Development and application of CATIA-GDML geometry builder

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Introduction

The task

Design optimization of complex, densely packed systems in severe radiation conditions (like FAIR experiments) requires iterative exchange of geometry and material info

For mechanical, thermal, and some of electromagnetic software the transfer is automated. For radiation simulation packages that's not a case.

We are presenting an update on the development and application of a tool for manual building of an optimized simulation geometry based on a CAD model. Earlier version of the tool was presented at CHEP2010 [1]

Geometry representations in CAD systems and G4/ROOT [2,3] are rather different from each other

The difference is twofold: in the description of solid bodies and in the hierarchy of assemblies. For this reason the automated geometry transfer can not be widely used. In some cases it is possible, but the result is not optimized for simulations and computations are too slow for big assemblies and complex shapes.

Solids:

In CAD systems quasi arbitrary boundary representation is used

In G4/ROOT a Boolean combination of primitives (Constructive Solid Geometry - CSG) is implemented.

The problem

In CAD hierarchy a minimal unit is a solid body (*part*).

Products (assemblies) and subproducts are only logical units – all the materials are assigned to solid bodies inside the part files or to parts

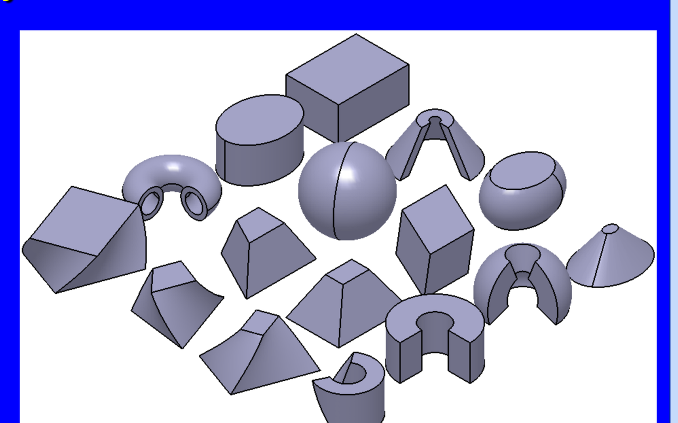
In the G4/ROOT hierarchy there are three conceptual layers:
- **G4VSolid: *shape, size***
- **G4LogicalVolume: *material, MF, sensitivity, daughter volumes, etc.***
- **G4VPhysicalVolume: *position and rotation of an instance of the logical volume inside its mother***

The method

1. Mapping the G4/ROOT like geometry into CATIA product tree

a) Solid (TGeoShape):

- Implementation of primitives as parameterized User Defined Features (UDF) in CATIA. The UDFs are placed into G4Catalog. The following primitives are realized: G4Box; G4Cons; G4Ellipsoid; G4EllipticalCone; G4EllipticalTube; G4Orb; G4Para; G4Sphere; G4Torus; G4Trap; G4Trd; G4Tubs; G4TwistedBox; G4TwistedTrap; G4TwistedTrd; G4TwistedTubs. Pilot versions of G4Polycone and G4Polyhedra are also available.
- Realization of Boolean combinations using CATIA operations *Add, Remove* and *Intersect*



b) LogicalVolume (TGeoVolume)

