The issue mentioned via email

Integral plot of muon energy depositions in liquid argon (Ge energy deposition >200 keV, ROI)
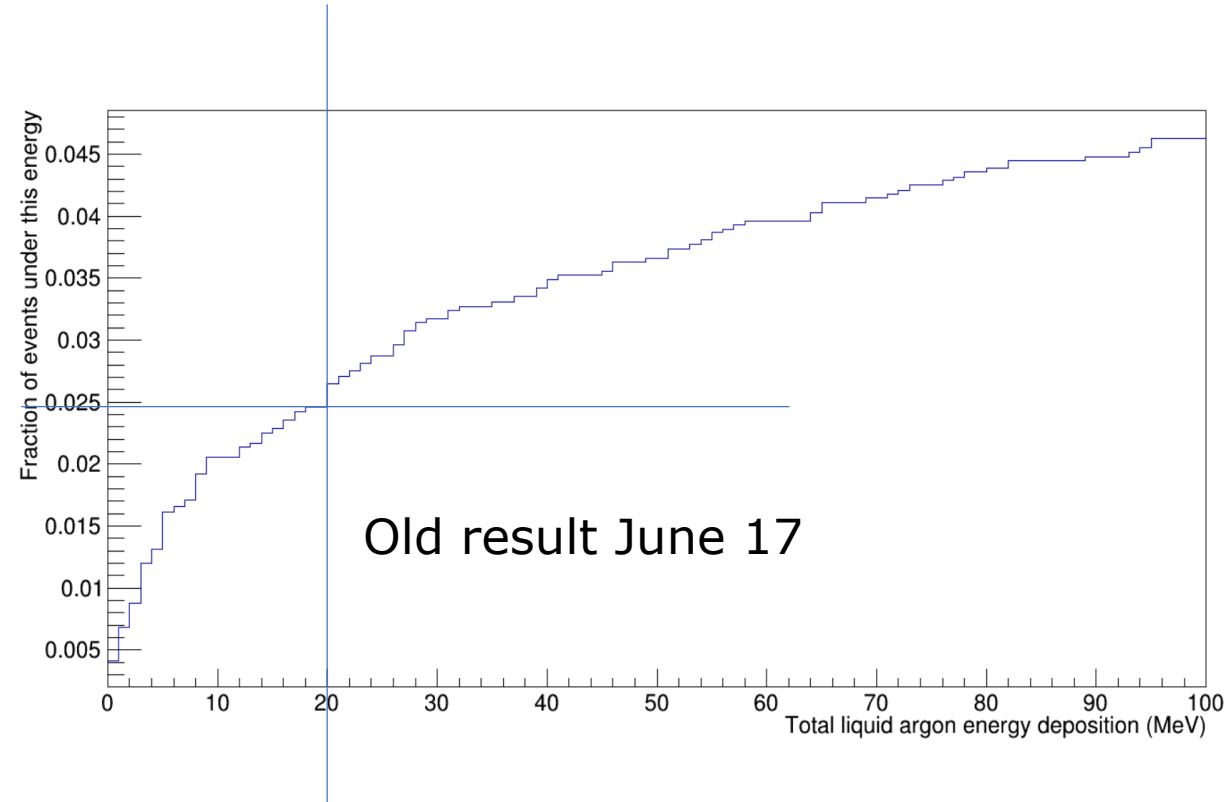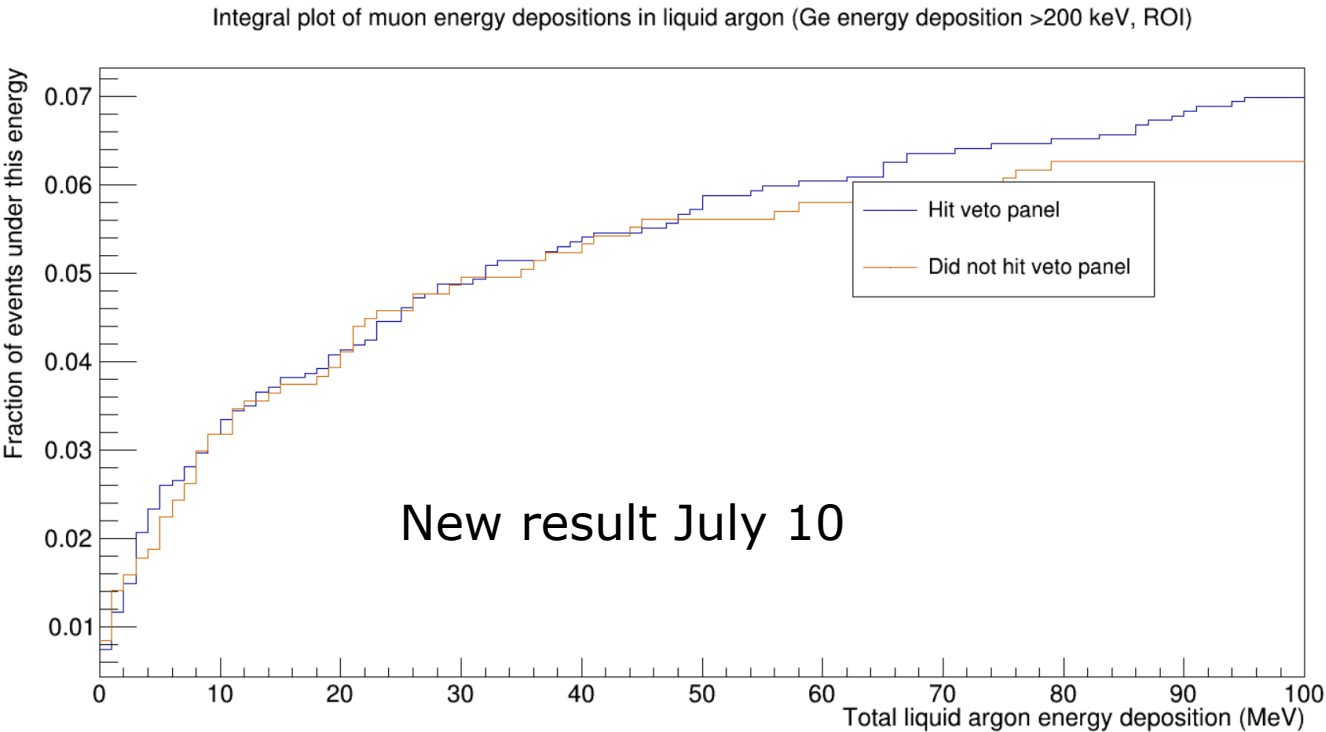
New result July 10

