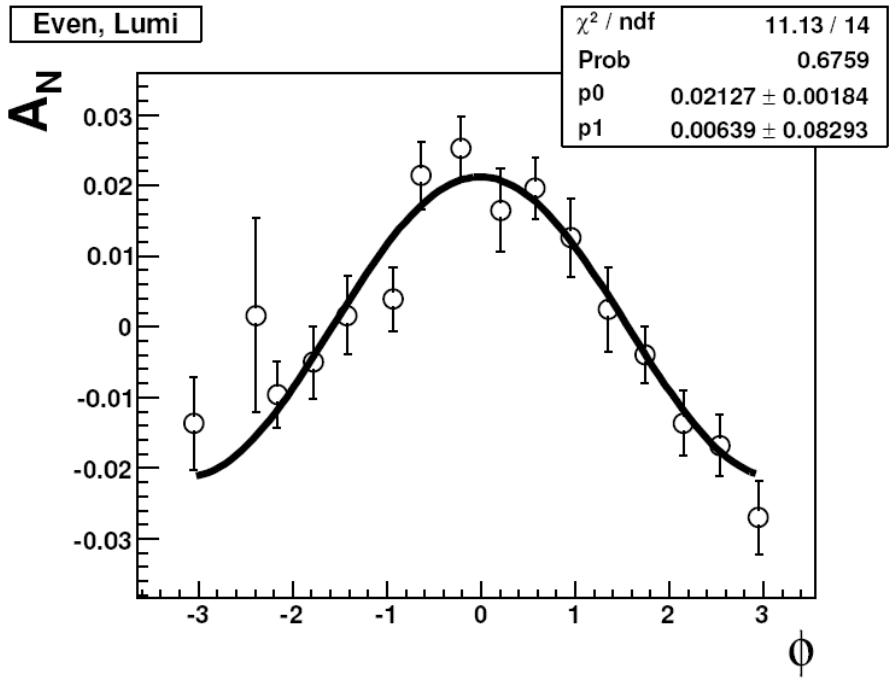
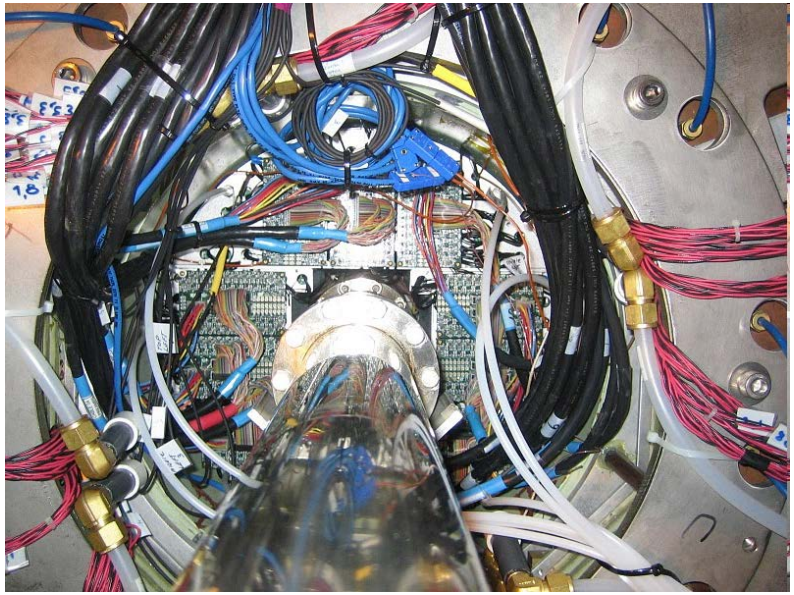
Measurement of Transverse Spin Asymmetries in Polarized proton-proton Collisions

