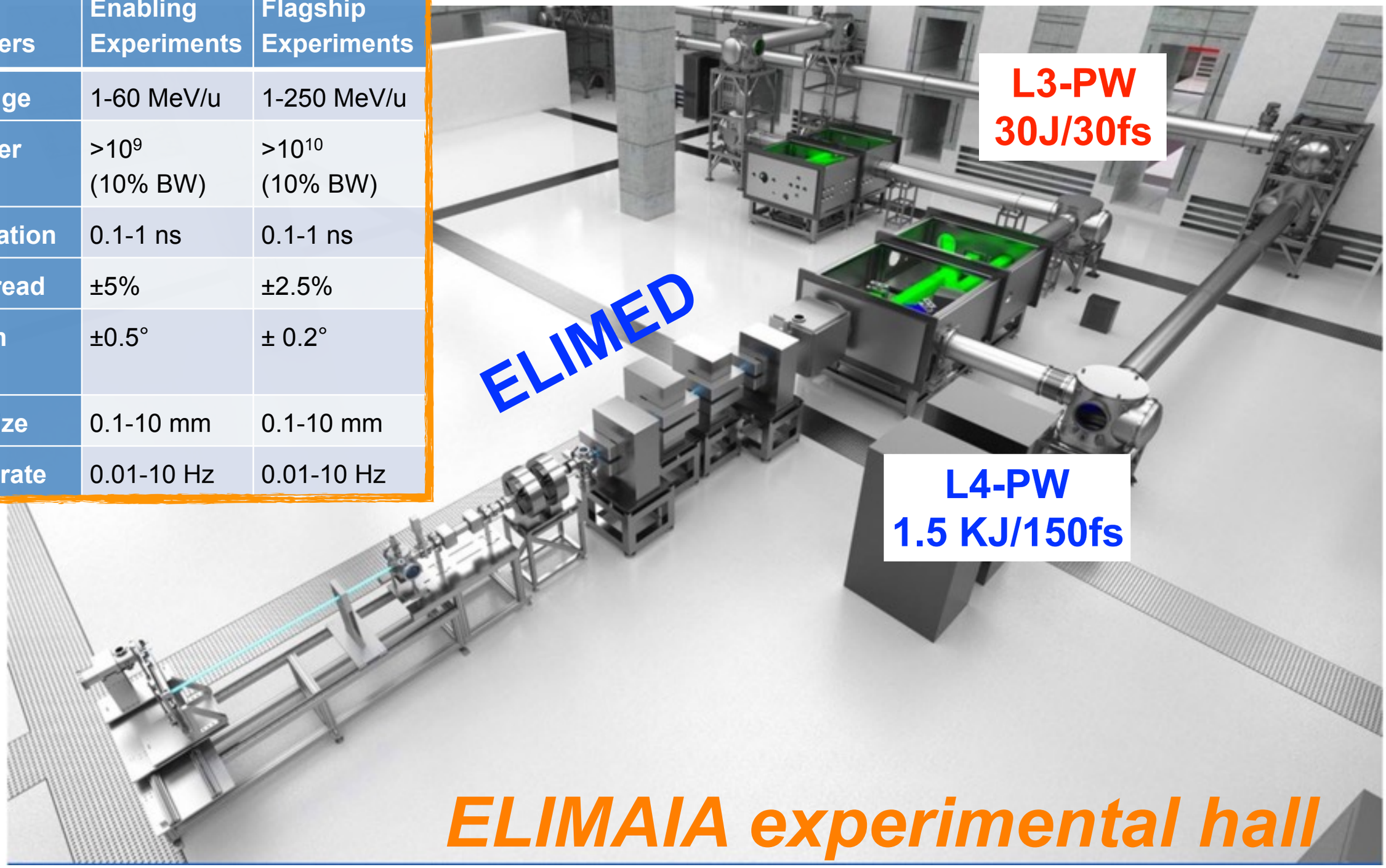
Geant4 simulation of the ELIMED transport and dosimetry beamline for high-energy laser-driven ion beam multidisciplinary applications

G. Milluzzo

On behalf of the ELIMED collaboration

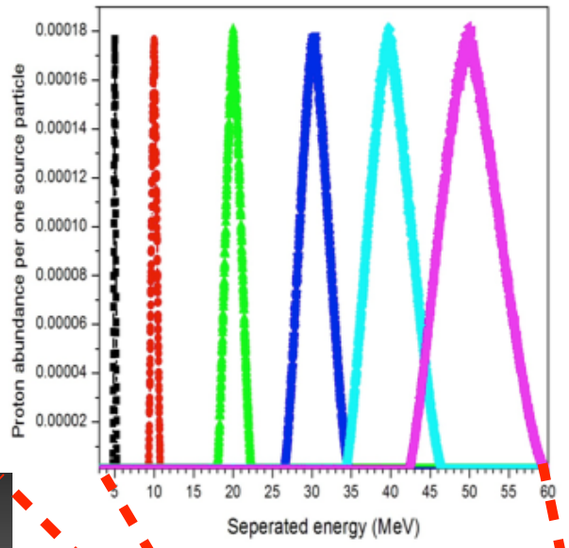
ELIMAIA beamline

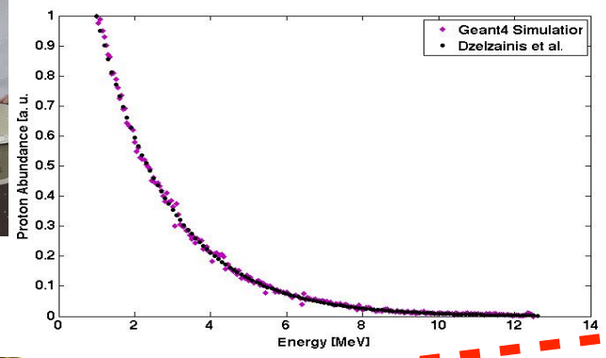
Beam Parameters	Enabling Experiments	Flagship Experiments
Energy range	1-60 MeV/u	1-250 MeV/u
Ion No./laser shot	$>10^9$ (10% BW)	$>10^{10}$ (10% BW)
Bunch duration	0.1-1 ns	0.1-1 ns
Energy spread	±5%	±2.5%
Collimation Degree	±0.5°	± 0.2°
Ion Spot Size	0.1-10 mm	0.1-10 mm
Repetition rate	0.01-10 Hz	0.01-10 Hz

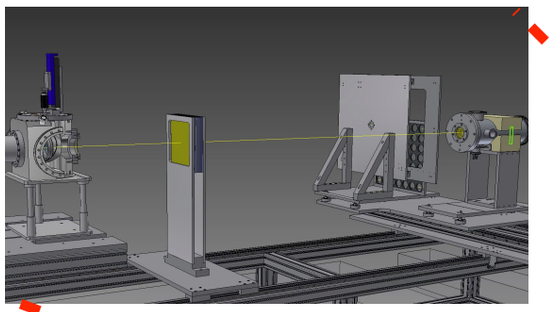


ELIMAIA experimental hall

The ELIMED beamline







Collection and diagnostics

Selection, transport and diagnostics

Dosimetry and sample irradiation

Front. Oncol. (in press)
NIM A, Vol. 829 (2016)
JINST, Vol. 11 (2016)
JINST, Vol. 10 (2015)
NIM A, Vol. 769 (2015)
NIM A, Vol. 714 (2014)

Graphics by L. Allegra

Beam line features:

- Tunable (deliver ion beams from 5 up to 60 MeV/u) with a controllable energy spread (5% up to 20%) and 10^6-10^{11} ions/pulse
- Large acceptance
- Flexibility to meet different User's requirements

ELIMED Monte Carlo WP

ELIMED (*LNS-INFN*)
@ ELI-Beamlines

WP1 (*LNS-INFN*)
Ion Beam Transport

WP3 (*LNS-INFN*)
Ion Beam Diagnostics and Dosimetry

WP2 (*LNS-INFN*)
Monte Carlo Simulations

Resp.: F. Romano
J. Pipek
G. Milluzzo

The ELIMED application

J. Pipek, F. Romano, G. Milluzzo et al.,, Journal of Instrumentation, Volume 12, March 2017

Geant 4

http://www.geant4.org

"Toolkit for the simulation of the passage of particles through matter."

Requirements from ELI

* Easily modify geometrical configurations
* Accurate transport in magnetic fields
* User friendly

Application structure

* Component realistic model
* Magnetic and electric field implementation
* Realistic laser-driven particle source
* Information scoring along the beamline

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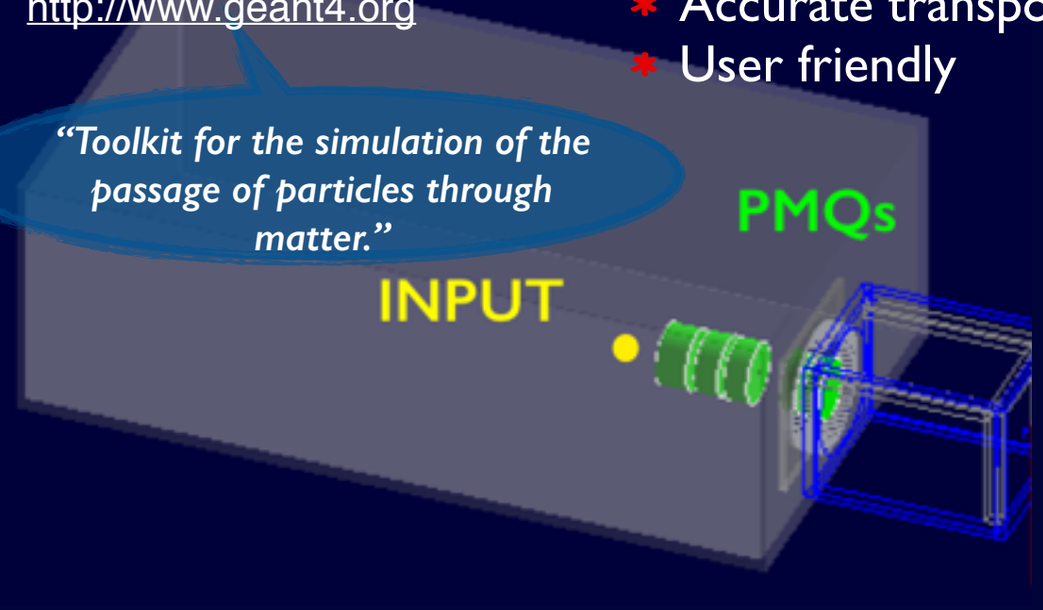

