2014 Jan 21 Subaru Users Meeting @ NAOJ Mitaka

Prime Focus Spectrograph – Progress Report –

Hajime Sugai (Project office; Kavli IPMU (WPI))

Events after Subaru UM 2013 Jan

0. PFS Overivew

1. Project Preliminary Design Review in 2013 Feb

(2. 4th (2013 Mar: Hongo) & 5th (2013 Nov: Sao Paulo) Collaboration Meetings)

3. PFS Management Review by NAOJ in 2013 Apr

3.1. From “Summary of PFS project review by NAOJ”

3.2. My visits on management issues

4. Subsystem Reviews

4.1. ASIAA PFI Subsystem Review in 2013 Sep

4.2. Winlight “One spectrograph” CDR in 2013 Nov

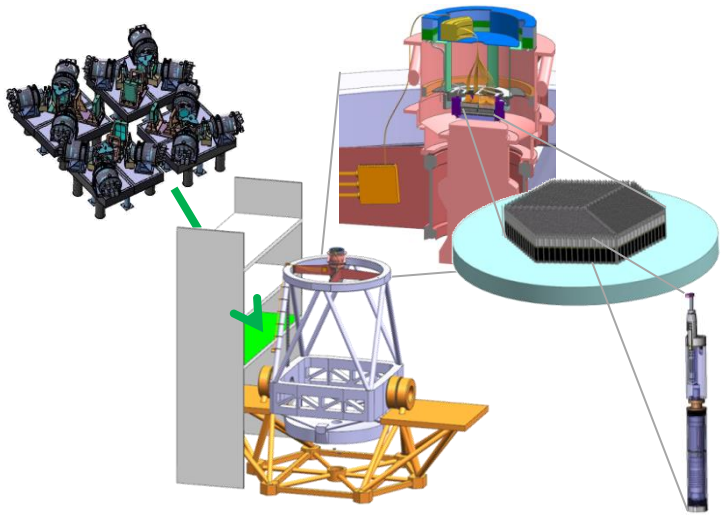
5. Technical Updates

5.1. Tradeoff Studies & Decisions

- Fiber selection
- Metrology Cam aperture

5.2. Present Status of Construction

6. Timescale of Project

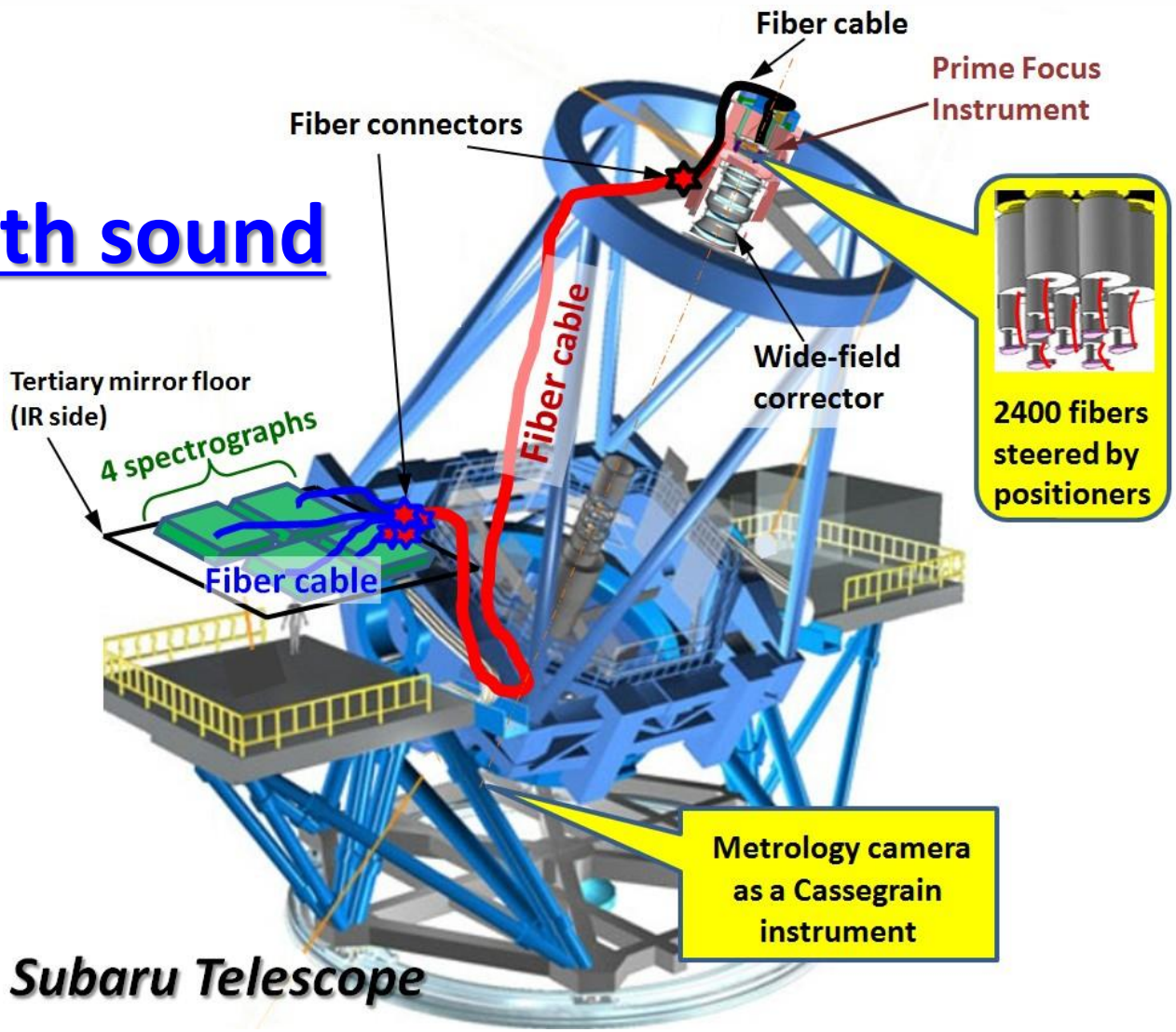


0. Prime Focus Spectrograph Overview

0. How the system works

movie

movie with sound



0. Basic Parameters

Optical + NIR Multi-object fiber spectrograph

- Number of fibers: 2400
  600 per module X 4 Spectrograph modules

- Fiber core diameter 128μm
  Microlens attached to fiber input edge
  fiber input F/2.2 -> F/2.8 (1".1 diameter per fiber)

- Field of view: 1.3 deg
- Wavelength: 0.38 - 1.26 μm

0. Basic Parameters

Optical + NIR Multi-object fiber spectrograph

- Each spectrograph module: 3-color-arm design

Arm	Coverage[A]	Resolution[$\lambda/\delta\lambda$]	
Blue	3800 - 6400	2500	
Red	6400 - 9550	3200	(cf. Medium resolution mode)
NIR	9550-12600	4500	

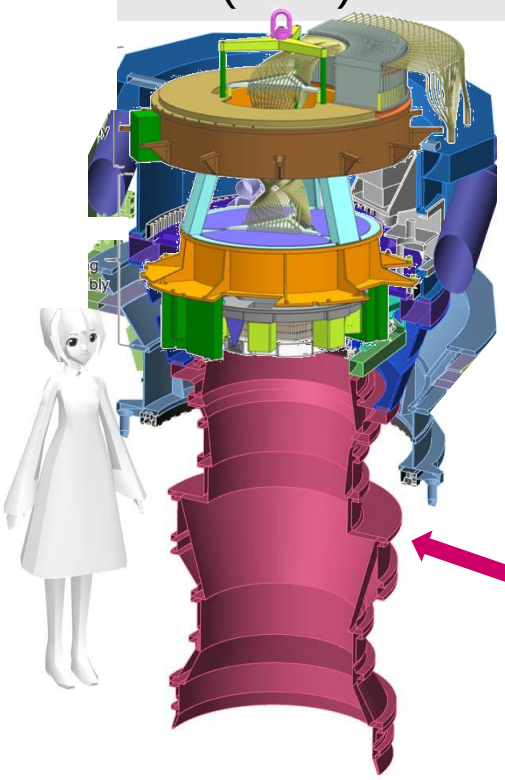
Spectrograph collimator F/2.5, camera F/1.1

Detector pixel 15μm (2Kx4K x 2 FDCCDs for each Blue/Red arm,
4Kx4K HgCdTe(1.7μm cutoff) for NIR arm)

Sharing Wide Field Corrector with HSC

Prime Focus Spectr. (PFS)

(HSC)



PFS case:

Optical interface with Wide Field Corrector

Field element

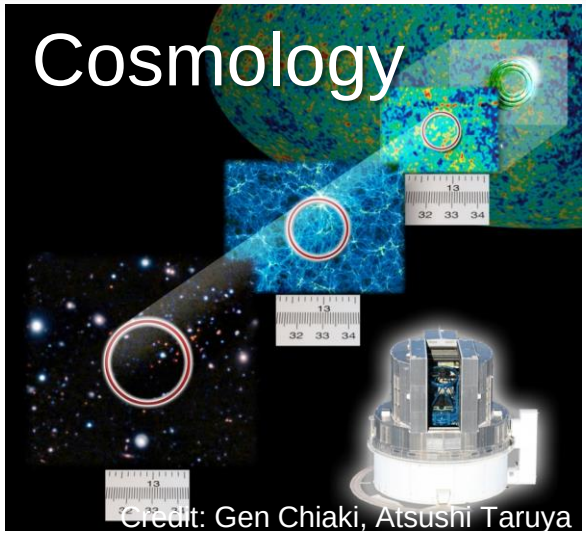
= 54-mm thickness flat plate

substitutes for filter + dewar window

Wide Field Corrector (WFC)

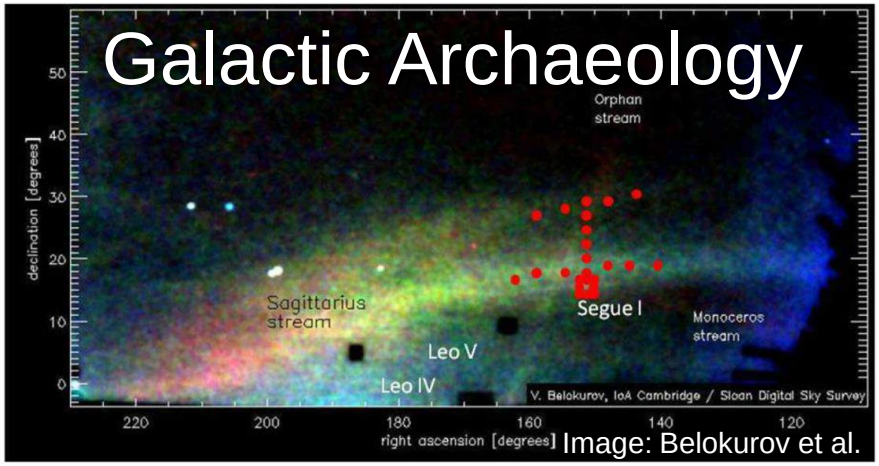
http://www.eso.org/sci/facilities/eelt/fp7-elt-pub/wfi_workshop/pdffile/SMiyazaki.pdf

0. Science targets

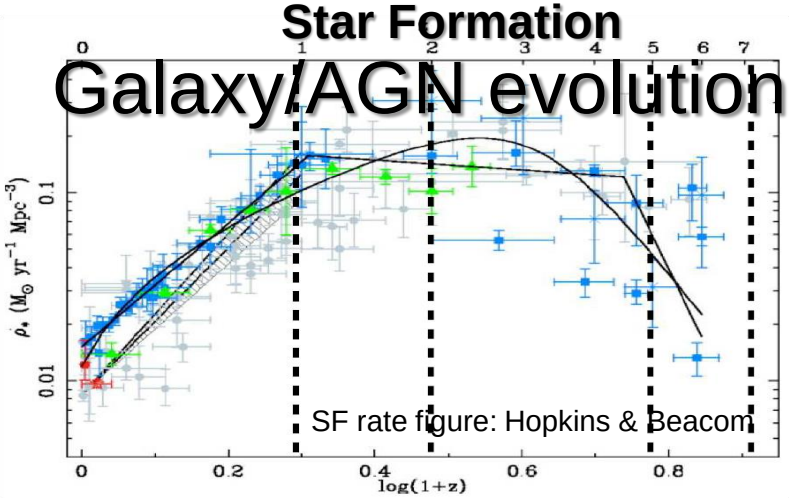


9.3 h^{-3} Gpc^3 in 0.8<z<2.4
1400 deg^2
Dark Energy
Test General Relativity

Milky Way 17<V<21.5 390 deg^2
M31halo 21.5<V<22.5 65 deg^2
Dark Matter



1<z<2 16 deg^2 to J_{AB}~23.4
Chemical Evolution
Star Formation



1. PDR panel report

1. **Membership**

Ray Sharples (Durham University, Chair)
David Crampton (HIA/NRC)
Tomonori Usuda (NAOJ)
Hermine Schnetler (UK ATC)
Masashi Hazumi (KEK)
John Wilson (University of Virginia)

1. PDR panel report

4. General Comments

- The Panel commends the project on the excellent **progress** it has made since the start of the PDR phase in March 2012 and its response to issues raised in the Panel CoDR report. These were addressed in both a formal written response and a presentation at the PDR meeting.

- PFS has an extremely strong and compelling **science case** which the Panel agrees has been enhanced by the addition of the medium resolution Galactic Archaeology case in the period since the CoDR. Whilst this mode is extremely desirable from a scientific perspective, the full impact in terms of cost and schedule needs to be assessed.

- The Panel did not identify any significant major concerns in the **technical design** proposed for PFS, although there are clearly some areas of higher risk which are detailed below.

1. PDR panel report

4. General Comments

- The Panel continues to be impressed by the **strength and breadth** of the consortium partners, and its **enthusiasm** for the project, and believes that this will be key to the successful completion of this ambitious instrument.

- The Panel also appreciates the excellent job the project has done in building strong relationships with **key vendors**, which will smooth the procurement phases that begin immediately after PDR.

- Whilst there are clearly funding issues to be resolved, the Panel believes that the final $80M **cost** to completion, including contingency, presented at the meeting is a reasonable estimate at this stage of the project.

3. PFS Management Review by NAOJ in 2013 Apr

3.1. From “Summary of PFS project review by NAOJ”

3.2. My visits on management issues

3. PFS Management Review by NAOJ in 2013 Apr

2013 Apr 16-17 @ NAOJ Mitaka, Tokyo

from PFS:

Hitoshi Murayama,

Hajime Sugai, Naoyuki Tamura, Hiroshi Karoji, Atsushi Shimono

(Kavli IPMU (WPI))

Reviewers:

Hideki Takami (chair)

Hideyuki Kobayashi (NAOJ Vice Director General for finance)

Satoru Iguchi (ALMA-Japan Project Manager)

Tomonori Usuda (Associate Director, Subaru Telescope)

3.2. My visits on management issues

- Dewar & Detector management related issues

  2013 May 28-30:

  Visit to PU/JHU to discuss with

  Steve Smee, Jim Gunn, David Spergel, Tim Heckman.

- PFI I&T management related issues

  2013 Jul 09-10:

  Visit on Mark Schwochert (JPL/CIT).

  Discuss also with Mike Seiffert, Dan Reiley, Rich Dekany.

