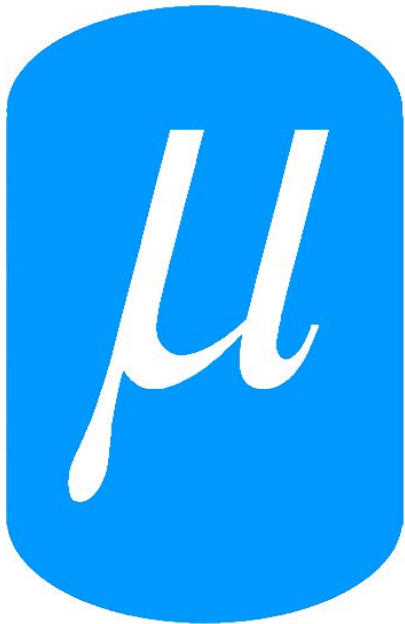# G4beamline

A beam/particle simulation program based on Geant4.

Muons, Inc.
Innovation in research

G4beamline goals

- G4beamline is intended to perform simulations as **realistically** as possible.
  - With validation via experiments and other codes.
- In a **user-friendly** manner.
  - Reduce user time and effort.
- Secondary goals:
  - Run on Windows, Mac OS X, and Linux.
  - Open source and freely downloadable.
    - So experts can examine and understand the code.

G4beamline has become very popular.

"It is an absolutely central part of our software suite."

"To do the problems I am working on would be almost impossible without the aid of [G4beamline]."

"G4Beamline probably saved me a factor of 2 or more in time."

- Hundreds of users.
- Downloaded ~15 times per week.
- Used by physicists at most accelerator labs.
- >100 papers reference it.

"It's such a time saver."

"The simple command language interface has made it possible for undergraduates to use it."

"I think it points the way to the future of simulation studies in our field."

"it remains my favourite simulation program."

"I like the way it 'just works'."

G4beamline input files are readable by anyone familiar with beamlines.

Specify the list of physics processes.

Specify the initial beam (default along z).

Define an element Q1 (here a quad).

Place Q1 into the world (here three times).

```
# Quadrupole Triplet
physics default
beam nEvents=1000 P=200          # MeV/c
genericquad Q1 apertureRadius=100 \
      ironRadius=250 fieldLength=500 \
      ironLength=500                   # mm

place Q1 z=1000 gradient=5.4      # T/m
place Q1 z=2000 gradient=-7.2     # T/m
Place Q1 z=3000 gradient=5.4      # T/m
```

# G4beamline can be used in High Performance Computing.

- G4beamline is MPI enabled, so multiple instances of it can cooperate on a single problem.

- Works well on a modern desktop computer with multiple cores (Linux and Mac).

- Can achieve speed factors of 1,000 or more on a supercomputer.
    - This is especially valuable when optimizing the parameters of a system, which can require dozens to hundreds of simulation runs.

G4beamline teams with HistoRoot to examine rare, outlier events.

Plot1
Entries   991
Mean   -399.2
RMS   279.7
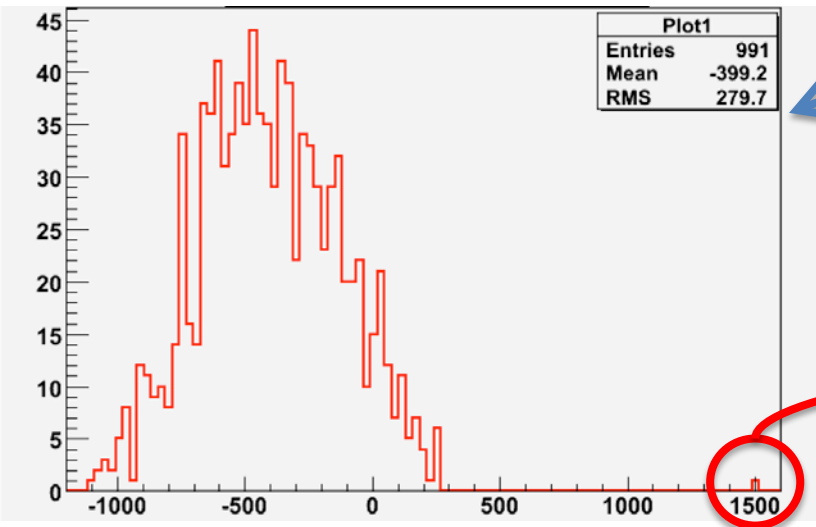
HistoRoot can select outlier events and communicate their EventIDs to G4beamline, which can re-run them with visualization. Here the bending magnet clearly needs additional shielding.

