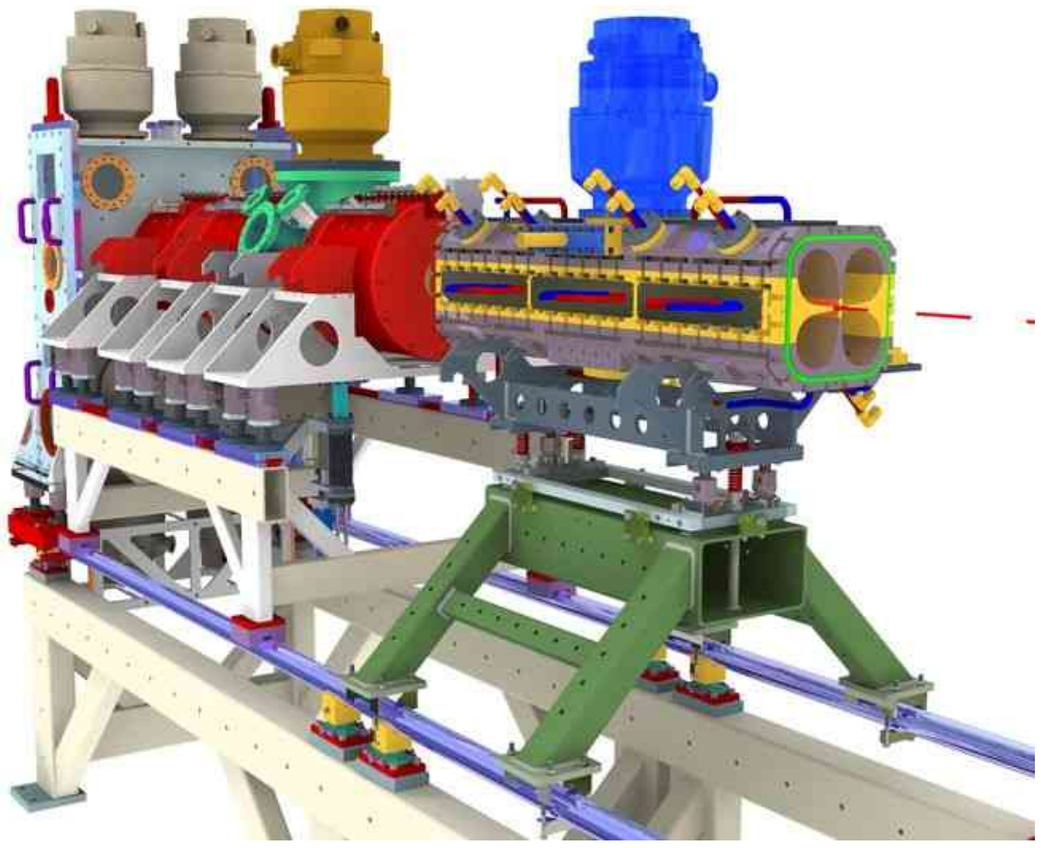
FETS Laserwire Emittance Scanner Status and Plans

on behalf of
C. Gabor, A. Letchford - STFC RAL
J. Pozimski, P Savage – Imperial College
G. Boorman, A. Bosco, S. Emery, S. Gibson – RHUL

FETS Meeting, RAL
3/07/2013

Outline

- Fibre pulling and tests.
- Opto/mechanical assembly
- CAD design
- Integration with Linac4/CERN.
- Project safety plan
- Schedule



Summary of progress

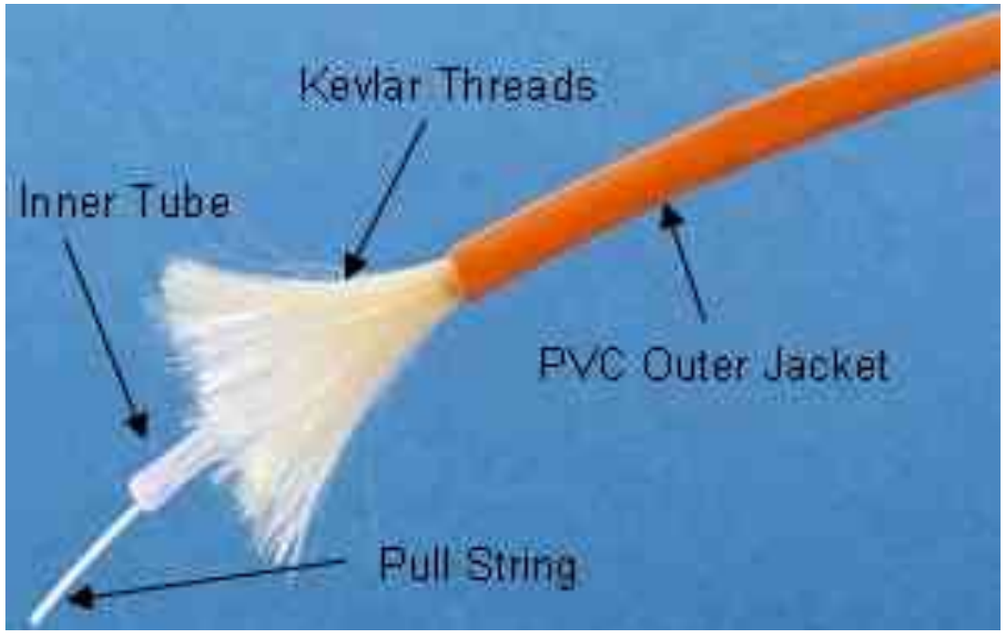
- Since the last presented update in May, all components have been delivered to RAL and brought to RHUL for assembly and test.

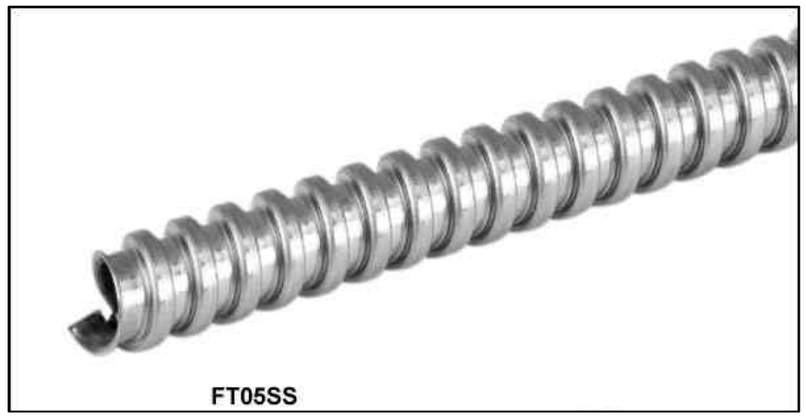
Main activities this month:

- Fibre pulling
  - 100m bare fibre pulled through furcation tube and armoured cable.
  - Fibre continuity checked.
  - Fibre connectorised and polishing ongoing.
- Beam delivery optics and translation stages assembled
  - Brackets for stages manufactured
  - Fibre holders, beam expander and base board assembled.
  - Drawings sent to P. Savage and CAD model kindly produced.
- Translation stage control software written (G. Boorman) and initial tests performed (S. Emery / A Bosco).
- Main enclosure / box designed and under manufacture in RHUL workshop.

Pulling the optical fibre

- Nufern Large Mode Area Fibre
  - 20um core (not quite single mode)
  - 125um cladding
  - 250um buffer
- Furcation tube:
  - Ø 3.0 mm outer PVC jacket
  - Kevlar threads
  - Polypropylene inner fibre tube
- Stain steel protective tubing.
  - Ø 5.0 ± 0.2 mm outer diameter
  - Ø 3.5 mm inner diameter.
  - No pull thread!
- Challenge to pull fibre + interlock wire in to furcation tube then into steel tubing ~100m long, with+/- 0.25mm clearance! Need a straight route…





Installation route: 100m straight

Get directions | My places

A Unknown road

B Unknown road

Add Destination - Show options

GET DIRECTIONS

Suggested routes

Route	331 ft, 16 secs
Or Walk	1 mi

Driving directions to Unknown road

This route has restricted usage or private roads.

Unknown road

1. Head **southwest**
Restricted usage road

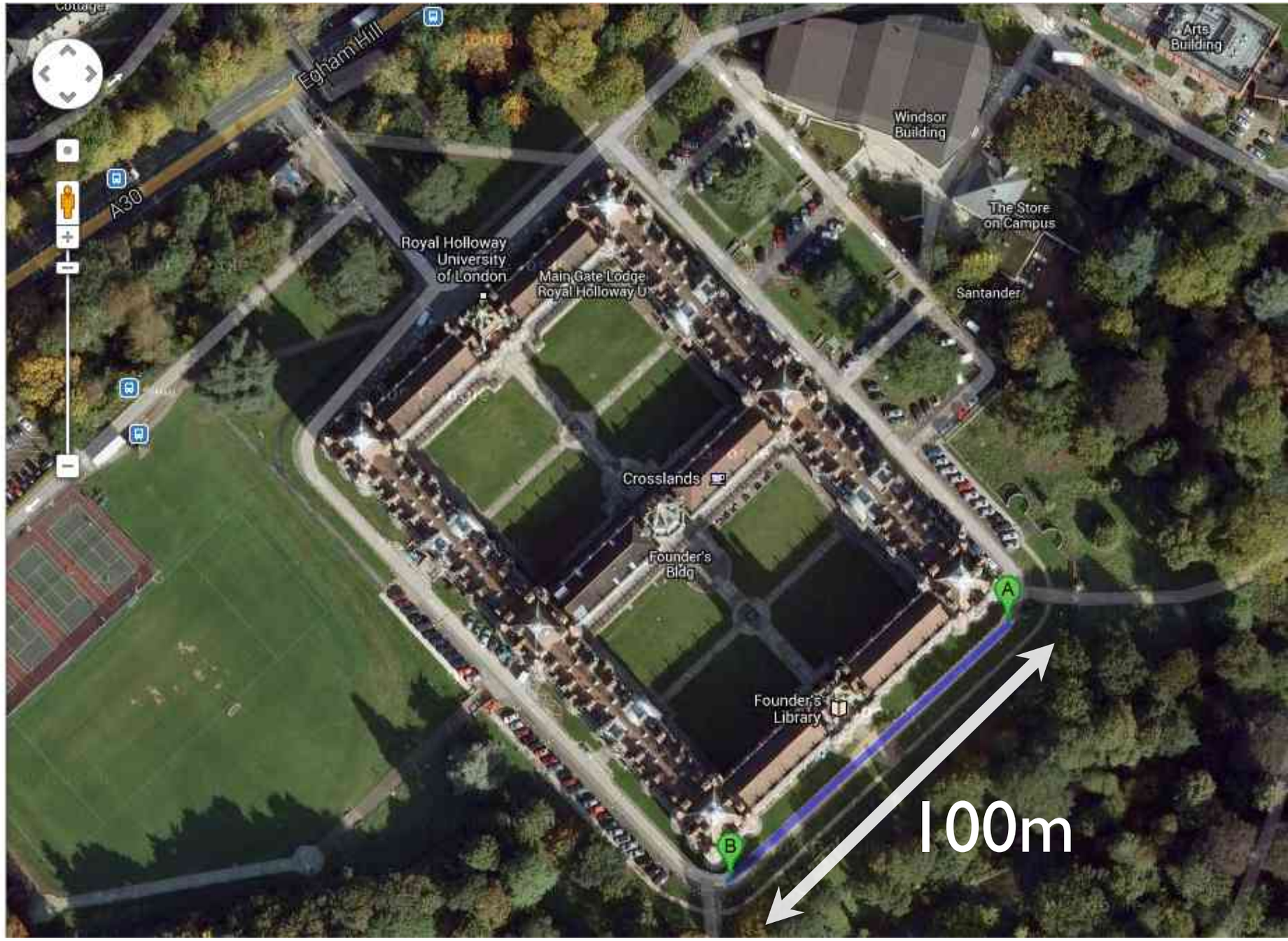
331 ft

Unknown road

Save to My Maps Est. fuel cost: £0.02

These directions are for planning purposes only. You may find that construction projects, traffic, weather, or other events may cause conditions to differ from the map results, and you should plan your route accordingly. You must obey all signs or notices regarding your route.

