Possibilities with ^{3}H

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Thanks to Ronald Gilman
for presenting this

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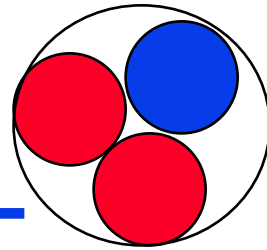
Technical Issues



- Safety considerations limit max activity to about 20 kCi
- High pressure (~225 psi) gas target is most likely candidate
- 40 cm long, 1.5 cm diameter cell with 80 μA would give luminosity of ~3 x 10^{36}/cm
- Commercial uranium bed storage devices available
  - Cost in the $50K-$100K range
- Total cost likely in the few $100K range
- Polarized target – many technical issues
  - Max current < 1 μA, few kCi – Don Crabb expert on this, will talk later in meeting

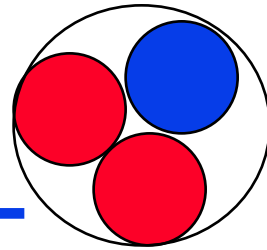
Physics

Workshop Sept. 1999 identified some feasible experiments with unpolarized target

- Elastic form factors of ^{3}H
- u/d ratio
- EMC effect comparison of ^{3}H and ^{3}He
- Coulomb sum
- Polarization transfer $^3\vec{H}(\vec{e},e'\vec{p})$
  - Similar to G^n_E , compare extraction of proton form factor from ^{3}H with neutron form factor from ^{3}He

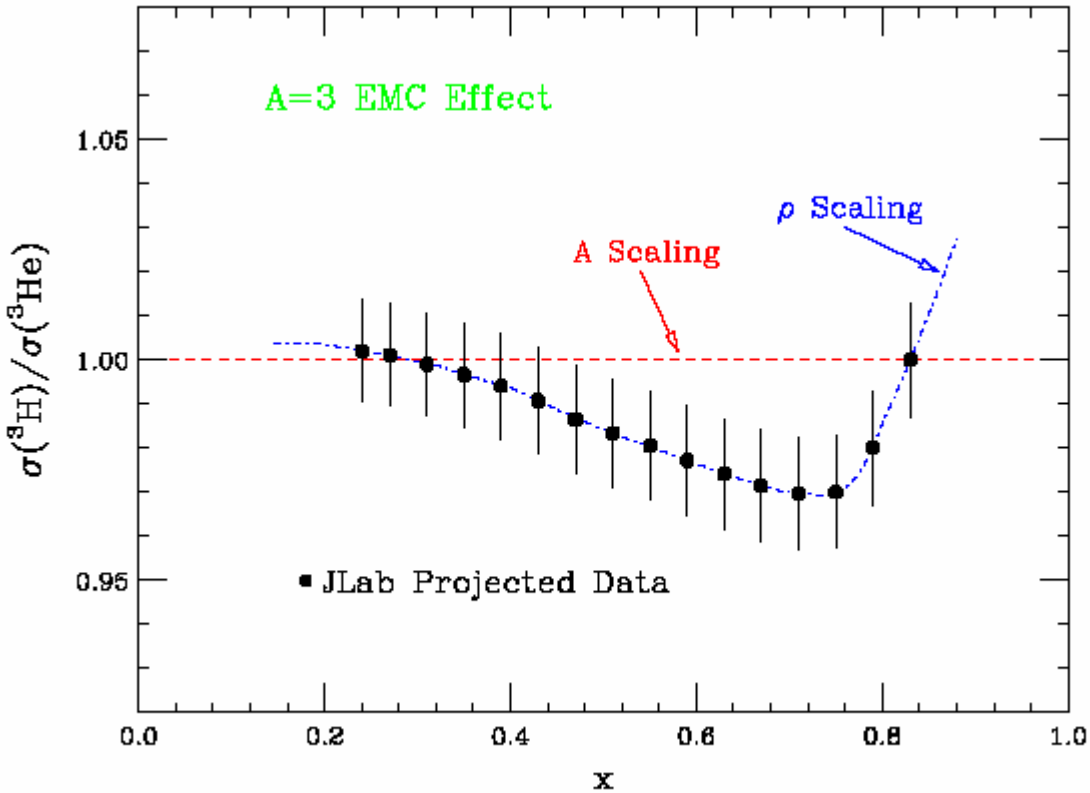
u/d and EMC conditionally approved as PR-12-06-118 – Petratos, Gomez, Holt, Ransome, co-spokespersons

