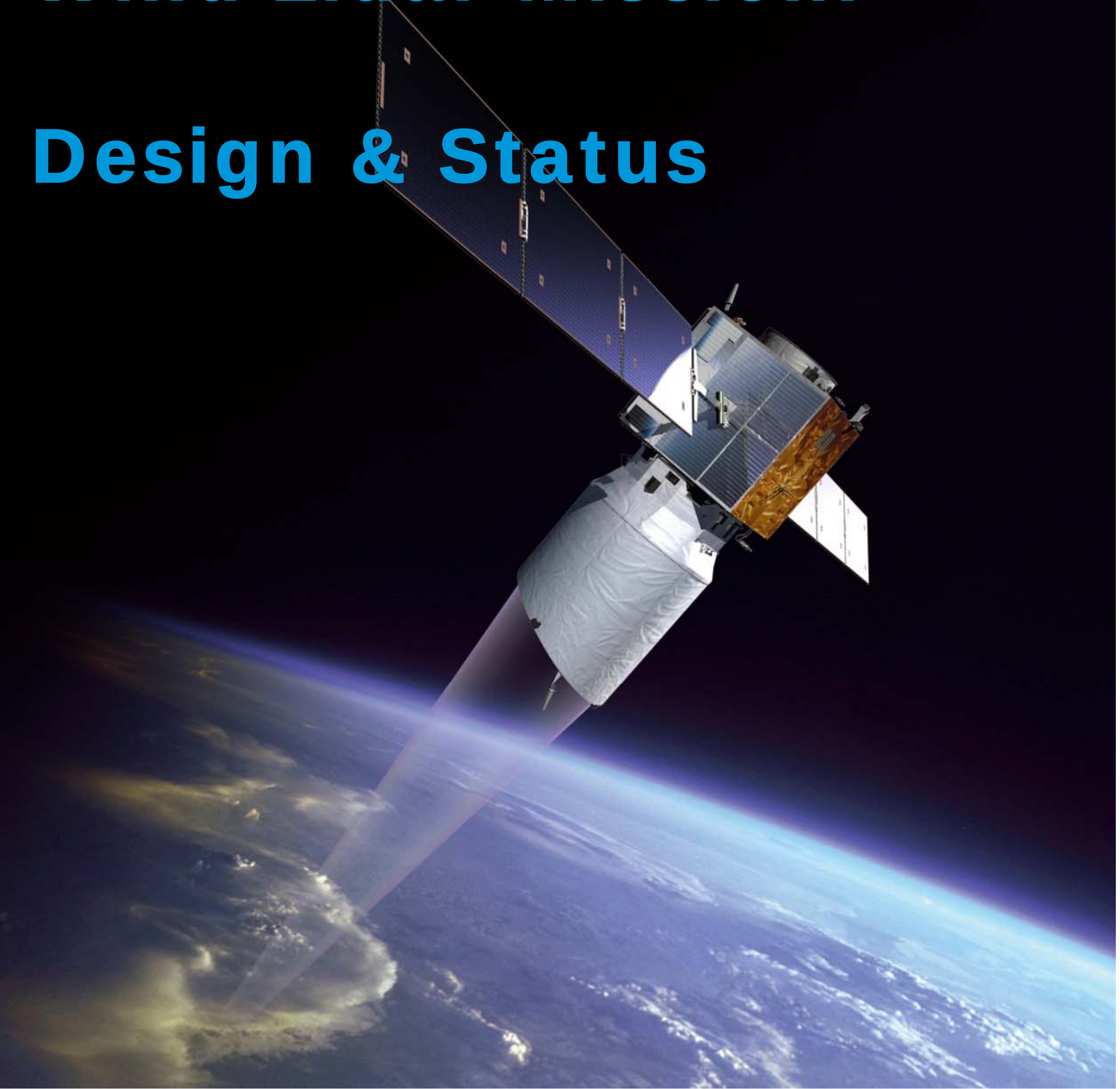
# Aeolus – ESA's Wind Lidar Mission:

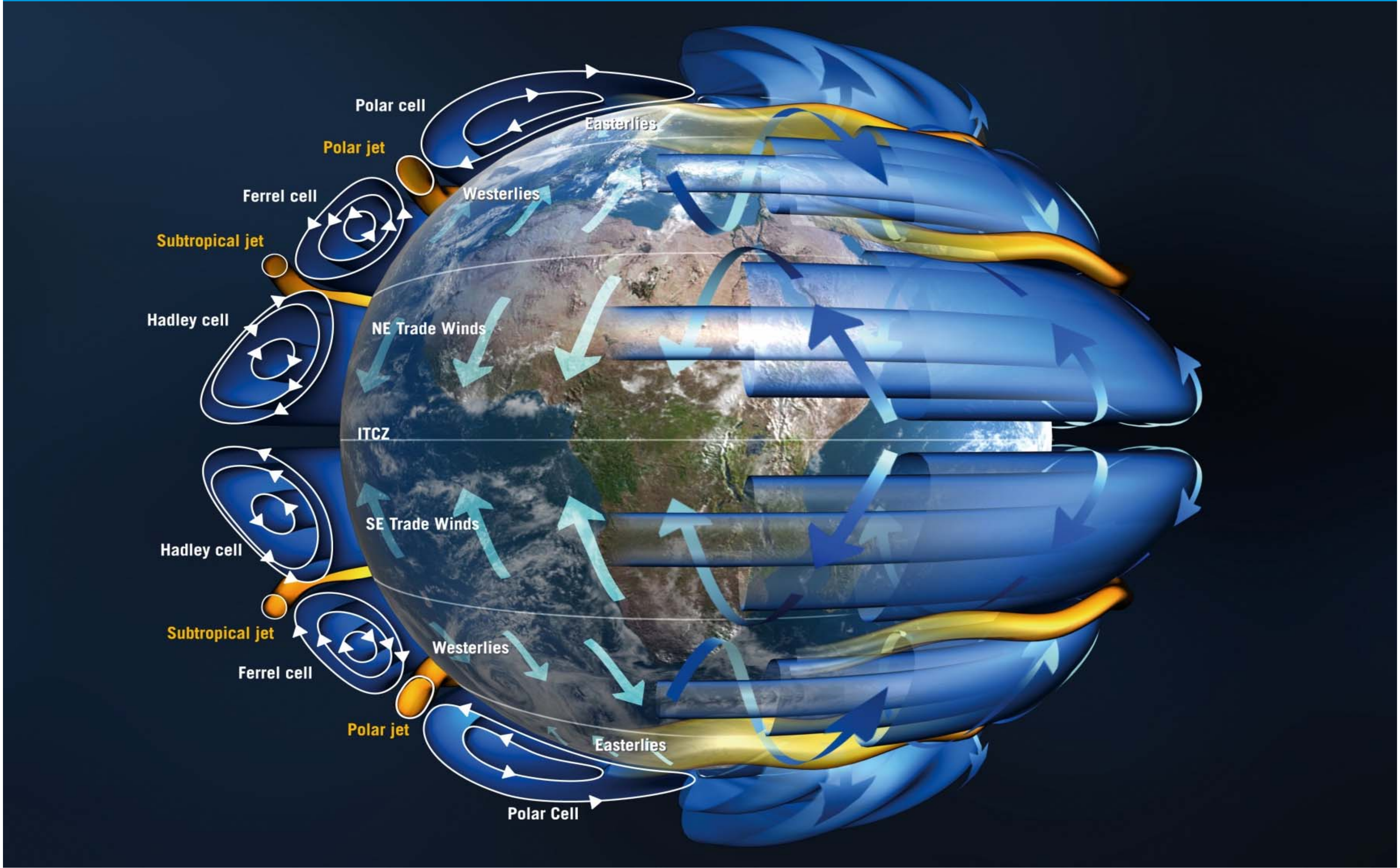
# Objectives, Design & Status




**Anne Grete Straume**
**on behalf of Anders Elfving**
European Space Agency/ESTEC


Working Group on Space-based Lidar Winds
Boulder, 28/04/2015

# Atmospheric Dynamics of the Earth



# Aeolus: Mission Objectives

## Scientific objectives

- To improve the quality of weather forecasts;
- To advance our understanding of atmospheric dynamics and climate processes;

## Explorer objectives

- Demonstrate space-based Doppler Wind LIDARs potential for operational use.

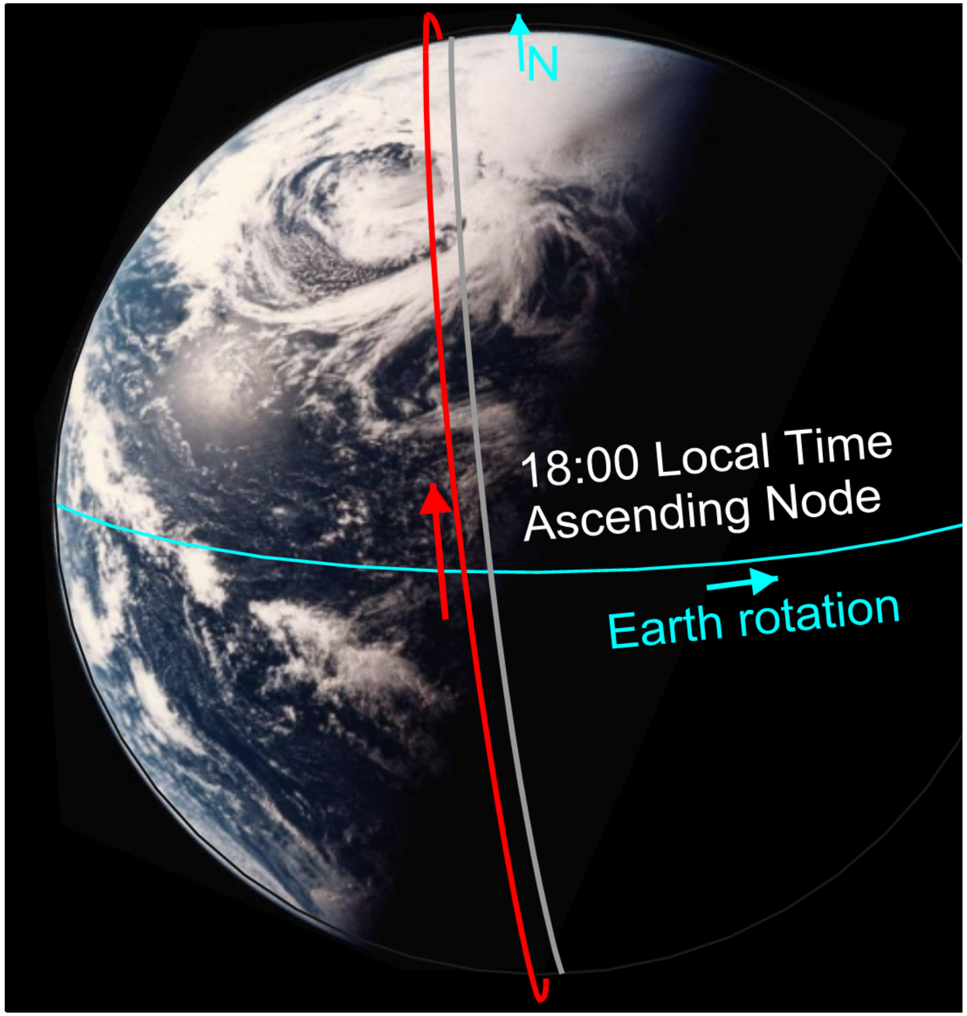
## Observation means:

