Subaru Telescope 2015 - 2016

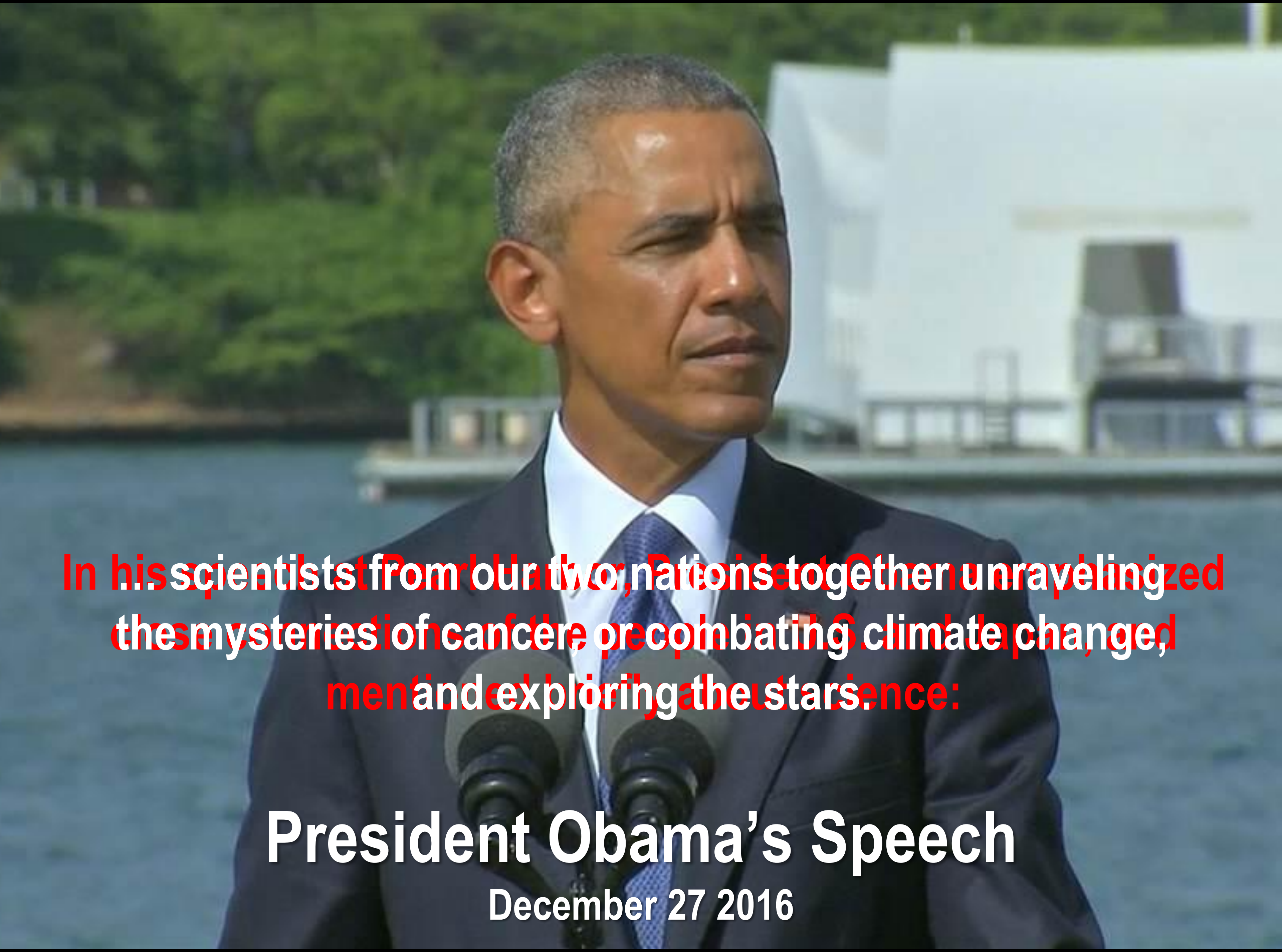
Season's Greetings

Nobuo ARIMOTO
Director

"Moon, Five Planets, and Subaru Telescope"
Photo by H. Fujiwara (Subaru Telescope, NAOJ)

Japan's Shinzo Abe and Obama to visit Pearl Harbor

December 27, 2016


… scientists from our two nations together unraveling the mysteries of cancer or combating climate change, and exploring the stars.
President Obama’s Speech
December 27 2016

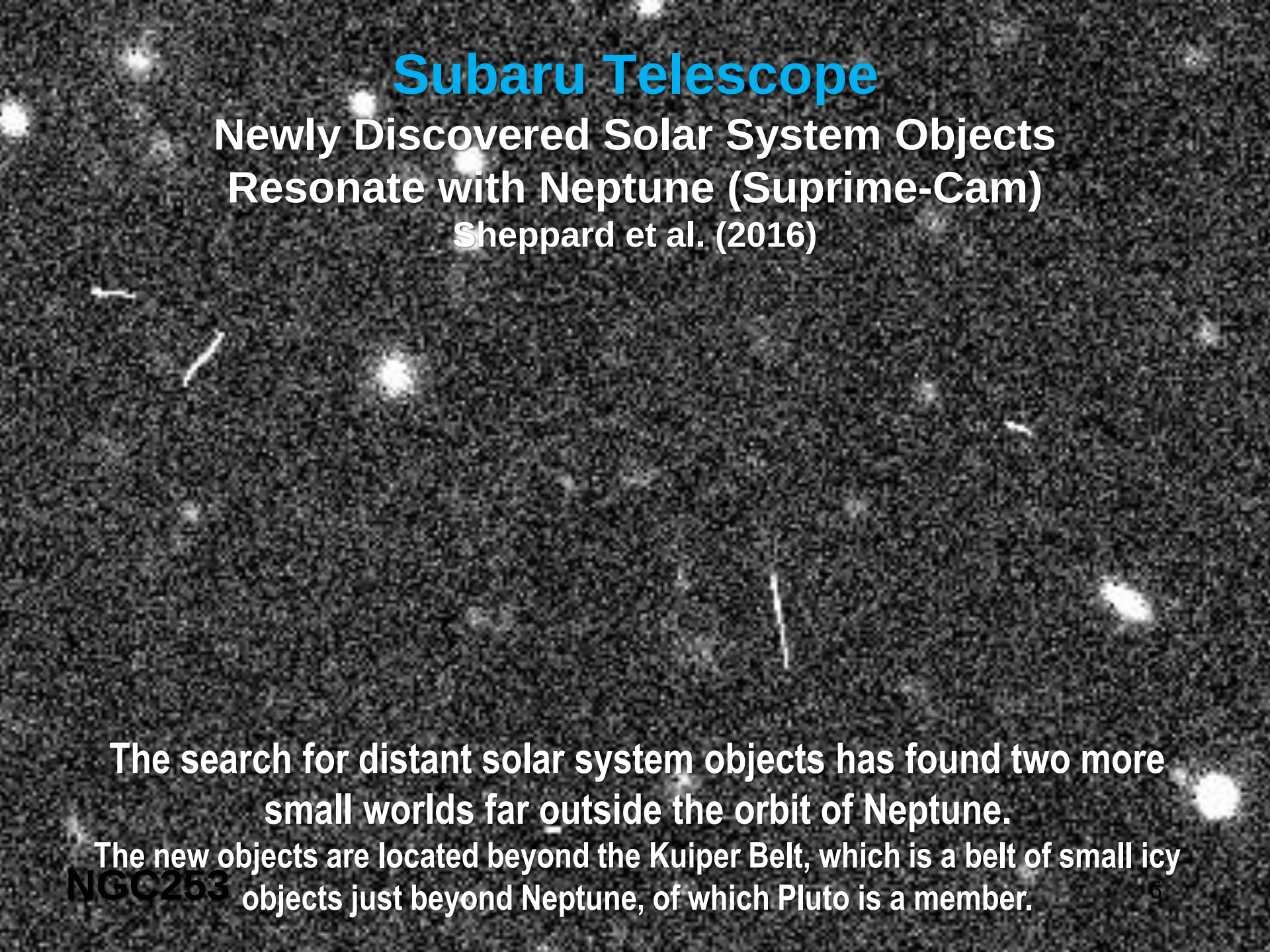

MIAMI


TAURUS
ORION
ARIES
ECLIPTIC
JUNE
Aldebaran
Bellatrix
Pleiades
Alcyone
Atlas
Electra
Merope
Taygeta
Celino
Maia
Subaru Telescope
Science Topics

Subaru Telescope

Newly Discovered Solar System Objects Resonate with Neptune (Suprime-Cam)

Sheppard et al. (2016)



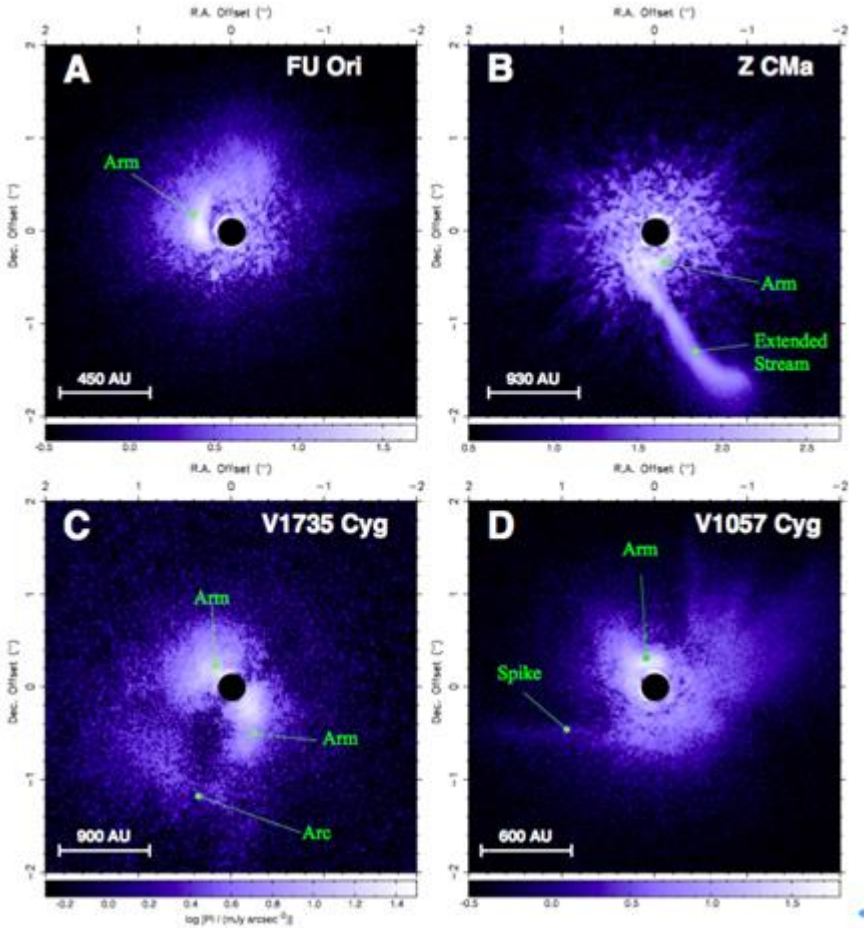
The search for distant solar system objects has found two more small worlds far outside the orbit of Neptune.

The new objects are located beyond the Kuiper Belt, which is a belt of small icy objects just beyond Neptune, of which Pluto is a member.

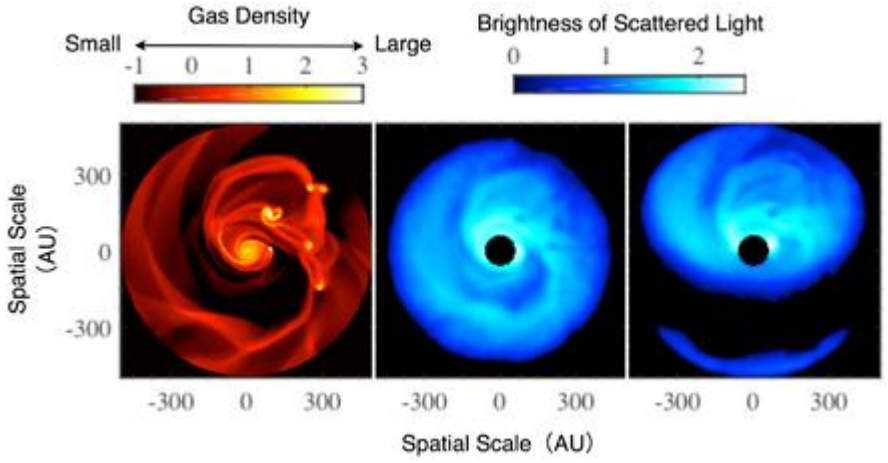
NGC253

Subaru Telescope

Subaru-HiCIAO Spots Young Stars Surreptitiously Gluttonizing Their Birth Cloud (HICIAO) (Liu et al. 2016)



Images made from computer simulations based on one theory for violent growth of a star. (Left) Simulations of the motion of circumstellar materials falling onto a baby star (Middle and right).

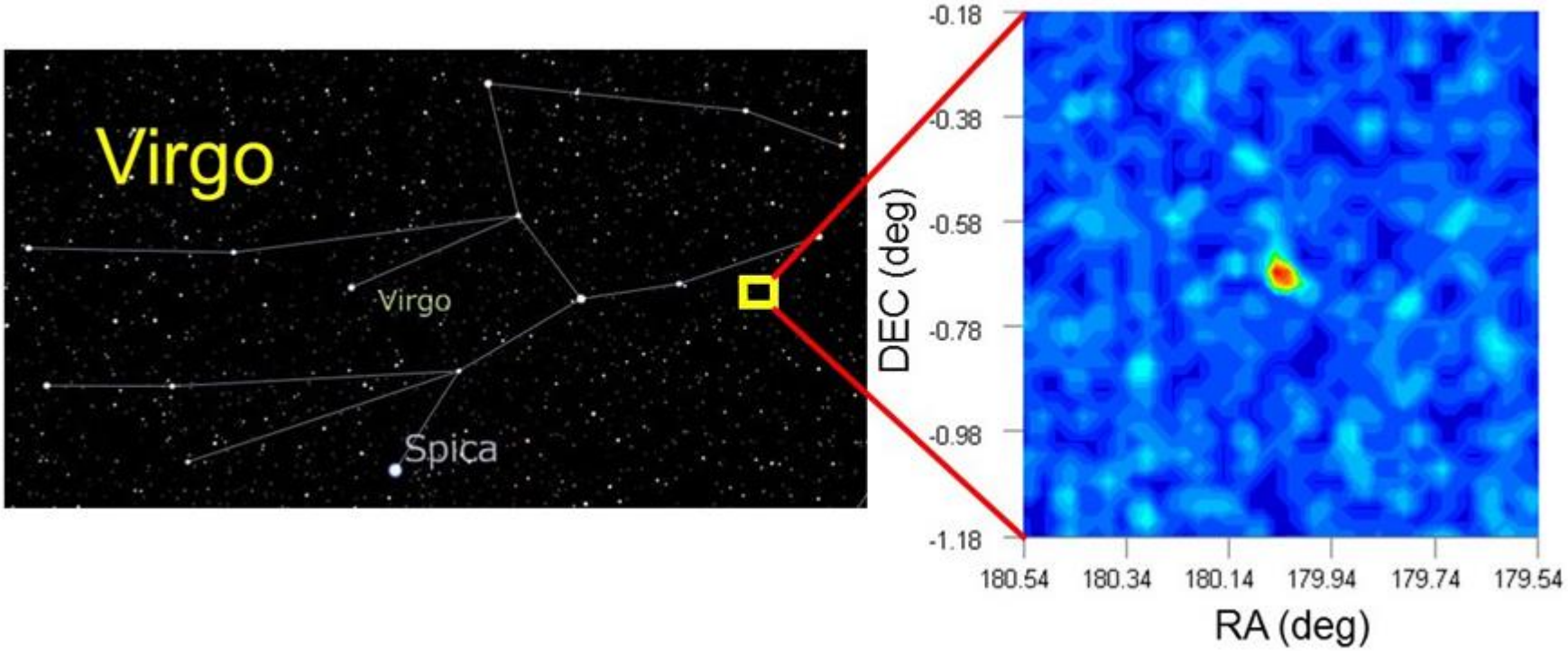


Circumstellar structures of young stars

Subaru Telescope

Record-breaking Faint Satellite Galaxy of the Milky Way Discovered

Honma et al. (2016)

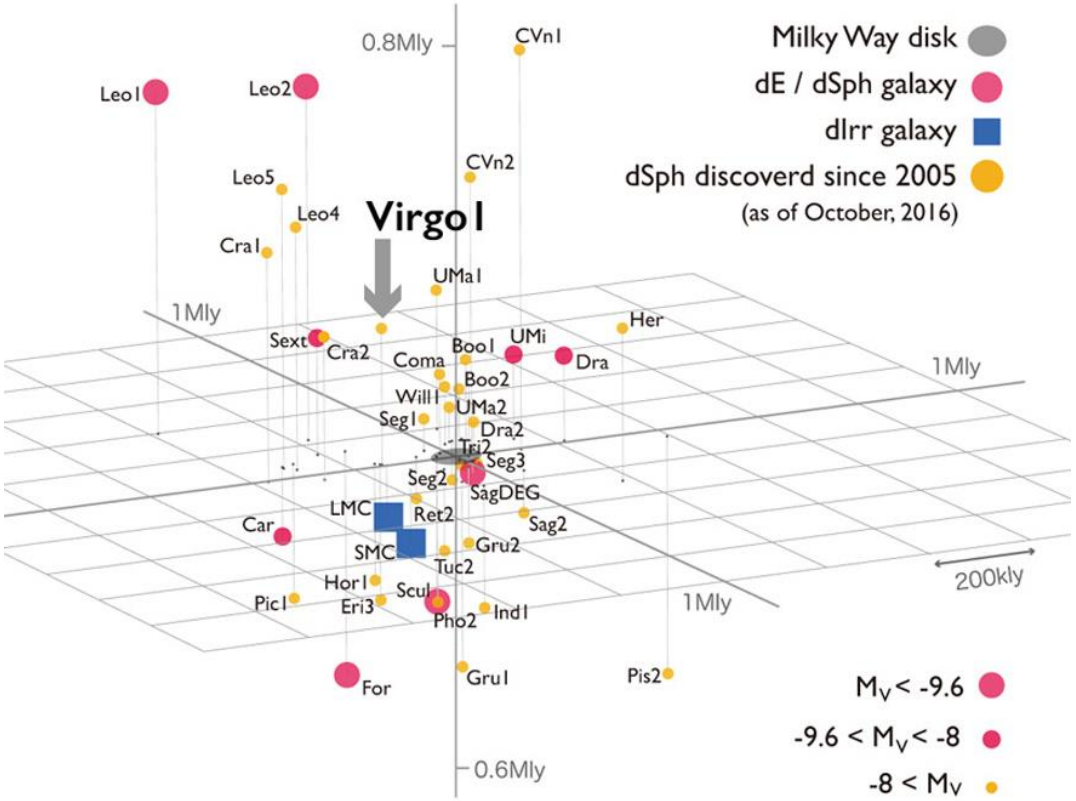


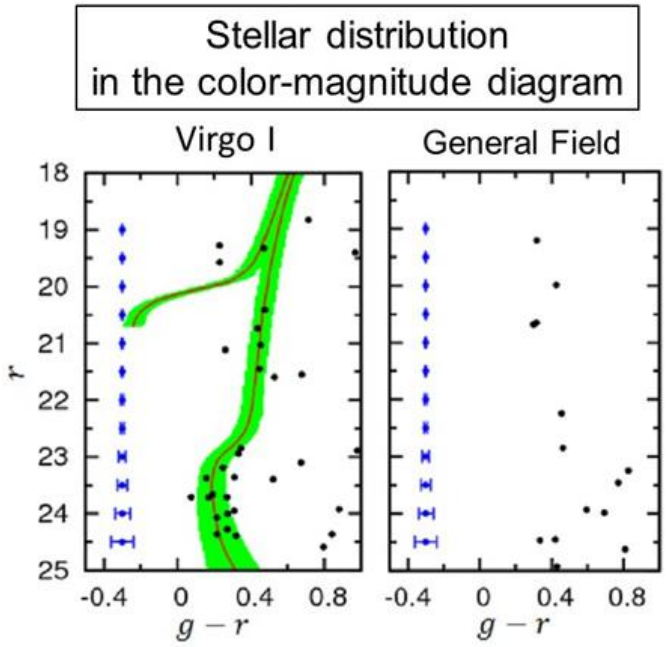
Its discovery suggests the presence of a large number of yet-undetected dwarf satellites in the halo of the Milky Way and provides important insights into galaxy formation through hierarchical assembly of dark matter.

