SANE (E07-003)
Spin Asymmetries of the Nucleon Experiment

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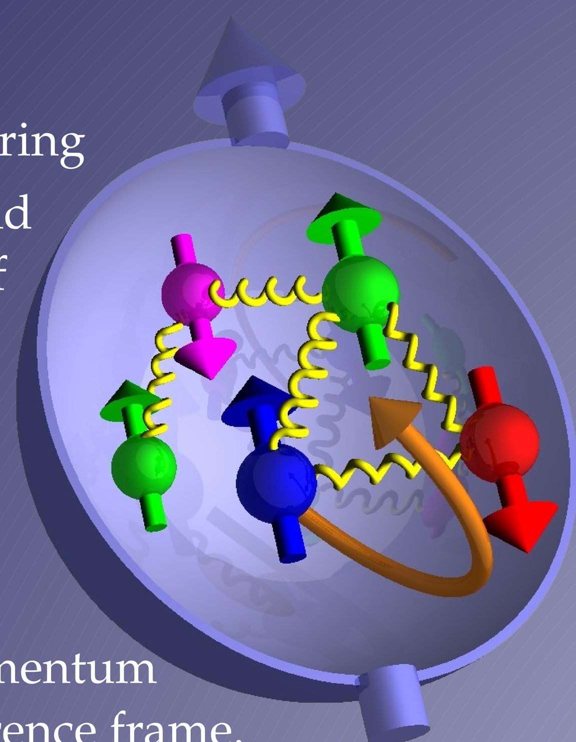
Nucleon Spin:

Polarized scattering experiments suggest that intrinsic quark and anti-quark spin only accounts for 20-30% of the proton's spin. How do we describe the proton's spin? What can it teach us?



When deeply probing the nucleon's structure, we parametrize its spin in "structure functions" that are functions of Bjorken x, the fraction of the nucleon's momentum carried by the struck quark, in a given reference frame. Using high momentum polarized electrons to probe a polarized proton target, these spin structure functions, g_1 and g_2, can be extracted from measurements of asymmetries in the observed yields at different spin orientations. The spin structures functions are then related to these asymmetries via kinematic factors.

$$A_1 = a(A_\parallel - bA_\perp) = \frac{1}{F_1}(g_1 - \gamma^2 g_2),\ A_2 = a(cA_\parallel + dA_\perp) = \frac{\gamma}{F_1}(g_1 + g_2)$$

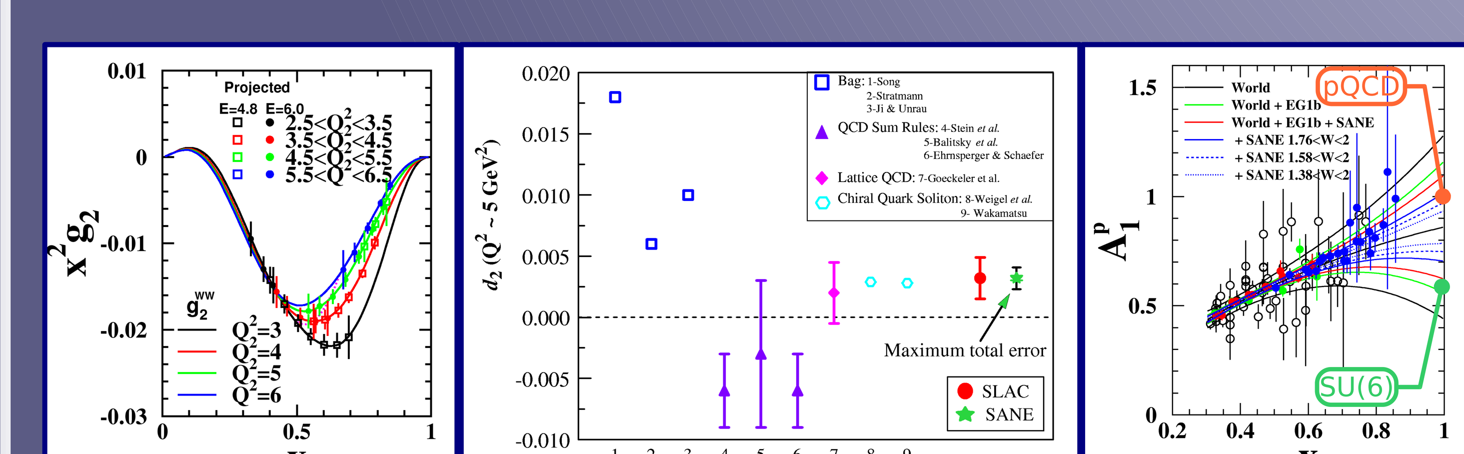
While g_1 can be written in terms of helicity dependent quark distributions and depends only on twist-2 (quark-quark) interactions, the largely unknown g_2 also depends on twist-3 (quark-gluon-quark). This twist-3 portion can shed light on the mystery of strong QCD and parton interactions at low energy.

