

# Commissioning Spin Rotators in RHIC

W. W. MacKay<sup>0</sup>, L. Ahrens<sup>0</sup>, M. Bai<sup>0</sup>, E. D. Courant<sup>0</sup>, H. Huang<sup>0</sup>,  
A. U. Luccio<sup>0</sup>, V. Ptitsyn<sup>0</sup>, T. Roser<sup>0</sup>, J. van Zeijtz<sup>0</sup>  
A. Bazilevsky<sup>1</sup>, L. Bland<sup>2</sup>, A. Bogdanov<sup>5</sup>, G. Bunce<sup>1</sup>, M. Chiu<sup>3</sup>, A. Denisov<sup>4</sup>,  
A. Deshpanda<sup>1</sup>, H. En'yo<sup>1</sup>, B. Fox<sup>1</sup>, Y. Fukao<sup>1</sup>, Y. Goto<sup>1</sup>, J. Haggerty<sup>2</sup>,  
K. Imai<sup>6</sup>, W. Lenz<sup>2</sup>, D. von Lintig<sup>2</sup>, M. Liu<sup>7</sup>, Y. Makdisi<sup>2</sup>, R. Muto<sup>8,6</sup>,  
S. Nurushev<sup>4</sup>, E. Pascuzzi<sup>1</sup>, C. Pinkenburg<sup>2</sup>, M. L. Purschke<sup>2</sup>, N. Saito<sup>6,8,1</sup>,  
F. Sakuma<sup>8,6</sup>, S. Stoll<sup>2</sup>, K. Tanida<sup>8</sup>, M. Togawa<sup>8,6</sup>, J. Tojo<sup>6,8</sup>,  
Y. Watanabe<sup>1,8</sup>, S. White<sup>2</sup>, C. Woody<sup>2</sup>, C. Zhang<sup>3</sup>

# Affiliations

---

- 0 Collider Accelerator Dept., BNL, Upton NY
- 1 RIKEN BNL Research Center, BNL, Upton NY
- 2 BNL, Upton, NY
- 3 Columbia University, NY, USA
- 4 IHEP, Protvino, Russia
- 5 Moscow Engineering Physics Institute, State University Russia
- 6 Kyoto University, Kyoto 606-8502, Japan
- 7 Los Alamos National Laboratory, Los Alamos, NM 87545, USA
- 8 RIKEN, Wako, Saitama 351-0198, Japan

---

Work performed under the auspices of the U. S. DOE and RIKEN of Japan.

