WFIRST-AFTA
Wide-Field Infrared Survey Telescope

WFIRST

Toru Yamada (ISAS/JAXA)
ISAS WFIRST-WG*,
(* under ISAS Space Science Advisory Committee
WG Chair: Takahiro Sumi))

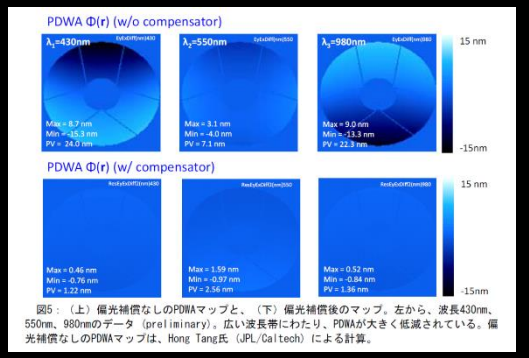


図5：（上）偏光補償なしのPDWAマップと、（下）偏光補償後のマップ。左から、波長430nm、550nm、980nmのデータ（preliminary）。広い波長帯にわたり、PDWAが大きく低減されている。偏光補償なしのPDWAマップは、Hong Tang氏（JPL/Caltech）による計算。

宇宙科学研究所　WFIRST WG

住　貴宏（大阪大学、准教授）（主査）、田村 元秀（東京大学/国立天文台、教授）
村上 尚史（北海道大学、助教）、　小谷 隆行（国立天文台、研究員）、
松尾 太郎（大阪大学、助教）、　河原 創 （東京大学、助教）
西川 淳 （国立天文台、助教）、　塩谷 圭吾（JAXA、助教）
成田 憲保（東大、アストロバイオロジーセンター、助教）
Olivier Guyon（Arizona 大学/すばる望遠鏡、准教授）、
櫨 香奈恵（JAXA、研究員）、　馬場 直志（北海道大学、教授）、
日下部 展彦（国立天文台、研究員）、　權 靜美 （JAXA、研究員）、
福井 暁彦（国立天文台岡山観測所、研究員）、
鈴木 大介（NASA/GSFC、研究員）、
山田 亨 （ISAS、教授）、　高田 昌広（東京大学カブリIPMU、教授）、
宮崎 聡 （国立天文台、准教授、すばるHSC責任者）、
大内 正己（東京大学 宇宙線研究所、准教授）、 大栗 真宗（東京大学、助教）、
田中 賢幸（国立天文台、特任助教）、　芝井 広 （大阪大学、教授）、
山田 良透（京都大学、助教）、　郷田 直輝（国立天文台、教授）、
村田 泰宏（JAXA、准教授）

興味のある方は是非参加ください。

WFIRST https://wfirst.gsfc.nasa.gov/

- **Space Telescope Mission planned in middle 2020's**
- NASA's flagship in astrophysics after
  JWST (6.5m IR telescope to be launched in 2018)
- **Highest priority space program in the US**
  Astrophysics Decadal Survey for 2010's (Astro2010)
- 2.4m-diameter wide-field telescope given 'free' by
  NRO (National Reconnaissance Office) to NASA
- **Dark Energy / Extrasolar Planets / GO(25%)**

- **International Collaboration**: **Japan, Europe, Canada**
- To be launched in 2025 (planned) to Sun-Earth L2 orbit
- Expected total cost ~$2.5B (preliminary, then year)

@ NASA

- Successful KDP (Key Decision Point)-A,

  Phase A started in 2016 Feb

- Formulation Science Working Group started

  FSWG #1 (2016 Feb), FSWG #2 (2016 May), FSWG #3 (2016 Oct)

  FSWG #4 (2017 Feb)

- System Requirement Review in June 2017

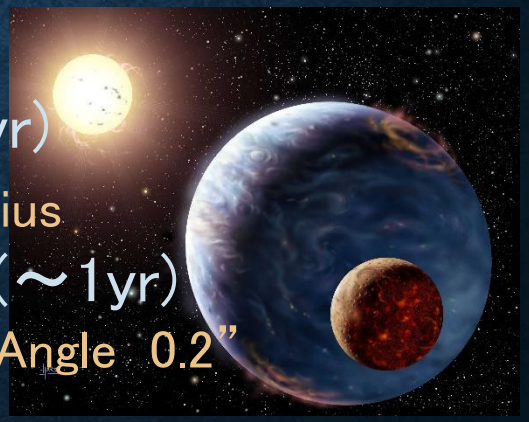
  KDP-B (late 2017) KDP-C (middle 2019) expected