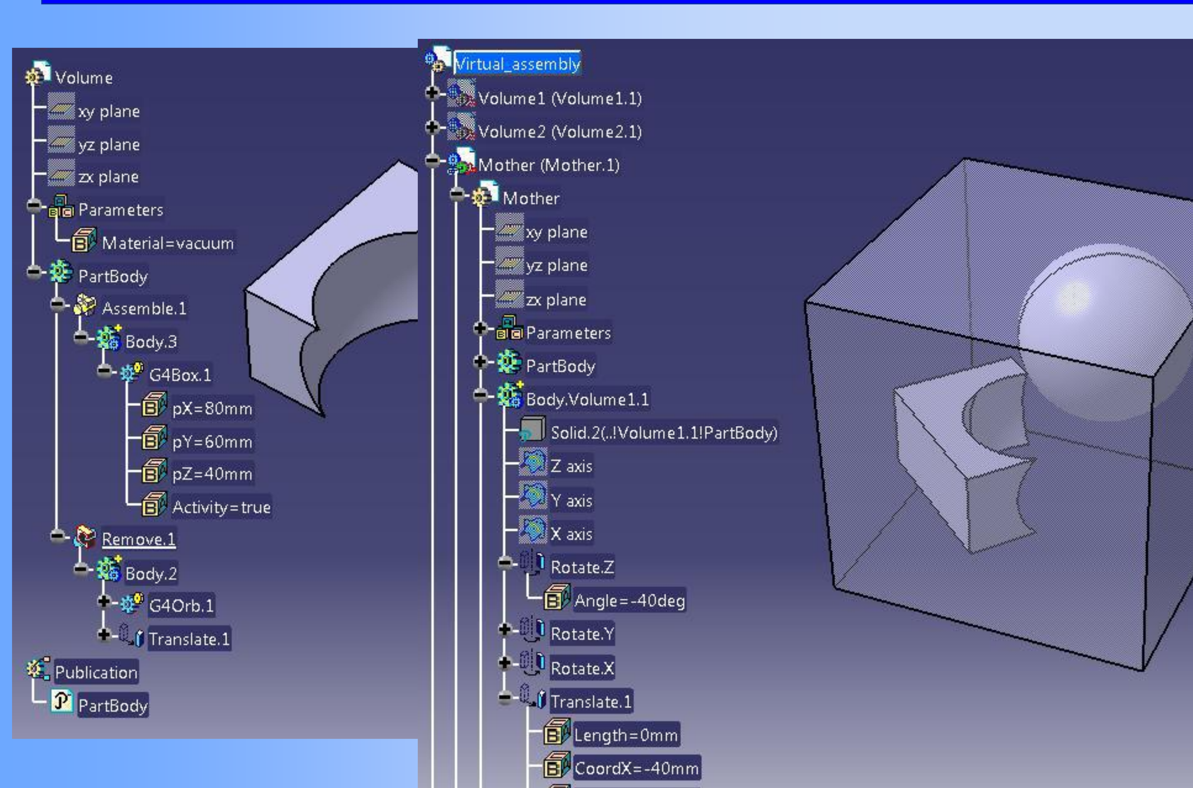
- File structure is realized in a template.
- Name of the material is introduced as a parameter.
- *PartBody* contains a parameterized CSG solid.
- Unparameterized copy of the *PartBody* is published

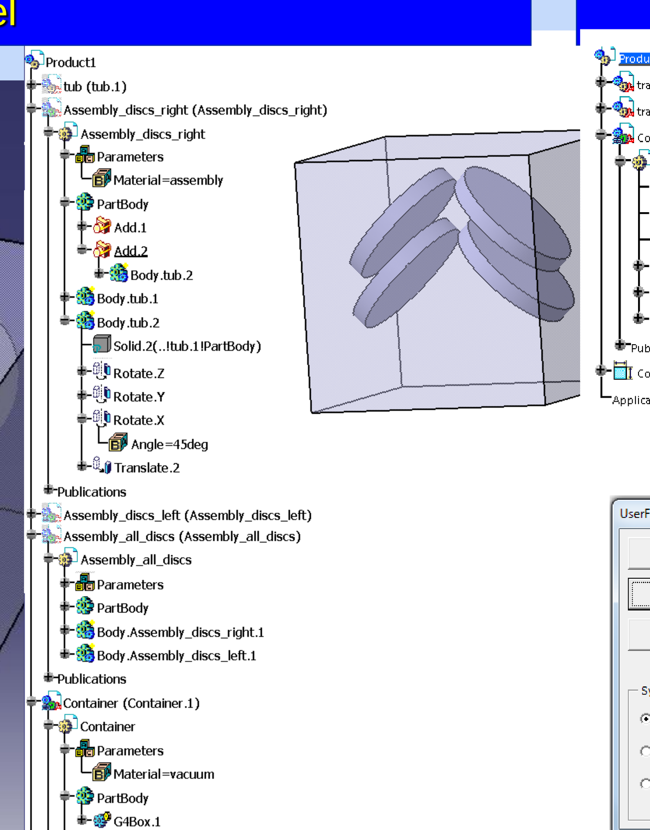
c) PhysicalVolume (TGeoNode)

