



# **New Features in PHITS3.36**

PHITS development team, Apr. 2026

## Recent Updates

2023 Dec. Update PHITS official reference\*

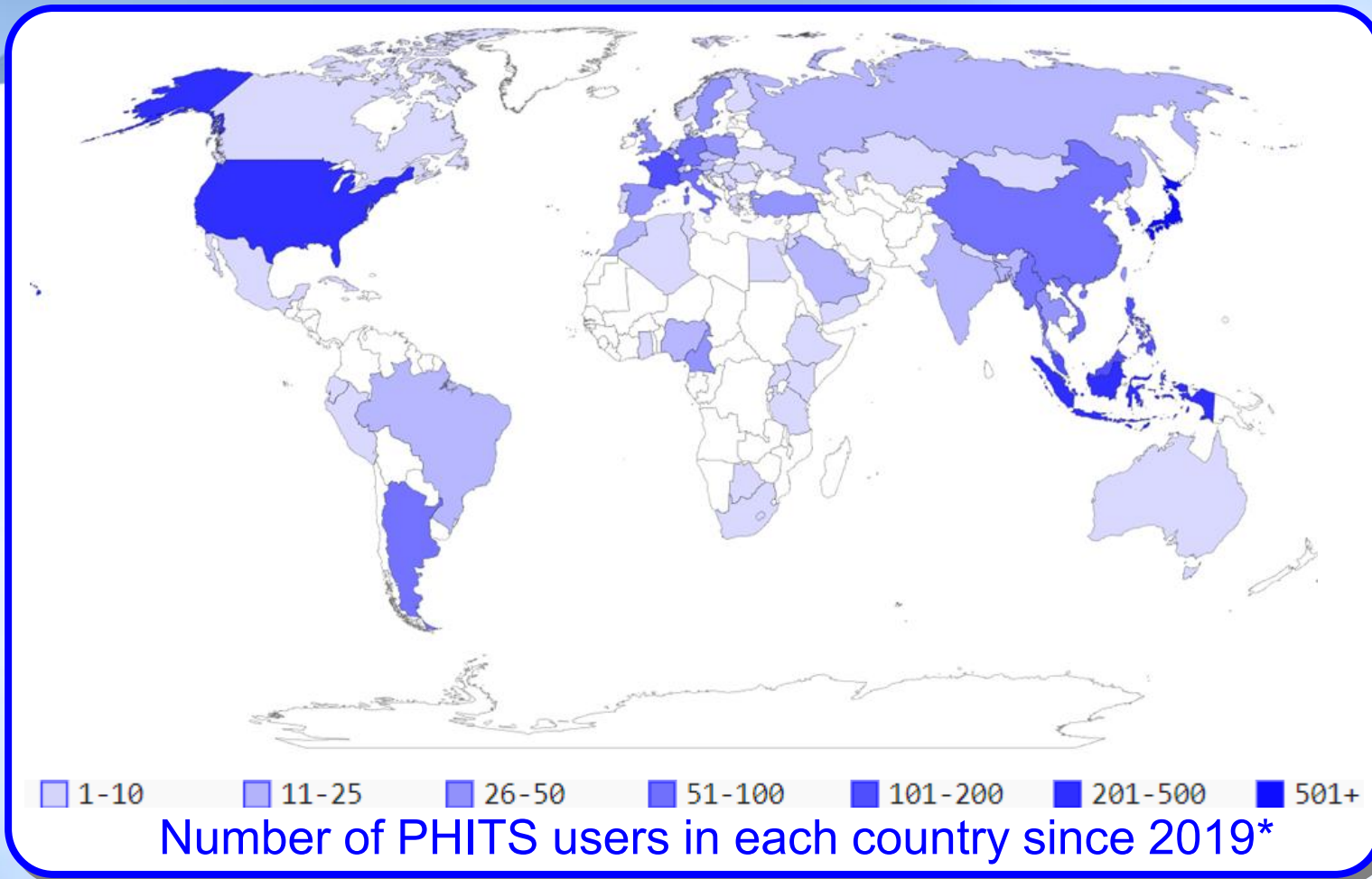
2024 Apr. Register PHITS 3.34 to OECD/NEA Data bank

2025 Apr. Register PHITS 3.35 to OECD/NEA Data bank

2026 Apr. Register PHITS 3.36 to OECD/NEA Data bank

\*T. Sato et al., Recent improvements of the Particle and Heavy Ion Transport code System - PHITS version 3.33, J. Nucl. Sci. Technol. 61, 127-135 (2024)