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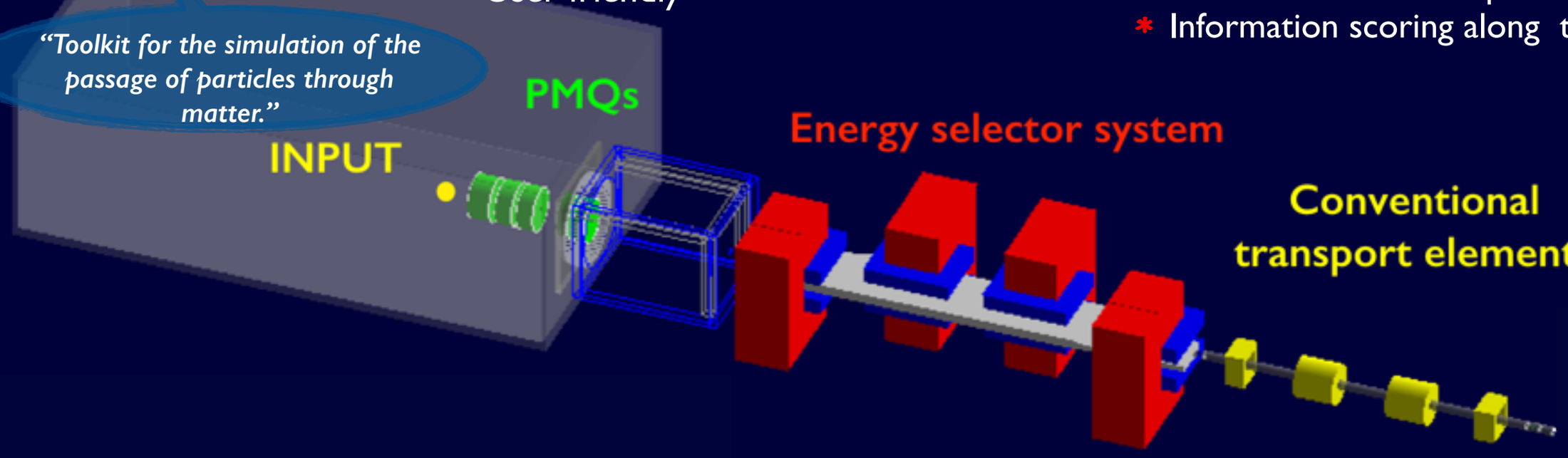

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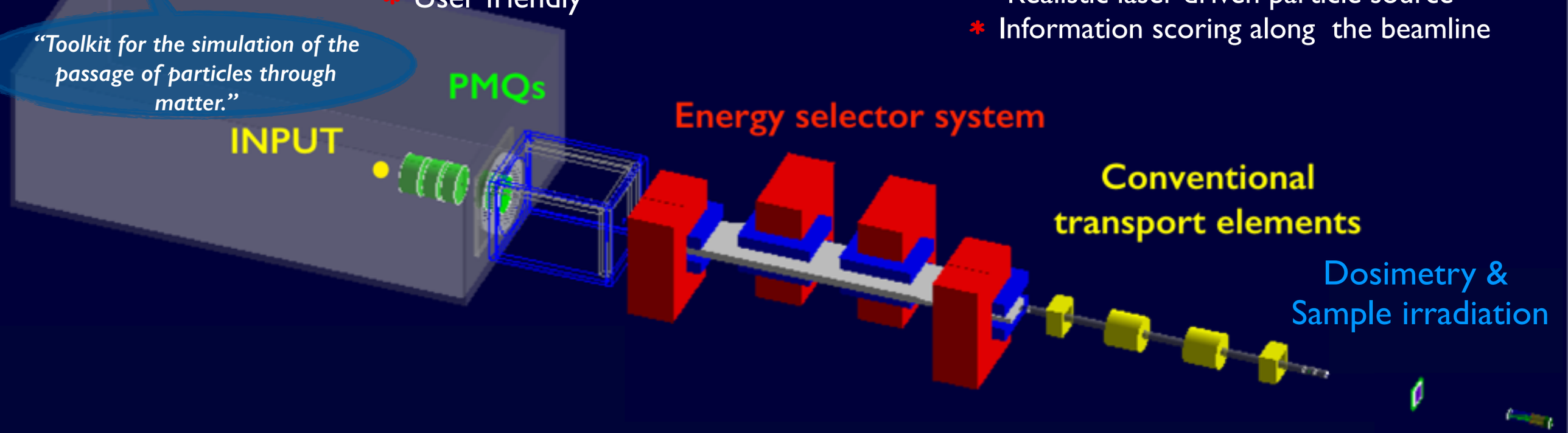

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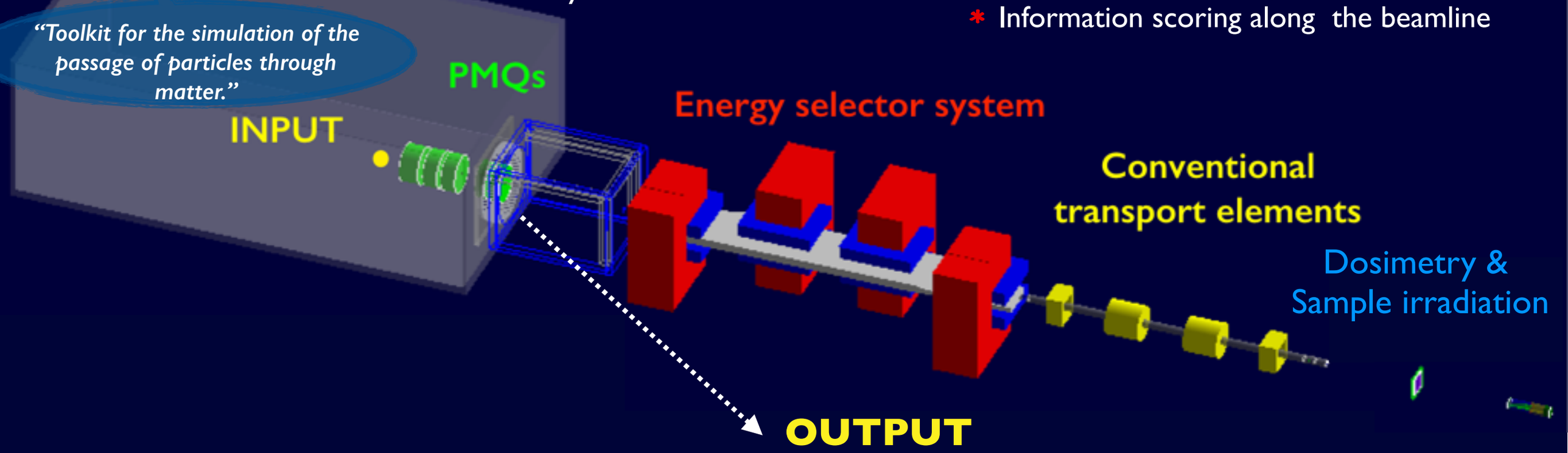

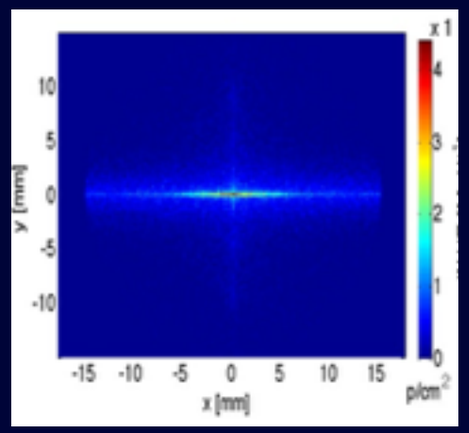

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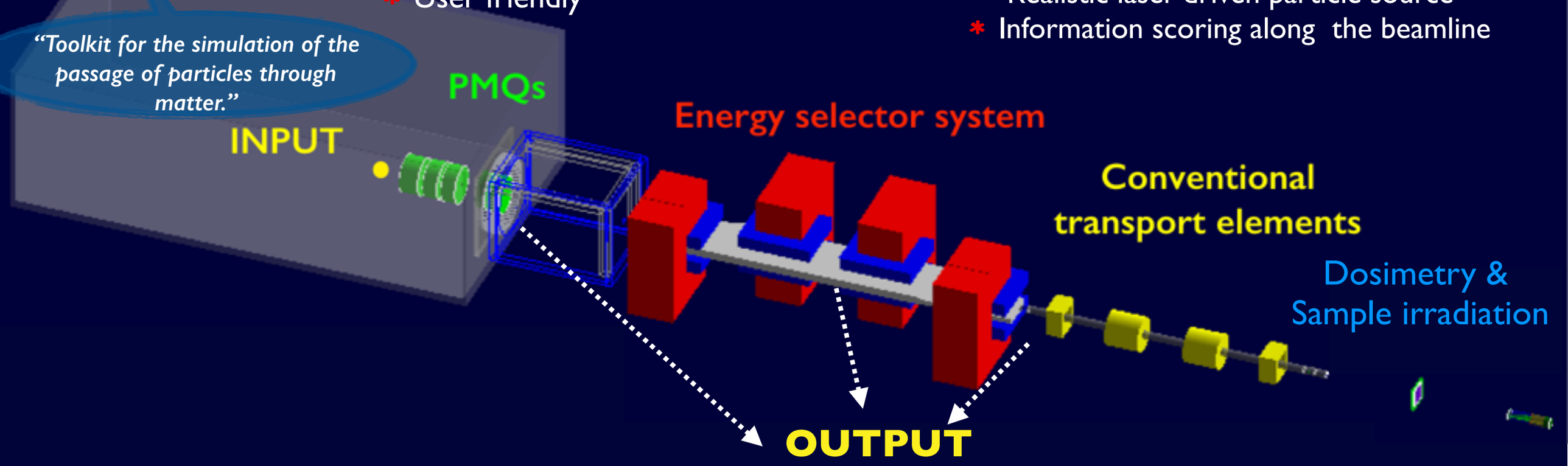

