Challenges of High Repetition Petawatt-class Lasers

The Spanish Center for Pulsed Lasers, CLPU, Salamanca

Luis Roso CLPU Director

on behalf of the CLPU team

CLPU CENTRO DE LÁSERES PULSADOS

In collaboration with

UNIVERSITY OF ALBERTA

UNIVERSITY OF MARYLAND

old times ...

PHYSICAL REVIEW A, VOLUME 65, 042902

Strong-field approximation to the relativistic channeling of electrons in the presence of electromagnetic waves

Julio San Roman, Luis Plaja, and Luis Roso
Departamento de Física Aplicada, Universidad de Salamanca, E-37008 Salamanca, Spain
(Received 6 July 2001; published 1 April 2002)

PHYSICAL REVIEW A, VOLUME 65, 052904

Characterization of the channeling process in the scattering of relativistic electrons with periodic structures

Julio San Roman, Luis Plaja, Luis Roso, and Uwe Schwengelbeck
Departamento de Física Aplicada, Universidad de Salamanca, E-37008 Salamanca, Spain
(Received 20 December 2001; published 6 May 2002)

This talk is about PW-class lasers

intensity lasers 30J/30fs

not about energy lasers kJ/ps

Infraestructuras Científicas y Técnicas Singulares

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Things feasible with a

PW-class laser

30J/30fs

Proton acceleration

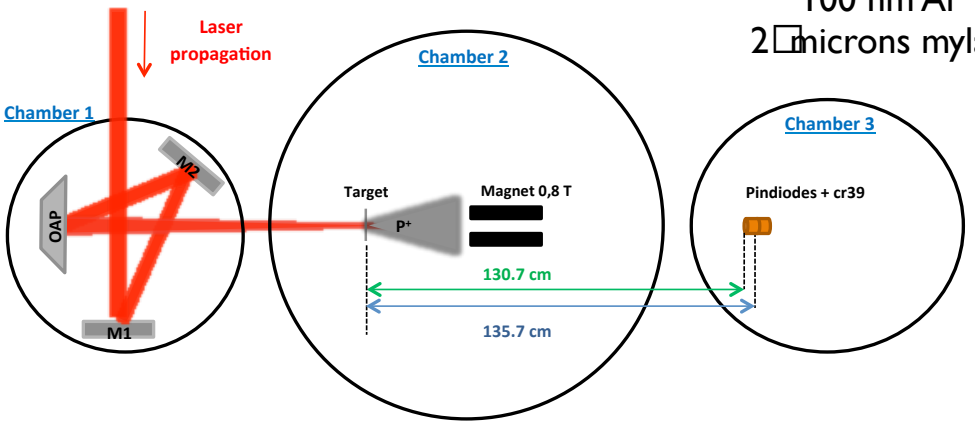
TNSA

Target Normal Sheath Acceleration

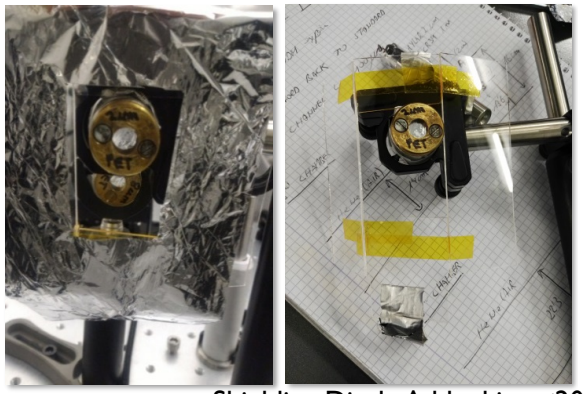
Proton acceleration

Fast PiN X diodes
CR39 Track detector

Set-up



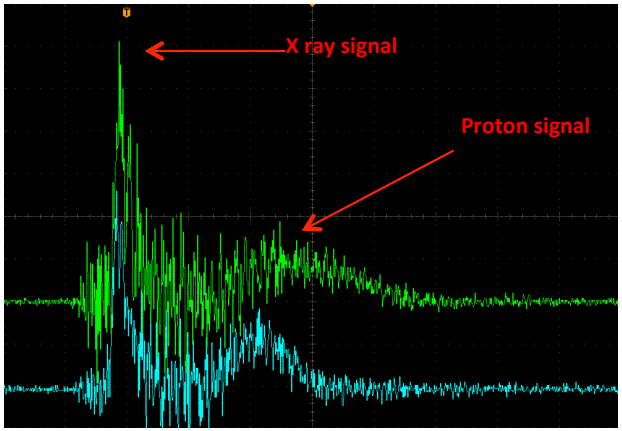
Targets
100 nm Al
2□microns mylar

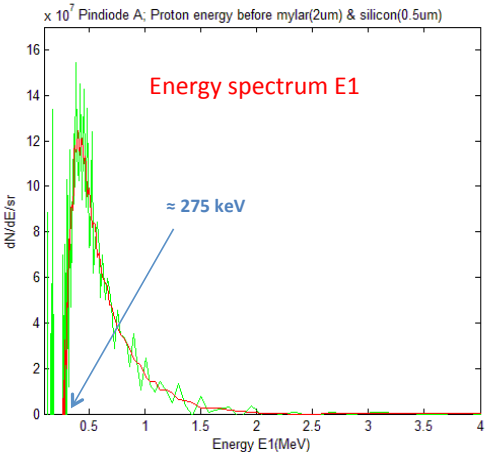


Shielding Diode A blocking <200 KeV
Shielding Diode B blocking <500 KeV

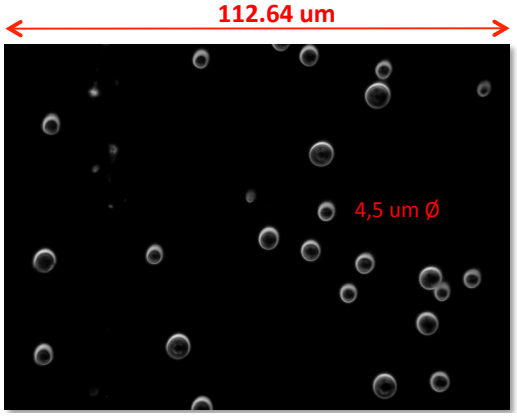
Spectral characterisation by ToF

Raw signals





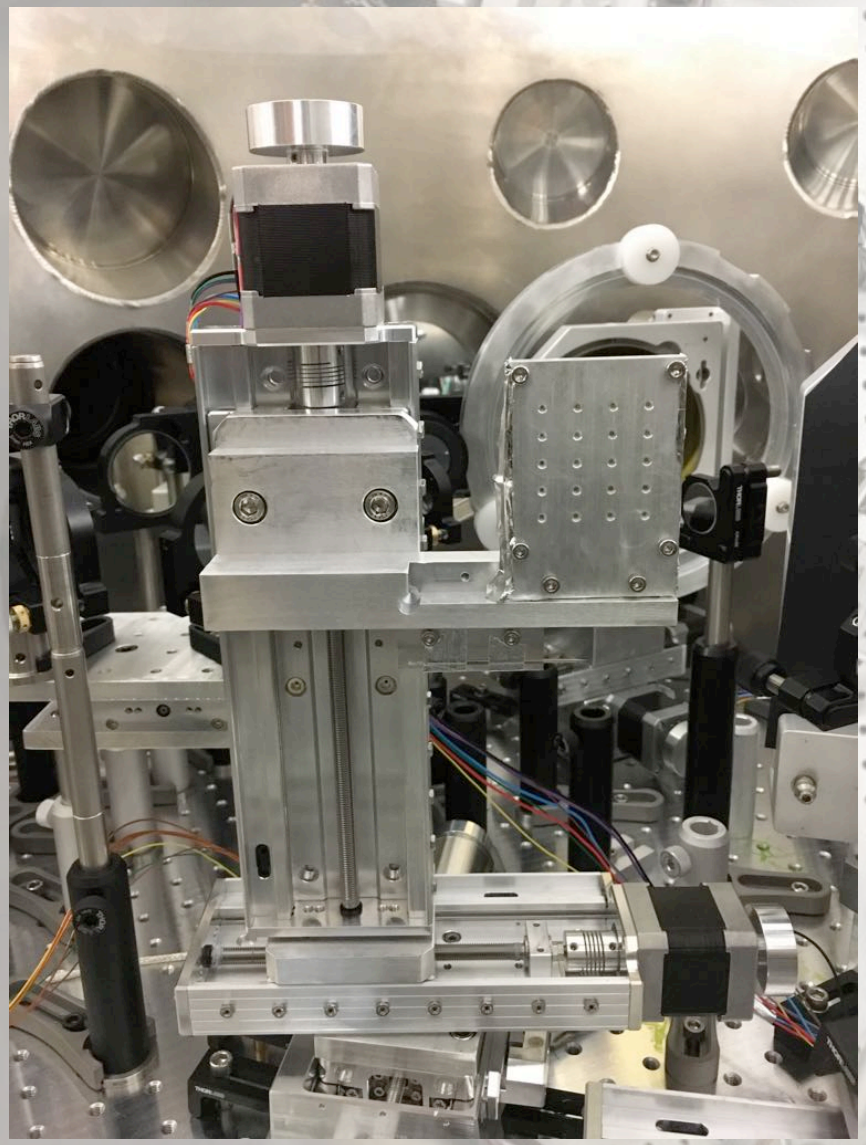
CR39 after 10 shots

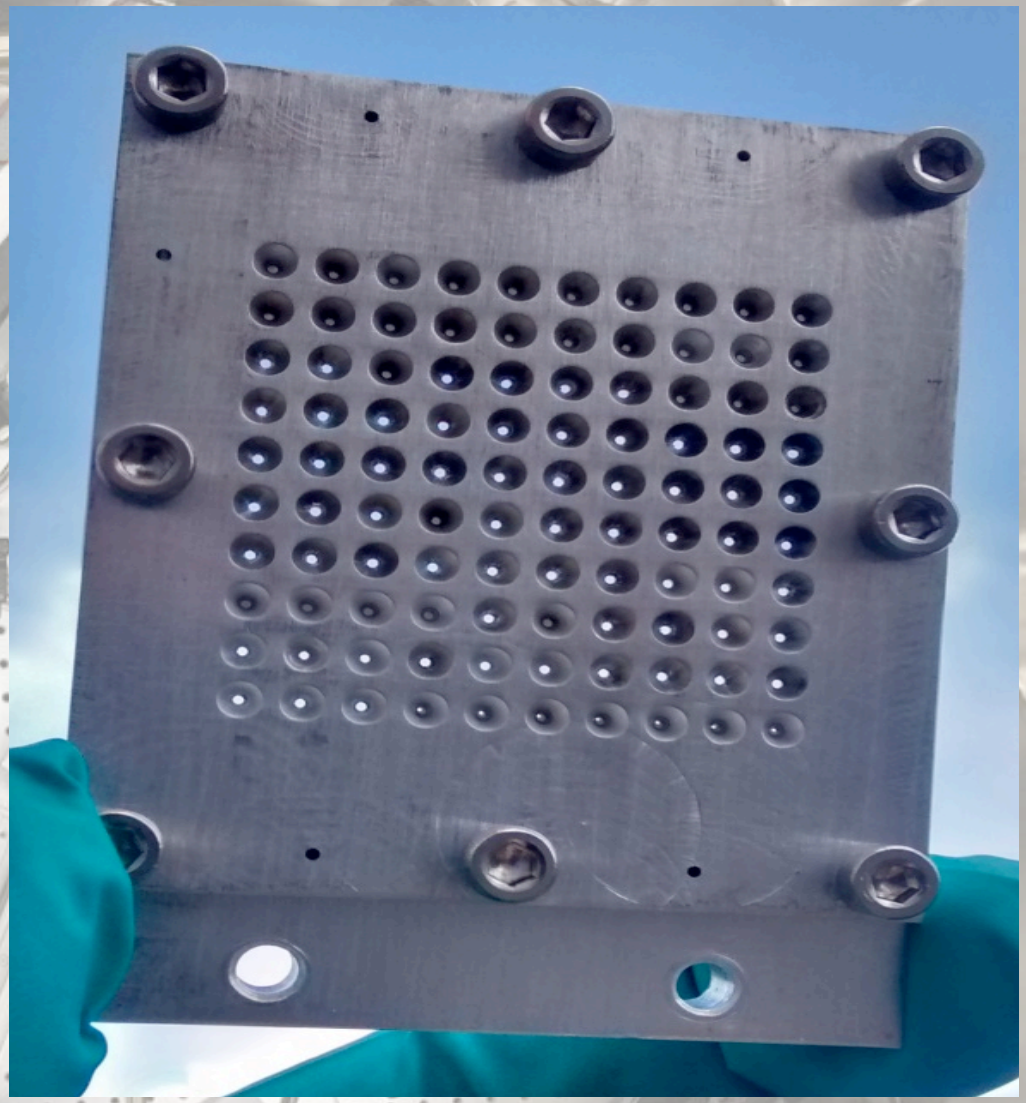


100X Optical Microsc. dark field

Measurements & analysis: M. Huault

Proton acceleration





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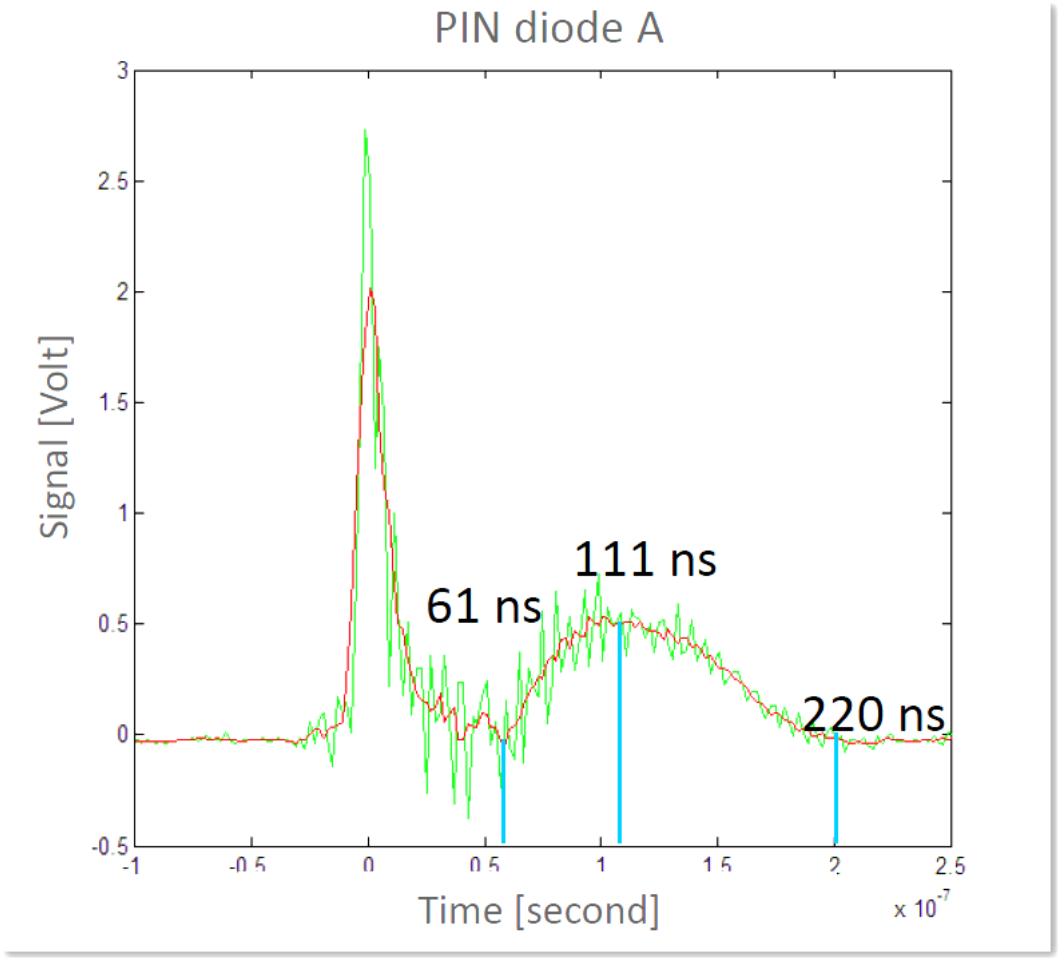
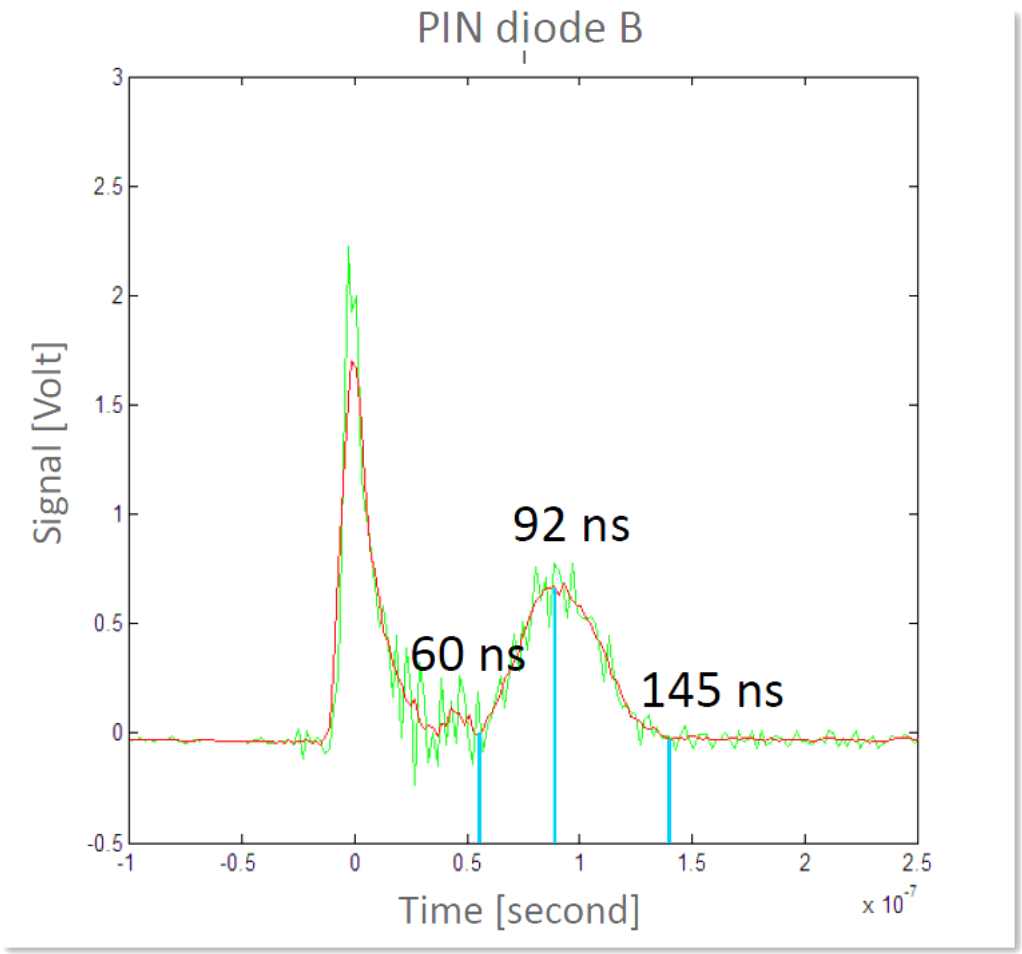
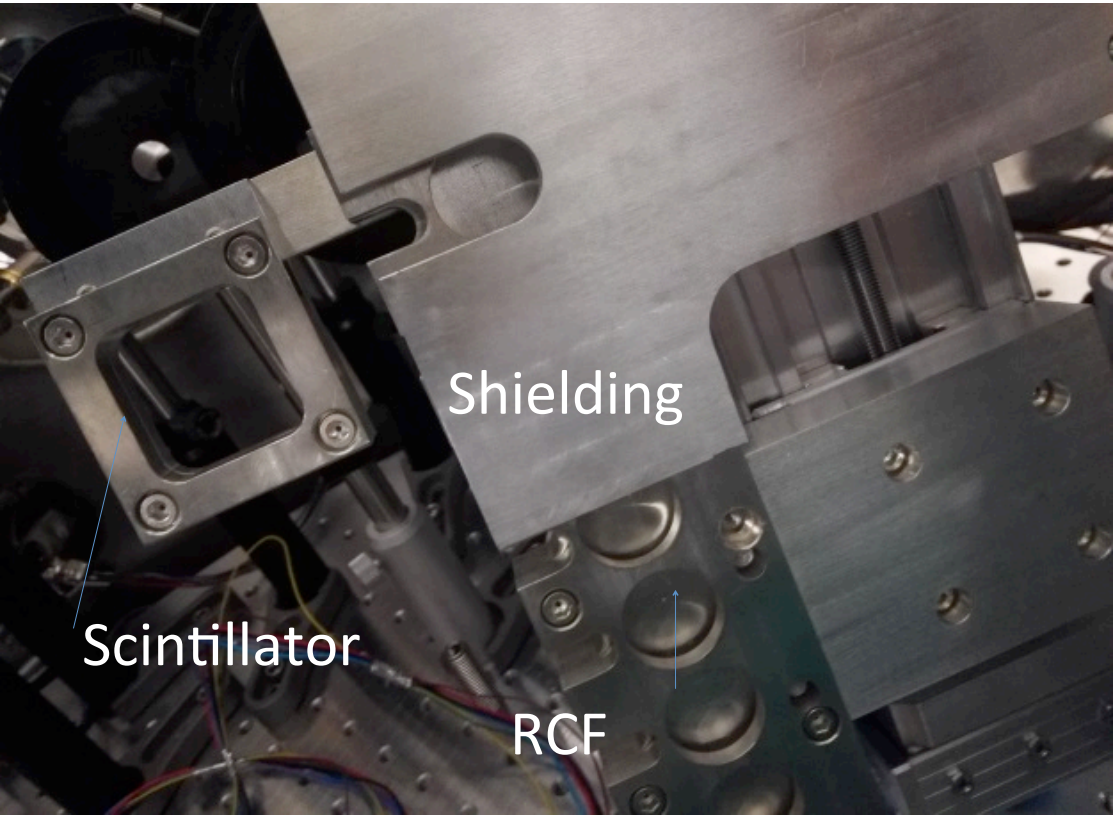
Proton acceleration

