DUNE 10kt HD Initial Tests

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FD sim/reco meeting
1st July 2024

Thanks to Haiwang for providing Hydra/wirecell
Thanks to Viktor for providing the latest 10kt HD geometry

Introduction

- We have been using workspace geometries for physics studies due to computing footprint constraints

    - The largest footprint comes from the signal simulation and signal processing: memory and CPU time are prohibitively large out of the box

- Recent developments in wirecell (Hydra: previous talk) have potentially unlocked the signal simulation and signal processing for the full 10kt

- Workflows are now being configured for the horizontal drift 10kt geometry

    - Heavily reuses well-tested 1x2x6 HD sim/reco

Branches for 10kt HD

- **Larsoft**: v09_91_00

- **dunesw**: dbrailsf_dune10kt
  - Sets up job fcls

- **dunesim:** dbrailsf_dune10kt
  - Sets up larg4 sensitive detector

- **dunereco:** hydra
  - Wirecell signal sim/sig proc for full 10kt (hydra)

- **dunecore:** feature/vpec_add_fd_full_geom_gdml
  - Latest 10kt geometry

Test sample

- Single particle gun muon

  - 5 GeV

  - Fired from near the edge APA into the detector

  - Shallow-ish angles

- Blue line is the true muon trajectory traced through the 10kt geom
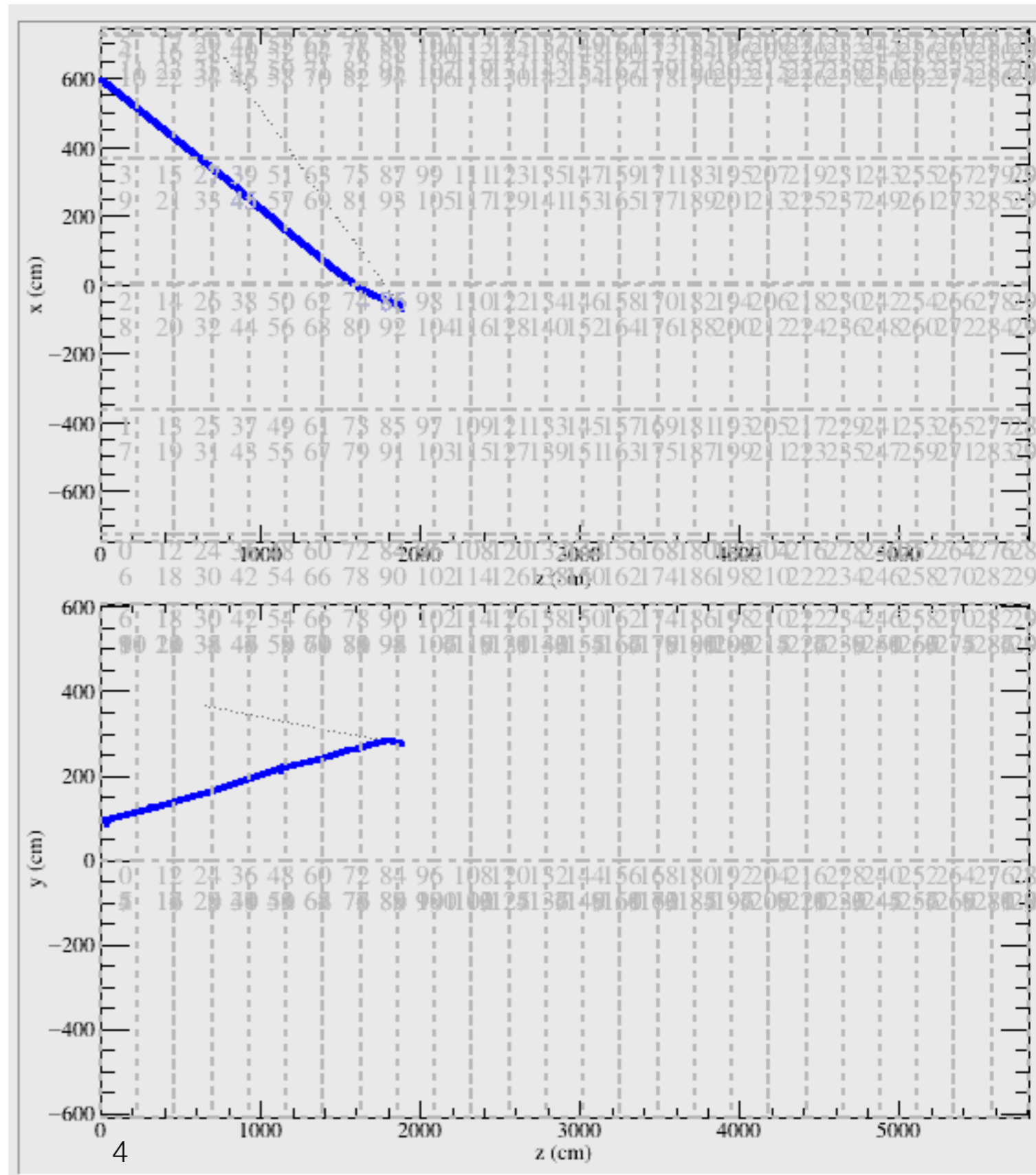
Computing footprint

