Update on SoLID Simulation Track Reconstruction

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SoLID Collaboration Meeting
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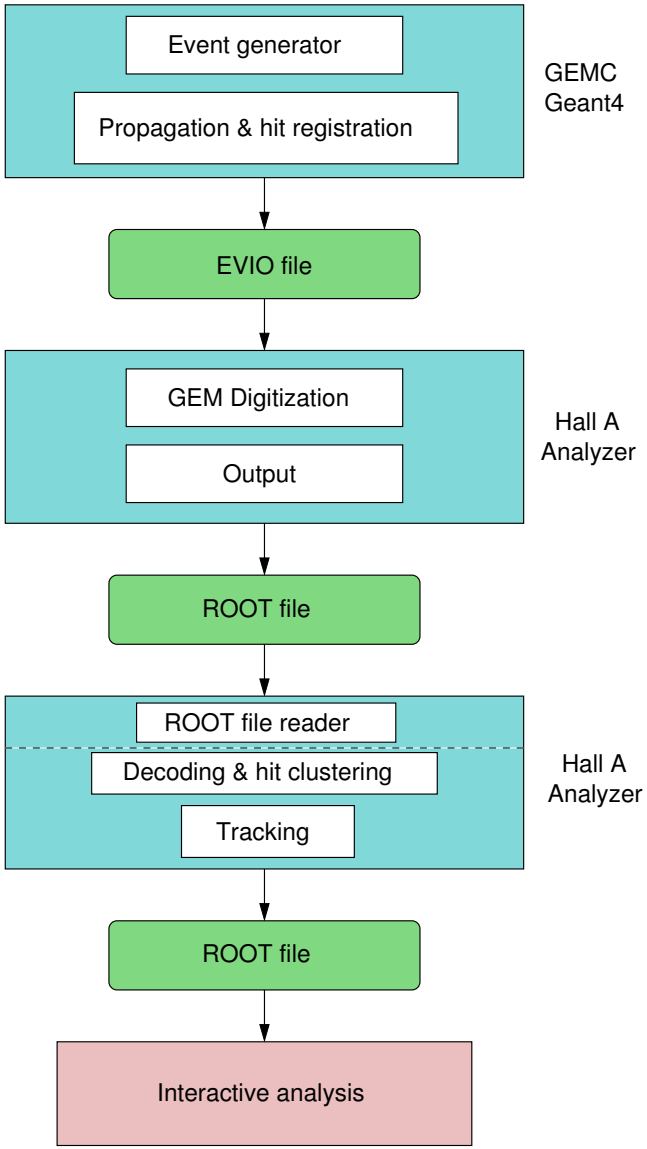
Track Reconstruction Simulation

- `solgemc` EVIO files as digitization input (S. Riordan)
- GEM digitization based on SBS work (E. Cisbani, R. Holmes)
  - APV25 pulse shape simulated
  - Ad-hoc noise simulation (random time offset)
  - No other detectors digitized yet
  - Partial passthrough of generated data (tracks, vertices)
- ROOT file interface
- Tracking



