



Geometry Debugging in OSCAR

(Geant4 Simulation of CMS)

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Martin LIENDL

(CERN, Geneva & HEPHY Vienna)

presented by

Pedro ARCE

(CERN, Geneva)



Motivation



- a) Have problems with tracking with/without magnetic field**
 - Due to wrong geometry?**
 - Due to instabilities in Geant4?**
 - > provide at least a correct geometry**

- b) When building/implementing a new geometry:**
 - How does it look like (hierarchy, dimensions, ...)?**
 - How can we debug more easily, browse hierarchies, ...**

- c) Tools like DAVID don't use the tracking geometry, want to debug the tracking geometry!**



Geant4 Requirements



Geant4 expects

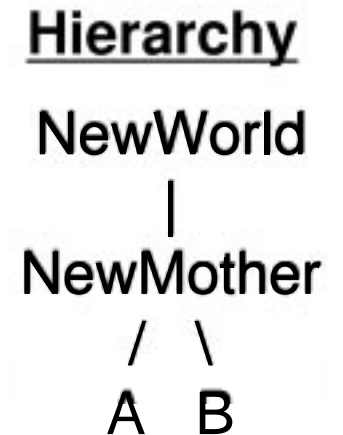
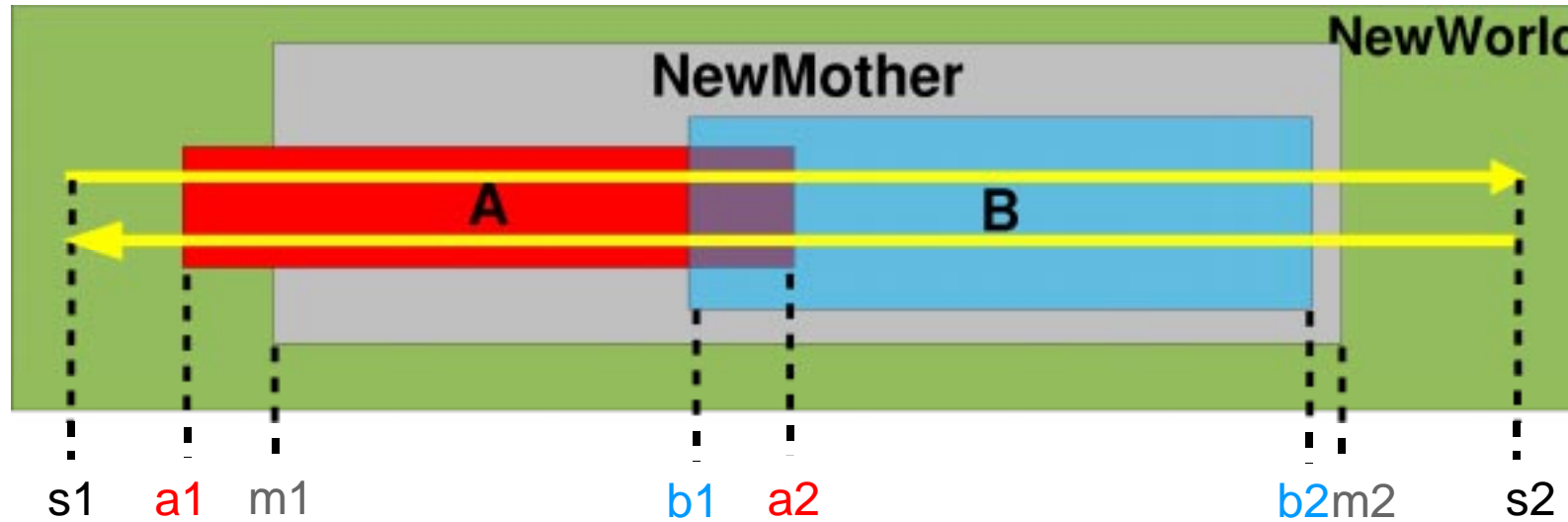
(a) Daughters of the same mother must not intersect each other

(b) Daughters of the same mother must be fully contained in their mother

(c) some refinements of the above in case of replication and parameterization



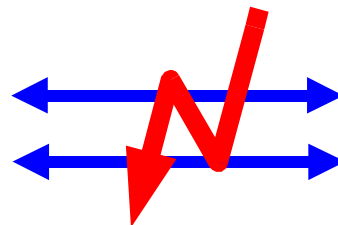
If these conditions hold for every mother–volume and the first level of daughters therein, the geometry is ok!



