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Program Sănătate

Radiation protection assessments of pulsed fields for laser-driven medical applications

Prepared for ELIMED 2026

16-19th of February

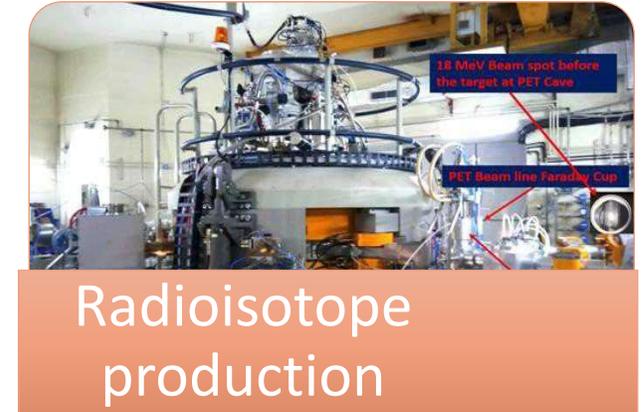
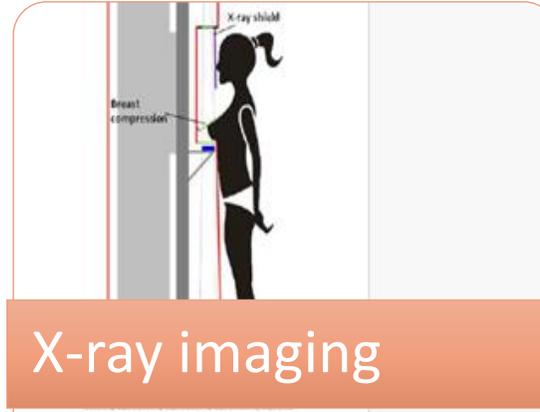
I. O. Mitu, R. Virág, M. G. Popovici, I. E. Dinescu L. L. Bilteanu, F. Costache, M. Dumitrache,
A. Anghelache, M. Oprisan, M. Iovea, C. Balan, C. Gheara, A. R. Stefan, C. A. Ur

Content

- Laser-driven medical applications at ELI-NP - research activities
- Main goals of RP and dosimetry group
- Design targets
- RP and dosimetry considerations for:
 - Laser X-ray imaging
 - Hadron therapy
 - Radioisotope production
- Experimental dosimetry measurements
- Medical classical protocols – dose assessments
- Remarks

Laser-driven medical applications at ELI-NP

Dr.LASER project: three demonstrative experimental setups are developed (activities A.1 – A.3)



Three support activities:

A.4 Preclinical experiments (cells, phantoms)

A.5 Numerical simulations and theoretical modeling

A.6 Radiation protection calculations and dosimetry

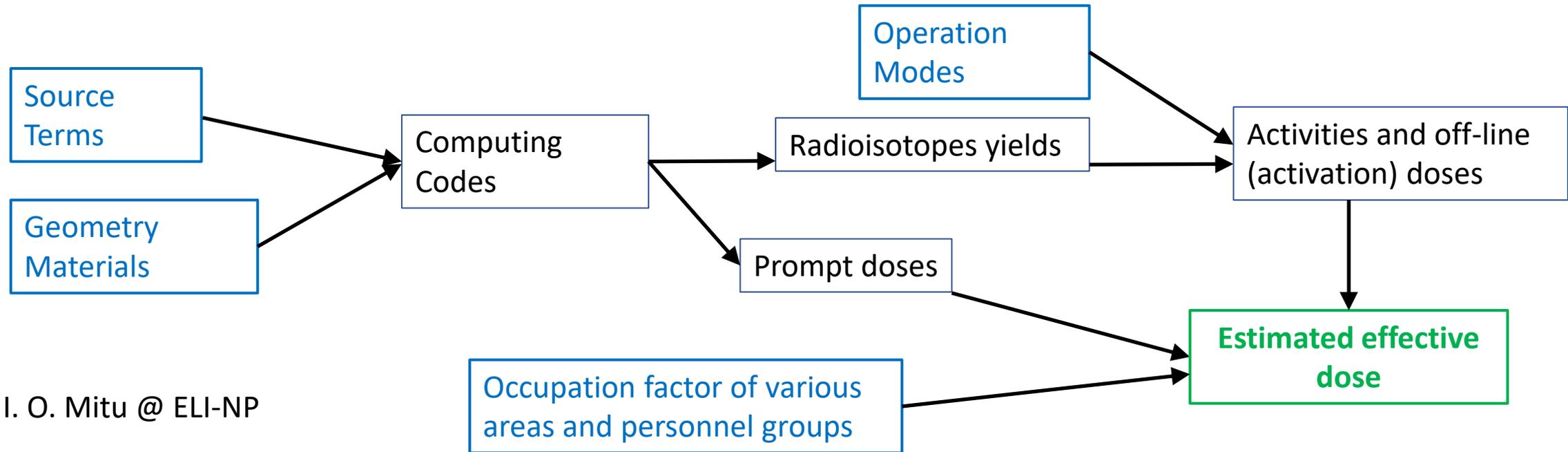


Main goals of A.6

Radiological installations implementation site assessment;
Identification of exposure modes/operation scenario;
Primary sources identification
Preliminary calculations of dose distribution in normal operation;
Shielding configurations;
Secondary sources characterization;
Dose and dose rate measurement techniques identification;
Experimental dosimetry measurements, calibration and applied corrections;
Efficient radiation protection measures definition for each research field



Design targets – ELI-NP compliant



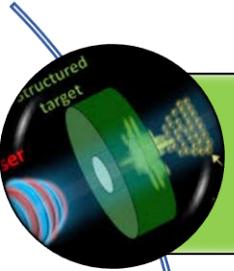
I. O. Mitu @ ELI-NP

The input data are adjusted in a loop till compliance with design targets is achieved.

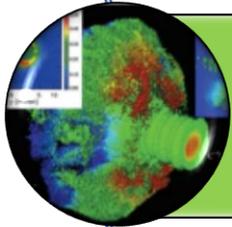
- **ELI-NP design targets:** 2 mSv/year for radiation workers at ELI-NP
- 1 μ Sv/h at exterior of ELI-NP bunker
- 0.1 μ Sv/h at exterior of ELI-NP building

Primary sources identification

Laser acceleration mechanisms

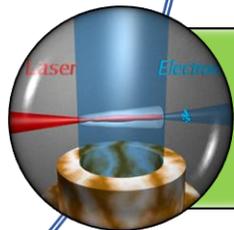


Target Normal Sheath Acceleration (TNSA)



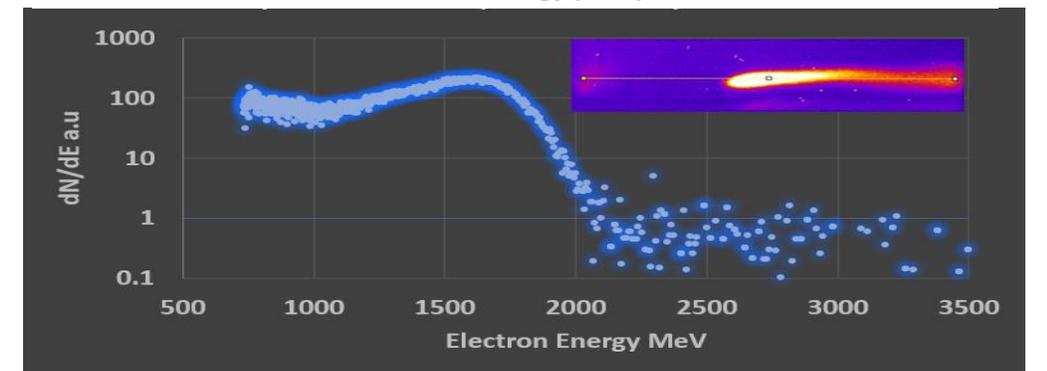
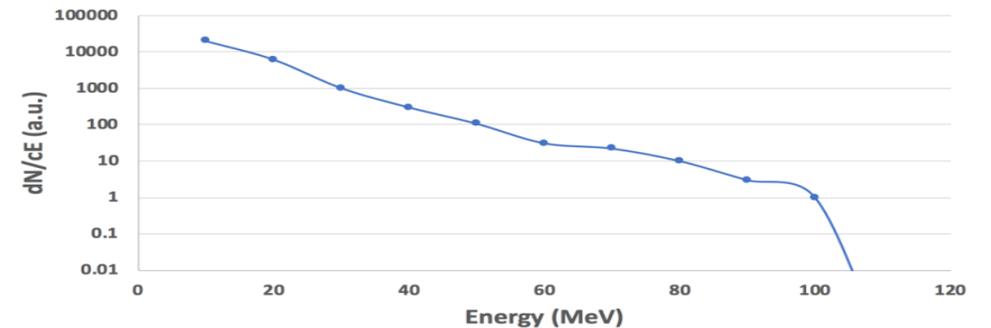
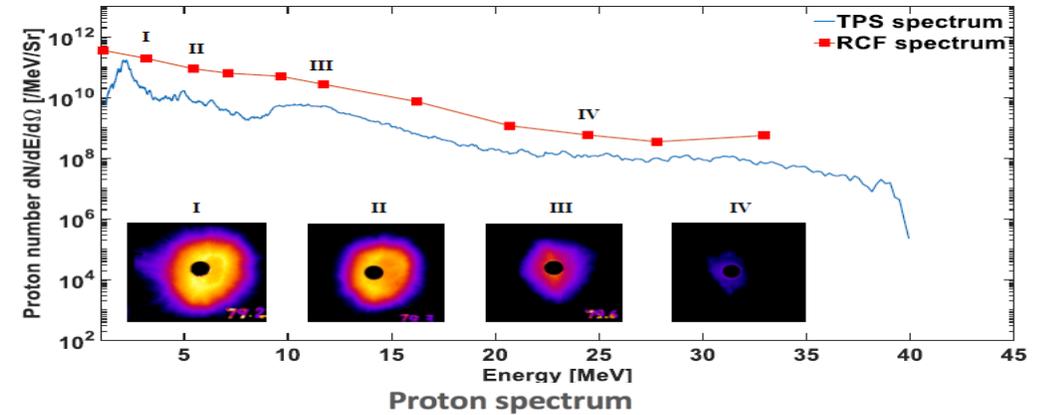
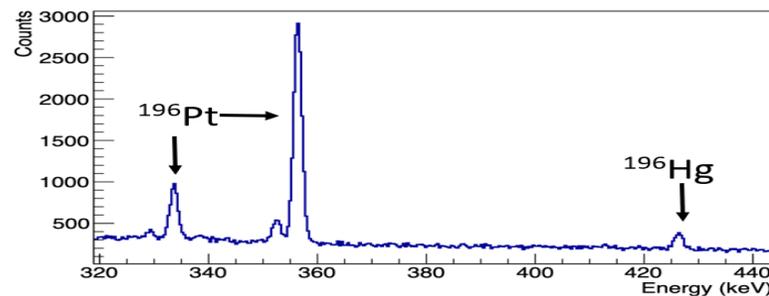
Advanced mechanisms:

- Radiation Pressure Acceleration (RPA)
- Break-Out After – burner (BOA)
- Collisionless Shock Acceleration (CSA)



Laser Weak Field Acceleration (LWFA)