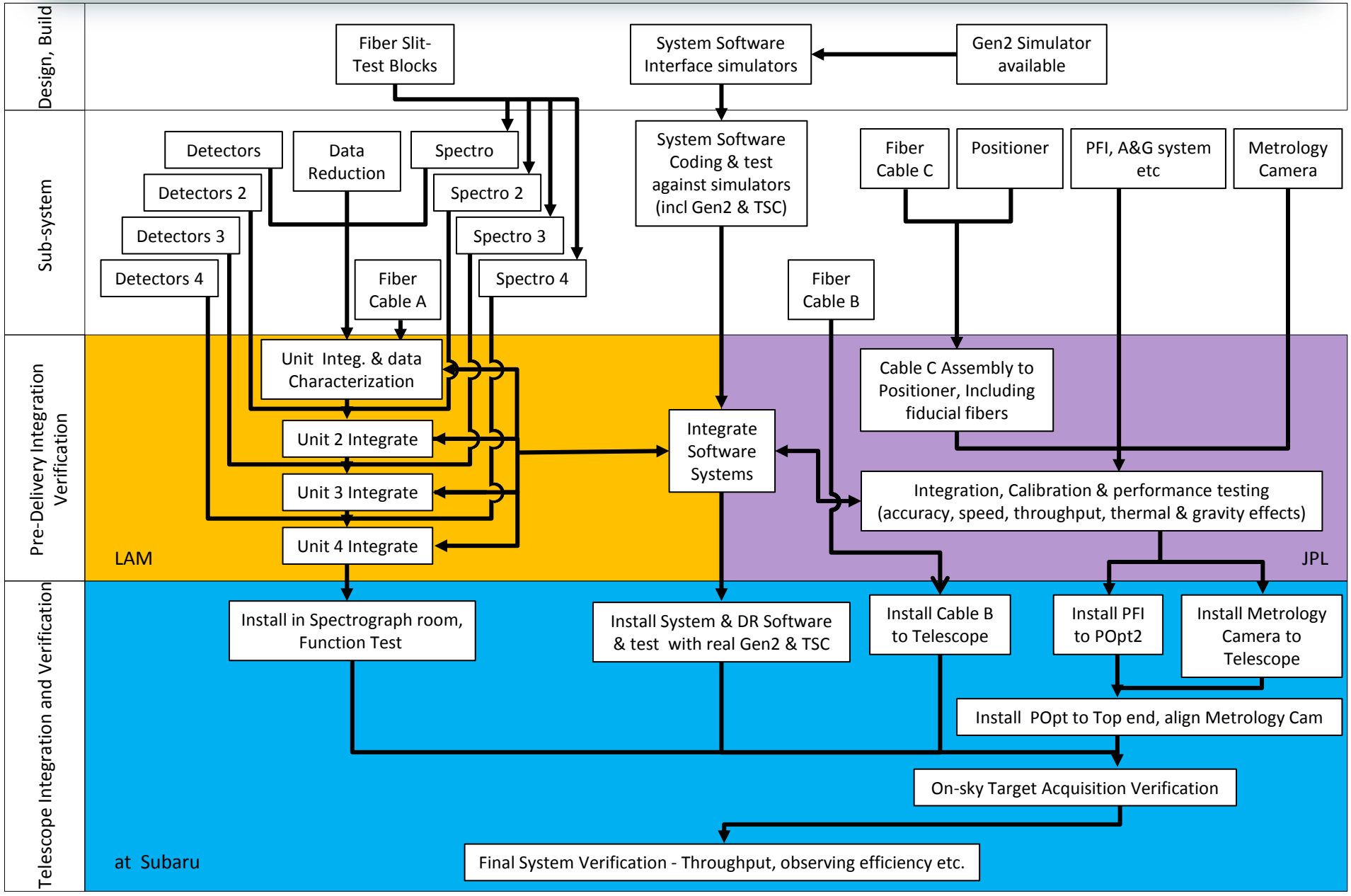
Reply to NAOJ has been submitted in 2013 Nov, including descriptions on **further fund raising efforts** & **new partner possibilities**.

4. Subsystem Reviews

4.1. PFI Mechanical (ASIAA) component PDR in 2013 Sep

4.2. WS One spectrograph CDR in 2013 Nov

Instrument integration & test flow



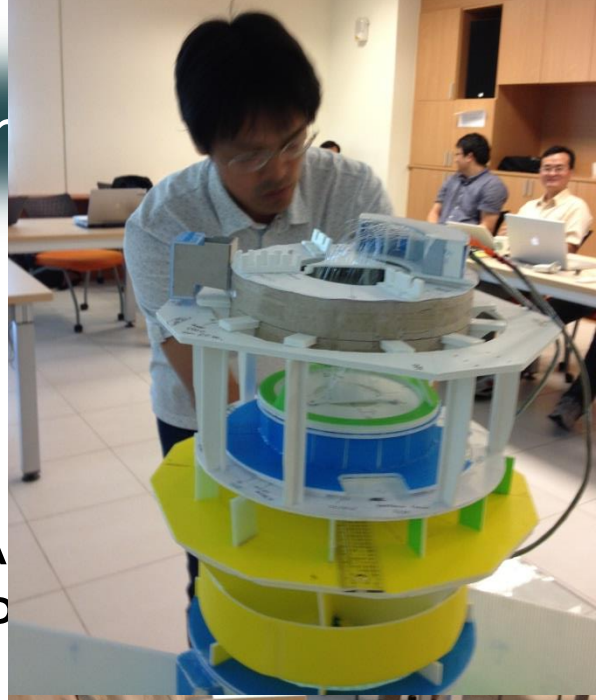
4.1. ASIAA PFI Subsystem Review in

2013 Sep 11(,12)

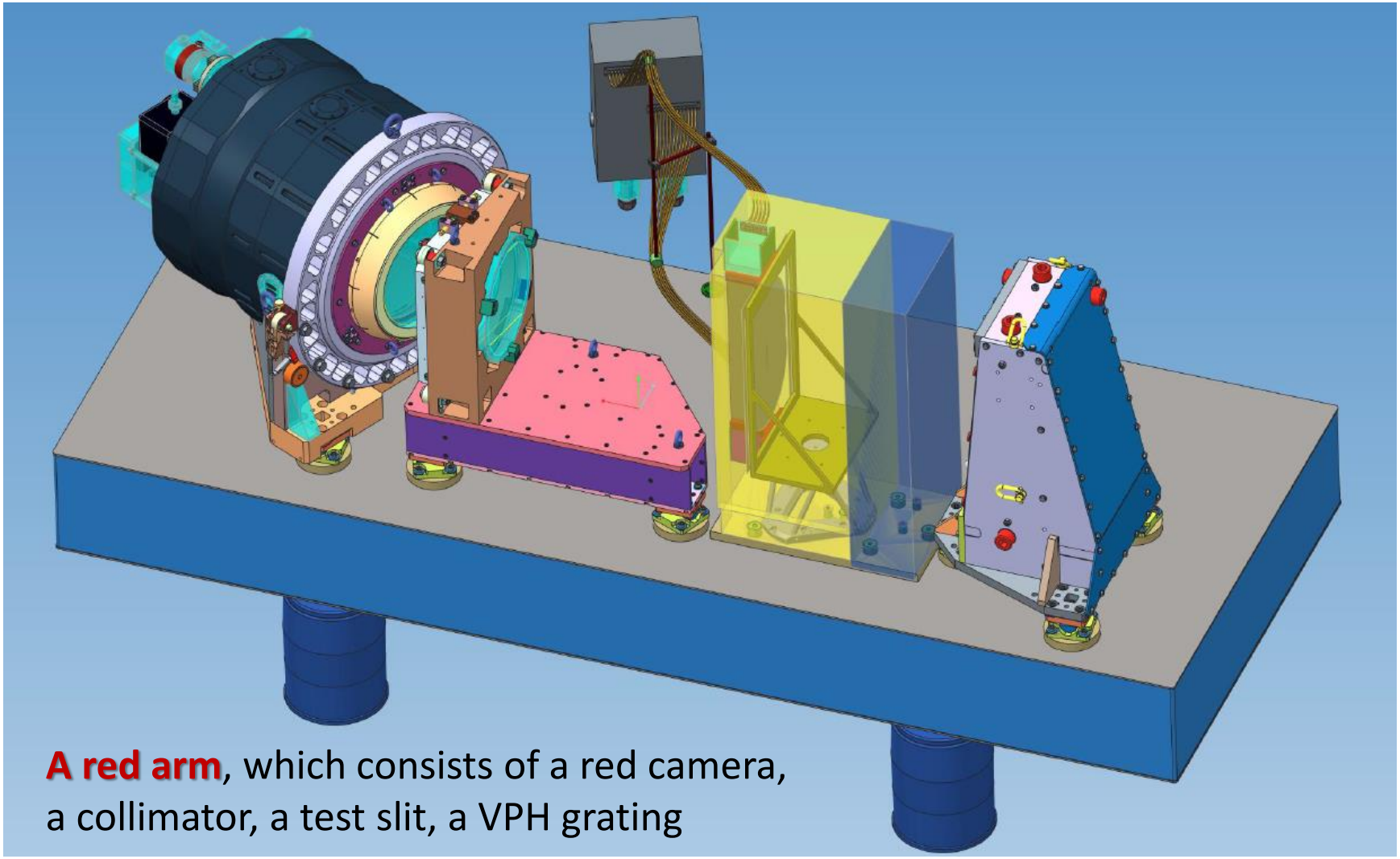
Reviewers:
Ted Huang (ASIAA: Chair)
Yutaka Komiyama, Naruhisa Takato (NA
Hajime Sugai, Atsushi Shimono (Kavli IP

PFI components transferred from JPL/CIT to ASIAA in 2012 Dec, i.e., right before the PFS project PDR.

