Imaging with the VLTI

Adaptive Optics

TNO TPD

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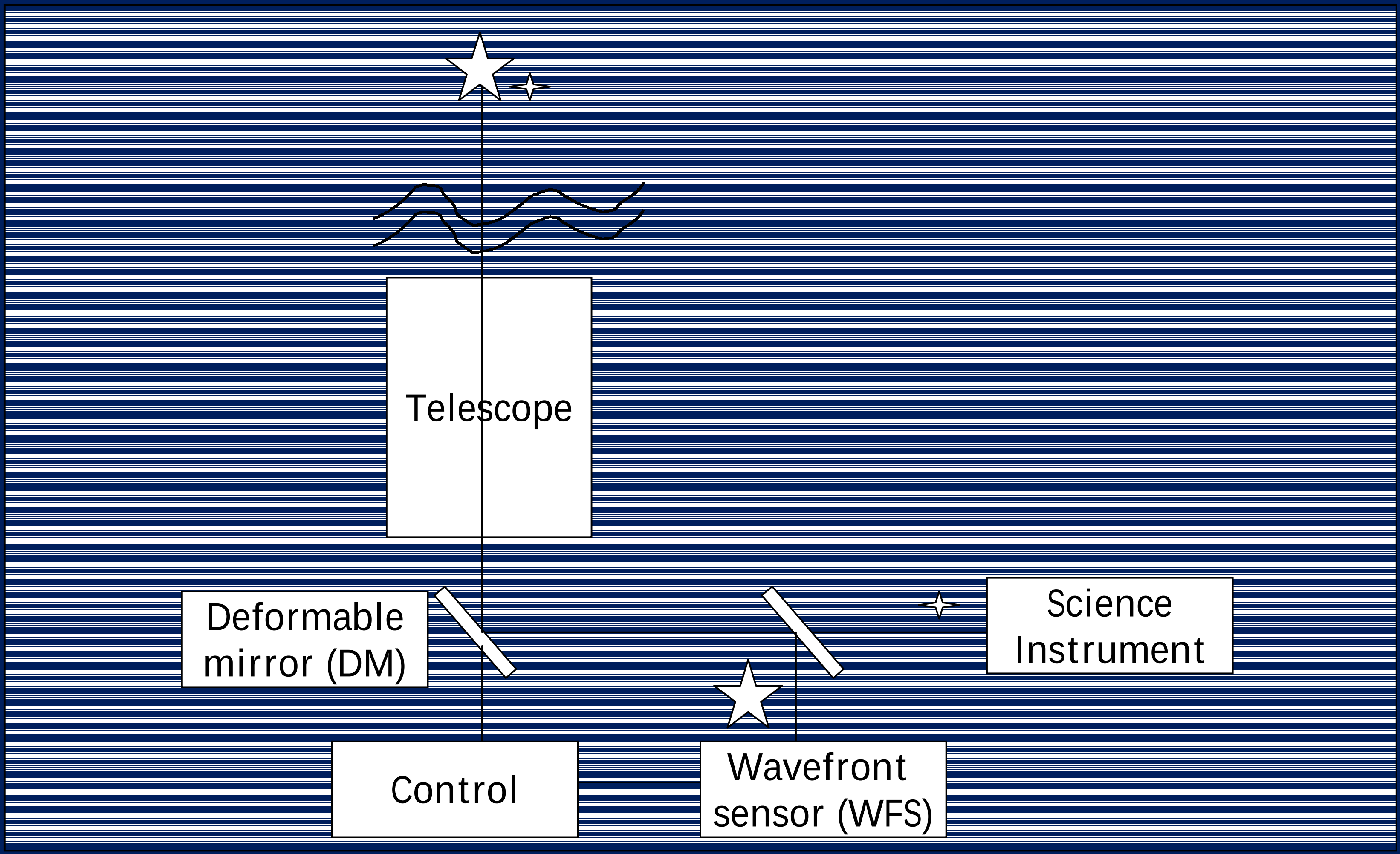
Contents

- Introduction: AO & interferometry
- Conventional AO system performance
- MCAO performance
- MAD
- Interferometry
- AO development strategy
- Conclusions

