



# LINC NIRVANA Integration & Alignment

AstroTechTalk MPIA

Peter Bizenberger & the complete LN team

HD • January 2015





## Outline

- Introduction to LINC-NIRVANA
- Concept of the alignment strategy
- Integration of the warm optics
- Integration of the cold optics
- Outlook

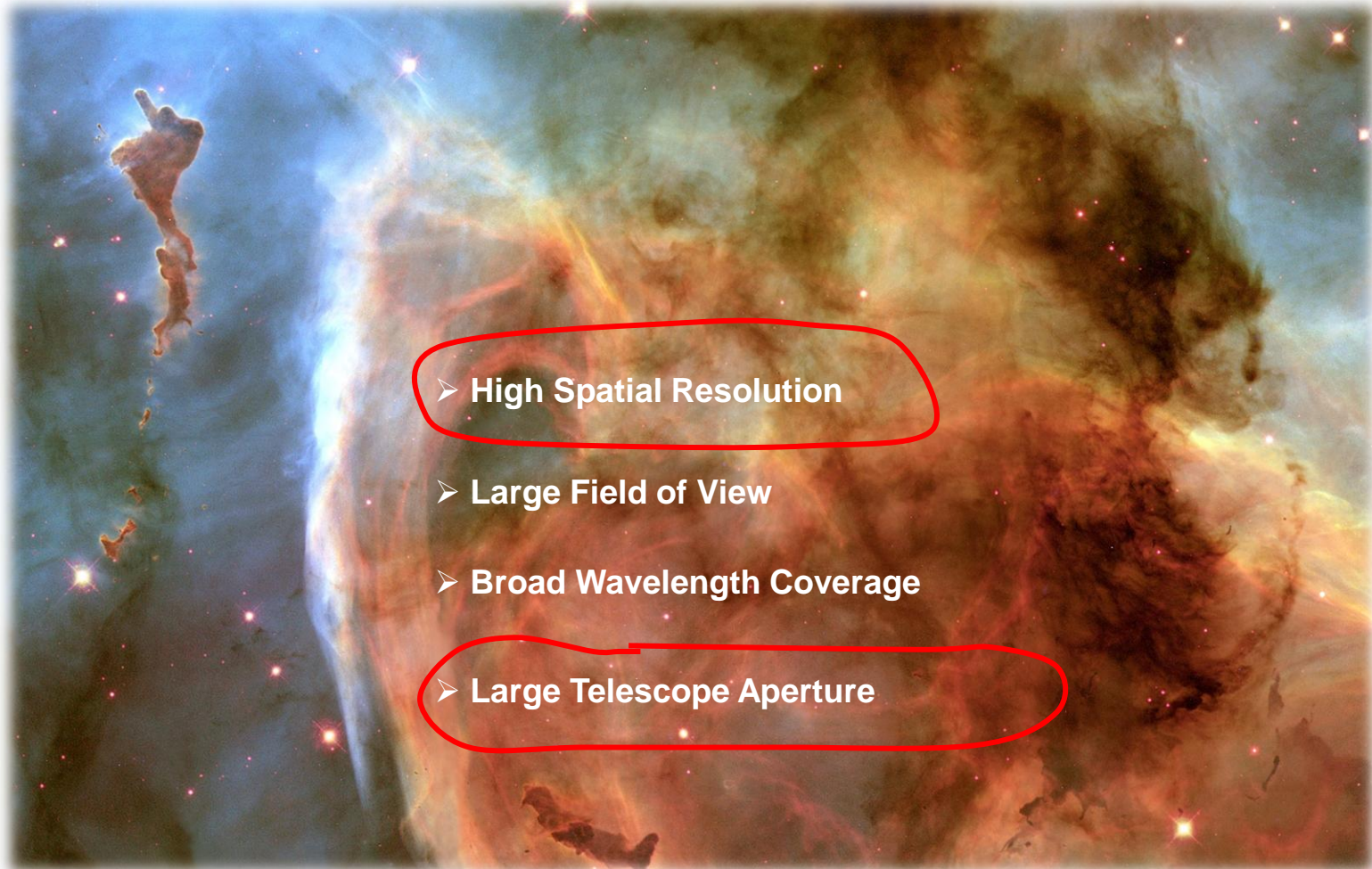


## Outline

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Why do we want LINC-NIRVANA?



Keyhole Nebula in NGC 3372, HST

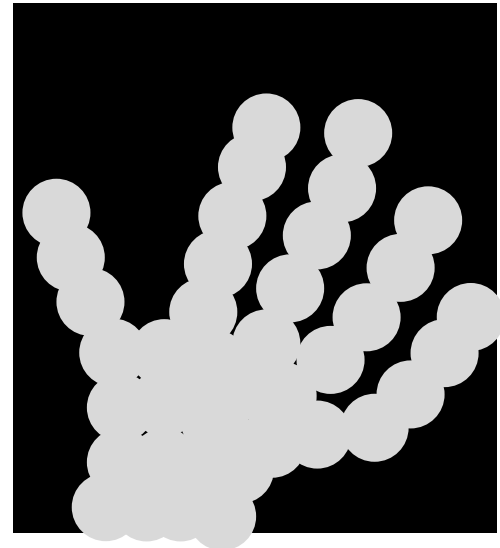
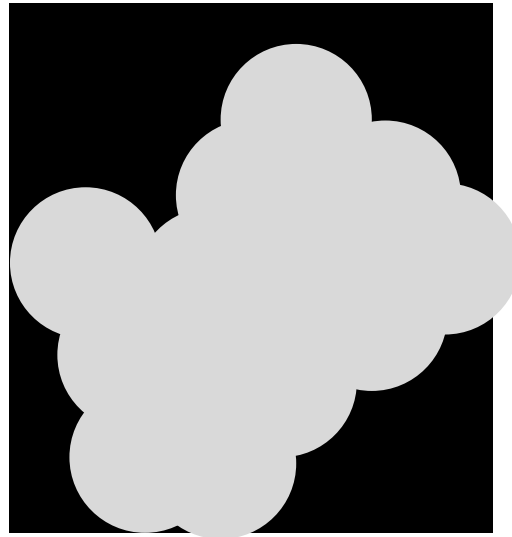


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Why high resolution?



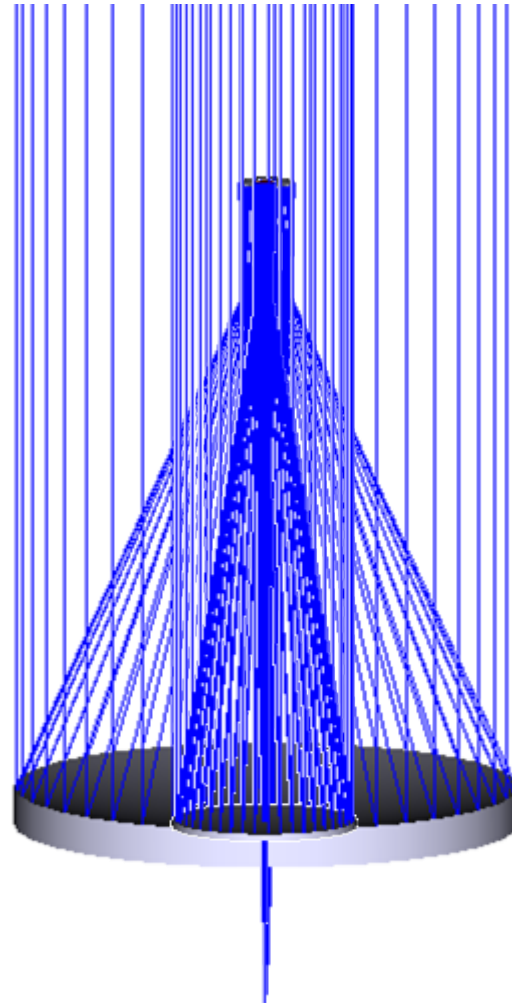


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How to achieve high resolution



... but there are limits

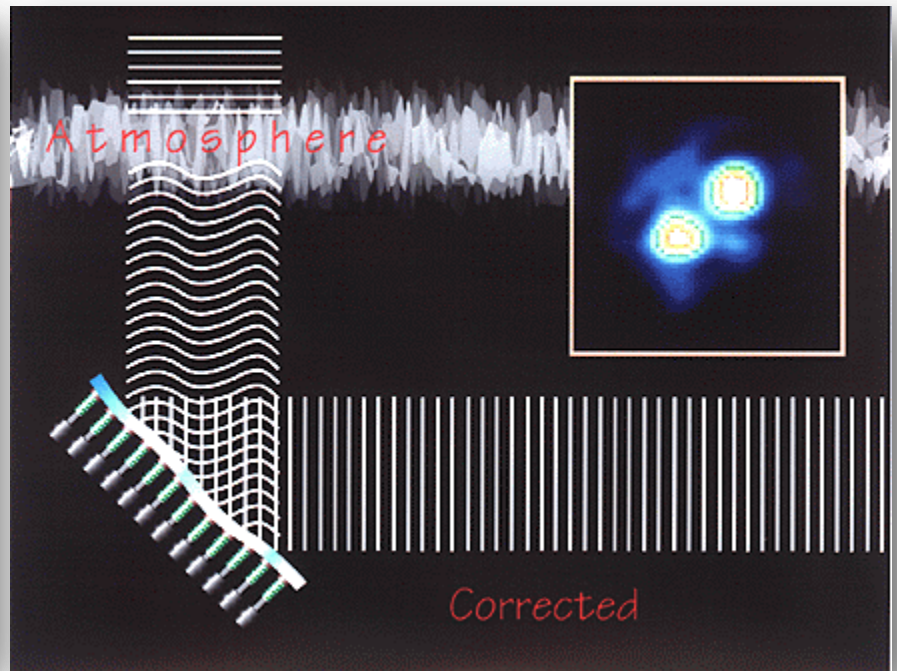
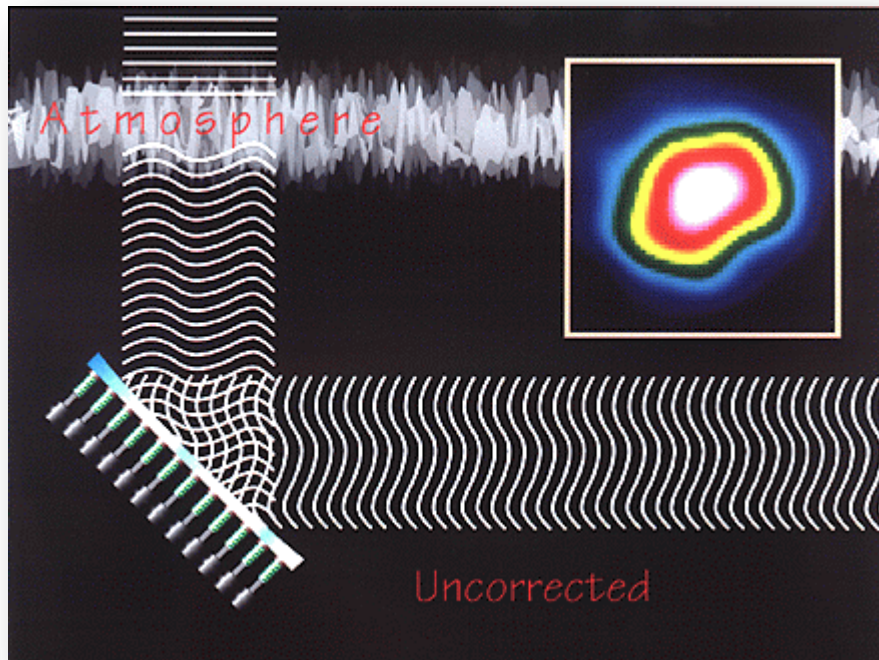


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The Atmosphere: You need Adaptive Optics



.... still, there are limits



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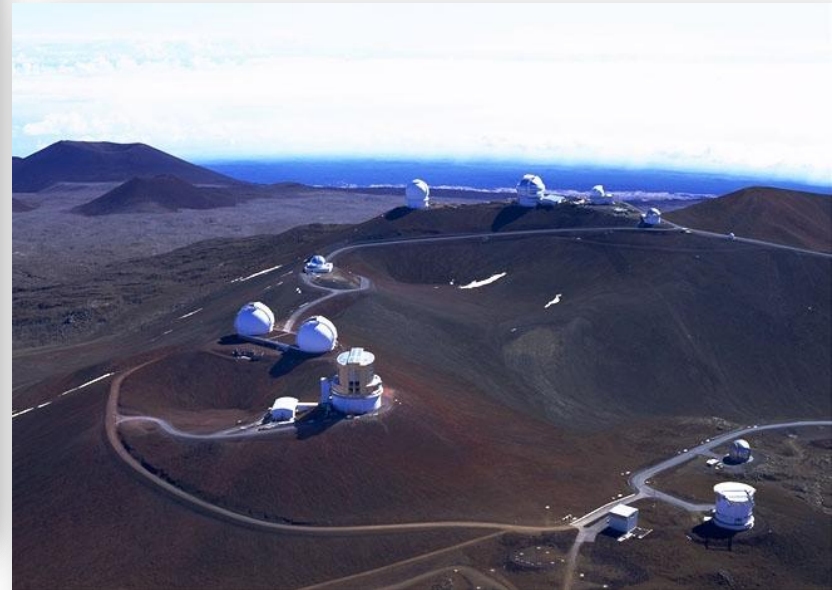


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The Size: State of the art in telescopes



VLT - Paranal, Chile



Gemini, Subaru, Keck, ... - Mouna Kea, Hawaii

- ~ 8 m diameter solid mirrors
- ~ 10 m diameter segmented mirrors

→ ~ total 15 available

... what's next

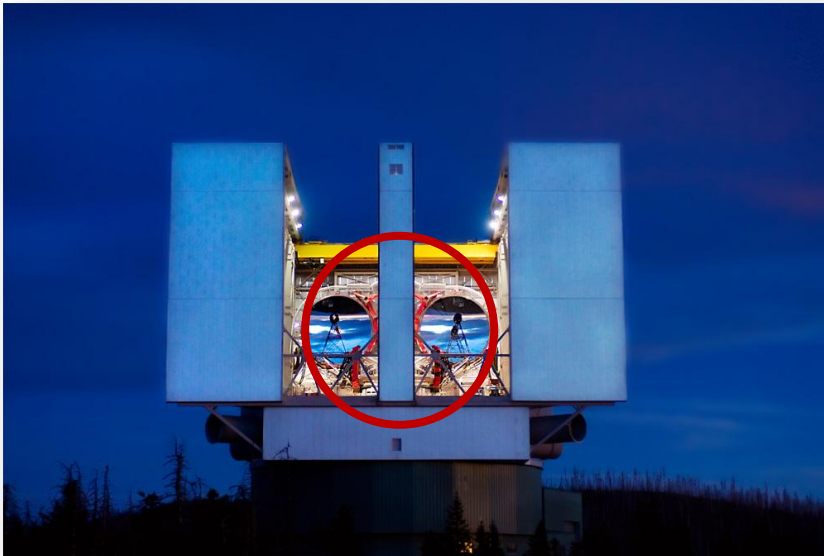


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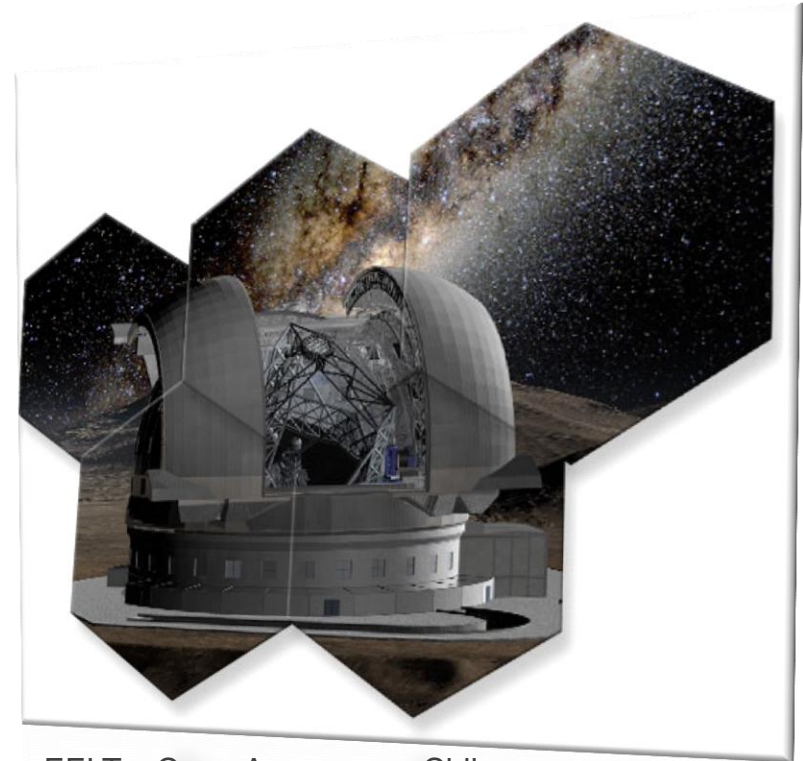


