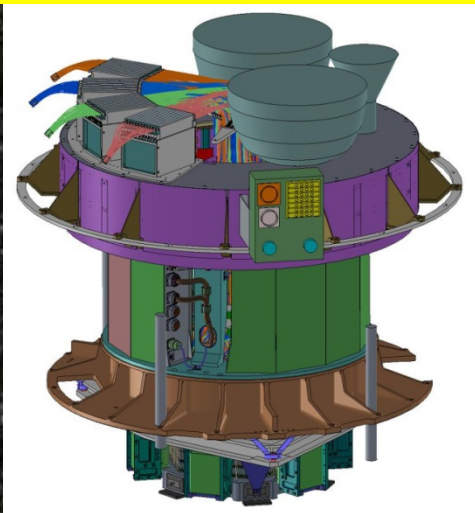


# SUBARU PRIME FOCUS SPECTROGRAPH

## PFS 進捗報告

田村直之 (Kavli IPMU)  
& PFSコラボレーション

Prime Focus Instrument "PFI"



Fiber connectors



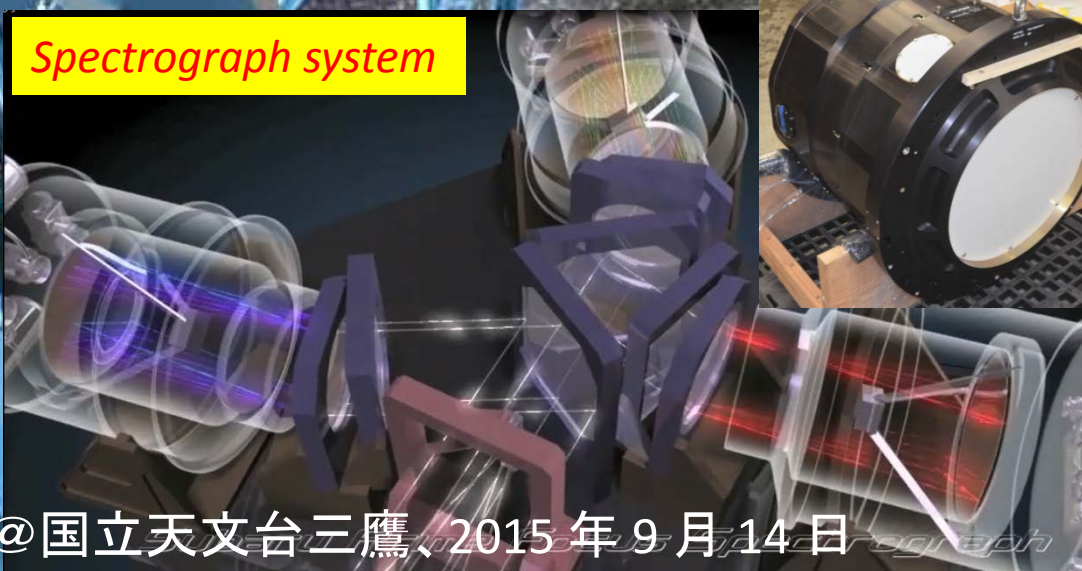
"Cobra" engineering model module



Camera cryostat



Spectrograph system



光赤天連シンポジウム@国立天文台三鷹、2015年9月14日



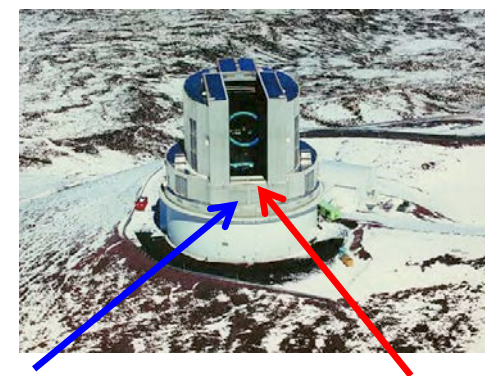


# The “SuMIRe” project

*Subaru Measurement of Images and Redshifts*

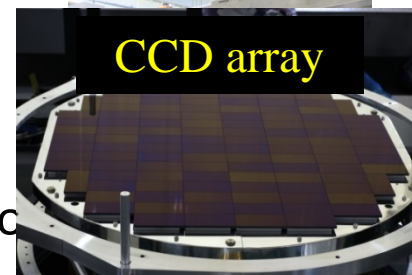
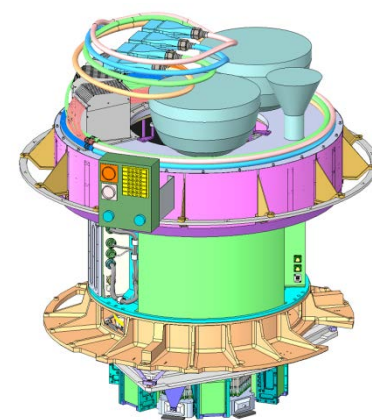
**HSC + PFS**

- Exploiting the  $\sim 1.5$  deg field of view on the prime focus of the 8.2m Subaru Telescope.
- Wide-field imager “Hyper-Suprime Cam (HSC)”
  - ✓  $\sim 0.9$  billion pixels
  - ✓ 300 nights in 2014--2018
  - ✓ 1400 sq. degrees,  $\sim 1$ B galaxies
- Wide-field multi-object spectrometer “Prime Focus Spectrograph (PFS)”
  - ✓ 2400 optical fibers
  - ✓ 300? nights from 2019?
  - ✓  $\sim 4$ M galaxy redshifts
  - ✓  $\sim 1$ M stars in MW, M31, dSphs.
- SDSS-like survey at  $z > 1$  & Galactic Archaeology to address cosmic evolution & dark sector.
- Enables Subaru to be a world-leading facility out to the next decade making effective synergy with *TMT*, *SPICA*, *LSST*, *JWST*, *Euclid*, *WFIRST*, etc.



HSC

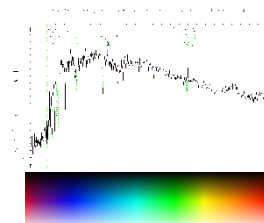
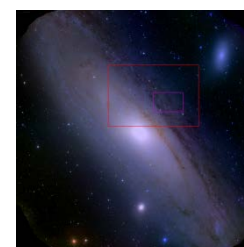
PFS



CCD array



Fiber array



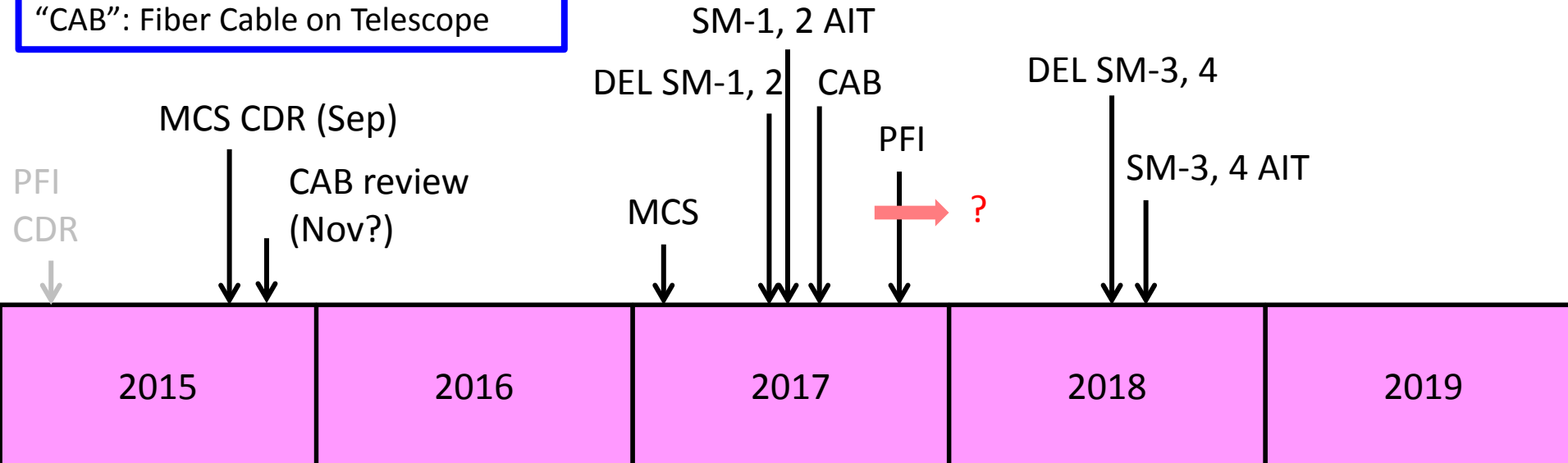
# “PFS” – Fast facts

- Subaru *Prime Focus Spectrograph*
  - Wide field: *~1.3 deg* diameter
  - Highly multiplexed: *2400 fibers*
  - Quick fiber reconfiguration: *~60 sec* (TBC)
  - Optical-NIR coverage: *380-1260nm simultaneously*
- Developed by *international* collaboration, under the initiative of *Kavli IPMU*
- *Cosmology, Galaxy/AGN evolution, Galactic Archaeology* as the key science areas in the PFS collaboration
- Aiming to start science operation from *2019*, as a *facility instrument* on Subaru.