Included:
Acquisition and Guiding Cameras
Fiducial Fiber illuminator
Field element and Dots
Cable wrap
Mechanical structure
PFI coolant system design



4.2. Winlight “One Spectrograph” CDR in 2013 Nov



A red arm, which consists of a red camera, a collimator, a test slit, a VPH grating

5. Technical Updates

5.1. Tradeoff Studies & Decisions

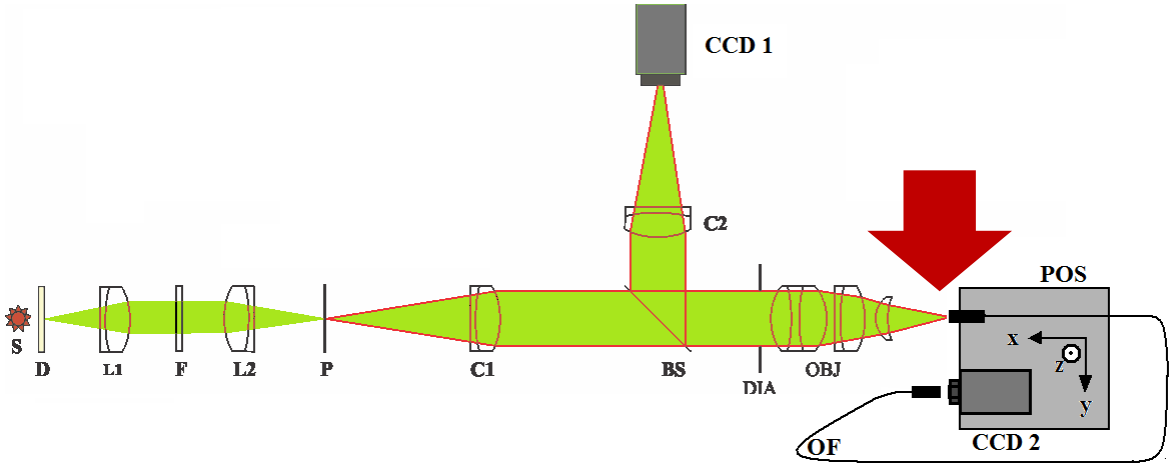
- Fiber selection: hybrid
- Metrology Camera aperture size

5.2. Present Status of Construction

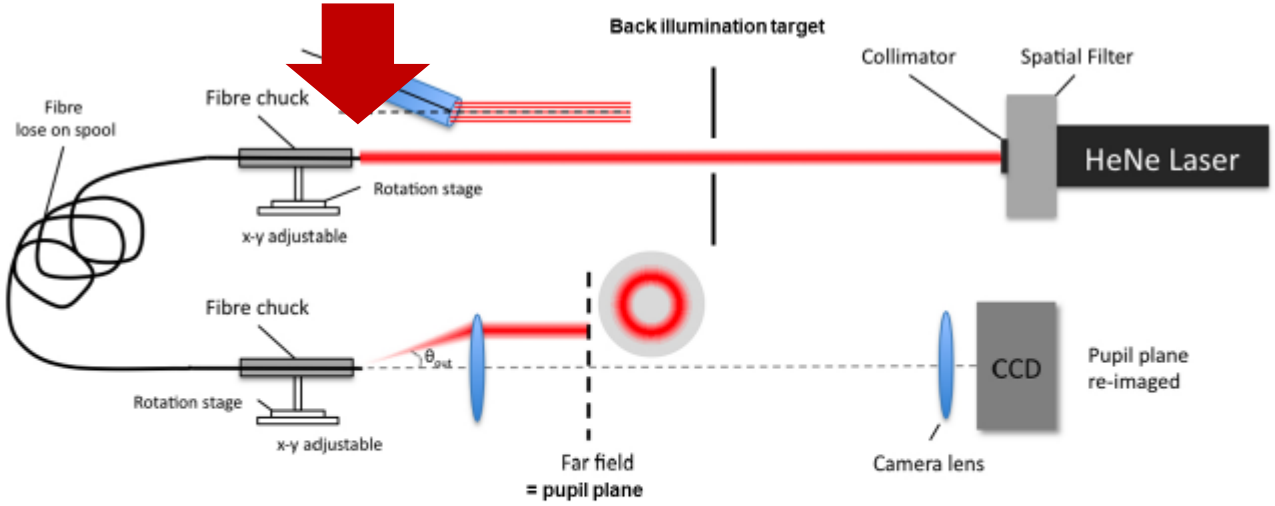
5.1. Tradeoff Studies & Decisions: Fiber selection

Careful investigations by using two kinds of methods (LNA; Durham Univ)

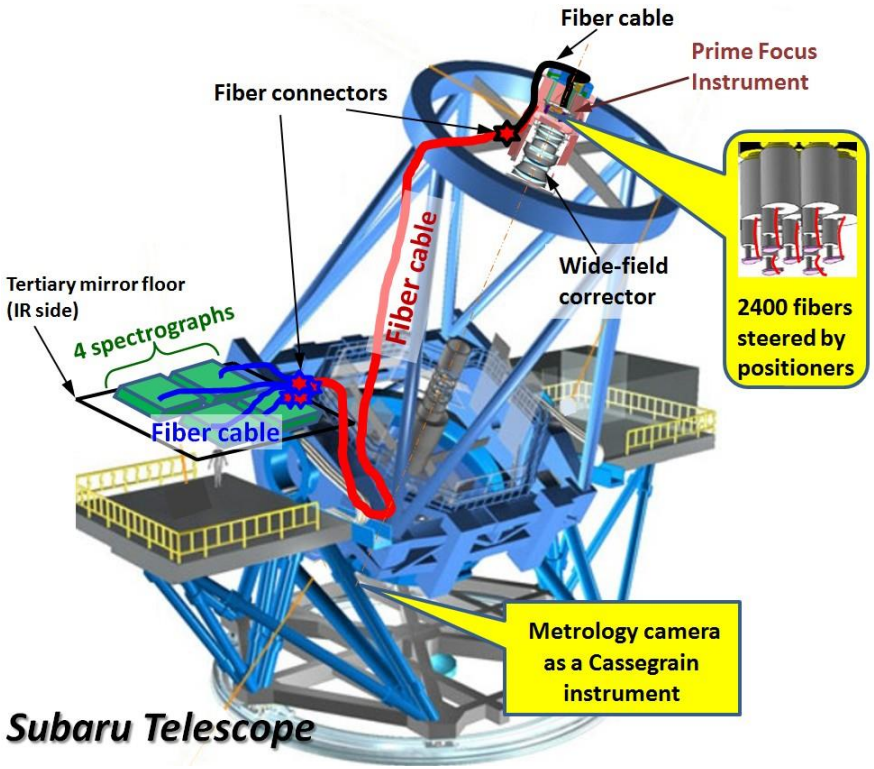
1st method: Inputting light with actual **F-ratio**



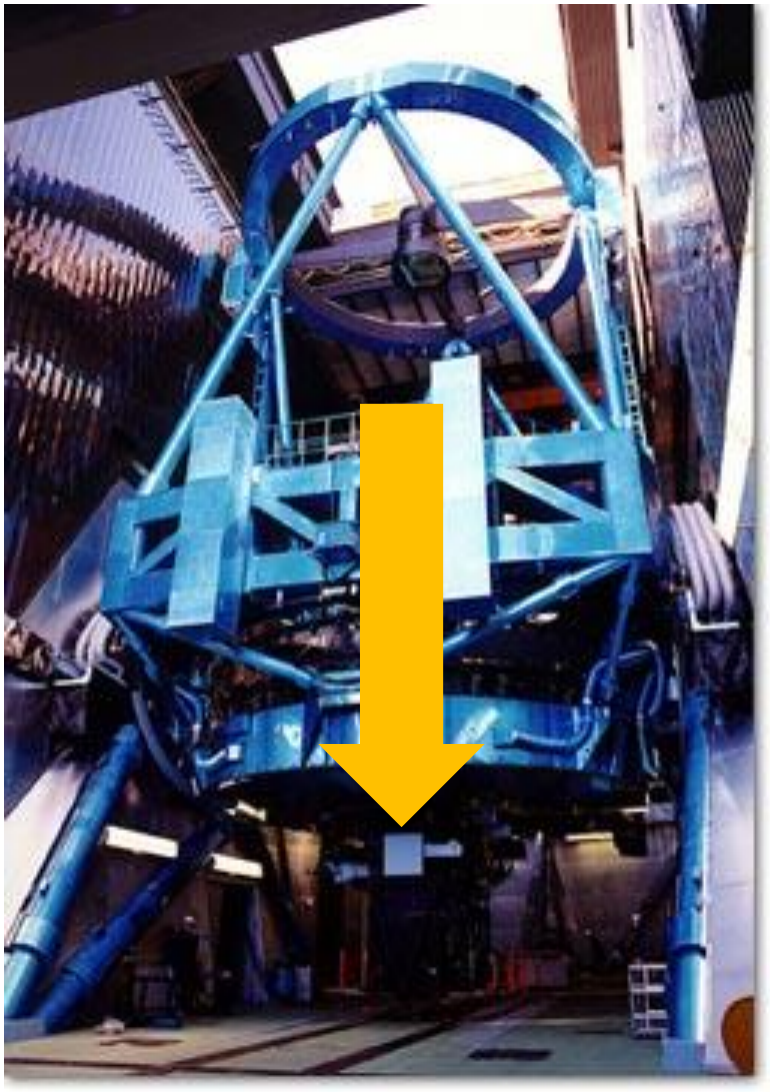
2nd method: Inputting **collimated** light with input angle scanned



5.1. Tradeoff Studies & Decisions: Fiber selection



Back-illuminated fiber observed by **metrology camera**



5.1. Tradeoff Studies & Decisions: Metrology Cam aperture

Careful considerations on effects of individual Wide Field Corrector lens surface shape errors on fiber position determination by Metrology Camera.