Physics & Expected Results:

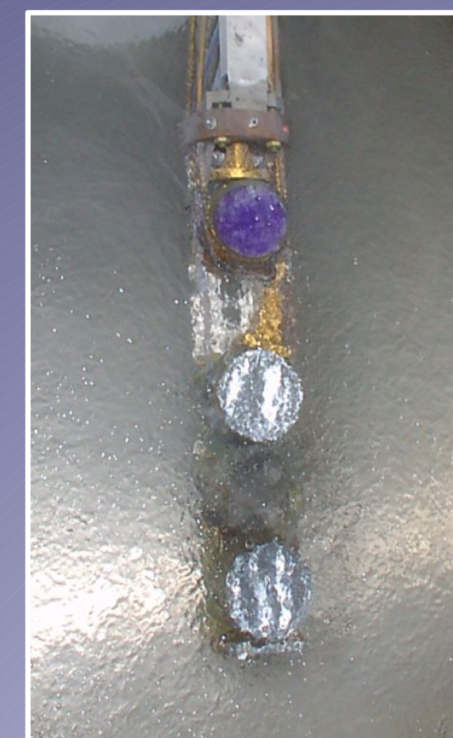
Measure proton spin structure function g_2 and spin asymmetry A_1 at $2.5 \leq Q^2 \leq 6.5$ GeV^2 and $0.3 \leq x_{Bj} \leq 0.8$.

Lessons from inclusive double polarization measurement:

- Twist-3 effects from spin structure function moments
- Compare Lattice QCD, QCD sum rules, bag models, chiral quarks
- Exploration of "high" x region: A_1's approach to $x_{Bj} = 1$
- Test polarized local duality for final state mass W > 1.4 GeV

