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Extreme Light Infrastructure - Nuclear Physics (ELI-NP) – Phase II

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Back reflection monitoring developments for 10 PW experiments

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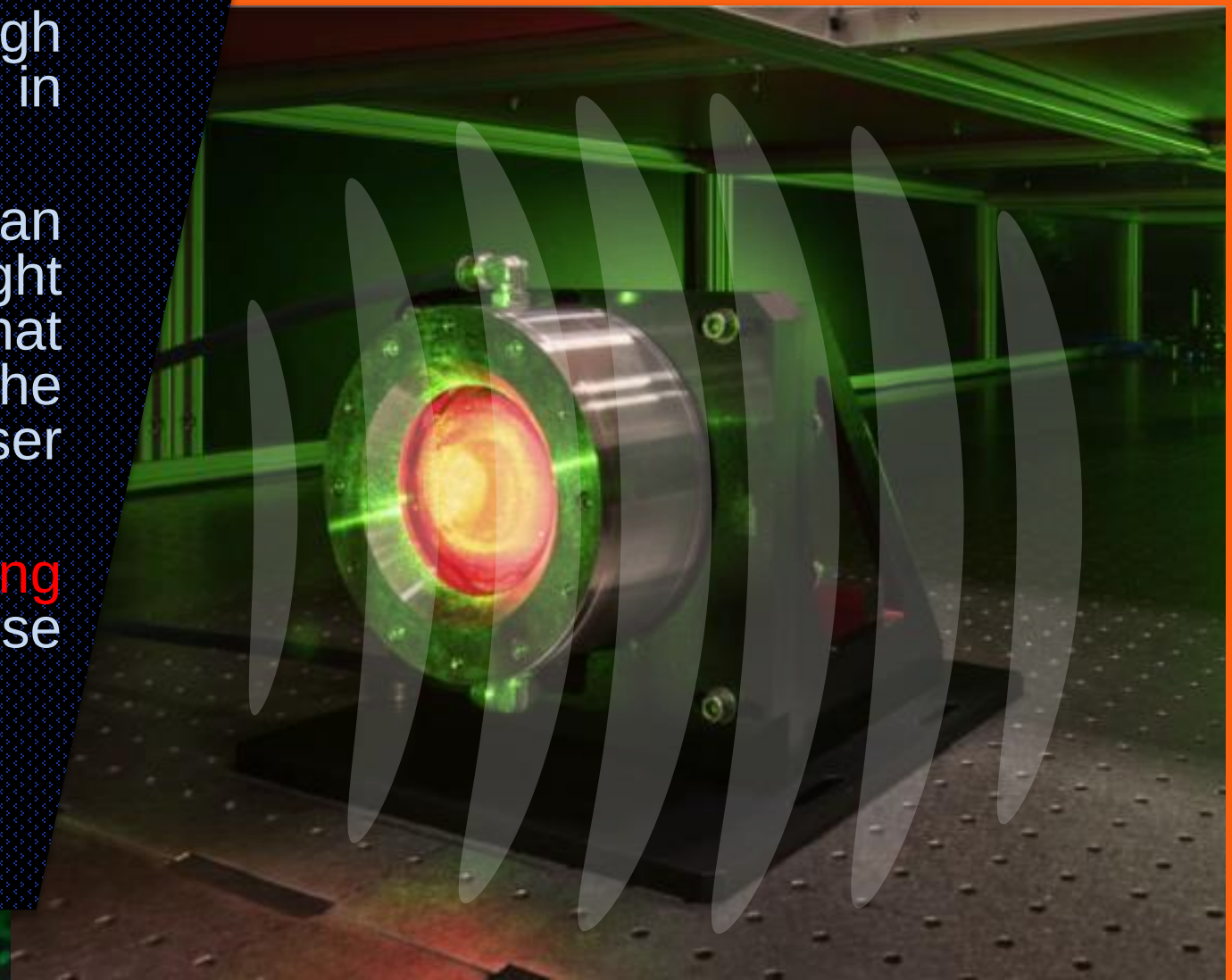
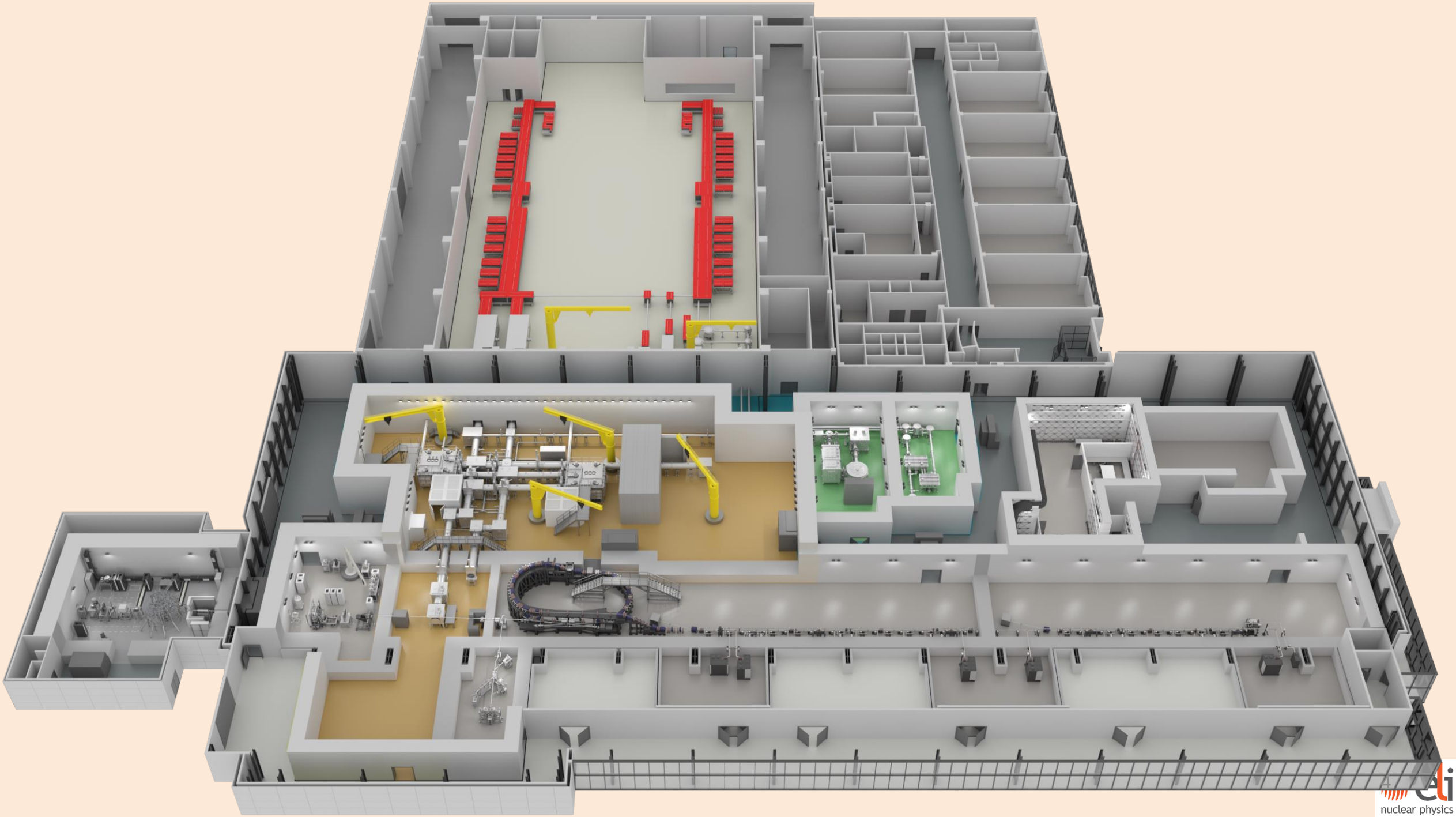
Content

Introduction

- The current experimental plan involves the usage of the High Power Laser System (HPLS) in experimental areas E1 and E6.
- Irradiating a target with 10 PW can create back-scattered, coherent light (e.g. 1% BR means 100TW) that travels upstream from the experimental area to the laser system.
- Several safeguards and monitoring systems were installed to diagnose the BR and protect the HPLS.