Progress Since Last Meeting

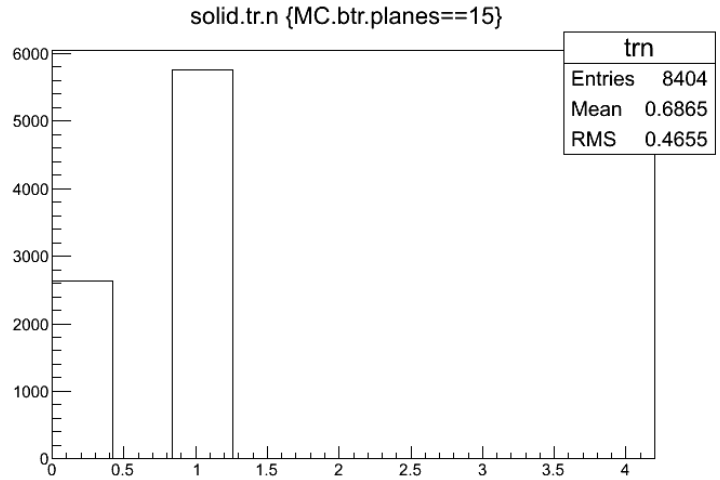
- Investigated "low" (88%) tracking efficiency for "muons, no field, no materials" (clean data set)
- Analyzed "muons, no field, with materials" data set
  - Surprise: Apparent tracking efficiency drops to $\approx 69\%$
  - Not yet understood
- Added background to "with materials" data set
  - Full background defined by 50 μA beam current, 200 ns time window
  - 0.2% – 10% background levels studied
  - Higher levels very time-consuming to digitize (can be improved)
  - NB: Background runs done with field on
    - ★ Good: low-energy charged particles deflected from trackers $\rightarrow$ realistic simulation of noise
    - ★ Bad: actual secondary tracks curved, reconstruct with low efficiency (see last meeting's talk), thus underestimated
- Details: next slides

Why Only $\approx 88\%$ Tracking Efficiency With Clean Data?

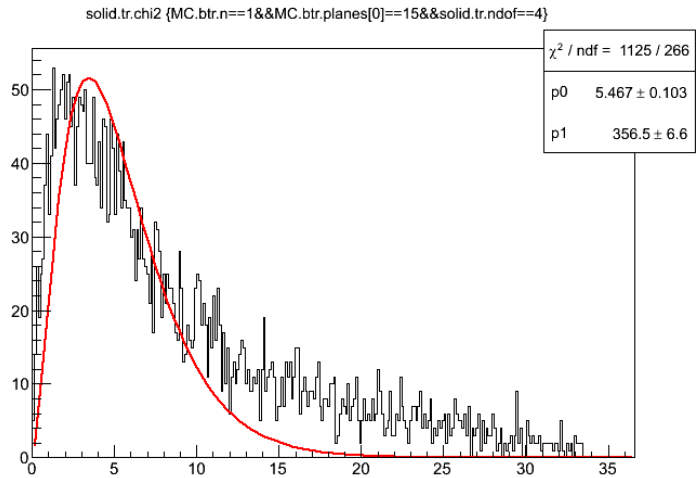
- Single-hit efficiency
  - Digitization with present parameters gives $\approx 90\%$
  - u and v hit efficiency almost perfectly correlated
  - 2D fit with 4 planes allowing up to 1 missing hit $\rightarrow \approx 95\%$ fit efficiency
  - Could be improved with 5th tracker plane, allowing 2 missing hits
- Amplitude correlations
  - u-v amplitude asymmetry $< 18\%$ considered a match
  - Allowing 1 out of 4 mismatches
  - Almost 100% efficient
- χ^2 cuts
  - Cuts applied to both 2D and 3D fit results
  - Long tails $\rightarrow$ multiple scattering?
  - $\approx$ 92–96% of tracks pass each cut (partly correlated)
  - Could possibly be improved with different tracking algorithm
- Combining these (correlated) efficiencies largely explains observed overall tracking efficiency

Tracking Efficiency For "Muons, no field, with materials"

