PFS Proposal:
Getting Started

The obsproc working group

v1.1 (05.feb.2025)

First of all...

- First, carefully go over the PFS instrument page for the operation scheme and associated policy: https://www.naoj.org/Observing/Instruments/PFS/index.html
- The PFS science operation scheme is totally different from that of the other instruments at Subaru. So, forget all your previous Subaru experience!
- Why different? Well, PFS is a massively multiplexed spectrograph with ~2,400 fibers. We, the observatory, do not expect that all PIs can use all the fibers efficiently at all pointings. So, we collect science targets from accepted programs, optimize pointing coordinates and fiber assignments, and observe the targets as efficiently as possible. As you can imagine, the default observing mode is queue. There are many other differences, too.
- The PFS science operation is complicated, but it is to maximize the science output from your observing program!
- If you have any questions, feel free to contact us at pfs-obs-help@naoj.org!

This document

Here is the path to a successful proposal. We will walk you through each of these steps.

Science Case

- First of all, come up with a good science case! That is the key for a successful PFS proposal. You cannot write a good proposal without a good case.

- Make sure that PFS is the right instrument for your science. This is one of the review items at TAC. PFS is a much more powerful instrument than the previous spectrographs at Subaru, but it does not cover all science cases. For instance, it is not good at sampling objects in dense galaxy/globular cluster cores (its fiber density is about 0.6 objects / arcmin^2). Make sure that PFS is suited for your program.

The bottom bar shows you where you are.

Target List

- OK, now, you have a science case. The next thing you should do is to prepare a list of targets. In some cases, however, you may want to consider the proposal category at this point, depending on the nature of your proposal. So, you may want to iterate the steps between here and proposal category.

- For PFS observations, you need to define the following properties for each of your target. This is a screenshot from the Target Uploader (which we will discuss later).

Name	Datatype	Unit	Description
ob_code	str		A string identifier for the target. Each `ob_code` must be unique within the list.
obj_id	64-bit int		Object ID (-9223372036854775808 to +9223372036854775807).
ra	float	degree	Right Ascension (J2000.0 or ICRS at the epoch of 2000.0)
dec	float	degree	Declination (J2000.0 or ICRS at the epoch of 2000.0)
exptime	float	second	Exposure time requested for the object under the nominal observing condition.
priority	int		Priority (integer value in [0-9]) for the object within the list. Smaller the value, higher the priority
resolution	str		Grating used in the red optical arms. `L` for the low resolution and `M` for the medium resolution
flux	float	nJy	Flux of at least one filter in the pre-defined list
reference_arm	str		Reference arm name used to evaluate the effective exposure time (`b` : blue, `r` : red, `n` : near-IR, and `m` : medium-resolution red)

Target List

- Some of the properties are new to you, and they require attention. We explain them here.
  - `ob_code`:
    - Observing code for this object. This has to be set by the user. Any string ID is fine.
  - `obj_id`:
    - Object Id. This has to be an integer number.
  - `(R.A., Dec.)`:
    - Make sure you use the right coordinate system (ICRS; see the online document). We suggest you calibrate your astrometry against Gaia. Note that we do not check the coordinates of your targets; if your coordinates are systematically off by, e.g., -0.5 arcsec, you will lose significant fluxes. We do not compensate for it.
  - `exptime`: see next page.
  - `reference_arm`: see next page
- The list may include more columns. Refer to an example file at Target Uploader page (which will be discussed later).

Effective Exposure Time

- `exptime` is not a simple exposure time. It is 'effective exposure time', or EET for short. What is it?

- In the current queue system at Subaru, a 10min integration is considered 10min as long as the observing conditions meet the requested conditions. For instance, if the PI requests seeing < 1.5arcsec, an exposure under 0.6 arcsec seeing and another one with 1.4 arcsec are both 10min.

- Although this is operationally easy, it is certainly not optimal especially when we observe targets from multiple programs with different (likely a wide range of) requirements on observing conditions in the same exposure.

- We thus introduce the effective exposure time; it is an S/N-based exposure estimate.

Effective Exposure Time contd.

- For S/N estimates, we literally need the signal and noise measurements.
- We define the signal here as a relative throughput between the exposure in question and nominal (‘reference’ or ‘fiducial’ may be a better word here) throughput. We measure the throughput from FLUXSTDs (we will discuss calibration objects later) for each exposure. The median throughput from engineering observations is adopted as the nominal throughput.
- Likewise, we define the noise as a relative noise level between the exposure and nominal noise level. We measure the noise level from SKY objects (which we will discuss later) for each exposure. Again, the median noise level from engineering exposures is taken as the nominal noise level.
- We compute S/N with respect to the nominal conditions from these numbers assuming point sources (i.e., the most pessimistic case).
- …but, the S/N is wavelength dependent. We thus introduce another parameter, which is `reference_arm`.