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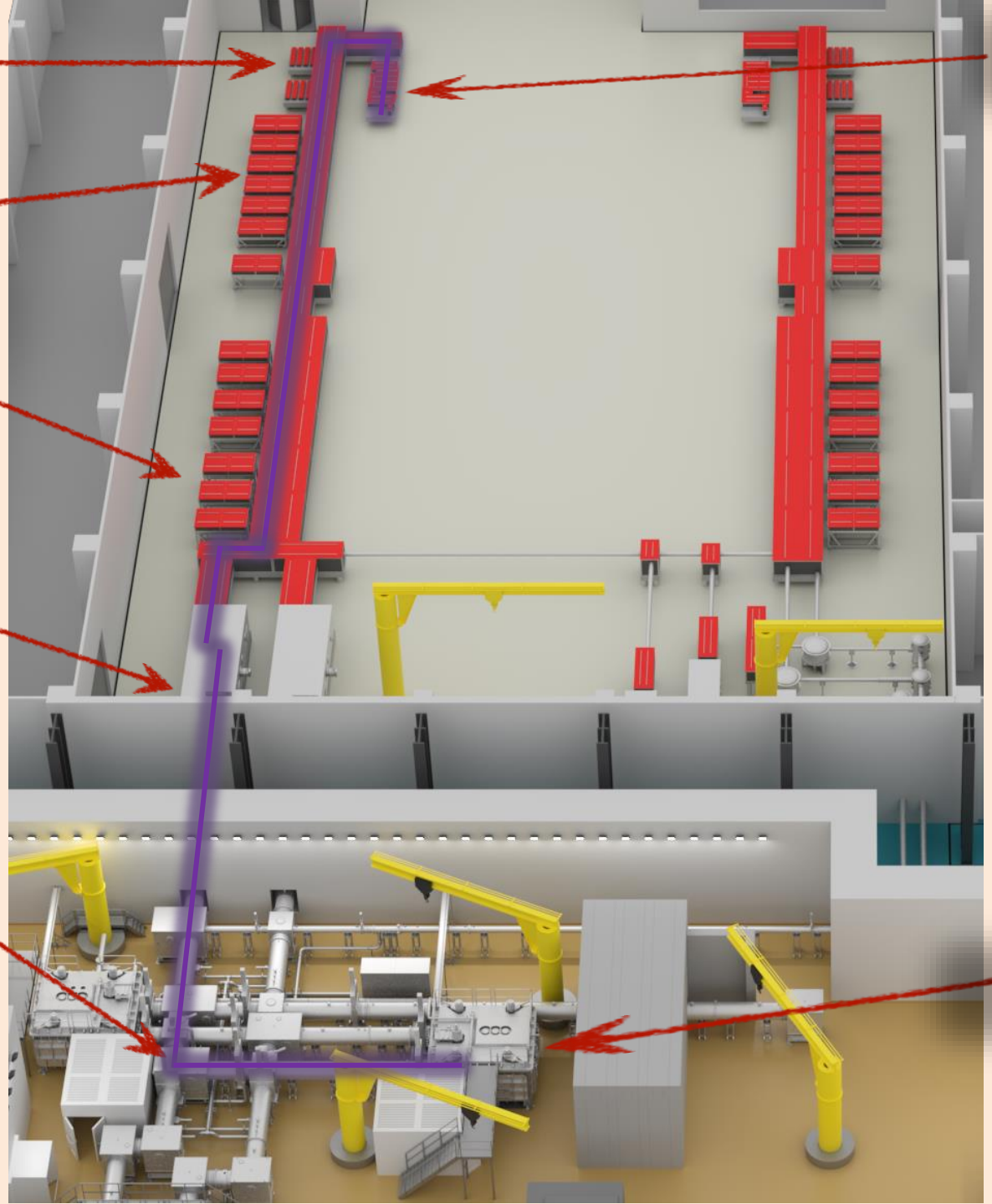
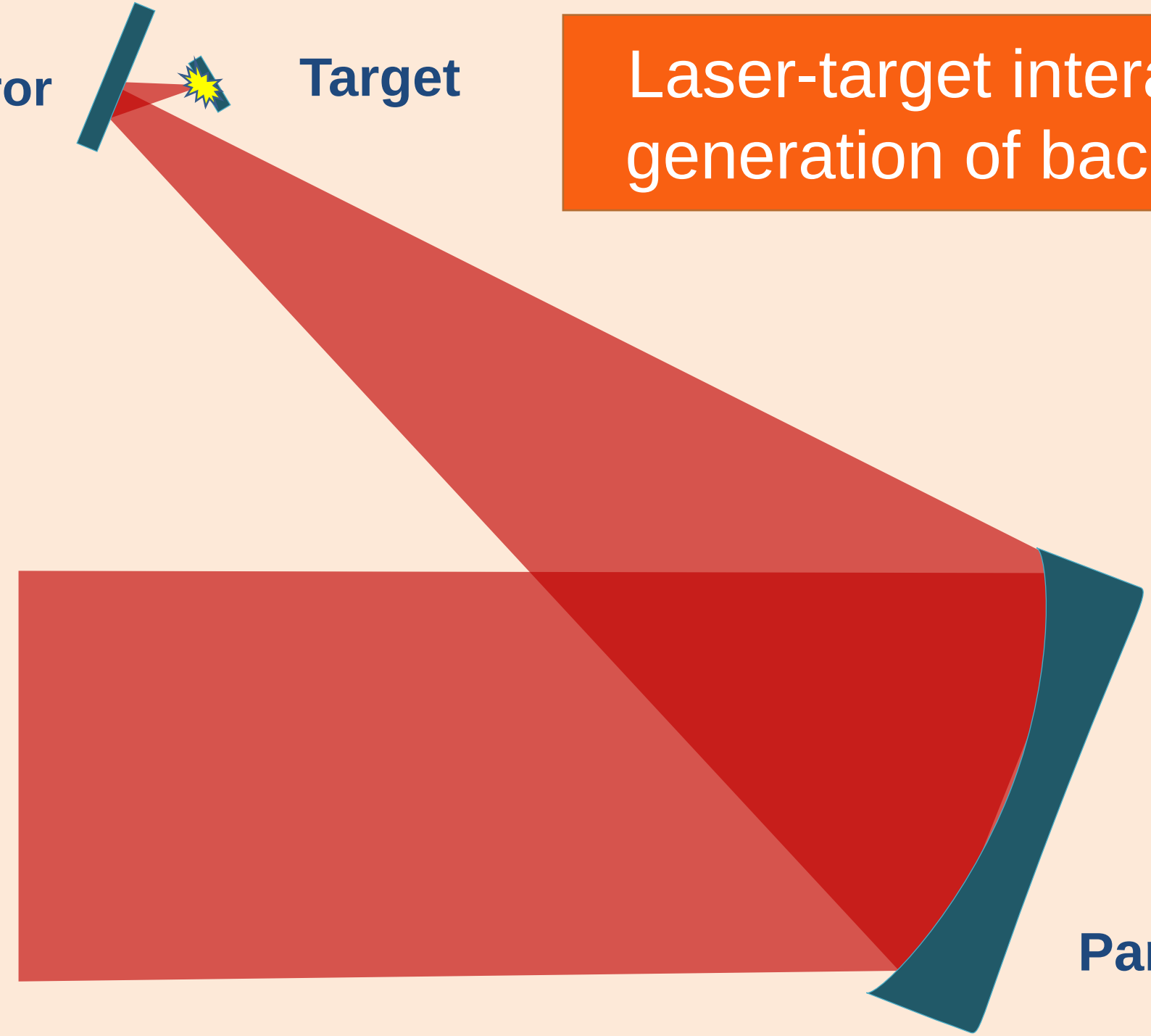

Amplifier 1
Amplifier 2
Amplifier 3
Compressor
Turning Box FMR3
Front End
Experimental Area E1

