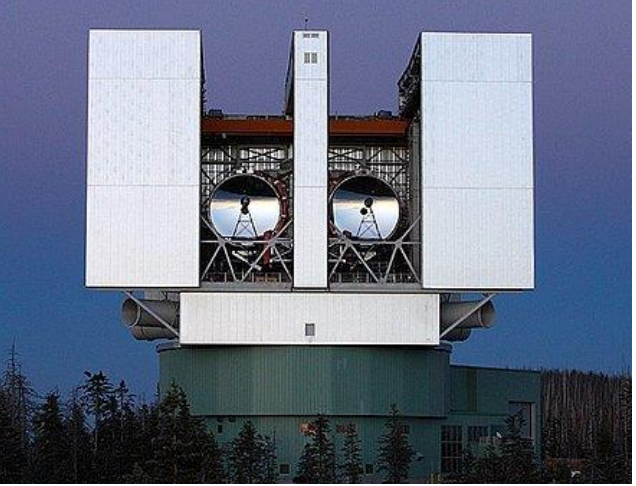
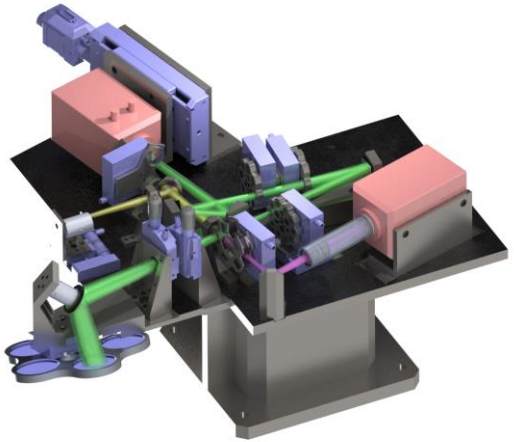
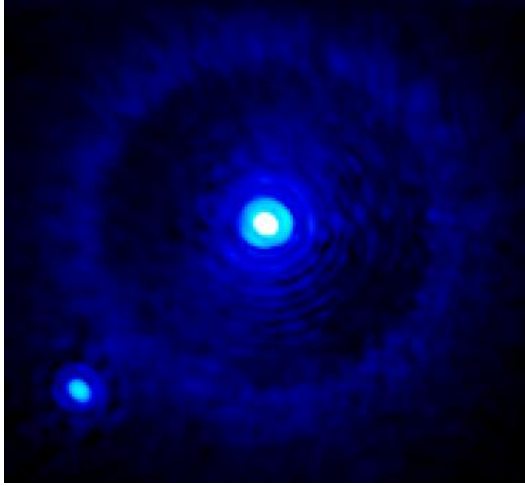






SHARK-VIS: project status

F. PEDICHINI &

SHARK-VIS TEAM

LBT USER MEETING 2017

LARGE BINOCULAR TELESCOPE

OSSERVATORIO ASTRONOMICO DI ROMA · INAF · ISTITUTO NAZIONALE DI ASTROFISICA

LABORATORIO NAZIONALE ADONI OTTICA ADATTIVA

SHARK-VIS team:

Osservatorio Astronomico di Roma

F. Pedichini	(P.I., optics)
S. Antoniucci	(science)
G. Li Causi	(data reduction)
M. Mattioli	(engineering, control SW)
M. Stangalini	(AO simulation)
V. Testa	(archive, pipeline, science)

Supervisor board

S. Esposito	(INAF Arcetri)
E. Giallongo	(INAF OAR)
R. Ragazzoni	(INAF OAPD)

Osservatorio Astronomico di Arcetri

E. Pinna	(SOUL)
A. Puglisi, G. Agapito	(AO simulation)

Osservatorio Astronomico di Padova

J. Farinato	(SHARK-NIR P.I.)
SHARK-NIR team	

INAF Trieste Archiving facility

Steward Observatory

P. Hinz	(LBTI)
M. Montoya	(LBTI)
E. Downey	(LBTI)

LBTO & LBTO mountain crew

SHARK Science team 70+ research[illegible] at

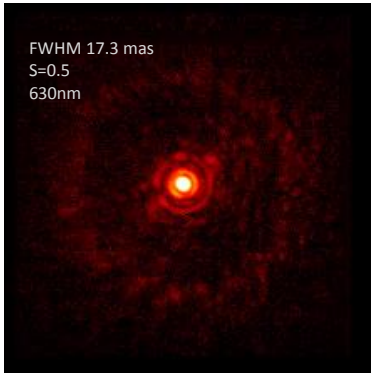
SHARK-VIS MISSION:
a fast track P.I. instrument to extend LBT AO-SCIENCE into the visible

Why not to go into the VISIBLE ?

- ✓ ***Sky background is low***
- ✓ ***Detectors are cheap and quite***
- ✓ ***Albedo is increasing***
- ✓ ***Bright recombination lines (Hα)***
- ✓ ***λ/D resolution 15mas at 8m (ELT at K)***

(L. Close et Al. SPIE 9148 – 2014)

*SHARK-VIS expected performance are based on "**on sky experimental data**" at 630nm from the Forerunner experiment with **5e-5** det. contrast*



Pedichini+ 2017

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SHARK-VIS project history:

2012 – first white paper from R to K

2014 – SHARK bino presented to LBT SAC

2014 – NIR and VIS from R to K with two PIs

2015 – Signature of SHARKS CDP MOUs

2016 - SHARK-VIS Conceptual Design Review

2017 Q1 – SHARK-VIS Final Deisgn Review

2017 Q3 – Delta FDR

Relevant publication:

2017/01 JATIS M.Stangalini, F. Pedichini et al.: *Speckle statistics in adaptive optics images at visible wavelengths.*

2016/09 arXiv 16090514P, AJ in press. F. Pedichini et al: *High Contrast Imaging in the Visible: First Experimental Results at the Large Binocular Telescope.*

2016/08 SPIE.9908E..32P. F.Pedichini, F.Ambrosino et al.: *The V-SHARK high contrats imager at LBT.*

2015/10 AO4ELT 2x F. Pedichini et al. J. Farinato et al.

2014/08 SPIE.9147E..7JF. J. Farinato, F. Pedichini, E. Pinna et al.: *SHARK (System for coronagraphy with High-order adaptive optics from R to K bands): a proposal for the LBT 2nd generation instrumentation.*

2014/08 SPIE.9147E..8Fs. M.Stangalini, F. Pedichini et al.: *The solar system at 10 parsec: exploiting the ExAO of LBT in the visual wavelengths.*

2014/03 ebi..confP4.74F. J. Farinato, C. Baffa et al.: *The NIR arm of SHARK (System for coronagraphy with High-order adaptive optics from R to K bands).*

SHARK-VIS requirements strongly driven by science cases to extend LBT AO science into the VISIBLE *(next talk by S. Antoniucci)*

YOUNG ACCRETING PLANETS

- hα PSF contrast at 150mas
  <1e-4 (0.6" seeing)
- Detection contrast at 150 mas
  <5e-5 (after p.p.)
- 10" ADI optimized FOV
- Coronagraphy

DISK AND JET MORPHOLOGY

- Detection contrast at 50 mas
  <1e-3 (after p.p.) (1.2"seeing)
- Fast frame rate (1kHz on 1.3" x 1.3")
  Fast & low RON detector
- SDI by pupil splitting
  Access to pupil plane

MINOR BODIES OF SOLAR SISTEM

- Wavelength coverage from
  400 to 1000nm
- Diffraction limited core PSF
  FWHM 10-25mas
- Nyquist sampling at 500nm
  6.5mas/pixel

Simultaneous observing with SHARK-NIR and LMIRCAM

CLOSE BINARY STARS

PATHFINDER for Coronagraphy and exoplanets reflected light

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SHARK-VIS *science driven* main requirements:

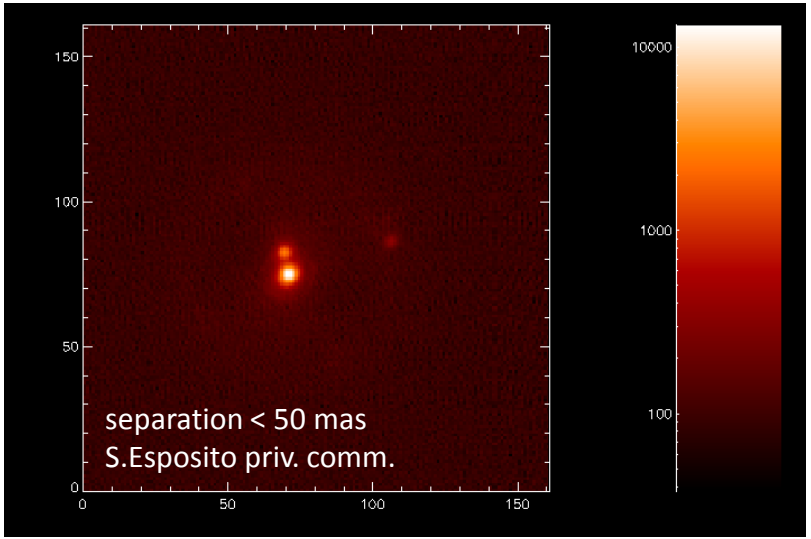
1. 10 arcsec Field Of View
2. Diffraction limited from 0.4 to 1 micron
3. Active PSF and Pupil Stabilization
4. Fast frame rate (1kHz) for lucky imaging
5. NCPA mitigation
6. Selectable pupil optics (stop, Wollaston, hologram, grism….)
7. Coronagraphy and IFU ready
8. ….

a) Low budget (HW ≈ 400k)
b) Low mass < 100kg
c) Fast Track P.I. instrument < 2y
d) Low impact on LBTO (< 0.5 FTE est.)
e) Designed to become an LBTO facility

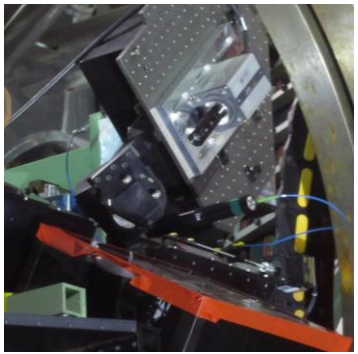
SHARK-VIS the origins:

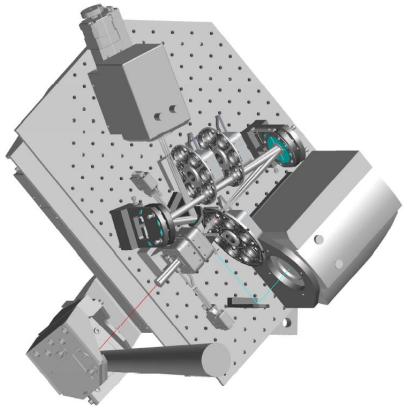
2011 - FLAO COMMISSIONING AT LBT

HIP 76041 AT 750NM



THE FORERUNNER (2015) AND CDP LAYOUT(2015-16)





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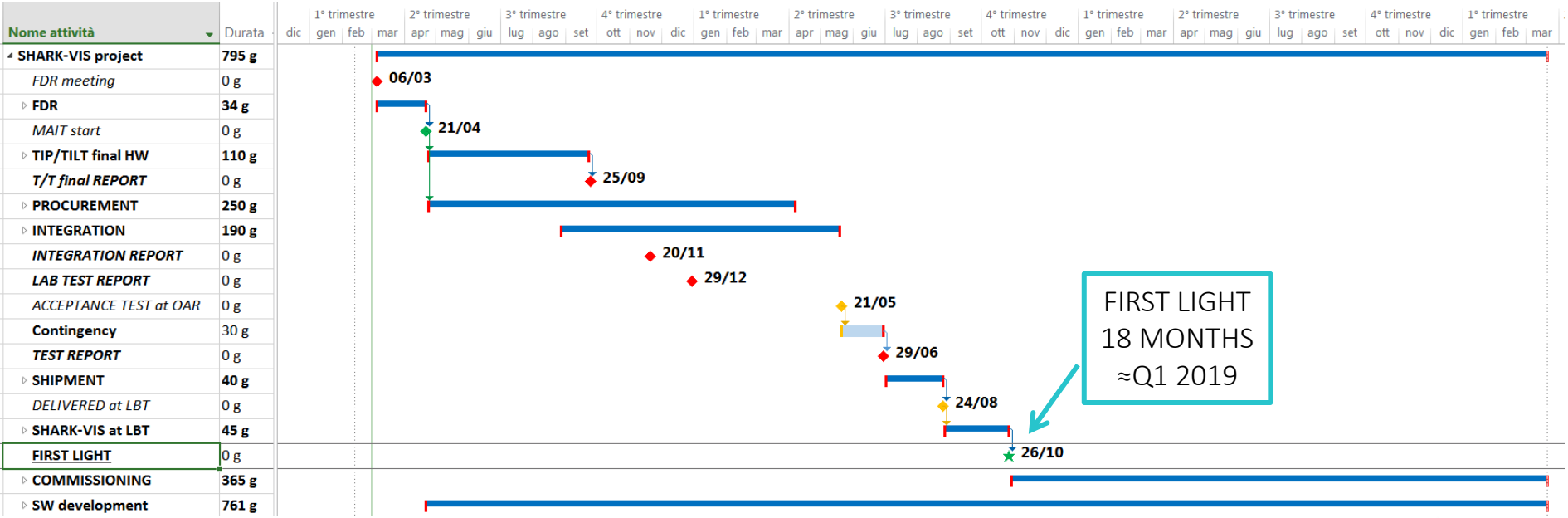
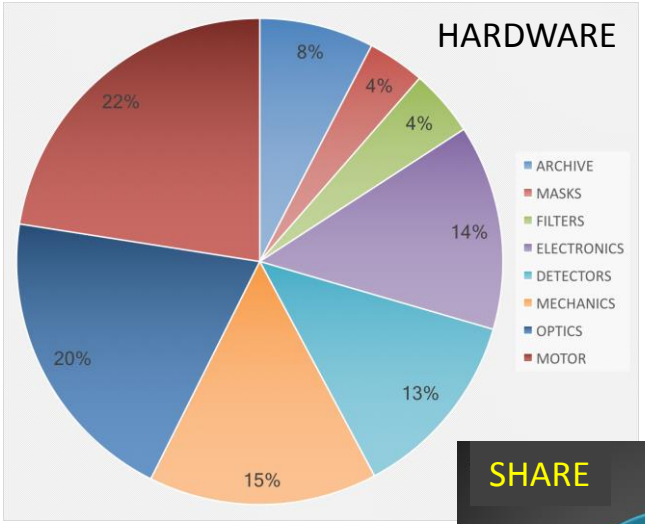
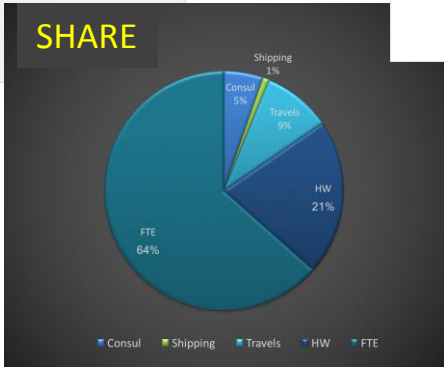
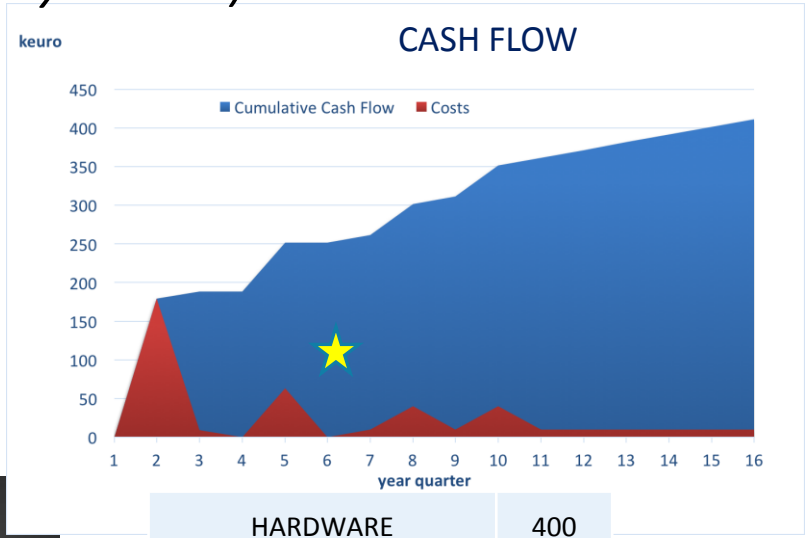
SHARK-VIS timeline:



BUDGET and CASH-FLOW *(by INAF)*:







HARDWARE	400
FTE	732
TOTAL VALUE	**1132**
TAXES 22%	249
CONTINGENCY 20%	226
TOTAL	**1607**

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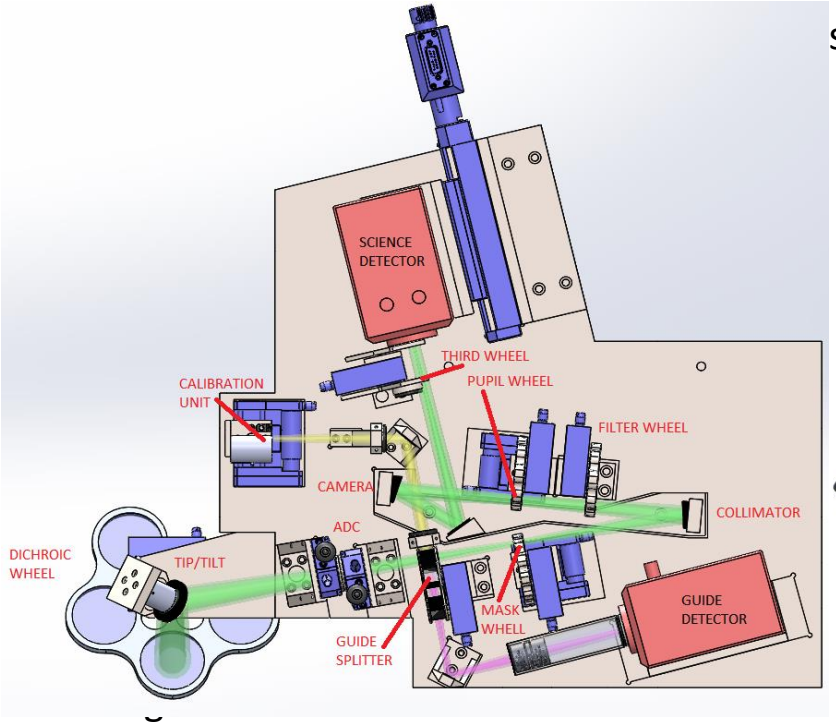
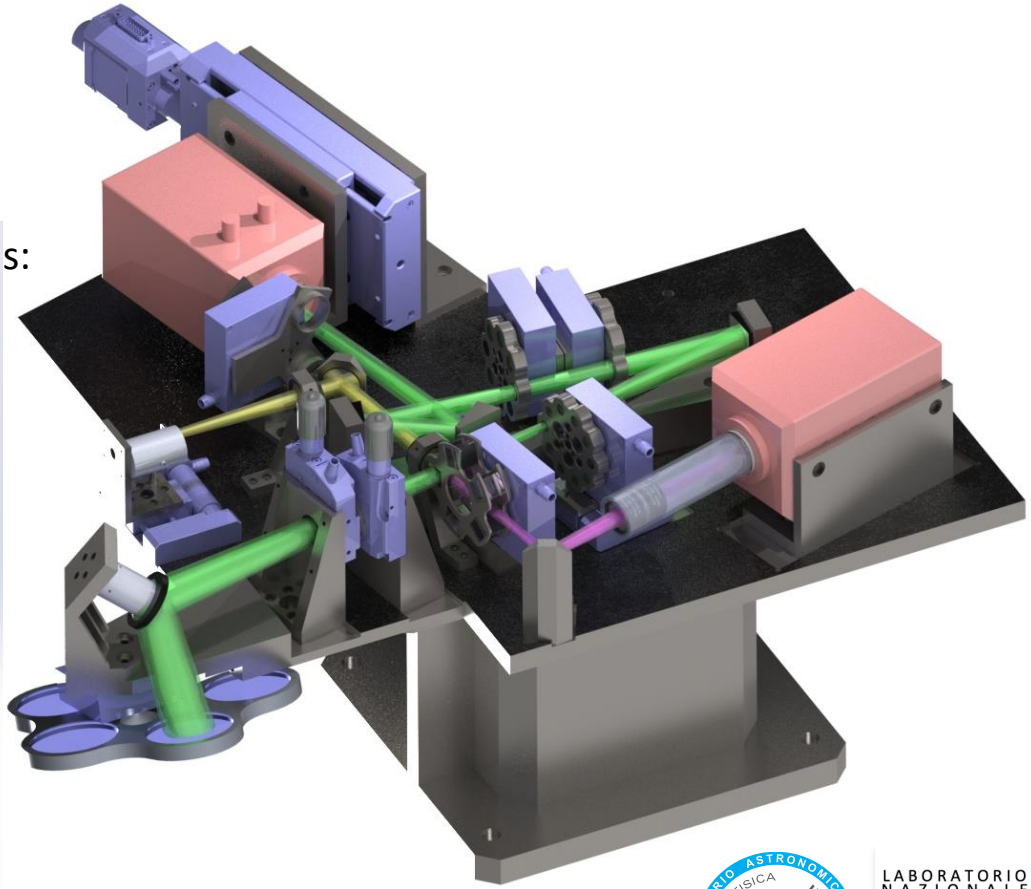
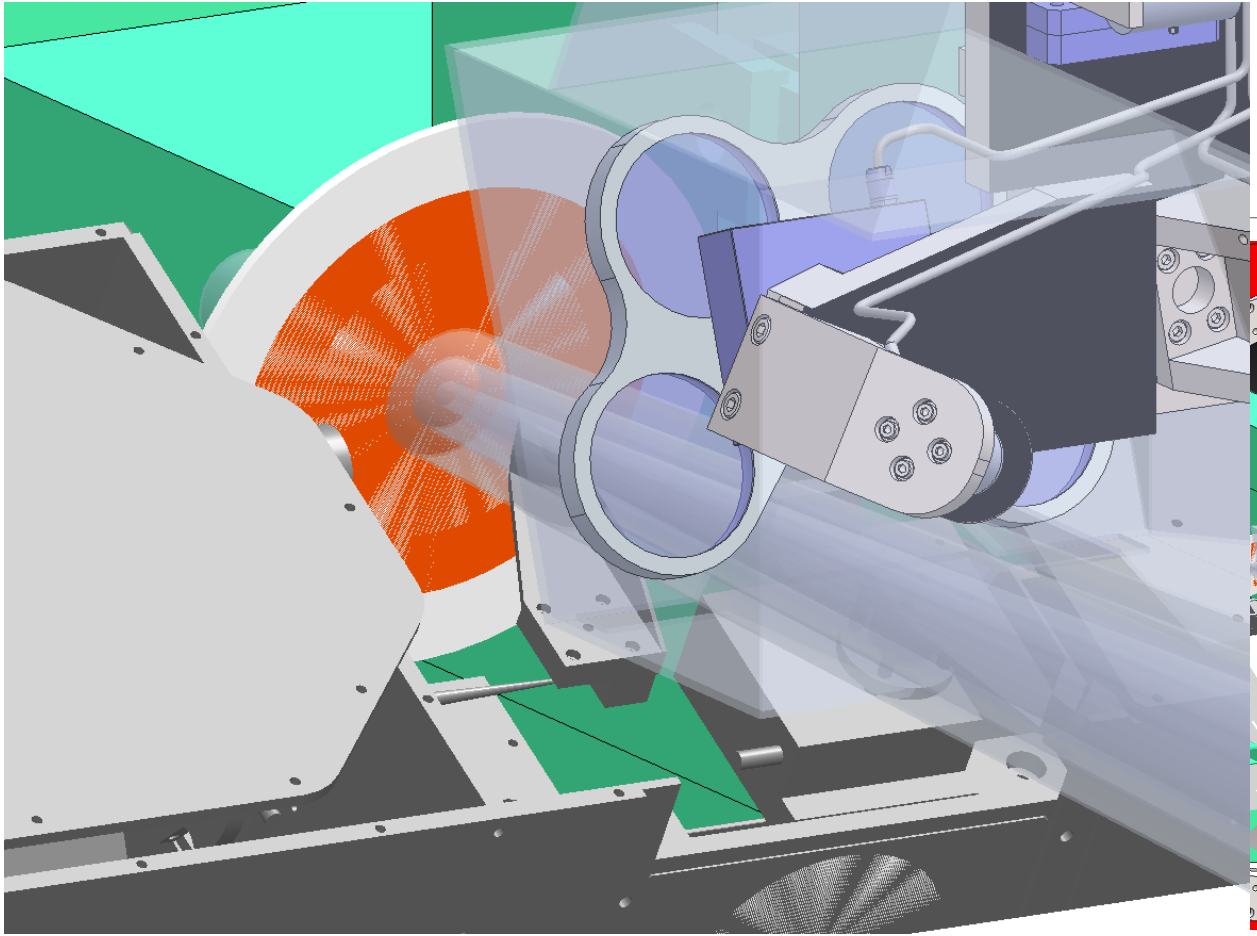
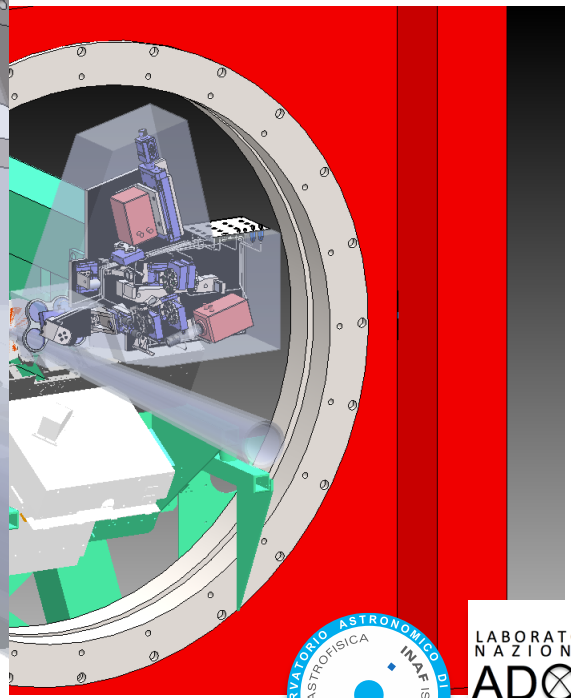
SHARK-VIS today:



s:







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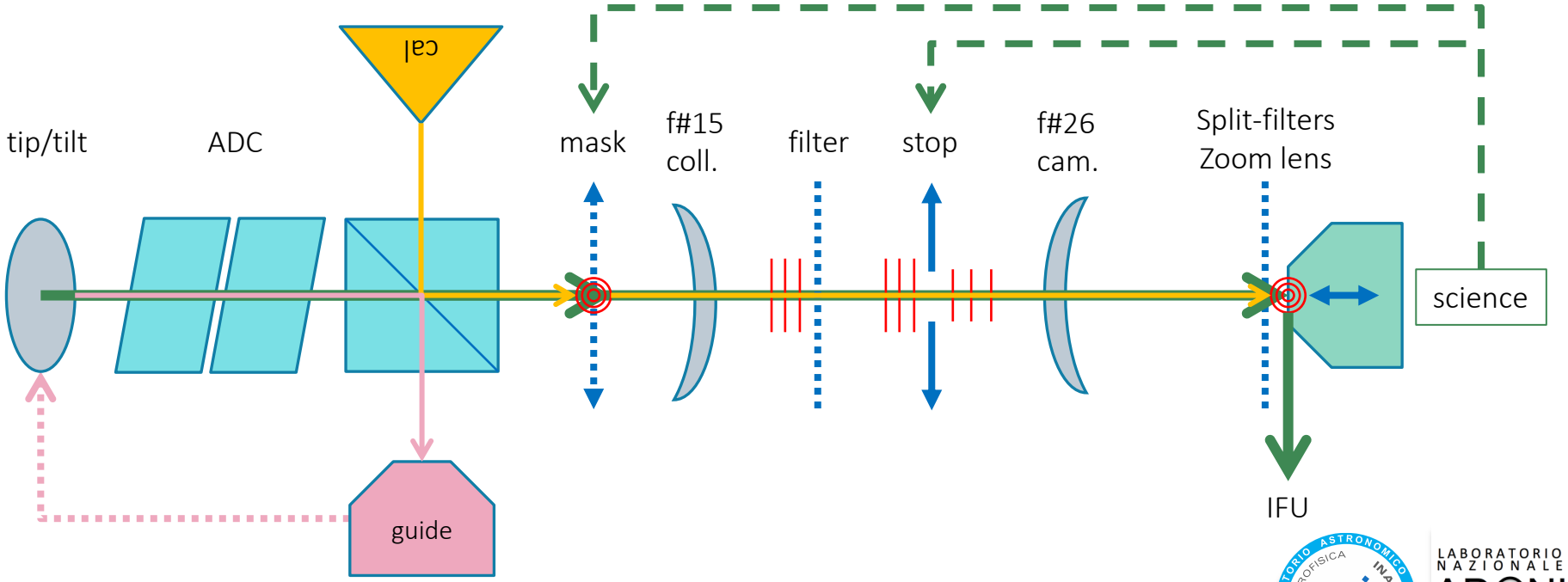
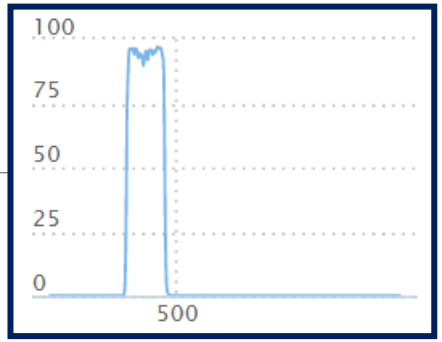
ADONI
OTTICA ADATTIVA

SHARK-VIS how does it work:



SHARK-VIS filters (#12+):
7 Wb + 2 Mb + 2 split SDI…



EXP - NIR 700 - 1000

I - 700 - 800

RED - NIR 600 - 900

RED - 600 - 700

VIS - NIR 500 - 750

VIS 500 - 600

VIS-BLUE 450 - 550

EXP - BLUE 450 - 400

r 650/30

v 550/30

Hα 2nm + cont *(T>90%)*

OI 2nm + cont *(T>90%)*

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SHARK-VIS Forerunner Experiment

