Current Overview of FF Simulations

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Discussion among ATHENA software experts, far-forward detector experts, and meson structure working group members

Preliminaries

- Current FF simulations are all over the place.
  - This was, in some sense, a product of the pre-YR era, when the FF section was for all intents and purposes detached from everything else.
  - Strongly depends on the IR development.
- As of now, IP6 is quite set in stone, so it's time to move past the phase of detached simulations, and have the FF + central detector act as one experiment.
- Multiple detectors, multiple reconstruction issues, QUITE COMPLICATED.
  - ZDC – calorimetric reconstruction, both EM and hadronic (plus software compensation), RP and OMD require transfer matrix reco, B0 requires more-standard tracking algorithms, e.g. KF.
- Multiple tools have been (and still are) used for the various FF simulations.
  - EicRoot, standalone GEANT4, DD4HEP

Our goal moving forward is to enable ANYONE with a relevant physics interest to perform simulations using the FF detectors, without needing a detailed understanding of all of the above.

This will require standardizing benchmarks so we can understand how a change to the lattice (e.g. when the quads change, which WILL happen) affects detector performance.

ZDC (ATHENA)

- Comprised of two independent subsystems.
  - W/SciFi EMCAL + Pb/Sci HCAL
  - Eventually need to add imaging layers, but this may be something we can “fudge” by simply adding a more granular digitization to a few layers.
- Performance verified in standalone GEANT4 simulations.
- No full reconstruction exists (in any framework) that includes clustering, etc.
- No studies have been carried out to establish linearity as a function of angle (transverse leakage will be worse for neutrons with larger polar angles).

Roman Pots

- Full reconstruction exists in both EicRoot, and DD4HEP.
- Detector reconstruction based on transfer matrix approach (see backup slides).
  - The transfer matrices come from the machine group, but can also be calculated by hand using a faux alignment procedure.
  - This method works well, as has been validated against the machine results. Makes calibration procedures fairly easy and allows us to be self-sufficient when running simulations.
- The reconstruction will be dependent on the species of particle (there is no PID in the RP or OMD).
  - Meaning, a pion and proton of the same momentum will land in different spots in the detector due to the different rigidities (the overwhelming majority of pions will not make it to the RP).

Off-Momentum Detectors

- Full reconstruction exists in EicRoot and DD4HEP.
- Basically the same setup as the Roman Pots, but modifications will NEED to be implemented when time permits.
  - Off-momentum particles do not always see linear transport through the quads, so an orbit-dependent reconstruction will be needed (rather complicated).

B0 Detector

- Full tracking and reco available in EicRoot (using GenFit); geometry exists in DD4HEP, still working out issue with ACTS tracking.
- Not much else to say – it's more or less conventional tracking, and the whole spectrometer can be pretty much self-contained.
- Preshower has not been studied carefully – it's just acting as a veto detector, but perhaps more can be done with it when more time is available.

Going Forward (pun intended)

- EicRoot had always been intended for retirement.
  - Its continued use was because of immediate needs for results between the EIC project IR design, proposals, YR, etc.
  - Its use now should be restricted to benchmarking and sanity checking as we complete the task in DD4HEP.
  - It will also be used for continued refinement for the IR with the project because the machine guys are used to it for checking BMAD orbits (nothing really to do with ATHENA).
- DD4HEP has all the pieces in place – the goal is to try and get things finished before the DPAP recommendation comes out so we are ready for what comes next.
- This gives us ~1.5 months to get the rest of the pieces working.

Task summary (non-exhaustive)

- Refine tracking algorithm for the RP and OMD.
  - Add-in ability for multi-track final states (e.g. for background rejection, He-3 breakup, etc.).
  - Refine matrix transport calculations (need to use local coordinates of detector – doesn't currently exist, so a transform is done…a bit inelegant).
- Clustering and reconstruction for the ZDC.
  - Island clustering et al. exists in the DD4HEP framework – how much can we reuse?
  - Software compensation (for neutrons) – need to configure calibrations to include the weighting for energy deposits in ECAL + HCAL for neutrons.
  - Add charged particle vetoing capability.
  - Imaging layers for hadron shower centroid determination.
- B0 tracking
  - Status of ACTS?
  - Benchmarks to ensure the performance matches previous studies.

For meson structure simulations; goal is to finalize simulation and ("fast") reconstruction for pion form factor, examine acceptance of detectors, kinematics of data.

Wait to begin studies of additional (more complicated) physics channels