Status of PIAA-related experiments and projects

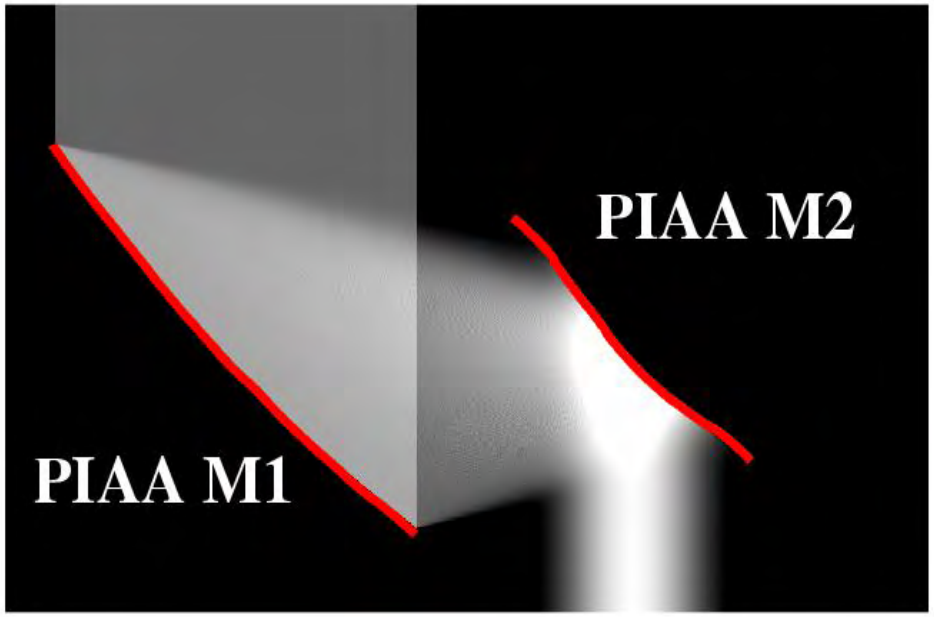
Abe L.[1], Guyon O.[2], Tamura M.[1], Enya K.[3], Tanaka S.[3], Matsuo T.[4]

[1]*National Astronomical Observatory of Japan*
[2]*Subaru Telescope, NAOJ, Hawaii*
[3]*Institute of Space and Astronautical Sciences, Japan*
[4]*Nagoya University, Japan*

In the Spirit of Bernard Lyot Conference, June 3rd – 8th 2007
University of California, Berkeley

Email: abe@optik.mtk.nao.ac.jp

Merits of the PIAA

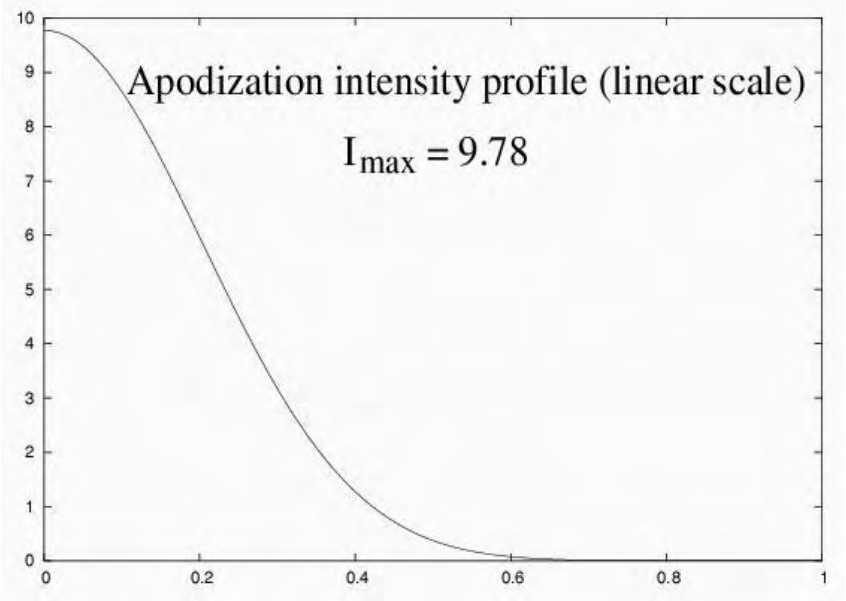


Phase Induced Amplitude Apodization

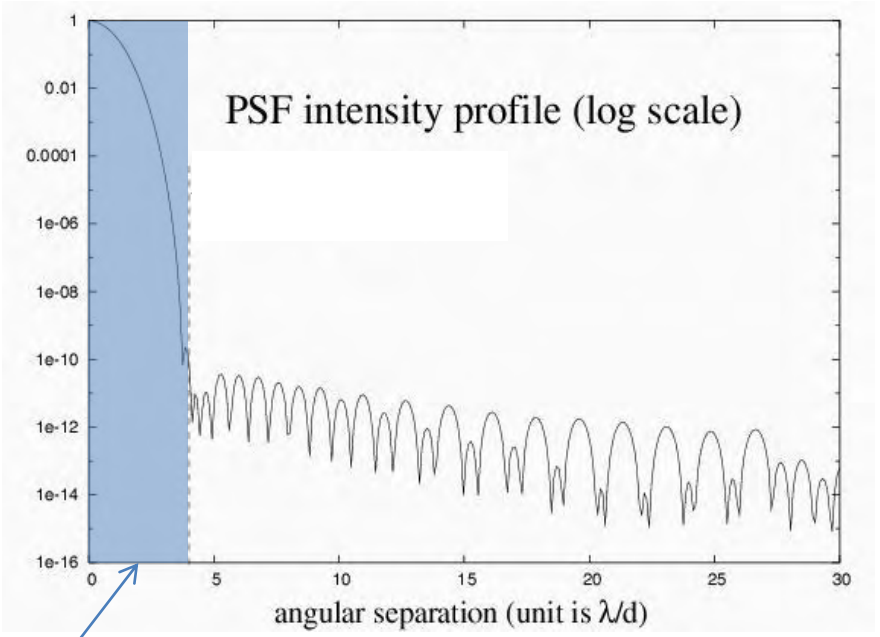
- ❑ Two-mirror apodization
- ❑ In theory, nearly 100% throughput
- ❑ 100% search area
- ❑ Small Inner Working Angle (<2 λ/D)

