Flagship 2.6.2: Enhancing Geant4 Monte Carlo Simulations through Machine Learning Integration

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LTT distribution (Geant4 v.11.2.2)
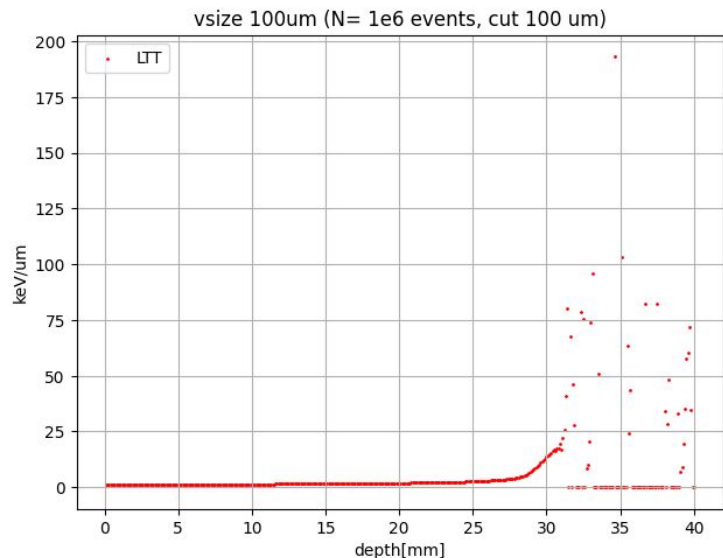
gps/pos/centre/-310 0 0 cm
PhysicsList:HADRONTHERAPY_1
energy=62.3 MeV
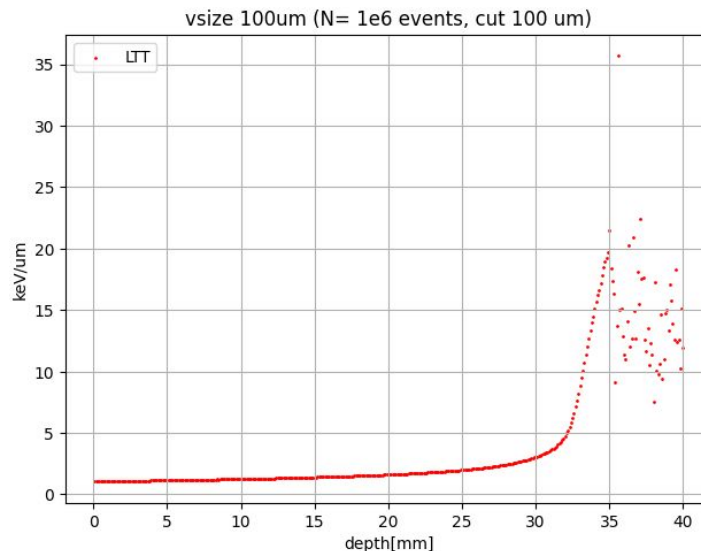
gps/pos/centre/-1 0 0 cm
PhysicdList:HADRONTHERAPY_1
energy=62.3 MeV

Simulation results

vsize 100um (N= 1e7 events, cut 100 um)

vsize 100um (N= 1e6 events, cut 100 um)

gps/pos/centre/-310 0 0 cm
PhysicsList:HADRONTHERAPY_1
energy=62.3 MeV

gps/pos/centre/-1 0 0 cm
PhysicsList:HADRONTHERAPY_1
energy=62.3 MeV
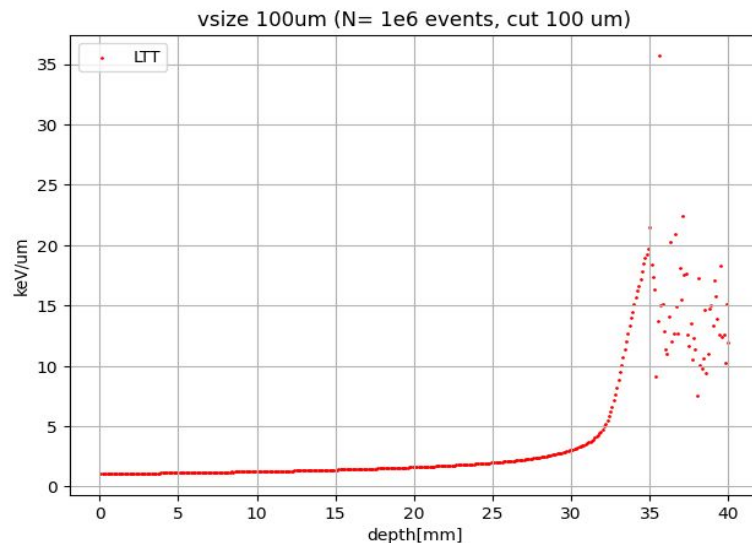
Hadrontherapy example Geant4 - Dataset

