

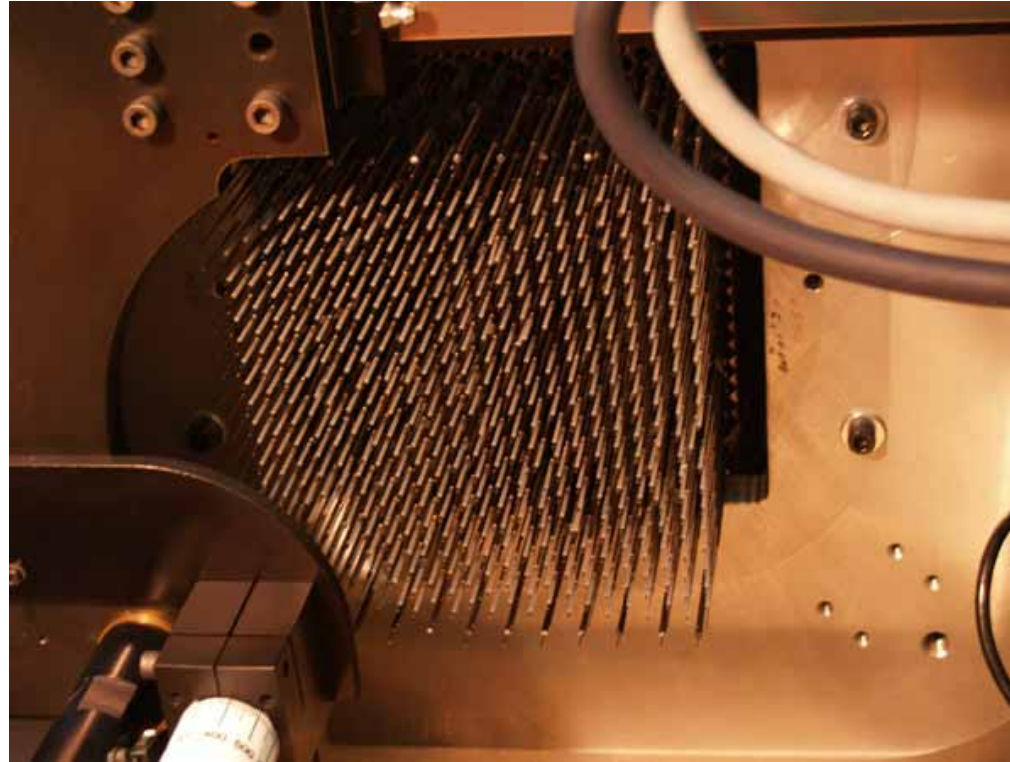


FMOS: Echidna
Hilo commissioning results

Echidna= fibre positioner for FMOS



Echidna: goal

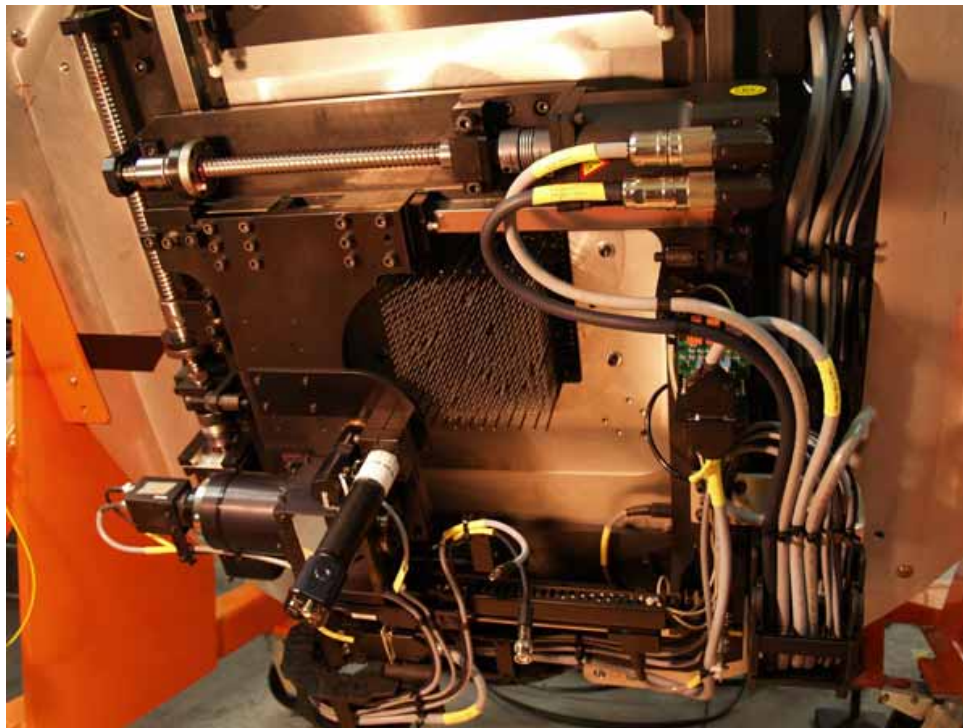
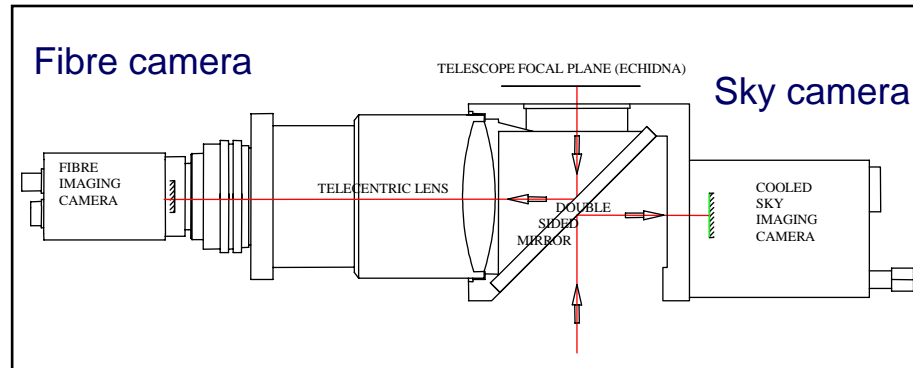


- Configure the tips of the 400 fibres in the focal plane with ~ 10 micron accuracy within ~ 10 minutes.