Target: GLIESE 777

R mag=5.7

NCPA correction

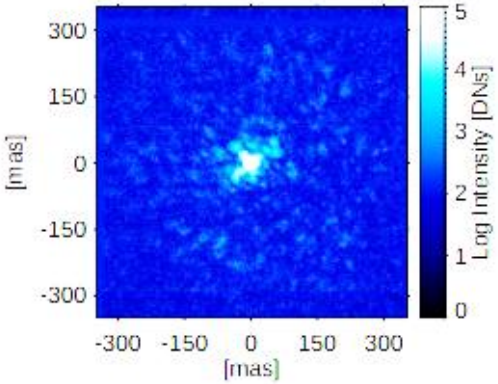
20 min data sequence

1 ms cadence

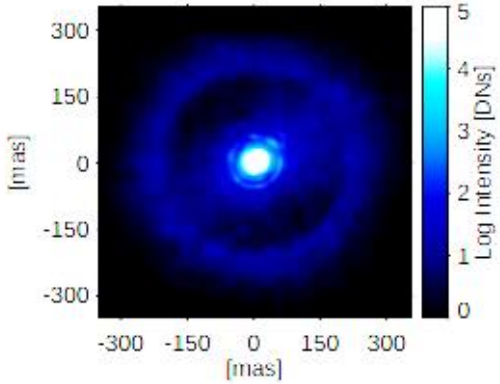
FLAO correcting 500 modes

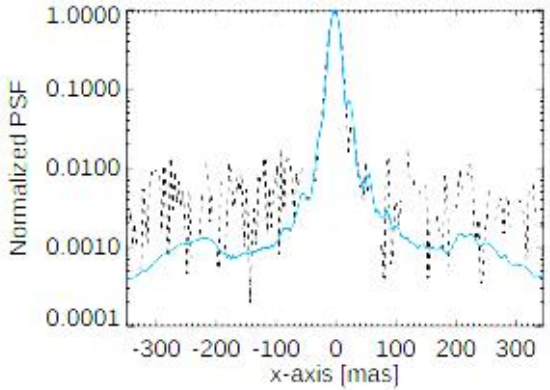
Band 610-650 nm

Short exposure



Long exposure





Pedichini+ 2017
Stangalini+ 2016

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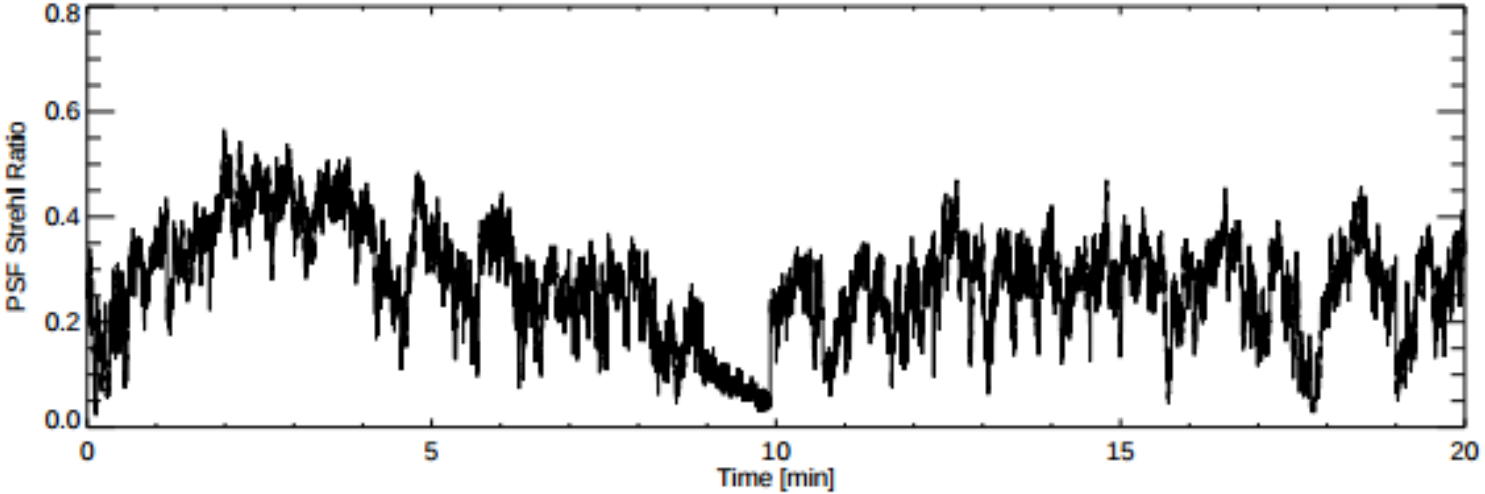
Data quality with seeing 0.8” – 1.5”

