



JT60-SA - WPSA GM

Thomson scattering status

08-09-2022

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for the EU-TS team



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Performance requirements

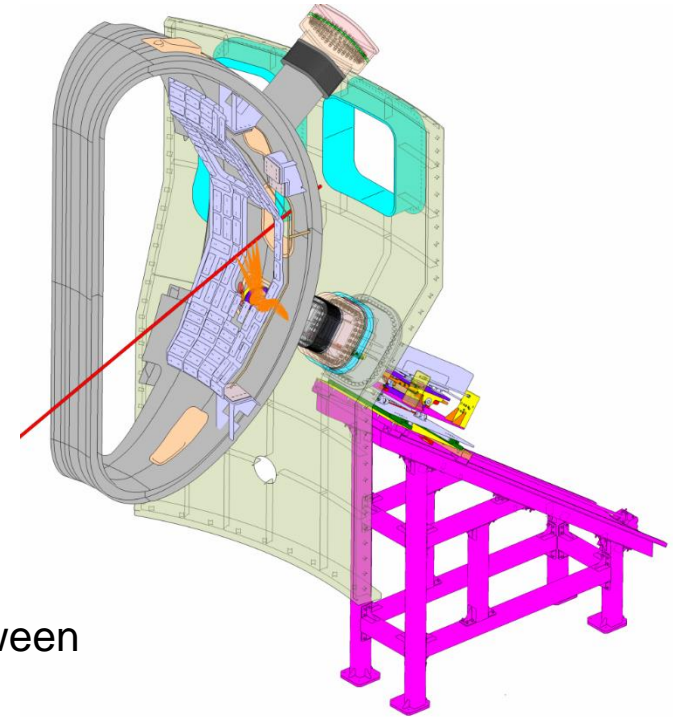


The **core TS system (P2)** shall measure T_e and n_e profiles

- **46 positions** from $R=2.6\text{m}$ to $R=3.725\text{m}$,
- scattering volume length **15 mm**,
- radial spatial resolution (points distance) **25 mm**
- dynamic range **0.1-30 keV**
- Laser pulse repetition rate will be **50 Hz**.

The **edge TS system (P1)** shall measure T_e and n_e profiles

- **49 positions** from $R=3.7\text{m}$ to $R=4.17\text{m}$,
- scattering volume length **5.5 mm**,
- radial spatial resolution (points distance) **25 mm** at $R < 3.9\text{ m}$, **5 mm** at $R > 3.99$ and **10 mm** in between
- dynamic range **0.01-10 keV**.
- Laser pulse repetition rate will be **100 Hz**.



For both systems:

The **accuracy** is expected to be better than 10% for T_e and 5% for n_e , at $n_e = 10^{19}\text{m}^{-3}$ (from simulation) → **Best Effort**

TS diagnostics layout in JT60-SA



EU components

Core TS components:

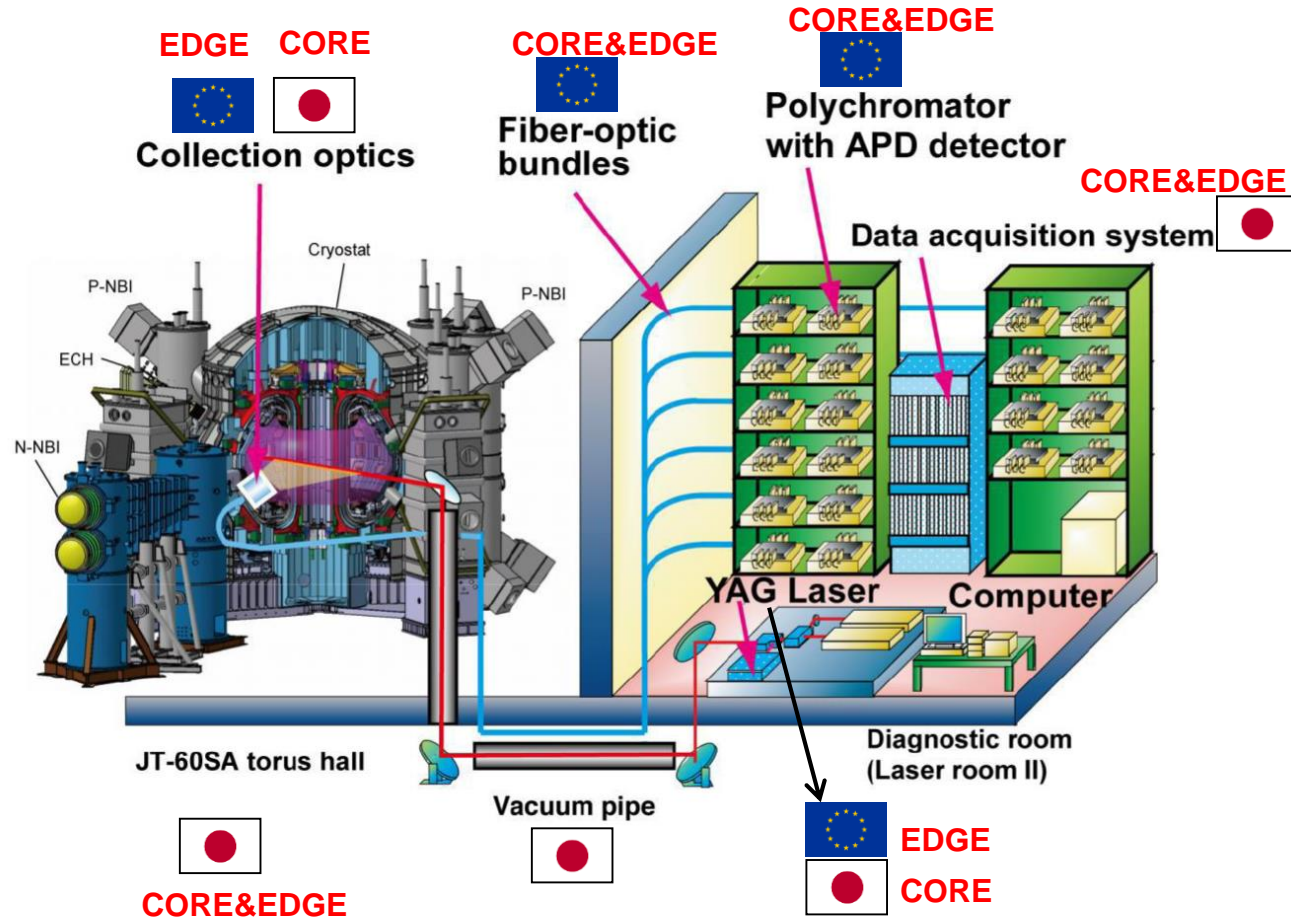
- Optical fiber
- Polychromators

Edge TS components:

- Optical fiber
- Polychromators
- LASER
- Collection optics

 Edge TS
 

 scientific exploitation



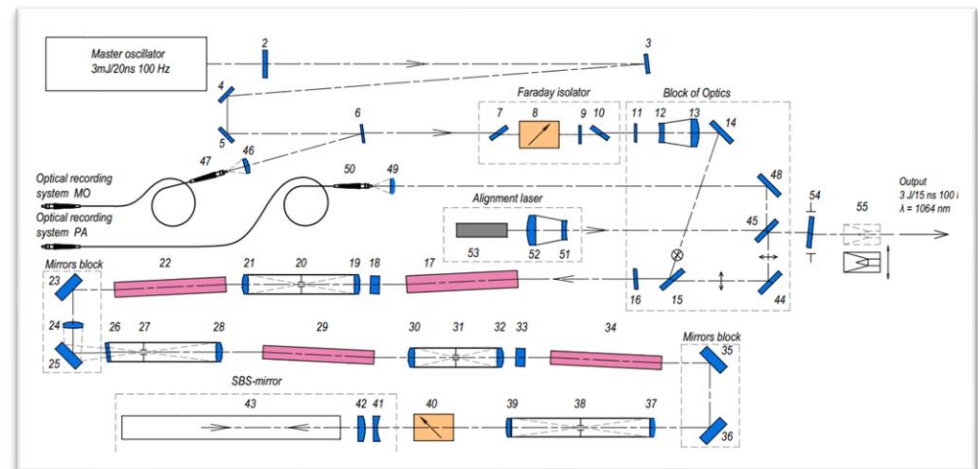
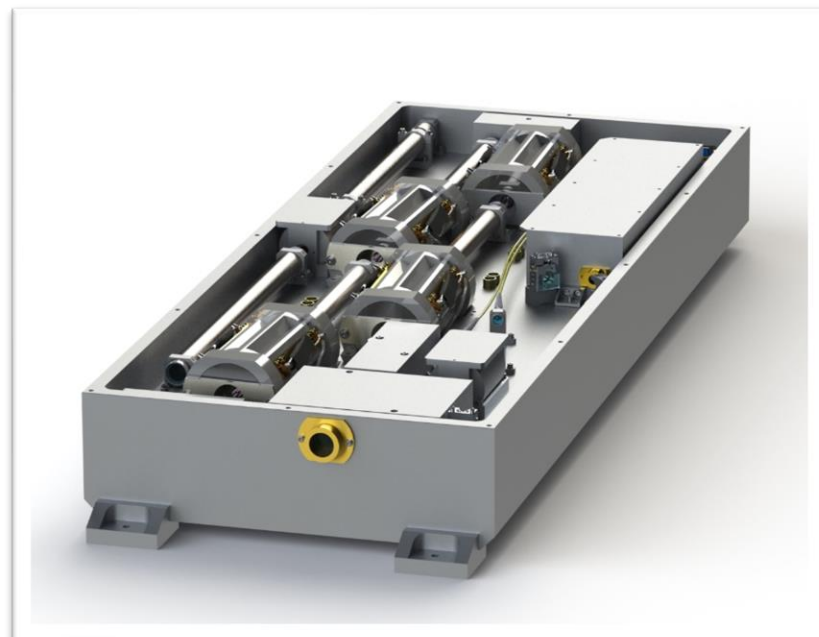
Laser system: status



The Main Technical Characteristics of the Laser

| | |
|--------------------|--------------------------|
| Wavelength | 1064.2 nm |
| Repetition rate | 100 Hz |
| Energy | > 3 Joules |
| Pulse duration | 8-18 ns |
| Divergence | 0.5 mrad |
| Beam diameter | ∅15 mm, flat top profile |
| Pointing stability | < 100 microrad |

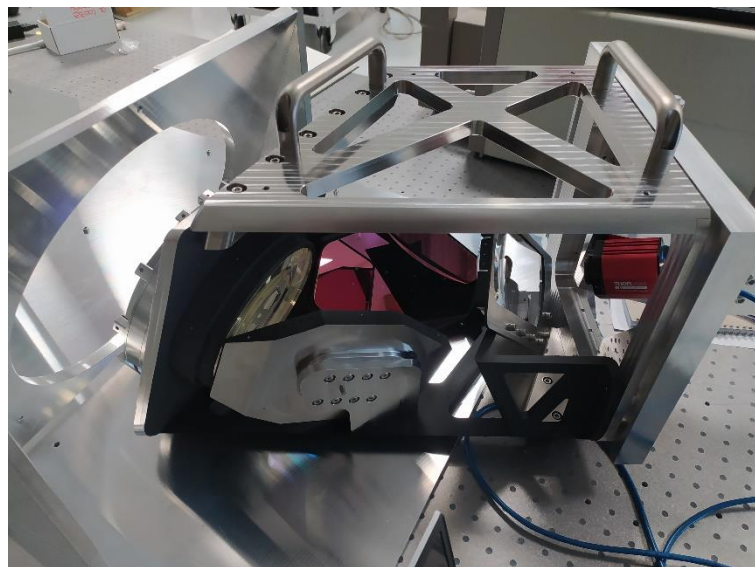
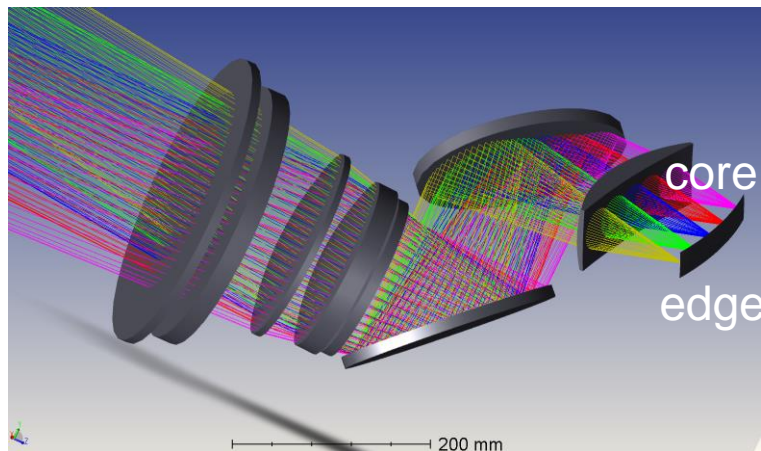
- Design documentation ready
- Assembly ongoing
- Export license renewed
- Delivery confirmed by end of November
- Installation (company remote):
First quarter 2023



