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PFS Project Office

Subaru Users Meeting at NAOJ Mitaka, Jan 13-15 2015
6th PFS collaboration meeting

- Dec 15-19 at ASIAA in Taiwan
  - 15th & 16th: Main session with all together
  - 17th, 18th & 19th: Break-up sessions

Two status reports from the project:
- 40+10min for technical aspects
- 45+15min for management

Squeezed into 15min today, highlighting latest/major updates ...
We are making good progress, and our challenges continue ...

• Recent updates in:
  – The collaboration
  – Funding situation
  – Technical aspects
  – Schedule
  – Summary
“PFS” – Fast facts

• Subaru *Prime Focus Spectrograph*
  – Wide field: $\sim1.3\ deg$ diameter
  – Highly multiplexed: *2400 fibers*,
  – Quick fiber reconfiguration: $\sim60\ sec$ (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 cases in the PFS collaboration
• Aiming to start science operation from *2019*, as a *facility instrument* on Subaru.
The PFS collaboration

11 institutions across 6 countries (JPN, TWN, USA, FRA, BRA, GER)

There are a few potential candidates.

New partner !!
The PFS collaboration

**PFS organization**

**Steering committee**
- One rep. from each partner

**Science WG**
- Co-chairs: Ellis (Caltech), Takada (Kavli IPMU)
  - Cosmology
  - Galaxy & AGN
  - GA

**Project Office (PO)**
- Tamura [PM, SE], Shimono, Ishizuka (Kavli IPMU)
- Takato (Subaru/NAOJ)
- Ueda (NAOJ)

**Subaru/NAOJ**
- Arimoto, Takami, Takato

(Sugai → LiteBIRD)

**Directorate & divisions**

**JPL-Caltech**
- ASIAA
- USP-LNA
- LAM
- Princeton
- JHU
- MPA

The PFS collaboration
Financial situation

Not fully funded yet, but getting very close!

includes $22M for HSC

FIRST approved
Aug 2009

FIRST allocated
Sep 2009

recovery

unit: ¥oku=¥100M ~ $1M
@ PDR (Feb 2013), we were short by $\sim 20M (another $\sim 5M for telescope modification)

- MPA: $3.3M ($2.7M cash)
- Kavli IPMU: $\sim 4.3M cash ($\sim 2.5M loan from U. Tokyo)
- NAOJ: committing telescope modification
  – Still conditional on a realistic funding plan
- NAOJ: $2.2M already, $2.3M in works
- Cost cutting measures

Now $\sim 6M to go ($\sim 3M excluding contingency)
Deferred plan

• Tentative descope $\rightarrow$ Some cash flow can be delayed. (E.g. Operating a good car only with a good engine, downgrading seats, tires, etc. until additional funds are available)

• A proposal was to defer the delivery of 3 NIR cameras.

It turns out however ...

• Only $\sim$1M could be saved by this, while $\sim$3M is short.

• In a worst-case scenario (i.e. no more funds become available), the tentative descope would have to be permanent descope, where the descoped instrument would very unlikely be competent.

• Some cost penalty and significant programmatic difficulties are expected when development resumes.
Steering Committee decisions

(By Murayama, 6th PFS collaboration meeting at ASIAA, Dec 2014)

- We will aggressively recruit single-investigator participation:
  - $1M per one senior investigator and one postdoc and one student
  - Within 2015, there is a discount to $800k
- What a bargain; surely people would sign up!
- We already have ideas on whom to contact
- "deferred plan" on NIR doesn’t make sense

The project will clarify the way forward in the next few months as much as possible (funding situation ➔ minimum spec, schedule ...)

• Apr 2011: Project Office was established. Design study activities were formalized.

