Code Comparison and Physics Process Monitoring

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Overview

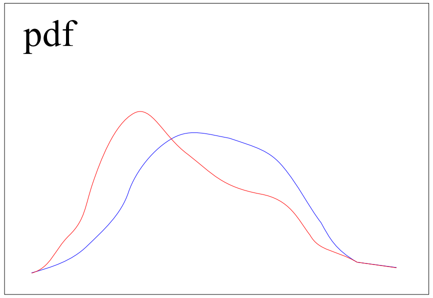
- For paper studies we are very dependent on Monte Carlo codes
- It is good to check that those codes do what we think
- Things we need to test:
  - Stepping through fields
  - Physics process model for passage through material
- Two approaches to testing
  - Run through lattice and check for agreement between different codes and versions
  - Test element-by-element and look for agreement between different codes and versions
    - Also check with experiment or analytical models
    - Quite lattice-independent
- Automated and code-independent
  - Want to test ICOOL and G4Beamline (and G4MICE)
  - Want to test for each new revision
- Also compare different build environments

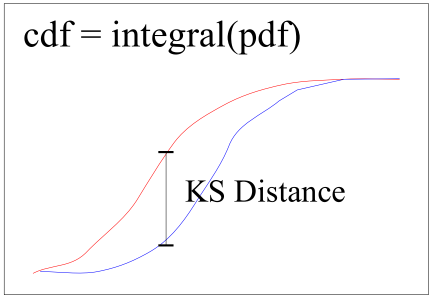
Geometries tested

- Look at a wide variety of materials and particles
  - Use a cylindrical block of material with some thickness
  - Fire ensemble of particles of some type with some nominal momentum on-axis
  - Concentrate on mu+ in Lithium Hydride and liquid Hydrogen
  - But consider all relevant charged particles and all relevant materials
    - No neutrals
  - Look at what happens to a monochromatic pencil beam
- Look at all ICOOL versions 3.10 (beginning 2008) to 3.26
  - ICOOL 3.20 is my reference version
  - Built with gcc version 4.3.4 (GCC)
  - Test on 32 bit build vs 64 bit build
- For all simulations I use
  - ldecay=.true. ldedx=.true. lstrag=.true. lscatter=.true.
  - delev=2 straglev=5 scatlev=6

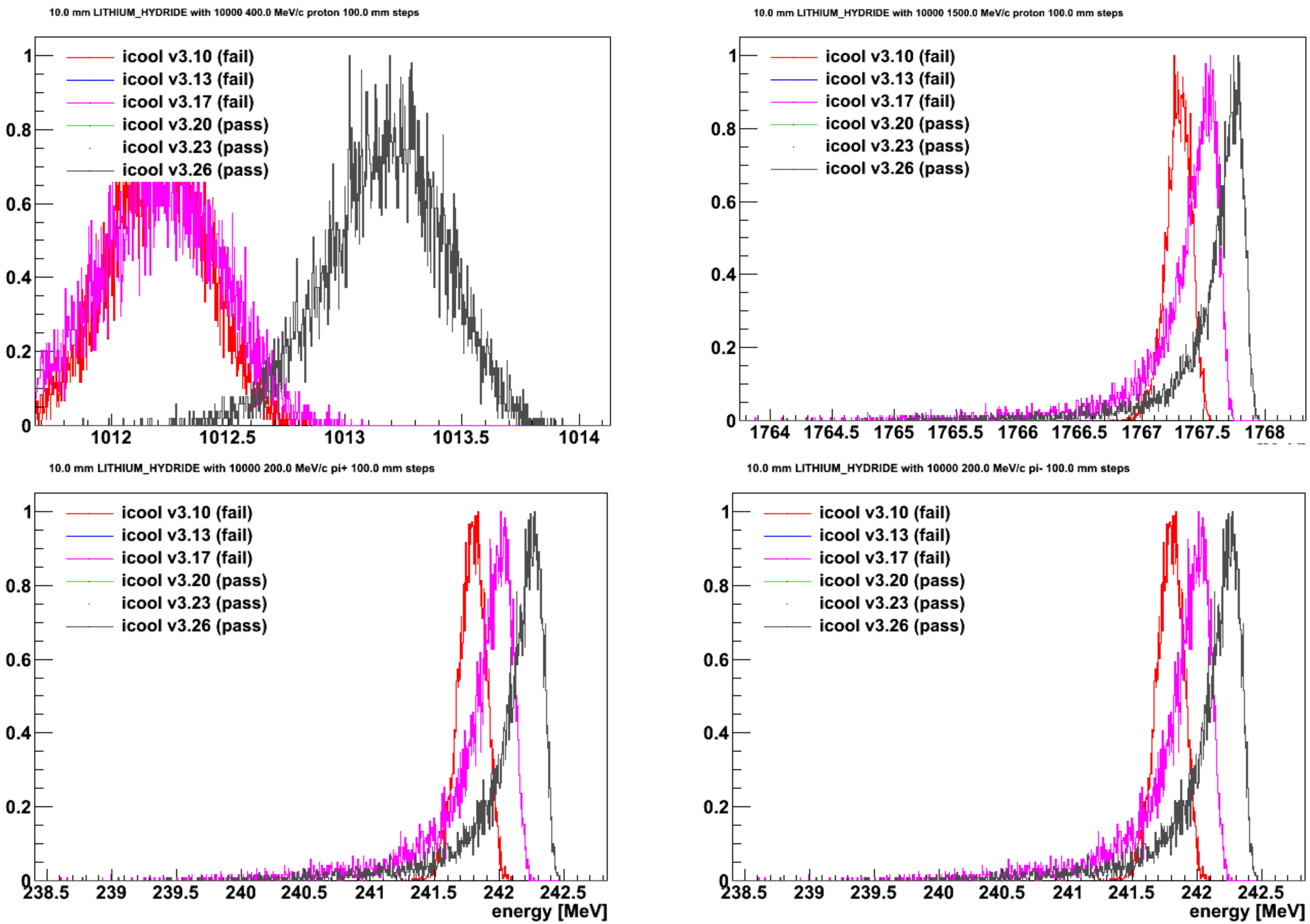
Test algorithm

- Test pass or fail determined by Kolmogorov-Smirnov test
  - Check distance between cumulative density plot
  - Compare with theoretical distribution
  - Determine probability that two plots are different
  - Note I make the test on binned data
- Look at both px distribution and energy distribution
  - Energy distribution is most sensitive test
- Nb apologise some labels overlap the plots
  - Built in an automatic way



