TRACK SENSITIVE TARGETS IN THE 25-FOOT BUBBLE CHAMBER

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ABSTRACT

From tests at DESY,[1] BNL,[2] and Rutherford,[3] it is evident that track-sensitive targets (TST) in bubble chambers will work (see Fig. 1). It appears quite feasible to operate TST's filled with H_2 or D_2 and surrounded by 0-100% hydrogen-neon mixtures. This report gives some of the technical details of a TST for the 25-foot, detection efficiencies for γ's, π^o's, K^o_L, and n with this TST and measurement errors on $e^\pm$ and γ.

I. TARGET CONSTRUCTION

In this report only rigid plexiglas cylinders with expansion bellows are considered. The reasons for this are the following:

1. Rigid structure - Any target in the chamber will act as a lens. Thus to do accurate reconstruction the position and shape of the target must be known. Clearly there will be fiducials on the target.

2. Cylinder - In comparing cylinders and boxes, for a given stress and volume a cylinder will have a much ($\lesssim 2$) thinner wall. Also a cylinder has the property that very little volume behind the cylinder is not seen, in fact some regions are "seen twice," once through the cylinder and once by the edge of the cylinder.

3. Plexiglas - For a given volume and stress, a structure made of plexiglas puts the least amount of material in the chamber. There are questions of optical quality which are being studied further.

4. Bellows - To operate a chamber in the TST mode with differences in pressure and/or temperature appears to be simplest with expansion bellows. (We appreciate discussions with R. P. Shutt at BNL and R. Watt at SLAC on the use of expansion bellows on TST's.)

To illustrate the construction of a TST for the 25-foot chamber, let us pick a target 6 feet in diameter and 15.4 feet long. (If possible it is advantageous to align the end of the cylinder with the two downstream cameras. The following table gives some of the parameters for this target.

Volume of bubble chamber	105 m^3
Volume visible by 3 cameras	72 m^3
Fiducial volume	~50 m^3
Volume of TST	10.5 m^3
Cylinder wall thickness	3-5 cm
End wall thickness	6-10 cm
X_0 (Rad length) plexiglas	~40 cm
X_0 H_2 or D_2	~10 m
X_0 Neon	24.2 cm
λ (int. length) plexiglas	~50 cm
λ H_2 (σ = 25 mb)	~10 m
λ D_2 (σ = 25 mb)	~5 m
λ neon	~75 cm
n (index of refraction) plexiglas	~1.5
n H_2	~1.10
n D_2	~1.11
n neon	~1.07

The expansion system could be arranged as shown in Fig. 2. This arrangement has the advantage of losing only a small volume of hydrogen-neon (in fact a volume where there are essentially no particles). Figure 3 shows the various operating regions for H_2, D_2, and neon.

As mentioned above, the TST discussed here is an example. TST's could be larger or smaller and different shapes. For example, it could have a hemisphere on the downstream end in place of a flat plate. The hemisphere would have 1/2 the wall thickness of a flat plate.

II. DETECTION EFFICIENCIES

To consider the detection efficiencies, let us pick the following example:

TST filled with H_2 or D_2

Chamber filled with mixture 15% neon-85% hydrogen (atomic)

X_0 mixture = 100 cm

λ mixture = 200 cm

Probability to detect forward γ = 0.85
(not using last 40 cm of chamber)

Probability for sideways γ $\gtrsim$ 0.50

For any given experiment, one must know the distribution of γ to get detection efficiency; however, let us be optimistic and say that we have events with forward π^0's, then

$1\pi^0$ No. of γ	$1\pi^0$ % of events	$2\pi^0$ No. of γ	$2\pi^0$ % of events
0	2	0	~ 0
1	26	1	1.5
2	72	2	10
		3	36.5
		4	52

Probability to detect neutron of $p \geq 150$ MeV/c	= ~ 0.4
Probability to detect K_L^0 (gives a star)	= ~ 0.6
Probability $K^\pm$ interacts and produces a visible V^0	= ~ 0.1

III. MEASUREMENT ERRORS ON $e^\pm$ AND γ

The method assumed for measurement of $e^\pm$ is that of A. M. Cnops and R. Huson.[4] In this report, angle errors are not considered since $\Delta p/p$ is greater than a few percent. The $\Delta p/p$ errors are