Old result June 17

Within statistical uncertainty, these should be the same

Problem with my data collection

How I defined the particle position in data collection (i.e. writing the file):

```
x = track->GetStep()->GetPostStepPoint()->GetPosition().x()/CLHEP::mm;
y = track->GetStep()->GetPostStepPoint()->GetPosition().y()/CLHEP::mm;
z = track->GetStep()->GetPostStepPoint()->GetPosition().z()/CLHEP::mm;
```

How I defined the particle position when performing the ROI cut:

```
stepx = step->GetPreStepPoint()->GetPosition().x()/CLHEP::mm;
stepy = step->GetPreStepPoint()->GetPosition().y()/CLHEP::mm;
stepz = step->GetPreStepPoint()->GetPosition().z()/CLHEP::mm;
```

(previously I did the ROI cut in post-processing, so it would have cut on the first values)
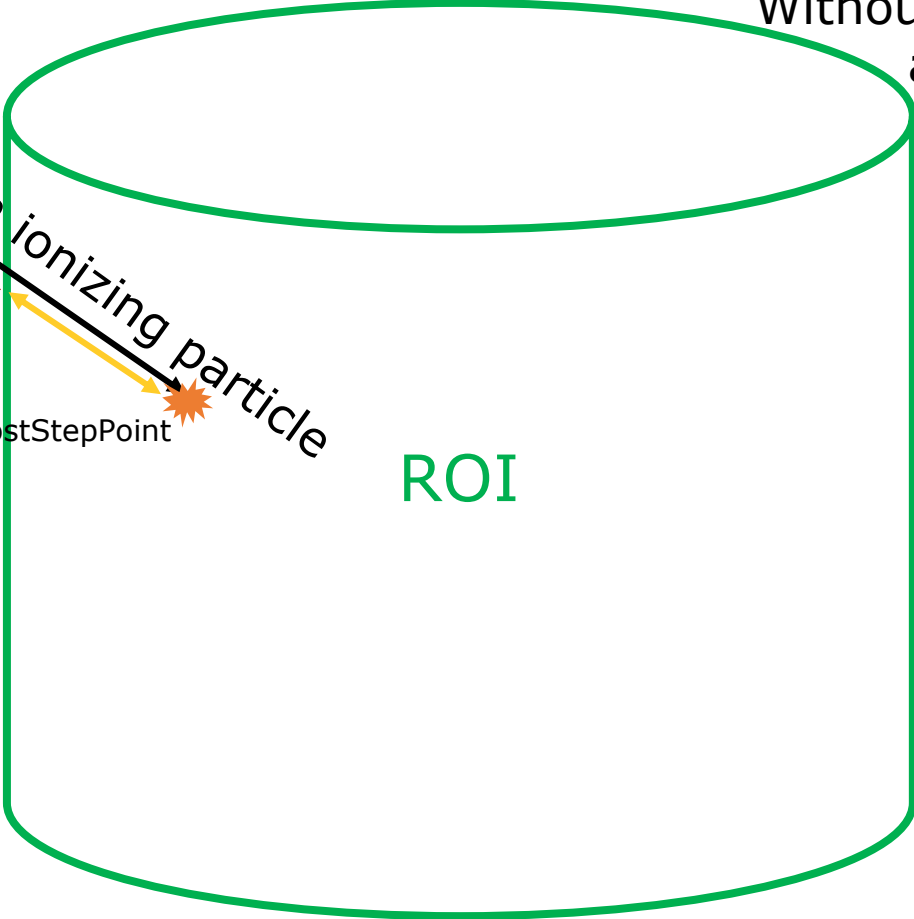Obviously, PreStepPoint and PostStepPoint are not the same thing!
I believed the first one to be the correct implementation, and the second one to just be an oversight, but after giving it some thought, the issue is more complicated than that.

Steps entering/leaving ROI are problematic

Part of the ionization energy deposition is inside ROI
