E1039 Physics Simulation: Status and Plan

Abinash Pun

NMSU

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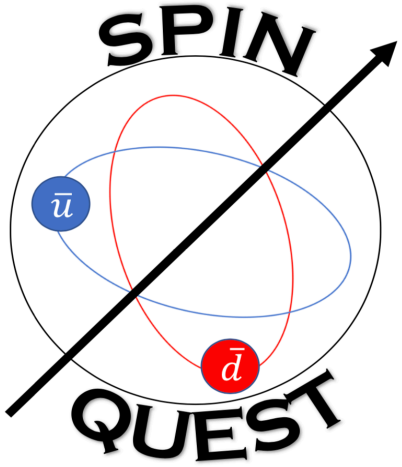


E1039-Simulation Flow

- Event Generators
- Geant4 Simulation
  - Detector Geometry
  - Hit extraction
- Digitization
  - Efficiency
  - Resolution
- Trigger emulator
- Tracking and reconstruction
- Analysis

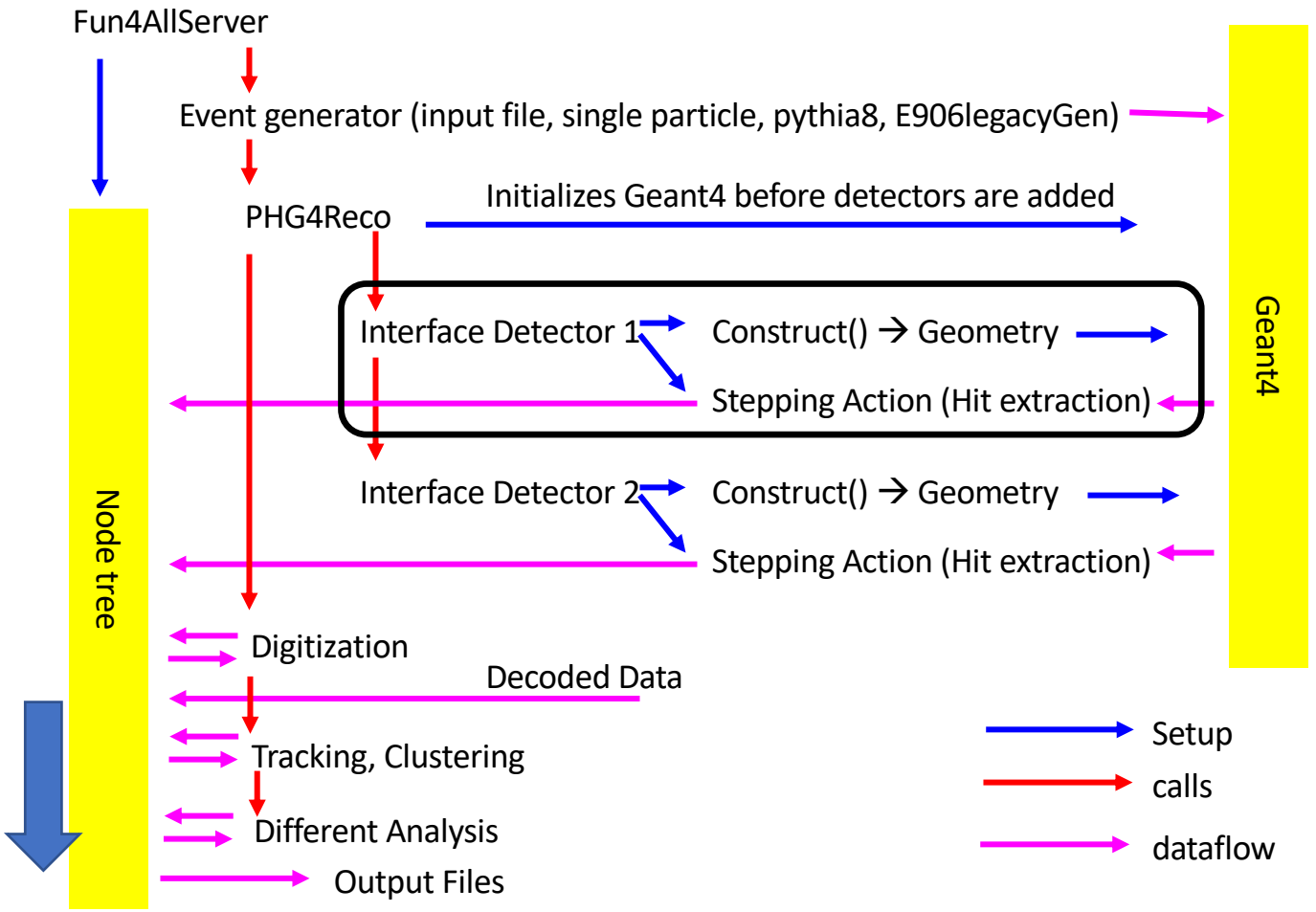
The simulation flow is implemented in Fun4Sim macro. Details in

