Radioisotope production using a high-repetition-rate, laser-based proton source (ID 236)

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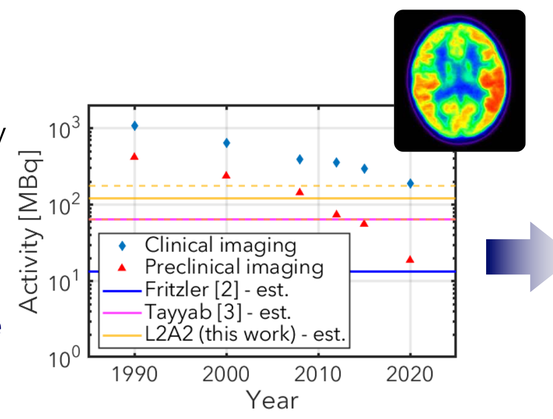
Motivation: radionuclides in medicine

Currently, radioisotopes are centrally produced in large and expensive conventional accelerators
⇓
^{18}F is almost the only radioisotope used [1]

Laser-based accelerators are an alternative for in-situ and on-demand production [1, 2]
⇓
Increased availability of radioisotopes with shorter lifetimes

	^{11}C	^{13}N	^{15}O	^{18}F
$T_{1/2}$ [min]	20.23	9.97	1.87	109.77

For medical imaging, such as Positron Emission Tomography (PET), an activity of hundreds of MBq is necessary [2]
⇓
Hundreds of shots at a relatively **high repetition rate** to overcome the radiation decay



An appropriate target is required
⇓
Wheel system

The target: rotating wheel

- The system consists of a wheel mounted on a 3-motor system that allows to replace and position the targets at the focal plane.

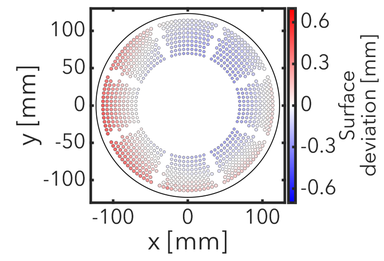
Conditions

- The target needs to be precisely positioned (μm).
- High repetition rate (multi-Hz).

Solution

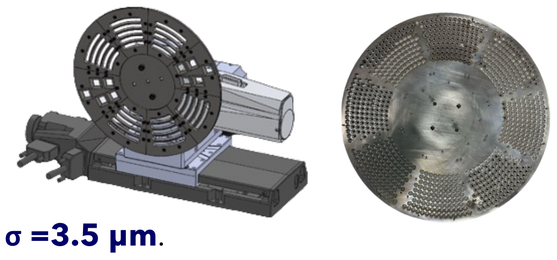
Pre-map of the target surface

+ Automatised movements

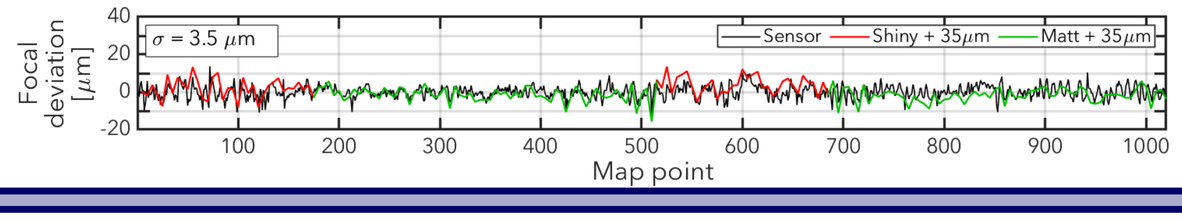


Advantages

- Suitable for multiple materials and thicknesses.
- Operations at up to 10 Hz.
- Quick target replacement.

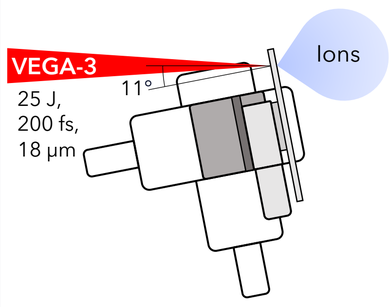


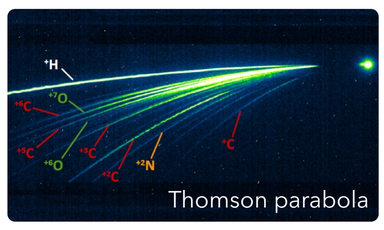
- The target is automatically positioned with **σ =3.5 μm**.

