Generation of a Primary Event

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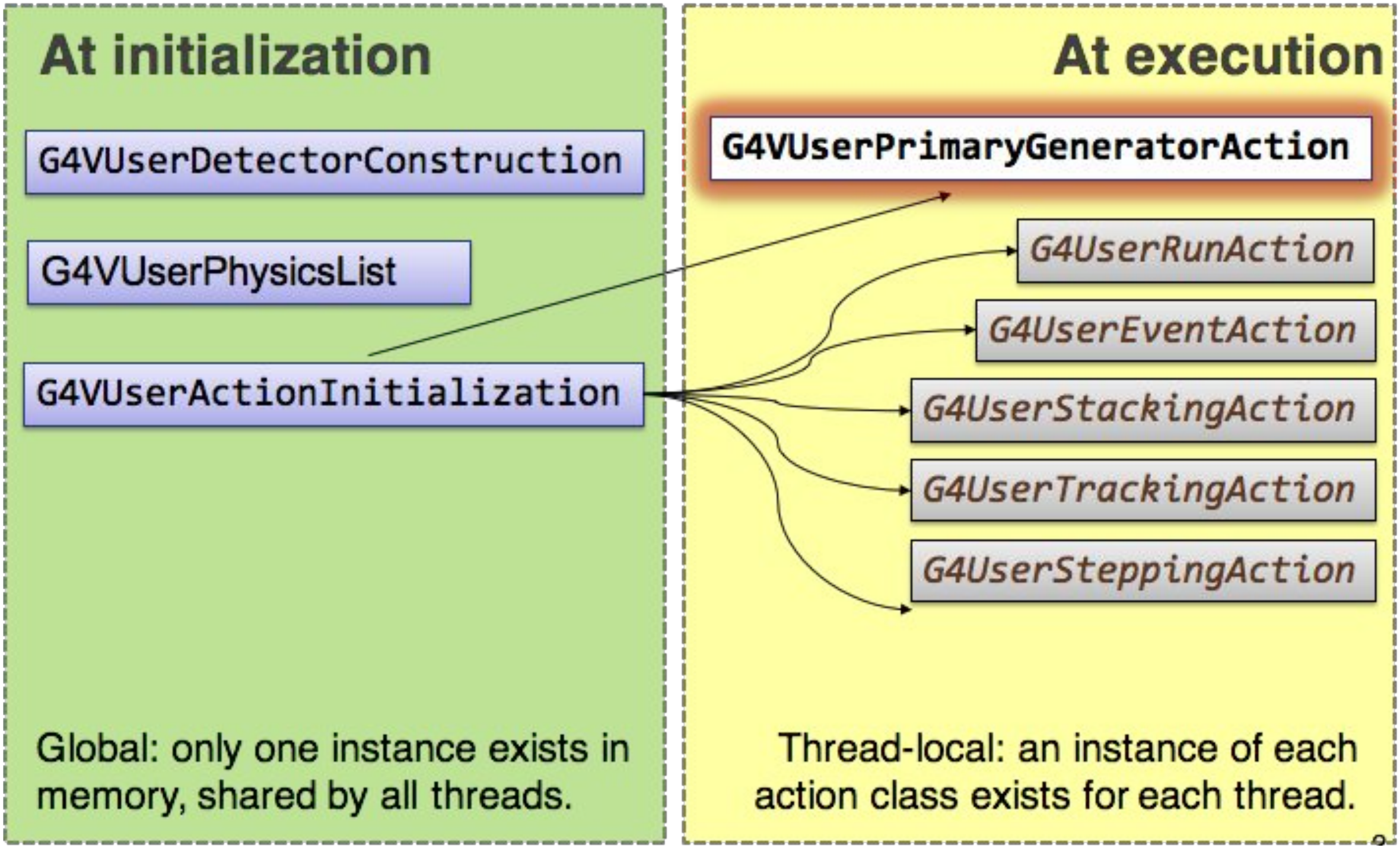
User Classes



The Primary is a mandatory action class

The **PrimaryGeneratorAction.cc** class file is an **Action** that must be defined. Actions are:

- **Initialization classes:**
  - Use:
    G4RunManager::SetUserInitialization( ) to define

  - Invoked at the initialization
    G4VUserDetectorConstruction;
    G4VUserPhysicsList;

- **Loop Actions:**
  - 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 gun = new **G4ParticleGun**(n_particle);

- Set the default values

  gun->**SetParticleEnergy**(1.0 * GeV);

GeneratePrimaries( ) method

- Randomise particle-by-particle value;
- Set these values to primary generator;
- Invoke GeneratePrimaryVertex( ) method of primary generator;

