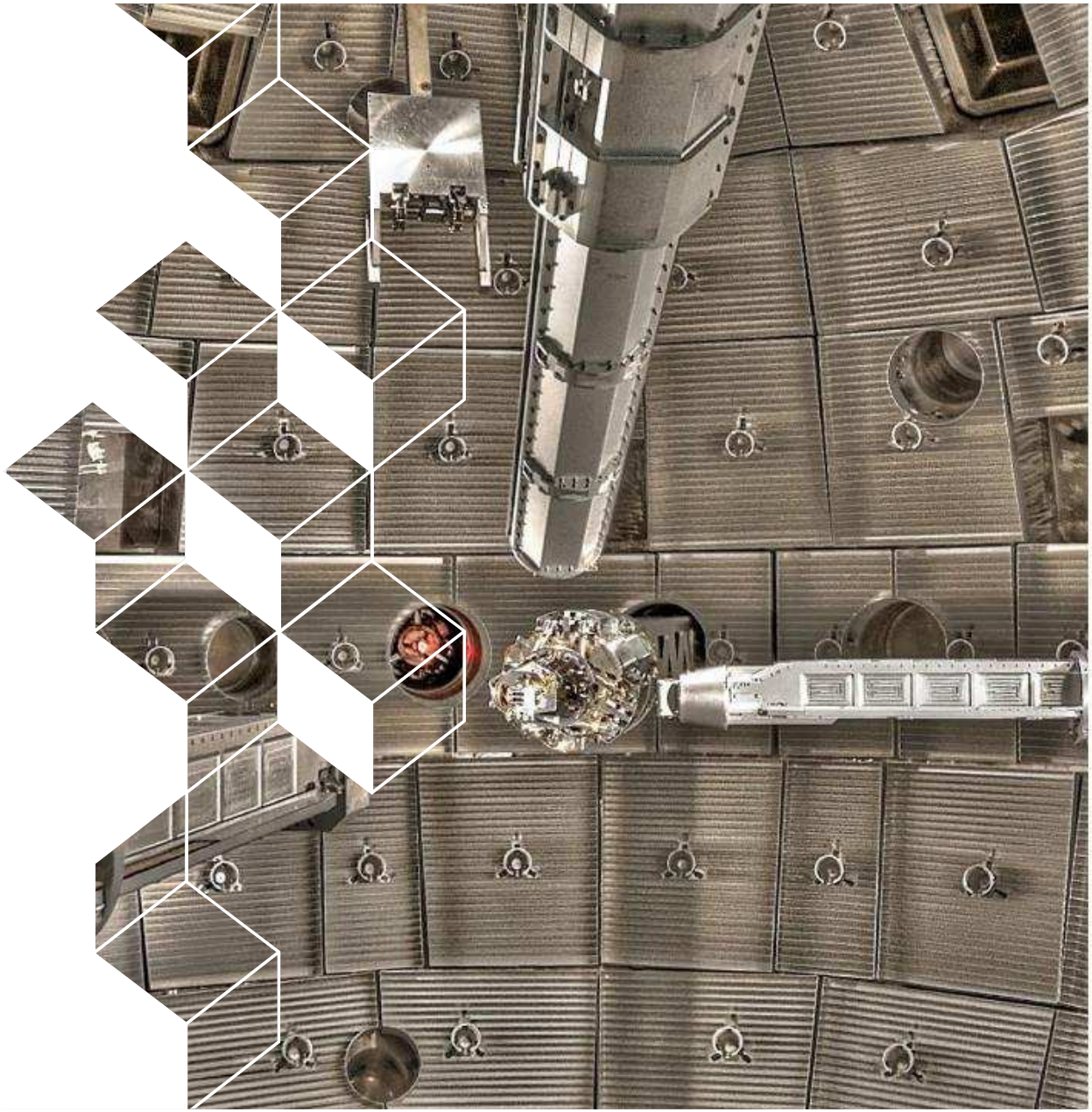
LMJ laser performance

LMJ-PETAL User meeting

CESTA-DLP / V DENIS



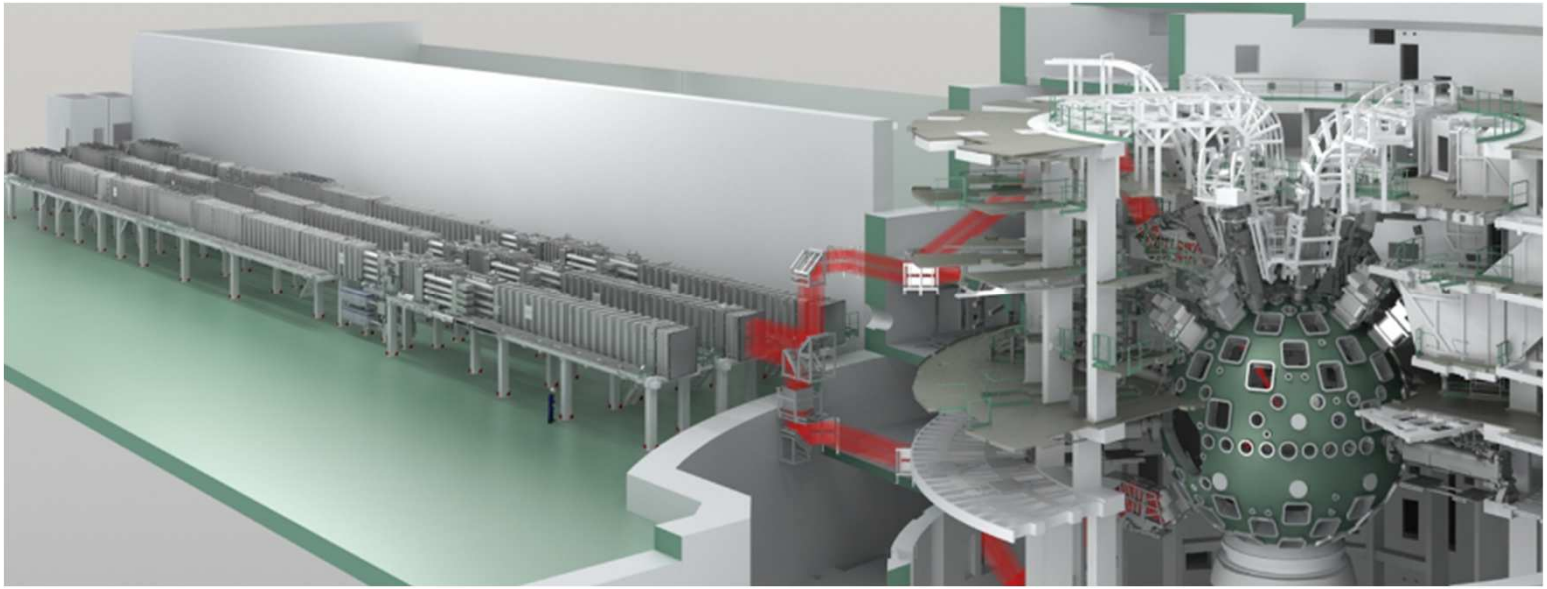
LMJ-PETAL Users Guide

This document describes the status of the LMJPETAL facility and provides the necessary technical references to researchers intending to perform experiments on LMJ-PETAL.