Outlier event

Nominal beam position

Detector
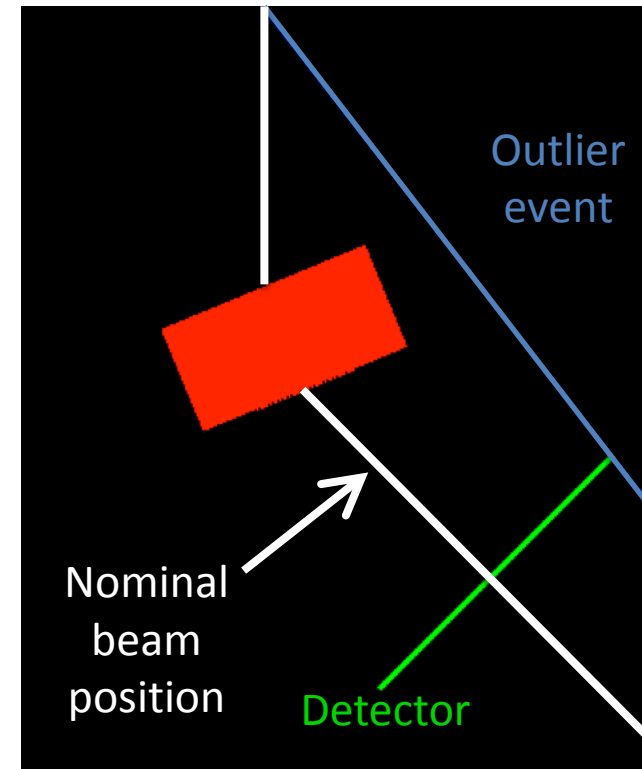
G4beamline users apply it to many different problems.

- The combination of ease of use and access to the full power of GEANT4 permits G4beamline to simulate many diverse systems, including current, upcoming, and next generation beamlines:
  - Muon Collider R&D
  - Neutrino Factory R&D
  - Muon to electron conversion experiments
  - Electron and proton experimental halls
  - and many more

