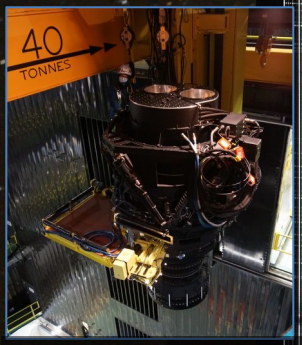
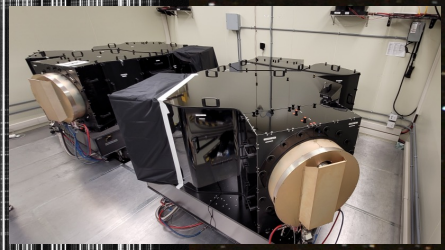
SUBARU PRIME FOCUS SPECTROGRAPH

Updates of the next-generation Subaru facility instrument ***under commissioning***







Naoyuki Tamura
[Kavli IPMU → Subaru/NAOJ]
On behalf of PFS collaboration

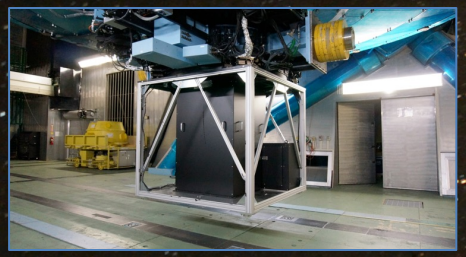
SuMIRe
Prime Focus Spectrograph

Jan 31 2023 JST
Subaru Users Meeting FY2022

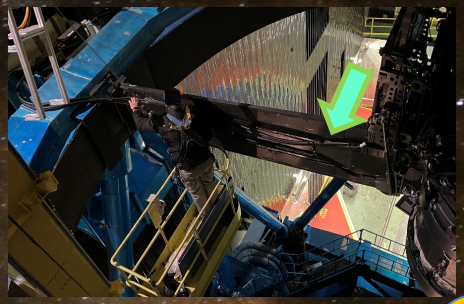
Prime Focus Spectrograph

PFS commissioning *has been* underway.

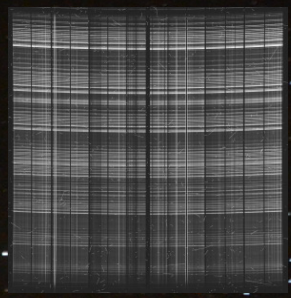
Metrology Camera System installed 1st time on the Cs focus (Jun 2018).



1st Fiber Cable (Cable B1) was installed (Feb 2021).



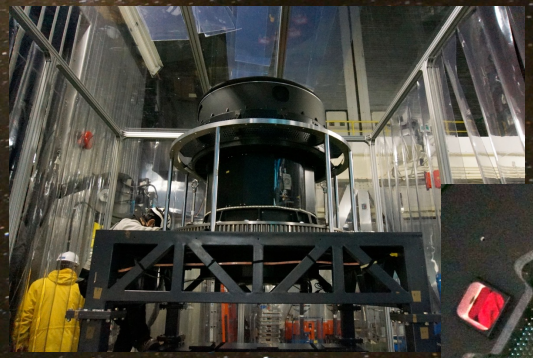
1st system test on the telescope (Sep 2021).



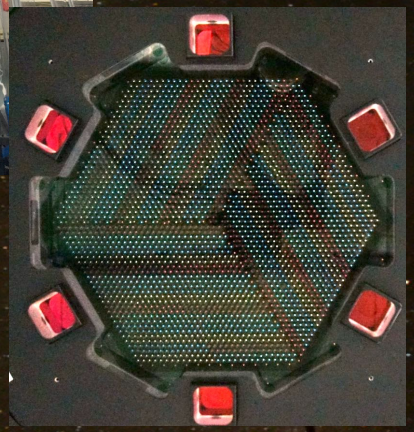
2018 | 2019 | 2020 | 2021 | 2022

Engineering observations

1st Spectrograph Module (SM1) was installed (Dec 2019).

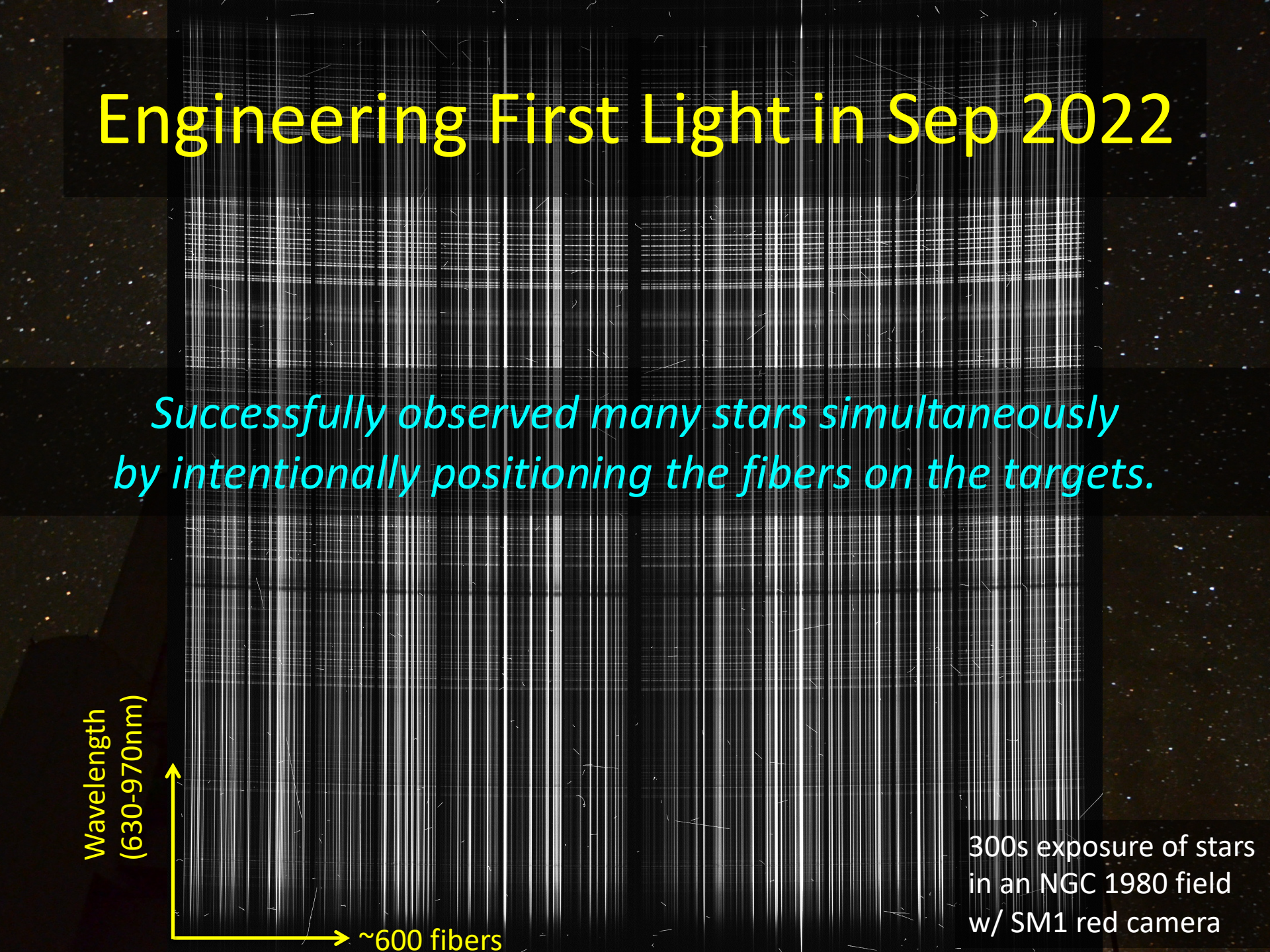


Prime Focus Instrument (PFI) was delivered & re-validated (Jun-Sep 2021).



