Contactless technology for large deformable mirrors

R.Biasi[a], D.Gallieni[b]

[a] Microgate S.r.l. – Italy
[b] ADS International S.r.l. – Italy

*Ad*Optica consortium

MICROGATE ENGINEERING

Electronic design (HW, SW)
Electronics manufacturing
Integration and test

ADS International

Mechanical design
Mechanical manufacturing
Opto-mechanical integration

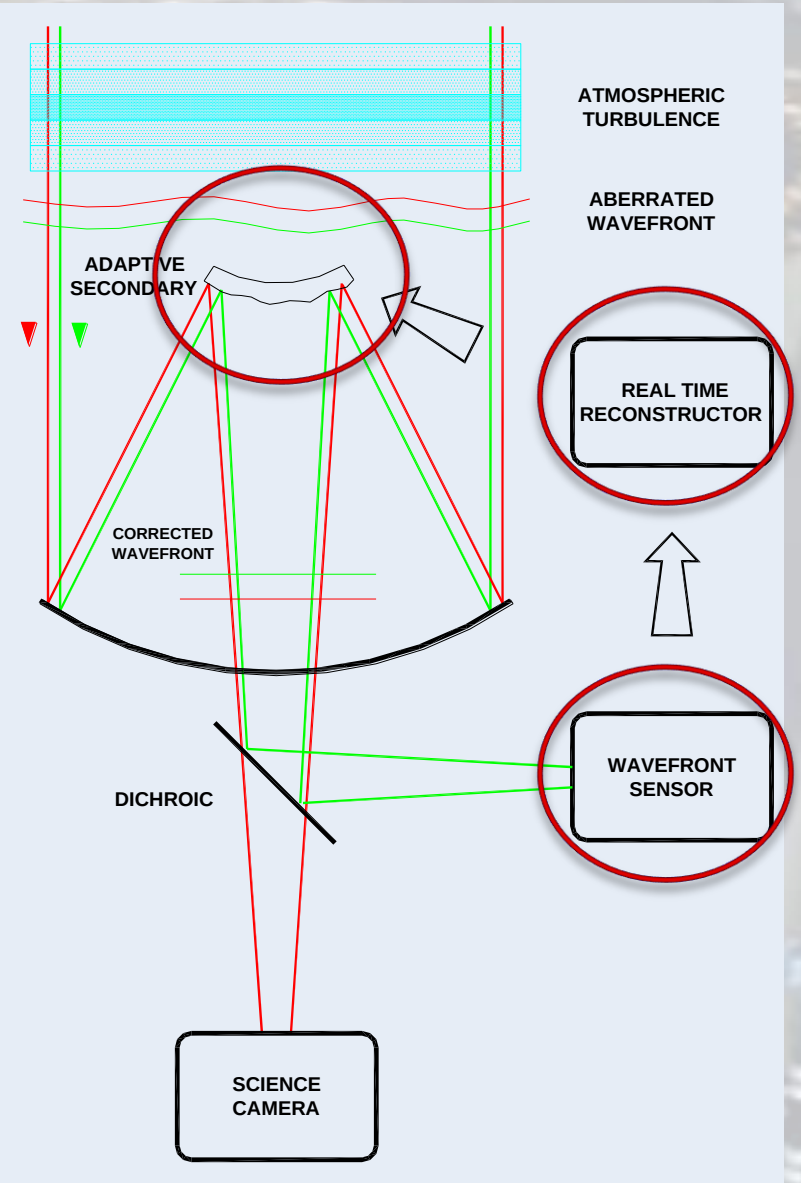
INAF

Original concept
Scientific advisor
Optical testing
…

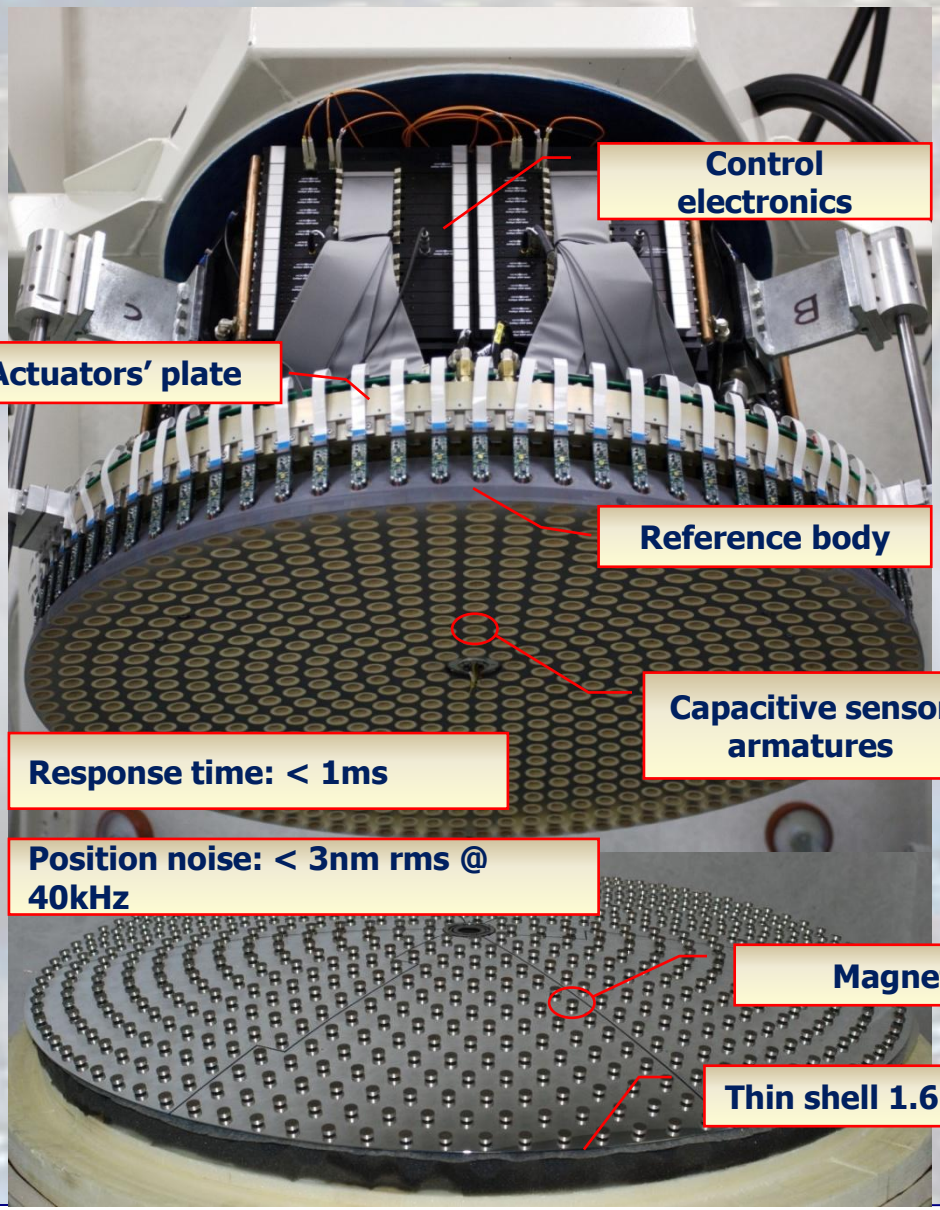
POLITECNICO DI MILANO

Control design
Simulation

Successful cooperation established along the past ~20 years

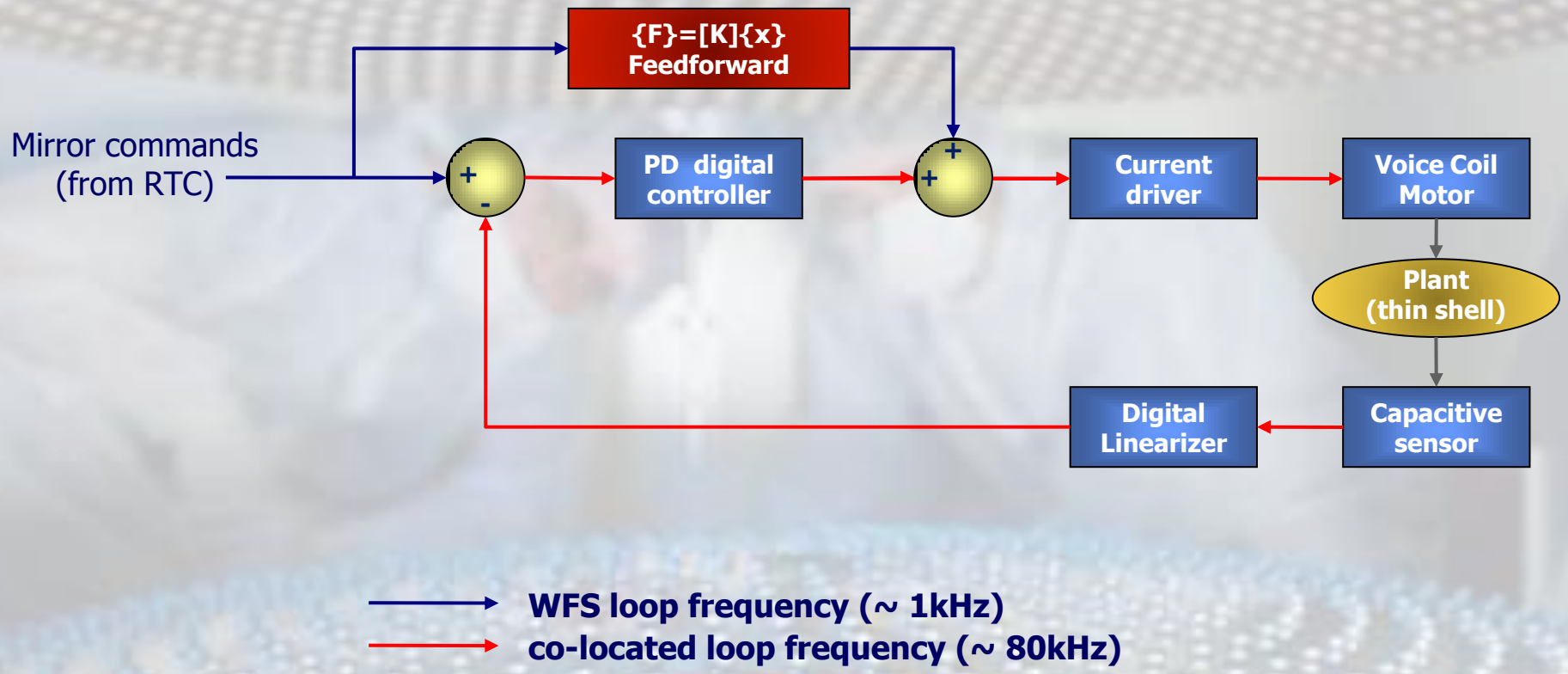


Principle of operation

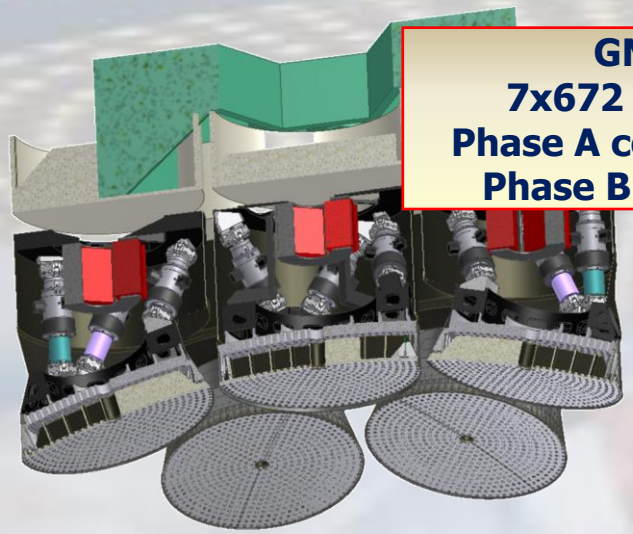


- The thin mirror levitates being **massively controlled** by a large number of electromagnetic actuators
- The actuators are **contactless**, only magnetic forces are transferred to the mirror
  Fail-safe concept
- The distance feedback is provided by **co-located capacitive sensors** measuring the distance between thin mirror and reference surface
- Accurate, stable **embedded metrology** = non AO mode capability + quasi open loop turbulence estimator

How to make a *position* actuator out of a *force* actuator?

