Hadronic Hands-On Exercises

Geant4 Users' Tutorial at CERN

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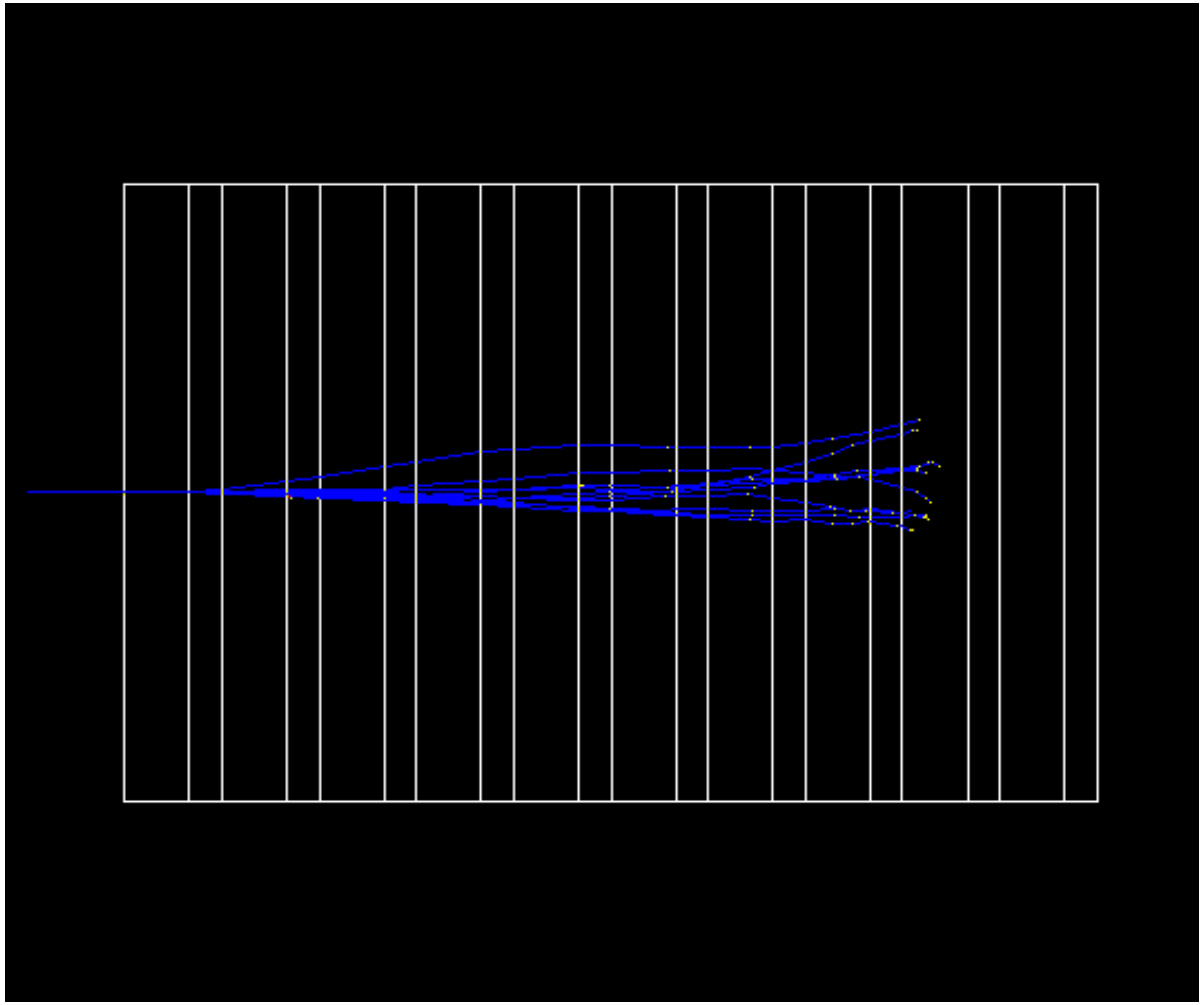
Exercise: run 300 MeV protons without hadronic interactions

- Download a fresh copy of novice example N03
- Build and run

Solution for no hadronic interactions

- Set particle and energy
  - /gun/particle proton
  - /gun/energy 300 MeV
- Or add the above lines to the end of vis.mac
- Run 10 protons
  - /run/beamOn 10