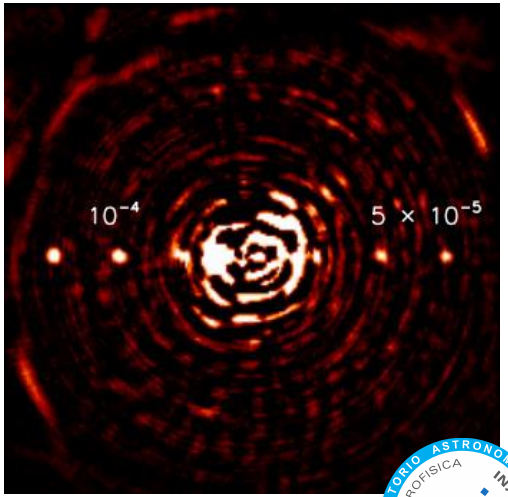


Very unstable seeing conditions SR ranging from 0.05 to 0.55

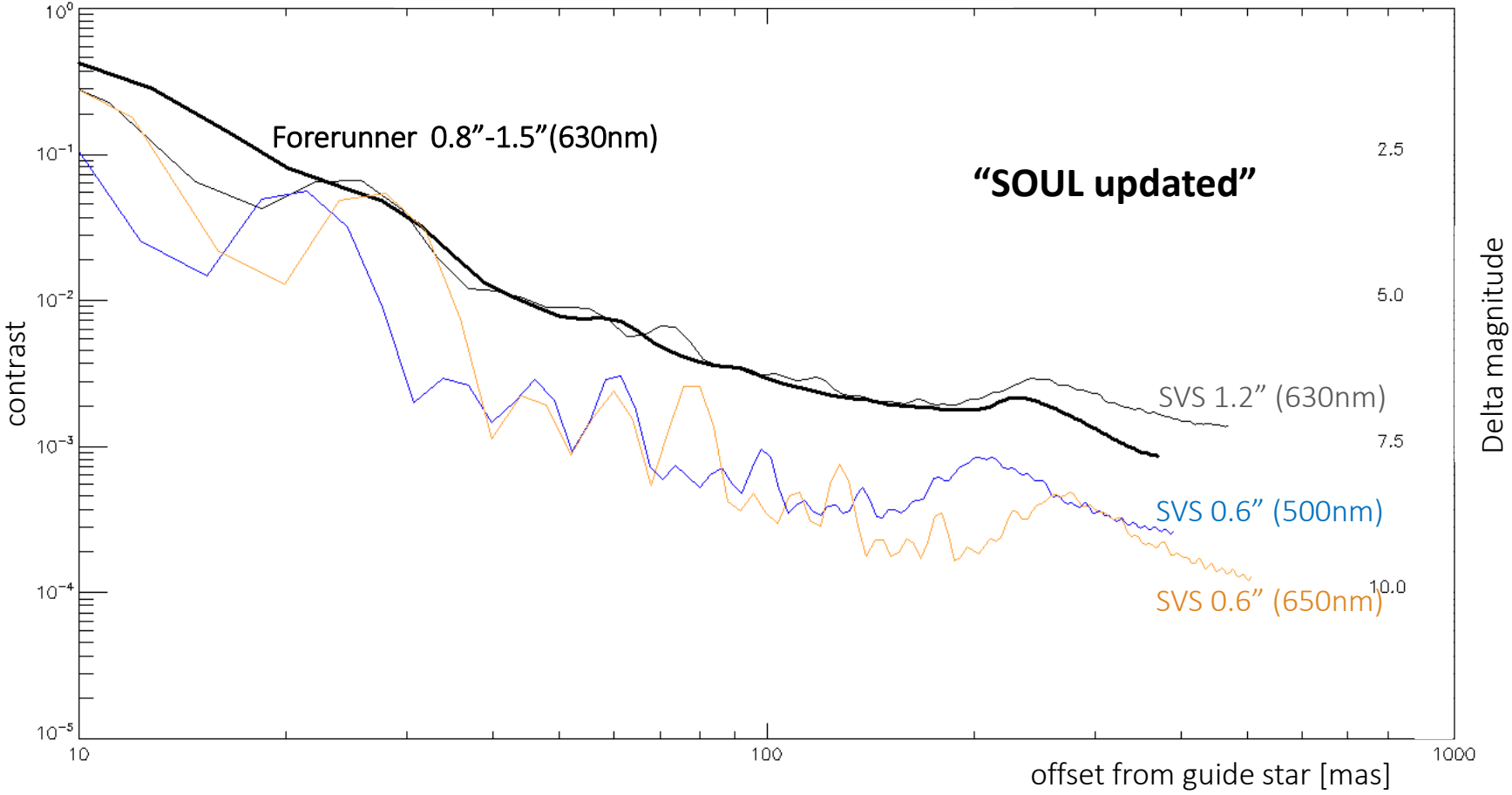
This makes PSF removal difficult

Forerunner on sky results:

- Forerunner PSF core is diffraction limited with 1.2” of unstable seeing
- DIT = 1ms PSF jitter frozen and recovered with post processing
- 630nm with 40nm of bandwidth
- 20 minute total exposure (70° of field rotation)
- Basic ADI processing on 1.2e6 frames (Marois 2005)
- Detection at S/N>6 of fake planets at contrast of 5e-5
- No data selection
- *Achieved Detection is 10 times the photon noise*



SHARK-VIS Radial Contrast for direct imaging

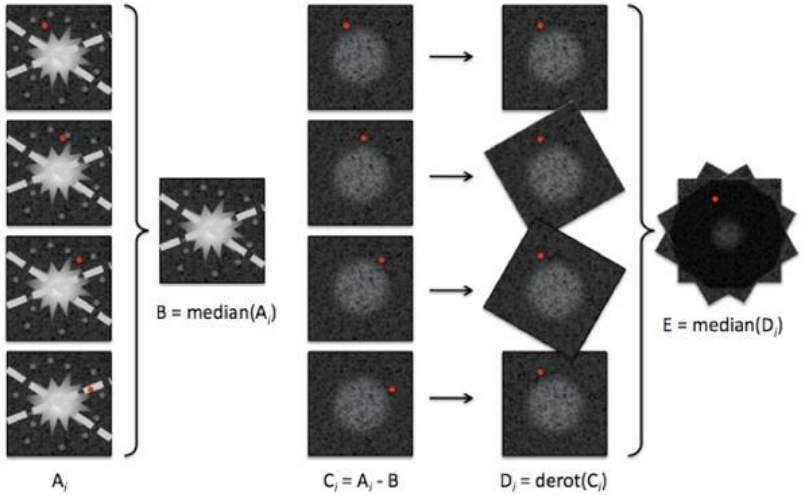


It’s Science Time for SHARK-VIS

Thank you!

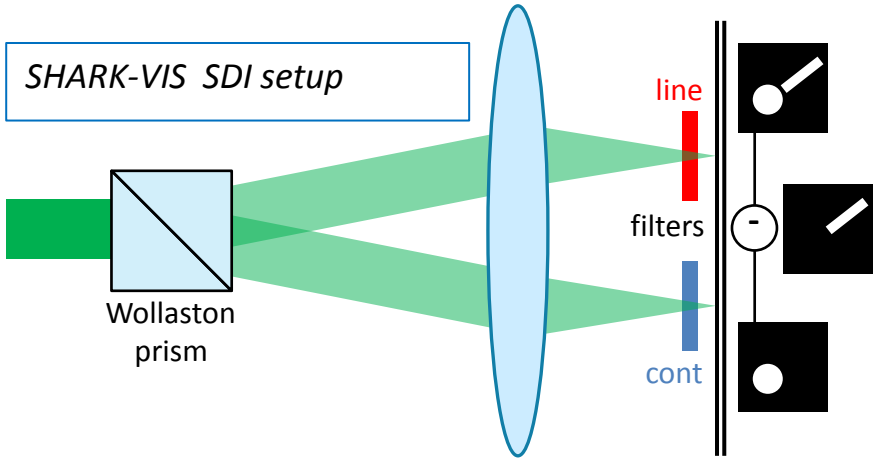
ADI *(Marois+ 2005)*

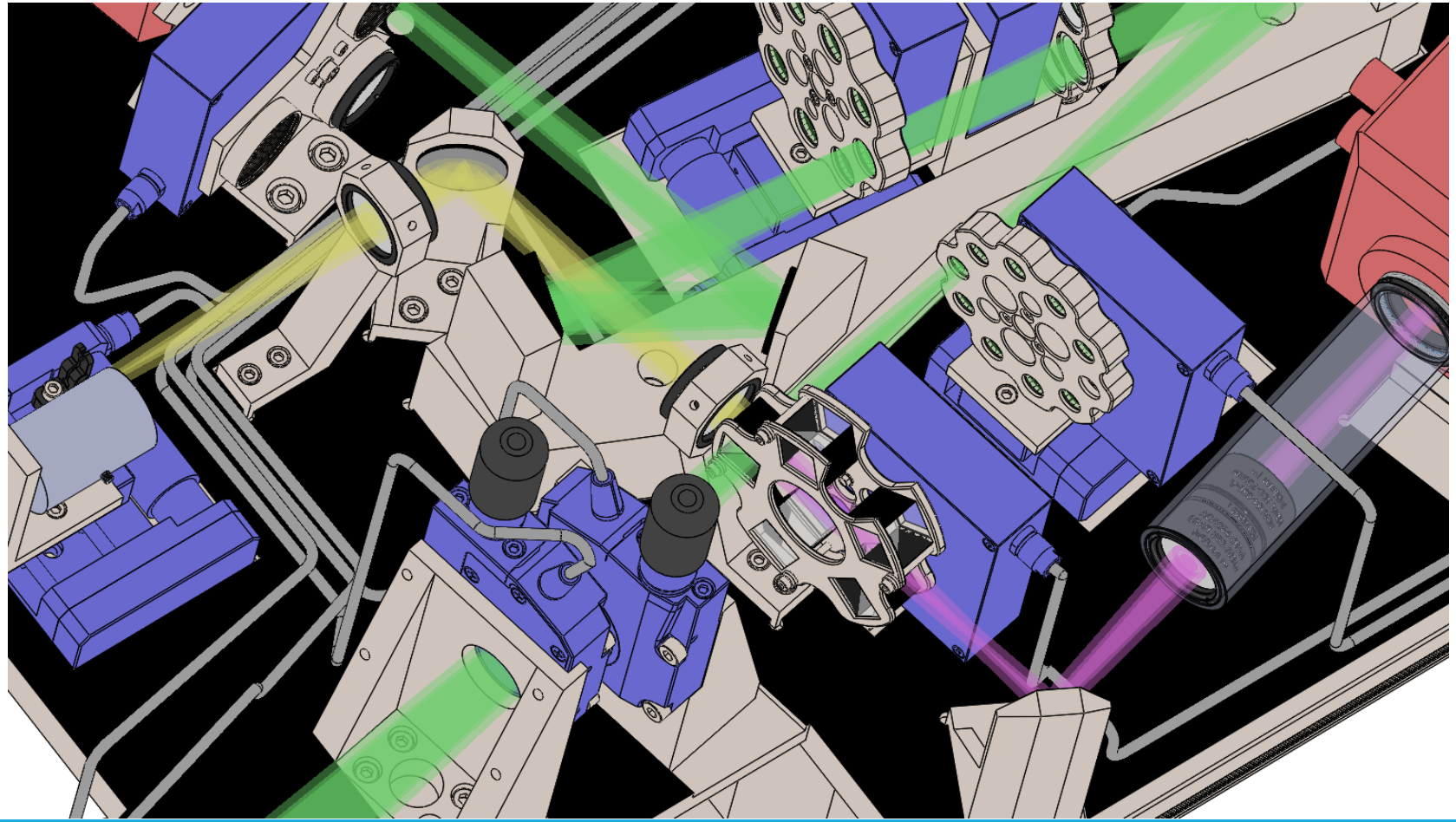
- Take images at different field angles (not derotated)
- Estimate by median the PSF to subtract to every the frames

