SUBARU PRIME FOCUS SPECTROGRAPH

PFS - Project status report

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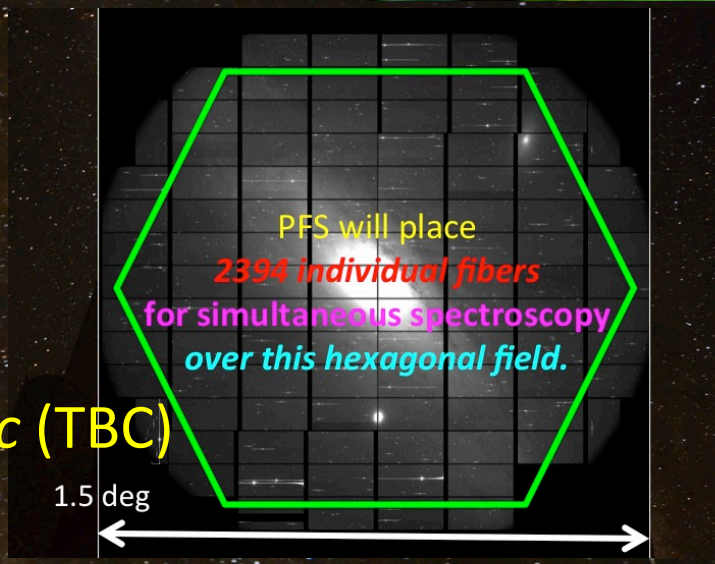
Subaru Users Meeting FY2017, Jan 17-19, 2018 JST

PFS - Fast facts

- Subaru *Prime Focus Spectrograph*:
  The spectroscopy part of the "SuMIRe" project.
  - Wide field: *~1.3 deg* diameter
  - High multiplicity: *2394 fibers*
    - Fiber diameter: ~1.05 arcsec
    - Fiber positioner pitch: ~85 arcsec
    - Minimum fiber separation: ~30 arcsec
  - Quick fiber reconfiguration: *~60-120 sec* (TBC)
    - *Dynamic* survey strategy is allowed.
  - VIS-NIR coverage: *380-1260nm simultaneously*
    - Low resolution mode: ~2.5 A resolution
    - Medium resolution mode (around 800nm): ~1.6 A resolution



- Aiming at start of science operation & survey program in *2021, as a facility instrument on Subaru Telescope.*

The *growing* PFS collaboration

rs in Japan & other 6 countries are co-
nent development & survey planning.

Dec 2014, Taipei

Dec 2015, Marseille

2016

Dec 2016, Baltimore

2015

sities is
now in the formal process of participation.

PFS collaboration meeting

- The last one was the 9th meeting.
- 5 days from Nov 27 to Dec 1, at Kavli IPMU.
- ~130 participants (cf. ~80 for the last few times)

PFS subsystems distribution

Software system

Spectrograph system (SpS)

On the TUE floor
(IR side)

4 spectrographs

Fiber cable

Fiber connectors

Fiber cable

Prime Focus Instrument

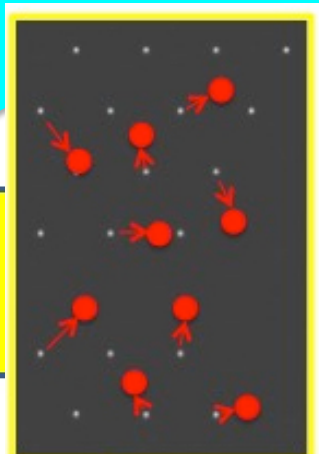
Wide-field corrector

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

Calibration system

This takes an image of the prime focus with the fibers "backlit" and measure their current positions*: Key part of iterative fiber positioning process.*

Metrology camera as a Cassegrain instrument



Subaru Telescope

Procurement of key elements

- All 2550 Cobras were delivered.
- All science-grade CCDs and H4RGs were delivered.
  - Detailed characterization is ongoing.
- 3x red and 2x blue dichroic coatings were completed.
  - The rest is in progress being off a critical path.
- Thermal cutoff coating is still taking time.
  - Difficulties have been mainly programmatic.
  - Found a good design. Now tests are underway.

Modularity in the instrument

- Fiber positioner system made of 42 “Cobra” modules

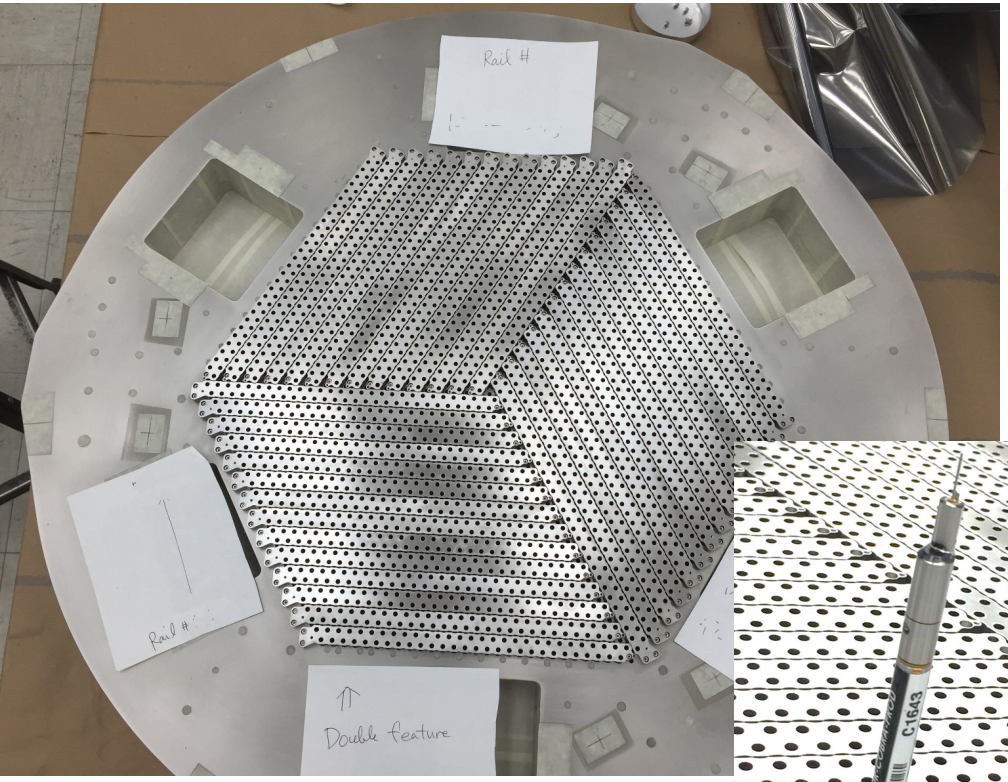
  “Engineering module” → 44 production modules
  - including 2 spares
  - The first production module is a spare.

