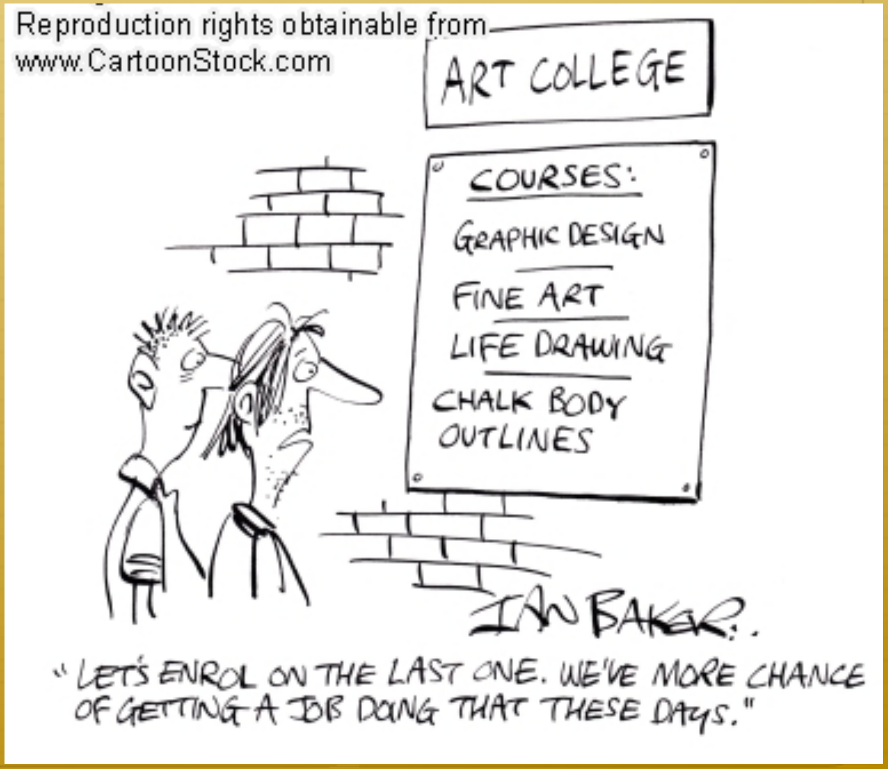
SANE

Hovhannes Baghdasaryan
University of Virginia
Hall-C Workshop

Outline

- Goal of SANE (Spin Asymmetries of the Nucleon Experiment)
- Motivation
- Experiment
- Parallel Setup
- Perpendicular Setup
- What still needs to be done
- Summary



Goal of the experiment

- Measure A_{80} and $A_{||}$ on polarized protons in frozen ammonia with polarized electron beam
- Extract A_1^p and A_2^p
- Extract g_1^p and g_2^p (Spin Structure Functions)
- Calculate Twist-3 matrix element $d_2 = \int_0^1 x^2 (2g_1 + 3g_2)\, \mathrm{d}x$

(Quantifying quark – gluon interactions)

- Probe the Approach of A_1 to x=1 at constant Q^2 to test quark models and pQCD

Structure Functions

- Structure Functions F_1,F_2 (Investigated thoroughly)
- Spin Structure Functions g_1 and g_2 (polarization observables)
  - In Quark-Parton Model

$$F_1(x) = \frac{1}{2}\sum_i e_i^2 (q_i^+ + q_i^-) \qquad g_1(x) = \frac{1}{2}\sum_i e_i^2 (q_i^+ - q_i^-)$$

Describe charge and spin distributions of the parton.

On the other hand $g_2 = g_2^{WW} + \bar{g}_2$

consists of twist-2 part g_2^{WW} (Wandzura-Wilczek) which is function of g_1 only

$\bar{g}_2$ which has part of twist-2 chiral odd transversity and twist-3 effect (responsible for quark-gluon correlations)

Extraction

$$A_{80} \sim [(\cos(\theta_0)\cos(80) + \sin(80)\sin(\theta_0)\cos(\phi))E' + \cos(80)E]M_pG_1 + 2[\cos(\theta_0)\cos(80) - \cos(80) + \sin(80)\sin(\theta_0)\cos(\phi)]E'EG_2$$

$$A_{180} \sim ((\cos(\theta_0)E' + E)M_pG_1 - Q^2G_2)$$

Solve for $\frac{M_p \cdot G_1}{W_1}, \frac{G_2}{W_1}$ which can be used to extract A_1 and A_2

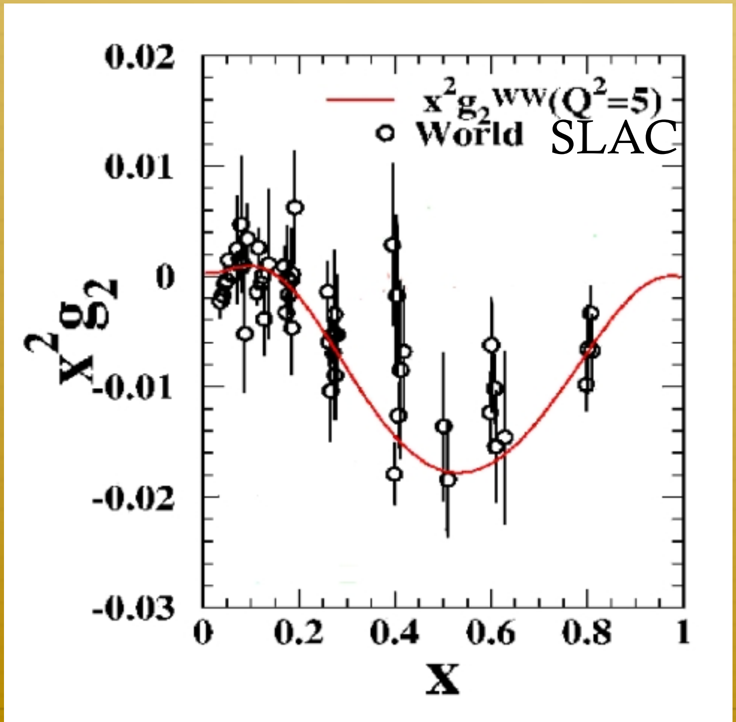
$$A_1 = \nu \cdot \frac{M_p \cdot G_1}{W_1} - Q^2 \cdot \frac{G_2}{W_1} \qquad g_1 = \frac{(E - E')}{M_p}G_1$$

