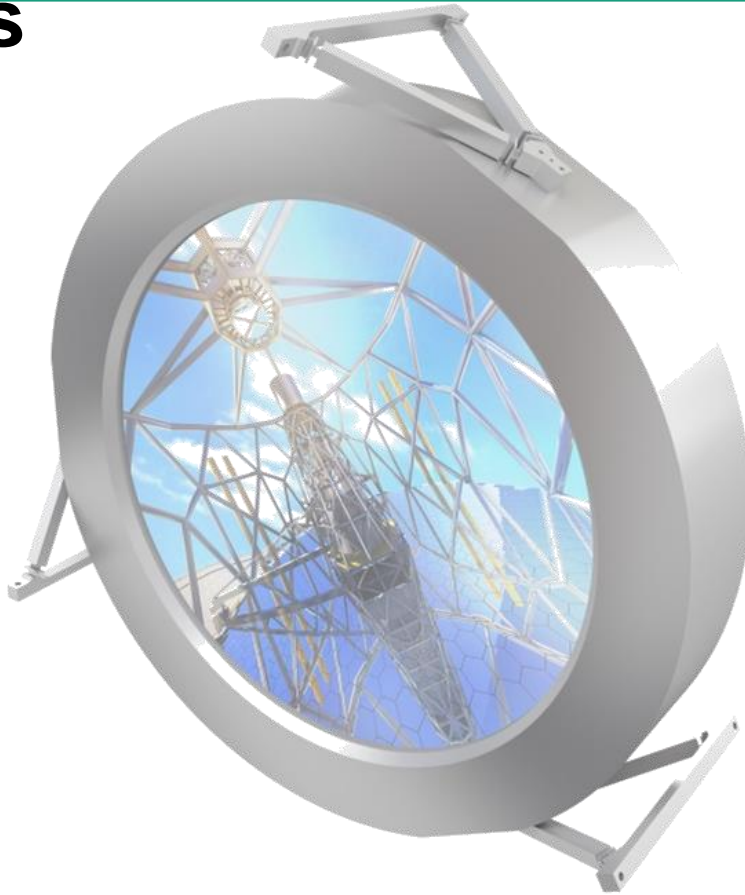

SWAP DM: preliminary design and schematics of a DM for extreme adaptive optics



 **Fraunhofer**
IOF

PI Piezo Technology

Funding:

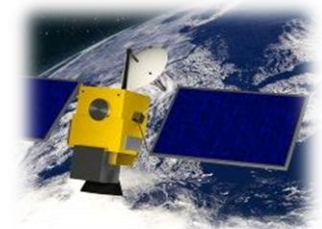
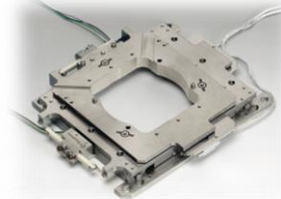
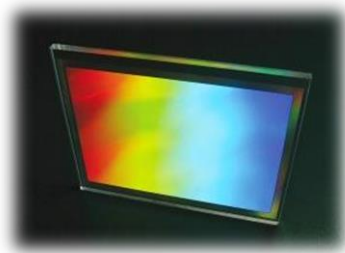
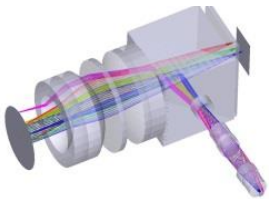


Teresa Kopf, M.Eng.

Fraunhofer Institute for Applied Optics and Precision Engineering IOF



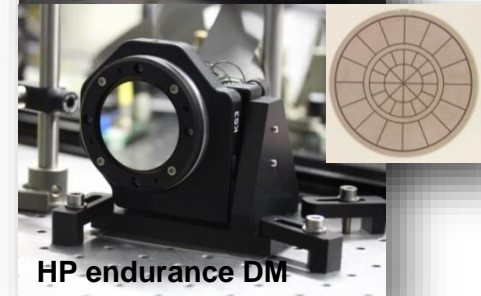
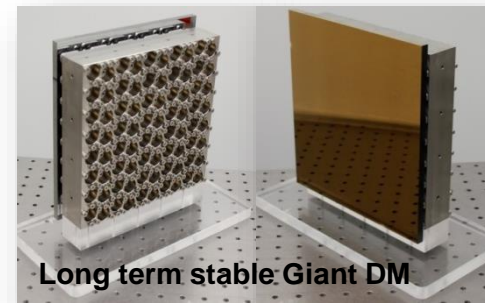
- About 7000 m² floor space
- 204 Employees
+ 72 Students
- Budget 2014: 25,0 mn. €
(45 % industry projects)



1. Background

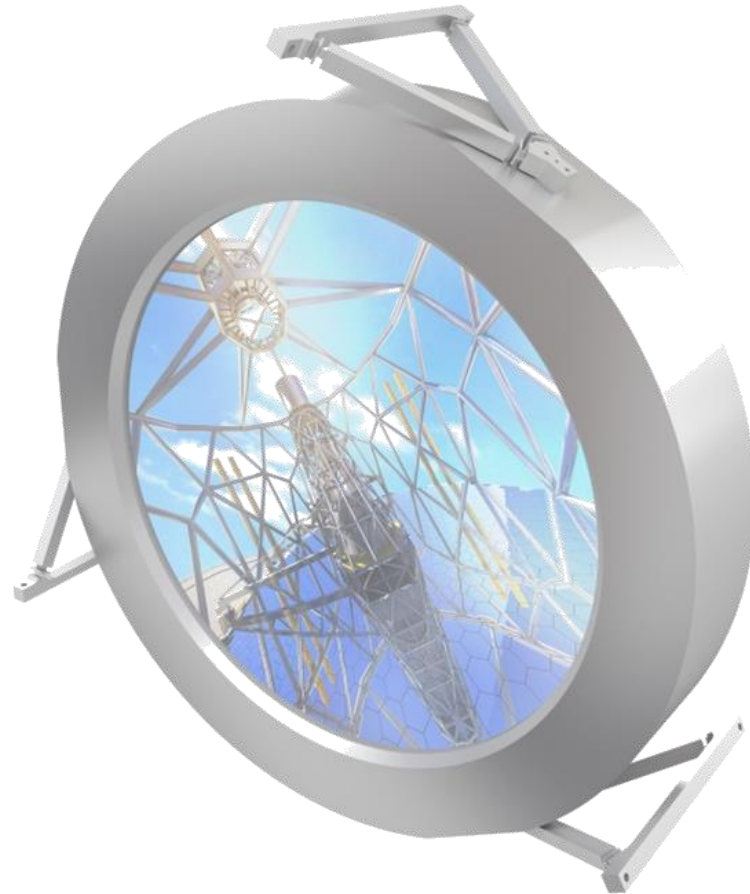
Active and Adaptive Optics Group

- Design and manufacturing of various deformable mirrors
 - 40 actuator high power DM for laser communication
 - > 6 kW cw focussing DM
 - DM for cryogenic applications
- AO system design
- Design and implementation of a real-time portable AO box for laser communication
- WFS design