Isomers (Au foils activation)



Experimental teams @ ELI-NP

Site assessment - X-rays imaging



FLUKA



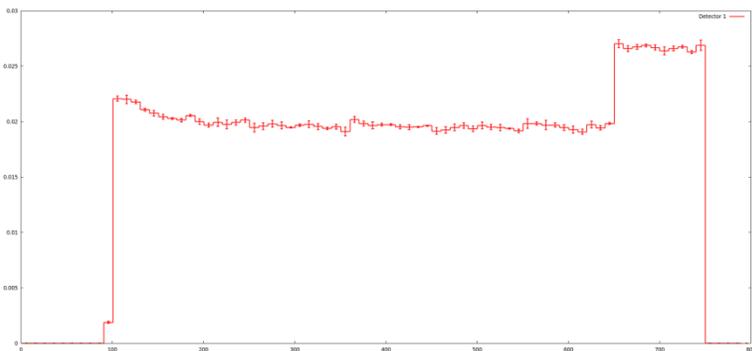
I. O. Mitu, R. Virág and M. G. Popovici @ ELI-NP



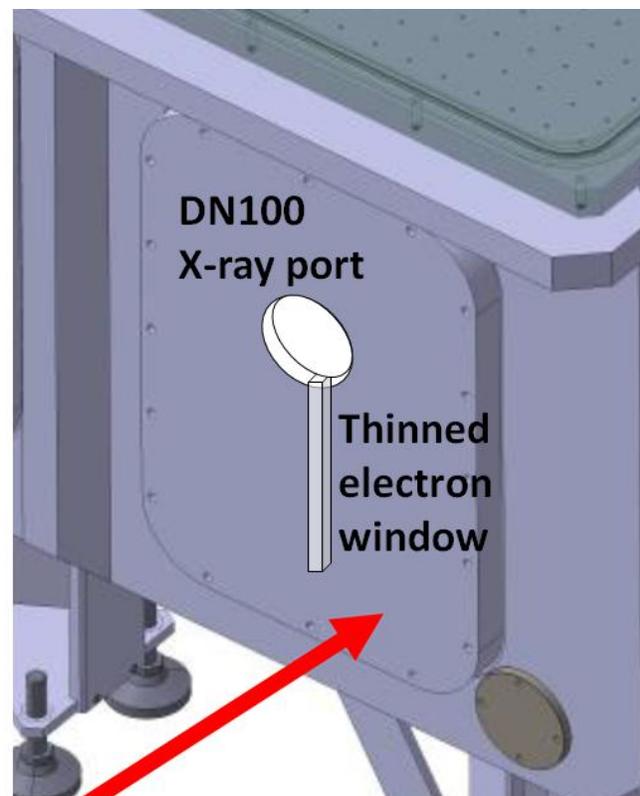
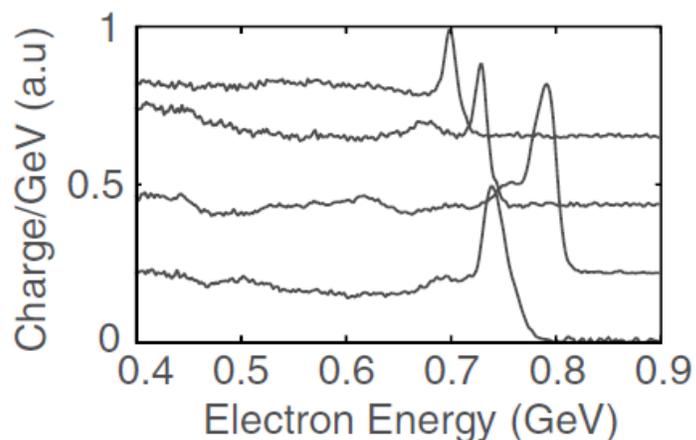
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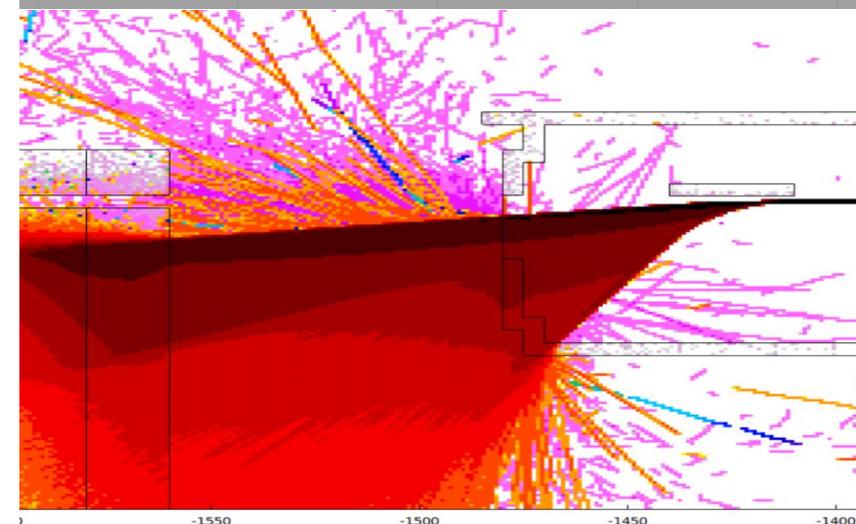
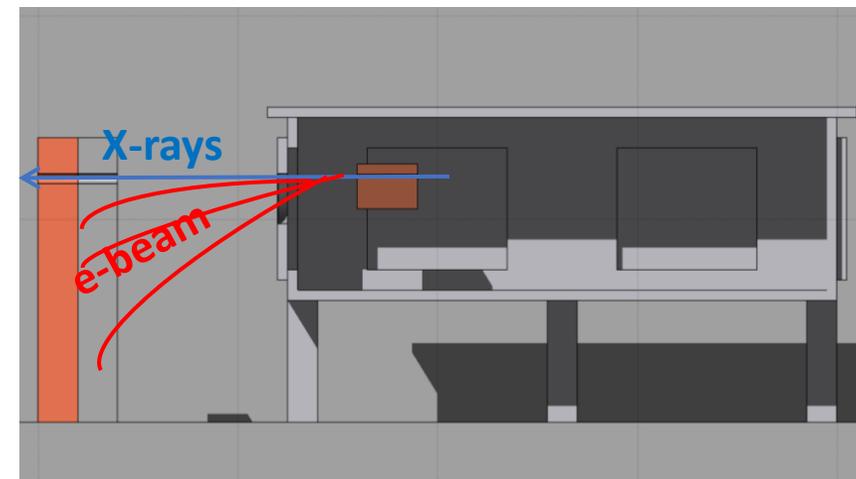
Primary sources and optimization – X-ray imaging



FLUKA electrons distribution (up) - adaptation after *Cole et al* (down).

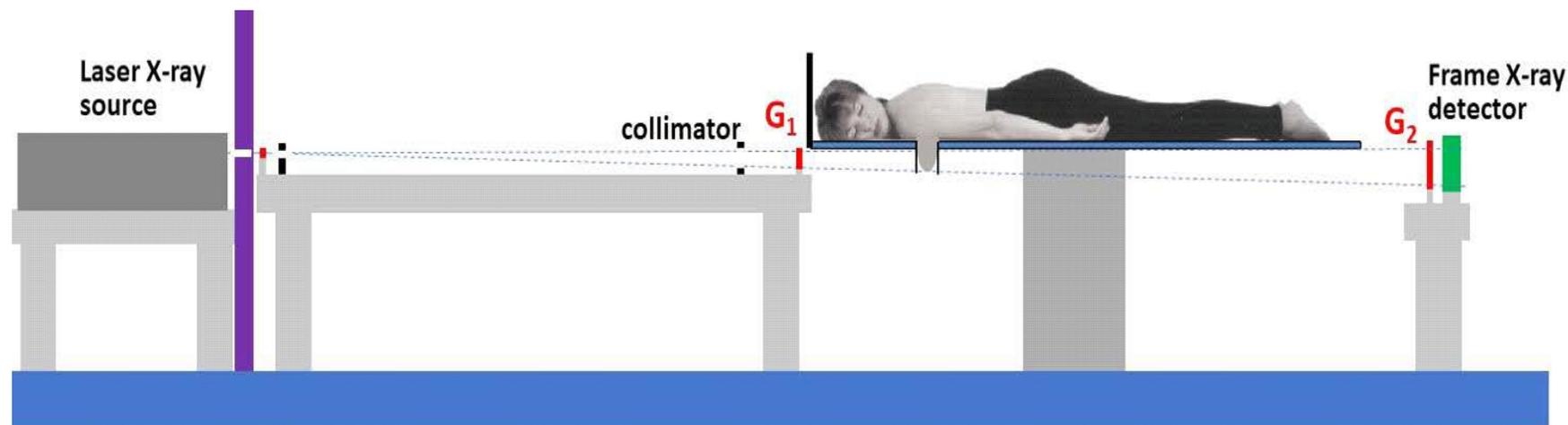


Adapting the IC configuration to avoid unwanted secondaries



Electrons beam bending in the magnetic field

Primary sources and optimization – X-ray imaging



Experimental considerations



TRL 7 system



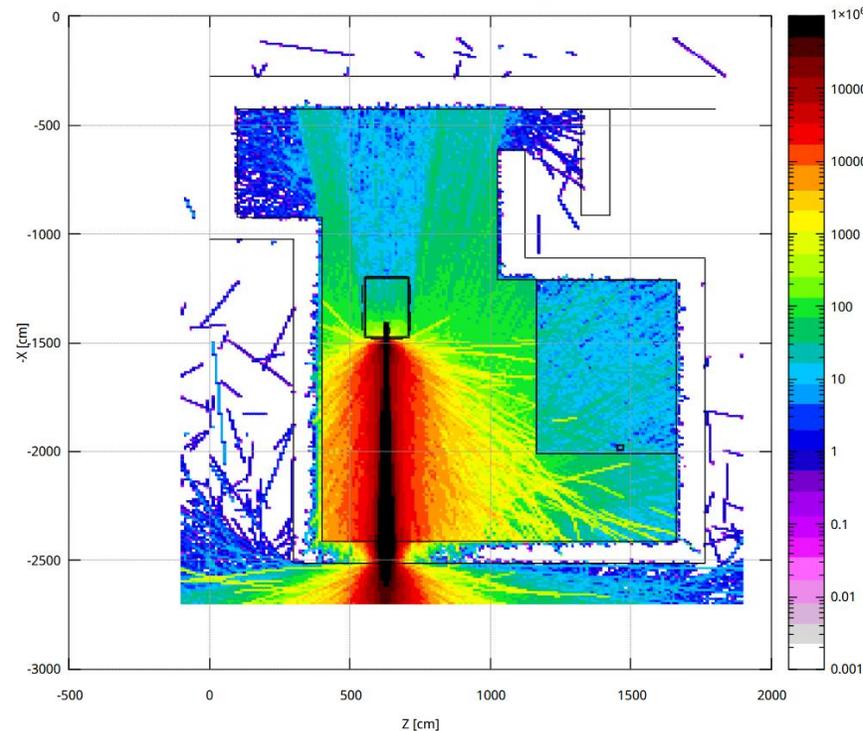
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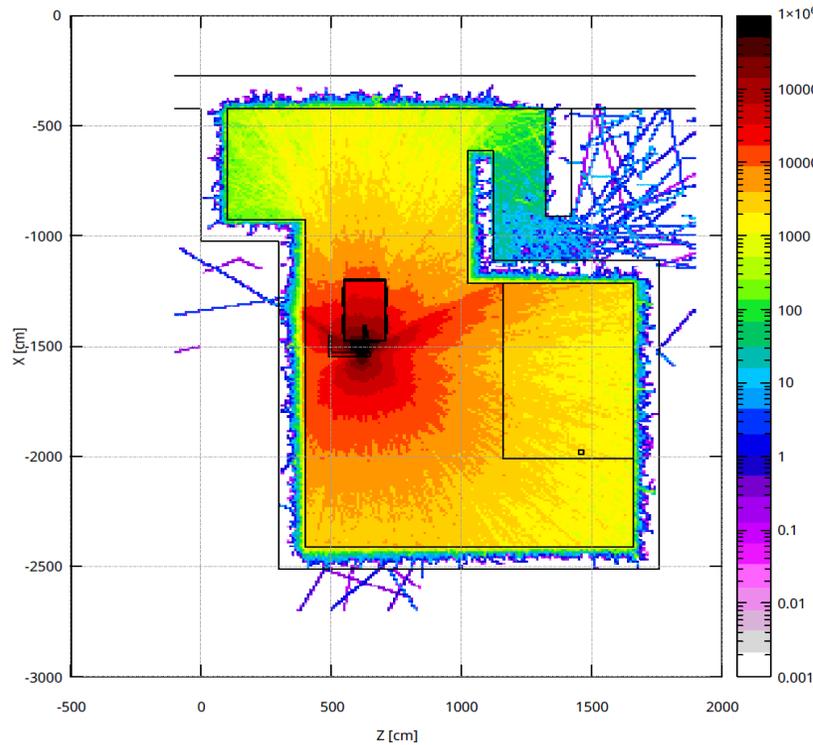
Exposure modes/Operating scenarios