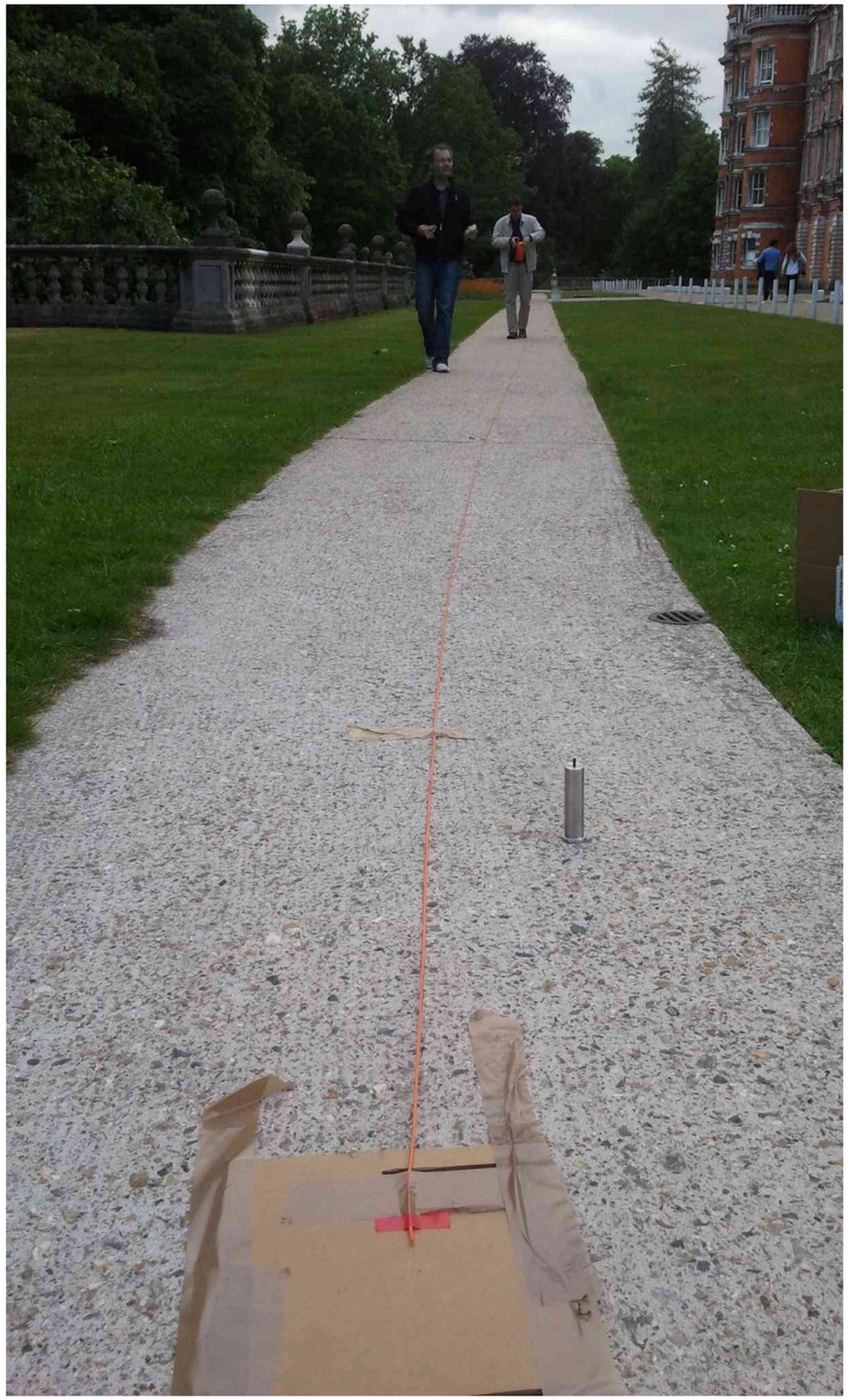
Map data ©2013 Google



- RHUL Founders Building is the ideal length!

Laying out the furcation tube

Pulling the fibre



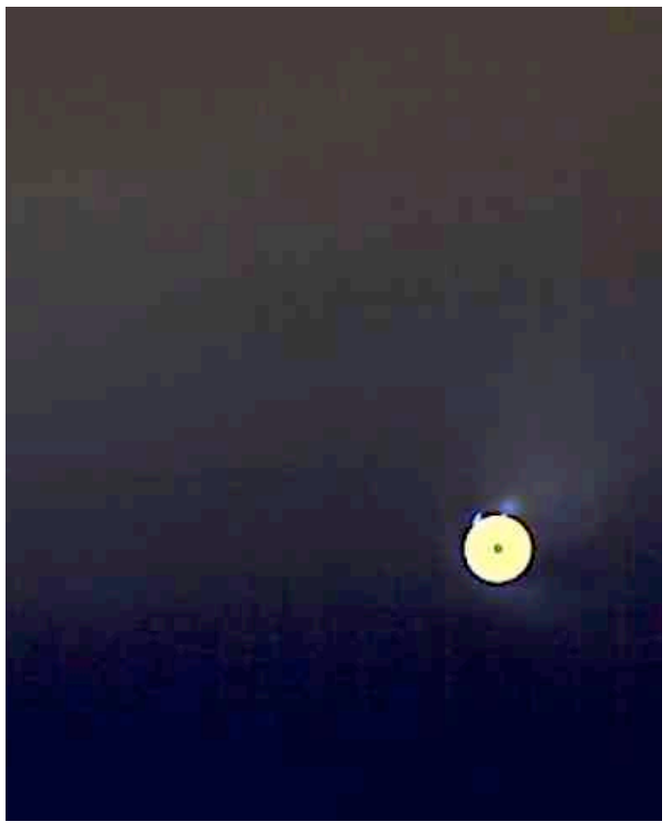
Pulling the fibre

Armoured cable

- Pulling the bare fibre into the furcation tube was relatively easy, using the pull string.
- The challenge was to pull the furcaton tube into the steel tube, with only 0.25mm clearance and no pull string installed in the tube!
- First used a S shaped wire + tool to pull through 100m of fishing line (rated to 15lb).
- Then pulled through the furcation tube with fishing line, while checking length of snags.

Basic continuity test

- After the strain of pulling the fibre through the tube and armoured cable, the fibre was checked for continuity
- One fibre end illuminated with white light and the image of the far end recorded with a camera:
- It passes light! White light is coupled via the fibre cladding.



Connector polishing

- Bare fibre connectorised with stainless steel ferules and at both ends and polished with progressively finer grades of lapping film.

30126G2
FC/PC with Stainless Steel Ferrule

- Polishing Pucks for 5 Different Connector or Ferrule Types
- Diamond and Aluminum Oxide / Silicon Carbide Lapping Film
- Glass Polishing Plate and Rubber Polishing Pad

