Minutes of the PANDA PID Computing Workshop 2108 at GSI

On May 3rd and 4th the PANDA PID Computing workshop was taking place at GSI. With around 30 participants, 14 contributions and intense discussions it was a very successful workshop which provided a deep insight into the PID capabilities of the PANDA detector and the implementation in the simulation framework. An extensive introduction and software overview was given at the start. Each of the PID capable subsystems introduced their principle of measurement, PID performance as well as beam test results, where available. Fast simulations, the tracking impact on PID as well as machine learning were covered at the end. There were in-depth questions and discussions amongst the experts, leading to a list of action items.
The introduction covered the PID quality measure definitions at PANDA. For Gaussian distributions the separation power definition used is Z=|m_1-m_2|/0.5(s_1+s_2). Also, a solution for non-Gaussian distributions was provided, which should be followed.

In the general overview and status report the inner works of the PID scheme were presented, which are at work since many years. Many of the open issues from back then are still to be taken up.
The way how to identify particles by their ionizing energy loss was presented in detail and an example was given how this information is used in the GlueX experiment.
One of the more recent developments was shown for the time-of-flight detectors (BTOF/FTOF), which attempt to reconstruct the event time t_0 as well as the PID of all charged particles in the event simultaneously from relative timing. A scheme how to combine this event based PID with the candidate based PID of the other detectors is not clear, yet.
The Cherenkov systems were represented by the DIRC, which received major improvements during the last years. Two approaches to the reconstruction, a geometric one and a time based are available and the test beam data agrees well with the simulations.
Electron and positron detection with the EMC as well as the correlation of tracks with clusters works= reasonably well. However the differences in the detection of particles and anti-particles has to be studied.
On the topic of muon detection, there is currently a beam Test at CERN, which will give more insight to the comparison of simulations with data.
Tracking employs a Kalman filter fit which takes material effects into account. This procedure depends on the particle hypothesis and will calculate different momentum values accordingly. At the moment all fits are done with a pion hypothesis which often does not lead to the most optimal resolution especially for low momentum particles. One major step is to extend the fits to all particle types and provide those fits to the PID and analysis stages.
The Fast Simulation generates PID information, based on full simulations and analytical functions. The results are comparable, yet not similar, to the full simulations.
Machine learning is a hot topic, especially in PID. We had a report about the activities and a first prospect to run hose algorithms with PandaRoot. The expected performance exceeds the current Bayesian approach significantly.

Action Items:

The open issues which have been discussed at the workshop are listed below and will enter the issue tracking system on our GitLab repository.

- Track fitting, PID and analysis with different tracking hypotheses. (W.Andersson, R.Kliemt)
- Test propagation of tracks to PID detectors
- Test Bayesian approach. If a detector is not used it should not influence the prob.
- Neutrals. Can we better distinguish them from charged particles?
- ChargedCand and NeutralCand use same class PndPidCandidate --> a lot of unused info in NeutralCand
- Propagator is GEANE --> should be exchanged to abstract propagator
- Correlator between tracks and PID detectors should be momentum dependent
- SetInputBranch / 2 should be more specific. 2 is for forward
- Test of pi0 detection
- Make default algorithms for PID
- Energy loss of electrons in MVD looks a bit too low. Check with experimental data
- Bethe-Bloch curve for protons in MVD looks strange
- Usage of BTOF as pre-shower detector
- Combine BTOF and FTOF data
- MDT: Muon / Pion separation looks different in data and MC. Specially the muons have a different shape
- Tracking with electron hyp gives very bad results
- STT: Implementation of reconstruction methods into PandaRoot
  - Usage of ToT method vs. full sampling
- MVA: connection of python classifier with PandaRoot
  - Check of bad performance of NN
- General
  - Should be possible to set cut values in analysis stage