Commissioning and exploitation of the Laser Laboratory for Accelerator and Applications

Aarón Alejo
aaron.alejo@usc.es

About us

Senior Staff (2)	
J. Benlliure	D. Cortina

Junior + PDRA (2)	
A. Alejo	R. Contreras

PhD students (4)	
J. Peñas	A. Bembibre
A. Coathup	A. Reija

MSci + BSci students (4)	
M. Rodríguez	A. Fernández
C. Nogueira	S. Gómez

Technical staff (2)	
J.J. Llerena	D. González

Outlook

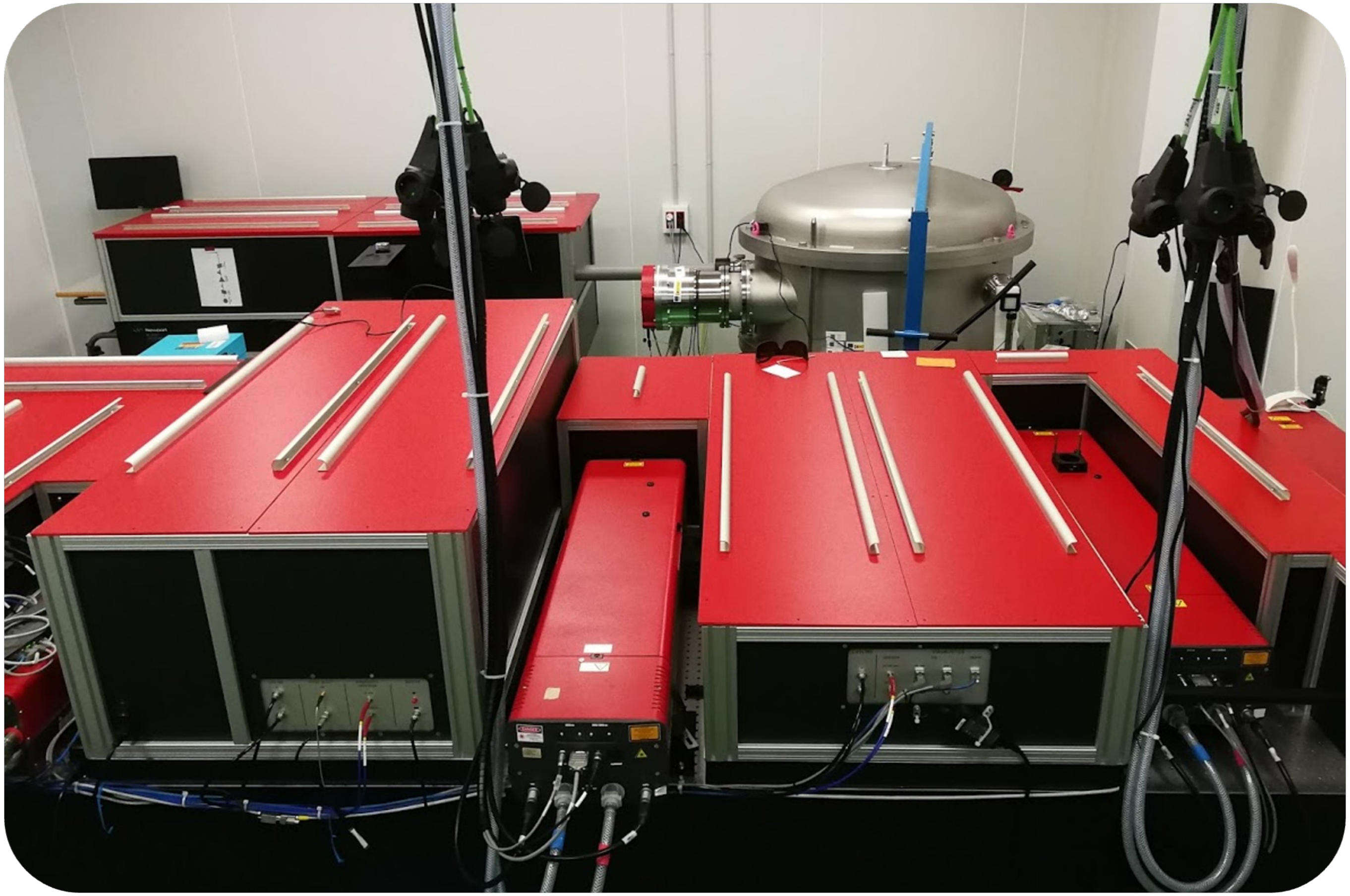
→ An update on the laser

→ Development of target systems and diagnostics

→ Applications

About the laser...