Subaru Telescope

Record-breaking Faint Satellite Galaxy of the Milky Way Discovered

Honma et al. (2016)

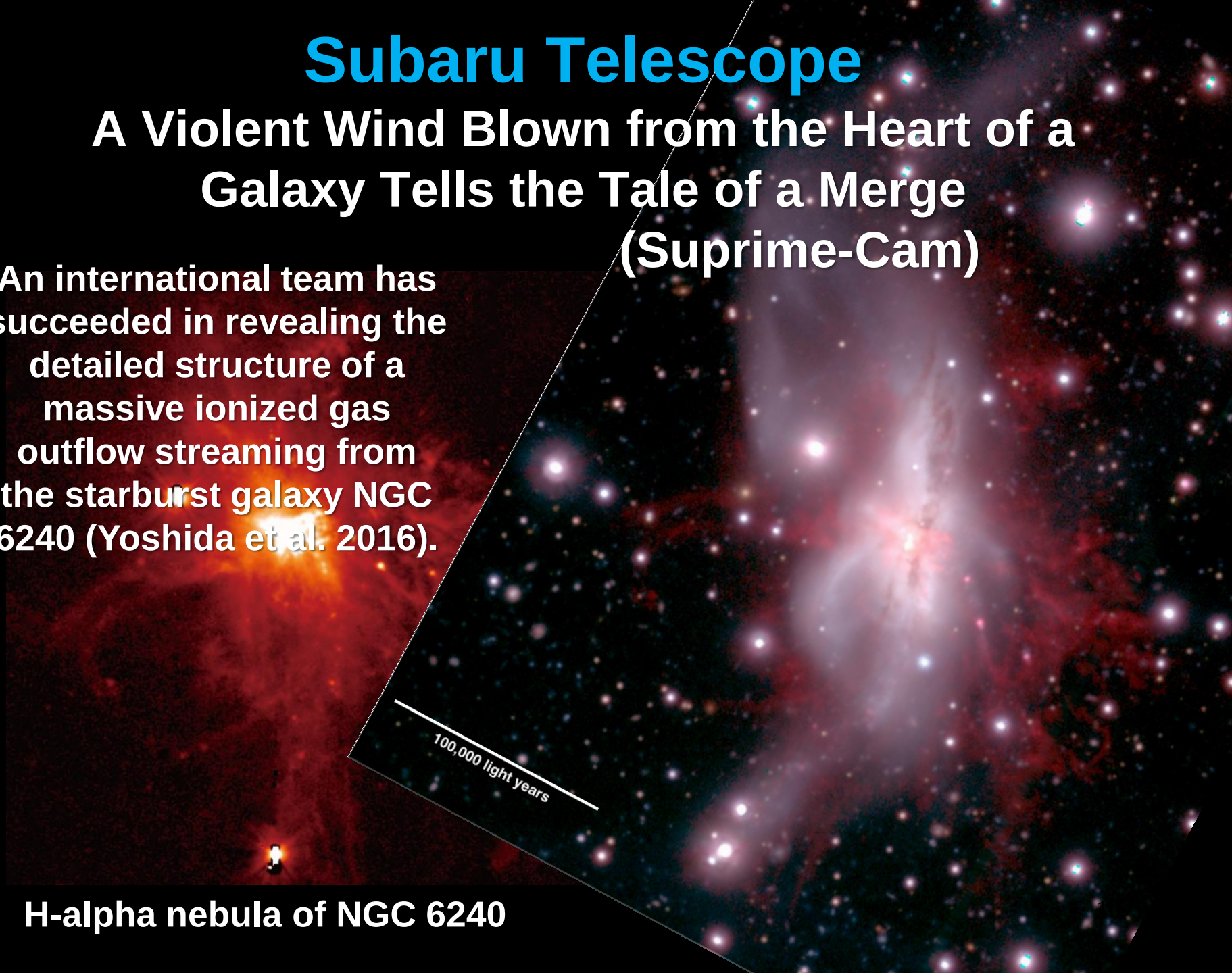




Subaru Telescope

A Violent Wind Blown from the Heart of a Galaxy Tells the Tale of a Merge (Suprime-Cam)

An international team has succeeded in revealing the detailed structure of a massive ionized gas outflow streaming from the starburst galaxy NGC 6240 (Yoshida et al. 2016).

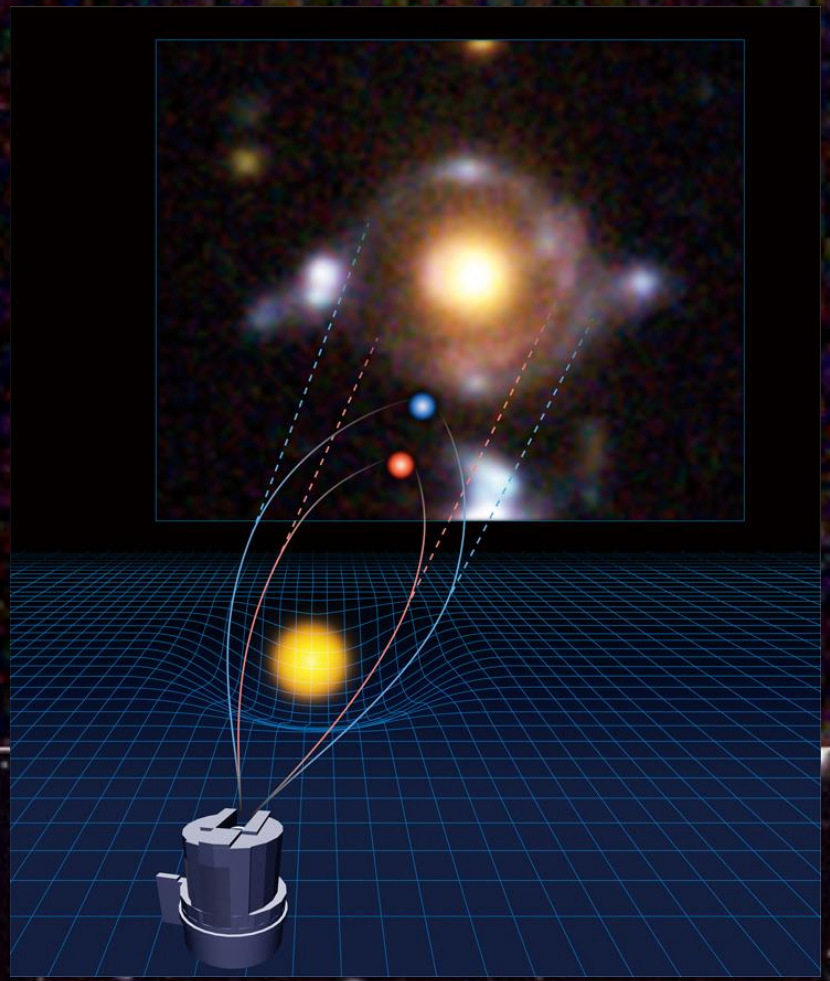


H-alpha nebula of NGC 6240

Subaru Telescope

Ancient Eye in the Sky (HSC)

Tanaka et al. (2016)



z=0.79

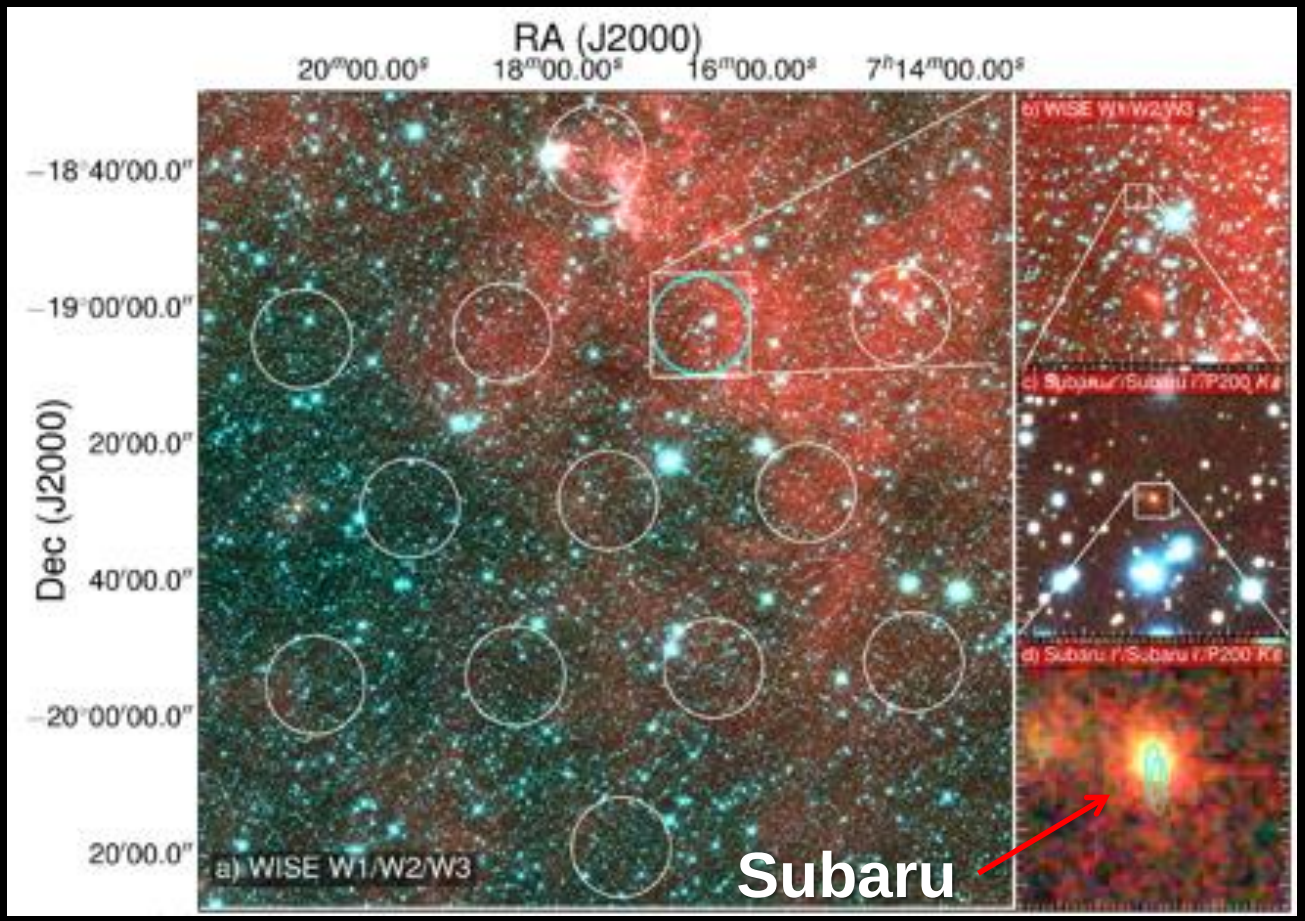
HSC-SSP


Subaru Telescope
Ancient Eye in the Sky
Data analysis workshop for undergraduate students 2015

Subaru Telescope

New Fast Radio Burst Discovery Finds 'Missing Matter' in the Universe

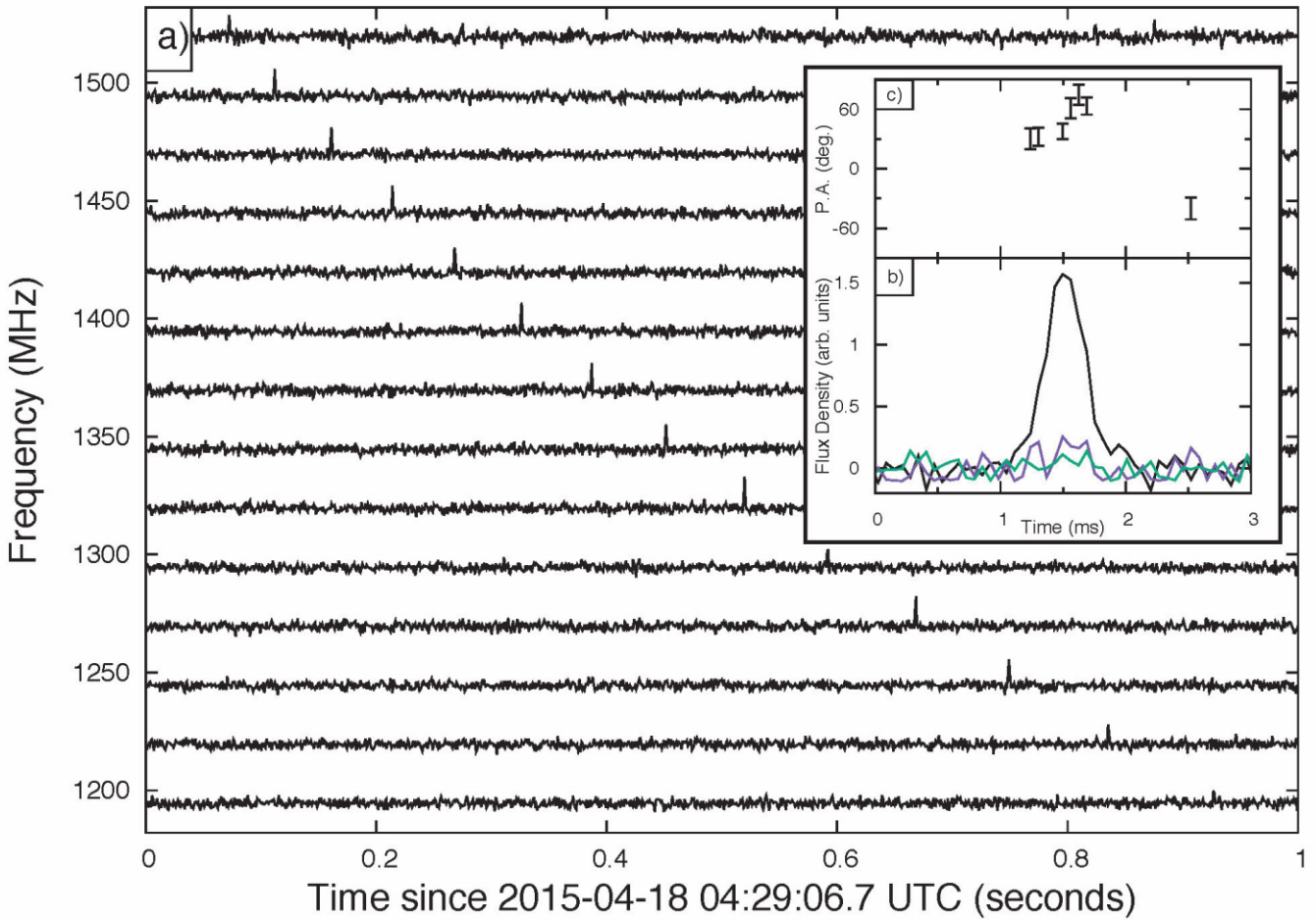
Keane et al. (2016)



For the first time, Subaru has identified the host galaxy and measured the distance to a fast radio burst (z=0.492）.

Subaru Telescope

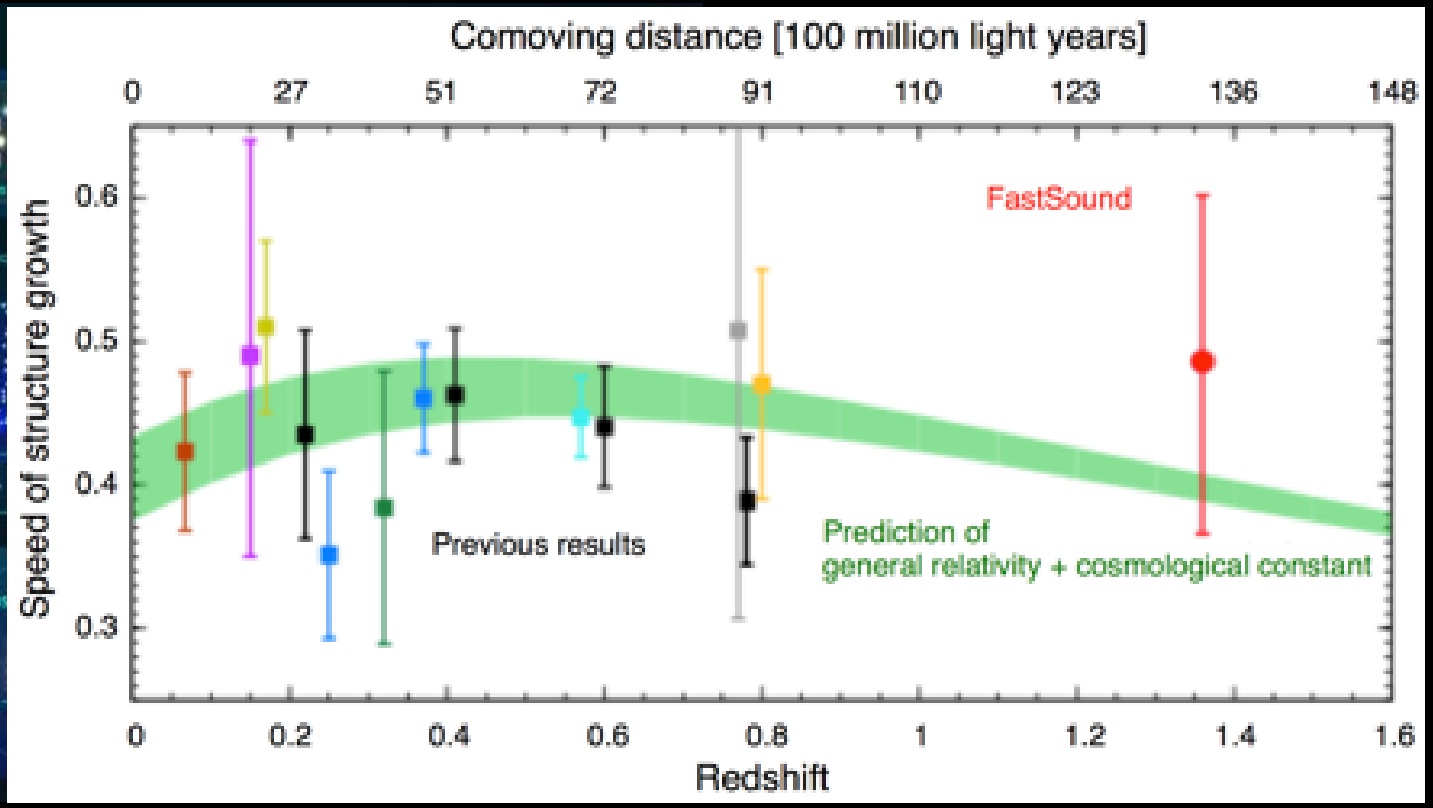
New Fast Radio Burst Discovery Finds 'Missing Matter' in the Universe



The increased delay in the arrival time of the Fast Radio Burst as a function of the frequency, which is caused by the material it goes through.

Subaru Telescope

New Test by Deepest Galaxy Map Finds Einstein's Theory Stands True (FMOS) Okumura et al. (2016)

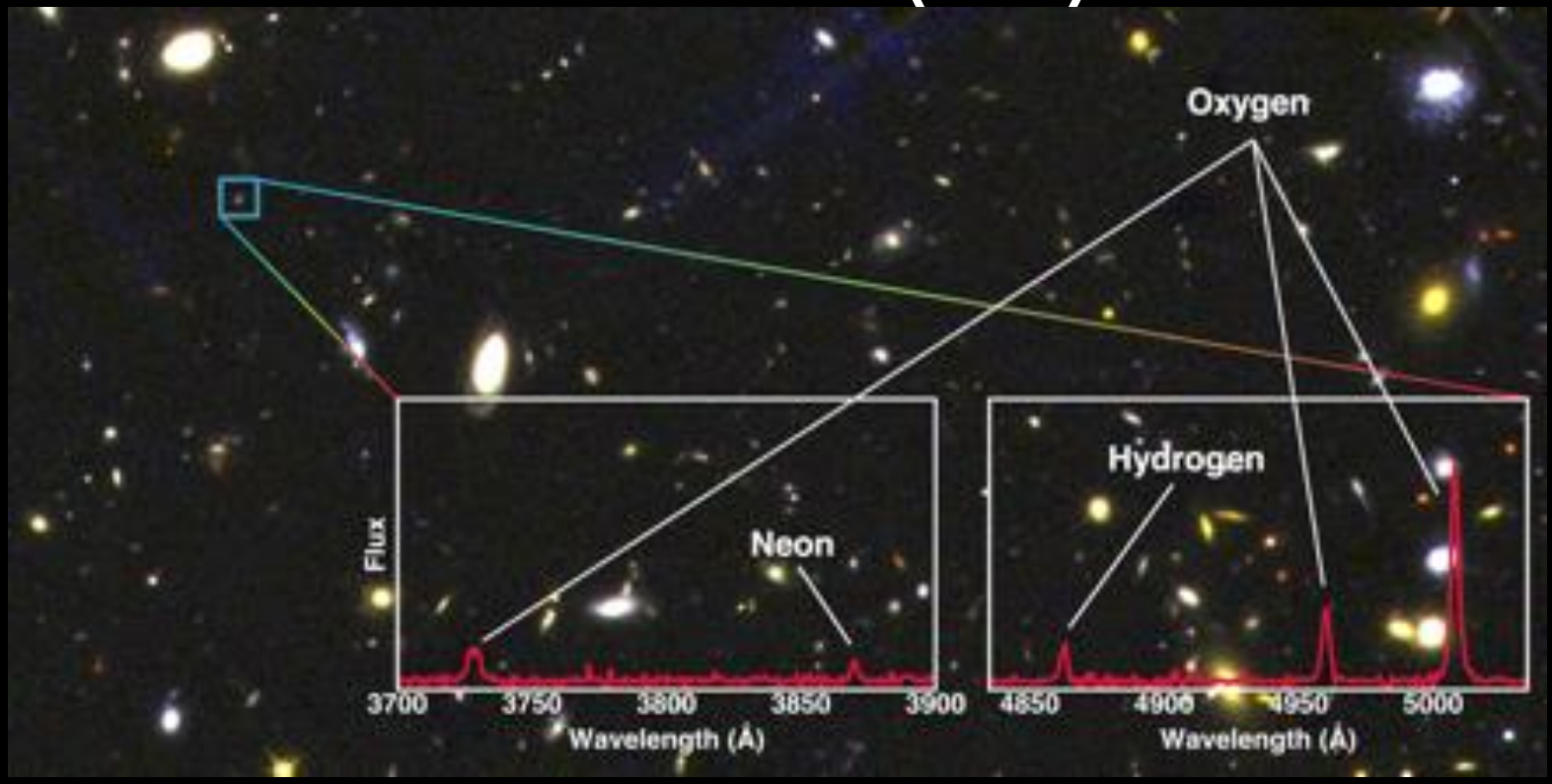


FMOS SSP has made a 3D map (velocity and clustering) of 3000 galaxies at z~1.4, the team was able to confirm that Einstein's general theory of relativity is still valid.

