

## Physics Parameters for Proton Therapy Applications

The use of the GEANT4 materials is highly recommended for Hadrontherapy Applications to obtain correct range values

### 1) EM Physics List

Please use the “Standard Physics List option 3” configuration, summarized in the tables below.

Particle	Process	Model
gamma	PhotoElectric	StandardModel
	Compton	StandardModel
	GammaConversion	StandardModel

Particle	Process	Model	Step Function	Step Limit Type
e-	ElectronIonisation	StandardModel	0.2 0.1 mm	-
	Bremsstrahlung	StandardModel	-	-
	MultipleScattering	Default	-	distanceToBoundary

Particle	Process	Model	Step Function	Step Limit Type
e+	ElectronIonisation	StandardModel	0.2 0.1 mm	-
	Bremsstrahlung	StandardModel	-	-
	PositronAnnihilation	StandardModel	-	-
	MultipleScattering	Default	-	distanceToBoundary

Particle	Process	Model	Step Function
proton	HadronIonisation	Default	0.2 0.05 mm

Particle	Process	Model	Step Function
pi+/pi-	HadronIonisation	Default	0.2 0.05 mm

Particle	Process	Model	Step Function
Ion (GenericIon, alpha, deuteron, triton, He3)	IonIonisation	Default	0.1 0.02 mm

### 2) Hadronic Models

Hadronic process	Particle	Geant4 processes	Geant4 models	Geant4 datasets	Energy range
Elastic scattering	Generic Ion	G4HadronElastic Process	G4LElastic	G4HadronElastic DataSet	-
	All other particles	G4UHadronElastic Process	G4HadronElastic	G4HadronElastic DataSet	-
Inelastic process for	Protons	G4ProtonInelastic Process	G4BinaryCascade	G4ProtonInelastic CrossSection	0-20 GeV

protons					
Inelastic process for ions	Generic Ion	G4IonInelastic Process	G4BinaryLightIon Reaction	G4IonsShen CrossSection	0-20 GeV
	Deuteron	G4Deuteron InelasticProcess	G4LEDeuteron Inelastic	G4TripathiLight CrossSection	0-80 MeV
			G4BinaryLightIon Reaction		80 MeV-20 GeV
	Triton	G4TritonInelastic Process	G4LETriton Inelastic	G4TripathiLight CrossSection	0-80 MeV
			G4BinaryLightIon Reaction		80 MeV-20 GeV
	Alpha	G4AlphaInelastic Process	G4LEAlpha Inelastic	G4TripathiLight CrossSection	0-80 MeV
			G4BinaryLightIon Reaction		80 MeV-20 GeV
	Inelastic process for pions	$\pi^+$ , $\pi^-$	G4PionPlus InelasticProcess G4PionMinus InelasticProcess	G4LEPionMinus Inelastic G4PionPlus Inelastic	G4HadronInelasticDataSet
Radiative capture (neutrons)	Neutron	G4HadronCapture Process	G4NeutronHP Capture	G4NeutronHPCapture Data	0-20 MeV
			G4LCapture	G4HadronCapture DataSet	14 MeV-20 GeV
Inelastic scattering for neutrons	Neutron	G4NeutronInelastic Process	G4NeutronHP Inelastic	G4NeutronHP InelasticData	0-20 MeV
			G4BinaryCascade	G4Neutron InelasticCrossSection	14 MeV-20 GeV
Fission (neutrons)	Neutron	G4HadronFission Process	G4NeutronHPFission	G4NeutronHPFission Data	0-20 MeV
			G4LFission	G4HadronFissionDataSet	14 MeV-20 GeV

### 3) Options

Options	Value
Min Energy	100 eV
Max Energy	10 TeV
dE/dx table binning	220
Lambda table binning	220

### 4) Cuts – recommended values

Particles	Value
Gamma	0.1 mm
Electron	0.1 mm
Positron	0.1 mm

### 5) References

L. Grévilot, T. Frisson, N. Zahra, D. Bertrand, F. Stichelbaut, N. Freud and D. Sarrut, “Optimization of GEANT4 settings for Proton Pencil Beam Scanning simulations using GATE”, Nucl. Instr. Meth. Phys. Res. B (2010), doi: [10.1016/j.nimb.2010.07.011](https://doi.org/10.1016/j.nimb.2010.07.011).