- FY14 $56M, FY15 $50M, FY16 $90M , FY17 $130M

- OTA temperature 260K or 285K
- Star-shade (optional)

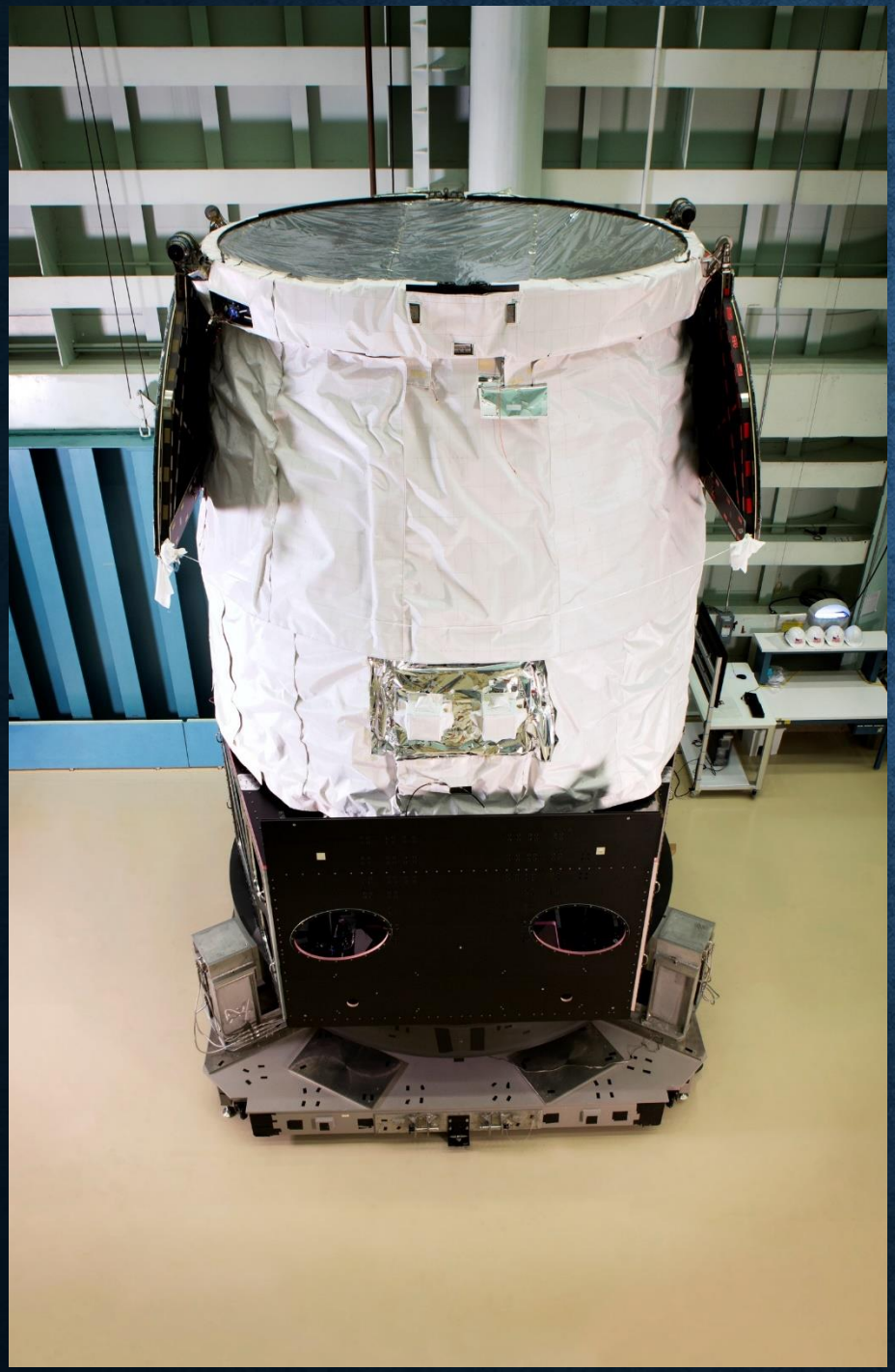
WFIRST Science Objectives

- **Dark Energy / Modified Gravity （～2.5yrs）**
  - **Wide-area galaxy survey (High Ecliptic Latitude Survey)**
    Distribution of Galaxies and Dark Matters
    ➔Structure Formation and Geometry of the Universe
  - Type-Ia Supernova **➔Accelerating Expansion of the Universe**
- **Extrasolar Planets （～2yrs）**
  - Gravitational Microlensing Search (～1yr)
    Galactic bulges, Planets at the large orbital radius
  - Direct Observations with Coronagraph (～1yr)
    Visual, High contrast goal 10^{-9}, Inner Working Angle 0.2”



- **Guest Observers’ Program (1.5yrs)**


LIFE
LINE



Japanese Interest to WFIRST

- Participation in WFIRST SDT (Sumi) 2012
- JAXA representative observer (Yamada) for WFIRST-AFTA Science Definition Team (2013-2015)
- Japanese Interest shown in WFIRT SDT Final Report (2015 Feb)
- Invitation from Dr. Paul Hertz (NASA HQ) (2015 July)
- Observer in WFIRST Formulation Science Working Group (2016 Feb~)

Interests by Foreign Groups for Potential Contributions

- Japan
  - WFI: Could provide coordinated ground-based observations (wide and deep spectroscopy and deep optical imaging) and microlensing/galactic bulge science imaging processing pipeline & precursor ground observations
  - CGI: Interested in a polarization module, mask fabrication, analysis/algorithm support, PIAA module