To limit damage growth and thus the maintenance of the optics during the end of the LMJ assembly, the energy is currently limited to 3.75 kJ and the power to 1,25 TW per beam.

https://www-lmj.cea.fr/docs/2020/LMJ-PETAL-Users-guide-v2.0.pdf

Laser MegaJoule main characteristics



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LASER BAYS

- 22 bundles of 8 beams
- 2 quads per bundle.
- 176 beams
- 1 specific beam line for PETAL (PW laser).

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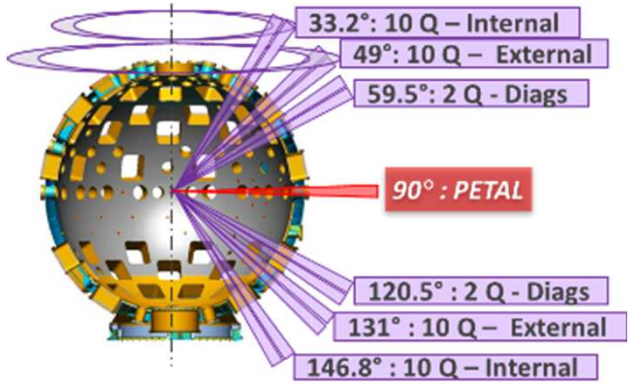
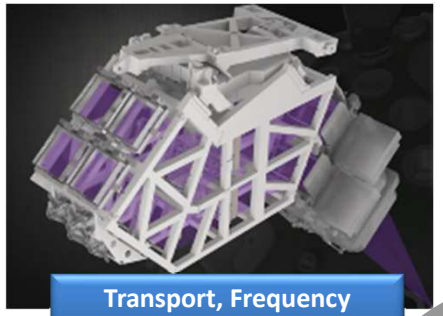
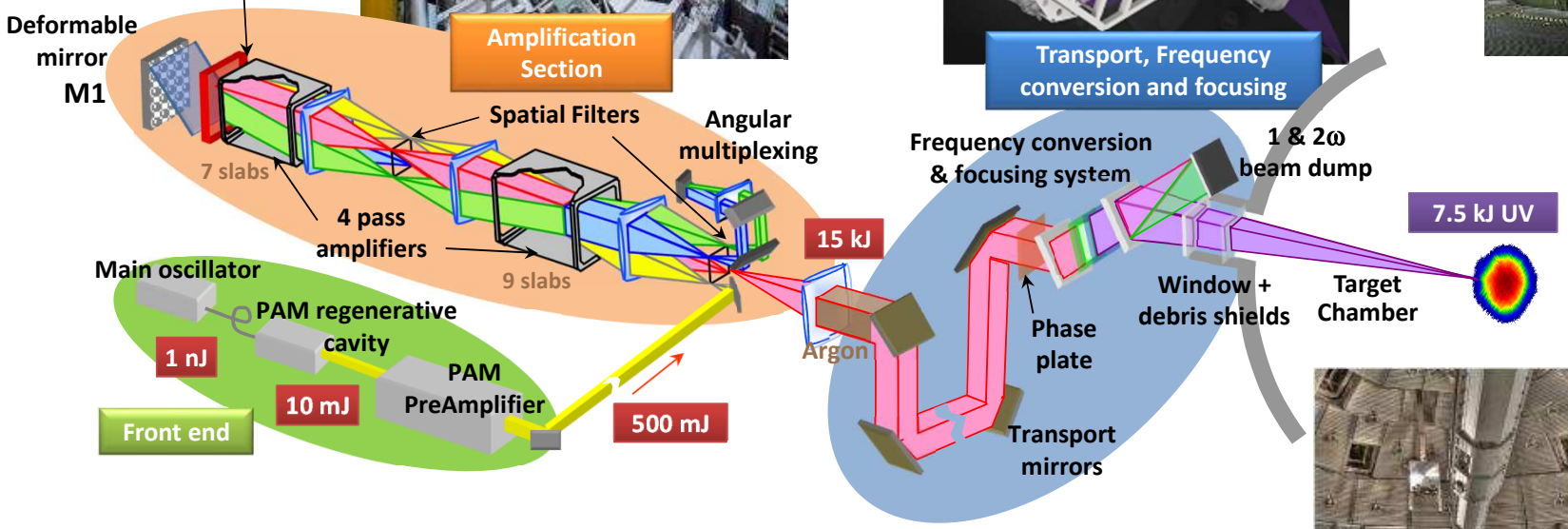
TARGET BAY

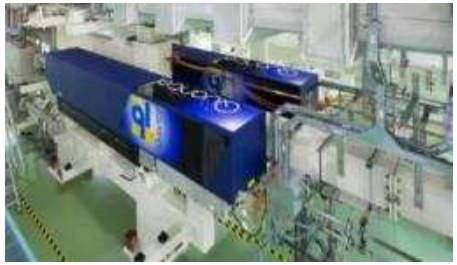
- 1 Target Chamber Ø10m
- 200 ports
- 2 x 2 irradiation cones
- 10 quads per cone
- 4 quads for diagnostics