Fibre core has 100micron diameter, which corresponds to 1.2" diameter at the prime-focus. 20 micron offset from each target is acceptable (10% light loss in relative to the on-source case for stellar objects under typical seeing condition). The tips of the fibres need to be configured within the offset from the targets: setting goals with ~ 10 micron (0.12") fibre configuration accuracy and ~ 10 micron (0.12") astrometric accuracy is a good break down.



Echidna: focal plane imager on XY gantry



The positions of the tips of the fibres are measured with the fibre camera, and the positions of relatively bright stars are measured with the sky camera. Both cameras are warm video-rate CCD camera. The two cameras are on the XY gantry to cover the entire focal plane. **No mechanical trouble happened with the XY gantry, so far.**

Each fibre can be “back” illuminated individually by the illumination mechanism at the other end of the fibres (i.e. inside fibre connector box). Fibre camera cover the entire FoV with 59 FoVs. 12-20 fibres covered in one FoV. The positions of 400 fibres can be measured in 100 seconds automatically and the positions are stored in text files.

Sky camera has 1.3'x1.0' FoV with 0.1"/pixel image scale. Based on test observations with 4m AAT, we expect R=16-17mag stars can be detected with the camera.

We also have “forward illumination unit” to illuminate the tip of the fibre with infrared light source from focal plane.

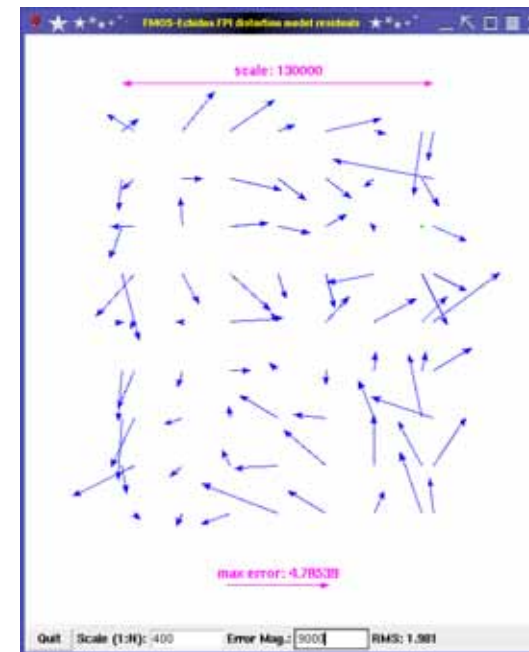


Echidna: focal plane imager : accuracy

- The distortion of the fibre camera and the distortion of the gantry XY movement (non-orthogonality etc.) are calibrated by measuring a grid-pattern illumination source on the focal plane of the echidna unit in stead of the fibre modules. The measurements were done at various ZD (tilting PIR) and rotator angle. The distortions of the fibre camera optics and the XY gantry movement can be described well with the “mean” distortion model determined by averaging the models measured at various positions. This means we do not need to consider ZD/rotator angle dependence of the model, and this simplifies the software. **Still need to check temperature dependence of the FPI distortion model up at summit.**



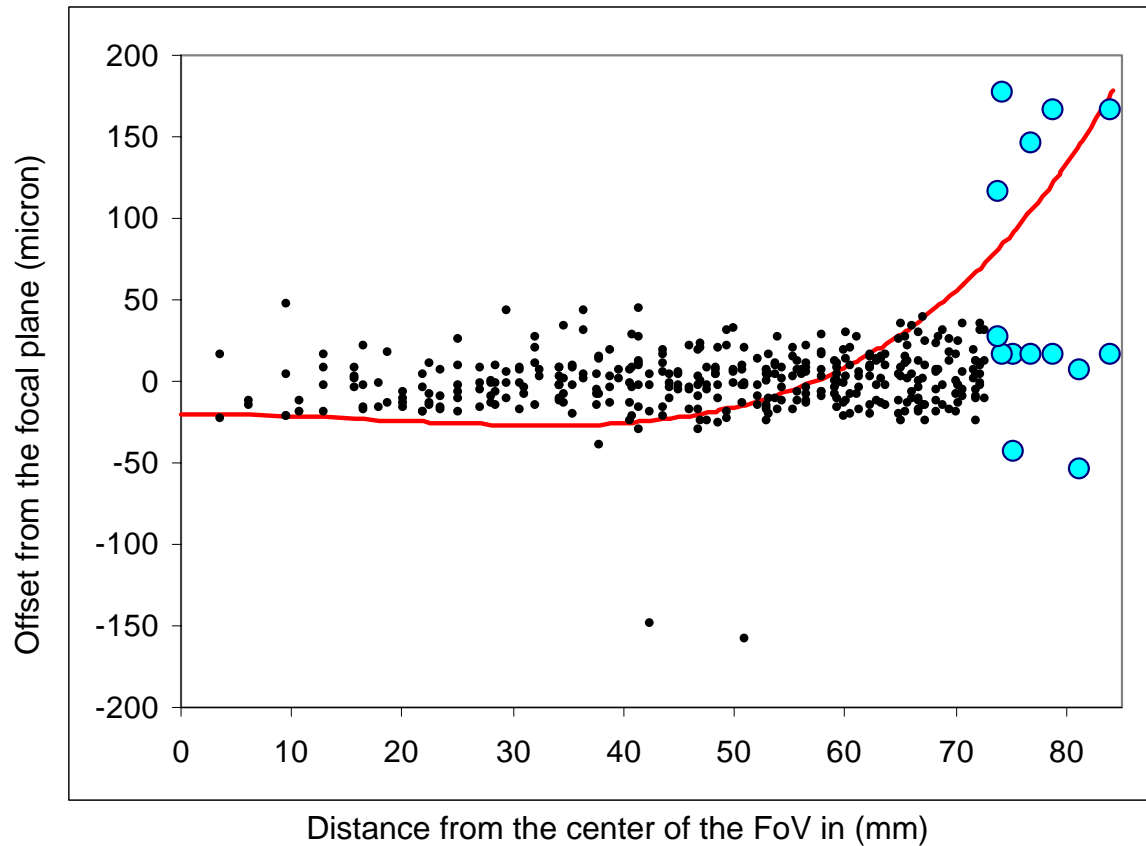
- Residuals in one FoV of the fibre camera after removing third order distortion is 1.27micron R.M.S. with maximum error of 3.14micron. No systematic residual.