PIAA Coronagraph Concept

Pupil



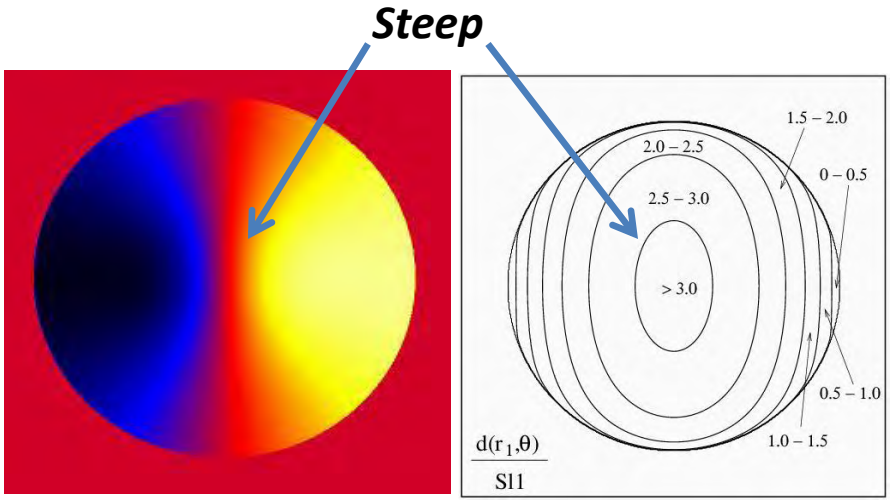
On axis image



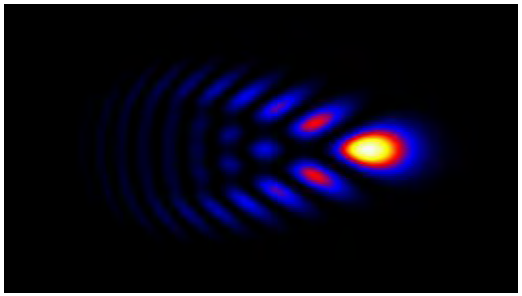
Occulter (focal mask)

Small IWA: the Phase Slope Amplification

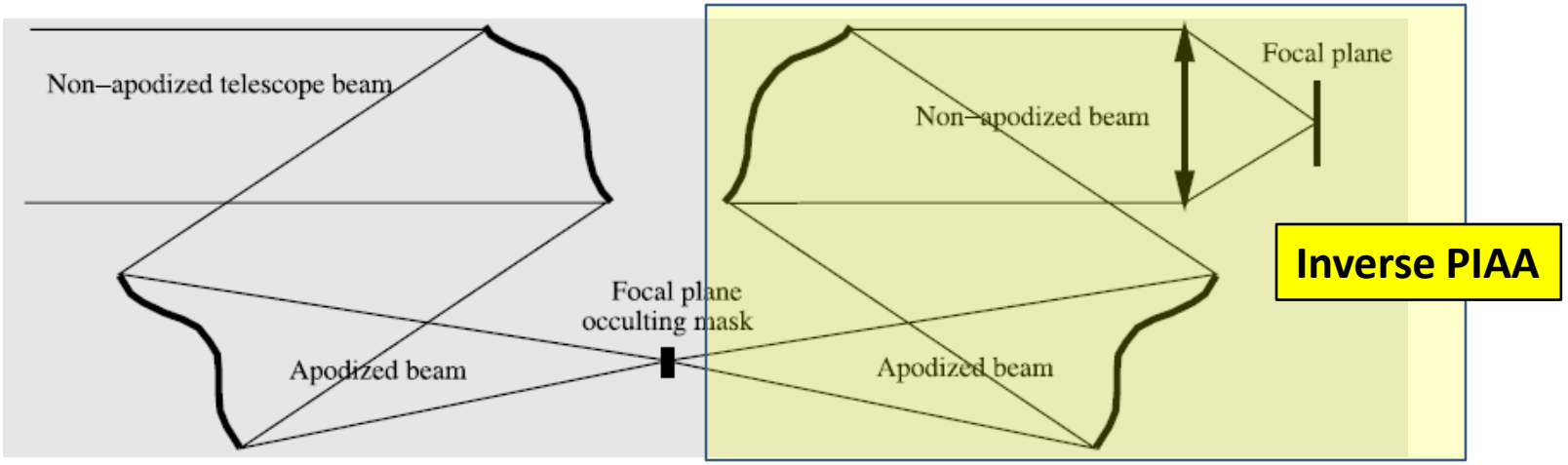
For off-axis objects, the phase slope is magnified ($\propto\sqrt{I_{max}}$)



Typical focal plane intensity distribution of the off-axis point-source (10 λ/D)



