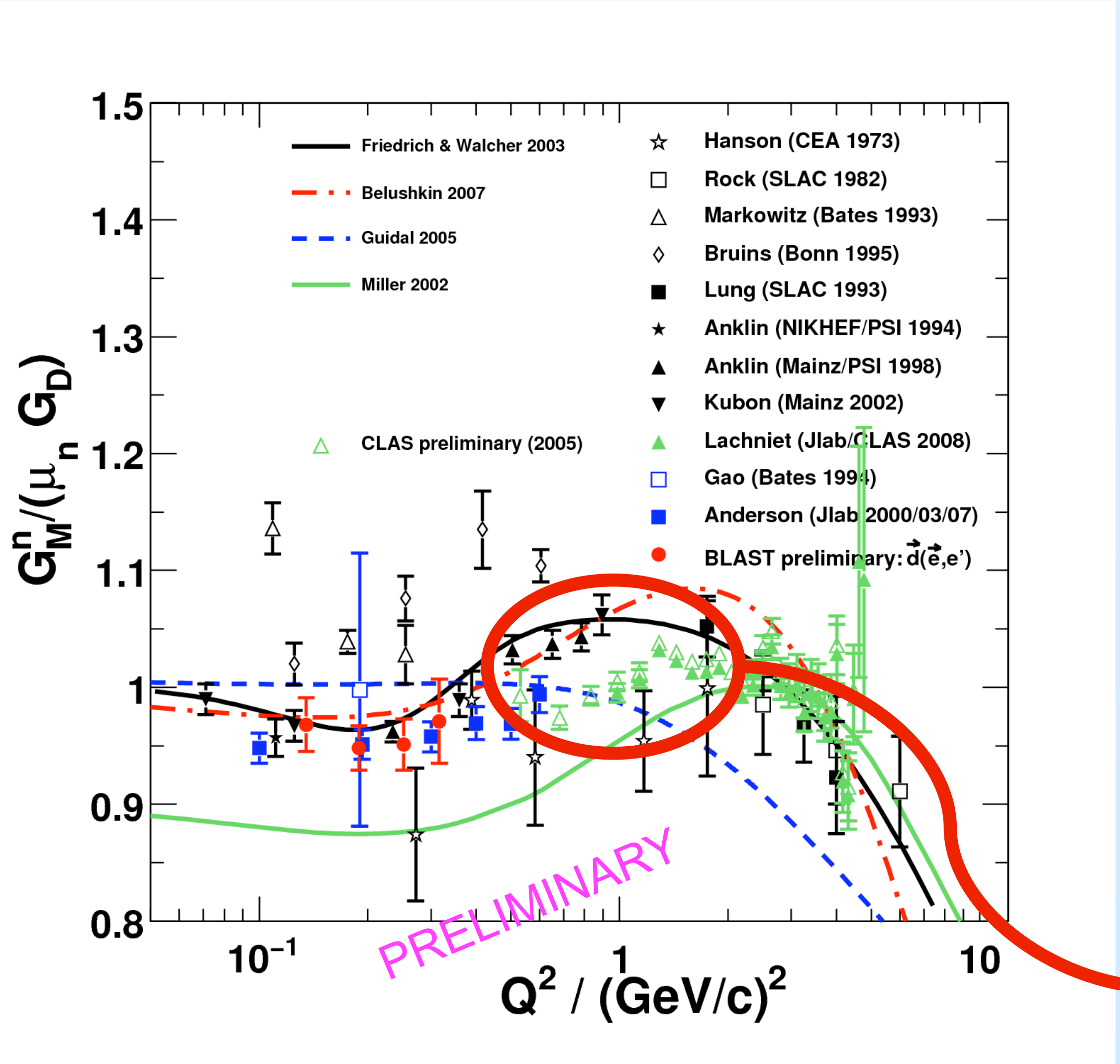
Hall C Users Meeting 2009, Jefferson Lab, January 30-31, 2009

LOI-09-003: IncAs – Inclusive Asymmetries from Vector-Polarized Deuterium for a Precise Determination of G^n_M at Intermediate Momentum Transfer

Michael Kohl

Hampton University and Jefferson Lab
Virginia, USA

Neutron Magnetic Form Factor G^n_M



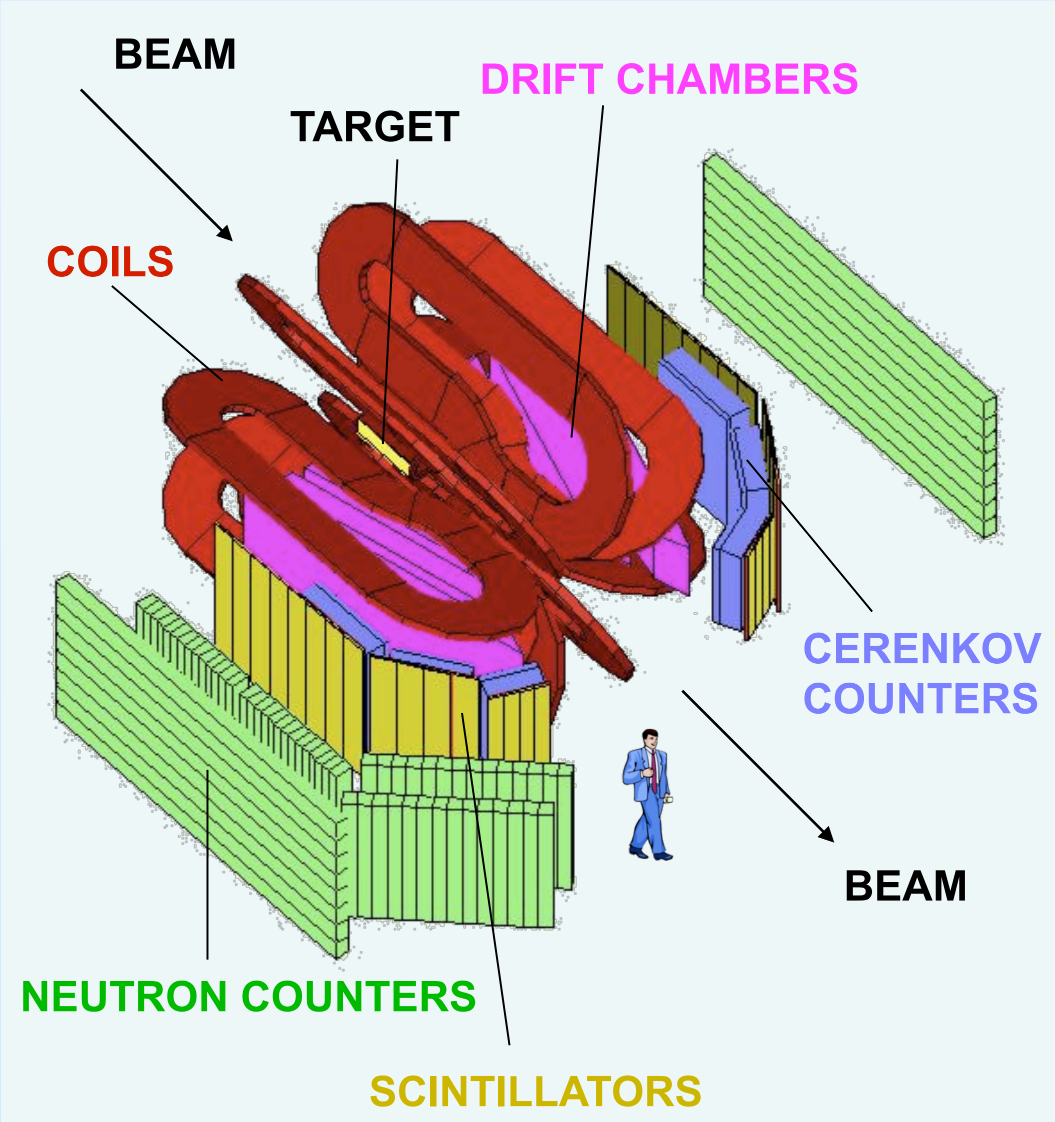
- **Pre-polarization era**
- G^n_M world data from unpolarized experiments
- Cross section ratio quasielastic $\frac{d(e,e'n)}{d(e,e'p)}$
- **+ CLAS preliminary (final)**
- **Polarization era**
- G^n_M world data **+ ^{3}He**
  + BLAST preliminary

