MeO-ODISSEE/CESAR

Optimize the injection into a fiber

Fabien Patru
& the SPICA team

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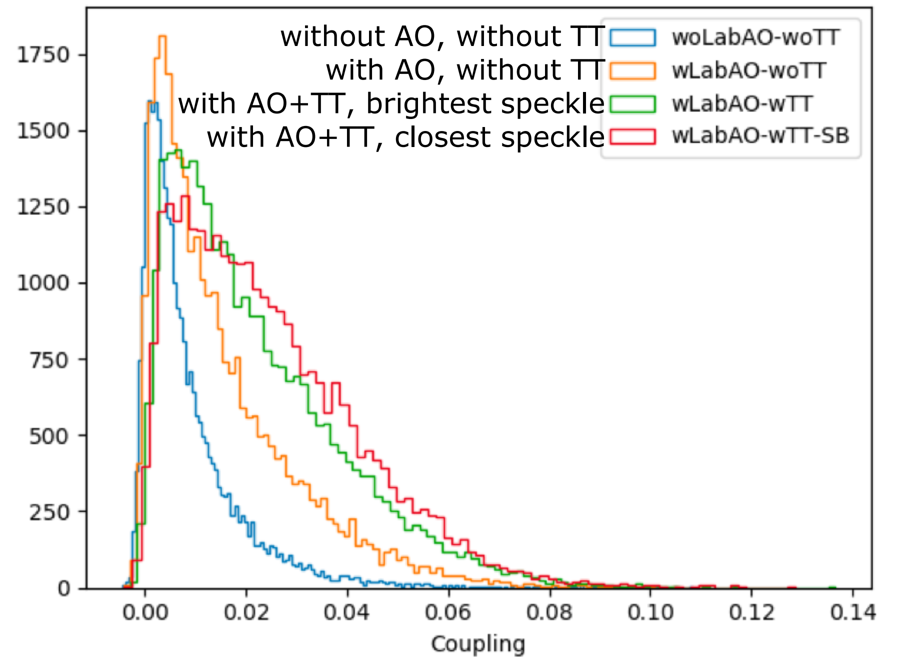
The Meo-ODISSEE/CESAR project

