

Subaru Laser Guide Star Upgrade: Current Status and Schedule toward the Open Use

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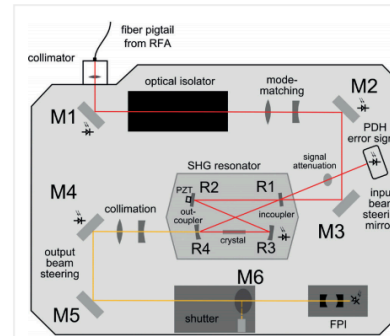
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Subaru Laser Guide Star Upgrade

- Upgrade the laser system from the old 4W pulse laser to the 22W TOPTICA Sodium Star CW laser
 - Generate a bright laser guide star ($R \sim 10\text{mag}$) for AO188 LGS mode.
 - Generate 4 laser guide stars with a constellation diameter from $10 \sim 40\text{ arcsec}$ for the LTAO mode with ULTIMATE-START



SodiumStar 20/2 laser head with RFA (left) and SHGM (right) on a water-cooled cold plate.



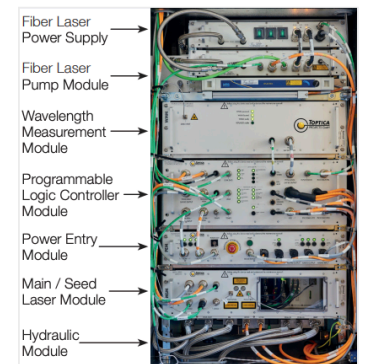
Schematic of the second harmonic generation module (SHGM).



Remote pumping option: The laser head can be separated up to 32 meters from the electronics cabinet.

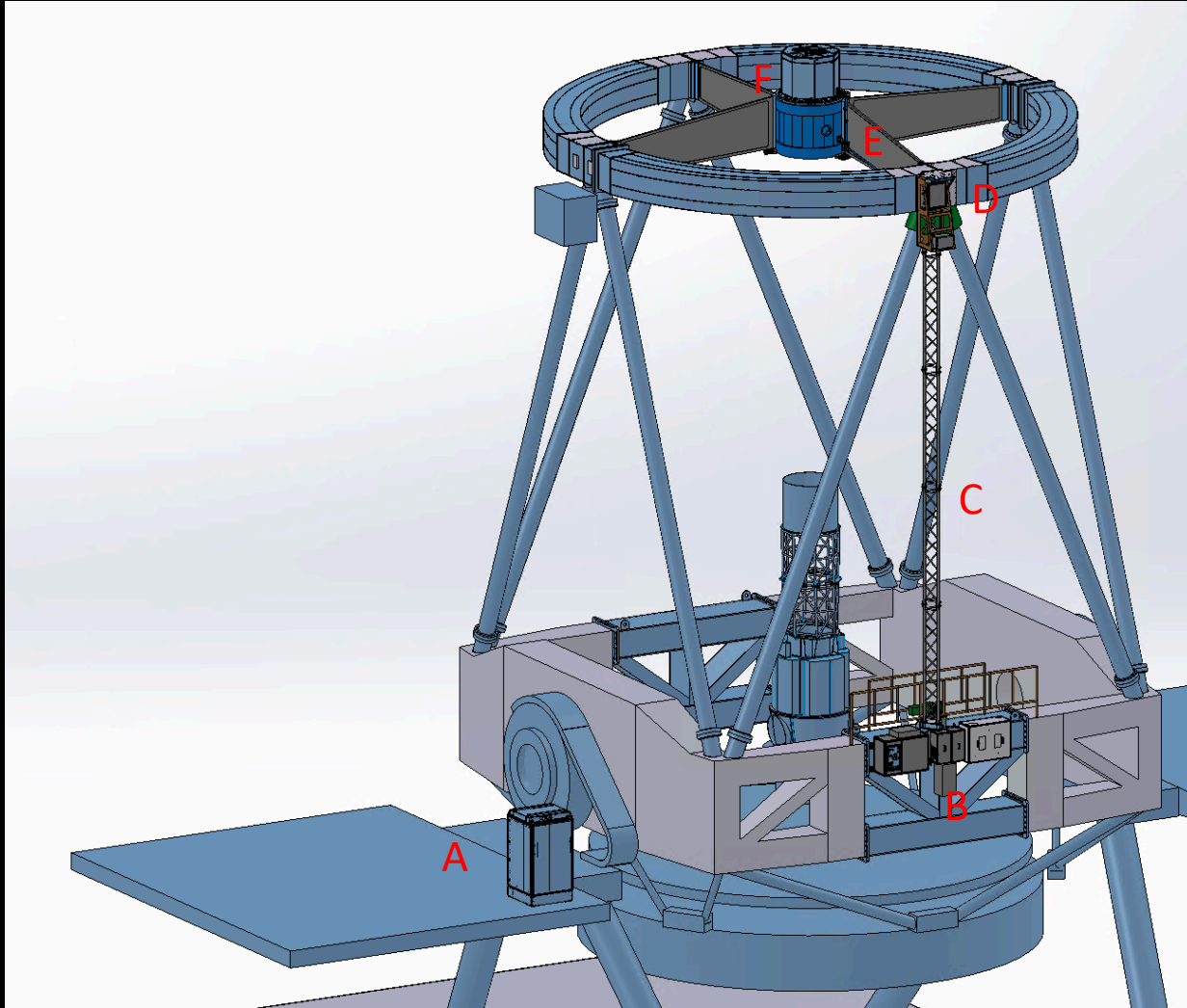


SodiumStar 20/2 electronics cabinet.