- **No pol. data >0.6 (GeV/c)^2**
- **Discrep./jump of several σ at Q^2 ~ 0.6-1.0 (GeV/c)^2**
- **Uncertainties ?**

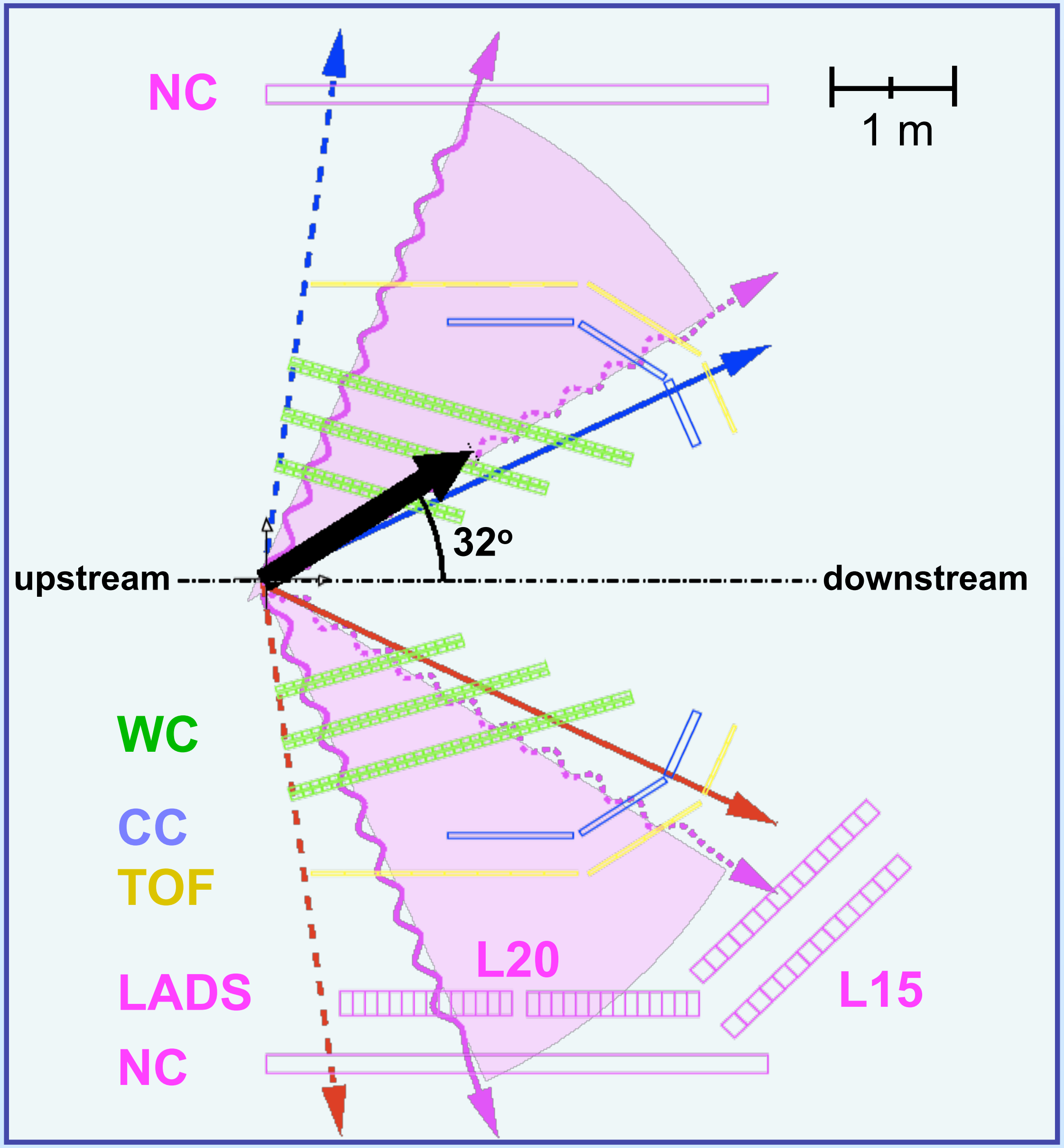
*Ph.D. work of N. Meitanis (MIT) and B. O'Neill (ASU)

The BLAST Detector

- **Left-right symmetric**
- **Large acceptance:**
  $0.1 < Q^2/(GeV/c)^2 < 0.8$
  $20^o < \theta < 80^o$, $-15^o < \phi < 15^o$
- **COILS** $B_{max} = 3.8$ kG
- **DRIFT CHAMBERS**
  Tracking, PID (charge)
  $\delta p/p=3\%$, $\delta\theta = 0.5^o$
- **CERENKOV COUNTERS**
  e/π separation
- **SCINTILLATORS**
  Trigger, ToF, PID (π/p)
- **NEUTRON COUNTERS**
  Neutron tracking (ToF)