Engineering First Light in Sep 2022

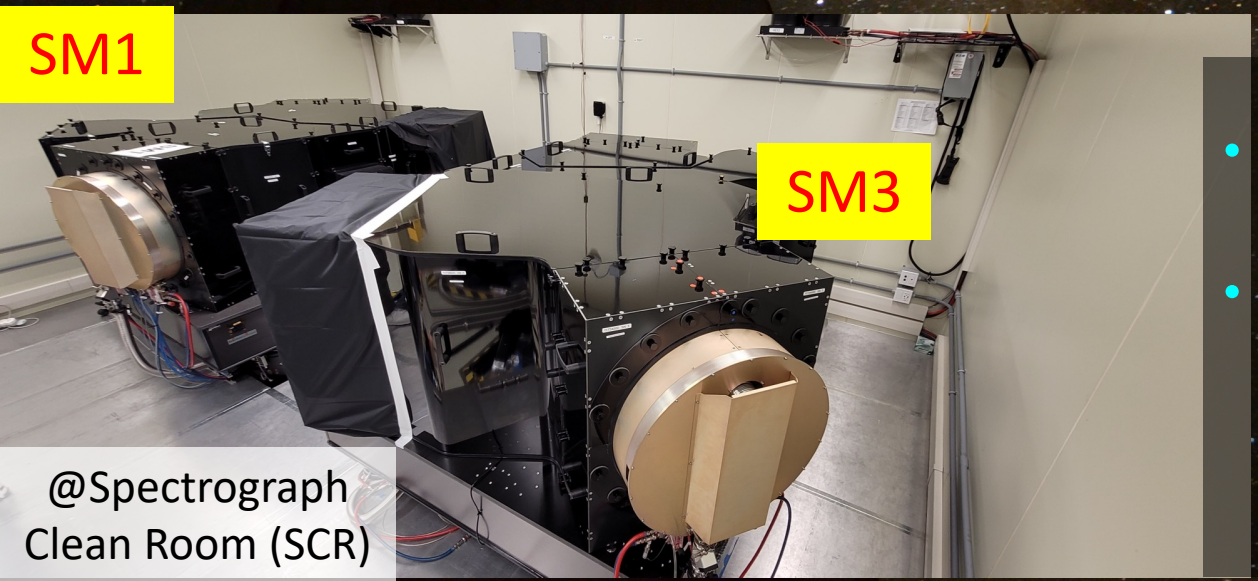
Successfully observed many stars simultaneously by intentionally positioning the fibers on the targets.



300s exposure of stars in an NGC 1980 field w/ SM1 red camera

Now two fiber cables & two spectrograph modules in place

Successful installation of 2nd Fiber Cable (Cable B2) in April 2022.

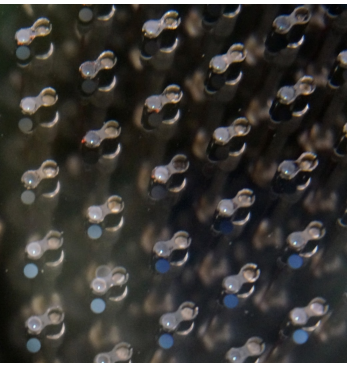


- *Completed installing SM3 in early Nov 2022.*
- *Started its operation right away according to the good results of post-installation tests.*

The observation in Nov 2022 with doubled multiplicity: ~600→~1200

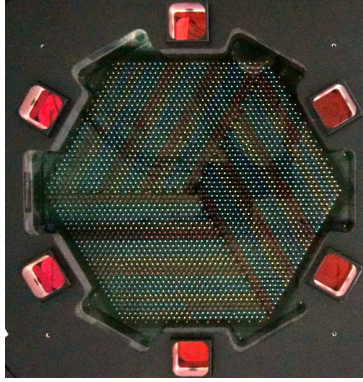
Two more modules to come for the full multiplicity of ~2400