and the

Realization of New Electromagnetic Calorimeters for Forward Physics



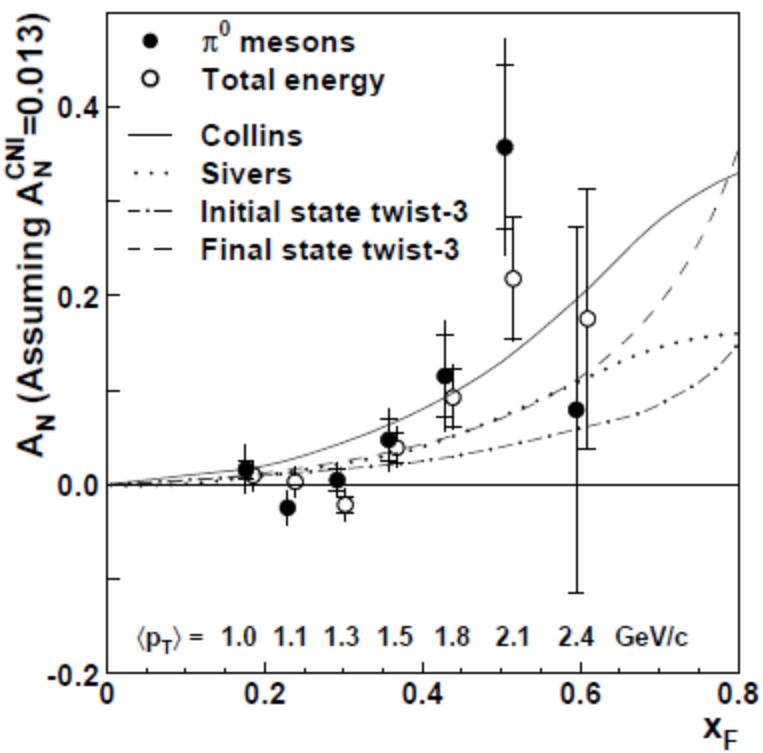


John Koster
RBRC
formerly University of Illinois at Urbana Champaign

2012/06/14

Motivation

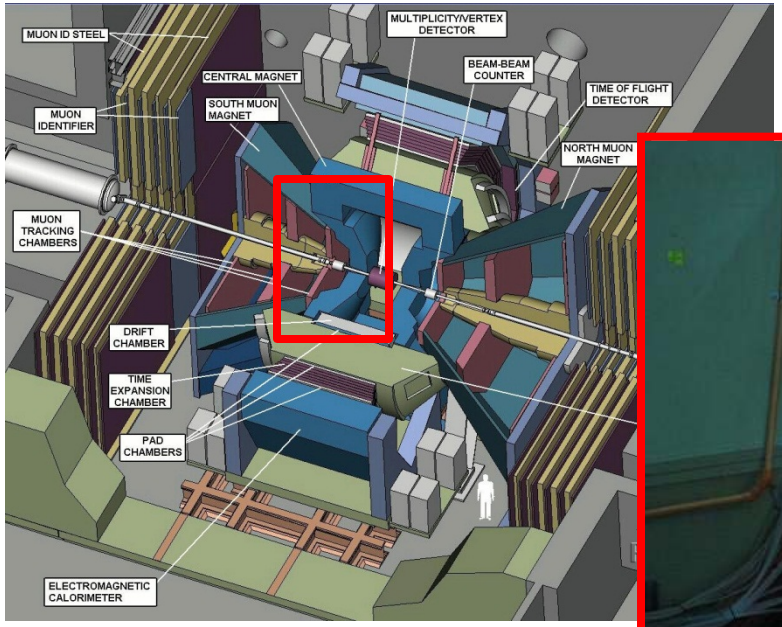
- How do the quar gluo contribute the proton spin?
- Why does well descr unpolarize structure, but fall short with the introduction of spin?



Phys. Rev. Lett. **92** (2004) 171801

- **Past results: non-zero results in forward region**
  - Long-standing tool for transverse spin: A_N e of + higher twist terms?

One Problem: No Forward EMC

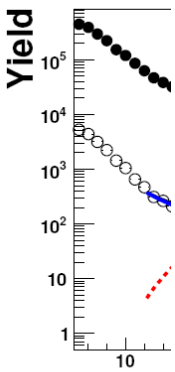


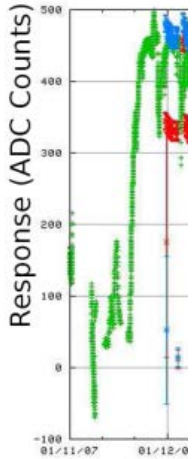
2 Holes Upstream and Downstream of IP

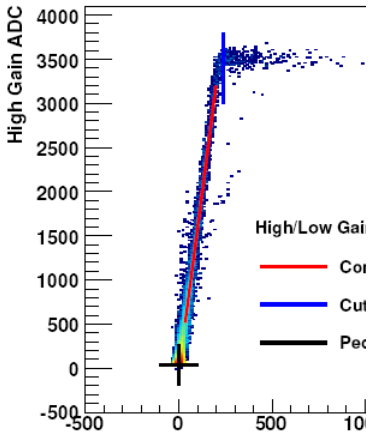
45 cm diameter, 43.1 cm depth with beampipe going through the middle

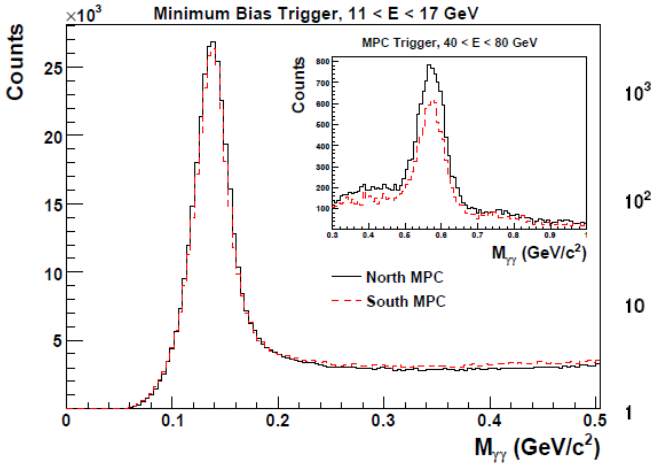
Let’s Build a Calorimeter

- Design detector
- $PbWO_4$ crystals
- Crystal wrap “party”
- Detector shells
- FNAL test beam
- Drive to BNL
- Prep for install
- Install
- Take data
- Calibrate



