Subaru Coronagraphic Extreme-AO (SCExAO) system

- ***Highly flexible platform for high contrast imaging science.***

- ***Enhances HiCIAO / SEEDS performance.***

- ***Powerful platform to rapidly turn new techniques into science results (very complementary to SPHERE and GPI), and train young researchers for high contrast imaging technology and science: precursor to future instrument(s) for ELT(s)***

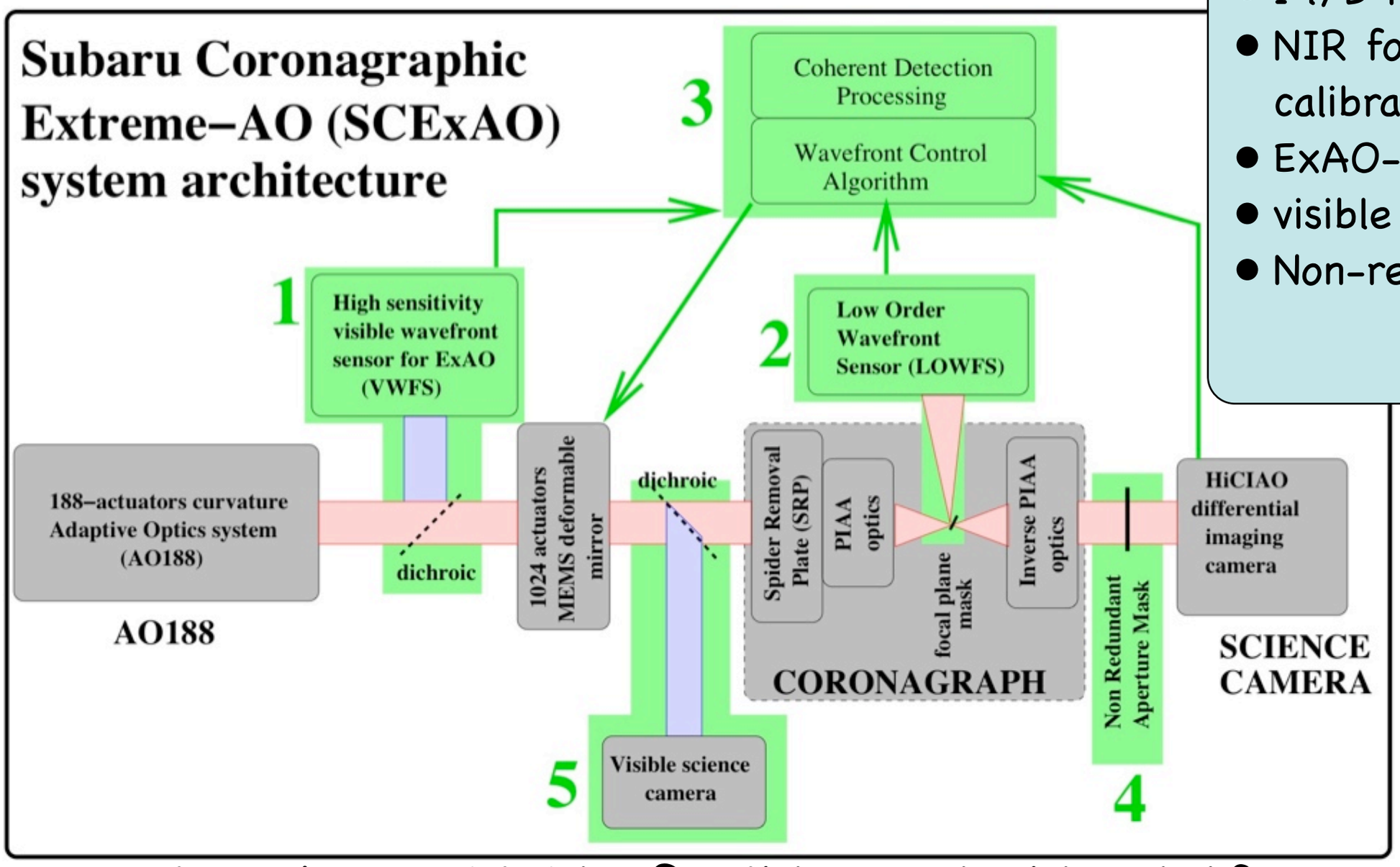
Optimized to provide high contrast and precise calibration of diffracted light at very small angular separations in H band

- Efficient *PIAA coronagraph* with 1 lambda/D inner working angle with *Coherent speckle calibration* with 32x32 MEMs DM
- Offers *Non-Redundant Aperture Masking* mode
- Includes diffraction limited visible imaging channel

First light scheduled in late 2010. Future upgrades include high sensitivity fast visible WFS (in collaboration with HIA in Canada and observatory of Paris) to augment raw contrast.

For more info: http://www.naoj.org/Projects/SCEXAO/

System Architecture combines several high performance new techniques validated in the Subaru lab over the last 5 years



