SIZE AND SHAPE OF THE PROTONS

- MEASURED IN SAME WAY AS NUCLEI
- ELASTIC $ep \to ep$ SCATTERING $\to \frac{d\sigma}{d\Omega}$
- COMPARE $\frac{d\sigma}{d\Omega} \to \left(\frac{d\sigma}{d\Omega}\right)_{POINT} \to F(q^2)$ FORM FACTOR
- BOTH ELECTRONS & PROTONS HAVE SPIN AND ARE RELATIVISTIC $\to$ GENERALIZE MOTT CROSS SECTION
- IN ADDITION TO CHARGE DENSITY DISTRIBUTION RELATIVITY $\to$ MAGNETIC MOMENT DISTRIBUTION

  NUCLEUS $\to$ 1 FORM FACTOR

  PROTON $\to$ 2 FORM FACTORS

SPIN 1/2 PROTON HAS TWO FORM FACTORS

$$\frac{d\sigma}{d\Omega} = \left(\frac{d\sigma}{d\Omega}\right)_{MOTT}\left[\frac{G_E^2 + b\,G_M^2}{1+b} + 2b\,G_M^2\tan^2\frac{\theta}{2}\right]$$

$b = -q^2/2m_N^2$

θ: SCATTERING ANGLE

$G_{E,M} \equiv G_{E,M}(q^2)$

ROSENBLUTH CROSS SECTION

ELECTRIC FORM FACTOR

$G_E(q^2=0) = \frac{Q}{e}$

$G(0)_{PROTON} = 1$

$G(0)_{NEUTRON} = 0$

MAGNETIC FORM FACTOR

$G_M(q^2=0) = \frac{\mu}{\mu_N}$ NUCLEAR MAGNETON

$G_M(0)_{PROTON} = 2.79$

$G_M(0)_{NEUTRON} = -1.91$

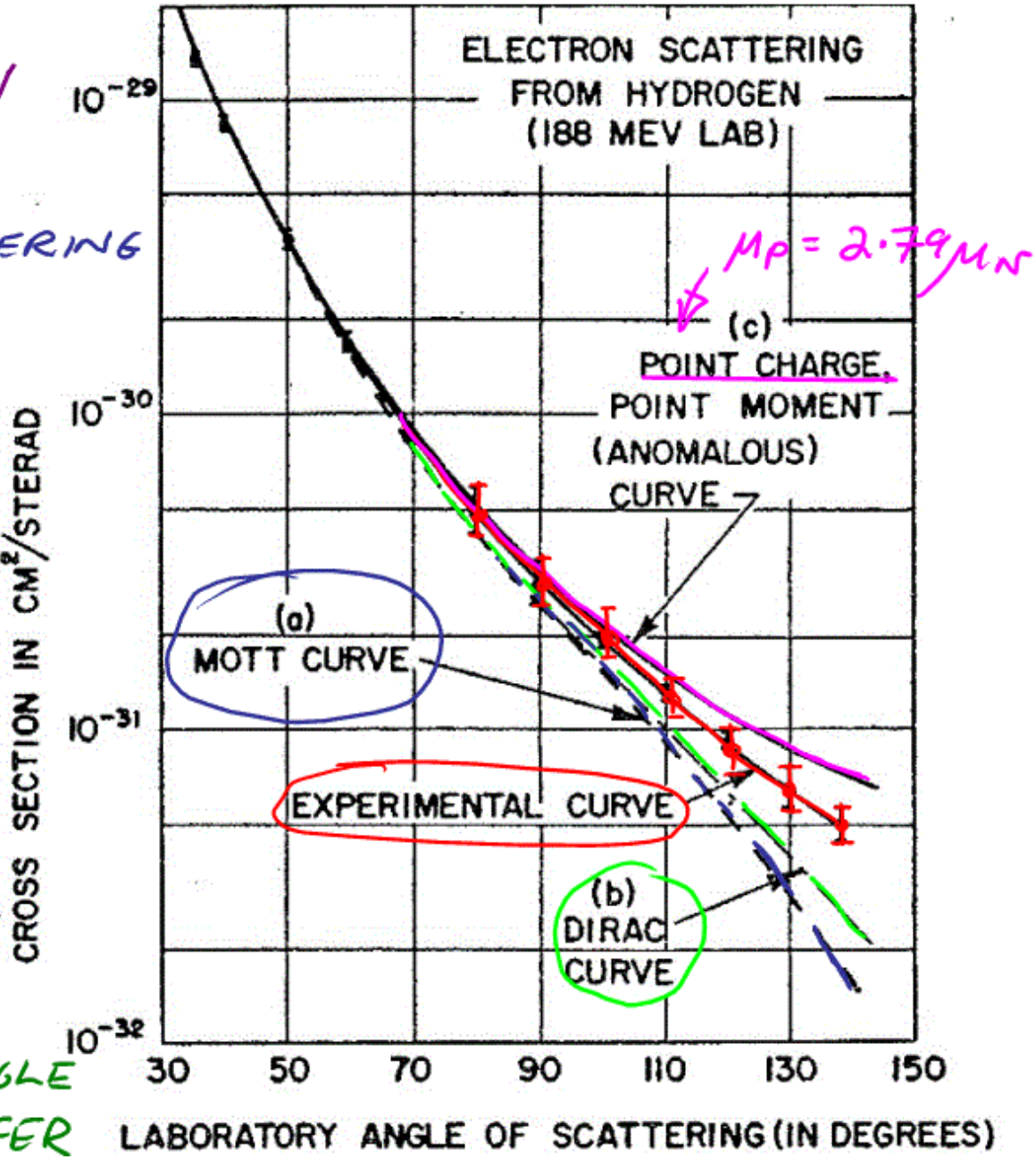
PROTON SHAPE & SIZE HOFSTADTER (AGAIN)

