



Physics Models Update



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Physics model comparisons

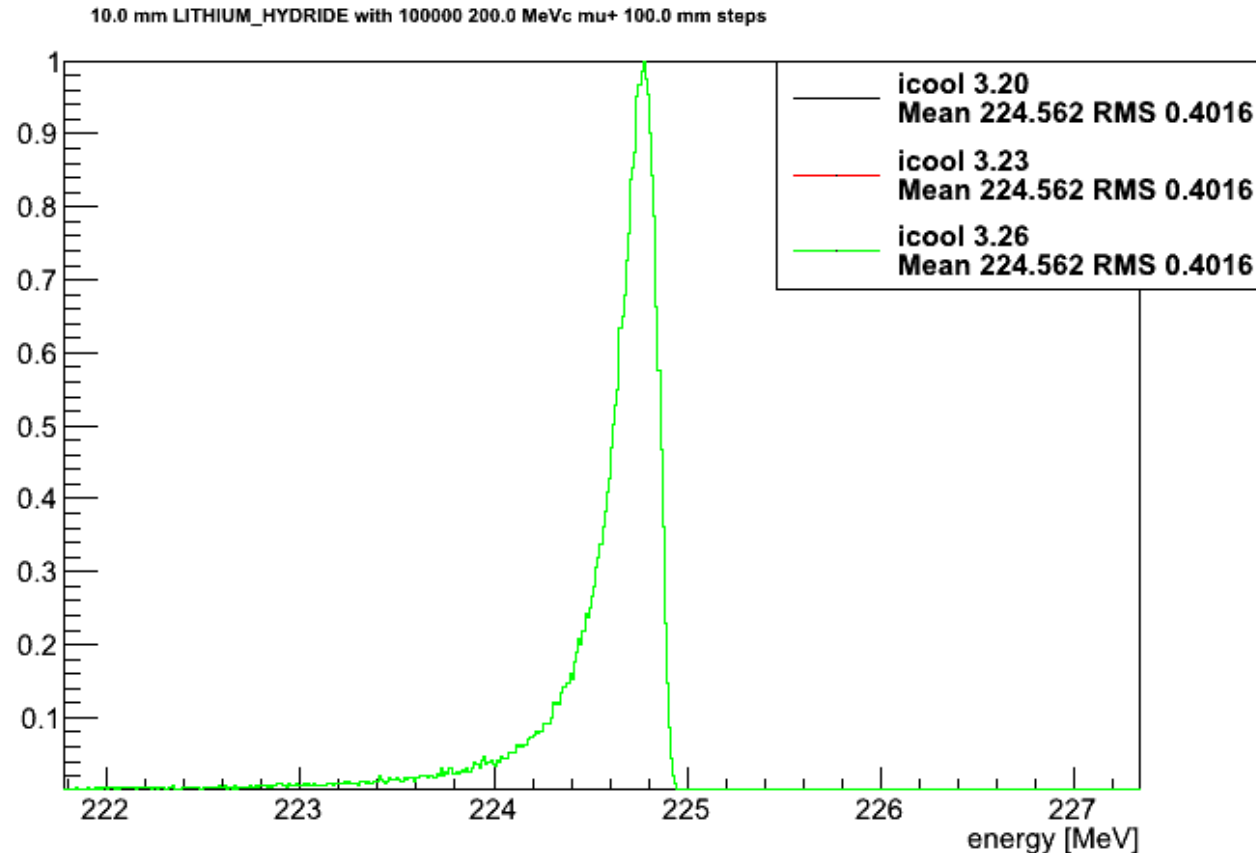


- Last time I looked at physics models
 - G4beamline and ICOOL showed surprisingly wide variation from version to version
 - Using nominally the same physics models
- GEANT4 for latest version GEANT4.9.5 suggest their model has improved (included in G4BL 2.12 as default QGSP model)