- DocDB 6974, Zulkaida Akbar
- DocDB 5509, Haiwang

Chris P.'s talk: https://indico.bnl.gov/event/7254/

Simulation Framework with Geant4

The processing is done by chaining up modules. At every step, the state of the Node Tree can be saved, and the analysis can pick up where it left



Common for raw and simulated data

Call the modules in the order in which they were registered (correct ordering is responsibility of the user)

E1039-Simulation: Event Generators

- Pythia
  - Configuration files for the Drell-Yan, J/Psi
- E906LegacyGen: DocDB -7187
- Particle gun
  - Singleparticle
  - Multiparticle
- Interface for external generators:
  - Can read the HepMC output format from other generators into the simulation chain
  - Should be possible for other output formats by working on Fun4All input/output managers

E1039-Simulation: Event Generators

HepMC output format

```
HepMC::Version 2.04.00
HepMC::IO_GenEvent-START_EVENT_LISTING
E 9 51 -1.0000000000000000e+00 -1.0000000000000000e+00 -1.0000000000000000e+00 20 0 309 1 2 0 0
U GEV MM
H 0 0 0 0 0 0 0 0 0 0 0 0 0 0
F 2 3 3.5000000000000003e-01 6.4999999999999991e-01 8.4499999999999993e+00 2.4499999779912355e+03 4.5499999591265787e+03 230 230
V -1 0 0 0 0 0 1 3 0
P 1 2212 0 0 6.9999999371178146e+03 7.0000000000000000e+03 9.3827000000000005e-01 3 0 0 -1 0
P 3 21 -9.5802904850995474e-01 3.4892974578914365e-01 1.5677975928920182e+01 1.5711094833049845e+01 0 3 0 0 -3 0
P 12 2101 2.5787537037233477e-01 -1.1110299643709216e-01 1.2403958218239170e+03
1.2403959888942973e+03 5.7933000000000001e-01 2 0 0 -9 0
P 25 2 7.0015367813761997e-01 -2.3782674935205150e-01 2.3333682308044050e+00 2.4698753078332274e+00 3.3000000000000002e-01 2 0 0 -15 0
V -2 0 0 0 0 0 1 2 0
P 2 2212 0 0 -6.9999999371178146e+03 7.0000000000000000e+03 9.3827000000000005e-01 3 0 0 -2 0
P 4 1 2.7745239600449745e-01 -1.8469236508822412e-01 -1.2668437617555701e+03 1.2668438056011901e+03 0 3 0 0 -4 0
P 116 2203 -2.7745239600449745e-01 1.8469236508822412e-01 -1.8910900158159372e+03 1.8910902024916190e+03 7.7132999999999996e-01 2 0 0 -15 0
```

BLOCK KEYS

- **begin event block**: *HepMC::IO_GenEvent-START_EVENT_LISTING*
- **end event block**: *HepMC::IO_GenEvent-END_EVENT_LISTING*