Reference Arm

- ‘arm’ is a PFS term, and it refers to a spectrograph arm and can be either b, r, n or m. As you can guess, b is blue, r is red, and n is near-IR. m is medium resolution in red.
- We define a wavelength window in each arm to compute the throughput and noise level.
- We compute EET with respect to the nominal conditions. Detailed math is summarized in a document available at the PFS instrument webpage.
- For a 15min exposure, if the conditions are better than average, then EET can be, e.g., 20min. If the conditions are poor, it can be, e.g., 5min.
- You should set `reference_arm` at the most important wavelength range of your object. If your important spectral features are in the red, then `reference_arm = r`. If you care about the moon, set `reference_arm = b`. If the medium resolution arm is important, `reference_arm = m`. If you have no specific arm to prioritize, then `reference_arm = n`.

Exposure Time Calculator

- OK, then how can you estimate the exposure time of your objects?
- Use the PFS ETC, which is available online: https://pfs-etc.naoj.hawaii.edu/etc/
- The ETC comes with a full documentation as well as a tutorial movie. Please refer to them. We do not explain how to use ETC here.
- The ETC assumes the nominal observing conditions. Thus, the exposure time you get from ETC is identical to EET.
- The individual exposure time of PFS queue observation is fixed to 15min, but your EET does not have to be a multiple of 15min. It can be any floating number, e.g., 32.6min.

Calibration objects?

- Now, you have your target list. Great!
- Next, you may ask yourself whether/how you prepare calibration objects such as standard stars. No worries. We prepare them for you.
- PFS requires two types of calibration objects in each exposure (or visit in the PFS terminology): SKY and FLUXSTD.
- SKY is a sky object and it samples the blank sky. We use these sky objects for sky subtraction in the pipeline. We typically have ~400 sky objects in each visit. But, this number may change in the future as we learn more about the sky subtraction.
- FLUXSTD is a flux standard. We adopt the same flux calibration method as SDSS, and we use F-type stars for FLUXSTDs. They are selected from PS1 DR2. We typically have 100-200 FLUXSTDs per visit, but again, the number may change.
- We do not charge you the observing time of the calibration objects in each visit.

Calibration objects in exotic regions?

- We have constructed these calibration objects from PS1 DR2 and Gaia DR3. They cover a large fraction of the observable sky from Maunakea but not completely.

- If your targets are located at Dec.< -30deg, where PS1 does not cover, contact us in advance (i.e., before you submit your proposal). We may ask you to prepare calibration objects by yourself.

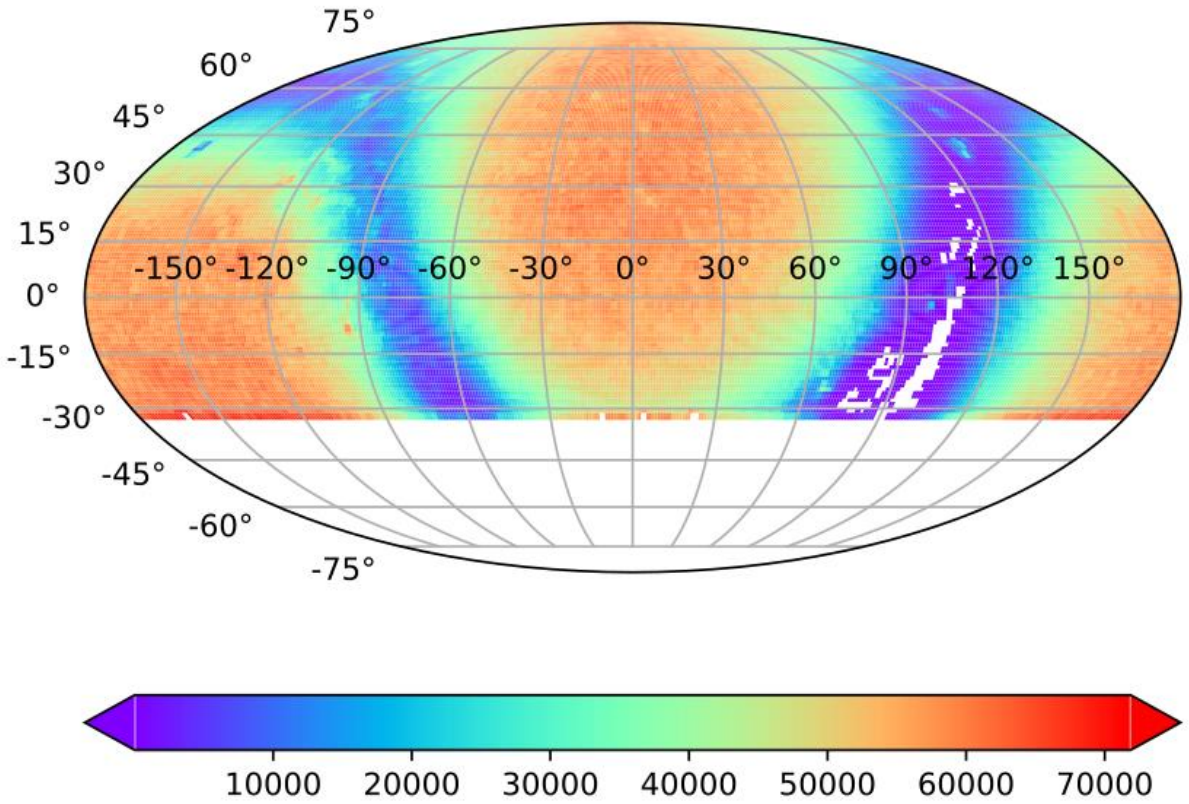
- If your targets are located at |Galactic latitude|<10deg, contact us as well. There is no blank sky in the Galactic disk (there may be exceptions, though), and we may ask you to prepare calibration objects by yourself.

