Open and new requirements

SPACE SCIENCE and ENGINEERING

Giovanni Santin
ESA/ESTEC and RHEA System

Outline:

- Physics
- Usability

25th Geant4 Collaboration Meeting
21-25 Sep 2020

www.esa.int

Neutrons: material data

- Neutron thermal scattering model has XS data only for a few materials, adding more materials (e.g. Si, SiO2) would be extremely useful for neutron induced SEE and for lunar neutron albedo simulations

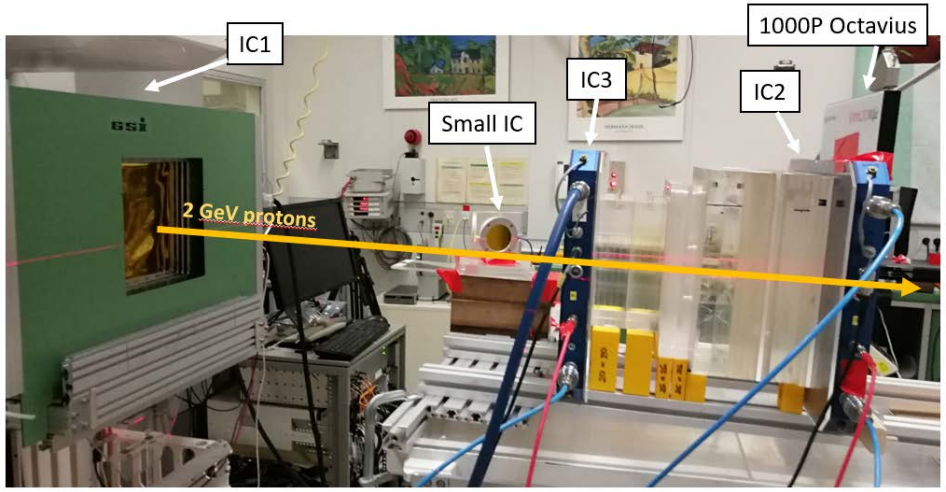
Source: Dávid Lucsányi @Puli Space Tech and CERN R2E

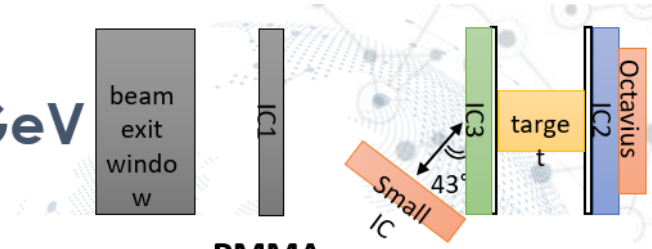
- Extension of thermal neutron scattering to include common propellants

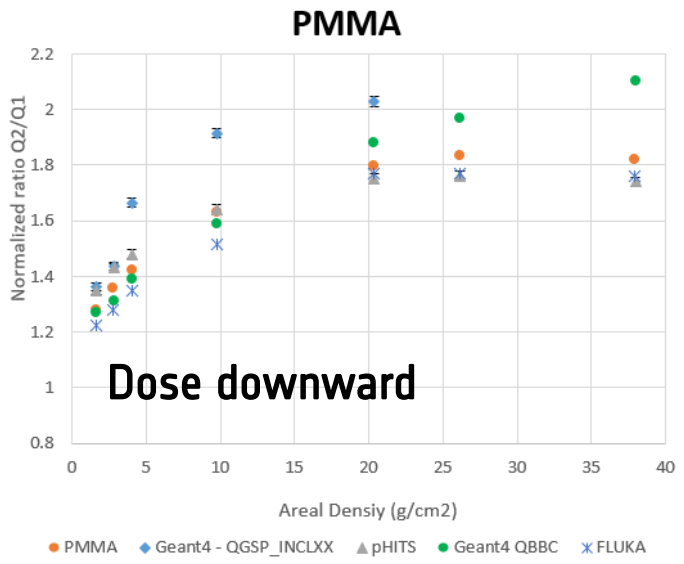
Source: Karl Smith @LANL Space Science and Applications