# Number of PHITS users since 2019



\*@2026/03/12, based on the location of users' affiliation

**9,282 new users from 80 countries in seven years!**

## Top 10 countries

Country	#users
Japan	4232
Indonesia	778
United States	581
South Korea	452
France	329
Philippines	308
Spain	221
China	216
Malaysia	163
Morocco	161

# Map of Models Recommended to Use in PHITS

	Neutron	Proton	Nucleus	Muon	e <sup>-</sup> / e <sup>+</sup>	Photon
	1 TeV	1 TeV/n		1 TeV		1 TeV
High	JAM + GEM 3.0 GeV		JAMQMD + GEM	JAM/ JQMD + GEM		JAM/ JQMD + GEM
↑ Energy	INCL4.6 + GEM 200 MeV		t 3He α JQMD + GEM	200 MeV	EGS5, ETS or ETSART	EPDL97 or EGS5
20 MeV		JENDL-5	d 10 MeV/n	ATIMA + Original Model		JENDL + NRF
↓ Energy	JENDL-4 or JENDL-5	1 MeV		1 keV	1 keV	1 keV
Low	0.01 meV	ATIMA or KURBUC / ITSART				
		*Only for negative muon capture		*JQMD + GEM	ETS or ETSART 1 meV	Original model

Red: Nuclear reaction model or library

Blue: Atomic interaction model or library

Models and libraries highlighted in gray are not used in the default setting

Original model has been implemented for transporting optical photons

# Major New Features in Version 3.36

- ✓ Implementation of light generation and transport algorithm
- ✓ Implementation of updated nucleus-nucleus reaction cross-section models
- ✓ Introduction of [outgoing particle bias] section to force generating secondary particles in specified directions
- ✓ Implementation of an algorithm for particle-induced characteristic X-ray (PIXE) and Auger electron production
- ✓ Introduction of HDF5-format tally output
- ✓ Improvement of rendering performance in PHIG-3D for visualizing voxel and mesh phantoms
- ✓ Development and public release of an AI-powered PHITS tutor

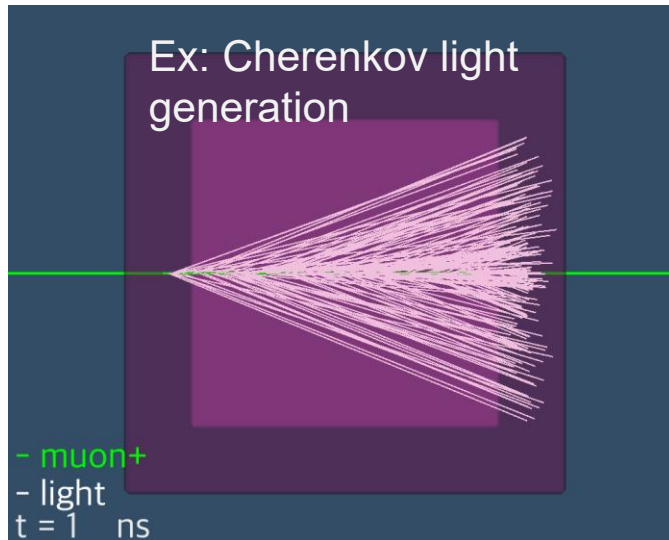
Details are highlighted in this file

# Implementation of Light Generation & Transport

## - Introduction of [Light] Section -

### Emission

- Scintillation light
- Cherenkov light
- Re-emission (Fluorescence / Phosphorescence / Wavelength Shifting)
- Light yield scaling factor
  - To reduce computation cost

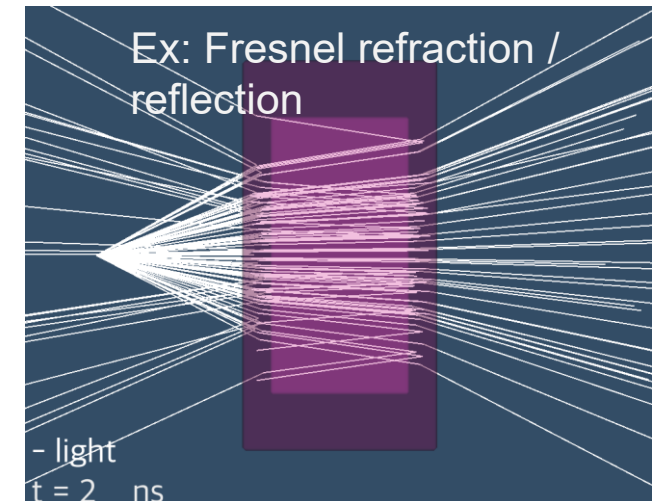


### Optical Properties of Regions

- Refractive index
- Absolute light yield, emission spectrum, Birks' law quenching
- Rise/decay time constants
- Absorption length / coefficient / internal transmittance
  - With/without wavelength dependence
- Scattering length / coefficient
  - With/without wavelength dependence
- Scattering type
  - Rayleigh, Mie scattering

