First generation of AO systems for ELTs: a short review of possible systems

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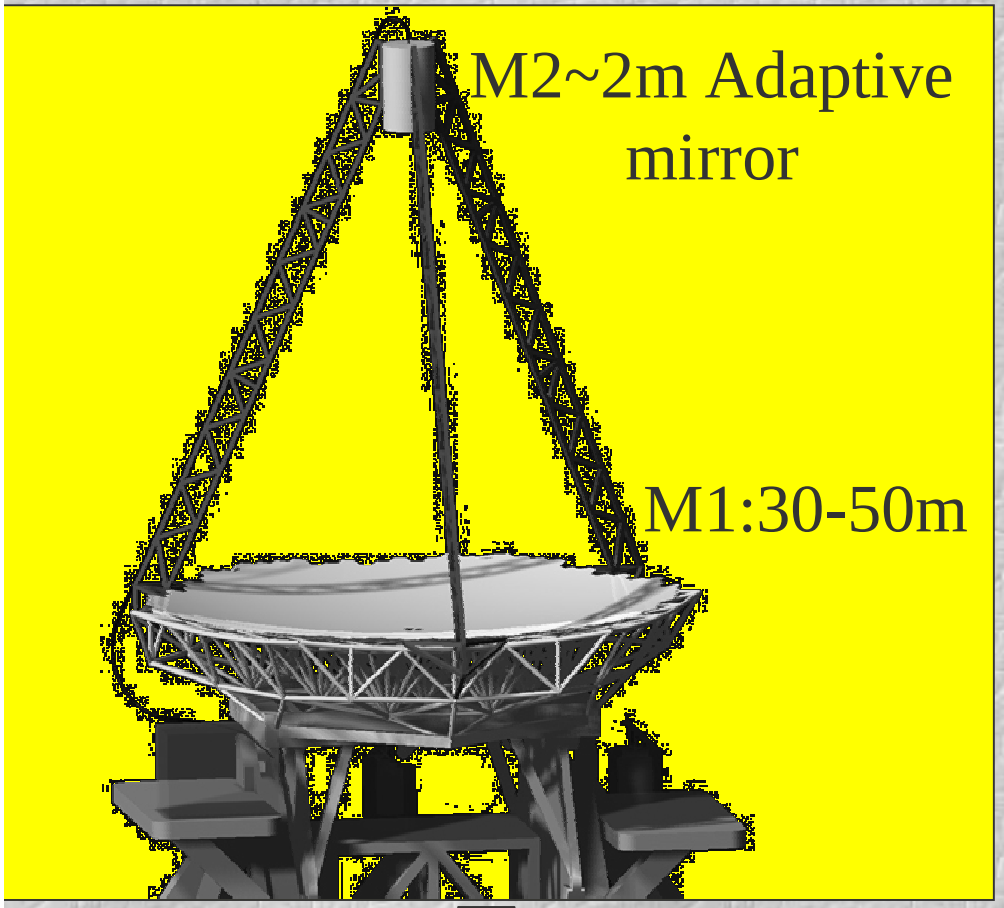
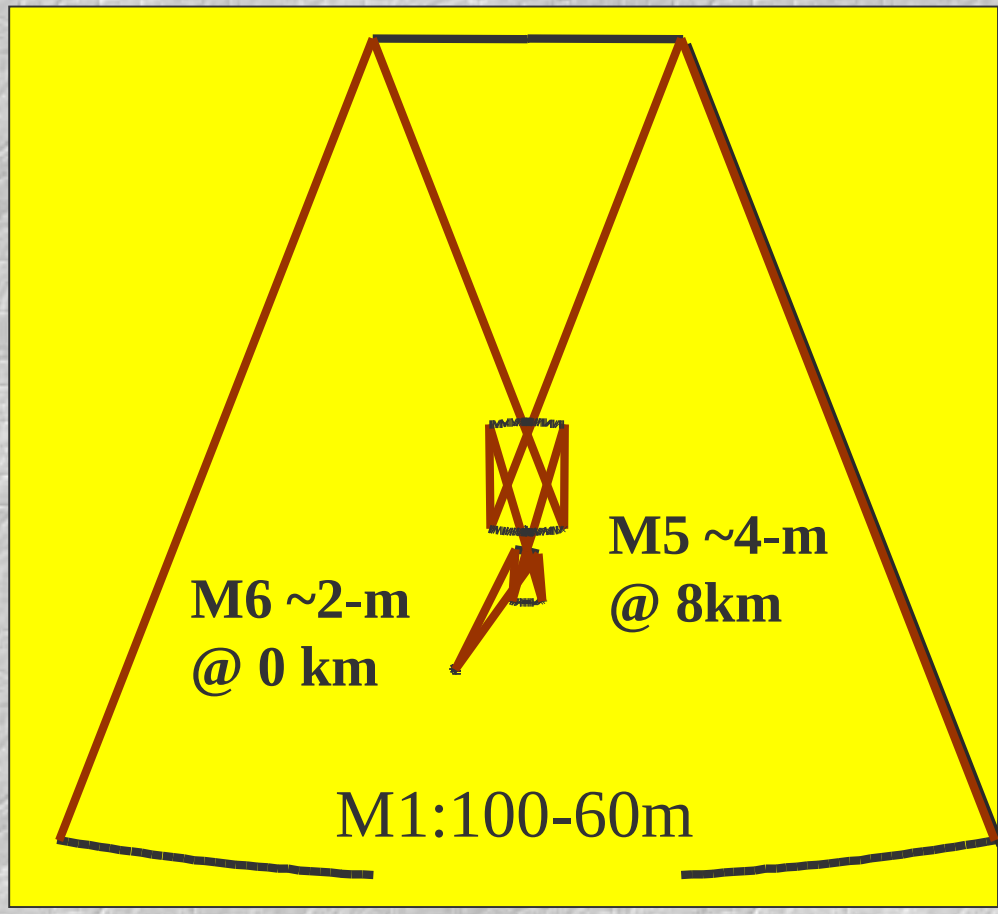
ELT optical design and Adaptive Optics