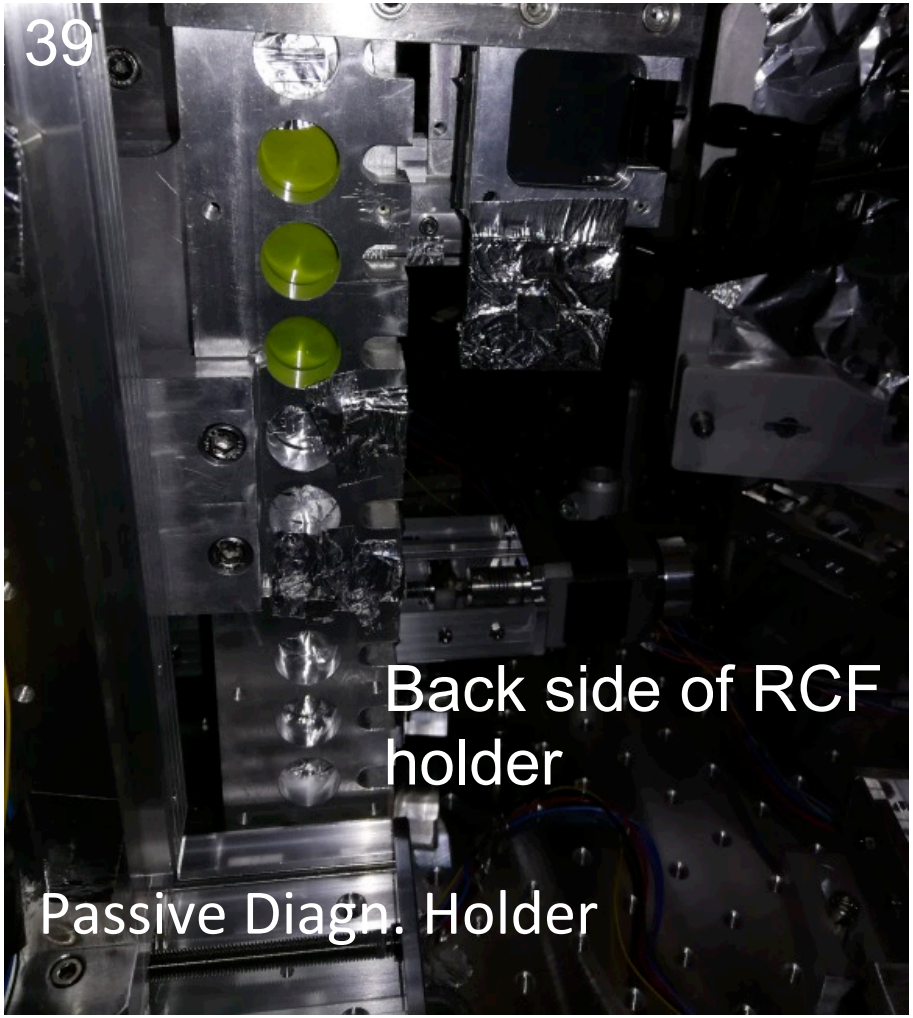


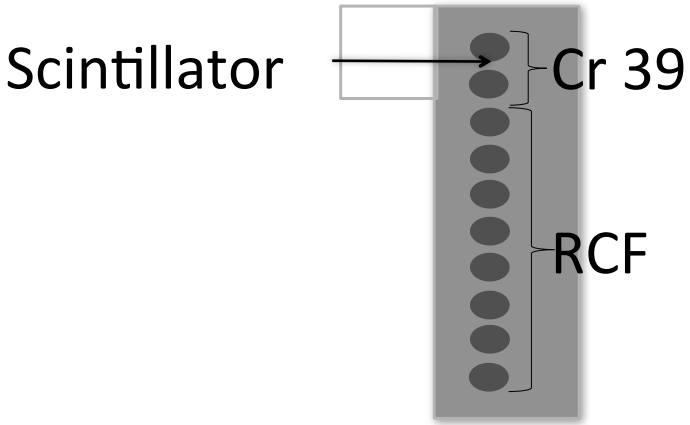
Max proton energy: 2,4 MeV



Max proton energy: 2,6 MeV

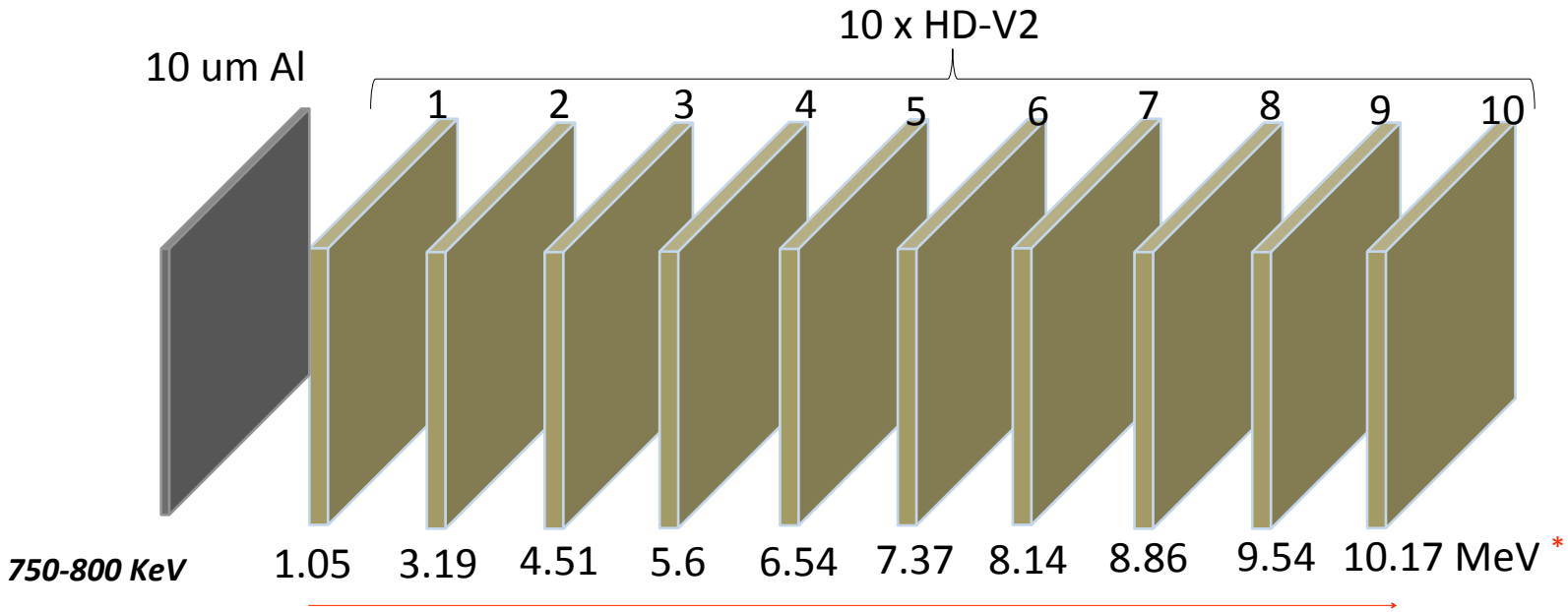

Shielding
Scintillator
RCF


39
Back side of RCF holder
Passive Diagn. Holder


Scintillator
Cr 39
RCF

RCF Stacks

RCF



* compared with SRIM and Fluka

Distances

Distance RCF – target = 3mm

Diameter RCF = 2cm

For Radiography

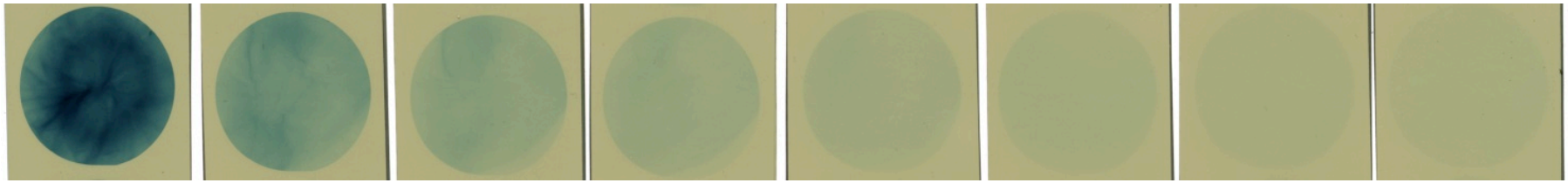
Distance Sample – target = 1cm

Distance Sample – RCF = 2 cm

Typical Results RCF (Dec. 2017)

