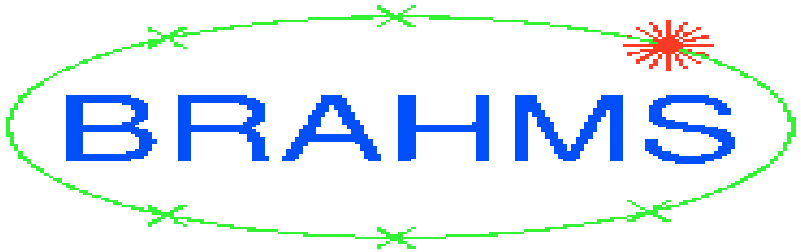



# BRAHMS Experiment at RHIC

**October 4, 2000**

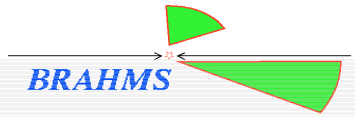
**DNP 2000**

F.Videbœk

Physics Department

Brookhaven National Laboratory

# BRHMS Collaboration

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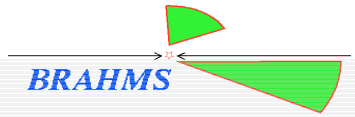
## Overview of presentation

- Physics Goals of BRAHMS
- Detector overview
  - Overall layout
  - Status, Detector Performance
- Global measurements
  - Centrality selection and multiplicities
- Spectrometer measurements
  - Status report for MRS, FS.




## Measurements

- p, K, π identified in wide range of rapidity, $0 < |y| < 4$ and $0.2 < p_t < \sim$ 3GeV/c (central and fragmentation region).
- Measure semi-inclusive $p_t$ spectra as function of centrality.
- Study this as function of collision system (Au, Si, p+A, and p+p)
- Capabilities for BE measurements.

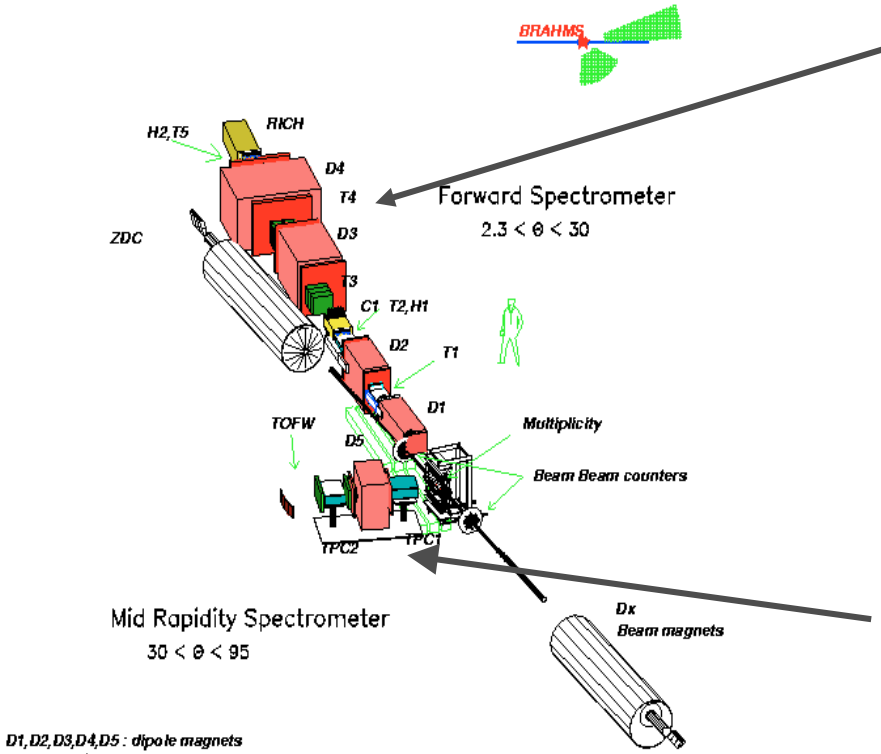
## Results will address

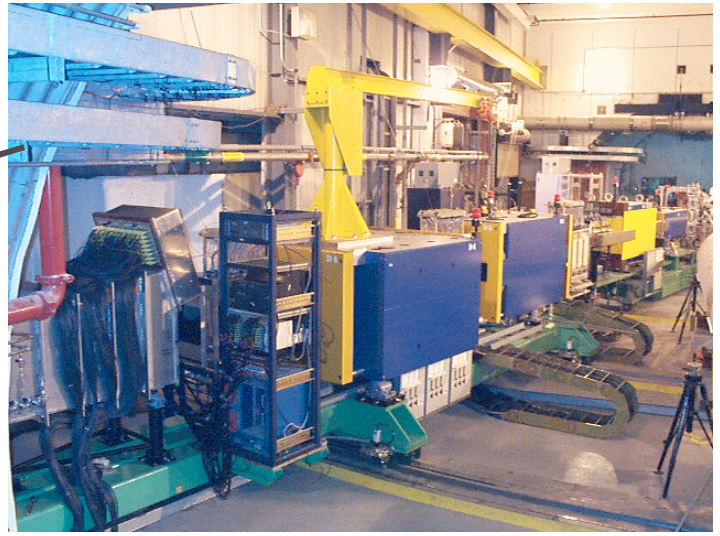
- Reaction Dynamics. Stopping, chemical equilibrium, thermalization.
- p,p-bar production. Baryo-chemical potential
- K+,K-. Strangeness enhancement.
- $< p_t >$ vs dN/dy.
- Mini-jet production systematic; rapidity dependence ($p_t >$ 2 GeV/c p, K, π ).