$ep \rightarrow ep$ 188 MeV

ELECTRIC & MAGNETIC SCATTERING

BEST FIT GIVES

$R_{PROTON} = 7 \times 10^{-14}$ cm



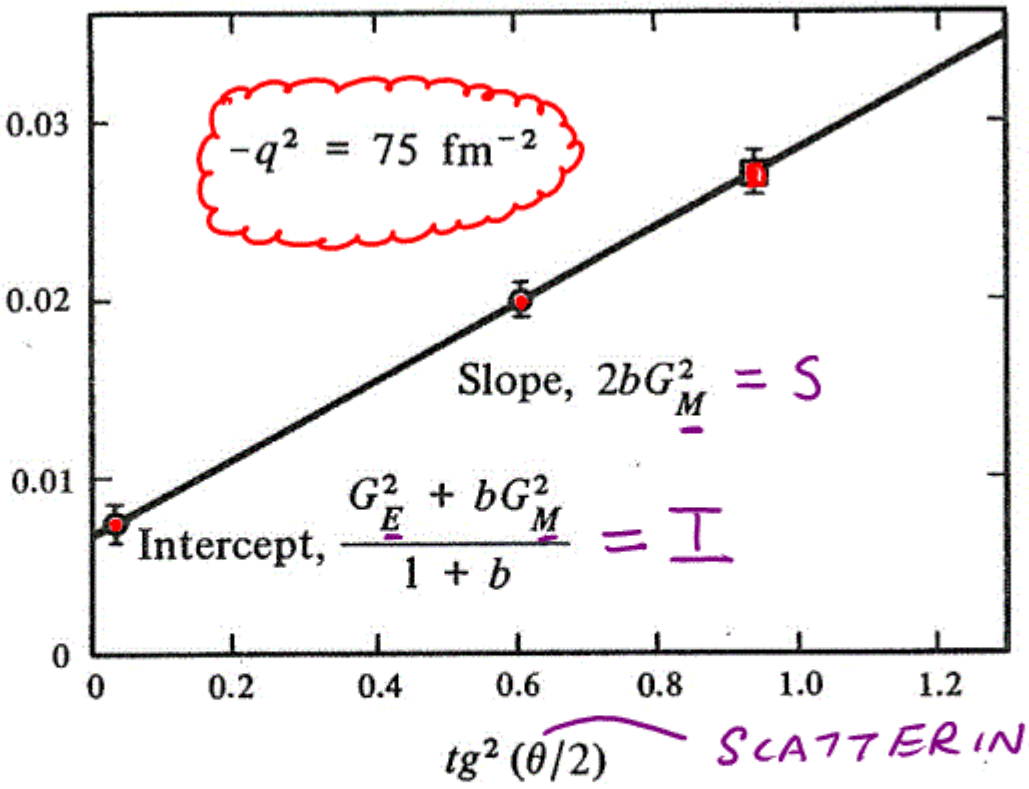
LARGE SCATTERING ANGLE
LARGE MOMENTUM TRANSFER

EXTRACTING ELECTRIC & MAGNETIC FORM FACTORS

$$R = \frac{(d\sigma/d\Omega)}{(d\sigma/d\Omega)_{\text{Mott}}}$$

EXPERIMENT

POINT CROSS SECTION