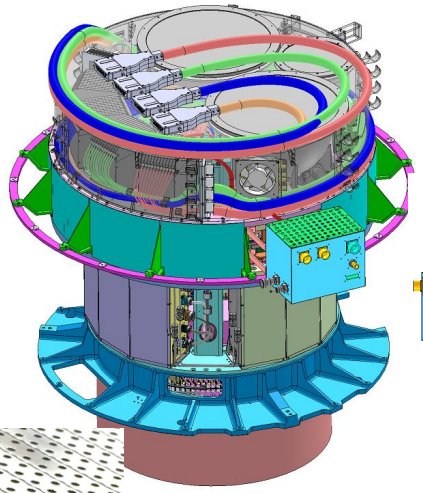
- Spectrograph system made of 4 modules

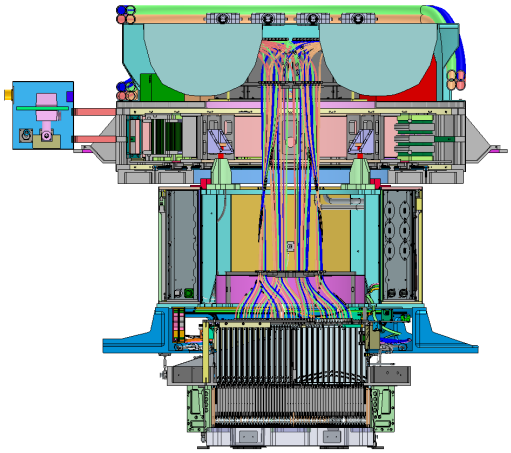
  “One channel” →
  - Spectrograph Module (SM) #1
  - SM #2
  - SM #3
  - SM #4

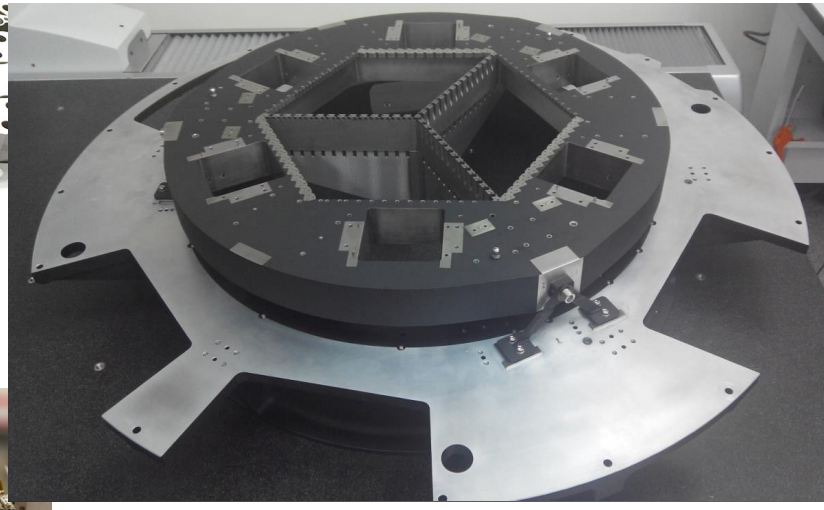
Validation of the first “module” is a key milestone.

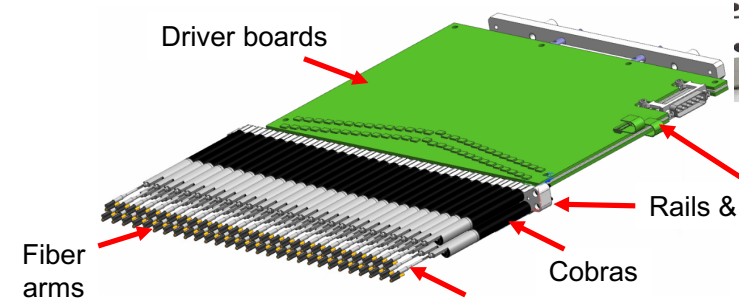
Prime Focus Instrument (PFI)

