PFS work report about fiberNorms Quality Assessment

Ayumi Takahashi (NAOJ) and the PFS DRP development team

Abstract

PFS has 2400 fibers; exploring how the light is through each fiber via calibration data is crucial. If the light in fibers is amplified, attenuated, or fluctuation with any parameters, the target light to be observed cannot be extracted precisely. We found from past engineering runs that relative fiber throughputs have been known to change during the night by changing the air gap with time. The variability of fiber-to-fiber throughput must be less than 1% because the required sky subtraction accuracy is at a 1 % accuracy level; this is especially important for detecting faint objects. In the last run, the gel-applied MTPs showed stable fiber throughput. However, we do not yet know the behavior of the fiber throughput when all MTPs are gel-applied. So then, we are developing tools to monitor fiber throughput long-term and analyze calibration data quality as a fiberNorms QA.

fiberNorms

"fiberNorms" is the model we guess for relative fiber throughput, representing normalized flux per fiber. These are the ratio of the flux of the new quartz to the flux of the original reference quartz, which applies (i) black spot correction and (ii) screen illumination correction.

$$\mathrm{pfsArm.norm} = \mathrm{fiberProfiles.norm} \times c_{bs} \times c_{scr}$$

$$\mathrm{fiberNorms} = \underbrace{\mathrm{pfsArm.flux}}_{\text{flux of the new quartz}} / \underbrace{\mathrm{pfsArm.norm}}_{\text{flux of the original reference quartz}}$$

If the quartz flux is indeed flat, then fiberNorms becomes 1.0.

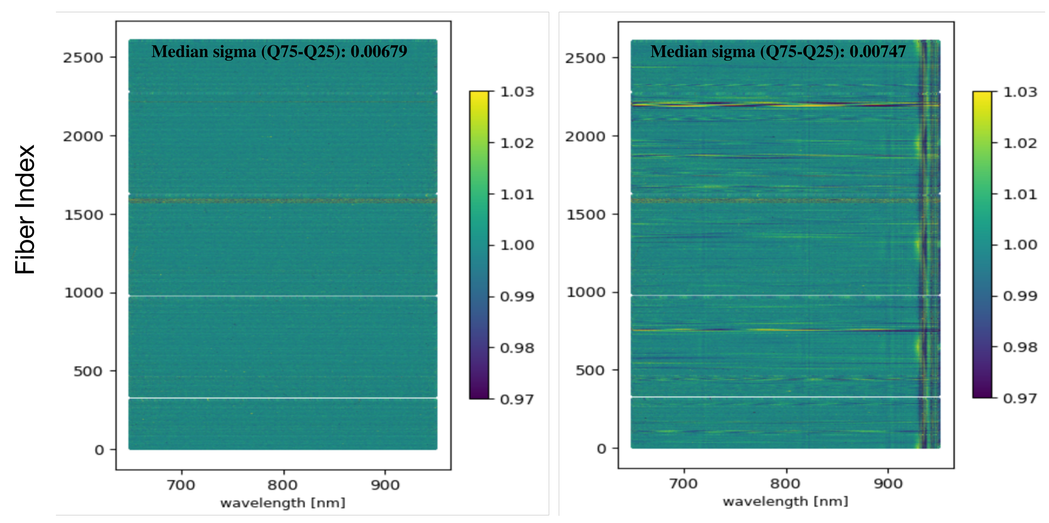
We use quartz exposure to monitor measured signals in different fibers, spectrographs, and wavelengths.

