

Accelerated Prompt Gamma estimation for clinical Proton Therapy simulations

B.F.B. Huisman, J.M. Létang, É. Testa, D. Sarrut



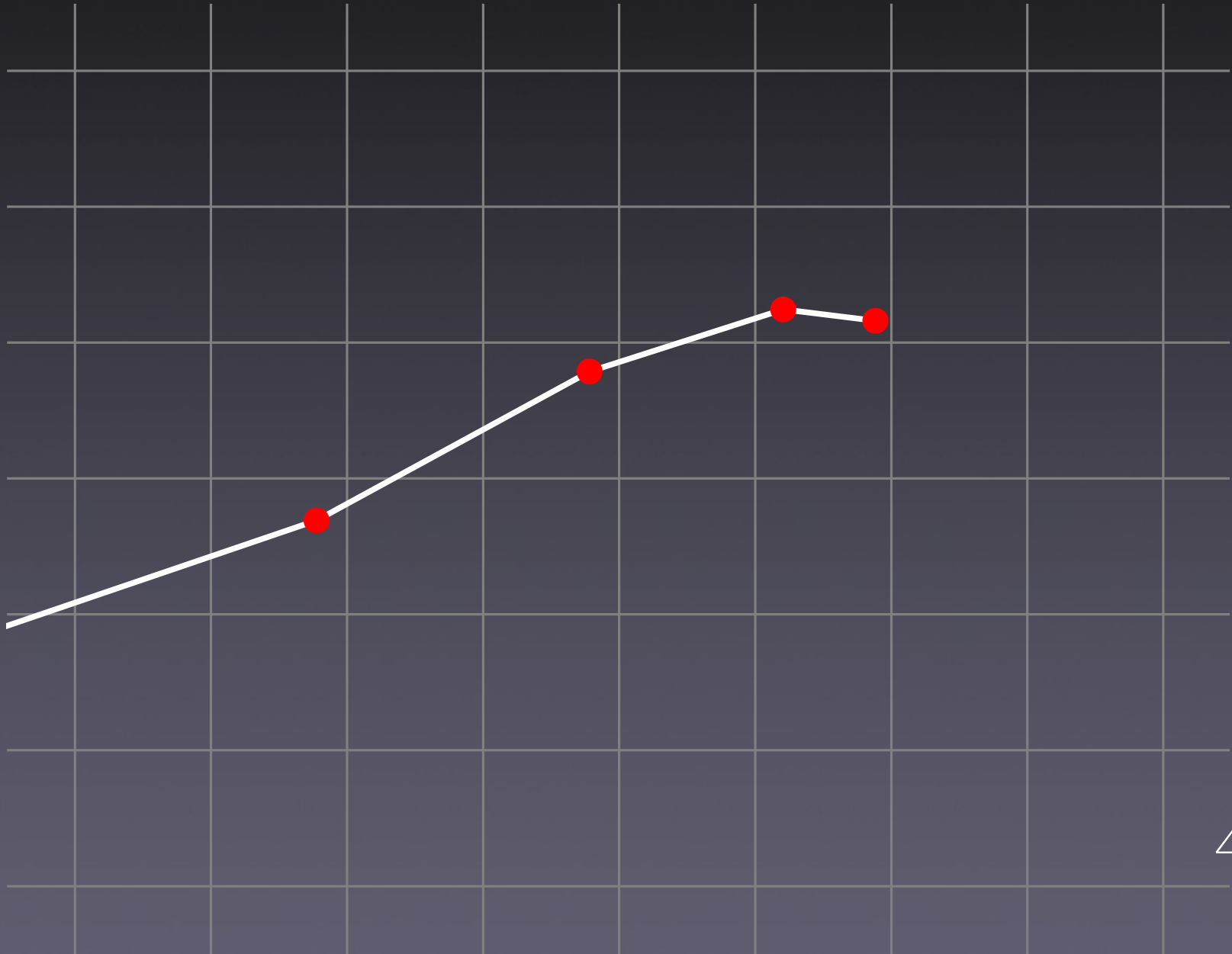
Prompt Gamma (PG)

- Promising modality for particle treatment monitoring
- However: detection yields are low
- 2 Gray treatment fraction $\approx 10^{10}$ protons
- Per spot: $10^3 - 10^4$ recoverable PGs
with collimation, knife-edge cameras
- Geant4/Gate: 4.5 cpu years
@ single core Intel Core i7 2.66GHz

