The Adaptive Optics Module of MAVIS: preliminary design and trade-offs

Valentina Viotto
on behalf of the **MAVIS AOM team**

WFS in the VLT/ELT era IV Workshop 2019

What is MAVIS?

MCAO
Assisted
Visible
Imager (and)

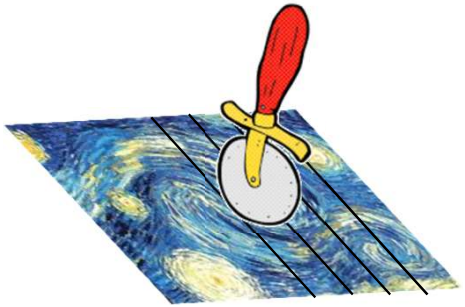
30”x30” corrected FoV

VRI

FoV 30”x30”
pxscl 7.1mas

Spectrograph

Monolitic IFU
3.6”x2.5”
370-950 nm
R 5000-10000



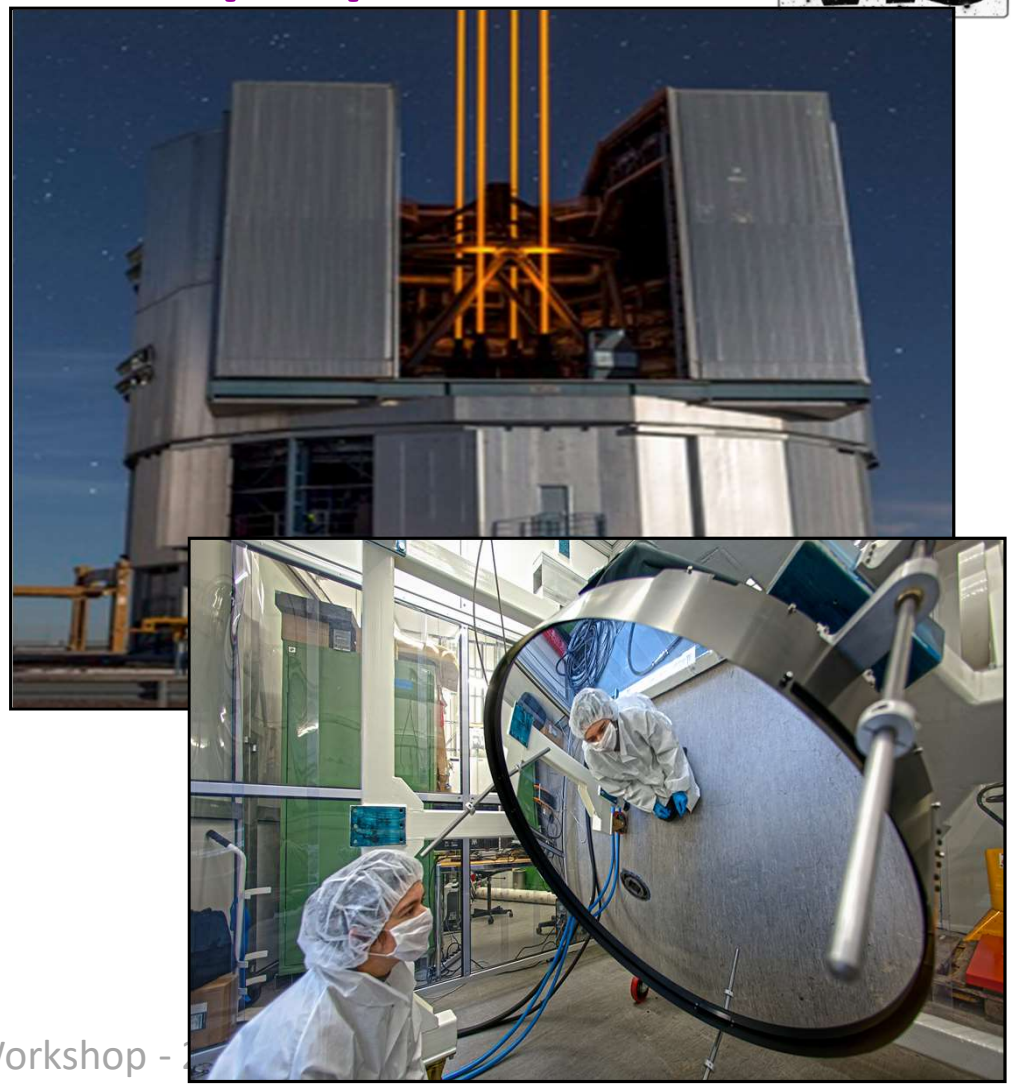
MAVIS AOM core team:
G. Agapito, M. Aliverti, M. Bergomi, M. Bonaglia, L. Busoni, T. Fusco, G. Gausachs, D. Gratadour, D. Greggio, P. Haguenhauer, L. Marafatto, B. Neichel, E. Pinna, C. Plantet, K. Radhakrishnan, **F. Rigaut**, S. Stroebele, A. Vaccarella, D. Vassallo, V. Viotto

Already existing AO equipment

Context:

Adaptive Optics Facility completed

- Where: VLT UT4
- What: key technical components are
  - **Deformable Secondary Mirror** (1170 act)
  - **4 Laser Guide Stars** (routinely working)
- Serving:
  - MUSE: Optical IFU
  - HAWK-I: Wide-field IR imager
  - ERIS (from 2020): 1-5µm imager/IFU



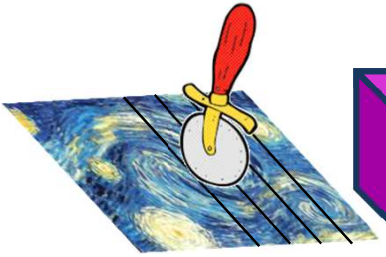
AOF full potential not exploited yet

AOM conceptual view

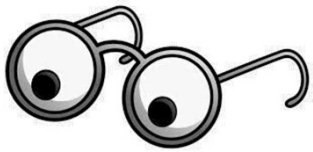
VLT Nas.