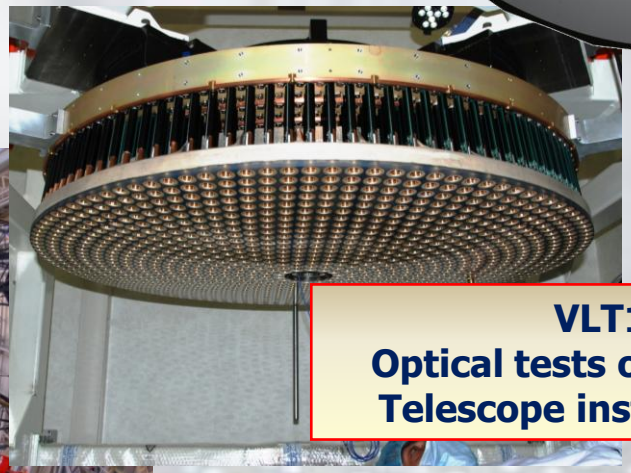


Past, present, future



GMT ASM
7x672 = 4704 acts
Phase A completed 2010
Phase B started 2012

E-ELT M4AU
5190 acts (39m)
Phase B completed 2010
Phase 1 started 2012

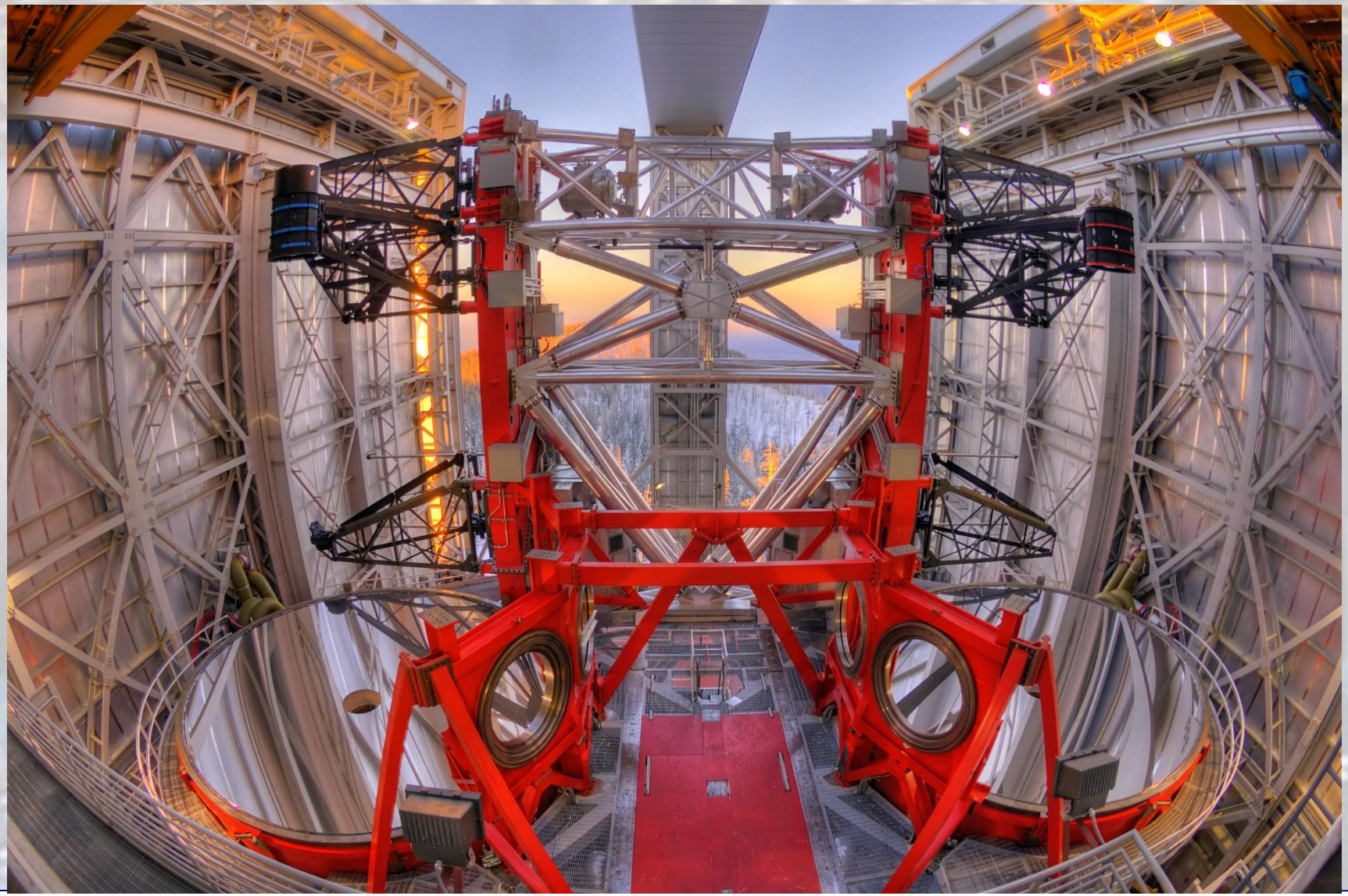


VLT1170
Optical tests ongoing @ ESO
Telescope installation 2014