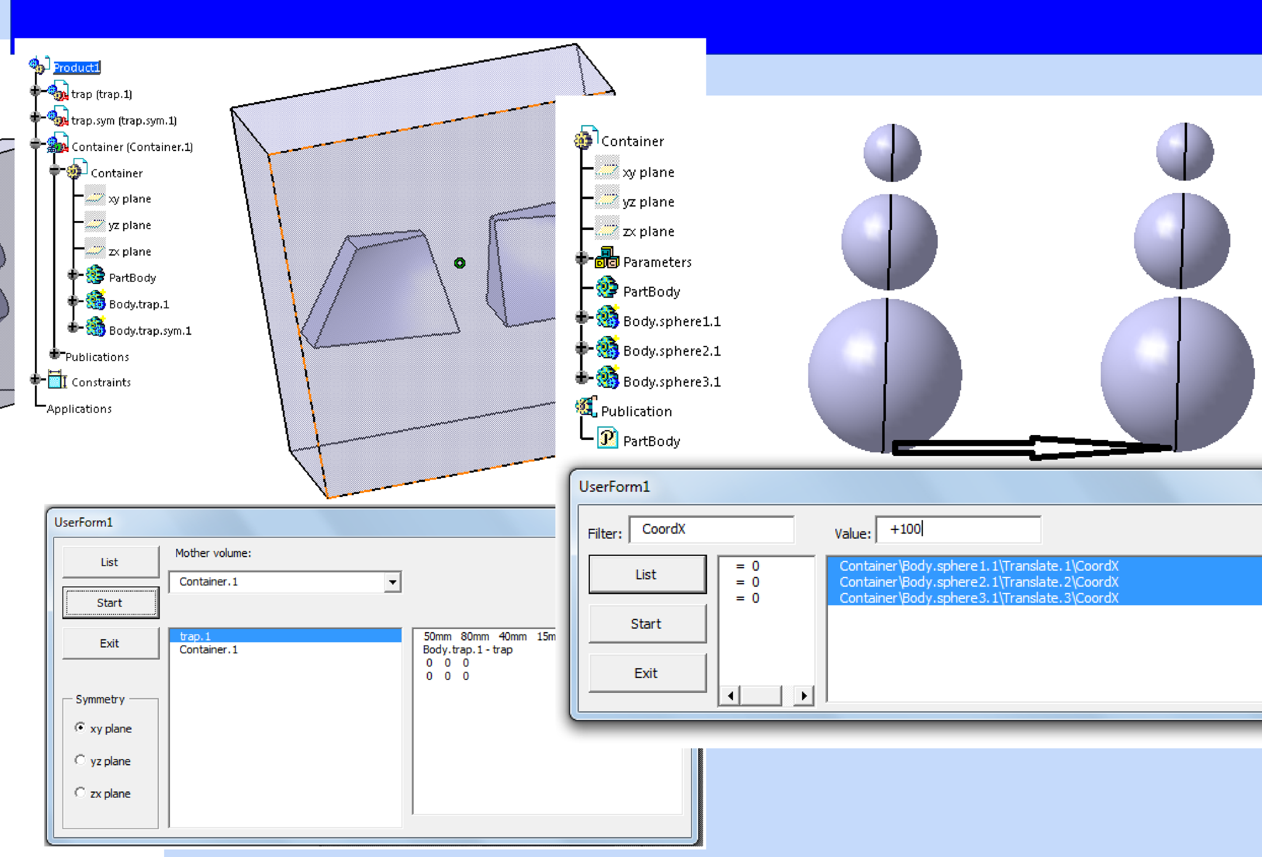
- Solids, published in files corresponding each to a smaller *LogicalVolume (TGeoVolume)* can be inserted into the tree with positioning. They represent daughter volumes
- Linear and circular G4PVReplica (TGeoVolume * Divide) are implemented for multiple instantiation
- G4AssemblyVolume (TGeoVolumeAssembly) are marked by *material=assembly* and are able to manifest representations of daughters at the upper level