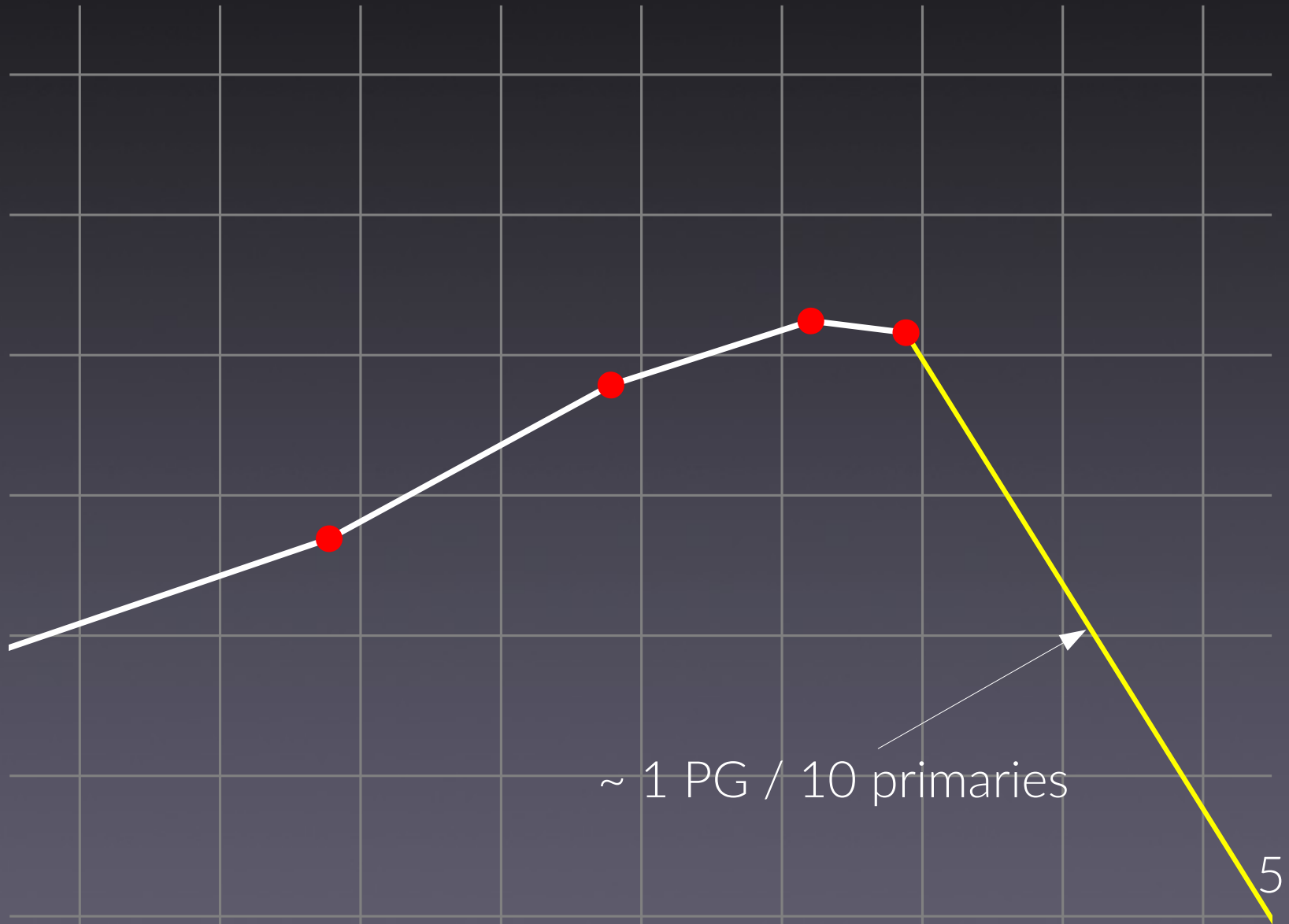
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- Let's see what we can do...