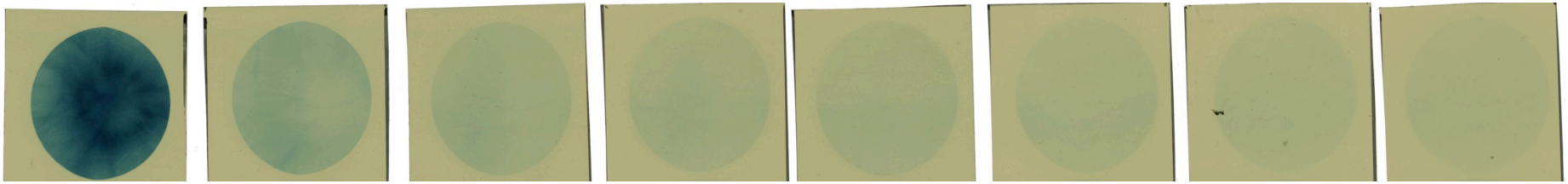
Target: Al 5 µm

Max energy RCF : 6.54 MeV



LASER ENERGY : 2.86J on Target

Max energy RCF : 8.86 MeV



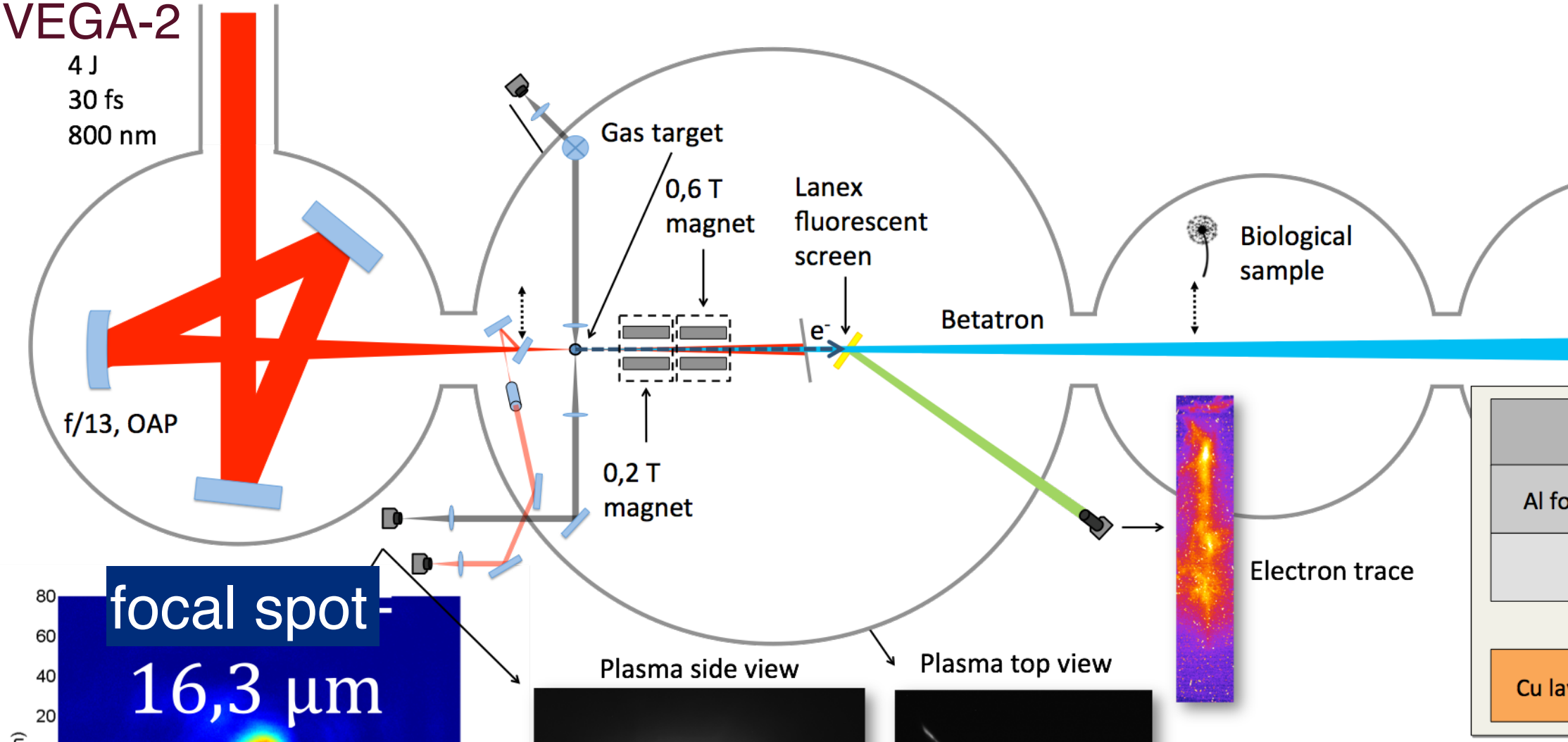
LASER ENERGY : 2.77J on Target

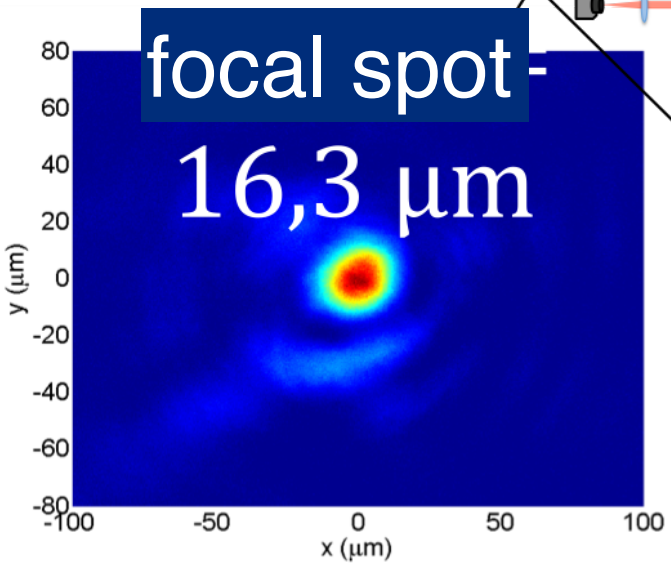
Electron acceleration

LWFA
Laser Wakefield Acceleration

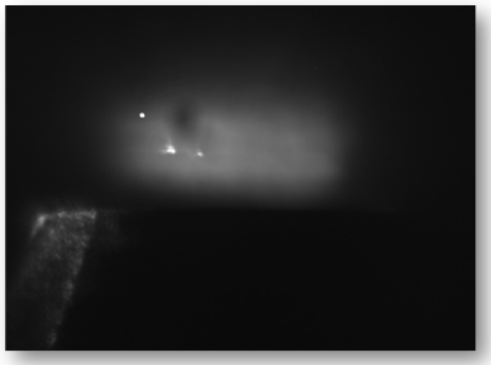
VEGA-2