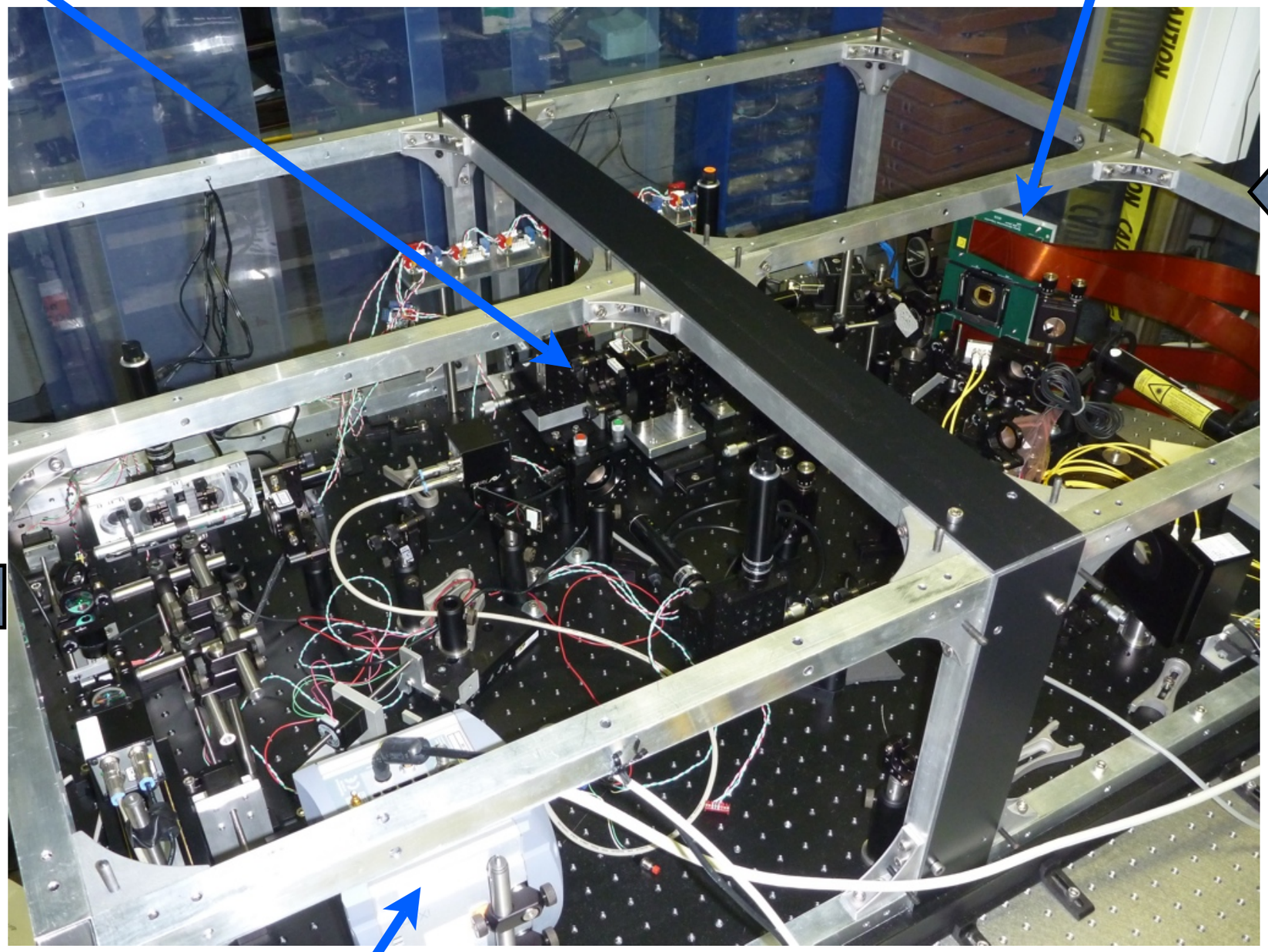
- 1 l/D PIAA coronagraph
- NIR focal plane WF control/ calibration
- ExAO-optimized visible WFS
- visible channel
- Non-redundant masking

Designed as a highly flexible, evolvable platform
Efficient use of AO188 system & HiCIAO camera
First light in mid 2010

