

FMOS status report

– Subaru users meeting 2011.01.19 –

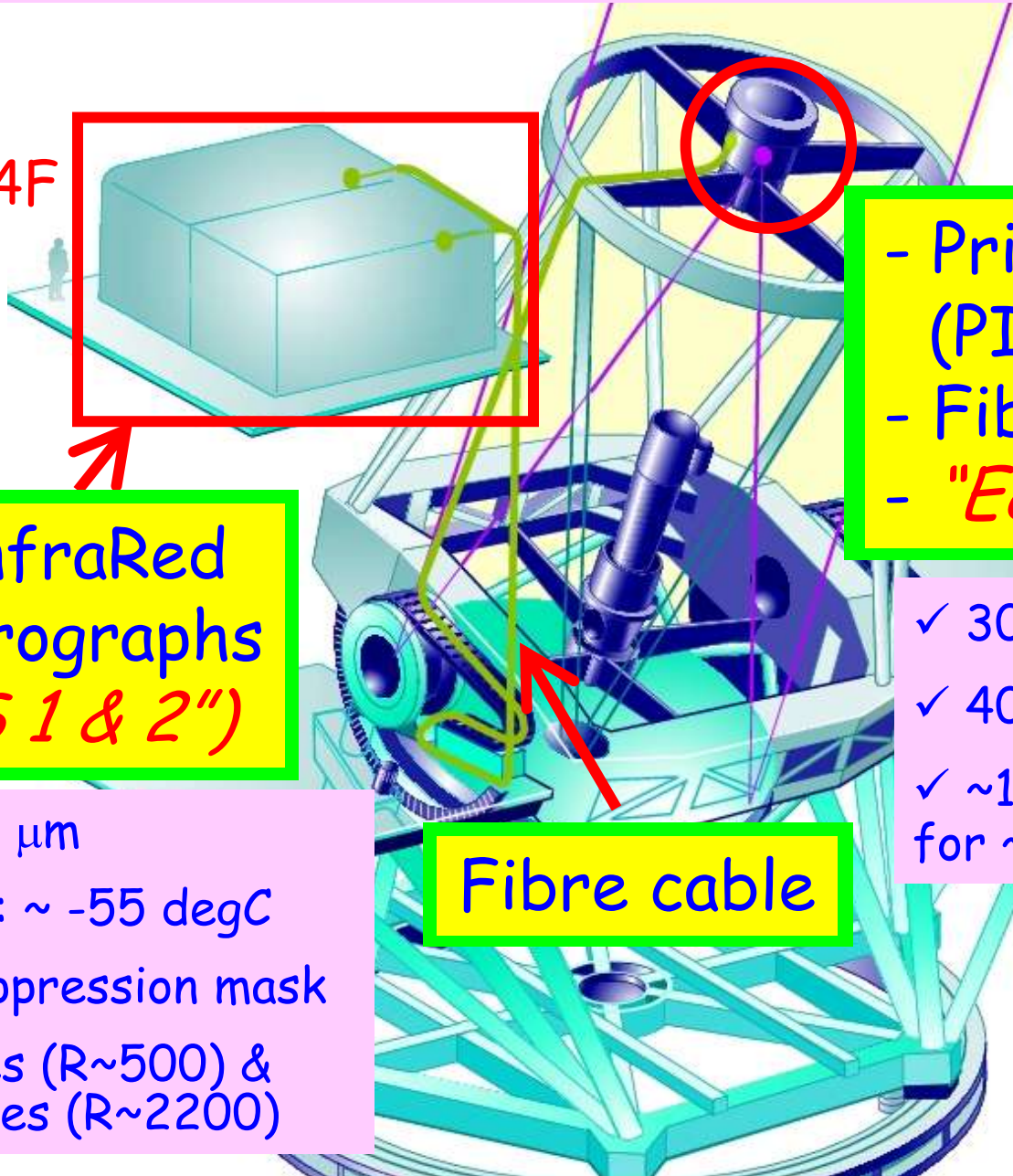
NAOYUKI TAMURA

*Subaru Instrument Astronomer
Subaru Telescope, NAOJ*

- * Overview*
- * Recent history & current status*
- * Schedule & future plan*
- * Summary*

Fibre Multi Object Spectrograph

@Dome 4F



- Prime focus unit (PIR)
- Fibre connector
- "Echidna"

2x InfraRed Spectrographs ("IRS 1 & 2")

- ✓ 0.9-1.8 μm
- ✓ Cooled: ~ -55 degC
- ✓ OH suppression mask
- ✓ Low Res ($R \sim 500$) & High Res ($R \sim 2200$)

Fibre cable

- ✓ 30' FoV
- ✓ 400 fibers w/ 1".2 dia.
- ✓ ~ 13 min configuration for $\sim 0".2$ accuracy.

One way to summarize the status ...

“Multi-phase” – all apply!

“Commissioning”

- IRS2
- High Resolution mode

“Operation” (Open use & GTO from S10A)

- Prep for observation & user support

“Stabilization”

- Maintenance, trouble-shooting
- Clean-up, simplification
- Upgrade (e.g. computers, HDDs, environment monitoring), fine-tuning (e.g. optical alignment)

Recent history

2009.12, 2010.02 & 04 Engineering observation

Performance verification by observing bright stars in open clusters, long integration of faint galaxies.

