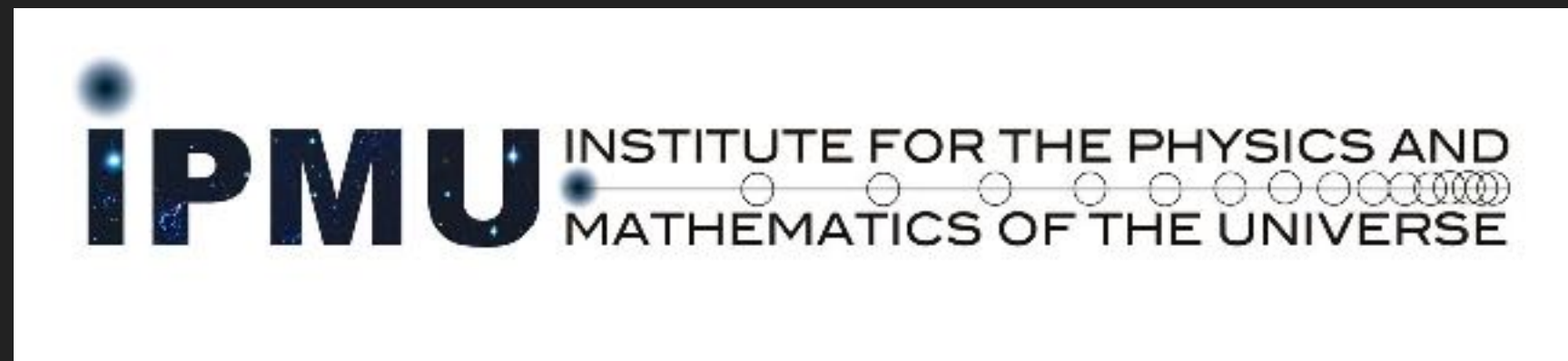
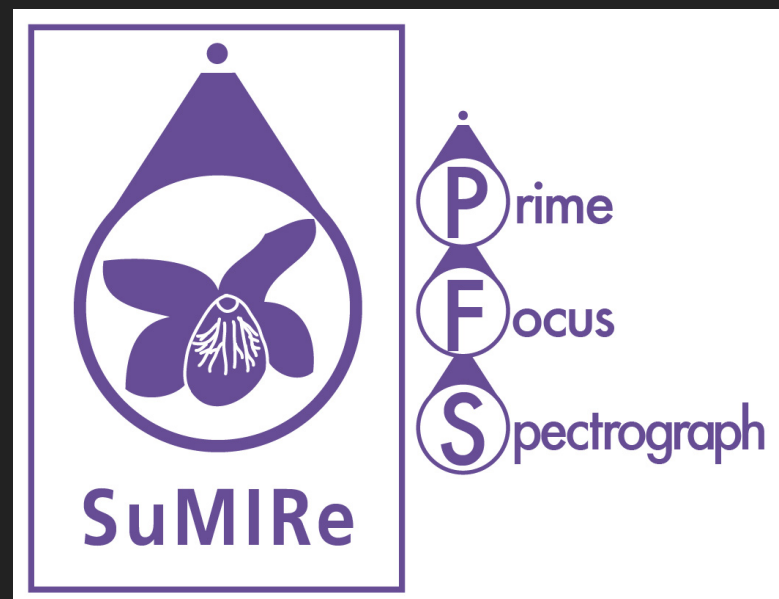