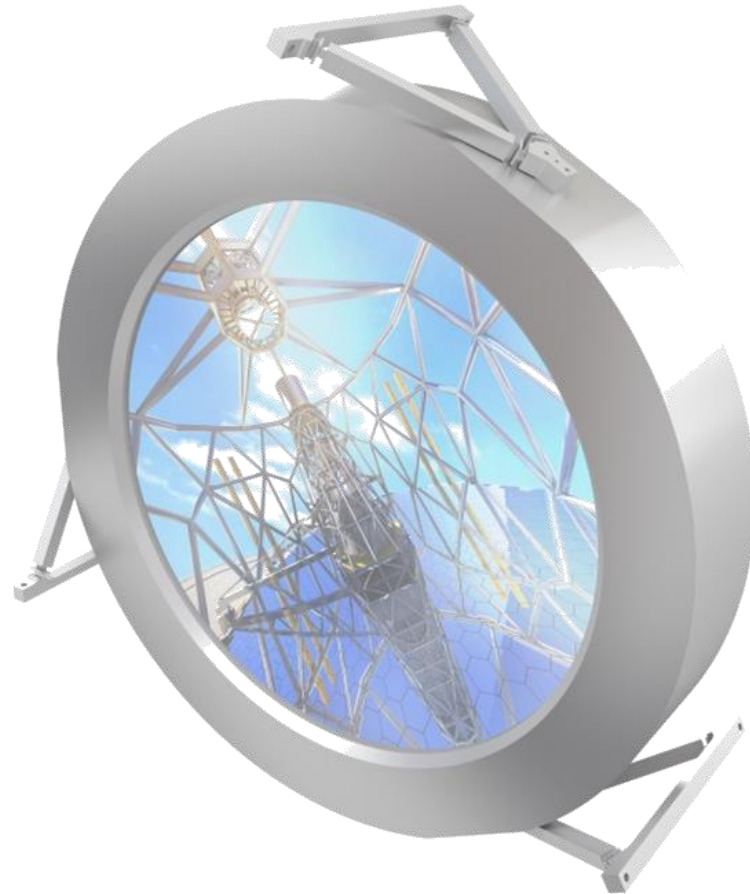
Structure

- 1) Requirements
- 2) Schematics
- 3) Preliminary Design
- 4) Breadboards
- 5) Summary and Outlook



Structure

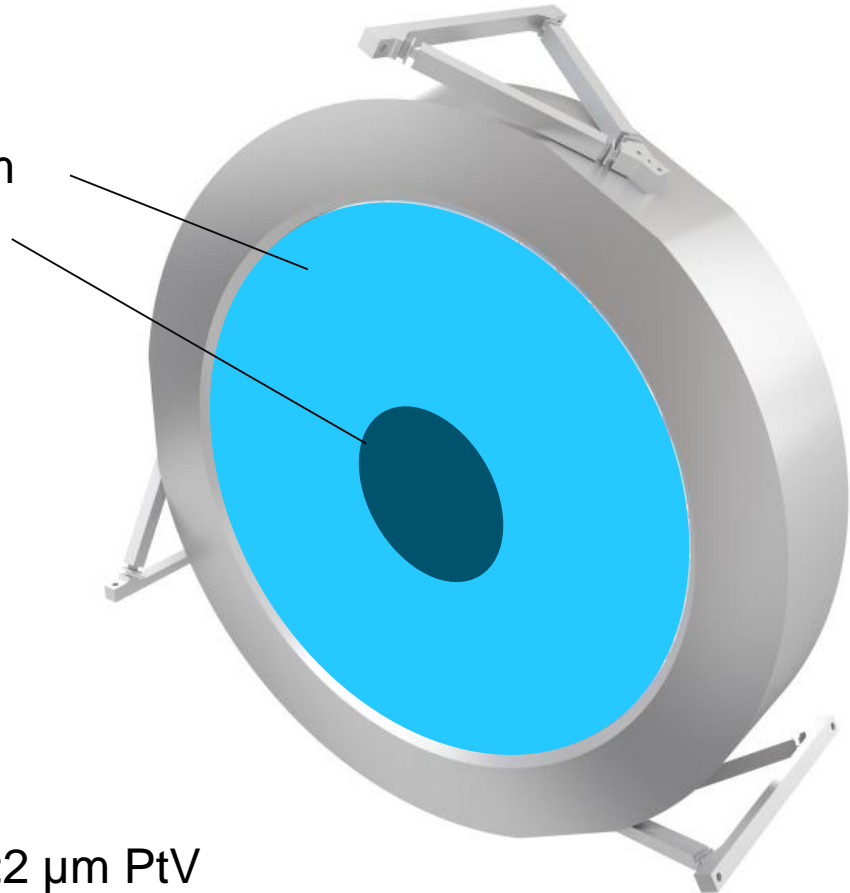
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Requirements

