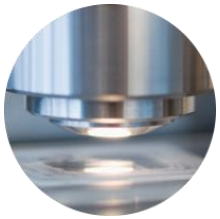
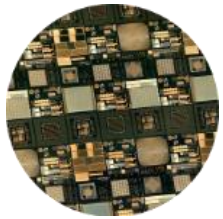
ALPAO CHARA Week







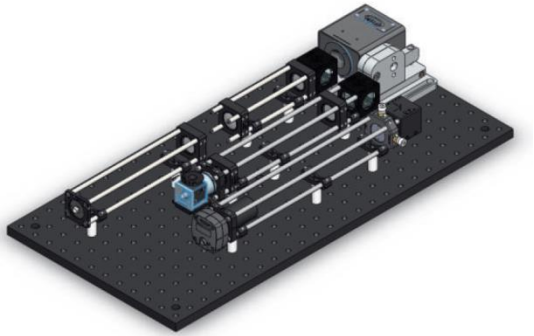
Bertrand Charlet

March the 12st 2018

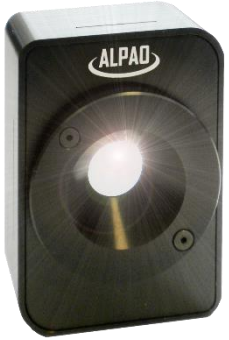
Content

- News at ALPAO: projects and technology
- CHARA DMs status and update
  - Actual status – Compliance matrix
  - The story:
    - Mechanical design
    - Actuator layout
    - Actuator testing
    - DM testing
    - Prototyping
  - News!
  - Planning update

Overview

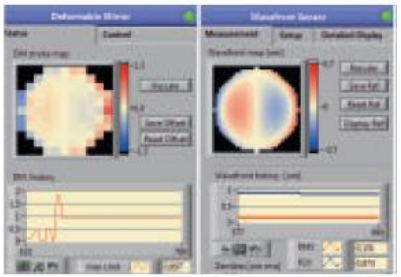


AO Systems



Deformable Mirrors (DM)

Wavefront sensor (WFS)



Software

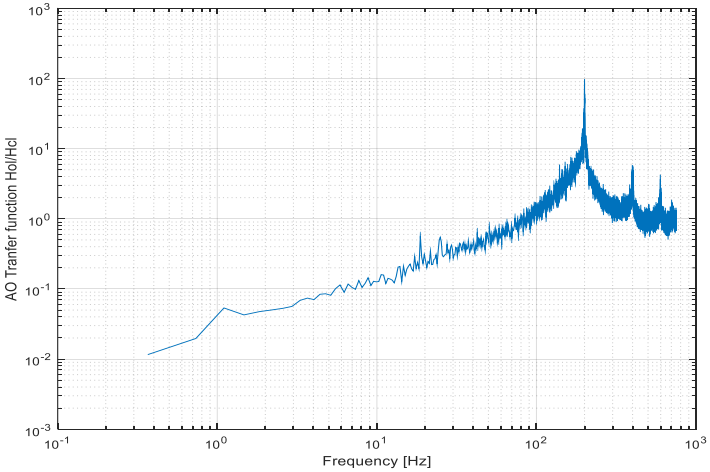
AO System for Satellite Comm.

- ALPAO DM241:
  - 241 actuators
  - ALPAO DEV5 DM Electronics
  - 160 Mbit/s

- ACE fast (RTC)

- CCD220 based WFS
  - Camera link Full IF
  - 1500 fps
  - 240x240 px
  - 20x20 sub pupils

- Performance
  - Loop rate 1500Hz
  - RTC delay 80µs
  - Rejection bandwidth 100Hz

