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## The Mark III Vertex Chamber: Studies Using DME\*

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### Abstract

We have performed studies using a prototype of a pressurised wire vertex chamber with 8 mm diameter straw geometry. We obtain 35  $\mu\text{m}$  spatial resolution using dimethyl ether (DME) at 1 bar and 30  $\mu\text{m}$  using argon ethane (50/50 mixture) at 4 bar. Preliminary studies show the DME to adversely affect such materials as aluminised Mylar and Delrin.

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## Chamber Design and Construction

A vertex chamber has been designed for use in the Mark III experiment. The chamber will be positioned inside the current main drift chamber and will be used to trigger data collection in addition to vertex reconstruction.

The vertex chamber consists of 640 thin-walled aluminised Mylar\* straws, each having a sense wire along its axis. The ends of the straws are fixed to 2.54 cm thick aluminum endplates, separated by 84 cm and epoxied to the beam pipe. The straws are arranged in 12 layers, the inner layer being at a radial distance of 5.4 cm and the last layer at 13.0 cm. The chamber sits in a carbon fibre pressure vessel, sealed with a second set of endplates, allowing operation at pressures of up to 4 bar.

The central 40 cm of the beam pipe is composed of 1.27 mm thick beryllium. The remainder of the beam pipe encompassed by the vertex chamber is made of 0.32 cm thick aluminum alloy 5086, which is connected to the beryllium through a small piece of aluminum alloy 1100.

Figure 1 shows the arrangement of the straws at one of the endplates. The first four *axial* layers each contain 40 straws which are parallel to the beam pipe axis. Layers 5-8, called the *stereo* layers, contain 40 straws placed at angles ranging from  $3.002^\circ$  to  $3.563^\circ$  (depending on the layer) with respect to the beam pipe axis. The outer four *axial* layers each contain eighty straws parallel to the beam pipe. The 0.422 cm diameter holes in the inner endplate which serve to

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\* Mylar is a registered trademark of E. I. Du Pont de Nemours & Co. (Inc.). We have used type A Mylar.

position the straws have been placed to an accuracy of  $\pm 50 \mu\text{m}$  for the axial layers and  $\pm 125 \mu\text{m}$  for the stereo layers.

The aluminised Mylar straws are 8 mm in diameter and the walls are roughly  $100 \mu\text{m}$  thick. The straw is constructed from sheets of  $25 \mu\text{m}$  and  $50 \mu\text{m}$  thick Mylar coated electrolytically on one side with  $0.25 - 0.30 \mu\text{m}$  aluminum. The sheets are cut into narrow strips, wound in a barber-shop pole fashion and laminated together, so that the aluminum forms the inner and outer surfaces. A Delrin<sup>†</sup> feedthrough is held in place at each end of the straw by an aluminum collar, glued to the straw using a silver-loaded epoxy. The epoxy also electrically connects the inner and outer aluminum surfaces of the straws.

The straws are tensioned at 500 grams by preparing the straws 0.6 mm shorter than the distance between the two endplates and stretching them during installation until they touch the endplates. The straw ground is thus electrically connected to the endplate and beam pipe assembly. The feedthrough passes snugly through the endplate hole and is secured on the back side with an aluminum nut.

The chamber sense wires are  $50 \mu\text{m}$  diameter gold-plated tungsten tensioned at 275 g. The sense wires are held in place by crimping stainless steel pins which have been press-fitted into the Delrin feedthroughs. The stainless steel pins have an outer diameter of 1 mm and an inner diameter of  $115 \mu\text{m}$ . Signals from one end of the sense wire are read out along the same coaxial cable as supplies the high voltage. The cables, which connect directly to the back of the inner endplates, pass through the outer endplates where a 1 cm thick layer of

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<sup>†</sup> Delrin is a registered trademark of E. I. Du Pont de Nemours & Co. (Inc.). We have used Delrin 500.

Stycast 2850 FT/24 LV epoxy provides a pressure-tight seal. The pins at the other end of the sense wires are covered with Delrin and shielded with 5 cm long brass collars. The use of the brass shields along with the uninterrupted coaxial readout cables reduces the crosstalk considerably.