STELA laser @ USC



Mid-energy beamline

$E_{laser} \cong 1mJ$

$\tau_p \cong 32fs$

$P_{peak} \cong 30GW$

$f = 1kHz$

High-energy beamline

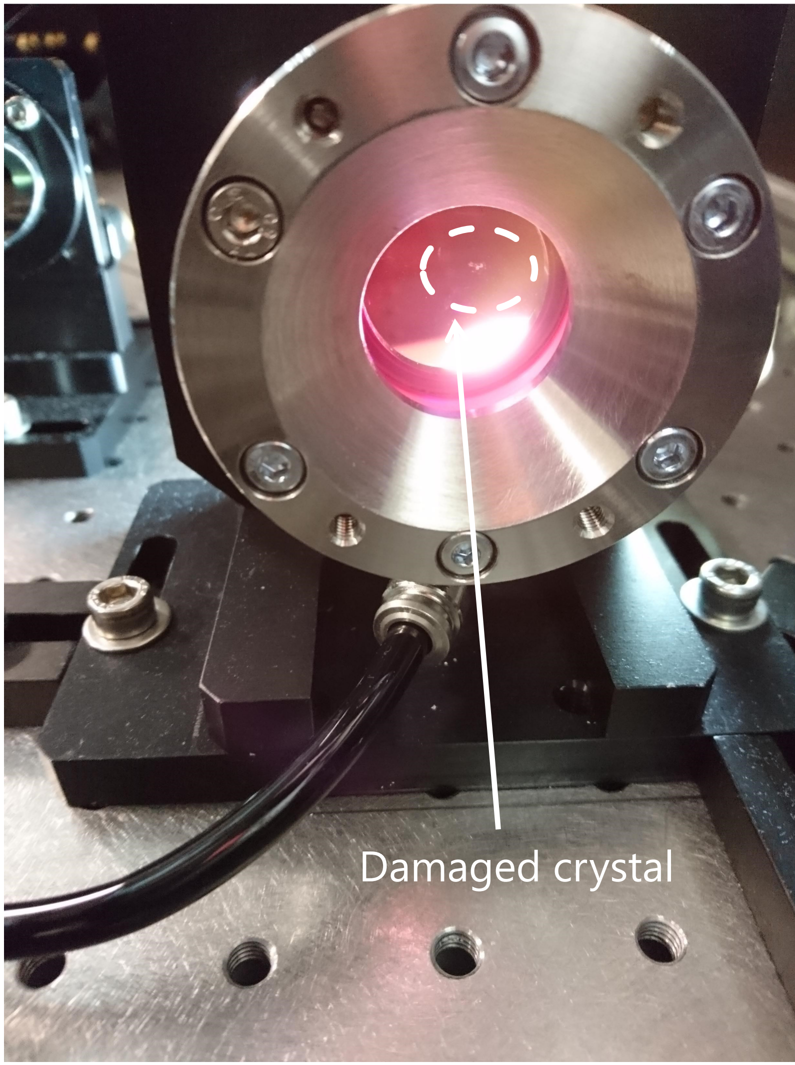
$E_{laser} \cong 1J$

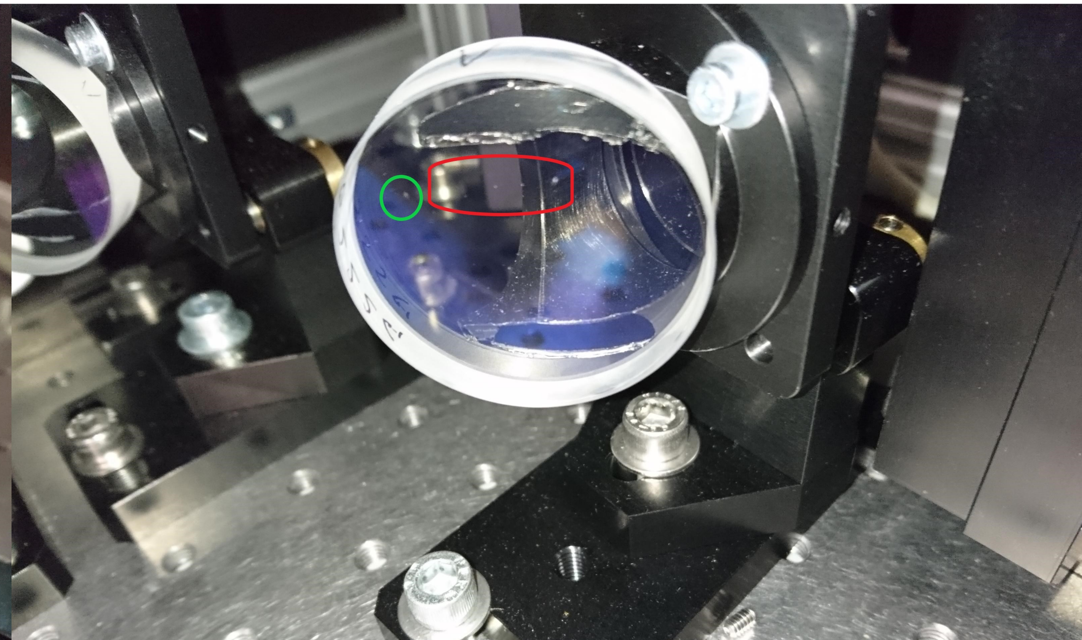
$\tau_p \cong 25fs$

$P_{peak} \cong 45TW$

$f = 10Hz$

The setback – April 2021





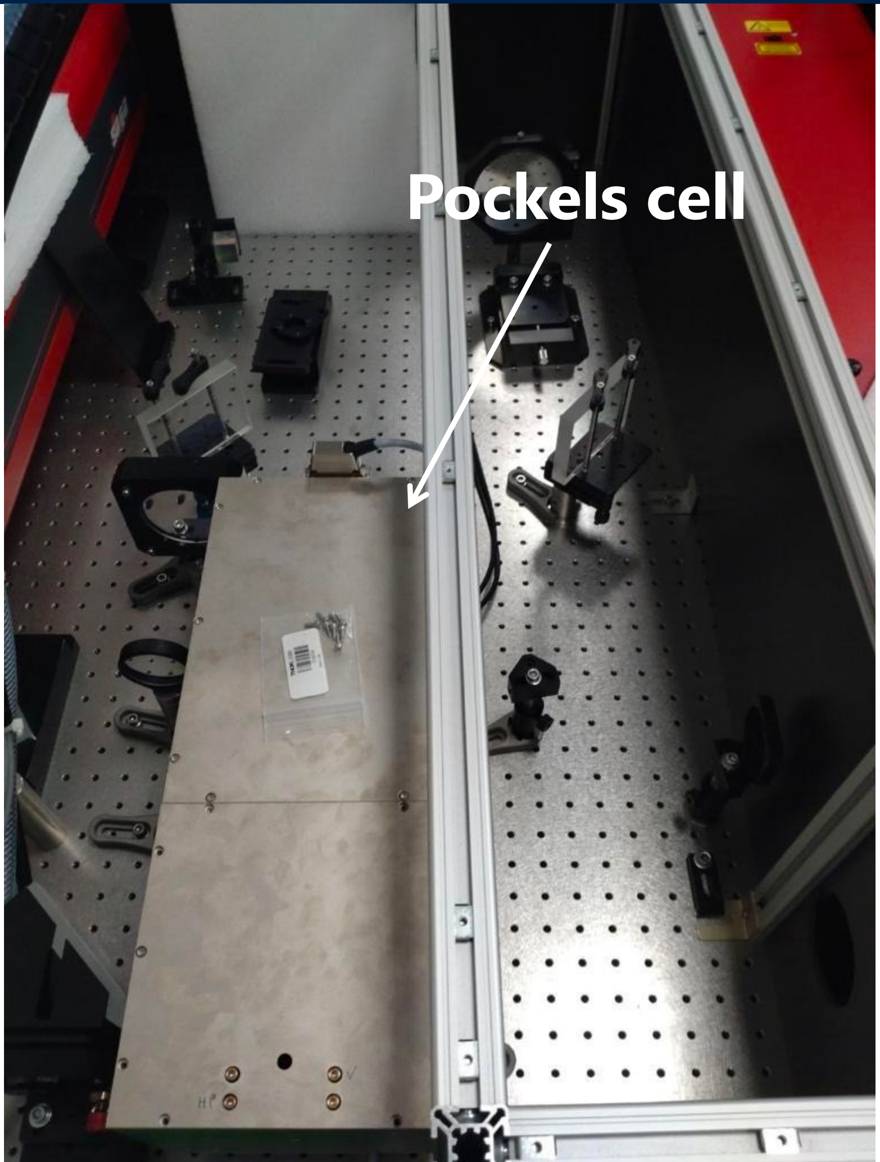
→ The reason for the damage was speculated to be due to improper experimental setup

→ Amplifying crystal is one of the most expensive and most complicated to produce parts in the system...

→ New crystal installed in July 2021

New damage appearing after a few shots!

The new setback



→ Several months of discussions with the manufacturer trying to understand the damage

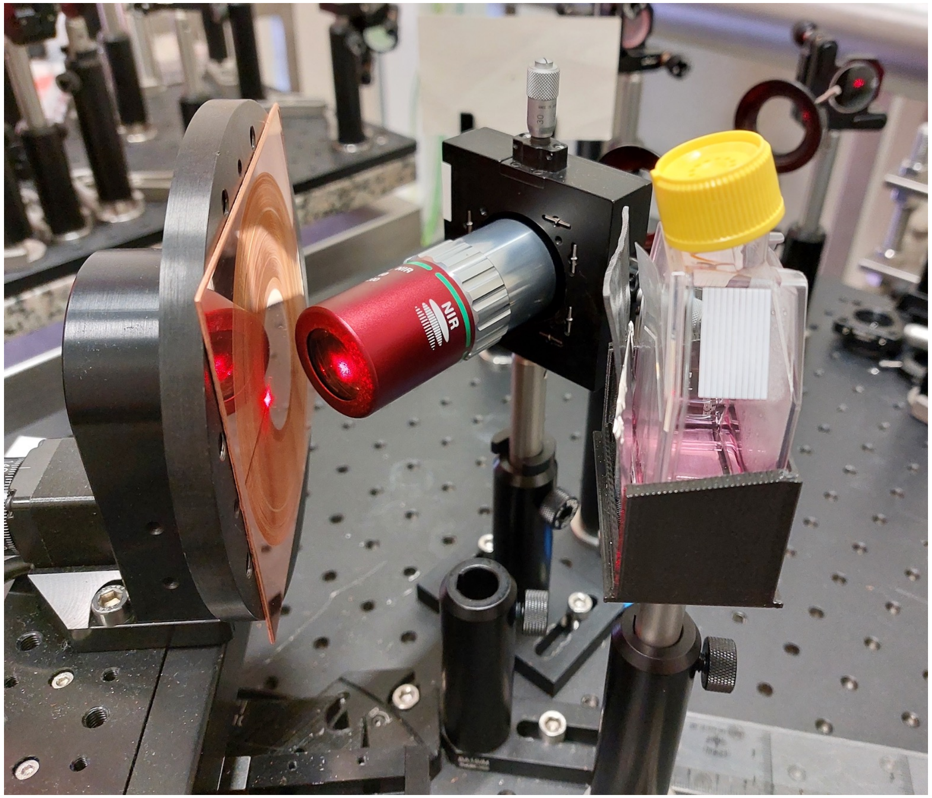
→ Conclusion: The actual reason for the damage was a **fundamental flaw in the design** of the system

→ On November 2021, the installation of a Pockels cell was decided as a potential solution [>100k€]

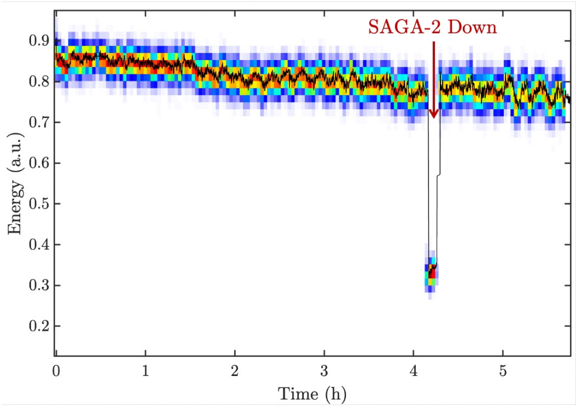
→ After several delays, the system was **upgraded 2 weeks ago**, commissioning in progress.

