ISSUE WITH HADRONIC PHYSICS AIIHP

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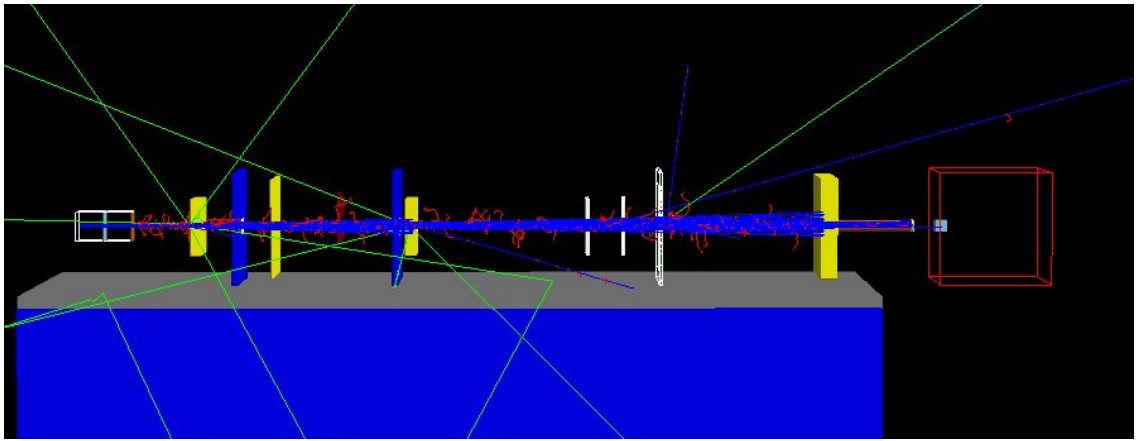
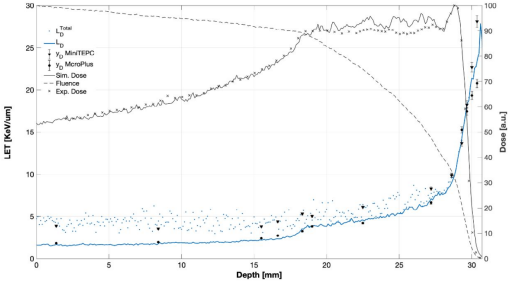
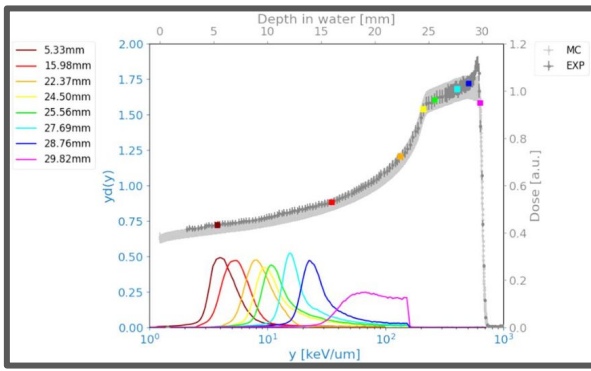
Hadrontherapy advanced example

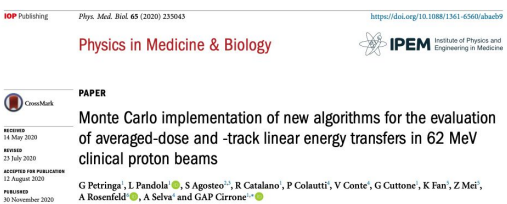


- Dose
- LET
- RBE

Benchmarked several times against experimental data






IOP Publishing Phys. Med. Biol. 65 (2020) 235043 https://doi.org/10.1088/1361-6560/abaeb9

Physics in Medicine & Biology

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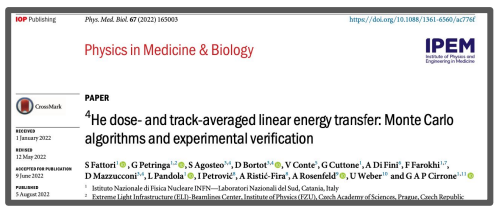
PAPER

Monte Carlo implementation of new algorithms for the evaluation of averaged-dose and -track linear energy transfers in 62 MeV clinical proton beams

G Petringa, L Pandola, S Agosteo, R Catalano, P Colautti, V Conte, G Cuttone, K Fan, Z Mei, A Rosenfeld, A Selva and GAP Cirrone