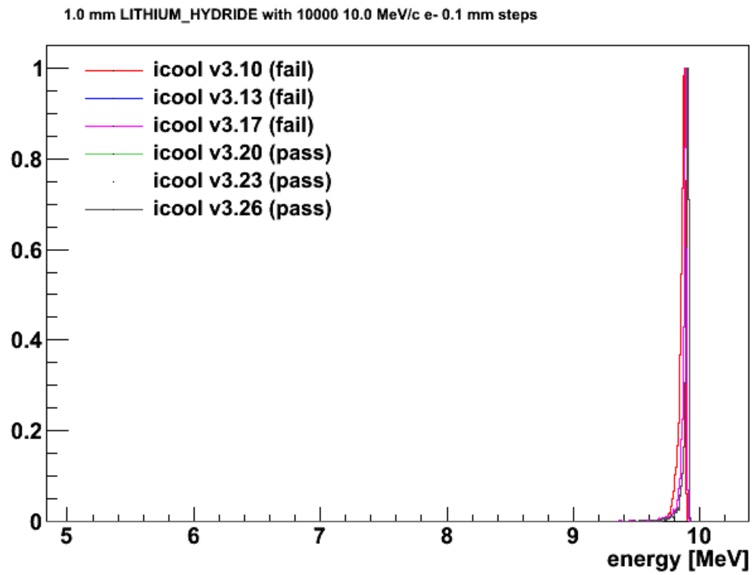


Hadrons

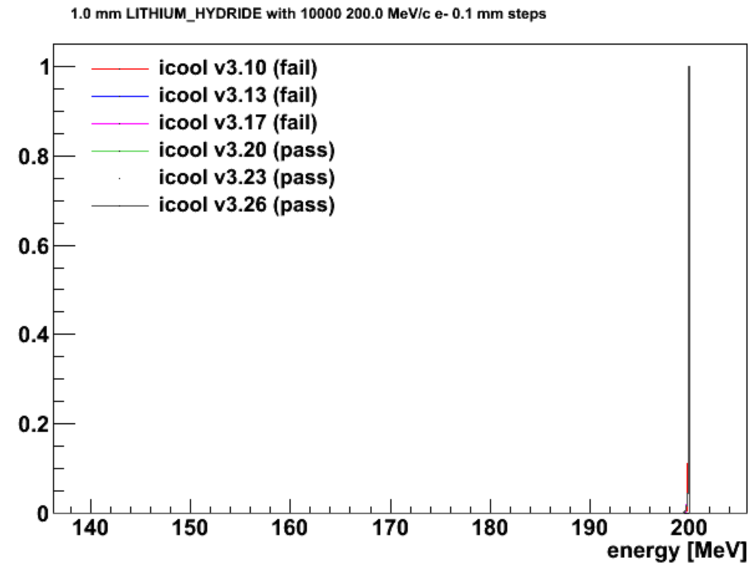


10.0 mm LITHIUM_HYDRIDE with 10000 400.0 MeV/c proton 100.0 mm steps
10.0 mm LITHIUM_HYDRIDE with 10000 1500.0 MeV/c proton 100.0 mm steps
10.0 mm LITHIUM_HYDRIDE with 10000 200.0 MeV/c pi+ 100.0 mm steps
10.0 mm LITHIUM_HYDRIDE with 10000 200.0 MeV/c pi- 100.0 mm steps
icool v3.10 (fail)
icool v3.13 (fail)
icool v3.17 (fail)
icool v3.20 (pass)
icool v3.23 (pass)
icool v3.26 (pass)
energy [MeV]

Electrons



1.0 mm LITHIUM_HYDRIDE with 10000 10.0 MeV/c e- 0.1 mm steps
icool v3.10 (fail)
icool v3.13 (fail)
icool v3.17 (fail)
icool v3.20 (pass)
icool v3.23 (pass)
icool v3.26 (pass)
energy [MeV]



1.0 mm LITHIUM_HYDRIDE with 10000 200.0 MeV/c e- 0.1 mm steps
icool v3.10 (fail)
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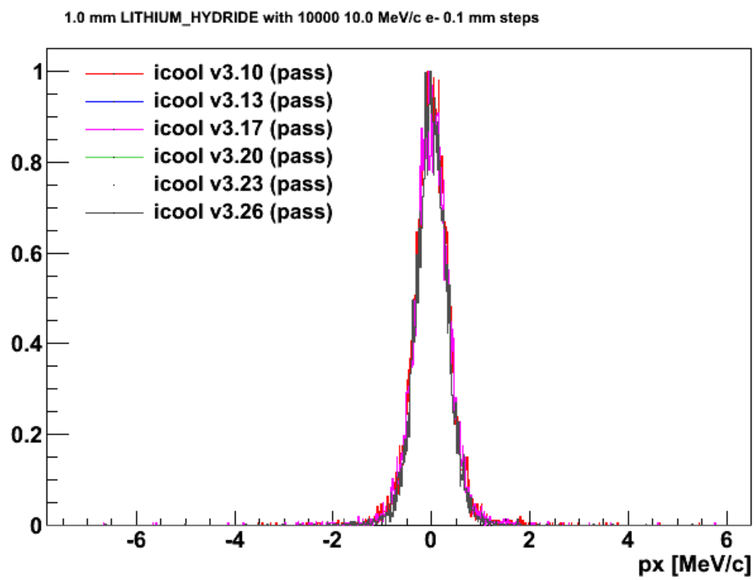
energy [MeV]



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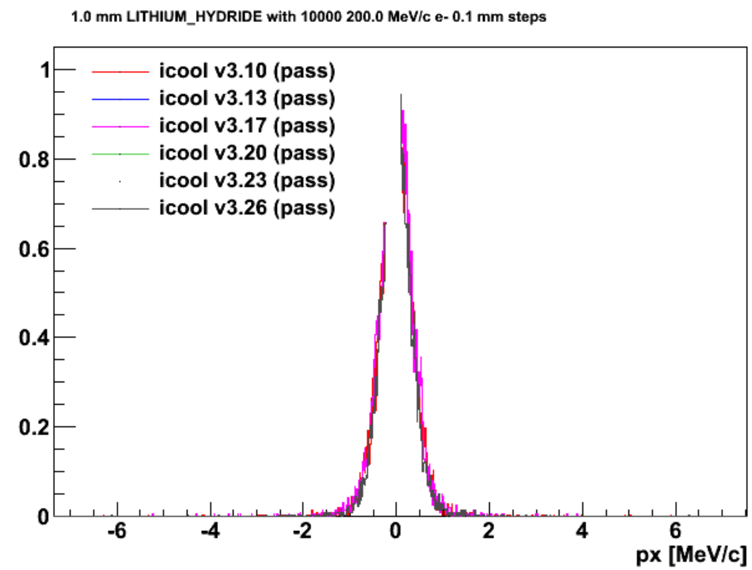
icool v3.23 (pass)
icool v3.26 (pass)
px [MeV/c]



