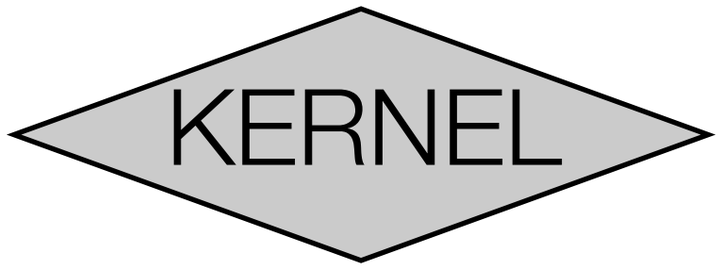
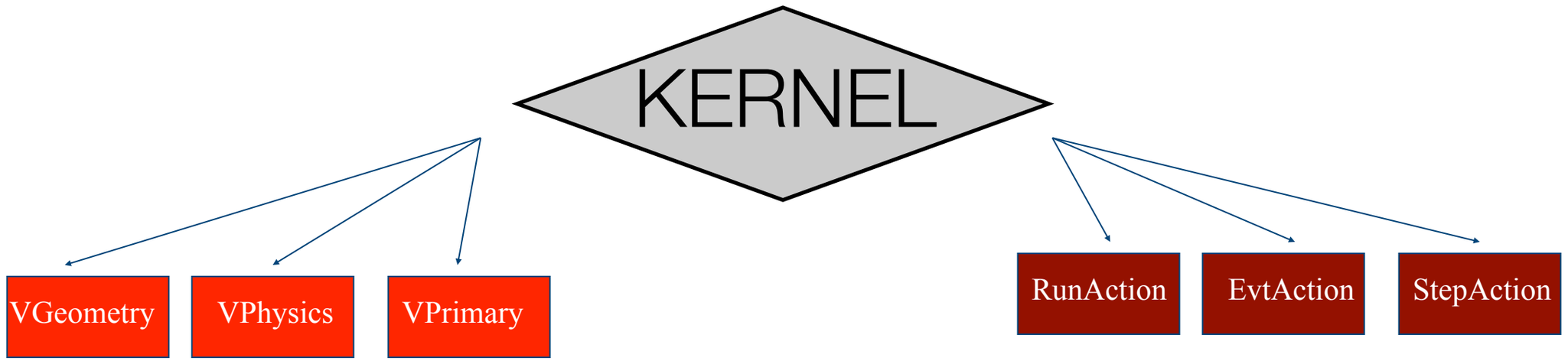
Generation of a primary event

XII Seminar on Software for Nuclear, Subnuclear and Applied Physics
May 24-29, Alghero

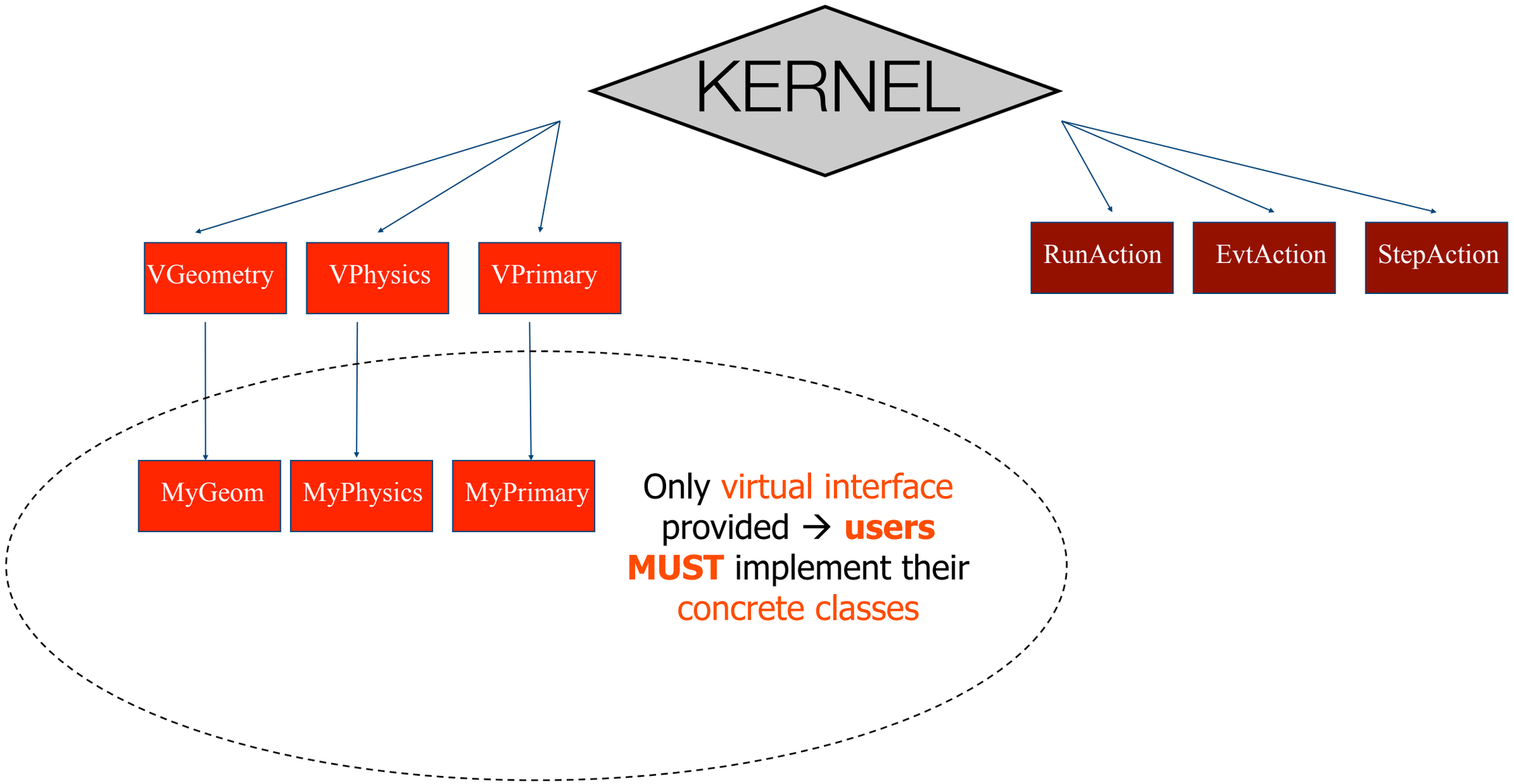
Logical structure of a Geant4 application