- Provide global measurements of horizontal wind profiles in the troposphere and lower stratosphere

## Payload

- ALADIN: Atmospheric LAser Doppler INstrument

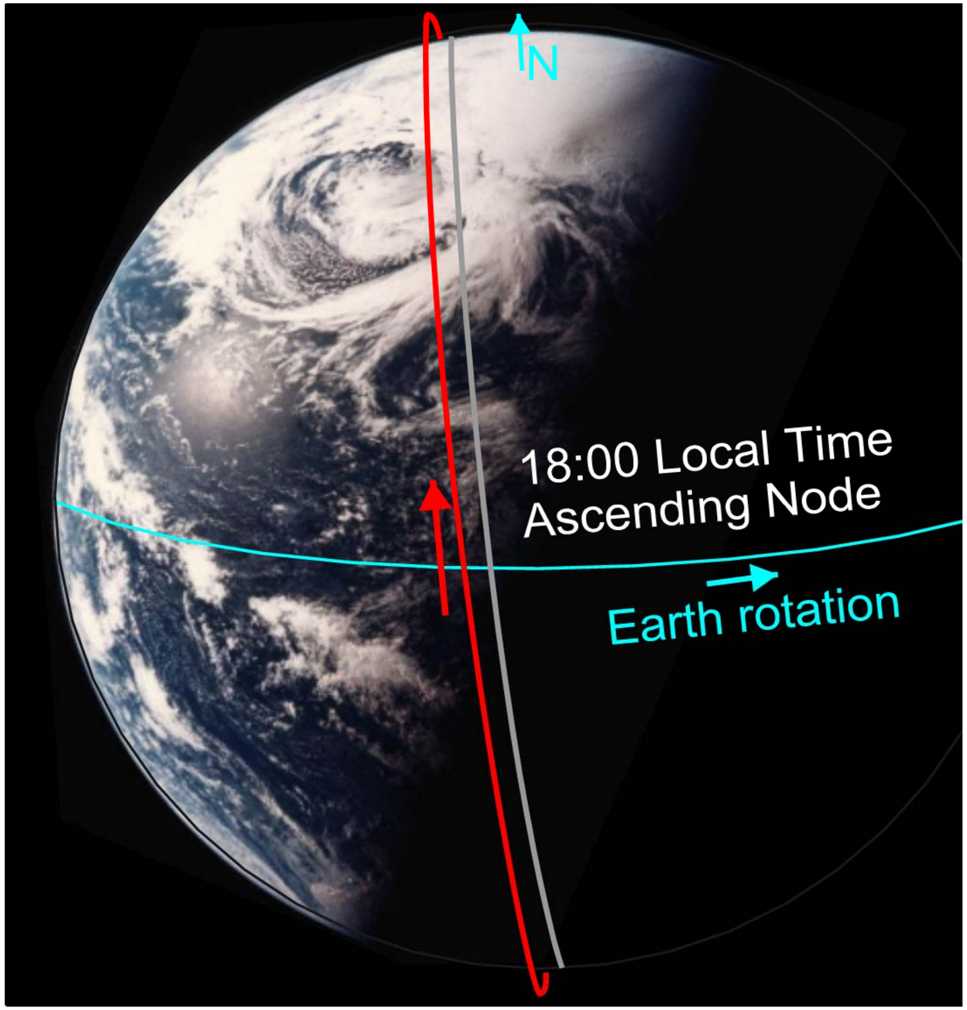
# Mission Design

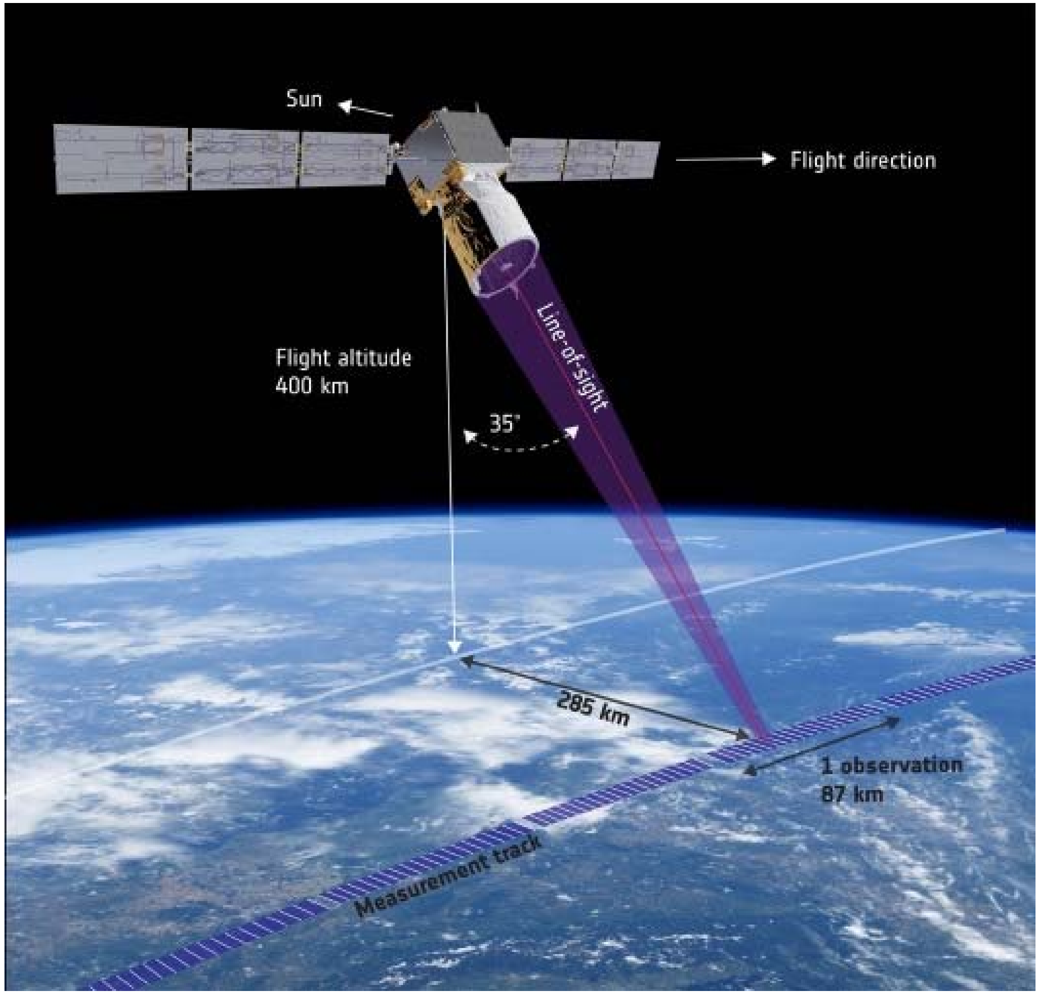



## Mission Parameters

- Orbit: sun-synchronous
- Mean altitude: ~400 km
- Local time: 18:00 ascending node
- Inclination: 96.97º
- Repeat cycle: 7 days / 109 orbits
- Orbits per day: ~16
- Mission lifetime: 3 years

# Mission Design



# Satellite Control

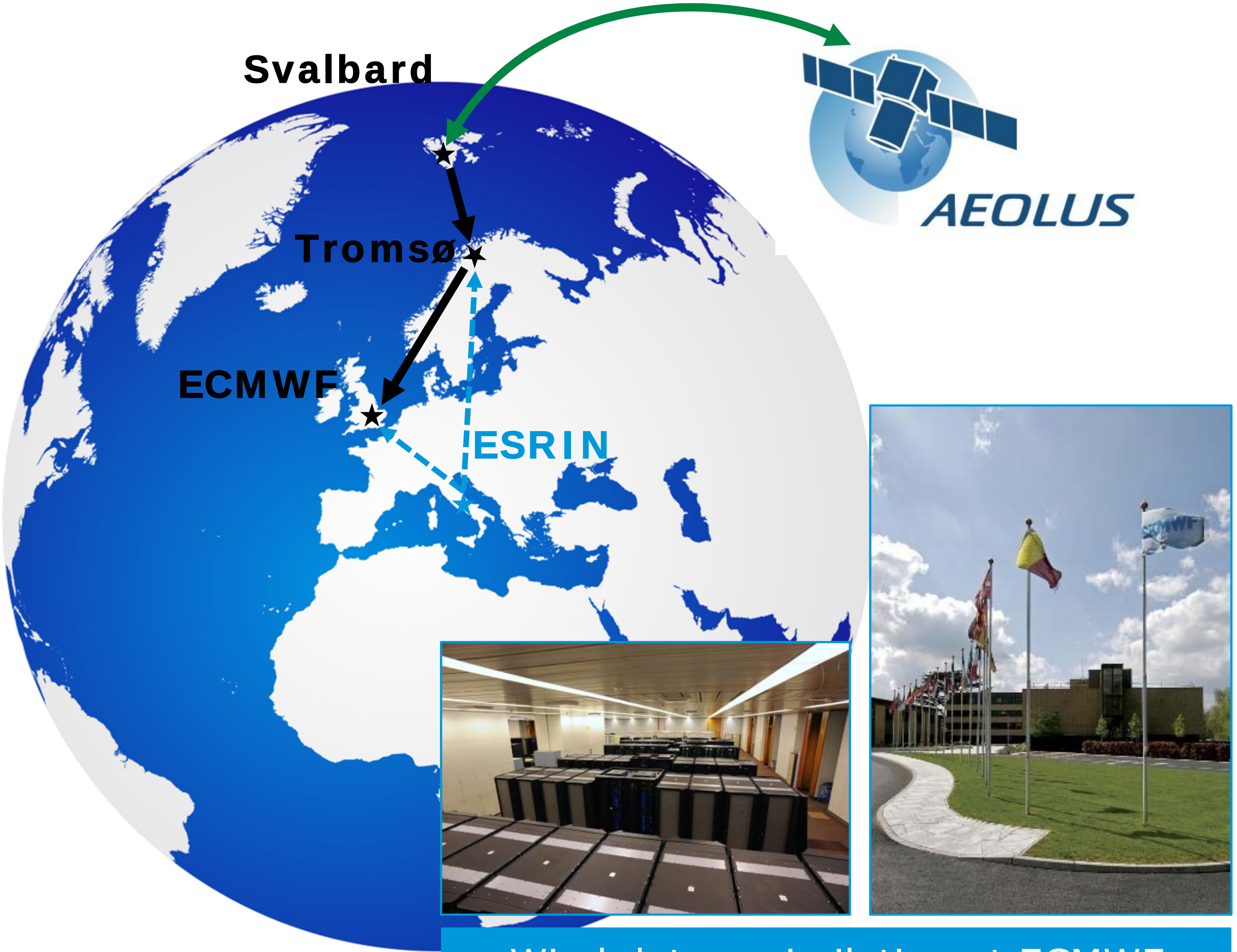
Ground station
at Salmijärvi (Kiruna)