Mirror surface

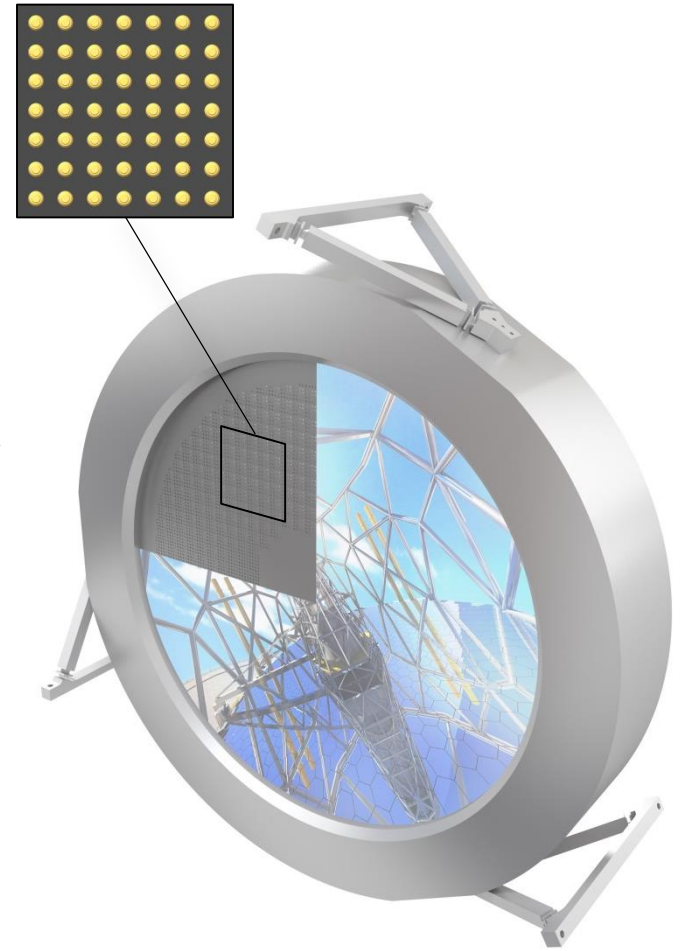
- Ring-shaped mirror
 - Activated outer diameter 450 mm
 - Passive inner diameter 108 mm
- Reflectivity
 - 97% @ 450-1000 nm
 - 98% @ 1000-2000 nm
- Mirror roughness < 1.5 nm rms
- Mirror surface flatness
 - Defocus < 2 μm PtV
 - High order modes Σ (Z5-Z11) < 2 μm PtV
 - after subtraction of modes with PZT activation \leq 10 nm rms



Requirements

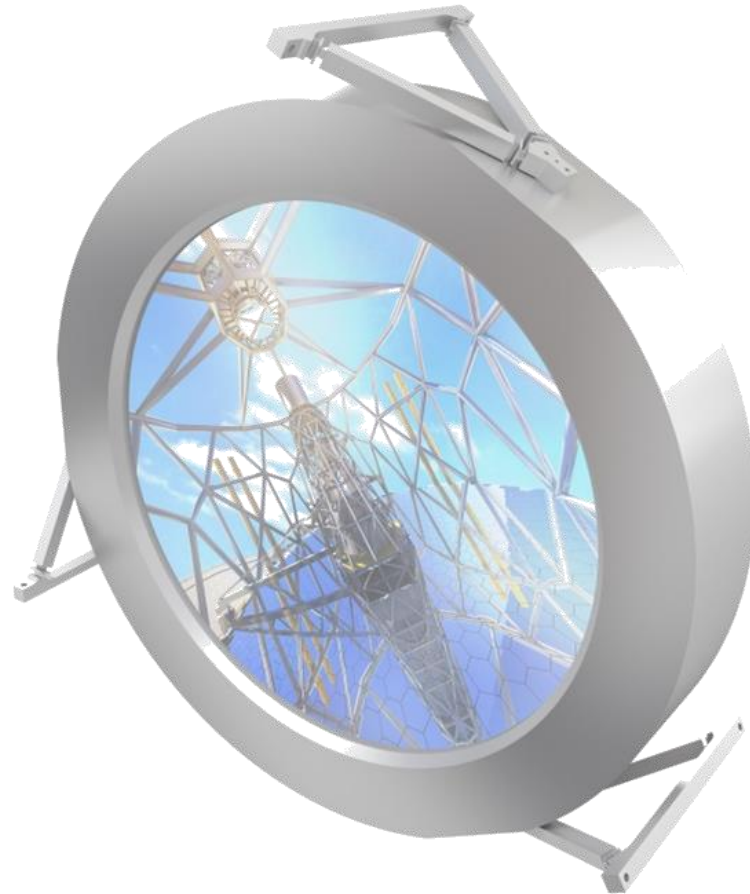
Actuation Capability

- 11,000 actuators within the aperture
- Actuator pitch of 3.7 mm
- Bidirectional activation $\pm 1.5 \mu\text{m}$
- Interactuator stroke $1.2 \mu\text{m}$
- Compensation for hysteresis and non-linearity
- Initial failure rate 5 stacks (out of 11,000)
- **Replaceable actuator units \rightarrow SWAP DM**