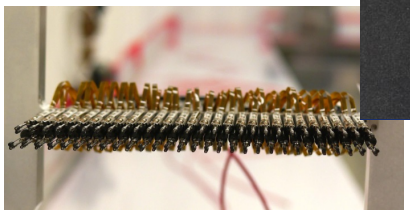








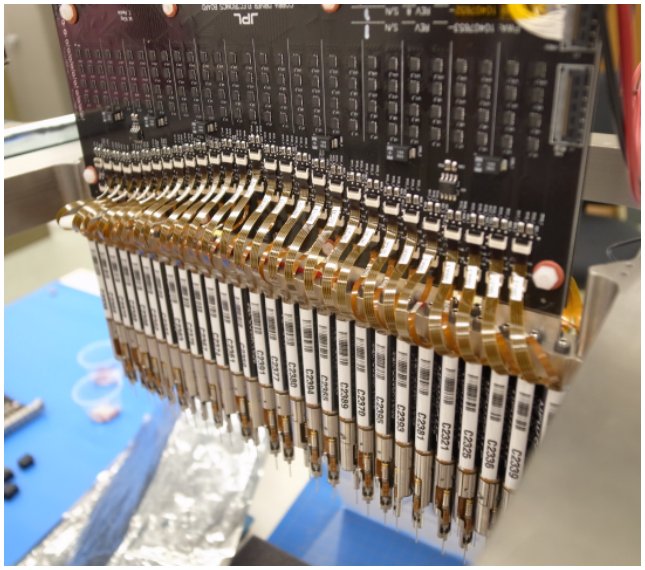


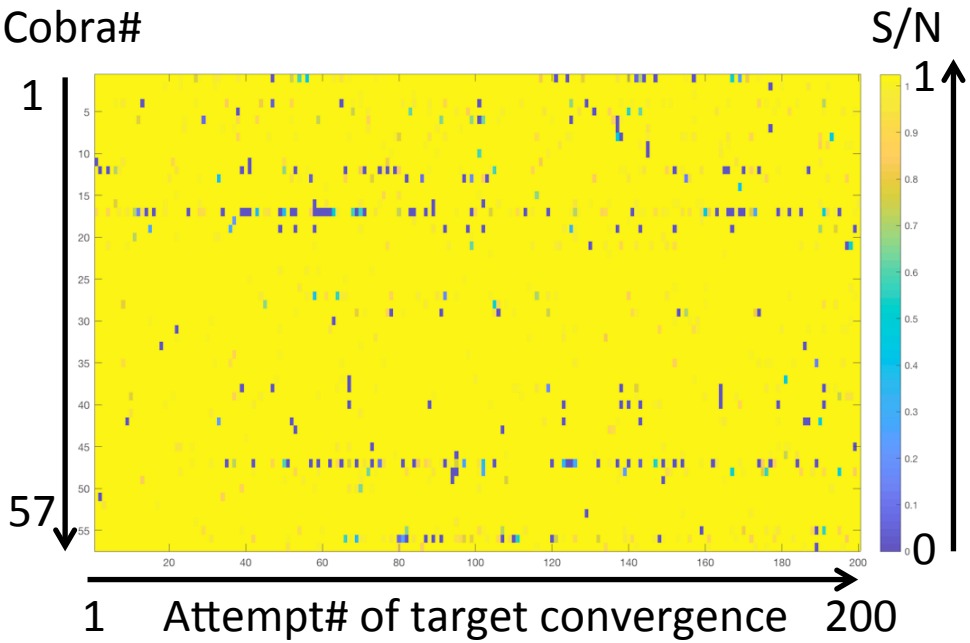


All parts are on-hand for assembly of all 44 Cobra modules

Prime Focus Instrument (PFI)

- The 1st Cobra module integration & test will be completed soon!





This will be delivered to ASIAA soon.

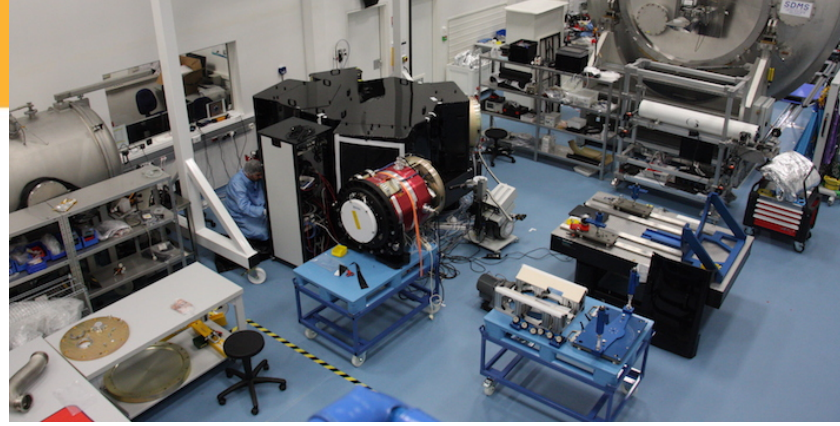
- There was a delay of several months:
  - Cobra driver electronics design flaws
  - Electronics firmware trouble shooting

Gross [JPL]

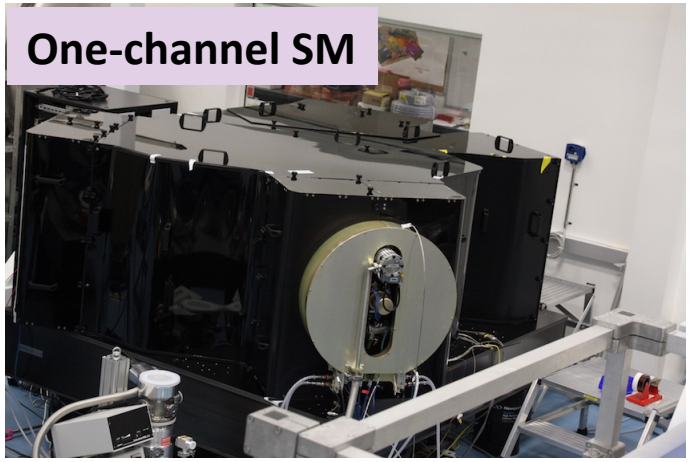
Wang [ASIAA]

- The assembled PFI mechanical parts (Positioner Frame & Cobra optical bench) deflect differently from expected.

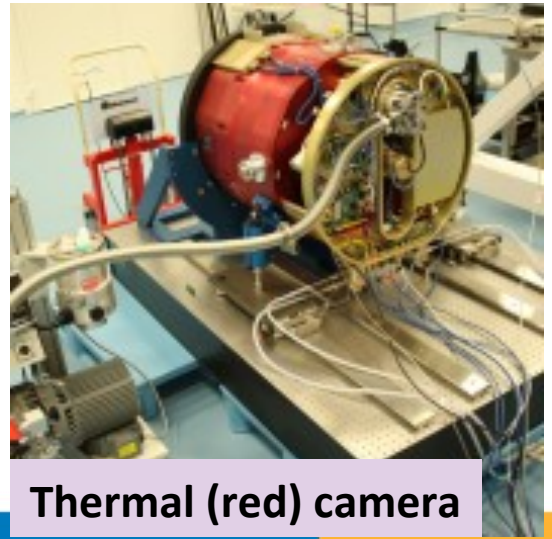
CONFIGURATION AT LAM



- **Red One-channel equipped with <u>OPTICAL CAMERA</u> and CCDs, used to**
  - perform optical alignment, validate I&T procedures
  - investigate and measure optical performance
  - investigate and debug optical issues: straylight, scattered light
  - Validate ICS AIT tools

