



29th Geant4 Collaboration Meeting

The Radiobiology Example:

A Flexible Framework for Machine Learning, Phase Space testing and beyond in Monte Carlo Applications

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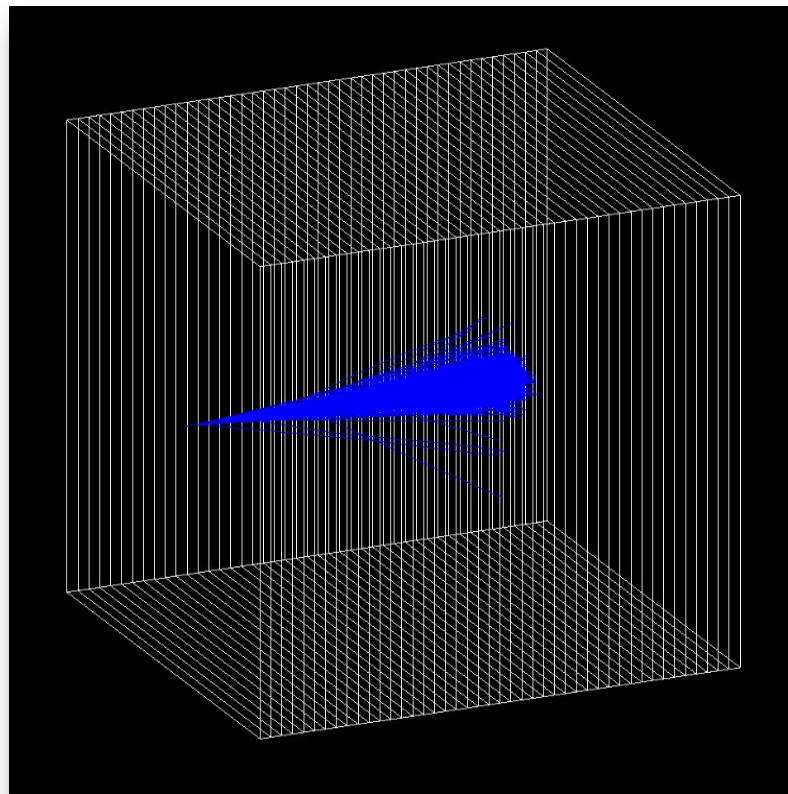
The Radiobiology Application

- Medical Extended Example
- Released with Geant4 version 11.2 on December 8th, 2023.
- It hereditates from the advanced example "hadrontherapy" classes to compute:
 - Dose;
 - LET;
 - Survival Fraction Curves;
 - RBE.
- The geometry is intentionally extremely simple to implement the concept of "sand-box"