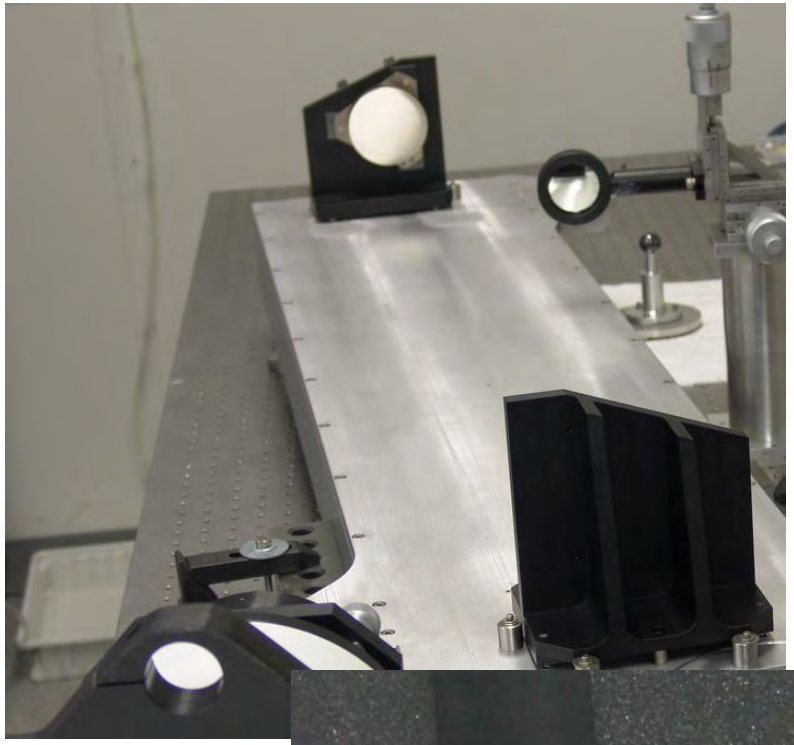
PIAA



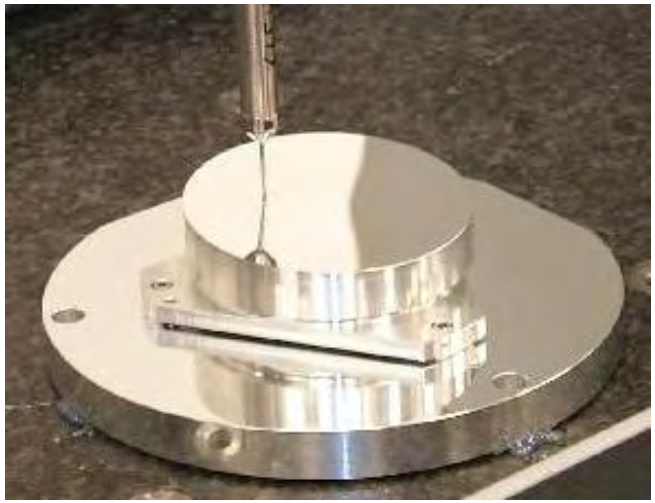
Inverse PIAA

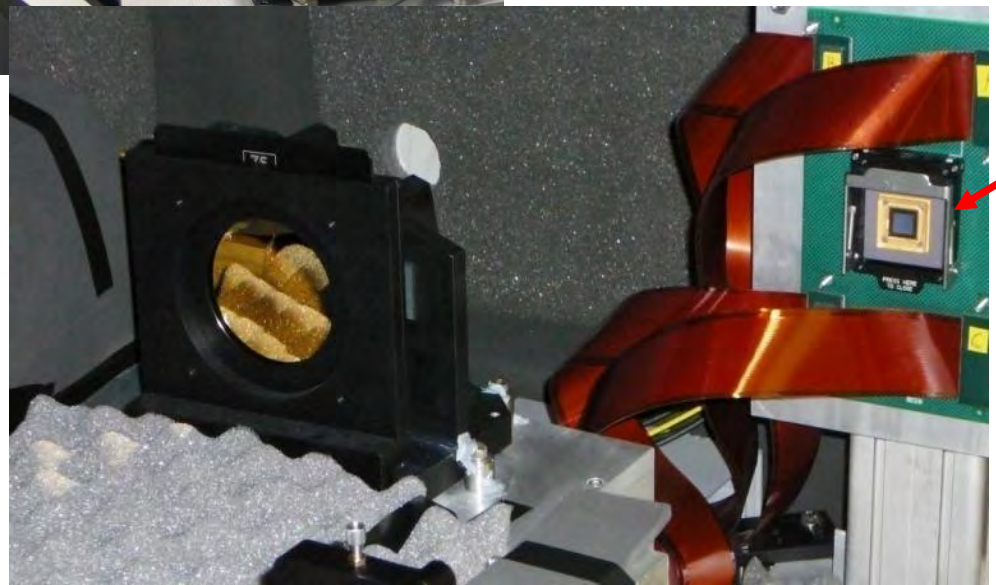
PIAA Lab Demonstrator

(JPL and NAOJ funds)



Optics manufactured by AXSYS





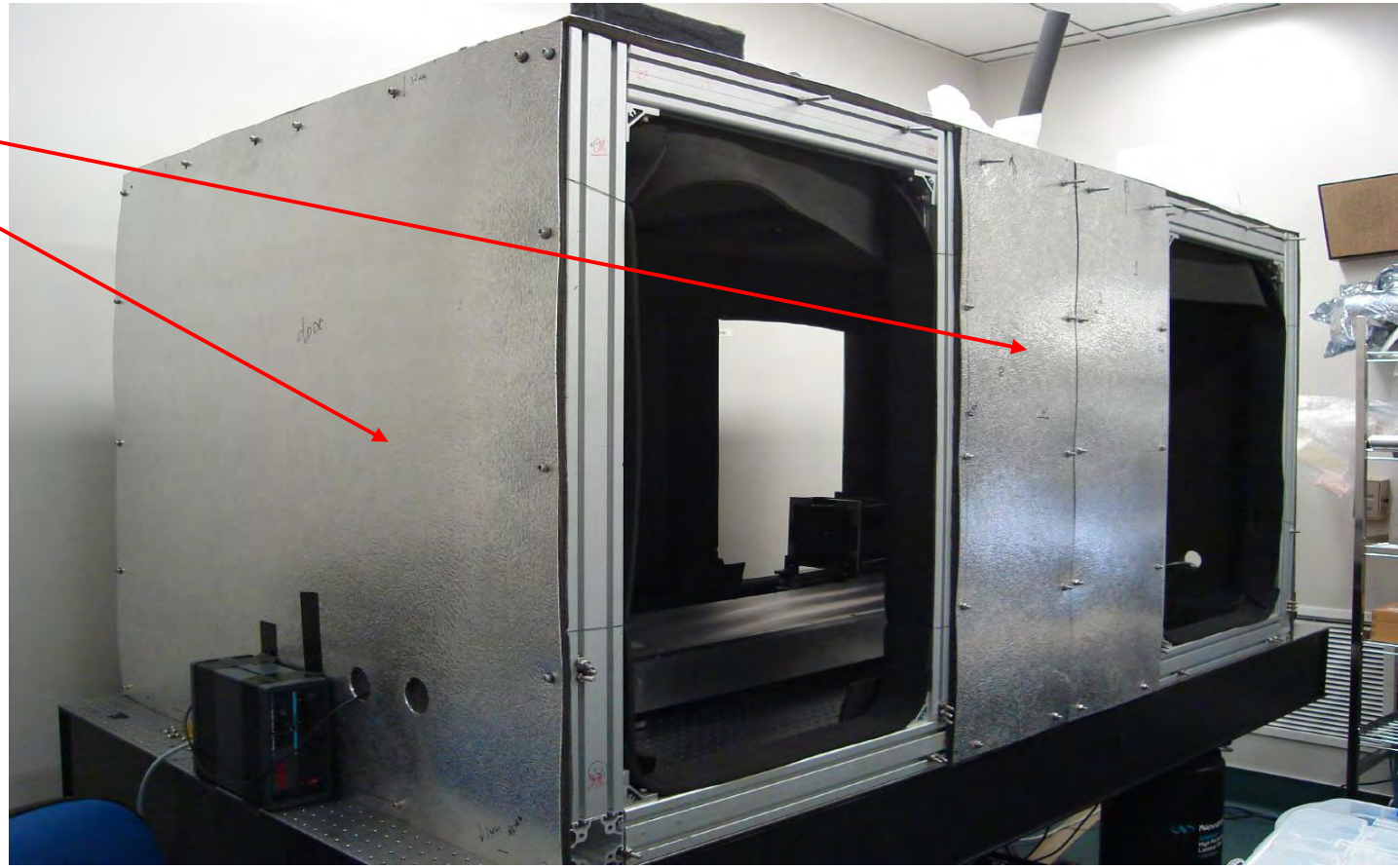
32×32 BMC DM

PIAA Lab Demonstrator

(JPL and NAOJ funds)

PIAA Experiment in Subaru Bldg. Clean Room (Hilo)

Acoustic & Thermal isolation panels



(some panels removed in this picture)

➔ *See J. Totems et al. Poster*

PIAA Lab Demonstrator

(JPL and NAOJ funds)

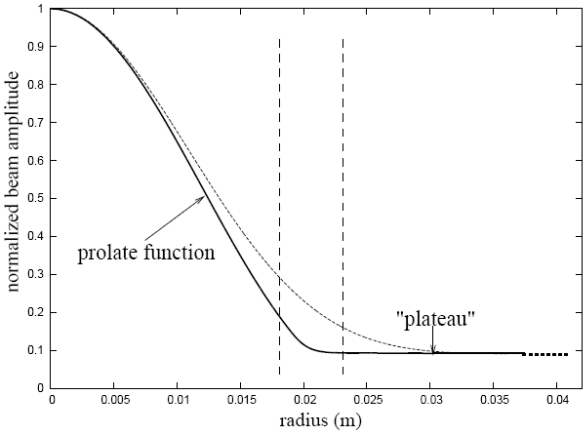
❑ Hybrid PIAA/conventional apodization is best