# PFS project top-level schedule

“SM-N”: Nth Spectrograph Module  
“MCS”: Metrology Camera System  
“PFI”: Prime Focus Instrument  
“CAB”: Fiber Cable on Telescope

Subsystem DEL & AIT at Subaru



Construction, subsystem integration & test

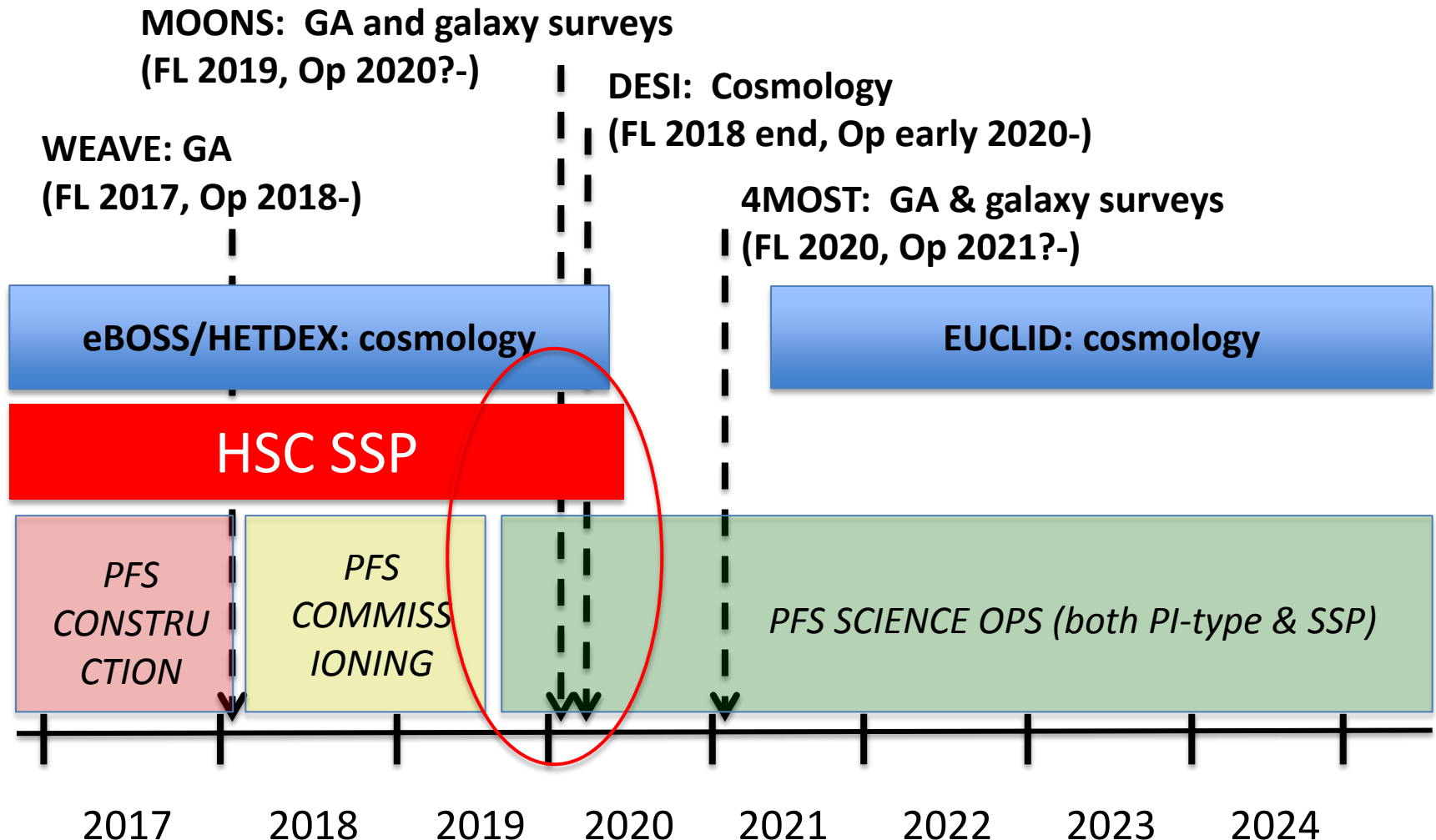
System integration

On-sky commissioning

*Science operation*

# The Competition: Schedules

Note: The schedules of the competitors are represented by *their starts of science operation* based on the information in the official websites etc.



# PFS science team activities & timeline

- **Takada et al. 2014, PASJ**: A summary of the survey design studies & top-level requirements to the instrument by the time of PDR.
- Semi-regular discussions in the working groups and by the working group chairs.
- Coordinating the survey strategies of the three key science programs under one big umbrella.
- **Preliminary timeline:**
  - **2015**: Maturing survey strategies and drafting an SSP proposal. Project-wide discussions at the collaboration meeting in Dec
  - **2016**: Continuing the above and brush up the draft.
  - **2017**: Proposal submission. Start of review process.
  - **2018 – early 2019**: Tweaking the survey details having inputs from engineering observations → Delta review
  - **Mid-late 2019**: Start of science operation & SSP

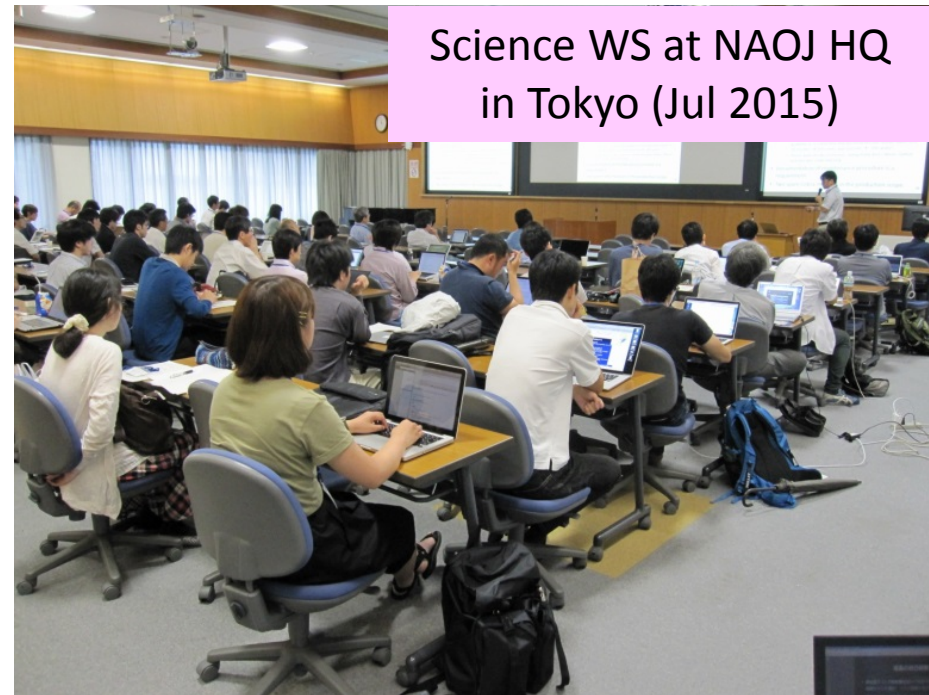
These procedure  
& timeline are TBC,  
under discussions  
at SAC etc



# PFS science meetings

- AGN ワークショップ  
(5/18-19@国立天文台)
- サイエンスワークショップ  
(7/9-11@国立天文台)
- 銀河ワークショップ  
(11/13@Kavli IPMU)

PFS galaxy WS at Kavli IPMU  
(Nov, 13 2015)