### Prototype Tests

A prototype of the vertex chamber was used to study various gases and gas pressures, sense wire diameters, and operating conditions. The construction of the straws in the prototype was identical to that used in the vertex chamber. The geometrical arrangement of the straws in the prototype was different. Cosmic ray data from two sets of triplets staggered by approximately  $\pm 100 \mu\text{m}$  were used to calculate the resolution by fitting a Gaussian to the distribution,

$$\sigma = (d(t_1) + d(t_3))/2 - d(t_2),$$

where  $t_i$  is the drift time for straw  $i$ , and  $d(t_i)$  is the drift distance corresponding to the time  $t_i$ . For saturated gases such as argon/ethane,  $d(t) = v_D t$ , where  $v_D$ , the drift velocity, remains relatively constant ( $50 \mu\text{m}/\text{ns}$ ) at high voltages. For DME, in which the drift velocity varies with the drift distance, we have determined  $d(t)$  using a parametrization derived from a formula of Bari *et al.* (CERN EP/86-56).

Figure 2 shows the single tube resolution,  $\sigma_{\text{tube}}$ , obtained using the prototype assembly. Assuming the three tubes in a triplet contribute equally to the resolution,  $\sigma_{\text{tube}} = \sqrt{2/3} \sigma$ . The data includes tracks at all radial and longitudinal

positions. No corrections have been applied as a function of the longitudinal position of the track. We obtain 35  $\mu\text{m}$  spatial resolution at 1 bar using DME and 30  $\mu\text{m}$  resolution for argon/ethane at 4 bar. The optimum resolution obtained using DME remains fairly constant over a broad range of operating voltages, in contrast with that obtained using argon/ethane which is quite sensitive to the voltage.

### Materials Studies

A study was undertaken to evaluate the potential effects on the straws of pressurised air, DME, argon/ethane (50/50 mixture) and argon/ethane (50/50) with a small (0.2%) percentage of water. One metre long samples of the straws, half with feedthroughs and half without, and 20 cm x 3 m x 25  $\mu\text{m}$  sheets of aluminised Mylar were placed in pressurised containers. Control samples were left exposed to the ambient temperature and pressure in our clean room.

The straws weighed between 3 and 6 g, depending upon whether they contained Delrin feedthroughs, and the aluminised Mylar sheets weighed about 18 g. The accuracy of the measurement was 0.01 g. The lengths of the Mylar and of those straws containing feedthroughs were measured to an accuracy of 0.25 mm.

The samples were removed from the containers after one month and were measured. The results are shown in Figure 3. The relative weights of the samples exposed to DME increased by approximately  $10^{-2}$  and the relative lengths increased by about  $10^{-3}$ . No significant change was observed for the samples in other gases. It was also noticed that the Delrin feedthroughs exposed to DME swelled and the sheets exposed to DME exhibited a strong tendency to

curl along their lengths.

### Conclusions

Good spatial resolution from a prototype wire vertex chamber has been obtained at 1 bar using DME and at 4 bar using argon/ethane (50/50). Preliminary results, however, show that DME adversely affects at least two common drift chamber materials, Mylar and Delrin. Further studies must be performed to ascertain the extent of the effects on these and other drift chamber materials. The effects of DME on Kapton,<sup>\*</sup> Stesalit and G-10 are currently being investigated.