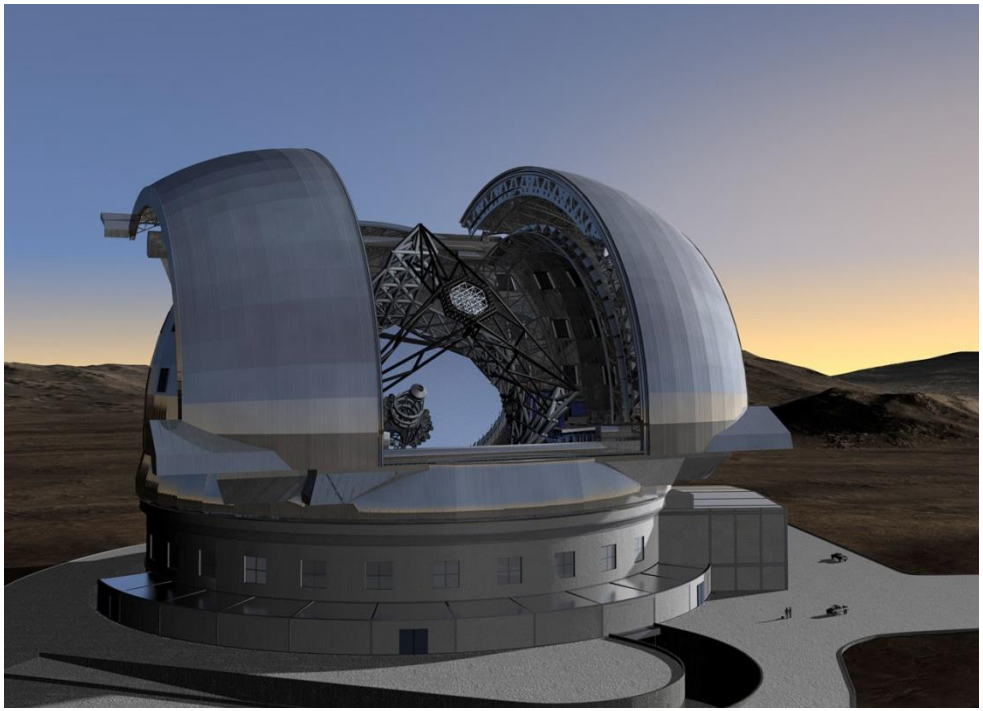


Laser Guide Star System

- Space debris and satellite observation
- System including:
  - DM277
  - Laser Guide Star
  - Real Time Computer

ESO Projects

- 2 won projects:
  - Compact DM (64x64 actuators): more than 3 000 actuators
  - XAO DM (128x128 actuators): more than 12 000 actuators