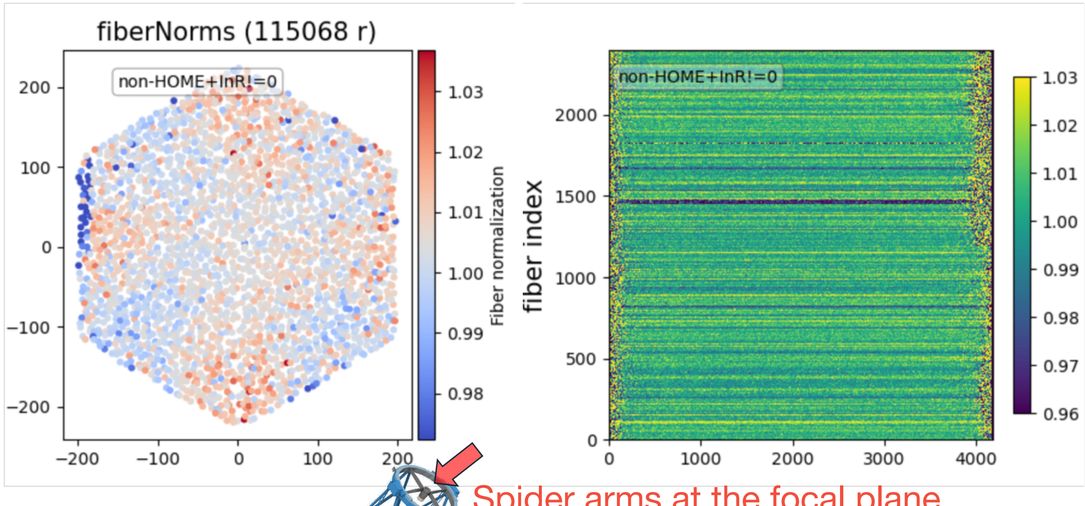
Right-top: the flux ratio of subsequential exposures. The left image shows stable throughput, but we can see the fringes in many fibers in the right one. We have investigated when and how these phenomena occur during observations. We measured robust-sigma as an indicator of flat-changing, estimated from a flattened array of fibers and pixels of subsequent quartz ratio.

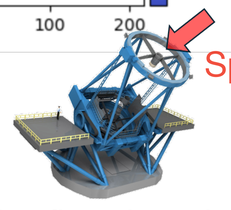
Right-bottom: We are also looking at fiberNorms when the instruments move. A few quartzes with non-zero rotator angles show a sub-structure in their focal plane, like a spider arm. This represents a few % higher flux levels. Some visits show flux gradient in only the b-arm. From our QA side, we will continue looking at this kind of data more to get information on the relationship between measured flux and observing conditions.

Quartz ratio: 113731 (2024-08-28 05:54 HST)/113729 (2024-08-28 05:50 HST), arm=r

Quartz ratio: 113752 (2024-08-28 19:07 HST)/113731 (2024-08-28 05:54 HST), arm=r







Spider arms at the focal plane

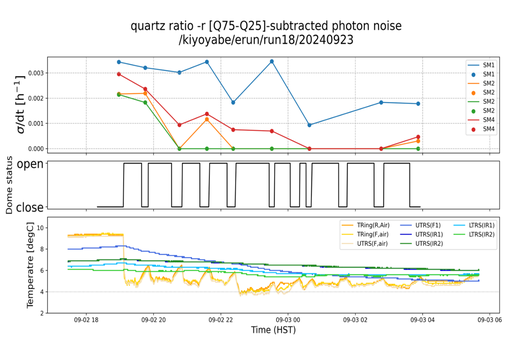
Development tools to monitor fiber throughput

