New physics ideas with NPS

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The concepts shown here are not "new", and most have already been submitted to the Hall C white paper.

NPS calorimeter in future Hall C

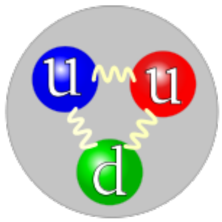
"Old"

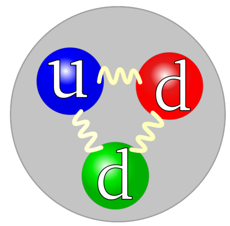
1. Wide Angle Compton Scattering, E12-14-03 with NPS + HMS
2. Wide Angle, Exclusive Photoproduction of π^0 Mesons, E12-14-05
3. Polarization Observables in WACS, E12-17-008, CPS+NPS+HMS
4. Timelike Compton Scattering, C12-18-005, CPS + NH3 + NPS*2

"New"

5. Strange Form Factor at high Q2, PR-06-004, arXiv:2001.02190
6. CPS as a source of positrons for TPE at high Q2, CPS + BB + NPS
7. A1p/A2p experiment with 11 GeV beam, wide aperture NH3 + BB/NPS

Strange Form Factor at high Q2



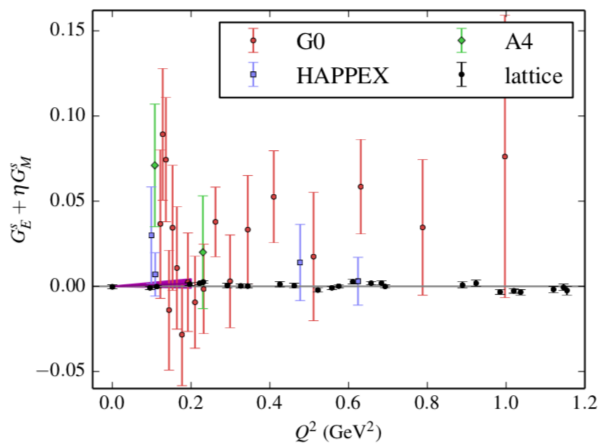


Expectations for
the strangeness FF

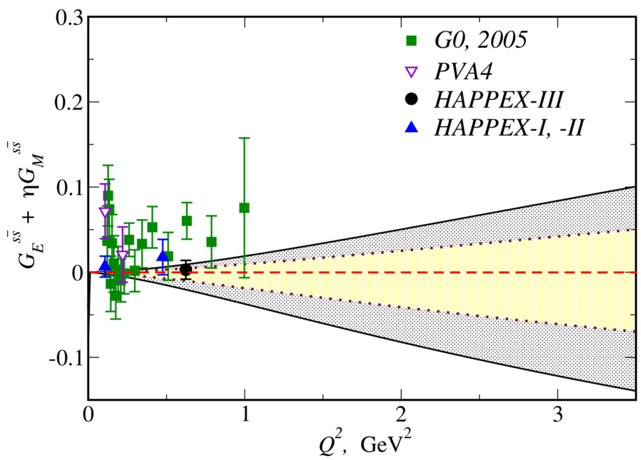
G_D at 3 GeV^2 is 0.037

G_s/G_D ~ 1 is not excluded

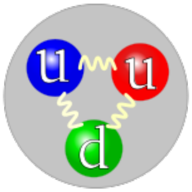
J.Green etal, 2015

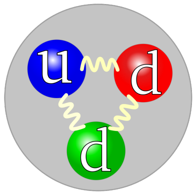


T.Hobbs & J.Miller, 2018



The proton and the neutron



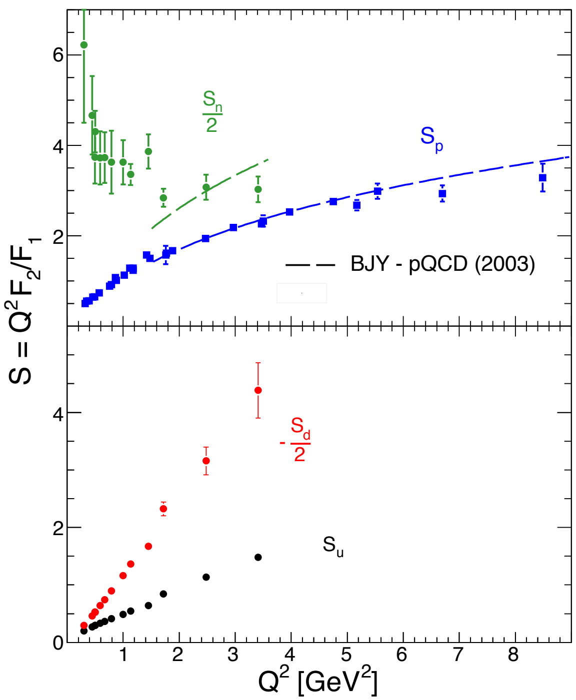


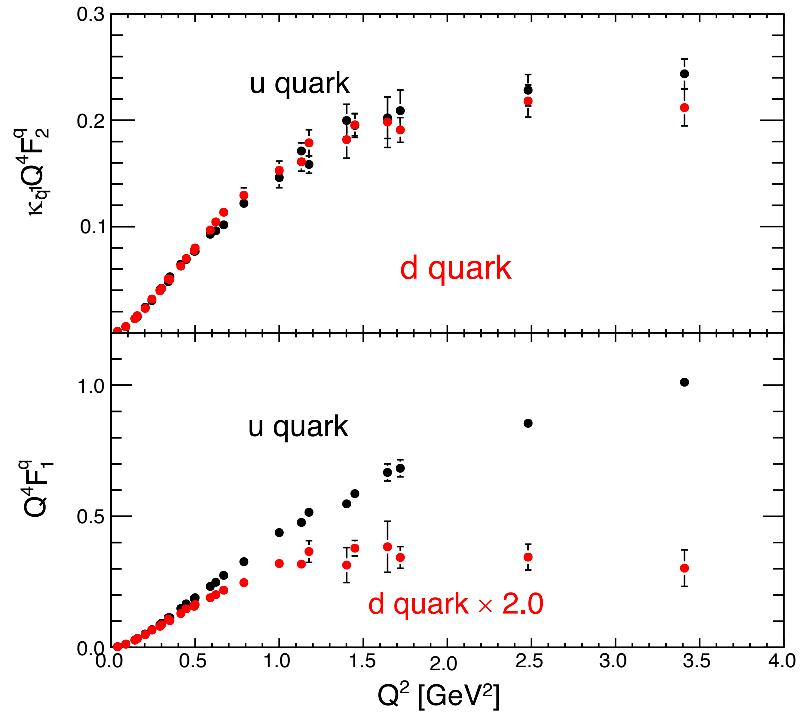
$$F_{1p} = \frac{+2}{3} F_{1u} + \frac{-1}{2} F_{1d}$$