5 DM for VLTi at Paranal

- Application : Astrophysics (interferometry)
- 241 actuators

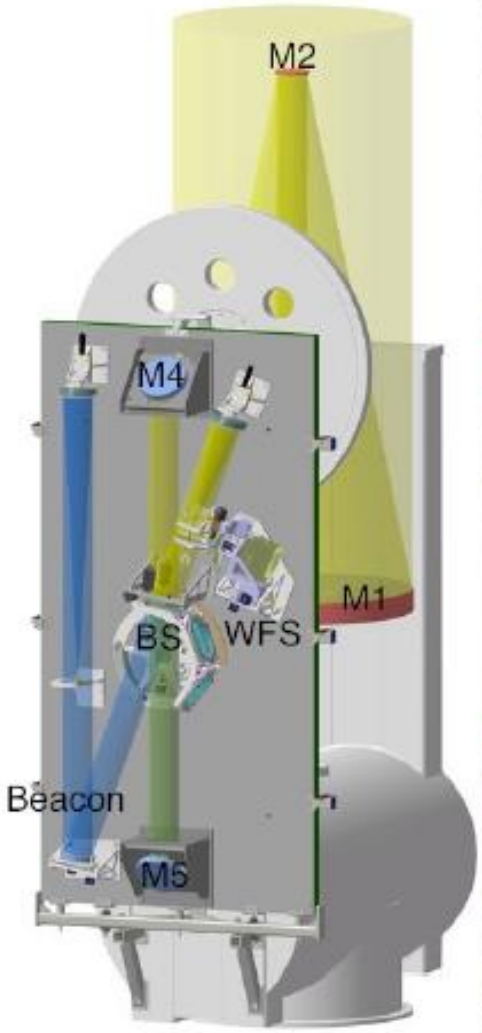
6 DM for the CHARA Array Telescope

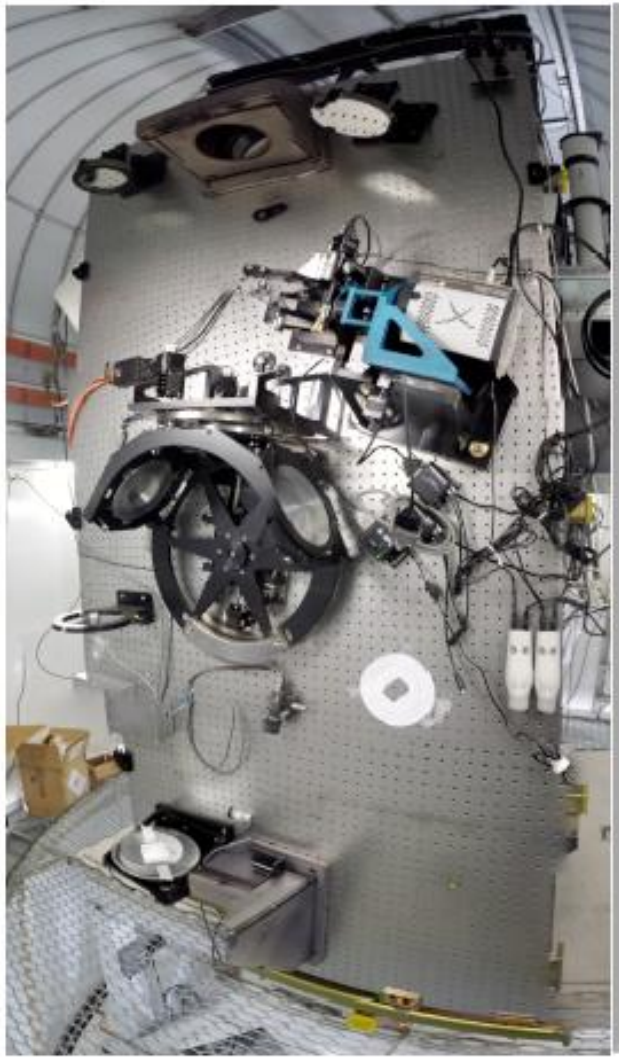
- Application : Astrophysics (interferometry)
- 60 actuators
- 177mm x 125mm

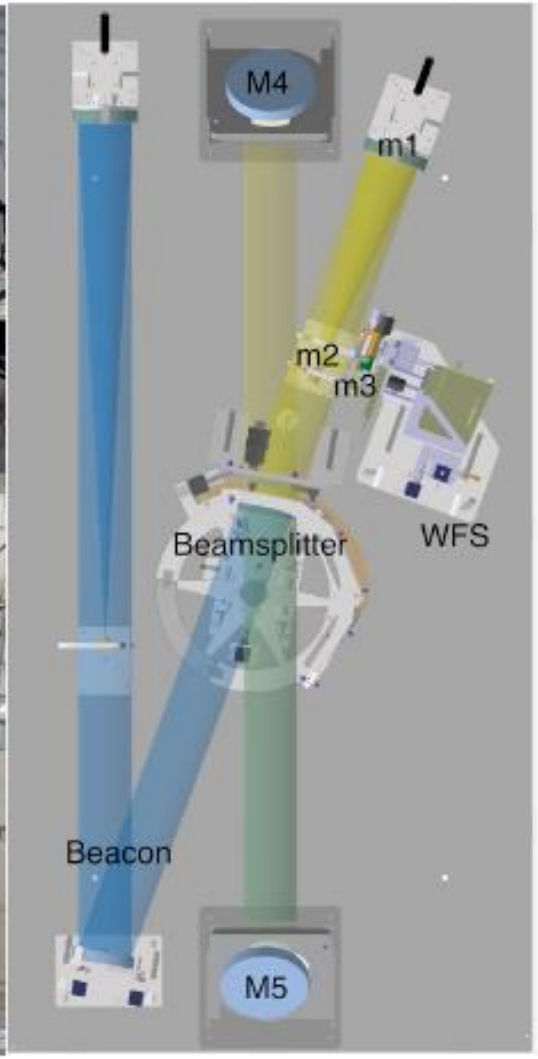
Compliance matrix

Item	CHARA spec	ALPAO proposal	Measured spec	Compliant
Active mirror area	125 x 177 mm	125 x 177 mm	125 x 177 mm	Yes
Number of actuator in active area	~50 actuator	60<x<70	60	Yes
P-V mechanical stroke after flattening	±4 µm	15 µm PV	24 µm PV	Yes
Inter-actuator mechanical stroke	±2 µm	> 3 µm PV	10 µm PV	Yes
Flatness after removal of the static error	30 nm rms	<30 nm rms	42 nm rms	No
Lowest resonance frequency	>500 Hz	750 Hz	520 Hz	Yes
Working wavelength	0.45 .. 2.5 µm	Silver coating	0.45 .. >2.0 µm	Yes
Surface roughness	<1 nm rms	To be measured	<1 nm rms	Yes
Maximum lag	1ms	<200 µs	~ 10µs	Yes
Communication maximum frequency	1 kHz	<10 kHz	>250 kHz	Yes

