



Subaru Coronagraphic Extreme Adaptive Optics
すばるコロナグラフ極限補償光学装置



New NIR spectro-polarimetric modes for the SCExAO instrument

Julien Lozi

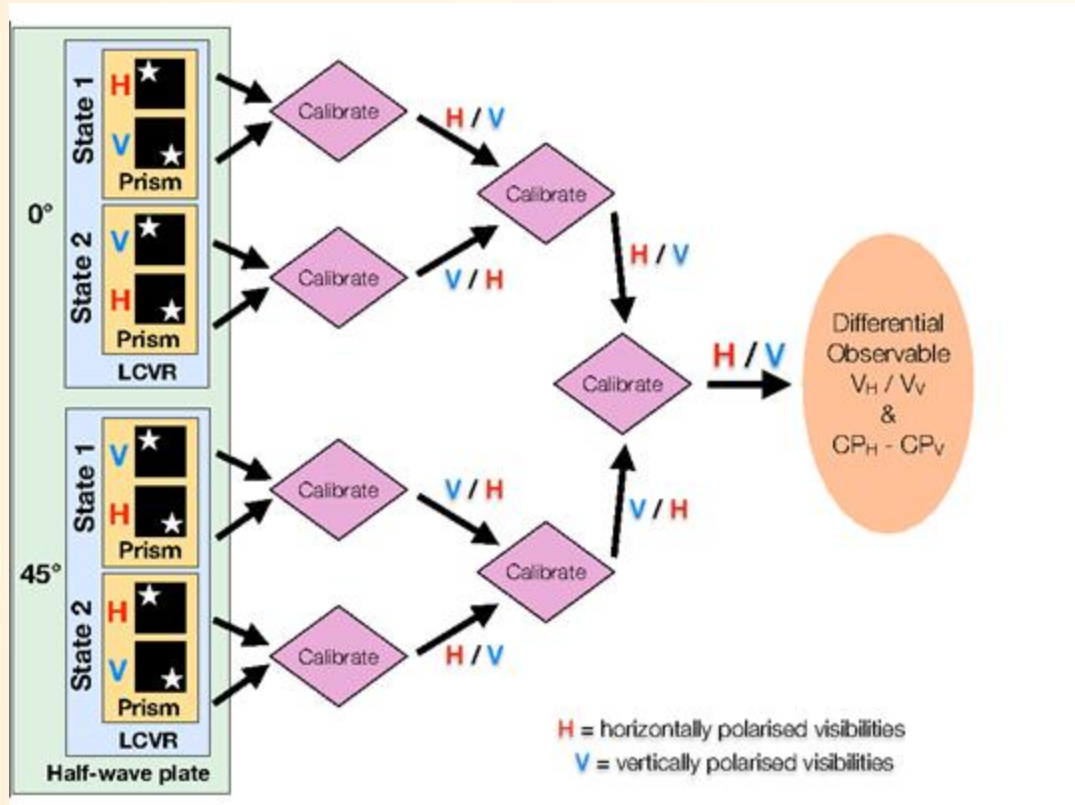
O. Guyon, N. Jovanovic, B. Norris, T. D. Groff, J. Chilcote, J. Kasdin, T. Kudo, M. Tamura, Jin Zhang, S. Bos, F. Snik, D. Doelman, B. Mazin, A. Walter, S. Vievard, A. Sahoo, F.

Martinache

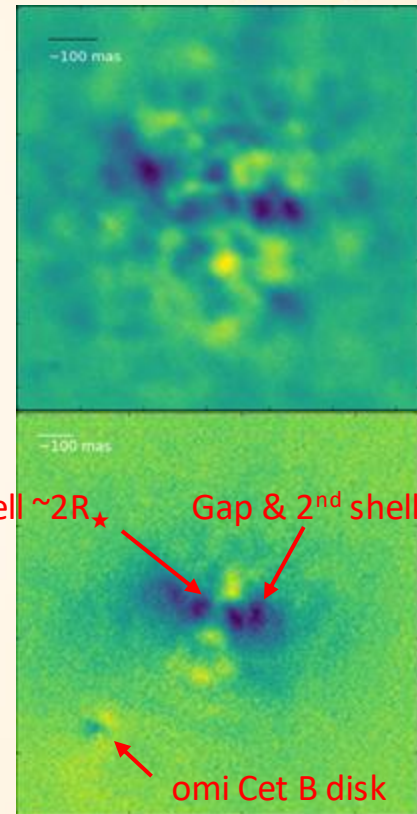
Polarization differential imaging (PDI) is the most successful mode for GPI and SPHERE. Dozens of new protoplanetary disks, transition disks and debris disks were imaged using these modes.