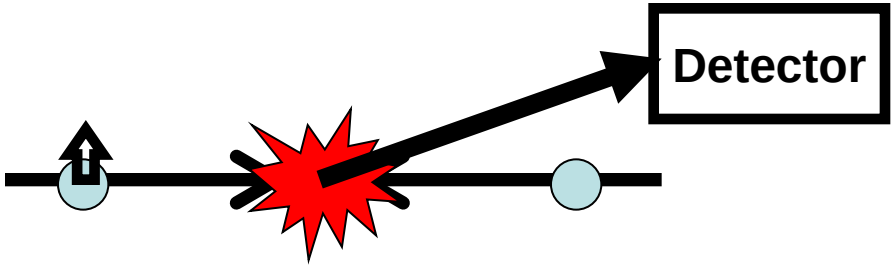




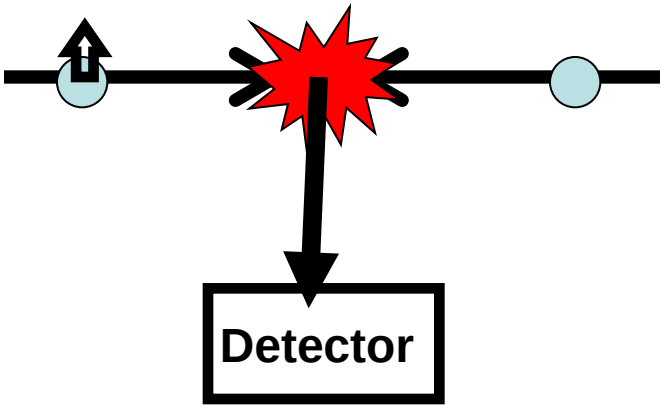


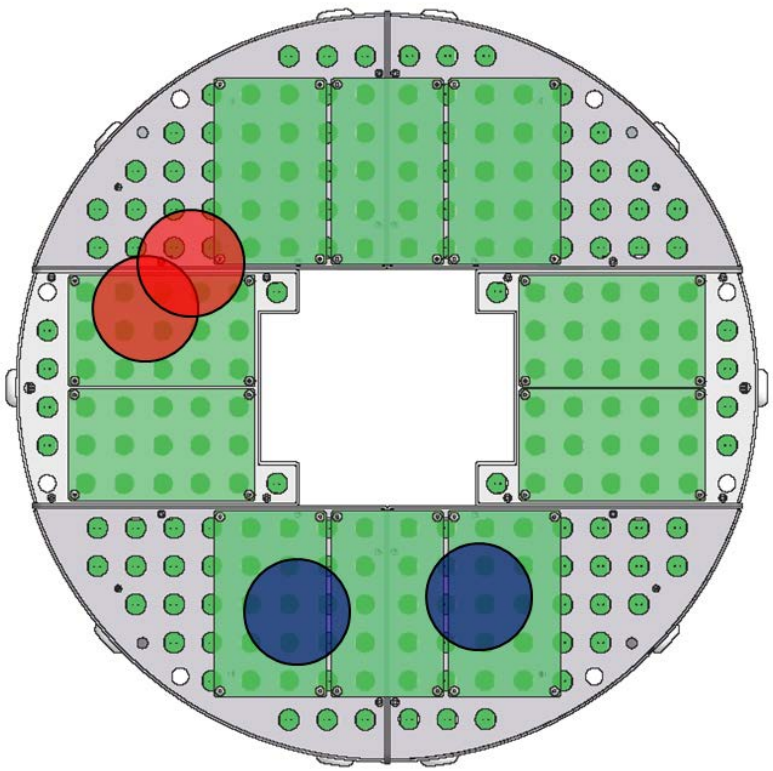
Results

1
Forward Rapidity



2
Mid-Rapidity

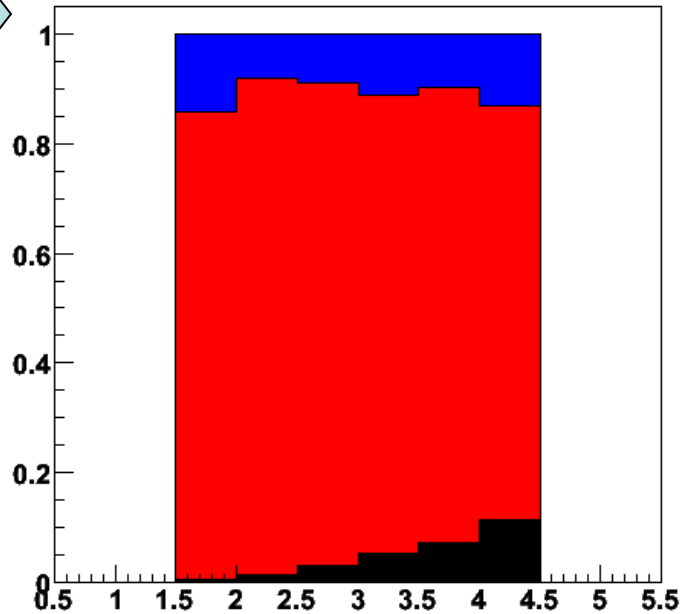