Interior view of SodiumStar 20/2 electronics cabinet.

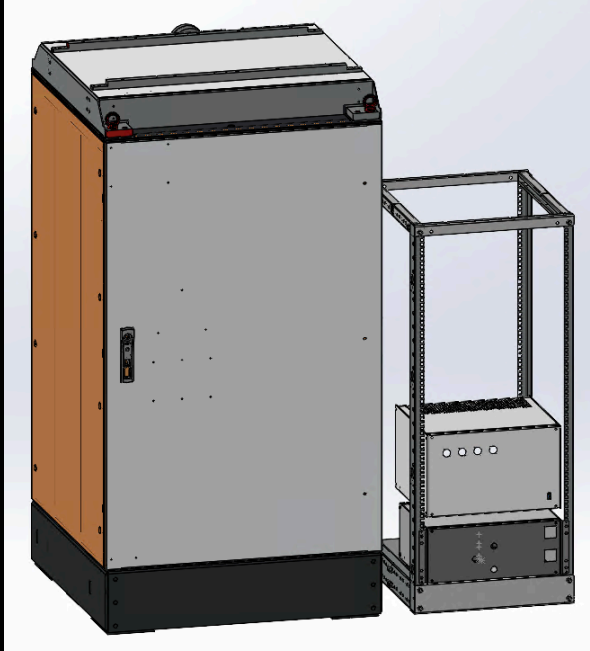
New Laser Guide Star System Overview



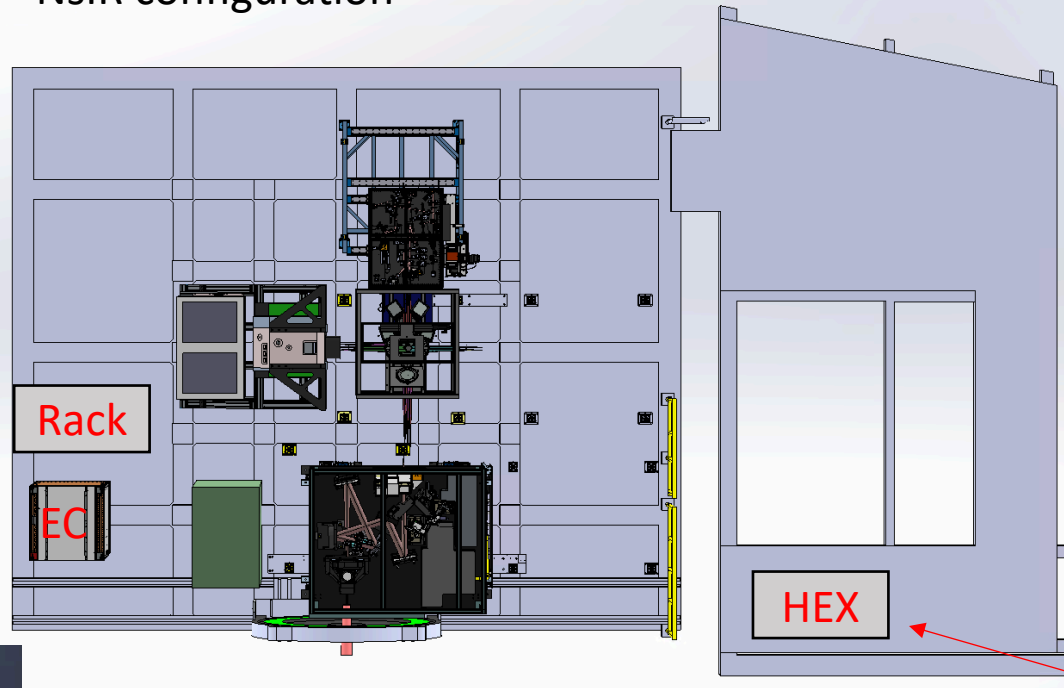
- A. TOPTICA Electric Cabinet on the NsIR platform
- B. Laser Head (LH) and Laser Diagnostic Bench (DB) on the front side of the center section
- C. Laser Relay Truss between the Center Section and the Top Ring
- D. Laser Steering Mirrors and TBAD (Aircraft Monitor) at the front side of the Top Ring
- E. Relay pipe along with the front side spider
- F. Launching Telescope behind the secondary mirror

Sub-System (A): TOPTICA EC at NsIR

Old Laser room has been replaced by a small TOPTICA Electric Cabinet.



NsIR configuration



Dedicated heat exchanger for the Laser to keep the temperature of the system at 15 degC.