Target Spin Orientation



Freedom of in-plane spin angle

32° (2004) / 47° (2005)

e- left → $\theta^* \approx 90^o$

“spin-perpendicular”

e- right → $\theta^* \approx 0^o$

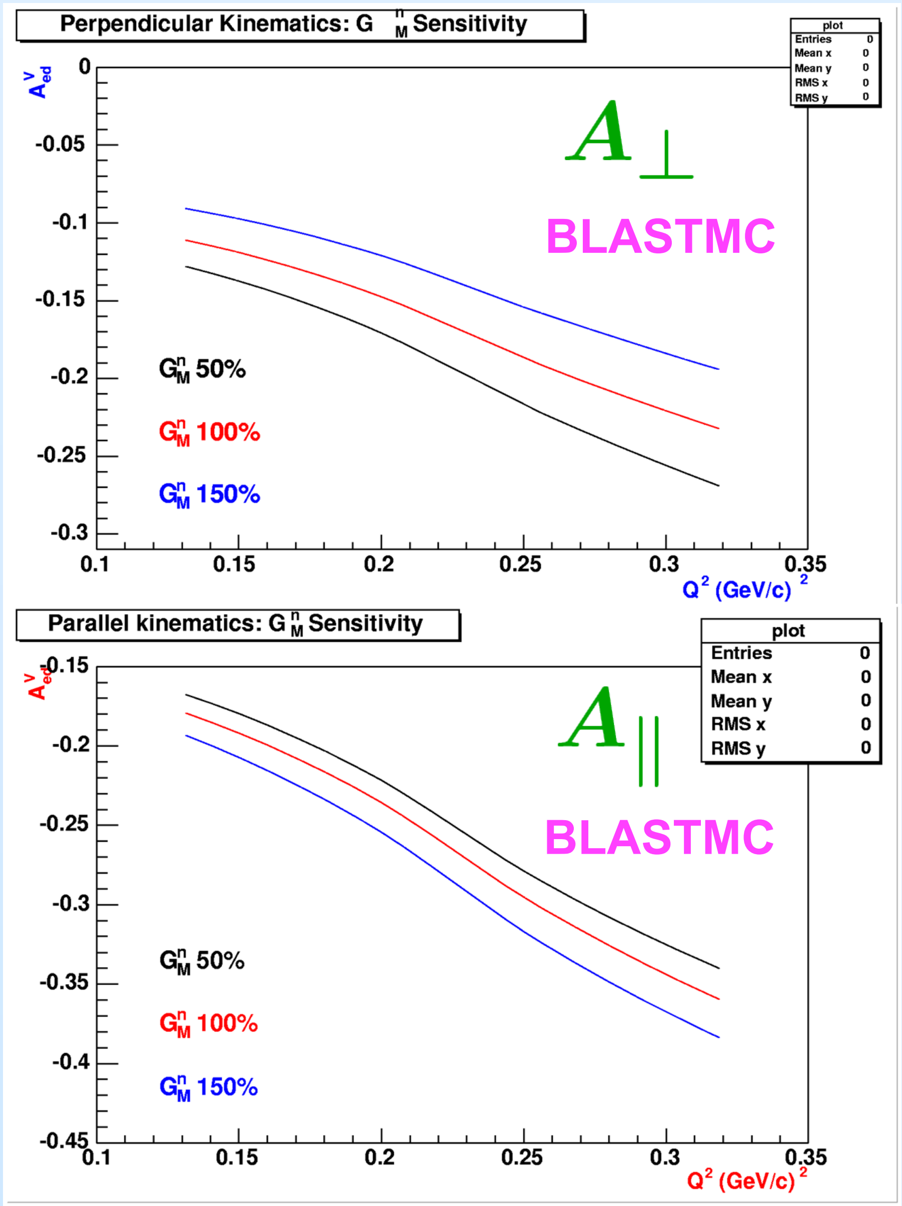
“spin-parallel”

Extraction of G^n_M

- Quasielastic $^2\vec{H}(\vec{e},e')$ inclusive
- Full Montecarlo simulation of the BLAST experiment
- Deuteron electrodisintegration by H. Arenhövel
- Accounted for FSI,MEC,RC,IC
- Beam-target vector asymmetry A^V_{ed} spin-parallel + perpendicular show sensitivity to G^n_M
- PWIA:

$$A_\perp \approx \frac{c\,(G^p_E/G^p_M)}{a+b\left(1+\left(G^n_M/G^p_M\right)^2\right)}$$

$$A_\parallel \approx \frac{d\left(1+\left(G^n_M/G^p_M\right)^2\right)}{a+b\left(1+\left(G^n_M/G^p_M\right)^2\right)}$$



Extraction of G^n_M*

$$\frac{A_\perp}{A_\parallel} \approx \frac{\kappa \frac{G_E^p}{G_M^p}}{1 + \left(\frac{G_M^n}{G_M^p}\right)^2}$$

