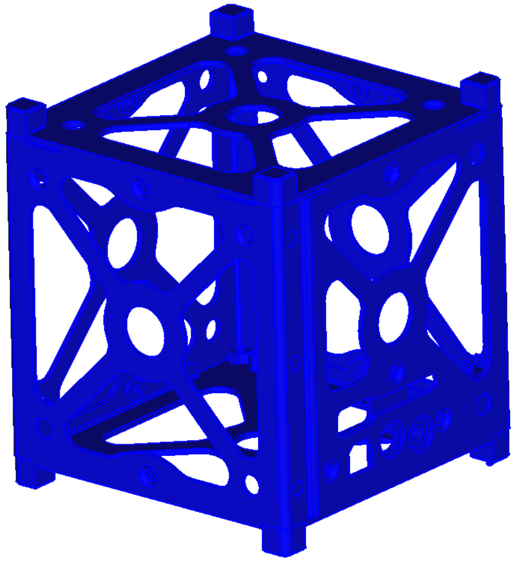
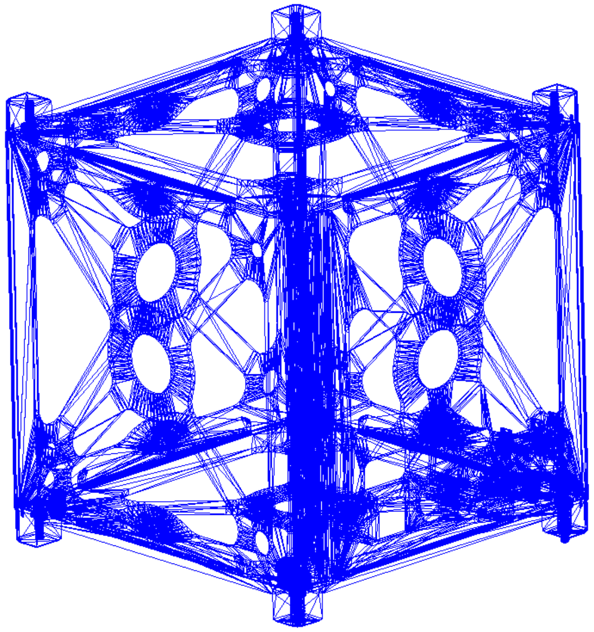
14th Geant4 Space User's Workshop



GUIMesh
A tool to convert STEP geometries in to GDML

M. Pinto and P. Gonçalves

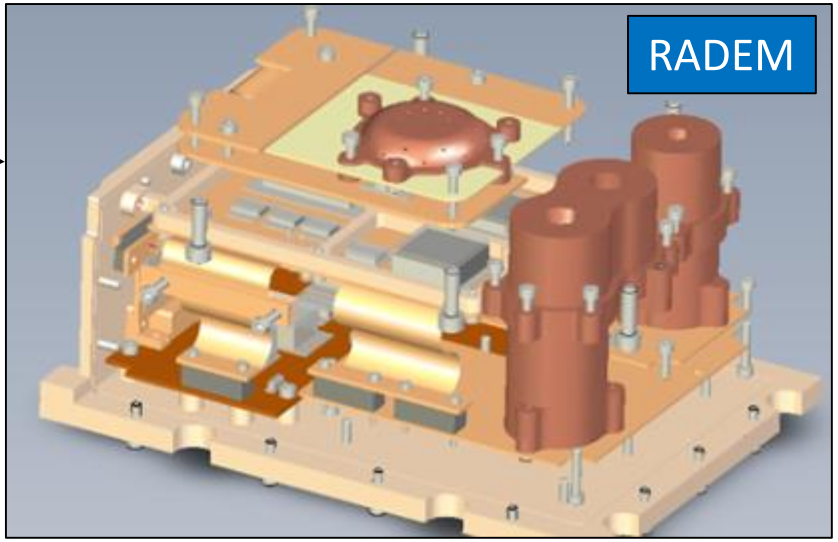


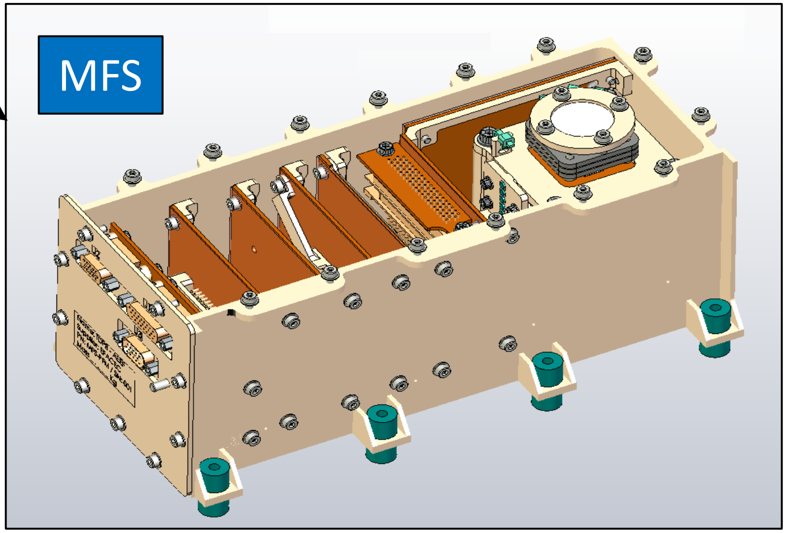
21-23 October 2019 – Korinthia, Greece

Motivation

Space instruments can be rather complex:

- Complicated geometries
- Several materials
- CAD format





Difficult to implement via Geant4 C++ geometry classes:

- Great number of volumes
- Volumes with different complexities

Subject to Human Error

Very Time Consuming

Critical

- Detector response
- Radiation analysis

Motivation

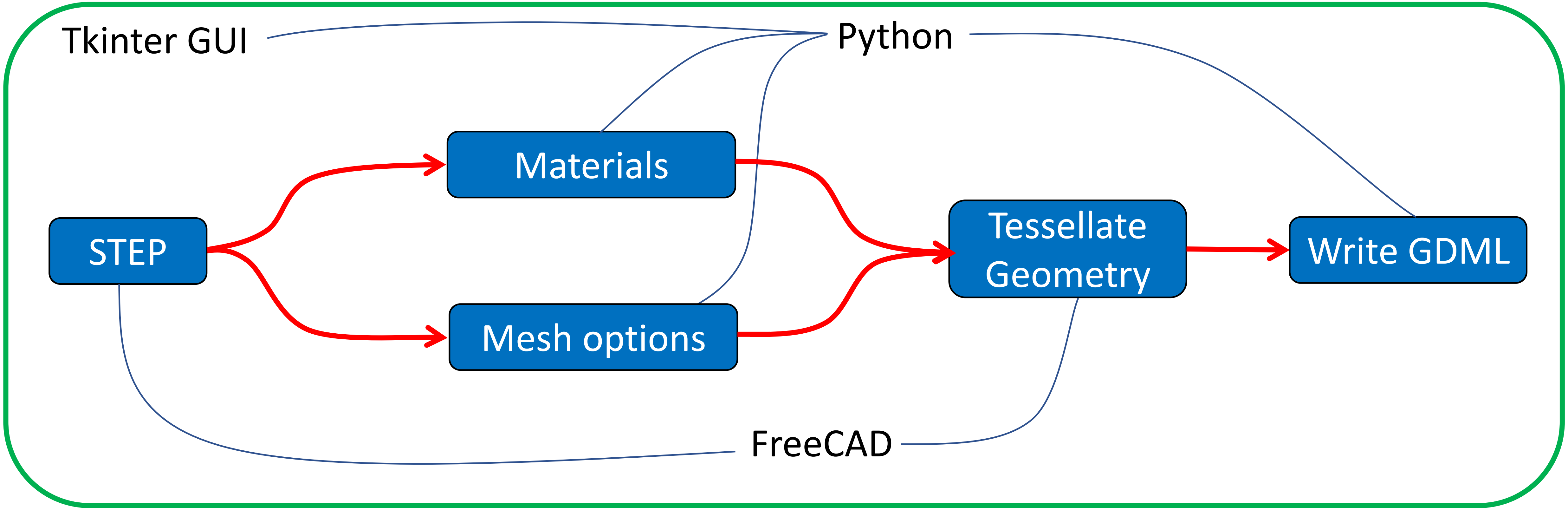
State-of-the-art tools

Name	Availability	Application
FASTRAD	Commercial	STEP format
ESABASE2		
STEP-Tools		
SW2GDML	Open-source	SolidWorks
CADMesh		STL
STL2GDML		STL

New open-source tool – GUIMesh

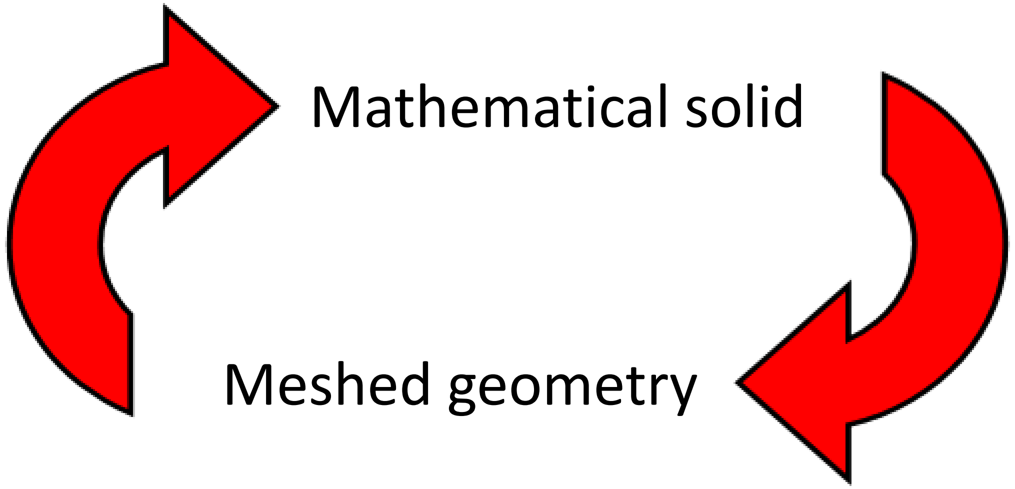
Built on a previous method presented in 12th Geant4 Space Users Workshop (Surrey)