Keck Telescope

Did Star Formation Regulation Change as the Universe Evolve? (MOSFIRE)

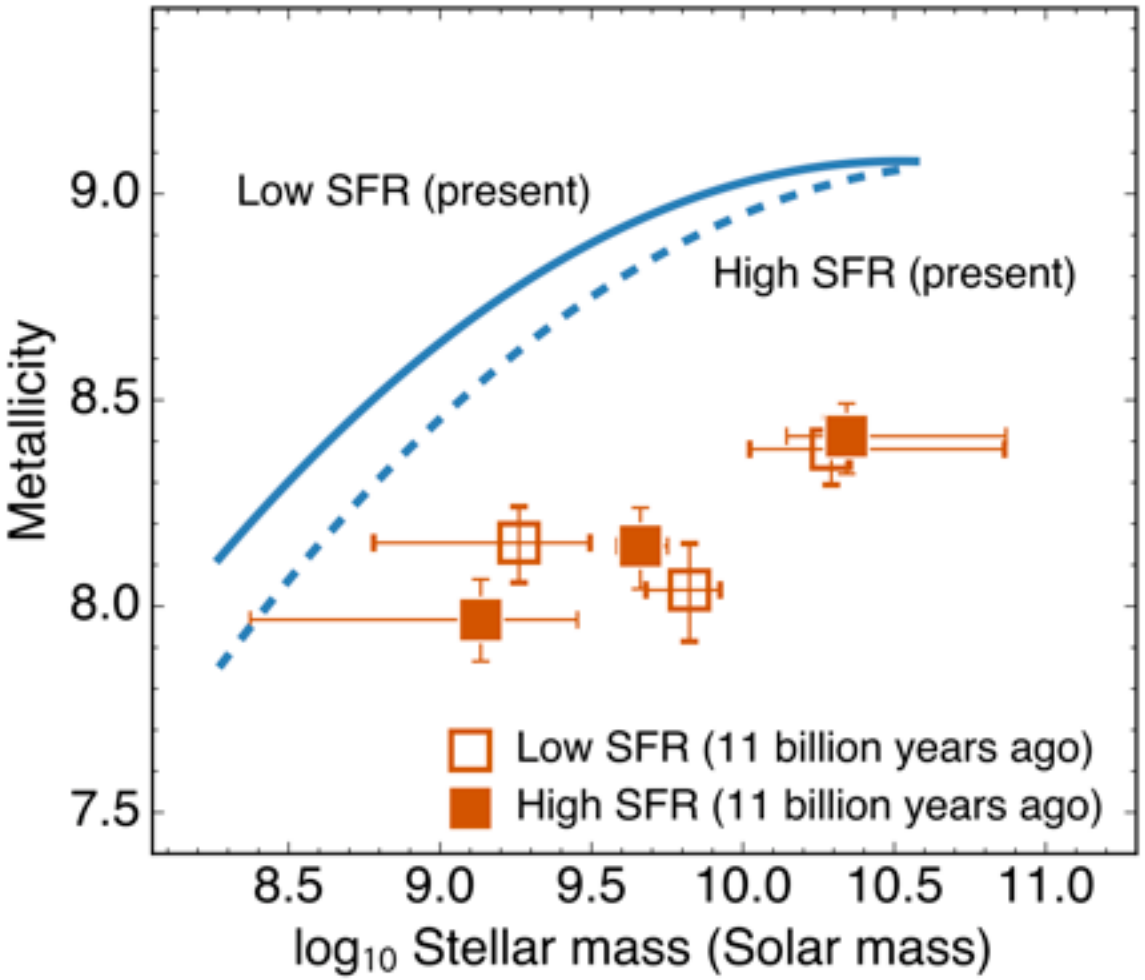
Onodera et al. (2016)



What they discovered is that the amount of metals is very similar irrespective of galaxies' star formation activity, raising new questions about star-forming theory.

Keck Telescope

Onodera et al. (2016)



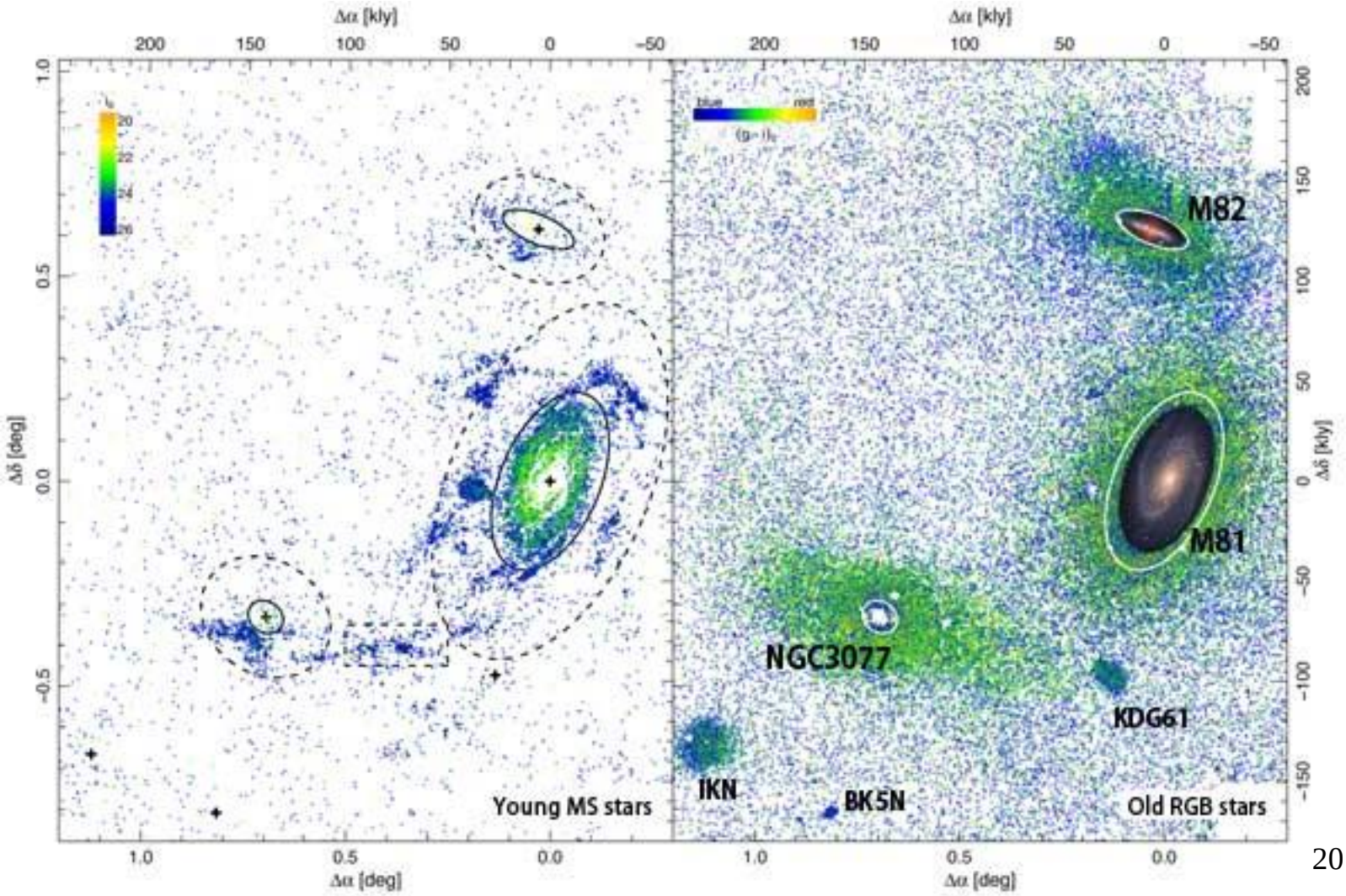
The star formation rate (SFR) of distant galaxies (z~3.3)and today's galaxies versus their metallicity. The former does not show any distinction in the metallicities with respect to the SFRs, while the latter is divided into two distinct metal contents according to their SFRs.


TAURUS
ORION
ARIES
Aldebaran
Bellatrix
Pleiades
JUNE
ECLIPTIC
MAY
Subaru Telescope
Instruments


Hyper-Suprime-Cam (HSC)

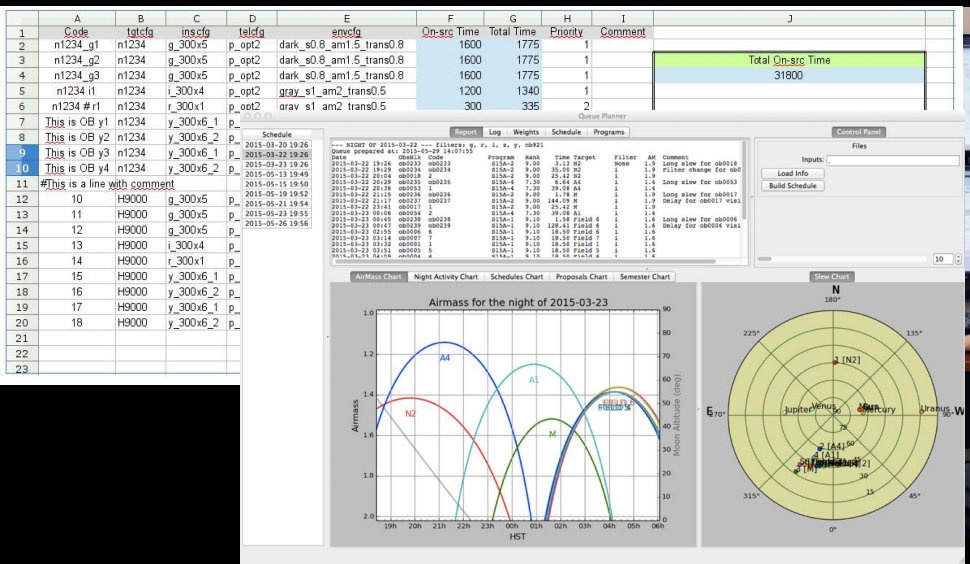
Subaru Telescope

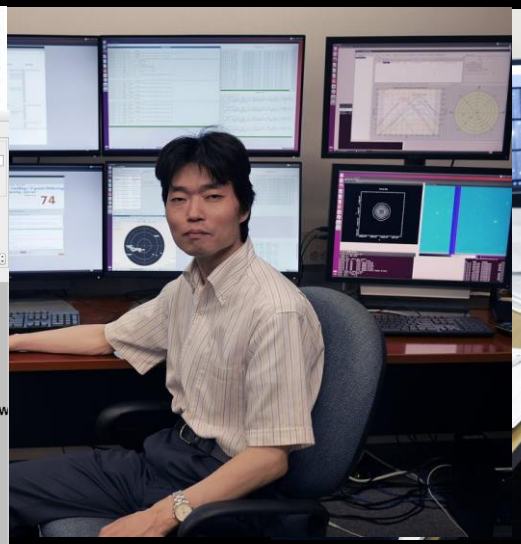
Young main-sequence stars and old red-giant branch stars around M81, M82, and NGC 3077 (Okamoto et al. 2015)

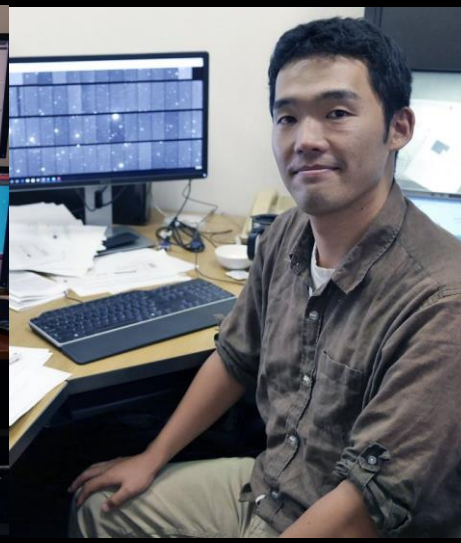


HSC Operations

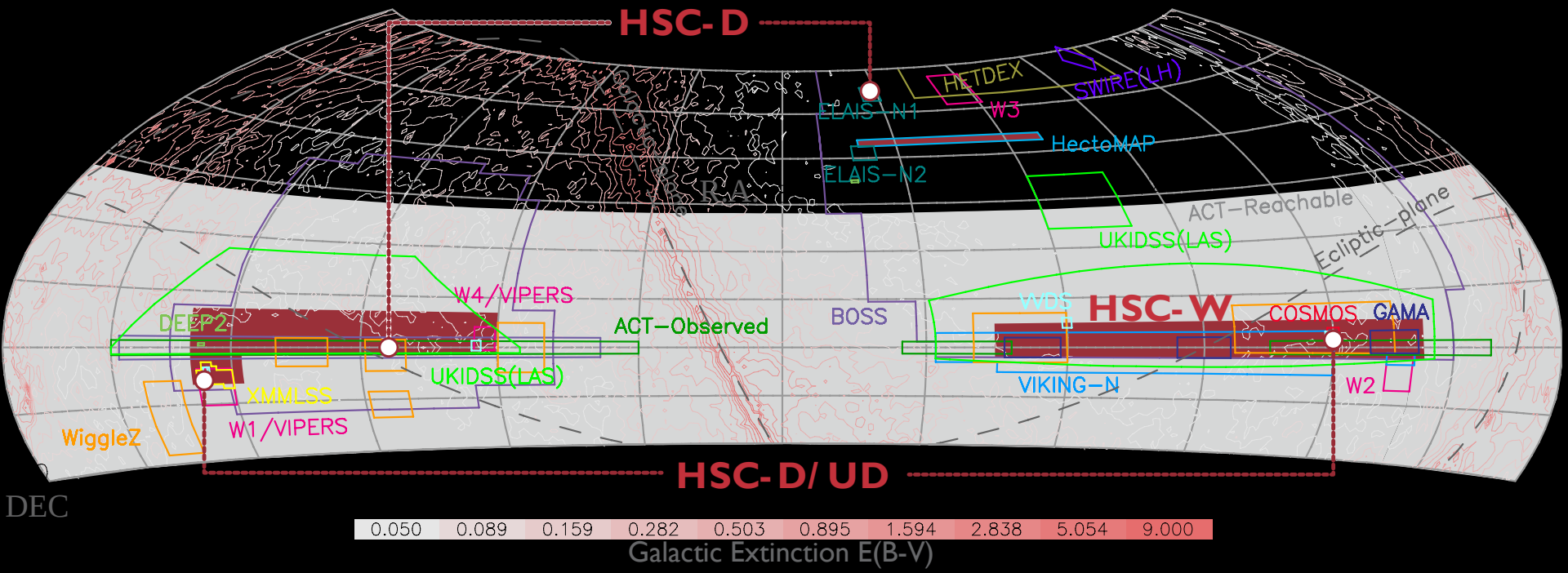
- HSC is being operated smoothly thanks to many efforts by Subaru staff and developers.
  - 318 HSC nights (128 HSC SSP nights) from S14A to S16B.
- HSC queue-mode observation successfully started from S16A.
  - In-house software development
  - Much efforts on operation and improvements







HSC-SSP Survey Area



- **HSC Survey Area**
  - **Include the previous surveys**
  - **Little absorption by dust**
  - **Observable whole year**
  - **Observable from south (chile)**

Subaru Strategic Program
2014 – 2019A
300 Nights

HSC Subaru Strategic Program

Data releases for HSC collaboration have been made (S14A_0, S14A_0b, S15A, S15B, S16A)

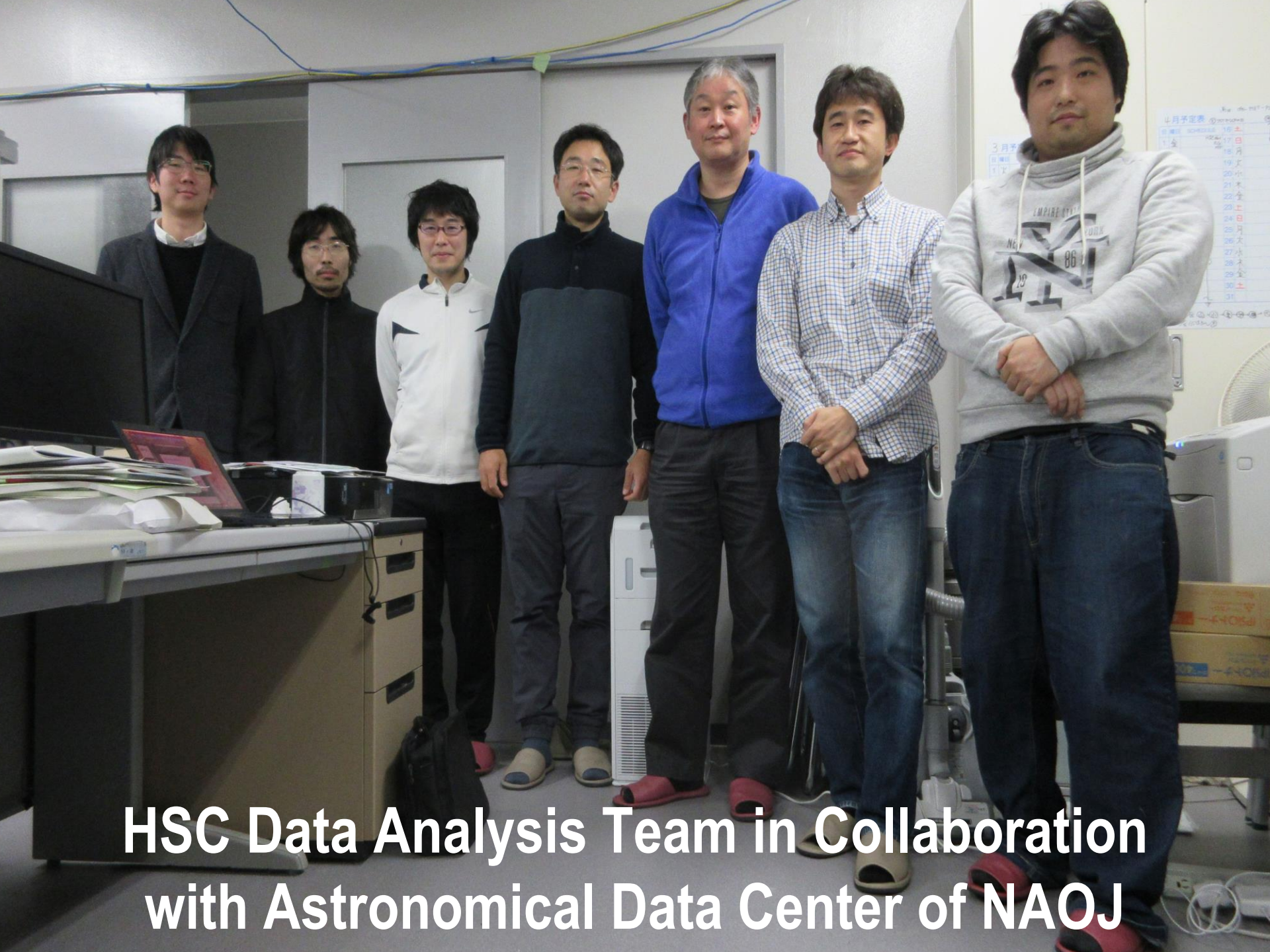
- **Including processed catalogs (w/ photo-z) and images**

Initial science results are out.

- **So far 7 papers based on HSC SSP were published/accepted.**
- **PASJ special issue is in preparation.**

The first Public Data Release in February 2017.

