Update on Requirements

59th Geant4 Technical Forum
April 6th 2023
CERN

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On behalf of the Geant4 Collaboration

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

New/under analysis requirements

Requirements from 2022 Geant4 Collaboration Meeting (CM)

- Requirement sessions during CM are usually quite productive
  - https://indico.cern.ch/event/1156193/sessions/440344/#20220926
- First level of filtering done:
  - This is about 45 requirements to be analyzed !
  - Some are duplication/update of last year CM
    - (Some are pending to be entered in JIRA : my shame, but on-going, and no requirements are "forgotten")
- Requirements shared among several experts:
  - HEP : Alberto Ribon
  - Intensity Frontier : Soon Yung Jun
  - Nuclear Physics : no new requirements !
  - Space Science and Engineering : Makoto Asai
  - Medical and Bio Science : Susanna Guatelli
- Requirements will be added to JIRA as they are validated
- Thank you for your patience !

Open requirements

5002 : Support for "sub-event“ parallelism across G4 threads

- Originator:
  - ALICE
  - Page 6 of Requirements from energy frontier
  - Declined by ALICE, but requirement still considered of interest
- Scope:
  - ~~ALICE handles~~ For experiments which handle very big events
  - These would be processed faster if one event could be split into “sub-events” (= {subset of primary tracks}) -each processed on one thread- with merging back of sub-events into the event at the end
- Responsible:
  - Makoto Asai
- Status:
  - This comes along with the tasking model, released with 11.0.
  - Phase-I developments planned for this year.
  - Open

5006 : Improve simulation of gamma induced neutron background

- Originator:
  - LZ (LUX-ZEPLIN), SuperCDMS
  - Page 7 of Requirements from intensity frontier
- Scope:
  - Low energy gammas producing neutrons in various materials can generate a significant background
  - But photo-nuclear process does not model this well below 30 MeV
  - Point that G4LEND gamma models might resolve the issue
- Responsible:
  - Vladimir Grichine
- Status:
  - Improved gamma-nuclear cross sections in G4 11.0.
  - Some progress made recently, but more validation is needed.
  - JLab is willing to contribute to the validation of gamma-nuclear.
  - Open.

5007 : Improve electro-nuclear models

- Originator:
  - Markus Diefenthaler (EIC Center, EICUG) for:
    - JLAB 12 GeV Science program
    - Electron-Ion Collider (EIC)
  - Page 12 of Requirements from nuclear physics experiments
- Scope:
  - Electro-nuclear models 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.
- Responsible:
  - Vladimir Grichine
- Status:
  - Will be continued this year.
  - On going
  - Open.

5009 : Extend energy and material coverage of G4-DNA beyond DNA and liquid water

- Originator:
  - General demand
  - Page 11 of Requirements from Medical and bio science
- Scope:
  - Develop track structure models for specific materials (beyond liquid water and DNA)
  - Extend energy coverage of existing models
    - Need to fill the gap from where DNA model stop (~100-500 keV) up to at least ~100 MeV.
- Responsible:
  - Sébastien Incerti
- Status:
  - Gold G4-DNA model has been included in 11.0 beta release.
  - In progress for electrons: for water (option4 : 10 keV -> 10 MeV) by I. Kyriakou et al, for DNA materials (by S. Zein et al.), for N2 (by C. Villagrasa et al.)
  - Extend ionisation cross sections to heavy ions: Al, Ar, Cl, F, Mg, Na, Ne, P, S (beyond 7 Li, 9 Be, 11 B, 12 C, 14 N, 16 O, 28 Si, 56 Fe) for space radiation protection, by D. Bolst, D. Sakata, J. Archer, S. Guatelli
  - In progress, but still long way to go.
  - Open.

5010 : Physics models for ions below 1 MeV/u for Boron Neutron Capture

- Originator:
  - General demand
  - Page 12 of Requirements from Medical and bio science
- Scope:
  - Allows usage of Geant4 in BNC therapy field
- Responsible:
  - Sébastien Incerti & Jose Ramos-Mendez (University of California, San Francisco)
- Status:
  - Work taken care by Naoki Domínguez (Ph.D. student at BUAP, México), and José Ramos (UCSF)
  - In development since 2021
  - No recent news.
  - Open.