Echidna operation software bug-fix & parameter optimization

IRS1 spectrograph chiller upgraded.

IRS2 low background level confirmed.

IRS2 detector stabilized with an anomaly component

2010.05–06 S10A open-use observation & GTO,

Confirmed IRS2 detector anomaly subtracted well.

2010.07-09 Telescope down time, engineering observation

IRS1 detector tilt stage repair

IRS1 slit stage movement mechanism maintenance

IRS1 mask mirror holder upgrade

IRS1 spectrograph vibration suppression

Echidna softwares (operation, spine allocation) bug-fix & upgrade

2010.11–12 S10B open-use observation & GTO,

FMOS observation in S10A & S10B

[IRS1 LR only, shared-risk mode]

Overall, successful.

2010.05–06 4 programs (all two nights)
 [3 extragalactic, 1 Galactic]
 (Engineering: 2 nights, GTO: 2 nights)

- IRS1 spectrograph vibration → “Jitter” of spectra on the detector
 ← *Well suppressed now.*
- Trouble in time generator of telescope system (6/26-27)
- IRS1 detector noise increased temporarily (6/3, 11/23).
- The locking mechanism of a spectrograph-side fiber connector broke in an instrument exchange. A damaged conduit of fiber cables was found. ← *Both repaired in the 1st week of Nov 2011.*

2010.09 (Engineering: 2 nights)

2010.11–12 6 programs [5 extragalactic, 1 Galactic]
 (1 x 3 nights, 3 x 2 nights, 2 x 1 night)
 (Engineering: 2 nights, GTO: 8 nights)

Schedule & future plan

- S11A observation
 - ✓ IRS1 & IRS2
 - ✓ LR only
 - ✓ Shared-risk mode
- S11B observation (TBD - Refer to CfP to confirm)
 - ✓ LR (IRS1 & IRS2)
 - ✓ HR (IRS1 only)
 - ◆ Sensitivity to emission lines is expected $\sim 2x$ higher than LR due to the higher throughput (NOTE: Not much HR data yet, so the number is subject to change in future).
 - ◆ Less sensitive to continuum due to the higher resolution.
 - ◆ Choice of λ coverage: J-short, J-long, H-short, H-long.
Restriction: Max. 2 bands per night (including LR).
 - ✓ Shared-risk mode (HR only??)

Schedule & future plan

- Engineering work items

- ✓ IRS2

- ◆ Installation of new thermal blocking filter

- ◆ Optical alignment

- ✓ IRS1 and/or IRS2

- ◆ Testing spare VPH gratings → Better throughput in LR??

- ✓ Echidna, observing sequence

- ◆ Monitoring fiber positioning accuracy for a long time
→ Improve auto-guiding?

- ◆ Testing less often spine re-configuration:

- Reduction of overhead vs. flux loss from fibers

- Others

- ✓ Support of open-use observers is being transferred to K. Aoki-san: Tamura will take care of eng. run, GTO (& SSP), and daytime works (instrument setup, trouble-shooting, upgrade, etc).