D50-F
Ferrule
Polishing Puck

D50-FC/APC
Polishing Disk

D50-FC
Polishing Disk

For Ceramic Ferrules

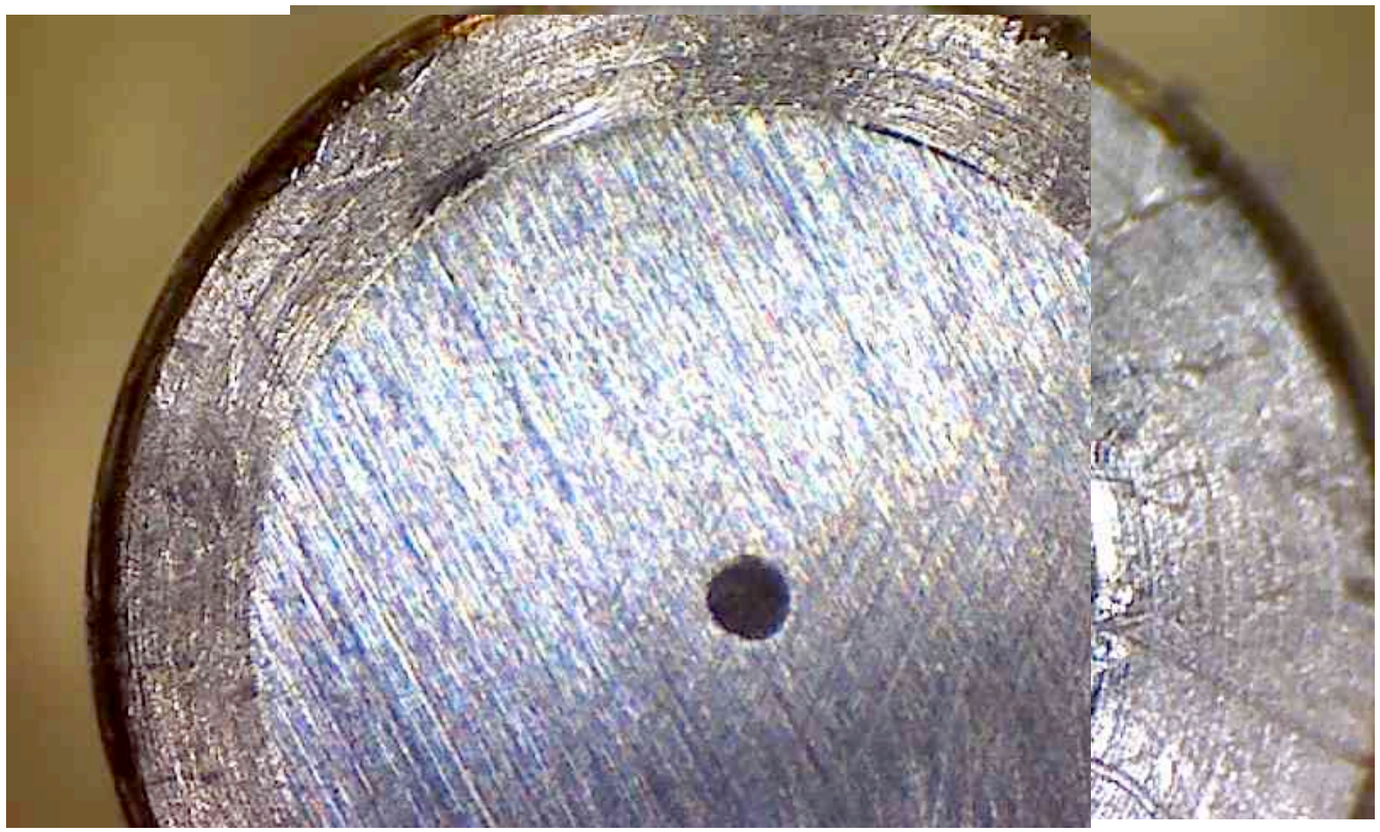
NRS913
Polishing Pad

Connector Polishing

Fibre end unpolished

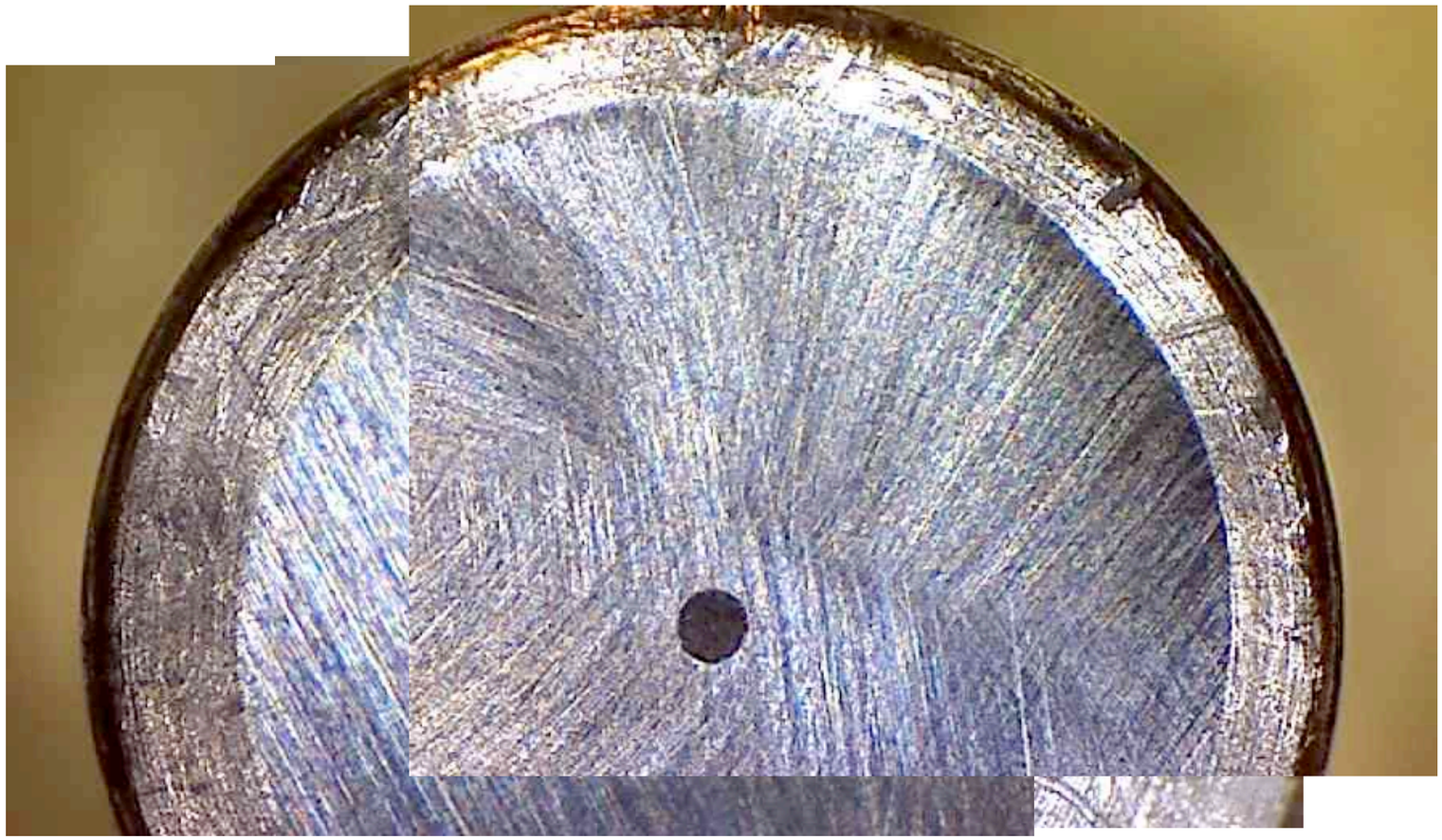
Connector Polishing

6 μm step



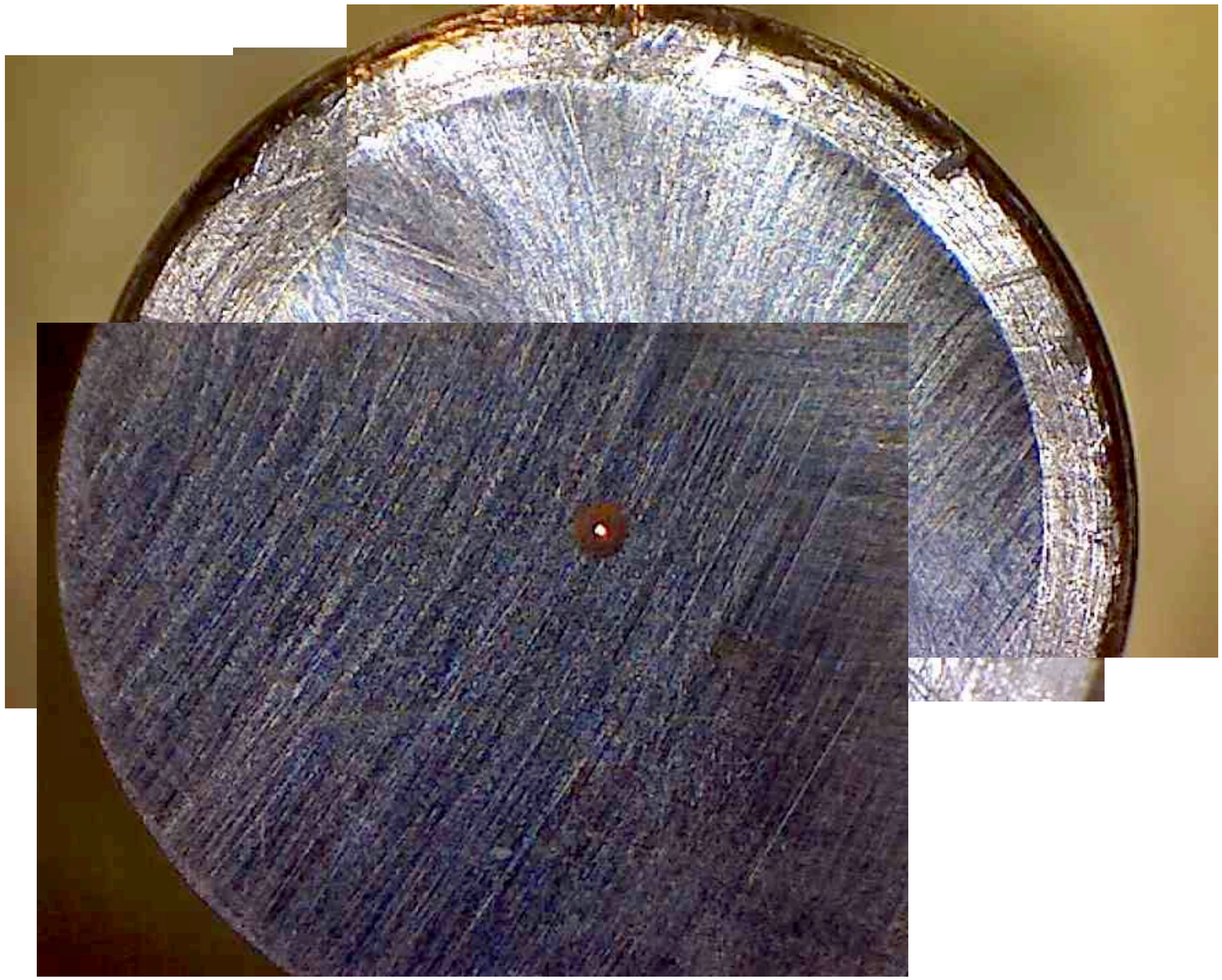
Connector Polishing

