Magnetic form factor of the neutron up to 8 GeV^2

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Technique: Quasi-elastic scattering from the deuteron

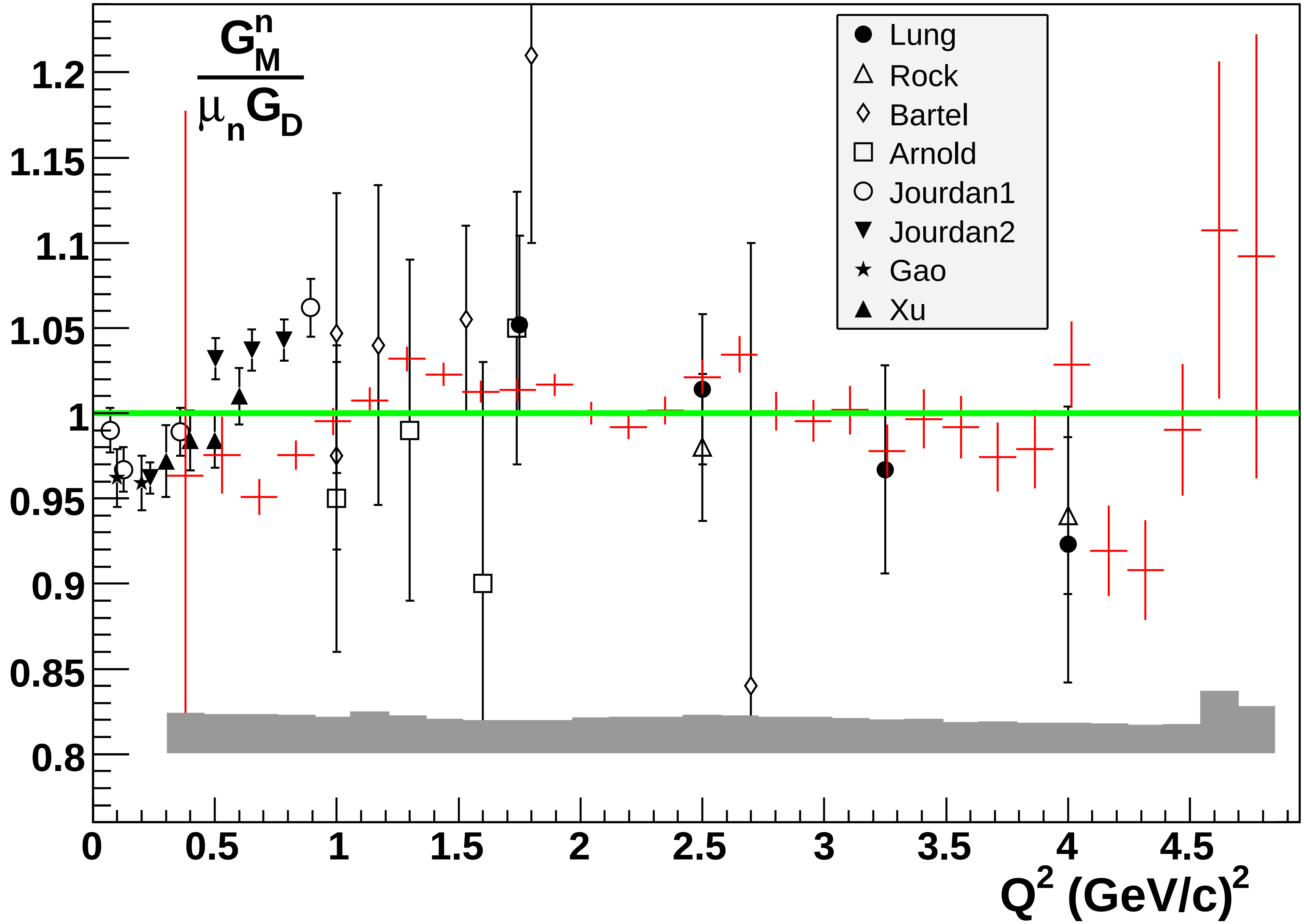
Measure: $\frac{\text{d(e,e'n)}}{\text{d(e,e'p)}}$

Calibration: H(e,e'p) $\quad$ H(γ,π^+n)

Physics Motivation

- Probe nucleon structure
- Evolution from non-perturbative to perturbative description
- Test Lattice QCD structure predictions
- Constrain generalized parton distributions

