Development & Architecture of the EOS Guide Star Laser

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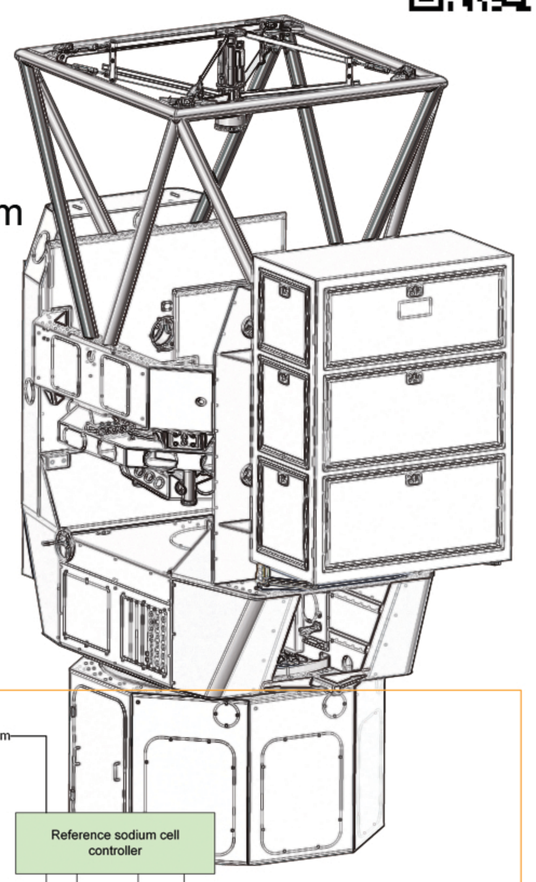
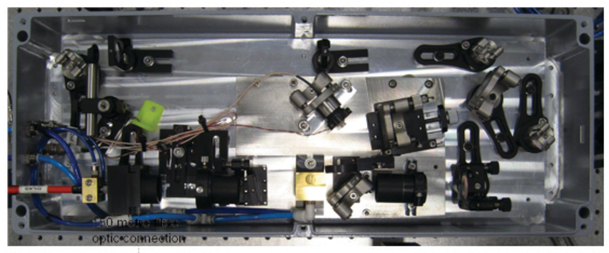
Architectural Overview

The EOS Guide Star Laser is a solid-state non-linear wavelength conversion architecture. It is designed for narrow intrinsic linewidth combined with excellent beam quality ($M^2 < 1.2$) at output powers approaching 30 W. The 589 nm output wavelength is generated by combining two high power (30 W) lasers at 1050 nm and 1342 nm in a non-linear sum frequency generator stage (SFG). The laser system is physically distributed across three carbon fibre breadboards within a temperature & humidity regulated enclosure mounted directly on the the EOS 1.8 m telescope at Mount Stromlo.