Logical structure of a Geant4 application



Logical structure of a Geant4 application



The Primary is a mandatory action class

- The initialization classes
  - Use:
    `G4RunManager::SetUserInitialization()` to define;
  - Invoked at the initialisation:
    G4VUserDetectorConstruction
    G4VUserPhysicsList

- Action classes
  - **`G4RunManager::SetUserAction()`** to define;
  - Invoked during an event loop
    - ✓ G4VUserPrimaryGeneratorAction
    - ✓ G4UserRunAction
    - ✓ G4UserStackingAction
    - ✓ G4UserTrackingAction
    - ✓ G4UserSteppingAction

G4VUserPrimaryGeneratorAction

- Is one of the **mandatory user classes** and it controls the generation of primary particles
  - This class does not generate primaries but invokes the **`GeneratePrimaryVertex()`** method to make the primary
  - It sends the primary particles to the *G4Event* object
- **Constructor**
  - Instantiate primary generator (i.e. **`G4ParticleGun()`**)
    `particleGun = new G4ParticleGun(n_particle);`
  - Set the default values
    `particleGun -> SetParticleEnergy(1.0*GeV);`
- **Mandatory method:** **`GeneratePrimaries()`** method
  - Randomise particle-by-particle value
  - Set these values to primary generator
  - Invoke **`GeneratePrimaryVertex()`** method of primary generator

G4VUserPrimaryGeneratorAction

Where? → geant4.10.01.p01-install/include/Geant4

```
26 //
27 // $Id: G4VUserPrimaryGeneratorAction.hh,v 1.5 2006/06/29 21:13:38 gunter Exp $
28 // GEANT4 tag $Name: geant4-09-03-patch-02 $
29 //
30
31 #ifndef G4VUserPrimaryGeneratorAction_h
32 #define G4VUserPrimaryGeneratorAction_h 1
33
34 class G4Event;
35
36 // class description:
37 //
38 //  This is the abstract base class of the user's mandatory action class
39 // for primary vertex/particle generation. This class has only one pure
40 // virtual method GeneratePrimaries() which is invoked from G4RunManager
41 // during the event loop.
42 //  Note that this class is NOT intended for generating primary vertex/particle
43 // by itself. This class should
44 //  - have one or more G4VPrimaryGenerator concrete classes such as G4ParticleGun
45 //  - set/change properties of generator(s)
46 //  - pass G4Event object so that the generator(s) can generate primaries.
47 //
48
49 class G4VUserPrimaryGeneratorAction
50 {
51   public:
52     G4VUserPrimaryGeneratorAction();
53     virtual ~G4VUserPrimaryGeneratorAction();
54
55   public:
56     virtual void GeneratePrimaries(G4Event* anEvent) = 0;
57 };
58
59 #endif
```

G4VUserPrimaryGeneratorAction

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58
59 #endif
```

.... its concrete implementation

Construction