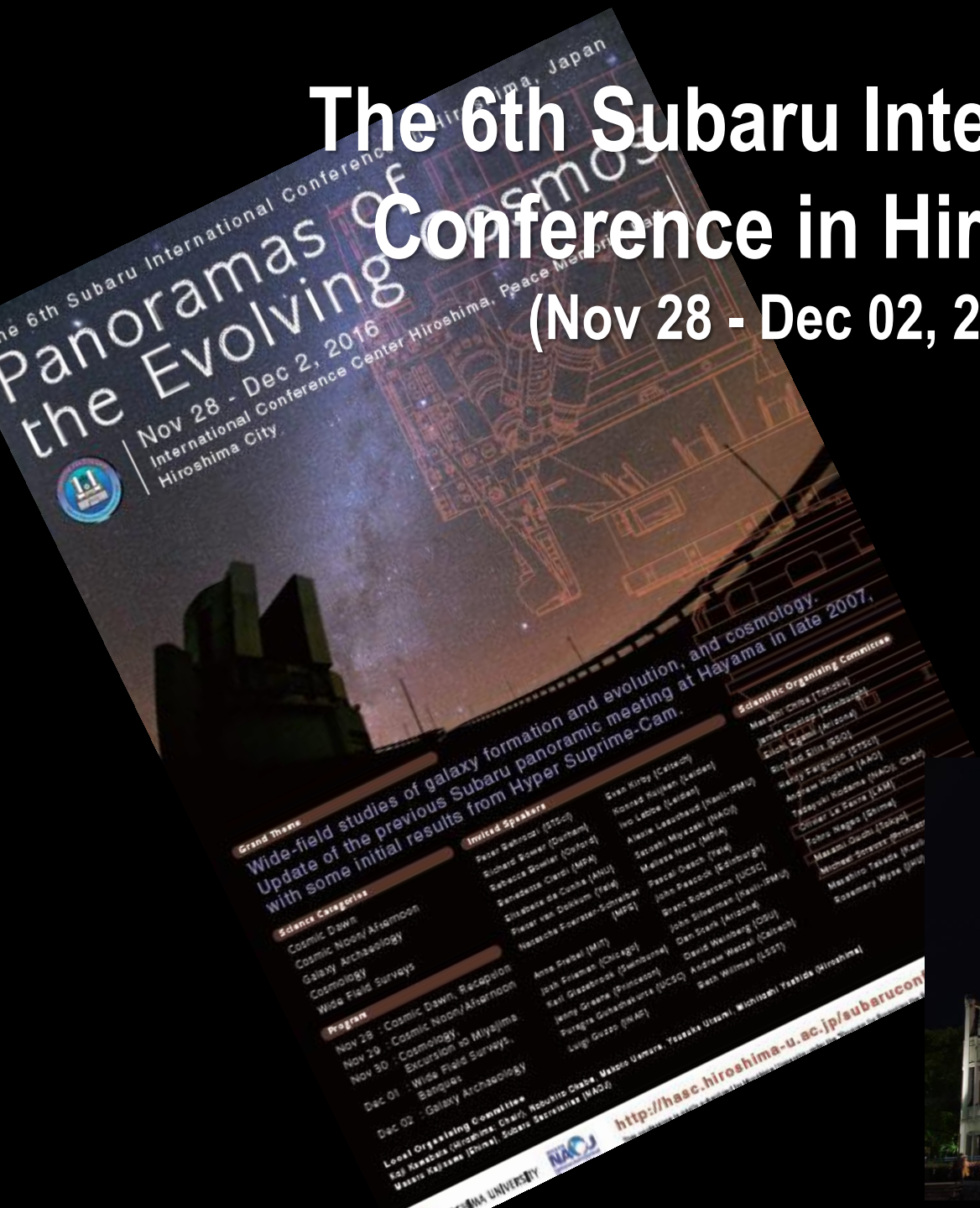
The survey will continue until S19A.



HSC Data Analysis Team in Collaboration with Astronomical Data Center of NAOJ

The 6th Subaru International Conference in Hiroshima

(Nov 28 - Dec 02, 2016)



Science Categories:

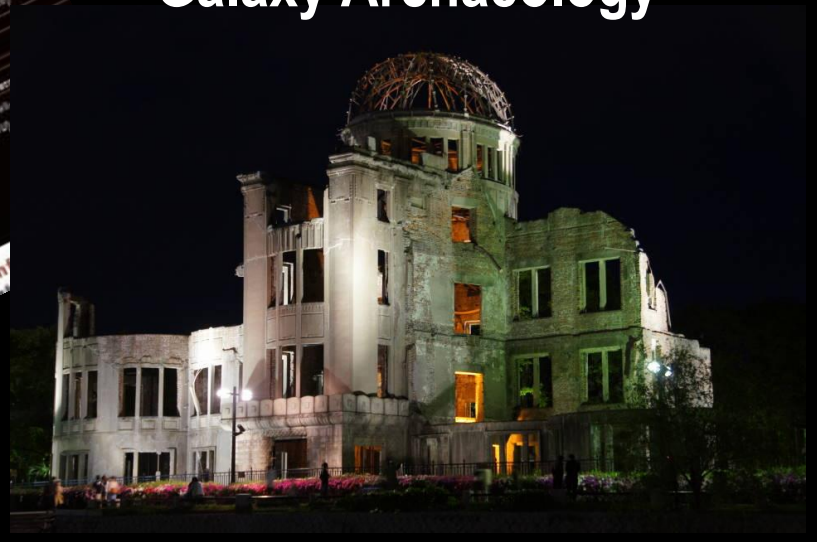
Cosmic Dawn

Cosmic Noon/Afternoon

Cosmology

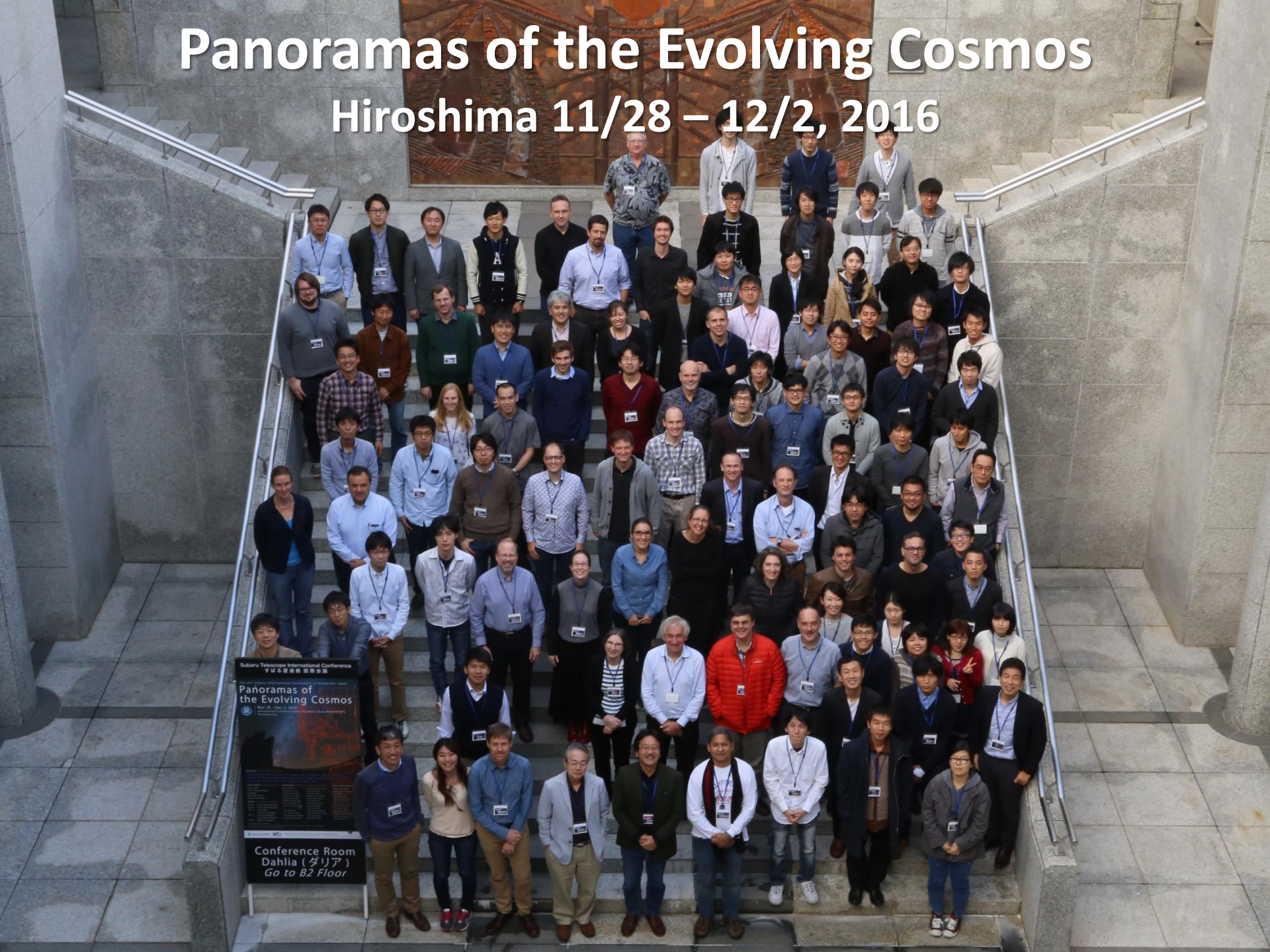
Wide Field Surveys

Galaxy Archaeology



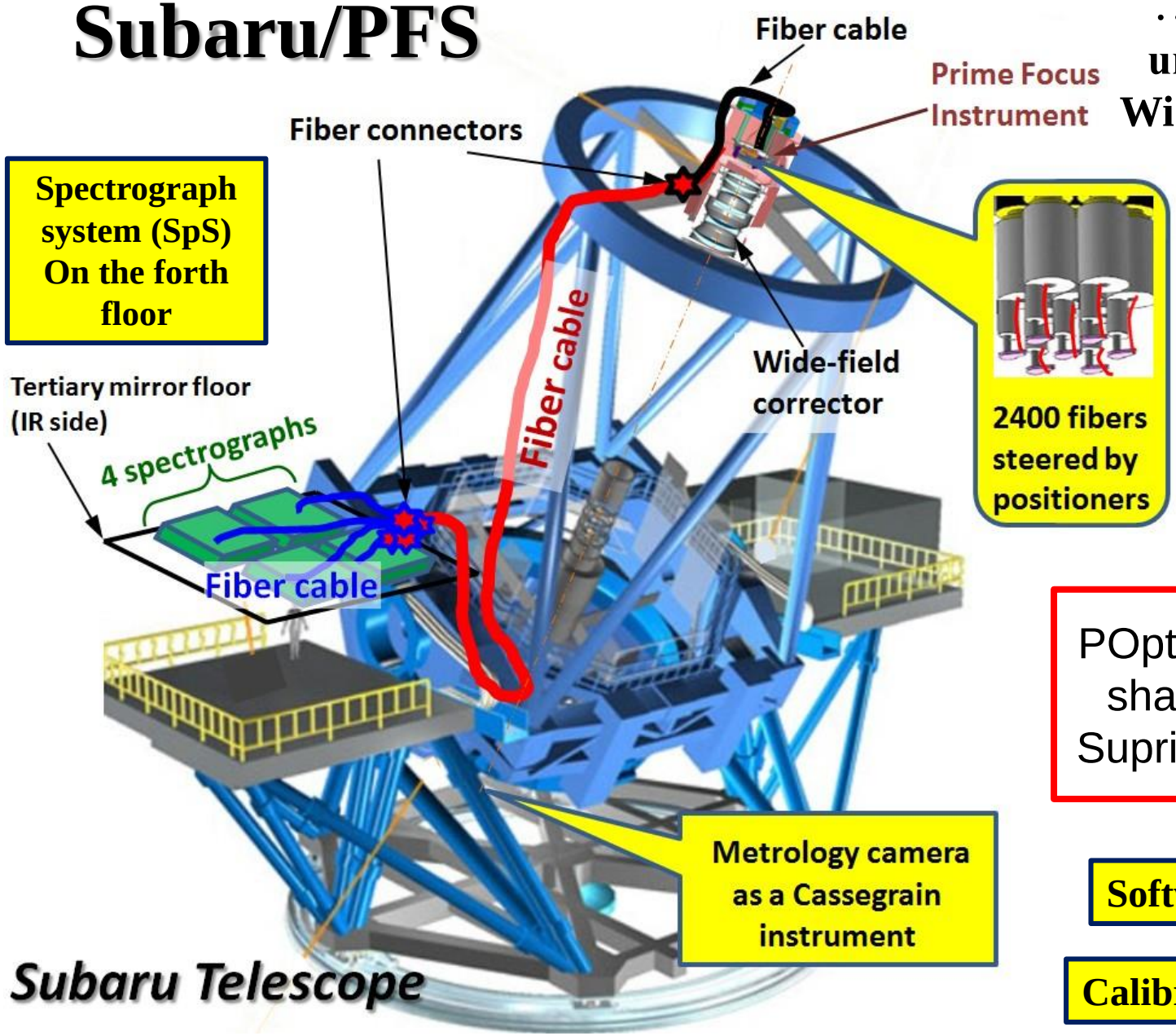
Panoramas of the Evolving Cosmos

Hiroshima 11/28 – 12/2, 2016



Subaru/PFS

. . . in Prime focus unit "POpt2" with Wide Field Corrector "WFC".



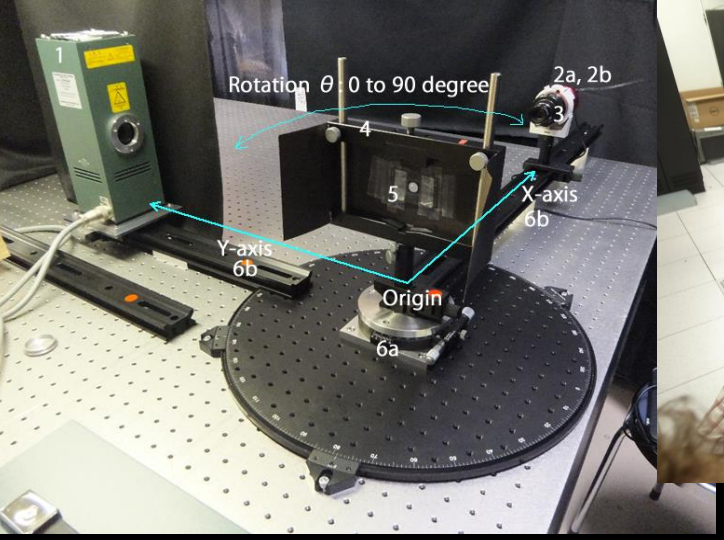
POpt2 & WFC will be shared with Hyper Suprime Cam (HSC).

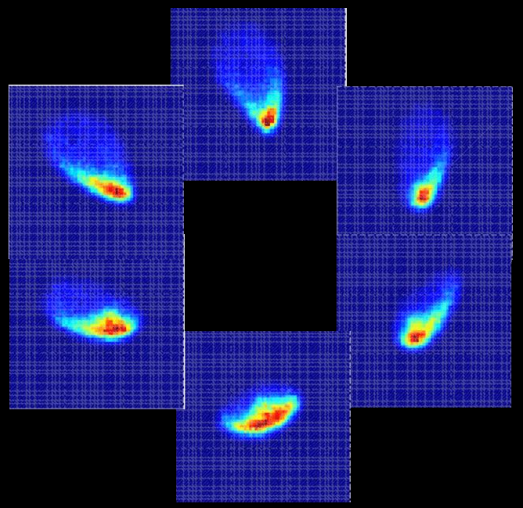
Software system

Calibration system

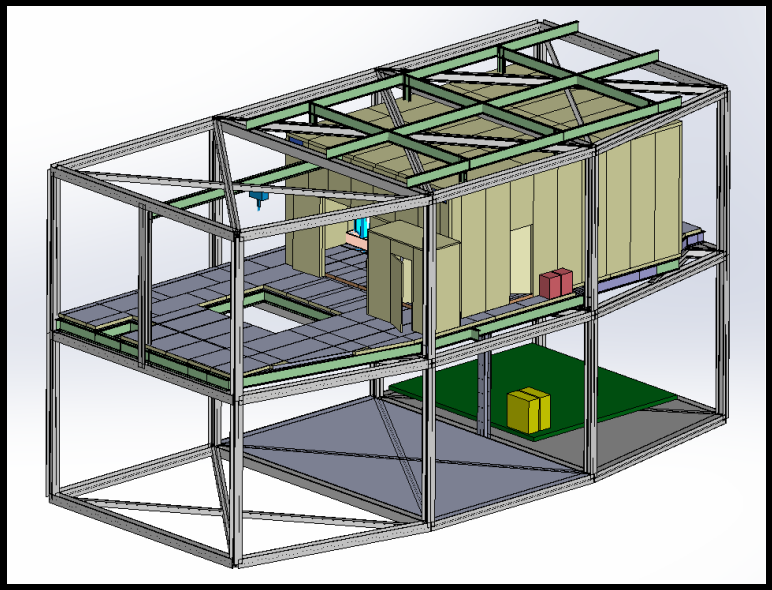
Support PFS Development

Conduct necessary modifications of telescope/enclosure to accept PFS

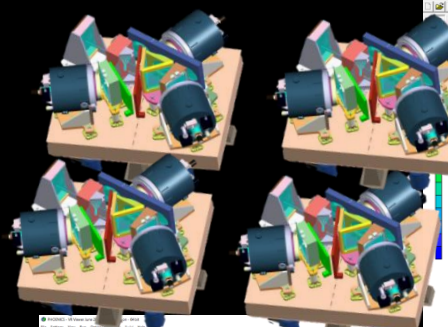


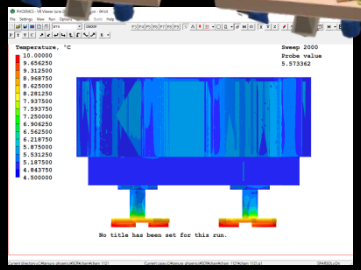


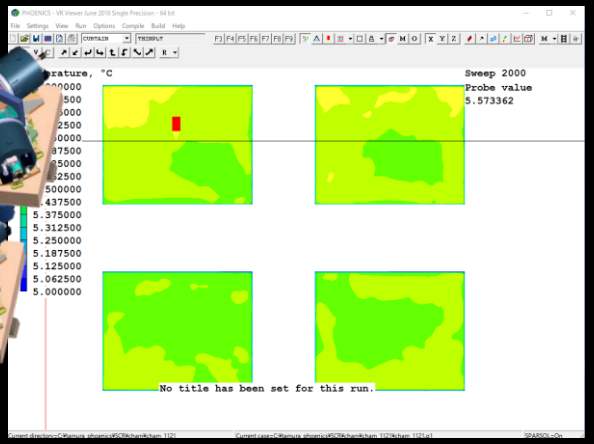
BRDF meas. of dome-flat screen



Design of IR4 and Spectrograph room



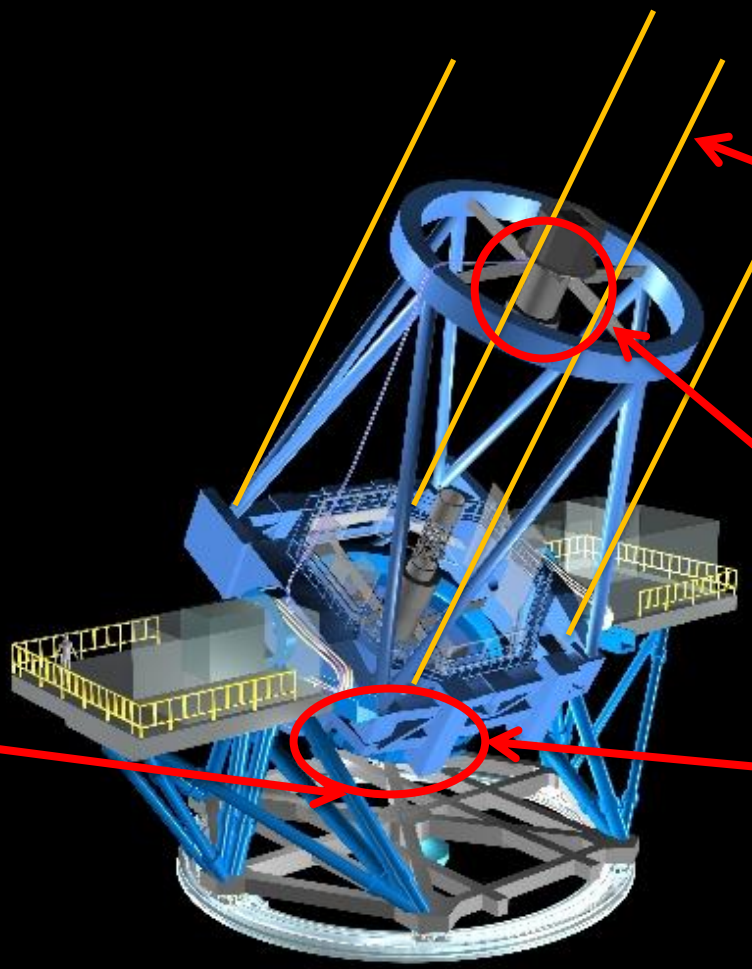




Temperature uniformity of the bench

Heat flow from the legs

ULTIMATE-Subaru (GLAO)



4 Lasers
(side irradiation)

Deformable secondary mirror

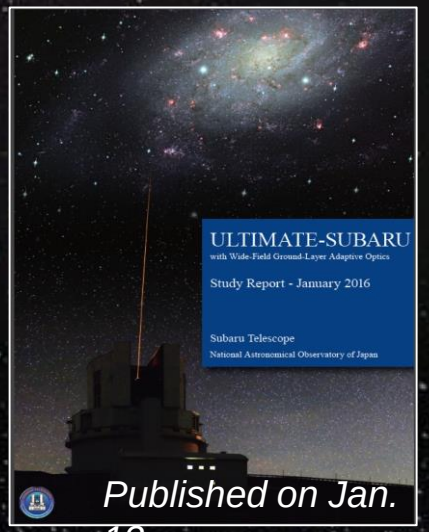
Wave front sensor

NIR inst.