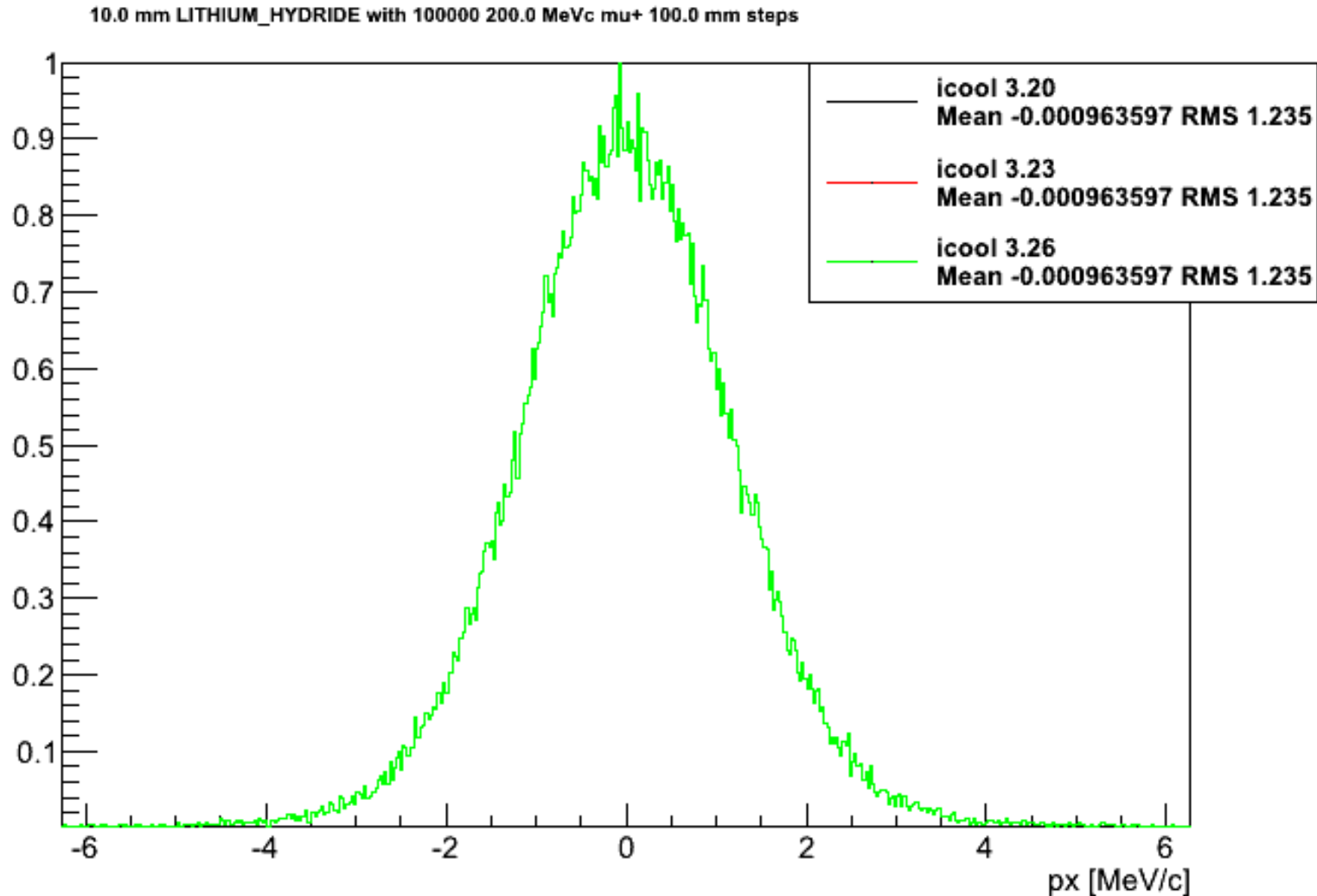
LiH - ICOOL



- ICOOL physics model is stable from 3.20 to 3.26
 - $delev=2$ $straglev=5$ $scatlev=6$
- RMS/Mean is calculated for central 99% of the bunch
 - Remove outliers to improve statistical stability