Summary

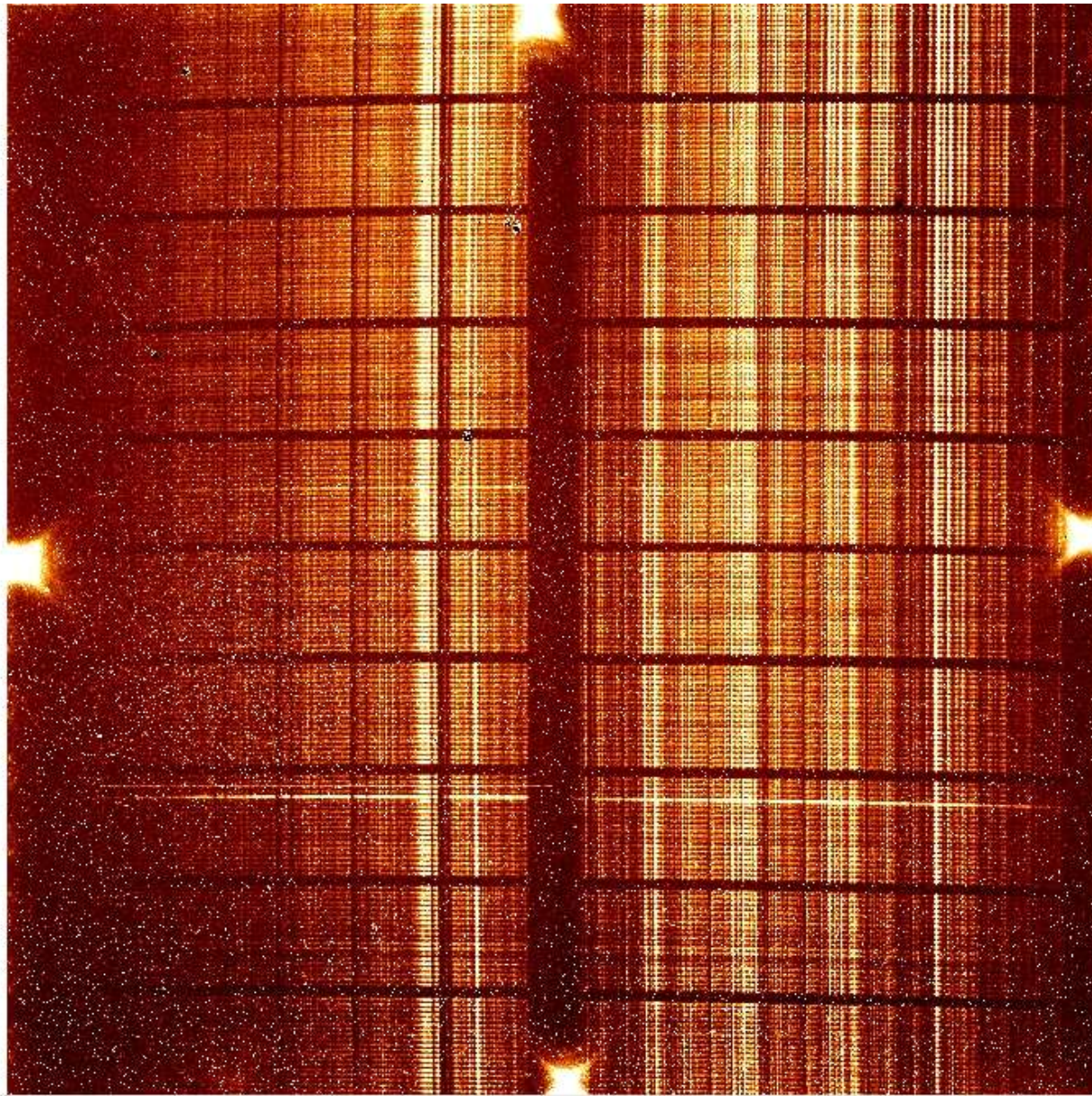
- ✓ Open-use observation started with IRS1 LR only.
The instrument is still on the way from commissioning to stable operation.
- ✓ *S10A and S10B observation went well overall with no serious troubles during the nights.*
- ✓ IRS2 LR will be available from S11A.
- ✓ IRS1 HR will also join from S11B [TBD].
- ✓ Will work on outstanding items to stabilize & enhance the instrument performance.

[Feb 28-Mar 2: FMOS science workshop in Mitaka](#)

Instrument status report, future plans.

Discussions of SSP, GTO, & individual science programs.

Data



15 min exposure
ramp sampling
image by IRS1.