+ post focal AO correctors

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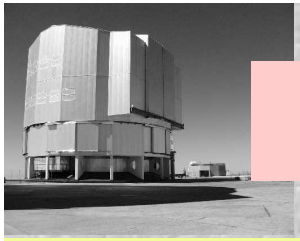
Conventional AO with NGS

- Telescope 30-50 m
- 1 DM with ~2-3act/m
- DM diameter 2m
- 2800-5000 actuators
- 1 WFS within $?_o$
- Diffraction limit at 1µm
- XAO above L-band

- Telescope 60-100m
- 1 DM with ~1/2act/m
- DM diameter 2-4 m
- 5000-20000 actuators
- 1 WFS within $?_o$
- Diffraction limit at 1.5 µm
- XAO>M-band!

Questions:

- Median seeing, seeing variability
- Median correlation time and variability
- Outer scale Lo and its impact on max. actuator stroke, low order modes
- Median Ho (in case of mono-conjugate DM)

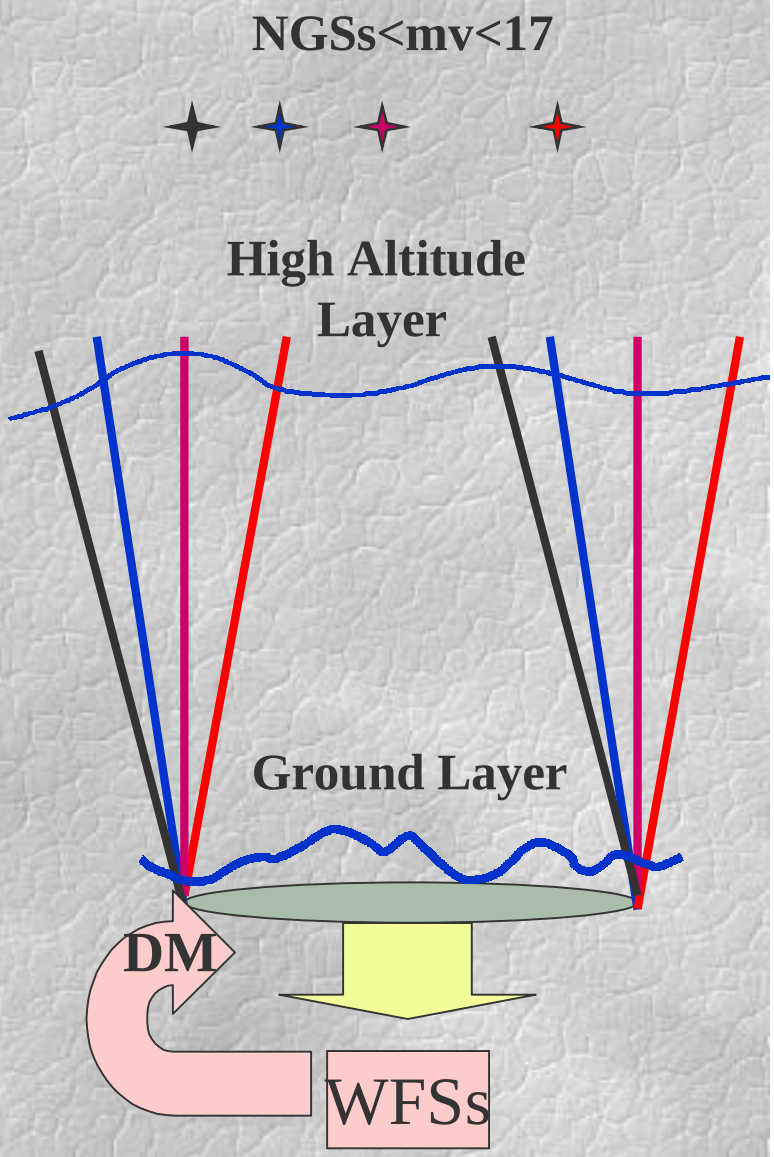


Large FOV Ground layer tomography with N or LGS

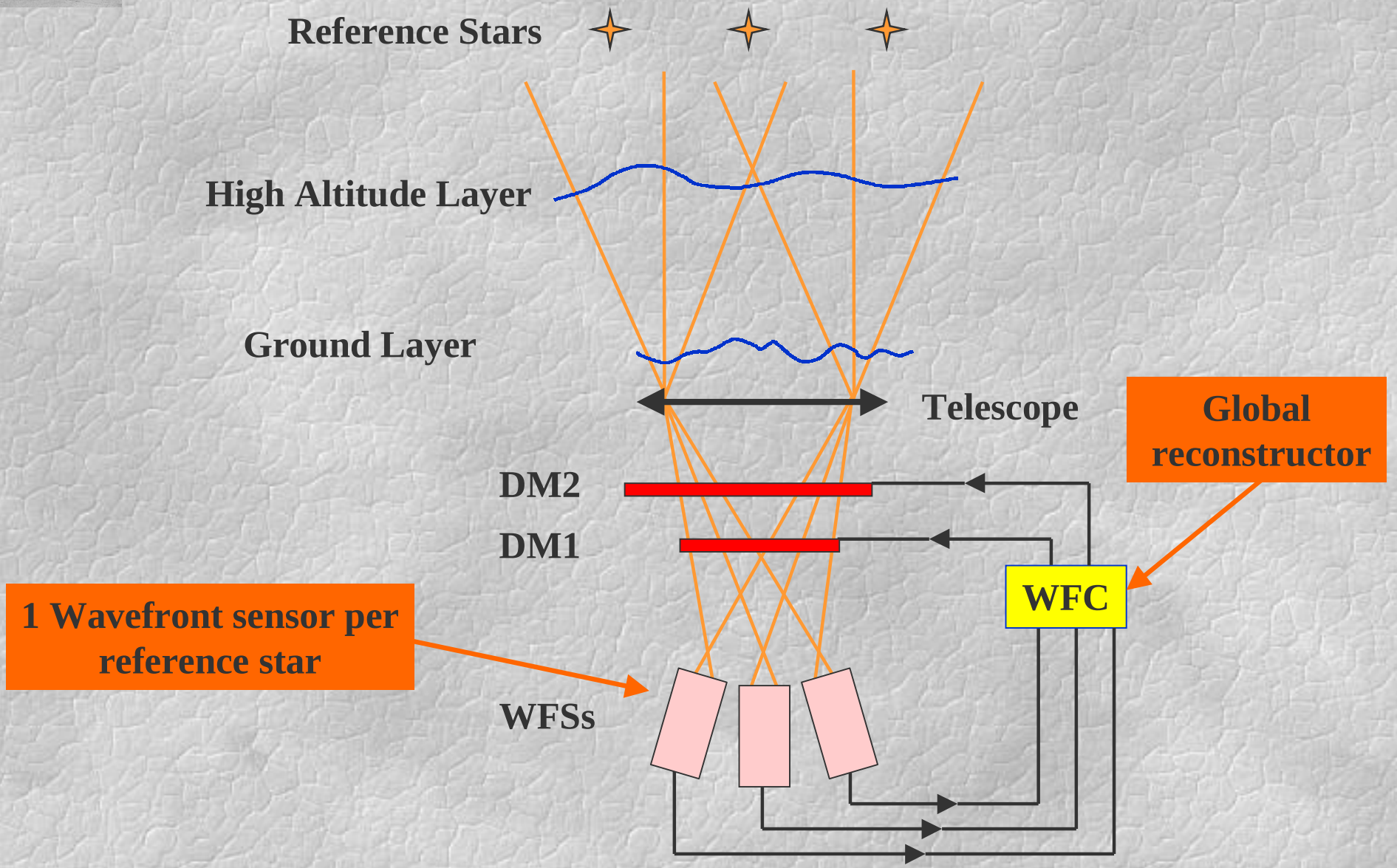
- Tomography with 6-8 NGSs in 6’
- Multi-WFSs with ~ mv=15.5
- Or tomography with 5-9 LGSs in 5’
- Corrected FOV 5-6’
- One 2.5- 5kact. DM corrector at 0km
- Seeing reducer in K-band (factor 2)