Part of the ionization energy deposition is outside ROI
Without additional features, Geant4 cannot separate these
and <u>both</u> will be added to the energy deposited in ROI

The step will be limited by a discrete process
This, at least, should be separable from the
continuous energy loss contributions

The situation is the same, but in
reverse, for steps leaving the ROI
Part of the ionization energy will escape!

PreStep
Point

One step for an ionizing particle

PostStepPoint

ROI

Fixing the issue

- Make another artificial LAr geometric boundary
  - E.g. an 'inner' LAr volume with no physical differences from surrounding LAr, but which is considered separate by G4
  - This forces a step to be ended at the boundary between the materials
  - Then, we discard events outside of the ROI volume and get the entire ionization energy recovered

Inner argon volume the size of the ROI
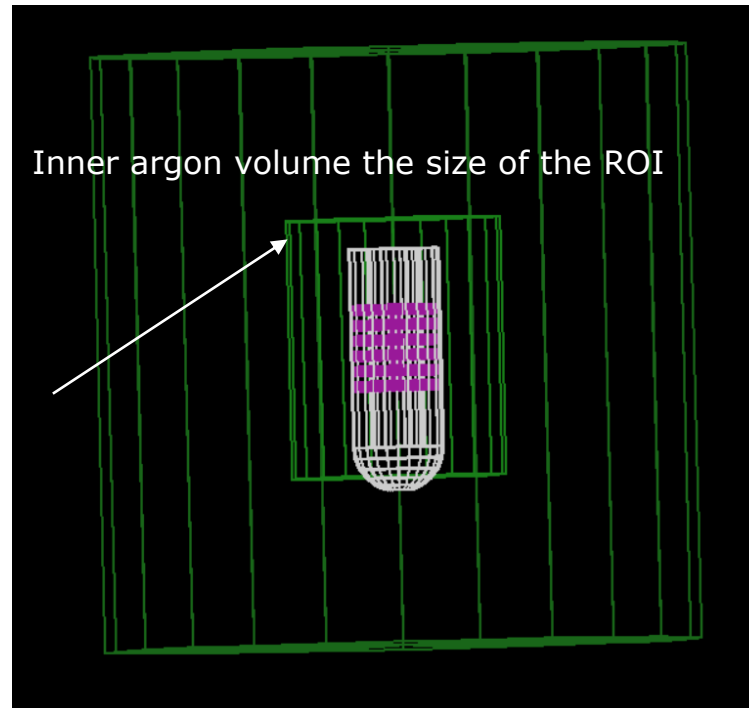
Summary of the July 25th data

- 10 million muons, sampled from the 26 million MUSUN muons available
- Only events within the ROI are kept (and ionization energy is correctly accounted for this time!)
- Default units are still keV, mm, ns