Geant4 Collaboration Meeting 2016

USER REQUIREMENTS – SPACE

Giovanni Santin – ESA/ESTEC

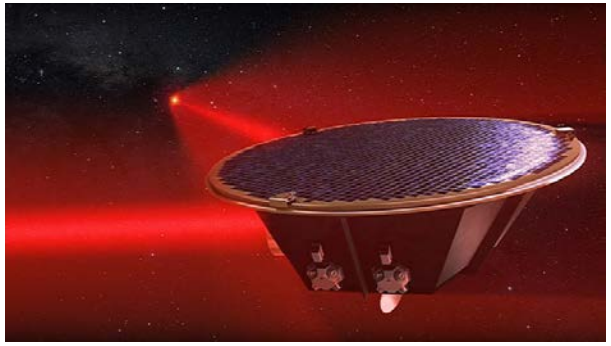
Based also on input from:

Mathias Cyamukungu – Centre for Space Radiation
Fan Lei – RadMod Research
Pete Truscott – Kallisto Consultancy
Christophe Inguimbert – ONERA
Melanie Raine – CEA
Martina Giraudo – Thales Alenia Space Italy
Robert Weller – Vanderbilt University

Ferrara
12 - 16 September 2015

Background for spaceborne experiments

- ESA **Athena** X-ray telescope
  - Proton grazing angle scattering
    - Protons reach sensors through X-ray mirrors open configuration
    - *Earlier: Geant4 implementation of Firsov scattering (F/Lei, P.Truscott, R.Nartallo)*
    - *Ongoing: Review, model dev. and exp. validation (ESA AREMBES, see talk by A. Mantero)*
  - Radioactive decay, atomic de-excitation, PIXE (LD: and hadronics as input)
    - Short and long-term activation and X-ray lines induced by Solar Proton Events, GCRs
    - *RDM: significant effort in past few years, mini-workshop @CERN March 2016*
    - *Ongoing: Update of DB, bug-fixing, transition to MT*
    - *See talk by Dennis on Thu PM, and by Alfonso*
- Proof-mass charging as in **eLISA**
  - Hadronics, electron surface emission
    - *Earlier studies by E.Araujo, A.Howard et al*
    - *Review & Physics dev. funding request at ESA*



(Single Event) Effects in microelectronics (1 / 3)

Robert Weller, Vanderbilt University

1. The **best nuclear reaction physics possible**. Whatever it is, it should be able to at least
   - compute **as accurately as LAQGSM** and
   - be **tested with the same thoroughness** as the results for that program as published both externally and internally in Los Alamos reports

It is absolute critical in my opinion for microelectronics that these reactions, and particularly the **heavy fragments** from these reactions be of as high quality as the state of the part permits.

A lot is going on in hadronics. Still many open issues (see also shielding UR)

Are LAQGSM based simulations in our verification dataset?

2. Better treatment of **low(er) energy electrons at short distances**. As you know we collaborated with Makoto to include the **PENELOPE 2008** that he had from Salvat into mred. I know that there are penelope implementations in Geant4, but the last time I looked at tracks on a scale of a few nm, as is necessary for microelectronics today, **the "real" PENELOPE tracks at least looked physical**. **The Geant4 PENELOPE tracks clearly didn't look physical**

MSC / SS appears as culprit. Add nm scale use-cases in MSC/SS verification plan

(Single Event) Effects in microelectronics (2 / 3)

Christophe Inguimbert, ONERA
Melanie Raine, CEA

- Extensions to secondary emission in **microelec** module.
  - e- emission phenomena at vacuum/material and in general material/material interfaces
  - Quantum **reflections at interface** analogous to optical reflection/refraction process
  - Similarly electrons can **excite surface plasmon** near the surface

- Requirement of better handling of **surface of a volume**
  - Extend surface mechanisms in Geant4 for optical photons to other kind of applications

See talk in parallel session "New EM developments" on Tuesday afternoon

Possibly link to UR for surface effects and e- emission for eLISA, and ATHENA p reflections

(Single Event) Effects in microelectronics (3 / 3)

Experience from the Nanotrack project (ESA funding)

Fan Lei, RadMod Research
Pete Truscott, Kallisto Consultancy

- FL: problems appearing in determining accurate location with tally mesh sizes **< 10 nm** scale

  (we'd need some details, but I'd be glad to discuss this limitation at this meeting)

- FL: apparent discrepancy in the performance in MicroElec physics between the results of Geant4 microelectronics example and that of GRAS

  Ongoing (but interrupted) discussion with Pete/Fan/Vladimir

- PT: MuElec seems to run extremely **slow** compared with standard DNA EM physics. Also, thus far, MuElec **only treats Si**, and I think Au is promised. I think once the above issues have been addressed, the extension to other materials would be valuable.

