SoLID Tracking

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SoLID Collaboration Meeting

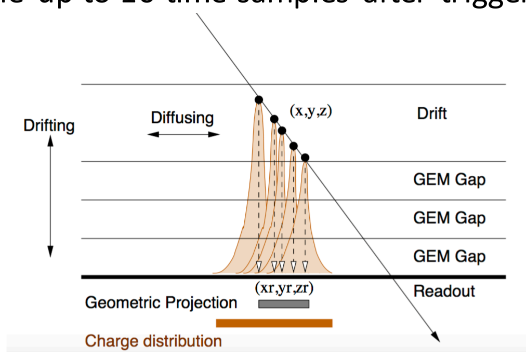
May 6th 2016

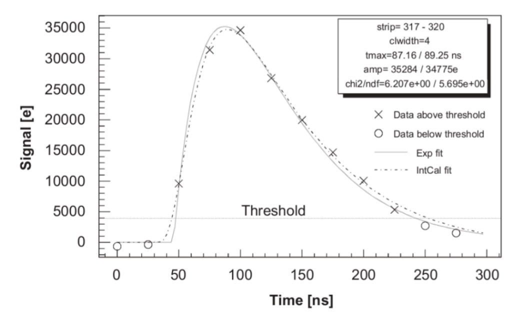
Outline

- Digitization for SoLID-SIDIS and J/ψ configuration
- Progressive tracking for SIDIS configuration with Helium-3 target
- Conclusion and plan

Digitization

- GEM digitization based on SBS work (E. Cisbani, R. Holmes) and Ole's work for SoLID.
- Input: GEMC hit position and energy deposition in the gas layer above the first GEM foil.
- Process:
  - Poisson-distributed number of ion pairs based on energy deposition
  - Uniform distribution for ionization probability along the path
  - Assume constant-velocity diffusion and drift
  - Gaussian distribution of charge deposition on strips
  - GEM response tuned to match COMPASS observation
  - Sample up to 10 time samples after trigger





Digitization for SIDIS (J/ ψ)

- Geometry:
  - 6 GEM trackers in total (4 for LA, 5 for FA). Each contains 30 non-overlapping GEM chambers. No dead-area
  - Need to update this once the design of GEM trackers is finalized
  - 40 cm Helium-3 target (15cm LH2 target)
- Signal run (from Zhiwen):
  - Generator: uniform
  - Only interactions of primary particles recorded
  - Signal particles: electron
- Background run (From Zhiwen):
  - 1e8 electrons shooting at the target
  - Randomly select background event to mix with the signal (total number depends on the beam current and size of simulation time window)
  - For each event, also randomize the timing

