Recent Results about Correcting Components at CILAS

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Topics

Experimental results obtained with:

- Monomorph Deformable Mirrors
- 1-mm spacing Deformable Mirror (miniDM)
- Tip/Tilt Mount for heavy SAM

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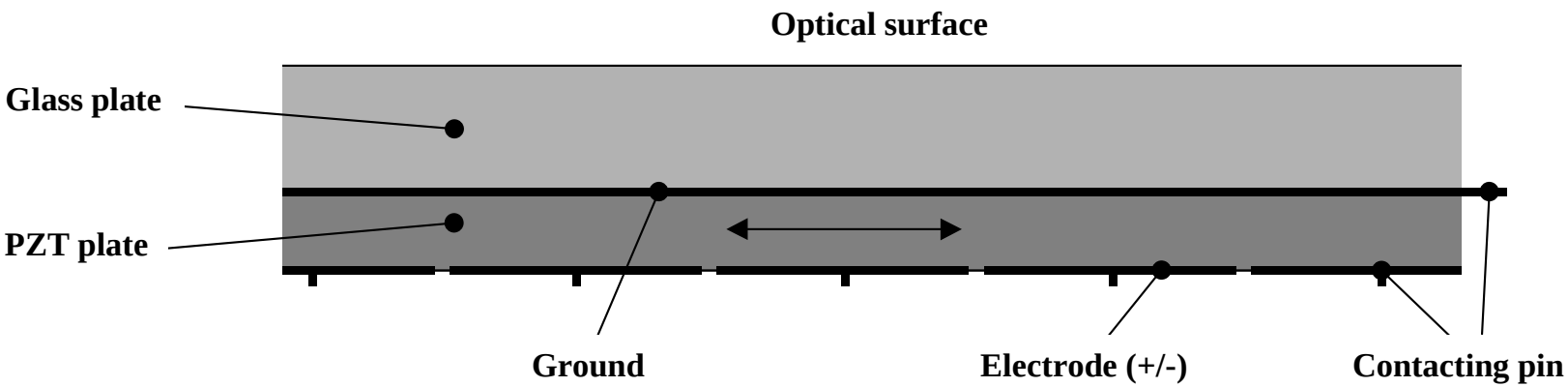
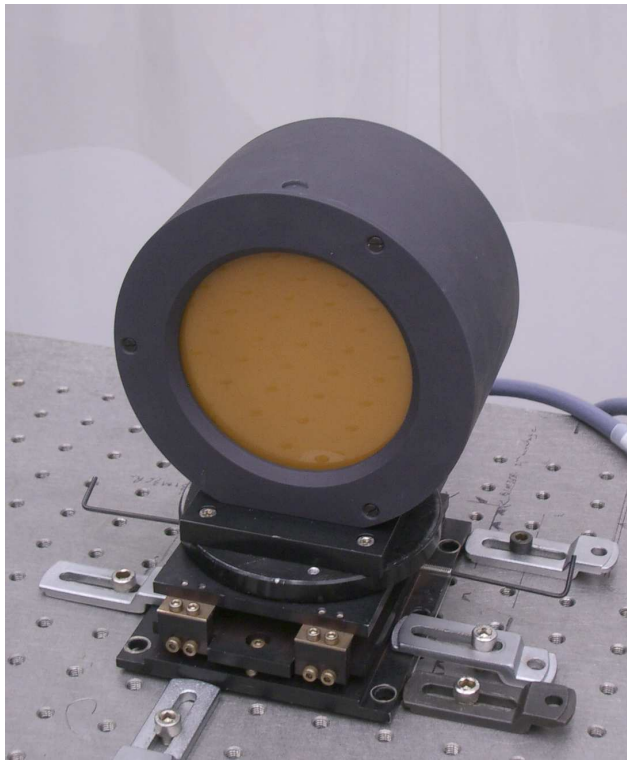
Monomorph

Monomorph concept

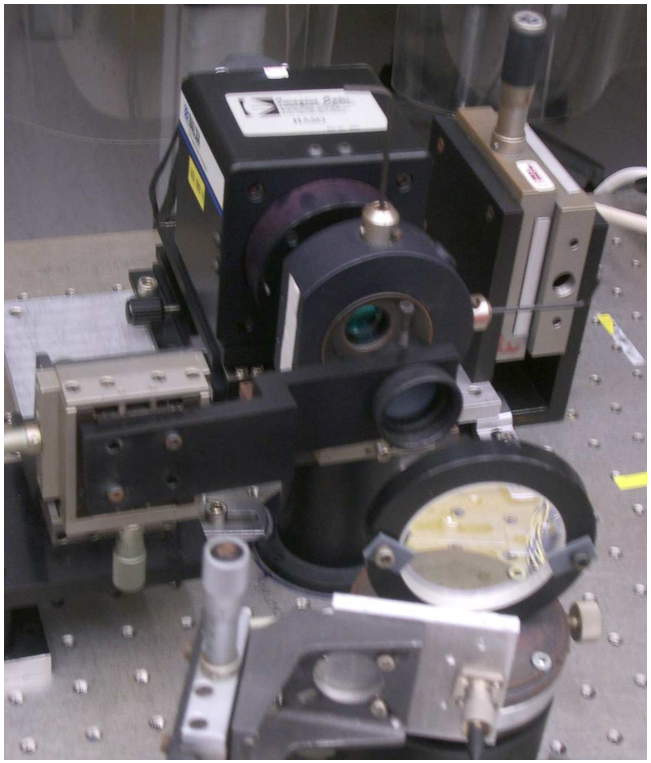


Pupil diameter:	**up to 200 mm diameter**
Optical quality:	**10 nm rms wavefront error obtained once the mirror is flattened**
Temperature dependence:	**compensated by DM stroke (mainly used at ambient)**
Temporal behavior:	**curvature resonance frequency > 700 Hz**

63 electrode monomorph test

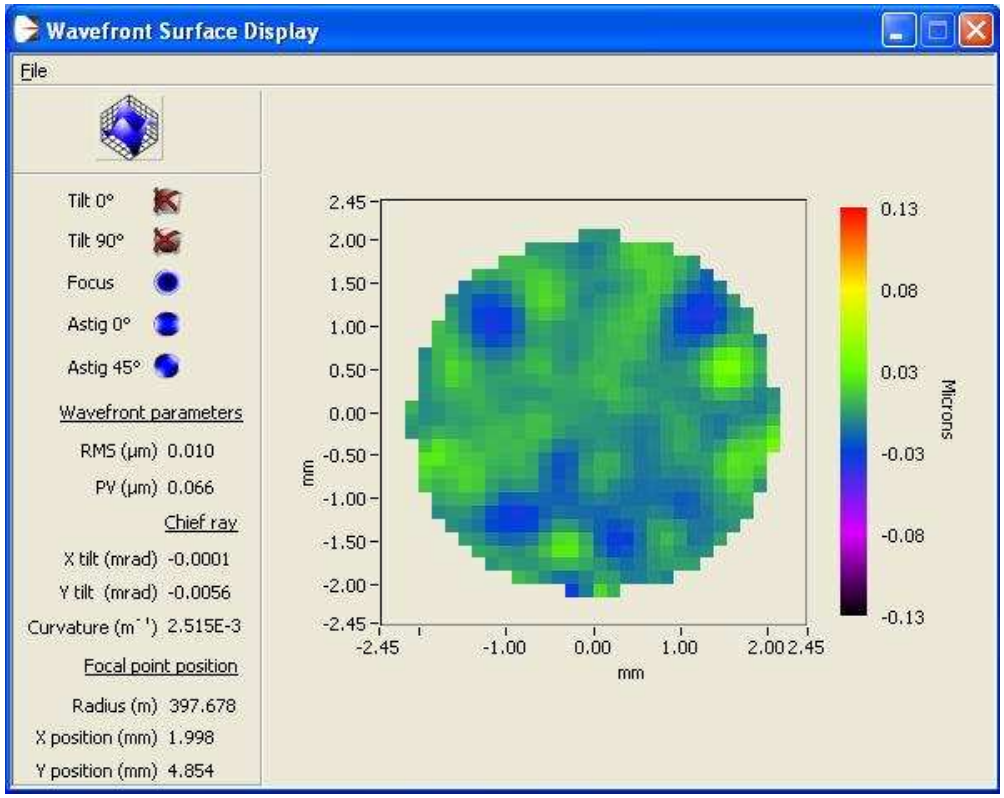


Cilas 63 electrode monomorph mirror
86 mm useful aperture
(before coating)