AOM machine

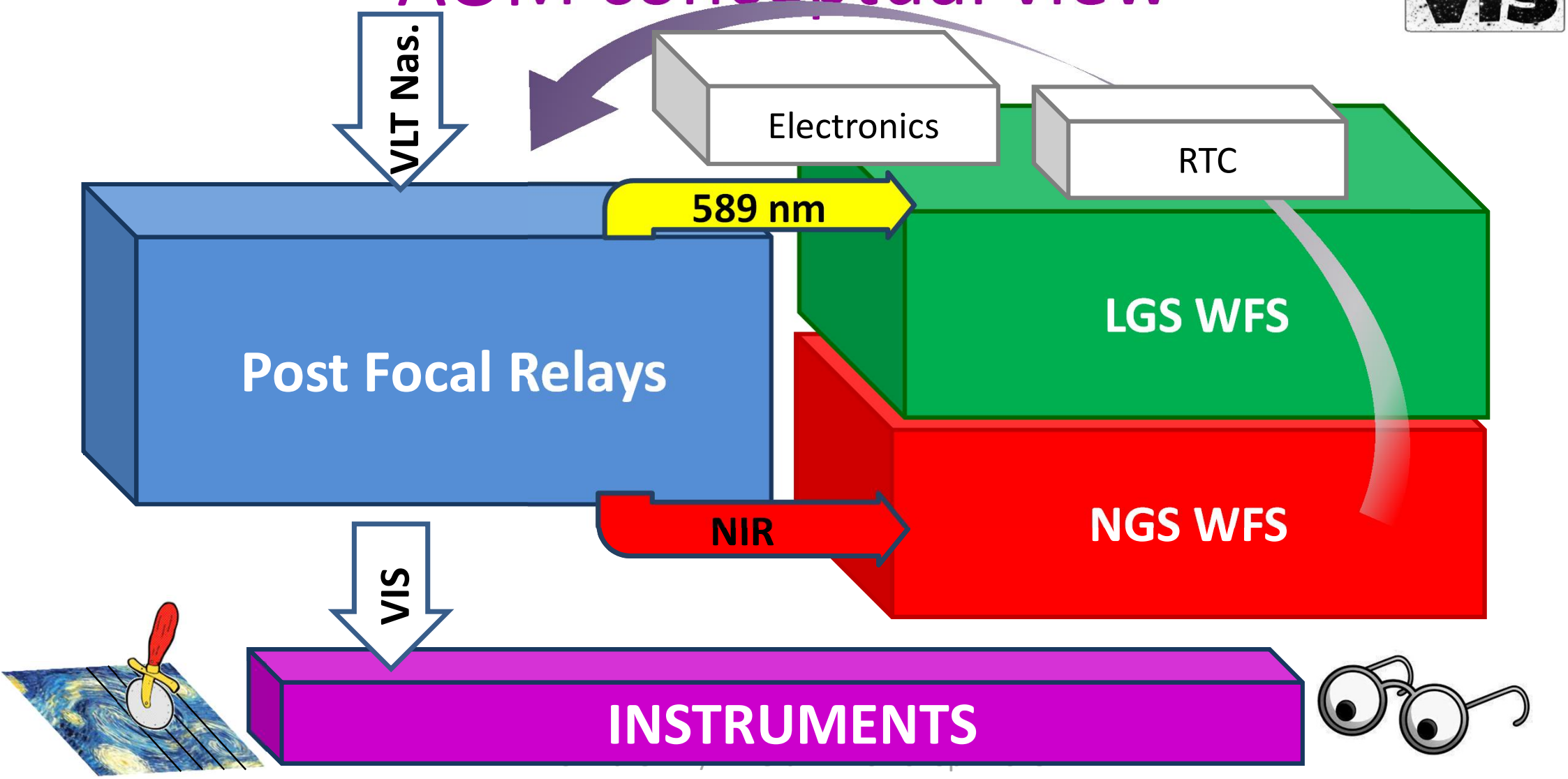
VIS



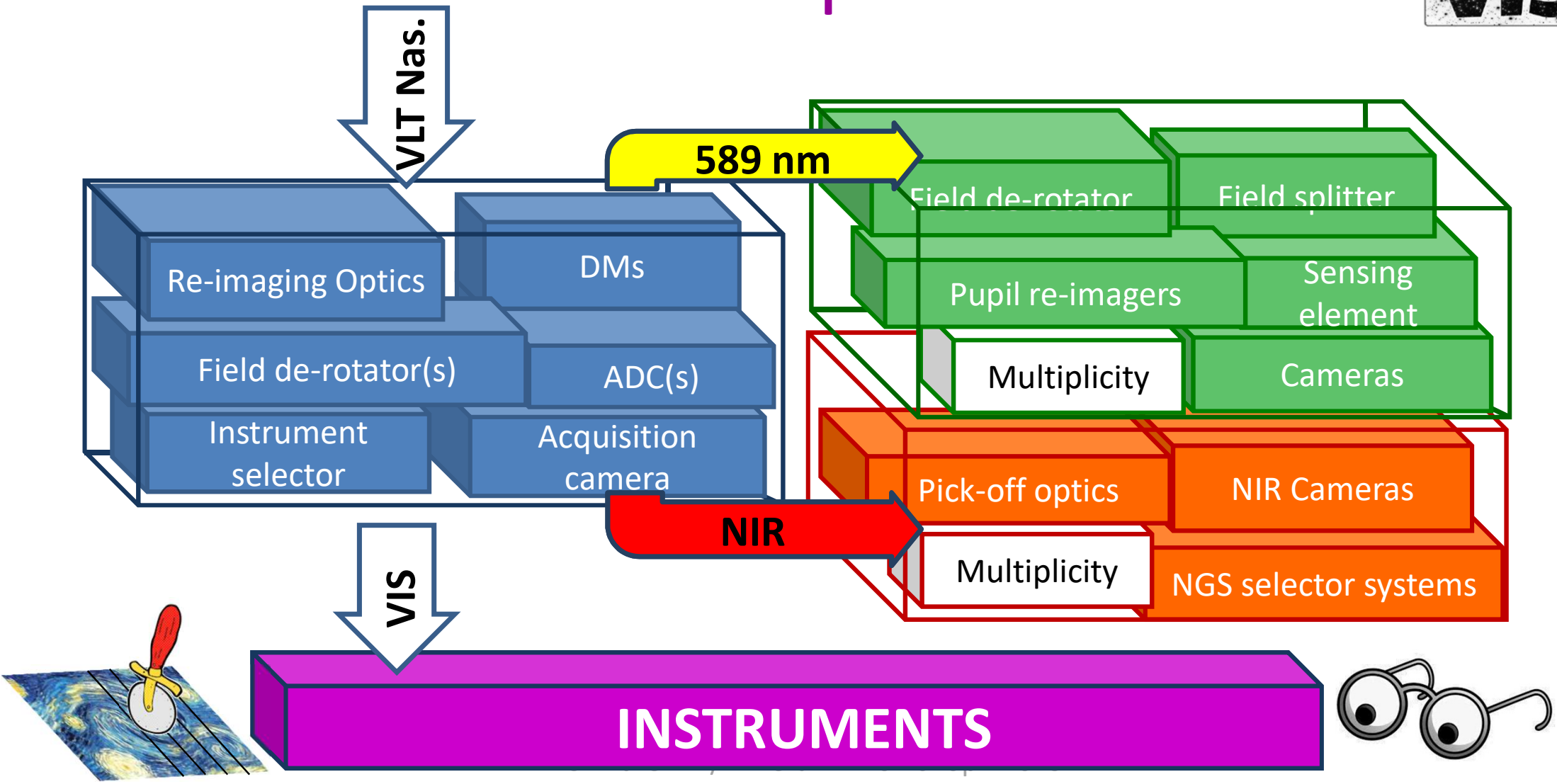
INSTRUMENTS



AOM conceptual view

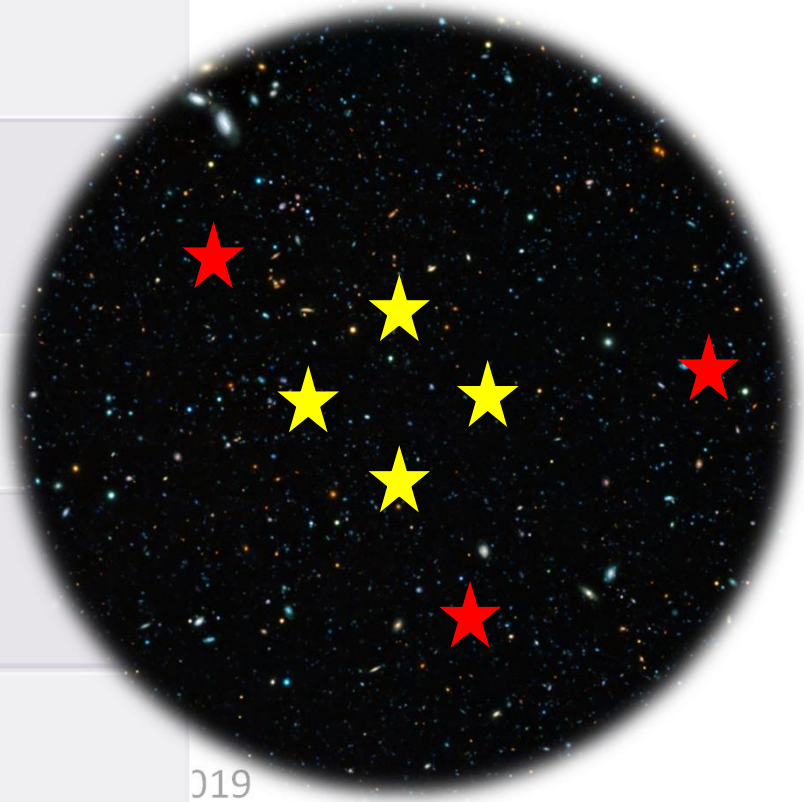


AOM conceptual view



AOM trade-offs

Trade-off	Questions
De-rotation scheme	• How to compensate NGS FoV, LGS FoV and SCI FoV apparent rotations
PFR optical design	• Reflective vs Transmissive • 1 or 2 ADCs
DM configuration	• # of DMs • Conj. altitude • Pitch
LGS configuration	• # of LGSs • Asterism
NGS WFS trade-off	• # of NGSs • FoV accessibility • Before/after DMs
Wavelengths	• How blue? • J-H band for NGS?



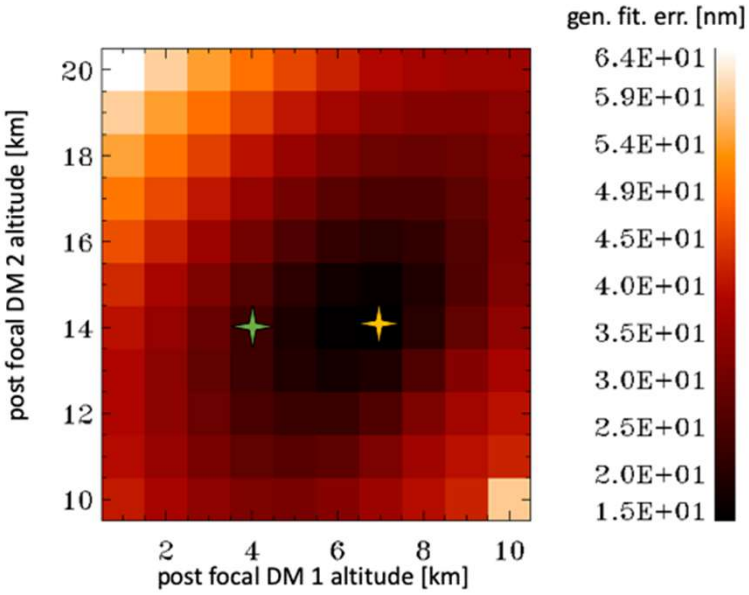
AOM trade-offs

Trade-off	Questions
De-rotation scheme	• How to compensate NGS FoV, LGS FoV and SCI FoV apparent rotations
PFR optical design	• Reflective vs Transmissive • 1 or 2 ADCs
DM configuration	• # of DMs • Conj. altitude • Pitch
LGS configuration	• # of LGSs • Asterism
NGS WFS trade-off	• # of NGSs • FoV accessibility • Before/after DMs
Wavelengths	• How blue? • J-H band for NGS?

Rationales:
- **Quality**
- Throughput
- MAIT
- Flexibility
- Modularity

AOM trade-offs

Trade-off	Questions
De-rotation scheme	• How to compensate NGS FoV, LGS FoV and SCI FoV apparent rotations