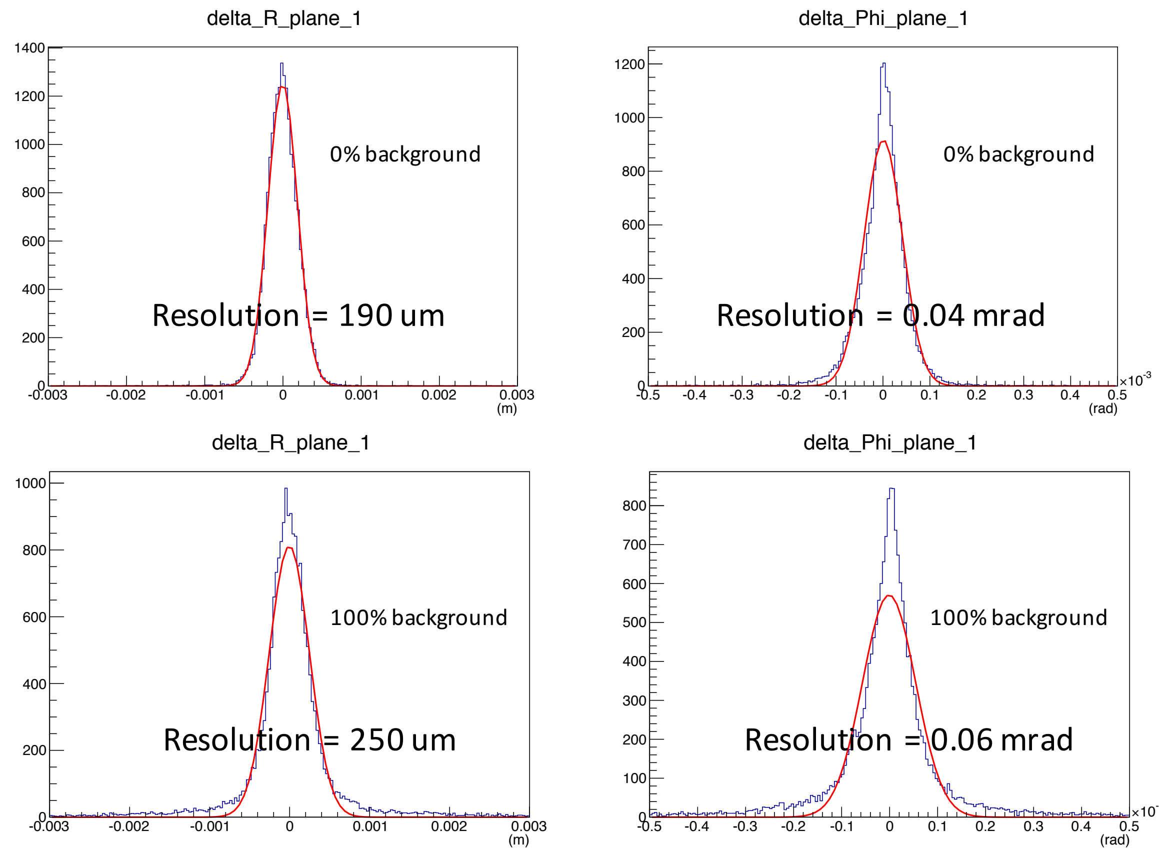
GEM Occupancy for SIDIS (J/ ψ)

- 100% background.
- 275 ns time window in the simulation (200ns before trigger start time and 75 ns after)
- Raw Occupancy: # of u/v strips above threshold / # of total u/v strips
- Noise cut (NC): amplitude ratio between 3 time-samples, require raising edge

	Raw Occu for u (threshold = 0) (%)	Raw Occu for v (threshold = 0) (%)	Raw Occu for u (threshold = 10) (%)	Raw Occu for v (threshold = 10) (%)	Occu after decon and NC for u (%)	Occu after decon and NC for v (%)
GEM 1	4.7 (11.7)	4.9 (11.8)	4.3 (10.8)	4.5 (10.9)	0.9 (2.4)	0.9 (2.4)
GEM 2	16.6 (22.8)	16.6 (22.9)	15.7 (21.7)	15.7 (21.9)	3.5 (5.1)	3.5 (5.1)
GEM 3	8.7 (15.3)	8.8 (15.4)	8.0 (14.2)	8.1 (14.3)	1.6 (3.2)	1.6 (3.2)
GEM 4	4.7 (12.7)	4.8 (12.8)	4.4 (11.7)	4.4 (11.8)	0.9 (2.6)	0.9 (2.6)
GEM 5	4.8 (13.0)	4.7 (13.0)	4.3 (11.7)	4.2 (11.7)	0.8 (2.6)	0.8 (2.6)
GEM 6	3.8 (10.8)	3.7 (10.9)	3.3 (9.6)	3.3 (9.7)	0.6 (2.1)	0.6 (2.1)