$$F_{1n} = \frac{-1}{3} F_{1u} + \frac{+2}{2} F_{1d}$$

Assuming the charge symmetry and zero strangeness contribution

Flavor decomposition of FF at high Q2





Here we assumed the s-quark role is zero

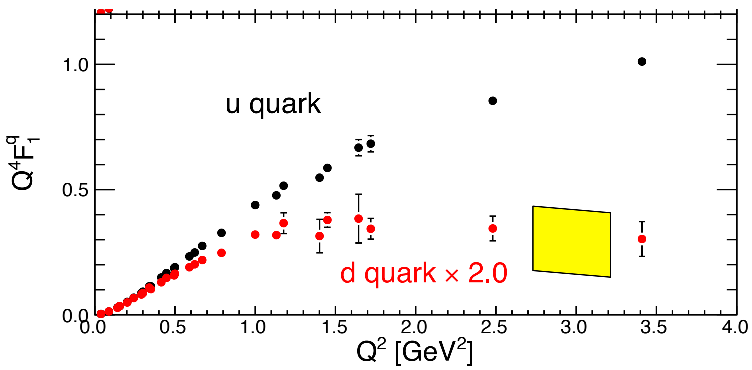
Uncertainty due to sFF is significant

Electromagnetic Form Factors

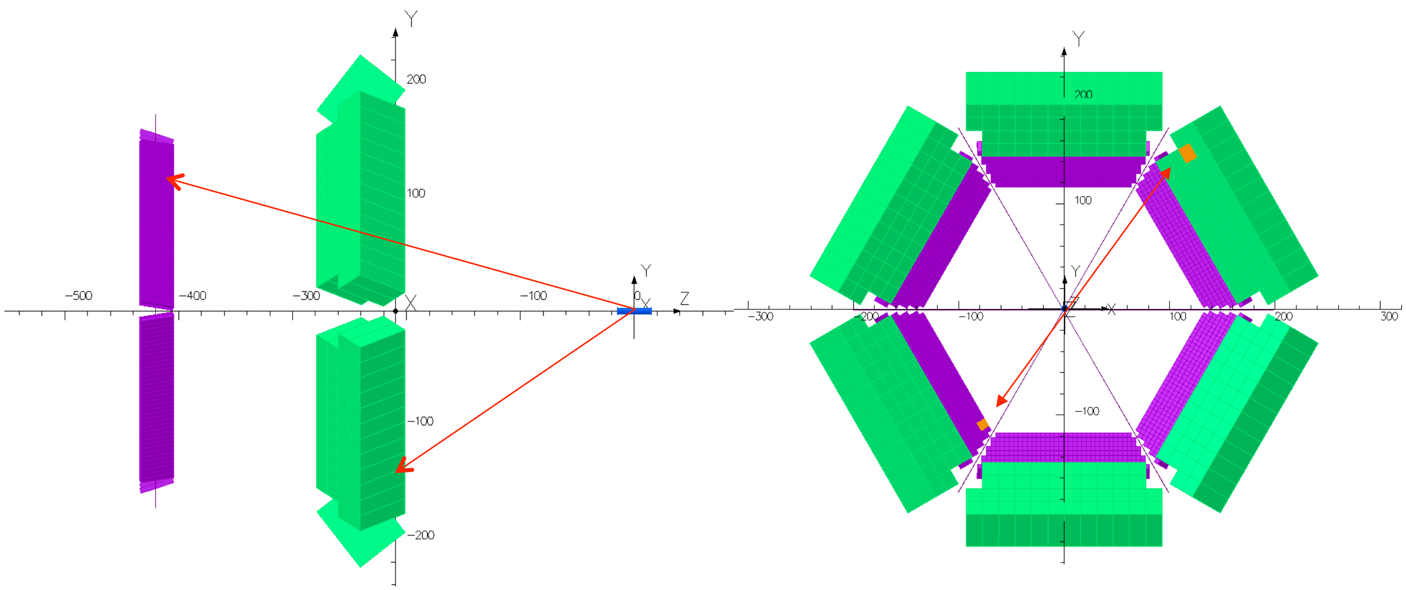
$$F_{1p} = e_u\, F_1^u \;+\; e_d\, F_1^d \;+\; e_s\, F_1^s$$

$$F_{1n} = e_u\, F_1^d \;+\; e_d\, F_1^u \;+\; e_s\, F_1^s$$

$$F_1^u = 2\, F_{1p} \;+\; F_{1n} - \tfrac{1}{3} F_1^s, \quad F_1^d = 2\, F_{1n} \;+\; F_{1p} - \tfrac{1}{3} F_1^s$$