300s exposure of stars
in an NGC 1980 field
w/ SM1 & SM3 blue cameras



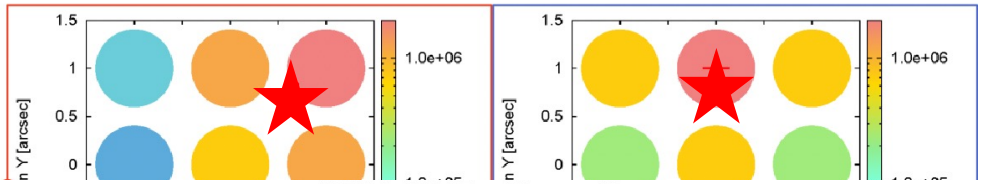
8mm between
adjacent Cobras

40cm



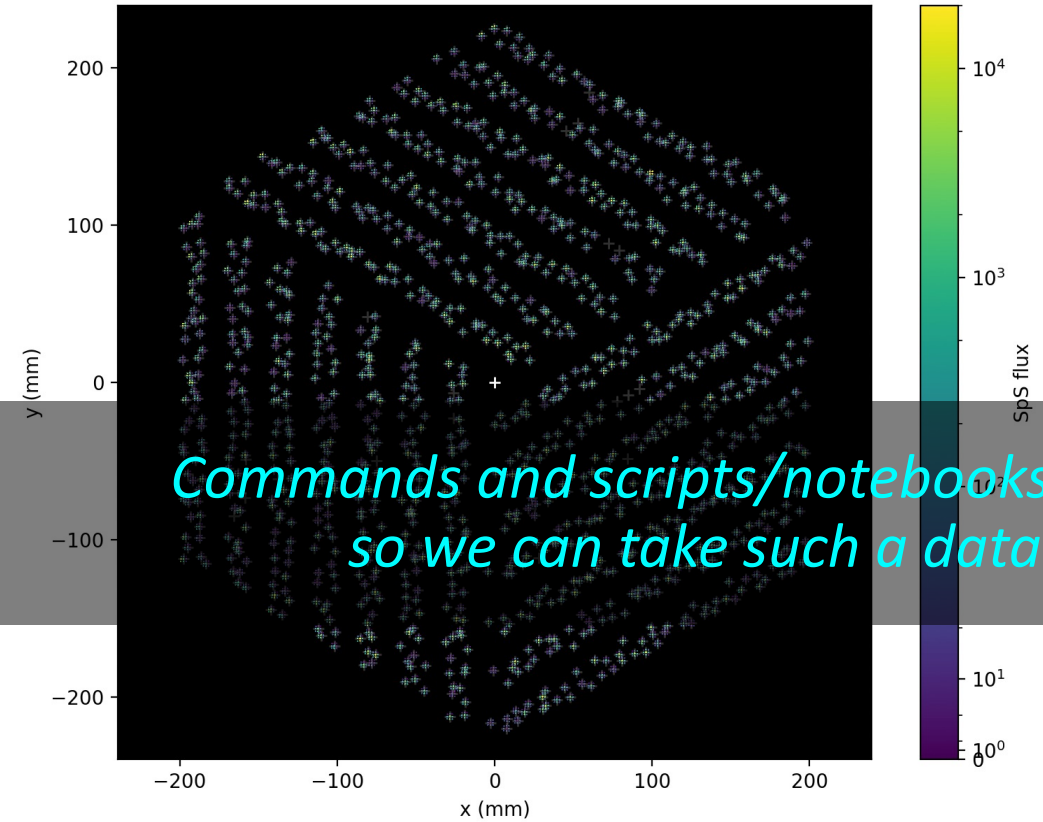
Fiber positioning accuracy

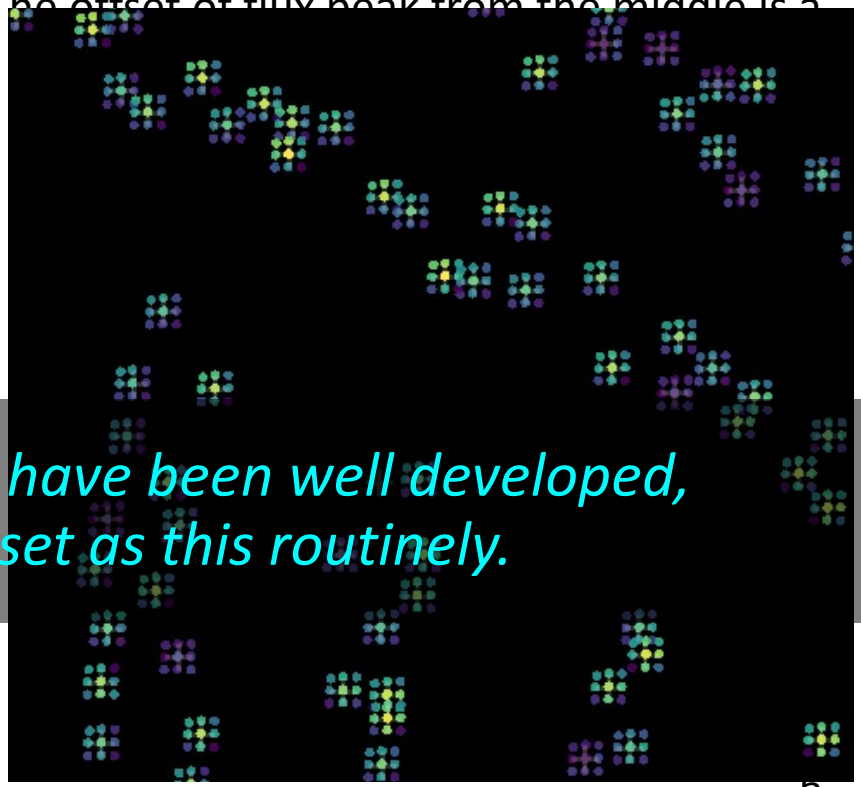
1. Accurately predict (x,y) from (α, δ).
2. Accurately move the fiber to requested (x.y).



Raster scan

- To generate a 2D map of flux coming into the instrument around each fiber.
- The offset of flux peak from the middle is a



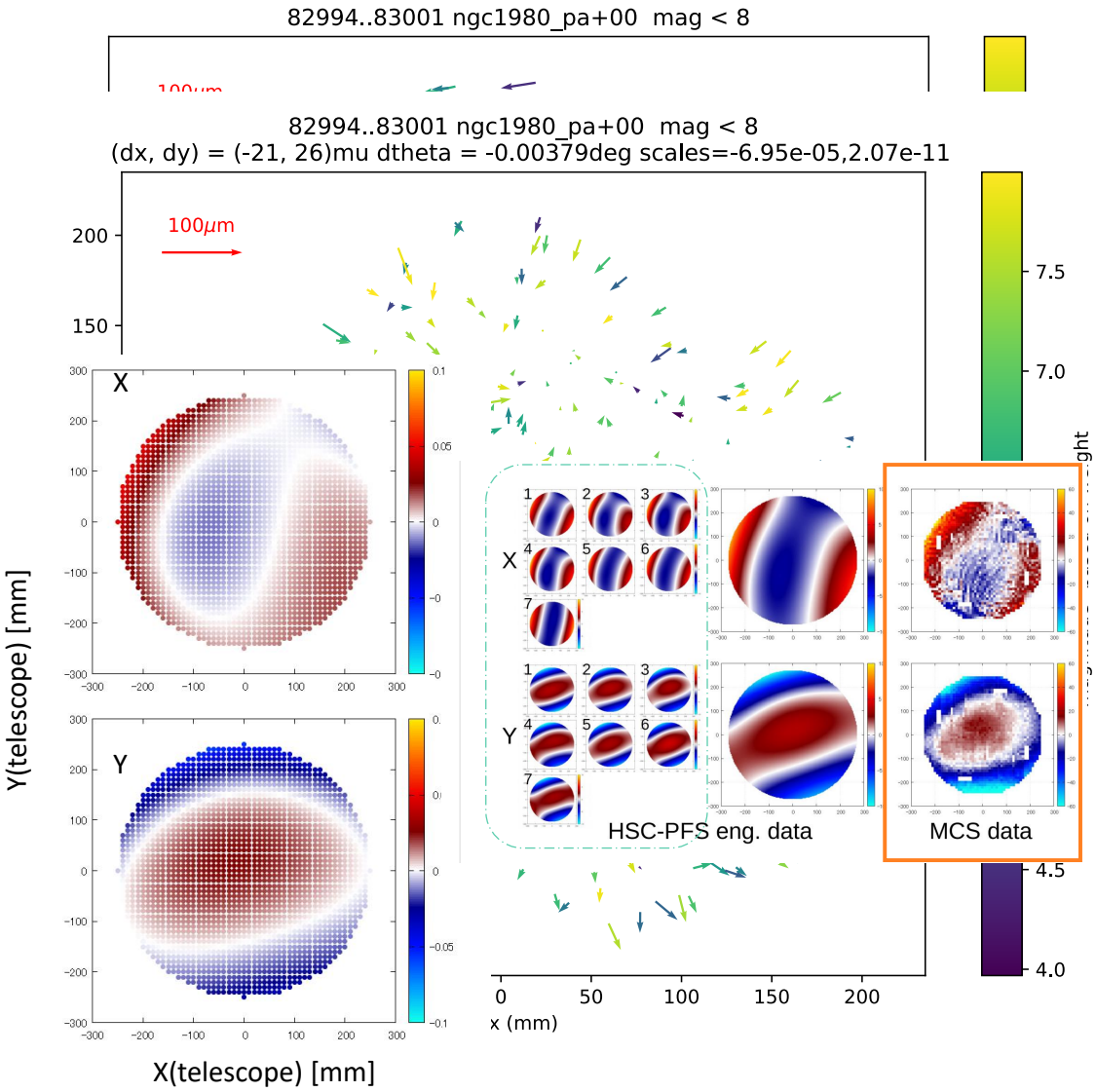


Commands and scripts/notebooks have been well developed, so we can take such a data set as this routinely.

The fiber diameter is equivalent to 100um

- 1”.13@Field center
- 1”.03@Field edge

Fiber positioning accuracy



Systematic errors are dominant.

- Translational/rotational offset
  ← Some issues in the field acquisition and/or guiding?
- Scale error
  ← Inaccurately modeled?

