29th Geant4 Collaboration Meeting

Hadrontherapy example: Current Status and Future Perspectives

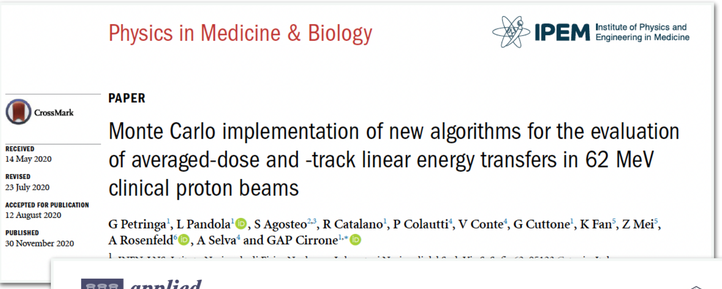
Giada Petringa*

G.A.P. Cirrone, F. Farokhi, S. Fattori, A. Hassan, L. Pandola, A. Sciuto

*Istituto Nazionale di Fisica Nucleare - Laboratori Nazionali del Sud (Italy)

Validation work on LET with ion beams

2 Ongoing activity



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

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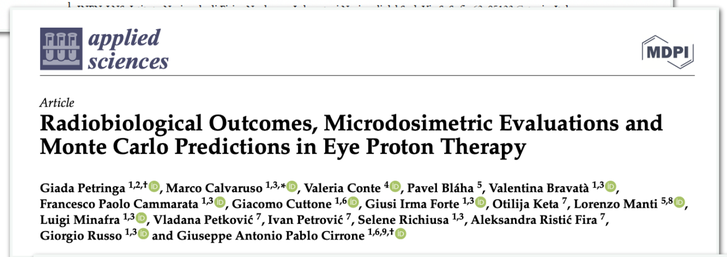
PUBLISHED 30 November 2020

G Petringa[1], L Pandola[1], S Agosteo[2,3], R Catalano[1], P Colautti[4], V Conte[4], G Cuttone[1], K Fan[5], Z Mei[5], A Rosenfeld[6], A Selva[4] and GAP Cirrone[1,*]



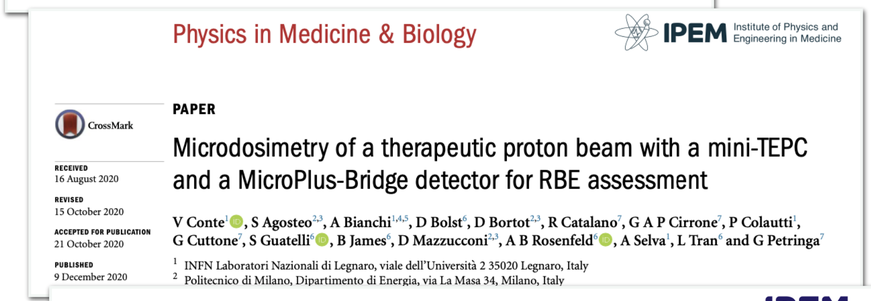
applied sciences

MDPI

Article

Radiobiological Outcomes, Microdosimetric Evaluations and Monte Carlo Predictions in Eye Proton Therapy

Giada Petringa [1,2,†], Marco Calvaruso [1,3,*], Valeria Conte [4], Pavel Bláha [5], Valentina Bravatà [1,3], Francesco Paolo Cammarata [1,3], Giacomo Cuttone [1,6], Giusi Irma Forte [1,3], Otilija Keta [7], Lorenzo Manti [5,8], Luigi Minafra [1,3], Vladana Petković [7], Ivan Petrović [7], Selene Richiusa [1,3], Aleksandra Ristić Fira [7], Giorgio Russo [1,3] and Giuseppe Antonio Pablo Cirrone [1,6,9,†]



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PAPER

Microdosimetry of a therapeutic proton beam with a mini-TEPC and a MicroPlus-Bridge detector for RBE assessment

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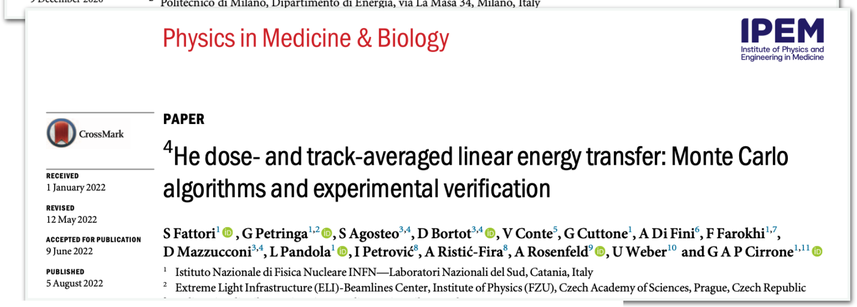
V Conte[1], S Agosteo[2,3], A Bianchi[1,4,5], D Bolst[6], D Bortot[2,3], R Catalano[7], G A P Cirrone[7], P Colautti[1], G Cuttone[7], S Guatelli[6], B James[5], D Mazzucconi[2,3], A B Rosenfeld[6], A Selva[1], L Tran[6] and G Petringa[7]