### Boundary Properties

- Fresnel refraction / reflection
- Reflection
  - Specular, specular lobe
  - Lambertian, backscatter lobe
- Absorption / transmission
- Boundary type
  - Unidirectional / bidirectional



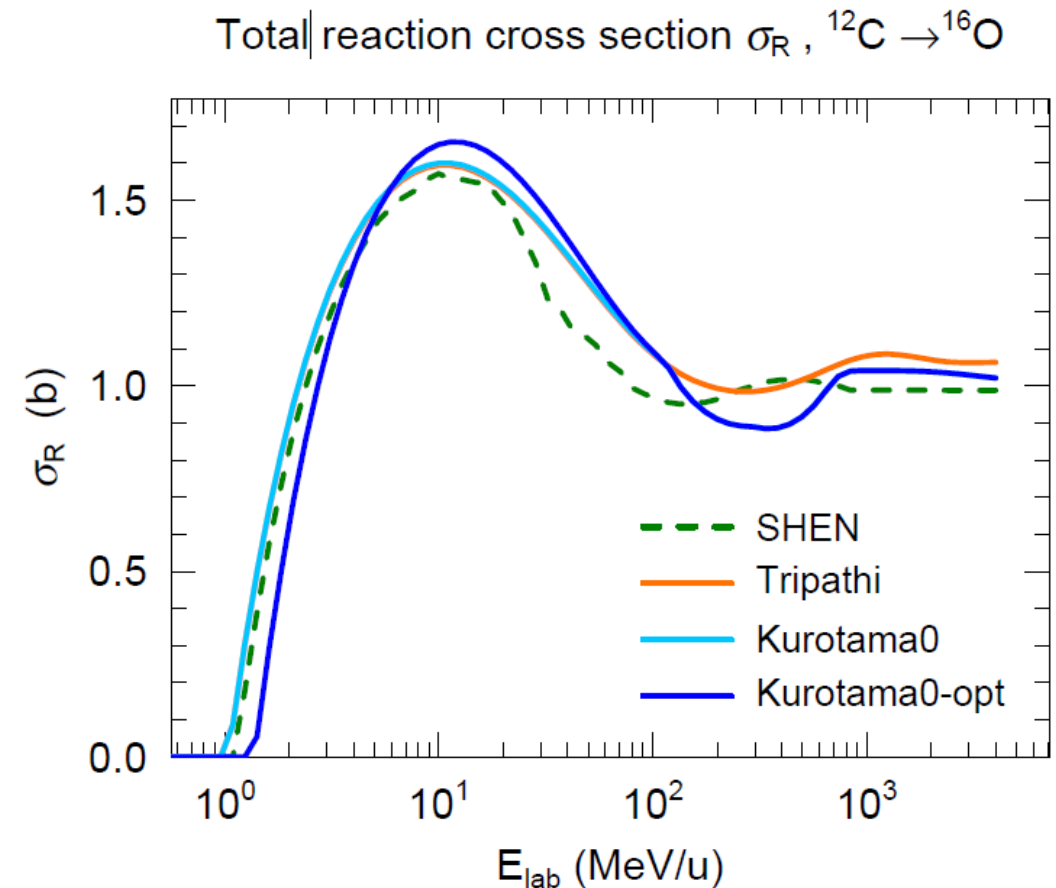
For more details, see the [Light] section in the manual and sample input included in recommendation¥light

# Enhanced Reaction Cross-section Models

## Implementation of the optimized hybrid KUROTAMA and Tripathi models [1]

- ✓ Selectable via **icrhi**, the nuclear reaction cross-section option
- ✓ Cross-section output function also added.

icrhi	Description
0	Shen
1	Tripathi
2	KUROTAMA hybrid
3	d special treatment
4	Tripathi optimized <b>NEW</b>
5	KUROTAMA hybrid optimized <b>NEW</b>
99	XS output mode <b>NEW</b>



# Implementation of [outgoing particle bias]

## What is [outgoing particle bias] ?

A new variance reduction technique\*. To improve statistics of outgoing particles from reactions, specified particles are directed to designated coordinates.