Satellite Control from ESOC
Darmstadt (Germany)

# Data Reception & Processing (1/2)

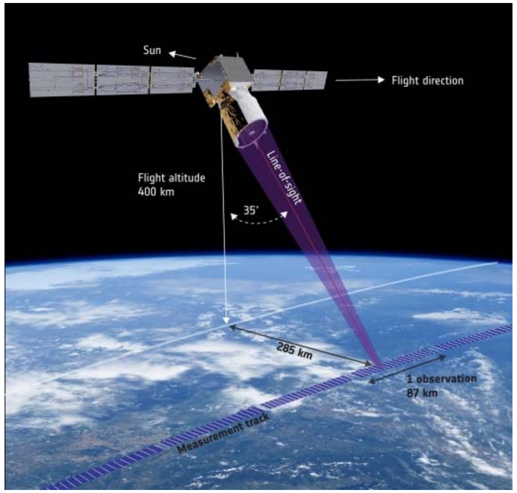
## Data reception at Svalbard

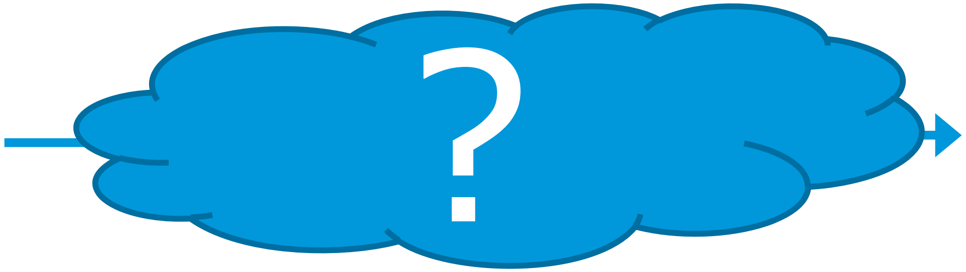
## Data processing at Tromsø



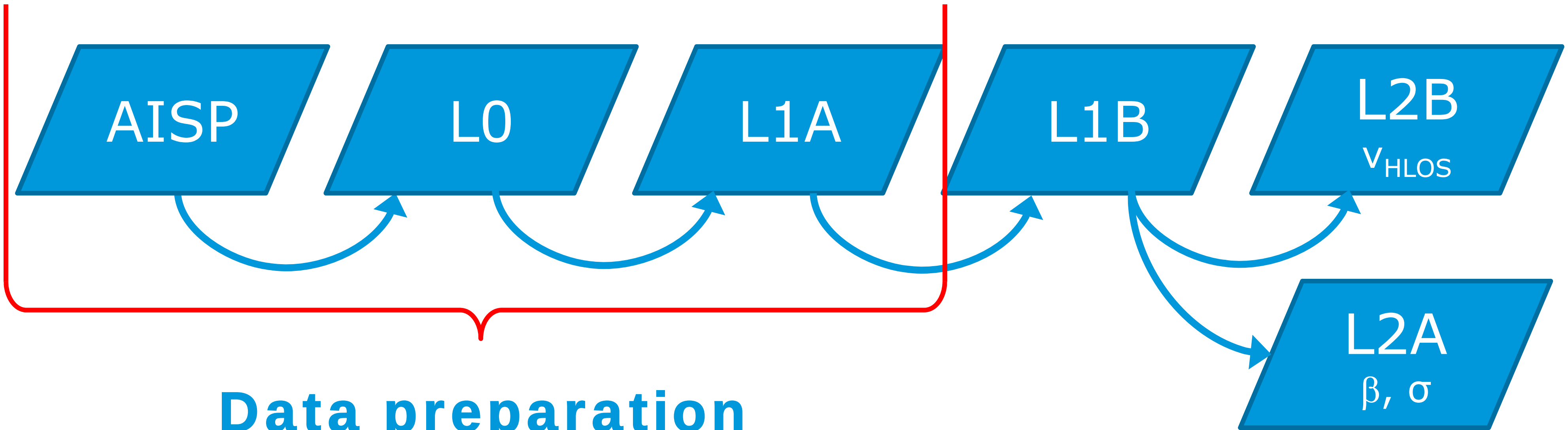

Wind data assimilation at ECMWF

# Aeolus: Instrument Data Processing



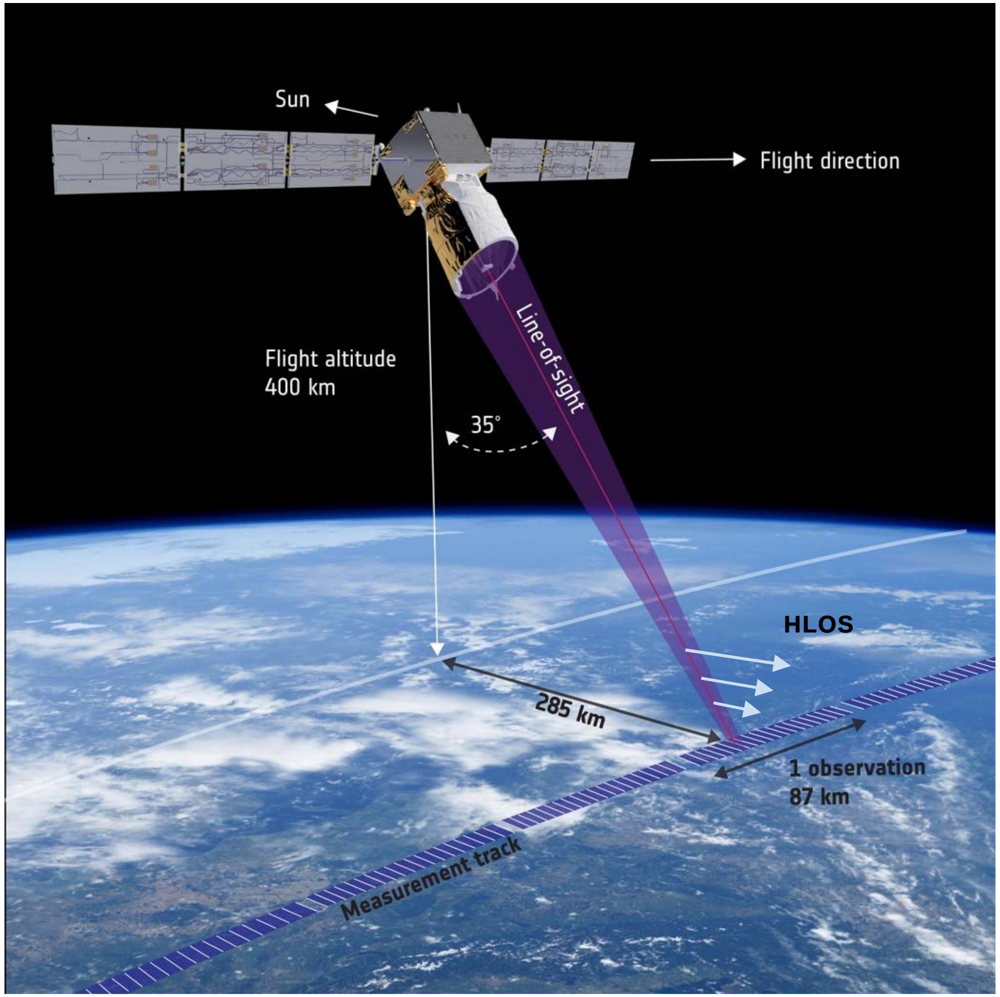




**Wind Velocity**



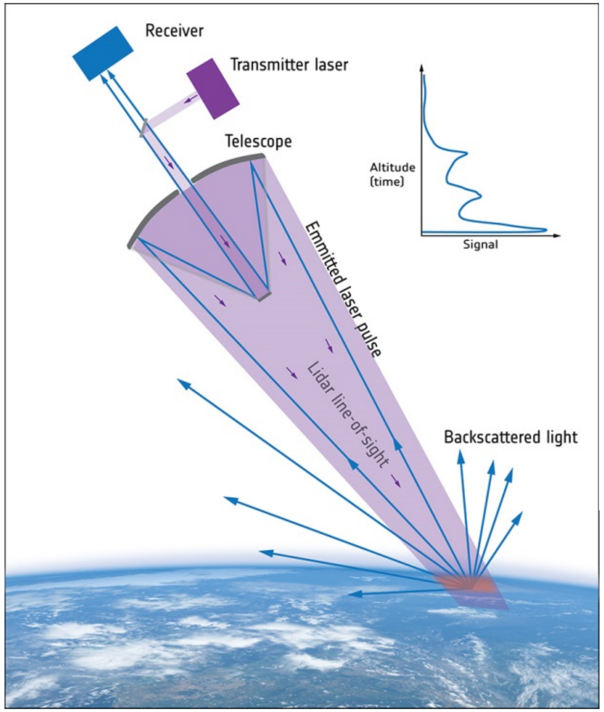

**Data preparation**

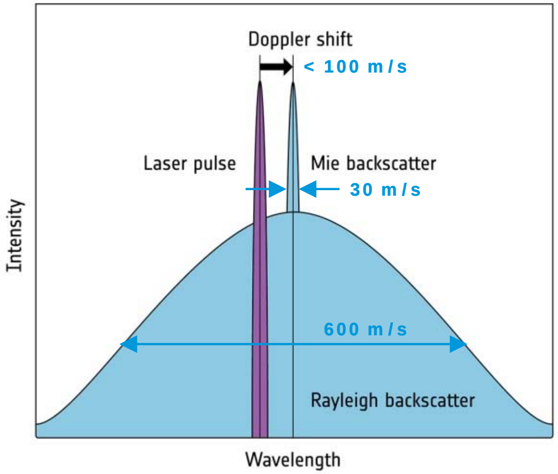
# Aeolus: Measurement Principle (1/2)