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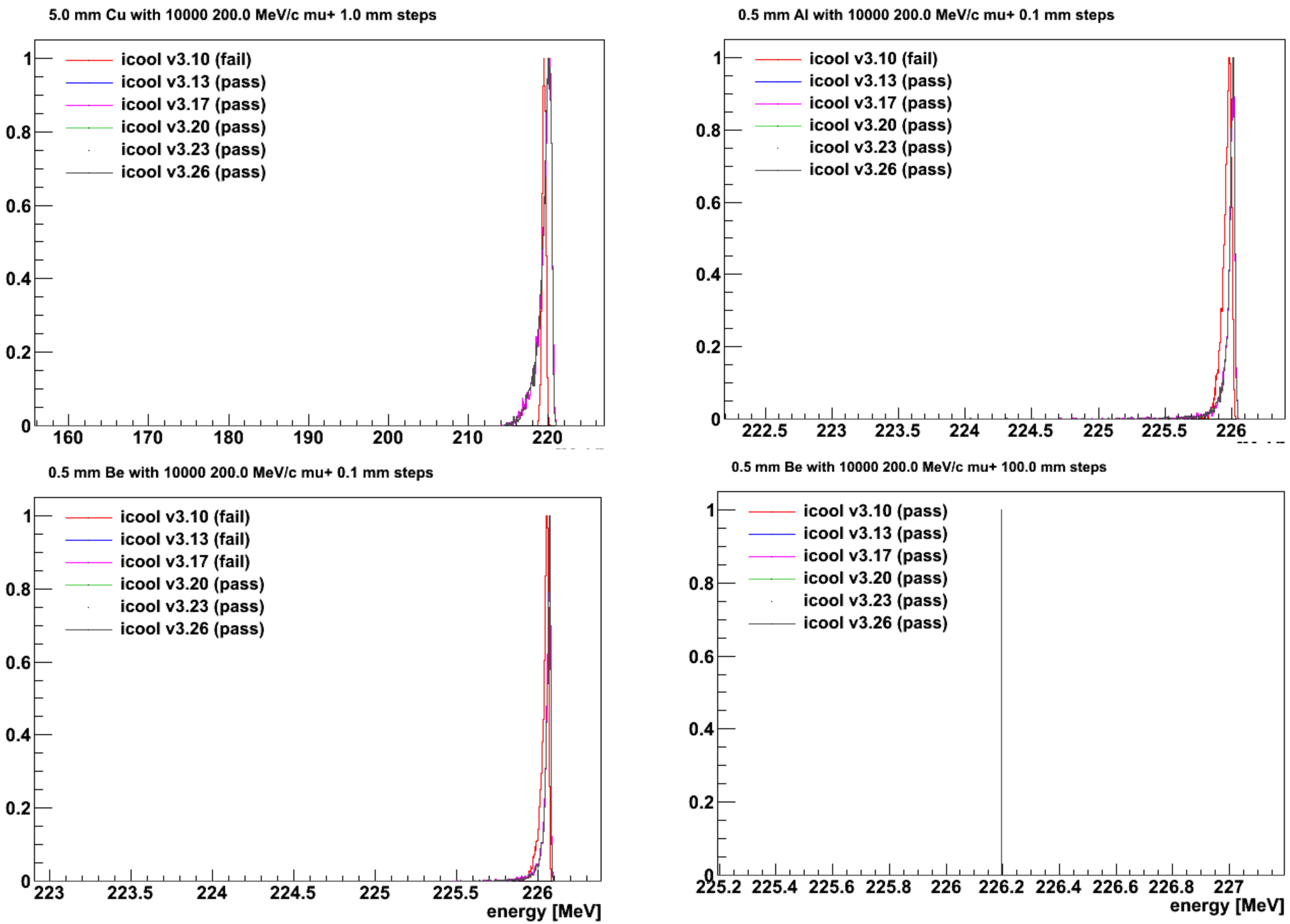
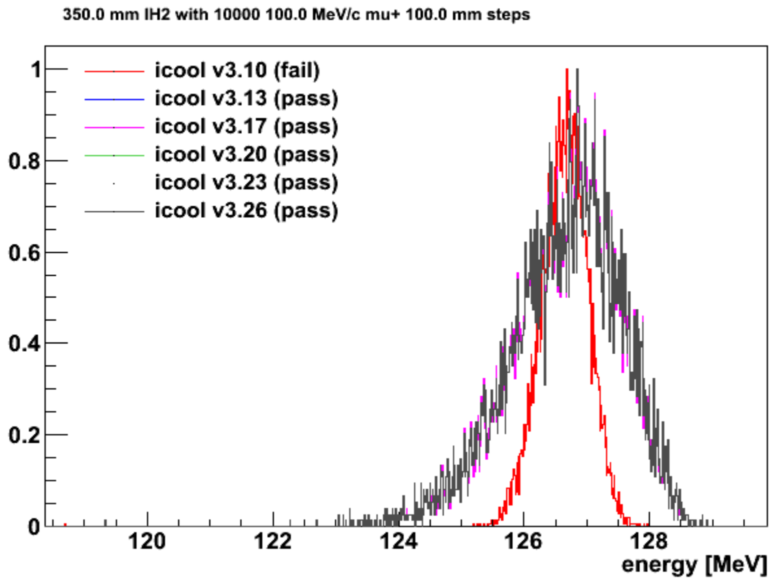
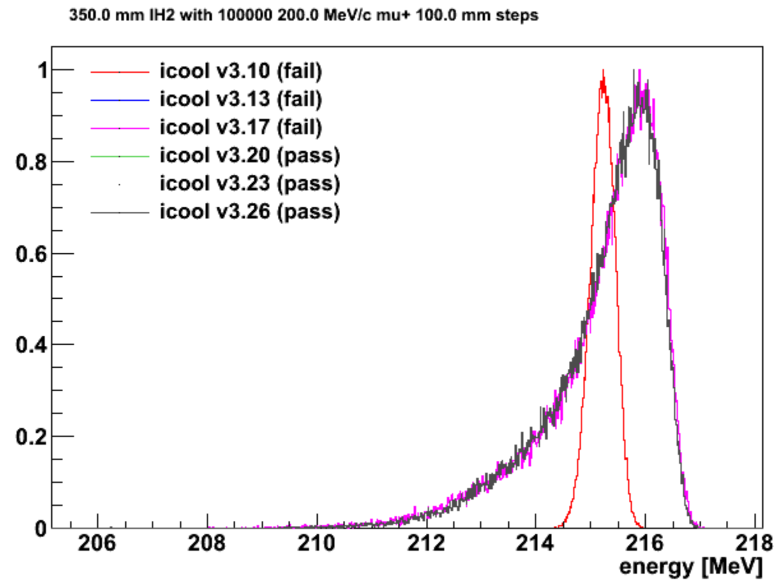
icool v3.26 (pass)
px [MeV/c]