Mechanical design

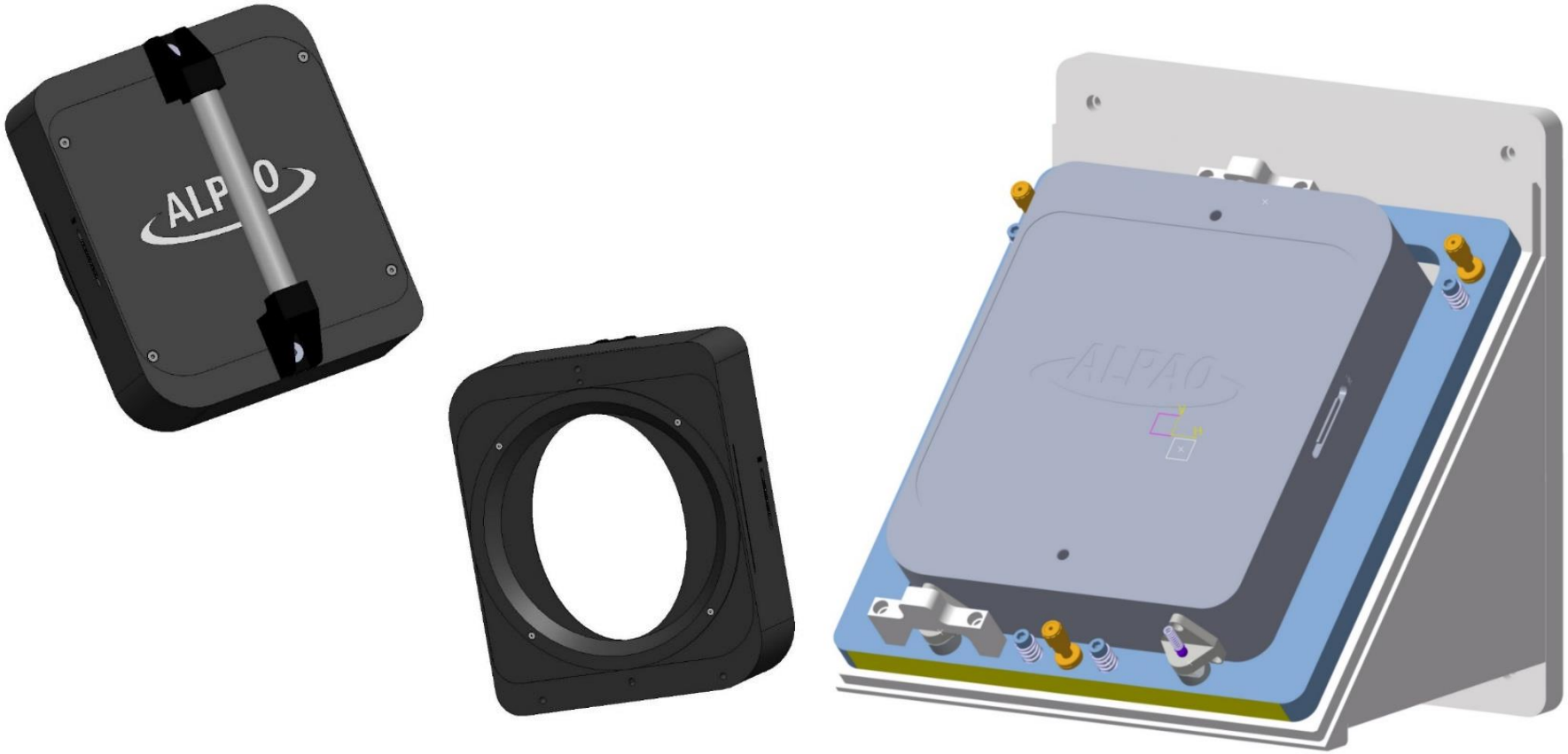






Mechanical design

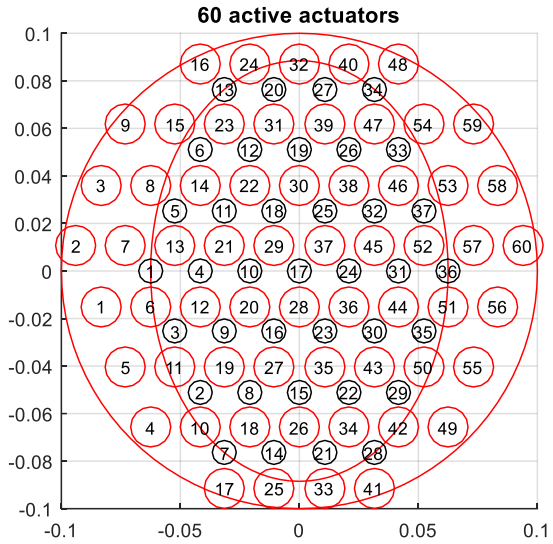
- Design was made accordingly with our discussions with CHARA Array
  Size and mounting fixtures were taken into consideration

