MARATHON E12-06-118

Me**A**surement of the F_2^n / F_2^p, d/u ***RA***tios and A=3 EMC Effect in Deep Inelastic Electron Scattering Off the **T**ritium and **H**elium Mirr**O**r **N**uclei

Spokesperson: G. Petratos
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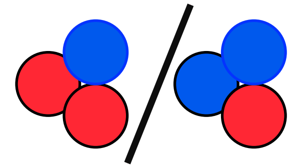
Objectives

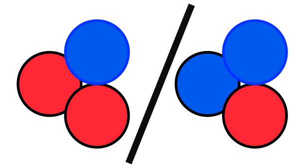


Fundamental goal of nuclear is to determine the quark structure functions in nucleons.

Difference between u and d quark distributions can be determined by comparing DIS for proton and neutron.

Lack of free neutron means comparison has to be done with neutron in a nucleus.

At high x, nuclear effects are important.

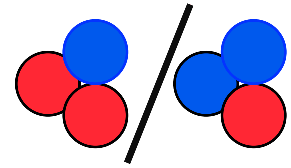


A solution is to compare 3H to 3He. The nuclear structure is very similar, and largely cancels in the ratio, allowing a precision extraction of the d/u ratio.

In addition, the EMC effect for A=3 nuclei is not known.

We can determine this by comparing to 2H and 1H.

Deep Inelastic Scattering and Structure Functions



Parton model: $F_2(x) = 2xF_1(x) = x\Sigma e_i^2(q_i(x) + \bar{q}_i(x))$ $\quad x = \frac{Q^2}{2M\nu}$

Proton structure function $F_2^p = x\left[\frac{4}{9}\left(u+\bar{u}\right)+\frac{1}{9}\left(d+\bar{d}\right)+\frac{1}{9}\left(s+\bar{s}\right)\right]$

Assuming isospin symmetry $u_p\left(x\right) = d_n\left(x\right) \equiv u\left(x\right)$

Neutron structure function $F_2^n = x\left[\frac{4}{9}\left(d+\bar{d}\right)+\frac{1}{9}\left(u+\bar{u}\right)+\frac{1}{9}\left(s+\bar{s}\right)\right]$

Ratio

$$\frac{F_2^n}{F_2^p} = \frac{u+\bar{u}+4\left(d+\bar{d}\right)+s+\bar{s}}{4\left(u+\bar{u}\right)+d+\bar{d}+s+\bar{s}}$$