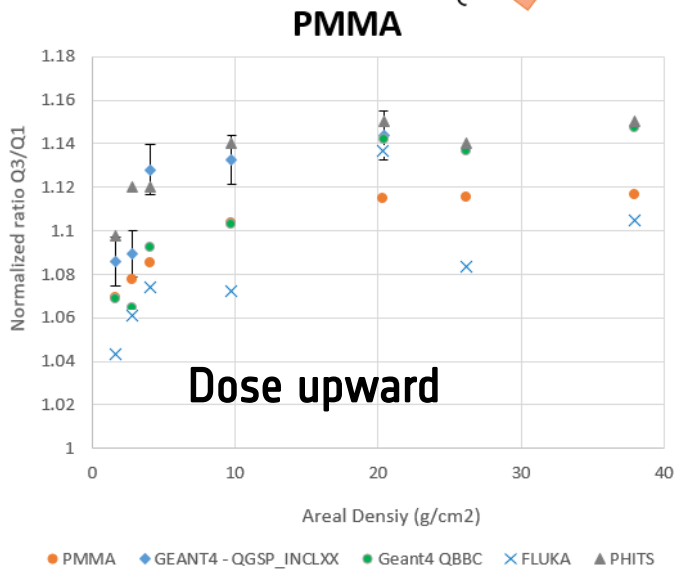
Passive shielding
Proton 2GeV: fragments / evaporation

- 2GeV protons in PMMA @GSI
  - Dose build-up in ICs
  - Problems reproducing data both downstream and upstream
- Knocked out fragments and evaporation being investigated
- Interesting experimental behavior for upstream dose build-up in some materials (not shown here) – could be used for model validation
- Data can be made available