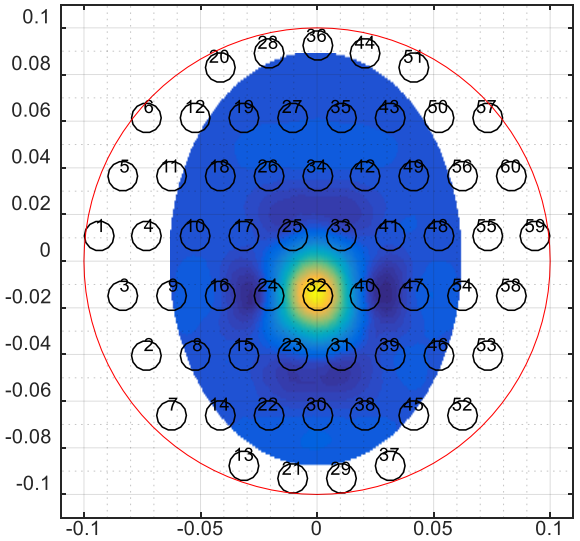


Actuator layout

- Layout
  - Fit existing wavefront sensor
  - Actuator over the full circular faceplate
  - Edge actuators are slaved

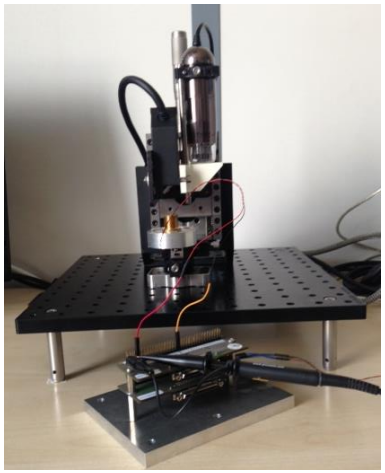
- Simulation results:
  - First eigenmode: 800 Hz
  - P2V mechanical stroke: 16.8 µm
  - Inter-actuator mechanical stroke: 7.9 µm

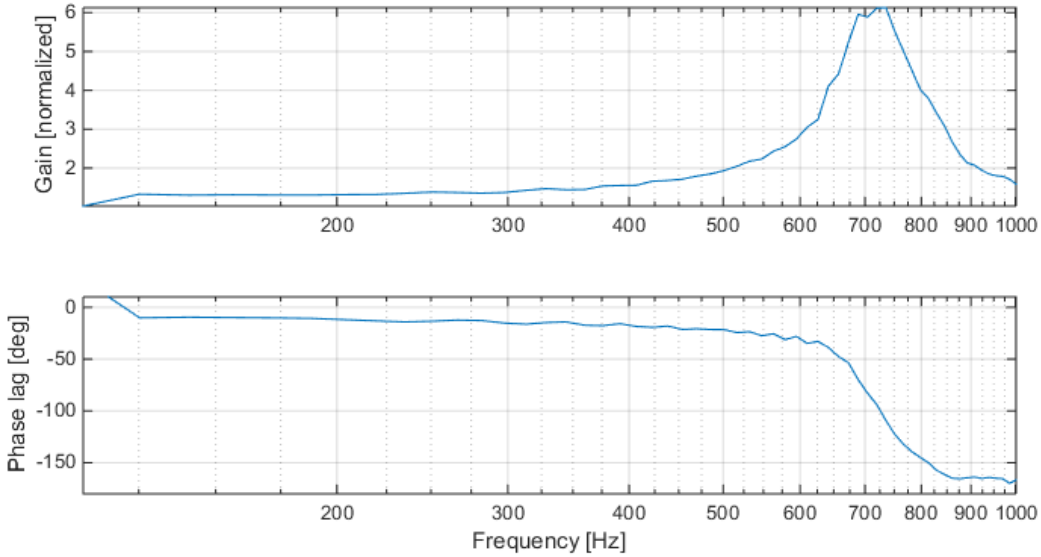




Dynamic measurements

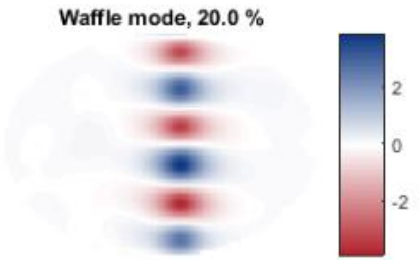
- Goal: check actuator transfer function
  - Dedicated test setup
- Result :
  - Actuator alone: f_0 = 720 Hz
  - Expected DM frequency: f_0=520 Hz
    (with additional mass from faceplate)

