

Theory and motivation

Ground based laser transmitters are necessary for

- satellite laser ranging
- ground based optical communication to satellites
- free space quantum information applications
- optical time transfer

Requirements for laser transmitters:

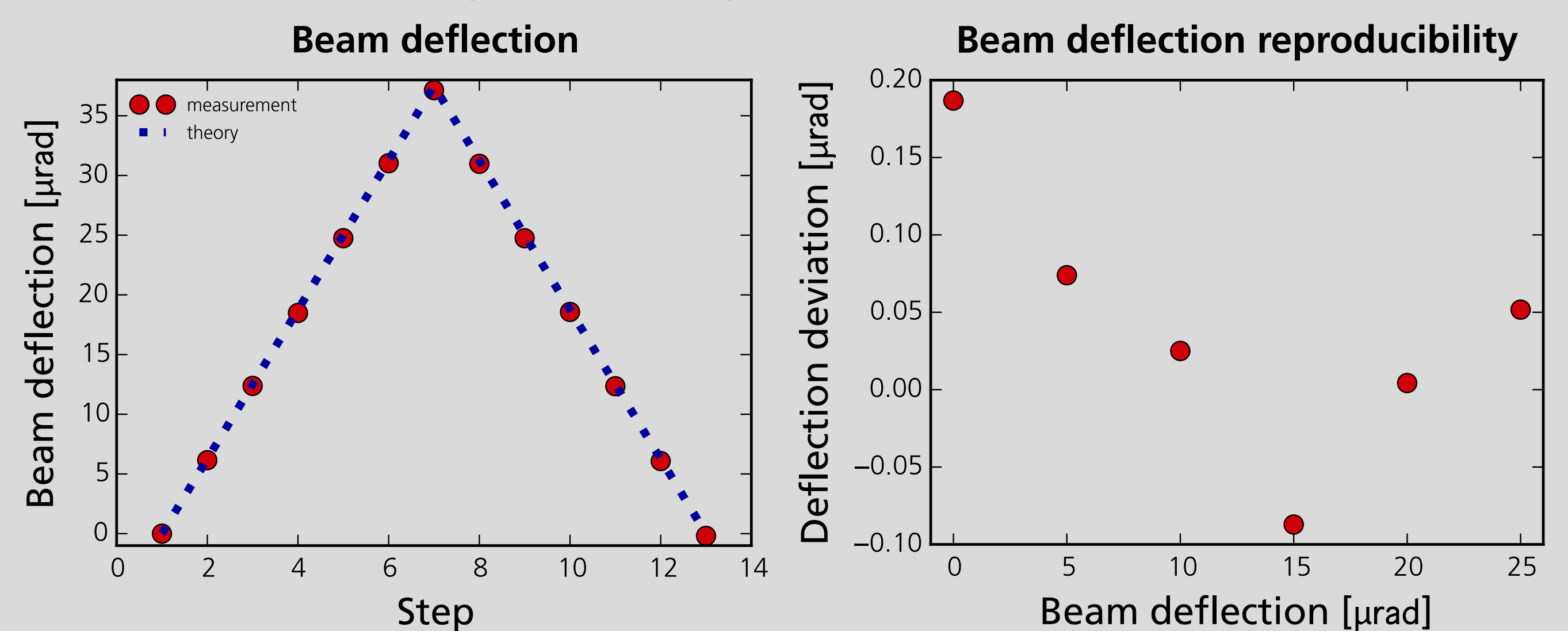
- expand the laser beam to reduce diffraction limited divergence to several $10\mu\text{rad}$
- enable reproducible fine steering of the beam in the μrad regime
- control beam divergence to compensate misalignment/achieve best performance