➔PIAA optics manufacturing tolerances are relaxed

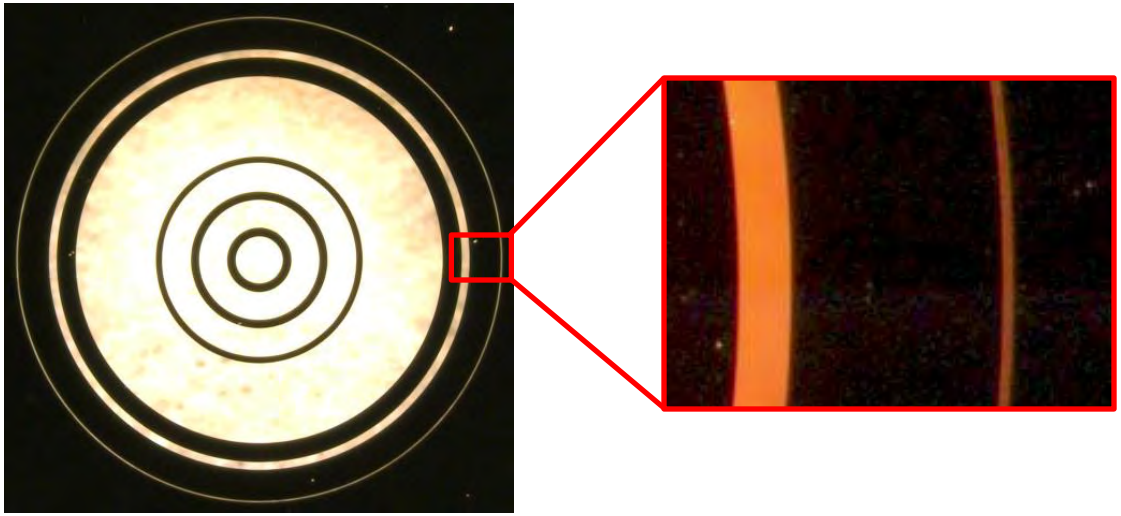
➔ Binary apodizer (ring mask)

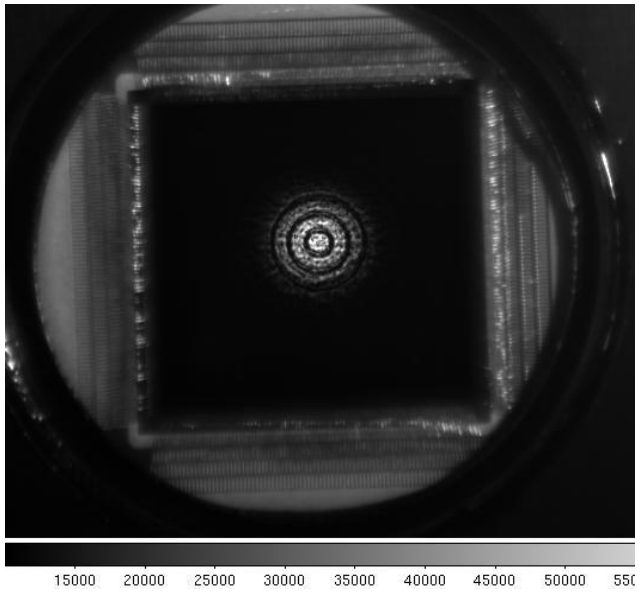
See S. Tanaka et al. – poster

➔ Good achromaticity



PIAA output pupil image on the 32×32 BMC DM



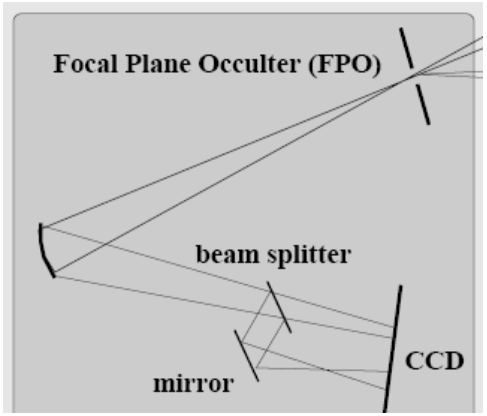


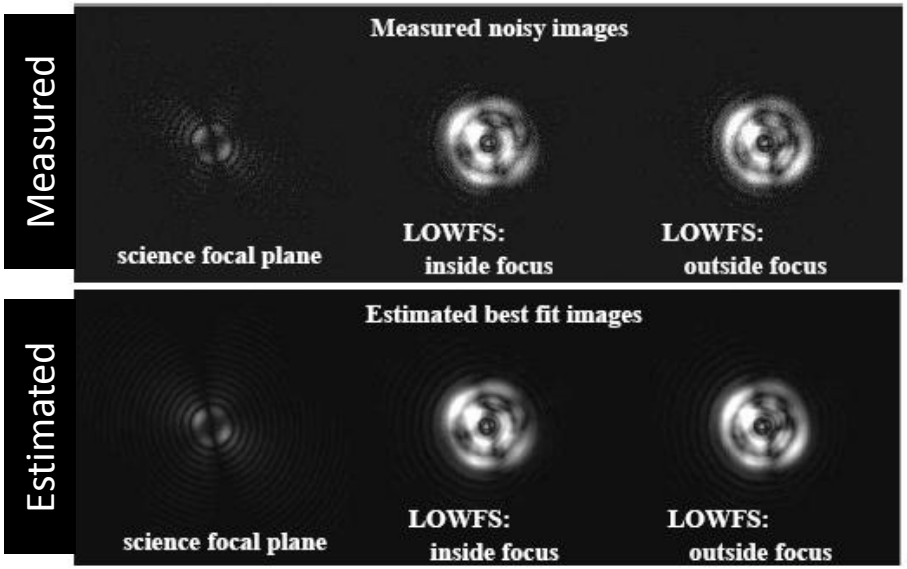
PIAA Lab Demonstrator

(JPL and NAOJ funds)