IOP Publishing Phys. Med. Biol. 67 (2022) 165003 https://doi.org/10.1088/1361-6560/ac776f

Physics in Medicine & Biology

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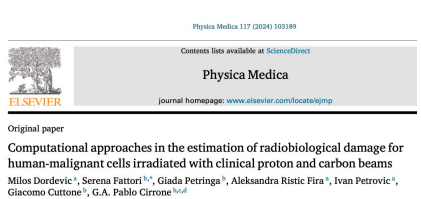
PAPER

^{4}He dose- and track-averaged linear energy transfer: Monte Carlo algorithms and experimental verification

S Fattori, G Petringa, S Agosteo, D Bortot, V Conte, G Cuttone, A Di Fini, F Farokhi, D Mazzucconi, L Pandola, I Petrović, A Ristić-Fira, A Rosenfeld, U Weber and G A P Cirrone


Physica Medica 117 (2024) 103189

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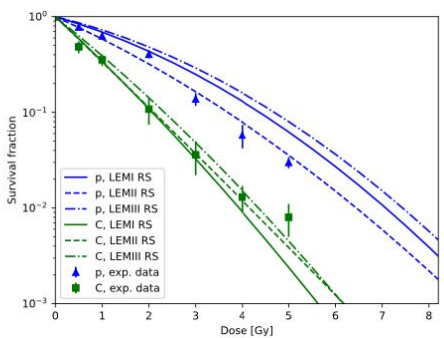
journal homepage: www.elsevier.com/locate/ejmp

Original paper

Computational approaches in the estimation of radiobiological damage for human-malignant cells irradiated with clinical proton and carbon beams

Milos Dordevic, Serena Fattori, Giada Petringa, Aleksandra Ristic Fira, Ivan Petrovic, Giacomo Cuttone, G.A. Pablo Cirrone



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S Fattori et al 2022 Phys. Med. Biol. 67 165003 https://doi.org/10.1088/1361-6560/ac776f