- ICOOL physics model is stable from 3.20 to 3.26

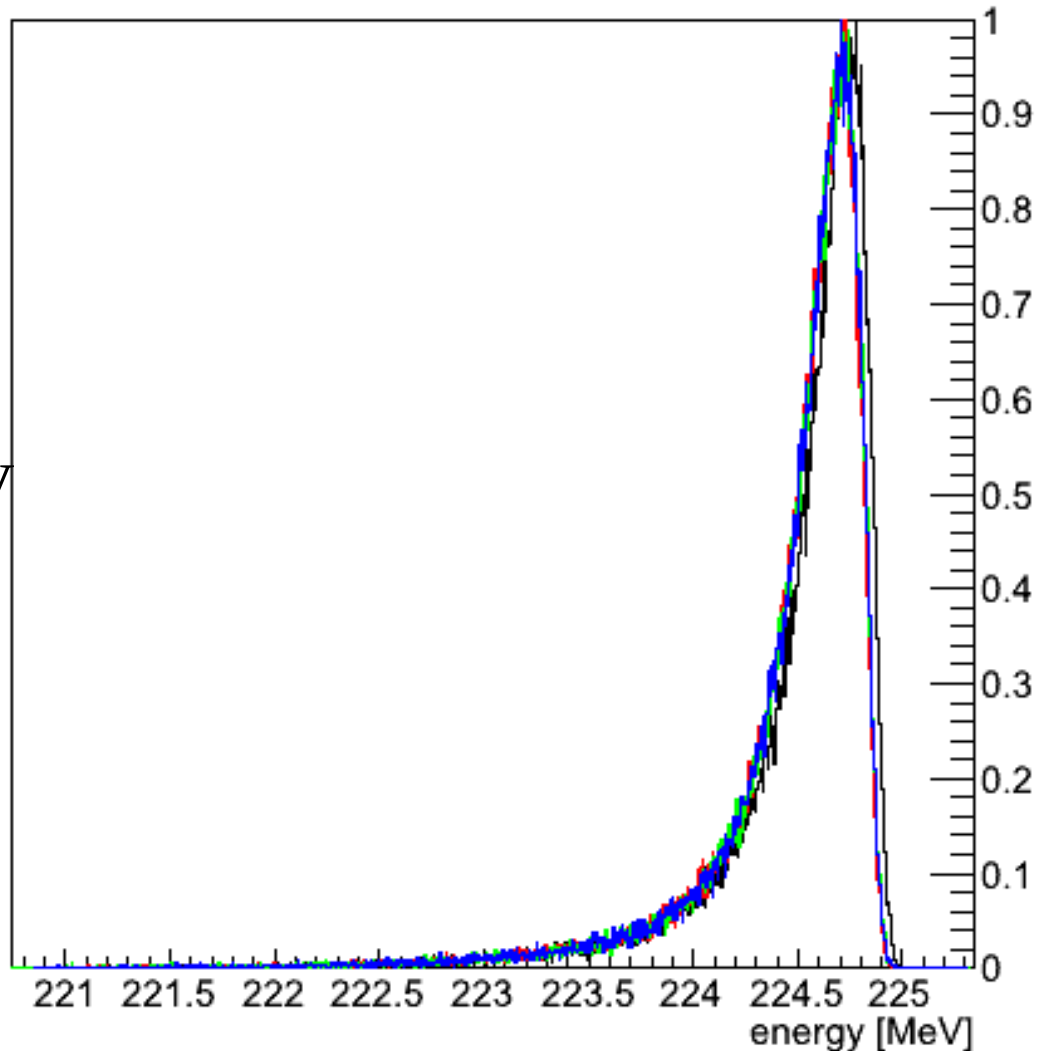


LiH - G4BL



- 10 mm LiH, 100000 200 MeV/c mu+, energy, QGSP_BIC

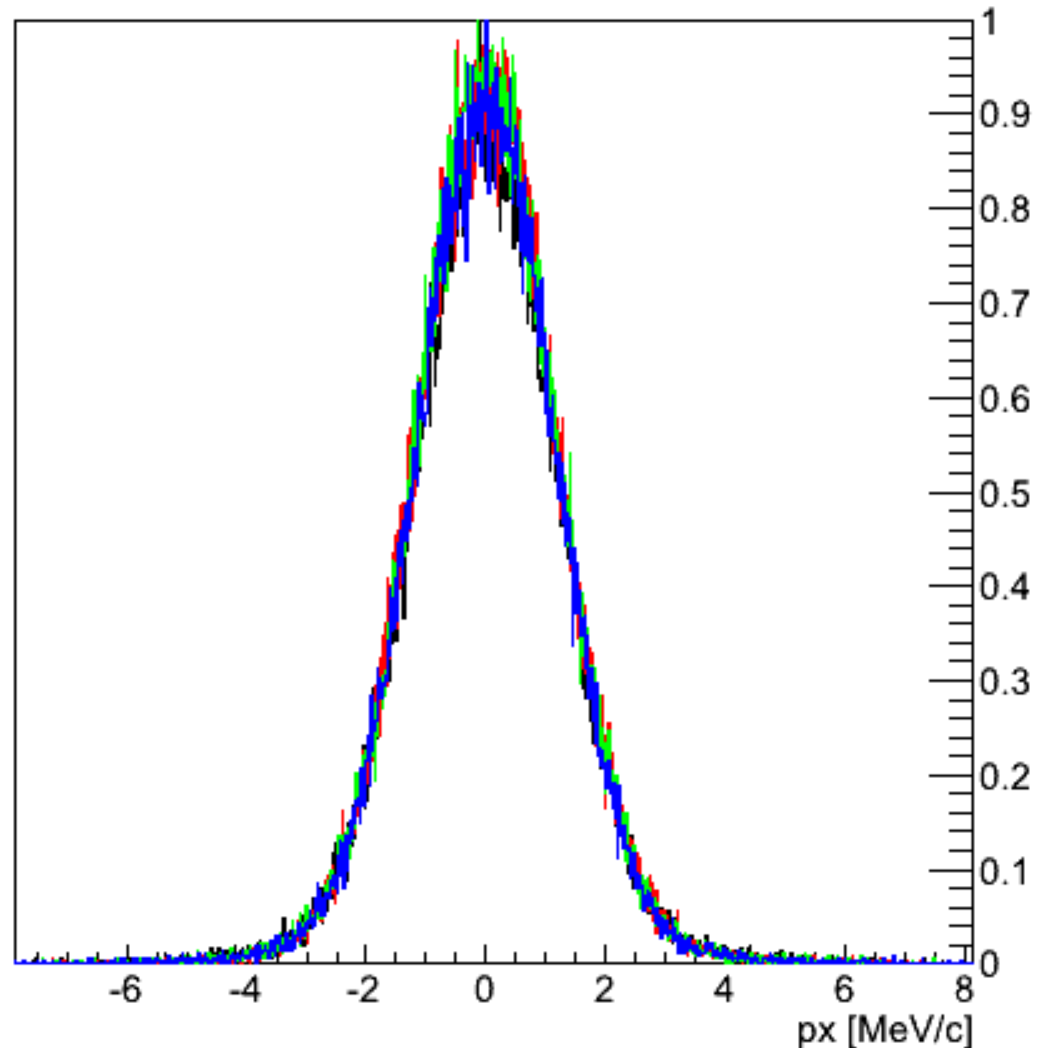
— g4bl 2.06
Mean 224.518 RMS 0.4173
— g4bl 2.12-64bit
Mean 224.474 RMS 0.4152
— g4bl 2.08
Mean 224.482 RMS 0.4189
— g4bl 2.10
Mean 224.481 RMS 0.4131



200 MeV/c \Rightarrow 226.194 MeV
(total energy)

- 10 mm LiH, 100000 200 MeV/c mu+, px, QGSP_BIC

—	g4bl 2.06
	Mean 0.0042535 RMS 1.311
—	g4bl 2.12-64bit
	Mean 0.0101664 RMS 1.259
—	g4bl 2.08
	Mean 0.00527031 RMS 1.27
—	g4bl 2.10
	Mean 0.00423272 RMS 1.279



- Equilibrium emittance $\sim \langle d\theta^2/dz \rangle / \langle dE/dz \rangle$
- G4BL 2.12-64bit* will give an equilibrium emittance about 11% lower than *G4BL 2.06*