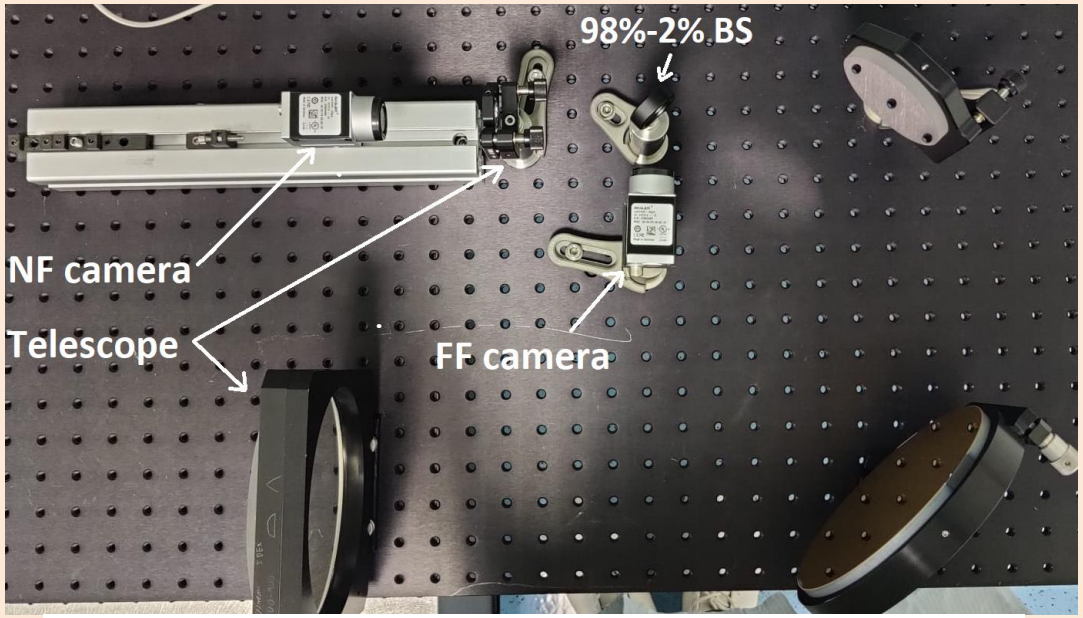
Laser-target interaction and generation of backreflection



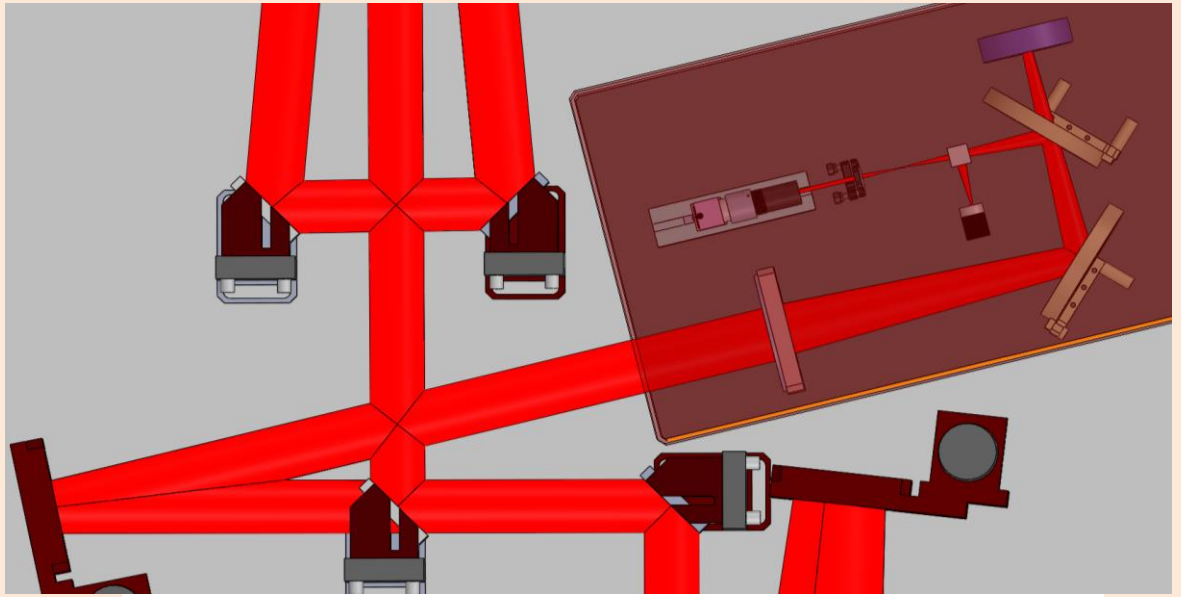
Installed Systems

Full Aperture Image Relay System for laser beam diagnostic (FAIRS)

- Installed in HPLS between AMP. 3.1 and 3.2 to capture back-reflected beam at 10 PW.
- Compressor spectrally filters BR; for additional safety measures, we installed FAIRS.
- Image relay system designed with an ray transfer matrix analysis software designed in SageMath at ELI-NP.