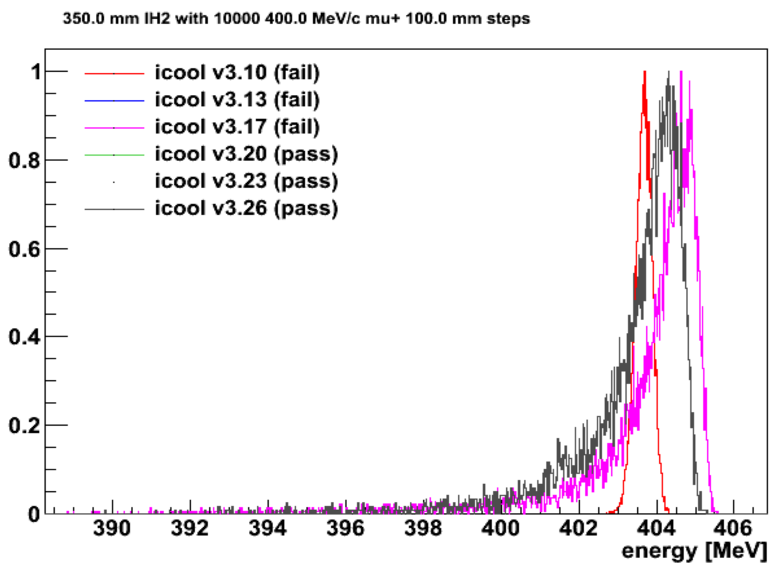
Muons in windows, etc

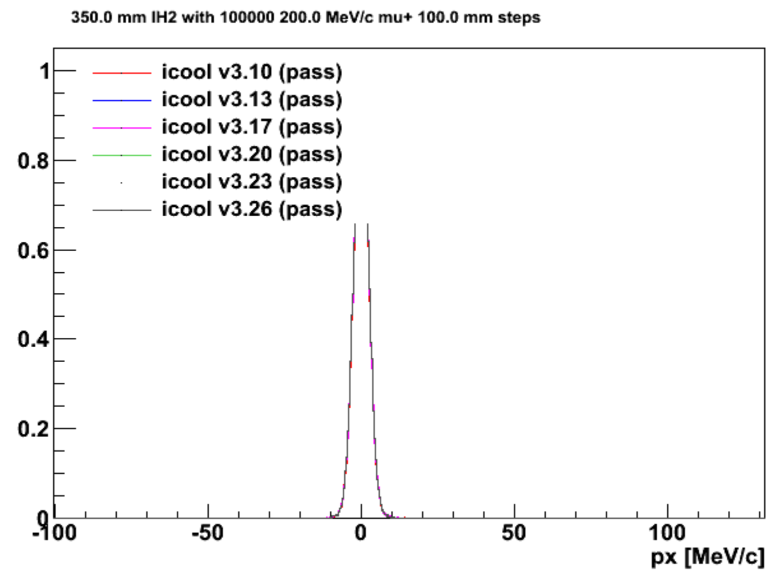


Muons in liquid Hydrogen

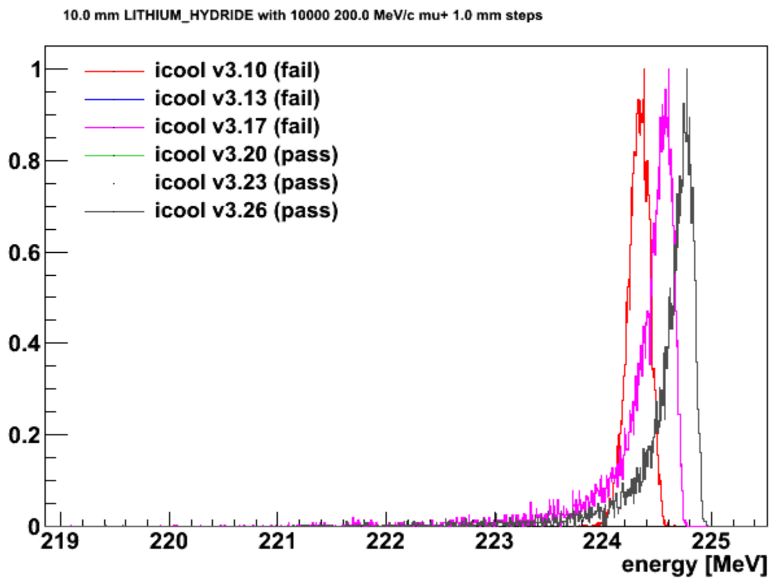


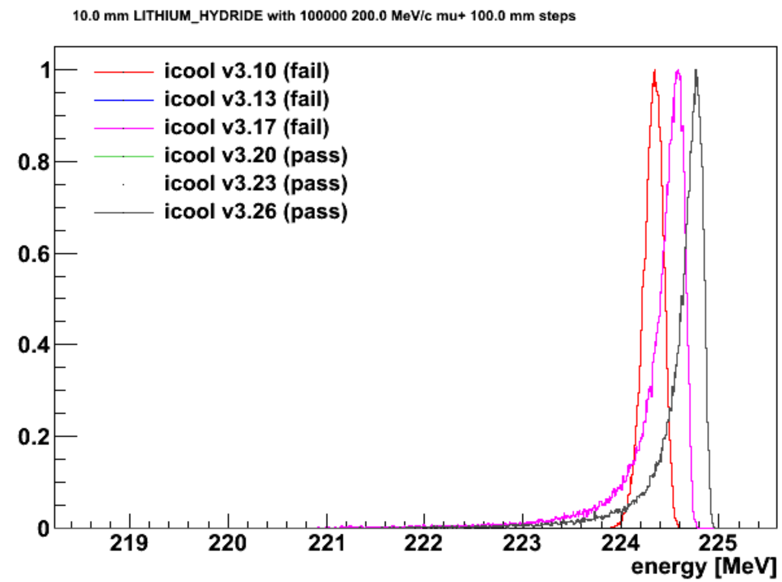


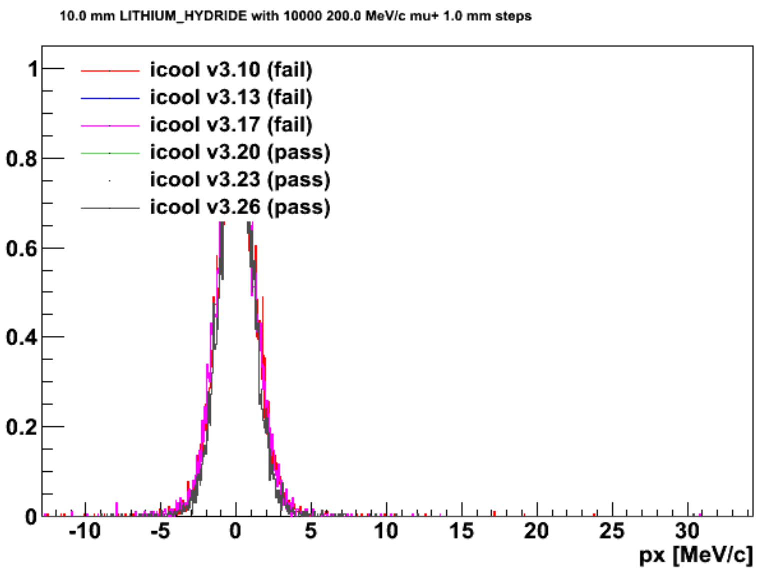


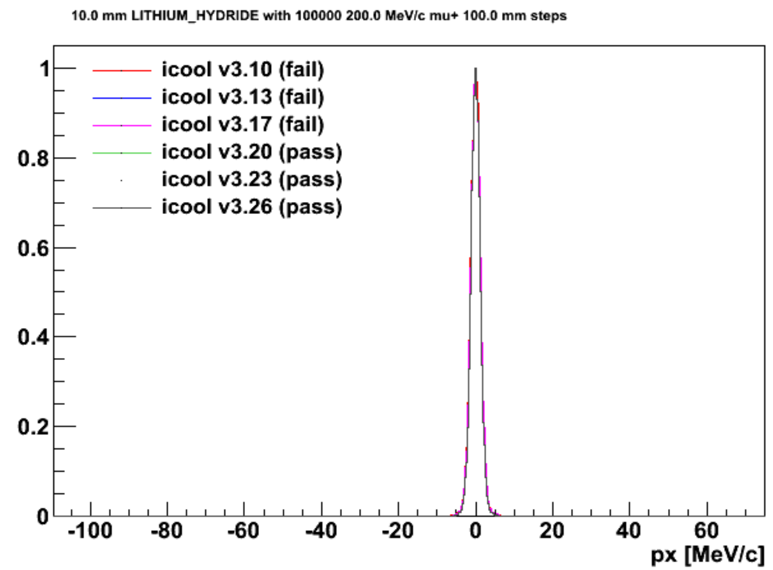


Muons in LiH (step size)

