INELASTIC ELECTRON – PROTON SCATTERING

UP TO NOW CONSIDERED — ELASTIC SCATTERING

ROSENBLUTH CROSS SECTION → ELASTIC SCATTERING

→ THE PROTON REMAINS A PROTON

HAVE ESTABLISHED THAT PROTON HAS STRUCTURE

INELASTIC SCATTERING POSSIBLE

$ep \to ep$ ELASTIC

EXCITE PROTON STRUCTURE →

$ep \to e\Delta^+$, $\Delta^+ \to p\pi^0$ } INELASTIC "EXCLUSIVE"

$ep \to e n \pi^+$ — "

$ep \to Xe$ — INELASTIC "INCLUSIVE"

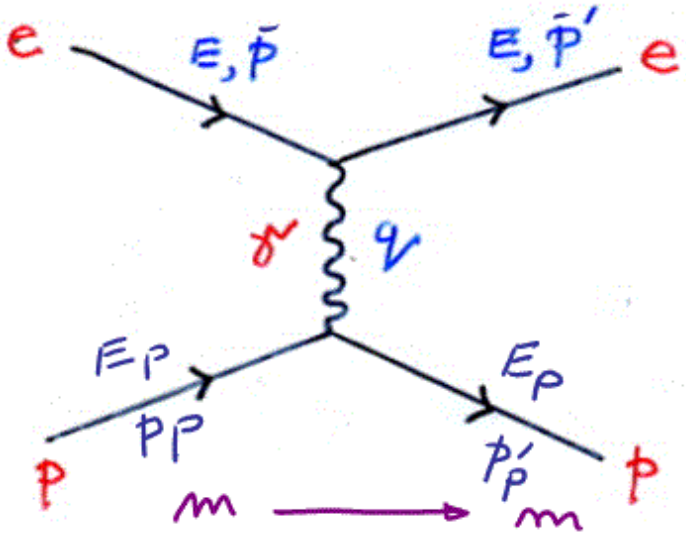
ANY HADRONIC SYSTEM FROM BREAK UP OF PROTON

JUST MEASURE ELECTRON

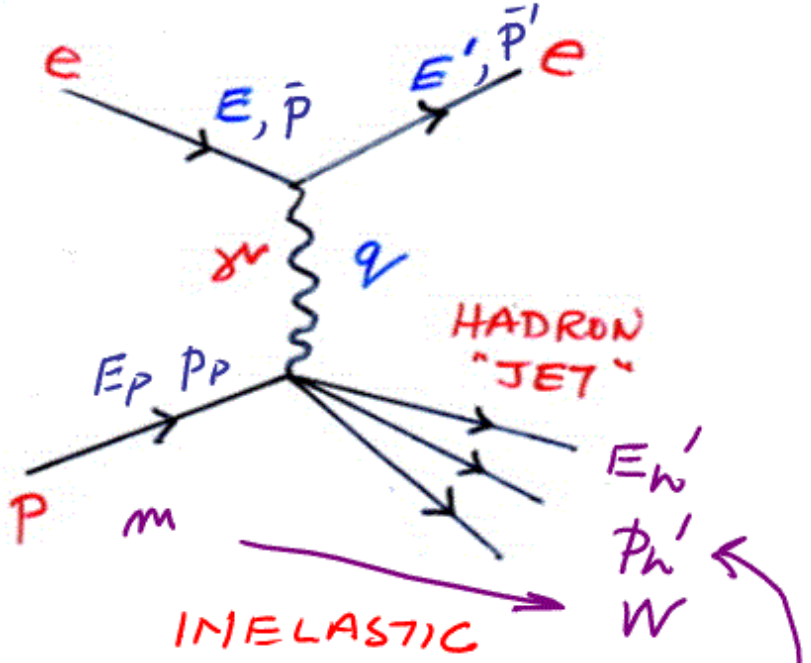
INELASTIC ep SCATTERING

POWERFUL TO TO LOOK AT PROTON STRUCTURE

NUCLEUS → NUCLEONS → QUARKS



ELASTIC - TARGET NOT EXCITED / FRAGMENTED



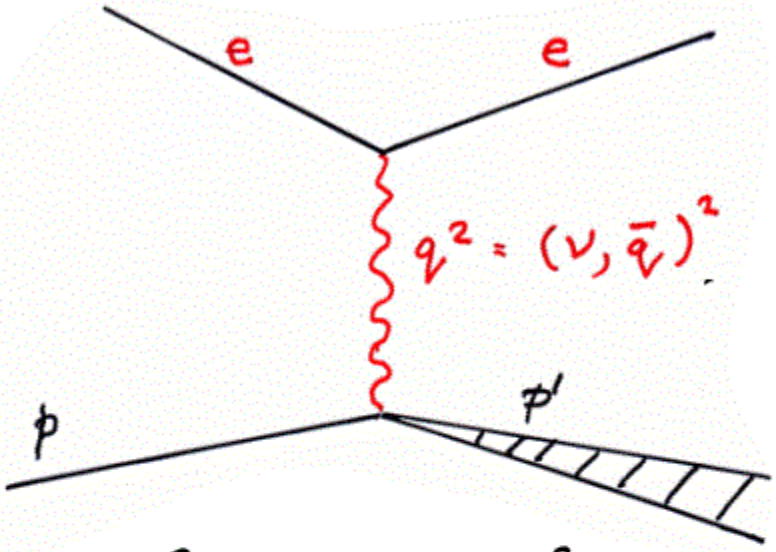
$\nu = E - E'$ ENERGY TRANSFER - INELASTICITY

$q = (\nu, (\bar{p} - \bar{p}'))$

$\nu = \frac{|q^2|}{2m_p}$ ← 4-MOMENTUM TRANSFER; ← TARGET MASS

$q^2 = \nu^2 - p_h'^2$

ELASTIC & INELASTIC SCATTERING



MASS OF PROTON
ELASTIC SCATTERING

INVARIANT MASS OF FINAL HADRONIC SYSTEM
INELASTIC SCATTERING

m_p OR W_H

$$q^2 = (p' - p)^2$$

$$q^2 = p'^2 + p^2 - 2p' \cdot p$$

INVARIANT SO EVALUATE IN LAB FRAME

$$= W_H^2 + m_p^2 - 2(\nu + m_p, \bar{p}') \cdot (m_p, 0)$$

$$= W_H^2 - m_p^2 - 2\nu m_p$$

$$W_H^2 = q^2 + m_p^2 + 2\nu m_p$$

2 INDEPENDENT VARIABLES FOR INELASTIC

$$q = (\nu, \bar{q})$$

GENERALLY $W_H^2 = q^2 + m_p^2 + 2\nu m_p$

FOR ELASTIC SCATTERING $W_H^2 = m_p^2$