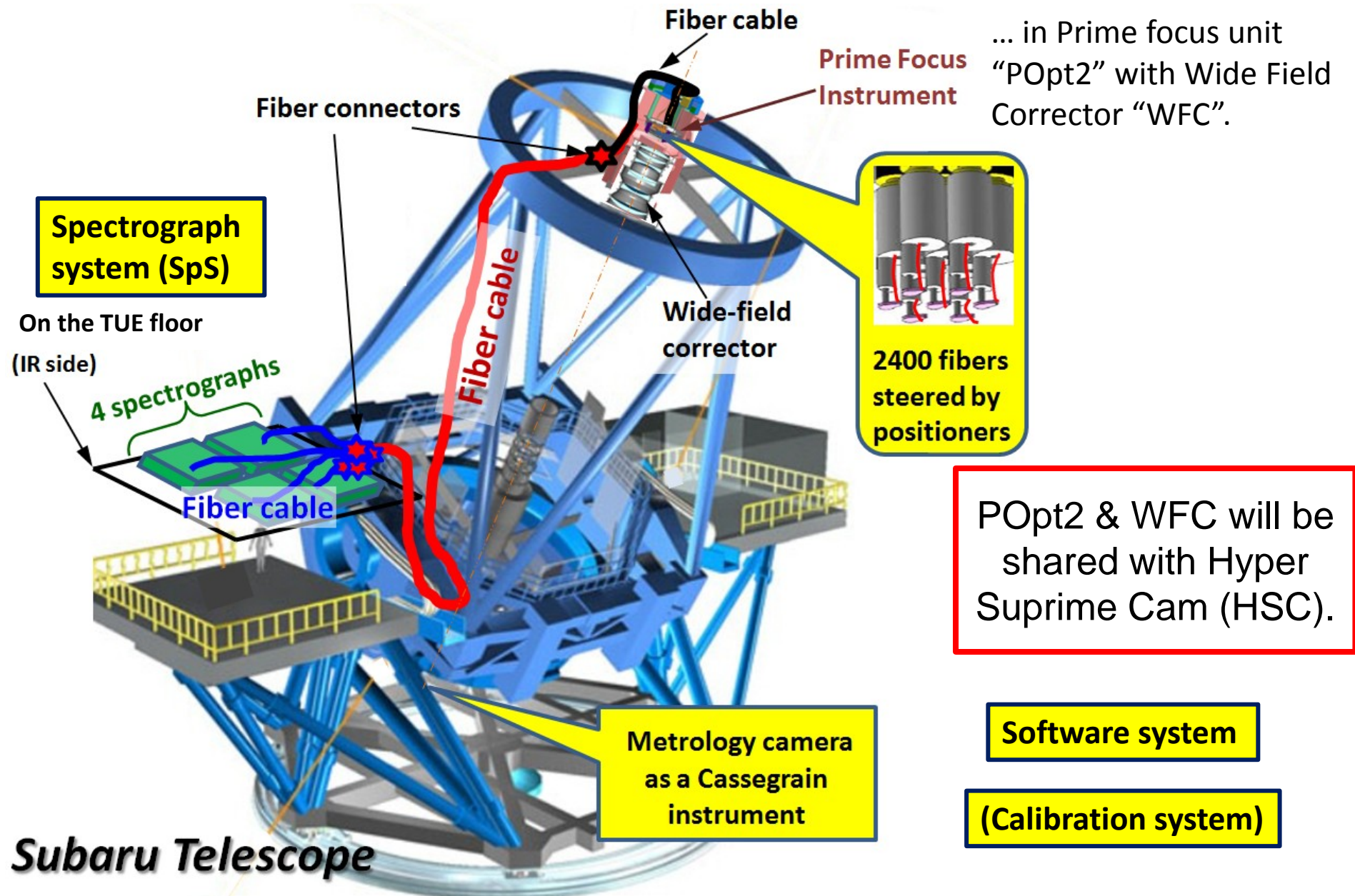


Science WS at NAOJ HQ  
in Tokyo (Jul 2015)



- PFS は Kavli IPMU 主導で開発中のすばるの観測装置。
- ぜひ一緒に PFS SSP の牽引を。
- 今後も日本で研究会を開催していこうと思いますので、ご参加よろしくお願いします。

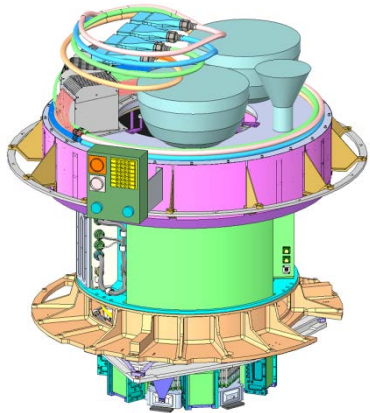
# PFS subsystems distribution



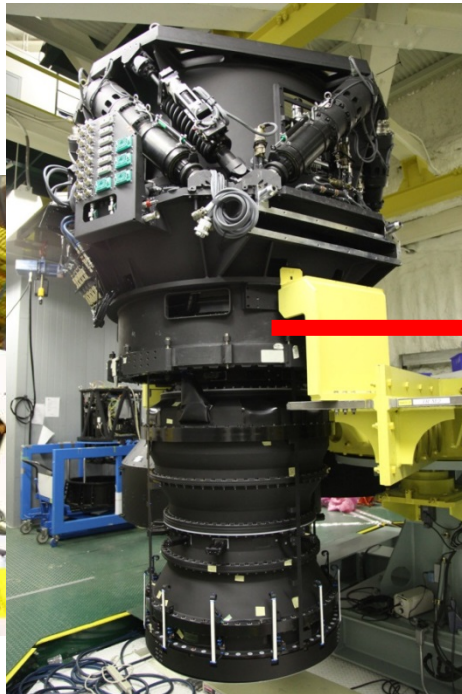
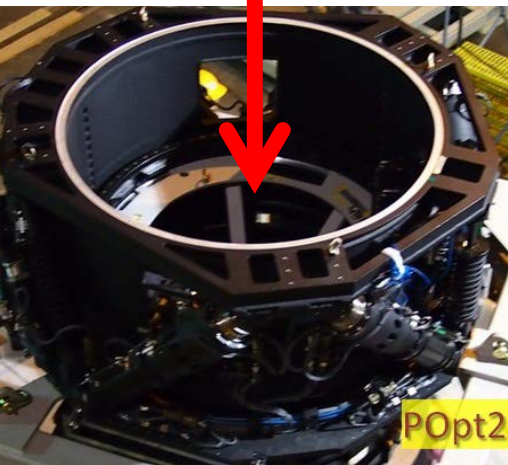


# Prime Focus Instrument (PFI)

Sits in the prime focus unit “POpt2” and installed to the telescope



- Fiber positioner system
- Acquisition & Guide (AG) camera
- Fiber cable: “Cable C” & fixed fiducial fibers
- Fiducial fiber illuminator
- Field element (cf. Filter+dewar window@HSC)
- Cable wrapper
- Calibration lamp system



HSC builder's blog

<http://anela.mtk.nao.ac.jp/hscblog/builder/>

# PFI CDR (Mar 10-11, at Caltech)

- Review board
  - External x 6: T. Huang (ASIAA), F. Leger (Washington), K. Seaman (JPL), M. Colavita (JPL), R. Foehner (JPL), K. Aaron (JPL)
  - Internal x 4: N. Takato (NAOJ), J. Gunn (Princeton), G. Murray (Durham), N. Tamura (Kavli IPMU, chair)