P1 collection optics: status



Status of procurement

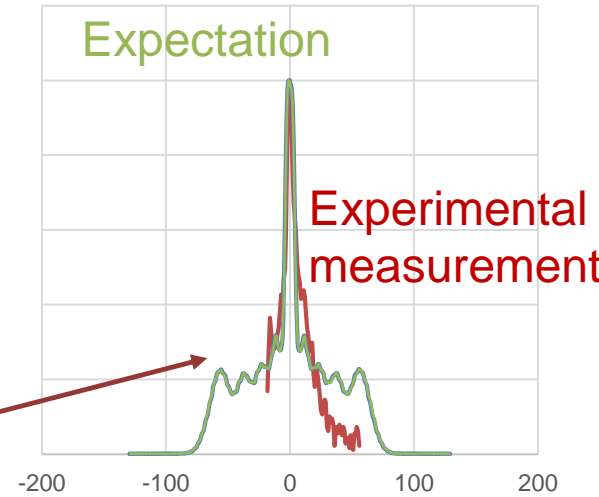
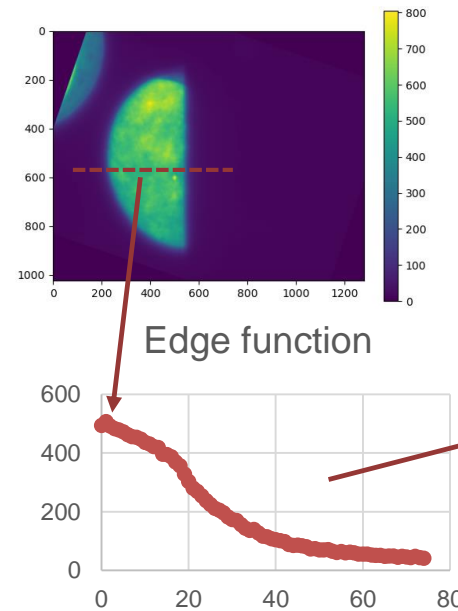


- M1 (Dichroic mirror) procured:
 - M1 ready the mid of October
- Test assembly: completed
- First test on mockup performed: beginning of June
- Test setup evaluation: completed
 - Modifications are being implemented to improve the test setup
- Window holder for test: procurement ongoing
- Window coating progressing delivery expected by October-November

P1 collection optics: performance test



Preliminary verification of linear spread function



- ✓ Linear spread function verified
- ✓ Magnification verified
- ✓ Focal plane identification

P1 mechanical structure: status



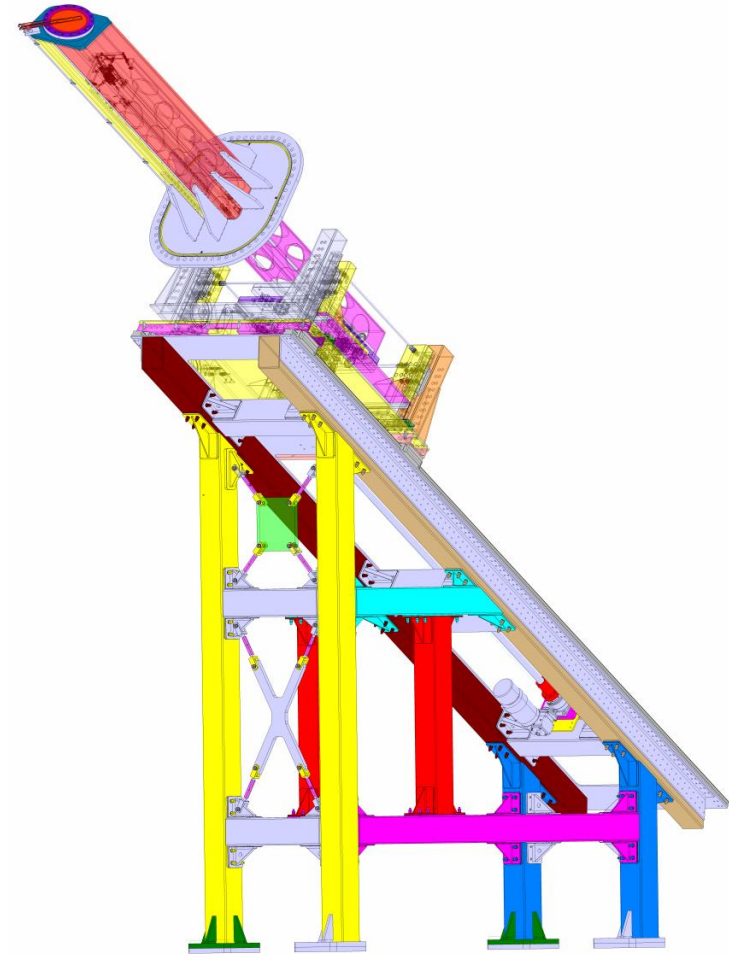
- Collection optics on a retractable arm
- Decoupled from cryostat
- On supporting structure standing on floor
- Same structure to install port plug