…its concrete implementation

```
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;
}
```

Class constructor

Class distructor

…its concrete implementation

Generate primaries

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

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

G4VPrimaryGenerator

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

Geant4 provides three **G4VPrimaryGenerators**:

- G4ParticleGun
- G4HEPEvtInterface
- G4GeneralParticleSource

G4HEPEvInterface

- 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.
- In particular it reads the /HEPEVT/ fortran block used by almost all event generators
- It does not give a place for the primary particle so the interaction point must be still set by the User

G4ParticleGun()

```
G4ParticleGun* pG = new G4ParticleGun();
```

- Concrete implementation of **G4VPrimaryGenerator**
- It shoots a certain **number** of primary particles of a certain **energy** from a certain **point** at a certain **time** toward a certain **direction**
- Various "**Set**" methods are available (see https://geant4.kek.jp/lxr/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

G4GeneralParticleSource()

```
G4GeneralParticleSource* GPS = new G4GeneralParticleSource();
```

- https://geant4.kek.jp/lxr/source//event/include/G4GeneralParticleSource.hh
- Concrete implementation of **G4VPrimaryGenerator**

  class G4GeneralParticleSource : public G4VPrimaryGenerator
- Is designed to replace the G4ParticleGun class
- It is design 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
- Distribution defined by **UI commands**

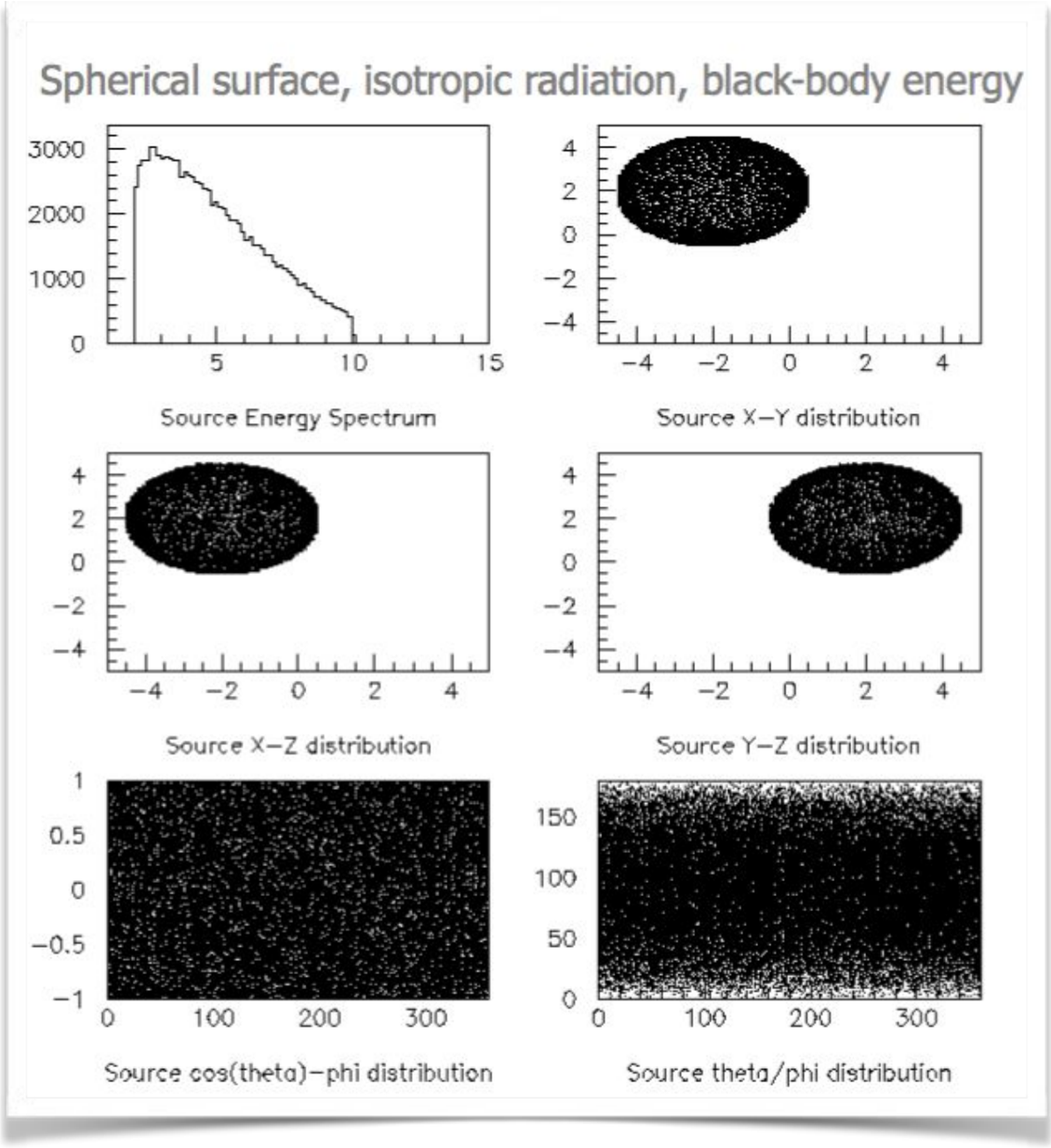
G4GeneralParticleSource()