```
ExN02PrimaryGeneratorAction::ExN02PrimaryGeneratorAction(
                                ExN02DetectorConstruction* myDC)
:myDetector(myDC)
{
  G4int n_particle = 1;
  particleGun = new G4ParticleGun(n_particle);
// default particle
  G4ParticleTable* particleTable = G4ParticleTable::GetParticleTable();
  G4ParticleDefinition* particle = particleTable->FindParticle("proton");

  particleGun->SetParticleDefinition(particle);
  particleGun->SetParticleMomentumDirection(G4ThreeVector(0.,0.,1.));
  particleGun->SetParticleEnergy(3.0*GeV);
}

ExN02PrimaryGeneratorAction::~ExN02PrimaryGeneratorAction()
{
  delete particleGun;
}
```

.... its concrete implementation

.... its concrete implementation

```
void ExN02PrimaryGeneratorAction::GeneratePrimaries(G4Event*
anEvent)
{
  G4double position = -0.5*(myDetector->GetWorldFullLength());
  particleGun->SetParticlePosition(G4ThreeVector(0.*cm,0.*cm,position));

  particleGun->GeneratePrimaryVertex(anEvent);
}
```

GeneratePrimaries

GeneratePrimaries(G4Event*)

- **GeneratePrimaries(G4Event* aEvent)** is the mandatory method

- Geant4 provides three *G4VPrimaryGenerators*
  - G4ParticleGun
  - G4HEPEvtInterface
  - G4GeneralParticleSource

G4ParticleGun()

```
particleGun = new G4ParticleGun();
```

- Concrete implementation of G4VPrimaryGenerator

- Various "Set" methods are available (see ../source/event/include/G4ParticleGun.hh)

```
void SetParticleEnergy(G4double aKineticEnergy);
void SetParticleMomentum(G4double aMomentum);
void SetParticlePosition(G4ThreeVector
aPosition);
void SetNumberOfParticles(G4int aHistoryNumber);
```

G4ParticleGun()

```
void T01PrimaryGeneratorAction::GeneratePrimaries(G4Event* anEvent)
{ G4ParticleDefinition* particle;
  G4int i = (int)(5.*G4UniformRand());
  switch(i)
  { case 0: particle = positron; break; ... }
  particleGun->SetParticleDefinition(particle);
  G4double pp = momentum+(G4UniformRand()-0.5)*sigmaMomentum;
  G4double mass = particle->GetPDGMass();
  G4double Ekin = sqrt(pp*pp+mass*mass)-mass;
  particleGun->SetParticleEnergy(Ekin);
  G4double angle = (G4UniformRand()-0.5)*sigmaAngle;
  particleGun->SetParticleMomentumDirection
          (G4ThreeVector(sin(angle),0.,cos(angle)));
  particleGun->GeneratePrimaryVertex(anEvent);
}
```

You can repeat this for generating more than one primary particles

G4HEPEvtInterface

- Concrete implementation of ***G4VPrimaryGenerator***
- Almost all event generators in use are written in ***FORTRAN*** but Geant4 does not link with any external ***FORTRAN*** code
- Geant4 provides an **ASCII** file interface for such event generators
- **G4HEPEvtInterface reads an ASCII file produced by an Event generator** and reproduce the G4PrimaryParticle objects.
- It does not give a place for the primary particle so the interaction point must be still set by the User

G4GeneralParticleSource()