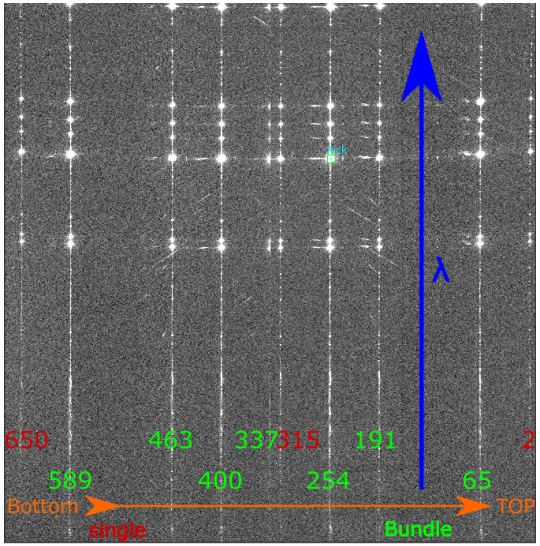


- **Red <u>THERMAL CAMERA</u> equipped with dummy CCDs, used to**
  - test & validate the thermal hardware configuration
  - validate the baking procedure
  - validate the thermal performance in operations



A TYPICAL RED IMAGE

- HgAr arc lamp
- 630 to 970 nm
- 10 science fibers
- 2s exposure
- typical image used for alignment and testing – minimal DRP



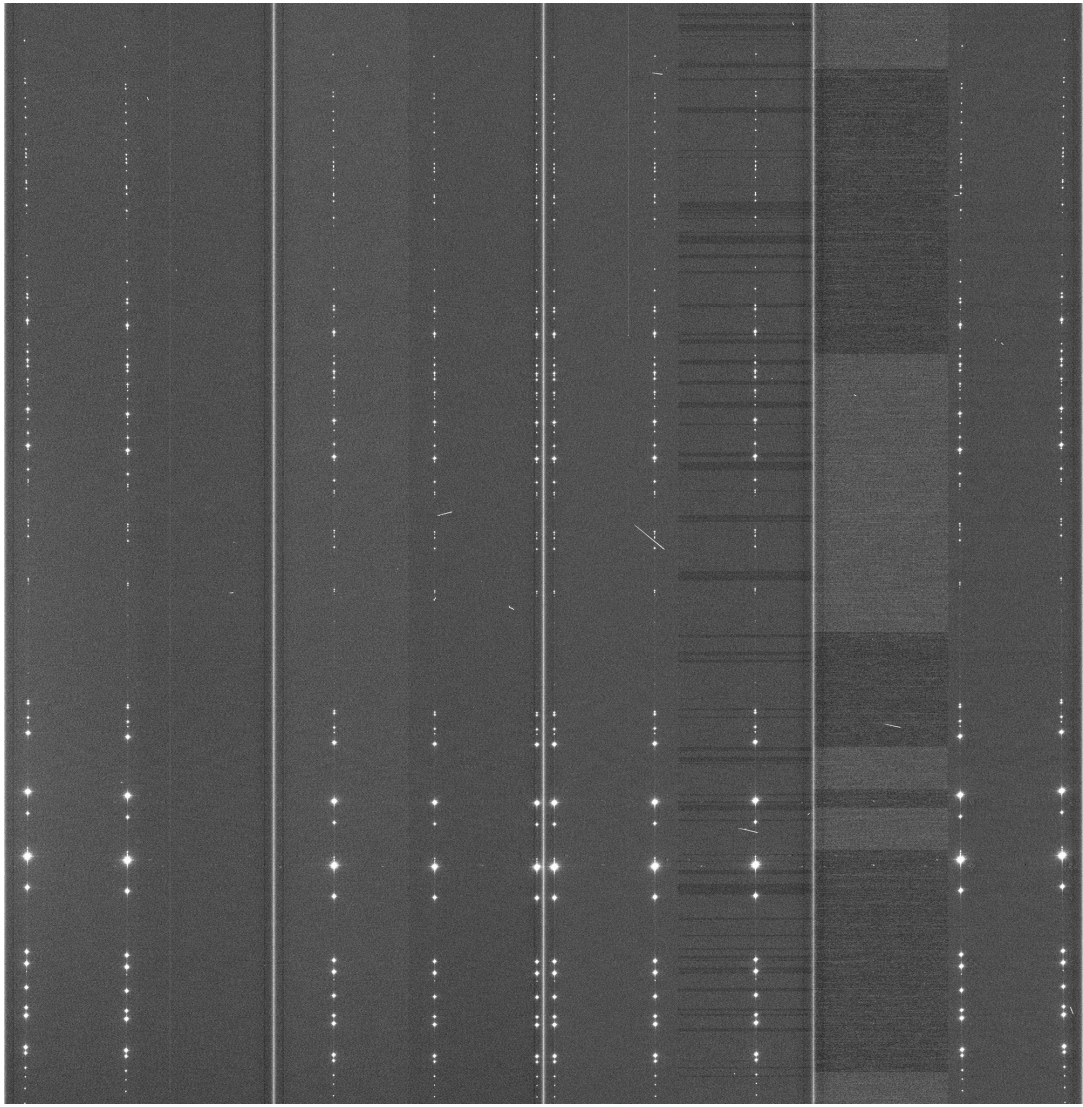
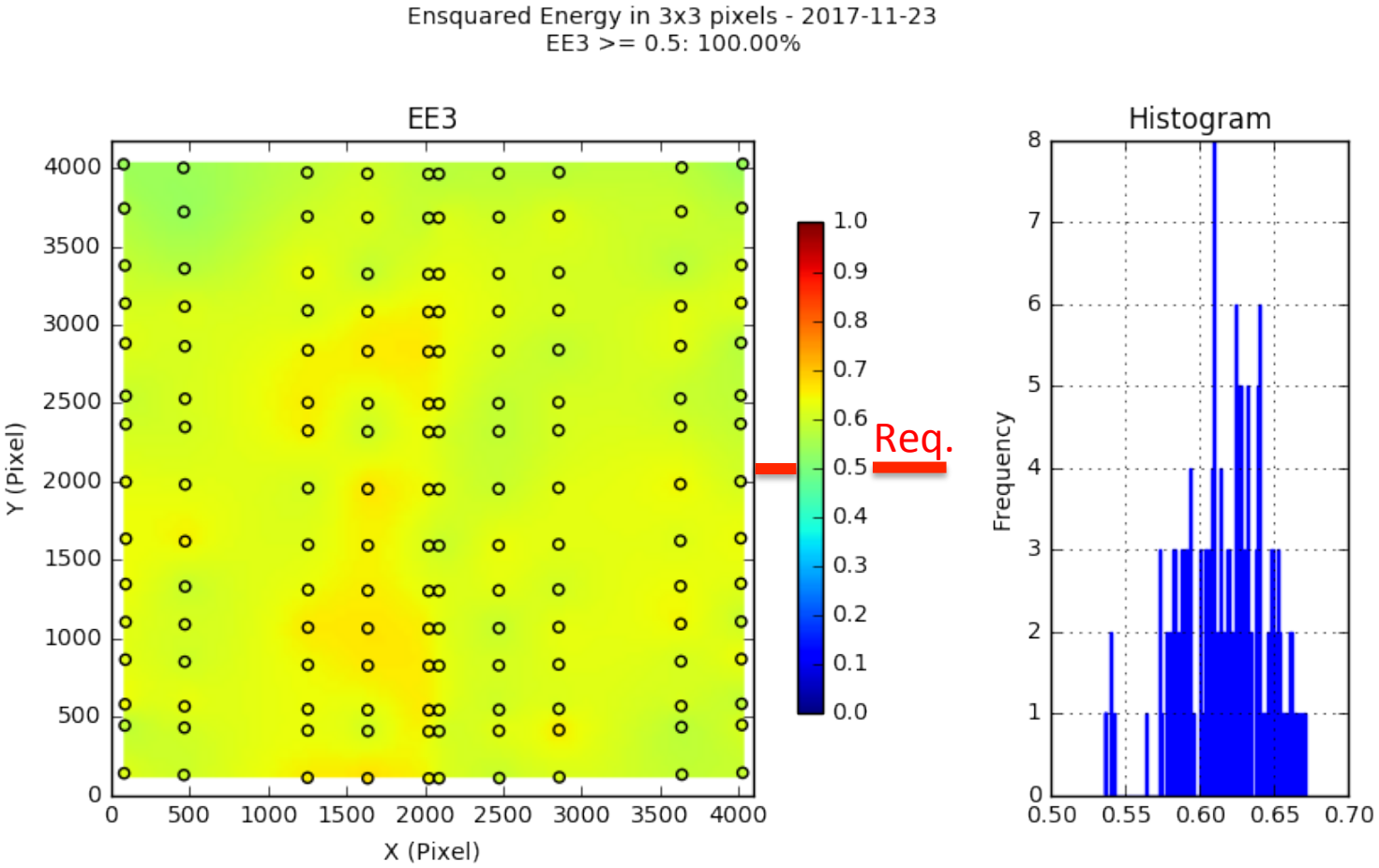