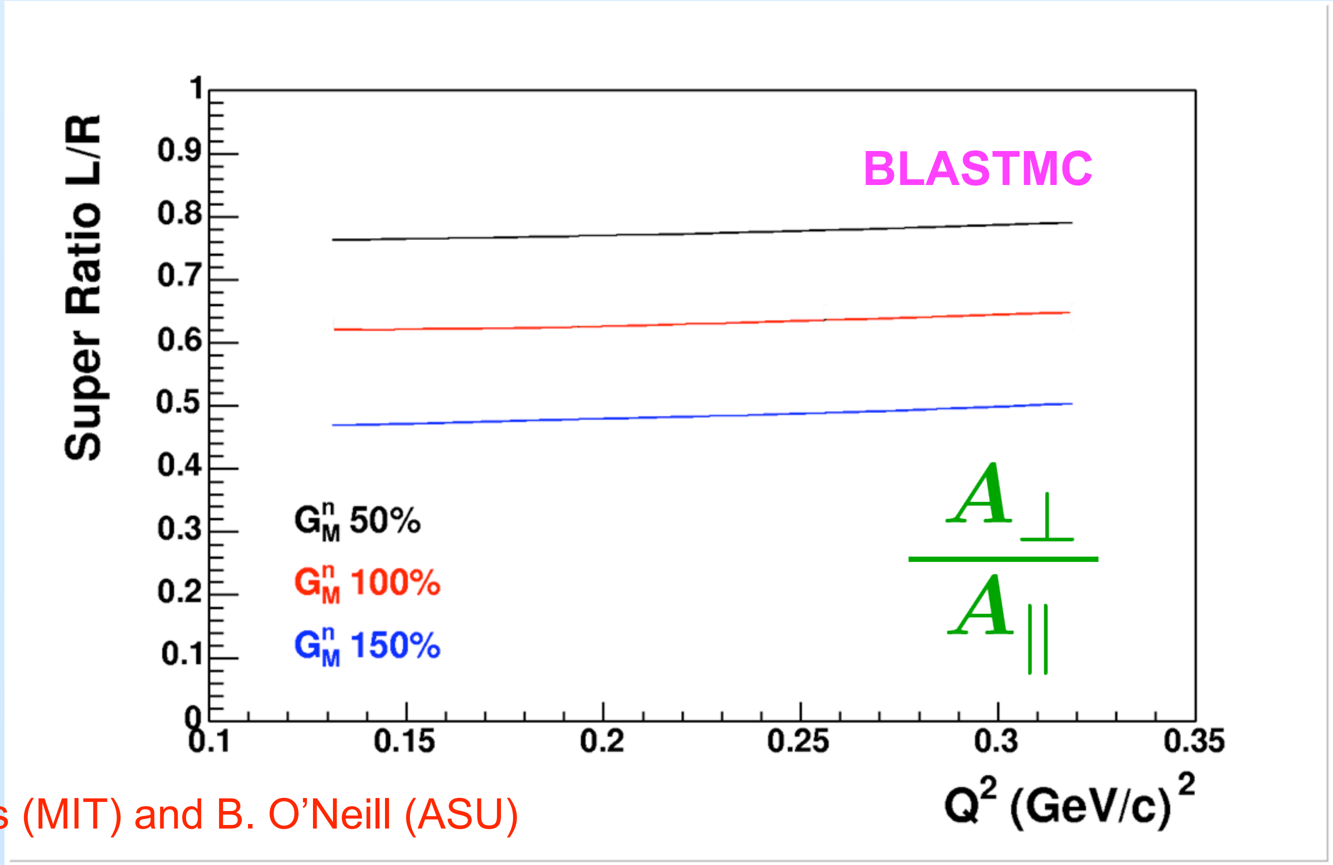
Enhanced sensitivity in super ratio

Independent of polarization

50% variation in GMn

⇔

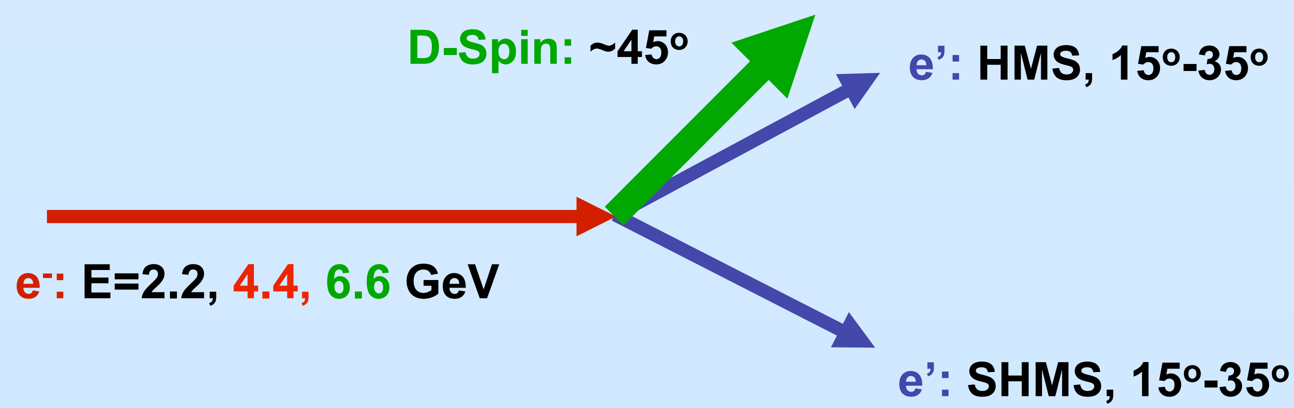
20% variation in R



*Ph.D. work of N. Meitanis (MIT) and B. O'Neill (ASU)

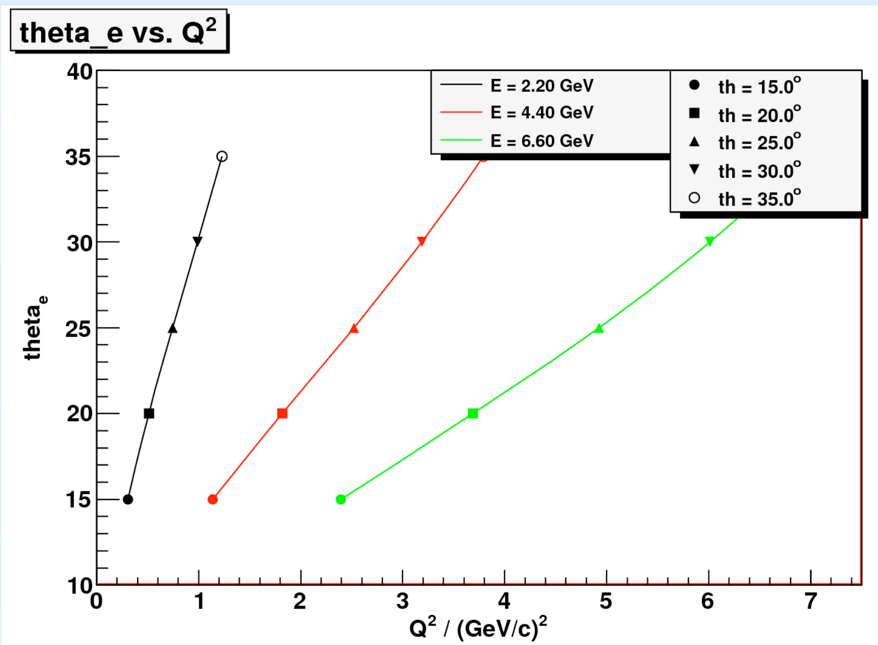
How to reconcile G^n_M around 1 (GeV/c)^2

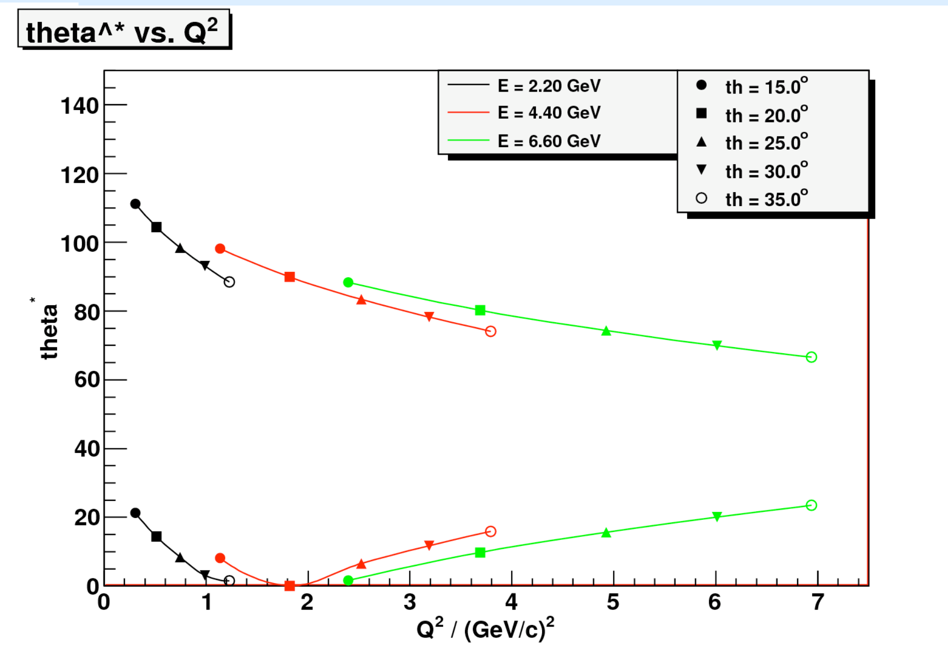
- **IncAs: Simultaneous measurement of inclusive beam-vector asymmetries in equal, quasifree kinematics with 2 target spin orientations relative to momentum transfer**
- **Vector-polarized deuterium target (UVA), θ_d ~= 45^o (left)**
  P_b*P_t = 0.8*0.3 = 0.24, F_{DF} = 0.8, L=3*10^{35} / (cm^{2}s)
- **HMS + SHMS / assuming solid angle 6 msr**
  single-arm (e,e') left and right at symmetric angle



