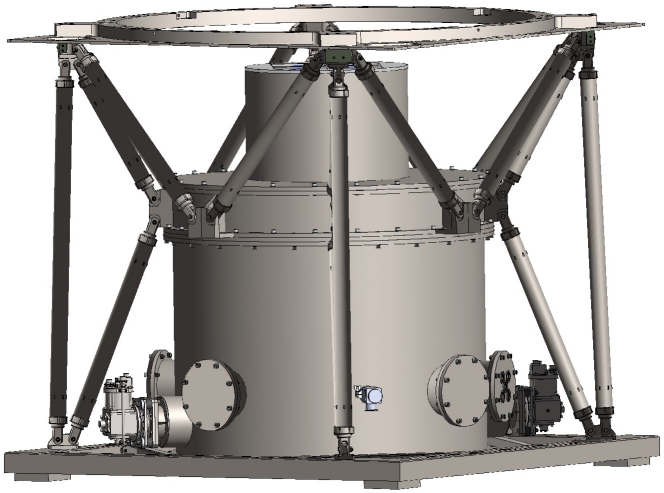


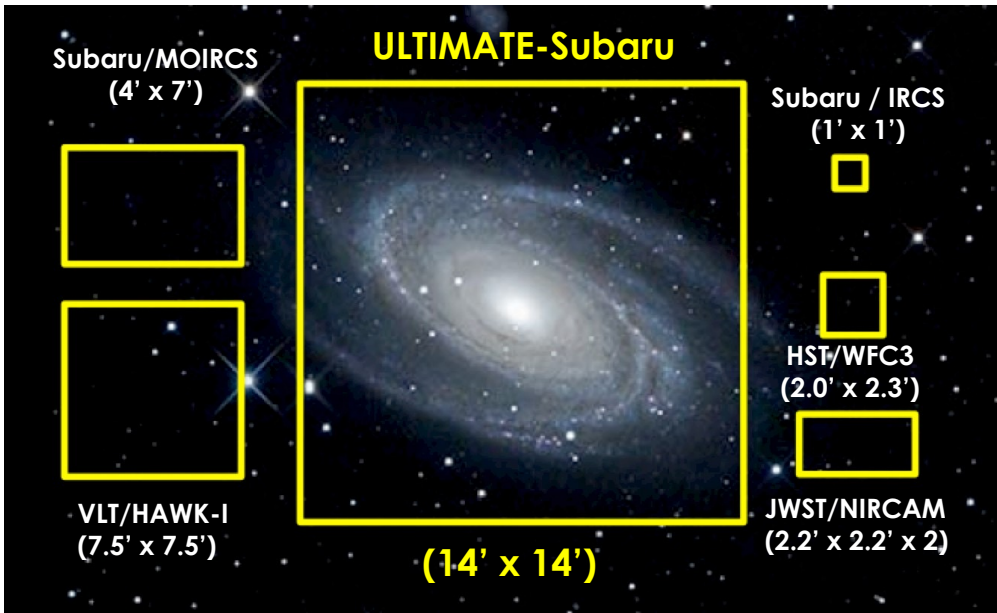
ULTIMATE Wide-Field Imager

Kentaro Motohara (ATC, NAOJ/Univ.Tokyo)

Y. Minowa, I. Tanaka T. Hattori, Y. Koyama, M. Konishi, K. Yanagisawa, I. Iwata, S. Wang, R. C. Y. Chou, M. Kimura, J. Pazder

Requirements for WFI

- Effective FoV $> 190\square' \Leftrightarrow > 14' \times 14'$
- Spot size $\leq 0.11''$
- Pixel scale $\sim 0.11''$/pix
  → more than 8k x 8k pixels necessary : Four H4RGs
- 0.9-2.5μm
- Installed on the Cassegrain focus of Subaru
  - length from the telescope focal plane to detector < 1510mm