Stage	Max mem. (GB)	Average time (s)	Producer	Average time (s)
Gen	0.7	0.002	SingleGen	0.002
G4	1.2	**221**	LArG4Main	0.19
			IonAndScint	0.04
			PDFastSimPAR	**220**
Detsim	**6.5**	**154**	WireCellToolkit	**128**
			OpDetDigitizerDUNE	26
Reco1	1.0	0.6	GausHit	0.37
			SpacePointSolver	0.17
			DisambigFromSP	0.01
Reco2	**3.4**	**160**	Pandora	2.7
			EMTrackMichelID	**82**
			PMAlgTrackMaker	12.5
			…	62

On-disk size is ~30MB per event (for all stages)

Event display
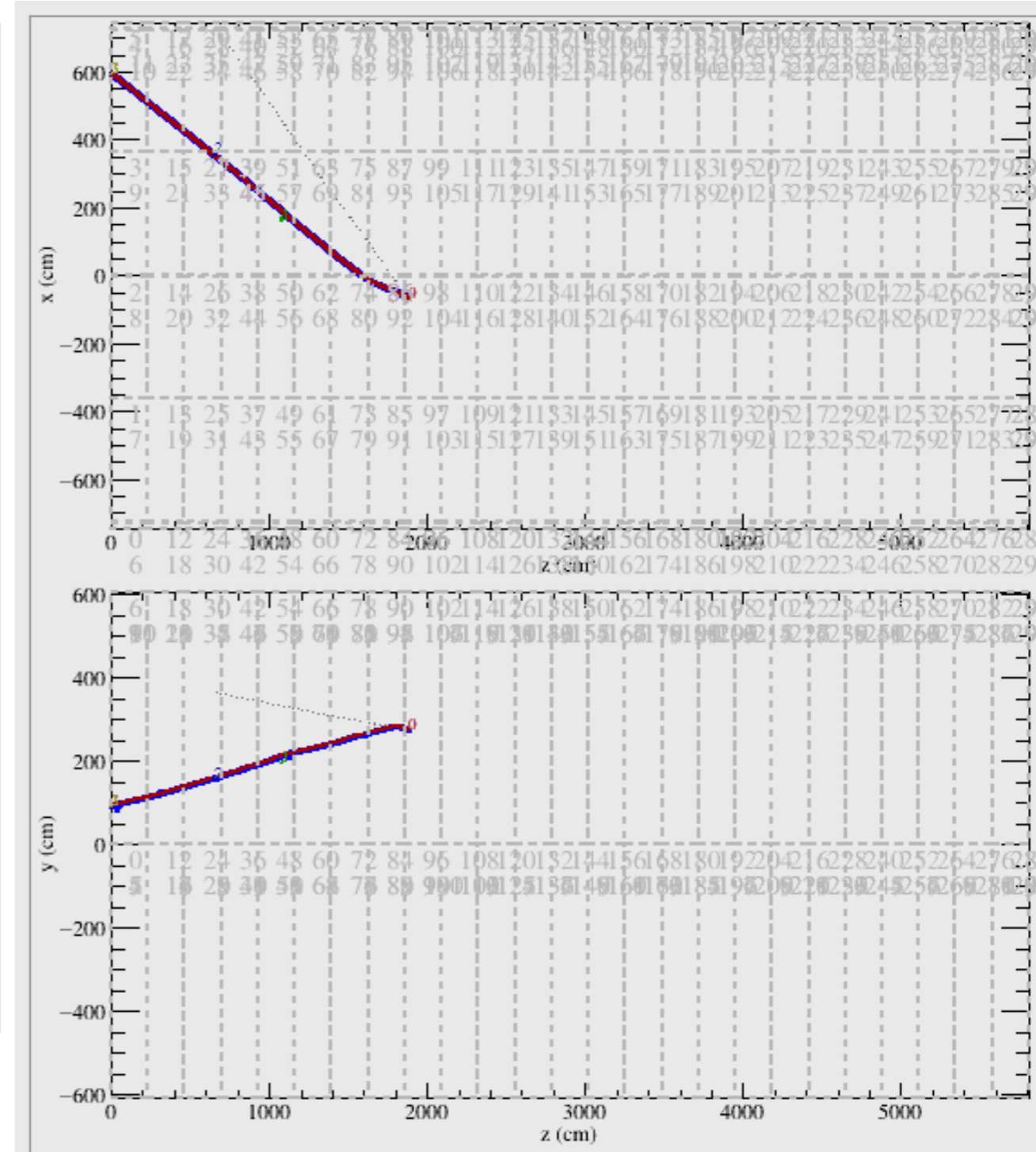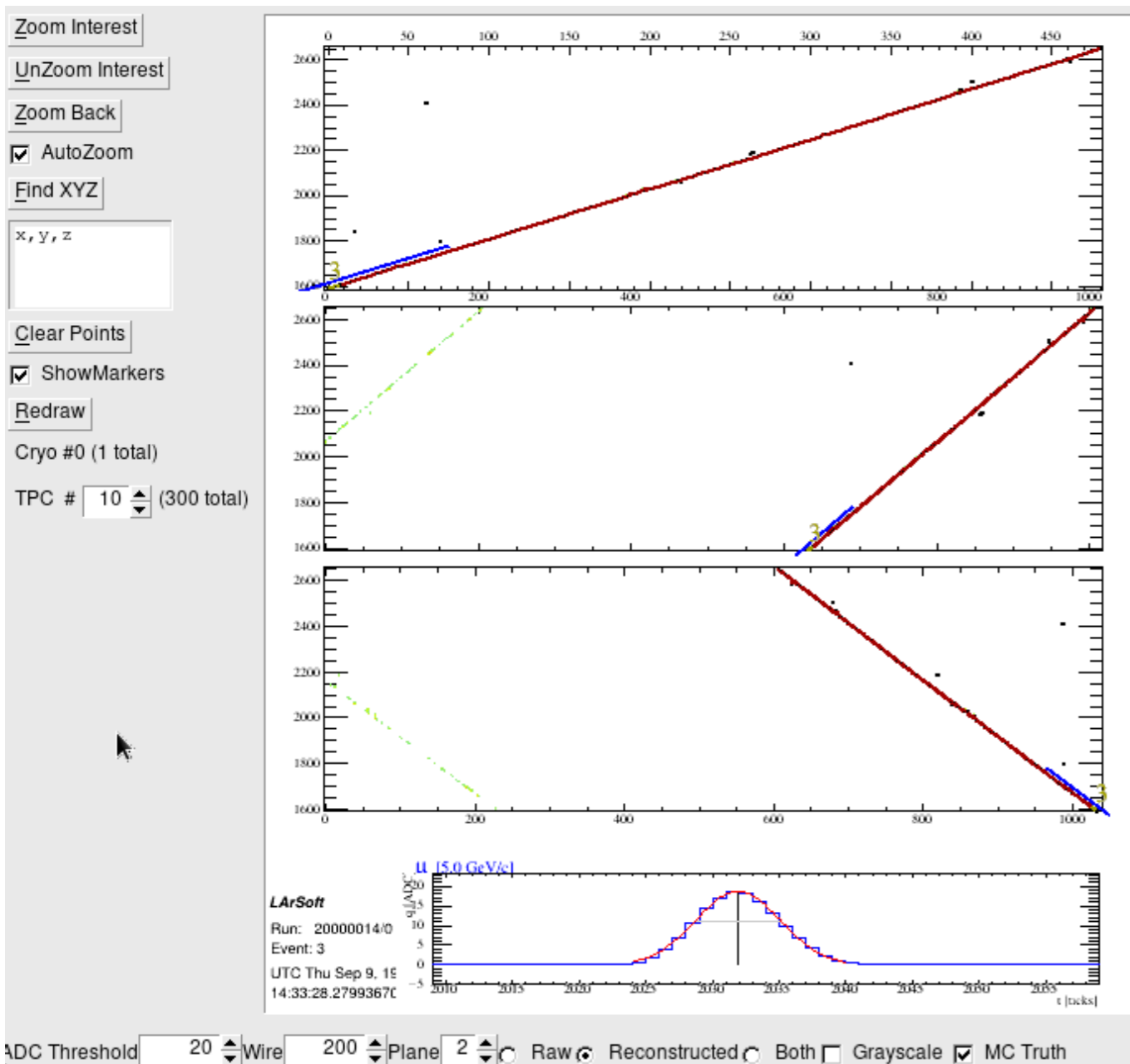
Event display