Describe geometry as a mesh – G4Tessellated



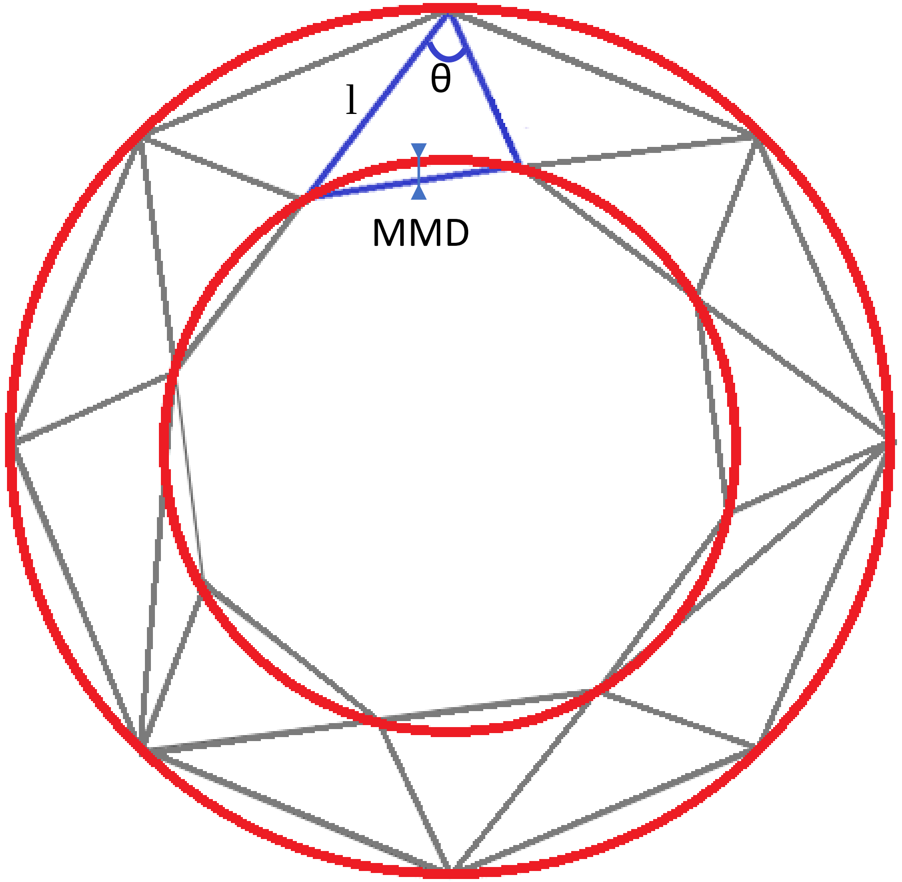
(M. Pinto et al, DOI: https://doi.org/10.1016/j.cpc.2019.01.024)

GUIMesh – Tessellation



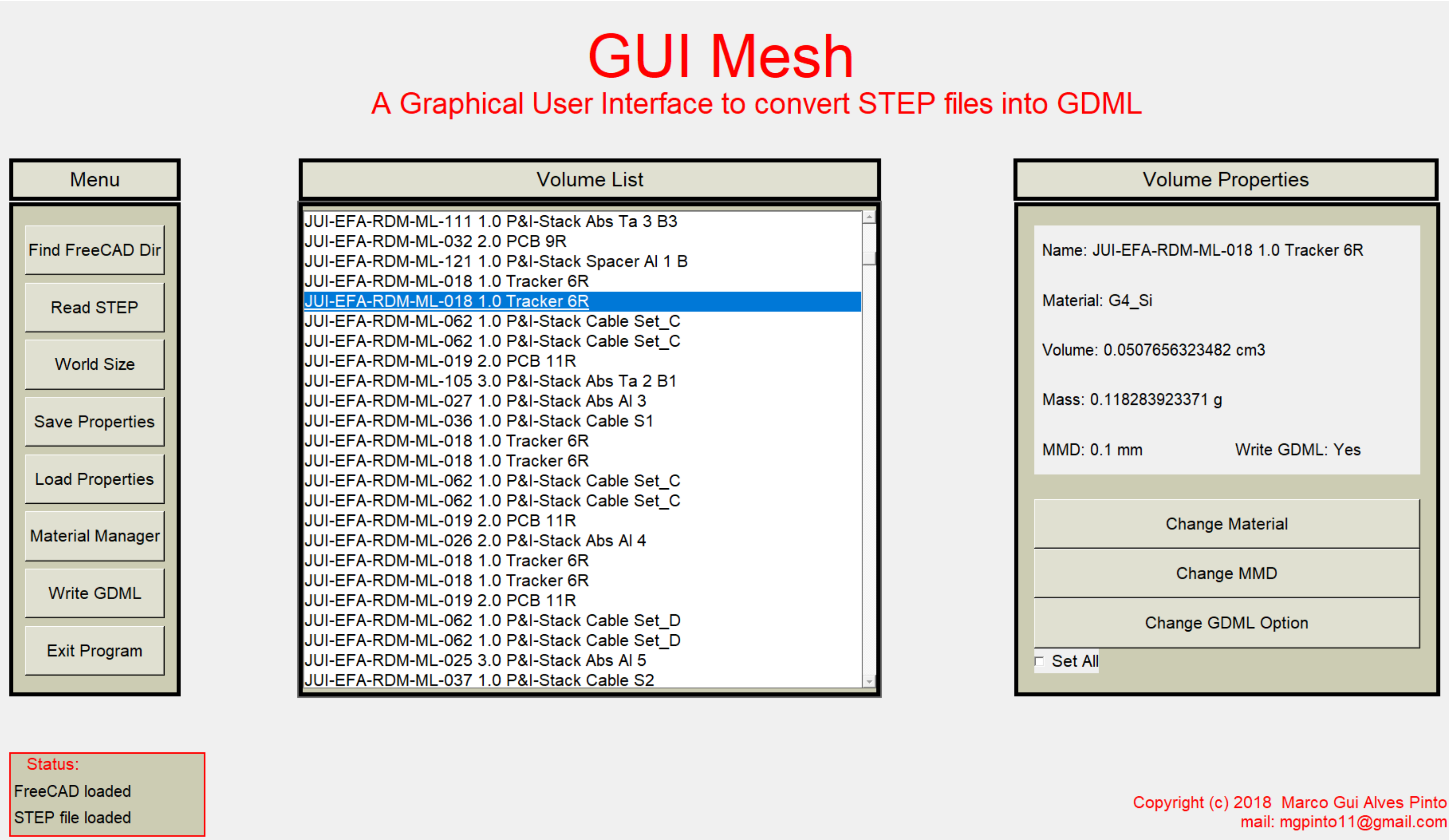
- ❑ Mesh quality depends on three parameters:
  - Maximum Mesh Deviation, MMD – Sag
  - Maximum Angle between edges, θ
  - Maximum edge length, l

- ❑ GUIMesh uses FreeCAD standard algorithm:
  - MMD=user option (0.1 mm default)
  - $\theta=45^{o}$
  - $l=\infty$



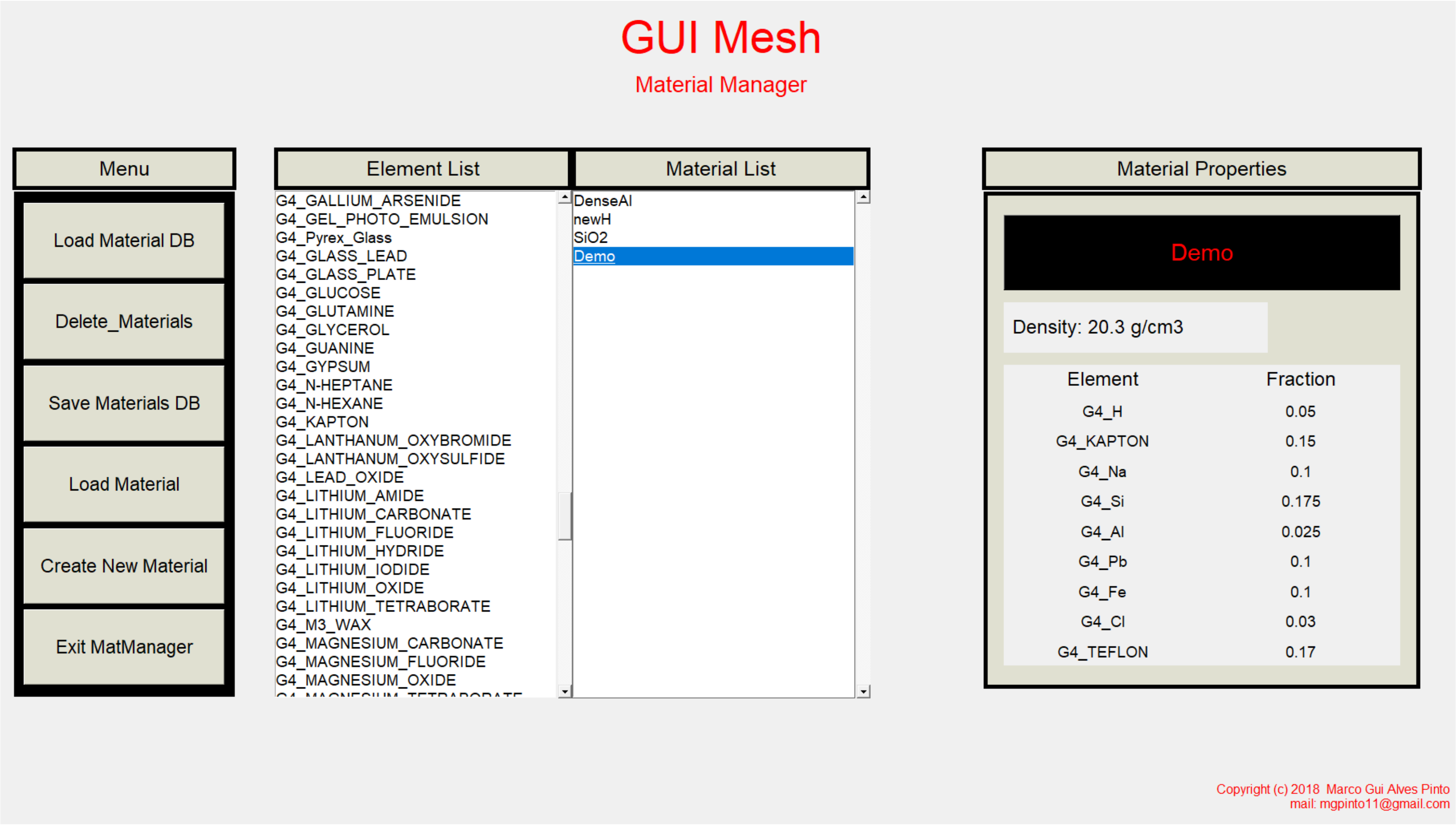
(M. Pinto et al, DOI: https://doi.org/10.1016/j.cpc.2019.01.024)