IMAGE QUALITY – ENSQUARED ENERGY IN 3X3 PIXELS

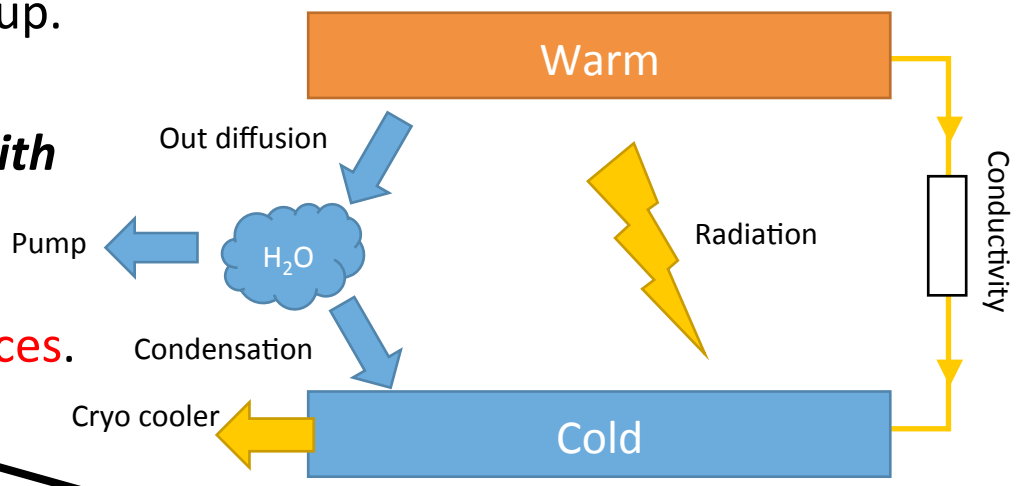


Meets the requirements

**Thanks Fabrice Madec for the slides

Major topics specific to camera dewar

- Problem about ***thermal performance***: Very briefly:
  - To keep the temperature low, the cooler power has to slowly drifts up.
  - From a number of experiments & discussions (including ***a review with external experts***), we conclude that this is due to condensation of ice on cold surfaces.
  - Minimizing contamination
    → (Medium-)hot bake
  - Minimizing maintenance for long operation
    → Automated "regeneration" proedure



Now under much better control

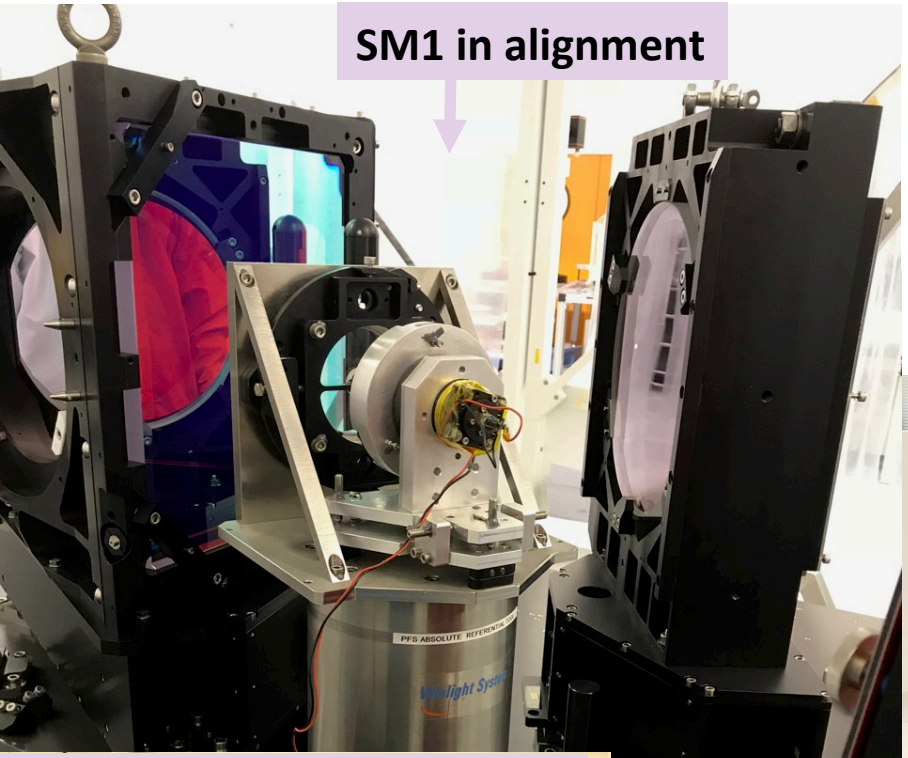
- Trying to improve/accelerate:
  - Quality control of cables and electronics.