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The next steps



LBT – Mount Graham, Arizona



EELT – Cerro Armazones, Chile

We focus on the LBT approach – interferometric beam combination

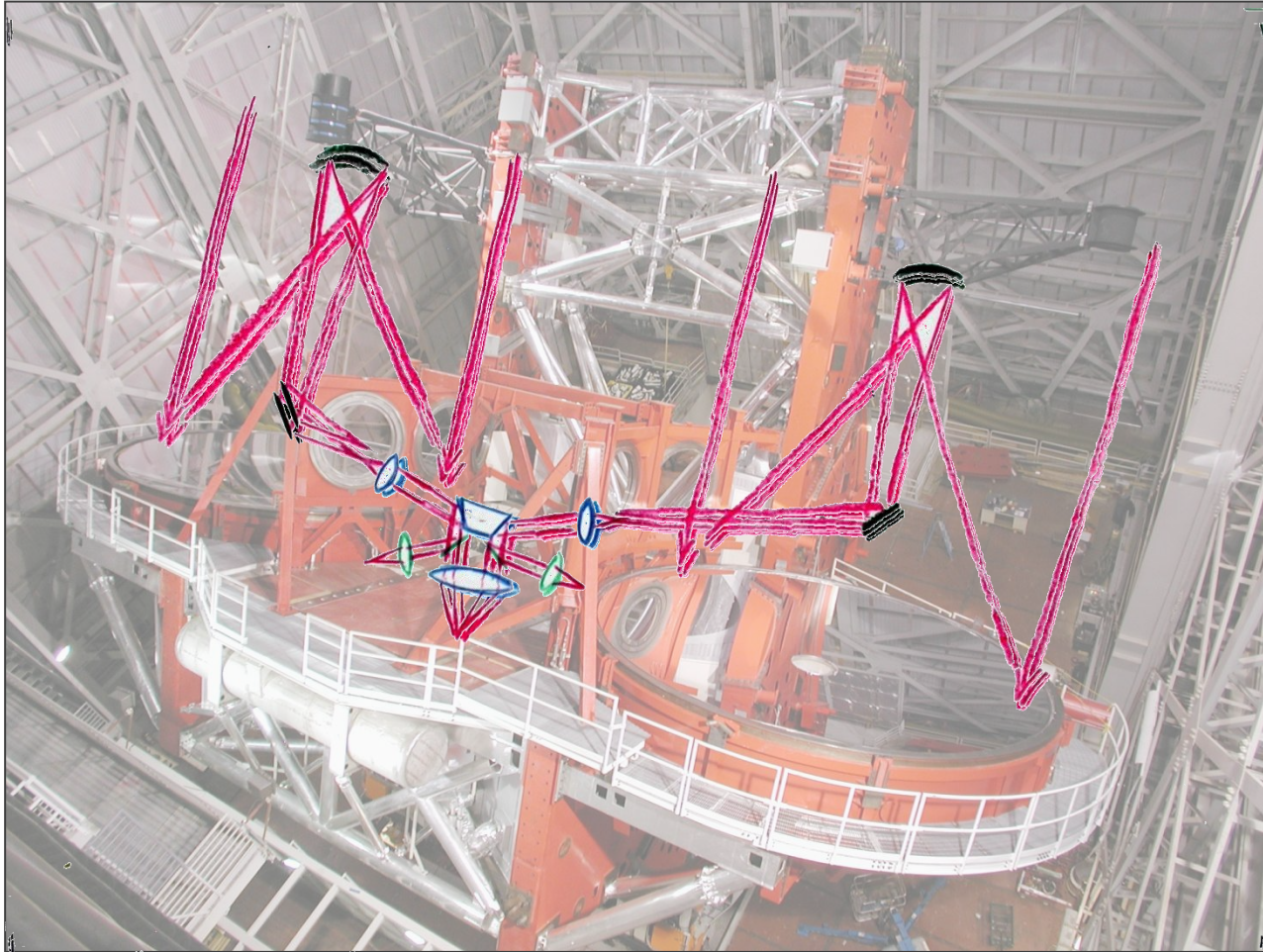


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How do we do this? The Concept of LINC-NIRVANA

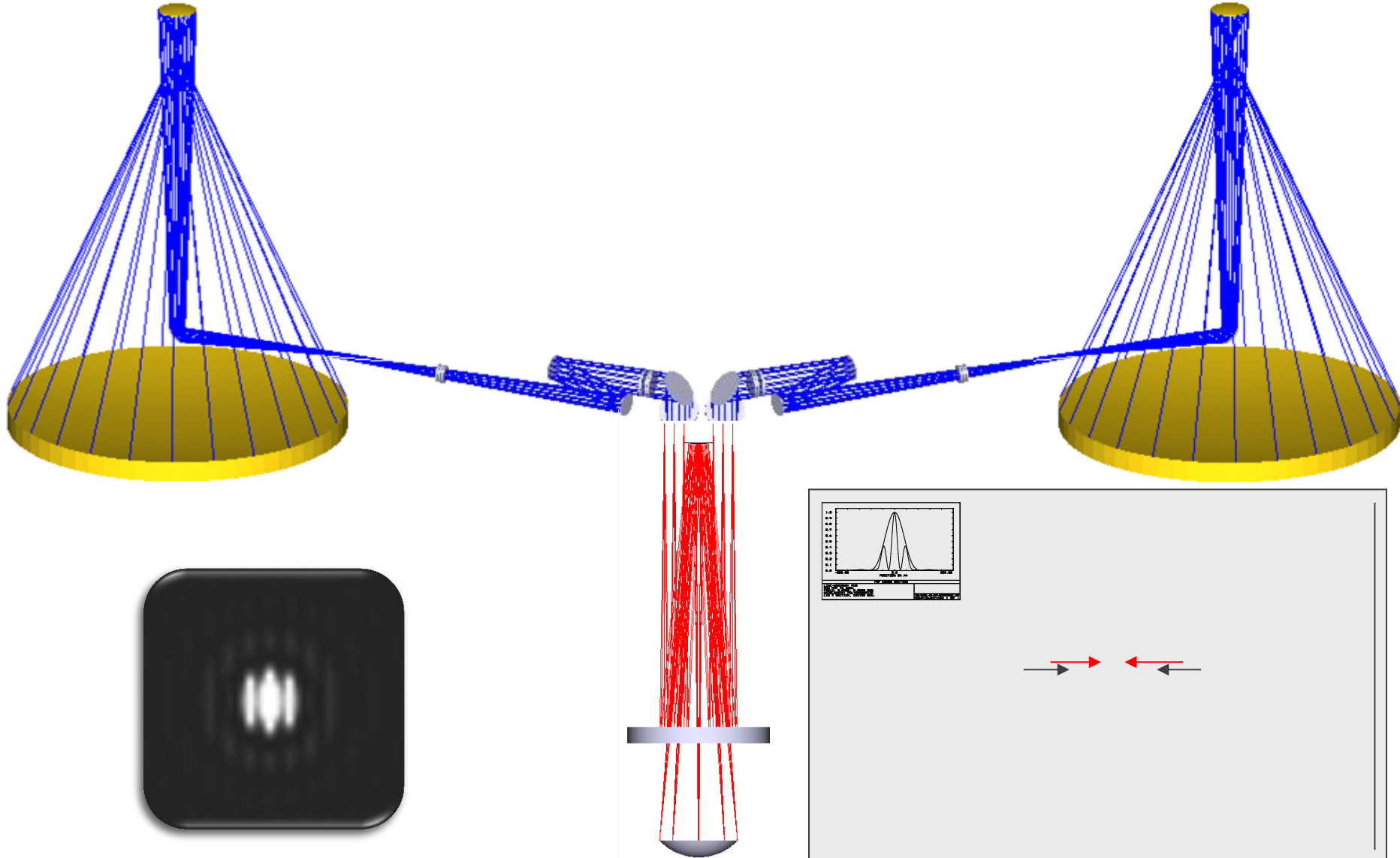




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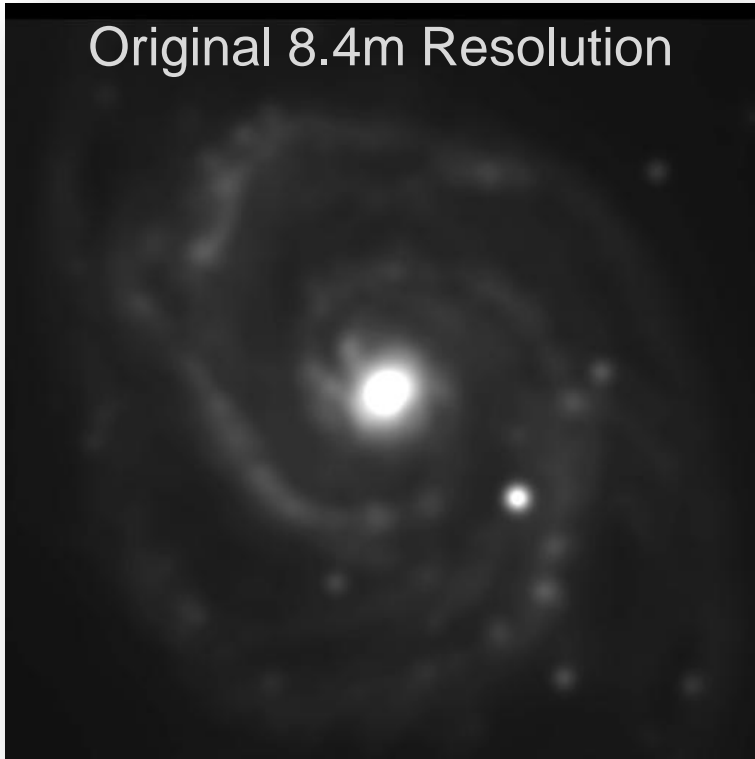


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Original 8.4m Resolution



Reconstructed 23m Resolution





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Short break .....

..... of a few years



## Outline

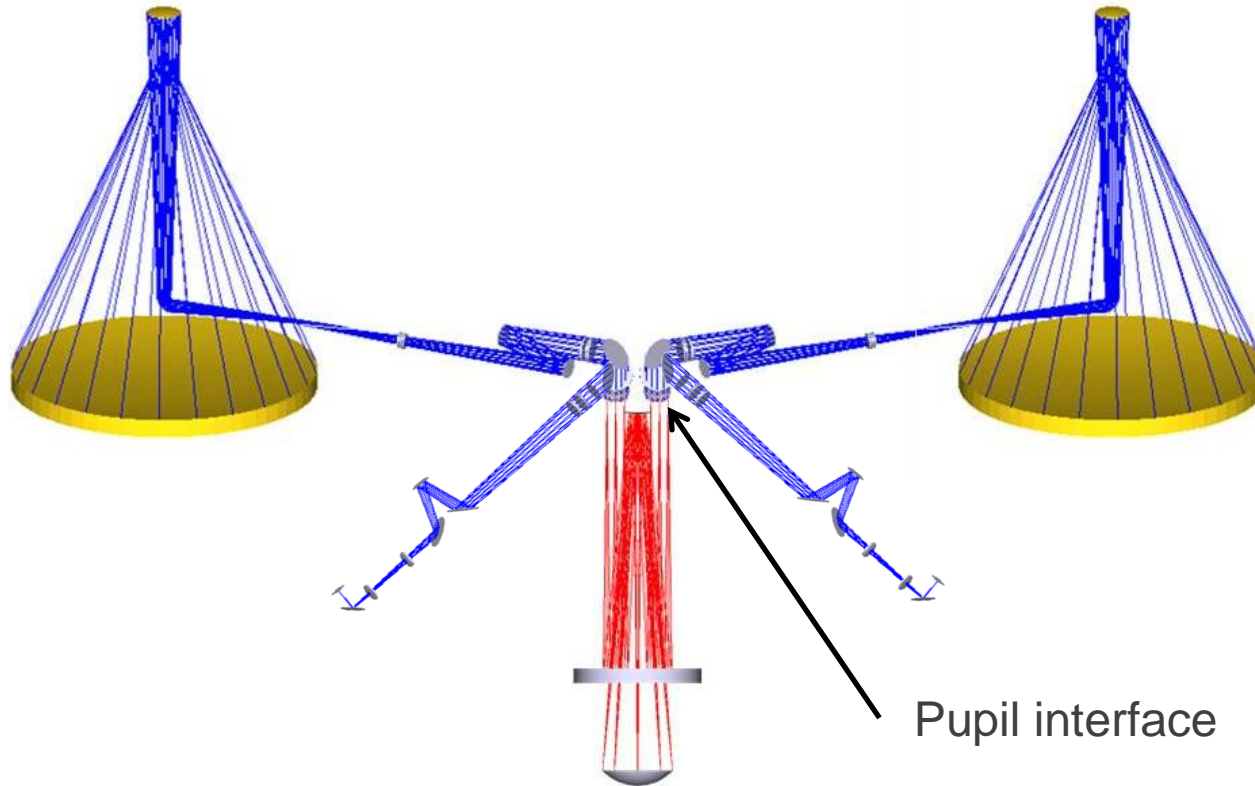
- Introduction to LINC-NIRVANA
- **Concept of the alignment strategy**
- Integration of the warm optics
- Integration of the cold optics
- Outlook