PFS SSP survey: Cosmology & Galaxy/AGN Evolution

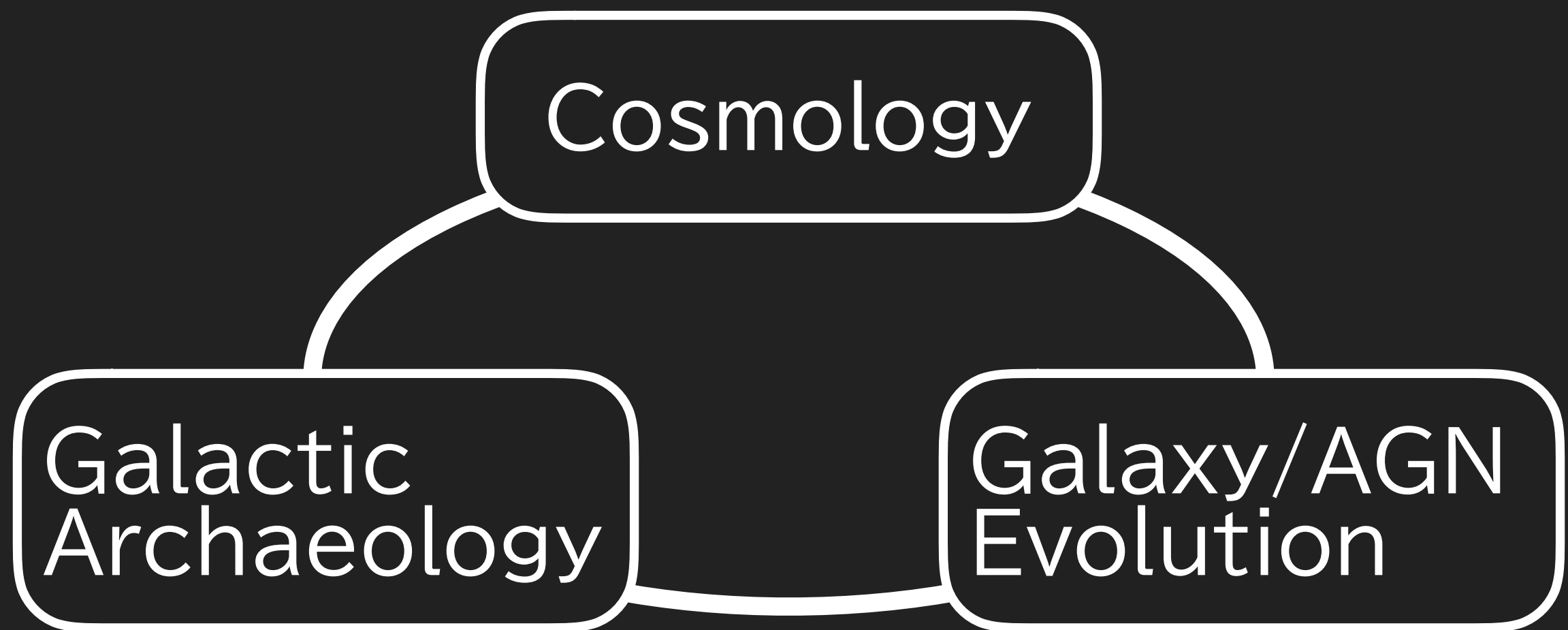
Kiyoto Yabe

(PFS project office, Kavli IPMU)



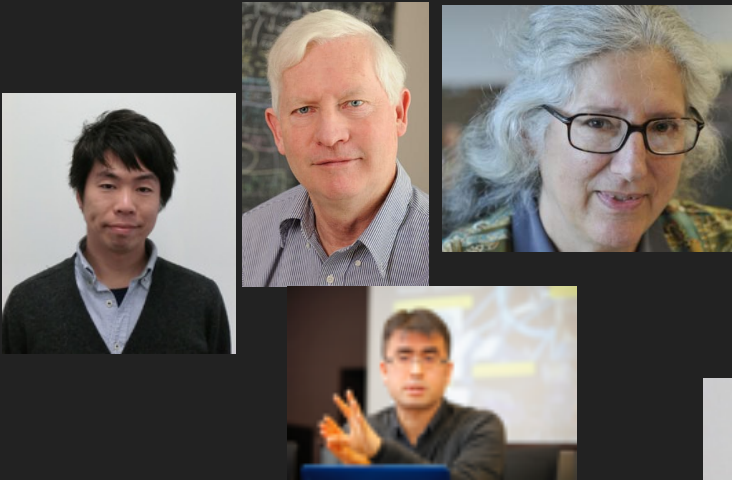
PFS SSP survey:

- Subaru Strategic Program (SSP): ~ 300 nights over ~ 5 years
 - ▶ HSC SSP has been started since 2014 and continues until ~ 2020 ?
 - ▶ PFS SSP is going to start after the HSC SSP is finished
 - ✓ Expected to start from early 2022
 - ✓ A proposal is currently in preparation
 - ✓ A survey program with three big science topics

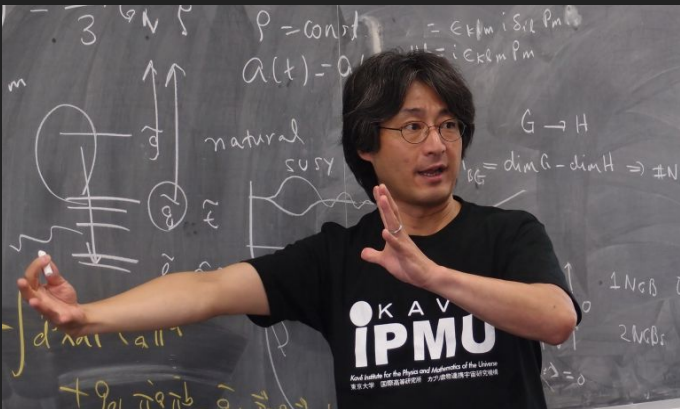


”Comprehensive Challenge on Standard Model of the Universe and Beyond”