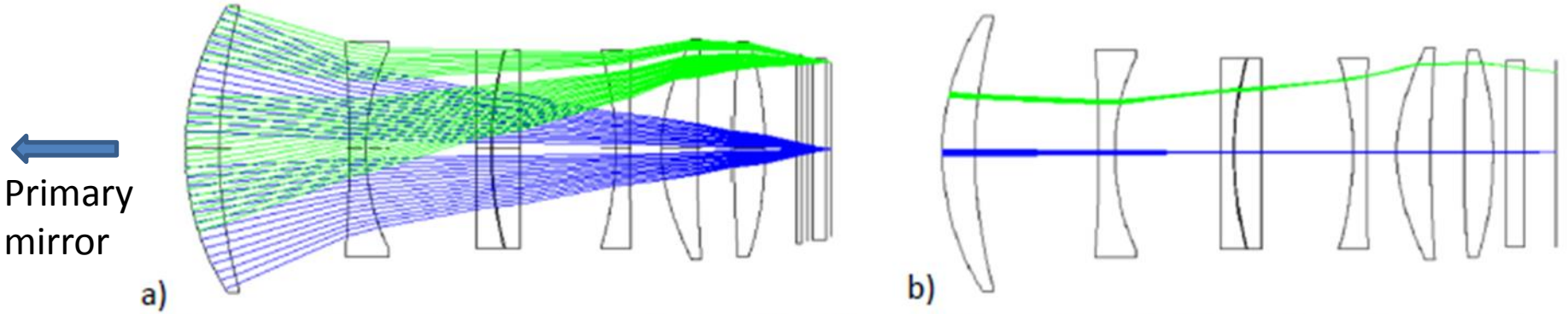


Figure 5: Schematic of the ray paths for a) the HSC and telescope, and b) the HSC and the metrology camera. Notice that the light captured by the metrology camera is only a thin pencil, and that this pencil has no overlap with the light collected by the primary mirror.

Taken from:
"Technical note: Errors in coordinate mapping from metrology camera to PFI plane" (Dan Reiley: 2012 October 30)

5.1. Tradeoff Studies & Decisions: Metrology Cam aperture

380mm aperture Metrology Camera optical design completed.
→ 2μm determination error.
Now cost issue being discussed.

Back-illuminated fibers

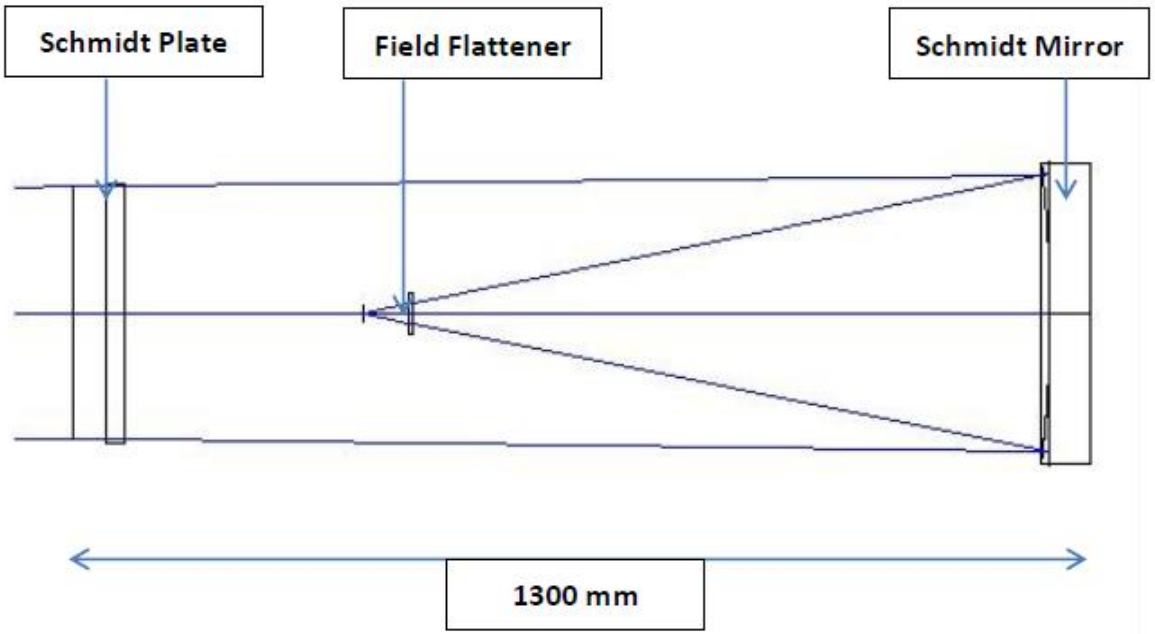


Figure 1. The layout of the 380mm metrology camera

Taken from:
"Design Study of Large Aperture Metrology Camera" (Shiang-Yu Wang: 2013 October)

Light from telescope through WFC & Field element to **microlens + fiber**

5.2. Present Status of Construction: Microlens at fiber entrance

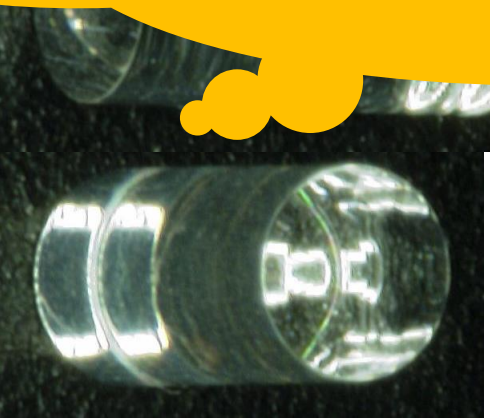
Transforms input f-ratio (F/2.2 → F/2.8)

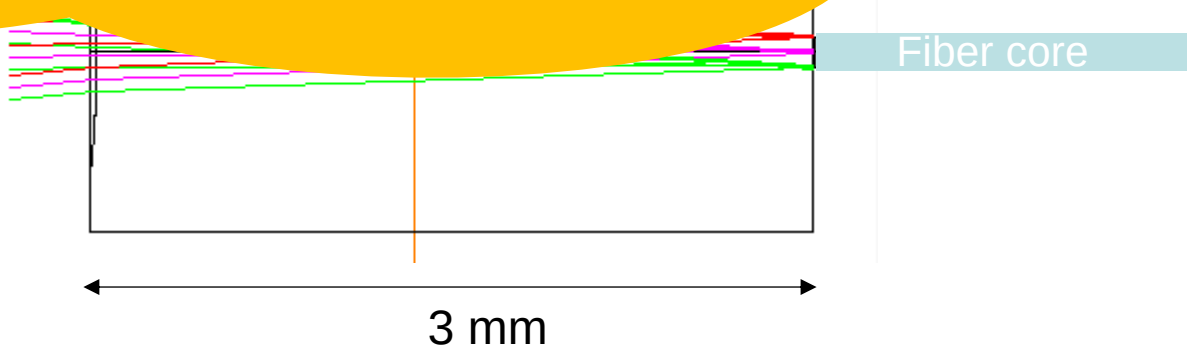
(1) to reduce light loss caused by over-filling acceptance angle of fiber

(2) to ease difficulties from retrograd

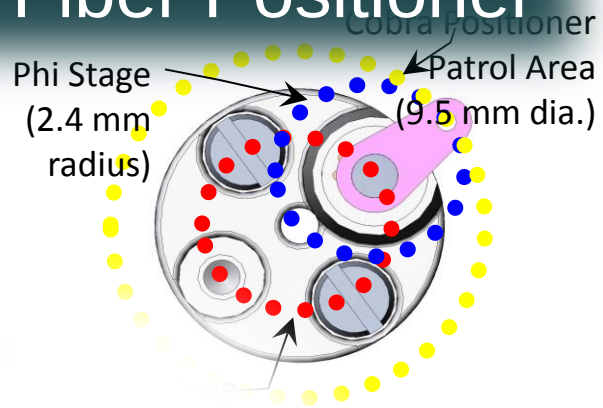
Challenge with Microlens on fast telesope F-ratio.