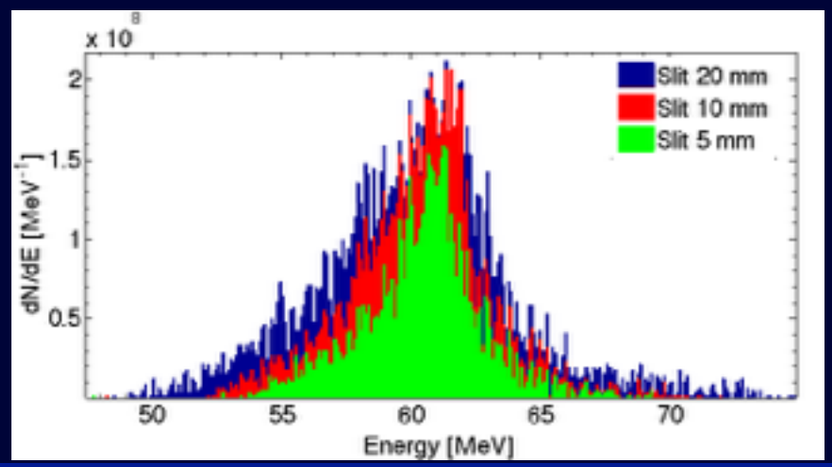

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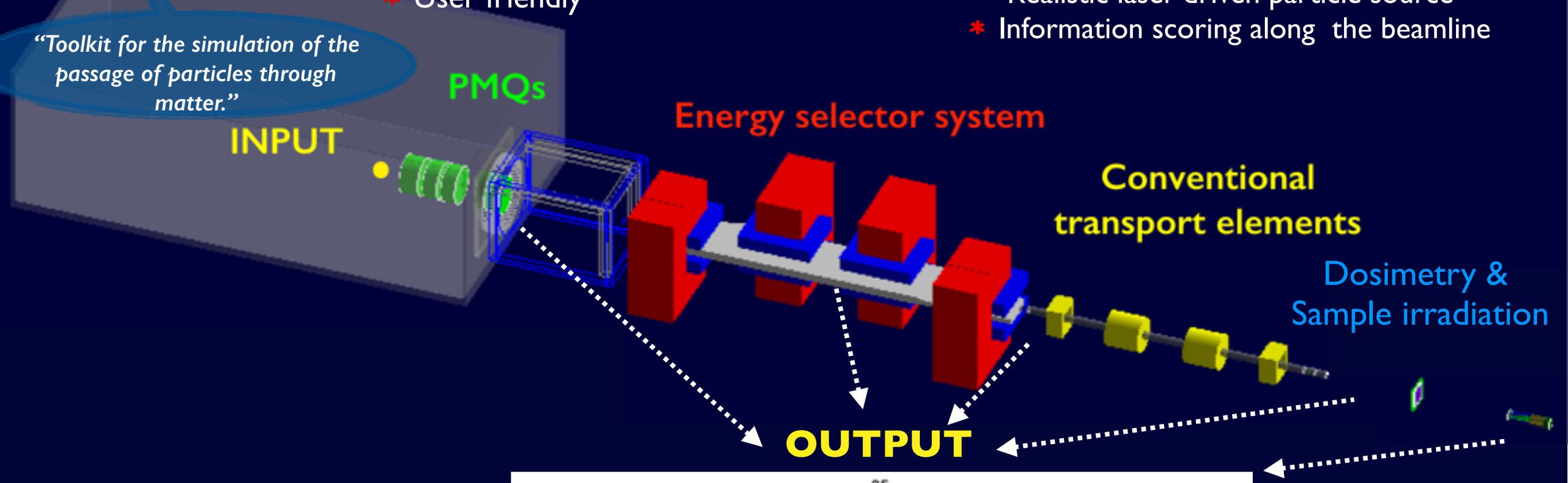
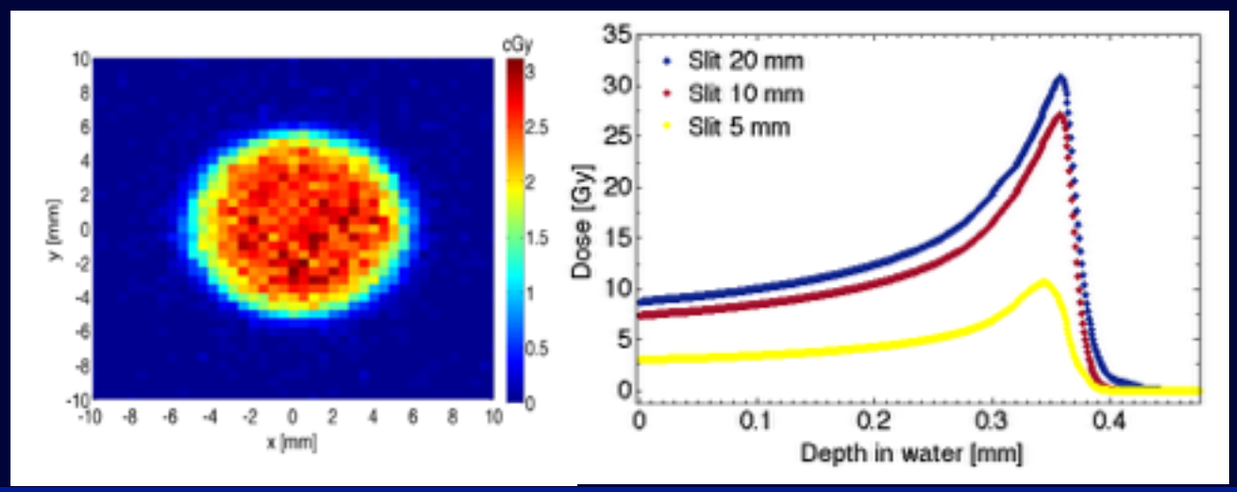
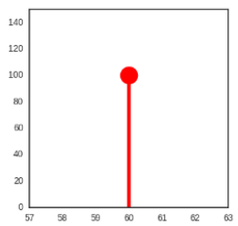




Adaptive source

Monoenergetic



Adaptive source

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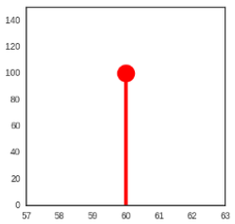
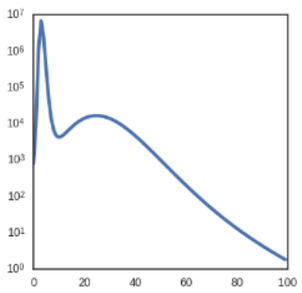
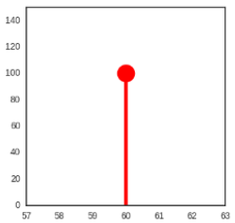


Analytic



Adaptive source

Monoenergetic



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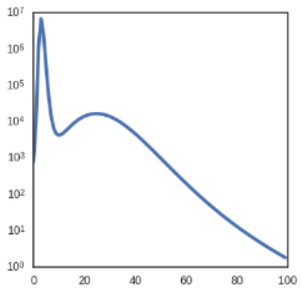
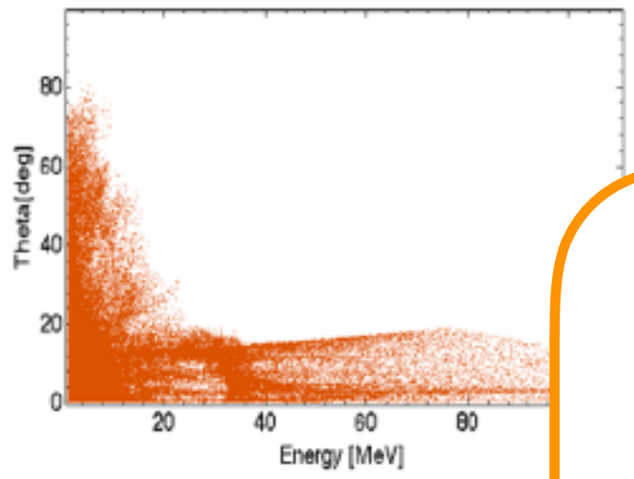
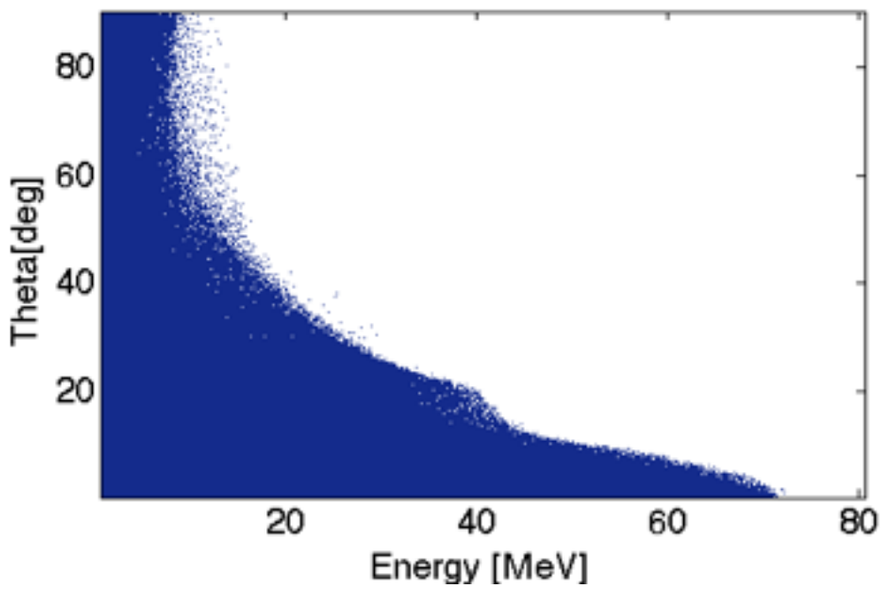


Detailed laser-driven proton and ion beam source to use as input

PIC 2D



PIC 3D



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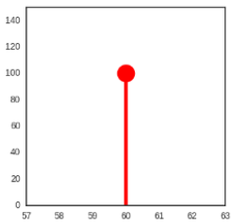

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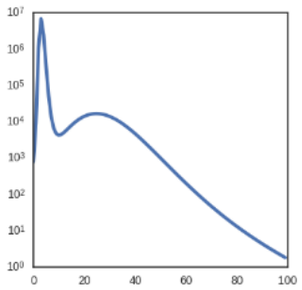

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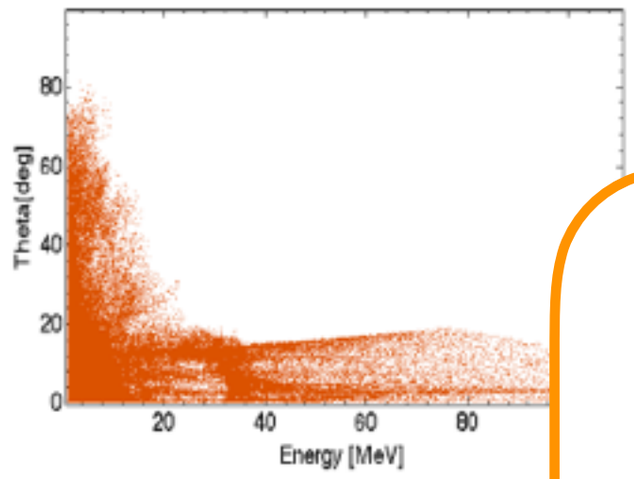

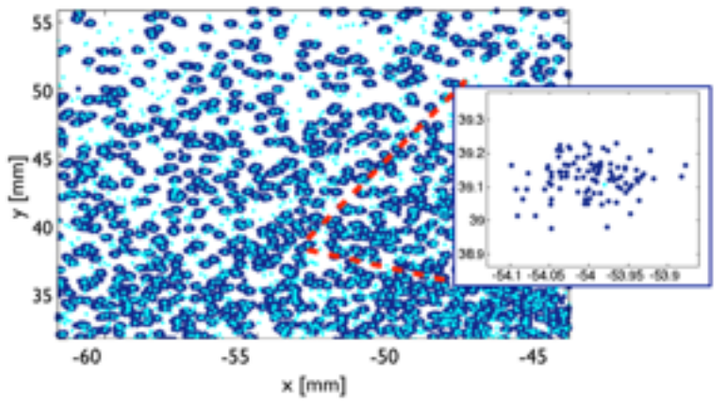

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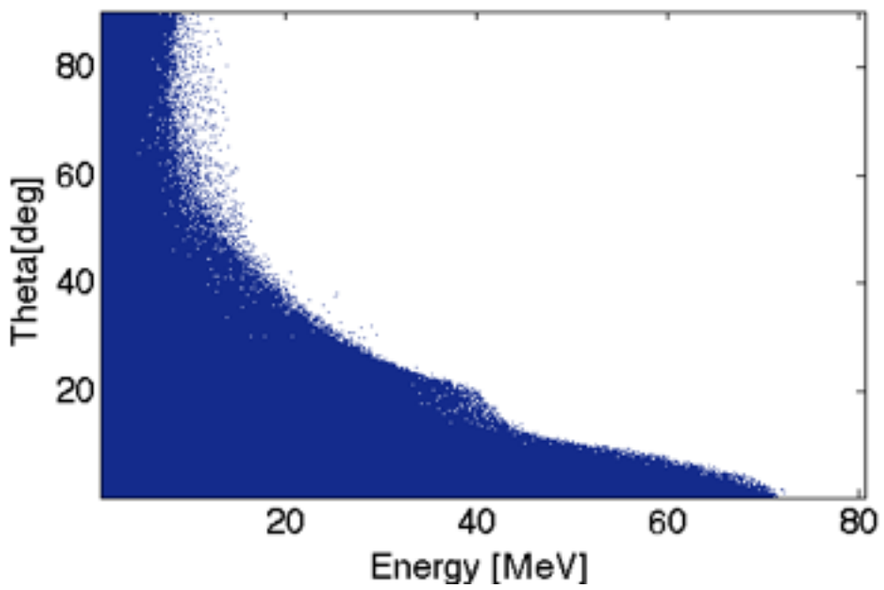