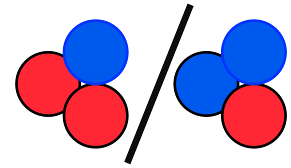
Nachtmann Inequality

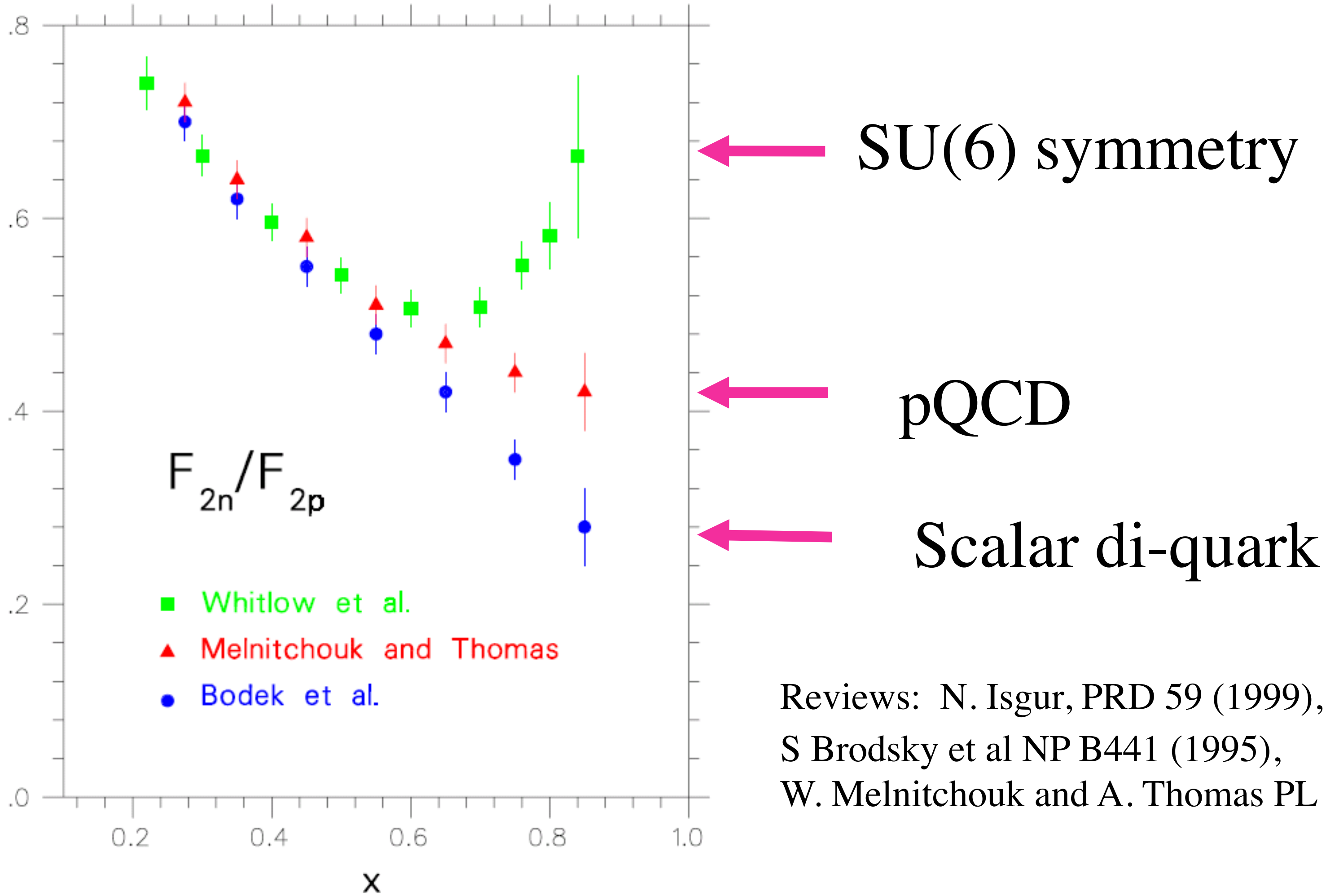
$$\frac{F_2^n}{F_2^p} = \frac{1}{4} \le \frac{F_2^n}{F_2^p} \le 4$$

$$\frac{F_2^n}{F_2^p} = \frac{\left[1+4\left(d/u\right)\right]}{\left[4+\left(d/u\right)\right]}$$