All particles dose rate contours (uSv/hour) - no beam dump, no magnetic field



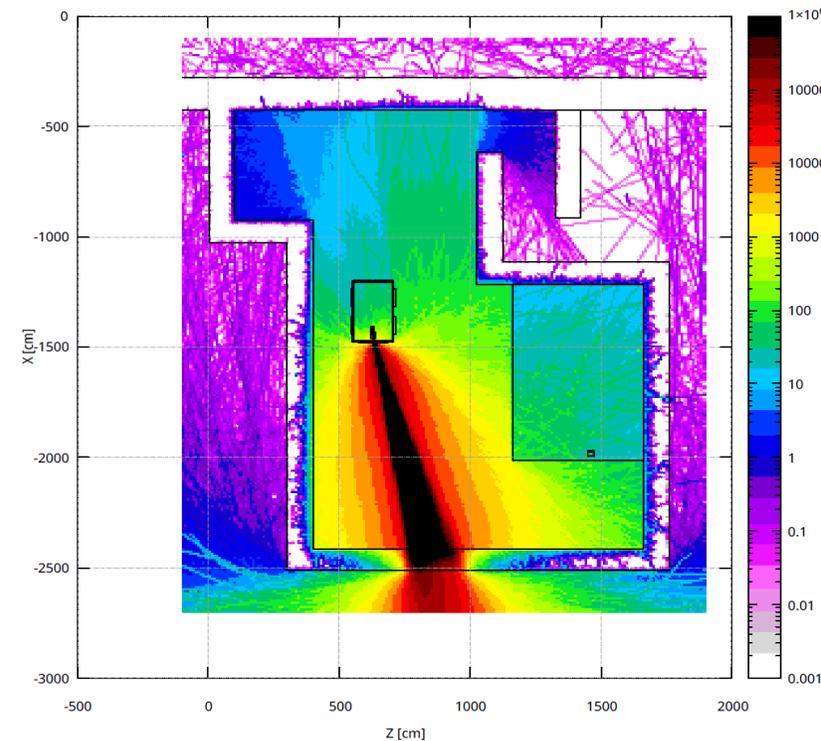
No beam attenuator (beam dump)

All particles dose rate contours (uSv/hour) - 20 cm + 10 cm lead dump (L shaped), magnetic field, e-beam goes left



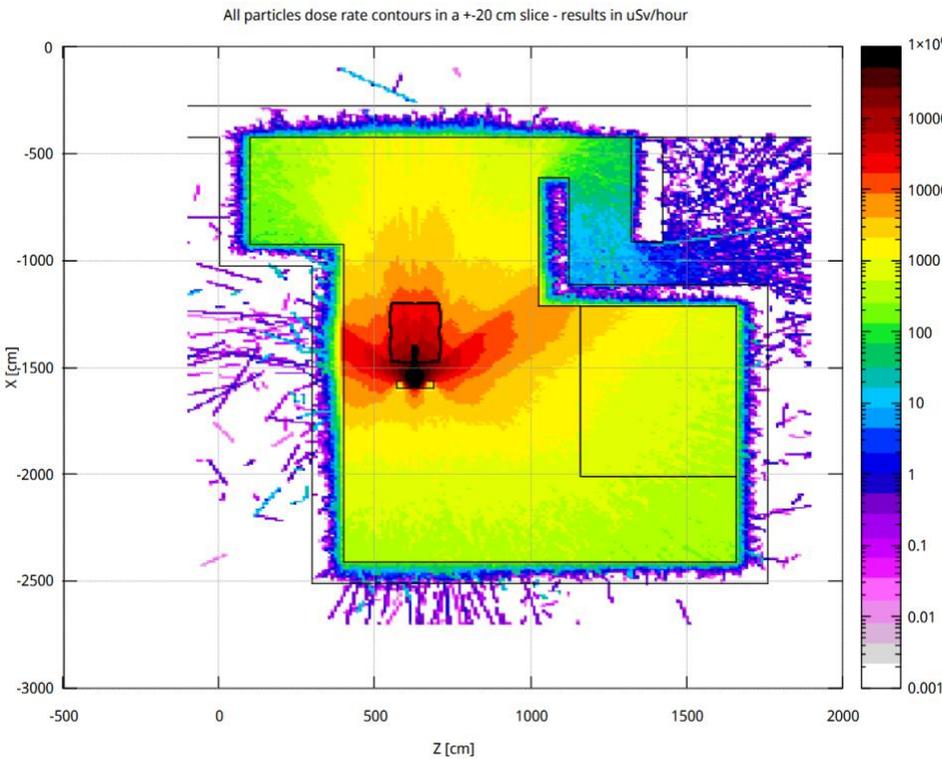
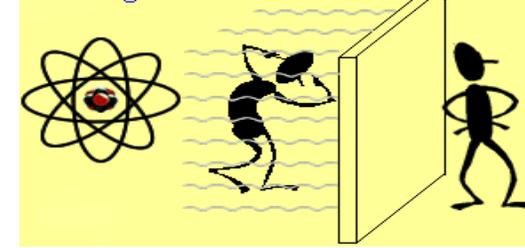
Beam goes lateral

All particles dose rate contours (uSv/hour) - no beam dump, with magnetic field, e-beam directed towards E3 center