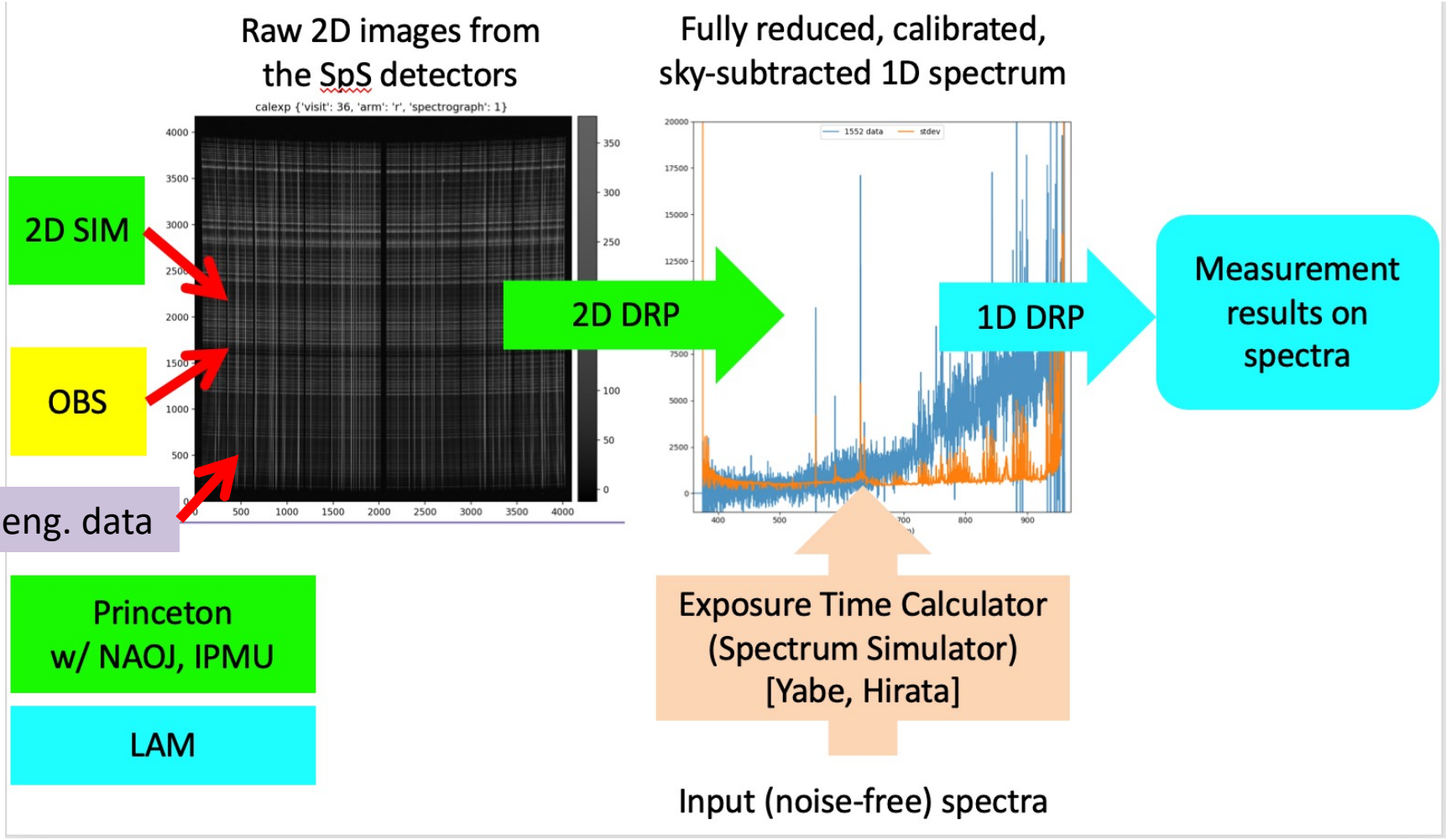
After numerically subtracting these offsets and scale error.

Furthermore, averaging the errors from 10 sets of raster scan data.

Takeaways:

- The error seems dominated by the large-scale & small-scale systematics. Minimizing these is the priority.
- The contribution from the positioner’s stochasticity seems very little.

Data processing



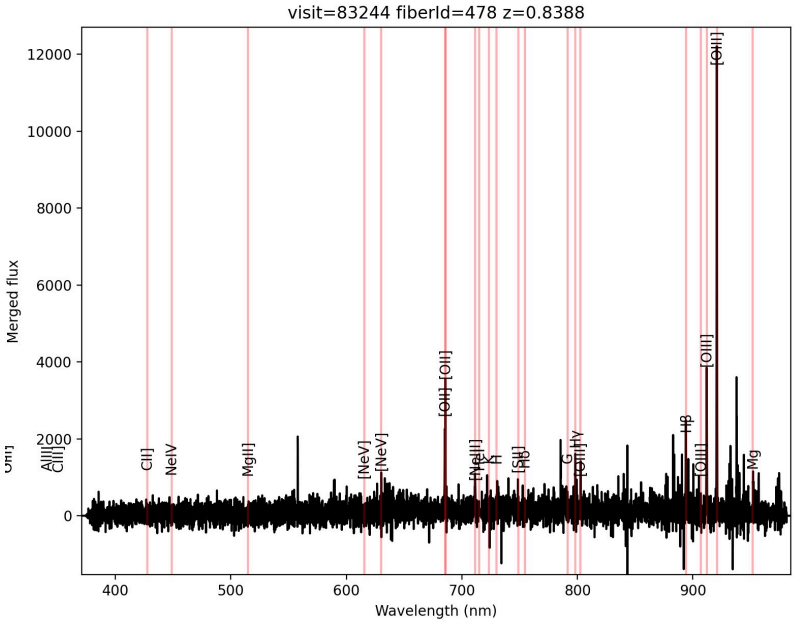
Updates are applied to the pipelines continuously.

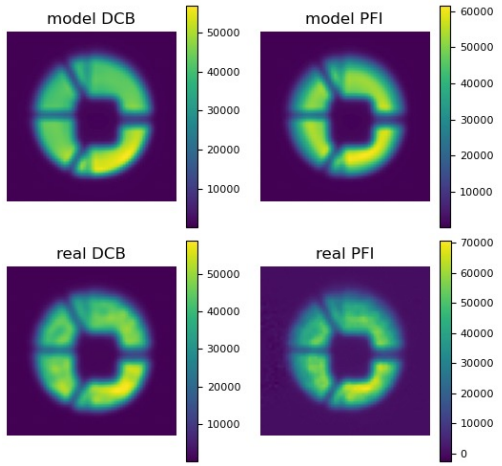
→ ***Weekly*** integration test: 2D (Princeton), 1D (LAM) & ***End-to-end (IPMU)***

2D Data Reduction Pipeline (2D DRP)

Current status:

- The pipeline (Lupton, Price+) is getting to be able to process data from engineering observations all the way down to flux calibration that is being developed at NAOJ (Yamashita, Mineo+).
- 2D PSF modeling as a key to very good sky subtraction still needs substantial development, while the spectrograph part seems quite well modeled already (Caplar, Hayashi, Yabe, Kawanomoto+).
- Useful QA plots are being identified (e.g. those for accuracies of wavelength calibration and sky subtraction) and appropriate tools need to be developed (Hamano, Tanaka, Yabe, Siddiqui, Price+).