- There may be other cases where we do not have calibration objects. It is known that sky objects in gaseous nebulae are not good. If you plan to propose targets in non-blank sky regions, please contact us.

- Detector-level calibrations such bias, dark, flat, etc are taken by the observatory in each observing run and are available to everyone. The time for these calibrations is shared by accepted normal programs and are already included in the overheads in your ROT from the uploader (we will discuss ROT later).

Calibration objects in exotic regions?

- For reference, here is the density of sky objects per tract, which is one of HSC's areal unit and is approximately 1.7deg x 1.7deg, in the equatorial coordinates. Note that 180<R.A.<360 is plotted as -180<R.A.<0.



Proposal category

- Phew, you have come this far. Wonderful! Now, it is time for you to make an important decision.

- There are a few different proposal categories for PFS:
  - Normal program (either queue or classical)
  - ToO program (which may be considered a normal program, but we separate it here)
  - Community filler program

- If you aim to observe transient objects in a time-critical way, then ToO is your observing mode. Please refer to the PFS instrument page for details of this mode. Note that the ToO time request is in half-night units in S25A (not hour units, yet).

- For the remaining two, normal vs. community filler, let's first look at the summary table on the next page.

Priority order

Normal programs

category	Competitive?	Proprietary period	multi-semester	priority	Drive pointing center?
Grade A	○	○	X	1	○
Grade B	○	○	X	2	○
Grade C	○	○	X	3	△ *1
Community filler	△*2	o	○	4	X
Observatory filler*3	—	X	○	5	X

*1) When there are no grade A+B targets to observe, we use targets from grade C to define PFS pointings.
*2) TAC process for community filler programs is less formal than normal programs.
*3) The observatory prepares the observatory filler. It is a flux-limited sample of PS1 sources (see Appendix).

Proposal category contd.

- As you saw, a normal program and a community filler program are VERY different. There are other differences that are not captured in the table:
  - A normal program runs for one semester, while a filler programs runs for two semesters (i.e., one year).
  - Accordingly, we make a call for community filler only once in two semesters. To be specific, 'A' semesters only.
  - The maximum time for a normal program is 3.5 nights (= 5 nights x weather factor) for queue and 5 nights for classical, while there is no time limit on filler programs.

- These differences primarily stem from the difference in the scopes of the categories; PFS introduced the filler category to fill spare fibers with low priority targets. A filler program does not drive PFS pointings. Filler targets are observed only when they happened to be located in the PFS pointings set by high priority targets and when there are spare fibers.

- So, if you have interesting targets to observe, we very strongly encourage you to submit a normal proposal, not a filler proposal!

More about filler

- To describe more about fillers:
  - Due to the way how filler targets get fibers assigned, do not expect to get more than 15min integration (i.e., single exposure). They may get longer integrations depending on high priority targets nearby, but 15min should be considered default.
  - You will not be able to access the raw data.
  - The processed data will be made available at the PFS Science Platform (PFS SP). We will describe PFS SP in detail later.
  - Filler PIs have to review each other's proposals (i.e., distributed review system).

- Further details of the filler category can be found at the PFS instrument page.

- We emphasize once again; submit a normal proposal and drive the PFS pointings to your targets!

Normal Program

- OK, let's get to normal program.
- There are two observing modes: classical and queue.
- For PFS, queue is the default mode because it is the best way for the observatory to efficiently execute multiple programs in the same exposures. So, choose queue unless you have a good reason otherwise.
- Classical mode is only for observations that cannot be executed in queue such as exposure times shorter than 15min for very bright sources. More example cases for classical observations can be found at the instrument page. You have to justify why you need classical mode in your proposal.
- Let's look at some of the key features of each observing mode in the following slides.

Queue Mode

- Starting with queue, we collect ALL of your targets at the proposal submission phase as we discuss in detail later.

- After TAC, we have proposal grades/scores. We weight targets from each proposal with its score.

