



# JT60-SA - WPSA GM

## Thomson scattering status

### 04-05-2022

**Federico D'Isa**

**for the EU-TS team**



This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.

# Performance requirements

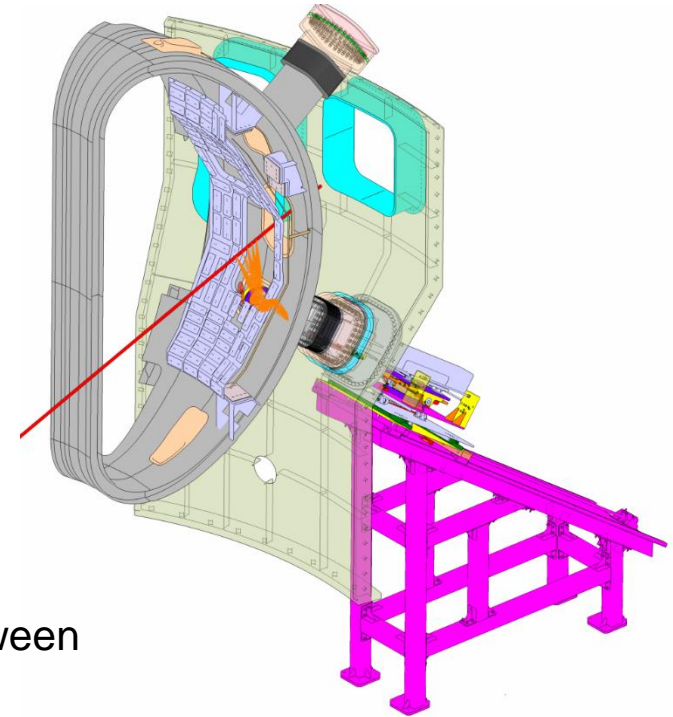


**The core TS system (P2)** shall measure  $T_e$  and  $n_e$  profiles

- **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



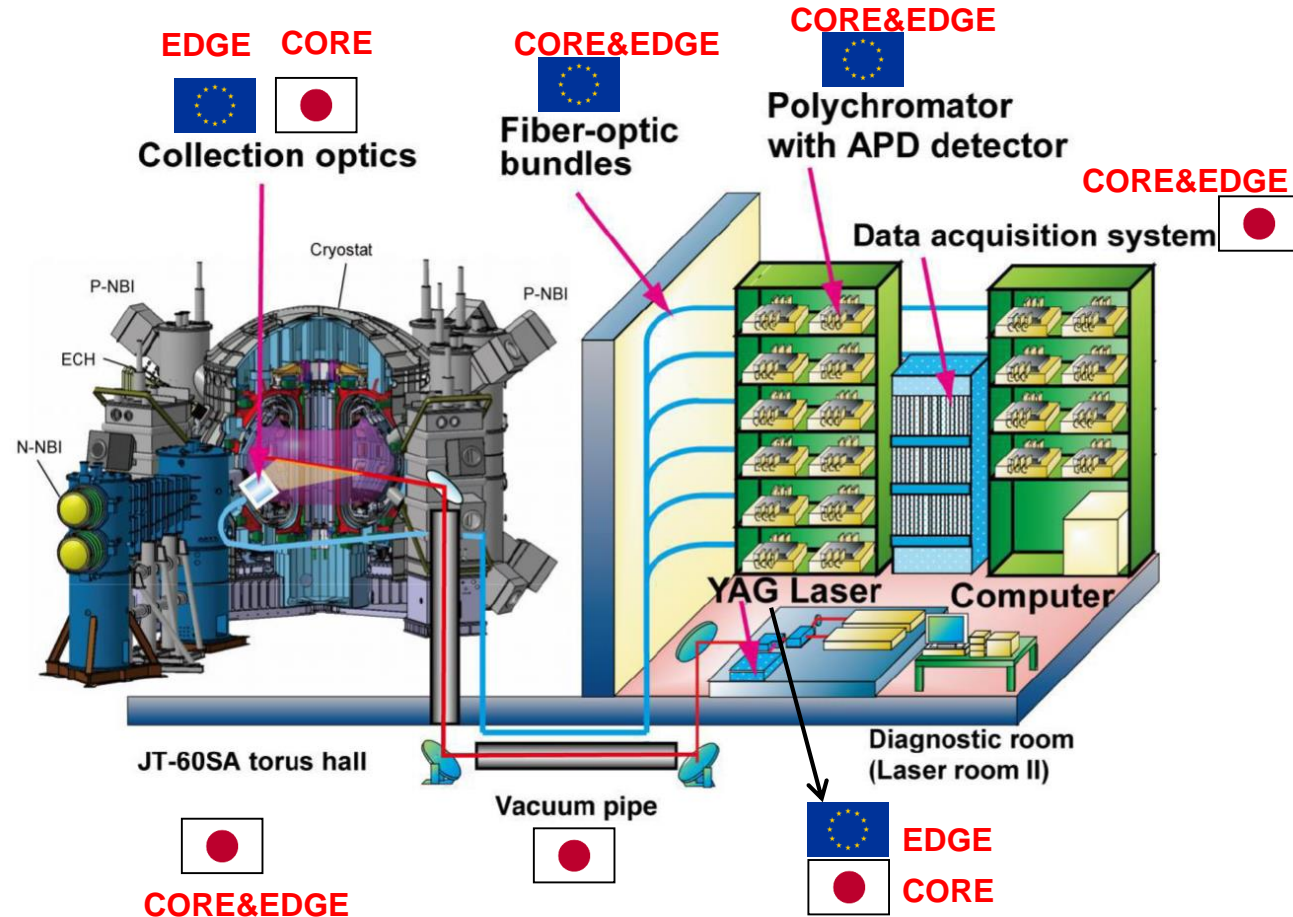
## EU components

### Core TS components:

- Optical fiber
- Polychromators

### Edge TS components:

- Optical fiber
- Polychromators
- LASER
- Collection optics



 Edge TS
 
  
 scientific exploitation

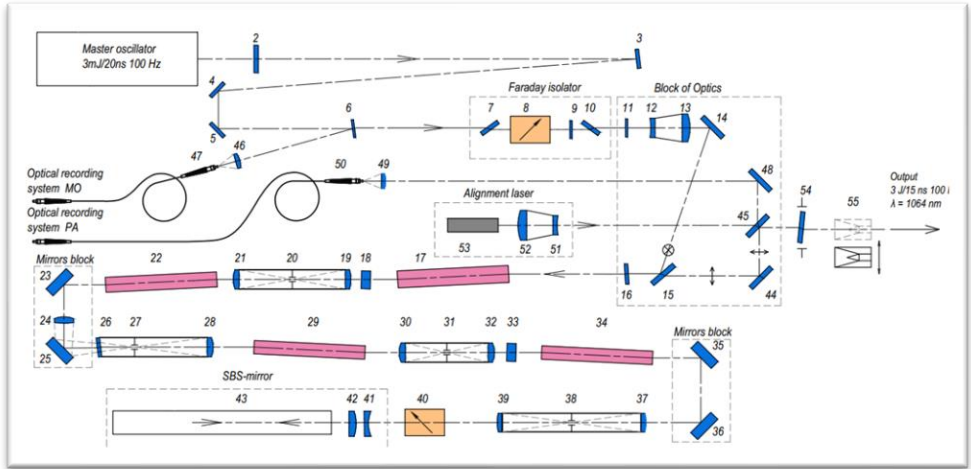
# Laser system: status



## 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

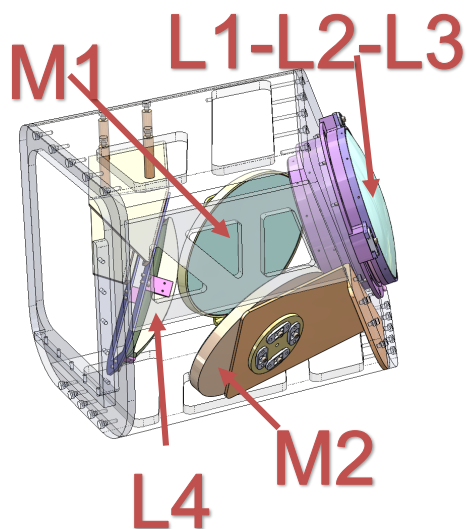
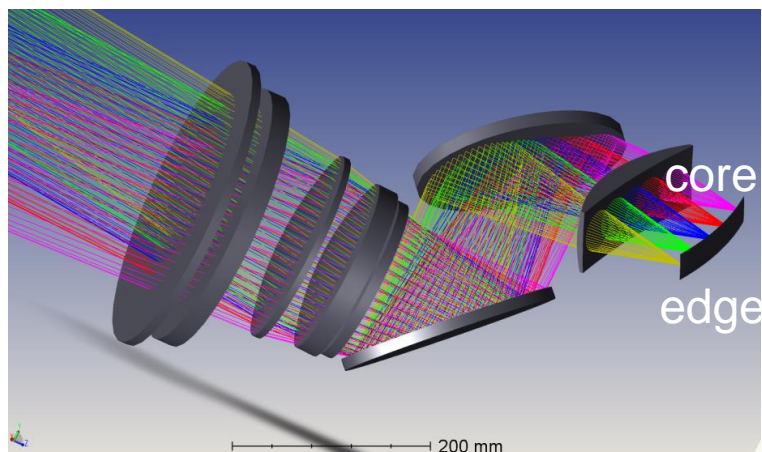
- Design documentation ready
- Assembly ongoing
- Payments suspended until June
- Contract still valid
- If there are export issues f4e may procure a commercial laser.



