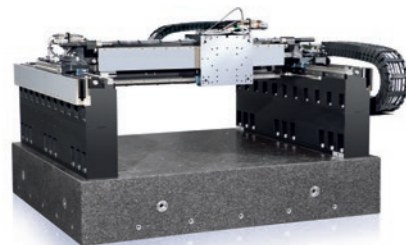


# Engineered Systems Capabilities



Precision components, stable control and a great deal of experience in engineering are essential for high-precision complex motion and positioning solutions. PI is a supplier of technologically sophisticated drive components and high-precision positioners and also offers all levels of integration up to the turnkey solution.

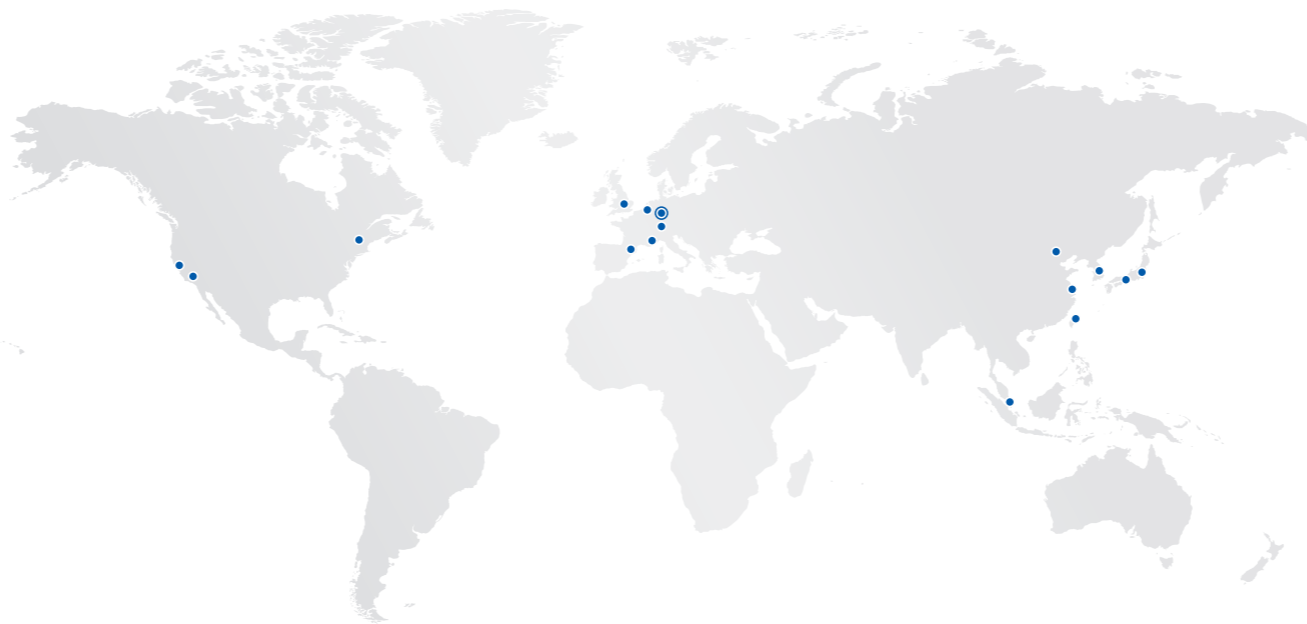
Engineering services have been a part of PI's core business for many years. Complete solutions, fitting seamlessly into existing processes, advance automation in major research installations as well as manufacturing and inspection processes for chip production or photonics packaging.



Gantries are normally equipped with linear motors. Travel ranges of up to 2 meters in XY are possible. If preferred, DC or stepper motors can be used for the Z axis. If nano-meter precision is required, piezo actuators take care of dynamic fine adjustment.