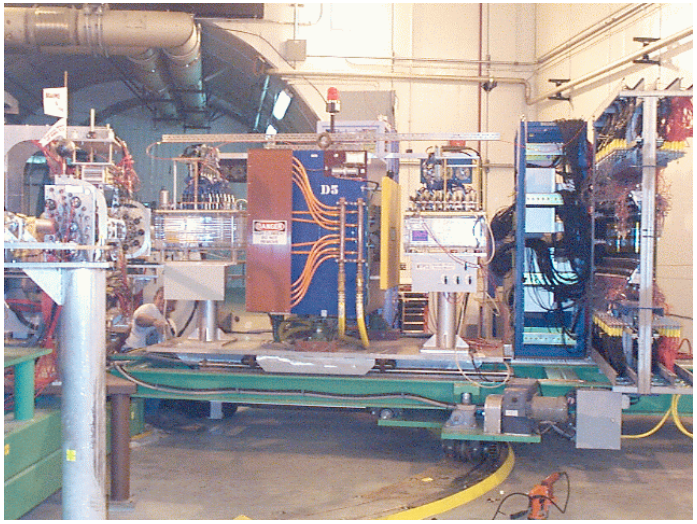
# Early Physics Goals (Au+Au)

- Global measurements
  - multiplicity measurements, and correlation's with forward neutrons.
- Hadron rapidity distributions and $\pi$, K, p yields for soft $p_t$ region.
- Overall goal to determine aspects of initial conditions in the collision process and aspects of the freeze-out phase.
- Stopping in particular
  - Baryon number transfer in rapidity
    - Different mechanism in HI reactions like Gluon junction or di-quark breaking mechanism may result in higher transfer than simple extrapolations from pA will indicate.
    - A rapidity shift in baryon kinematically corresponds to an energy loss. This energy can show up as increased particle production at mid-rapidity , or carried by high rapidity particles.

# Perspective View of Spectrometer





## Forward Spectrometer

➡ $2.3^o < \Theta < 30^o$ Coverage

- Full Forward Spectrometer ($2.3^o < \Theta < 15^o$ )

  High-momentum mode

  – sweeping D1,D2

  – tracking and momentum determination by T2-T5, D3,D4

  – PID: RICH ($\pi$/K/p) separation < 25 GeV/c) Tof-H2 ($\pi$ /K < 5, K/p < 8.5 GeV/c with 4$\sigma$ cut)

  **Low-momentum mode**

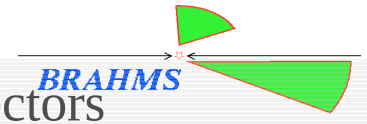
  – tracking and momentum determination by **T1-T2, D2**

  – PID: **C1** ($\pi$/K) separation < 9 GeV/c) **Tof-H1** ($\pi$ /K < 3.3, K/p < 5.7 GeV/c with 4$\sigma$ cut

- Front Forward Spectrometer ($15^o < \Theta < 30^o$ )

  – Same as Low-momentum Mode

Momentum resolution $\sigma$**(dp/p)** ~ 1%




## Mid-Rapidity Spectrometer

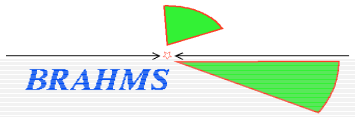
➡ $30^o < \Theta < 95^o$ Coverage

- Tracking and Momentum determination, **MTP1, MTP2 and D5.**
- PID **TOFW** ($\pi$ /K < 2.2, K/p < 3.7 GeV/c with 4$\sigma$ cut). Essentially one charge sign measurements.

The **global detectors** provides event characterization off-line as well as level 0 and level 1 triggering.

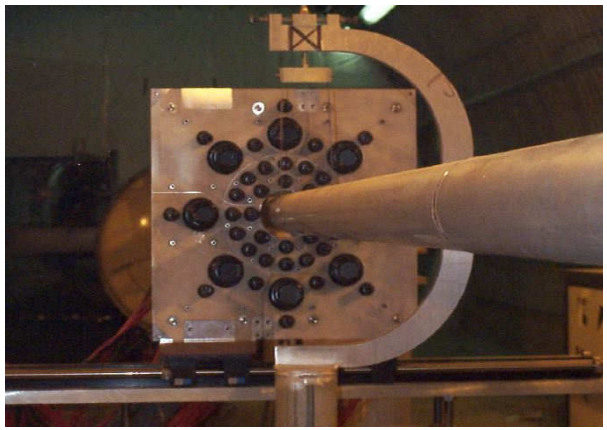
- Beam-Beam Counter
  - provide a start time and Level 0 trigger
  - ~50psec time resolution and vertex determination to ~2-3 cm.
  - Provide multiplicity information at high $\eta$.
- Multiplicity Detector ( Tiles and Si-det)
  - Provide a measure of charged particle multiplicity in the central region
  - Sufficient segmentation to provide dN/d$\eta$
  - Provide triggering on central/ non central events in Au-Au and Si-Si reactions.
- Zero Degree Calorimeters (ZDC). Common to RHIC experiments