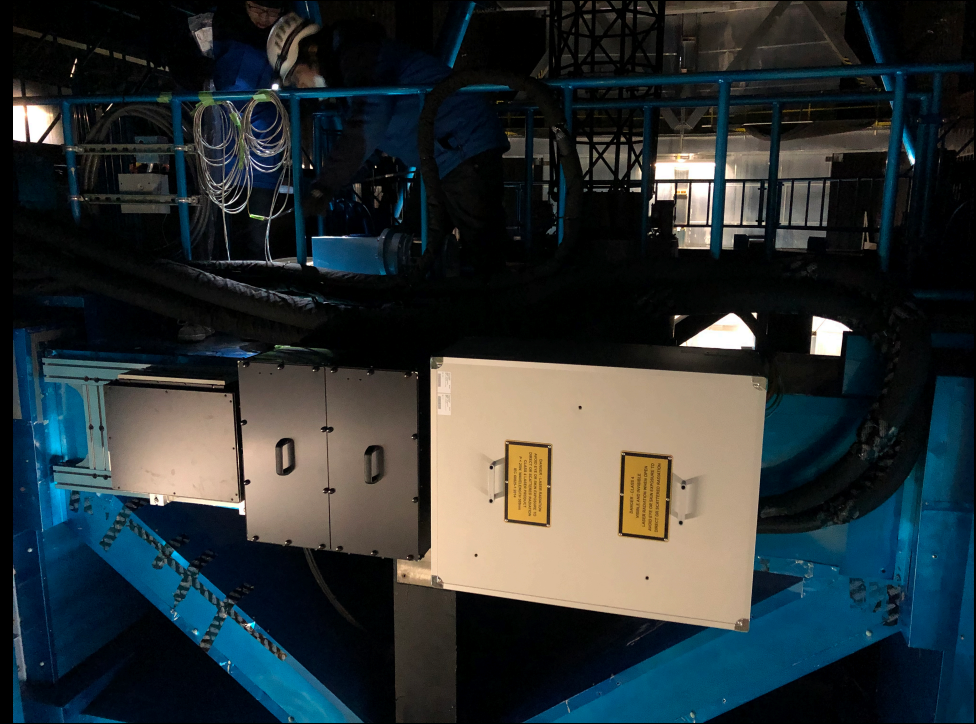
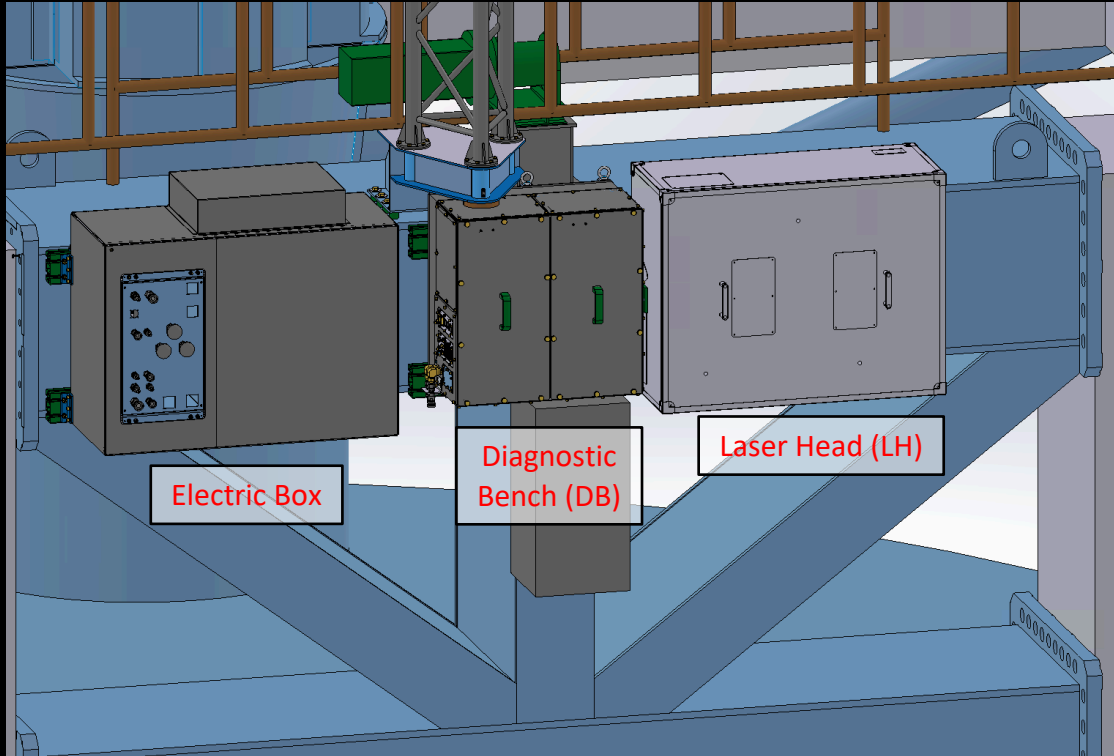


EC and HEX (along with the cooling line) were successfully installed at the NsIR.