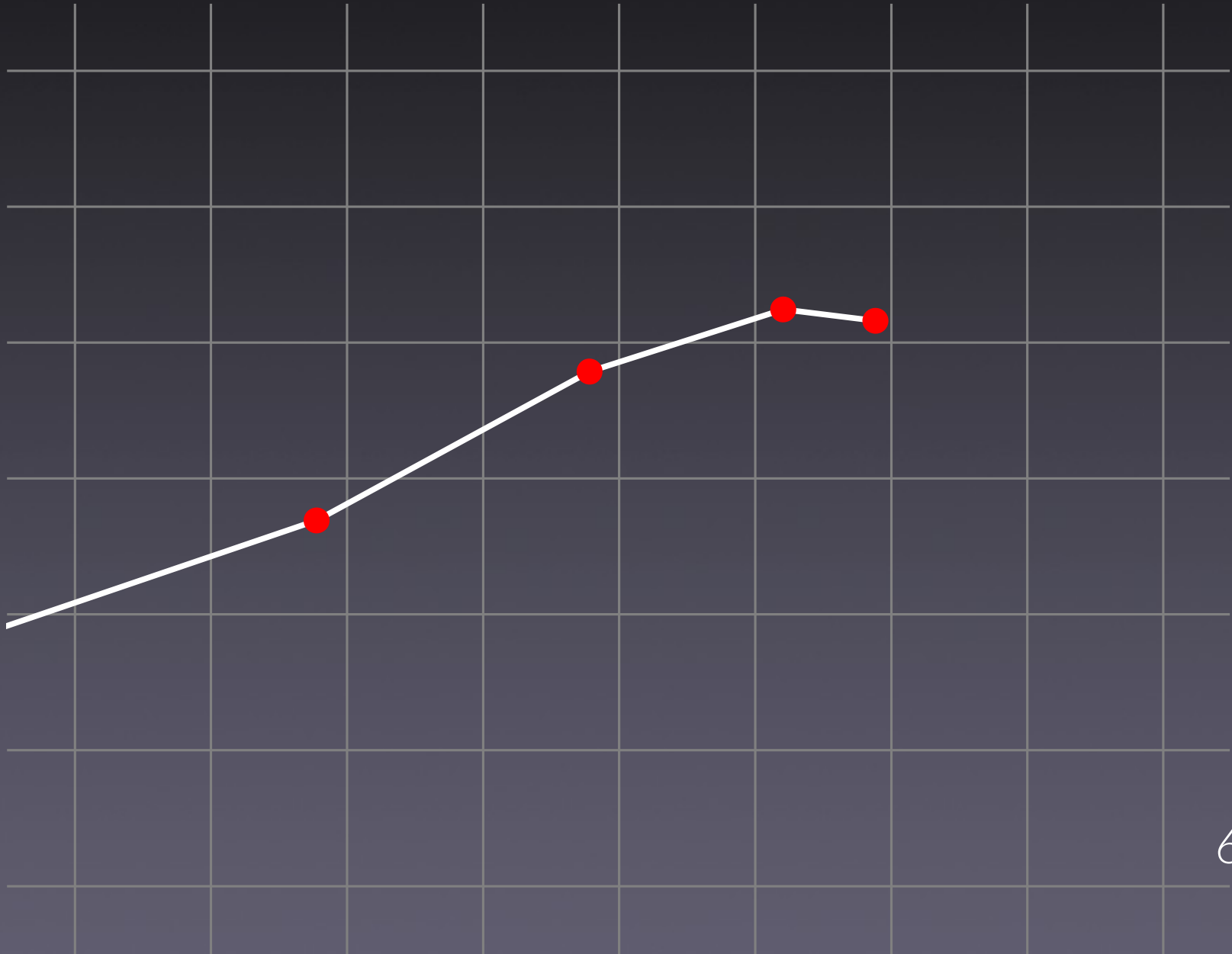
Analog MC



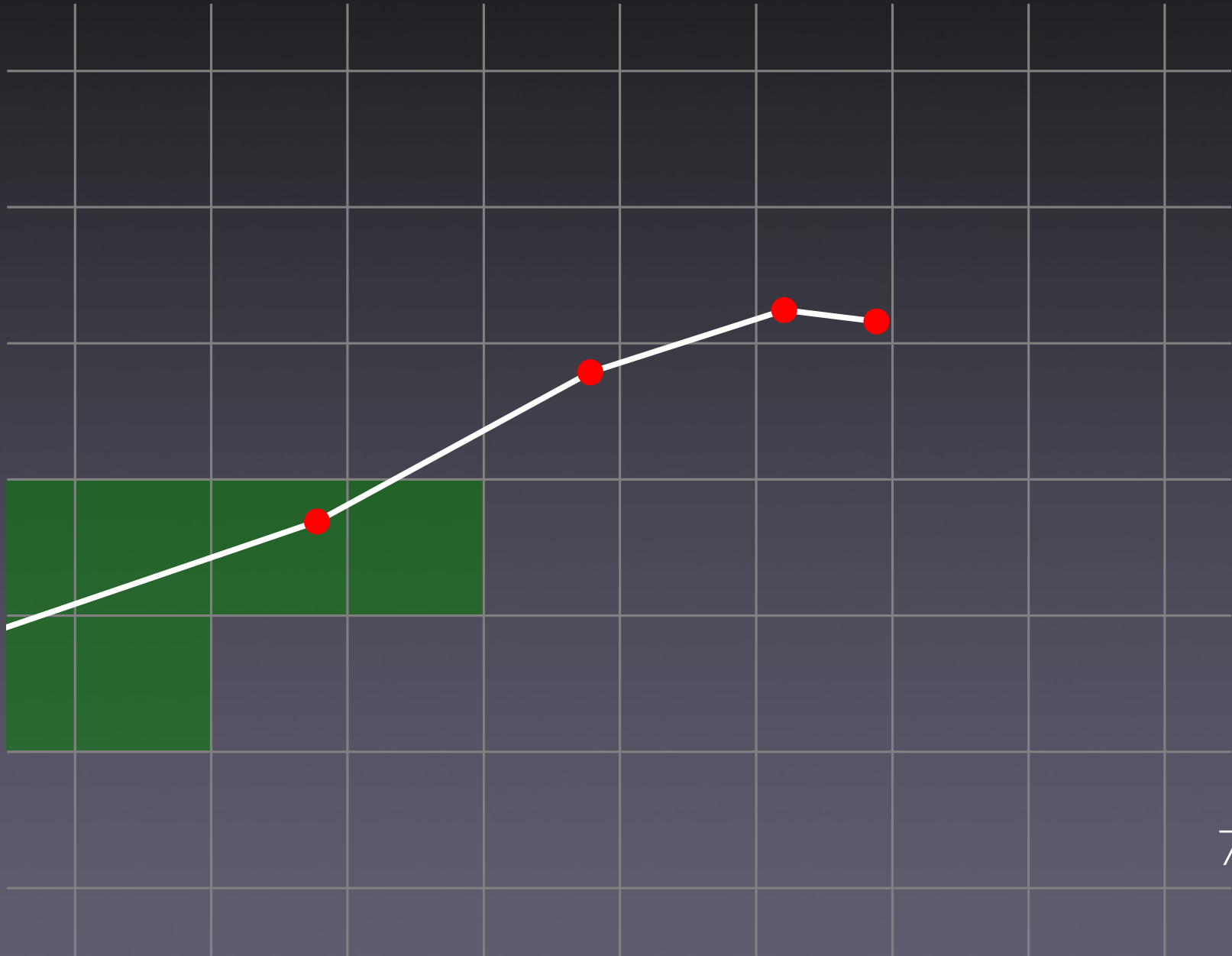
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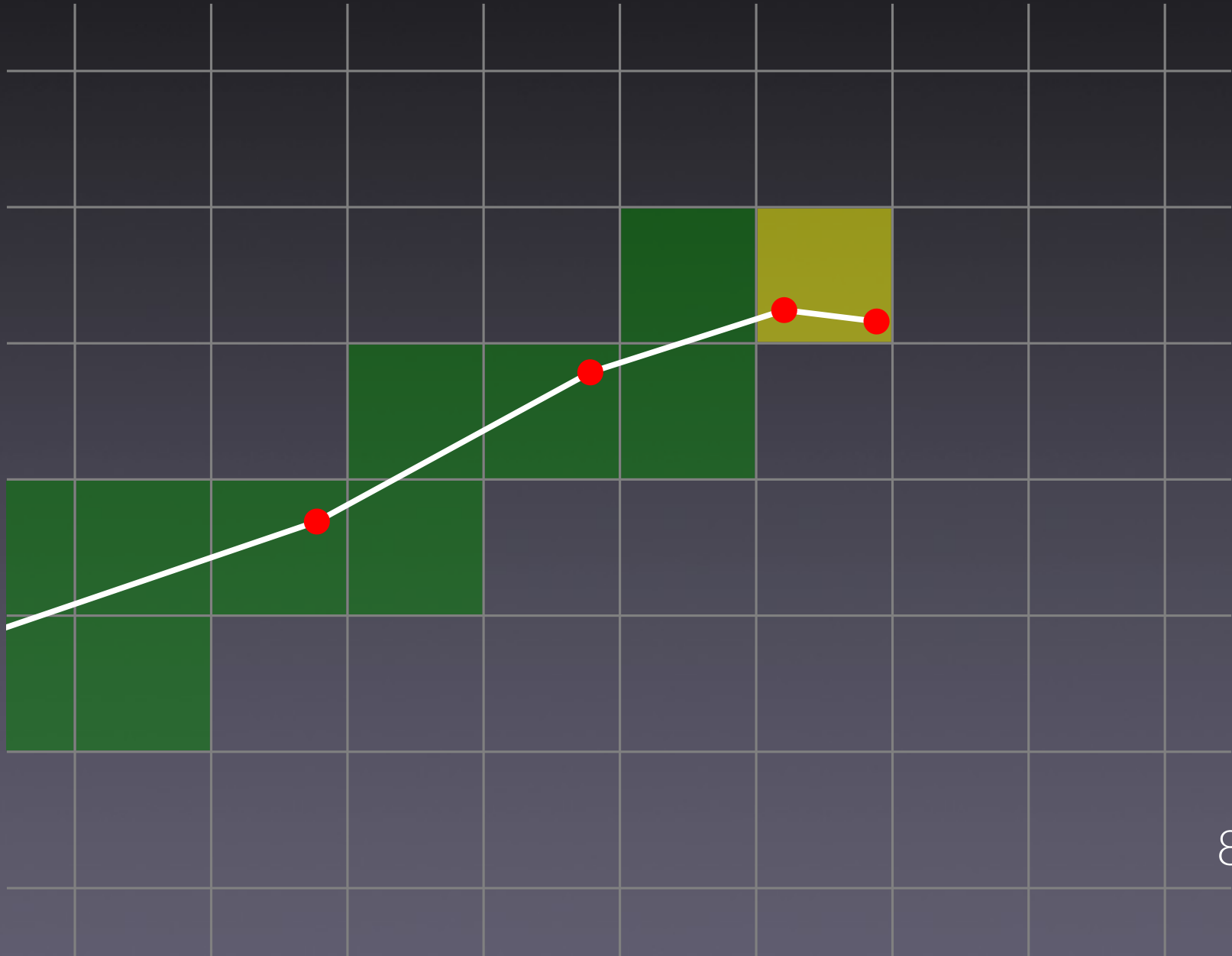
vpgTLE