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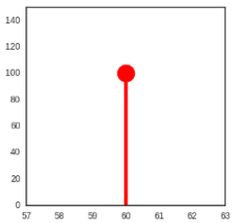

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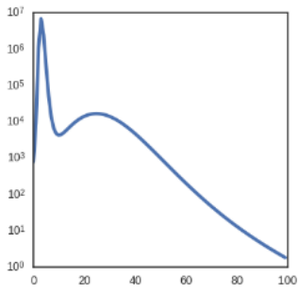

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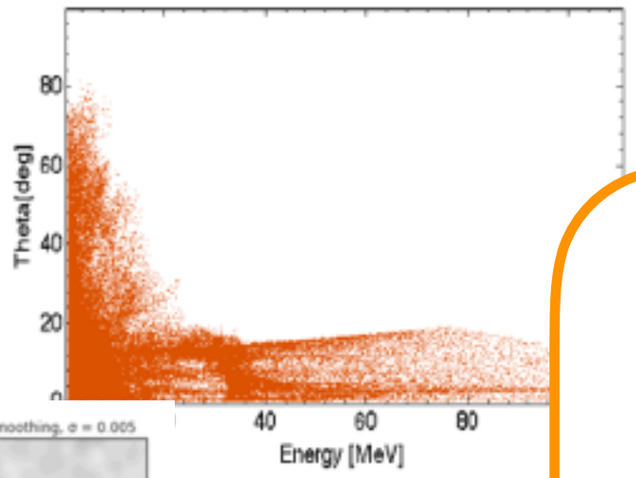

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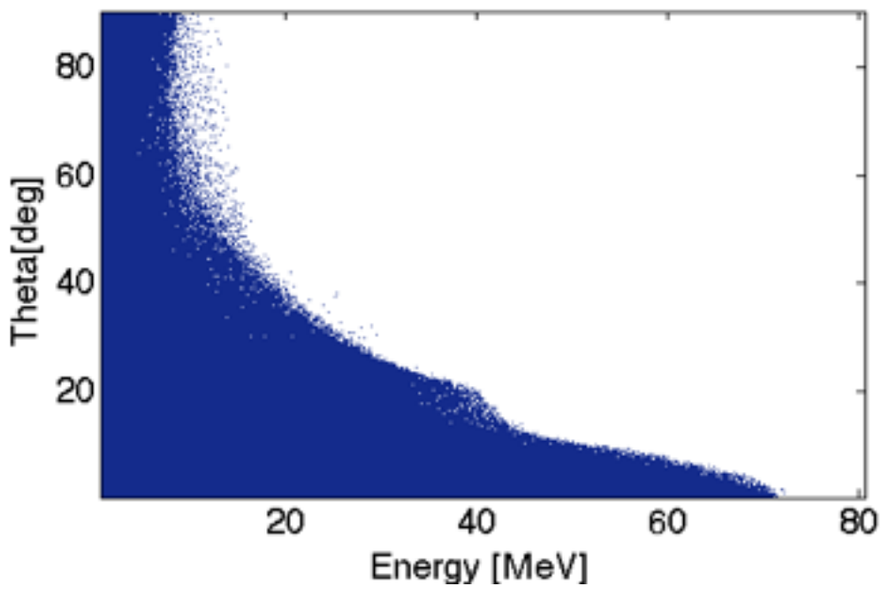
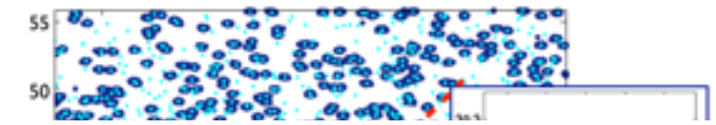
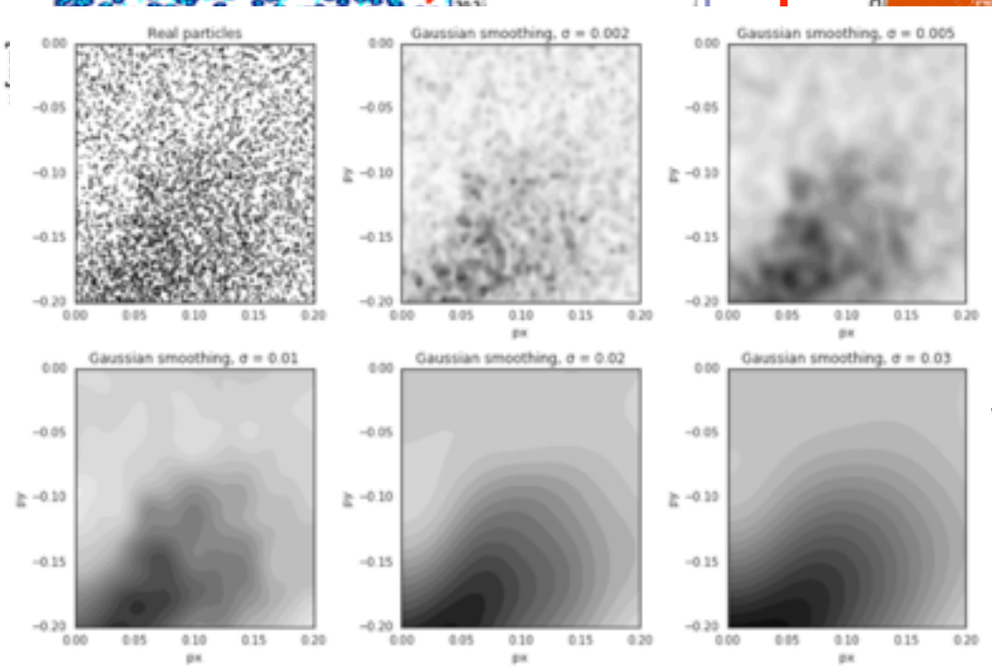
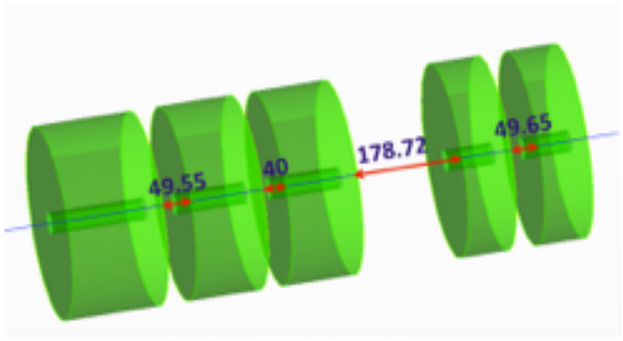


