# Discussion on updating the GEANT4 version of larsoft

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## Poblem

- The current GEANT v4_10_3_p03e contains a bug in the decay of $\tau$'s (tau leptons)
  - $\rightarrow$ The $\tau$ daughter particle 4-momentum vectors are wrong, sometimes causes jobs to crash
  - $\rightarrow$ Problem for the atmospheric neutrino background samples for proton decay and $n\bar{n}$-oscillation studies

- GEANT v4_10_3 is from 2016 and patch p03e from 2017

- Workaround in place: when running the GENIE module in dunetpc/larsoft, genie_phyopt is called that forces GENIE to decay $\tau$'s (and charm and bottom hadrons) via pythia before they are tracked in GEANT4

- We don't want to use that workaround for proton decay and $n\bar{n}$-oscillation studies since we want to have the $\tau$ track

## Proposed solution

- Short term solution: move larsoft to GEANT v4_10_6_p01
- $\rightarrow$ has many improvements and bug fixes, including the decay of $\tau$'s
- $\rightarrow$ larsoft team in favor of moving to a newer GEANT4 version

- But: $\tau$'s from neutrino CC interactions are polarized, which affects the momentum spectrum of the $\tau$ daughter particles. GEANT4 does not take this into account.
- $\rightarrow$ Long term solution: track $\tau$ in GEANT4, call external package for $\tau$ decay (like TAUOLA), track $\tau$ daughter particles in GEANT4

**Considerations for DUNE code and physics**

- GEANT v4_10_6_p01 should work without problems with the new (refactored) GEANT4 module in larsoft
- Make sure that the new GEANT4 version also works with the old GEANT4 module in larsim (LArG4) as I believe many people are still using it
- $\rightarrow$ can be checked with a larsoft test release (requested) and the CI system

- Understand the changes to the GEANT4 physics and their impact on DUNE physics
- $\rightarrow$ Krzysztof Genser will give a talk about the GEANT4 changes (probably) in the next larsoft coordination meeting
- $\rightarrow$ changes to DUNE physics should be minor and can partially be tested with CI system

### **Planned checks with larsoft test release**

1. DUNE FD CI test: check for errors and changes in data products for a single $\nu_e$ interaction at every stage of the test
- Stages and FHiCL's:
- prodgenie_**nue**_dune10kt_1x2x6.fcl (always the same $\nu_e$ interaction)
- standard_g4_dune10kt_1x2x6.fcl (this is using the old LArG4 module)
- standard_detsim_dune10kt_1x2x6.fcl
- standard_reco_dune10kt_nu_1x2x6.fcl
- standard_ana_dune10kt_1x2x6.fcl
- select_ana_dune10kt_nu.fcl

2. DUNE FD CI validation

2.1 Check for changes in **track** reconstruction efficiencies for $\mu$, $\pi$ and $p$ with 7 500 $\nu$ interactions in the following reco algorithms: pandoraeff, pmtrackeff, pmtracktceff, pmtrajfiteff, pmtrajfittceff

- Used FHiCL's:
- prodgenie_**nu**_dune10kt_1x2x6.fcl (interactions randomly chosen)
- standard_g4_dune10kt_1x2x6.fcl (this is using the old LArG4 module)
- standard_detsim_dune10kt_1x2x6.fcl
- standard_reco_dune10kt_nu_1x2x6.fcl
- standard_ana_dune10kt_1x2x6.fcl
- select_ana_dune10kt_nu.fcl

2.2 Check for changes in **shower** reconstruction efficiencies for electrons with 7 500 $\nu_e$ interactions in the following reco algorithms: emshowershweff, pandorashweff

- Used FHiCL's:
- prodgenie_**nue**_dune10kt_1x2x6.fcl (interactions randomly chosen)
- standard_g4_dune10kt_1x2x6.fcl (this is using the old LArG4 module)
- standard_detsim_dune10kt_1x2x6.fcl
- standard_reco_dune10kt_nu_1x2x6.fcl
- standard_ana_dune10kt_1x2x6.fcl
- select_ana_dune10kt_nu.fcl

### Next steps

- Start mentioned checks as soon as larsoft test release is ready:
  https://cdcvs.fnal.gov/redmine/issues/24180

- Krzysztof Genser's talk about changes in GEANT4 at larsoft
  coordination meeting (probably next week)

- If larsoft decides to pursue moving to GEANT v4_10_6_p01,
  experiments will be asked for approval