Questions:

- Cn2(h)
- Intensity of the ground layer
- Variability of intensity/altitude
- Impact on correction efficiency over large FOV



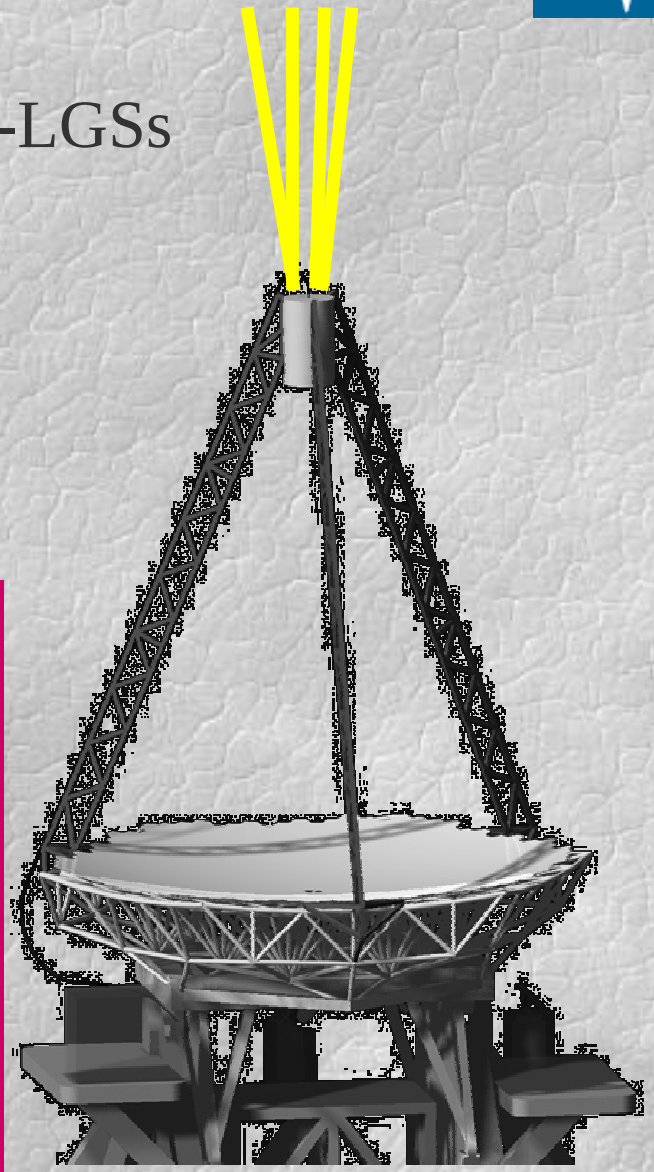
Global Reconstruction MCAO concept



MCAO with LGSs on 30m ELT

- 3 DMs at 0, 5 and 10 kms
- ~ 8500 actuators total
- 5 sodium LGS
- 3 NGSs
- FOV: 2’
- NIR imager