10 Protons at 300 MeV
no hadronic interactions



Add Hadronic Elastic Scattering

```
#include "G4HadronElasticProcess.hh"
#include "G4LElastic.hh"

void ExN03PhysicsList::ConstructHad() {
   G4ProcessManager* pManager = 0;
   pManager = G4Proton::Proton()-
>GetProcessManager();
   // proton elastic
   G4HadronElasticProcess* elasticProcess = new
G4HadronElasticProcess();
   G4LElastic* elasticModel = new G4LElastic();
   elasticProcess->RegisterMe(elasticModel);
   pManager->AddDiscreteProcess(elasticProcess);
}
```

Exercise: add proton inelastic scattering

The process for proton inelastic scattering is G4ProtonInelasticProcess.hh

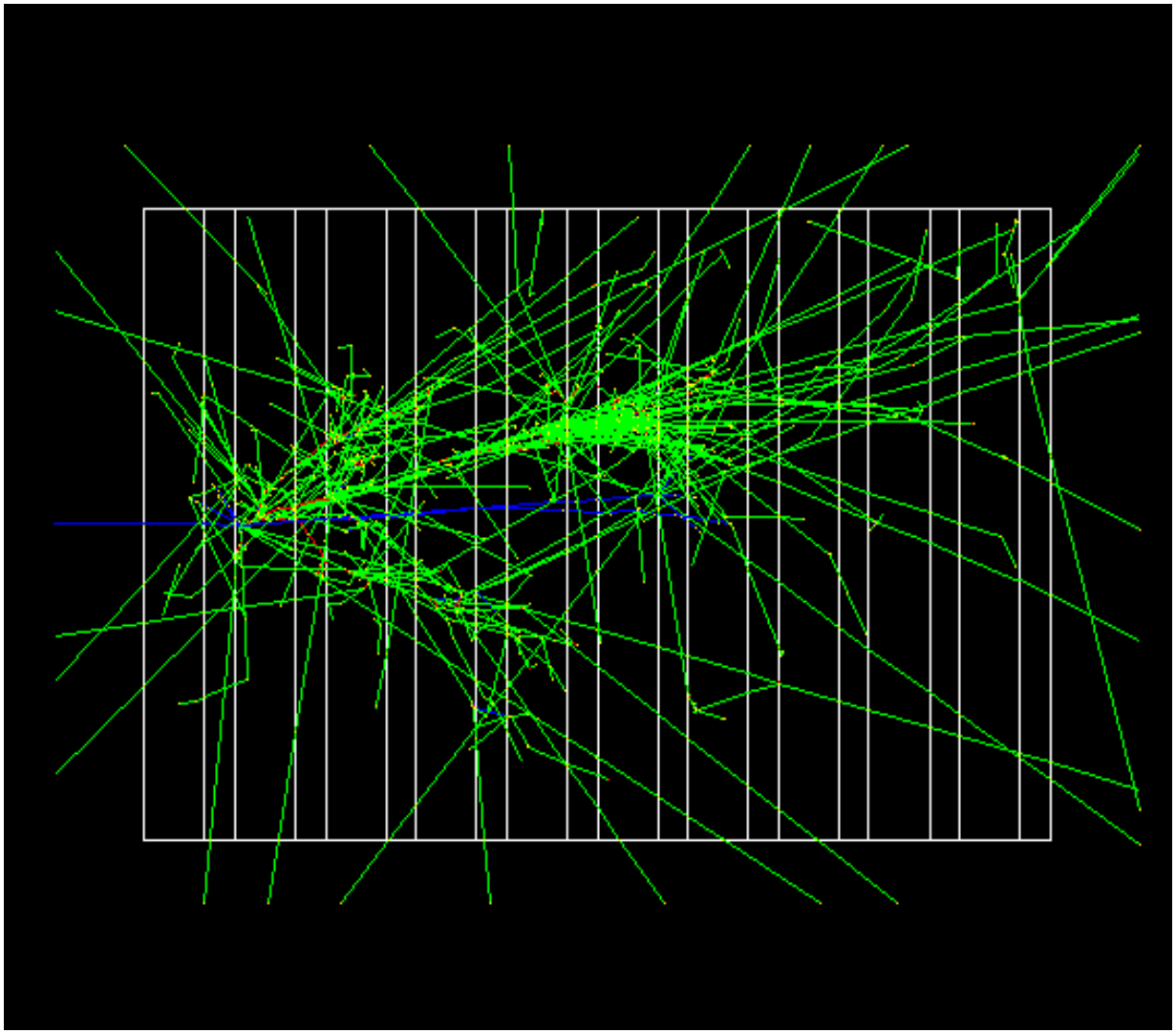
The LEP model for proton inelastic scattering is G4LEProtonInelastic.hh