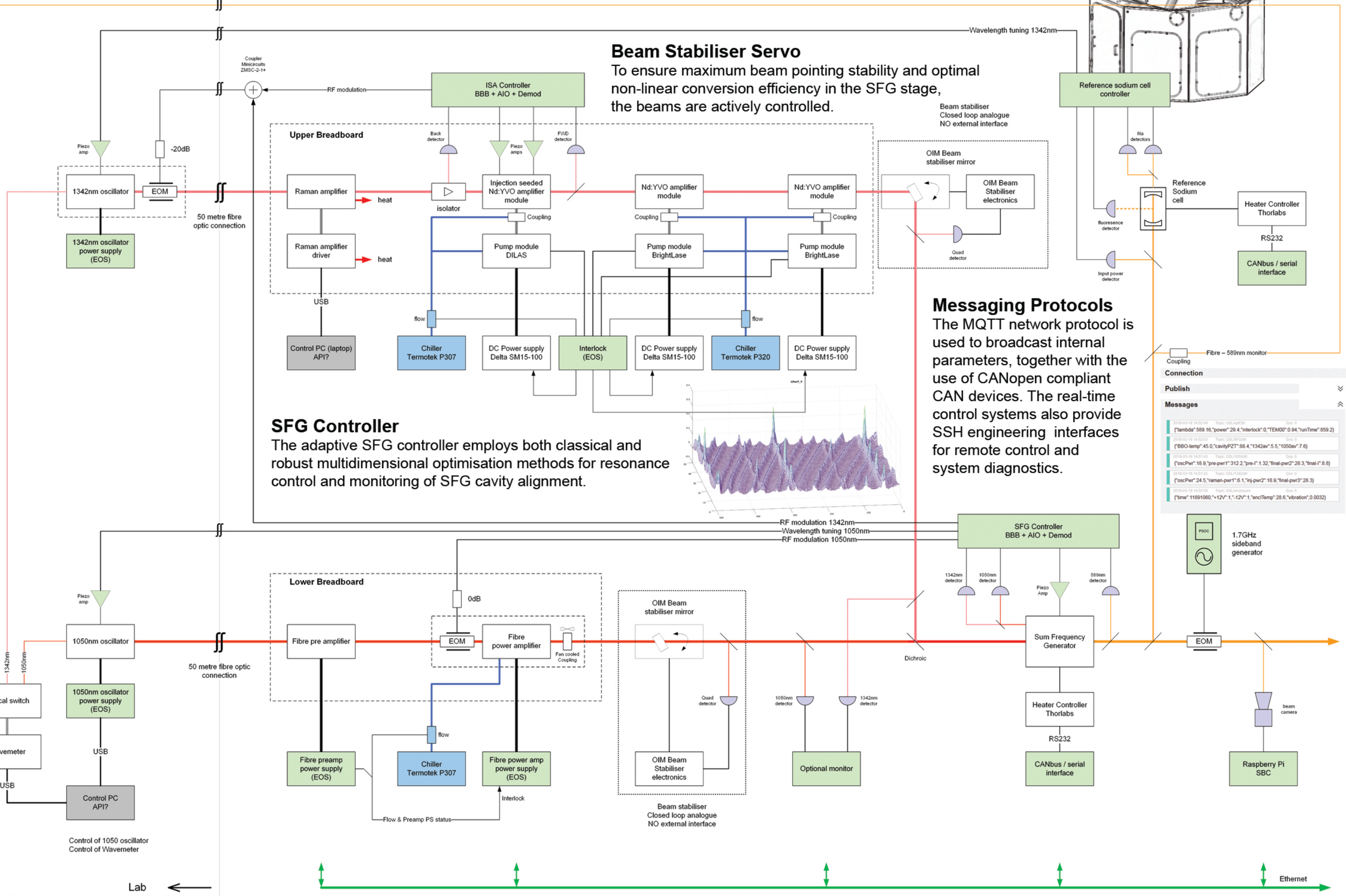


Injection Seeded Amplifier (ISA)

The ISA provides large amounts of optical gain at 1342 nm. It is part of the amplifier chain within the master-oscillator-power-amplifier (MOPA) architecture adopted for both the infra-red laser subsystems. The amplifier generates approximately 15 W output from 7 W of seed laser input. It is actively maintained in the injection-locked state by a dedicated closed loop controller which combines high bandwidth suppression of external disturbances with automated cold-start capability.

Beam Stabiliser Servo

To ensure maximum beam pointing stability and optimal non-linear conversion efficiency in the SFG stage, the beams are actively controlled.

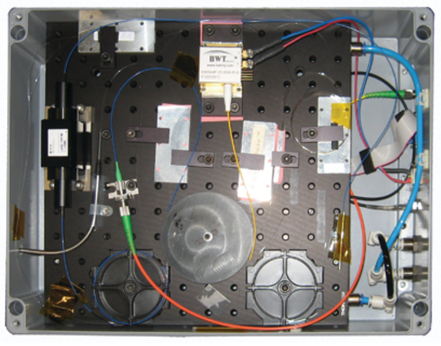


SFG Controller

The adaptive SFG controller employs both classical and robust multidimensional optimisation methods for resonance control and monitoring of SFG cavity alignment.

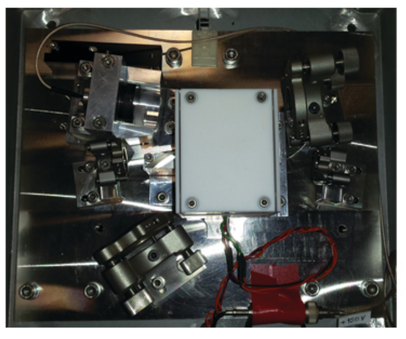
Messaging Protocols

The MQTT network protocol is used to broadcast internal parameters, together with the use of CANopen compliant CAN devices. The real-time control systems also provide SSH engineering interfaces for remote control and system diagnostics.



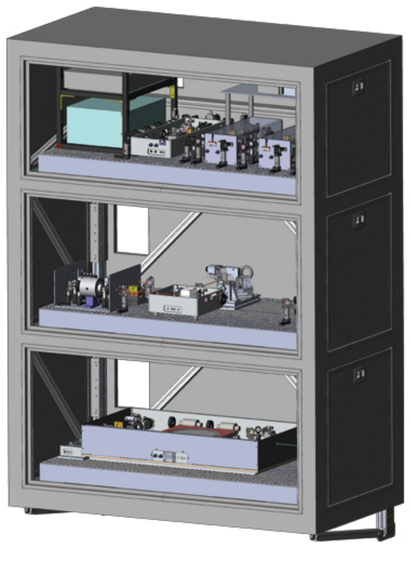
Oscillators

The oscillators provide a tunable, yet high stability source of laser energy for each of the 1050 nm and 1342 nm laser subsystems.
For maximum environmental isolation they are physically located in a cleanroom laboratory space nearly 30 m from the telescope.
Their outputs are delivered to the power amplifiers within the laser enclosure by lengths of polarisation-maintaining fibres that pass through the telescope azimuth cable chain.



Sum Frequency Generator (SFG)

The SFG combines the two infra-red lasers in a temperature controlled non-linear crystal of barium borate (BBO) within an optical cavity.
A multiple-in-multiple-out (MIMO) real-time control system ensures the cavity remains doubly resonant for both input lasers.



Enclosure

The enclosure maintains a clean environment for the laser optics while providing easy access for maintenance/adjustment and thermal isolation from the external climate.
The enclosure is a fibreglass/polyurethane foam composite rigidly mounted to an aluminium internal frame which also supports the internal laser components.

Environmental Management

The interior of the enclosure is required to be held within a small window of temperature around 20 °C to ensure both correct operation of the laser optics and long term opto-mechanical alignment. As the exterior of the enclosure is directly exposed to the ambient conditions which deviate ±20 °C around the interior temperature, a distributed thermoelectric heating/cooling system is used within the laser enclosure. Closed loop controllers condition and monitor the interior environment, including active dehumidification and warning to prevent the access panels being opened to a potentially condensing atmosphere.