6 μm step2



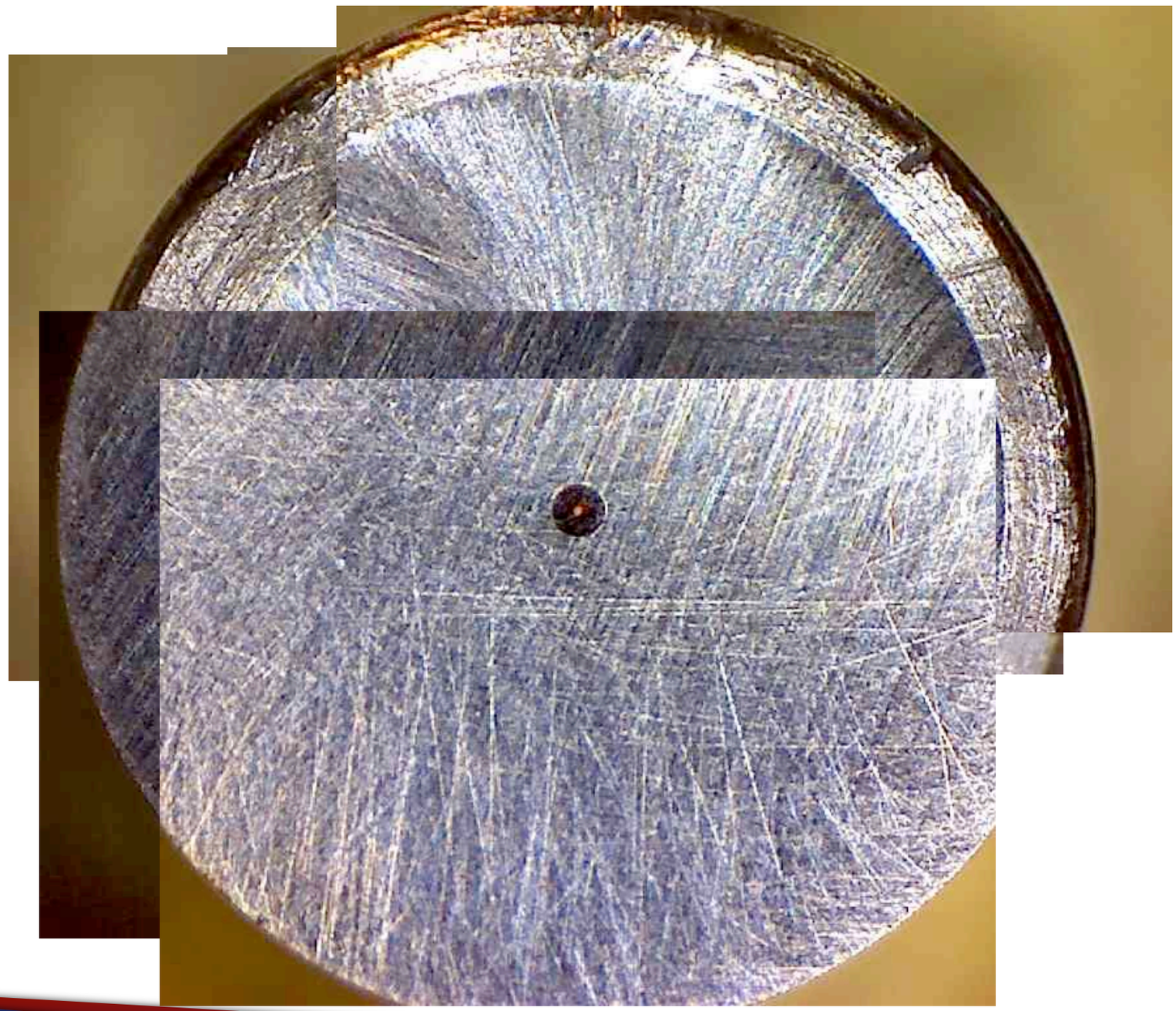
Connector Polishing

6 μm step3: light visible



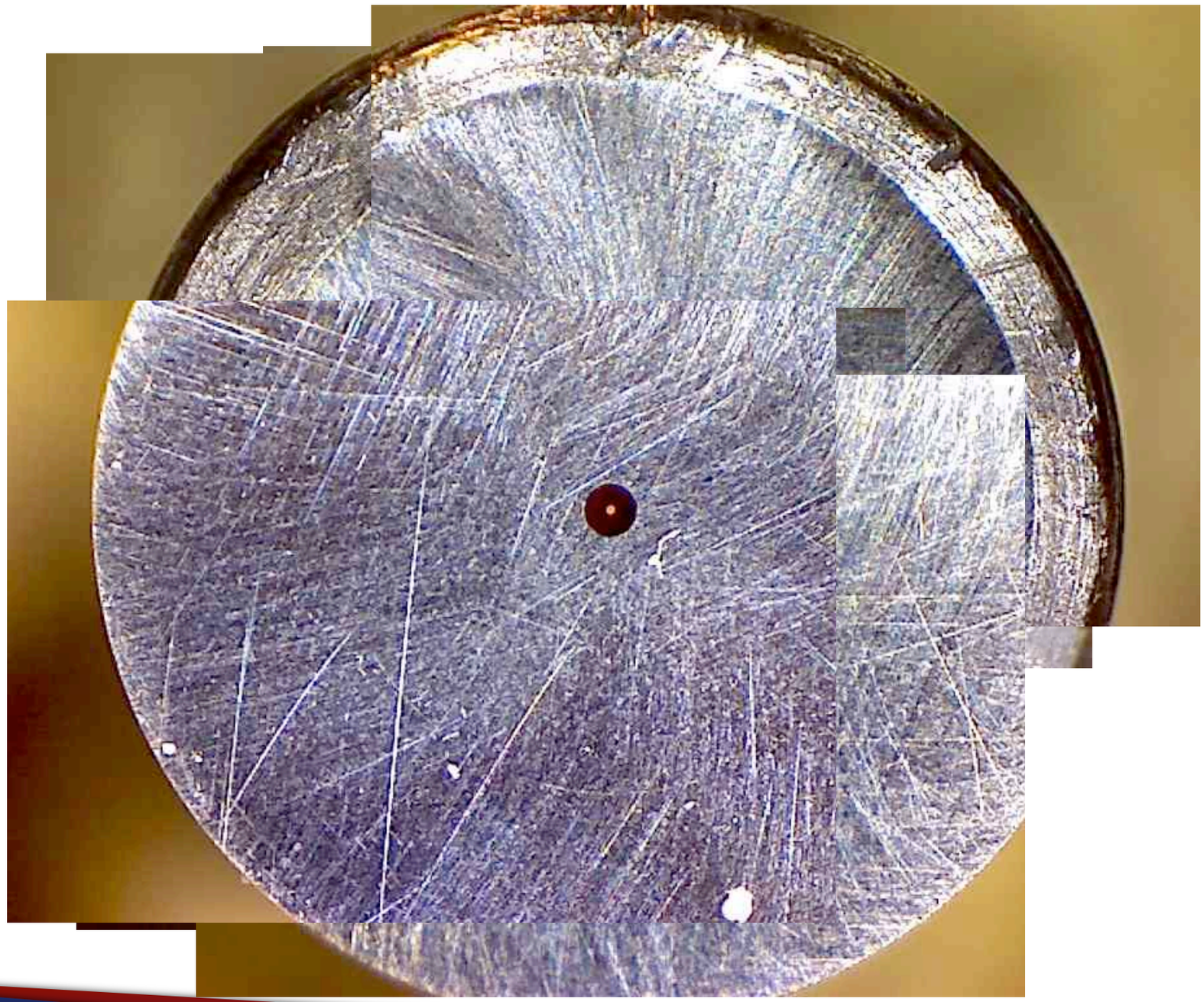
Connector Polishing

3 μm step4



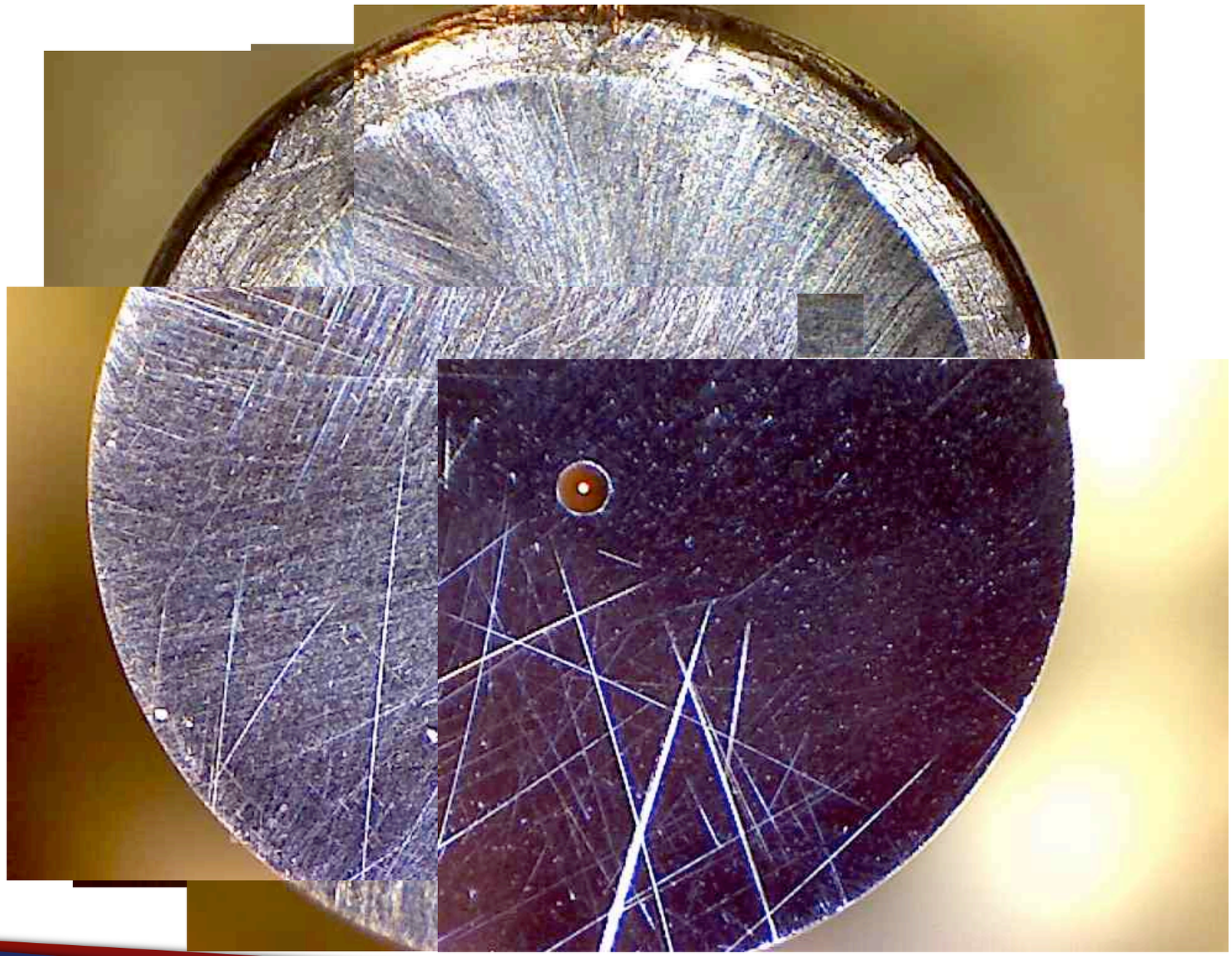
Connector Polishing

1μm step5



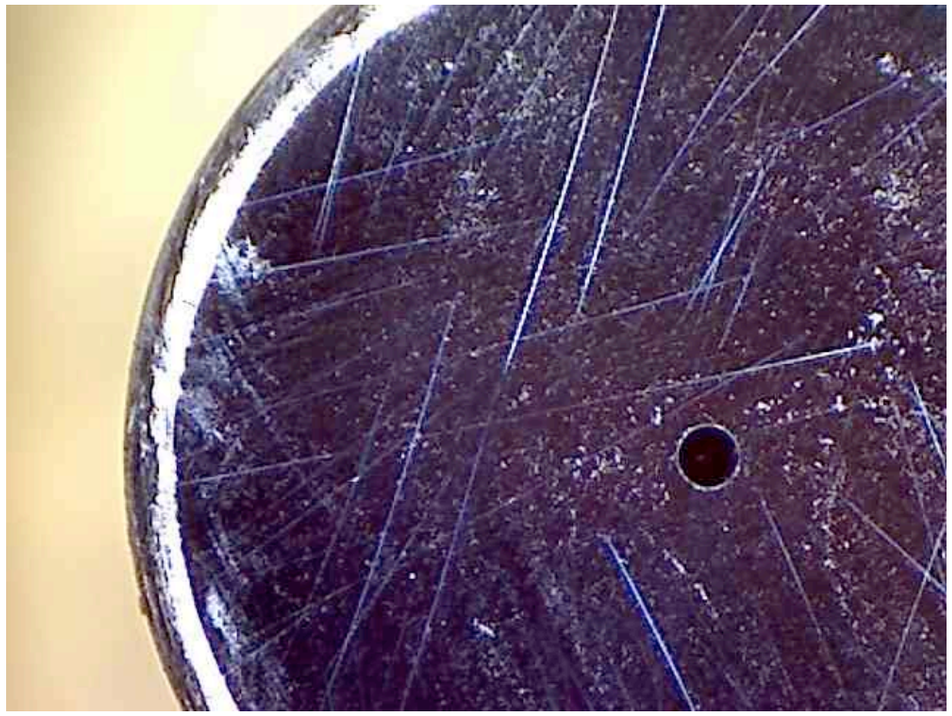
Connector Polishing

0.3 μm step6