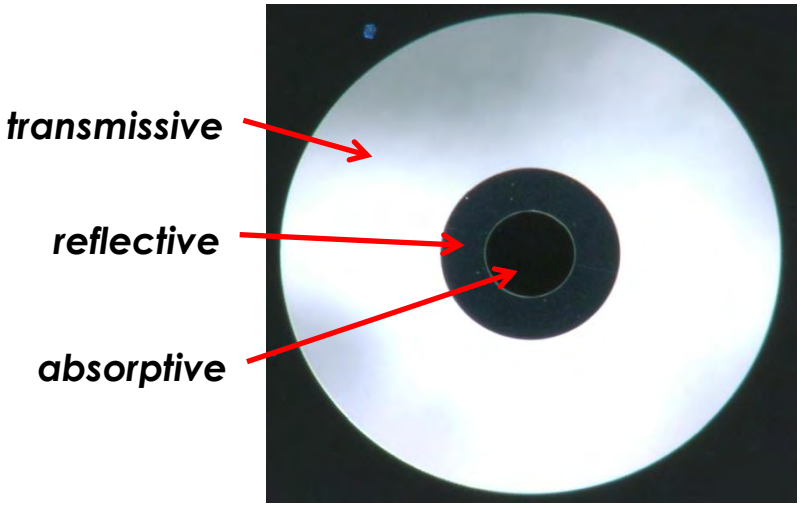
- **Pointing is critical**

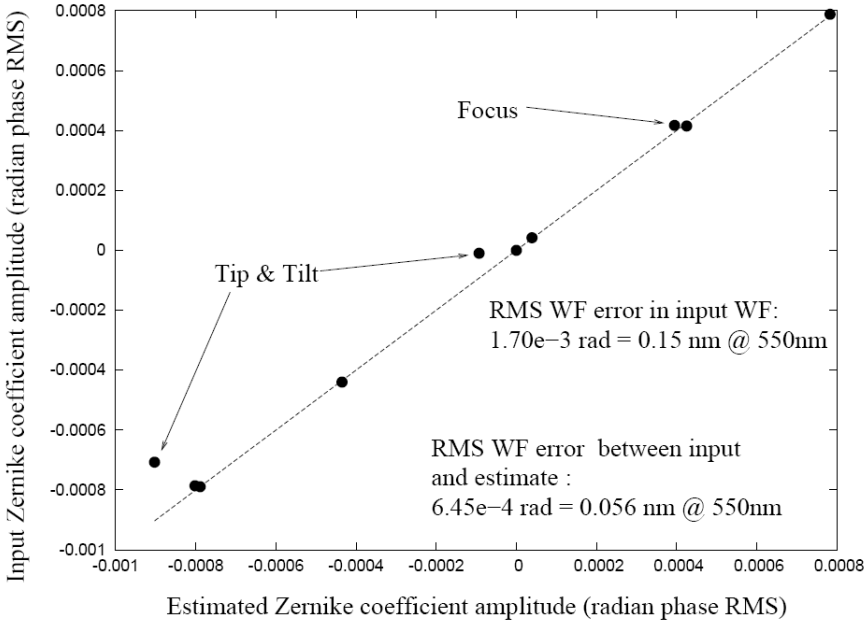
➔ Continuous pointing corrections





- **Annular reflective occulting mask**

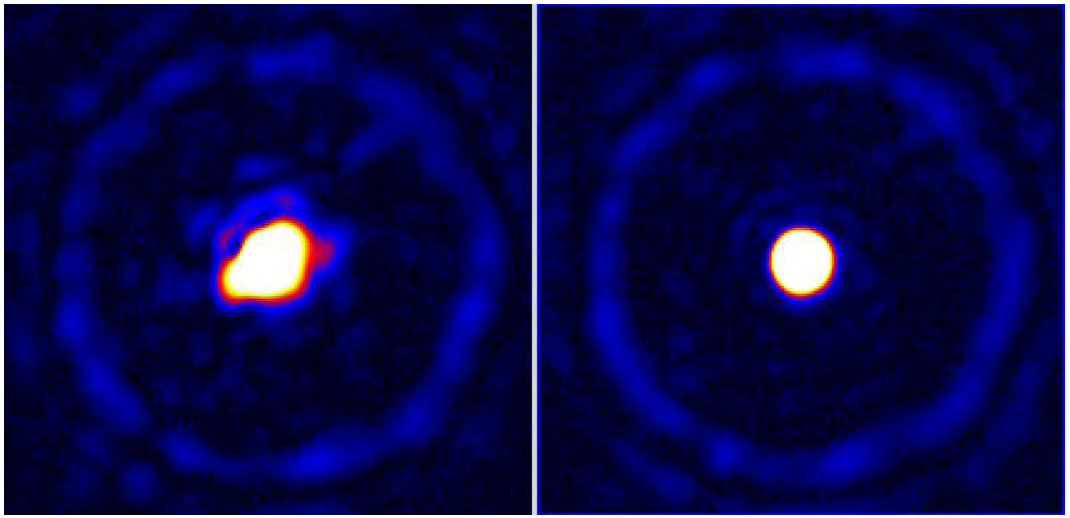




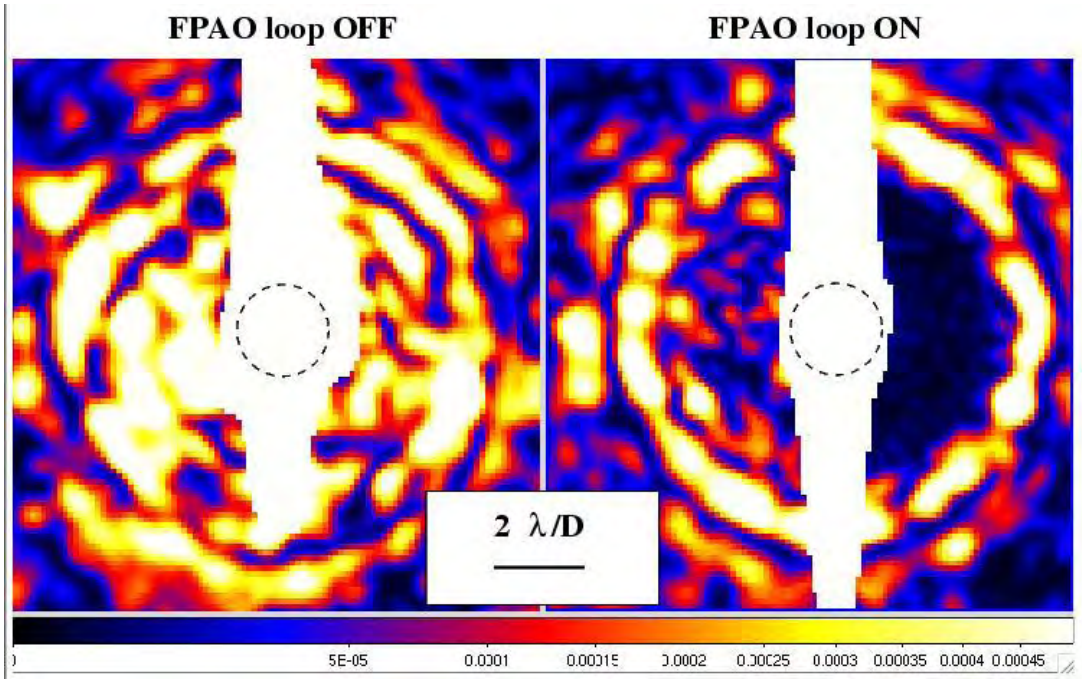
PIAA Lab Demonstrator

(JPL and NAOJ funds)

