Experiences from the CBM collaboration: CAD to ROOT conversion for Detector Geometries

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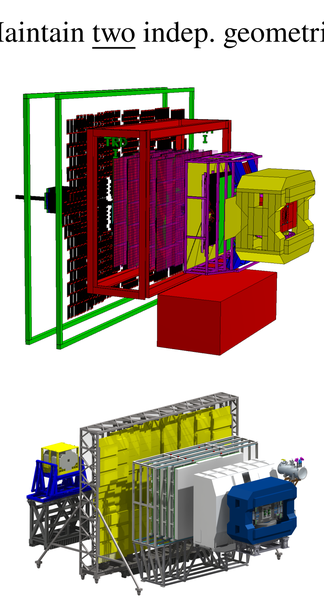
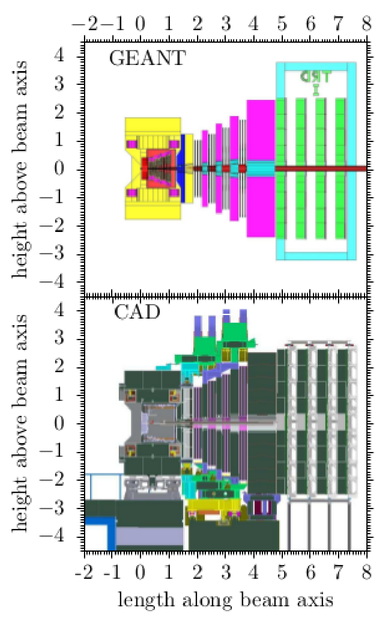
Experimental Setup [1]

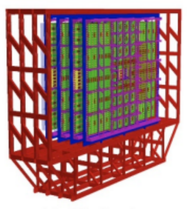
Maintain two indep. geometries

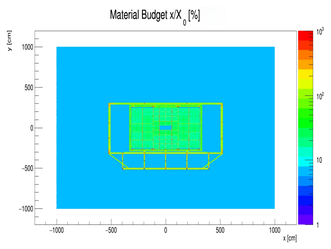




Transition Radiation Detector [2]


Tessellated Objects

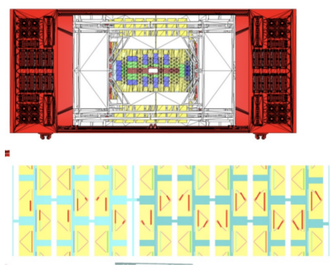

trd_v23a_1h setup



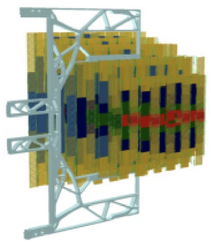
Aim: Model complex hollowed structure of support frame outside acceptance

Silicon Tracking System [2]

CAD - cut-away



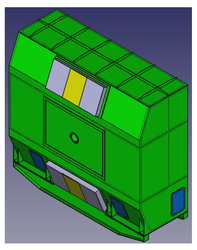
SIM - C-frames



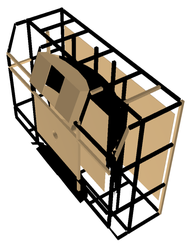
Aim: Model complex C-frame inside acceptance to validate current speed optimised implementation

Ring Imaging Cherenkov [3]

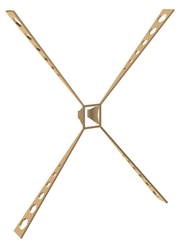
CAD



ROOT



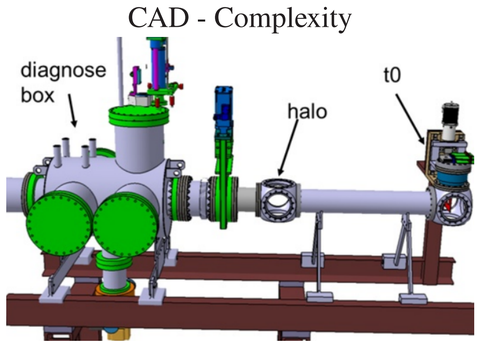
Beamcross



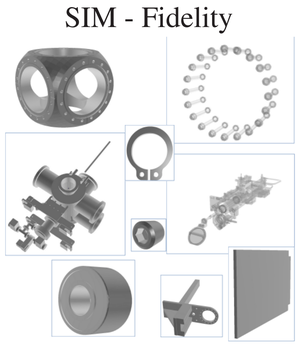
Aim: Fast assessment of the effect of supporting structure (right) added to traditional ROOT geometry (middle)