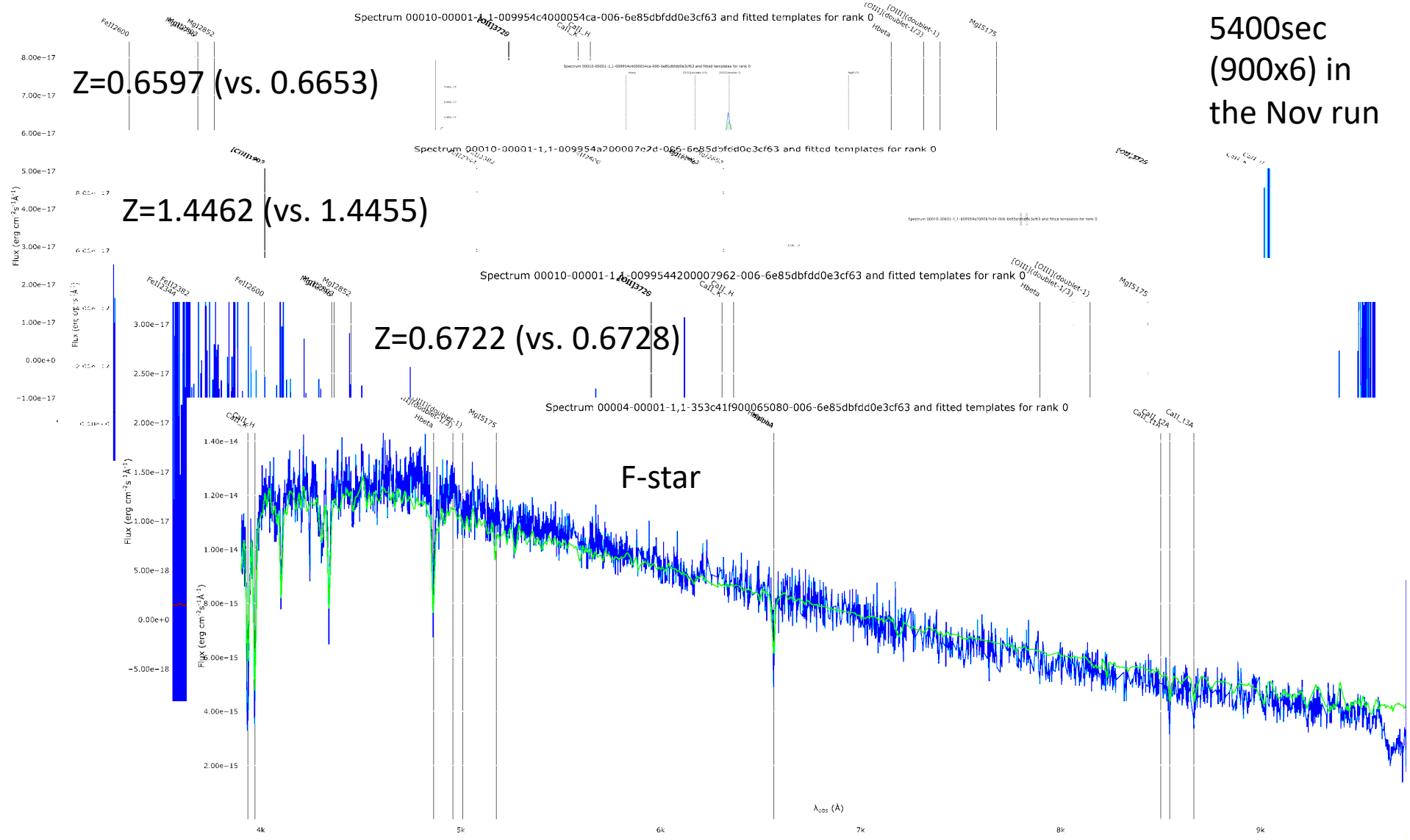




"DCB" ~= Spectrograph
"PFI" ~= Everything

(Hayashi, Yabe+)

1D Data Reduction Pipeline (1D DRP)

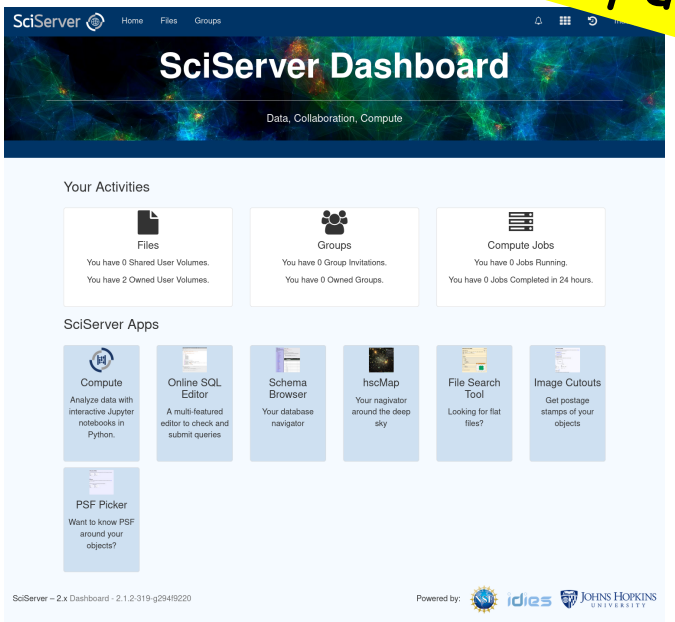


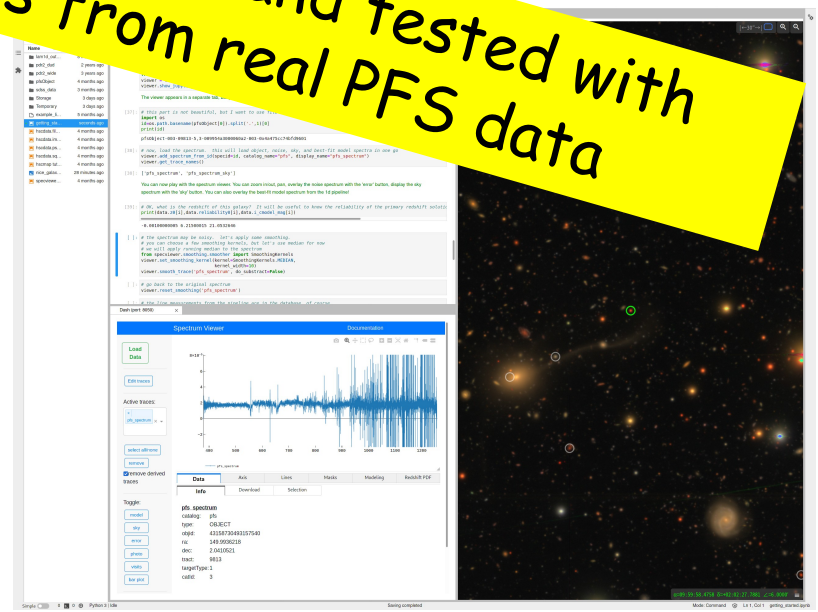
5400sec (900x6) in the Nov run

HSC+PFS Science Database (SciDB)

- SciDB (currently ver. 2.5) is a ***Science Platform*** for HSC+PFS being jointly developed by **NAOJ** and JHU which plans to:
  - Provide easy access to outputs from the PFS pipelines as well as those from ir… data such as HSC.
  - Have … the primary analysis environment
  - Enable to b… …t to massive data.