PFS SSP survey:

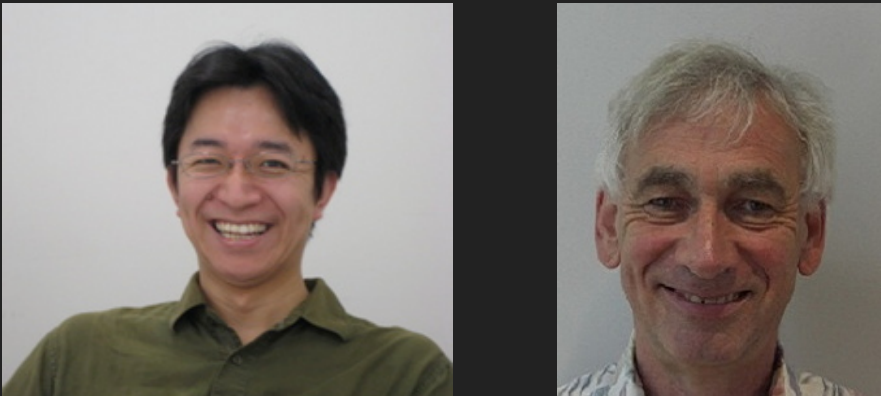


Masahiro Takada
[Kavli IPMU]



Hitoshi Murayama
[PI of PFS project]

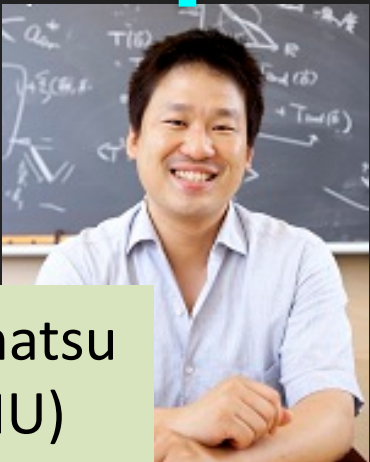
Survey integration
team



Richard Ellis
[UCL]

Science working group co-chairs

Cosmology



Eiichiro Komatsu
(MPA/IPMU)

Galaxy/AGN
evolution



Jenny Greene (Princeton)