# Abstract

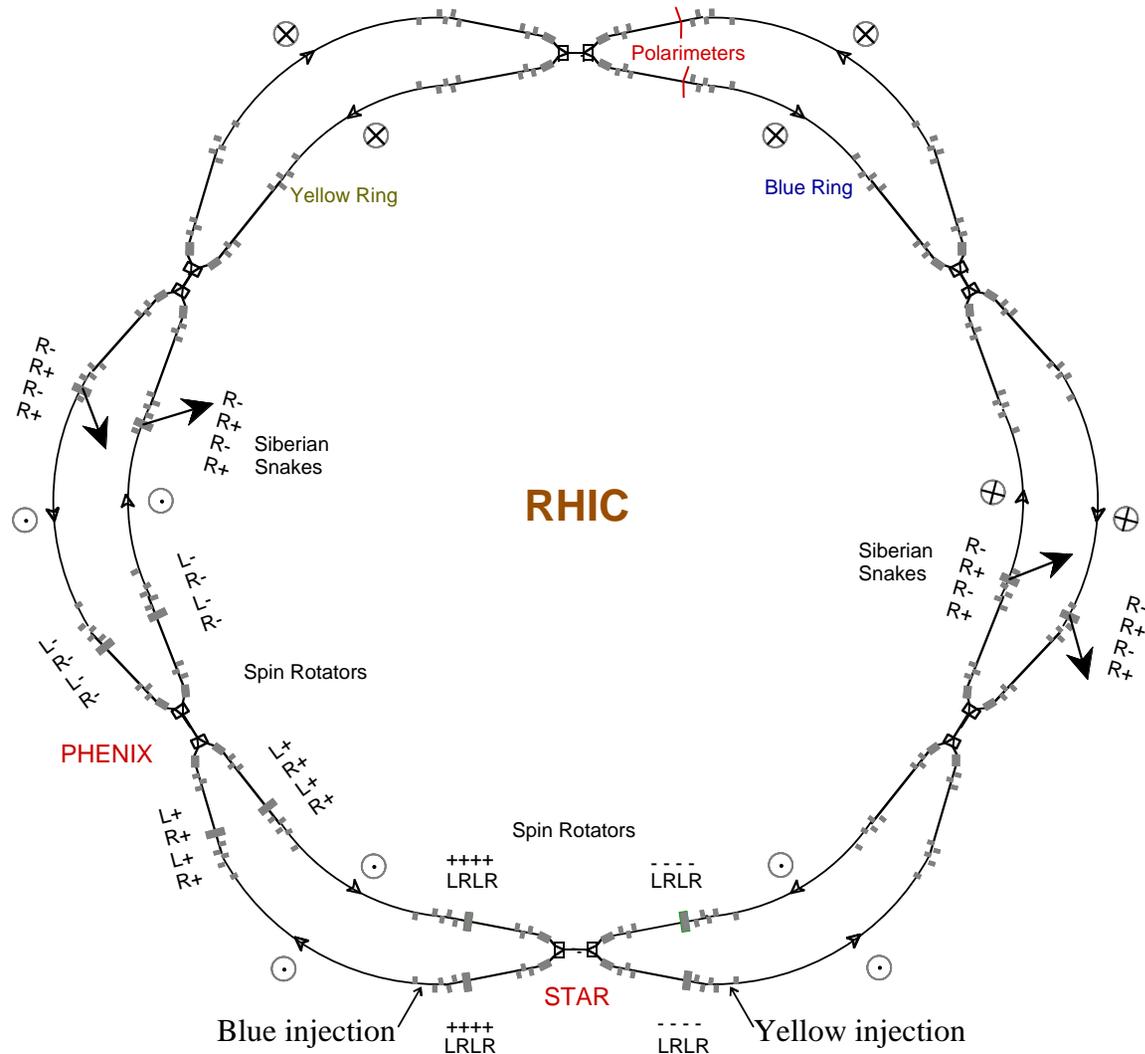
---

During the summer of 2002, eight superconducting helical spin rotators were installed into RHIC in order to control the polarization directions independently at the STAR and PHENIX experiments. Without the rotators, the orientation of polarization at the interaction points would only be vertical. With four rotators around each of the two experiments, we can rotate either or both beams from vertical into the horizontal plane through the interaction region and then back to vertical on the other side. This allows independent control for each beam with vertical, longitudinal, or radial polarization at the experiment. In this paper, we present results from the first run using the new spin rotators.

# Layout of RHIC

Rotators: + indicates field at end of helix points radially outward.

Snakes: + indicates field at end of helix points up.



PAC2003: Commissioning Spin Rotators in RHIC  
 Waldo MacKay et al. 13, May, 2003

# PHENIX Polarimeters: Motivation

Spin rotators for PHENIX were installed before Run 3. There was no experimental way of testing the operation of the spin rotators: that they turn the proton spin vector orientation from normal (vertical in the RHIC) to longitudinal (in the RHIC Experimental IRs).

PHENIX Local Polarimeter (the LocalPol) was based on the experimental evidence from a test experiment performed at IP12 in Run 2\* : that there is a left-right asymmetry in very forward neutron production in single spin transversely polarized proton collision. So, if the rotators are off or they are not functioning properly (i.e. there is residual transverse, longitudinal or radial component to the proton spin direction in the experimental IRs) then there would either be left-right or up-down asymmetries observed in the very forward neutrons produced in such collisions. If the rotators function as they intended, there would be no observed asymmetries.

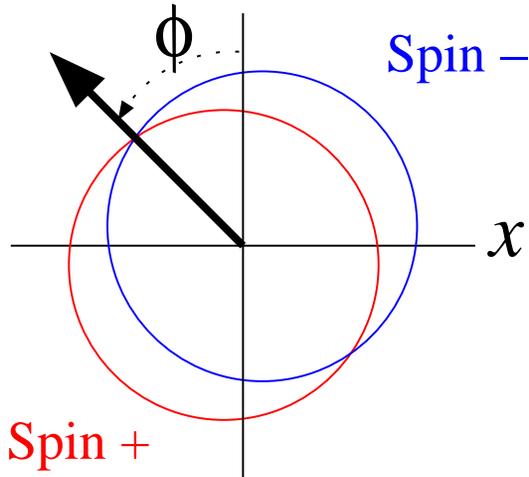
---

\* Y. Fukao for the IP12 Local Polarimetry Collaboration, *Observation of analyzing power in very forward neutron production in single spin pp collisions at  $\sqrt{s} = 200$  GeV*, Proceedings of SPIN2002