- We compute optimal pointings of PFS observations and assign fibers to objects to maximize the observing efficiency. We try to achieve high completeness for high priority programs. The details of this algorithm will be summarized in He et al. (in prep.), but a brief summary can be found here.

- When we cannot fill all the fibers with science and calib objects, we include community and observatory fillers.

Classical Mode

- Once again, classical mode is only for programs that cannot be executed in queue mode.
- An accepted programs will be allocated observing nights a priori.
- Even for classical programs, we ask you to upload your targets in phase 1 (the proposal submission phase). We do now allow target updates after upload. If you cannot fix your targets due to the nature of your science (e.g., you observe transient sources), please contact us in advance.
- We do not allow the user to make fiber designs. Instead, we make fiber designs for you; we have all the calib + filler targets in a massive DB, and we have all the tools set up for designing fibers configuration. We will get in touch with you a couple of weeks prior to your observing run, so you can check our design.
- As you see, there is not a lot of flexibility for the classical observer. The PI can choose which design to execute next, and that is probably the only flexibility compared to queue. We do not generate new designs during the night.

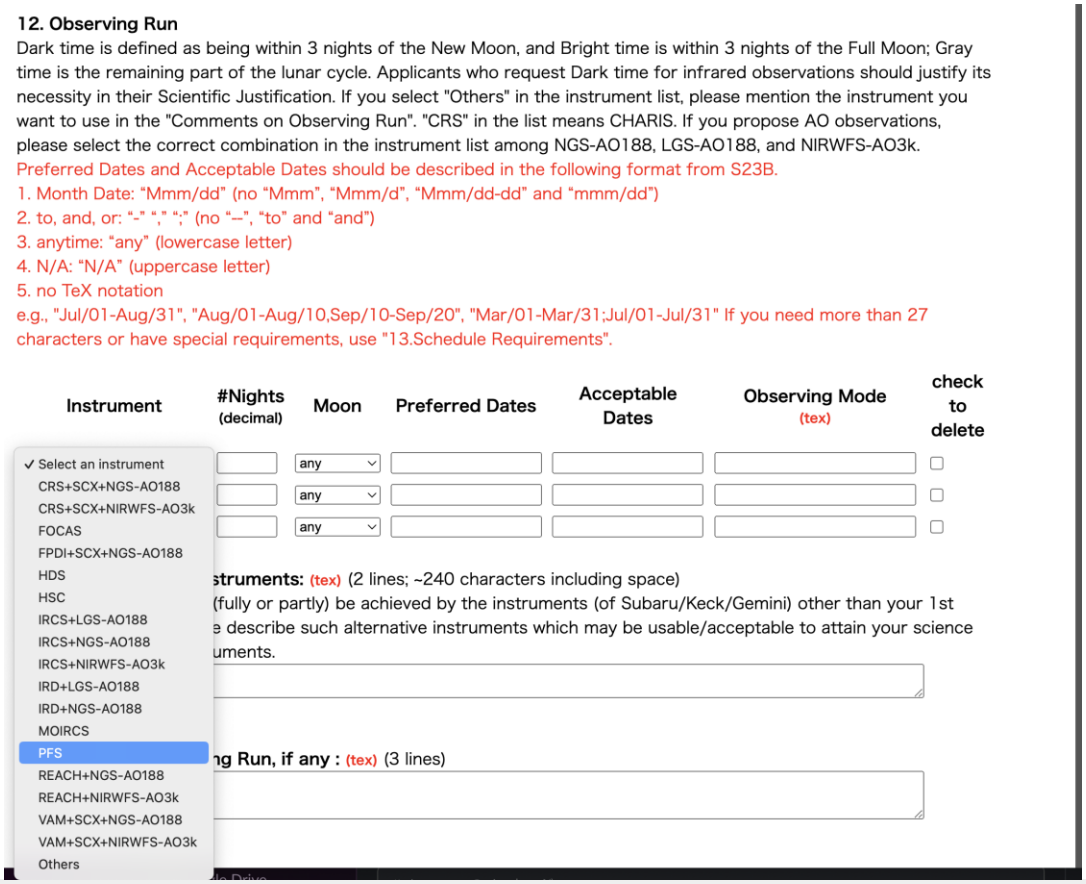
Proposal category

- We hope you understand the differences between the different categories. You can choose your category now.

- …OK, you have made up your mind by now. You can login to PROMS, choose your category, and work on the proposal form.

Proposal category

- Here is a tip to get your proposal form:
  - Select ‘PFS Queue’ for queue mode
  - Select 'Subaru’ for classical mode and put ‘PFS’ in the instrument section of box 12 (‘Observing Run’). See the screenshot below.