Structure

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Schematics

Actuator selection

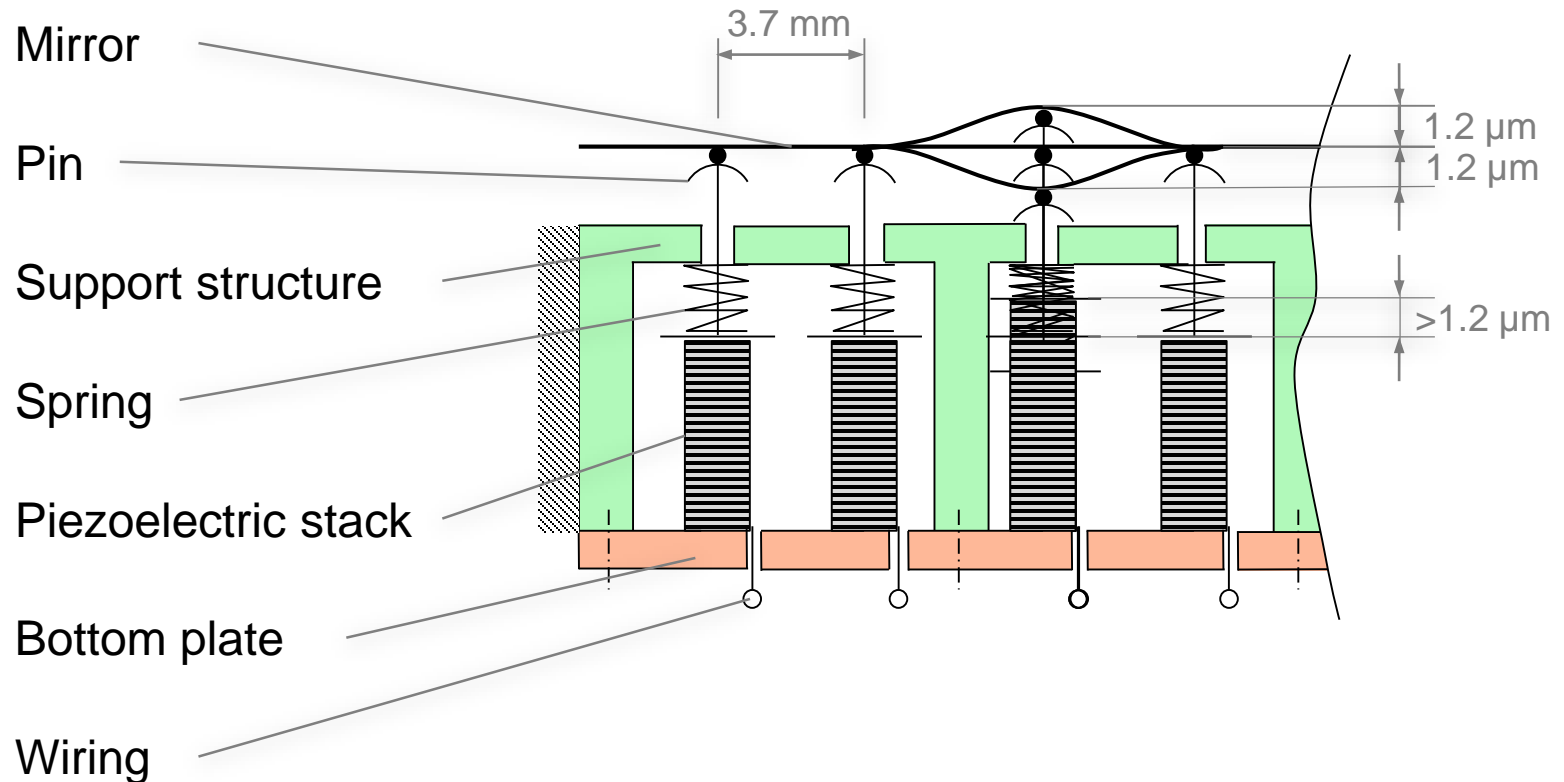
- Usage of PICMA[®] stack actuators
 - High force generation
 - High resolution
 - Full-ceramic insulation for long lifetime and increased reliability
 - Small foot prints available



- **Exchangeability of actuator modules**
- **Repairable with minimum disassembly**