parameters of the CATANA beamline

- Geant4 v.11.2.2

Vsize= 1 um
Cut= 1 mm
Nevents=1e8

/gps/pos/centre -310 0 0 cm,
/gps/pos/centre -1 0 0 cm
Energy: 62.3 MeV
PhysicsList: HADRONTHERAPY_1

DATASET-HTG4

LET values after the Bragg Peak

	voxel	trackID	PosX	PosY	PosZ	processName	parentID	eKin	particleName
482	35	1	3.50629	0.093802	-0.096678	Unknown	0	0.000000	proton
494	35	1	3.51870	-0.172788	0.169806	Unknown	0	0.000000	proton
768	35	1	3.50217	0.082205	0.217139	Unknown	0	0.000000	proton
818	35	1	3.51557	0.004394	0.039288	Unknown	0	0.000000	proton
823	35	1	3.50215	0.128493	-0.308730	Unknown	0	0.000000	proton
...	...	...	...	...	...	...	...	...	...
1396	40	13	4.00000	0.613325	-1.174340	conv	11	2.608580	e+
478	40	13	4.00000	-1.275400	0.020257	conv	11	2.744010	e+
4144	40	15	4.00000	0.961870	-0.995953	conv	13	0.445489	e+
16091	40	24	4.00000	-0.486771	-1.495000	hadElastic	7	8.681360	proton
7446	40	35	4.00000	-0.983696	-0.512757	hadElastic	6	6.995860	proton

LET values after the Bragg Peak (2)

3D Distribution of particles after the Bragg Peak
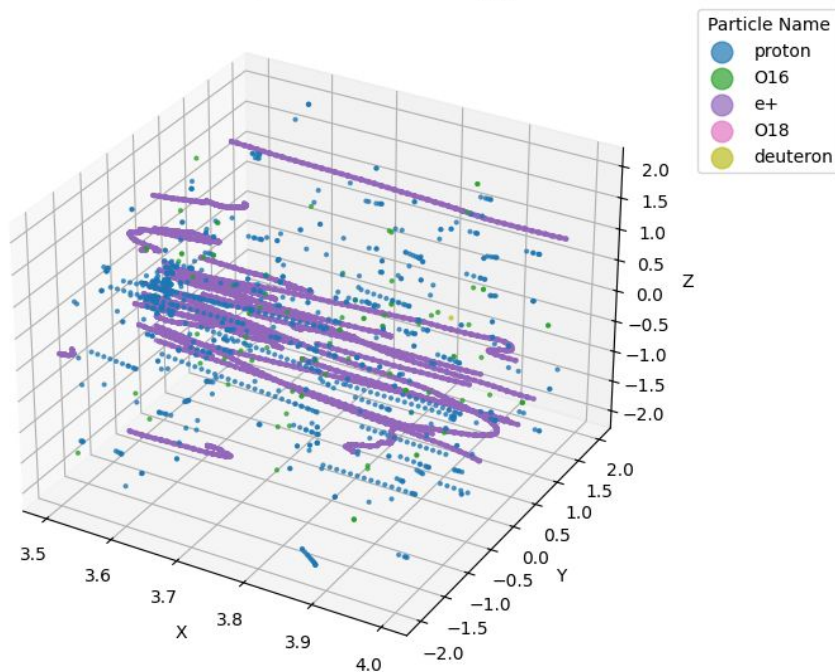
Wrap-up

o DATASET-HTG4 for testing machine learning model (done)
o Accelerating Geant4 simulations in medical physics with machine learning: A super-resolution approach (proceeding SIF 2024 - under review *Nuovo Cimento*)
o Draft paper (in progress)
o Patch code applied to Geant4 Hadrontherapy example (done)(to share with Geant4 Collaboration)
o ICSC - RAC 1558323 - ML-G4-wp6 (1-node HPC bubble) (in progress)

Next steps

o Complete exploratory analysis of LET values
o Run the code using assigned resources
o Finalize draft paper

Thanks for your attention