- Blue is the true muon

- Red is the reconstructed trajectory with Pandora

- Muon traversed two TPC boundaries and the reconstruction successfully merged

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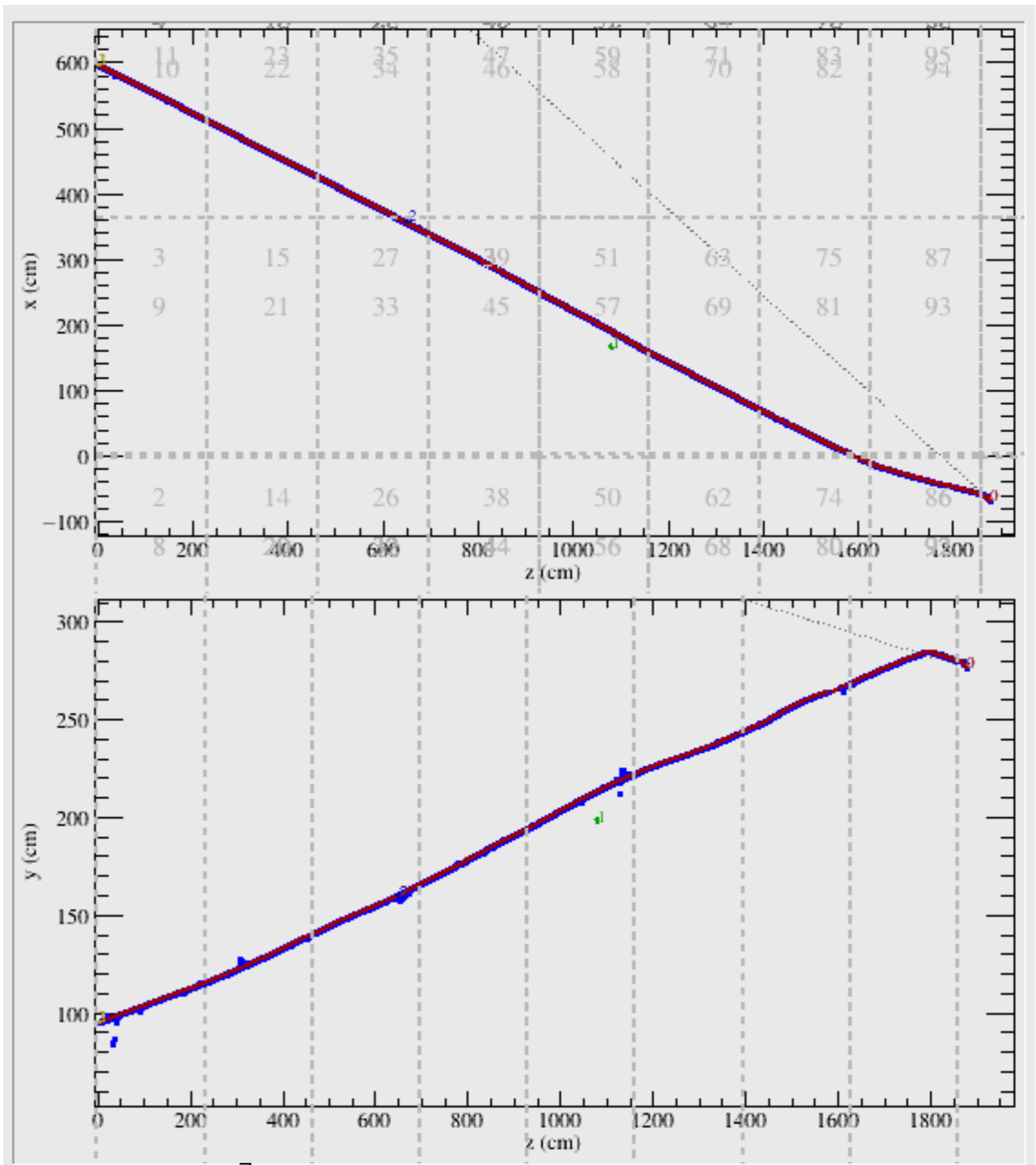
Summary and to do list