14’ x 14’ FoV
Wide-field Camera
Multi-Object IFU

ULTIMATE-Subaru 2016 Summary

- **Published "Study Report" (Jan)**
  - 150 pages in English, contributed by ~35 scientists (including partner countries)
- **International Review (Feb)**
  - Detailed discussion on science, development, & organization with 5 external reviewers.
- **Science Workshop (June)**
  - ~80 participants, from inside & outside Japan. Discussion on ULTIMATE instrument plans and survey design



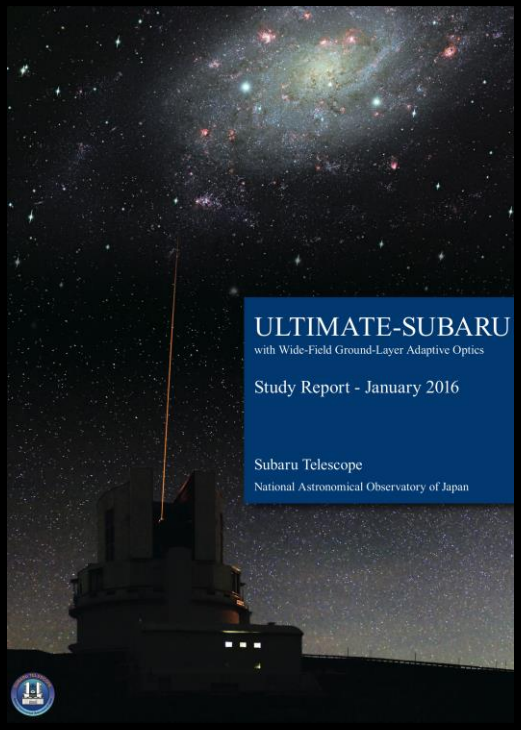
Published on Jan. 13


Feb. 24 @ Hilo

June. 16-17@ Mitaka

ULTIMATE-Subaru Study Report 2016

http://www.naoj.org/Projects/newdev/ngao/20160113/ULTIMATE-SUBARU_SR20160113.pdf



- **Science Case**
- **Adaptive Optics**
- **Instruments**
- **Development Plan**

External review (Feb. 24, 2016)

Review committee:
Yoshida, M. (Hiroshima, chair),
Doi, M., Shimasaku, K. (Univ. of Tokyo), Renzini,
A. (INAF), Kissler-Patig, M. (Gemini)

Comments from reviewers:

- ULTIMATE-Subaru will enable Subaru Telescope to be a leading facility worldwide in the field of near infrared astronomy in 2020s – 2030s.
- Current proposal is too big to be accepted by funding agency as a whole. The two phase implementation plan, which will develop GLAO first and new instrument second, is suggested.
- Wide-field imager is the most suitable among the proposed new instruments for ULTIMATE-Subaru.
- The consequence of time delay with respect to competing facilities (such as VLT GLAO system) should be seriously considered in planning science case.

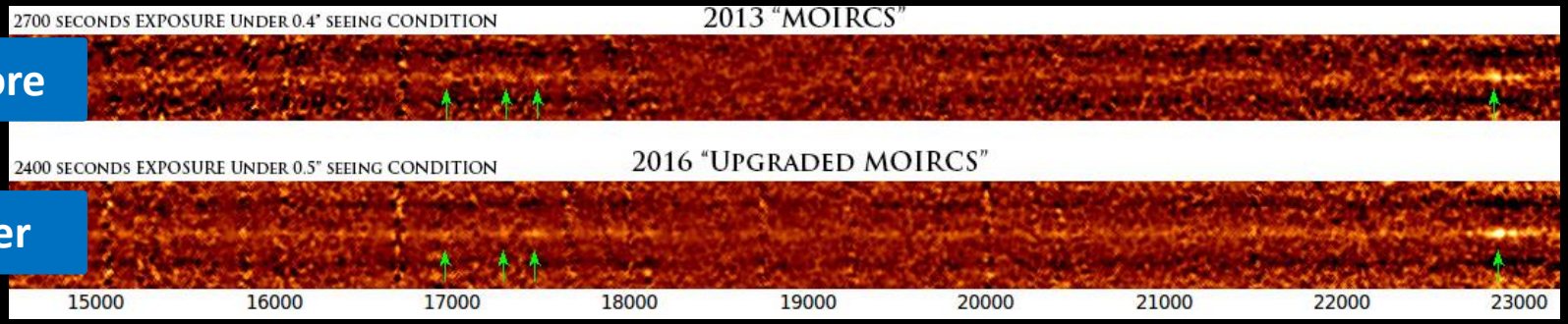
Upgrade of the existing instruments

MOIRCS: Multi-Object near-InfraRed Camera and Spectrograph

1. Detector upgrade completed in 2016

- Installed new Hawaii-2 RG detectors and Sidecar ASIC, SAM controllers
- Large read-out noise improvement
  (15e → 5e by 10 multi correlated double sampling)
- Better total observing efficiency

HK500 spectra of a z~2.5 star-forming galaxy

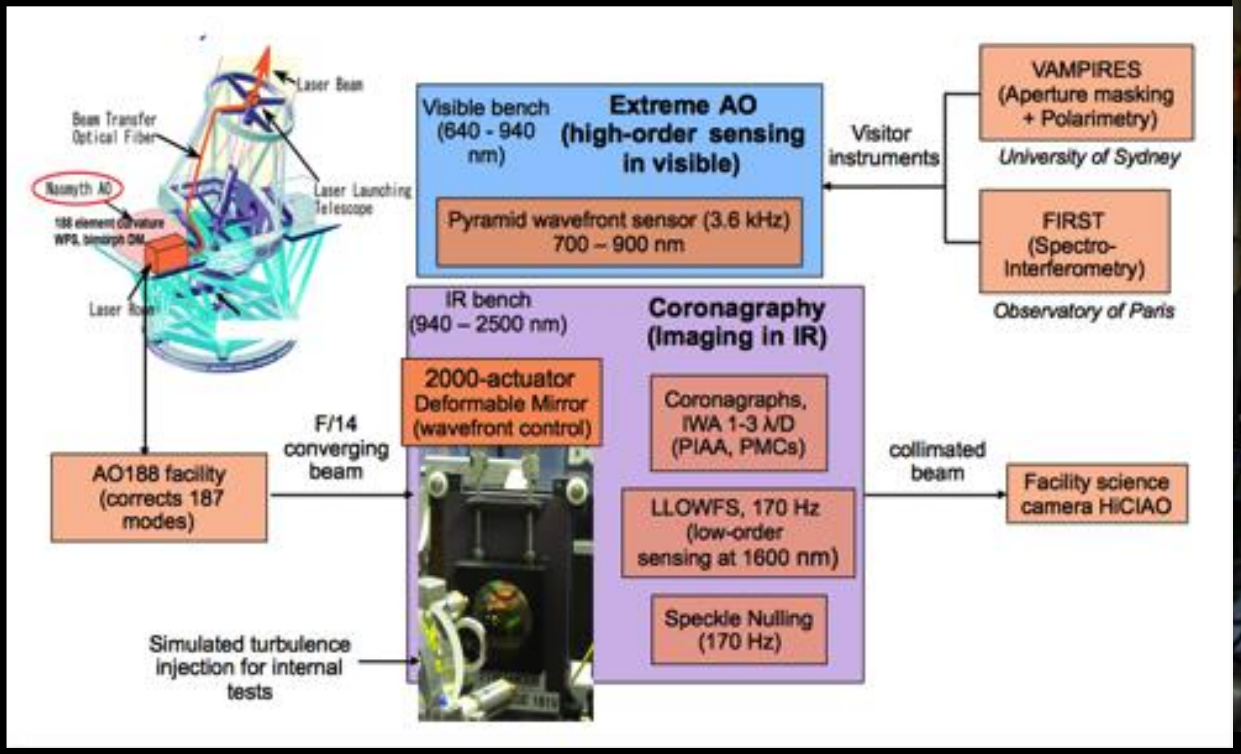


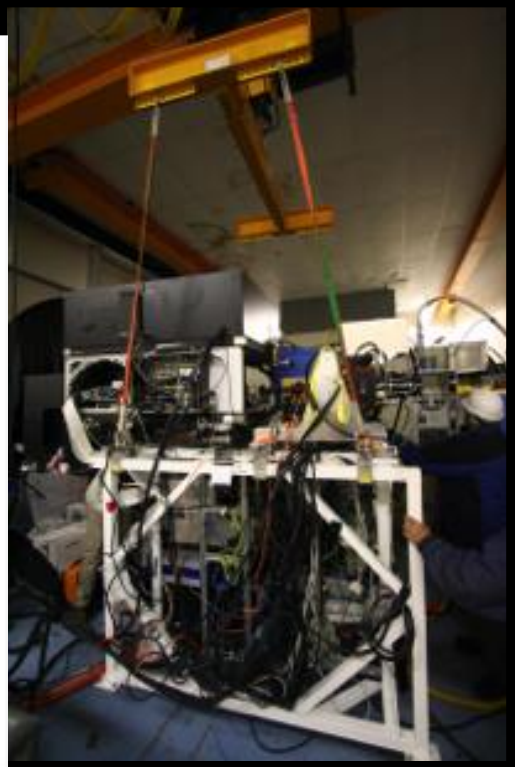
2. Micro-lens array IFU is being built

- FoV: 1".8 x 6".2 with 9 x 31 lenses (0".2/lens)
- Laboratory test is ongoing.
- Will be installed to MOIRCS focal plane unit in 2017-2018.

Visitor instrument for exoplanets

SCExAO: Subaru Coronagraphic Extreme Adaptive Optics (PI: Olivier Guyon at Subaru)





SCExAO: high contrast imager in visible and near-IR, capable of imaging circumstellar environments (binaries, exoplanets, disks), near the diffraction limit of the telescope.

In near-IR (y, J, H and K band):

- Coronagraphs provide high contrast images down to 1-3 λ/D.
- Low-order wavefront sensor stabilizes the wavefront behind the coronagraph
- Speckle nulling improves the contrast on the image plane

In visible (600-940nm):

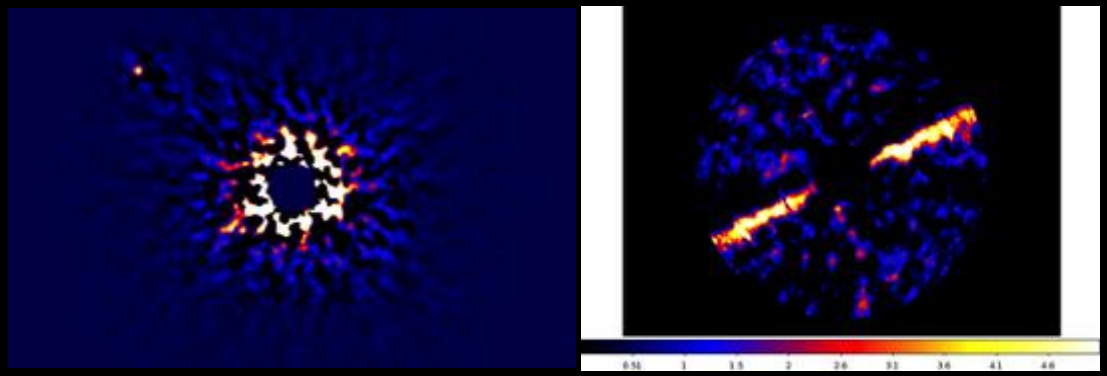
- Pyramid Wavefront Sensor provides the cleanest wavefront possible
- Several visitor instrument modules:
  - VAMPIRE, FIRST, RHEA, NULLER

Visitor instrument for exoplanets

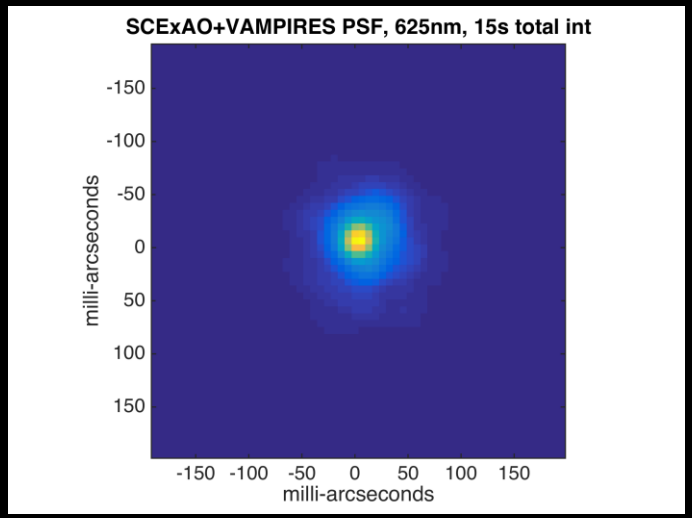
SCExAO: Subaru Coronagraphic Extreme Adaptive Optics (PI: Olivier Guyon at Subaru)

Current Status

- Low-order mode and Speckle nulling are commissioned on sky.
- Extreme-AO is not fully commissioned. Current performance is 70-80% Strehl in H-band on average.
- The goal is to achieve ~90% Strehl in H-band after controling the effect of the telescope vibration which mainly limits the performance.
- SCExAO (including VAMPIRE) is open to the community in shared-risk basis.
- First science paper with SCExAO has been accepted (Garcia et al. 2016, ApJ in press, arXiv:1610.05786)
- SCExAO optics has been reconfigured to accommodate two science instruments CHARIS and HiCIAO (or MKID in future) at the same time.
- Commissioning of MKID, a new type of photon counting detector with discrimination of energy (low-resolution spectra with no dispersive optics), is being planned.



Recent preliminary results (T. Currie et al.):
kappa And b (left), debris disk of HIP 79977 (right)

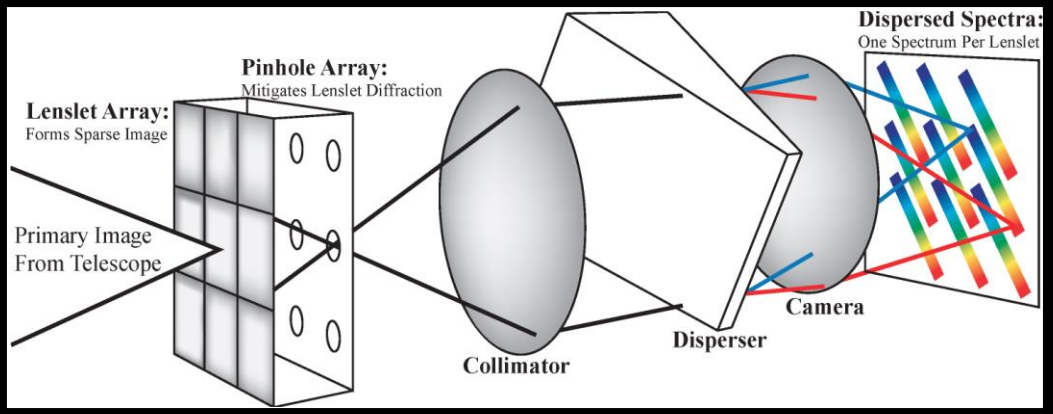


Nearly diffraction limited PSF in visible wavelength (625nm) recently obtained with SCExAO and VAMPIRE

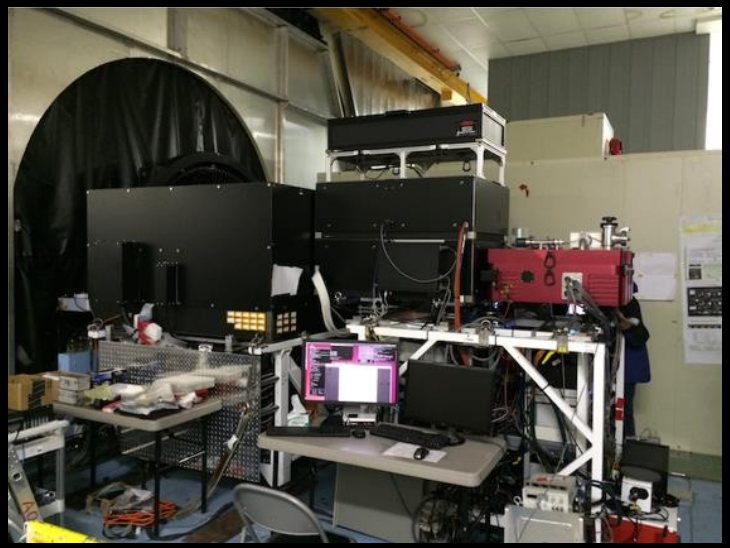
New Visitor instrument for exoplanets

CHARIS: Coronagraphic High Angular Resolution Imaging Spectrograph (PI: Jeremy Kasdin at Princeton)

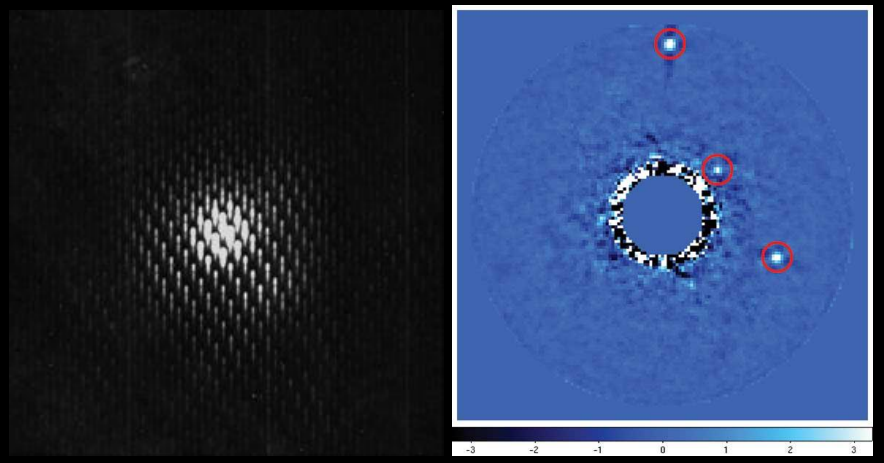
- Characterize sub-stellar companions down to 3λ/D (~ 90mas)
- Lens-array IFU with the FoV of 2”.07 x 2”.07
  - Low-resolution: R~20 (J,H, and K-bands)
  - High-resolution: R~80 (J, H, or K-band)
- Commissioning started from July, 2016
- Science operation will start from S17A



CHARIS First Light



CHARIS installed after AO188 and SCExAO at Subaru Nasmyth IR focus

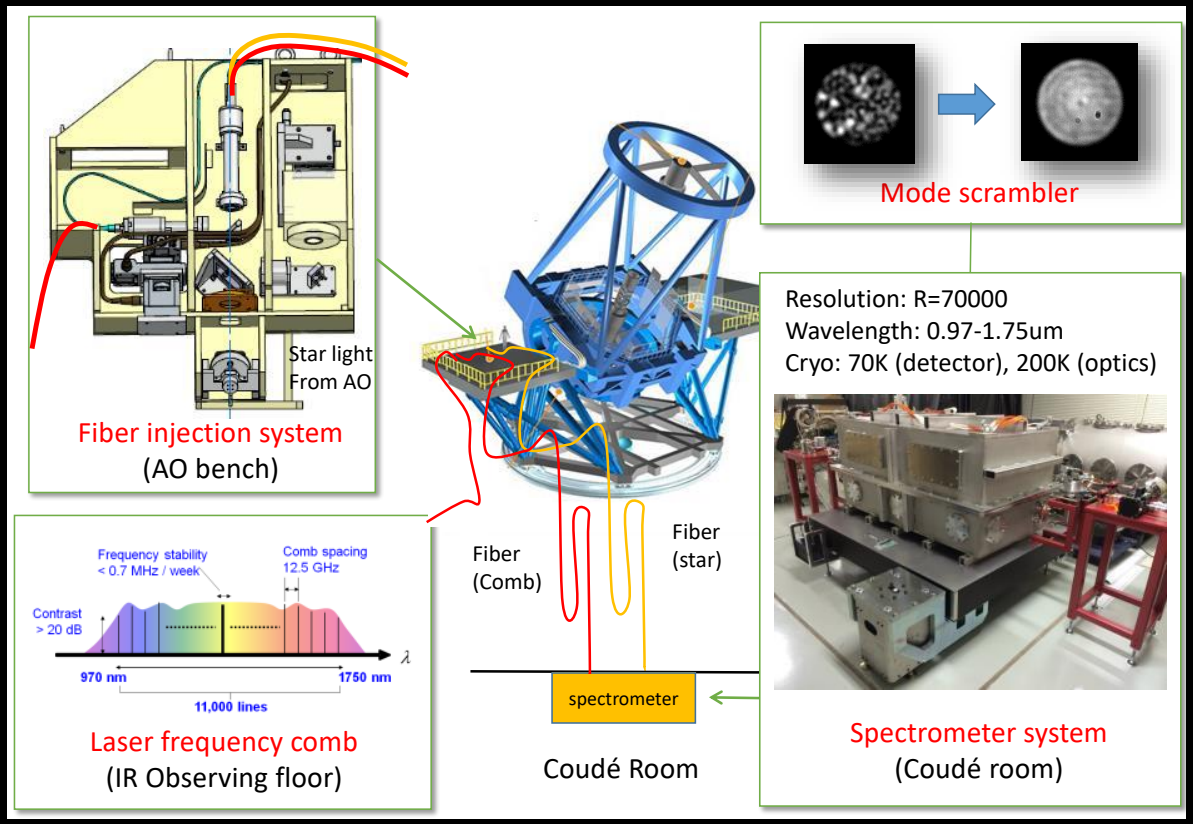


First light image of a known planetary system HR8799. Raw (left) and reduced (right) images are shown.