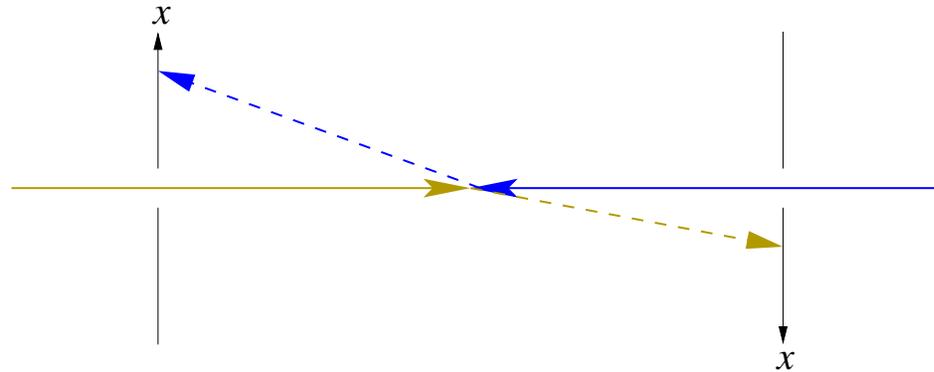
# PHENIX Polarimeters

The PHENIX local polarimeter consisted of the Zero Degree Calorimeter (ZDCs) and a Shower Max Detector (SMD) inserted between the first and the second module of the (three module-ZDC units) on both sides of the PHENIX IR. The ZDCs sampled the neutron energy through the hadronic shower development within its volume. The SMDs consisted of 8 horizontal and 7 vertical 1.5 cm strips of plastic scintillator read by a 16 channel PMT (M16, Hamamatsu). Based on the energy observed in each strip, we reconstructed the energy deposited profile, and hence deduced the hit position of the neutron which was then used to reconstruct the left-right and up-down asymmetries. Both these types of asymmetries were further combined to show a  $\phi$  distribution of asymmetry,  $\phi = 0$  starting from the vertical direction, increasing in the anti-clockwise direction.

# Orientation of Polarimeters



"Left-Right" Asymmetry  
(Tilted at 45°)

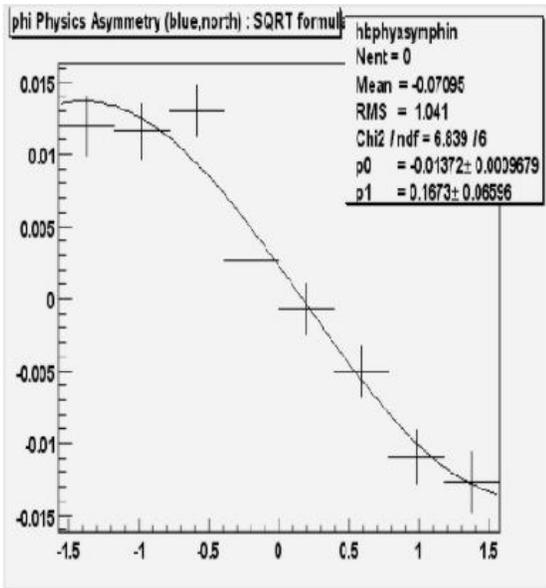


Schematic layout of PHENIX polarimeters  
Yellow from left. Blue from right.

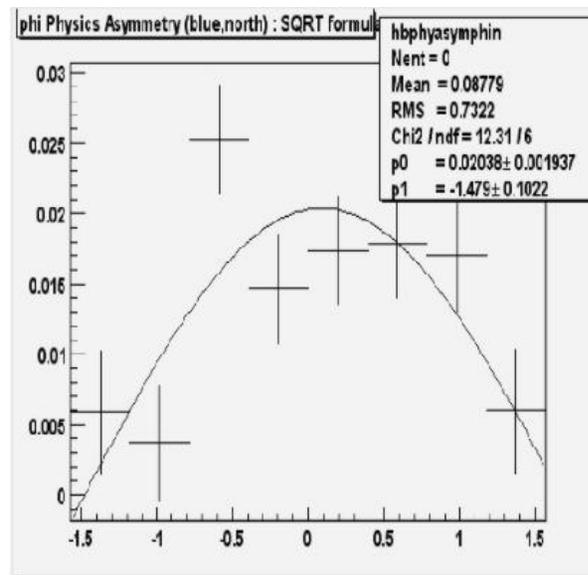
The PHENIX Local Polarimeter measures an asymmetry in small angle scattered neutrons which is proportional to transverse polarization.

