# Update on Requirements

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CERN

Marc Verderi, LLR, Ecole polytechnique
On behalf of the Geant4 Collaboration

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

# New requirements

# Requirements from JLab collaboration meeting

- Requirements session of JLab Collaboration Meeting (Sep. 2019)
  - About 25 requirements expressed
  - From
    - LHC and other HEP Energy Frontier experiments
    - HEP Intensity and Cosmic Frontiers experiments
    - Nuclear Physics experiments
    - Space science and engineering
    - Medical and bio science

- Examination of these ongoing by the Steering Board.

- At present:
  - 11 entered in JIRA
  - 8 under clarifications with requesters
  - 6 are considered invalid



# requests in JIRA in last 3 months

**New requests**

**Resolved requests**
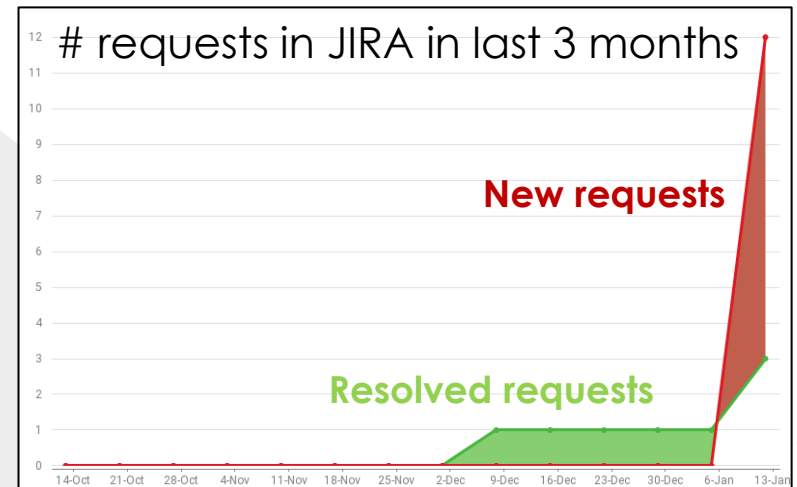
# 5001 : Hadronic physics processes for c-mesons and b-mesons

- Originator:
  - › ATLAS, LHCb
  - › Pages 3 & 5 of <u>Requirements from energy frontier</u>

- Scope:
  - › Provide cross-sections and final state models for c- and b-mesons

- Responsible:
  - › Alberto Ribon

- Status:
  - › Work started in 2019
  - › Open.

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

- Originator:
  - ALICE
  - Page 6 of Requirements from energy frontier
- Scope:
  - ALICE handles 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:
  - Work already started
  - Open.

# 5003 : Benefit from VecGeom & VecGeom Navigation

- Originator:
  - ALICE
  - Page 6 of <u>Requirements from energy frontier</u>
- Scope:
  - VecGeom solids already usable in Geant4
    - Under "standard" navigation
  - Request specialized navigation to be interfaced too
    - Similarly to what exists with TGeo
- Responsible:
  - Gabriele Cosmo

- Status:
  - Interface with navigation planned for 2020
  - Open.

# 5004 : Precise calculation of the Fermi density effect using atomic data

- Originator:
  - NOvA
  - Page 6 of Requirements from intensity frontier
- Scope:
  - MC / Data differences on Fermi density effect can not be calibrated in neutrino experiments
    - Needs precise calculation
  - Suggests to perform density effect calculations "free" of approximations
    - following 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
- Responsible:
  - Vladimir Ivanchenko

- Status:
  - Progress reported during JLab collaboration meeting
  - Implementation provided with help of requester
  - Final confirmation was awaited
  - Can be closed.

# 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 is a big work
    - requires significant manpower to be served
  - Might be put in "missing manpower" state.

# 5006 : Improve simulation of gamma induced neutron background

- ◉ Originator:
  - › LZ (LUX-ZEPLIN), SuperCDMS
  - › Page 7 of <u>Requirements from intensity frontier</u>
- ◉ 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
  - › Solution partly exists, but verifications are needed:
    - • ShieldingLEND physics list provided candidate solution since 10.4/10.5
      - • Below 20 MeV
    - • ParticleXS2.1 must be looked at too
      - • But no isotope wise XS
  - › 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
  - In work plan of Vladimir Grichine
  - Open.