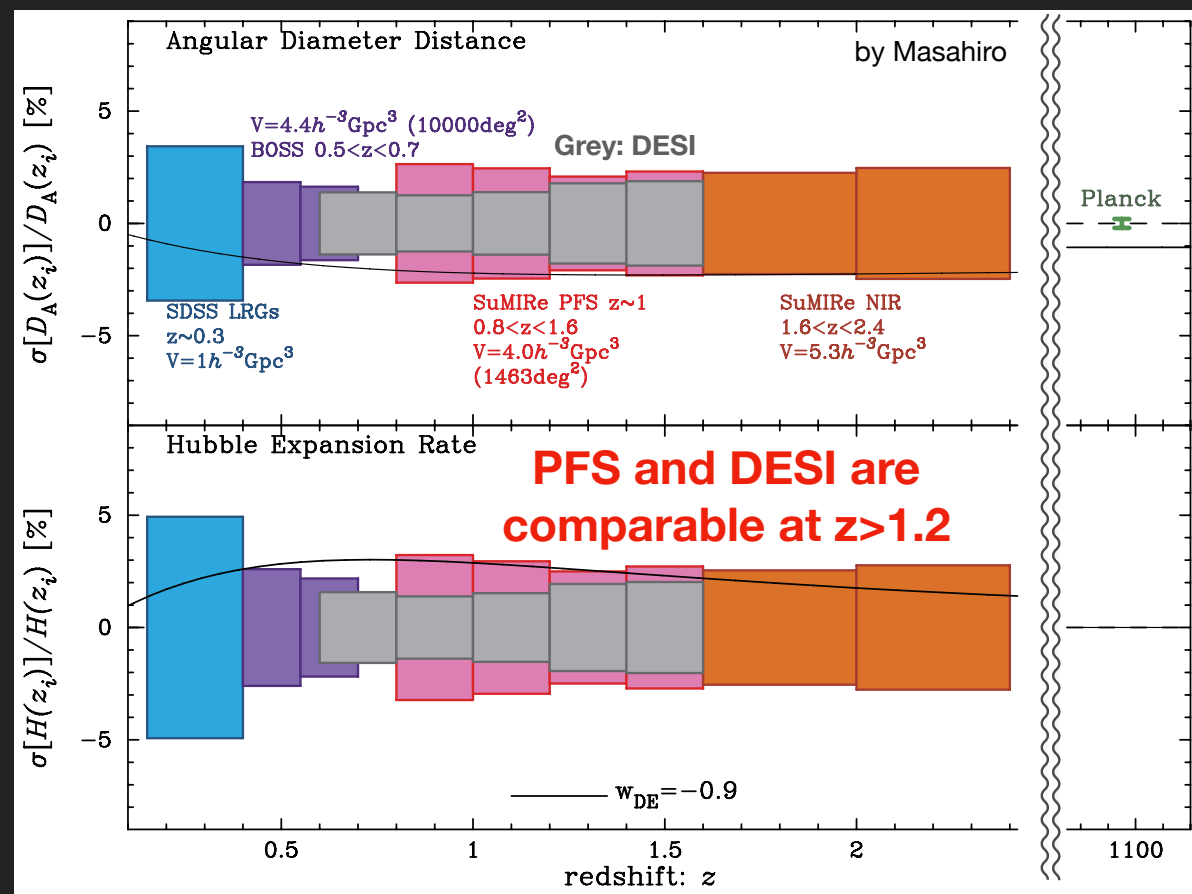
Galactic
Archaeology



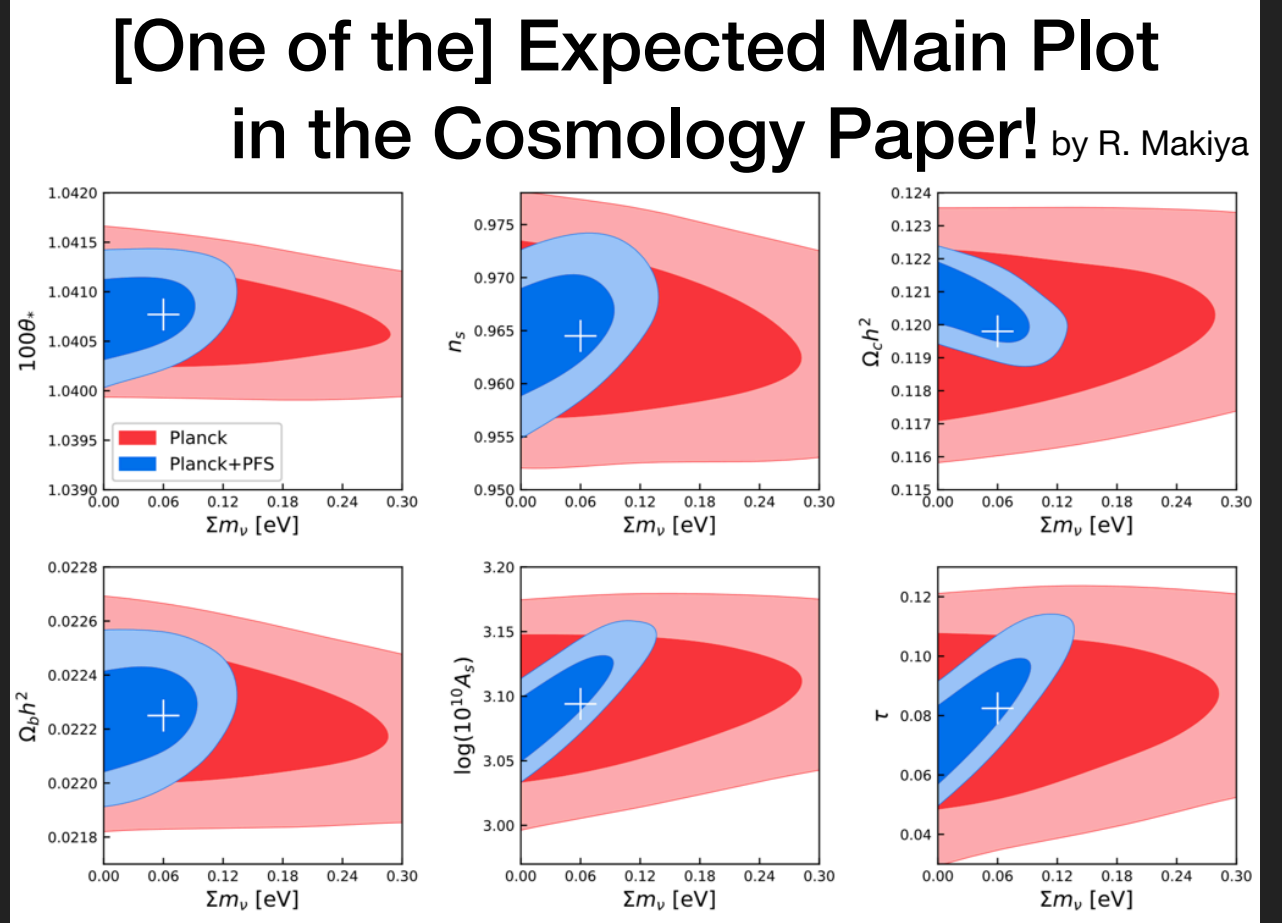
Masashi Chiba
(Tohoku U.)