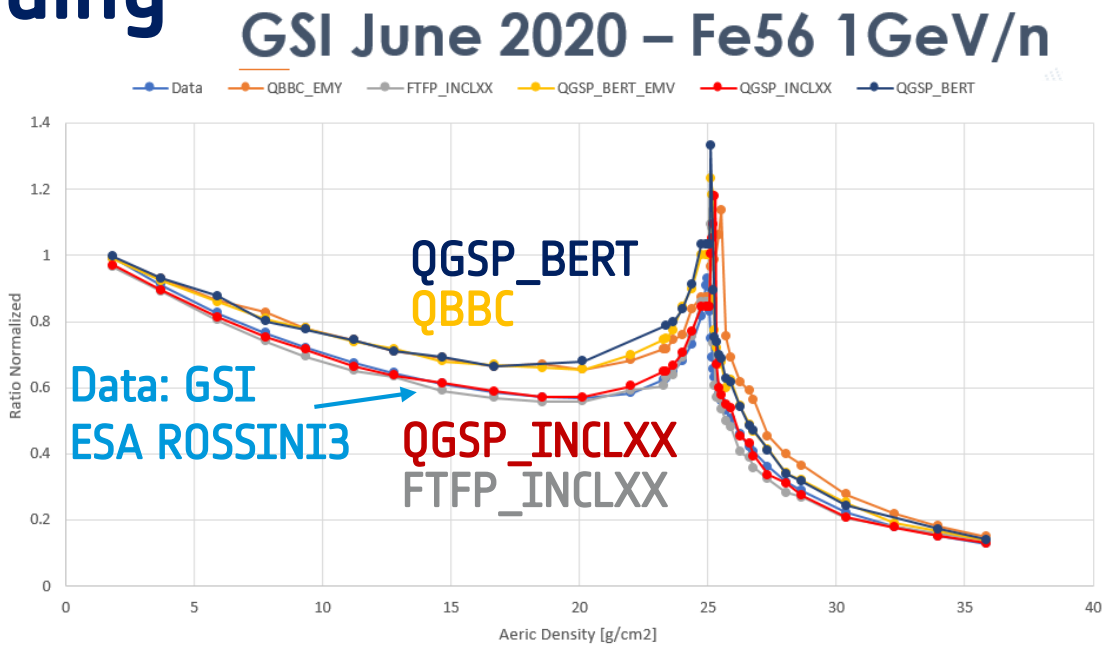




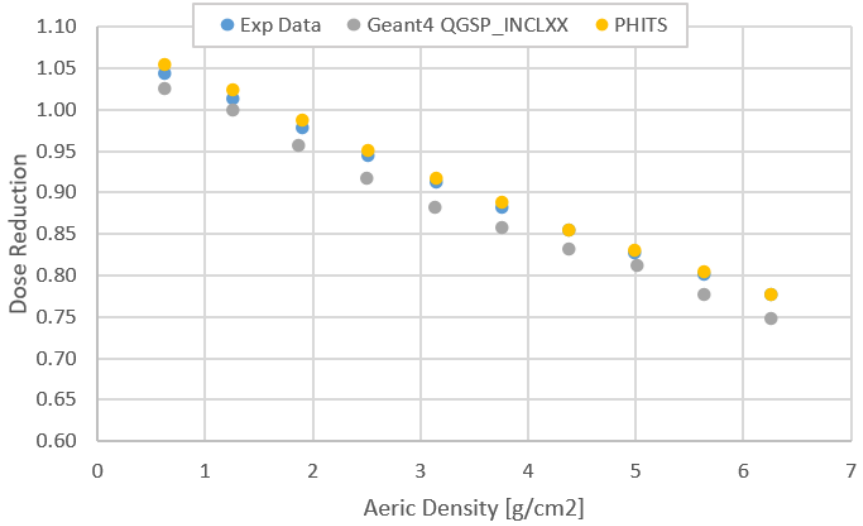
Source: L.Bocchini, M.Giraudo @ TAS-I, U.Weber, F.Luoni @GSI

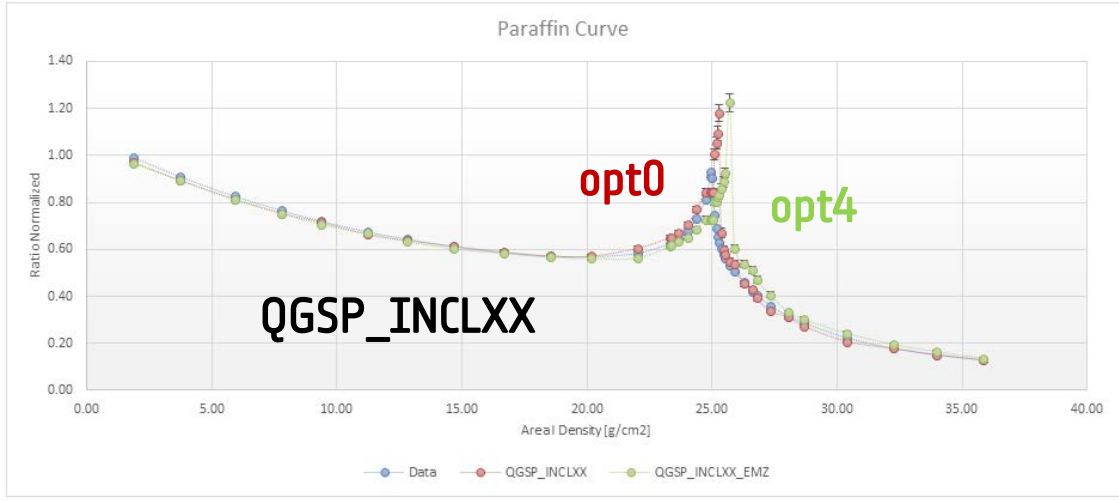
Ion physics
Moon scenarios GCR passive shielding

- HADRONICS: significant differences in XS
  - Reported @G4CM 2015 Fermilab
  - Converged for now on INCLXX (Geant4 10.6 p02)
- EM: opt0/4 behaviour to be understood
- Data can be made available



Advanced shielding material research



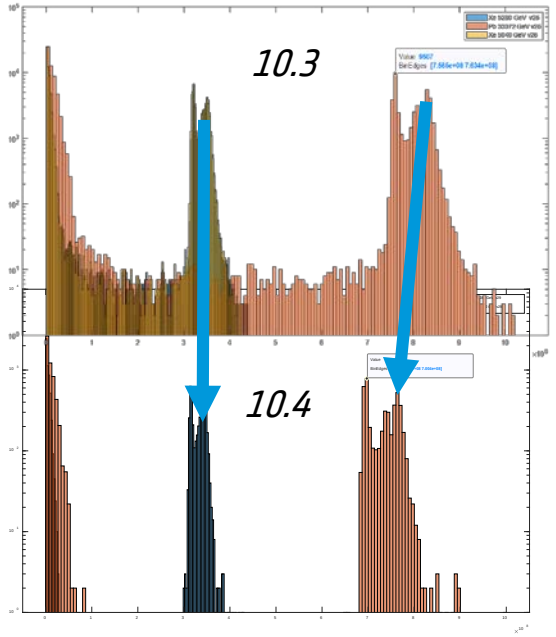


Source: L.Bocchini, M.Giraudo @ Thales Alenia Space Italia

EM: dE/dx of heavy ions at high energies

M.Bagatin et al,
IEEE Trans Nuc Sci
vol 67 no 7, 2020

- Context: SEE test of EEE parts with heavy ions: traditionally at low energy
  - Pros: high LET, easier to obtain (cyclotron)
  - Cons: very limited range (10s-100s um), physics not fully representative of GCR effects
- Energy deposition in Si diode:
  - Pattern correctly reproduced (em peaks, hadronics bkg)
  - Quantitative disagreement on absolute dE/dx
- new G4LindhardSorensenIonModel (A.Bagulya & V.Ivanchenko)
  - Geant4 10.4: noticeable effect, but not yet sufficient



