First Observation of Ionization Cooling: referees meeting #2: 30Nov18

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Notes:

1. Introduction: KL

Many issues raised in the first referees meeting have been addressed by the authors. Other issues are stilll under investigation. This meeting is partly to take stop and partly to provide guidance in the development of the analysis.

2. Presentation: update on analysis: CR

- Resolution:
  - TOF0/TOF1 now used to seed the tracker fit.
  - The MC distributions of the residual between the generated and reconstructed time difference between TOF0 and TOF1 show no bias.
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  - The tracker resolution plots u/s and d/s show no bias in position and transverse momentum. However, pz shows a bias at the 2MeV/c level. This is small but significant. Presently needs to be accounted for in the systematic uncertainty.
    - It was unclear whether the same effect was seen by FD in his thesis. **It was agreed that FD/CR would check consistency between the two analyses.**
  - We noted that the amplitude was eventually calculated using the transverse variables making the bias in pz comparatively less important.
- Glue density and chi2 distribution:
  - Track-fit-ci2 distribution is 'fixed' by increasing the glue density to account for the silica beads added to the mix. Hunt is measuring the density and trying to establish the composition. The changes in the chi2 distribution are relatively small. So, while waiting for the Hunt measurement, we accepted the practical approach taken by the authors.
  - Presently have adopted a composition of 20% by mass of silica with 2g/cm^3 density.
- Noise in tracker clusters:
  - Number of clusters per event distribution now shows good agreement between MC and data. Issue resolved by plotting only clusters used in tracks. In TKD there was more noise generated in the MC than was present in the data. The development of a tuned noise algorithm is ongoing.
- Beam distributions:
  - Momentum distribution compared data/MC. Agreement between the distributions improves from 4-140 to 10-140. The tail in the 4-140 distribution is explained by the authors as being due to pions. Banana plots to follow later in the presenation.
  - Disagreements are at the MeV/c level.
  - Comparison of y distribution at tracker reference plane looks acceptable.
  - The time-of-flight distributions between TOFs 0 and 1 show systematic shifts of MC relative to data. This can be accommodated in the cuts.
  - We discussed the 1000 vs 1024 clock-tick issue **and agreed that it would need to be checked once more.**
  - The 4D beta functions had been produced for MC. The data/MC comparison was good.
- Energy-loss across absorber:
  - The MC is systematically shifted w.r.t. data. The MC sees around 2.5MeV/c

less momentum loss between the u/s and d/s trackers. We discussed possible causes, but, were not able to explain the effect satisfactorily.
  - The scatter plots of momentum loss versus y and radius were presented. Accounting for the shift in the momentum-loss distribution noted above, the shapes of the scatter plots looks OK.
- TOF-slab delta t:
  - The deltaT between TOF slabs shows an offset of MC relative to data. We did not understand and **referred the issue to D.Rajaram.** The issue can be dealt with in cuts boundaries and systematic uncertainties. However, it would be good to understand.
- Muon identification:
  - The momentum vs TOF plots were shown for data. The region selected by the cuts was noted. It is conceivable to make a tighter cut on the TOF. It was not clear whether the low-P tail noted above where the MC momentum distribution lies above the data is indeed due to pions. Probably worth showing the MC banana plots.
- Amplitude resolution:
  - The feature at amplitude ~ 20mm in the migration plots was investigated by studying the resolution on the amplitude. No features in the resolution were found that might explain the feature (dip) observed.
  - The amplitude resolution plots themselves justified the bin widths chosen.
- Inefficiency:
  - Adoption of FD track-seeding algorithm and other code updates have improved the situation. However, still see inefficiency where px~py~0. Efficiency correction also has a shape and rises to 1.06 as Amp->0. This effect is observed in both trackers.
  - This observation does not appear to be the same in the FD analysis presented in his thesis. **Authors asked to compare to seek origin of difference.**
  - Need to make an average, a fit, or larger bins to present the efficiency for amp>50.
- Correction to amplitude distribution:
  - We discussed the shape of the correction function, particularly at low amplitude. There is significant variation which we were not able to explain.
  - We discussed whether it would be better to make a migration correction rather than a simple efficiency correction.
  - It is important to ensure that the systematic uncertainties account for data/mc differences in this area.
- Systematic uncertainties:
  - The present systematic uncertainty analysis was presented. One-sided error estimates are made because of the time taken to make the systematic variations. This was felt to be, most likely, OK. The issue will be kept under observation.
- The Money Plots:
  - The present status of the principal results were presented. We noted the difference between data and MC, particularly at low amplitude. FD asked whether the effect in data was larger than was physically possible. This amplified the worry about the correction factor dependence on amplitude at low amplitude. We noted too that there appeared to be cooling in the empty-channel data.
  - We discussed the observation that transmission was worse in MC than in data. It was not clear that we understood this observation.
- Drielsma plot:
  - The authors were reminded to bring forward a proposal for the density

evolution plot.

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3. Discussion: All

- The progress that had been made impressed the referees. There was consensus that the authors should move to updating the MICE Note and, in parallel, begin to work on the paper.
- Data/MC comparison issues remain and will be dealt with in parallel to bringing the paper forward. In particular, we needed to agreed what set of settings for MC/cuts in data would be used for the central values of the results presented and which for the estimation of uncertainties.

3. Summary and actions: KL

- We agreed to look for a date for the next meeting early in January. KL will make a Doodle poll.
- The authors are asked to present a revised MICE Note a week before the date of the meeting.

4. AOB

All items noted above.