Future Instrumentation at Subaru

Naruhisa Takato, Ikuru Iwata
(Subaru Telescope)
Future Instrumentation at Subaru

1. Strengthen Subaru’s advantage
   - wide-field capability
   - good image quality
     * Optical : HSC + PFS
     * NIR high Res. : AO188 + SCExAO
     * NIR wide-field: GLAO

2. Balance between survey or specific-science instruments and general purpose instruments.

3. Test-bed for future developments
HSC

- Φ1.5 deg FoV
- Prime focus
- Commissioning run: 2012/08 ~
- Open use (expected): S13B or S14A
Prime-Focus Spectrograph (PFS)

- Dark energy survey (BAO) +
- 2400 fibers
- $\phi 1.3^\circ$ patrol area
- 0.38 – 1.26 $\mu$m simultaneously (4 sets of 3 arms spectrograph)
- $R \sim 1400$ (blue) to $R \sim 4800$ (NIR)
- cooled spectrograph optics ($\sim < 5^\circ$C)
Science targets of PFS

Cosmology

9.3 $h^{-3}$ Gpc$^3$ in $0.8<z<2.4$
1400 deg$^2$

Galactic Archaeology

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

$1<z<2$  16 deg$^2$ to $J_{AB} \sim 23.4$

See arXiv:1206.0737 “Extragalactic science and cosmology with Subaru PFS” Ellis et al. (2012)
International Collaboration
IPMU, NAOJ (Japan), ASIAA (Taiwan), Caltech/JPL, Princeton, JHU (USA), LAM(France), LNA+ (Brazil)

2011/01: supported by Subaru UM
2012/03: CoDR
2013/02: PDR
2013/04: review by NAOJ

~ 2017: engineering first light
Subaru leads Wide-Filed Survey

- HSC
  - S-Cam
  - PFS
  - LBC blue, red /LBT 8.4 m (23’x25’ x2)
  - DEcam/CTIO 4m (2.2 deg)
- TMT/GMT
- JWST
- LSST
Exoplanet Science Instruments

• HiCIAO
  Coronagraphic imager (SDI, PDI)
  Use with AO188, SCExAO
  SEEDS program (120 nights) are ongoing

• SCExAO
  extreme AO, speckle nulling

• CHARIS
  integral-field unit, J + H (+ K), R~40, > 1.8” x 1.8”
  use with AO188, SCExAO
  Led by Univ. Princeton

• IR Doppler instrument (IRD)
  M-type star survey
  R=70,000, J+H, Optical Frequency Comb (OFC), < 1 m/s
  fiber feed from AO188
SCExAO phase I (speckle nulling)

Display snap-shot of raw image (Nov. 2012)
Exoplanet Science Instruments

• HiCIAO
  Coronagraphic imager (SDI, PDI)
  Use with AO188, SCExAO
  SEEDS program (120 nights) are on going

• SCExAO
  extreme AO, speckle nulling

• CHARIS
  integral-field unit, J + H (+ K), R~40, > 1.8” x 1.8”
  use with AO188, SCExAO
  Led by Univ. Princeton

• IR Doppler instrument (IRD)
  M-type star survey
  R=70,000, J+H, Optical Frequency Comb (OFC), < 1 m/s
  fiber feed from AO188
CHARIS

- integral-field unit, J + H (+K), R~40, > 1.8” x 1.8”, use with AO188, SCExAO
- Led by Univ. Princeton
Exoplanet Science Instruments

• HiCIAO
  Coronagraphic imager (SDI, PDI)
  Use with AO188, SCExAO
  SEEDS program (120 nights) are ongoing

• SCExAO
  extreme AO, speckle nulling

• CHARIS
  integral-field unit, J + H (+ K), R~40, > 1.8” x 1.8”
  use with AO188, SCExAO
  Led by Univ. Princeton

• IR Doppler instrument (IRD)
  M-type star survey
  R=70,000, J+H, Optical Frequency Comb (OFC), < 1 m/s
  fiber feed from AO188
IRD

- M-type star survey
- \( R=70,000, \) J+H, high stability
- Optical Frequency Comb (OFC)
- \(< \sim 1 \text{ m/s}\)
- fiber feed from AO188
$C_1 = 0.1$

Habitable zone

Detection limit
Competitor of planet finders

HiCIAO + SCExAO + CHARIS ≒ GPI (Gemini-S) + SPHERE (VLT) - (spectro-polari mode)

IRD (NIR) ↔ ESPRESSO (Optical)

Small-scale, PI-type instruments

Short turn-around time, use latest technology
Subaru is competitive in Exo-planet science

AO188/LGS
SCExAO
IR-Doppler
CHARIS

HiCIAO

GPI, SPHERE, ESPRESSO

JWST
TMT/GMT

PI-type instruments

- Non-facility instruments
- Less supported by Subaru
- Complementary to facility instruments
- Short turn-around time
- Provide opportunities for developing human resources, especially for students (Investment for the future)
Pl-type instruments on the waiting list

- RAVEN (UVic)
- CHARIS (Princeton U.)
- IR Doppler (NAOJ/Tamura)
- MIMIZUKU (U. Tokyo/Miyata)
- SWIMS (U. Tokyo/Motohara)
- GIGMICS (U. Nagoya/Hirahara)

Acceptance schedule have to be commensurate with the manpower of Subaru
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S-Cam</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FMOS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HSC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PFS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FOCAS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOIRCS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMICS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K3DII</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SWIMS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MIMIZUKU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GLAO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NsOpt</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HDS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IRD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AO188</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IRCs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HiCIAO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCExAO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHARIS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K3DII</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RAVEN</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GIGMICS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Next facility instrument?

High resolution Wide-Field instrument?
- GLAO + wide-field NIR spectrograph/camera
- MOAO + spectrograph (w/IFU)

Working group discussion from 2010
Sep. 2010: Subaru Future Instrumentation Workshop
Sep. 2011: Subaru Next-Generation AO Workshop

- Gemini/VLT have been developing MCAO/GLAO for long time.
- How can we make a competitive instrument in this field?
- competitive with/complementary to TMT?
Summary

- HSC commissioning run have started. Open use is expected to be S13B or S14A.
- PFS passed CoDR. PDR and NAOJ review will be Feb. and Mar. 2013.
- **Subaru can lead wide-field survey next 5-10 yrs**
- Planet finding instruments are lining up (they are all visiting instruments)
- **Subaru should be competitive in exo-planet science**
- GLAO + wide-field NIR instrument is a possible future facility instruments
For PIs who want to use their PI-type instruments for open-use science time:

A **fact sheet** and **performance tables** must be provided to Subaru(*) by the deadline date of call for proposal of the open-use observations.

This enables referees to make reliable judgment by providing sufficient information of the instruments.

(*) notify the URL of the instrument web-site where the fact sheet and performance tables are provided