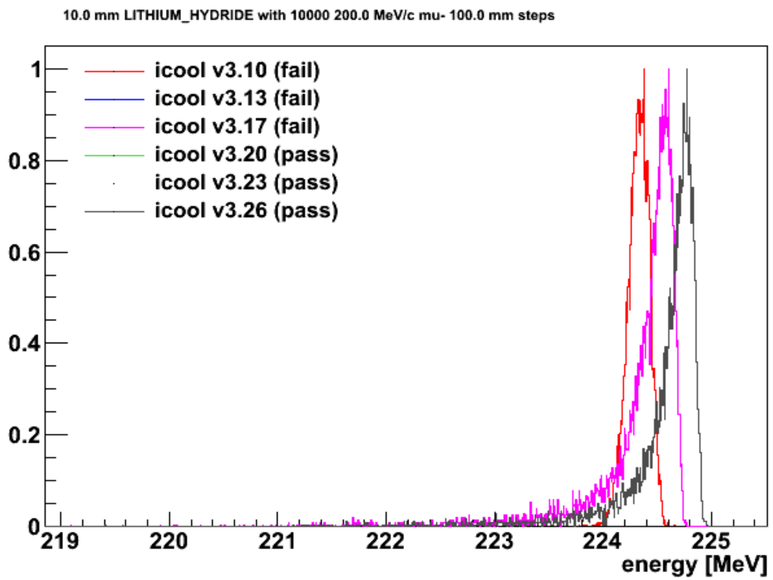


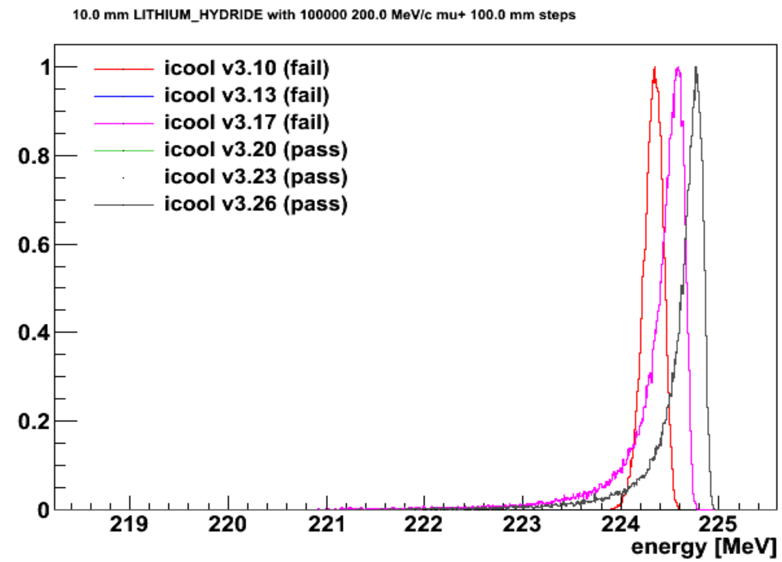


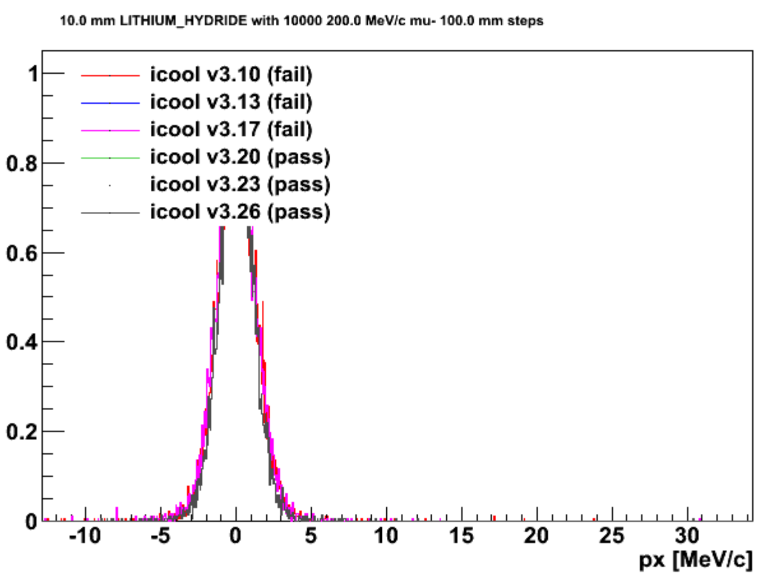


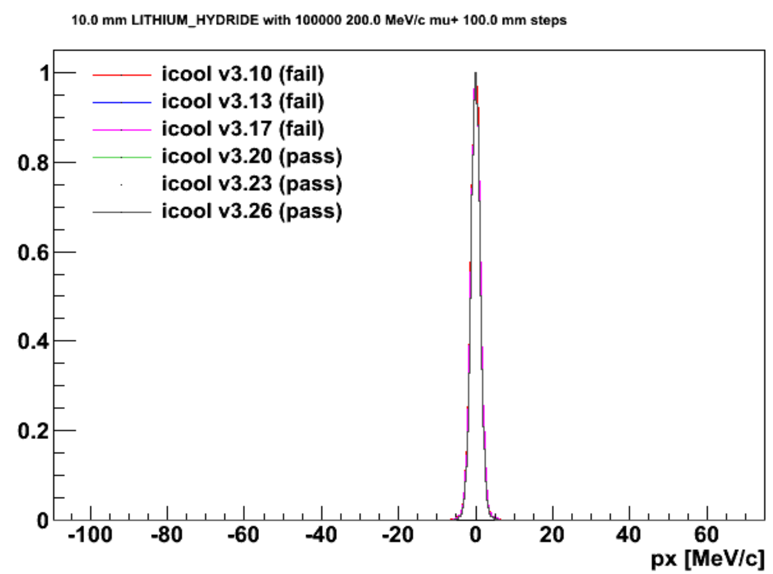


Muons in LiH (mu- vs mu+)

