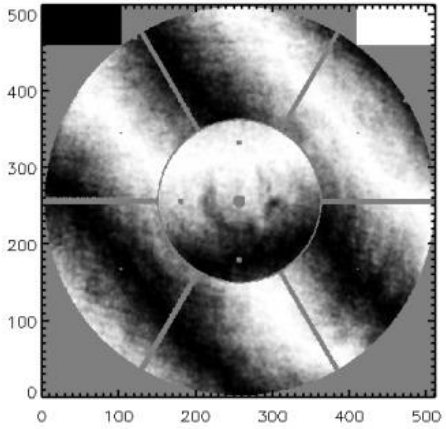
LABORATORIO NAZIONALE ADONI OTTICA ADATTIVA

INAF ISTITUTO NAZIONALE DI ASTROFISICA

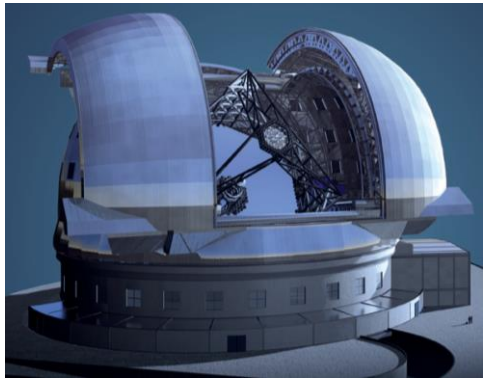
M4
the ELT's adaptive mirror

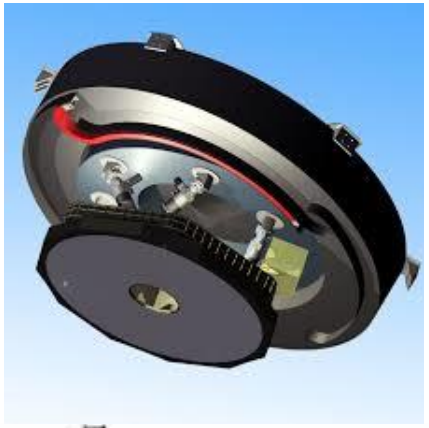


Runa Briguglio

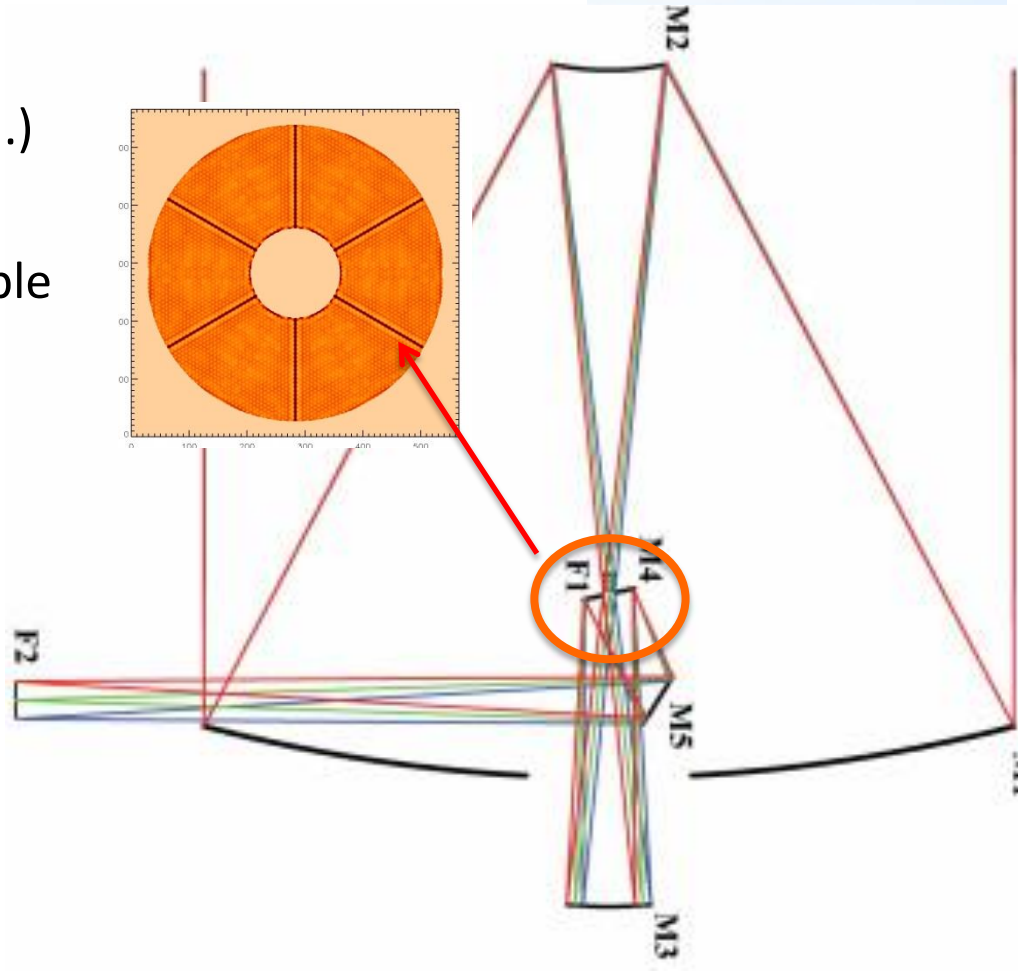
On behalf of the INAF team

M4 & ELT

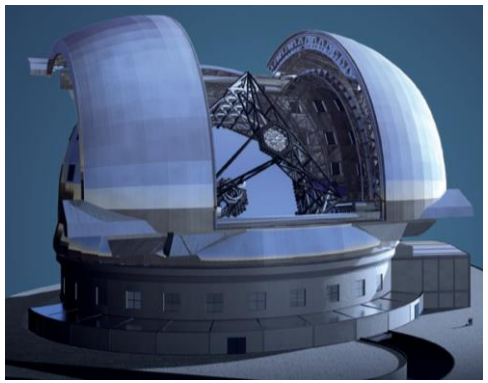


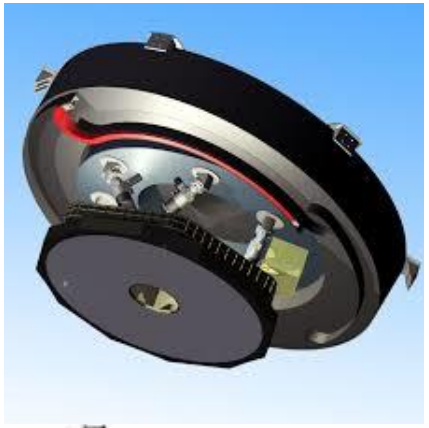


- The wavefront corrector of the ELT
- Serving all ELT instruments (MAORY-MICADO-HARMONY-HIRES..)
- Will be the most advanced deformable mirror ever built
- Unprecedented complexity & specifications