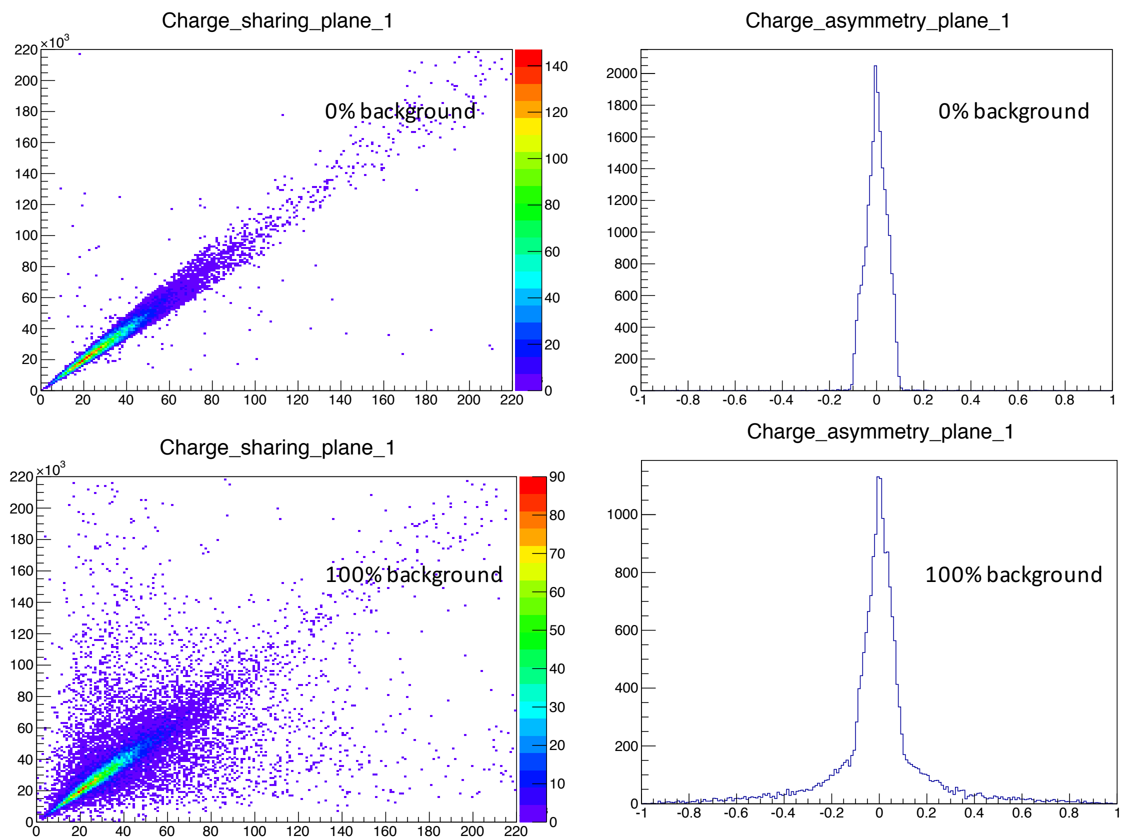
Signal Hit Resolution

- R resolution and phi resolution on the second GEM plane (the one has highest background rate)
- Resolution at 100% background level deteriorate due to clusters hitting the same strips (overlapping)
- Resolution way too good (should get 60um resolution along the readout strip direction)



Signal Charge Sharing and Asymmetry

- Charge sharing and charge asymmetry on the second GEM plane
- Charge asymmetry: (qu-qv)/(qu+qv)
- Cut on charge asymmetry can be effective at killing false hit (due to ambiguity in hit coordinate matching in 2D readout device). But the effect deteriorate as the occupancy goes up



Tracking

- Developed a semi-new tracking program based on Ole's TreeSearch program
  - Decoder, clusterization, and deconvolution identical as TreeSearch
  - Software structure modified a bit in order to take into account also SIDIS and J/ ψ configuration
  - Hit amplitude matching can be done before (or after) tracking
  - Checked the decoded result against the TreeSearch program with the Old PVDIS digitization input. No difference.

- Use Xin Qian's progressive tracking algorithm as pattern recognition:

Loop over all hits on all GEM detectors, select candidate tracks based on the track model

Examine the candidate tracks:
how well they can be described by helixes
Charge asymmetry for each hit
Coarse vertex z reconstruction

Select the best track(s) pass the second step exam as the final output

SIDIS Large Angle Event

- Signal particle:
  - 15k Electrons that hit LAEC with E deposition > 0.9 GeV
- Condition:
  - 100% background
  - LAEC hit info (1 cm resolution) used in pattern recognition.
  - 3-sample deconvolution algorithm applied
  - Signal hit recon efficiency (after noise cut): ~97%

	Zero track	Single track	Multi track
Efficiency	2.0%	97.2%	0.8%

	0	1	2	3	4
# of ghost hit per track	95.2%	3.7%	0.4%	0.7%	0.1%

SIDIS Forward Angle Event

- Signal particle:
  - 8k Electrons that hit FAEC with E deposition > 0.9 GeV
- Condition:
  - 100% background
  - FAEC hit info (1 cm resolution) not used in pattern recognition.
  - 3-sample deconvolution algorithm applied
  - Signal hit recon efficiency (after noise cut): ~97%

	Zero track	Single track	Multi track
Efficiency	1.7%	77.0%	21.3%

	0	1	2	3	4	5
# of ghost hit per track	70.7%	7.2%	0.8%	0.1%	12.7%	8.4%

Result pretty bad. Possible explanation is high energy tracks exists in background file, cannot distinguish them with GEM info only, need help from downstream detectors.

