GMn ERR

June 15, 2017

Introduction / overview of experiment

Charge 5) General requirements of apparatus
(specifications of actual detectors in next talk,
details in detector-specific talks.
5a, 5b, 5c addressed in separate talks.)

E12-09-019 (GMn)

Precision Measurement of the Neutron Magnetic Form Factor up to Q^2=13.5 (GeV/c)^2 by the Ratio Method

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Hall A collab

Approved by PAC 34

PAC 35 allocated 25 of requested 31 days.

Technique

$$R'' = \frac{\left(\frac{d\sigma}{d\Omega}\right)_{d(e,e'n)}}{\left(\frac{d\sigma}{d\Omega}\right)_{d(e,e'p)}} \xrightarrow[\text{corr.}]{\text{nucl.}} \frac{\left(\frac{d\sigma}{d\Omega}\right)_{n(e,e')}}{\left(\frac{d\sigma}{d\Omega}\right)_{p(e,e')}} \xrightarrow[1\gamma]{} \frac{\eta \frac{\sigma_{\text{Mott}}}{1+\tau}\left(\left(G_E^n\right)^2 + \frac{\tau}{\varepsilon}\left(G_M^n\right)^2\right)}{\left(\frac{d\sigma}{d\Omega}\right)_{p(e,e')}}$$

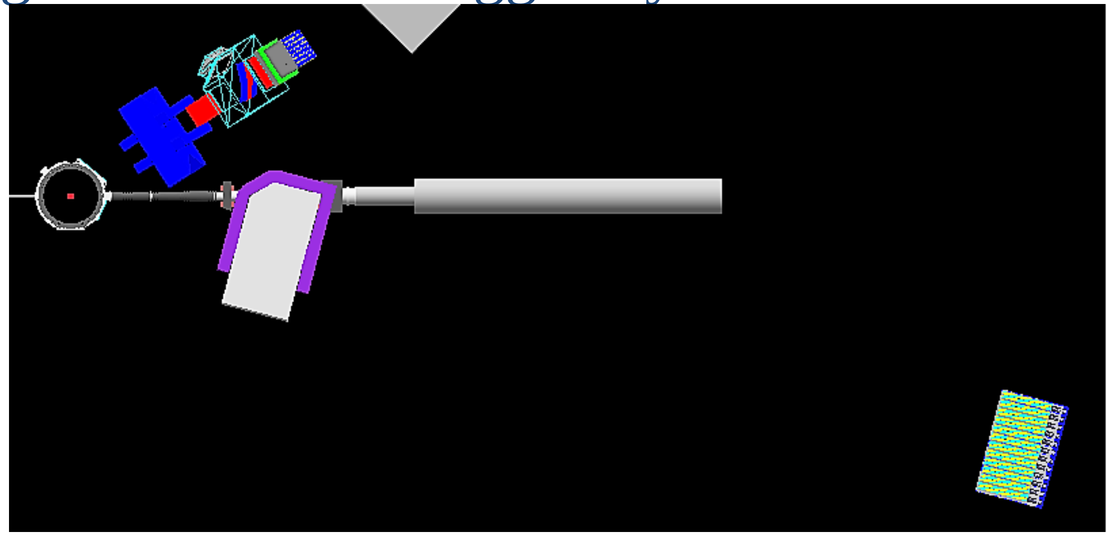
$$\xrightarrow[\text{Electric}]{\text{neutron}} \boxed{R = \frac{\eta\sigma_{\text{Mott}} \frac{\tau/\varepsilon}{1+\tau}\left(G_M^n\right)^2}{\left(\frac{d\sigma}{d\Omega}\right)_{p(e,e')}}}$$

Many systematic effects (experimental and theory) cancel in ratio.

Expect very small correction for Electric because small form factor and large kinematic weighting of Magnetic

Technique

Ratio Method:
Measure quasi-elastic scattering from deuteron tagged by coincident nucleon: d(e,e'p) and d(e,e'n)



BigBite as electron arm
(Beam left)
Identifies q-vector ($\vec{q}$)

HCal-J as hadron detector with CDet in front (Beam right)

48D48 (SBS spectrometer magnet)
Deflects protons vertically on HCal-J to distinguish from neutrons

Fiducial cut in BigBite selects high, matched acceptance for n <u>and</u> p.