GUIMesh – User Interface (1)



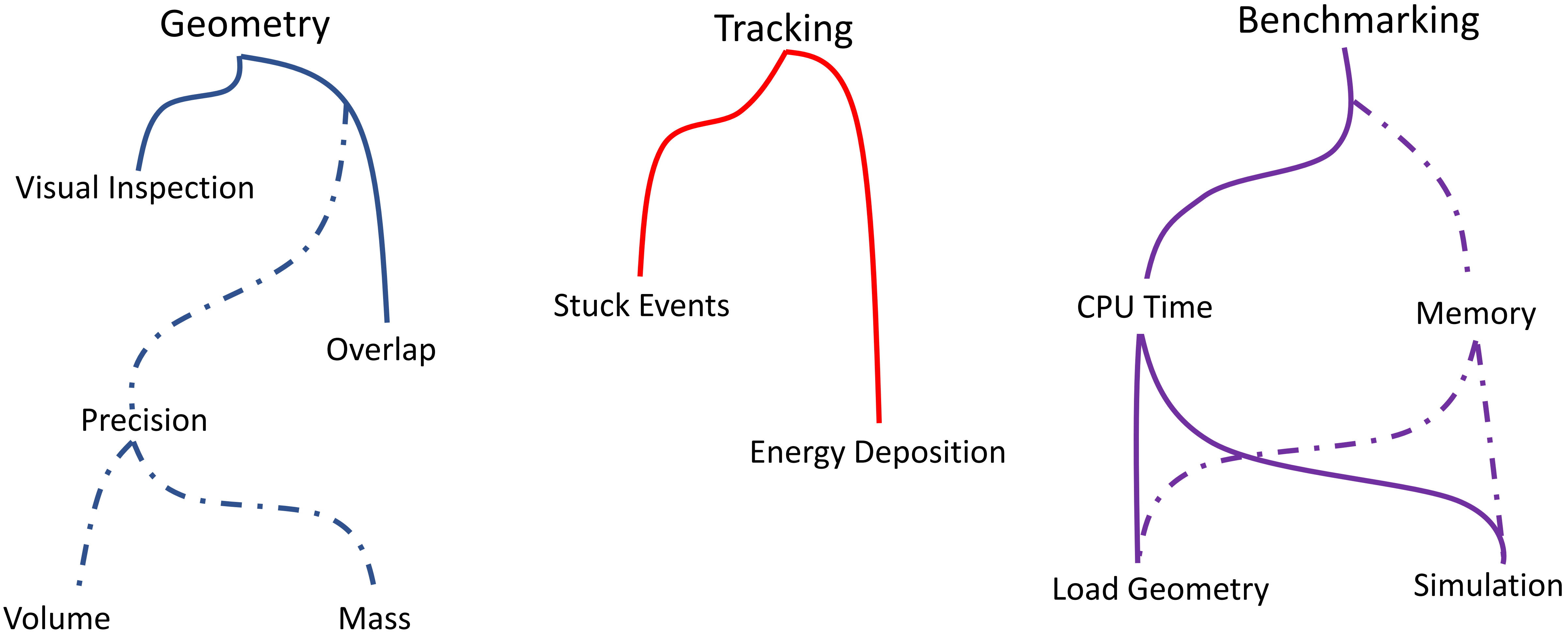
(M. Pinto et al, DOI: https://doi.org/10.1016/j.cpc.2019.01.024)

GUIMesh – User Interface (2)



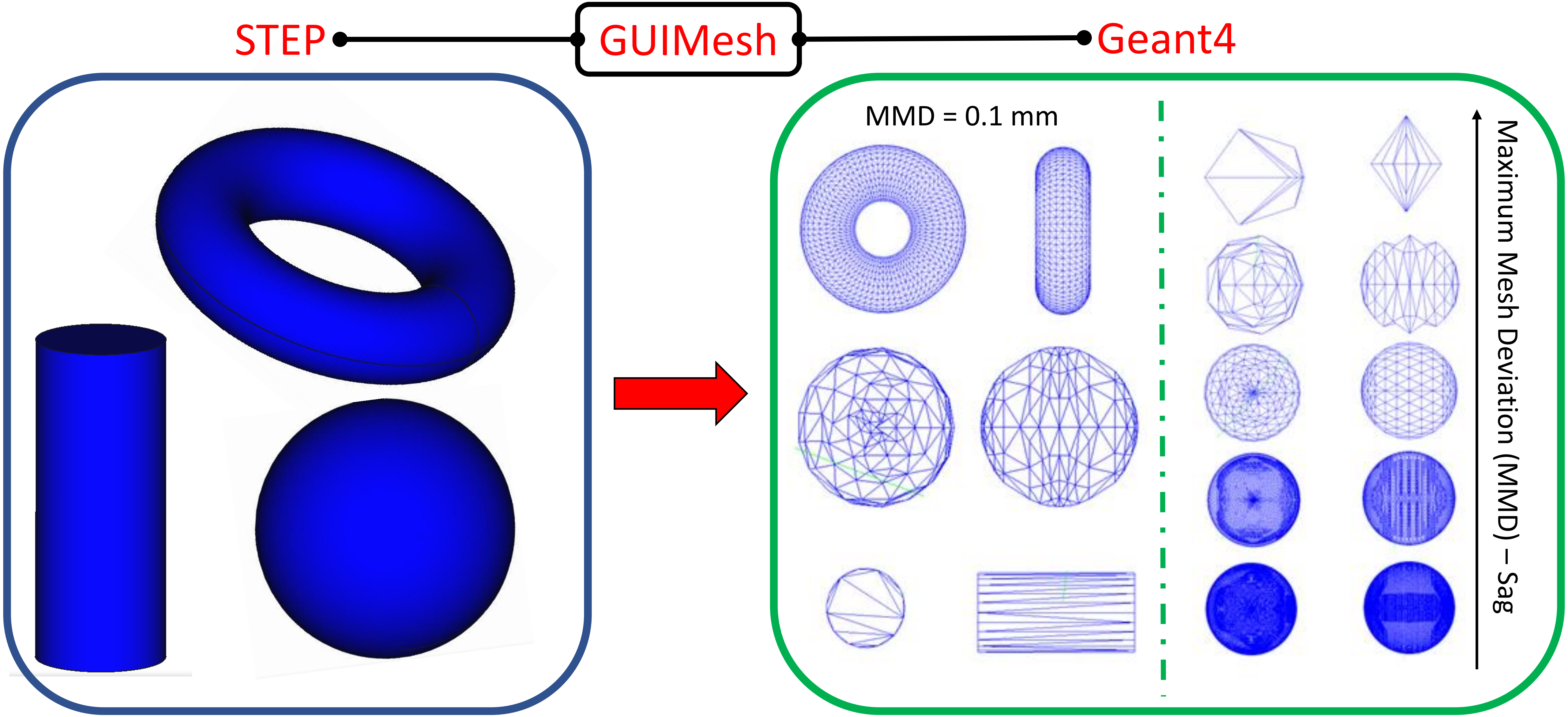
(M. Pinto et al, DOI: https://doi.org/10.1016/j.cpc.2019.01.024)