- Residuals in the entire focal plane after removing the camera distortion model and the gantry XY movement distortion model. 1.98micron RMS using “mean” distortion model.



Echidna: fibre “spine” properties : length



“Co-planarity” of the tips of the fibre is also important. If a tip of a fibre is offset larger than 100micron then the image of an star on the tip of the fibre is blurred by 50micron (25micron radius) with F/2 light.

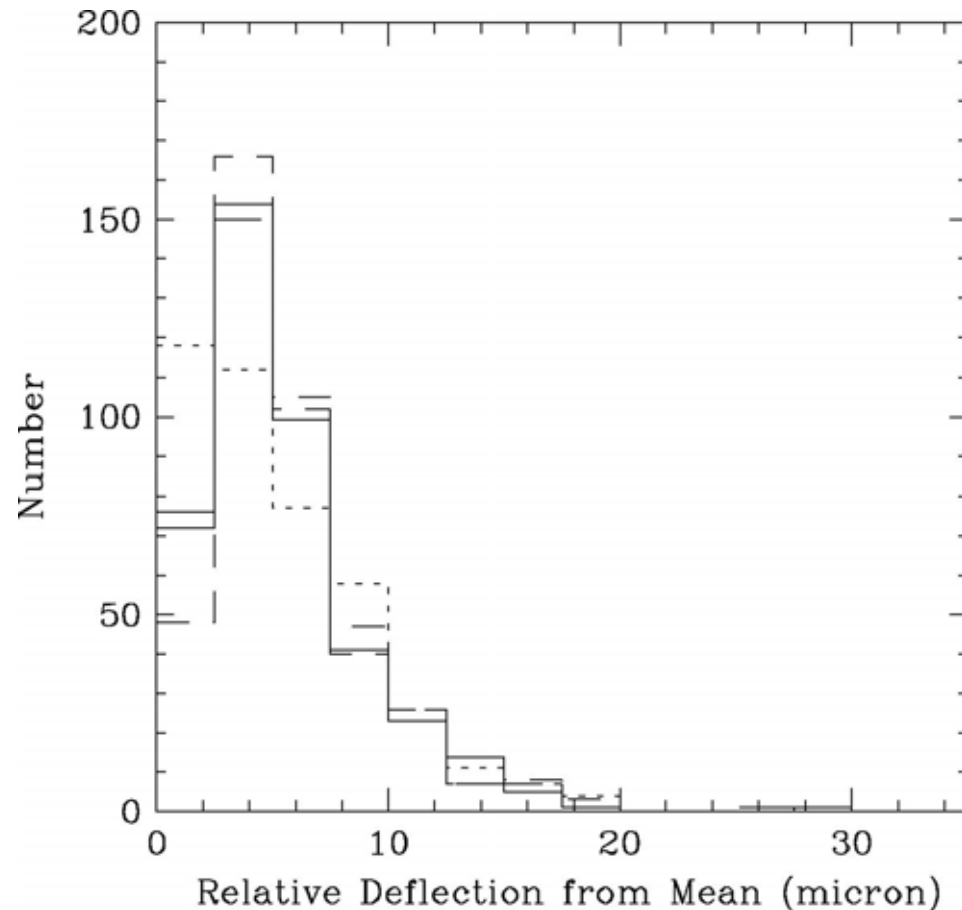
The “z” positions of the fibre tips (i.e., length of the fibre “spines”) are measured with a microscope attached to the FPI. The focused position of the microscope is recorded for each fibres.

Most of the fibres are within 100micron of the curved focal plane (shown with red line). Three fibres have large offset with >100micron. They will be remade (“re-terminate” we call) in the next 2 weeks.

Science fibres in black, and guide fibres in light blue



Echidna: fibre “spine” properties : relative deflection



The size of the relative deflection from ZD=60deg to ZD=0deg measured at 4 different position angles (shown with different line type).