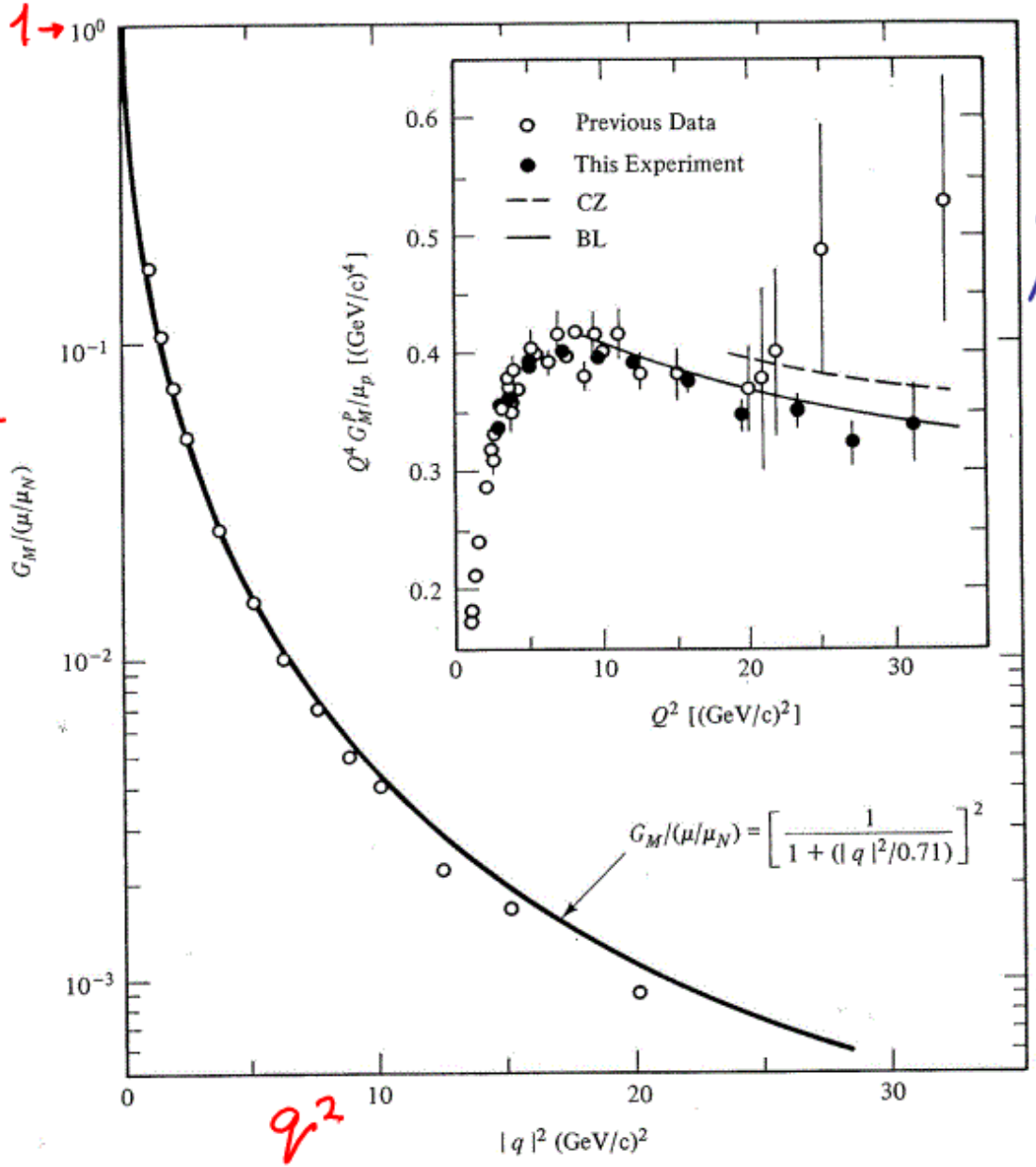


SCATTERING ANGLE

AT FIXED q^2 MEASURE $R = I + S \tan^2\frac{\theta}{2}$

VARY q^2 BY VARYING INCIDENT OR RECOIL ENERGY, AND SCANNING IN ANGLE θ

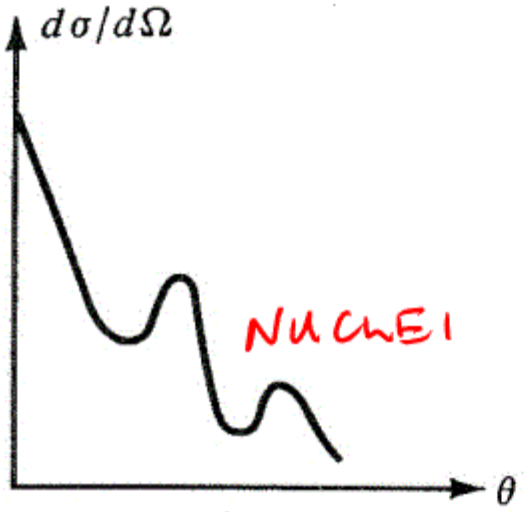
MAGNETIC DIPOLE MOMENT DISTRIBUTION



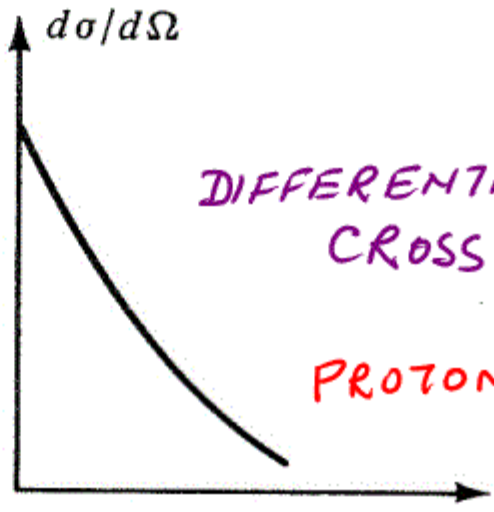
$\frac{G_M}{\mu/\mu_N}$

BOTH ELECTRIC CHARGE & MAGNETIC MOMENT DISTRIBUTIONS IN PROTON ARE DIFFUSE