Sub-System (B): Center Section LH and DB

LH and DB were successfully installed at the telescope

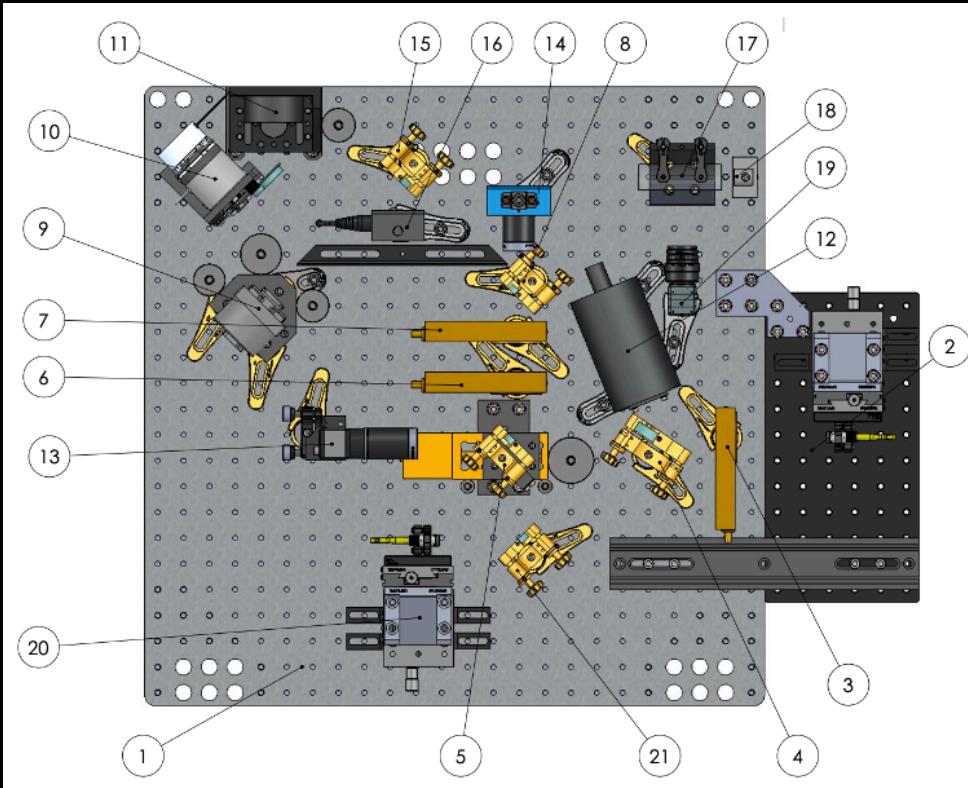


- Seed and pump laser from the EC are transferred to the LH through fiber cables.
- 589nm laser is emitted from the LH and redirected toward the top ring at the DB while monitoring and alternating the laser power, beam direction, beam quality, wavelength, etc.
- All of the electric components required for the DB are located in the Electric Box. The box will be thermally insulated so as not to emit hot air to the telescope optical path.

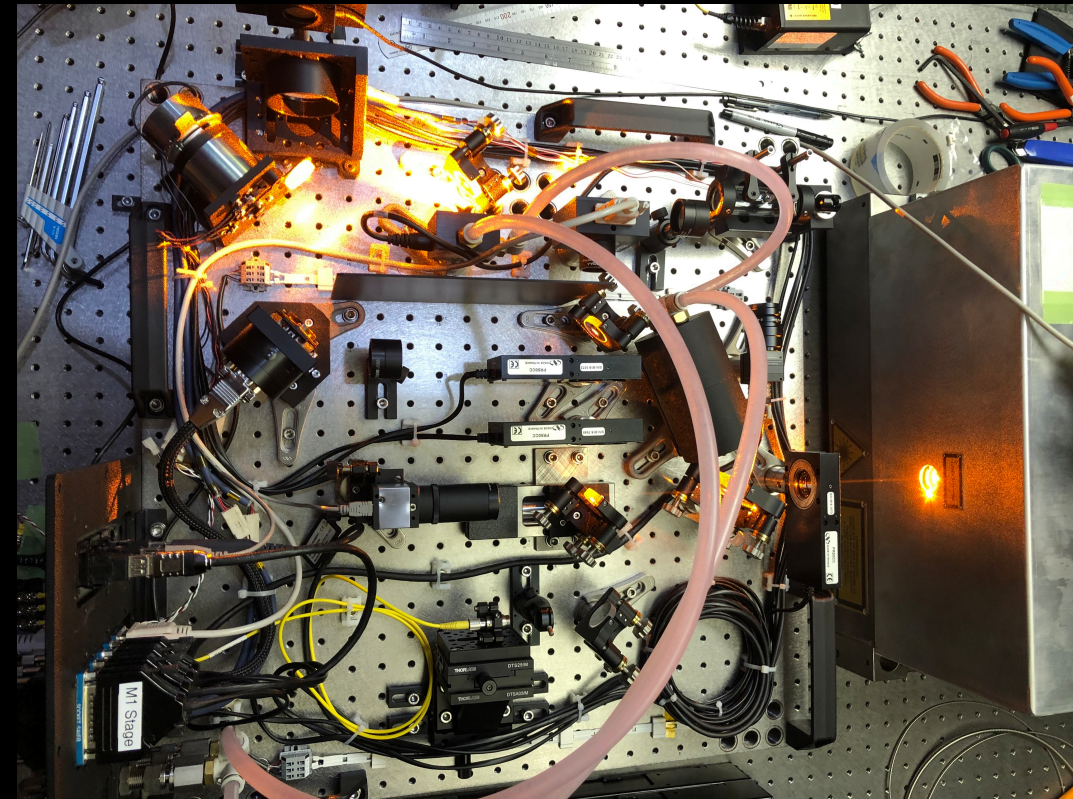
Laser Diagnostics Bench (DB)

- Laser power adjustment using a polarizer and a half waveplate
- Wavefront monitoring with a wavefront sensor
- Adjust the polarization state with a combination of half and quarter waveplates
- Monitor the laser power with a power meter
- Monitor the laser wavelength with a Na gas cell