# P1 collection optics: status



## Status of procurement



- Mechanical parts procured and available in Officina Stellare (OS);
- L1 procured and available in OS
- L2 delivered at the end of April
- L3 procured and available in OS
- L4 procured and available in OS
- Polarizers procured and available in OS
- M1 and M2 (Dichroic mirrors) procured:
  - M1 ready at the end of August
  - M2 available in OS
- Windows: delivery expected by mid May. Coating by end of August.
- Preliminary tests: first and second week of June



# P1 mechanical structure: status



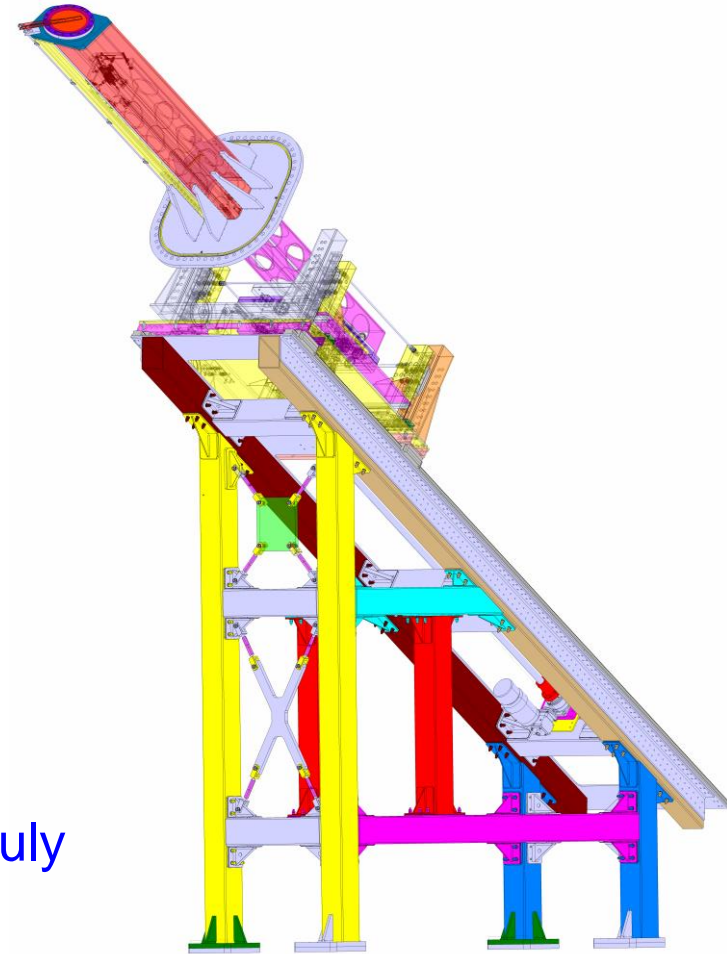
- Collection optics on a retractable arm
- Decoupled from cryostat
- On supporting structure standing on floor
- Same structure to install port plug

## Status of procurement

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

## Production

- Support Structure & Trolley (contract signed July 2021): manufacturing in progress.
- Port plug assigned to Forth engineering (Contract signed April 2022). Components available and ready to order.