Status of procurement

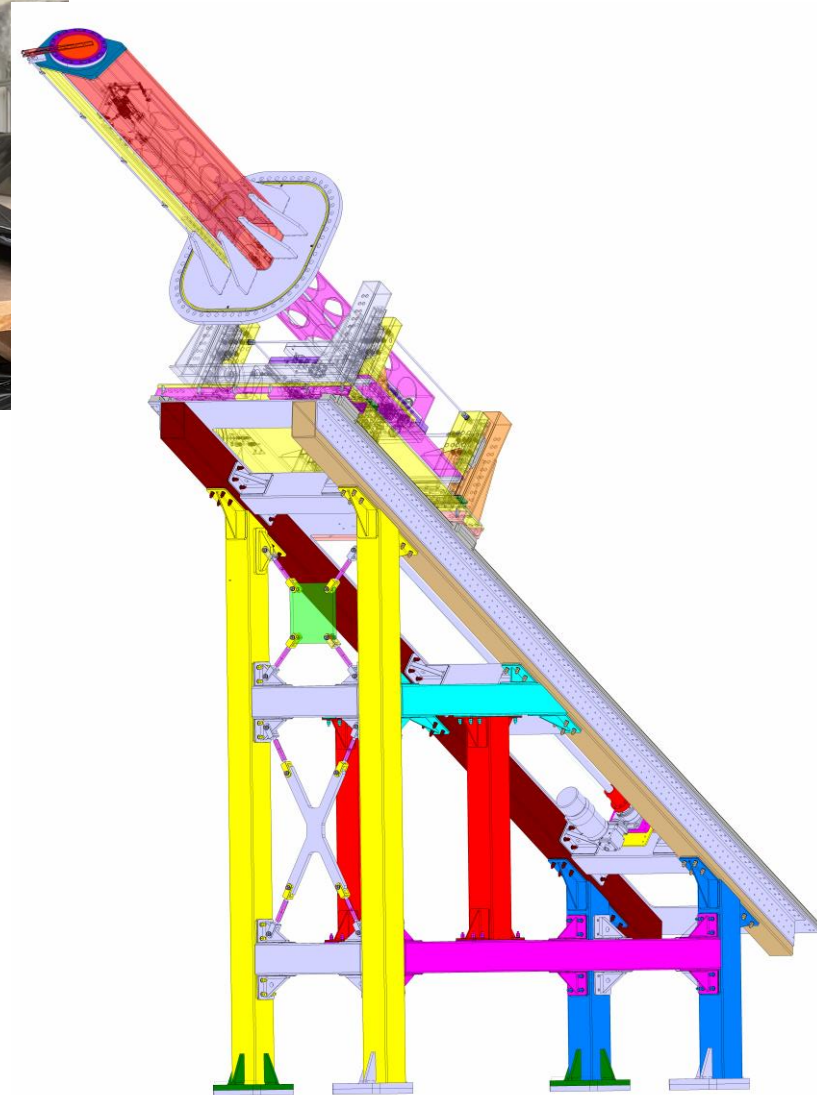
- Support structure and installation procedure accepted
- Port plug drawings accepted

Production

- Support Structure & Trolley: manufacturing in progress.
- Port plug assigned to Forth engineering: Manufacturing in progress, use of additional resources to mirror polish the outer surface of the port plug.



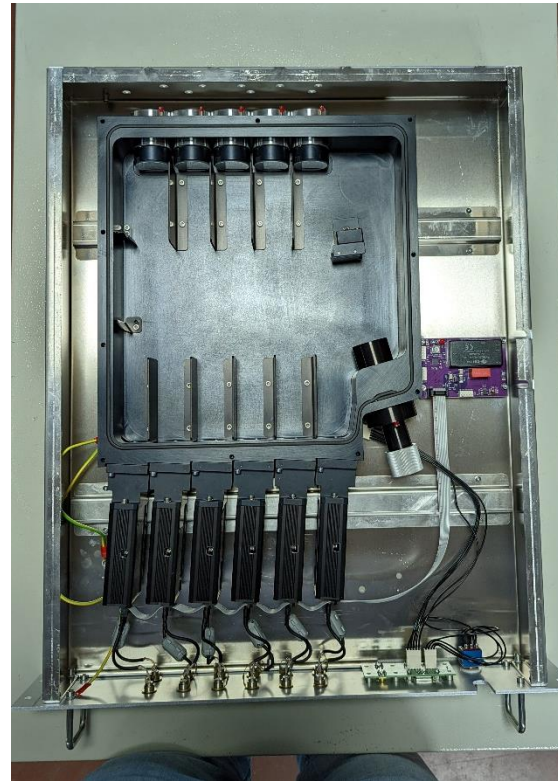
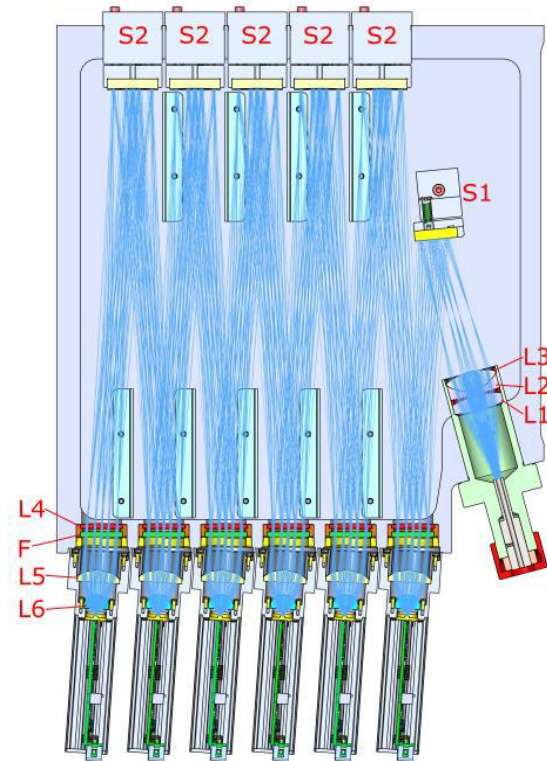
P1 mechanical structure: status



Polychromators: status



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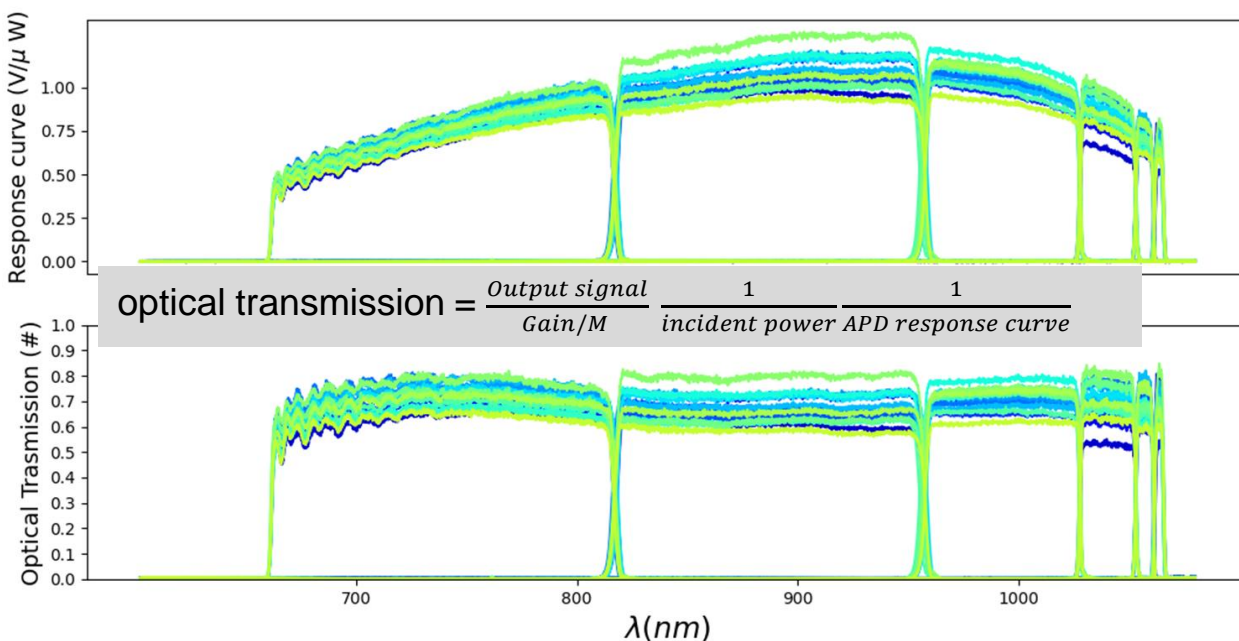
- Alignment of all polychromators completed
- Tests ongoing: 31 edge polychromators fully tested and assembled
- Vibrational tests: successfully concluded
- Delay in the installation: expected march 2023