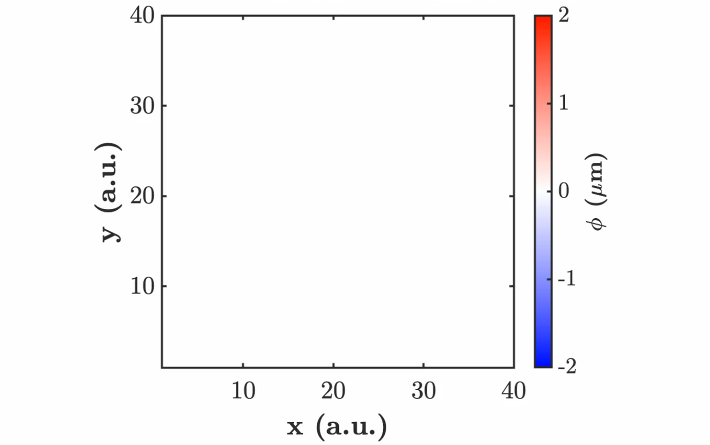
In the meantime…

Heavy use of the kHz – mJ beamline



Full characterisation of the J beamline

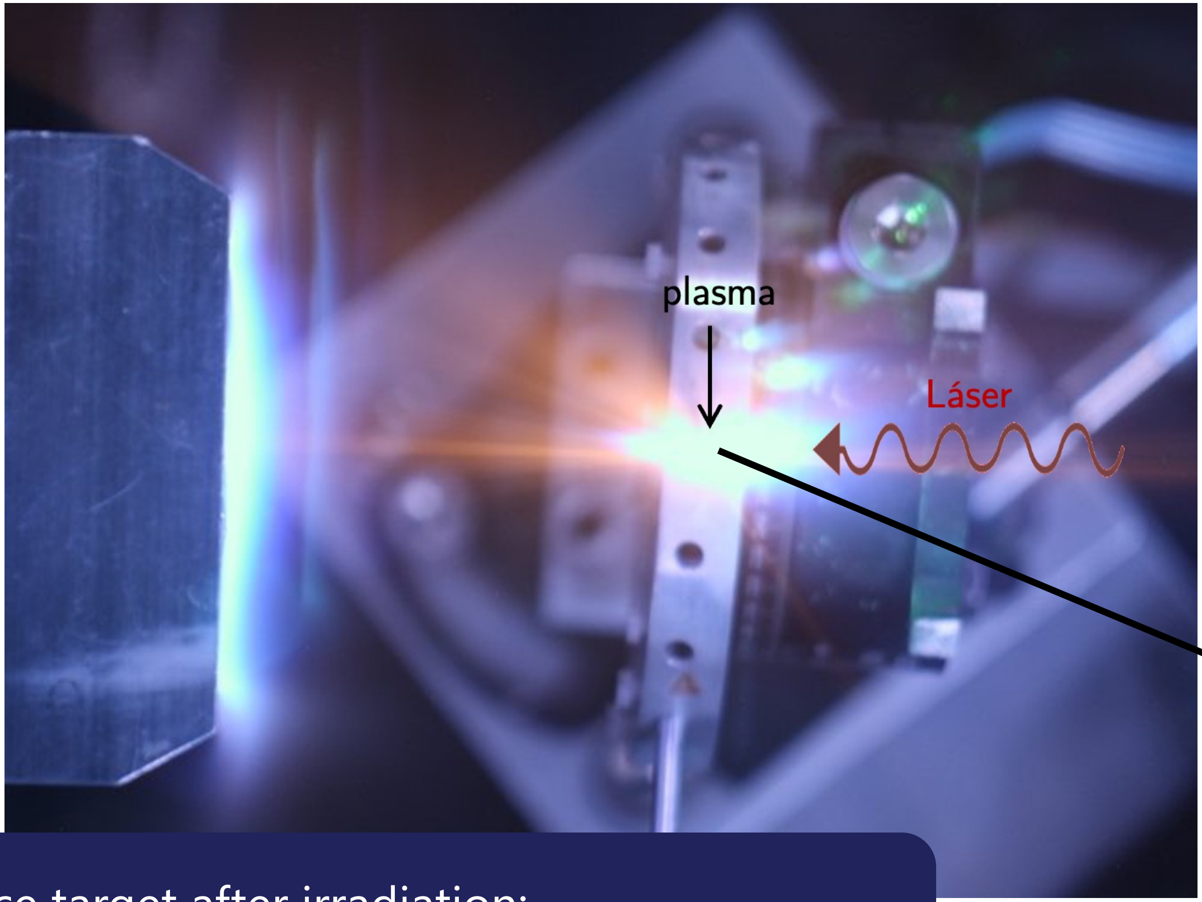




+ Experiments at international facilities

Targetry developments

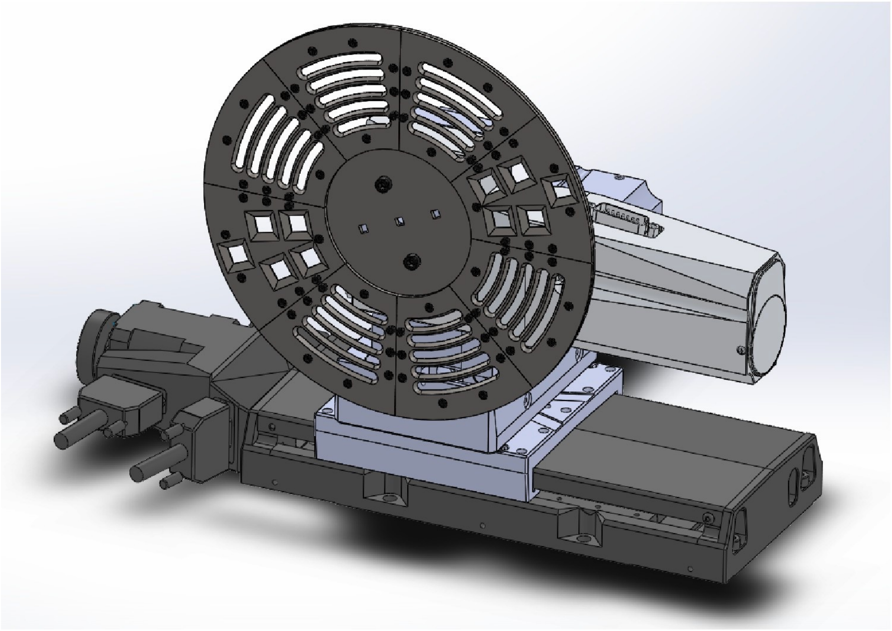
The need for targets

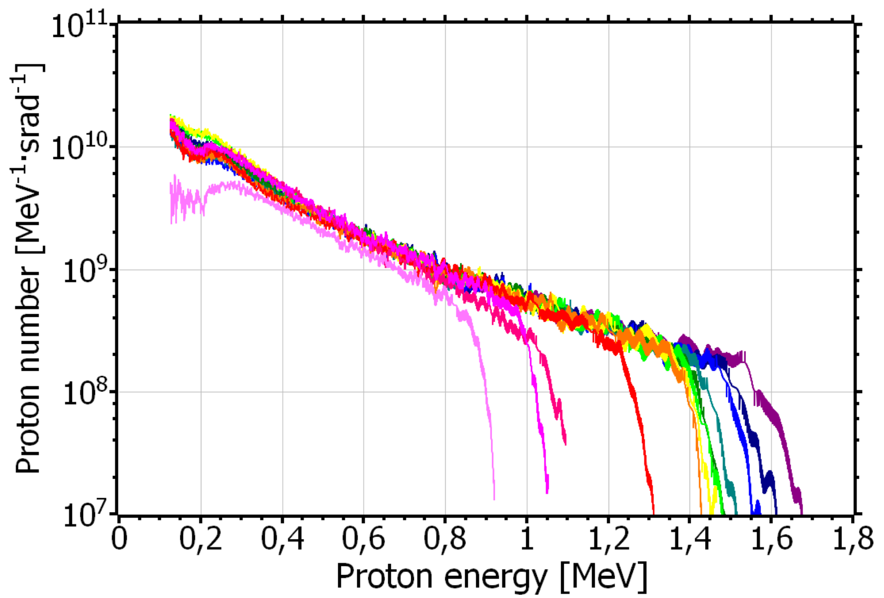


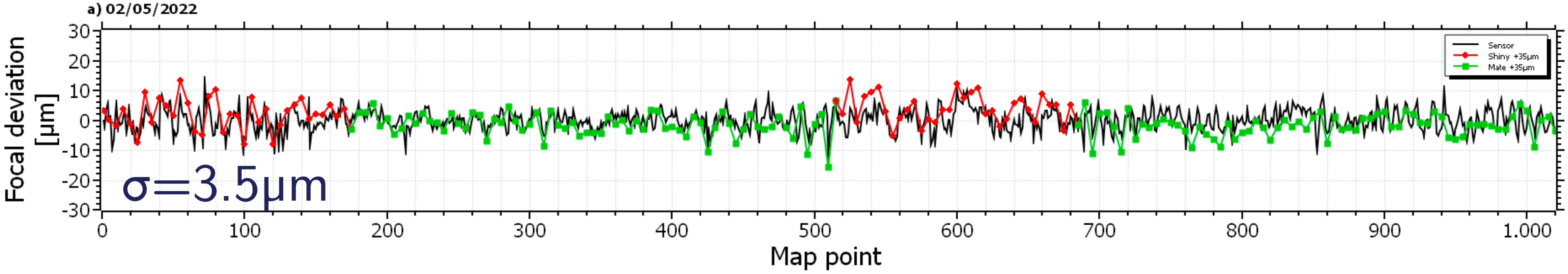
≅1mm Crater
after irradiation

⇒ Replace target after irradiation:
micron precision alignment required!

