MULTIPLY-ESA HRSL status of development and implementation

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Project overview

- **Objective :**

Development of a novel multi-wavelength HSRL system (3b + 3a + 3d) for both ground based (phase 1) and airborne operation (phase 2: after-2024)

- Target of the HSRL: better than EarthCARE specifications

System specifications

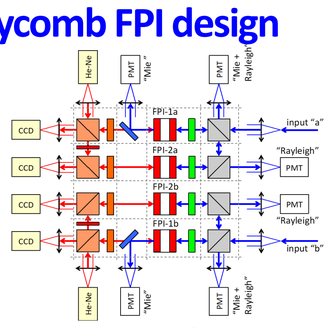
• Laser	Mephisto Q Nd:YAG DPSSL
• Emission wavelegnths	355nm, 532nm, 1064nm
• Target energy @ 355nm	2mJ @ 1064nm, 1.5mJ @ 532nm, 1.5mJ
• Repetition rate	4 kHz
• Frequency	locking Iodine vapour cell (line 1109, 532.26nm)
• Telescopes	5
• Aerosol products	Backscatter, extinction, depolarization
• HSR filter at 532nm	Iodine vapour cell
• HSR flter at 355, 1064nm	Fabry-P erot interferometers
• Depolarization separation	Wollaston prisms

Requirement	Data products (EarthCARE)	MULTIPLY target
Detectability threshold		
α (355nm)	0.05 (1/km)	0.02-0.05 (1/km)
β (355nm)	0.0008 (1/km/sr)	0.0003-0.0008 (1/km/sr)
AOD (355nm)	0.05	0.02-0.05
δ (355 nm)	N/A	0.02
Accuracy		
α (355nm)	10-15%	10-15%
β (355nm)	10-15%	10%
AOD (355nm)	10-15%	10%
δ (355 nm)	N/A	10%
Vertical resolution (m)		
α (355nm)	100-500	100
β (355nm)	100-500	7.5
AOD (355nm)	-	-
δ (355 nm)	NA	7.5
Horizontal resolution (m)		
α (355nm)	10000	5000-8000
β (355nm)	10000	500-800
AOD (355nm)	10000	5000-8000
δ (355 nm)	NA	500-800

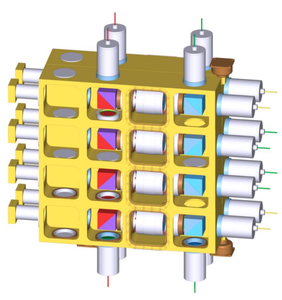
Main features

- *3β + 3α + 3d*
- *Fabry-Pérot Interferometers for HSR filtering at 355 and 1064 nm – based on pressure adjustment for tuning the alignment*
- *Iodine filtering technique at 532 nm*
- *Low laser pulse energy (to conform the eye-safety requirements)*
- *High laser frequency rate*
- *Decoupling spectral separation unit (interferometers, iodine filter) from telescope with optical fibers (to allow better mechanical stability)*
- *Extra telescopes for polarization channels*
- *Additional "near"-range telescope (to extend dynamic range)*

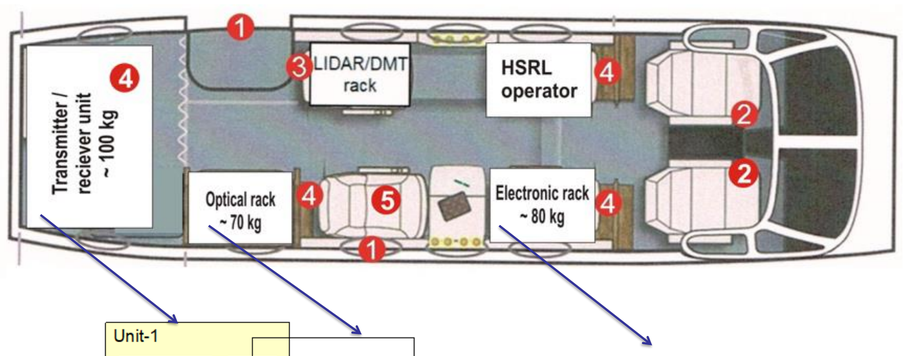
Honeycomb FPI design



2xFPIs per channel
2 Telescopes
2 Wavelength
1 Polarization
Total: 8 FPIs
matrix: 4x4x2
size: 488x484x216 mm
weight: 55 kg

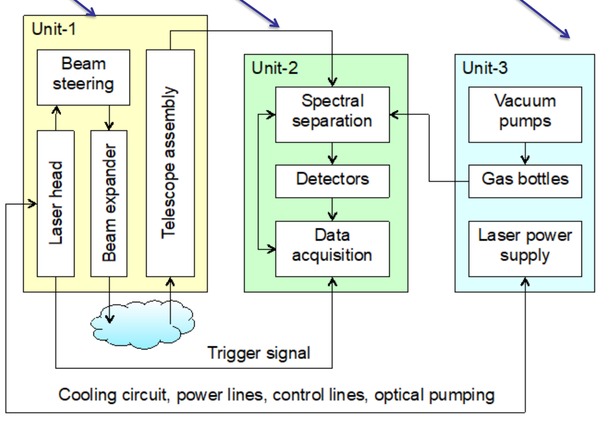


Airborne platform



Foreseen configuration of the ATMOSLAB aircraft

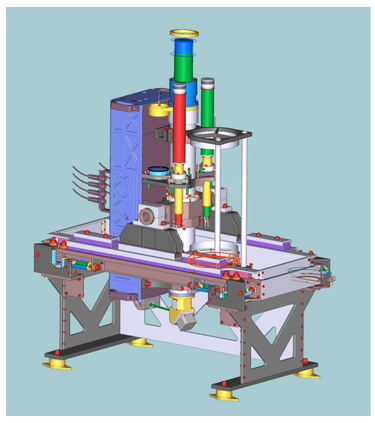
inside view
1 - door
2 -pilot seats
3 -topographic lidar rack
4 - HSRL modules
5 - reserve seat



