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AN ULTRA-THIN-WINDOW GAS CELL

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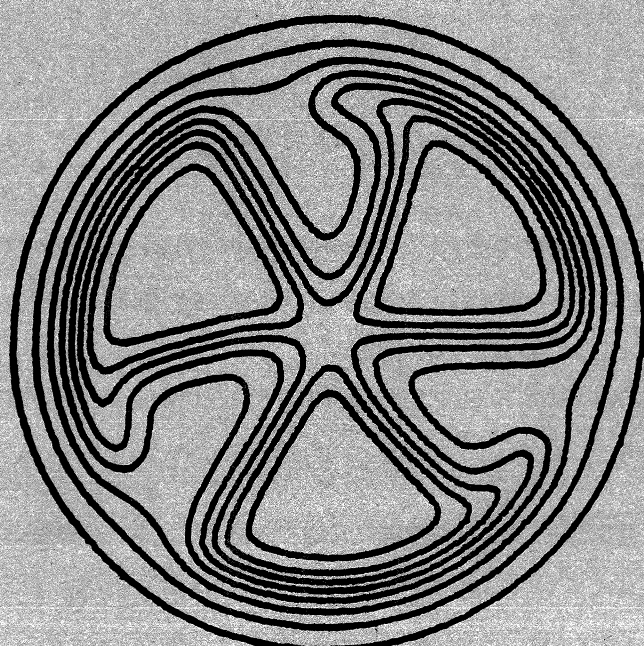

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AN ULTRA-THIN-WINDOW GAS CELL*

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A gas cell has been developed for which the total areal density encountered by outgoing reaction products can be as low as 50 μg/cm^2 at 25 torr gas pressure.

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During a program of cross section measurements for the proton induced spallation of ^{12}C, ^{14}N, ^{16}O, and ^{20}Ne[1,2] gas targets were found necessary for all targets except ^{12}C. Usually the gas for such a target is confined in a cell by a thin foil or "window" through which the beam enters the cell and through which the reaction products leave to be detected outside the cell. For the relatively heavy low energy reaction products one must detect in the spallation experiments, commonly used foils such as 13 μm thick Kapton (which stops 10 MeV ^{11}C ions) give large and unacceptable energy losses. For the gas cell described here, on the other hand, the areal densities encountered by the reaction products are typically less than 130 μg/cm^2, which corresponds to the range of a 210 keV ^{11}C ion.

The gas cell is shown in Figs. 1 and 2. Its unique feature is the moveable shell, the shell end closest to the beam serving both as the front defining slit and as the exit window support. The beam end of the shell is tapered to allow close approach to the beam at forward angles. In this design the counter is rigidly attached to the gas cell and both rotate together as the scattering angle is changed. Thus at different angles the beam passes through different parts of the entrance window. The geometry of the shell and its vacuum seal determine the accessible angular range, which for this cell is 10° to 170°.

The entrance beam window was 13 μm thick Kapton bonded to the cell structure with epoxy Ciba Araldite 502. It could withstand differential pressures of about 200 torr and beam currents of about 1 μa. The exit window was made of formvar. The slit end of the shell was buffed so the lips of the slit were rounded, and no sharp edges remained. A 2% solution of formvar in 1,2 Dichloroethane was prepared and 1.4 $\mu g/cm^2$ thick films were produced by casting on water.[3] The film was picked up with a wire loop and transferred immediately to the shell. This process was repeated until a formvar window of the desired thickness was built up. A 30 $\mu g/cm^2$ formvar window over a 1 mm wide slit sustained a pressure of 25 torr for many hours.

Reaction products lose energy not only in the formvar window but also in the gas they must traverse. To avoid repeated mechanical adjustments of the shell, while minimizing energy loss in the gas, we mounted the gas cell and slit system slightly off center on the scattering chamber table. As shown in Fig. 2 table rotations between 15° (or 165°) and 90° can then be carried out with one shell setting. For the geometry used, the distance between the beam and the closest point of the shell, varies slightly with beam angle θ and is given by

$$d = 1.26\ B \sin(142.5-\theta)-w. \qquad 15° \leq \theta \leq 90°$$

$$d = 1.26\ B \sin(\theta-37.5)-w. \qquad 90° \leq \theta \leq 165°$$

Here B is the distance from the beam center to the nearest point on the shell at $\theta = 90°$ and w is half the beam width. The average distance D which reaction products must travel in gas to reach the

formvar window is then given by

$$D = B + \frac{A+0.768B}{|\tan\theta|}$$

where A is half the width of the tapered end of the shell; it is 0.75 mm for a 1.0 mm slit. Typically D varies only from 5 mm to 25 mm over the accessible angular range (15°-165°), a sufficiently small value for most applications. For example, for the nitrogen pressure, slit width, formvar window and beam geometry mentioned above the average total exit areal density is 50 $\mu g/cm^2$ at 90° and 130 $\mu g/cm^2$ at 15° detection angle.