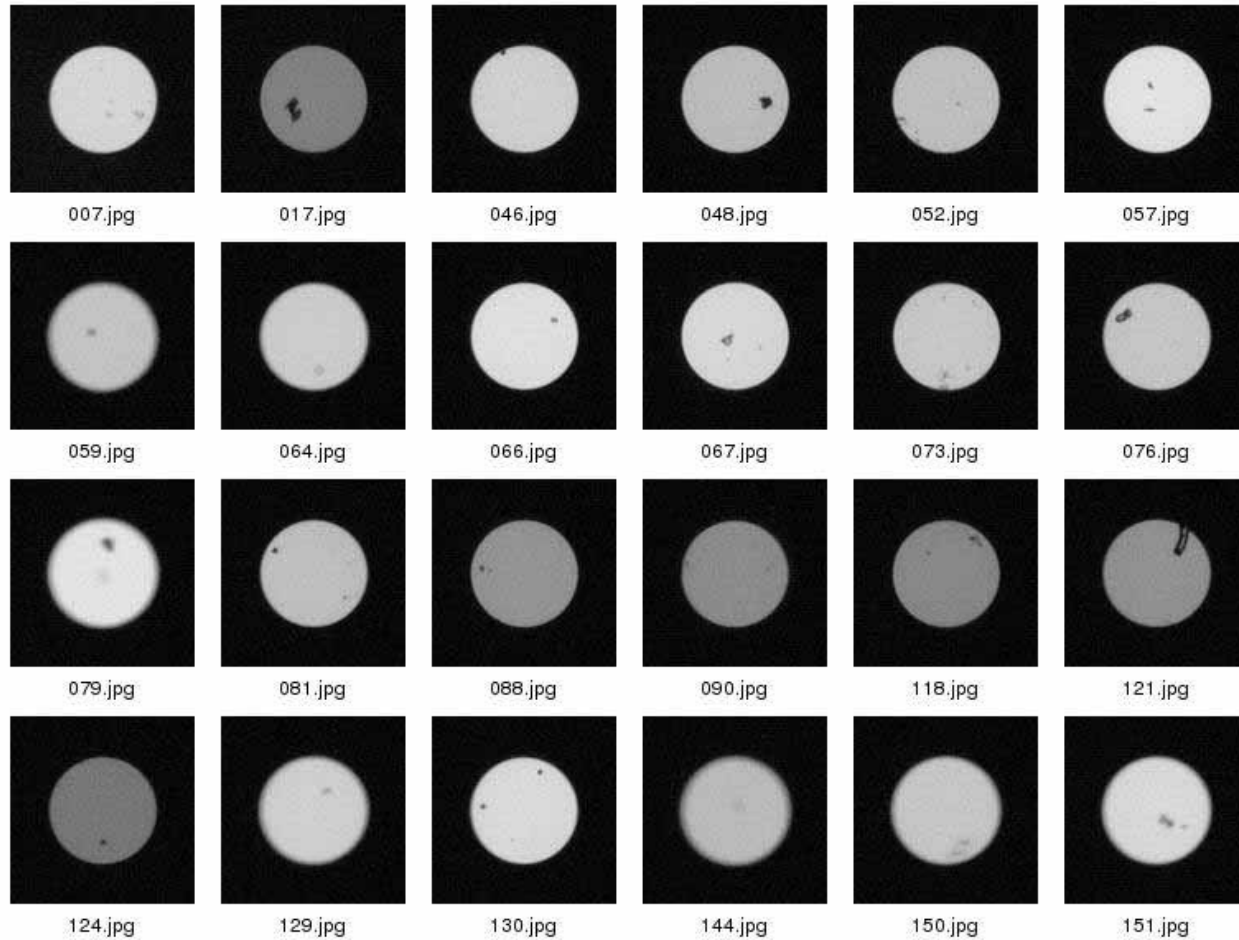
Deflection of the spines are measured with rotating the instrument at ZD=60deg. The positions of the fibre tips are measured with the fibre camera.

The absolute deflections of the spines are expected to be 25microns at ZD=60deg. But, it should be noted that the absolute deflection is not an issue and the relative deflection needs to be examined, because the “science” fibre tips are configured relative to the “guide” fibre tips, and both types of fibres are expected to be deflect similar amount.

The size of the relative deflection is smaller than 15micron (0.18”) for most of the fibres from ZD=60deg to ZD=0deg. The scatter of the relative deflection is sufficiently small for long integration time.



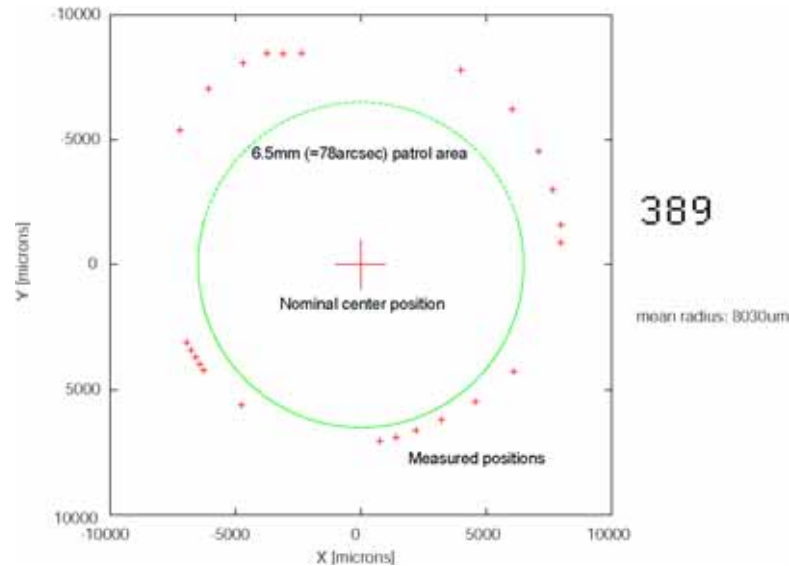
Echidna: fibre "spine" properties : cleanliness