4 J
30 fs
800 nm

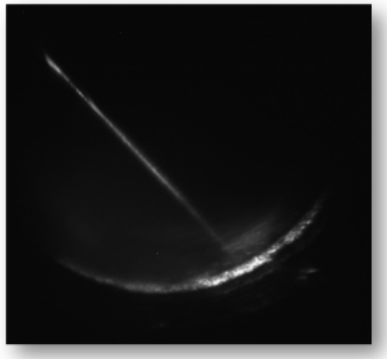


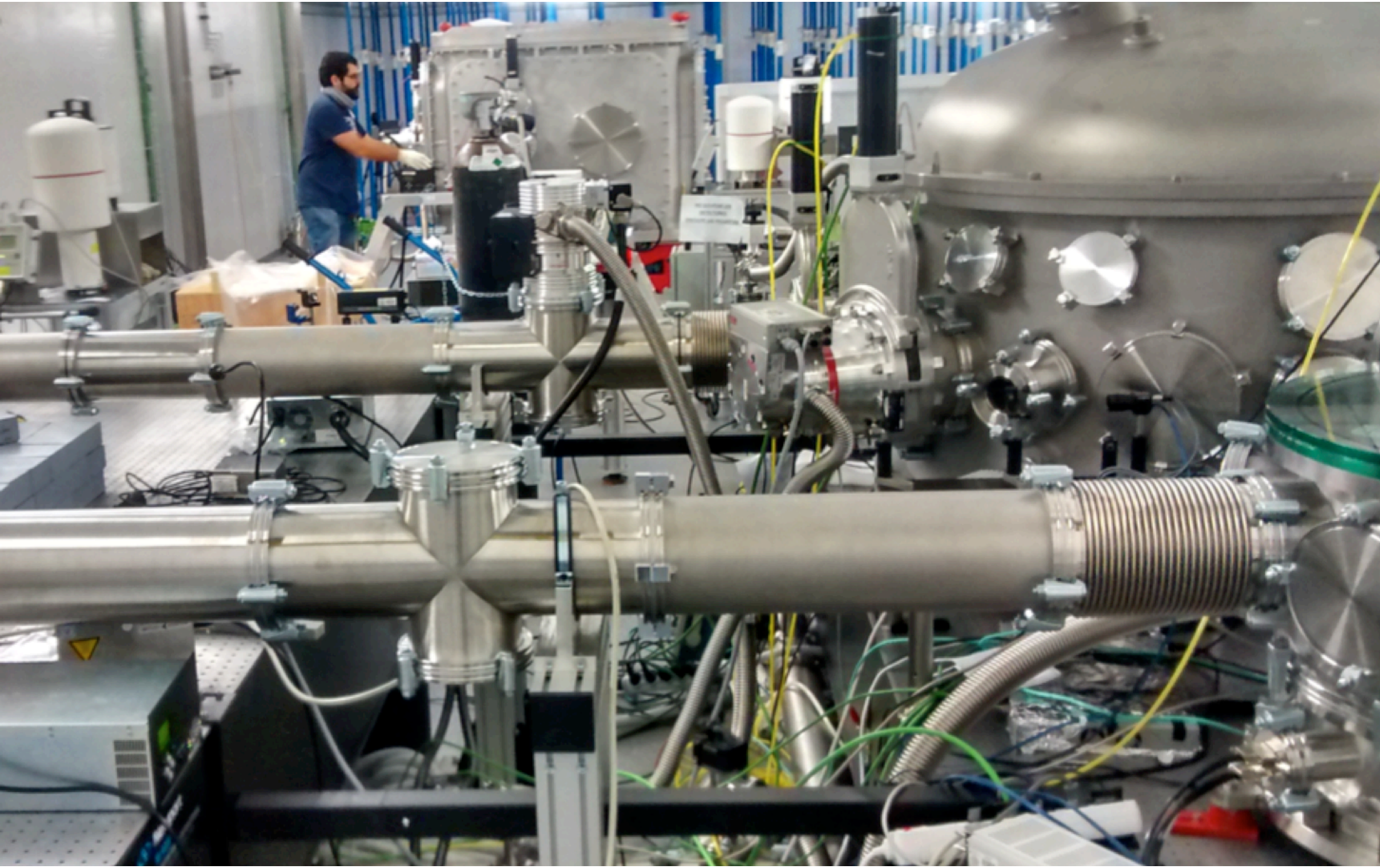


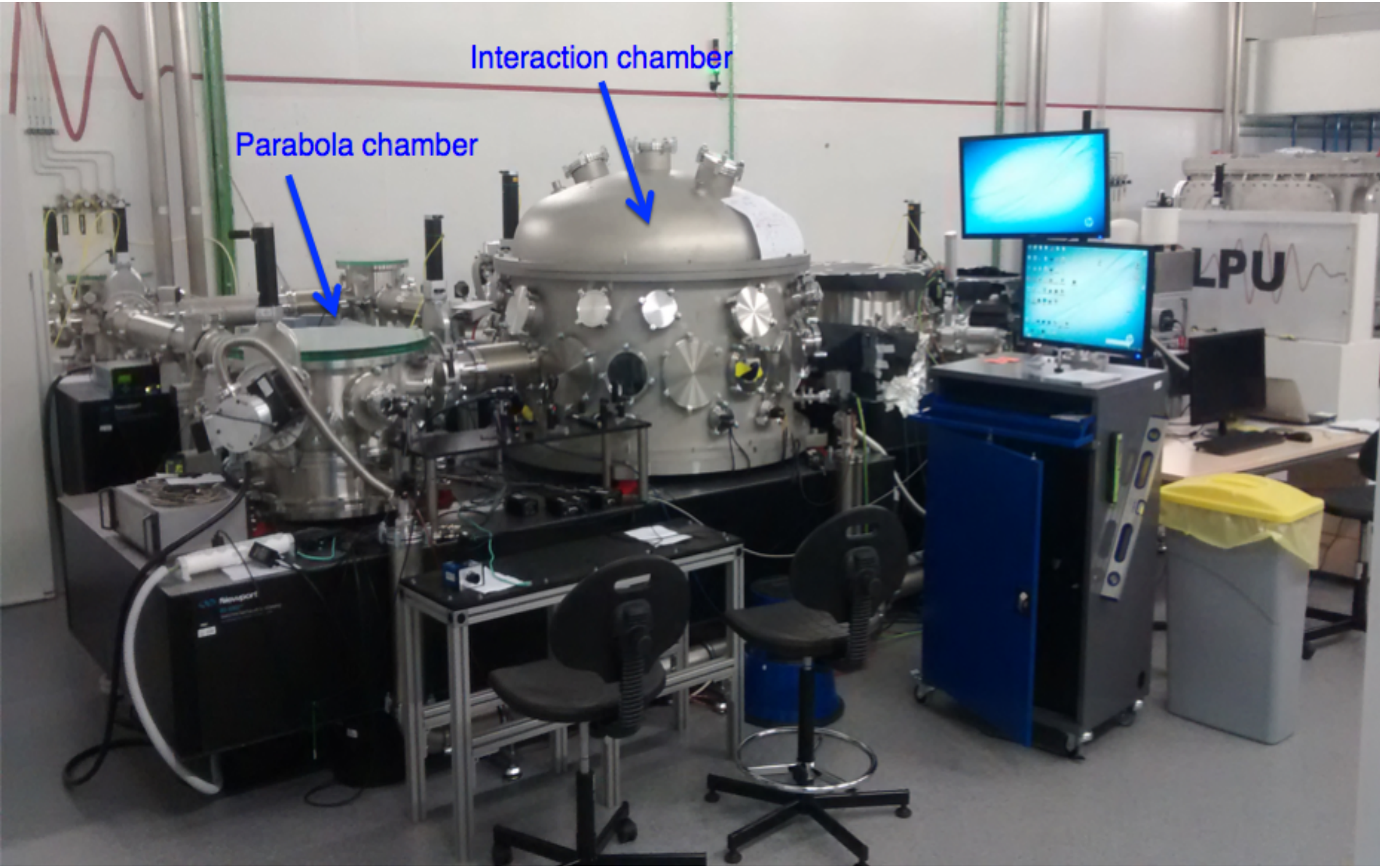
Plasma side view



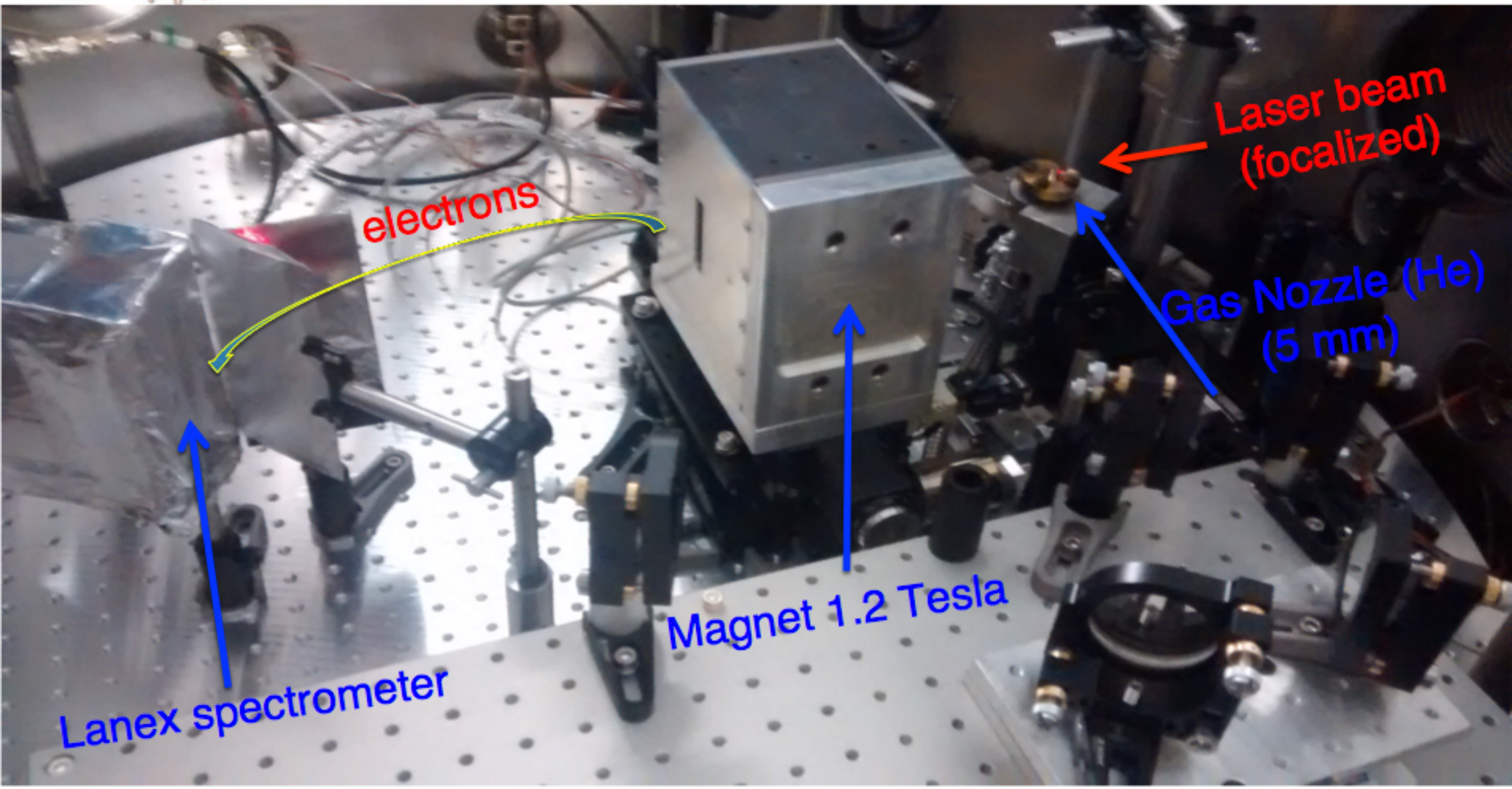
Plasma top view






Interaction chamber
Parabola chamber
LPU

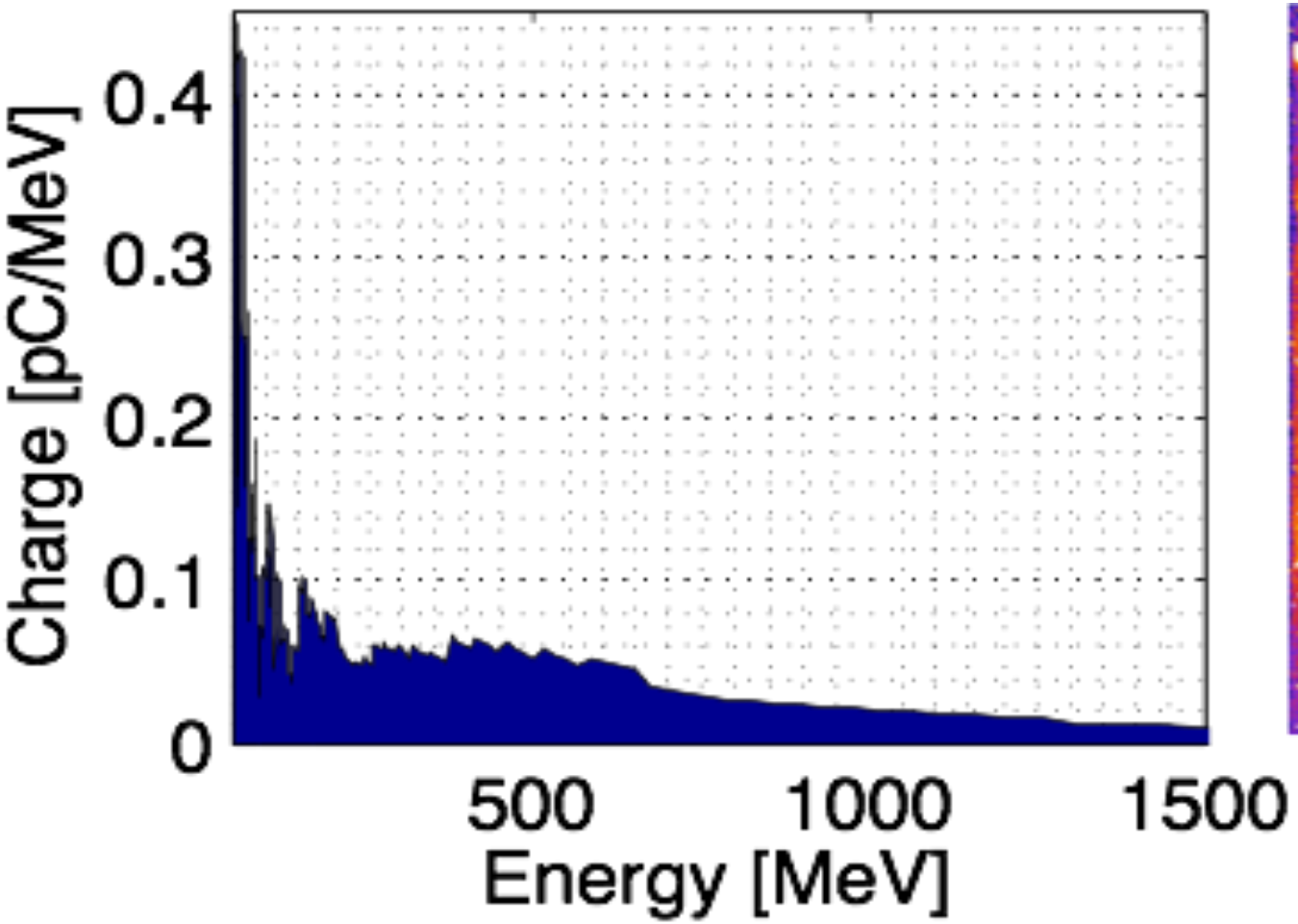
Electron acceleration and Betatron radiation at VEGA