ELT & M4

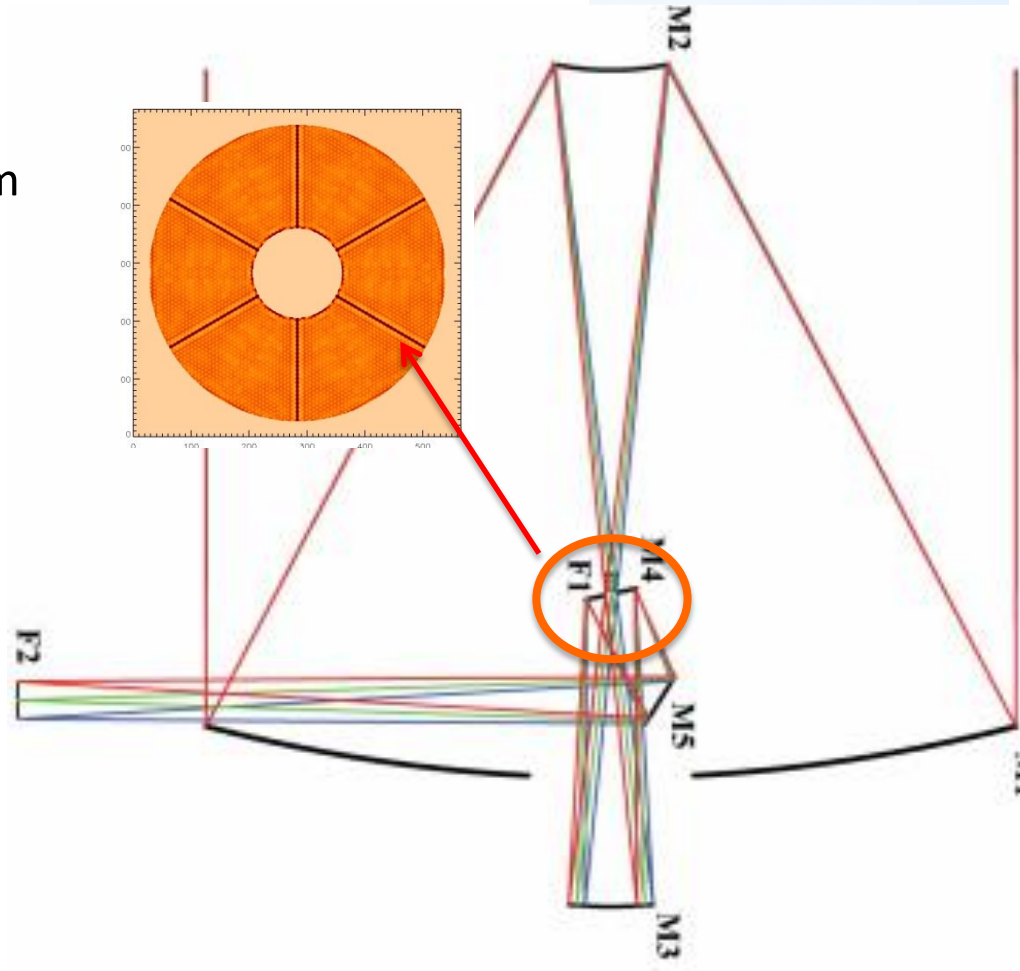




Segmented flat mirror

- O-diam: 234cm, I-diam: 54cm
- # segments: 6
- # actuators 5316
- triangular pattern (3 cm pitch, projected on M1)
- Settling time< 1ms
- Fitt. Error, median seeing:
  145 nm WF
- Flattening/co-phasing spec:
  20 nm WF

52 cm



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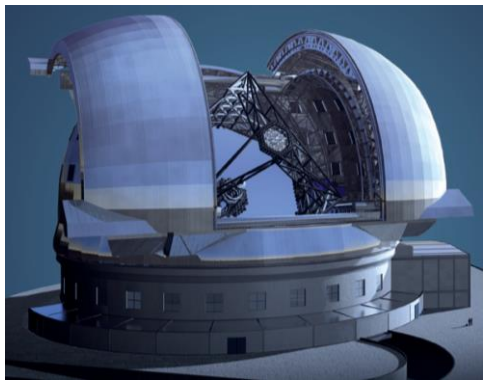

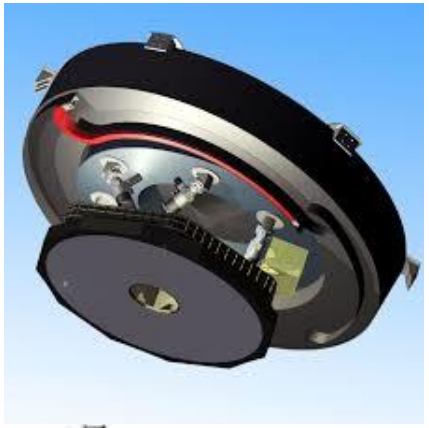

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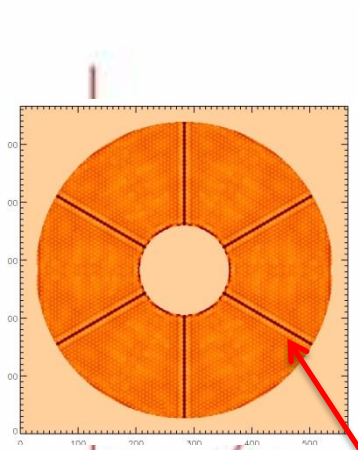

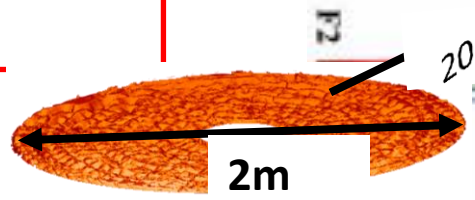

M4 project

- **Customer: ESO**
- **Partners**
  - **AdOptica**: prime-contractor (companies consortium, MG+ADS)
  - INAF (OAA+OAB: sub-contractor)

- **Budget:**
  - AdOptica: ~30M€ (tot)
  - **INAF: 1.3M€**
  - 2.5FTE/y (16 FTE tot)

- **Milestones**:
  - Koff 2015
  - FDR 2017
  - OTT 2022
  - OptTest 2024

- Building on PhaseA (OAB)

- **INAF Tasks:**
- **Adaptive Optics expertise**
- Error budget
- **Optical design of Test Tower OTT**
- Test plan and procedures
- Support of Tower integration and characterization
- **Optical Calibration**

A long time ago,
in a test tower far far away…

''I feel a disturbance in the force'' [Kenobi, O.W.]