## 6) GATE implementation

```
#-----oooooooooooooooooooooooo-----#
#                                     #
#                               PHYSICS #
#                                     #
#-----oooooooooooooooooooooooo-----#

#####
#   Electromagnetic processes
#####

/gate/physics/addProcess PhotoElectric
/gate/physics/processes/PhotoElectric/setModel StandardModel

/gate/physics/addProcess Compton
/gate/physics/processes/Compton/setModel StandardModel

/gate/physics/addProcess GammaConversion
/gate/physics/processes/GammaConversion/setModel StandardModel

/gate/physics/addProcess ElectronIonisation
/gate/physics/processes/ElectronIonisation/setModel StandardModel e+
/gate/physics/processes/ElectronIonisation/setModel StandardModel e-
/gate/physics/processes/ElectronIonisation/setStepFunction e+ 0.2 0.1 mm
/gate/physics/processes/ElectronIonisation/setStepFunction e- 0.2 0.1 mm

/gate/physics/addProcess Bremsstrahlung
/gate/physics/processes/Bremsstrahlung/setModel StandardModel e+
/gate/physics/processes/Bremsstrahlung/setModel StandardModel e-
/gate/physics/addProcess PositronAnnihilation
/gate/physics/processes/G4PositronAnnihilation/setModel StandardModel

/gate/physics/addProcess MultipleScattering
/gate/physics/processes/MultipleScattering/setGeometricalStepLimiterType e-
distanceToBoundary
/gate/physics/processes/MultipleScattering/setGeometricalStepLimiterType e+
distanceToBoundary

/gate/physics/addProcess HadronIonisation
/gate/physics/removeProcess HadronIonisation deuteron
/gate/physics/removeProcess HadronIonisation triton
/gate/physics/removeProcess HadronIonisation He3
/gate/physics/removeProcess HadronIonisation alpha
/gate/physics/removeProcess HadronIonisation GenericIon
/gate/physics/processes/HadronIonisation/setStepFunction proton 0.2 0.05 mm
/gate/physics/processes/HadronIonisation/setStepFunction pi+ 0.2 0.05 mm
/gate/physics/processes/HadronIonisation/setStepFunction pi- 0.2 0.05 mm

/gate/physics/addProcess IonIonisation
/gate/physics/processes/IonIonisation/setStepFunction GenericIon 0.1 0.02 mm
/gate/physics/processes/IonIonisation/setStepFunction alpha 0.1 0.02 mm
/gate/physics/processes/IonIonisation/setStepFunction deuteron 0.1 0.02 mm
/gate/physics/processes/IonIonisation/setStepFunction triton 0.1 0.02 mm
/gate/physics/processes/IonIonisation/setStepFunction He3 0.1 0.02 mm

#####
#   Hadronic processes
#####
```

```

/gate/physics/addProcess HadronElastic GenericIon
/gate/physics/processes/HadronElastic/setModel G4LElastic GenericIon

/gate/physics/addProcess UHadronElastic
/gate/physics/processes/UHadronElastic/setModel G4HadronElastic
/gate/physics/processes/UHadronElastic/setDataSet G4HadronElasticDataSet

/gate/physics/addProcess ProtonInelastic
/gate/physics/processes/ProtonInelastic/setModel G4BinaryCascade
/gate/physics/processes/ProtonInelastic/G4BinaryCascade/setEmin 0 MeV
/gate/physics/processes/ProtonInelastic/G4BinaryCascade/setEmax 500 GeV

/gate/physics/addProcess IonInelastic
/gate/physics/processes/IonInelastic/setModel G4BinaryLightIonReaction
/gate/physics/processes/IonInelastic/setModel G4LEDeuteronInelastic deuteron
/gate/physics/processes/IonInelastic/setModel G4LETritonInelastic triton
/gate/physics/processes/IonInelastic/setModel G4LEAlphaInelastic alpha
/gate/physics/processes/IonInelastic/G4BinaryLightIonReaction/setEmin 80 MeV
deuteron
/gate/physics/processes/IonInelastic/G4BinaryLightIonReaction/setEmax 20 GeV
deuteron
/gate/physics/processes/IonInelastic/G4BinaryLightIonReaction/setEmin 80 MeV triton