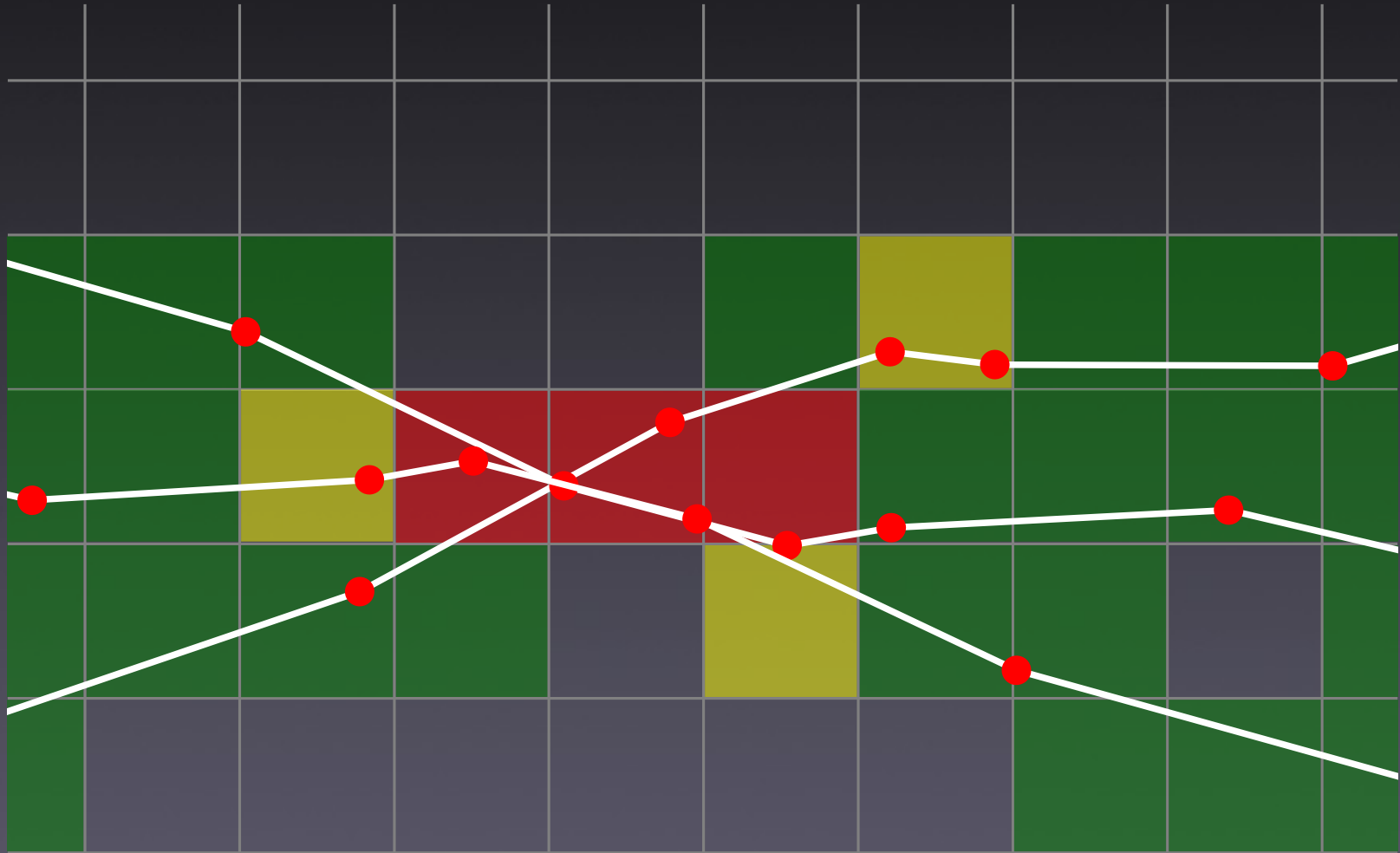
vpgTLE



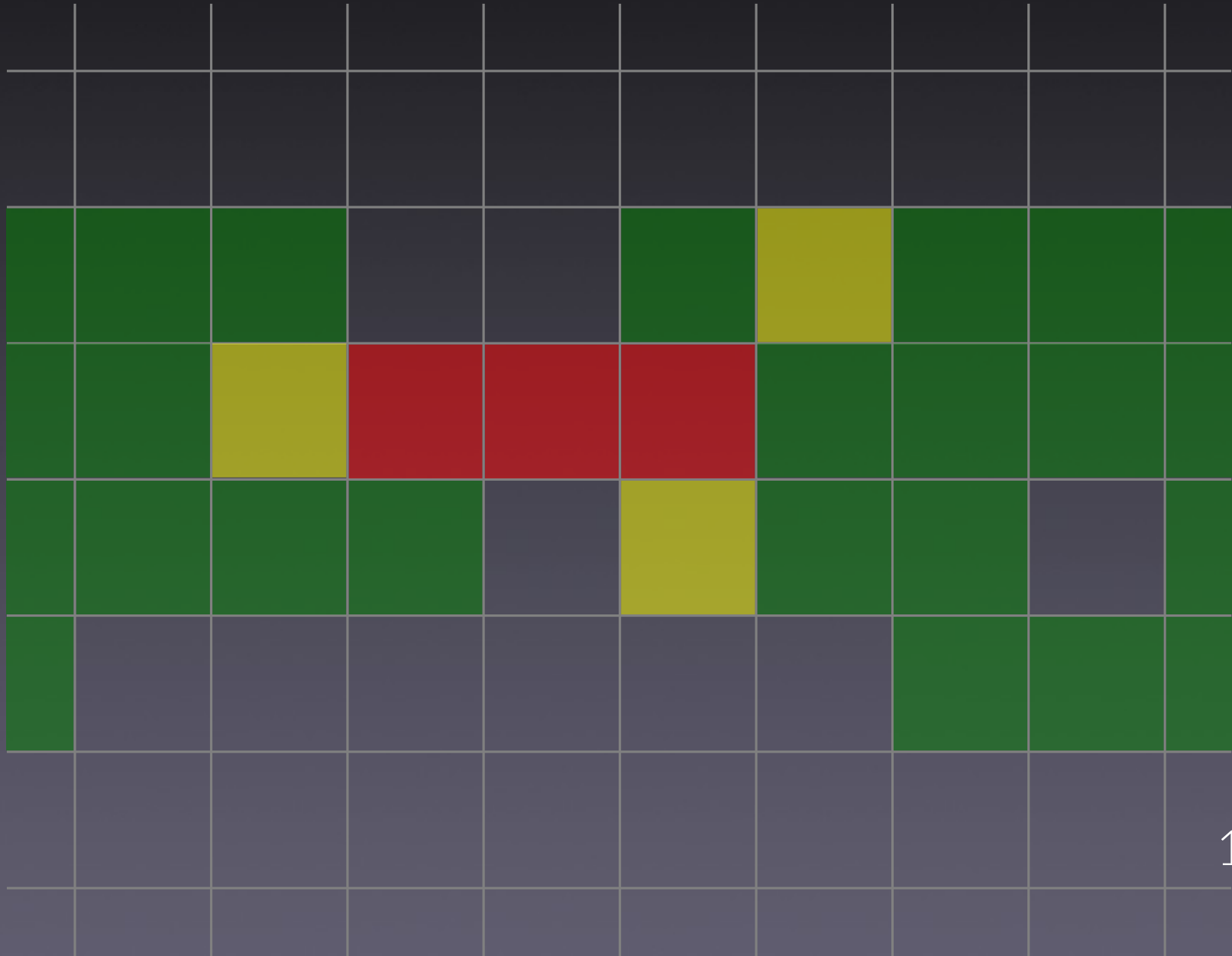
vpgTLE



vpgTLE



vpgTLE



Implementation of vpgTLE

- Voxellized extension of pgTLE (Kanawati et al. PMB 2015)