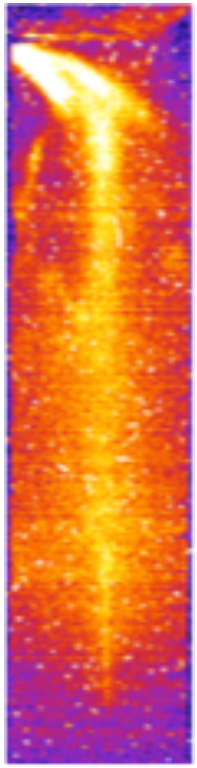


Electron acceleration LWA

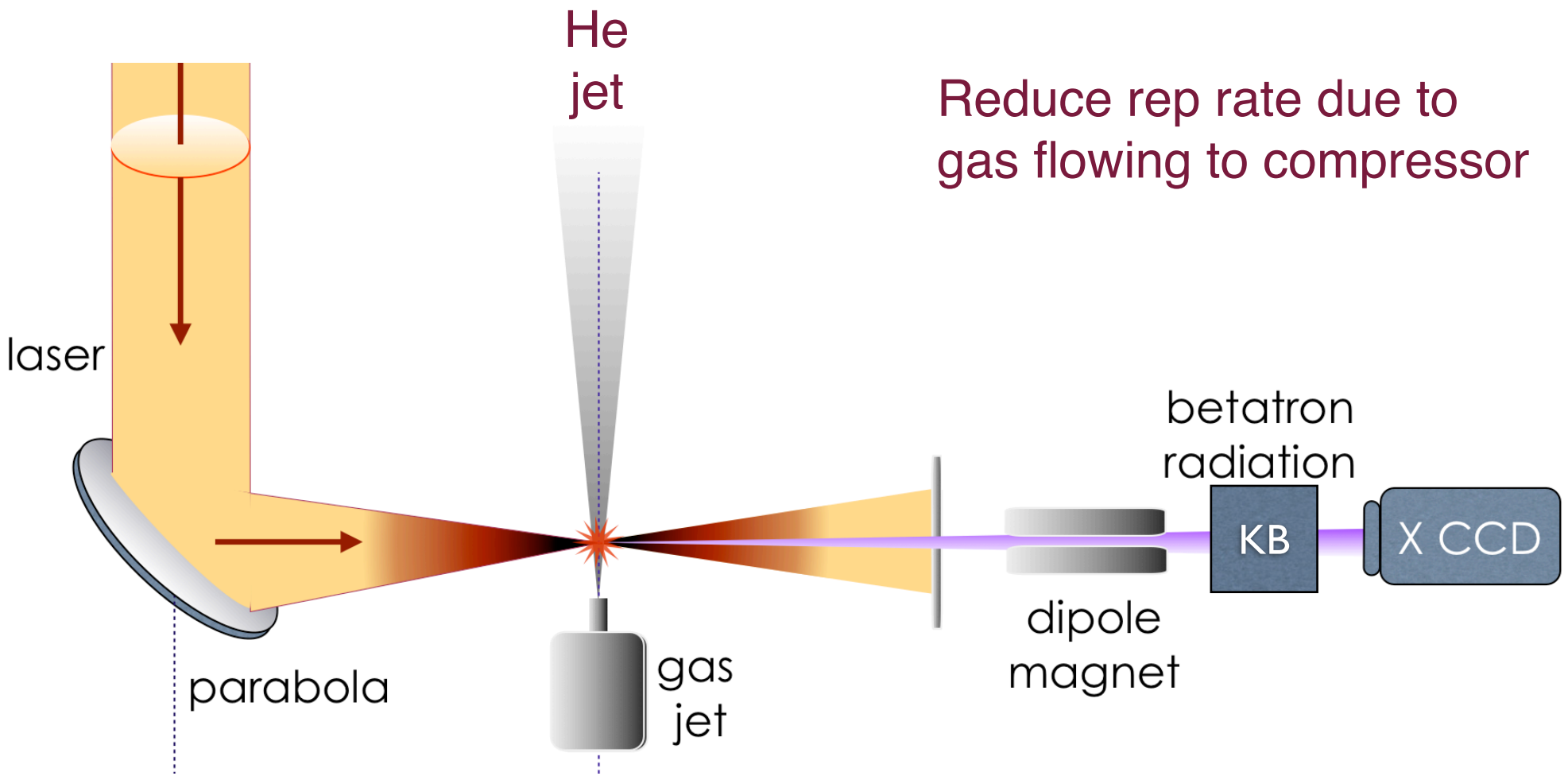
Acceleration in cm-scale
with table-top lasers
Ultrashort bunch (few fs)
Up to GeV energies

Electron energy spectrum





Betatron radiation imaging system



Reduce rep rate due to gas flowing to compressor

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Things feasible with a PW-class laser, 30J/30fs

TNSA proton acceleration at 10 MeV
LWFA electron acceleration at 1 GeV

well known in many labs,
including Salamanca

What needs a laser accelerator to be competitive in front of conventional accelerators?

High repetition lasers (log scale)

10 TW	100 TW	1 PW	10 PW	
100 shots/sec	10 shots/sec	1 shot/sec	0.1 shot/sec	Now
1000 shots/sec	100 shots/sec	10 shots/sec	1 shot/sec	Near
?	1000 shots/sec	100 shots/sec	10 shots/sec	Far

1 PW
1 shot/sec

BELLA Berkeley, California
DRACO Dresden, Germany
VEGA Salamanca,Spain

High Power Laser Science and Engineering, (2015), Vol. 3, e3, 14 pages.

doi:10.1017/hpl.2014.52

Petawatt class lasers worldwide

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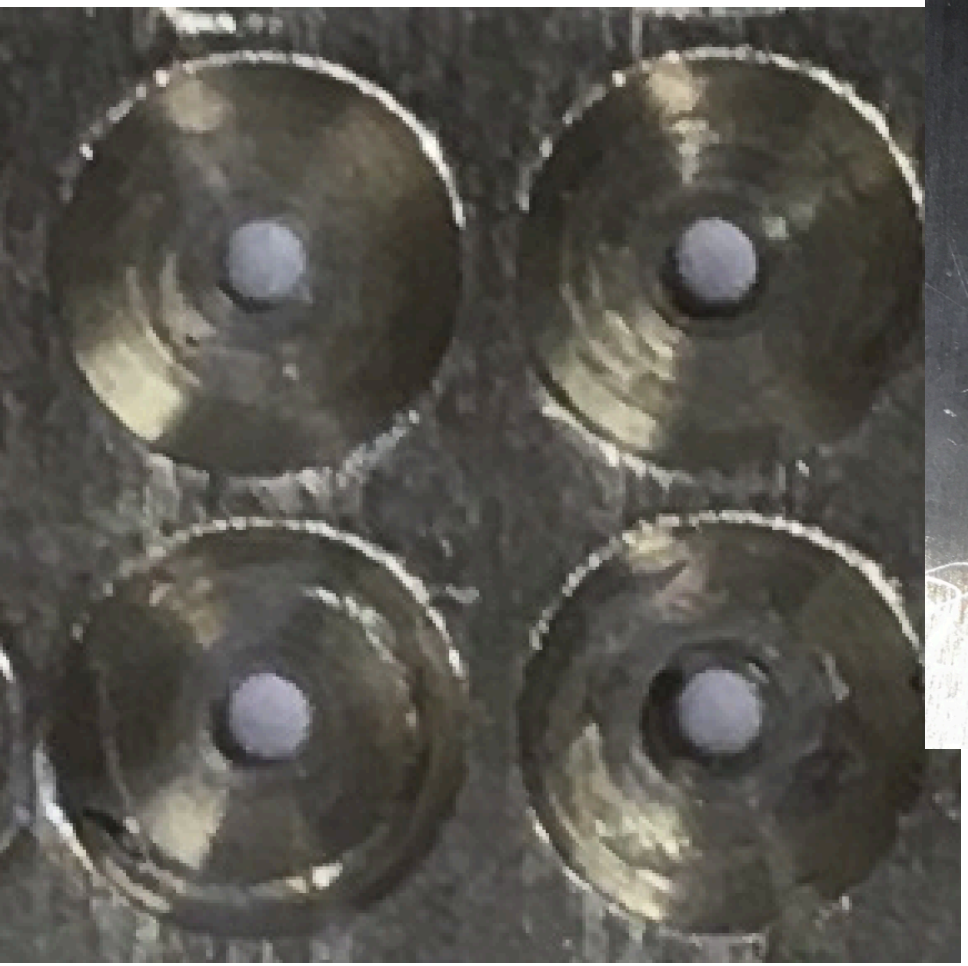
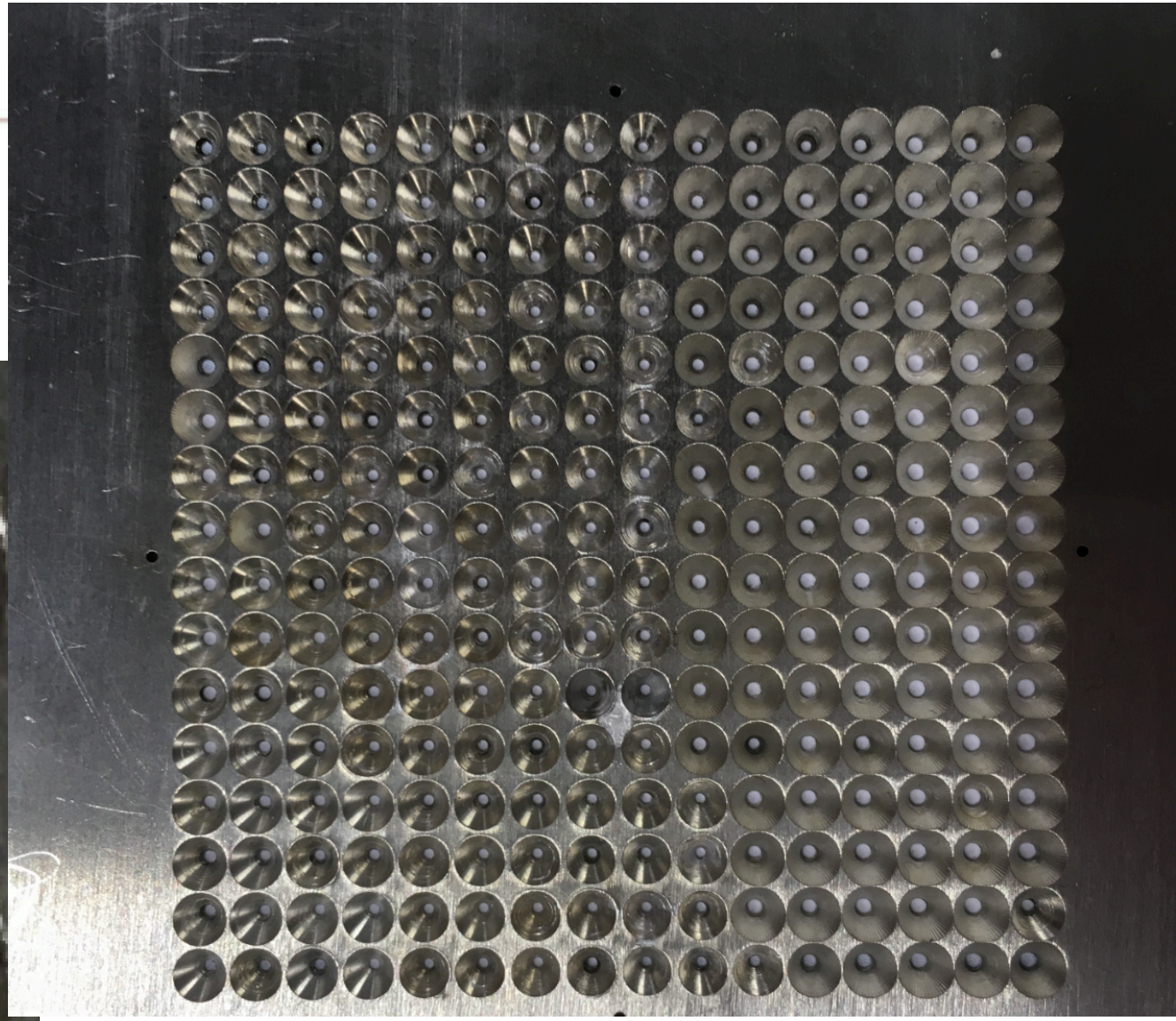
(Received 12 September 2014; revised 26 November 2014; accepted 5 December 2014)

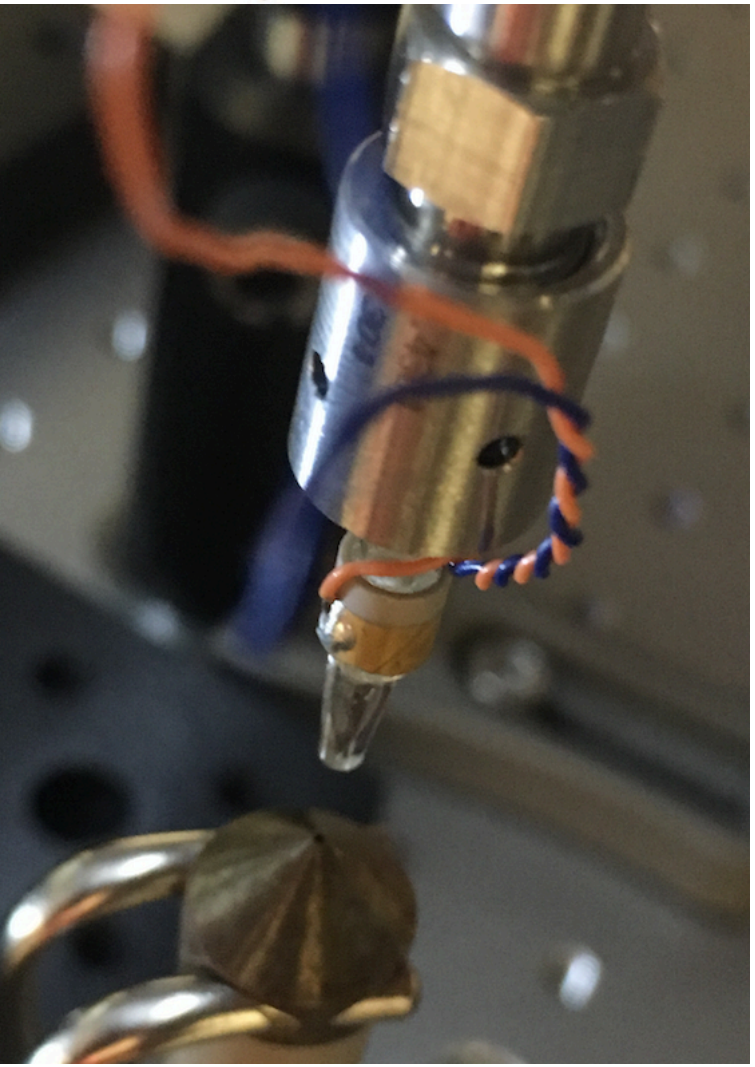
High repetition targetry is a major problem