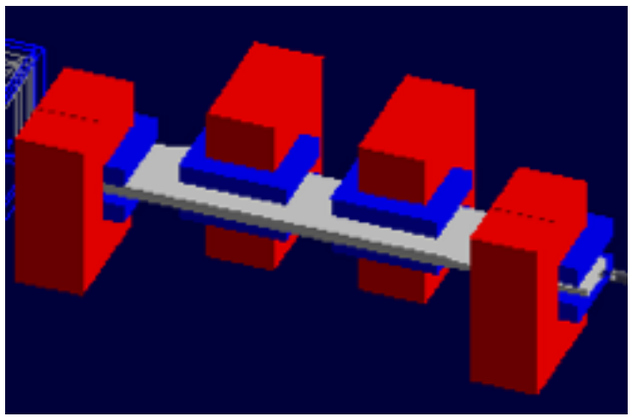


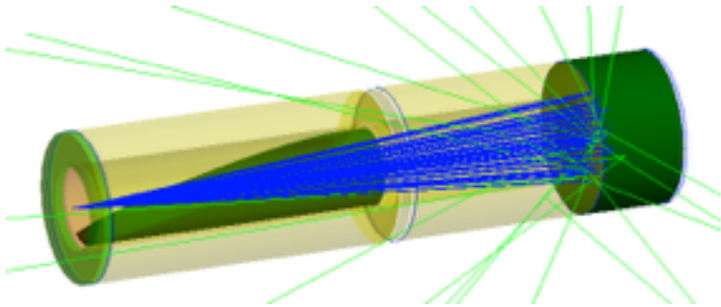


Validation with reference code: magnetic and electric fields

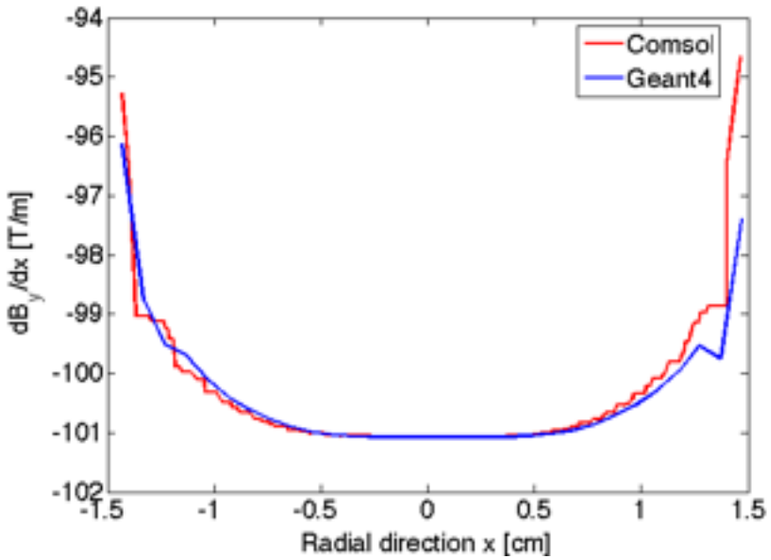
Comparison with COMSOL software



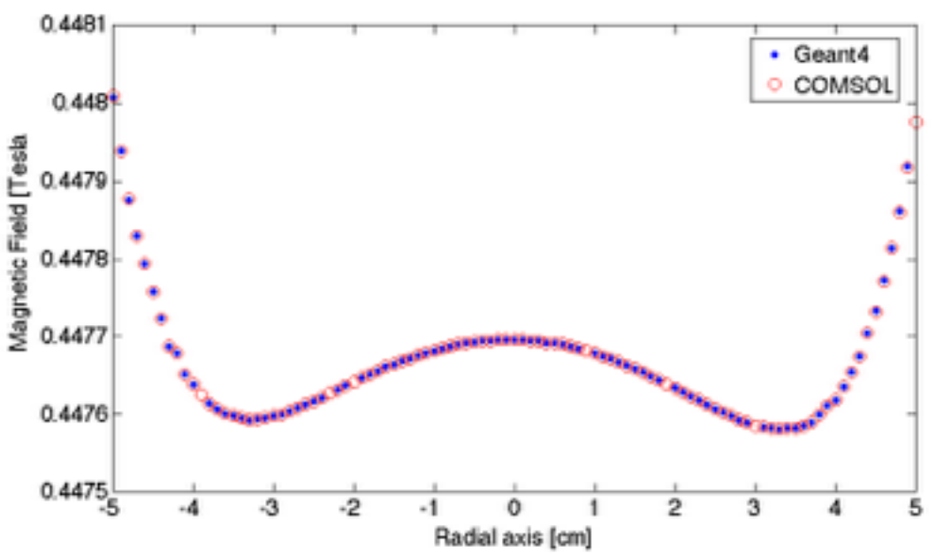




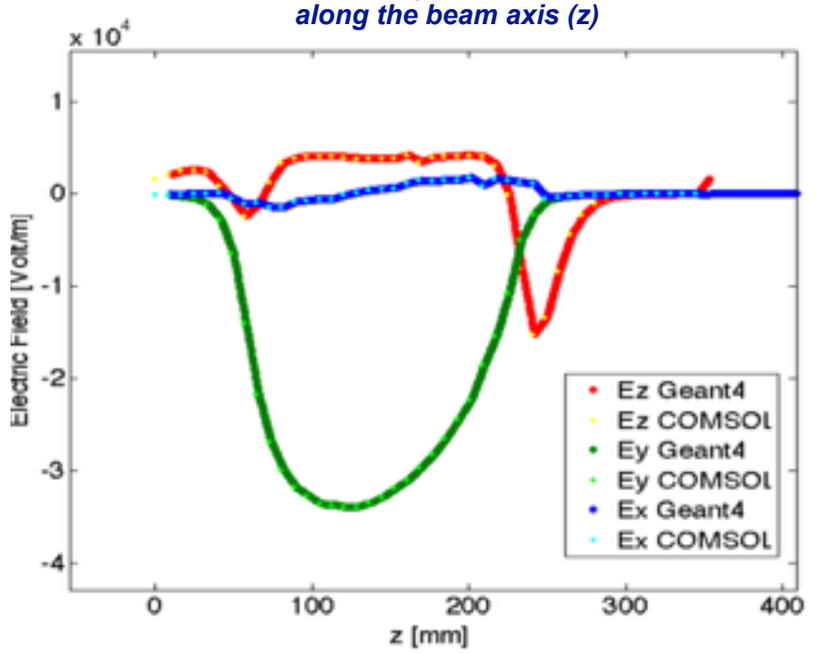
Magnetic field gradient within the 160 mm quad



Magnetic field intensity along the radial axis of the dipole

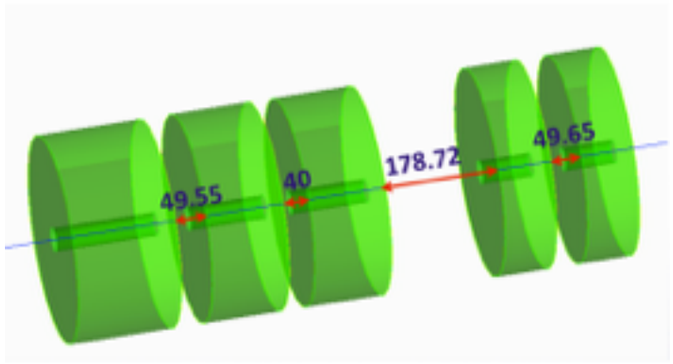


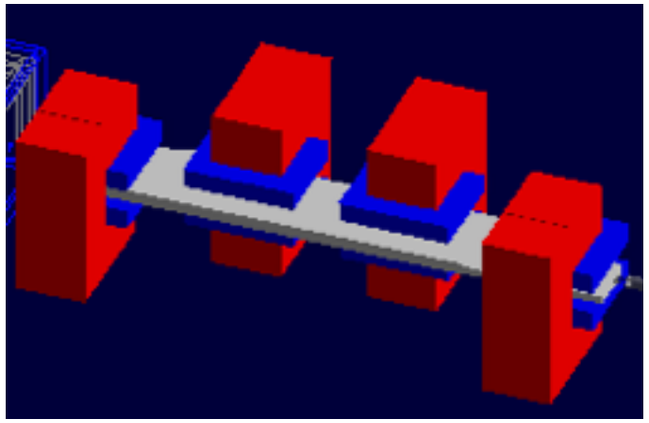
Electric field component within the FC along the beam axis (z)

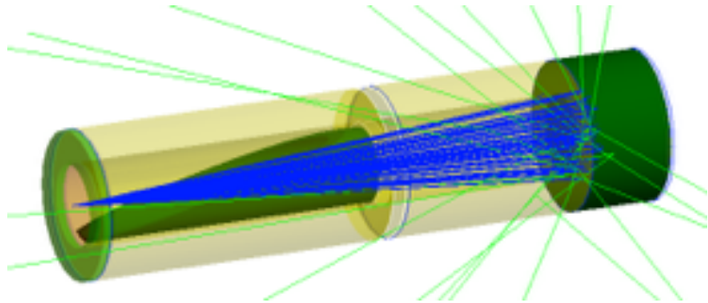


Validation with reference code: tracking

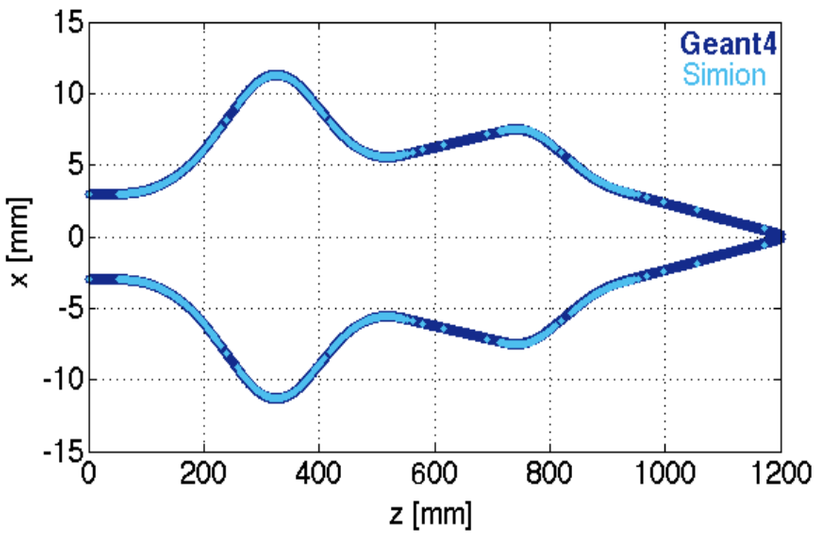
Comparison with SIMION software



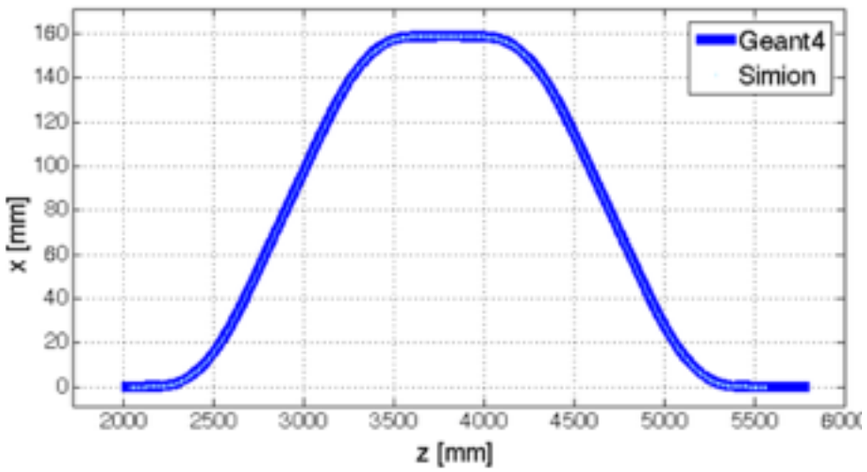




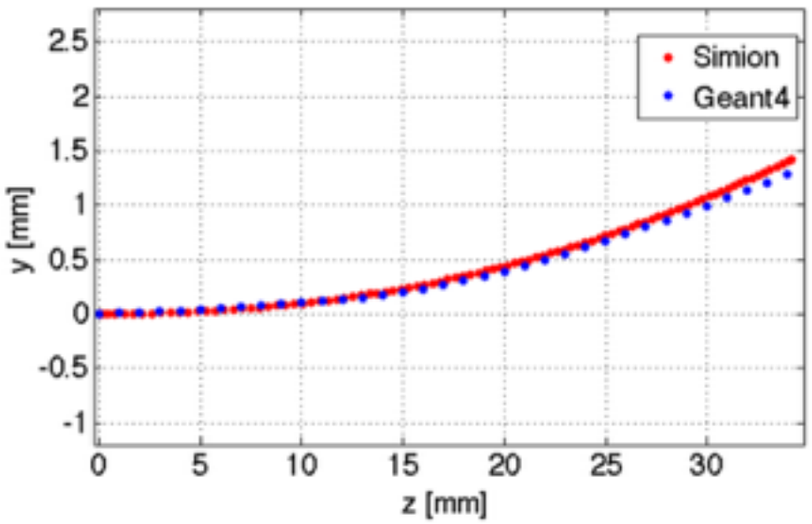
60 MeV p track within PMQ system in the x-z plane



60 MeV p track within ESS system in the x-z plane

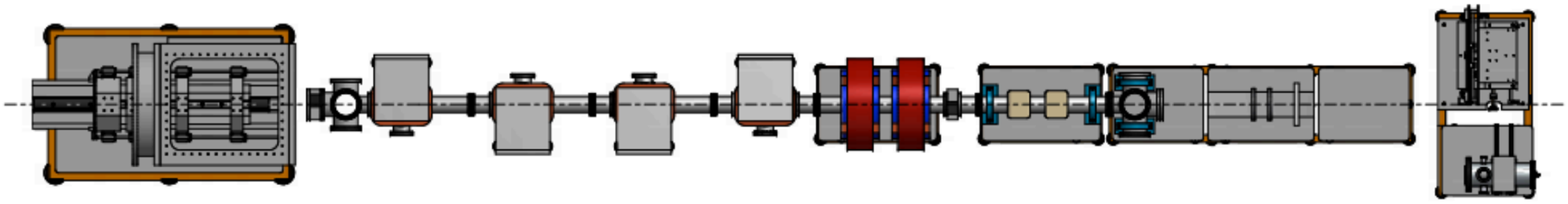


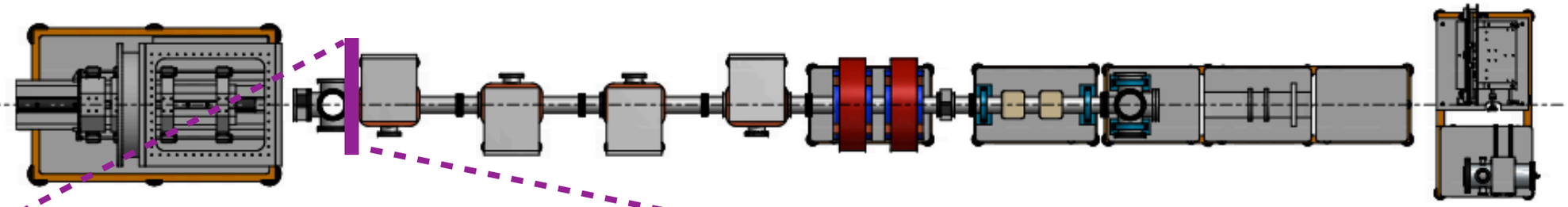
700 KeV electron track within the FC electric field in the y-z plane