High x limit

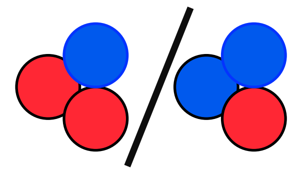
Structure Functions at high x

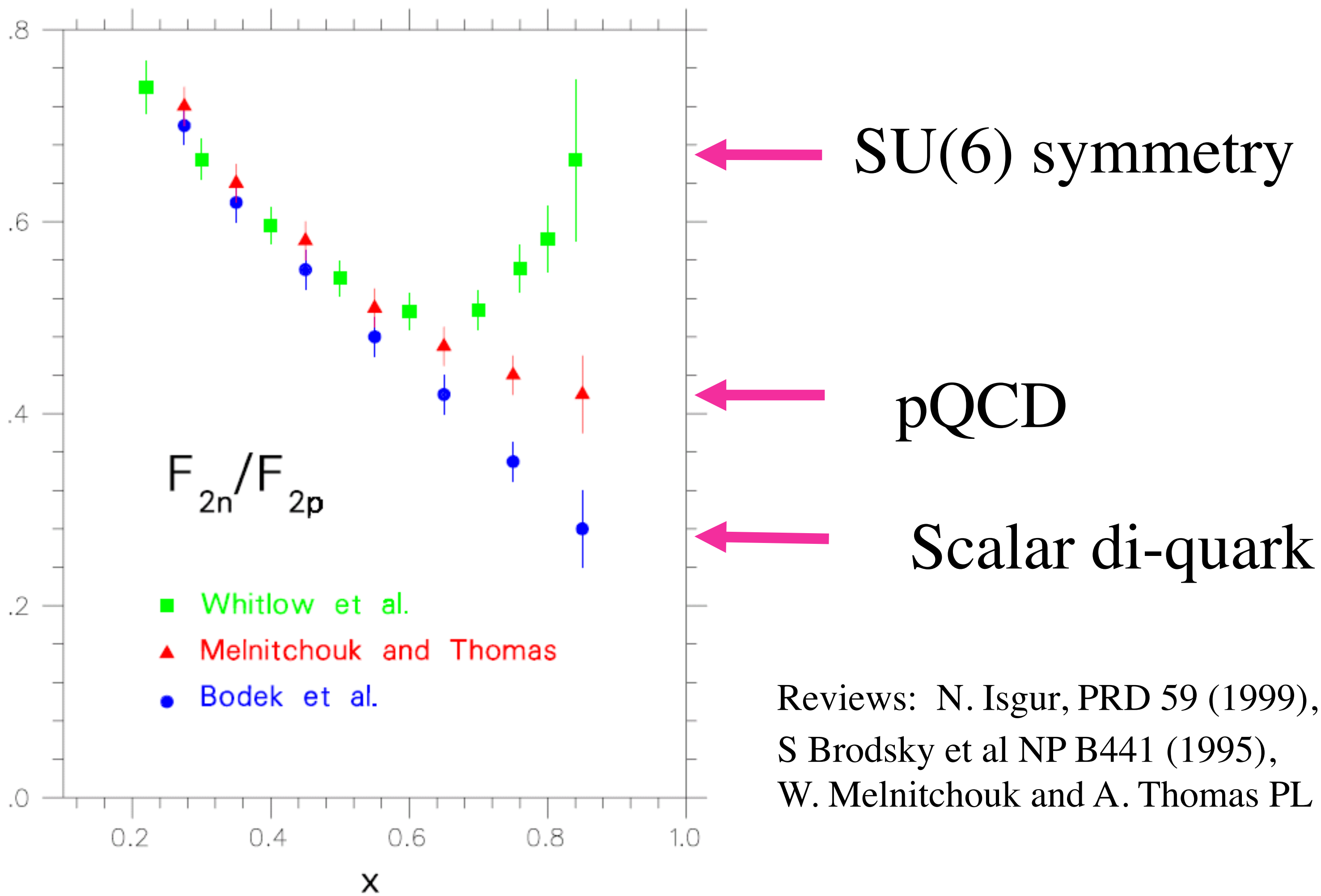




Reviews: N. Isgur, PRD 59 (1999),
S Brodsky et al NP B441 (1995),
W. Melnitchouk and A. Thomas PL B377 (1996) 11.