To be populated and tested with outputs from real PFS data





国立天文台 NAOJ National Astronomical Observatory of Japan

Hisanori Furusawa
Michitaro Koike
Sogo Mineo
Takahiro Morishima
Kazumi Murata
Yuki Okura
Masayuki Tanaka

JOHNS HOPKINS UNIVERSITY

Dmitry Medvedev
Arik Mitschang
Manu Taghizadeh-Popp
Ani Thakar
Sue Werner

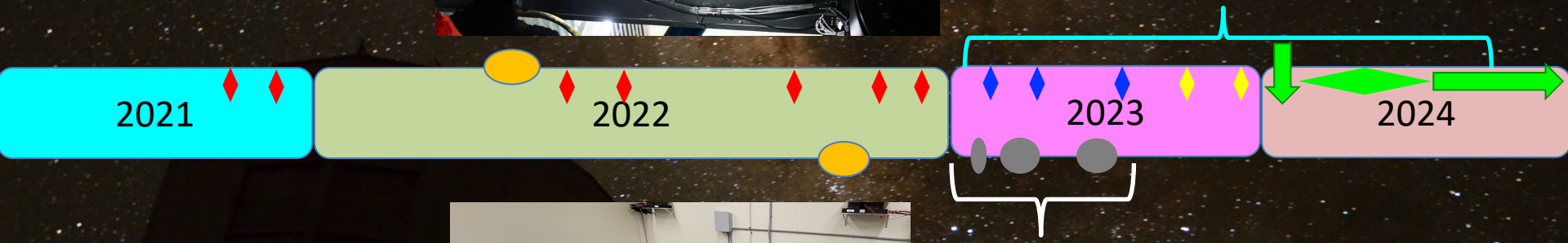
Towards the end of PFS commissioning & beyond

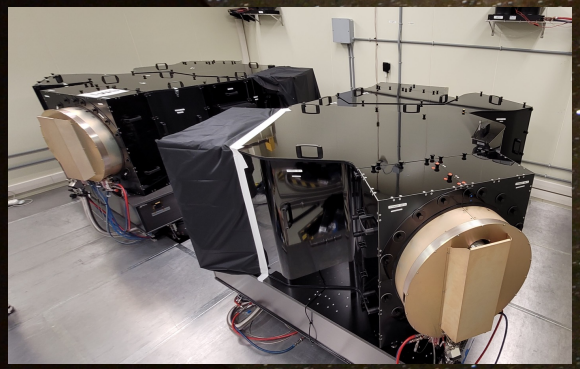
2nd Fiber Cable (Cable B2) was installed (Apr 2022).

Engineering observations
- 3 runs in S23A
- 2 (TBC) runs in S23B

Open use readiness review
- TBD runs in S24A for e.g. stabilization

Start of science operation (S24B)



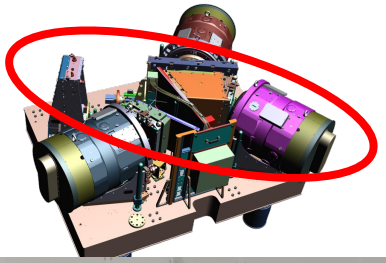


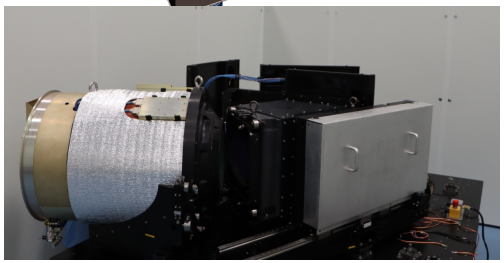
2nd Spectrograph Module (SM3) was installed (Nov 2022).

Fiber Cable installation
- Cable B3 on 2/6-8 (next week)
- Cable B4 (TBC)

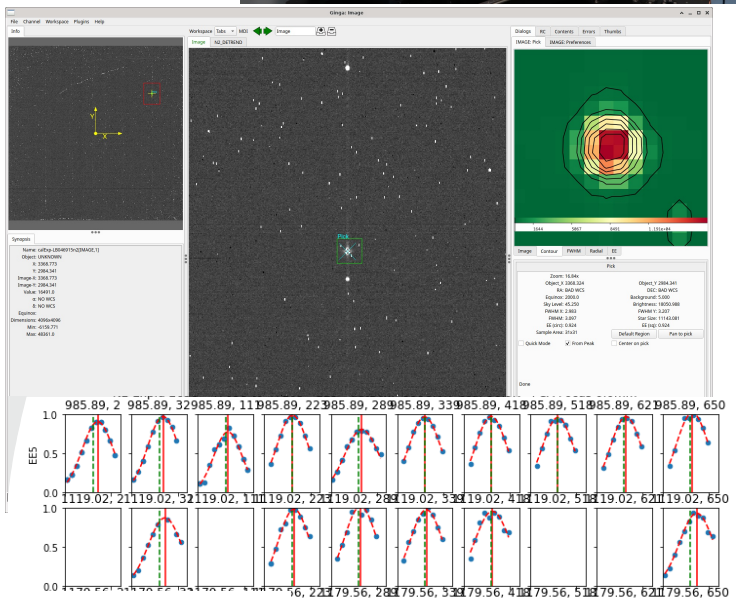
Spectrograph implementation
- NIR camera SN1, SN2 by mid April
  → NIR First Light in the April run
- All the rest in June-July
  → 1st run w/ the full hardware in July.

Spectrograph System (SpS) at LAM

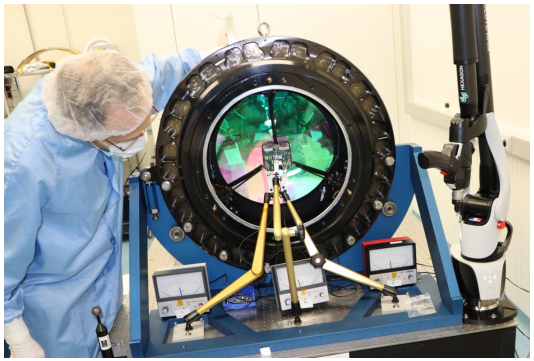




- Tests of the 1st NIR camera (N1) as part of Spectrograph Module #2 (SM2) are ongoing.
  - N1 itself was fully assembled and tested at JHU, passed the preship review and was shipped to LAM.
  - The optical alignment at LAM looks as good as how it was at JHU. The image quality and thermal background are being investigated in detail at 5℃ in the chamber to simulate the operating condition at Subaru.
  - The NIR camera will be soon confirmed to be confocal to a visible camera.
  - **Near-term goal is to deliver N1 to Subaru in Mar.**
- The assembly & test of the remaining visible cameras are also ongoing.



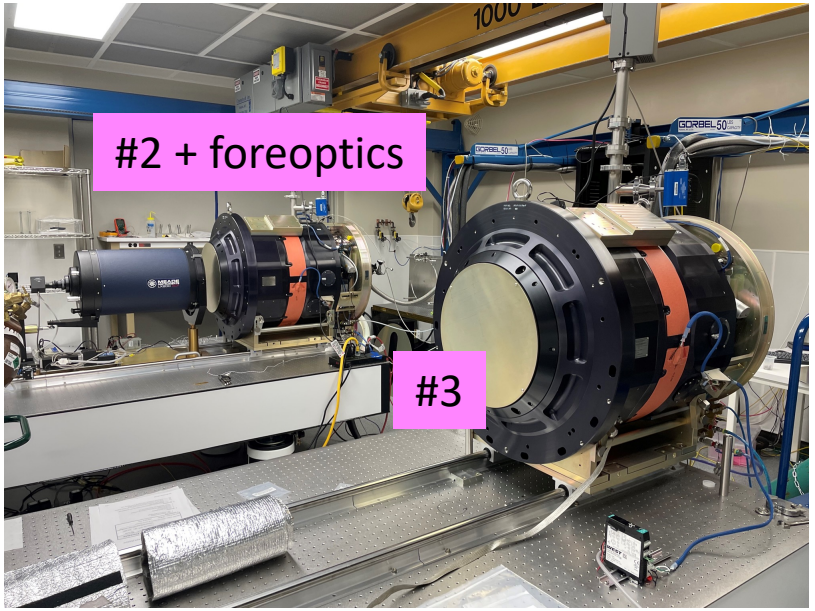
Ensquared energy at various emission lines along through focus

