Geant 4

Low Energy Electromagnetic Physics

R. Capra, S. Chauvie, G.A.P. Cirrone, G. Cuttone, F. Di Rosa, Z. Francis, S. Guatelli,
S. Incerti, A. Mantero, B. Mascialino, G. Montarou, Ph. Moretto, P. Nieminen,
L. Pandola, S. Parlati, L. Peralta, M.G. Pia, P. Rodrigues, G. Russo, A. Trindade,
C. Zacharatou, V. Zampichelli

ESA/ESTEC
IN2P3 - CENGB, Univ. Clermont-Ferrand
INFN Genova, LNGS, LNS, Torino
LIP Lisbon
Univ. Lund (new member)

Geant4 Workshop

Bordeaux, 7-10 November 2005

Maria Grazia Pia, *INFN Genova*

Status

- Consolidation of existing physics models
- New developments
- Validation

- Software process

- Concerns

Models based on the Livermore library

- Improvement in the gamma conversion cross-sections
  - account for pair and triplet production in cross sections
- The 1st validation publication documents their accuracy
  - they are consistently the most accurate models available in Geant4
- Plans
  - Explore extension below 250 eV
  - Document final state validation

Penelope models

- Design iteration planned
  - also to “mix and match” with library-based models
- I am guilty for not doing it
  - completely absorbed by bureaucracy to find funds for the group
- Multiple scattering not implemented yet
  - it is a peculiar algorithm
  - worth having it in Geant4 (reference NIM publication)
- Plan to design and implement Penelope multiple scattering
  - subject to the availability of funds for young developer

Photoelectric angular distribution

- Part of plans for accurate angular distributions at low energy
  - see Bremsstrahlung angular distributions (2BN, 2BS, Tsai)
- Model based on the Gavrila theory in progress
  - Activity proposed in December 2003 (Pedro Rodrigues, Andreia Trindade)
- Difficulties encountered
  - inconsistencies in the analytical formulae
  - contacts with theorists in progress
  - we may consider releasing a limited version of the model

Models for hadrons and ions

- Design iteration urgently needed to provide adequate precision both for hadrons and ions
  - current critical situation due to uncontrolled design change w.r.t. original design
- Design to merge models across an extended energy range has been in place since 1999
  - but implementation problem with accuracy of merging models
- Bug fixes in December 2005 release (thanks to Riccardo Capra!)
- Code review needed (fortran++!)
- Main problem
  - lack of documentation and transparency about what is actually in the software
- Solution
  - restore rigorous software process
  - need some time to review the code and improve transparency

Fluorescence and PIXE

- Atomic relaxation OK
  - extension of Auger model needed, but 2nd priority at this stage
- Fluorescence and Auger currently subject to validation
  - paper planned in 2005, but we lost the developer (no funds for his PhD fellowship, moved to high school teaching)
- PIXE
  - protons, K shell: model available in literature
  - protons L shell and ions: model and cross section database available, design is open to extension, lack developer to implement
  - to be validated against experimental data
- Molecular fluorescence
  - contacts with expert group
  - no time for design and education to adequate software process

New models

- Polarised Rayleigh scattering
  - released in June 2005 (Riccardo Capra)
- Extensions to the eV scale in water
  - in progress (Riccardo Capra, Ziad Francis, Sébastien Incerti, MG)
  - so called “track structure” modelling
  - more in “New models” parallel session
  - **major design effort** (policy based class design)
  - implementation and unit testing at advanced stage
  - need time for thorough integration testing, beta release early 2006
- Extension to the eV scale for other materials
  - planned, subject to availability of funds for young developer (Riccardo)
- Biological models
  - in progress in the Geant4-DNA project (Stéphane Chauvie, Barbara Mascialino, *Christina Zacharatou*)

Validation

- Major activity in the Working Group
  - to consolidate current models
  - to document accuracy and relative strength to users
  - to have sound regression testing tools for future design iterations
- See talk on EM Physics Validation

Software process

- The LowE EM inherited a level 1 (CMM) / level 0 (ISO 15504) process when created in 2000
- Major effort invested in SPI since 2000
  - young developers educated to a rigorous software process
  - Unified Process adopted successfully (equivalent to level 3 at least)
  - various higher level key practice areas (e.g. defect analysis and prevention)
- Rigorous software process pays back
  - faster development cycle
  - higher quality code (fewer bugs, hardly any problem report from users, in spite of heavy usage)
  - experimental observation: software developed “wildly” is not maintainable, is prone to bugs and in the end must be trashed
- Continuous SPI
  - areas where the quality of the software is still to be improved
  - software to be released in Geant4 LowE package MUST comply to the WG software process

Publications

- We have not published the Geant4 LowE models yet
  - lack womanpower
  - in the meantime, others have copied our models and published them (without any reference to our CERN/INFN preprints, of course!)
- It should be our first priority
  - it is not, because of external constraints

- We need publications
  - for the CV of our young collaborators
  - to document our work with our funding agencies
  - to provide an authoritative scientifc reference to users
  - but we can't find the time to focus to producing publishable material

- Publications are the best way to consolidate Geant4 physics models!
  - often compelled to distract effort into other projects just to get funds, without being able to consolidate physics first

Concerns

- Scientific work is hindered from the continuous effort to get funds for young developers
- We lost Riccardo Mantero (PhD student, atomic relaxation)
  - no funds for his PhD fellowship, now high school teacher
- We lost Michela Piergentili (PhD student, dosimetry & validation)
  - no funds for her PhD fellowship, now full time hospital trainee
- Riccardo's PhD fellowship expired January 2004
  - 6-month fellowship August 2005-January 2006, what next?
  - Polarised Rayleigh model developed and released while unpaid
- Susanna's PhD fellowship expires April 2006
  - what next?
- Hardly any support from INFN
  - 50% funds cutting in 2006, no position for Geant4 young developers
  - Geant4 is not a "mainstream" project (like LHC experiments, astroparticle experiments etc.)

Conclusions

- Slow progress in Low Energy Electromagnetic Physics
  - limited by available womanpower
  - difficulties at finding support for young Geant4 developers
  - resources drained by validation work
- Consolidation of existing models
- New extensions to the eV scale
- Validation is the main activity in the group