Number of tracks found for MC tracks crossing all planes



Track χ^2 for $n_{dof} = 4$



- Track finding efficiency

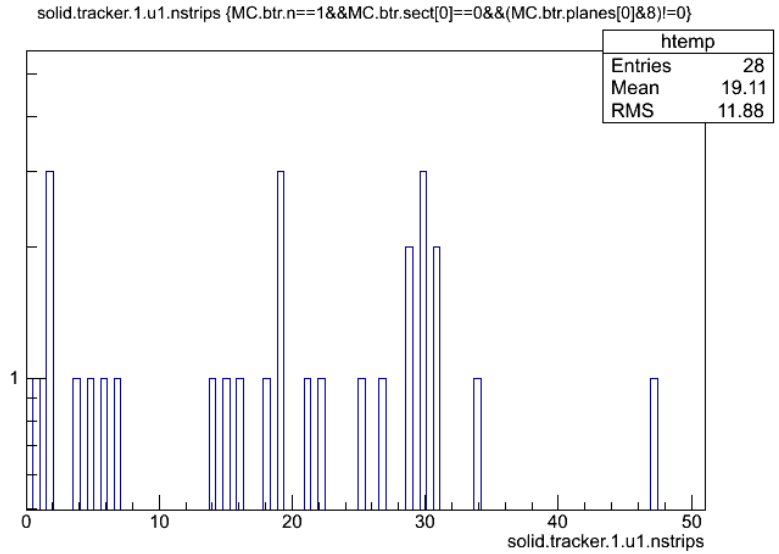
$$\frac{5766}{8404} = 68.6\%$$

- Much lower than $\approx 88\%$ of "no materials" data set!?
- Bug? Wrong parameter? Geometry problem? Beam spray?
- Don't panic. This might be a bug. To be investigated.

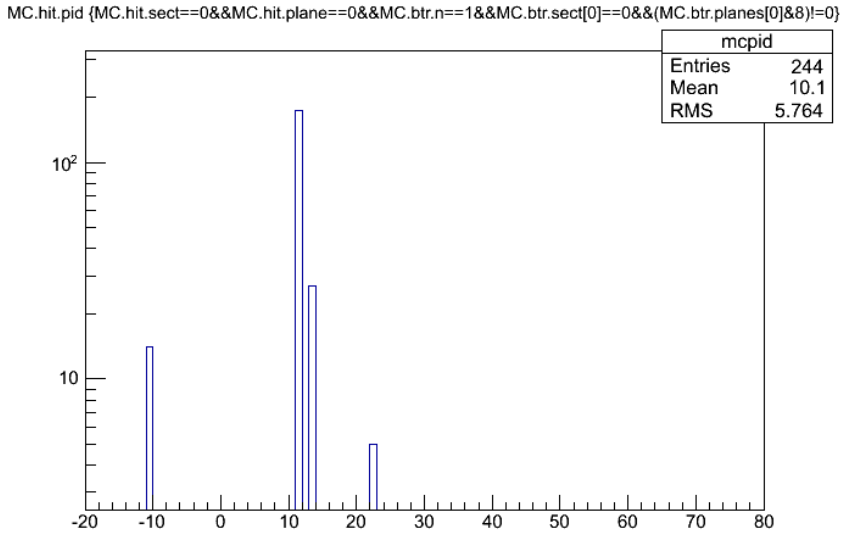
Muons, no field, with materials
10% background added

Strip Occupancy, 10% background

Number of strips above ADC threshold, sector 0 plane 0



PID of hits, sector 0 plane 0

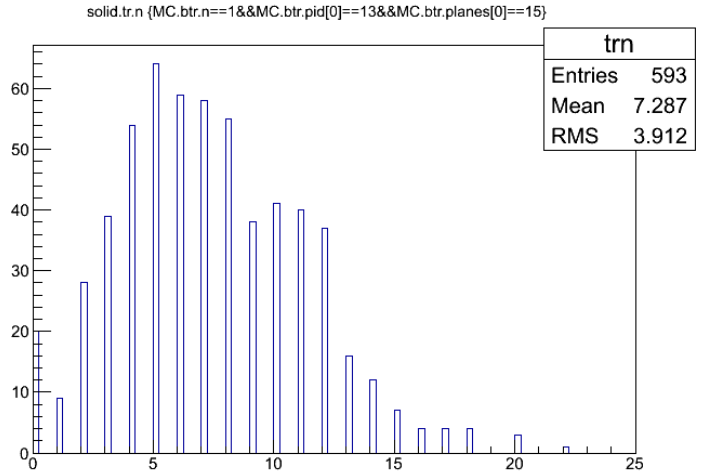


PRELIMINARY			
Plane	nstrips_{mean}	# strips	Occupancy (%)
u1	20.8	681	3.1
v1	22.3	579	3.9
u2	16.1	897	1.8
v2	17.9	643	2.8
u3	15.7	1077	1.5
v3	16.1	1077	1.5
u4	14.6	1153	1.3
v4	15.1	1153	1.3