# LN Integration & Alignment



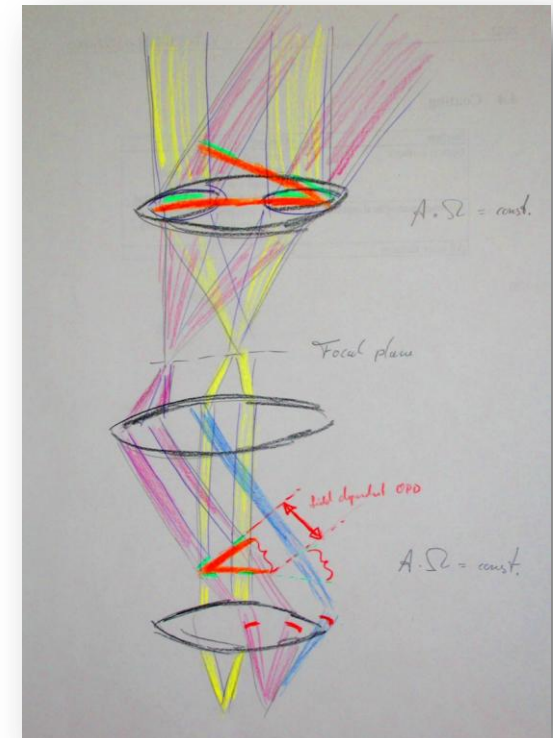
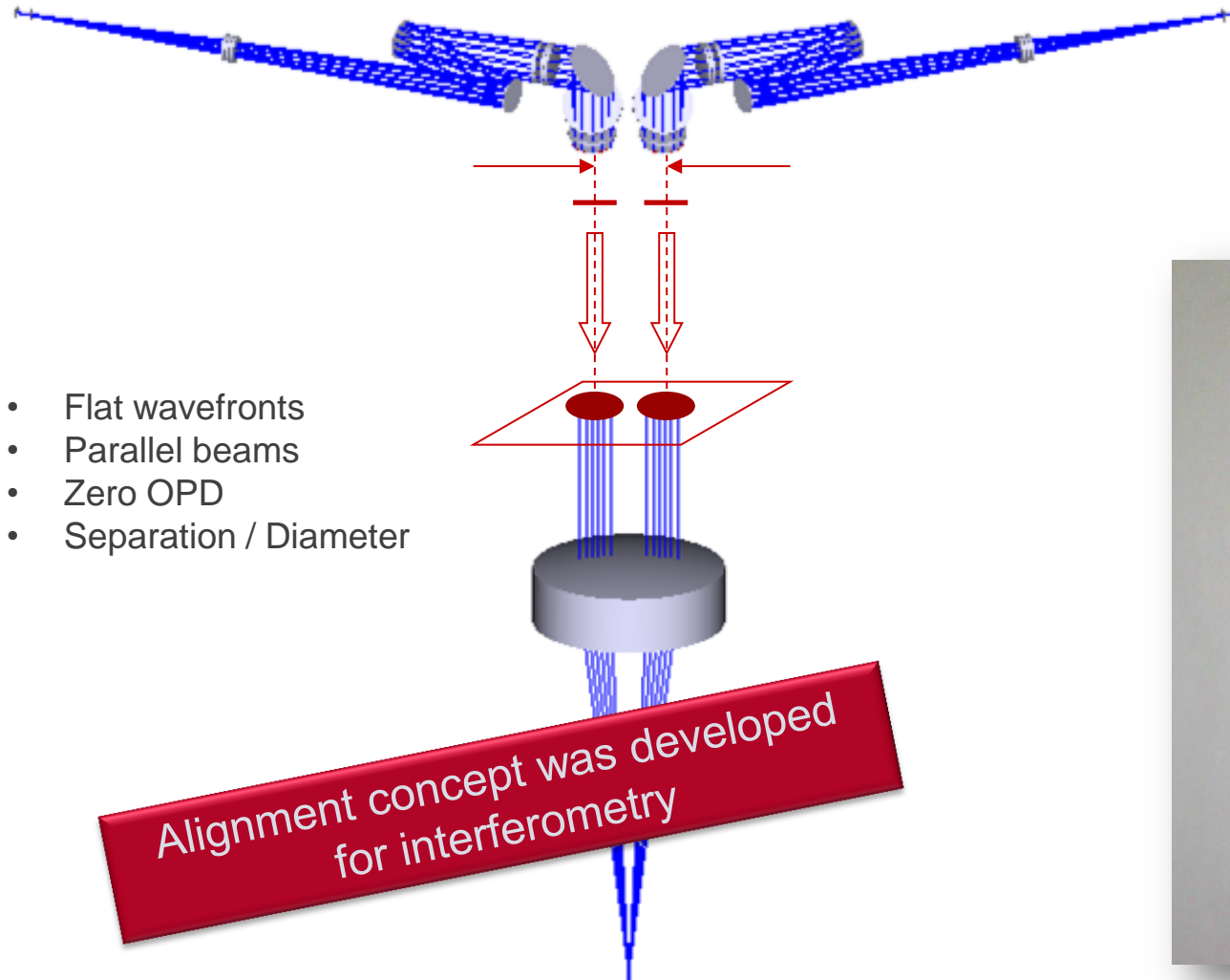
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Why do we start to align in the center?



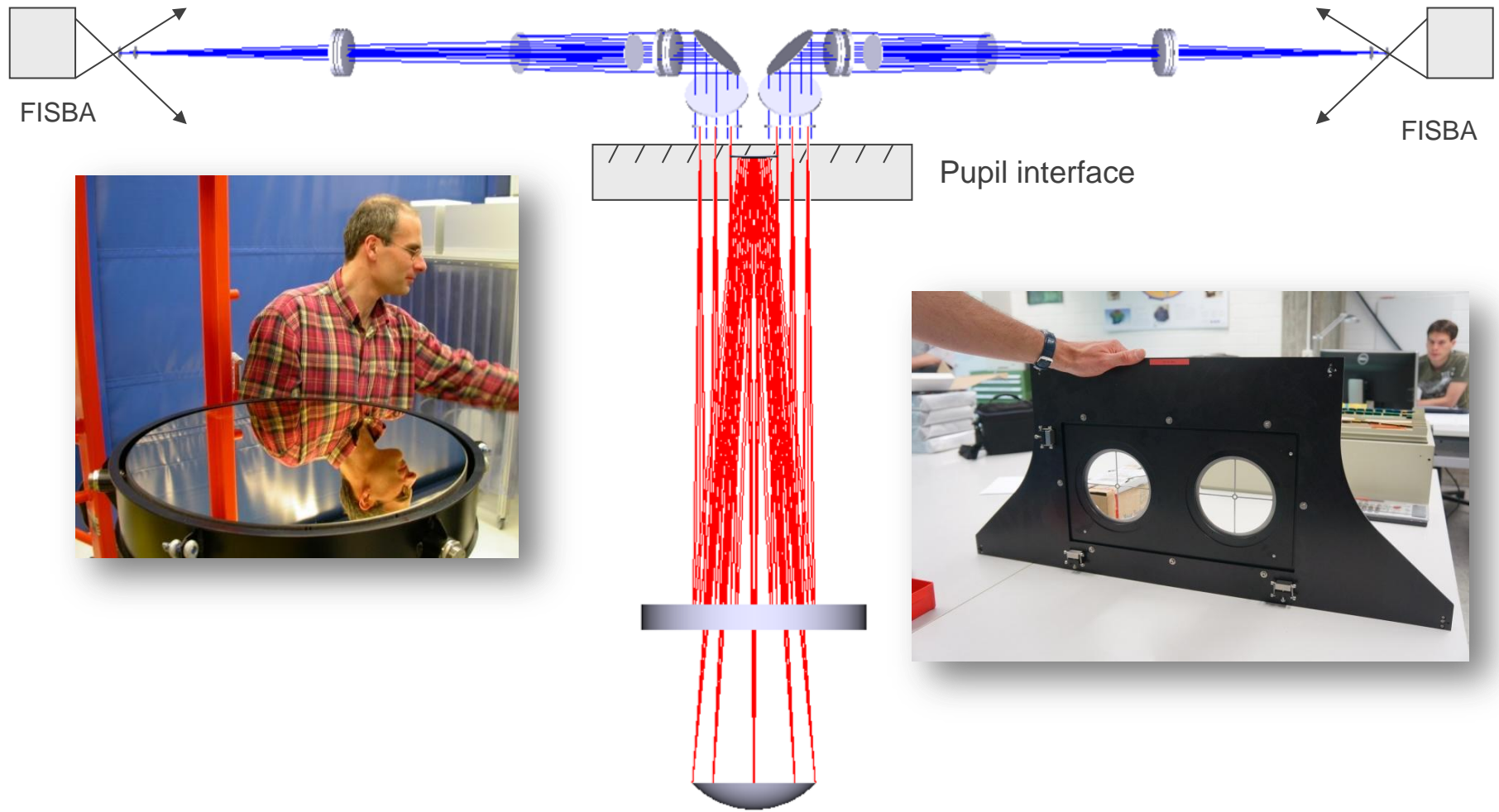


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## Alignment of the warm optics



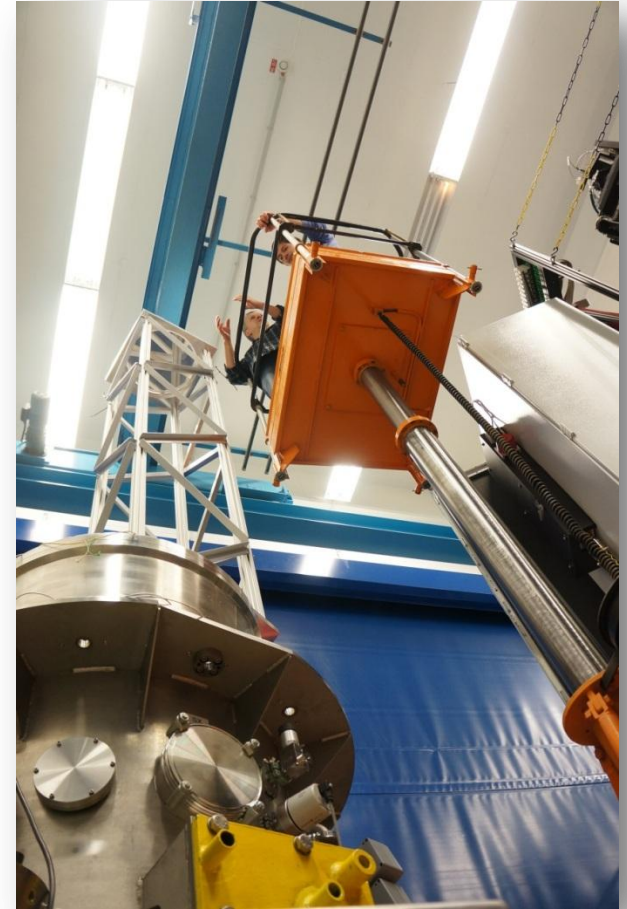
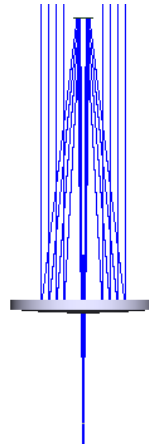
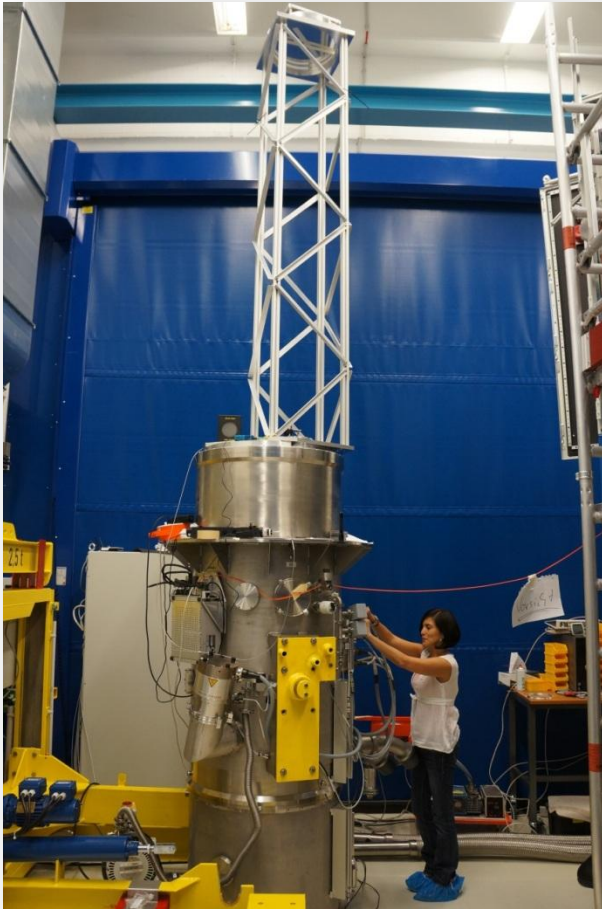


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## Alignment of the cold optics



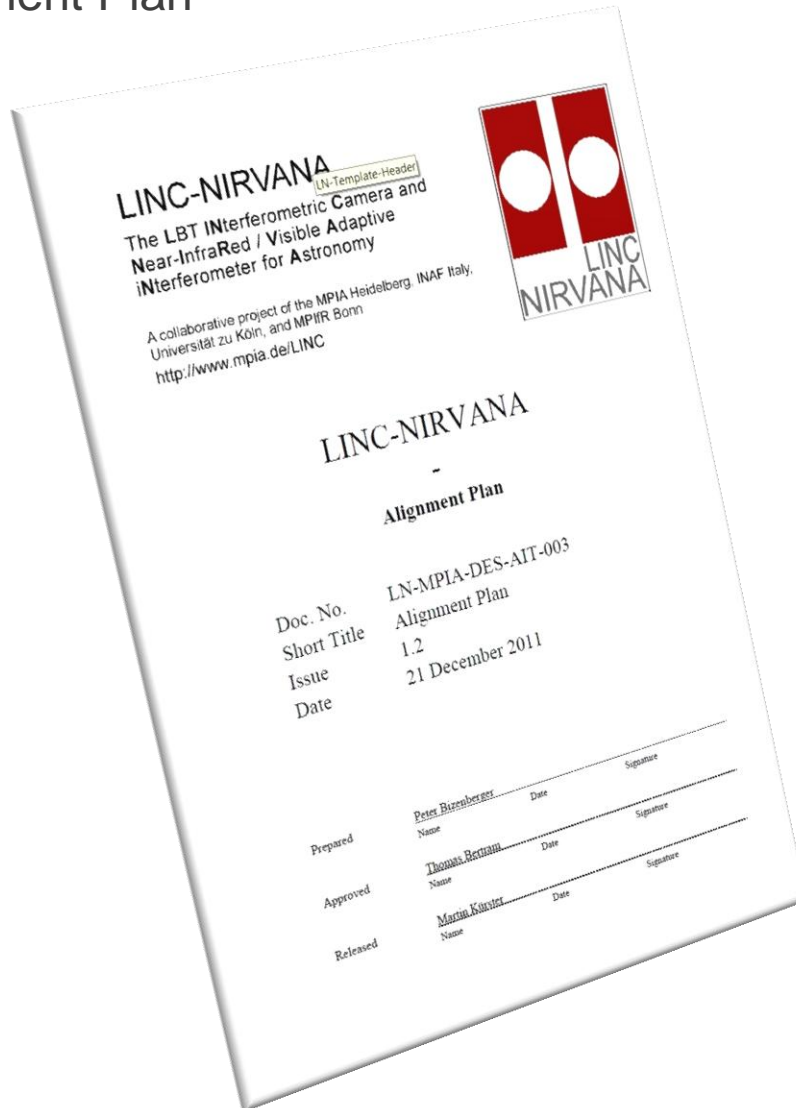


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## Alignment Plan



## Internal alignment of LN

- Procedures for warm optics
- Procedures for cold optics
- References
- Tools



## Outline

- Introduction to LINC-NIRVANA
- Concept of the alignment strategy
- **Integration of the warm optics**
- Integration of the cold optics
- Outlook



## Alignment of the warm optics

- Alignment of piston mirror
- Alignment of the optical axis
- Alignment of the powered optics



## Alignment of the warm optics

- Mask to Cryostat
- Alignment of piston mirror
- Alignment of the collimator axis – left side
- Alignment of the collimator optics – left side
- Alignment of the FP20 axis & warm dichroics – left side
- Alignment of the K-mirror – left side
- Alignment of the FP20 optics – left side
- Alignment of the HWS – left side
- Alignment of the collimator axis – right side
- Alignment of the collimator optics – right side
- Alignment of the FP20 axis & warm dichroics – right side
- Alignment of the K-mirror – right side
- Alignment of the HWS – right side
- Alignment of the FP20 optics – right side

Integration of components not shown



# LM Integration & Alignment

## Integration

### ► Preparation

### ► Initial Alignment

### ▼ Collimator Alignment

Ticket	Kurzbeschreibung	Verantwortlicher	Fällig	Blocking	Blocked By
#1186	Alignment of the Collimator Axis	biz	04/09/2013	#1187, #1188	#1177, #1188, #1185

Erstellt von bertram, vor 19 Monate.

- Beschreibung
- Dependencies:
    - #1185: Coffee Table aligned
    - #1177: Collimator Fold Unit prepared
    - #1180: DM flat
  - Tools:
    - 1 FISBA with 10mm objective
    - Pupil Mask / large Reference Mirror
  - Procedure:
    1. Align FISBA to reference mirror and pupil mask.
    2. Mount reference mirror for collimator axis shift.
    3. Align reference mirror in tip/tilt.
    4. Integrate FISBA mount on the folded beam position.
    5. Align tip/tilt of FISBA mount to reference mirror.
    6. Integrate DM Fold Unit.
    7. Flatten DM.
    8. Align Fold Mirror until FISBA beam is perpendicular again.
    9. Define named position for aligned tip/tilt within basda device
    10. Adjust FISBA laterally until FISBA beam is centered again wrt. pupil mask

#1187	Alignment of the Axial Reference Mirror Unit	biz	12/09/2013		#1186
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Erstellt von bertram, vor 19 Monate.