# Optical Fibers: status - completed



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

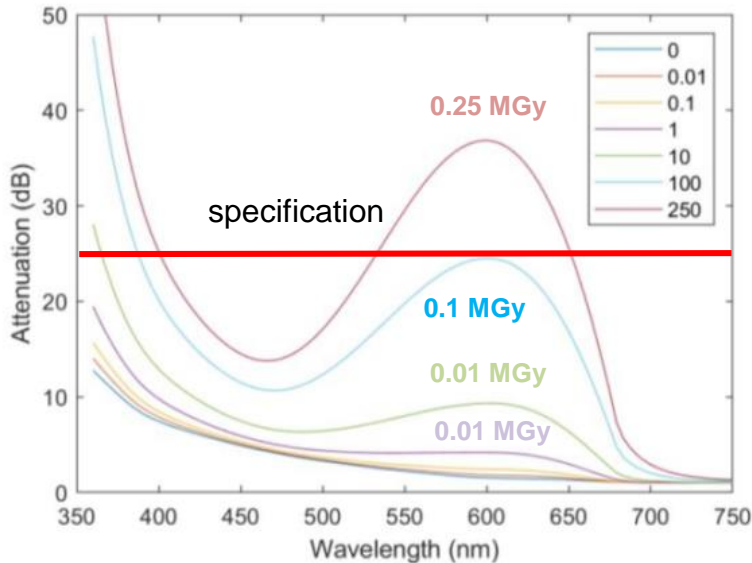
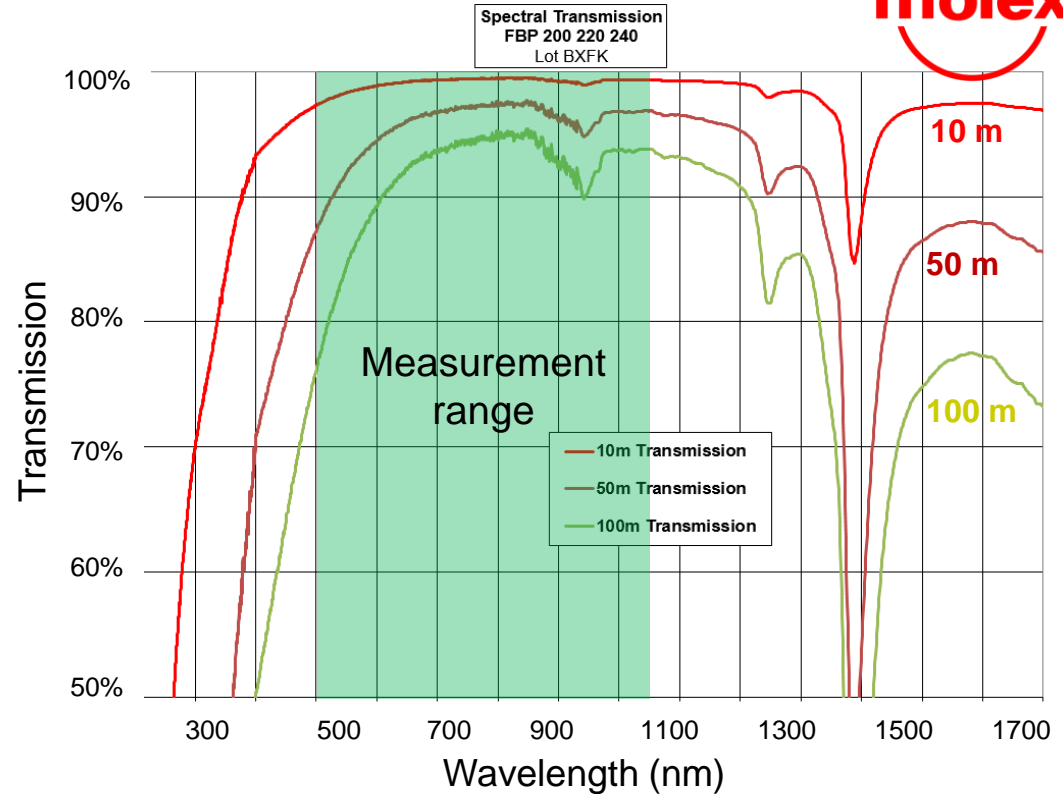


Figure 1: Radiation-induced attenuation in a 200-m fiber irradiated over 10 m, for various doses in kGy.



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

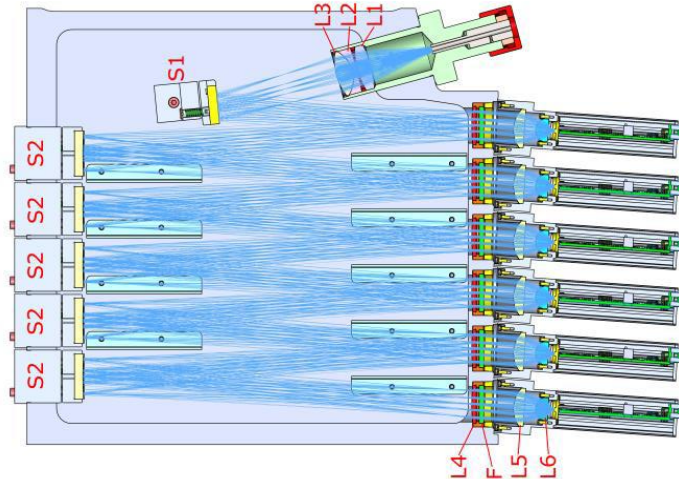
## SPECIFICATION

- 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/cm<sup>2</sup>)

