The importance of Monte Carlo (Geant4) physics settings for clinical proton therapy treatment plans.

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Purpose

This study investigates the influence of **GATE/Geant4 settings** on dose results and calculation times for **clinical proton therapy.**

A paper giving full details of the presented work is currently under review.

Materials and Methods

- Same **GATE/Geant4** versions as used in **GATE-RTion1.0** [1]: GATE8.1 and Geant4.10.3.p03.
- Investigated **physics lists** (**QGSP_BIC_EMY**, **QGSP_BIC_EMZ**, **QGSP_BIC_HP_EMZ**).
- Investigated **production cuts** on photons, electrons and positrons (restrict which particles are explicitly produced, 0.1mm-10mm).
- Simulations in a **solid water phantom** (for patient specific quality assurance) and within the **patient CT** (treatment sites: Neck, spine with titanium implant, paranasal), 0.25% statistical uncertainty at the 90-100% isodose level.

Conclusion

Physics lists:

No substantial dose difference when using the **HP (High Precision neutron) module**. Best agreement to measurement data was found for **QGSP_BIC_EMZ** reference physics lists at the cost of 10-30% increased execution times compared to **QGSP_BIC_EMY**.

Production cuts on electrons, photons and positrons of 1 mm (phantom/range-shifter) and 10 mm (world) substantially reduce calculation times.

Comparison within solid water (patient specific quality assurance)

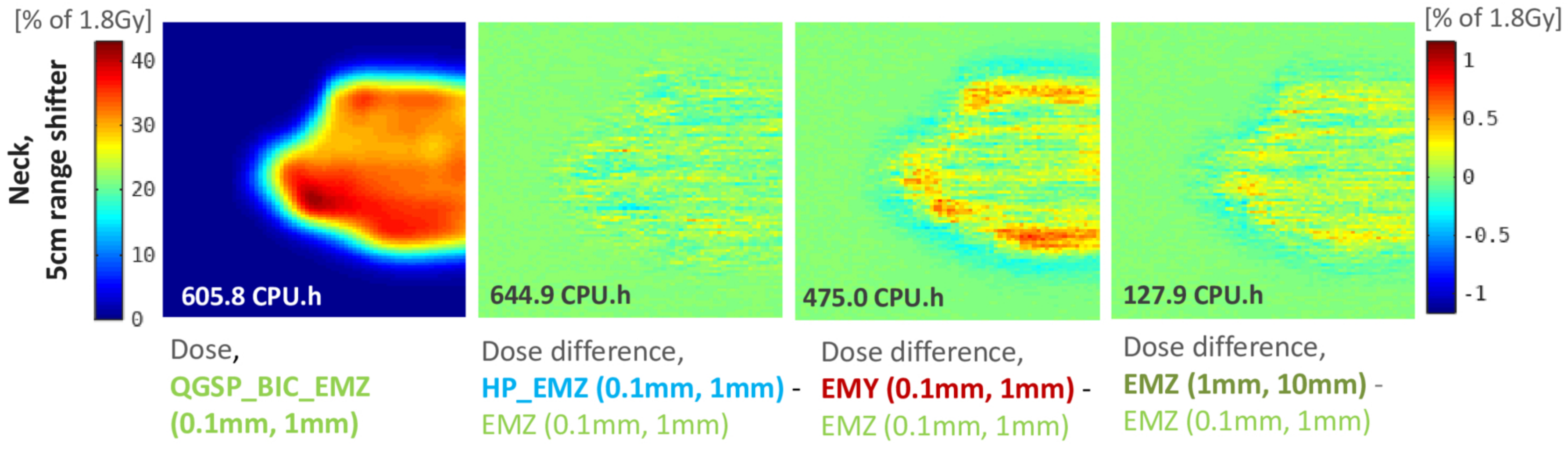


Figure 1: Calculation time & dose difference due to physics settings and production cuts in (phantom/range shifter, world).