12. Observing Run

Dark time is defined as being within 3 nights of the New Moon, and Bright time is within 3 nights of the Full Moon; Gray time is the remaining part of the lunar cycle. Applicants who request Dark time for infrared observations should justify its necessity in their Scientific Justification. If you select "Others" in the instrument list, please mention the instrument you want to use in the "Comments on Observing Run". "CRS" in the list means CHARIS. If you propose AO observations, please select the correct combination in the instrument list among NGS-AO188, LGS-AO188, and NIRWFS-AO3k.

Preferred Dates and Acceptable Dates should be described in the following format from S23B.

1. Month Date: “Mmm/dd” (no “Mmm”, “Mmm/d”, “Mmm/dd-dd” and “mmm/dd”)
2. to, and, or: “-” “,” “;” (no “—”, “to” and “and”)
3. anytime: “any” (lowercase letter)
4. N/A: “N/A” (uppercase letter)
5. no TeX notation

e.g., "Jul/01-Aug/31", "Aug/01-Aug/10,Sep/10-Sep/20", "Mar/01-Mar/31;Jul/01-Jul/31" If you need more than 27 characters or have special requirements, use "13.Schedule Requirements".

Instrument	#Nights (decimal)	Moon	Preferred Dates	Acceptable Dates	Observing Mode (tex)	check to delete
✓ Select an instrument		any				
CRS+SCX+NGS-AO188		any				
CRS+SCX+NIRWFS-AO3k		any				
FOCAS						
FPDI+SCX+NGS-AO188						
HDS						
HSC						
IRCS+LGS-AO188						
IRCS+NGS-AO188						
IRCS+NIRWFS-AO3k						
IRD+LGS-AO188						
IRD+NGS-AO188						
MOIRCS						
PFS						
REACH+NGS-AO188						
REACH+NIRWFS-AO3k						
VAM+SCX+NGS-AO188						
VAM+SCX+NIRWFS-AO3k						
Others						

struments: (tex) (2 lines; ~240 characters including space)
(fully or partly) be achieved by the instruments (of Subaru/Keck/Gemini) other than your 1st
e describe such alternative instruments which may be usable/acceptable to attain your science
uments.

ng Run, if any : (tex) (3 lines)

Requested Observing Time

- The PFS form has a few new columns such as ROT. You can get your ROT from the targetUploader, but before we get to the uploader, let us first explain ROT and why we need it.

- How should we define the observing time for a program? The classical Σ T(visit) estimate does not work because we execute multiple programs in a given exposure.

- The concept of fiber hour (FH) is useful here. We count T(visit) x N(fibers_used) for each program and for each visit and sum it up. For example, if we expose 100 fibers for 1 hour, that is 100 FHs. This way, we can easily handle the fiber-sharing.

- However, greedy details of the TAC process make it hard to do the time allocation even in units of FH. We do not go any further from here, but if you are interested, you can talk to an obsproc WG member. It will probably take a few hours to tell the whole story…

- ROT is introduced to reduce complexities coming from the fiber-shared queue mode.

Requested Observing Time contd.

- What is ROT, then? It is the observing time to complete a program by itself without sharing fibers with other programs. So, it is essentially the observing time in classical mode.

- This concept largely eliminates the TAC complexities. It also makes the time exchange with Keck/Gemini a lot easier (again, we do not go into details).

- There might be a better way to go around the complexities. We continue to explore other possibilities. But, we adopt ROT for now.

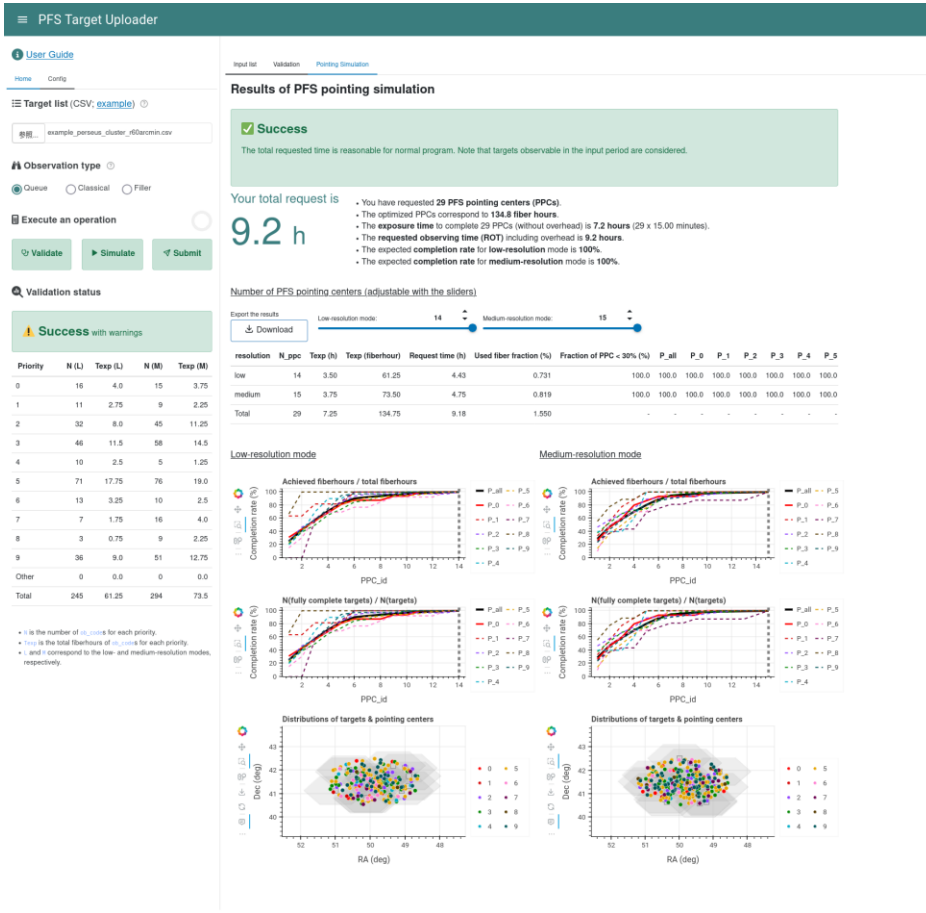
- How can you get ROT of your program? Good question. Now, it is time to talk about the Target Uploader.