# Polychromators: status



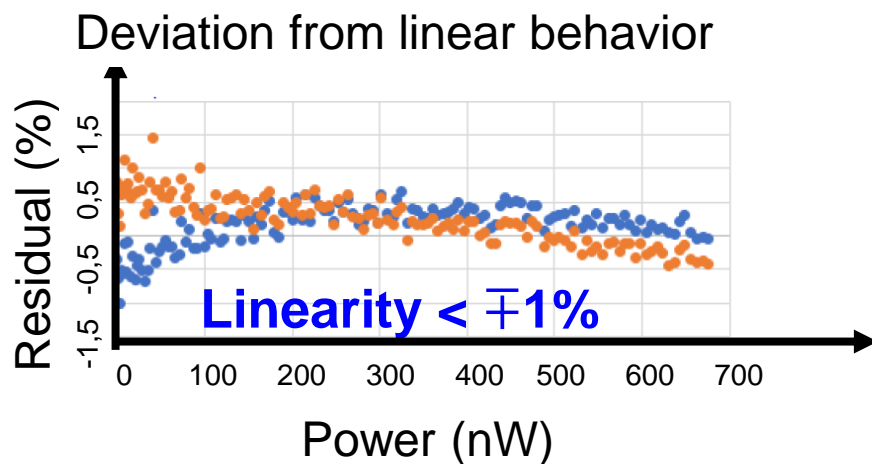
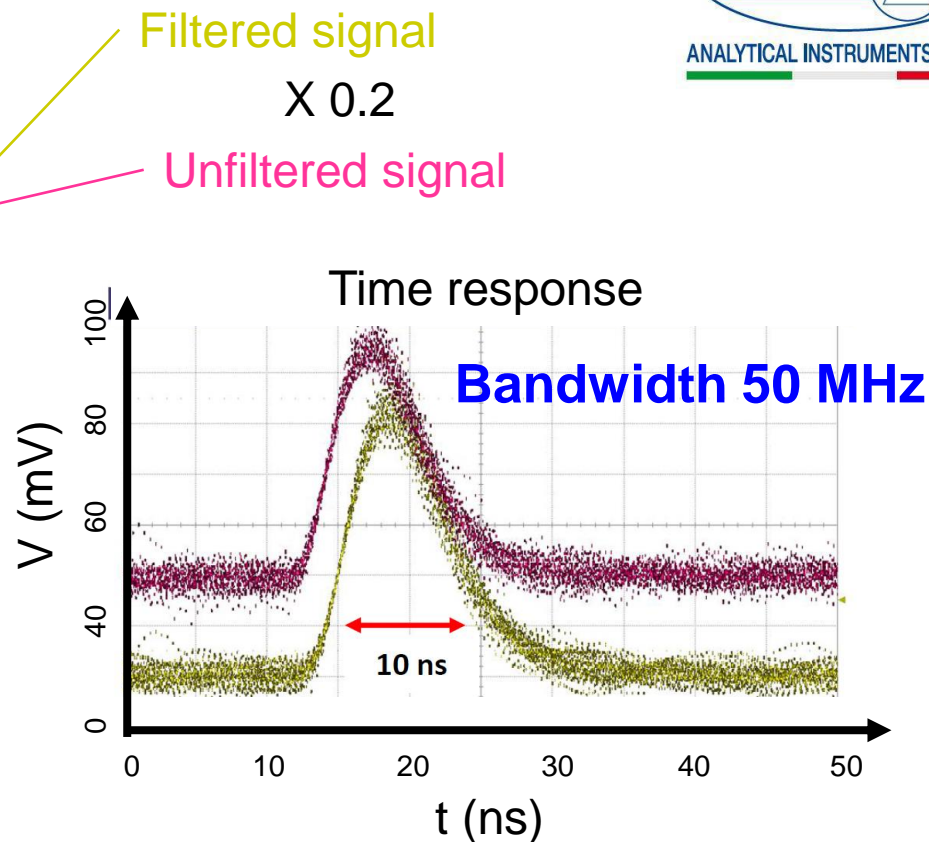
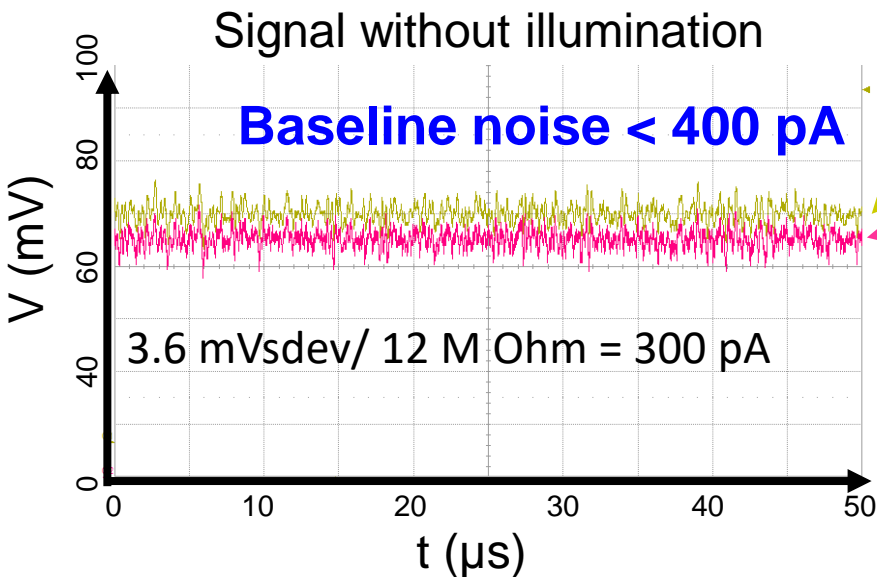
ANALYTICAL INSTRUMENTS GROUP



- Preliminary test successfully passed in November 2021
- mechanical elements: procured and delivered
- Lens/Filter/Mirror procured and available in GNR
- Assembly and alignment: 16 Box ready, works completed at end of May
- APD: procured and available at GNR
- Electronic circuit elements: all purchased and available at supplier.
- Electronic boards: 50 assembled. Others in production.



# Polychromators test: detector characteristics



Inspection & acceptance tests 22-23 November 2021

# Polychromators test



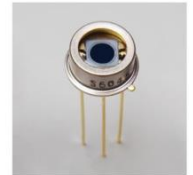
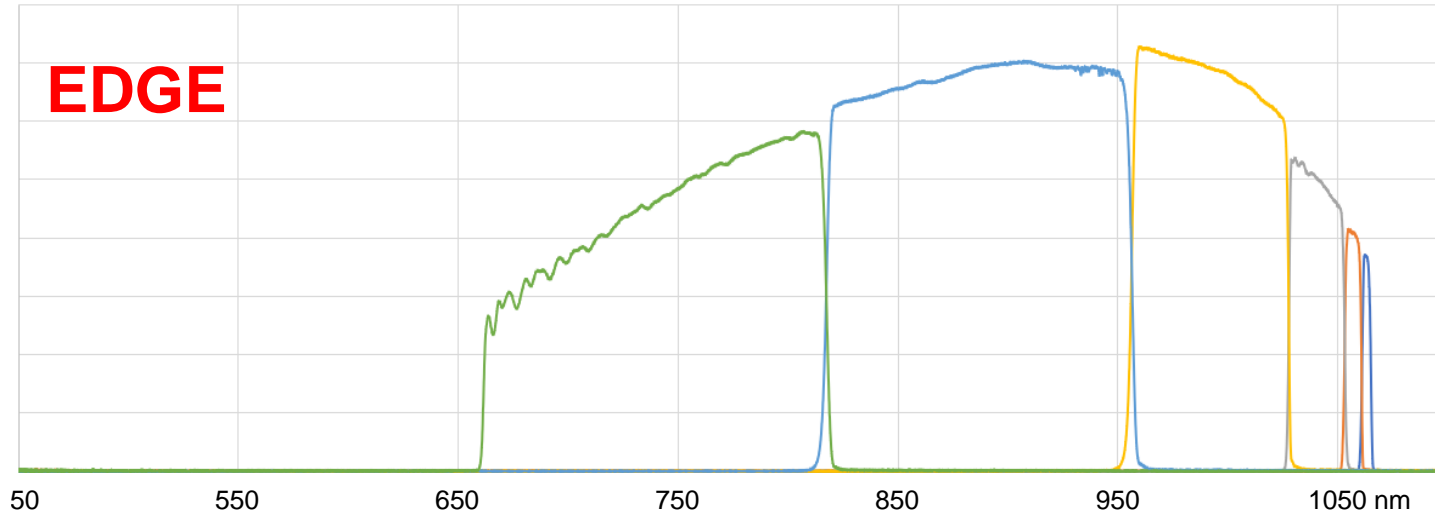
P1.1 Gain = 48 MΩ



ANALYTICAL INSTRUMENTS GROUP

Spectral response (V/W)

