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dE/dx measurements in a drift chamber filled with CO_2(90%)/Isobutane(10%)

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In a present design of the detector for a future linear e+ e- collider JLC, the central draft chamber (CDC) is required to have inner and outer radii of R_{in}=45 cm and R_{out}=230 cm, and a length of L=460 cm. In order to achieve an r-ϕ resolution better than 100 μ m over the whole drift volume, we propose a mini-jet-cell type drift chamber filled with a CO_2(90%)/Isobutane(10%) gas mixture. This gas mixture choice is due to its small diffusion coefficient and small Lorentz angle under a magnetic field of 2 T .

In order to evaluate the particle identification capability with this gas mixture, we made dE/dx measurements using a test chamber with 10 sampling wires for e, π, and p beams with momenta of 0.5–2.0 GeV/c at the T1-beam line of 12-GeV KEK proton synchrotron (KEK-PS). The layout of our experimental apparatuses on the T1 beam line is shown in Fig.1. A coincidence of four trigger counters, TOF1, TC1 , TC2, and TOF2, signaled the passage of a particle through the drift chamber. Its particle identification was made by the time-of-flight (TOF) measurement between TOF1 and TOF2 together with a pair of gas Cherenkov counters, C1 and C2, and a total absorption-type lead-glass Cherenkov counter.

Since the gas gain is expected to saturate at high ionization densities, it is interesting to study the low energy region for protons. In Fig. 2, we plot the truncated mean of dE/dx measurements as a function of $\beta\gamma$, where the parameter is the incident angle. In the figure, the normalized values (dE/dx)/(dE/d$x|_{MIN}$) are shown. The calculated most-probable energy-loss is shown by the solid line. From the figure, it can be seen that the measured dE/dx decreases when the incident beam angle becomes smaller, especially at low $\beta\gamma$. This again indicates that there are some space charge effects on the dE/dx measurement for larger energy-loss particles at the incident angle close to normal to the sense wire. However, in a practical application, this incident-angle dependence of dE/dx can be corrected based on the tracking information.

The results show good separation capability under practical operating conditions of the chamber. Assuming 80 sampling layers with 10mm thickness, the expected resolution of the dE/dx measurement is 5.2% for minimum-ionizing particles at atmospheric pressure. Although the primary purpose of using this gas mixture is to achieve good spatial resolution over long drift distance, the dE/dx information can also be used effectively for particle separation in the low momentum as well as in the relativistic-rise region.

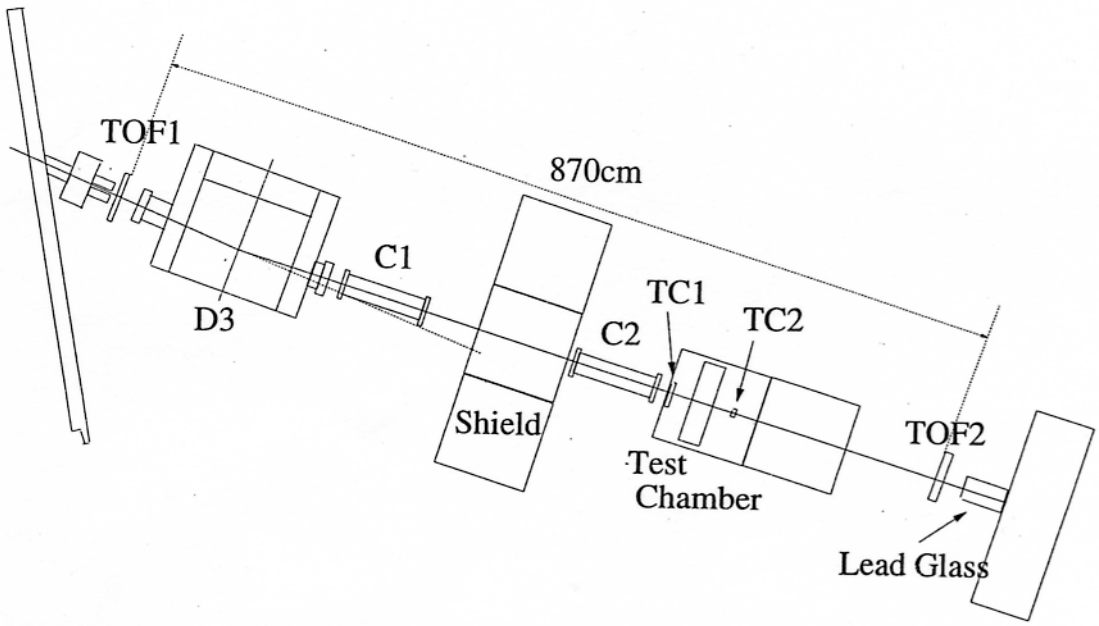

Fig.1. Layout of the experimental apparatuses on the T1 beam line at the 12GeV KEK proton synchrotron.

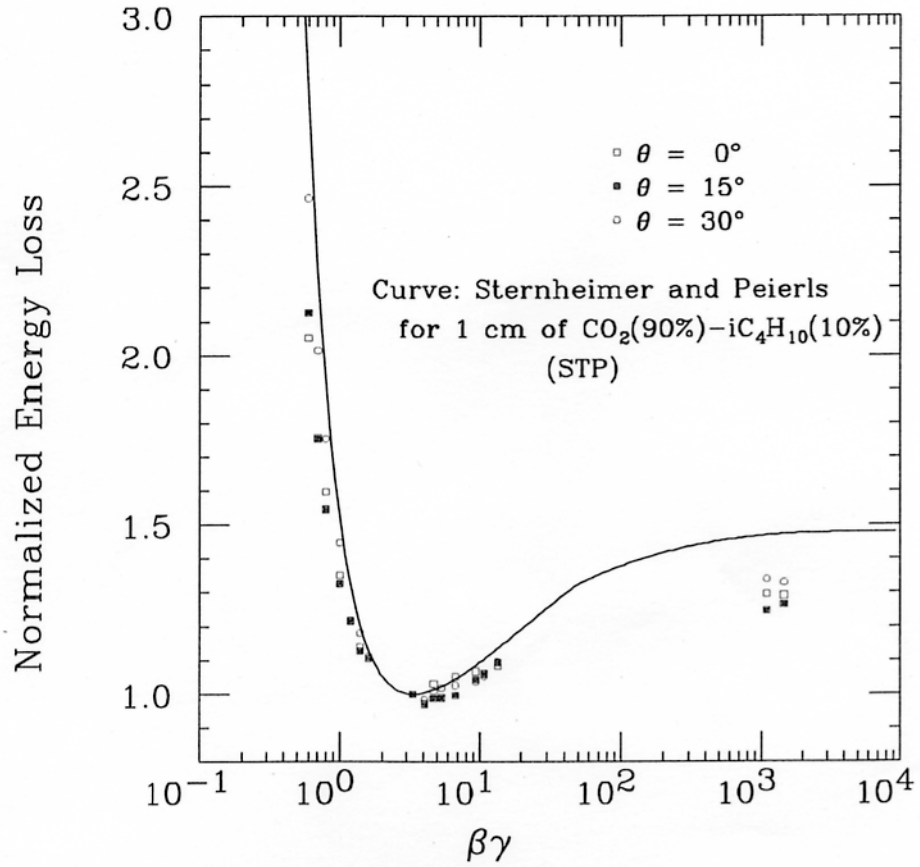

Fig.2. Truncated means of the dE/dx measurements as a function of $\beta\gamma$, where the parameter is the incident beam angle. The dE/dx values are normalized to 1.0 at 0.6 MeV/c pions. The calculated most-probable energy-loss is shown by the solid line.