Imagine Optic 32x32
wavefront sensor

Best flat accuracy

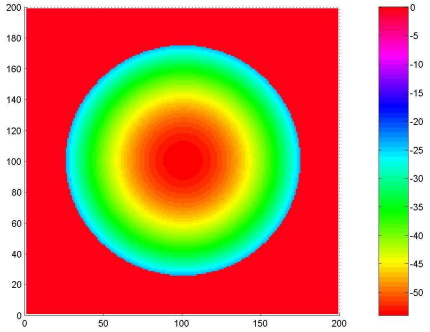


- WFE: 10 nm rms
- No “print through” effect

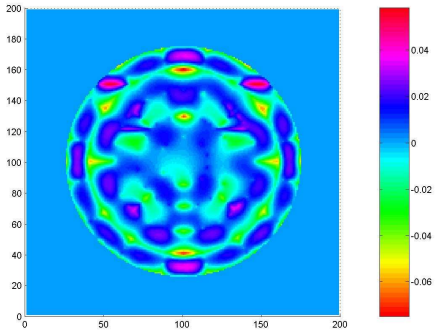
Correction accuracy: Z4 defocus

Simulation:

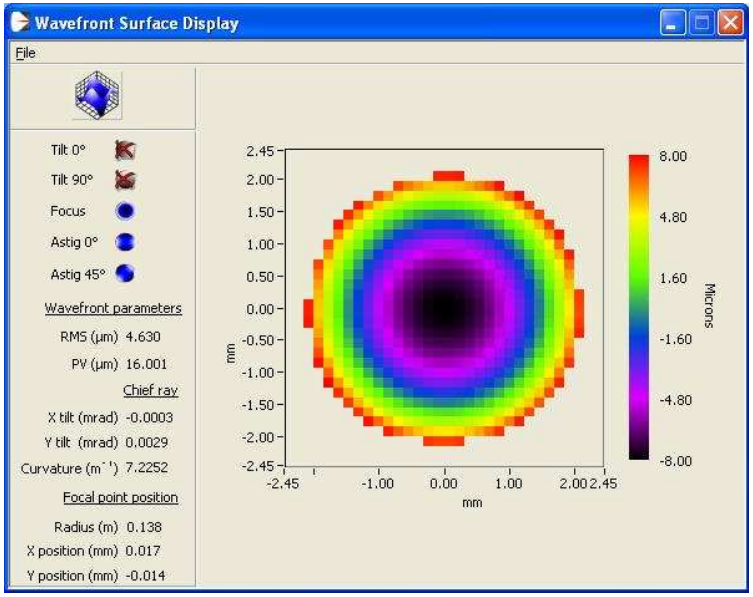
Shape

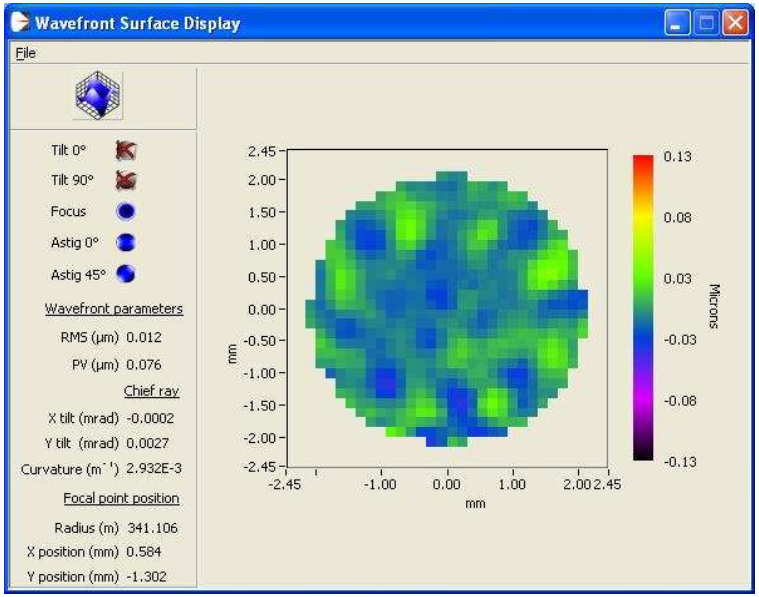


Residual



Measurement:



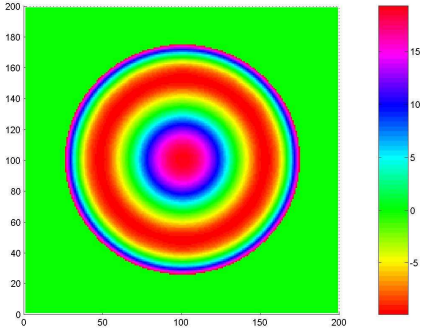


- WFE: 12 nm rms for 16 µm PV wavefront correction

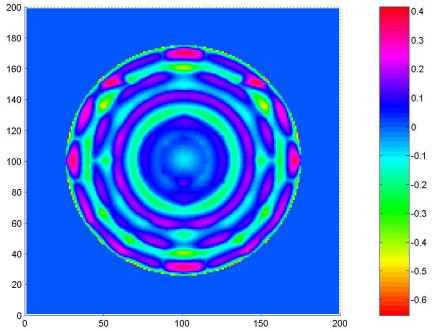
Correction accuracy: Z9 primary spherical

Simulation:

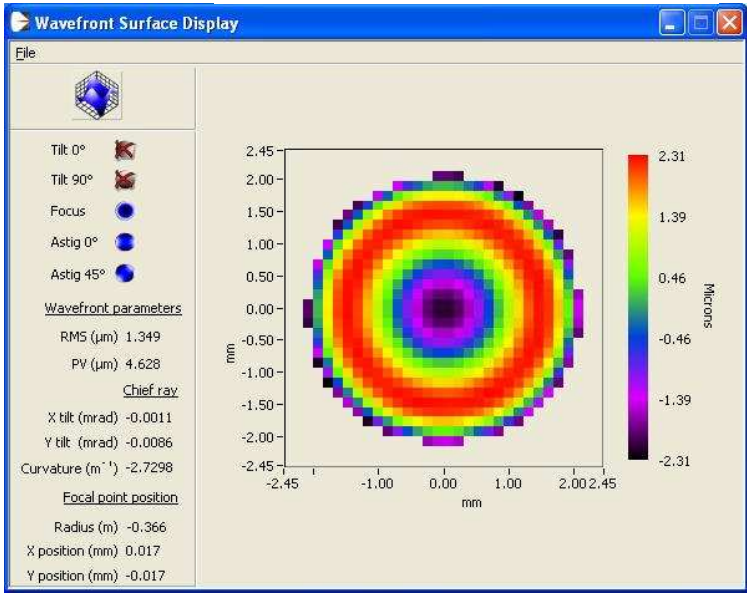
Shape

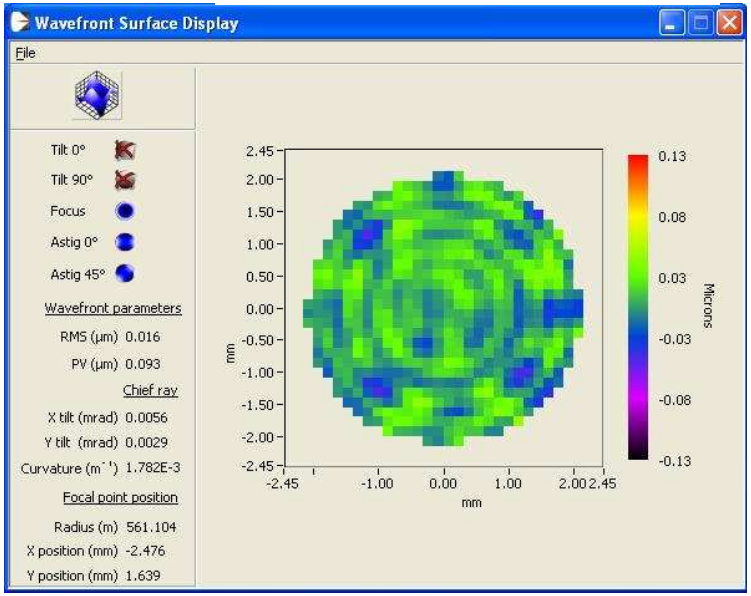


Residual



Measurement:

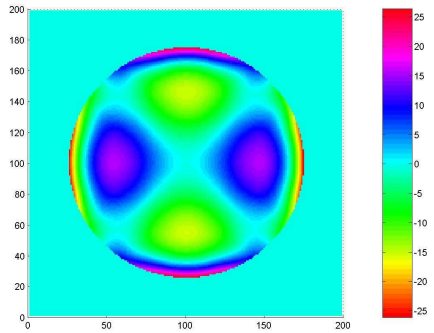


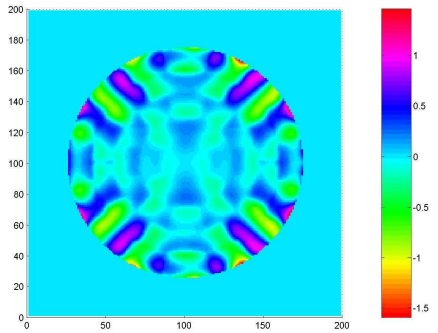


- WFE: 16 nm rms for 4.6 µm PV wavefront correction

Correction accuracy: Z12 secondary astigmatism

Simulation:

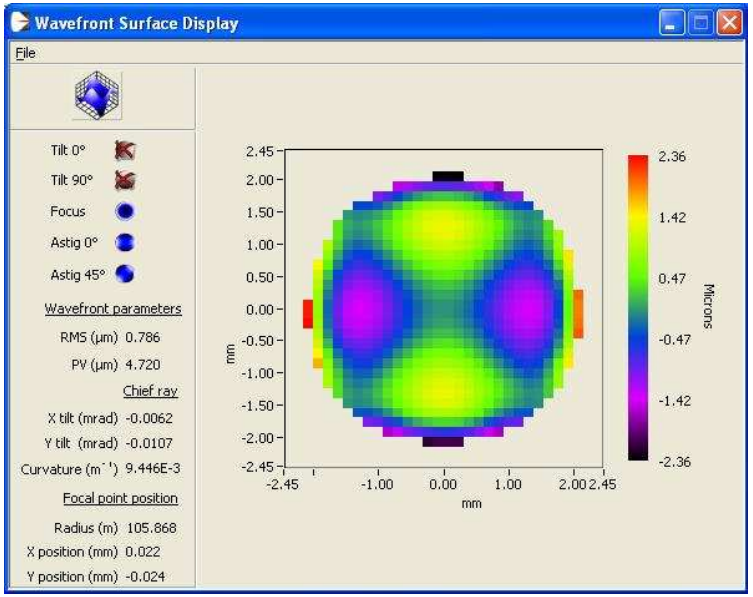


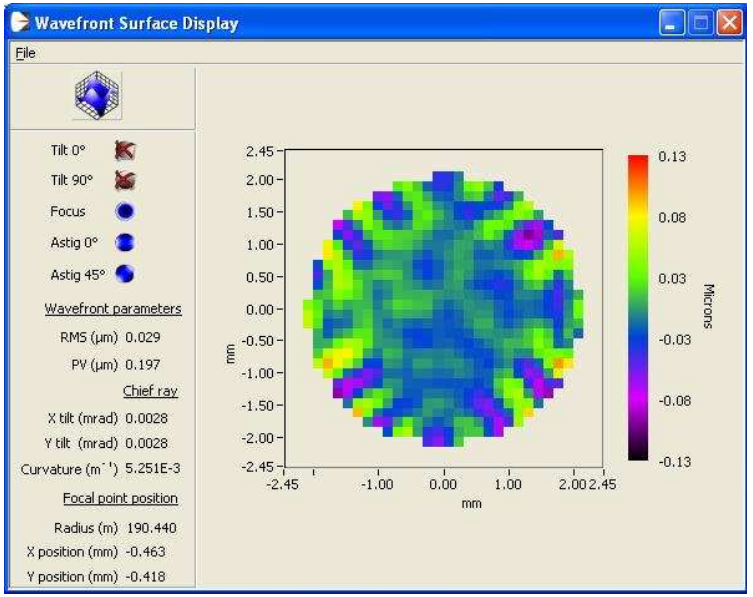


Shape

Residual

Measurement:





- WFE: 29 nm rms for 4.7 µm PV wavefront correction

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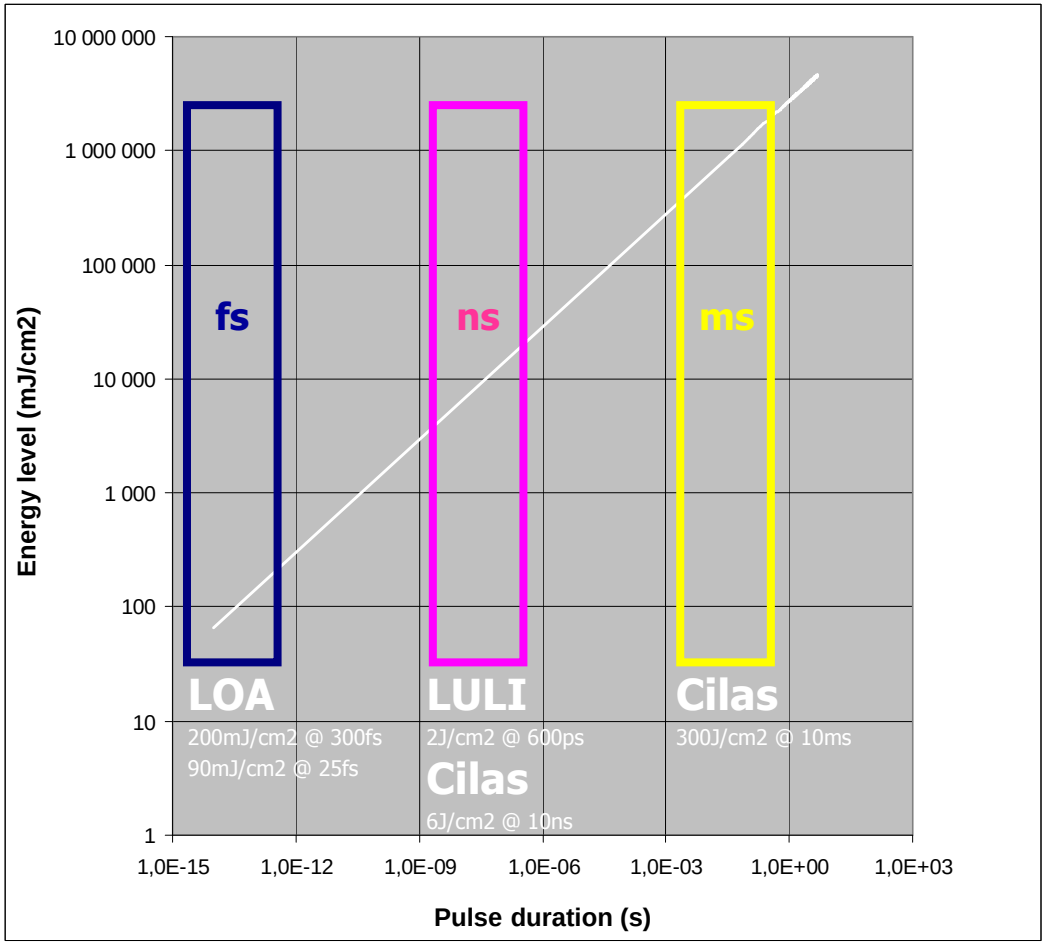
Monomorph laser energy level