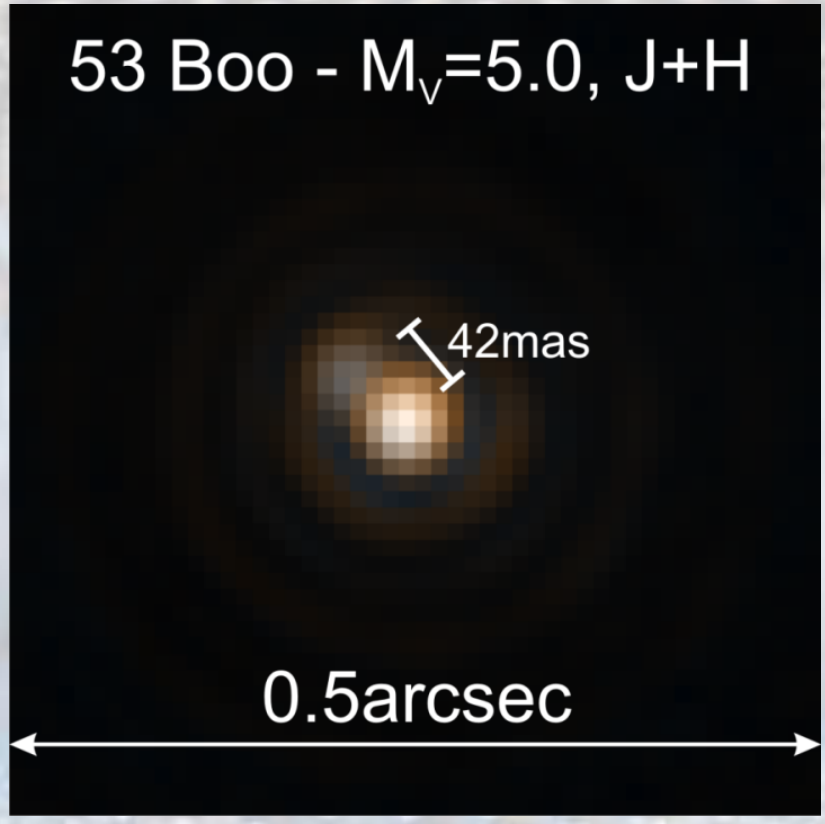
LBT672a/b + MAG585
Operation started 2010

MMT336
Operational since 2002

LBT672 results



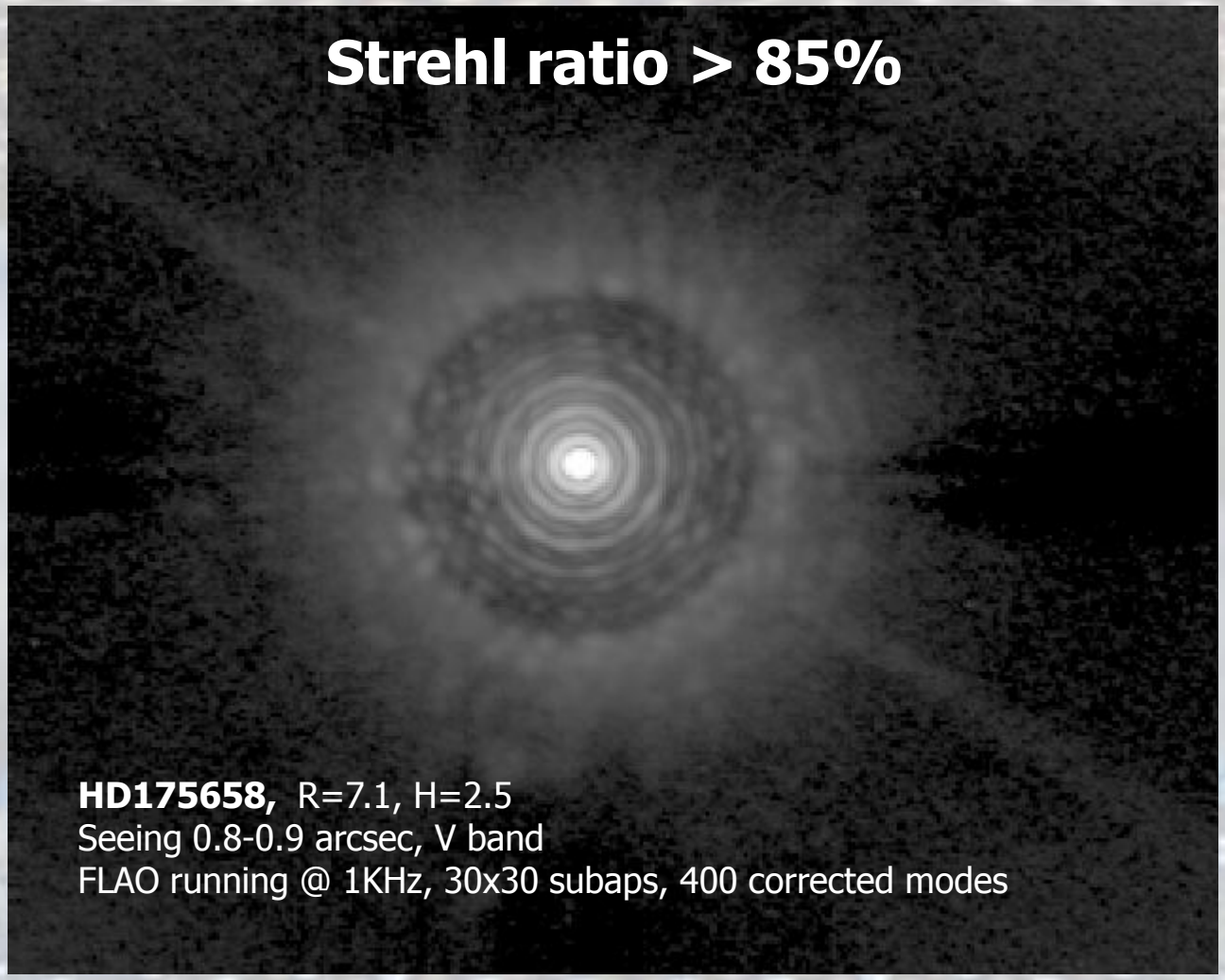
Very first results - FLAO



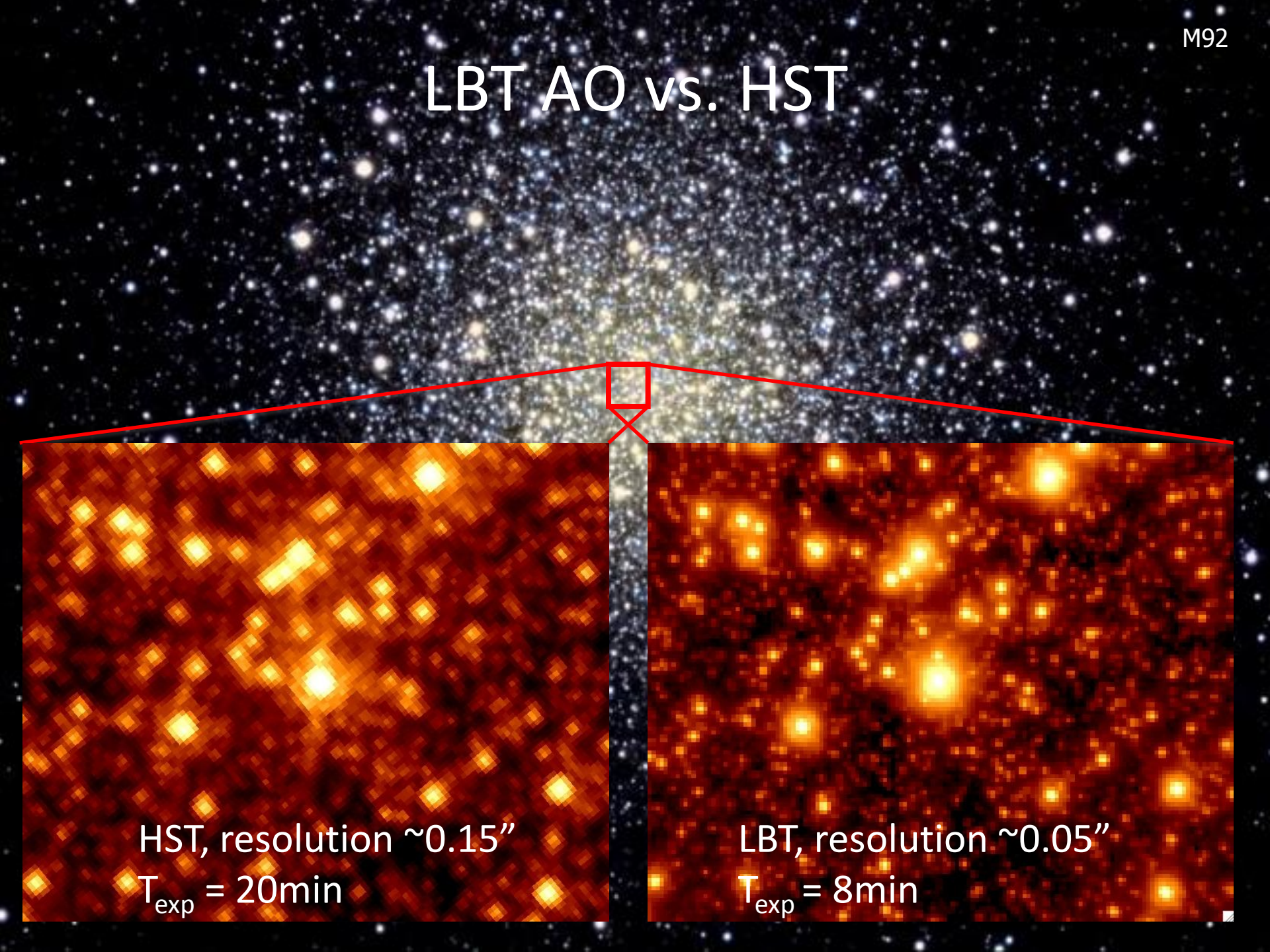
FLAO parameters
30x30 subaps
400 corrected modes
1Khz frame rate