PFR optical design	• Reflective vs Transmissive • 1 or 2 ADCs
DM configuration	• # of DMs • Conj. altitude • Pitch
LGS configuration	• # of LGSs • Asterism
NGS WFS trade-off	• # of NGSs • FoV accessibility • Before/after DMs
Wavelengths	• How blue? • J-H band for NGS?



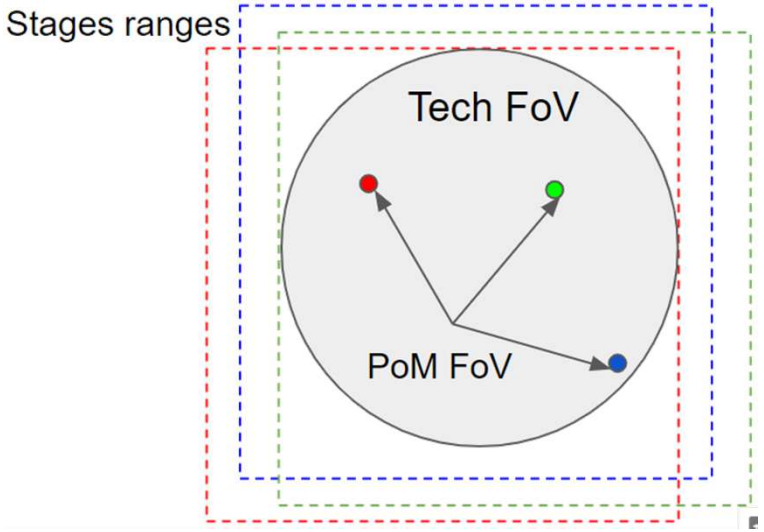
AOM trade-offs

Trade-off	Questions
De-rotation scheme	• How to compensate NGS FoV, LGS FoV and SCI FoV apparent rotations
PFR optical design	• Reflective vs Transmissive • 1 or 2 ADCs
DM configuration	• # of DMs • Conj. altitude • Pitch
LGS configuration	• # of LGSs • Asterism
NGS WFS trade-off	• # of NGSs • FoV accessibility • Before/after DMs
Wavelengths	• How blue? • J-H band for NGS?

«One laser, two LGS for two WFS: technology, on-sky demonstration and first results»
-> P. Haguenauer tomorrow!!!

AOM trade-offs

Trade-off	Questions
De-rotation scheme	• How to compensate NGS FoV, LGS FoV and SCI FoV apparent rotations
PFR optical design	• Reflective vs Transmissive • 1 or 2 ADCs
DM configuration	• # of DMs • Conj. altitude • Pitch
LGS configuration	• # of LGSs • Asterism
NGS WFS trade-off	• # of NGSs • FoV accessibility • Before/after DMs
Wavelengths	• How blue? • J-H band for NGS?