Validation



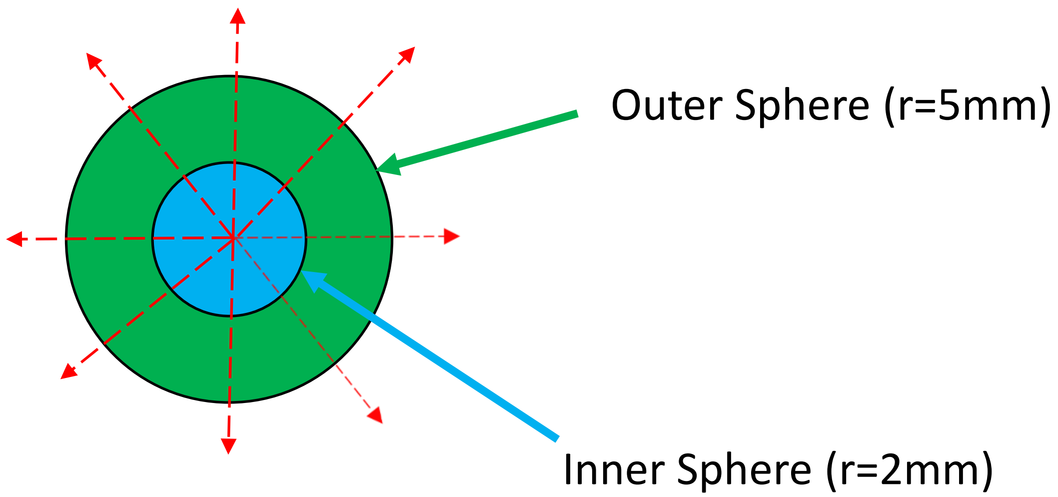
Tests done with: Geant4.10.01.p02

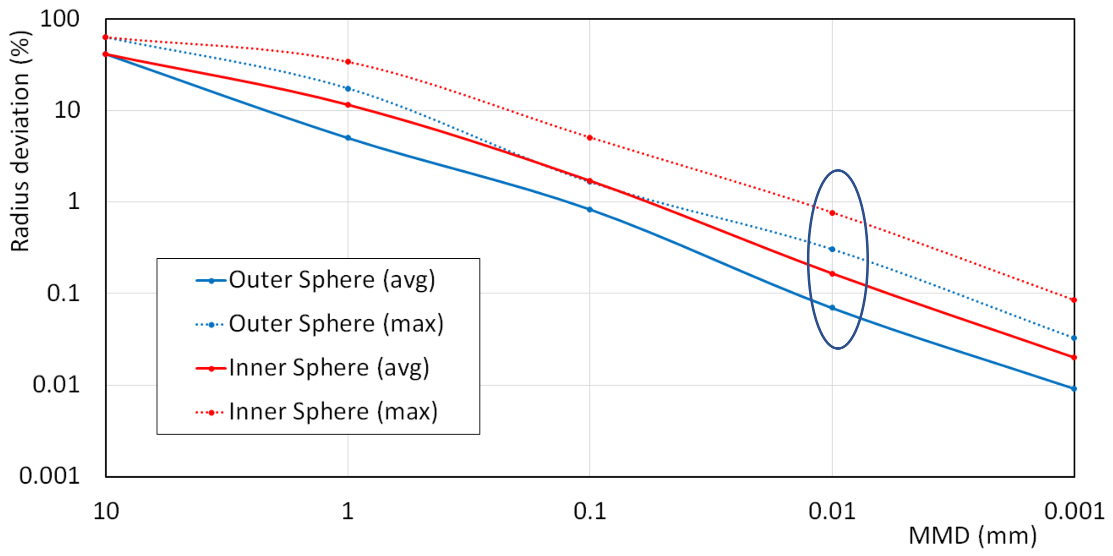
Validation – Geometry

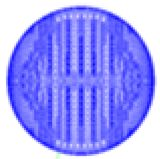


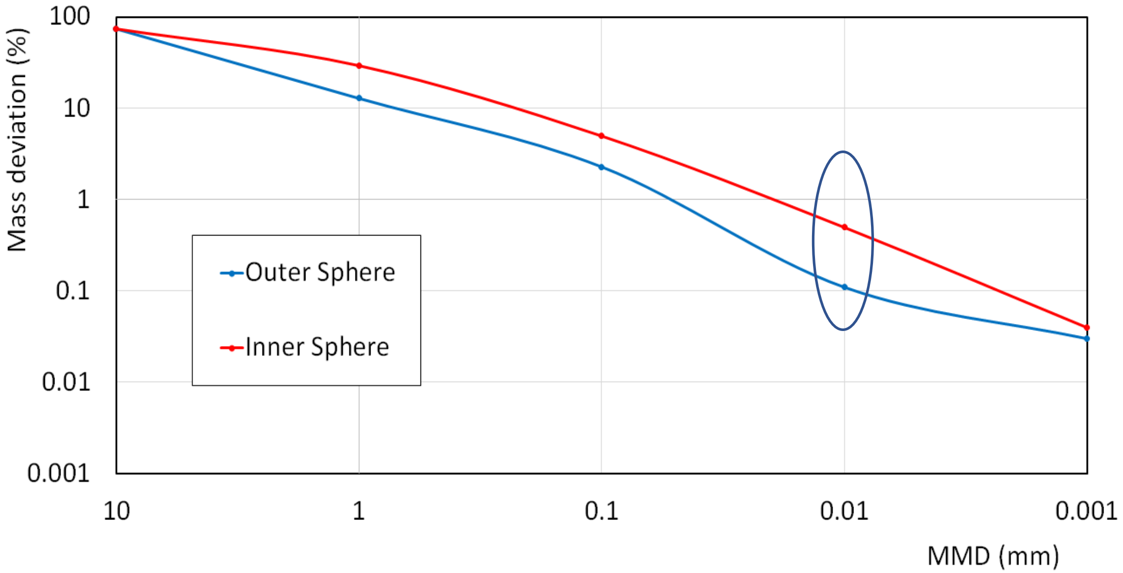
Validation – Geometry Precision

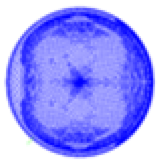
Tests done on a Sphere System with geantinos:









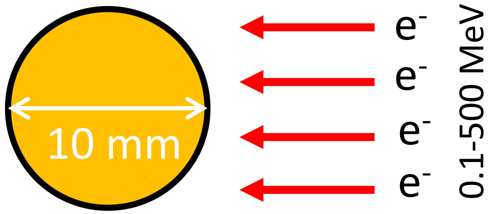


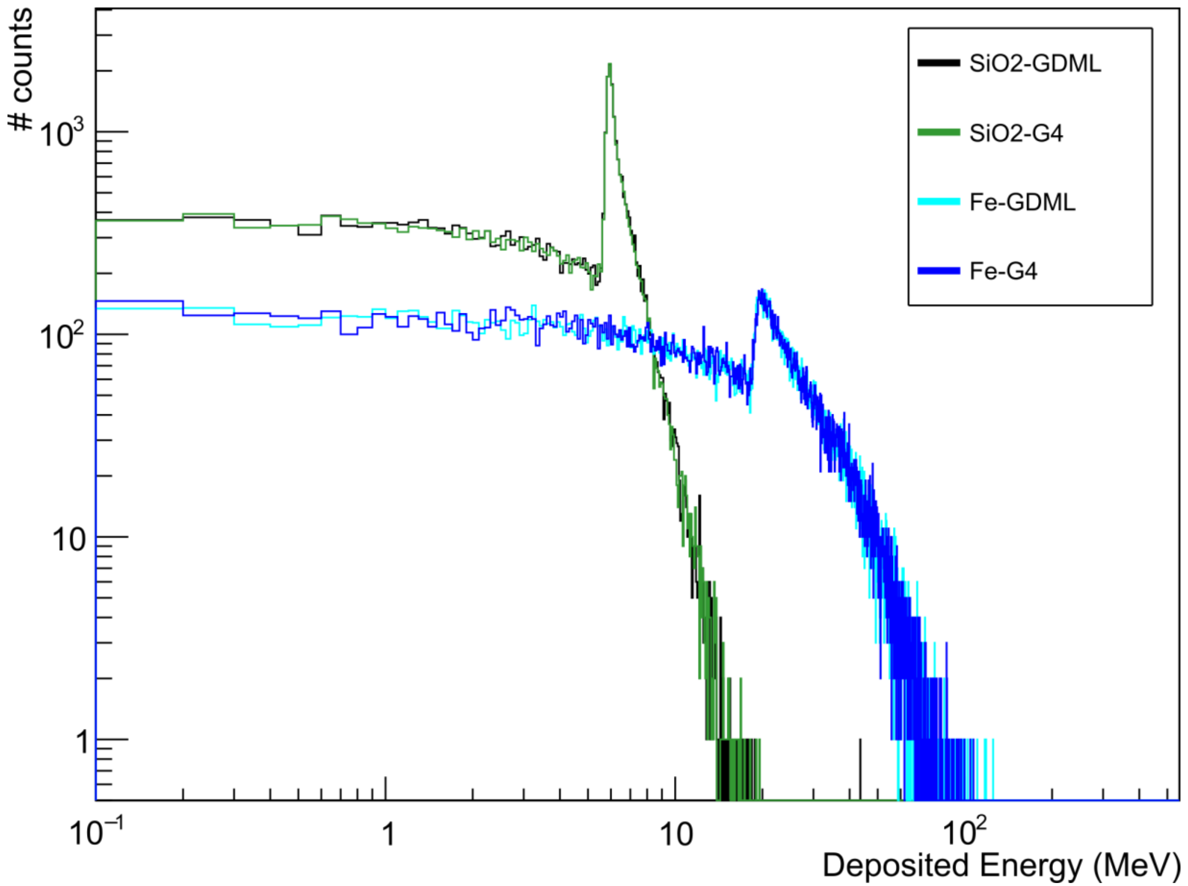
- No Overlaps!
- Size and mass are always lower
- Precision is a function of MMD and volume size
- # stuck events <0.1% all cases

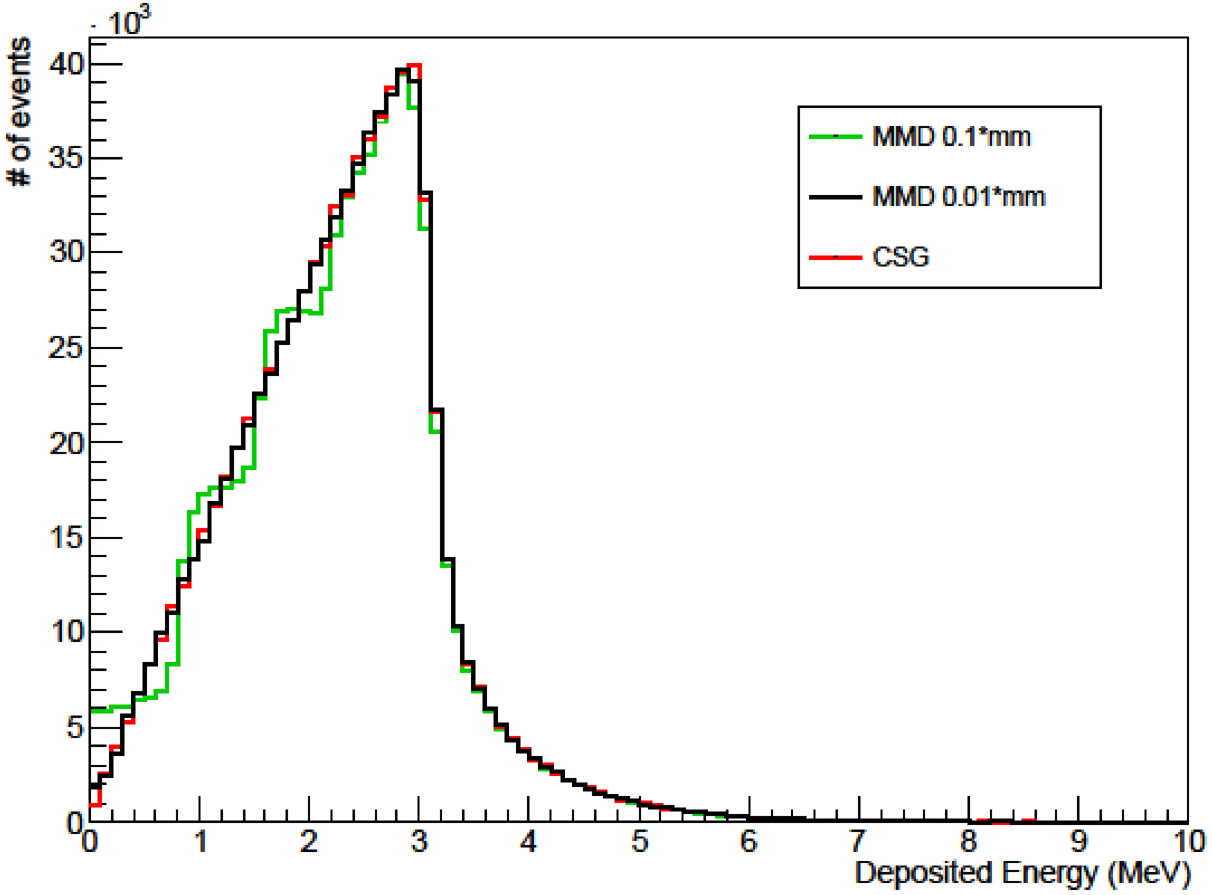
Validation – Tracking

Material well implemented - GUIMesh and G4 implementations equivalent

Deposited energy distribution depends on geometry precision - Average values are equivalent