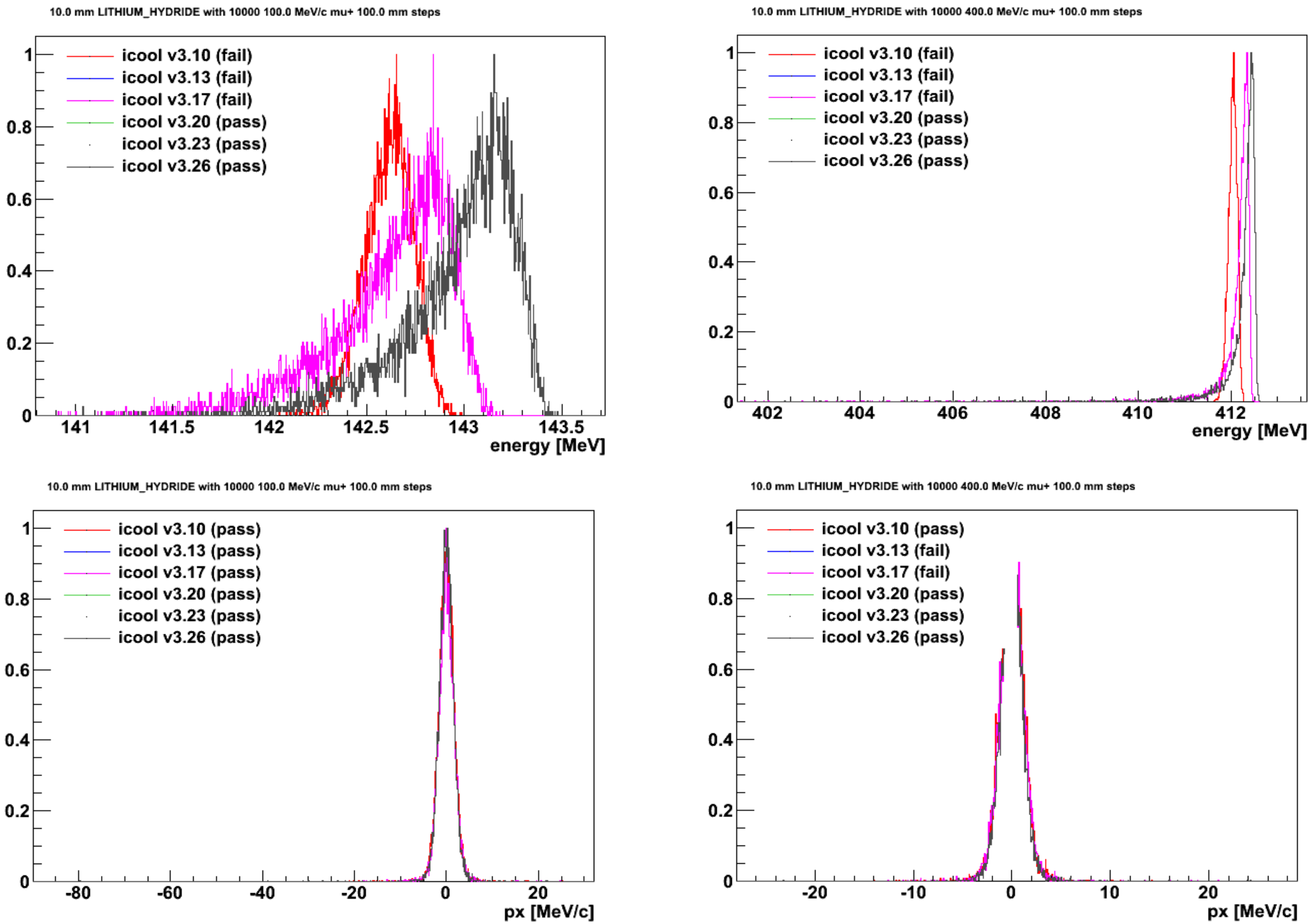




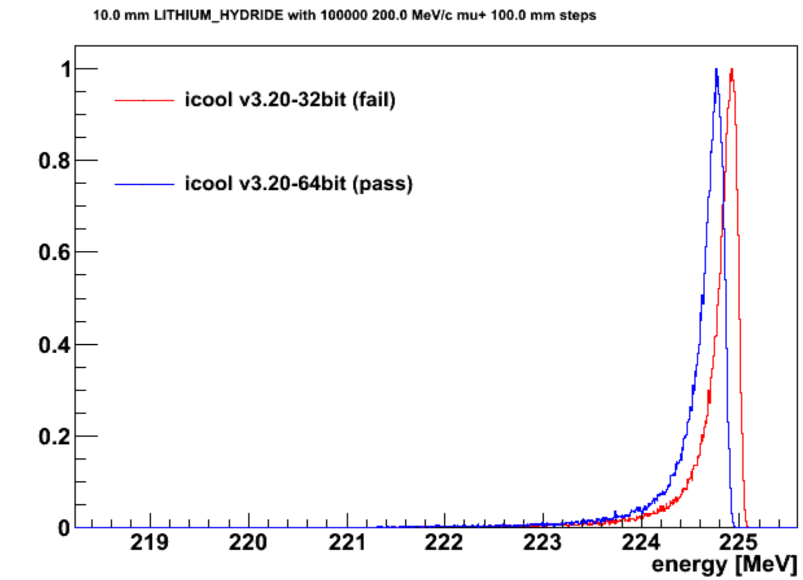


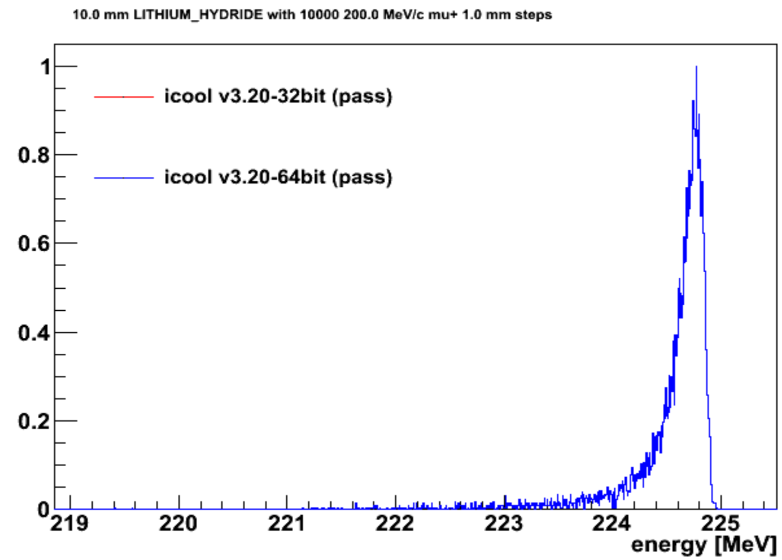