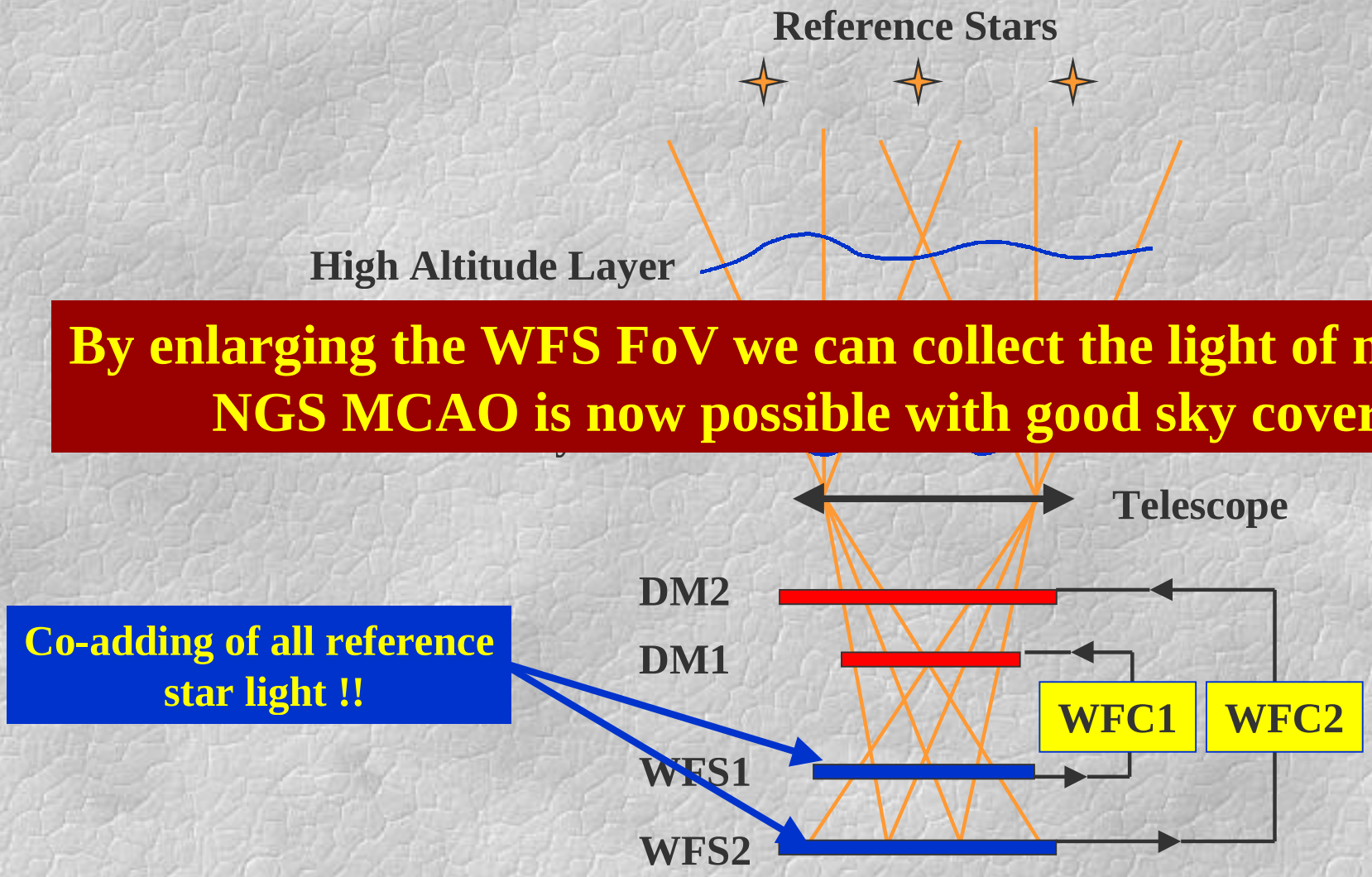
Multi-LGSs



Questions (for scale 30-100m!)