Shooting 2 geantinos in opposite direction along the same 'ray':

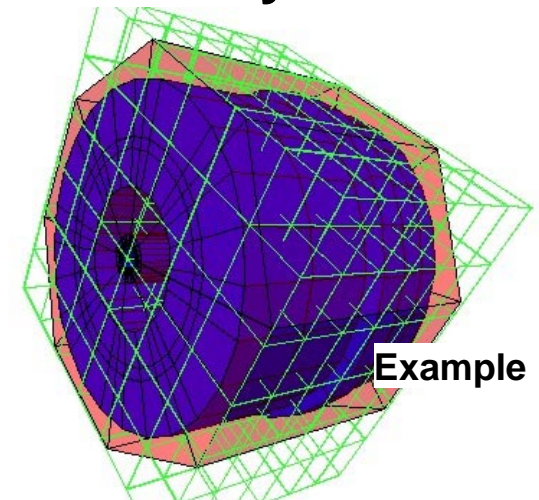
s1 to s2:

coord.	vol.
m1	World → A
a2	A → B
b2	B → M
m2	M → World



s2 to s1:

coord.	vol. (reversed)
a1	A → World
b1	B → A
b2	M → B
m2	World → M





Implementation(1)



- select any mother (logical) volume from full geometry (called **NewMother** below)
- build up a new tracking world consisting of
 - a **NewWorld** – world–volume (a box which is slightly larger than the VisExtent of the NewMother)
 - put the NewMother inside the NewWorld
 - put all physical daughters inside the NewMother
- **Event**: 2 geantinos flying in opposite direction (from A to B and from B to A)
- **Run**: several events of geantino–pairs flying in an user defined grid through the NewWorld
- **SteppingAction**: Per event save boundary crossing of geantino flying from A to B and of geantino flying from B to A
- **EventAction**: Save non–equal boundary–transitions from A to B and B to A including the NavigationHistories of the 2 geantinos at these points and filter (only one detected overlap per volume–pair should be reported)
- **RunAction**: report detected overlaps

DetectorConstruction UserAction: takes any G4VUserDetectorConstruction, thus any Geant4 geometry

GUI depends on Qt – Library



User Interface (command line)



/olap/goto <regexp>

sets the NewMother to the LogicalVolume (its name matching the regexp.)

/olap/cd <regexp>/<regexp>/ ...

setting the NewMother by Unix-like navigation through the logical volume hierarchy

/olap/ls , /olap/pwd

lists all logical daughters of the current NewMother, print position in logical hierarchy

/olap/grid i j k

set the density of the grid of geantino rays

/olap/whereIs

highlight all physical volumes of NewMother and her daughters in the full geometry

/olap/trigger , /olap/triggerFull

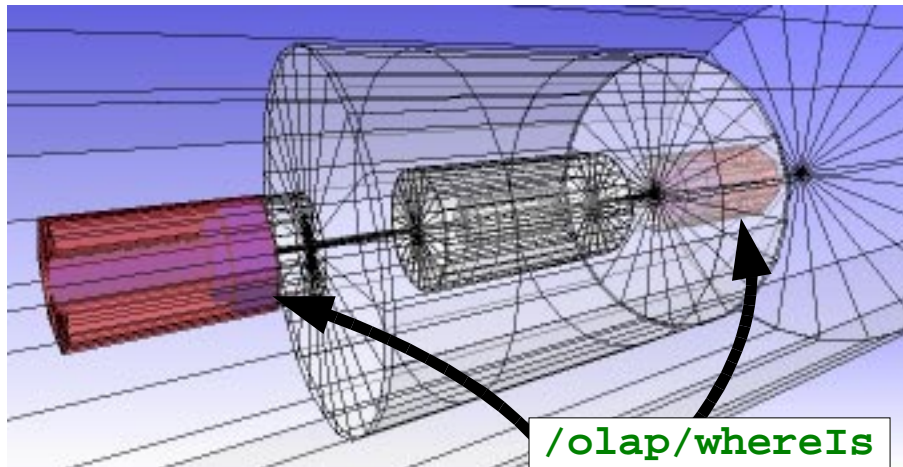
check for overlaps in current NewMother or in the logical volume subtree

/olap/gui

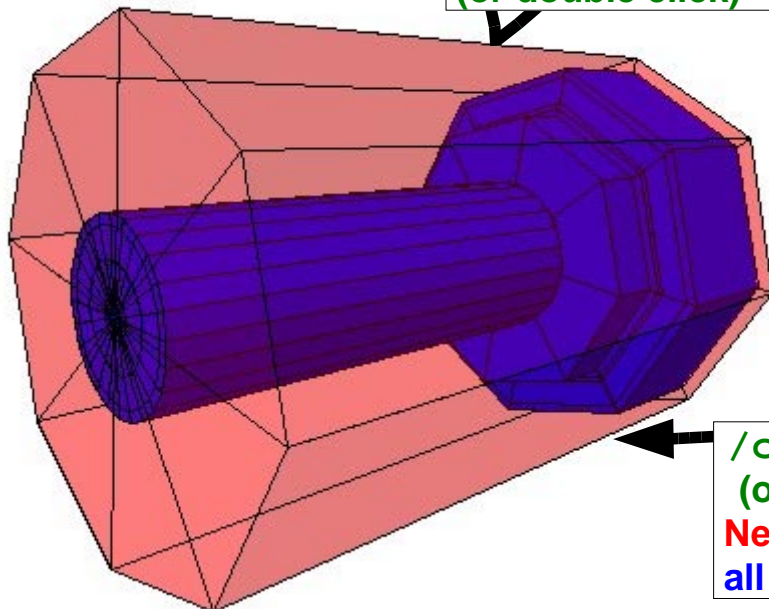
start graphical user interface for geometry navigation