$$A_{LR} = \frac{\sqrt{L^+R^-} - \sqrt{L^-R^+}}{\sqrt{L^+R^-} + \sqrt{L^-R^+}} \propto P_y$$

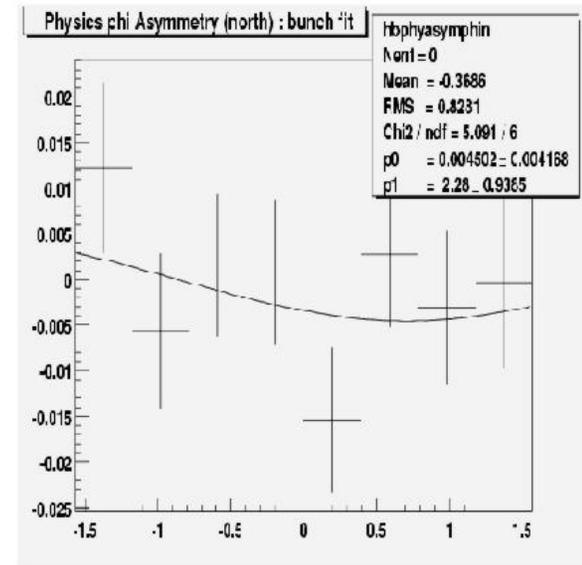
# Tale of the Blue Ring



Vertical polarization  
with rotators off.  
Spin is down.



Rotators on  
Spin is radially inwards!  
OOPS!



Reverse all rotator  
power supplies and try  
again.  
YES!

🐍 Ouch!

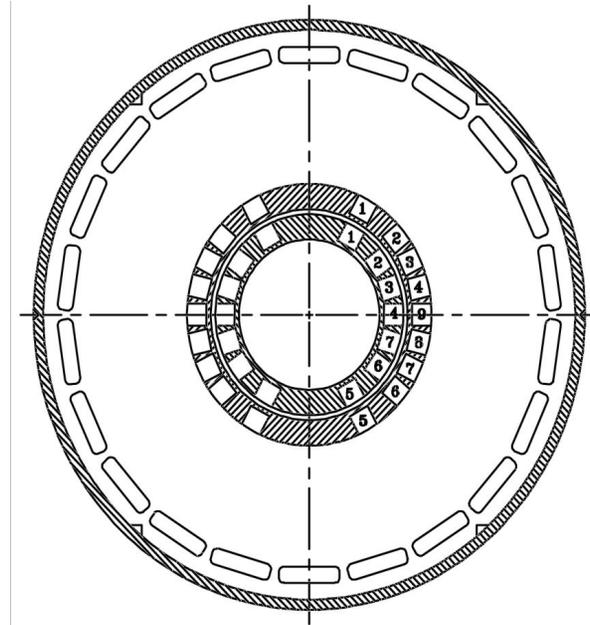
Snake Bite! 🐍

🐍 A helical dipole in one of the Yellow snakes failed at the beginning of the run.