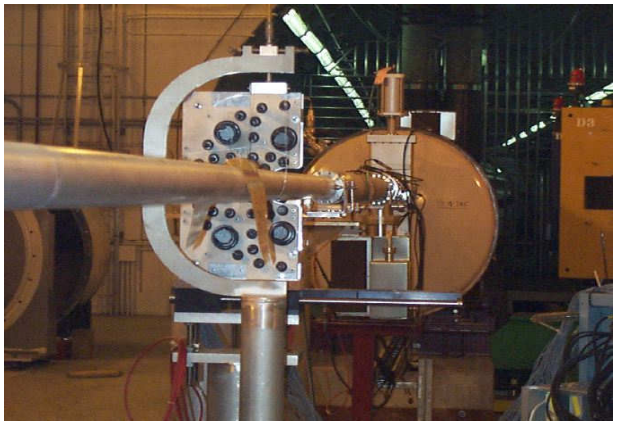
## Expected result from 2000 data

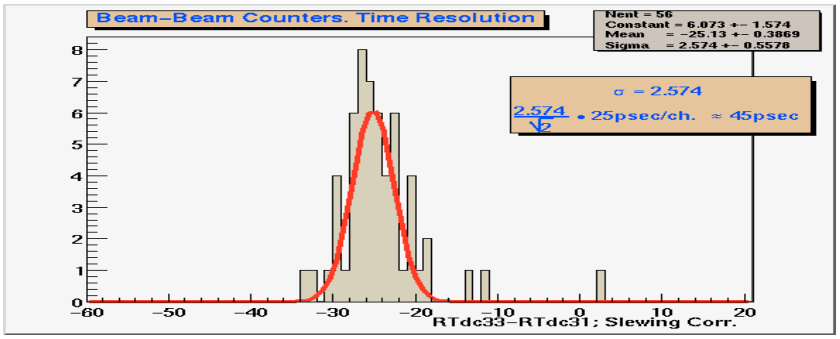



- The present analysis focuses on results that can be obtained from the short data taking run this year. Following section describes the status and progress towards the first Brahms results.
- Event Selection and min bias distributions
  - BB, Tiles, ZDC
- Multiplicity information
  - Charged Particle "Multiplicity" in $+-2 > \eta$ (Tile) $+-4.3 > \eta > +-3$ at sqrt(s) = 130 GeV/nucleon: Beam rapidity ~ 5
  - $dN/d\eta$: Yield and Centrality Extracted from Tiles, BB
- Charged hadrons (pi,K,p)
  - $dn/dp_t$ at mid -rapidity
  - $dn/dp_t$ at forward angles 4,5 degrees.

# Beam Beam Counters

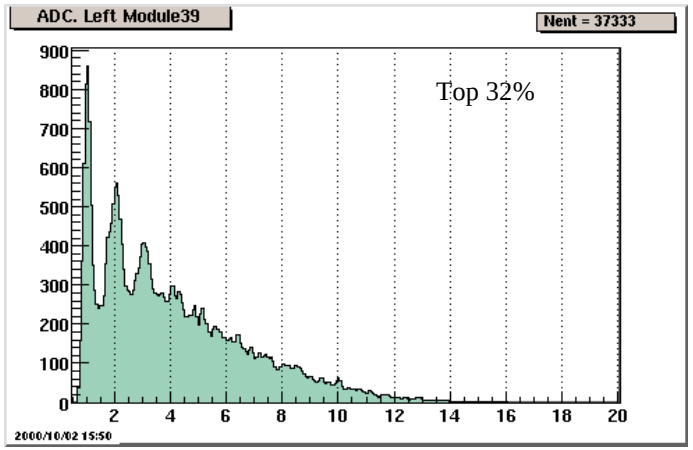






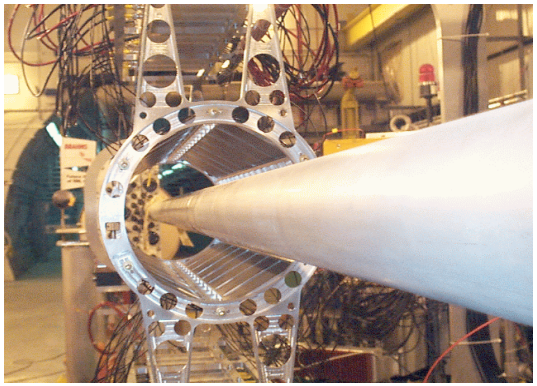

Timing from large tubes is $\sigma \sim 50$ psec.

