A first magnetic field

First steps in field propagation in Geant4

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Contents

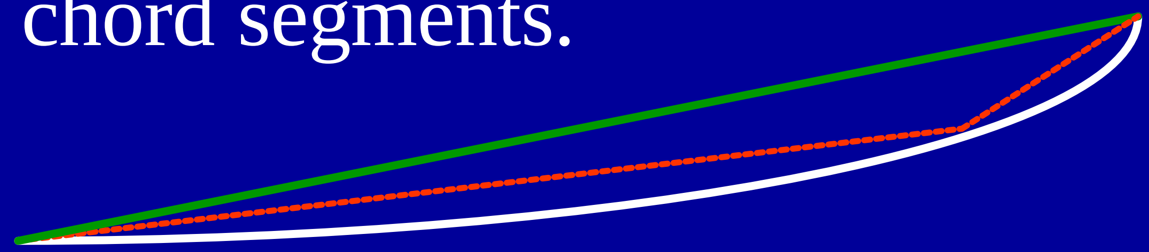
1. What is involved in propagating in a field
   - calculating the motions
   - intersecting the volume boundaries
2. A first example
   - Defining a simple field in Geant4
3. More capabilities
   - Using your own field
   - Many fields,
- Tomorrow: tuning for performance, ..

Magnetic field: overview

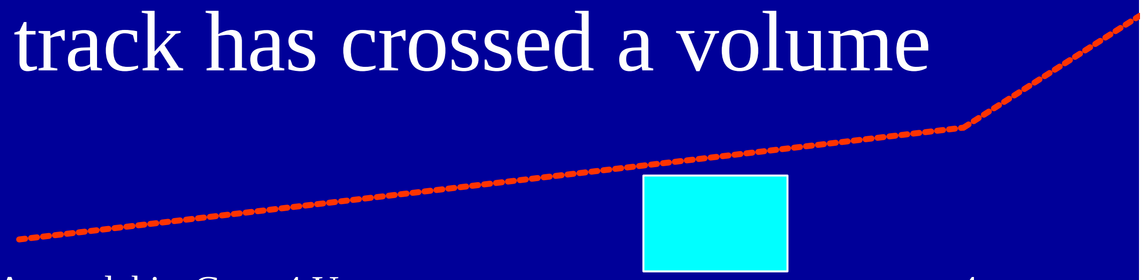
- In order to propagate a particle inside a field (e.g. magnetic, electric or both), we solve the equation of motion of the particle in the field.
- We use a Runge-Kutta method for the integration of the ordinary differential equations of motion.
  – Several Runge-Kutta 'steppers' are available.
- In specific cases other solvers can also be used:
  – In a uniform field, using the analytical solution.
  – In a nearly uniform field (BgsTransportation/future)
  – In a smooth but varying field, with new RK+helix.

Magnetic field: overview (cont)

- Using the method to calculate the track's motion in a field, Geant4 breaks up this curved path into linear chord segments.