Estimation based upon test results

Enhanced protected silver coating

Dielectric coating

Under study

MiniDM

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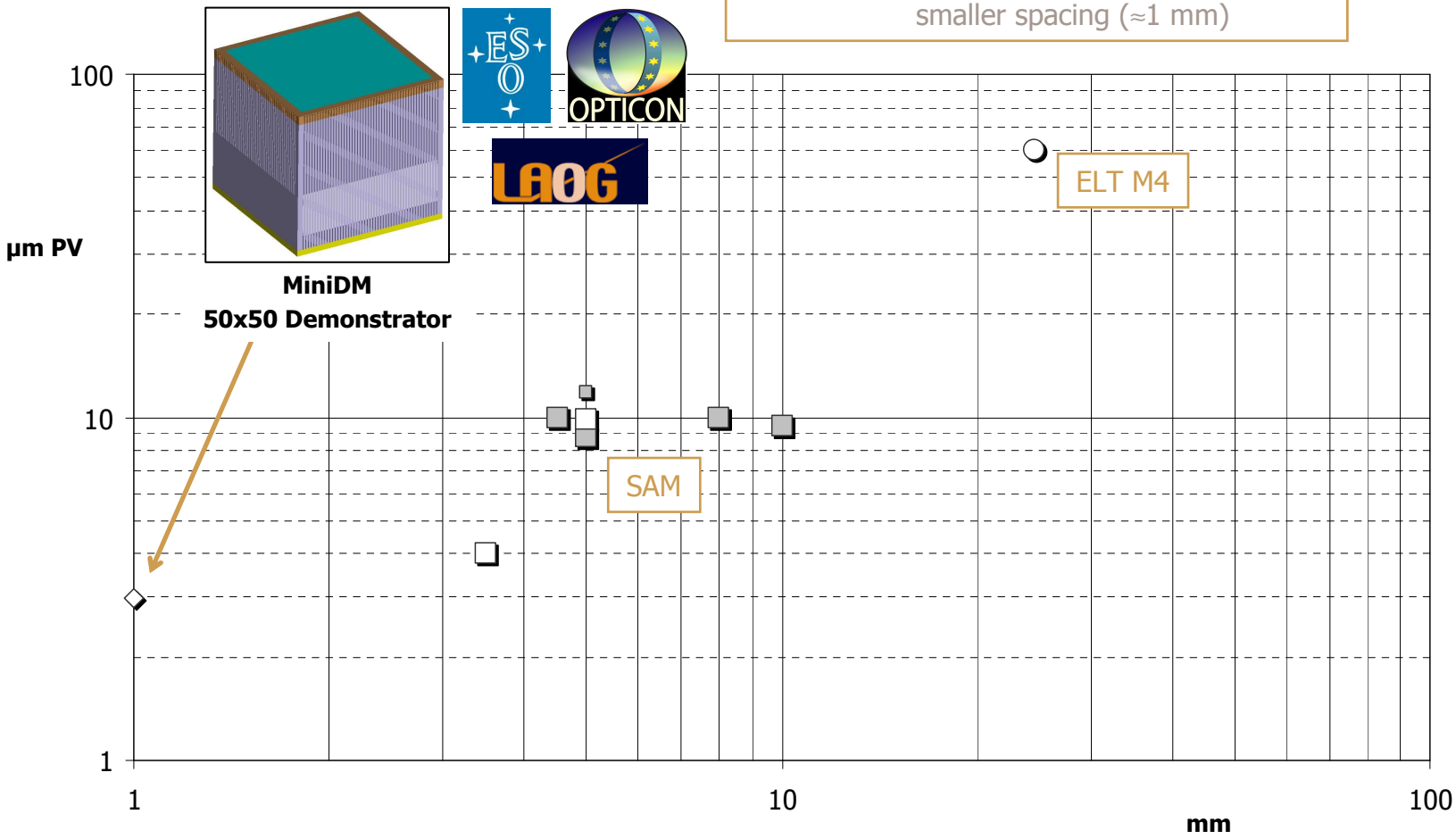
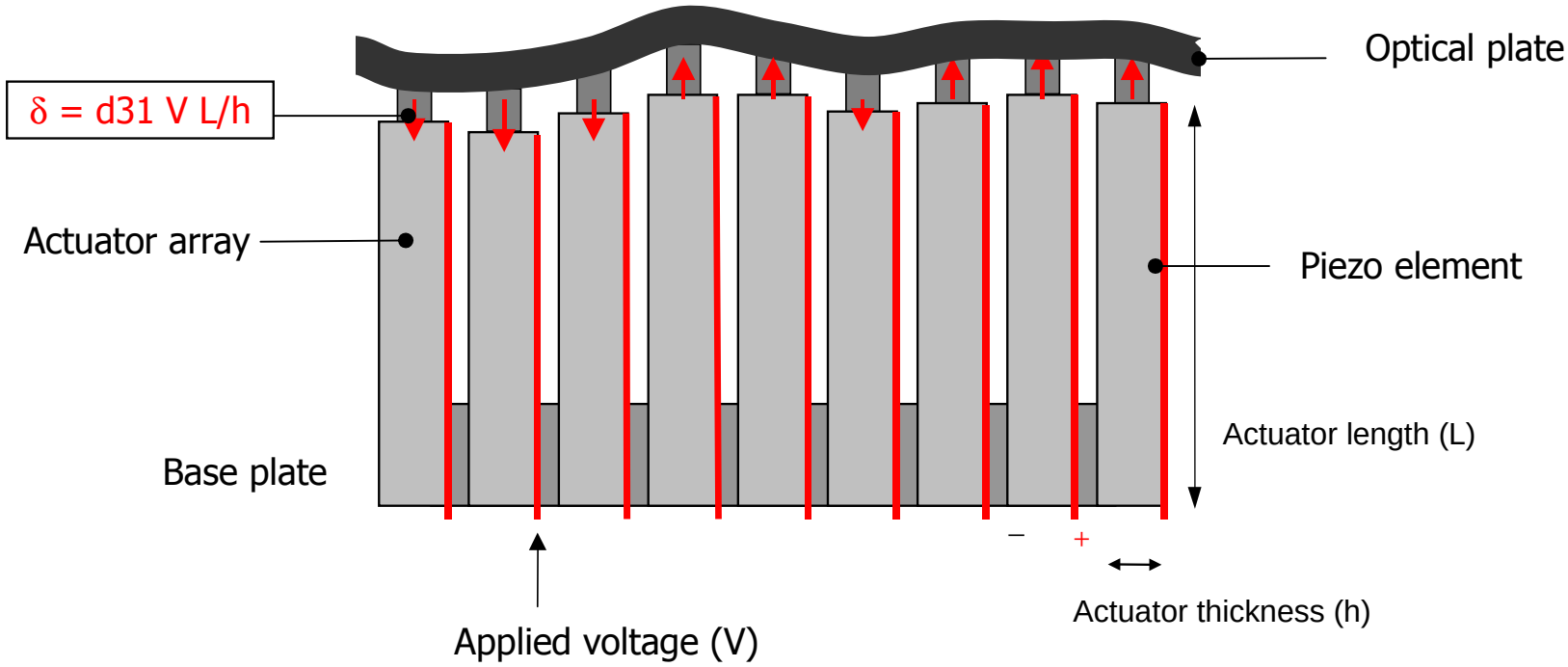
Towards very high order DMs

Stroke vs. spacing

Preparing:
very high order (200x200 range)
smaller spacing (≈1 mm)



MiniDM concept



Issues to demonstrate

- Lines of actuators manufacturing
- 1-mm spacing electrical contacting
- Head manufacturing and polishing

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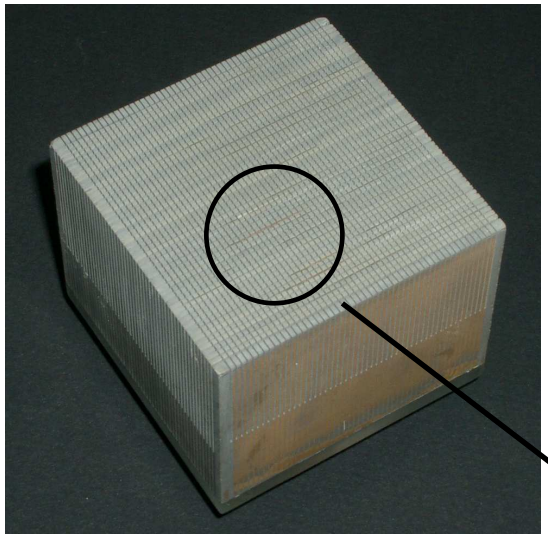
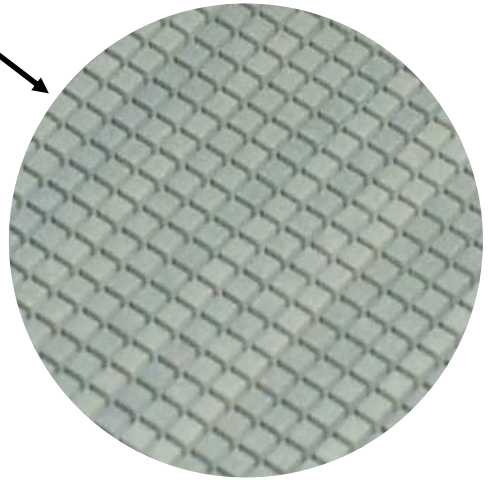
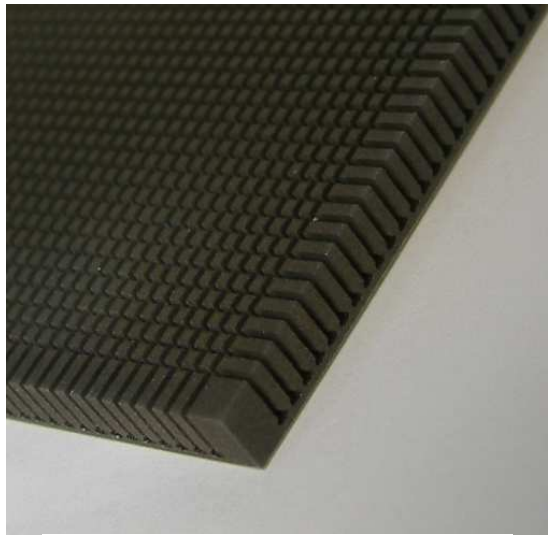
MiniDM demo prototype



Actuator array (front view)





Optical head (back view)