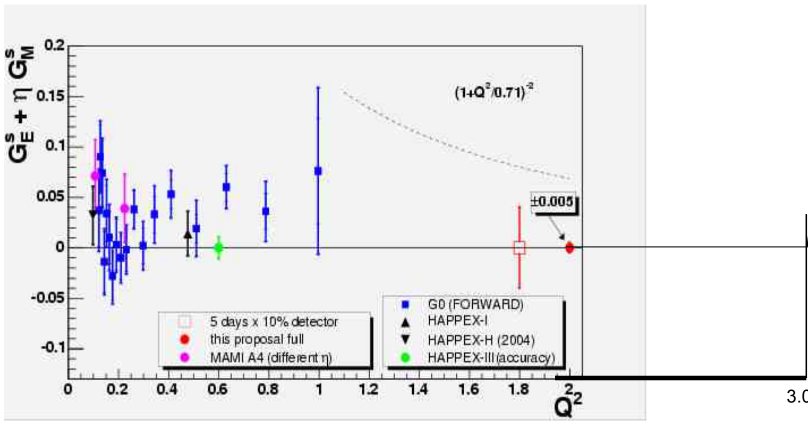


Coincidence parity experiment



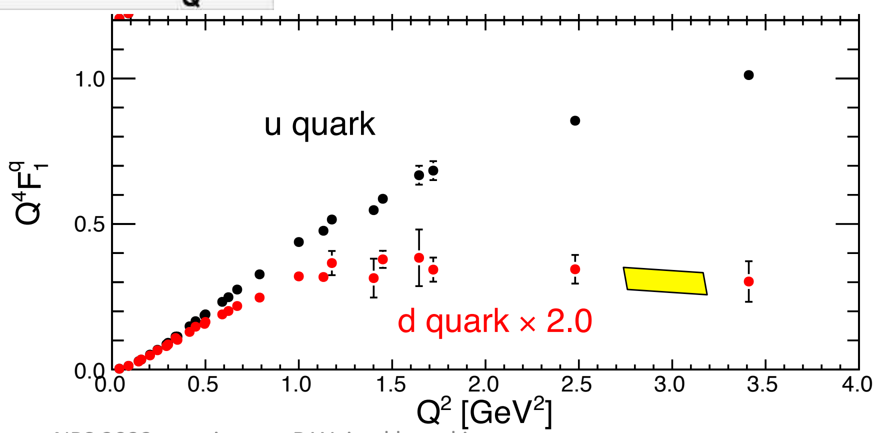
Coincidence parity experiment

Strangeness Form factor

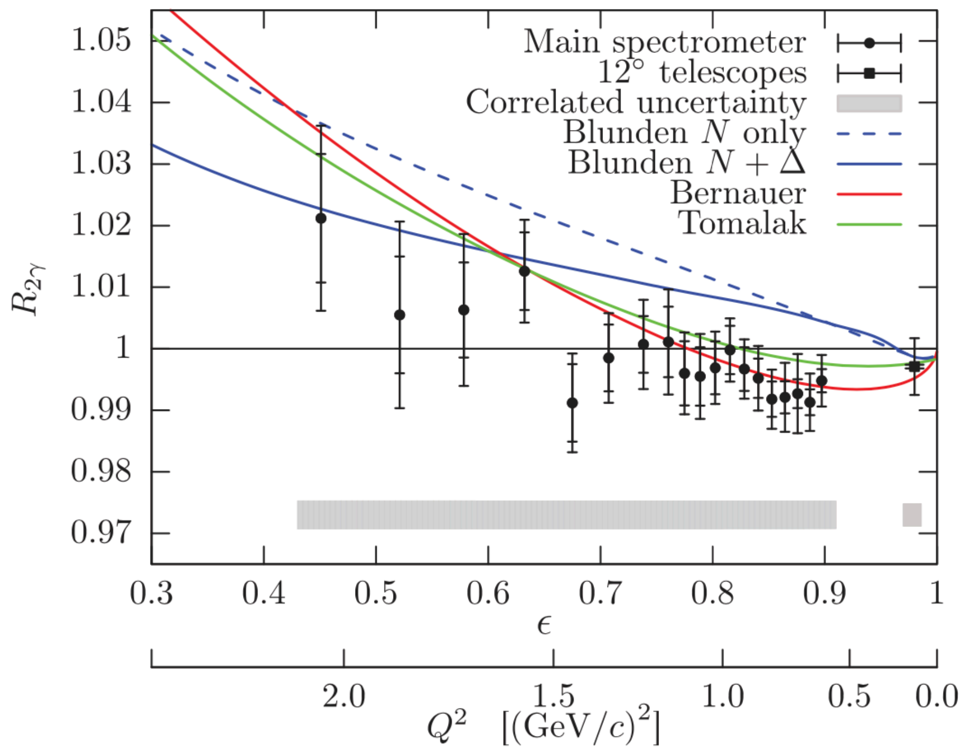


projected precision
at Q^2 = 3 GeV^2

$\Delta G^s/G_D = 0.05$



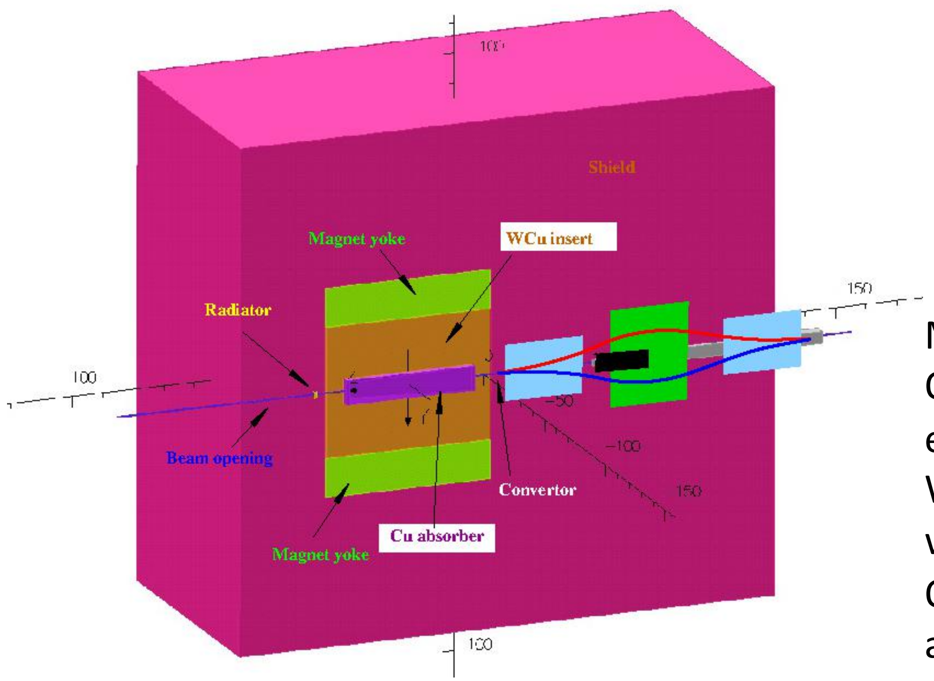
Two Photon Exchange in e-p scattering



Not sufficiently large Q2