- Beschreibung
- Dependencies:
    - #1186: Collimator Axis aligned
    - #1183: Calibration Unit Breadboard prepared
  - Tools:
    - Axial Reference Mirror Unit
  - Procedure:
    1. Mount Axial Reference Mirror Unit on Calibration Unit Breadboard ✓
    2. Align Axial Reference mirror to FISBA direction ✓
    3. Lock alignment screws. ✓
    4. Remove and store Axial Reference Mirror Unit ✓

#1188	Alignment of the Powered Collimator Optics	biz	26/09/2013	#1189, #1190, #1192	#1182, #1186
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Erstellt von bertram, vor 19 Monate.

- Beschreibung
- Dependencies:
    - #1186: Collimator Axis aligned
    - #1182: Lens Units prepared
  - Tools:
    - 1 spheric objective
  - Procedure:
    1. Mount Collimator Lens Group 2
    2. Initial alignment with back reflections from lens surfaces
    3. Mount Collimator Lens Group 1
    4. Initial alignment with back reflections from lens surfaces
    5. Mount spheric objective on FISBA
    6. Minimize RMS wavefront error through fine-adjustment of the powered optics.
    7. Lock alignment screws / lens positions
    8. Define named position for aligned lenses within basda devices
    9. Protect / Remove large Reference Mirror

#1189	Alignment of the Laser Tracker Reference Sphere Unit	biz	27/09/2013		#1188
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Erstellt von bertram, vor 19 Monate.

- Beschreibung
- Dependencies:
    - #1188: Powered Collimator Optics aligned
  - Tools:
    - Laser Tracker Reference Sphere Unit
  - Procedure:
    1. Mount Laser Tracker Reference Sphere Unit on Calibration Unit Breadboard
    2. Align Laser Tracker Reference Sphere Unit to focus position as defined by the FISBA.
    3. Lock the alignment screws
    4. Remove and store Laser Tracker Reference Sphere Unit

### ► FP20 Alignment

### ► MHWS Sensor Alignment

### ► Components/Units

### Progress



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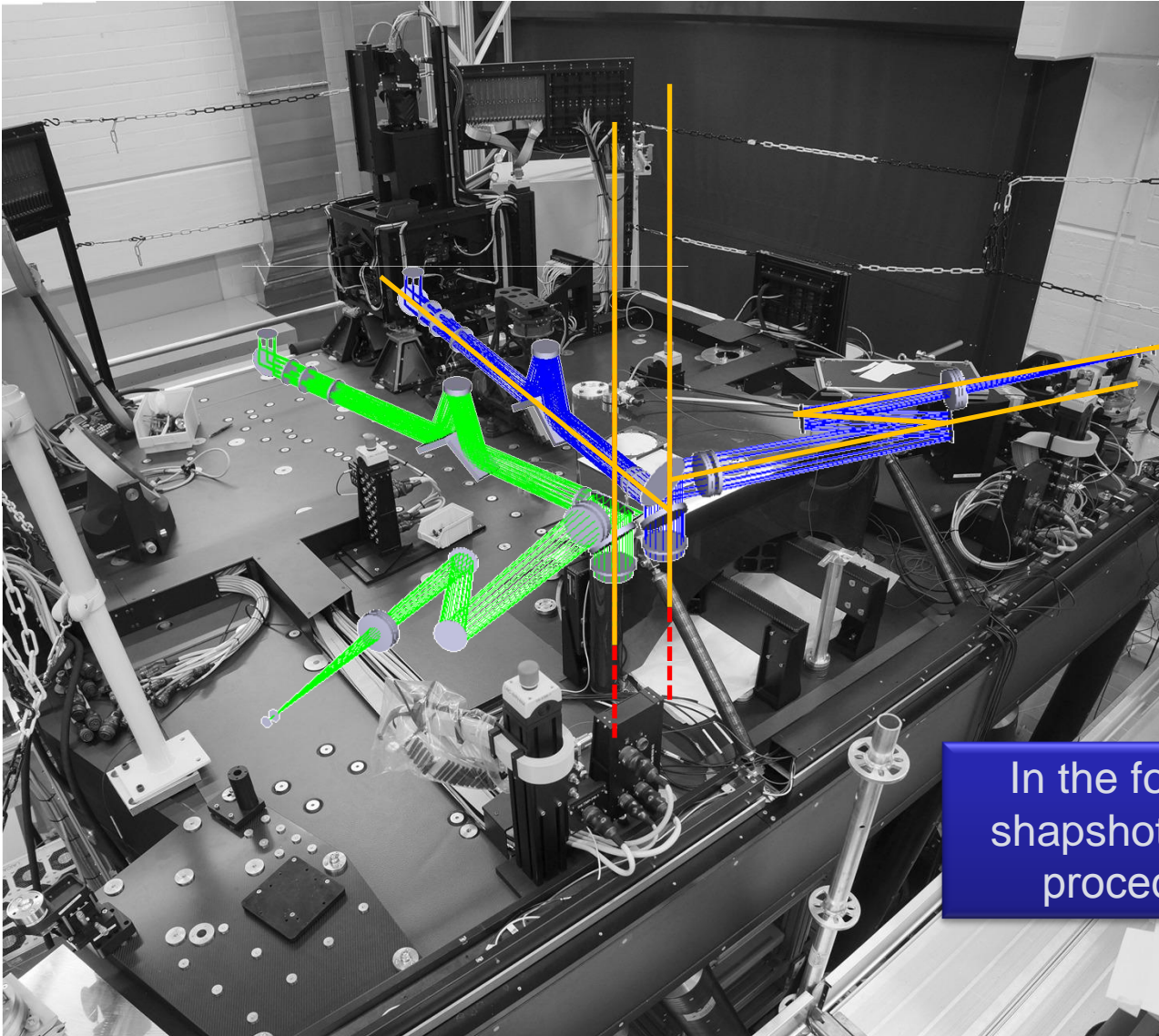
Sequence and  
procedures  
defined on trac  
~ 100 tickets



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In the following only a few  
snapshots, not the complete  
procedure, don't worry

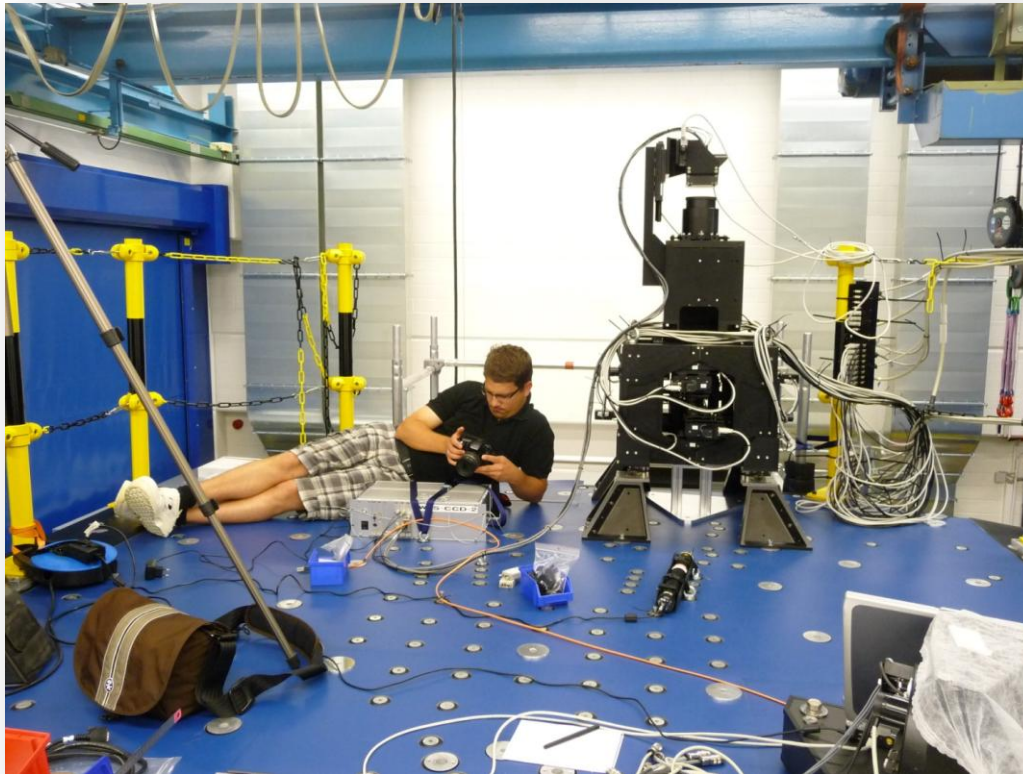


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Actual integration on the bench ...



.... started relaxed with placing a few things

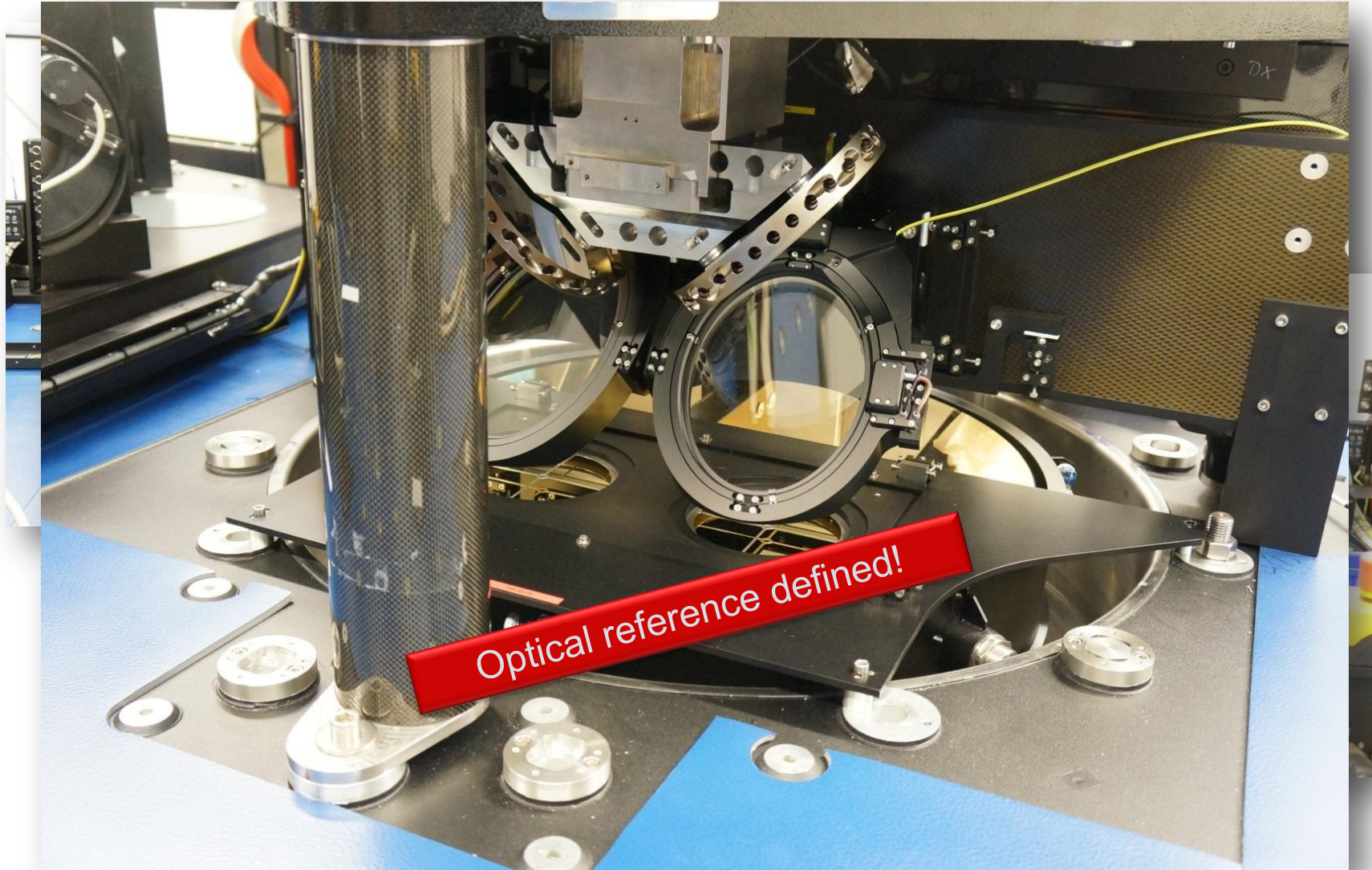


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Reference: Pupil position of the cryostat



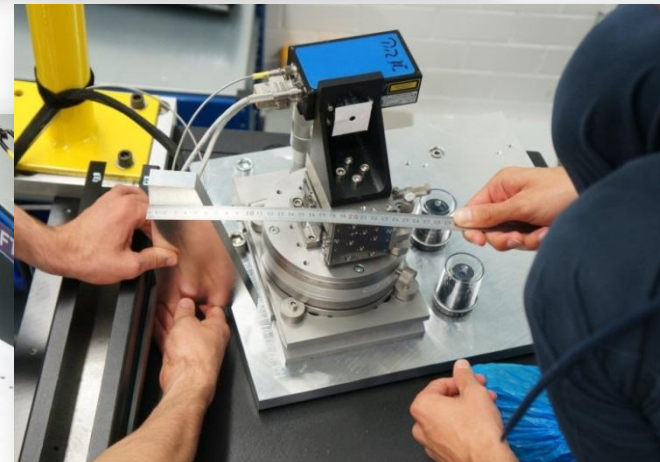
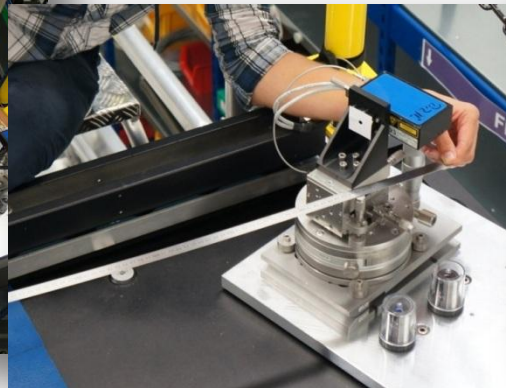
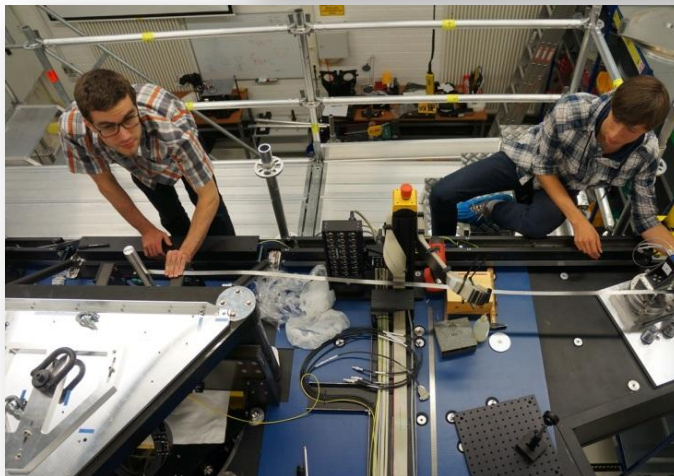
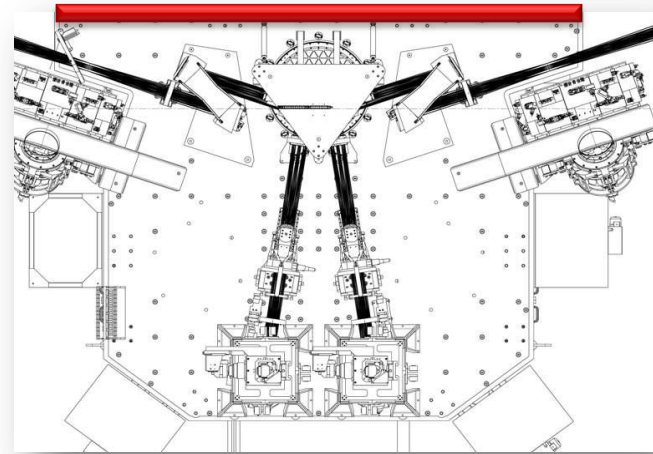
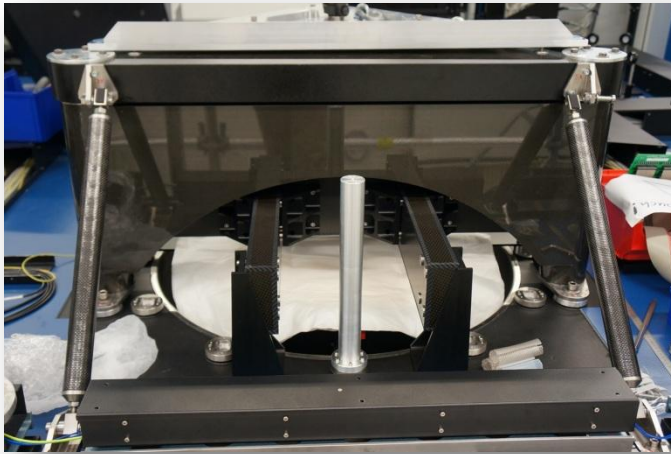