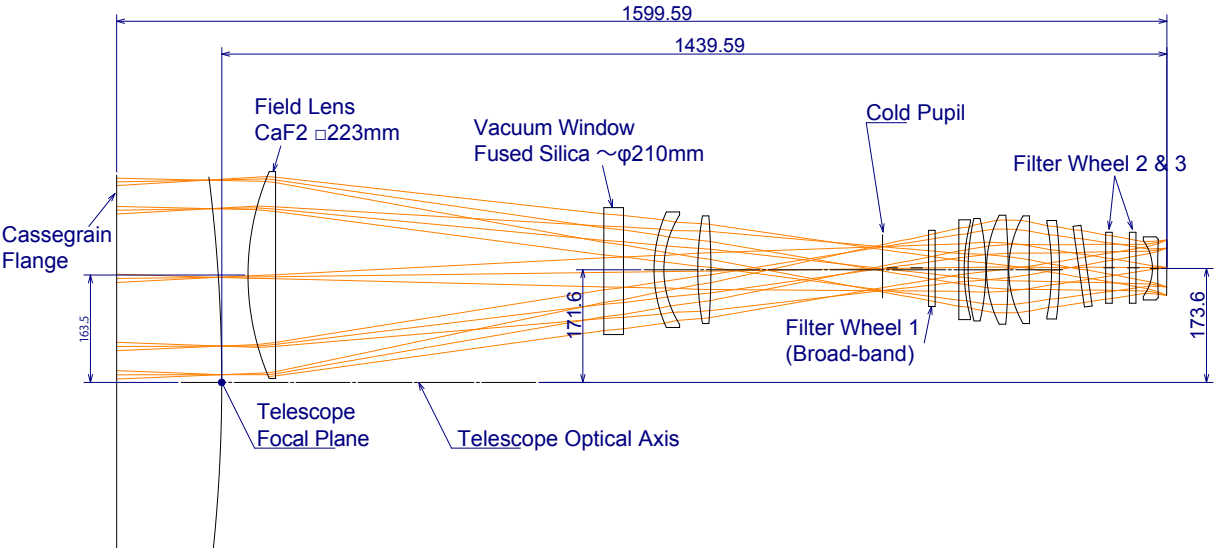


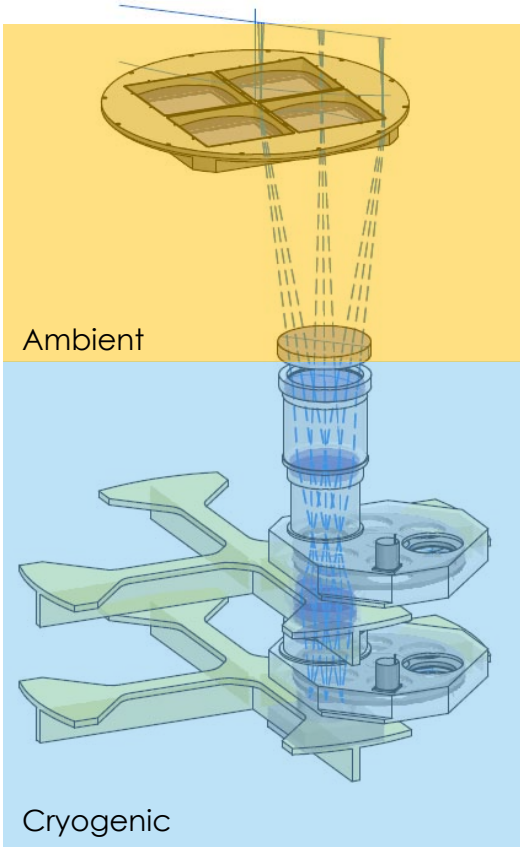
Optical Design is Limited by Available Glass Material

- Focal plane has large physical size :
  $\phi 20' \rightarrow \phi 600$mm @Cassegrain focus of Subaru
- Largest optical glass material currently available
  - Fused Silica
    - $> \phi 1000$mm / $t = 80$mm : Suprasil / Company "H"
  - CaF_2
    - $\phi 440$mm / $t =$? : Company "N"
    - $\phi 350 - 400$mm / $t =$? : Company "C"