### Core Competences

- Application support and consulting for motion and positioning applications
- Reliable and prompt series production even for large quantities
- Economic design
- Commissioning of turnkey solutions
- Complex multi-axis designs and parallel kinematic robotics
- Broad spectrum of technologies: Drive, guide, and sensor technologies
- In-house motion control electronics and software platform
- Customized software integration such as Epics, LabVIEW, Tango, ...
- Top-quality components from PI's broad portfolio of high-end standard products



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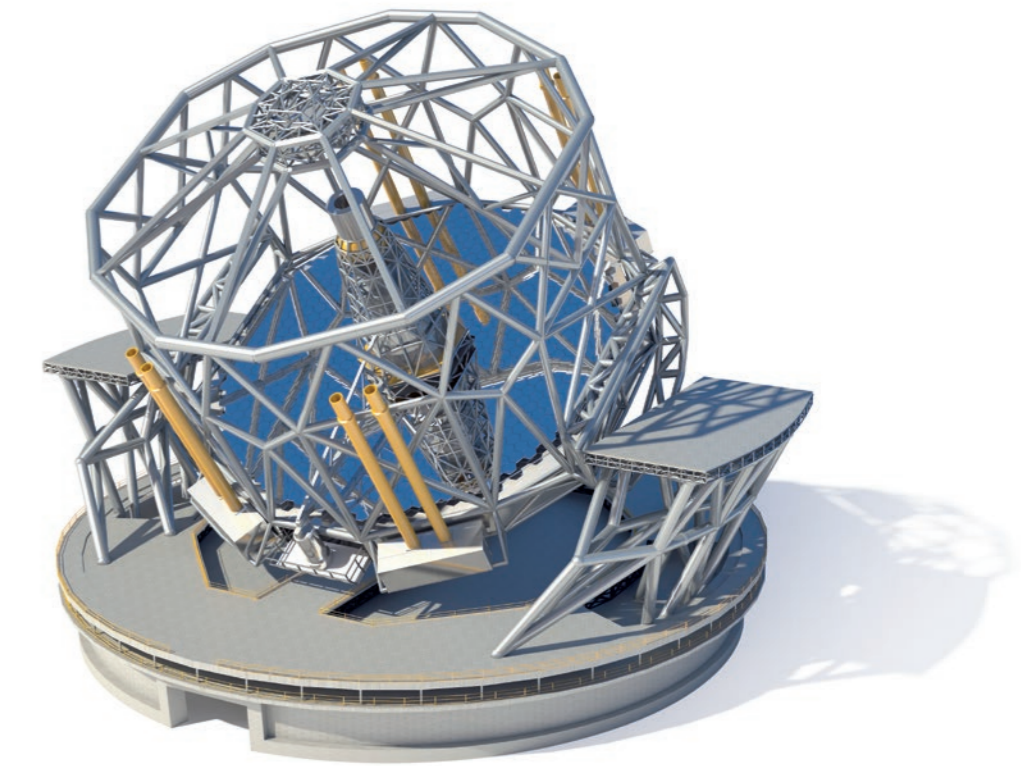
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# Detection of Exoplanets Around Stars

FOR E-ELT EPICS (EXOPLANET IMAGING CAMERA AND SPECTROGRAPH)

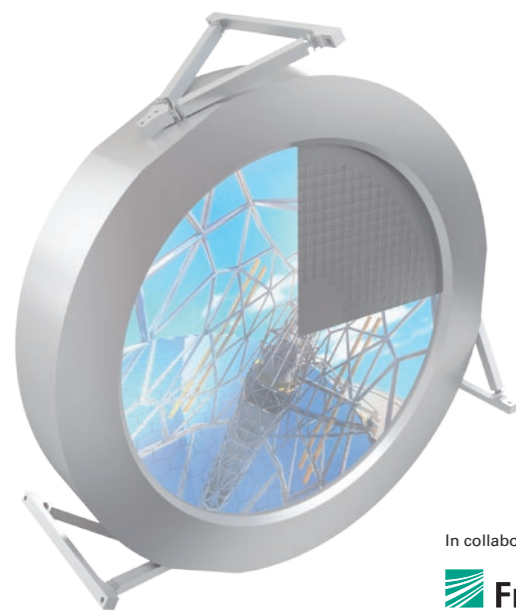
# Piezo-based Deformable Mirror

## With Exchangeable Actuation Modules

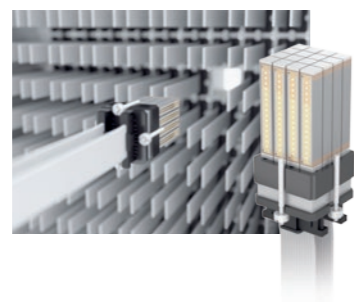
- Adaptive optics performance providing diffraction-limited images with angular resolutions down to 5 milliarcseconds (mas)
- Characterization of exoplanets down to the size of rocky planets by direct imaging, spectroscopy, and polarimetry
- The systematic intensity contrast between the exoplanet and the host star is better than  $10^{-8}$  at 30 mas and  $10^{-9}$  beyond 100 mas angular separation