GUI, Navigation, Visualization



`/olap/whereIs`
(or double click)



`/olap/cd /CMS/Calo/Ha.*For/Rear`
(or mouse-click in the GUI)
NewMother (red)
all direct physical daughters (blue)

logical volume hierarchy

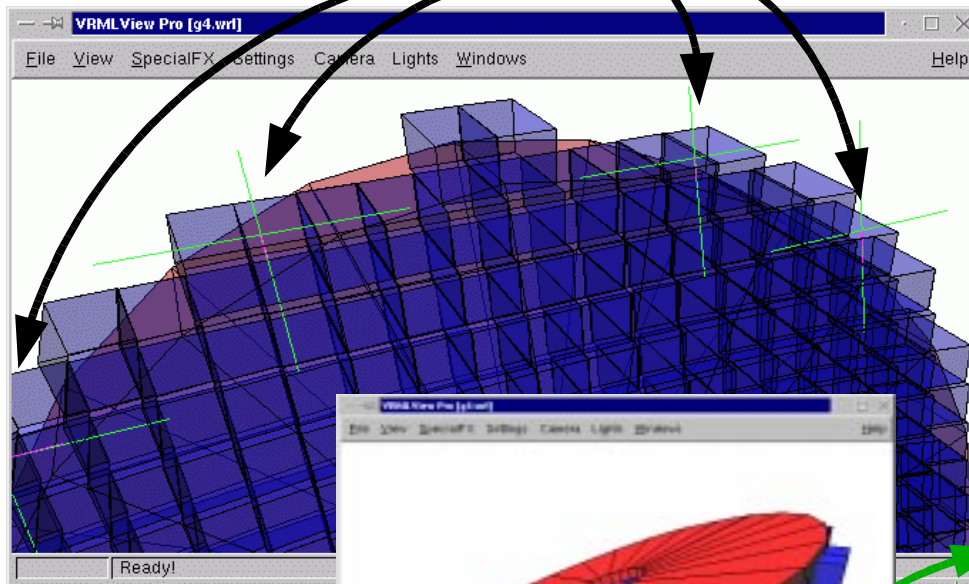
number of direct physical daughters

solid specifications

lv-name	in-ph-d	rep-d	SolidType: G4Polyhedra
CMS			SolidName: HFRearPart
BeamPipe	20	n	SolidPara:
Calorimeter	4	n	startPhi 5.89049
ElectromagneticCalorimeter	5	n	endPhi 5.89049
HadronCalorimeter	3	n	nrSide 8
HadronForward	3	n	startPhi 5.89049
HFAvanShield	3	n	nrRZ 4
HFCentralPart	3	n	z_0 3610
HFRearPart	10	n	r_0 119.063
ForwardQuadrupole	14	n	z_1 -3610
MuonChamber	6	n	r_1 119.063
BarrelMuon	33	n	z_2 -3610
ForwardMuon	17	n	r_2 2521.97
MuonChamberAlignmentTube	1	n	z_3 3610
MuonChamberMagnetVolume	1	n	r_3 2521.97

is daughter replicated/paramet.?

graphical indication of detected overlaps



red: mother
blue: daughters

daughters are protruding their mother

Geant4 Macro:

```

/vis/scene/create
/vis/sceneHandler/create VRML2FILE
/vis/viewer/create
/olap/goto ECalEnd
/olap/grid 7 7 7
/olap/trigger
/vis/viewer/update
    
```

Output:

```

delta=59.3416
vol 1: point=(560.513,1503.21,-141.4)
vol 2: point=(560.513,1443.86,-141.4)
A -> B:
[0]: ins=[2] PVName=[NewWorld:0] Type=[N] ...
[1]: ins=[0] PVName=[ECalEndcap:0] Type=[N] ..
[2]: ins=[1] PVName=[ECalEndcapO7:38] Type=[N]

B -> A:
[0]: ins=[2] PVName=[NewWorld:0] Type=[N] ...
    
```

NavigationHistories of points of overlap
(including: info about translation, rotation, solid specs)



Outlook, Questions



Outlook for overlap detection tools in CMS:

- Current implementation assumes that all mother volumes are logical mothers or if a mother is physical, she should only exist once in order to avoid detection of ghost overlaps. In CMS this assumption is true.
Dropping this assumption is not a big problem – some modifications have to be done.
- Only specification of CMS–used solids can be shown in the GUI (see below ...)
- Extensions for materials, enhance GUI,

Questions to Geant4 collaboration:

- Would like to have a sort of generic parameter retrieval for solids.
 - . This is currently implemented for CMS–used solids, but would be fine to have in G4
 - . One should additionally get back the parameters he gave in the constructor of the solid (many constructors for the same solid!)
 - . Maybe: Debug–version of solids vs. version as currently available
- Export / Import facilities in the way of GDML would help a lot!!!
- **Concerning overlaps: Are overlaps a problem for the stability of a Geant4 simulation (including magnetic field?)**
- When converting geometries from Geant3 we often get slight overlaps because the boundary tolerances in Geant3 are not that tight. Is this a problem for Geant4??