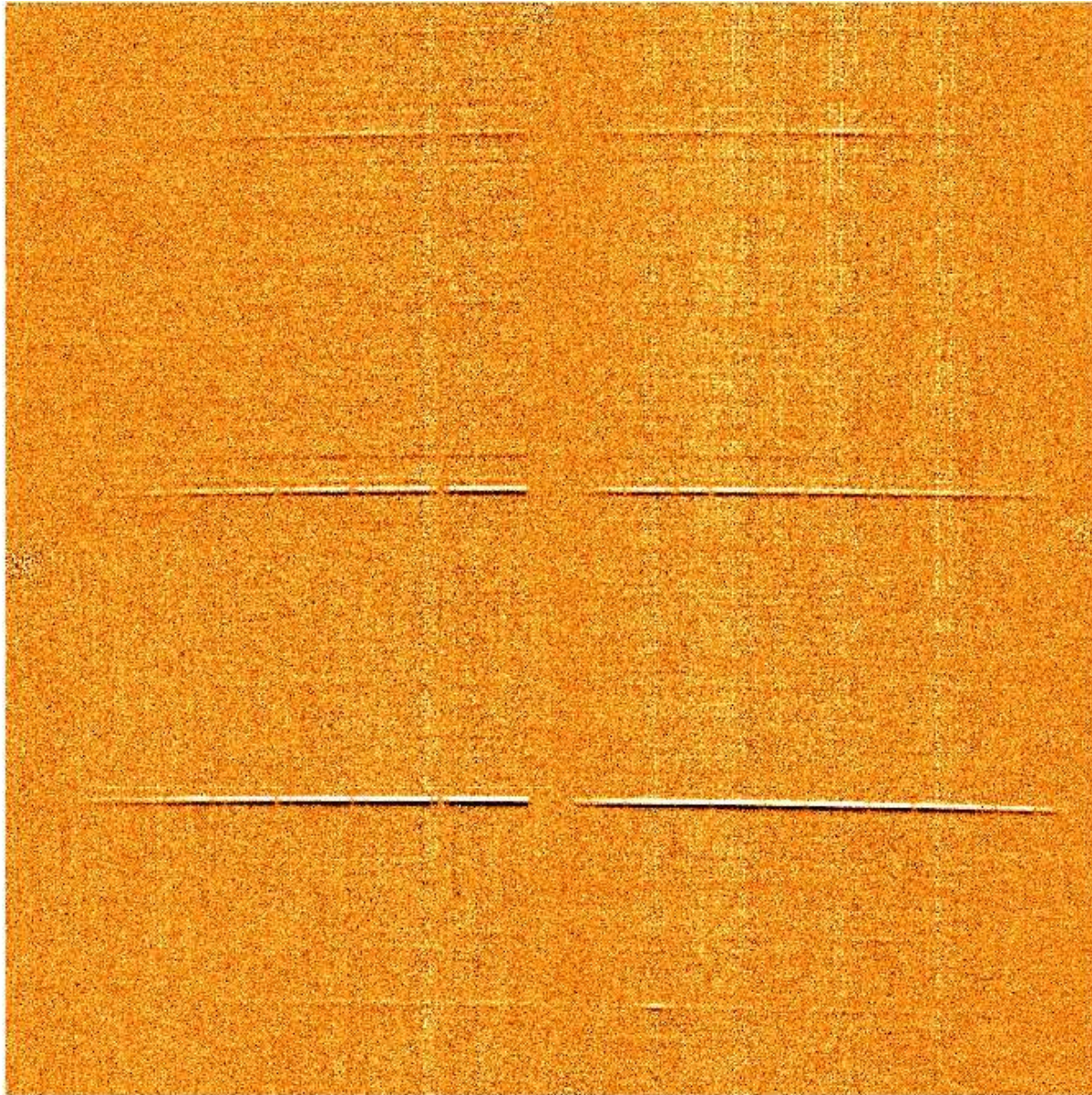
Left: J-band

Right: H-band

The gap in the
middle is due to
fiber slit (no light
comes through).

There are 4 glows
at the readout ports.

Data



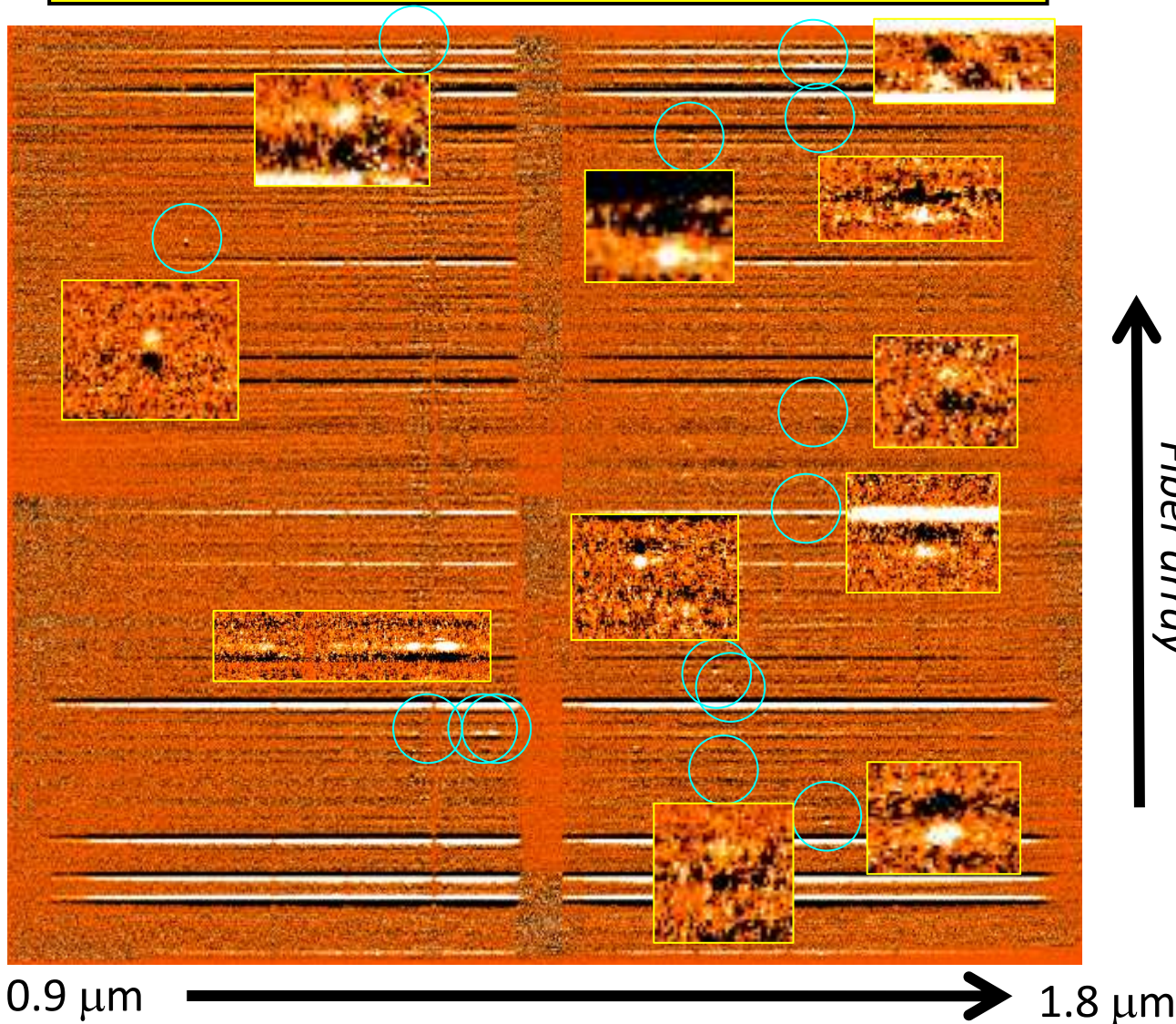
2 frames taken with the same exp. time & the telescope dithered and one is subtracted from another. This data is an image after this subtraction.