Target wheel

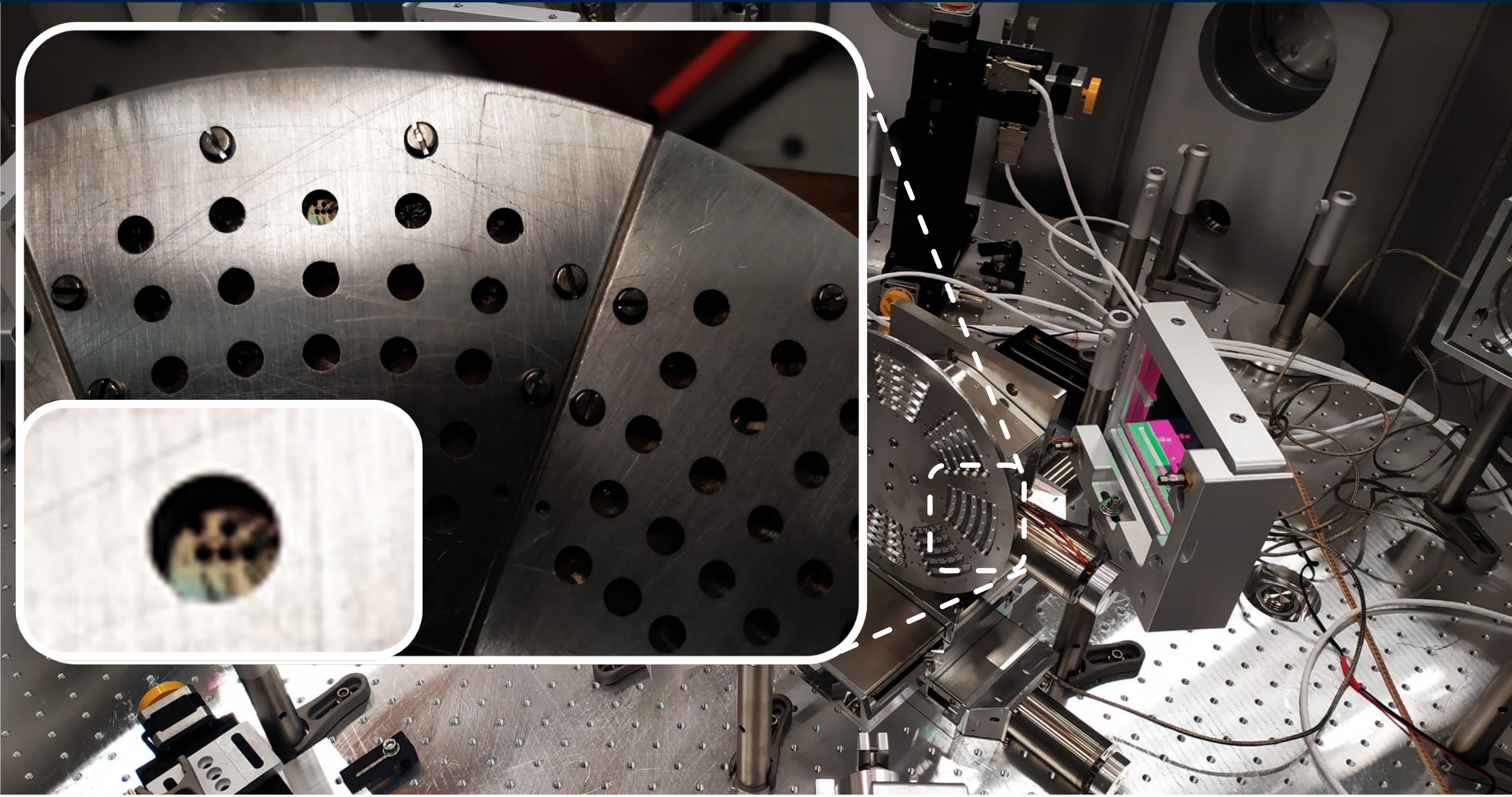




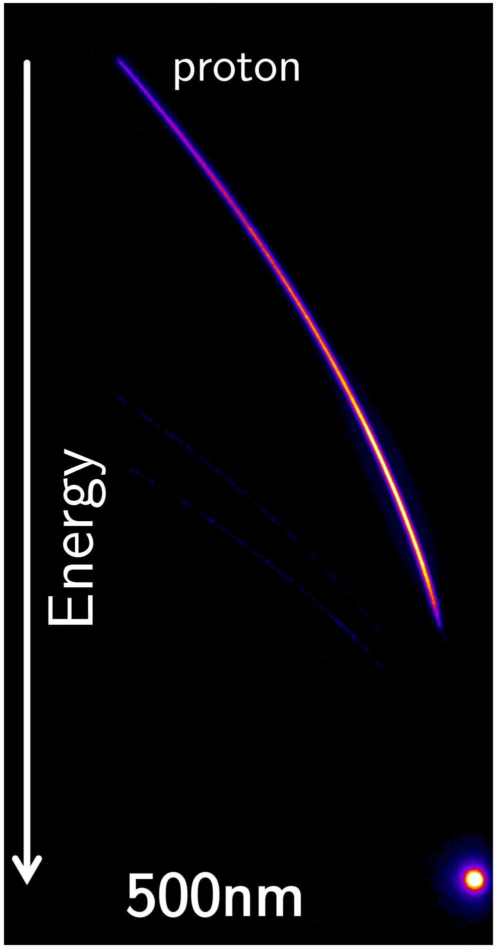


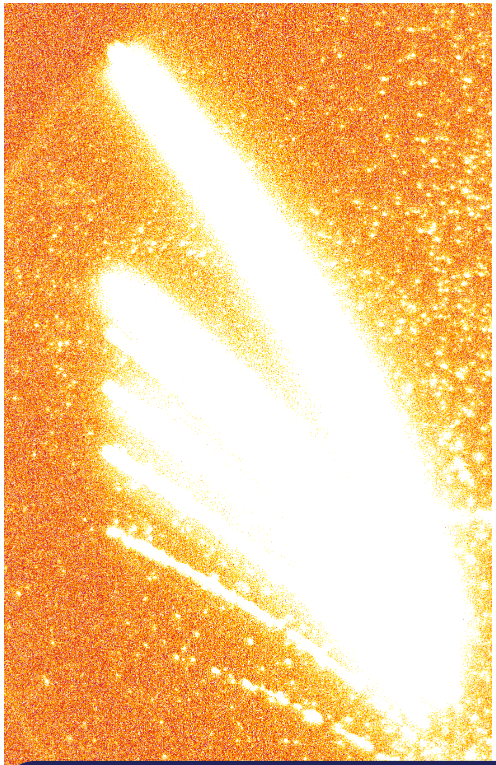
HRR system for ultra-thin targets

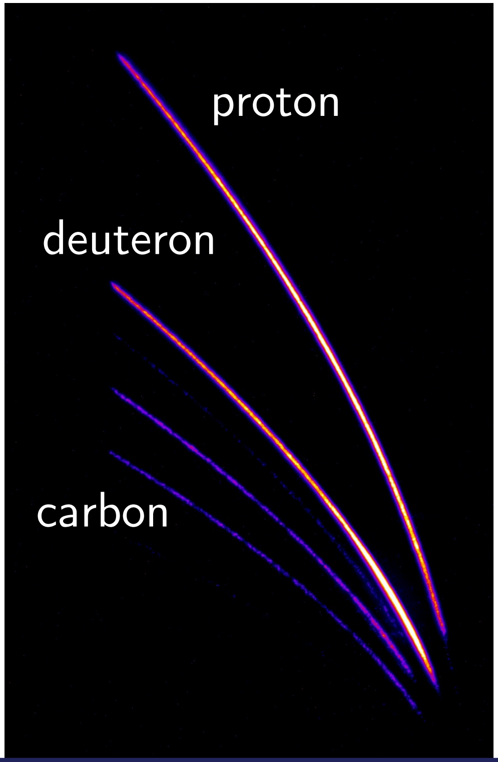
HRR system for ultra-thin targets



HRR system for ultra-thin targets

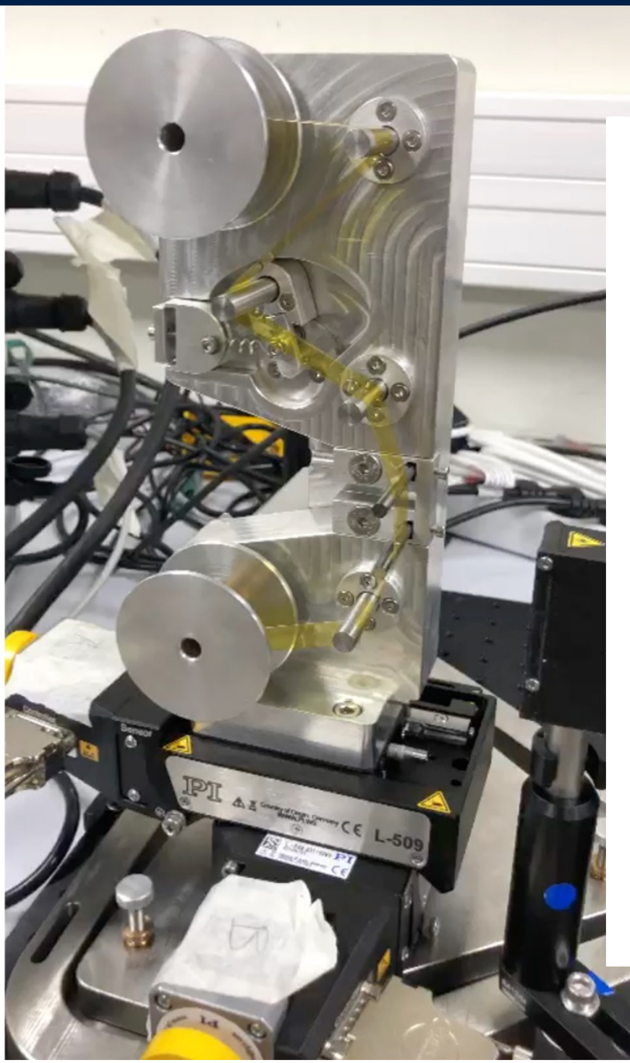


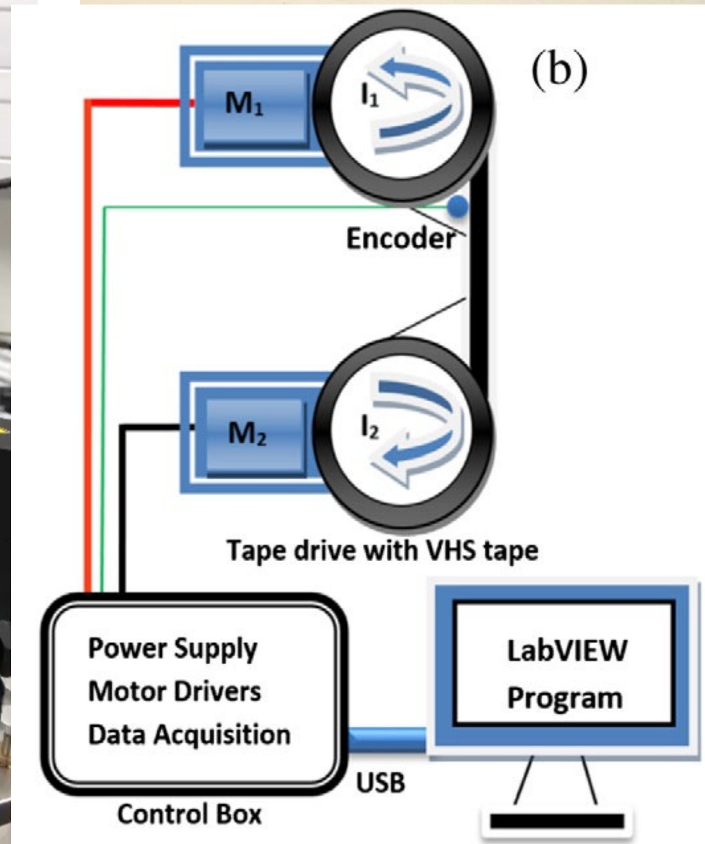


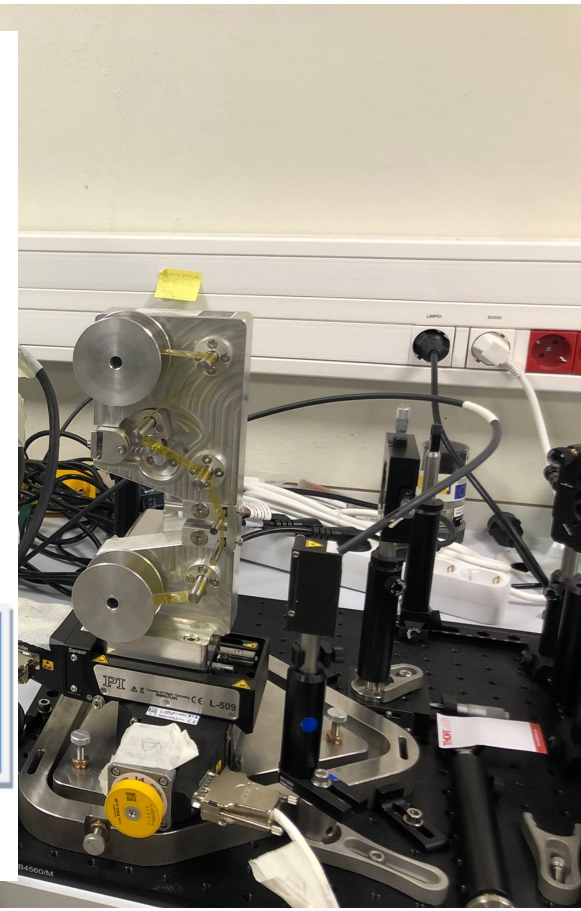


And this is from a <50mJ laser!
Currently studying the use of these targets at L2A2