Optical bench

PIAA Coronagraph

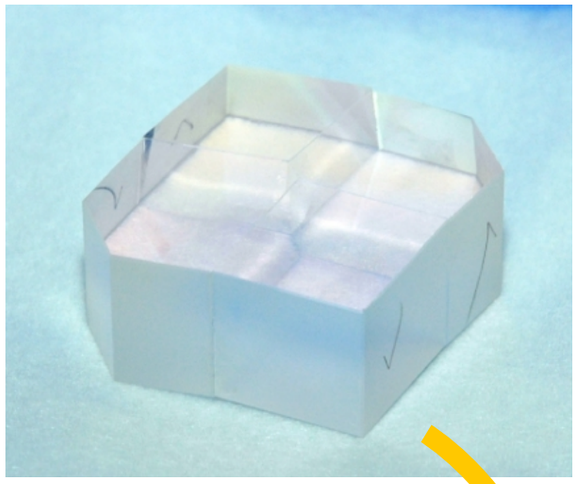
1024 actuators deformable mirror



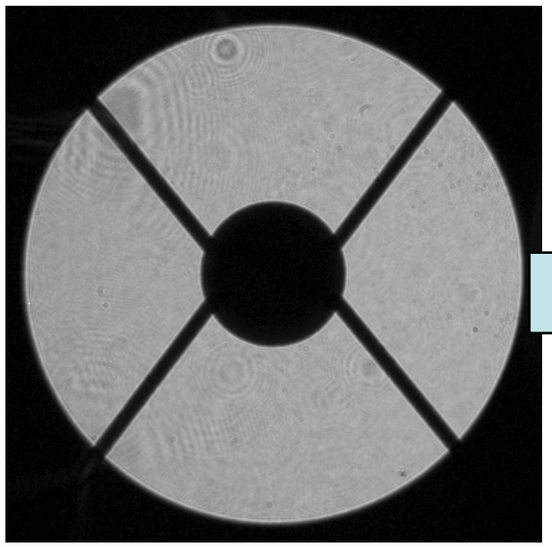
Light output is sent to HiCIAO

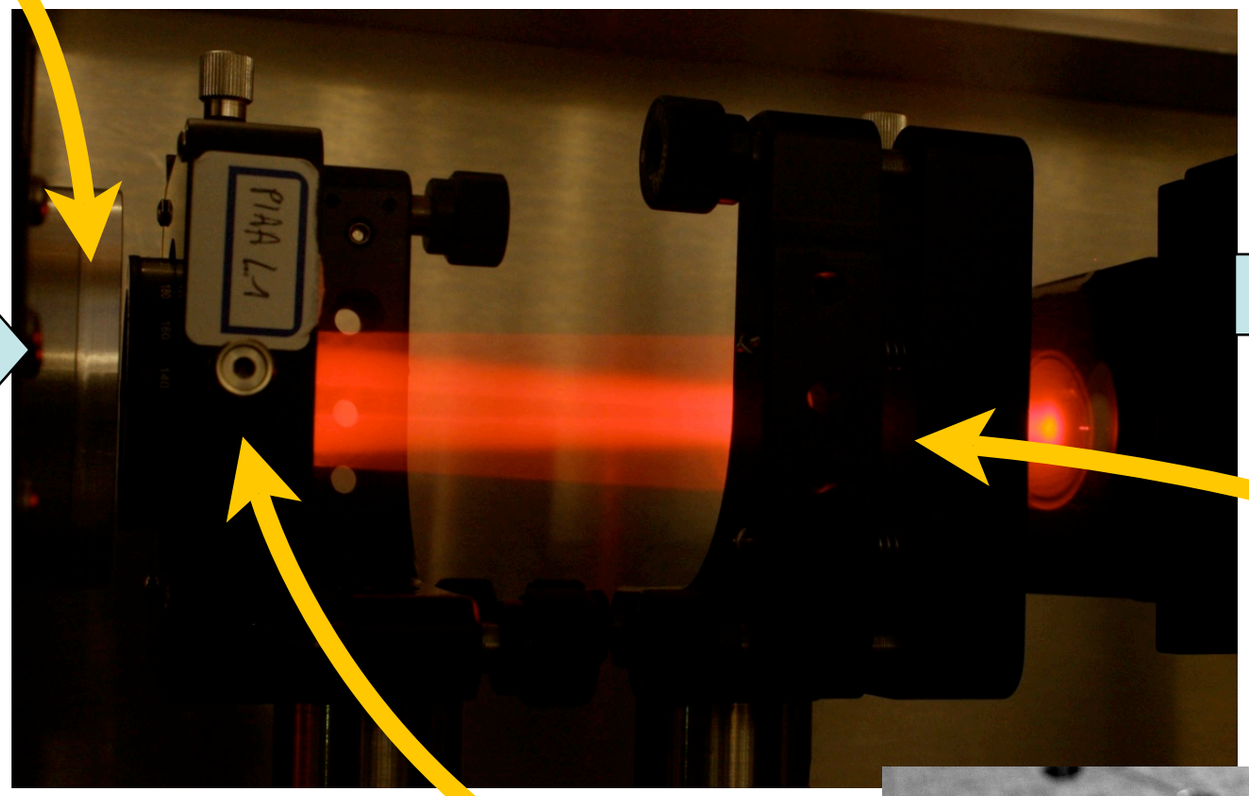
Light comes from AO188

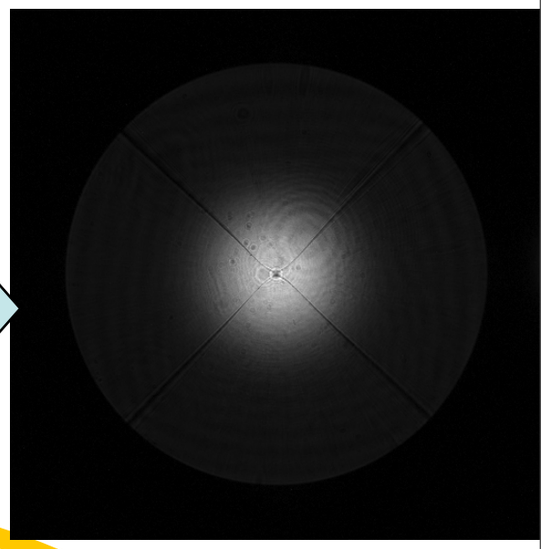
Visible photon counting camera



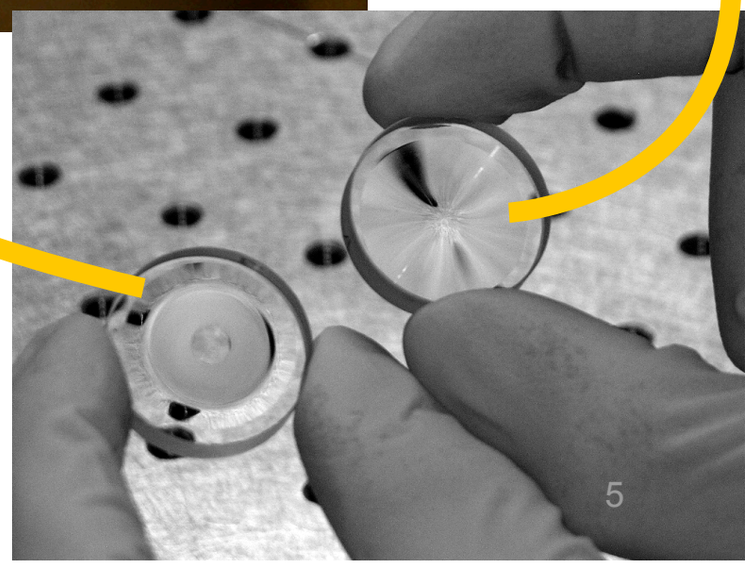
PIAA lenses + spider removal plate apodize the Subaru pupil with no light loss

