Update on Requirements

50th Geant4 Technical Forum
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Jefferson Lab

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Requirements Tracking System Page:
https://jira-geant4.kek.jp/secure/Dashboard.jspa?selectPageId=10000

New requirements

Requirements from Monday's plenary 1 session

- On Monday's plenary 1 session, a number of new requirements and requests were expressed in:
  - LHC and other HEP Energy Frontier experiments
  - HEP Intensity and Cosmic Frontiers experiments
  - Nuclear Physics experiments
  - Space science and engineering
  - Medical and bio science
- Display here the list of expressed new requirements
  - If your favorite requirement is missing, or is badly phrased, please let me know !
  - 28 new requirements collected…
- They will be examined by the Steering Board & discussed with requesters, and entered in JIRA if considered addressable
  - In practice, and in most cases, decisions rely on one working group

LHC and other HEP Energy Frontier experiments

- Hadronic physics processes for **c**-mesons and **b**-mesons
  - Requesters: ATLAS, LHCb, (CMS ?)
  - Note: work started this year in G4, for both cross sections and final states
- Ability to set up physics processes without creating a G4RunManager
  - Requesters: ATLAS, LHCb, (CMS ?)
- Being able to deal with particles with pre-defined zero life-times
  - Requester: ATLAS
  - Note: non-zero lifetime seems *a priori* a deep assumption in Geant4
- Ability to set a parametrised description of volumes
  - Requester: LHCb
- Review of hadronic cross sections for protons and anti-protons
  - Requester: LHCb
- Support for "sub-event" parallelism across G4 threads
  - Requester: ALICE
- Benefit from VecGeom developments
  - In particular, Geant4 interface with VecGeom navigation
  - Requester: ALICE
- Promote monopole physics classes up to the source levels
  - Only in example
  - Requester: ALICE
- Ability to track changes w.r.t. to reference versions by easy switching between older and recent physics lists
  - By e.g. a plug-in mechanism for physics lists
  - Requester: CALICE

HEP Intensity and Cosmic Frontiers experiments

- Incorporate precise calculation of the Fermi density effect using atomic data
  - Requester: NOvA
  - Note : reference mentioned for this calculation : R.M. Sternheimer *et al.* "Density Effect For The Ionization Loss of Charged Particles in Various Substances" Atom. Data Nucl. Data Tabl. 30 (1984) 261-271
- Neutron self-shielding effect
  - Significant modification of flux for neutron in the resonance region of material
  - Requesters: LZ (LUX-ZEPLIN), SuperCDMS
- Improve simulation of gamma induced neutron background
  - Improve photo-nuclear process below 30 MeV by using G4LEND
  - Requesters: LZ (LUX-ZEPLIN), SuperCDMS

Nuclear Physics experiments

- Nuclear physics and in particular nuclear physics @ JLab is the highlight of today's technical forum

- Expressed on Monday:
  - Improve electro-nuclear models
    - Today rely on Weizsacker-Williams approximation.
    - Not sufficient for high-intensity and high precision electron scattering.
    - The full, off-shell electron scattering vertex, must be implemented for nucleons within the nuclear target.
  - Improve Bertini cascade near the kinematic endpoint of reactions at 4.5 GeV
    - Today unphysical and over-production of protons and neutrons in this region
- Today's presented requirements will be collected too.

Space science and engineering

- Energy loss in volumes smaller than 10 nm
  - To properly take into account the small size parts in microelectronic in the Single Event Effect simulation
  - Requester : Robert Reed – Vanderbilt
- Electron transport down to ~10 eV
  - In view of giving an insight of the scales at which quantum effects become important
  - Requester : Robert Reed – Vanderbilt
- Better/easier process to convert from CAD to G4 geometry
  - Requesters: Insoo Jun, Chad Lindstrom, Brian Zhu – JPL
- Better visualization tools for debugging geometry
  - Currents tools not easy, produce too few details, and have no rendering
  - Requesters: Insoo Jun, Chad Lindstrom, Brian Zhu – JPL
- Enable tally of any flux- or fluence-based quantity using user supplied conversion coefficients
  - coefficients are material dependent factors affecting the score
  - Requester : Fan Lei, RadMod Research
- May come : heavy fragments produced pion- and muon-induced reactions
  - Requester : Vanderbilt, JPL

Medical and bio science

- Provide real part of the refractive index for x-ray refraction
  - Used for phase-contrast imaging
  - Exercised already on an application
  - (correct ?)
- Make EPICS2017 models available in Geant4 (electrons, photons) as an alternative to Livermore
- Increase energy coverage of PIXE models
  - up to a few tens of MeV
- Extend material coverage of G4-DNA beyond DNA and liquid water
- Extend energy coverage of G4-DNA
  - ex. option4 is limited to 10 keV for electrons
- Extend physics models coverage for ions below 1 MeV/u
  - Application to boron-neutron capture
- Provide "Independent Reaction Times" as an alternative to step-by-step approach