After successful productions of Mechanical & Optical samples,
Mass production of 3500 microlenses completed.

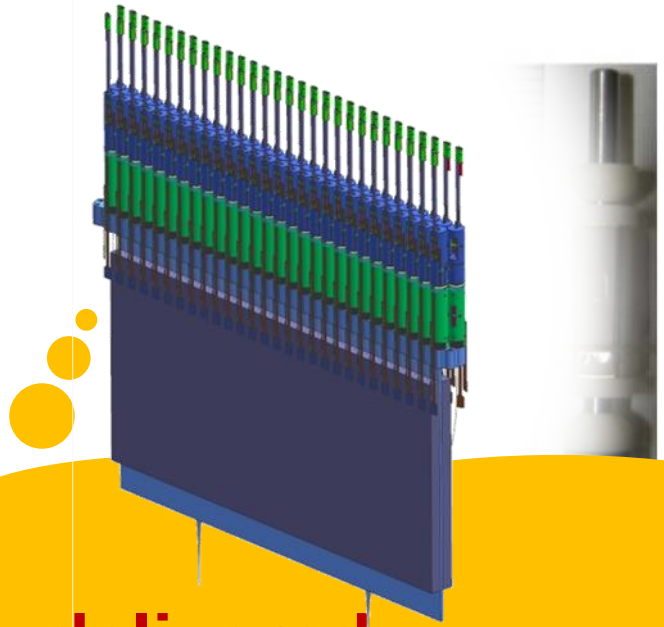




5.2. Present Status of Construction: Fiber Positioner



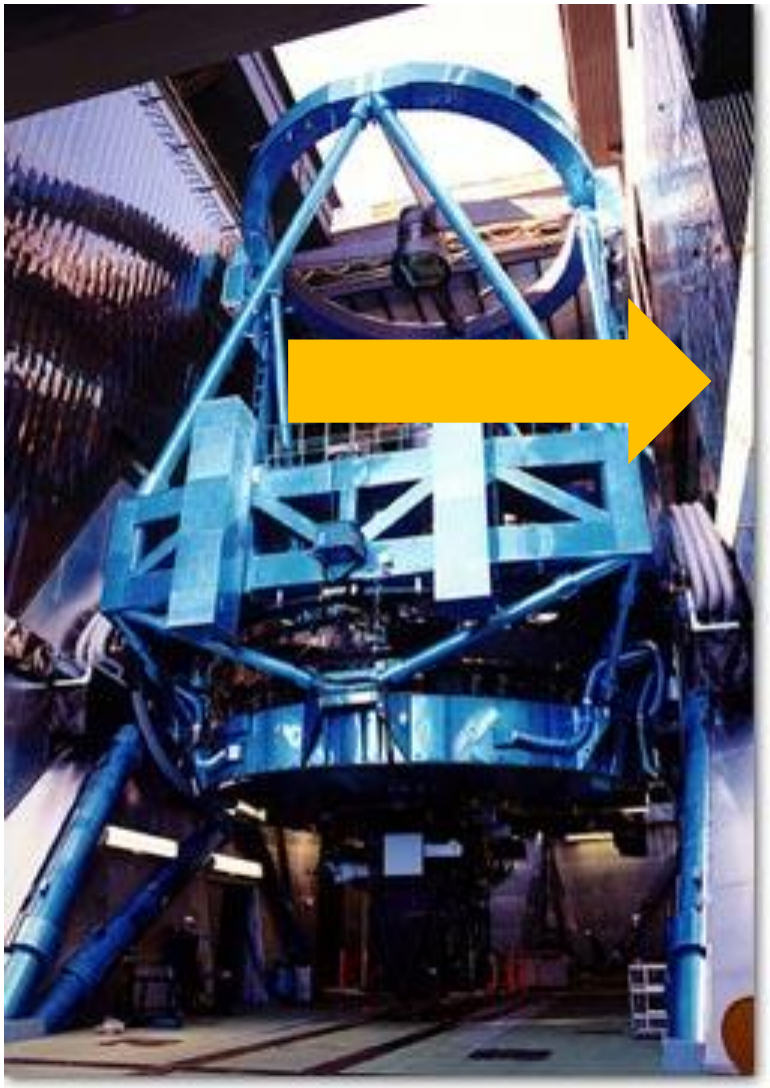
1.3° Field of View



Generation 3 successful.

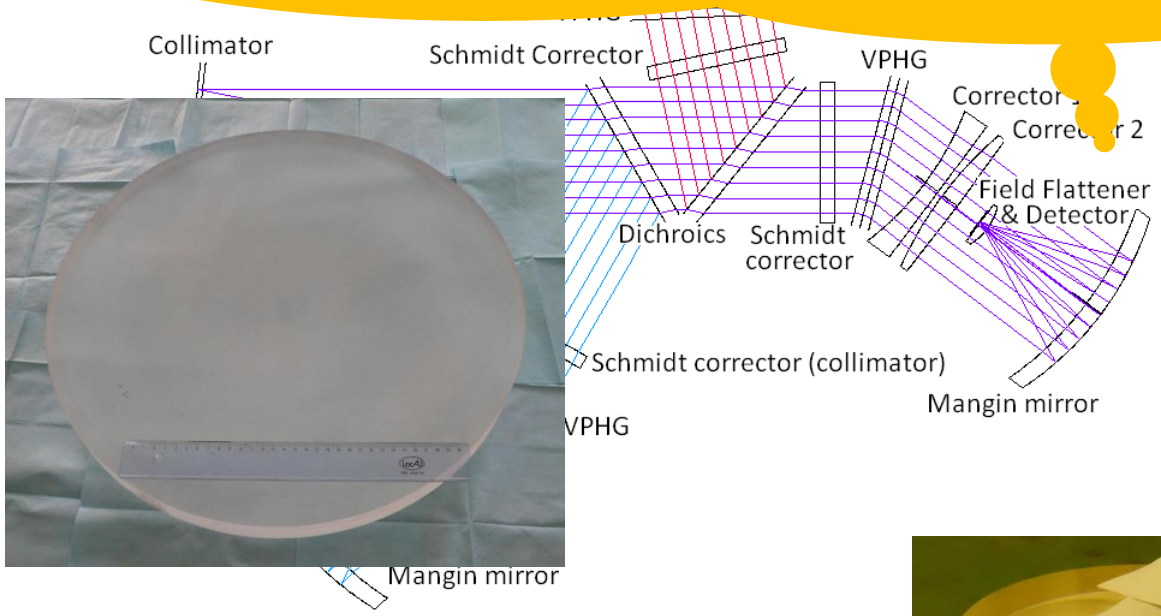
Engineering Model being delivered (one module with 30 Cobras).

through fiber to **spectrograph**

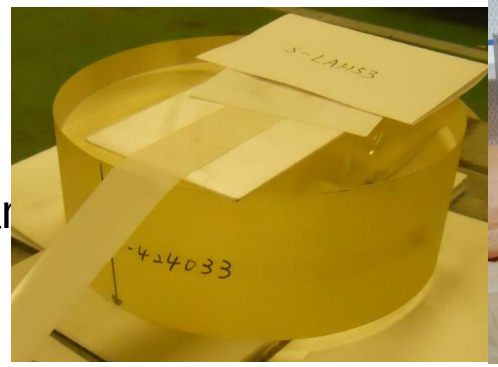


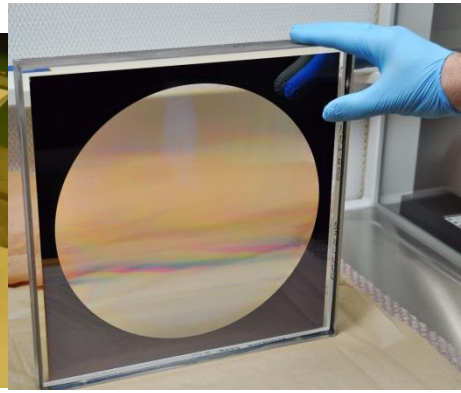
5.2. Present Status of Construction: Spectrograph

Production of optical elements ongoing, including completions of prototype VPH gratings & a pair of Medium resolution prisms



0.38-1.26μm:
VPH grating clear aperture ~ 280 mm diar
Resolving power = λ/δλ ~ 3000