```
fGeneralParticleSource=new G4GeneralParticleSource();
```

- ../source/event/include/G4GeneralParticleSource.hh
- Concrete implementation of G4VPrimaryGenerator
  `class G4GeneralParticleSource : public G4VPrimaryGenerator`
- Is designed to replace the G4ParticleGun class
- It is designed to **allow specification of multiple particle sources each with independent definition of particle type, position, direction and energy distribution**
- Primary vertex can be randomly chosen on the surface of a certain volume
- Momentum direction and kinetic energy of the primary particle can also be randomized
- **Distributions are defined by UI commands**

G4GeneralParticleSource

- On line manual: http://geant4.web.cern.ch/geant4/UserDocumentation/UsersGuides/ForApplicationDeveloper/html/ch02s07.html#sect.G4GPS.Commands

- /gps main command

  - /gps/pos/type (Planar, Point, etc.)

  - /gps/ang/type (iso, planar wave, etc.)

  - /gps/energy/type (monoenergetic, linear, User defined)

  - .....

Example of gps commands

- **/gps/pos/type Point**
- **/gps/particle proton**
- **/gps/energy 100 MeV**
- **/gps/direction 0 0 1**

→ Point-like proton source

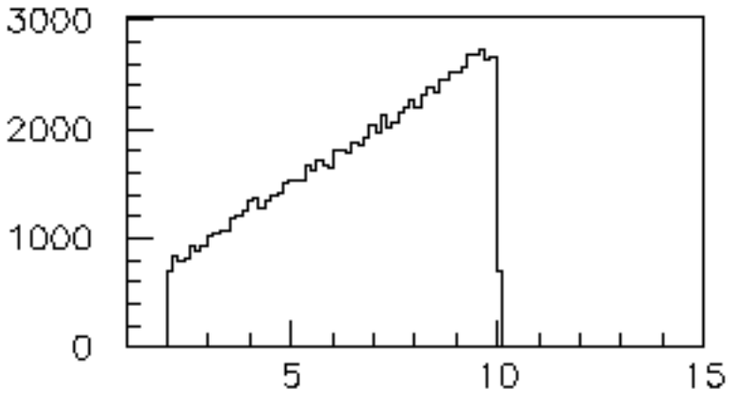
- **/gps/pos/type plane**
- **/gps/pos/shape square**
- **/gps/pos/centre x y z**
- **/gps/pos/Halfx**
- **/gps/pos/Halfy**

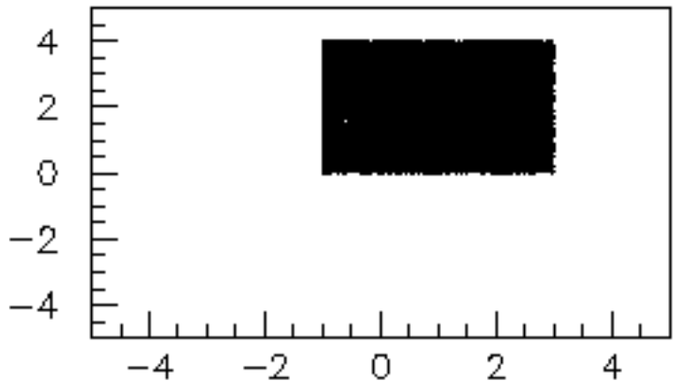
→ Plane proton source

- **/gps/pos/shape Circle**
- **/gps/pos/centre x y z**

→ Gaussian-like proton source

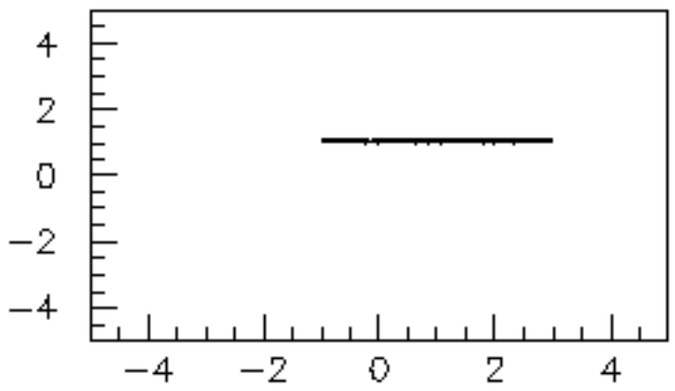
Square plane, cosine-law direction, linear energy

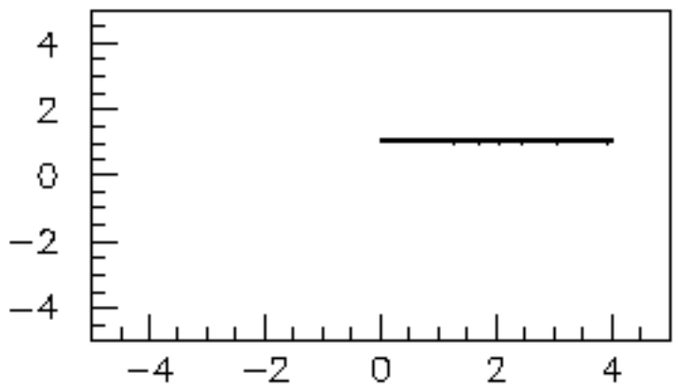




Source Energy Spectrum

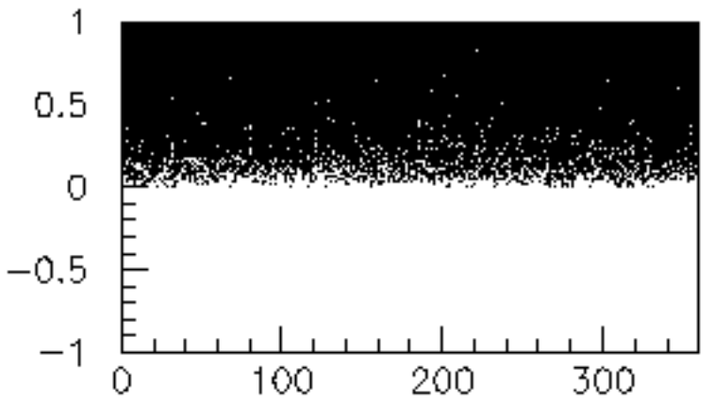
Source X−Y distribution

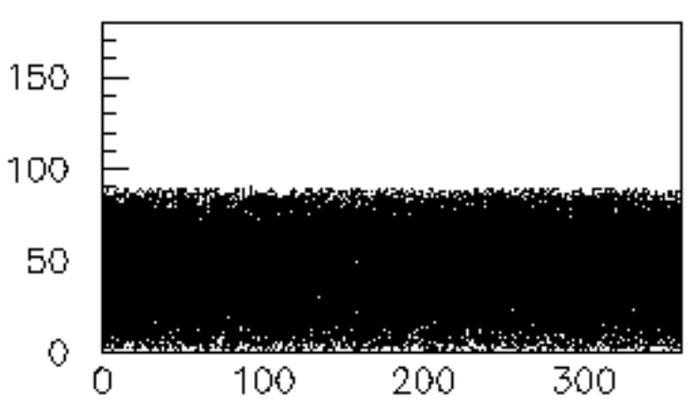