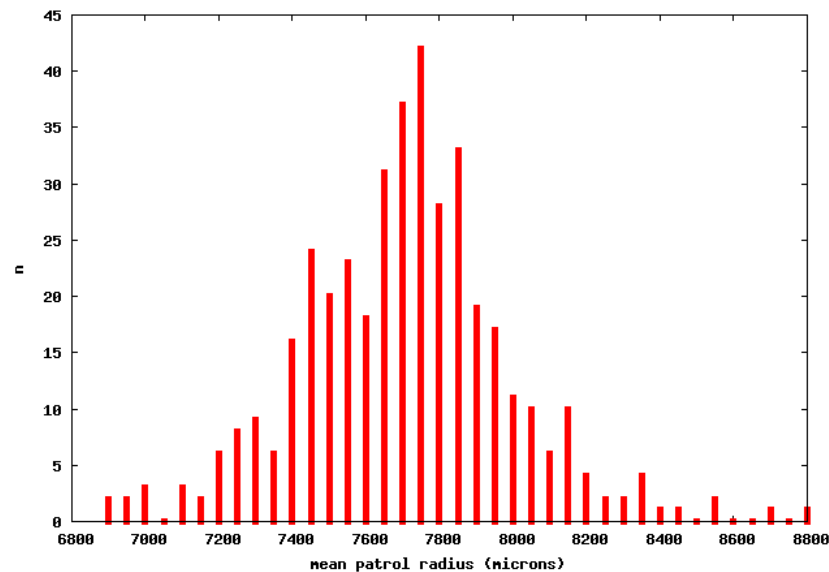
Cleanliness of the fibre tip is examined attaching microscope on the FPI. There are some dirty fibres (samples are shown above), but we found they can be cleaned easily. They will be cleaned before installation to PIR at summit.



Echidna: fibre “spine” properties : patrol area



Spine patrol area histogram
(mean-subtracted translation from nominal home position)

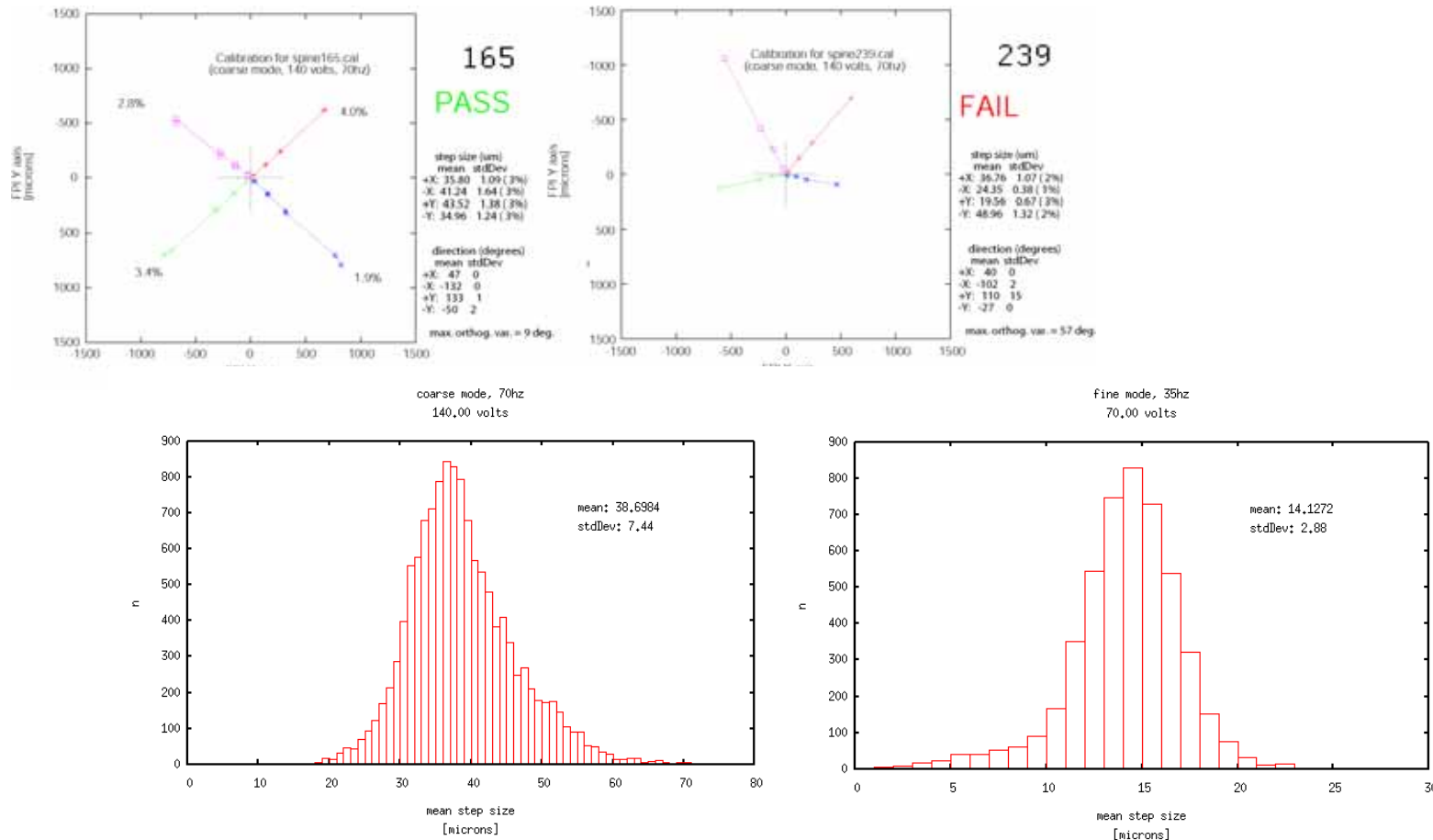


The “spines” are designed to reach the center of the neighboring spines, i.e. 7mm-0.5mm (tip thickness) = 6.5mm. The size of the patrol area for each fibre “spines” are measured by moving each spines to the edges.

Patrol area of a spines is defined with the mean radius from the center of the patrol area. All of the spines have the patrol area larger than 6.5mm radius.