## 2 Executive summary

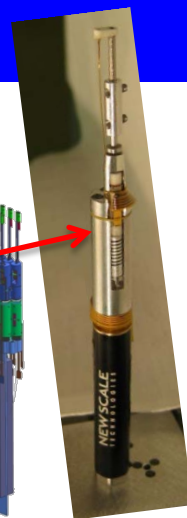
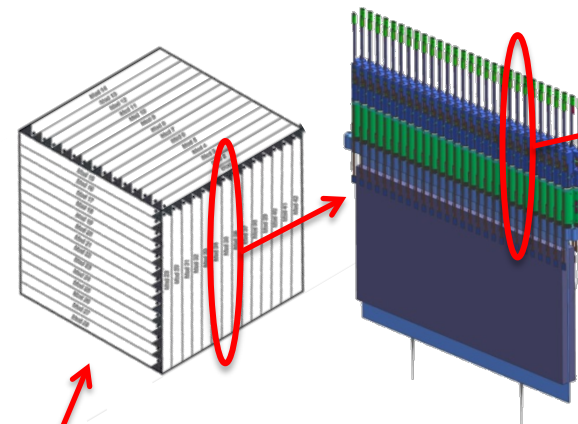
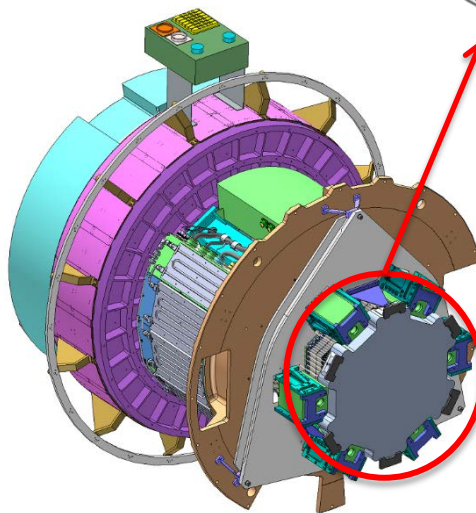
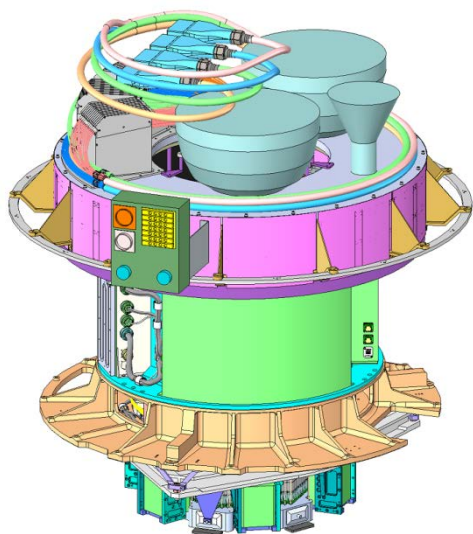
The review board was very pleased to see such an impressive amount of achievement and progress in spite of the complexity in the system to be developed and the diversity of the team in various senses. Although the team still needs to continue their efforts and finalize the design, the review material was at a sufficient level to understand the issues and risks the project will face moving forward through delivery. We congratulate the team on having brought the design study to its current status. Below we assemble feedbacks from the board members that range from general comments to high-level issues to inputs and advices for specific areas. The board expects the team to take them into account in the final design studies for successful fabrication of subcomponents and integration of the PFI system.

- The JPL-Caltech team successfully passed the fiber positioner system delta CDR on Jun 22.

# PFI CDR (Mar 10-11, at Caltech)

- “PFI” – Prime Focus Instrument

Fiber positioner system, Fiber cable, mechanical structure, AG cameras, Calibration lamp system, ...



Engineering model module

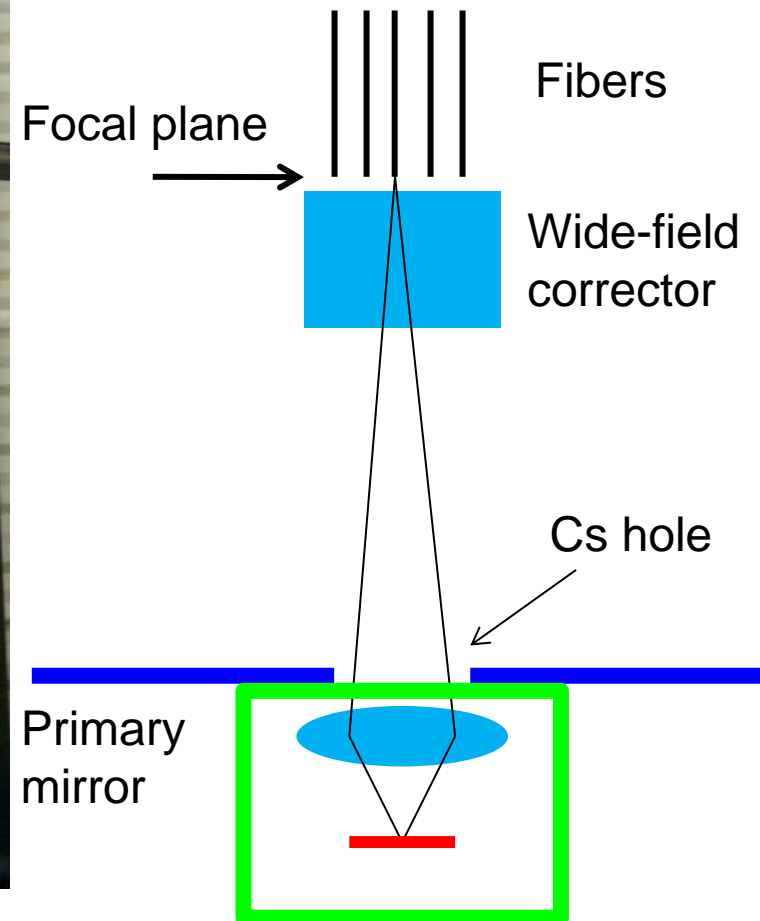
- Fiber positioner “Cobra”
  - On-going work on the durability issue.
  - Mass production will start soon.
- PFI delivery to Subaru in 2017 (TBC)





# Metrology Camera System

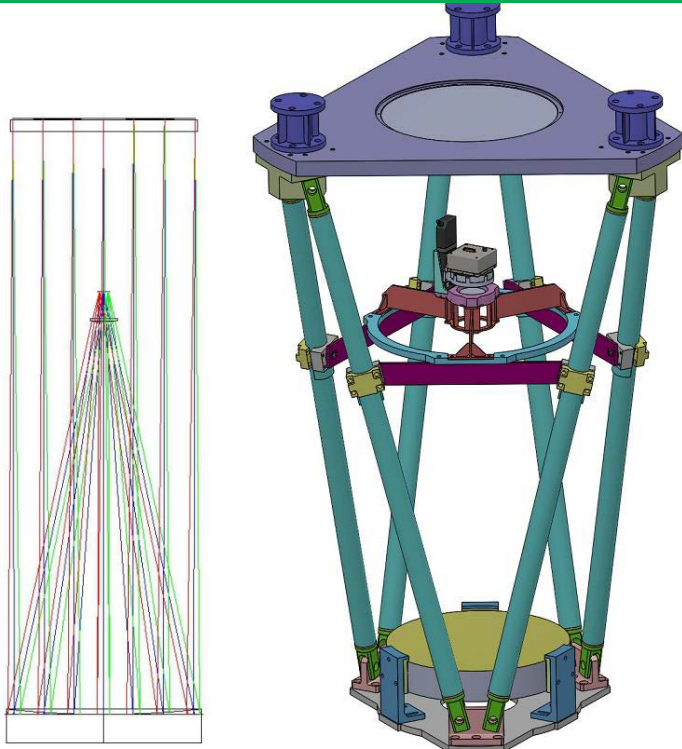
To image all backlit fibers at one exposure and measure the current fiber positions at the prime focus.



HSC builder's blog  
<http://anela.mtk.nao.ac.jp/hscblog/builder/>

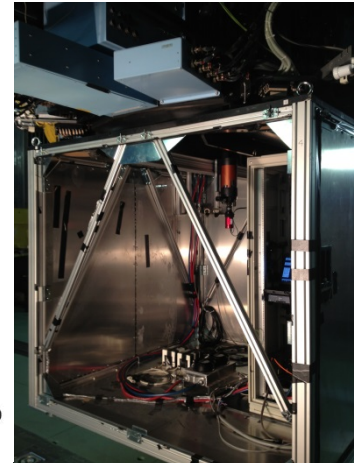
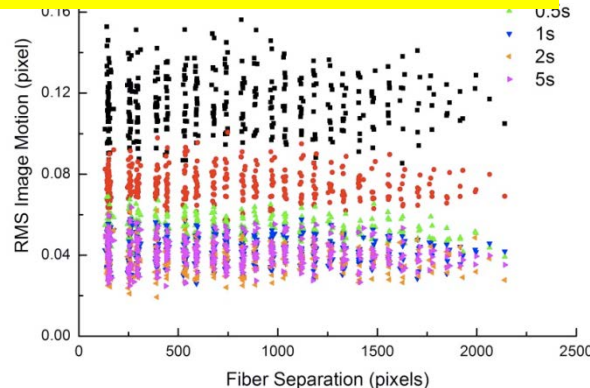
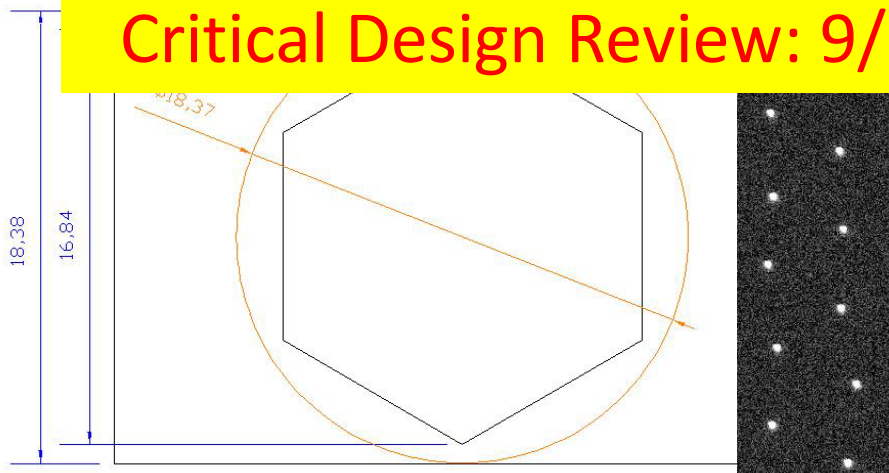
Met. Cam. System in the  
general purpose Cs container