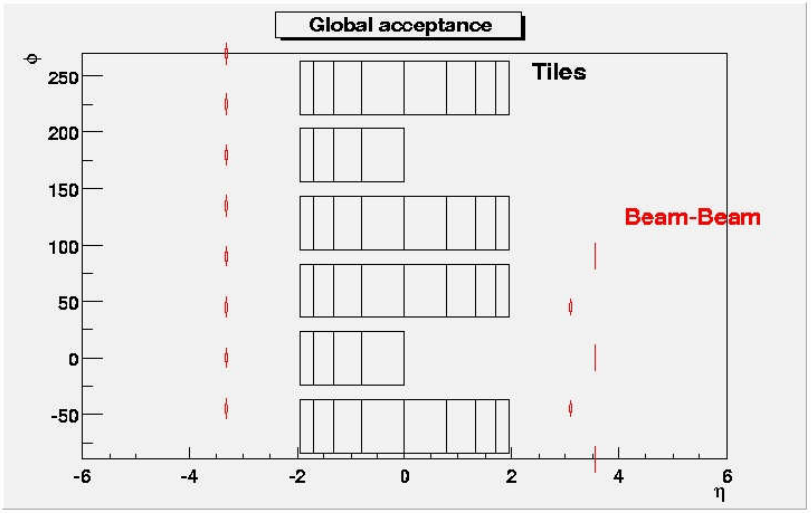
Typical ADC spectrum showing 1,2,3.. hits



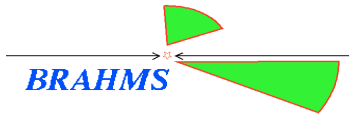
Hybrid Detector consisting of two layers of

- 175 channels of Si-detector channels
- 38 segments of 12*12 cm scintillator tiles
- coverage $-2.2 < \eta < 2.2$.



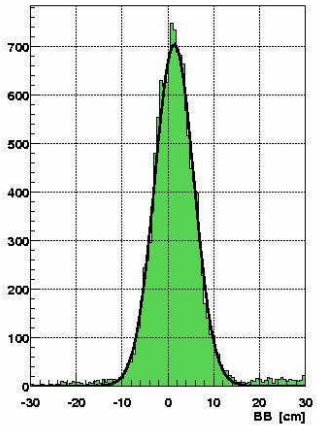


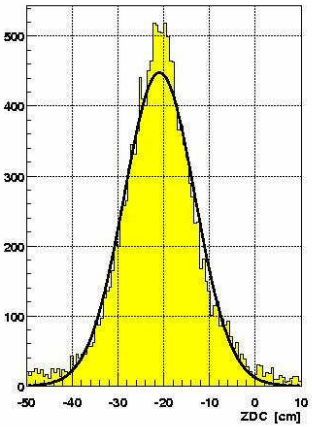
## Event Selection




- Event are selected by requiring timing signals from BB, ZDC consistent with a collisions for background rejection.
- Events are required to have at least one hit in tiles. This rejects the very peripheral electromagnetic dis-association of the nuclei.
- A vertex is calculated from the timing signals.