Presented design made of COTS components

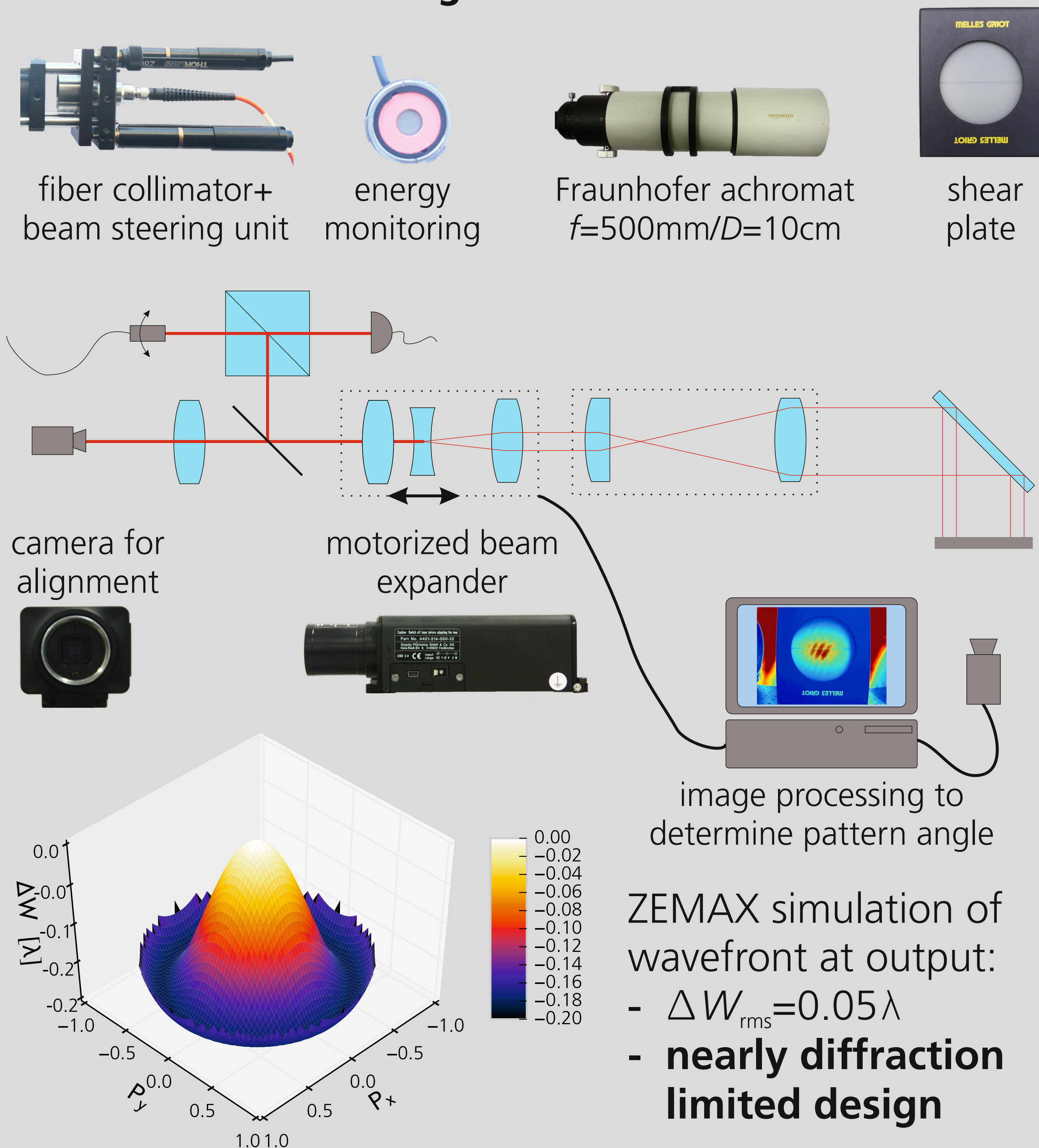
- easy upgrade of existing telescopes possible

Beam steering

- tip/tilt mount equipped with two DC servo-motors
- placed in conjugate plane of output aperture
- total travel range: $\pm 1\text{mrad}$
- reproducible movement of motors $< 200\text{nm}$
- **beam steering accuracy $< 1\mu\text{rad}$**