- Canada
  - Strong science interest in SN and WL surveys as well as coronagraphy
  - WFI: Interested in the IFU, FGS, photometric calibration (pre-flight or flight), UV/blue wide-field instrument
  - CGI: Interested in the IFS, EMCCDs, LOWFS, filter/mask wheels, data reduction pipeline, data processing, and archiving
- UK and Europe
  - WFI: Interested in the IFU and opto-mechanical systems and associated electronics, ground processing of spectroscopy data, image/data processing and analysis pipeline, lenses and mounts, and calibration hardware
  - CGI:
    - Expertise in flight instruments, high contrast test bed for testing coronagraphs and post-coronagraphic techniques and detector technology
    - Interested in LOWFS design, optical element, CCDs and associated camera
- Korea
  - No formal statement in the report, discussions are at the very early stages, but strong interest & possible funding, likely centered around the HgCdTe detectors

Update of Japanese contribution plan

Potential Japanese Contribution "Package" for WFIRST

1. Subaru-WFIRST Coordinated/Synergistic Observations

2. Potential Contribution to Coronagraph Instrument
   Polarimetry capability
   w/ Polarimetry Compensation Unit

3. Ka-band Data Downlink Station in Japan

4. Coordinated Ground-based microlensing survey
   pre/concurrent observations with a new 1.8m telescope
   (a dedicated telescope for microlensing)