AO schematic

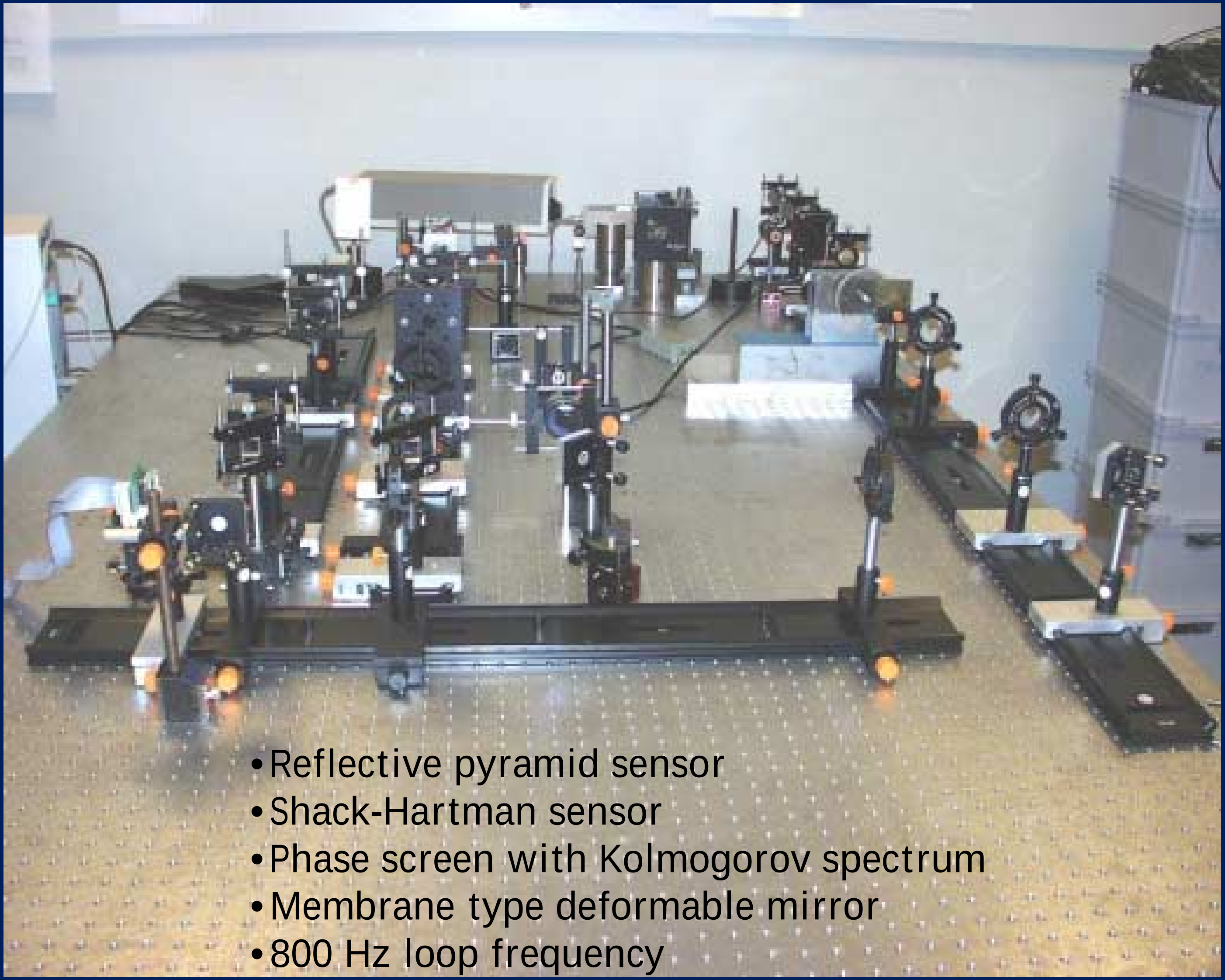
Problem: turbulence of the atmosphere



Conventional AO performance

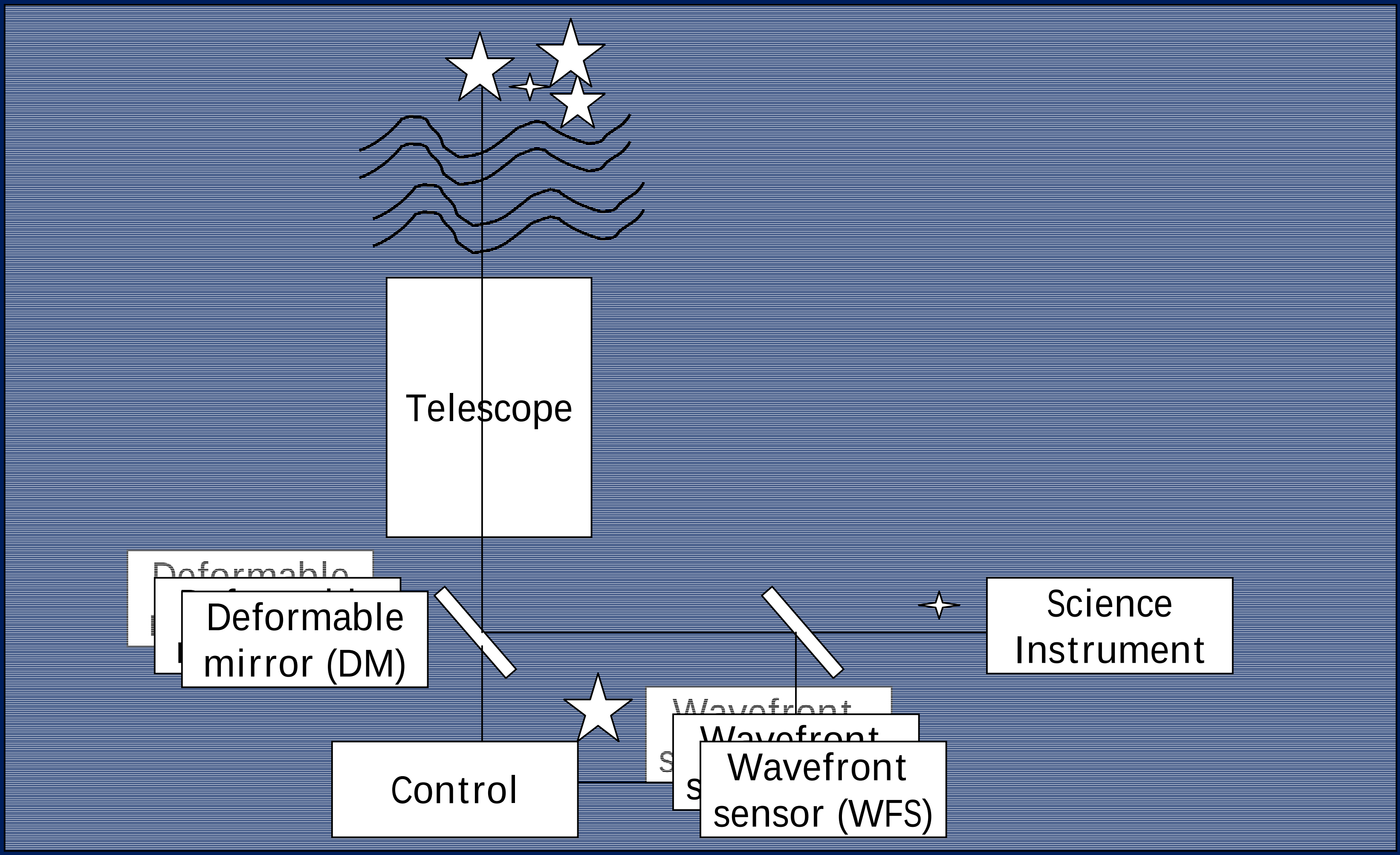
- **Key parameter: Strehl ratio**
- **Error contributions:**
  - DM actuator diameter
  - detector S/N
  - anisoplanatism
  - wind
  - non common-path errors
- **Actuator diameter relative to seeing cell size r0**
  - r0 is 10 cm for visible, > 1 meter for IR
- **Detector signal**
  - star magnitude
- **Anisoplanatism and detector signal limit sky coverage**

TPD Adaptive Optics Breadboard



- Reflective pyramid sensor
- Shack-Hartman sensor
- Phase screen with Kolmogorov spectrum
- Membrane type deformable mirror
- 800 Hz loop frequency