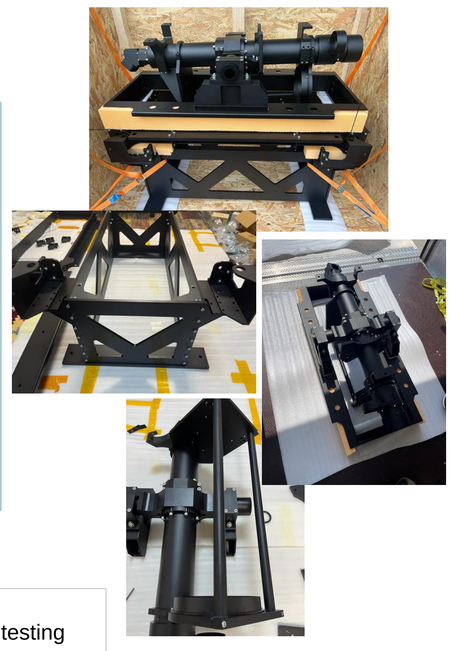
ATMOSLAB – C 90 GTx own by *INCAS*

Project status

HSRL CAD design@MPI



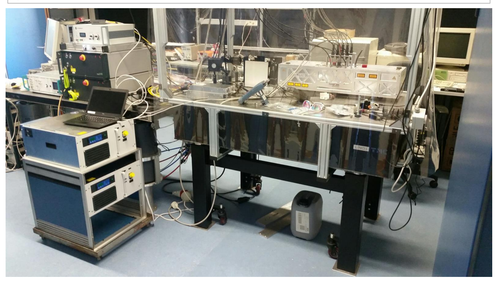
Structure of the instrument manufactured

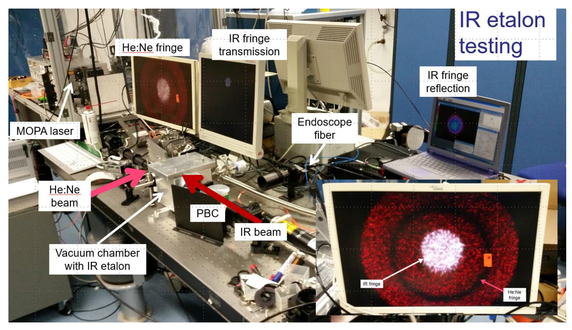


Detailed design report completed
- breadboard design: transmitter, HSRL receiver, vibration filtering module, data acquisition block and framing
- FPI etalons

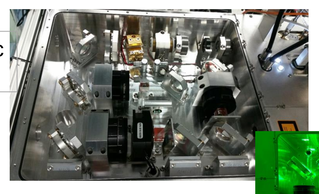
Manufactured
- First vacuum chamber (one
- channel)
- HSRL laser
- 8 FPI (4 UV; 4IR)
- Telescopes
- PMT unit parts
- Iodine filter for VIS HSRL
- Emission unit (beam expansion)
- Polarization channels
- Frame components

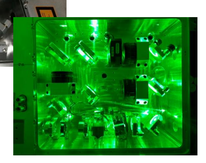
MOPA System including the Coherent Mephisto-Q Seed Laser at MPI during testing phase



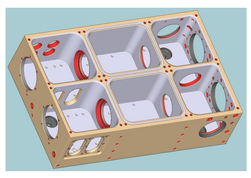


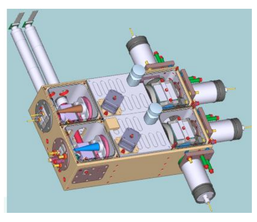
Laser harmonic compartment

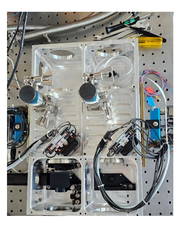




One-channel HSRL-honeycomb housing

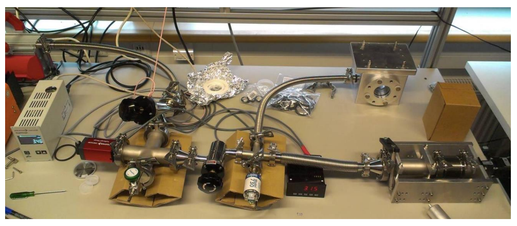






Detection unit – one channel

Vacuum chamber & control
- Low pressure to relax the constraint to control the temperature
- Compensation by piezo actuators
- Vacuum pumps + N_2 bottles at ground
- Small vacuum pumps, no gas bottles in the aircraft
- Individual control and valves for each vacuum chamber



Vacuum control unit-for one FPI

Some numbers from the lab

- *1064 FPI elastic suppression in molecular channel of 525 (two etalons) (800 required for aerosols* and 30000 for water clouds)*
- *tests with frequency locking off – expect better results with frequency locking on – over 800*
- *355 FPI elastic suppression of 450 (two etalons) (300 required for water clouds*)*
- *532 iodine not tested yet but 60 required for aerosols* and 1500 for water clouds*)*

**to retrieve aerosol optical properties with 1% uncertainty*

Project implementation plan

- One channel operational by end of 2023
  - night-time: background suppression not fully integrated (additional FPI)
- Fully operational on all channels by end of 2024 (ground based)
  - 3b + 3a + 3d
  - night-time and day-time
- Airborne integration by end of 2025

ESA-JAXA Pre-Launch EarthCARE Science and Validation Workshop
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