Systematics of the detector acceptance in the toroidal system

Positron source based on CPS

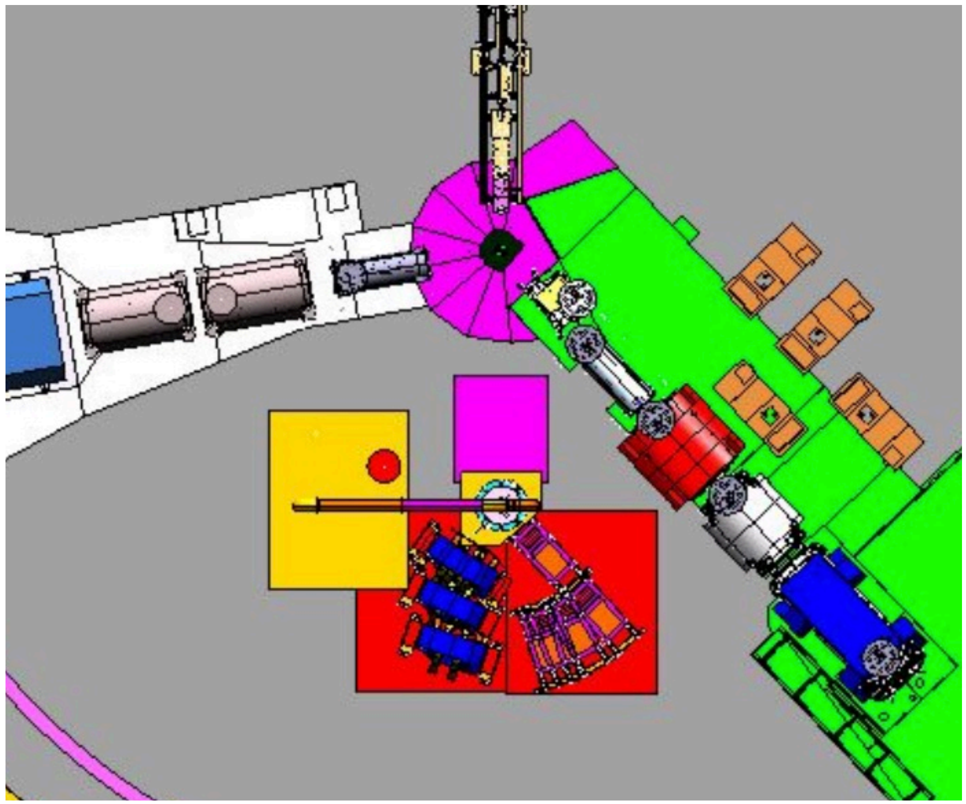


Small phase space of the photon beam

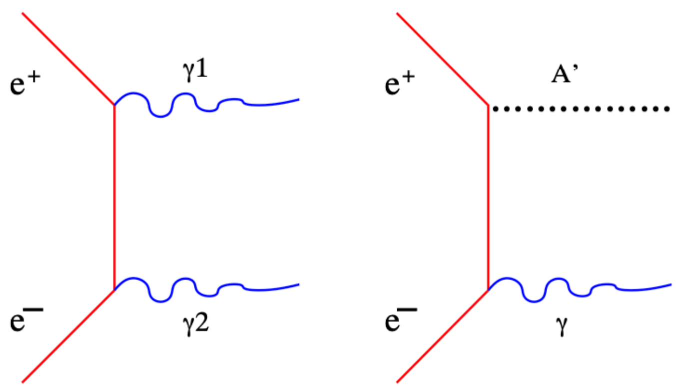
$$I_{\pm} = \frac{P}{E_{beam}} \times t1 \cdot \frac{\Delta E_{\gamma}}{E_{\gamma}} \times t2 \cdot \frac{\Delta E_{\pm}}{E_{\pm}}$$

Measurements at Q2=3 GeV2 at several kinematic points.