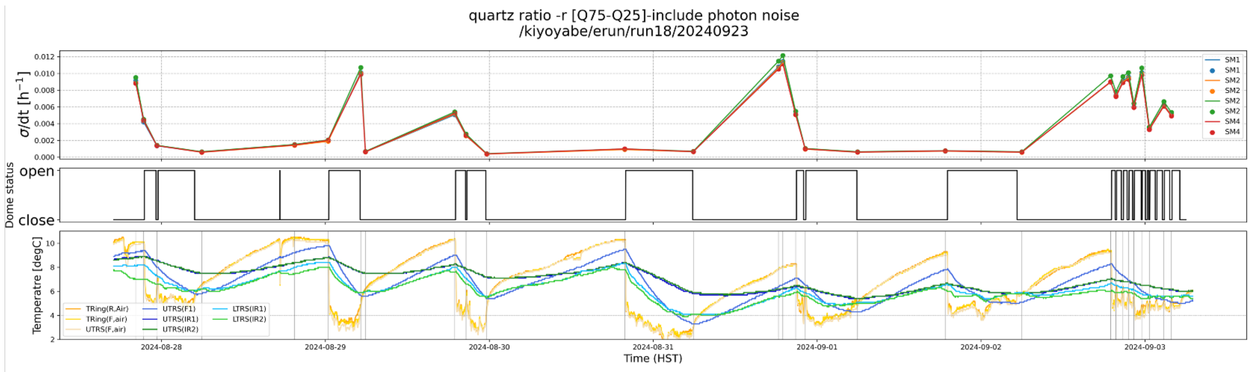
Time dependency of flat-changing rate

One of the questions regarding fiber throughput is related to time during the night. These figures show the flat-changing rate between two quartz exposures, comparing the time for each spectrograph. These provide us with information about how it varies in the night. The color is a different story, but in most cases, the flat-changing is faster in earlier times in observing night. The flat-changing is related to the effects of the timing of the opening dome.

Run18 data (not applying gel)

