

Update on Requirements

55th Geant4 Technical Forum
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Virtual Meeting

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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/analyzed requirements

Requirements from 2021 Geant4 Collaboration Meeting (CM)

- Requirement sessions during CM are quite productive
 - > 2021 session ended with O(> 50) requirements expressed !
 - > <https://indico.cern.ch/event/1052654/sessions/401937/#20210920>
- Some first level of filter done, but analysis process is on-going
 - > Is requirement new ? Is it relevant to Geant4 ? Does it need clarification ? Etc.
 - > In interaction / iteration with requesters
- Requirement analysis work shared among several volunteers:
 - > 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

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 $H \rightarrow \gamma \gamma$
 - 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 progress, continuing this year.
 - > Open.

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

- Originator:
 - > ALICE
 - > Page 6 of [Requirements from energy frontier](#)
 - > Declined by ALICE last year, 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.
 - > Reproducibility is the main issue
 - > Will be continued this year
 - > Open

5005 : Neutron self-shielding effect

- ◉ Originator:
 - > LZ (LUX-ZEPLIN), SuperCDMS
 - > Page 7 of [Requirements from intensity frontier](#)
- ◉ Scope:
 - > Significant reduction of the neutron flux in material when neutron energy is in the resonance region
 - The capture process can reduce the flux at one position in a crystal creating a kind of shadow in which the downstream atoms see a reduced flux (a ~10% effect)
- ◉ Responsible:
 - > Vladimir Ivanchenko
- ◉ Status:
 - > Valid requirement but big work
 - Needs theoretician support as well as manpower.
 - > Collection of publications and references on-going.
 - > Not expected to be concluded in the short term.
 - > 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:
 - > Valid requirement and possible solutions under verification.
 - > Alternative model to treat low-energy gamma-nuclear interactions is available in 10.7.
 - Need to study its effect.
 - > **Continuing this year.**
 - > **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:
 - > Big work, but good progress
 - > Data-sets have been introduced in 10.7
 - > Will be continued this year.
 - > Open.

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:
 - > On-going in framework of thesis of Z. Li (CENBG+CERN EM group)
 - Thesis will end in 2023 (initial end year was 2022)
 - > **Expected to be concluded by then.**
 - > **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.
 - > Will be continued this year (with, eg, DNA bases + sugar/phosphate).
 - > 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:
 - > 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, will be continued this year.
 - > 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:
 - > Will be continued this year.
 - > Open.

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 optimisations are ongoing together with our ATLAS colleagues.
 - > Will continue in 2022
 - > Open.

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

- ◉ 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 2022.
 - > 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 **3γ (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
 - > In the plan of work, but not with high priority
 - > 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.
 - > Have to agree on how to tag/record the type of transition
 - > 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 this year
 - > Open

Recently closed requirements

5304 : β -delayed neutrons: develop understanding of highly excited level densities in nucleus and model neutron decay from this region

- ◉ Originator:
 - > From CM2020 requirement session
- ◉ Scope:
 - > Nucleus beta decays to highly excited level in daughter, daughter then emits neutron
 - > Crucial for reactor studies
- ◉ Responsible:
 - > Alberto Ribon
- ◉ Status:
 - > De-excitation module may be potentially used. This would require a change in Radioactive decay class
 - add a possibility to call not only photon evaporation but excitation handler.
 - > Valid requirement, but needs additional manpower to address it
 - > Put as stand-by for "lack of resources"

5305 : Fix overproduction of n and p near endpoints of reactions at 4.5 GeV

- ◉ Originator:
 - > From CM2020 requirements session
- ◉ Scope:
 - > Related to Bertini Gamma-Nuclear
 - > Problem fixed for gamma-D reactions
 - > More work required for other nuclei
- ◉ Responsible:
 - > Alberto Ribon
- ◉ Status:
 - > Valid requirement, but difficult to achieve with present manpower
 - > Put on stand-by for "lack of resources"