Tape drive for HRR operation







[A. Bembibre et al., (in preparation, 2022)]

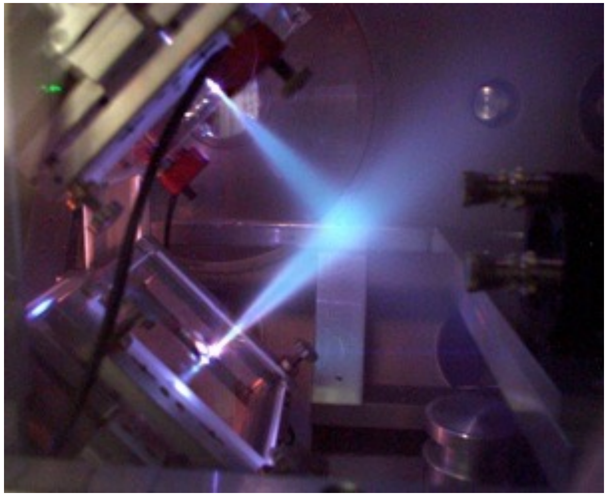
Applications

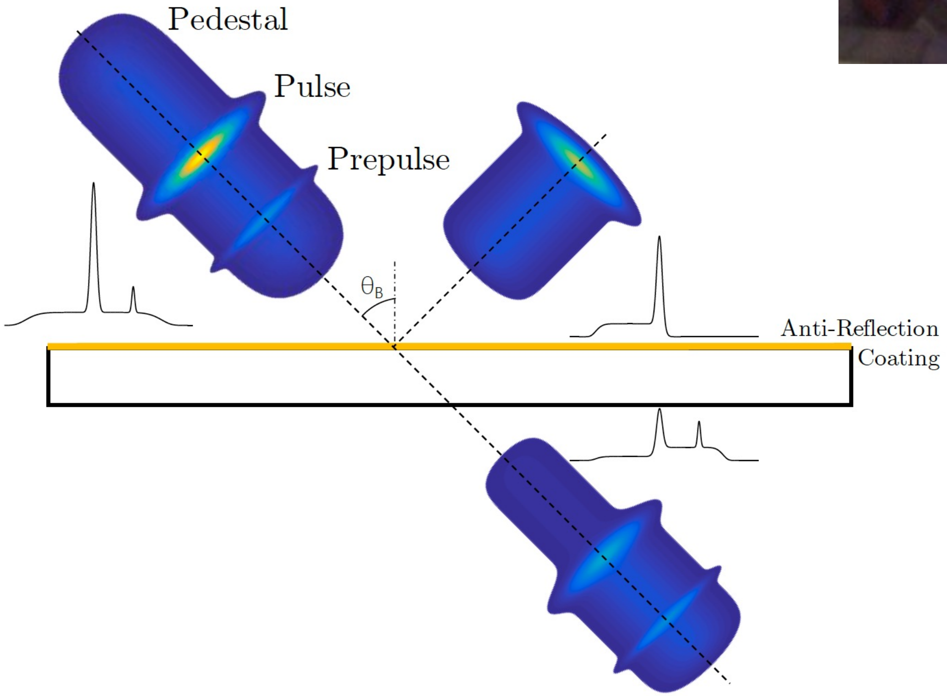
Plasma mirror development

Plasma mirror development

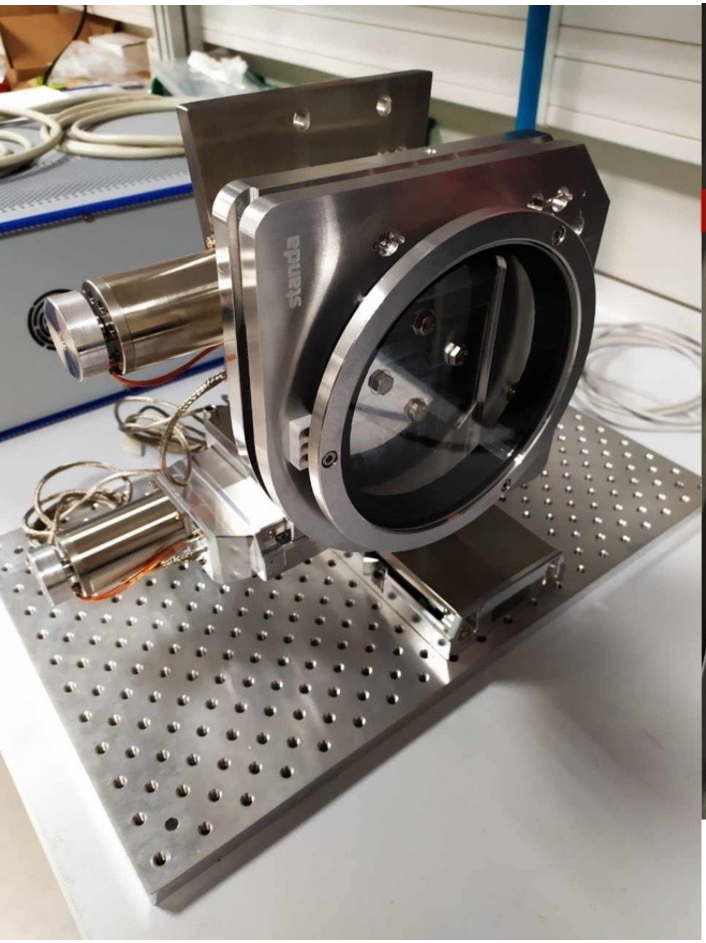
→ A plasma mirror (PM) acts as an ultrafast optical shutter, rapidly changing from almost perfectly transmissive to highly reflective.

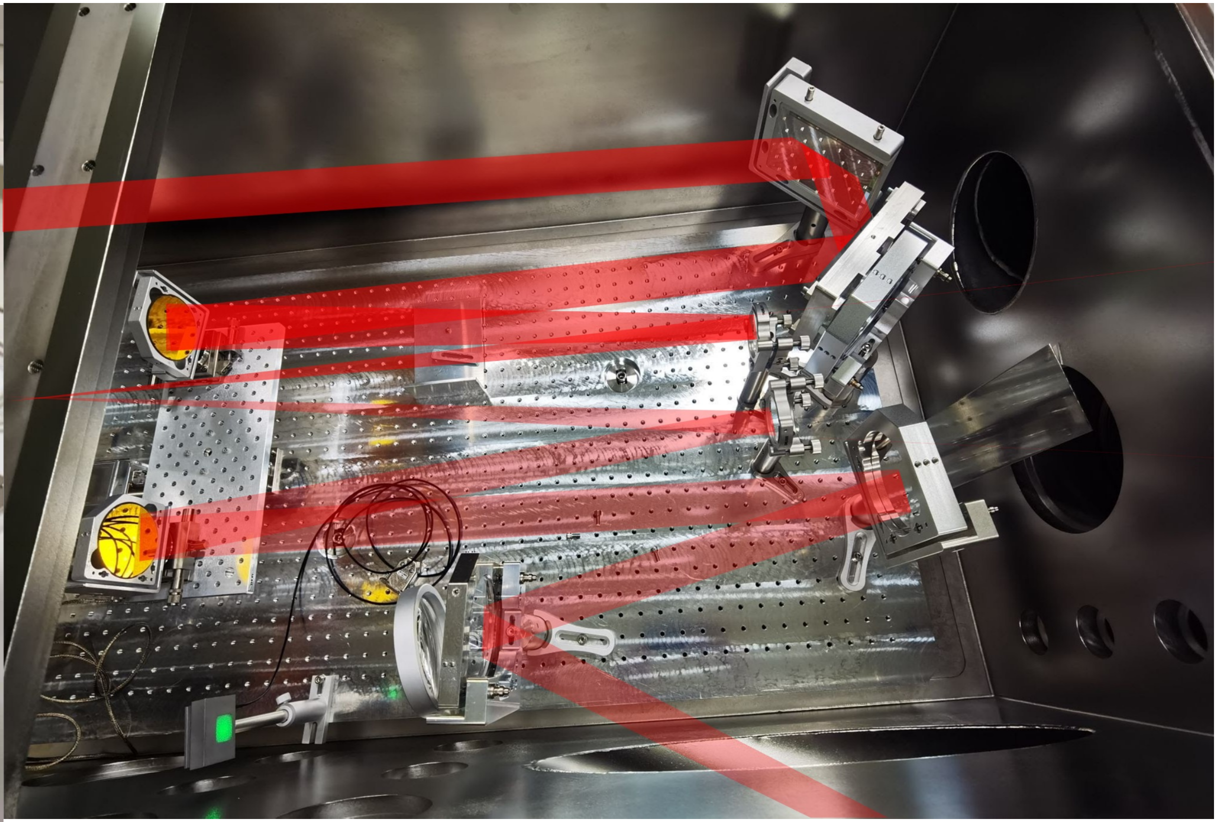
→ In general, a PM consists of a glass substrate that transmits the laser light. As the intensity increases, the ionization level is achieved. An overdense plasma is rapidly generated, leading to a very reflective surface.