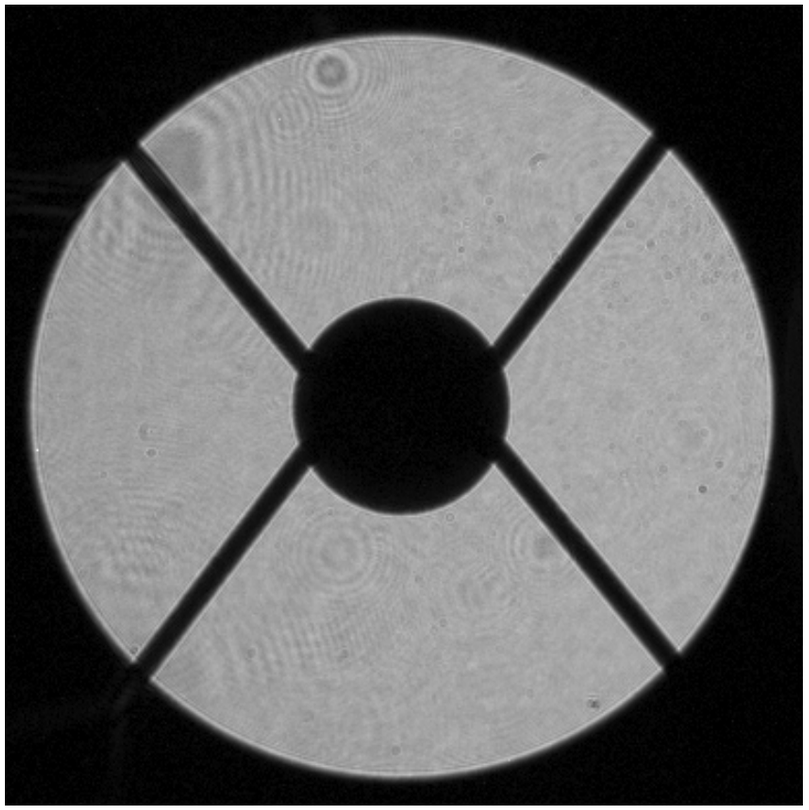




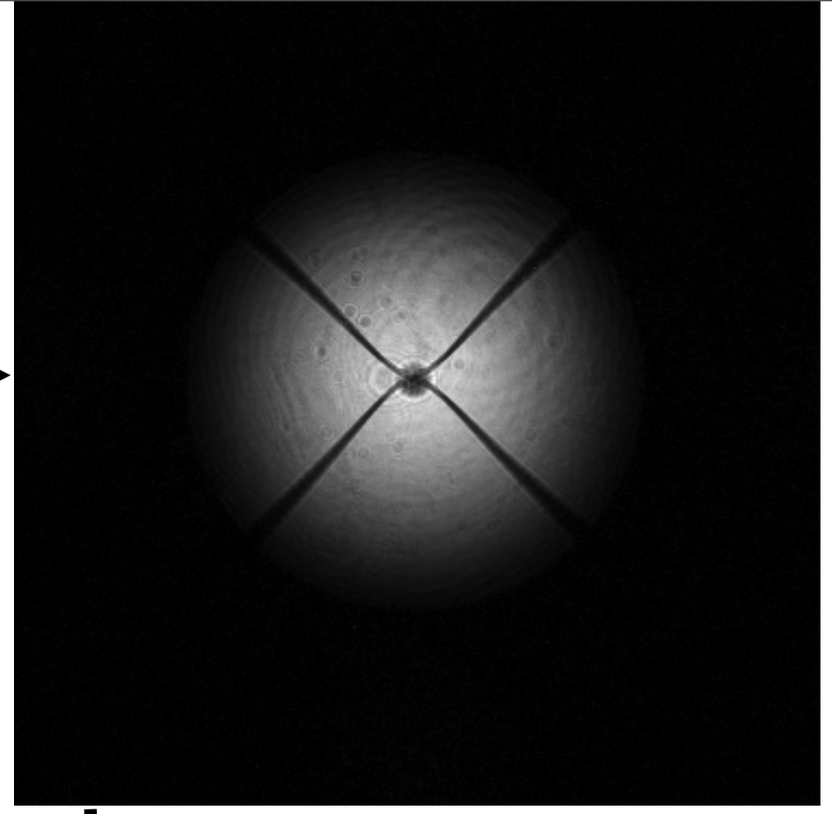


- On-axis lenses
- Lenses are 96 mm apart
- Apodize the beam
- Remove the central obscuration
- Spider removal plate to remove spiders