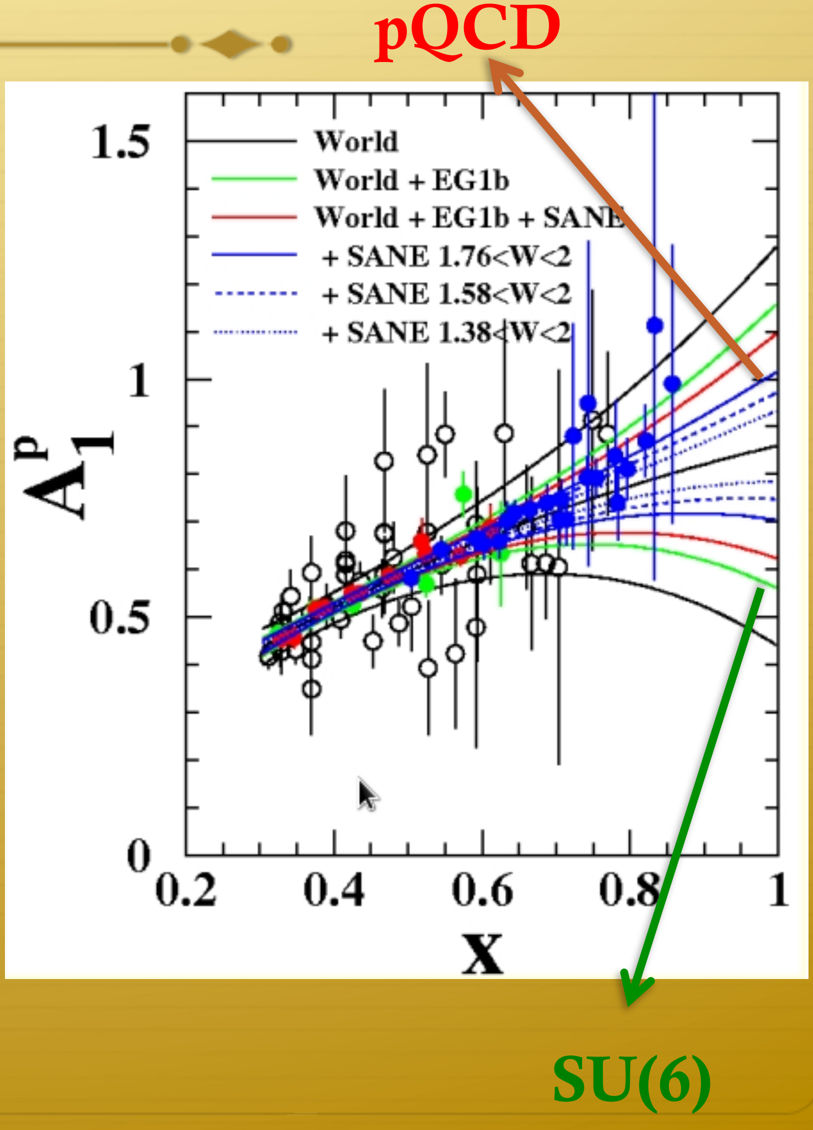
$$A_2 = \sqrt{Q^2}\left(\frac{M_p \cdot G_1}{W_1} + \nu \cdot \frac{G_2}{W_1}\right) \qquad g_2 = \frac{(E - E')^2}{M_p^2}G_2$$

A_1 and A_2 are obtained in model independent way using experimental asymmetries only

Motivation

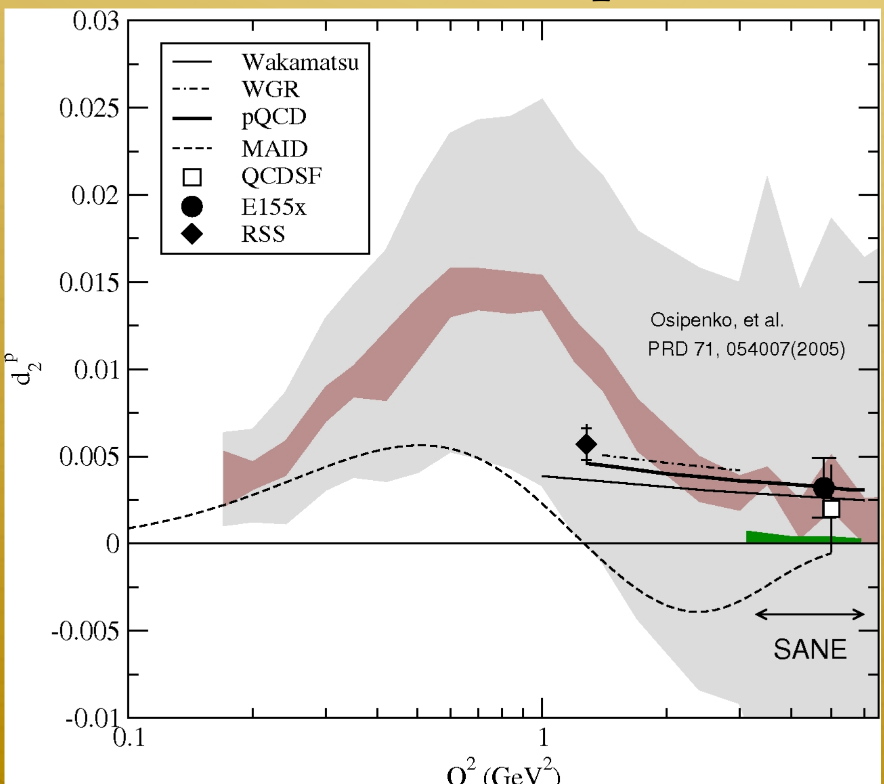
- World Data (or lack of it)
  - Little data on A_2^p
  - A_1^p data (assumption)
  - Low precision data for g_2^p