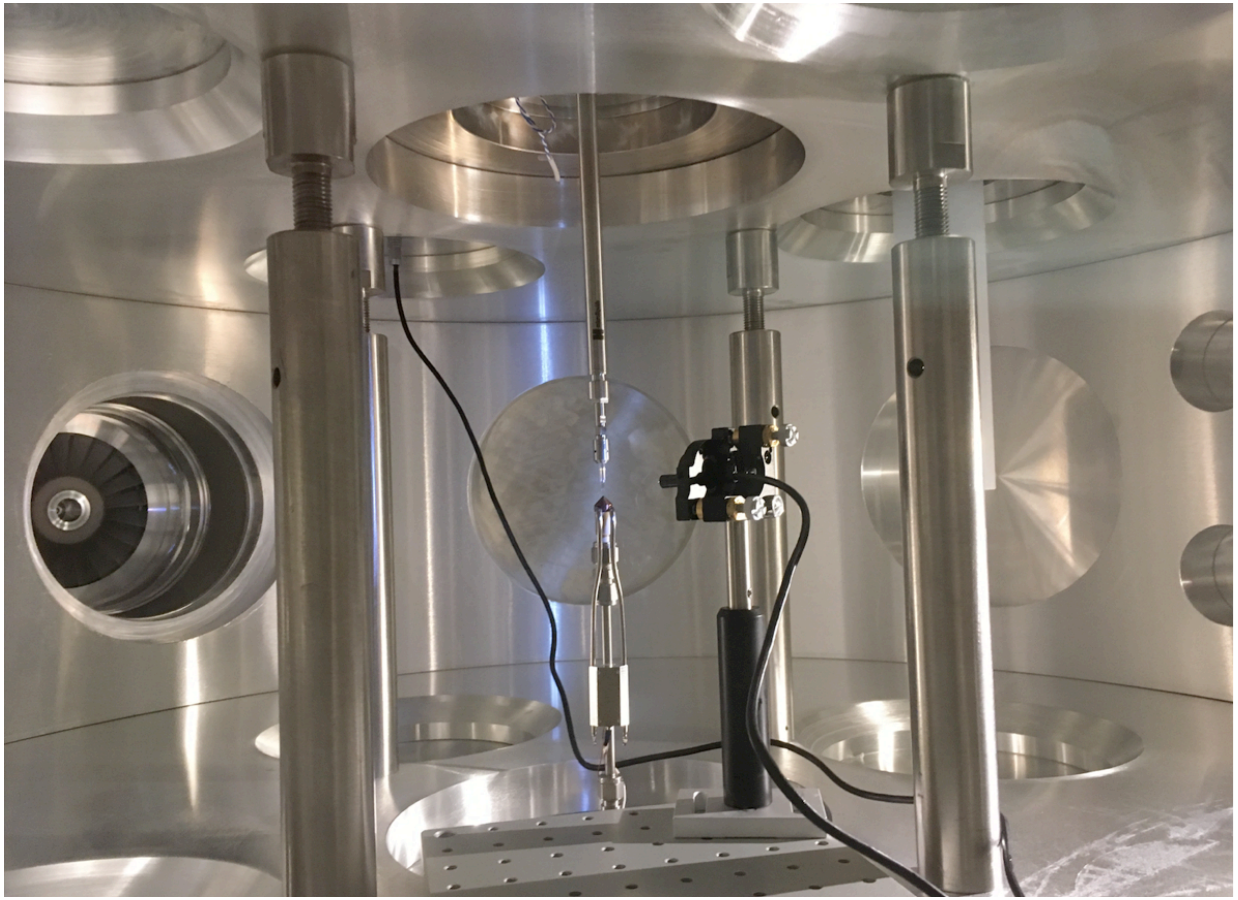
Target arrays

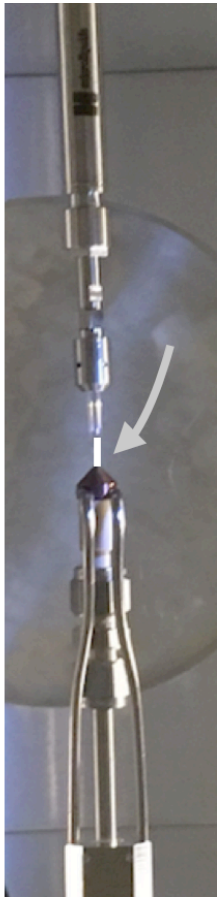




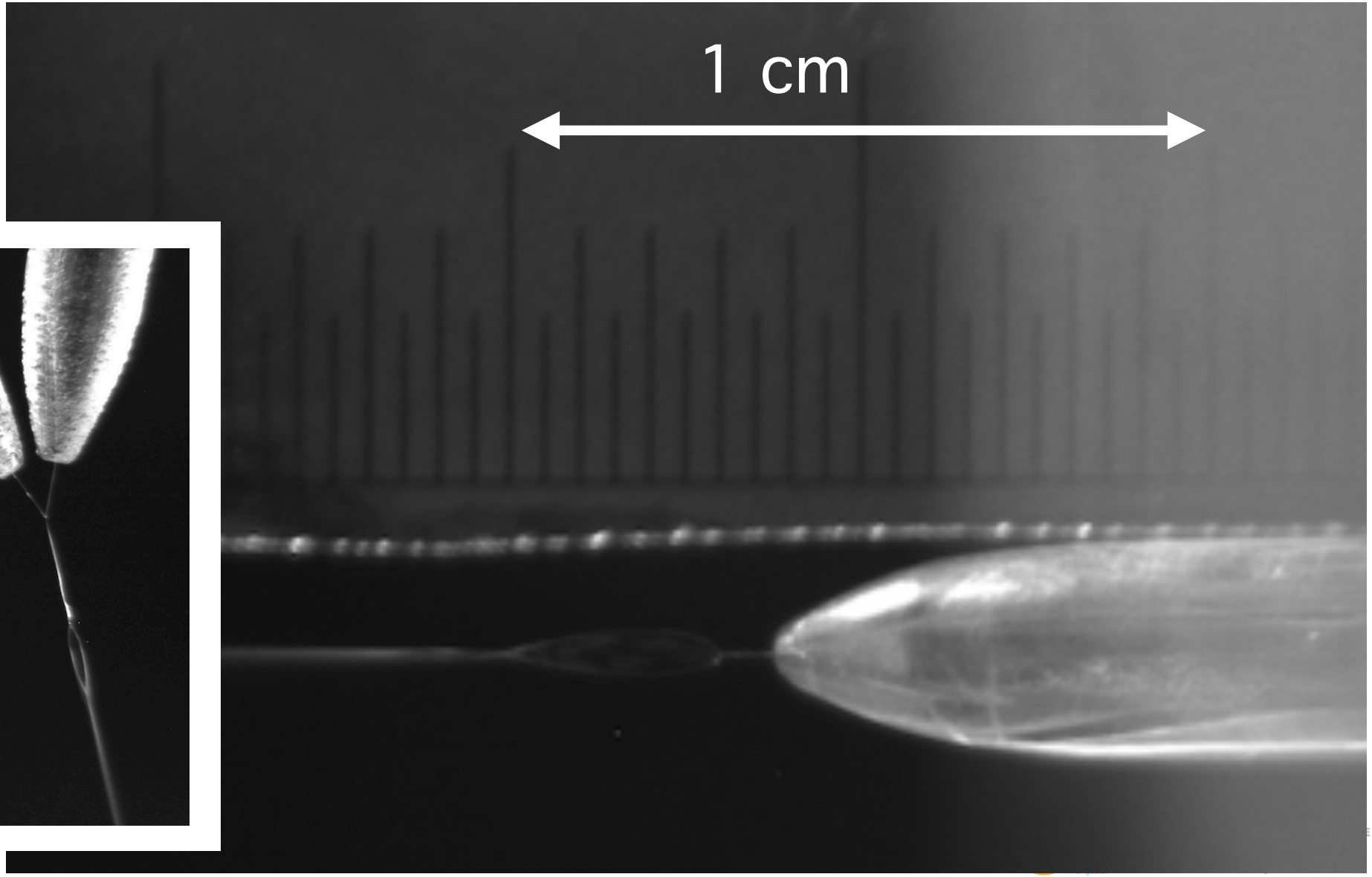
Liquid Targets: liquid microjet

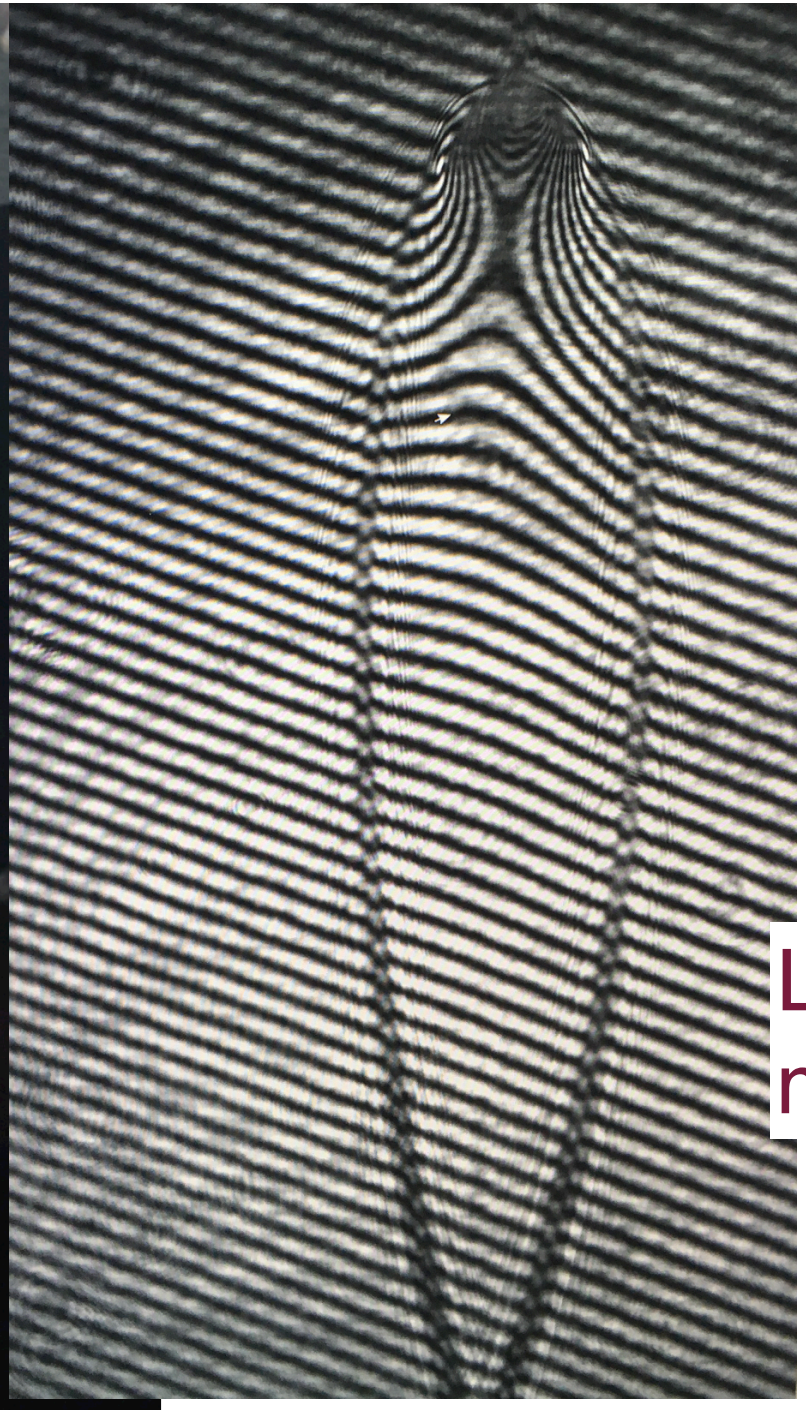


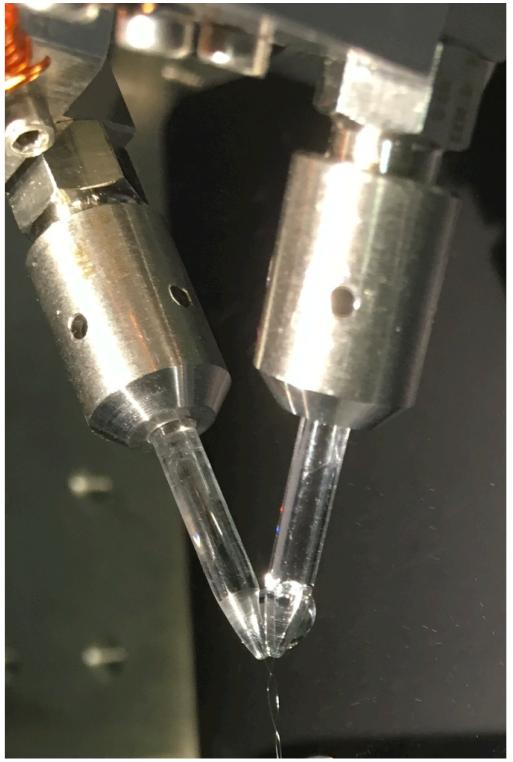




Liquid microcourtain



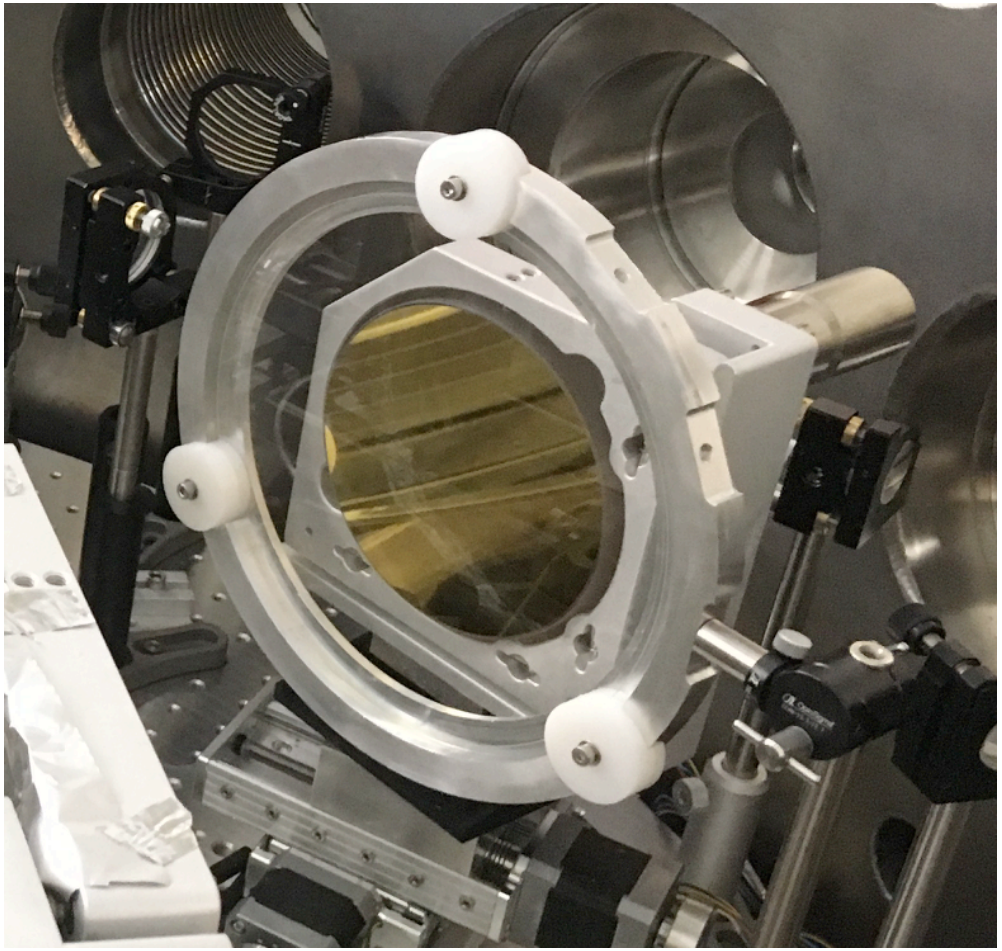


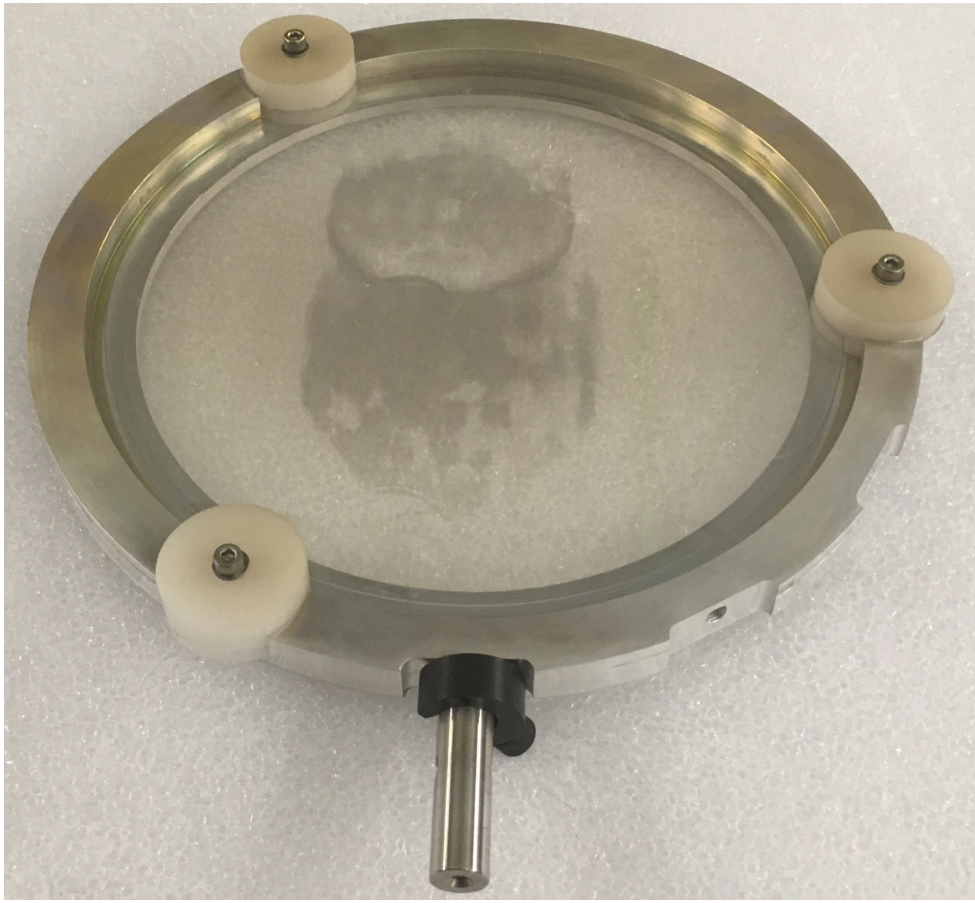


Liquid microcourtain