Q2 projected counting rate (using a magnetic spectrometer, e.g. BigBite with a solid angle of 50 msr) to be 2.5 Hz .
With 10 hours of production time, e±p event statistics will be ~90k events.
Overall beam time for a sub 0.5% accuracy experiment at 3 GeV2 is about 500 hours.

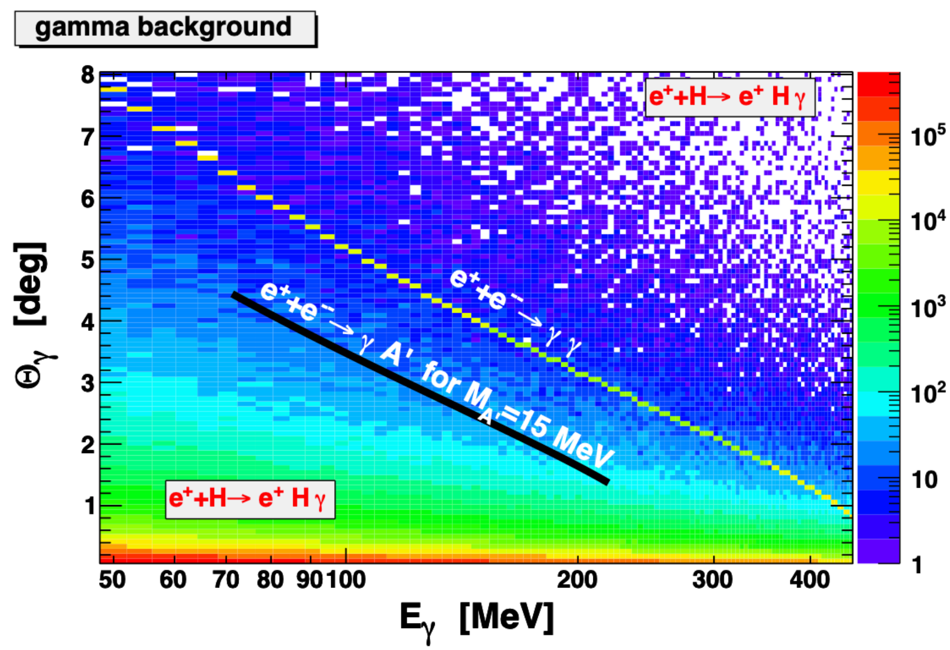
TPE experiment with the CPS positron source