Selected World Data



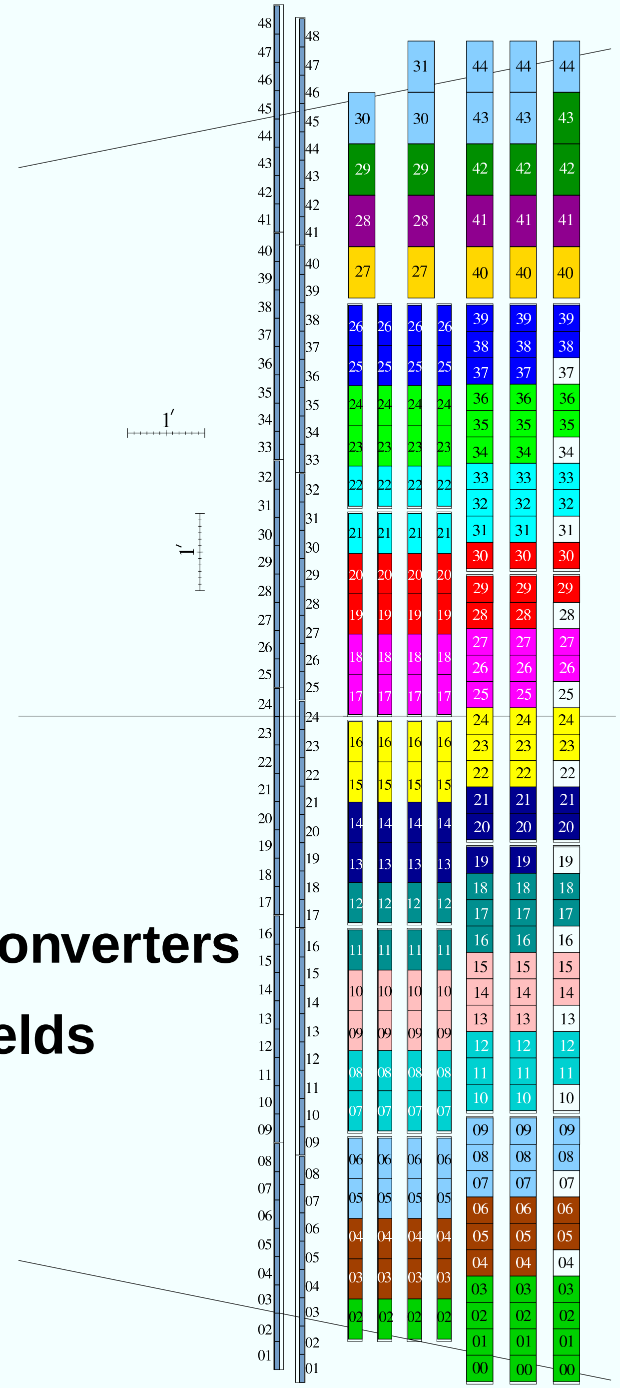
Red points: Lachniet et al. CLAS (e5) Preliminary

Kinematics

Q^2 $(GeV/c)^2$	E_{beam} (GeV)	θ_e	θ_N	E' (GeV)	P_N (GeV/c)
3.5	4	37.5°	29.2°	2.1	2.65
4.5	4	49.5°	22.4°	1.6	3.2
6	5	48.1°	19.5°	1.8	4.0
8	6	$52.^\circ$	15.5°	1.7	5.1

Apparatus

Big Bite spectrometer (Electron arm and π^+)



“Big Hand” detector (neutron and proton arm)

244 scintillator bars in 7 layer with $\frac{1}{2}$” iron converters

Two veto layers with 2” lead and 1” iron shields

Input for rate estimates

Luminosity (electron-nucleon): $\mathcal{L} = 10^{37}$ /cm^2/s

Quasi-elastic cross sections: Scaled Dipole ($G_{E,p}$,$G_{M,p}$,$G_{M,n}$), Galster($G_{E,n}$)

(Rough) combined Big Bite/Big Hand acceptance ($\times 0.8$ if BH defines edge of acceptance)

40% n-efficiency

40% p-efficiency

80% live-time $\times$ tracking efficiency

For H(γ, π^+n):

6% Cu radiator ($\mathcal{L} = 0.25 \times 10^{37}$/cm^2/s)

Counting rule scaling for (γ, π) at $90°$: $s^7 \frac{d\sigma}{dt} \approx 0.5 \times 10^7$ GeV^{14} $\frac{\text{nb}}{\text{GeV}^2}$

(actual $\theta^*_{\gamma,\pi} = 93°,\ 110°,\ 99°,\ 123°$)

Bremsstrahlung end-point method with $E_{\gamma_{min}}$ chosen to give P_π at least 1.5% above maximum possible pion momentum from ($\gamma, 2\pi$).

$$\int_{E_{min}}^{E_e} \Gamma dk = 0.0030,\ 0.0039,\ 0.0015,\ 0.0025$$

for $Q^2 = 3.5,\ 4.5,\ 6,\ 8$ (GeV/c)^2

Rate Estimates

(Counts per hour)

Q^2 (GeV/c)^2	3.5	4.5	6	8	6
E_{beam} (GeV)	4	4	5	6	6
d(e,e'p)	14000	2200	850	140	1500
d(e,e'n)	6000	950	370	65	650
H(e,e'p)	28000	4400	1700	280	3000
H(γ, π^+n)	600	550	150	39	45