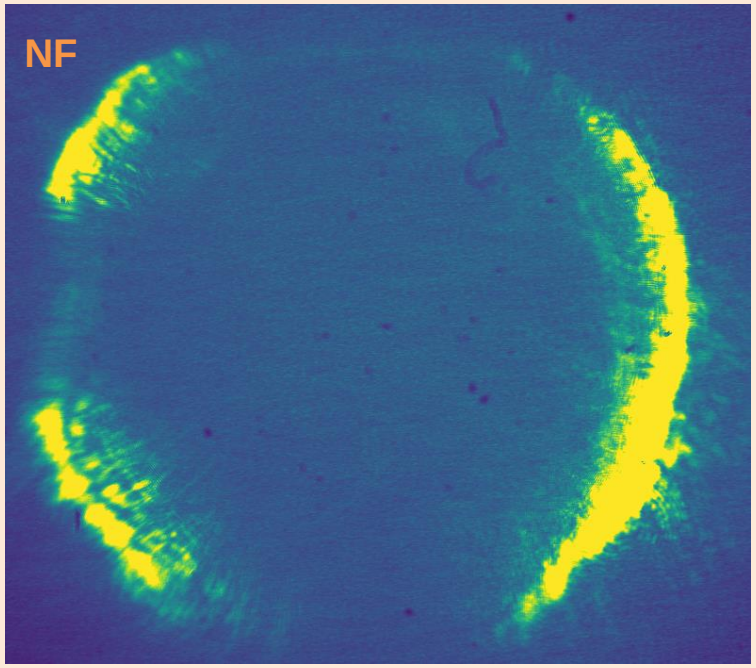


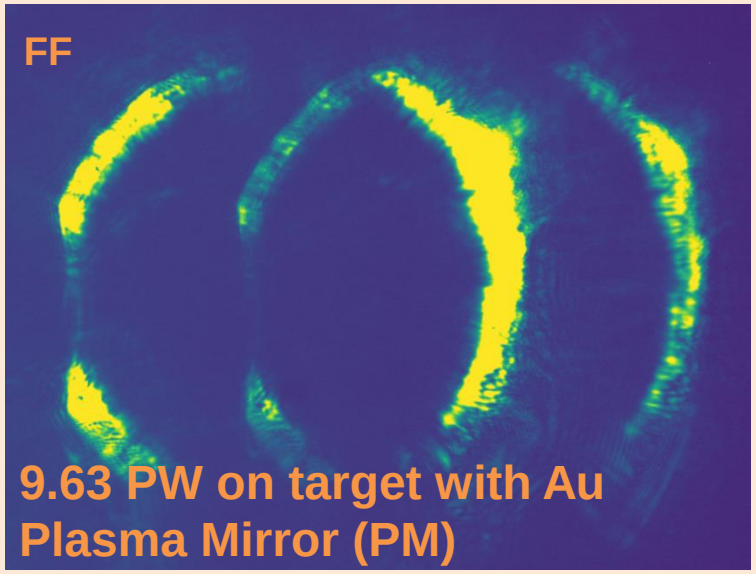
Top view of optical setup


Solidworks assembly of optical setup

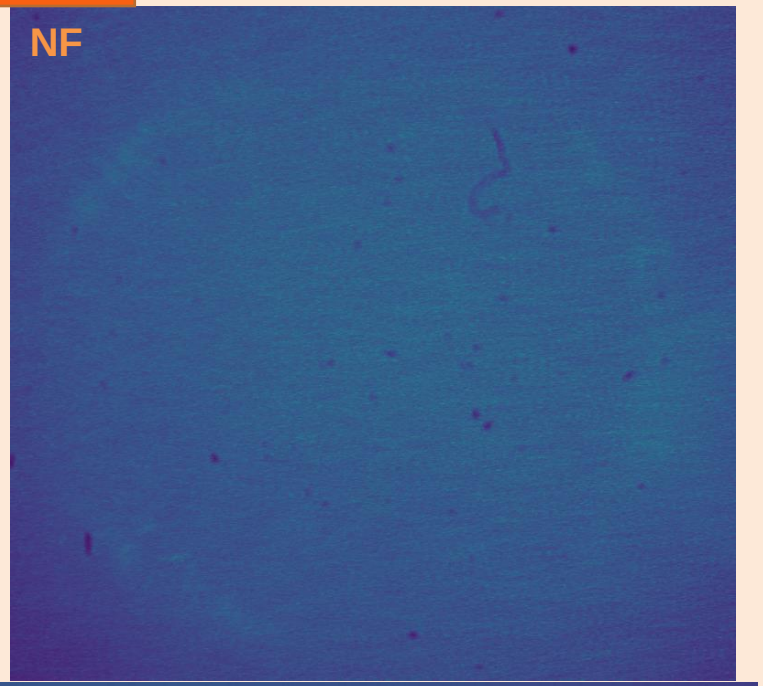
- Setup: CCD, 3.45 µm pixel size, Lens f=835 mm.
- Can detect angle deviation in FF up to +\-2.15 µrad.
- NF beam profile captured at 2448x2048 px and can image from 1 to 130 m.

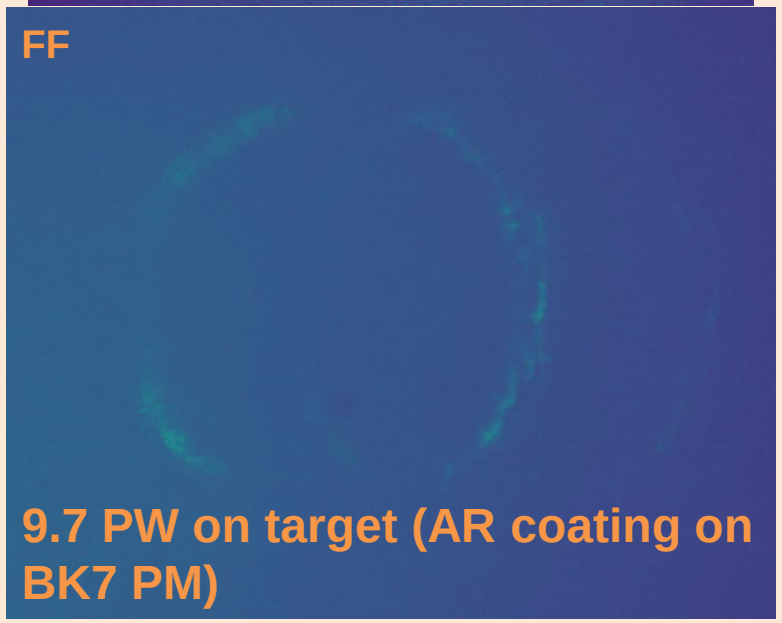
Images of BR



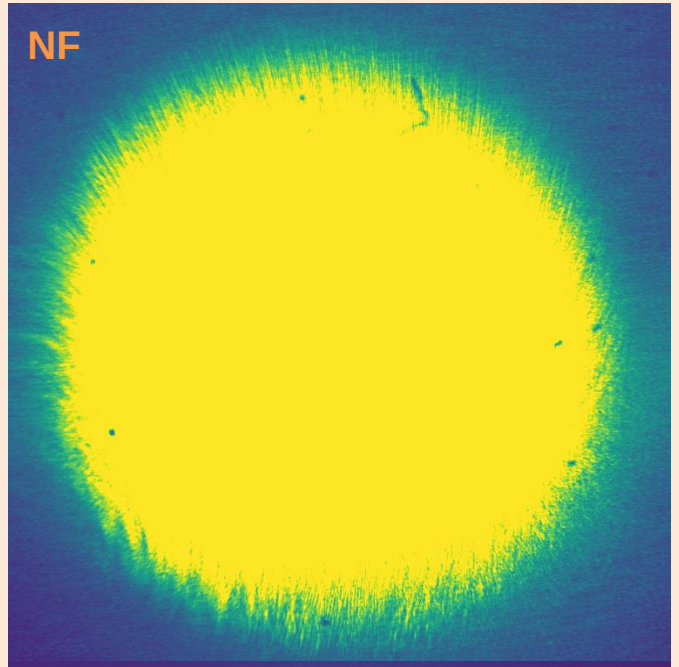


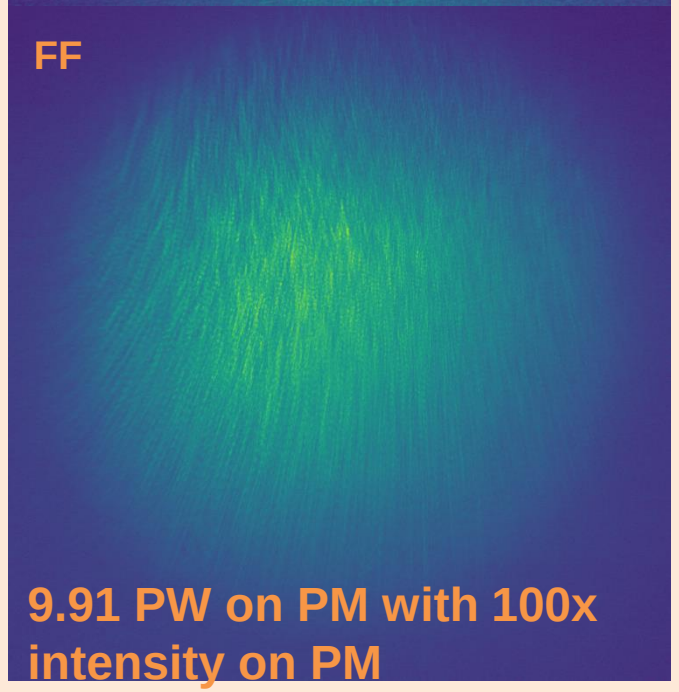
9.63 PW on target with Au Plasma Mirror (PM)