IncAs: Kinematic Coverage

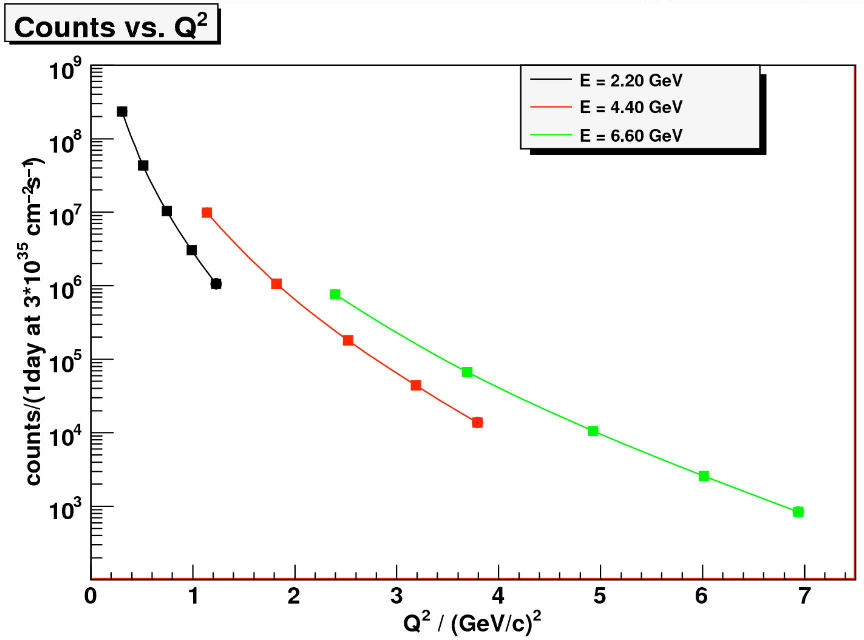
D-Spin: θ_d=45°

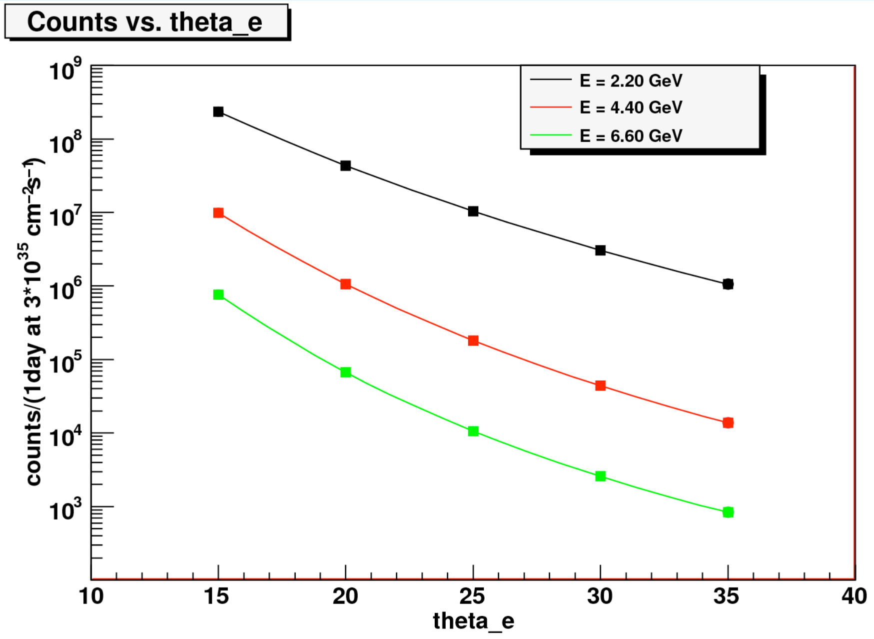




"Perpendicular" and "parallel" orientation well established at Q^2~1-2 $(GeV/c)^2$

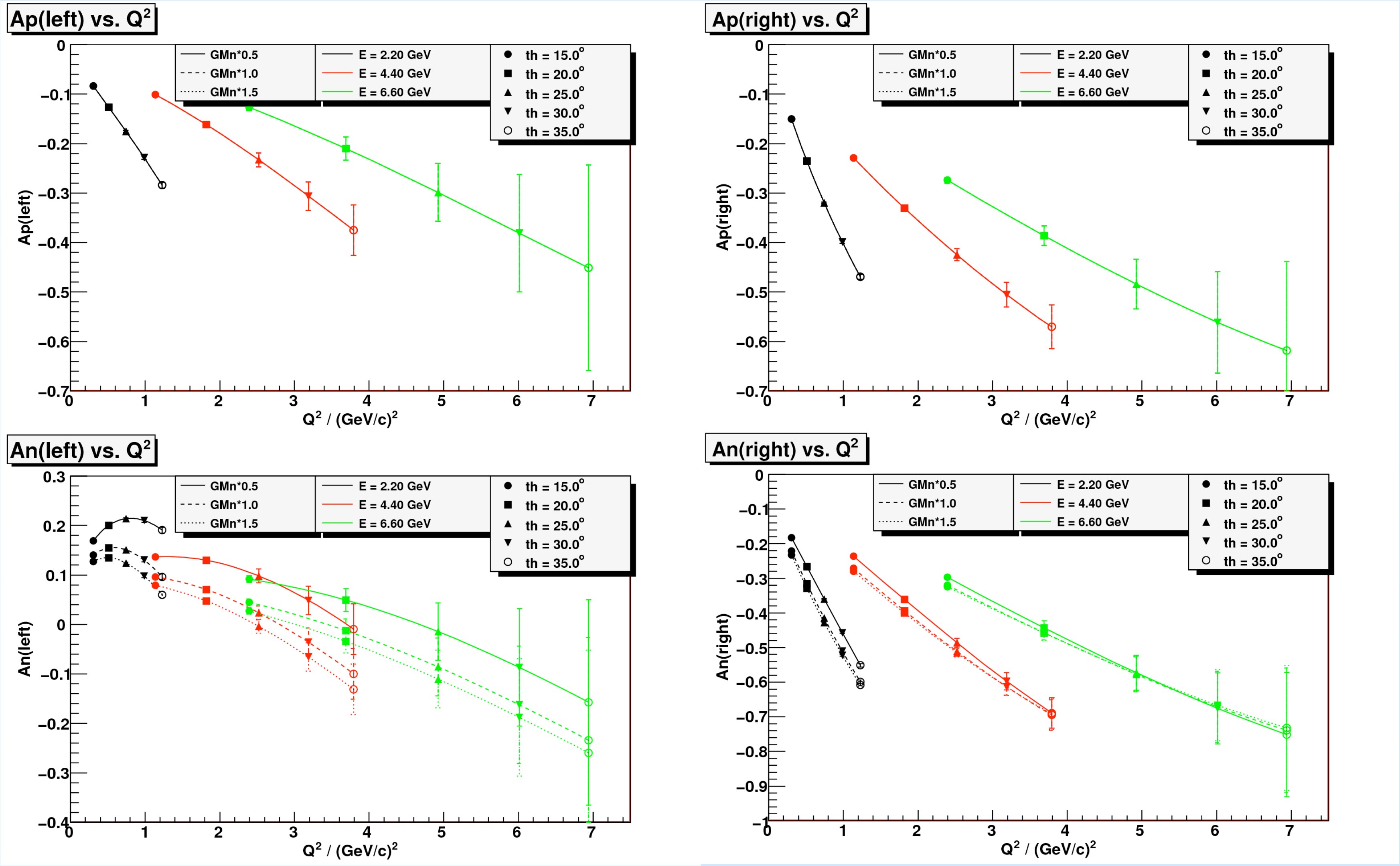
IncAs: Count rates





Counts per day assuming luminosity L=3*10^{35} / (cm^{2}s) and 6 msr solid angle
Cross section = elastic e-p + e-n
Each point representing one angle setting (15^o-35^o)