Beam Monitoring Assembly

CAD - Complexity

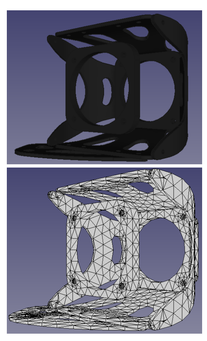


SIM - Fidelity



Aim: To handle complexity in conversion of complete assembly with multiple detectors

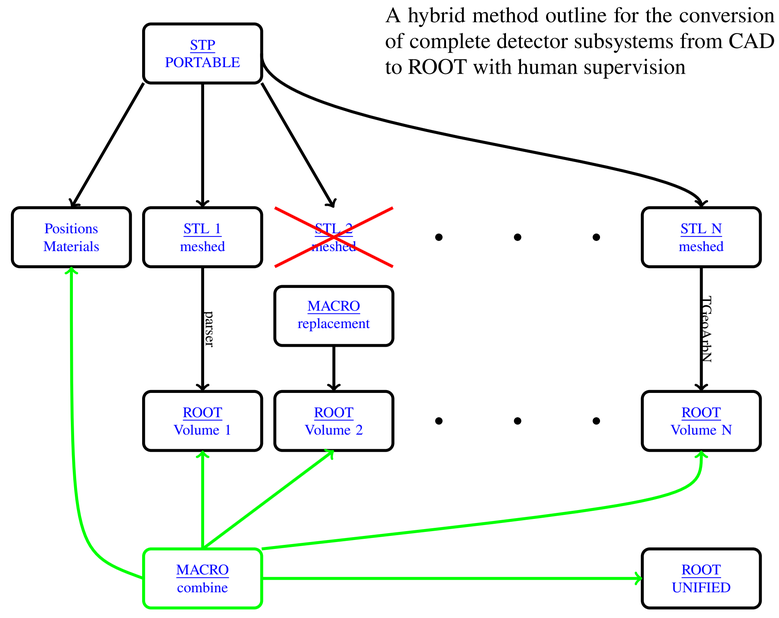
Tessellation | Meshing



- Accurately approximate an intricate CAD solid by completely surrounding its surface with a large number of small triangles of varying size
- Almost all CAD software can convert from their proprietary (or STP) format into STL format which is made up of a large list of these triangles.

A Procedure

A hybrid method outline for the conversion of complete detector subsystems from CAD to ROOT with human supervision



Solution A - VecGeom [4,5]

- Geometry modeller library (in development) as part of the GEANT V R&D initiative
- Offers traditional functionality for use in GEANT 3 / 4, and ROOT/TGeo
- SIMD support in various flavours (multi-particle API, single-particle API)
- Collision detection and navigation in complex scenes

CHEP2024 presentation on Monday by Mehul Shiroya discussing VecGeom implementation to mini-CBM mini-STS geometry

CHEP2024 presentation on Tuesday by Phat Srimanobhas discussing R&D adoption and process in CMS using VecGeom

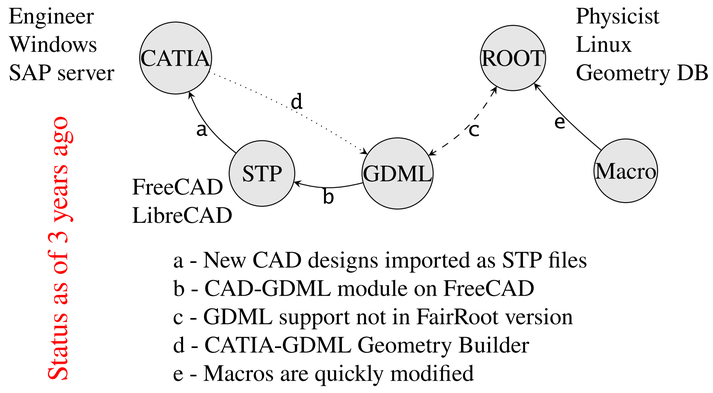
CHEP2024 presentation on Tuesday by Severin Diederichs discussing VecGeomm and GPU-friendly surface models