LiH - G4BL vs ICOOL

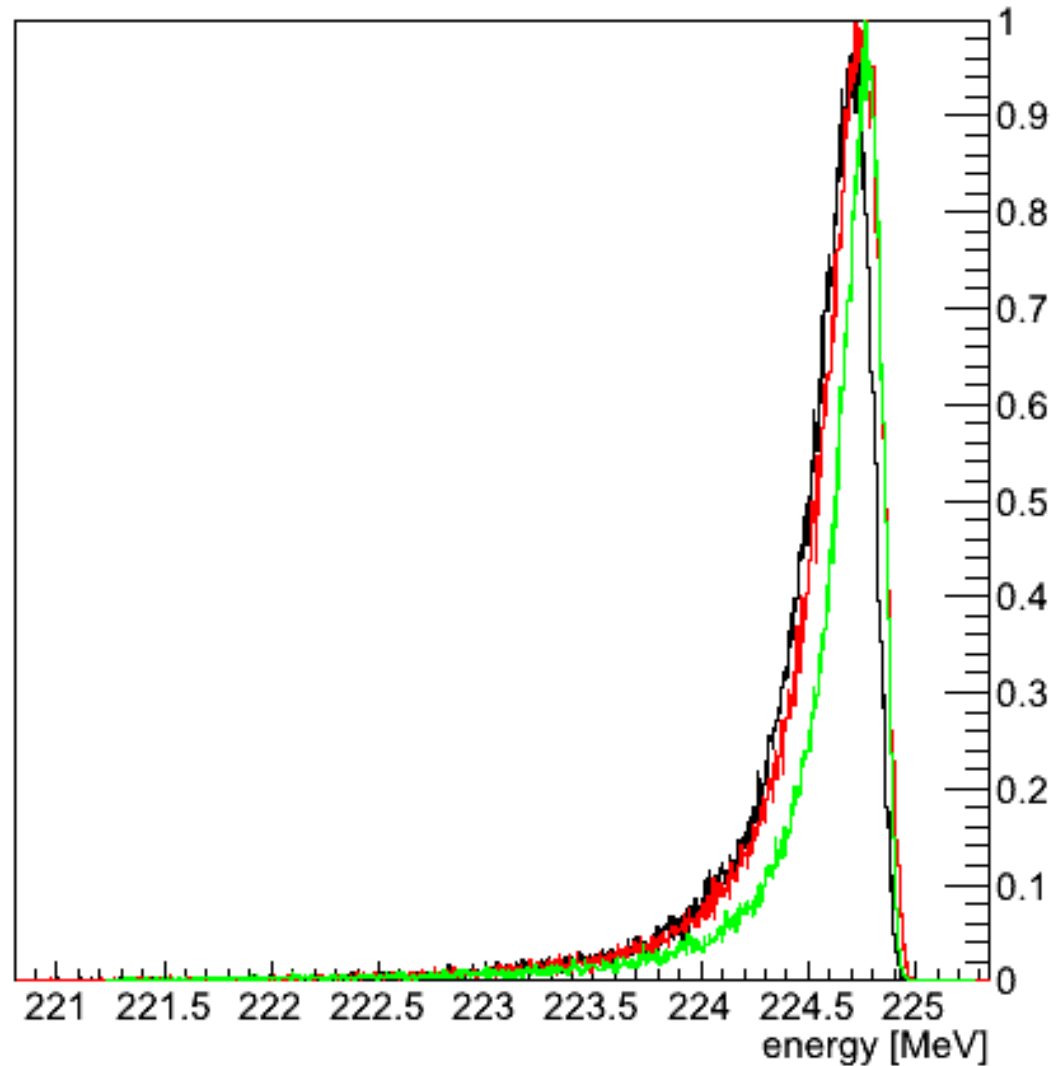


- 10 mm LiH, 100000 200 MeV/c mu+, energy

— g4bl 2.12-64bit
Mean 224.474 RMS 0.4152

— g4bl 2.06
Mean 224.518 RMS 0.4173

— icool 3.20
Mean 224.555 RMS 0.4258



- Difference in mean dE/dz between *ICOOL3.20* and *G4BL 2.06* is about 2%

LiH - G4BL vs ICOOL



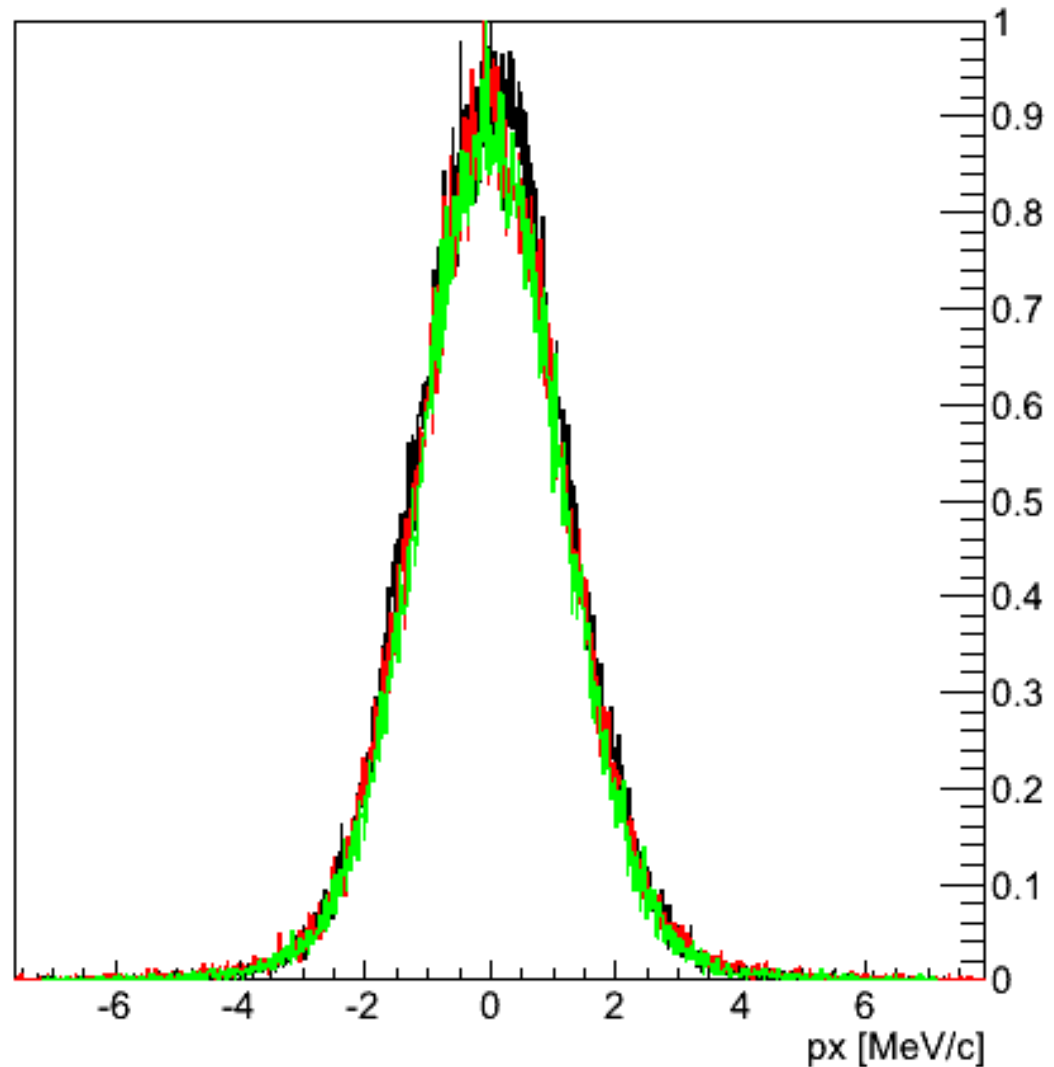
- 10 mm LiH, 100000 200 MeV/c mu+, px

— g4bl 2.12-64bit
Mean 0.0101664 RMS 1.259

— g4bl 2.06
Mean 0.0042535 RMS 1.311

— icool 3.20
Mean -0.000699664 RMS 1.247

- Equilibrium emittance
 $\sim \langle d\theta^2/dz \rangle / \langle dE/dz \rangle$
- ICOOL 3.20 will give
an equilibrium
emittance about 8%
lower than G4BL 2.06