$$\Gamma_m(E) = \rho_{m_v} \sum_{k=1}^{k_{m_v}} \omega_k \frac{\Gamma_{Z_k}(E)}{\rho_{Z_k}}$$

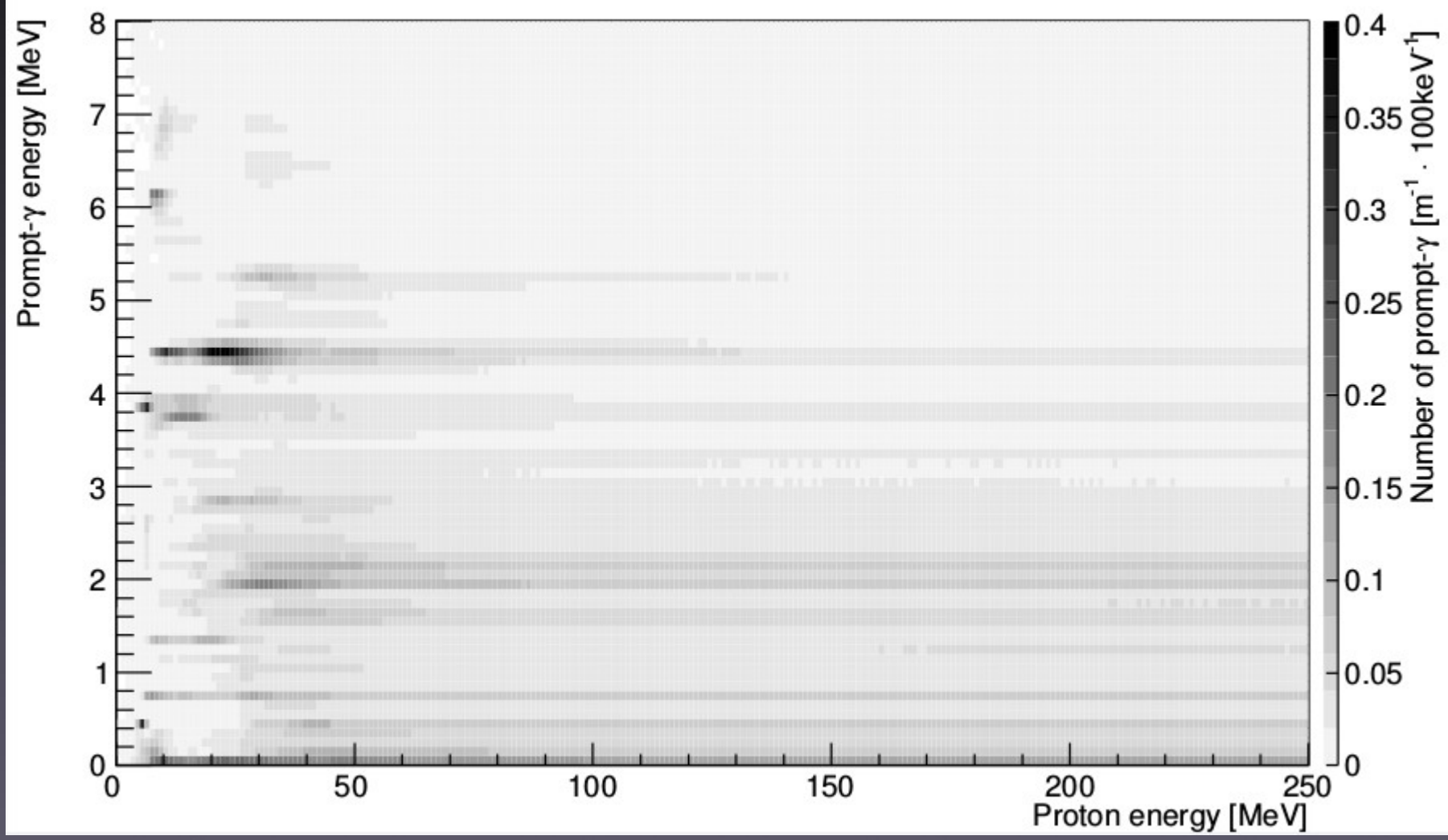
$$\hat{S}_i(v) = \Gamma_{m_v}(E_g) L_g(E_g, v)$$