Target Uploader

- The Target Uploader is the heart of the PFS proposal submission system. Go to https://pfs-etc.naoj.hawaii.edu/uploader/

- The web page looks like this →

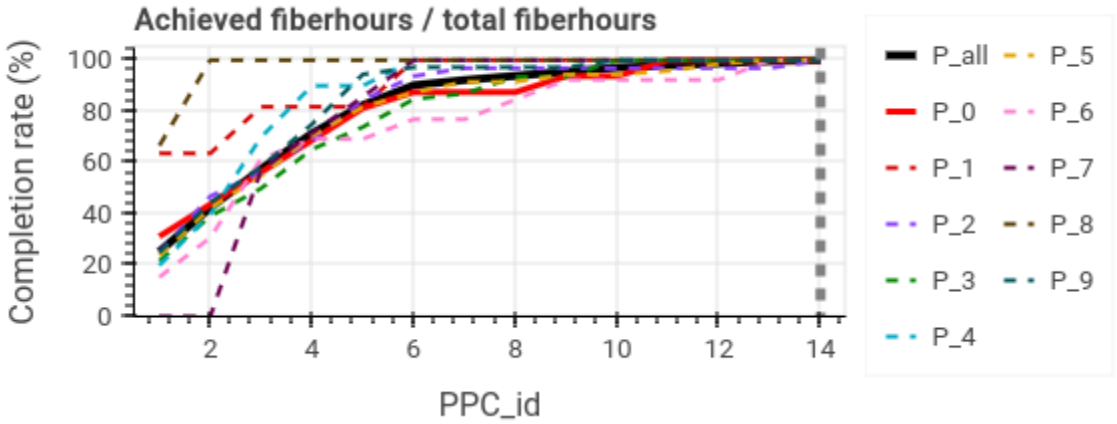
- Just like ETC, the uploader comes with
  a full documentation and tutorial movie.
  So, we do not show you how to use it here.



ROT

- Once you ‘simulate’ your observation, you will get your ROT on your screen (see ‘Your total request is’...). It is the total time required to complete your program, including overheads.

- There is a plot showing the completion rate of your program vs. N(visit). This is an important plot. The completion rate does not linearly increase with N in most cases (see the sample plot here). The slow increase at the end is combination of reasons; close neighbors (recall PFS has fiber collisions), locally dense targets compared to the PFS fiber density, etc.