LINE KEYS

- **E**: *general GenEvent information*
- **U**: *momentum and position units*
- **H**: *HeavyIon information: This line will contain zeros if there is no associated HeavyIon object.*
- **F**: *PdfInfo information: This line will contain zeros if there is no associated PdfInfo object.*
- **V**: *GenVertex information*
- **P**: *GenParticle information*

E1039-Simulation: Geometry

- PHG4Reco: interface to Geant4
  - Sets geometry and physics list ("*FTFP_BERT*")
- Geometry
  - Sensitive detector system: spectrometers
    - Currently configured via sql data base but has interface in macro level to change the configuration
  - Insensitive detector system: FMag, KMag
    - Currently configured via sql data base and does not have interface in macro level to change the configuration
  - Target, shielding and collimator
    - Configured on the fly on macro level
- Run dependent configurations:
- Alignment:

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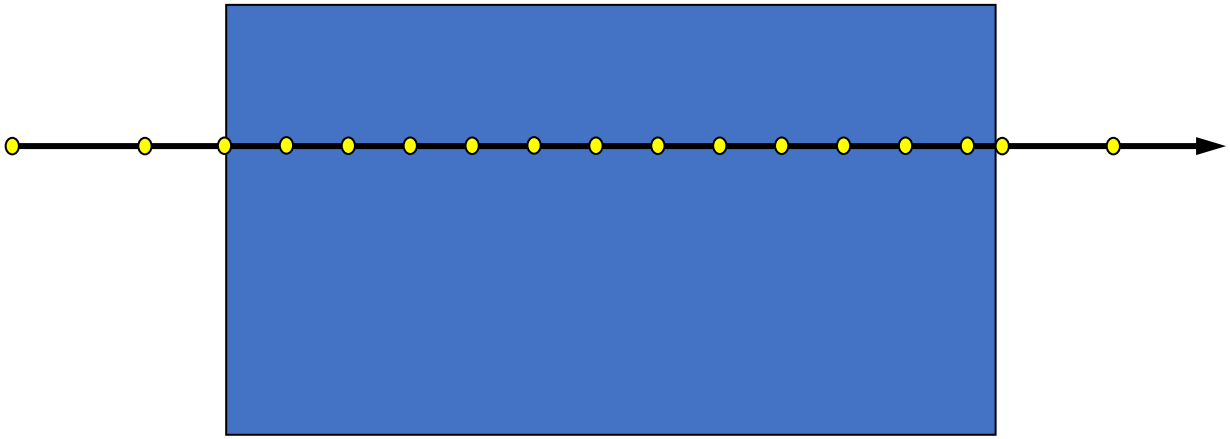
E1039-Simulation: Geant Steps

GEANT propagates particles one step at a time. The step size is determined by the physics processes associated with the current particle or when a boundary between volumes is crossed



After each step the user stepping method is called with a pointer to the current volume which has access to the full information (energy loss, particle momentum at beginning and end of step, …)

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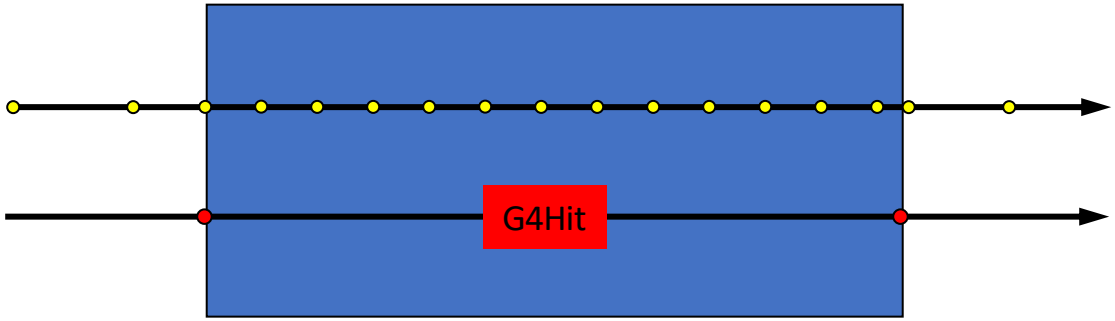
E1039-Simulation: Geant Steps