effective linear PG production coefficient
precomputed, stored once, per element Z

$$\Gamma_m(E) = \rho_{m\nu} \sum_{k=1}^{k_{m\nu}} \omega_k \frac{\Gamma_{Z_k}(E)}{\rho_{Z_k}}$$

$$\hat{S}_i(\nu) = \Gamma_{m\nu}(E_g) L_g(E_g, \nu)$$

$$\frac{\Gamma_{Z_k}(E)}{\rho_{Z_k}}$$



computed for each type of material m in CT

$$\Gamma_m(E) = \rho_{m\nu} \sum_{k=1}^{k_{m\nu}} \omega_k \frac{\Gamma_{Z_k}(E)}{\rho_{Z_k}}$$

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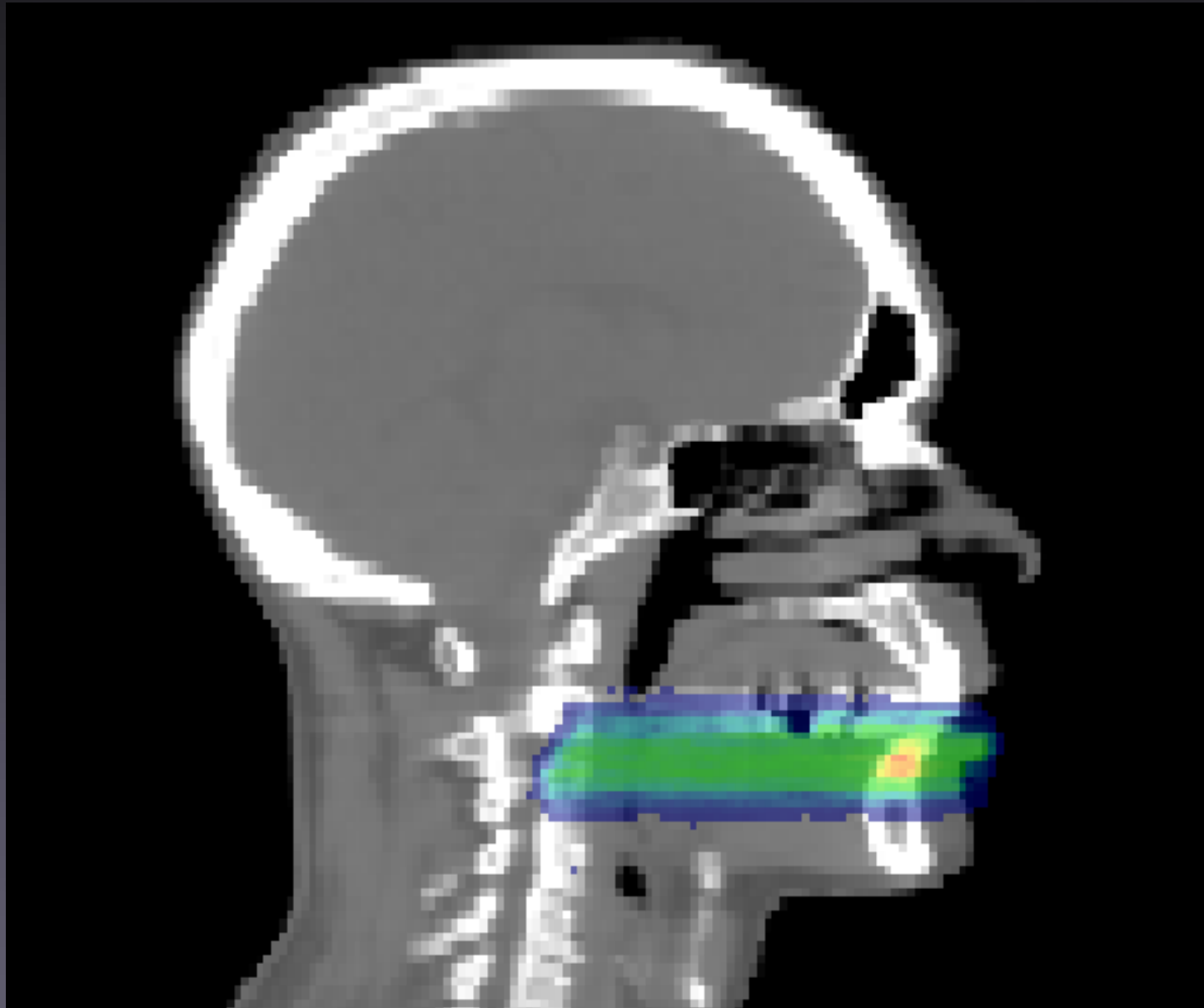
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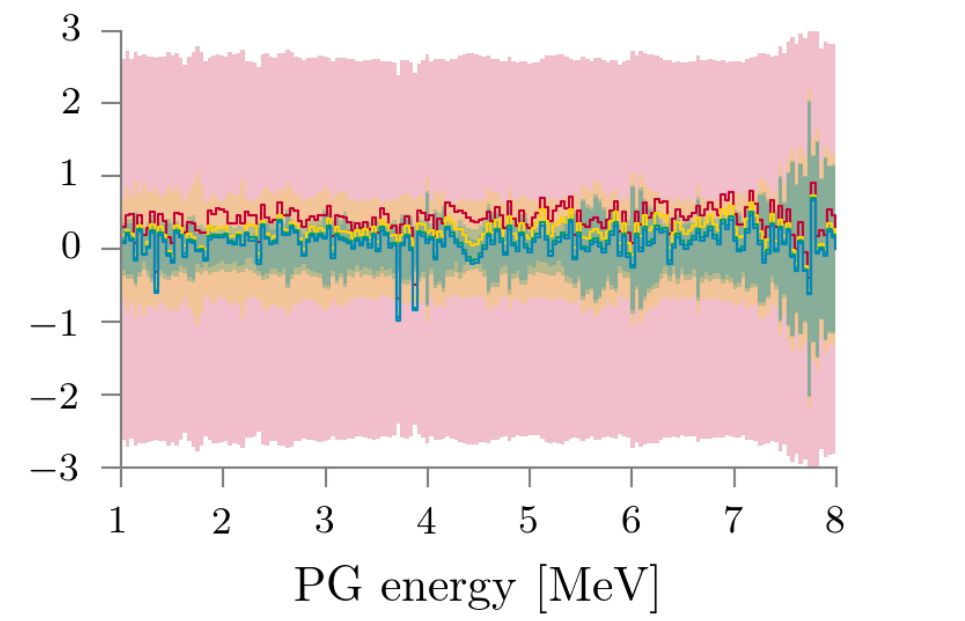
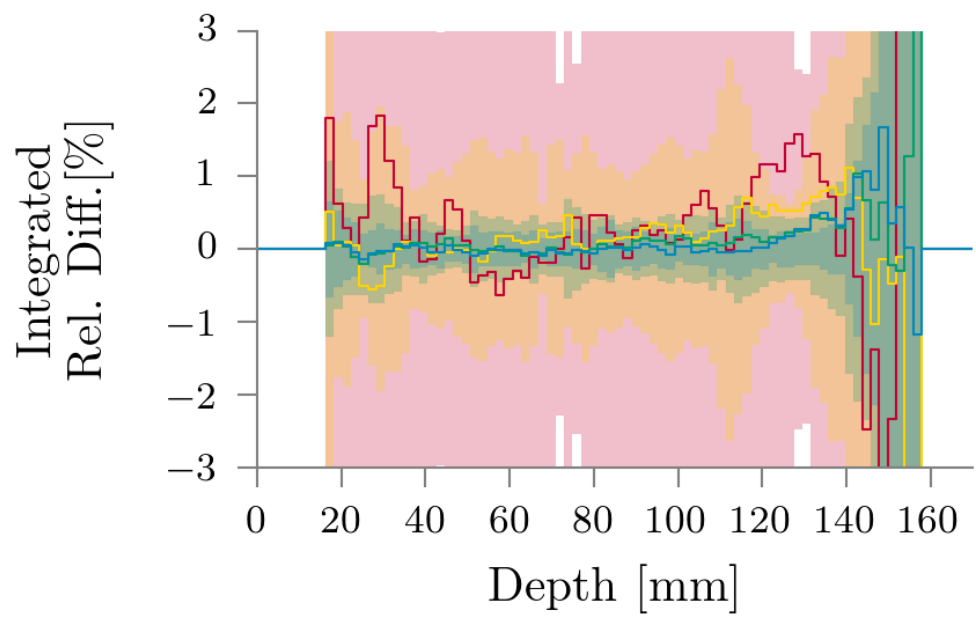
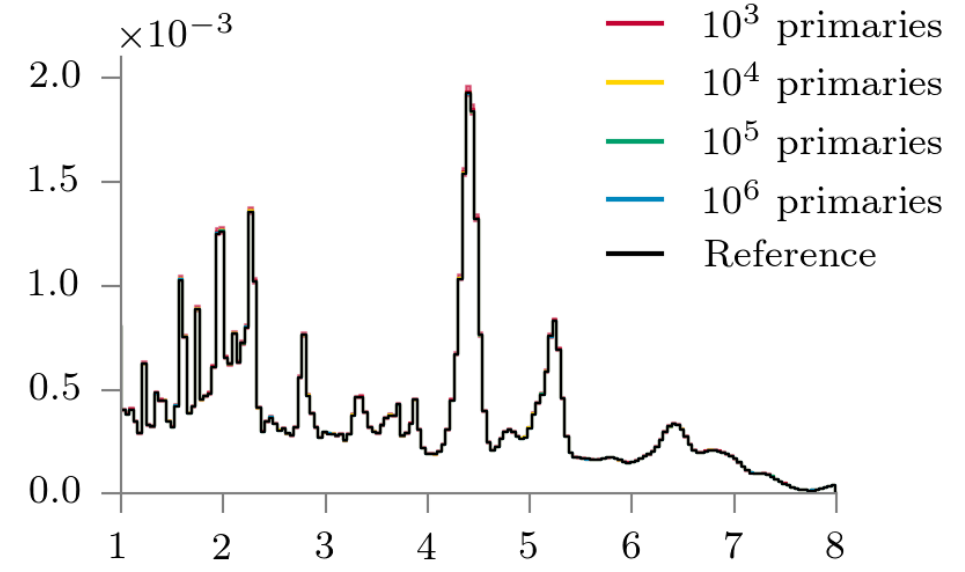
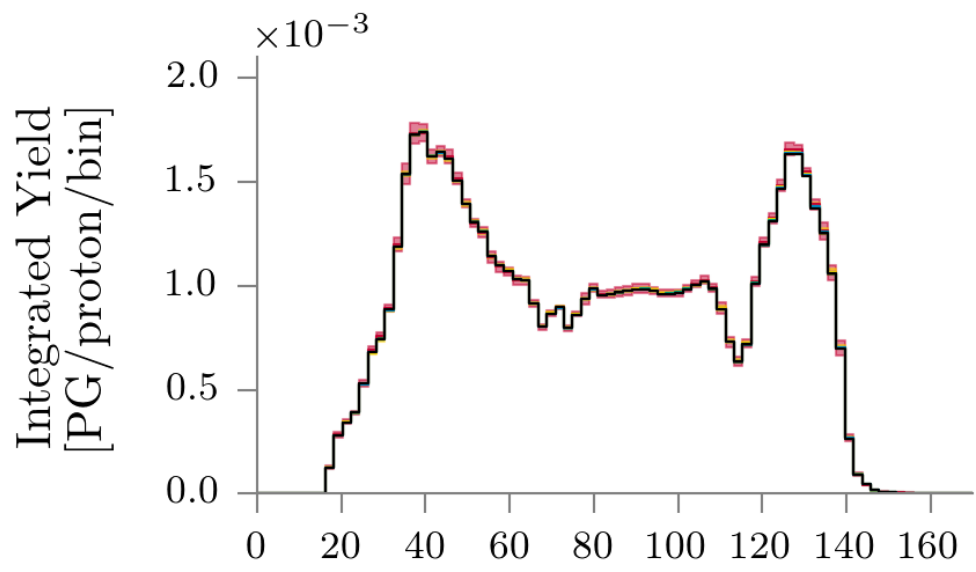
estimated PG yield
in voxel v for i histories