DB was assembled and tested at the Hilo base laboratory



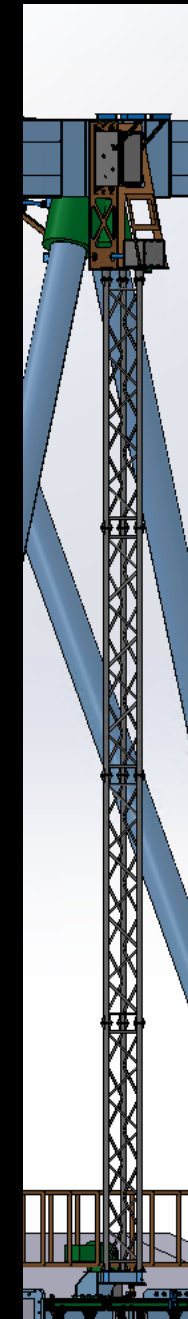
Item #	Name
1	Optical Bench
2	Alignment Platform
3	1/2 Waveplate Unit
4	Thin Film Polarizer Unit
5	M1 Unit
6	1/2 Waveplate Unit
7	1/4 Waveplate Unit
8	M2 Unit
9	M3 Unit (Fast Steering Mirror)
10	Exit Shutter Unit
11	Exit Window Unit
12	Water Cooled Beam Damper
13	SH Wavefront Sensor Unit
14	Position Sensitive Device Unit
15	M4 Unit
16	Power Meter Unit
17	Sodium Cell Unit
18	Sodium Cell Beam Damper
19	Sodium Cell Monitoring Camera
20	Alignment Laser
21	Alignment Mirror
22	Laser Safety Screen



Sub-System (C): Laser Relay Truss

- Relay truss is made of aluminum pipe.
 - Total length is 9.2m, can be split into 4 pieces
 - Total weight is ~ 36 kg (~9 kg for each)
- One of the three main pipes are used to propagate the laser inside.
- The truss is fixed on the lower truss support using bolts.
- The truss is not fixed to the upper truss support, but connected through dry bearings so as to absorb the change in the distance between the center section and the top ring due to the telescope deflection.

Truss was fabricated and assembled in Japan and transferred to the Subaru summit on Dec, 2020, waiting for the installation on Mar, 2021.



Upper truss support

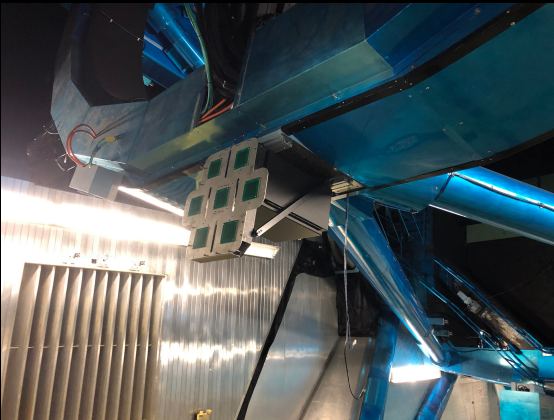
Relay truss
~9.2m

Lower truss support

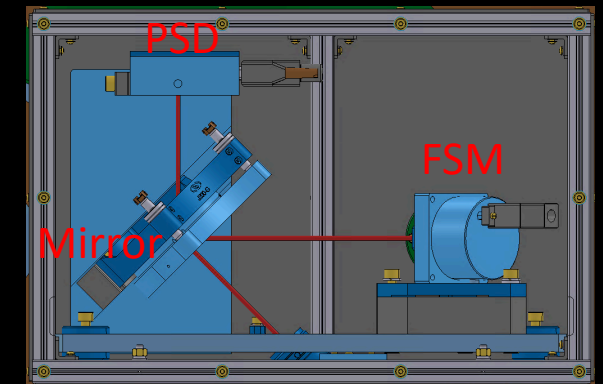
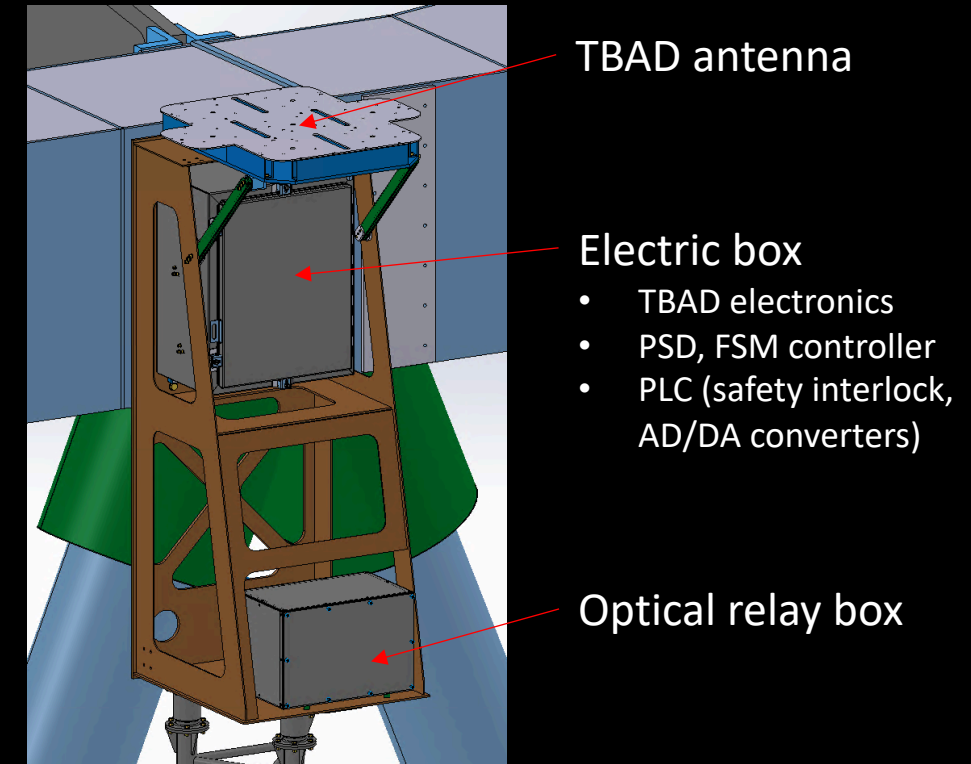
Sub-System (D): Laser Steering Mirror and TBAD

- The upper truss support is made of steel
 - Weight ~ 90.4 kg
- The upper truss support is designed to hold the TBAD antenna, electric box, and the optical relay box inside, as well as to support the relay truss.
- The laser from the center section is reflected toward the inner hub of the telescope at the optical relay box.
- The optical relay box detects the mis-alignment of the laser beam using a position sensitive device (PSD) and compensate the mis-alignment by moving fast steering mirrors (FSM) in the optical relay box and the diagnostic bench at the center section.