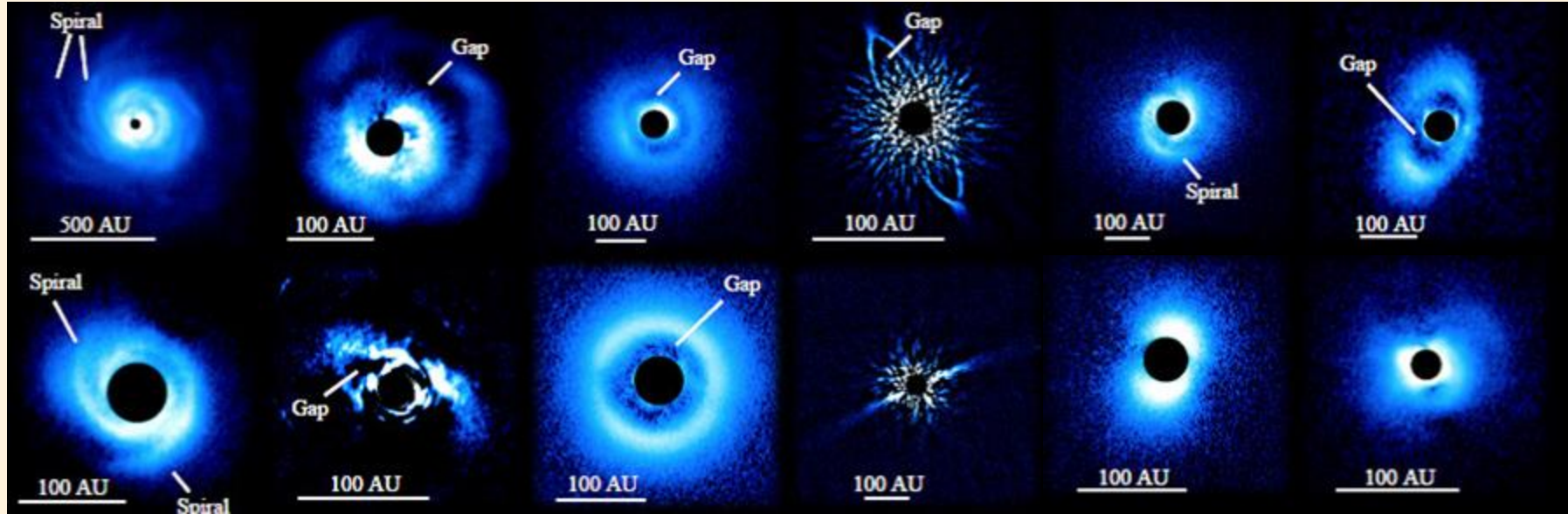
This capability was lost when transitioning from AO188+HiCIAO to SCExAO+CHARIS. But a lot of interest is still present in the Japanese community, especially the post-SEEDS group.

Two polarimetric modes are being added in 2019: a spectro-polarimetric mode using CHARIS, and a fast IR mode using a newly purchased C-RED ONE (Kudo-San's Kiban A grant).