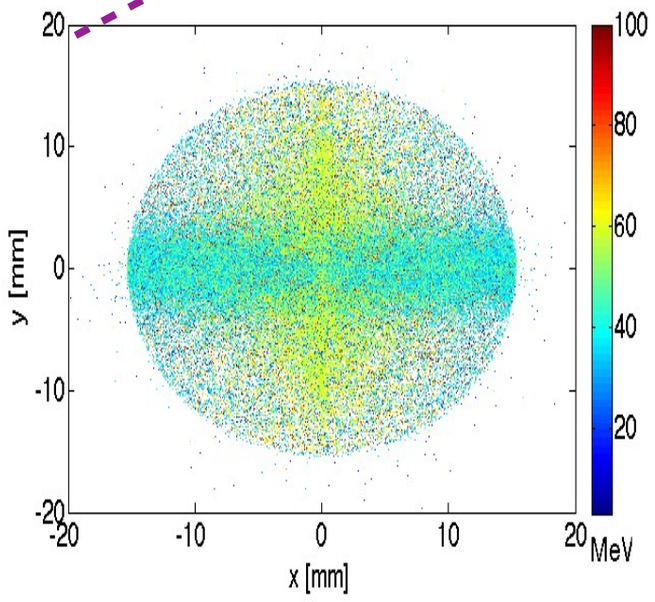
The ELIMED application as a tool for beam optimization and feasibility studies for multi-disciplinary applications

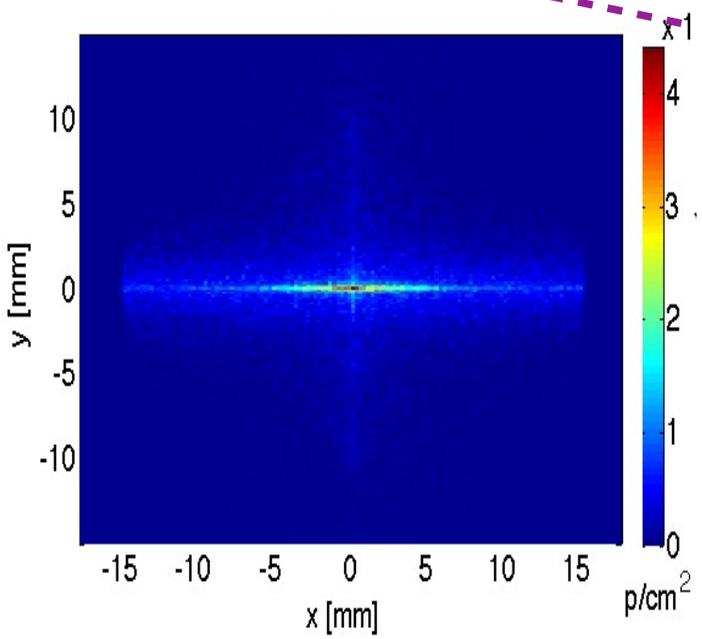
G. Milluzzo- INFN-LNS (Italy) - gmilluzzo@lns.infn.it