9.7 PW on target (AR coating on BK7 PM)

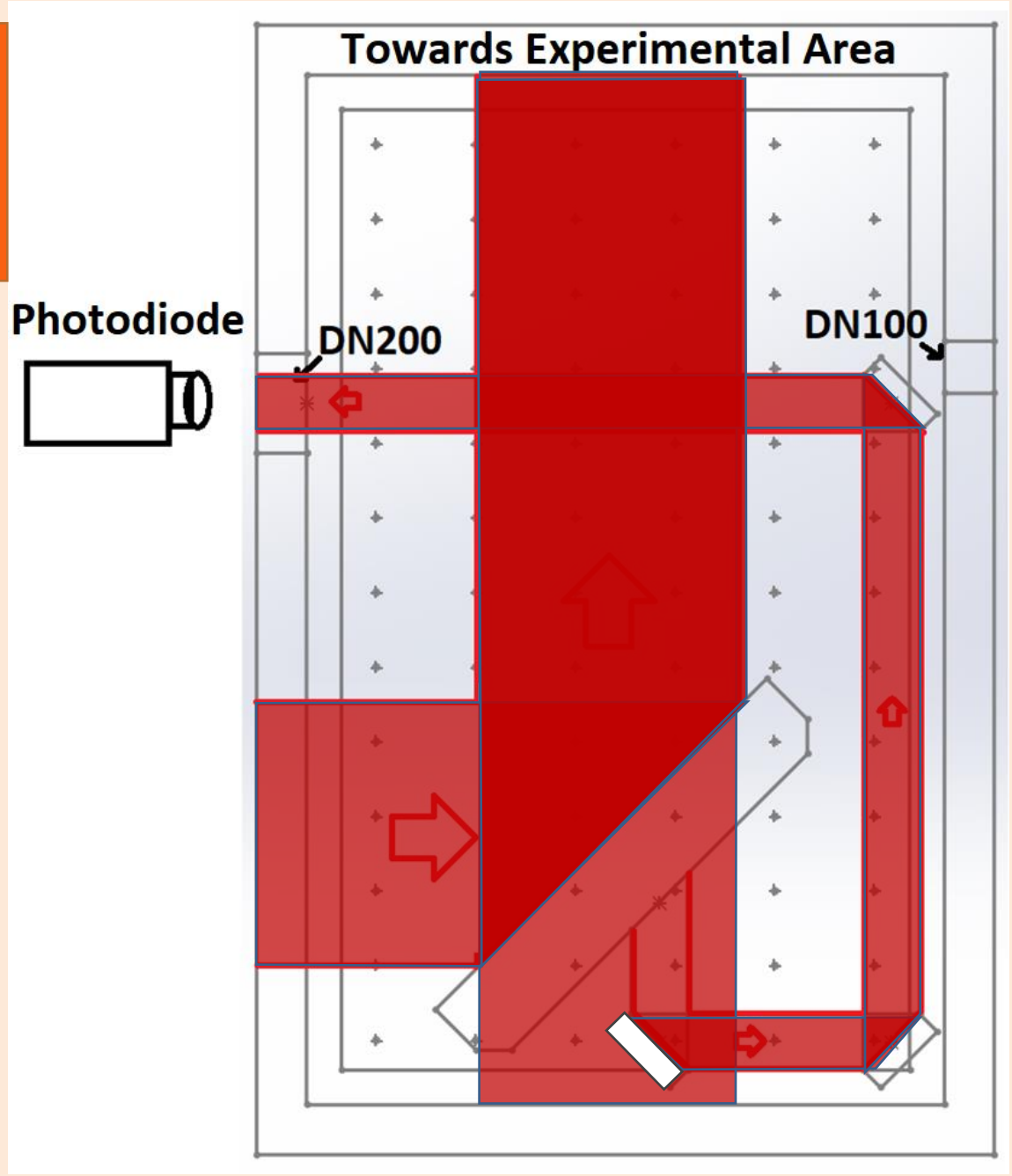




9.91 PW on PM with 100x intensity on PM

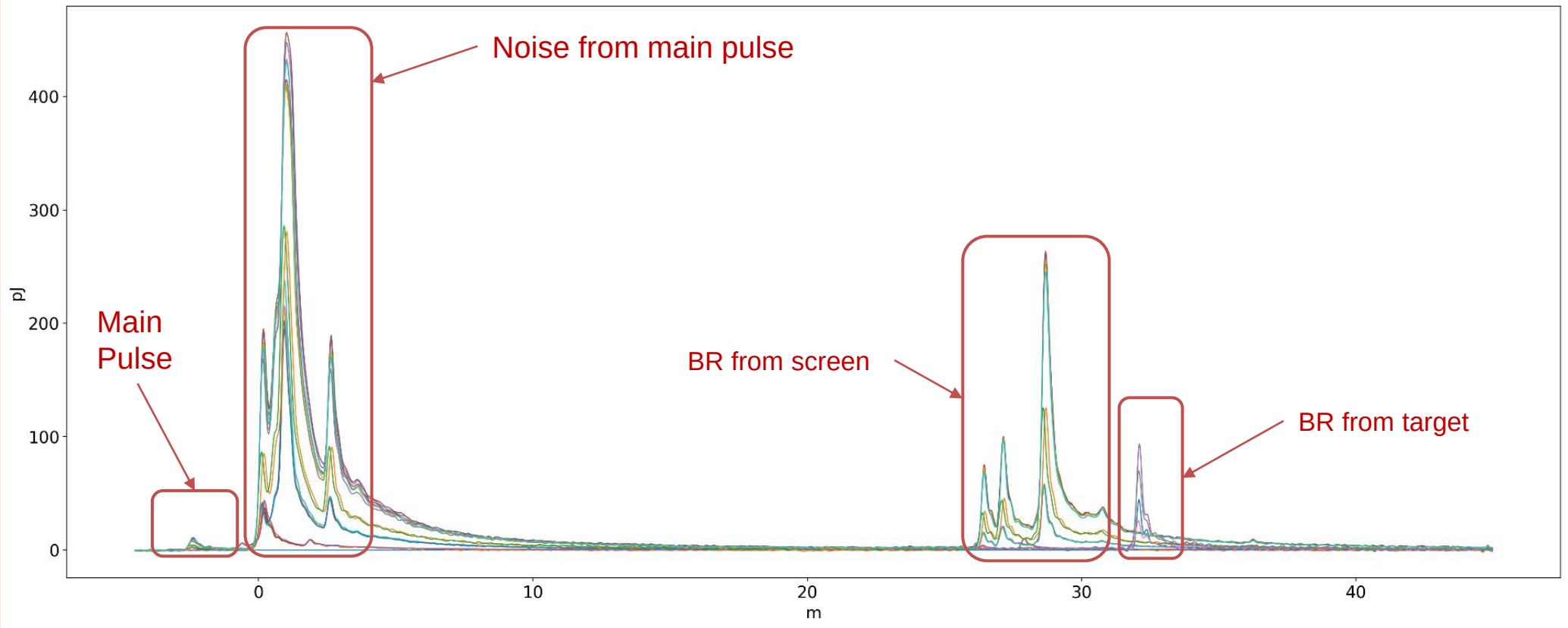
Small Aperture backreflection Monitoring System installation (SAMS)

- Installed in FMR3 to monitor BR directly from target in E1.
- 6” aperture from 22” full beam centered on beam axis.
- Three high-reflectivity (99.4%) mirrors aligned to extract the beam through the DN200 viewport.
- Fast photodiode collects light with a 2” lens.