49 mm dia. - 50x50 array - ≈ 1900 actuators - Spacing: 1 mm x 1 mm

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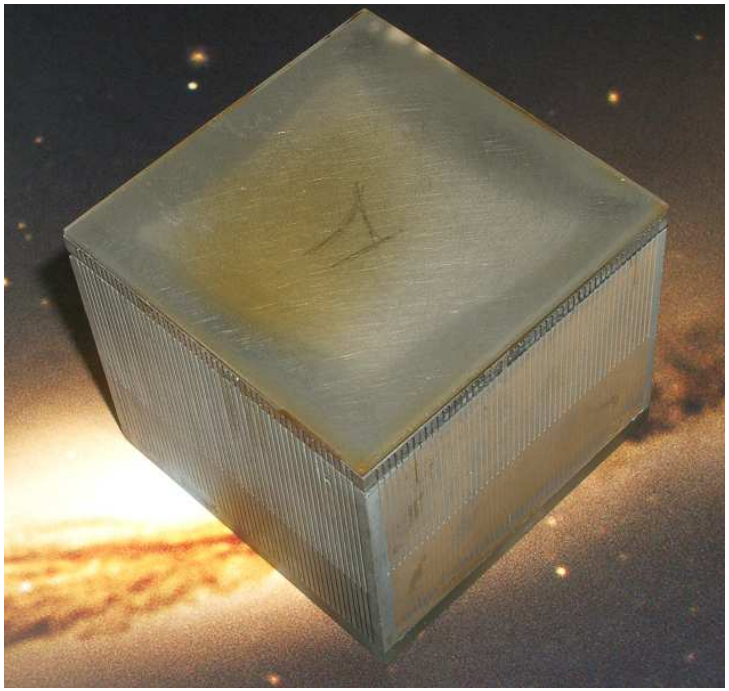
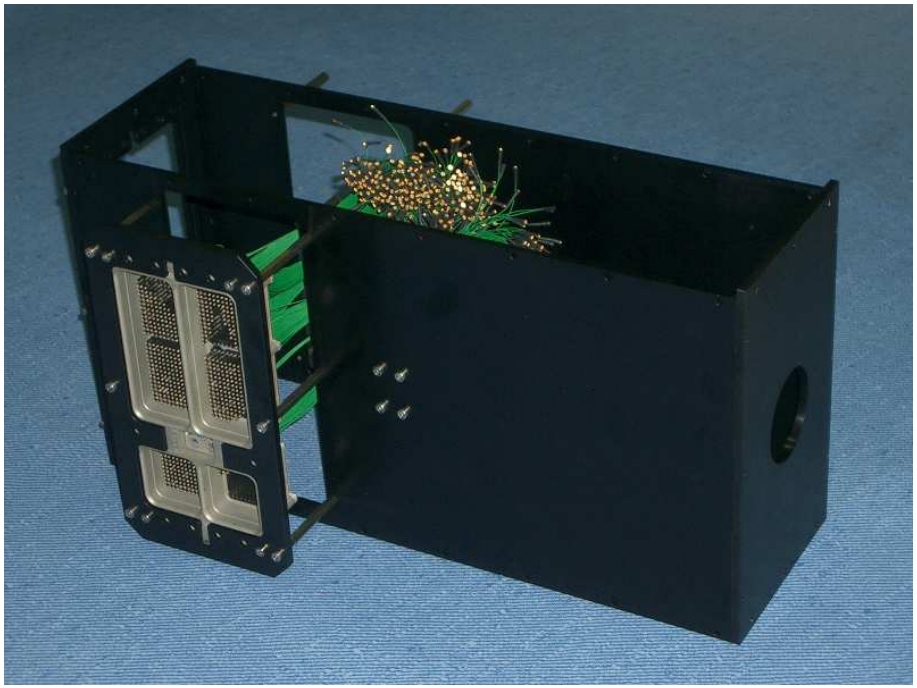
MiniDM demo prototype



Assembled MiniDM



Mechanical mount
with 1(/3) HV connector

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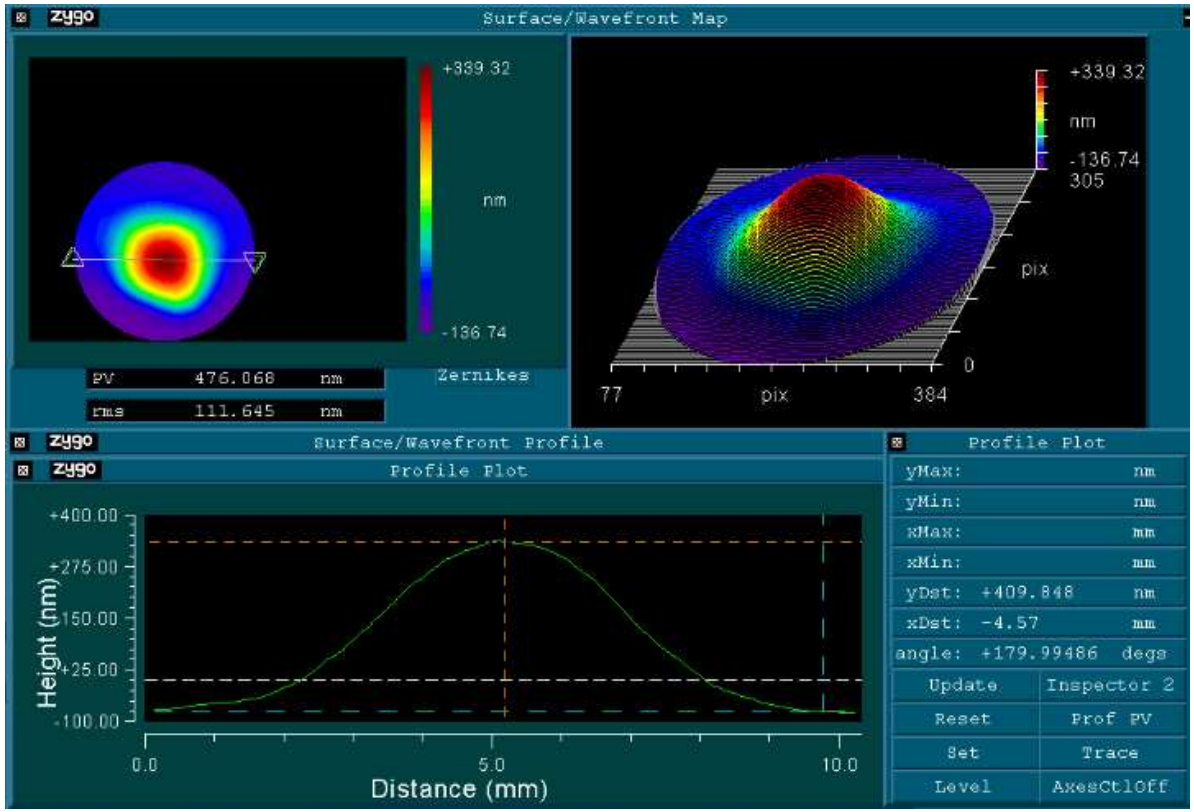
MiniDM spatial characteristics