### Acknowledgements

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### Figure Captions

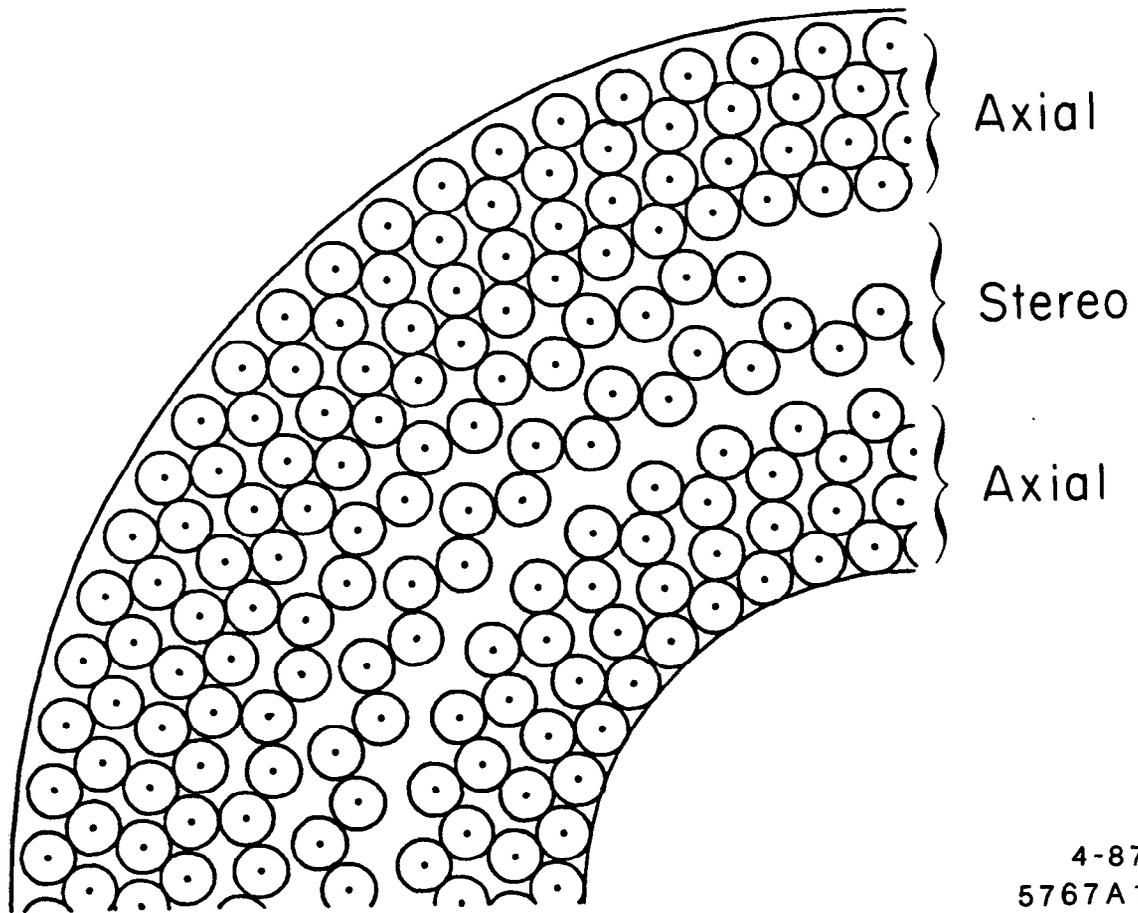
*Figure 1.* A cross section of the vertex chamber at the interaction point. The inner four and last four layers have straws parallel to the axis of the beam pipe. The middle four layers have straws at small angles relative to the beam pipe axis. The first layer is at a radial distance of 5.4 cm and the last layer is at 13.0 cm.

*Figure 2.* The single tube resolution obtained using a prototype for a) argon/ethane (50/50) at various pressures as a function of the voltage on the sense wire, and b) DME at 1 bar as a function of the voltage.

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<sup>\*</sup> Kapton is a registered trademark of E. I. Du Pont de Nemours & Co. (Inc.)

*Figure 9.* Measurements made of the changes in length and weight of samples of aluminised Mylar straws and sheets after exposure to various gases. Samples were exposed to pressurised air, DME, argon/ethane (50/50), and argon/ethane with 0.2% water. There was also a control sample. a) Changes in the relative weight ( $\Delta W/W$ ). b) Changes in the relative length ( $\Delta L/L$ ).