Top view schematic of Turning Box

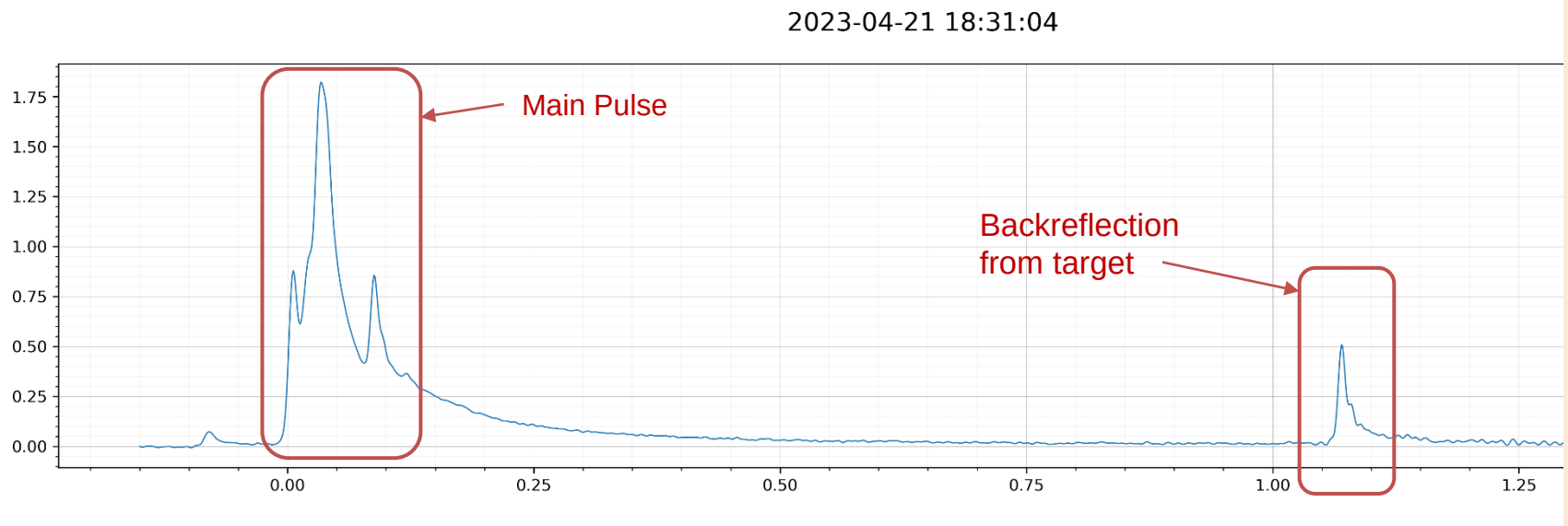
Back-reflection acquired signals



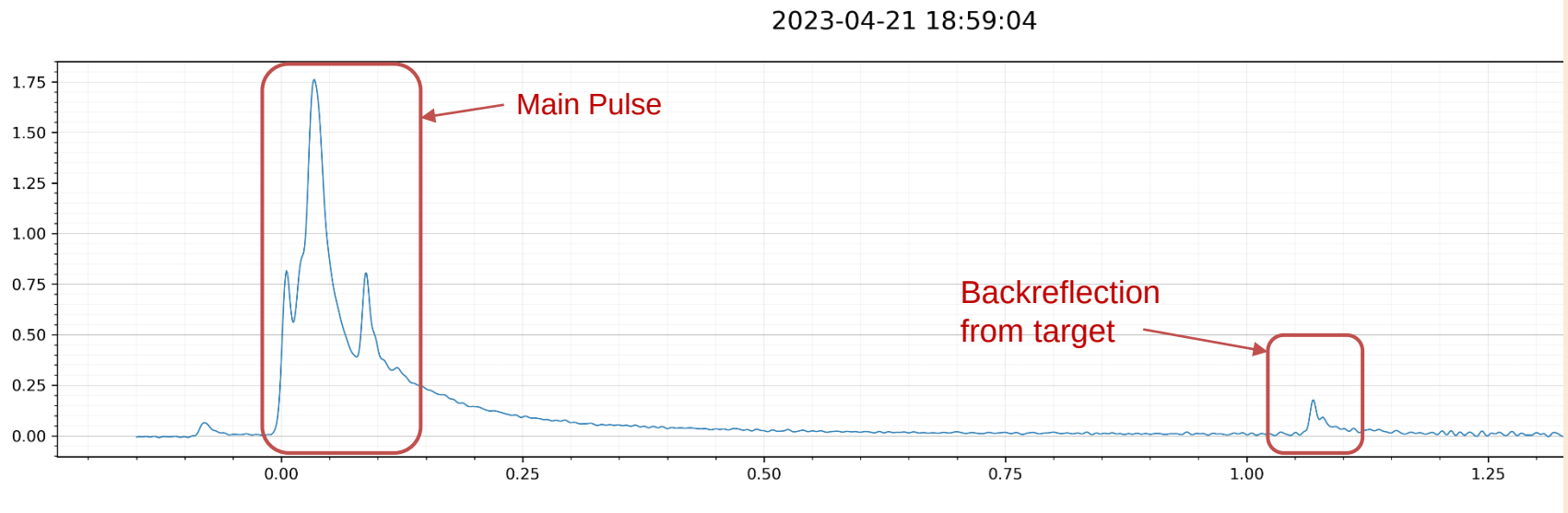
20 shots with ≈ 10 PW shot delivered towards E1

- Noise from main pulse: scattered light from LBTS generated by main pulse
- Tested with two shooting regimes: with Spectralon screen and with target (including PM)
- Shots recorded from 2 PW to 10 PW
- Photodiode calibrated in energy with Avesta laser.

Monitoring against calibrated energymeter in HPLS



9.7 PW shot delivered on target (104 ns between main pulse and backreflection)



9.2 PW shot delivered on target (105 ns between main pulse and backreflection)

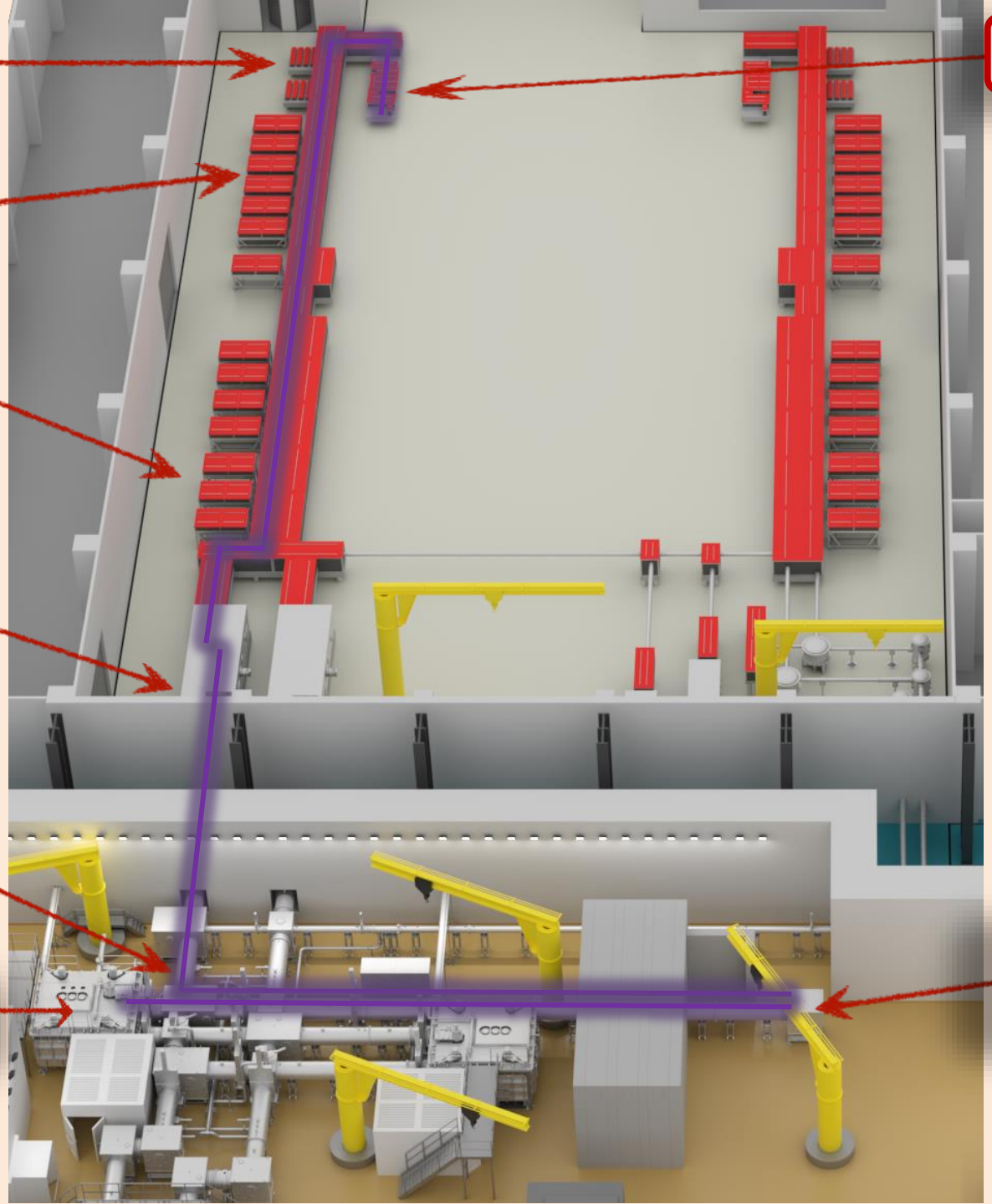
- BR: **296 uJ** against **100 mJ** measured in energymeter placed in AMP. 1.
- BR: **106 uJ** against **20 mJ**
- This shows the amplification of BR inside the HPLS.
- Fluorescence lifetime of TI:Sapphire is 3.2 µs and BR propagation time is 900 ns

In development: BR monitoring in E6

Developing 2 setups:

Off-axis Small Aperture Monitoring System
- To be installed in FMR2 turning box
- Capture small part of mirror leakage