- Mechanically, the 10kt sim/reco workflow (with wirecell/hydra) works

    - The output from the small stats look good (by eye)

    - Some sections of the workflow carry a large computing footprint

- TODO

    - Configure the beam window for generating GENIE events

    - Understand the larger chunks of the computing footprint

    - Run the validation system with this workflow to test with high statistics

Gen (20 degree muon)

```
=============================================================================================================================
TimeTracker printout (sec)                            Min         Avg         Max         Median        RMS         nEvts
=============================================================================================================================
Full event                                       0.000162549   0.00248577   0.0070452   0.000249571   0.0032242       3
-----------------------------------------------------------------------------------------------------------------------------
source:EmptyEvent(read)                          3.6959e-05    9.04353e-05  0.000171681  6.2666e-05    5.84001e-05     3
simulate:rns:RandomNumberSaver                   1.0474e-05    6.3165e-05   0.000159154  1.9867e-05    6.79827e-05     3
simulate:generator:SingleGen                     1.177e-05     0.00159966   0.00476455   2.2659e-05    0.00223792      3
[art]:TriggerResults:TriggerResultInserter       5.44e-06      1.43973e-05  3.0761e-05   6.991e-06     1.15882e-05     3
end_path:out1:RootOutput                         1.021e-06     3.59633e-06  8.315e-06    1.453e-06     3.34126e-06     3
end_path:out1:RootOutput(write)                  3.8857e-05    0.000576375  0.00163908   5.1183e-05    0.000751466     3
=============================================================================================================================

%MSG-i NuRandomService:   RootOutput:out1@EndJob 01-Jul-2024 06:36:26 CDT  ModuleEndJob

Summary of seeds computed by the NuRandomService
Random policy: 'perEvent'
  algorithm version: EventTimestamp_v1

%MSG

=============================================================================================================================
MemoryTracker summary (base-10 MB units used)

  Peak virtual memory usage (VmPeak)  : 1464.53 MB
  Peak resident set size usage (VmHWM): 776.589 MB
=============================================================================================================================


TrigReport ---------- Event summary --------------
TrigReport Events total = 3 passed = 3 failed = 0

TrigReport ---------- Modules in End-path ----------
TrigReport          Run     Success     Error Name
TrigReport           3         3          0 out1

TimeReport ---------- Time summary [sec] -------
TimeReport CPU = 0.934645 Real = 1.576066

MemReport  ---------- Memory summary [base-10 MB] ------
MemReport  VmPeak = 1464.53 VmHWM = 776.589
```

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G4 (20 degree muon)

```
============================================================================================================
TimeTracker printout (sec)                      Min          Avg          Max          Median       RMS           nEvts
============================================================================================================
Full event                                      196.185      221.27       263.593      204.032      30.0977       3
------------------------------------------------------------------------------------------------------------
source:RootInput(read)                          0.000256035  0.000351667  0.000522129  0.000276838  0.000120833   3
simulate:rns:RandomNumberSaver                  2.3512e-05   7.77933e-05  0.000185794  2.4074e-05   7.63683e-05   3
simulate:largeant:larg4Main                     0.177095     0.184385     0.193803     0.182256     0.00698521    3
simulate:IonAndScint:IonAndScint                0.0393406    0.0399552    0.0409011    0.0396239    0.000678781   3
simulate:PDFastSim:PDFastSimPAR                 195.432      220.481      262.745      203.265      30.0559       3
[art]:TriggerResults:TriggerResultInserter      1.0755e-05   1.90243e-05  3.551e-05    1.0808e-05   1.16571e-05   3
end_path:out1:RootOutput                        2.204e-06    6.06333e-06  1.3531e-05   2.455e-06    5.28143e-06   3
end_path:out1:RootOutput(write)                 0.535966     0.564178     0.611856     0.544712     0.033902      3
============================================================================================================

%MSG-i NuRandomService:  RootOutput:out1@EndJob 01-Jul-2024 06:50:55 CDT  ModuleEndJob

Summary of seeds computed by the NuRandomService
Random policy: 'perEvent'
  algorithm version: EventTimestamp_v1
  Configured value       Last value    ModuleLabel.InstanceName
     (per event)          43289153     IonAndScint.ISCalcAlg
     (per event)          674737852    PDFastSim.photon
     (per event)          379256812    PDFastSim.scinttime
     (per event)          174405059    largeant
%MSG

============================================================================================================
MemoryTracker summary (base-10 MB units used)

  Peak virtual memory usage (VmPeak)  : 2016.69 MB
  Peak resident set size usage (VmHWM): 1205.78 MB
============================================================================================================

TrigReport ---------- Event summary -------------
TrigReport Events total = 3 passed = 3 failed = 0

TrigReport ---------- Modules in End-path ----------
TrigReport       Run     Success      Error Name
TrigReport        3         3           0 out1

TimeReport ---------- Time summary [sec] -------
TimeReport CPU = 673.084238 Real = 674.742238

MemReport  ---------- Memory summary [base-10 MB] ------
MemReport  VmPeak = 2016.69 VmHWM = 1205.78
```