Be window - G4BL vs ICOOL



- 0.5 mm Be, 10000 200 MeV/c mu+, energy

g4bl 2.12-64bit

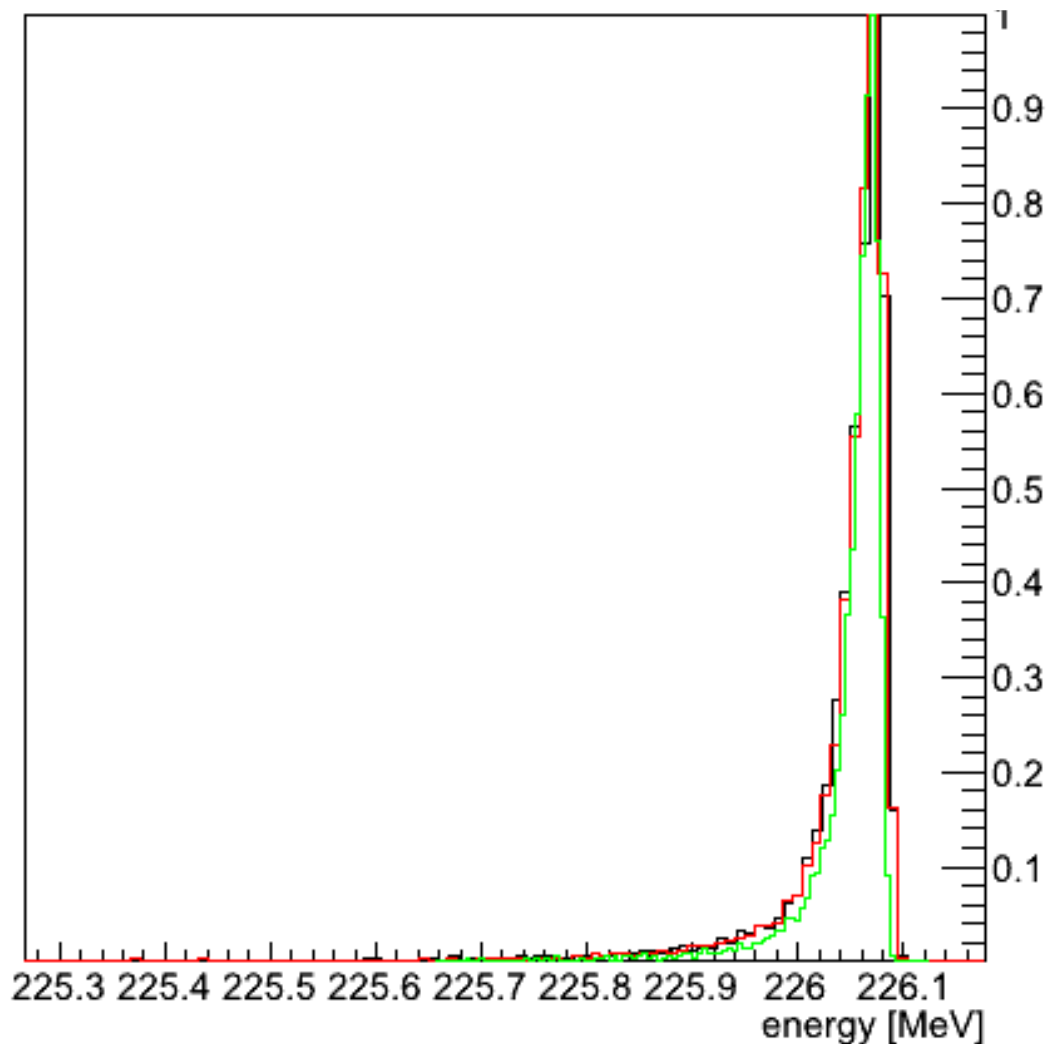
Mean 226.039 RMS 0.07697

g4bl 2.06

Mean 226.041 RMS 0.07305

icool 3.20

Mean 226.047 RMS 0.04691



Be window - G4BL vs ICOOL



- 0.5 mm Be, 10000 200 MeV/c mu+, energy

g4bl 2.12-64bit

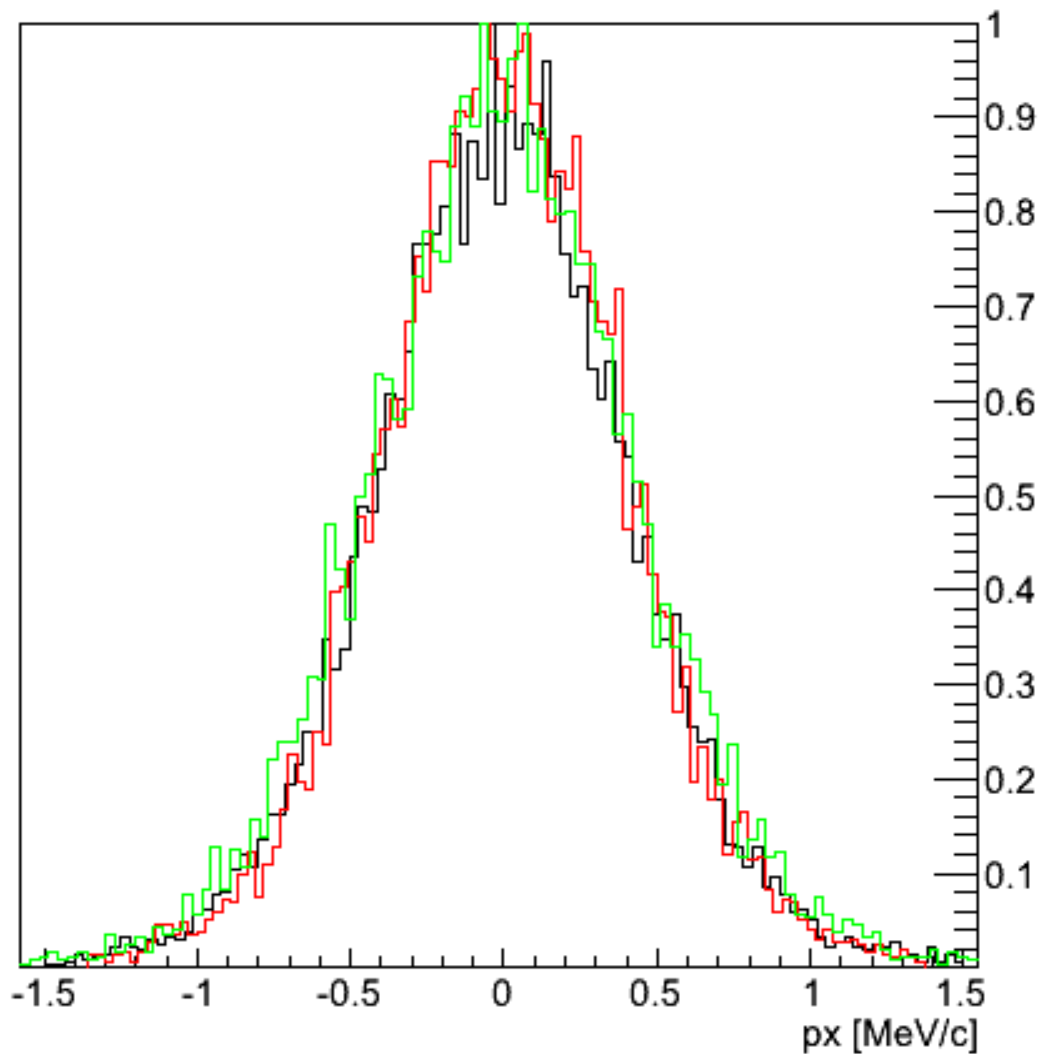
Mean -0.00396626 RMS 0.4209

g4bl 2.06

Mean 0.00398129 RMS 0.4011

icool 3.20

Mean -0.00404916 RMS 0.4447



