

GENIE v3_02_00 Preparation in NuTools

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May 18, 2021

GENIE v3_02_00 is coming

- Yes, it's long overdue 🙌 2020 was a dumpster fire
- Chris Backhouse's event library interface
- New Comprehensive Model Configurations and tunes
 - CMC:
 - GTEST18_02c (INCL++ FSI), GTEST18_02d (Geant4 BertiniCascade FSI) *need special builds*
 - GTEST19_10b – (add QEL-EM, MEC-EM, RES-EM, DIS-EM)
 - GHE19_00[abc] – specifically for high energy
 - GVLE18_01a – low energy (not new)
 - GDM18_00[ab] – boosted dark matter
 - GDNu19_00a – dark neutrino
 - – GNHL20_00a – ~~hockey~~ neutral heavy lepton
 - More models, not all of which are incorporated in sanctioned CMCs
 - Tunes: re-fits with data
 - E.g. G18_10a_02_11a is deprecated in favor of G18_10a_02_11b

A few changes impact nugen and nusimdata (and users)

- Yes, a few “breaking” API / encoding changes
 - Sorry ...
- PDG code for resonances are updated to new standard encoding (per 2019?)
 - E.g. N0(1440) 12112 → 202112, N+(1440) 12212→202212, N0(1520) 1214→ 102114, etc
 - Could impact user (“breaking”) if directly looking at evt record rather than enum code
 - Could also be an issue using old files against newer PDG data table to lookup names

• IsCoherent

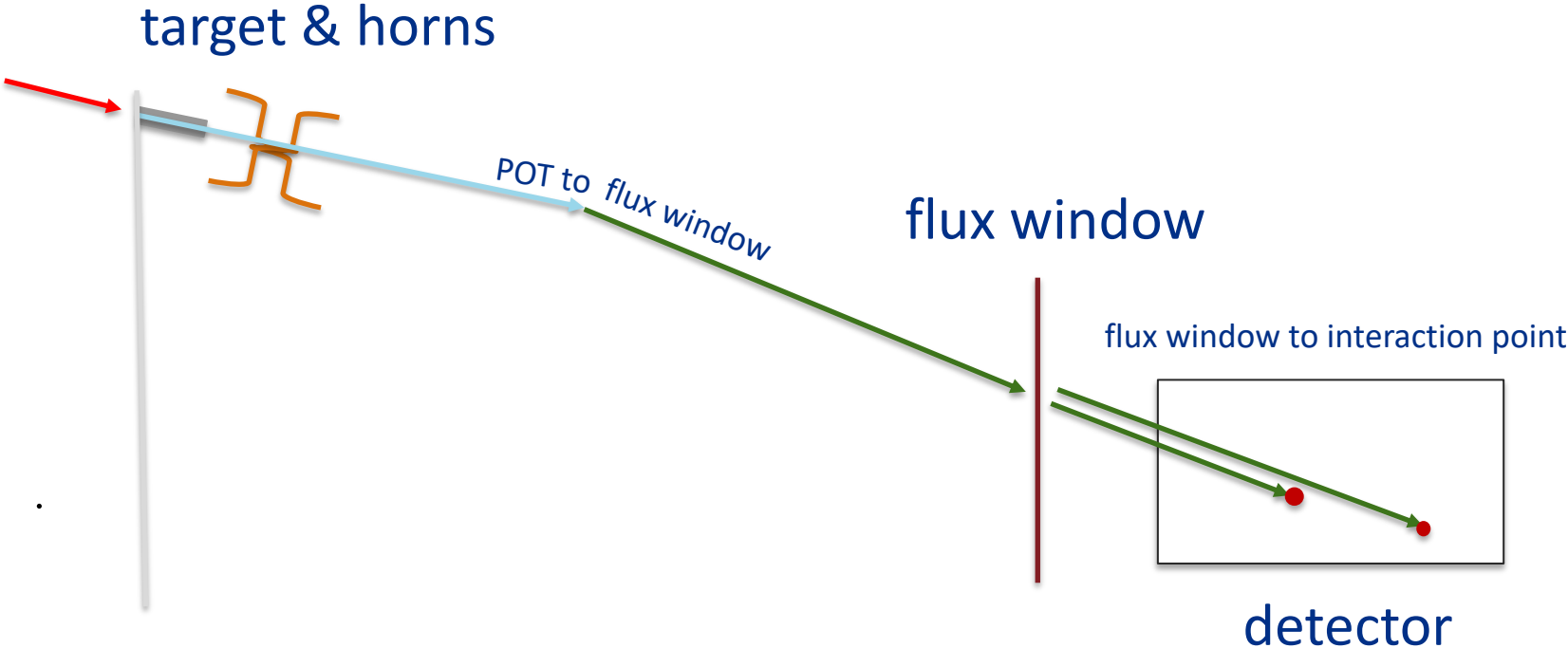
```
#if __GENIE_RELEASE_CODE__ >= GRELCODE(3,2,0)
    else if (procInfo.IsCoherentProduction() ) mode = simb::kCoh;
    else if (procInfo.IsCoherentElastic()    ) mode = simb::kCohElastic;
#else
    else if (procInfo.IsCoherent()           ) mode = simb::kCoh;
    else if (procInfo.IsCoherentElastic()   ) mode = simb::kCohElastic;
#endif
```