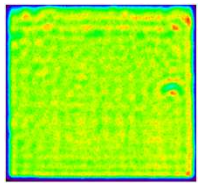


LMJ Beamline Architecture









Square beam 35 x 35 cm²

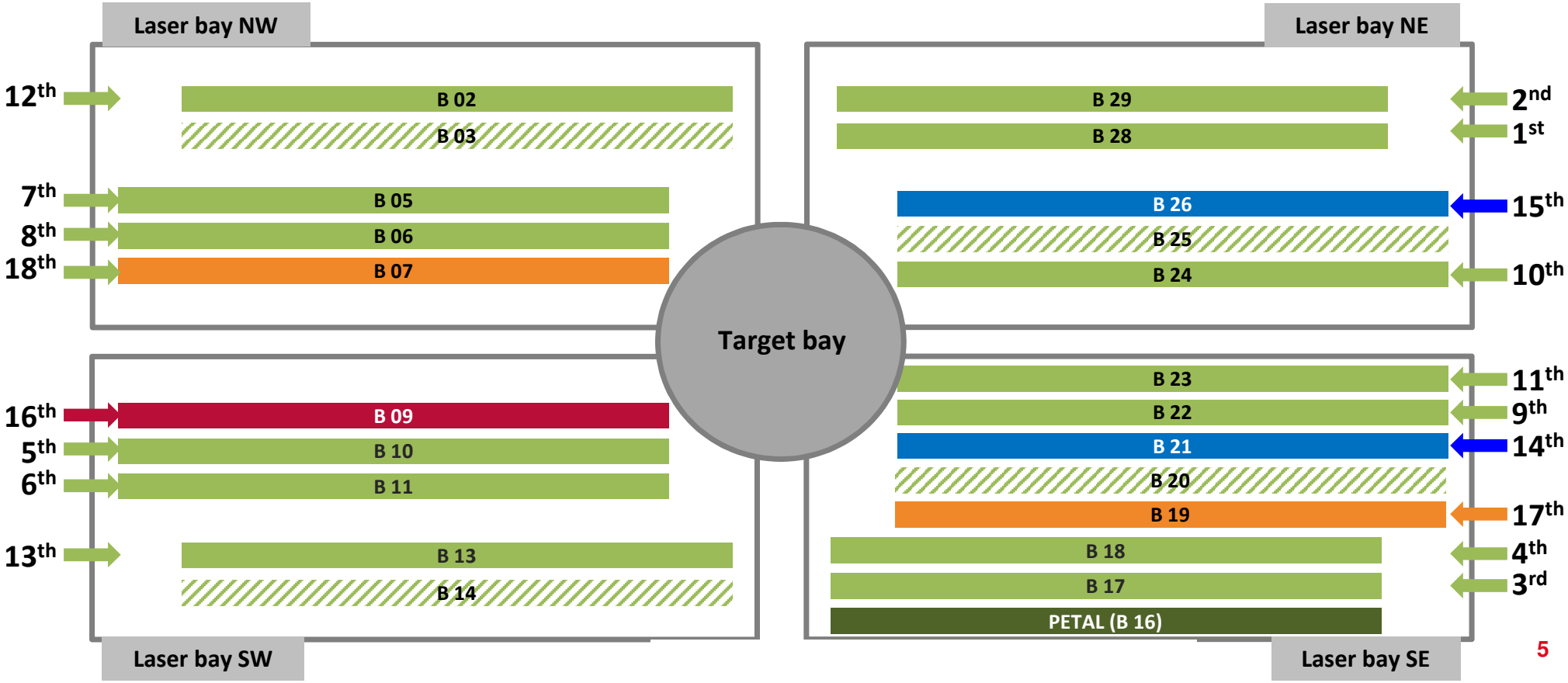
Grouped by 4 = Quadruplet

1 LMJ bundle = 2 quadruplets

1 PAM for 2 beams

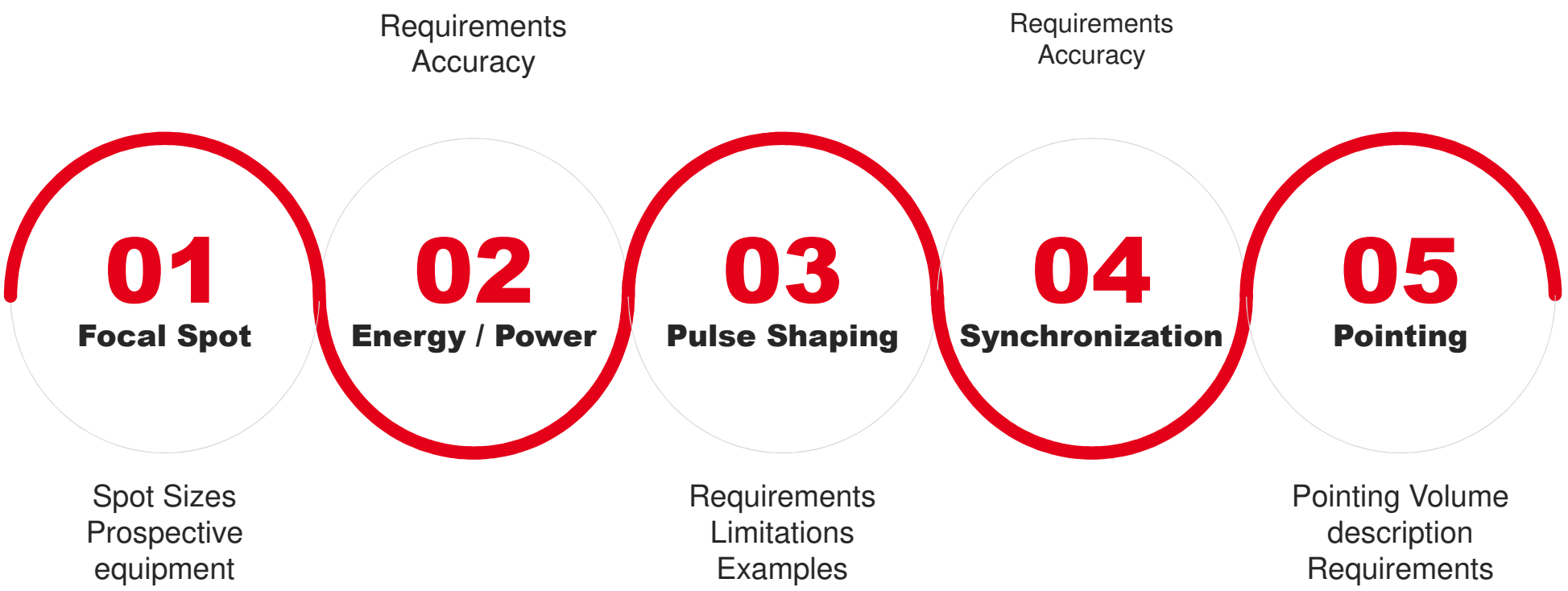
LMJ bundles status

13 LMJ bundles are operational (B28, B29, B17, B18, B10, B11, B05, B06, B22, B24, B23, B02, B13) + PETAL,
2 LMJ bundles are being commissioned (B21, B26) → end 2023,
1 LMJ bundle is already assembled: B09,
2 LMJ bundles are being assembled: PAM, PEPC, transport mirrors, SCF (B19 et B07).