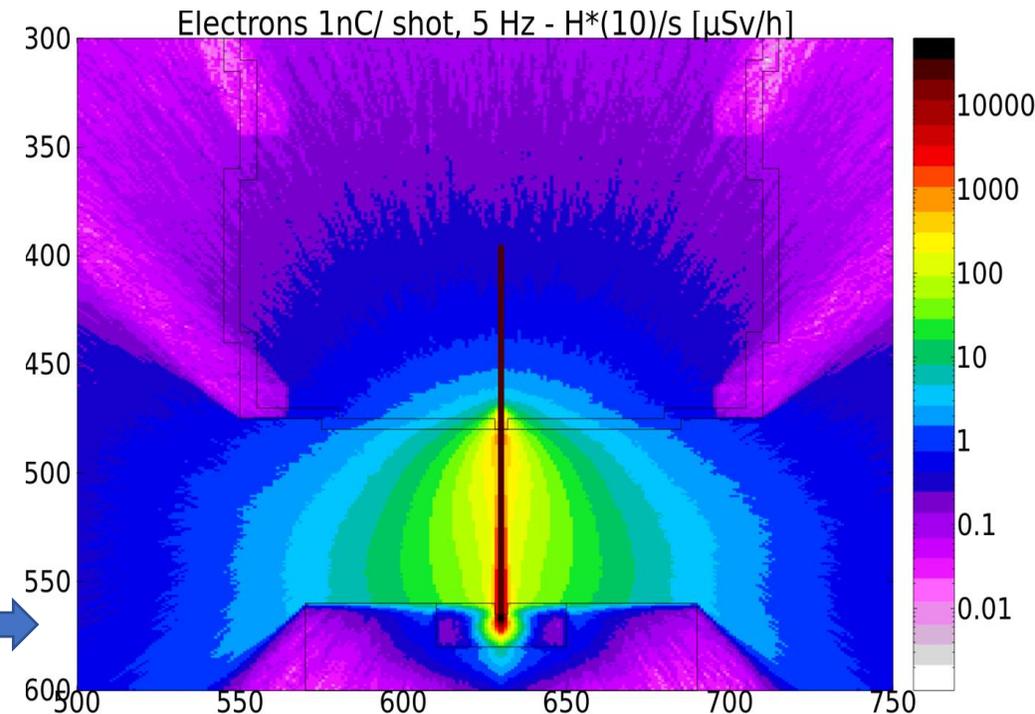
Electrons beam misses the beam dump

Calculations of dose distribution – focus on shielding



All particles dose rate contours, $\mu\text{Sv}/\text{hour}$

Electrons distribution, 1 nC/shot – $\text{H}^*(10)/\text{s}$



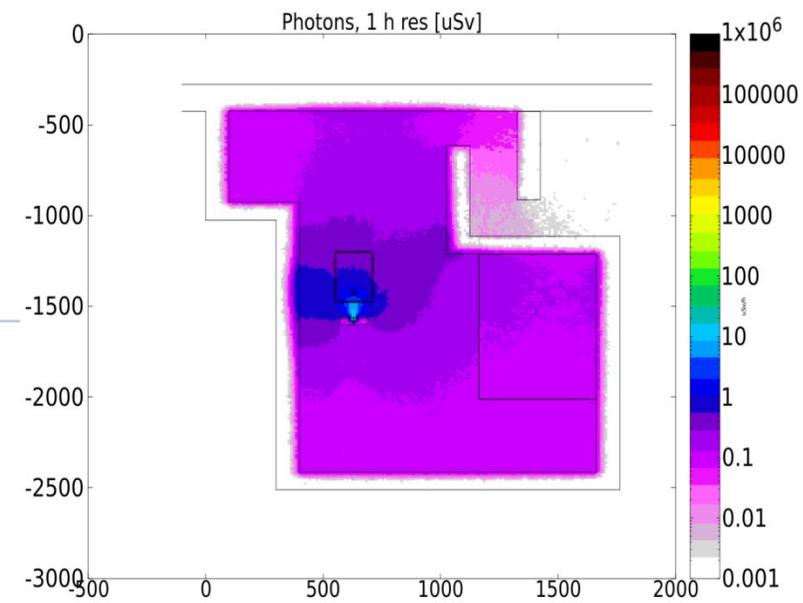
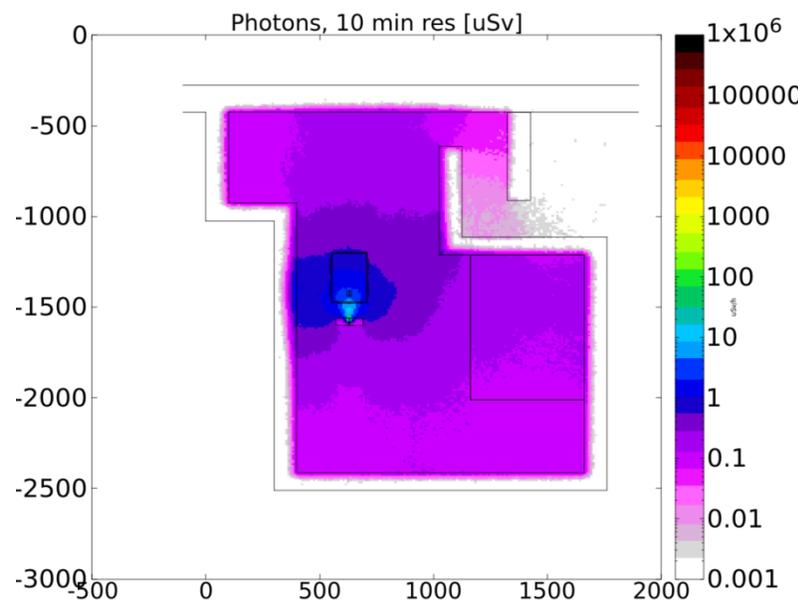
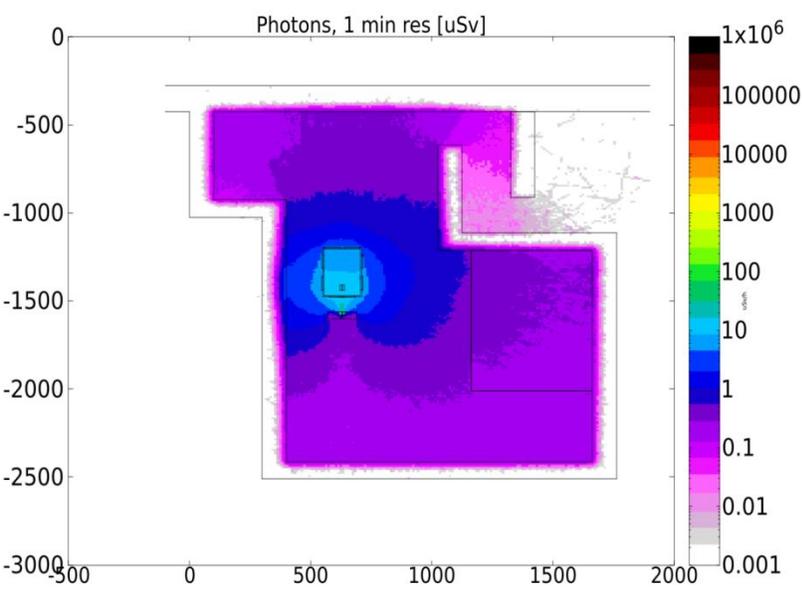
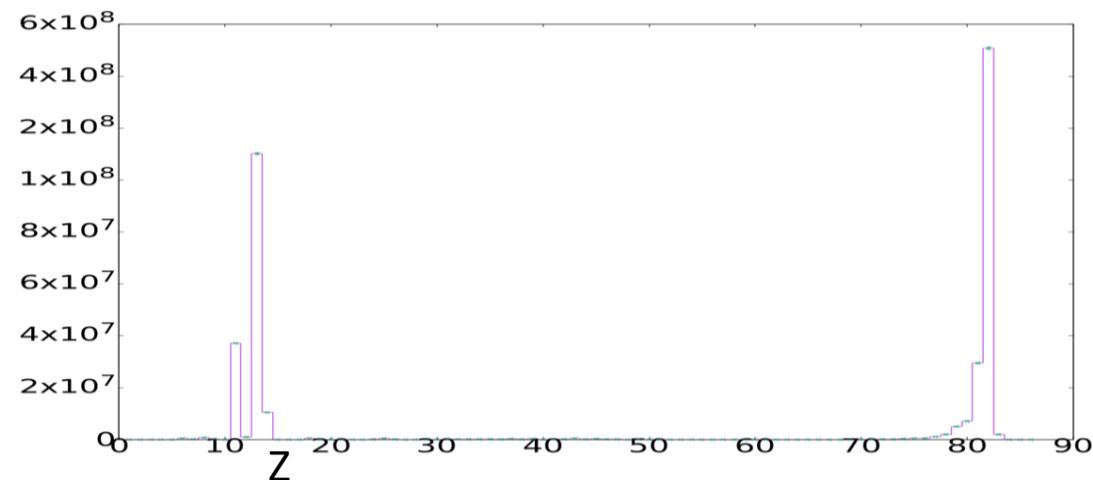
Secondary sources assessment

Activation assessment

Operation scenario:

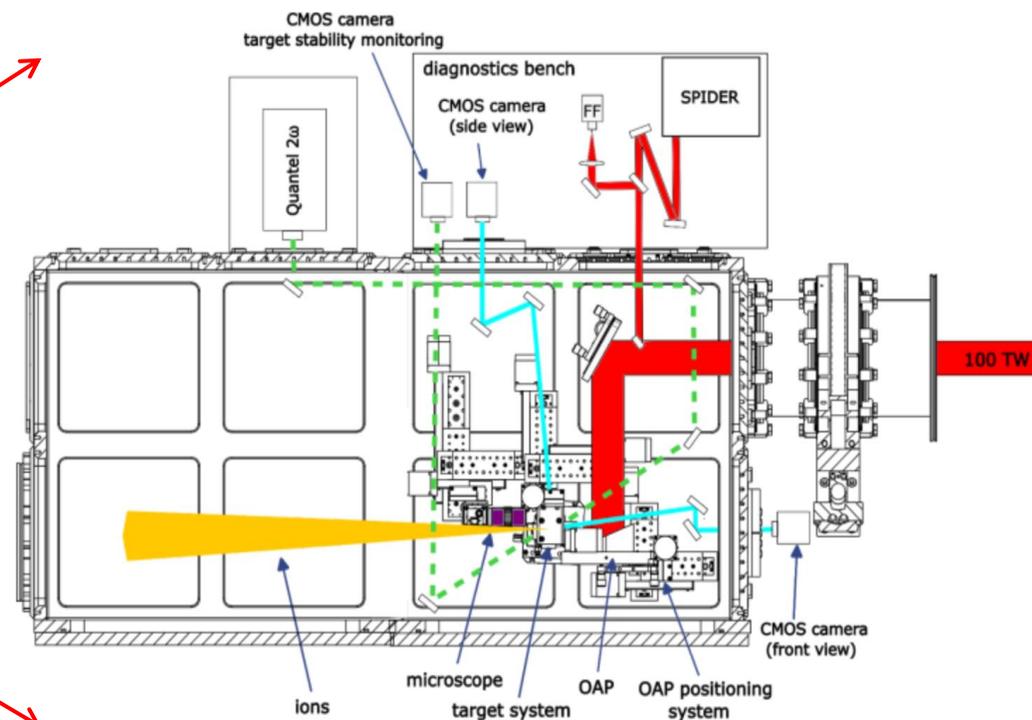
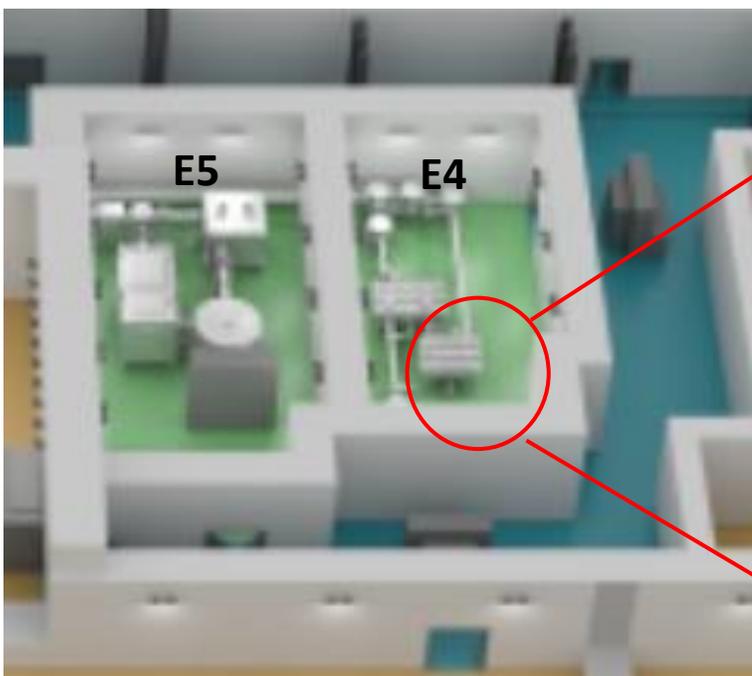
- 5 Hz (laser shots/second)
- 5 hours a day continuous exposure
- 1 week of operation

