

User Requirements - Nuclear Physics



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on behalf of the UR responsables and many more

Lund University
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[Open] User Requirements

-New-

UR-98:

Add the width of the energy states to the modeling of the radioactive nuclei decay

Status: **Open**

Assignee: ...

Requested by JUNO at the 60th Technical Forum (Feb 2024).

Contact: Cécile Jollet (Bordeaux university, LP2iB - CNRS/IN2P3)

- ▶ Pico: Presumably a big effort. For states with known half-life the width of the states can be *trivially* computed.
This can be keep in mind for next iteration of our Radioactive Decay and Photon Evaporation datasets.

UR-96:

Incorporate NUDEX generator into GEANT4

Status: Closed(?)

Assignee: Emilio Mendoza Cembranos

The LUX-ZEPLIN exp. would like to have NUDEX (A new nuclear γ -ray cascades generator) incorporated into GEANT4 to improve the de-excitation gamma simulations following n -capture. This helps BG rejection in their DM searches (WIMP).

- ▶ ~~Ready to be inserted in GEANT4 since February 2024.~~ Available for 11.3.
- ▶ Progress done by Emilio. Can be enabled as environment variable USENUDEX or selecting photo evaporation model `/process/had/particle_hp/use_photo_evaporation #` instead of a boolean.
- ▶ Minor tweak and validation to be done.

UR-93:

Add a way to handle particles unknown to GEANT4 modeled on G4GenericIon

Status: Closed(?)

Assignee: Alberto Ribon

Requested by LHCb to Address a challenge related to particles unknown to GEANT4 (like exotic particles or excited mesons or ions).

Contacts: Gloria Corti and Michele Veltri

- ▶ Already in 11.2.ref08
- ▶ Alberto introduced the classes G4DynamicParticleIonisation and G4DynamicParticleMSC which work for the new G4ChargedUnknownParticle (which do not rely on G4ParticleDefinition).

UR-87:

Include (currently customised for SuperCDMS) databases for PhotonEvaporation and RadioactiveDecay in the official releases

Status: **Lack of Resources**

Assignee: ...

Request by SuperCDMS; reported at the 27thCM at Rennes.

Include (fully?) (currently customized for SuperCDMS) databases for PhotonEvaporation and RadioactiveDecay in the official releases.

- ▶ Pico: What is the benefit from including it *officially*?. We would have to support it.
- ▶ Pico: Can this be superseded by NUDEX and/or the new Datasets?
- ▶ See also: UR-98 and UR-96.

[Open] User Requirements *-Standing-*

UR-80:¹

Isotope production from protons using IAEA medical cross-section

Status: **Open**
Unchanged

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.

¹also reported as Med-bio requirement.

UR-78:

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

Status: In progress(!)

Assignee: Vladimir Ivantchenko

From Requirement session @ Rennes CM

Contact : Susanna

► In Geant4 11.2 new features are provided:

- In DNA Physics Lists condensed history models are used for positrons and other charged particles. For e^- , p , α , heavy ions DNA models are working up to defined threshold in energy, above - condensed history models. DNA physics applied to the full geometry setup.
- On top of any PhysicsList (EM only or full) it is possible to define `G4Region(s)`, for which DNA physics will be used for e^- , p , α , heavy ions below the defined threshold.

So, it is possible to start implementing an example.

UR-75:²

Verify HP physics lists wrt Total Ionizing Dose (TID)

Status: **Closed**

Assignee: ~~Alberto Ribon~~

From Requirement session @ Rennes CM (ATLAS)

Problem: $\sim 30\%$ discrepancy between 10.1 and ≥ 10.6 in neutron spectra HP physics lists.

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

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

- ▶ An overproduction of gammas due to a bug in neutron capture (purged by Sven Menke), and other potential contributions were found to be the culprit.
- ▶ An extended, hadronic example, ParticleFluence has been added in GEANT4 11.1. The particle fluence is conveniently evaluated as the sum of the track lengths inside a scoring volume, divided by the cubic volume of such scoring volume. Four different set-ups are considered, corresponding to four variants (i.e. subdirectories) of the ParticleFluence example: Sphere, ConcentricSphere, Layer, Calo. Using this extended hadronic example [...] [t]he task has been successfully completed and can be closed.

²also reported as HEP requirement.

UR-69:

Ability to turn off intranuclear scattering

Status: **Lack of Resources**
Unchanged

Assignee: ~~Alberto Ribon~~

From Requirement session @ G4CM21 (DUNE)

In the pion inelastic process (in π -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)

UR-66:

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

Status: **Lack of Resources**
Unchanged

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**
Unchanged

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 person-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

Pico: Perhaps this will change with the new datasets in the future

UR-64:

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

Status: **In progress (again!)**

Assignee: ~~Alberto Ribon~~ Douglas Wright

- ▶ 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 writing a new, redesigned version in C++. **New funding found!**
- ▶ One of the member of the Livermore team, Douglas Wright, has started to participate regularly to our monthly GEANT4 hadronic physics meetings.
- ▶ No news -yet-.

UR-54:³

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

Status: **In progress**

Assignee: ~~Alberto Ribon/Jose Ramos-Mendez?~~

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

- ▶ In progress reported by Vladimir Grichine
- ▶ ~~To be [formally] assigned to Jose Ramos-Mendez (University of California, San Francisco).~~
- ▶ Jose 2023CM: The data is ready and the corresponding paper under writing.
- ▶ Sebastian: See EM session on Thursday seems to address the EM part of this.

³also reported as Bio-Med requirement.

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.
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- ▶ **Alberto: A major, long term work item.**
 - ▶ **In progress reported by Vladimir Grichine.**

UR-50:

Improve simulation of gamma induced neutron background

Status: **In progress**
Unchanged

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
- ▶ **Alberto: A major, long term work item.**
- ▶ **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: **Lack of Resources**
Unchanged

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.
- ▶ This is not Vladimir's area of expertise and the actual physics involved are not fully understood.
Missing person-power
- ▶ See Hadronic session on Thursday.