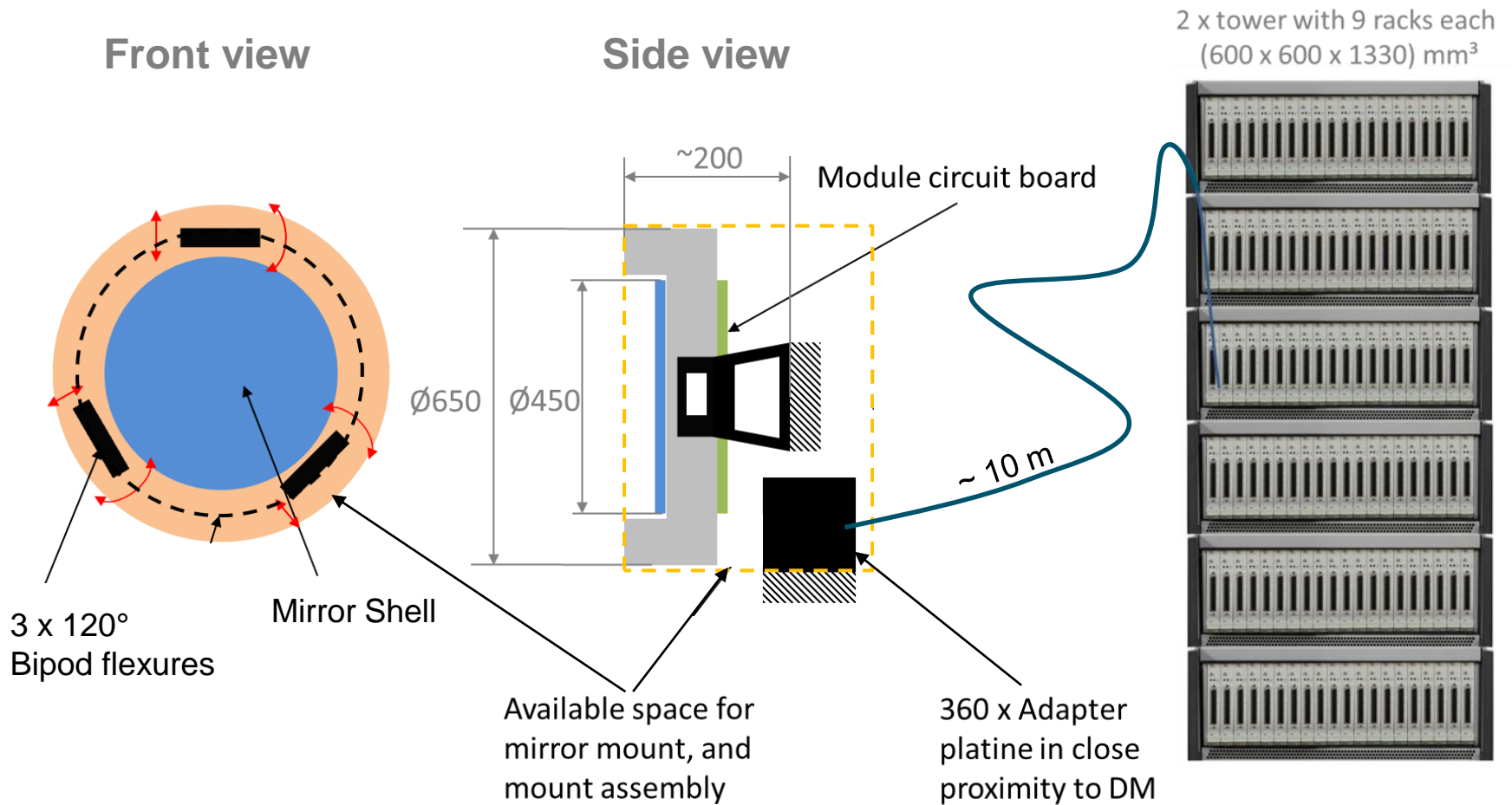
Schematics

Technical Principle



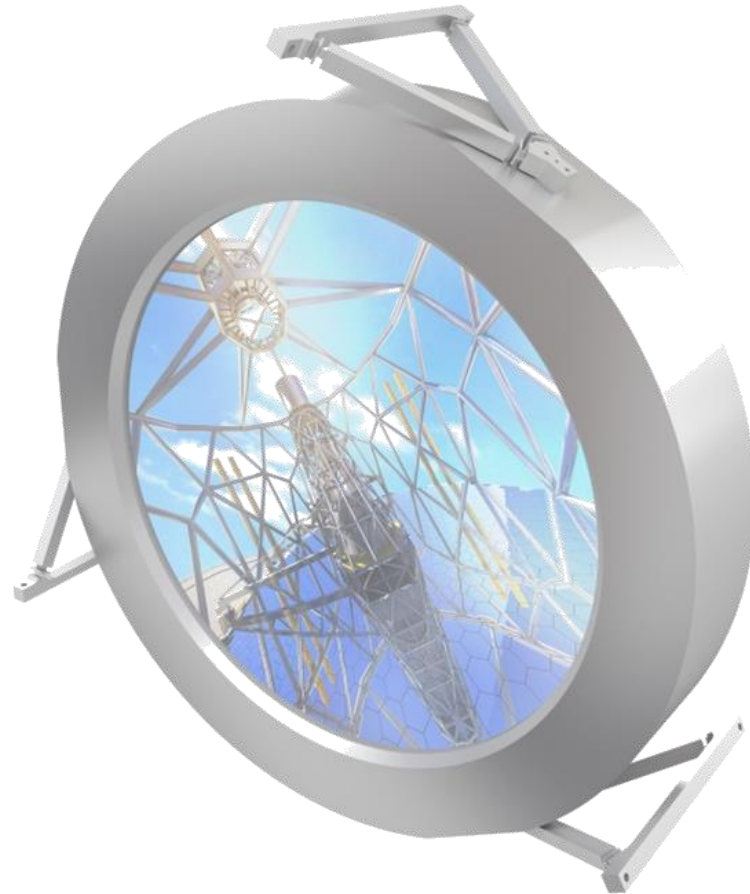
Schematics

Schematic System Design



Structure

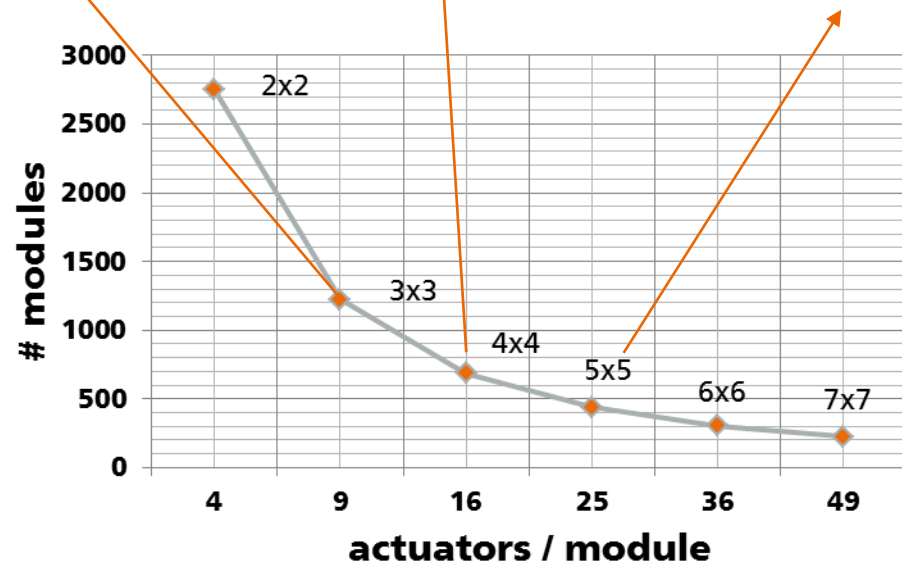
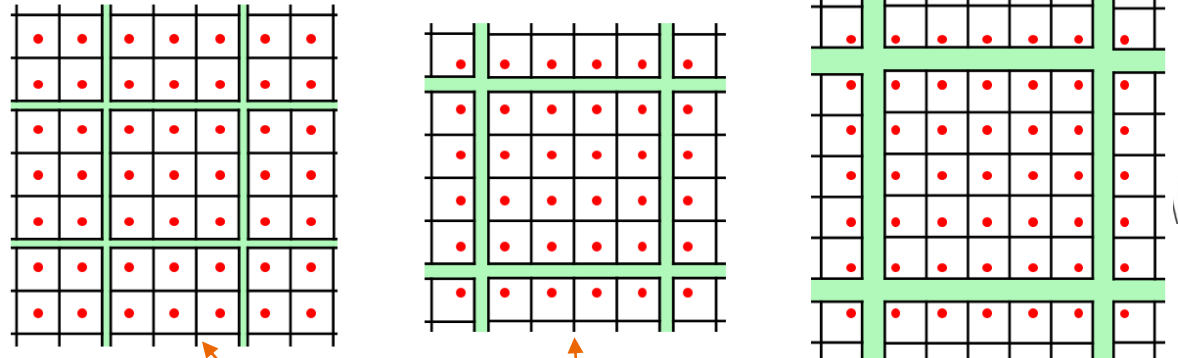
- 1) Requirements
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- 3) Preliminary Design**
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Preliminary Design