- ***NIR camera production, integration & test.***

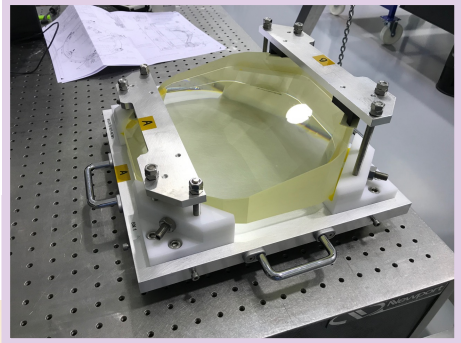
Dewar performance test at 5 degC

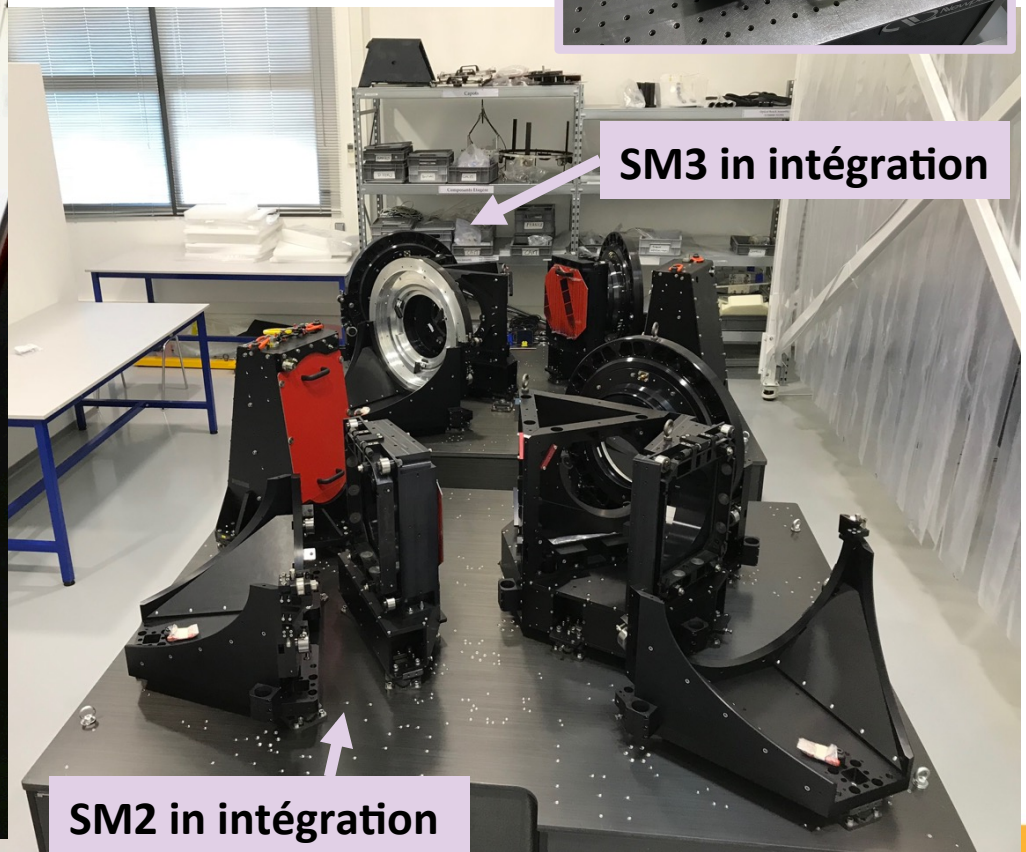
Cf. Production dewar has got updated a lot.

PROGRESS AT WINLIGHT SYSTEM (2/2)