Decay photon impact positions for low and high energy π^0's

Most interesting region: High Energy, High p_T

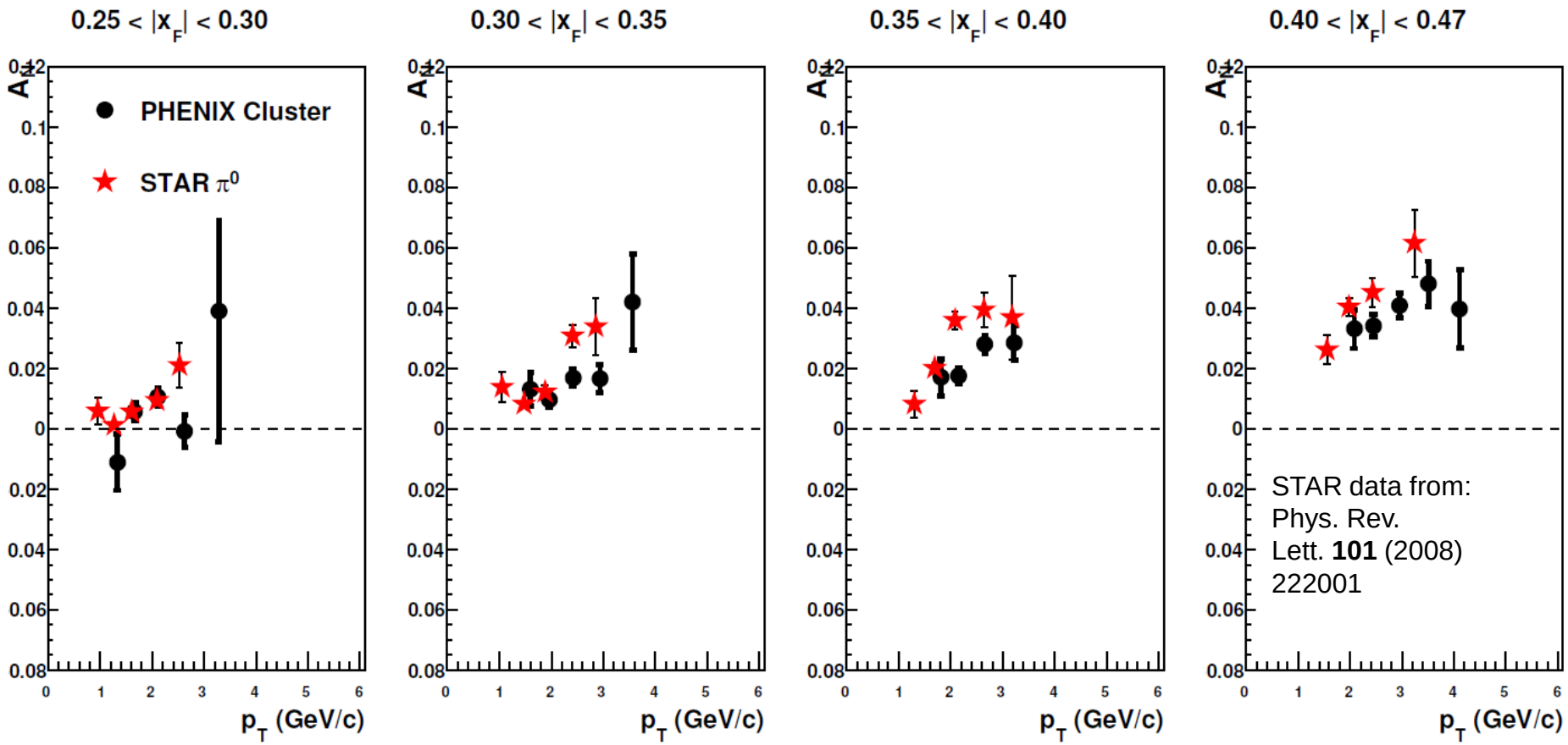
Measure high energy clusters & perform decomposition using Monte-Carlo