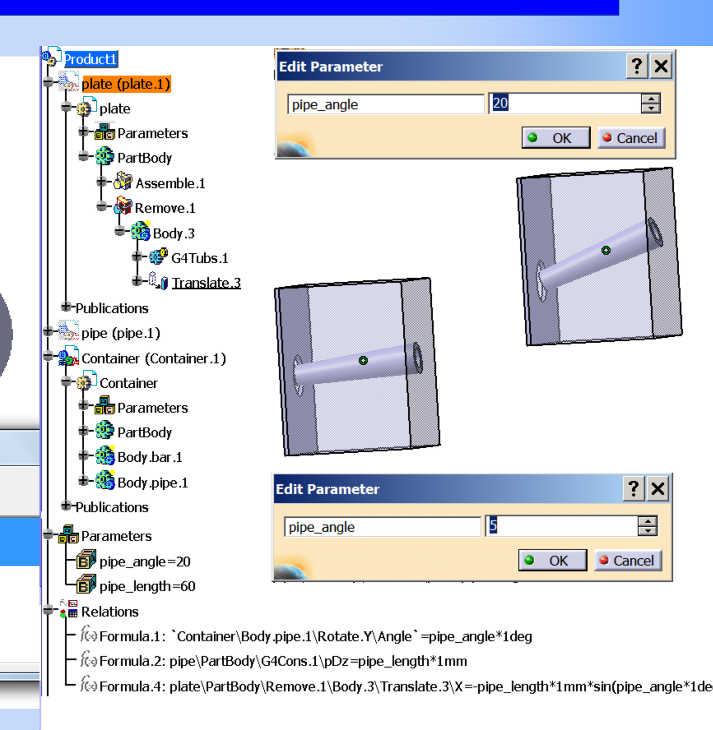
2. Developing the VBA tools facilitating creation of the G4/ROOT like geometry

- **Inserter:** places a daughter volume inside the mother one and creates a template for rotations and translations. A dedicated checkbox allows to transform the mother volume into assembly.
- **Array maker:** Creates a circular or linear array of individual placements of daughter or "granddaughter" volumes or generates G4PVReplica (TGeoVolume * Divide).
- **PtPa:** Allows to translate a Boolean operand or a daughter volume by clicking initial and final points.
- **Measure:** Allows to measure length (radius) of an object or a distance (angle) between two objects. and put th result into any parameter of a G4/ROOT like model.
- **Mover:** Allows to translate simultaneously a set of volumes.
- **Symmetry:** Creates Physical volumes symmetric to selected set w.r.t a given plane. When necessary a chiral partner of an existing volume is generated. So far works only with primitives.
- **PickPoint Trap:** Calculates and puts into the tree the values of parameters, translations and rotations for a Trapezoid defined by picking with a mouse 8 vertices.
- **Checker:** Allows to check the correctness of G4/ROOT compatible tree and overlaps of volumnes
- **Material reassigner**: Allows to assign all the materials from the upper level of the CATIA product.
- **GDML Parameterization:** For exchange of the G4/ROOT compatible geometry between CATIA and MC packages GDML [4] is used. GDML variables are implemented using CATIA parameters and relations.
- **CATIA2GDML:** It is a converter from the G4/ROOT compatible CATIA tree to the GDML file readable by ROOT and GEANT4.
- **GDML2CATIA**: It is a converter from GDML to CATIA. It allows to bring any simulation geometry into CATIA