Polychromators: P1 optical transmission



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$$\text{Response curve} = \frac{\text{Output signal}}{\text{Gain} * \text{Incident power}}$$



$$\text{optical transmission} = \frac{\text{Output signal}}{\text{Gain}/M} \frac{1}{\text{incident power}} \frac{1}{\text{APD response curve}}$$

Inferred from APD data

Equal within the error on APD function.

| channel | Exp | Cal |
|---------|------|-----|
| 6 | 79.4 | 74 |
| 5 | 77.6 | 77 |
| 4 | 80 | 68 |
| 3 | 79.3 | 65 |
| 2 | 80 | 68 |
| 1 | 77.6 | 76 |

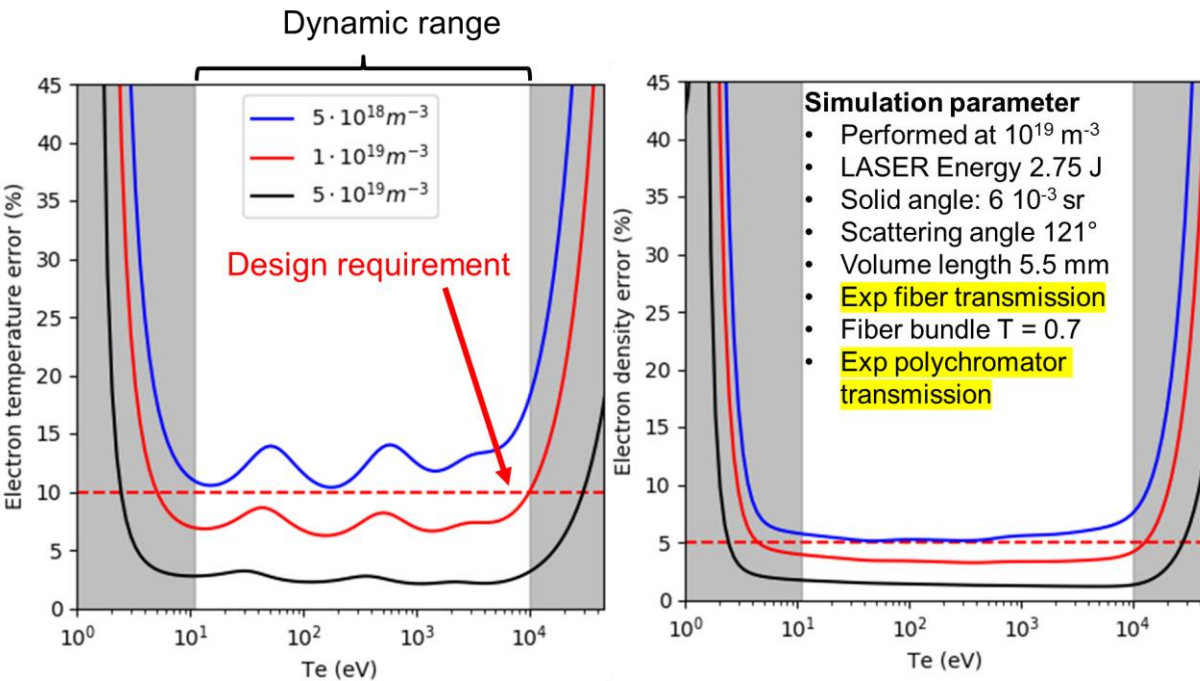
Optical transmission measurement using calibrated photodiode

✓ Noise level ≈ 5 mV @ 100 MHz bandwidth

✓ Bandwidth ≈ 50 MHz

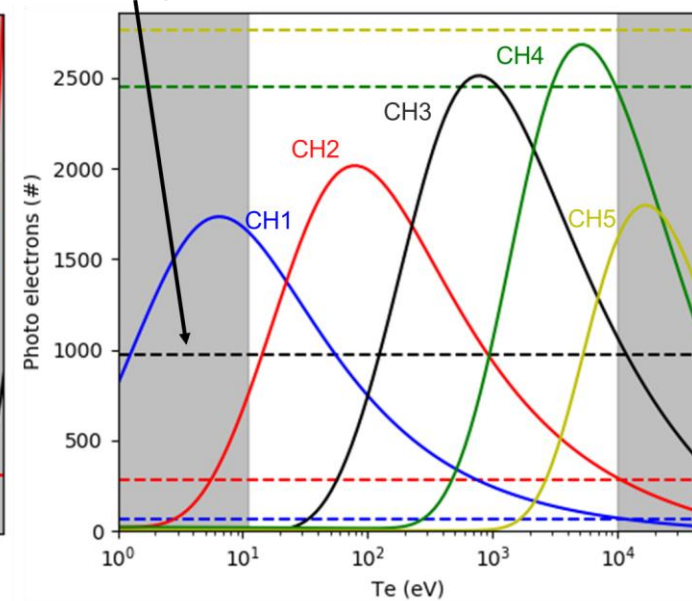
For more: poster #480 at 32th SOFT

Edge TS performance prediction



Plasma light intensity:

Uniform bremsstrahlung: View depth 2m,
Te in plasma 7.5 keV , $4 \cdot 10^{19} \text{ m}^{-3}$