M. S.	Setting error	Bremsstrahlung
$\sim \frac{50}{B\sqrt{\ell X_0}}$	$\frac{0.002\ p\epsilon}{B\ell^2}$	$-0.5\ \ell n\,(1-\alpha)\sqrt{\frac{\ell}{X_0}}$

where α is a parameter that is defined by

$$\frac{dE}{dx} = -1.5\rho + \frac{E}{X_0}\ \ell n\,(1-\alpha)\ .$$

For a given energy and radiation length $\ell n\,(1-\alpha)$ is approximately proportional to the rate of change of curvature. In other words, this method takes care of bremsstrahlung by measuring it for each electron. Note for different experiments the average behavior of α depends on B, ρ, ℓ, and X_0.

To have an idea of the error on $\Delta p/p$ let us consider an existing experiment[5] on 12.7 GeV/c K^- in 50% hydrogen-50% neon (atomic). The events in this experiment are

$$K^- \text{ neon} \rightarrow \text{neon} + K^o \pi^- \pi^o \qquad \sim 1/8$$

$$\rightarrow \text{neon} + K^- \pi^o \pi^o \qquad \sim 1/8$$

$$K^- n \rightarrow n + K^o \pi^- \pi^o \qquad \sim 1/8$$

$$n + K^- \pi^o \pi^o \qquad \sim 1/8$$

The majority of the above $K\pi\pi$ are $Q_{1300} \rightarrow K^*_{890}\,\pi$.

$$K^- n \rightarrow n \begin{pmatrix} K^- \\ \pi^- \end{pmatrix} \pi^- \pi^+ + \begin{pmatrix} \pi^o \\ 2\pi^o \end{pmatrix} \qquad 1/2 .$$

Let us "scale" these properties to a 50 GeV/c $K^- d \rightarrow d + K\pi\pi$ experiment.

	12.7 GeV/c K^- (80-in.)	50 GeV/c K^- (25-foot)
B	17.5 kG	40
X_0	43 cm	100
ℓ	≤ 12 cm*	≤ 28
ϵ	50μ	200μ
p	p	4p

*Half of the e^- have $\ell > 12$ cm.

Figure 4 gives the distribution of γ momenta and the errors on $\Delta p/p$ for $e^\pm$ and γ. Note setting error dominates above 10 GeV/c.

IV. CONCLUSION

The conclusion is that track-sensitive targets are feasible for the 25-foot bubble chamber. From many other reports it appears that one may want to operate the 25-foot most of the time with a TST.

REFERENCES

[1] G. Horlitz et al., Operation of a Track-Sensitive Deuterium Target Inside a Neon-Hydrogen Bubble Chamber, Nucl. Instr. and Methods, to be published. We appreciate discussions with H. Leutz of CERN on TST's.

[2] Tests were made in the 30-in. and 31-in. bubble chambers.

[3] H. Leutz, C. Fischer, and D. Miller et al., private communication.

[4]A. M. Cnops and R. Huson, BNL to be published.

[5]BNL, Milan, and Orsay, U. C. Berkeley collaboration.

Fig. 1. The actual film taken is much better than this picture implies. (a) D_2 inside, 90% neon-10% hydrogen (atomic) outside. Picture from DESY bubble chamber.[1] (b) H_2 inside, 10% neon-90% (atomic) hydrogen outside. Picture from 30-in. BNL bubble chamber. (c) H_2 inside, 25% neon-75% hydrogen (atomic) outside. Picture from Rutherford Laboratory, 150-cm bubble chamber.[3]