Image data
H band
Exposure: 10s

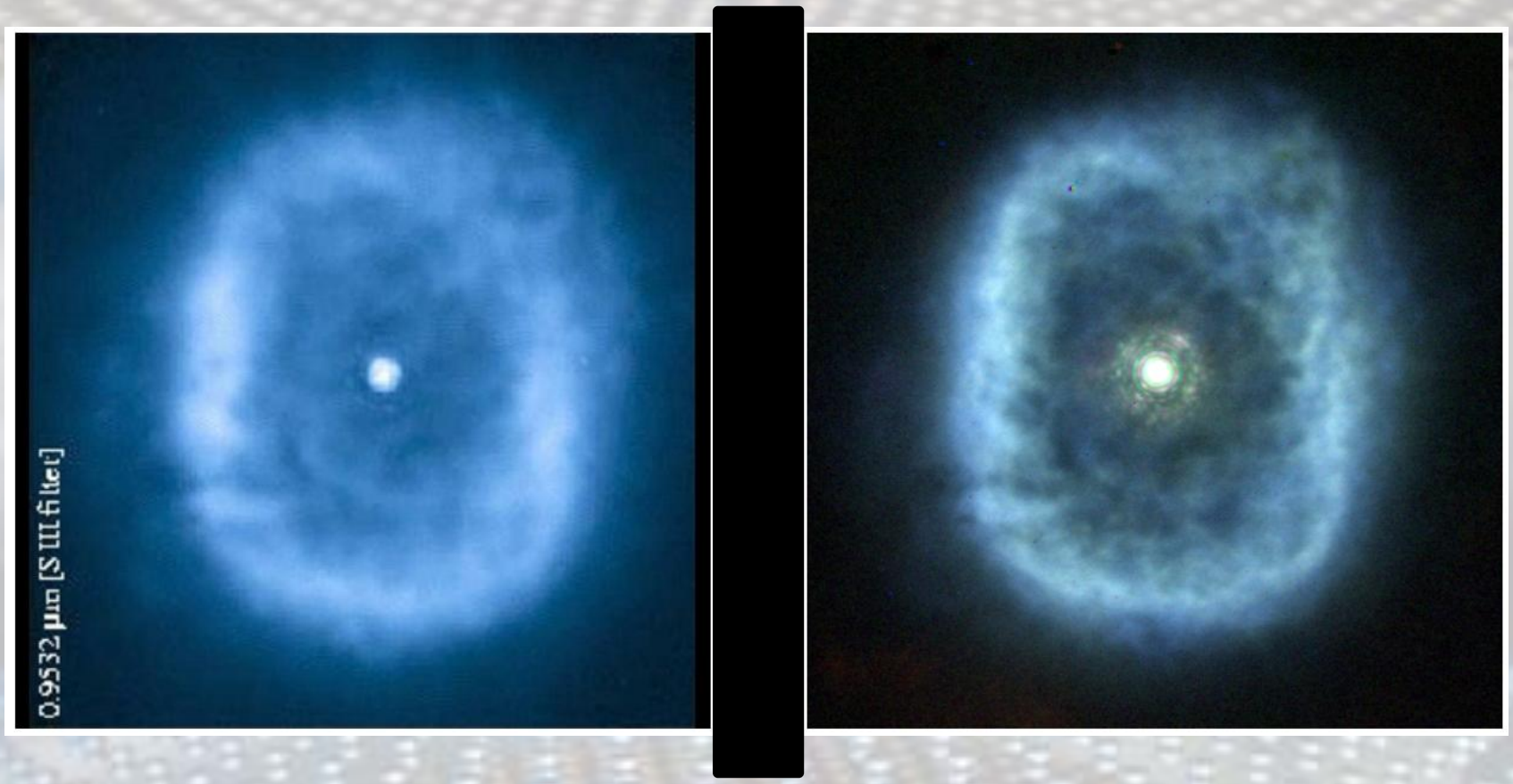
Very high resolution images



LBT AO vs. HST

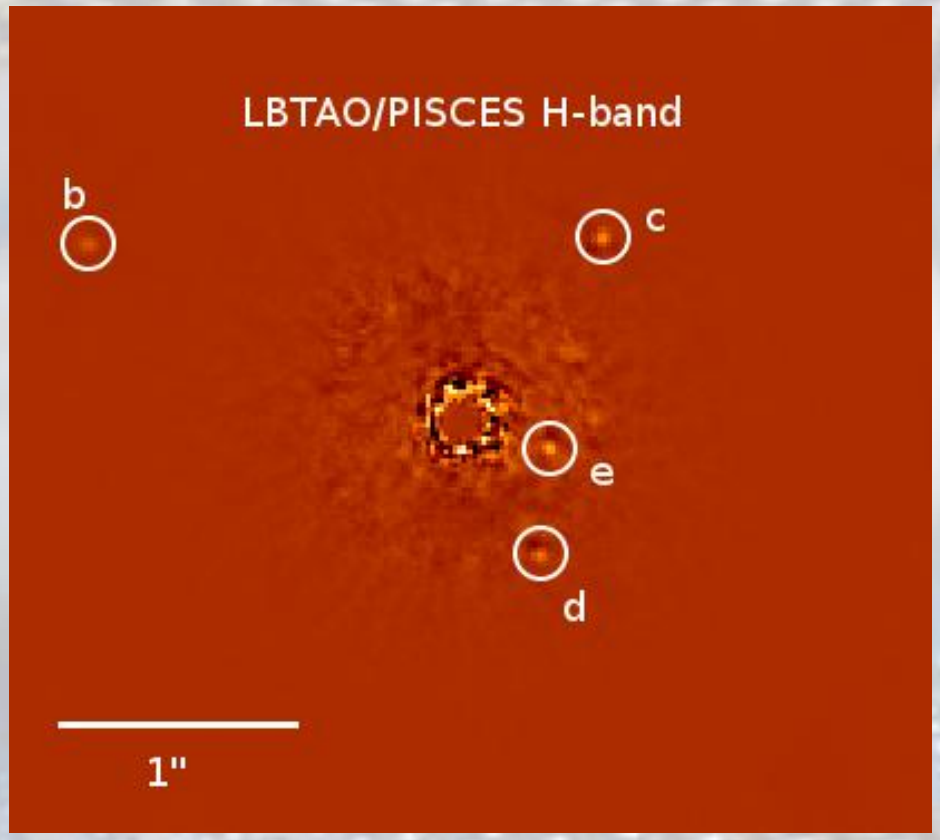

M92
HST, resolution ~0.15”
T_{exp} = 20min
LBT, resolution ~0.05”
T_{exp} = 8min

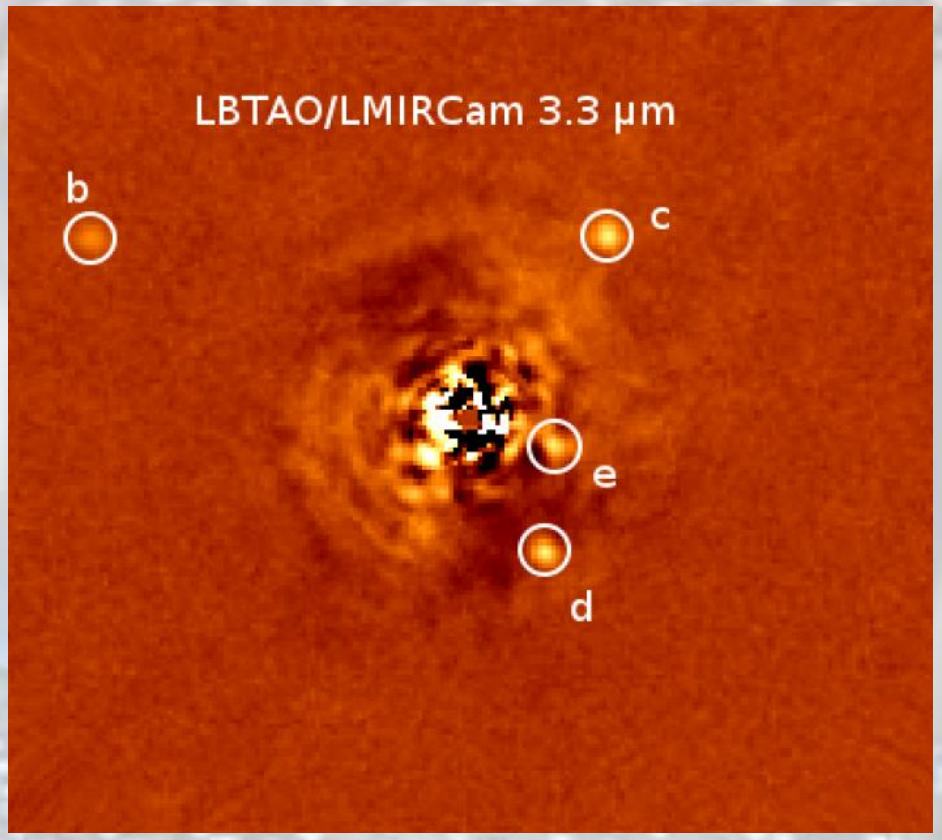
LBT AO vs HST



Planetary Nebula BD+303639 (Cygnus) Left: HST – Right: LBT AO 10 images, 60s exp., H+J