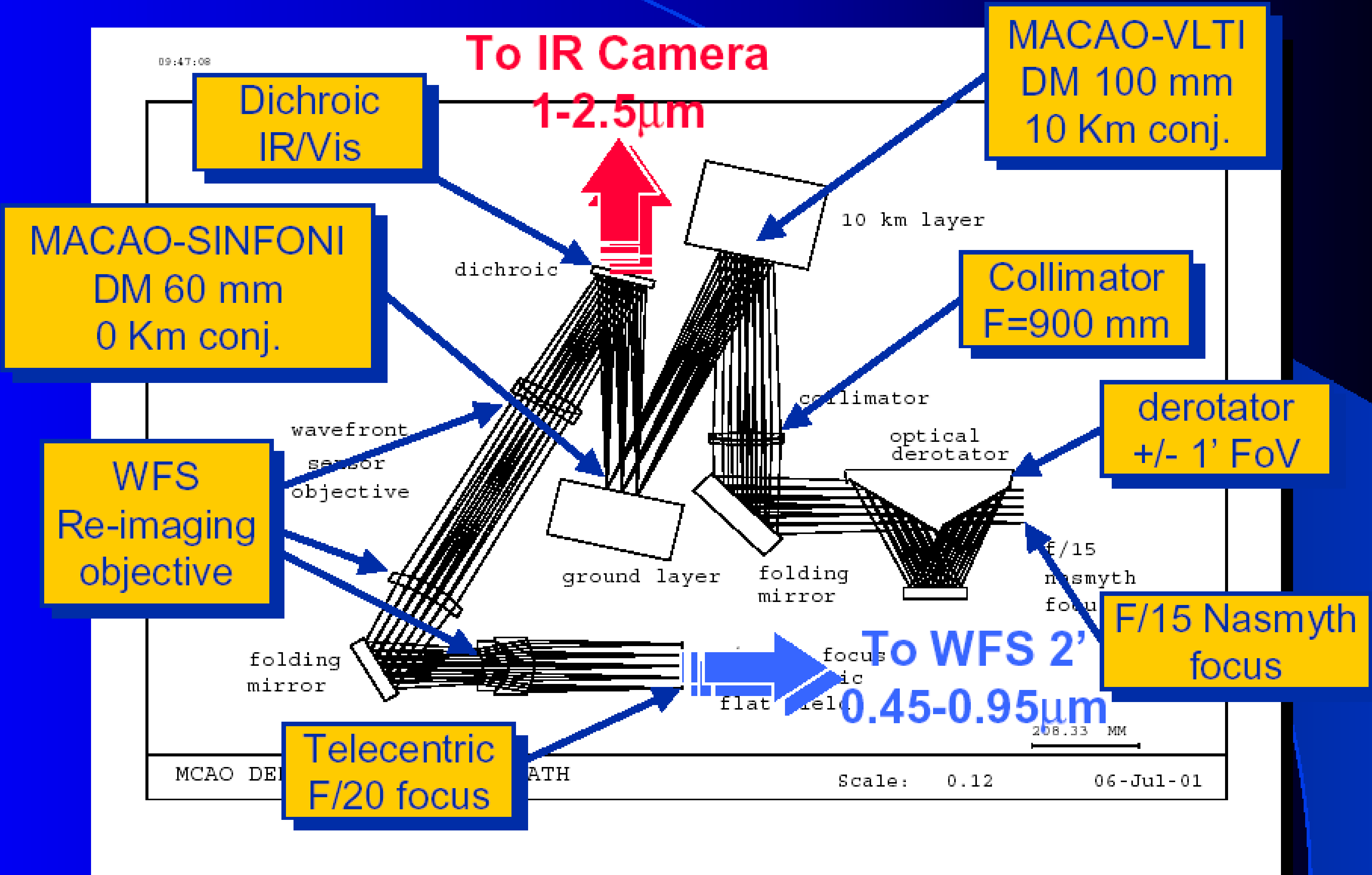
Multi Conjugate AO configuration



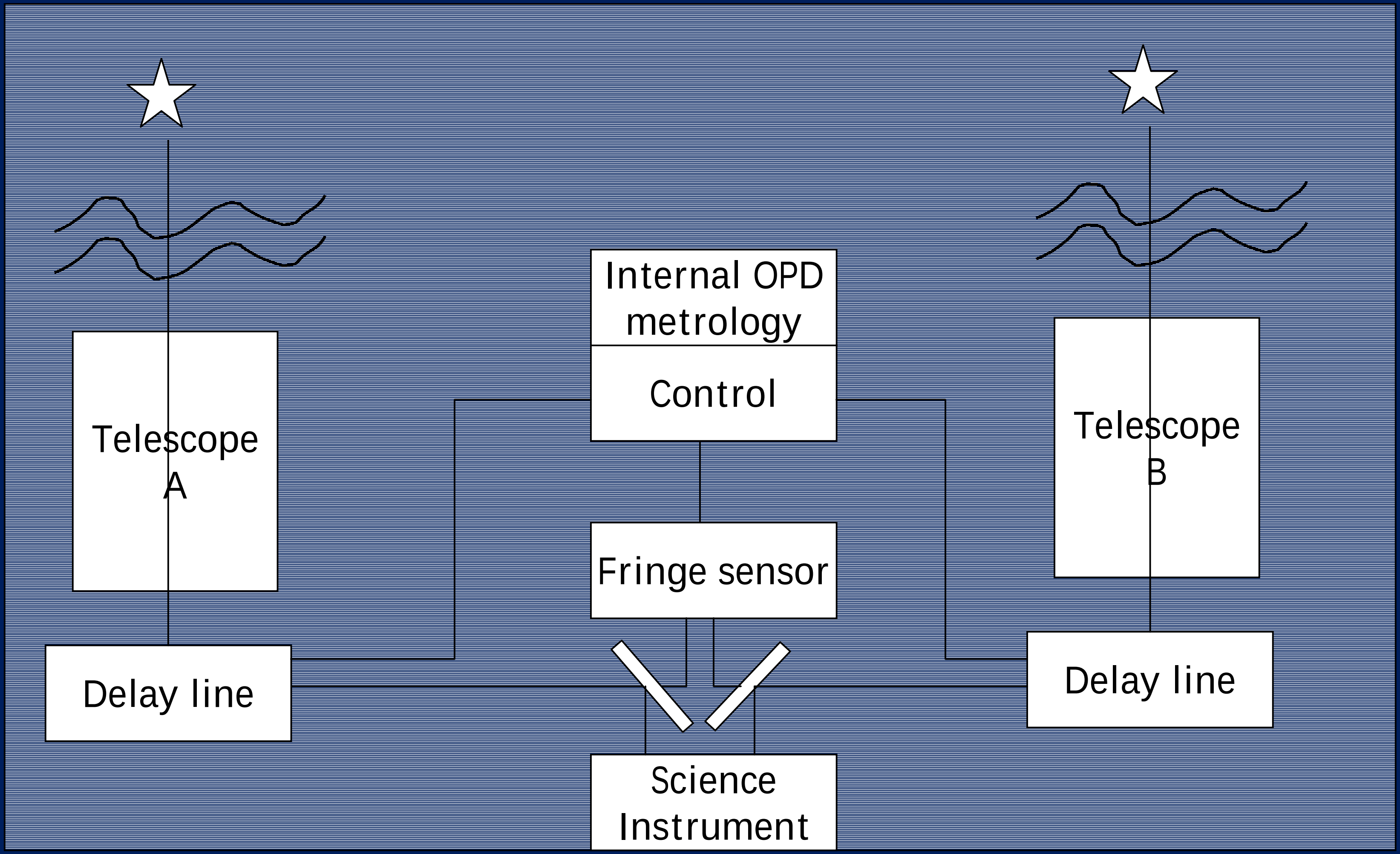
Multi Conjugate AO performance

- **Key parameter: Strehl ratio**
- **Error contributions:**
  - DM actuator diameter
  - detector S/N + + +
  - residual anisoplanatism + + +
  - wind + + + (model based control)
  - non common-path errors
- **Strehl ratio improvement over larger FoV**
- **Further improvement by Laser Guide Star (LGS)**