Single (top) vs.
Triple layer PDI
(bottom) on
omi Cet
(VAMPIRES,
SCEXAO)



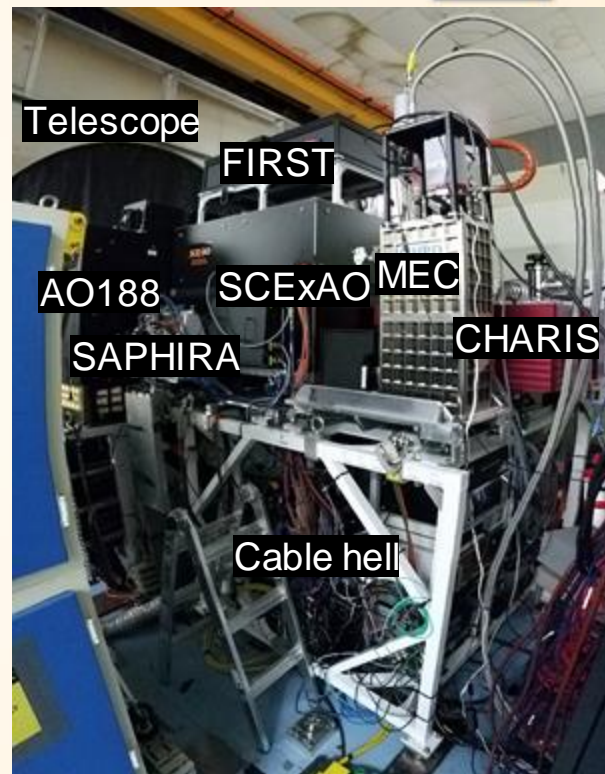


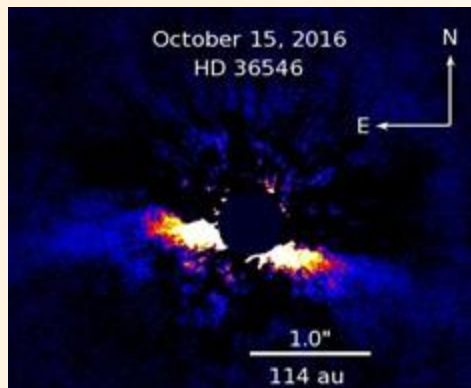
SCExAO: Subaru Coronagraphic Extreme Adaptive Optics

High-contrast PI instrument installed on the IR Nasmyth platform of the Subaru Telescope.

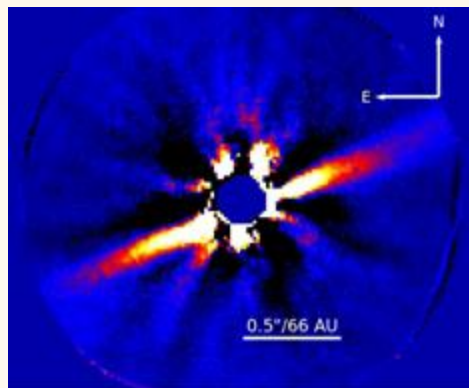
Very modular design that enables testing of new technologies necessary for future high-contrast imagers as a laboratory testbed.

But it is also a instrument used on-sky to perform competitive science.

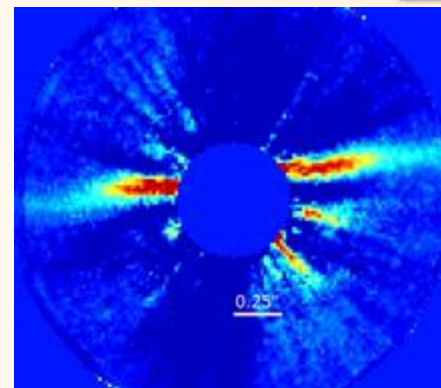




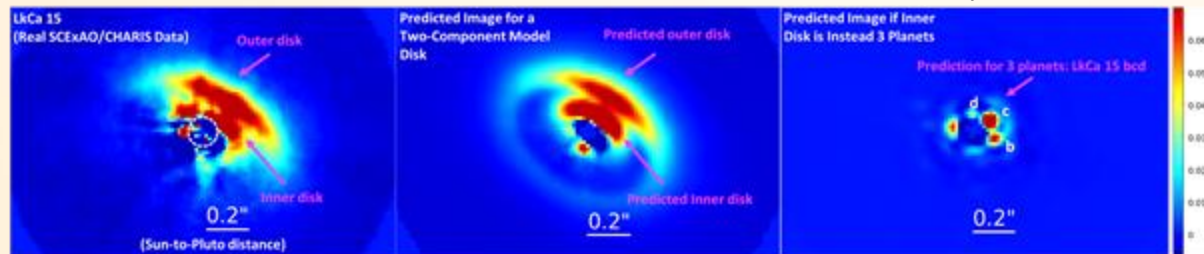
HD 36546 (Currie et al. 2017)
Direct Imaging Discovery of a
Luminous Debris Disk