A'/X17 search experiment based on CPS + NPS



arXiv:0906.5265

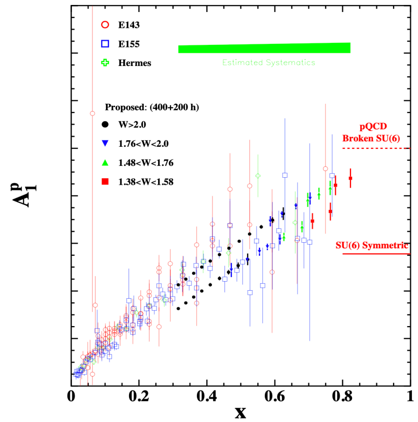


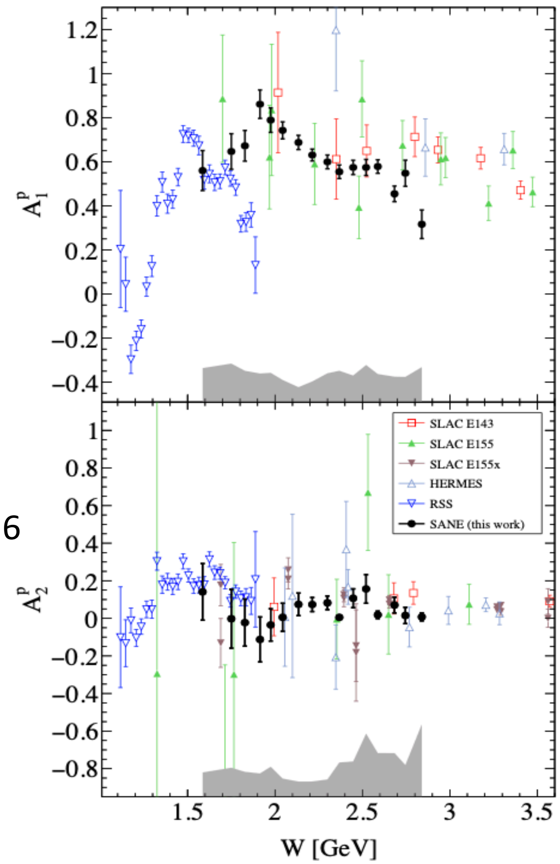
With 1% energy spread, the intensity is 10^9 e+/sec

CPS-based experiment will be 1000x the productivity of PADME

A1p/A2p was done with a 5.9 GeV beam by SANE

Expected in SANE proposal, 2002

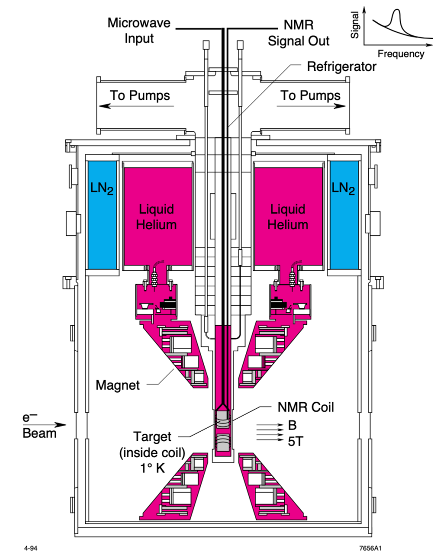


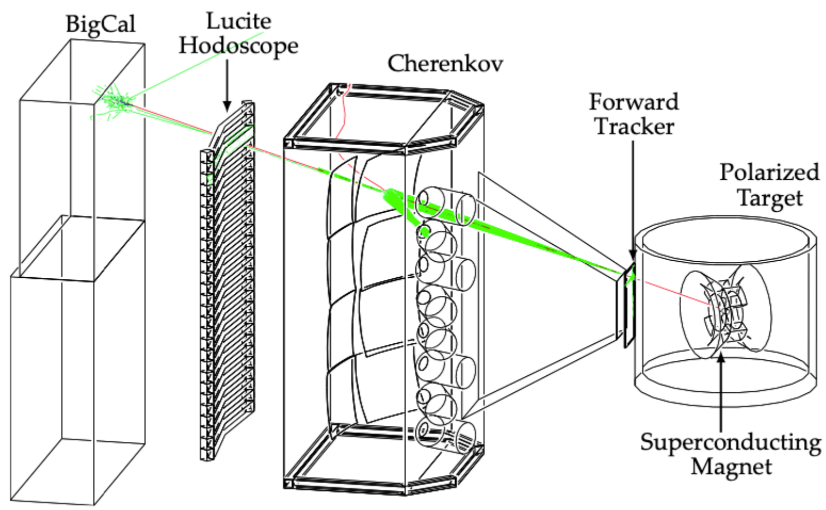


Published results
arXiv:1805.08835v4
PRL 122, 022002 (2019)

The advance in data accuracy and high x (low W) is needed. Reference to P. Bosted's comment in 2016

Apparatus in SANE experiment





Kinematics in DIS experiment with polarized target

E_{beam} (GeV)	I (nA)	θ_N (°)	θ_e (°)	Time (h)
6.0	85	180	40	325
6.0	85	80	40	75
4.8	85	180	40	170
4.8	85	80	40	30
2.4	1000	26	58	50