MAD Bench optical design



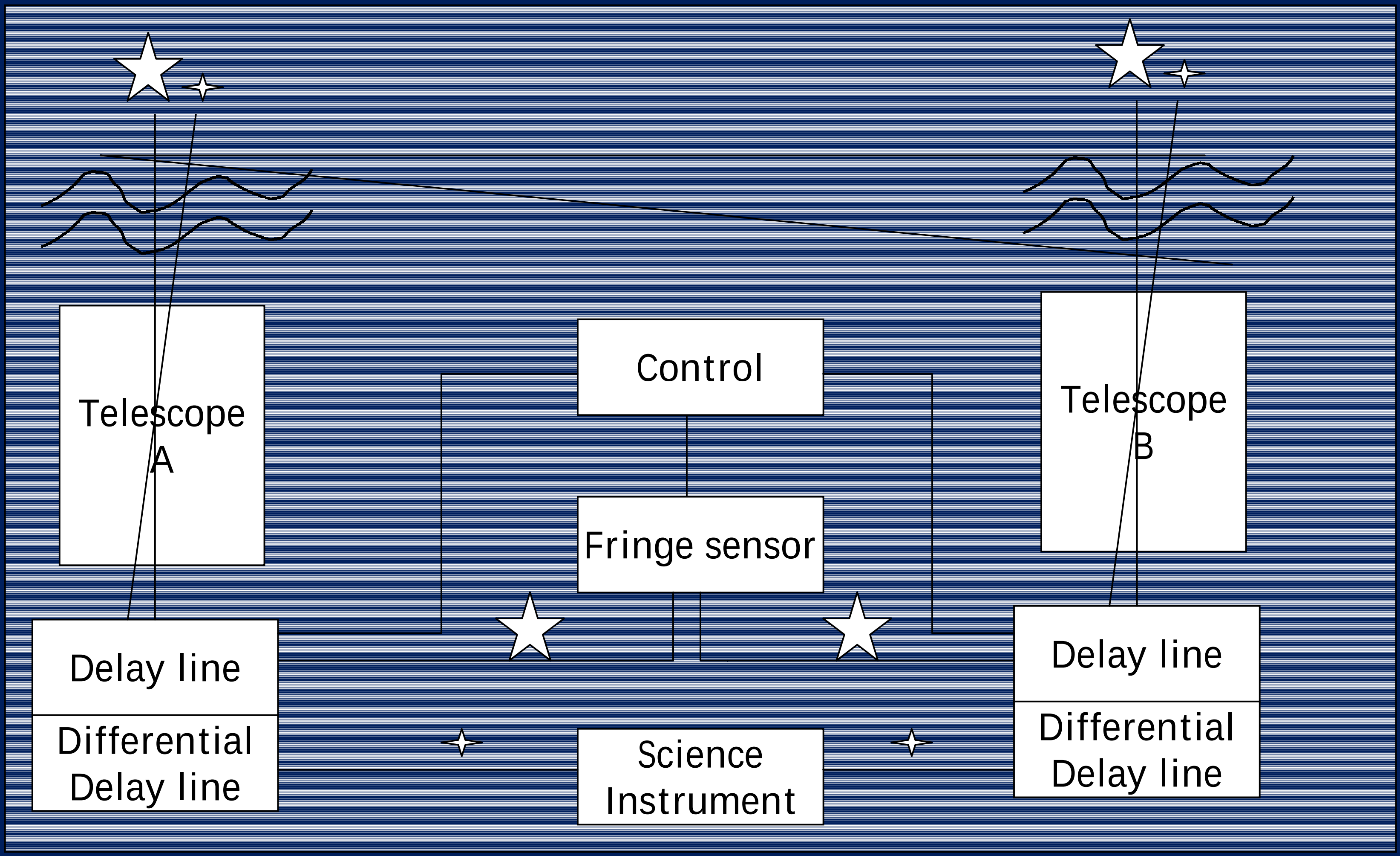
Interferometry configuration



Interferometer performance

- **Key parameter: fringe visibility**
- **Error contributions:**
  - Strehl ratio telescope A, Strehl ratio telescope B
  - piston: optical path difference (OPD)
  - fringe sensor S/N
  - outer scale of turbulence
  - residual OPD metrology error & OPD caused by DM
- **Fringe sensor signal**
  - star magnitude
  - limits sky coverage