R. Virág @ ELI-NP



Site assessments – radioisotopes production setup

Setup implementation into E4 experimental area



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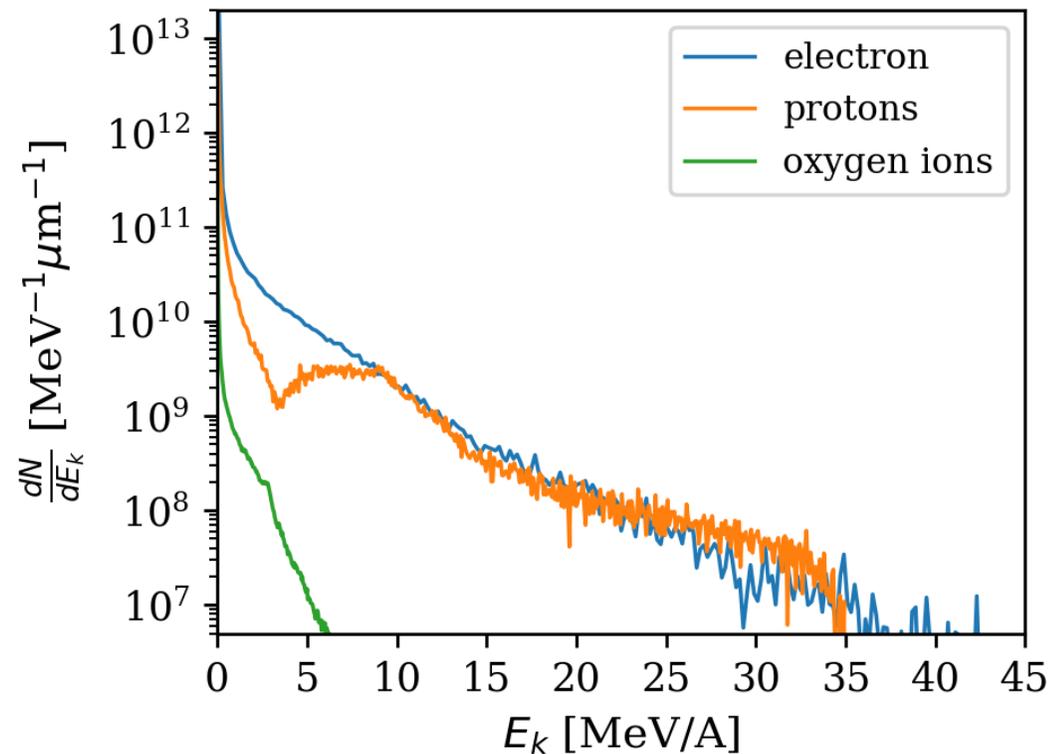
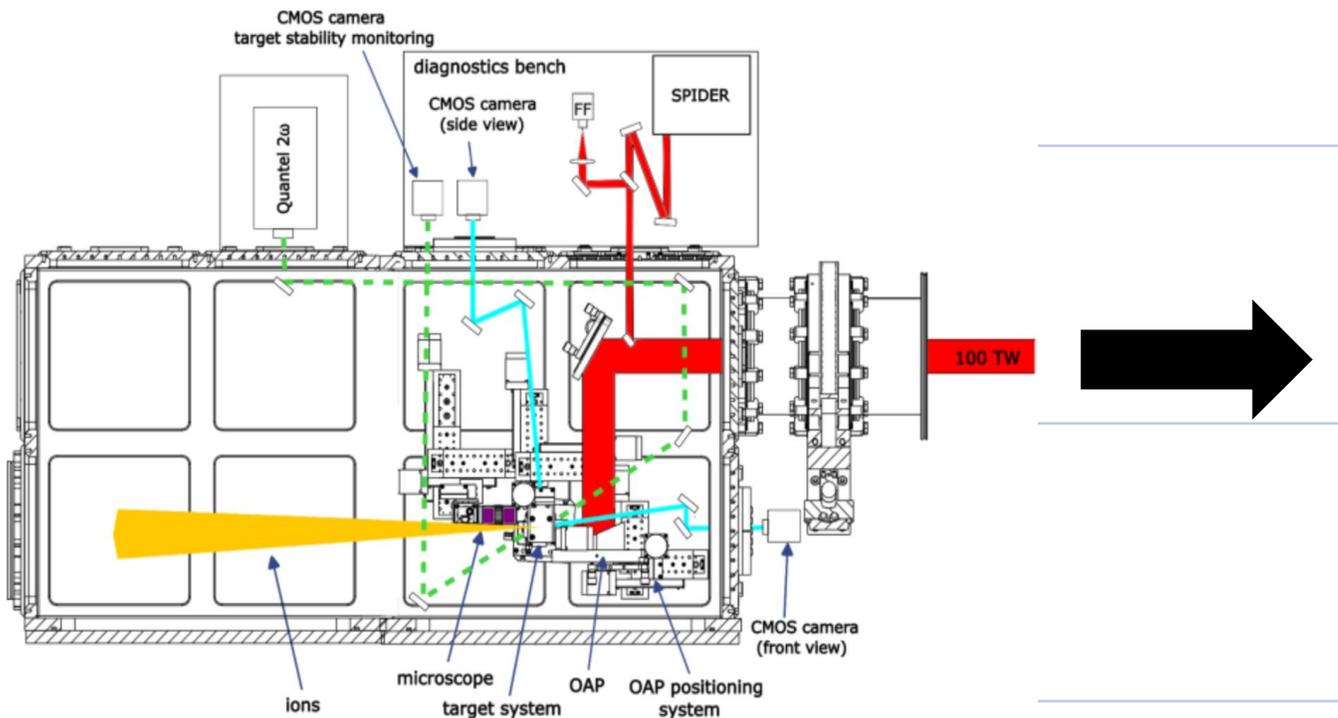
A. Cucoaneș @ ELI-NP



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Site assessments – radioisotopes production setup

Primary beams to be analyzed

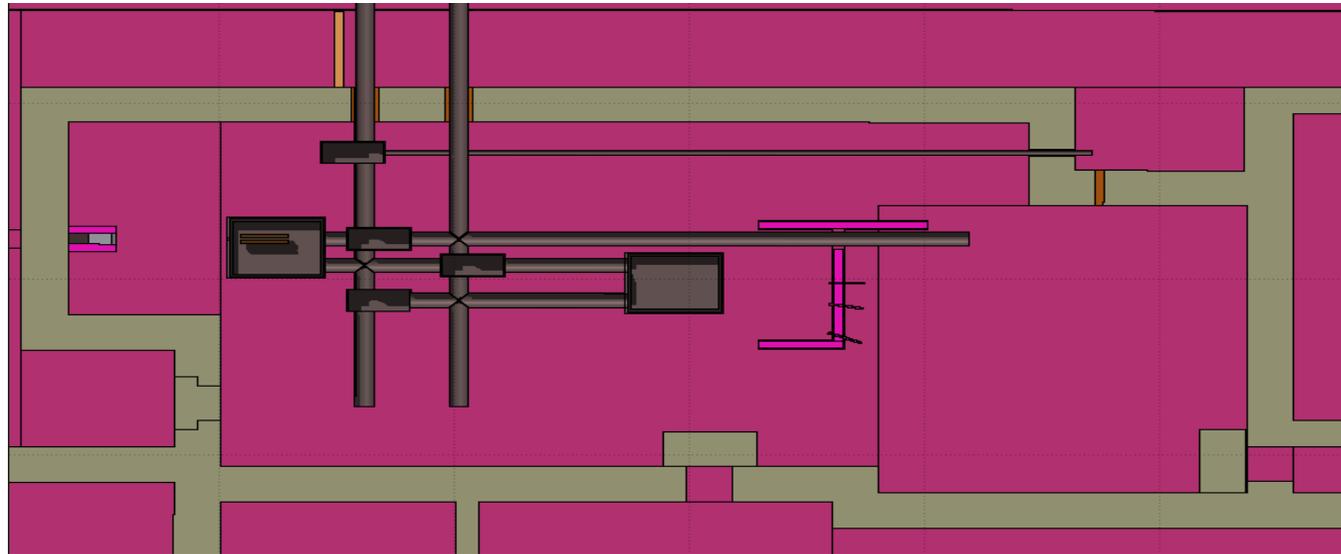


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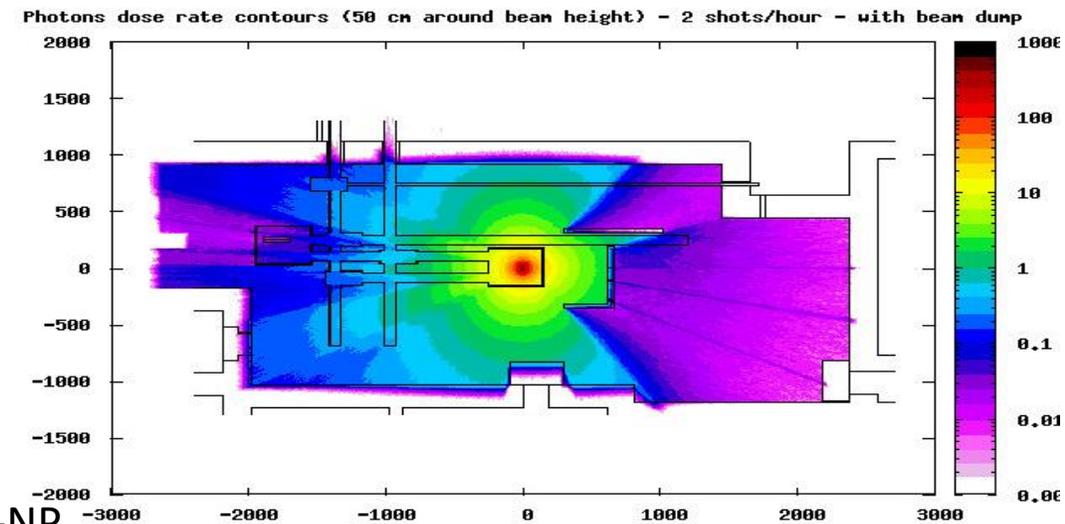
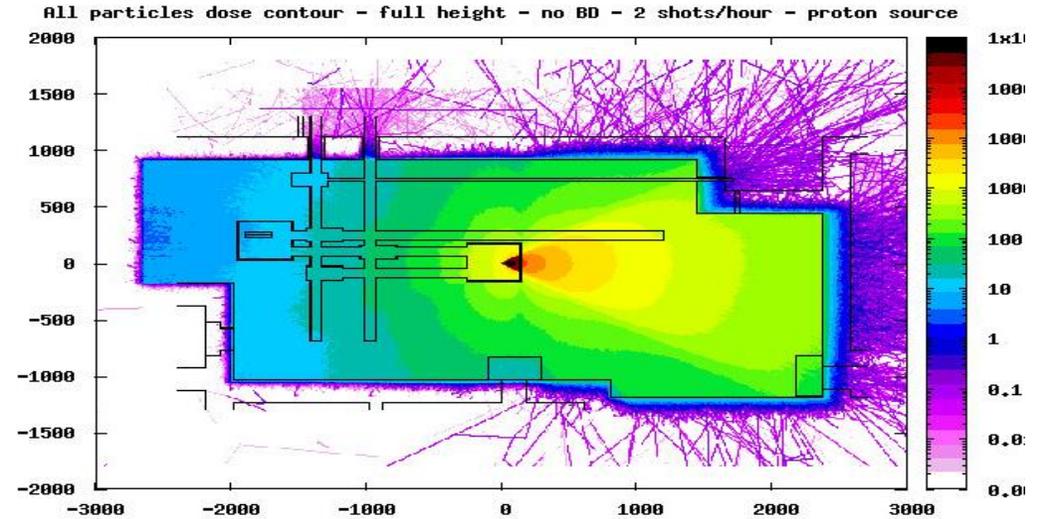