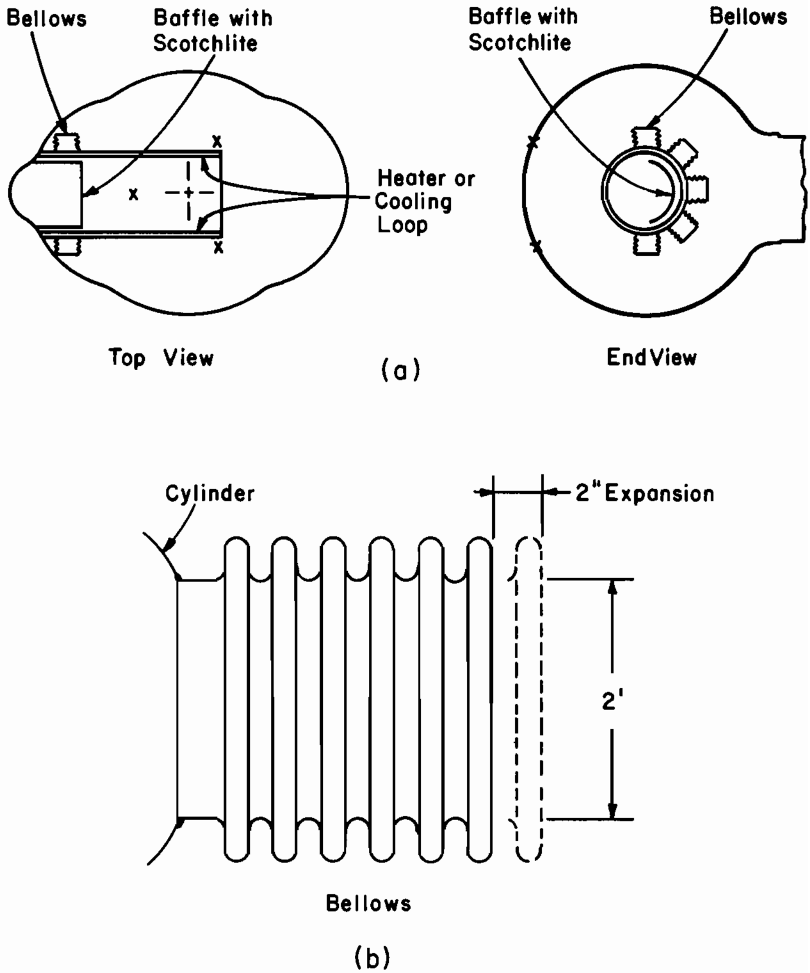


Fig. 2. Expansion system for proposed TST.