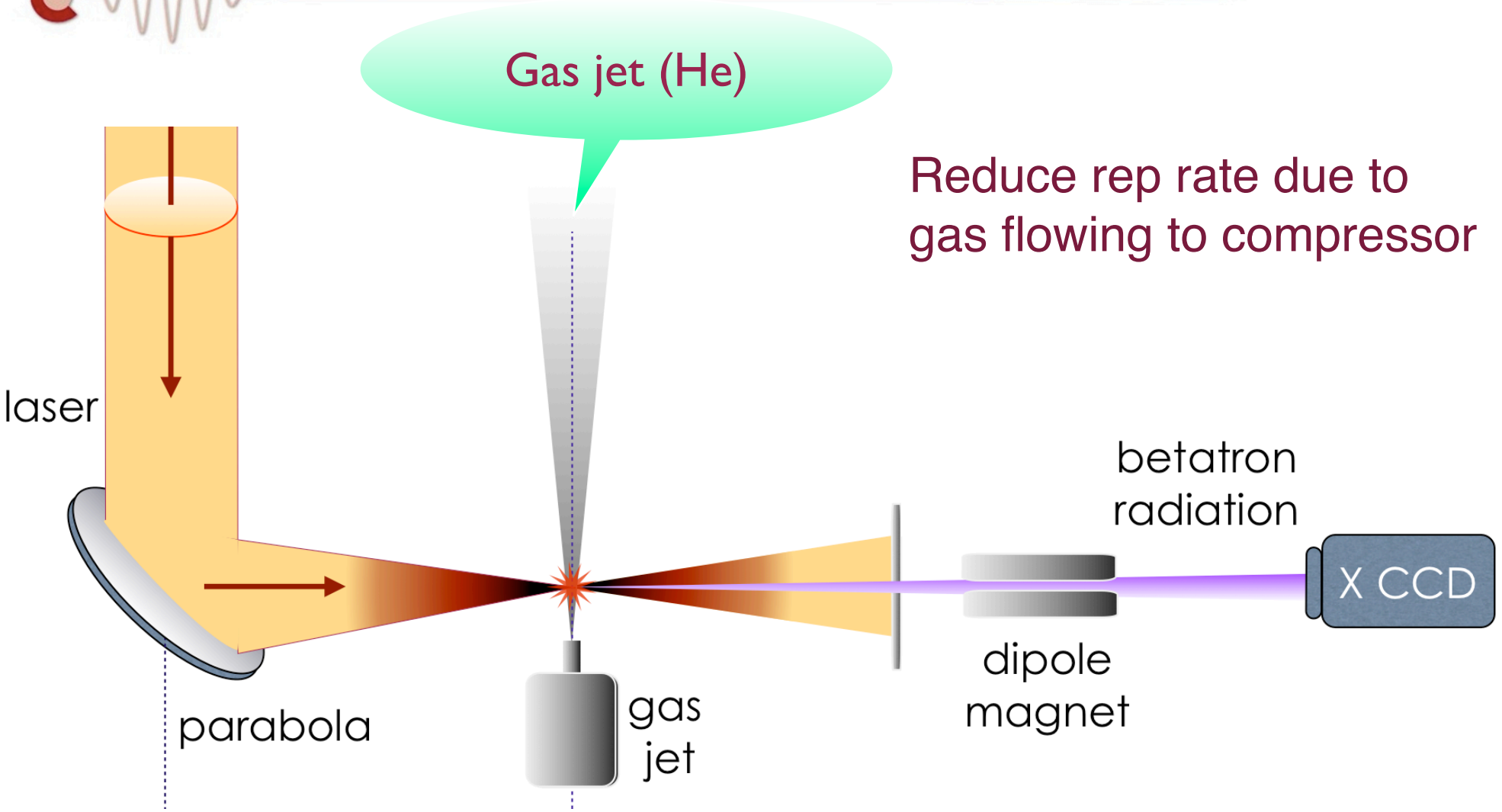
Target debris is a major problem

- Prepare continuous targets ready for 1 Hz
- Avoid debris from the targets





Betatron radiation imaging system



Reduce rep rate due to gas flowing to compressor

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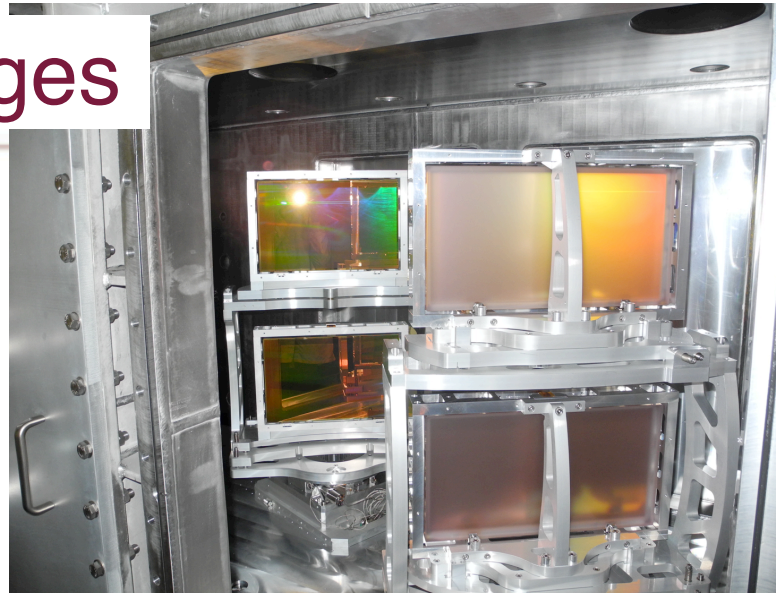
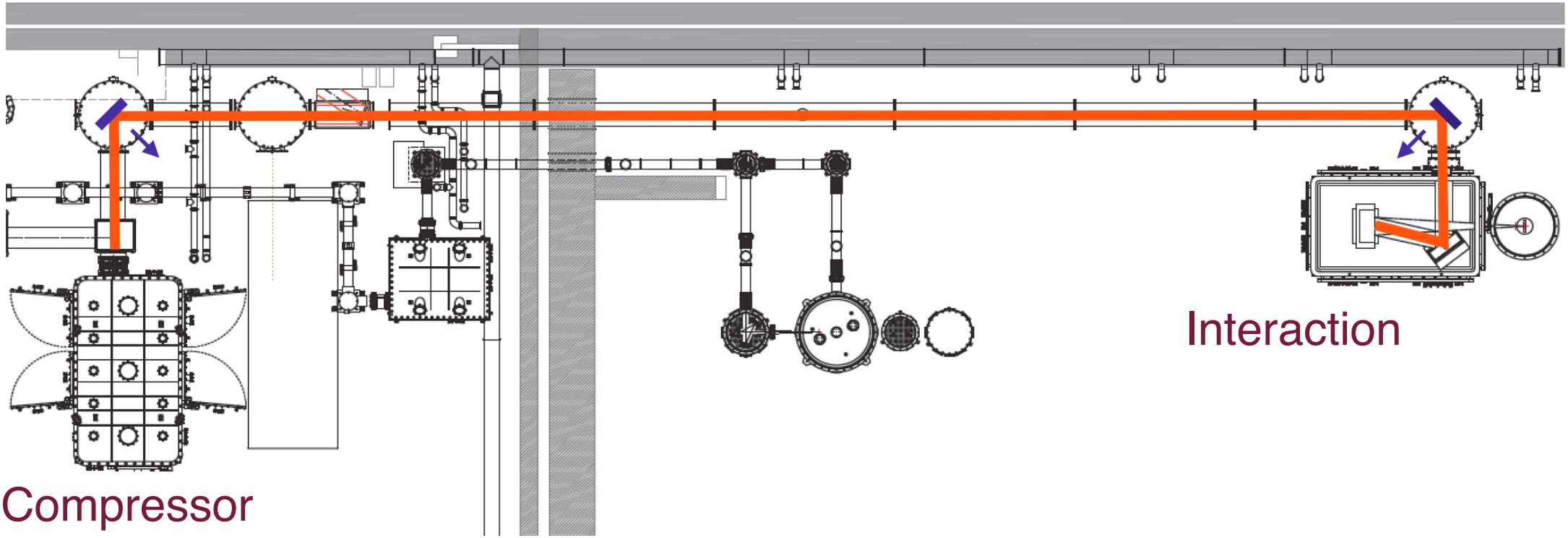
High repetition rate challenges