Performance expectation met.
Reasonable performance can be expected down to 5 eV

Status procurement: summary

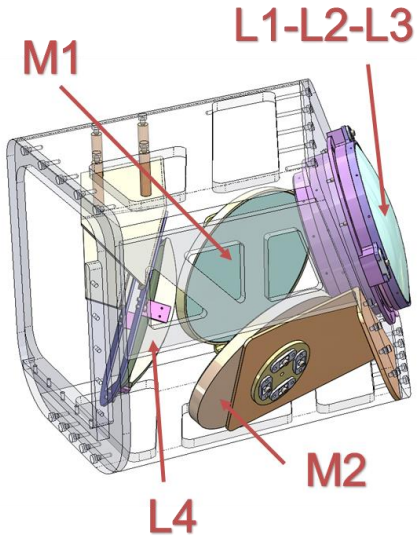


- **Annex B for PA:** Approved in Feb 2021 (<https://users.jt60sa.org/?uid=2A77BS>)
- **Fibers**
F4E procurement contract with **Polymicro-Molex** closed in October 2021.
Fiber delivered to QST. **Successfully concluded.** Fiber bundles under production by QST.
- **Polychromators**
F4E procurement contract with **GNR** (Italy) ongoing (KOM 03-11-2020):
Design passed test in November 2021 (uid=2CYP9J), **All polychromators aligned. 31 Polychromators are tested. Vibration test successfully completed.**
- **Optics edge TS (P1)**
Procurement contract with **Officina Stellare** (Italy) ongoing (KOM 24-11-2020):
design approved in April 2021 (uid=2A5UVQ), **First test performed in June 2022. Waiting new M1 mirror. acceptance test November 2022.**
- **Laser edge TS (P1)**
Procurement contract with LOS (Russia) ongoing: design report approved in **January 2022** (uid = 2D3BJH), components purchase ongoing, payments suspended until June. Risk to stop the contract losing Eurofusion budget: plan B-purchase in 2023 by F4E. **Installation (remote company participation) is expected by the first quarter 2023.**
- **Mechanics edge TS (P1)**
Pending drawings and installation procedure informally approved; Manufacturing **MKT** (Romania) of support structure ongoing; Contract for port plug with **forth engineering** signed **April 2022. Manufacturing ongoing.**