[1] INFN Laboratori Nazionali di Legnaro, viale dell'Università 2 35020 Legnaro, Italy
[2] Politecnico di Milano, Dipartimento di Energia, via La Masa 34, Milano, Italy



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PAPER

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

RECEIVED 1 January 2022
REVISED 12 May 2022
ACCEPTED FOR PUBLICATION 9 June 2022
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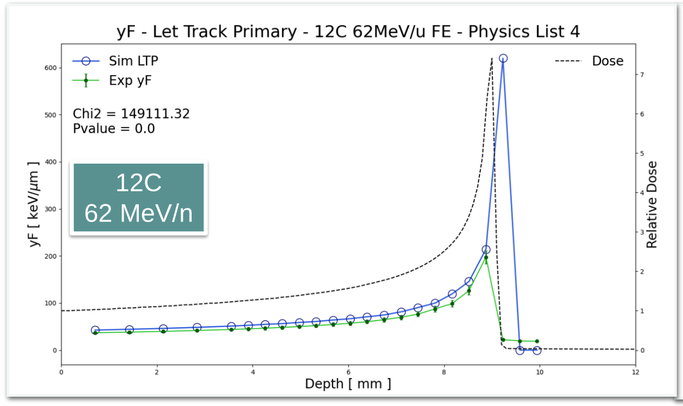
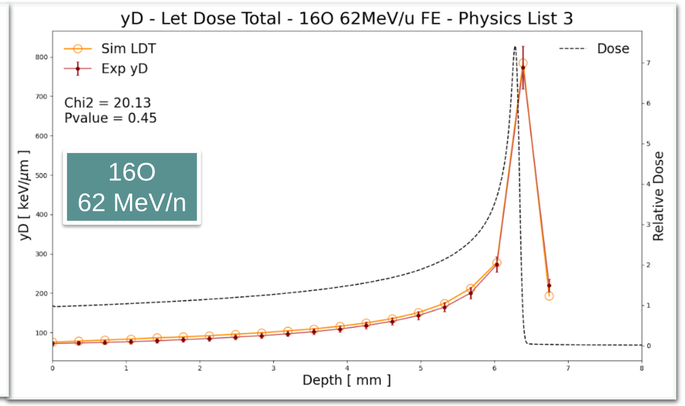
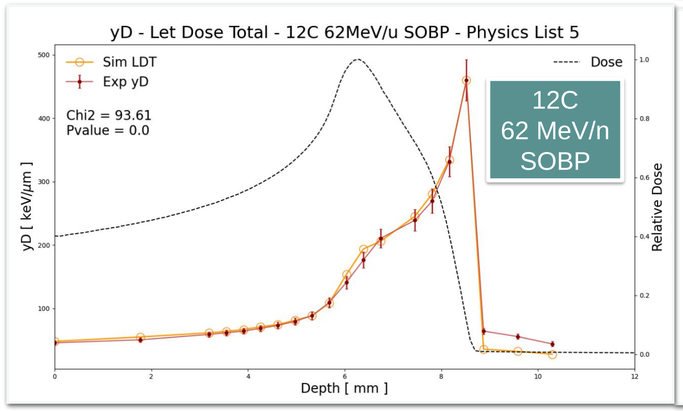
S Fattori[1], G Petringa[1,2], S Agosteo[3,4], D Bortot[3,4], V Conte[5], G Cuttone[1], A Di Fini[6], F Farokhi[1,7], D Mazzucconi[3,4], L Pandola[1], I Petrovic[8], A Ristić-Fira[8], A Rosenfeld[9], U Weber[10] and G A P Cirrone[1,11]

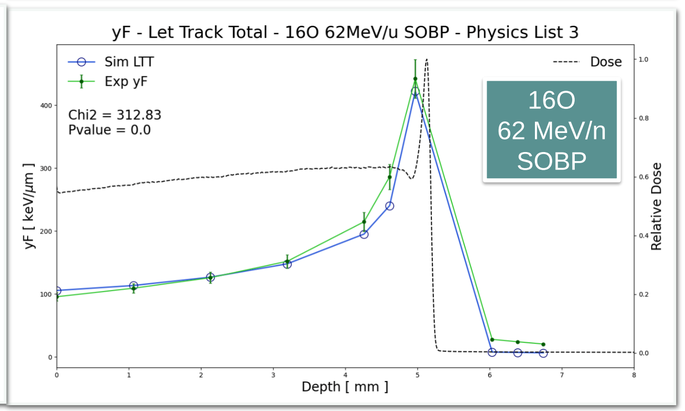
[1] Istituto Nazionale di Fisica Nucleare INFN—Laboratori Nazionali del Sud, Catania, Italy
[2] Extreme Light Infrastructure (ELI)-Beamlines Center, Institute of Physics (FZU), Czech Academy of Sciences, Prague, Czech Republic