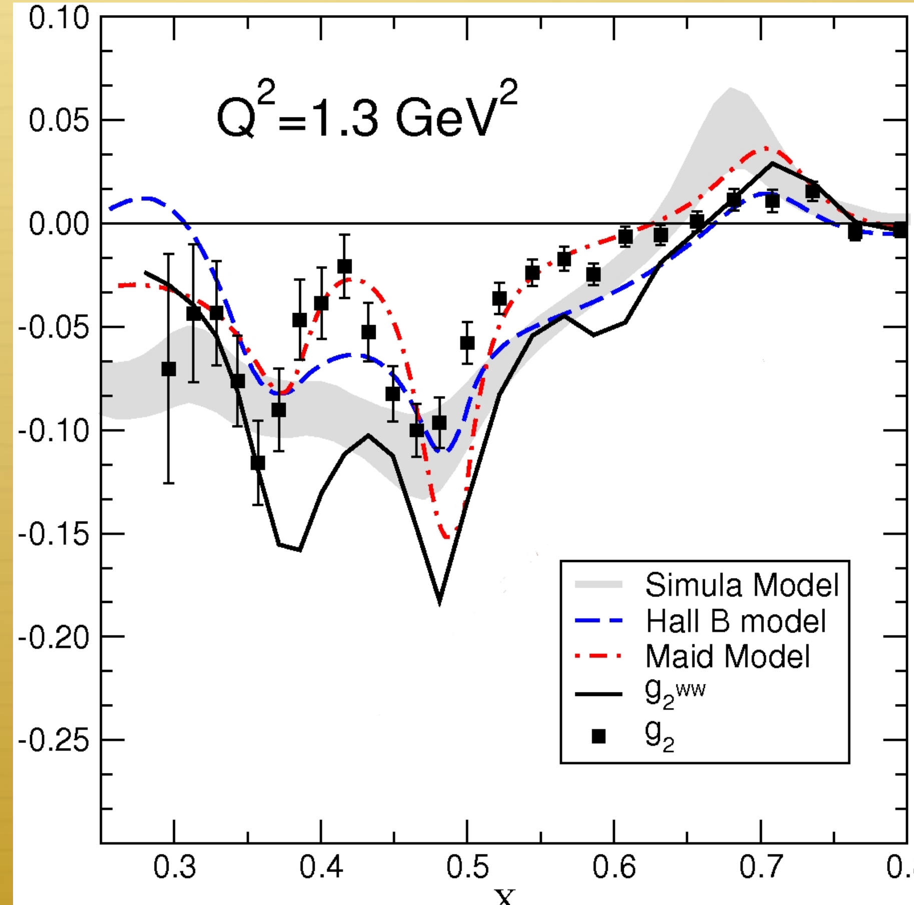




Motivation

- Recent Data from RSS
- Little info on d_2





EXPERIMENT

Hall-C –TJNAF

UVA NH_3 Polarized target

80 and 180 degree

Electron arm BETA detector

Tracker (Regina, NSU)

Cerenkov (T)

Lucite (N.Carolina A&T)