• Mar 2012: Conceptual Design Review (CoDR) @ Hilo

• Feb 2013: Preliminary Design Review (PDR) @ Hilo

• Mar 2013 – Present: A hybrid of critical design phase & production phase
  • Critical Design Review is held at subsystem level (i.e. no project CDR).
    – Mar 2014: Cable A & Spectrograph System (SpS) CDR
    – Early 2015: Metrology camera, PFI, fiber positioner system, Cable C
    – Late 2015: Cable B

• 2017-- : System integration & commissioning

• ASAP: Start open use (i.e. science operation)
PFS subsystems distribution

On the TUE (4th) floor... in Prime focus unit “POpt2” with Wide Field Corrector “WFC”.

Spectrograph system (SpS)

On the TUE (4th) floor (IR side)

4 spectrographs

Fiber connectors

Fiber cable

Prime Focus Instrument

2400 fibers steered by positioners

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

Software system (Calibration system)

Fiber cable

Wide-field corrector

Metrology camera as a Cassegrain instrument

Subaru Telescope
Models & prototypes

- Cable wrapper
- PFI (3D model)
- PFI (real-size mock-up)
- Spectrograph system
- Fiber positioners “Cobra”
- Fiber connectors
- Detector focus mech.
- Metrology camera
Fiber positioner “Cobra”

Positioners with a 8mm pitch. → Patrol areas have some overlaps.

- Fiber is routed from the arm on the phi-stage through the center of the Cobra
  - Stages utilize hard stops to allow for full range of motion, yet prevent over twisting of the optic fiber
  - Protects fiber during handling and operation
- Piezo motors use phase shifted signals to excite the motor body at the first bending resonant frequency
Cobra “Engineering model” performance

Fisher+ (2014, SPIE)
### A summary of PFS focal plane

<table>
<thead>
<tr>
<th></th>
<th>Current situation</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optical configuration</td>
<td>WFC → Field Element → Microlens → Fiber</td>
<td></td>
</tr>
<tr>
<td>Mech. configuration</td>
<td>POpt2 + PFI</td>
<td>With microlens</td>
</tr>
<tr>
<td>Input F/# to Fiber</td>
<td>2.8</td>
<td>Min. ~2350 [TBC] fully operational at delivery</td>
</tr>
<tr>
<td># of science fibers</td>
<td>2394</td>
<td>~50-50 split to interleavedd &amp; perimeter</td>
</tr>
<tr>
<td># of fixed fiducial fibers</td>
<td>99</td>
<td>~1.1 arcsec w/ microlens</td>
</tr>
<tr>
<td>Input fiber core diameter</td>
<td>127um</td>
<td>Hexagonal, ~1.4 deg on chord</td>
</tr>
<tr>
<td>Field of view</td>
<td>1.3 deg</td>
<td></td>
</tr>
<tr>
<td>Positioner pitch</td>
<td>8mm</td>
<td></td>
</tr>
<tr>
<td>Positioner patrol field</td>
<td>9.5mm diameter</td>
<td></td>
</tr>
<tr>
<td>Reconfiguration time</td>
<td>~60-70 sec</td>
<td></td>
</tr>
<tr>
<td>AG camera</td>
<td>Number: 6 (one on each side of hex. Field)</td>
<td>One on each side of hex. field</td>
</tr>
<tr>
<td></td>
<td>Format: 1K x 1K CCD, 13um pixel size</td>
<td>5.5 sq. arcmin per camera</td>
</tr>
<tr>
<td></td>
<td>Sensitivity: S/N=100 in 4 sec for r`=18.5 (AB)</td>
<td>&gt;=1 star per camera</td>
</tr>
</tbody>
</table>
# A summary of SpS