TBAD being tested at the telescope

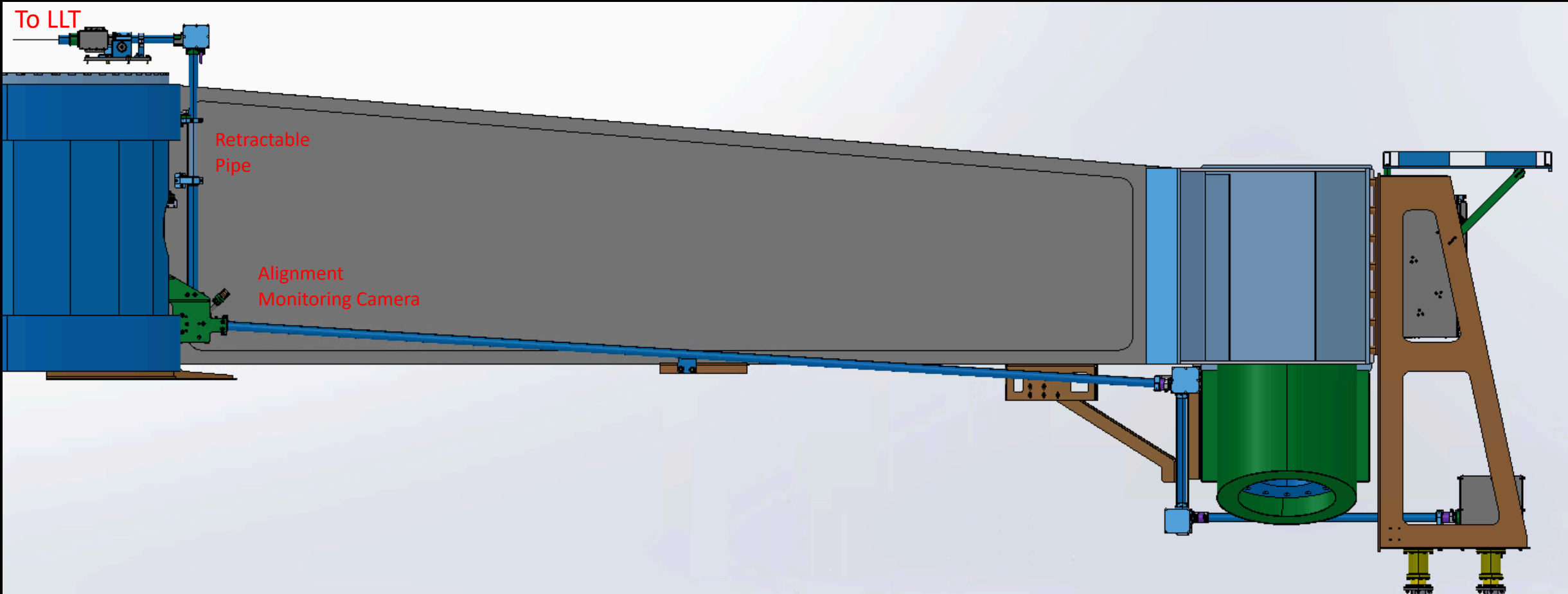


Upper truss support fabricated



Sub-System (E): Spider Relay Pipe

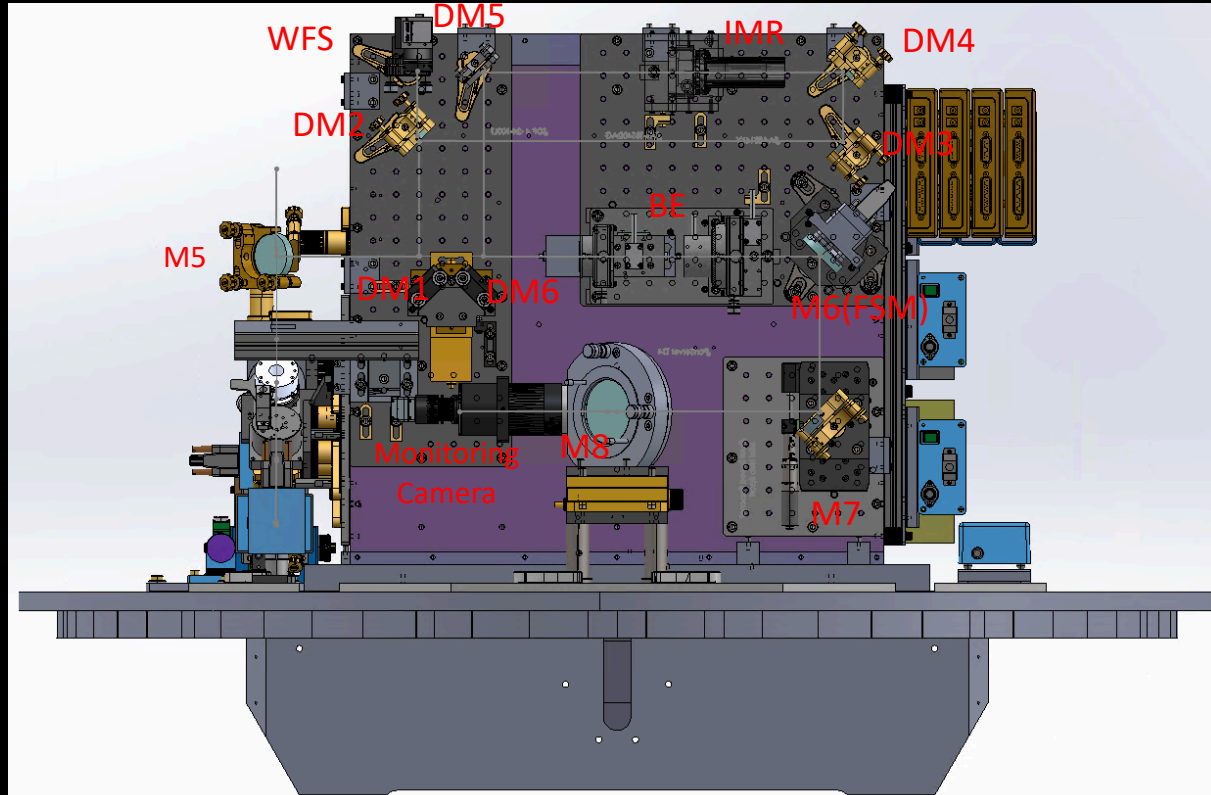
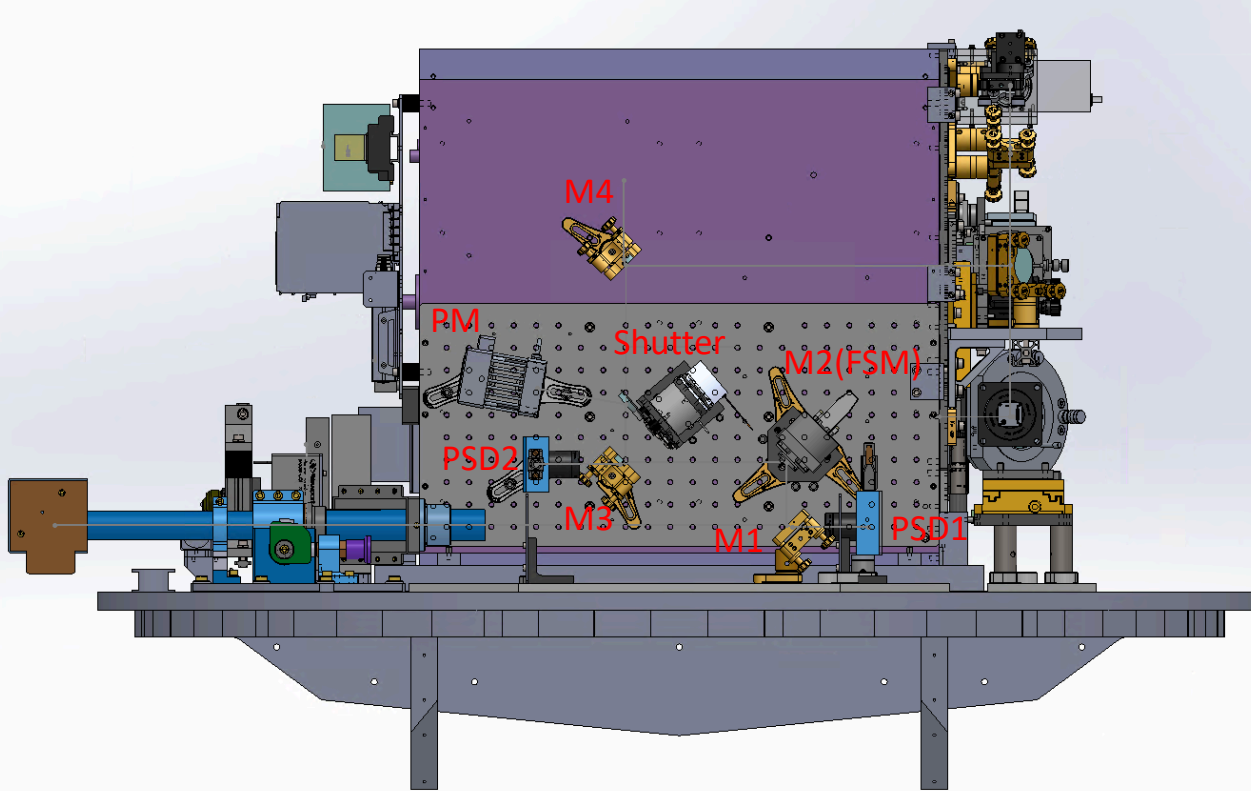
- Laser beam will be transferred from the top ring to the LLT thorough the pipe with the reflected mirror boxes.
- All components are hidden in the shadow of the IR reflected mirrors located at the Tertiary spider (the pipe cannot be seen from the instrument)