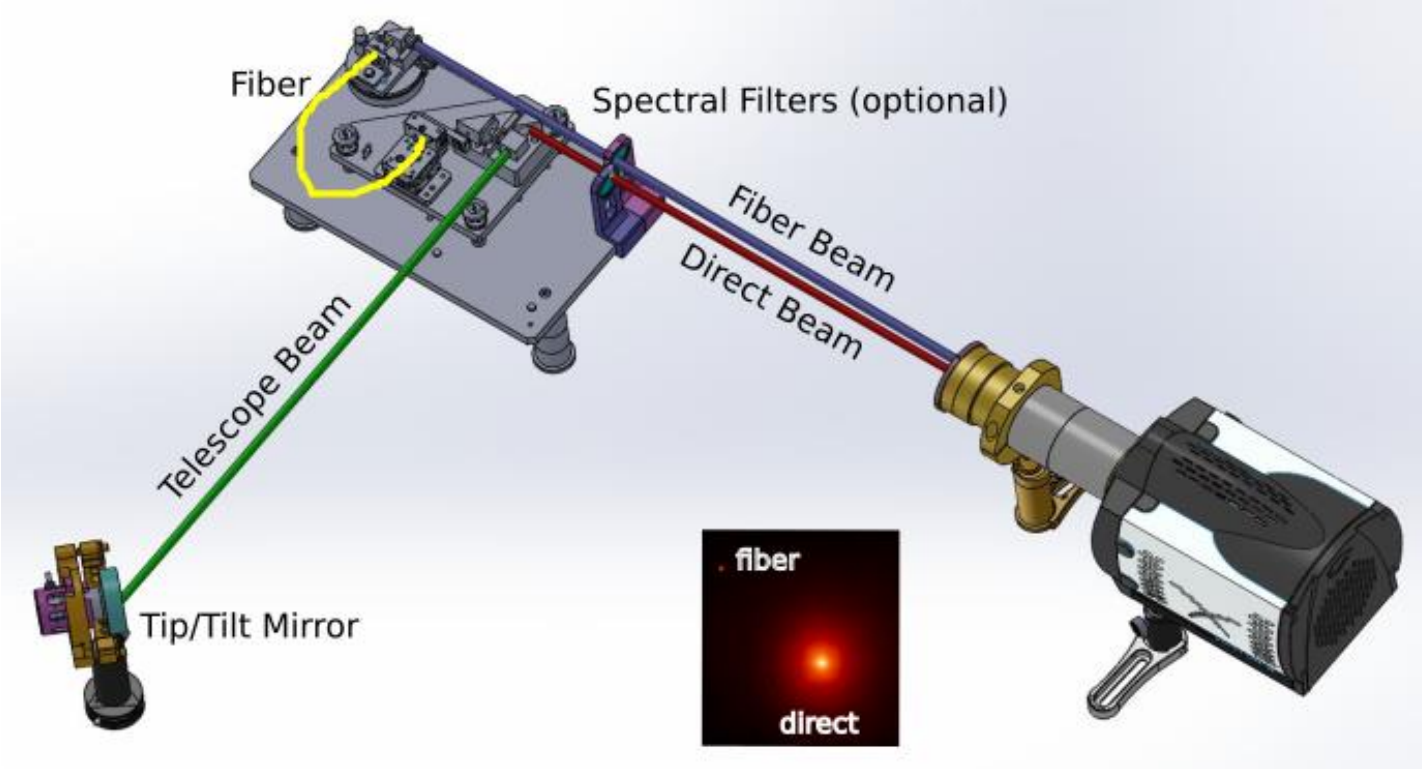
- **Objectives of the project CESAR**
  - Quantify and improve the **injection into a single-mode optical fiber** by controlling a **tip-tilt mirror** and by analyzing direct **images**
    - in the **visible** domain (R band and around),
    - in **real-time** (about 2 frames of delay in practice),
    - with partial **AO** correction (typically 8x8 actuators),
    - with **on-sky** conditions (by using the MeO/ODISSEE bench).

- **Previous results with CESAR at CHARA**
  - TT correction is needed in the visible.
  - Photocenter estimation on the closest bright speckle (not the brightest speckle).