Large Aperture Imaging System
- To be installed in PME6
- Capture large aperture of laser beam behind the LFM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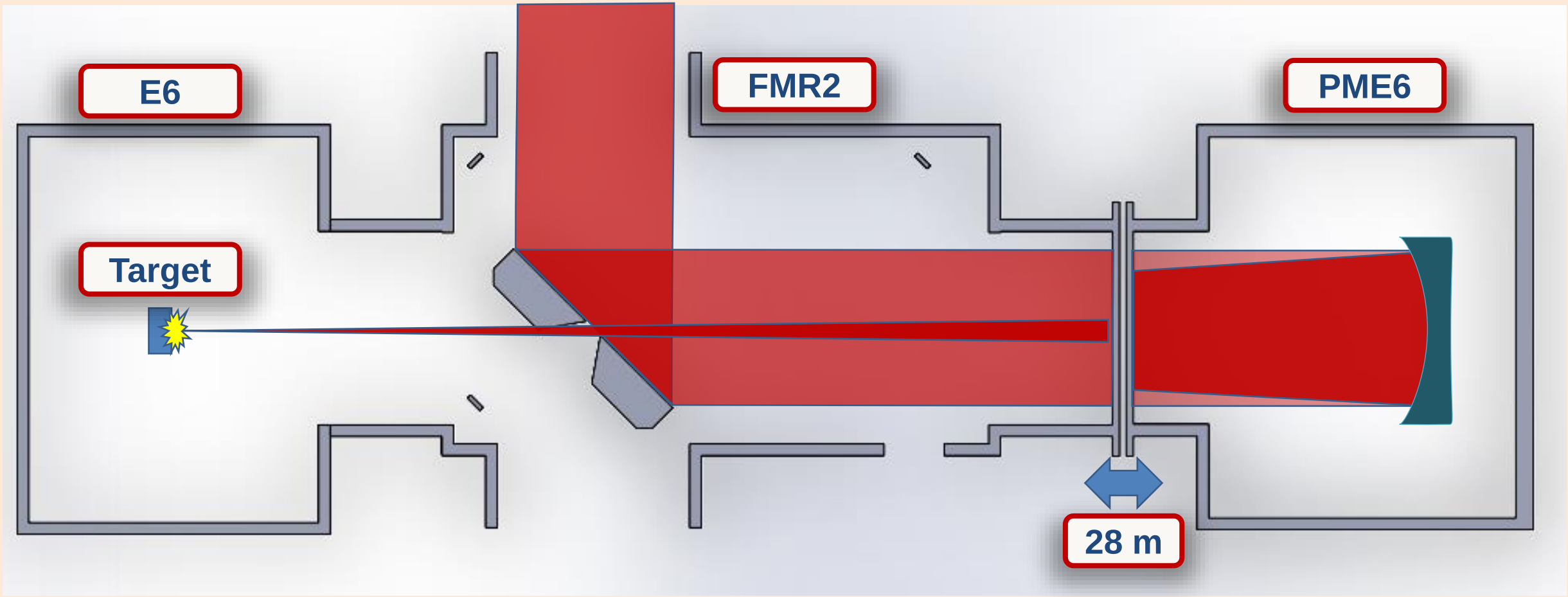
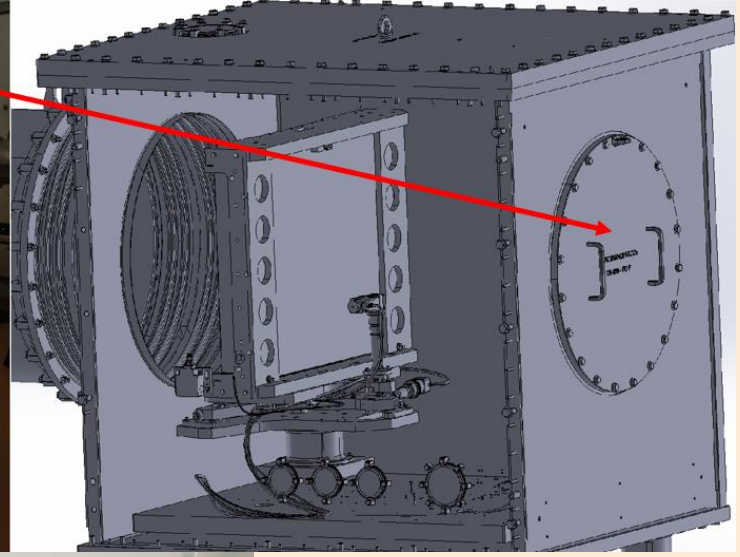
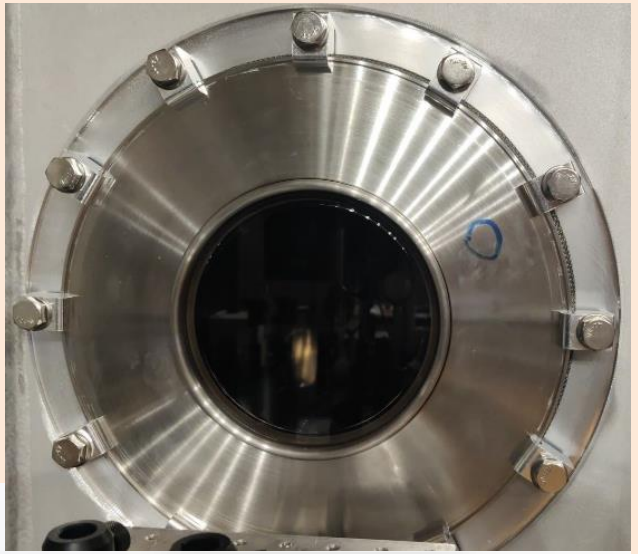
Laser-target interaction and generation of backreflection