\* Currently applicable to only Rutherford scattering simulated by ITSART track-structure model

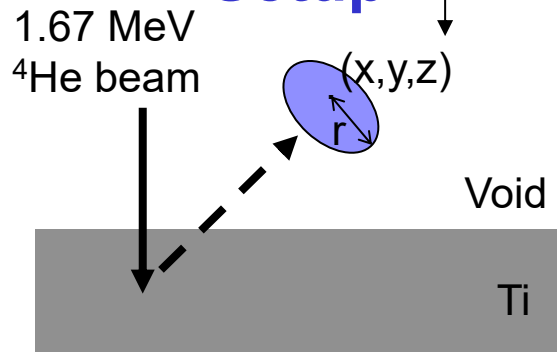
### Sample Format

#### [outgoing particle bias]

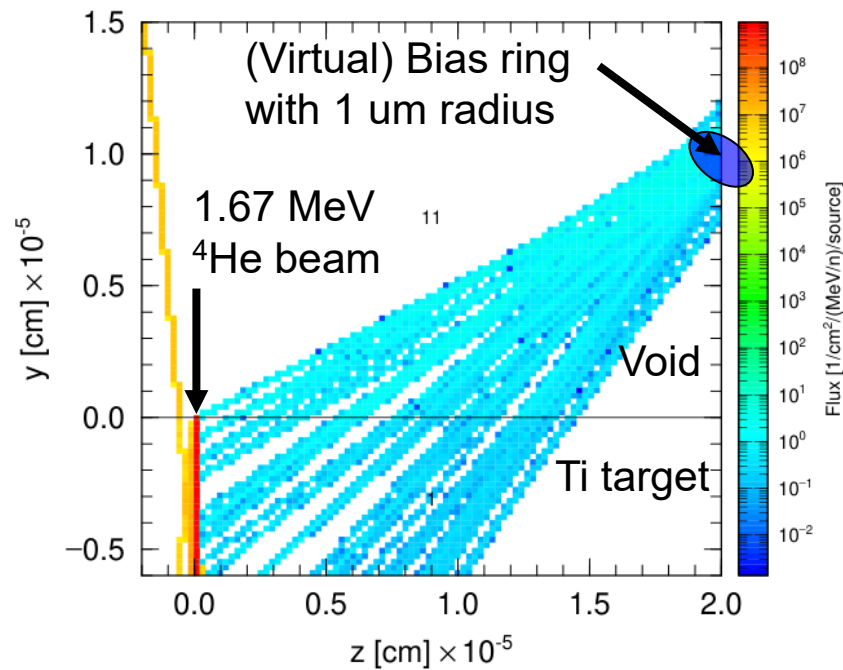
```
part = 4He
reg  x  y  z  r
1    0 1e-5 2e5 1e-6
```