$$m_p^2 = q^2 + m_p^2 + 2\nu m_p$$

$$q^2 = -2\nu m_p$$

ONLY ONE VARIABLE ν

LOOKING BACK AT DIAGRAM

$$q^2 = (\nu, \bar{q})(\nu, \bar{q}) = -2\nu m_p$$

SO $\nu^2 - \bar{q}^2 = -2\nu m_p \rightarrow \bar{q}^2 = \nu^2 + 2\nu m_p.$

IN LIMIT $\nu >> m_p \rightarrow \bar{q}^2 \simeq \nu^2$

THEN 4-MOMENTUM XFER $\rightarrow q = (\nu, \bar{q}) \simeq (\nu, \nu)$

FOR HIGH ENERGY ELASTIC SCATTERING $q^2 \simeq \nu^2 - \nu^2 \simeq 0$

REPRISE ON SCATTERING CROSS SECTIONS

RUTHERFORD: NON RELATIVISTIC, SPINLESS POINT TARGET & BEAM

$$\frac{d\sigma}{d\Omega}_R = \frac{4m^2(3Ze^2)}{q^4}$$

3 MOMENTUM

$=1$ FOR ELECTRON

MOTT: RELATIVISTIC SPIN $\frac{1}{2}$ ELECTRON SCATTERING OFF SPINLESS POINT TARGET

$$\frac{d\sigma}{d\Omega}_{MOTT} = \frac{4E^2(Ze^2)^2}{q^4}\left(1-\beta^2\sin^2\frac{\theta}{2}\right)$$

4-MOMENTUM

FORM FACTOR: ELECTRON SCATTERING FROM AN EXTENDED TARGET

$$\frac{d\sigma}{d\Omega}_{EXTENDED} = |F(q^2)|^2 \left(\frac{d\sigma}{d\Omega}\right)_{MOTT}$$

POINT

ELASTIC SCATTERING OF ELECTRONS & PROTONS !

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

→ COULD WRITE $\frac{d\sigma}{dq^2}$ → ONE SCATTERING VARIABLE

INELASTIC ELECTRON PROTON SCATTERING

$$\left(\frac{d^2\sigma}{dq^2 d\nu}\right)_{INEL} = \left(\frac{d^2\sigma}{dq^2 d\nu}\right)_{POINT} \left[W_2(q^2,\nu) + 2W_1(q^2,\nu)\, b \tan^2\frac{\theta}{2}\right]$$

TWO SCATTERING VARIABLES

TWO FORM FACTORS FUNCTIONS OF TWO VARIABLES

STRUCTURE FUNCTIONS