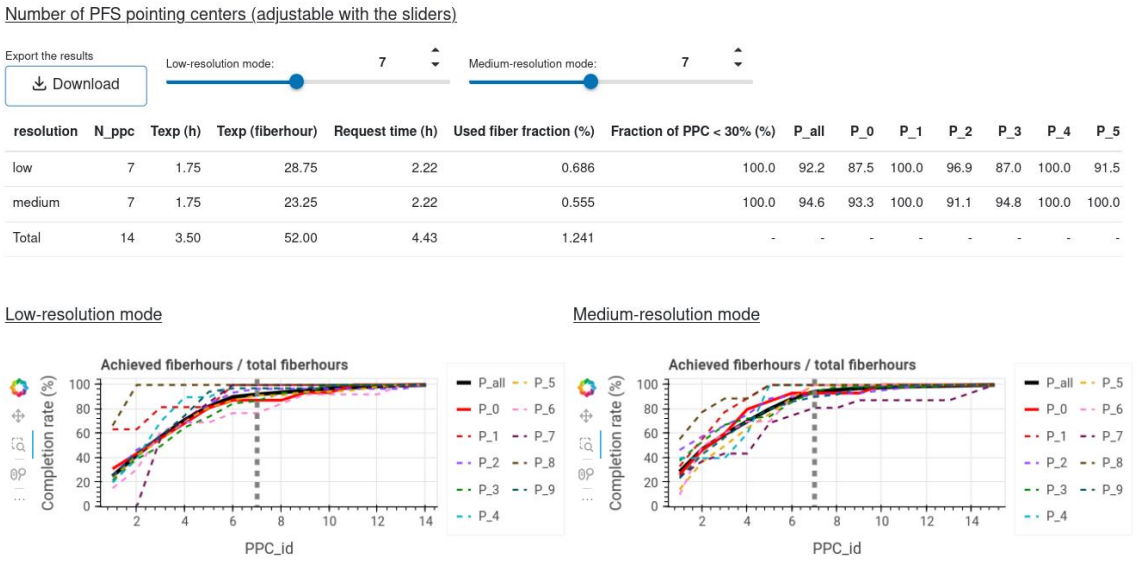


PPC_id here is a sequential visit number.

ROT

- If you move the slide bar right below your ROT, you can change N(visit). Your completeness and ROT change accordingly. You may find that a relatively large change in N(visit) does not result in a significant change in completeness, e.g., if you reduce N(visit) to half, your completeness is still ~90% in the example below.

- If you can do your science with this 90% sample, then the ROT on your screen is the one you put in your proposal. Make sure to justify in your proposal why you do not need 100% and 90% is good enough for your science. If you are interested in close-pairs, the reduction may not be a wise choice. So, think carefully.



resolution	N_ppc	Texp (h)	Texp (fiberhour)	Request time (h)	Used fiber fraction (%)	Fraction of PPC < 30% (%)	P_all	P_0	P_1	P_2	P_3	P_4	P_5
low	7	1.75	28.75	2.22	0.686	100.0	92.2	87.5	100.0	96.9	87.0	100.0	91.5
medium	7	1.75	23.25	2.22	0.555	100.0	94.6	93.3	100.0	91.1	94.8	100.0	100.0
Total	14	3.50	52.00	4.43	1.241	-	-	-	-	-	-	-	-

ROT contd.

- You can estimate your minimum time in the same way. Again, justify the minimum time in your proposal.
- Once you are happy, you can ‘submit’ your list.
- You will see your Upload ID on your screen. Copy it! This is the ID we need for TAC and the following processes. So, don’t lose it! You will be asked to put in the ID in the proposal form. It is a good idea to put the ID in your proposal right away.
- In addition to Upload ID, you also need to type in ROT and corresponding FH in your proposal. Just copy the numbers on your uploader screen.
- We have no phase 2 for PFS. The target list you uploaded is the final version. In other words, you will not be able to change your list after upload.

Notes on the uploader

- Here are some useful/important notes about the uploader.
- The ‘simulate’ button in the uploader runs a code to simulate your observation. Depending on the nature of your catalog, it can be slow; it may take 10min or even longer.
- A catalog of dense targets is normally slow, while reasonably sparse targets over ~PFS FoV are normally fast.
- Due to the heuristic nature of fiber assignment algorithm (fiber assignment is a NP-hard problem), you may observe a slightly different result for the same catalog if you run multiple times. The difference is normally small and does not significantly affect your proposal.
- We expect people will be using the uploader like crazy from a few days before the deadline. This uploader simulation part can be even slower due to significant CPU loads and will certainly become a bottleneck of your proposal work.
- So, start early! We suggest you first finalize your target list and then work on the form and scientific justification.

Notes on the uploader contd.

- OK, we think it is worth spending one more slide on this important point:

Start working on your target list early! Start now! The uploader submission takes time. If you upload your list in the last minute, the submission may not finish before the deadline. We do not accept a proposal without uploadID.

Phase 1 is now complete...

- We hope you successfully submitted your target list and proposal itself. Congratulations! Well done!
- An important note: once you submit a PFS proposal, we consider that you agree with the data privacy policy; we do not process fibers for other PIs (i.e., you process your fibers only). See the instrument page for details.
- Is there anything you should do after phase 1? Nothing.
- There is no phase 2 for PFS. So, we will use your uploaded target list for observations. We do not allow target changes after phase 1 (this holds even if TAC reduces your observing time). Please be aware.
- For community filler PIs: you will be asked to review other filler proposals. Thank you for your cooperation. If you cannot review them, you can delegate to your Co-I. Please get in touch with TAC.
- TAC will grant observing time in units of FHs, not ROT, to each accepted program. ROT is no longer relevant after TAC. We use FHs for science operations. If you are fully awarded the requested FHs, that means your proposal is fully accepted. Check your requested vs. approved FHs.

After the semester starts

- For classical observers: PFS support astronomer (SA) will contact you about fiber designs some time before your observing run starts.