- Additions to GENIE XclsTag class (carried over to nusimdata GTruth)
 - As usual new code versions should be okay with old data, but not necessarily the reverse
- Need for later (post-tune determination) filling of PDG data table
 - Should have no user impact; change how GENIE banner is triggered though

Background info: GENIE's units and use of time

- GENIE Interaction Vertex 4-position in {meters,seconds}
 - T includes time from flux window to interaction point and from any time given by the flux driver (i.e. proton-on-target to flux window)
 - the later non-zero for dk2nu and new versions of gsimple after update to dk2nu \Rightarrow gsimple conversion

Time components



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- Particles in the event record {femtometers (10^{-15} m), **new** yoctoseconds (10^{-24} s)}
 - Relative to nucleus at interaction vertex
 - T was never set, even for delayed decays
 - Now propagation times and decay times are recorded
 - Decayed particles (e.g. τ and charm hadrons if using `genie_phyopt`) are offset in time & space

GENIE GHEP Event Record [print level: 13]

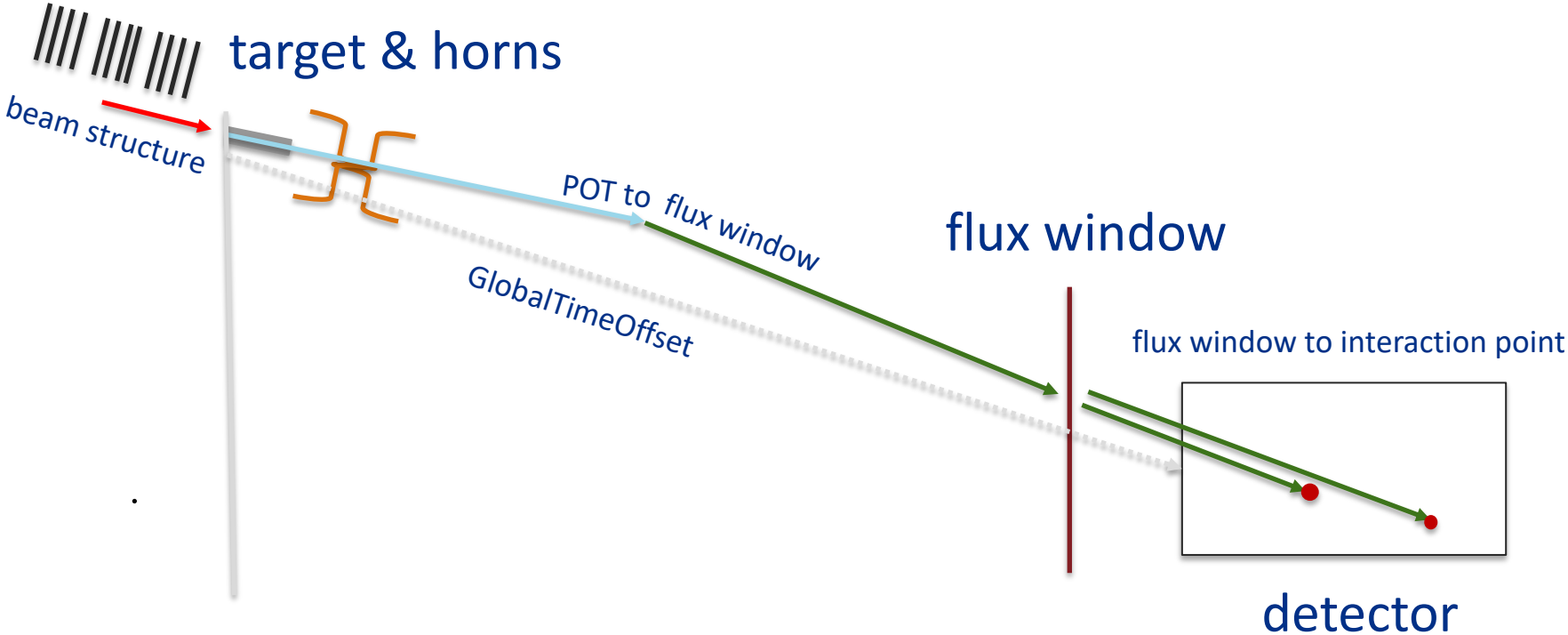
Idx	Name	Ist	PDG	Mother	Daughter	P _x (x)	P _x (y)	P _x (z)	P _x (t)	m				
0	nu_mu	0	14	-1	-1	4	4	0.006	-0.225	2.251	2.263	0.000		
1	Fe56	0	1000260560	-1	-1	2	3	-3.509	-0.284	-1.383	0.000	52.090		
2	proton	11	2212	1	-1	5	5	0.000	0.000	0.000	0.000	0.000		
3	Mn55	2	1000250550	1	-1	17	17	-0.105	0.063	0.140	0.928	**0.938	M = 0.909	
4	nu_mu	1	14	0	-1	-1	-1	-3.509	-0.284	-1.383	0.000	0.000	P = (0.016, 0.005, -1.000)	
5	N+(1520)	3	2124	2	-1	6	7	0.105	0.063	0.140	51.162	51.162	**1.520	M = 1.506