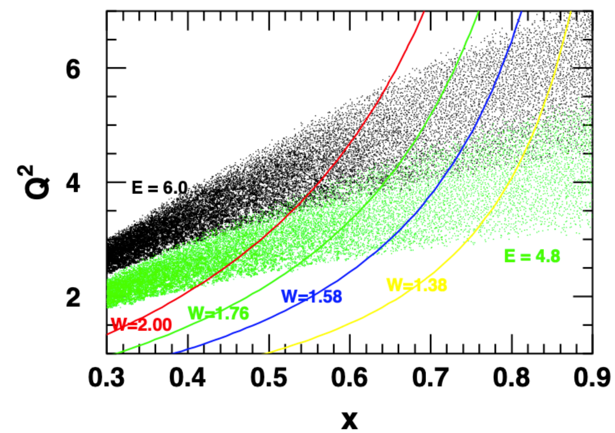


Table 2: Resolutions of SANE for $E = 4.8$ and 6.0 GeV and $\theta_{central} = 40°$. The momenta shown roughly correspond to the lowest and highest x for DIS and the highest x for the second resonance region.

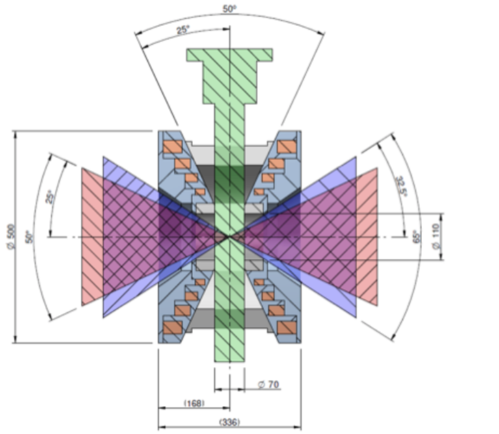
E' (GeV)	x	W (GeV)	$\delta\theta$ (mrad)	$\delta E'$ (GeV)	δx	δQ^2 (GeV^2/c^2)	δW (GeV)
$E = 6.0$ GeV							
1.0	0.30	2.73	10.1	0.050	0.024	0.160	0.045
1.7	0.59	2.04	4.5	0.065	0.035	0.196	0.076
2.2	0.87	1.35	2.9	0.074	0.048	0.214	0.130
$E = 4.8$ GeV							
0.8	0.24	2.57	17.0	0.045	0.028	0.131	0.039
1.4	0.49	2.03	5.9	0.059	0.034	0.143	0.061
1.9	0.78	1.43	3.9	0.069	0.050	0.162	0.100

Motivated by need for a wider magnet opening I come to an idea of shimming and submitted a patent disclosure to JLab office in 8/2016

3. The invention consists of a device comprising a pair of the field-producing coils and two iron rings profiled and installed according to the example below. We have developed a design of the magnet for a 5.8 Tesla field by using as a starting point the geometry of the coils in the magnet from Ref. [2]. We moved the coils out by +/- 5 cm to double the opening angle and increased the length of the superconducting coils also by a factor of two. The modified coils have the same current density as the coils in the original magnet. The field produced by the coils has a non-uniformity of 0.2% in the central area of 2 cm diameter. The coils and their support structure leave about a 60 degree opening angle (almost double that available in the magnet per Ref. [2]). Two symmetric iron rings are installed between the coils in an unused space. The iron in those rings is magnetized and creates an additional field, which restores the uniformity to the level of 0.01% in the reference area.

A real magnet was built by JLab target group

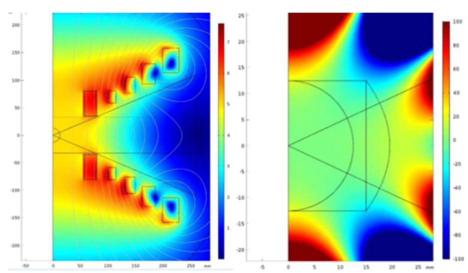
A new magnet with improved acceptance for transverse polarization was procured for experiments in Hall C. Compared to the original Hall B and C magnets:
±35° acceptance for longitudinal polarization (30% smaller)
±25° acceptance for transverse polarization (67% larger)



Cross-section through the magnet showing the beam and cold finger access diameters (in mm) and

The coils are shimmed using iron to achieve desired 100 ppm uniformity for dynamic polarization.

- Cost saving
- Higher coil margin (SSP)
- Uniformity guaranteed only at 5.0 T



The next A1p/A2p experiment with 11 GeV beam,
wide aperture NH3, BigBite and SBS/NPS
is ready for PAC proposal formulation