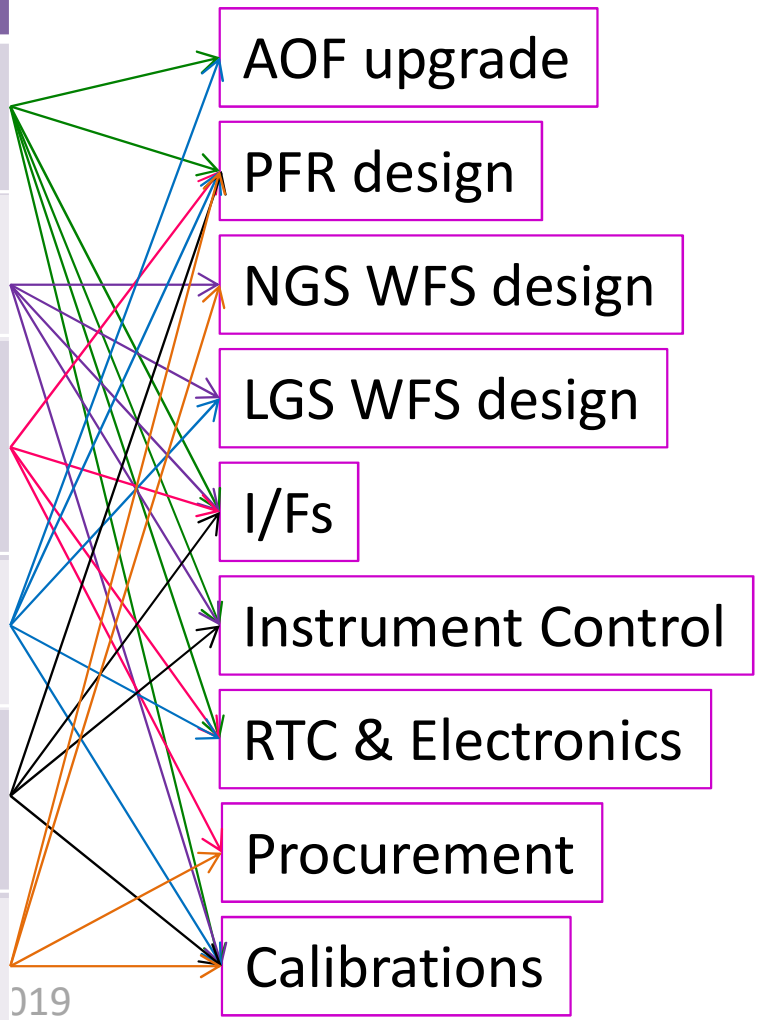


AOM trade-offs

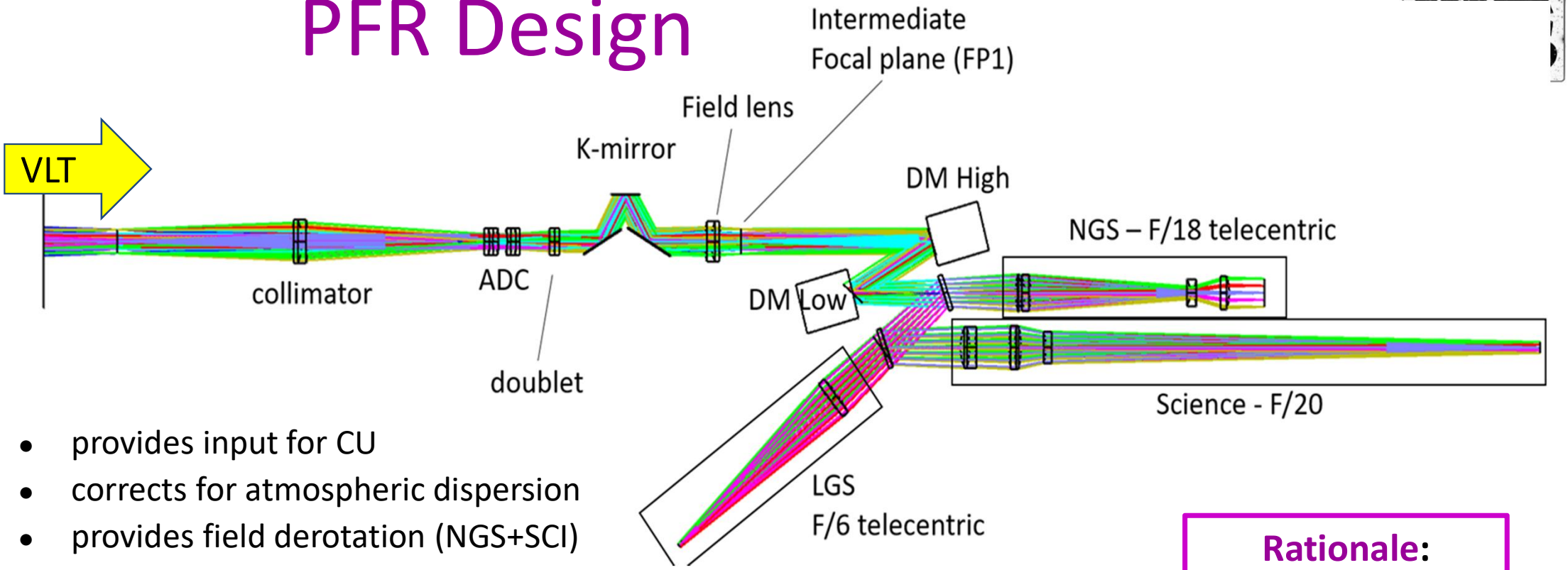
Trade-off	Questions
De-rotation scheme	• How to compensate NGS FoV, LGS FoV and SCI FoV apparent rotations
PFR optical design	• Reflective vs Transmissive • 1 or 2 ADCs
DM configuration	• # of DMs • Conj. altitude • Pitch
LGS configuration	• # of LGSs • Asterism
NGS WFS trade-off	• # of NGSs • FoV accessibility • Before/after DMs
Wavelengths	• How blue? • J-H band for NGS?

AOM trade-offs

Trade-off	Questions
De-rotation scheme	• How to compensate NGS FoV, LGS FoV and SCI FoV apparent rotations
PFR optical design	• Reflective vs Transmissive • 1 or 2 ADCs
DM configuration	• # of DMs • Conj. altitude • Pitch
LGS configuration	• # of LGSs • Asterism
NGS WFS trade-off	• # of NGSs • FoV accessibility • Before/after DMs
Wavelengths	• How blue? • J-H band for NGS?