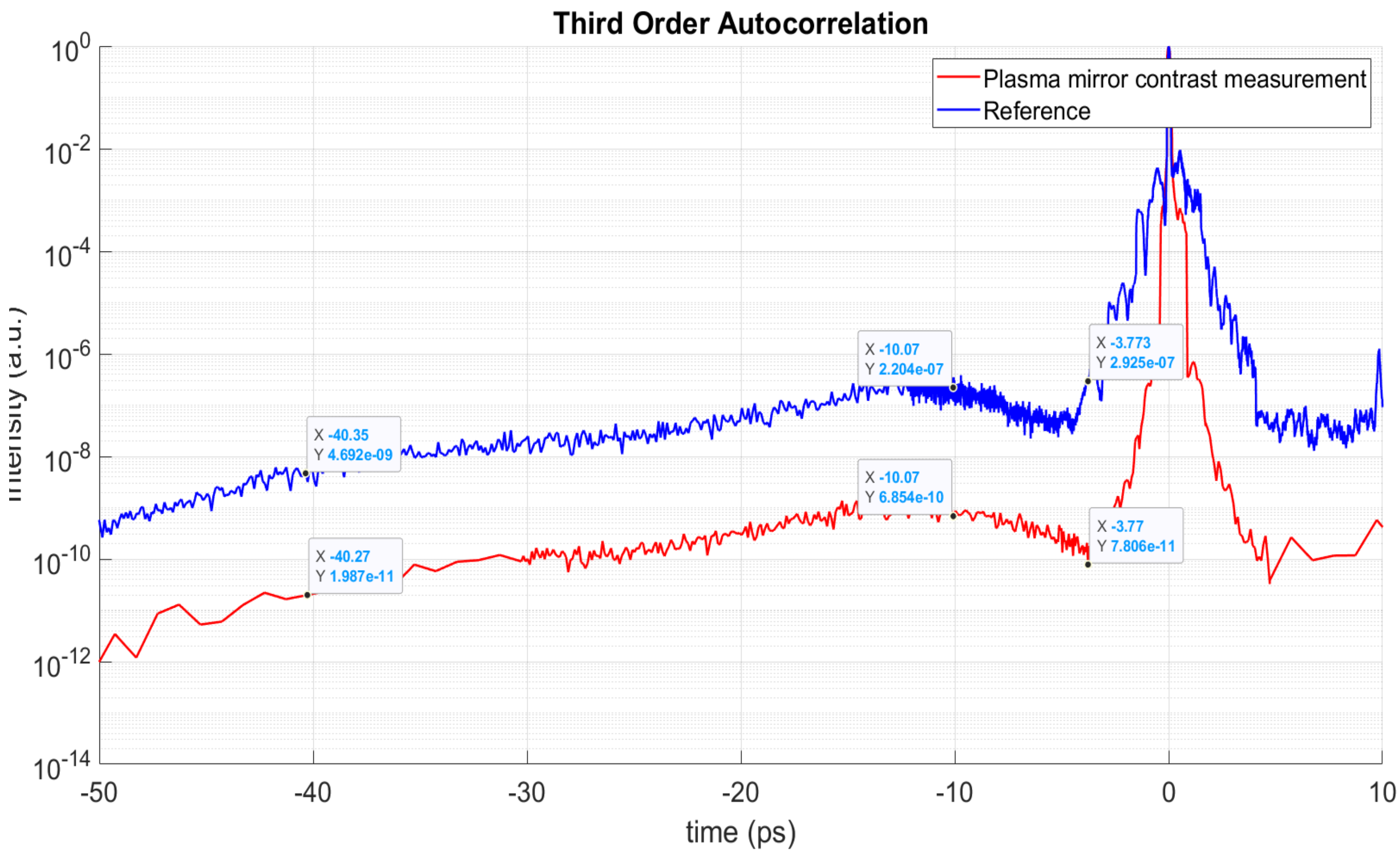


Plasma mirror development





Plasma mirror development



[R. Contreras et al., ELI-ALPS Technical Reports (2021)]

LD X-rays for phase contrast imaging

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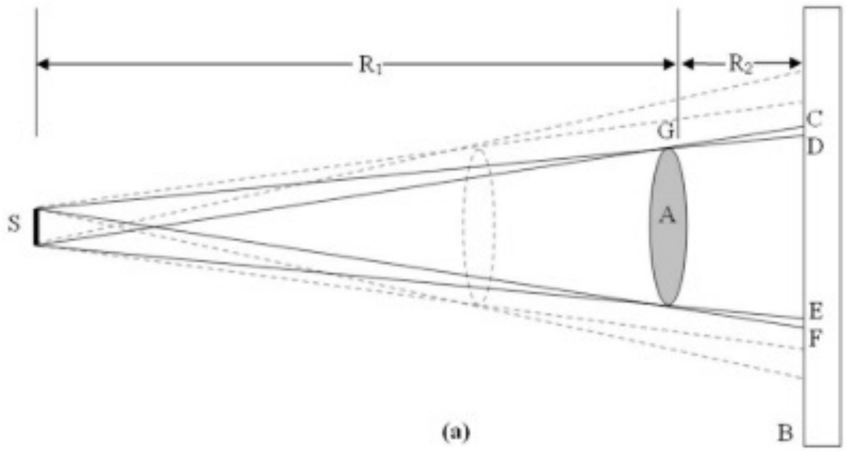


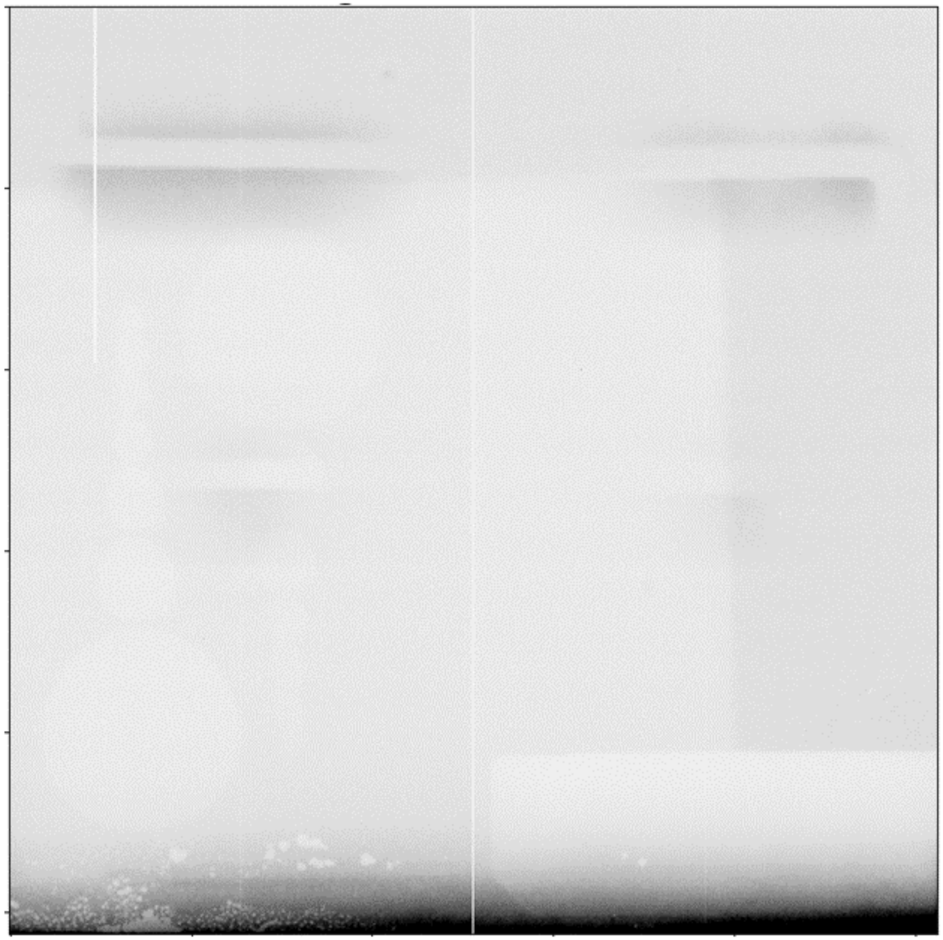
Absorption

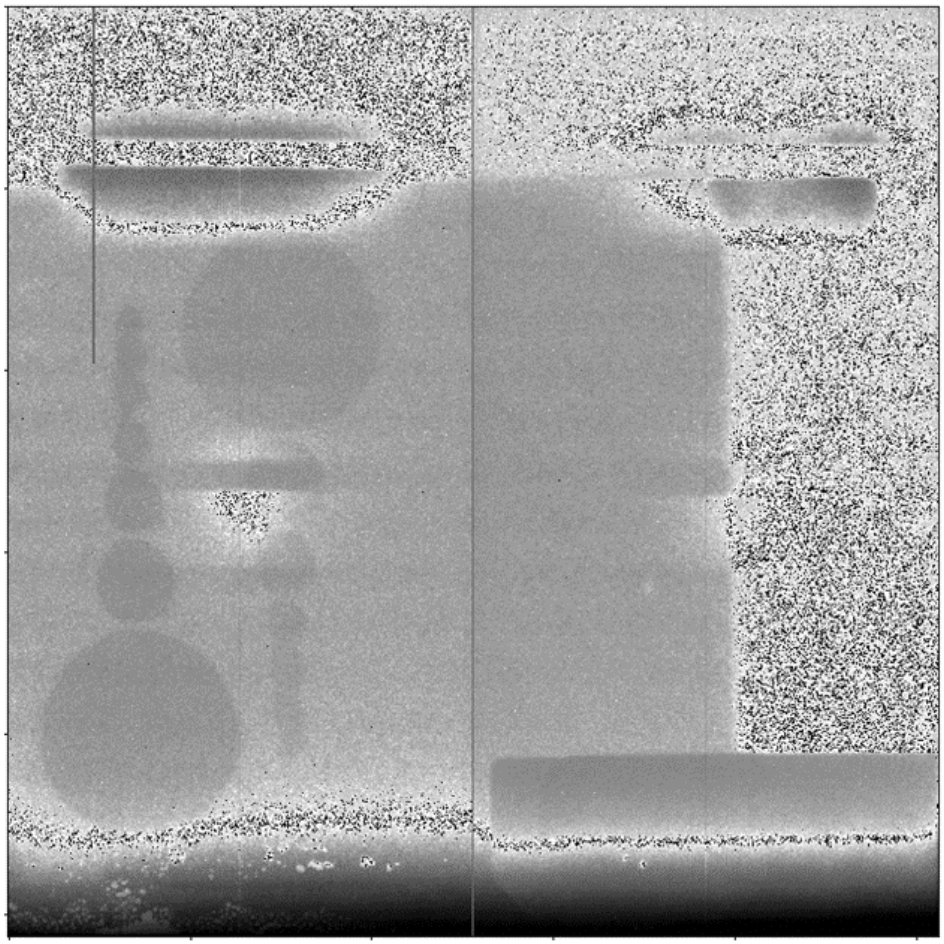
Phase

The x-rays are refracted forming areas of higher and lower intensity. Allows for enhanced contrast and imaging of objects with similar absorption coefficients