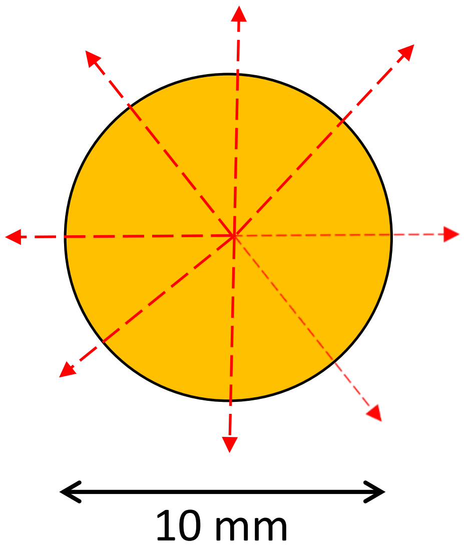


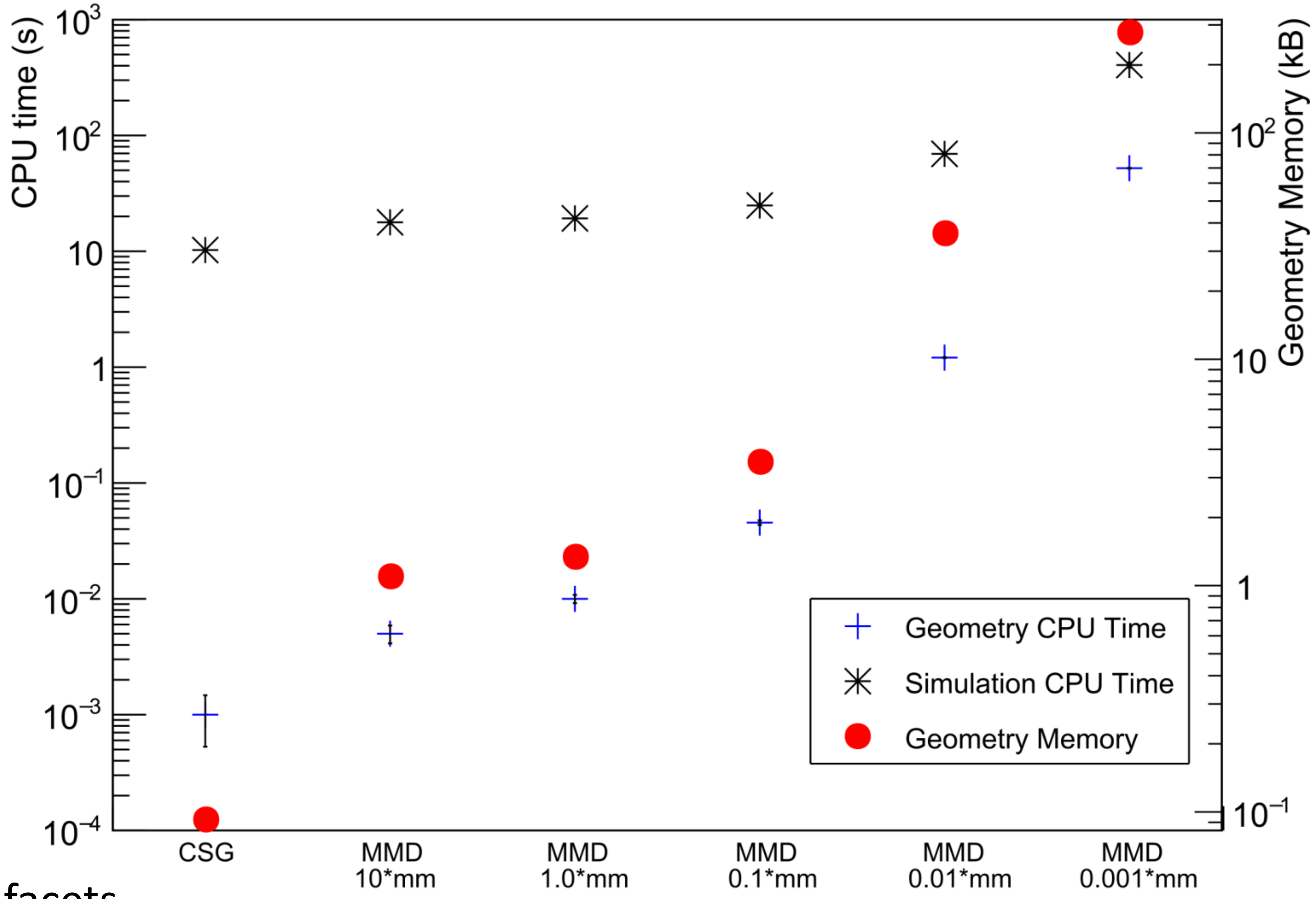


Benchmarking

Computing time and memory usage are critical:

- A mesh can contains a lot of triangles
- Navigation computing time is high





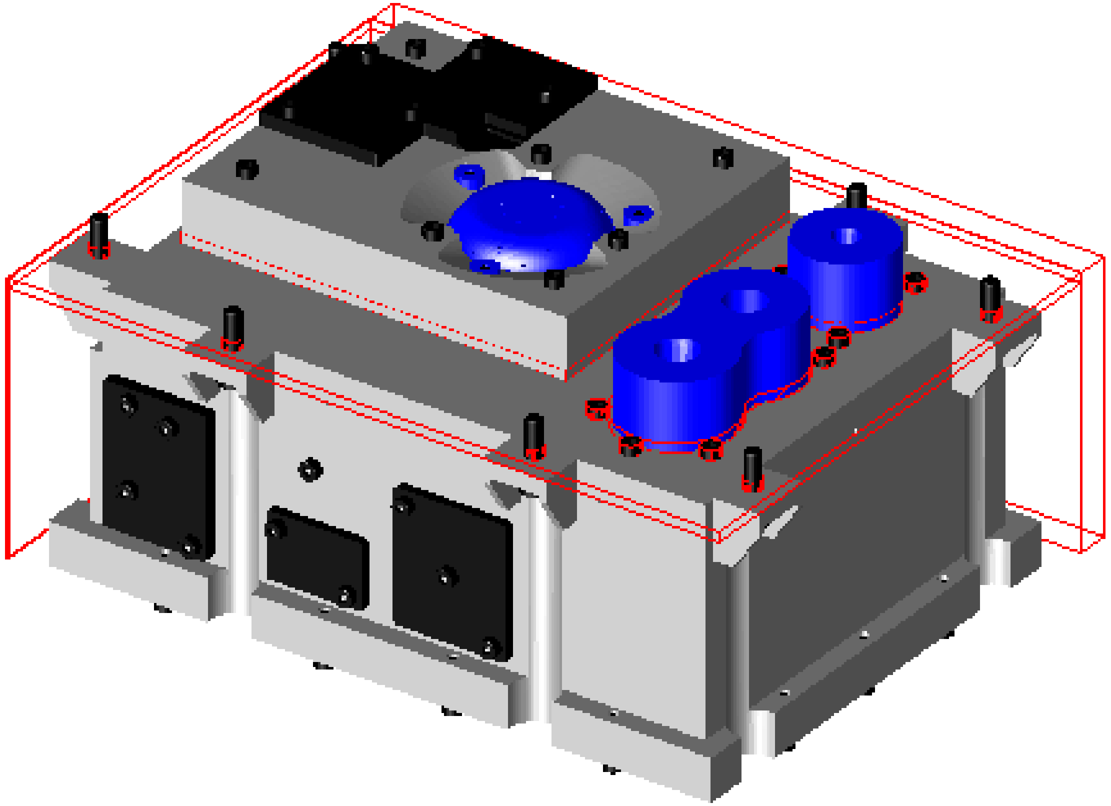
- Tested with 10E+5 geantinos
- Navigation and memory usages

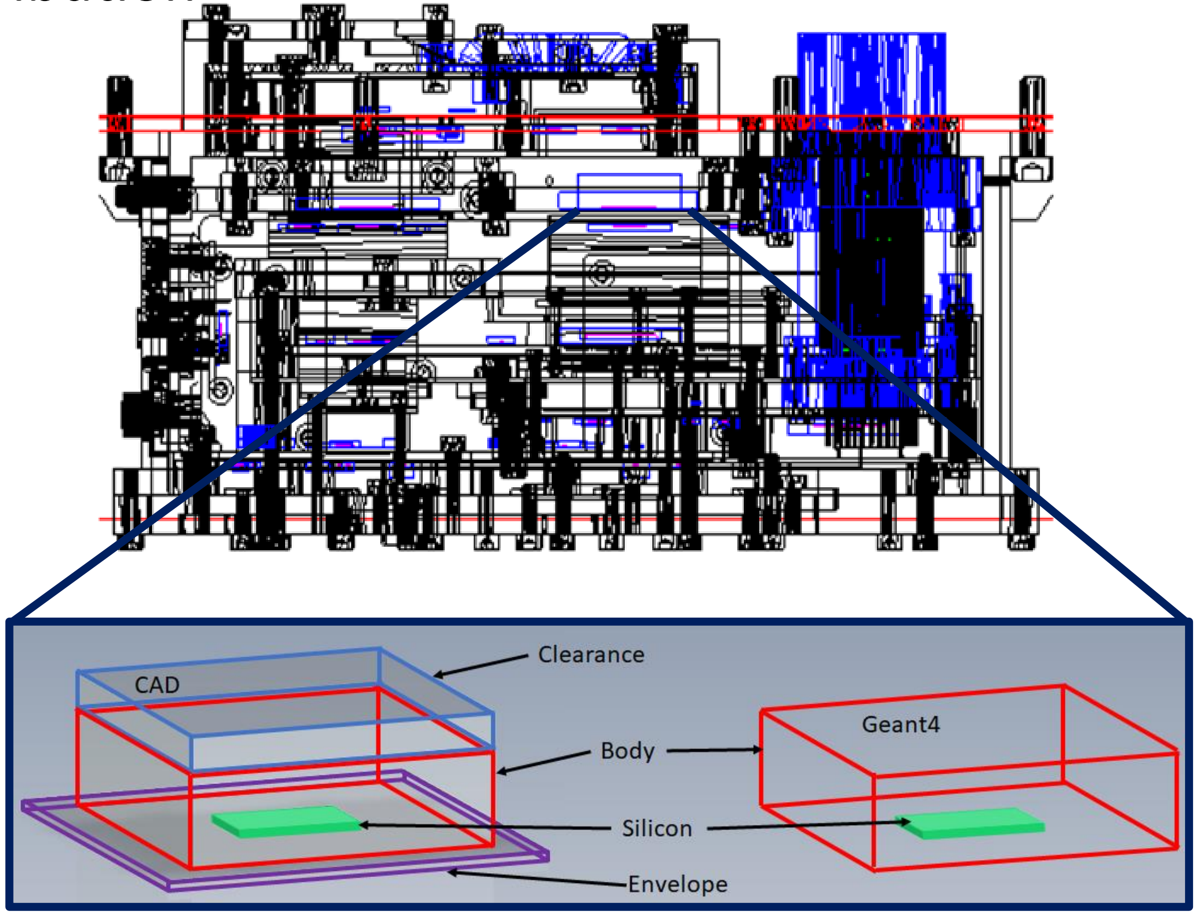
Increase exponentially – with the number of facets