- For ToO observers: please refer to the PFS instrument page about how you make a ToO trigger.

- There is an online tool to monitor the queue progress. We hope to make it available to the PIs so that they can check their progress during the semester. We consider your program done once we execute the FHs allocated to your program. As discussed before, we use EET to evaluate 'executed FHs'.

- The raw data can be retrieved from STARS just like other instruments at Subaru, except for filler programs as mentioned earlier.

- We plan to reduce PFS data and deliver processed data to the user through the PFS SP (https://hscpfs.mtk.nao.ac.jp/; see the next page). We will inform you of the details in due course.

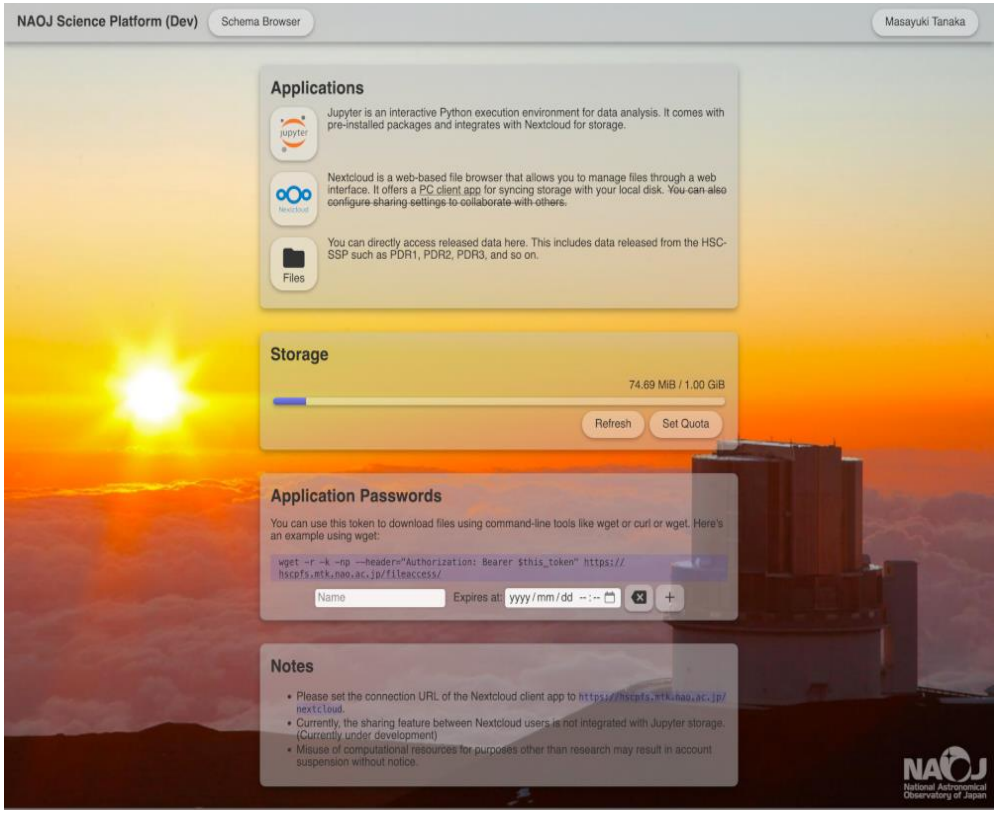
- If you would like to process your data, please consult the PFS helpdesk page, which will be linked from the PFS instrument page. We also plan to prepare a pipeline tutorial there.

PFS Science Platform

- PFS Science Platform (PFS SP) provides you with a data analyses environment located right next to the massive data set from PFS (and HSC). You can analyze your data without transferring them to your local disk. Jupyter is the main environment. We may be able to provide ssh and X11 support.

- We plan to deliver pipeline processed data from your program to you there. The data come with quality assurance plots, explanatory documents, data processing commands and logs. In addition to calibrated spectra, we plan to deliver redshifts as well. The exact delivery schedule is TBD. We hope to deliver data after each observing run, but the cadence may be less frequent in the first semesters.

- We will inform the PIs of accepted proposals of the details of PFS SP in due course.



Appendix

How we built the science operation framework

- We, the obsproc working group, have discussed with the Japanese community over the last 5+ years.
  - Subaru users meeting: 2020, 2021, 2022, 2023
  - PFS community meeting: 2022 Sep, 2023 Sep, 2024 May (+2 forms to collect feedback)

- The PFS observation framework/policy is based on the discussions with the community.
- This is the first time for Subaru Telescope to build a whole new observing scheme through this close discussion with the community.

- We welcome your suggestions for improvements!

Observatory filler

PS1 sources with 18<i<21 for S25A. The magnitude range may change in the future.

- For point sources, we can measure abundances of bright stars and radial velocities of fainter stars. We may discover QSOs as well.
- For extended sources, we should be able to measure redshifts under reasonable conditions.