Decay photon
π^0
Direct photon

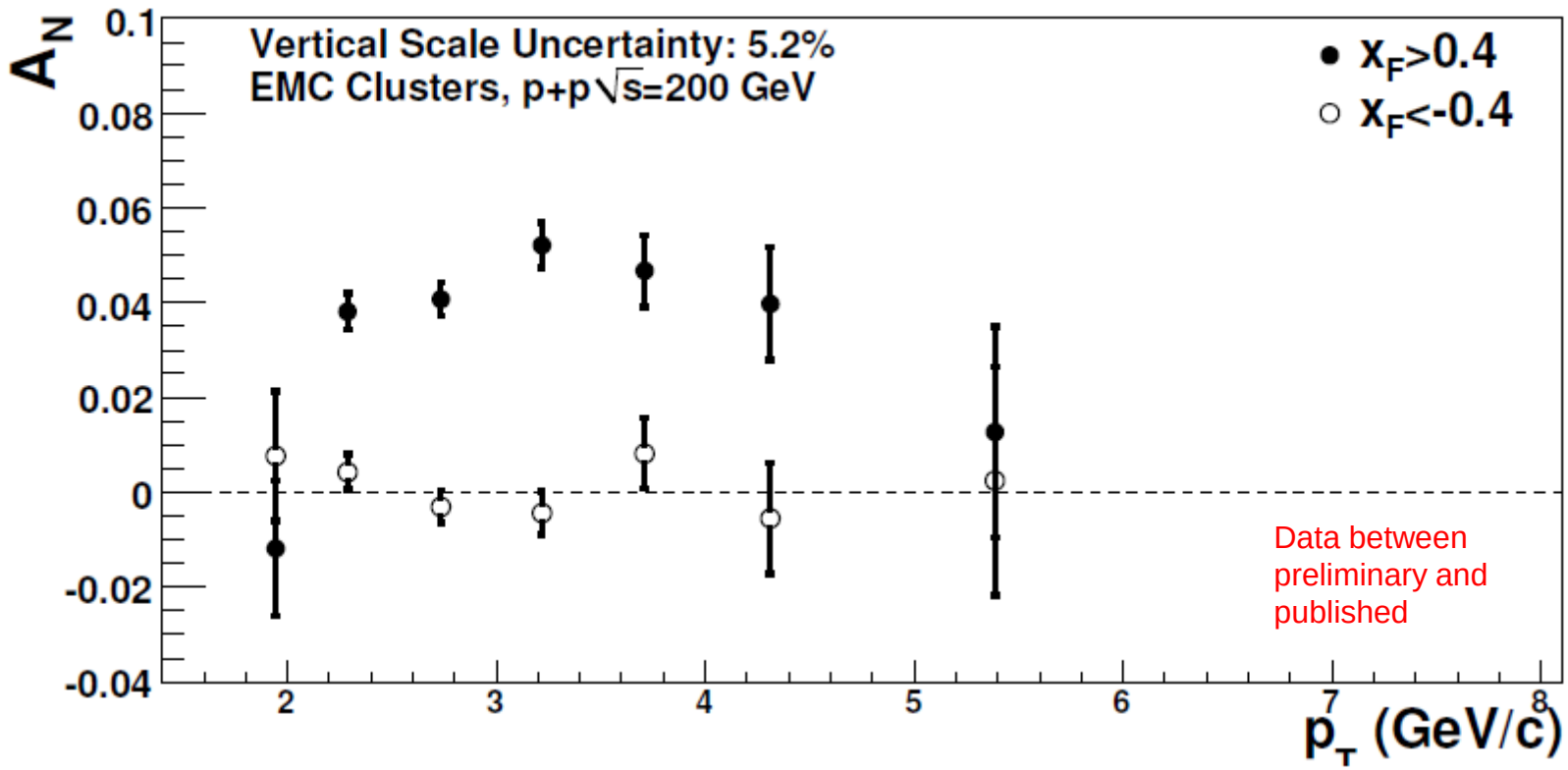
Direct photon contribution creeps up, especially at high p_T

Forward Results (i)



- **Discrepancy between STAR and PHENIX caused by direct photon "contamination" in PHENIX sample?**
  - If true, indication that Collins effect dominates.
- **Future detector upgrades from experiments will resolve!**

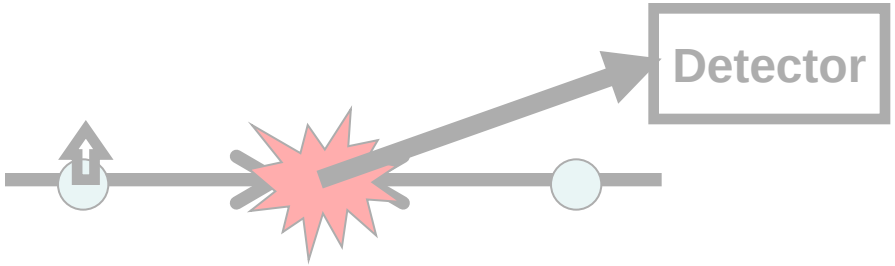
Forward Results (ii)