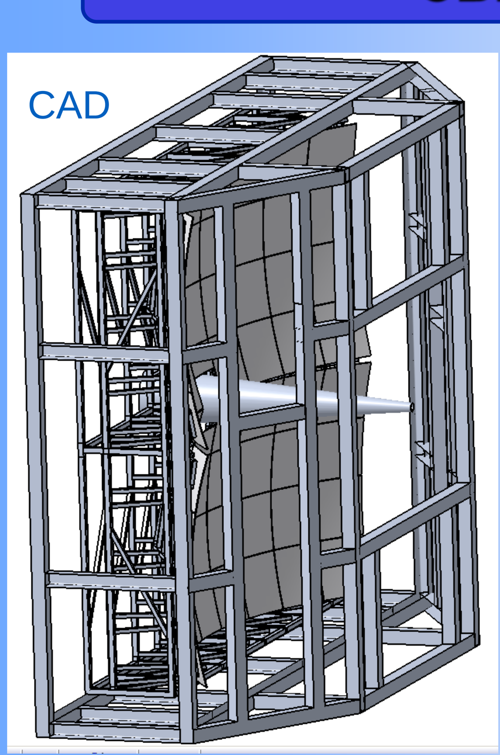


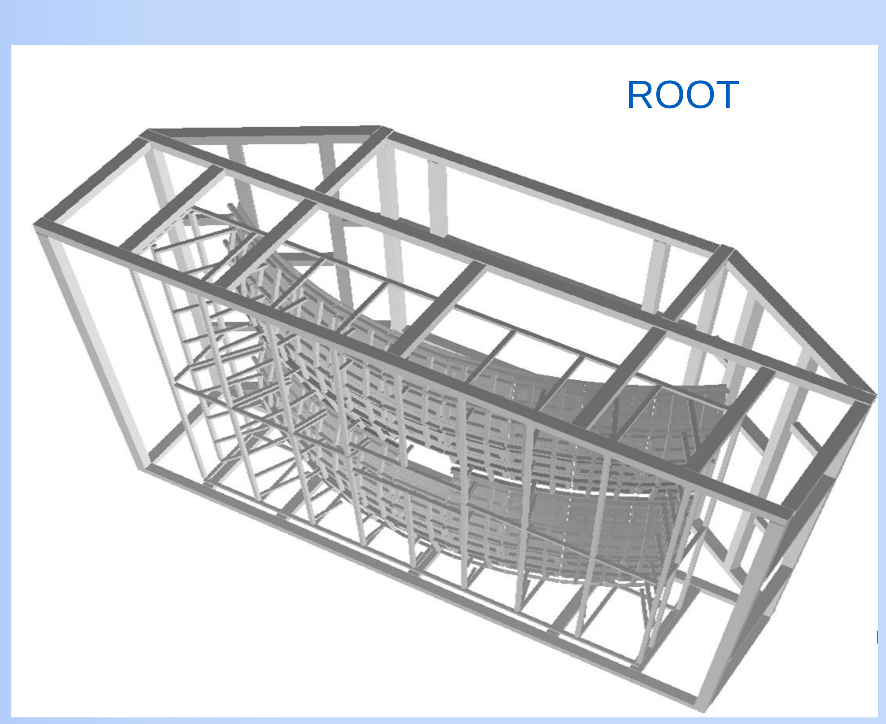




Examples

CBM RICH





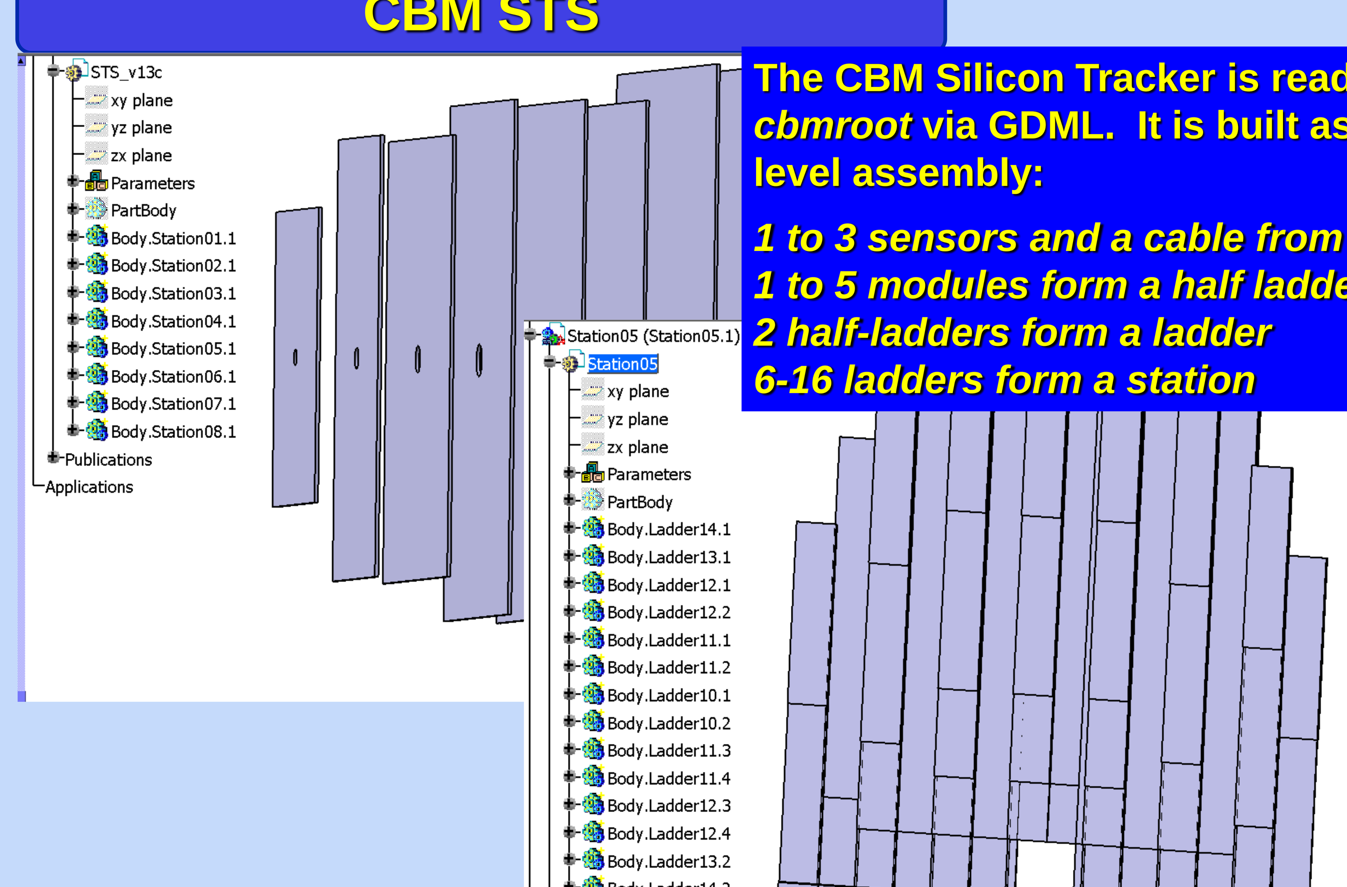
Specific Tools used for building G4/ROOT compatible CBM RICH:

Mirror tilting angle, position and size of photodetectors and deflection angle of the beam pipe were **parameterized.**

For rear frame **PickPoint Trap** and **Symmetry** were used

For mirror supporting belts **circular array**, **divisions** and **assembly** were used