Asymmetries for free nucleons

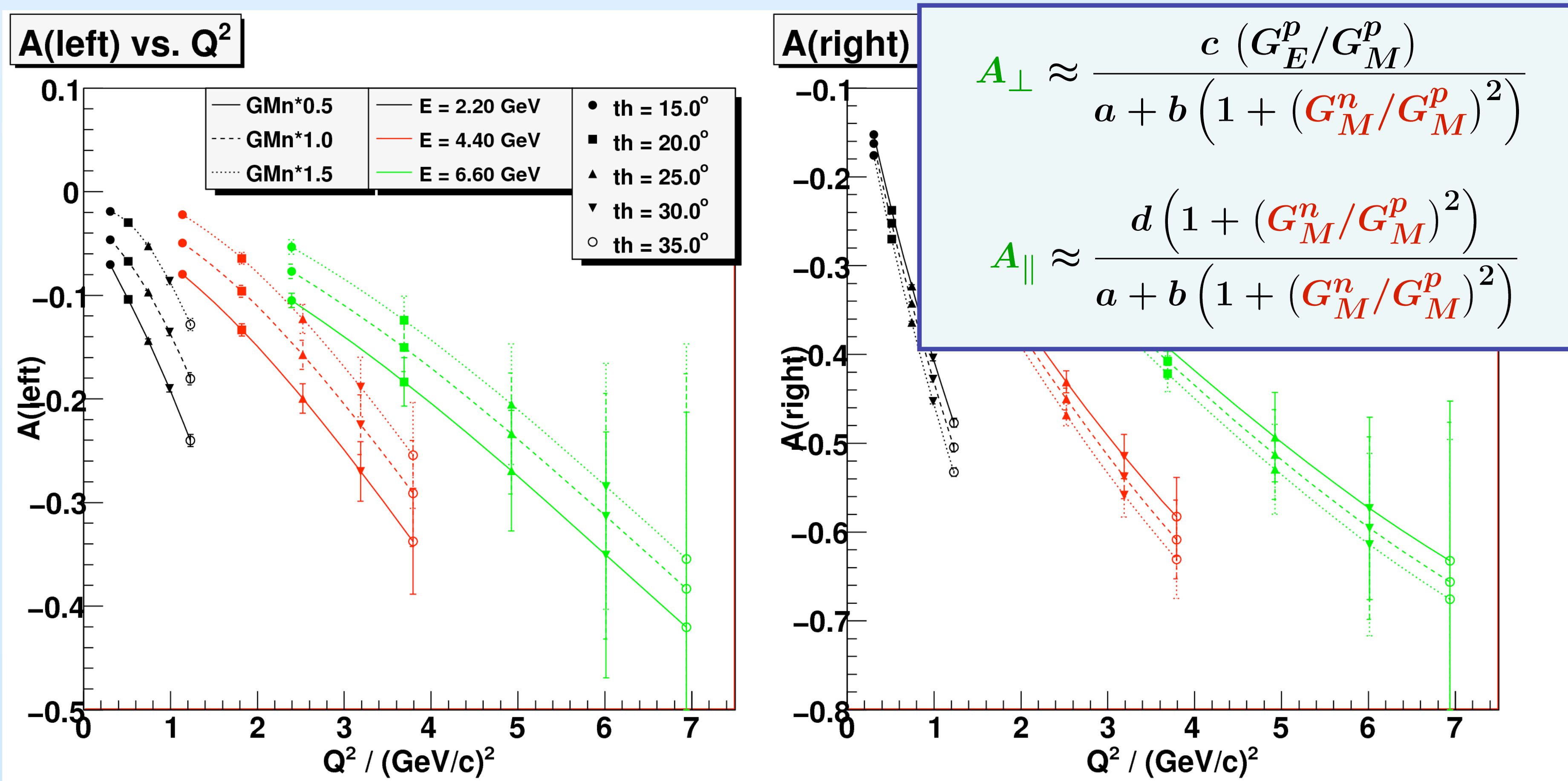


Error bars corresponding to 1 day / 6 msr / $3*10^{35}$ cm^{-2}s^{-1} / F_{DF}=0.8 / P_bP_t=0.24