DM correction using
Phase diversity ▶



Speckle control ▶



<u>Achieved dyn.</u>: 6. 10e-7

Future Tests & 2nd Generation PIAA

NASA Ames / TOPS partnership / JPL

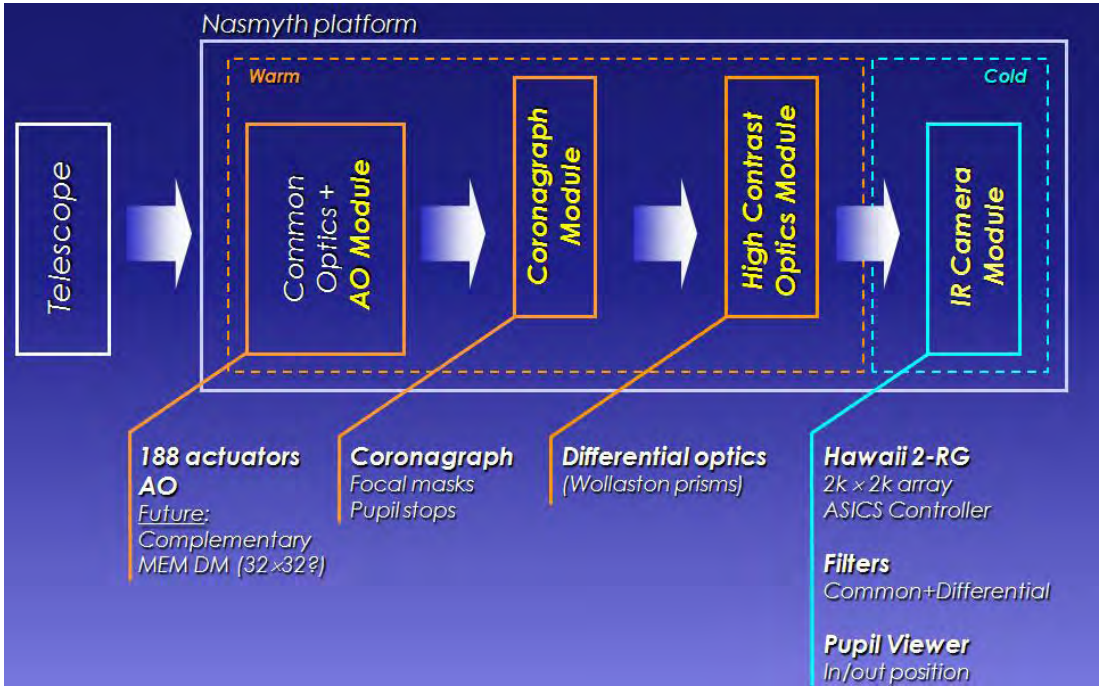
- ❑ **We are acquiring a 2nd generation PIAA improved optical quality & better design (lessons learned with 1st generation PIAA)**
- ❑ **Moving to tests in Vacuum – putting PIAA into HCIT**
- ❑ **Testing PIAA fed by large mirror (~1m) in vacuum for end-to-end tests at 1e10 contrast**

➔ *see O. Guyon talk on TOPS (Friday)*

Subaru/HiCIAO Upgrade Plans (I)

❑ **HiCIAO is a differential imager combined to a coronagraph**

➔ ***See M. Tamura (Thu. afternoon)***



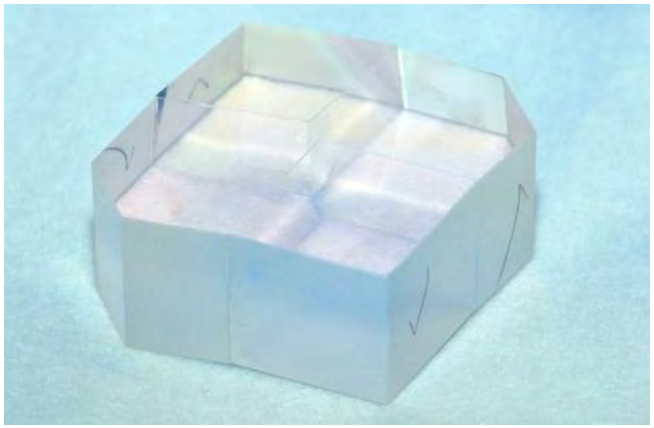
***Upgrade plans (MEXT funded)*:**

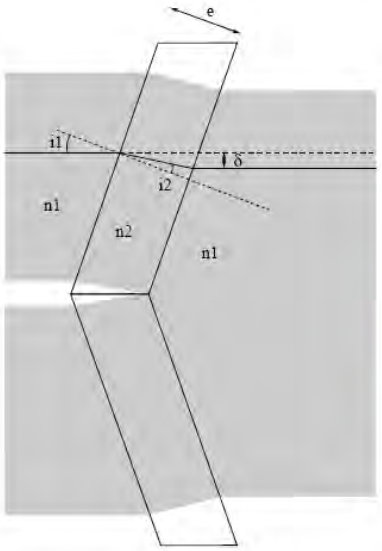
❑ **Coronagraph: PIAA w/ lenses**

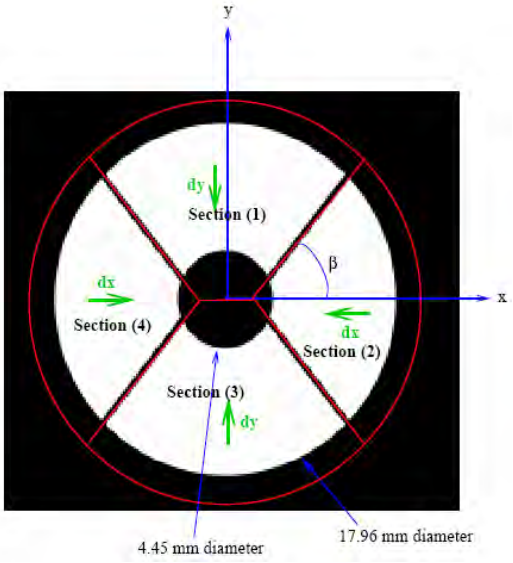
❑ **Adaptive Optics: 32×32 MEMS DM + FP WFC**