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Fig. 1

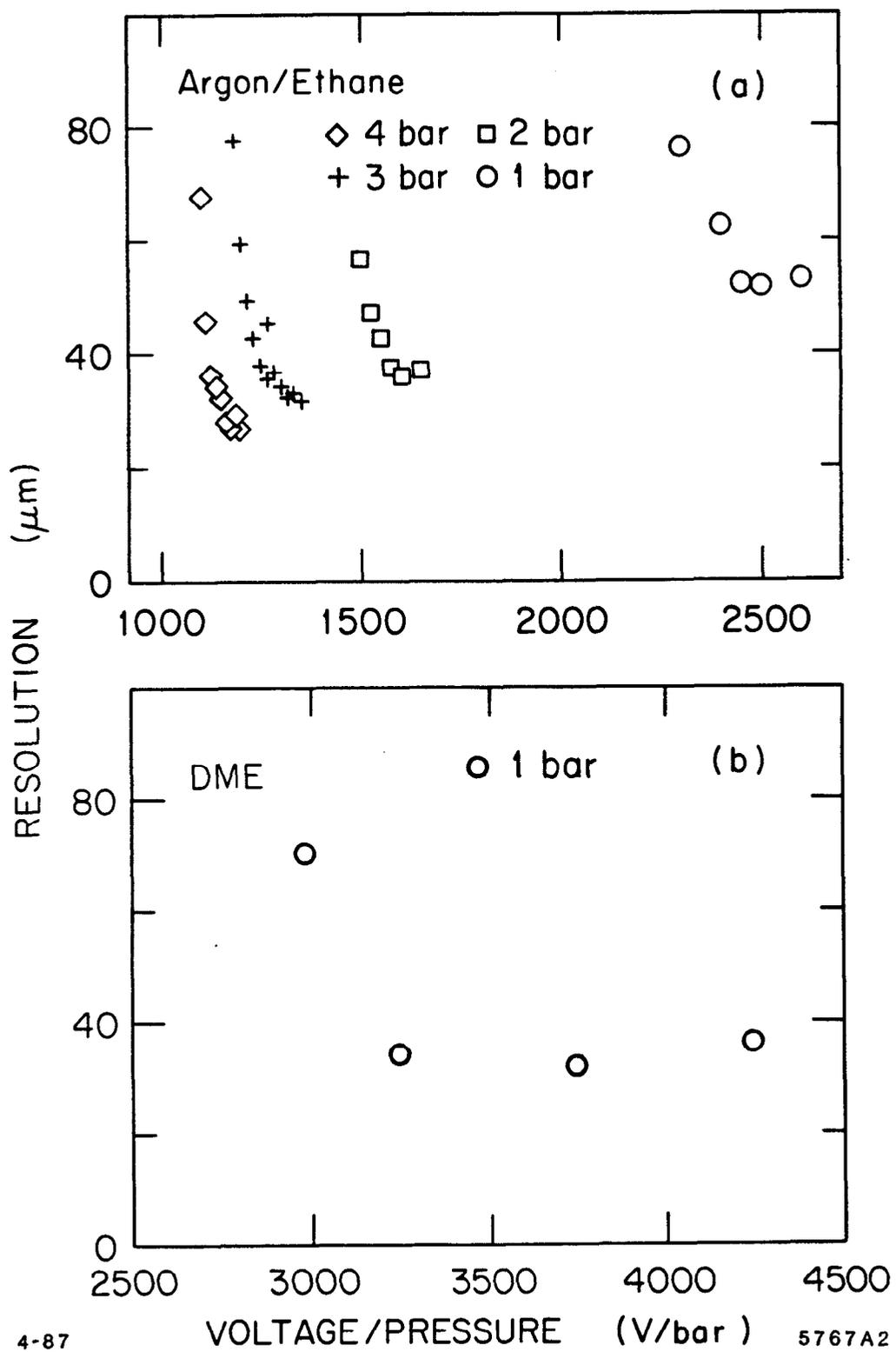