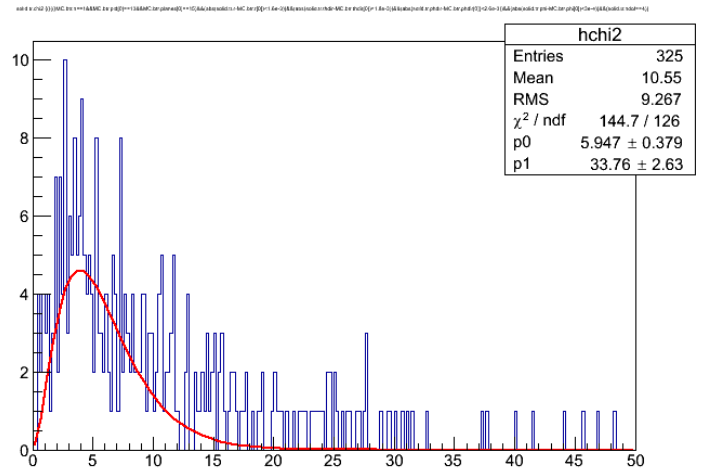
- First plane sees many slow electrons ($p < 1$ MeV)
- Occupancy depends on ADC cut. Not yet optimized
- Obviously, will get $\times 10$ higher occupancy with 100% background
- Estimated SBS raw occupancy $< 20\%$ in all planes

Tracking Efficiency For 10% Background

Number of tracks found for MC tracks crossing all planes



χ^2 of tracks with $n_{dof} = 4$ and passing 3σ-cuts on residuals



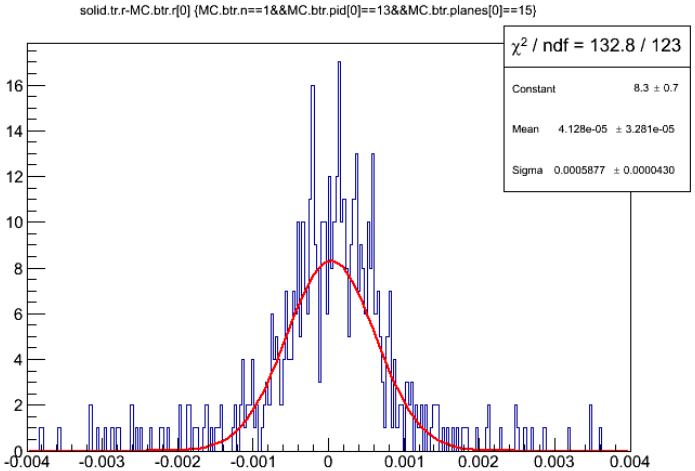
- Track finding efficiency

$$\frac{373}{593} = 62.9\%$$

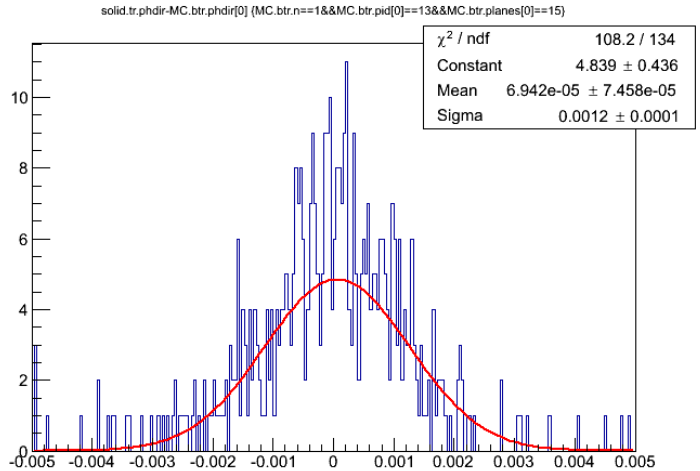
- This is this probability that an actual track will be "accurately" reconstructed.
- Experimental track finding probability will likely be higher because
  - Even "not accurately" reconstructed tracks might appear acceptable
  - Some ghost or secondary tracks might look like real tracks, too
- Ghost and secondary track rates not yet determined. Requires additional analysis code (in development).