HIP 79977 (Goebel et al. 2018)
Strongly forward—scattering
dust from a 60 au belt, neutral to

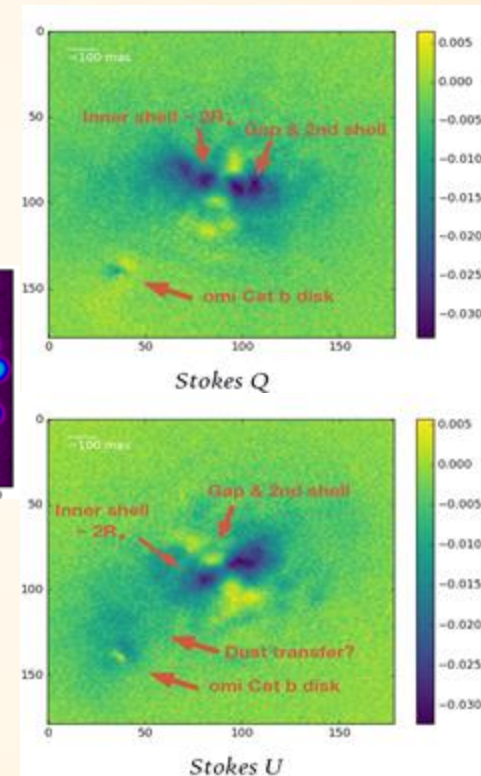
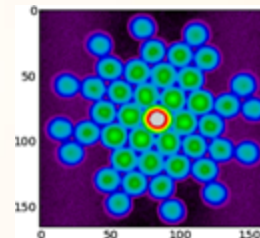
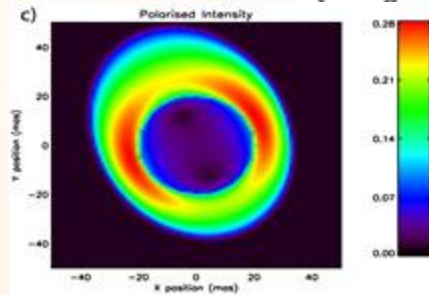
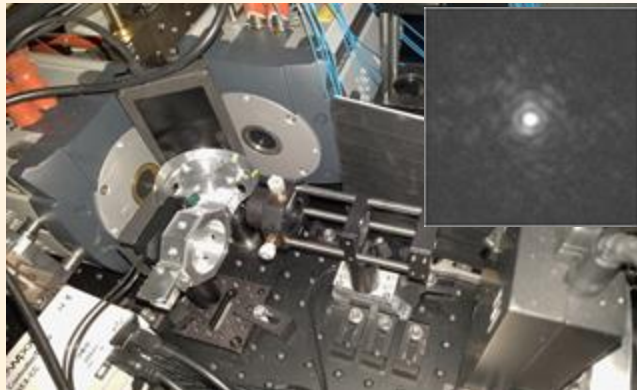