Fig. 2

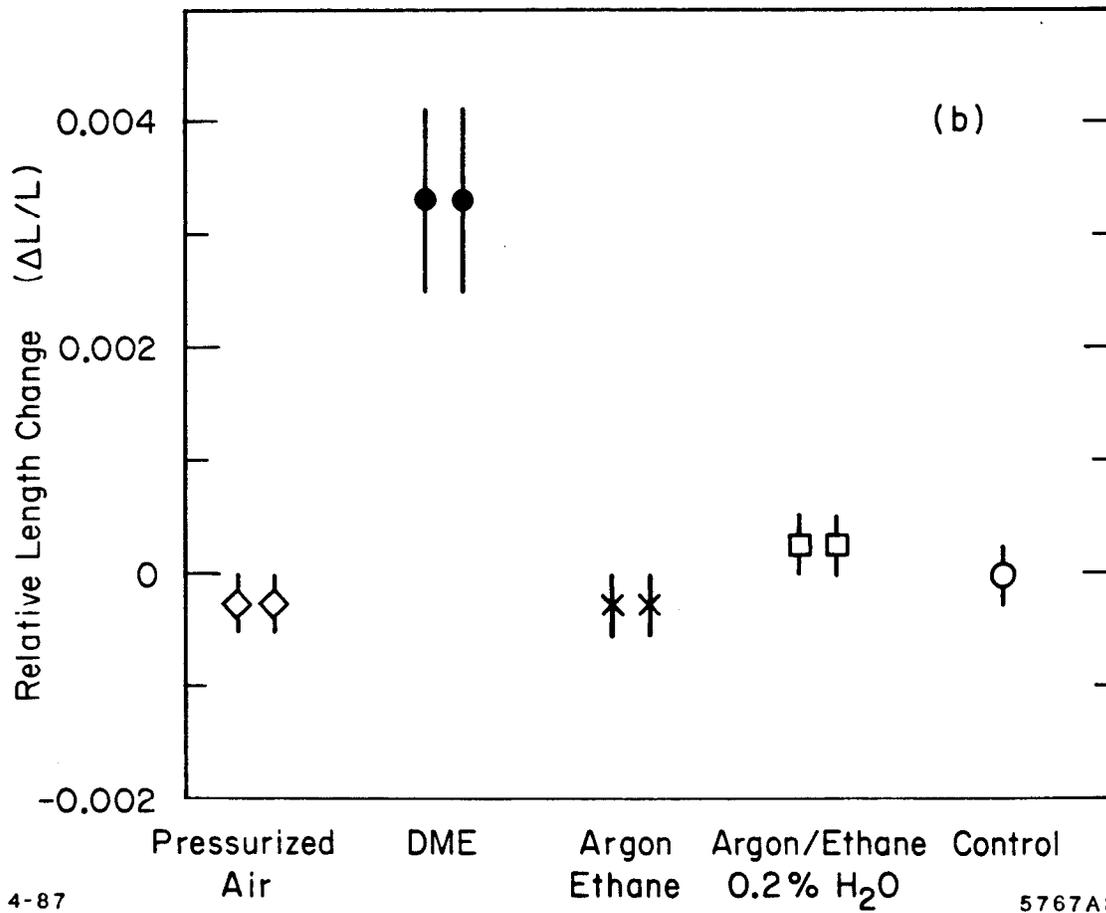
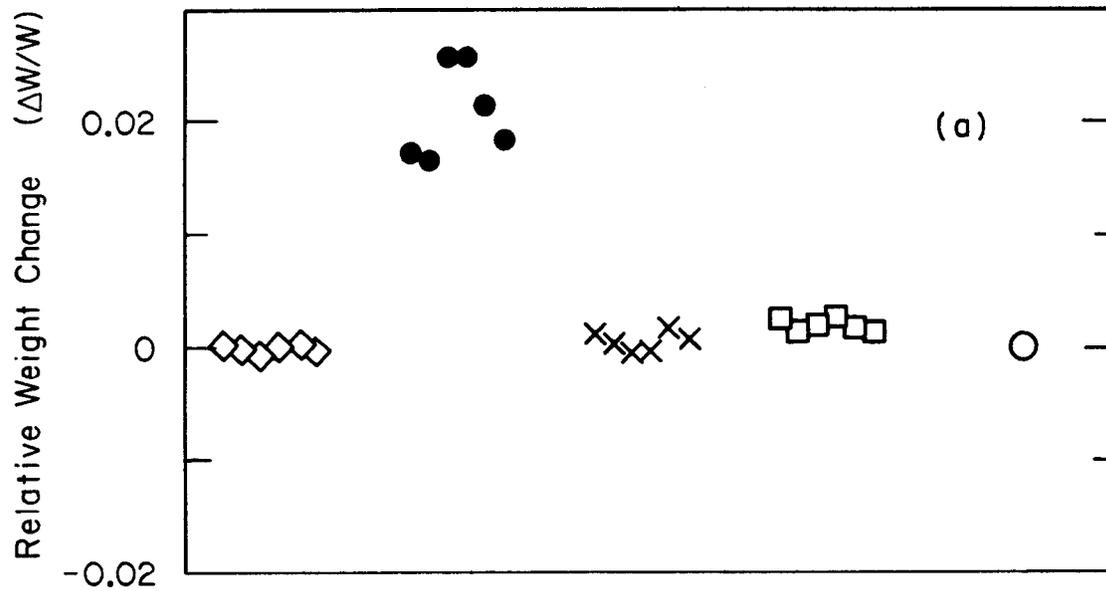


Fig. 3