Five hadronic models: QGSP_BIC; QGSP_BIC_HP; QGSP_BIC_AllHP; QGSP_BERT; QGSP_BERT_HP







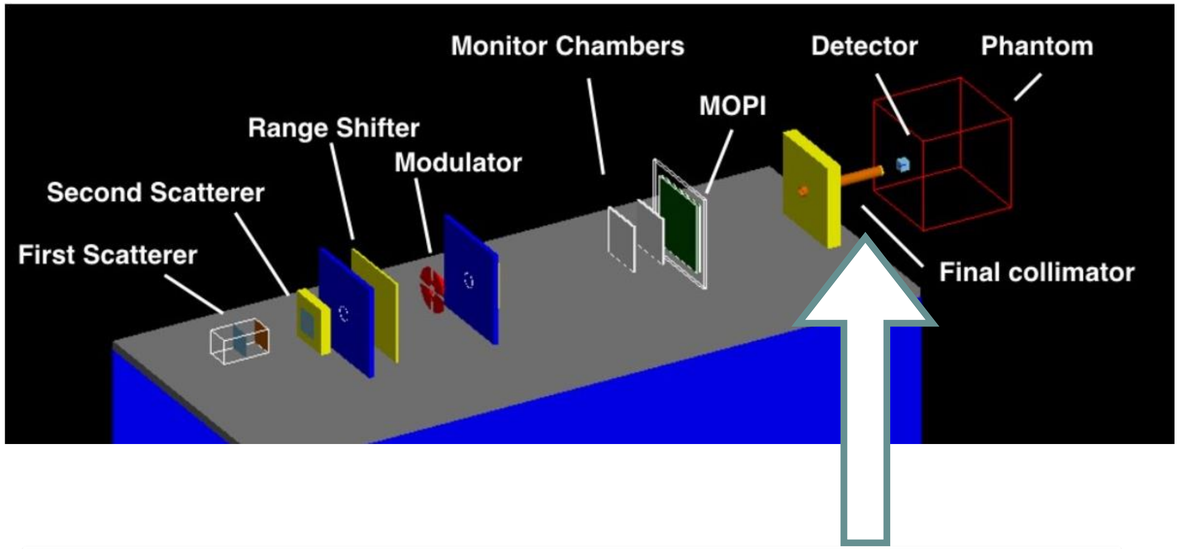


L. Brighel, R. Catalano, G.A.P. Cirrone, L. Manti, G. Petringa

Changing in the source: the phase space file

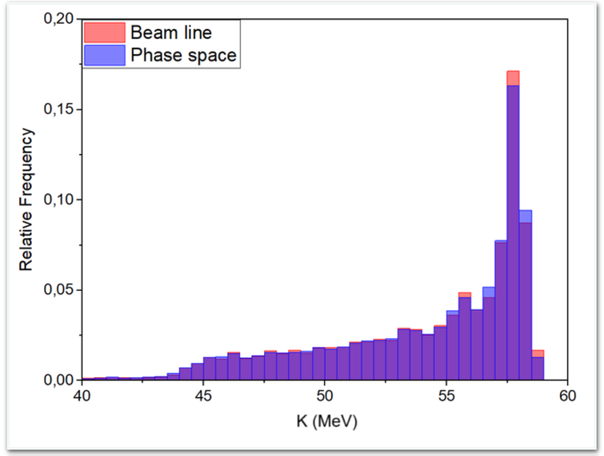
3

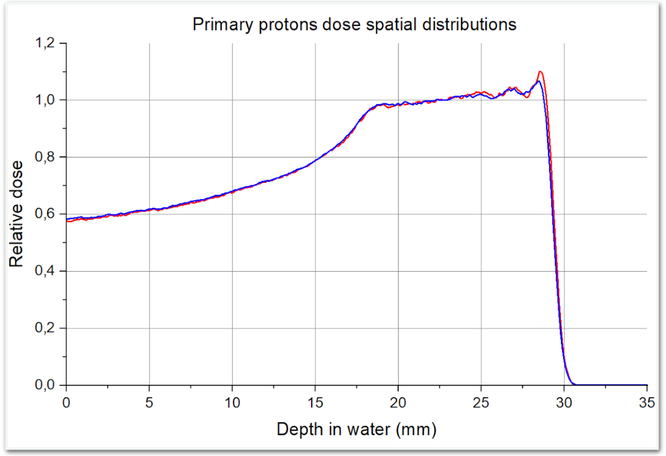
Ongoing activity

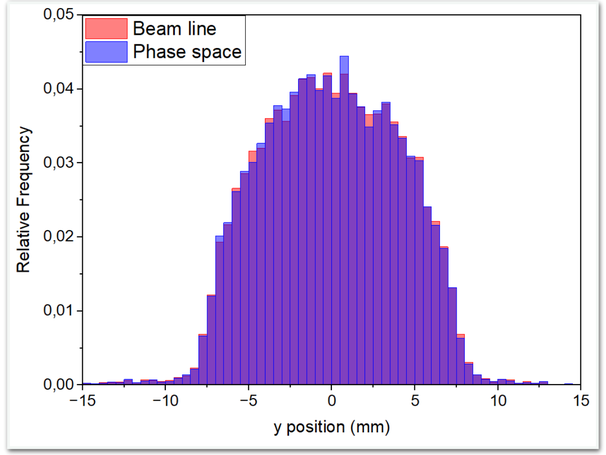


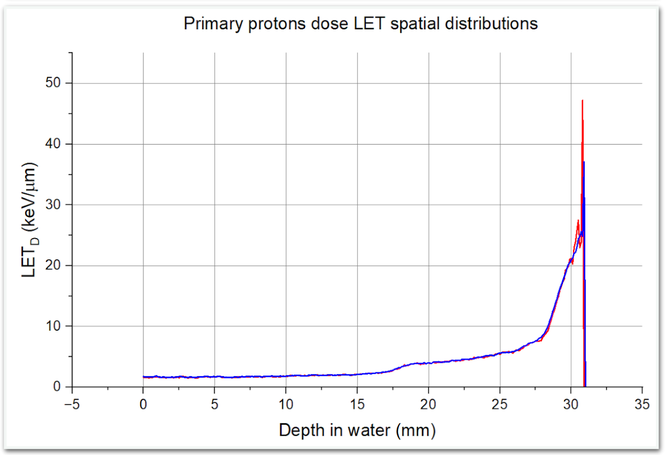
Implementation and Validation

1) The particles are registerd at the end of the beamline.
2) The capability to read an external phase space file has been implemented in the hadrontherapyPrimaryGeneratorAction.cc class