Connector Polishing

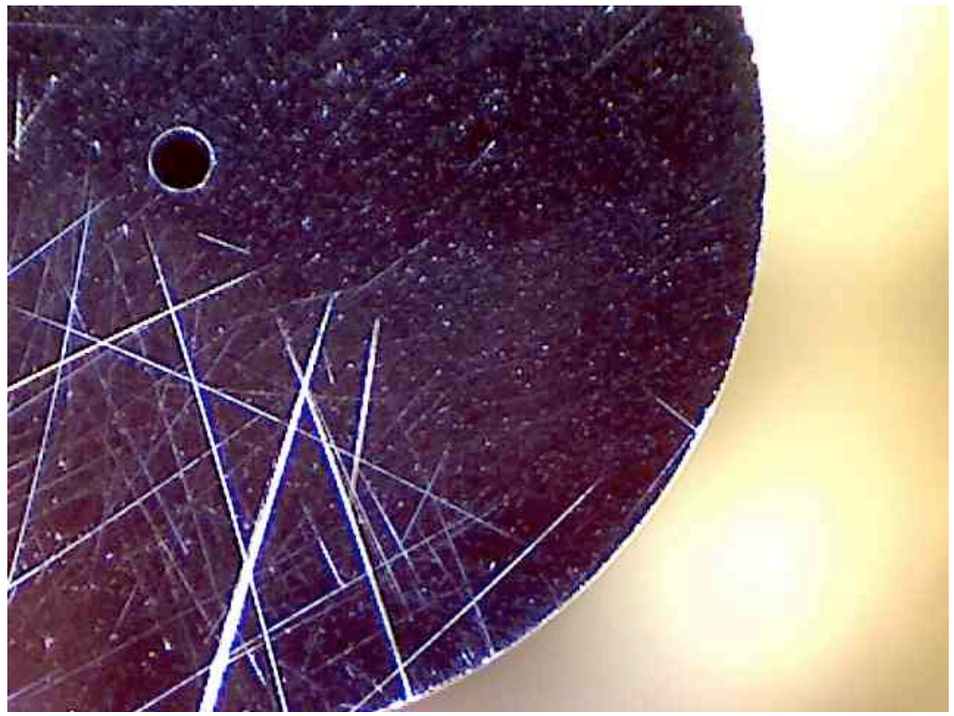
Face1

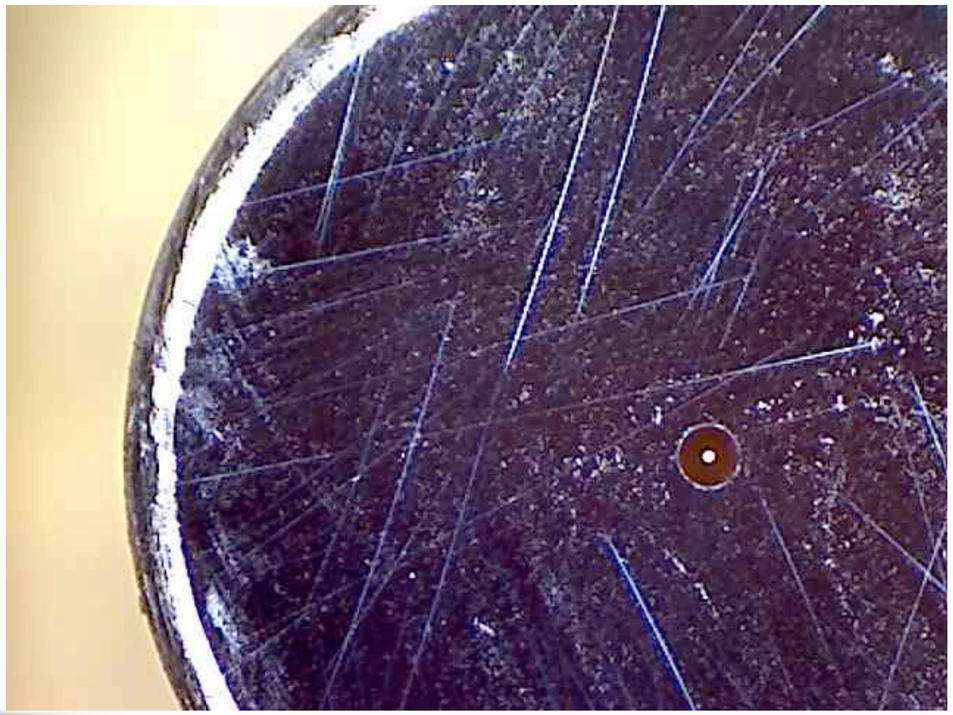


0.3 um

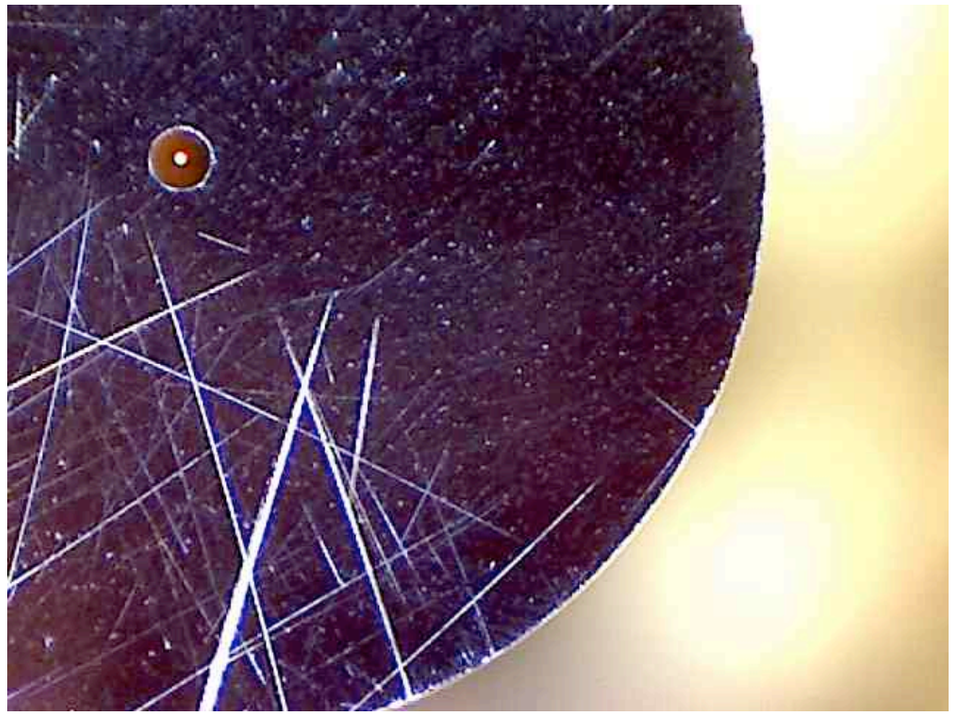
Dark

Face2

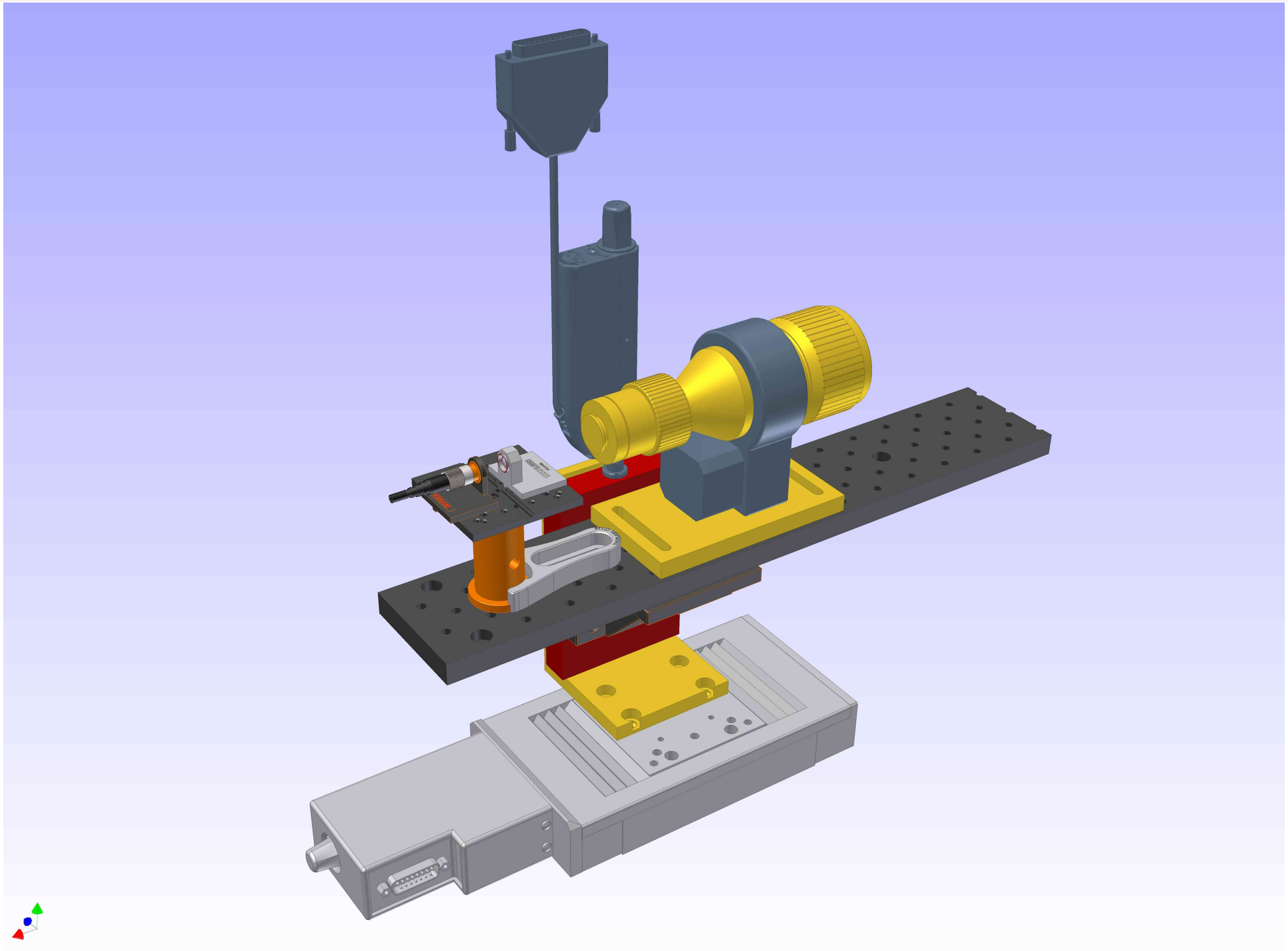




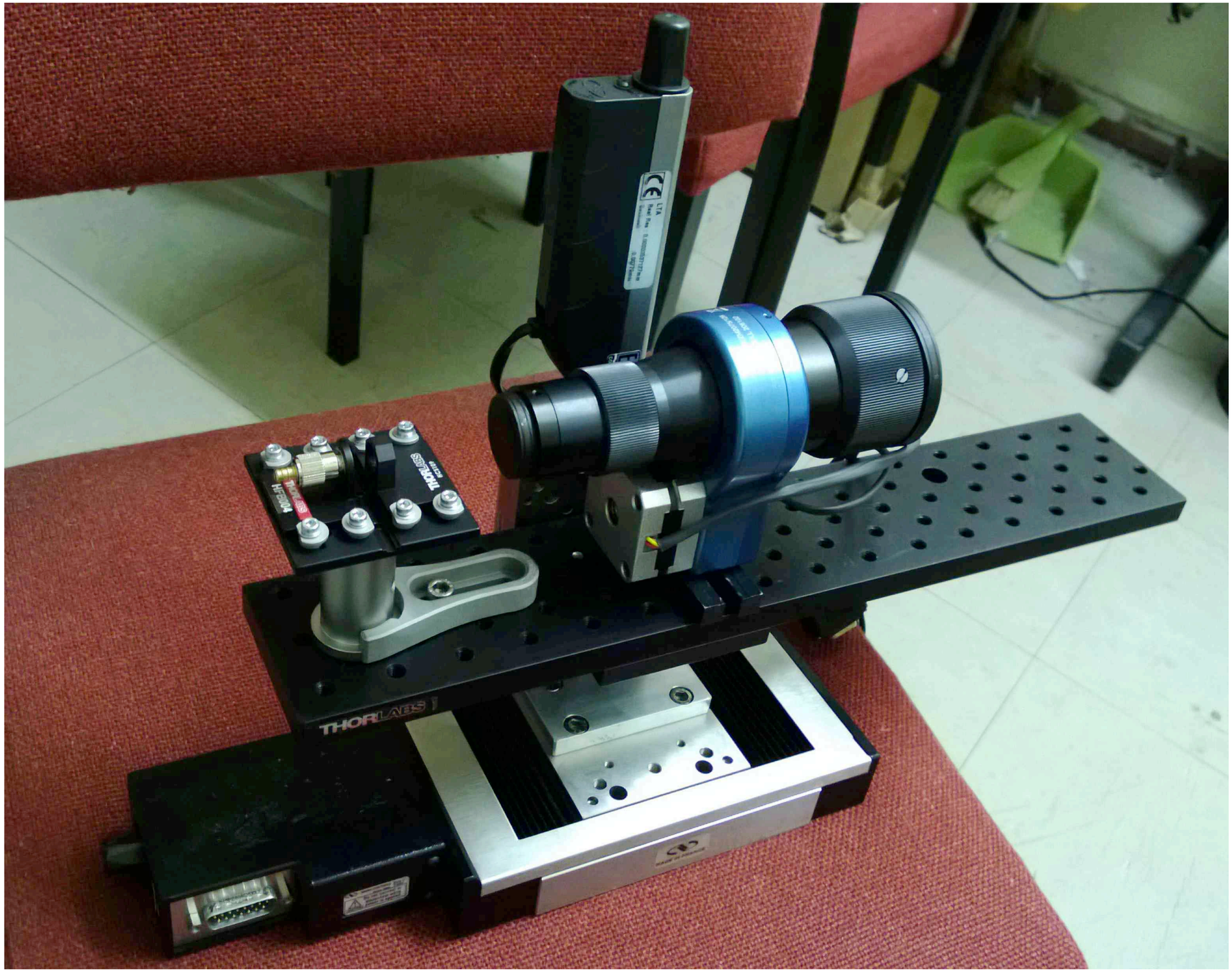
Illuminated



Beam Delivery System CAD

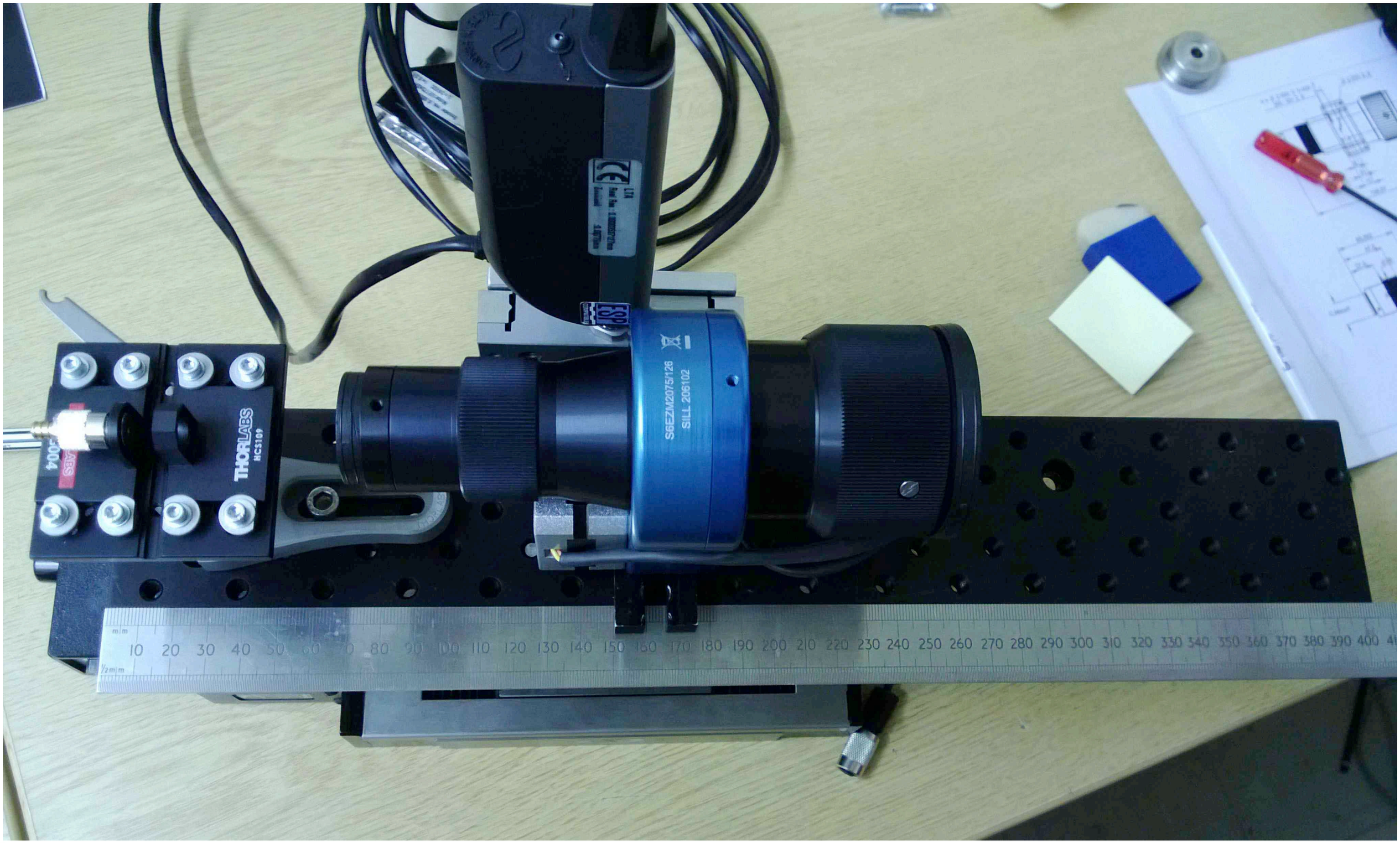