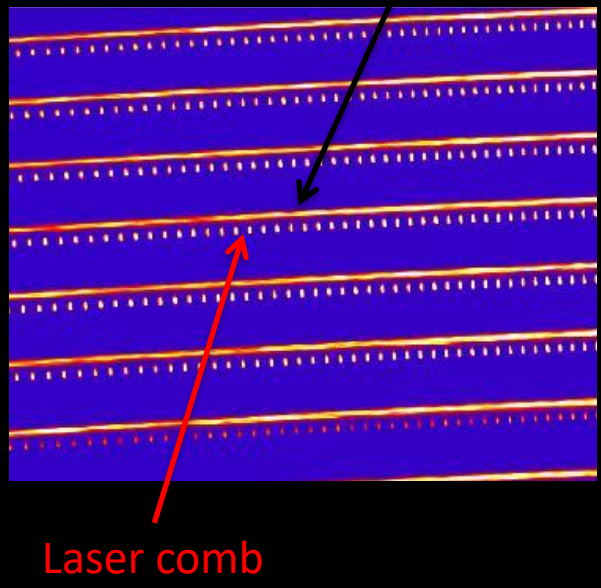
New Visitor instrument for exoplanets

IRD: InfraRed Doppler spectrograph (PI: Motohide Tamura at ABC)

- NIR (YJH, 1.0-1.8μm) echelle spectrograph with laser frequency comb.
- Spectral resolution: R~70,000
- Aiming to detect Earth-mass planets around late M-type stars with 1 m/sec RV resolution
- Instrument has been shipped to Hawaii and testing at UH, Hilo.
- Will be delivered to Subaru Telescope on Jan, 2017.
- SSP survey using 120 nights from S18A is being planned.

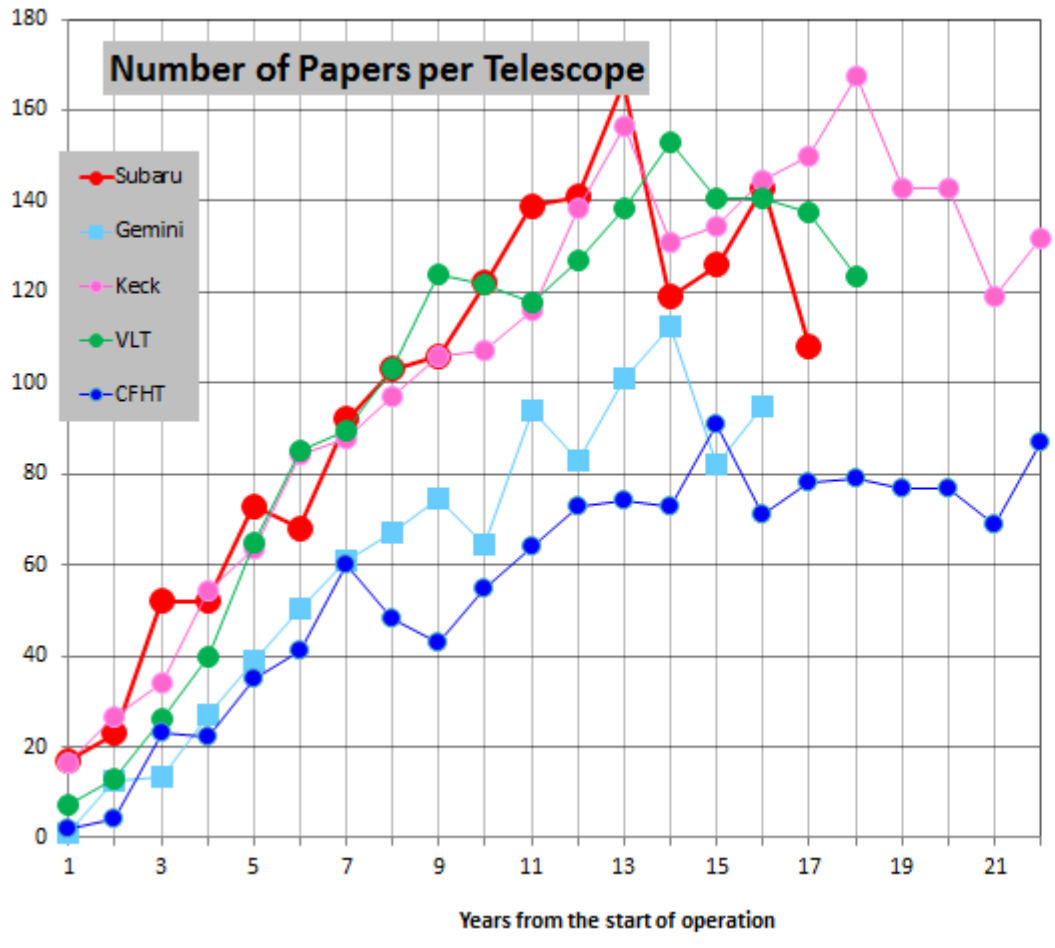


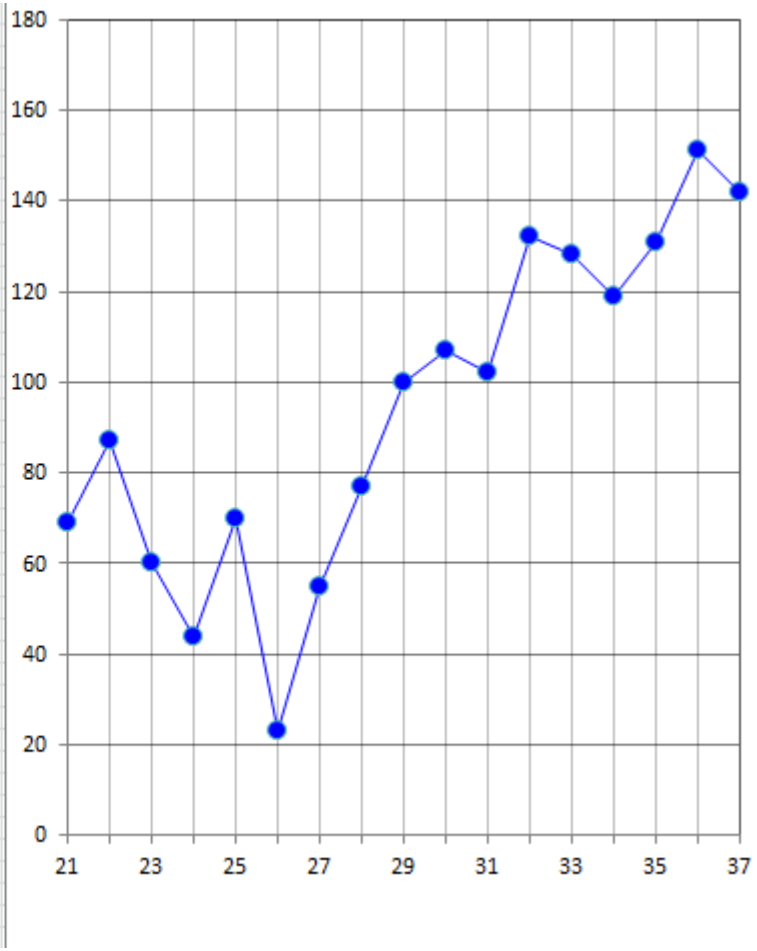
IRD spectrum obtained in the laboratory



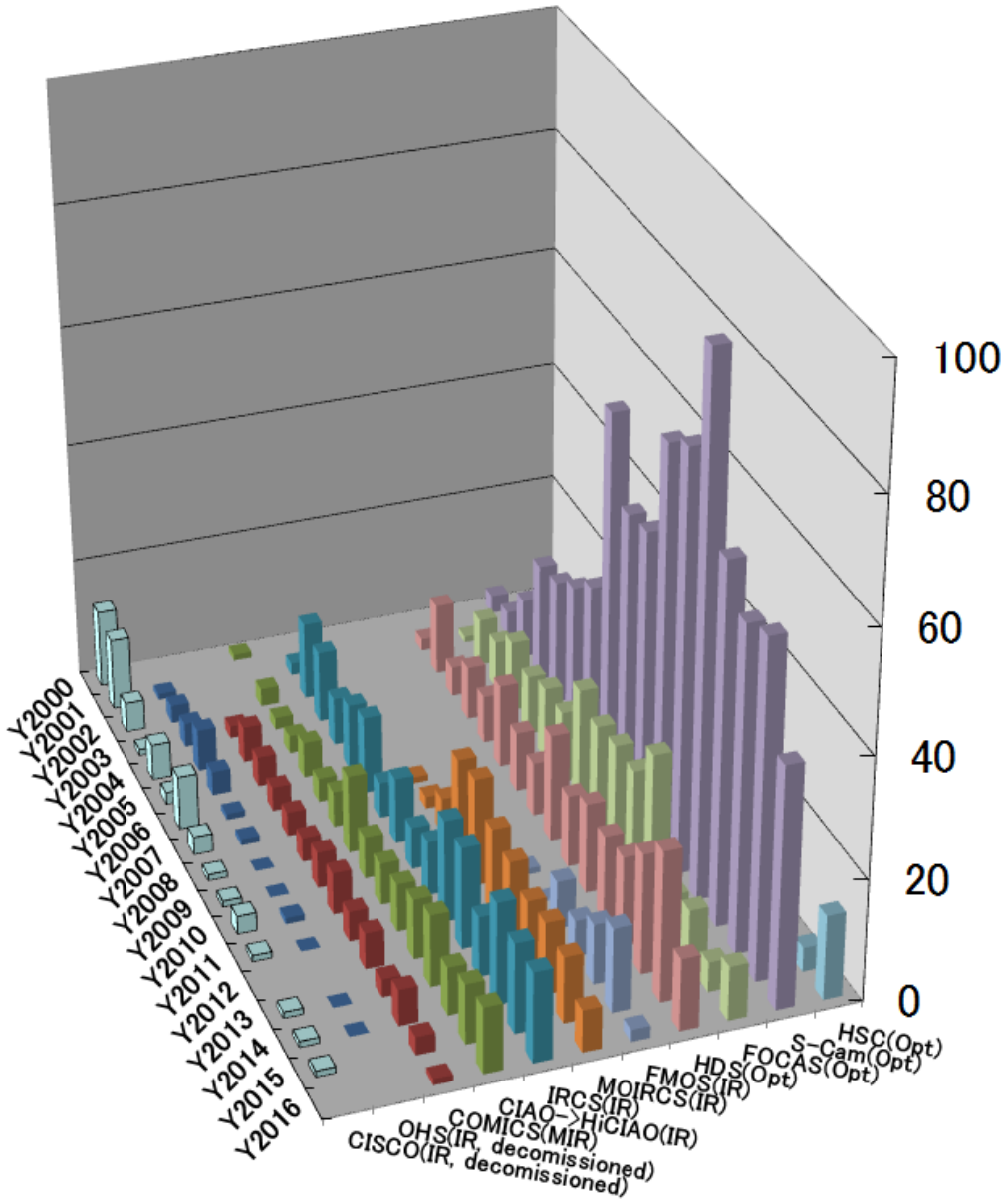

TAURUS
ORION
ARIES
20 ECLIPTIC 15
JUNE
MAY
Pleiades
Bellatrix
Publications 2016

Subaru's Publications





Performance of Subaru Instruments



International Cooperation

EAO Board Meeting

Apr 2016 NAOJ Sep 2016 ASIAA

3 (S17A) + 3 (S17B)

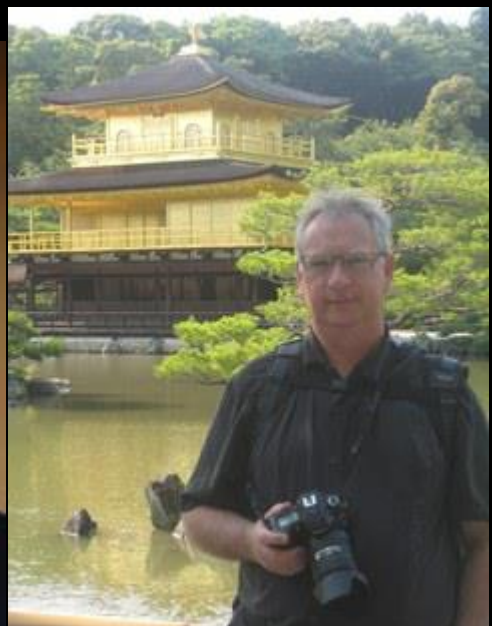
There was agreement that EAO should engage with Subaru on behalf of the regional communities. This will increase EAO portfolio and help promote EAO in the regions.

International Partnership with Australia

- **Discussion and negotiation with Astronomy Australia Limited (AAL) and representatives of major astronomical institutes in Australia**
- **Agreed on ‘short-term access’ program: cash + in-kind contributions and telescope access through director’s time (2017-2018)**
- **Discussion on-going for long-term partnership from 2019**

International Partnership with Canada

- **Collaboration in instrumentation (RAVEN and ULTIMATE-Subaru)**
- **Discussion with NRC-Herzberg continues**
- **Current: 20% partner of Gemini until 2021**
  - **Renewal decision to be made by 2018**



Telescope Maintenance against Ageing

Telescope Maintenance against Ageing

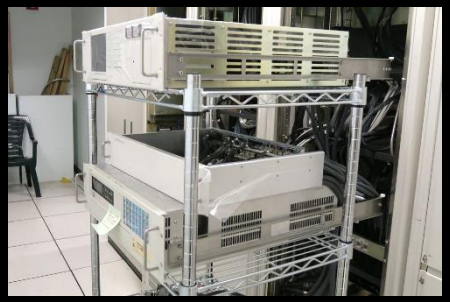
1. Preventive maintenance (reduce failure and keep condition)

A) Replaced critical controllers

B) Bought spare parts

C) Made a long-term plan

D) Developed status monitor



Replaced Balance and 3rd Mirror controller

Bought spare parts for controller

中長期の望遠鏡・ドーム関連経費の概算

2016年4月26日最終修正

沖田博文

維持・運用に1億円、老朽化対策に3億円、機能追加・性能向上に1億円、合計5億円となるようにした場合の将来

三菱会議資料(2016/1/15)と決算データ(古畑さん)に基づく

黄色のセルは精度の高い概算額					平成
緑色のセルは精度の低い概算額(沖田の想定金額)					西暦
(色つきで空欄のセルは実施済みだが金額不詳を表す)				3756.6	維持・運用
				9292.5	老朽化対策
				1510.1	機能追加・性能向
				81	事故対応
			実施頻度	観測停止	横軸合計	合計
		Mirror Hatch(リレー回路 -> PLC制御)	30年		61.5	
		Bogie	30年		91.2	
		CP1, 2, 3	30年		109.4	
		DP1, 2	30年		65.3	
		その他 制御系				

Made a Long-term maintenance plan

差出人 teldiv@naoj.org

件名 [OK] Early Morning check 12/5/2016

宛先 teldiv@naoj.org

```
To whom this may concern,

Good morning everyone. This is TWS4 computer from summit.
Today's Early Morning Check Results are as follows:

*****12/05/2016 07:30:01*****

ANALOG Results  --------------------
 OK: Dome Real Angle: -90.0 #Expected Value: -90.00
 OK: AZ Real Angle:  89.988403 #Expected Value:  90.00
```

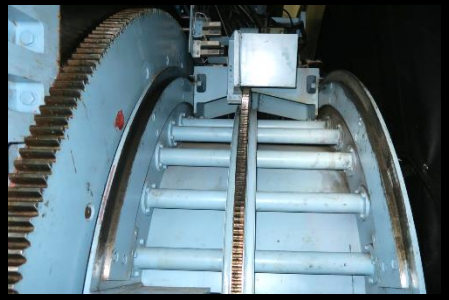
Developed an automatic telescope status monitoring system

2. Breakdown maintenance (repair and fix)

Mirror hatch incident (Feb.)

Circuit breaker burn out (June)

Oil leak on Hydrostatic Bearing (July)



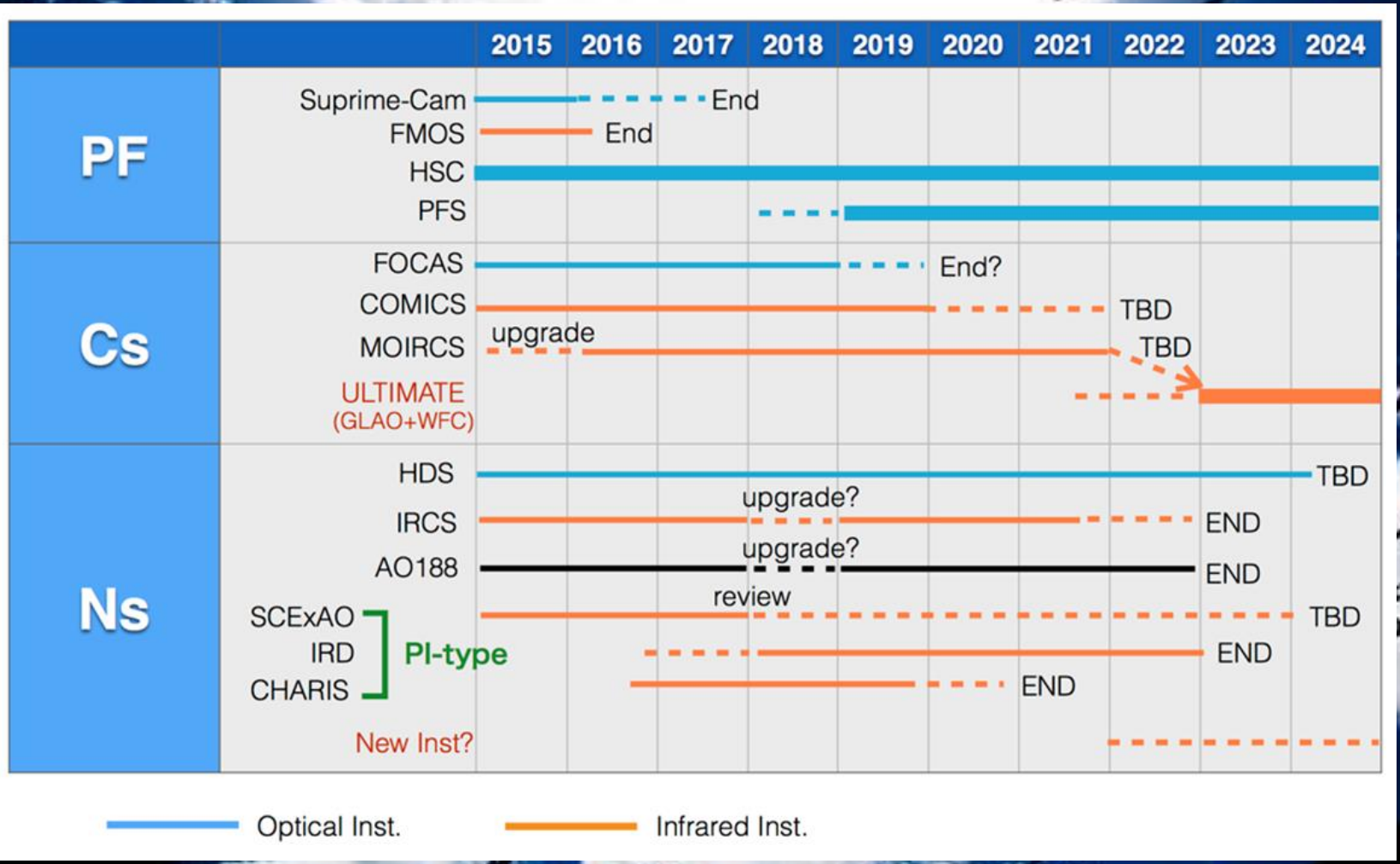
Elevation cable wrapper stuck (Nov.)