PFR Design



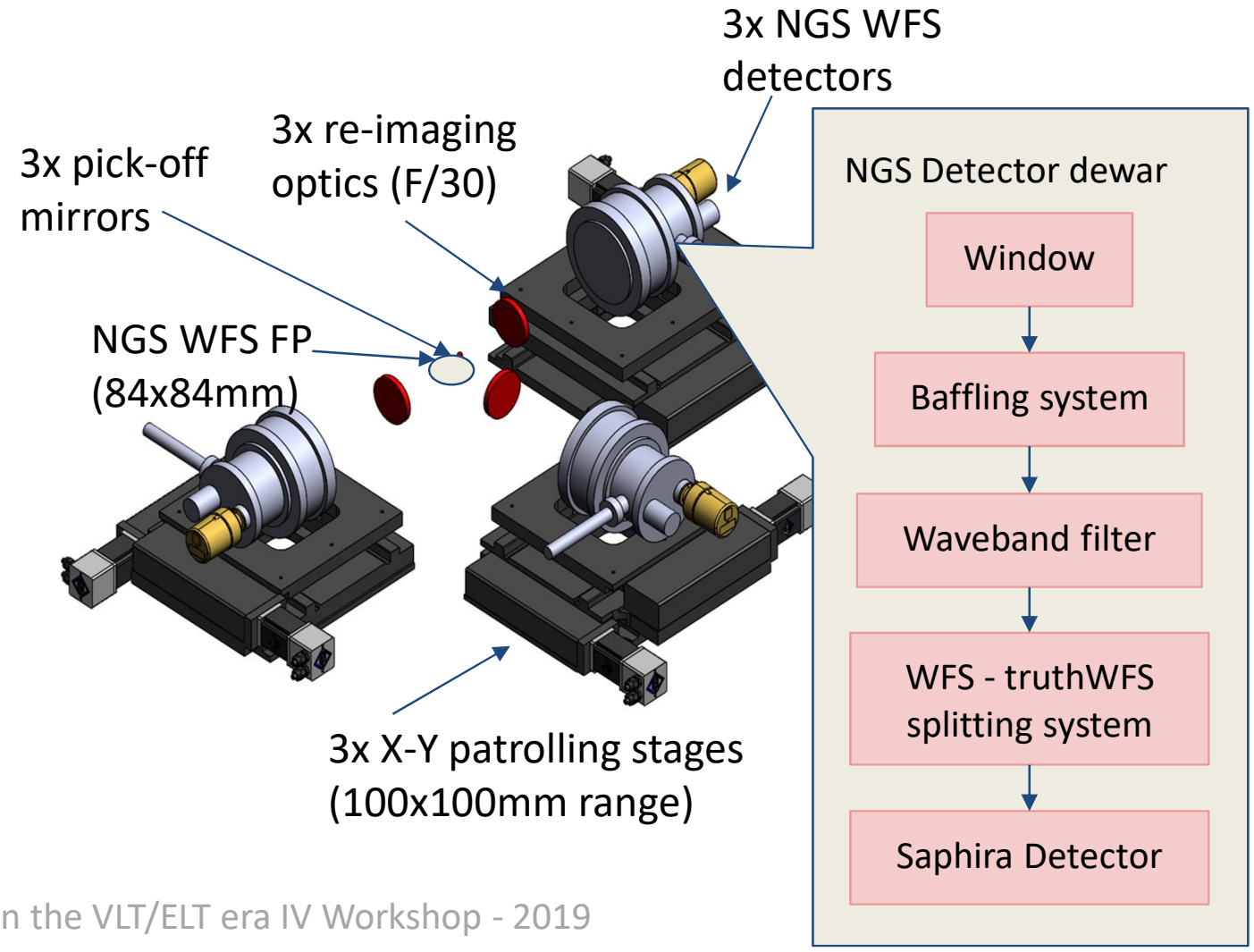
- provides input for CU
- corrects for atmospheric dispersion
- provides field derotation (NGS+SCI)
- re-images meta-pupils onto DMs
- feeds the NGS WFS with a 2 arcmin FoV at infinity (NIR band)
- provides means for stars acquisition [acquisition camera still missing]
- feeds the LGS WFS with the LGSes FoV at 90-230km altitude (Na line)
- delivers a 30” diameter FoV to the instruments (VIS band)
- provides at least 2 output ports and includes means to switch