Since this is from **Cross Beam Switching**, a few pairs of positive and negative spectra from single bright objects are visible.

Residual sky is subtracted by a way like “skysub” for long-slit data after fiber extraction.

Data

SXDS, Cross beam switching, 4.5 hr on-source
with IRS1, LR [GTO, Nov 2010]



The image shown here is that after data reduction and stacking several frames (still flux-uncalibrated).

Data reduction & calibration is performed in parallel to the observation using a reduction package developed by Iwamuro-san (Kyoto Univ.).

Observing sequence

- Telescope pointing, spine configuration (& focusing)
- Field alignment (fine tuning of pointing & rotator angle)

Using “SKYcamera” (a small CCD camera in the Echidna Focal Plane Imager (FPI) system), take images of several bright stars (“Coordinate Calibration Star”) in the FMOS FoV.

cf. Telescope pointing accuracy: ~ 4-5”

FoV of guide fiber bundle : ~2”

NOTE: Field rotation cannot be corrected by AG.

- Start auto guiding

~15 (20) minutes

- Start exposure

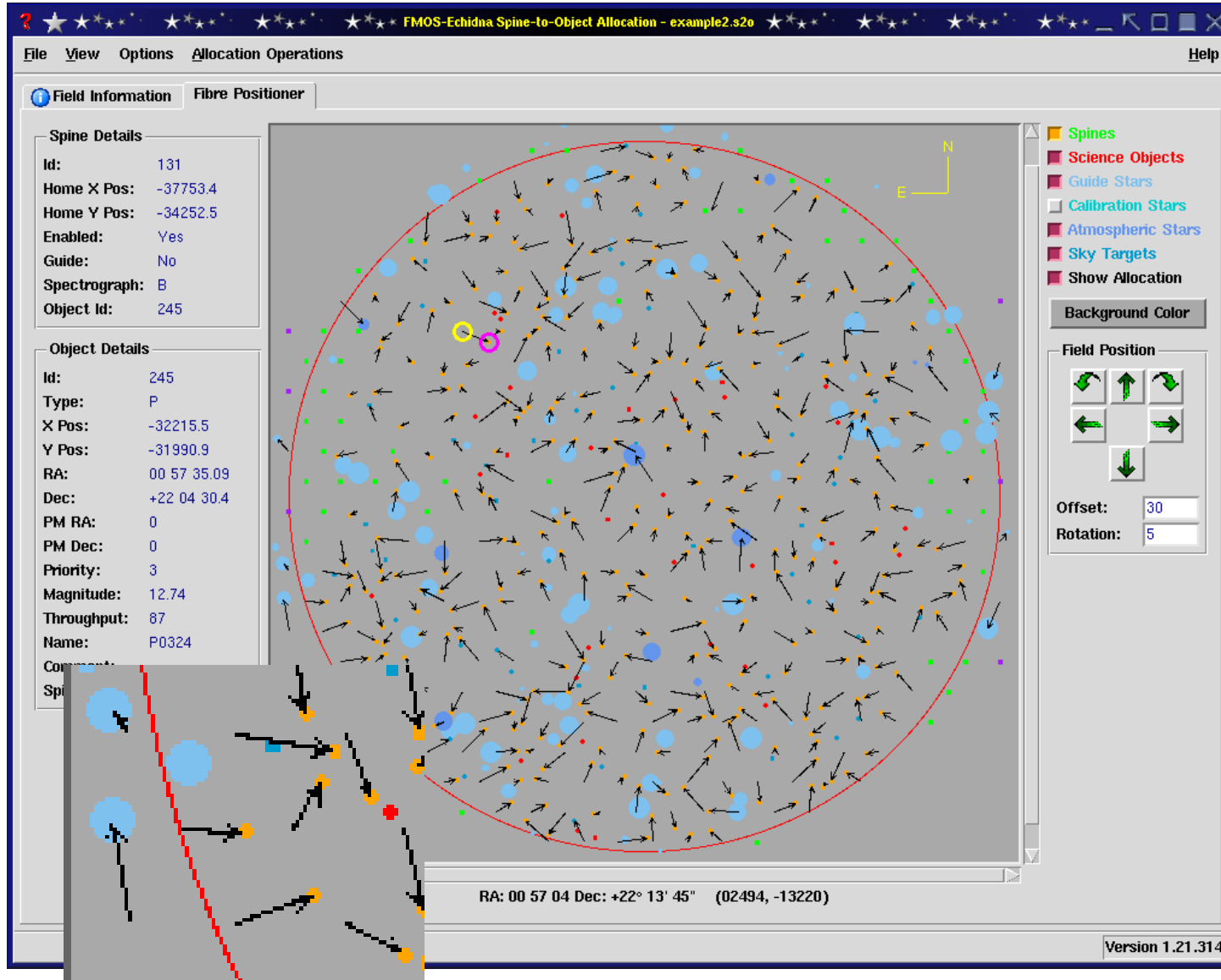
Softwares & tools

- Spine-to-Object (S2O) allocation software

Output file (.s2o) is input to the Echidna instrument control system.*

Latest version (Linux & Mac OS X) will be available on the Subaru FMOS web site.