- Originator:
  - General demand
  - Page 11 of <u>Requirements from Medical and bio science</u>
- Scope:
  - EPICS2017 : Electron and Photon Interaction Cross Sections
    - Mention : these data supersede all earlier versions of the data libraries EADL, EEDL and EPDL
- Responsible:
  - Sébastien Incerti

- Status:
  - On-going in framework of thesis of Z. Li (CENBG+CERN EM group)
  - 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
    - ex. option4 is limited to 10 keV for electrons
- Responsible:
  - › Sébastien Incerti

- Status:
  - › On-going.
  - › Open.

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

- ◉ Originator:
  - › General demand
  - › Page 12 of <u>Requirements from Medical and bio science</u>
- ◉ Scope:
  - › Allows usage of Geant4 in BNC therapy field
- ◉ Responsible:
  - › Jose Ramos-Mendez (University of California, San Francisco)
    - • Put Sébastien Incerti temporarily

- ◉ Status:
  - › Work started with Naoki Domínguez (Ph.D. student at BUAP, México), and José Ramos (UCSF)
  - › Open.

# Requests under clarifications

- Ability to set up physics processes without creating a G4RunManager
  - Requesters: ATLAS, LHCb, (CMS ?)
- Ability to set a parametrised description of volumes
  - Requester: LHCb
- Review of hadronic cross sections for protons and anti-protons
  - Requester: LHCb
- Initialization in parallel mode
  - Requester: CMS
- 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
  - EIC
- 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 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
- Communication ongoing with requesters.

# Requests considered as invalid

- Promote monopole physics classes up to the geant4/source level
  - Only in example for now
  - Requester: ALICE
  - Only existing particles are at the geant4/source level
- 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
  - Already under investigation
- 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
  - Too complicated (in term of compatibilities)
- Better/easier process to convert from CAD to G4 geometry
  - Requesters: Insoo Jun, Chad Lindstrom, Brian Zhu – JPL
  - Existing tools will be reminded. Generic (free) solution is a too big work.
- 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
  - Too user's specific
- Provide real part of the refractive index for x-ray refraction
  - Used for phase-contrast imaging
  - Exercised already on an application
  - Already possible. References provided to requester.
- Will be followed-up with requesters

# 5012 : Alternative (in)elastic cross-sections and models for systematic uncertainties studies

- Originator:
  - › NA61/SHINE
- Scope:
  - › Have at least one alternative hadron elastic treatment (including both cross-sections and final-state models) for any reference physics list, which can be enabled by users, without the need of modifying Geant4 source code.
  - › Have at least one alternative hadron inelastic cross-section treatment for any reference physics list, which can be enabled by users, without the need of modifying Geant4 source code.
- Responsible:
  - › Alberto Ribon

- Status:
  - › Recently requested, agreed as valid.
  - › Open.

# 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 → 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.

# Recently closed requirements

- ⦿ 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:
  - › Study completed.
  - › Submitted to JINST (Nov. 14) : arXiv:1910.06417
  - › Closed
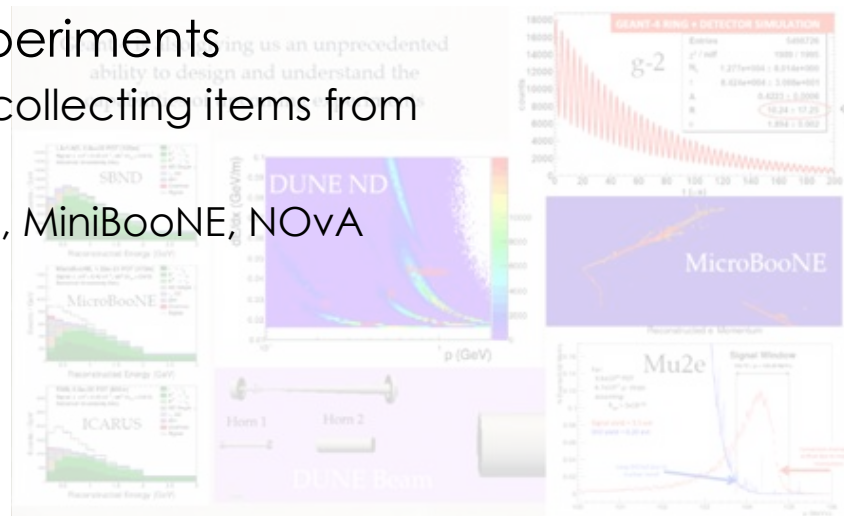
# 4701 : More realistic matrix element for decays τ → ν + hadrons

- 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:
  - › Solution external decayer verified and agreed.
  - › Closed.

# 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).
  - › Closed.