Fermilab U.S. DEPARTMENT OF ENERGY Office of Science

Update to the Radiological Generator

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Radiological Generator Features

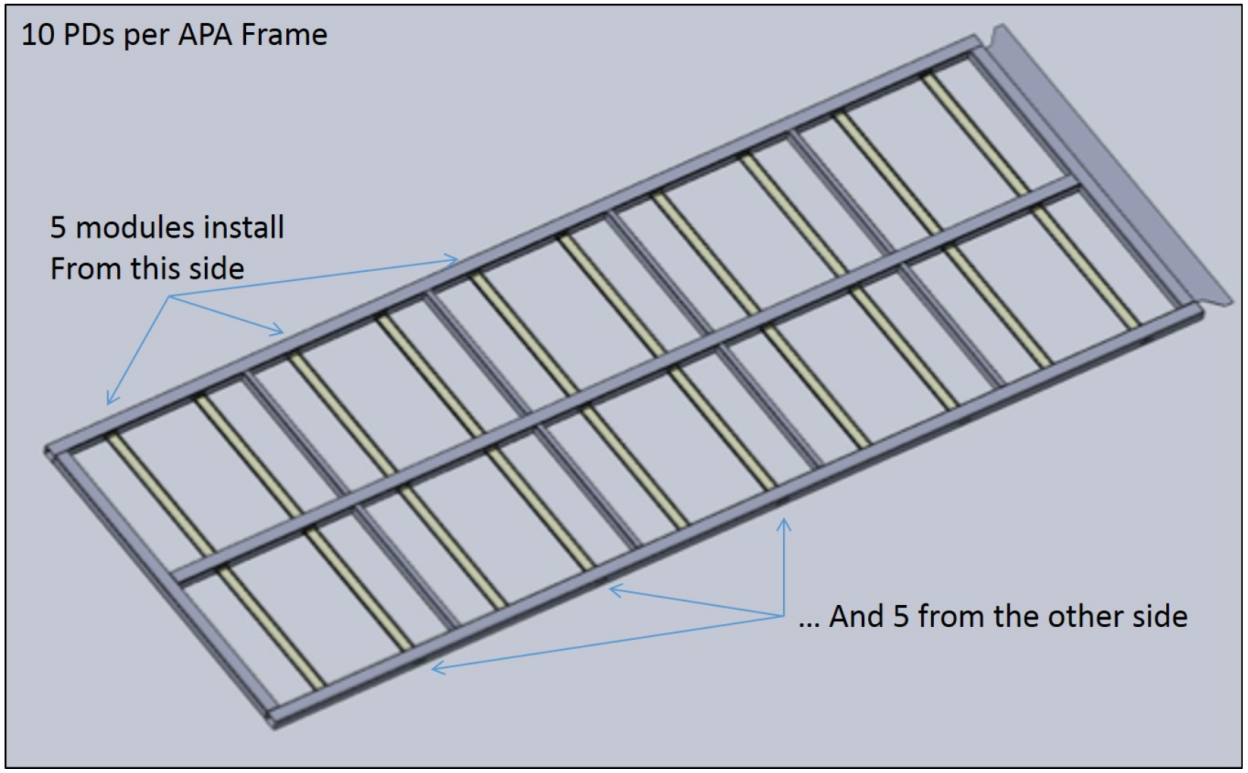
Provides injection of radionuclide daughter particles into the event record. Patterned after SingleGen_module.cc

Homogeneous and isotropic within a rectangular box in space and a uniform time interval.

- FCL parameters X0,Y0,Z0,X1,Y1,Z1 are box corners, and T0 and T1 are the time ranges.
- FCL parameters are arrays to allow for multiple nuclides and multiple boxes to be simulated.
- Supported nuclides: ^{39}Ar, ^{60}Co, ^{85}Kr, ^{40}K, ^{232}Th, ^{238}U, ^{222}Rn (last one handled in code)
- Spectra provided in TGraph format by Vic Gehman
- Radioactivity levels specified in Bq per cc

Problems with Uniform Boxes

- Detector geometry, while usually regular, is composed of many pieces.



- Ten bar-shaped light guides in the ProtoDUNE-SP APA, and the DUNE APA.
- 150 APA's in the FD
- Want to simulate ^{39}Ar decays next to the bars but not *in* the bars. Awkward!

A Simple Solution

- Suggested by Alex Himmel, Jason Stock, Kate Scholberg, Juergen Rechenbacher, and others at the DUNE Collaboration Meeting in January
- Proposal: check the material type in the box and only generate decays in the volumes with the specified materials
- I implemented this in feature branch trj_radiogeom of larsim.
- I added a new fcl parameter to the inputs, "Material".
  - It's an array of strings. Regular expressions, really. So you can use wildcards like * and ?
  - The array indexes are the same as for the other variables – one per simulated nuclide per box.
  - Only volumes with material names matching the corresponding regex will have decays simulated in them.

Comments

- A more ambitious solution:
  - specify the radionuclides in the gdml file.
  - There are interesting features in TGeoElementRN
    - provides list of decays, half-lives, even mass excess
    - no spectrum of decay products however!
  - This solution almost certainly will cause us troubles however
    - GENIE pays attention to all the nuclides we put in the GDML.
    - Radionuclides are a tiny fraction of the detector material.
    - GENIE does not have cross sections for everything.
    - Changing the radioactive modeling would be more difficult if we have to generate new GDML for this
    - Some mixtures with the same name may have different activity. Not every batch of FR4 looks like every other batch.

Breaking Change

- Adding "Material" as a new array of strings requires the user to specify them.
- We could see if the parameter is unspecified and fill it in with an array of "*"s.
- Discussed this, and we want users to think about this just a bit.
- Small community so far.

Suggested removal of a feature

- An old attempt at ^{39}Ar which can be retired:
  The cheesy non-G4 solution cobbled into LArVoxelReadout.cxx: simulated steps for low-energy electrons.
- The goal was to skip the G4 step for the tens of thousands of ^{39}Ar decays expected in the FD on each event.
- Turns out that wasn't really a problem, and the cheesy solution lacked the generality to do PD simulation.
- If we're factoring out LArVoxelReadout anyway, this might be a good time to retire that.
- Not done yet