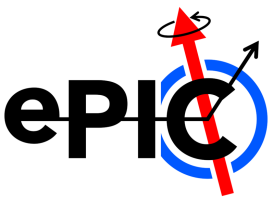
Tracking Alignment in SRO

Joe Osborn

Brookhaven National Laboratory

ePIC Collaboration Meeting

July 15, 2025

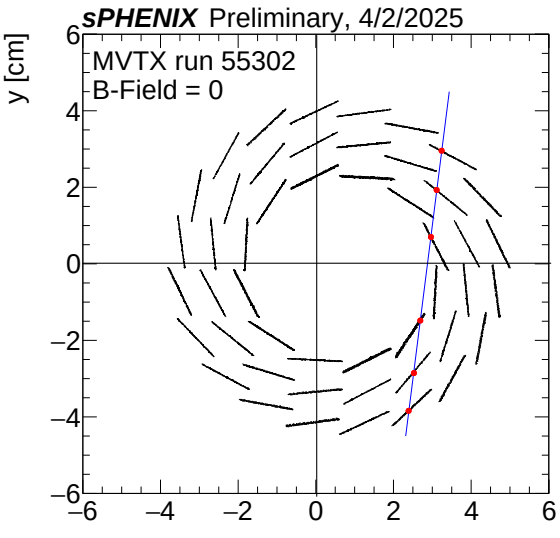


Alignment Preliminaries

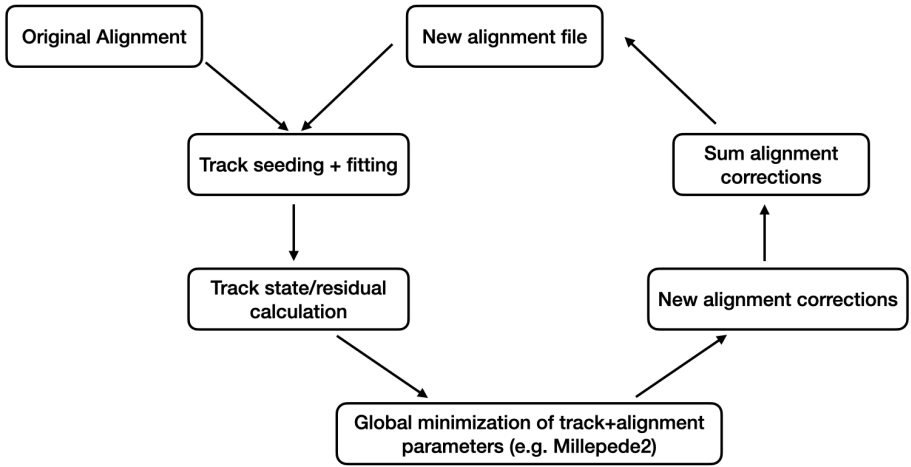
- Alignment of tracking detectors is an inherently iterative process, involving many types of data
  - Examples (in order): survey information, cosmics, tracks from signal/pileup collisions
  - Valuable to also include field off and on data
- There is not necessarily a "signal" need other than a good quality charged particle traversing as many subsystems as possible
- In the context of SRO - 100% of data could in principle be used for alignment

Survey Information

- Before any track based data is taken, survey should provide info on large global shifts
- Example: sPHENIX MVTX (ITS2 technology) installed 6 mm shifted from nominal origin (!)
- This is in principle “one and done” - modulo any maintenance



General Alignment Workflow

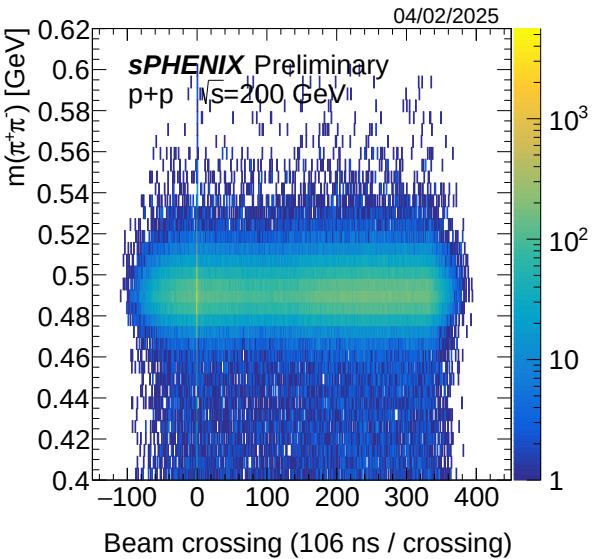


Streaming Cosmics

- Increase statistics in cosmic tracks by streaming 100% of data
- More imortantly - provides unbiased sample of cosmics traversing wide range of angles
  - Valuable for suppressing weak modes in alignment minimization
- Needs:
  - Dedicated cosmic track reconstruction
  - Offline software based “trigger”

Streaming Beam

- Tracks in the full time frame can be used for alignment
- Implementing a vertex constraint in the minimization requires an identified event
- Utilizing both pileup and collision tracks provides a more unbiased view of the alignment (and more data)
  - Example: $\mathcal{O}(1000)$ K_s^0 in triggered crossing, $\mathcal{O}(10k)$ in streaming crossings



Calibration Work Needed

- Still much offline development needed for alignment work in EICRecon
  - Transformation hooks in EICRecon
  - Calibration file format and storage (fit into broader calibration database structure)
  - Development (in Acts) of residual and derivative calculations (ongoing work, some examples exist)
  - Linking output into Millepede2 (or something else?)
  - Putting the workflow together

Discussion Questions

- Alignment inherently involves "glueing" separate subsystems together. How do we do this for the FF/FB/CB detectors?
- Alignment strategy - what is the reference subsystem with which we align all of ePIC to?
  - e.g. internally align inner most silicon, then work outwards...
- How much data is needed to run alignment? Depends on N_{trk}/time
- How often will we need to re-run alignment machinery? Depends on maintenance, access, field conditions, more...
- There will be a commissioning period - Reconstruction and calibration machinery will not be in a steady state initially
  - In order to align properly with tracks, you need to confirm your tracks look like you expect! We will need to verify every step of the reconstruction

Useful references

- https://cds.cern.ch/record/1047047/files/thesis-2007-049.pdf
- https://www.desy.de/∼kleinwrt/GBL/doc/cpp/html/
- https://www.desy.de/∼kleinwrt/MP2/doc/html/index.html