Short notes on Tracking Efficiency

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These are just my notes of tracking and tracking efficiency, you are welcome to make additions to it. Tracking efficiency is the measure of tracking. Tracking efficiency shows that how good are our detectors, hardware set up, data acquisition and the reply code is.

1: HMS drift chamber design is based on R. Bolton Nucl. Instr. and Meth. A 292 (1983) 571.

2: First Paper on HMS drift chambers is O. K. Baker Nucl. Instr. and Meth. A 367 (1995) 92-95.
Highlights of this paper are:

- Drift cell dimension 10.0 mm × 8.0 mm.
- Spatial resolution = 140 μm per plane.
- 98% efficiencies.
- Order of planes: X, Y, U, V, Y' and X'.
- Spacing between planes is 1.4 cm.
- U is rotated at +15° w.r.t X and V is rotated at -15° w.r.t X.
- X' (Y') plane is offset form the X (Y) by 1/2 cell (5mm).
- The cell scheme is consists of 1 cm × 0.8 cm drift cells with anode planes separated by 2 cm.
- Anode wires are 25 μm gold-plated tungsten wire.
- Field wires (cathodes) are 150μm gold-plated copper-beryllium.
- All the wires received the same tension with in ±5%.
- 50:50 mixture (by weight) of argon and ethane is doped in isopropyl alcohol bubbler at 0°C.
- Gas flow from 80 to 200 cm^3/min.
- Operating voltage 2500 volts.

3: Earliest Report that I am able to find is "Tracking in the SOS spectrometer" by D. F. Geesaman date September 14 1993.
I found only latex file without figure so my pdf version has no figures. It will help a lot if someone has this report with figures. Highlights of this report are.

- This report describes the tracking fitting with mathematical formulations. It also describes the order of calling different routines in ENGINE for the track fitting.
- A drift chamber plane itself is defined by the z coordinate of the intersection of the plane with z axis z_0 and three rotation angles α, β and γ.

- "A wire chamber measures a ψ coordinate in the plane of the chamber"
- "The measured coordinate is ψ and the orthogonal coordinate is χ
- Focal plane coordinates in terms of local coordinates and parameters of the wire plane are given in equation 1.
- Minimization of χ^2 is defined in equations 12 and 15.
- General steps of tracking are given in section 2 and the working of ENGINE is given in section 5.

4: Next report is "Measurement of Tracking Error in the Regular and 4 of 6 Tracking Algorithms" by D. V. Westrum date November 11 1996.
This is a long report which describes the detailed study of 5/6 and 4/6 tracking algorithms. Highlights of this report are:

- This report is written after experiment E89-012.
- Mathematical efficiency for 5/6 tracking including both of the drift chambers is:

$$P_{\geq 5} = (6P^5 - 5P^6)^2 \tag{1}$$

  where P is the efficiency of each plane of drift chamber, for P we can use the average value of 12 planes since all the wire planes are the same.
- Mathematical efficiency for 4/6 tracking:

$$P_{\geq 4} = (3P^6 - 8P^5 + 6P^4)^2 \tag{2}$$

- At the end of report it is said that 4/6 method is good to use.

5: Next report is "Measurement of the Tracking Efficiency" by D. V. Westrum date January 23 1998
In this report they went back to 5/6 algorithm and then they compare the calculated (mathematical) efficiency with the measured efficiency.

- This report is written after experiment E91-013.
- Two tests were performed. One, take two identical runs with different efficiencies and apply fiducial area cut. Second, compare the calculated (mathematical) and the measured efficiency for different values of the wire chamber efficiency.
- "Test A shows that the discrepancy between two runs with drastically different tracking efficiencies is reduced to a level consistent with statistical fluctuations when the fiducial efficiency is applied."
- The efficiency of a given plane is obtained from the number of events that have at least one firing wire and pass the same fiducial scintillator cuts.
- Test B shows that for most of the runs the disagreement between measured and calculated tracking efficiency is not more than 1% and for the runs which have disagreement more than 1% there are two reasons, one too many hits and second, too few hits.

6: Next report is "Tracking efficiencies in the SOS for E91003" by Dave Gaskell date June 23 1998.
These are the highlights of this report.

- For experiment E91-003 the efficiency was as low as 80%.
- 8% increase in efficiency is obtained by narrowing the TDC timing windows.
- Four tests were performed:

  - A maximum of fifteen hits in each chamber and no particle ID.
  - A maximum of fifteen hits in each chamber with particle ID.
  - A maximum of thirty hits in each chamber and no particle ID.
  - A maximum of thirty hits in each chamber with no particle ID.
- By increasing the maximum number of hits in each drift chamber, the fiducial tracking efficiency of the SOS can be increased to reason able level, this also increase the risk of getting junk tracks.
- Expected and measured efficiencies are not in ideal agreement, part of the reason is too many hits and rest is undetermined.

7: Next report is the "HMS/SOS Tracking Code Enhancement" by Mark Jones and others date March 2005. This report describe the prune method.

- Extra cuts on tracks.
- 3.1 % gain in useful tracks.

8: Next report is "Rate Dependence of the HMS Tracking Efficiency" by T. Horn and others date August 23 2007.

- This report is about a change in the ENGINE code to take account of multiple track events contribution to the tracking efficiency at high rates.
- There is a linear relationship between probability for arbitrary multiple-track events and drift chamber rates.
- $P_2 = \mathrm{R}\ \tau$, where R is drift chamber rate and τ is drift chamber gate width.
- Total track efficiency is:

$$\epsilon_{tr} = \epsilon_1 - R\tau \times (\epsilon_1 - \epsilon_2) \tag{3}$$

  where ϵ_1 and ϵ_2 are the tracking efficiencies for single and multiple tracks respectively.

9: **Thesis of Vladas Tvaskis 2004**.

- Best thesis to understand tracking and tracking efficiency.
- Memorize the section of 4 of this thesis. :-)

10: Thesis of Christopher Armstrong 1998. Important sections are these.

- Whole section 4.2 is important.
- Section 4.2.3, Scintillator Timing Corrections

11: Thesis of Tigran Navasardyan 2007. Important sections are these.

- Section 3.5.3, Path Length Correction.

12: Thesis of Tomislav Seva 2009. This thesis describes the drift chambers of HKS. I did not read it yet but if needed I will read it.

13: Thesis of Benjamin M. P. Clasie 2006.
Lesson: Do not plan your experiment in the winter. :-)
Reason: Low temperature affected the gas mixture in drift chamber resulted in low efficiency. (First paragraph of page 87)