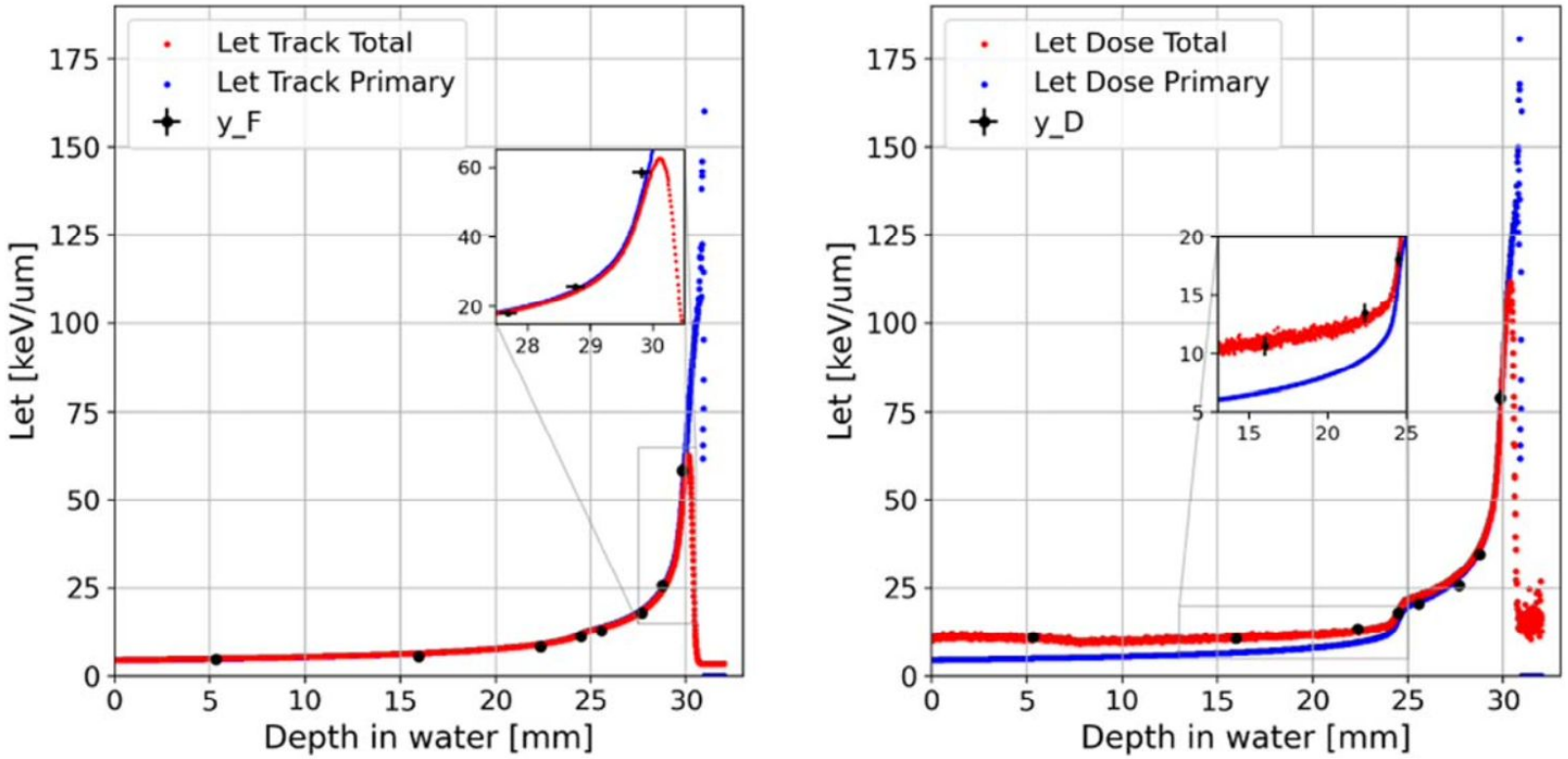

Figure 5. Configuration B: $\bar{y}_F$ values in comparison with the $\bar{L}_t$ values (image on the left), and $\bar{y}_D$ values in comparison with $\bar{L}_d$ values (image on the right): in red $\bar{L}_{t/d}^{Total}$, in blue $\bar{L}_{t/d}$ of the primary, and in black the corresponding microdosimetric quantities $\bar{y}_{F/D}$.

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Hadrontherapy Physics Lists used

HADRONTHERAPY_1

- standard_opt4
- G4DecayPhysics()
- G4RadioactiveDecayPhysics()
- G4IonBinaryCascadePhysics()

- G4EmExtraPhysics()
- G4HadronElasticPhysics**HP**()
- G4StoppingPhysics()
- G4HadronPhysicsQGSP_BIC_**HP**()
- G4NeutronTrackingCut()

HADRONTHERAPY_2

- standard_opt4
- G4DecayPhysics()
- G4RadioactiveDecayPhysics()
- G4IonBinaryCascadePhysics()

- G4EmExtraPhysics()
- G4HadronElasticPhysics()
- G4StoppingPhysics()
- G4HadronPhysicsQGSP_BIC()
- G4NeutronTrackingCut()

HADRONTHERAPY_3

- standard_opt4
- G4DecayPhysics()
- G4RadioactiveDecayPhysics()
- G4IonElasticPhysics()
- **G4IonPhysicsPHP()**
- G4EmExtraPhysics()
- **G4HadronElasticPhysicsHP()**
- G4StoppingPhysics()
- **G4HadronPhysicsQGSP_BIC_AllHP()**
- G4NeutronTrackingCut()