Use Cases – RADEM

RADEM – Radiation Hard Electron Monitor for the ESA JUICE mission

- Radiation Analysis – Total Ionizing Dose (TID) and fluence
- Detector response – energy and angular distribution





Use Cases – RADEM

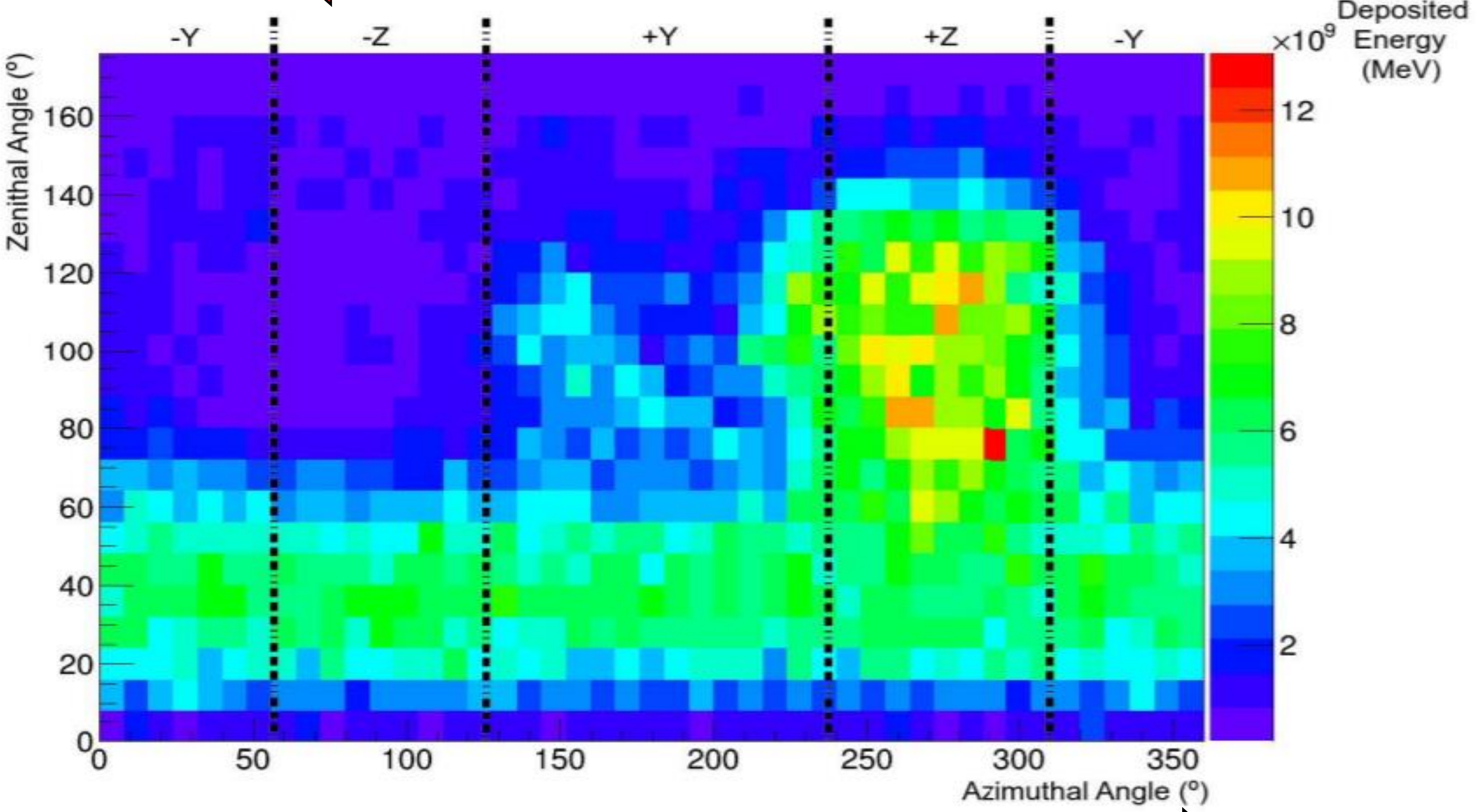
TID angular distribution

129 SVs

Iterative Process

Detail Is key!

Multiple conversions



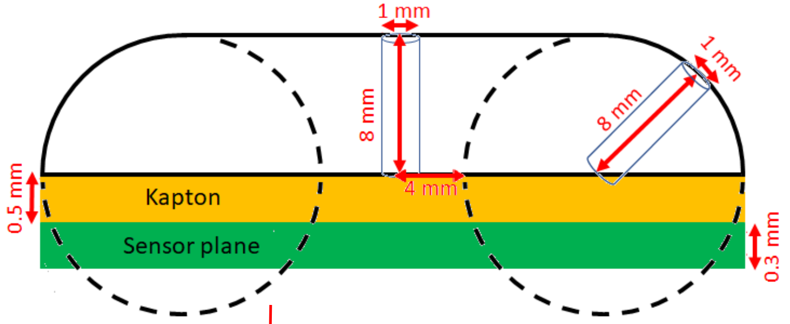
Shielding decisions

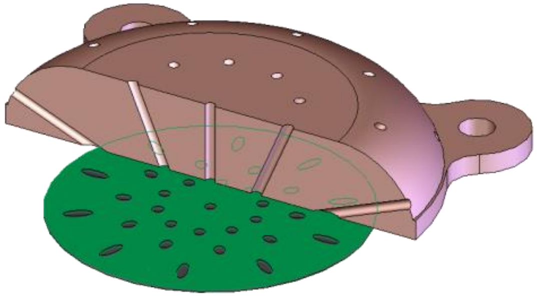
Use Cases – RADEM

New concept

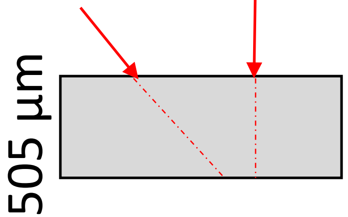
(M. Pinto et al, DOI: 10.1109/TNS.2019.2900398)

Copper Collimator
- ❑ 28 holes (directions)
- ▪ Diameter: 1mm
- ▪ Length: 8mm



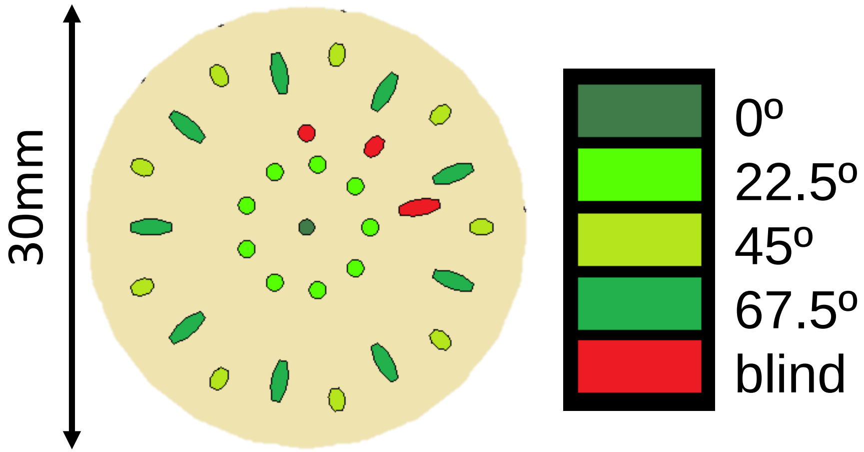


Single 505 µm Kapton absorber
- ❑ Different energy thresholds



Zenith Angle	0 deg	22.5 deg	45 deg	67.5 deg
Electrons	0.3 MeV	0.3 MeV	0.35 MeV	0.5 MeV
Protons	7 MeV	7 MeV	8.5 MeV	12.5 MeV

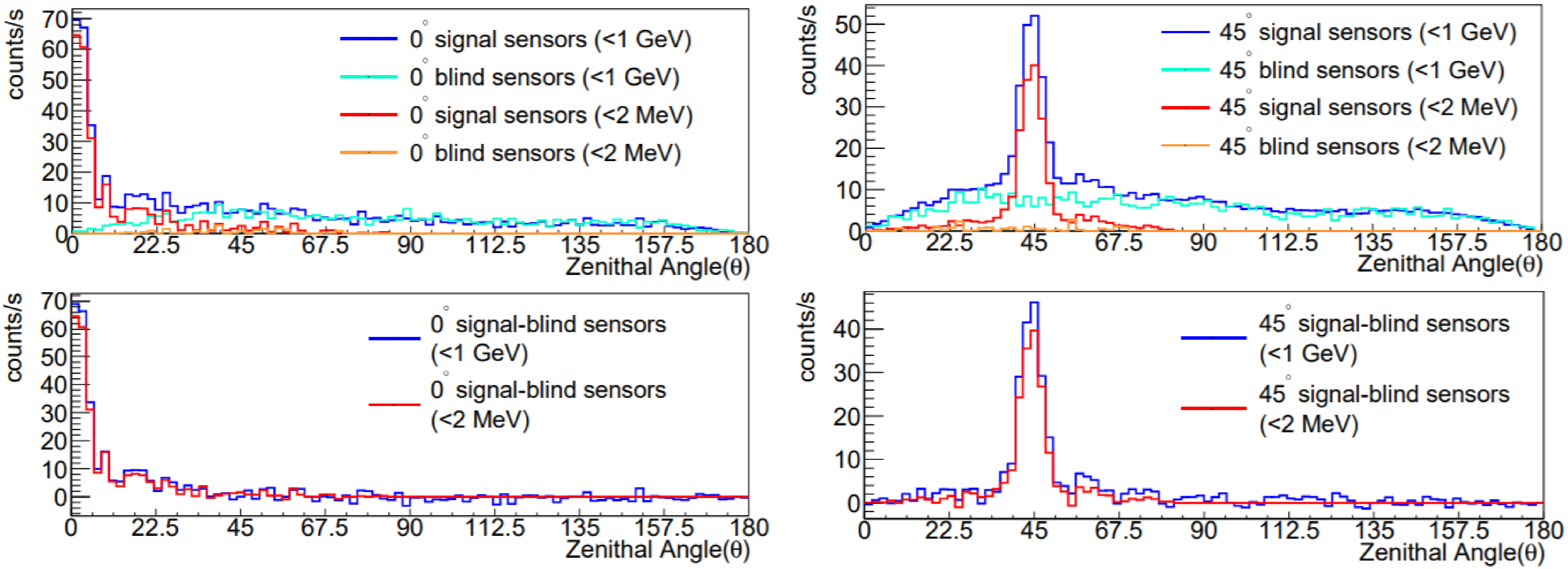
Detection Plane (instrumented PIN diode):
- ❑ 31 Silicon sensors (300 µm thick)
- ▪ 4 zenithal directions
- ▪ 9 azimuthal directions
- ▪ 3 blind sensors



