

Field propagation in Geant4

John Apostolakis

representing the effort of the Field sub-category
of the Geometry & Transportation WG
of Geant4

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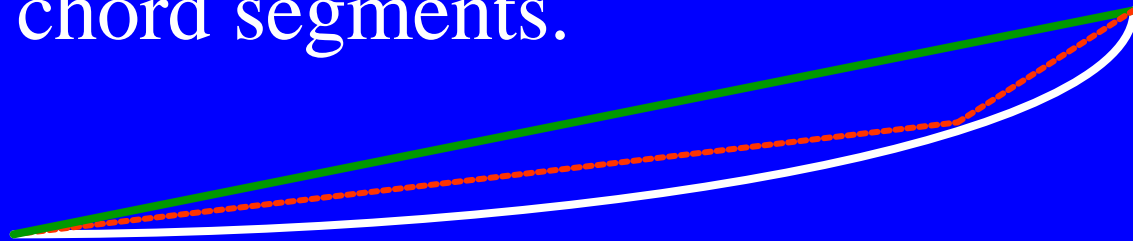
1. What is involved in propagating in a field
 - calculating the motions
 - intersecting the volume boundaries
2. A first example
 - Defining a simple field in Geant4
3. More capabilities
 - Using your own field
 - Many fields,
 - Tomorrow: tuning for performance, ..

Magnetic field: overview

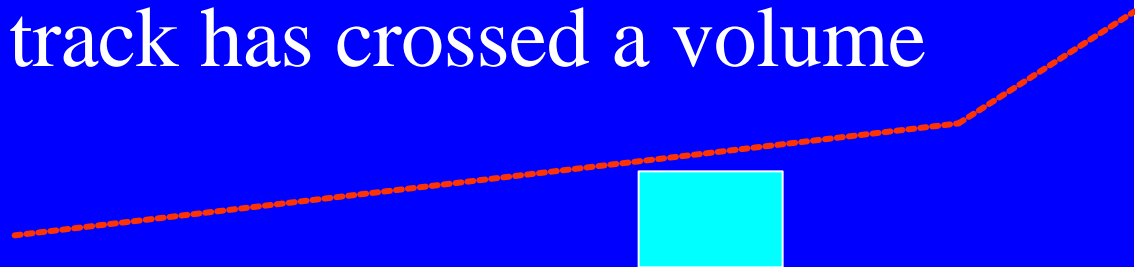
- In order to **propagate** a particle inside a field (e.g. magnetic, electric or both), we **solve** the equation of motion of the particle in the field.
- We use a Runge-Kutta method for the integration of the ordinary differential equations of motion.
 - Several Runge-Kutta ‘steppers’ are available.
- 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.

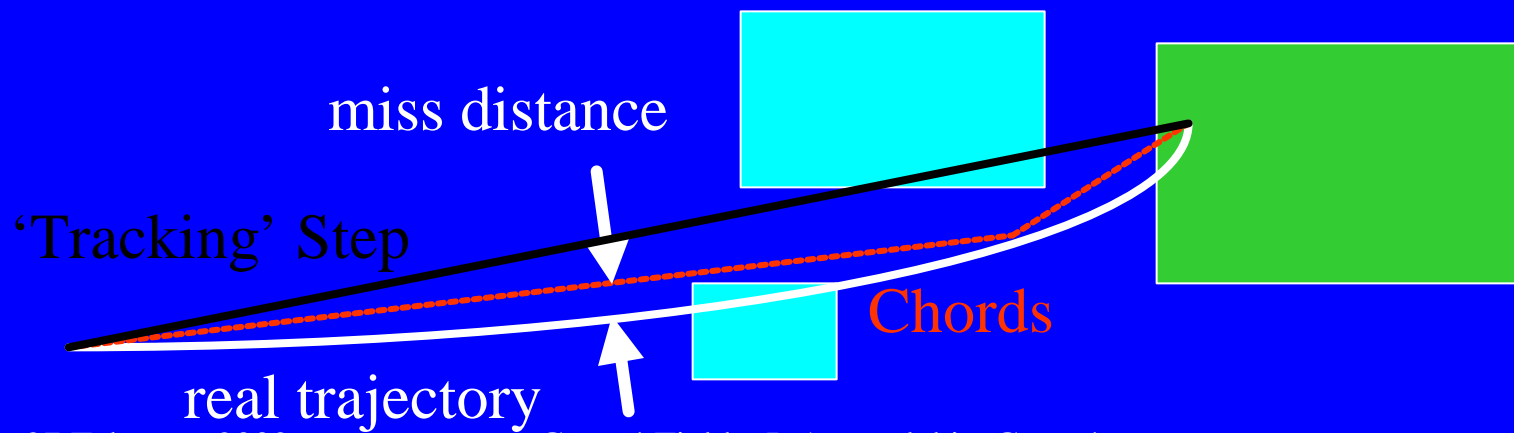


- We determine the chord segments so that they closely approximate the curved path.
- We use the chords to interrogate the Navigator, to see whether the track has crossed a volume boundary.



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

Part 1/2

Create your Magnetic field class

– 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 own concrete class derived from

27 February 2007 **G4MagneticField** Geant4 Fields, J. Apostolakis, Geant4
Users Workshop, SLAC

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`

```
G4VP hysicalVolume * ExN04DetectorConst
{
  // -----
  // Magnetic field
  // -----

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

```
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.; }
}
```

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

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.

Contributors to Field sub-category

- John Apostolakis
- Simone Giani
- Vladimir Grichine
- Wolfgang Wander

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- and expected contribution