Actuator Properties

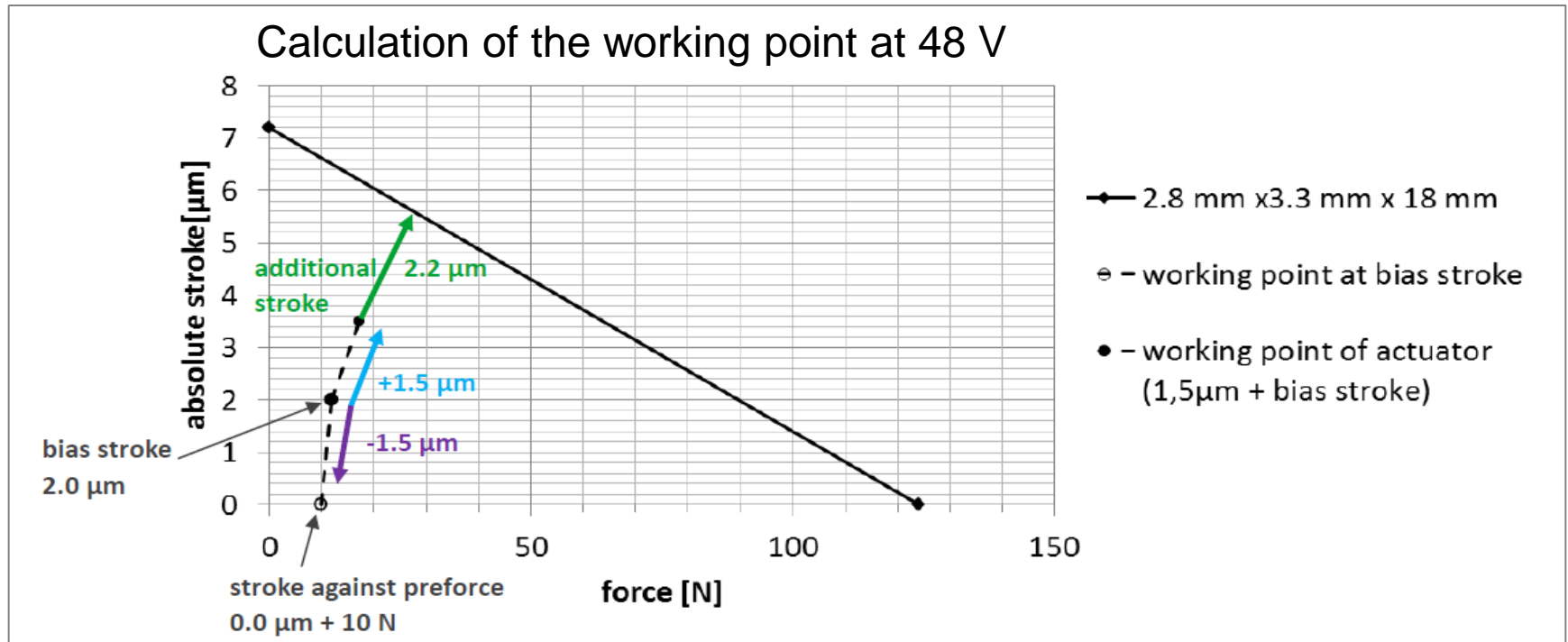
- Increasing module size
 - fewer modules need to be installed
 - larger force acting on the bottom plate and its fixation
- thickness of the support structure vs. degree of acentricity



- Actuator modules of 4 x 4 actuators
- Acentricity of < 60%

Preliminary Design

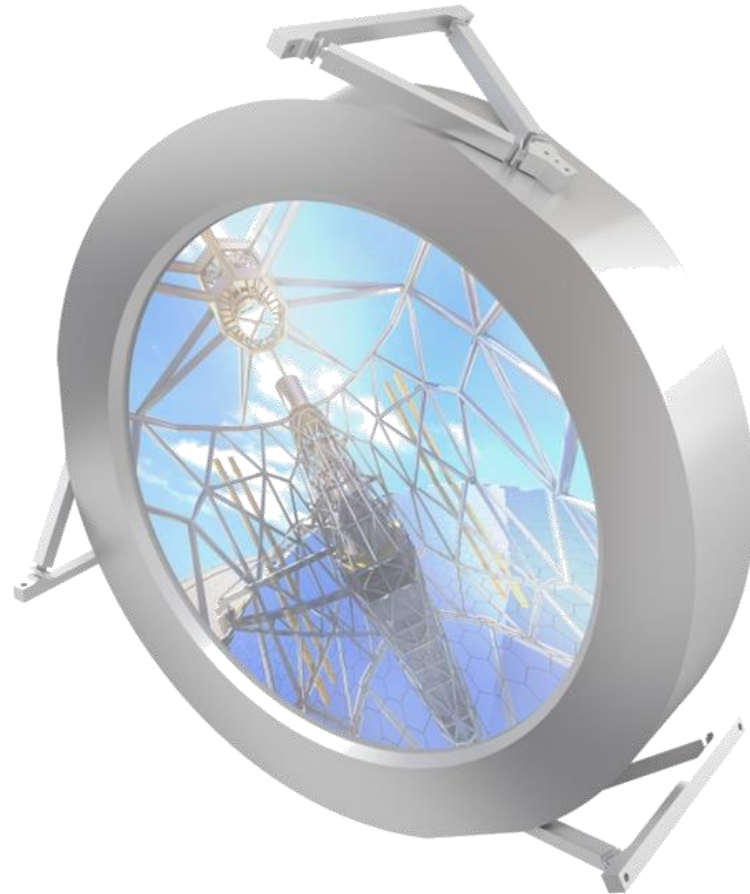
Actuator Properties



- 7,2 μm stroke @ 0 N force down to 0 μm at 125 N
- 2 μm bias-stroke
- 2.2 μm additional stroke to initially flatten mirror surface

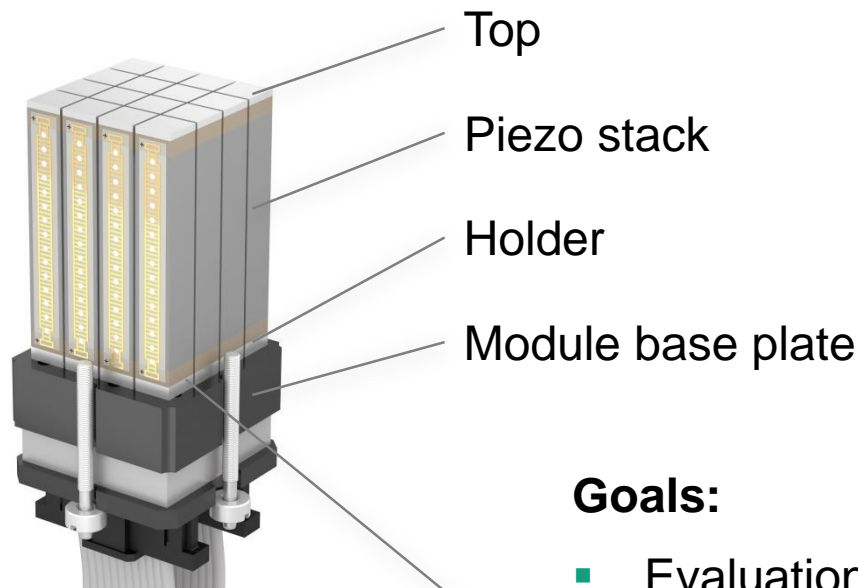
Structure

- 1) Requirements
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- 4) **Breadboards**
- 5) Summary and Outlook