Beam Delivery System



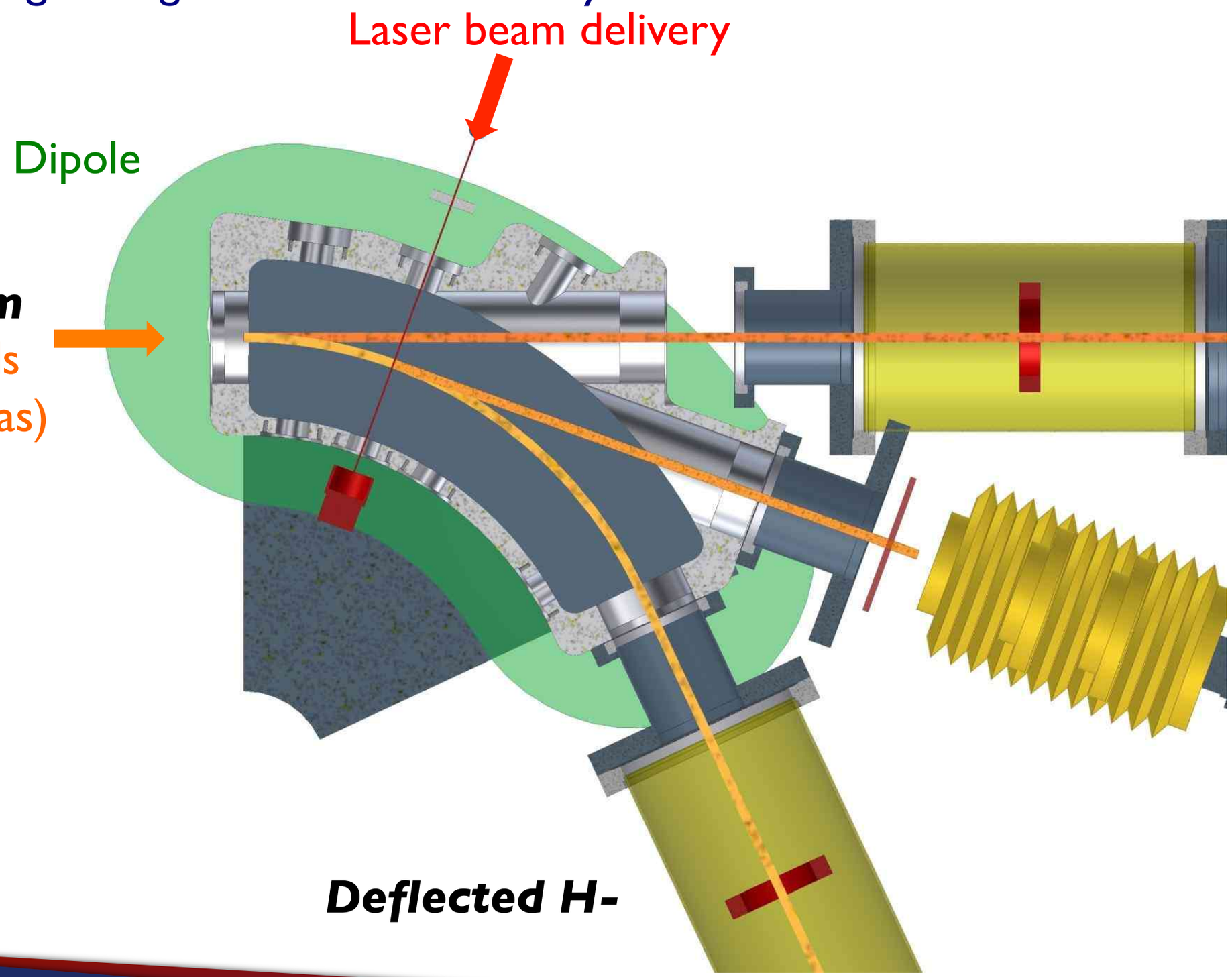
Beam Delivery System

Beam Delivery System

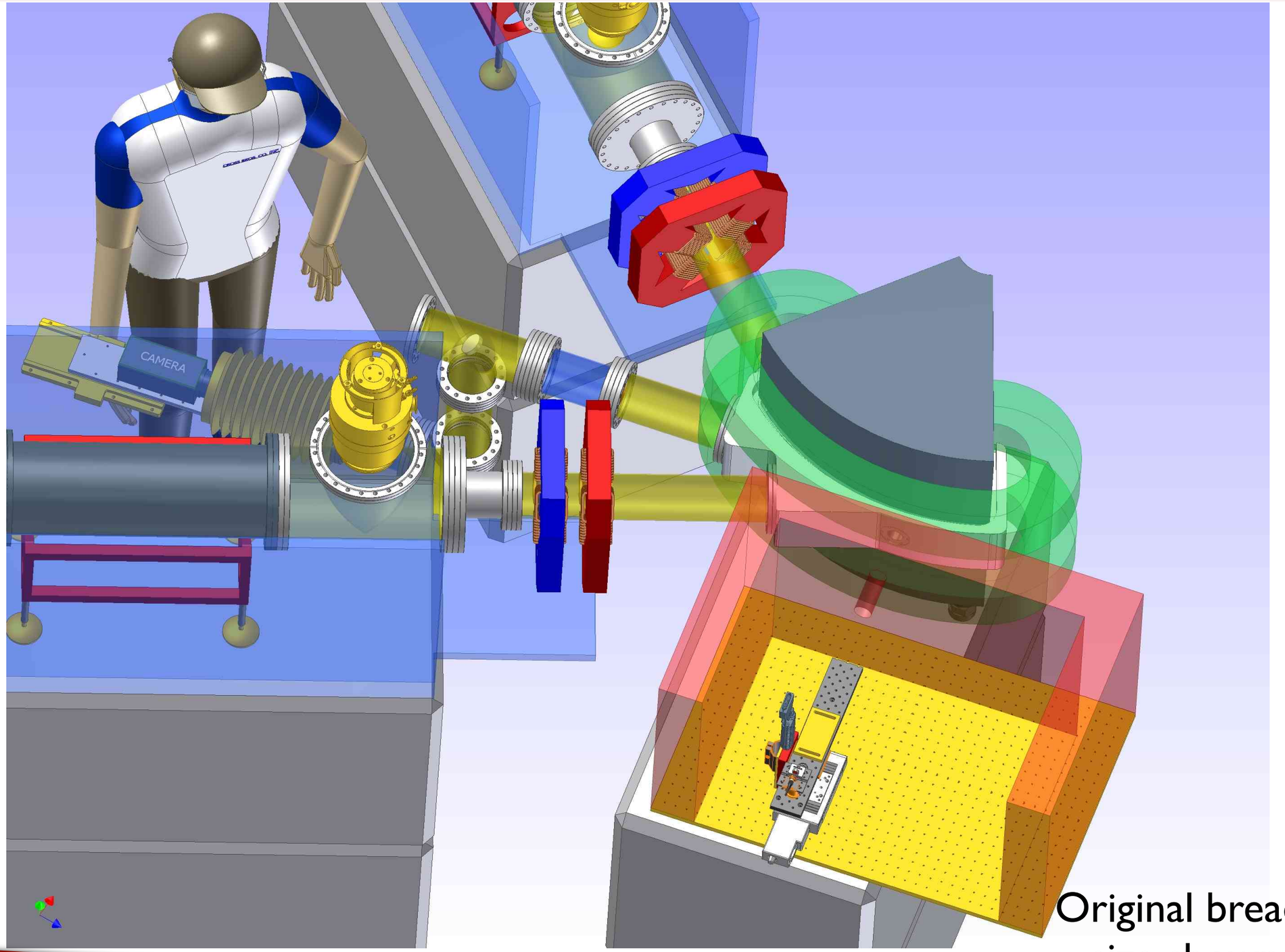


Emittance via photo-detachment

- Basic principle: laser interacts with H- in chamber to photo-detach electrons, leaving H0 signal to be measured by scintillator + camera.