Rationale:
- Distortions
- Throughput
- Compactness
- Alignment
- Modularity

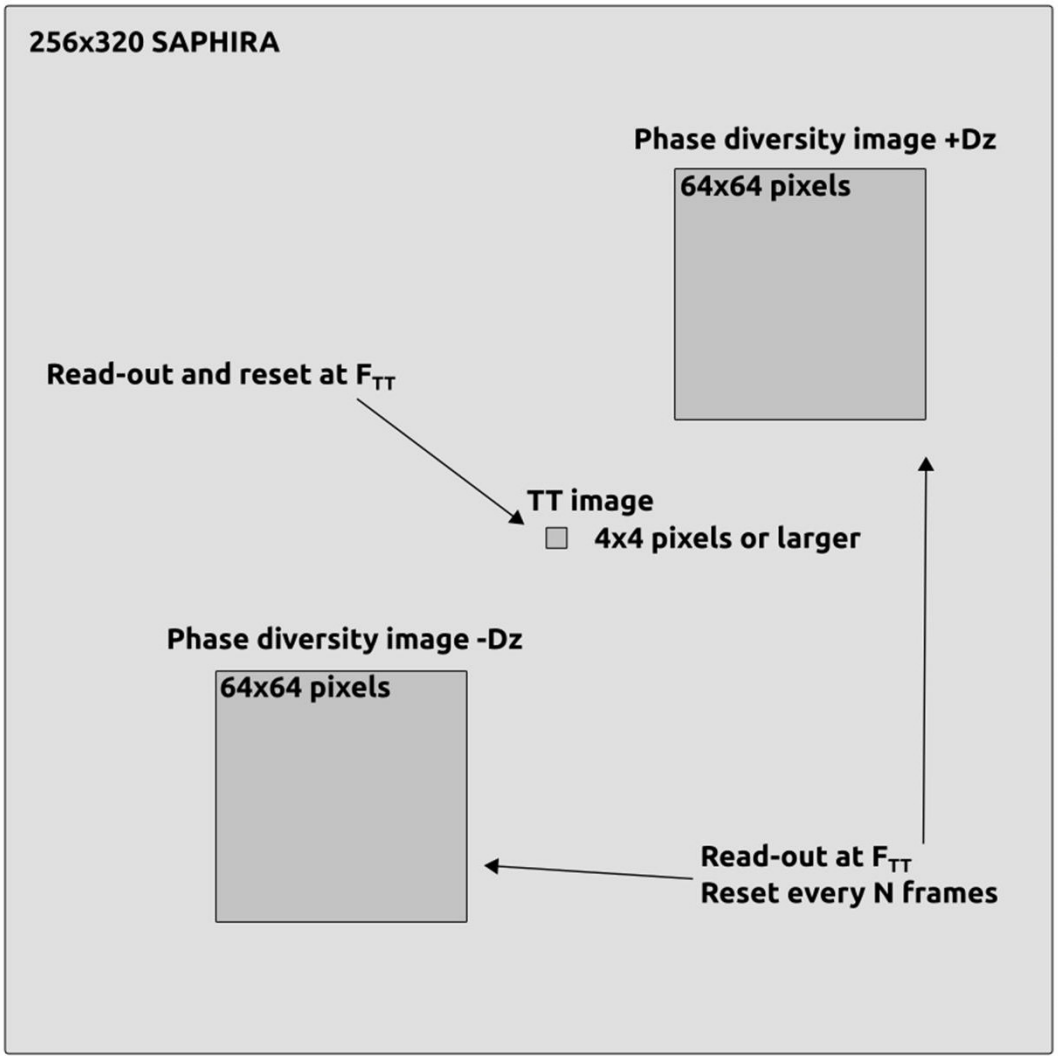
NGS WFS Design

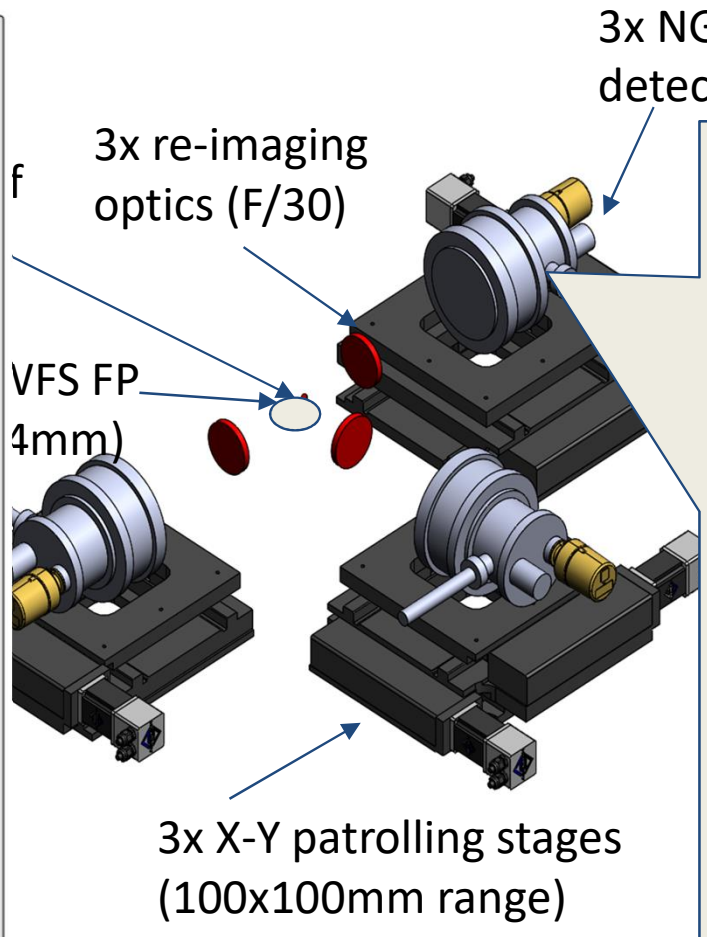
- **3 NGS**es can be sensed, in the J+H bands, at the same time
- 2 arcmin diameter unrestricted patrolling **FoV** (including SCI FoV)
- **1x1 subaperture** pupil sampling
- **30mas sampling** on the detector

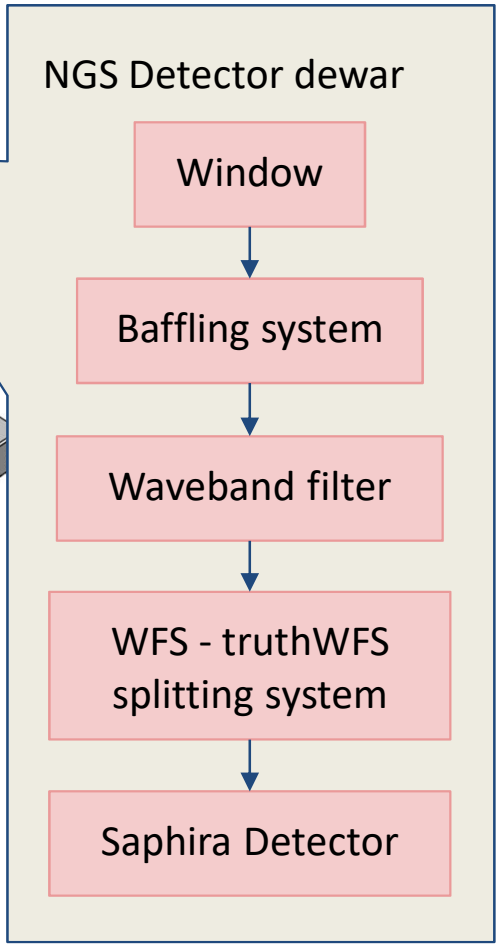
- Tomographic **truth sensing** included



NGS WFS Design

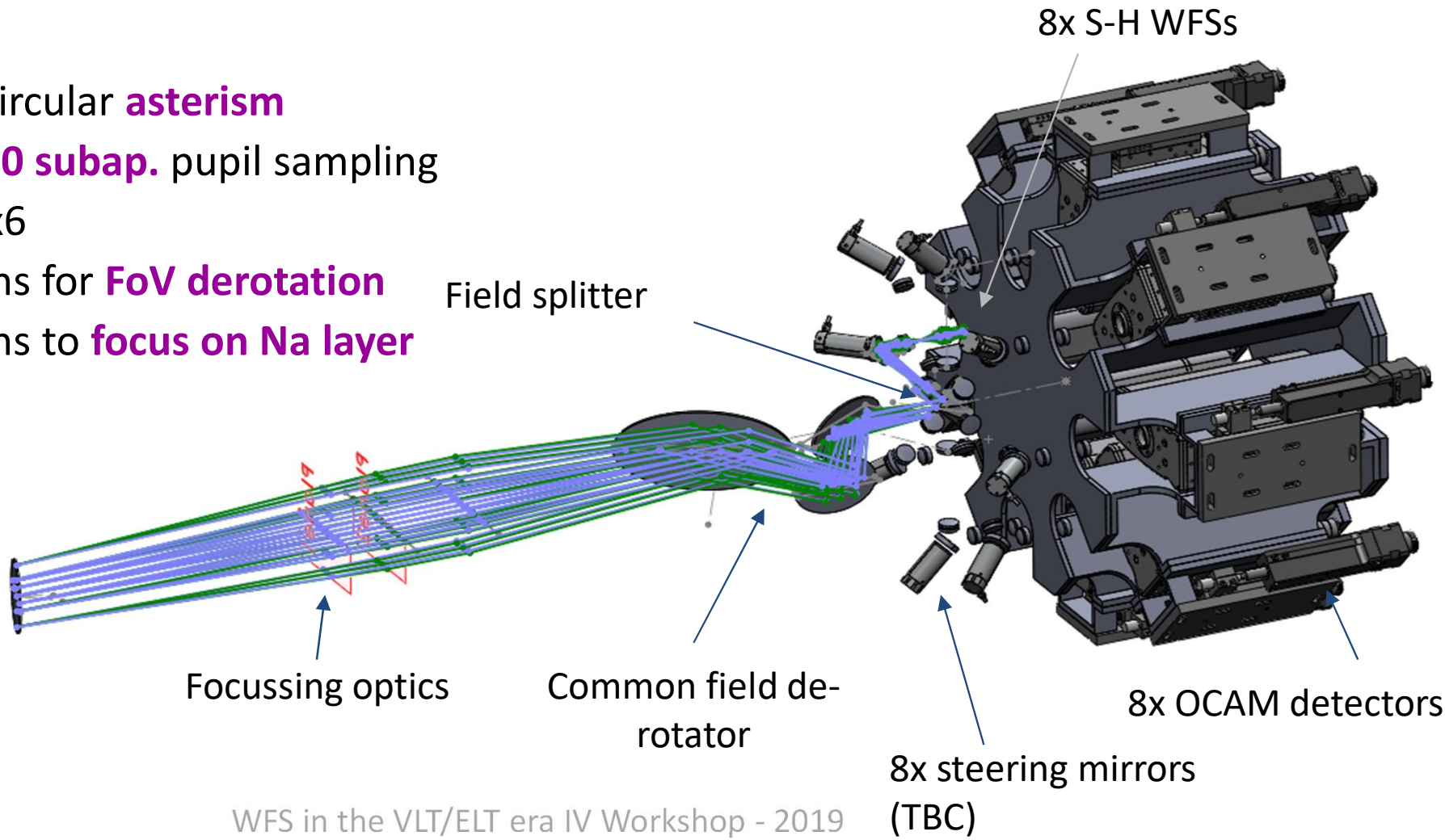






LGS WFS Design

- **8 LGSes**
- 17.5” radius circular **asterism**
- S-H WFS **40x40 subap.** pupil sampling
- #pix/subap 6x6
- includes means for **FoV derotation**
- includes means to **focus on Na layer** (elevation)