In our stepping method we add the energy loss in each volume and store the entry and exit coordinates and time



We also keep the ancestry for G4Hits so any hit can be traced back to a primary particle. To reduce size we do not store particles which do not leave G4Hits and are not in the ancestry of a particle which created a G4Hit

E1039-Simulation: Digitizer and Trigger Emulator

- Digitizer: grouping the hits into detector/element ID
  - Resolution
  - Efficiency
  - The efficiency and resolution are set to ideal value
- Trigger Emulator: to mimic the trigger condition in the simulation (Developed by Mindy)

E1039-Simulation: Tracking

1. Pre-Tracking Analysis
   - Hit Removal (out of time, random noise, cluster hit..)
   - Occupancy Cut
2. Single Track Reconstruction
   - Building Tracklets
   - Connecting Tracklets in St. 2 and St. 3
   - Constructing Global Tracks
3. Reaction Vertex Reconstruction
   - Single Track Vertex Reconstruction
   - Dimuon Vertex Reconstruction

Imported and developed by Kun Liu
For Details: DocDB-1283
For status: Look at my previous presentation

E1039-Simulation: Analysis

- Analysis modules:
  - TrkEval: creates file including 4-Vector of the generated and reconstructed events, reconstruction status, detector hit, etc.
  - AnaSimDst: for analyzing DST files from simulation
- Analysis work
  - Asymmetry: Zulkaida (Mock Data Challenge)
  - J/Psi: Kenichi (First day Physics)

To Dos

- Tracking optimization
- Alignment
- Implementation of efficiency and resolution (kinematic dependence)
- Embedding the background
  - E906 data/Simulation production
  - Embedding interface available but not explored
- Standard procedure for the asymmetry extraction

Thank You

Back Ups

Chris P.'s talk: https://indico.bnl.gov/event/7254/

Node Tree

- **Storage for Data Objects**. The center of the Fun4All software universe (but it's more or less invisible to users). It's the way our data is organized and make them accessible to modules.
- **NOT a Root TTree**
- 3 different Types of Nodes:
  - PHCompositeNode: contains other Nodes
  - PHDataNode: contains any object
  - PHIODataNode: contains objects which can be written out to DST
- PHCompositeNodes and PHIODataNodes can be saved to a DST and can be read back
- This DST contains root TTrees, the node structure is saved in the branch names.
- Input Managers put objects as PHIODataNodes on the node tree, output managers save selected PHIODataNodes to a file.

Node Tree for SpinQuest

```
List of Nodes in Fun4AllServer:
Node Tree under TopNode TOP
TOP (PHCompositeNode)/
   DST (PHCompositeNode)/
      PHG4INEVENT (PHDataNode)
      DimuonInfo (IO,SQDimuonTruthInfoContainer)
      G4HIT_Collimator (IO,PHG4HitContainer)
      Coil (PHCompositeNode)/
         G4HIT_Coil (IO,PHG4HitContainer)
      Target (PHCompositeNode)/
         G4HIT_Target (IO,PHG4HitContainer)
      G4HIT_D0U (IO,PHG4HitContainer)
      G4TruthInfo (IO,PHG4TruthInfoContainer)
      SQHitVector (IO,SQHitVector_v1)
      SQEvent (IO,SQEvent_v1)
      SRecEvent (IO,SRecEvent)
   RUN (PHCompositeNode)/
      FIELD_CONFIG (IO,PHFieldConfig_v3)
      G4GEOPARAM_Insens_0 (IO,PdbParameterMapContainer)
      Collimator (PHCompositeNode)/
         G4GEOPARAM_Collimator (IO,PdbParameterMapContainer)
      BLOCKGEOM_Collimator (IO,PHG4BlockGeomContainer)
      Coil (PHCompositeNode)/
         G4GEOPARAM_Coil (IO,PdbParameterMapContainer)
```