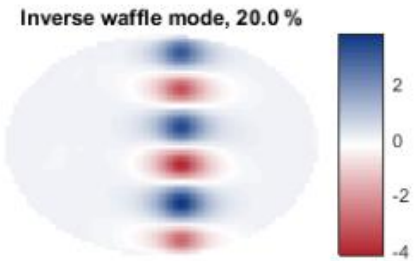




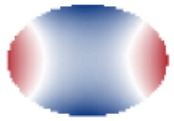
Stroke measurements

- Goal: Verify the stroke of the DM
- Result :
  - Inter actuator stroke > 7 µm PV mechanical
  - Mechanical stroke after flattening > 25 µm PV mechanical



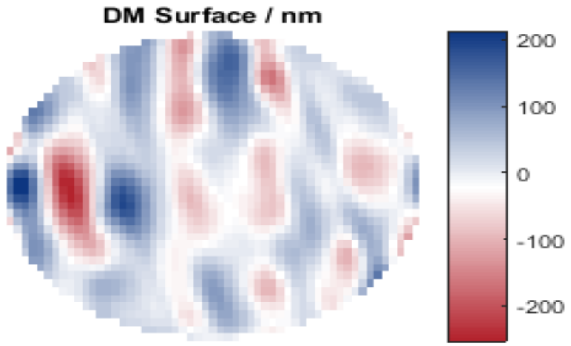


Surface	PV/µm (@20) %)	PV/µm (@100%)
Mirror	1.89	9.45
Wavefront	3.78	18.91

Measured wavefront	Noll index	PV/µm	RMS/µm
	2	66.30	16.65
	3	53.54	13.36
	4	39.89	9.52
	5	46.17	9.55
	6	56.83	11.50

Work done for best flat

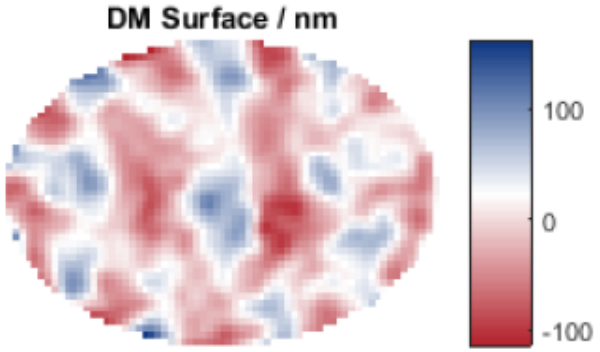
- 4 different membranes tested
  - Best results is 65 nm rms mechanical
- Explanation
  - Membrane natural shape is mainly defocus = 120 µm PV mechanical
  - Fitting error of the defocus leads to 60 nm rms
  - Experiment and simulations shows the same results
- Solution: find a <10 µm natural defocus membrane

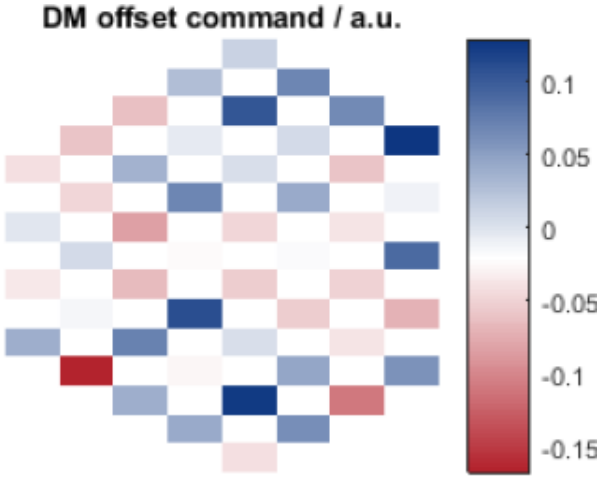


Surface	RMS[1]/nm	PV[2]/nm
Mirror	64.91	466.75
Wavefront	129.81	933.51

- Applied research lab contacts
  - We had a recent project with them on thin and very large membrane and was successfull
  - Discussion with them leads to interesting understanding of materials behavior
  - Plan to launch a contract with them for low stress membranes (95% chances that results are good)