Site assessments – hadron therapy experiments

10 PW experiments on solid target modelled in FLUKA

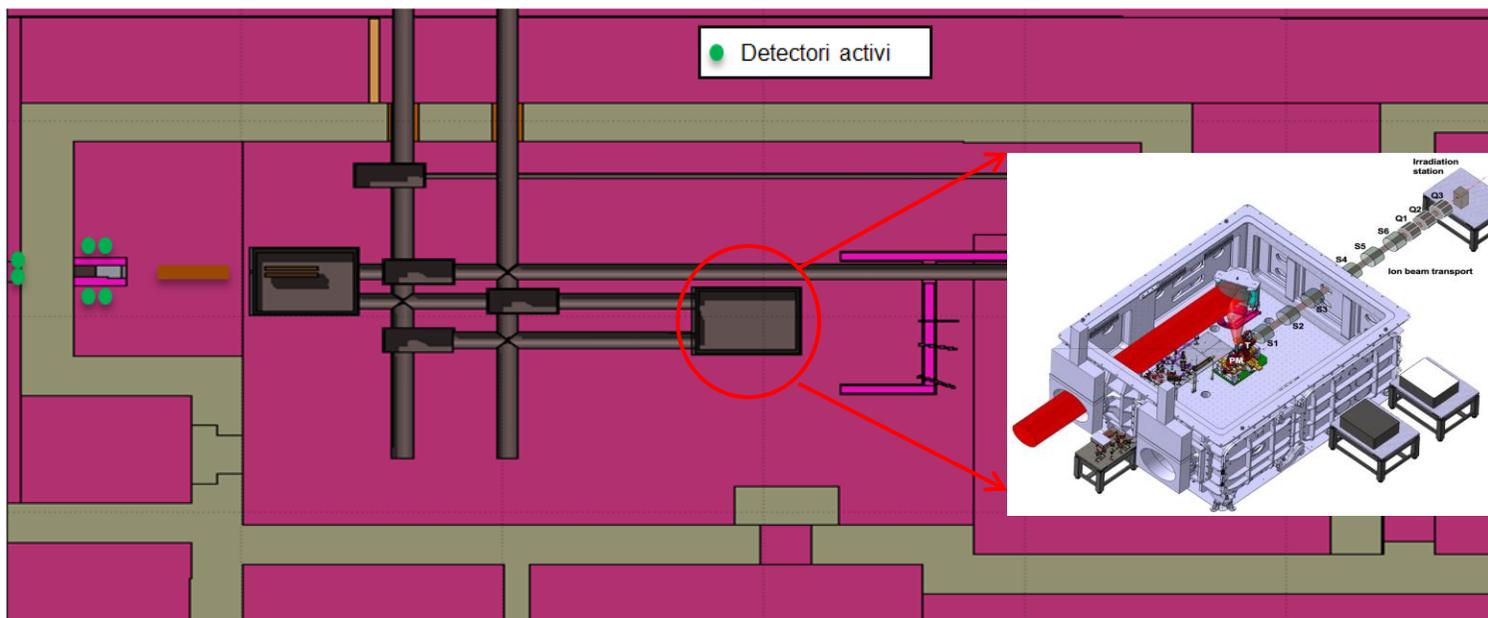


Target dose rate: <math>< 1 \mu\text{Sv}/\text{hour}</math> on the corridor

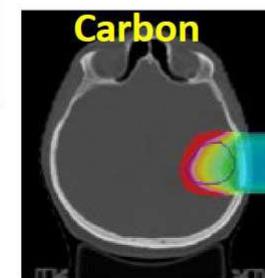
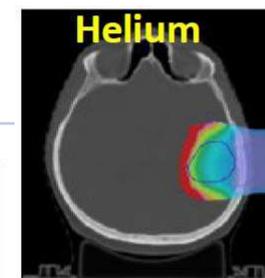
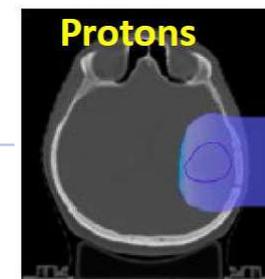
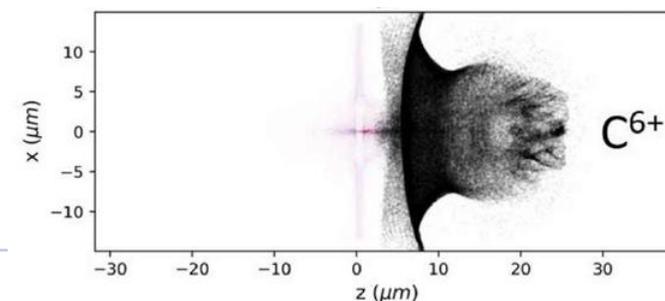


Site assessments - hadron therapy experiments

C-ion experiment accommodation in E1 setup



Modification of the IC to include the additional setup proposed



P. Tomassini and V. Horny ELI-NP



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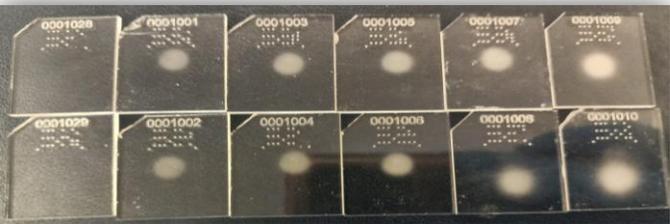


Experimental dosimetry assessments of pulsed radiation fields

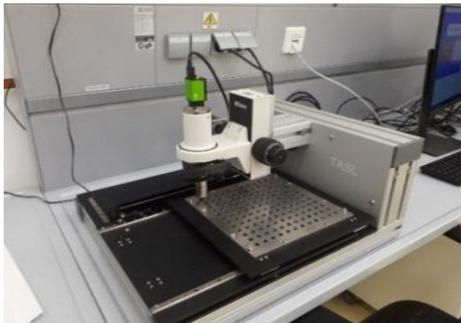
Detection setup used for assessing the pulsed fields



BeOSL dosimeters for gamma and X-rays monitoring



CR-39 detectors for neutron passive dosimetry



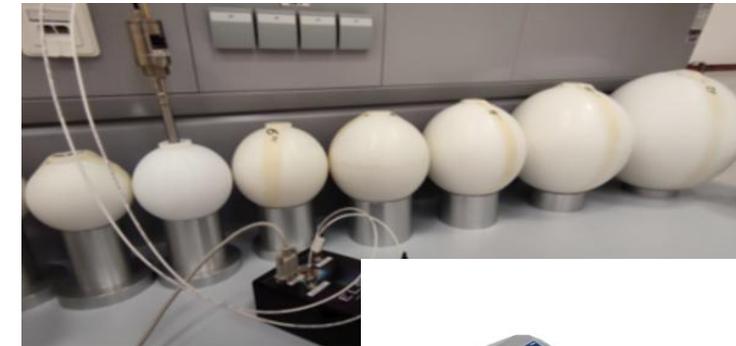
TASL System for CR-39 analysis

B-Rad hand-held radiation spectrometer and dose rate meter for gamma radiation



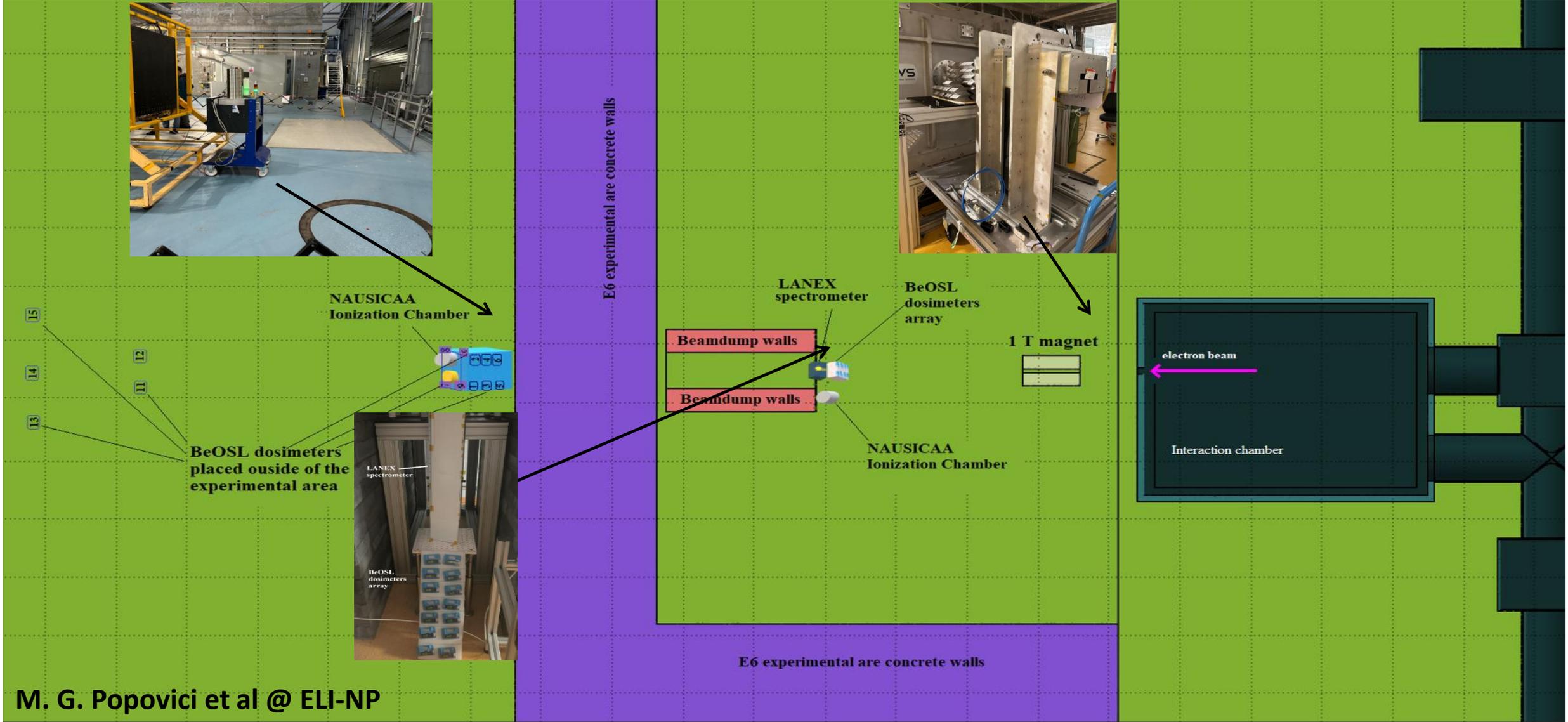
SATURN 5702 - mobile station - two detectors for gamma and neutron dose rate monitoring.