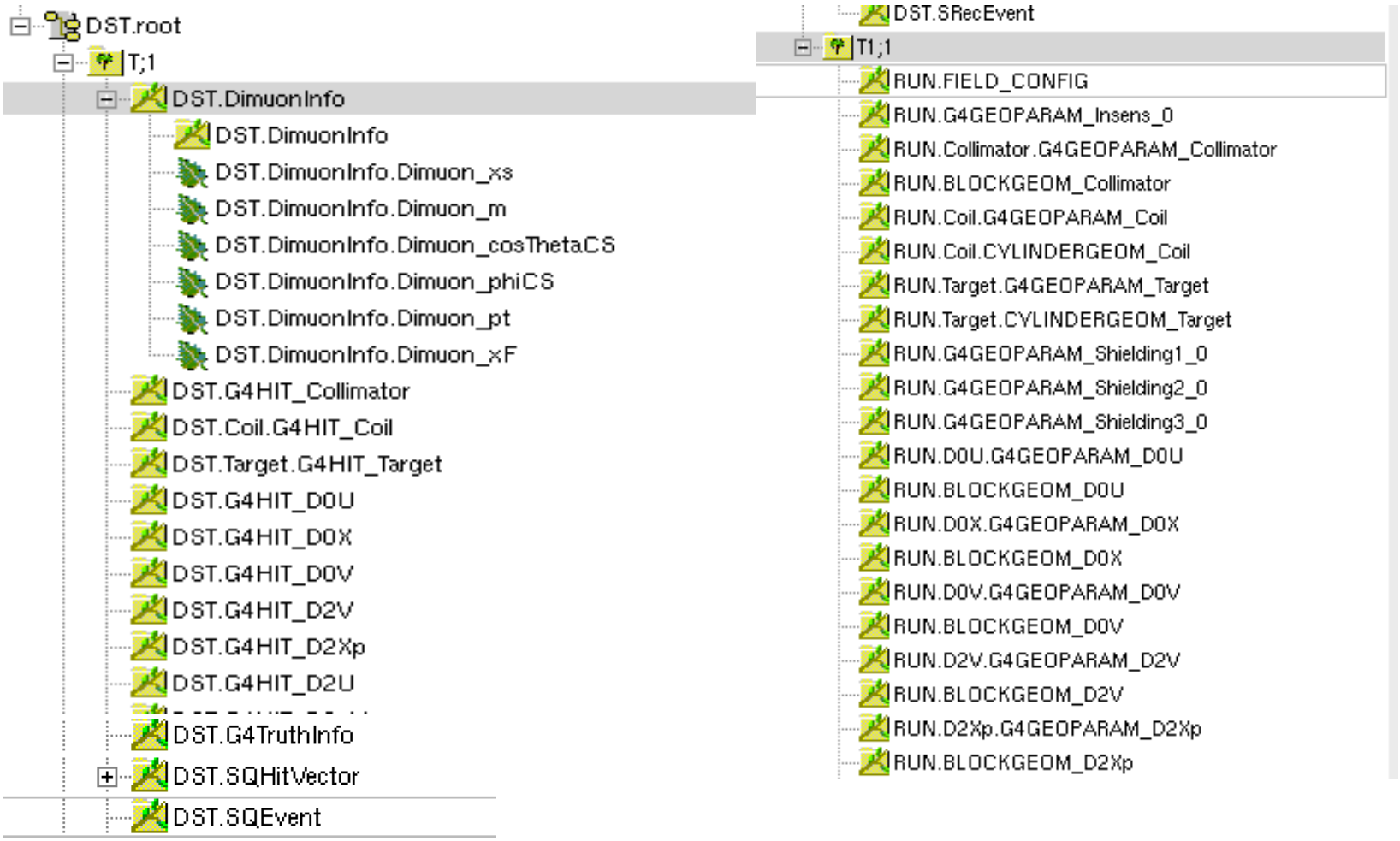
TOP: Top of Default Node Tree

DST and RUN Node: default for I/O

- DST – Eventwise
- RUN - Runwise

Class of Data IO Object is given (you will need to know this when accessing the data)

DST (Data Summary Tape)



Decoded Data