EMC effect



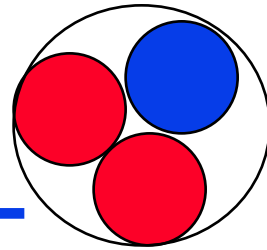
- Origins of EMC effect not completely understood
  - Preliminary JLab E03-103 results show significant EMC effect in ^{3}He and that it is about the same in ^{4}He and ^{12}C
  - Appears to be density dependent, based on latest JLab data
  - Precision comparison of ^{3}H and ^{3}He can help distinguish models – around 2% statistical precision possible for *x* up to about 0.8

EMC in A=3



Projected data from PR-12-06-118

u/d ratio

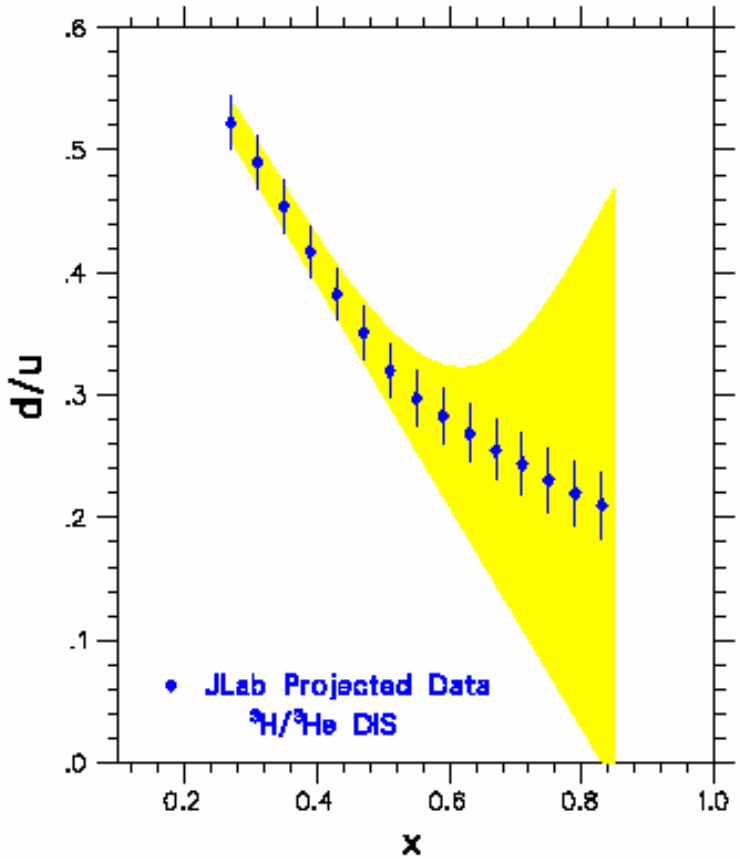


- u/d quark distribution function can be determined by comparison of $^3H/^3He$ cross section ratio
- Extraction of u/d from deuteron depends on model for deuteron structure – major uncertainty at high *x*

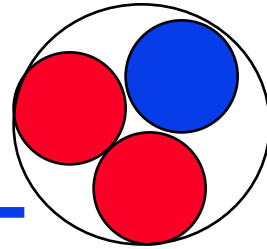
u/d ratio

Projected data from PR-12-06-118

Yellow band indicates current uncertainty, mainly from deuteron wave function uncertainty