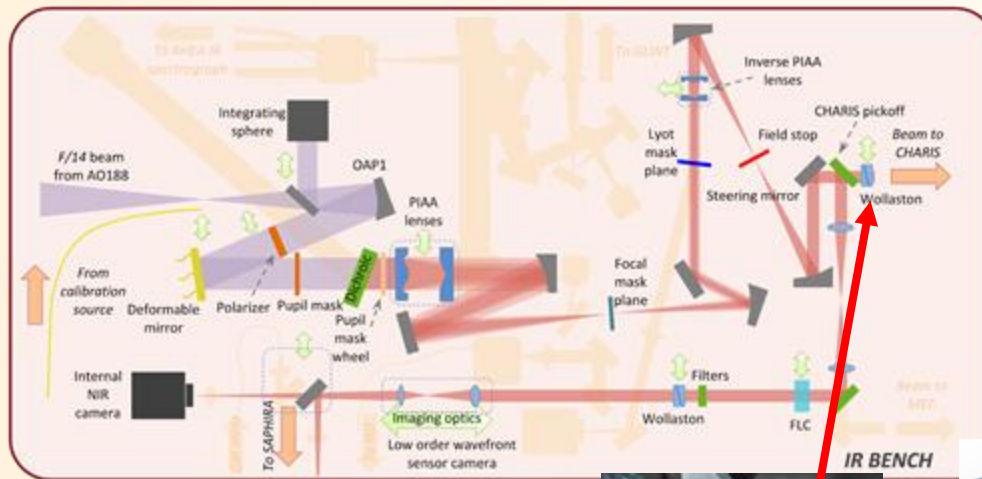
HD 15115 (Kwon et al. 2018)
Some evidence for brightness
asymmetry at small separations;
spatially-resolved spectrum



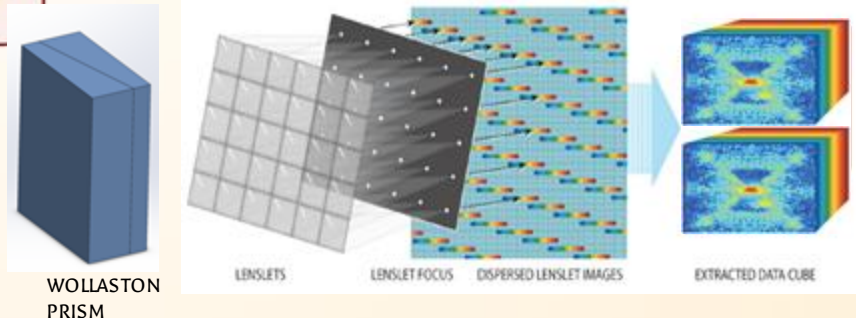
LkCa15 (Currie et al. 2019)
Non-detection of the potential
planets

- VAMPIRES is a visible aperture masking interferometer with polarimeter capabilities. Using Sparse Aperture Mask (S(P)AM) and soon Holographic Aperture Mask (HAM).
- It operates from 600-940 nm and allow for sub-diffraction limited imaging of post AGB stars and disks with full polarimetric information.
- The instrument showed that the 3 levels of polarisation calibration can achieve exquisite normalised visibilities with $\sigma \sim 0.17^\circ$!
- New dual camera system with fast polarisation switching FLC
- New H-alpha differential mode

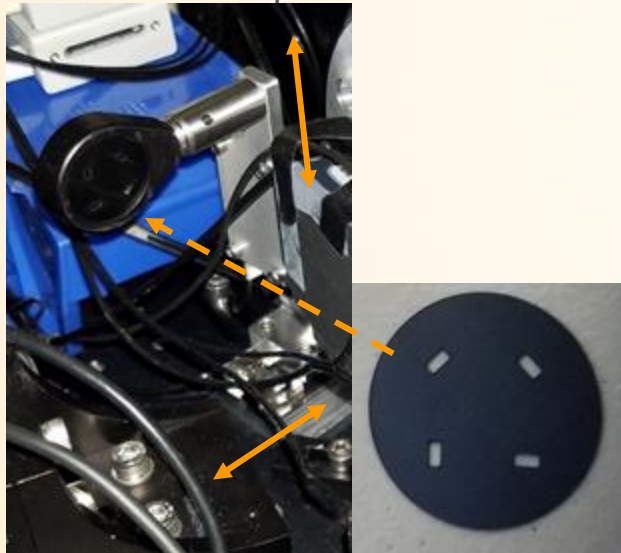




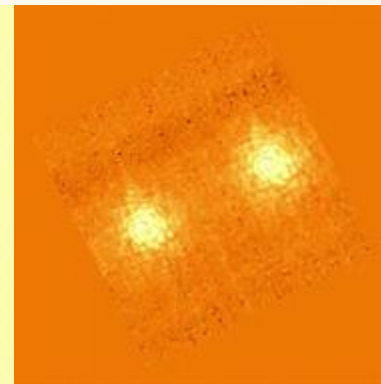
A new observing mode was added for CHARIS, simply by adding a Wollaston prism in front of the CHARIS window. The field of view is reduced to 2×1 arcsec, but both polarizations are imaged at the same time, with the spectroscopic capability preserved.