Open requirements

4701 : More realistic matrix element for decays $\tau \rightarrow \nu$ + hadrons

- Originator:
  - CMS
  - 47th Technical Forum (link)
- Scope:
  - The current implementation of tau decay to hadrons uses phase space decay.
  - More realistic matrix elements are requested.
- Responsible:
  - Vladimir Ivantchenko
- Status:
  - Similar requirement expressed by ATLAS earlier
    - With suggestion to use external decayer
  - Will contact requester to see if external decayer would be a satisfactory solution.
  - ☞ **But in view of HL-LHC it would be useful to extend Geant4 decays of heavy particles and in some cases use more accurate final state**
  - Open.

4702 : Inclusion of γ polarization effects in the high energy EM models

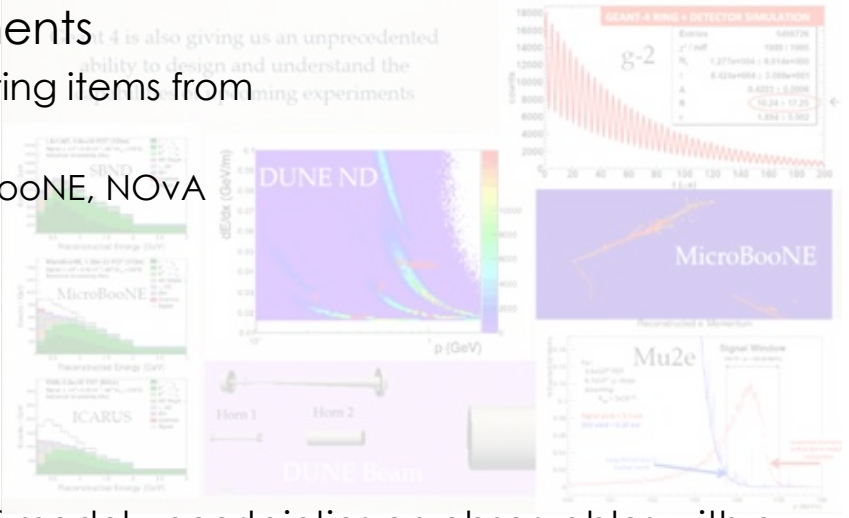
- Originator:
  - CMS
  - 47th Technical Forum (link)
- Scope:
  - Include Linear Polarization into HE γ Models
  - This has potential usage in the analysis of H → γ γ
    - Polarization planes of scalar (pseudo-scalar) particle to γ's are parallel (perpendicular)
    - Investigate the effect of polarization in the shower shape of photons
      - May give additional handles to distinguish direct γ's from H decay from BG
- Responsible:
  - Vladimir Ivantchenko
- Status:
  - In this year work plan.
    - Development will require several years.
  - Open.

4703 : Improved light nucleon production in FTFP_BERT

- Originator:
  - ALICE
  - Lund Geant4 CM, requirements session (link)
- Scope:
  - ALICE switched to FTFP_INCLXX physics lists
    - Because FTFP_BERT –recommended for calorimetry- has a deficit of light nuclei (d, t, 3He) production from secondary particles
  - But FTFP_INCLXX brings a performance penalty
  - Request to get the light nucleon production in FTFP_BERT improved
    - and keep the support for FTFP_INCLXX physics list, until ALICE can switch back to FTFP_BERT
- Responsible:
  - Alberto Ribbon, Dennis Wright
- Status:
  - ☞ **Solution (based on "Generic Biasing") to use INCLXX only in the Tracker region (while using BERT elsewhere) under testing**
  - Open.

4002 : Reweightable uncertainties for systematic uncertainties estimation

- Requester: Intensity Frontier FNAL experiments
  - Request made at 40th TF @ FNAL (link) , collecting items from
    - Muon : g-2, Mu2e
    - Neutrino : DUNE, MicroBooNE, MINERvA, MiniBooNE, NOvA
    - Fixed Target : SeaQuest
    - Test Beam : LArIAT
- Responsible:
  - Soon Yung Jun
- Scope:
  - The technique allows to estimate the effect of model uncertainties on observables with a single MC sample
    - Model uncertainties provided under guidance of experts
    - Suggested from usability of GENIE Neutrino MC Generator



- Status:
  - **Bertini, Precompound & FTF models being looked at and the impact of parameter variation studied**
  - **An API is being worked on; See Soon's talks in Sessions 4 & 3A and Julia's talk in 3A**
  - Open.

No Recently closed requirements