Showcase example of technological transfer

20+years long history of R&D about adaptive mirrors:

1. Original idea developed in Arcetri
2. Partnership with industry for Manufacturing/Integration
3. Result: MMT+LBT Adaptive secondaries + prototypes
4. INAF as tech.incubator

adoptica

MICROGATE ENGINEERING

ADS

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5. INAF yields its leadership in electronics/control and keeps the optical metrology/WFS one (strategic)
6. Industry is now independent, prime contractor vs VLT, KECK, SUBARU, ELT, GMT
7. INAF involved in more specific studies
   → research, not assembly line
8. Industry acquires knowledge in optical metrology
   →industrial application

9. INAF: next move?

adoptica

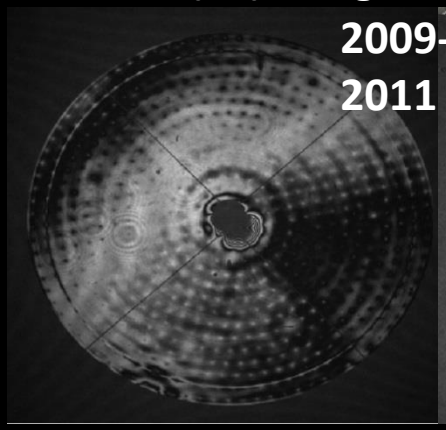
MICROGATE ENGINEERING

ADS

THE FORCES AWAKEN

LBT (2x), Mag

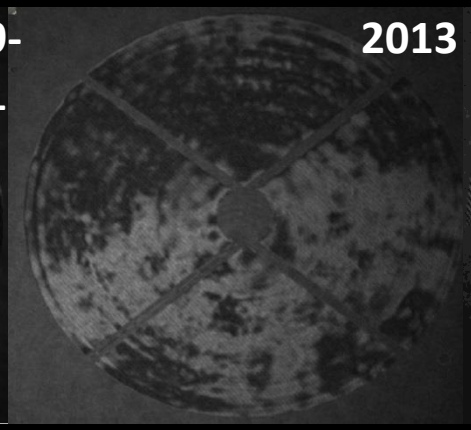
2009-2011



1m diam, 672acts

VLT-DSM

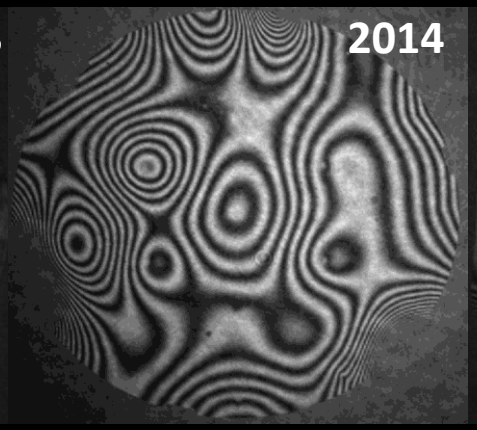
2013



1.2m diam, 1170 acts

LATT

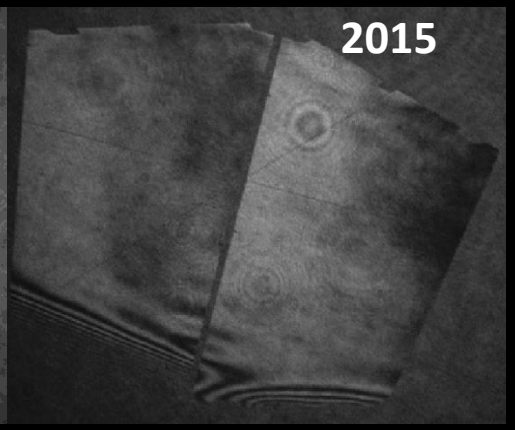
2014



40cm diam, 19 acts

M4DP

2015



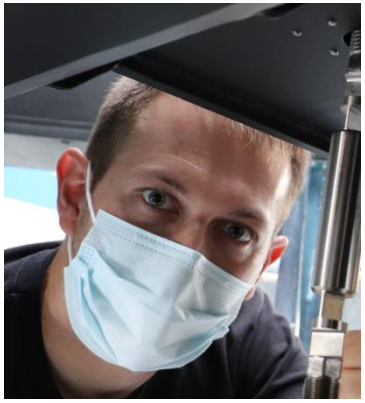
2x 30cm x70cm, 2x 111 acts

Team