**EDGE**

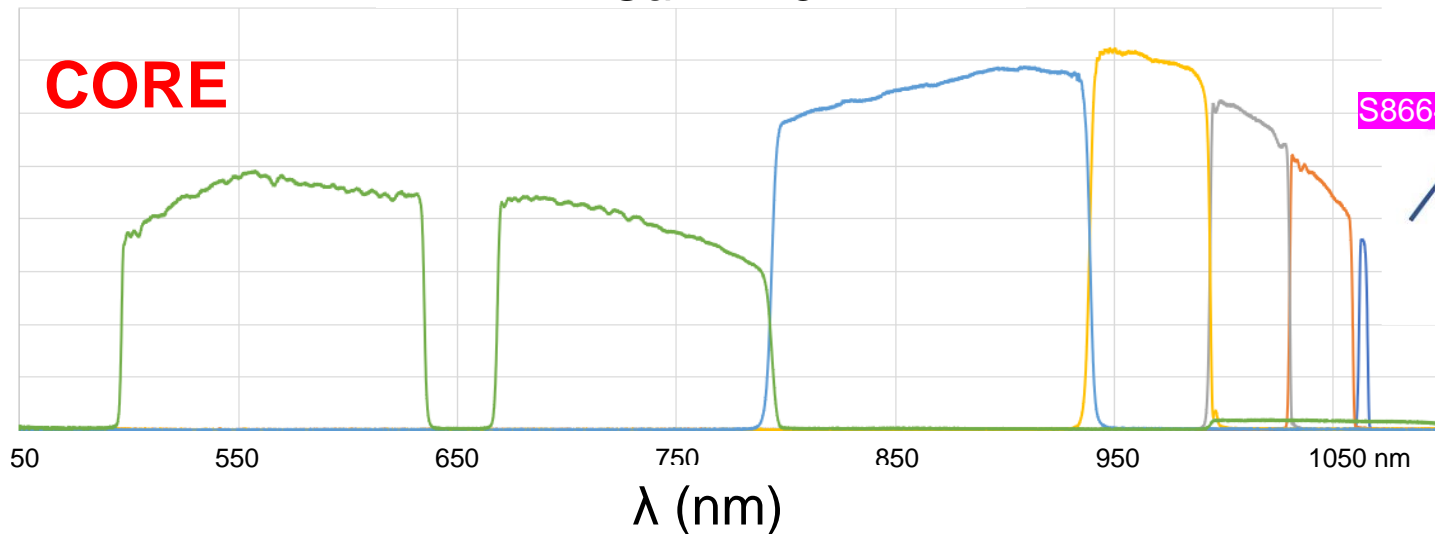


HAMAMATSU S8664-20  
better spectral response and lower dark noise

P2.1 Gain = 48 MΩ

Spectral response (V/W)

**CORE**



Spectral response (M=100, Ta=25 °C, typ)



S8664-20

S15995-30

λ (nm)

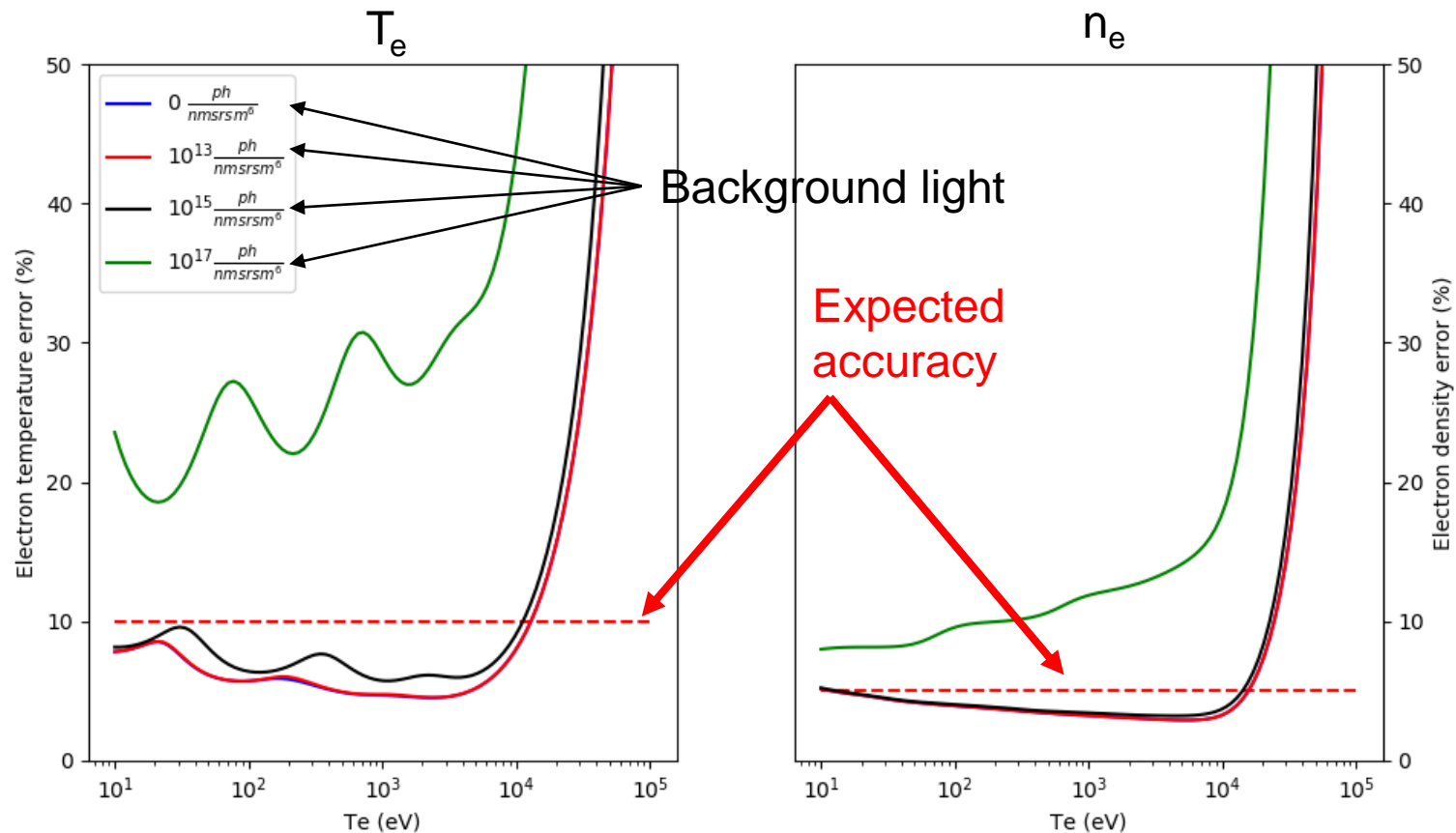
Inspection & acceptance tests 22-23 November 2021

# Edge TS performance prediction



Simulation including:

- Polychromator experimental transmission
- Fiber experimental transmission
- Optics experimental transmission



Expected performance met

# 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 components are procured. 16 Polychromator are assembled.**
- **Optics edge TS (P1)**  
Procurement contract with **Officina Stellare** (Italy) ongoing (KOM 24-11-2020):  
design approved in April 2021 (uid=2A5UVQ), **assembly in progress (issues with M1 and L2), test to start first week of June.**
- **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.
- **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.** Raw materials being purchased.