BigCal

HMS arm

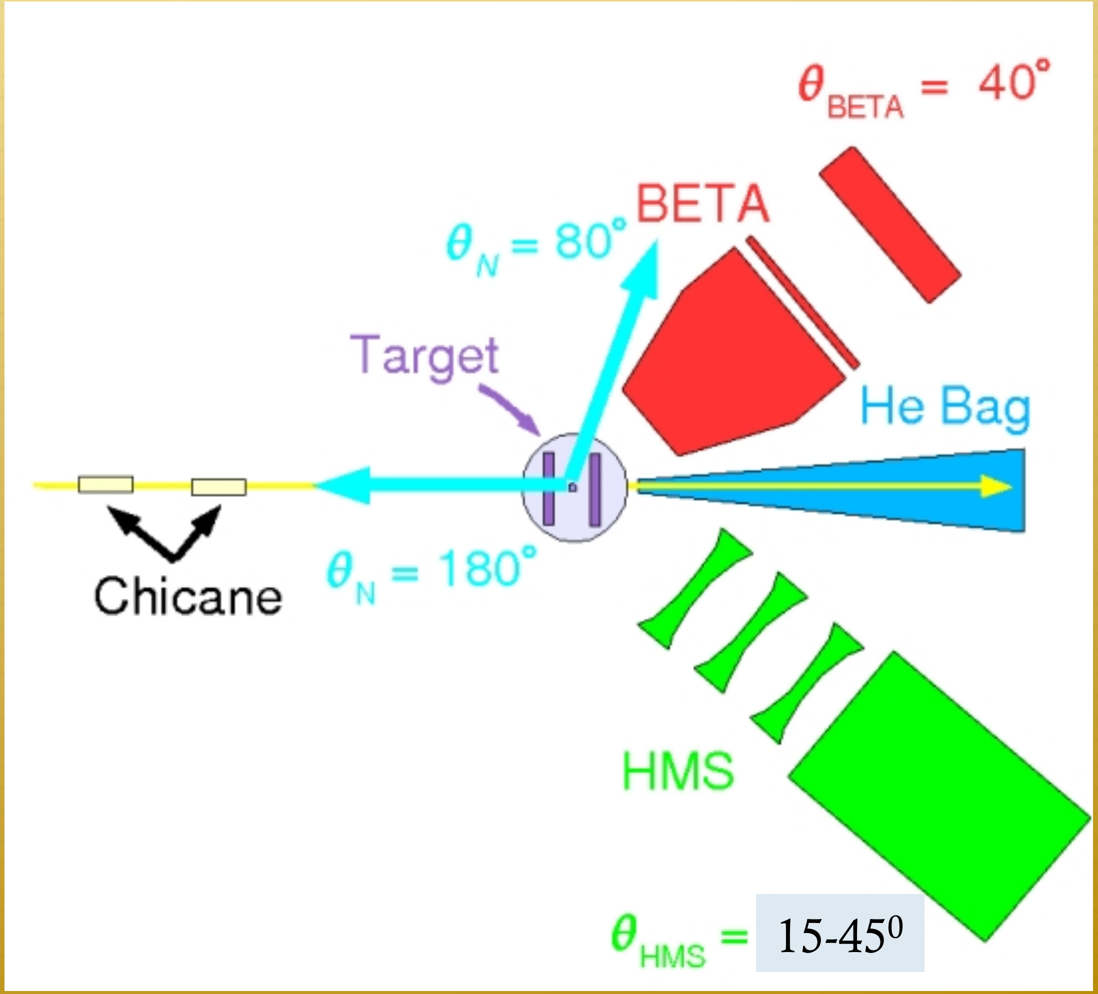
15-45°

BEAM

80-100nA current

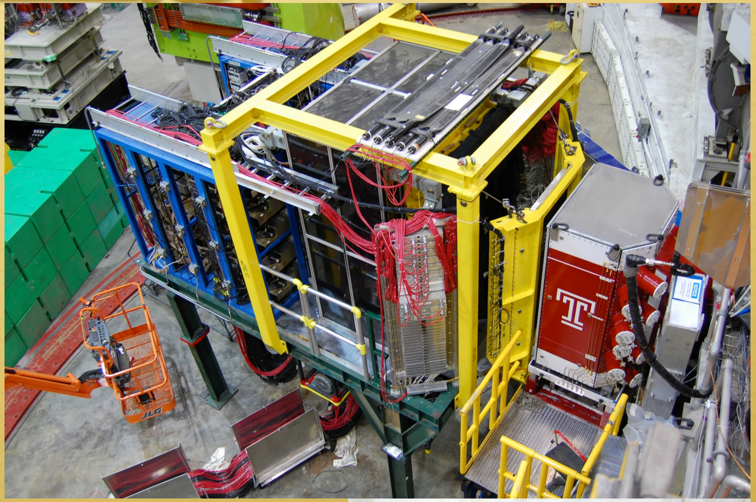
Chicane

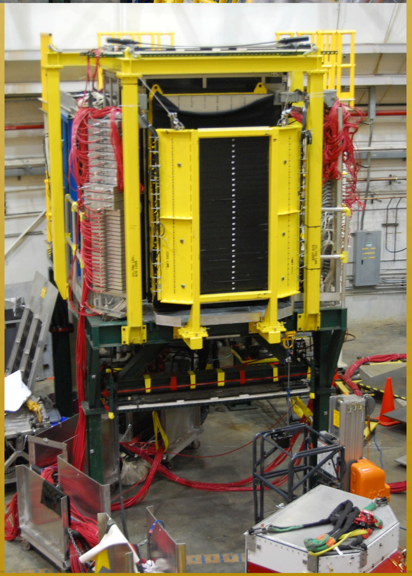
He bag

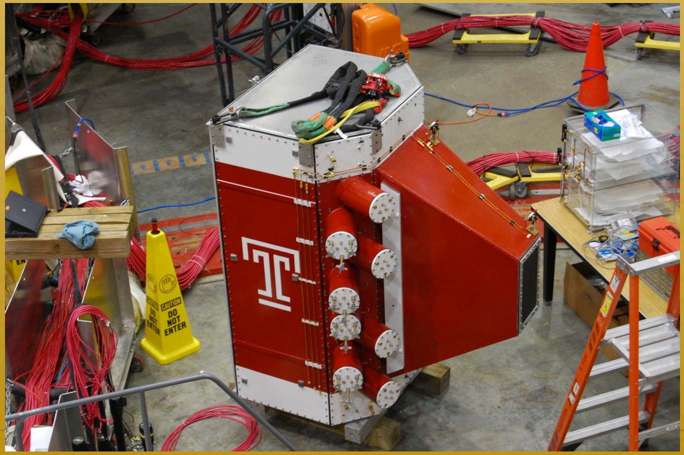


Detectors

- Tracker
  - 3 planes X(64),Y1(128),Y2(128) 3mm
- Cerenkov
  - 8 Mirrors (4 spherical, elliptical)
- Lucite
  - 28 Lucite bars
- BigCal
  - 32x32(3.82cm)+24x30(4cm) lead glass







Experiment Challenge

✧ BigCal Calibration

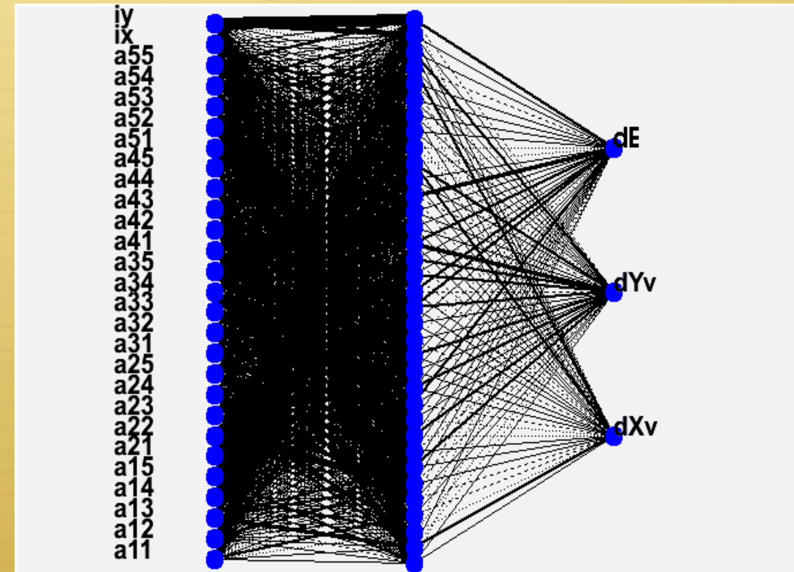
No time for detector calibration using elastic events