PFS SSP survey: Cosmology

- Scientific goals:
 - ▶ Precise measurement of cosmological parameters
 - ▶ Constraint on the neutrino mass hierarchy
- Front loading survey because of other competitors?
- Neutrino science and the higher redshift would be unique



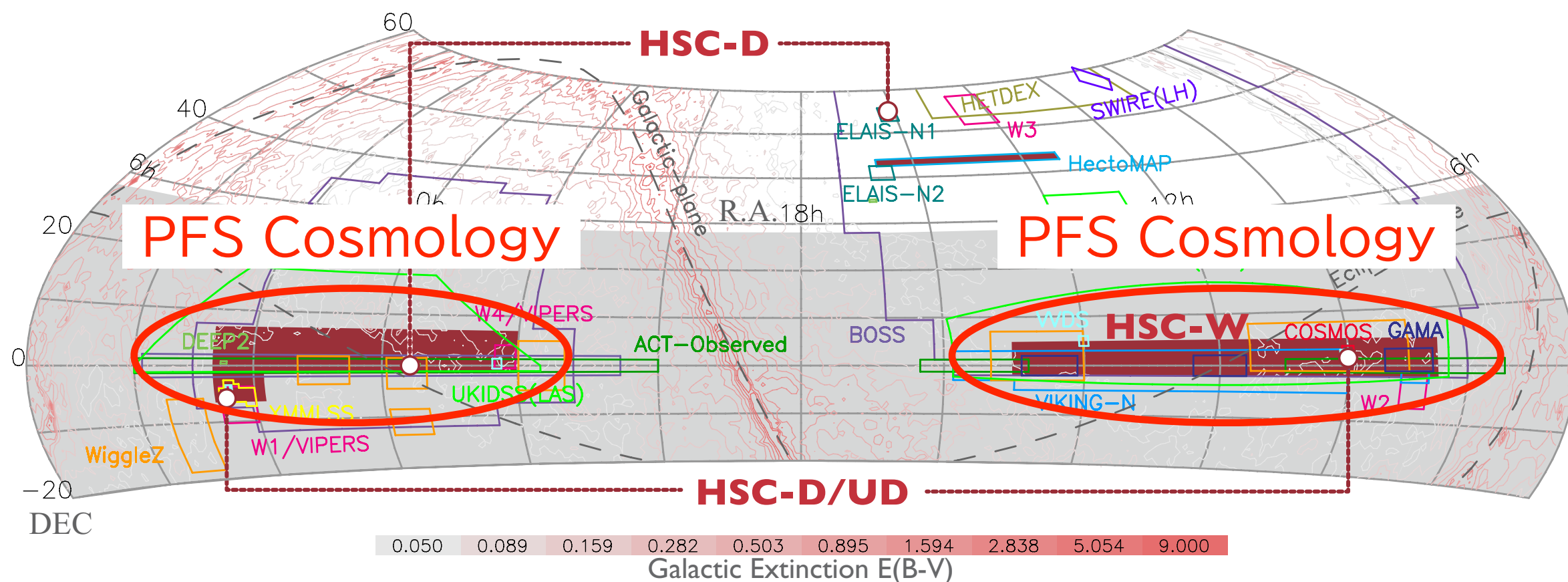
Measurements of cosmological parameter as a function of redshift