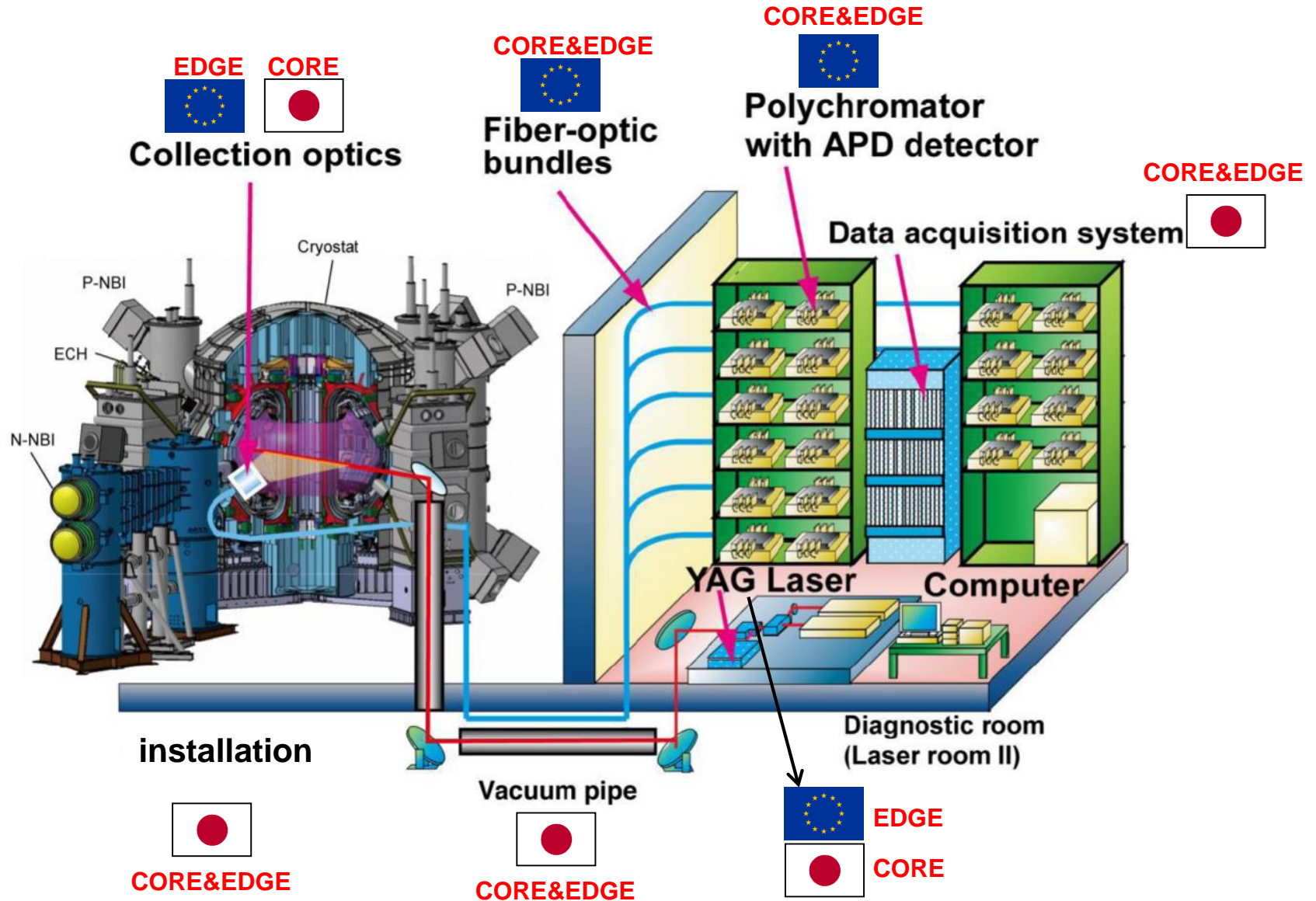




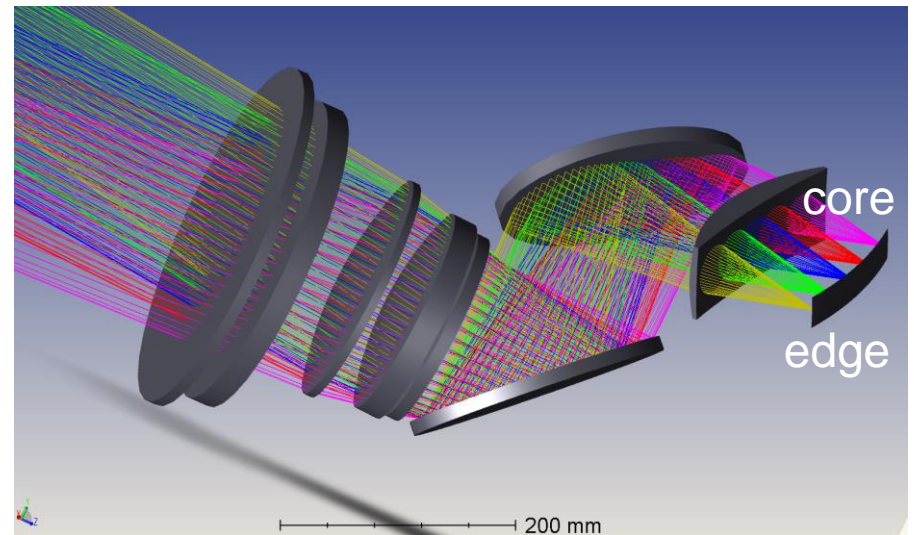
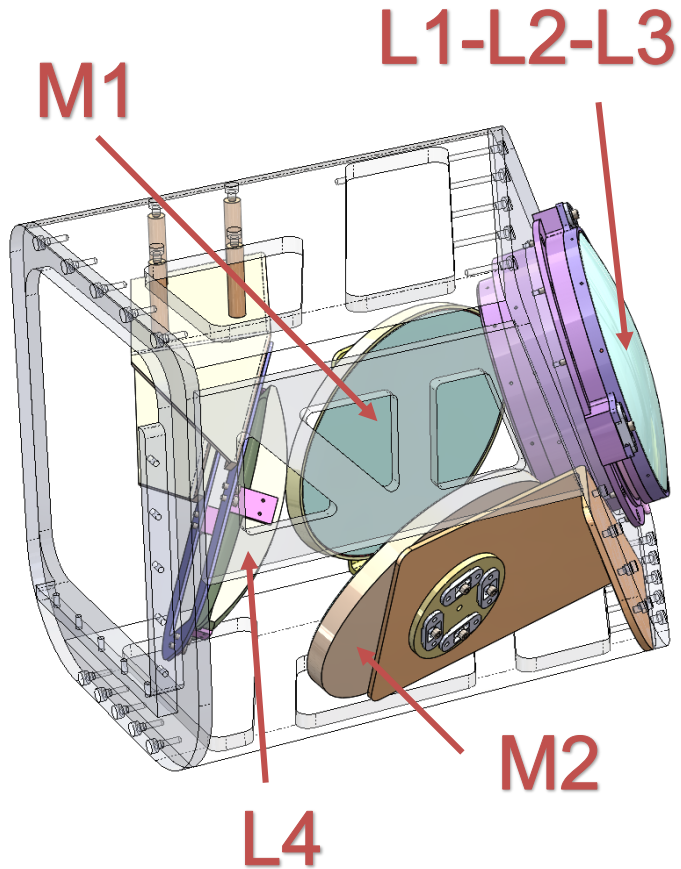