total steplength
per proton energy g

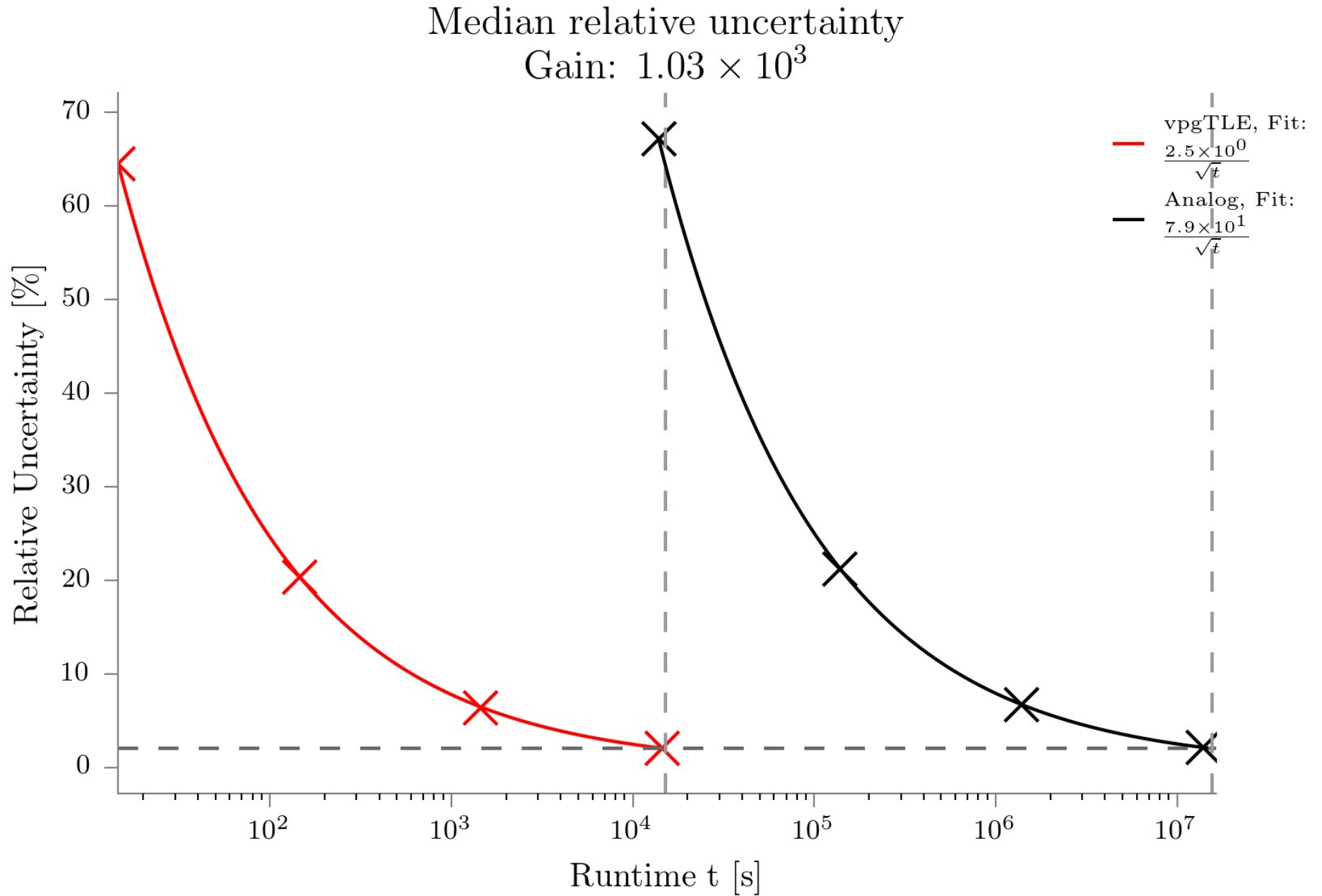
Validation vpgTLE @ CT image



Bias? Reference: Geant4 with 10^9



Gain? Runtime?



Summary

- A generic PG simulation method: vpgTLE
- Negligible bias, speedup: $\sim 10^3$
- Submitted to Phys. Med. Biol.
- Poster 42
- Available as of this week in Gate 7.2
 - opengatecollaboration.org
 - see the vpgtle example
 - brent.huisman@insa-lyon.fr

End