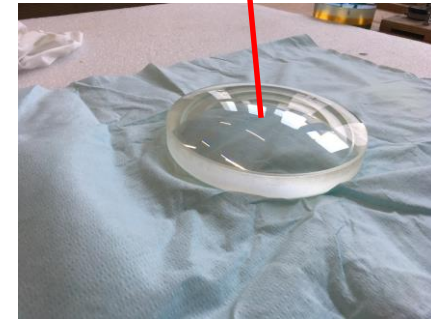


**Thank you for the
attention**

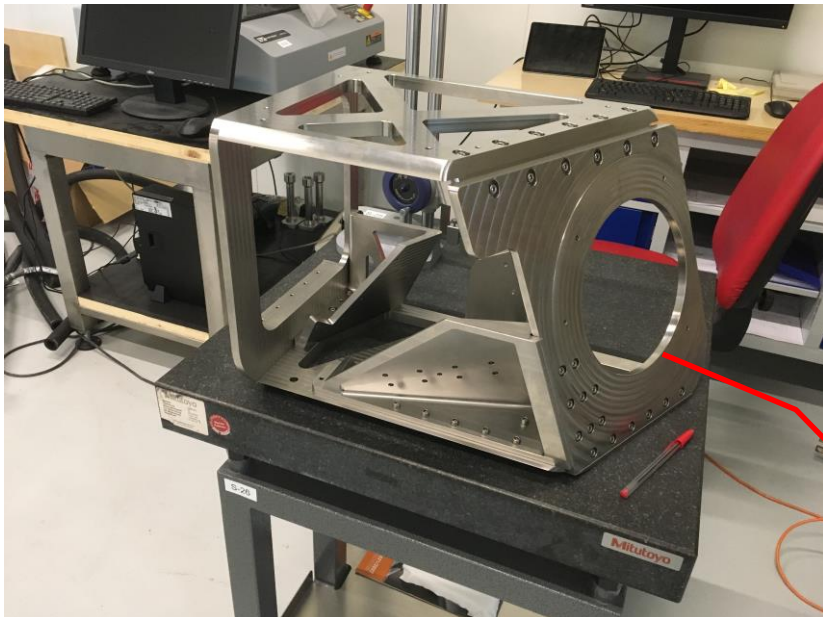
P1 collection optics



M2
dichroic

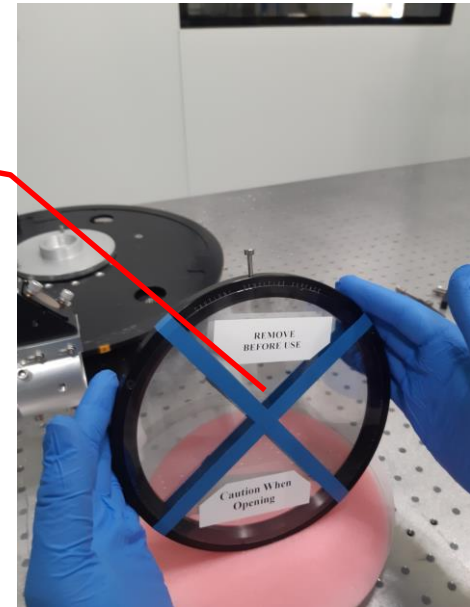


L2 before
coating



Main
structure

Polarizer



Optical Fibers: status - completed



- Fiber delivery to QST completed
- Fiber bundles under manufacturing by QST

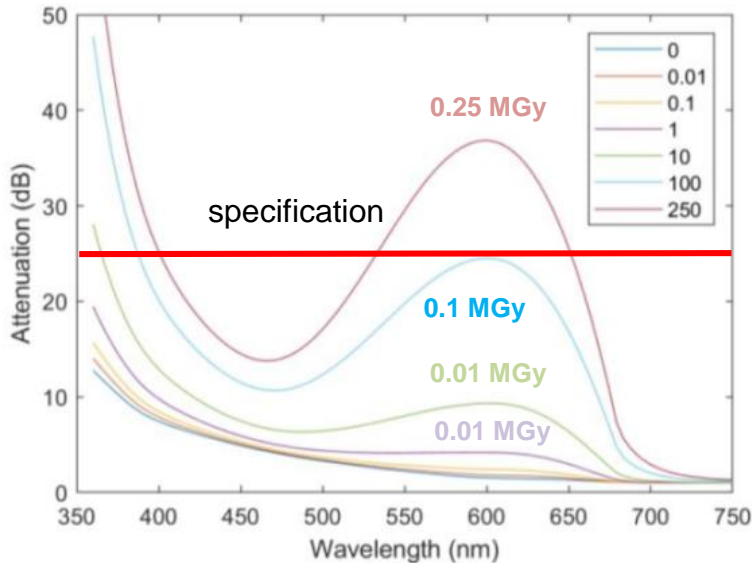
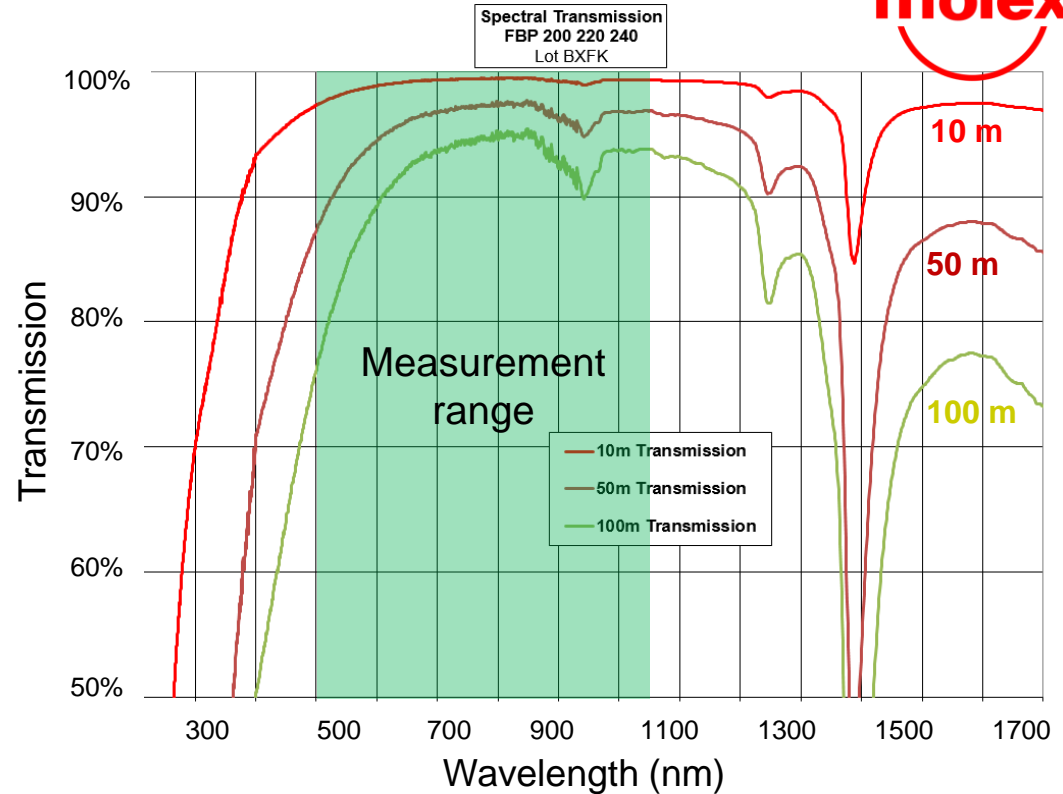


Figure 1: Radiation-induced attenuation in a 200-m fiber irradiated over 10 m, for various doses in kGy.



| Attenuation dB/m@600nm | FBP |
|---------------------------|-----|
| 0.1 | 0.2 |
| 1 | 0.4 |
| 10 | 0.9 |
| 100 | 2.4 |

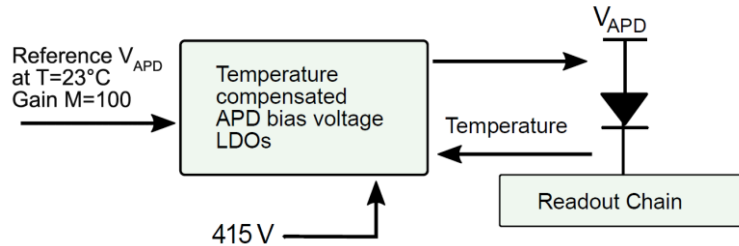
SPECIFICATION

- Silica core / fluorine silica cladding / polyimide coating (max T=150°C)
- 200/220/250 micron
- 0.22 NA
- **1100 km → 1200 km**
- Neutron dose: 0.13 MGy (10^{16} n/cm²)

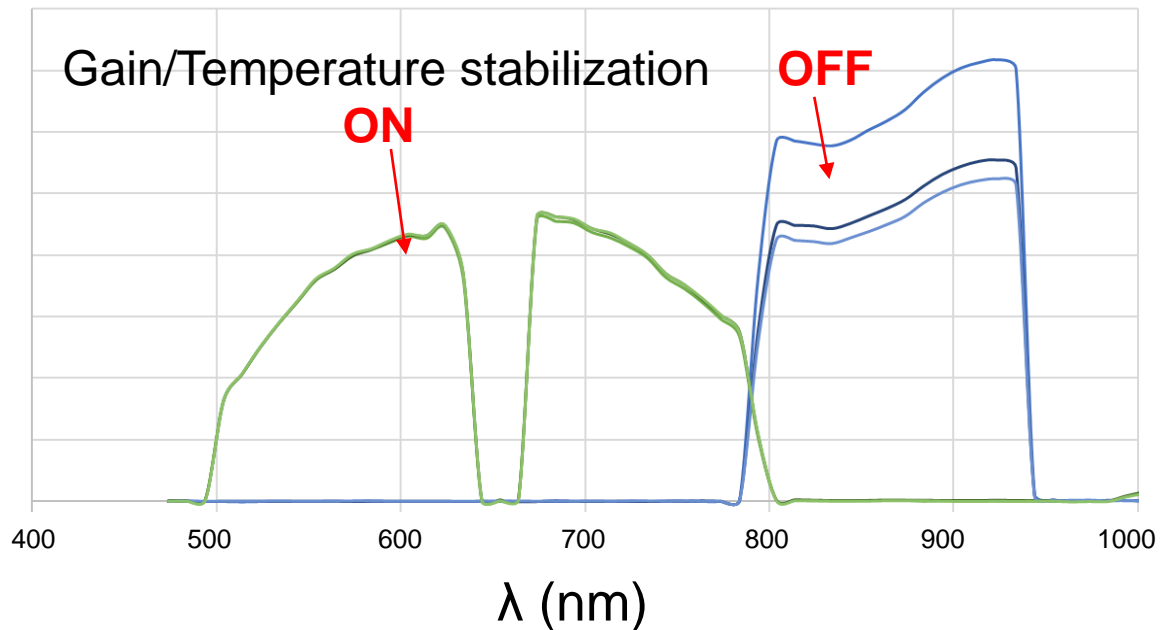
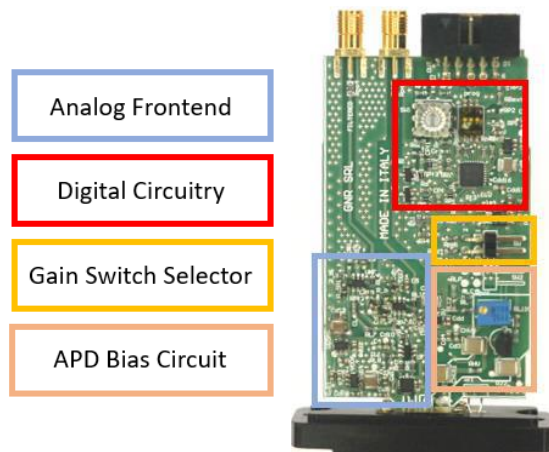
Polychromators test