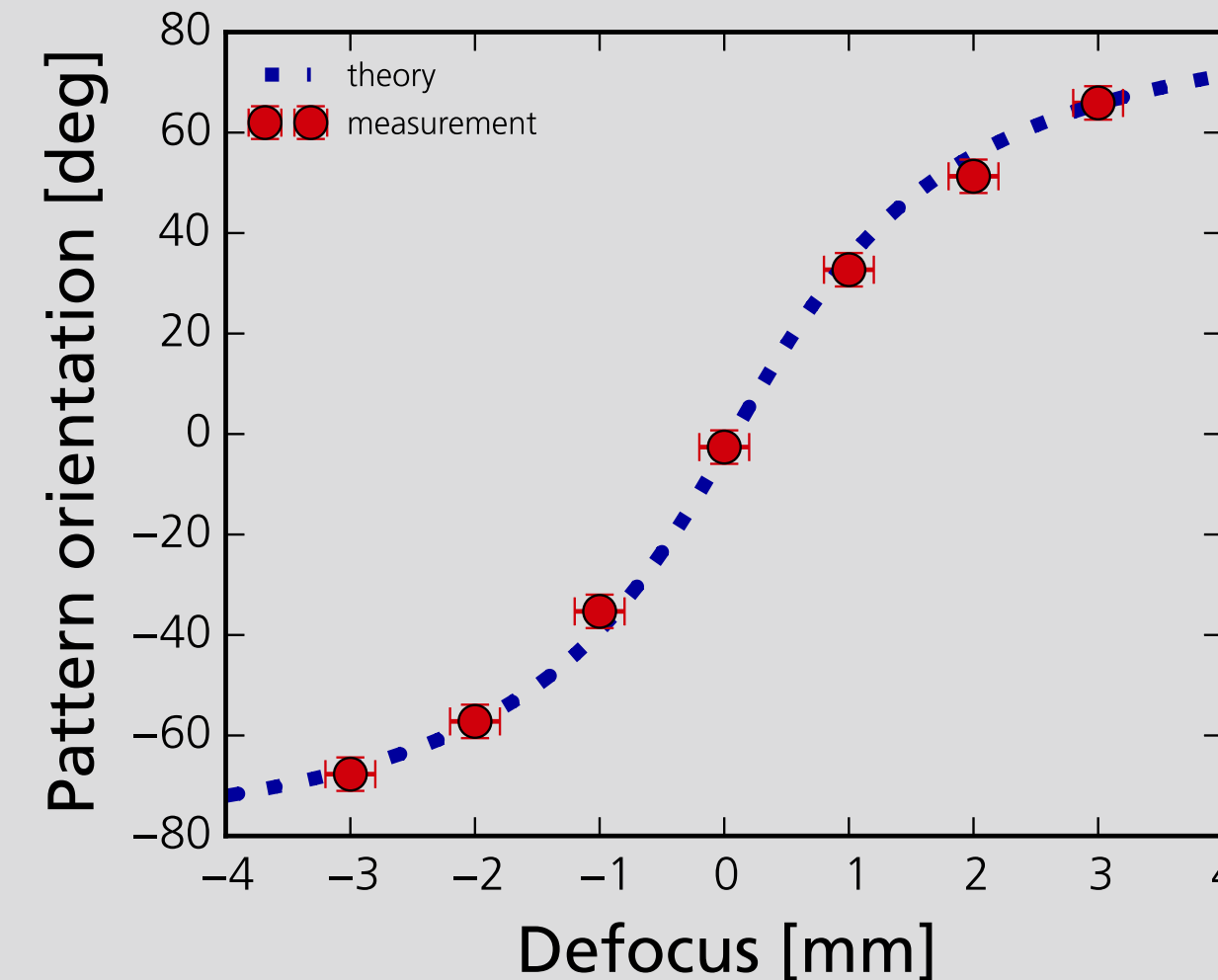


Laser transmitter design



Divergence control

Measured pattern orientation vs. theory



Shearing interferometer:

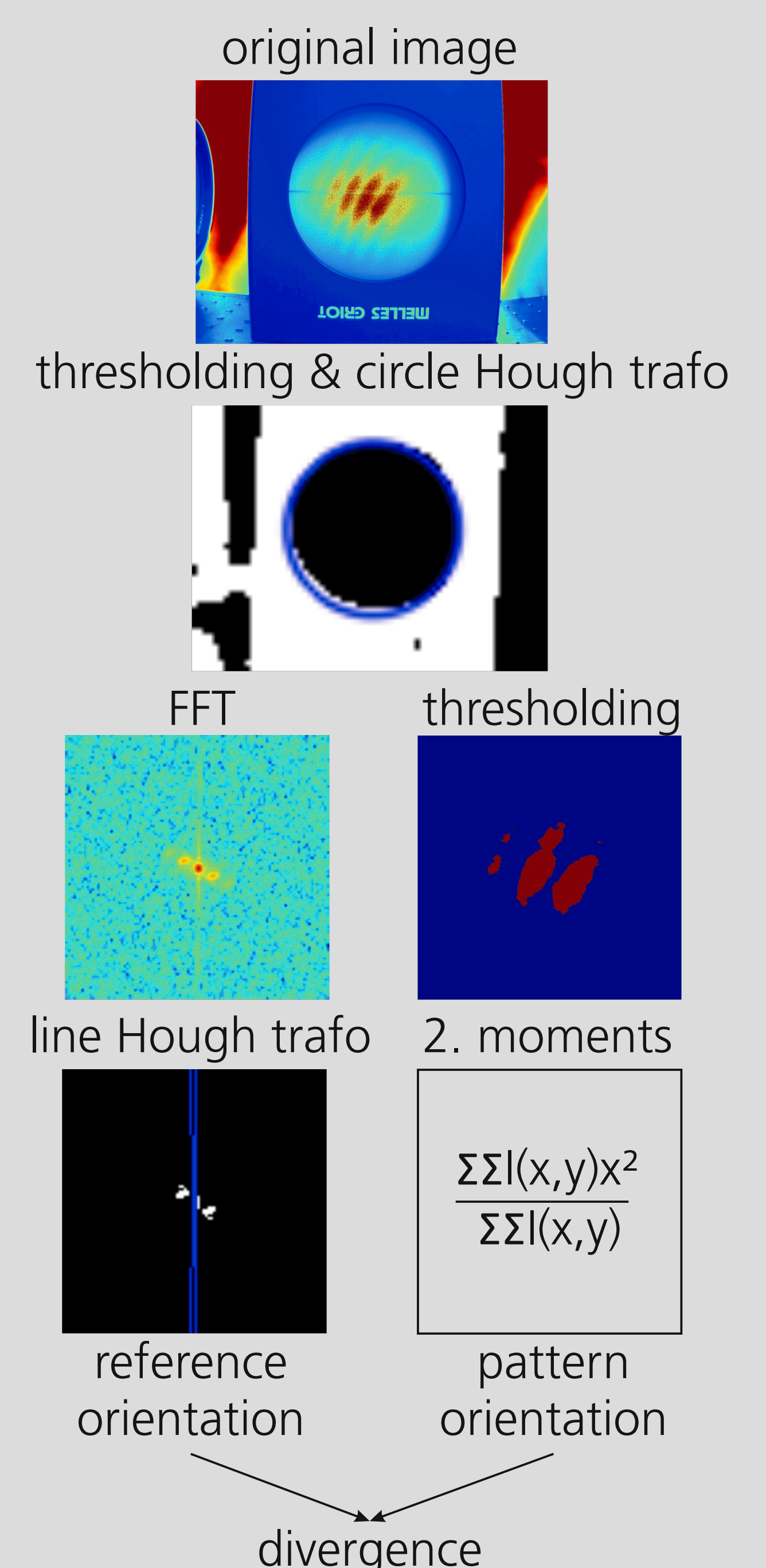
- pattern orientation φ depends on defocus Δf
- $$\tan \varphi = \frac{\Delta f s}{f^2 n \alpha_w}$$
- robust and alignment free

Motorized beam exp.:

- adjustment of divergence in sub- μrad regime

Image processing:

- std. deviation of angle determination $\Delta\varphi = 2.6^\circ$
- **achievable divergence accuracy ca. $10\mu\text{rad}$**



Literatur

P. Senthilkumaran et al.; Applied Optics, Vol. 34, No. 7, 1995
D. Hampf et al.; Advances in Space Research, 2016