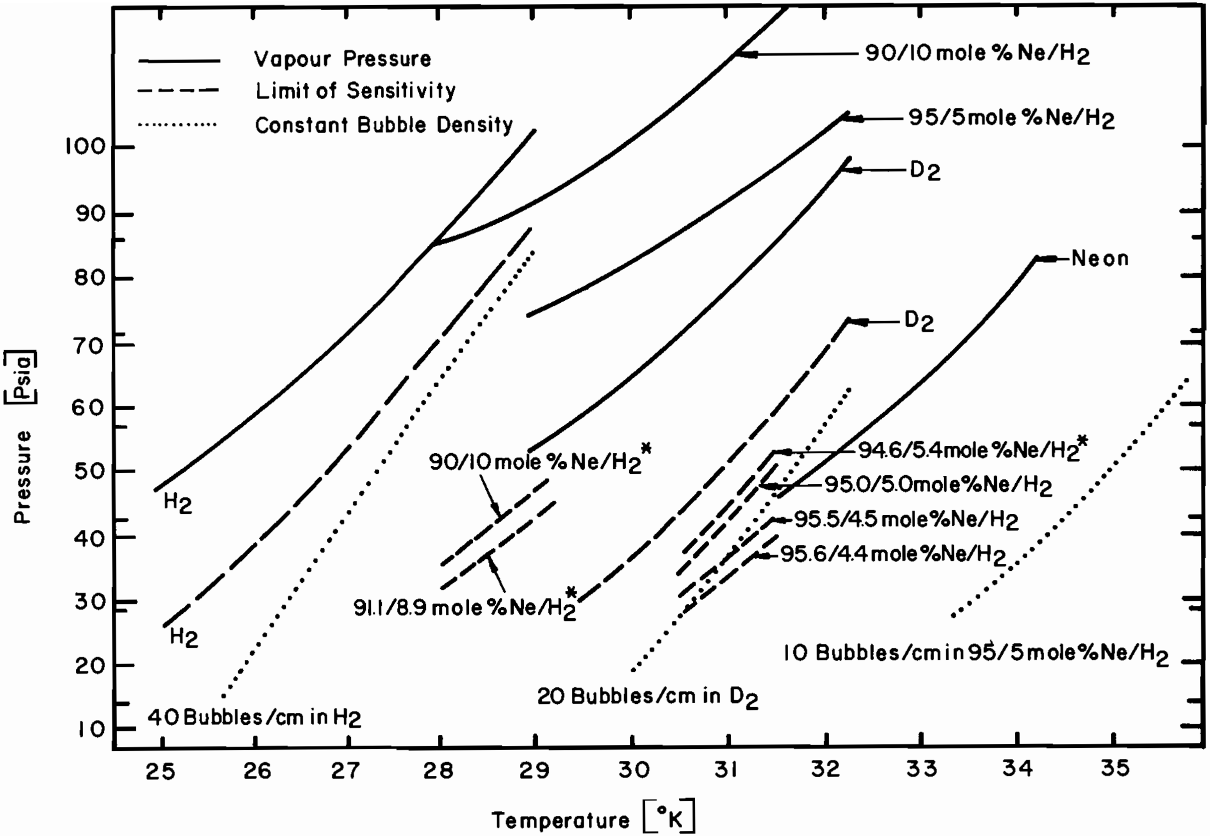
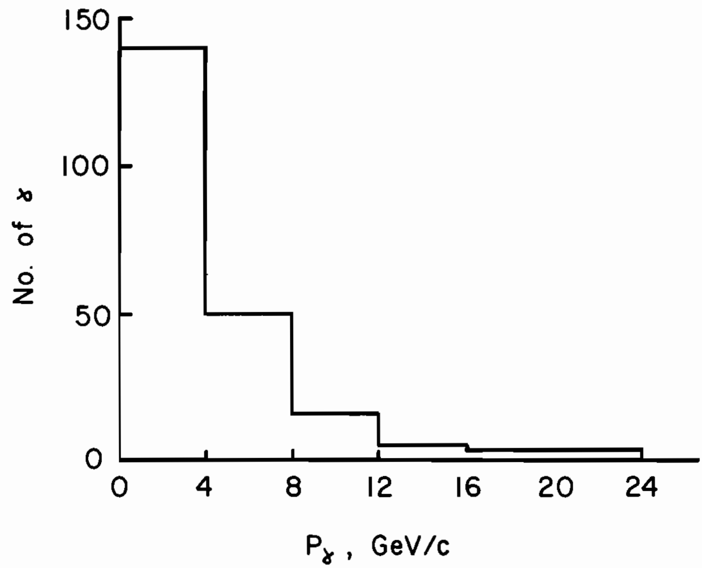


Fig. 3. Vapor pressure curves for H_2, D_2, and neon. This figure was taken from Ref. 1 and modified by changing the scale to PSIA and adding pure neon.



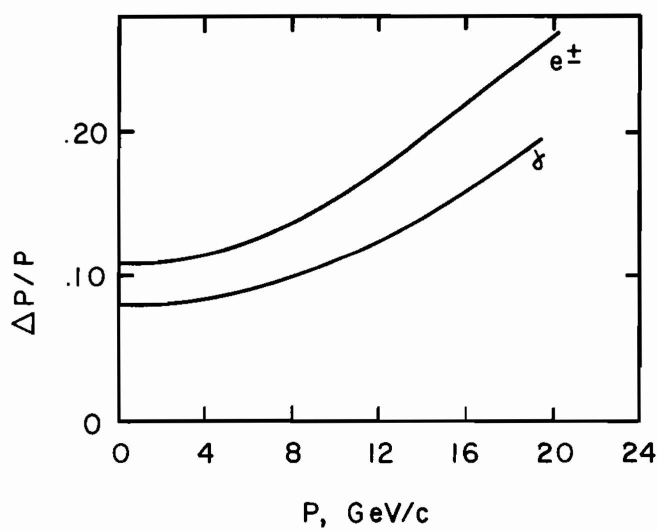


Fig. 4. (a) Momentum distribution for γ from 50 GeV/c $K^-d \rightarrow dK\pi\pi$ (see text). (b) $\Delta p/p$ for $e^{\pm}$ and γ in the 25-foot with the TST proposed in this report.