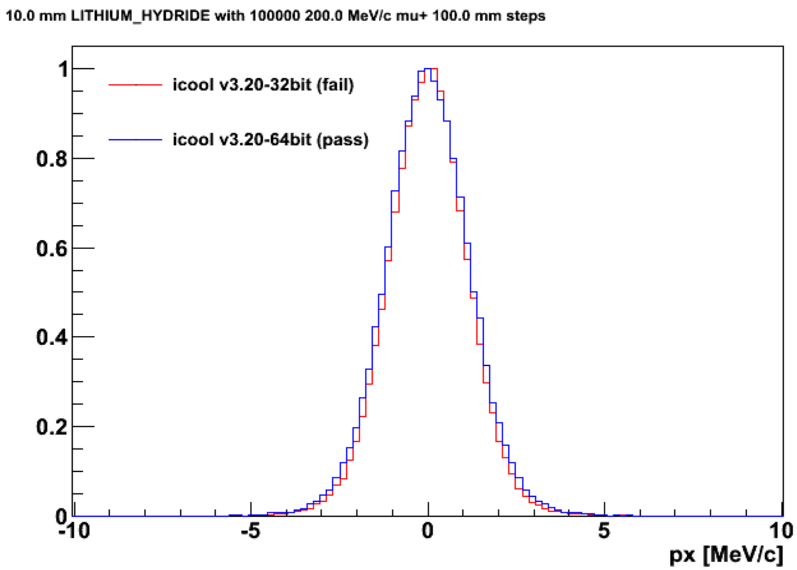
Muons in LiH (momentum)

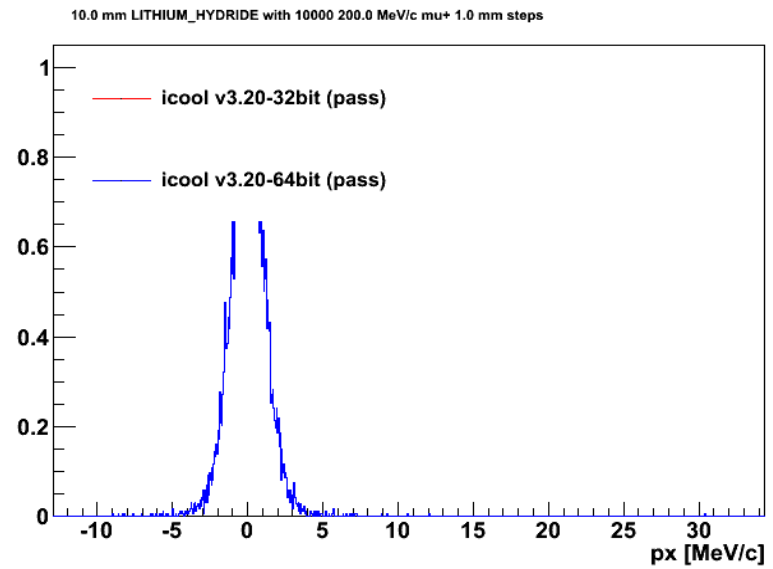


Muons in LiH (64 bit vs 32 bit)