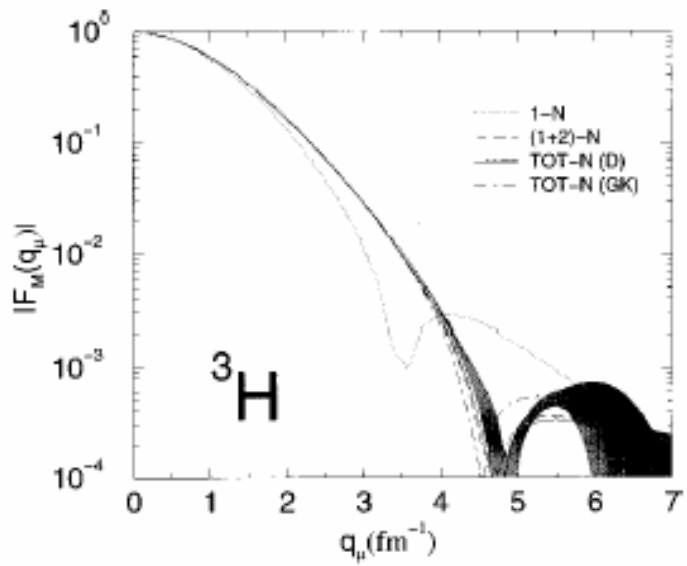


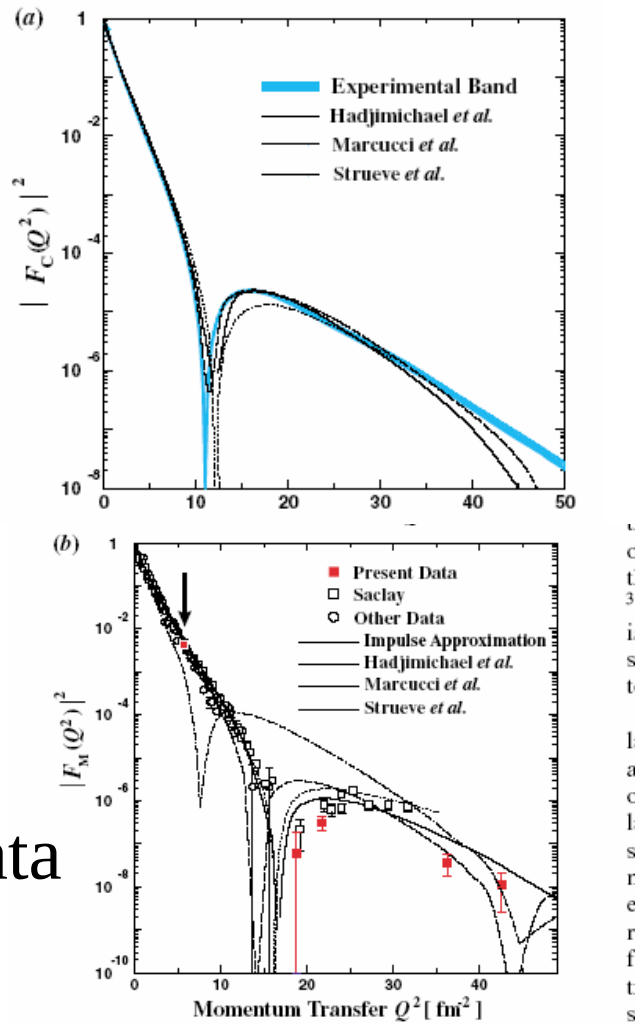
Elastic Form Factor



- Precision measurement of elastic form factors of light nuclei are essential test for nuclear models
  - Location of diffraction minimum can distinguish models
- ^{3}He well measured with recent Hall C data
  - ^{3}He known to $Q^2 = 40$ fm^{-2} PRL **86**, 5446, (2001) Nakagawa et al.
  - Not well explained by current models
- ^{3}H needed for isospin dependence

Light nuclei form factors

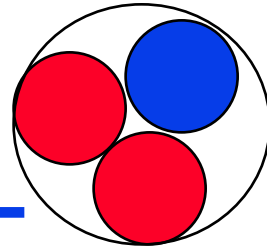




^{3}H poorly known for $Q^2>16$ fm^{-2}, theoretical calculations from PRC 58, 3069 1998 Marucci, Riska, Schiavilla

JLab data on ^{3}He

Form factor



- Requires ~5 beam energies in 1-4 GeV range
- Could be measured in ~600 hours with current Hall A spectrometers

Coulomb Sum rule

- Provides information on correlations
- Sum defined as:

$$S_L(k) = \frac{1}{Z}\int_{\omega_{el}^+}^{\infty} d\omega \quad \frac{R_L(k,\omega)}{[G_{E,p}(k,\omega)]^2}$$

$$S_L(k) = \frac{1}{Z}\langle 0|\rho_L^\dagger(\mathbf{k})\rho_L(\mathbf{k})|0\rangle - \frac{1}{Z}|\langle 0|\rho_L(\mathbf{k})|0\rangle|^2$$
$$\equiv 1 + \rho_{LL}(k) - Z\frac{|F_L(k)|^2}{[G_{E,p}(k,\omega_{el})]^2} \quad ,$$