Simulations

ESO TLR atmospheric profile:

- L_0 [m]=25m
- seeing (zenith) [arcsec] = 0.8
- Na multi-peak profile

Telescope:

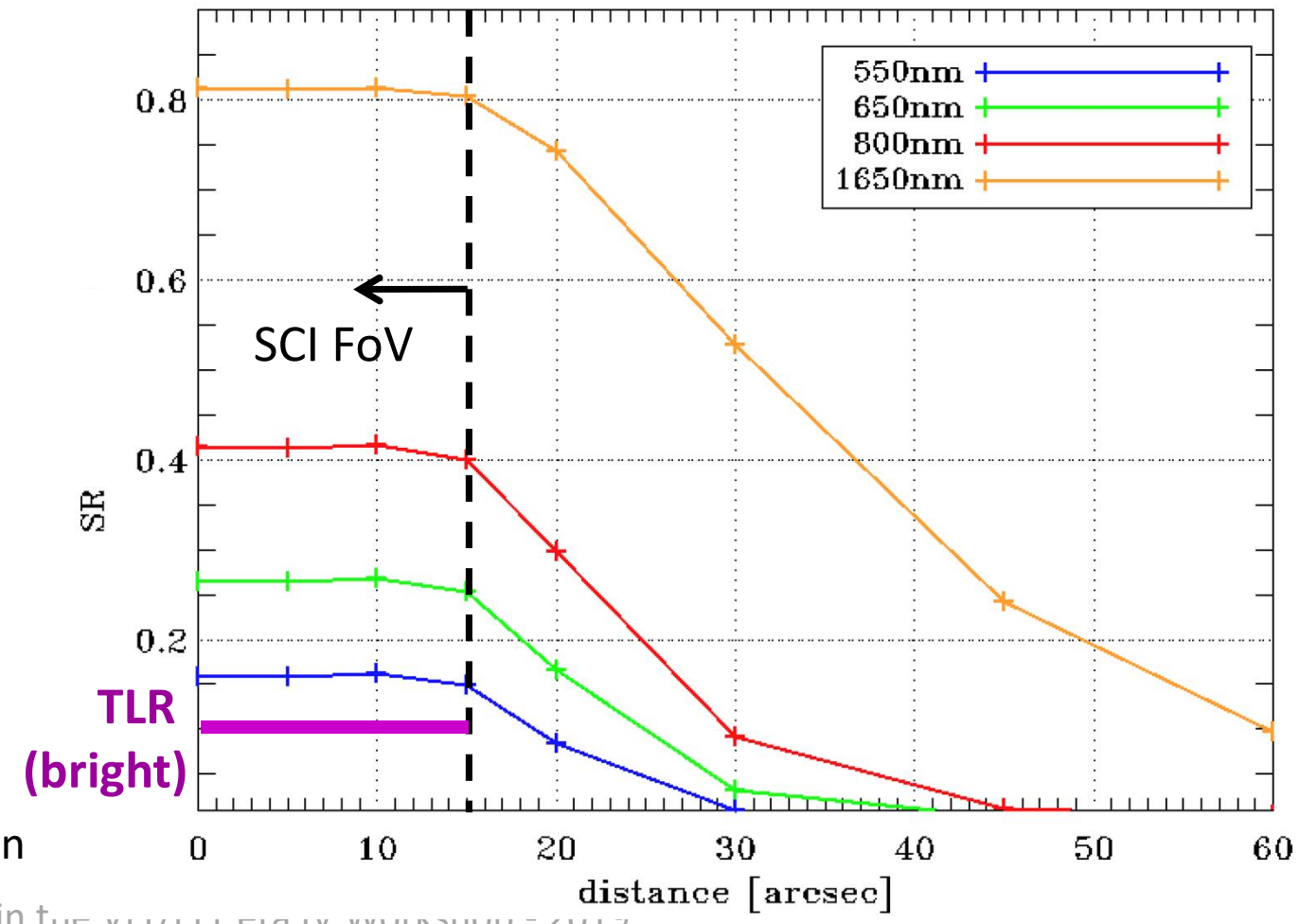
- Pupil = 8m with 16% obscuration
- Zenith angle= 30deg
- TFoV 120arcsec diameter

DMs:

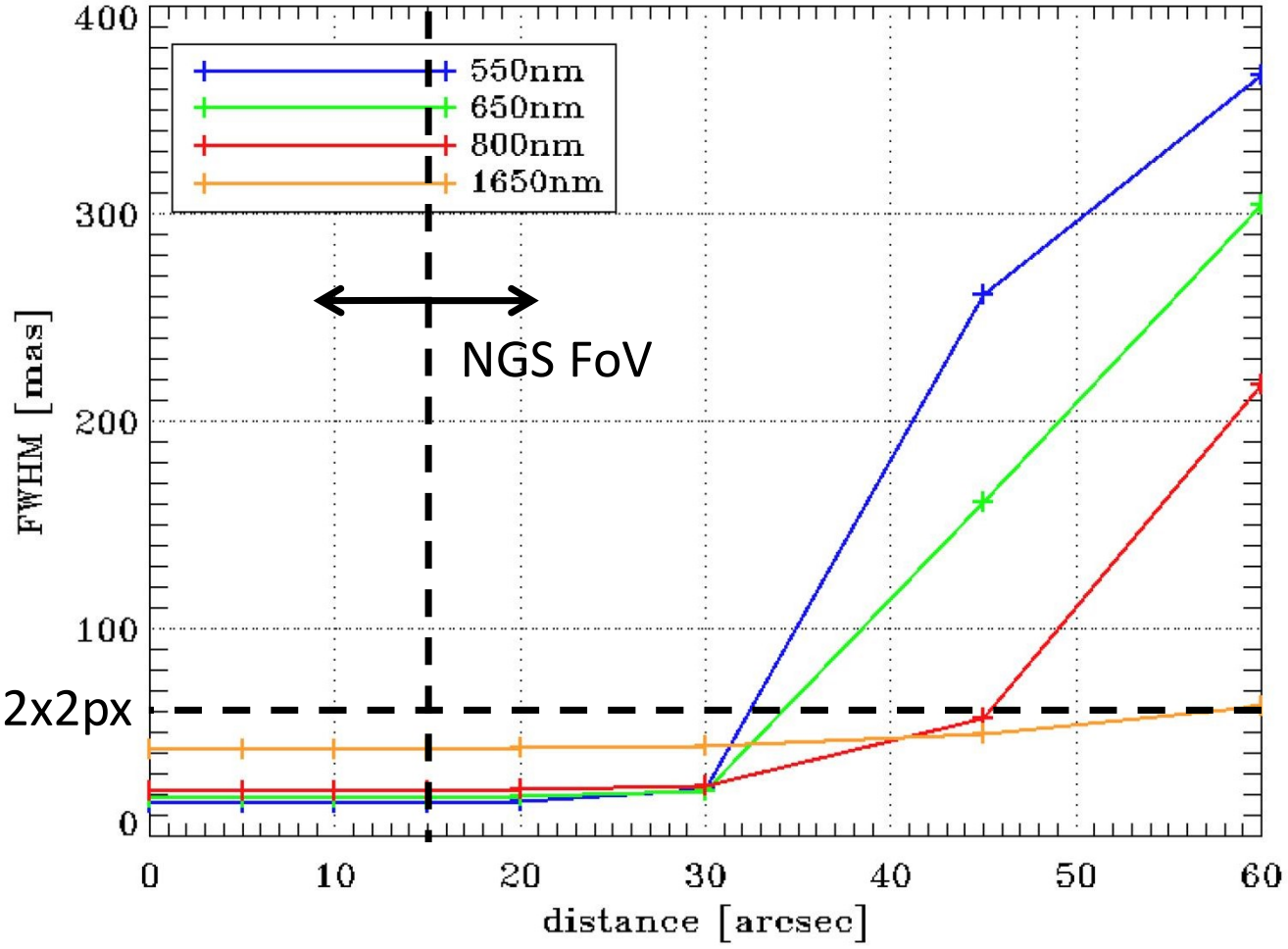
- pitch [0.22,0.22,0.3]m
- altitude [0,4,14] km