SIDIS Forward Angle Event

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  - 3-sample deconvolution algorithm applied
  - Signal hit recon efficiency (after noise cut): ~97%

	Zero track	Single track	Multi track
Efficiency	2.0%	95.0%	3.0%

	0	1	2	3	4	5
# of ghost hit per track	86.8%	8.9%	1.0%	0.2%	2.2%	0.9%

Simulation indicates that $\Delta\varphi$ between hits on last GEM and FAEC is no larger than 70 degs. Look for hits only in a region +/- 70 degs around the hit on FAEC. This is a very crude judgment.

SIDIS Large Angle Event

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  - 15k Electrons that hit LAEC with E deposition > 0.9 GeV
- Condition:
  - 100% background
  - LAEC hit info (1 cm resolution) used in pattern recognition.
  - 3-sample deconvolution algorithm not applied
  - Signal hit recon efficiency (after noise cut): ~95%

	Zero track	Single track	Multi track
Efficiency	5.8%	83.2%	11.0%

	0	1	2	3	4
# of ghost hit per track	74.8%	9.5%	4.5%	1.1%	0.7%

SIDIS Forward Angle Event

- Signal particle:
  - 8k Electrons that hit FAEC with E deposition > 0.9 GeV
- Condition:
  - 100% background
  - FAEC hit info (1 cm resolution) used in pattern recognition.
  - 3-sample deconvolution algorithm not applied
  - Signal hit recon efficiency (after noise cut): ~95%

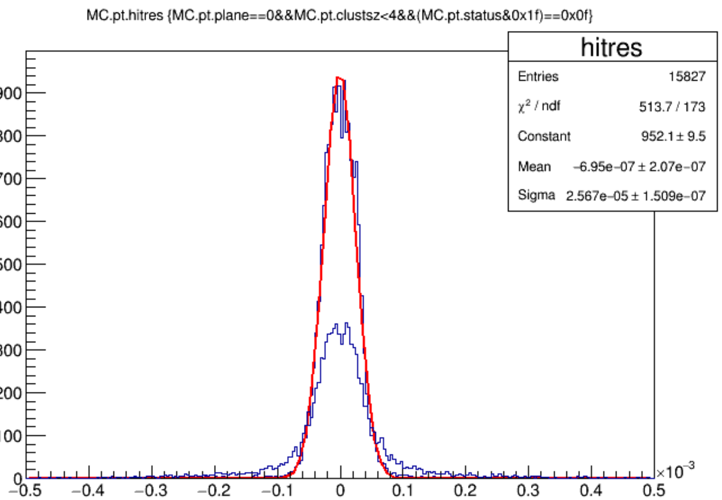
	Zero track	Single track	Multi track
Efficiency	2.1%	38.4%	59.5%

	0	1	2	3	4	5
# of ghost hit per track	28.7%	8.6%	2.8%	2.6%	55.4%	1.9%

Conclusion

- Info on downstream detectors is necessary for pattern recognition (FAEC, SPD, Cherenkov and MRPC)
- Progressive tracking is good enough for current SIDIS background level and current digitization
- Progressive tracking is not sufficient if we have only one APV25 time sample, if without major modifications to the algorithm