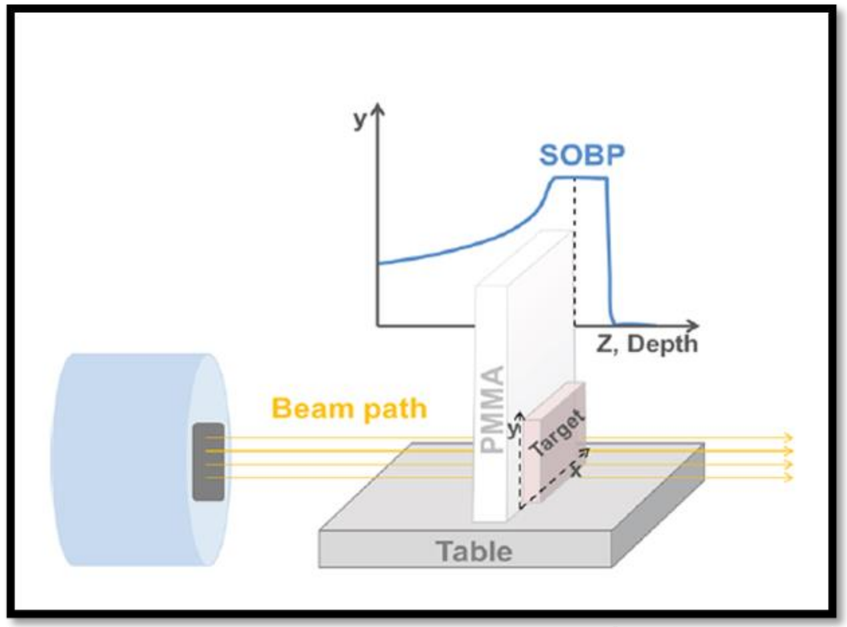


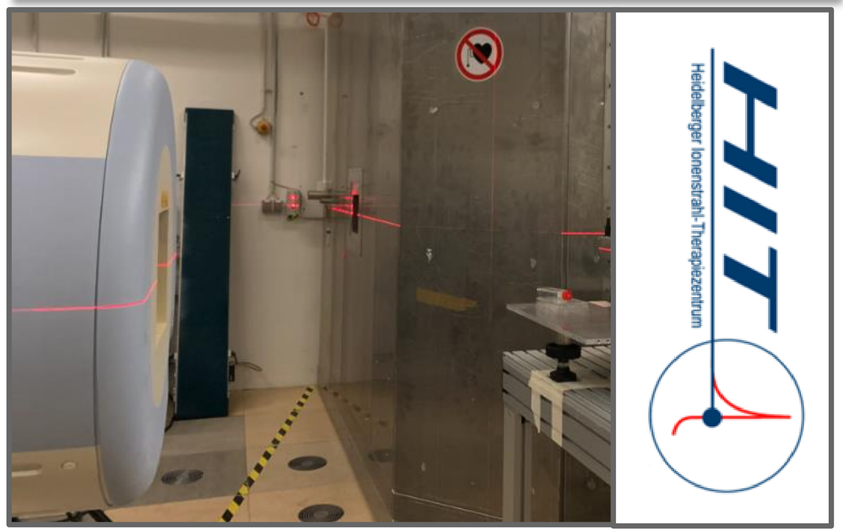


R. Catalano, G.A.P. Cirrone, S. Fattori, L. Manti, A. Nivuori, G. Petringa, C. Verona

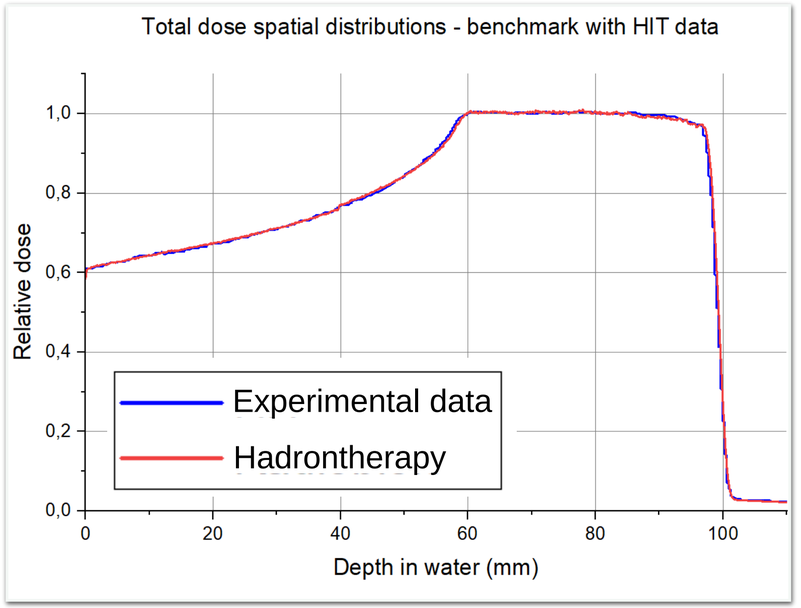
Changing in the source: the phase space file

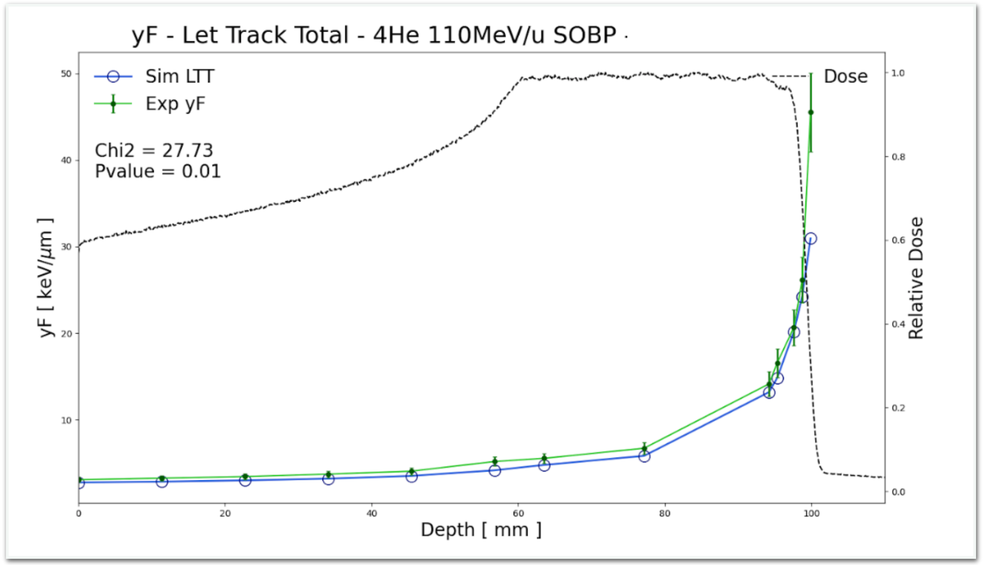
4 Ongoing activity





Experimental data in a completely new configuration





Future developments

5 Changing in the structure of the example

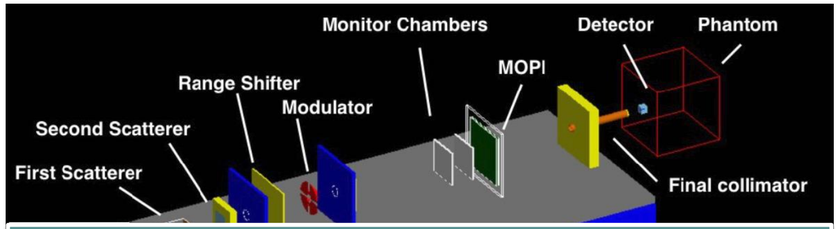
GEOMETRY → **We will decrease the number of classes by modifying the underlying "philosophy" of the example**