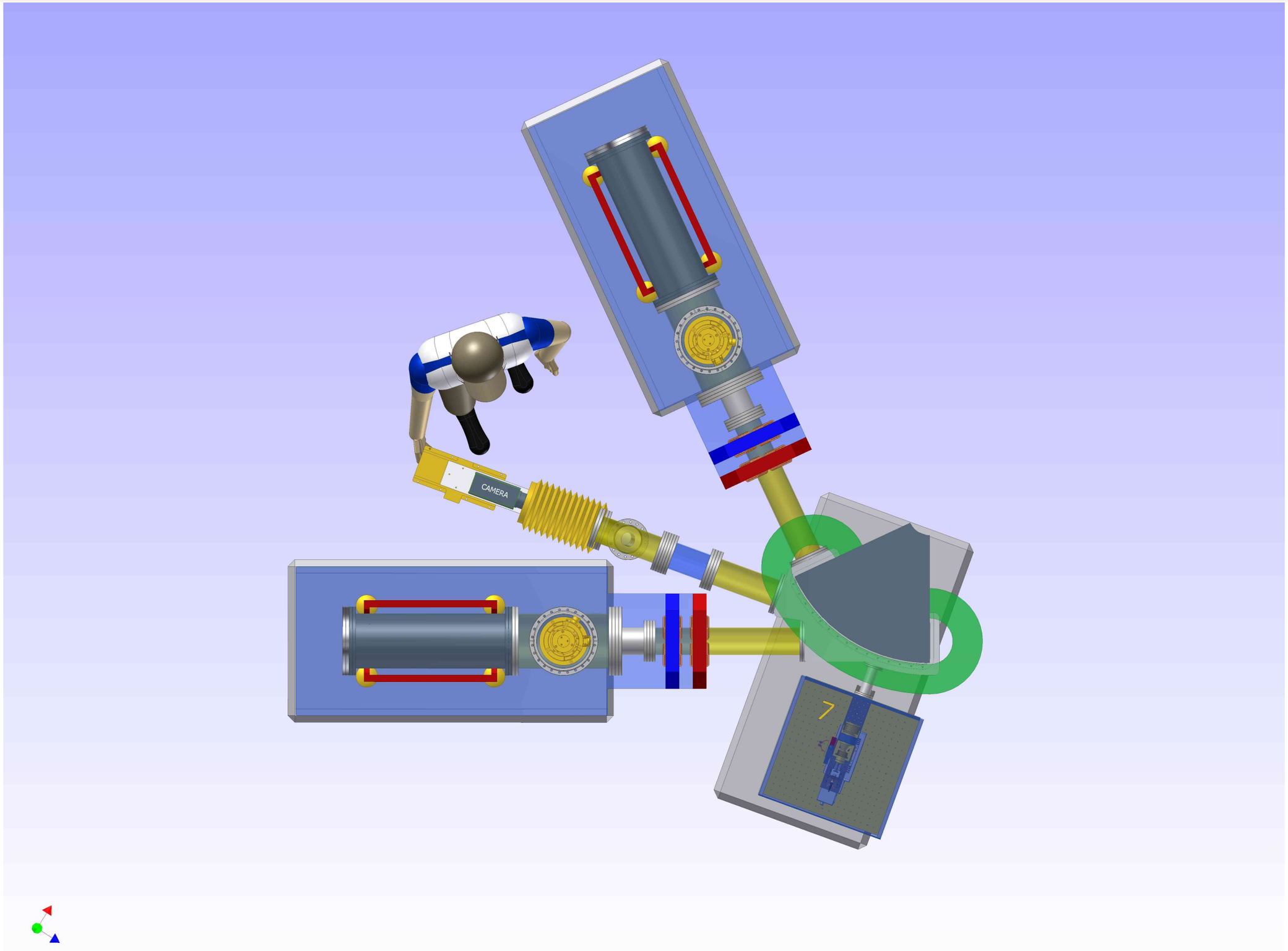


Installation Route: 100m needed

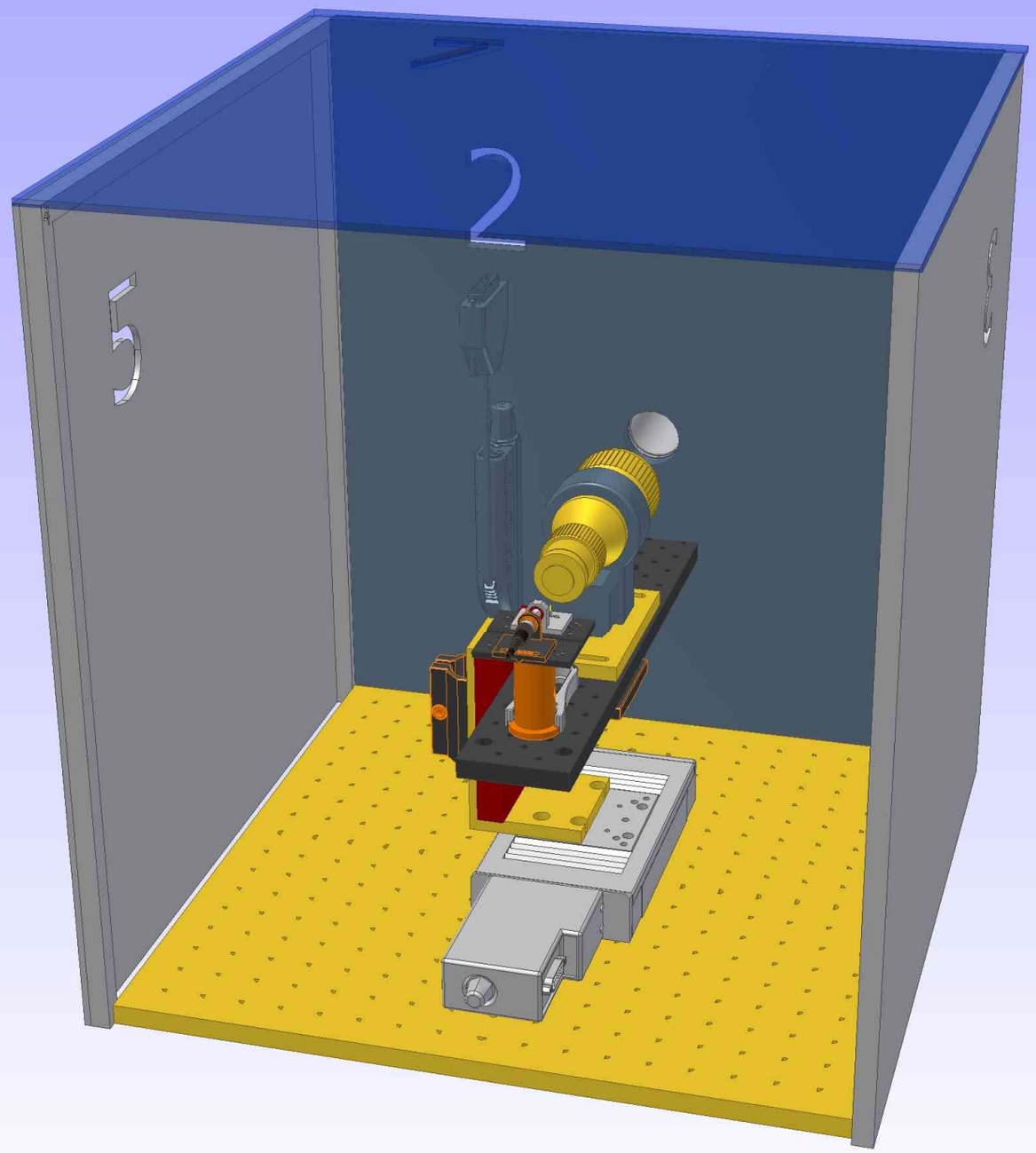


Original breadboard size shown here

Installation Route: 100m needed

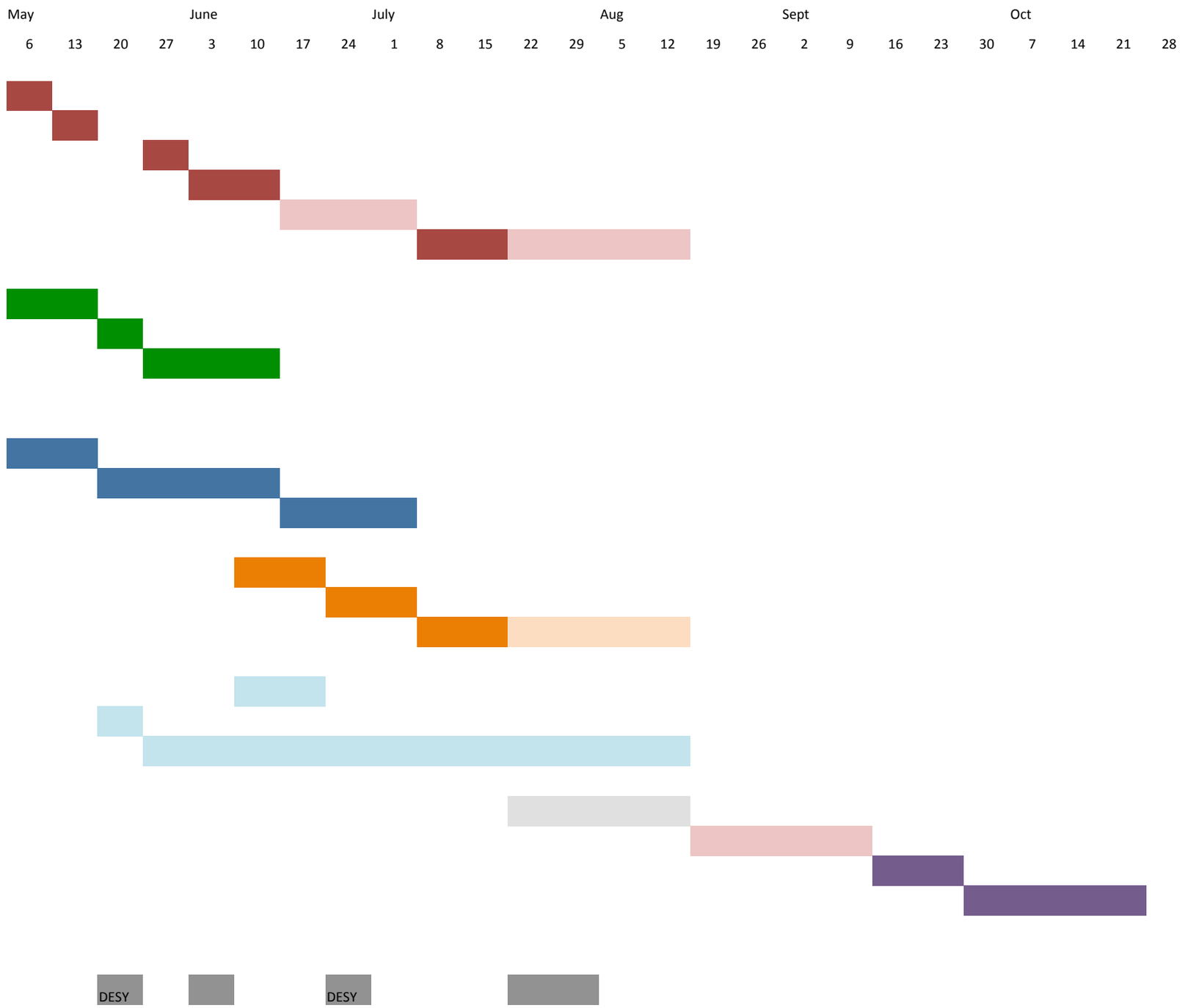


Interlocked enclosure



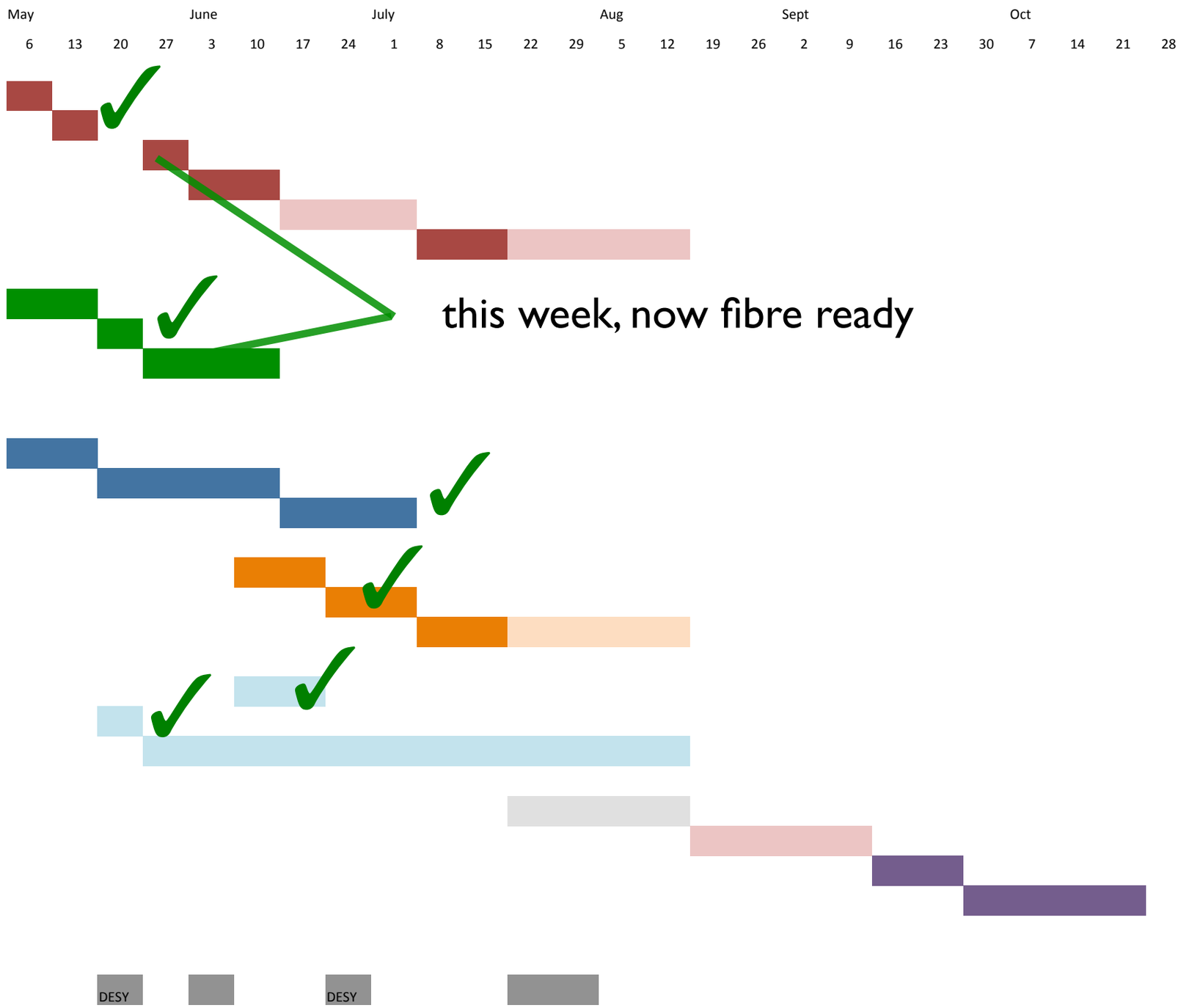
450x450mm breadboard

Laser-diagnostics schedule



Laser-diagnostics schedule

	Task
Laser characterisation tests at RHUL	Power vs duty cycle
	Mode quality
	Fibre coupling efficiency
	Fibre optimization and mode quality
	Integration with mechanics
	Beam expanded mode quality
Fibre coupling	Delivery of fibre from Nufern ?
	Prepare armoured fibre & termination
	Test fibre coupling
Beam delivery system	Beam expander order completed?
	Mechanics design in workshop
	Assemble mechanics: stages, optics
Control and DAQ	Develop translation stage control
	Develop beam expander control
	Combined test
Safety	Interlocked box
	Laser safety specification meeting
	RAL laser room preparation
	Contingency for further tests
Possible to test at RAL?	
Proposed ship date to CERN	
Proposed tests at Linac4	
	A Bosco



Next steps

- Minor schedule slippage (~ 2 weeks) due to delayed delivery of components and challenge of pulling fibre in good weather! Slippage can be absorbed by contingency in schedule.

Next steps:

- Final check of fibre polished connectors
- Fibre coupling assembly:
  - Set up free-space to fibre input coupling using stage.
  - Check the fibre / epoxy can take the laser power.

System tests:

- Measure quality of Gaussian beam output from fibre and after beam expander:
  - Camera + Z translation stage already set up.
- Extend software for control of zoom beam expander.
- Verify movements of zoom and translation stage alignment with measurements.

Project Safety Procedure

Safety discussed and essential plan agreed with Steve Warner and Duncan Francis on Monday. Brief summary below, being written up in Project Safety Procedure:

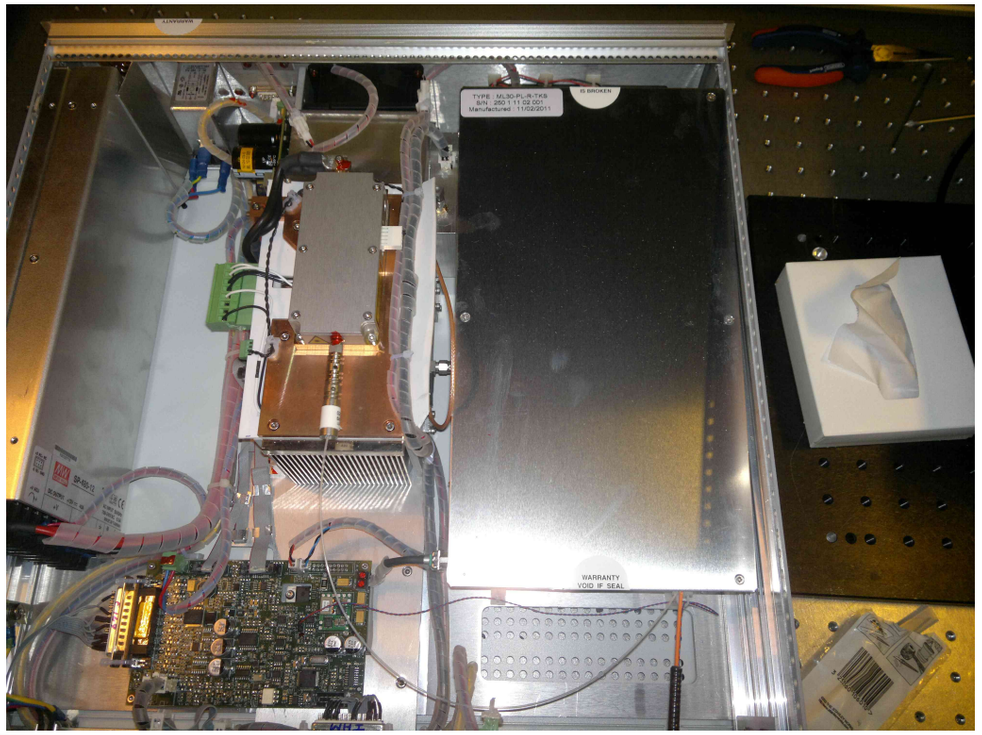
- Swipe card access to outer door, with competent person list maintained by LRO.
- Keypad on inner door, code only given by LRO after explaining local procedures and checking safety training.
- Breaking the door interlock either stops laser via interlock (to be checked) or IEC lead to cut mains. Gravity fed safety shutter on output beam.
- Red/green laser signage on outer door and inner door.
- Interlock wire in armoured fibre to interlocked laser box within the radiation shielding. Cutting the fibre or opening laser box breaks the interlock and drops the shutter in laser room.
- For exceptional maintenance / alignment with laser box open within the radiation shielding, a castell double key on outer door us used for an override key on the interlocked laser box, so that particle beam is off while personnel are working in the radiation shielded area.
- Three level signage on outer shielding door.