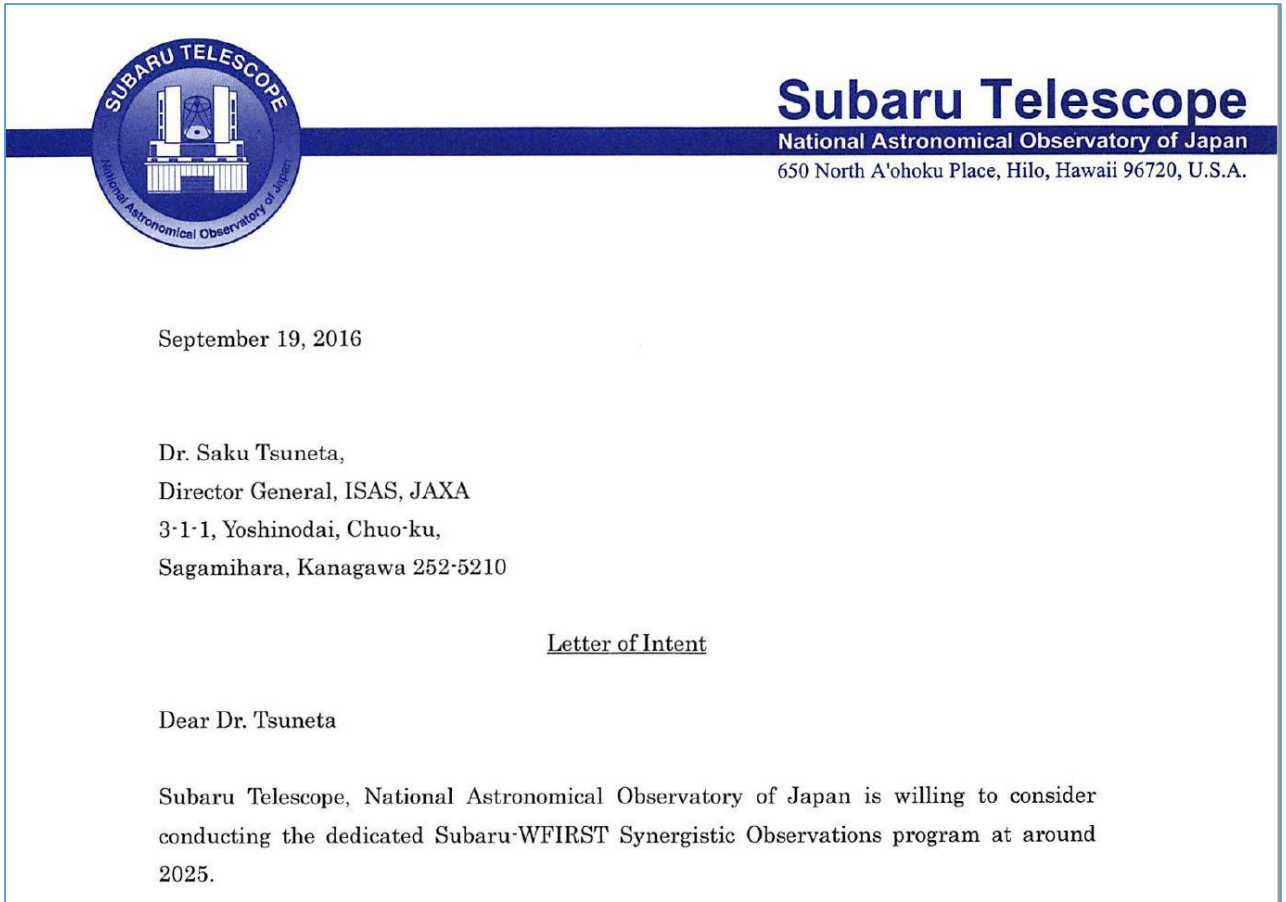
1. Subaru Synergistic Observations

- Subaru users show great interest in the synergistic observations with WFIRST
- Subaru Telescope can reserve a certain number of nights (~100 TBD) at ~2025 for the Subaru-WFIRST synergetic program, ***if it is supported by the Subaru community***.

- **Letter of Intent** from Nobuo Arimoto, Director of Subaru Telecope to ISAS/JAXA Director General Saku Tsuneta, which is CC-ed to Dr. Paul Hertz of NASA
- **Good support in the GOPIRA symposium (Sept 27, 16)**
  GOPIRA=group of optical and infrared astronomers
- **Presenation at HSC consortium meeting (Aug 25, 16)**

■Letter of Intent from Nobuo Arimoto, Director of Subaru Telecope to ISAS/JAXA Director General Saku Tsuneta, CC-ed to Dr. Paul Hertz of NASA .

Subaru Advisory committee supported



Subaru Telescope
National Astronomical Observatory of Japan
650 North A'ohoku Place, Hilo, Hawaii 96720, U.S.A.

September 19, 2016

Dr. Saku Tsuneta,
Director General, ISAS, JAXA
3-1-1, Yoshinodai, Chuo-ku,
Sagamihara, Kanagawa 252-5210

Letter of Intent

Dear Dr. Tsuneta

Subaru Telescope, National Astronomical Observatory of Japan is willing to consider conducting the dedicated Subaru-WFIRST Synergistic Observations program at around 2025.

■ Next Step

- ISAS/JAXA WFIRST WG has recommended the names of researchers as SIT 'observers'.

  We propose their names
  for the certification by NASA HQ and FSWG PIs, and
  by each SIT chairs.

■ Toward the Commitment

- Based on the strong support by community,
  Subaru Telescope/SAC will consider to **commit** 100 nights for WFIRST-Subaru synergistic observations at around 2025.