IGFAE Instituto Galego de Física de Altas Enerxías
USC Universidade de Santiago de Compostela
XUNTA DE GALICIA

LD X-rays for phase contrast imaging





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[A. Coathup et al., (Ongoing analysis, 2022)]

Radiobiology. FLASH therapy

Radiobiology. FLASH therapy

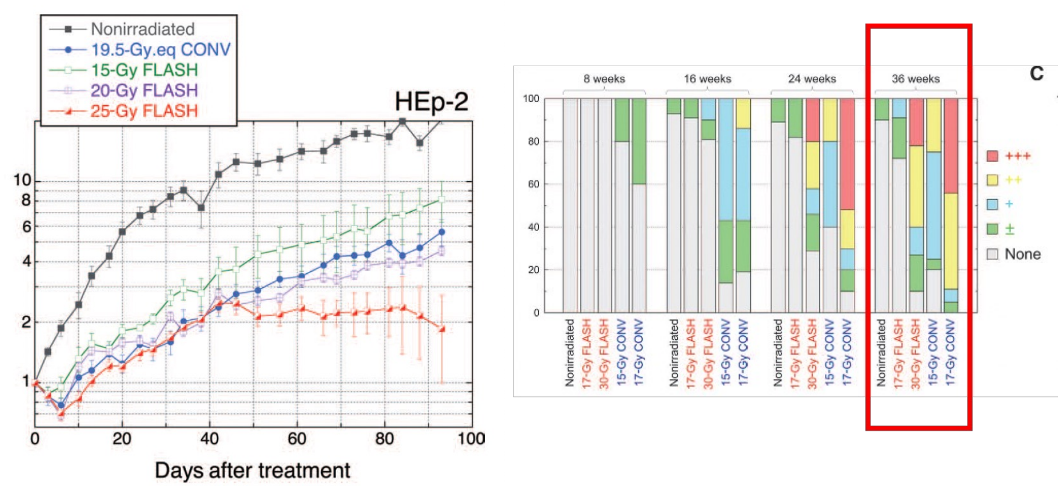
- → Reduce toxicity on healthy tissue by irradiating using ultra-high dose rates
- → FLASH regime: dose rates >40Gy/s delivered in <100ms
- → Healthy tissue becomes radio-resistant thanks to hypoxic capabilities
- → Laser-driven sources appear as an ideal candidate due to their intrinsic ultra-short duration and high dose rates

RESEARCH ARTICLE

RADIATION TOXICITY

Ultrahigh dose-rate FLASH irradiation increases the differential response between normal and tumor tissue in mice

Vincent Favaudon,[1,2]* Laura Caplier,[3†] Virginie Monceau,[4,5‡] Frédéric Pouzoulet,[1,2§] Mano Sayarath,[1,2¶] Charles Fouillade,[1,2] Marie-France Poupon,[1,2‖] Isabel Brito,[6,7] Philippe Hupé,[6,7,8,9] Jean Bourhis,[4,5,10] Janet Hall,[1,2] Jean-Jacques Fontaine,[3] Marie-Catherine Vozenin[4,5,10,11]



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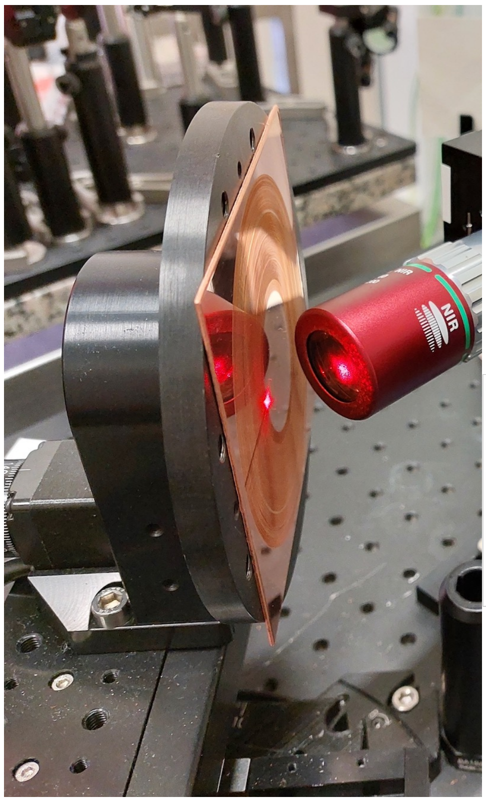
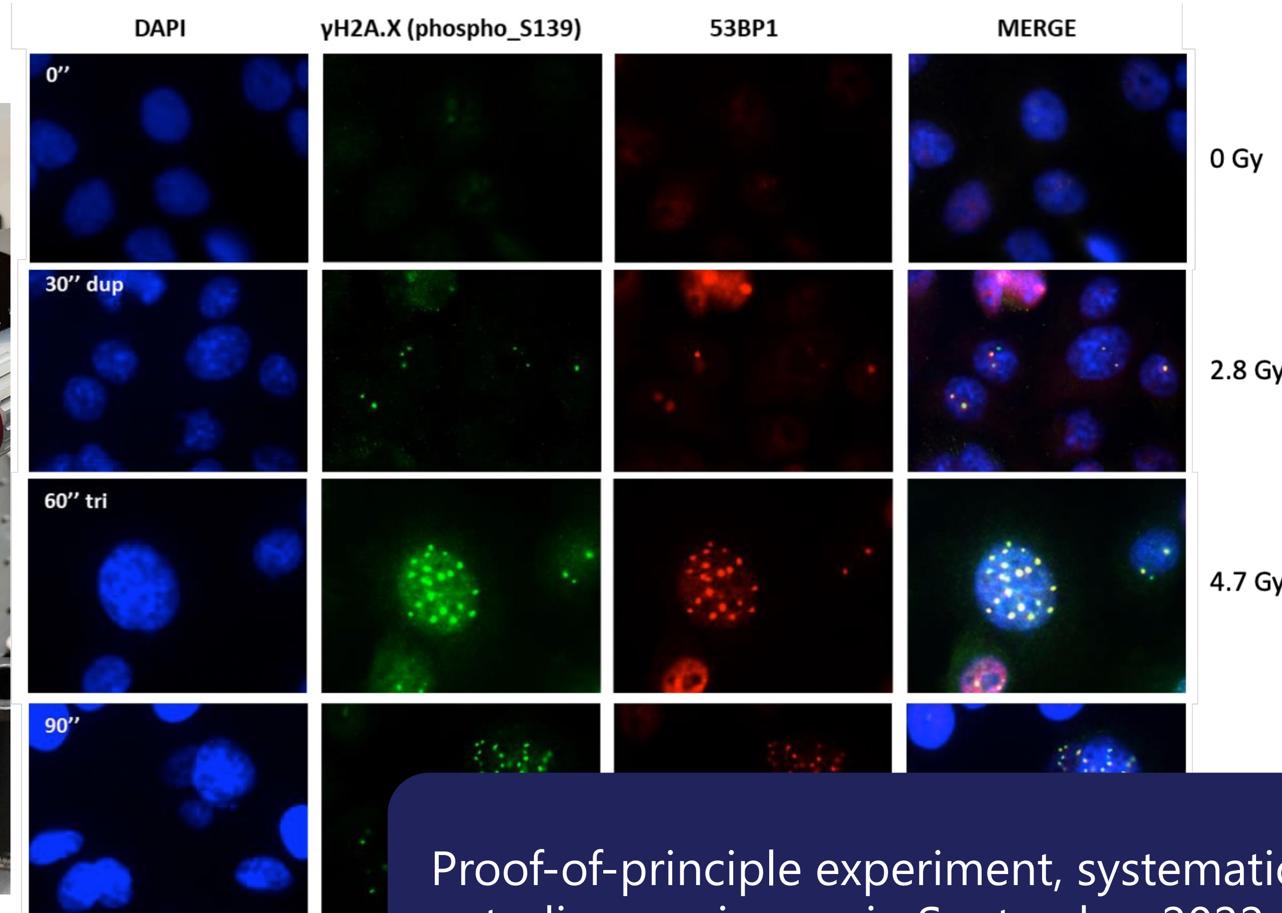
Radiobiology. FLASH therapy





Proof-of-principle experiment, systematic studies coming up in September 2022

LAIA

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[A. Torralba et al., Quantum Beam Science 6 (2022)]

Laser-driven neutron sources

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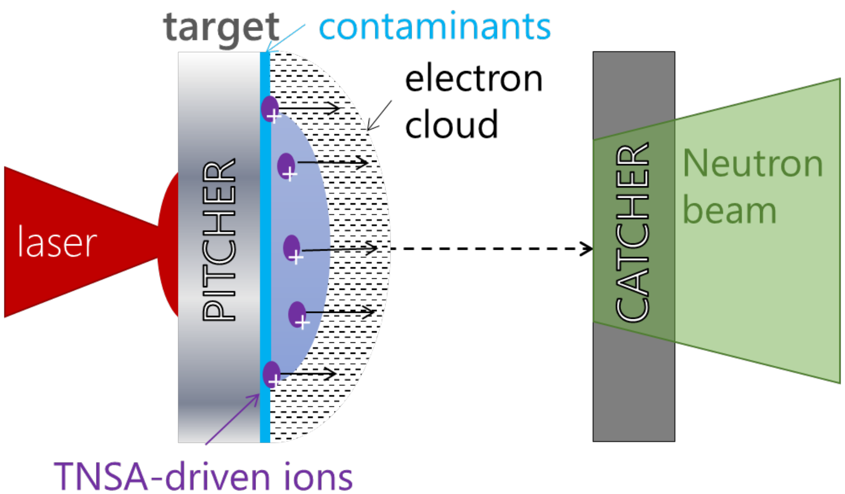
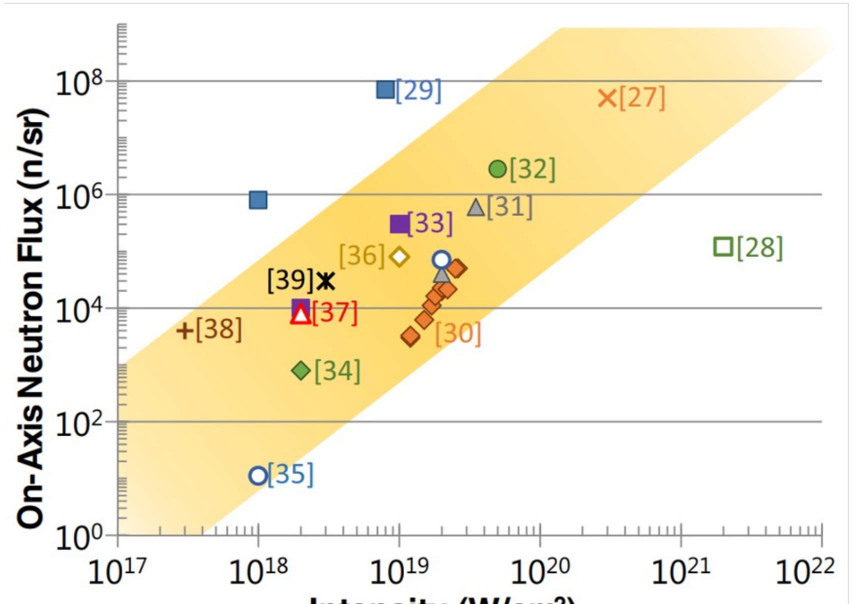