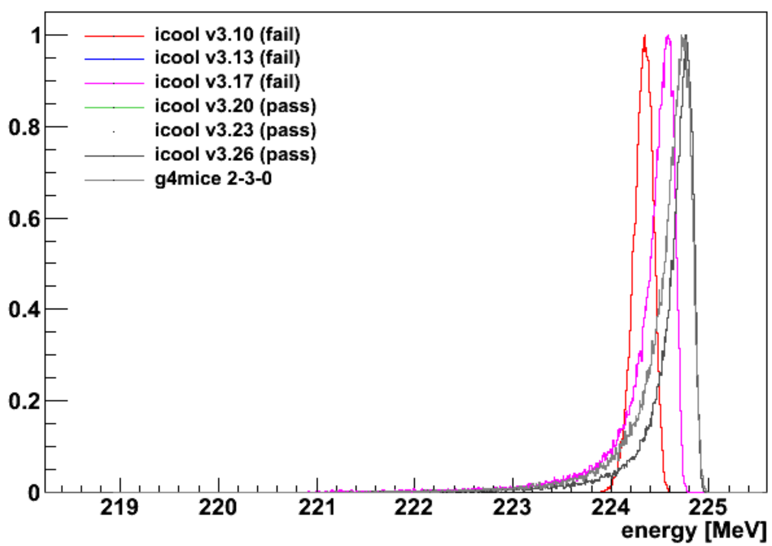




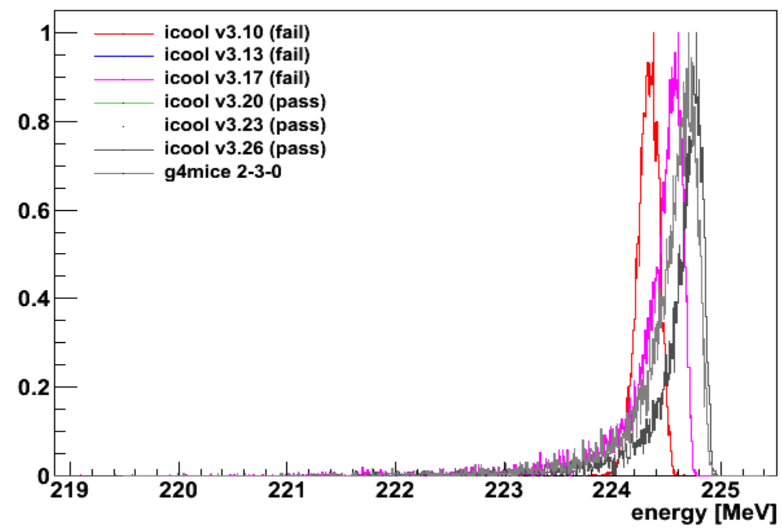


Muons in LiH (incl. G4MICE)

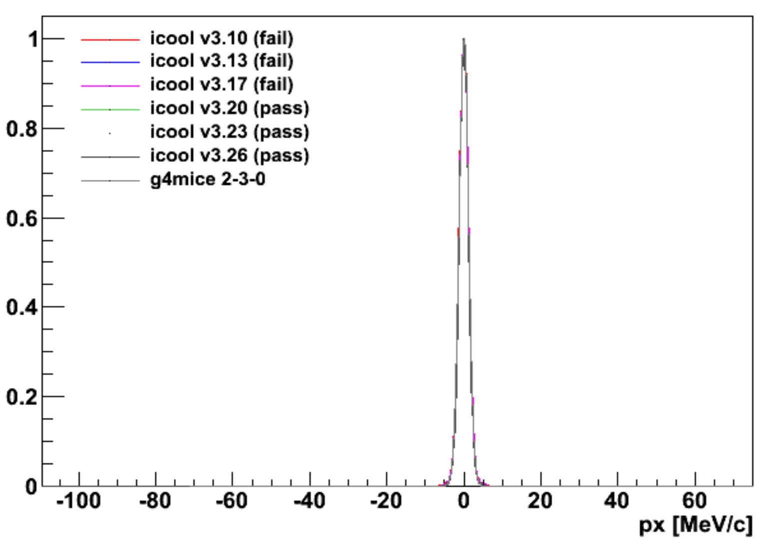
10.0 mm LITHIUM_HYDRIDE with 100000 200.0 MeV/c mu+ 100.0 mm steps



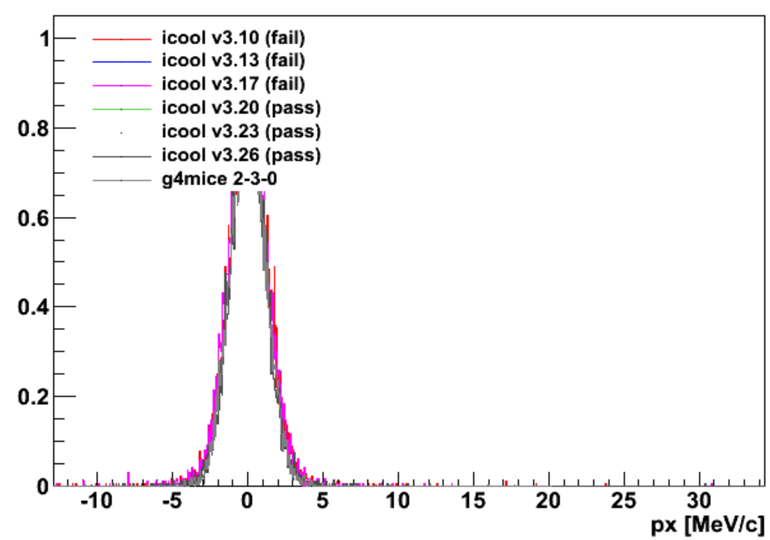
10.0 mm LITHIUM_HYDRIDE with 10000 200.0 MeV/c mu+ 1.0 mm steps



10.0 mm LITHIUM_HYDRIDE with 100000 200.0 MeV/c mu+ 100.0 mm steps



10.0 mm LITHIUM_HYDRIDE with 10000 200.0 MeV/c mu+ 1.0 mm steps



Conclusions

- ICOOL delev=2 scatlev=5 and straglev=6 models have moved quite a bit in the last 2 years
  - For all particles
  - For all materials
- We now have a (mostly) automated test to monitor this
  - Easy to monitor other physics models
  - Difficulty is in trying to come up with a finite number of things to test
- To do
  - Set up equivalent tests for g4beamline (and G4MICE)
  - Add some more test types (beam moments are important to us)
  - Add MuScat data
- Probably next year sometime
  - Tests on field tracking
    - Pillbox cavity
    - Constant Bz
    - Solenoid field