detsim (20 degree muon)

TimeTracker printout (sec)	Min	Avg	Max	Median	RMS	nEvts
Full event	126.488	154.597	203.822	133.482	34.9242	3
source:RootInput(read)	0.000321813	0.00345096	0.00524862	0.00478246	0.00222081	3
simulate:tpcrawdecoder:WireCellToolkit	117.901	127.734	146.429	118.872	13.2255	3
simulate:opdigi:OpDetDigitizerDUNE	7.95325	26.2209	56.7334	13.976	21.7153	3
simulate:rns:RandomNumberSaver	1.5041e-05	6.15843e-05	0.000154368	1.5344e-05	6.56081e-05	3
[art]:TriggerResults:TriggerResultInserter	8.016e-06	1.50377e-05	2.8545e-05	8.552e-06	9.55363e-06	3
end_path:out1:RootOutput	2.472e-06	5.847e-06	1.2348e-05	2.721e-06	4.59803e-06	3
end_path:out1:RootOutput(write)	0.62728	0.638221	0.658198	0.629186	0.0141469	3

```
MemoryTracker summary (base-10 MB units used)

  Peak virtual memory usage (VmPeak)  : 8410.23 MB
  Peak resident set size usage (VmHWM): 6492.72 MB
```

Reco1 (20 deg muon)

```
=====================================================================================================================
TimeTracker printout (sec)                    Min        Avg         Max         Median       RMS         nEvts
=====================================================================================================================
Full event                                 0.562171    0.653427    0.804269    0.593842    0.107442       3
---------------------------------------------------------------------------------------------------------------------
source:RootInput(read)                     0.00017172  0.000232571 0.00033539  0.000190602 7.31118e-05    3
reco:gaushit:GausHitFinder                 0.365286    0.369666    0.374231    0.369481    0.00365443     3
reco:spsolve:SpacePointSolver              0.0934346   0.173415    0.309918    0.116894    0.0969957      3
reco:hitfd:DisambigFromSpacePoints         0.0176585   0.0192031   0.021661    0.0182899   0.00175698     3
reco:rns:RandomNumberSaver                 1.7532e-05  5.53463e-05 0.000130956 1.7551e-05  5.34641e-05    3
[art]:TriggerResults:TriggerResultInserter 8.743e-06   1.56783e-05 2.9511e-05  8.781e-06   9.78118e-06    3
end_path:out1:RootOutput                   2.408e-06   5.844e-06   1.2225e-05  2.899e-06   4.5165e-06     3
end_path:out1:RootOutput(write)            0.0847628   0.0905599   0.0975232   0.0893938   0.00527426     3
=====================================================================================================================

=====================================================================================================================
MemoryTracker summary (base-10 MB units used)

  Peak virtual memory usage (VmPeak)  : 5002.31 MB
  Peak resident set size usage (VmHWM): 1048.04 MB
=====================================================================================================================
```

Reco2 (20 deg muon)