### Specification

- Mirror diameter: 450 mm
- Number of actuators: 11,000
- PICMA® piezo actuators with high reliability for >1 billion cycles
- Actuator pitch: 3.7 mm
- Actuator stroke:  $\pm 2 \mu\text{m}$
- Actuator resolution: <0.1 nm
- Settling time: 2 ms (full stroke)
- Settling time: 100  $\mu\text{s}$  (small stroke <50 nm)
- Exchangeability of actuator modules: 4 x 4 modules without complete disassembly; modular design, adaptable to other XDM applications
- High performance and power-density of 11,000 amplifiers in two 19" rack towers for compact on site operation
- Low noise: 200  $\mu\text{Vrms}$  (DC-100 kHz and 1  $\mu\text{F}$  load)
- Small-signal (<50 nm) bandwidth: 30 kHz
- Displacement linearity:  $\pm 1.5 \%$  (from 1 Hz to 1 kHz)
- Nom. DAC resolution of 16 bit with an update rate of 4 kHz



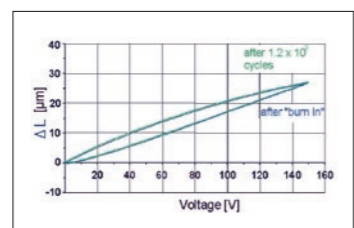
In collaboration with



### PICMA® Piezoceramic Actuators High Reliability and Superior Lifetime

- Low operating voltage: <150 V
- Few  $\mu\text{s}$  response times
- High force generation
- Minimum power consumption when holding the position

Long-term tests with full-ceramic insulated PICMA® actuators show not a single failure and no significant changes in displacement.



### Testing conditions

>4.0 x 10<sup>9</sup> cycles; 116 Hz sine wave excitation with 1.0 x 10<sup>7</sup> cycles per day; 15 MPa preload



### Piezo hexapod for M2 alignment coarse and fast travel in one system

#### Coarse travel specifications

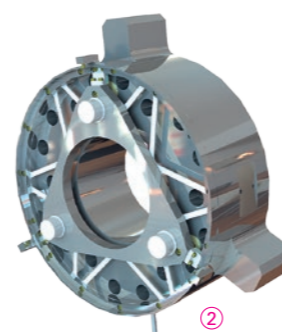
Stroke XYZ:	$\pm 10 \text{ mm}$
Res. frequency:	appr. 100 Hz
Dimensions:	
Diameter	550 mm
Height	300 mm