  - Process to select the programs for 100 nights
  - Allocation should be consistent with the planned SSP with PFS

  Desired 'return' for the commitment, to be discussed.
  - participation to SIT/WGs as members
  - participation to GO program (a TAC member)

SAC News Letter 67 (November, 2016)

WFIRSTとすばるの共同観測を100晩程度2025年以降に実行するというcommitment letterを出すことを承認した。
今後日本の具体的な参加の方法について検討していく。

SAC concluded to certify that NAOJ/Subaru issues the Letter of Commitment to NASA to desceibe Subaru reserves ~100 nights after 2025.

Further discussion should be made how to implement the program.

Key Issues *to be discussed with WFIRST FSWG*

- Surveys, or Selected Programs
- Sky Coverage in Surveys (Subaru access)
  - Supernova Survey
  - High Latitude Survey
  - Exoplanet targets
- Strategy
  - to expand the program in 2020's
  (cannot be reserved / committed now)

- Preparation for Subaru-WFIRST Meeting in Japan, 2017

- Involvement in Formulation Science Working Group (FSWG), and Science Integration Team (SIT)

- *Sharing information of our activity with Subaru community*

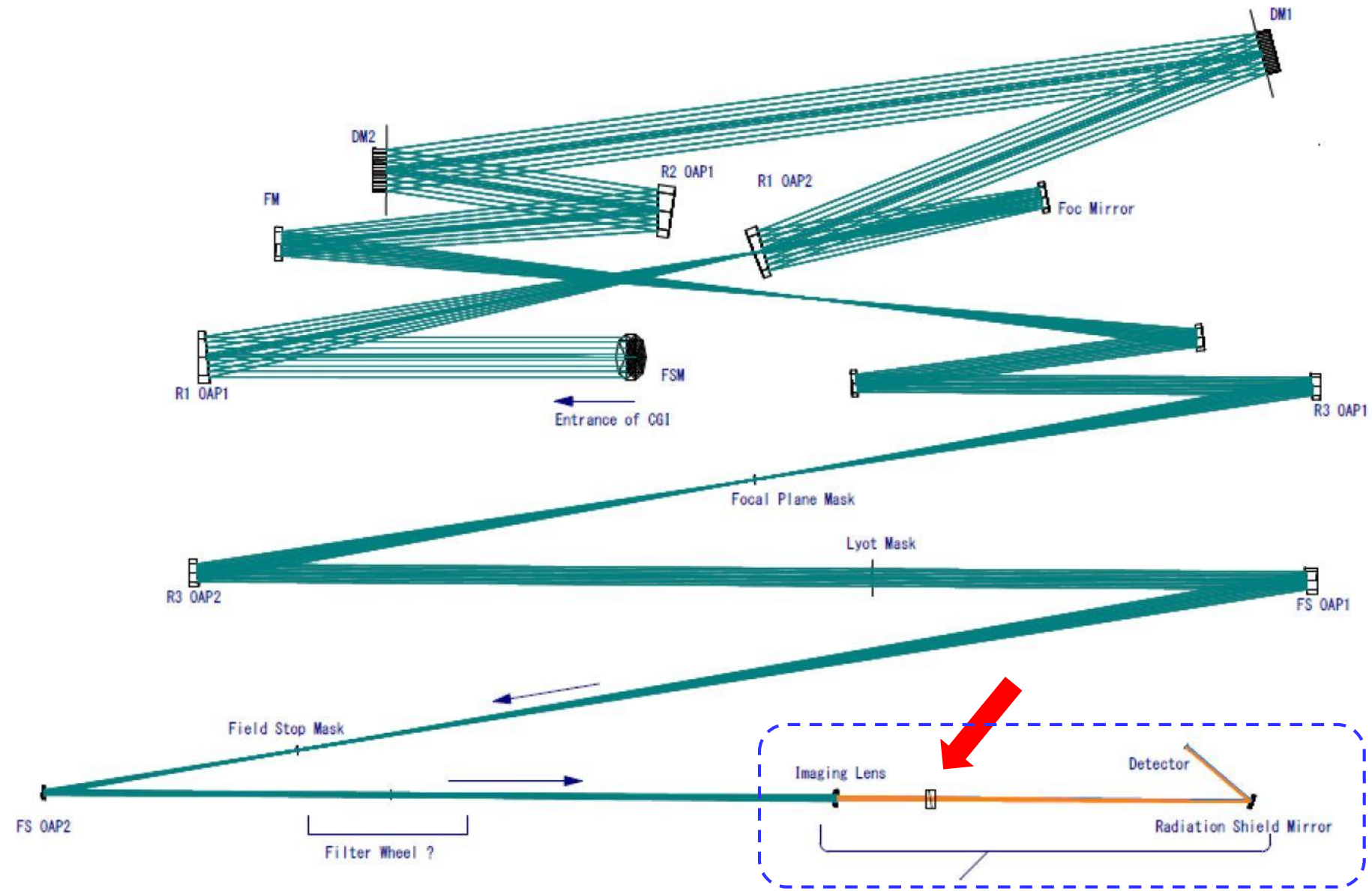
2. Polarimetry Capability for CGI

- **Polarimetry Unit (Imaging Polarimetry)**

- **Development of Polarization Compensator**
  correcting polarization-differential wavefront aberration (PDWA)

Adding accurate polarimetry capability
- important science cases for planets and disks
- achieving higher contrast

WFIRST Polarimeter : Ray Tracing



Development of Polarization Compensator

N. Murakami, et al.

- **Broadband high-contrast polarimetry observations**

- **Problem:**
  - Instrumental polarization causes polarization-differential wavefront aberration (PDWA)
  - DM cannot correct different X- and Y-polarized WFs simultaneously

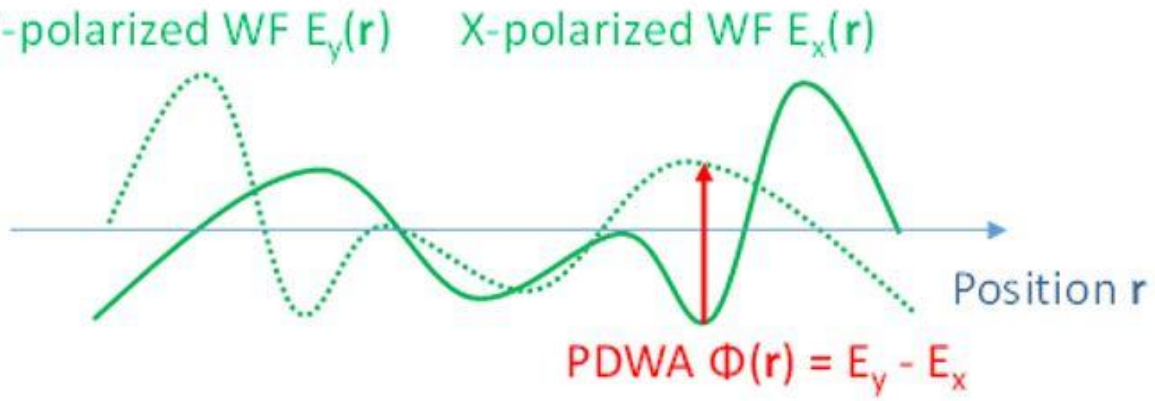
- **Polarization-compensating system**

  Birefringent plates: reduce the PDWA to make the X- and Y-polarized WFs be identical