IncAs: Inclusive Asymmetries: θ_d=45°

$$A = \frac{A_p\sigma_p + A_n\sigma_n}{\sigma_p + \sigma_n}$$

Effect of G^n_M opposite in left and right sectors



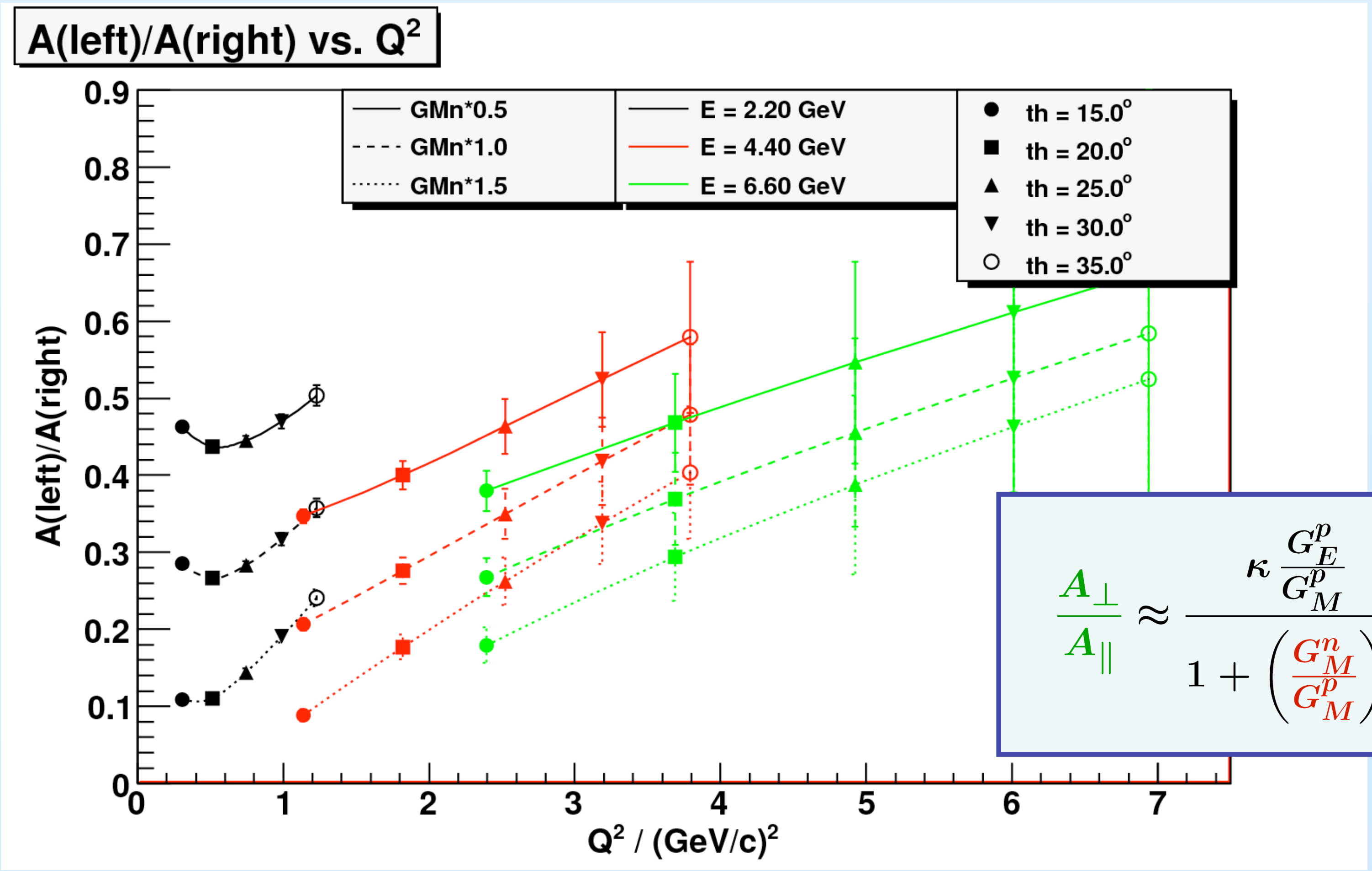
$$A_\perp \approx \frac{c\,(G^p_E/G^p_M)}{a + b\left(1 + (G^n_M/G^p_M)^2\right)}$$

$$A_\parallel \approx \frac{d\left(1 + (G^n_M/G^p_M)^2\right)}{a + b\left(1 + (G^n_M/G^p_M)^2\right)}$$

Error bars corresponding to 1 day / 6 msr / $3{*}10^{35}$ cm^{-2}s^{-1} / F_{DF}=0.8 / P_bP_t=0.24

IncAs: Inclusive Asymmetries: θ_d=45°

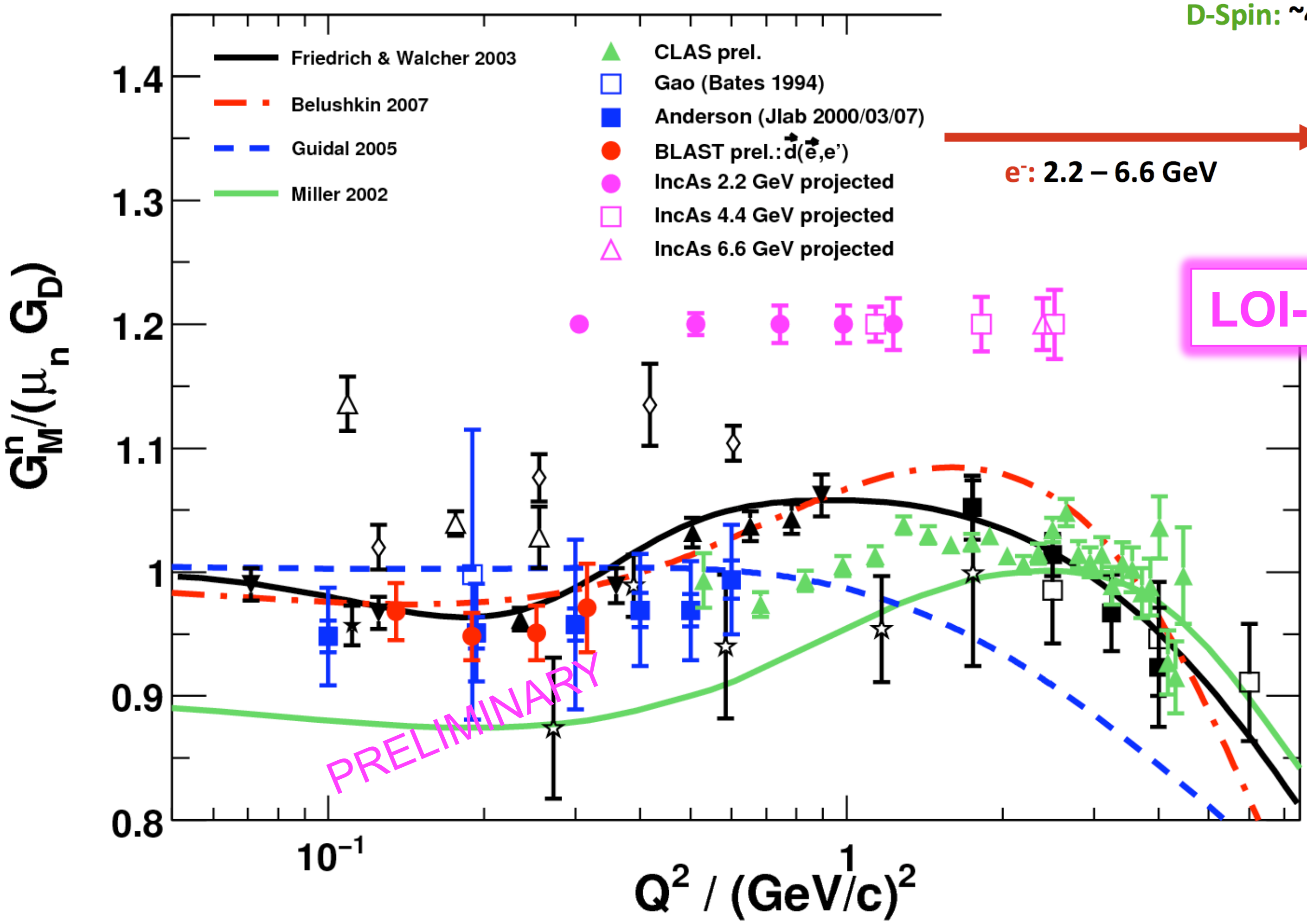
50% variation in G^n_M ⇔ 50% variation in R