# Vertex Determination in Brahms

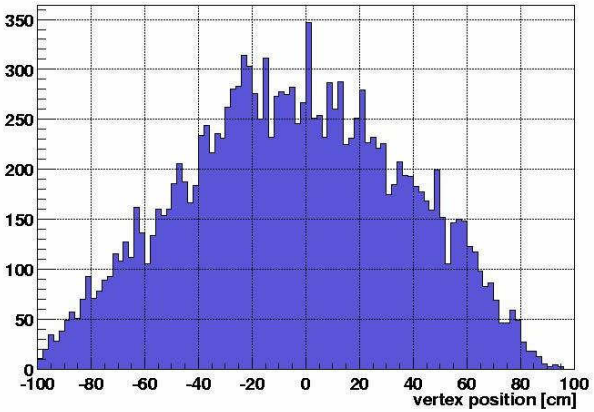


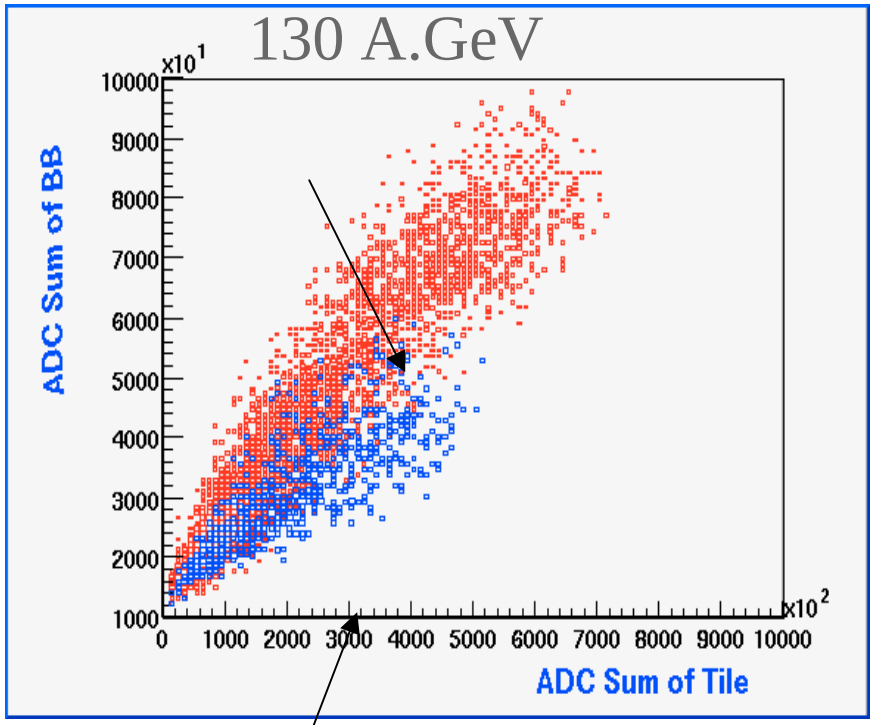

σ(BB)~4cm. σ(ZDC)~ 7cm.

Comparison of found collision vertex using
a) ZDC & BB timing information and
b) TPM1 tracking

Vertex distribution of accepted tracks in TPM1.



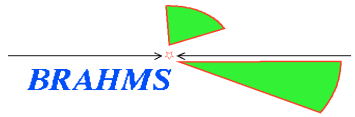
# BB vs Tile



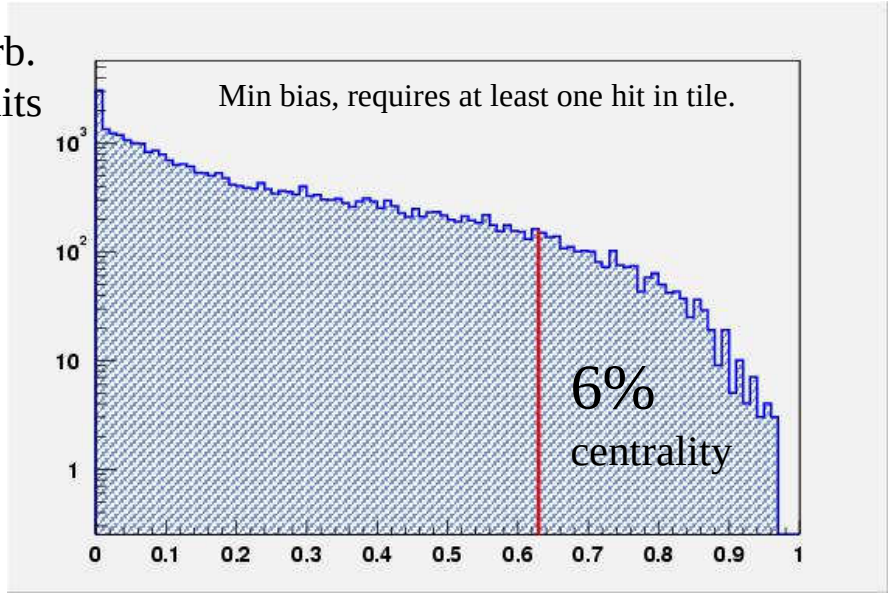

- Correlation of summed detector signals between BB (Forward region) and Tile (Central region)

- 56GeV/nucleon to 130GeV/nucleon
  Signal increases : BB > Tile
- The two measures centrality but at different η range.

## Event Selection Distributions

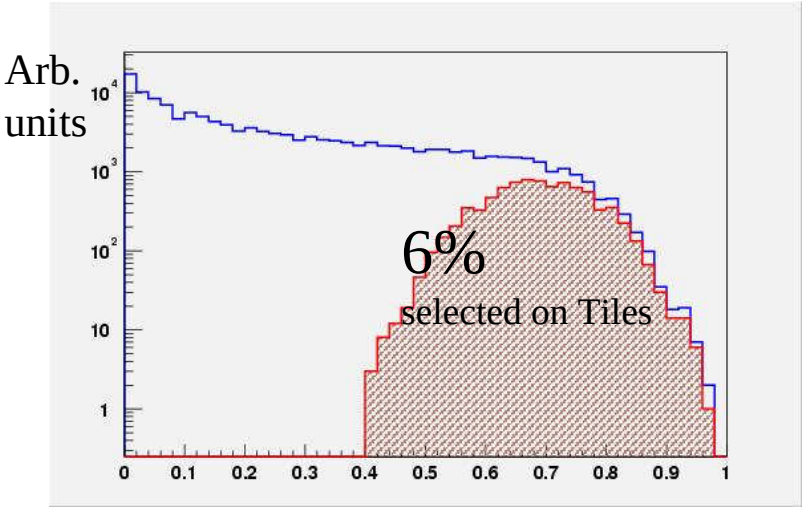



# Tile Distribution

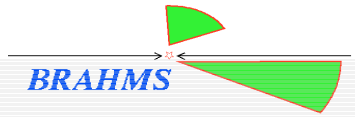



Gain corrected detector response is used to evaluate Normalized Multiplicity for BB and Tiles