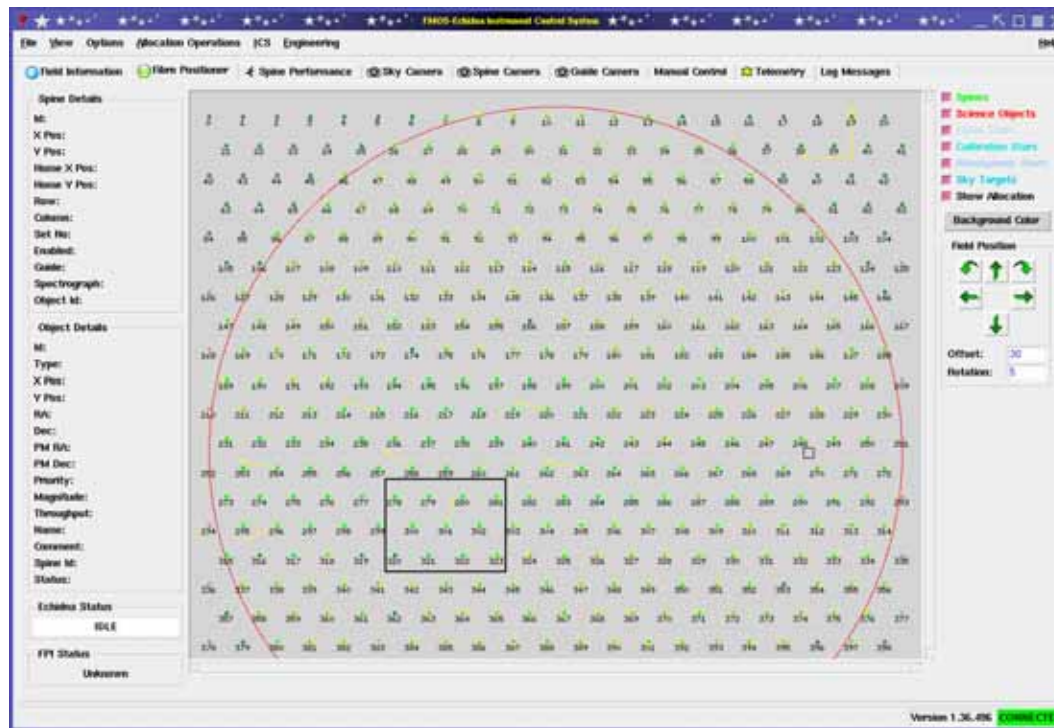
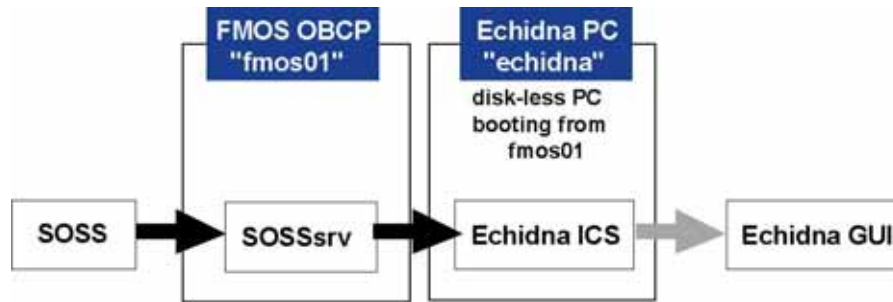
Echidna: calibrate fibre movement size and direction



The size and the direction of the fibre “spine” movement need to be calibrated. The calibration can be done automatically for 400 fibres. The number of signals sent to a certain spine is determined with the calibration results. Based on the size and the directions, the “PASS” and “FAIL” conditions are determined. Most of the spines pass the calibration. There are two mode for the spine movement, coarse and fine. First a few iterations are done in coarse mode and the later iterations are done in fine mode.



Echidna: control s/w and GUI



Echidna is controlled by the ICS s/w running on the “echidna” PC in the electronics enclosure of the unit. “echidna” PC is a disk-less PC booting using linux image on “fmos01”.

Observation catalog with targets’ RA, DEC, priority etc. is fed to the fibre allocation s/w. Optimizing fibre assignment (observe higher priority targets, minimizing fibre tilt, etc.) the s/w determines the fibre allocation and store the data in .s2o file.