PHYSICS LISTS → **We will expand the number of physics lists to facilitate studies involving clinical ion beams**

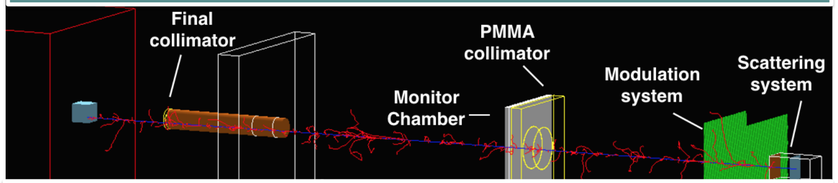
VOXELLIZED DETECTOR → **We will modify the voxelized detector located within the phantom. The implementation using the "parallel world" will be replaced by the “readout geometry”**

Future developments

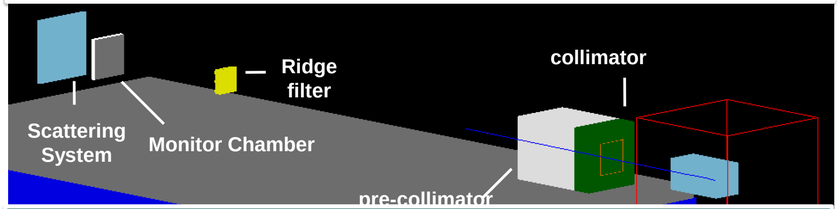
6 Changes in the structure of the example



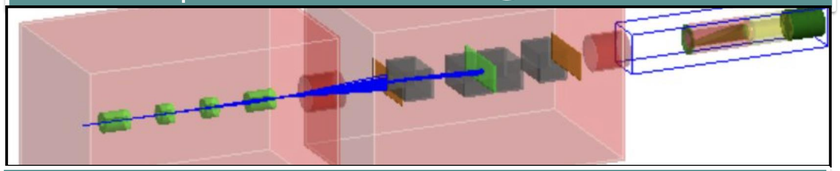
CATANA beamline @LNS-INFN



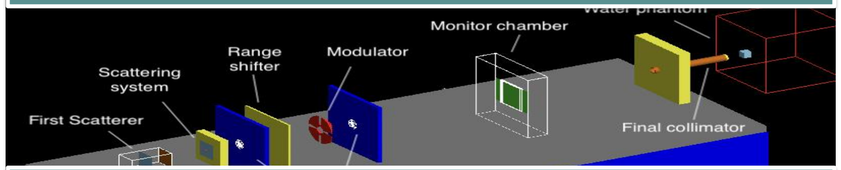
Ion beamline @LNS-INFN



Experimental beamline @PTC-Trento



Laser-driven beamline

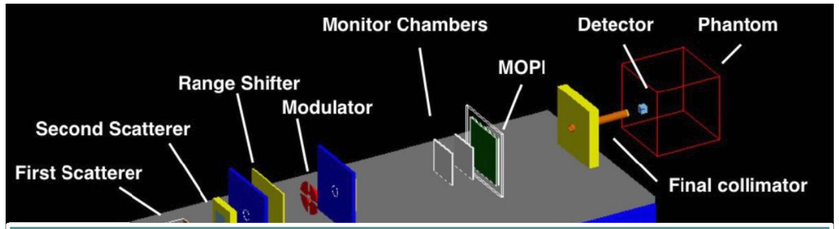


Best-Beamline

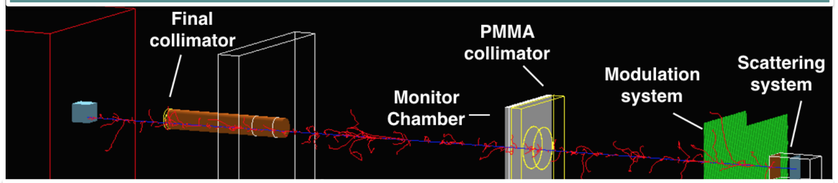
several geometries

Future developments

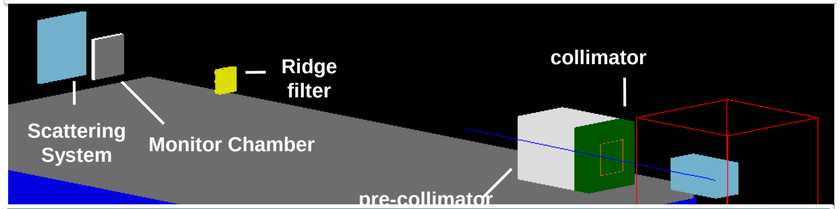
7 Changes in the structure of the example