	154.154	160.143	164.849	161.428	4.45969	3
Full event						
source:RootInput(read)	0.000536006	0.00106974	0.00201775	0.000655461	0.000672118	3
reco:linecluster:LineCluster	0.16588	0.173771	0.18554	0.169895	0.00848139	3
reco:trajcluster:TrajCluster	0.703679	0.771496	0.900419	0.710391	0.0912033	3
reco:pandora:StandardPandora	2.29312	2.74453	3.53526	2.40521	0.560998	3
reco:pandoraTrack:LArPandoraTrackCreation	0.0235611	0.0296299	0.0385715	0.0267573	0.00645586	3
reco:pandoraShower:LArPandoraModularShowerCreation	0.234249	0.284688	0.354233	0.265583	0.0508122	3
reco:pandoracalo:Calorimetry	0.114903	0.190992	0.23867	0.219402	0.0543749	3
reco:pandorapid:Chi2ParticleID	0.000202883	0.00058606	0.00134082	0.000214476	0.000533718	3
reco:trkshowersplit:TrackShowerHits	0.0214843	0.0224226	0.0235508	0.0222326	0.000854292	3
reco:pmtrack:PMAlgTrackMaker	9.35814	12.5501	15.9087	12.3836	2.67684	3
reco:pmtrackcalo:Calorimetry	0.0534947	0.0570082	0.059558	0.0579718	0.00256742	3
reco:pmtrackpid:Chi2ParticleID	0.000264689	0.000280584	0.000290788	0.000286276	1.13896e-05	3
reco:pmtrajfit:PMAlgTrajFitter	3.64515	4.90468	5.87982	5.18906	0.934201	3
reco:pmtrajfitcalo:Calorimetry	0.120835	0.201746	0.242439	0.241964	0.0572131	3
reco:pmtrajfitpid:Chi2ParticleID	0.000209601	0.000249999	0.00027638	0.000264016	2.90082e-05	3
reco:pmtracktc:PMAlgTrackMaker	7.52694	8.92581	9.85538	9.3951	1.00684	3
reco:pmtracktccalo:Calorimetry	0.0754187	0.0944027	0.127247	0.0805424	0.0233184	3
reco:pmtracktcpid:Chi2ParticleID	0.000314567	0.000332646	0.000346205	0.000337166	1.33057e-05	3
reco:pmtrajfittc:PMAlgTrajFitter	6.13312	8.83165	14.0814	6.28048	3.7126	3
reco:pmtrajfittccalo:Calorimetry	0.0479835	0.0515862	0.0545332	0.052242	0.00271381	3
reco:pmtrajfittcpid:Chi2ParticleID	0.00045644	0.000476482	0.00051233	0.000460675	2.54075e-05	3
reco:blurredcluster:BlurredClustering	5.56572	8.23416	9.83854	9.29821	1.89972	3
reco:emtrkmichelid:EmTrackMichelId	81.3853	82.622	83.3401	83.1406	0.878276	3
reco:emshower:EMShower	0.00607916	0.00689143	0.00845543	0.00613968	0.00110619	3
reco:cvnmap:CVNMapper	0.0221676	0.0298515	0.0448657	0.0225213	0.0106176	3
reco:cvneva:CVNEvaluator	0.90381	1.54649	2.82975	0.905916	0.907401	3
reco:energyrecnumu:EnergyReco	4.02714	5.83256	7.05728	6.41326	1.30342	3
reco:energyrecnue:EnergyReco	0.00714511	0.00863338	0.0104886	0.00826637	0.00138944	3
reco:energyrecnc:EnergyReco	0.153286	0.155013	0.157016	0.154736	0.00153507	3
reco:energyrecnumurange:EnergyReco	3.97807	5.6795	6.86776	6.19267	1.23425	3
reco:energyrecnumumcs:EnergyReco	3.98247	5.7799	7.00938	6.34785	1.29935	3
reco:opdec:Deconvolution	0.793508	0.825001	0.860511	0.820985	0.0275007	3
reco:ophitspe:OpHitFinderDeco	8.33495	8.65908	8.85214	8.79016	0.230589	3
reco:opflash:OpFlashFinder	0.0105104	0.012096	0.0151597	0.010618	0.0021668	3
reco:rns:RandomNumberSaver	1.819e-05	8.50657e-05	0.000217771	1.9236e-05	9.38378e-05	3
[art]:TriggerResults:TriggerResultInserter	9.933e-06	1.65733e-05	2.9345e-05	1.0442e-05	9.03332e-06	3
end_path:out1:RootOutput	2.518e-06	5.716e-06	1.1637e-05	2.993e-06	4.19127e-06	3
end_path:out1:RootOutput(write)	0.896995	0.913084	0.925985	0.916273	0.0120479	3

MemoryTracker summary (base-10 MB units used)

  Peak virtual memory usage (VmPeak) : 8448.89 MB
  Peak resident set size usage (VmHWM): 3386.96 MB