# BB Distribution.

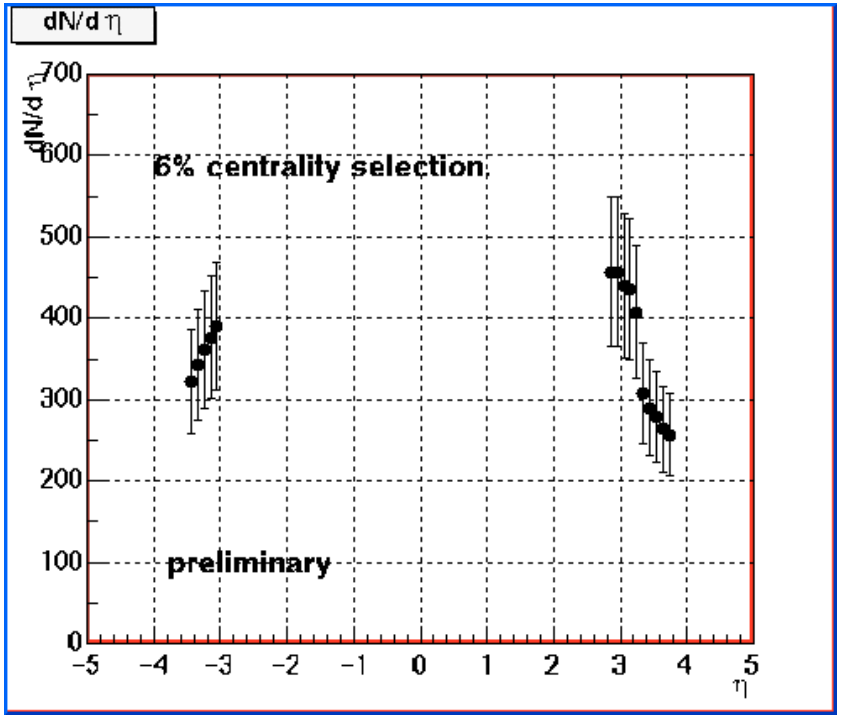


## Procedure for Beam Beam



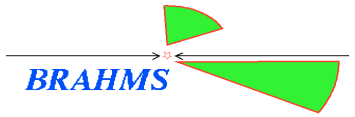

- Contribution to raw dn/dη calculated event by event using thecollision vertex position, known geometries and calibrated ADCsignals.
- Presently only a subset of the detector (ie large tubes) are used in the analysis.
- The contribution from background i.e. background particles given additional signals in the detector (from conversion in beam pipe) is evaluated from geant simulation with a event model as input, and full digitization of the response. The simulated data are subject to an identical analysis as the real data. By comparing the model input a correction factor is extracted.
- The response of the tubes is reasonably well understood; simulated and actual data agrees quite well (underestimate of background by ??)
- More details in Talk on Friday *First results from RHIC I session* (Y.Blyakhman)

# Beam Beam results




Systematic errors at present 10% from tube to tube variation, and another 15% from ADC to primary hit information

## Procedure for extracting Global information.

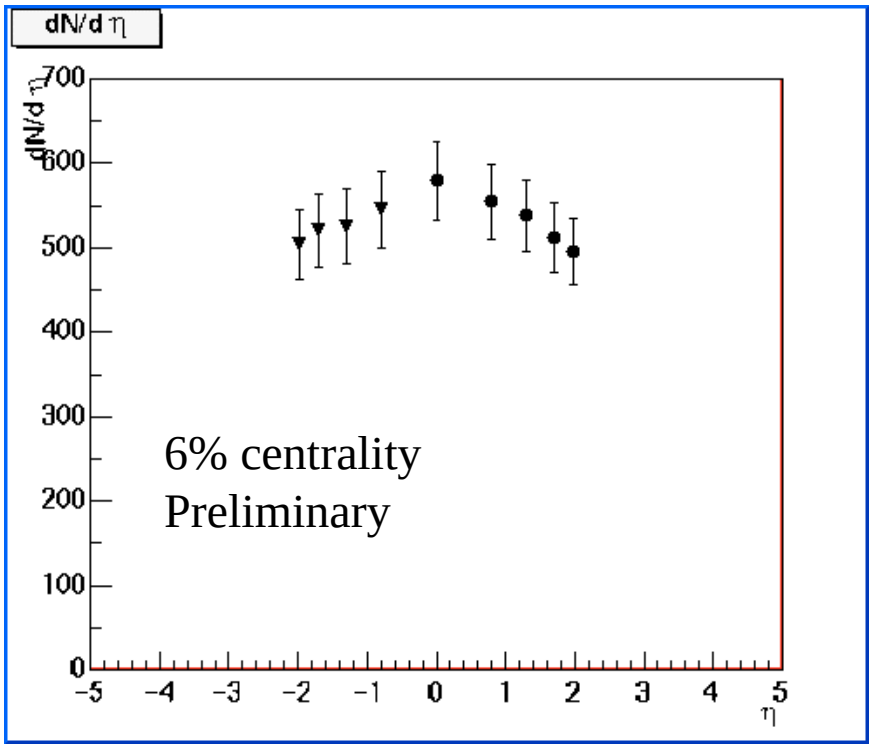



Scintilator Tiles

- Large linear Dynamic Range (1-100 hits),but no single hit resolution at higher multiplicities
- De/dx measurement includes secondary particle contribution and thus relies on simulations to ‘convert’ to multiplicity ( Secondaries ~30-40%)
- Gain from Cosmic Ray Calibration and very peripheral collisions.
- High Gain Channel excluding (10%>ADC Sum) (equivalent to truncated mean).
- More details in Talk on Saturday *First results from RHIC II session* (H.Hito)

- First set of corrections has been applied, but requires another round of analysis to reduced the present systematic errors.