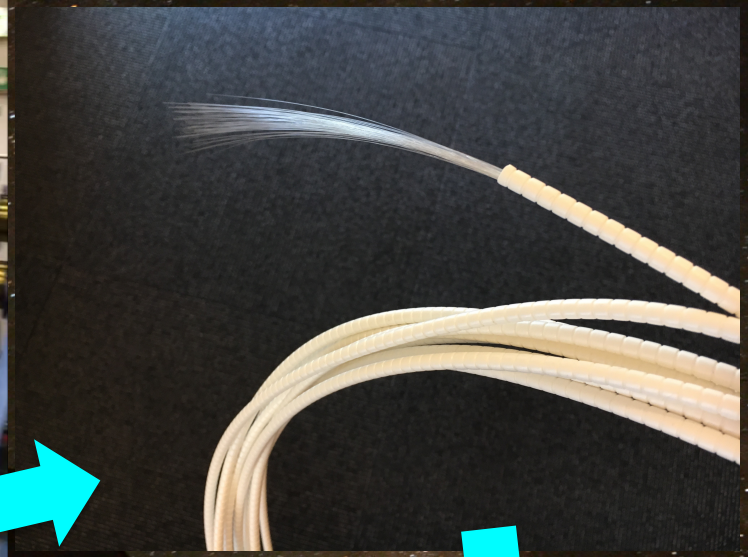


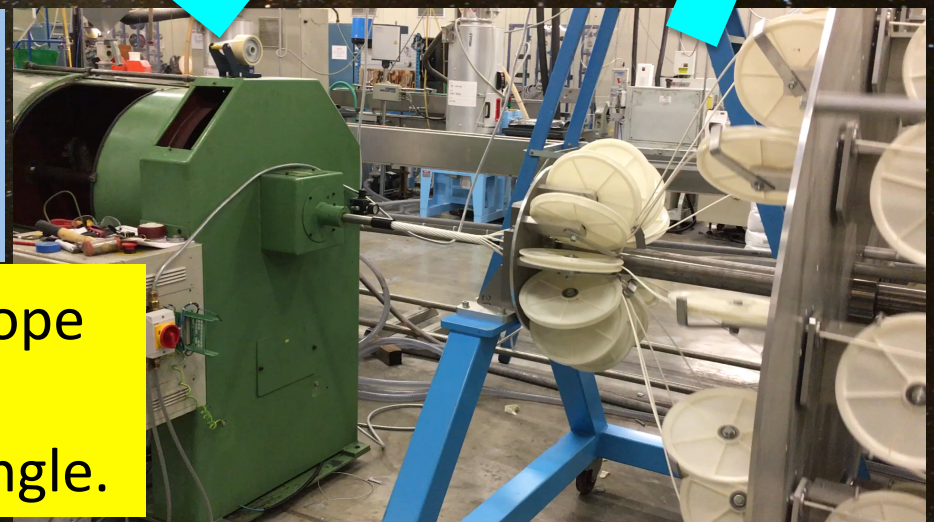
Winlight System





Prototype on-telescope fiber cable





Same design principle as FMOS:

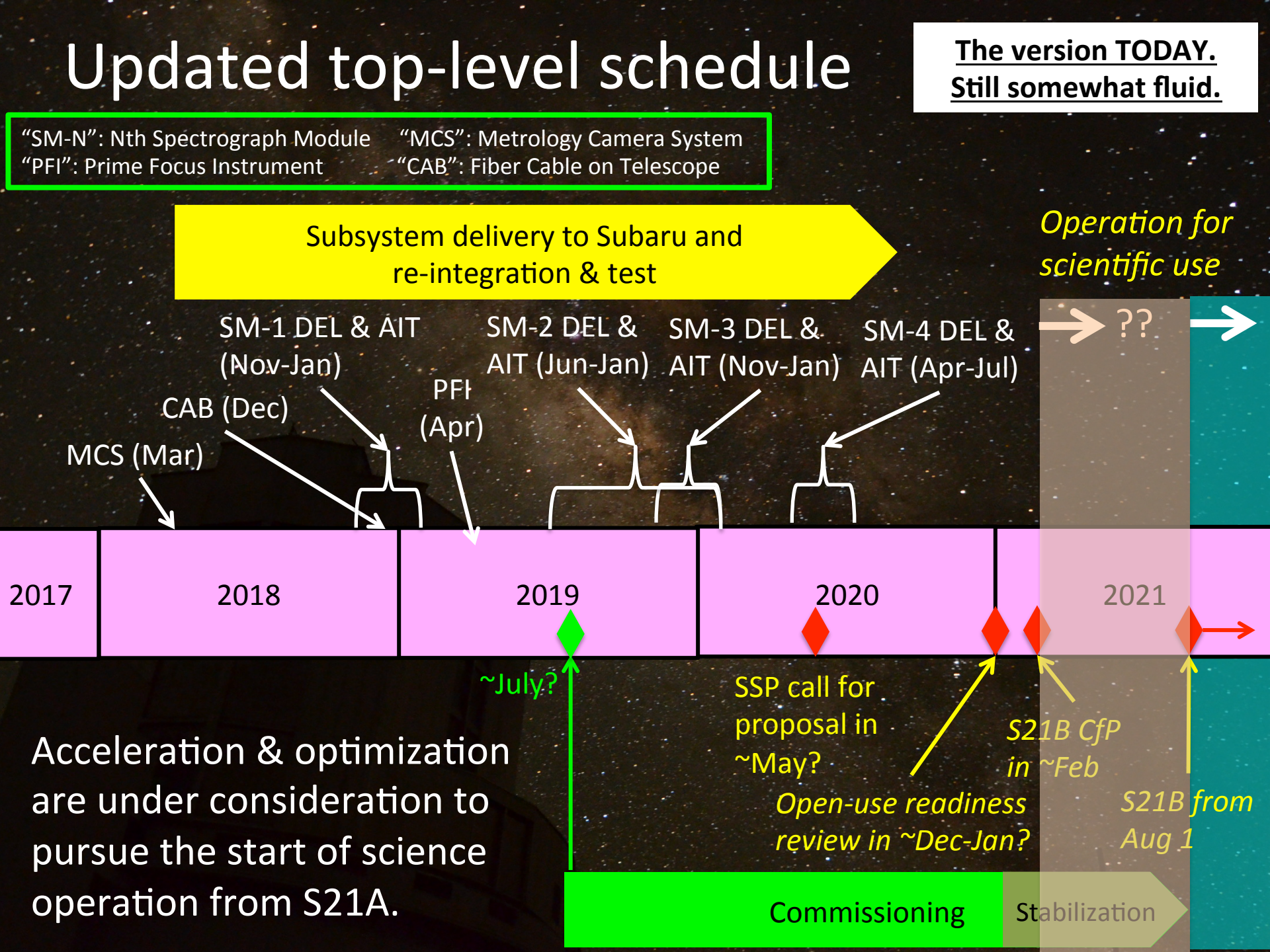
- Fibers are tension free
- No race tracking effect

The will be installed to the telescope soon. FRD will be measured as a function of telescope elevation angle.

Updated top-level schedule

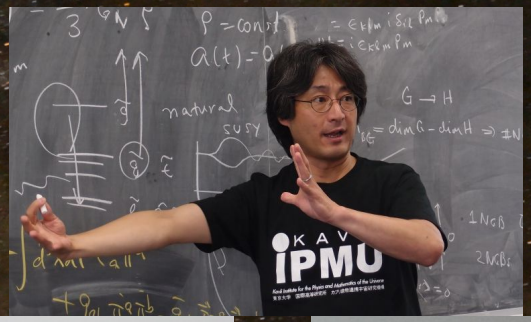
The version TODAY.
Still somewhat fluid.

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



Acceleration & optimization are under consideration to pursue the start of science operation from S21A.

PFS is a perfect suite for *Panoramas of the Evolving Cosmos*



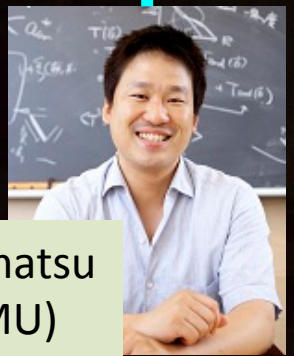
Hitoshi Murayama
[Kavli IPMU director,
PFS project PI]

Masahiro Takada
[Kavli IPMU]

Richard Ellis
[UCL]

Science working group co-chairs

Cosmology



Eiichiro Komatsu
(MPA/IPMU)

Galaxy/AGN
evolution

Jenny Greene (Princeton)

Galactic
Archaeology

Masashi Chiba
(Tohoku U.)