(Detector's) coordinates

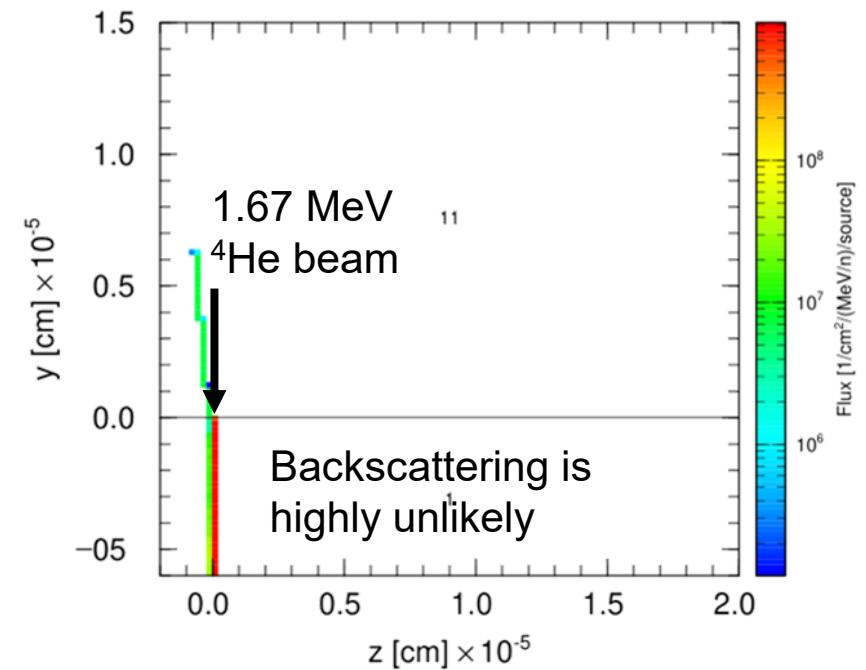
#### Setup



### With Bias



### Without Bias

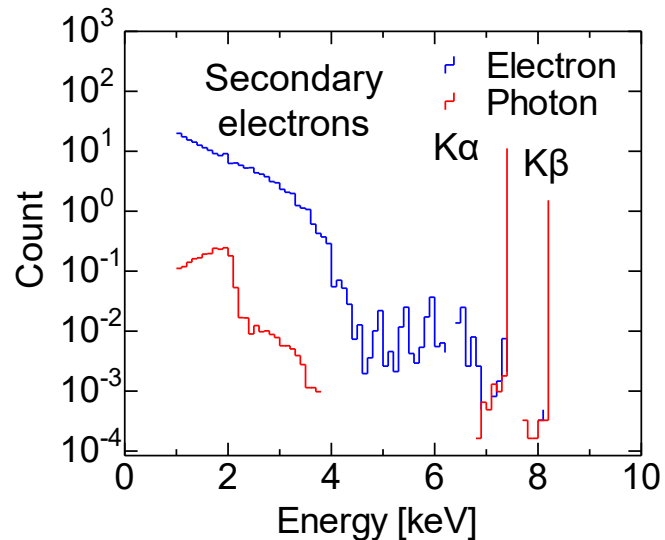


- ✓ Rare events (Rutherford back-scattering) are forced to happen.
- ✓ Particle weight is reduced based on differential X-section

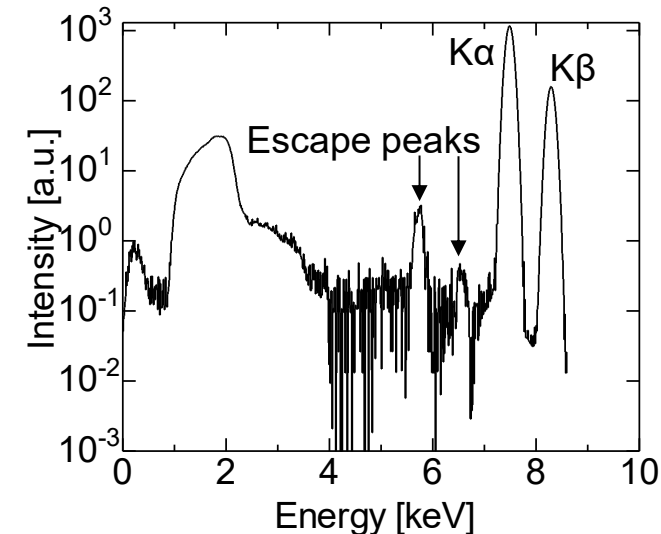
# Particle-Induced Characteristic X-ray and Auger Model

- ✓ Characteristic X-rays and Auger electrons from proton and heavy-particle beams can now be simulated.
- ✓ The *irelax* parameter controls the range of electron shells included in the generation. (1: K ... 7: all).

Example calculation: Simulation of 2 MeV proton irradiation of a Ni sample (*irelax* = -1)



**Generated Electron and Photon Spectra**



**Detector Response Spectrum**

Characteristic X-rays, Auger electrons, and background secondary electrons can be simulated (left). [T-deposit] gives the detector response (right). This makes it possible to simulate the full process, including PIXE measurements.

# Tally output in HDF5 format

- ✓ Development of a tally output function in Hierarchical Data Format (HDF).
- ✓ The output format has been adopted for PHITS tally files (.ph5 extension).
- ✓ Currently available for t-deposit and t-wwg tallies only.
- ✓ Future work: support for other tallies and a loading routine for restart calculations.

[ T-deposit ]

```
file = ***.out  
mesh = xyz
```

...