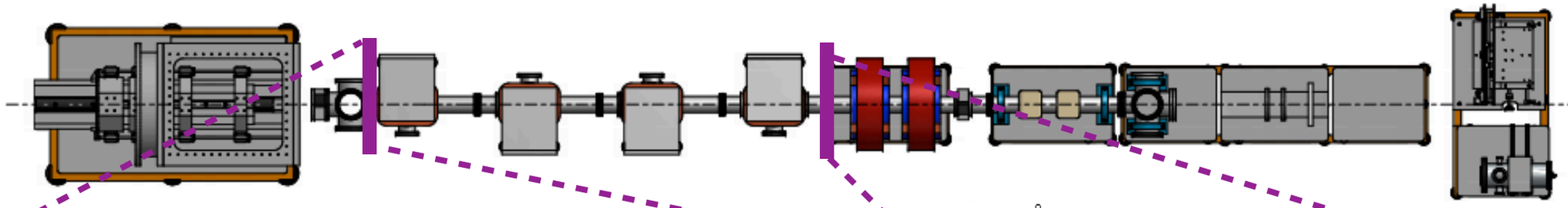




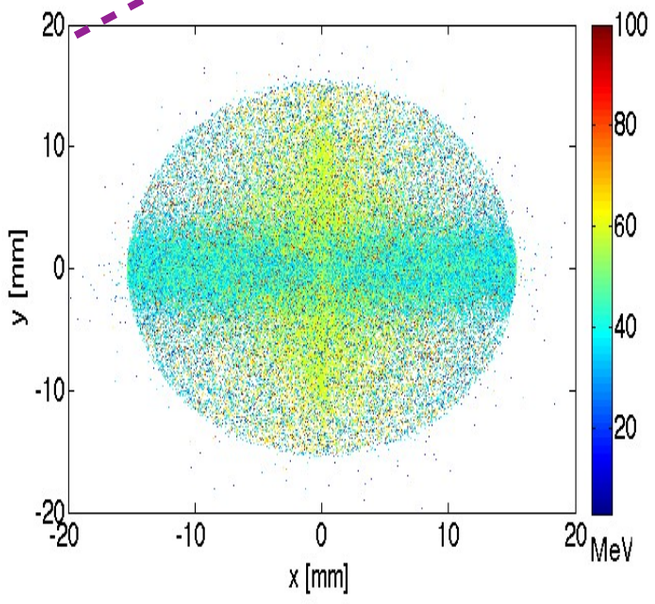
60 MeV

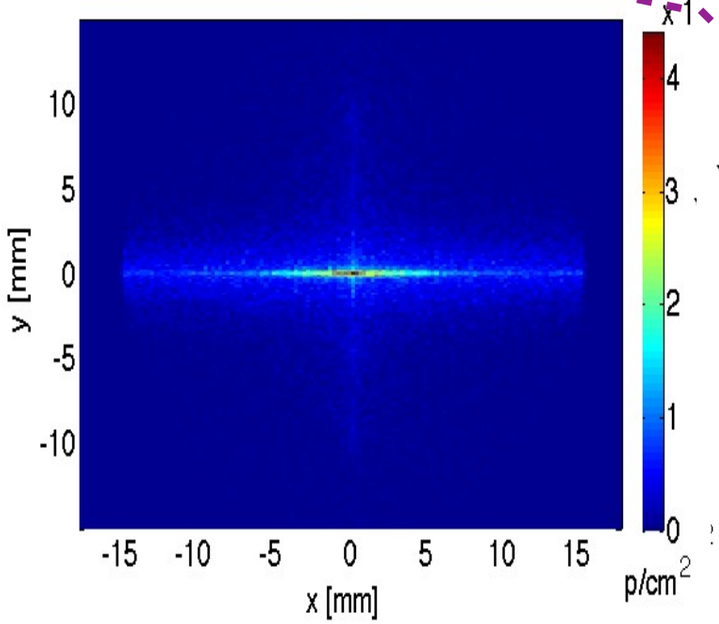

20
10
0
-10
-20
y [mm]
-20
-10
0
10
20
x [mm]
100
80
60
40
20
MeV

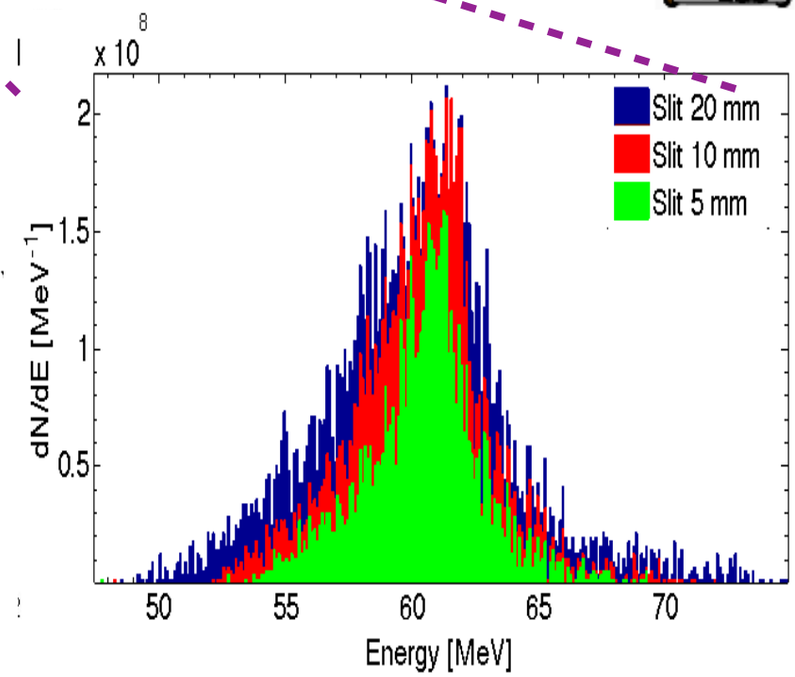

10
5
0
-5
-10
y [mm]
-15
-10
-5
0
5
10
15
x [mm]
x 1
4
3
2
1
0
p/cm2



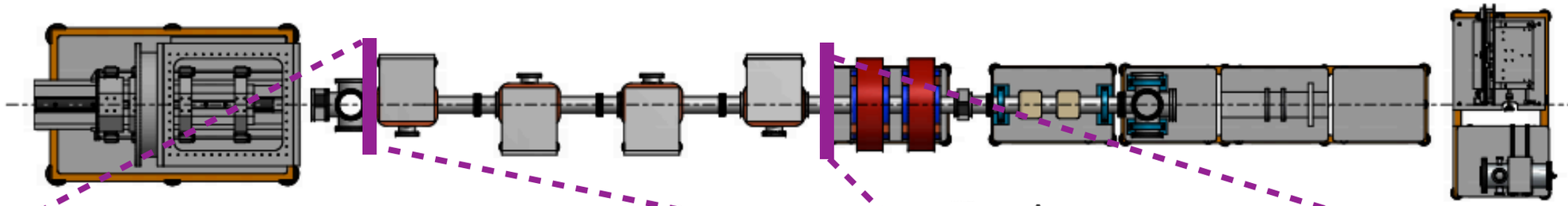
60 MeV







ΔE/E	Tr. Eff.
11%	9.9%
8%	8.0%
7%	4.9%



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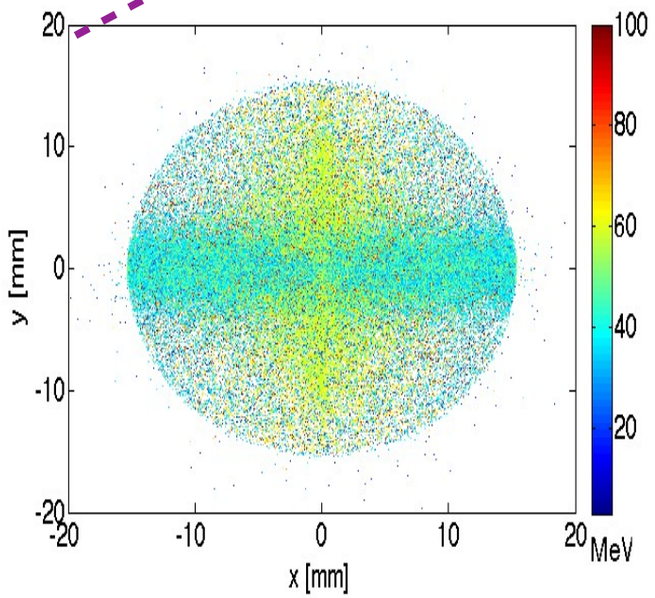
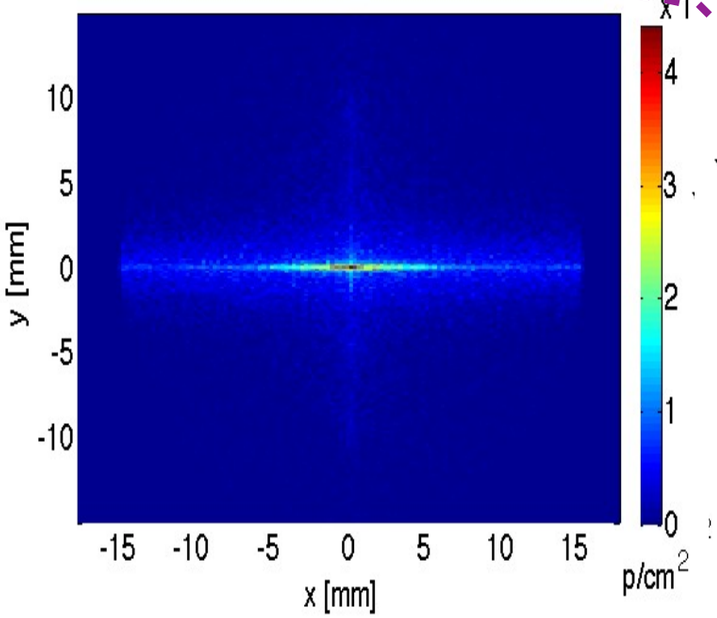
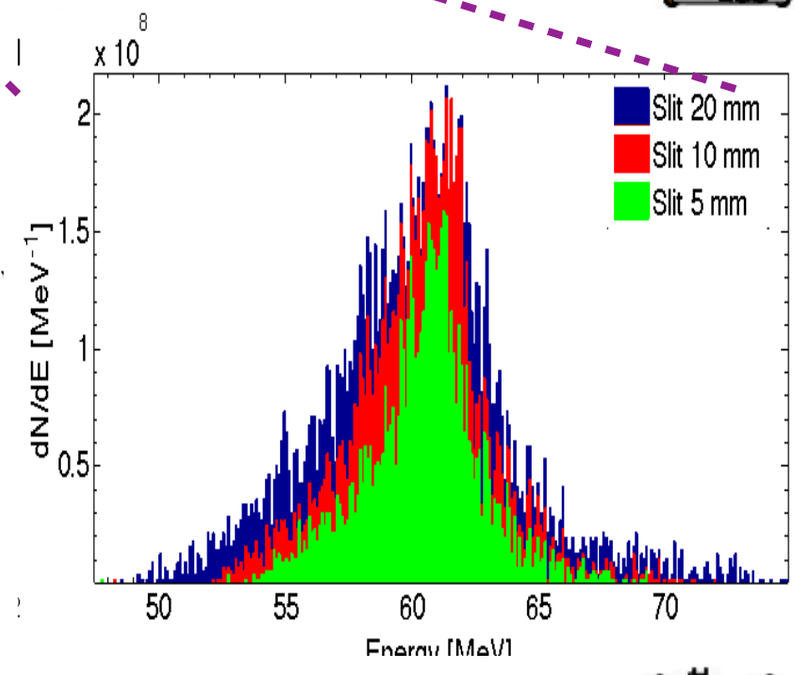
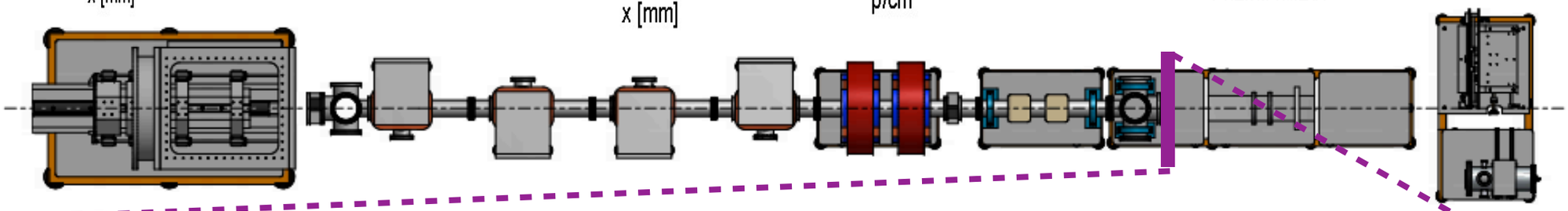
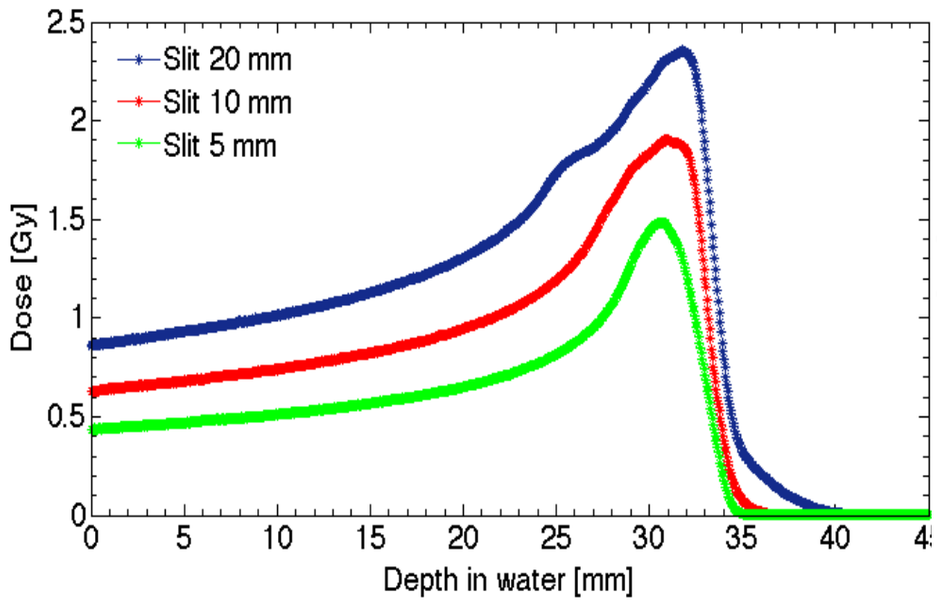