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## Mechanical reference for integration





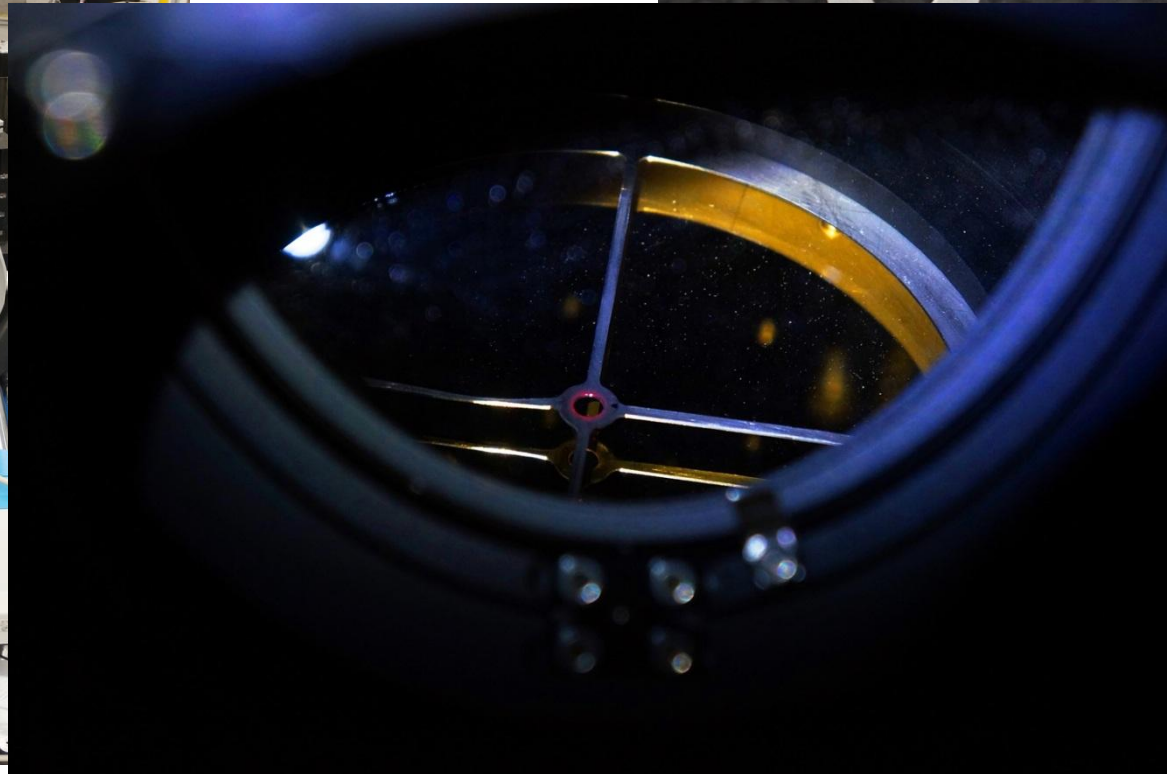
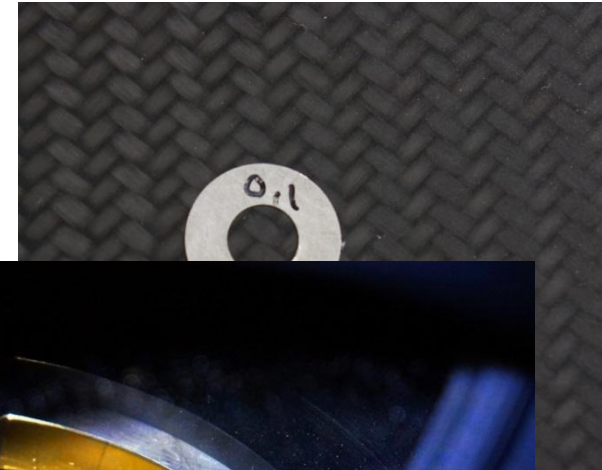
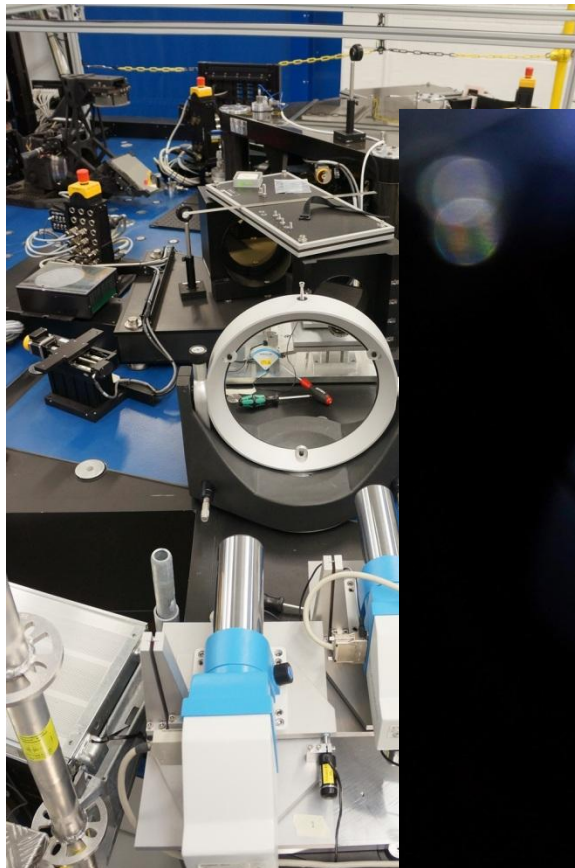
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## Alignment of the axis

- Align Fisba beam to be parallel to bench
- Align DM to be perpendicular to bench
- Align DM unit to allow a parallel shift of the beam
- Position Fisba to the mask



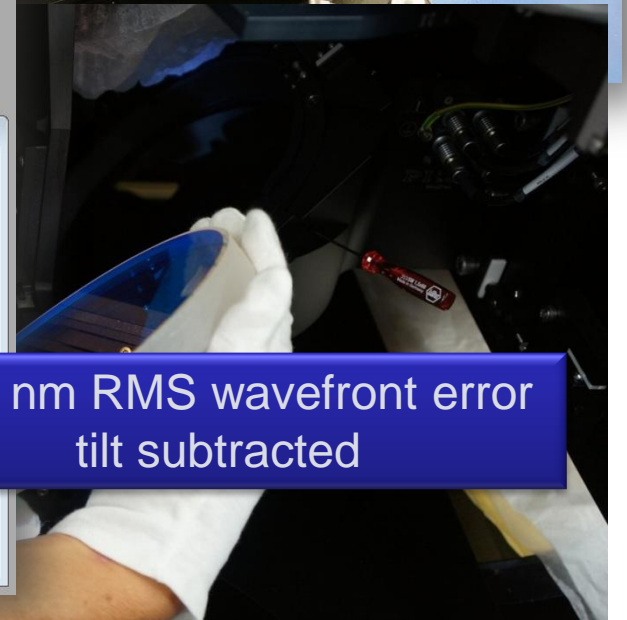
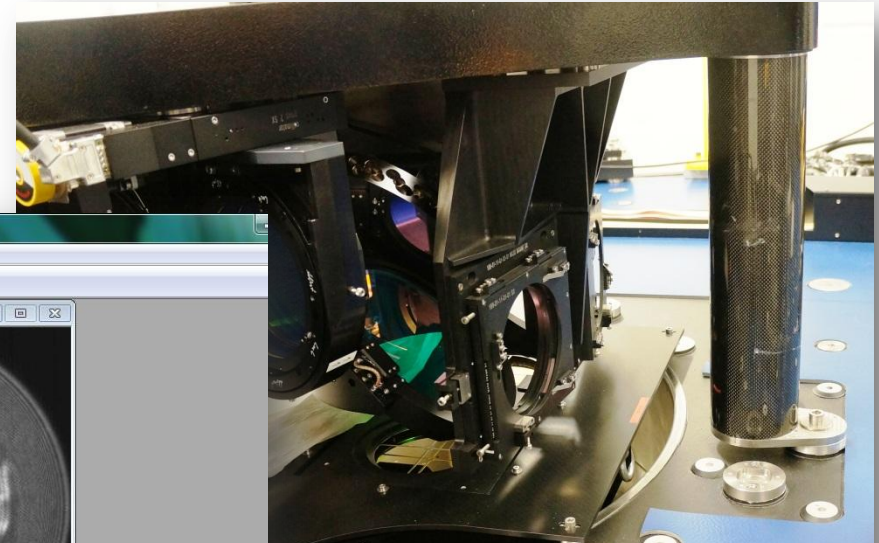
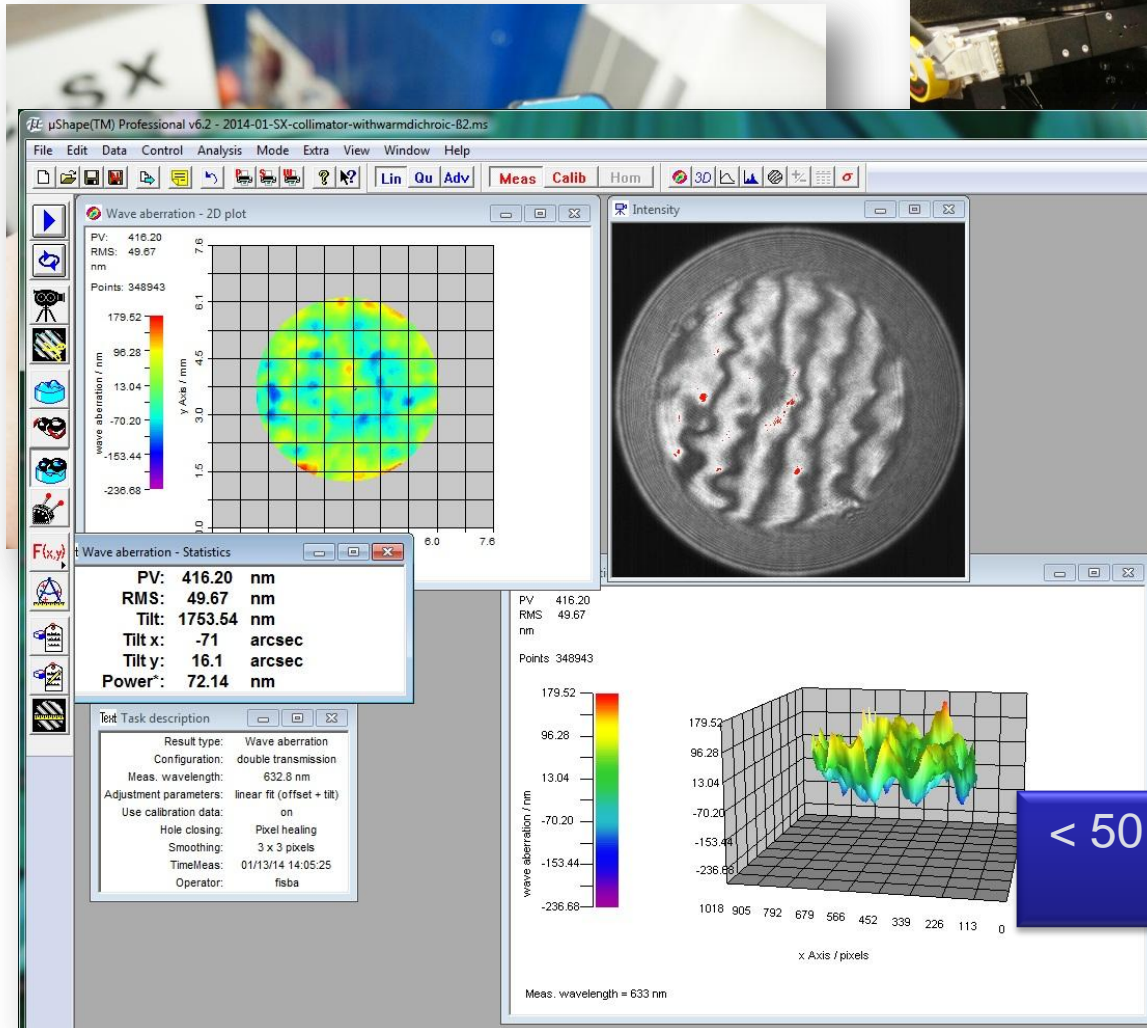


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## Alignment of the powered optics