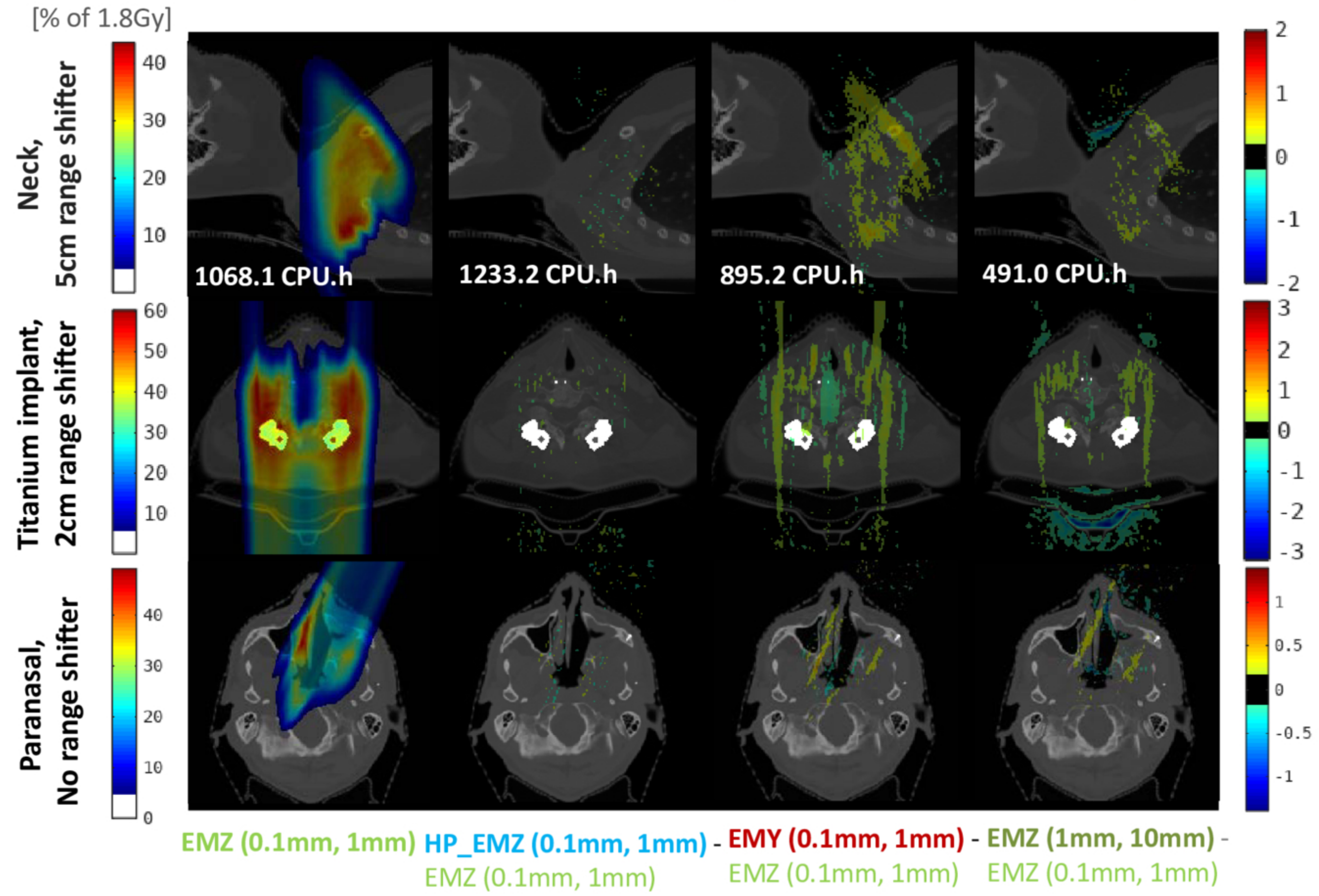
Physics lists:

- No substantial dose differences in the target volume when using the **HP module**, calculation times are increased by a factor of 1.1.
- Difference in scattering when comparing **EMY** against **EMZ**, calculation times are decreased by a factor of 1.3.

Production cuts:

- No substantial influence on dose, calculation times are decreased by a factor of 4.7.

Comparison within the patient CT



Physics lists:

- The high precision neutron libraries (**HP**) do not cause substantial dose differences in the field, calculation times are increased by a factor of 1.2.
- In agreement with the solid water calculations, there is a difference in scattering when comparing **EMY** against **EMZ**. Calculation times are decreased by a factor of 1.2.

Production cuts:

- Dose differences at interfaces between high and low density tissues when comparing production cuts. Calculation times are decreased by a factor of 2.2.

Figure 2: Calculation time & dose difference in patient CT due to physics settings and production cuts in (phantom, world).

References

[1] L. Grevillot et al., Technical Note: GATE-RTion: a GATE/Geant4 release for clinical applications in Scanned Ion Beam Therapy, accepted in Medical Physics (2020).

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