5.2. Present Status of Construction: Spectrograph

Production of silica blanks completed and ready for polishing

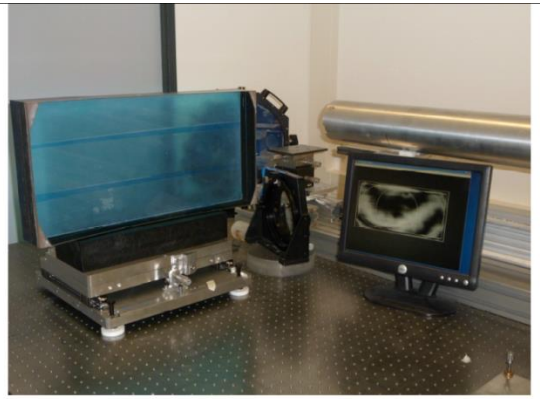
@Winlight

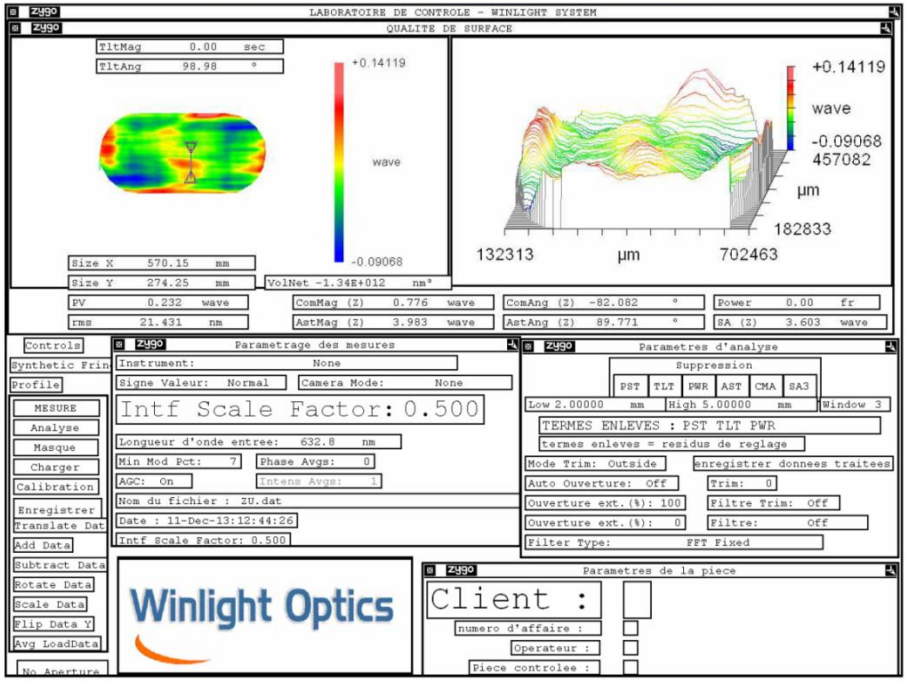
5.2. Present Status of Construction: Spectrograph

Actually, collimator mirror polished within specifications

305mm x 600mm x 60mm(@center)

R=1389mm (spec=1387.1+/-6mm)
Shape error per subpupil <130nm PTV (λ/5)
Roughness between 1 and 1.3nm RMS

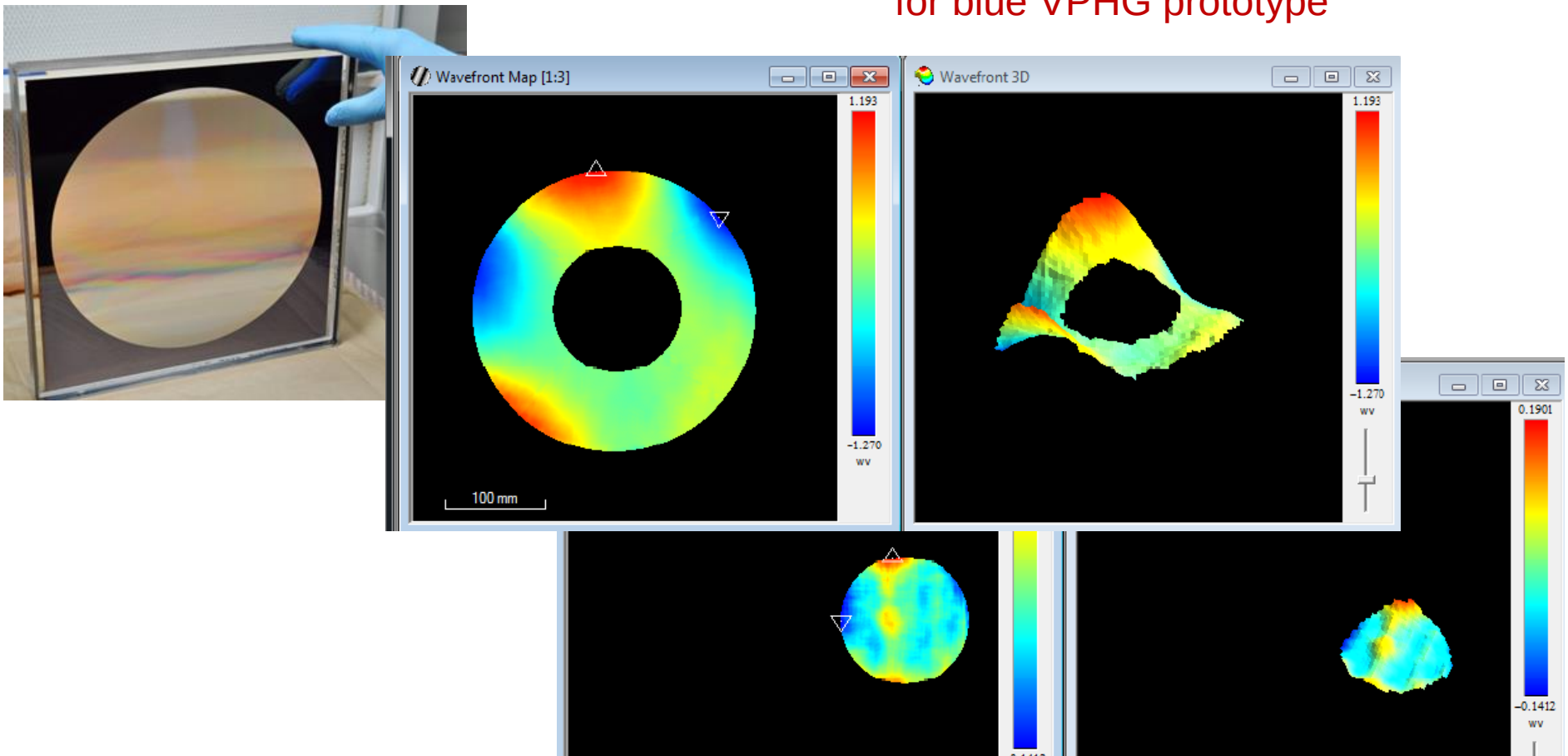




5.2. Present Status of Construction: Spectrograph

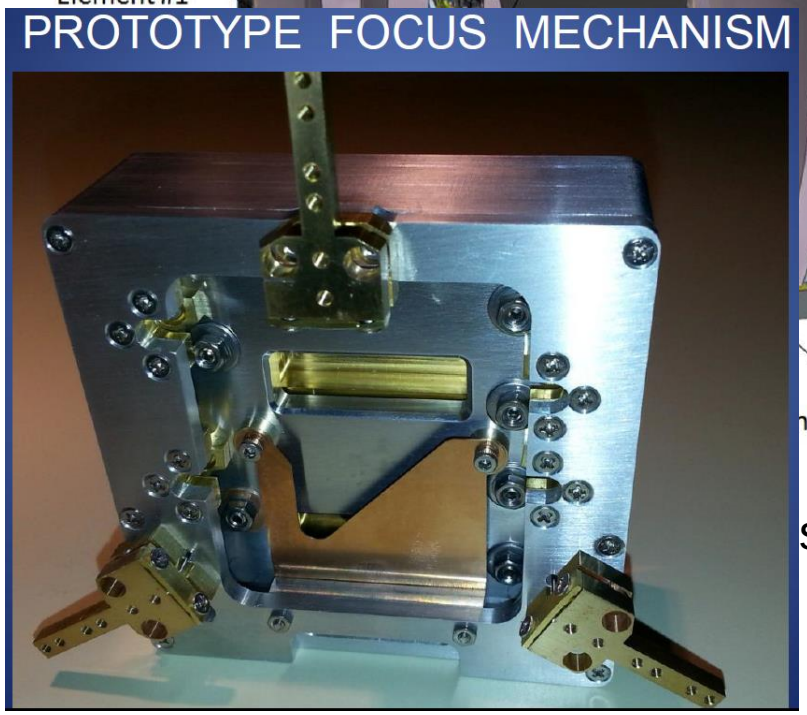
Measurements on “prototype” VPHGs carried out at JHU

