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REPORT ON THE DRIFT CHAMBER WORKSHOP

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A workshop was held at Fermilab on June 7th and 8th to discuss drift chambers and the associated electronics. Over 120 scientists attended the meeting sponsored by Research Services. The invited speakers were J. Sanford, Fermilab; J. Rosen, Northwestern; W. W. Allison, Oxford University; M. Atac, Fermilab; C. B. Brooks, Oxford University; D. Hartill, Cornell University; C. Kerns, Fermilab; F. Kirsten, Lawrence Berkeley Laboratory; W. Kozanecki, Harvard University; E. Platner, Brookhaven National Laboratory; B. Sadoulet, Lawrence Berkeley Laboratory; F. Sauli, CERN; E. Schüller, CERN; W. Sippach, Columbia University; A. Walenta, Heidelberg University; and H. Weedon, Harvard University.

J. Sanford indicated that Fermilab is thinking about future experiments which would require new and more sophisticated detector systems. He said that this conference is the beginning of a series of planned workshops on detectors and electronic readout systems.

J. Rosen discussed "Detector Needs at Ultra-High Energies". He emphasized that there is a need for improvement in calorimetry and in detectors to resolve closely spaced tracks and provide high spatial accuracies, and suggested that W. J. Willis' Liquid Argon Ionization Chamber[1] type of total absorption detector may be an answer to better calorimetry. Particle identification above 200 GeV/c is a problem.

B. Sadoulet talked about LBL's cylindrical drift chamber development effort to look at e^+e^- interactions at SPEAR. A spatial accuracy of σ = 100 microns is required for obtaining transverse momentum resolution of $\frac{\Delta p}{p}$ = 10% from drift chambers operating in 4kG magnetic fields.

F. Sauli presented CERN's data on drift chamber development work.[2] Here 50 cm x 50 cm area, 5 cm wire spacing drift chambers with field shaping wire network were developed. 100-200 micron spatial accuracies were obtained from these chambers operating under high fields (1.3 kV/cm) in the drift region with saturated drift velocities using 67.2% Argon - 30.3% Isobutane - 2.5% Methylal. Tests were made in magnetic fields up to 15 kG. Distortions of primary electron trajectories were compensated by proper shaping of electric fields. Sauli claimed that two track resolution of 1.5 - 2 mm may be achieved from individual wires. This number was obtained from a test using a β- source and detecting the β's and backscattered β's by a thin material.

W. W. M. Allison presented some data on "The Identification of Secondary Particles by Ionization Sampling (ISIS)". The recently proposed ISIS[3] is a large drift chamber, 5 m long and 1 m high, with 2 m drift space. It is expected to distinguish between π's, K's and P's from 5 GeV/c to about 100 GeV/c. A spatial accuracy (σ) of 5 mm is obtained with a drift distance of 85 cm using a 1 m long drift chamber. This large chamber would be used downstream of a rapid cycling bubble chamber to cover a large solid angle.

D. Hartill reported that he has observed about 1% difference in the height of the induced pulses from a pair of cathode wires on the left and right side of the signal wire. This difference is too small to detect for resolving left-right ambiguity in determing track positions. He has managed to build an inexpensive ($22.00/wire) readout system with 2 nsec timing accuracy.

I talked about Fermilab's effort in developing parallel foil drift chambers (PFDC)[4] which provide excellent field uniformity in the drift region of the primary electrons and presented some data from such a chamber. For very large chambers, the parallel foils may be replaced with several wires. The PFDC allows us to use small drift spacing with uniform fields. This results in short memory times, high repetition rates and high multitrack resolutions. I also presented some results from high pressure studies (up to 4 atmospheres) using 20% CO_2 + 80% Ar gas mixture. The drift time is doubled at a pressure slightly above 2 atmospheres from 203 nsec/cm to 417 nsec/cm.