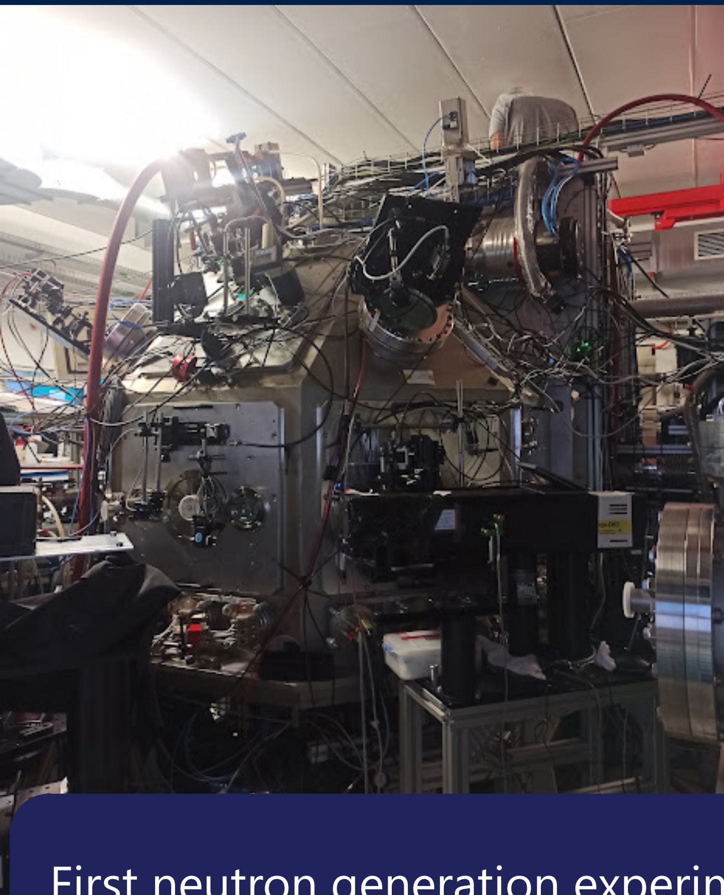
LS-driven Neutrons

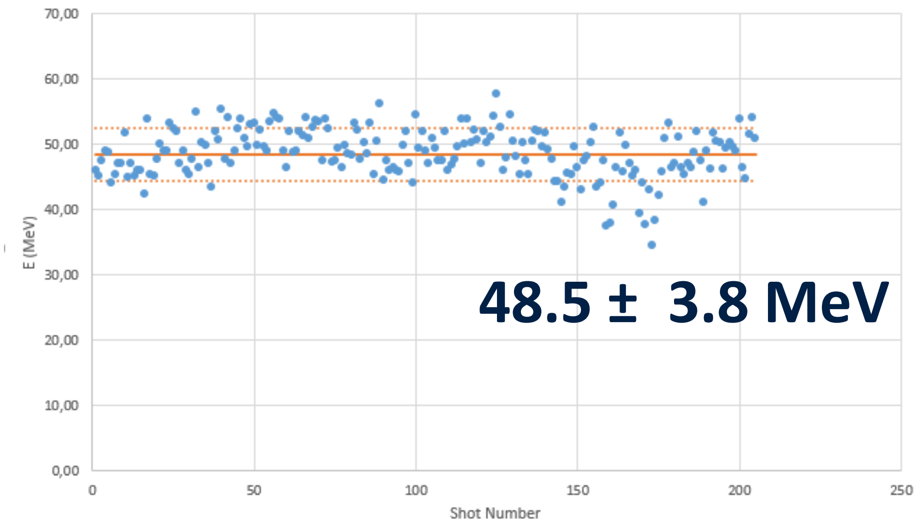


High flux in ultra-short bunch,
but only 1 shot every 20 minutes…

[A. Alejo et al., Phys. Rev. Lett. (Accepted - In press, 2022)]

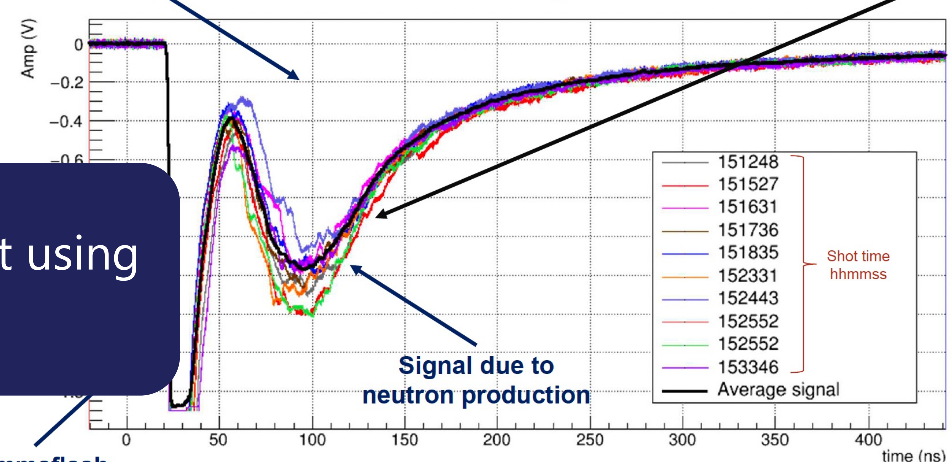
Laser-driven neutron sources





Individual traces

Deuterated targets + LiF



First neutron generation experiment using a Hz, Petawatt system

HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF

Laser-driven neutron sources

Follow-up experimental campaign @CLPU coming up in September 2022

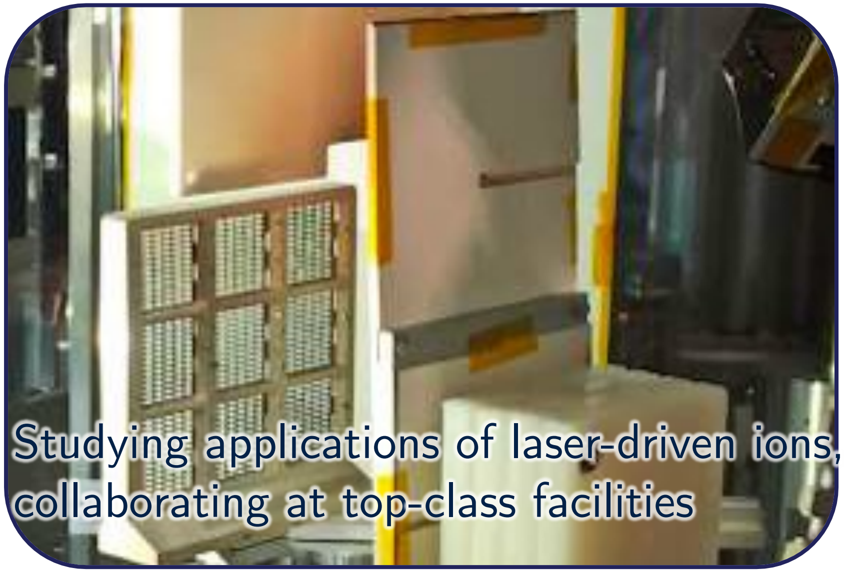
CLPU CENTRO DE LÁSERES PULSADOS
CNA Centro Nacional de Aceleradores

To conclude

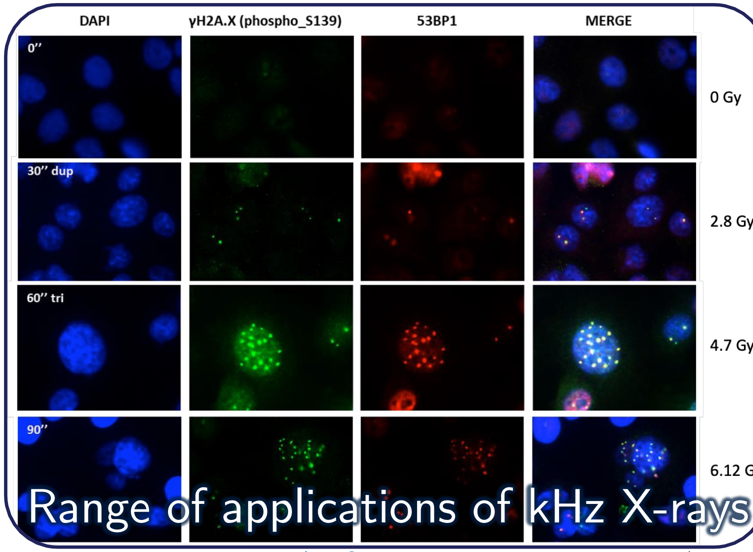
Take-home messages

Currently commissioning the upgrade of the laser system

Ongoing developments on target and diagnostic systems



Studying applications of laser-driven ions, collaborating at top-class facilities



Range of applications of kHz X-rays

Acknowledging...

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