Analysis Recipe

Note: This is just a basic concept for an analysis of a COLTRIMS experiment. Feel free to add or change steps.

0) Detector Adjustment:

- understand the concept of an LMF file containing multiple hits which are stored in vectors and arrays. Find and check on all detector channels, bunchmarker or other timing signals, ADC channels etc. (compare correlated channels and check the number of hits).
- find detector time sums of all layers and bring them to zero. Plot the sums against each layer position and correct towards a straight line.
- reconstruct positions on each detector using all layer combinations (take the default detector calibration values). Make sure that all layer combinations result in the same positions. Especially for a HEX anode a consistency check is needed; find the position offsets and scale factors if needed. Check the detector size with a dark count run to see the edges of the MCPs. Using a clean run with mostly single hits helps. Feed the RESORT routine.

1) Pre-Cleaning & Pre-Sorting:

- filter out electrons in good TOF window (check the simulation). Make sure to check on all hits in each event. Guess the TOF-zero or extrapolate it from the wiggle runs (check the simulation); use fish spectra.
- For electron double hits, also require the TOF difference to be in the right range (check simulation). Make sure to check on all hits in each event.
- filter out recoil ions in good TOF window (check the simulation). Make sure to check on all hits in each event. Guess the TOF-zero or use the relative elec-rec TOF; use fish spectra and PIPICO(s).
- single out the reaction channels of interest in the PIPICO(s) while checking the simulation. Use spectra like TOF difference vs TOF sum as well and use fit functions to create gates around PIPICO lines.
- if reaction channel and spectrometer configuration permit exploit the motion of the center of mass in ion TOF and positions on the detector to single out the event. If no simple function can be found, try to trace the Coulomb explosion by checking on ion TOF differences and position differences.
- Make all these TOF windows not too narrow (but if possible narrower as the bunchmarker spacing to rule out false electrons-bunchmarker coincidences)
- store all reaction channels that are visible (in case N^+/N^+ was the topic, take also N^{++}/N^+, N^{++}/N^{++}, non-dissociating N_2^{++} etc.). Note: This step needs a lot of CPU time and can take days or even weeks; you only want to do it once, so think carefully.

2) Calibration (convert Times to Energies and Momenta):

a) General:

- check stability of important values like time and position zeros against event counter (such as TOF and position of wiggles, TOF and position of single ionization).

b) Photons:
   - photon energy: compare scanned resonances to the literature and adjust the photon energy read out from the beamline monochromator control window accordingly.

c) Ions:
   - Electric field – ion side: add absolute electron TOF to electron-ion-TOF difference. Use differences in single or double ionization TOF peaks (different q/m) to get a first idea of the electric field. If available (and resolvable), exploit photo effect spheres for converting TOF and positions in momentum components. Fit the PIPICO spectrum (fit parameters are: spectrometer dimensions ±2 mm, time and position zeros ±5 %, E-field according to simulation or TOF peaks ±5 %). Calculate momentum components according to photo effect results or simulation and derive KER (use center of mass coordinates to improve the resolution). If measured use N^+/N^+ KER for calibration. Adjust momentum spheres to fit the KER. Calculate polar and azimuthal angels and plot them vs KER; use CUDA if possible.
   - check for momentum conservation in all components and on the sum on the ions.

d) Electrons:
   - Magnetic field: check electron fishes and correct any slope with a (linear) fit function. Then get the average of node TOFs distances and extrapolate to find an electron TOF zero via the simulation (this zero should be good to ±2 ns).
   - Electric field – electron side: if available, exploit photo effect measurements and fit spectrometer function in TOF vs Energy plots (fit parameters are: photon energy ±0.5 eV, spectrometer dimensions ±2 mm, E-field from ion calibration ±5 %, time and position zeros ±5 %). Calculate momentum components according to the photo effect results or the simulation and derive the electron energy. Adjust the momentum spheres to fit the electron energy. Calculate polar and azimuthal angels and plot them vs the electron energy; use CUDA if possible. If the electron electric field differs more than 3 % from the electric field on the ion side retune the ion side.
   - calculate momenta and derive electron energies.

e) Ions & Electrons:
   - check direction of the B-field and the relative orientation of the detectors. Use MFPADs of N_2 or CO for that or set gates on the ion detector and look for the respective positions on the electron detector. Use the residual gas line and the jet offset to find out the up/down direction on the ion detector.
   - If appropriate check for momentum conservation in all components and on the sum momenta.

3) Fine Sorting and Tuning:

- check for non-linearities (tilted spectrometer, lensing effects etc.)
- set gates on the ion energy or KER of interest if needed.
- for double electron hit: plot electron energies against each other and set gates if needed.
- plot electron single/sum energy vs. KER
- check energy conservation via electron sum vs KER and set gates.

4) Analysis:

- exchange particle numbering. Mirror TOF direction if needed due to a lack in statistics.
- generate internal frame coordinates. Define planes like electron & polarization vector, molecular axis (ion momentum difference) & polarization vector, molecular axis & electron, electron 1 & electron 2….
- make Dalitz plots