CATANA beamline @LNS-INFN

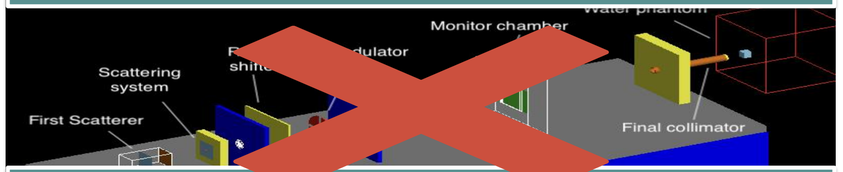


Ion beamline @LNS-INFN



Experimental beamline @PTC-Trento

Laser-driven beamline



Best-Beamline

several geometries

An example focused on the existing beamlines in Italy for hadrontherapy applications

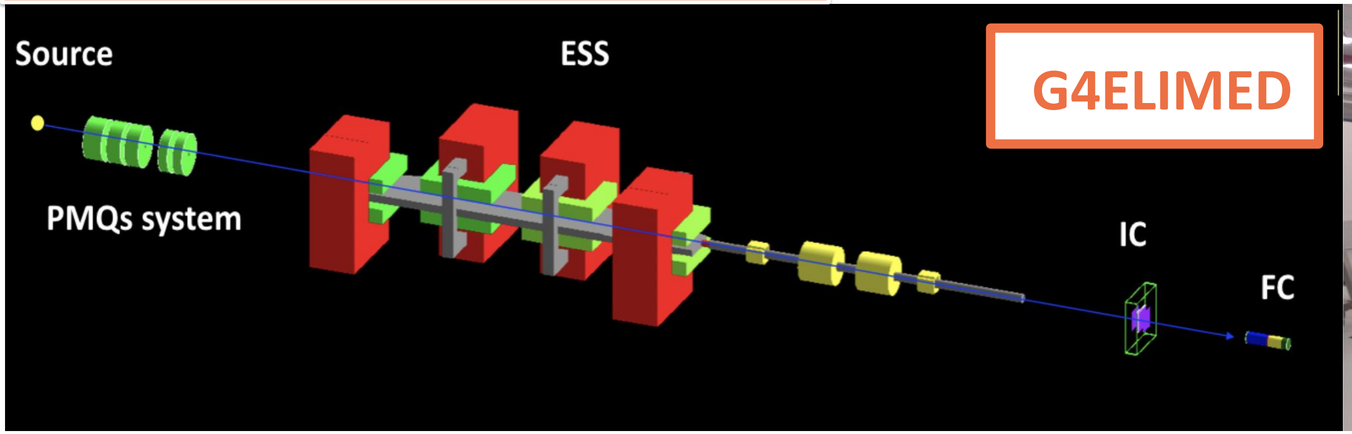
Capability to read an external phase space file containing two clinical configurations implemented at CNAO: proton and carbon beams.

fondazione CNAO
Centro Nazionale di Adroterapia Oncologica per il trattamento dei tumori

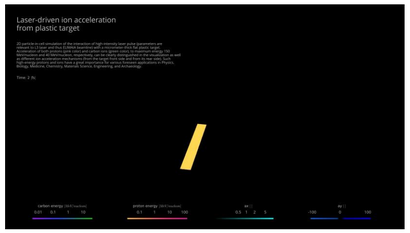
Future developments

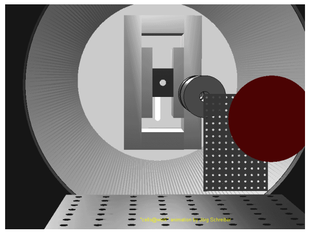
A new dedicated example on laser driven applications