Armando Riccardi-OAA

Giorgio Pariani-OAB

Nicolò Azzaroli-OAA



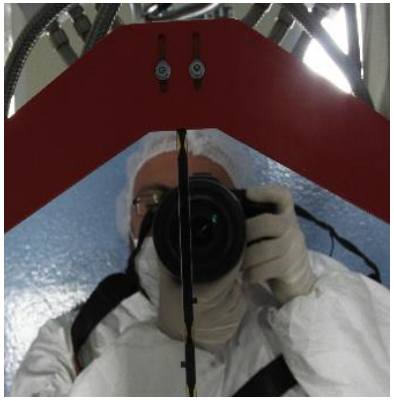
Marco Xompero-OAA

Marco Riva-OAB

Chiara Selmi-OAA

Luca Oggioni-OAB

Runa Briguglio-OAA

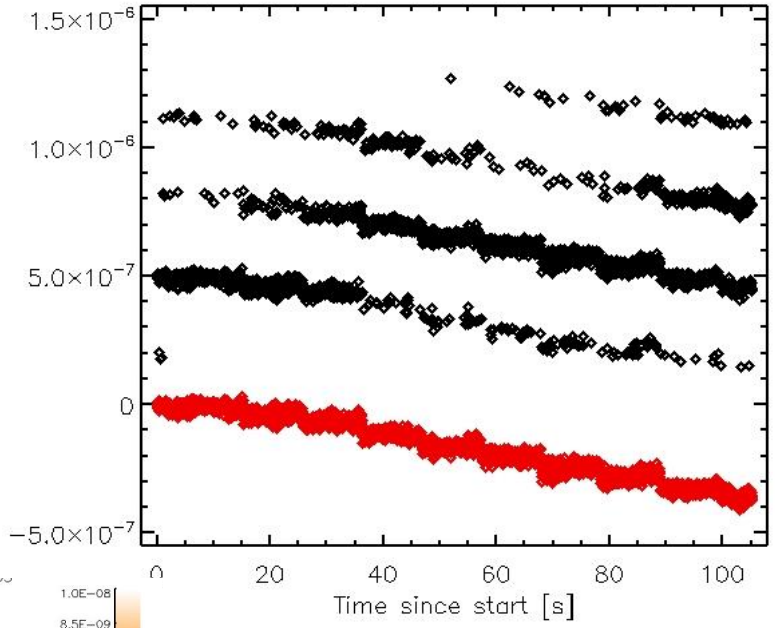


Ciro Del Vecchio-OAA

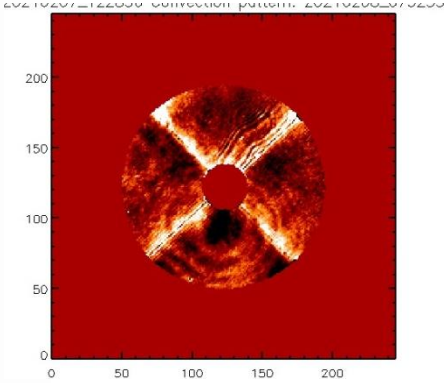
Scientific/Technological challenges

- Demanding requirements vs overwhelming **noise**
  - Accuracy, precision, non-stationarities
- Segments co-alignment and **phasing** vs vibrations
- Local measurements vs global commands
- Measurement offset: alignment, optics quality...

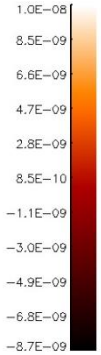
Differential piston, unwrapped

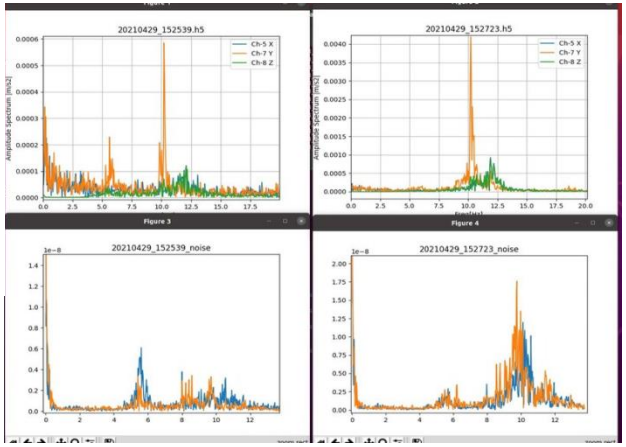


Convection noise



Spider arms
thermal print-through





Program: research!

The project is a flammable mix of
unknowns, challenges, waitings and rushes

For this reason most of the tasks so far are
knowledge oriented, risk mitigation laboratory activity.

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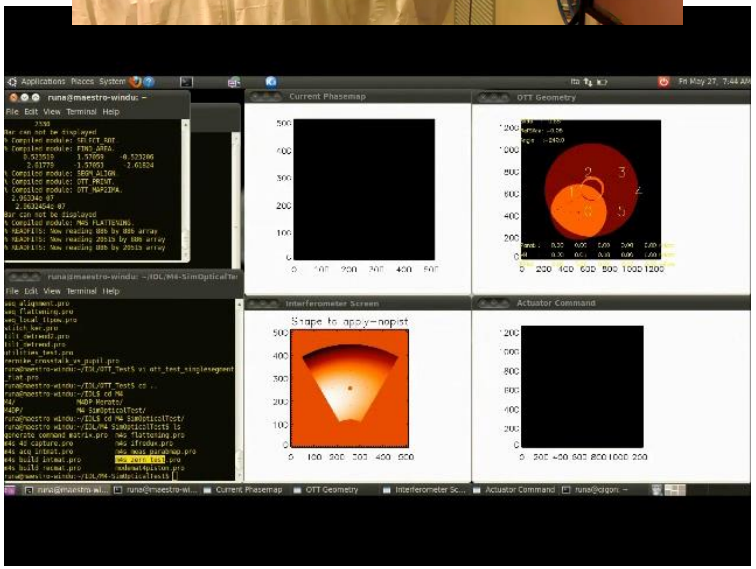
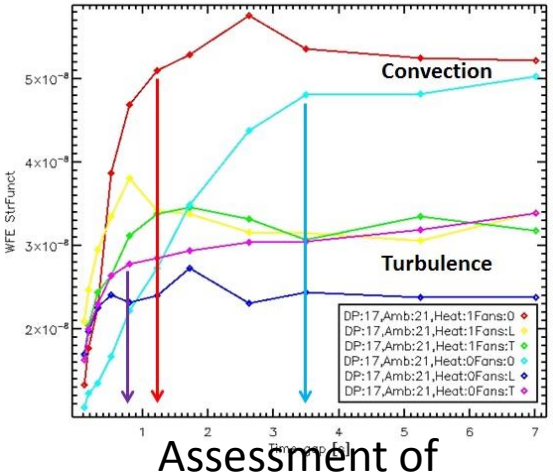
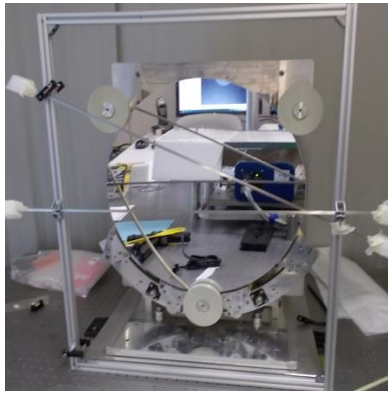
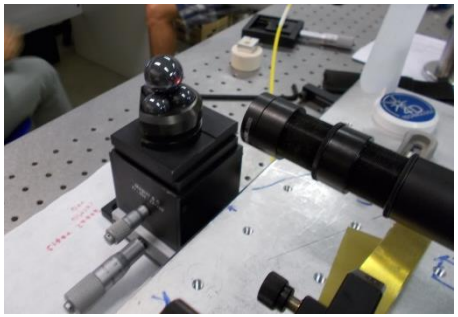