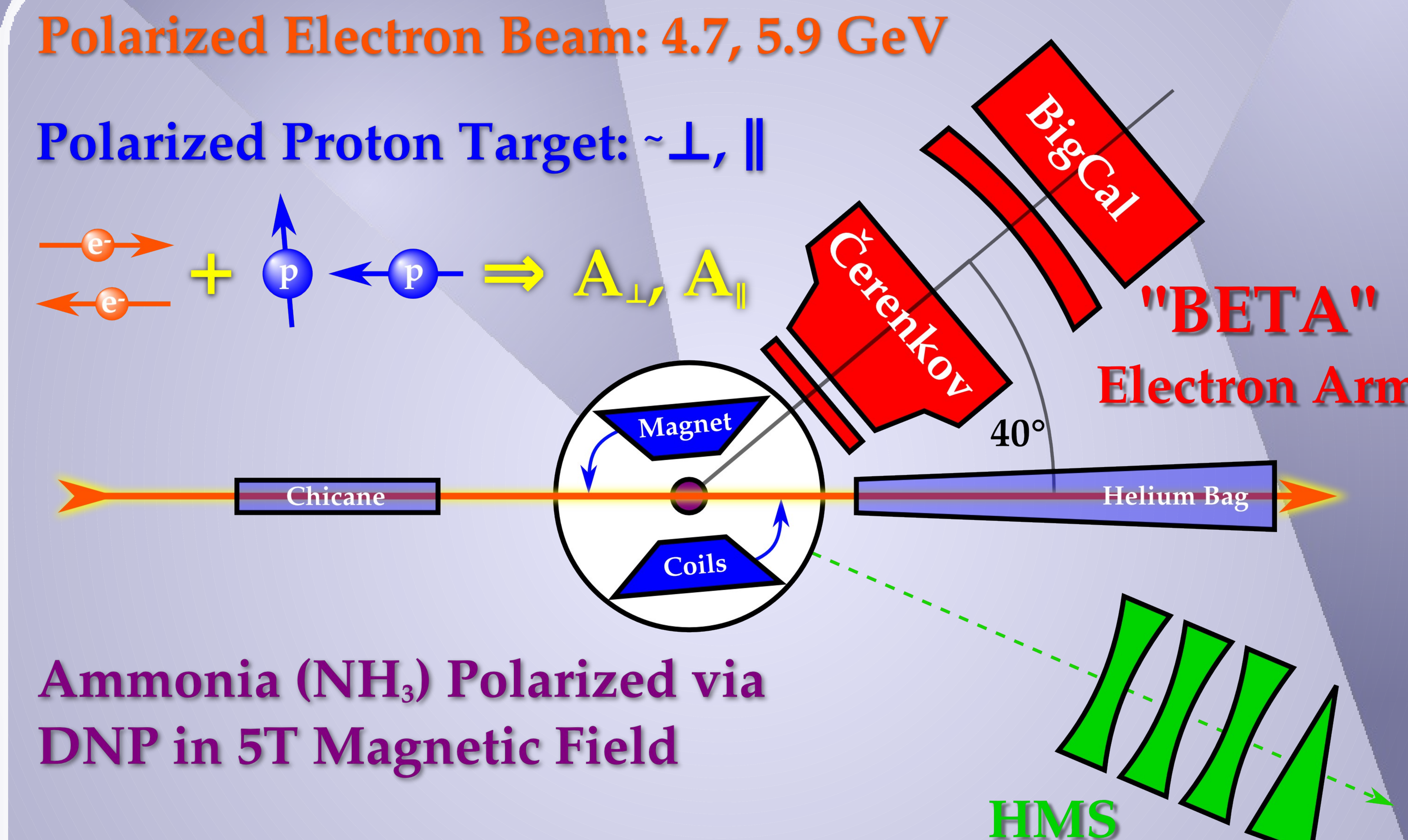


To the left are expected uncertainties on $x^2 g_2^p$ in illustrative bins, plotted on the curve of g_2^{WW}, known due to its dependence on g_1. In the center are shown various predictions and measurements of d_2, a useful moment that depends on g_2 and g_1 and probes the quark-gluon interactions of twist-3. As shown in green, SANE will provide valuable accuracy in its measure of d_2. To the right is constraint on A_1^p's approach to $x_{Bj} = 1$. Black is existing data, and the colors are simulated data from SANE. SANE can provide enough constraint to differentiate between predictions of pQCD and SU(6) symmetric.

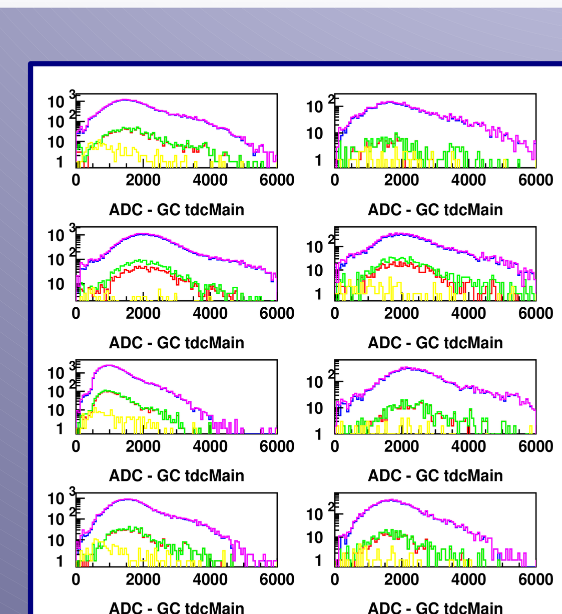


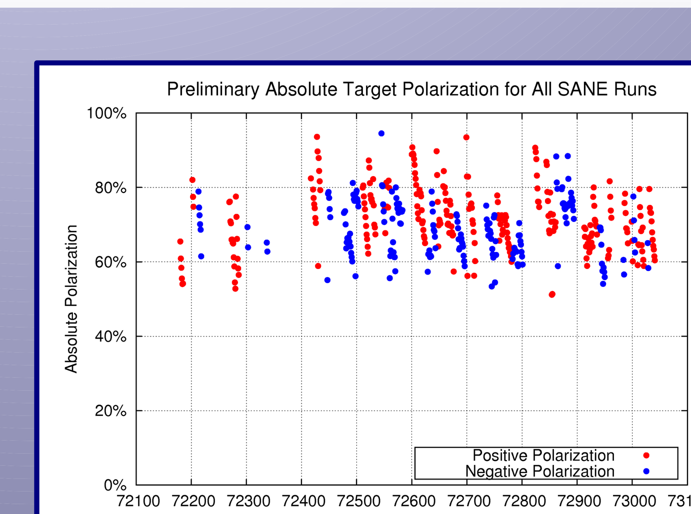
UVa Polarized Target:

Polarized protons are provided by frozen ammonia, irradiated to create paramagnetic centers that allow dynamic nuclear polarization in a 5T magnetic field. This supplies in-beam polarization of >70% at beam intensities of <100nA. Open magnet coil geometry allows B field at 80° as well as 180°.



