



[Open] User Requirements - Nuclear Physics

L.G. Sarmiento
on behalf of the UR responsables

Lund University
Sweden

28th Geant4 Collaboration Meeting, 2023



¹ <https://en.visit-hokkaido.jp/news/best-places-to-view-autumn-leaves-in-hokkaido-vol-2>

[Open] User Requirements

-New-

UR-80:

Isotope production from protons using IAEA medical cross-section

Status: **Open**

Assignee: ~~Alberto Ribon~~

From Requirements session (medical) @ Rennes CM

IAEA has made an extensive work to cover isotope production for medical applications (<https://wwwnds.iaea.org/medical/>) database

- ▶ Review and include IAEA medical cross sections into the Geant4 ParticleHP
- ▶ **Susanna:** This is a huge work to do. The responsible should be the hadronic group. We can also ask to contributors of G4-Med if anyone could take the work onboard.

UR-78:
em + hadronic. Provide an example of physics list activating both Geant4-DNA and hadronic physics, including radioactive decay

Status: **Open(!)**

Assignee: Vladimir Ivantchenko

From Requirement session @ Rennes CM

- ▶ Physics case implemented in v11.1. No explicit example demonstrates it.

UR-75:

Verify HP physics lists wrt Total Ionizing Dose (TID)

Status: **Open**

Assignee: ~~Alberto Ribon~~

From Requirement session @ Rennes CM (ATLAS)

Problem:

from 10.6, TID and neutron fluence > 10.1 patch provided to Geant4 and included since May 2022
~30% discrepancy between 10.1 and ≥ 10.6 in neutron spectra HP physics lists. 10.1 had already higher neutron fluence compared to FLUKA. **Now is even higher.**

Major suspect: the caching code for Particle in the HP physics lists

Contact: Sven Menke: menke@mppmu.mpg.de

UR-69:

Ability to turn off intranuclear scattering

Status: **Lack of Resources**

Assignee: ~~Alberto Ribon~~

From Requirement session @ G4CM21 (DUNE)

In the pion inelastic process (in pi-Ar scattering), would like to

- ▶ turn off intranuclear scattering ([Link to forum](#))
- ▶ turn off short range correlation

be able to obtain the momentum of the initial nucleon (Fermi momentum)

[Open] User Requirements *-Standing-*

UR-66:

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

Status: **Lack of Resources**

Assignee: ~~Alberto Ribon~~

- ▶ Related to Bertini Gamma-Nuclear
- ▶ Problem fixed for γ -D reactions
- ▶ More work required for other nuclei

UR-65:

Beta-delayed Neutrons : develop understanding of highly excited level densities in nucleus and model neutron decay from this region

Status: **Lack of Resources**

Assignee: ~~Alberto Ribon~~

- ▶ Missing from Radioactive Decay models
 - ▶ Nucleus beta decays to highly excited level in daughter, daughter then emits neutron
 - ▶ Crucial for reactor studies
- ▶ (Vladimir I.) To use de-excitation module (not precompound one) will require a change in Radioactive decay class - add a possibility to call not only photon evaporation but excitation handler.
- ▶ (Alberto) In practice, we don't have enough man-power available to work on it.

Some discussions were held some years ago but no agreement on implementation was achieved.

Dataset size and handling issues

UR-64:

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

Status: **In progress**

Assignee: ~~Alberto Ribon~~

- ▶ Future of high precision neutrons looks like it will be GND (Generalized Nuclear Data)
 - ▶ new, simpler data format will replace ENDF
 - ▶ also includes low- to medium-energy nuclear data
 - ▶ however, not as complete as ENDF
- ▶ Current LEND models in Geant4 are based on this
 - ▶ GIDI, the interface between GND data and LEND physics models is currently written in C
 - ▶ many bugs uncovered by users and LEND validation effort
 - ▶ Livermore ~~is~~^{was} writing a new, redesigned version in C++. **No funding?**
- ▶ It is in the plan of work for 2022, but **it is often postponed**

UR-54:

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

Status: **In progress**

Assignee: Alberto Ribon

From JLab CM [Med. and Bio.] requirements session [Models - Page 12]:

- ▶ Physics models for ions below 1 MeV/u.
- ▶ Labelled EM (Geant4-DNA) more than nuclear/hadronic process
- ▶ **The data is ready and the corresponding paper under writing.**

UR-51:

Improve electro-nuclear models

Better photo-nuclear for 15 GeV and below

Status: **In progress**

Assignee: Vladimir Grichine

From JLab CM requirements session [page 12]:

- ▶ Today electro-nuclear relies 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.

- ▶ There is progress in the e-nucleus integral XS and corrections for structure-function effects are ready to be implemented. **Already in G4.**
- ▶ The neutrino QE and production integral XS **were implemented in G4 in 2021. New QE integral XS was implemented for neutrino-A. The neutrino-A model was updated for the new QE/IN ratio.**
- ▶ **New $e - A$ approach will be implemented in G4 up to the end of 2022. Concerning $A(\gamma, n)$, improving of the existing models is underway.**

UR-50:

Improve simulation of gamma induced neutron background

Status: **In progress**

Assignee: Vladimir Grichine

From Fermilab CM requirements session [Other Requirements: Dark Matter Experiments - Page 7]:

- ▶ Low energy gammas producing neutrons in various materials can be a significant background
 - ▶ Photo-nuclear process does not model this well below 30 MeV
 - ▶ An improved process using the G4LEND gamma models is required
- ▶ **Alternative model to treat low-energy gamma-nuclear interactions is available since 10.7.**
- ▶ SB 132: Some progress made recently, but more validation is needed.
- ▶ SB 132: **JLab is willing to contribute to the validation of gamma-nuclear.**

UR-49:

Neutron self-shielding effect

Status: **In progress**

Assignee: Vladimir Ivantchenko

From Fermilab CM requirements session [Other Requirements: Dark Matter Experiments - Page 7]:

- ▶ Implement simulation of neutron self-shielding effect
 - ▶ Neutron flux through a material can be significantly modified when the 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 different background flux (a 10% effect)

- ▶ A number of other problems in nuclear physics need fix. UR-49 (this) would follow
- ▶ **Missing manpower to serve it.**