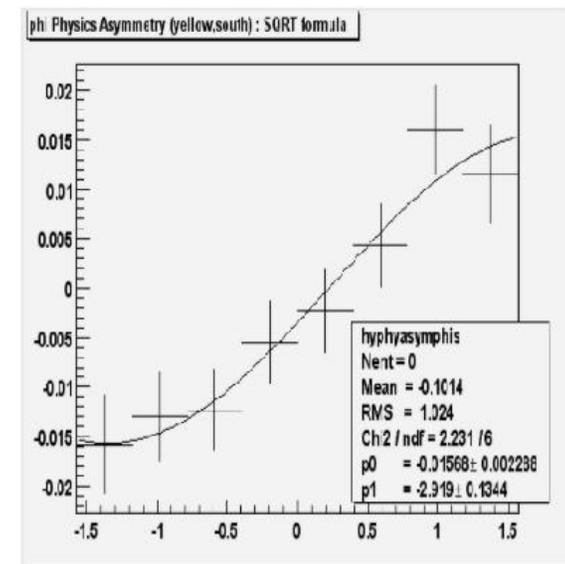
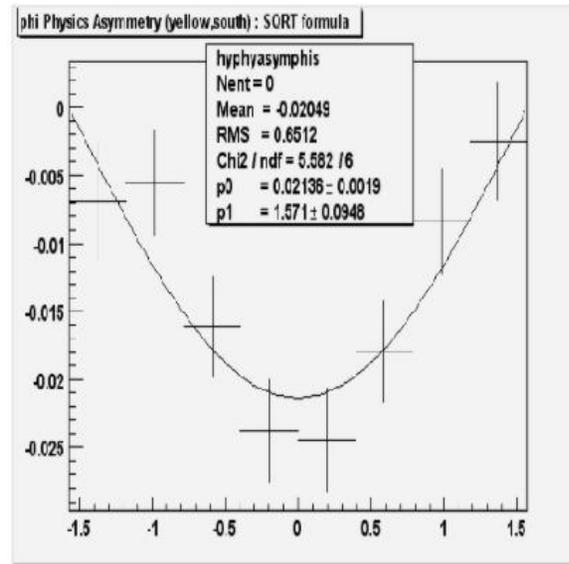
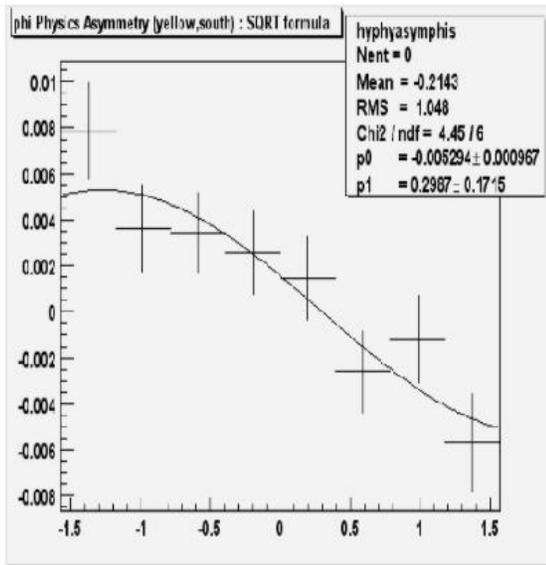
We believe the superconductor opened up in coil # 3 of the outer layer.

🐍 Develop plan B:

Operate it as a partial snake. By reversing the power supply for the other pair of helices we can rotate the spin by  $\mu = 158^\circ$ .



# The Saga of The Yellow, Part 1



Try correction.

Rotators off.

Beam vertical: down.

Rotator on.

Standard currents.

Radial polarization.

Reverse power supplies.

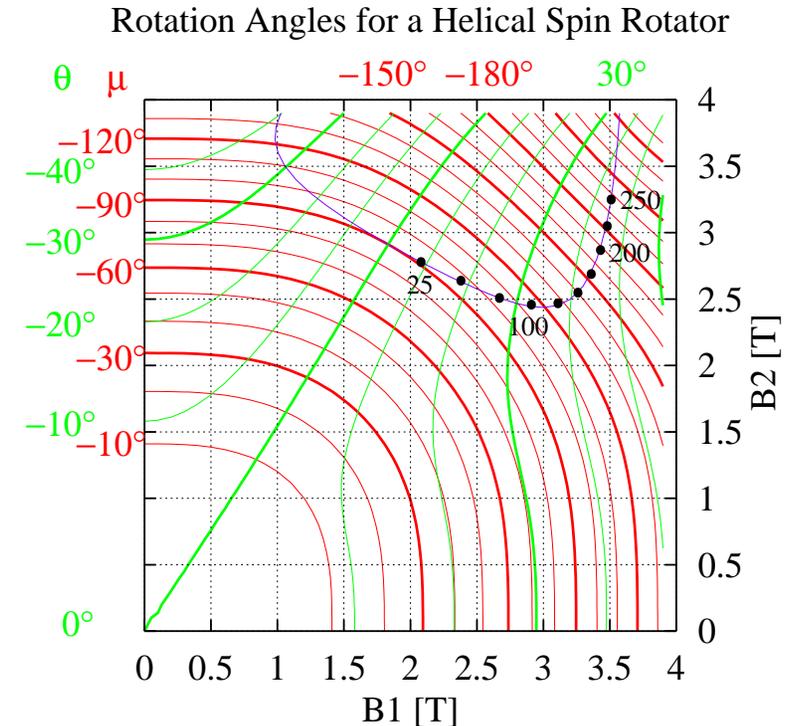
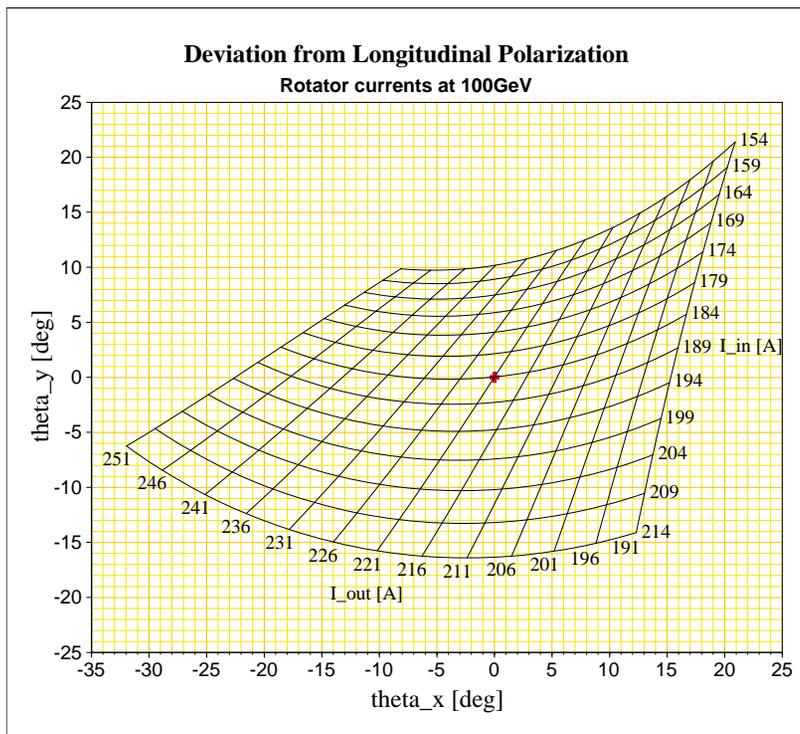
Pointing up a bit.