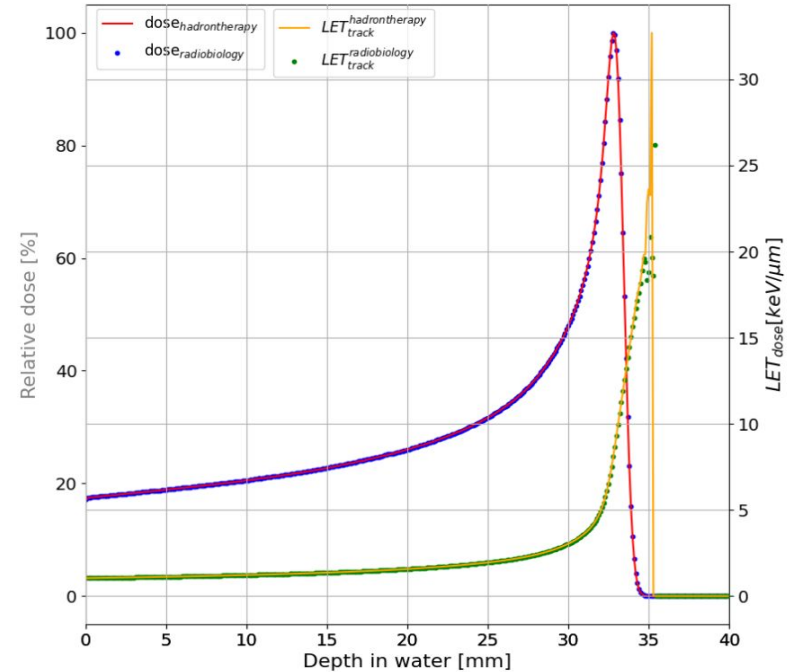
Radiobiology: Features

- LET (Linear Energy Transfer) Calculation
 - Dose-weighted (LETdose) and track-weighted (LETtrack) distributions provided
 - Algorithms validated through benchmark tests and publications
 - Calculates LET for both primary particles and secondary fragments
- Survival Curves and RBE (Relative Biological Effectiveness)
 - Built-in C++ classes to compute survival curves based on dose distributions
 - Integrated algorithms for RBE calculations, validated through multiple studies
- Future developments
 - ML algorithms will convert Geant4 micrometric scale outputs to Geant4-DNA nanometric scale without additional CPU load
 - Support for phase-space input from specific beamline facilities



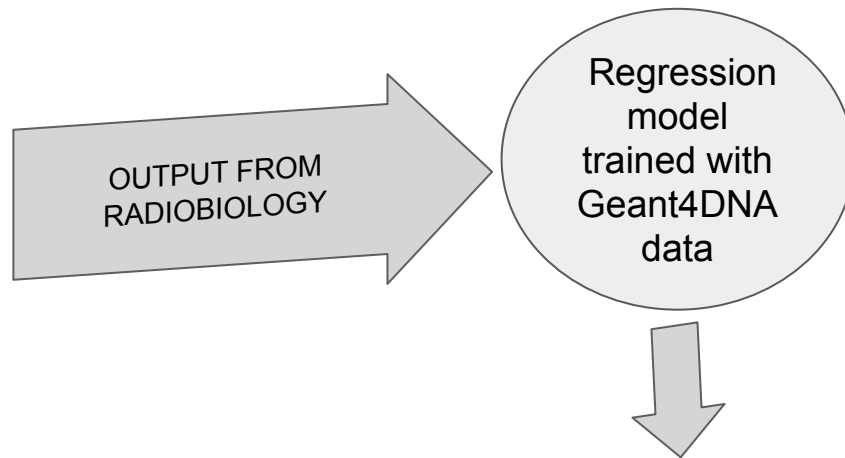
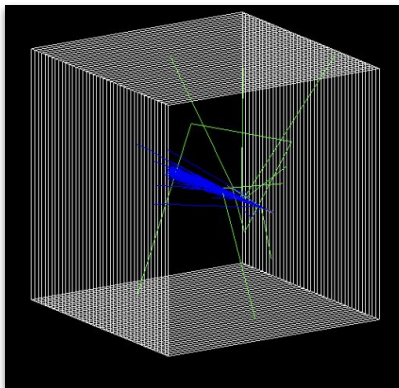
Radiobiology: Benchmarking and Validation

- The "radiobiology" application underwent rigorous testing and benchmarking against the "hadrontherapy" application, using identical beam configurations for comparison.
- Results of one such comparison, focusing on **dose** and **LETtrack** distributions with a **62 MeV beam**, are presented
- The comparison reveals full agreement between the outputs of both applications, with slight differences in LETtrack distributions attributed to low statistics in the distal part.



Radiobiology: Current and future development

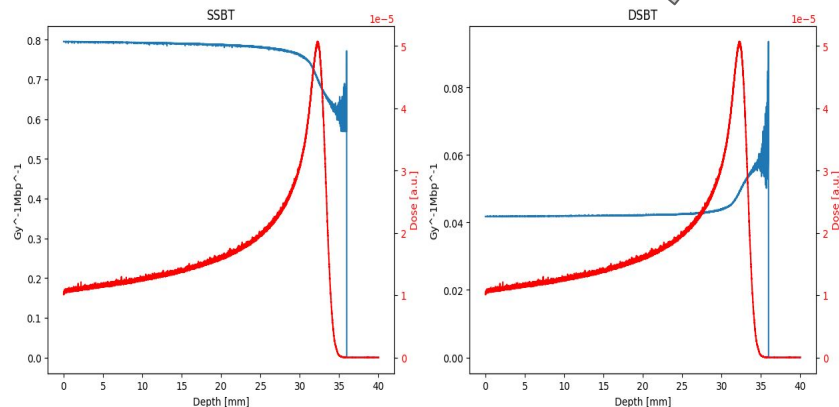
Simple workflow
on how to use
NN regression as
a postprocessing
step