# Metrology Camera System



- 380mm aperture Schmidt type
- Mech. design is being finalized.
- CANON 50M pixel CMOS sensor
  - $8960 \times 5778$ ,  $3.2\mu\text{m}$  pixel
  - $28.67 \times 18.49\text{mm}$
  - $\sim 3$  sec per iteration (depending on exposure time)
- Dome seeing measurement using FMOS & test camera

Critical Design Review: 9/22-23@ASIAA+TV



# Spectrograph System (SpS)

CDR completed  
in Mar 2014

**"Red"**

Mangin mirror

Field Flattener & Detector

Corrector 2

Corrector 1

VPHG

Schmidt Corrector

Collimator

Entrance Slit

Dichroics

Schmidt corrector

Corrector 1

Corrector 2

Schmidt corrector (coll)

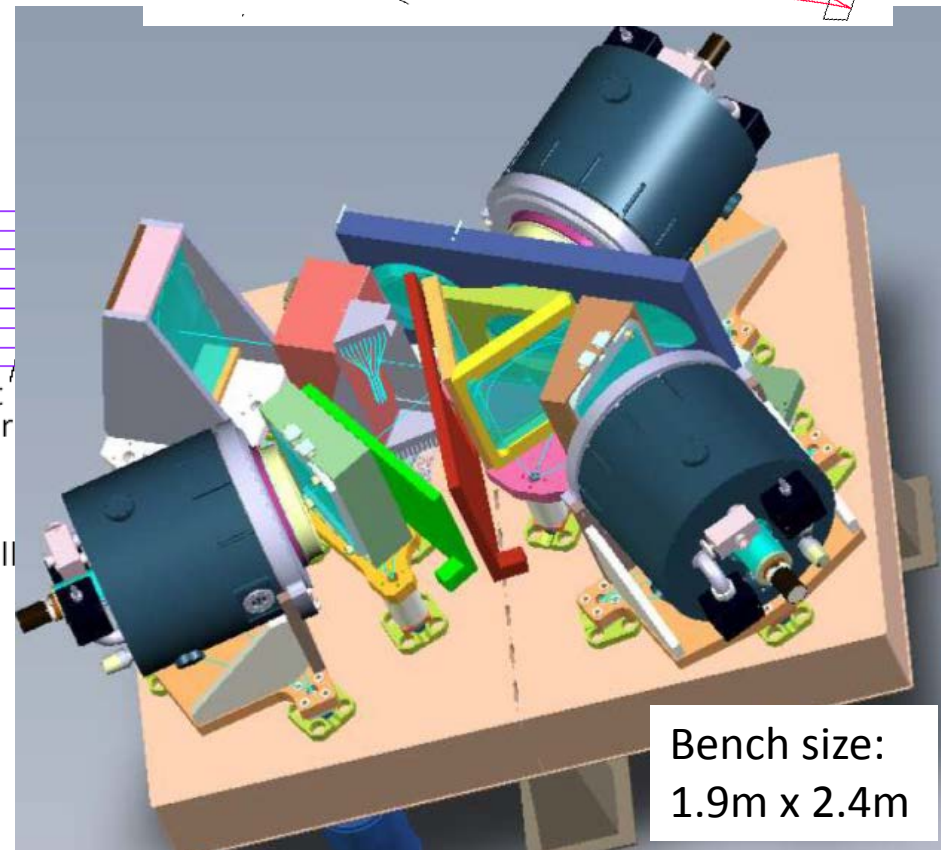
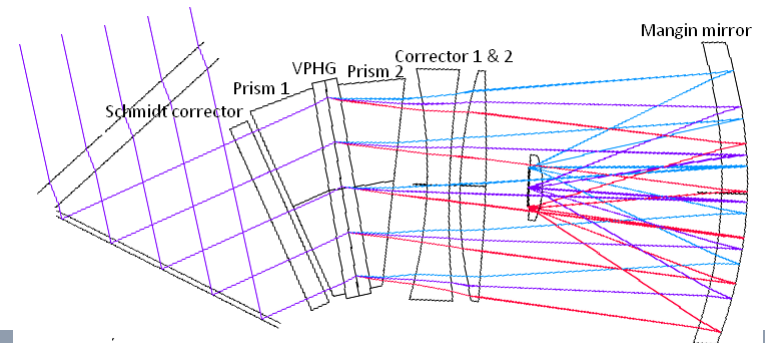
VPHG

Field Flattener & Detector

Mangin mirror

**"Blue"**

Mid. Res mode in the red arm

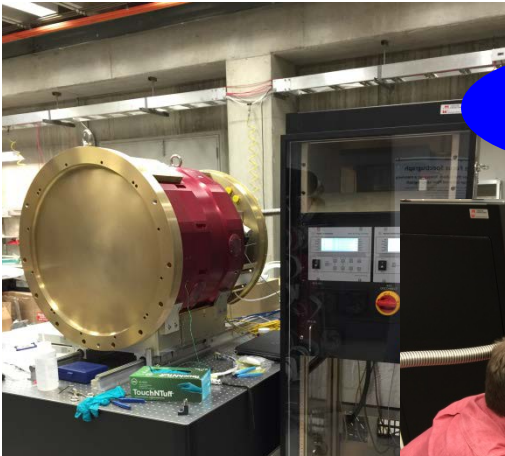


Bench size:  
1.9m x 2.4m

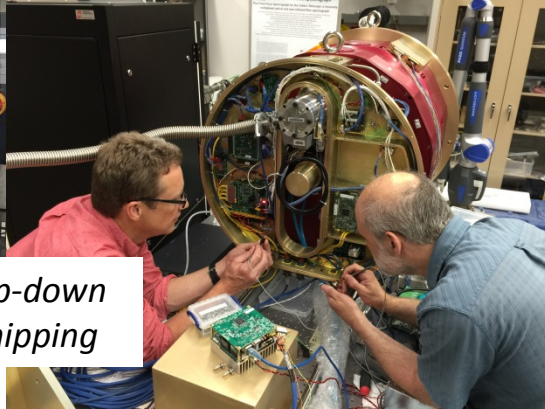


# SpS – What's happening now

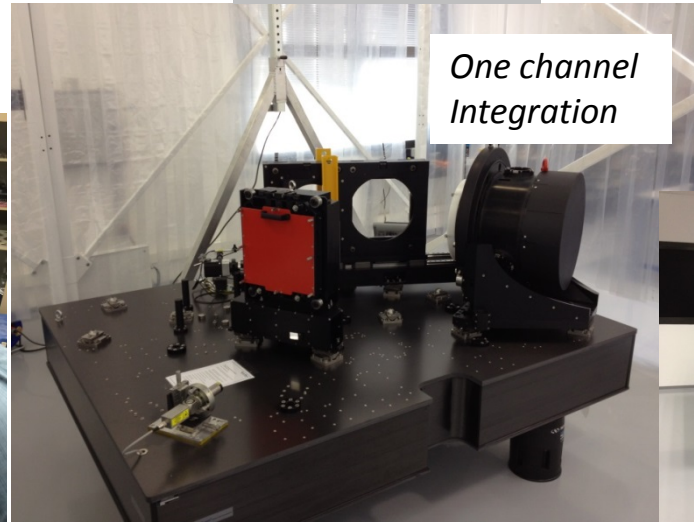
JHU



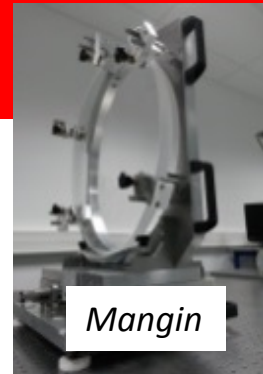
*Cryostat assembly, pump-down and cool-down before shipping*



