



BEAMDE MADETS

MRADSIM SOFTWARE

Behcet Alpat, **Giovanni Bartolini** IV Geant4 International User Conference, 26 October 2022



MRADSIM DEVELOPMENT TEAM

The idea comes from INFN senior resercher Behcet Alpat after his experience with the AMS experiment. The intention is to create a user-friendly software to study the effects of radiation on electronic components. For this purpose, the spin-off company of INFN Perugia section BEAMIDE S.r.I. was created, after receiving the national approval of the INFN Tech Transfer section.

The development of the software is carried out by the members of BEAMIDE with Behcet Alpat (INFN) and with the help of a working group from IRADETS company.

The agreement between INFN and BEAMIDE provides that all INFN sections and labs can request and use the software for free for their research activities. A beta version of the software is currently being distributed.





MRADSIM: SOFTWARE STRUCTURE

- Conversion tool: from STEP files (CAD output) to GDML (simulation input)
- Simulation tool: based on Geant4
- Graphic interface: Modern and intuitive, it allows the user to visualize the geometry of his project, easily set the simulation parameters and visualize the plotted results





- Source code developed in C++
- Compilation tool CMake
- GUI developed using Qt5
- 3D engine developed using **OpenCascade**
- Monte Carlo based physics simulator developed using Geant4
- Graphical results representation developed using Qt5

Bilateral agreements with Qt and OpenCascade for licensing & commercialization



MRADSIM has a modern interface. It is not necessary to know any software language for use. It is capable of reliable and extremely fast STEP file viewing and processing. It offers an interactive and modern graphic display system together with detailed result analysis methods. MRADSIM needs these five key inputs to perform the analysis:

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- 1-GEOMETRY
- 2-SOURCE PARTICLE
- 3-ANALYSIS PARAMETERS
- 4-PHYSICS DEFINITION
- 5-OTHER

After user define these parameters, calculation start and when finished, the graphical display screen will appear to show the results.





MRADSIM: FEEDBACK FROM THE FREE DEMO

tiles.

A free demo of the conversion software was published to gather initial feedback on the project. It had great success and has already been revised and used by many highquality institutes, such as NASA, Stanford University, ESA, CERN, NCSS-CAST, M.I.T. of Boston, Brookhaven National Lab-BNL, etc.



Conversion of CAD STEP file to GDML file MRADSIM developed by INFN is very promising Developer team is very responsive! Thanks to Wouter and Jan, few issues were identified and reported to the developers. Some of them have already been addressed As a backup solution, a commercial tool is confirmed to work. Thanks Elke and Rolf for sample STEP As a preliminary measurement. navigating through tessellated solids is ~5 times slower than simple CSGs - With physics interactions, difference should be much smaller. - Further study is required with The LL LL tuning gra MRADSIM – STEP to GDML Converter



MRADSIM CONVERTER

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(eA)ST Sample GDML for preliminary benchmarking

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			SLA
File	CSG (hand-written)	Tessellated solids (Commercial converter)	Tessellated solids (MRADSIM converter)
File size	2,423 Byte	2,575,524 Byte	3,427,771 Byte
200,000 geantino's 12 threads			Many warning messages from GDML Parser
Total time (within event loop)	User=9.120000s Real=0.822846s Sys=0.060000s [Cpu=1115.6%]	User=44.090000s Real=3.821735s Sys=0.120000s [Cpu=1156.8%]	User=47.060000s Real=4.059320s Sys=0.110000s [Cpu=1162.0%]
Total memory	120 MB	107 MB	122 MB

SLAC

Development of CAD Interface to Detector Simulation M. Asai (SLAC), J. Bernauer (Stony Brook), W. Deconinck (Manitoba)

- (eA)ST Conversion of CAD STEP file to GDML file
- We need to develop an automated way to convert CAD file to GDML.
- CAD file format : STEP (STL, PLY)
 - Available for most, if not all, of CAD tools used for EIC accelerator design studies
- STEP to GDML conversion tool
 - Most promising : MRADSIM
 - <u>http://mc-infn.lns.infn.it/?action=Geant4/MRADSIM_Converter</u>
 - New free tool developed by INFN Perugia. Need evaluation.
 - Alternative : CADMesh
 - Converting one solid at a time known volume overlap issue if two solids are touching to each other with their curved surfaces.
 - There are some commercial tools to evaluate as a backup
- Is tessellation good enough?? Or, too good???
 - NURBS can be converted to Tessellated solid. If tessellated solid is good enough, we want to avoid using NURBS in simulation geometry.
 - NURBS is more accurate, but harder to deal with.
 - Not fully convertible to GDML. Manual conversion to some Geant4-native solids, including Extruded solid, may be required.
 - Granularity of facets may need to be optimized.

LAC

Development of CAD Interface to Detector Simulation M. Asai (SLAC), J. Bernauer (Stony Brook), W. Deconinck (Manitoba)

- ST Conversion of CAD STEP file to GDML file
- MRADSIM is very promising
 - Developer team is very responsive!
 - Few issues identified and reported to the developers. Some of them have already been addressed.
- As a backup solution, a commercial tool is confirmed.
- Thanks, Elke, for sample STEP files.
- As a preliminary measurement, navigating tessellated solid is ~5 times slower than simple CSGs
 - With physics interactions, difference should be much smaller.
 - Further study is required with tuning granularity of facets.



EIC_model.gdml converted by a commercial tool and simulated by Geant4-based application



Development of CAD Interface to Detector Simulation M. Asai (SLAC), J. Bernauer (Stony Brook), W. Deconinck (Manitoba) si ac

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FUNDINGS AND PROJECTS

The MRADSIM Project and BEAMIDE won two specific financing for startups

- Regional funding call SMARTup from Sviluppumbria
- National financing call Smart&Start from Invitalia

Currently under submission: HARVEST project in collaboration with Thales-Space

 Study the effects of HANE (High Altitude Nuclear Explosion) on satellite systems with the help of MRADSIM Software





MRADSIM-EARTH

MRADSIM Project also foresees a specific version of the software for Earth-based applications

- Computing centers, cloud services and remote computing
- Artificial intelligence, virtual reality, quantum computing
- Autonomous machines
- Sustainable energy plants
- Nuclear plants (radiation safety, hazard simulations)
- Medical centers (tools to help radiation safety, preparation of radiotherapeutic plans, in collaboration with Cuttone & Cirrone et al.)
- Research centers and particle accelerators
- Avionics applications
- Biological samples (G4-DNA as a plug-in?)





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WEBSITES

- <u>www.mradsim.com</u>
- <u>www.beamide.com</u>
- <u>www.iradets.com</u>

CONTACTS

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