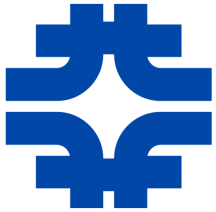


FNAL Software School
Day 4

Matt Herndon,

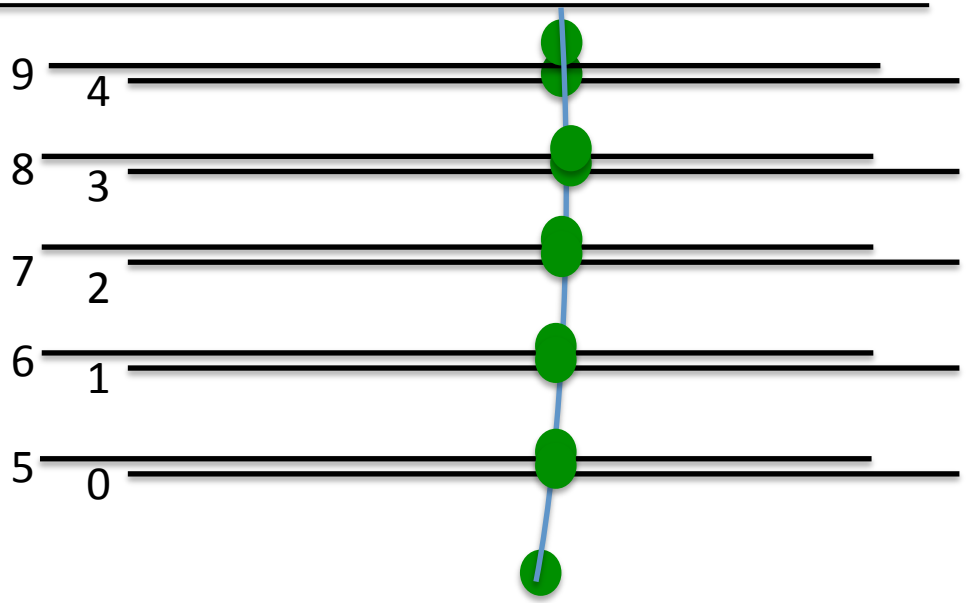
University of Wisconsin – Madison

Today's Activities

- Introductory slides
- Review Day 3 exercise
  - Did you succeed in building candidates?
  - Review of TrackCandidateStratech2X1SASML
    - ML searches multiple combinations of layers
- Lecture
  - Performance metrics in Tracking
  - Integrating assessment tools
- Daily project:
  - Candidate finding performance

Day 3 exercise

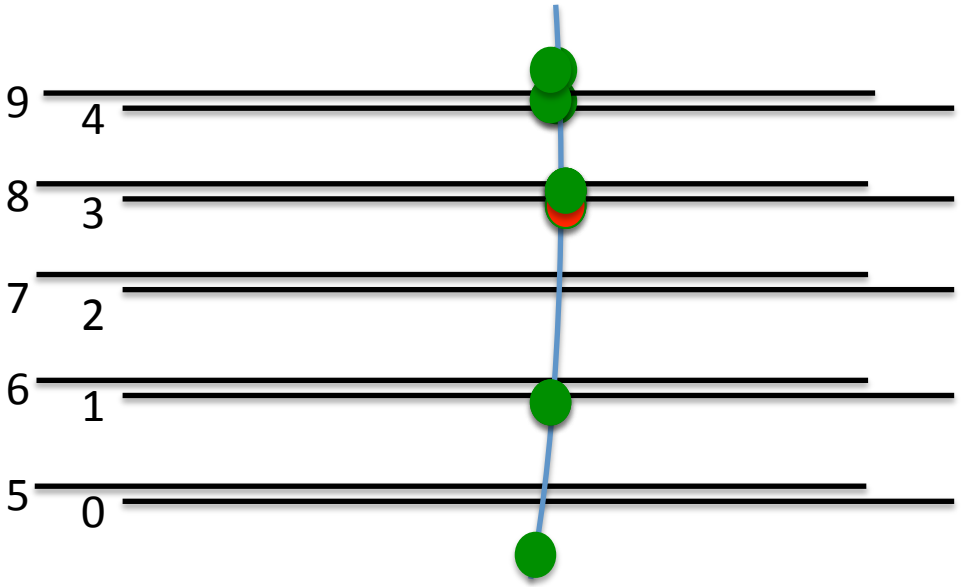
- TrackCandidateStrategies
  - Find 2 X hits and the PV
  - Find 1 SAS hit and the PV
  - Minimum information needed to form a helix trajectory
  - Leveraged that the 4 and 9 hits are near each other and the low SAS angle to determine the correct paring



- Candidates are the starting point for track reconstruction
  - Will search interactively from outside to in adding hits along the trajectory and refitting to get better uncertainties