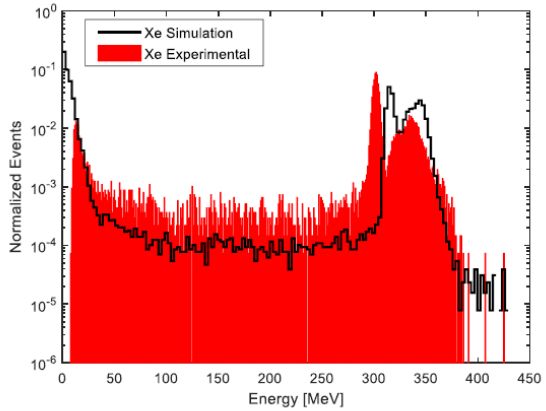


Fig. 7. Simulated energy deposition spectra with 40-GeV/n Xe ions obtained with GRAS, compared with Xe experimental data.

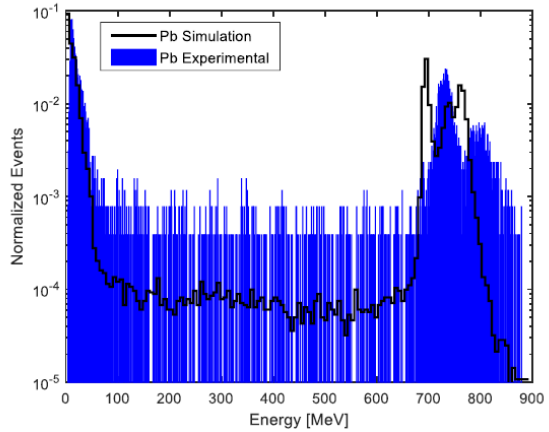


Fig. 8. Simulated energy deposition spectra with 150-GeV/n Pb ions obtained with GRAS, compared with Pb experimental data.

Xe 40 GeV/n, Pb 150 GeV/n @CERN SPS North Area

Source: S.Gerardin, M.Bagatin @DEI UniPd

Usability improvements Docker, Python

Docker

- Officially maintained G4 Docker images for all releases would be also useful for testing and dockerizing G4 applications, I have found this previous attempt (github, dockerhub) for such an official image, but unfortunately it is not maintained anymore

Source: Dávid Lucsányi @Puli Space Tech & CERN R2E

Python

- Expose more features/classes from Geant4 to Geant4Py
- Introduce Geant4Py compile switch to CMake configuration
  - This could make Geant4Py more visible to the users
- Replace Boost-python with Pybind11?
- More pythonic interface: rootpy vs. Pyroot?

Source: Christian Pommranz @ Uni Tübingen

- Lectures on use of Geant4 to be improved
- More documentation on Python I/F

Source: Mourad Elkefhali

Usability improvements GPS, verbosity, output

Phase-space files

- IAEA PS file definition is often too restrictive
- GRASPSTrackModule implements facilities to record PS information to ROOT and FITS files
- Geant4 standard phase-space persistency option?

Source: P.Truscott @Kallisto

GPS: Improvement in internal treatment of user spectrum

- Interpolation, differentiation / integration
- Differences of 30%

Source: Brian Xiaoyu Zhu @JPL

GPS

- Add GCR ions to the General Particle Source (e.g. Badhwar / O'Neill or CREME to easily compute the spectrum at various altitudes / sun activities)
- Function interpolation in GPS. Something along the lines of ROOT's TF1, providing an equation as a string.

Other minor items:

- RootOutputManager: missing branch w/ vector of strings.
- Extensible error severity: flag for this is a warning if interactive, otherwise fatal
- Verbosity manager: difficult to set the verbosity w/ many flags scattered throughout the code.