New membrane testing – Best flat



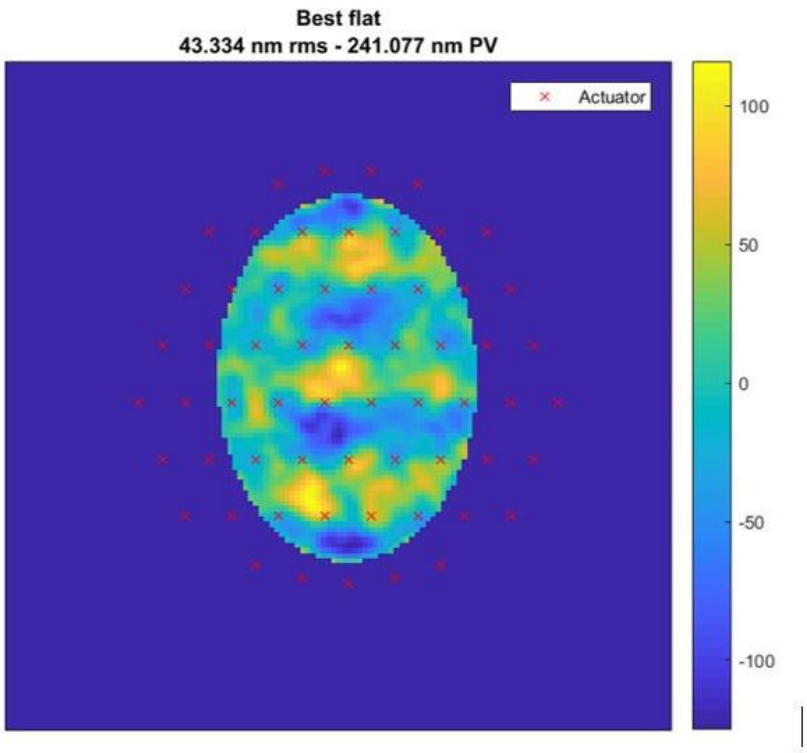


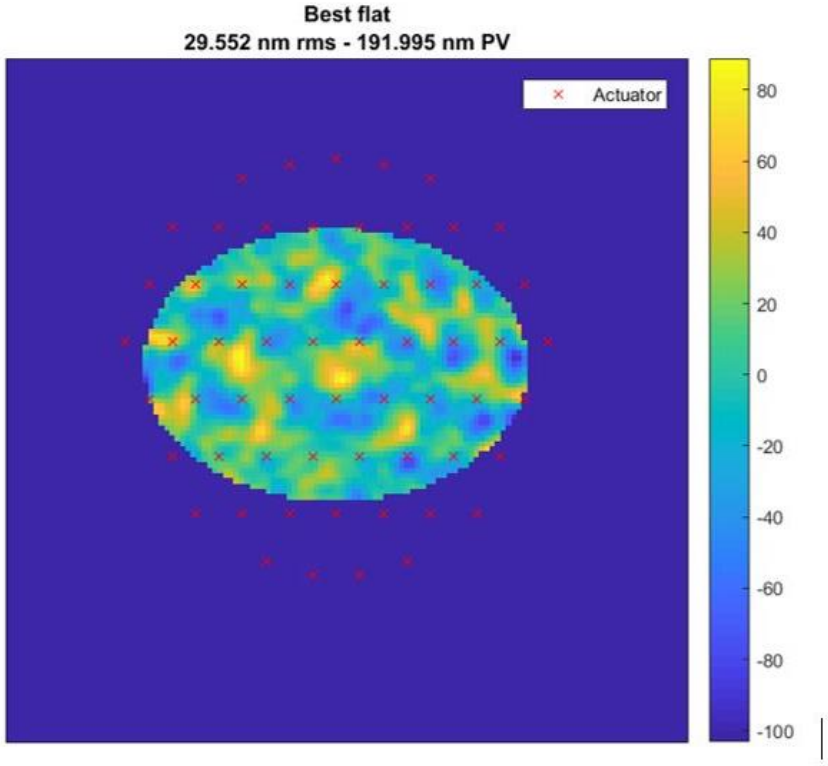
Surface	RMS[1]/nm	PV[2]/nm
Mirror	41.57	276.42
Wavefront	83.14	552.84