Four-barrel Optics

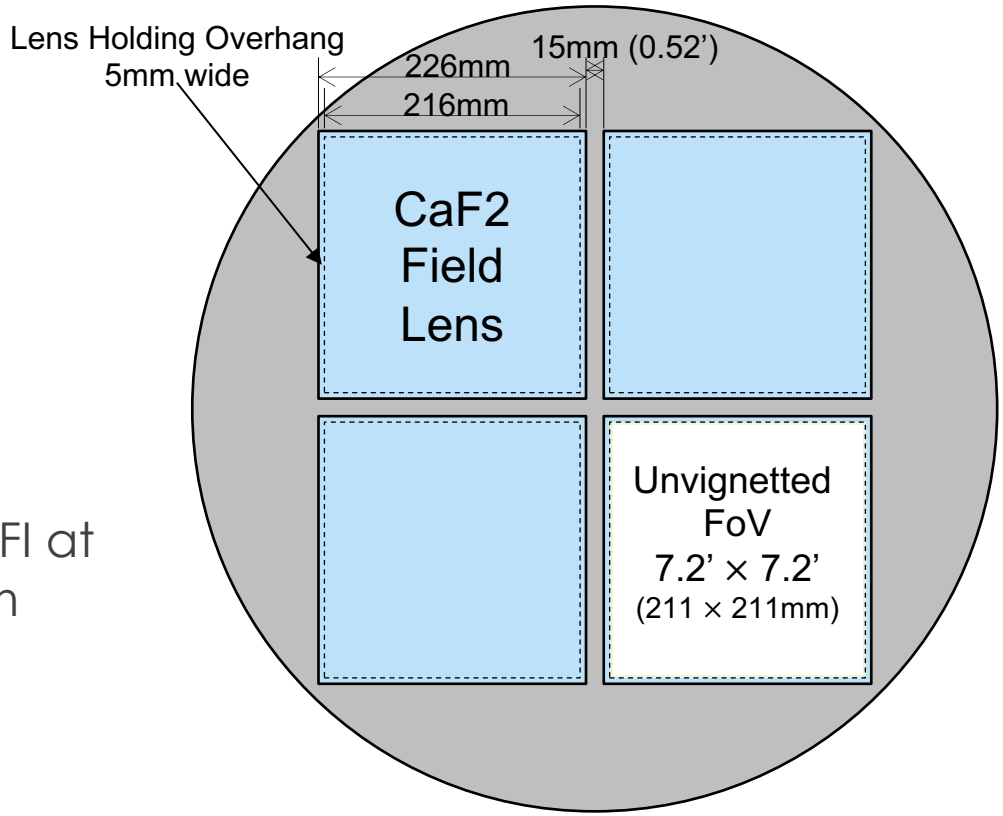
- Four independent relay optics with square field lenses
  - Field lenses placed at ambient temperature of normal pressure
- 11 Lens/vacuum window per barrel
- 3 filter wheels / max 15 filters per barrel





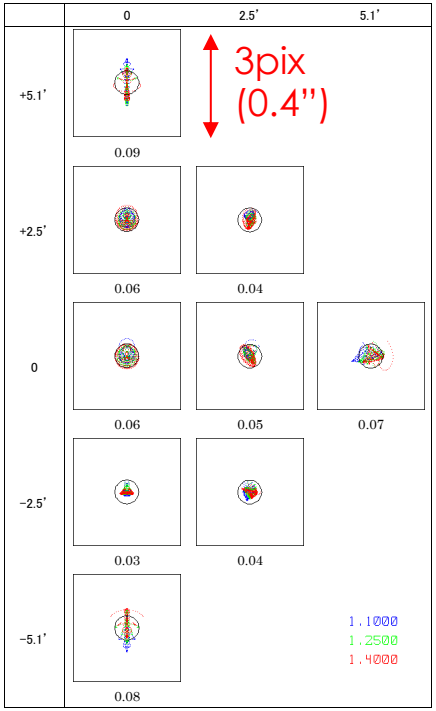
Arrangement of FoVs

- Field Lenses
  - CaF2 : 226mm x 226mm
  - Held by a overhang with 5mm width
- Effective Field of View
  $7.2' \times 7.2' \times 4 = 207\square'$
- Spacing between FoVs
  $\sim 30\text{mm} \Rightarrow \sim 1'$
- Diameter occupied by WFI at the focal plane : > 660mm