PFS science meeting

- Updated proposals of survey components *were critically reviewed by the "red team"* in June 2017.
- Strategies for improvements were discussed in the 3-day meeting (Aug 7-9) at MPA, Garching.

Yabe (IPMU)

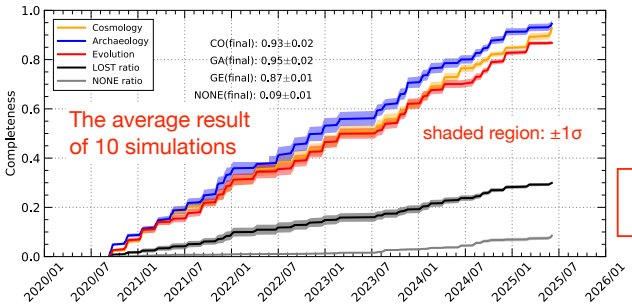
Survey simulation (by survey coagulation team)

Sunayama (IPMU)

Hayashi (NAOJ)

Ishigaki (IPMU)

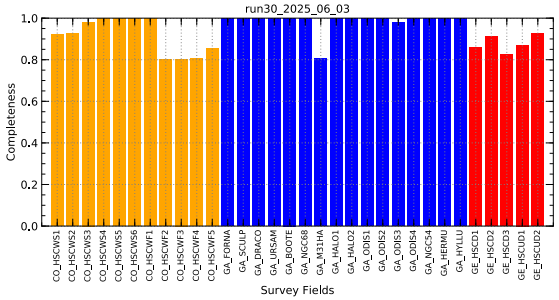
PFS SSP survey completeness:



We can achieve ~90% completeness

End-to-end (i.e. from fiber allocation to data QA) to see the possible completeness of each survey.

[Definition] Completeness: the number of *completed* hours over the *available CLEAR* hours (=517 hours)



Low completeness in a part of "CO fall fields", "GA M31", "GE XMM-LSS and DEEP23" because they are in crowded R.A.

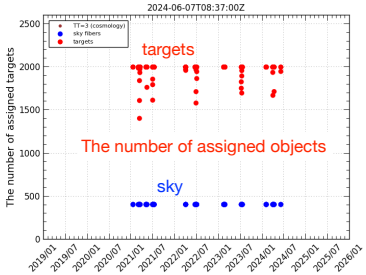
Scheduling all SSP nights to see how survey components fit together with high completeness.

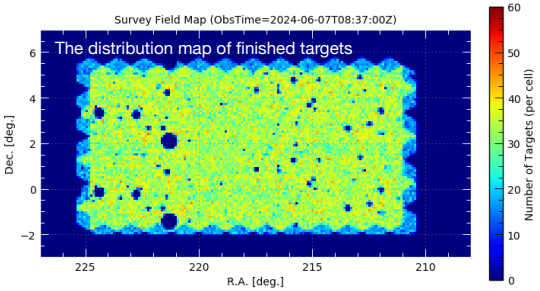
End-to-end simulation: cosmology

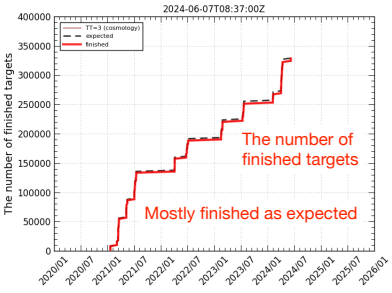
A simple case: Cosmology survey ...

We assume that we use 400 sky fibers

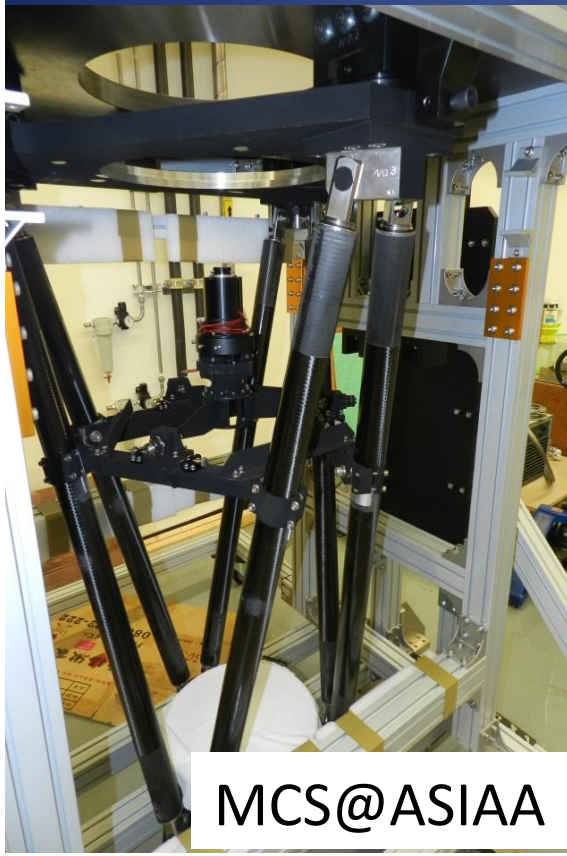
- HSC-wide GAMA15H (α=210-225 deg., δ=-2-+6 deg.)
- Mosaicking using existing data
- Selection is based on the previous criteria (Takada+14)
- An end-to-end simulation according to the simulated schedule presented in page 6-8
- 168 tiles to cover each place twice (2 visits)
- The total coverage is ~105 deg²
- The survey will be basically completed as expected







Summary


MCS@ASIAA

- Updates in the collaboration:
  - Still growing → The financial situation has improved a lot.
- Technical updates:
  - The first "module" is coming to completion: Although there were delays (so the science start is now envisioned in 2021), they are certainly technically meaningful.
  - Metrology camera system (MCS) will be the subsystem delivered to Subaru (~Mar-Apr is being pursued).
- Updates in the science team:
  - Optimization of the survey plan is ongoing with critical review & discussions and detailed survey simulations.
  - Participation of "Japanese" colleagues are encouraged.

PFS special session on Mar 14-15 at the ASJ spring meeting.