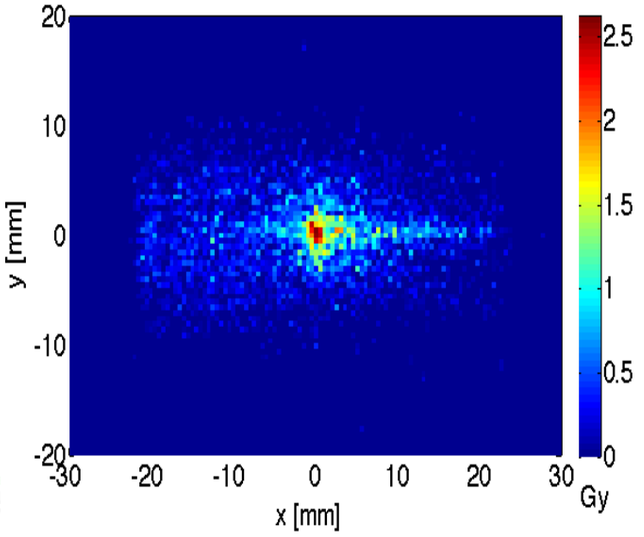


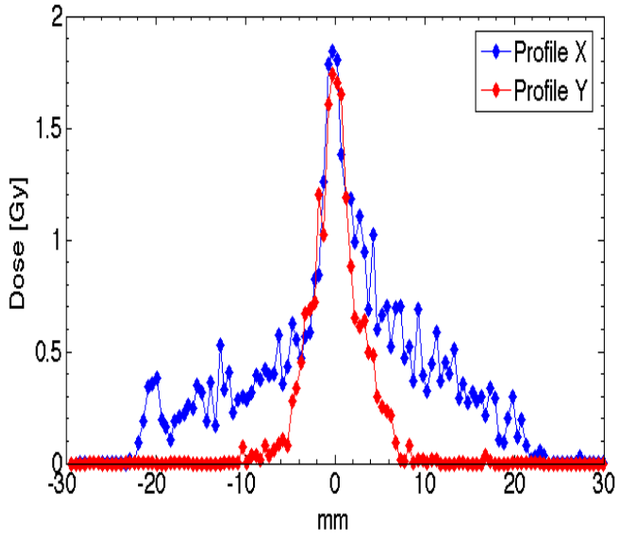


ΔE/E	Tr. Eff.
11%	9.9%
8%	8.0%
7%	4.9%

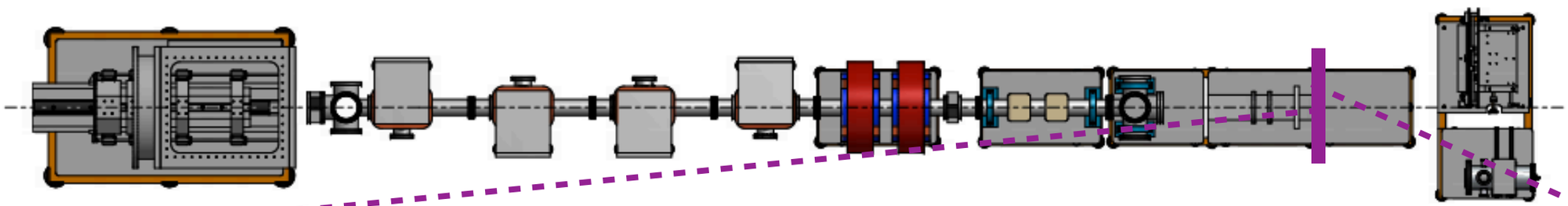


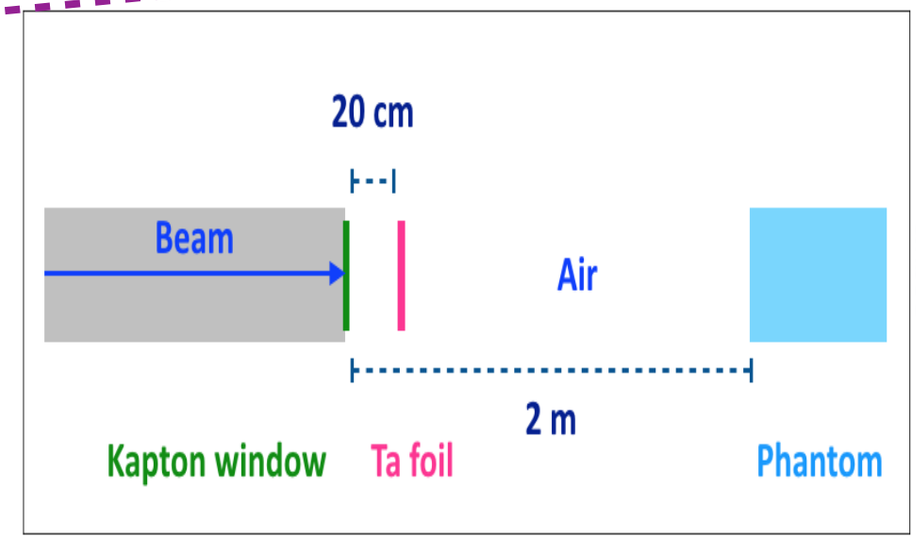


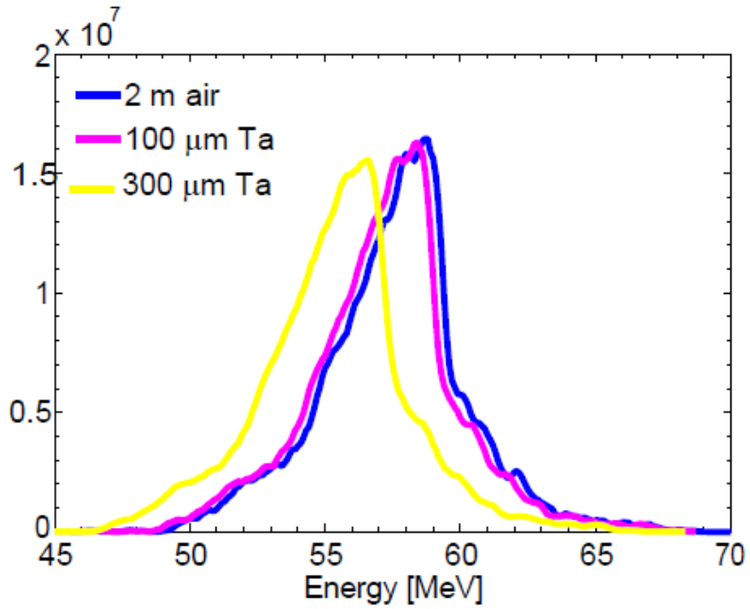


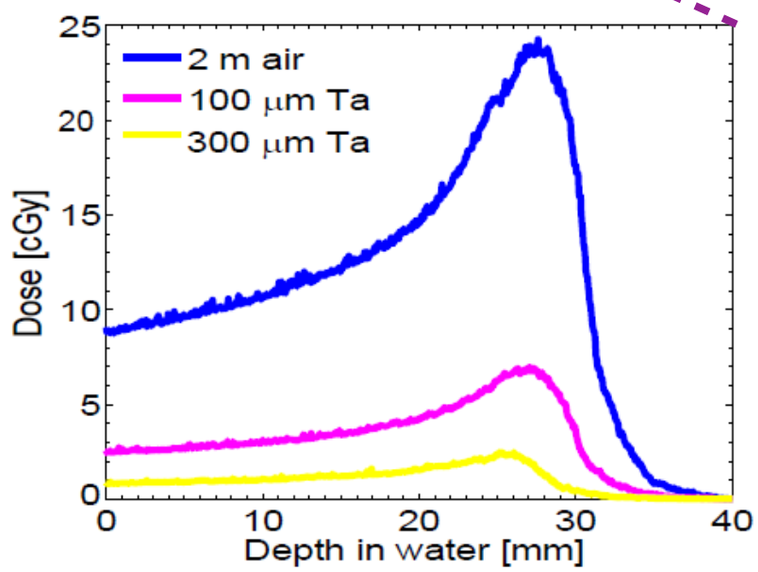


Optimization of transversal profiles for applications

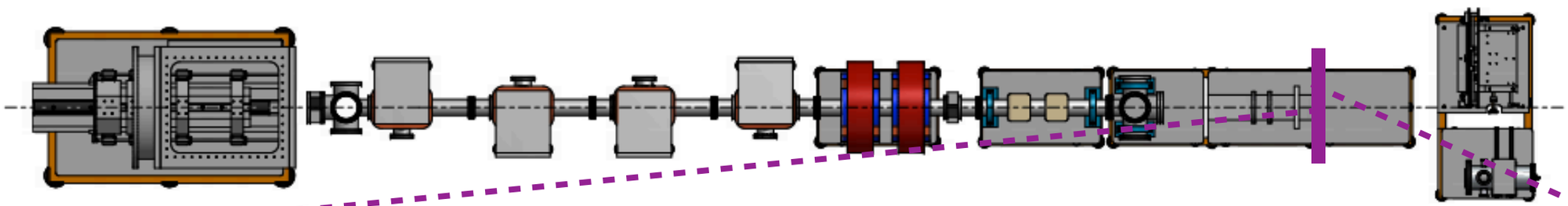


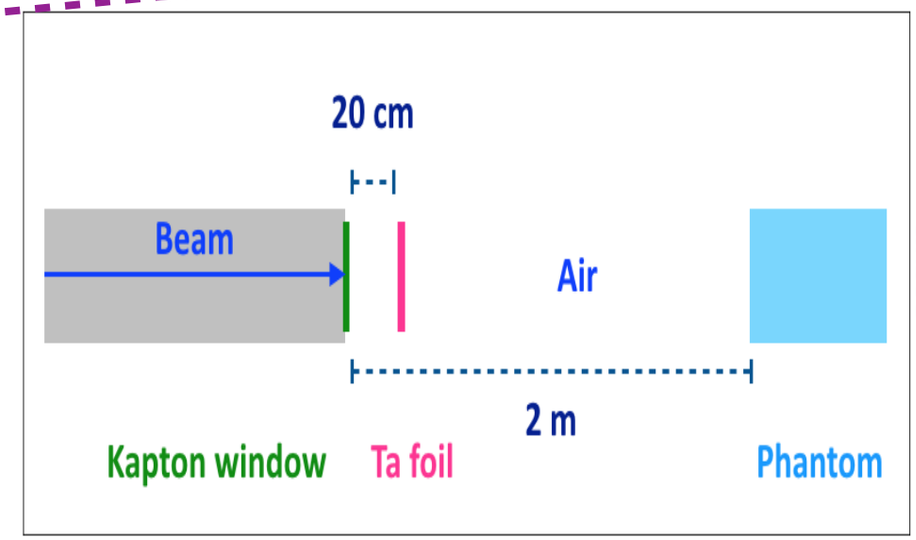


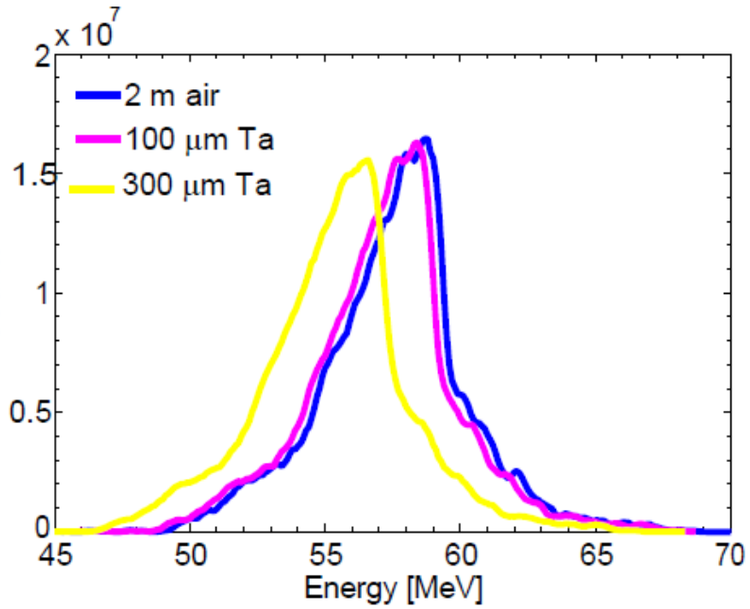


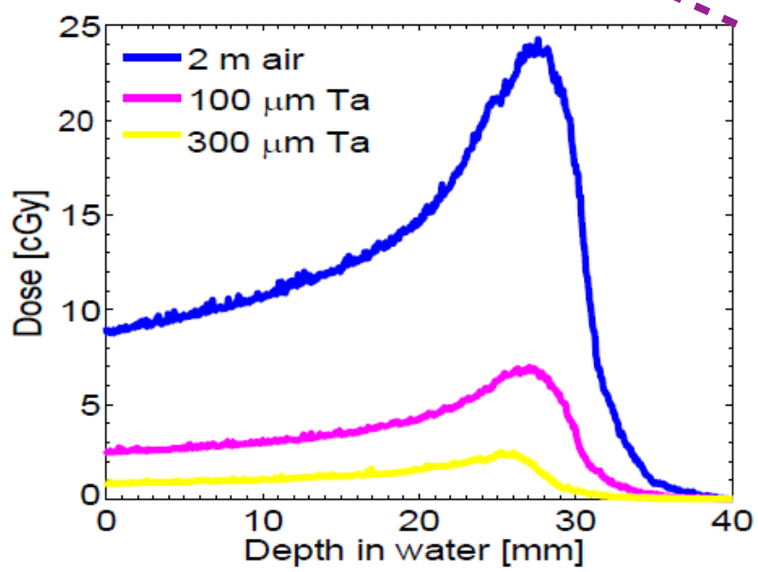


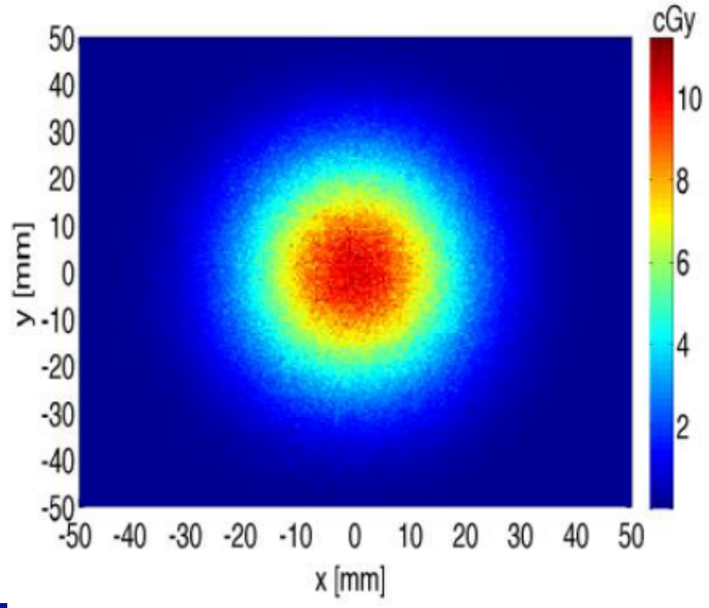
Optimization of transversal profiles for applications

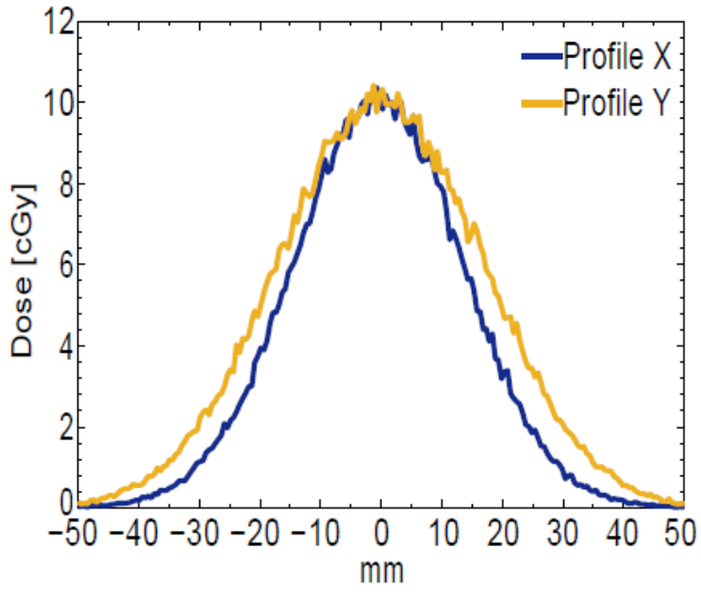












Thank you