Developed by AAO.



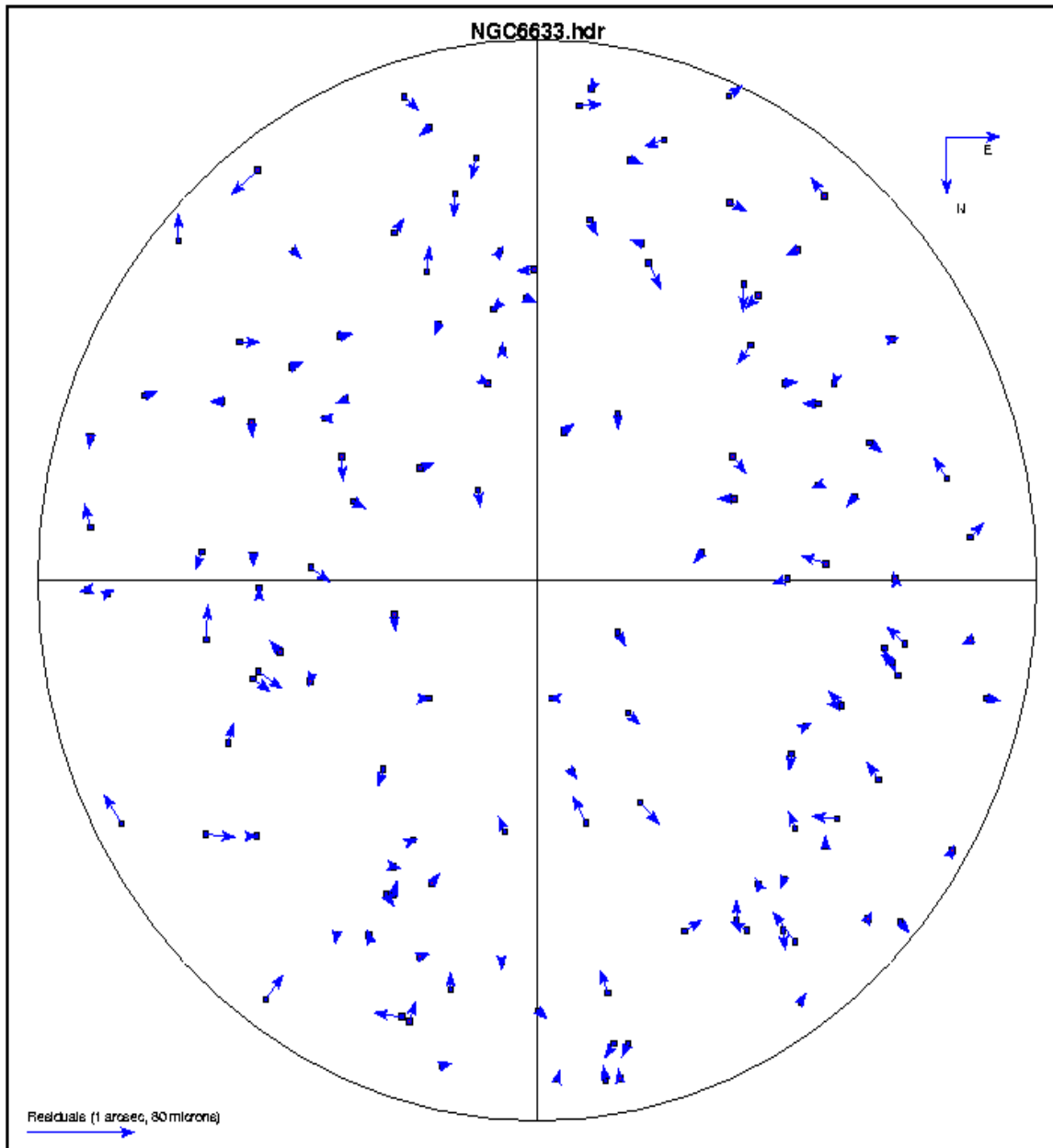
Software & tools

- Data reduction package

- ✓ *“F.I. DR” [tentative name]*

- Developed by F. Iwamoto (Kyoto Univ.)
 - IRAF, CFITSIO & C scripts from command line
 - Data reduction & calibrations (wavelength & flux)
 - Has been tested in engineering observations & GTO (optimization & upgrade is still on-going). Still in process of bug-fix, upgrade, & verification, but complete for IRS1 LR (nearly for IRS2 LR). HR is still in progress.
 - Distributed to open-use observers since S10A.