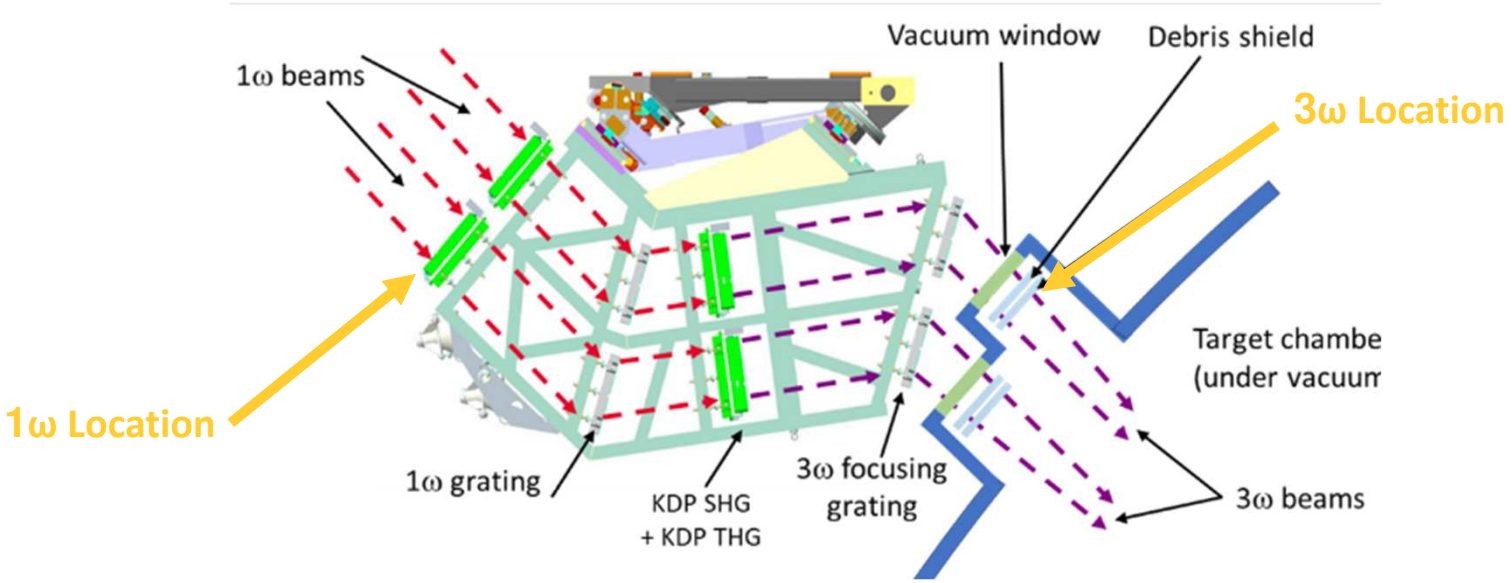
LMJ specifications

About 60 specifications, described in 5 items :



Focal Spot: Phase plates & location

Focal Spot is determined by the phase plate and 2 locations coexist



- 1ω location : mounted upstream the Frequency conversion and focusing System. No changes allowed during campaign period.
- 3ω location : mounted downstream the Frequency conversion and focusing System. Different phase plates are embedded in the final optics assembly and changes may occur between campaigns.

Focal Spot: Requirements and measures

Dimensions of focal spot are given for 3% of the maximum intensity

Requirement for each phase plate in the installation

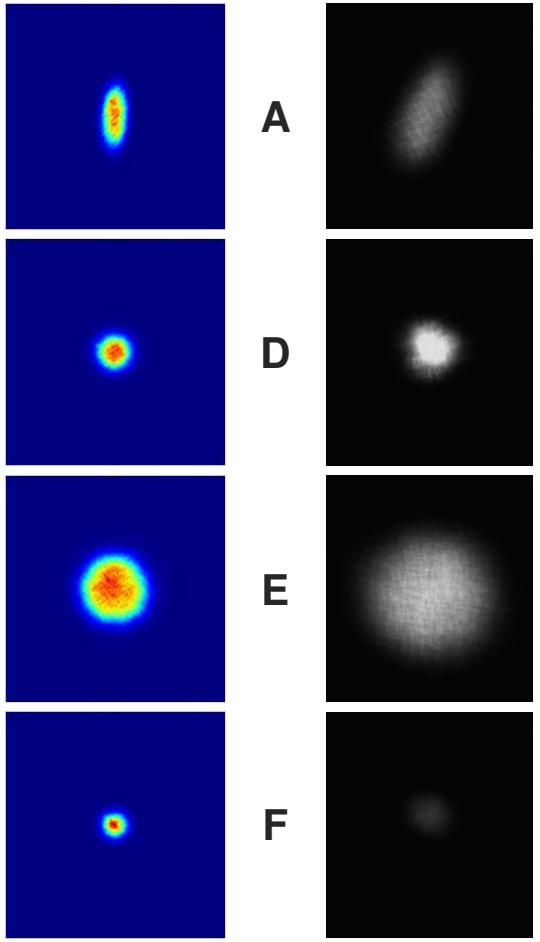
- A type : elliptical with dimensions of 750 x 1500 µm²
- B type : elliptical with dimensions of 1200 x 1700 µm²
- D type : circular with a diameter of 860 µm
- E type : circular with a diameter of 1500 µm
- F type : circular with a diameter of 630 µm

Requirement for defocus

- Up to 20 mm with superposition of the 4 beams

Data access

- No measures on power shots
- Low Energy measure on alignment sensor
- High Energy simulation with MIRO Code

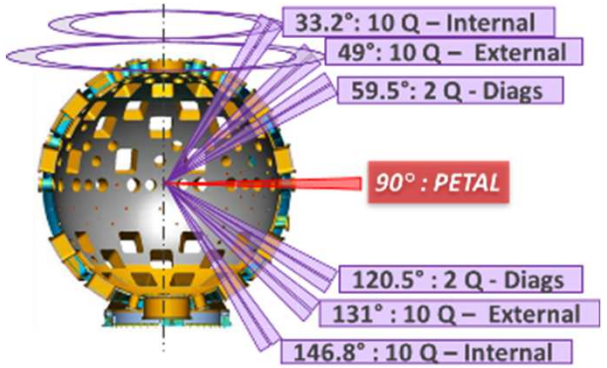


Focal Spot: prospective equipment

Progressive equipment with B type phase plates for heating internal quads

Year	Internal upper quads										Internal lower quads									
Quad	2H	6H	9H	11H	13H	17H	21H	24H	26H	28H	3B	5B	7B	10B	14B	18B	20B	22B	25B	29B
2023		A		A		A		A		ABEF		A		A		A		A		AEF
2024		A		A		A		A		ABEF		A		A		A		A		AEF
2025	B	A	B	A	B	A	B	A	B	ABEF		A		A		A		A		AEF
2026	B	A	B	A	B	A	B	A	B	ABEF		B		B		B		B		B
2027	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B

- External heating quads equipped with A type phase plate
- 2 radio quads (19 & 23) equipped with E and F types phase plates



Energy-Power Diagram (EP Diagram)