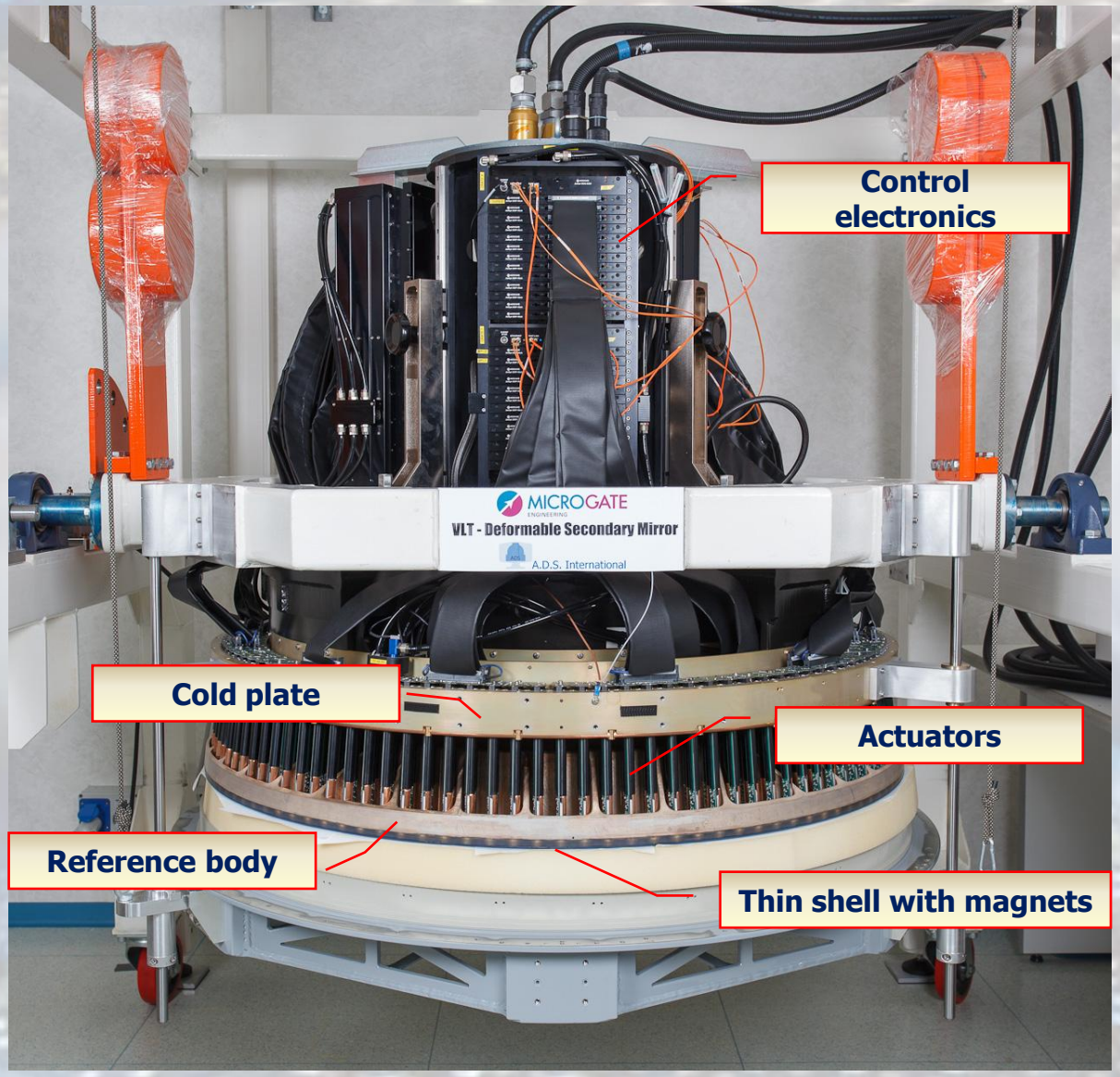
Extra solar planets direct imaging





HR 8799 (mV=6 in Pegasus) with LBT-FLAO

VLT Deformable Secondary Mirror

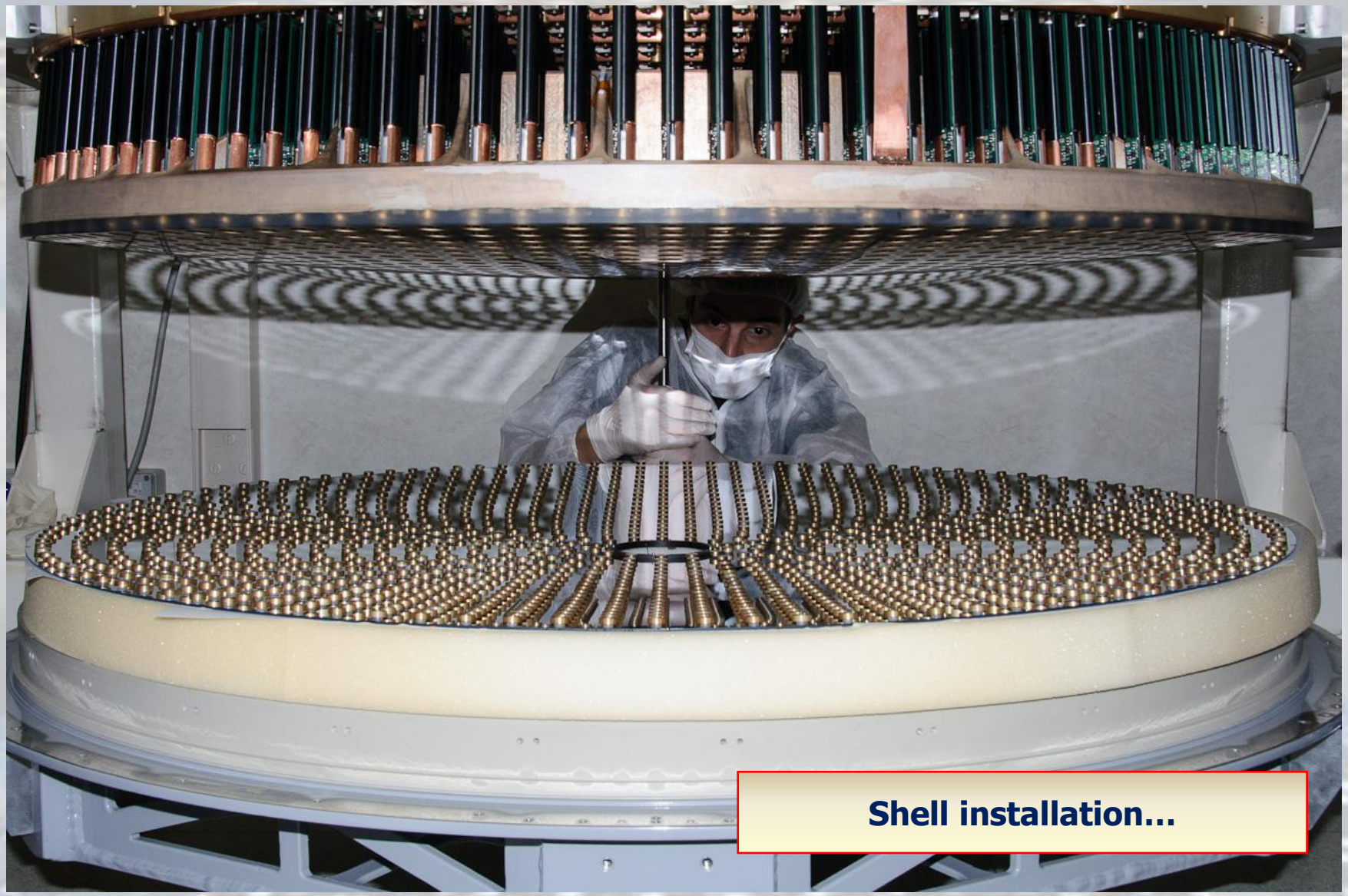


- 1.12m diameter
- 1170 actuators, 29mm spacing
- 2mm aspheric thin shell
- 78 DSP control boards
- 152 GMACs/s, floating point
- 3nm rms sensor noise
- hexapod positioning system

- atmospheric tip-tilt and field stabilization
- high order correction
- chopping