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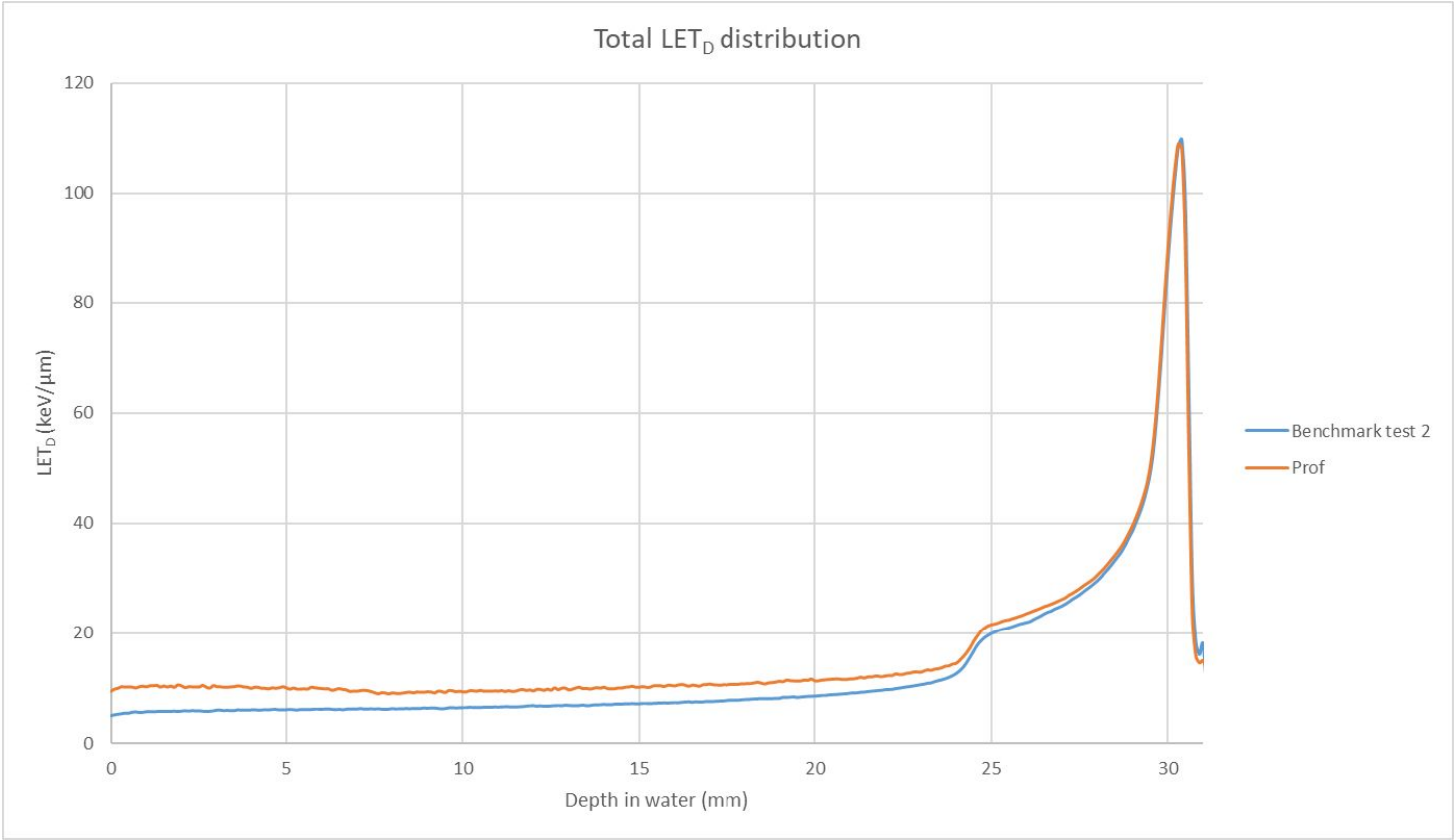
Comparison of Let_dose total

- Master Thesis on Geant4 code development
- Geant4 **11.2.1**
- Benchmark activity of comparison with results of **10.6.2**



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SEQUENCE OF TESTS:

1. LET_dose total was reproducing experimental data in version 10.6.2 with AllHP
   https://doi.org/10.1088/1361-6560/ac776f

2. We noticed LET_dose total with AllHP totally changed in version 11.2.1. The problem does NOT involve:
   - LET_dose of the primary (tested with He4)
   - LET_track total and of the primary

3. TENDL table (1.3.2 in 10.6.2 and 1.4 in 11.2.0) were exchanged (used 1.3.2 with 11.2.1) but the problem remained → **the issue is not caused by the change in the TENDL data tables**

4. Several hadrontherapy versions were compiled and run with their corresponding version of geant4 to identify when the change started to show up:
   - until version **11.1.3 of 10 Nov 2023 it was OK**
   - from version **11.2.0 of 08 Dec 2023 the problem started**

5. Hadrontherpy downloaded from version 11.1.3 was compiled and run with geant4 version 11.2.0: the result is **NOT OK** → **the issue is not inside the example**

6. Also the versions subsequent to 11.2.1 were tested to verify the issue was not solved in the newest releases:
   - 11.2.2: the problem is still there
   - 11.3.0.beta: the problem is still there