Assessment of convection noise



Spider arms test

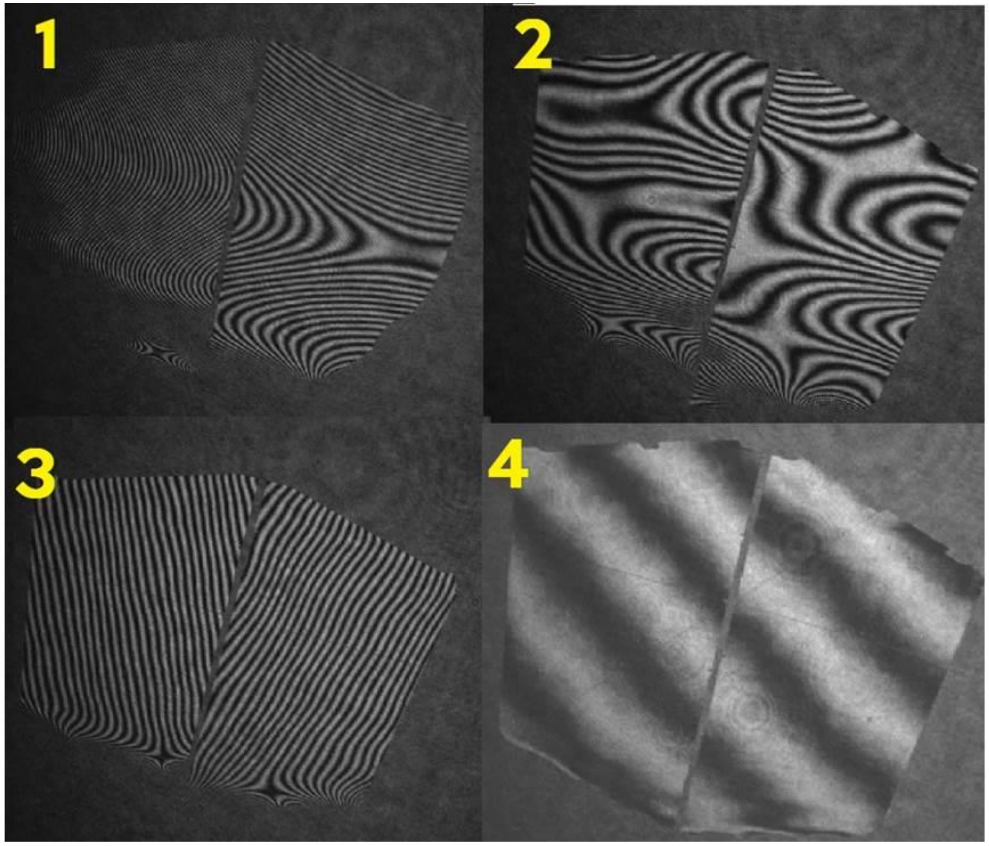


Random ball test

Status & results

2015- Optical calibration of Demostration Prototype

- Flattening + phasing: **12 nm RMS**



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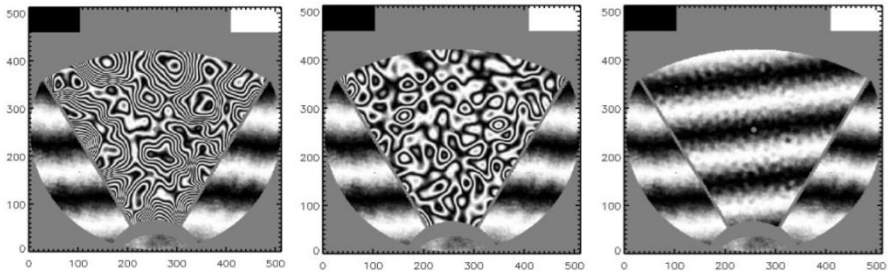
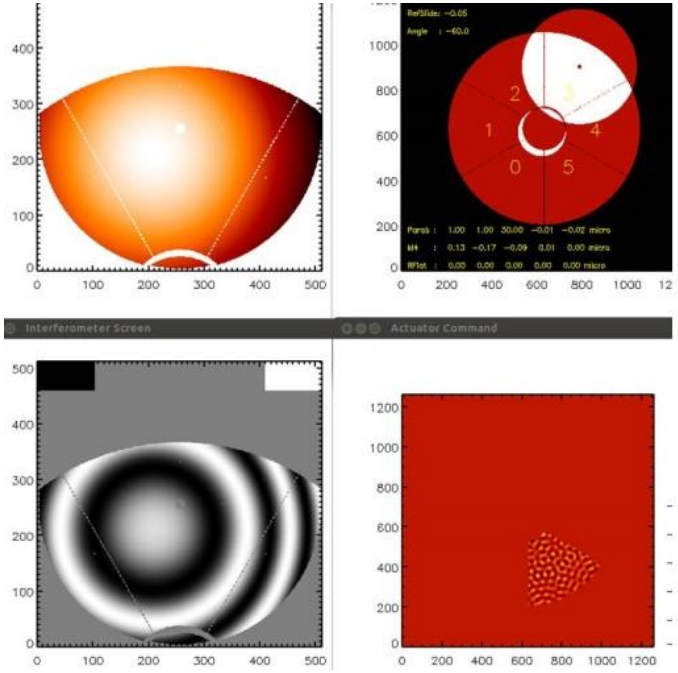
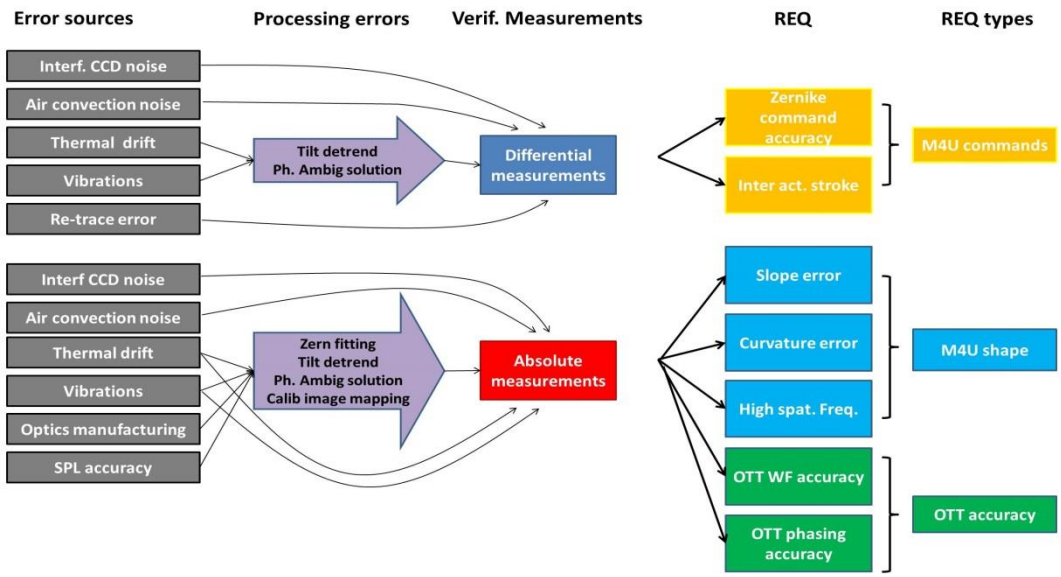