Source X−Z distribution

Source Y−Z distribution

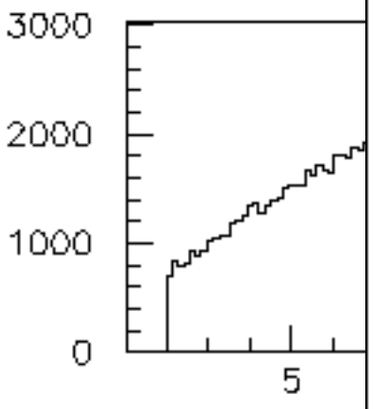




Source cos(theta)−phi distribution

Source theta/phi distribution

Square plan



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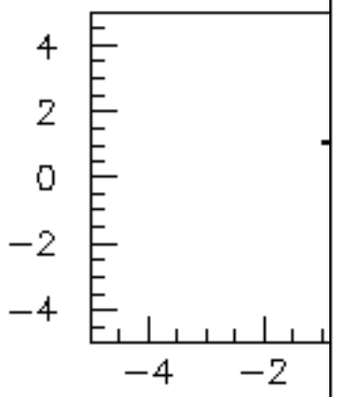
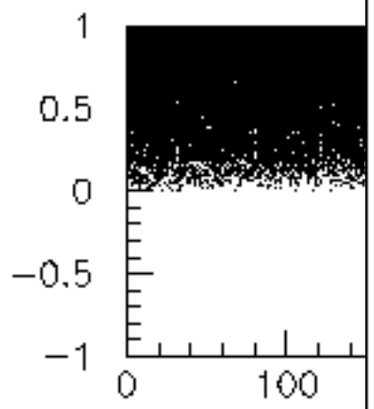
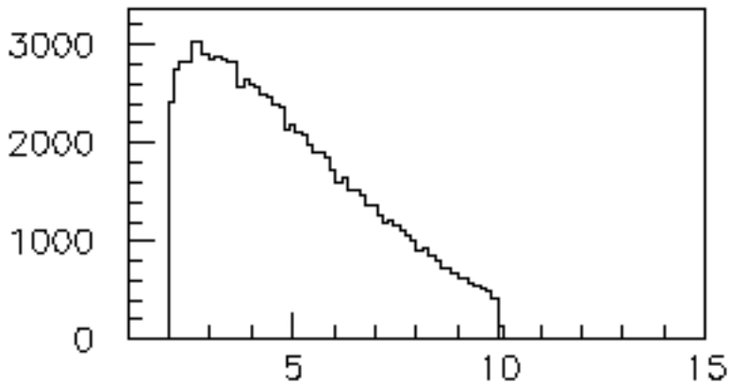


Source X



Source cos(th

Spherical surface, isotropic radiation, black-body energy



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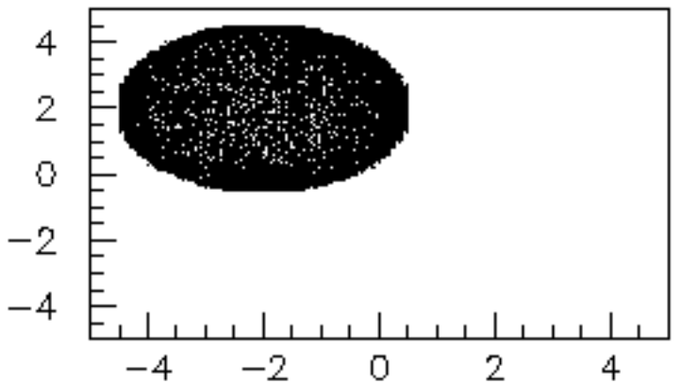
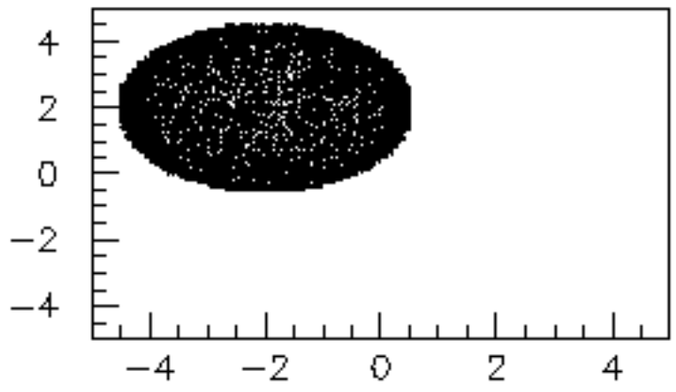
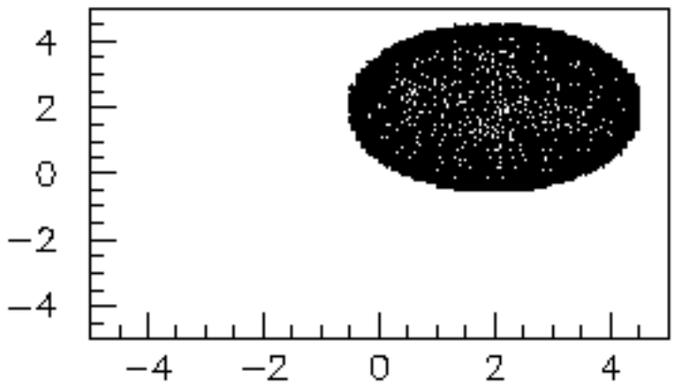


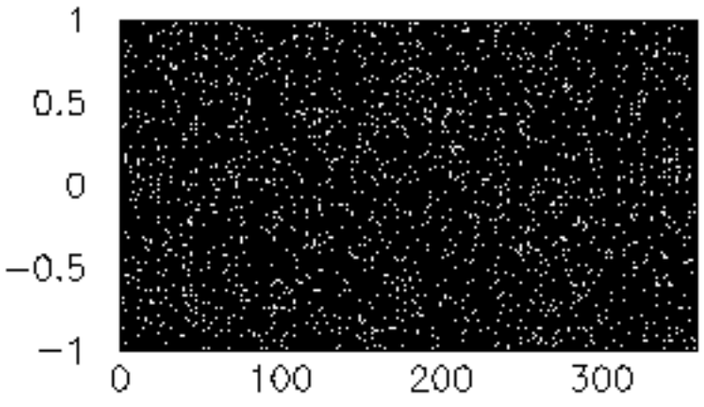
Source X−Y distribution



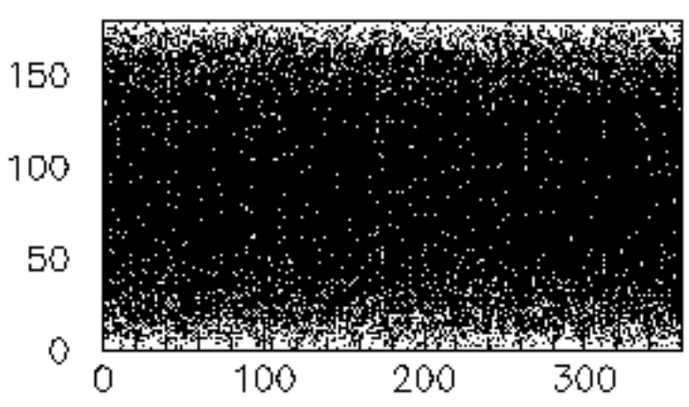
Source X−Z distribution



Source Y−Z distribution

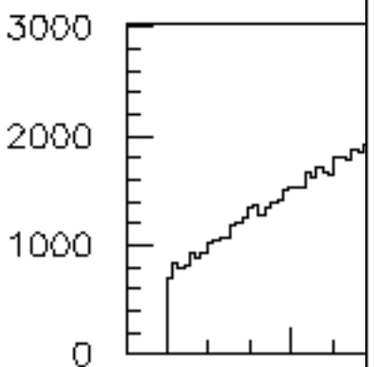


Source cos(theta)−phi distribution



Source theta/phi distribution