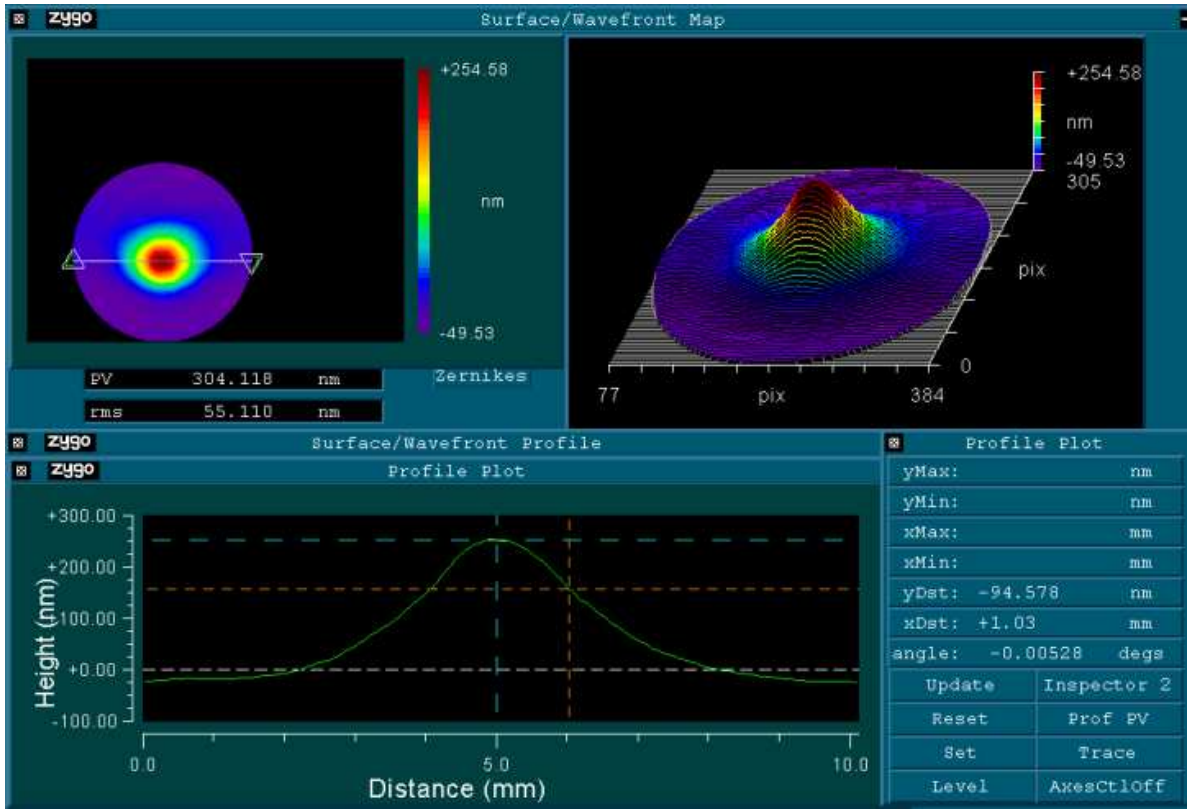


100 V on 3X3 actuators

Maximum stroke

> ± 1.6 µm for ± 400 V

MiniDM spatial characteristics



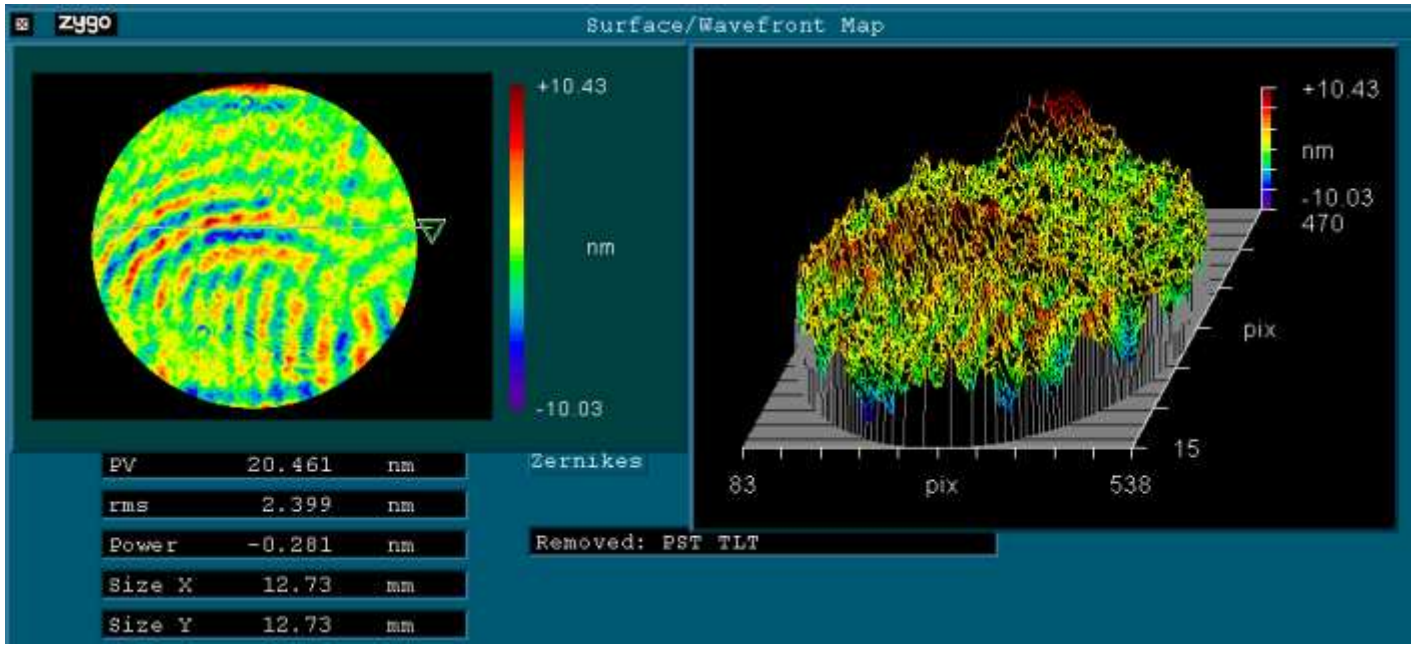
200 V on 1 actuator

Individual stroke

> ± 0.4 µm for ± 400 V

≈ 60 % mechanical coupling

Best flat accuracy



Filtered shape at rest (defects with spatial periods > 2 mm are filtered out)

- WFE: < 5 nm rms

Review of requirements

	Specified	Measured	Next*
• Pupil diameter:	49 mm	49 mm	
• Number of actuators:	≈ 1900 (50x50)	1952	
• Max stroke (after flattening):	> 2.6 µm	> 2.6 µm (≈ 3 µm)	
• Individual stroke:	> 1.2 µm	0.80 µm	
• Interactuator stroke:	> 1.0 µm	0.56 µm	1.0 µm
• Mechanical coupling:	≈ 20 %	≈ 60 %	
• Foreseen actuator resonance freq.:	> 30 kHz		
• Hysteresis:	≈ 5 %		
• High order WFE:	20 nm rms	< 5 nm rms	
• Voltage:	± 400 V	± 400 V	
• Actuator capacitance:	≈ 0.3 nF	0.6 nF (act. + mount)	

*Estimation with a thinner head (feasibility demonstration under process)

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Tip/Tilt Mount

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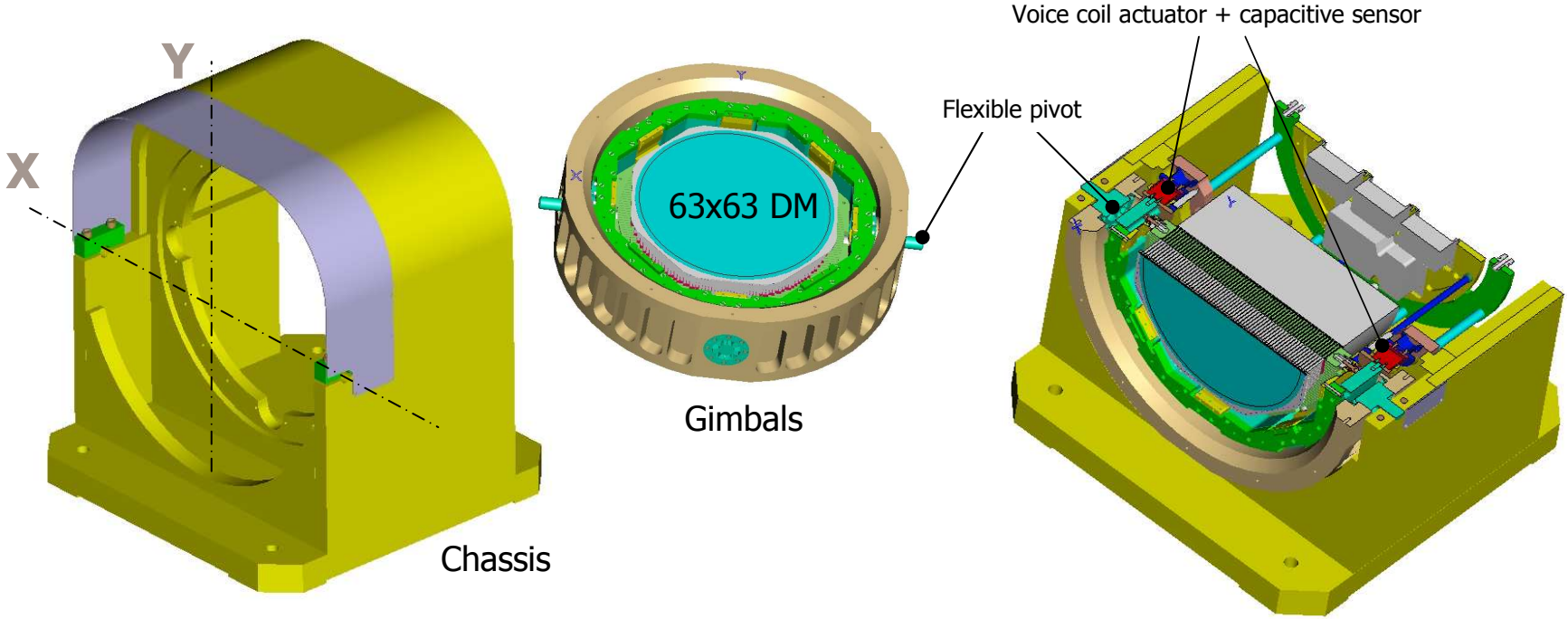
Tip/Tilt mount concept



Masses:	**DM: 32 kg Y axis: 60 kg X axis: 112 kg Overall system: 390 kg**
Specified angular stroke:	**500 µrad PV**
Specified -3dB bandwidth:	**20 Hz (goal 40 Hz)**
Specified angular noise:	**50 nrad rms**
Operating temperature:	**20 and -35°C**