Bonner Spheres and DIAMON Spectrometers



Experimental dosimetry assessments of pulsed radiation fields

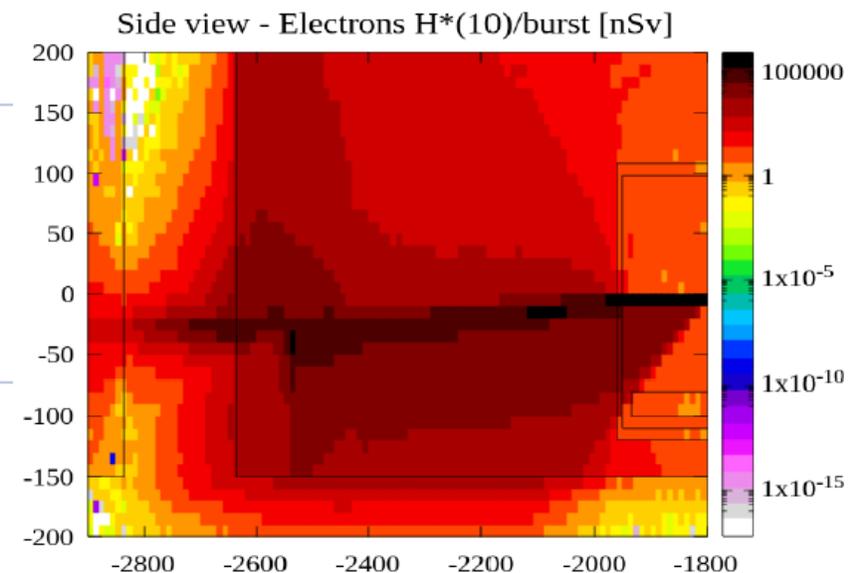
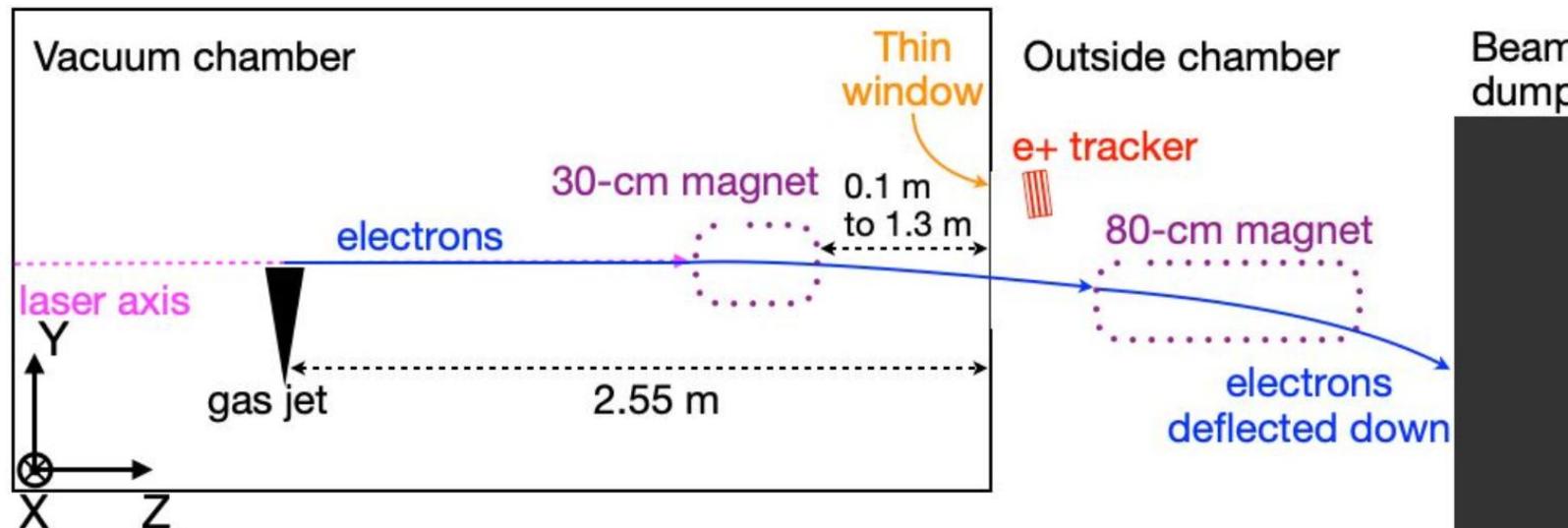
10 PW experimental setup - electrons (up to 8 GeV)



Experimental dosimetry assessments of pulsed radiation fields

Configuration of E6 e-beam experimental setup and expected distribution

View from the side



M. G. Popovici, I. O. Mitu and R. Virág @ ELI-NP

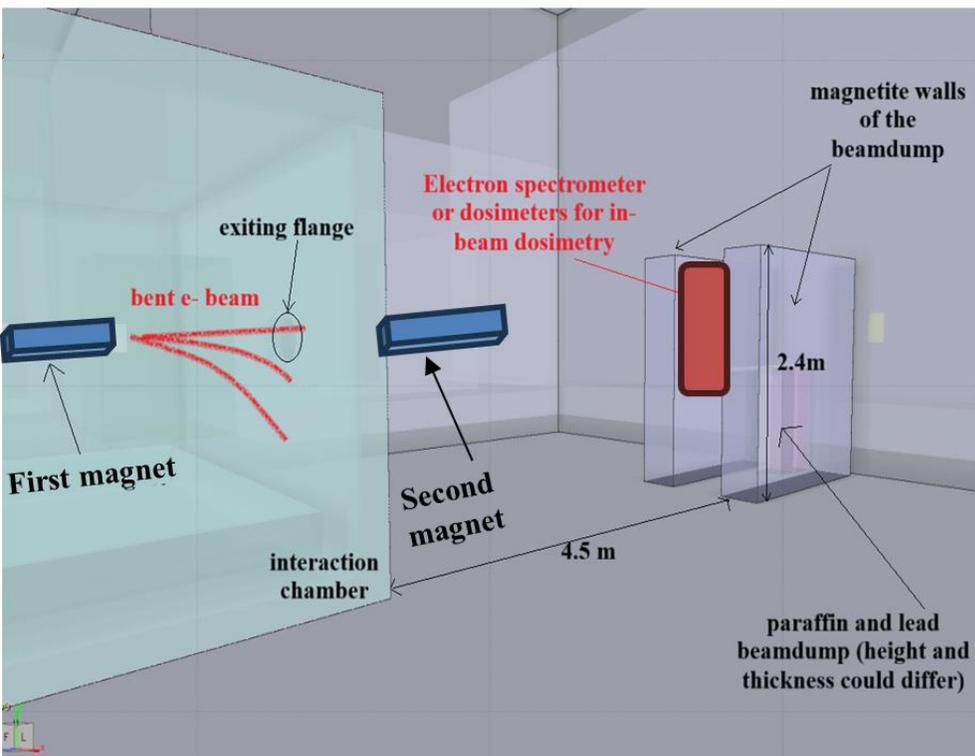


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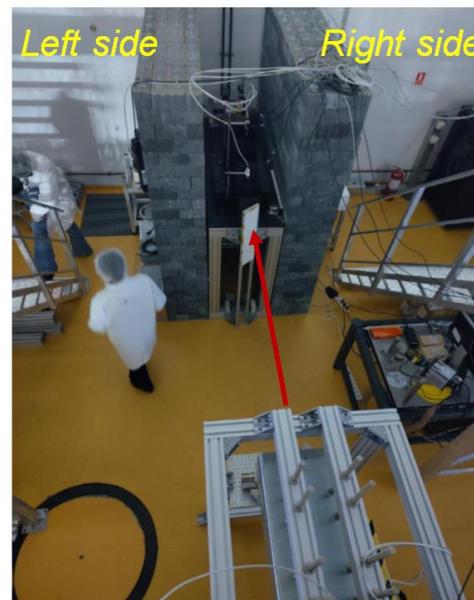
Experimental dosimetry assessments of pulsed radiation fields



Left side – LUPIN + LINUS



Top view of the setup



Right side – DIAMON + LB 6419



M. G. Popovici @ ELI-NP

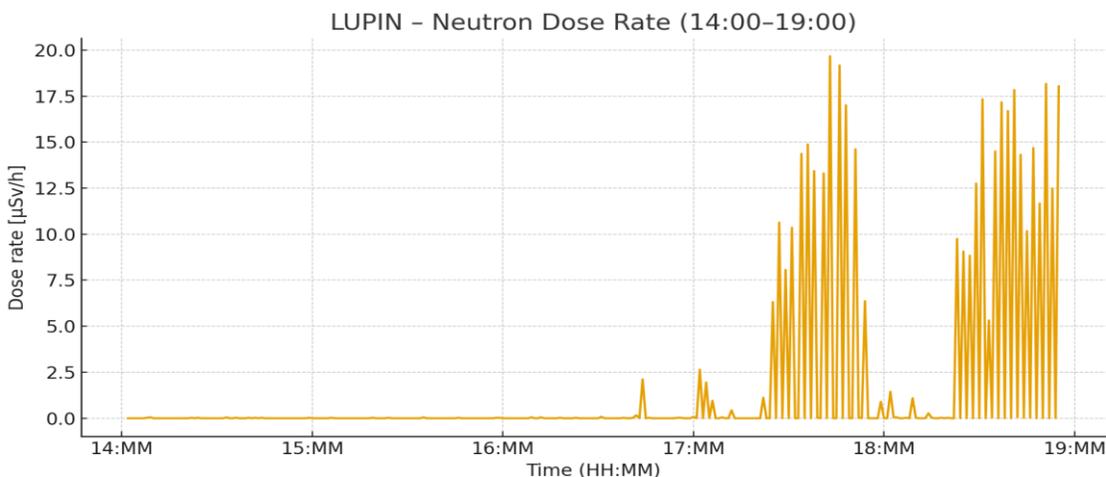


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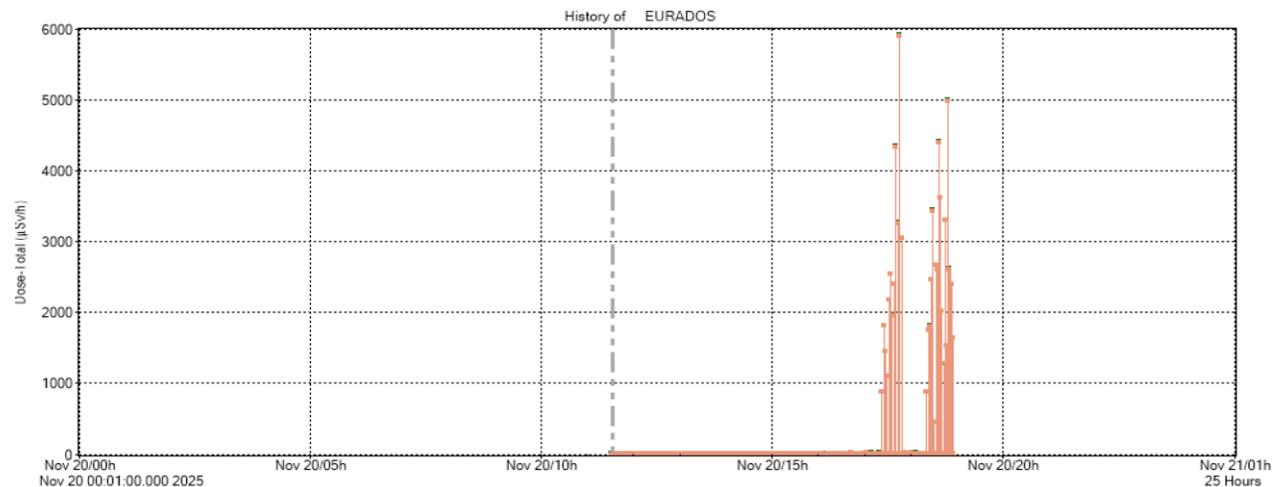


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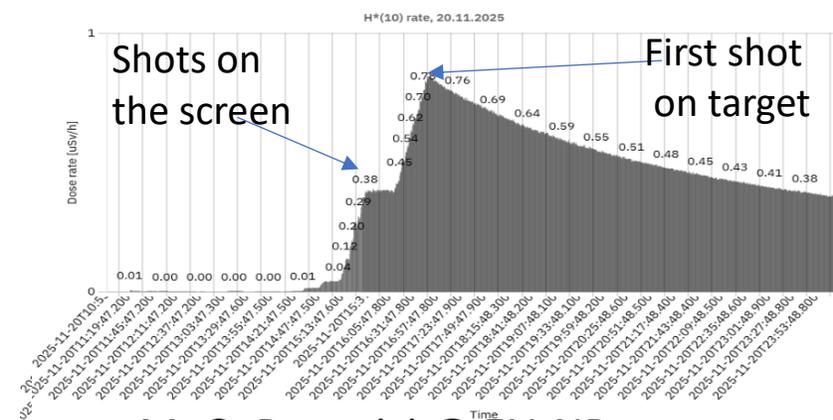
Experimental dosimetry assessments