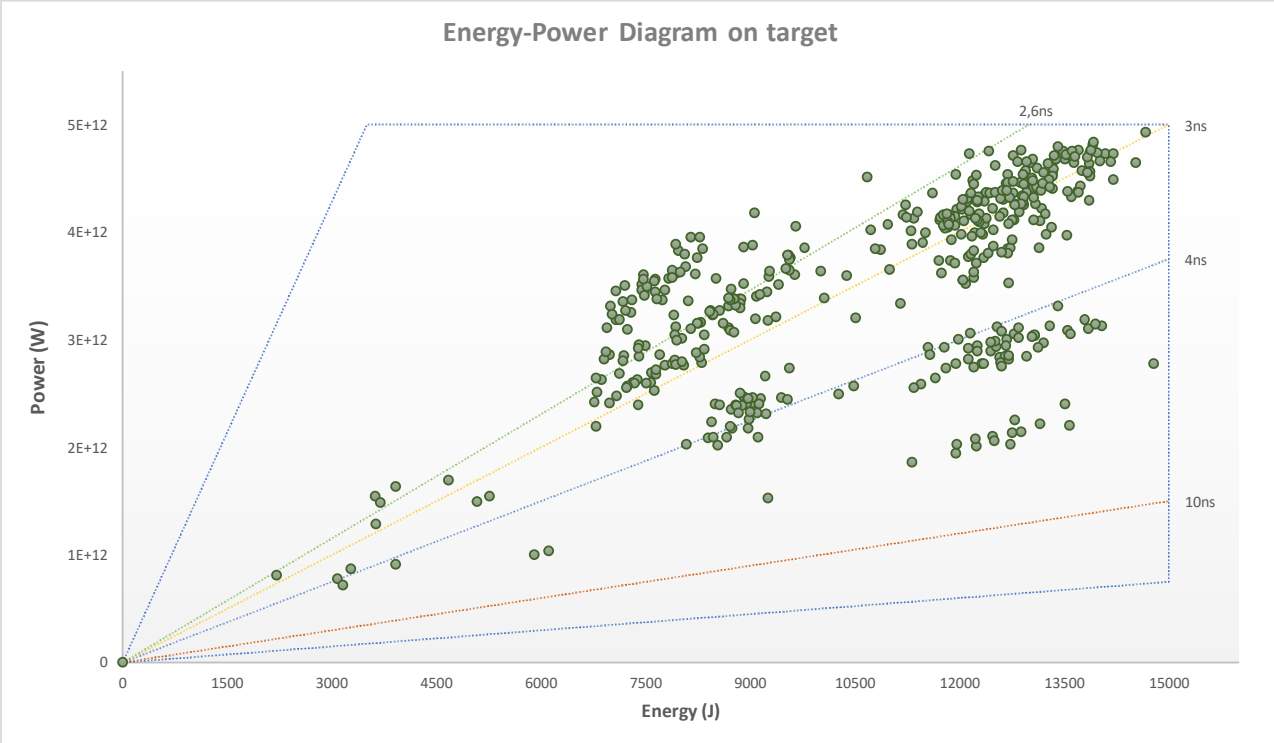
Limitation of the EP diagram to preserve the final optics up to the end of the mounting

Requirements on target

- Energy limit : 13.5kJ per quad
- Power limit : 4.5 TW per quad

Data access

- Immediately observable after the shot
- Consolidated laser energy and power are communicated at the end of the experimental campaign after evaluation of the vacuum window transmission



EP Diagram: characteristics and accuracy

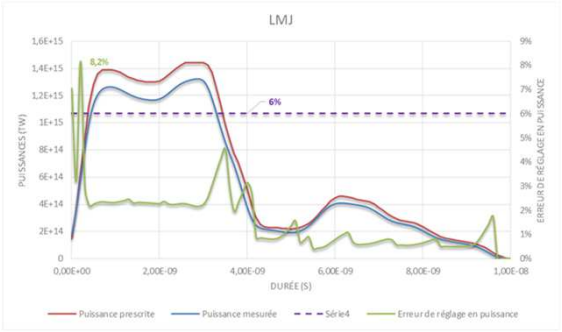
Measure performance

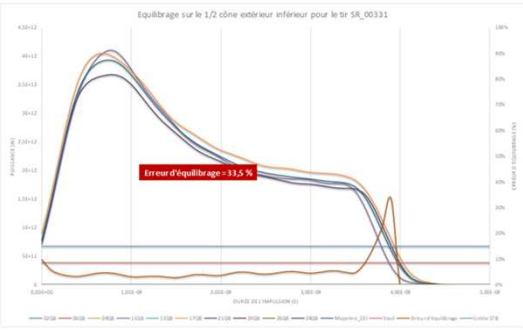
Measures are acquired for each beam

- **Accuracy with measured energy :** 5% rms
- **Accuracy with measured power :** 10% rms

Measures for a campaign

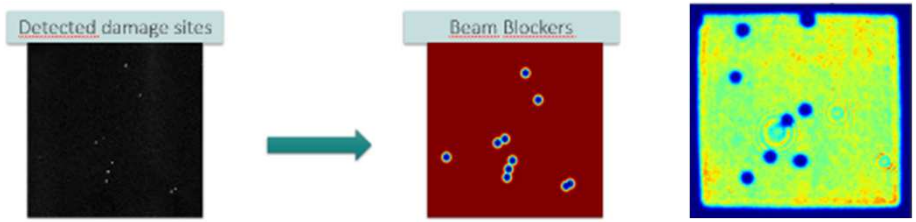
- **Accuracy with required energy :** 6% rms
- **Accuracy with balanced energy :** 15% rms





Vacuum window protection: limitation for EP Diagram

- Damage sites on vacuum window are detected with a dedicated device
- Beam blockers are defined at the PAMs
- Damage sites growth is blocked



Final Optics Transmission

- Final Optics Transmission is regularly assessed for consolidated datas

Temporal shapes

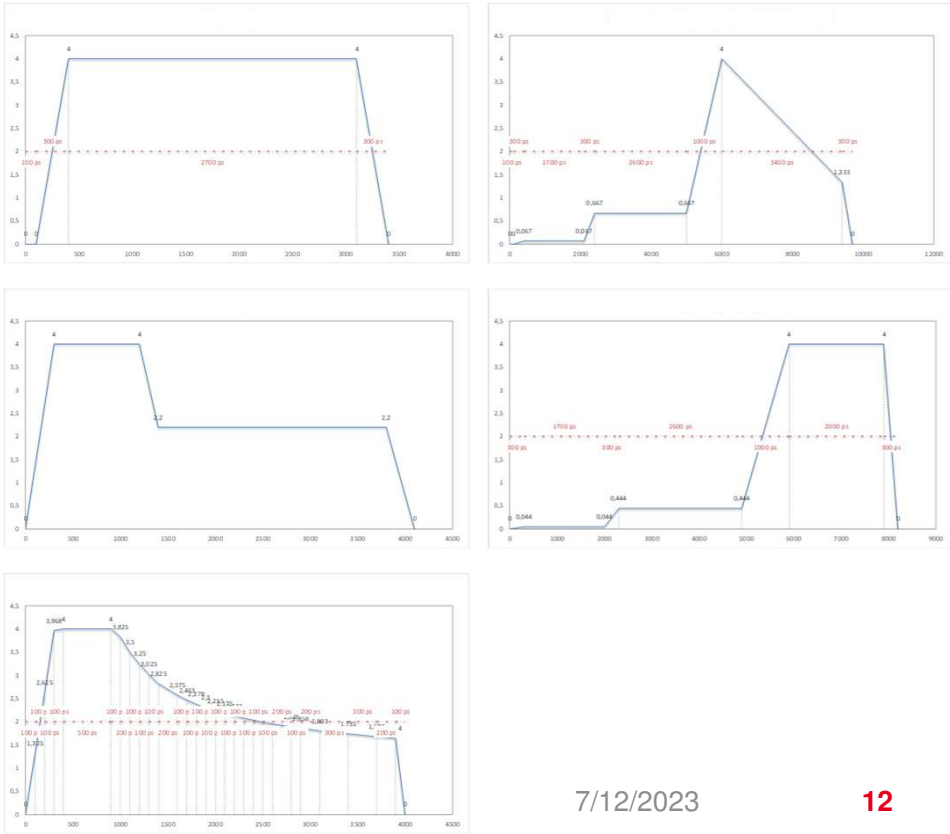
- **Limitation of one Pre-Amplifying Module per 2 beams**
- **Limitation of one Temporal Shape Module per quad**