[1] RMS: Root Mean Square
[2] P-V: Peak-to-Valley

How to improve

- Change of the actuator pattern:

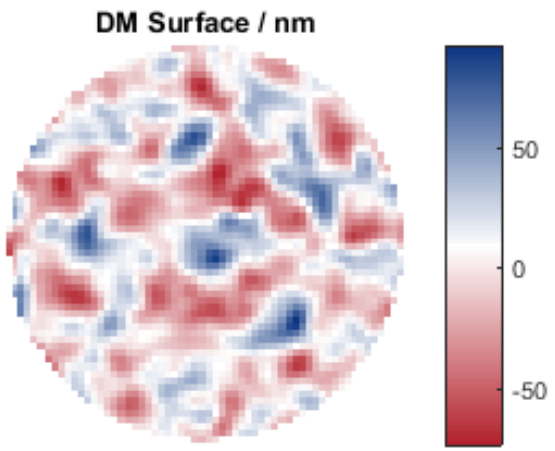


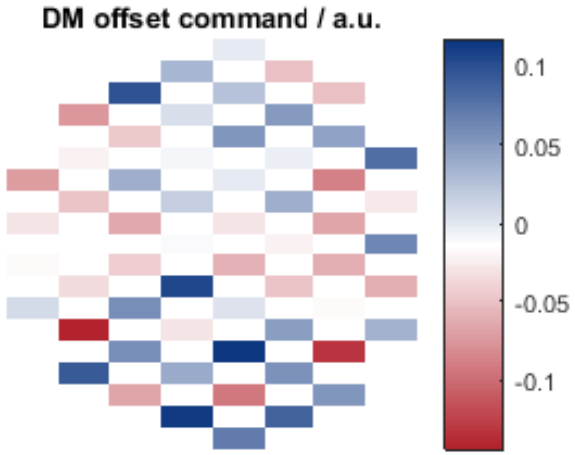


- Optimization of membrane rigidity: thickness

New membrane testing

- 125 mm diameter (like a DMX37):





Surface	RMS[1] / nm	PV[2] / nm
Mirror	27.24	164.92
Wavefront	54.48	329.84

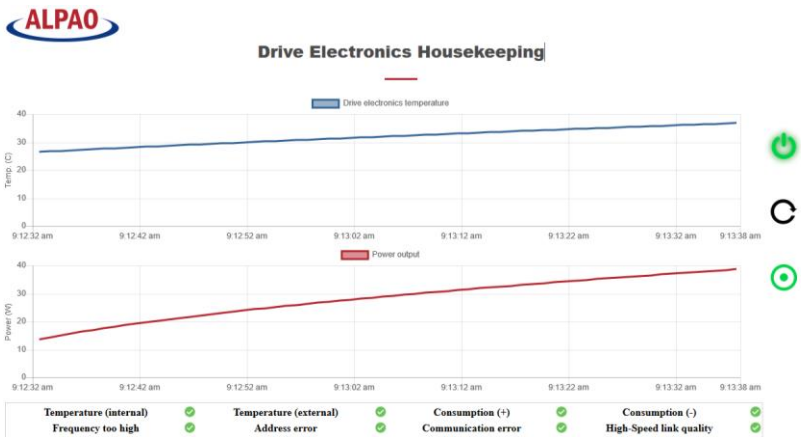
[1] RMS: Root Mean Square
[2] P-V: Peak-to-Valley

Drive electronics

- New ALPAO drive electronics
  - 1 card for monitoring
  - 1 card for High speed data Link
  - 1 Amplification card for the DM

- Maximum transfer speed = 10Mhz for communication
  - 60 channels so up to 150kHz update rate
  - Latency in the drive electronic ~ 6,4µs

- Monitoring via Ethernet or usb connection
  - Get status
  - Power On/Off amplification cards
  - Error acknowledge



Planning update

- Status:
  - One electronics under test at CHARA Array
  - One DM prototype under test at CHARA Array
  - All 6 DMs mechanics and actuators ready – waiting for coated membranes

- New and perfect membranes prototypes
  - Prototype testing and validation – on course

- Final DMs
  - Reception of new coated membranes: mid/March (now at Balzers)
  - Coated membranes assembly on the DMs + testing: End of March to mid April

  (everything else would be ready at that time from manufacturing side)
  - Delivery for end of April @ CHARA array

Merci