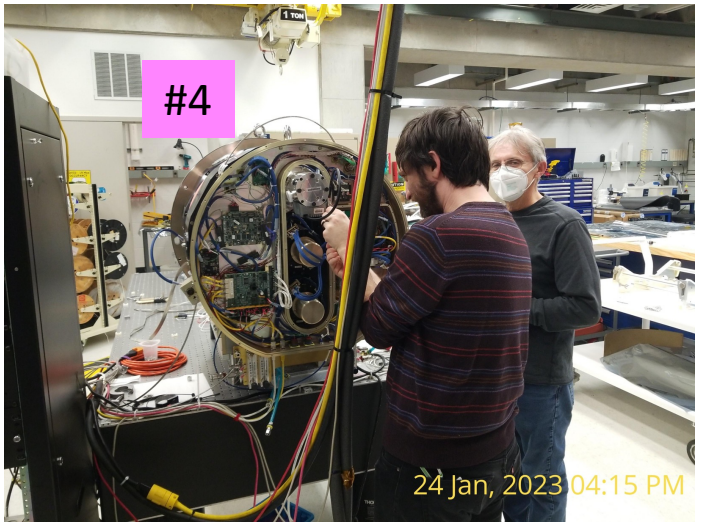


Visible camera under metrology

NIR Cameras #2,#3, #4 (N2-4) at JHU

- N2:
  - Image quality and thermal background have been conformed good.
  - Scattered light test is underway.
- N3:
  - Image quality check is ongoing. So far so good.
  - Thermal background measurement is ongoing.
- N4:
  - The cryostat assembly is nearly done to start pumping for tests.
  - The detector characterization is ongoing in the test dewar.
- **Near-term goal is to deliver N2 to Subaru in March.**





Preparations for open-use observation operation

The main site of discussion and development is the Observation processing ("***Obsproc***") WG.

Framework

- Mechanisms of proposal submission
- Processes to support time allocation
- Digesting accepted proposals into observation schedules
- Rules and policies for e.g. classical & queue modes, program's priority, filler, ToO, etc.
- Documentation

Infrastructure

- PFS Pointing Planner (PPP)
- Queue scheduler
- Selection of calibration stars & sky "objects"
- Target database
- Target duplication checker
- pfsDesign file generator
- Completion rate tracker
- Online tools such as PPP & ETC

Engineering observations

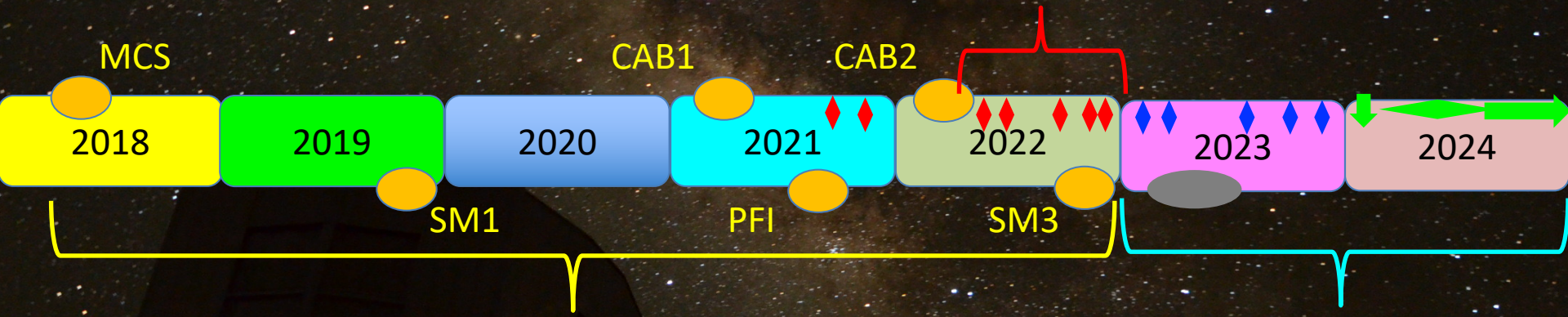
- Characterizing the instrument
- Maximizing observation efficiency
- Implementing required book-keeping

PFS lineup at this Users Meeting

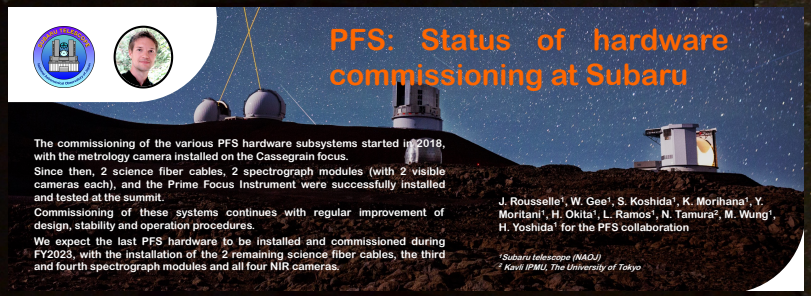
P07 by Shintaro Koshida (Subaru)

P07: Summary of PFS Engineering Observations in FY 2022

Shintaro Koshida, Yuki Moritani (Subaru Telescope/NAOJ), Naoyuki Tamura (Kavli IPMU), Robert Lupton, Craig Loomis, Arnaud Le Fur, Hassan Siddiqui (Princeton University), Chi-Hung Yan, Jennifer Karr (ASIAA), Hiroshige Yoshida, Satoshi Kawanomoto, Yuhei Takagi, Akira Arai, Eric Jeschke, Masato Onodera (Subaru Telescope/NAOJ), Kiyoto Yabe (Kavli IPMU), and PFS Collaboration



P08 by Julien Rousselle (Subaru)



P03 by Miho N. Ishigaki (NAOJ)

The selection of spectrophotometric standards for PFS observations based on PanStarrs1 and Gaia

Miho N. Ishigaki, Masayuki Tanaka, Masato Onodera, Wanqiu He, Yuki Moritani (NAOJ), Kiyoto Yabe, Naoyuki Tamura (Kavli IPMU), PFS obsproc working group members

P02 by Wanqiu He (NAOJ)

[p02] PFS Pointing Planner (PPP): optimal tiling algorithm for PFS open-use programs

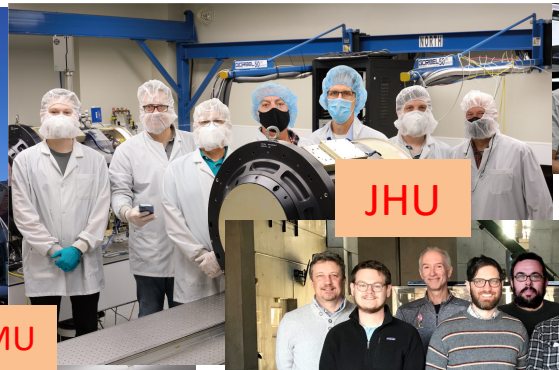
Wanqiu He, Masayuki Tanaka, Miho N. Ishigaki, Masato Onodera (NAOJ) & obsproc member

The discussion session later today
by Pyo (+ Tanaka, Onodera, Takagi) and Oguri.