Fiber positioning accuracy



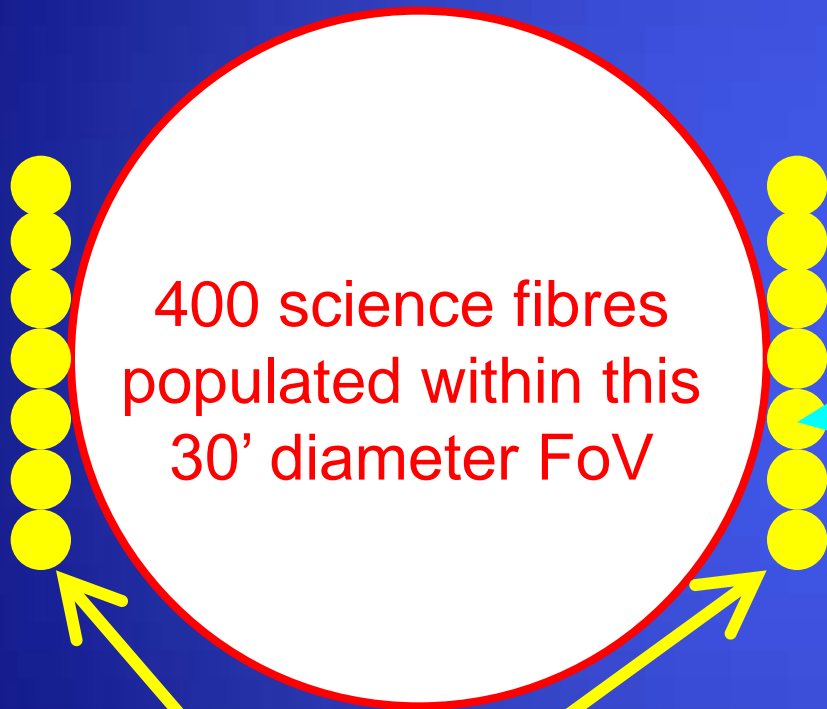
*Positioning accuracy
~ 0".2 in rms*

(including errors in
astrometry , model of
field distortion & time
variation, and Echidna
mechanical)

*Measured using
SKYcamera first,
and later confirmed
using the science
fibers by rastering
the telescope.*

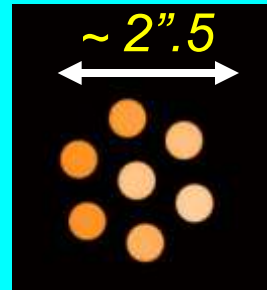
Fibre Auto Guiding (AG)

- Already operational.
- Long exposures have been successful with AG.



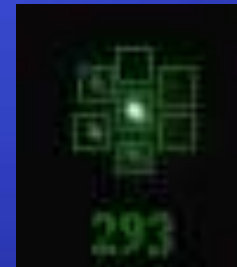
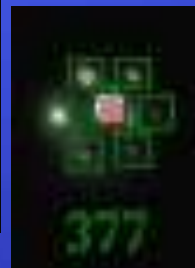
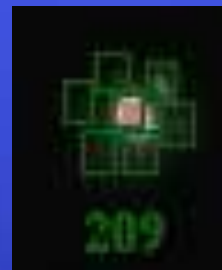
400 science fibres
populated within this
30' diameter FoV

14 fibre bundles for
AG (7 at one side)



7 fibres consist of a
guide fibre bundle.