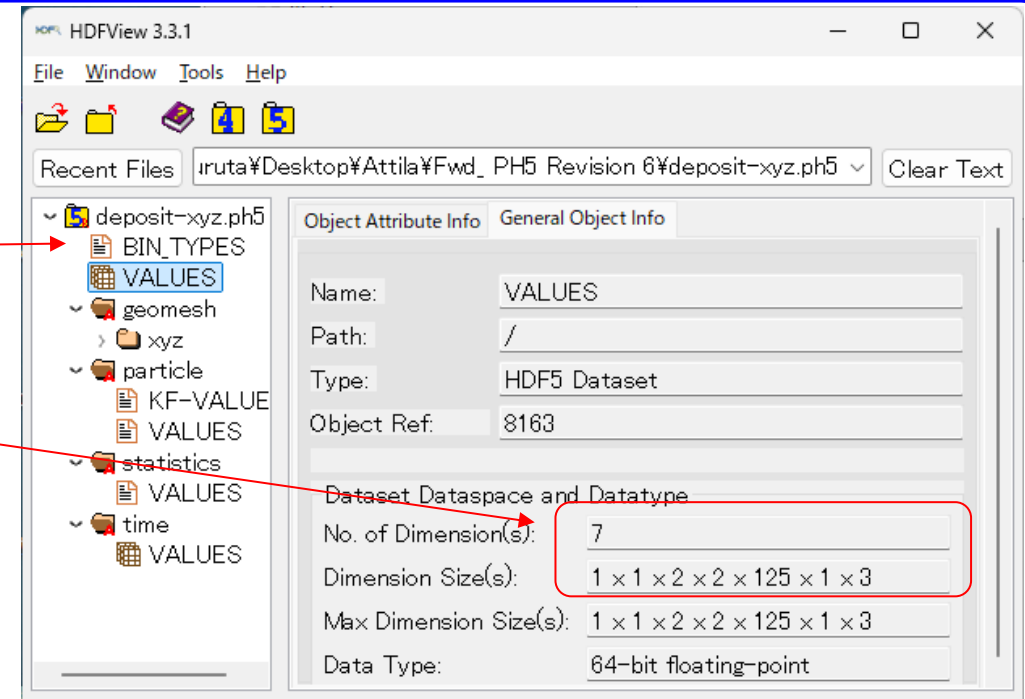
```
ph5out = 1
```

\*\*\*.ph5

Specifying data alignment

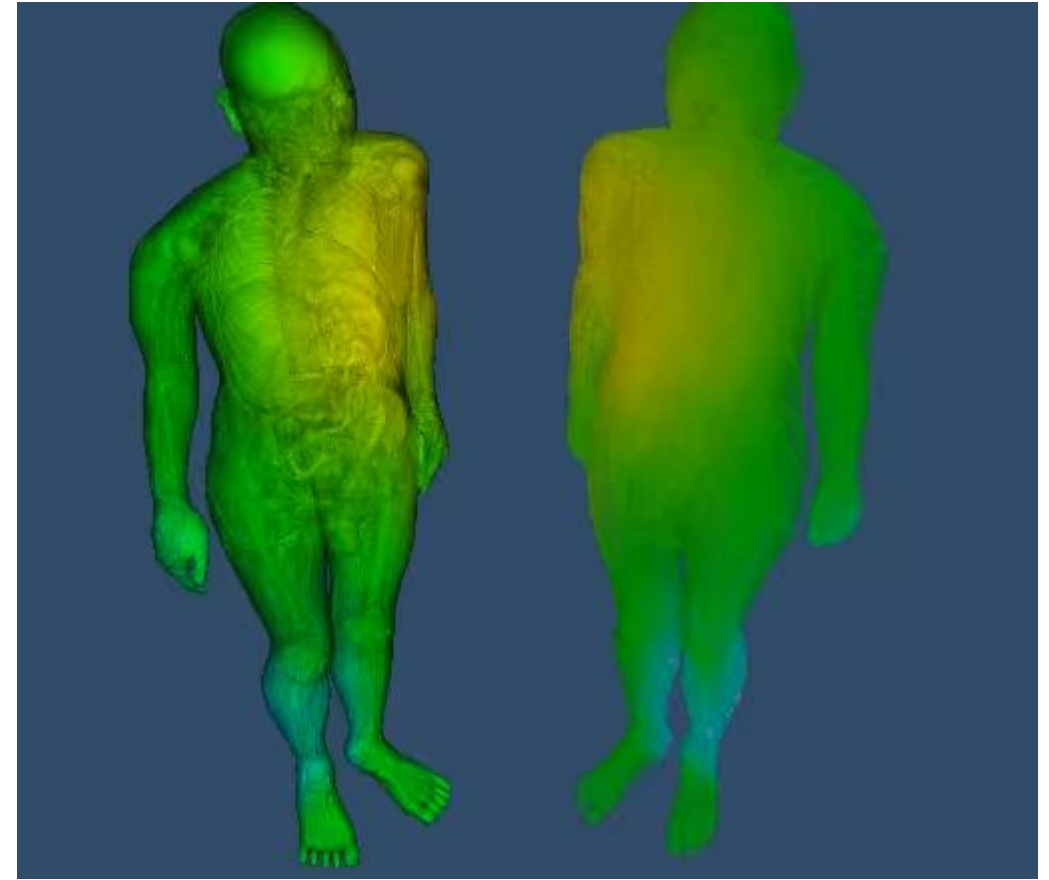
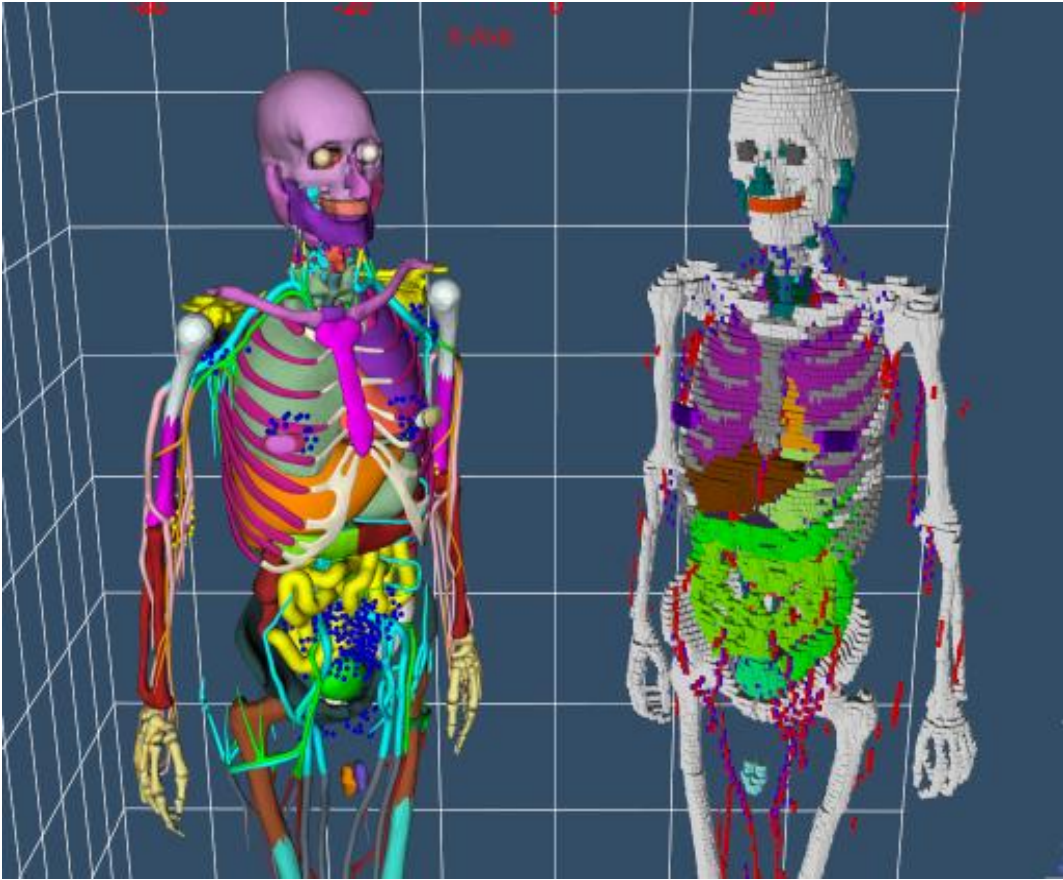
The 7-dimensional array used internally in PHITS tallies is output directly.