7. Hadrontherapy from 11.3.0.beta was compiled with geant4 **11.3.0.beta** and was run with **another hadronic physics model** and the result was compatible with that one of versions from 11.1.3 and older and so **OK**

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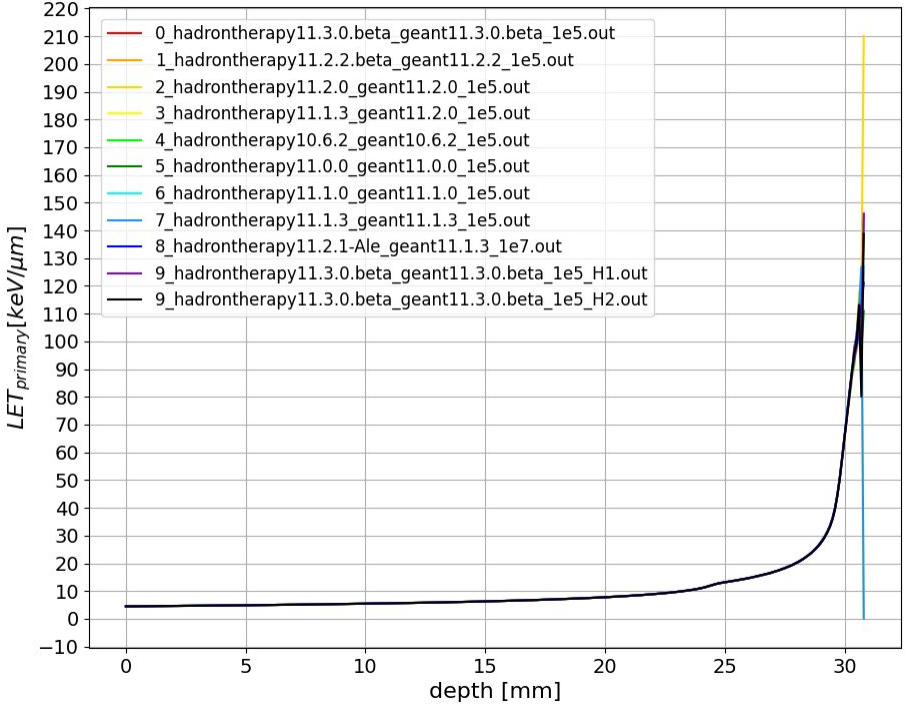
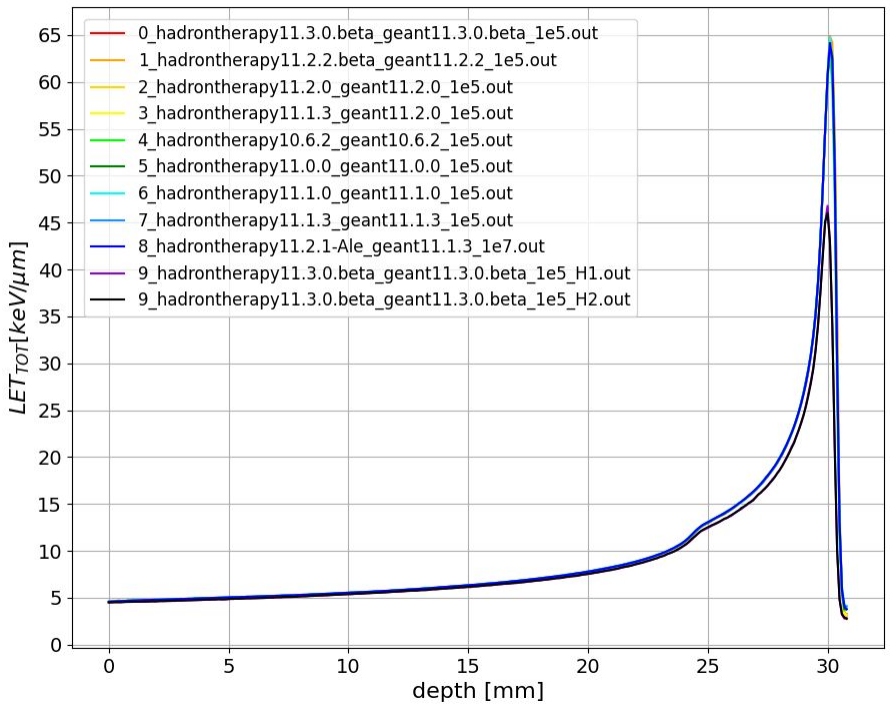
LET_track