While in our experiment we were mainly interested in minimizing energy loss, one also obtains good energy resolution for heavier particles. The data in Table 1 were taken at 15° detection angle with an exit particle areal density of about 100 $\mu g/cm^2$. The resolution of the detector for 5.48 MeV α particles was 35 keV FWHM, and the contribution of the beam energy resolution, after passing through the 13 μm of Kapton, was roughly 30 keV for these exit ions. There is a distribution of flight lengths as reaction products leave the target gas. The associated variable energy loss also adds to peak broadening. An estimate of this effect is entered in Table 1. While it is the most severe limit to the energy resolution for ^{16}O, it affects that of ^{6}Li only neglegibly. This contribution will be smaller at angles nearer 90°, reaching a minimum value about a factor of four smaller at 90°.

REFERENCES

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2. H. Laumer, S.M. Austin, L.M. Panggabean, and C.N. Davids, Phys. Rev. C8(1973)482.
3. L. Yaffe, Ann. Rev. of Nucl. Sci., 12(1962)153.

TABLE 1.--Energy resolution for various particles produced from $^{16}O+p$ at Ep=38 MeV, θ=15°.

Particle	Particle ENERGY (MeV)	Measured FWHM(keV)	Calculated[a] FWHM(keV)	Exit particle Straggling (keV)	Energy loss Variation (
^{6}Li	14.5	57±24	52	21	11
^{14}N	10.2	110±37	157	54	140
^{16}O	8.0	210±20	242	65	229

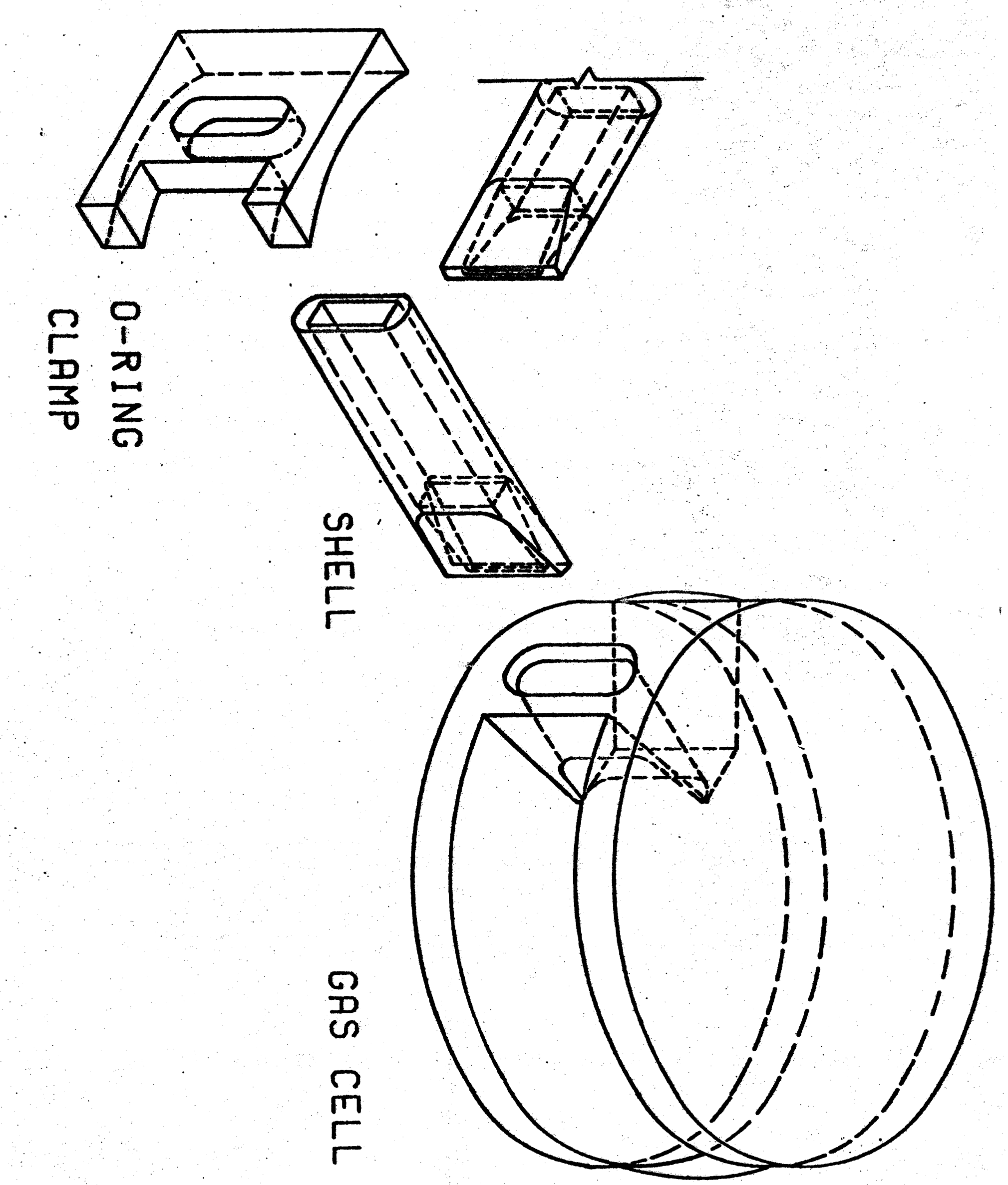
a) Obtained by combining in quadrature the detector resolution of 35 keV, the entrance beam resolution of 30 keV, the straggling of the exit particle (column 5) and the energy loss variation (column 6).

