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MASTER

Structure of the Brookhaven FSD System
for the Analysis of Bubble Chamber Film

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I. Introduction

In order to make the accompanying papers by members of the Brookhaven group more readily understandable we outline briefly the structure of the Brookhaven FSD analysis system. Some special advantages resulting from this structure are noted. We restrict ourselves throughout to the case of road-guidance.

II. Structure of the System

A. Scanning and Pre-digitizing

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At the predigitizing scan tables, road coordinates are stored in punched cards. After conversion to magnetic tape, the road data are checked by the IBM 7094 programs MISTY and MIST. Errors are detected in ~5% of the events. These events are predigitized again. An error level of ~1% is permitted to remain, the flawed events being noted on the bookkeeping tape as "terminated" at level 1.

B. FSD Measurement On-line to the 7094

The "MIST tape" guides the FSD in selection of frames to be measured, and in the selection (gating) of the raw coordinate data in order to preserve only the contents of the roads; fiducials are also measured and checked on this pass. The basic scheme is that developed by the Collège de France¹, but the gating is with respect to normal roads ~400 μ wide, rather than the "highways" of the French group. A real-time estimate of bubble density for beam tracks is made available to the FSD operator for aid in control of the digitizer. (This estimate is replaced by an improved measurement in FILTER.)

The FSD measurement proceeds one view at a time as indicated in the diagram. The output "HAZE tape" contains road contents, fiducial positions and miscellaneous measurement data (such as scan-line separation, stage speed and scan mode) for each event-view measured.

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C. FILTER

The "HAZE tapes" for the three views of a roll of film are input to the 7094 for filtering. The operation of the FILTER² program is the subject of the accompanying papers. Here we need only note that the "FILTER tape" contains 20 summary points for each track in each view when the filtering operation is successful; when not, the original road contents are preserved on the output tape. At this point 60-70% of the events could be made available for geometrical reconstruction and kinematic fitting.

D. Light-Pen Filtering

Normally, HAZE and FILTER are run during weekend and early-morning computer shifts. The "FILTER tape", containing a mixture of final data and road contents, is cleaned up during the normal working day. The 7094 is used on an interrupt basis between jobs of the normal batch-processing load. Auxiliary storage on a magnetic drum of the contents of 32 roads enables an operator to present the roads one after another on a CRT for hand filtering with a light pen. On a subsequent interrupt of the 7094, the light-pen program³ computes summary points and bubble density from the individual digitizings marked with the light pen, and then refills the drum. About 30 seconds of central processor time are used each 10 minutes of light-pen work. About 2 hours of light-pen work are required for 300 events, at the present level of performance of FILTER.

The "Light-pen Tape" contains only track and fiducial data, all road contents being discarded. Some 2% of the track-views will not have been rescued by the operation; cases of bad road fit and merged beam tracks are prominent in this category. Nonetheless, at this point about 95% of the events are complete and available for geometrical reconstruction and kinematic fitting.

E. "DAISY" and Single-Track Re-run

Any tracks affected by the light-pen filtering operation are checked by the three-view geometry diagnostic of FILTER, in a slight modification known as "DAISY". Any event containing a beam-track merge (within $\sim 20\mu$ at the vertex) is terminated on the bookkeeping tape, as is also any event for which an entire view has been lost. Up to 5% of the events are lost by this procedure, but they are very nearly unbiased. It is believed safe and economical to terminate such events here, correcting the total cross sections appropriately at the end of the experiment.

From the bookkeeping tape a remeasure list is generated for any track-views still unmeasured or any tracks which fail the diagnostic. A three-view measurement is required for each track. Individual track views needed (not whole events) are measured by hand on a measuring projector together with two fiducials for each view treated. The "single-track rerun" (STR) measurements are merged with the FILTER-plus-light-pen data to give a final "STR tape". At this point about 1% of the events will fail in geometrical reconstruction or kinematic fitting, or have errors which go undetected and appear in the final physics analysis. This 1% is to be added to the 1% lost in MIST to form the total biased losses in the system.

F. Geometrical Reconstruction, Kinematic Fitting and Fit Selection

Events are reconstructed in the space of the bubble chamber using the Harwell Geometry Program HGEOM⁴ and tested for kinematic fits using the Brookhaven version of KICK⁵.

Each mass assignment acceptable from the point of view of KICK (including assignments with multiple neutrals) is tested for compatibility with the bubble density measurements from the FSD. A kinematic χ^2 , a bubble-density χ^2 , and qualitative physics information (such as a rough relative frequency of occurrence of different event-types) are inputs for a Fit-Selection program⁶. This program identifies a given event uniquely, or ambiguously,

or asks for further information from the physicist. Further information is requested in about 5% of the cases. The Fit-Selection program has been shown to agree with physicist selection for about 100 events, but requires much additional testing.

The output tape from Fit Selection contains geometrical, kinematic and bubble density data for the particular identification chosen for each event, with all events retained in picture-number order on one tape library. This tape library is then input to the physics summary program Suffolk County Fair⁷ for physics study.

III. Some Special Advantages of the System

A special advantage of the light-pen and single-track re-run procedures is the very low percentage of biased losses which can be obtained.

The display on the light-pen CRT of tracks failing FILTER provides an easy and automatic monitor of FSD and FILTER performance.

The capability for merge of hand-measured tracks with FSD data, which is provided by Single Track Re-run, permits direct comparison of the track coordinates obtained by the two systems—since STR can be carried out as well for tracks believed correctly measured by the FSD. This direct check on individual tracks is a powerful tool for investigating systematic distortions in the coordinate systems of the two measuring instruments.

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