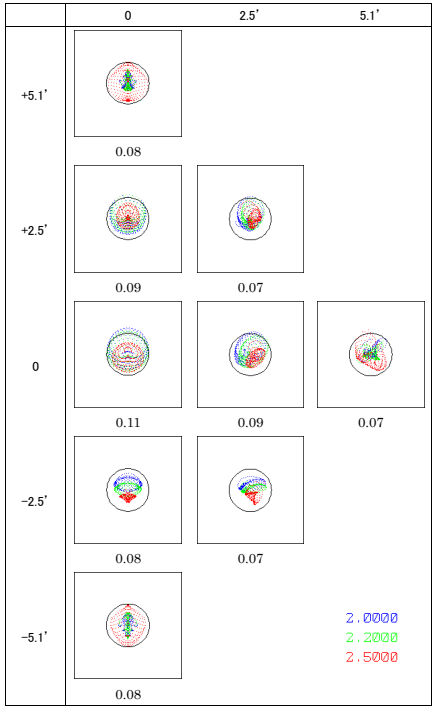


Optical Performance

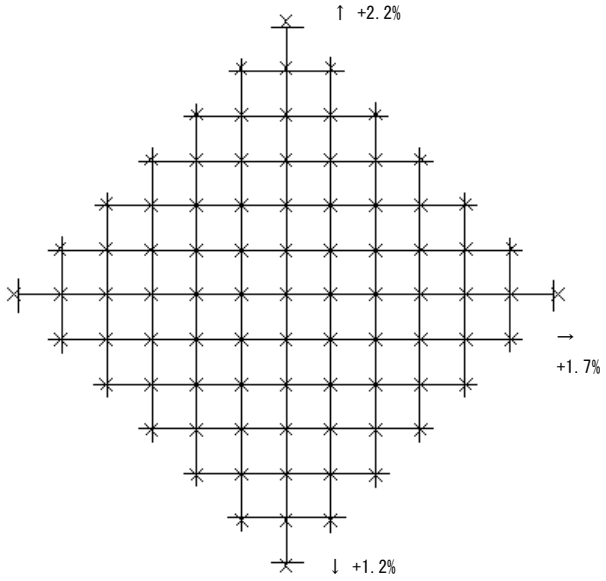
- 0.11″/pix, 15μm/pix (HAWAII-4RG)
- Image quality : ≤ 0.1″
- Strong distortion at the focal plane (max 2.2% / 61pix)



Spot Diagram (1.1-1.4μm)



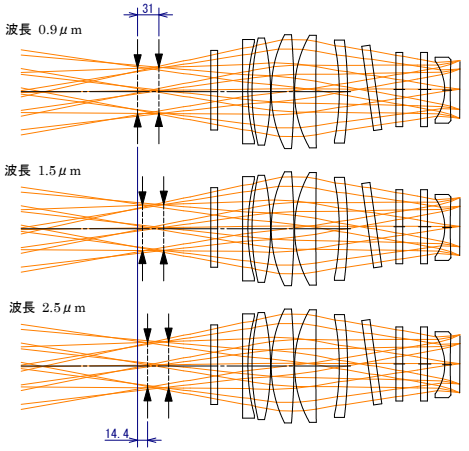
Spot Diagram (2.0-2.5μm)



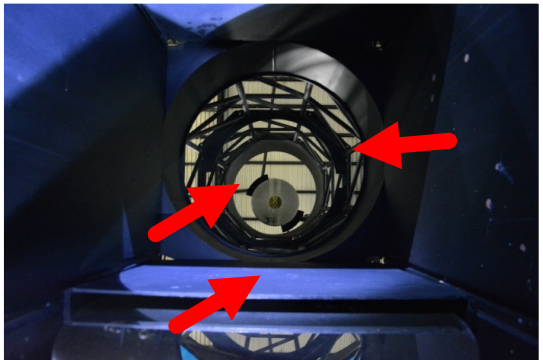
Distortion Map

Remaining Issues/Challenges

- Chromatic aberration of cold pupil
  - position of the pupil moves (max 14.4mm) with λ
  - adjustable cold stop is necessary

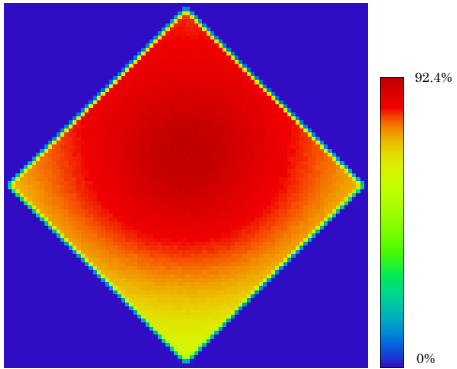


- Thermal emission from the telescope structure
  - Additional cold baffles are necessary
  - Optical transmittance will be degraded by 7 to 40% (max) due to the cold baffles