Possible beam allocation
(Hours)

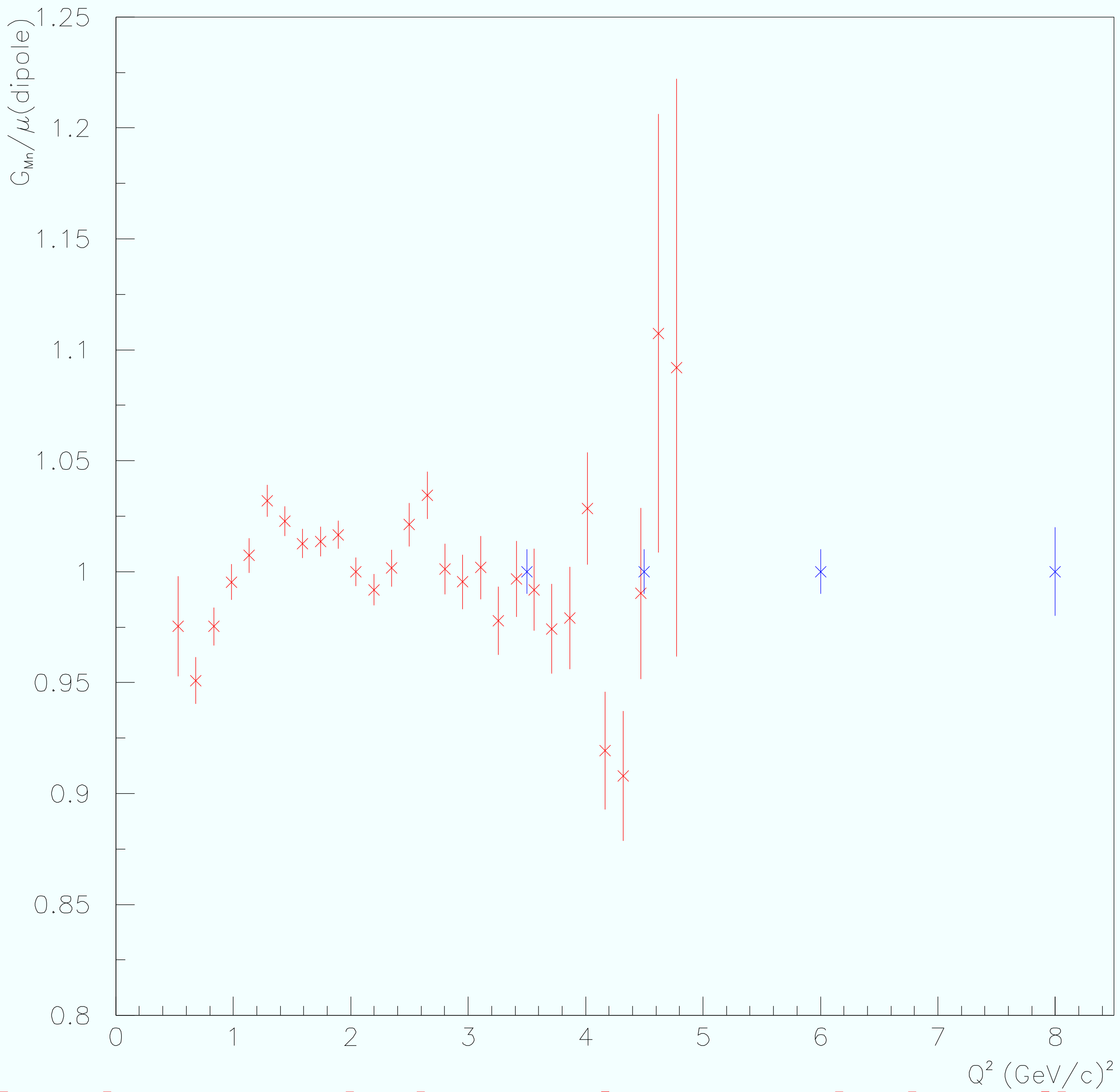
(Straw man)

Q^2 (GeV/c)^2 E_{beam} (GeV)	3.5 4	4.5 4	6 5	8 6
d	24	24	36	48
H no radiator (e,e'p) and (γ, π^+n)	18	18	32	36
H with 6% Cu rad H(γ_R, π^+n)	18	18	64	72

Total:408 Hours. Gives 1% (or better) statistical error on measurement and calibration at $Q^2 = 3.5,\ 4.5,$ and 6 (GeV/c)^2.

$\approx$2% errors for $Q^2 = 8$ (GeV/c)^2.

(Fractional err on $G_{M,n}$ = half of fractional error on cross section.)



Red points: Lachniet et al. CLAS (e5) Preliminary

Blue points: Projected error

assuming 1% (and 2% at Q$^2 = 8$ (GeV/c)^2)