6	neutron	14	2112	5	-1	8	8	0.000	0.000	0.000	0.000	0.000	FSI = 1	
7	pi+	14	211	5	-1	9	9	-0.825	-0.008	1.560	1.561	0.000	FSI = 4	
8	neutron	1	2112	6	-1	-1	-1	-3.509	-0.284	-1.383	0.000	0.000	FSI = 1	
9	HadrClus	16	2000000300	7	-1	10	16	0.078	-0.625	0.384	1.195	0.940	M = -0.246	
10	proton	1	2212	9	-1	-1	-1	-1.758	-14.311	7.223	0.000	0.000	M = 44.694	
11	proton	1	2212	9	-1	-1	-1	-0.152	0.345	0.168	0.435	0.140		
12	proton	1	2212	9	-1	-1	-1	-3.969	0.761	-0.874	0.000	0.000		
13	proton	1	2212	9	-1	-1	-1	0.074	-0.200	0.552	1.630	0.938		
14	neutron	1	2112	9	-1	-1	-1	-3.969	0.761	-0.874	0.000	0.000		
15	neutron	1	2112	9	-1	-1	-1	0.022	0.163	-0.161	0.966	0.938		
16	neutron	1	2112	9	-1	-1	-1	-3.969	0.761	-0.874	0.000	0.000		
17	HadrBlob	15	2000000002	3	-1	-1	-1	0.020	0.294	-0.063	0.986	0.938		
Fin-Init:						0.000	0.000	0.000	0.000					
Vertex: nu_mu @ (x = 2.06358 m, y = -1.73227 m, z = 23.57114 m, t = 7.088258e+02 s)														
Err flag [bits:15->0] : 0000000000000000				1st set:				none						
Err mask [bits:15->0] : 1111111111111111				Is unphysical: NO				Accepted: YES						
sig(Ev) = 4.92115e-39 cm^2 d2sig(W,Q2;E)/dwdQ2 = 3.60470e-38 cm^2/GeV^3 Weight = 1.00000														



NuGen / NuSimData MCTruth's use of Time

- MCTruth units {cm, ns}
 - GENIE Vertex.T() was ignored; now optionally (default off) considered
 - Controlled by GENIEHelper fcl parameter AddGenieVtxTime
 - If including proton-on-target to interaction point one may need to adjust overall global time offset (NOvA especially) to make data and MC overlay again.
 - No changes to experiment code necessary