All of the parts are fabricated and will be assembled in March-April, 2021

Sub-System (F): Laser Launching Telescope

All components are fabricated. To be assembled and tested in March, 2021

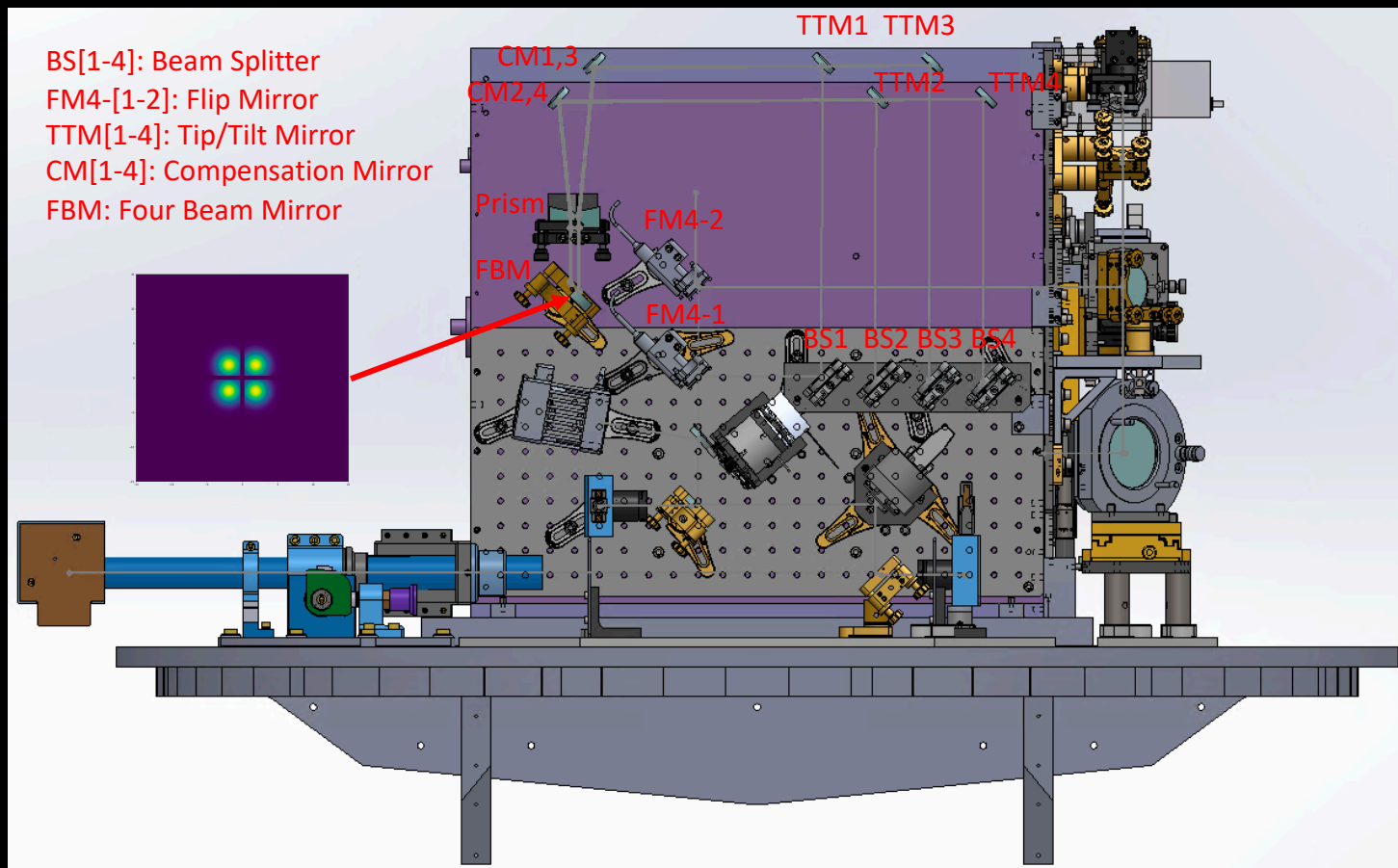


M[1-8]: Flat mirror
FSM: Fast Steering Mirror
PSD: Position Sensitive Device
PM: Power Meter
WFS: Wavefront Sensor

BE: Beam Expander
DM[1-6]: Delay mirror
IMR: Image Rotator

- The laser beam from the LH is relayed to the LLT, x6 expanded by the BE, and x12.5 expanded by the LLT.
- The beam diameter on-sky is ~ 225 mm at $1/e^2$ diameter.

Sub-System (F): Laser Launching Telescope (4 beam configuration)



- Single/four beam modes can be switched each other by moving FM4-1 and FM4-2.
- The 22W laser will be split into 4 by the beam splitter (BS1-4, ~5W for each).
- The LGS asterism diameter can be changed between 10-40 arcsec on sky by adjusting the tilt angle of the TTM and the CM.
- The DM1,6 at the Rear side will be inserted with the linear stage to adjust the location of the entrance pupil.

Design completed, optical components fabricated, opto-mechanical components to be fabricated in early 2021

Current Status

- All of the design works were completed.
- Most of hardware components were fabricated.
- Assembly, Integration, and Test phase is partly started.
 - Center Section components assembly and integration has been completed.
 - Remaining components will be assembled in March and April.
- Electric components as well as a laser safety system are being assembled and tested.
- Control software is being developed.
- Operation software development has not been started yet. We will modify the existing laser operation software to use with the new laser system.

Schedule toward the open-use

- Feb, 2021 -- Center section/NsIR sub-systems installation (completed)
- Mar, 2021 -- LLT assembly, Truss and truss support installation
- Apr, 2021 – Spider Relay pipe installation, Test the entire system
- Apr or May, 2021 -- First laser propagation on sky
- May - July, 2021 – Engineering Observation
- Aug --, 2021 – Partly open the LGS mode to the open use observers.
- Aug – Dec, 2021: 4 beam mode assembly, integration, and test
- Feb, 2022 – Open the LGS mode for the open use in S22A
- Aug, 2022 -- Open the 4 beam LGSs with the LTAO mode