- Plan to develop a Kalman Filter pattern recognition algorithm
  - Has numerous applications, argubaly the most popular tracking algorithm nowaday
  - Very good ability at selecting signal hits, this ability gets better as more hits added to the track
  - Drawback: slow due to field propagation, high dimentional matrices manipulation. Initialization is tricky, ability to distringuish signal hit weak at the beginning.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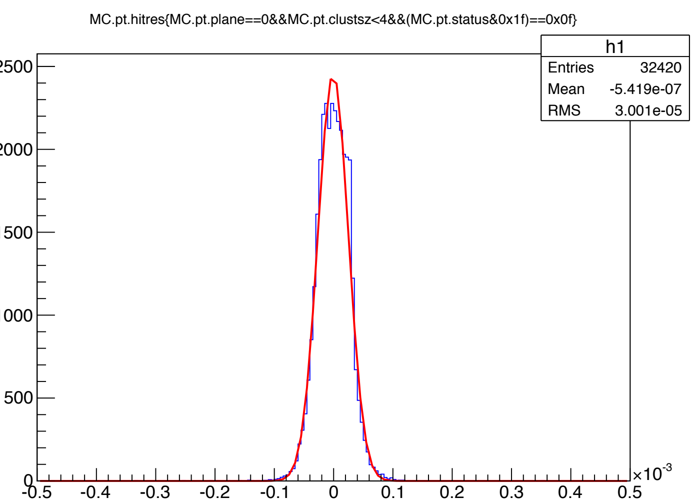
hitres
Entries 15827
χ^2 / ndf 513.7 / 173
Constant 952.1 ± 9.5
Mean −6.95e−07 ± 2.07e−07
Sigma 2.567e−05 ± 1.509e−07
×10^-3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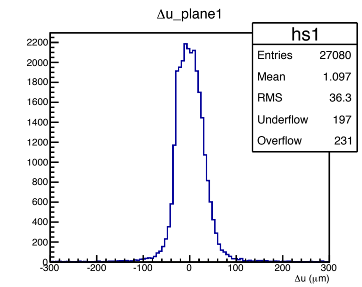
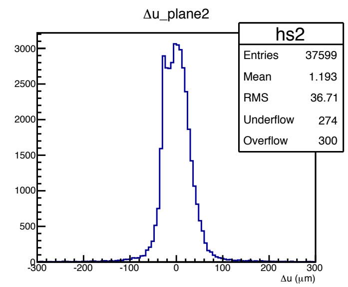
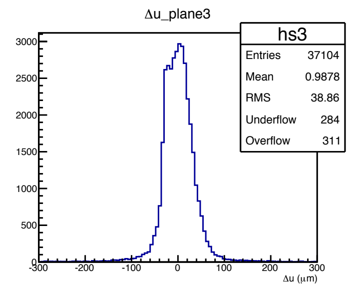
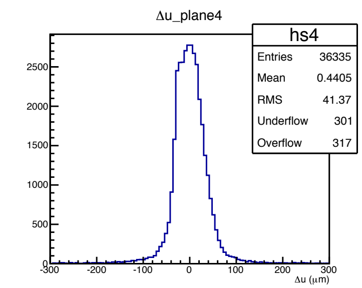
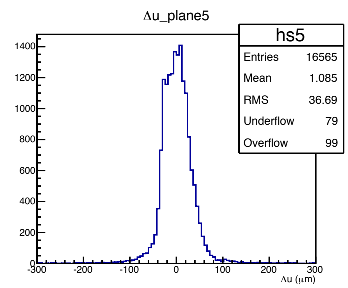
h1
Entries 32420
Mean -5.419e-07
RMS 3.001e-05
×10^-3

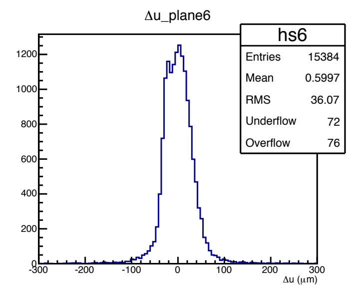

Δu_plane1
hs1
Entries 27080
Mean 1.097
RMS 36.3
Underflow 197
Overflow 231
Δu (μm)


Δu_plane2
hs2
Entries 37599
Mean 1.193
RMS 36.71
Underflow 274
Overflow 300
Δu (μm)


Δu_plane3
hs3
Entries 37104
Mean 0.9878
RMS 38.86
Underflow 284
Overflow 311
Δu (μm)


Δu_plane4
hs4
Entries 36335
Mean 0.4405
RMS 41.37
Underflow 301
Overflow 317
Δu (μm)


Δu_plane5
hs5
Entries 16565
Mean 1.085
RMS 36.69
Underflow 79
Overflow 99
Δu (μm)


Δu_plane6
hs6
Entries 15384
Mean 0.5997
RMS 36.07
Underflow 72
Overflow 76
Δu (μm)