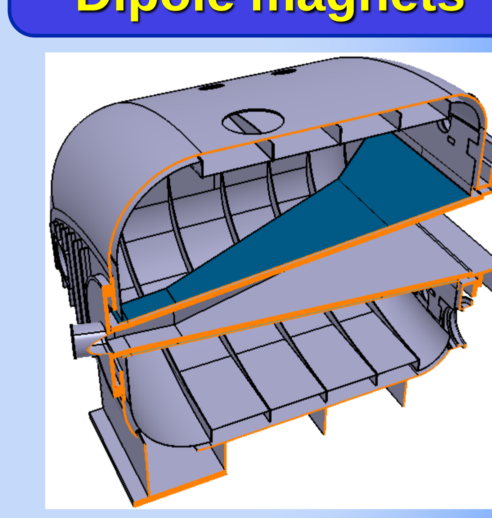
CBM STS

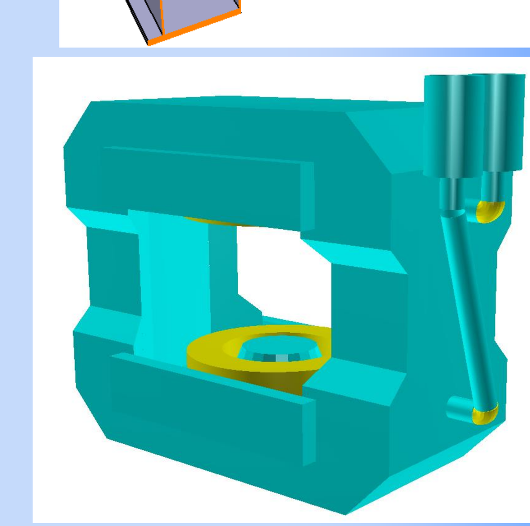


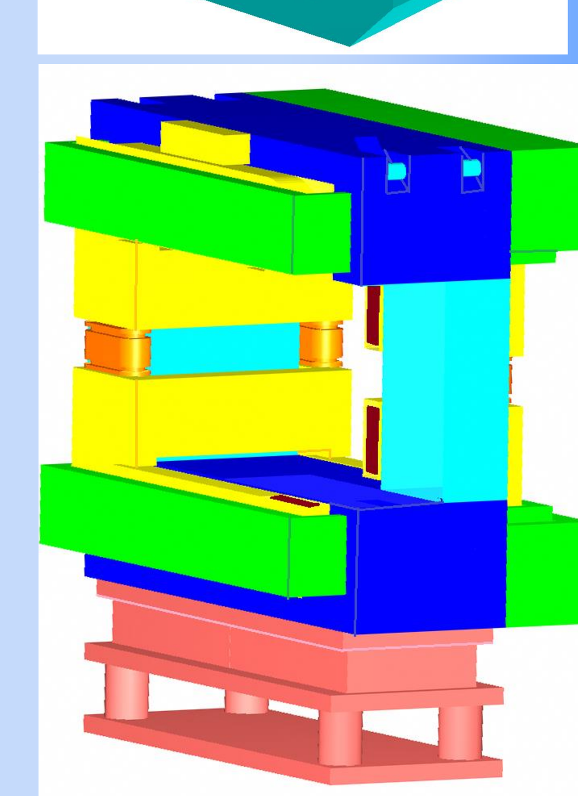
The CBM Silicon Tracker is read from *cbmroot* via GDML. It is built as a multi level assembly:

1 to 3 sensors and a cable from a module
1 to 5 modules form a half ladder
2 half-ladders form a ladder
6-16 ladders form a station

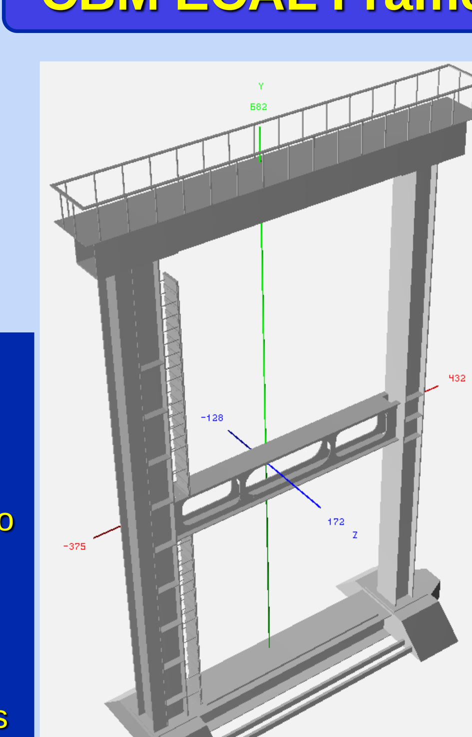
CBM and R3B Dipole magnets







CBM ECAL Frame



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Plans

- Extension of the pickpoint definition to other primitives
- handling of inaccuracies in the pick-point primitive definition
- Overcoming limitations of poly-primitives
- Adaptation of the CATIA Digital Mockup (DMU) optimizer for automatic fit of parameterized CSG models to existing parts
- Acceleration of GDML2CATIA converter
- Visualization of several hierarchical levels
- Case study and best practice elaboration

References

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