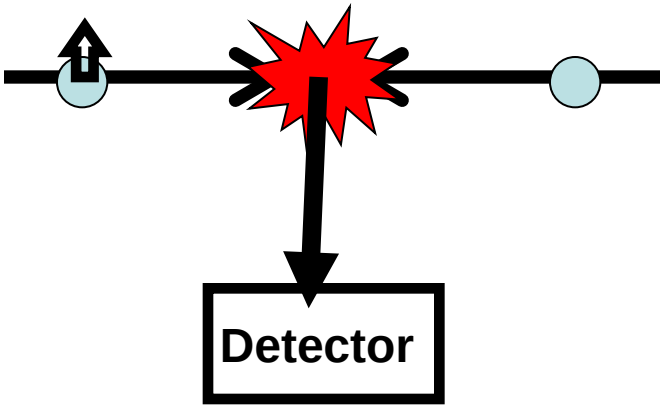
- **Suggestive drop in A_N at high p_T**
  Statistical significance is not large enough
- **Run12 will boost the significance!**

Results

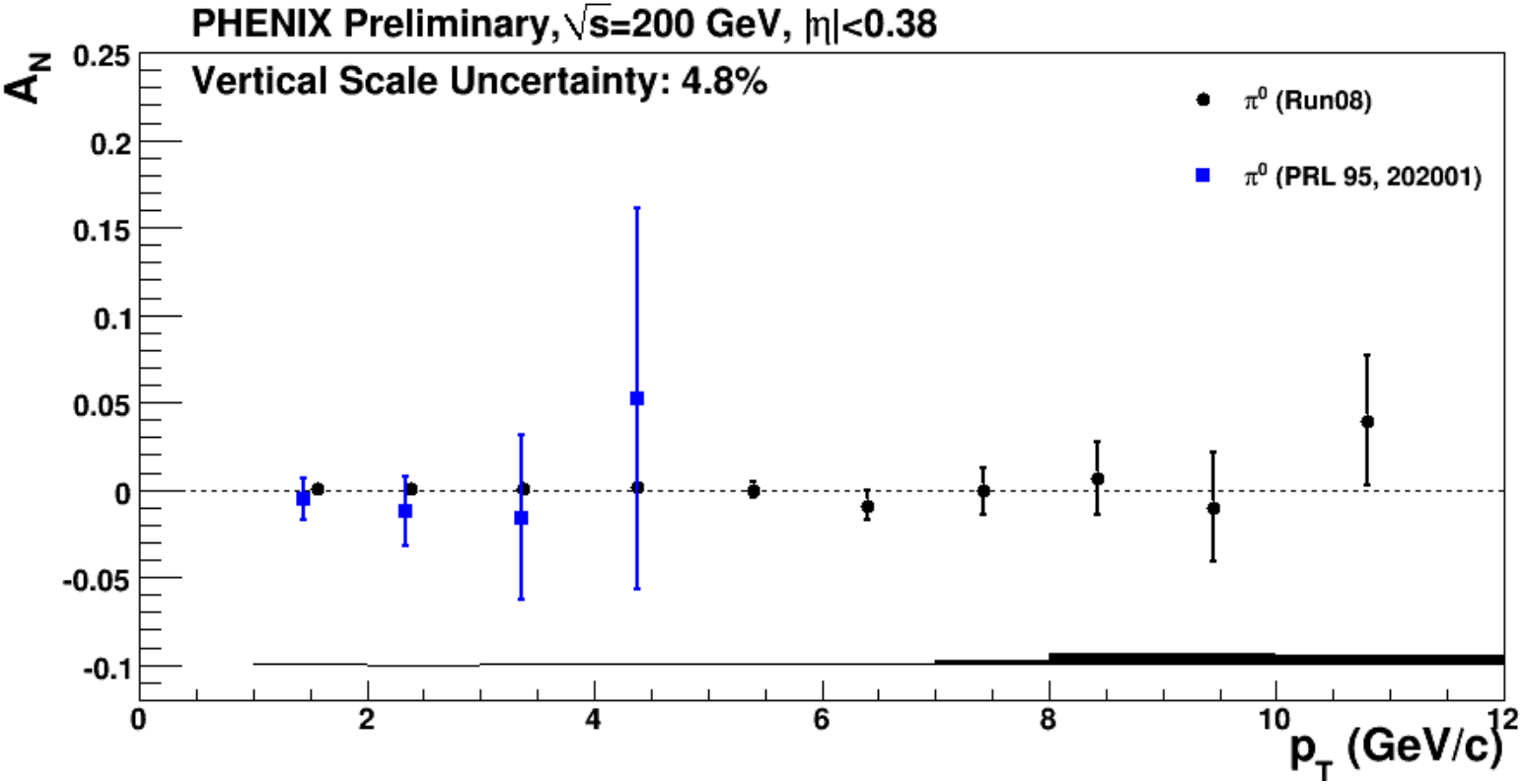
1
Forward Rapidity



2
Mid-Rapidity

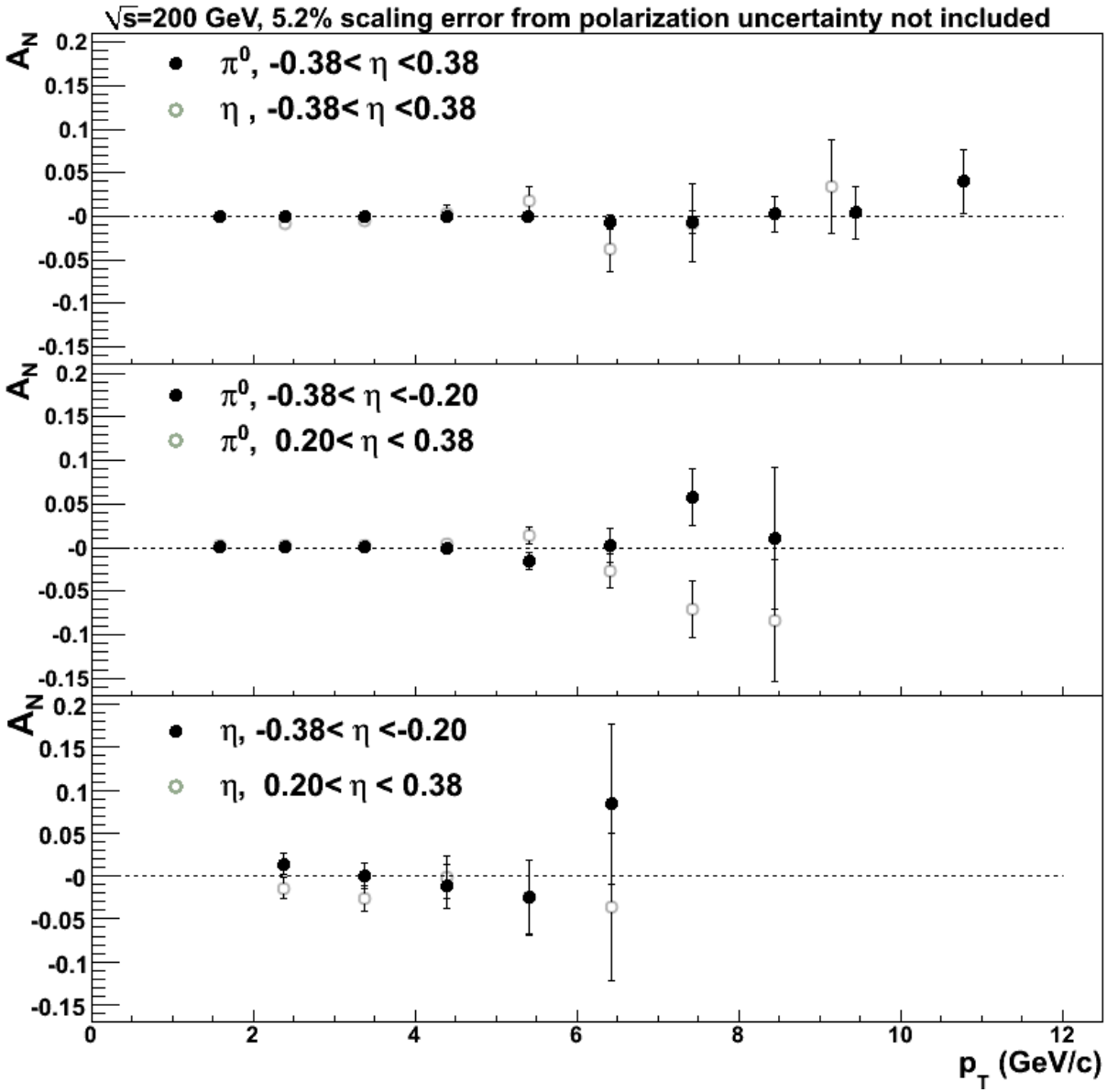


Mid-Rapidity Results (i)



- p_T range extended from 5 to 12 GeV/c
- Previous results used to constrain Gluon Sivers function.
- Statistical uncertainties reduced by more than factor of 30
  - Mainly due to RHIC's massive increase in P and L from previous result.