Breadboards

Manufacturing Process of Modules

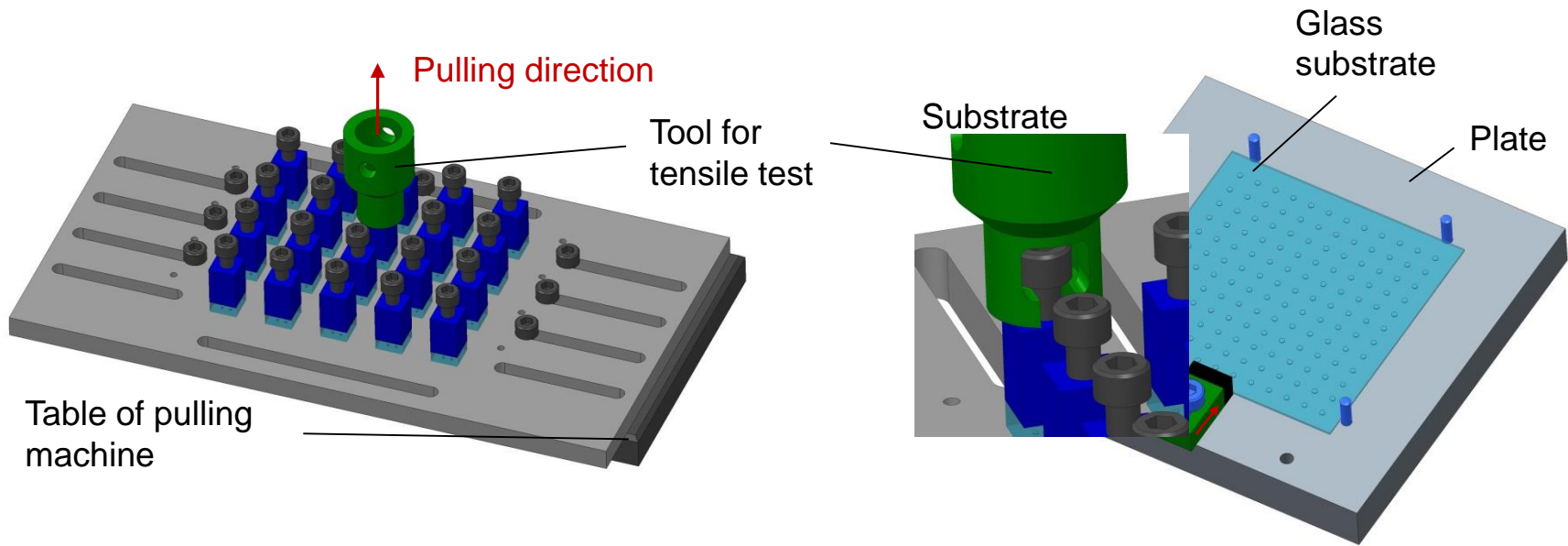


Goals:

- Evaluation of:
 - Manufacturing accuracy
 - Gluing process of piezo stack with holder
 - Handling and alignment procedure
 - Electrical contacting

Breadboards

Gluing of the mirror surface



Goals:

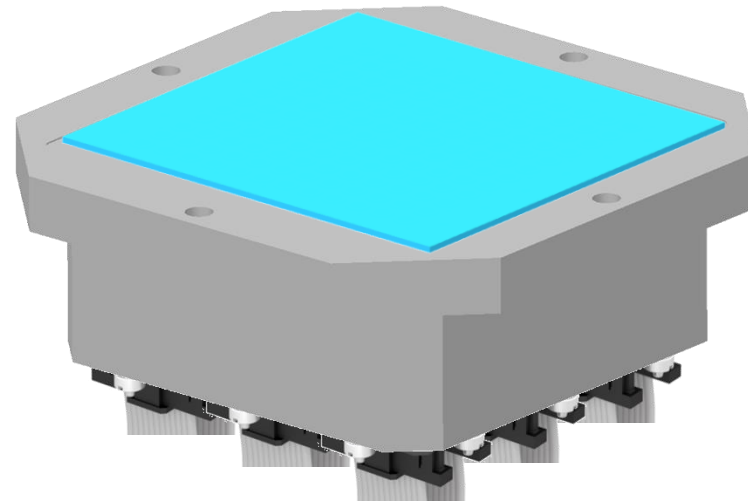
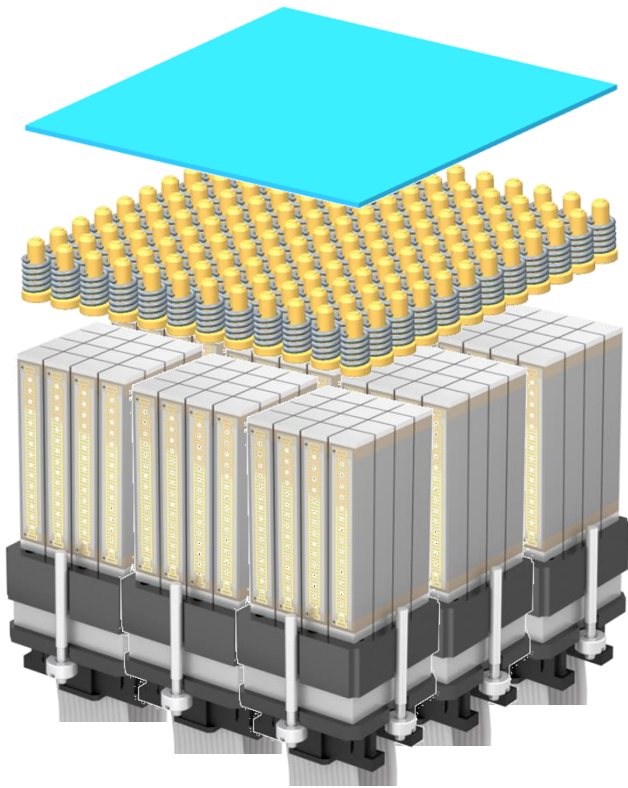
- Evaluation of:
 - Dosing parameters
 - Adhesive tensile strength
 - Gluing process (alignment, processing time, ...)