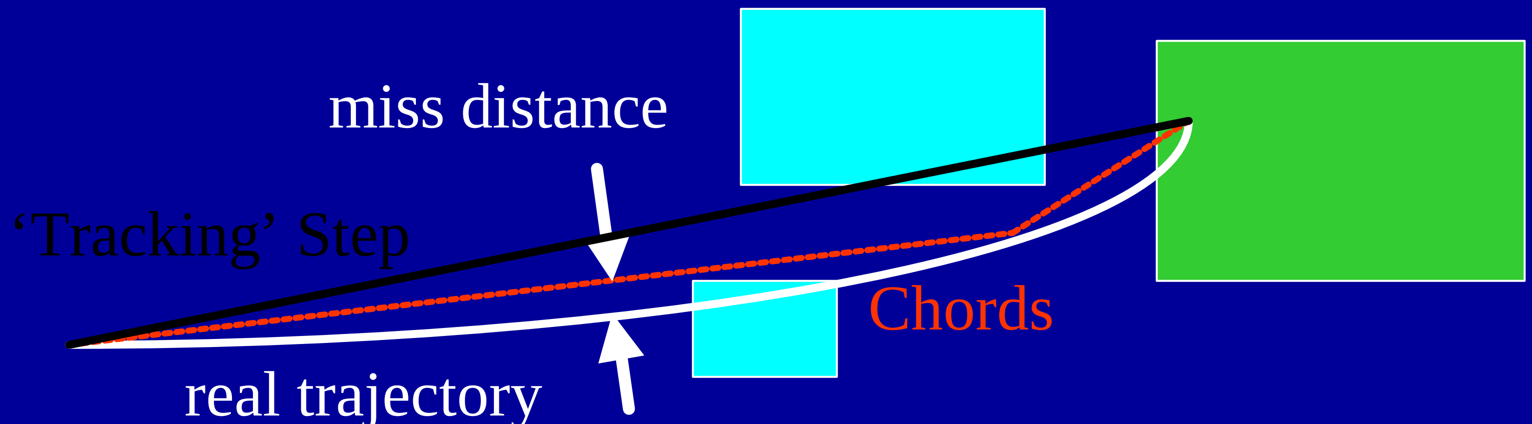


- We determine the chord segments so that they closely approximate the curved path.
- We use the chords to interrogate the Navigator, to see whether the track has crossed a volume boundary.



Stepping and accuracy

- You can set the accuracy of the volume intersection,
  - by setting a parameter called the “miss distance”
    - it is a measure of the error in whether the approximate track intersects a volume.
    - Default “miss distance” is 3 mm.
- One physics/tracking step can create several chords.
  - In some cases, one step consists of several helix turns.



Magnetic field: a first example

Create your Magnetic field class

Part 1/2

- Uniform field :
  - Use an object of the G4UniformMagField class

```
#include "G4UniformMagField.hh"
#include "G4FieldManager.hh"
#include  "G4TransportationManager.hh“

G4MagneticField* magField= new G4UniformMagField(
          G4ThreeVector(1.0*Tesla, 0.0, 0.0) );
```

- Non-uniform field :
  - Create your concrete class derived from G4MagneticField

Magnetic field: a first example

Tell Geant4 to use your field

Part 2/2

- Find the global Field Manager

```
G4FieldManager* globalFieldMgr=
 G4TransportationManager::
   GetTransportationManager()
                     ->GetFieldManager();
```

- Set the field for this FieldManager,

```
globalFieldMgr->SetDetectorField(magField);
```

- and create a Chord Finder.

```
globalFieldMgr->CreateChordFinder(magField);
```

In practice: exampleN04

From geant4/examples/novice/N04/src/ExN04DetectorConstruction.cc

```
G4VPhysicalVolume* ExN04DetectorConst
{
  //-------------------------------
  // Magnetic field
  //-------------------------------

  static G4bool fieldIsInitialized =
  if(!fieldIsInitialized)
  {
    ExN04Field* myField = new ExN04Fi
    G4FieldManager* fieldMgr
      = G4TransportationManager::GetT
        ->GetFieldManager();
    fieldMgr->SetDetectorField(myFiel
    fieldMgr->CreateChordFinder(myFie
    fieldIsInitialized = true;
  }
```

Beyond your first field

- Create your own field class
  - To describe your setup's EM field
- Global field and local fields
  - The world or detector field manager
  - An alternative field manager can be associated with any logical volume
    - Currently the field must accept position global coordinates and return field in global coordinates
- Customizing the field propagation classes
  - Choosing an appropriate stepper for your field
  - Setting precision parameters

Creating your own field

Create a class, with one key method – that calculates the value of the field at a Point

Point [0..2] position
Point[3] time

```
void ExN04Field::GetFieldValue(
  const double Point[4],
    double *field) const
{
  field[0] = 0.;
  field[1] = 0.;
  if(abs(Point[2])<zmax &&
  (sqr(Point[0])+sqr(Point[1]))<rmax_sq)
  { field[2] = Bz; }
  else
  { field[2] = 0.; }
}
```

Global and local fields

- One field manager is associated with the 'world'
  - Set in G4TransportationManager
- Other volumes can override this
  - By associating a field manager with any logical volume
    - By default this is propagated to all its daughter volumes

```
G4FieldManager* localFieldMgr=
   new G4FieldManager(magField);
logVolume->setFieldManager(localFieldMgr,
  true);
```

where '`true`' makes it push the field to all the volumes it contains.