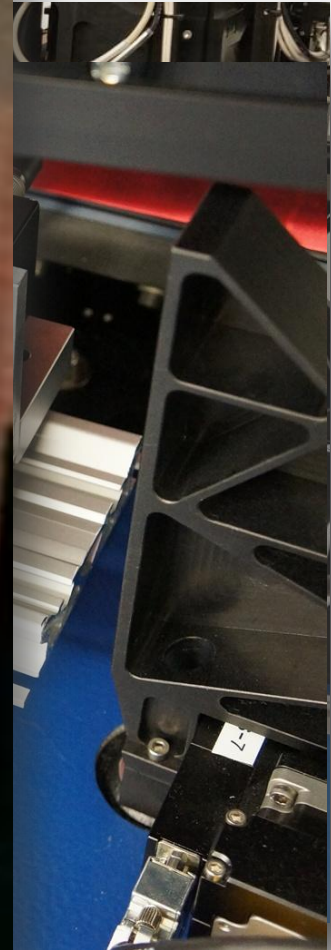
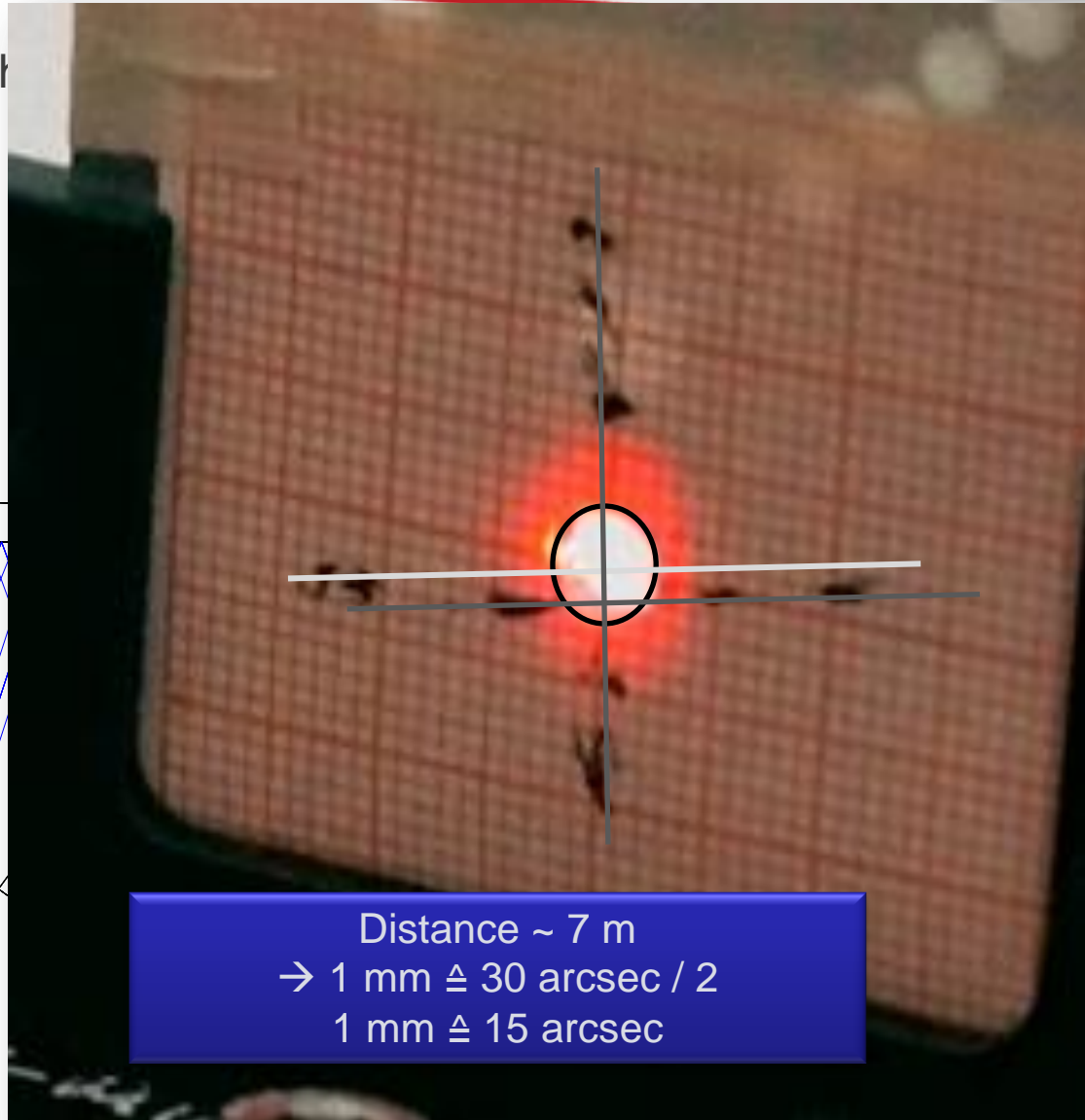
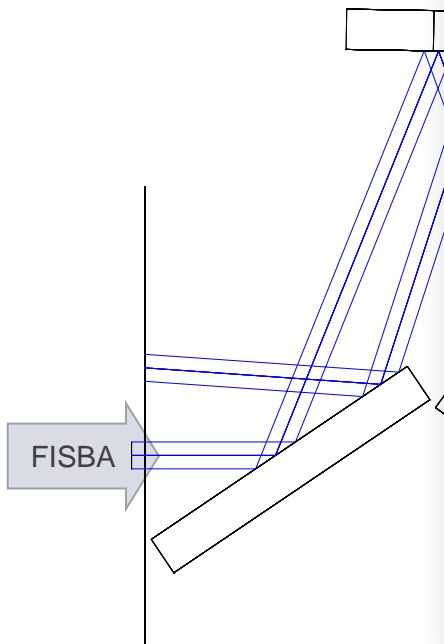


< 50 nm RMS wavefront error  
tilt subtracted



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Alignment of the



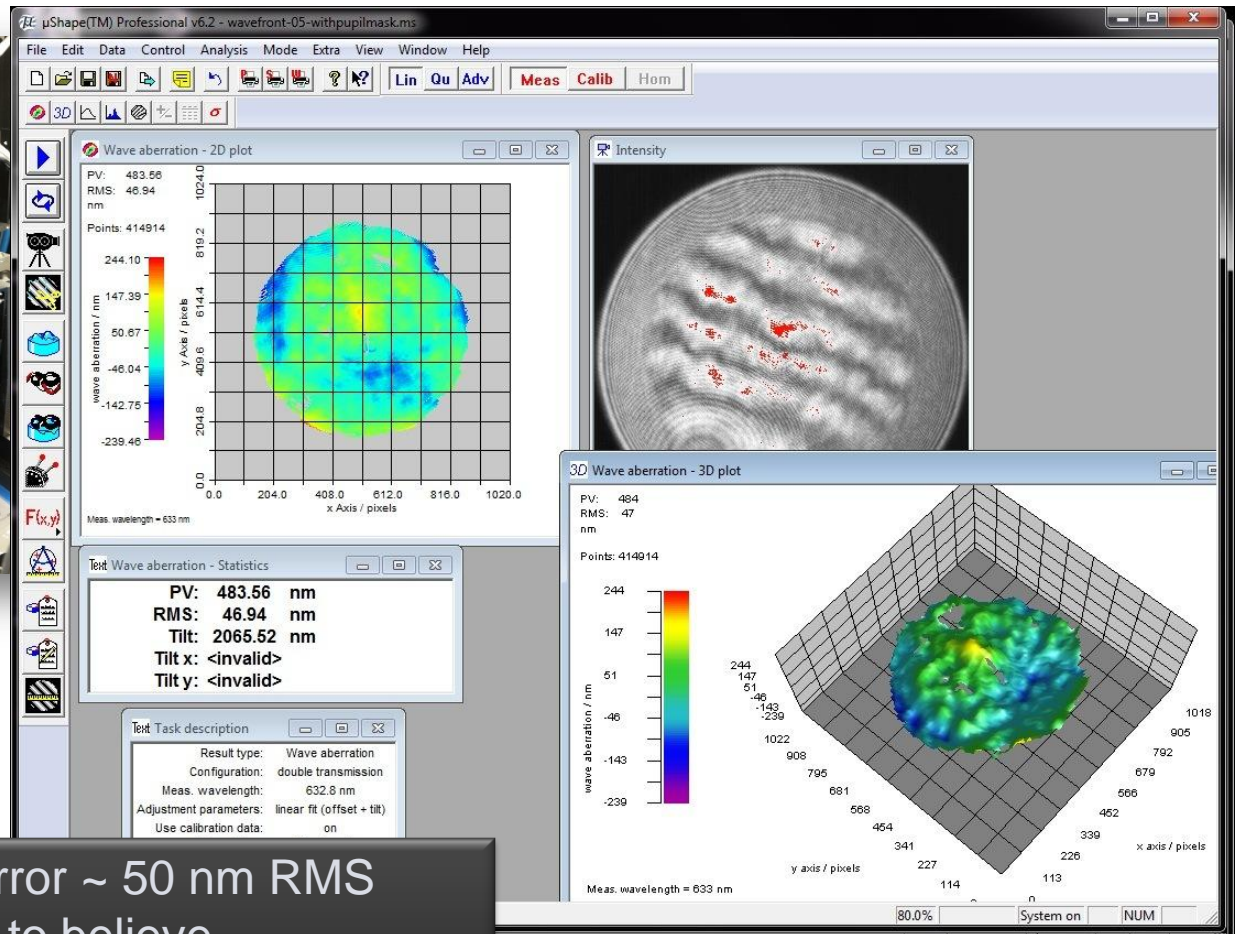
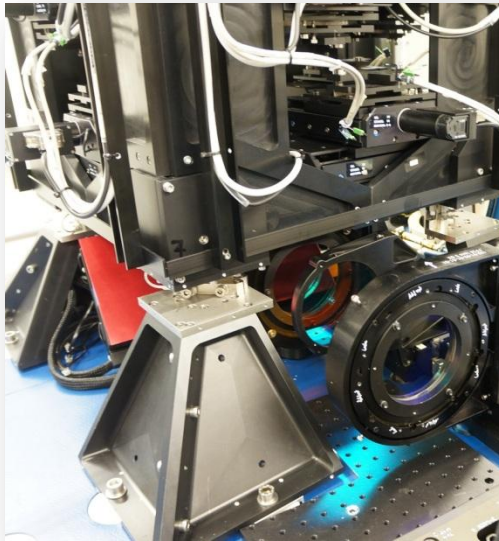


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## Alignment of the powered FP20 optics



Wavefront error ~ 50 nm RMS  
hard to believe

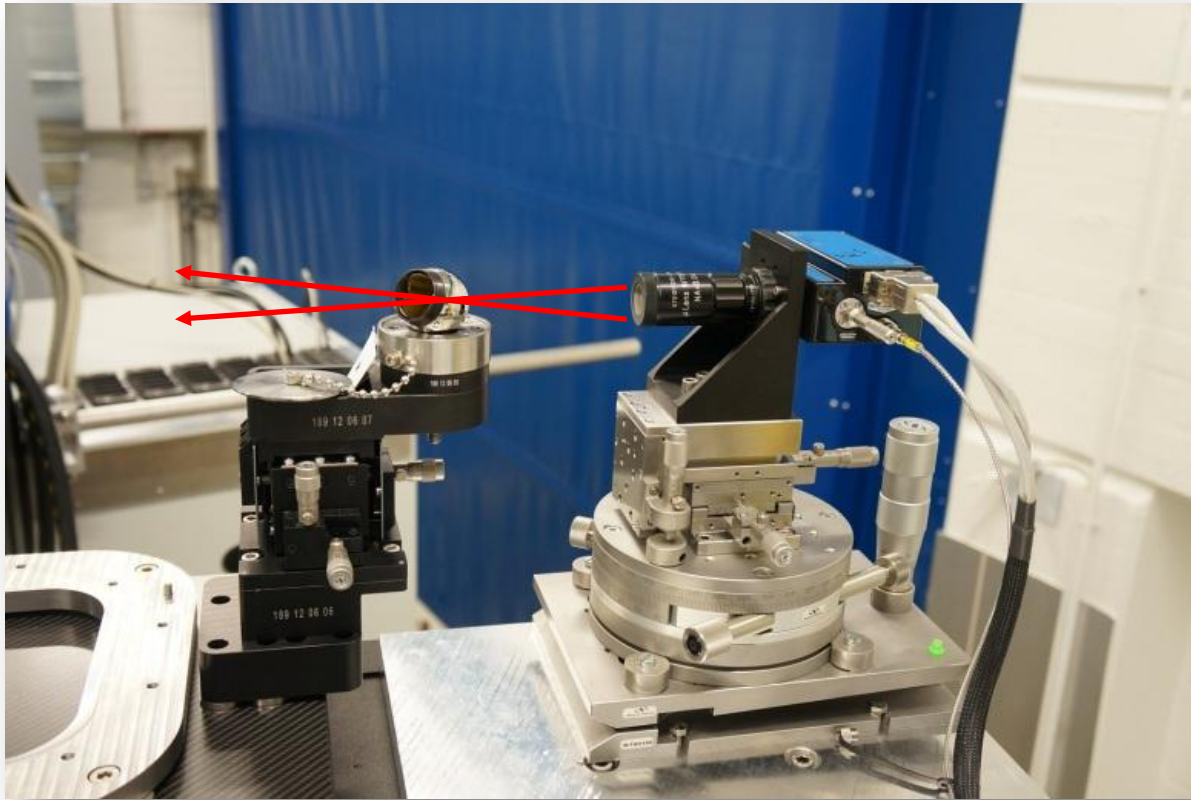


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Reference sphere – interface to LBT



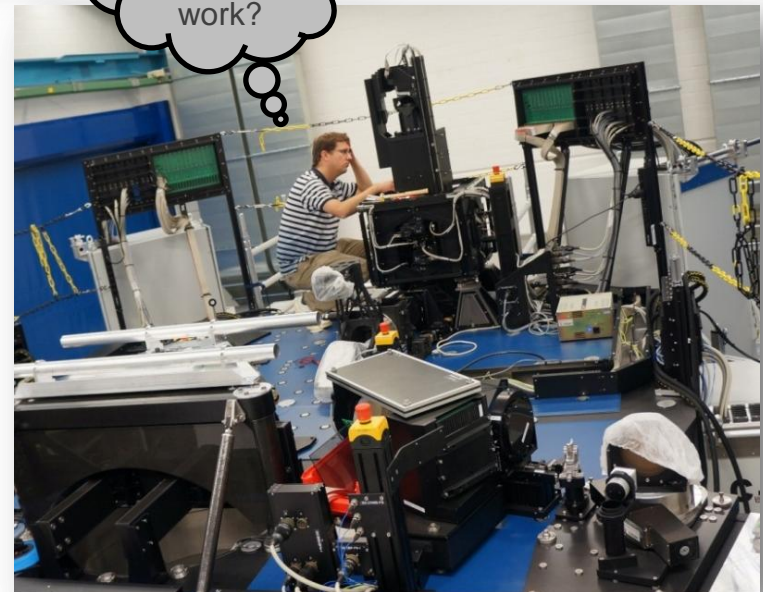
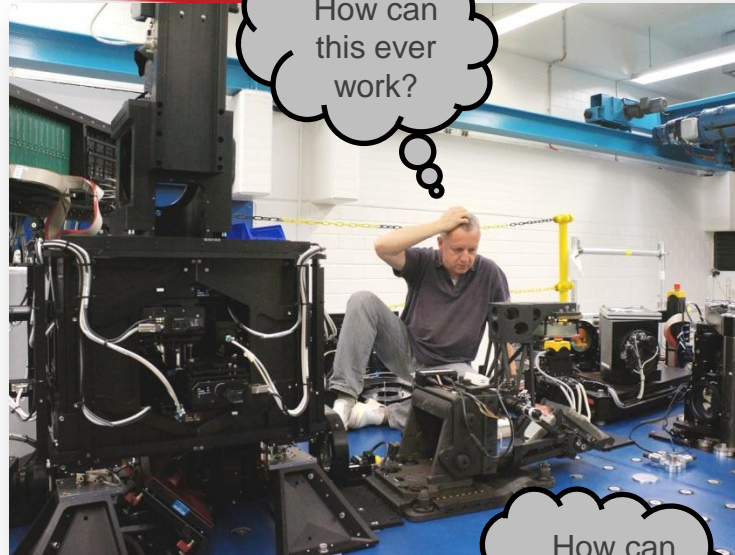


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Remaining question





## Outline

- Introduction to LINC-NIRVANA
- Concept of the alignment strategy
- Integration of the warm optics
- **Integration of the cold optics**
- Outlook



# LN Integration & Alignment



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Optical performance of the beam combiner optics