GANDALF: Generative ANsatz for DNA damage evALuation and Forecast. A Neural Network-Based Regression for Estimating Early DNA Damage Across Micro-Nano Scales

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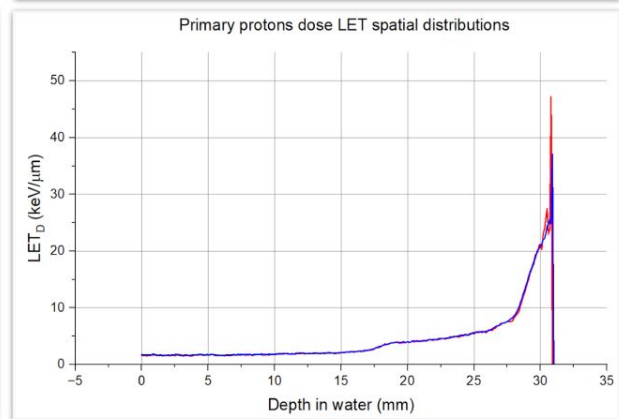
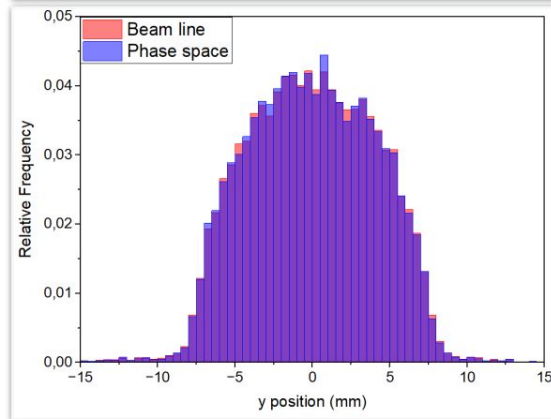
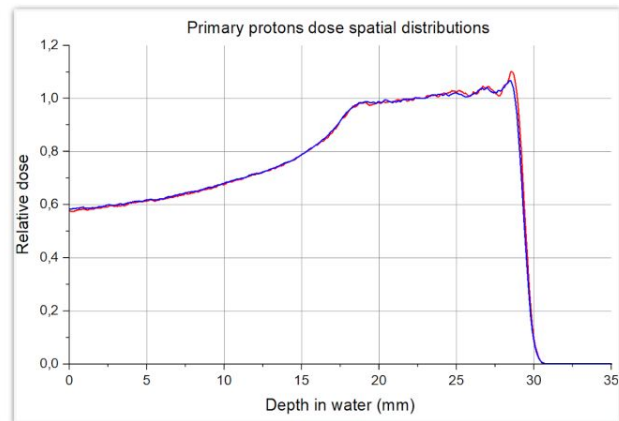
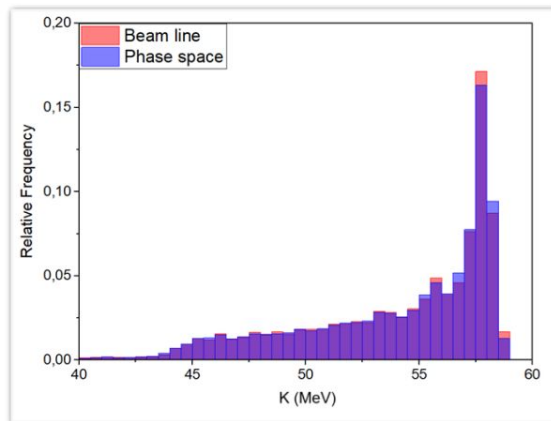
CURRENTLY UNDER REVIEW



Radiobiology: Current and future development

Phase-Space File Compatibility for Complex Beamline Geometries

- Inherited from the Hadrontherapy example, the application will be able to read phase-space files generated by real-world particle beam facilities.
- Enables simulation of highly complex beamline configurations, allowing detailed modeling of actual clinical or experimental setups.



**Thank
you**