# Preliminary Multiplicity results




The Brahms Multiplicity detectors will serve their purpose to provide centrality selection, provide dN/deta, and correlate with other RHIC experiments.

Analysis from Tiles

•Errors are relative between points.

•In addition there is an overall 15-20% systematic error from absolute energy calibration.

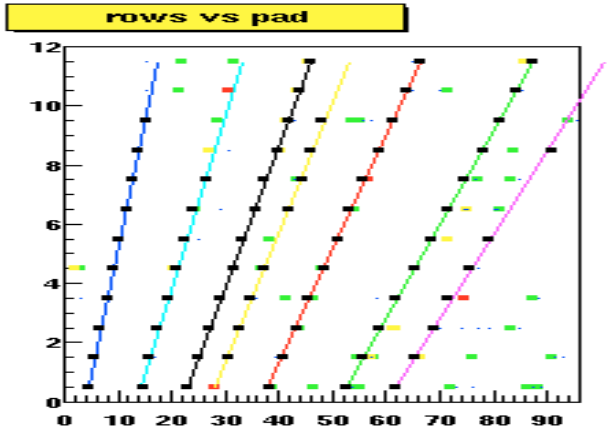
Data at η=0 in agreement with the published Phobos (PRL) results

- The Brahms Multiplicity detectors will serve their purpose to provide centrality selection, provide dN/deta, and correlate with other RHIC experiments.

•The total number of charged particles in the reaction is ~4000 in 7 units of rapidity.

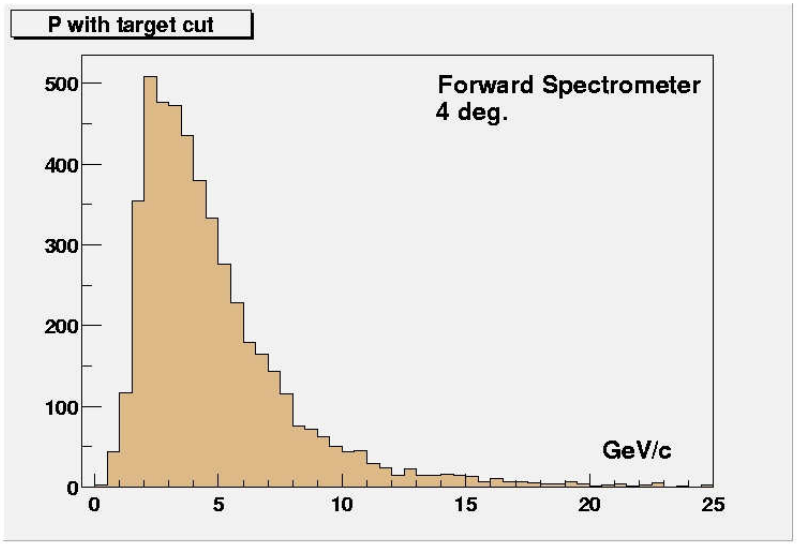
# TPCs

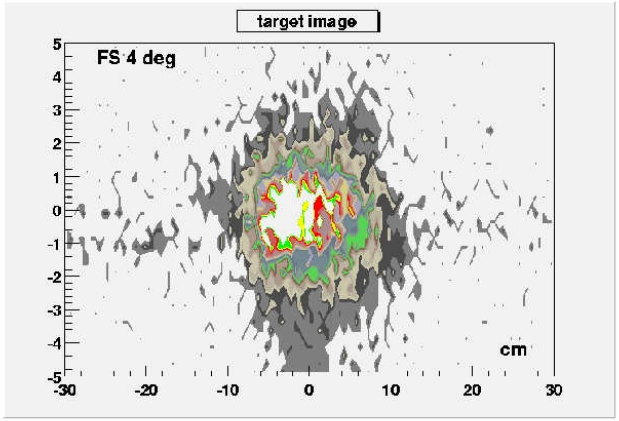
- The TPCs have a short drift (20 cm) using $ArCO_2$ (90:10)
- Each detector has about 1000 pads readout with STAR FEE electronics, and a BRAHMS VME receiver board