- Optical performance
- Interferometric Performance

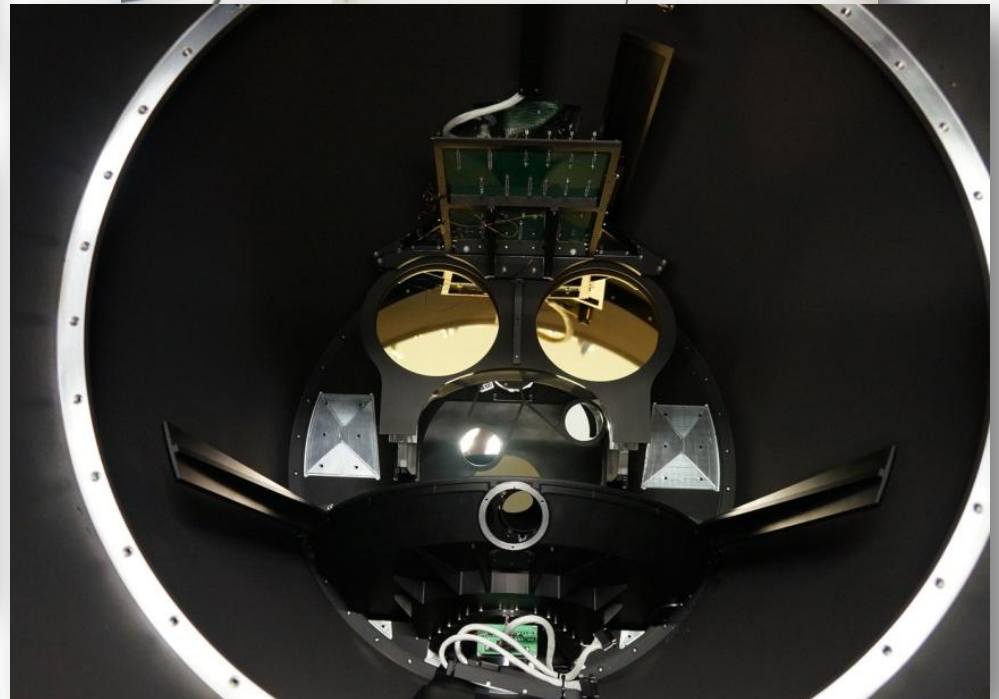
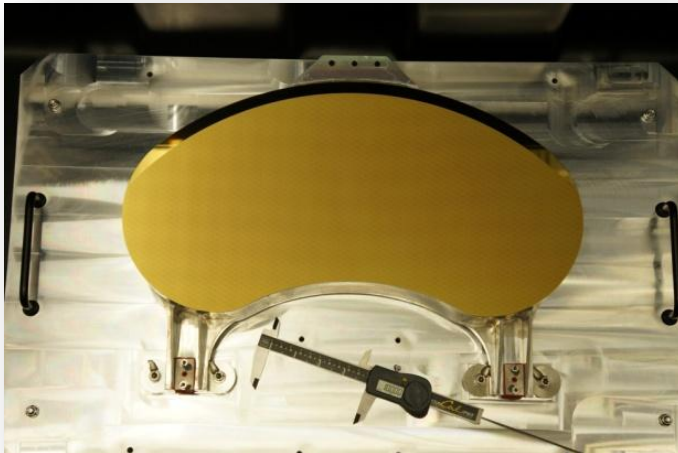
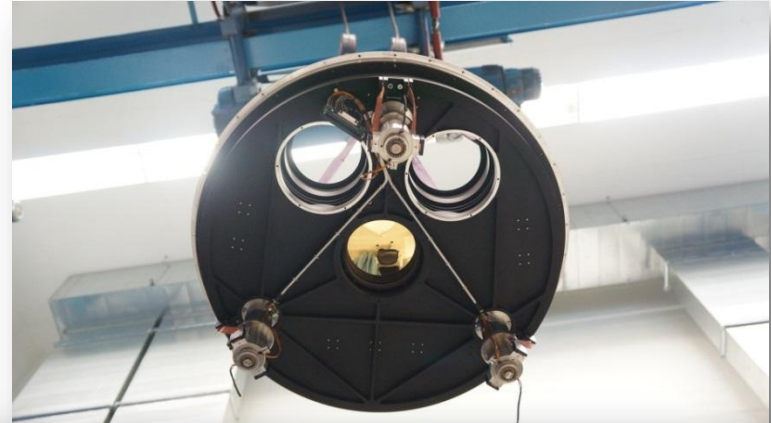
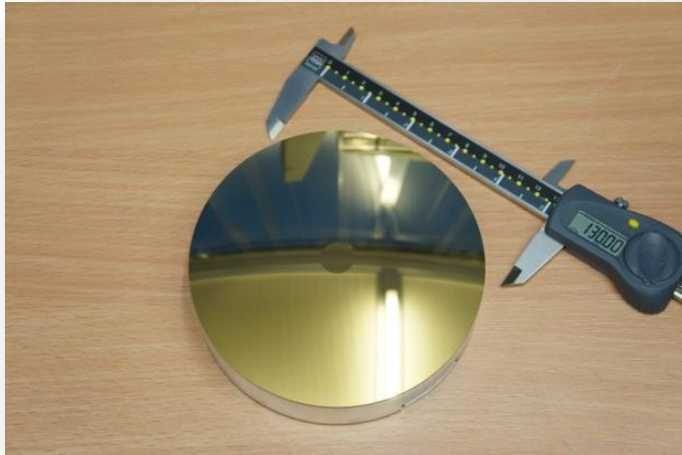


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## Optical performance



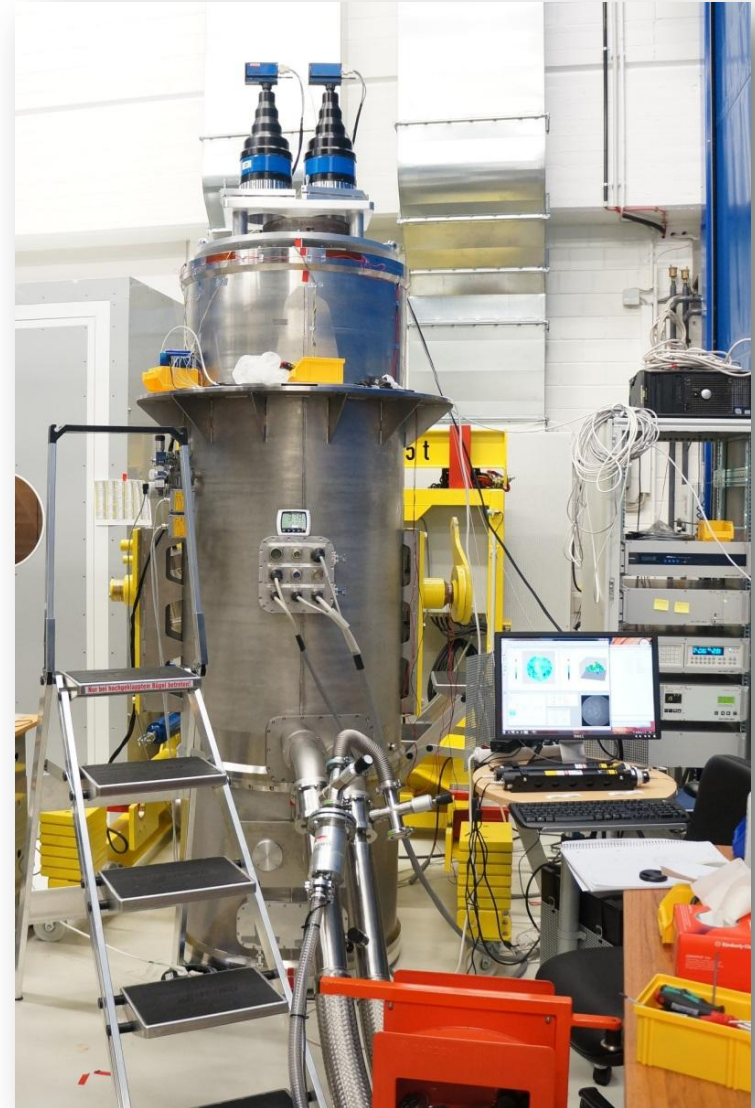
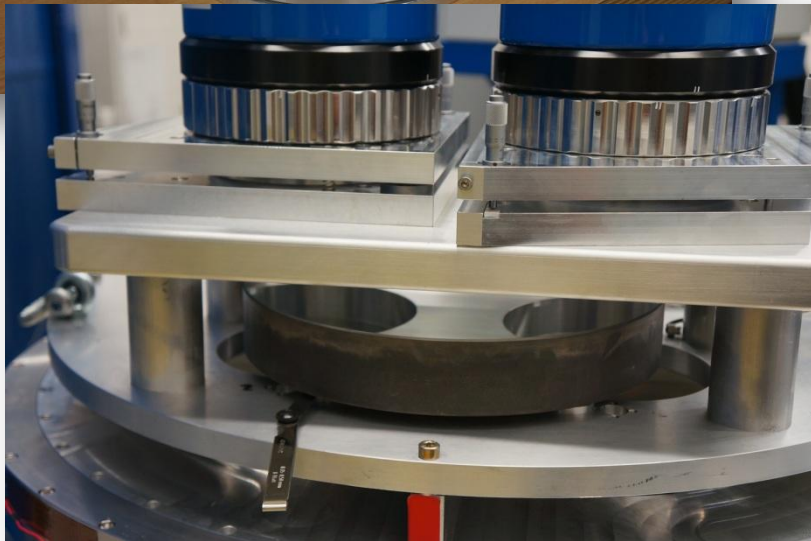


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Optical performance



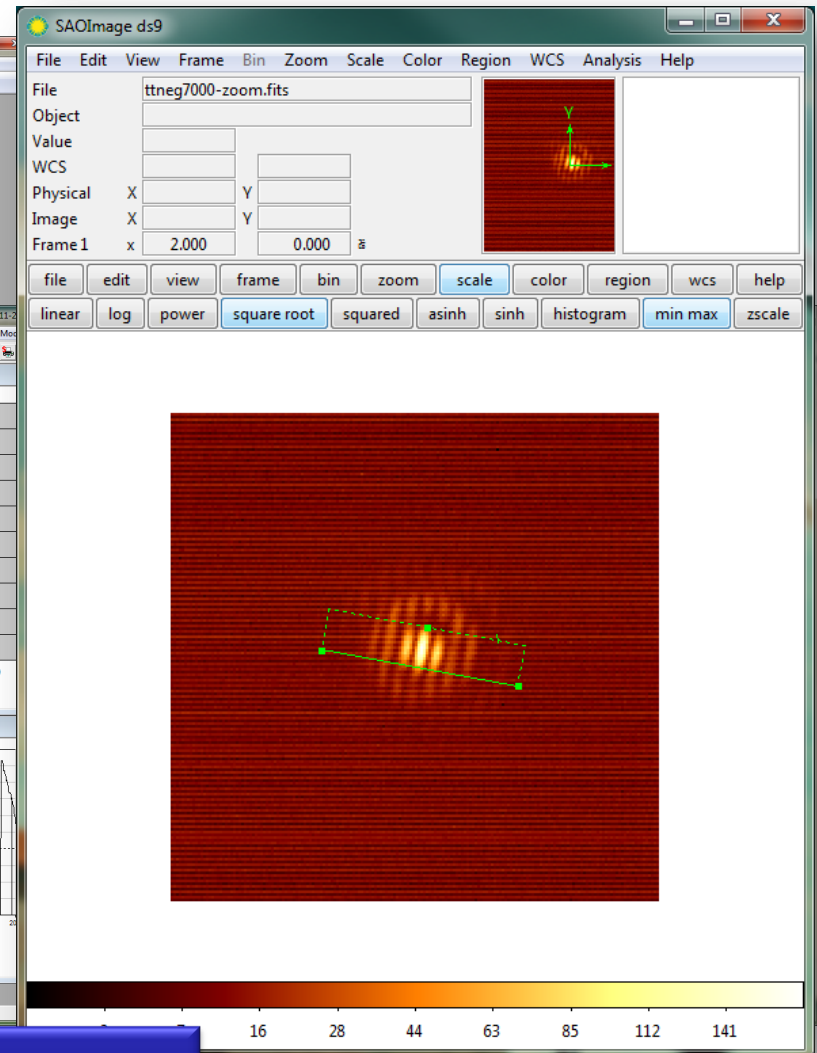
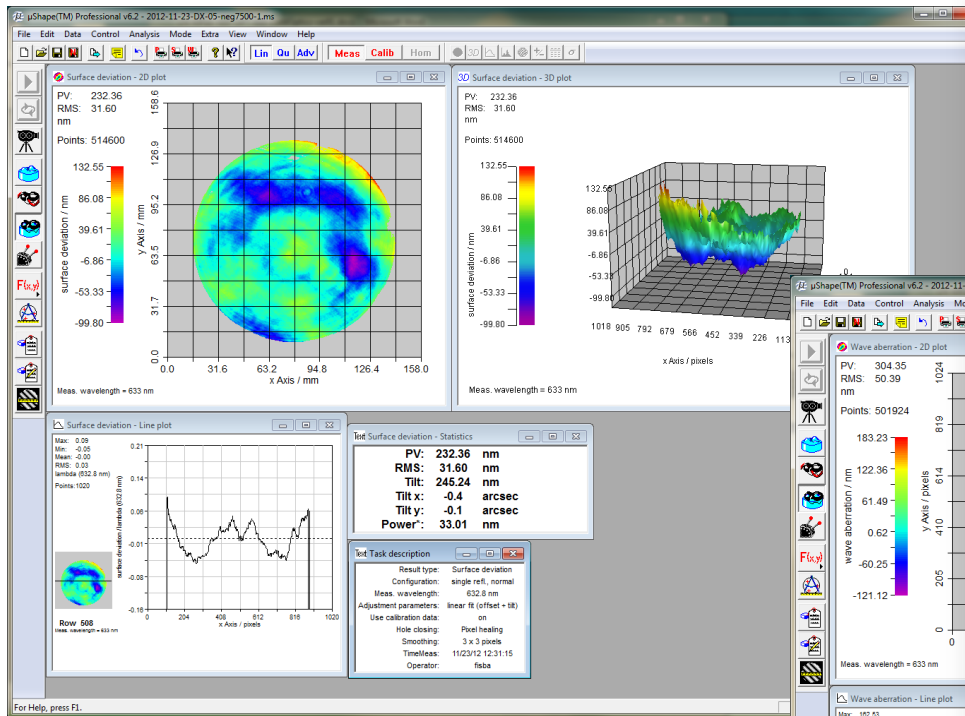


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Optical performance at cryogenic (optics & windows, no dichroic, filter)



Item	Value
DX – cryogenic	RMS 35.7 nm
SX – cryogenic	RMS 53.1 nm

@ 633 nm



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Optical performance at IR with coherent illumination

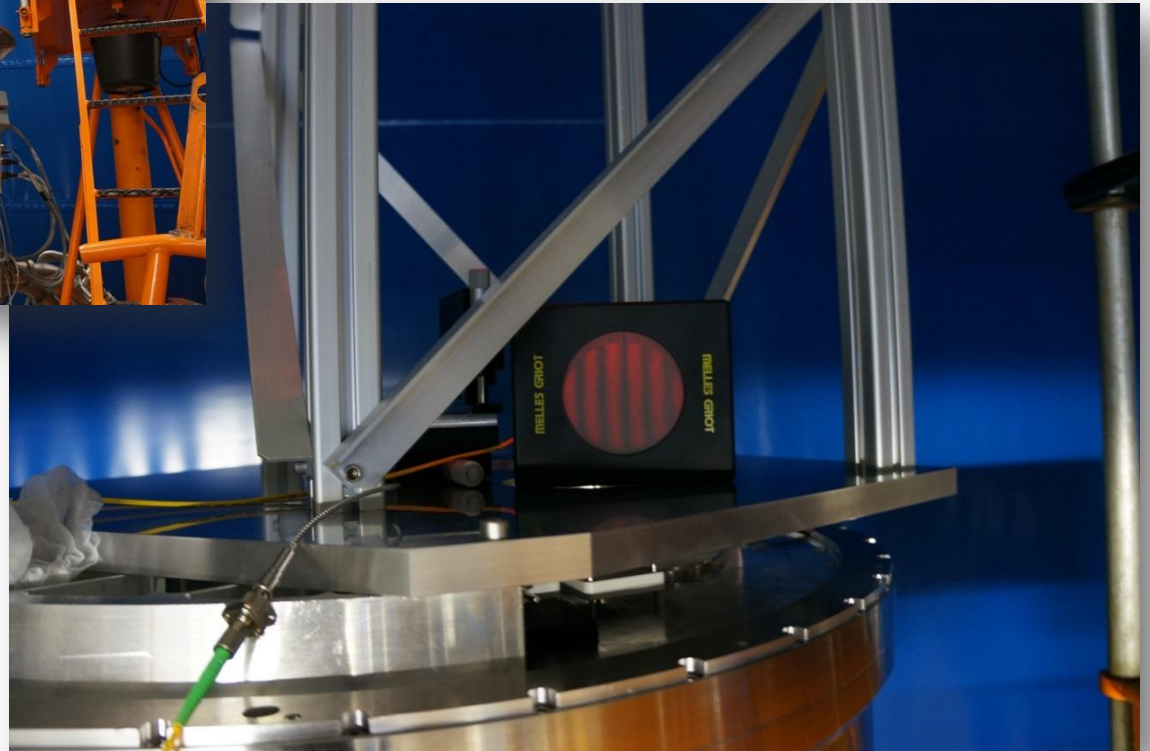


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Optical performance at IR with coherent illumination