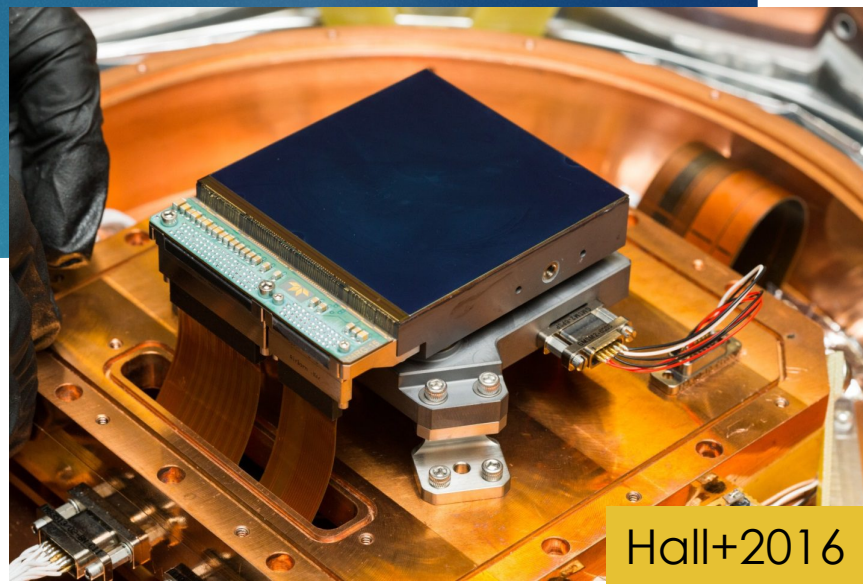


Telescope structure
Interfere with WFI optical path

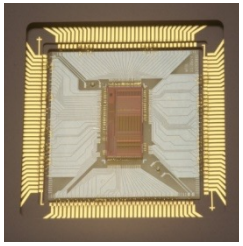
Transmittance map
introduced by additional baffle

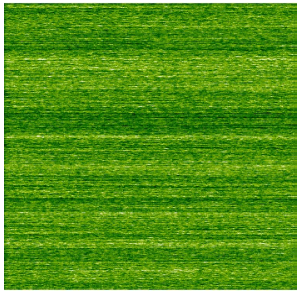


Focal Plane Arrays



- One HAWAII-4RG per barrel
  - 4088 x 4088 sensitive pixels
  - 15um/pix
  - Expensive!!
- Readout electronics
  - ACADIA ASIC (Markury Scientific)
  - Better bias performance than SIDECAR





SIDECAR ASIC
(HST test data)
- Bias buffer noise: **35μV**

ACADIA Design
(ADC Test Chip data)
- Bias buffer noise: **6.8μV**

Structure

- Sumitomo Heavy Industries design
  - Cylindrical shape
  - Connected to the Cassegrain interface flange by truss structure
- Fits the requirements of Subaru Cassegrain Instruments Interface
  - Total Weigh 2.9ton
  - Total Height 1.91m
  - Handled by CIAX cart

Funding Status and Schedule

- Budget : external funding is necessary
  - Planning to apply to 特別推進 FY2024
    - Only 1~2 out of 4 barrels will be fabricated
    - The rests are expected through international collaborations (but not secured yet)
  - Medium-band filters are funded by 国際先導
- Schedule
  - 2021/6 : CoDR completed
  - 2023 : finish preliminary design (国際先導)
  - Start fabrication in FY2024 if 特別推進 is successful
    - FY2024-2026 : Final design, procurement, and fabrication
    - FY2027 : Assembly, Integration and Test
    - FY2028 : Transport to Hawaii, First Light !

Summary

- WFI is a NIR wide-field imager for ULTIMATE-Subaru to cover ϕ20' FoV with 0.2" stellar image delivered by the GLAO system
- Optics
  - Covers $15.7' \times 15.7'$ with four identical relay optics with square field lenses
  - Effective FoV : $7.2' \times 7.2' \times 4 = 207\square'$
  - 0.11"/pix, <0.1" image quality
  - Max 15 filters can be mounted at once
- Structure
  - Fits within the Cassegrain Instrument Interface of Subaru
  - Dewar with two GM-cycle cryogenic coolers, achieve 50K at the optical bench
- Focal Plane Array
  - Four HAWAII-4RGs
- Expecting the first light in FY2028