Control:

- Rec layers @ Cn2 profile altitude.
- Opt. FoV: 15arcsec radius
- POLC
- Integrator controllers with 0.3 gain
- Delay = 2frames (2ms)



Simulations - TFoV



Sky Coverage criteria:

- Strehl Ratio
- Encircled Energy (info loss)
- FWHM (sensitivity)

Simulations – Sky Coverage

Assumption and terms

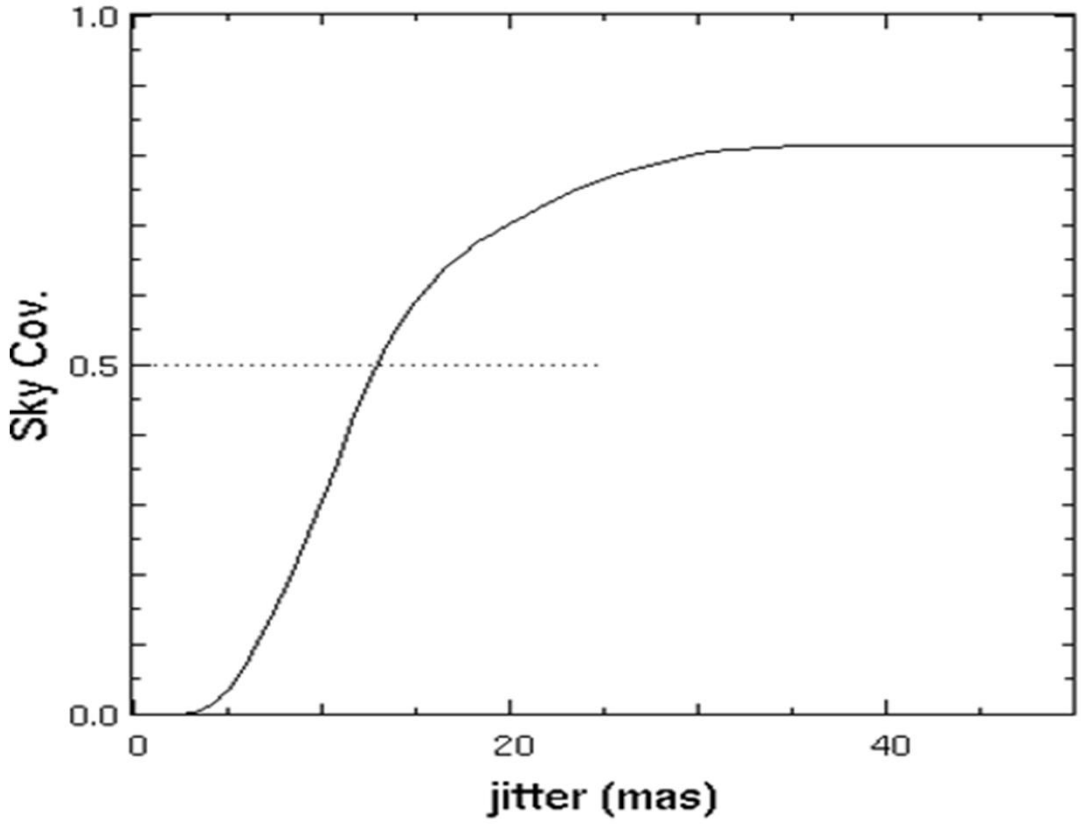
Tomographic error
(parameters: off-axis jitter + availability of stars)

+

Windshake error
(parameter: frame rate)

+

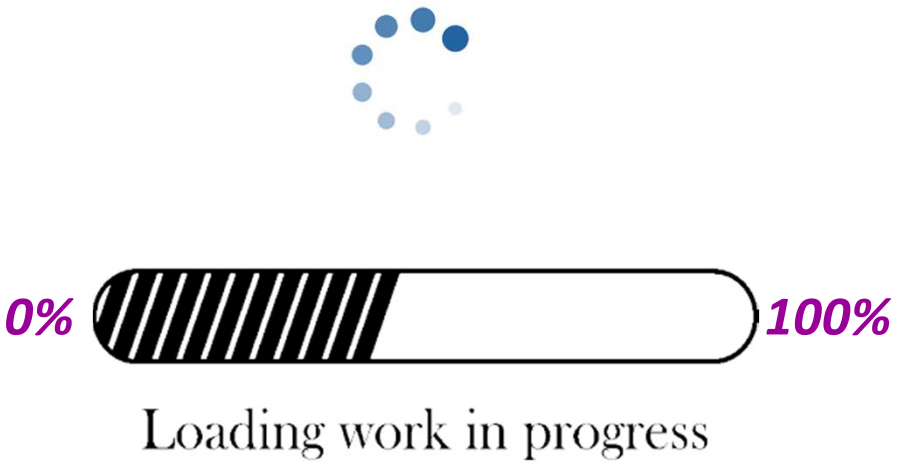
Noise error
(parameter: ph/subap/frame)



WFE Preliminary Budget

TLR-33: SR = 10% (15% goal) at V band (550 nm), ~132 nm (120 nm goal).

Contributions	Nominal [nm]	Calibration residual (%)	After calibration [nm]
AO (no vibration, bright NGS)	114	100	114
NCPA	50	50	25
Manufacturing	29	100	29
Alignment	8	100	8
Thermal	TBD		
Image motion	TBD		
Total			**120.5 nm**



Thank you

WFS in the VLT/ELT era IV Workshop - 2019