E. Platner briefly described a set of beam defining drift chambers for the Multiparticle Spectrometer (MPS). A σ of 80 microns per chamber has been measured.

A. H. Walenta presented some data from CERN-Heidelberg experiment[5] determining the $K_{e2}/K_{\mu 2}$ branching ratio using drift chambers of 2 cm wire spacing. The 600 wire-system has been operated in 6-7 kG fields producing σ = 0.3 mm per chamber. He also talked about cylindrical drift chamber development for the Hamburg storage ring experiments and a non-linear clock readout system.

W. Kozanecki talked about Harvard University's 4 x 4 m^2 area drift chambers.[6] These chambers with 5 cm drift spacing have produced track position accuracies less than σ = 0.5 mm.

The Saturday morning session was on drift chamber readout systems. Five out of six speakers talked about fast digital circuits.[7] Although there are very few readout systems in use, it was clear that the subject is rapidly developing. F. Kirsten talked about the West Coast effort to design a general purpose system for drift chambers. A dialog was started on this subject at a meeting at LBL in May.

After the invited talks, a discussion session was held on the following subjects:

a. Timing of drift chamber pulses

b. Electric field shaping

c. Count rate capabilities of drift chambers

d. Multitrack resolution

e. Input impedance of amplifiers

f. Stability of drift chambers and electronics

Some of the important points are written below.

a. Timing. Can we get better timing information if we do the timing relative to the center of gravity of composite pulses which are formed from single or a cluster of electrons produced by primary ionization? This would improve accuracy in determining positions of inclined tracks. It was found that at chamber gains above 10^5, pulse height shows saturation as a function of angular distribution of tracks. The saturation is due to space charge effects of large numbers of positive ions. This implies that timing with leading edge of the pulses provides higher spatial accuracies when the inclination of the tracks is known. This can be achieved by using more than two chambers. Closest approaching electrons give rise of the initial rise of the pulses.

b. Electric Field Shaping. It is generally accepted that shaping electric fields in drift chambers is important for obtaining high spatial accuracies. It can be argued that high spatial accuracies can be obtained under non-uniform fields when the drift velocity is fully saturated across the drift space, but electron multiplication around the signal wire may become very large under the full saturation and this may limit count rate capability of a chamber due to fast space charge build-up. The chamber may even go into Geiger region. In this case count rate may be limited to less than 10^3 per wire/sec. On the other hand, one may have to take velocity calibration spectrum more frequently if the drift velocity is not fully saturated.

c. Count Rate. Count rate capability of a drift chamber wire is dependent on gain (gas multiplication factor) and signal wire spacing. The gain is a function of many parameters (field, gas pressure, gas mixture, etc.) It was found that count rates may vary from ~ 10^3 - 10^5 per wire per second depending upon chamber construction and operating conditions. Operation under low fields (lower gas gain) has the very important consequence, that hydrocarbon depositions on the electrodes would be less when hydrocarbon gas quenchers are used.

d. Multitrack Resolution. In general, using more wires, if necessary, more chambers (depending upon experimental conditions) is more beneficial for improving multitrack resolution than timing multitracks through individual wires. Construction of drift chambers with 1 cm signal wire spacing is quite practical and would not cause electrostatic instabilities for reasonably large chambers. Cost of electronics would be about the same for both cases. Small signal wire spacing also shortens memory times and increases count rates.

e. Input Impedance of Amplifiers. Input impedances from 50Ω to 1kΩ have been tested by various groups. Low impedance becomes important when multitracks are detected through individual wires. This requires very sensitive current amplifiers and very high gains in the chambers. If one follows the suggestions mentioned in (d) one uses 500Ω to 1kΩ with voltage amplifiers.

f. Readout Systems. Digital readout concept is generally accepted for obtaining high timing accuracies and more stable electronics.

I believe that further research and development and usage with experiments will prove that drift chambers are powerful detectors for high energy research. Please, contact me or the other speakers for more information on the subject.

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