+ PIAA lenses



+ SRP

+ SRP

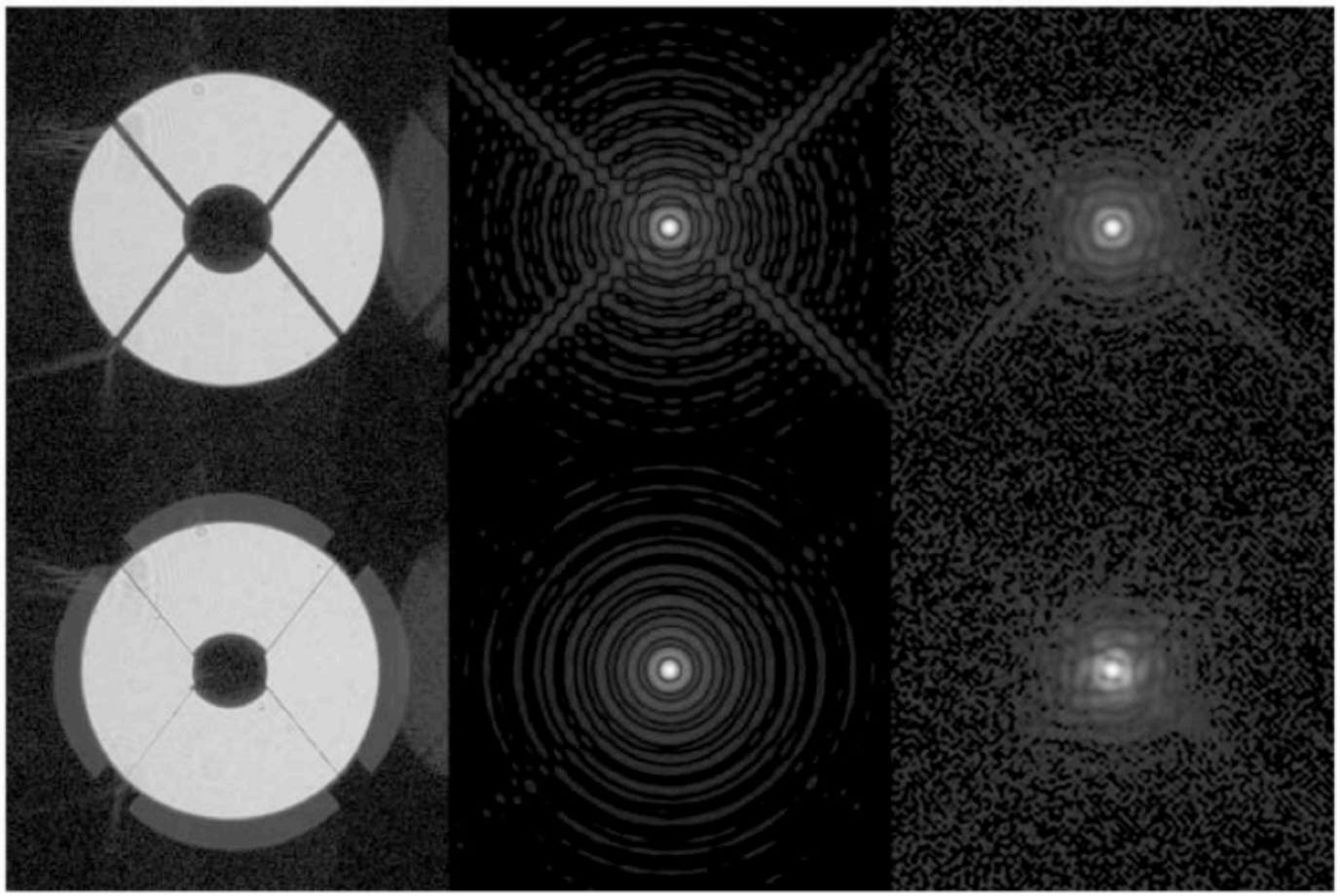
Experimental pupil

Simulated image

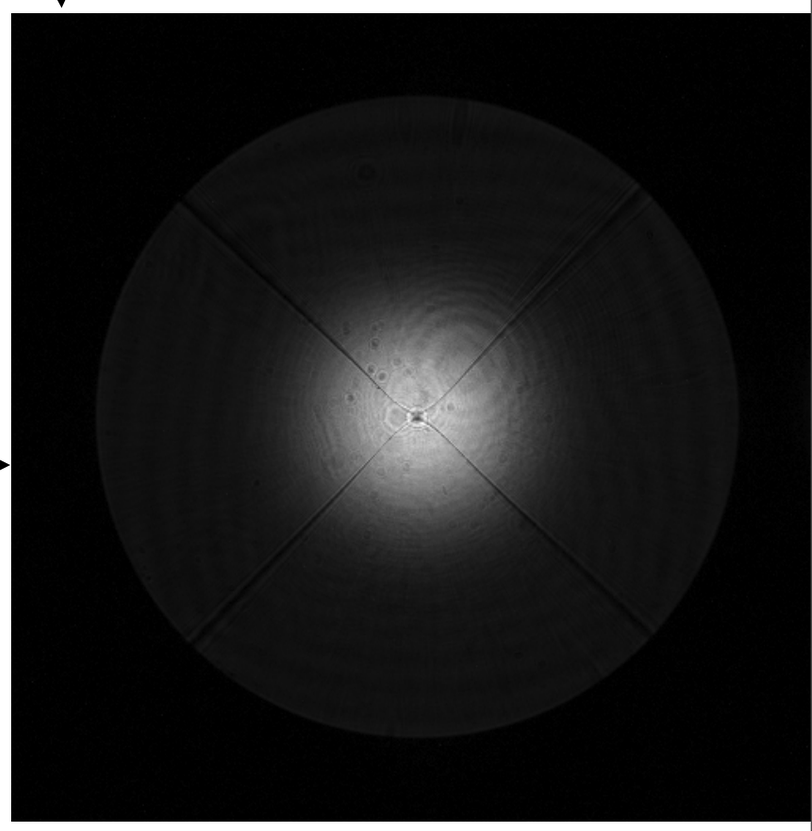
Experimental image

Without SRP

With SRP