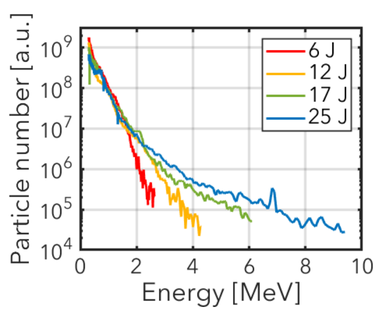


1 Hz acceleration using a PW laser

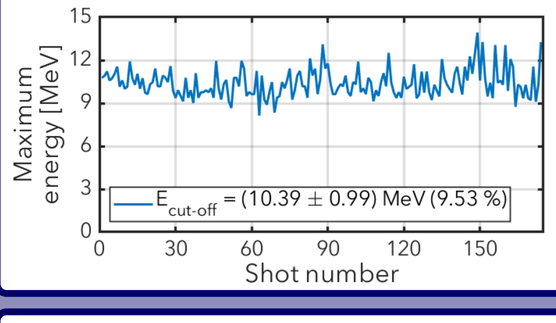
- This wheel system has been used at CLPU – PW arm.

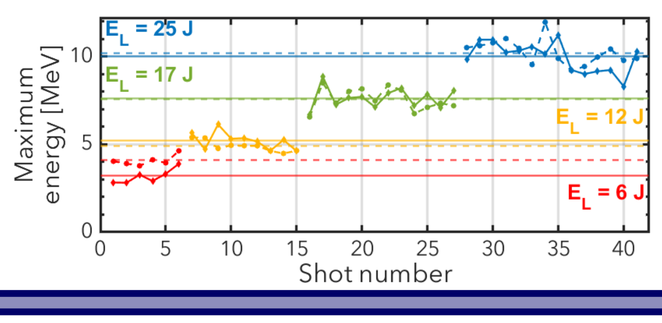






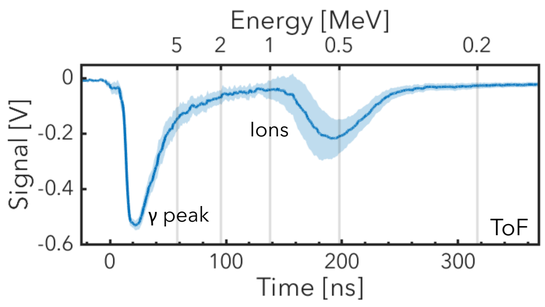
- Cut-off energies up to 15 MeV with **stability better than 10%** were observed.

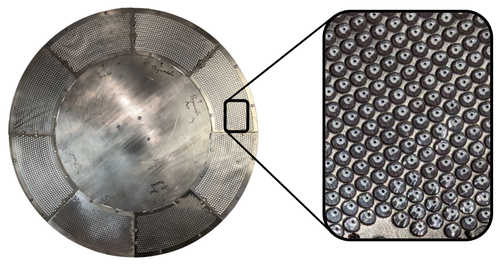




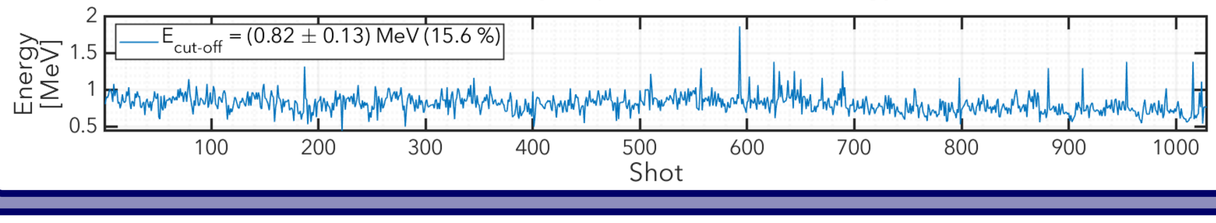
10 Hz demonstration

- Wheel operation at 10 Hz has been demonstrated using the 45 TW laser installed at *Laboratorio Láser de Aceleración y Aplicaciones* (L2A2).
- Dedicated wheel designed to allow **>5000 shots at 10 Hz**.