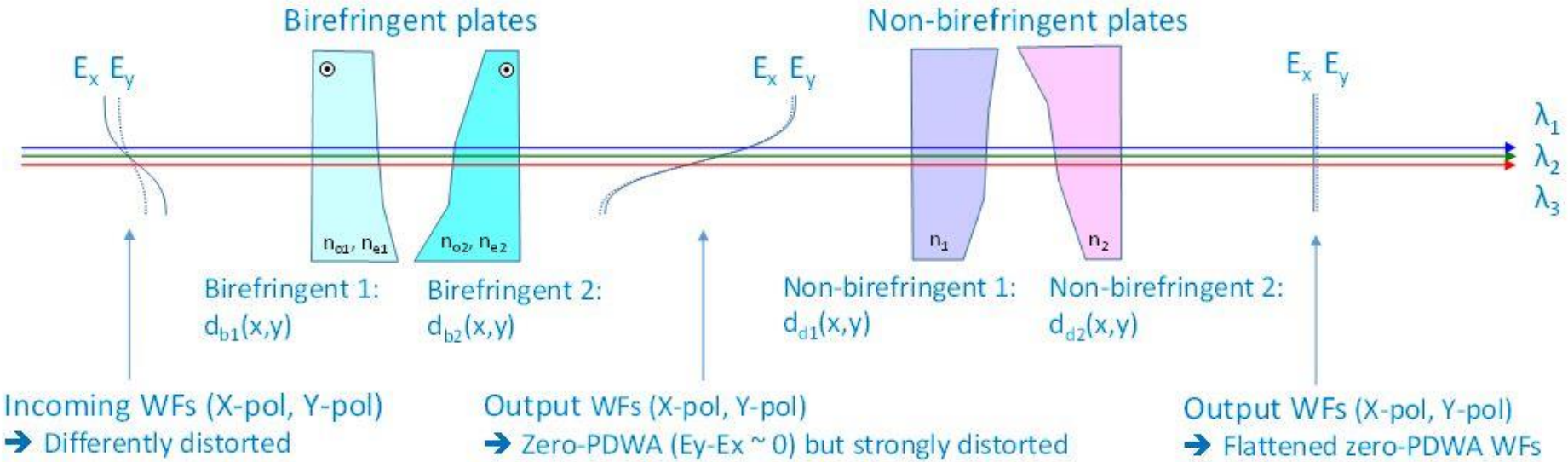
  Non-birefringent plates: correct (flatten) the distorted WFs

Development of Polarization Compensator

Definition of PDWA



Principle of polarization compensator



3. Ground Stations in Japan

- SE-L2 orbit selected, ground-station at Japan longitude is useful
- New Deep Space Antenna (Usuda, Φ50m, 2019~) now for PDR
  Ka band (need to built a backend receiver system for WFIRST)

WFIRST requirements

- 26.5 GHz (🡐🡒 32GHz New Usuda Antenna) band science downlink
  - G/T of approximately 48.5 dB/K
- Science data rate 262.5 Mbps
- Rate 7/8 Low Density Parity coding
- S-band housekeeping telemetry and commanding
- Tracking data – Doppler and ranging
- 95% availability
- Up to 12 hour contact each day
- 11.4 Terabits per contact
- S-band data sent in real time to US
- Ka-band data delivered within 24 hours

4. Ground-based Microlensing Observations

- Access to the MOA Data for pipeline development

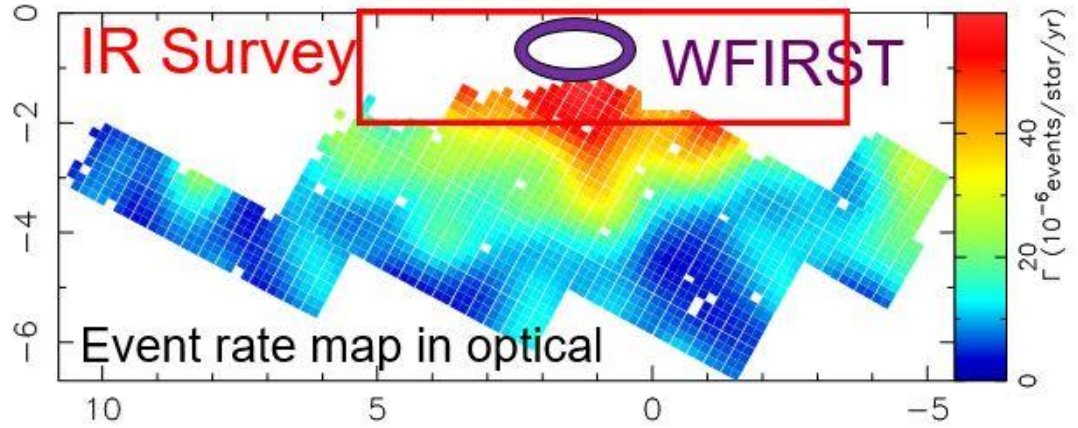
- New microlensing 1.8m IR telescope is funded (FoV 1.3deg^2, Sumi et al., South Africa)

- World largest class IR camera. Loan four 4kx4k H4RG-10s from WFIRST team

1. Precursor observations for the optimization of WFIRST microlensing survey field

2. Concurrent observations with WFIRST for determination of lensing mass

1. Precursor observations for optimizing WFIRST microlensing survey field



2. Concurrent observations with WFIRST for lens mass determination via Ground-Space parallax