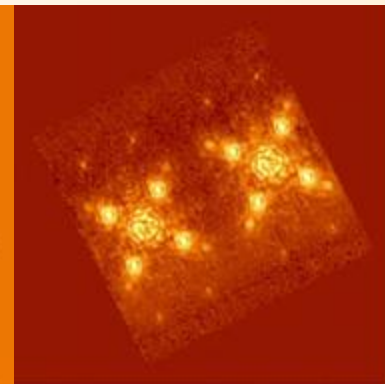
A field stop blocks the light outside the FOV to avoid cross-talks between polarizations.



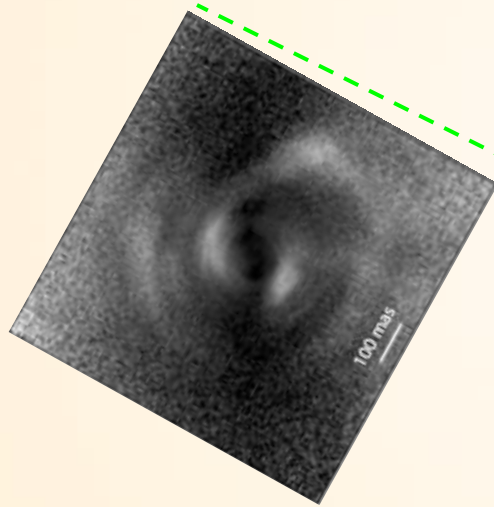
no field stop, no
speckle grid



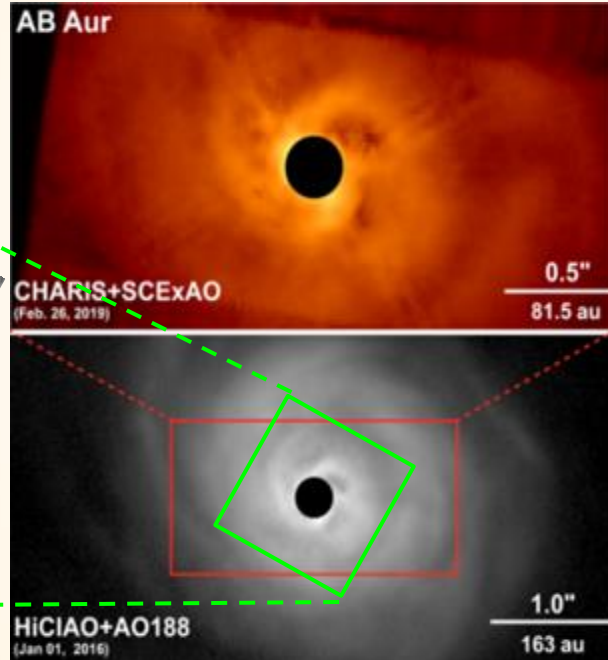
field stop, no speckle
grid



field stop, speckle
grid

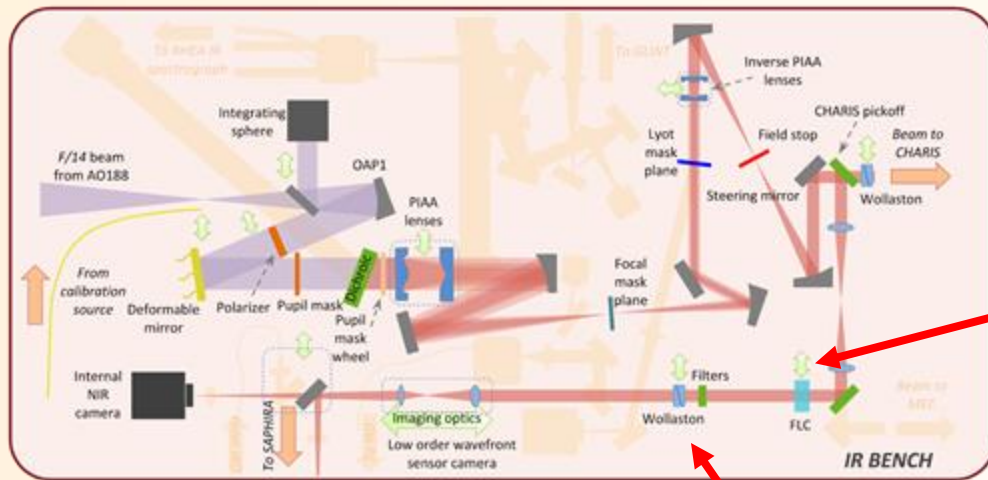


VAMPIRES+SCEAO
(Feb. 2018, work in progress)



Comparison of HiCIAO and the new PDI mode, as well as VAMPIRES, on the disk around AB Aurigae:

- Slightly better inner working angle
- But more diffraction residuals
- Distortion calibration needed.



A fast PDI mode, similar to VAMPIRES in visible, was added using a second Wollaston and a FLC for fast modulation of the polarization.



A C-RED ONE camera was purchased for that purpose, and will be delivered at the end of FY19. In the meantime, testing was done with the C-RED 2.



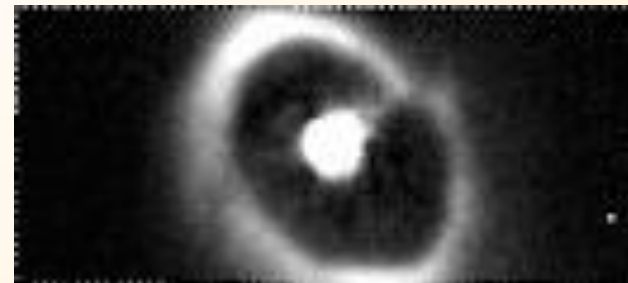
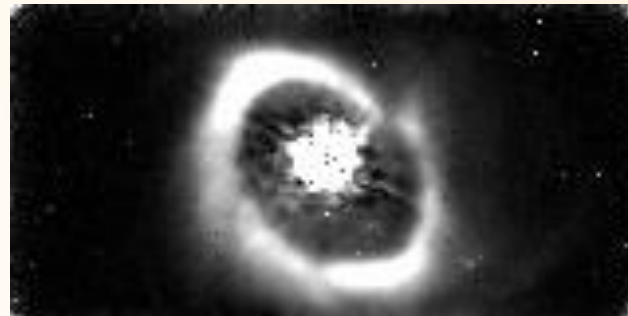
The same field stop can be used for both modes, as long as the Wollaston prisms are in the same orientation.

The mode was tested on-sky, on the bright disk around HD34700.

The FLC was not available at that point, so the polarization switching is slow.

Top: broadband (950-1700 nm) image with C-RED2 camera.

Bottom: broadband (1100-2400 nm) image with CHARIS.



- HgCdTe avalanche photodiode manufactured by Leonardo
 - < 1 electron readout noise
 - Up to 3500 FPS full frame
- The camera was purchased for two purposes:
 - PDI mode
 - IR PyWFS
- A C-RED ONE was already tested for fast speckle control and Kernel applications



- Spectro-polarimetric mode with CHARIS:
 - 90% completed
 - Only the synchronization with VAMPIRES for the rotation of AO188's half-wave plate needs to be done
 - Should be completed before the end of S19B.
- Fast IR polarimetric mode:
 - 50% completed
 - The FLC was successfully tested
 - We are working on the fast synchronization between the camera and the FLC
 - The science camera (C-RED ONE) will be delivered in March 2020.

Two upgrades are envisioned for the near future:

- The addition of sparse aperture masks, similar to the ones used by VAMPIRES, for increase resolution.
- The addition of a polarized vAPP, that would create a half dark zone for each polarization.