Requirements

- Temporal duration range : 700 ps do 20 ns
- Shortest riding edge : 350 ps
- Complex pulse can be created (rising pulse, decreasing pulse, multiple pulses, with pedestal, …)
- Modulation < 20 % peak to peak

Data access

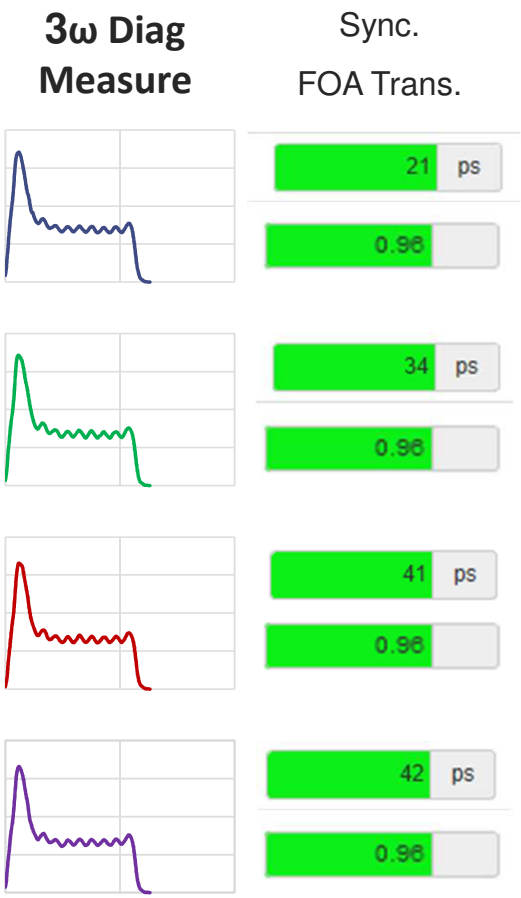
- Immediately observable after the shot
- One 3ω measure for each beam
- In the absence of any 3ω measures, a simulation of the 1ω measure is propagated with the MIRO code



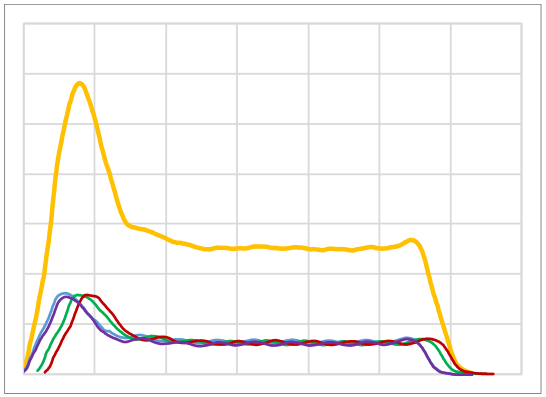
Temporal shapes: reconstruction

Quad Temporal shape on target is reconstructed from beam measures

- Final Optics Transmission of each beam reduces the energy contained in the temporal shape
- Quad temporal shape is reconstructed from these beam measures. Each beam synchronization value is taken into account in this reconstruction
- Beam Temporal shapes are smoothed with a 500 ps sliding window

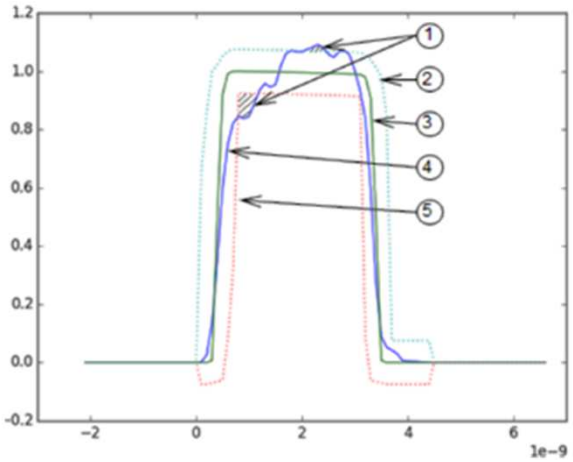


Smoothed quad temporal shape



Temporal shapes: analysis

Quad Temporal shape on target is compared to the required one



1. Outside template area,
2. Max template,
3. Desired signal,
4. Measured signal,
5. Min template,

- A template is designed around the required temporal shape
- The measured signal is compared to the template
- An evaluation of the number of the points outside the template gives information about the quality of the Temporal Shape

Synchronization on target

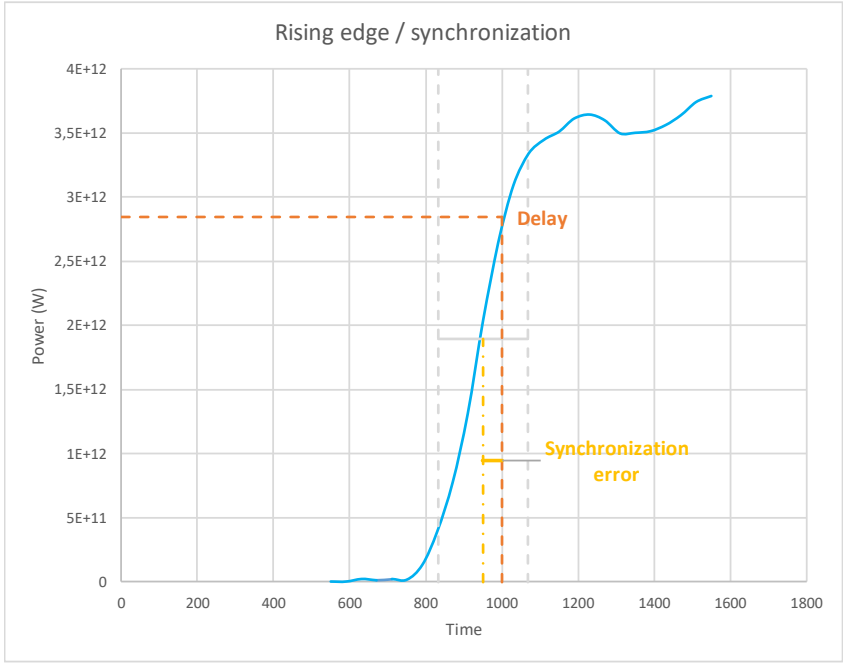
- **Synchronization is defined for the best focus of the quad**
- **Synchronization is defined at half power of the first rising edge**
- **Synchronization is defined relatively to the delay required for each quad**