The CESAR module

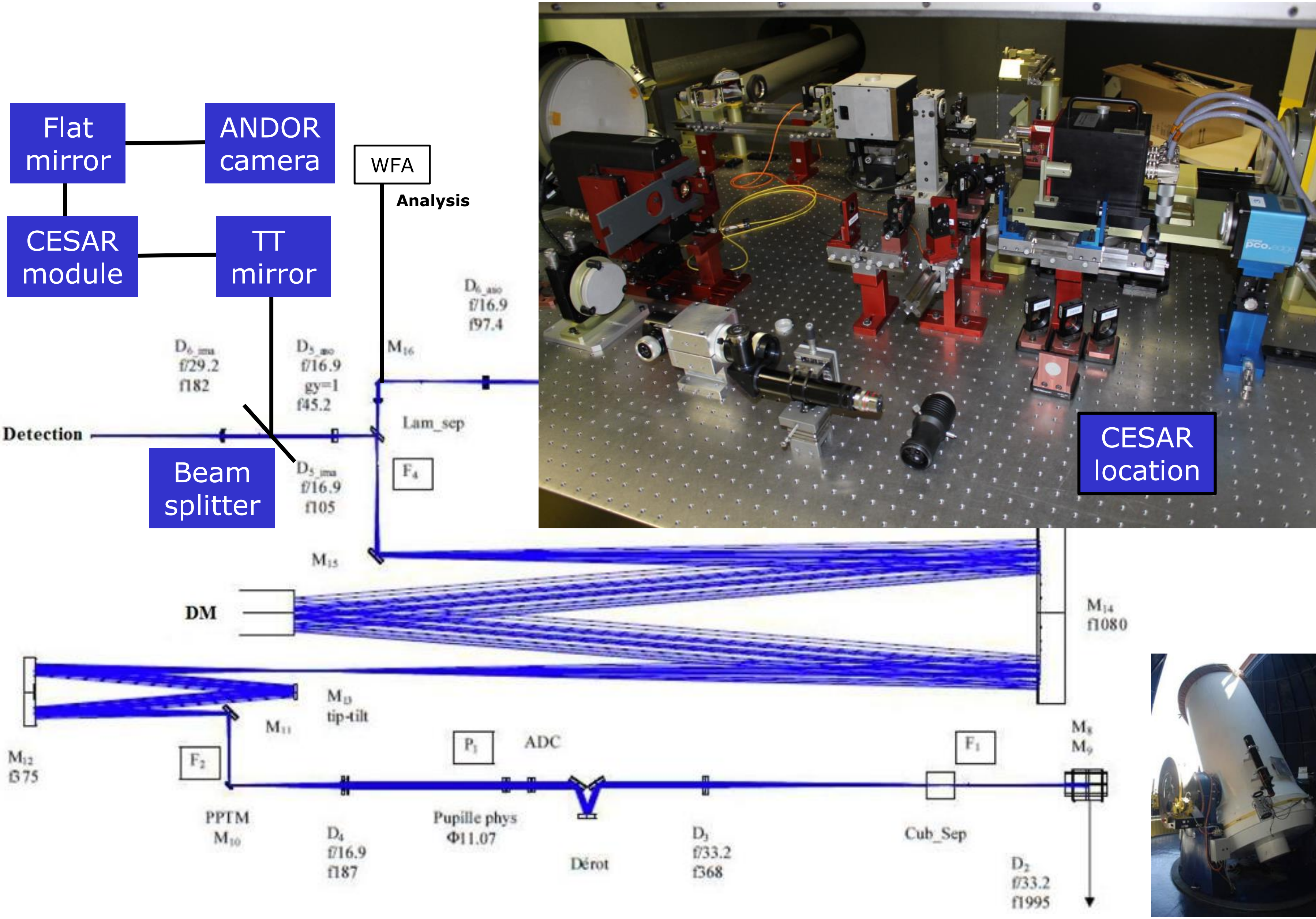
- **The CESAR module**
  - One beam is directly imaged onto the detector.
  - The other beam is injected into a single-mode fiber.
  - Both images with and without the fiber are imaged on the same detector.
  - A tip-tilt mirror (200Hz) enables to optimize the flux injected into the fiber.
  - Spectral filters can select equal or different wavelengths for each beam.



TT mirror control & images analysis

- **Photocenter estimation**
  - **Reference pixel** (= **fiber location**) calibrated with an artificial source.
  - **Photocenter** estimated for each short exposure image. 2 approaches:
  - 1. Photocenter of the **brightest speckle** on the whole image. The drawback is that the brightest speckle can be far from the reference pixel (due to a transition state), yielding to *speckle jump* and to TT correction unstability.
  - 2. Photocenter of the **closest bright speckle**. On a small area (2-3 times the speckle size) centered on the reference pixel. This algorithm stabilize and maximizes the injection (by a factor 3). It relies on the AO efficiency.
- **Tip-tilt correction**
  - Command sent to the TT mirror to bring the speckle onto the reference pixel.
  - TT_correction = **Gain** * Photocenter_estimation
  - Gain = 0.05 (should be as large as possible)
  - Delay = 2.1 frames (should be as small as possible)
- **Performance evaluation**
  - **Coupling efficiency** into the fiber = 1.6 * flux (fiber) / flux (direct)
  - Different **spectral filters** for the direct beam and for the injected beam (to increase the throughput at the cost of a worse TT correction).

CESAR implementation on MeO-ODISSEE



Timeline for Meo-ODISSEE/CESAR

- **February-March 2020 : Tests in laboratory**
  - Tests on a corner of the SPICA bench by using the collimated source.
  - Tests in open loop (without the tip-tilt command, sent back to the supplier).
  - Tests in close loop (with the tip-tilt command).