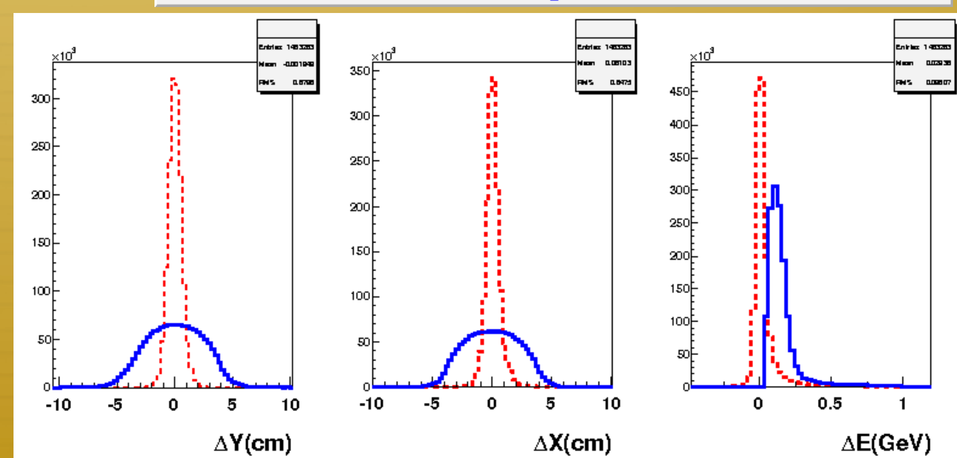
SOLUTION :

Neural Network (uses information from 25 blocks and position of central block)

Calibration using neutral pions

Better than 10% cluster energy resolution

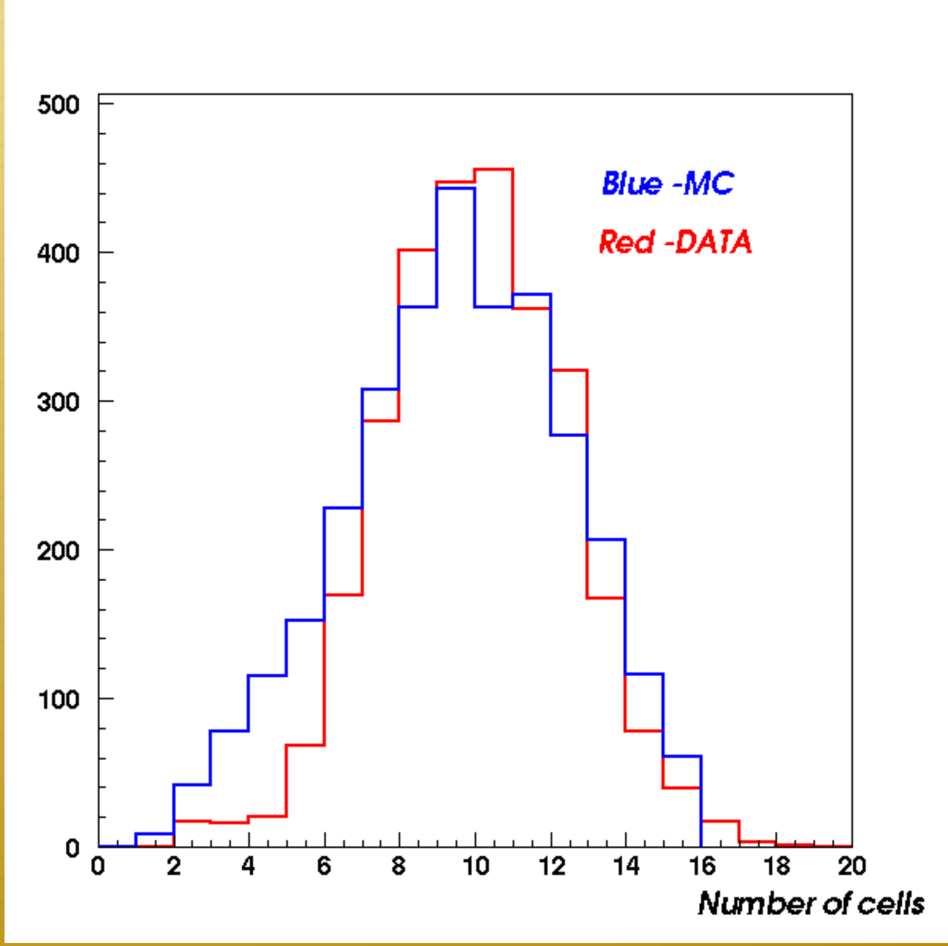




Pileup

Average cluster size with E>0.8 GeV

- Generated cluster size is similar to Data cluster size
- Block energy cut >10 MeV
- Most energetic block cut >150 MeV
- No Pile-up observer