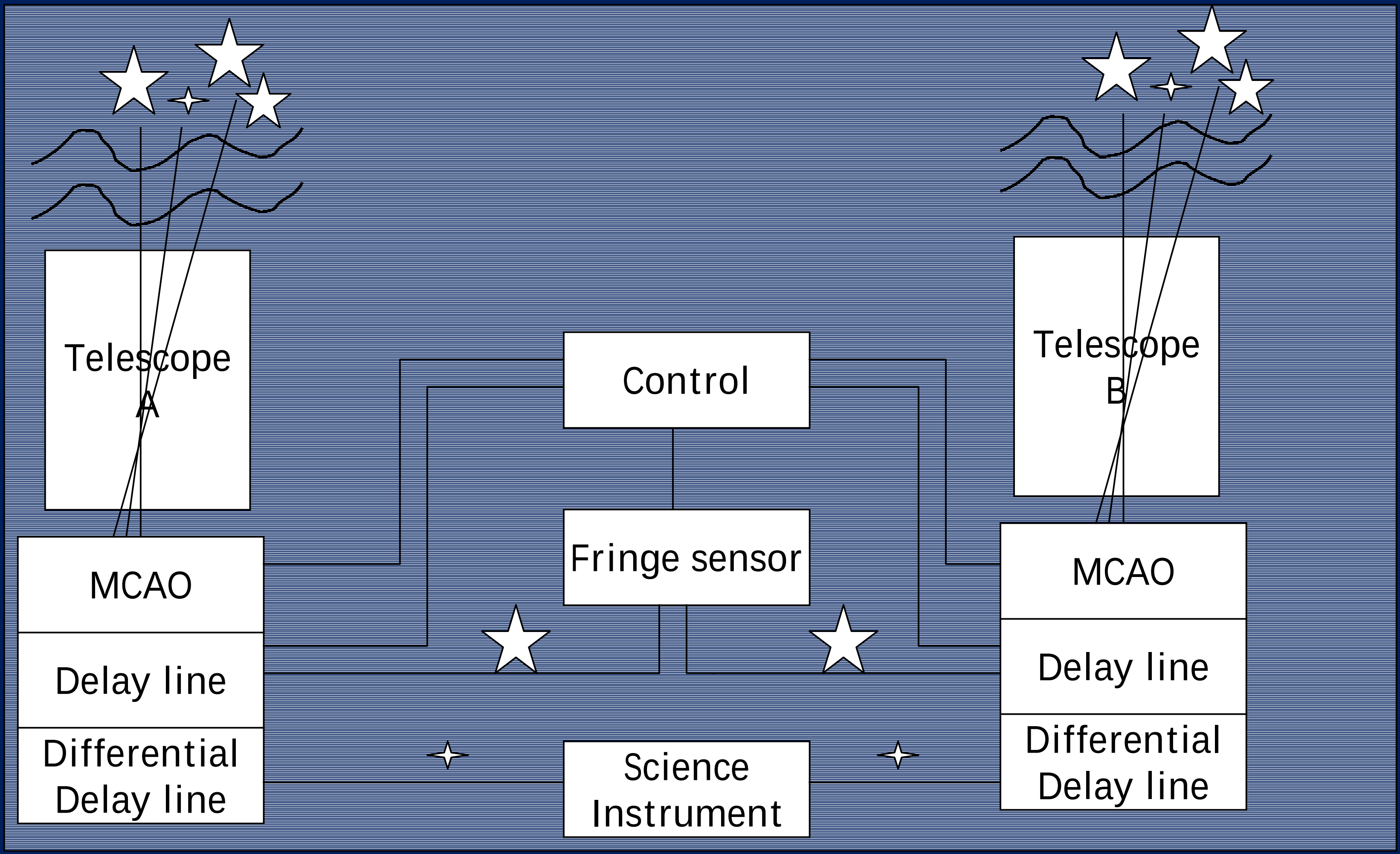
Phase reference interferometry schematic



Phase Reference Interferometer performance

- **Key parameter: fringe visibility**
- **Error contributions:**
  - Strehl ratio telescope A, Strehl ratio telescope B
  - piston: optical path difference (OPD)
  - fringe sensor S/N + + +
  - OPD anisoplanatism
  - outer scale of turbulence
  - residual (OPD) metrology error & OPD caused by DM
- **Improved sky coverage**