When done, run 300 MeV, 1 GeV, 5 GeV, 60 GeV protons

Solution for proton inelastic scattering

```
#include "G4ProtonInelasticProcess.hh"
#include "G4LEProtonInelastic.hh"

// proton inelastic
G4ProtonInelasticProcess* pinelProc = new G4ProtonInelasticProcess();
G4LEProtonInelastic* LEPpModel = new G4LEProtonInelastic();
pinelProc->RegisterMe(LEPpModel);
pManager->AddDiscreteProcess(pinelProc);
```

5 GeV proton with LEP model

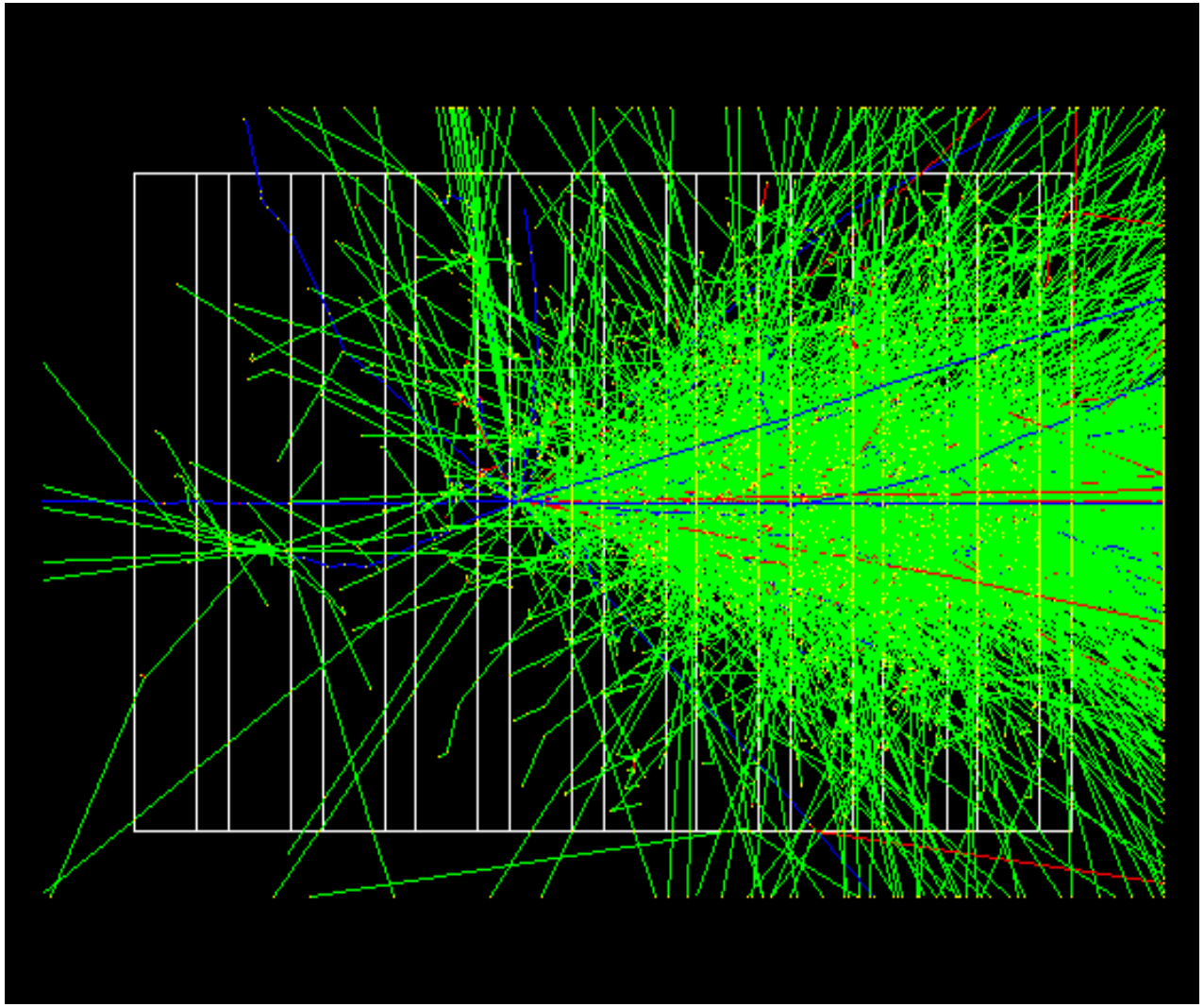


```
In src/G4EnergyRangeManager.cc, line 110:
===> GetHadronicInteraction: No Model found
Unrecoverable error for:
 - Particle energy[GeV] = 56.8701
 - Material = liquidArgon
 - Particle type = proton

*** G4Exception : 007
      issued by : G4HadronicProcess
ChooseHadronicInteraction failed.
*** Fatal Exception *** core dump ***

*** G4Exception: Aborting execution ***
Abort
```