# G4beamline for the Muon to electron conversion experiment.

A challenging experiment looking for an extremely rare process.
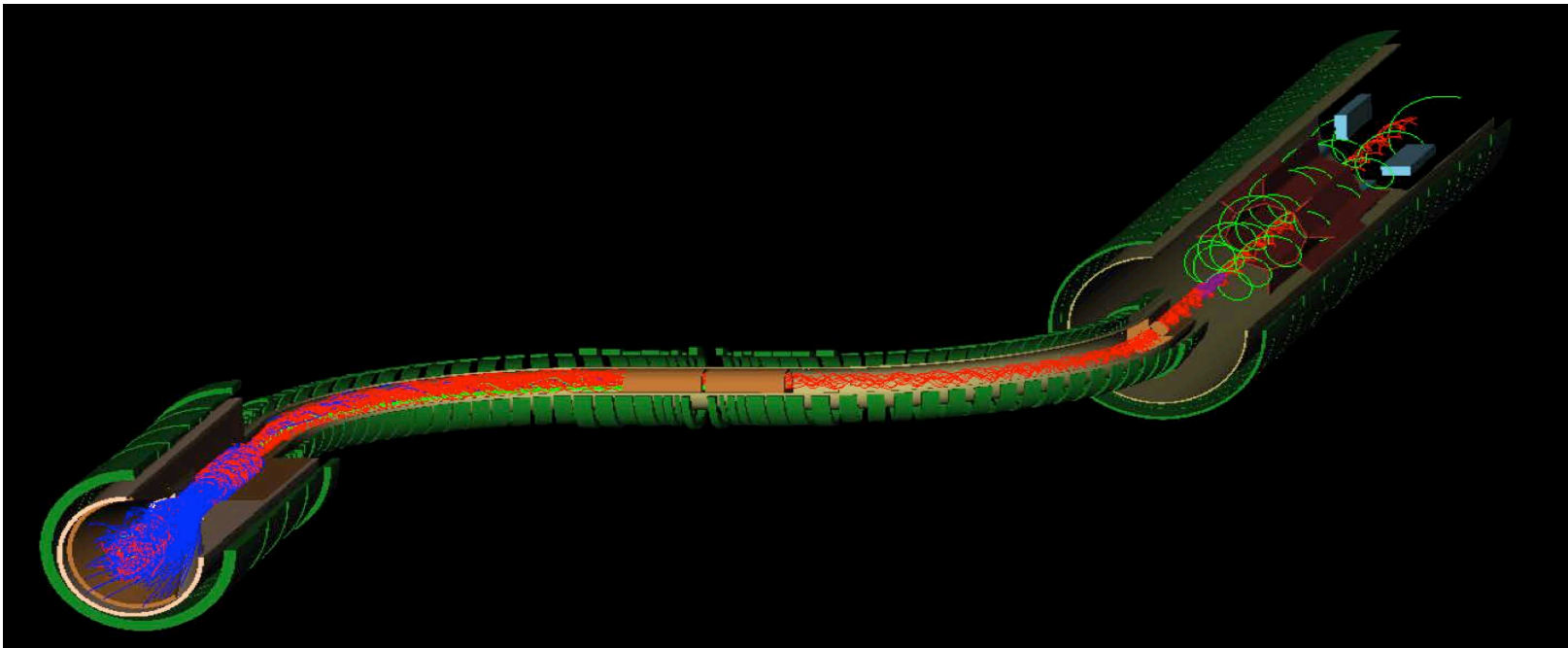
Protons interact inside the production solenoid at left, producing pions (blue), they are magnetically mirrored and decay into muons (red) which are transported to the detector solenoid at the right; some μ^- stop in the target and decay or are converted into electrons (green) which spiral into the detector.