VLTI Imaging schematic



Strategy for AO (*ESO N. Hubin, jan 2000*)

AO concept	Physical limitations	Performance @ SR=20%
2001 NGS AO for 8 m telescopes	NGS flux anisoplanatism	Sky coverage: 5% in IR Corrected FOV: 30’’ Diff.lim. in IR
2003 LGS AO for 8m	Cone effect, tilt NGS flux anisoplanatism	Sky coverage: 50% in IR Corrected FOV: 30’’ Diff.lim. in IR
2005 MCAO Tomography for 8m 2-3 DMs	NGS flux Residual anisoplanatism	Sky coverage: 30% in visible Corrected FOV: 1’ vis. Diff.lim. in vis. (0.012’’)
20?? OWL Multi LGS & Tomography for 100m, 2-3 DMs	Residual anisoplanatism	Sky coverage: 80% vis. Corrected FOV: 1’ vis. Diff.lim. in vis. (0.001’’)

Overwhelmingly Large Telescope (OWL)

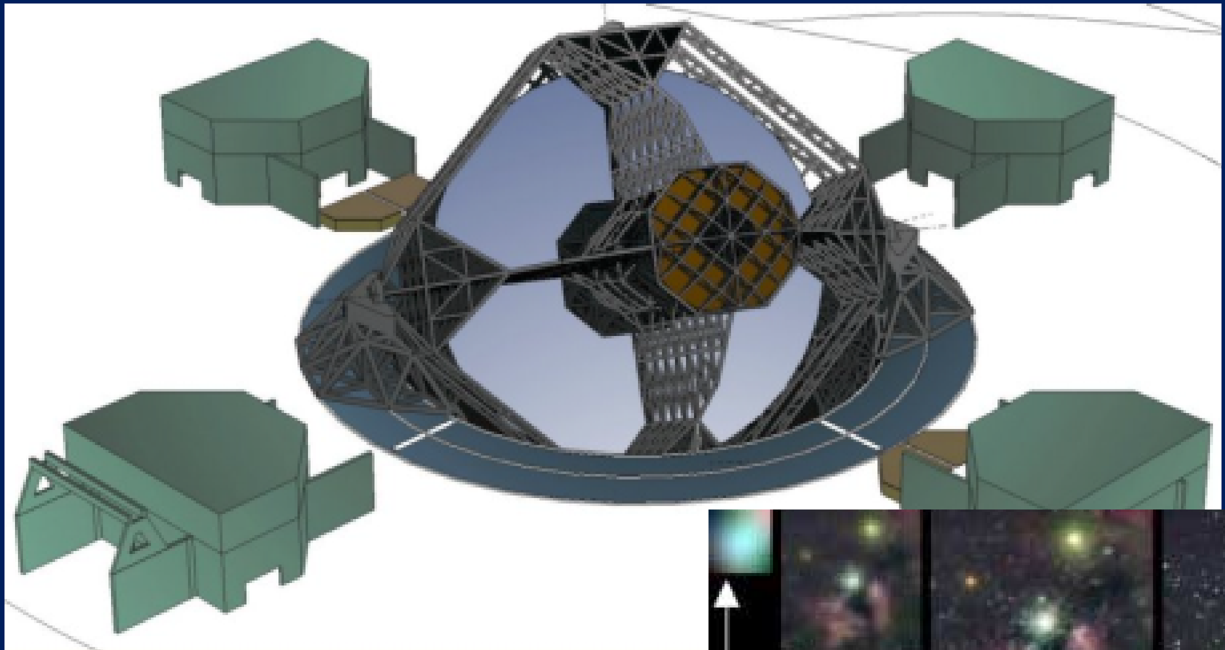


Figure 8. Telescope pointing at 60° from zenith, layout o

- Large Field of View
- Collecting Power = 40 * VLTI
- MCAO with 500.000 elements

Conclusions

- **Enormous gain in quality of observations is feasible**
- **Challenges:**
  - MCAO/Interferometer system complexity
  - Data-processing
  - Subsystem development:
    - Deformable mirrors
    - Wavefront sensors & detectors
    - Control algorithms
    - Phase reference subsystems (PRIMA)