- Best altitudes & variability for DMs: Cn2(h)
- Predictability of WF evolution/layer: WF frozen?
- WF temporal information for each layer
- Impact of Lo (h)!
- WF spatial & amplitude/freq. for each layer
- Sodium density/altitude/profile variability Seasonal and mid-short term

Layer Oriented MCAO concept

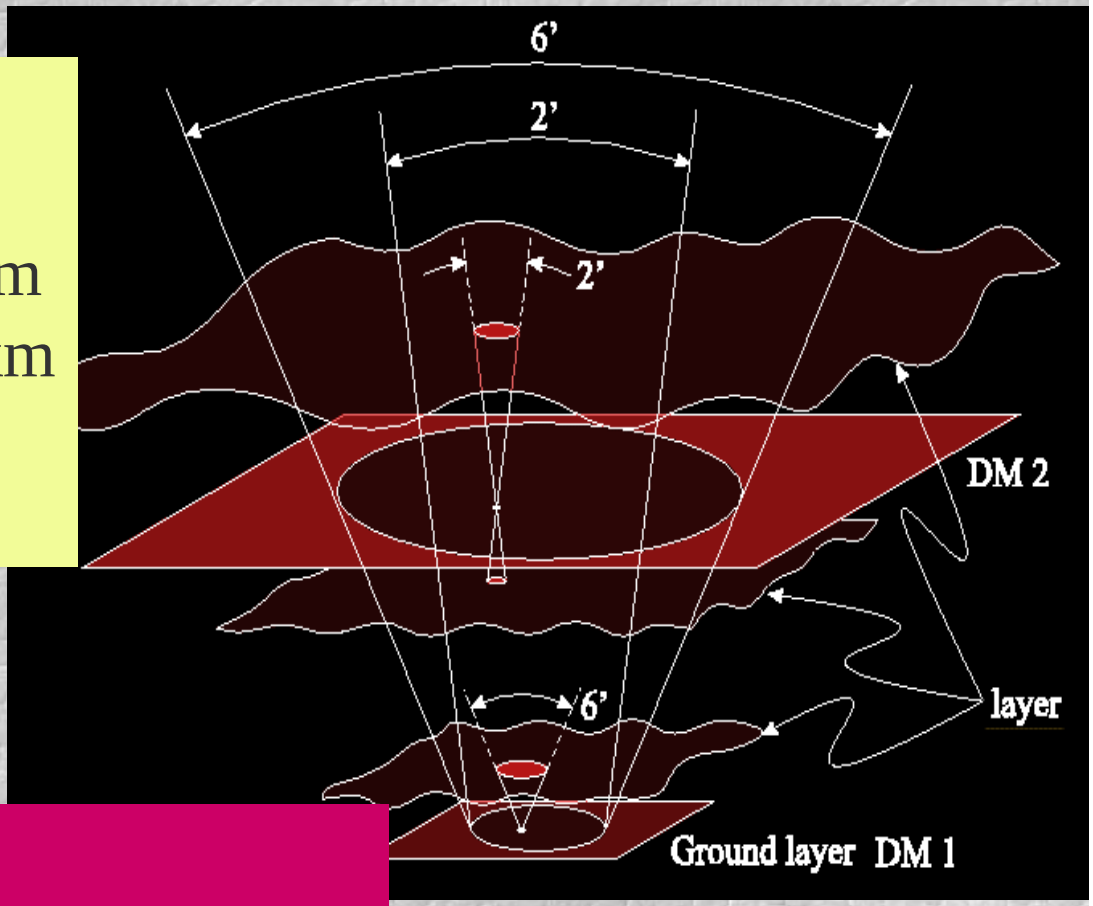


By enlarging the WFS FoV we can collect the light of more stars
NGS MCAO is now possible with good sky coverage

Co-adding of all reference star light !!

Multiple FOV Layer oriented MCAO with NGSs

- 2 DMs at 0 and 8kms
- ~15000 actuators/DM
- up to 12 NGSs in 6'FOV for 0 km
- up to 6 NGS in 2-3' FOV for 8 km
- Corrected FOV: 1-2'
- NIR imager with Sr(K)<20-30%



Questions (for scale 30-100m!)