→ ~100µm stroke

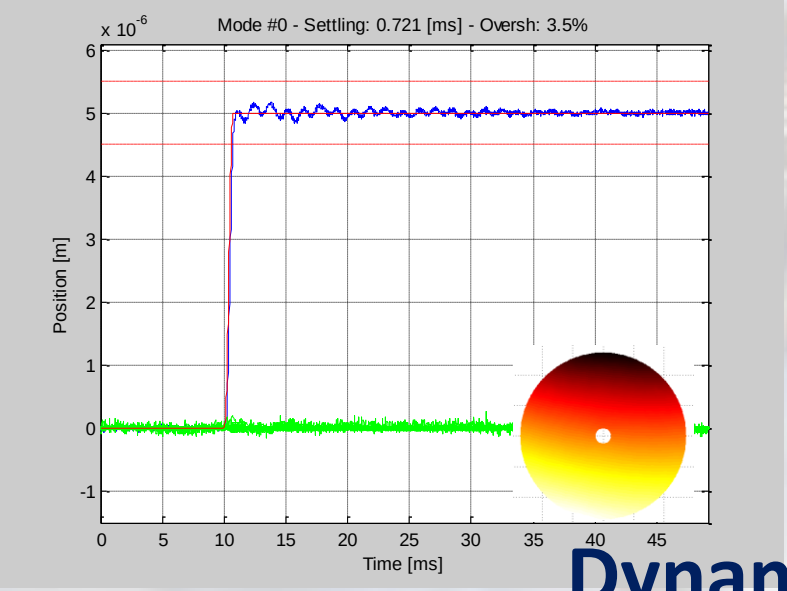
VLT Deformable Secondary Mirror

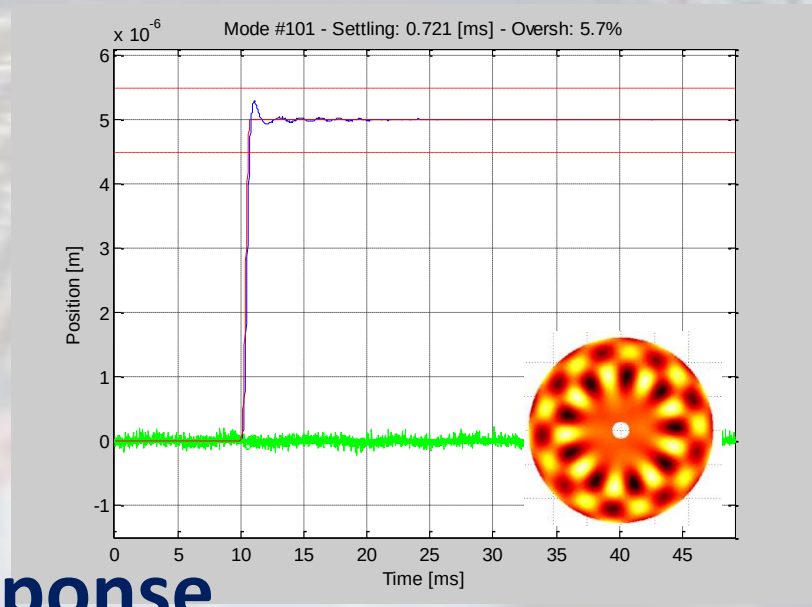


Shell installation…

VLT Deformable Secondary Mirror

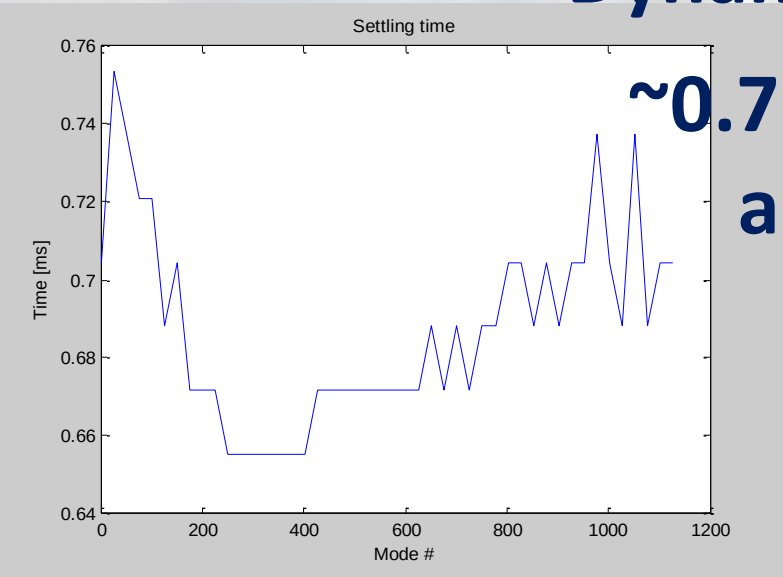
VLT Deformable Secondary Mirror

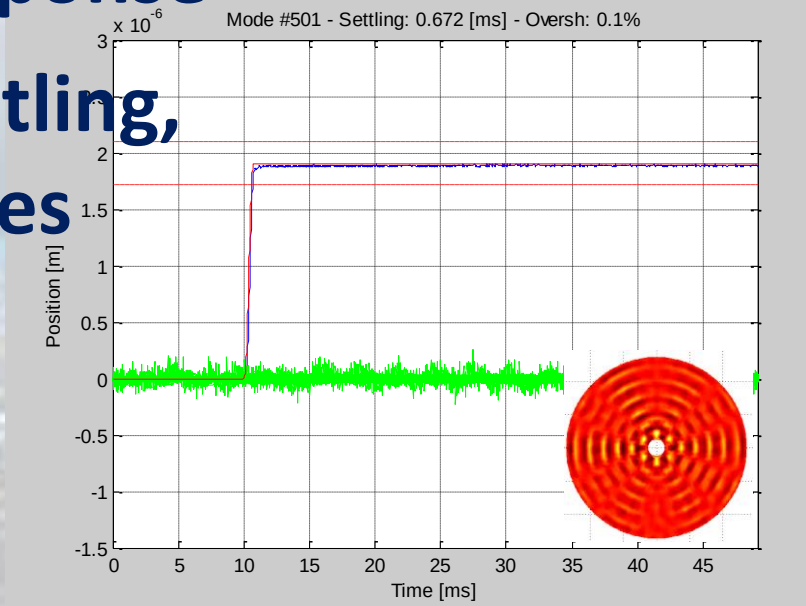




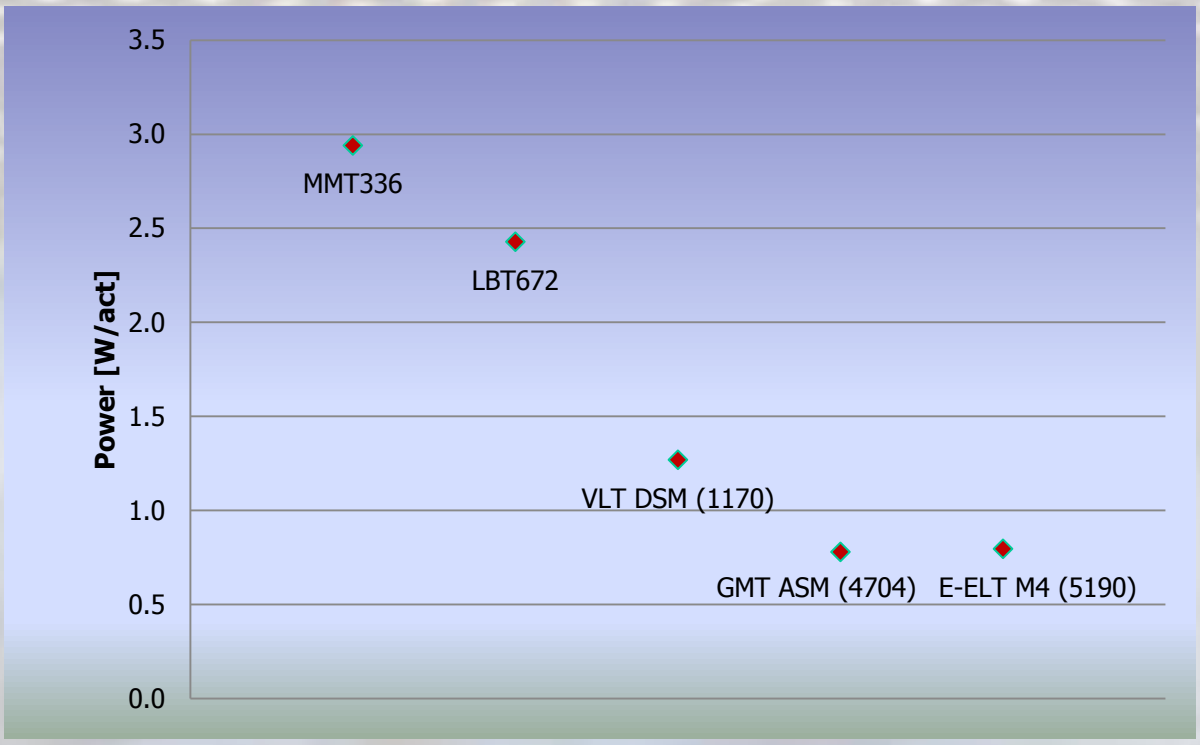
Dynamic response

~0.7ms settling, all modes



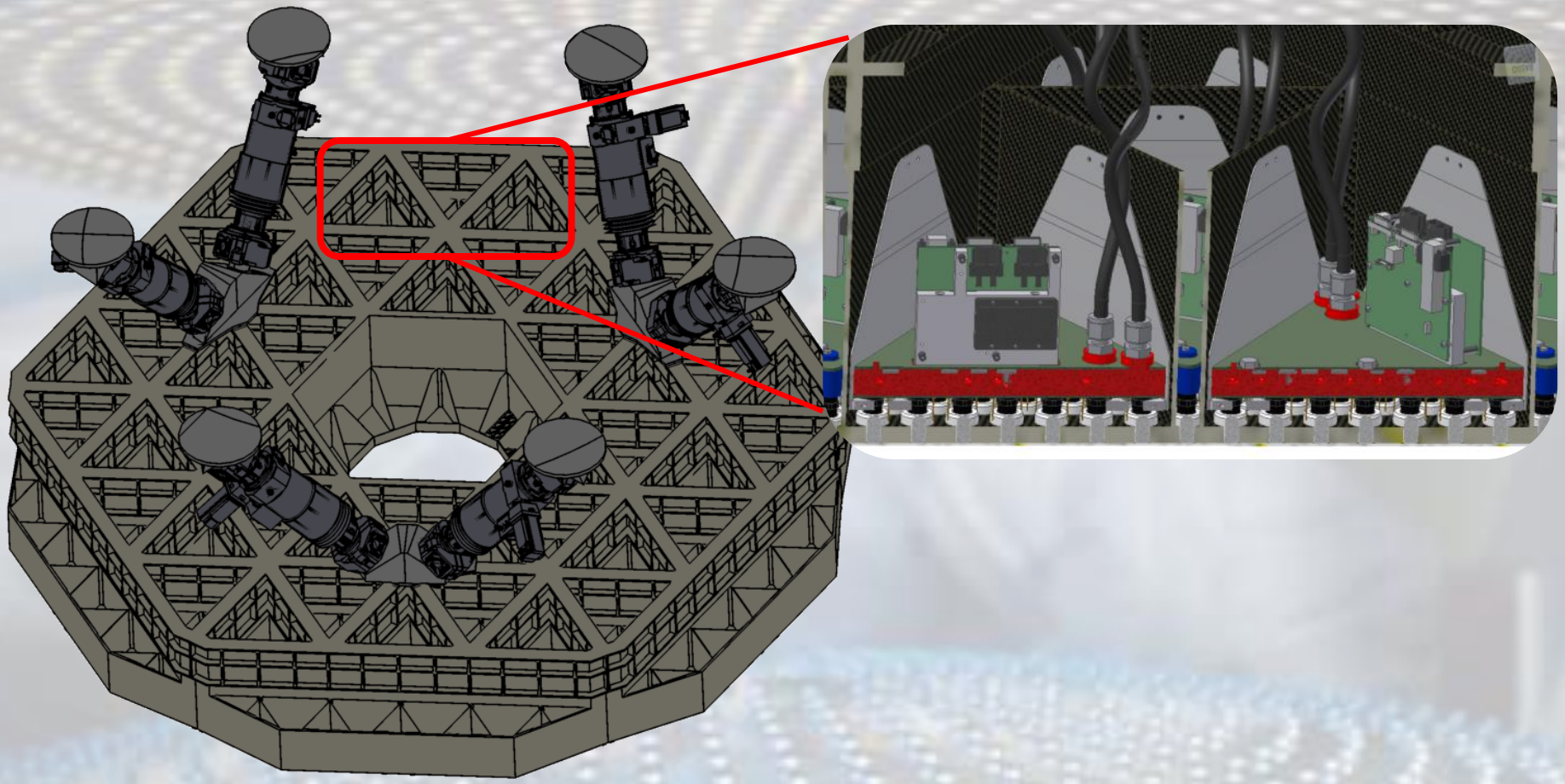


Power dissipation

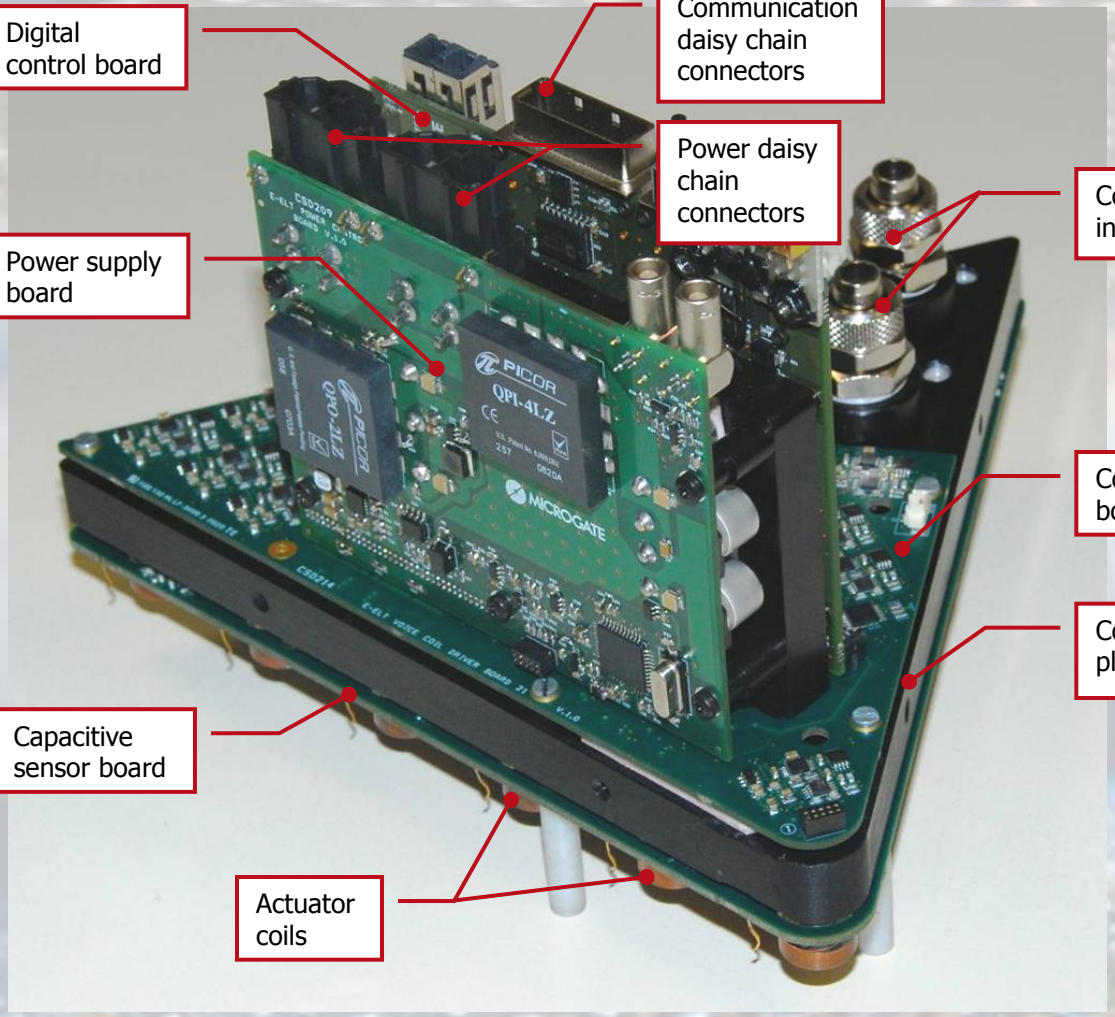


VLT DSM total power: 1485W (median seeing)