Based upon l'Observatoire de Paris concept

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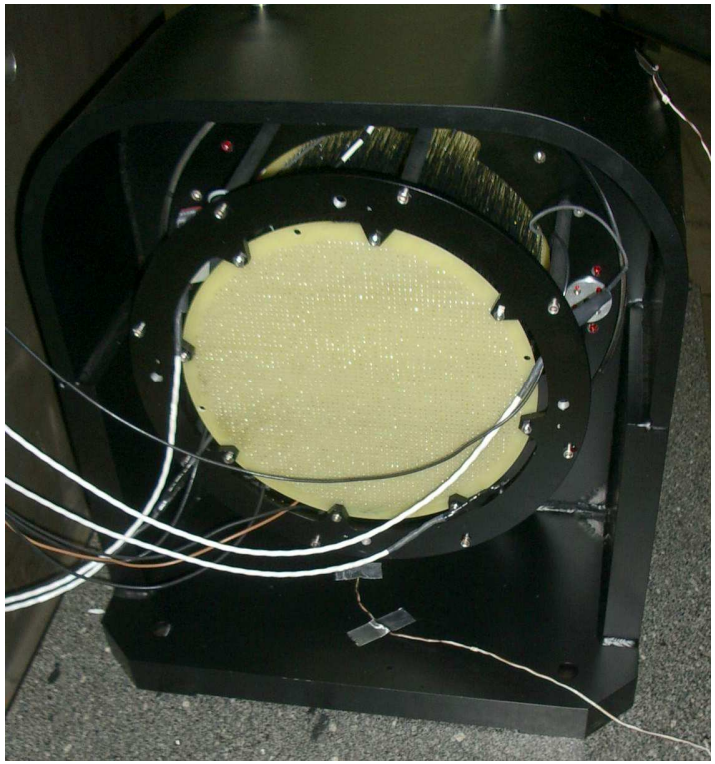
Tip/Tilt mount test



Back view (with DM wires)

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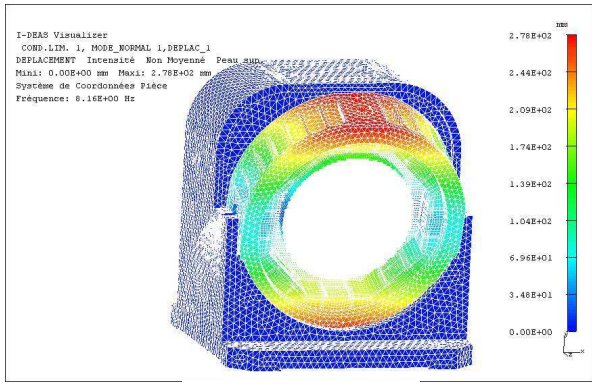
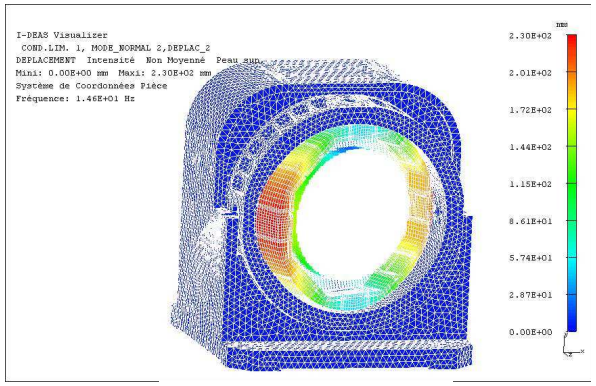
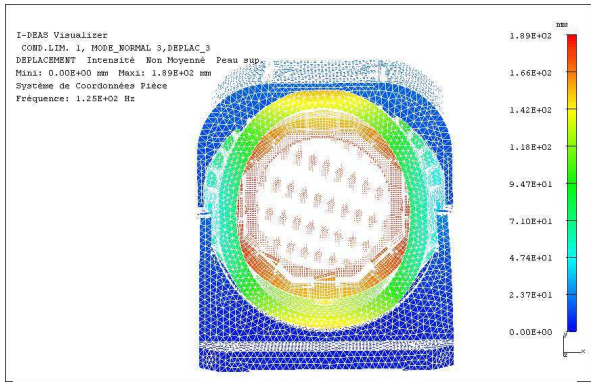
Mechanical modes

Simulation:







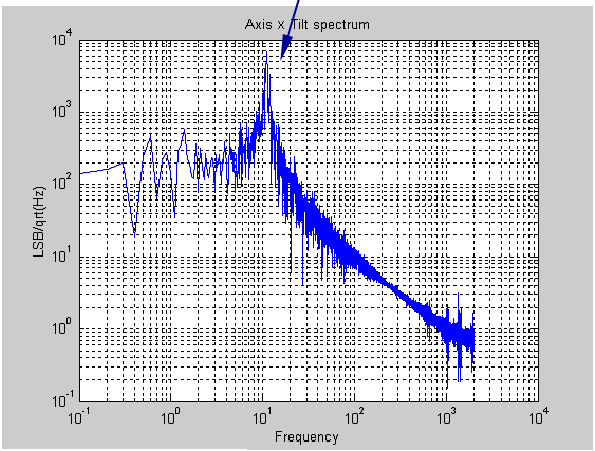
Tilt X: 8 Hz

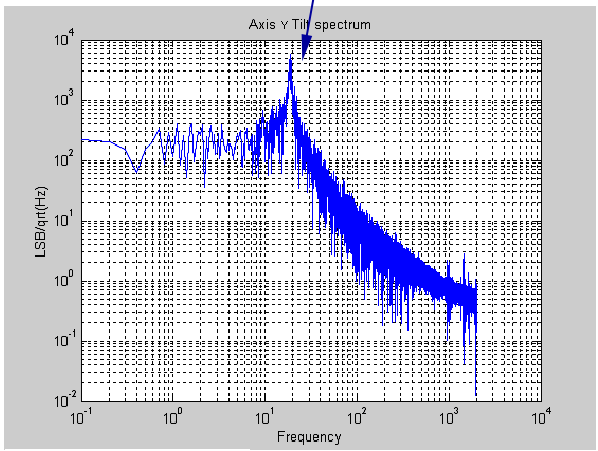
Tilt Y: 15 Hz

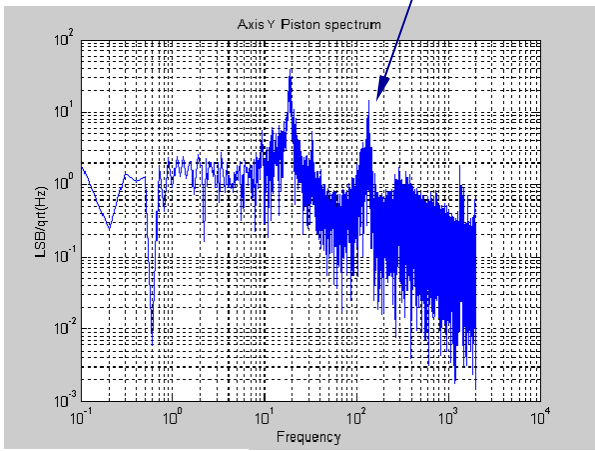
Piston (**spurious mode**): 125 Hz

$f_{X/Y} = 1/2\pi*(Tr/I_{X/Y})^{1/2}$

Measurement:







$P_{X+} - P_{X-}$

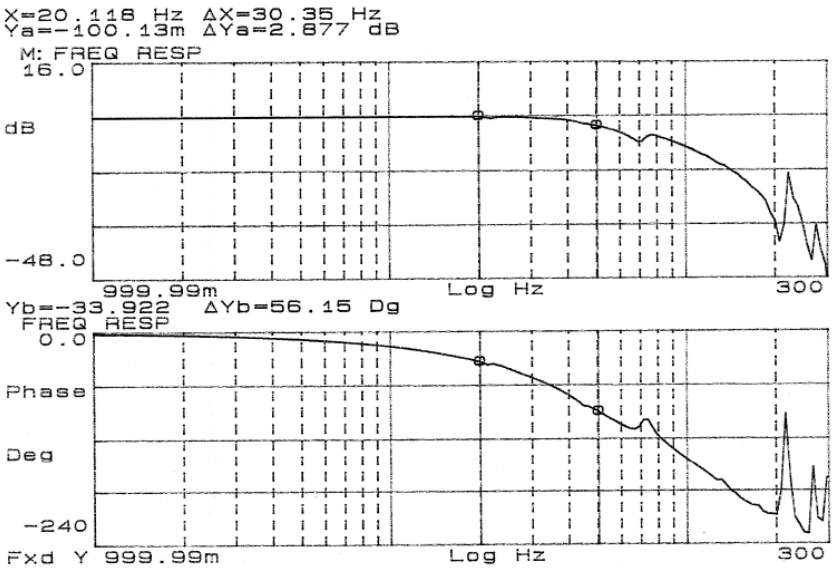
$P_{Y+} - P_{Y-}$

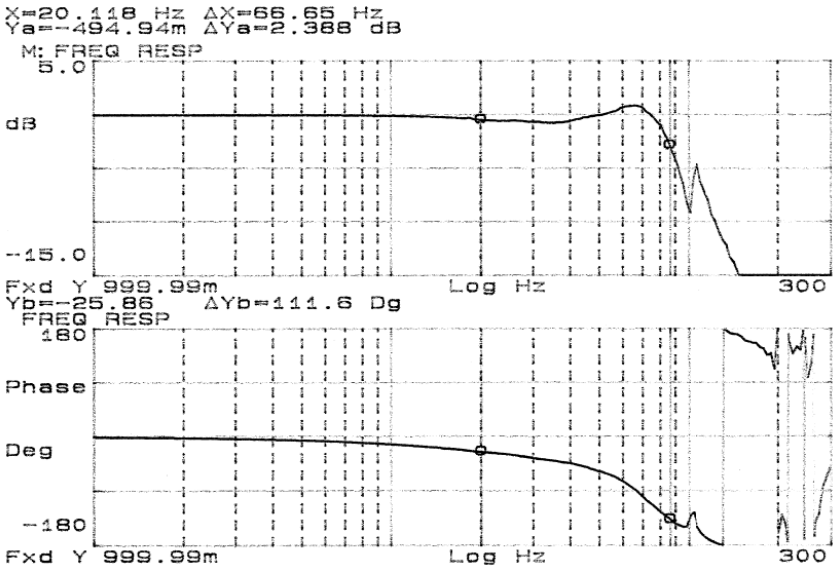
$P_{Y+} + P_{Y-}$

Open Loop responses to white noise

Correction bandwidth

Measurement:





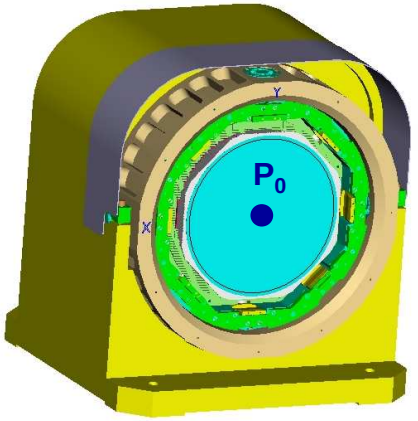
Tilt X: 50 Hz @ -3 dB (34° phase rotation @ 20 Hz)

Ti lt Y: 87 Hz @ -3 dB (26° phase rotation @ 20 Hz)

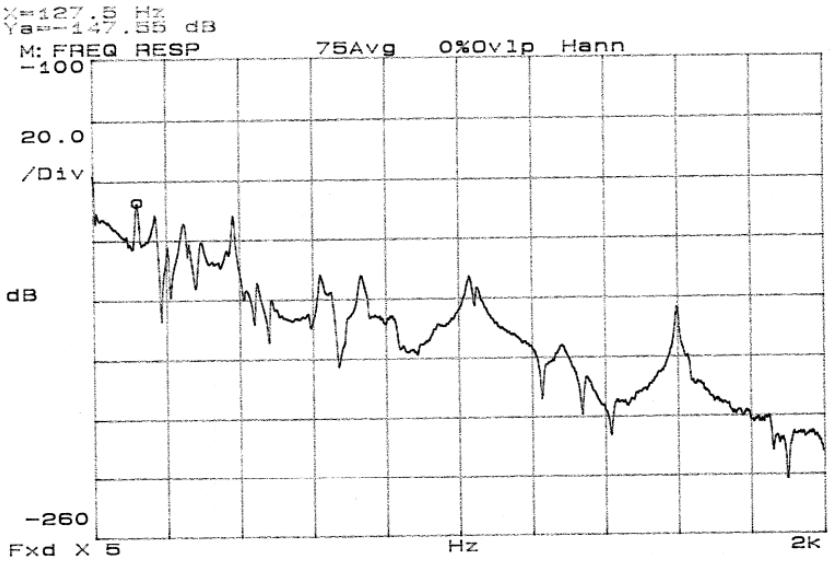
Closed Loop* responses to swept sine

* Used numerical corrector: Dumping loop on speed + Predictive Functional Command (PFC) on position

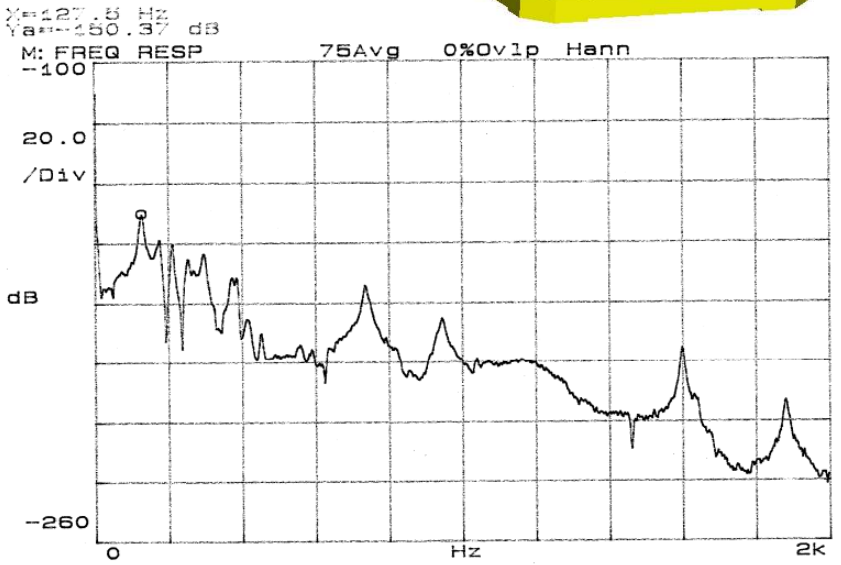
Piston issue



Measurement with accelerometer in P_0 (Z direction):



Acc. integration for X



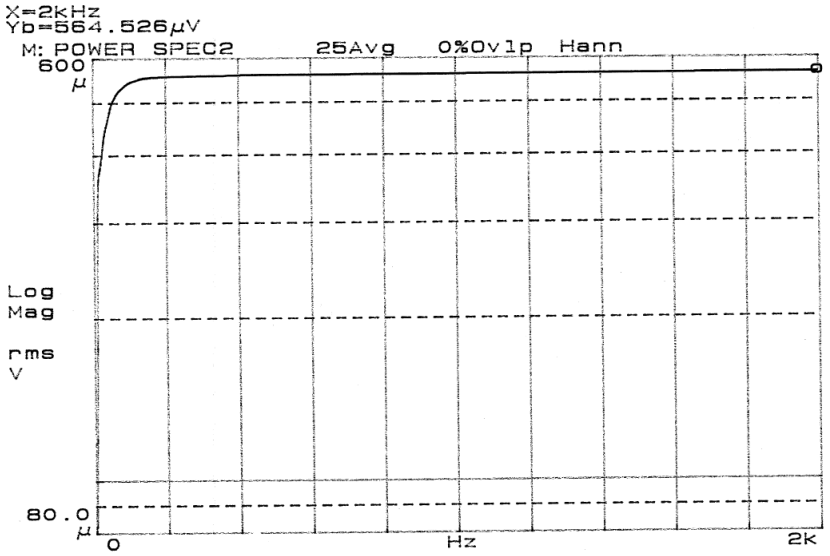
Acc. integration for Y

Piston/(Tilt command) transfer functions

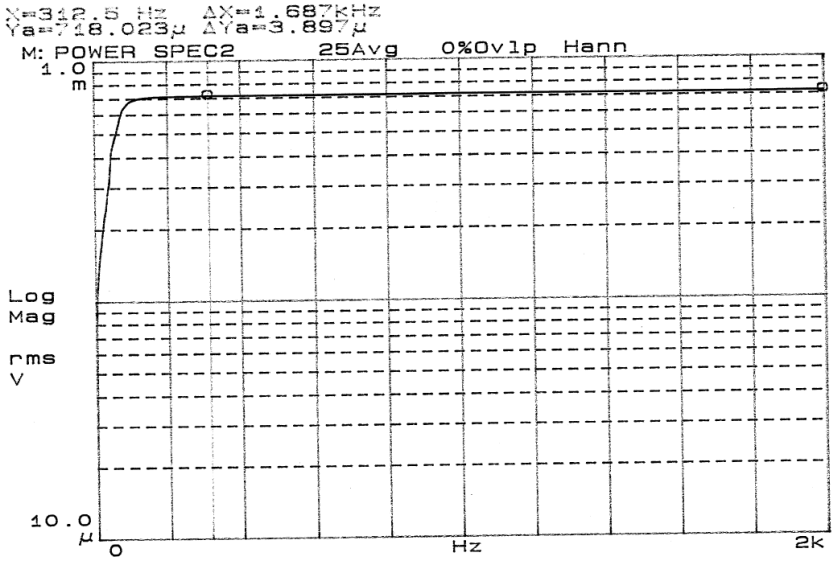
- @ resonance: Piston = 11.5 µm/mrad * 0.6 µrad = 7 nm

Angular noise

Measurement with optical sensor:



Noise integration for Tilt X



Noise integration for Tilt Y

Noise measurement in Closed Loop

- Noise = Gain.Voltage = 48 rad/V x 722 µV rms = 35 nrad rms

Merci

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