Source: Karl Smith @LANL Space Science and Applications

Usability improvements Geometry & integrated applications

Several development lines

- EDGE (by Artenum)
  - GDML, STEP, GMSH, STL import/export
  - Geant4/GRAS based simulation
- FASTRAD (by TRAD)
  - GDML, STEP import/export
  - Geant4-based simulation in own framework
- Rsim (by Tech-X)
  - CAD I/F, Geant4 simulation
- CIRSOS (RadMod for ESA)
  - No geometry dev, GDML import
  - Geant4/GRAS based FMC/RMC
- GUIMesh …

- Colours as part of core GDML standard
  - Would facilitate adoption by CAD tools

Source: P.Truscott @Kallisto

- Interesting development for FreeCAD
  - By Keith Sloan et al?
  - Open source
  - General purpose plug-in for GDML
  - Template for Geant4 application
  - Geant4 official support would limit proliferation of efforts
  - Interest @ESA to know if/how we can help

- A lot of interest still in CAD interfaces and CAD editing/simplification
  - Not only in space domain

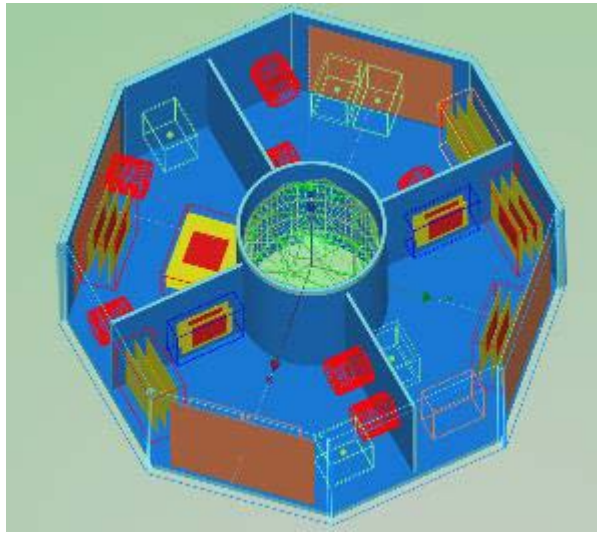
Source: T.Eraerds @MPE, B.Jeanty-Ruart @Artenum, GS@ESA

Reference space scenarios: geometry and source

- Cross-checks and code inter-comparisons
  - Similar published scenarios differ in source details and geometry models
  - Some effort at ESA
    - Geometries: ESA and TAS-I
    - Source: ESA HIERRAS project
  - Could become a simple example, to be used as user repository?

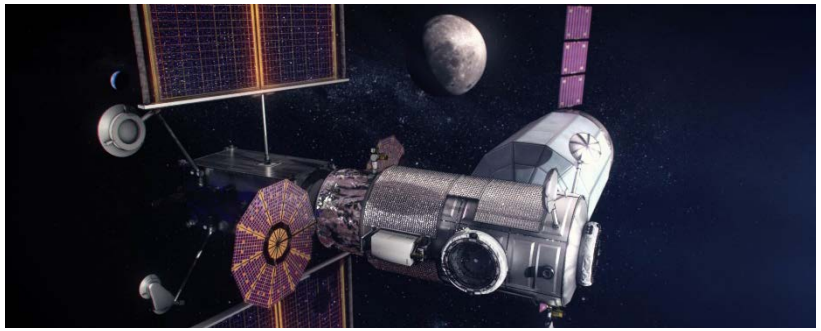
Current

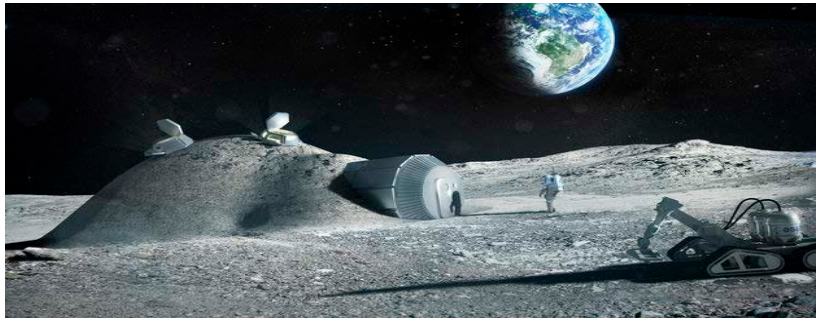
- ESA development
- Can be provided upon request



Ongoing

- ROSSINI 3 @TAS-I
- Simplified but realistic cases
- Coming 2021





Source: GS@ESA

Summary

Physics

- Neutron data
- dE/dx for ions @high energies
- Review of hadronic XS

Usability

- CAD I/F still by far the main requirement – FreeCAD efforts - Collaboration approach?
- GDML colours
- Reference scenarios – geometry models in example
- Python interface improvements
- Geant4 phase-space file standard
- GPS bugs / improvements