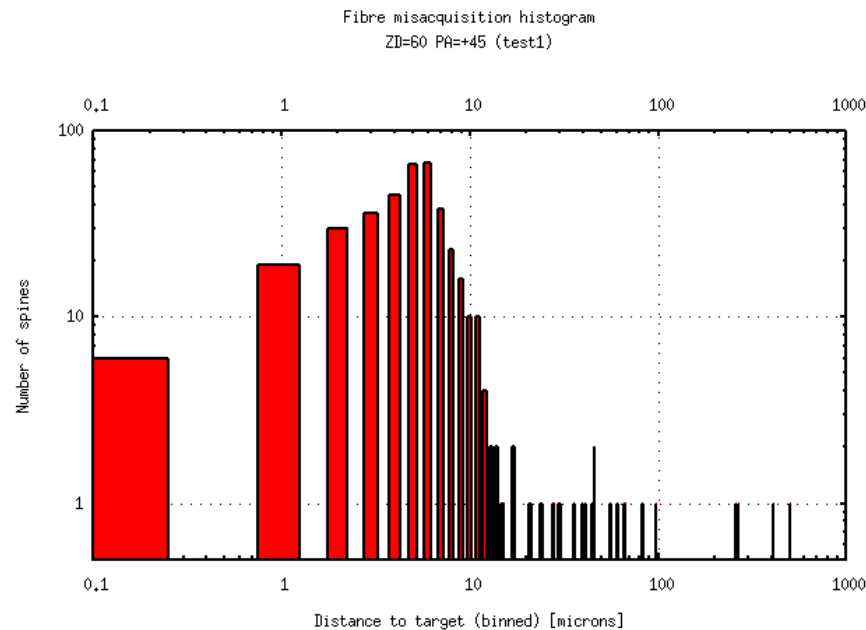
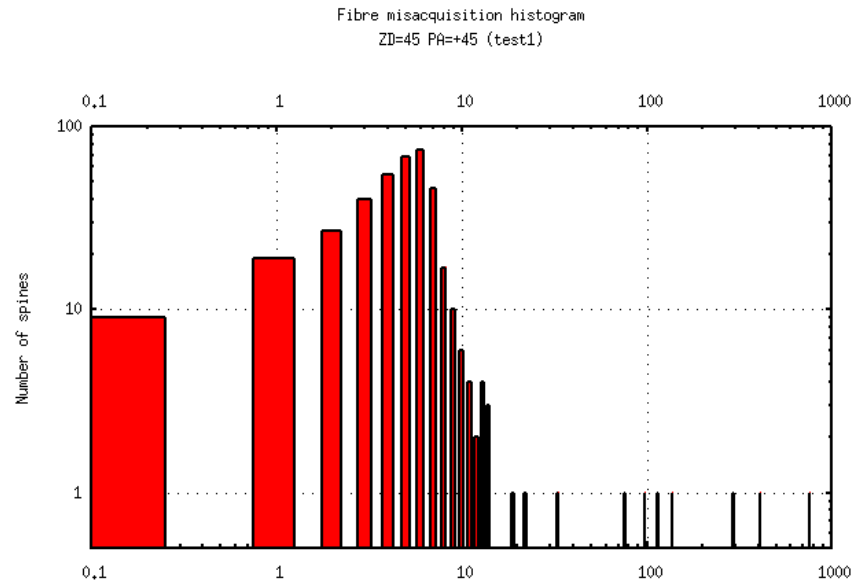
Based on the allocation, ICS s/w automatically configure fibres with several times (~7) iterations.

The results of the configuration will be stored in a text file in the “fmos01” and fetched by the FITS creation software. The target information, configuration information are stored as ASCII extension header of the FITS images file.

Engineering menus (for example calibrating fibre movement automatically) are also available from the GUI.



Echidna: fibre configuration test results !



Intensive positioning tests have been done inside tilted PIR at various rotation angles.

At $ZD < 60\text{deg}$, 95% of the spines reach target position within 12micron with 7 iterations. About 10 out of 395 fibres cannot reach the target positions.

At $ZD=60\text{deg}$ with some rotation angles, the performance degrades. ~20 out of 395 fibres cannot reach the target positions with 7 iterations.

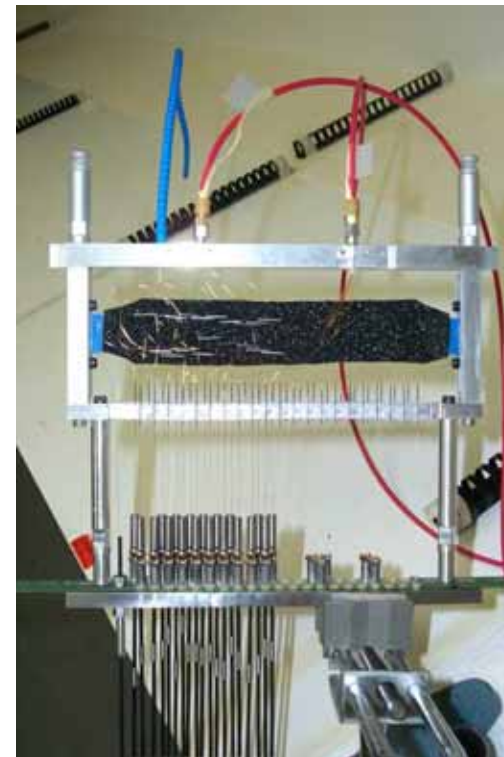
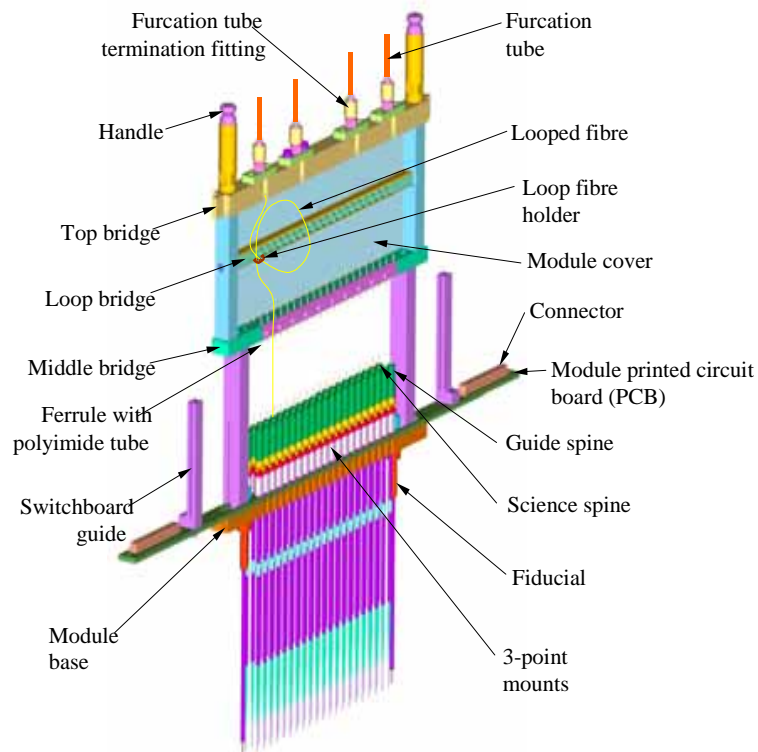
With 7 iterations, the fibre configuration takes 13 minutes currently.