- Best altitudes & variability for DMs: Cn2(h)
- Predictability of WF evolution/layer: WF frozen?
- WF temporal frequency for each layer
- WF spatial & amplitude/freq. for each layer

XAO with on-axis NGS

- 30 m telescope
- High order conventional AO
- 2 arcsec FOV
- One DM at 0km
- 10-50 kact.
- XAO in K-I bands
- Coronograph
- WFE<100nm rms!!

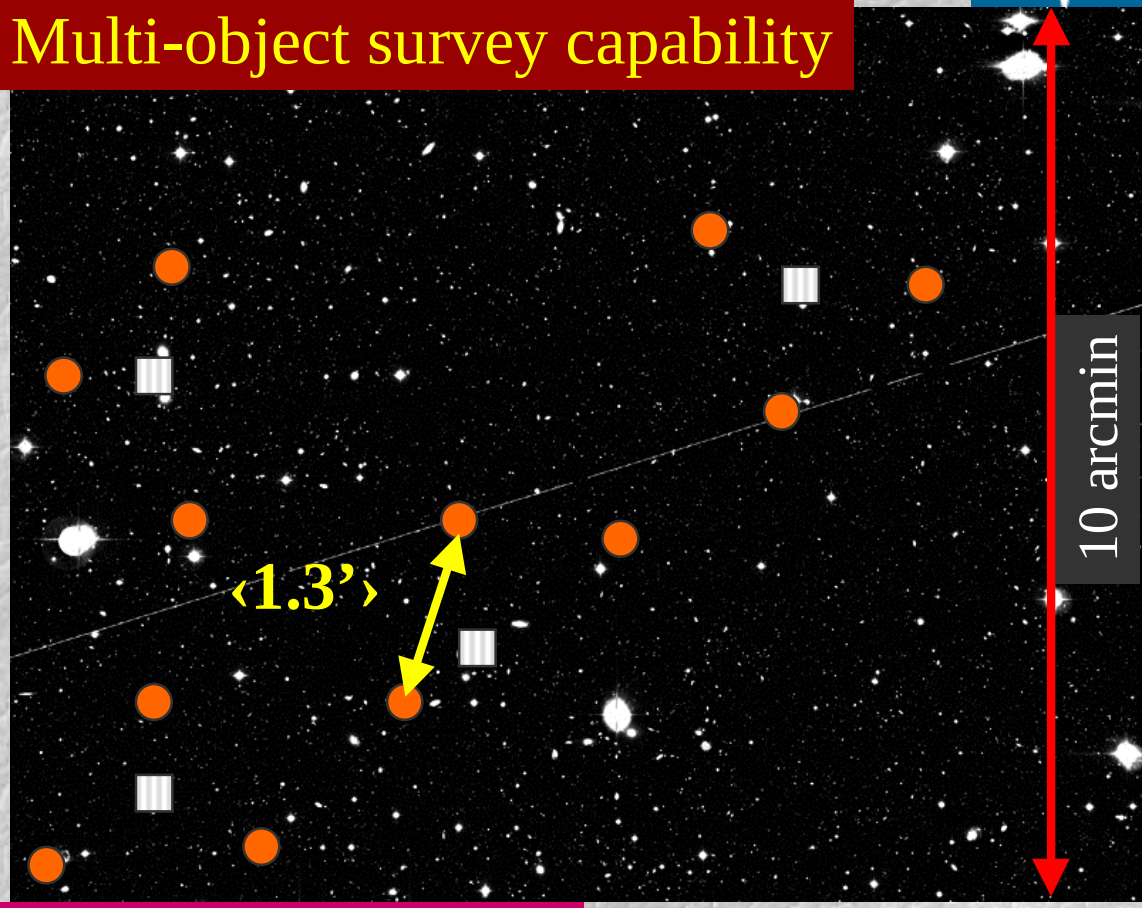
- 60-100m telescope
- High order AO
- Few arcsec FOV
- Two DMs at 0km
- 100-200 kact.
- XAO in the K-band; ~10% in V
- Coronagraph-Spectroscopy
- WFE<130nm rms!!