Run Info

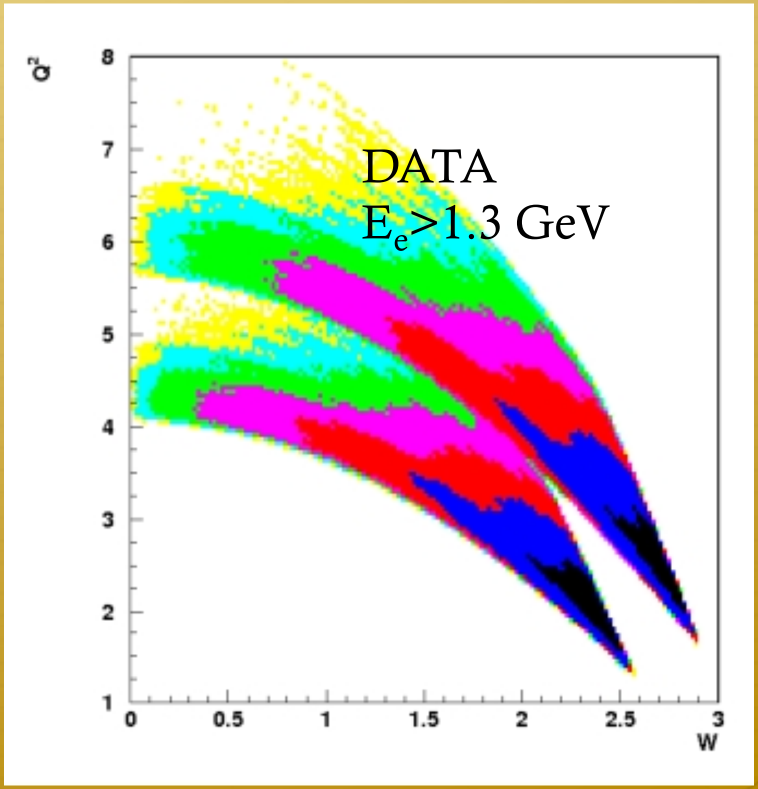
- **Experiment ran Feb – Mar 2009**
- **Energy/field — Beam Pol* — Proposed /FOM****

Energy/field	Beam Pol*	Proposed /FOM**
4.7 GeV Parallel	66%	39%
5.9 GeV Parallel	88%	35%
4.7 GeV Perp	85%	58%
5.9 GeV Perp	71%	62%

Target Pol 69%

(*) Measured by Moller polarimeter

(**) FOM=$(P_{targ} * P_{Beam})^2 * I_{Beam}$



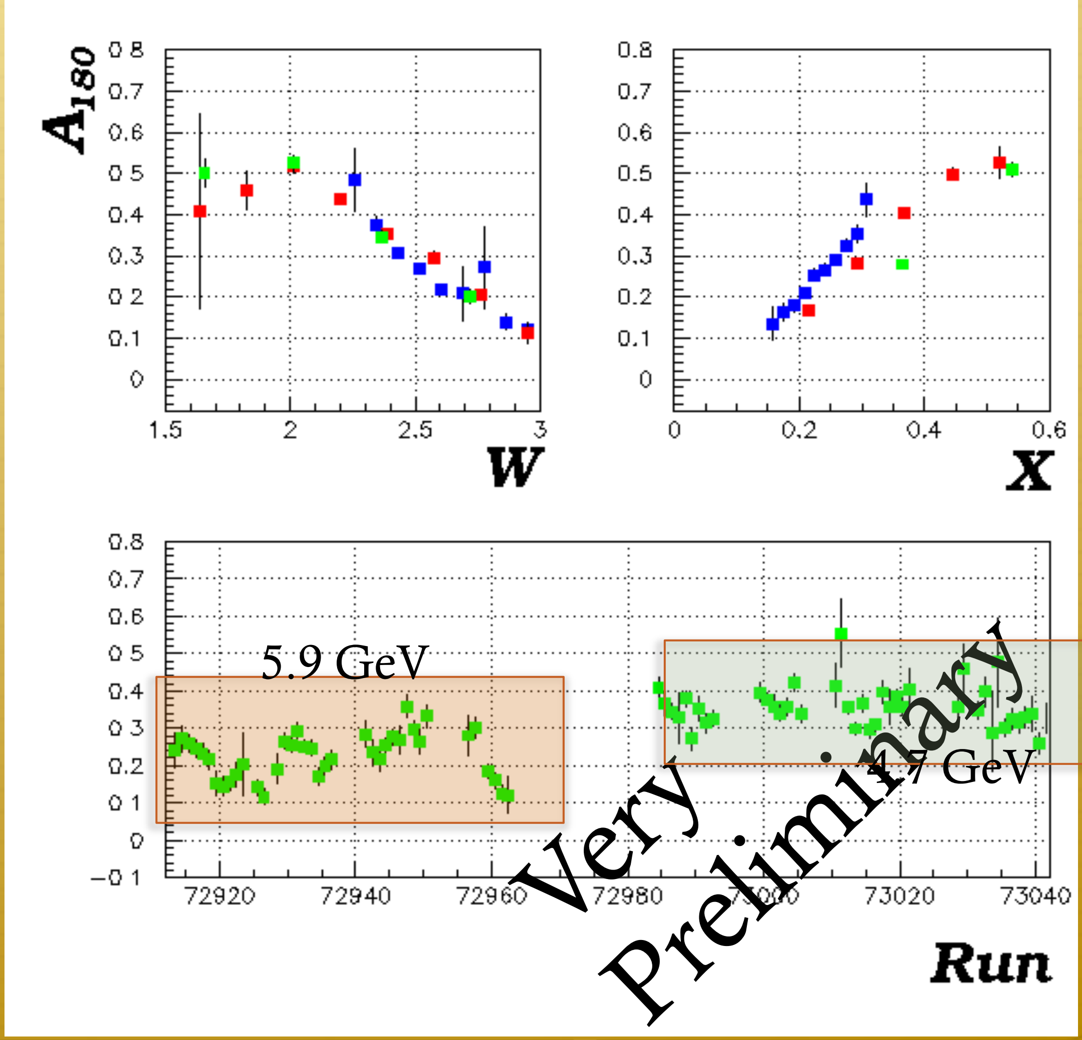
Parallel Field Orientation

- Q^2 1.7 GeV^2
- Q^2 2.5 GeV^2
- Q^2 3.5 GeV^2

- **Low x_{Bj} or High W shows small asymmetry**
- **Small Q^2 dependence**
- **Statistical errors only**