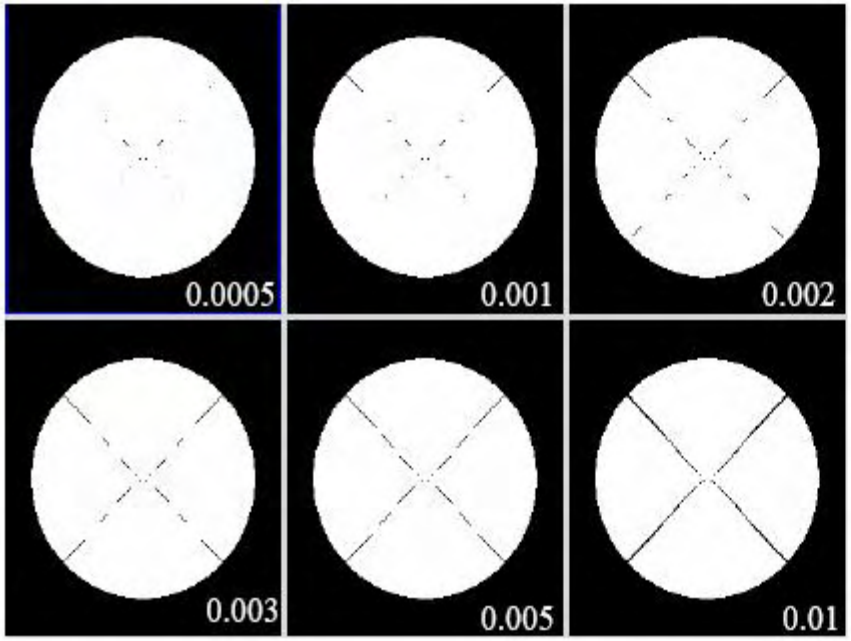
Subaru/HiCIAO Upgrade Plans (II)

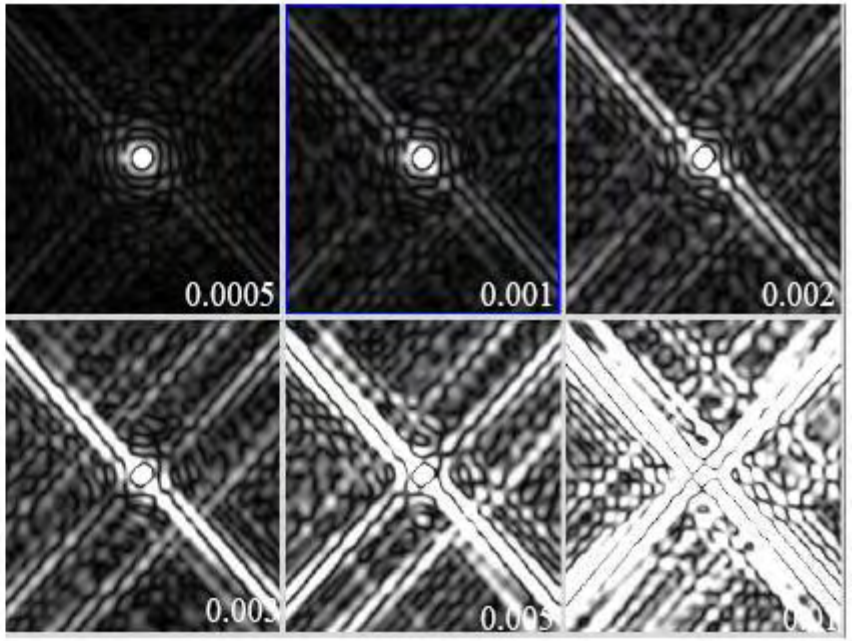
- Spider Removal Plate









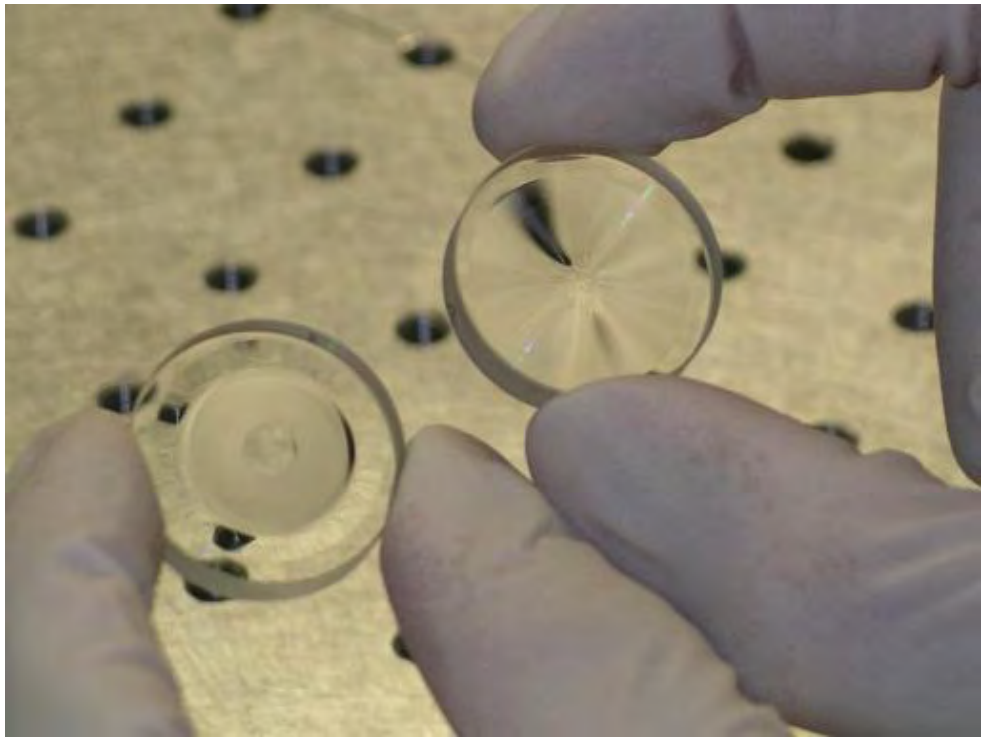


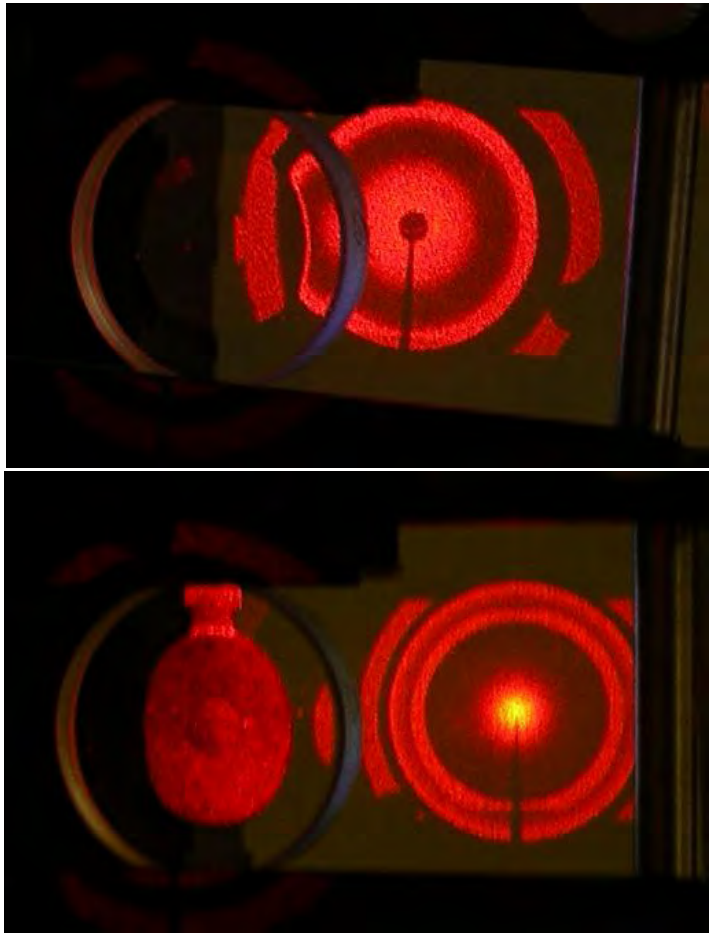
Subaru/HiCIAO Upgrade Plans (III)