Residuals

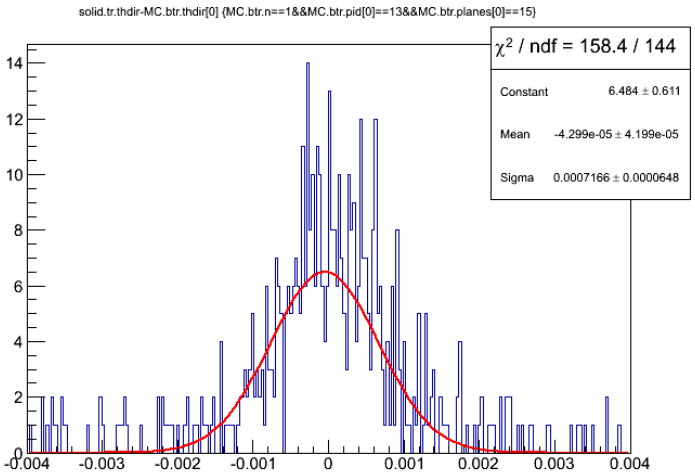
r-coordinate of crossing point in first GEM plane



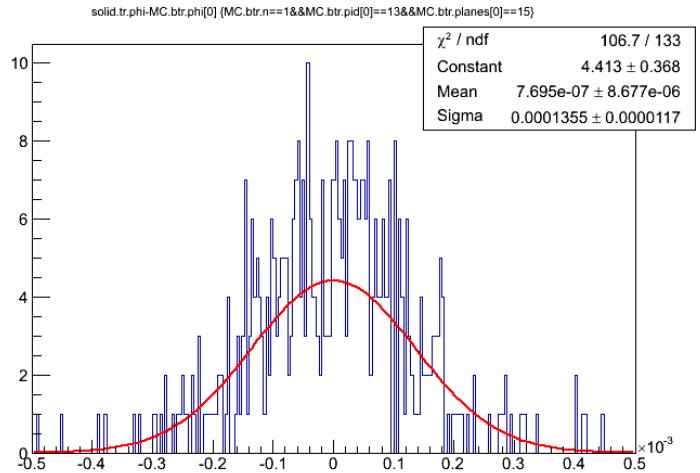
ϕ-coordinate of crossing point in first GEM plane



θ_{dir}: Polar angle of momentum



ϕ_{dir}: Azimuth of momentum



Preliminary Observations

- Occupancies appear similar to SBS case. Encouraging.
- Apparently only small tracking efficiency difference between 0% and 10% background cases. Encouraging, but to be confirmed.
- Presence of field in background data leads to underestimation of secondary track rate. Probably no workaround possible with TreeSearch algorithm.
- Impact of ghost and secondary tracks difficult to determine without information from other detectors.

Next Steps

- Investigate odd drop of efficiency when materials are added to signal runs (1 week)
- Finish code development for ghost & secondary track rate determination (1 week)
- Improve digitization speed, e.g. fold 30 sectors into one as suggested by Paul Souder (1 week)
- Add logic to distinguish signal from background similar to what non-tracking detectors would do (e.g., crude target reconstruction, rough approximation of Cherenkov & calorimeter responses based on known PID and momentum, etc.) (1 week)
- Simulate 50% and 100% background (few days)
- Extract performance data & finish writeup (1 week)