The bad positioning accuracy at $ZD=60\text{deg}$ some spines have difficulty with moving against the direction of the gravity in the current mode. This may be solved with different frequency and voltage signals to the fibre movement. The fine tuning of the frequency and voltage is still underway.



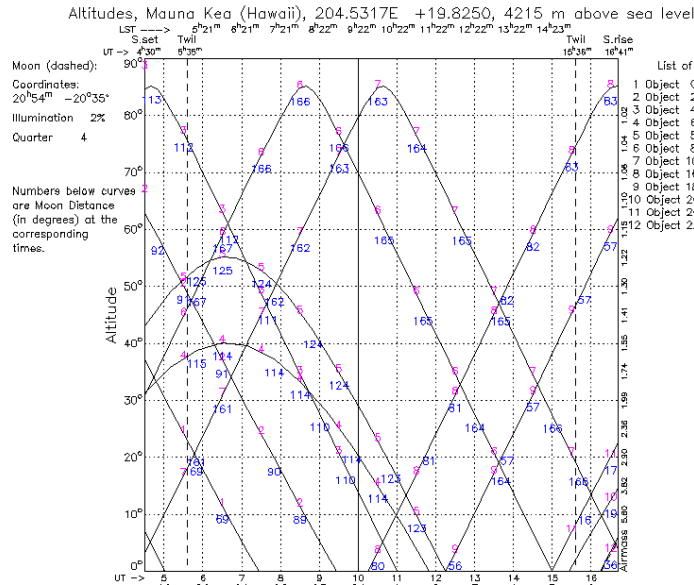
Echidna: spares

- Spare boards are available for most of the electronics boards.
- Two spare modules (with 40 fibres, there are 12 modules in the focal plane) will be made. They can be replaced with two of 12 modules currently on the focal plane. Module replacement is still a big task, but can be done by Subaru staff. We HOPE the two spare modules will cover the life time of the instrument (~10yrs).

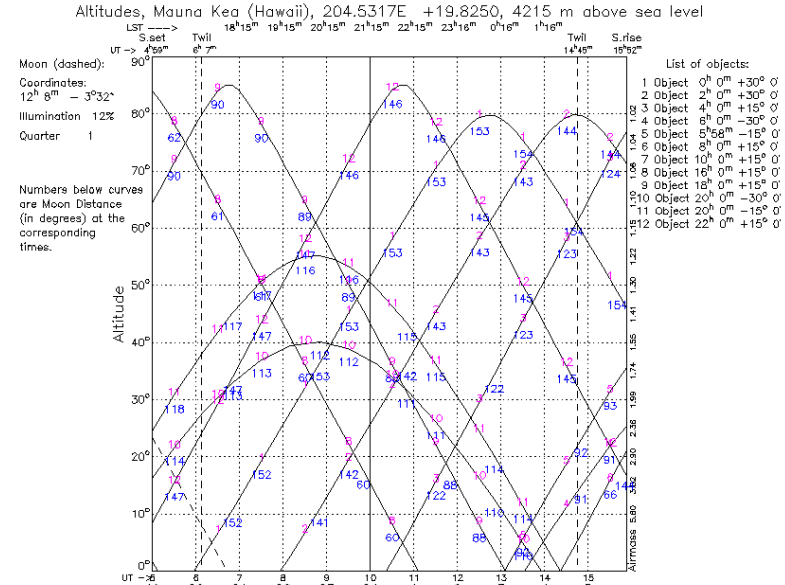




Echidna: FMOS astrometric standards for eng. obs.



FMOS astrometry fields in Feb.



FMOS astrometry fields in Aug.

We select several fields as the FMOS astrometric standard fields. In order to check the corrector distortion pattern and the positioning accuracy we need relatively low Galactic latitude fields with accurate astrometric calibration. We are proposing observations of 14 selected fields with >100 astrometrically calibrated stars (with UCAC2 catalog) with Scam in this Oct. The Scam data ensure better astrometric accuracy and covers fainter stars. The 14 fields will provide engineering targets at various ZD during whole night throughout year.

For open use observations, we need some sort of astrometry check s/w for observer's catalogs with UCAC3 catalog (not leave observer's own risk...like VIMOS, DEIMOS...)



Echidna: Issues (not mentioned so far)

Before on-sky commissioning

- Transfer to the summit ! With BSIT maximum acceleration is expected to be ~1G and spines are tested fine up to 8G, but...

- Piezo tube used to control fibre spines are fragile ceramic, and careful/gentle handling is necessary.



- Re-termination (replace carbon-fibre tube with new one) of fibre spines needs to be done for ~10 more spines. Will be completed in the next two weeks.
- Echidna properties up at summit need to be examined just after the summit transfer on Nov. 1.

On-sky commissioning

- Accuracy of fibre bundle guiding. We have a problem of even illumination of the bundles of 7 fibres. Better diffusers will be installed to the back-illumination unit for the guide bundles in the next two weeks.



Guide fibre image on “fibre” camera



Echidna: mechanical IF to PIR



- No serious problem with mechanical IF to the PIR.

- smooth fitting with two guide pins.

- interlock between SH/AG unit (PIR-side) and FPI unit (Echidna-side) checked.

- no obvious problem with rotating instrument inside tilted PIR (ZD=75).

- BUT, Minor issues:

- Fibre connector box handling during installation can be modified. (safer).

- Positioning FPI at correct position before removing/installing Echidna to PIR. (Sometimes remember after switch off the instruments...)