Winlight



*One channel Integration*

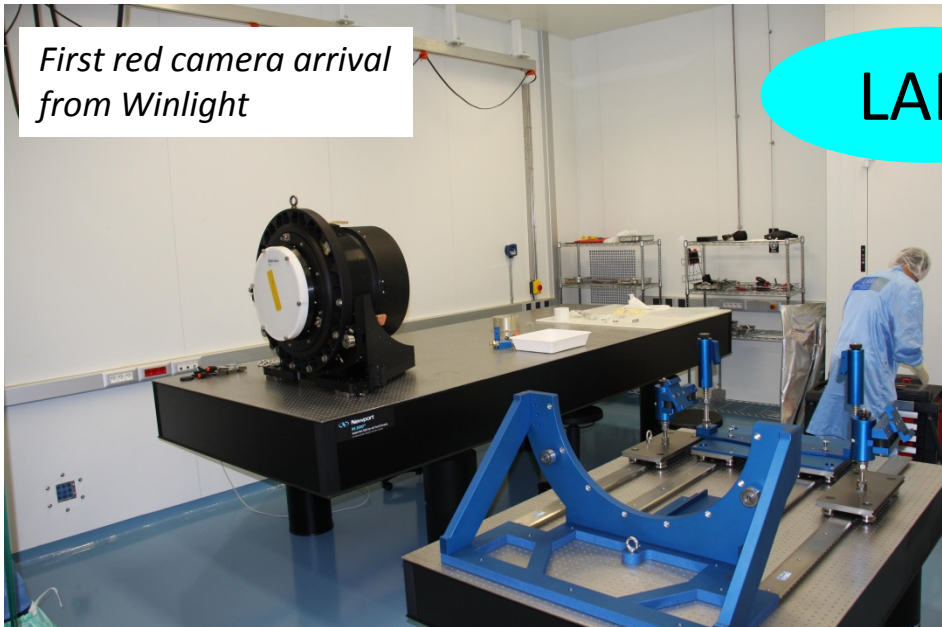


*Mangin*

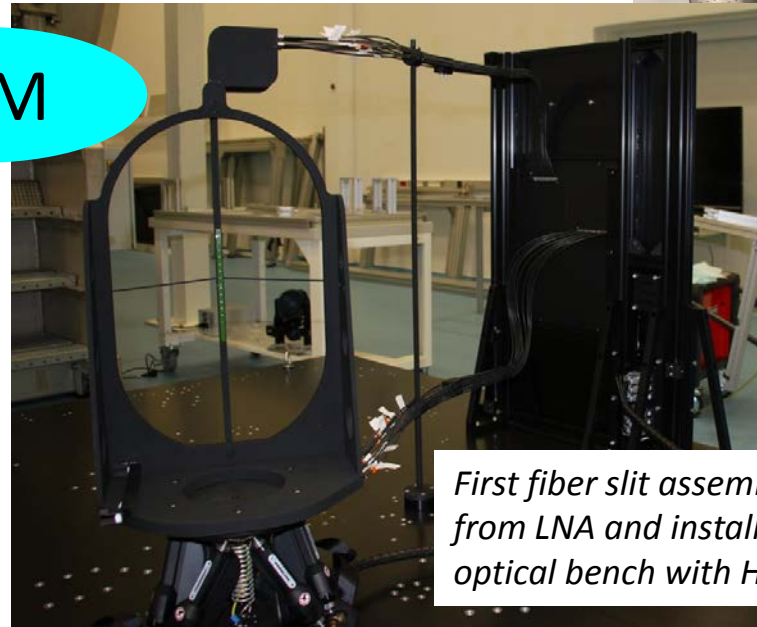


*Collimator*

*First red camera arrival from Winlight*



LAM

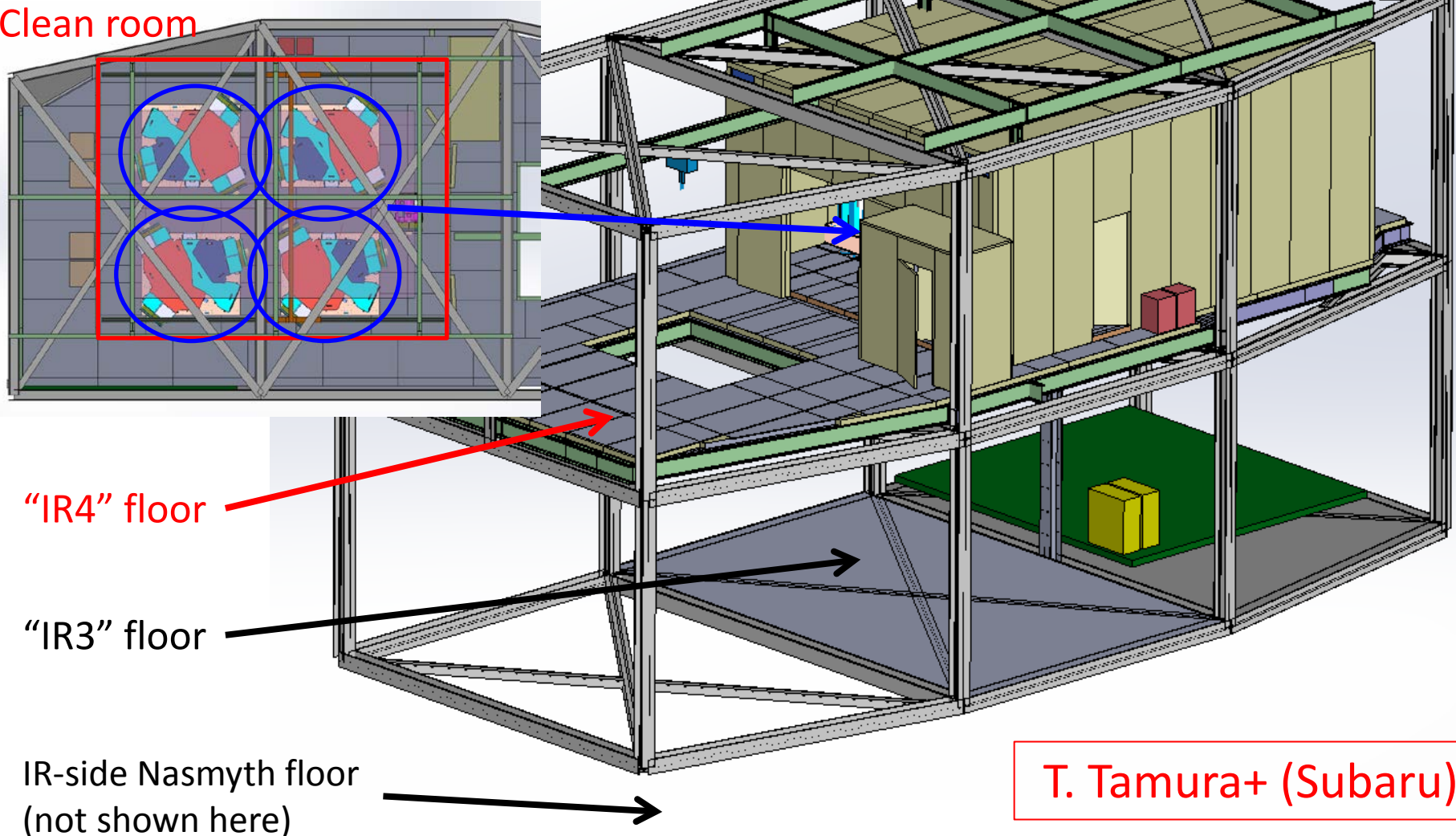


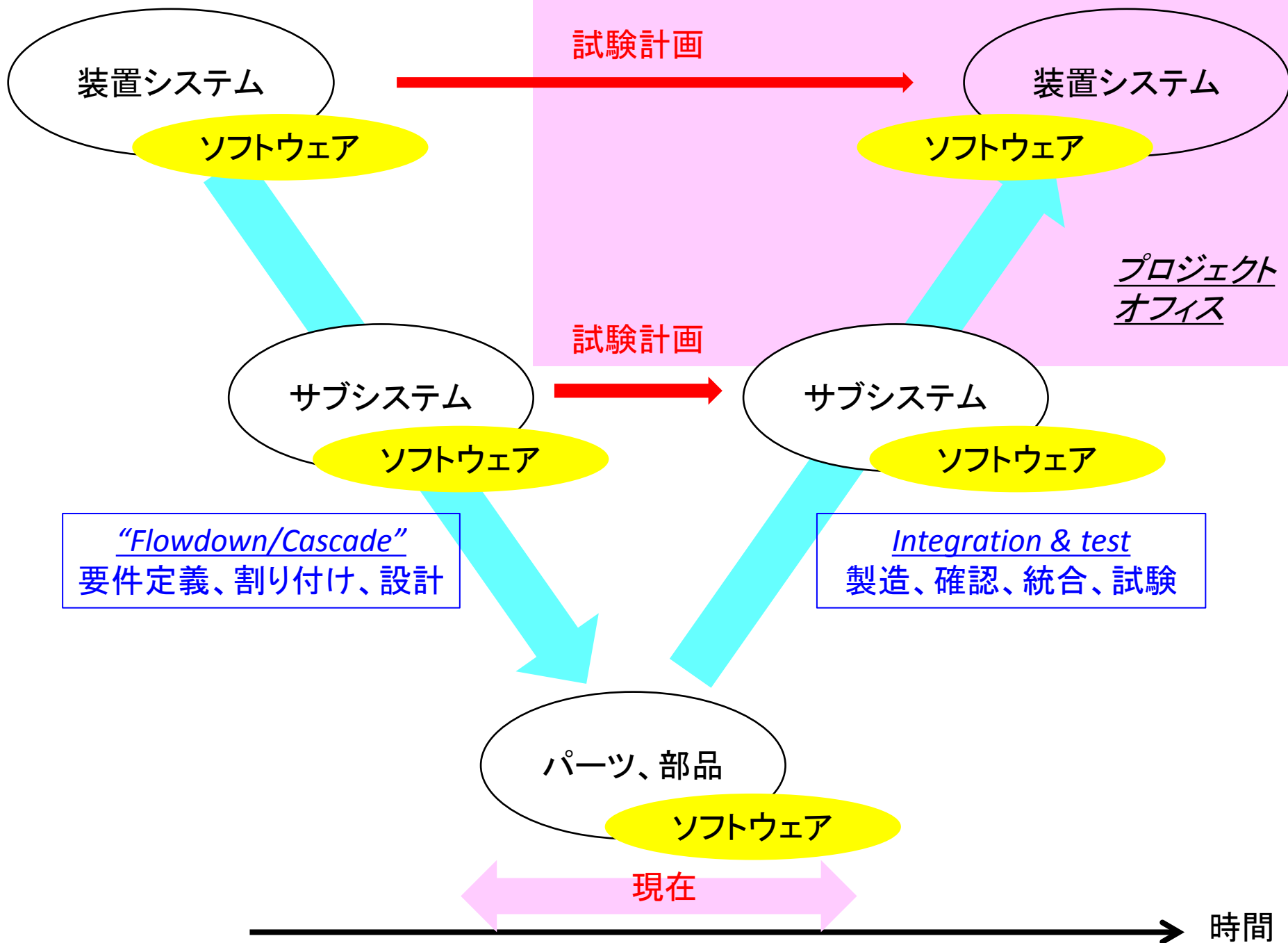
*First fiber slit assembly arrival from LNA and installed on the optical bench with Hexapod.*

# SpS: Configuration at Subaru

4x spectrograph modules (SM) are accommodated in a temperature-controlled clean room.

Clean room





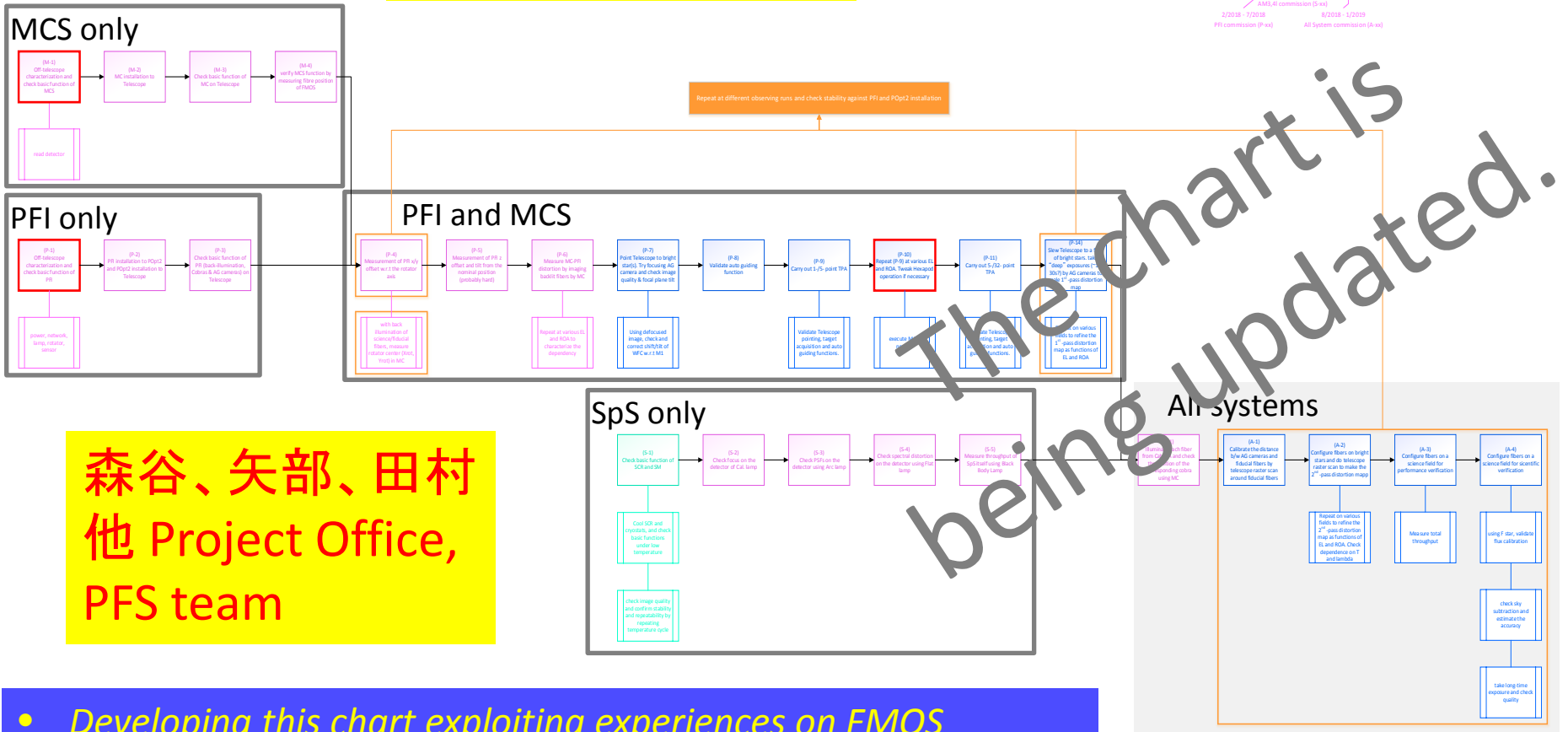
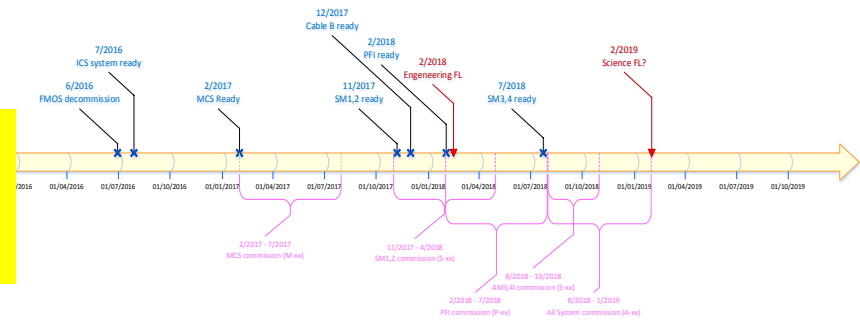




## Abbreviations

EL: Elevations  
MC: Metrology Camera  
PFI: Prime Focal Instrument  
ROA: Rotation Angle  
SCR: Spectrograph Clean Room  
SM: Spectrograph Module  
SpS: Spectrograph Subsystem  
TPA: Telescope Pointing Analysis

# システム統合及び 試験観測計画立案



森谷、矢部、田村  
他 Project Office,  
PFS team

- Developing this chart exploiting experiences on FMOS
- Individual processes will be matured with:
  - Inputs from previous processes or subsystem tests
  - Step-by-step procedure & required tools for analyses etc.
  - Success criteria to go to the next process

# PFS website <http://pfs.ipmu.jp>

The impressive PFS movie!

Asking donation!

Project top-level schedule, history, & upcoming events



Prime Focus Spectrograph

Introduction

Science

Instrument

Support PFS! 😊

People

Schedule

For Scientists

HOW  
DID THE  
UNIVERSE BEGIN?

