-Au with essentially the present setup (some improvements for triggering) can provide a significant improvement over the data taken in Run-3.
 - This will allow for $\pi^+, \pi^- R_{dA}$ at large y up to 3-4 GeV/c
 - Possibly both d-Au and Au-d

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π^0 in Brahms

- Discussions are underway with the ALICE PHOS group exploring having a supermodule (~ 3500 crystals) with complete readout brought to RHIC and integrated with BRAHMS for the RUN-6.
- This could e.g. allow for π^0 measurements at larger rapidities in the p_t -range 1-5 GeV/c in d-au, Au-Au and pp.
- Details are still being worked out; This is a potentially exciting enhancement for a Run-6.

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Summary of Total request for Run 5-6

Species	Energy	Luminosity	Weeks (approximate)
Cu-Cu	200	6 nb ⁻¹	10
p-p	200	2 pb ⁻¹	2-6
<i>Au-Au</i>	<i>62.4</i>	<i>8 nb⁻¹</i>	<i>6</i>
<i>D-Au</i>	<i>200</i>	<i>10 nb⁻¹</i>	<i>6</i>

Summary of requested species and luminosities.

Summary

- The highest priority is a high statistics Cu-Cu run at full energy to study in detail high- p_t suppression at larger rapidities for identified hadrons.
 - This is in good agreement with requests from other experiments. Choice of Cu has of course already been settled.
 - Should the goal of 6 nb⁻¹ be reached we will be glad for an energy change to 62.4 GeV, and would need order of 2 weeks to make a good measurement.
- The collaboration also puts importance on a measurement of the transverse spin asymmetries at large x_F for identified pions. Additional Au at full energy may be warranted, pending outcome of Run-4 and lessons learned.
- Learned just yesterday that 25 cryo weeks is a likely outcome for FY05 running.
 - The request given will fit into a two-mode running, but leaves little room if luminosities are near lower estimates from CA-D guidance.