What else needs to be done

- Radiative corrections
- Try to understand run dependent behavior for sum of the runs
- Match kinematic binning with 80^o data



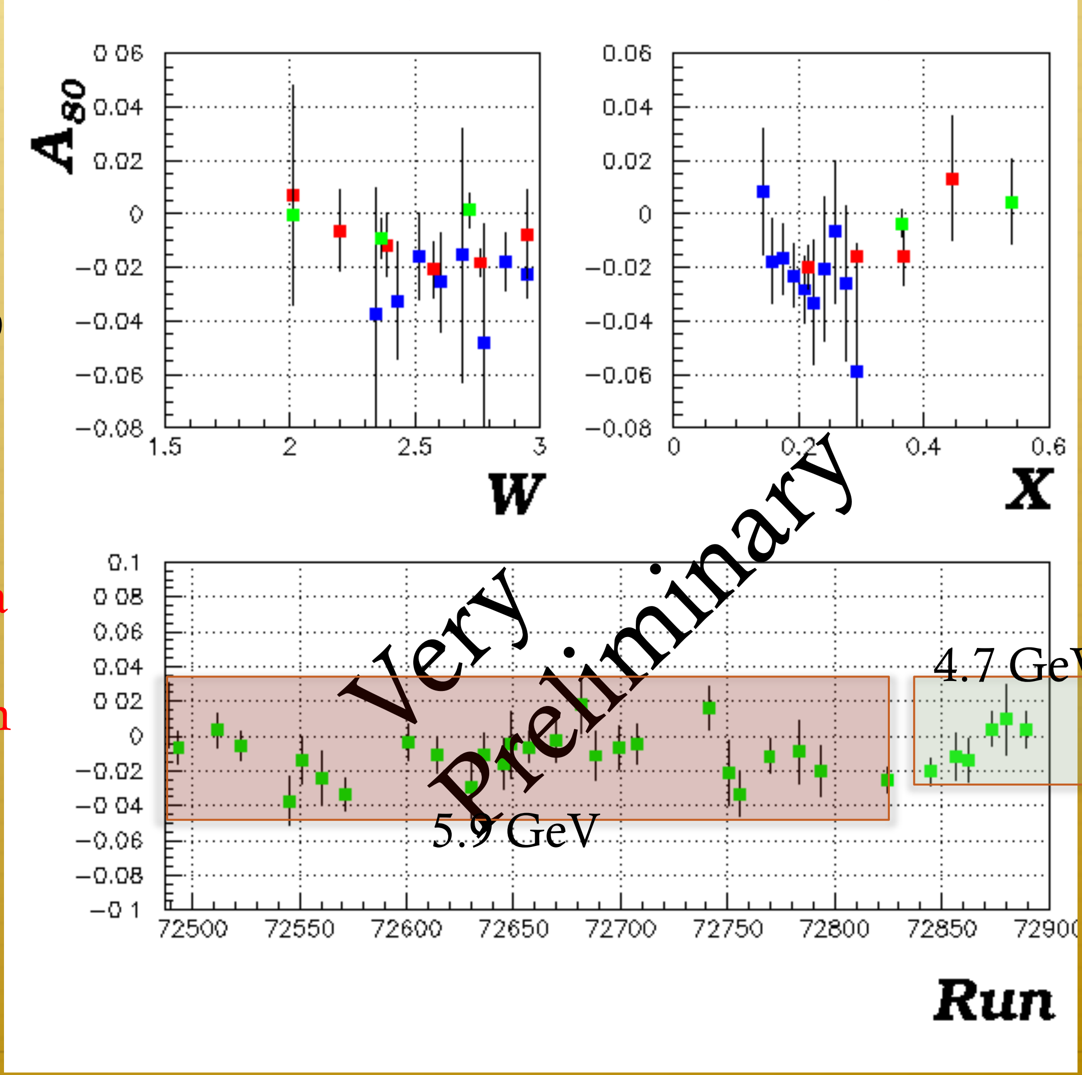
80^0 Field Orientation

- Q^2 1.7 GeV^2
- Q^2 2.5 GeV^2
- Q^2 3.5 GeV^2

- Non-zero Asymmetry (2%)
- In some kinematics ranges A_{80} is about 20% of A_{180}

What else needs to be done

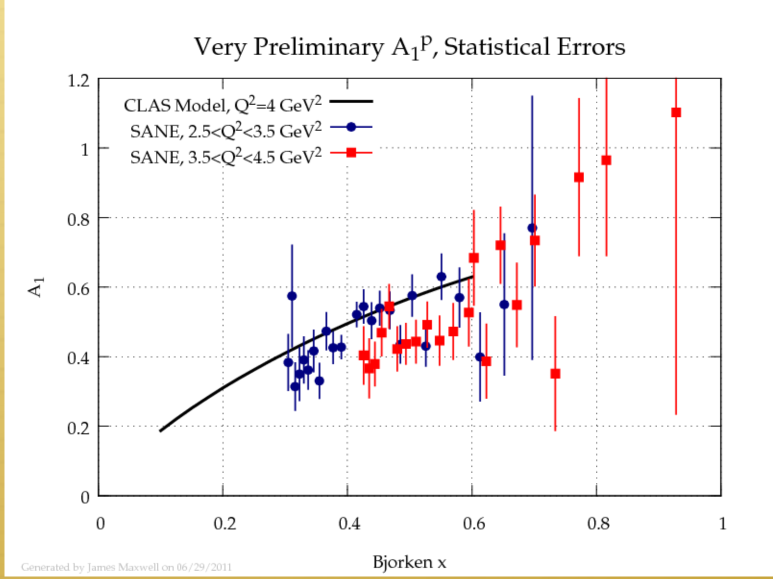
- Only shows about 50% of data taken
- Kinematics dependent dilution factors
- RAD corrections
- Better binning