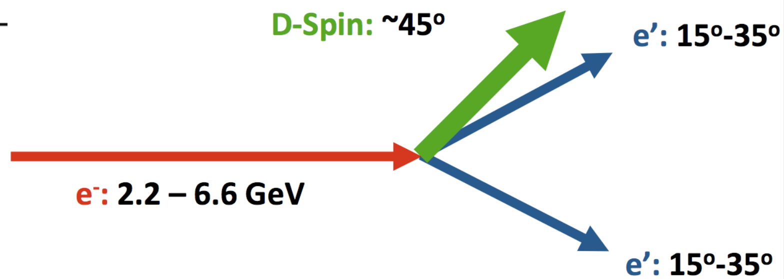


$$\frac{A_\perp}{A_\parallel} \approx \frac{\kappa \frac{G_E^p}{G_M^p}}{1 + \left(\frac{G_M^n}{G_M^p}\right)^2}$$

Error bars corresponding to 1 day / 6 msr / $3 \cdot 10^{35}$ $cm^{-2}s^{-1}$ / F_{DF}=0.8 / P_bP_t=0.24

IncAs: A precision G^n_M measurement



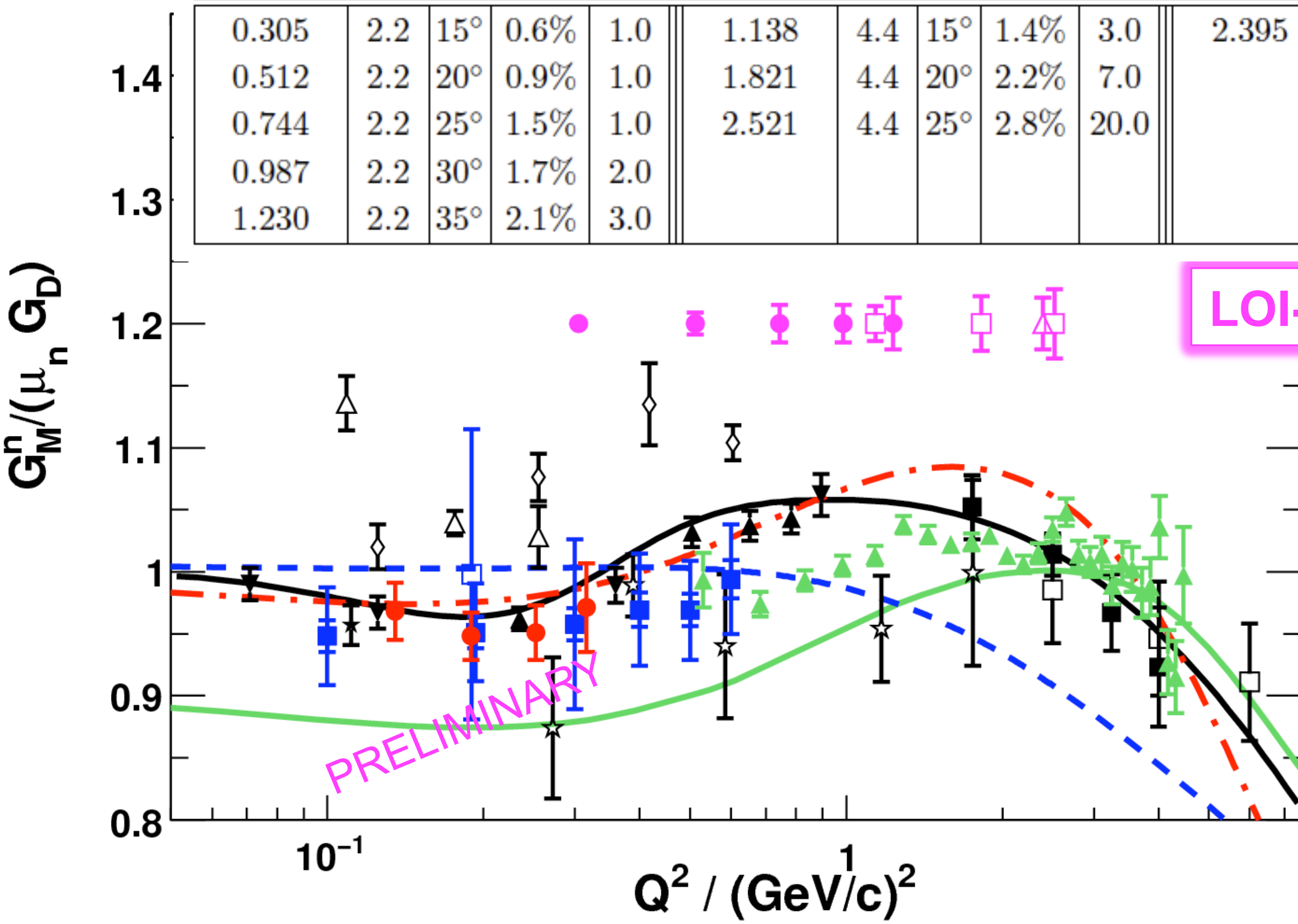


LOI-09-003/PAC34

IncAs: A precision G^n_M measurement

Q^2 $(\mathrm{GeV/c})^2$	E GeV	θ_e	ΔG^n_M	T days	Q^2 $(\mathrm{GeV/c})^2$	E GeV	θ_e	ΔG^n_M	T days	Q^2 $(\mathrm{GeV/c})^2$	E GeV	θ_e	ΔG^n_M	T days
0.305	2.2	15°	0.6%	1.0	1.138	4.4	15°	1.4%	3.0	2.395	6.6	15°	2.1%	20.0
0.512	2.2	20°	0.9%	1.0	1.821	4.4	20°	2.2%	7.0					
0.744	2.2	25°	1.5%	1.0	2.521	4.4	25°	2.8%	20.0					
0.987	2.2	30°	1.7%	2.0										
1.230	2.2	35°	2.1%	3.0										

LOI-09-003/PAC34



IncAs: Theory and TAC Reports

- Theory report by J. Goity
- New method to resolve issue raised by x-sec ratio exps.
- Deuterium super-ratio method well established at BLAST
- Use of Deuterium having advantages over He-3
- Reduced systematic uncertainties
- Interesting to probe oscillation around dipole form factor
- Inclusive asymmetries providing optimal access to G^n_M
- Excellent contribution to Jlab form factor program

IncAs: Theory and TAC Reports

- **Systematic error on GMn due to uncertainties of GEp/GMp and GMp to be investigated**
- **Experimental checks of systematic errors at 2.2 GeV: spin angle mapping**
- **To verify clearance between beam, coils and spectrometers at all proposed angles**
- **HMS/SHMS (Hall C) or HRS^2 (Hall A), or HD-Ice (Hall B)**
- **2.2 GeV has higher FOM in Hall A, but possible in Hall C**
- **4.4+6.6 GeV only in Hall C**

IncAs: Inclusive Asymmetries

- Inclusive asymmetries powerful tool for high precision measurement of G^n_M to resolve current inconsistency
- Excellent control of systematic uncertainties through cancellations (efficiency, luminosity, polarization, …)
- Super ratio method with enhanced sensitivity to G^n_M , no precise knowledge of polarization required
- For perp/par kinematics, $dR/R \sim= dG^n_M/G^n_M$
- IncAs is a polarization method superior to He-3 at intermediate Q^2 to precisely relate form factors
- "Simple" measurement, only e,e' with standard equipm.