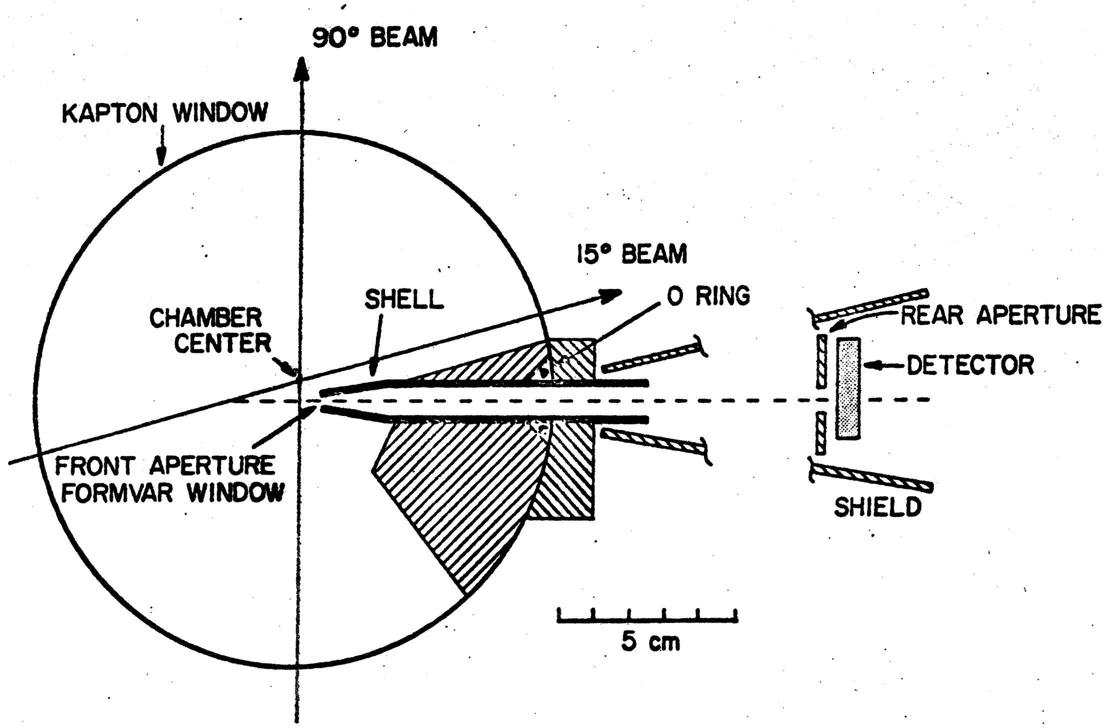
b) Energy loss spread of the exit particles due to variation of the exit flight length through the gas. The range quoted accounts for 76% of the detected particles (0.76 is the fraction of a Gaussian distribution lying within the FWHM limits). The accuracy of the estimate is limited by a lack of knowledge of the beam profile.

FIGURE CAPTIONS

Figure 1--The major components of the gas cell system are shown. An O-ring effects the shell to gas cell seal.

Figure 2--Schematic diagram of the geometrical relationship between the slit system and the beam trajectory when one is observing particles produced at 15° and at 90°.




90° BEAM
KAPTON WINDOW
15° BEAM
O RING
SHELL
CHAMBER
CENTER
REAR APERTURE
DETECTOR
FRONT APERTURE
FORMVAR WINDOW
SHIELD
5 cm