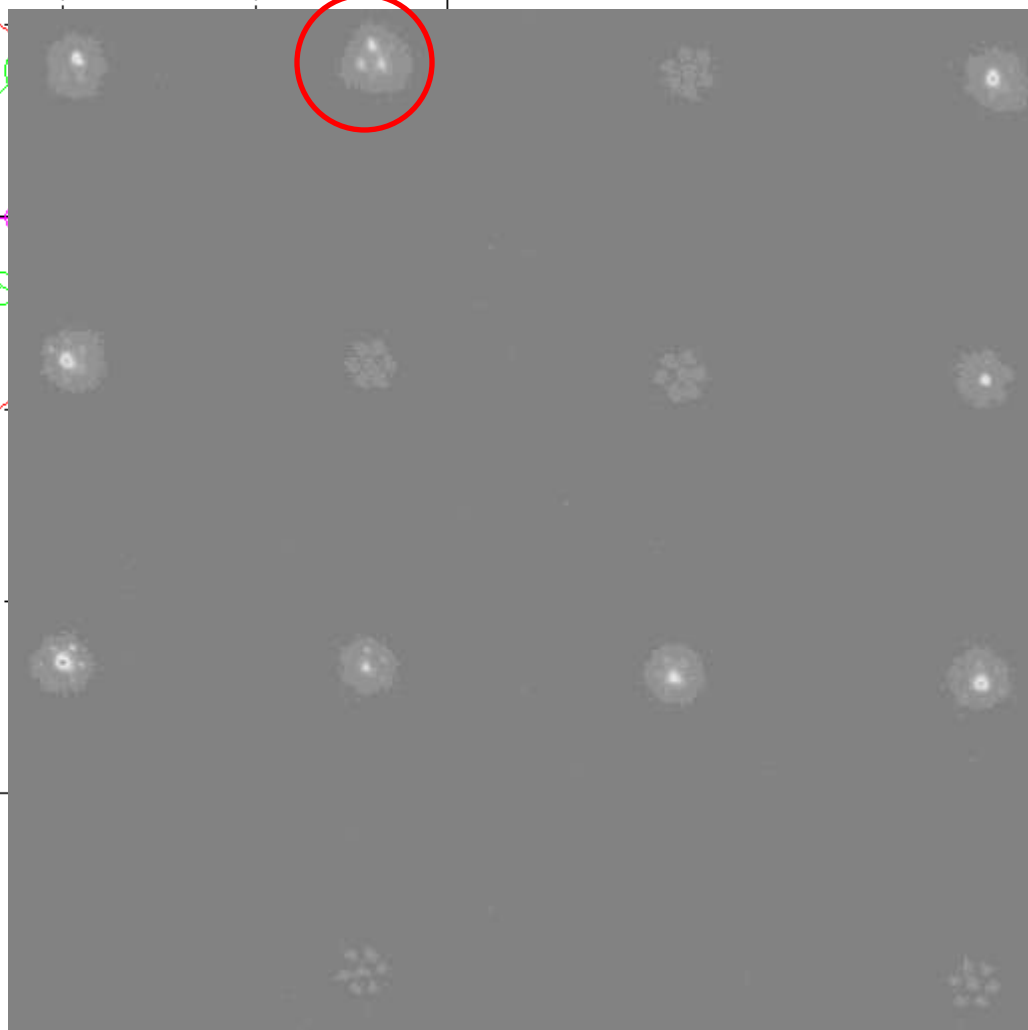
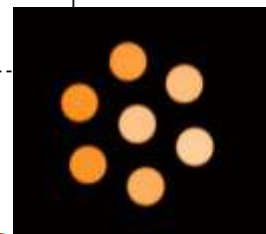
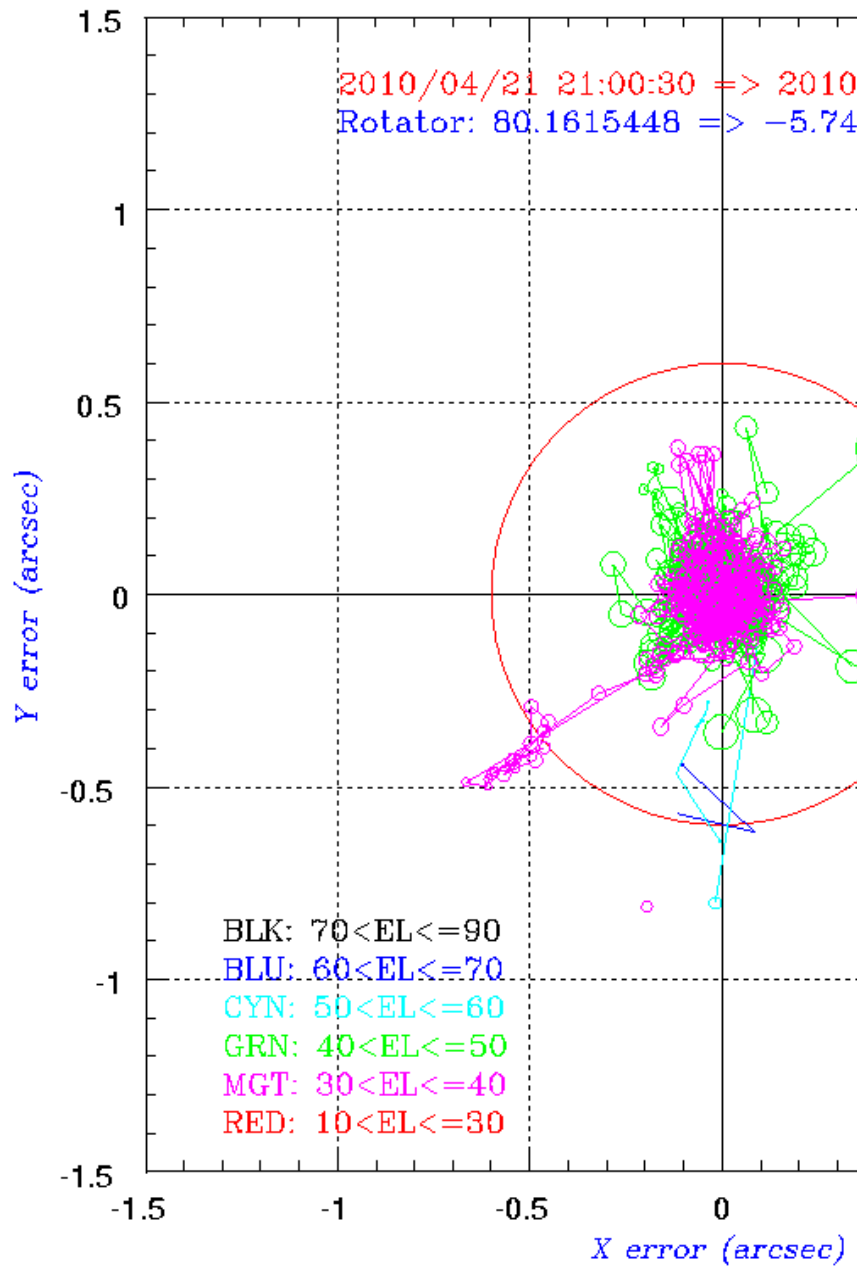
$R \leq 16.5$ mag have
been used for AG
(although the limit
depends on weather
& seeing)



Snapshots
of guide
stars on
guide fibre
bundles

2010/04/21 21:00:30 => 2010/04/22 04:58:13

Rotator: 80.1615448 => -5.744493961



Softwares & tools

- Spectral simulator (on the Subaru web site FMOS section)
www.naoj.org/Observing/Instruments/FMOS/simulator.html