<table>
<thead>
<tr>
<th></th>
<th>Blue</th>
<th>Red</th>
<th>NIR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low Res</td>
<td>Mid Res</td>
<td></td>
</tr>
<tr>
<td>Collimator F/#</td>
<td>2.5</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>Camera F/#</td>
<td>1.1</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td># of science fibers</td>
<td>597 or 600</td>
<td>597 or 600</td>
<td></td>
</tr>
<tr>
<td>Operating temperature</td>
<td>+5 degC</td>
<td>+5 degC</td>
<td></td>
</tr>
<tr>
<td>Input fiber core diameter</td>
<td>129um</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wavelength coverage</td>
<td>380-650nm</td>
<td>630-970nm</td>
<td>710-885nm</td>
</tr>
<tr>
<td>Resolving power</td>
<td>~2300</td>
<td>~3000</td>
<td>~5000</td>
</tr>
<tr>
<td>Detector Type</td>
<td>CCD (Hamamatsu, with a new blue coating)</td>
<td>CCD (Hamamatsu, with the same coating as HSC)</td>
<td>H4RG (Teledyne, 1.7um cutoff)</td>
</tr>
<tr>
<td>Format</td>
<td>(4K x 2K) x 2</td>
<td>(4K x 2K) x 2</td>
<td>4K x 4K</td>
</tr>
<tr>
<td>Pixel size</td>
<td>15um</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Readout noise</td>
<td>~4 e-/pix</td>
<td>4 e-/pix</td>
<td></td>
</tr>
<tr>
<td>Dark</td>
<td>~0.4 e-/pix/hour</td>
<td>0.01 e-/pix/s</td>
<td>0.006 e-/pix/s</td>
</tr>
<tr>
<td>Thermal background</td>
<td>None</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
“Baseline” throughput model

http://sumire.pbworks.com/w/page/65089522/Throughput%20prediction

![Graph showing throughput across different field elements and system components.](image-url)
Sensitivity estimation – Under way

- 1 pix: ~0.8A
- “Baseline” throughput is assumed.
- Gunn’s sky model
- Dark night
- Detector & thermal noises as specified.
- Point source: ~0.7 arcsec FWHM (→ ~85% energy input at the field center with no x-y error).

We are preparing to share all these information at a certain place (most likely a web site at Kavli IPMU) with a broad range of people.
Schedule: Commissioning

2017--2018: Delivery of subsystems to Subaru

2018: Start of nighttime engineering

SSP proposal evaluation

2019: Start of science operation

Boundary conditions given backwards

Real milestones given forwards by actual progresses
The Competition: Schedules

By Ellis (Caltech), 6th collab. meeting at ASIAA, Dec 2014, revised by Tamura.

DESI: Cosmology

MOONS: GA and galaxy surveys

4MOST: GA & galaxy surveys

eBOSS/HETDEX: cosmology

NB: The “realistic” schedules of the competing projects are preliminary/speculative.
To start science operation “on time”, we will aggressively try:

- Timely prepare IR4 (TUE-IR) floor for spectrograph.
- Control subsystem development schedule.
- Validate subsystem to be delivered as “ready to go”.
- Plan efficient nighttime engineering observation.

And we expect ...

- Timings & success criteria of readiness reviews are flexibly organized.
- Possibility of shortening SSP proposal evaluation process is explored.
Long-term uniqueness of PFS

• PFS will be an ideal suite for survey science.

• High potentials of good synergy with future facilities/missions (e.g. TMT, WFIRST)

• Bigger surveys than previous/on-going SSPs could be natural extensions:
  • >300 nights, over >5 years?
  • SSP2?

• The PFS collaboration will start studies to see how such big surveys can be justified scientifically.
Summary

- Subaru PFS is a \textit{wide-field, highly-multiplexed, optical-NIR} spectrograph, a Subaru future facility instrument.
- The three-folds key science cases: \textit{Cosmology, Galaxy/AGN evolution, & Galactic Archaeology}.
- Aiming to start science operation in \textit{2019}.
- Funding situation is improving – We are \textit{pretty close}!
- Moving forward to \textit{production phase} via subsystem CDR.

\textit{Please contact us if you are interested!} \\
\textit{Let’s commit this challenge together!!} \\
\textit{A PFS research meeting this year?} \\
\textit{To be announced ...}