- **March 2020 : Implementation on MeO/ODISSEE**
  - Implementation of CESAR on an auxiliary arm in a corner of ODISSEE.
  - Beam splitter 50/50 or 90/10 on the detection arm to split the light between:
    - the camera PCO sCMOS (used in operation for MeO-ODISSEE),
    - the camera ANDOR IXON 897 (used for CESAR).
  - CESAR works independently from MeO/ODISSEE.

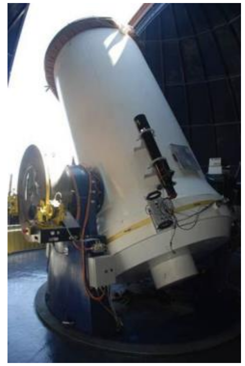
- **March-May 2020 : On-sky validation on MeO/ODISSEE**

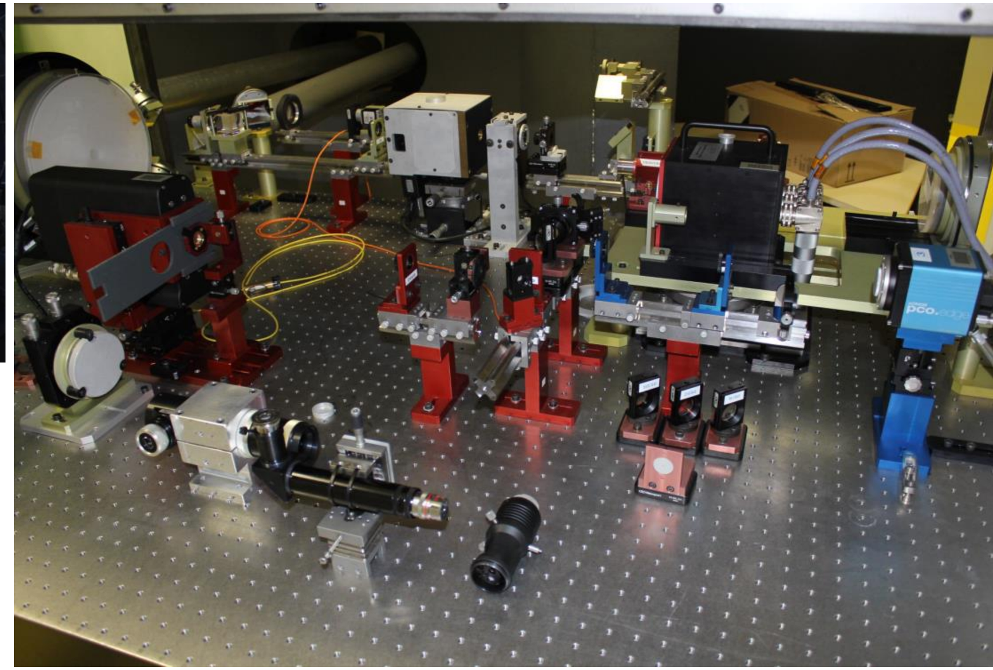
- **May-June 2020 : Memorandum**
  - Achieved performance on Meo/ODISSEE (simulation + on-sky data).
  - Expected performance on CHARA/SPICA (extrapolation by simulation).
  - A step beyond : Control the TT mirror by analyzing the WFA data (???).

MeO-ODISSEE/CESAR

The bench MeO/ODISSEE

- **The MeO telescope**
  - 1.5-m aperture
  - High-contrast NGS &
  - Wide-field LGS mode





- **The bench ODISSEE**
  - It corrects in real time the wavefront distortions caused by the atmospheric turbulence.
  - It mainly consists of an **adaptive optics** and an **imaging system** :
  - **Tip-tilt mirror** : correction of modes related tilting of the wave (87% in the dynamics of corrections) ;
  - **Deformable Mirror** (88 actuators) : correction of the remaining modes (13% in the dynamics of corrections) ;
  - **Wave Front Analyzer** : Microlenses array (8x8) and high-speed camera (< 1500Hz) with a CCD of 240x240 pixels (24µm)
  - **Detection** : Field iris diaphragm of 1" and sCMOS photodetector.