(Single Event) Effects in microelectronics (4 / 3)

Fan Lei, RadMod Research
Pete Truscott, Kallisto Consultancy

- Hadron physics: **low energy ion-ion** models (**<50 MeV/nuc)**
  - *Also protons? High interest from space community. Tatsumi: G4QMD?*

- PT: Sigmund and Schinner have been working on incorporating an improved **ion charge state** model for **PASS**, rather than using the present Thomas-Fermi charge model. It is recommended that this work be monitored, and the generation of **stopping power data** be repeated under ESA contact in order to allow the best possible stopping power data to be used in Geant4.
- PT: We should consider other **straggling models**, and again I think Peter Sigmund can bring some assistance here.

ESA, ongoing collaboration with CERN R2E group

- JUICE: Validation of **electro- and gamma-nuclear processes**, potential contribution to SEE
- Relevant e^- energies in the Van Allen belts
  - @ Earth : e- ~100 keV to 7 MeV, @ Jupiter e- ~100 keV to 50 MeV (tail >100 MeV)

UV-VIS-IR optical photons

Mathias Cyamukungu, Centre for Space Radiation & UC Louvain

- Proposal for extension of current physics to UV and IR in the Geant4 toolkit
  - UV and IR interaction process data
  - Optical properties of materials
- Envisaged application domains include
  - Photovoltaic cell design,
  - Heat radiative transfer in S/C
  - Imaging system design
  - Climatology
  - UV material degradation
  - Architectural design and energy saving
- *Looking for funding via ESA national programmes (and looking for model developers!)*
- *Would be more efficiently/quickly implemented if it was endorsed/handled by the GEANT4 Collaboration.*

Human space flight

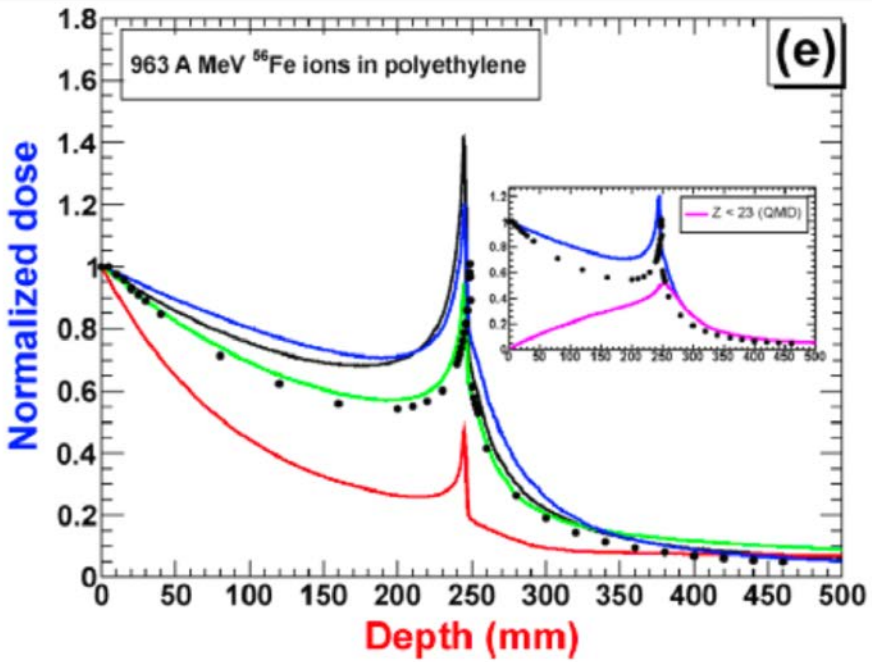
Martina Giraudo, Thales Alenia Space Italia

- Proton- and GCR-induced effects
  - Long-duration interplanetary journeys: rad. protection, shielding optimization
  - Biological dose from HZE ions: contribution from secondaries: fragments, neutrons, activation
  - Inaccuracy in **56Fe Bragg peak @~1GeV/nuc** (ROSSINI2, talk @Chicago), backed up by recent publication by another group (good results with Abrasion/Ablation, bad with all other models)
  - Geant4 presence traditionally limited in radiation therapy and rad. protection community
    - Earlier FLUKA reference **being replaced by PHITS?**
- *Link to UR by Bob Weller on SOTA hadronics models, and UR from medical physics*
- *Ongoing discussion with Geant4 Hadronics WG*

- **Low-E extensions with links to chemistry/biological effects** analysis capabilities (e.g. Geant4-DNA)
  - Physics models extended to more materials
    - *Link to low energy extensions for micro-electronics*
  - Improve link to measurable end points and macroscopic risk models
    - *Geant4-DNA has healthy work-plan, intermittent funding, but some excellent results*