Mid-Rapidity Results (ii)

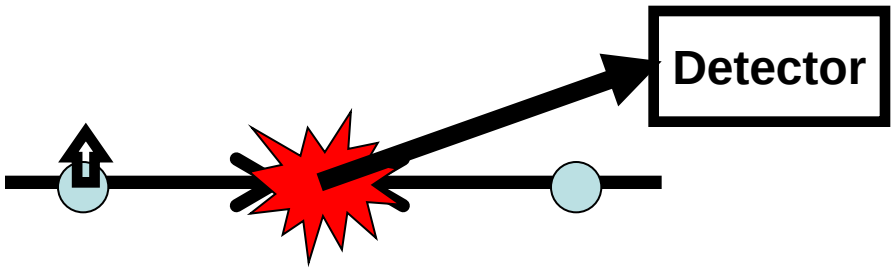


Inclusive selection for π^0 and η

Pseudorapidity binned π^0

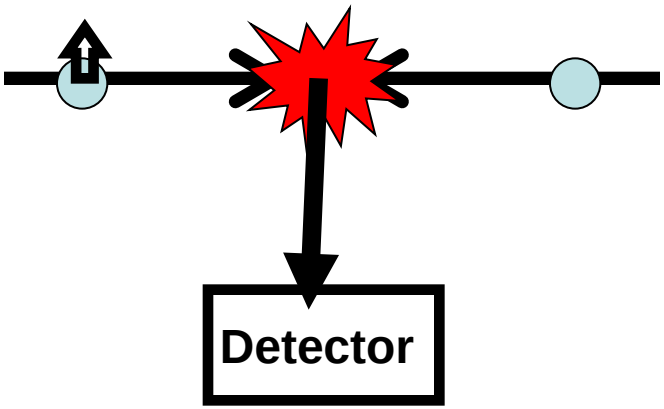
Pseudorapidity binned η meson

What's the punchline?



Indication A_N may drop at high p_T at $\sqrt{s}$=200 GeV

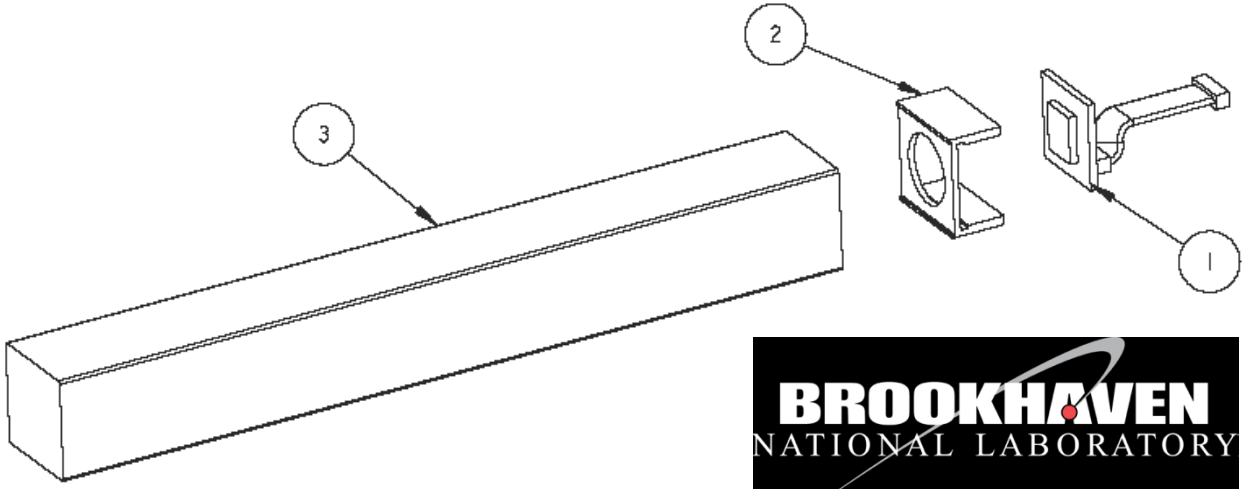
Future detector upgrades may find small direct photon A_N → Evidence against Sivers function



Precision measurements will constrain Gluon Sivers function

Acknowledgements

- **Work not possible without strong support of collaborators**



3) Kurchatov Institute

BROOKHAVEN NATIONAL LABORATORY

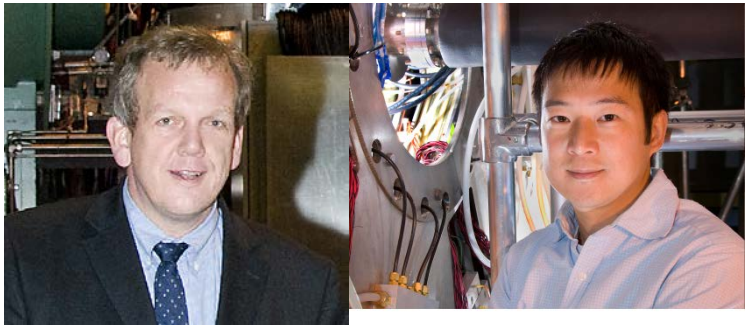
独立行政法人 理化学研究所 RIKEN

OAK RIDGE National Laboratory

2)

NSF

NSF contributions funded much of hardware + personnel



1)

HIROSHIMA UNIVERSITY