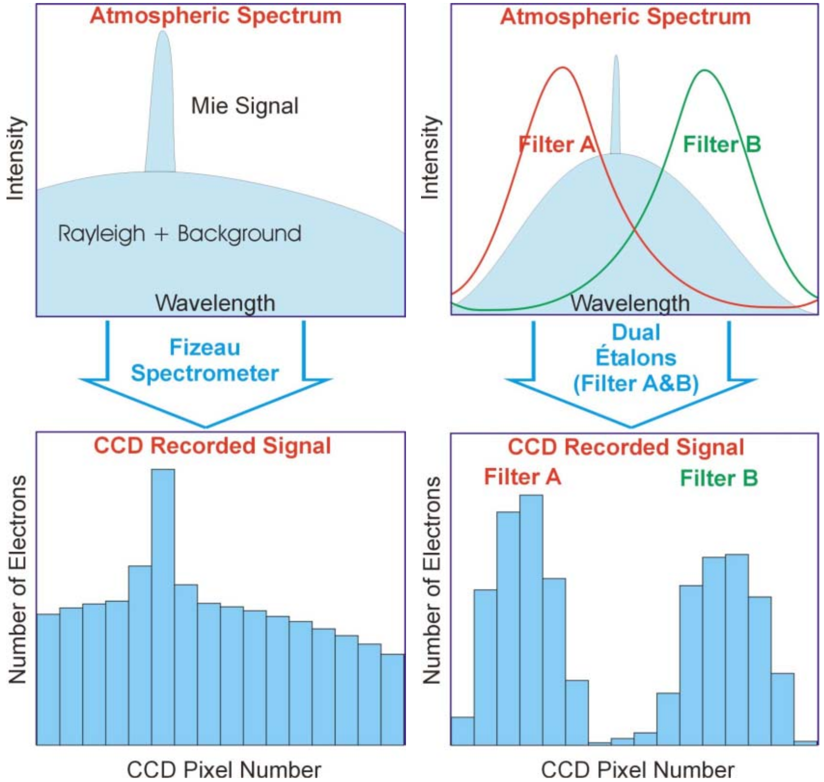



- Direct detection UV Doppler wind Lidar operating at 355 nm and 50 Hz PRF in <u>continuous mode</u>, with 2 receiver channels
- Mie receiver to determine winds from aerosol & cloud backscatter
- Rayleigh receiver to determine winds from molecular backscatter
- The line-of-sight is pointing 35º from Nadir to obtain horizontal backscatter component
- The line-of-sight is pointing orthogonal to the ground track velocity vector to remove contribution from the satellite velocity

# Aeolus: Measurement Principle (2/2)

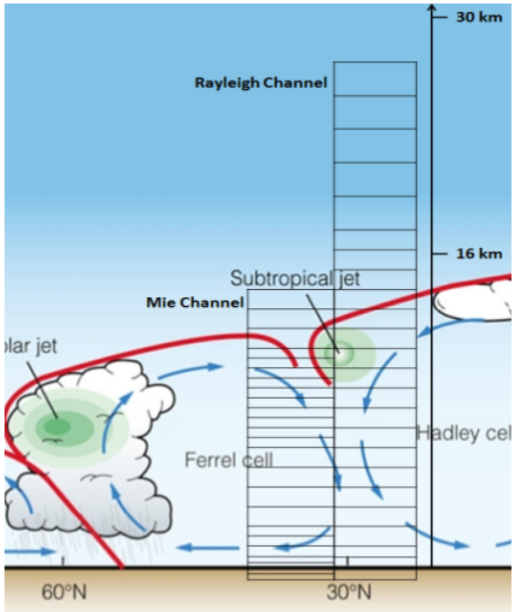



<u>Mie channel</u>:
- Aerosol/cloud backscatter
- Imaging technique

<u>Rayleigh channel</u>:
- Molecular backscatter
- Double-edge technique



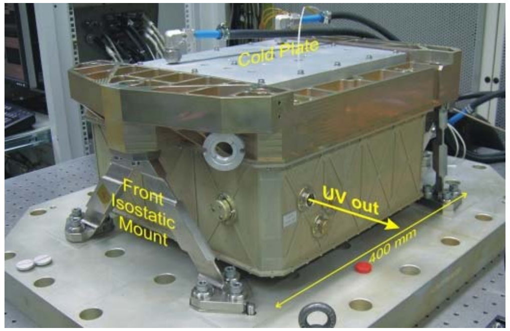
# Aeolus: Observational Requirements

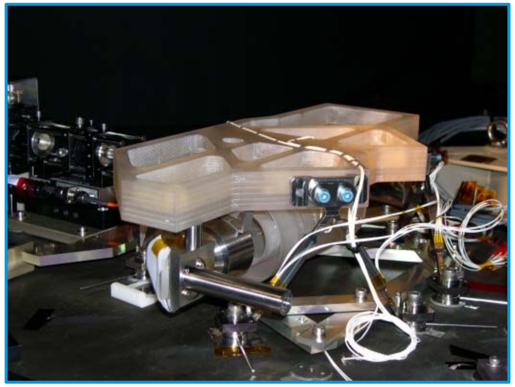
| | | PBL | Troposphere | Stratosphere |
|---|---|---|---|---|
| Vertical domain | [km] | 0-2 | 2-16 | 16-20 (30)* |
| Vertical resolution[1] | [km] | 0.5 | 1.0 | 2.0 |
| Horizontal domain | | Global | | |
| Number of profiles | [hour⁻¹] | >100 | | |
| Horizontal track data availability | | > 90% | | |
| Temporal sampling | [hr] | 12 | | |
| Horizontal resolution / integration length[2] | [km] | 15 (target) – 100 (threshold) | | |
| Horizontal sub-sample length | [km] | km scale | | |
| Random error (HLOS Component) | [m/s] | 1 | 2.5 | 3* |
| Systematic error (HLOS component) | [m/s] | 0.7 | 0.7 | 0.7 |
| Dynamic Range, HLOS | [m/s] | ±150 | | |
| Error Correlation per 100 km | | < 0.1 | | |
| Probability of Gross Error | [%] | 5 | | |
| Timeliness | | 3 | | |
| Length of Observation Dataset | [yr] | 3 | | |

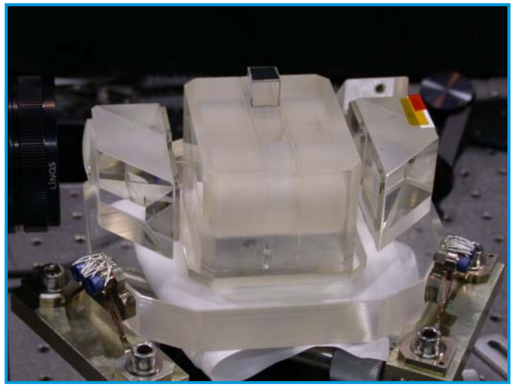
[1] 24 atmospheric samples for Mie & Rayleigh channel with 0.25km minimum vertical resolution

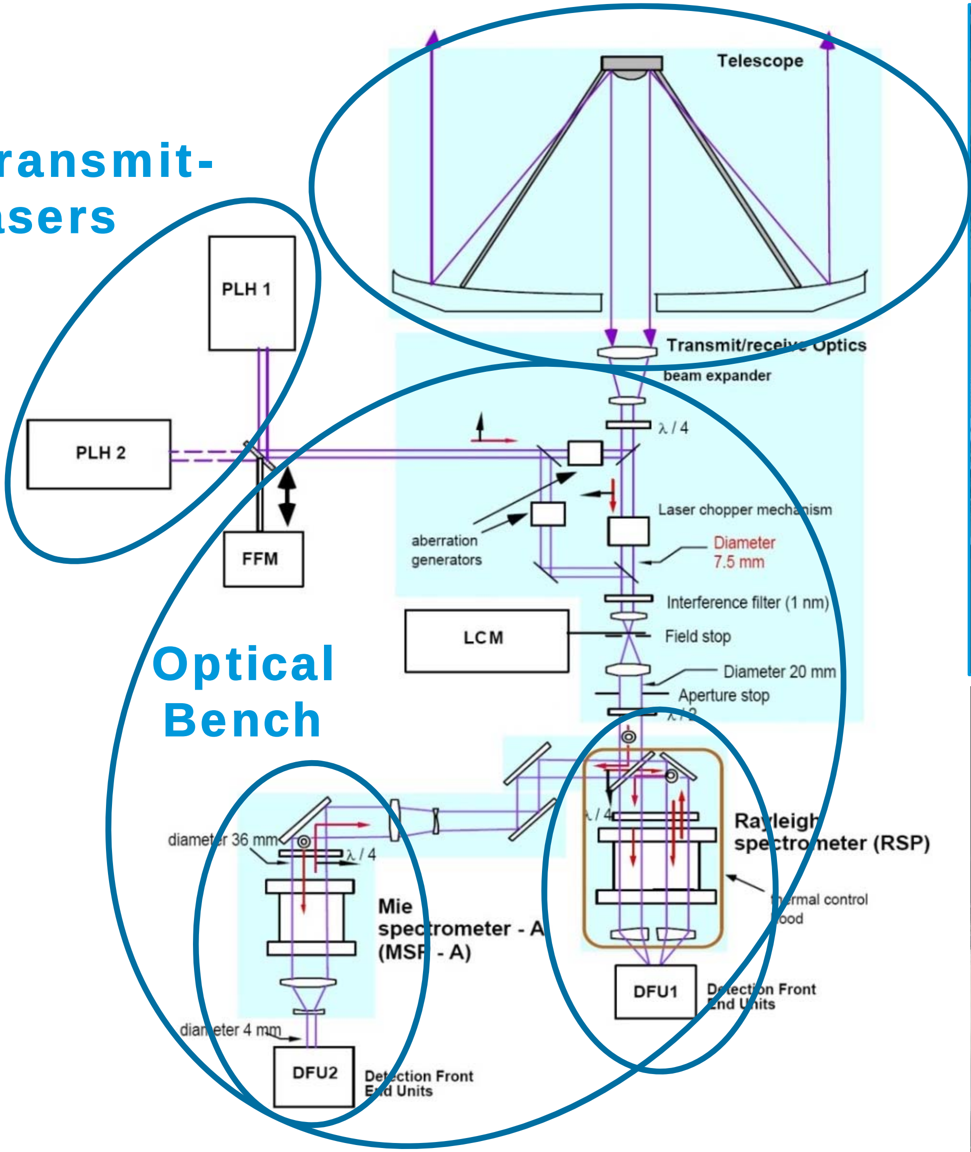
[2] L1B data: ~90 km horizontal integration length