HUGE thanks to ***all hard TEAM WORKs***

(Apologies to many people missed on the photos ...)

Subaru, Princeton, ASIAA, IPMU



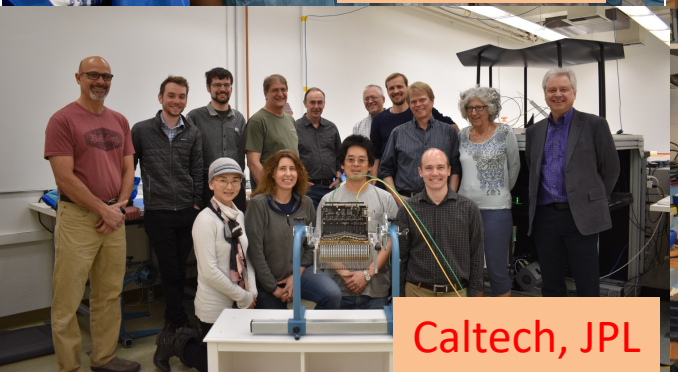
JHU

NAOJ, IPMU

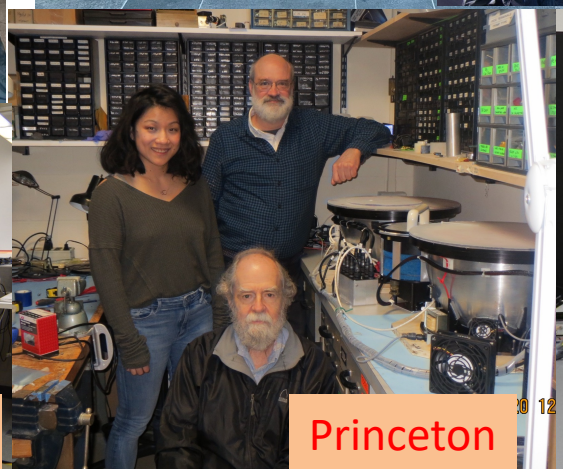
LAM

LAM & Subaru

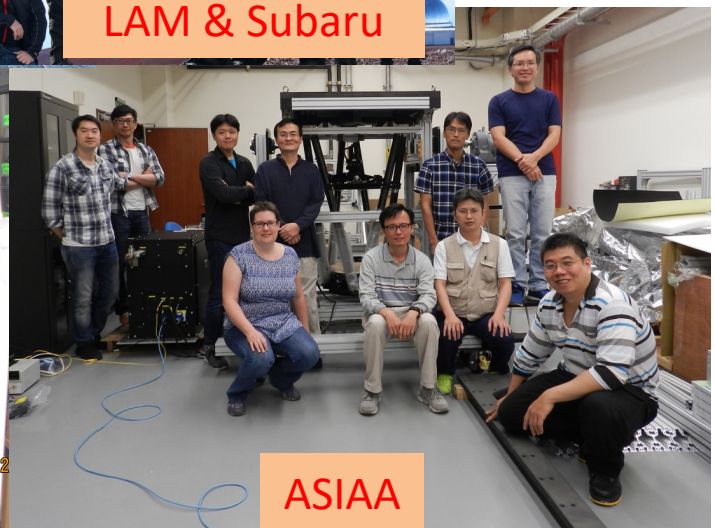
LNA (Brazil)



Caltech, JPL



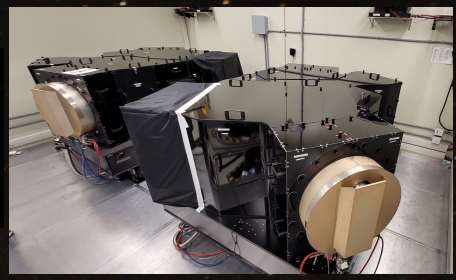
Princeton

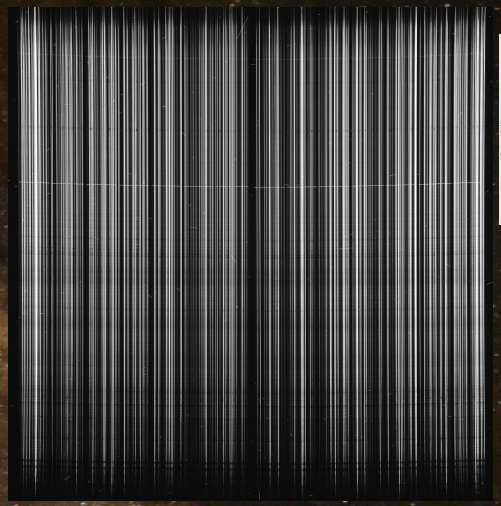


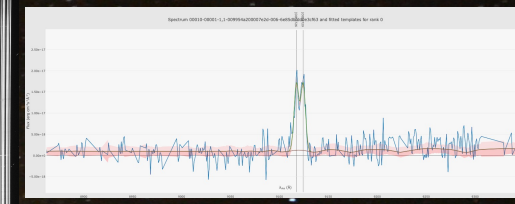
ASIAA

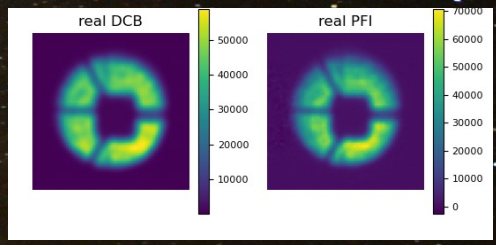
PFS instrumentation is now on the home stretch.

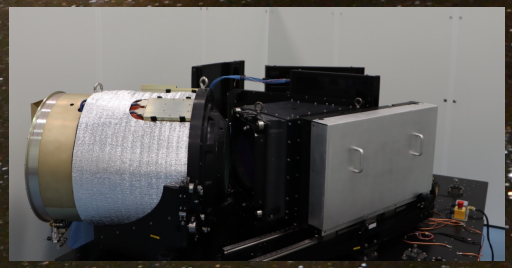
- Engineering observations
  - Engineering First Light in Sep 2022
  - Fiber positioning accuracy is getting better. Minimizing the systematic errors that dominate the accuracy is next priority.
- Ongoing hardware development
  - SM2 is being tested at LAM with the NIR camera. 3 other NIR cameras are being tested at JHU.
- Timeline
  - Installing Cable B3/B4 on the telescope next week/late Mar.
  - Aiming to install 1-2 NIR cameras by mid April, and the rest of SpS in June-July.
    - NIR first light in the April run.
    - 1st run with the full hardware in July.
  - Open-use readiness review in Jan 2024 for science operation from S24B.

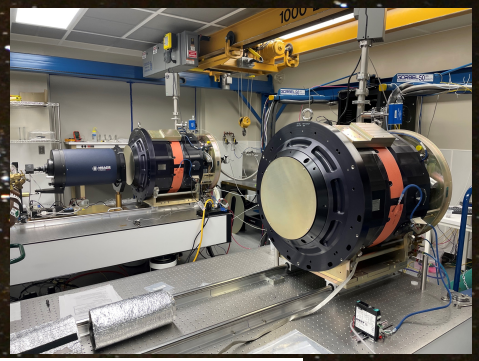












- ✓ Official web site - https://pfs.ipmu.jp/
- ✓ Membership registration - https://pfs.ipmu.jp/research/regist_collab.html
- ✓ Blog - https://pfs.ipmu.jp/blog/
- ✓ Instagram - https://www.instagram.com/pfs_collaboration/