5201 : To extend "force collision" biasing to charged particles

- Originator:
  - NA62
- Scope:
  - A "force collision" biasing scheme exists in Geant4, but is adapted to neutral particles.
  - NA62 uses a K+ beam
  - A biasing with forced collisions for charged particles would allow for generating samples of useful statistics within a reasonable time to study the rare inelastic interactions in thin material in more detail.
  - Space domain also expresses its interest for this (requirement session CM 2021)
- Responsible:
  - Marc Verderi
- Status:
  - Slow progress
  - Will be continued this year.
  - Open.

5203 : Improve the inelastic cross sections of $\bar{d}$ and anti_He3 at low energies (< 1-2 GeV/c).

- Originator:
  - ALICE, from 2020 LPCC workshop
- Scope:
  - Inelastic cross-section of anti-deuteron and anti_He3 is too low at low energies
  - Likely, the same is needed for anti_triton and anti_alpha cross sections.
- Responsible:
  - Vladimir Uzhinsky
- Status:
  - Started in 2021, will continue in 2023.
  - Waiting for further measurements by ALICE
  - Open.

5301: Model for positronium (aka Ps) creation and annihilation

- Originator:
  - David Sarrut and Lydia Maigne, on behalf of GATE community
  - From CM2020 requirements session
- Scope:
  - The e^+ annihilation proceeds in tissue via Ps creation in > 40% cases
  - Ortho-positronium (o-Ps; triplet spin state : s=1; m=-1,0,1) formed with 25% probability (in water)
    - Decay via 2γ (pickoff) or **3 γ (0.5% in tissue, 100% in vacuum)**
    - $\langle\tau\rangle$ o-Ps maybe correlated with metabolic disorders ($\langle\tau\rangle$ depends on the size of the free volumes between atoms; varies from 142 ns in vacuum, down to below O(few10 ps) in matter).
  - Feasibility study in Phys. Med. Biol. 64 (2019) 055017 to measure $\langle\tau\rangle$ using o-Ps $\rightarrow \gamma\gamma\gamma$ decay.
- Responsible:
  - Vladimir Ivanchenko
- Status:
  - Some implementation already in 10.7
    - 3-γ annihilation is available in G4EmStandardPhysicsWVI Physics List
  - Omrane Kadri plans to work on it this year
  - Open

5302 : Extended example to directly retrieve Auger e- E & associated atomic transition

- Originator:
  - Alfonso Mantero
  - From CM2020 requirements session
- Scope:
  - Have better/complete "MC truth" information for these emissions
- Responsible:
  - Susanna Guatelli
- Status:
  - In the work plan for this year to add a model sub-type
    - which will make it easy to identify Auger electrons.
  - Seeking for a student to work on the topic
  - Open

5303 : GIDI - LEND Models : install new GIDI when ready & validate with updated LEND

- Originator:
  - From CM2020 requirements session
- Scope:
  - Future of high precision neutrons looks like it will be GND (Generalized Nuclear Data)
    - New & simpler data format (will replace ENDF) & includes low- to medium-energy nuclear data
    - however, not as complete as ENDF
  - Current LEND models in Geant4 are based on this
    - GIDI (General Interaction Data Interface) = interface between GND data and LEND physics models
      - Written in C
      - Many bugs uncovered by users and LEND validation effort
    - Livermore is writing a new, redesigned version in C++
  - Makes this available when ready
- Responsible:
  - Alberto Ribon
- Status:
  - Was in the plan of work for 2021, but it is often postponed
  - Livermore got some grant to work on this last year.
  - Low communication rate.
  - Open

5501 : Propagation of polarized muons and taus in dense media

- Originator:
  - Requested by DUNE @ CM session 2021
  - Page 7 of:
  - https://indico.cern.ch/event/1052654/contributions/4525347/attachments/2312666/3936047/IFCosmicRequirementsG420210920.pdf
- Scope:
  - To be documented
- Responsible:
  - John Apostolakis
  - Krzysztof Genser (IF-liaison)
- Status:
  - Investigation on issue started.
  - On-going
  - Open