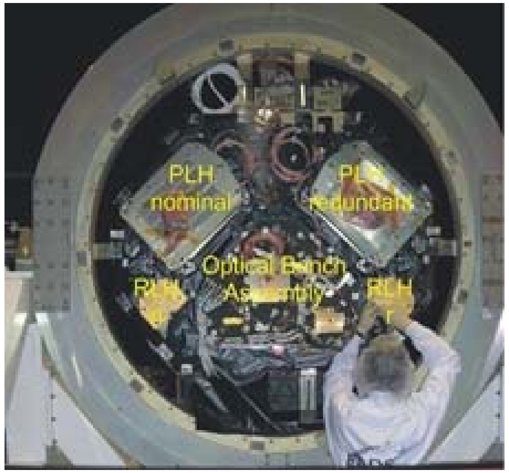
# Aeolus: ALADIN Instrument



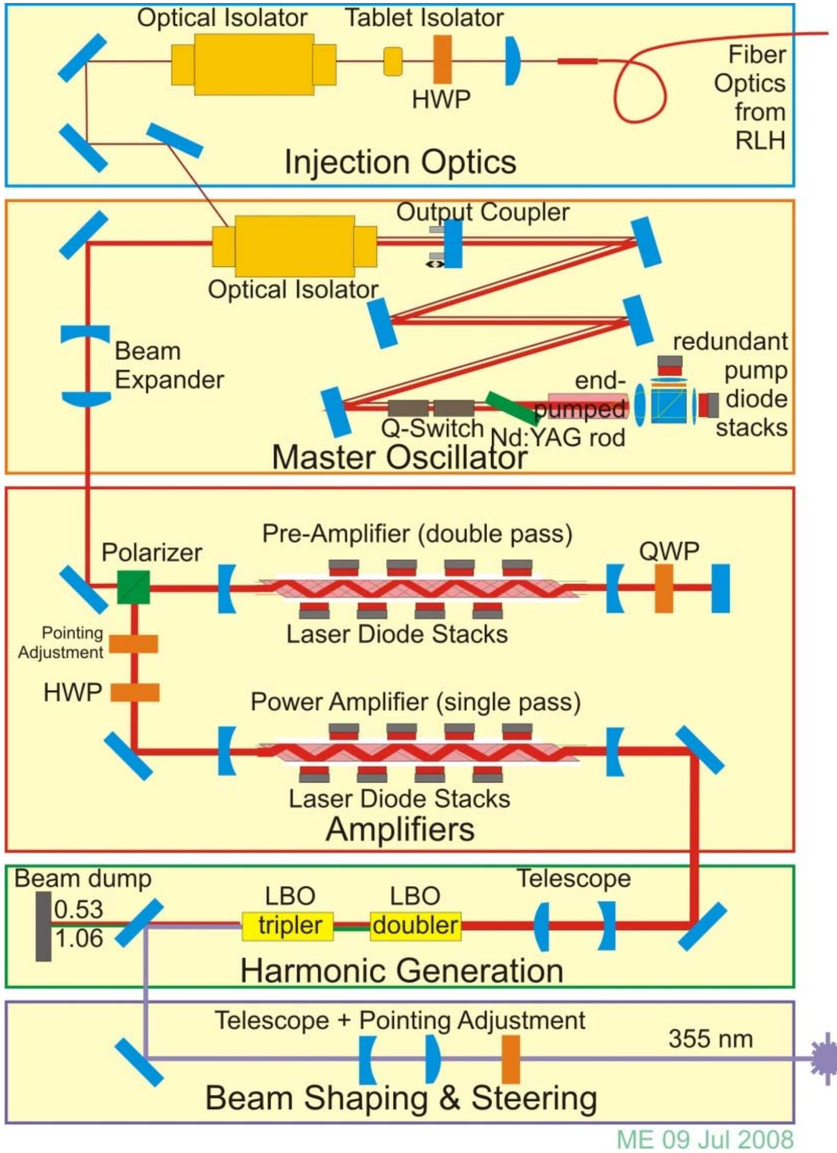





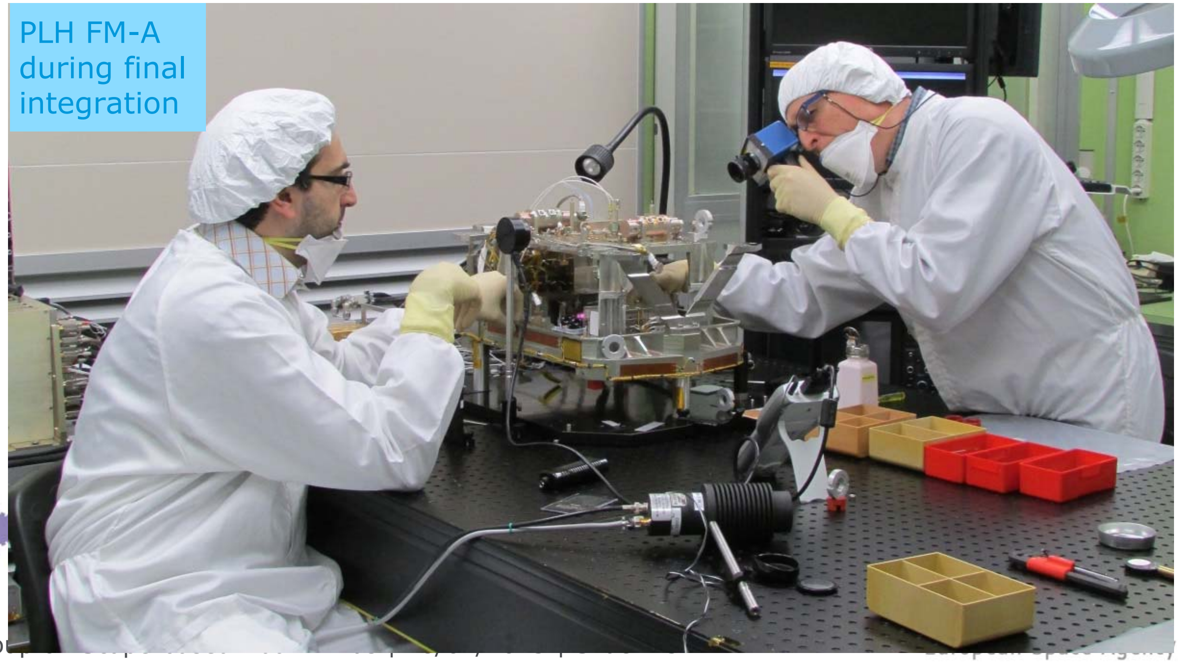


# Aeolus: ALADIN Laser Transmitter

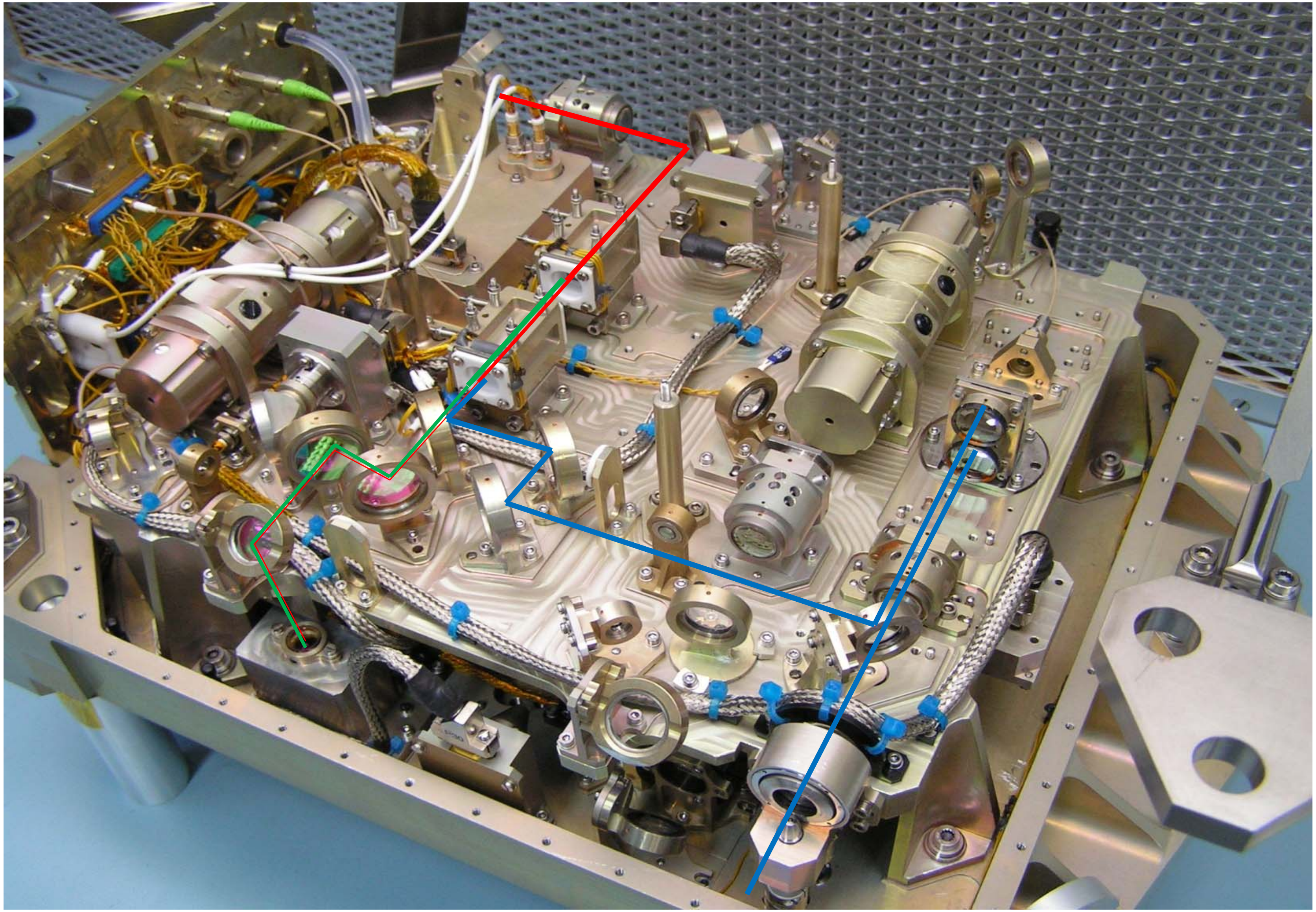



- The Master Oscillator is a stable resonator with an end-pumped rod. An RTP crystal q-switch is used. Pulses of about 5 mJ energy at 1065 nm are generated.
- Two diode pumped slab amplifiers generate about 350 mJ at 50 Hz pulse repetition frequency.
- These IR pulses are frequency tripled to the UV (355 nm) in two LBO crystals with ~40% efficiency.
- UV optics to shape and steer the output beam for compatibility with Aladin transmit optics.