ρ_{LL} is the proton-proton density

Coulomb Sum

Coulomb sum being measured now in Hall A for nuclei ^{4}He-^{208}Pb

Overall agreement with theory and experiment, but some discrepencies

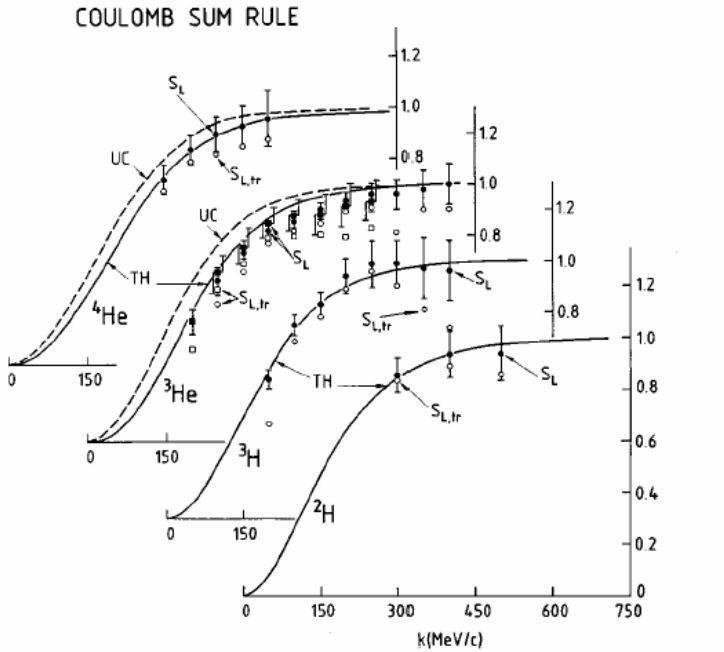


FIG. 45. The experimental $S_{L,\mathrm{tr}}$ (open data points) and tail-corrected S_L (filled data points with error bars) compared with theory in ^{2}H, ^{3}H, ^{3}He, and ^{4}He. Solid lines, Schiavilla, Pandharipande, and Fabrocini, 1989; dashed curves, the $S_{L,\mathrm{unc}}$ of ^{3}He and ^{4}He. Data for ^{3}He:O, Saclay (Marchand *et al.*, 1985); □, Bates (Dow *et al.*, 1988). Data for ^{2}H: Bates (Dytman *et al.*, 1988). Data for ^{3}H, Dow *et al.*, 1988; for ^{4}He von Reden *et al.*, 1990.

3H, 3He Coulomb Sum

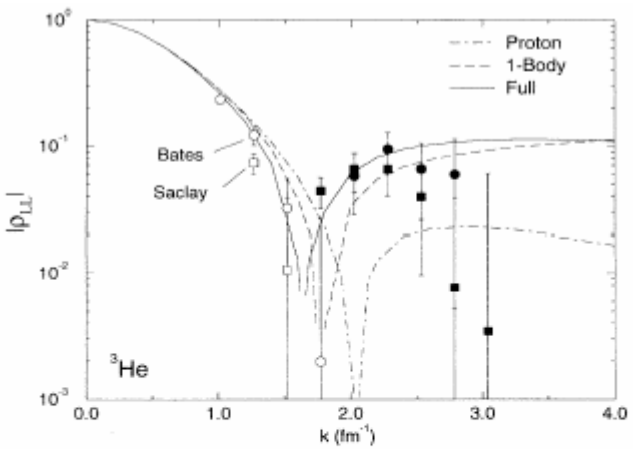


FIG. 1. Experimental and theoretical longitudinal-longitudinal distribution functions in ^{3}He. Circles (squares) denote Bates (Saclay) data; solid symbols denote negative values. The curves labeled proton, 1-body, and full show theoretical results obtained from the Faddeev wave function by including in ρ_L the proton, one-body, and one- plus two-body contributions, respectively.

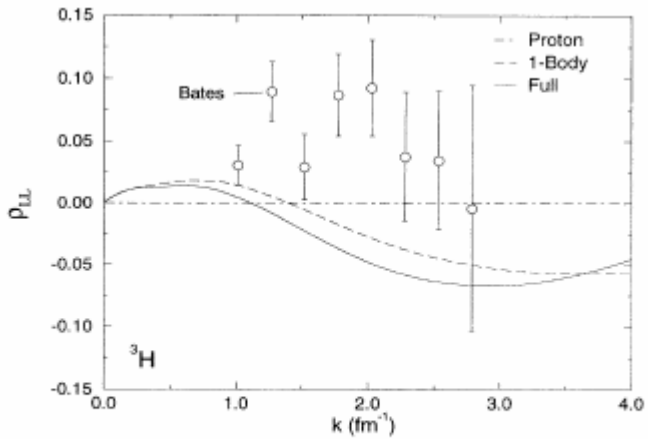
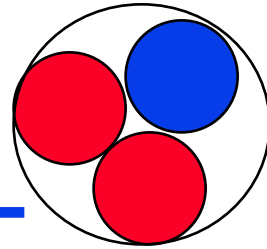


FIG. 3. Same as in Fig. 1 but for ^{3}H.

Discrepancy between theory and experiment – need improved statistics and systematics

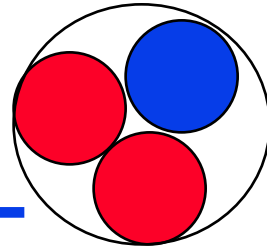
Figures from PRL 70, 3857, 1993 Schiavilla,Wiringa, Carlson
Data from PRL 64, 268, 1990 Beck et al.

Coulomb sum



- Could be measured in ~100-200 hours
- Requires several beam energies 400 MeV – 2 GeV

Conclusions



- Many interesting experiments with ^{3}H
- Target is technically feasible
- Coulomb sum, elastic form factor need lower beam energies
- u/d ratio, EMC effect best done with 12 GeV
  - Conditionally approved