2017- FDR: Optical test tower design, procedures, analysis





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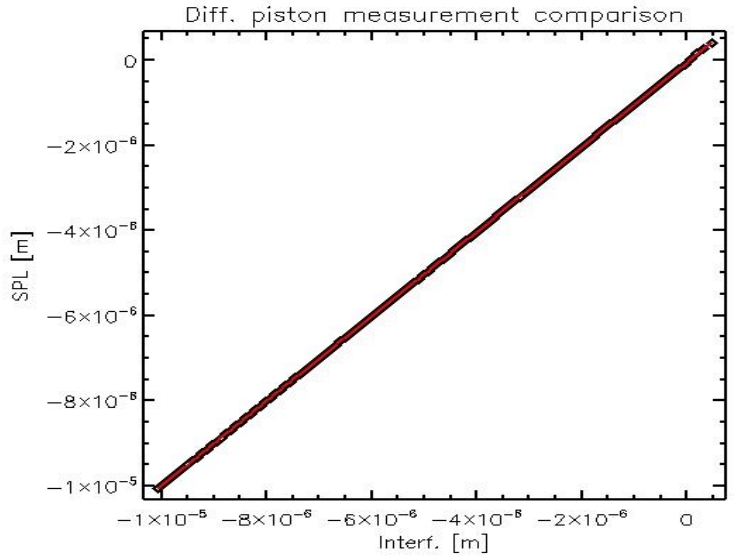
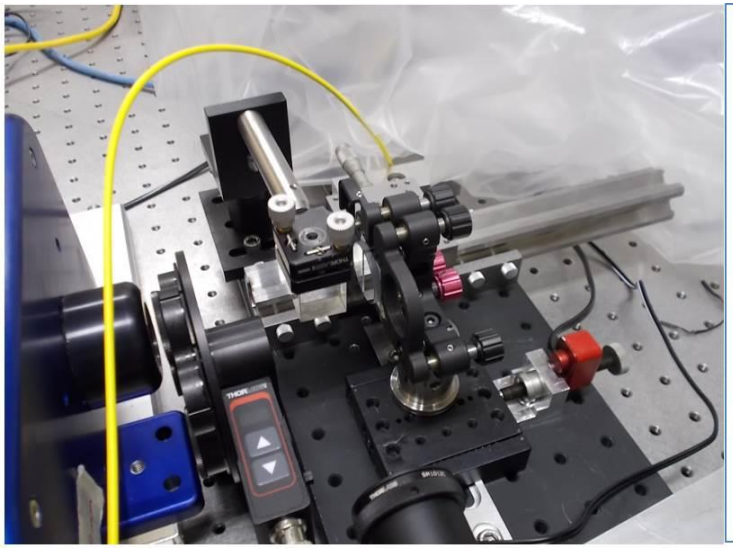
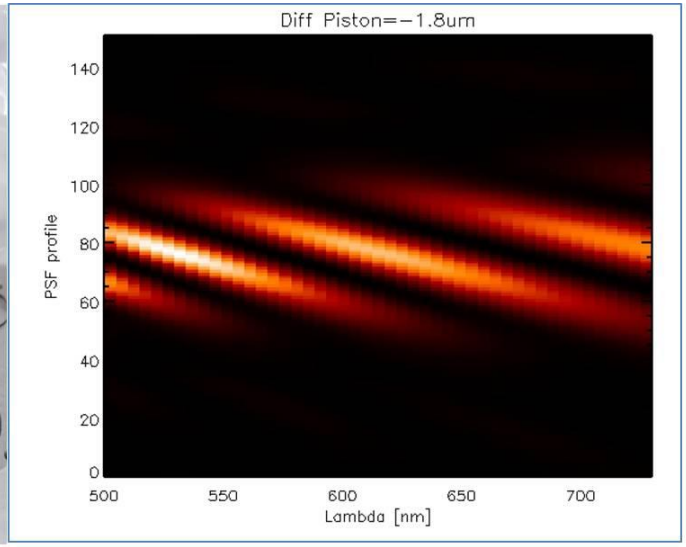
2019 – Absolute phase sensors (precision < 5 nm, 0.2% accuracy)



SPL id	Range	Fit Slope	Fit offset
#3	-10072 nm to 472 nm	0.9945	-50 nm





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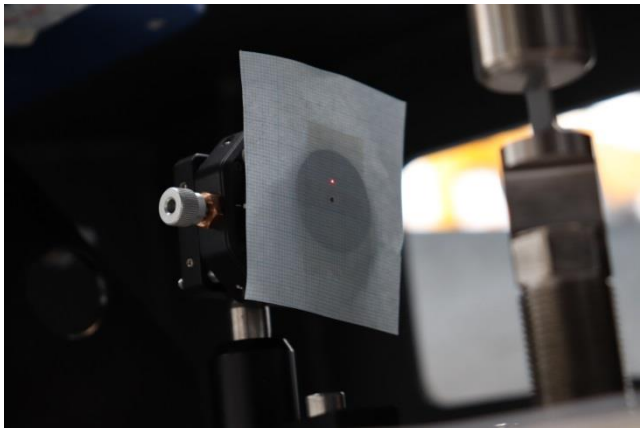