Square plan



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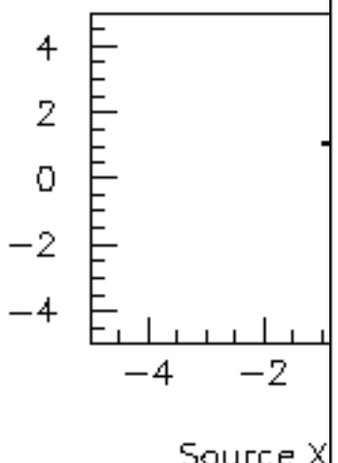
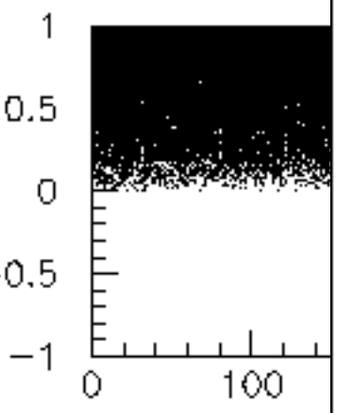
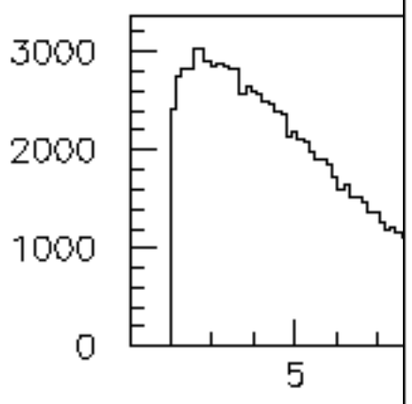


Source X

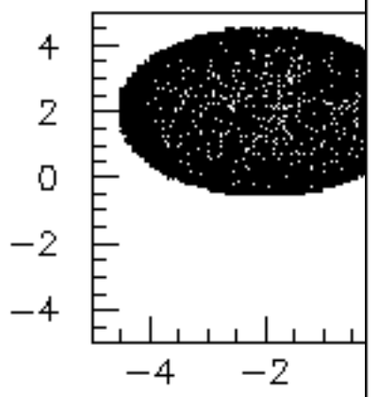


Source cos(th

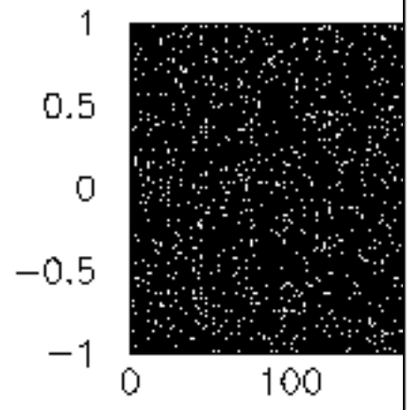
Spherical surfa



Source Ene

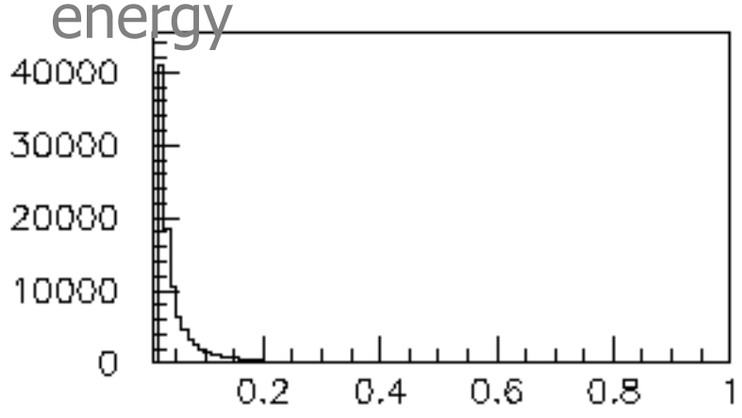


Source X−

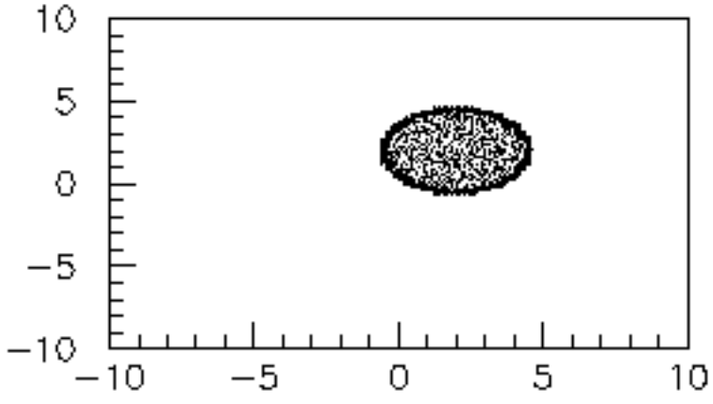


Source cos(theta

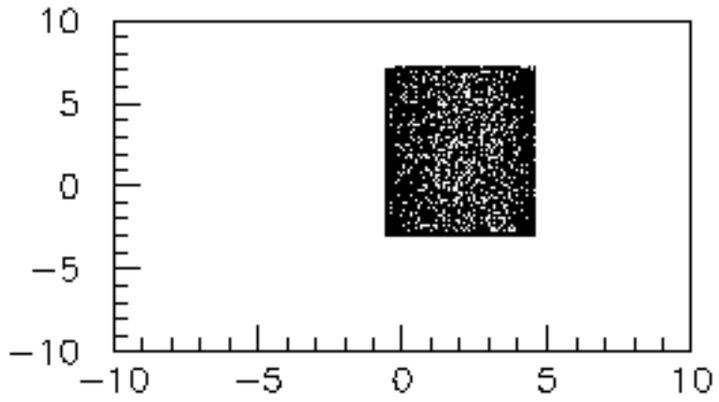
Cylindrical surface, cosine-law radiation, Cosmic diffuse energy



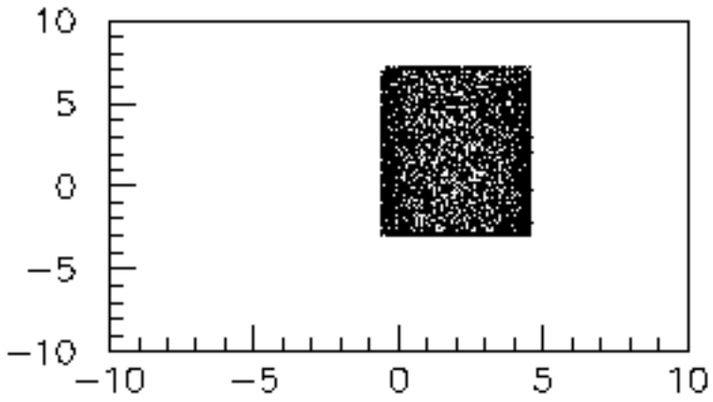
Source Energy Spectrum



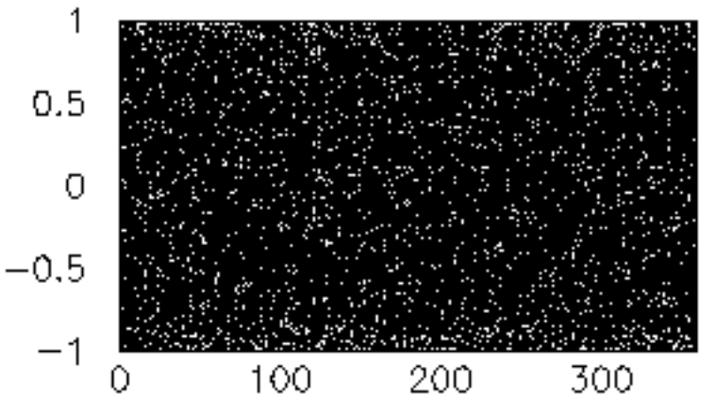
Source X−Y distribution



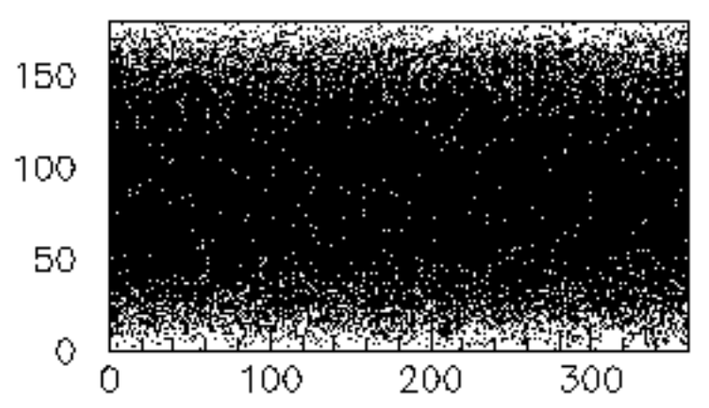
Source X−Z distribution



Source Y−Z distribution



Source cos(theta)−phi distribution



Source theta/phi distribution

Particle Gun vs GPS

- **Particle Gun**
  - Simple and native
  - Shoot one track at a time
- **General Particle Source**
  - Powerful
  - Controlled by UI commands (`G4GeneralParticleSourceMessenger.hh`)
    - ✓ Almost impossible to control with set methods
    - ✓ capability of shooting particles from a surface of a volume
    - ✓ Capability of randomizing kinetic energy, position, direction following a user-specified distribution (histogram)

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- If you need to shot primary particles from a surface of a complicated volume (outward or inward), GPS is the choice
- If you need a complicated distribution, GPS is the choice

Examples

- Examples also exists for GPS

  `examples/extended/eventgenerator/exgps`

- And for HEPEvtInterface

  `examples/extended/runAndEvent/RE01/src/RE01PrimaryGeneratorAction.cc`

Thanks for the attention