Back up

Laser characterization and status

- Light source is a Q-switched, diode pumped, all fibre master oscillator and power amplifier (MOPA) laser.
- ML-30-PL-R-TKS by Manlight S.A.S (Lannion France).

Wavelength	1064 nm
Average power	30 W
Repetition rate	Up to 30 kHz
Energy per pulse	1 mJ @ 30 kHz
Pulse duration (FWHM)	150 ns
Pulse peak power	6.7 kW
Beam quality:	Gaussian profile. M^2 not specified.



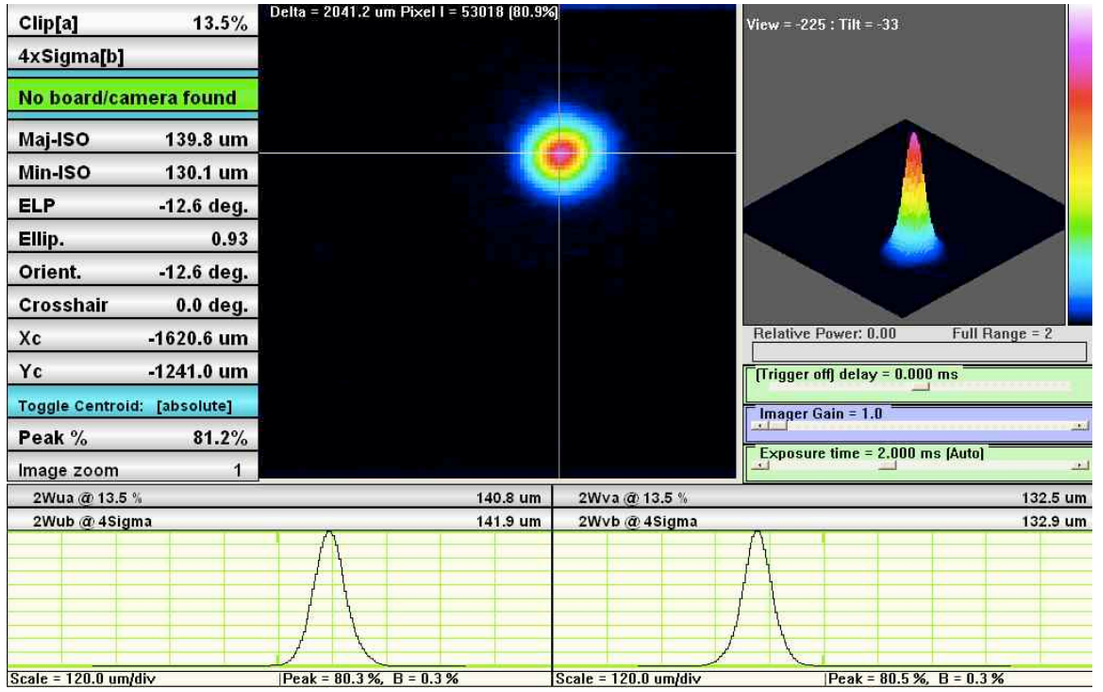
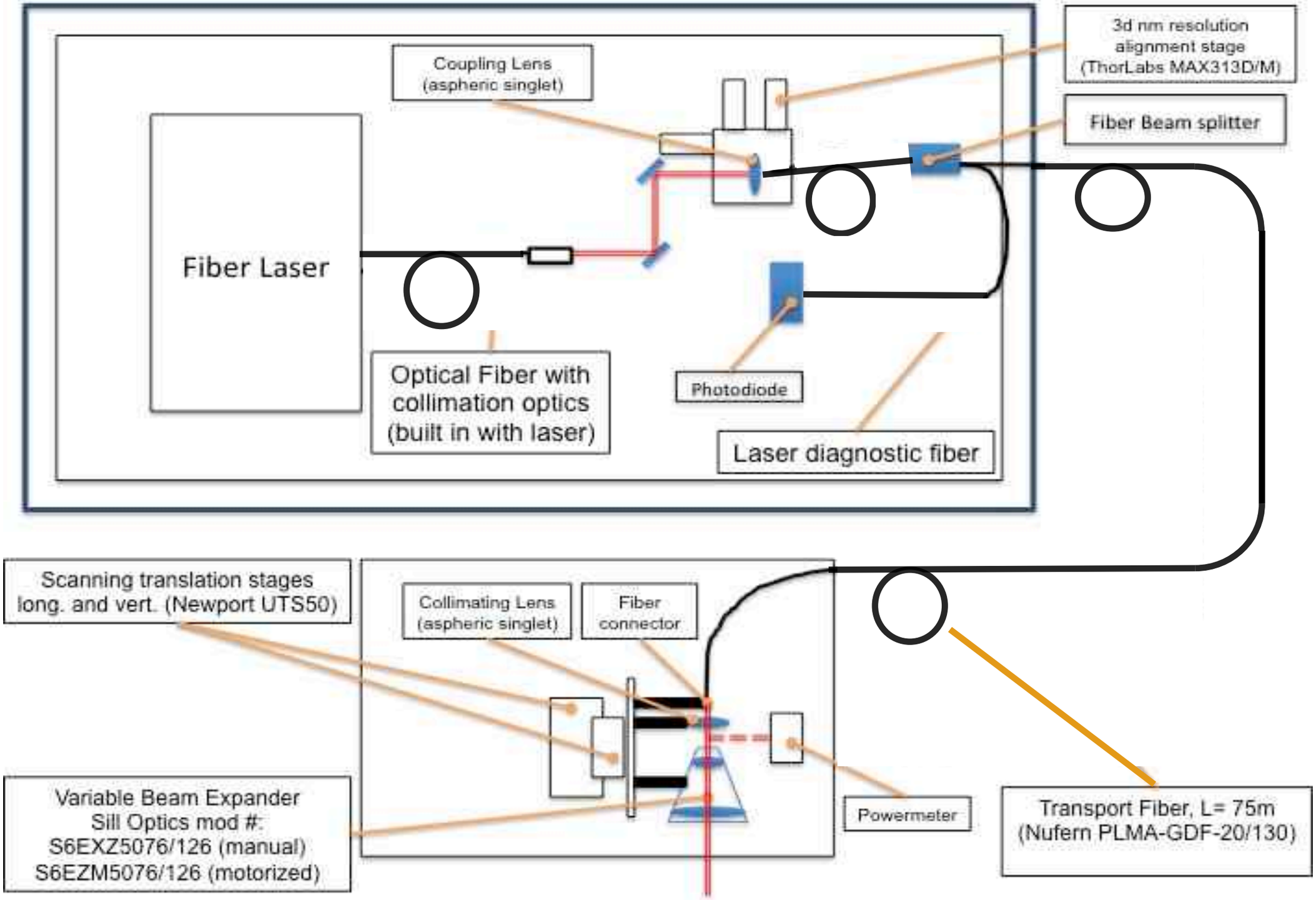


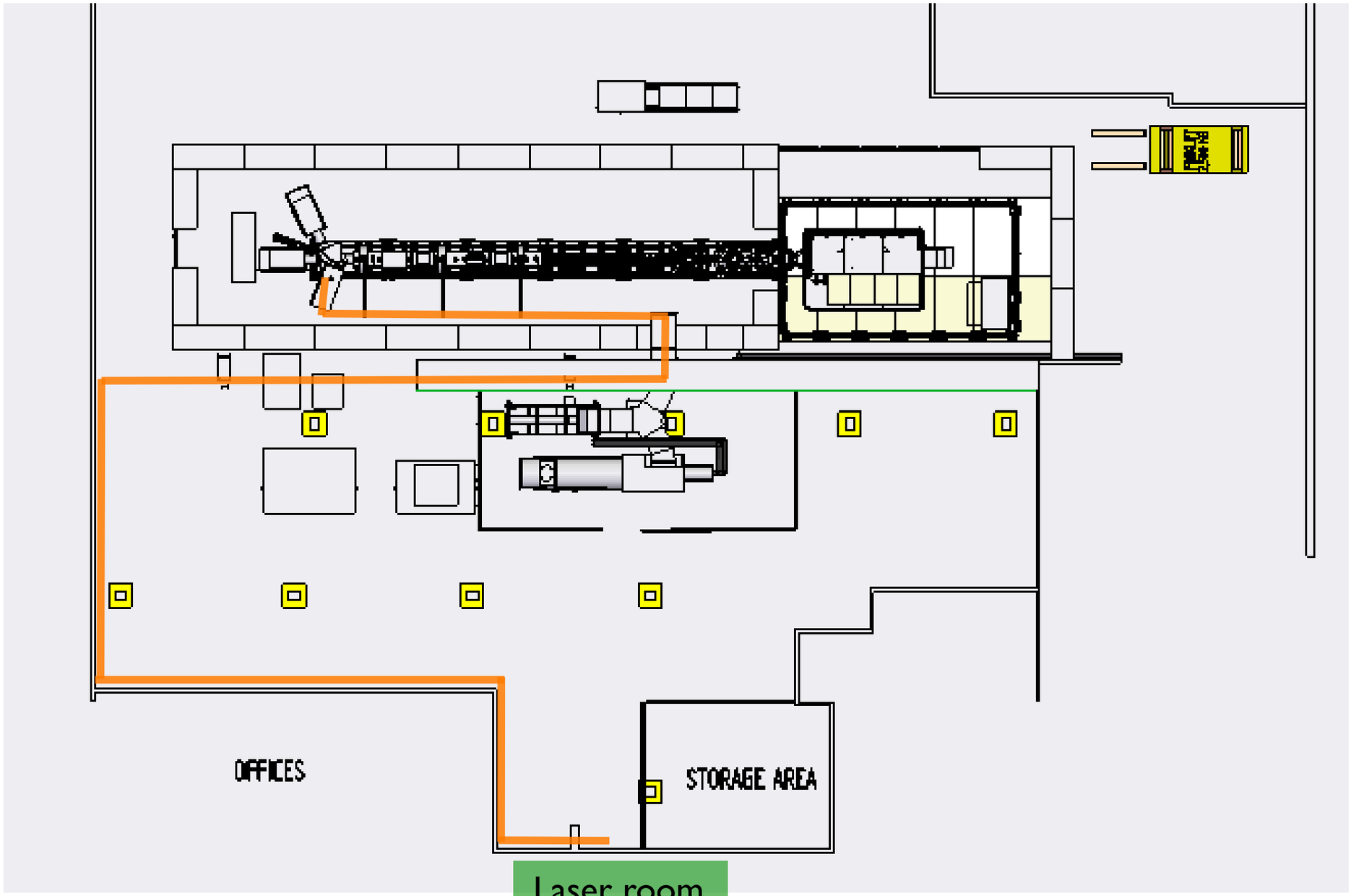
Fig. 6. Laser spot image recorded at the focal plane of the 500 mm plano-convex singlet lens.

Overview


3d nm resolution alignment stage (ThorLabs MAX313D/M)
Coupling Lens (aspheric singlet)
Fiber Beam splitter
Fiber Laser
Optical Fiber with collimation optics (built in with laser)
Photodiode
Laser diagnostic fiber
Scanning translation stages long. and vert. (Newport UTS50)
Collimating Lens (aspheric singlet)
Fiber connector
Variable Beam Expander Sill Optics mod #: S6EXZ5076/126 (manual) S6EZM5076/126 (motorized)
Powermeter
Transport Fiber, L= 75m (Nufern PLMA-GDF-20/130)

Proposed laser location in R8

- Safety interlocked laser room, with fibre to convey light to FETS.
- Route of existing cable tray shown (~75m)



R8 layout thanks to Mike