Comparative study of depth dose-distributions and partial fragmentation cross sections of ^{56}Fe ions on polyethylene using GEANT4

Summit Jalota, Ashavani Kumar *



- Italia
- on
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- publication by a… with all other models)
  - Geant4 presenc… ction community
    - Earlier FLUK…
  - *Link to UR by Bob… l physics*
  - *Ongoing discussi…*
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  - Physics models e…
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Usability and Space Industry

- **Windows** platform
  - Some issues at next slide
- Geometry
  - Exchange, including **CAD**, TCAD, meshed structures, …
- Computational **speed** (mainly for electrons)
  - Reverse MC, biasing, etc

Windows platform
UI & Visualisation

Fan Lei, RadMod Research Ltd

- **Windows/Qt/OpenGL/GDML** is the preferred combination of

  G4 space applications and G4 support in this area is not very prominent

- A couple of issues encountered in CIRSOS (ESA new sim. framework)
  - A bug in G4QtUi.cc, identified long ago but only "half fix" committed to SVN (users have to manually update the distribution, also G4GDMLReadStructure.cc) *[is it still the case?]*
  - **Bug with Qt/OpenGL/GDML in Windows**, which prevents CIRVis working on Windows. One can see the problem with example/extended/persistency/gdml/G01

  [PT: this might disappear when above is fixed]

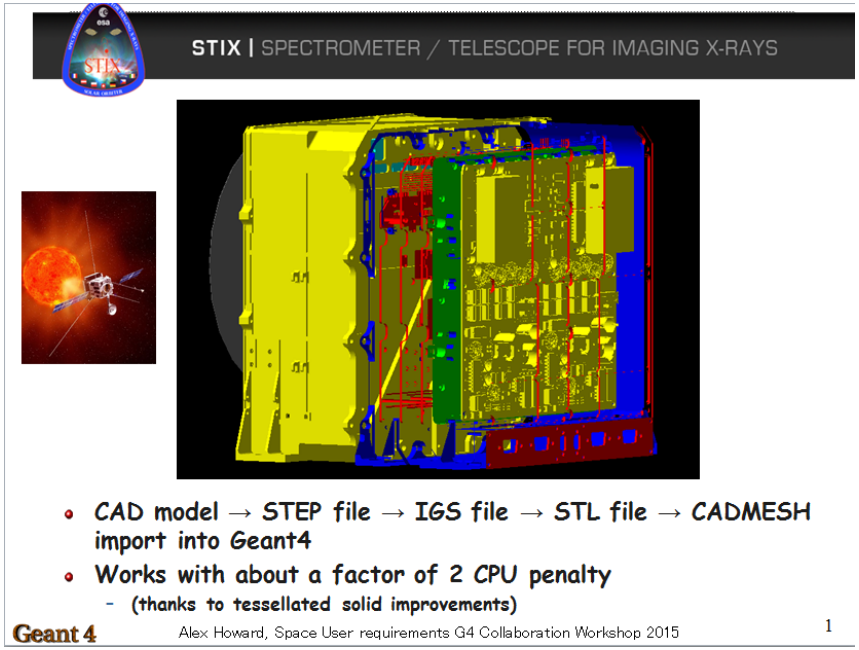
*Computing "workers" may reside on Linux clusters, but not preferred solution, and anyway **GUI and vis remain on Windows client***

- Geant4 **dataset**: problem with the large number of tiny ASCII files, need a more efficient solution

- Status of Geant4 **Multi-Thread on Windows?**
  - and MT GRAS *[this is for us to solve]*

Geometry modelling, visualisation, CAD

- Commercial tools (FASTRAD, ESABASE2) have GDML export + limited import
  - FASTRAD GDML output works quite well, and is improving, ESABASE2 GDML export also being improved
- Some CAD issues still not addressed
  - Manual **material** assignment
  - **Overlaps** (assessment / fix)
- Other export chains (e.g. CADMESH) seem to work but hard to sell in space engineering
- Look at (GUI and) **geometry modelling capabilities** of commercial tools



Computational speed

- **Reverse MC** – UR: quality control, missing validation reference studies / publications

  Ongoing:

  debugging and new features: splitting & other biasing, point detector (ESA funding)

  Missing verification also addressed during these months

  Parallel session Wed @ 9:00

- Transition to new **general biasing framework**

  status?

- **General Particle Source**: heavily used, but need
  - Review of code and algorithms (interpolations, sampling, UI…)
  - Better source biasing solutions to cover steep spectral shapes

Thank you

also to those who provided input for this presentation