Solution B - TGeoArbN [6]

- A tessellation tool conceived for the PANDA experiment, being newly developed by University of Bonn
- Has own navigation/propagation functionality and is Geant3 and Geant4 compatible
- TGeoArbN objects behave like other TGeoVolume, allowing easy installation and compilation on top of our existing ROOT, FAIRROOT environments
- Includes functionality for partitioning with Octree
  - 3D version of binary decision trees
  - Divide geometry in eight smaller cuboids each step
  - Stop dividing at given depth or for "empty" volumes

CHEP2024 presentation on Wednesday by Ben Salisbury which publicly introduces TGeoArbN for first time.

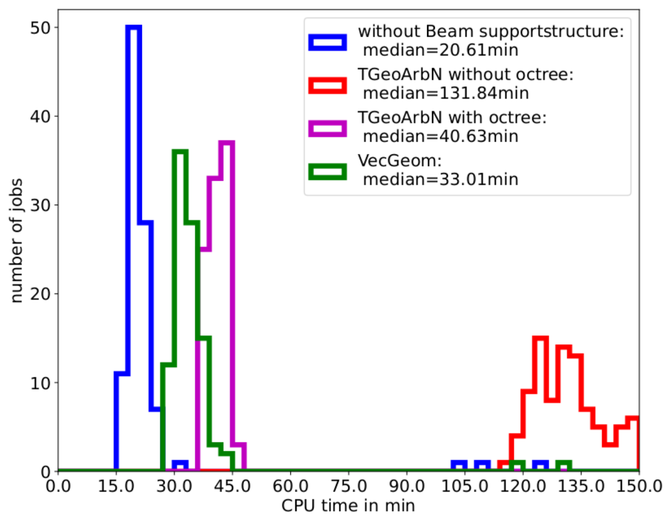
Two Geometry Worlds



a - New CAD designs imported as STP files
b - CAD-GDML module on FreeCAD
c - GDML support not in FairRoot version
d - CATIA-GDML Geometry Builder
e - Macros are quickly modified

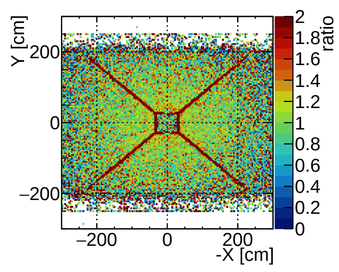
Preliminary Comparison

- Runtime comparison using GSI Virgo3 computing cluster, one tessellated volume (beamcross in RICH section) for Solution A & B with 100 URQMD events per job

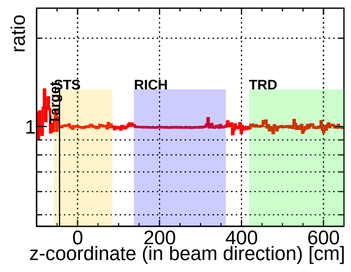


- Ratio of number of conversion vertices

with/without beamcross



with/without Octree



Conclusion

- The CBM collaboration continues its assessment of CAD2ROOT methods and procedures.
- In the last two years, these four use cases were trailed and completed by us using these procedures.
- When and how to implement are of importance to the labour saving efforts of the collaboration.

References

[1] E. Clerkin and P. Dahm, *"Recommended SIS100 subsystem positions for simulation of the future CBM experiment at FAIR"* CBM Progress Report 2020, pg. 170-172

[2] O. Singh, et al. *"Modelling of simulation geometries using Tessellated Shapes with the Vectorized Geometry (VecGeom) package"* CBM Progress Report 2023 pg. 174-175

[3] S. Neuhaus, C. Pauly, and K.-H. Kampert *"New RICH geometry v24a and first Monte Carlo tests"* CBM Progress Report 2023

[4] J. Apostolakis, et al. *"Towards a high performance geometry library for particle-detector simulations."* Journal of Physics: Conference Series. Vol. 608. No. 1. IOP Publishing, (2015)

[5] S. Wenzel, J. Apostolakis, and G. Cosmo *"A VecGeom navigator plugin for Geant4"* EPJ Web of Conferences 245, 02024

[6] B. Salisbury, *"TGeoArbN" privately communicated with S. Neuhaus*, University of Bonn (2024)

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