Detector gain stabilization



APD bias voltage is real-time tuned to compensate gain drift with temperature



Polychromators assebyly

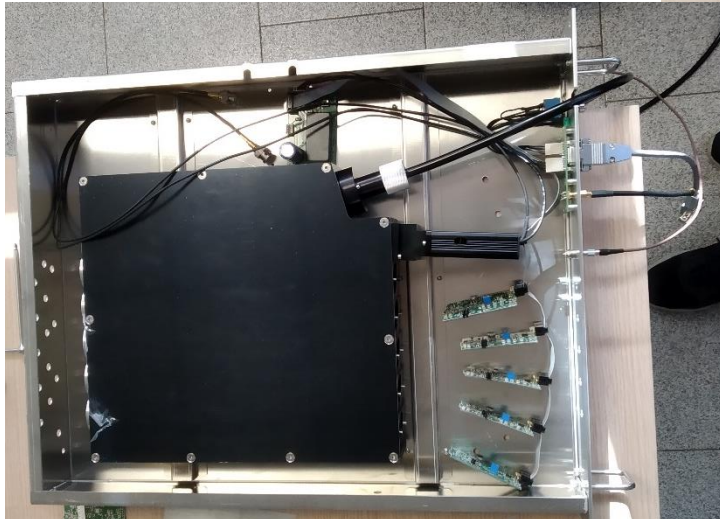


16 Polychromator Box assembled

Polychromator operational P1.01,P1.04 and P2.01



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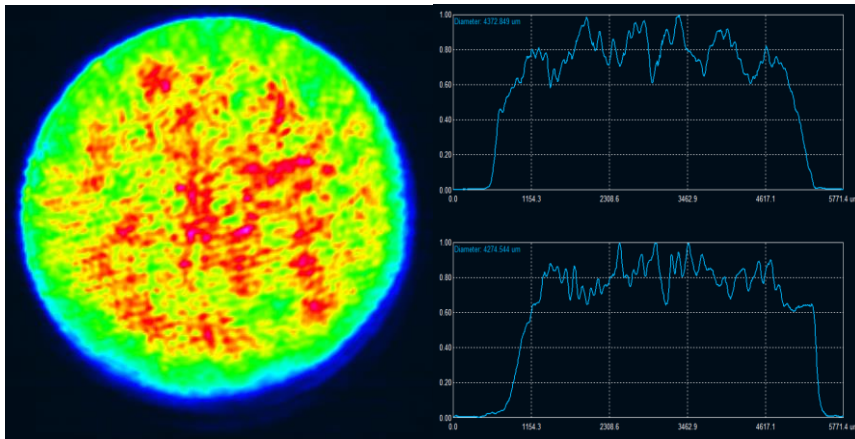
Inspection & acceptance tests 22-23 November 2021

Nd:YAG laser system for JT-60SA TS diagnostic

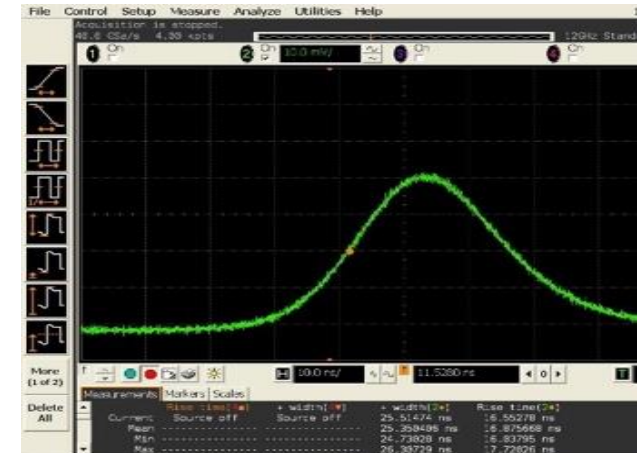


Experimental prototyping of Master Oscillator and Amplifier

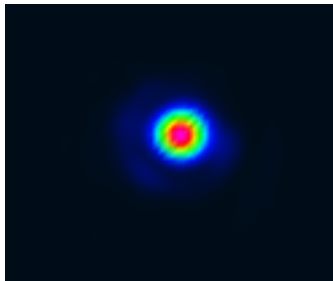
Near field of the Laser ($E=3J$, 100Hz)



Master Oscillator Pulse

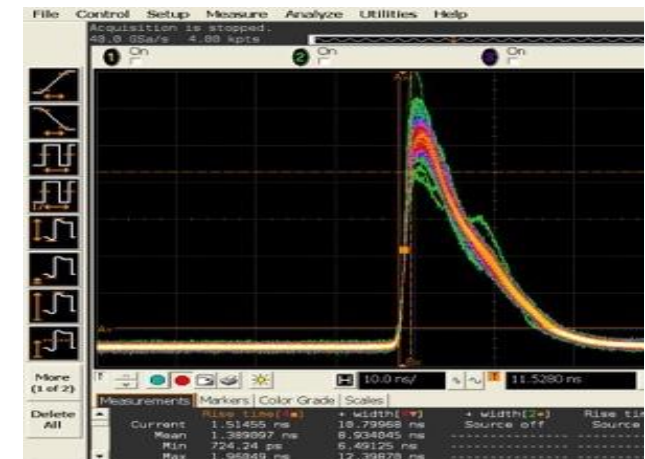


Far field of the Laser ($E=3J$, 100Hz)



Spot in the far field $< 2 \times DL$

Pulse Shape at Output Energy $E=3J$



Experimental prototyping has shown that the characteristics of the laser system will meet the Technical Specifications

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P1 mechanical structure



Support structure manufacturing started

