MEMO on Dilution factor measurements

from: I. Sick, May 12, 1998

1. Problem

In measurements of the asymmetry

$$A = \frac{\sigma_- - \sigma_+}{\sigma_- + \sigma_+} \tag{1}$$

only Deuterons contribute to the nominator, while N, He and the windows contribute to the denominator. The shape of the quasi-elastic (e,e'n) peak of D, He, N and the windows differ. We therefore need to know (measure) the contribution of N, He and windows to σ in order to deduce A^D for the deuteron. It is not good enough to consider nuclei simply as sum of nucleons, as we basically did (modulo EMC-effect) in E143.

Things would be easier if we would integrate (e,e'n) over the full quasi-elastic peak of N, He, D. This we dont want to do, as the D-peak is narrower than the N, He-peaks. Cutting out the D-peak gives a smaller stat. error on $\sigma_- - \sigma_+$. But then we need to measure the contribution of N, He, windows to σ in the region of the cut.

The problem is complicated by the fact that the different targets ($^{15}ND_3$,$^{15}NH_3$, etc) have different packing fractions, and the fact that they are time-dependent (E143 experience).

A measurement using a N-target is not very practical. A ^{14}N target is reasonably straightforward to build: a tight container of the shape of the target insert, connected to a long tube so that evaporating N gets to the outside atmosphere, filled with gaseous N_2 in a LN2 dewar with the gas brought in by a concentric small-diameter tube. Such a liquid N-target can be rapidly transfered to the pol.target dewar. But a ^{15}N target would be tricky.

2. Proposed approach

The general idea is to use $^{15}NH_3$(e,e'n) to determine the shape of ^{15}N(e,e'n) as the proton does not contribute to (e,e'n) (modulo charge exchange in the target). This shape then can be used to subtract the ^{15}N contribution in $^{15}ND_3$(e,e'n).

Complications arise from the fact that the packing fraction of $^{15}NH_3$ and $^{15}ND_3$ are not the same. We have to measure it.

This approach can also work for (e,e'p) whichj we may want to measure in parallel. In $^{15}N(e,e'p)$ the protons of ammonia will contribute, but only in a very narrow bin of initial momentum and energy. We can probably subtract them out via a fit.

3. Measuring packing fraction

We can measure single arm scattering, at an energy loss *below* the deuteron elastic peak for a) target filled with He, b) without He, c) with He + $^{15}NH_3$, and d) with He + $^{15}ND_3$. Basically, the contributions to these measurements are:

a) windows + He

b) windows

c) windows + He – He(pushed away by $^{15}NH_3$) + $^{15}NH_3$

d) windows + he – He(pushed away by $^{15}ND_3$) + $^{15}ND_3$

The term "He(pushed away by ammonia)" is presumably small, as the density of He is low and the quasi-elastic peak of helium is narrow, so it can be calculated from an approximate knowledge of the packing fraction. From a combination of a)–d) we can derive the contribution of $^{15}NH_3$ and $^{15}ND_3$, and the ratio of the thickness of N in the two targets.

4. Measurement of dilution factor

Once the ratio of the N thicknesses is known, one can use (e,e'n) measurements on $^{15}NH_3$ and $^{15}ND_3$ to get at the dilution factor for the G_{en} measurement. The measurements required involve: a) He b) no He c) He + $^{15}NH_3$, d) He + $^{15}ND_3$. Since we deal here with (e,e'n) data, the time to take them is not negligible. But it still should be << than for the asymmetry measurements. We need no precise data for a) and b), and d) we take anyway.

To the degree that the protons are measurable in parallel by the n-detector, no extra time is needed for the measurement of the (e,e'p) contribution of nitrogen.

5. Option

It might be advantageous to have target sticks with *two* $^{15}ND_3$ targets. This could be achieved if at one q^2 we measure also the single arm and coincidence data on our dummy target C. We then possibly could use the $^{15}N/^{12}C$ ratio measured to recalculate at other q's the ^{15}N contribution from the measured ^{12}C-contribution.