Breadboards

Assembling, testing and exchanging of modules

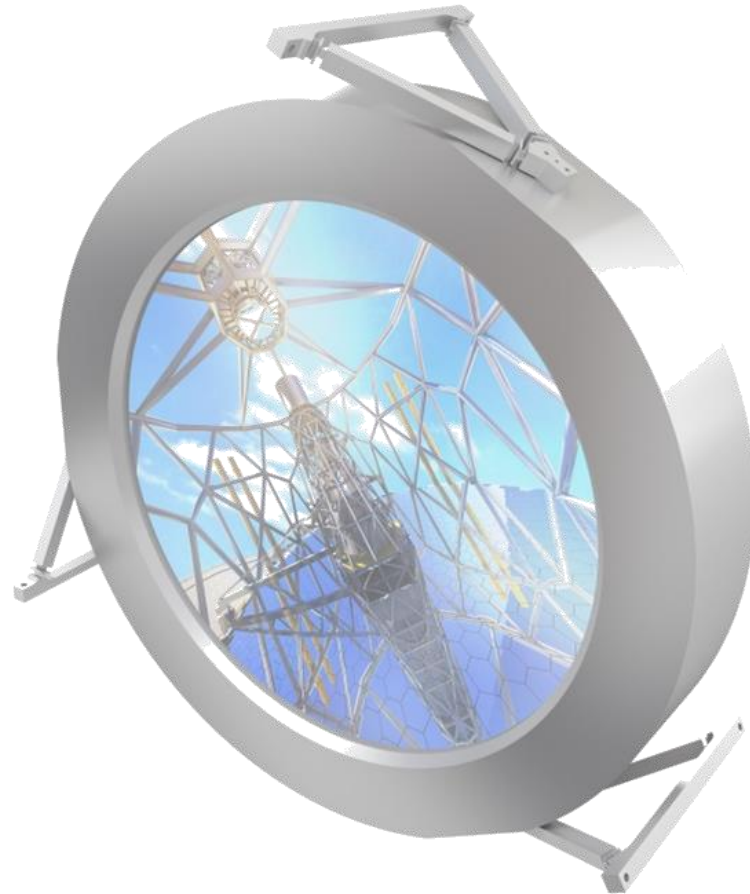
Goals:

- Evaluation of manufacturing, alignment and assembly procedures
- Functional demonstration of stroke
- Swap modules



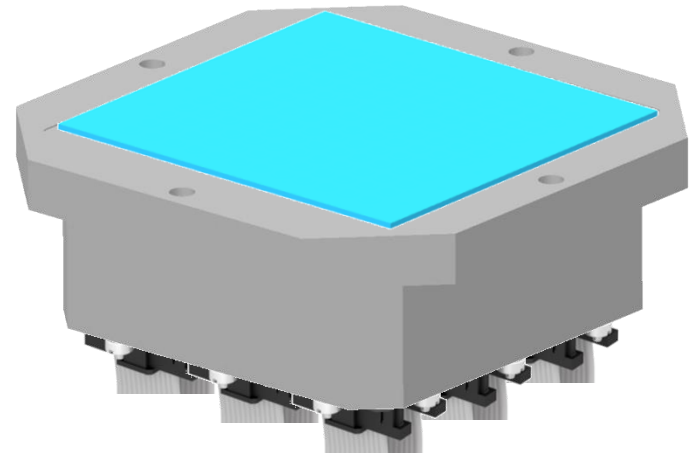
Structure

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Summary

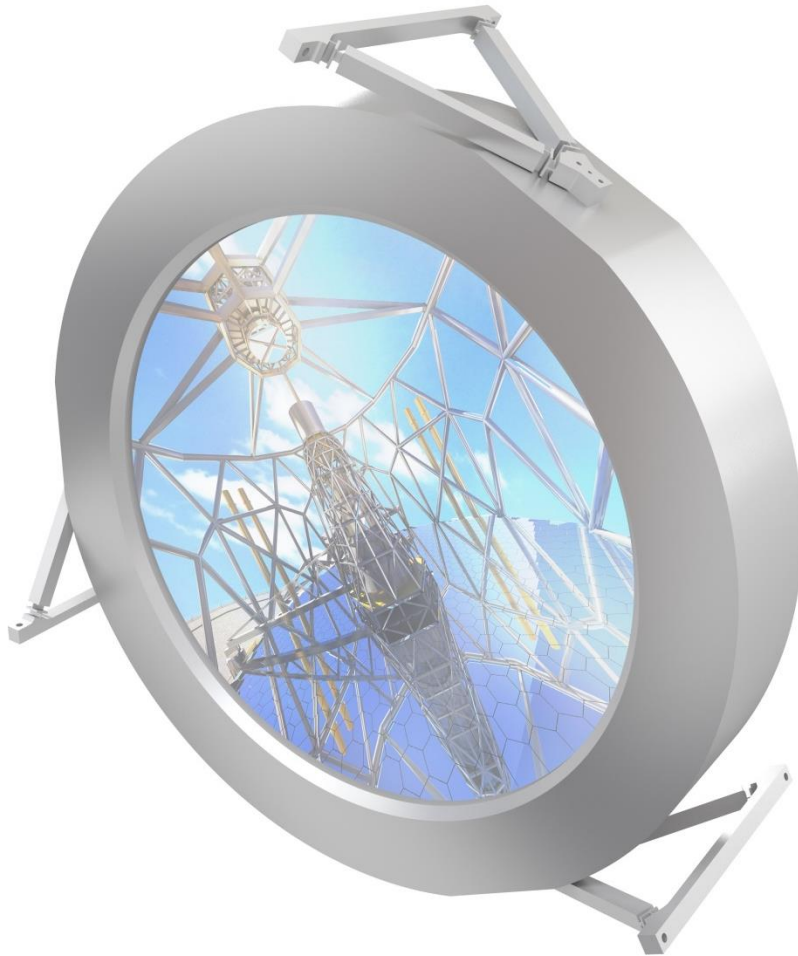
- Analysis of the requirements
- Development of the technical principle based on requirements
- Further development from the technical principle to the preliminary design
- Identification of critical technologies
- Definition of breadboards



Outlook

- Tests of the breadboards until end of 2017
- Assembly of a mirror demonstrator with 3 x 3 modules
- Technology is available from mid-2018, could be adapted to your needs!

Thank you for your attention!



SWAP DM:

- \varnothing 450 mm
- 11,000 actuators
- Actuator pitch 3.7 mm
- Interactuator stroke 1.2 μm
- Update rate 4 kHz

Visit us at our info-table!