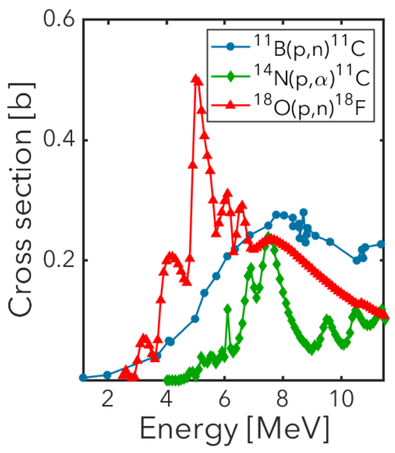


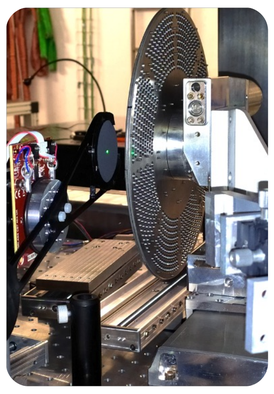
- The measurements show a stability in proton cut-off energy of 15.6 %.



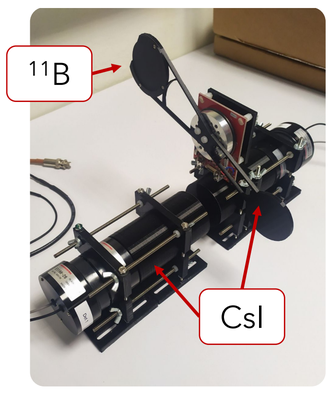
Radioisotope production

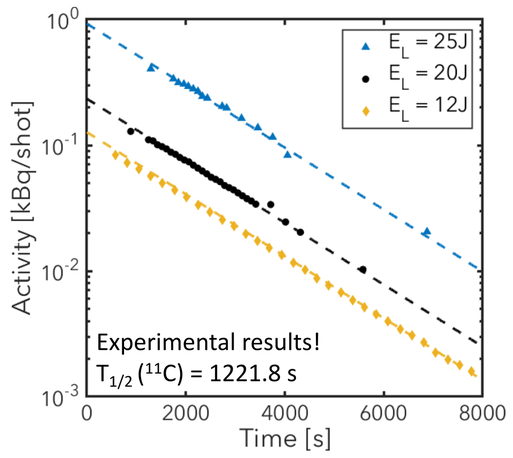
- Radionuclides are produced through activation of a secondary target with the accelerated particles.
- **Carbon-11 has been successfully produced** via ^{11}B(p,n)^{11}C reaction during the experimental campaign at CLPU.



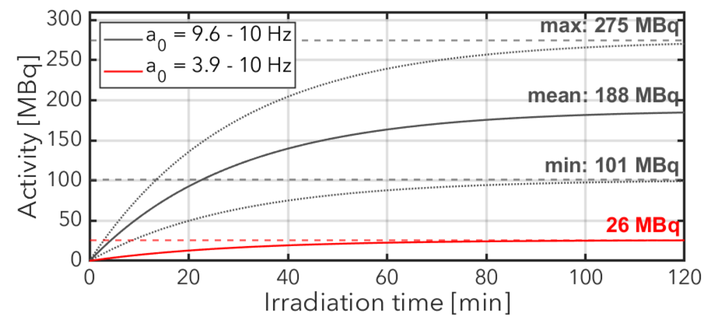


- Activity diagnostics developed in-house for in-vacuum irradiation and detection, based on two CsI scintillators working on coincidence.
- Measured activity higher than 230 kBq from a burst of only 20 shots with an activity >12 kBq per shot.





- Under optimal conditions at L2A2, estimations predict that clinical activities can be reached with several minutes of irradiation at 10 Hz.



	a_0	E_{max} [MeV]	Rep. rate [Hz]	A@30min [MBq]
CLPU (25 J)	20.23	9.97	1.87	109.77
L2A2 (non-opt)	3.9	3.6	10	16
L2A2 (opt)	9.6	8.9	10	177

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Acknowledgements

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