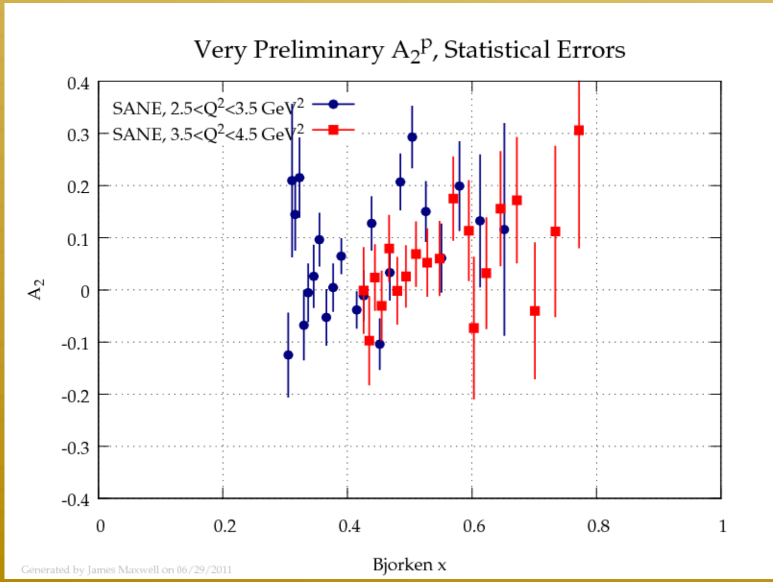


Physics Asymmetries

A_1 asymmetries show fair agreement with CLAS Model for $2.5<Q^2<3.5$ GeV2

We observe some disagreement at larger Q^2





Preliminary A_1 and A_2 asymmetries were obtained

Radiative corrections need to be applied

Summary

- SANE collaboration collected data and extracted in model independent way preliminary A_1 and A_2
- Obtained A_1 agrees with CLAS model curve at small Q^2 and disagrees at Q^2>3.5 GeV2
- A_{80} is about 2% for $Q^2 = 1.7$ GeV^2
- Preliminary A_{80} from only part of the data set with tight event selection cut

To Do List:

- Use all statistics to decrease statistical errors
- Calculate radiative corrections
- Calculate g_1 and g_2
- Calculate Nachtmann moments

SANE Collaboration (E-07-003)

E. Brash, **P. Carter, M. Veilleux**
Christopher Newport University, Newport News, VA

W. Boeglin, P. Markowitz, J. Reinhold
Florida International University, Miami, FL

I. Albayrak, O. Ates, C. Chen, E. Christy, C. Keppel, M. Kohl, **Y. Li**, **A. Liyanage**, P. Monaghan, **X. Qiu**, L. **Tang, T. Walton, Z. Ye, L. Zhu**
Hampton University, Hampton, VA

P. Bosted, J.-P. Chen, S. Covrig, W. Deconink, A. Deur, C. Ellis, R. Ent, D. Gaskell, J. Gomez, D. Higinbotham, T. Horn, M. Jones, D. Mack, G. Smith, P. Solvignon, S. Wood
Thomas Jefferson National Accelerator Facility, Newport News, VA

A. Puckett
LANL, Los Alamos, NM

W. Luo
Lanzhou University, China

J. Dunne, D. Dutta, **A. Narayan, L.Ndukum, Nuruzzaman**
Mississippi State University, Jackson. MI

A. Ahmidouch, S. Danagoulian, **J. German, Martin Jones**
North Carolina A&T State University, Greensboro, NC

M. Khandaker
Norfolk State University, Norfolk, VA

A. Daniel, P.M. King, J. Roche
Ohio University, Athens, OH

A.M. Davidenko, Y.M. Goncharenko, V.I. Kravtsov, Y.M. Melnik, V.V. Mochalov, L. Soloviev, A. Vasiliev
Institute for High Energy Physics, Protvino, Moscow Region, Russia

C. Butuceanu, G. Huber
University of Regina, Regina, SK

V. Kubarovsky
Rensselaer Polytechnic Institute, Troy, NY

L. El Fassi, R. Gilman
Rutgers University, New Brunswick, NJ

S. Choi, H-K. Kang, **H. Kang, Y. Kim**
Seoul National University, Seoul, Korea

M. Elaasar
State University at New Orleans, LA

W. Armstrong, **D. Flay**, Z.-E. Meziani, **M. Posik**, B. Sawatzky, H. Yao
Temple University, Philadelphia, PA

O. Hashimoto, D. Kawama, **T. Maruta,** S. Nue Nakamura, **G. Toshiyuki**
Tohoku U., Tohoku, Japan

K. Slifer
University of New Hampshire

H. Baghdasaryan, M. Bychkov, D. Crabb, D. Day, E. Frlez, N. Kalantarians, **K. Kovacs**, N. Liyanage, **V. Mamyan**, J. Maxwell, J. Mulholland, D. Pocanic, S. Riordan, O. Rondon, M. Shabestari
University of Virginia, Charlottesville, VA

L. Pentchev
College of William and Mary, Williamsburg, VA

F. Wesselmann
Xavier Unniversity, New Orleans, LA

Asaturyan, H. Mkrtchyan, V. Tadevosyan
Yerevan Physics Institute, Yerevan, Armenia

Ph.D. student, M.S. Student, Student