Status of Openn Use
Decommission
Time Exchange

Status of Open Use

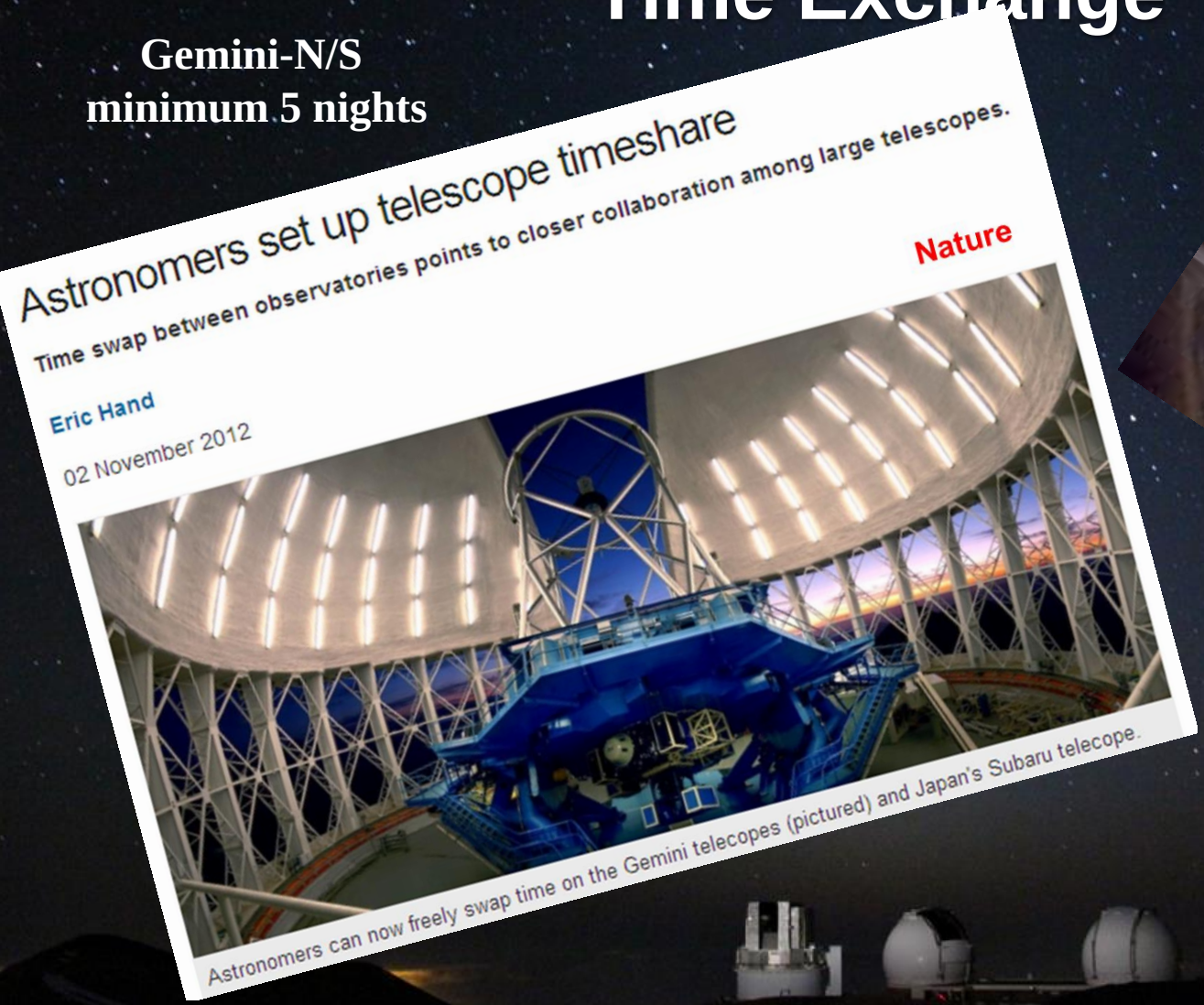
- S15B+S16A: 98 programs, 254.5 open-use nights (including the HSC Strategic Program)
- Mirror hatch incident in Feb. 2016
  - 7 nights (incl. 3 open-use) lost
  - M1 recoating postponed to 2017
- Downtime in S15B+S16A: 7.5%

Instrument Timeline
Decommission Plan 2017



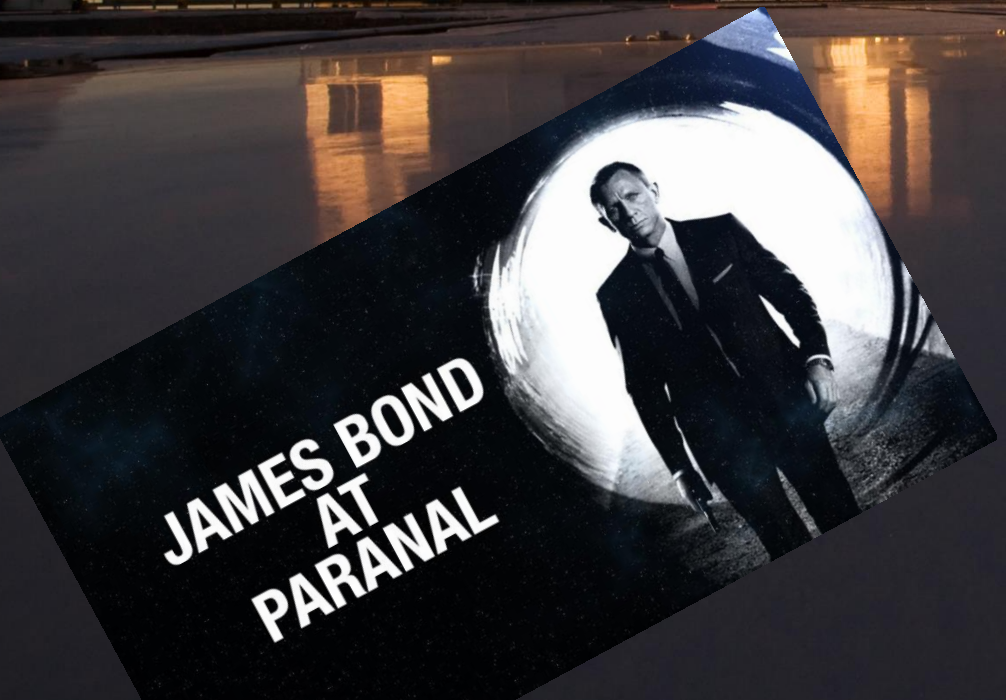
Keck/Gemini
Time Exchange

Gemini-N/S
minimum 5 nights



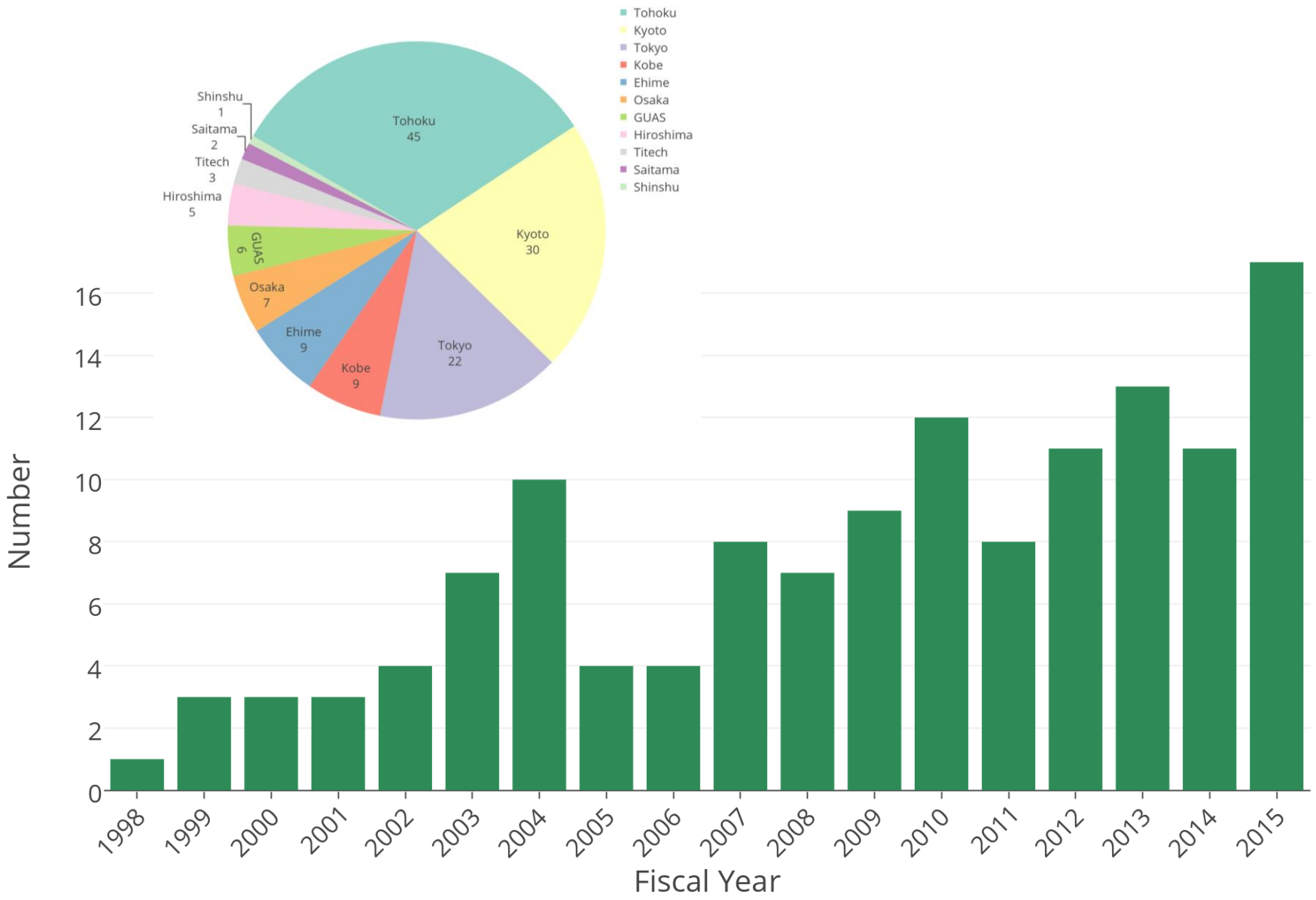
Keck-I/II
5-8 nights

VLT/GTC
Time Exchange

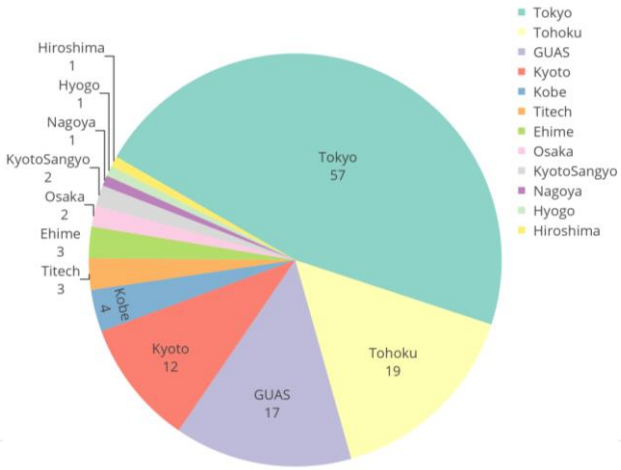


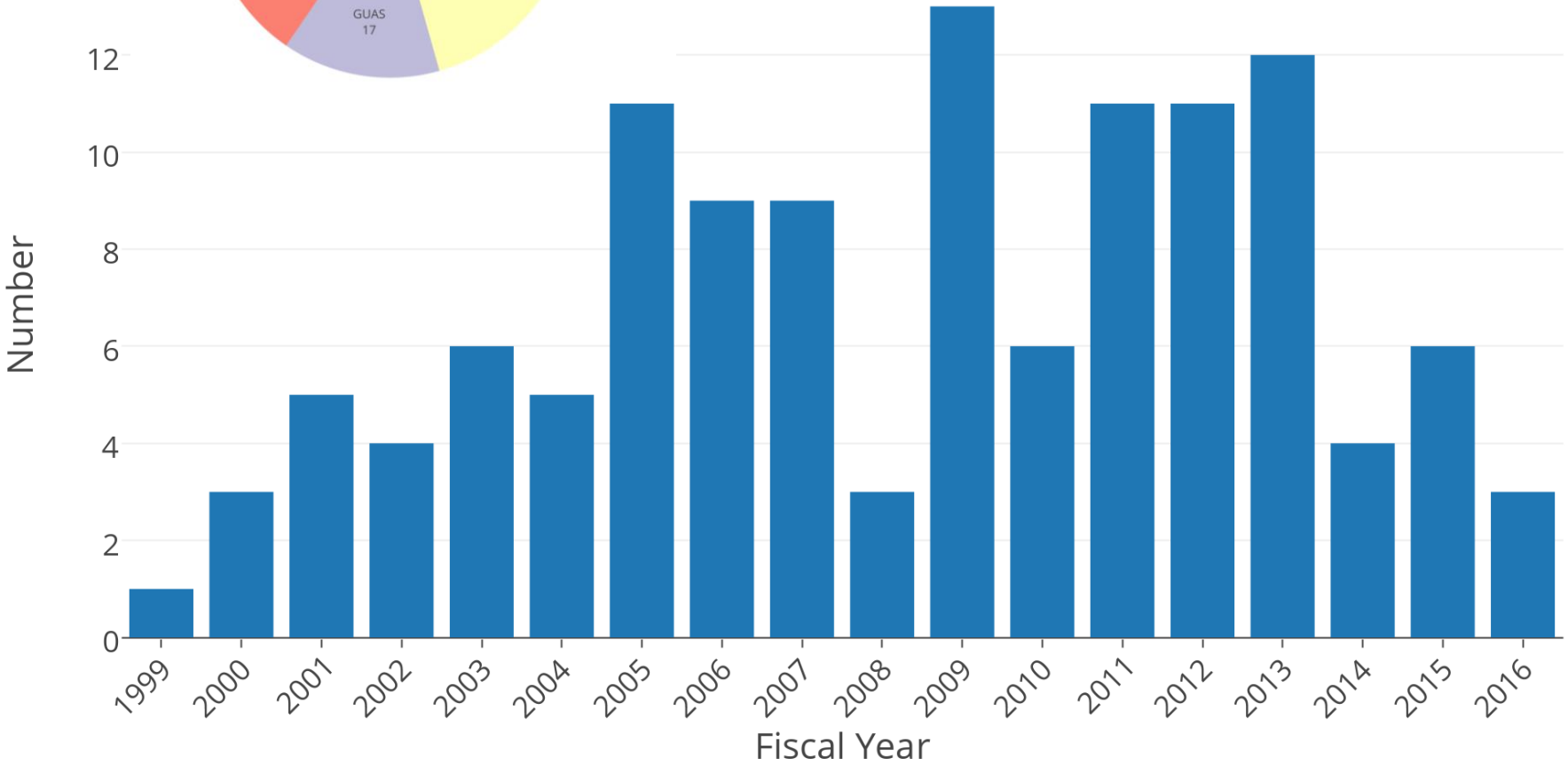
Subaru's Contribution to University Education

Master Theses (1999-2016)



PhD Theses (1999-2016)





Japanese Astronomy must address the low level of Female Participation among its Workforce

37

138

Female Master
1999-2016

25

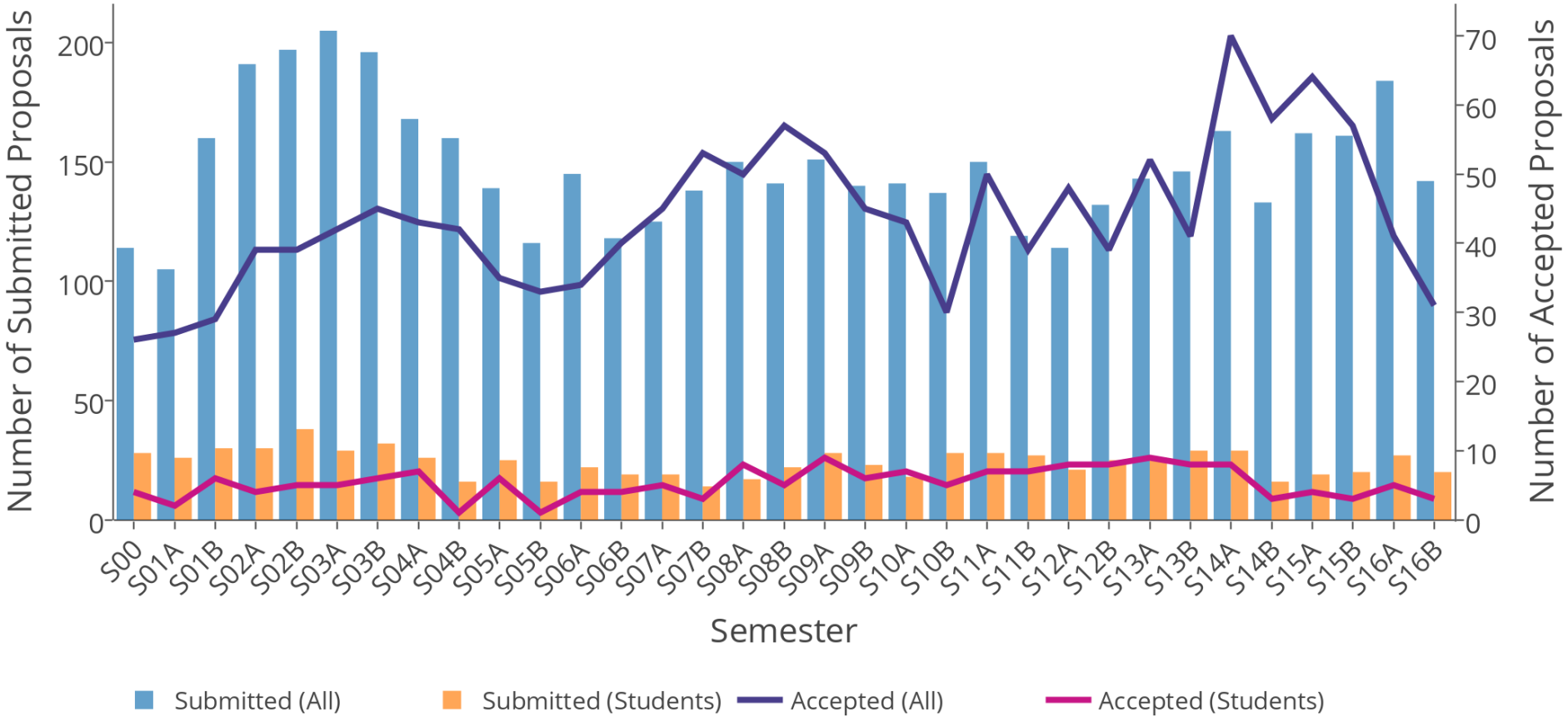
122

Female PhD
1999-2016

Women Observing Stars, 1936

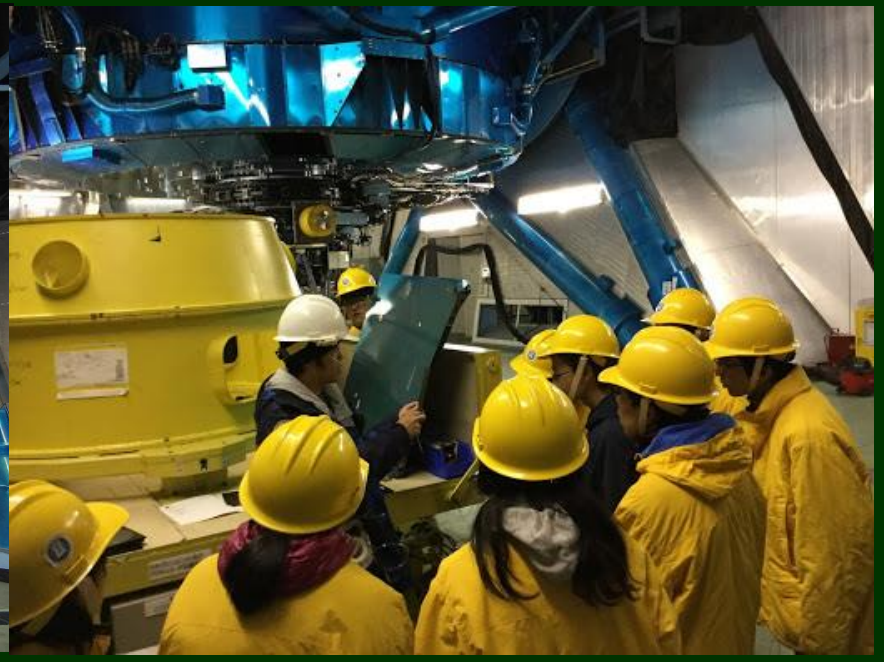
Female Samurai

Statistics on students' proposals



Observation Exercise with Subaru 2016

- Target: undergraduate students
- Learning the fundamental knowledge and techniques of Opt-NIR observation through a practical training
- Annual event from 2004. Many participants have entered GUAS (SOKENDAI)
- 8 students. Spectroscopic observation for high-z quasars.