Be window - G4BL vs ICOOL



- 0.5 mm Be, 10000 200 MeV/c mu+, energy

g4bl 2.12-64bit

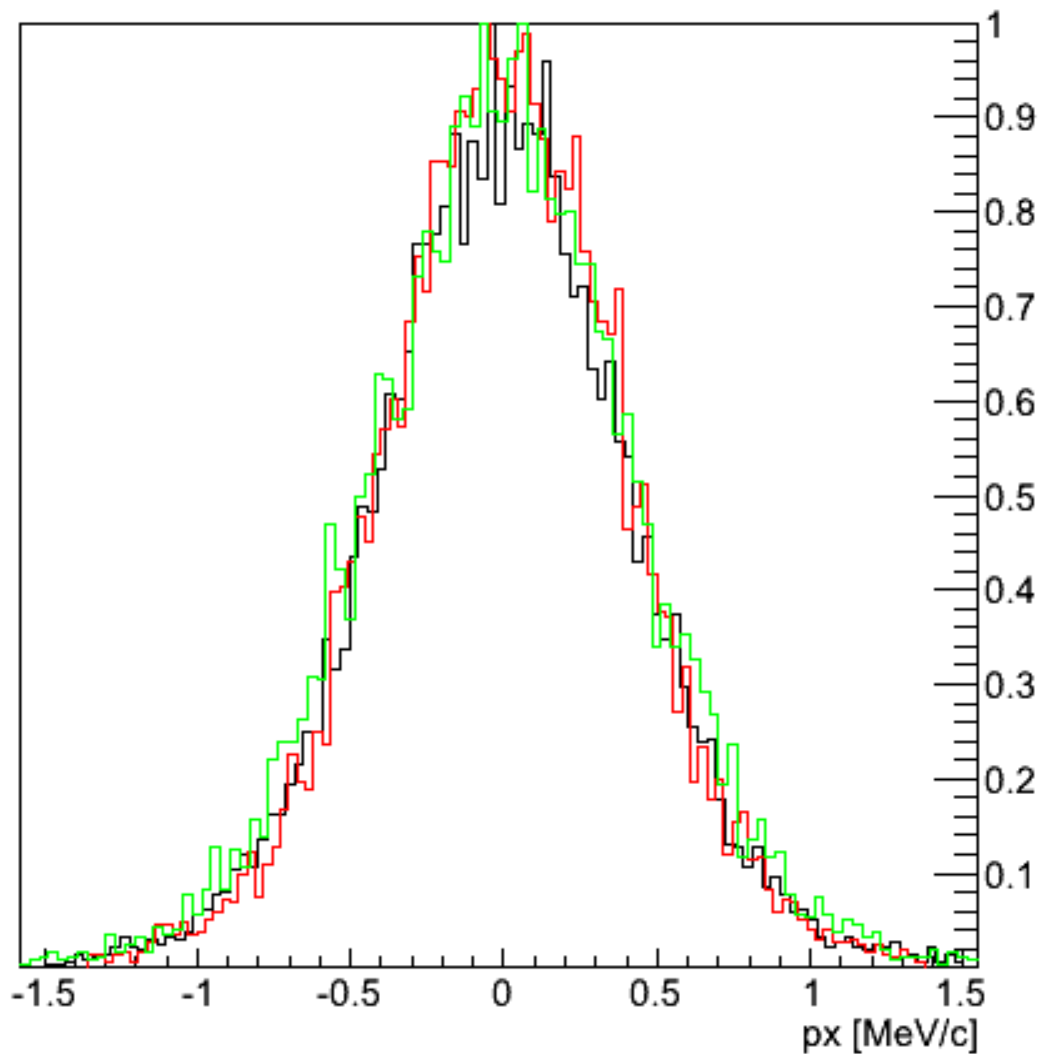
Mean -0.00396626 RMS 0.4209

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icool 3.20

Mean -0.00404916 RMS 0.4447

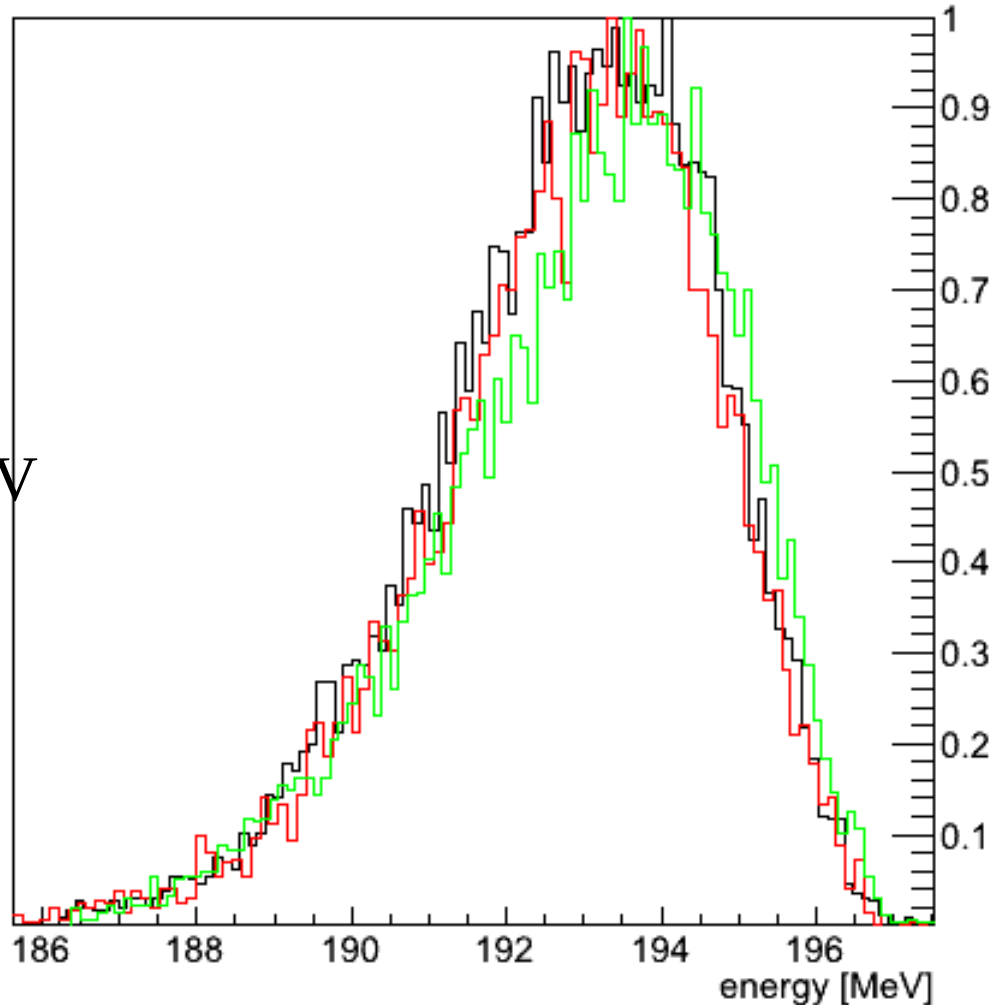


Be plug - G4BL vs ICOOL



- 100 mm Be, 10000 200 MeV/c mu+, energy

— g4bl 2.12-64bit
Mean 192.797 RMS 1.823
— g4bl 2.06
Mean 192.799 RMS 1.83
— icool 3.20
Mean 193.003 RMS 1.889