Use Cases – RADEM

Detector response

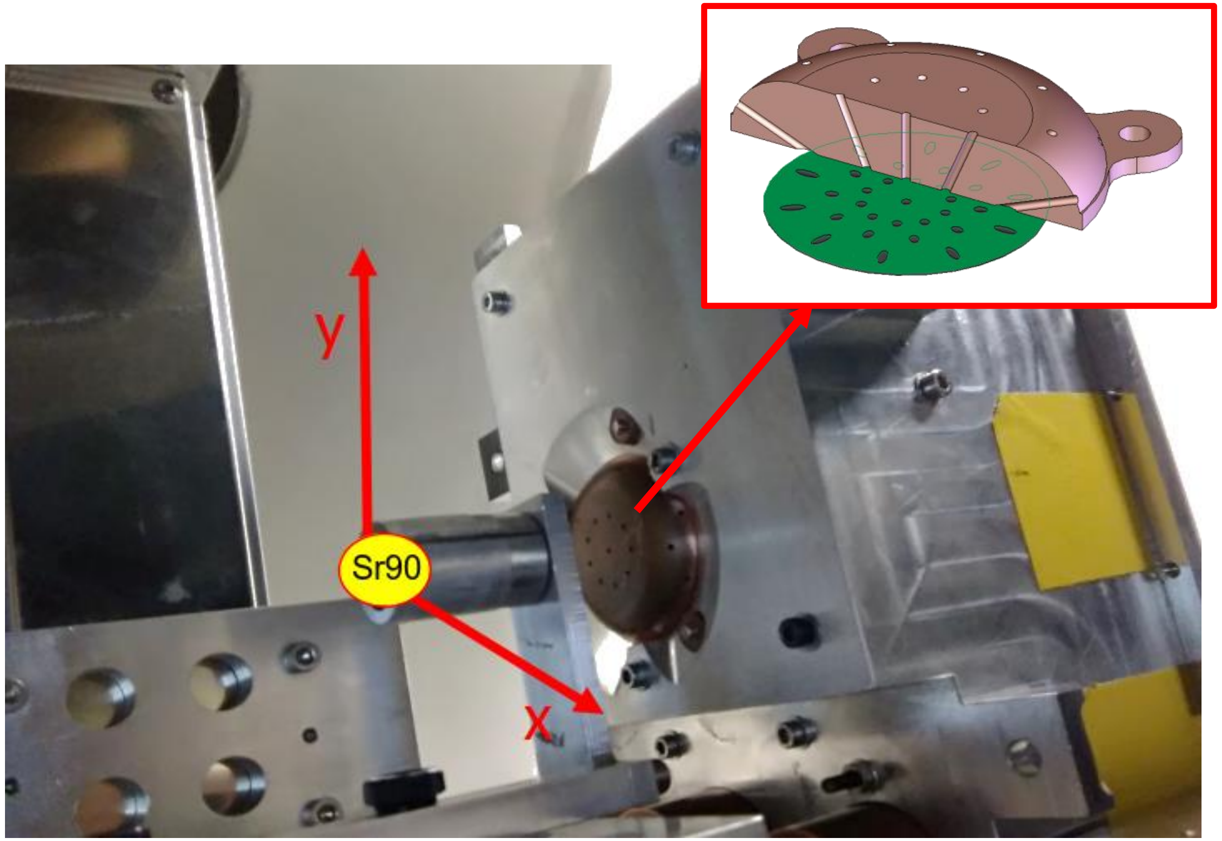
(M. Pinto et al, DOI: 10.1109/TNS.2019.2900398)

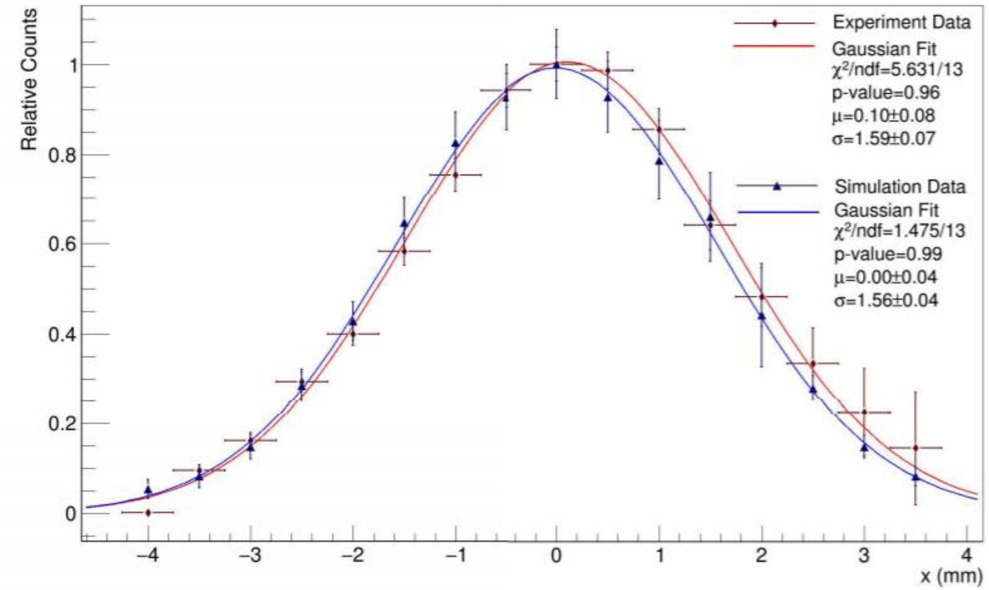


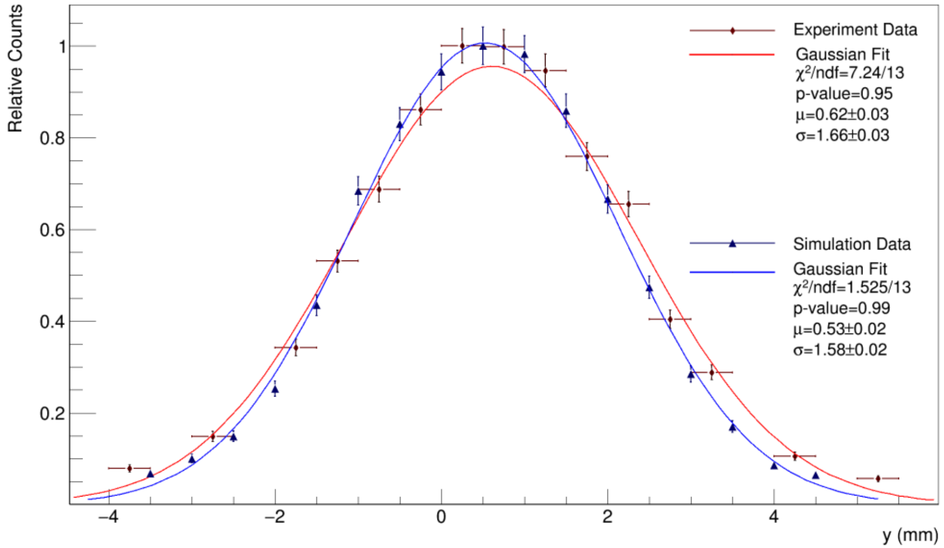
Comparison between simulation and source test

(M. Pinto et al, DOI: [10.1109/TNS.2019.2900398](https://doi.org/10.1109/TNS.2019.2900398))