Subaru Data Reduction Winter School 2016 in Taiwan (Dec 7-9 2016)

National University
The Graduate University for Advanced Studies [SOKENDAI]

Subaru Data Reduction Winter School 2016 in Taiwan (Dec 7-9 2016)


TAURUS
20 ECLIPTIC 15
JUNE
Aldebaran
Alcyone
Pleione
Atlas
Electra
Merope
Taygeta
Celino
Pleiades
ORION
Bellatrix
ARIES
Public Information
Subaru Outreach

Public Information

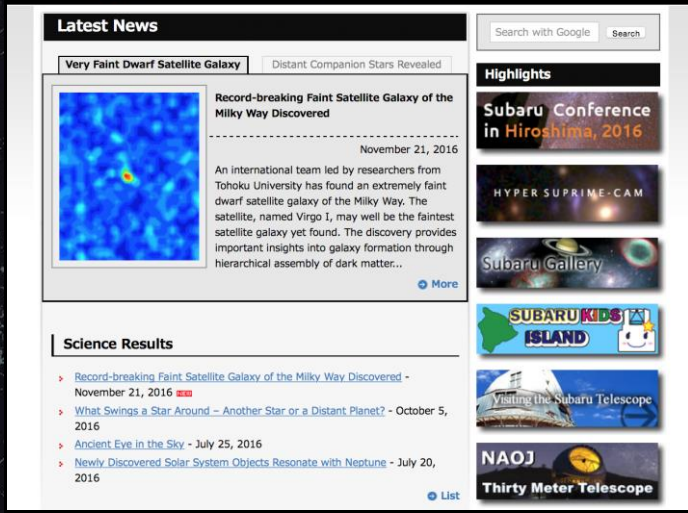
Web-based Activities

- Science Press Releases
  - 2016: 11, 2015: 14 Stories
  - Significant # of Media Coverage
- Topics/Announcements
  - 2016: 50, 2015: 27 Stories
- Social Media (Twitter/Facebook/YouTube)

Publication, Exhibitions

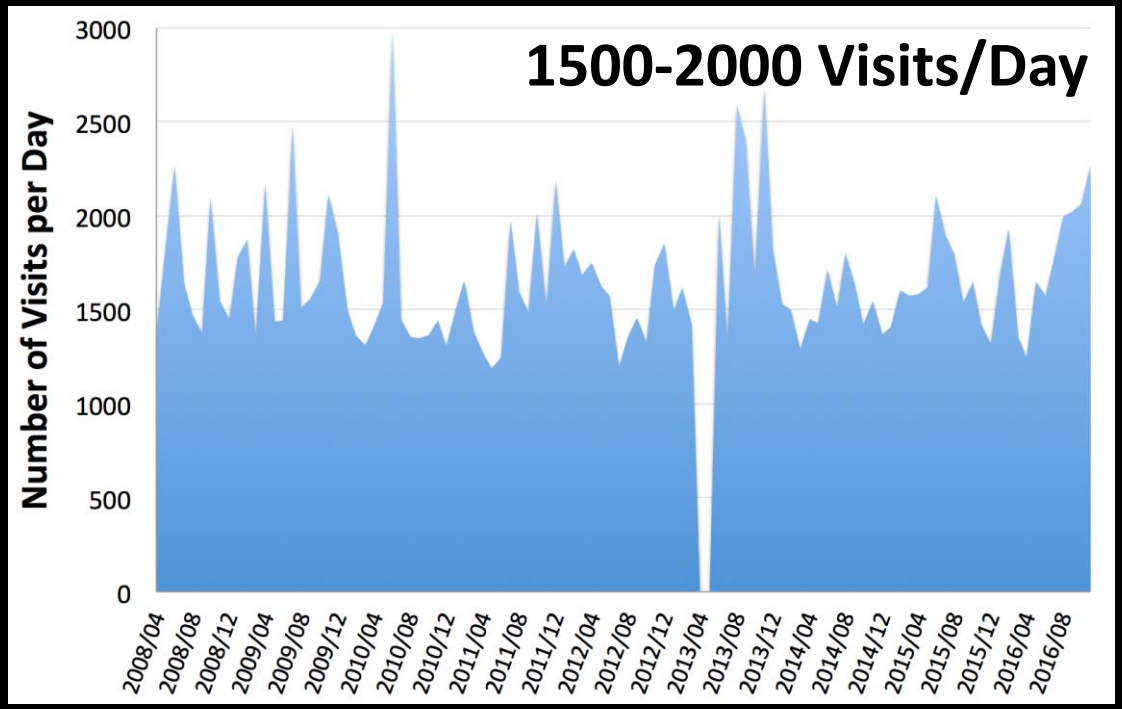
- NAOJ Calendar 2017, NAOJ News (2016/07) etc..

NAOJ Calendar 2017
Featuring Subaru Telescope



Website, Social Media

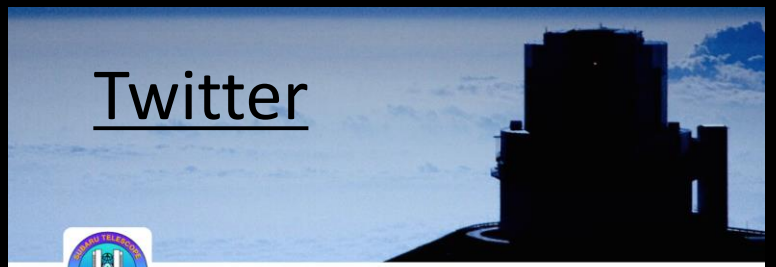
Website Statistics



YouTube

38 Video Clips with >146000 Views
(since 2012, in Japanese account)

Twitter

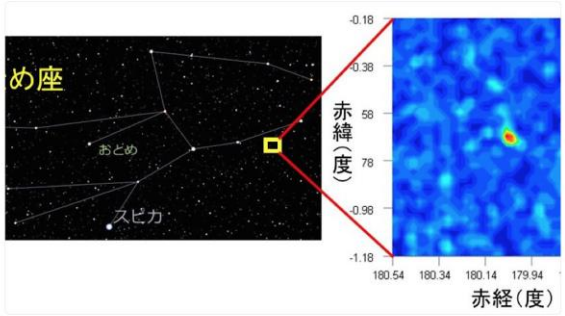


国立天文台 すばる望遠鏡
@SubaruTelescope
ハワイ島のマウナケア山頂にある「すばる望遠鏡」は、国立天文台ハワイ観測所が運用する口径8.2mの光学赤外線望遠鏡です。すばる望遠鏡公式アカウントから最新の情報をお届けします。
Maunakea, Hawaii subarute
20 フォロー 32,316 フォロワー

The Most Followers among NAOJ's Projects

ツイート

国立天文台 すばる望遠鏡 @SubaruTelescope · 2016/11/22
【観測成果】東北大学などの研究チームは、すばる望遠鏡の超広視野主焦点カメラHSCの観測から、銀河系に付随する衛星銀河を新たに発見しました。最も暗い矮小銀河のひとつであり、銀河系の形成史やダークマターの性質を知る上で重要な発見です。 subarutelescope.org/Pressrelease/2...

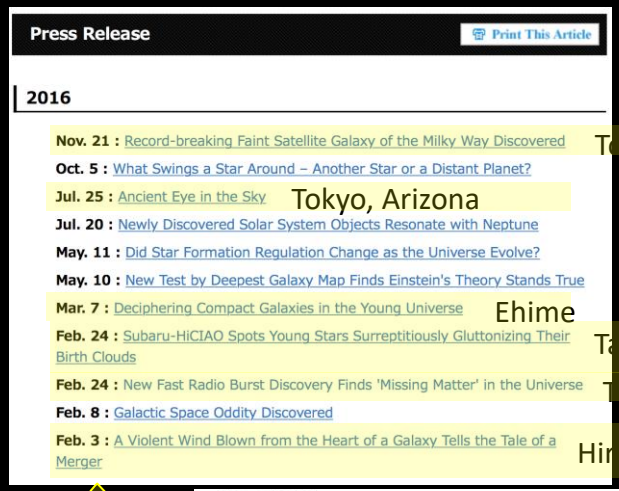


141 216

国立天文台 すばる望遠鏡 @SubaruTelescope · 2016/11/21
【再掲・イベント情報】すばる望遠鏡×信州大学公開レクチャ

Collaborative Activities with Universities

- Joint Science Press Releases



Media Coverage by Asahi Shimbun

- Subaru Public Lectures
  - Shinshu U. (2016/11/23)

  - Hiroshima U. (2016/11/27)

Facility Tours

- Tour program for general public to see the telescope: April – October, up to 2 days a week, up to 3 times a day; total visitor count as of 10/31 is 393
- Special arrangement for researchers, educators, officials, etc. – 69 groups, 353 guests
- Base visit – 27 groups, 286 guests including high school groups from Japan
- Kamaʻāina Observatory Experience – special tour for Hawaiʻi residents, started this year
  - one Saturday in three months (observatories take turns)
  - 2 van-load guests (24)

Primary mirror is visible for these fortunate visitors

Outreach Activities

- Lecture/base facility visit: 14 groups, 246 people
- Remote presentation: 11 cases, 1869 people
- On-site lecture: 13 cases, 2592 people
- Exhibits, workshops at events: 8 cases, 1905 people
- Staff development training (Makali‘i Seminar -> see other page)
- Interaction with local community
- Video featuring locally hired staff

Counts as of October 31, 2016

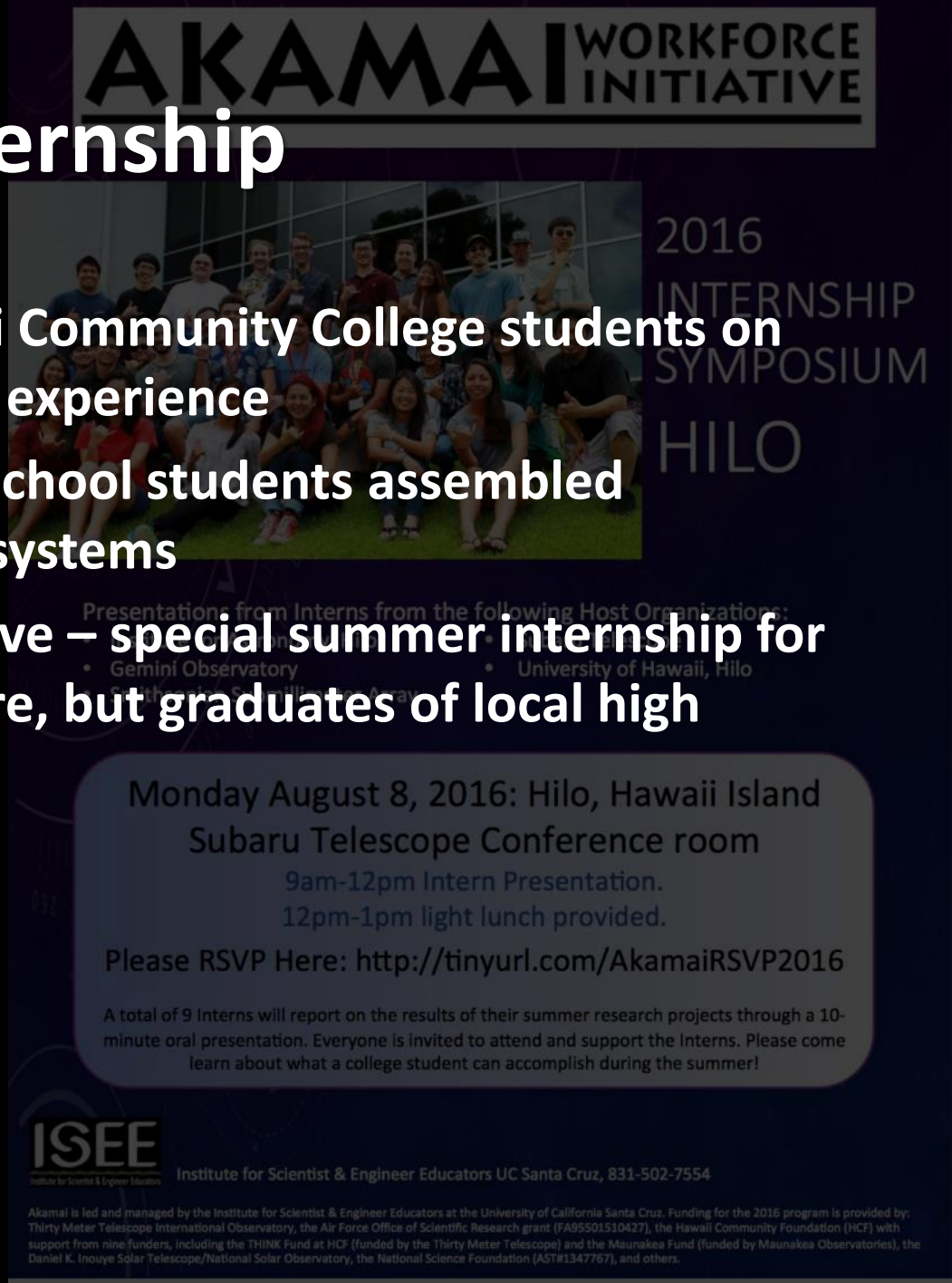
New in 2016/2017!

Maunakea Scholar Program

- 1-2 hour observation time for groups of students from local high schools
- Mentoring throughout the process - from the proposal idea to the data analysis and discussion, by UH-IfA graduate students or postdocs in the observatories
- Pilot program last year by CFHT
- Subaru participates in 2016

Internship

- Employ UH-Hilo or Hawaii Community College students on continuous base for work experience
- Summer students – high school students assembled PANOPTES robot camera systems
- Akamai Workforce Initiative – special summer internship for college students elsewhere, but graduates of local high schools



Astronomy/STEM events

(Science, Technology, Engineering, Math)

- Onizuka Science Day at UH-Hilo in January
  - Grades 4-12 with strong interest
  - Workshops, exhibit, hands-on activities
  - Gave 4 workshops, total 114 students in Jan. 2016
- Journey through the Universe in Hilo in March
  - Visit K-12 classrooms (elementary to high schools) for story telling, hands-on demonstration, talk about jobs etc.
  - DOE (Dept. of Education) = public schools including charter schools (many are Hawaiian immersion schools)
  - 20 Subaru staff covered 55 classes, reached 1034 students in March 2016
- AstroDay in a shopping mall in May
  - Exhibit, hands-on activities
  - opportunity to interact with general publi
  - Direct interaction with ~ 600 people

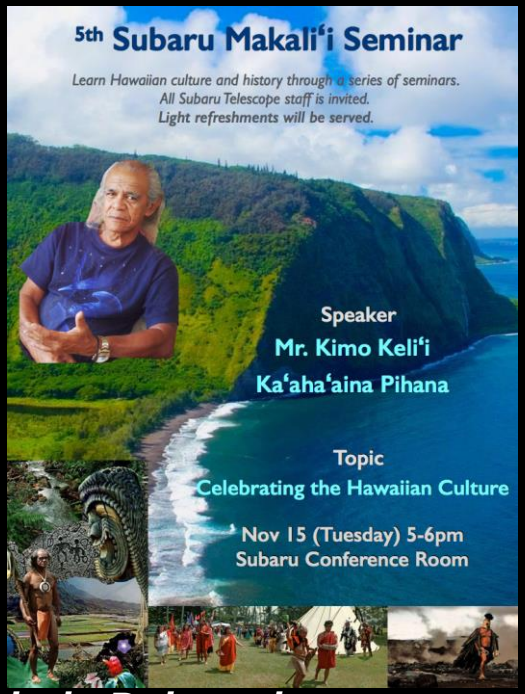
Subaru Makali'i Seminar

Subaru Makali‘i Seminar

- ***Purpose***: **To learn Hawaiian culture, history, and perspectives through a series of seminars from experts in the field.**

- ***Target***: **All staff members at Subaru Telescope. Although this seminar is not mandatory, it is considered part of the staff education and is very important.**

- ***Speakers and Topics:***
  Since the first seminar in Nov 2015, we have held five seminars on various topics (e.g. Hawaiian language, philosophy, history, and immigration.)



Seminars have been well received by the staff. Future topics include Polynesian navigation and Hawaiian immersion schools.

Subaru Makali'i Seminar

Learn Hawaiian culture and history through a series of seminars.
All Subaru Telescope staff is invited.

Ka'iu Kimura
(Executive Director, 'Imiloa Astronomy Center)

Topic:
Hawaiian Identity, History of 'Imiloa

Nov 24 (Tuesday) 5pm-6pm
Subaru Conference Room

Future Seminars:

- Hawaiian Origins
  (Larry Kimura: associate professor at College of Hawaiian Language, UHH)
- Hawaiian immersion school education (TBD)
- Polynesian Wayfinding (TBD)
- Hawaiian Perspective (TBD)
- History of Immigrants: Culture and Cuisine
  (Arnold Hiura, executive director of the Hawai'i Japanese Center)

Subaru Makali'i Seminar

Learn Hawaiian culture and history through a series of seminars.
All Subaru Telescope staff is invited.

Dr. Larry Kimura
Associate Professor
College of Hawaiian Language at UHH

Topic:
Hawaiian Origins

Jan 12 (Tuesday) 5pm-6pm
Subaru Conference Room

Future Seminars:

- Hawaiian immersion school education
- Polynesian Wayfinding
- Hawaiian Perspective
- History of Immigrants: Culture and Cuisine

3rd Subaru Makali'i Seminar

Learn Hawaiian culture and history through a series of seminars.
All Subaru Telescope staff is invited.
Light refreshments will be served.

Mr. Kahoʻokahi Kanuha
Spokesperson of the
Kū Kiaʻi Mauna

Topic
Hawaiian Perspective

June 27 (Monday) 5-6pm
Subaru Conference Room

Future Seminars:

- Hawaiian Immersion School Education
- Polynesian Wayfinding
- History of Immigrants: Culture and Cuisine

4th Subaru Makali'i Seminar

Learn Hawaiian culture and history through a series of seminars.
All Subaru Telescope staff is invited.
Light refreshments will be served.

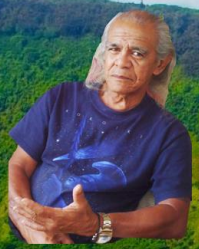
Mr. Arnold Hiura
Executive Director of the
Hawaii Japanese Center

Topic
History of Immigrants: Culture and Cuisine

July 19 (Tuesday) 5-6pm
Subaru Conference Room

5th Subaru Makali'i Seminar

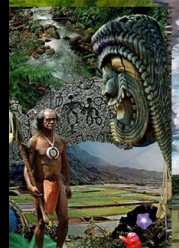
Learn Hawaiian culture and history through a series of seminars.
All Subaru Telescope staff is invited.
Light refreshments will be served.

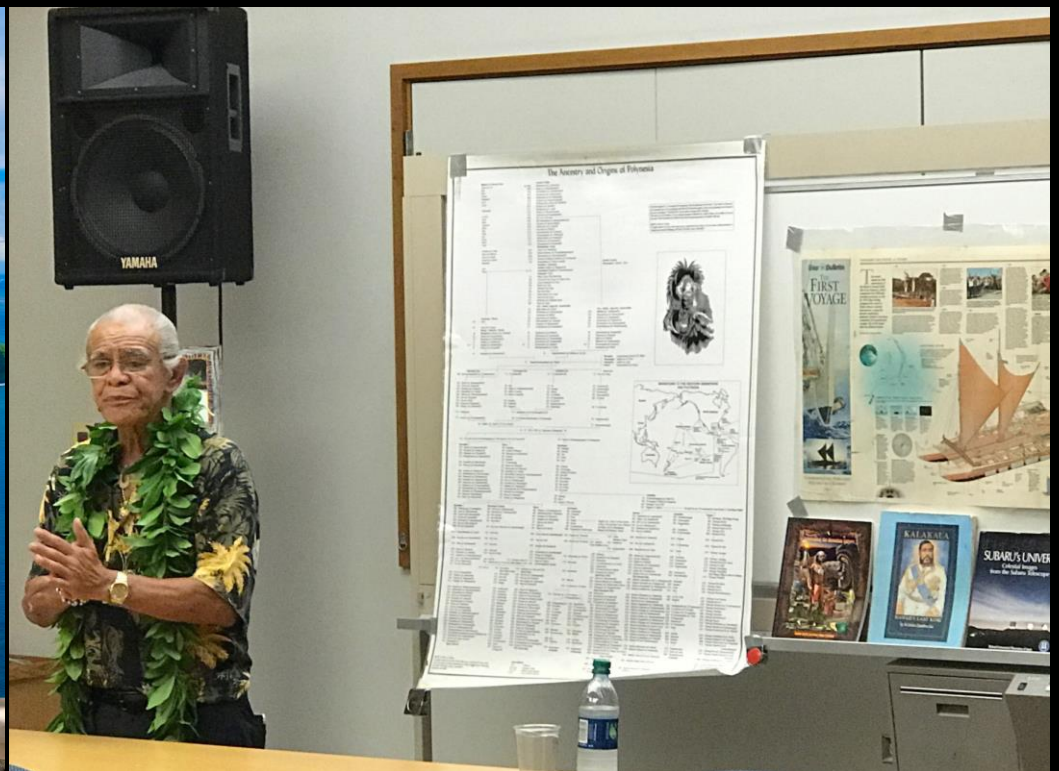


Speaker
Mr. Kimo Keli'i
Kaʻahaʻaina Pihana

Topic
Celebrating the Hawaiian Culture

Nov 15 (Tuesday) 5-6pm
Subaru Conference Room





Working at Subaru Telescope - Staff Interviews

https://youtu.be/eXh3UkE3MhM
https://youtu.be/cQ_tM9NmH7w
https://youtu.be/shCMkZI9LuQ
https://youtu.be/rSsK9C2jf-0