As mentioned the issue does not affect the LET_track

LET_{TRACK}





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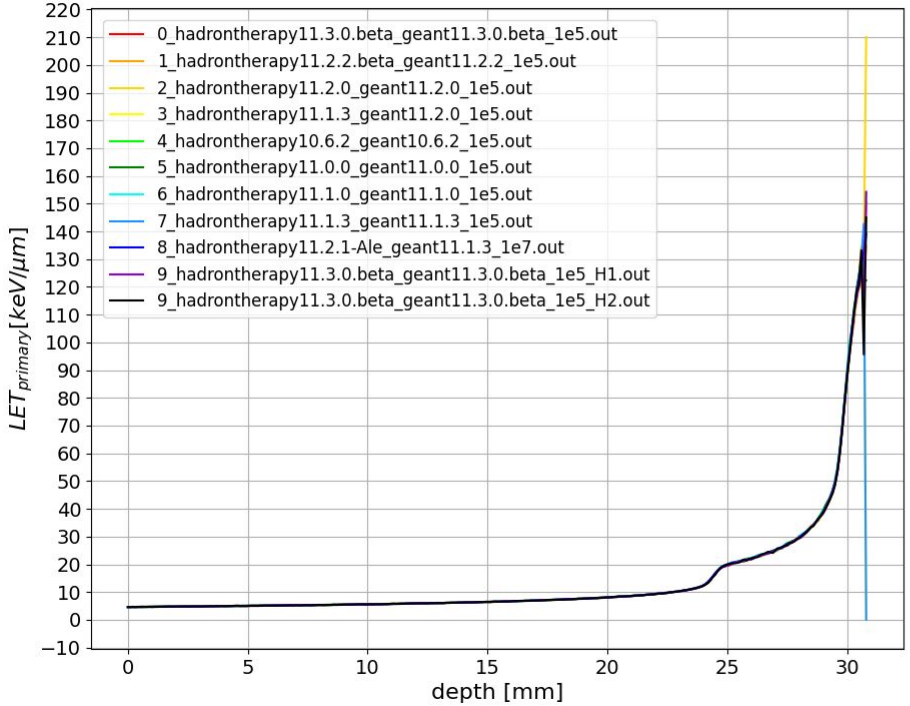
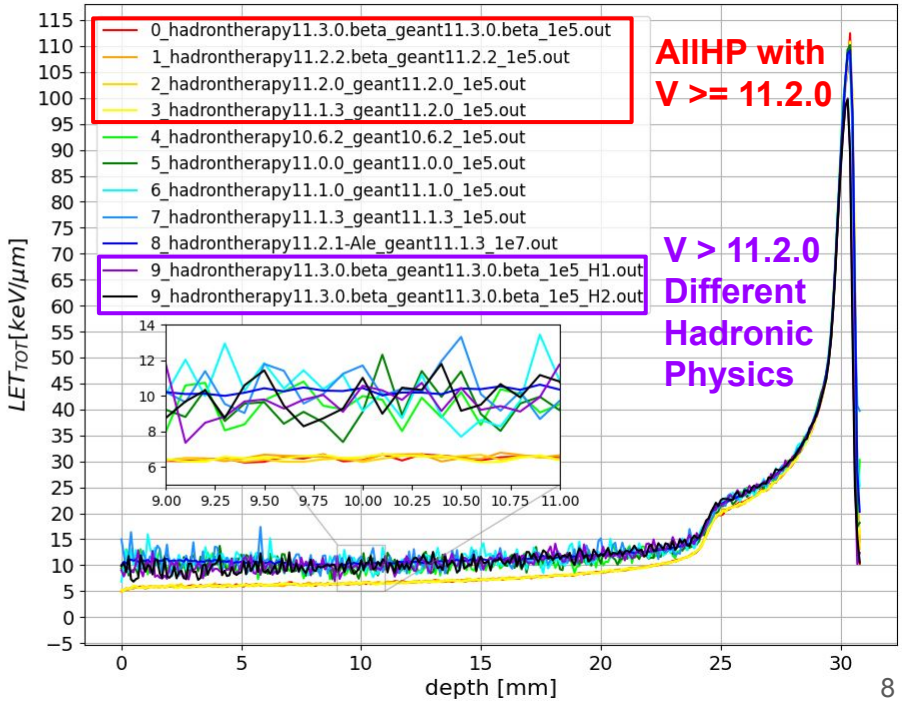
LET_dose