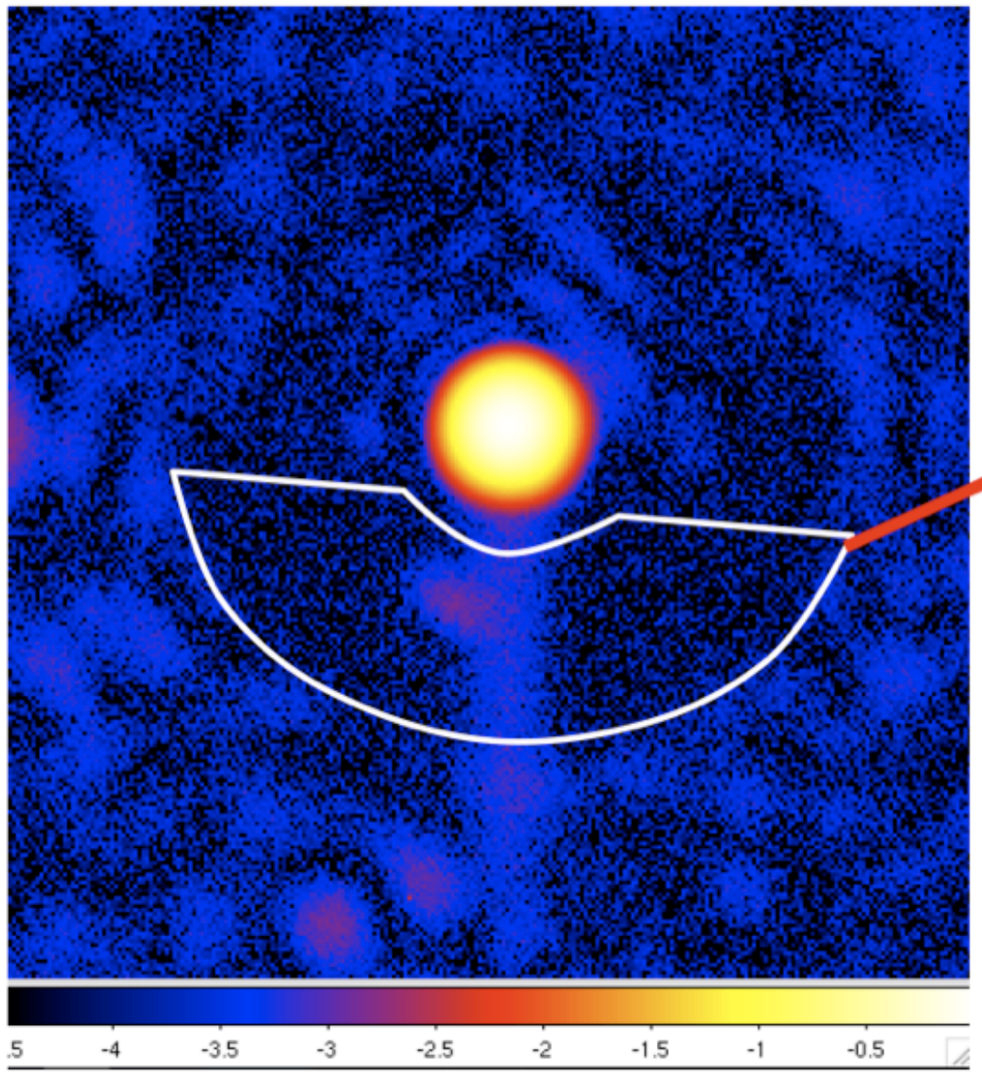


+ PIAA lenses

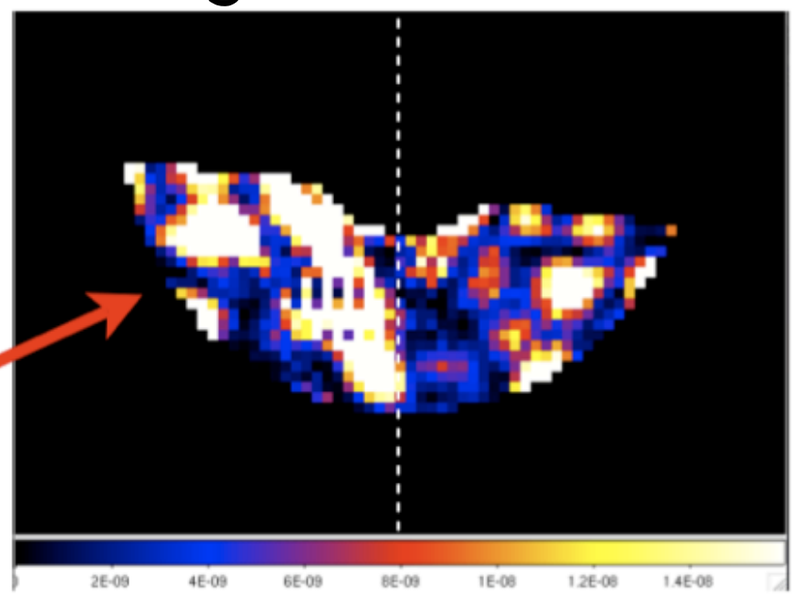


Subaru lab demonstration of PIAA coronagraph (in visible light)

Raw image



Coherent starlight (single frame)