- PIAA Lenses → APLC configuration (i.e. Mask + Lyot Stop)
  → Small mask (radius 1 λ/D)

- Speckle control → ASICS controller flexibility

▼PIAA Lenses (Calcium Fluoride)





SPICA Coronagraph (I)

SPace **I**nfrared telescope for **C**osmology and **A**strophysics

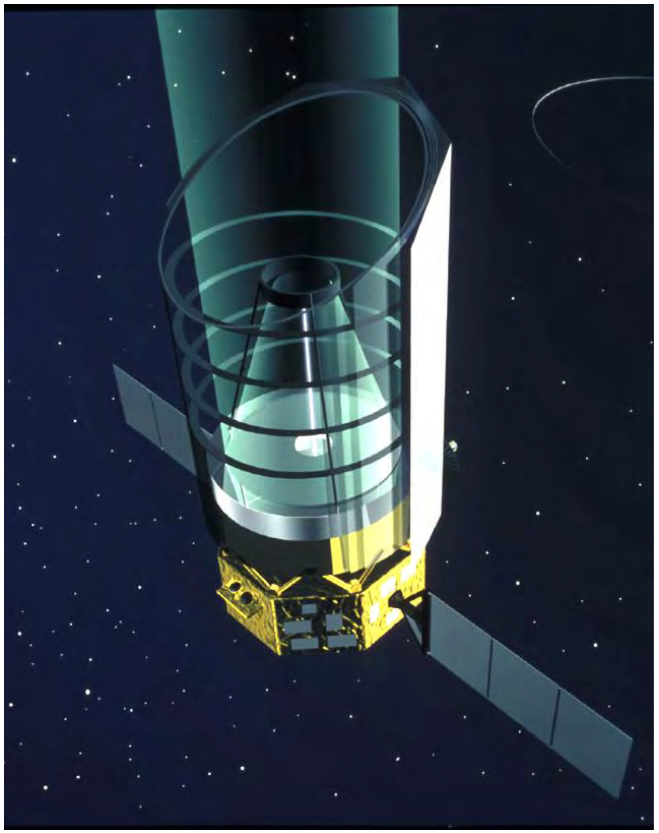
SPICA Mission

❑ 3.5m on-axis / 4.5K active cooling
❑ mIR to submm astrophysics *(5-200 μm)*
➔ Complementary to JWST @ >15mic

➔ **Coronagraphic mode**
❑ Direct observation of outer self-luminous planets (20~100+ UA orbits)
❑ **Goal contrast >10^{-6}** within the exploration area
❑ Benefit from monolithic pupil

➔Baseline candidate: Checkerboard Pupil Mask
(***See K. Enya et al. – Thu. afternoon***)

➔ **Advanced option: PIAA**



SPICA telescope concept

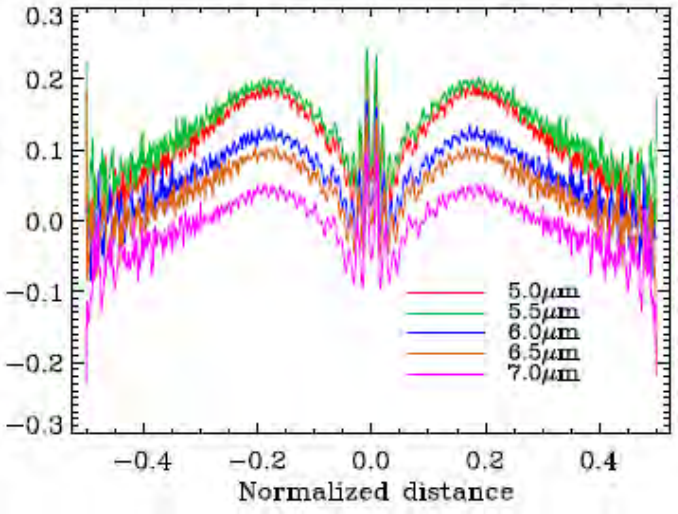
SPICA Coronagraph (II)

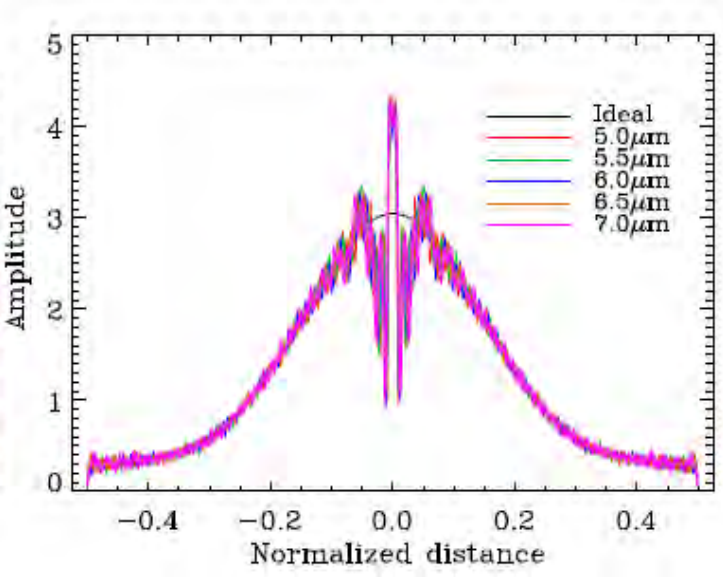
Preliminary work

- ❑ **Central obstruction constraint (20~25%)**
  → **Sensitivity to tip-tilt (phase discontinuity)**
  → **increased IWA**
  → **…Solution for an APLC?** *(insensitive to central obstruction)*

- ❑ **PIAA Hybridisation**
  → **Best combination for PIAA optics/apodizer**
  → **Achromatization issues**

λ: 5-7µm / Fresnel propagation simulations





More informartion:

Subaru testbed & Subaru Extreme-AO project:
http://www.naoj.org/staff/guyon/PIAA/index.html
http://www.naoj.org/staff/guyon/ExtremeAO/index.html

PIAA-related papers, by our team and others:
http://www.naoj.org/staff/guyon/PIAA/Papers.html

Wanted:
Post-doctoral fellow (available funds for at least 2 years)
Subaru Telescope, Hilo, Hawaii

Contact: guyon@subaru.naoj.org