- Reduces bugs in input/output routines
- Makes future extension easier



**Future goal: Standardization of ph5 format for tally output**  
**Development of software to generate plots from ph5 files**

# Improvement of PHIG-3D



## Visualization of phits/sample/icrp tetra and voxel phantoms

- ✓ Improved rendering performance for tetra mesh geometries in TetGen and BDF formats
- ✓ Support for visualization of large-scale lattice structures, such as voxel phantoms
- ✓ Support for video export in WebM format

# Development of AI-powered PHITS tutor

## How to use it?

- ✓ Simply access NotebookLM page for PHITS (<https://x.gd/WAynQ>)\*

\*Google account is required to access this page

## How to create it for your own? (Optional)

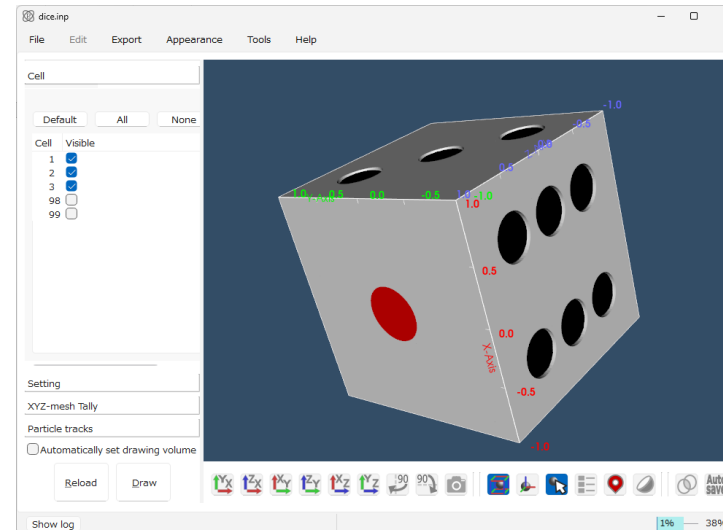
- ✓ Access your NotebookLM page\*
- ✓ Create a new notebook
- ✓ Upload manuals of PHITS/ANGEL/DCHAIN
- ✓ Upload text files\*\* in *manual/forAI* folder
- ✓ Edit *crucial\_notice\_forAI.txt* in *manual/forAI* if necessary