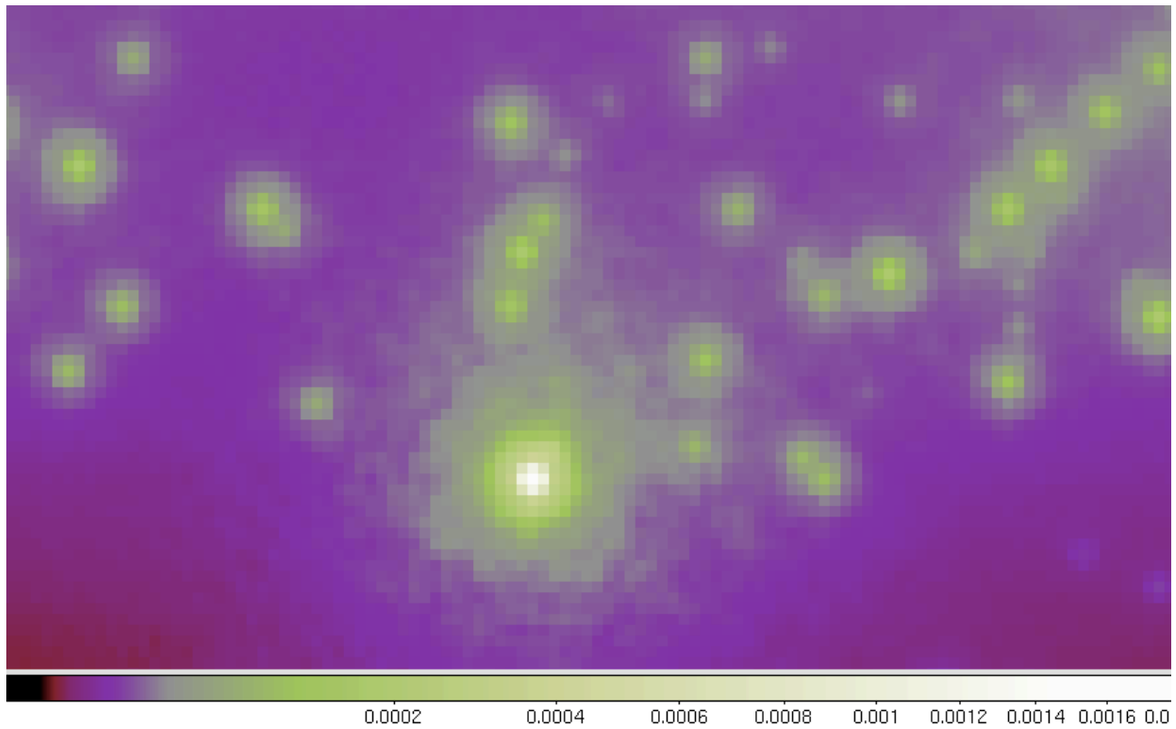
Average contrast in right half of the science field shown above (excludes the ghost on the left) = 7e-9

Contrast achieved in 1.65 to 4.5 l/D zone:

1.6e-7 incoherent halo ghost (equivalent to exozodi)

3.5e-9 coherent bias (measured over 1300 frames)

Diffraction limited imaging with photon-counting camera and new data processing algorithm



Photon-counting camera allows visible light diffraction-limited imaging. (Simulation by V. Garrel, 0.7" seeing, 35 Hz acquisition, mV=10 guide star in AO188, 20mas FWHM)

- 500 Hz frame rate (1" x 1") to 1 kHz (0.6" x 0.6")
- EMCCD: no readout noise, 90% QE
- 0.6 to 0.85 um. Using ADC/dichroic configuration of Kyoto-3D visible AO IfU

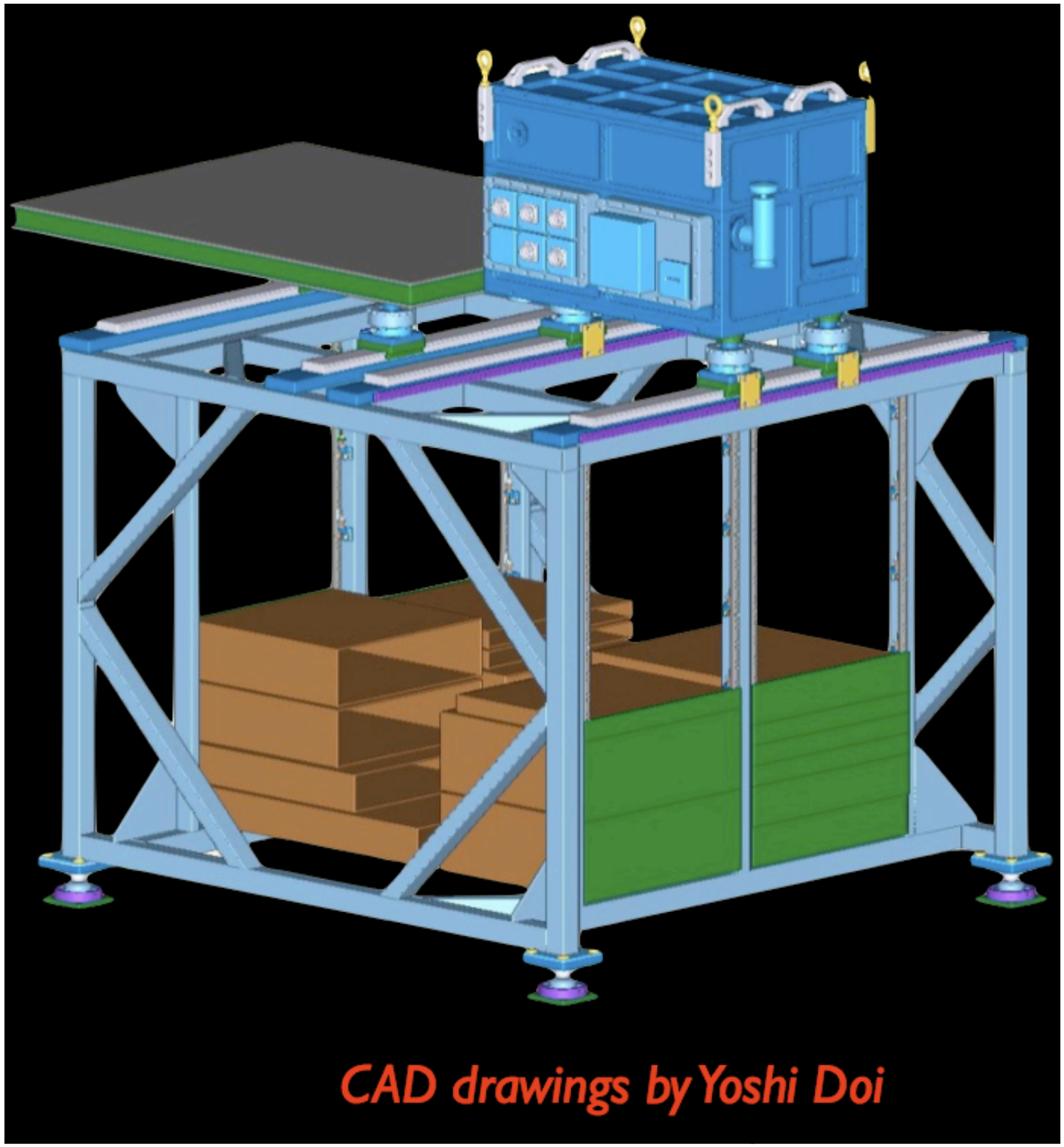
- End-to-end data simulation and processing pipeline used to estimate performance / algorithms
- Initial data processing: Fourier-based statistical filter
- higher performance options under study