Another evident anomaly, beside the absolute value, is represented by the statistical fluctuations: all versions are run with a 10^5 histories and results are expected to be very noisy for LET_dose total, and so it is for versions before 11.2.0, while for the subsequent versions (red, orange, gold and yellow curves) the fluctuations are unbelievably tiny, comparable with statistics of the order of 10^7 histories (run represented with blue curve)

LET_{DOSE}





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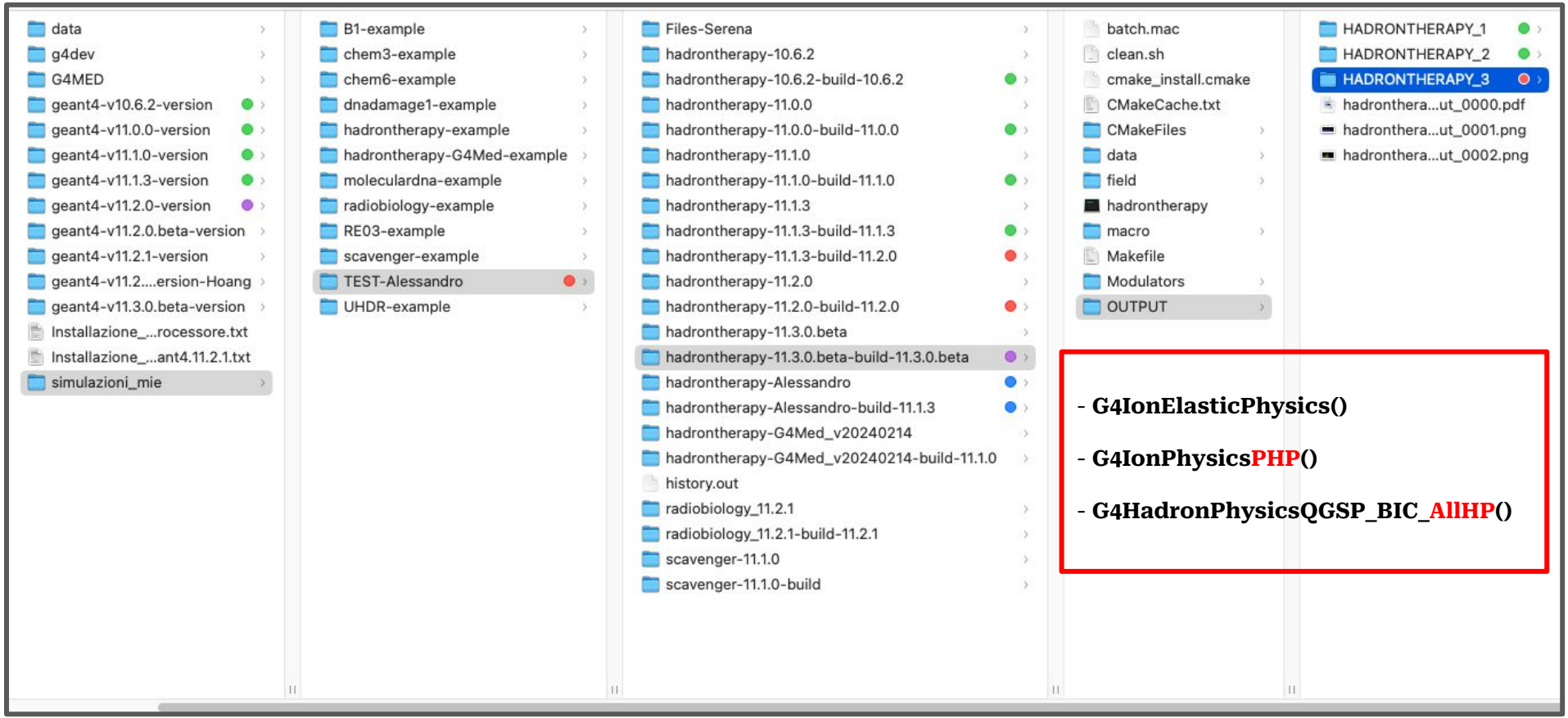
Summary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- G4IonPhysicsPHP()
- G4HadronPhysicsQGSP_BIC_AllHP()