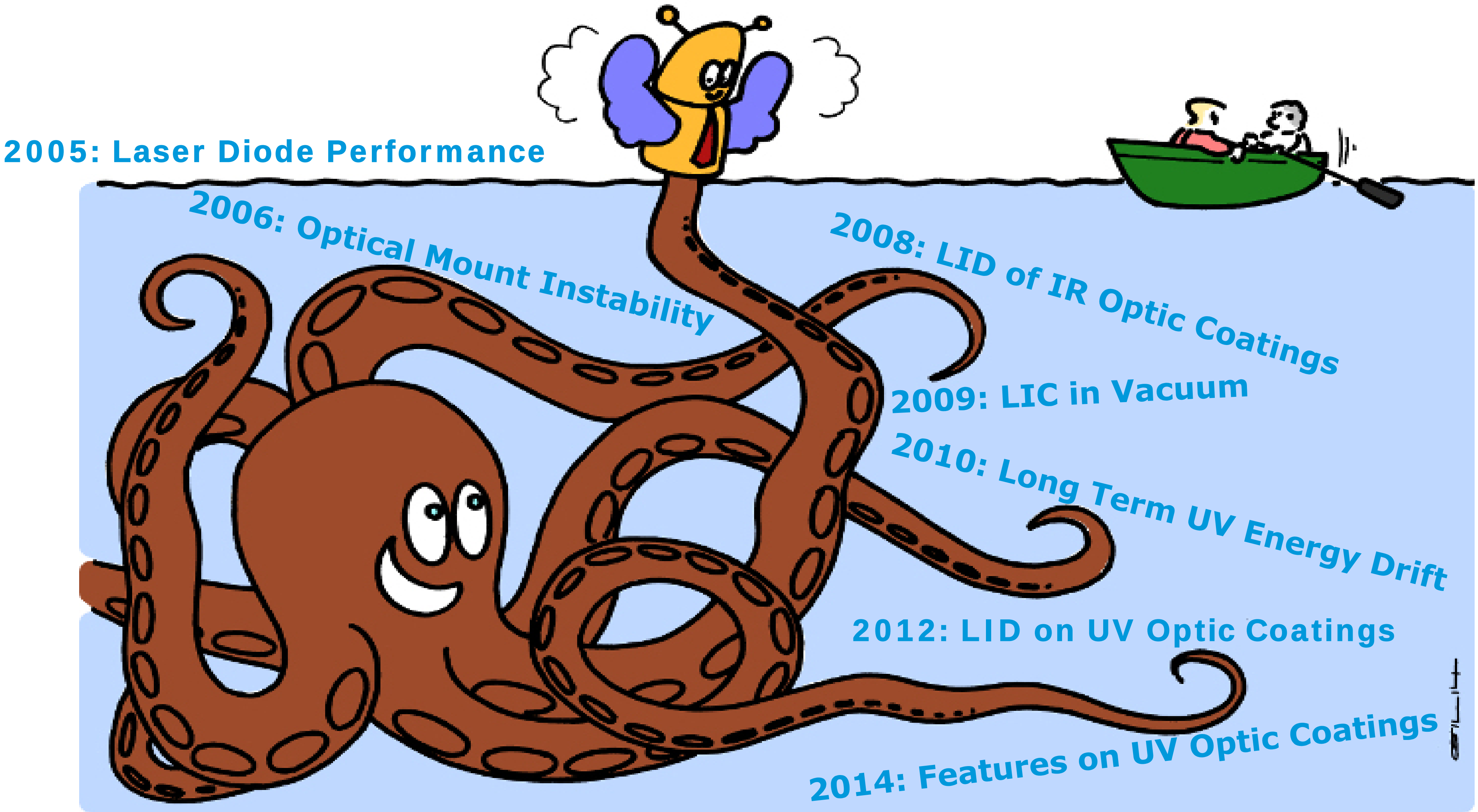


PLH FM-A during final integration

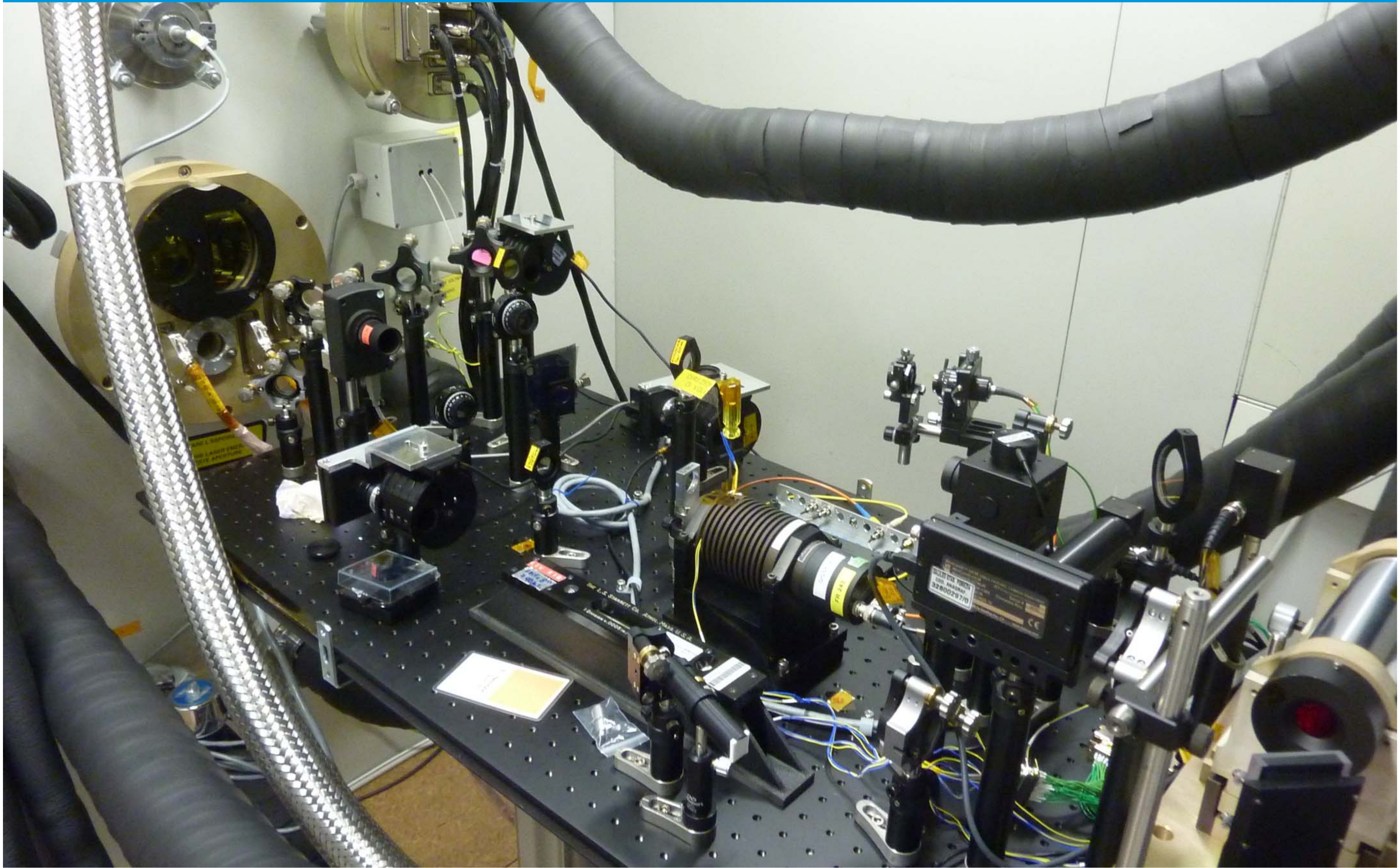
# Harmonic Conversion and UV section



# Aeolus: Major events, Laser Test Experience

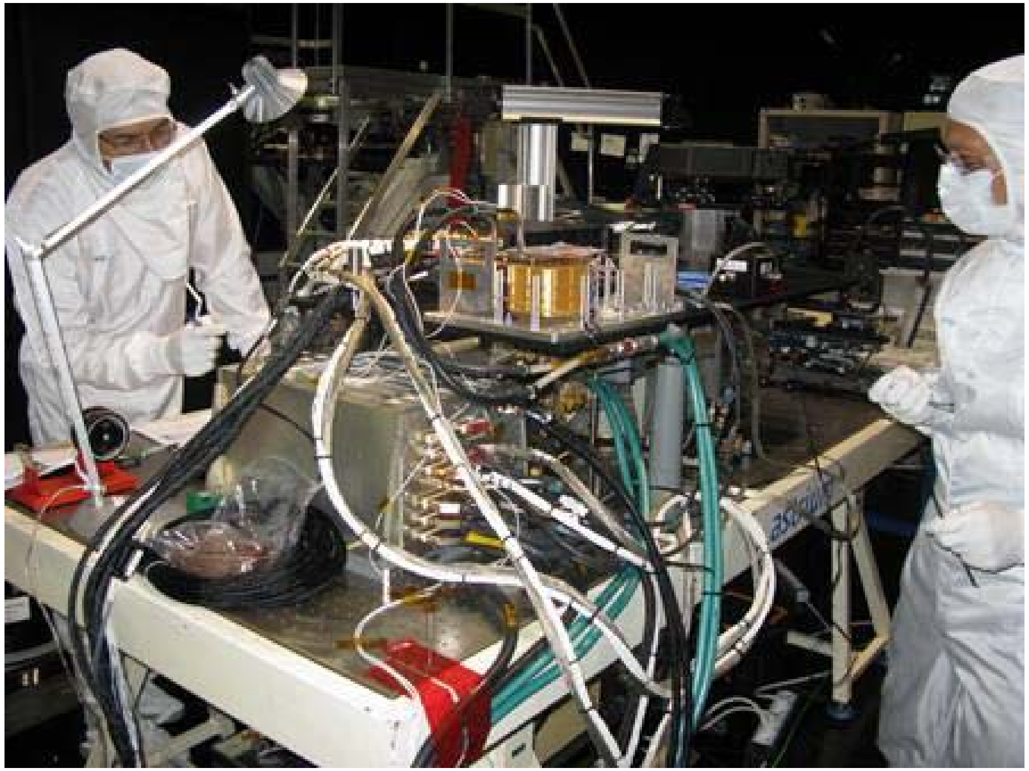


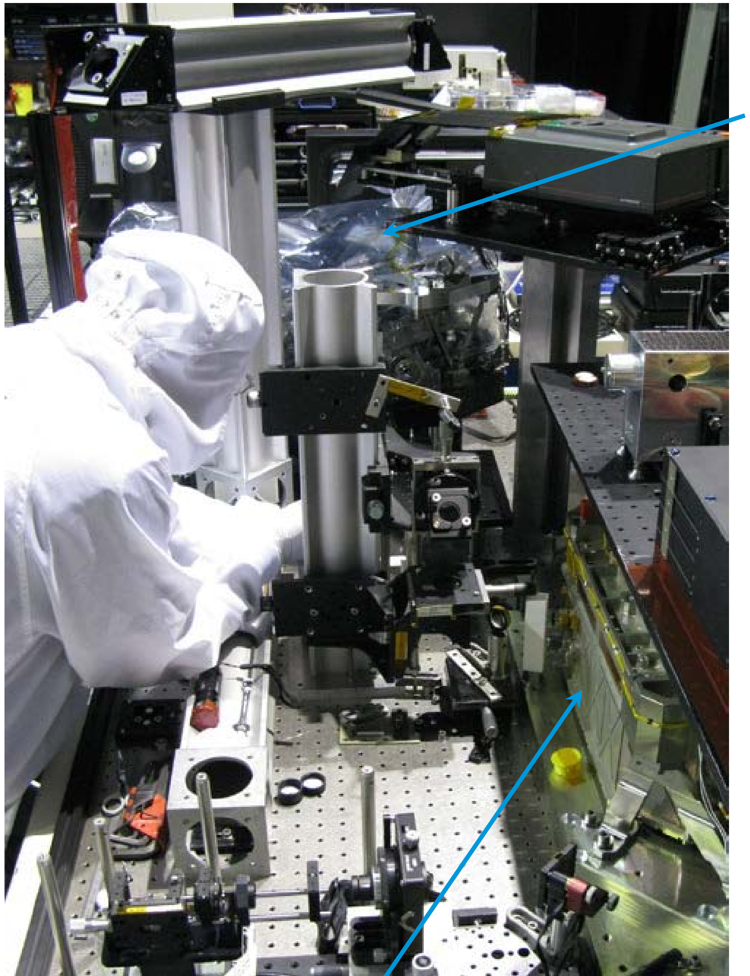
# Laser Endurance Test in Vacuum Chamber 150 M shots



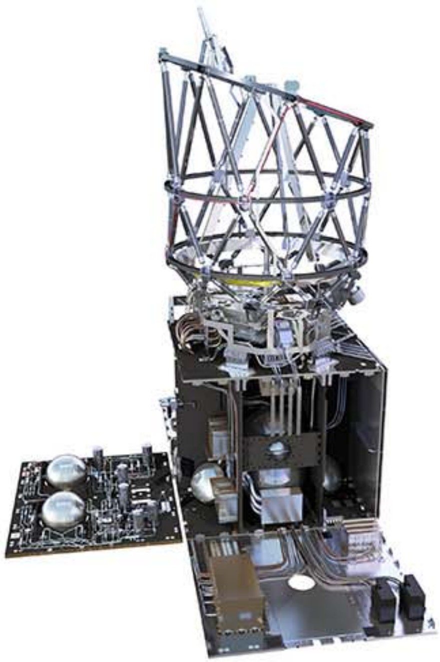
# Optical Bench Assembly (OBA) with Transmit & Receive Optics (TRO)

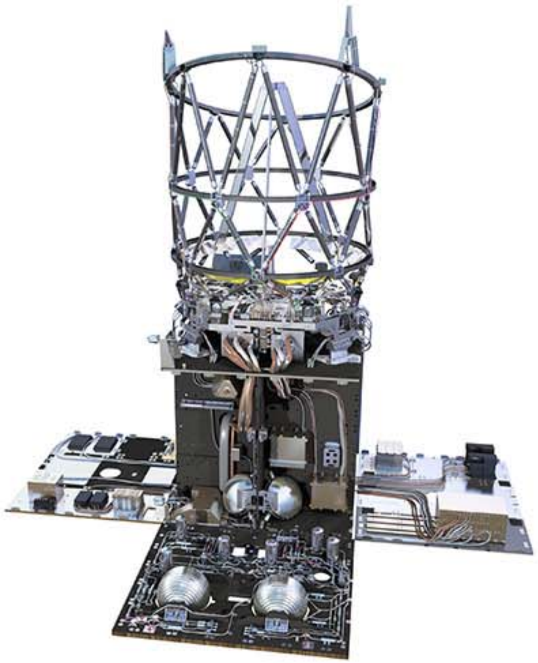
# Optical Bench Fluence Test

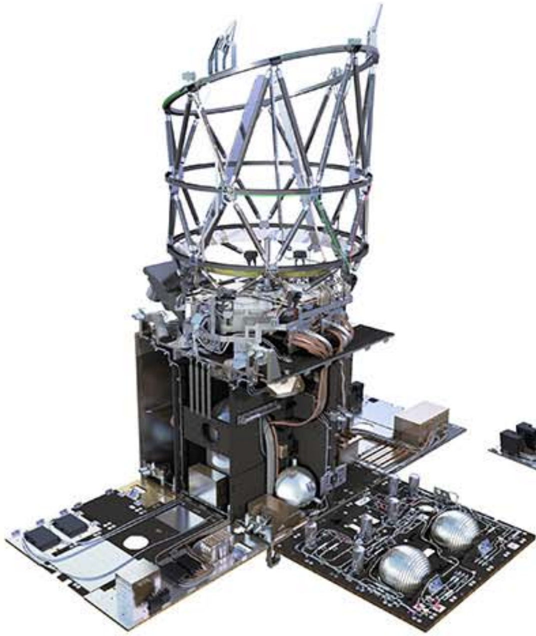


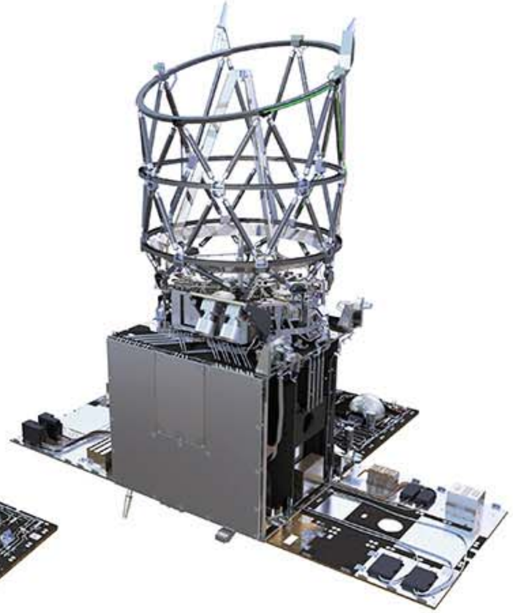


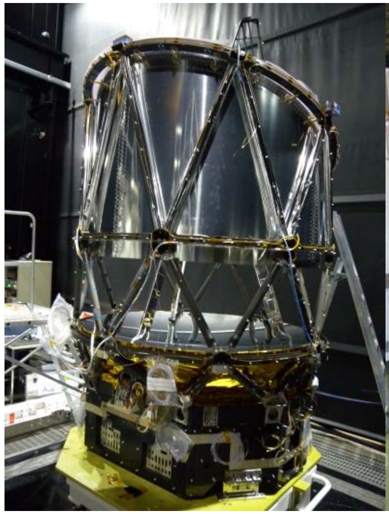
# ALADIN Satellite

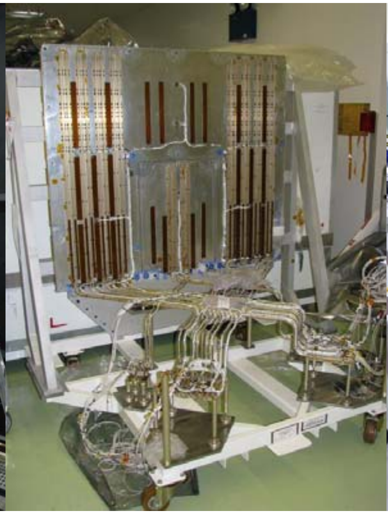








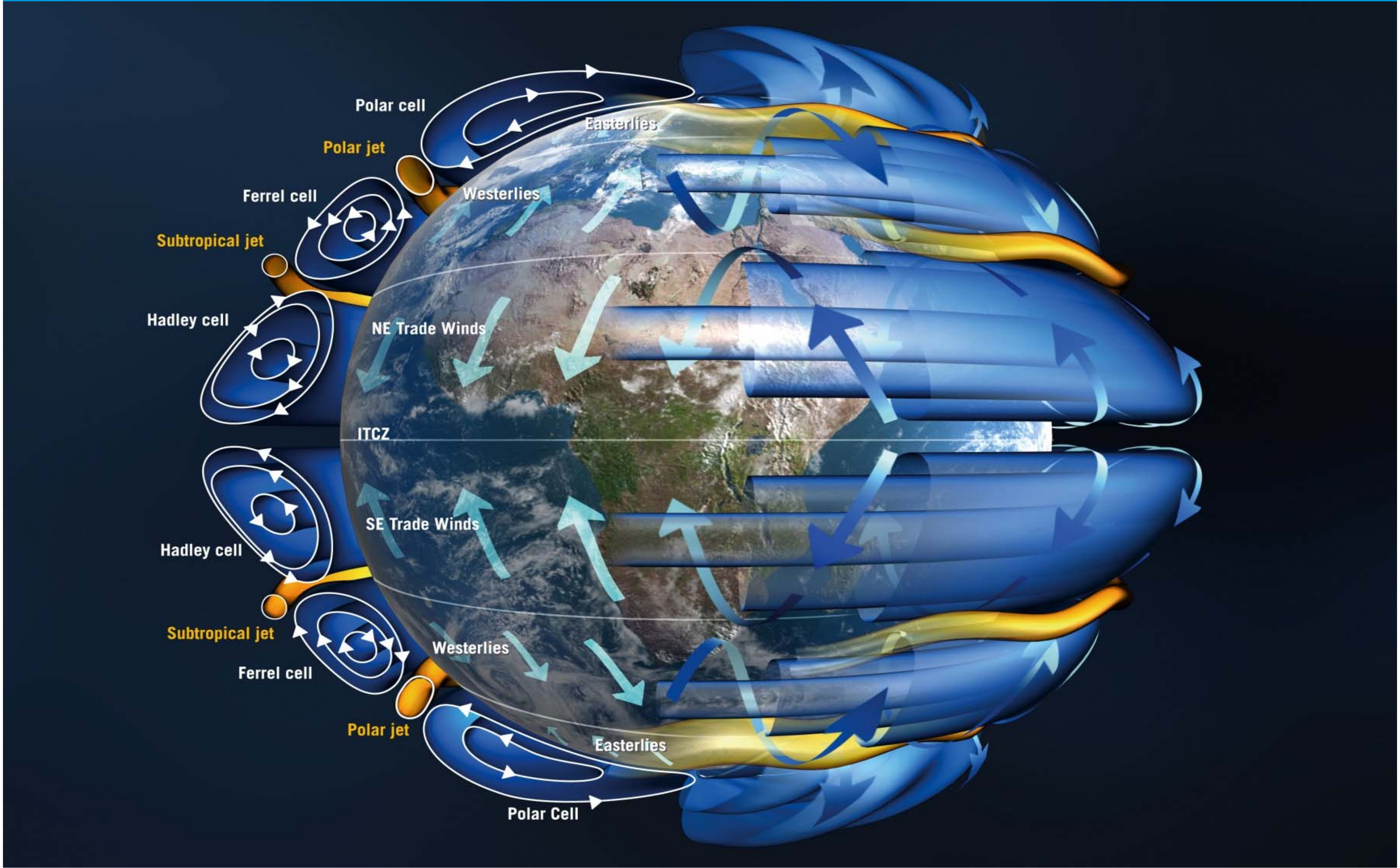




# Key validation test remaining

1. ***Instrument Functional Performance Tests (IFP) Aladin level***
    a. Primary and redundant lasers emitting via transmit optics and telescope to On Ground Support Equipment (OGSE). OGSE simulate atmospheric return signal through reception chain and spectrometers.
2. ***Aladin Electromagnetic Compatibility (EMC) test*** (Conducted emissions and susceptibility)
3. ***System level initial functional and performance tests (IST1 & SVT1)***
4. ***Satellite vibration, acoustic and shock tests***
5. ***Satellite EMC test***
6. ***Satellite Thermal Vacuum Test (Tvac) including***
    a. Functional and performance tests for hot and cold cases (IST2&3)
    b. ALADIN operating at full energy via OGSE
7. ***System level final functional and performance tests (IST4 & SVT2)***