Requirements

- Actual requirement < 80 ps RMS
- Delay between 2 quads < 70 ns

Data access

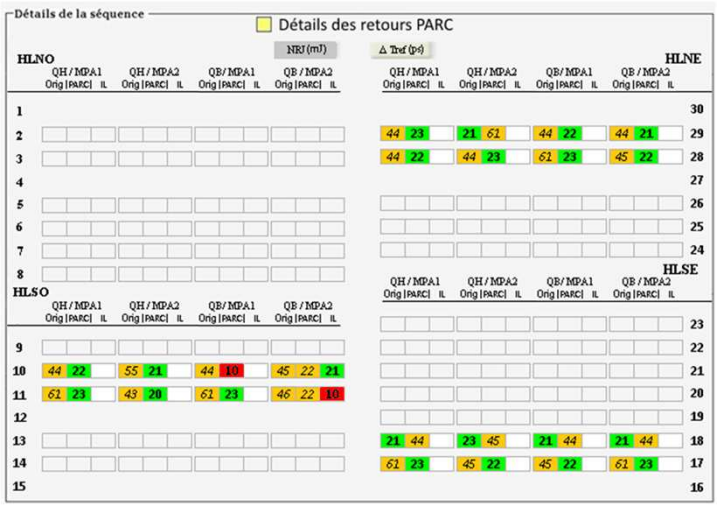
- Immediately observable after the shot
- One 3ω measure for each beam
- In the absence of any 3ω measures, the 1ω measure is used instead



Synchronization on target: setting

Synchronization is tuned just before the power shot

- A 1ω synchronization measure is realized for each validation shots
- A setting of the quad synchronization is achievable after each validation shot
- A setting requires a new validation shot



Pointing performance

The requirements depend on the coordinates in the pointing volume

Requirement in the cylinder of 30 mm height and 30 mm diameter : < 75 µm rms

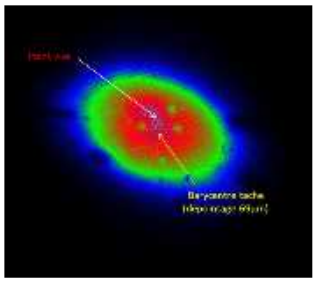
Requirement in the cut cylinder of 30 mm height and 100 mm diameter : < 115 µm rms

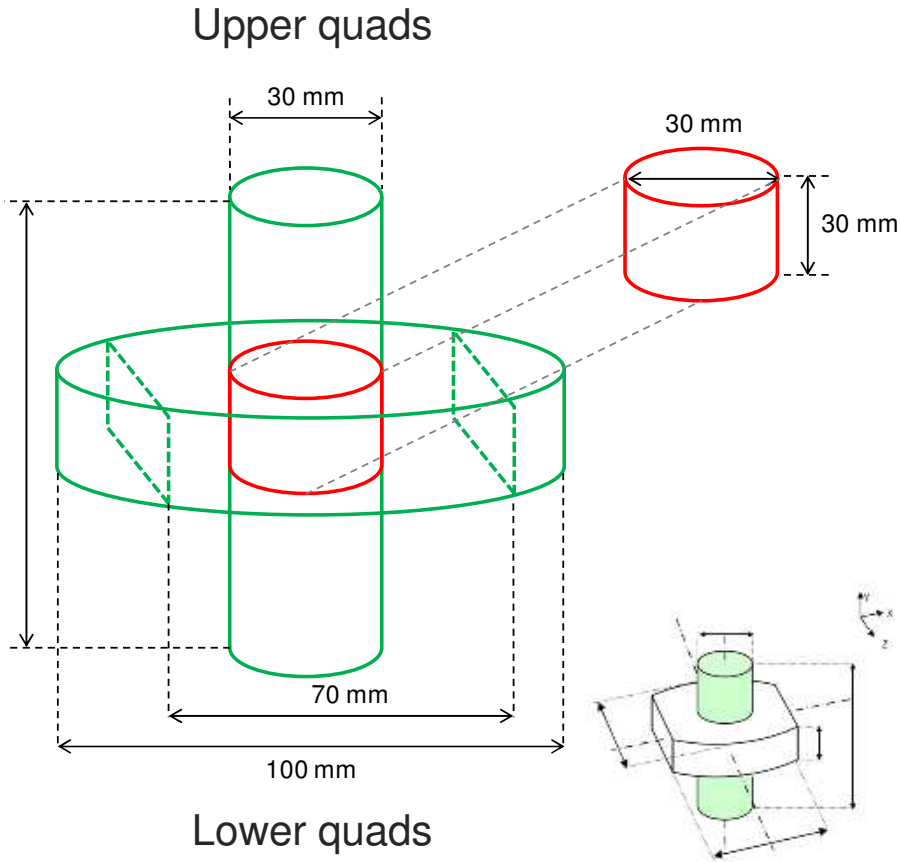
Requirement in the cylinder of 100 mm height and 30 mm diameter

- For quads in the same hemisphere < 115 µm rms
- For quads in the other hemisphere < 150 µm rms