5503 : Improve pbar annihilation process

- Originator:
  - Requested by Mu2e @ CM session 2021
  - Page 7 of:
  - https://indico.cern.ch/event/1052654/contributions/4525347/attachments/2312666/3936047/IFCosmicRequirementsG420210920.pdf
- Scope:
  - Mu2e context
    - with including being able to affect the nuclear destruction process at energy below 2GeV
  - The same request is coming also from CERN AD and astrophysical experiments.
- Responsible:
  - Alberto Ribon
- Status:
  - Work is on-going on INCLXX to extend it to antiproton.
  - On-going
  - Open

Requirements pending because of “Lack of resources”

Valid requirements, but no resources to address them

- 5504 : Excess ratio of pi-/pi+ in p W reaction with Bertini
- 5305, "Fix overproduction of n and p near endpoints of reactions at 4.5 GeV“
- 5304, "Beta-delayed Neutrons : develop understanding of highly excited level densities in nucleus and model neutron decay from this region“
- 5005, "Neutron self-shielding effect“
- 4005, "Neutron production in muon showers at the %-level“
- 4001, "Anti-proton production from proton beam (Mu2e request)“
- Contribution/resources welcome to address these requirements !

Recently closed requirements

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:
  - Provided since 11.0.
  - Closed

5008 : Make EPICS2017 models (electrons, photons) as an alternative to Livermore

- Originator:
  - General demand
  - Page 11 of Requirements from Medical and bio science
- Scope:
  - EPICS2017 : Electron and Photon Interaction Cross Sections
    - Mention : these data supersede all earlier versions of the data libraries EADL, EEDL and EPDL
- Responsibles:
  - Sébastien Incerti, Claire Michelet
- Status:
  - Framework of thesis of Z. Li (CENBG/LP2I Bordeaux+CERN EM group)
    - Thesis will end in 2023
  - Provided for gammas, electrons found good enough.
  - Closed.

5202 : Precision versus speed optimized EM physics simulation configuration for ATLAS

- Originator:
  - ATLAS, from 2020 LPCC workshop
- Scope:
  - The most precise Geant4 (_EMZ) EM physics option provides more accurate simulation results in some cases (compared to the standard EM option). However, this precision gain comes at the expense of a significant increase of the simulation time.
  - The goal is to find the EM physics configuration that provides the optimum in terms of computing time and simulation accuracy.
- Responsible:
  - Mihaly Novak
- Status:
  - Effort started in 2021, the related studies and optimizations are ongoing together with our ATLAS colleagues.
  - On-going, complex task, but significant speed-up obtained (20%).
  - Considered as a regular, continuous activity, rather than a requirement per se.
  - Closed ? As regular support activity.

5502 : Ability to turn off intranuclear scattering

- Originator:
  - Requested by DUNE @ CM session 2021
  - Page 7 of:
  - https://indico.cern.ch/event/1052654/contributions/4525347/attachments/2312666/3936047/IFCosmicRequirementsG420210920.pdf
- Scope:
  - In the pion inelastic process (in pi-Ar scattering), would like to
    - turn off intranuclear scattering
      - ref: https://geant4-forum.web.cern.ch/t/turn-off- intranuclear-scattering-in-pion-argon-interaction/5535
    - turn off short range correlation
  - be able to obtain the momentum of the initial nucleon (Fermi momentum)
- Responsible:
  - Alberto Ribon
- Status:
  - Agreed but lack of resources
  - Suspended because of lack of resources

5504 : Excess ratio of pi-/pi+ in p W reaction with Bertini

- Originator:
  - Requested by Mu2e @ CM session 2021
  - Page 7 of:
  - https://indico.cern.ch/event/1052654/contributions/4525347/attachments/2312666/3936047/IFCosmicRequirementsG420210920.pdf
- Scope:
  - Details to be provided
- Responsible:
  - Alberto Ribon
- Status:
  - Agreed but lack of resources
  - Suspended because of lack of resources