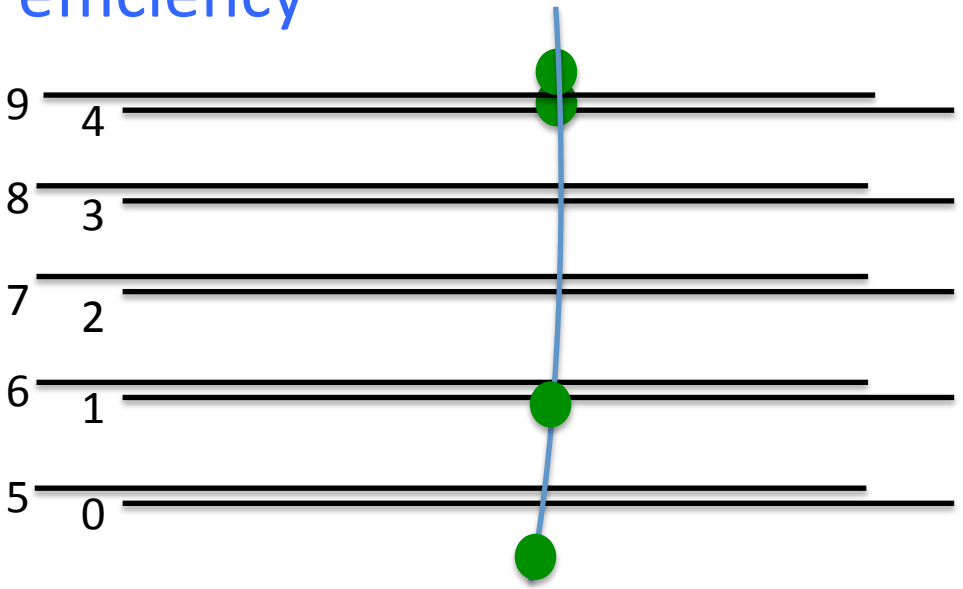
Day 3 exercise

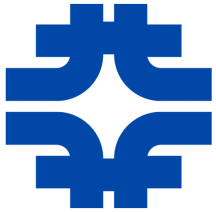
- TrackCandidateStrateg2X1SAS
  - 4,9,3 algorithm Inefficient. One hit lost due to inefficiency and the track is not found
- TrackCandidateStrateg2X1SASML
  - Address this by adding redundancy. 1 extra X layer and 1 extra SAS in patterns of 3
  - 4,9,3, 4,9,1, 4,3,8, 3,8,1
  - All triplets must include a a X-SAS pair: 4,9 or 3,8
  - Issue, typically the same track is found 4 times.
- Duplicate issue solution
  - duplicateTrackSetFilter
  - Identify and remove them



Initial performance Assessment

- TrackCandidateStrateg2X1SASML
  - Very fast
  - Produces ~200 track candidates with 10 tracks
  - 40 may be real, but 4x duplicated
  - Today we will assess the efficiency
  - Should be ~100%






FNAL Software School: Lecture 4 Tracking Performance

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Performance Assessment

- Assess
  - Efficiency
  - Accuracy of parameters and uncertainties
  - Fake object rate
  - Execution speed and memory usage
- A General principal
- Need a mechanism of unambiguously associating reconstructed objects to generated ones to assess efficiency, resolution and fake rate.

Performance Assessment

- Efficiency, resolution, fake rate
- Hit
  - Position matching work perfectly
  - (Demonstrated that efficiency, parameters unbiased, uncertainties well estimated after some work)
- Candidates
  - Helix parameter matching (equivalent of position matching) unlikely to work since they are so poorly measured.
  - Hit matching will work since we understand which track each hit was from
- Fully reconstructed tracks
  - Either hit matching of helix parameter matching would be interesting.
- Fake track rate: what doesn't get matched
- These first three consideration requires a infrastructure for performance assessment
- Execution speed, Memory usage
  - Use tools like profilers, or even date command

Performance Assessment Hits

- Hit
  - Position matching work perfectly
  - Demonstrated that efficiency, parameters unbiased, uncertainties well estimated after some work
- With a fully realistic simulation
  - May not work in a fully realistic detector simulation
  - Answer: include track number information with each simulated strip. 100% effective by design.
  - Will also have a fake rate

Performance Assessment Candidates

- Track Candidates
  - Goal, to have near 100% efficiency.
  - Will assess efficiency using a technique called hit matching
  - As opposed to helix matching used in TrackCompareModule
  - Helix parameters are very poorly measured for track candidates.
- Hit matching
  - Perfect tracks are designed to have all the correct reconstructed hits by matching against the simulated hits.
  - To demonstrate near 100% efficiency we will check how many matching patterns of 3 hits are found in the track candidate set.
  - Layers 9, 4 8, 3 7, 2 6, 1 5, 0
  - Ptrack 15 26 37 45 66 78 79 85 90 95
  - Cand 15 26 45
  - Cand 15 26 85
  - Cand 26 37 45
  - Cand 37 45 85
  - Without efficiency all four patterns found – remember we only need 1 of 4
  - Once we have matched we can plot the helix parameters for all the matches

Fake rate, how many non matching candidates were there?

Performance Assessment Tracks

- Tracks
- Goal, to have high efficiency: > 95%
  - Helix parameter matching will probably work
  - Matching against perfect tracks is best
  - Modify TrackCompare module to use perfect tracks and have appropriate tolerances.

Integrated Design

- Performance assessment has to be built into the system from the beginning.
- Hits: hit matching by position is 100% effective
- Track Candidates
  - Essentially finding a seed set of Hits. Assessed by hit matching
- Full track reconstruction
  - Can go wrong or partially wrong. Hit matching and parameter matching possible solutions.
- TrackFit performance
  - PerfectTracking driven by Hit matching 100% effective.
- Required correct choices in data object design and a full set of performance assessment Modules designed to work with the reconstruction modules.

Daily Project

- Compare the performance of
  - TrackCandidateStrategy2X1SAS
  - TrackCandidateStrategy2X1SASML
  - TrackCandidateModule now has a switch controlling which is called
  - Try different hit efficiences 98%, 90%
- Metrics
  - Efficiency
  - Candidates list size and number of fakes
- Coding project
- Starting module: CandidateCompareModule
- Input: perfectRecoTracks and trackCandidates TrackSet objects
  - Tracks in those objects both contain lists of Hit indices.
- Output: How many matched patterns are found: 0-4
- Once you have a match you can Histogram track parameters
- Coding
  - Using perfectRecoTrack hit indices and check all candidates to find matches

Duplicate Track Issue!

- If time
  - Run TrackRecoModule
  - Place to implement duplicateTrackSetFilter is already prepared and execution time and prinouts can be used a check the effect.