Time components



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 - No changes to experiment code necessary
 - Trajectory position of particles of status code !=0 & != 1 was “funky”
 - Not converted to lab (cm) frame; remained (unnecessarily) in fm
 - True info is also in GVtx variable, so no need for special handling to recover GENIE evt record
 - Now all trajectory points in cm; no one should care but it is “breaking”

Idx	Name	Ist	PDG	Mother	Daughter	Px(x)	Py(y)	Pz(z)	E(t)	m			
0	nu_mu	0	14	-1	-1	5	5	-0.156	-2.028	19.176	19.283	0.000	
1	016	0	1000080160	-1	-1	2	4	0.937	-2.304	-0.173	0.000	0.000	
2	neutron	11	2112	1	-1	6	6	0.000	0.000	0.000	14.895	14.895	
3	015	2	1000080150	1	-1	15	15	0.000	0.000	0.000	0.000	0.000	
4	gamma	1	22	1	-1	-1	-1	-0.024	-0.122	-0.027	0.923	**0.940	M = 0.914
5	mu-	1	13	0	-1	-1	-1	0.937	-2.304	-0.173	0.000	0.000	M = 13.965
6	HadrSyst	12	2000000001	2	-1	7	8	0.000	0.000	0.000	0.000	0.000	P = (0.032, 0.188, -0.982)
7	Lambda_c+	14	4122	6	-1	11	11	0.166	-0.095	8.408	9.265	**0.000	M = 3.887
8	HadrBlob	12	2000000002	6	-1	9	10	0.000	0.000	0.000	0.000	0.000	M = 1.454
9	proton	14	2212	8	1	12	12	0.946	-2.278	0.419	0.000	0.000	FSI = 1
10	pi-	14	-211	8	1	13	14	0.104	-0.269	4.458	4.698	**0.000	M = 1.454
11	Lambda_c+	14	4122	7	-1	16	20	0.937	-2.304	-0.173	0.000	0.000	FSI = 3
12	proton	1	2212	9	1	-1	-1	0.842	-2.510	10.348	0.000	0.000	
13	pi-	1	-211	10	1	-1	-1	0.160	-0.180	0.033	0.280	0.140	
14	neutron	1	2112	10	1	-1	-1	1.642	-3.203	0.829	0.000	0.000	
15	HadrBlob	15	2000000002	3	-1	-1	-1	0.145	-0.117	0.287	1.000	0.940	M = 13.025
16	proton	1	2212	11	-1	-1	-1	0.000	0.000	0.000	0.000	0.000	
17	pi0	1	111	11	-1	-1	-1	1395199680.701	3925416152.924	89390307664.871	344746042843.519		
18	pi+	1	211	11	-1	-1	-1	0.340	0.058	0.561	0.672	0.135	
19	pi-	1	-211	11	-1	-1	-1	1395199680.701	3925416152.924	89390307664.871	344746042843.519		
20	pi0	1	111	11	-1	-1	-1	-0.235	0.061	0.283	0.398	0.140	
								1395199680.701	3925416152.924	89390307664.871	344746042843.519		

Fin-Init:

Vertex: nu_mu @ (x = -4.06022 m, y = -3.10006 m, z = 4.42860 m, t = 1.942502e-06 s)

Err flag [bits:15->0] : 0000000000000000 1st set: none
 Err mask [bits:15->0] : 1111111111111111 Is unphysical: NO Accepted: YES
 sig(Ev) = 3.25358e-38 cm^2 | d2sig(x,y;E)/dxdy = 1.15894e-37 cm^2 | Weight = 1.00000



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 - Now all trajectory points in cm; no one should care but it is “breaking”
 - GENIE2ART::FillMCTruth allowed supplying offset – no one should have been using this
 - Used to inject “beam structure” (batches and buckets)
 - Position was meant eventually for randomizing geometry-less interactions in a far detector
 - Units were unclear, now MCTruth units {cm,ns}

NuGen / NuSimData change vs. Experiment/User code

- Consistent set using `feature/rhatcher_genie_30200` on `nugen` & `nusimdata`
- Entirely self-contained – NO changes to experiment *code*
 - Unless for some reason making use of unconverted MCTruth units for intermediates
 - (check MCTruth dumper that isn't mine)
 - Unless hard coded resonance PDG values (not resonance #s)
 - FHICL values if `AddGenieVtxTime` flag set true, adjust `GlobalOffset` time