Structure Functions at high x





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E12-06-118 Projected Results

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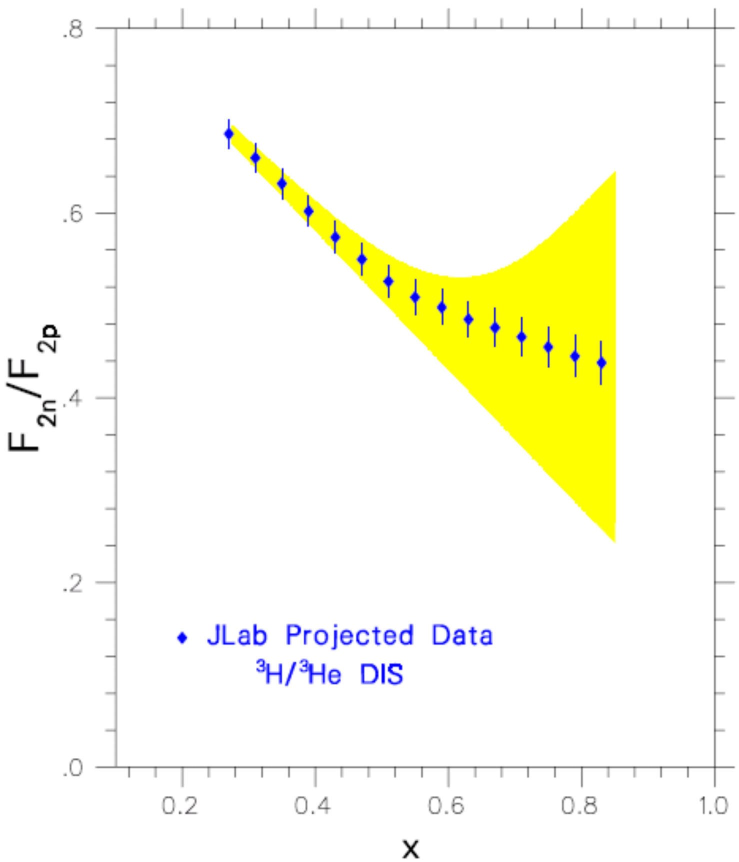
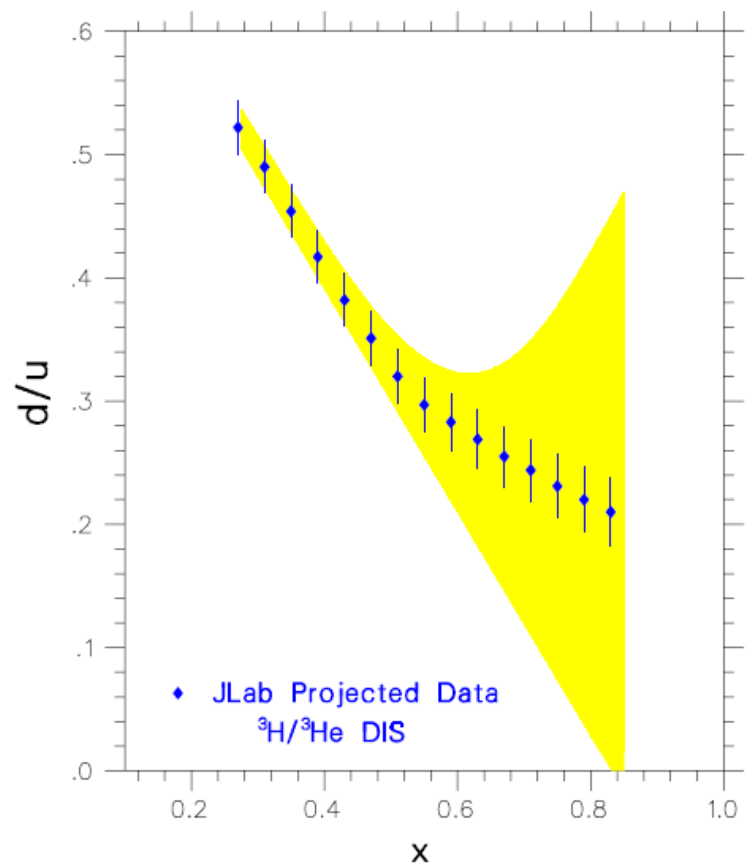