DOES IT HAVE AN  
END?

WHY  
DO WE EXIST?

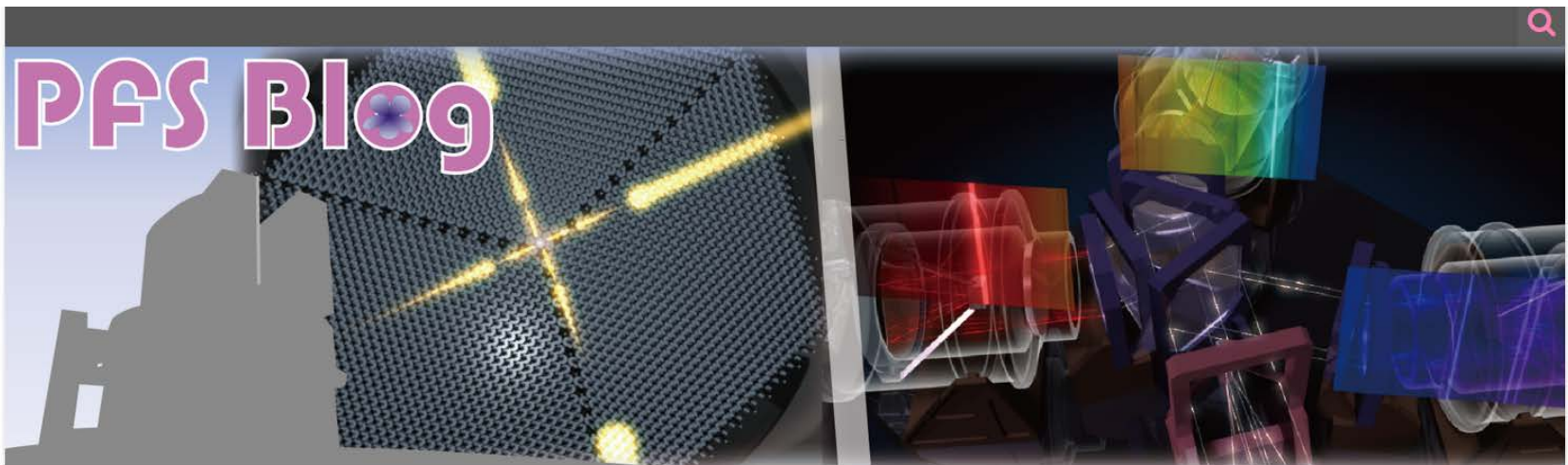
Address the role of DARK MATTER

- Instrument parameters
- Estimated throughput & on-sky performance

- Main contents are prepared for non-experts.
- Collaboration with IPMU PIO team is in the scope.

# PFS blog <http://pfs.ipmu.jp/blog/>

- Started just a month ago!
- Both English and Japanese.
- Trying regular updates at meetings, milestones, etc, with photos.



HOME

## IAU General Assembly / IAU総会で発表しました。

PFS Project 2015-08-21 No Comments



From third to fourteenth August, International Astronomical Union (IAU) general assembly was held in Honolulu, Hawaii, the US. Astronomers from all over the world gathered for discussions during this international workshop. The PFS project presented a poster, with which the project

### LINKS

- PFS web site
- Kavli IPMU
- Subaru, NAOJ
- ASIAA

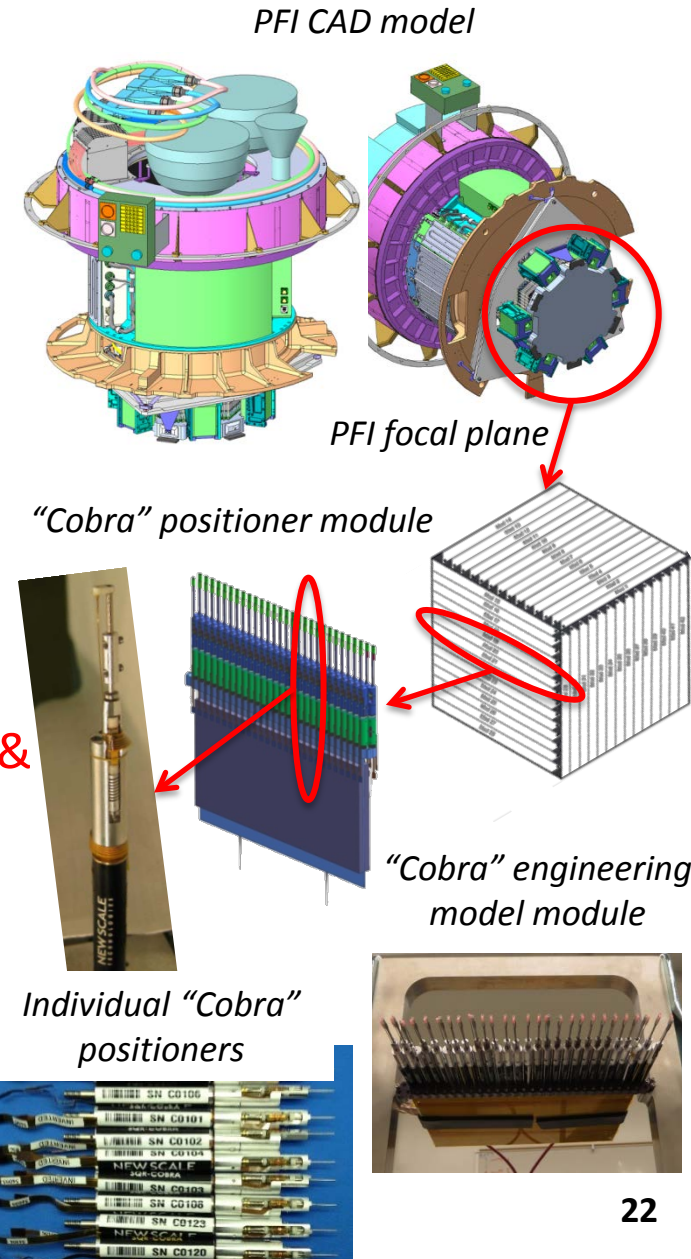
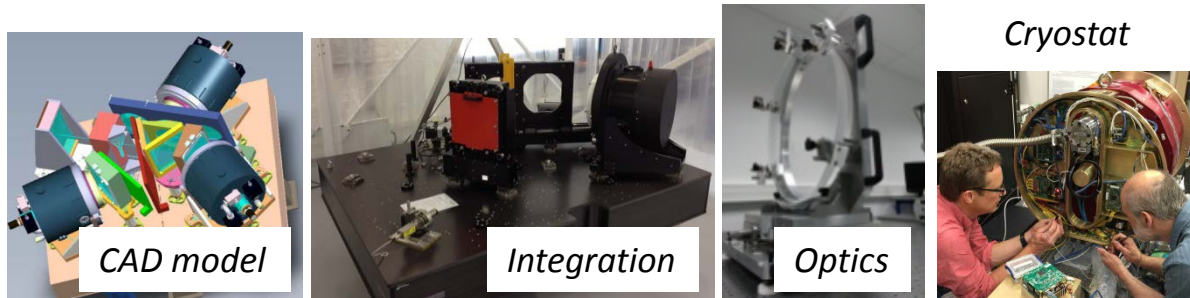


# Funding situation

- *Good news!* The Murayama et al.'s application to Grant-in-Aid for Scientific Research on Innovative Areas (科研費新学術) has been approved!
  - \$~1.5-2M for the PFS development!!
  - Shortfall still remains ~several millions \$ (TBC) including contingency ...
- Contributions from new partners: *There are a few (promising) candidates.*
- Other funding applications:
  - Budget request for PFS to Ministry/Government via U. Tokyo (概算要求)
  - NSF MSIP proposal has been submitted by the US team.
  - Grand-in-Aid (科研費) applications again this year

# Summary about PFS

- 概念設計評価 (2012)、基本設計評価 (2013)
- 詳細設計評価
  - 3014/03 分光器, 2015/03 主焦点装置, 2015/09 メトロロジカメラ, 2015/TBD 望遠鏡用ファイバーケーブル
- Now finalizing the design studies and proceeding with production, integration & test.



- Aiming at engineering observation from early 2018 & science operation from mid-late 2019.
- **SSP サーベイ計画詳細検討中。ぜひご参加を！**
- **Unique capability of Subaru for unique science via synergy w/ TMT, SPICA, LSST, JWST, Euclid, WFIRST**

Refer to [PFS web](#) & [blog](#) for more detailed information and updates.