COMPARE SHARP EDGE OF NUCLEI

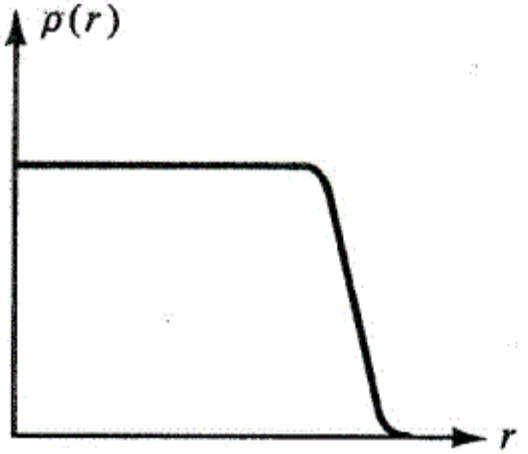


NUCLEI

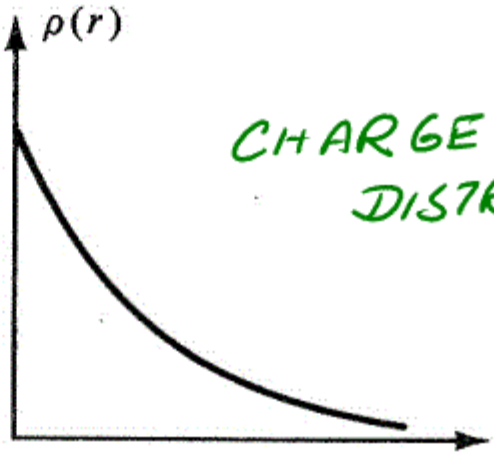


DIFFERENTIAL CROSS SECTION

PROTONS



NUCLEI



CHARGE DISTRIBUTION

NUCLEI

NUCLEONS

PROTONS

SHARP EDGE

$\frac{d\sigma}{d\Omega}$ → DIFFRACTION PATTERN

CHARGE DISTRIBUTION DIFFUSE

$\frac{d\sigma}{d\Omega}$ → SMOOTH