Experimental Setup





The plot to the left shows Čerenkov ADC spectra for all 8 mirrors during the parallel configuration. Above are offline target polarizations during the entire run.

Analysis Progress:

SANE's run was completed in March of 2009. Over 60% of the proposed data were collected, and the main program was complemented with HMS data taken simultaneously for technical as well as physics purposes. Analysis is underway, using the parallel field configuration data for detector calibration in preparation for perpendicular analysis.

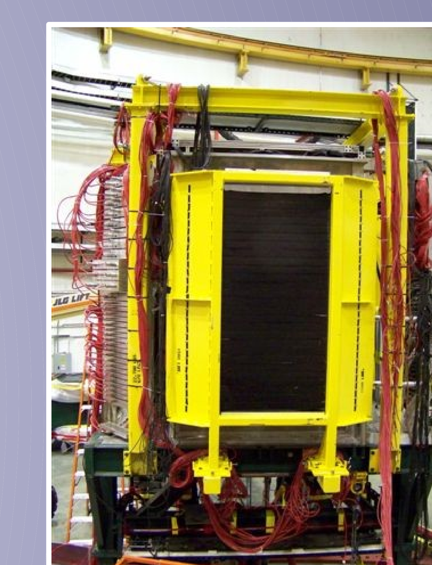
Big Electron Telescope Array:

Our electron arm, BETA is a non-magnetic detector with a solid angle of 0.2SR, pion rejection of 1000:1, energy resolution of $5\%/\sqrt{E}$, angular resolution of ~1mr and vertex resolution of ~5mm.

BigCal:

The electron's final destination in BETA, this big calorimeter measures its energy & angle and was built for G_E^p-III collaboration of 1744 Pb-glass blocks.

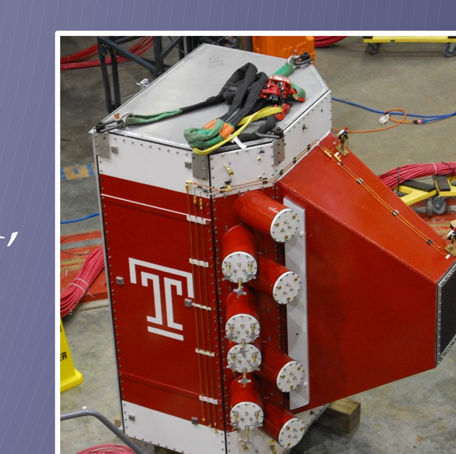
Lucite Hodoscope:



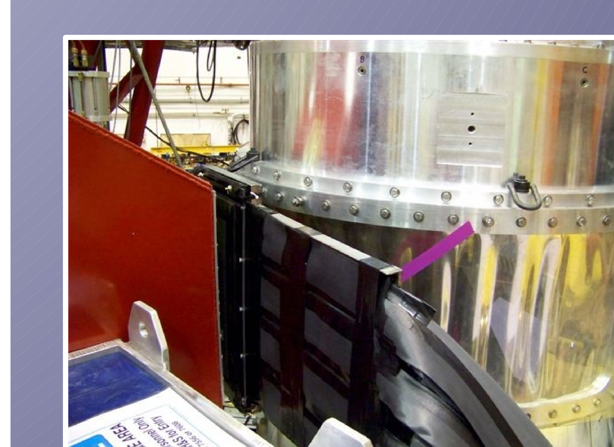
Provides position resolution and background rejection. Its 28 lucite bars are curved to allow normal incidence of particles from the target.

Gas Čerenkov:

This threshold Čerenkov tank tags particles according to their speed, allowing rejection of charged pions that might otherwise be identified as electrons.



Tracking Hodoscope:



Gives a particle's position very close to the target's magnetic field, allowing differentiation of e^+ and e^- at low momentum.

SANE Collaboration

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