Add high energy proton inelastic scattering model

```
#include "G4ProtonInelasticProcess.hh"
#include "G4LEProtonInelastic.hh"
#include "G4HEProtonInelastic.hh"

 // proton inelastic
 G4ProtonInelasticProcess* pinelProc = new
G4ProtonInelasticProcess();
 G4LEProtonInelastic* LEPpModel = new G4LEProtonInelastic();
 G4HEProtonInelastic* HEPpModel = new G4HEProtonInelastic();
 pinelProc->RegisterMe(LEPpModel);
 pinelProc->RegisterMe(HEPpModel);
 pManager->AddDiscreteProcess(pinelProc);
```

100 GeV proton with HEP model



Exercise: add pions

Inelastic scattering process for pi+ is G4PionPlusInelasticProcess

LEP model for pi+ inelastic scattering is G4LEPionPlusInelastic.hh

When done, run 10 pi+ 170 MeV and 10 at 300 MeV

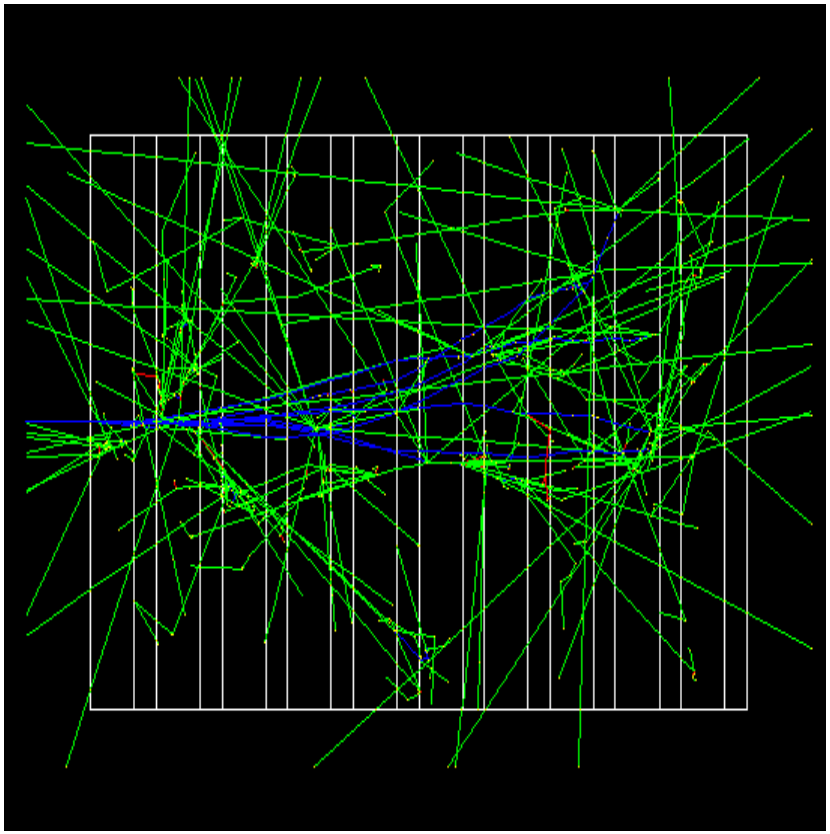
Do you see a difference ?