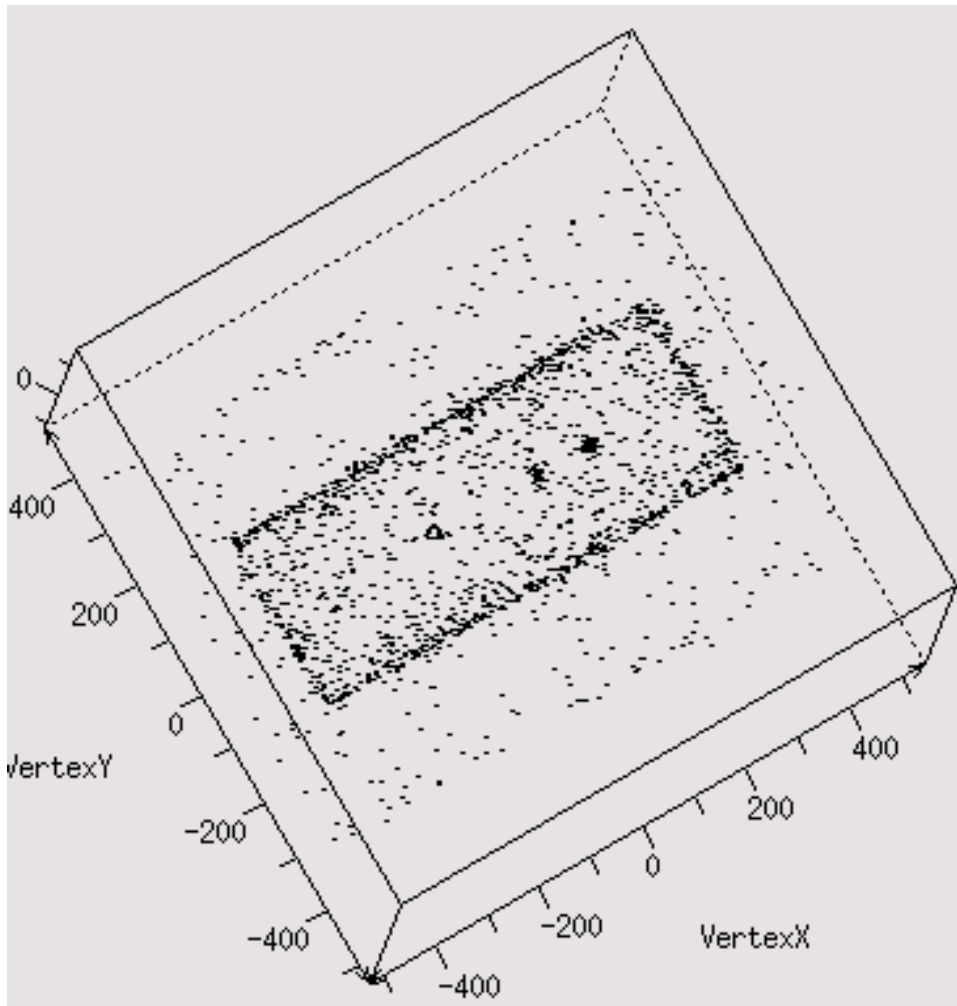
G4beamline for Muon beam cooling channels
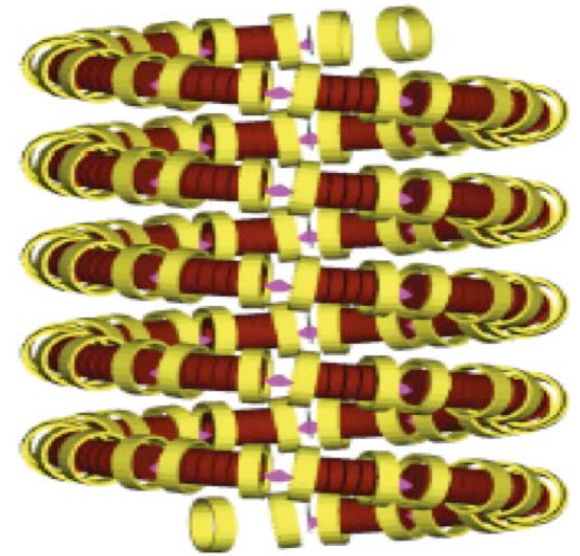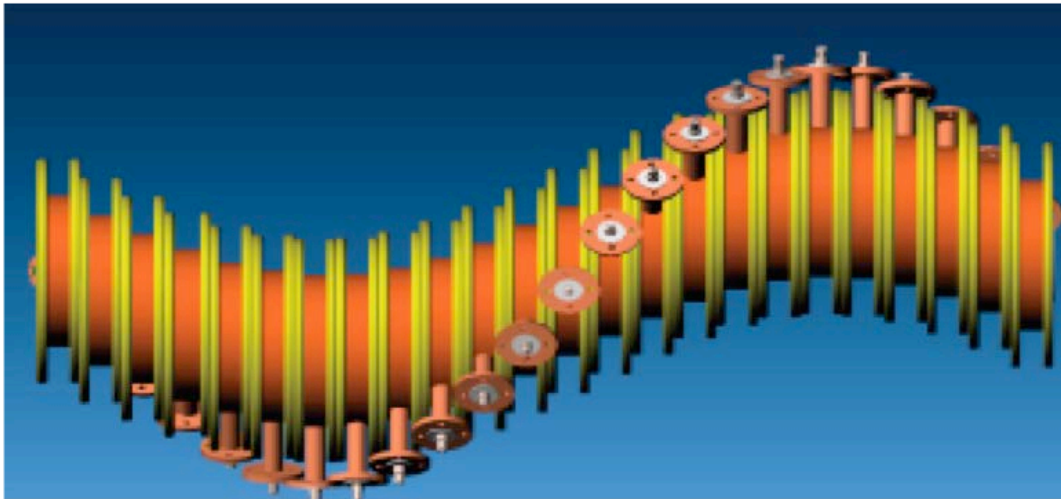
Muon beam cooling channels are complicated beam lines which integrate beam absorbers, radio frequency cavities, and magnets. G4beamline has been, and continues to be, used to study these cooling channels for the U.S. Muon Accelerator Program.
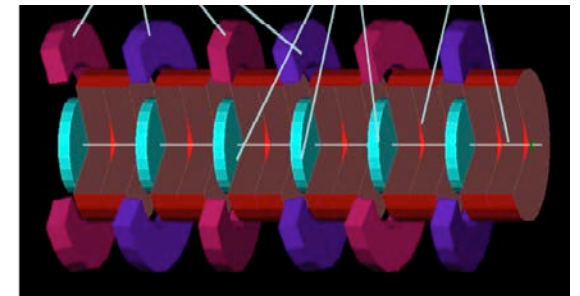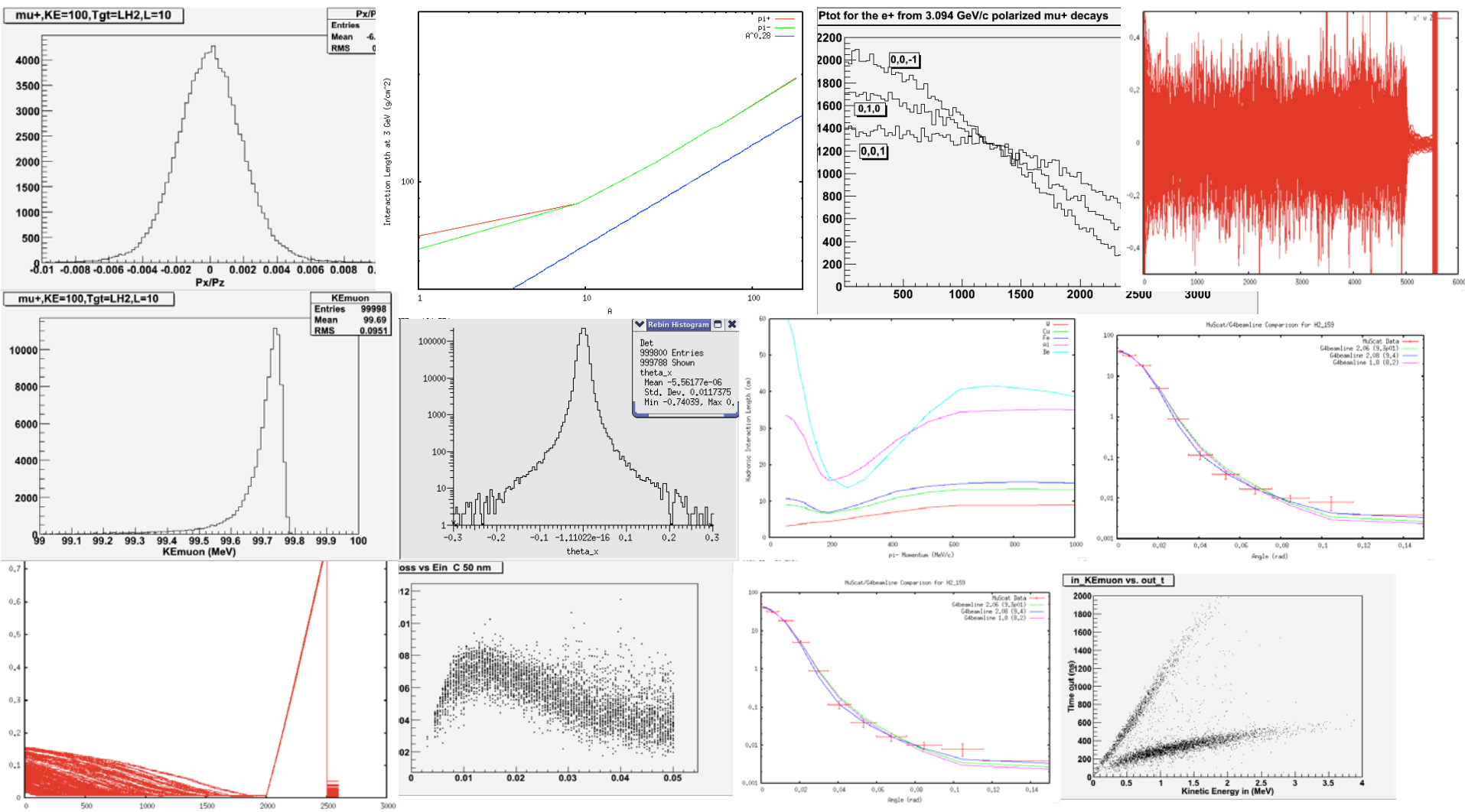
G4beamline for cosmic ray Muon tomography.

This is a 30-second exposure of a cargo container in air, with four small cubes near the center; the uranium and iron cubes are clearly visible, the aluminum cube is barely visible, and the cube of water is not.

G4beamline plus a histogram package can generate any plot of interest.

G4beamline is open source, and
is freely available for download.

http://g4beamline.muonsinc.com