Gratings degradation due to gas flowing to compressor

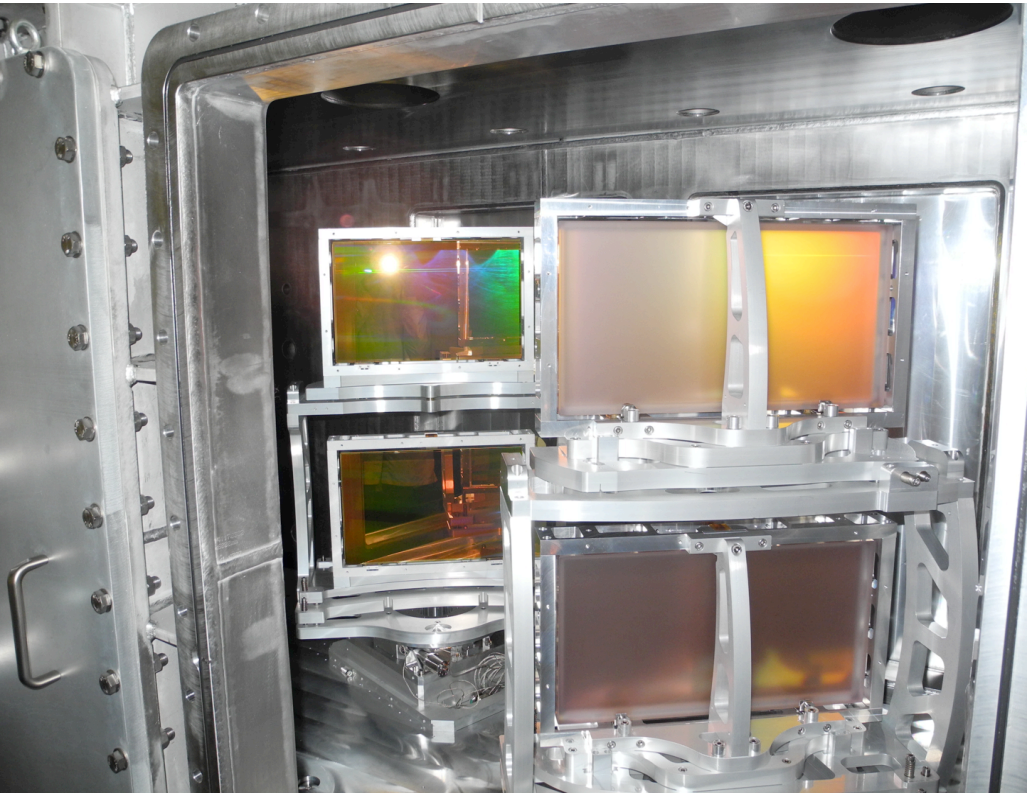
Compressor vacuum 10^{-6} mb





PW compressor

Gratings



Spanish ICTS

Unique Equipment, in our case the Petawatt High Rep Rate laser

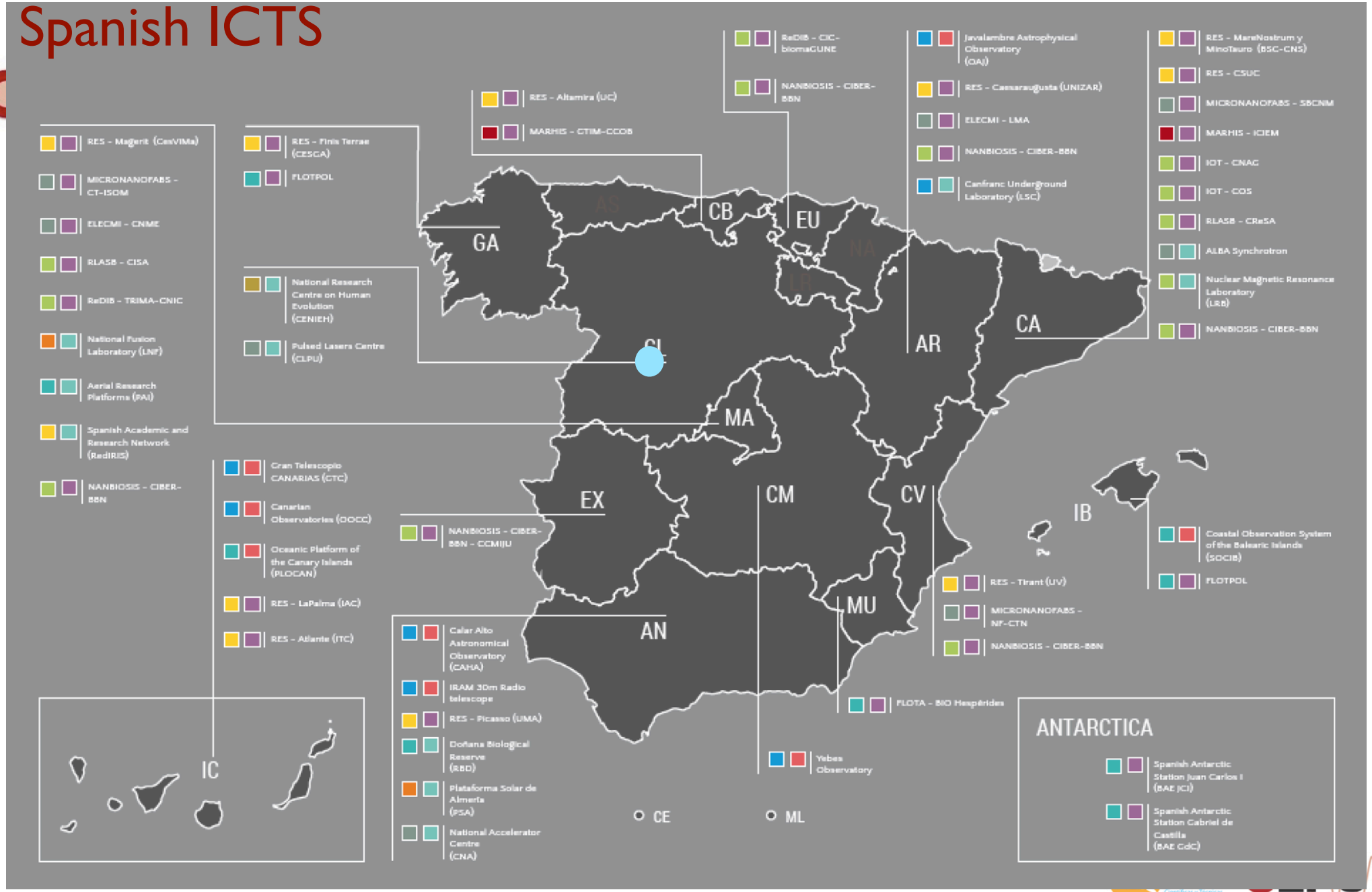
MAP OF UNIQUE SCIENTIFIC AND TECHNICAL INFRASTRUCTURES (ICTS)

GOBIERNO DE ESPAÑA

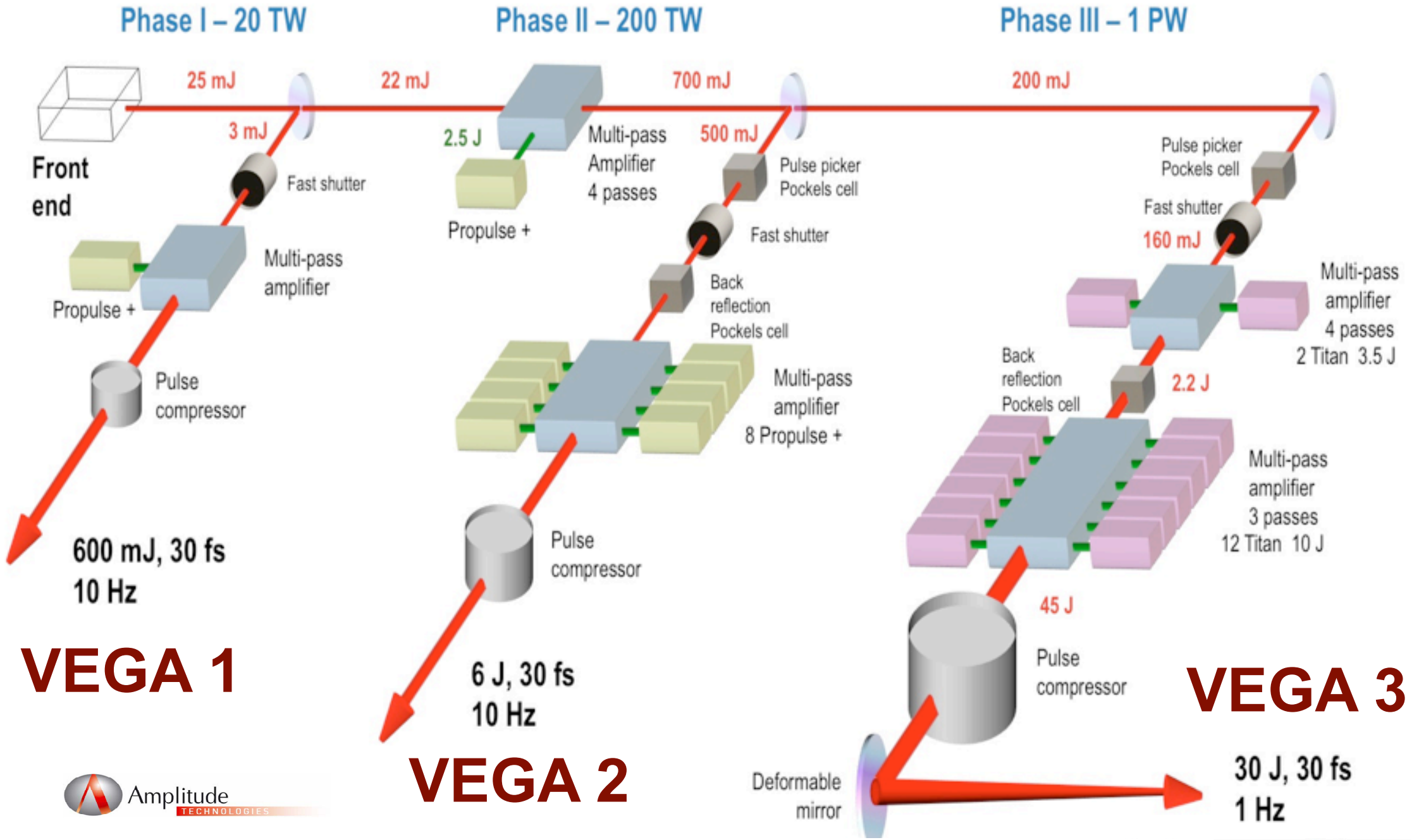
MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES

Infraestructuras Científicas y Técnicas Singulares

Spanish ICTS




VEGA laser



Amplitude TECHNOLOGIES

VEGA System

	Energy / shot	Pulse duration	Central wavelength	Peak power	Rep Rate
VEGA-1	600 mJ	30 fs	800 nm	20 TW	**10 Hz**
VEGA-2	6 J	30 fs	800 nm	200 TW	**10 Hz**
VEGA-3	30 J	30 fs	800 nm	1 PW	**1 Hz**

VEGA system is open to domestic and international users through competitive access

Amplitude TECHNOLOGIES

Infraestructuras Científicas y Técnicas Singulares

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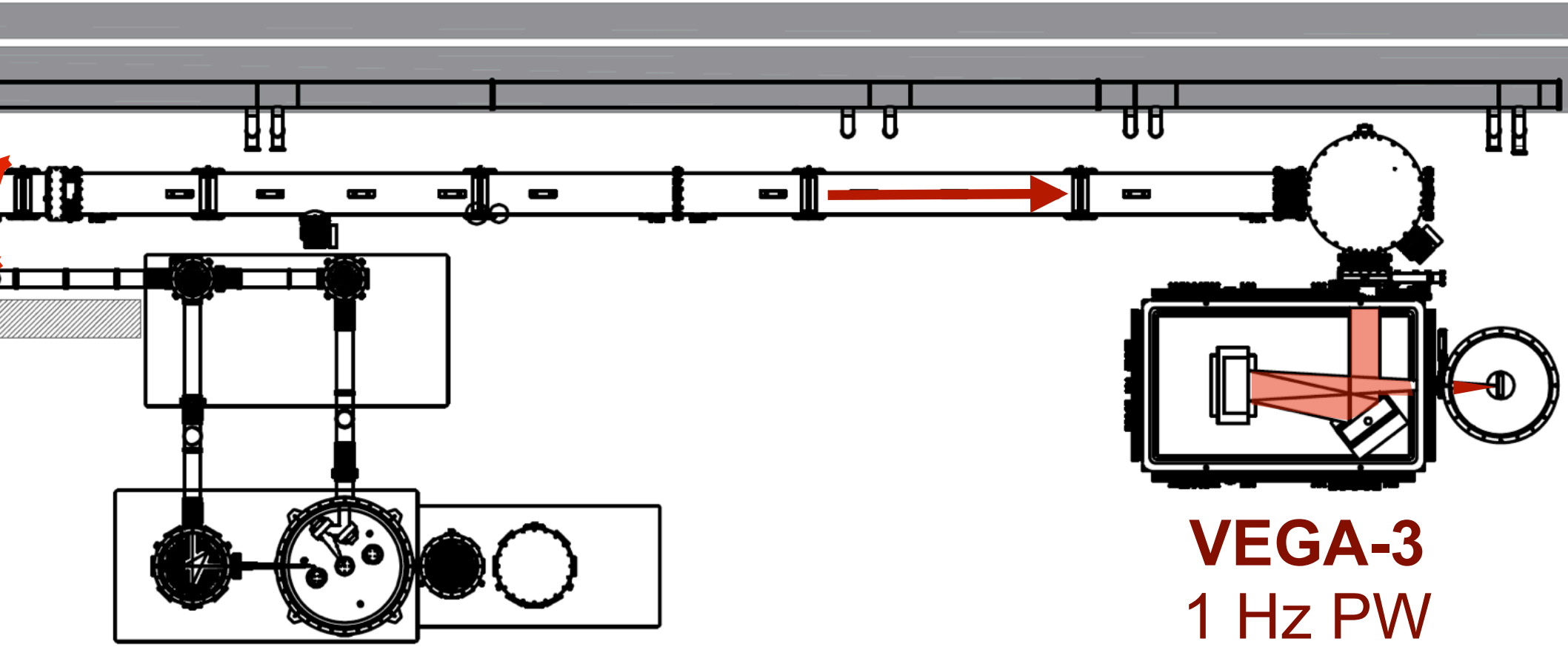
6,3t
CLPU

VEGA-3 beam transport



VEGA-2
10 Hz
6J/30fs
800 nm

Same seed

VEGA-3
1 Hz PW
30J/30fs
800 nm

Conclusions

- Laser technology is quite advanced to get
  1 Hz reliable sources at 100 TW, PW and soon multi-PW

- Difficulty to get targets at 1Hz

- Lasers vs conventional accelerators ...
... main problem is repetition rate of the bunch of accelerated particles

- Deliver a bunch of particles, that can be interesting for channeling

- At Salamanca we have a PW laser at 1 Hz and a 200 TW at 10Hz
open for competitive access and we are looking for users/collaborators !!!

Team

Giancarlo Gatti
Luca Volpe

Cruz Mendez

Jose Antonio Perez

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Mauricio Rico
Carlos Salgado
Ghassan Zeraouli
Sophia Malko
Marine Huault
Massimo de Marco
Diego de Luis

Enrique García
Oscar Varela
Irene Hernandez
Jose David Pisonero
Javier García
Jose Luis Sagredo

UNIVERSITY OF ALBERTA

Robert Fedosejevs
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UNIVERSITY OF MARYLAND

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Calvin He

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