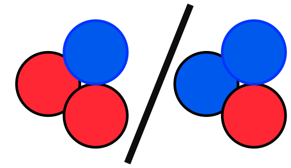


- JLab E12-06-118, G. Petratos, J. Gomez, R. J. Holt, R. Ransome *et al*

The biggest issue is a tritium target.

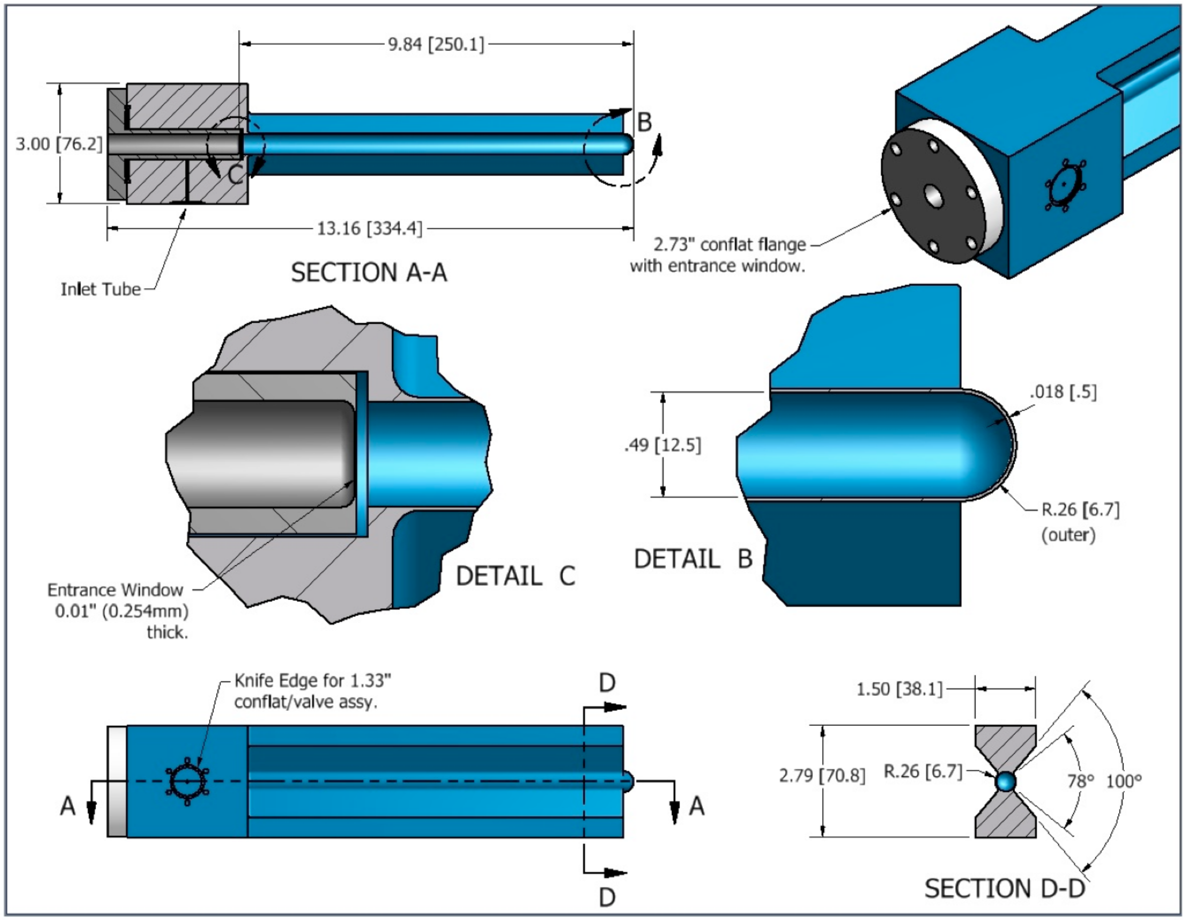
The “Tritium Task Force” let by Roy Holt, has developed a design for a tritium target. A few meetings to review progress held in past 2 years (last in May 2012). So far no major issues.