Data access

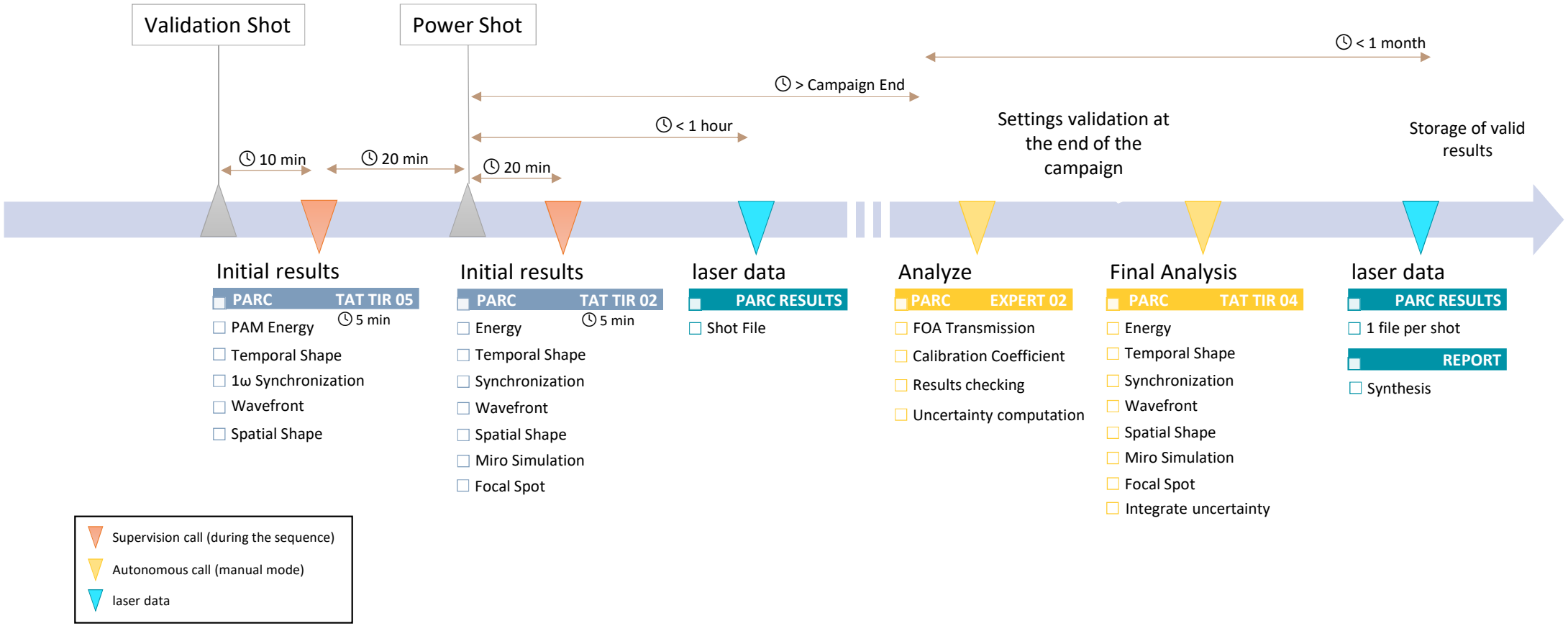
- No measures on power shots
- Low Energy measure on alignment sensor
- Dedicated shots on specific targets for estimation





Shot and campaign process

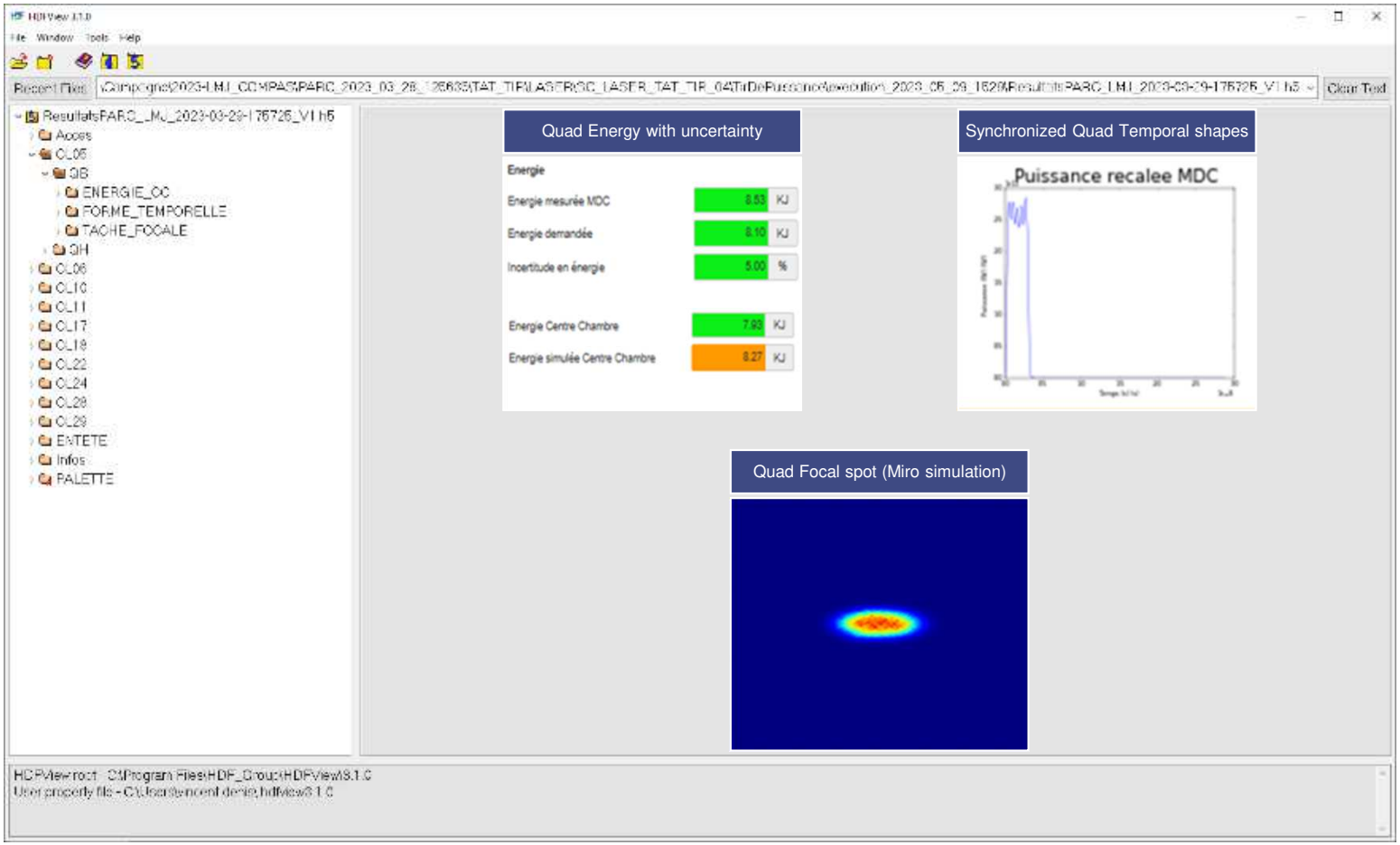
One shot on target per day

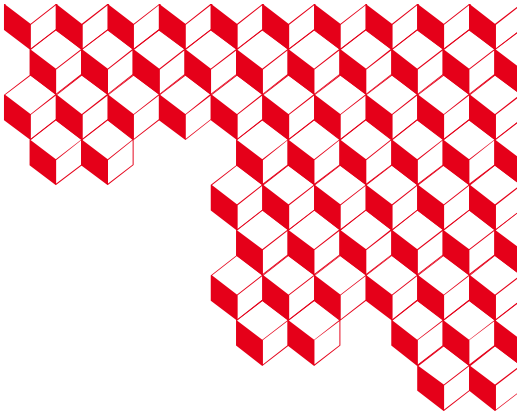


Laser data format

The laser data delivered is a H5 file

ResultatsPARC_LMJ_2023-03-29-175725_V1 09/05/2023 15:38 Fichier H5





Thanks for your attention

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