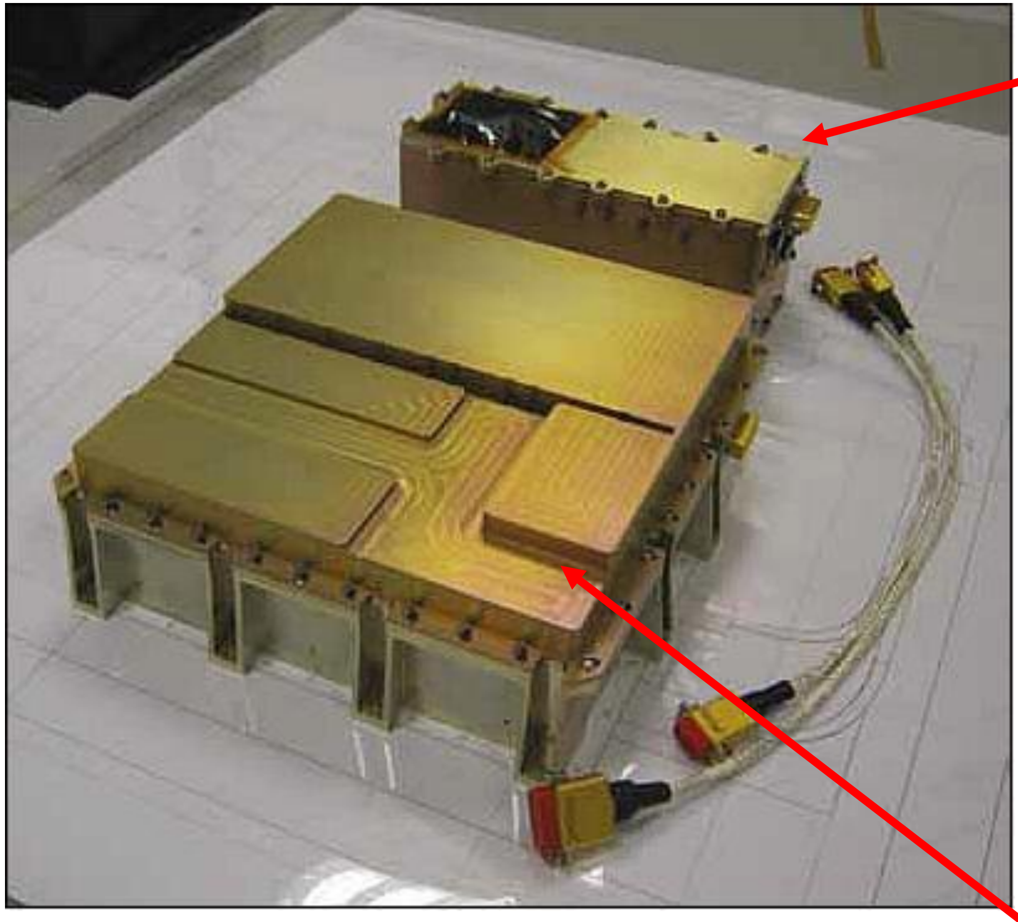
Directionality Detector





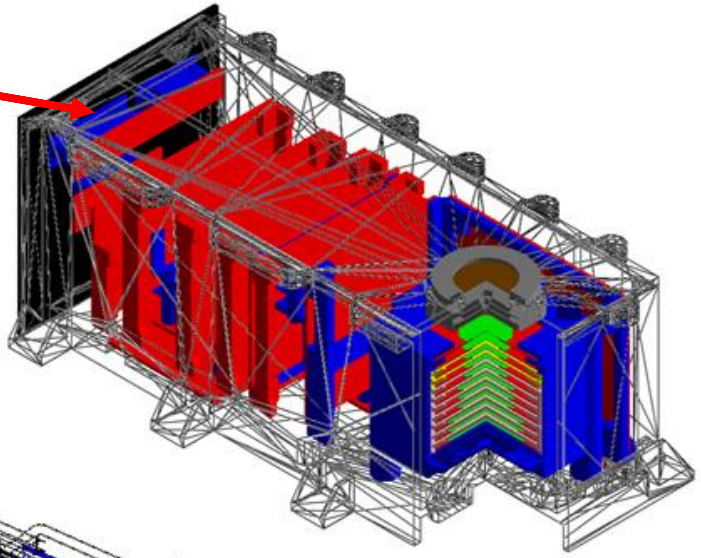


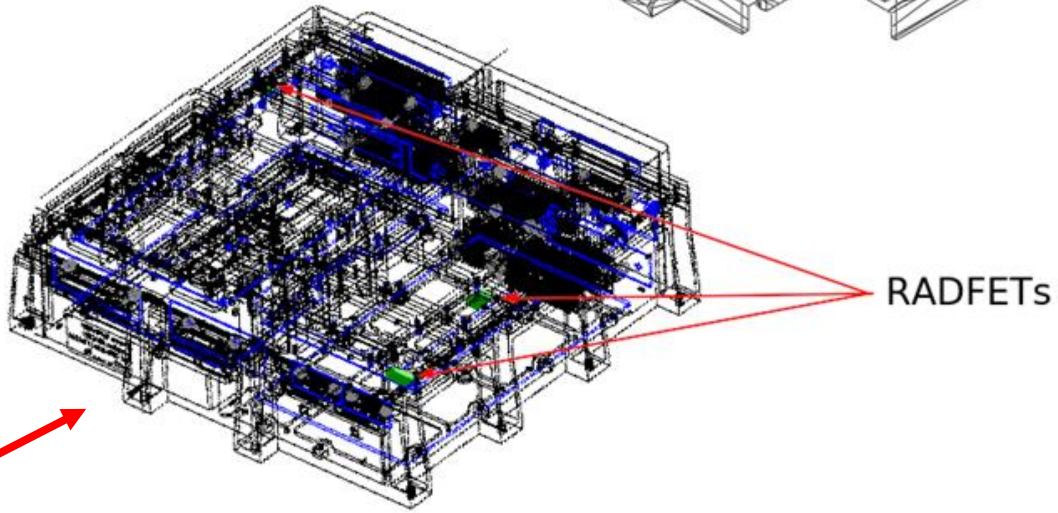
Use Cases – AEEF-TDP8



MFS

Response function

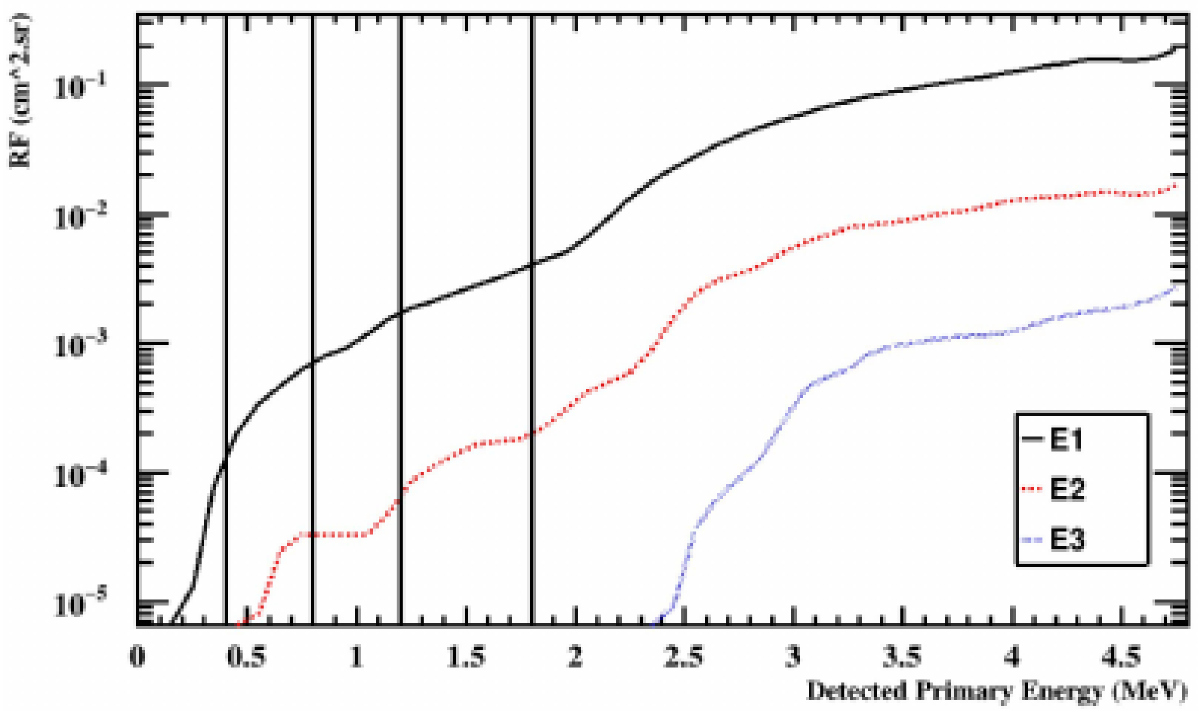




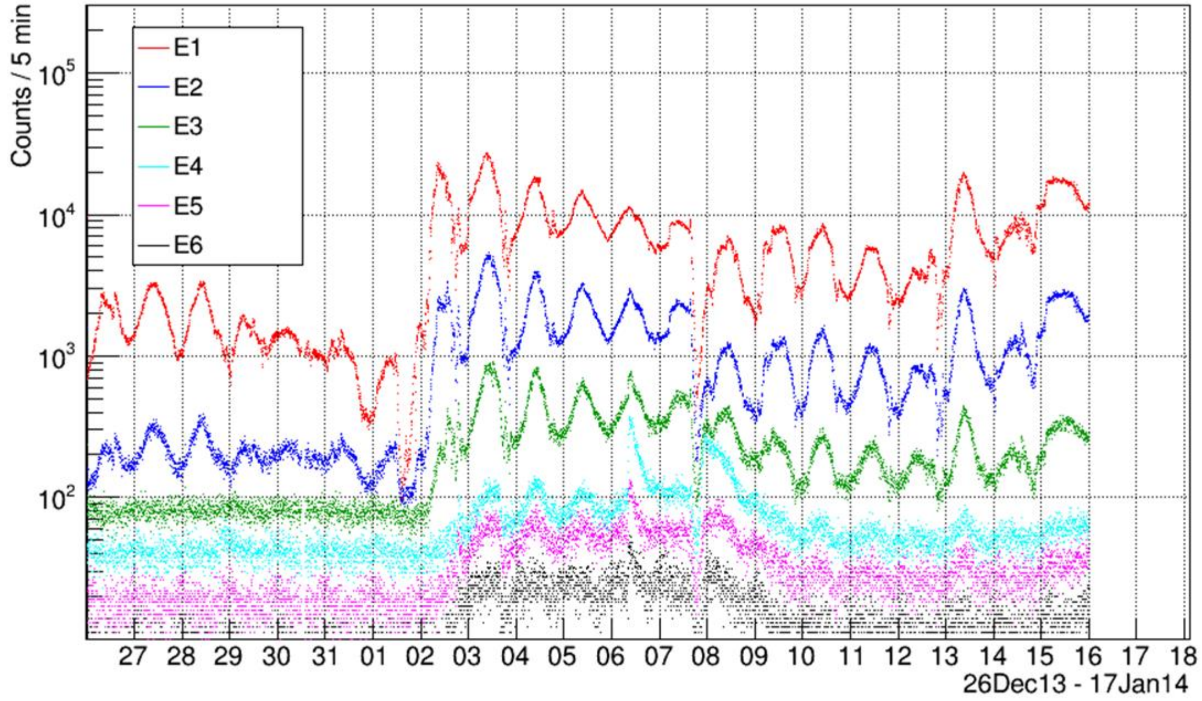
TID

CTTB

MFS Response function



MFS Electron counts – SEP event 01/2014



Conclusions

- ❑ Fully open-source and generic tool developed
  - https://github.com/MPintoSpace/GUIMesh
  - https://doi.org/10.1016/j.cpc.2019.01.024

- ❑ Very very easy to install and use

- ❑ Leverages on the mesh format
  - Effect on computation studied
  - Computing time higher for higher detail

- ❑ Detail and materials customable

- ❑ Application extends to other relevant fields
  - High Energy Physics
  - Nuclear Physics
  - Medical Physics

Python 3 port – still needs testing

Future Work

Wrapper
- ❑ FreeCAD
  - Full integration
  - Plugin
- ❑ Open Cascade
- ❑ Internet application

Conversion
- ❑ Basic Shapes
- ❑ New conversion algorithms
  - Tessellation
  - Voxelization

Optimization

Functionality
- ❑ Pre-visualization
- ❑ Smart shape transformation
- ❑ Ray-tracing – sectoring analysis

Tracking
- ❑ Faster navigation