200 MeV/c \Rightarrow 226.194 MeV
(total energy)

Be plug - G4BL vs ICOOL

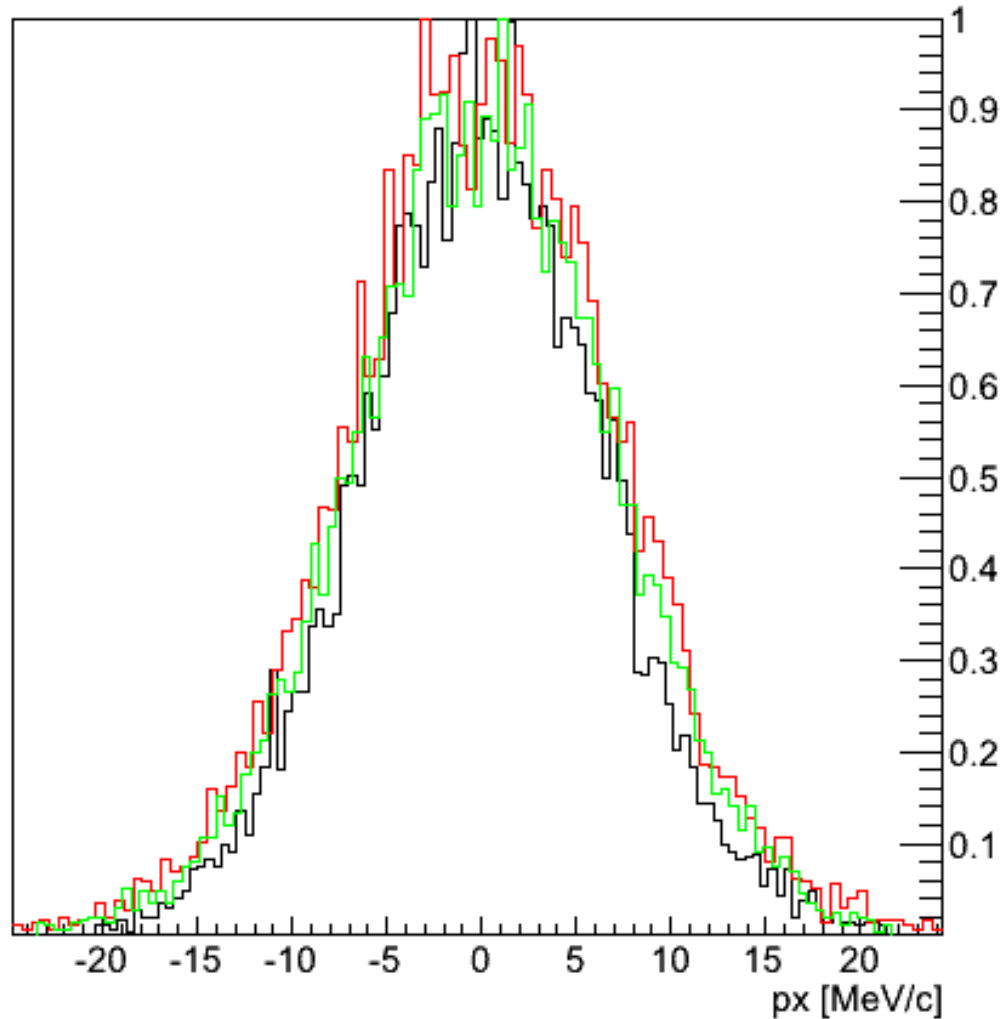


- 100 mm Be, 10000 200 MeV/c μ^+ , px

— g4bl 2.12-64bit
Mean 0.0329584 RMS 6.42

— g4bl 2.06
Mean 0.054511 RMS 7.282

— icool 3.20
Mean 0.0337082 RMS 6.96



Be plug - G4BL vs ICOOL



- 100 mm Be, 10000 200 MeV/c pi+, energy

g4bl 2.12-64bit

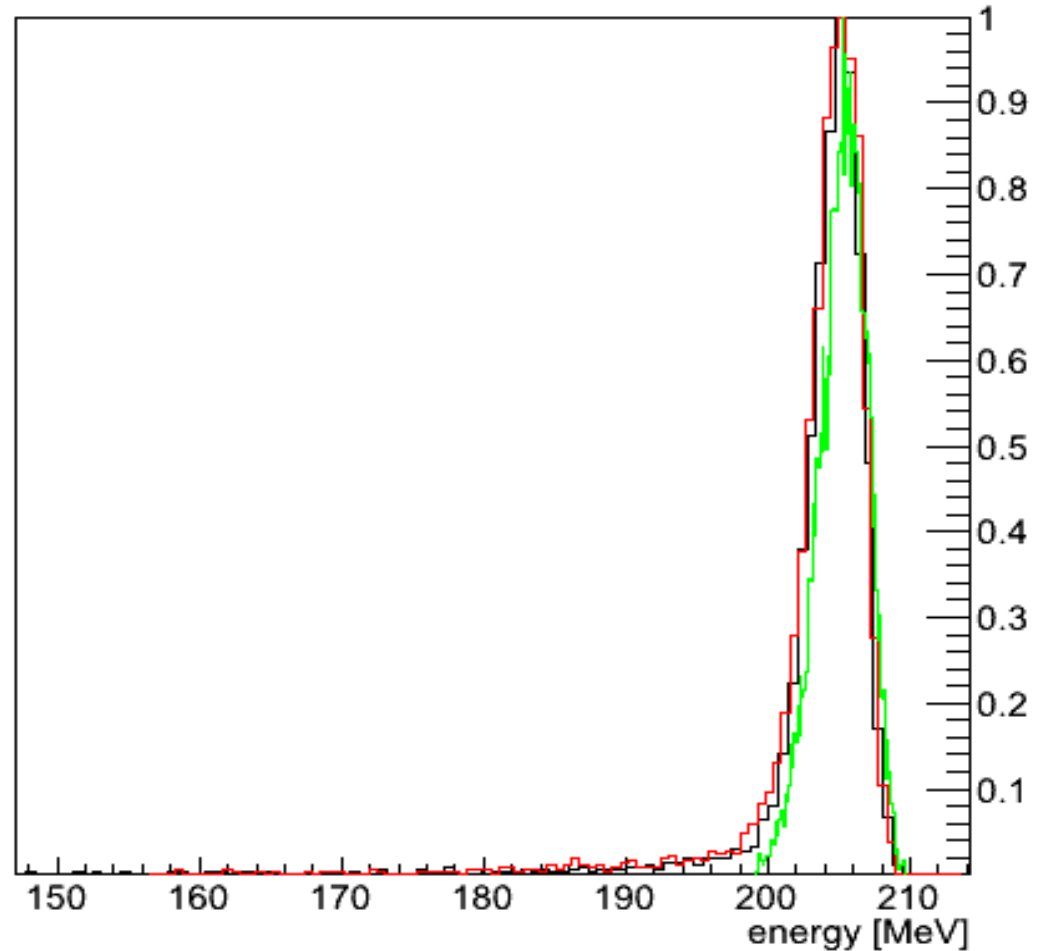
Mean 203.6 RMS 5.83

g4bl 2.06

Mean 203.637 RMS 4.86

icool 3.20

Mean 205.206 RMS 1.715



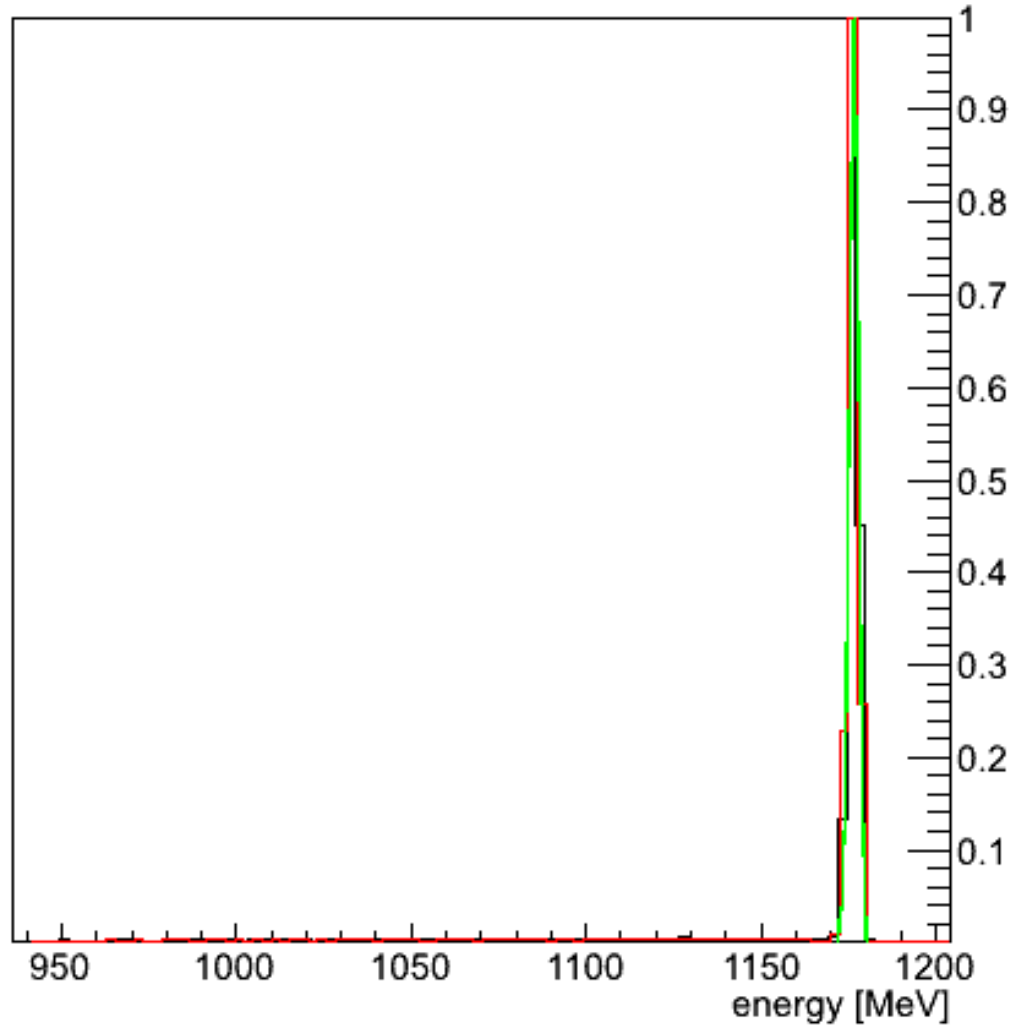
Be plug - G4BL vs ICOOL



- 100 mm Be, 10000 800 MeV/c proton, total energy

— g4bl 2.12-64bit
Mean 1162.31 RMS 42.75
— g4bl 2.06
Mean 1162.82 RMS 41.74
— icool 3.20
Mean 1176.61 RMS 1.338

Proton mass 938.27 MeV



Physics model conclusions



- Within approximations
 - Expect G4BL2.12 and recent ICOOL to give about 10 % lower equilibrium emittance in the cooling channel
 - Energy loss about the same
- Be plug
 - ICOOL fine for muons
 - Less good for pions, protons
 - That's okay, I think we know this (little/no hadronic model)
 - Would be nice to include MARS in comparison
- Nb I have loads of plots for different materials and can make more
 - e.g. IH₂ where I looked at ICOOL ELMS vs Stephen Brooks implementation using ELMS data tables
- Discussion
 - Do we want RDR to use latest version of G4BL (and ICOOL)?