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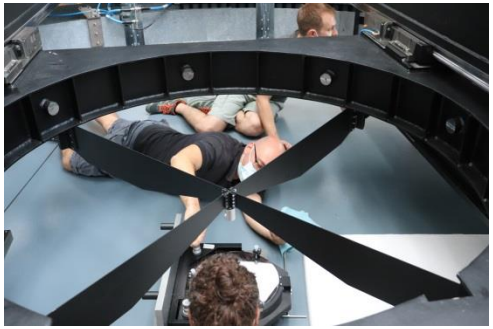
2020 - miniOTT



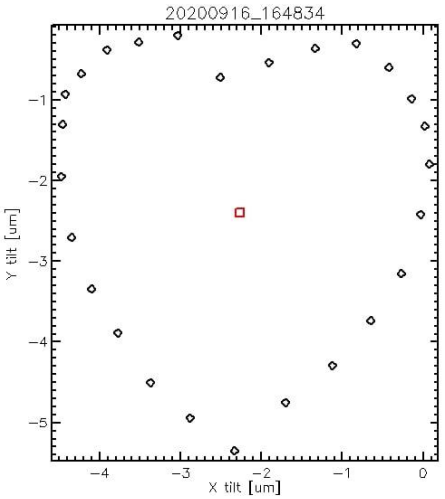
Status & results

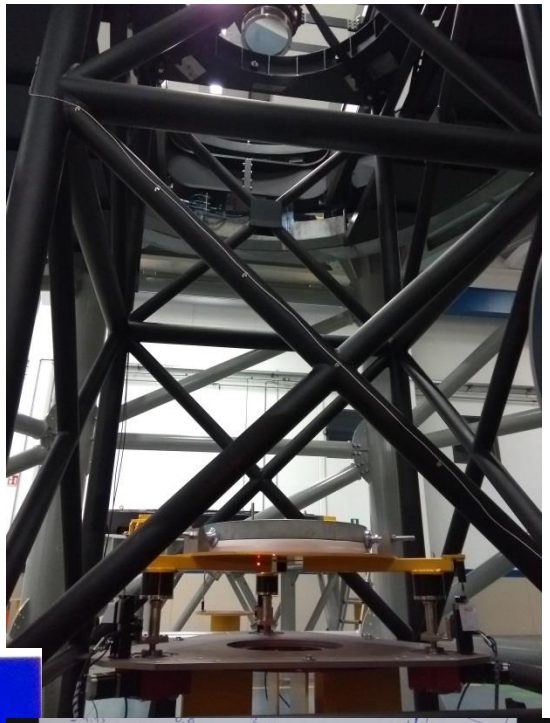
The Optical Test Tower OTT

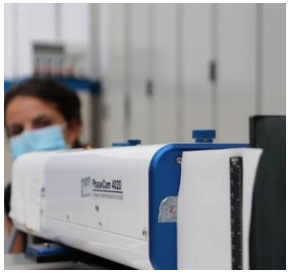
The OTT in a nutshell

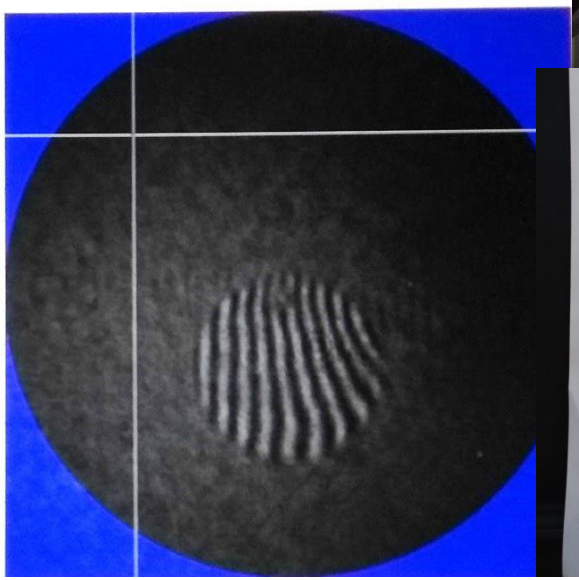
Status & results

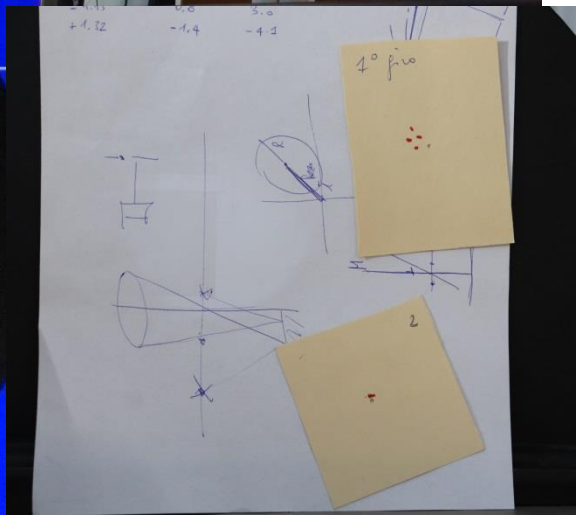
The Optical Test Tower OTT











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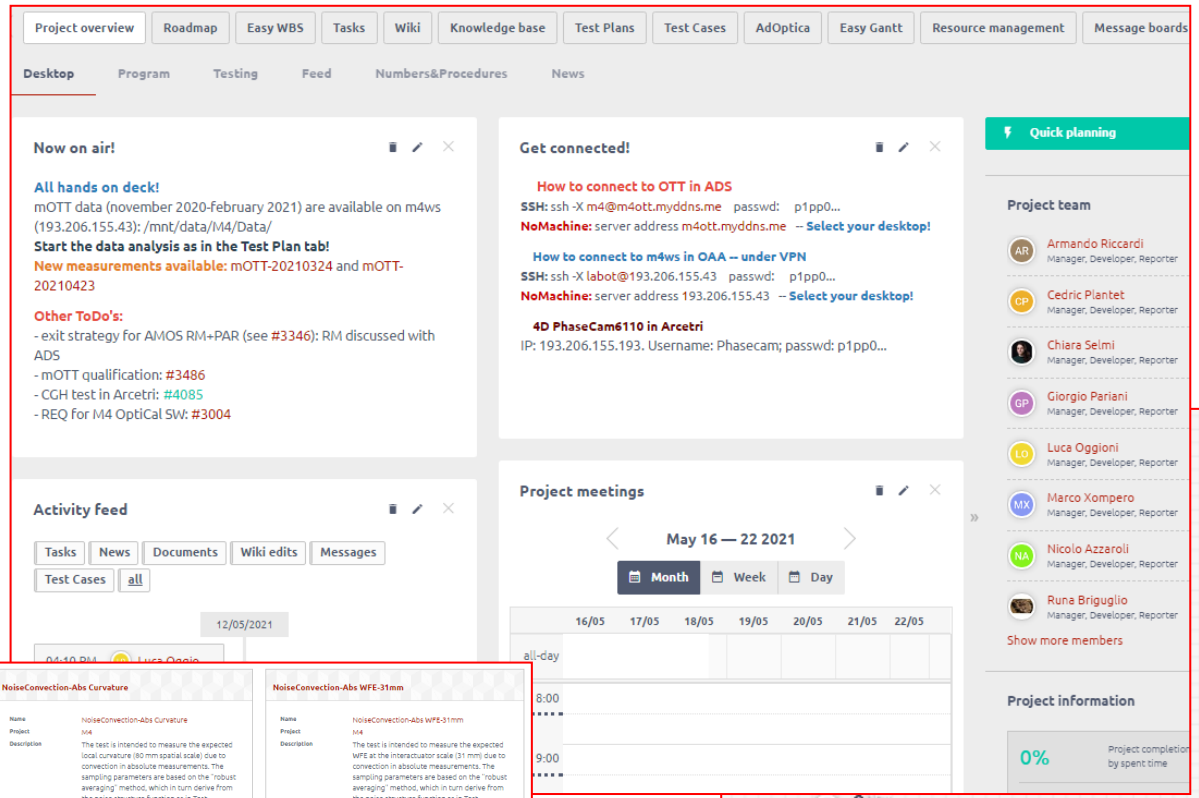

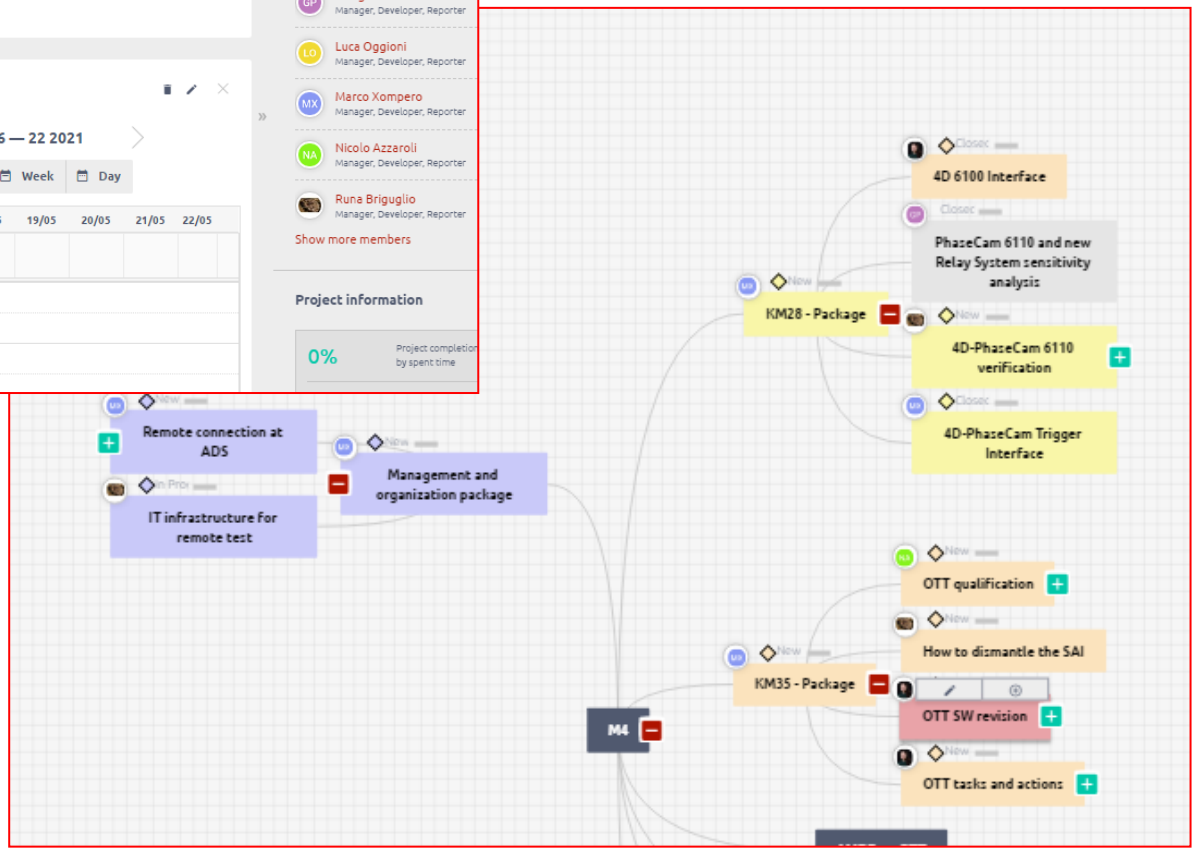

Effective team engagement with the RedMine (thanks Riccardo!)

Criticalities

- The project schedule is not under our control:
  - Delays, strategies, activities re-arrangement have strong impact in our work.
- ESO project:
  - Complex management
  - Uneffective addressing of the requirements
- Cashflow organized on a milestones basis, delays may occurr
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- Optics manufacturing error: possible impact
- 99% of works 2015-19 carried out by non-staff:
  - Risks related to loss of knowledge
- In general, difficulties in hiring people
- Need for technical support (to maintain laboratories/facilities)

Leadership

- Large format voice coil adaptive mirrors:
  - Italian-way, with industry mastering the production and INAF the expolitation.
  - Proposed for space applications
- Optical calibration of large deformable mirrors, nm-level optical interferometry in noise
- How to use M4: in-house expertise
  - while it is a black box for others

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