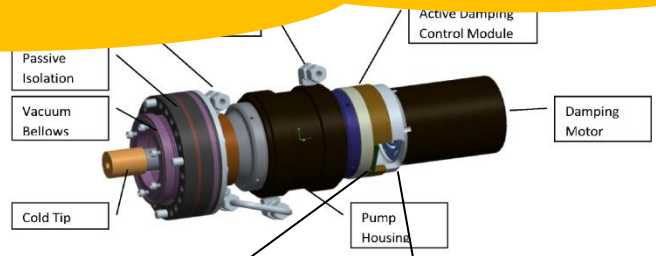
Wavefront error measurements: e.g., 0.4 waves RMS for 280mm clear aperture for blue VPHG prototype

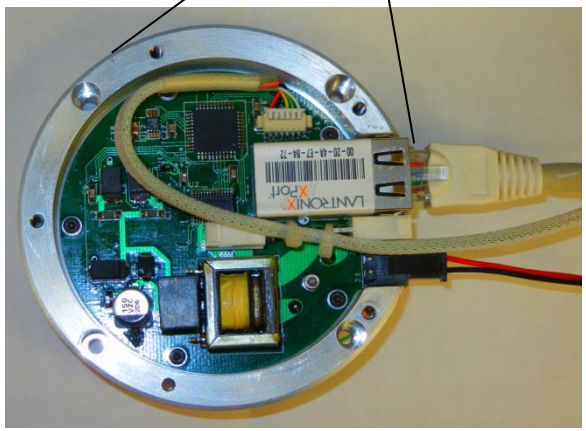


5.2. Present Status of Construction: Dewar & Detector

Active vibration damper working excellent.
Prototype focus mechanism completed.

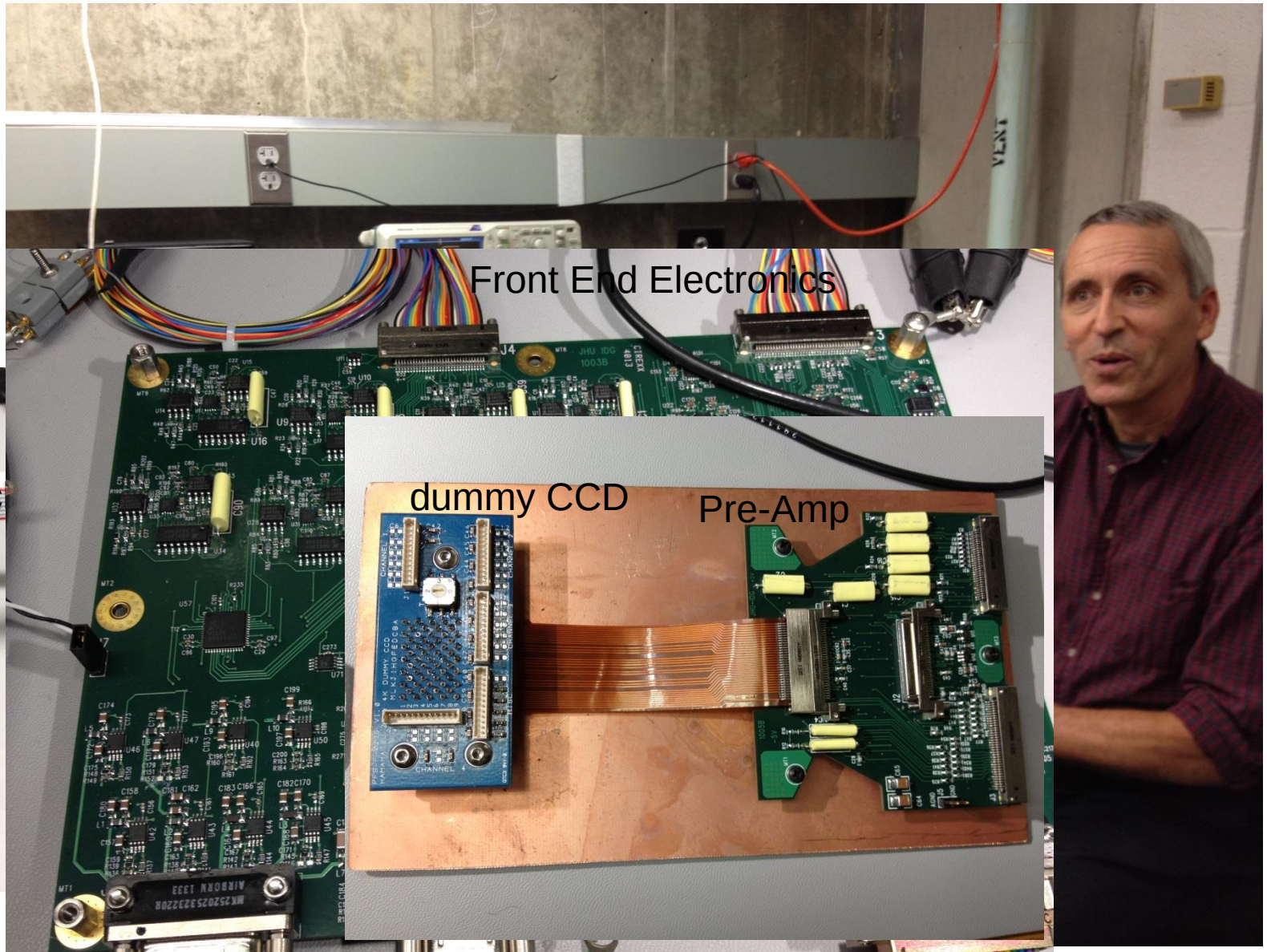






Active vibration damper system for a Stirling cryocooler

New readout system on Hamahoto Fully Depleted CCDs



New Blue-optimized Hamahoto Fully Depleted CCDs

6. Timescale of Project

Technical First Light 2017 Jun

Why more than three years from now?

Two flows of Integration & Test

- PFI-related flow

after Engineering Model:

if Cobra mass production rate reaches 100 Cobra/month,

→ 2 years for 2400 cobra productions.

- Spectrograph-related flow

after "One spectrograph",

a half year or more per spectrograph module I&T

→ 2-3 years for 4 spectrograph modules

2014 Jun SPIE paper submission from PFS

Instrument overview

Progresses on Prime Focus Spectrograph: optical/near-infrared multi-fiber spectrograph at Subaru Telescope (Sugai et al.)

Microlens

Design and performance of a F/#-conversion microlens for Prime Focus Spectrograph at Subaru Telescope (Takato et al.)

Fiber system

Fiber Optical Cable and Connector System (FOCCoS) for PFS/ Subaru (Cesar Oliveira et al.)

Studying focal ratio degradation of optical fibers with a core size of 128 microns for FOCCoS/ PFS/ Subaru (dos Santos et al.)

Slit device for FOCCoS – PFS – Subaru (Cesar Oliveira et al.)

Polish device for FOCCoS/PFS slit system (Cesar Oliveira et al.)

Multi-fibers connectors systems for FOCCoS-PFS-Subaru (Cesar Oliveira et al.)

Fiber positioner

Developing Engineering Model Cobra fiber positioners for the Subaru Telescope's Prime Focus Spectrometer (Fisher et al.)

PFI, Metrology camera

Prime Focus Instrument of Prime Focus Spectrograph for Subaru Telescope (Wang et al.)

Metrology camera system of Prime Focus Spectrograph for Subaru telescope (Wang et al.)

Spectrograph

Current status of the Spectrograph System for the SuMIRe/PFS (Vivès et al.)

Optical design of the SuMiRe/PFS Spectrograph (Pascal et al.)

Integration and test activities for the SUMIRE Prime Focus Spectrograph at LAM : first results (Madec et al.)

Dewar & Detector

Focal Plane Alignment and Detector Characterization for the Subaru Prime Focus Spectrograph (Barkhouser et al.)

CCD readout electronics for the Subaru Prime Focus Spectrograph (Hope et al.)

Cryocooler vibration damping for the Subaru Prime Focus Spectrograph (Hope et al.)

VPH gratings for the Subaru PFS: performance measurements of the prototype grating set (Barkhouser et al.)

The near infrared camera for the Subaru Prime Focus Spectrograph (Gunn et al.)

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