Solution for adding pions

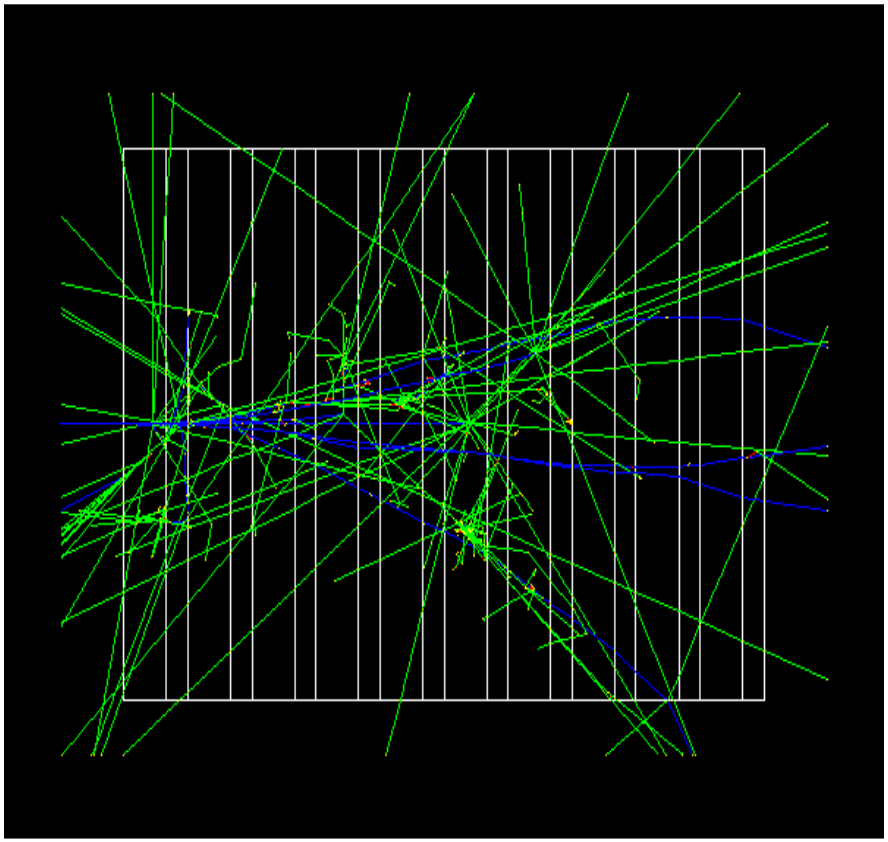
```
#include "G4PionPlusInelasticProcess.hh"
#include "G4LEPionPlusInelastic.hh"

 // pion inelastic
 pManager = G4PionPlus::PionPlus()->GetProcessManager();
 G4PionPlusInelasticProcess* pipinelProc = new
G4PionPlusInelasticProcess();
 G4LEPionPlusInelastic* LEPpipModel = new
G4LEPionPlusInelastic();
 pipinelProc->RegisterMe(LEPpipModel);
 pManager->AddDiscreteProcess(pipinelProc);
```

Pion cross section dependence

10 events,170 MeV



10 events, 300 MeV



Replace cross sections for pions

```
#include “G4PionPlusInelasticProcess.hh”
#include “G4LEPionPlusInelastic.hh”
#include “G4PiNuclearCrossSection.hh”

  // pion inelastic
  pManager = G4PionPlus::PionPlus()->GetProcessManager();
  G4PionPlusInelasticProcess* pipinelProc = new
G4PionPlusInelasticProcess();
  G4LEPionPlusInelastic* LEPpipModel = new
G4LEPionPlusInelastic();
  pipinelProc->RegisterMe(LEPpipModel);
  // new cross sections
  G4PiNuclearCrossSection* piNucCS = new
G4PiNuclearCrossSection();
  pipinelProc->AddDataSet(piNucCS);
```

Exercise: replace pion and proton model

The Bertini cascade model does a better job than LEP for pions, protons and neutrons. The name of the model class is G4CascadeInterface.hh

Solution for replacing pion, proton model

```
#include "G4CascadeInterface.hh"

// new model
G4CascadeInterface* bertiniModel = new G4CascadeInterface();
pipinelProc->RegisterMe(bertiniModel);
pinelProc->RegisterMe(bertiniModel);
```

In src/G4EnergyRangeManager.cc, line 118:
===> GetHadronicInteraction: Energy ranges of two models fully overlapping
Unrecoverable error for:
 - Particle energy[GeV] = 0.108953
 - Material = liquidArgon
 - Particle type = pi+

*** G4Exception : 007
    issued by : G4HadronicProcess
ChooseHadronicInteraction failed.
*** Fatal Exception *** core dump ***

Limiting the Model Energy Range

```
G4LEProtonInelastic* LEPpModel = new G4LEProtonInelastic();
LEPpModel->SetMinEnergy(9.5*GeV);
G4HEProtonInelastic* HEPpModel = new G4HEProtonInelastic();
pinelProc->RegisterMe(LEPpModel);
pinelProc->RegisterMe(HEPpModel);
pManager->AddDiscreteProcess(pinelProc);
// pion inelastic
pManager = G4PionPlus::PionPlus()->GetProcessManager();
G4PionPlusInelasticProcess* pipinelProc = new
G4PionPlusInelasticProcess();
G4LEPionPlusInelastic* LEPpipModel = new
G4LEPionPlusInelastic();
LEPpipModel->SetMinEnergy(9.5*GeV);
pipinelProc->RegisterMe(LEPpipModel);
// new model
G4CascadeInterface* bertiniModel = new G4CascadeInterface();
```