/gate/physics/processes/IonInelastic/G4BinaryLightIonReaction/setEmax 20 GeV triton
/gate/physics/processes/IonInelastic/G4BinaryLightIonReaction/setEmin 80 MeV alpha
/gate/physics/processes/IonInelastic/G4BinaryLightIonReaction/setEmax 20 GeV alpha
/gate/physics/processes/IonInelastic/G4LEDeuteronInelastic/setEmin 0 MeV deuteron
/gate/physics/processes/IonInelastic/G4LEDeuteronInelastic/setEmax 80 MeV deuteron
/gate/physics/processes/IonInelastic/G4LETritonInelastic/setEmin 0 MeV triton
/gate/physics/processes/IonInelastic/G4LETritonInelastic/setEmax 80 MeV triton
/gate/physics/processes/IonInelastic/G4LEAlphaInelastic/setEmin 0 MeV alpha
/gate/physics/processes/IonInelastic/G4LEAlphaInelastic/setEmax 80 MeV alpha
/gate/physics/processes/IonInelastic/setDataSet G4IonsShenCrossSection GenericIon
/gate/physics/processes/IonInelastic/setDataSet G4TripathiLightCrossSection
deuteron
/gate/physics/processes/IonInelastic/setDataSet G4TripathiLightCrossSection triton
/gate/physics/processes/IonInelastic/setDataSet G4TripathiLightCrossSection alpha

/gate/physics/addProcess PionPlusInelastic
/gate/physics/processes/PionPlusInelastic/setModel G4LEPionPlusInelastic

/gate/physics/addProcess PionMinusInelastic
/gate/physics/processes/PionMinusInelastic/setModel G4LEPionMinusInelastic

/gate/physics/addProcess NeutronCapture
/gate/physics/processes/NeutronCapture/setModel G4NeutronHPCapture
/gate/physics/processes/NeutronCapture/G4NeutronHPCapture/setEmin 0 MeV
/gate/physics/processes/NeutronCapture/G4NeutronHPCapture/setEmax 20 MeV
/gate/physics/processes/NeutronCapture/setModel G4LCapture
/gate/physics/processes/NeutronCapture/G4LCapture/setEmin 14 MeV
/gate/physics/processes/NeutronCapture/G4LCapture/setEmax 20 GeV
/gate/physics/processes/NeutronCapture/setDataSet G4NeutronHPCaptureData
/gate/physics/processes/NeutronCapture/setDataSet G4HadronCaptureDataSet

/gate/physics/addProcess Fission
/gate/physics/processes/Fission/setModel G4NeutronHPFission
/gate/physics/processes/Fission/G4NeutronHPFission/setEmin 0 MeV
/gate/physics/processes/Fission/G4NeutronHPFission/setEmax 20 MeV
/gate/physics/processes/Fission/setModel G4LFission
/gate/physics/processes/Fission/G4LFission/setEmin 14 MeV
/gate/physics/processes/Fission/G4LFission/setEmax 20 GeV
/gate/physics/processes/Fission/setDataSet G4NeutronHPFissionData
/gate/physics/processes/Fission/setDataSet G4HadronFissionDataSet

/gate/physics/addProcess NeutronInelastic
/gate/physics/processes/NeutronInelastic/setModel G4NeutronHPInelastic
/gate/physics/processes/NeutronInelastic/G4NeutronHPInelastic/setEmin 0 MeV
/gate/physics/processes/NeutronInelastic/G4NeutronHPInelastic/setEmax 20 MeV

```

```
/gate/physics/processes/NeutronInelastic/setDataSet G4NeutronHPInelasticData
neutron
/gate/physics/processes/NeutronInelastic/setModel G4BinaryCascade
/gate/physics/processes/NeutronInelastic/G4BinaryCascade/setEmin 14 MeV
/gate/physics/processes/NeutronInelastic/G4BinaryCascade/setEmax 20 GeV
/gate/physics/processes/NeutronInelastic/setDataSet G4NeutronInelasticCrossSection
neutron
```

```
/gate/physics/addProcess Decay
```

```
#=====
# Options
#=====
```

```
/gate/physics/setEmin 0.1 keV
/gate/physics/setEMax 10 TeV
/gate/physics/setDEDXBinning 220
/gate/physics/setLambdaBinning 220
```

```
/gate/physics/Gamma/SetCutInRegion world 0.1 mm
/gate/physics/Electron/SetCutInRegion world 0.1 mm
/gate/physics/Positron/SetCutInRegion world 0.1 mm
```

```
/gate/physics/Gamma/SetCutInRegion cible 0.1 mm
/gate/physics/Electron/SetCutInRegion cible 0.1 mm
/gate/physics/Positron/SetCutInRegion cible 0.1 mm
```