Online manual:
http://geant4-userdoc.web.cern.ch/geant4-userdoc/UsersGuides/ForApplicationDeveloper/html/GettingStarted/generalParticleSource.html?highlight=gps#macro-commands

- **/gps** main commands:
  - /gps/pos/type (Point, Planar, Beam, …)
  - /gps/ang/type (iso, planar, cos, …)
  - /gps/ene/type (Mono, Lin, Pow, …)
  - Many more!

G4GeneralParticleSource()

- **Source I: point-like source, 100 MeV proton, along Z**
  - /gps/pos/type Point
  - /gps/particle proton
  - /gps/ene/mono 100 MeV
  - /gps/direction 0. 0. 1.
- **Source II: plane source (2x2 cm^2), 100 MeV proton, along Z**
  - /gps/pos/type Plane
  - /gps/pos/shape Square
  - /gps/pos/halfx 1. * cm
  - /gps/particle proton
  - /gps/pos/halfy 1. * cm
  - /gps/ene/mono 100 MeV
  - /gps/direction 0. 0. 1.
- **Source III: gaussian-like (σ_x and σ_y= 2 cm), 100 MeV proton, along Z**
  - /gps/pos/type Beam
  - /gps/pos/sigma_x 2.0 * cm
  - /gps/pos/sigma_y 2.0 * cm
  - /gps/particle proton
  - /gps/ene/mono 100 MeV
  - /gps/direction 0. 0. 1.



ParticleGun Vs GPS

- **Particle Gun**
  - **Simple and native**
  - **Shoot one track at a time**
  - **Easily to handle**
- **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)**

- 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

example/extended/…..

- **GPS**

/eventgenerator/exgps

- **HEPEvInterface**

/runAndEvent/RE02/srcRE01PrimaryGeneratorAction.cc

Next task

- Task 2a Geant4 Particle Gun
- Task 2b Geant4 General Particle Source

Exercise 2a.1: Instantiate and customize the Particle Gun

```
// complete particle name, energy and momentum
G4ParticleDefinition* myParticle;
myParticle = G4ParticleTable::GetParticleTable()->FindParticle("...");
fGun->SetParticleDefinition(myParticle);
fGun->SetParticleEnergy(...);
fGun->SetParticleMomentumDirection(G4ThreeVector(...));
```

Exercise 2a.2: Change parameters of the particle gun

```
void PrimaryGeneratorAction::GeneratePrimaries(G4Event* anEvent)
{
    // Task 2a.2: Include the position randomization
    // Definition of the new original coordinates
    G4double x0  = ..., y0  = ..., z0  = ...;

    // Definition of the spatial extent of the uniform source
    G4double dx0 = ..., dy0 = ..., dz0 = ...;

   // Start the randomization of the initial coordinates using the G4UniformRand() function
   x0 += dx0*(G4UniformRand()-0.5);
   y0 += dy0*(G4UniformRand()-0.5);
   z0 += dz0*(G4UniformRand()-0.5);

   ...
   fGun->Set...
   fGun->GeneratePrimaryVertex(anEvent);
}
```

Next task

- Task 2a Geant4 Particle Gun
- Task 2b Geant4 General Particle Source

Exercise 2b.1: Instantiate the GeneralParticleSource

```
PrimaryGeneratorAction::PrimaryGeneratorAction()
{
    // Task 2b.1: Comment out the particle gun creation and instatiate a GPS instead
    fGPS = new ...();

    // Task 2b.1: Set the same properties for the GPS (removing previous lines)
    fGPS->SetParticleDefinition(...);
    fGPS->GetCurrentSource()->GetEneDist()->SetMonoEnergy(...);
    fGPS->GetCurrentSource()->GetAngDist()->SetParticleMomentumDirection(G4ThreeVector(...));
    fGPS->GetCurrentSource()->GetPosDist()->SetCentreCoords(G4ThreeVector(...));
}
```

Exercise 2b.2: Changing GPS parameter from macro commands

Exercise 2b.3: Creating a complicated GPS source with macro commands

…It's all!