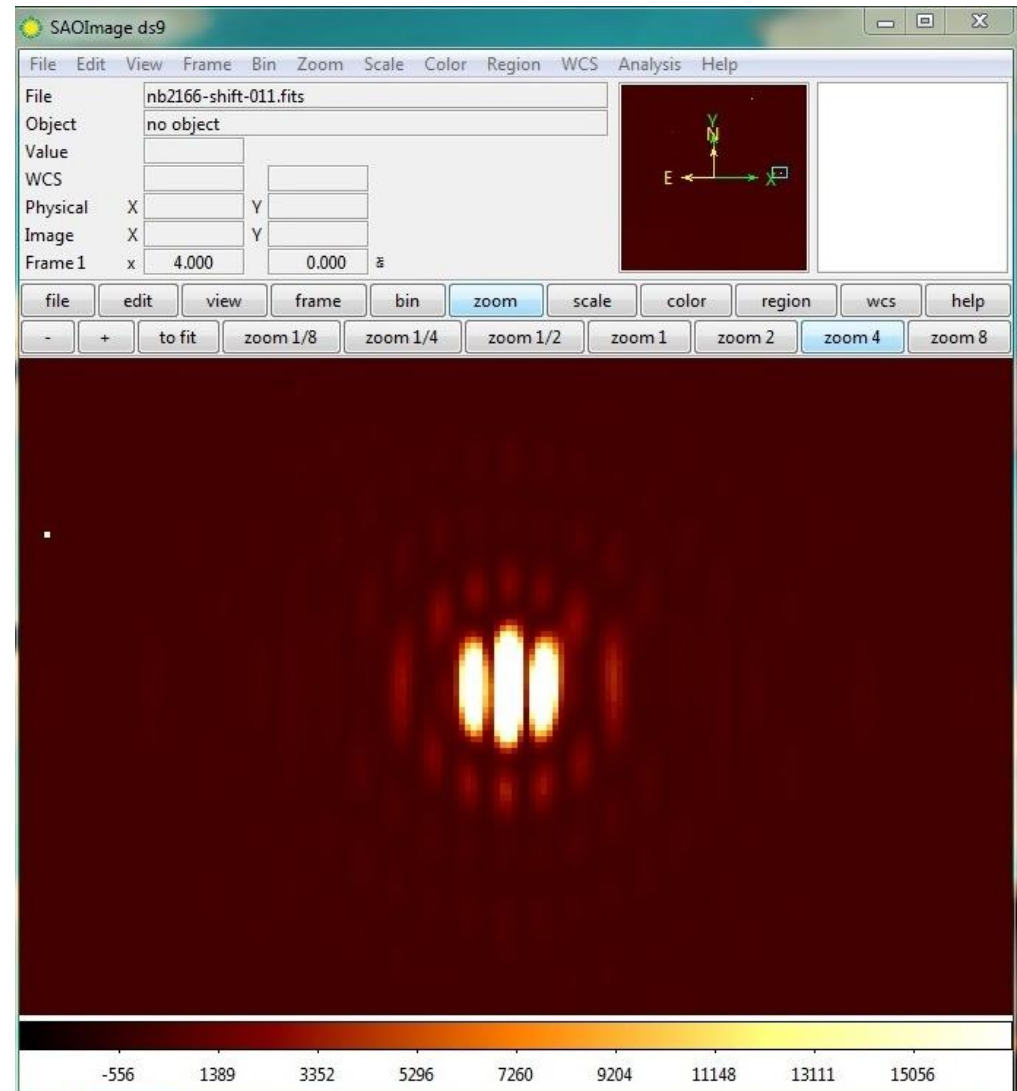
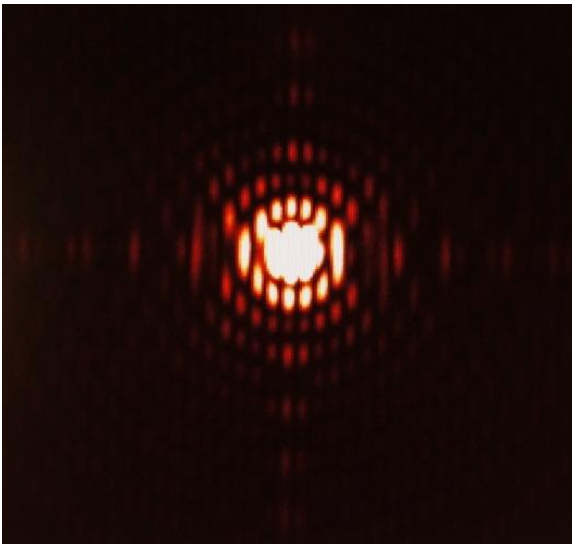
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Optical performance at IR with coherent illumination

2.122  $\mu\text{m}$



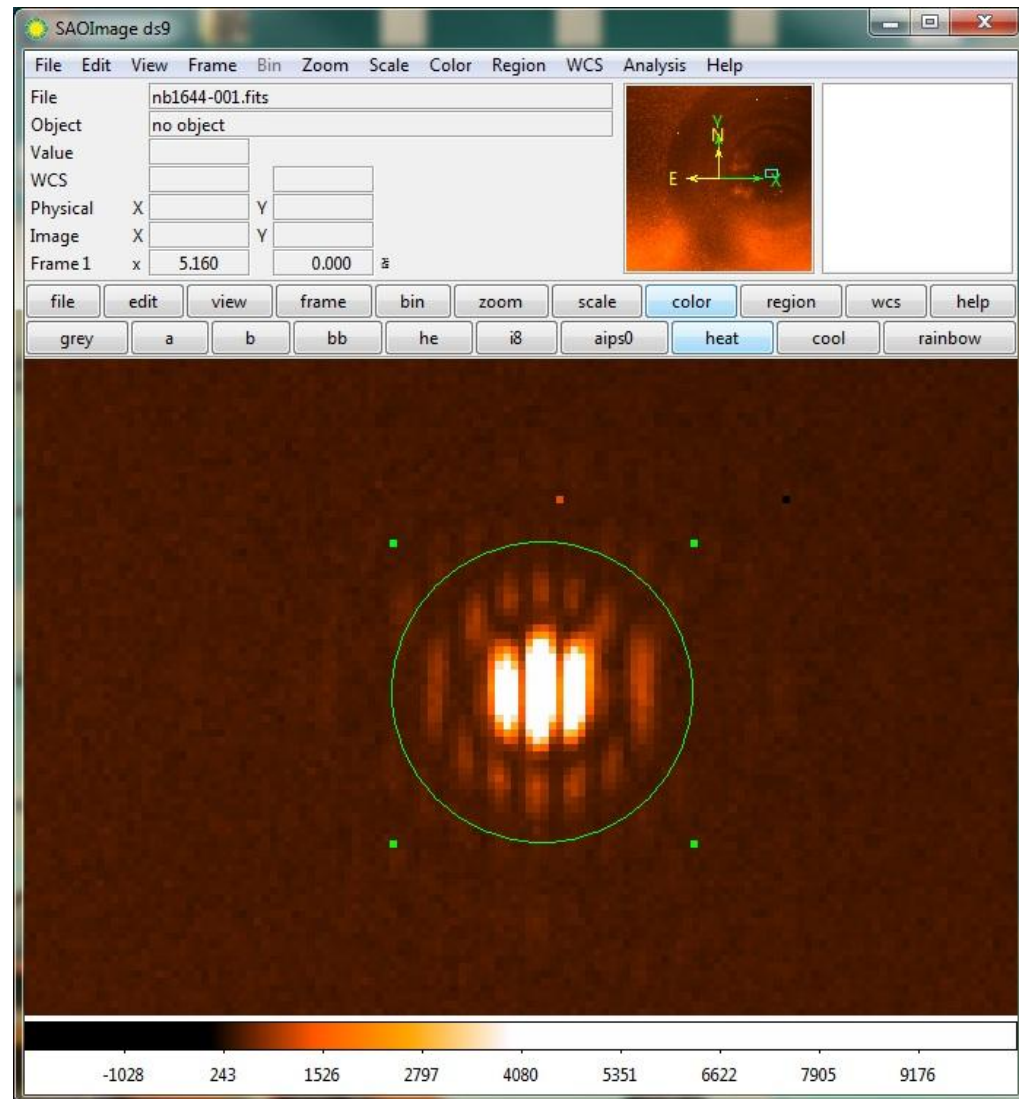


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Optical performance at IR with coherent illumination



1.644  $\mu\text{m}$

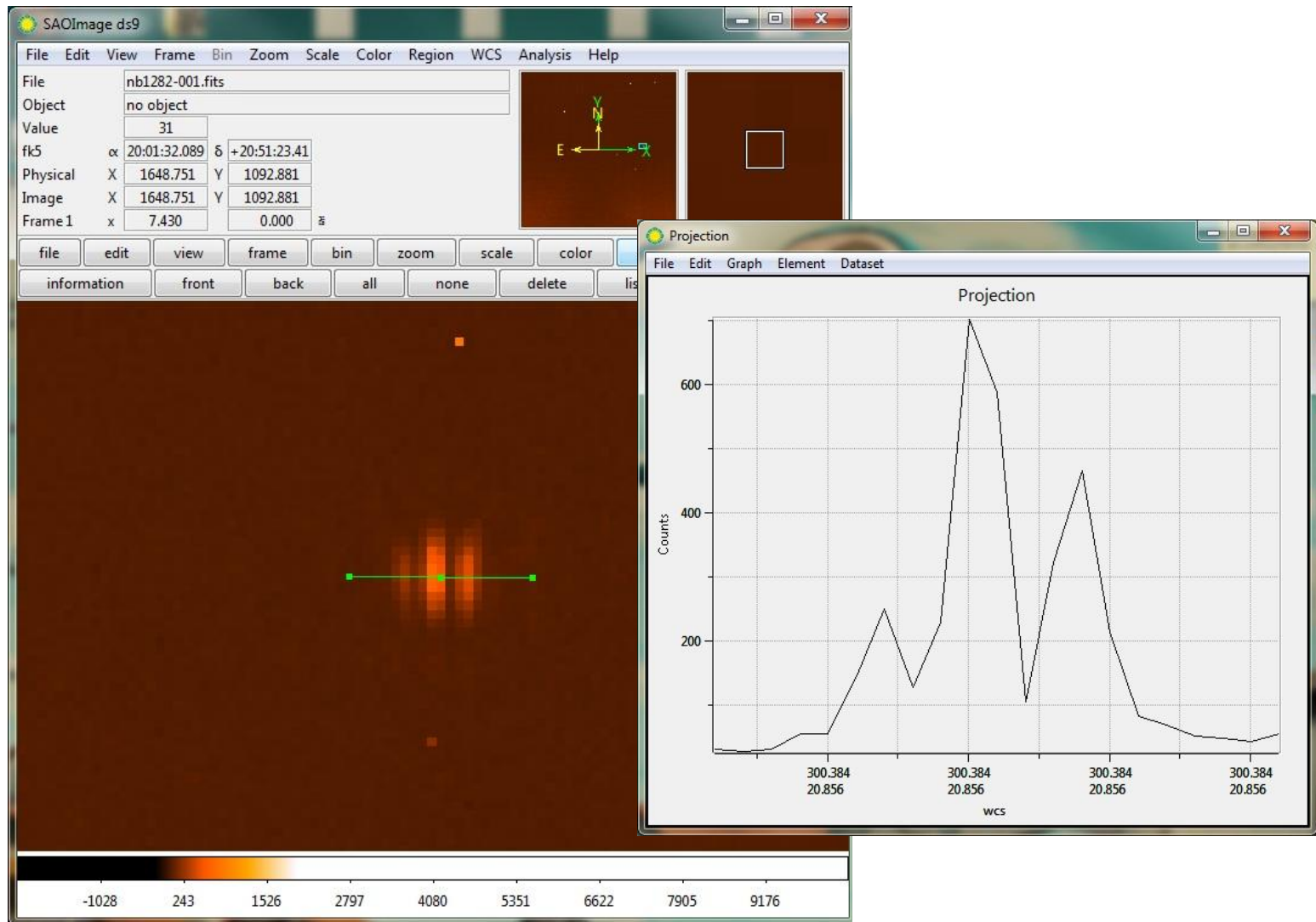


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Optical performance at IR with coherent illumination



1.282  $\mu\text{m}$



## Outline

- Introduction to LINC-NIRVANA
- Concept of the alignment strategy
- Integration of the warm optics
- Integration of the cold optics
- **Outlook**



What you have not seen here ....

- Alignment of the HWS wavefront sensor to the warm optics
- Alignment of the GWS
- Alignment of the calibration unit
- Alignment of the annular mirror
- End-to-end performance

.....



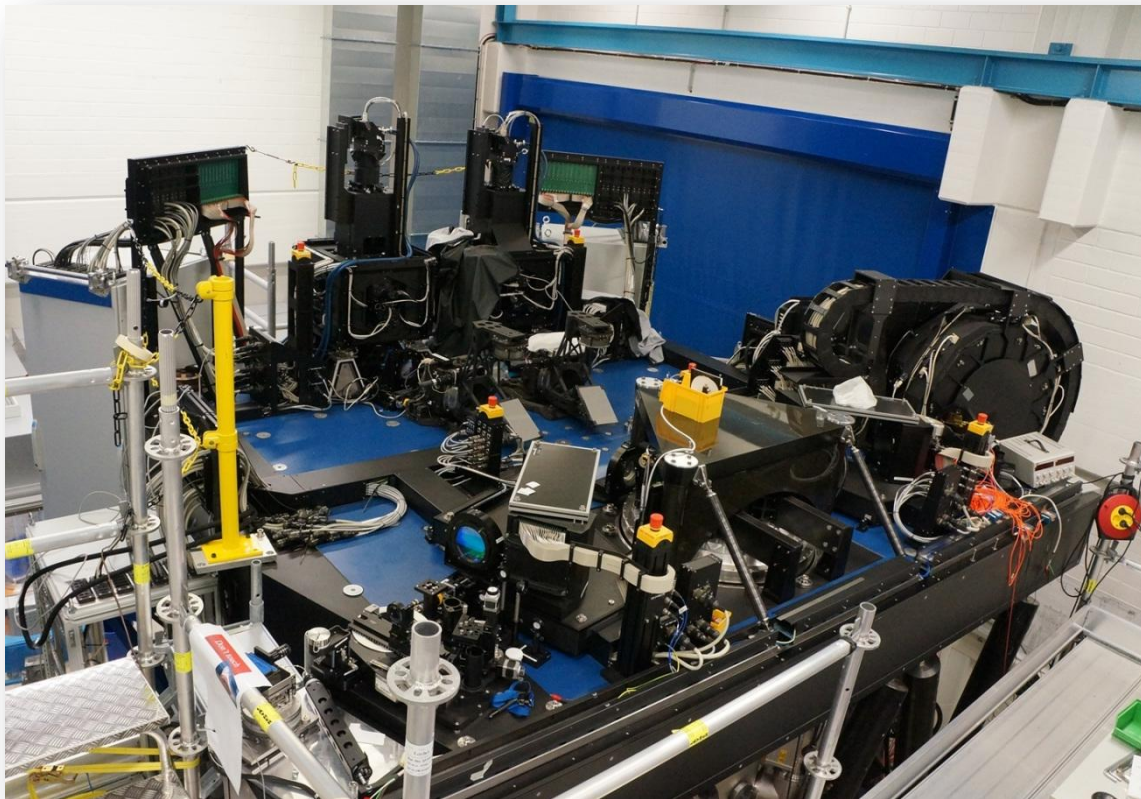
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## Outlook

- System tests at MPIA Jan – Mai 2015
- Preliminary Acceptance Europe Mai 2015
- Shipment Aug - Sep 2015
- Re-integration at LBT Oct 2015 – mid 2016





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The End