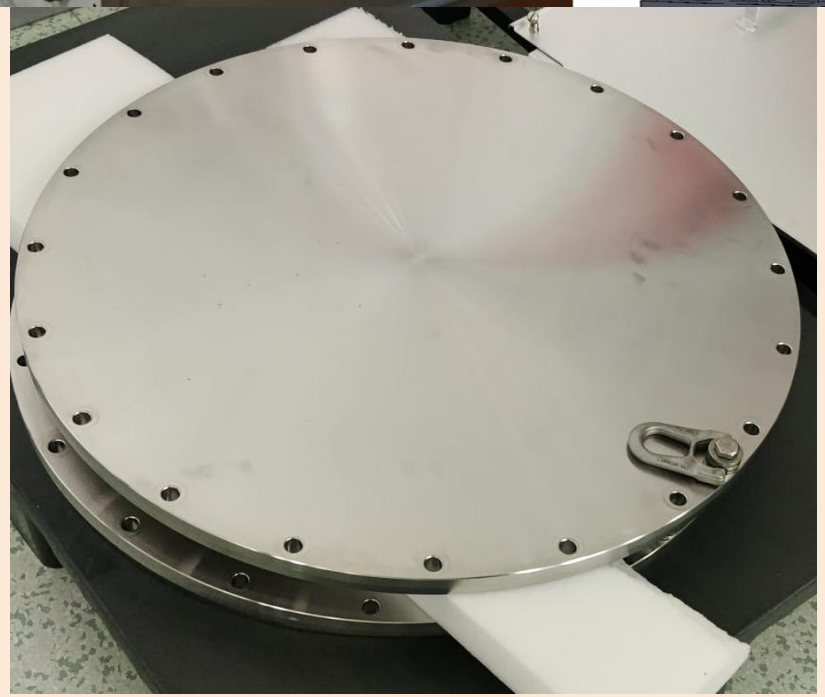


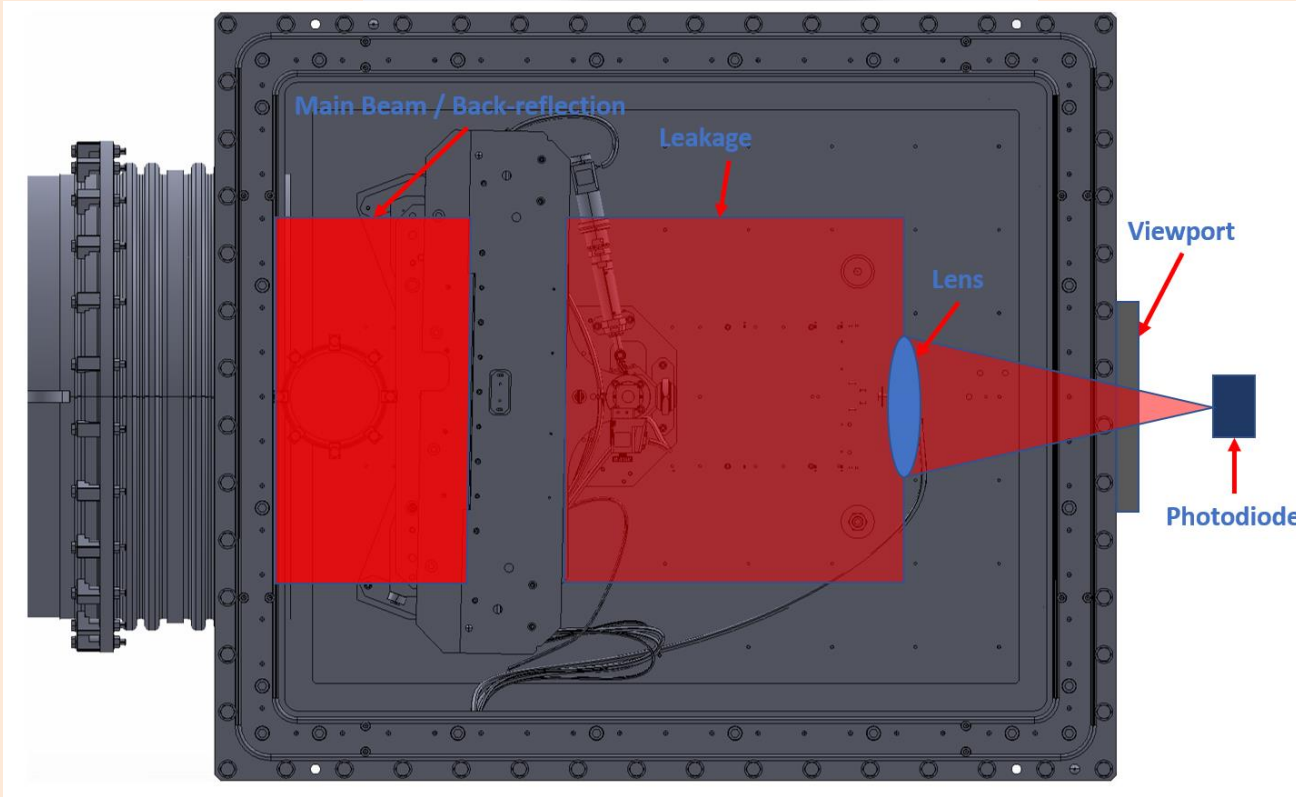
Off-axis Small Aperture Monitoring System

Three 6” kinematic mounts were prepared for vacuum





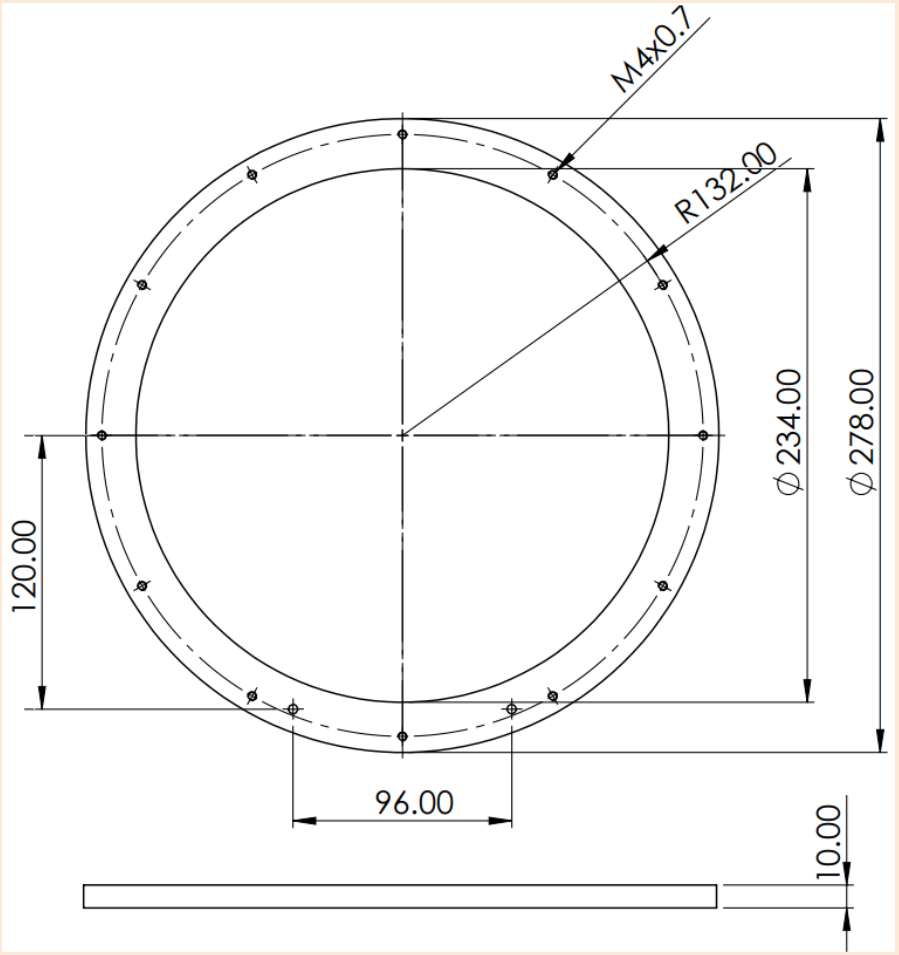




ISO 630 F Flange to be machined and replace the existing flange.
To the replaced flange will be added an ISO 250 K Viewport

Large lens for collecting BR signal

Custom Lens mount with kinematic stage



Flange Design

Lens-to-Mount Interface

10” lens with F = 500 (6” mount for scale)

- Large lens is used to collect enough energy to be visible by our detector
- LFM has High-reflectivity dielectric substrate and Ag coating
- Rough estimation: 5 orders of magnitude of attenuation

Conclusions

Work done

- FAIRS developed in-house was implemented in HPLS and successfully used for 10 PW experiments in E1.
- SAMS developed in-house and implemented in LBTS; reliably captured almost all high power shots delivered.

Work in progress

- FAIRS on stand-by to be used for 10 PW experiments.
- O-SAMS prepared to be installed in FMR2.
- Large aperture BR monitoring system awaits for lens mount to be finished.
- Research paper on commissioning BR system in E1

Aknowledgements

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- Help with Laser Beam Vacuum Transport System: Andrei Grădinariu, Alice Dumitru, Sergiu Rusnac.
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- Setup developments: Bogdan Tatulea, Alexandru Bălăceanu, Stefania Ionescu, Matei Tătaru, Bogdan Diaconescu
- HPLS and LBTS: Olivier Chalus, Christophe Derike,

Bibliography

- [1] S. Ter-Avetisyan, A. Andreev, K. Platonov, Surface modulation and back reflection from foil targets irradiated by a Petawatt femtosecond laser pulse at oblique incidence. Opt. Express vol. 24, 28104-28112 (2016).
- [2] Wagner F, Hornung J, Schmidt C, Eckhardt M, Backreflection diagnostics for ultra-intense laser plasma experiments based on frequency resolved optical gating, Review of Scientific Instruments, 88, 023503-1/7 (2017)
- [3] K. A. Tanaka, K. M. Spohr, D. L. Balabanski, S. Balascuta, L. Capponi, M. O. Cernaianu, M. Cuciuc, A. Cucoanes, I. Dancus, A. Dhal, B. Diaconescu, D. Doria, P. Ghenuche, D. G. Chita, S. Kisyov, V. Nastasa, J. F. Ong, F. Rotaru, D. Sangwan, P. A. Soderstrom, D. Stutman, G. Suliman, O. Tesileanu, L. Tudor, N. Tsoneva, C. A. Ur, D. Ursescu, and N. V. Zamfir. Current status and highlights of the eli-np research program. Matter and Radiation at Extremes, 5(2), 2020.
- [4] Lureau, F., Matras, G., Chalus, O., Derycke, C., Morbieu, T., Radier, C., Casagrande, O., Laux, S., Ricaud, S., Rey, G., Pellegrina, A., Richard, C., Boudjemaa, L., Simon-Boisson, C., Baleanu, A., Banici, R., Gradinariu, A., Caldararu, C., Boisdeffre, B. D., … Ursescu, D. High-energy hybrid femtosecond laser system demonstrating 2 × 10 PW Capability. High Power Laser Science and Engineering, 8 (2020).
- [5] Edwina D Vernon, Ian Musgrave, James Green, Robert Heathcote, Characterization of the backscattered radiation from petawatt laser matter interactions, 47(18):3258-63 (2008)


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