# Particle spectra

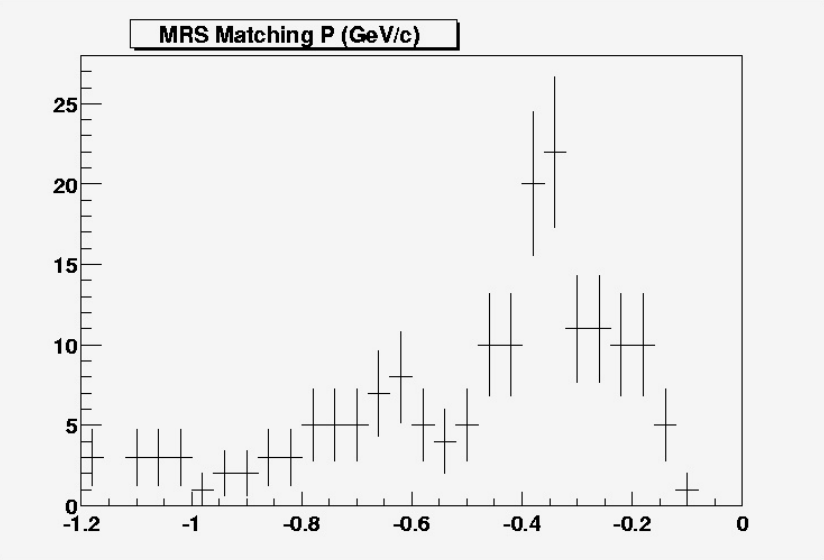
- The forward spectrometer data was taken at 4,5 and 8 degrees, with the front FS operational.
- The detailed study of detector response and calibrations is underway.
- The amount and quality of data should enable us measure the low pt range at rapidity 2.5-3.5 for pions, protons.
- As example of tracking is show projection onto nominal IP plane with distributions near expected values.



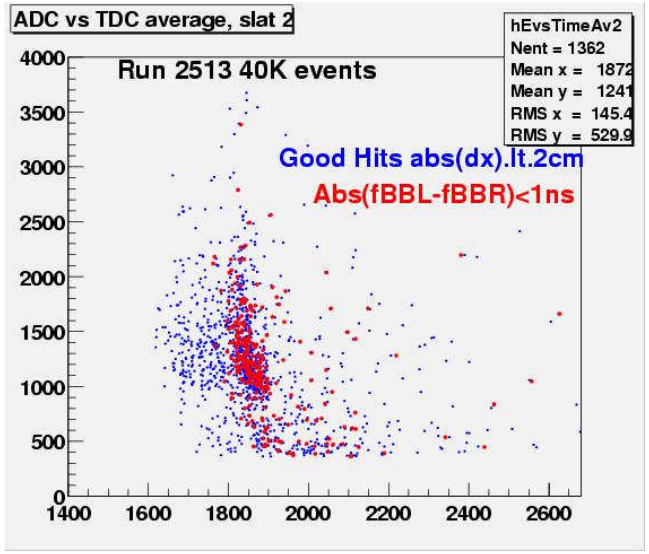

A sample momentum spectrum is shown for all charged particles in spectrometer. The yield is not corrected for acceptance.

The MRS spectra have lower statistics per run. One example shown. Overall Brahms collected ~10M triggers for mid-rapidity data.




Data in this years run cover essentially the low pt region ~0.2-1.2 GeV/c at rapidities of 0, 1 (MRS) and 3.5

- The on-going work is in calibrations, and track matching.
- Raw TDC timing and for  for track selected hits  illustrates the performance .




ADC

TDC

In addition to TOF the Cerenkov C1 will be used in forward spectrometer.

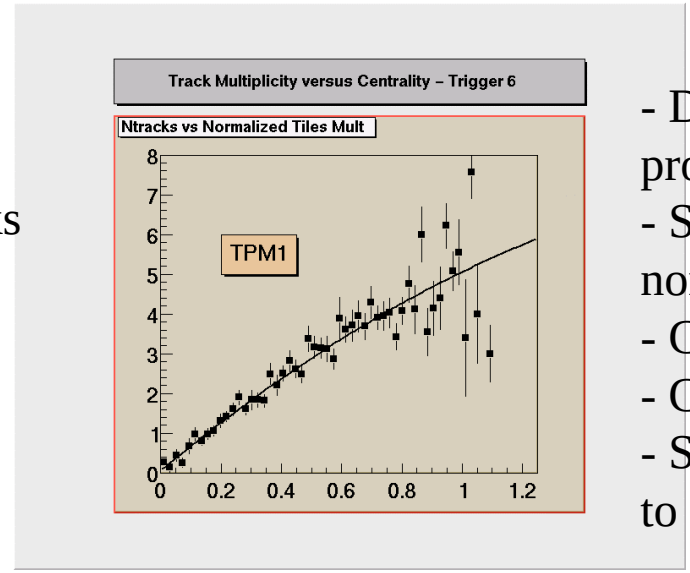
# Multiplicity information from MRS tracking

The solid angles of the TPC do
not match those of other experiments, but will
be valuable for Multiplicity measurements
in their own right

Ntracks

in

TPM1




N(tiles) norm.

- Determine local tracks and make cuts on projection to IP
- Selects track with BB/ZDC vertex near nominal IP.
- Correct for solid angle.
- Correction for efficiency ~20%
- Systematic error evaluate at 10%, likely to improve. Work in progress

## Summary and outlok

- The first year of RHIC running has yield a first set of good quality data that will give us  hadronic spectra at several rapidities , and will enable us to establish the baseline properties for Ultra- relativistic Au-Au collisions.
- Subsequent running period will give high statistics systematic vs. collisions systems as well as insight into higher pt regions over a wide range of rapidity. (AuAu, SS (or similar), pA)

**Finally the music started playing**