$\vec{P}_\perp \sim 12^\circ$  tilt from  $\hat{y}$

$\vec{P} \sim 40^\circ$  away from  $\hat{z}$

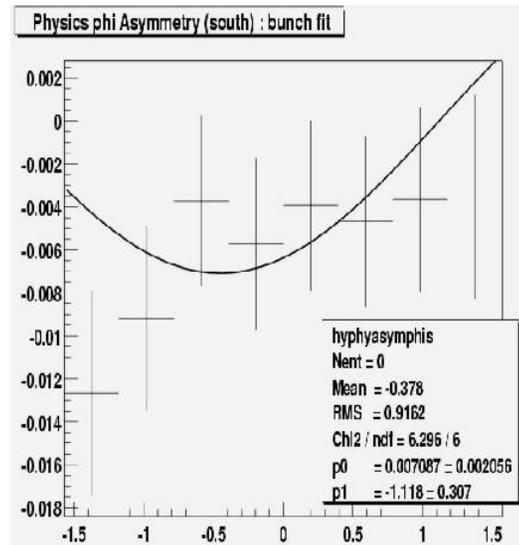
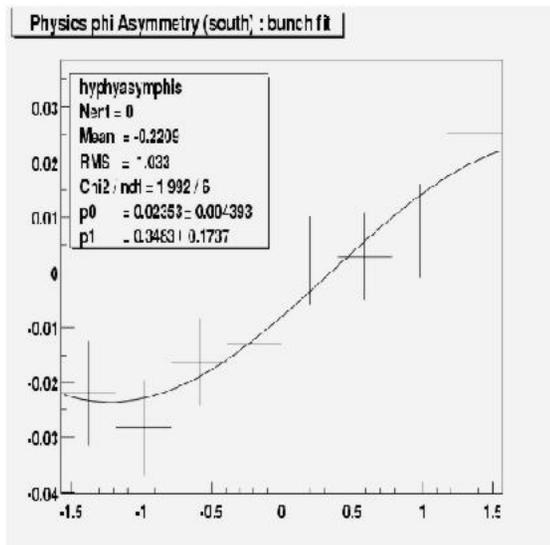
# Intermission: Late Night Powwow

Frantic writing on the blackboard.



Note: Purple contour for rotation into horizontal plane.  
Black dots show settings for RHIC energies in increments of 25 GeV from 25 to 250 GeV.

# The Saga of The Yellow, Part 2



Try correction.

It got worse.

Forgot we reversed power supplies.

Go the other way.

OK. Looks longitudinal to me.

# Summary

---

$$(e^{i\pi})^?$$