proposed

configuration	Q^2 $(GeV/c)^2$	E_{Beam} (GeV)	θ_{BB} (deg.)	θ_{SBS} (deg.)	d_{BB} (m)	d_{48D48} (m)	48D48 field integral (T-m)	Luminosity (10^{38}/A/cm^2/s)	dHCal (m)
1	3.5	4.4	32.5	31.1	1.80	2.00	1.40	0.7	6.2
2	4.5	4.4	41.9	24.7	1.55	2.25	1.70	1.4	6.2
3	6.0	4.4	64.3	15.6	1.55	2.25	0.70	2.8	11
4	8.5	6.6	46.5	16.2	1.55	2.25	1.20	2.8	11
5	10.0	8.8	33.3	17.9	1.75	2.25	1.30	1.4	13
6	12.0	8.8	44.2	13.3	1.55	2.25	1.20	2.8	14
7	13.5	8.8	58.5	9.8	1.55	3.10	0.70	2.8	17
8 & 9	3.5/6.0	calibration of HCal using L-HMS at kinematics of config. 1 &3							

modified

configuration	Q^2 $(GeV/c)^2$	E_{Beam} (GeV)	θ_{BB} (deg.)	θ_{SBS} (deg.)	d_{BB} (m)	d_{48D48} (m)	48D48 field integral (T-m)	Luminostiy (10^{38}/A/cm^2/s)	dHCal (m)
1	3.5	4.4	32.5	31.1	1.80	2.00	1.71	0.7 (2.8 ?)	7.2
2	4.5	4.4	41.9	24.7	1.55	2.25	1.71	1.4(2.8 ?)	8.5
3	5.7	4.4	58.4	17.5	1.55	2.25	1.71	2.8	11
4	8.1	6.6	43.0	17.5	1.55	2.25	1.65	2.8	11
5	10.2	8.8	34.0	17.5	1.75	2.25	1.60	1.4(2.8 ?)	11
6	12.0	8.8	44.2	13.3	1.55	2.25	1.50	2.8	14
7	13.5	11.0	33.0	14.8	1.55	3.10	0.97	2.8	17
			θ_{L-HRS}						
8	6.06	4.4	61.1,64.3	14.8		3.10	1.71	0.93	17
			67.5,70.7						
9	4.4	4.4	39.,42.	25.5		3.10	1.71	0.93	17

config	Changes required
1	
	reposition 48D48, HCal, BigBite
2	
	reposition 48D48, HCal, BigBite
3	
	Energy change, reposition BigBite
4	
	Energy change, reposition BigBite
5	
	reposition 48D48, HCal, BigBite
6	
	reposition 48D48, HCal, HRS , BigBite change beam pipe Energy change
7	
	Energy change/rig out BigBite
8	3 HRS moves (3 degrees each)
	reposition 48D48, HCal, HRS
9	one HRS move (3 degrees)

Total

1 Beam set-up

4 Energy changes

5 SBS 48D48/HCal moves

7 BigBite moves

1 Change of beamline

1 Rig out BigBite

6 HRS moves

SBS Collaboration

Argonne National Lab
Cal. State Los Angeles
Carnegie Mellon Univ.
Christopher Newport Univ.
Univ. of Glasgow
Hampton Univ.
Idaho State Univ.
INFN/Bari
INFN/Catania
INFN/Rome
INFN/Genoa
Norfolk State Univ.

North Carolina A & T
North Carolina Central Univ.
James Madison Univ.
JLab
Univ. of Connecticut
Univ. of Virginia
College of William and Mary
Rutgers Univ.
St. Mary's Univ.
SUNY Stony Brook
Yerevan Inst. of Phys.

Expected workforce availability from outside JLab for installation, testing, calibration 8 months before experiment

	(person-months)
Faculty	47
Postdoc	22.8
Graduate students	64.5
Technician	5
undergrad	14
Total	153.3

Expected workforce availability for running shifts (if over 3 months)

Faculty	13
Postdoc	9.2
Graduate students	29
undergrad	1
Total	52.2

5) General requirements for equipment

BigBite as electron arm (Beam left)

- Instrumented for high luminosity (GEMs)
  - 30uA on 15cm LD2 (or 45uA on 10 cm) $1.4\text{X}10^{38}$ /cm^2/s
- Good electron ID (preshower/shower & GRINCH)
- Identifies q-vector ($\vec{q}$) ~10 mrad resolution needed
- Single-arm trigger efficiency NOT critical
- Count event only if BOTH n and p would be in high-acceptance region of HCal-J

HCal-J as hadron detector (Beam right)

- Similar (high) efficiency for neutrons and protons
- Good position resolution to test whether hit is associated with $\vec{q}$
  - Cuts inelastics. Fermi-motion sets resolution limit.
- No tracking detectors needed in hadron arm
- TOF information will improve inelastic rejection (not included in proposal)

Coordinate detector

Positive ID of proton (useful check for proton efficiency calibrations).

Vertical hit position, useful for calibrating HCal-J position resolution

48D48 (SBS spectrometer magnet)

Up to 1.71 T-m 'kick' to separate protons from neutrons

Field uniformity not important – Not used as spectrometer

(map must be reasonably well understood)

Trigger/DAQ

~1 kHz trigger rates with single-arm BB trigger