**Thank you for the  
attention**

# TS diagnostics layout in JT60-SA

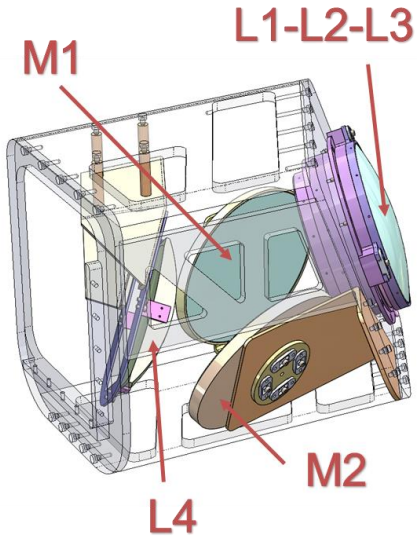


# P1 collection optics

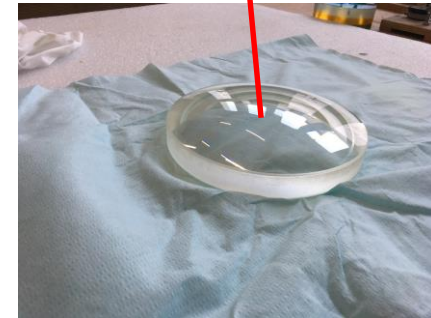


Final Design review: February 2021

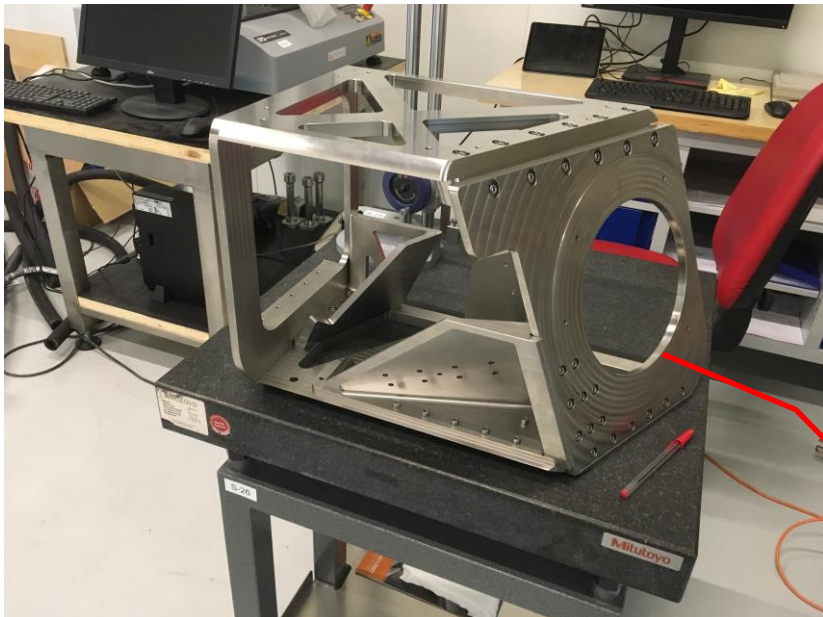
# P1 collection optics



M2  
dichroic

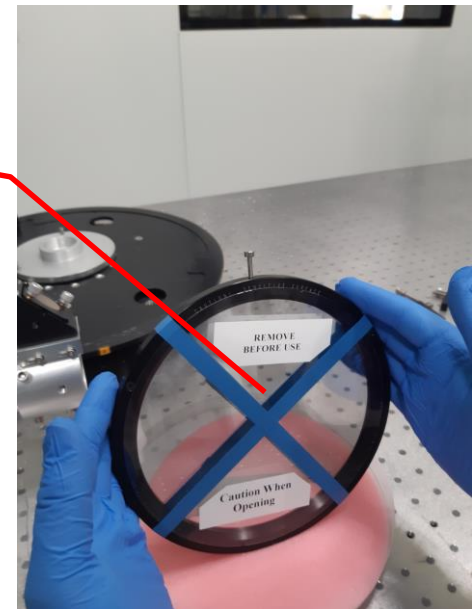


L2 before  
coating



Main  
structure

Polarizer

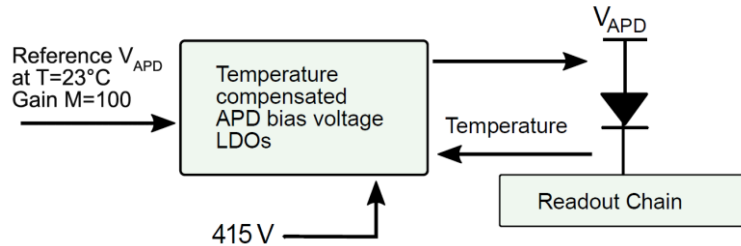




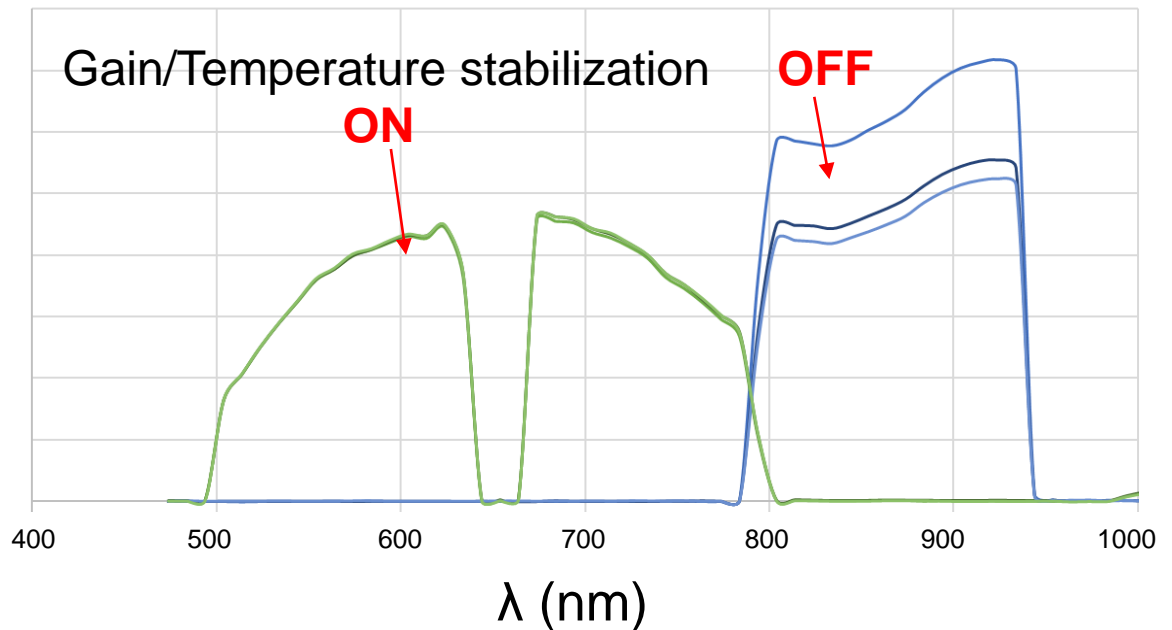
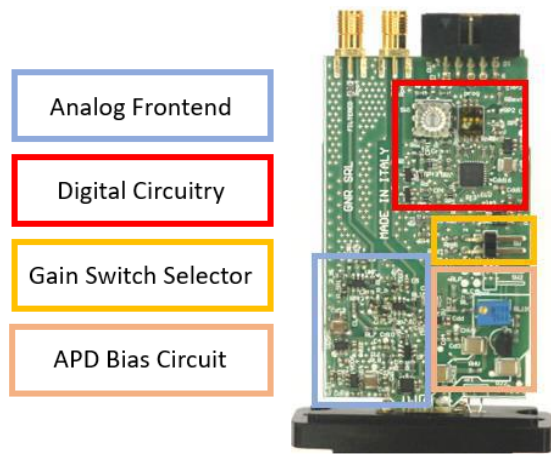
# Polychromators test