\*You can also use equivalent services in other AI

\*\*They contains all information given in *lecture*, *recommendation*, *sample*, *utility* folders

## Examples of prompts

- ✓ Please tell me the recommended settings for using PHITS in accelerator shielding calculations
- ✓ I would like to use the cosmic-ray source mode, so please tell me where the lecture materials and sample files are located
- ✓ I do not fully understand the content of Exercise 5 in lec01, so please explain it in detail
- ✓ Please modify the geometry in lec02 to a dice shape



## Example of geometry generated by AI

Note: It is better to give instructions in smaller pieces, since too many instructions at once can increase the likelihood of errors.

## Other New Features in Version 3.36

- ✓ Conversion of the entire source code to Fortran90 format and adoption of “cmake” for compilation
- ✓ Conversion of the manual of PHITS from PDF to HTML format
- ✓ Implementation of heat calculation algorithm using JENDL-5 for high-energy neutrons
- ✓ Parallelization of DCHAIN-PHITS to be applicable to both distributed- and shared-memory computing
- ✓ Introduction of reaction identification numbers for reaction-type output in user tallies and dump mode
- ✓ Introduction of dump mode in various tallies for output of individual contributing particle information
- ✓ Implementation of particle cutoff based on counter values
- ✓ Introduction of the ihistout parameter for progress output without batch splitting
- ✓ Introduction of new e-types in [source] for direct definition of energy & angular double-differential flux
- ✓ [t-point] calculations using the charged-particle and photonuclear data libraries becomes feasible
- ✓ Addition of a user-defined mirror function for neutron optics calculations
- ✓ Development a DVK mode for nuclear medicine in conjunction with RT-PHITS
- ✓ Introduction of the e-unit parameter to convert the energy in tally results into wavelength (nm or Å)
- ✓ Preparation of lecture notes on how to generate PHITS input files and run PHITS via Flair
- ✓ **Change in the default energy unit for nuclei in tallies from MeV to MeV/n**
- ✓ **Change in the default value of ides (a few % difference in photon deep-penetration calculations)**

More features are given in manual “1.1 Recent Improvements”

## Important bug fixes in Ver. 3.36

- ✓ Bug in the execution batch files (phits.bat and dchain.bat) when run in Windows PowerShell
- ✓ Bug causing underestimation of secondary particle energies when projectile fission occurs
- ✓ Three bugs related to the cosmic-ray source mode
- ✓ Bug in which trcl was ineffective in [weight window] and [t-dchain]
- ✓ Bug in which positrons were not taken into account with proj=all when only daughter nuclei underwent  $\beta^+$  decay
- ✓ Bug where electrons traveling against the electric field are cut off instead of flowing in the field direction after coming to a stop.
- ✓ Bug where user-defined time-dependent magnetic fields were not applied to electrons and positrons.
- ✓ Bug in nuclear reaction calculations using JAM, where angular momentum was not correctly taken into account.
- ✓ Bug in which cross sections for specific MT numbers could not be output when icntl = 1 and inucr = 100
- ✓ Bug where lost particles occur under specific conditions in the tetrahedral mesh.
- ✓ Bug in which anatally and restart calculations did not work properly for [t-deposit] with unit=5
- ✓ Bug in [t-time] where decay particles were not tallied with output = all, and cutoff particles were tallied with output = decay

Please refer “Recent Improvements” for more details

# Upcoming Futures

We are planning to ...

## ➤ Improve the track structure mode

- ✓ Extension of the precise mode applicable to other elements/compounds
- ✓ Improvement of coupling modules connecting to material & life sciences

## ➤ Develop user support functions

- ✓ Improvement of PHITS-Pad (help function)
- ✓ Coupling with deterministic codes via tetrahedral mesh in the HDF format
- ✓ Improvement in AI-powered PHITS tutor

## ➤ Improve accuracy and nuclear reaction model

- ✓ Improvement of JQMD to be faster and more accurate
- ✓ Improvement in the evaluation methods for both statistical & systematic uncertainty
- ✓ Comprehensive V&V