External surface temperature within ±0.2 T_{amb}



Structural Reference Body



Line Replaceable Unit ~30 actuators, control electronics and supply

Motivation

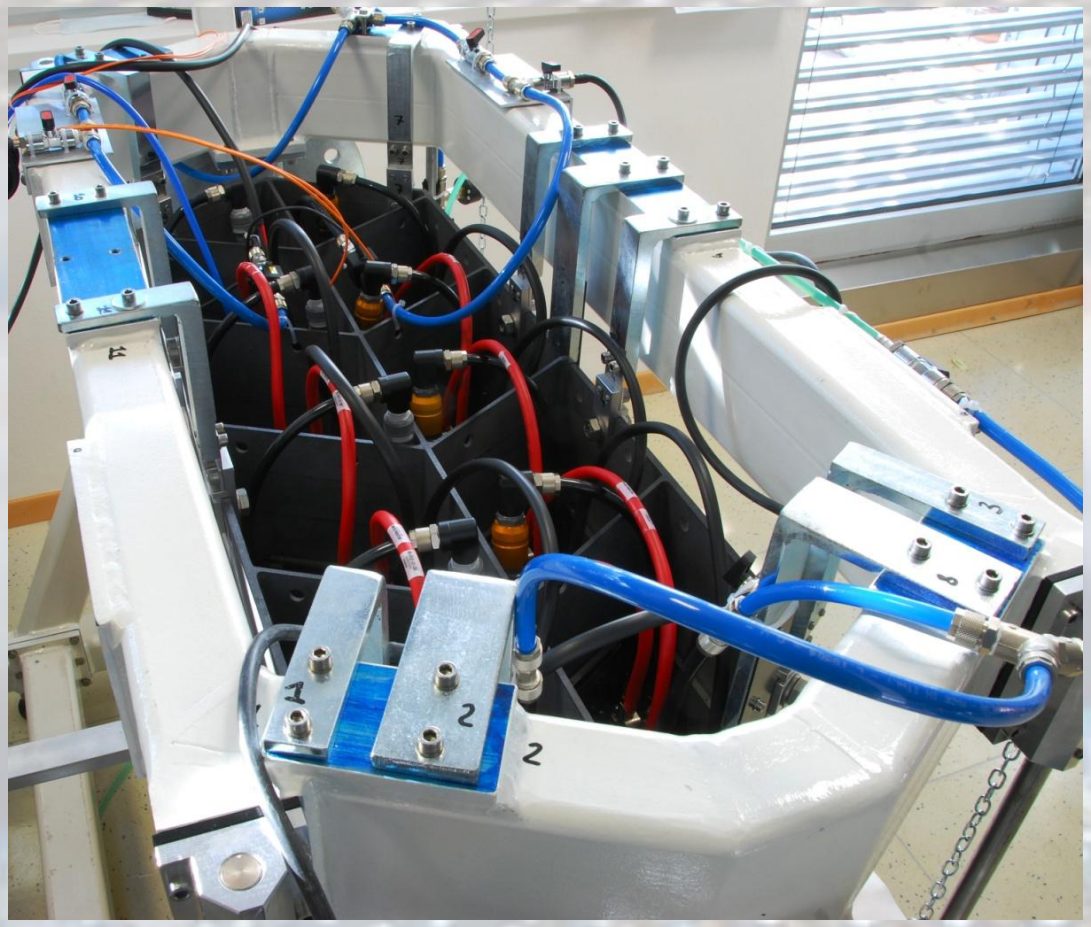
- Integration - Maintenance
- Harness/interfaces
- Power optimization

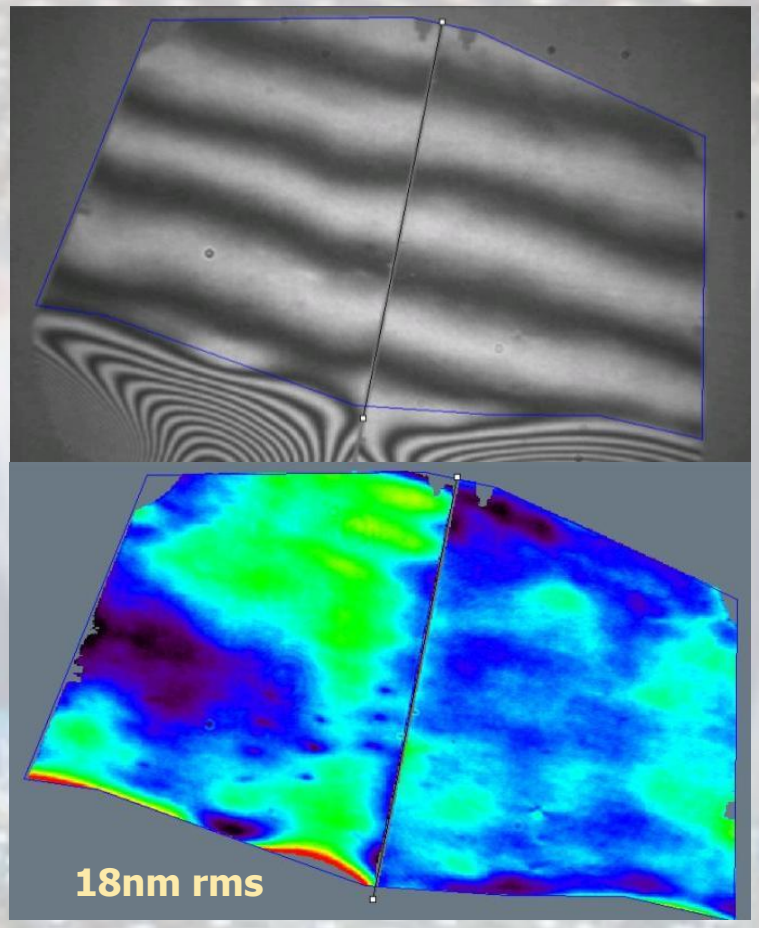
Facts

- Simplified interfaces and harness (supply, data, cooling)
- Sound maintenance concept, maximize system availability
- FPGA-based local control, minimum latency (200ns)
- Global control moved away from adaptive unit
  → on-board power minimized

Brick concept (LRU)

M4 Demonstration prototype





18nm rms flattening (2 segments)
60nm rms thermal stability (ΔT=5°C, 3 hours)

- **Contactless technology suited for large deformable mirror**
- **Not irrelevant number of *telescope units***
- **Large stroke, field stabilization + high order AO on a single corrector**
- **Robust vs. actuators failure**
- **Accurate embedded metrology, no hysteresis**
- **Complex system, but reliability reached through design refinement and experience on deployed systems**
- **Not so expensive…**
- **Limited towards significantly higher density**