# Aeolus: Mission Impact for Weather Forecast



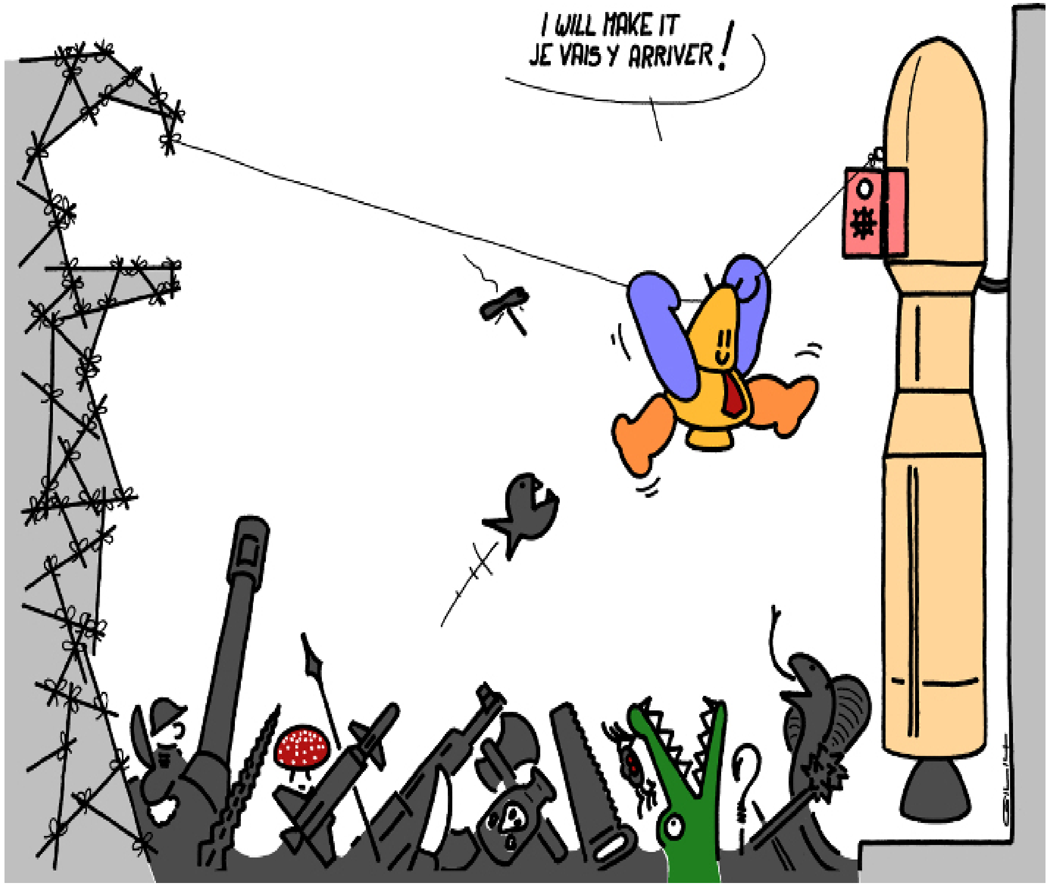
# Aeolus: Mission Impact for Weather Forecast

**Summary conclusions by two impact studies led by ECMWF and KNMI**

- ✓ **Especially beneficial in the tropics and at high altitudes**
- ✓ **HLOS winds provides approximately 75% of the full wind vector information**
- ✓ **Impact on forecast quality is of the same order as the currently available radiosonde observation network**
- ✓ **Impact rather insensitive to random wind error variation**
- ✓ **Even small wind biases can be detrimental, so try to reduce biases!**
  - ➢ **Wind bias calibration efforts will be essential!**

# Conclusions

- ✓ **More than 10 years of development challenges**
- ✓ **Invaluable experience has been gained**



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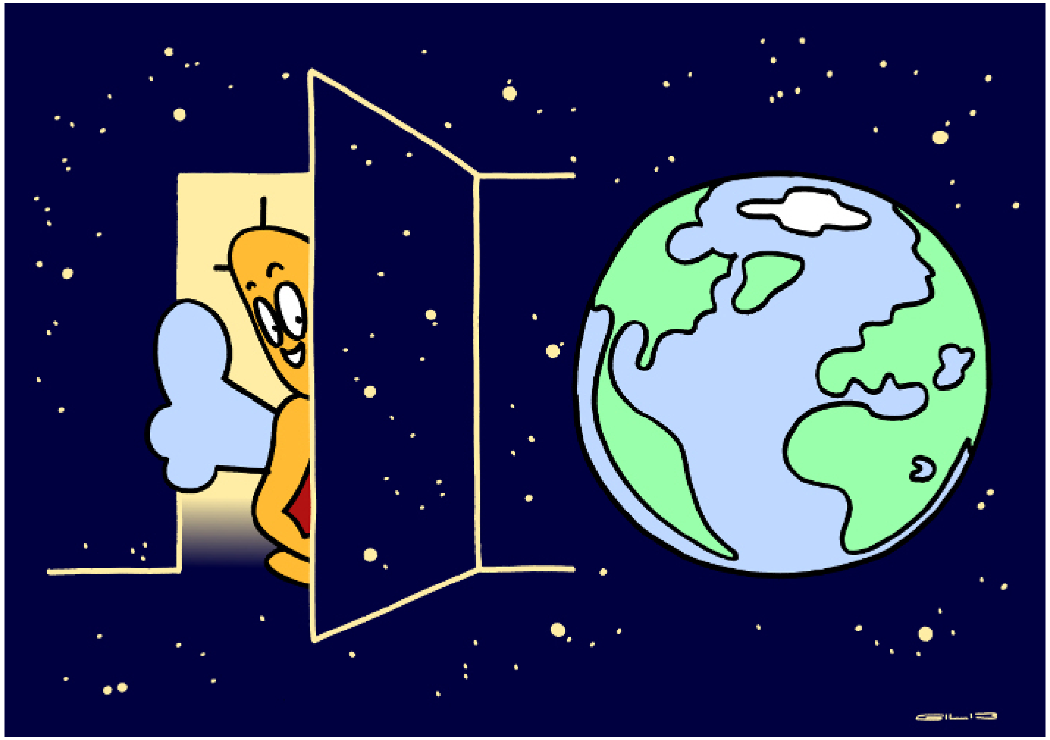
- ✓ **The mission remains <u>worldwide unique</u>**



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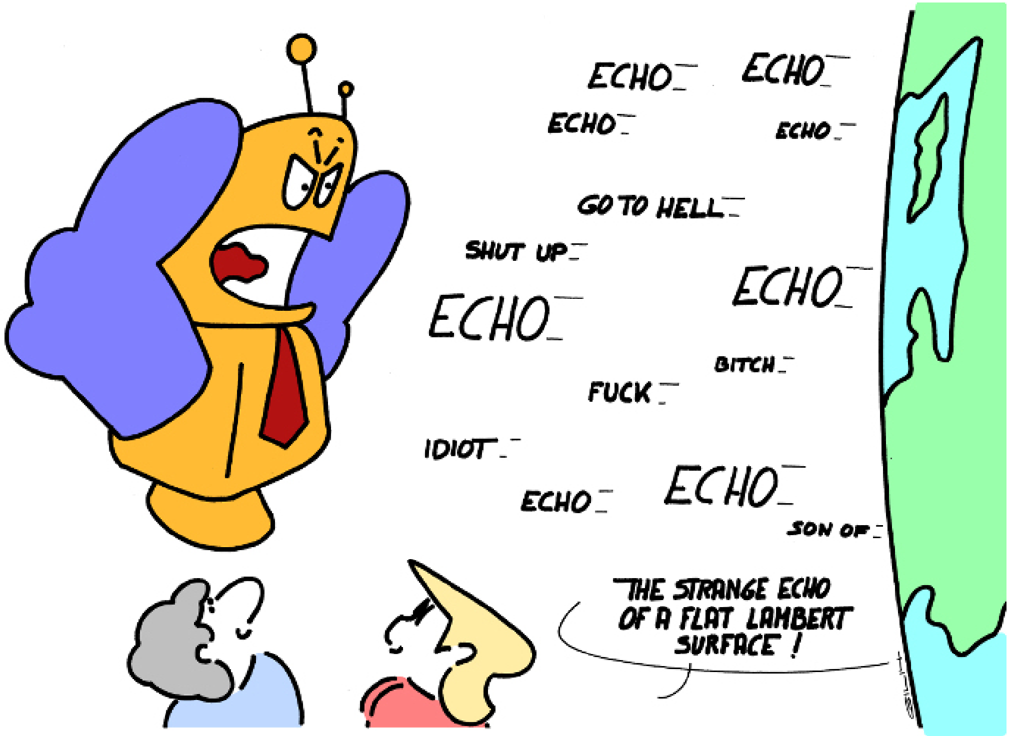
- ✓ Enthusiastic user communities anticipating break-through in weather forecast and climate research



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- ✓ Invaluable experience has been gained
- ✓ Laser and LIDAR modifications are very time consuming
- ✓ The mission remains worldwide unique
- ✓ Enthusiastic user communities anticipating break-through in weather forecast and climate research
- ✓ The Project and the Industrial team committed to complete Aladin by end 2015 and be ready for launch in 2016.

## Important link:

- Aeolus Living Planet web site: www.esa.int/The_Living_Planet_Programme/ADM-Aeolus