LUPIN BF3 REM COUNTER

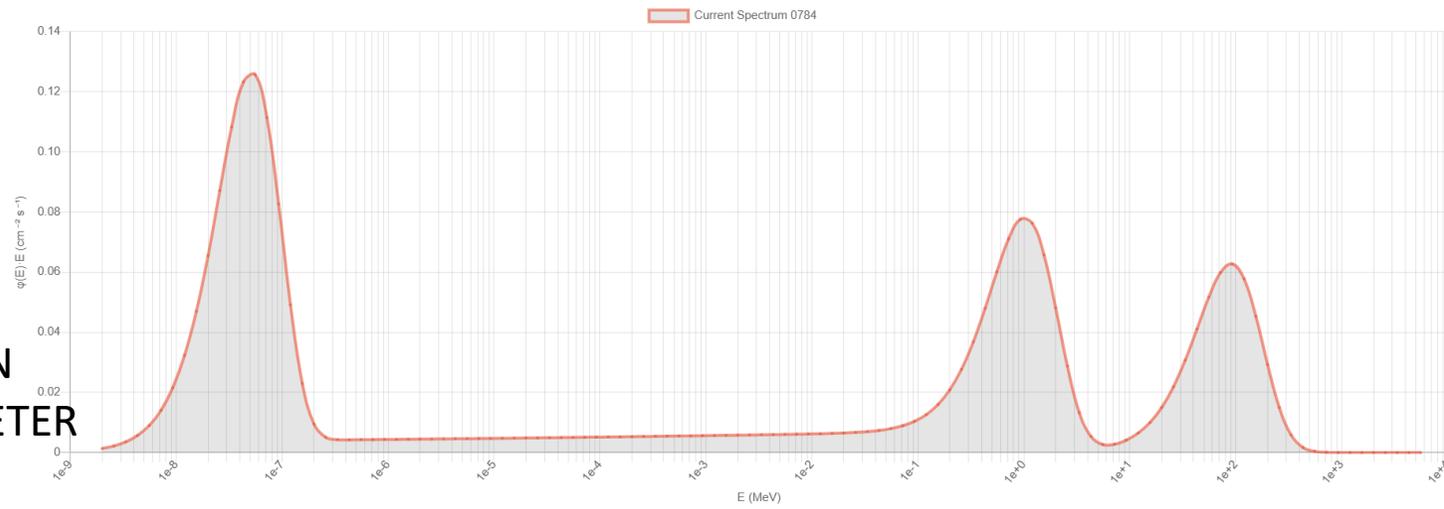


PANDORA- LB 6419

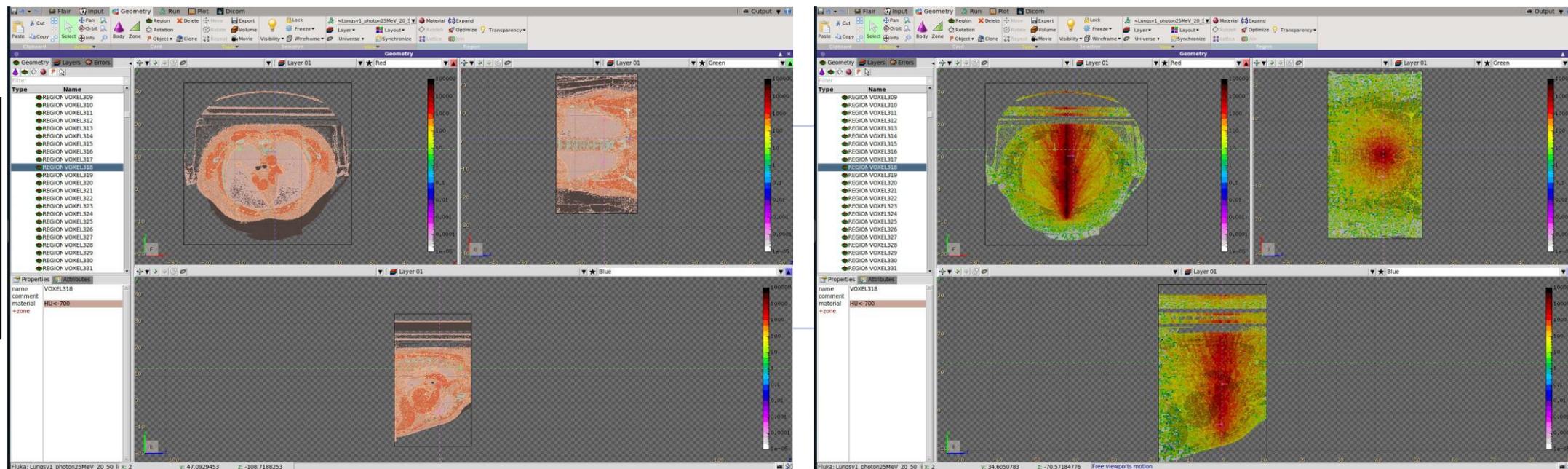


M. G. Popovici @ ELI-NP

DIAMON SPECTROMETER



DICOM files in FLUKA implementation



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Voxel geometry CT scan (left) and FLUKA application in radiotherapy (right): a 15 MeV photon beam



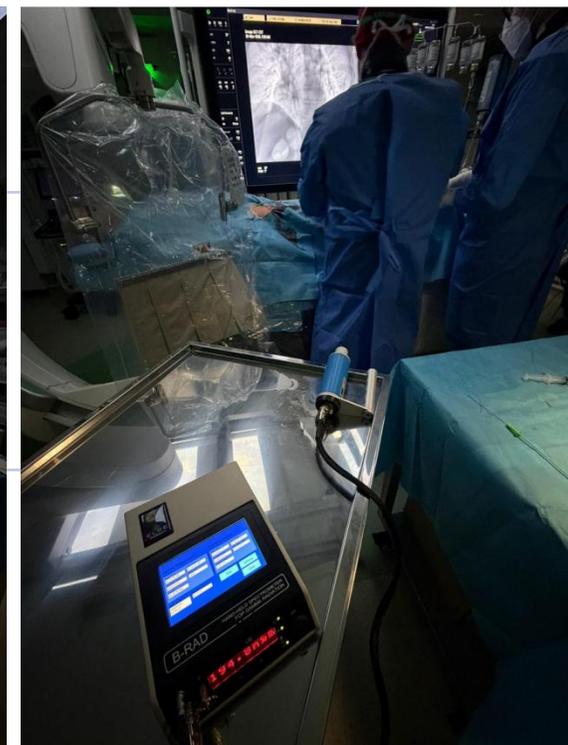
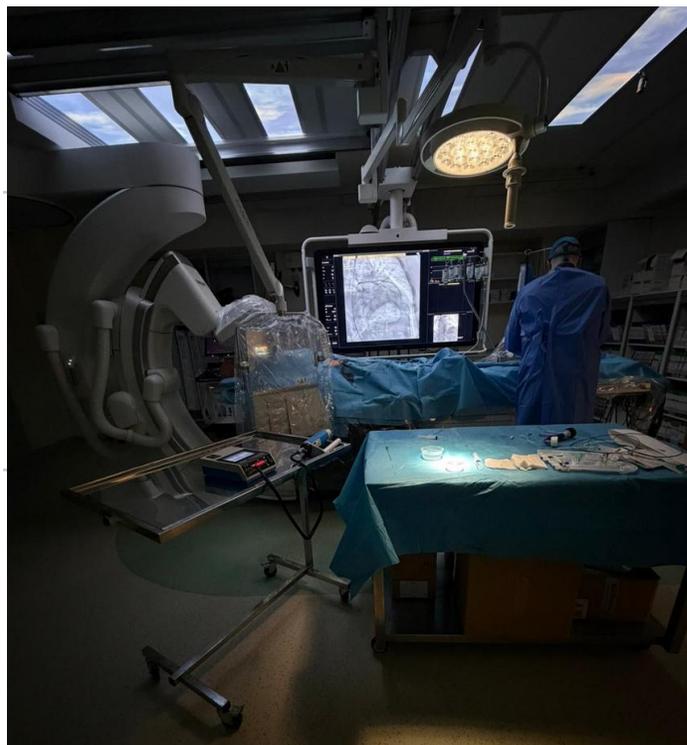
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Medical scans (CT, RD and IC) dose measurements

Locația	Nr. cutie	Ianuarie	H*(10) Calc. Dose (mSv)
CT - Siemens	1	0100028583	14,952
CT - Siemens	3	0100030417	23,544
CT - Siemens	5	0100036416	80,808
CT - Siemens	30	0100031738	4,3092
Apollo DRF	4	0100031636	0,2424
GXR-68 SD	8	0100036173	1,37592
GXR-68 SD	7	0100037449	1,02144
GXR-68 SD	6	0100038119	2,1168
Apollo DRF	15	0100031207	0,3216
GXR-68 SD	9	0100030545	1,7976
Apollo DRF	20	0100083975	0,1566
Apollo DRF	13	0100037321	1,386
Apollo DRF	2	0100031591	0,7848



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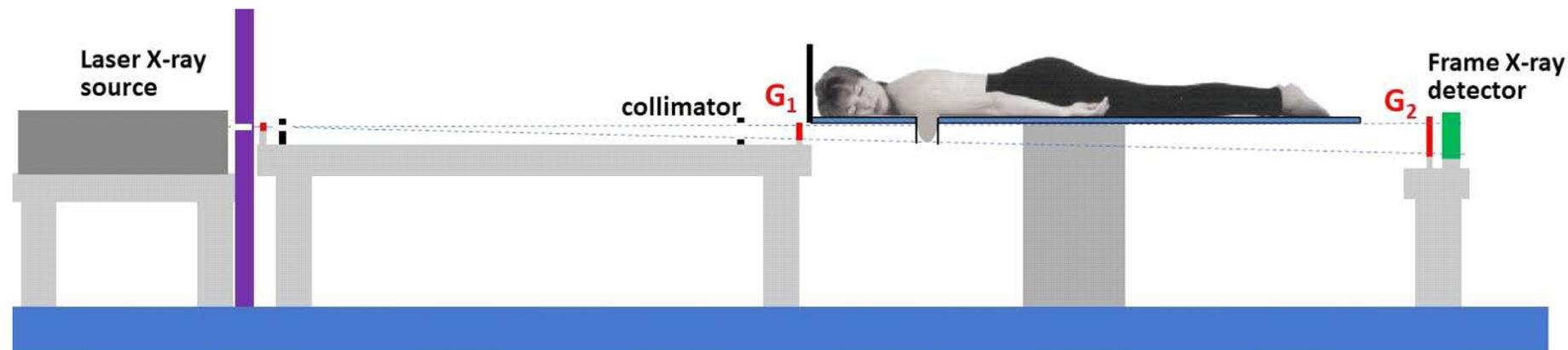


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Remarks

Why the need for assessing both inside and outside of the experimental area/irradiation zone?

- Each irradiation protocol involves delivery of a primary beam to the patient
- For laser setups, primary beam is always accompanied by secondary particles, either from the source or scattered by the setup
- Instability or shot to shot variations lead to considerable impact on the dose to operators or patients
- Maturity of the safety setup will have a major contribution for the clinical tests commencing



Dr. LASER



“Medical applications of high-power lasers - Dr. Laser”

www.eli-np.ro/projects/drlaser/

SMIS Code: 326475

Project co-financed by the European Union and the Romanian Government within the Romanian Health Program

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Program Sănătate

Dr. LASER



“Aplicații medicale ale laserilor de mare putere - Dr. Laser”

www.eli-np.ro/projects/drlaser/

Cod SMIS: 326475

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