Project Overview

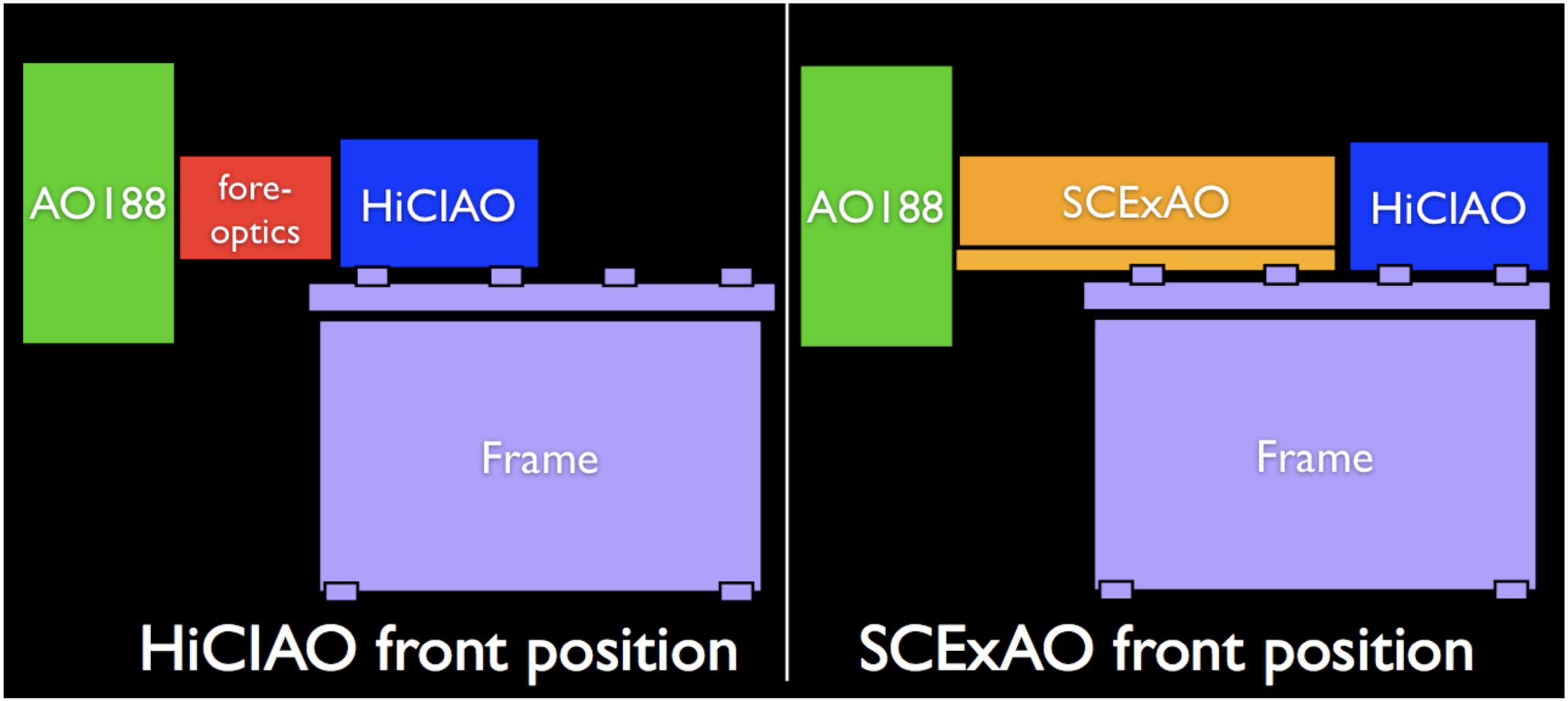
- Highly flexible system, incremental upgrade
- Uses HiCIAO differential camera, optimized for H band
- New frame can hold [SCExAO + HiCIAO] or HiCIAO only
- First light in late 2010

- Phase 1 (late 2010):
  - PIAA
  - Visible imaging
  - Aperture Masking
  - Focal plane AO
  - LOWFS

- Phase 2 :
  - High speed ExAO WFS (under dev., to be deployed in late 2011)
  - Spectroscopy/IfU ? (funding has been requested for IfU)



Observing configurations



"Wide field" observations for SEEDS with current HiCIAO configuration

"Narrow field" observations with Extreme-AO and high efficiency coronagraph

- SEEDS follow-up of interesting targets requiring imaging close in to the star
- New targets (close-in region of disks, close in-planets)
- Visible imaging at the diffraction limit

SCExAO Expected performance

SCExAO combines high contrast and small inner working angle to detect a larger number of young planets and may be able to detect reflected light from known exoplanets

Witness planet formation in the central 5AU of young stars is a key goal of SCExAO