Questions (for scale 30-100m!)
- Scintillation and impact on AO correction
- WF spatial & amplitude frequency

Very Large FOV Multi- seeing reducer

- **Search FoV=10-12’**
- **Corrected FOV: few”**
- **Multi-AO buttons (~2kact.)**
- **Coupled with ground layer DM ?**
- **Multi- DM/IFUs**
- **Partial correction AO**
- **Spatial sampling: 0.12”**
- **Gain 1-2 mag. @ 1.4 µm**
- **R=3000-20000**
- **Multiplex gain= 60**

Multi-object survey capability



Questions:

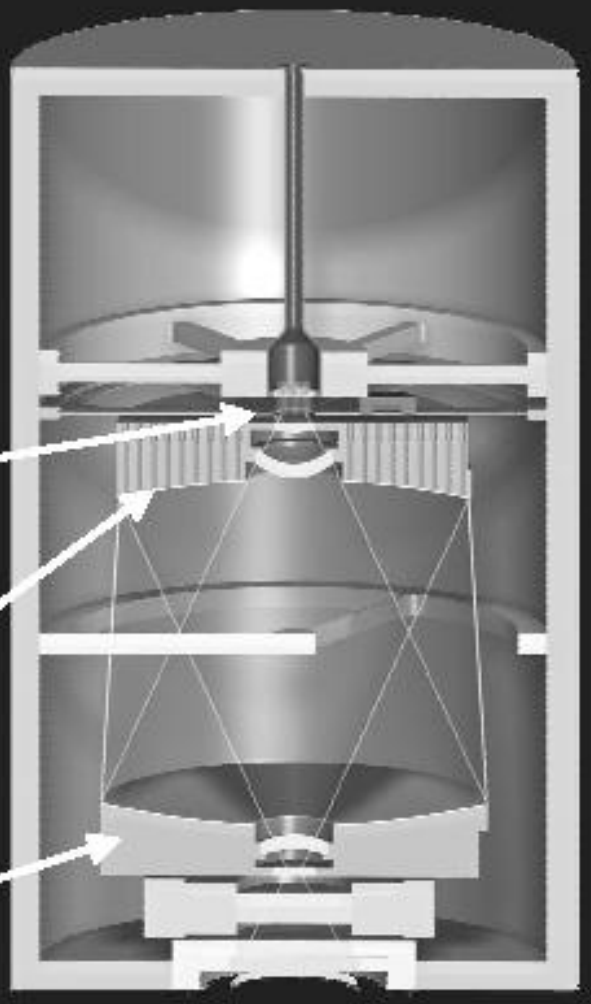
- Ground layer amplitude & altitude/ very large FOV
- Best second layer for 2nd stage AO corrector

mini-WFS

mini-DM/IFU

Prime Focus AO System

- Corrects M1 warping and ground-level turbulence
  - Achieves moderate improvement over 20-arcmin FOV



Atmospheric parameters requires by AO-ELTs

- Conventional AO requires ro, t o, ?o, Lo
- Ground layer tomography requires: Cn2(h,t) with good resolution at low h; impacts on corrected FOV of 2-10'!!
- MCAO requires: Cn2(h), Spatial and temporal information of WF at scale up to 100m (including frozen WF or not, Lo(h)..
- LGS MCAO requires: Sodium density/altitude/profile variability (Seasonal and mid-short term)
- XAO requires amplitude of scintillation and effect on WF sensing for high Strehl

Sky coverage issue

Coverage < 0.5
0.5 < coverage < 0.8
Coverage > 0.8

Courtesy: R. Stuik

No of stars	Field Size (‘)	Limiting Magnitude		
		<14.5	<17.5	<18.5
1	1	0.09	0.43	0.55
	2	0.27	0.76	0.86
	3	0.47	0.91	0.97
	6	0.83	1.00	1.00
3	1	0.00	0.11	0.20
	2	0.02	0.39	0.54
	3	0.09	0.63	0.78
	6	0.45	0.97	1.00
6	1	0.00	0.02	0.07
	2	0.00	0.20	0.32
	3	0.01	0.40	0.54
	6	0.19	0.84	0.96
8	1	0.00	0.01	0.04
	2	0.00	0.14	0.25
	3	0.00	0.31	0.45
	6	0.12	0.74	0.90
12	1	0.00	0.00	0.01
	2	0.00	0.07	0.16
	3	0.00	0.21	0.34
	6	0.05	0.58	0.76