Previous experience



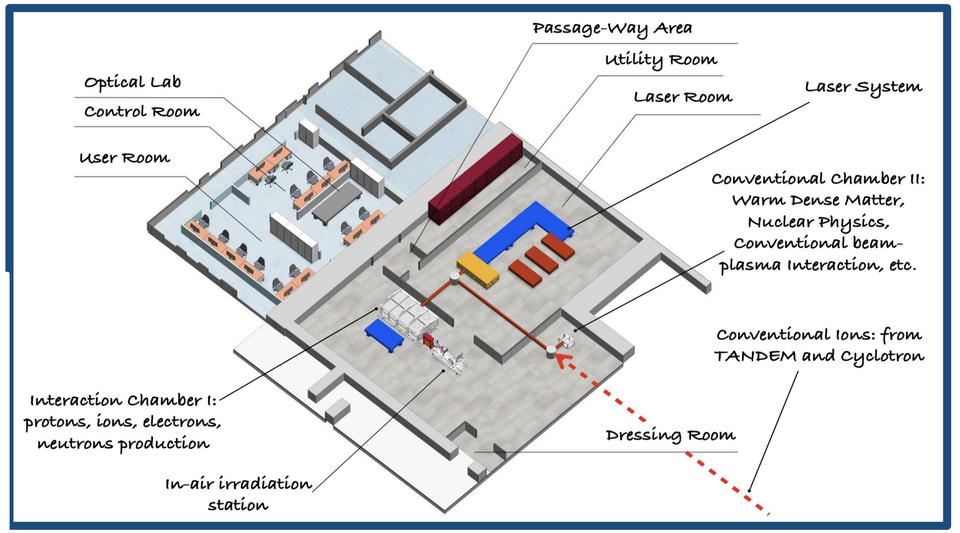
The future @LNS-INFN





Protons acceleration up to 50 MeV with solid target
Electrons acceleration up to 800 MeV with capillary and gas-jet system
Neutron beam
Irradiations stations for both protons and electrons for medical and multidisciplinary applications
- *Fusion reactions*
- *FLASH radiotherapy applications*
- *Material science*

Interaction of conventional ion beams with laser-generated plasmas



Future developments

10

A new dedicated example on laser driven applications

Geometry

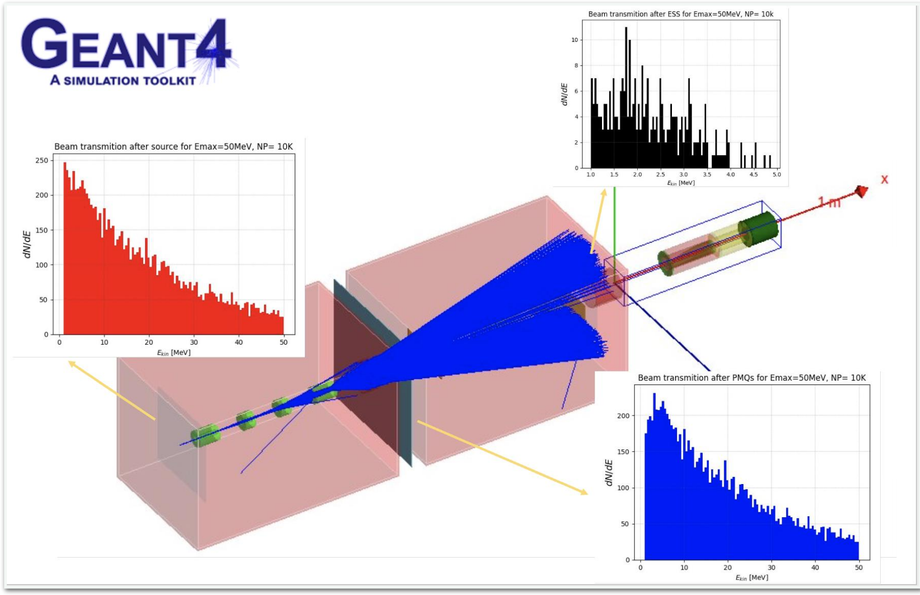
- A straightforward configuration for the transport and selection of proton beams
- A straightforward configuration for the selection of electron beams

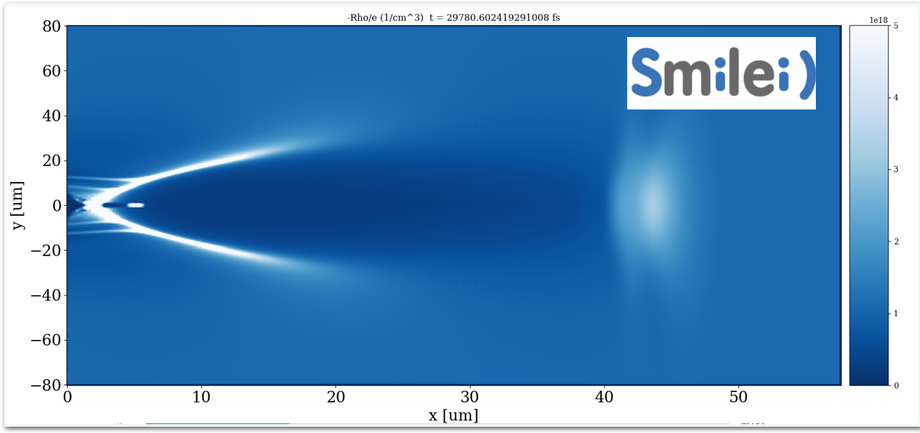
Source

- Capability to read an external file generated by a Particle-In-Cell (PIC) code
- Implementation of Machine Learning techniques

Beam Transport Information

- Divergence and beam emittance
- Energy distribution
- Spectrum for each produced species
- Dose information





Ongoing research on Stopping Power simulations in plasma using Geant4 focuses on selecting an appropriate algorithm to model ion energy loss in a time-independent plasma, within specific temperature and density ranges

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Thanks to everyone