#### Fast travel specifications

Stroke:	$\pm 15 \text{ arcsec}$
Mirror diameter:	640 mm
Mirror weight:	16 kg

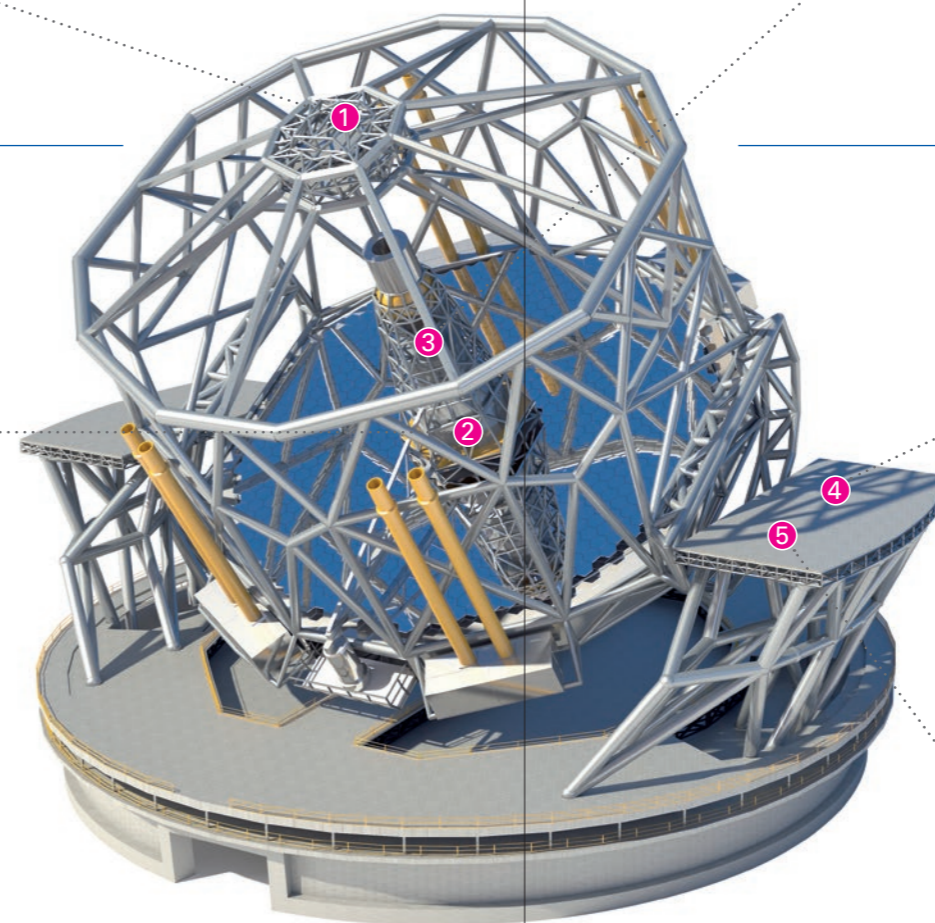
Operating frequency:	60 Hz – 80 Hz
Resonant frequency:	440 Hz
Resolution:	<1 $\mu\text{rad}$

Hexapod Dimensions:	
Diameter	550 mm
Height	130 mm



### Fast tip/tilt M5 for image jitter correction

SiC mirror:	230 mm diameter, 900 g
Tip/tilt travel:	$\pm 194 \mu\text{rad}$ ( $\pm 40 \text{ arcsec}$ )
Resolution:	0.07 $\mu\text{rad pp}$
Sensor:	Capacitive
First resonance:	800 Hz
Bandwidth (-3dB):	150 Hz
Phase shift:	<25° at 50 Hz
Housing, Interface Plate & posts:	Invar

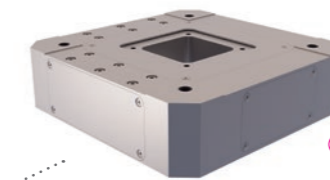


### M3 and M6 Z/tip/tilt positioner

Drives:	NEXLINE® (customized N-216)
Sensors:	Renishaw Resolute ETR
M3 mirror:	175 mm x 140 mm, 2.72 kg
M6 mirror:	Diam. 270 mm, 5.44 kg
Z stroke:	$\pm 3 \text{ mm}$
Tip/tilt:	$\pm 4.4 \text{ mrad}$
Operating:	Static
Resonant frequency:	60 Hz (rot Z)

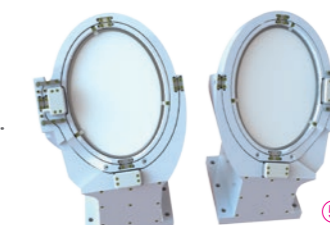
Accuracy:	
Z:	0.15 $\mu\text{m}$
Tip/tilt:	3.5 $\mu\text{rad}$

Dimensions:	
Diameter	200 mm
Max. height	100 mm
Weight	5.9 kg



### Nonmagnetic NEXLINE® XY stage for 77K

Travel XY:	200 $\mu\text{m}$
Load:	1.2 kg
Sensors:	Capacitive
Resolution:	<10 nm
Material:	Titanium
Dimensions :	150 x 150 x 30 mm



### Motorized cardanic mirror mounts

Stroke:	$\pm 2^\circ$
Mirror:	205 x 150 x 20 mm <sup>3</sup> , 1 kg
Res. frequency:	125 Hz
Sensor:	LVDT
Resolution:	0.3 $\mu\text{rad}$
Tip/tilt axis in plane with mirror surface!	