## Detector gain stabilization



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



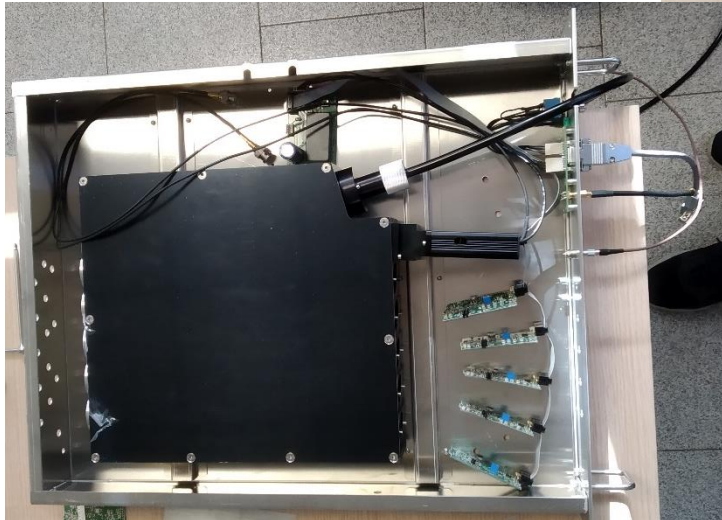


# Polychromators assebley



## 16 Polychromator Box assembled

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



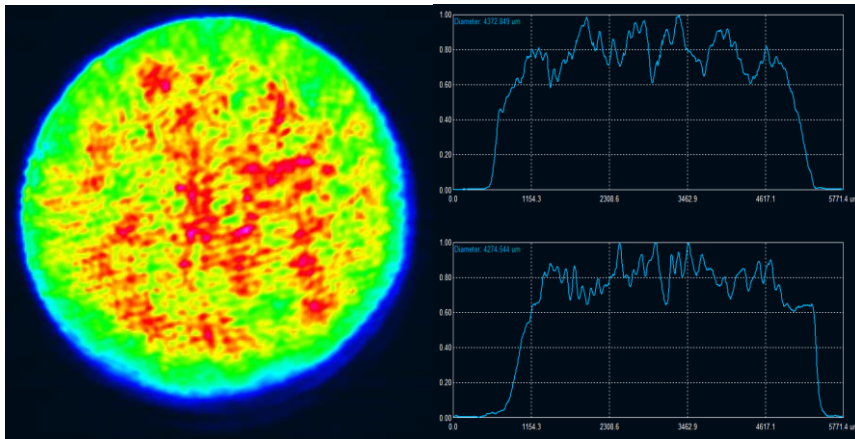
Inspection & acceptance tests 22-23 November 2021

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

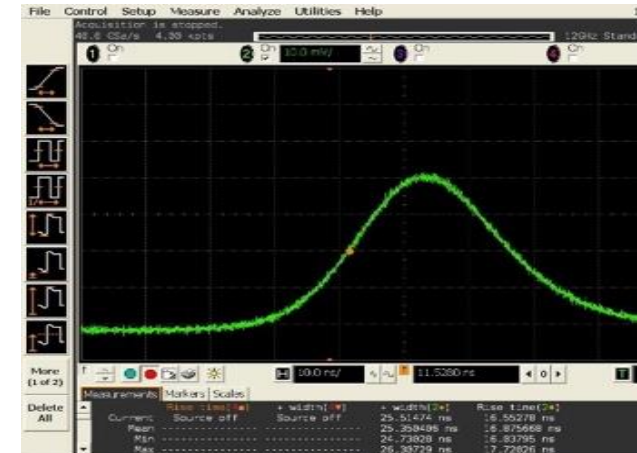


Experimental prototyping of Master Oscillator and Amplifier

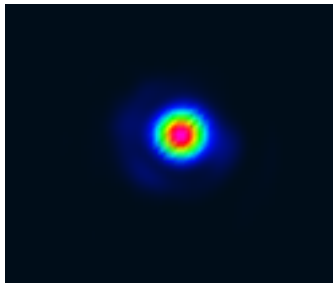
Near field of the Laser ( $E=3J$ , 100Hz)



Master Oscillator Pulse

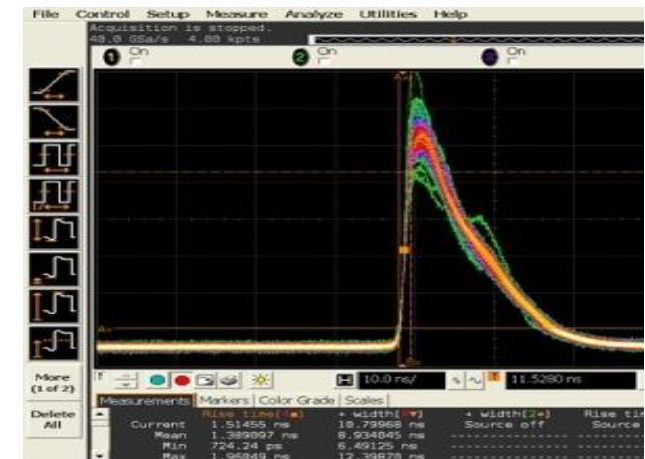


Far field of the Laser ( $E=3J$ , 100Hz)



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

Contacts: **Aleksei Kornev** [afkornev@hotmail.com](mailto:afkornev@hotmail.com)



# P1 mechanical structure



Support structure manufacturing started

