# Overview of Analysis Tasks for the next 6–12 months

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Included below is a summary of the analysis tasks the students (and ourselves) from UoR will be focusing on in the coming 6–12 months

## 1 Ali Usman

### 1.1 HMS and SHMS tracking efficiency and algorithm investigations

- If we always had only one track per event in each spectrometer, tracking would be relatively straightforward, a matter of matching "track stubs" from the two drift chambers with hit location information from the hodoscopes and coming up with a best fit.
- The issue arises when there are two focal plane hits in the same event, which arises for high singles rates runs, or when the SHMS is at very forward angle. In addition to de-convoluting the two tracks, one has to figure out which one corresponds to the physics event and which one can be safely ignored. Since the L/T-separation involves the comparison of runs at high and low epsilon, with very different rates, how this selection is done can have great bearing on whether the L/T-separation is done correctly or not.
- This likely involves changes to the timing windows, separate from those that were used to determine the drift chamber calibrations, to reduce the probability of a second track being registered while not throwing away good tracks.
- In addition, the hcana tracking algorithm has two different choices of "pruning algorithm", one described in Vladis Tvaskis PhD thesis (choose general track "pruning" flag psel_using_scin = 1) and the other written by Peter Bosted (psel_using_prune = 1). In principle, it would be good to see how the two methods compare.
- The different assumptions in each algorithm will result in differing tracking efficiencies for the same run and particle type. The question is which one is most "accurate" for the physics analysis? Some important figures of merit to look at will be tracking efficiency versus rate, separately for each spectrometer, and also for various PID cuts. We will also probably want to look at the luminosity scan data with the different tracking efficiencies, to see which one is "better behaved"
- You will have to delve into the tracking code to understand the differences between the two algorithms, be sure their respective (timing and other) parameters are set correctly, etc. Probably this will involve discussing the code with various experts (e.g. Mark Jones, Dave Gaskell, Peter Bosted) and making improvements to the existing code. For sure, we would want your studies to be more widely disseminated and discussed within the Hall C Collaboration, as they are likely to affect the analysis of other experiments less sensitive to these issues than the Rosenbluth separation is.

## 2 Vijay Kumar

### 2.1 SHMS HGC calibration, event reconstruction and efficiencies

- Vijay currently has one complicated code (that he does not fully understand) which does all tasks, and he has to comment out different parts to perform different studies. This is a bad idea, as a poorly-understood code is likely to result in unknown errors. Vijay's first task is to write separate well-understood codes that separate out these tasks in a reproducible, easily and well documented manner.
- We need to be completely satisfied that events where multiple PMTs are hit are handled correctly. Do the timing cuts select the PMTs correctly, or are events incorrectly thrown away when one PMT has a good time that passes the cut and another PMT has a bad time that fails the cut?
- The data show signs of electronic cross-talk between PMTs in the HGC. This means that some PMT information needs to be identified as such, and ignored. This will require studies to be sure we understand the data, and coding changes to deal with the cross talk correctly.
- We presume that neither of these issues will have much affect on HGC calibration (i.e. photoelectron/channel conversion), but they could have a large effect on the HGC efficiency, particularly at high rate. Since the L/T-separation involves the comparison of runs at high and low epsilon, with very different rates, how this is done can have great bearing on whether the L/T-separation is done correctly or not.
- Some important figures of merit to look at will be tracking HGC versus rate, and also versus SHMS angle, since the focal plane background seems to be much higher at very forward angle. For many of the small angle settings we took physics data at different currents; we will want to also look at the SHMS normalized yields versus current in these settings, to see if things make sense or not.
- We don't want to slow down Richard's analysis work, so progress needs to be communicated to the rest of the Kaon-LT group on a timely basis.

### 2.2 SHMS PID study

- We need to use the HGC, in concert with Aerogel, TOF, and Calorimeter information for reliable particle ID. The issue, unfortunately, is that the HGC has an inefficient region near the middle. We need to get as reliable $\pi^+/K^+$ separation as possible, and the inefficient HGC region near the middle likely means we have to treat this region differently than the rest of the focal plane. Also note that the HGC optics were adjusted between the fall 2018 and winter 2019 runs, so these have to be studied separately.
- Questions: What cuts are needed for reasonably clean $\pi^+/K^+$ identification for each kinematic setting? Some figures of merit to look at include: events from $p(e, e'\pi^+)n$ and $p(e, e'\pi^+)\Delta^0$ leaking into the $K^+$ MM distribution, and cointime vs $\beta$ with PID cuts applied.
- Likely, it will not be possible to have completely clean $K^+$ identification for the fall 2018 data, although this might be possible for the winter 2019 data. To remove the remaining $\pi^+$ contamination in the $K^+$ data sample, it will probably require some intelligent subtraction of the $\pi^+$ background underneath the $K^+$ MM distribution. Not only will we have to investigate whether this is necessary, and if so, how best to do it, but we also need to carefully evaluate the systematic uncertainty involved in this. If we come up with several possible ways of doing this, we need to choose the one with the smallest systematic uncertainty, and thus the correct estimate of any uncertainties will become crucial.
- Likely, Richard will be doing some of his own PID studies in parallel. Cross-checking of results between you and Richard will be important, so we can learn from each other and obtain the best result.

# 3 Stephen Kay

## 3.1 Kaon/PionLT Calibrations

- Finalise Drift Chamber, calorimeter and Hodoscope Calibrations, for both the HMS and SHMS
- Verify consistency of calibrations, re-adjust as needed
- Maintain collaboration git repositories with latest parameters files and general analysis codes
- Contribute to student analysis efforts wherever and whenever needed

# 4 Garth Huber

## 4.1 SIMC updates

- The Hall C Monte Carlo, SIMC, is vitally needed for the L/T-separation part of the data analysis, where data at same Lorentz invariant observables $(Q^2, W, -t)$, but differing virtual photon polarization (epsilon) are combined to produce the separated cross sections.
- GH has his own fork of SIMC, which includes physics generators for many exclusive meson reactions needed for this analysis that are not in the master branch. GH needs to update his fork with the latest SHMS optics and reconstruction from the master version. He also needs to work with Mark Jones, Peter Bosted, and others, to make improvements to the SIMC master branch of broader benefit.