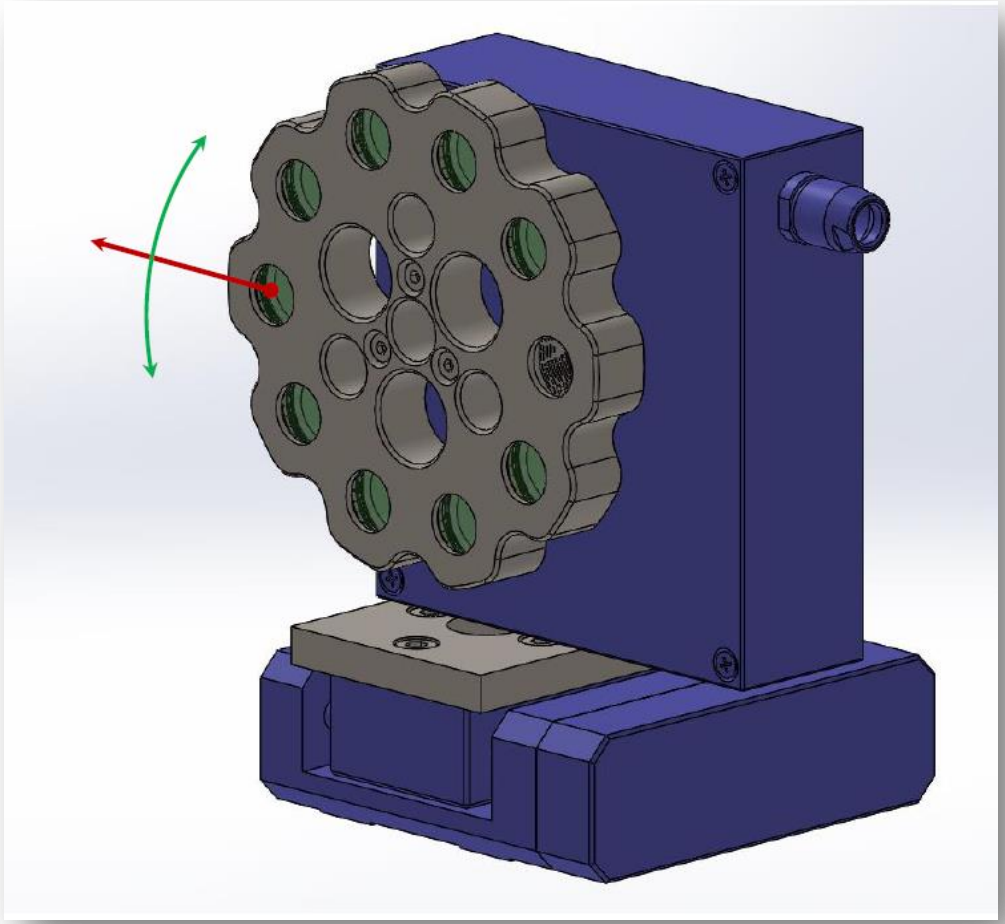


SDI

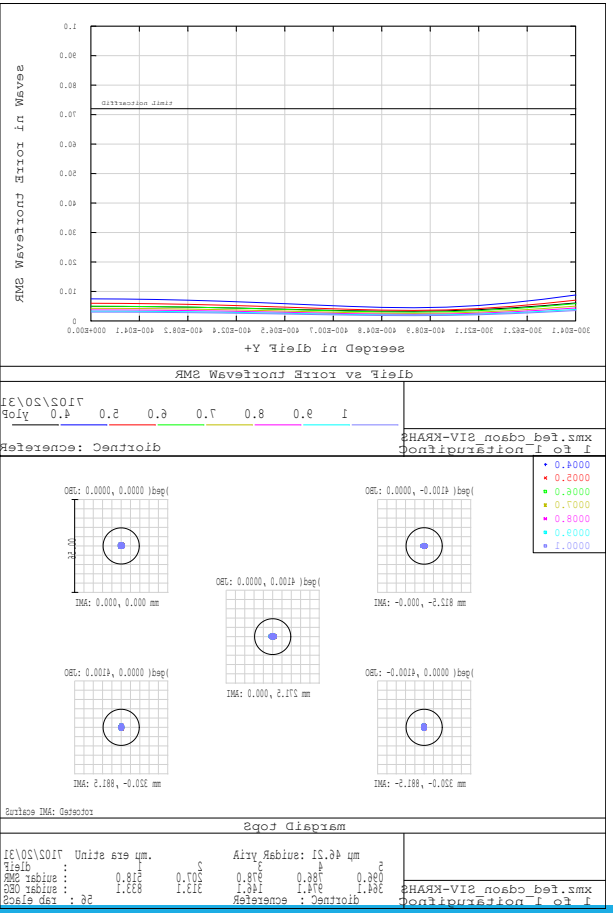
- Observe simultaneously in two narrow-band filters: line and adjacent continuum
- Estimate by the continuum image the PSF to subtract at each frame







OPTICAL relay performances and tolerances:



Tries: 1000

Statistic: flat

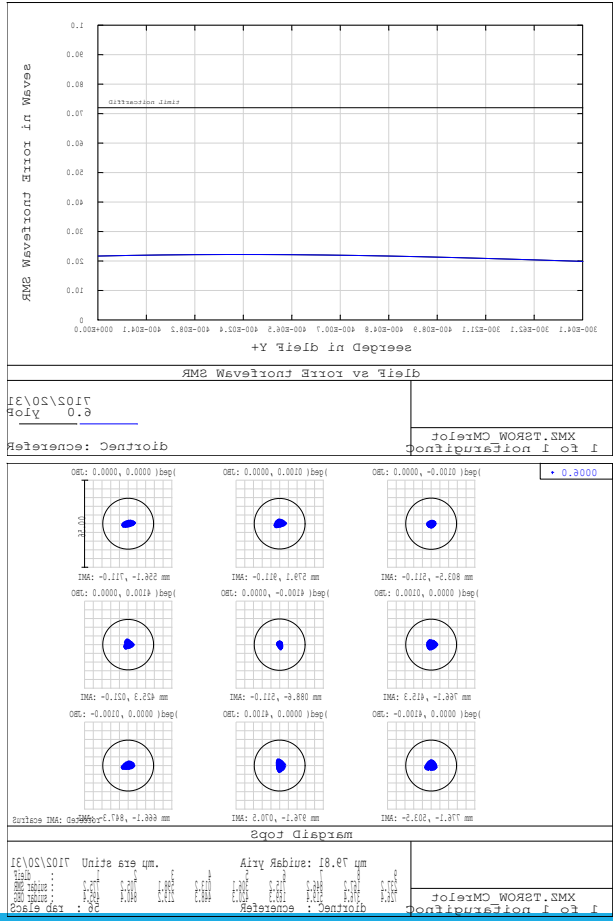
Radius: ±0.2 mm

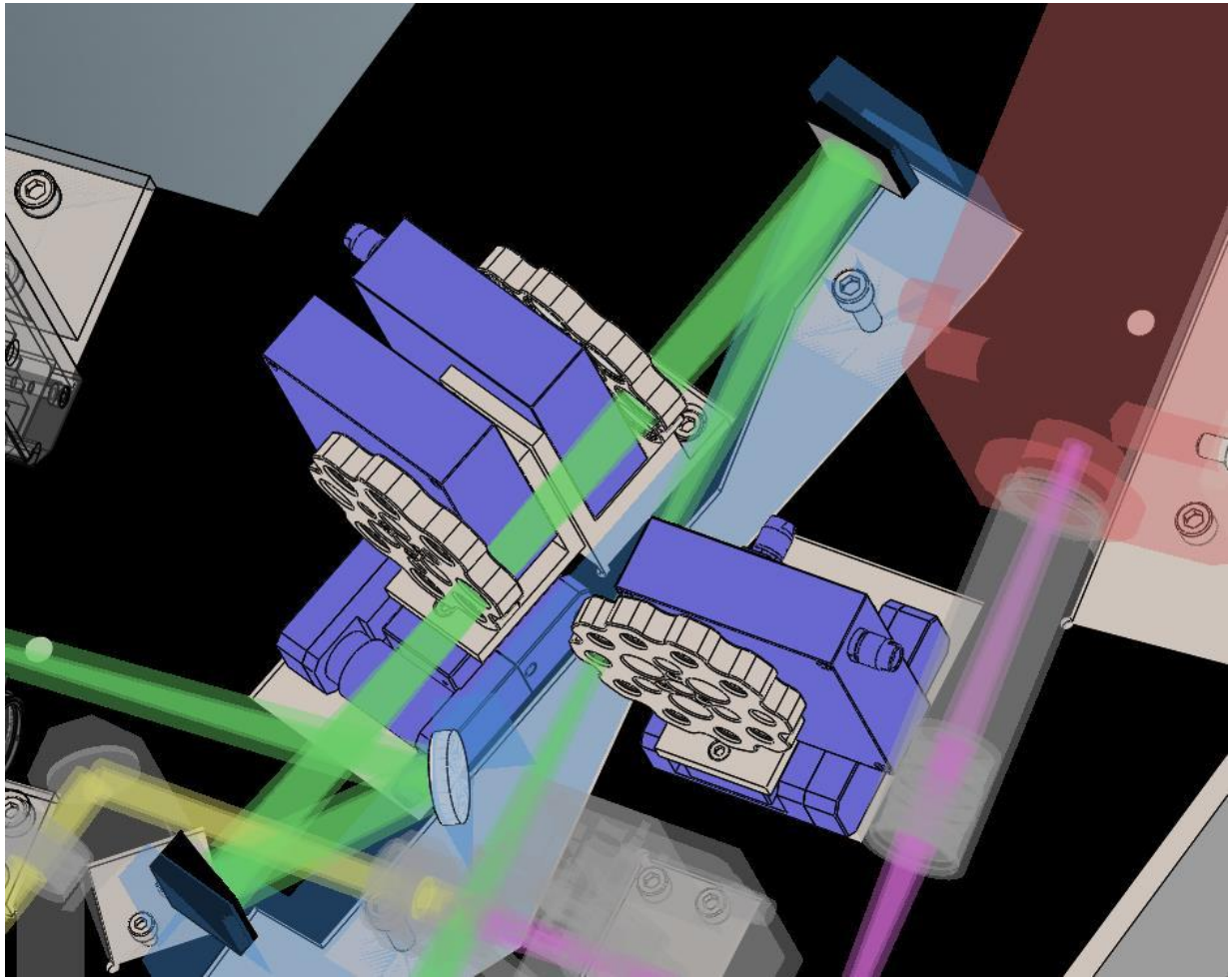
Shifts: ±0.2 mm

Tilt: ±0.1 degrees

Only camera refocus

To avoid high order aberration λ/100 optical quality required





ABS system

REQUIREMENTS

- Mitigates residual PSF jitter (≈ 17mas rms)
- Allows fine subpixel centering of PSF
- Compensates ADC chief ray tilt

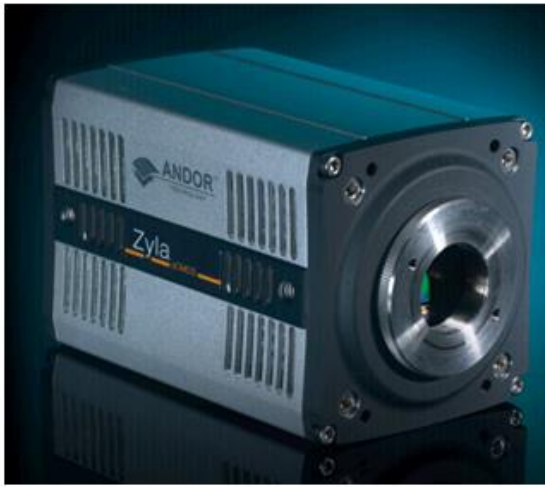
EXPECTED PERFORMANCE

- Reduction of Jitter by a factor 6 at least
- 0.3 pixel r.m.s.

HARDWARE PI PIEZO S-330

SHARK-VIS detector: sCMOS+ or EMCCD

READOUT format	Frame rate [kHz]	DIT [ms]	Data rate [MB/s-TB/h]	
2k x 2k	0.04	25	360	1.30
512 x 512	0.4	2.5	210	0.75
200 x 200	1	1	80	0.29



+EFFICIENT
+DYNAMIC
+FOV

-CALIBRATION

+RON
+CALIBRATION
+Q.E.

-SHUTTER
-DYNAMIC
-FOV
-BLOOMING

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ADC performances

4.2.4 EXPERIMENTAL BLU (450-550nm)

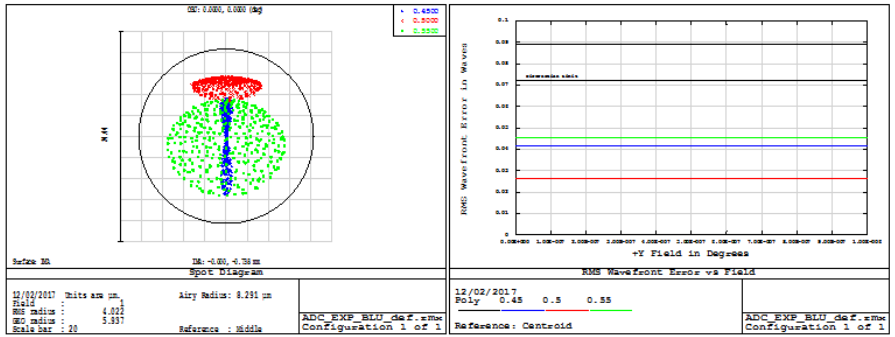

Figure 15 - Max Zenith 56°, Focus 40.32.94, beam tilt 0.74mm, ADC position 90°.

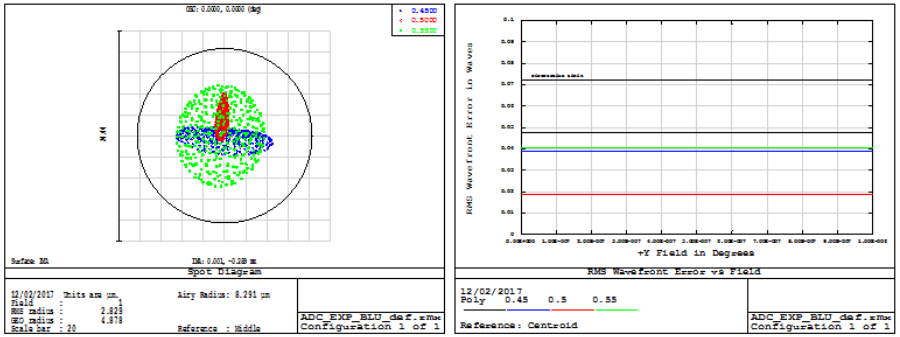

Figure 16 - Zenith 30°, Focus 40.31, beam tilt 0.29mm, ADC position 23°.

ADC BANDWIDTH vs WAVE