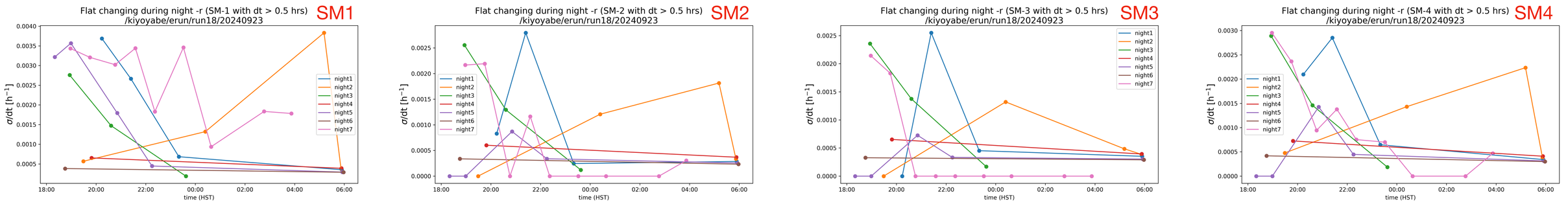
Flat-changing rate comparing dome staus



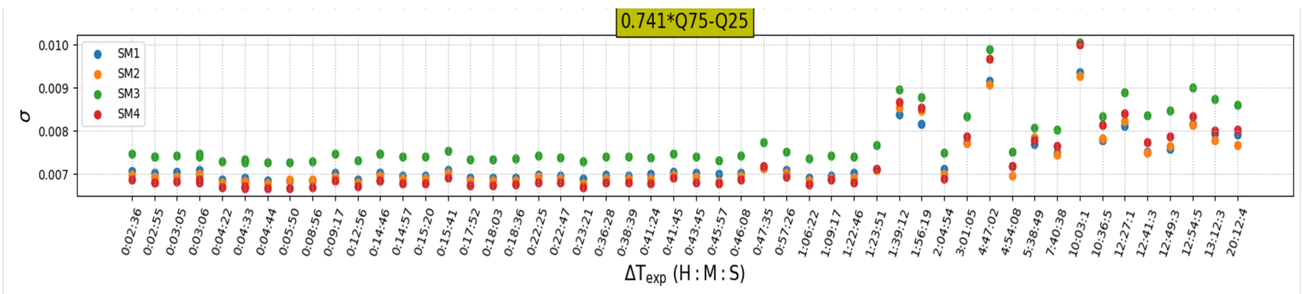


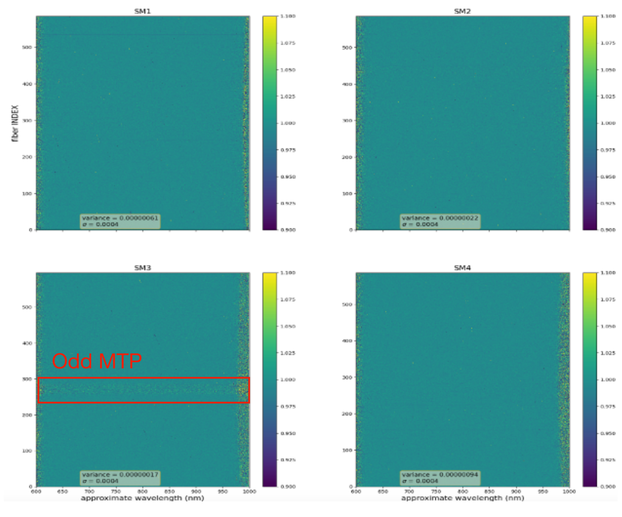
(Left) The comparison between the flat-changing rate and the telescope condition. The top panel shows Sigma divided by time difference, and the middle panel shows dome status; high is open, and low is closed. The bottom one shows the temperature evolution inside the dome with various points on the telescope system. This result compares that the flat changing rate becomes smaller in proportion to the temperature. (Right) Similar to the left-upper figure but across the run. See also Y.Moritani-san's poster (P15).

Each flat-changing rate per spectrograph comparing time



Sigma evolution comparing the time time differences btween two quartz sets

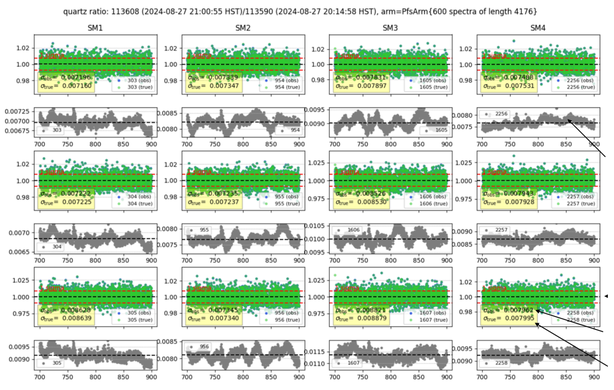




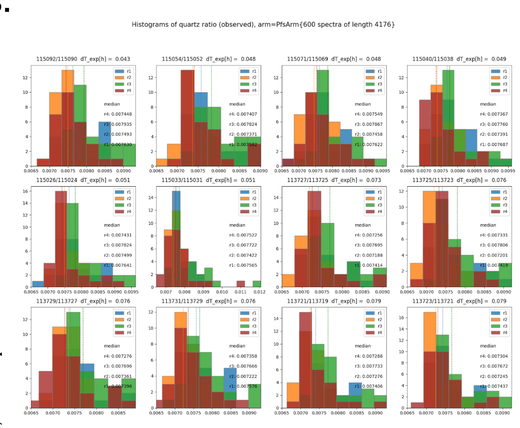
We also looked at throughput evolutions, comparing the exposure time difference. The horizontal axis shows a more significant exposure time difference toward the left. SM3 has larger Sigmas than others systematically. This may be because SM3 has an odd MTP where it has low S/N (under investigation).

Future prospects

We will provide the fiberNorms QA tool, which plots various results, such as capturing odd fiber spectra, fiber throughput variation with MTP/fiber unit per visit, and providing sigma and flat-changing rate evolution across future runs to monitor their stability with our tools in future runs.



Top-panel: flux ratio. Blue scatters represent observed flux ratio measured via normalized pfsArm.flux(v2)/pfsArm.flux(v1).
Light green scatters represent noise-subtracted flux ratio.We subtracted error of
flux ratio using pfsArm.covariance (see bottom figures) from observed flux ratio.
Black and red dashed lines represent median, and 1sigma of noise-subtracted flux ratio, respectively.
Robust sigmas in yellow box represent measured IQR(Q75,Q25) of observed spectra and noise subtracted supectra.
Bottom-panel: flux error measured via propagated two quartz flux. Black dashed lines represent median of noise.



👆The histograms of quartz flux ratios. The color difference shows the difference in spectrographs. The exposure time interval and sigmas are also represented. These plots trace variation distribution comparing all arms.