E. J. Beise (U. of Maryland), B. Brajuskovic (Argonne), R. J. Holt (Argonne), W. Korsch (U. of Kentucky), D. Meekins (JLab), T. O’Connor (Argonne), G. G. Petratos (Kent State U.), R. Ransome (Rutgers U.), P. Solvignon (JLab), and B. Wojtsekhowski (JLab)



Design Criteria

Minimize tritium (1 kCi)
Limit beam current (25 μA)
FEA thermo-mechanical design of the target cell
^{3}He, $^{2}H_2$ and H_2 targets at more than twice the pressure of the $^{3}H_2$ target (450 psi/200 psi)
Minimize tritium handling at JLab – fill target offsite
Completely sealed cell design
Secondary containment – isolated scattering chamber
Hood and ventilation system
Tritium, vacuum, temperature monitors
Interlocks on raster, vacuum, tritium monitor, coolant
Ease of installation and alignment

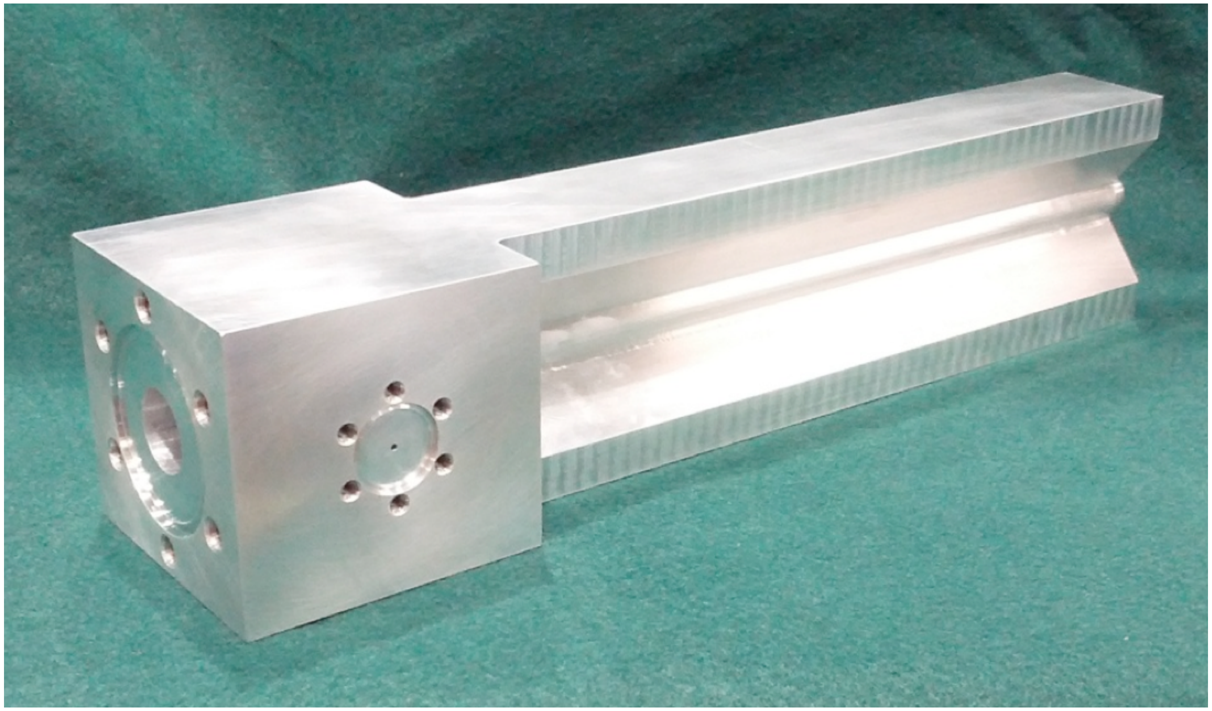


Target design. Aluminum body, .018” walls on side.
Estimated max pressure is 2500 psi.

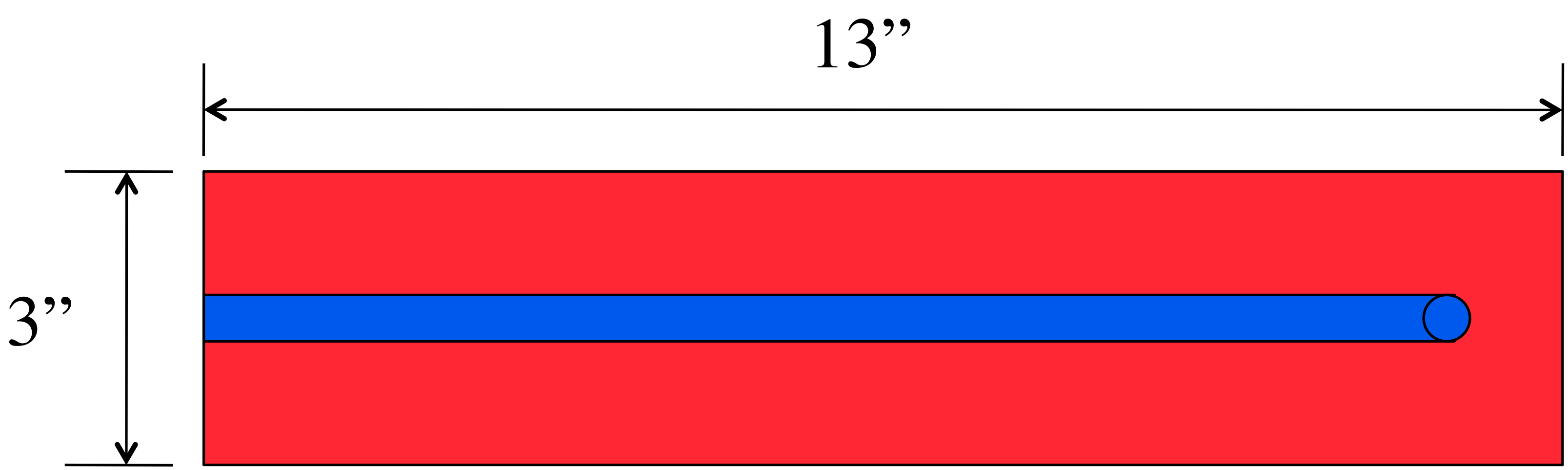
The Plan

- Use 5 targets
  - H_2
  - D_2
  - T_2
  - ^3He
  - Dummy
- Allows determination of both u/d ratio and EMC effect in 3He and 3H
- Targets are all high pressure gas
  - Pressure for 3H about 200 psi
  - Pressure for other targets 450 psi
  - Cell designed to hold at least 2500 psi

Prototype



Target Construction at Rutgers



Single block of aluminum cut to final shape.

Precision hole by company specializing in deep drilling.

Initial hole is ~12” deep, ½” diameter.

Prototype problems

The initial hole varies from the perpendicular by a very small amount, resulting in an offset, giving too thin a wall on one side.

First prototype – failed when wall cut through.

Second prototype ended up with thinnest part being only 0.003" thick.

Even with this thin wall, cell did not fail until 900 psi.

Full design should easily hold design pressure of 2500 psi.

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Possible Solution

- Cell cut oversize by about 0.030”
- Shipped to JLab and measured to determine offset
  - Done
- Shipped back to Rutgers for final machining
  - Shipped late last week
- Shipped to Jlab for final testing
  - Anticipated around week of Dec 17
- If this succeeds, we can begin production of cells in early 2013.
  - Failure – not an option