Constraint on Σm_ν from measurements of power spectrum with high precision

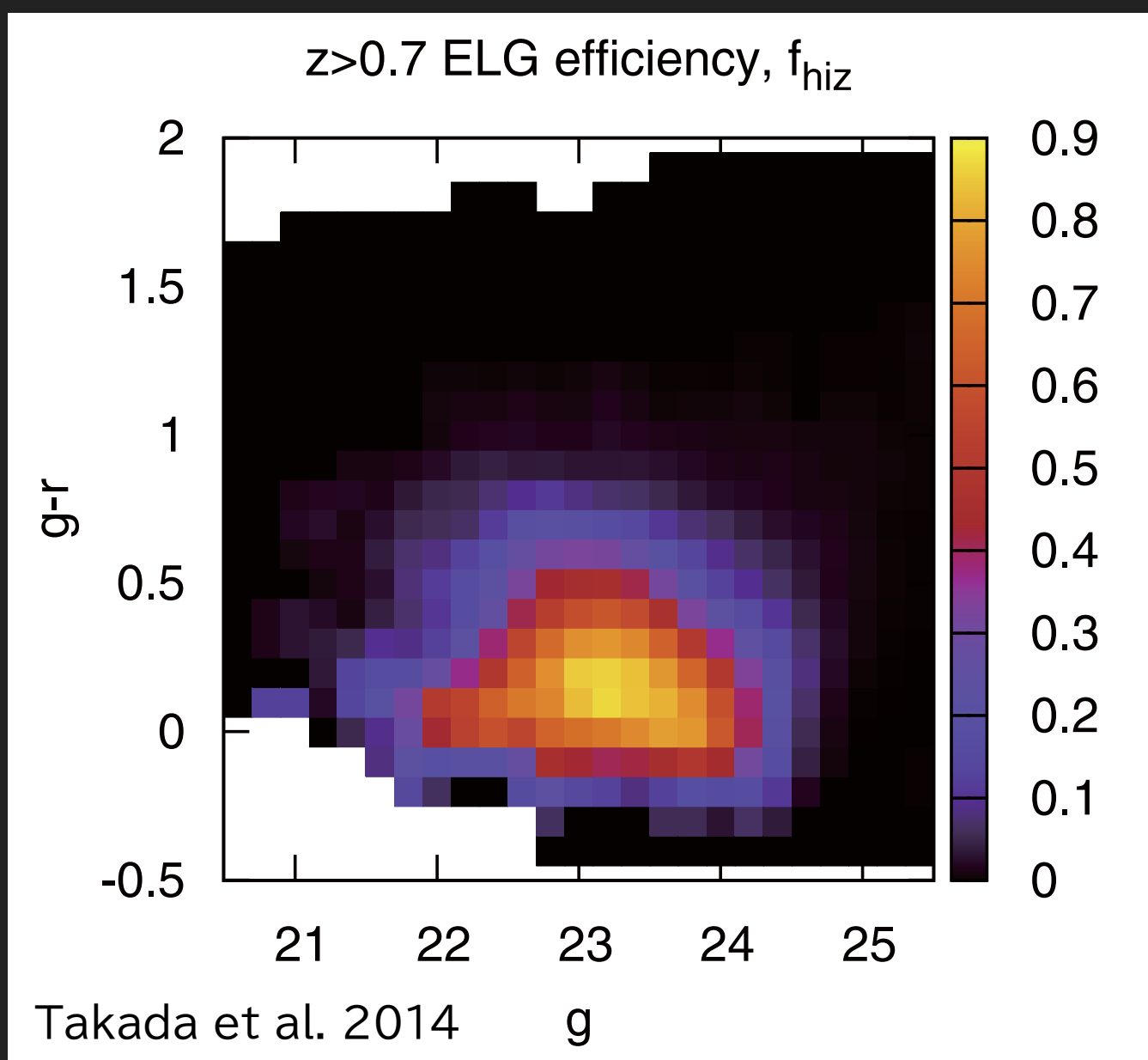
PFS SSP survey: Cosmology

- Target fields:
 - ▶ $\sim 1400 \text{ deg}^2$ of HSC-wide fields
 - ▶ cf. eBOSS= $\sim 6000 \text{ deg}^2$, DESI= $\sim 14000 \text{ deg}^2$
- Targets:
 - ▶ Emission line ([OII] emitters) galaxies at $0.6 < z < 2.4$
 - ▶ Various AGNs (BL AGNs at $z > 4$, MIR/radio AGNs, time variable AGNs, QSO absorption, and so on...) are also included



PFS SSP survey: Cosmology

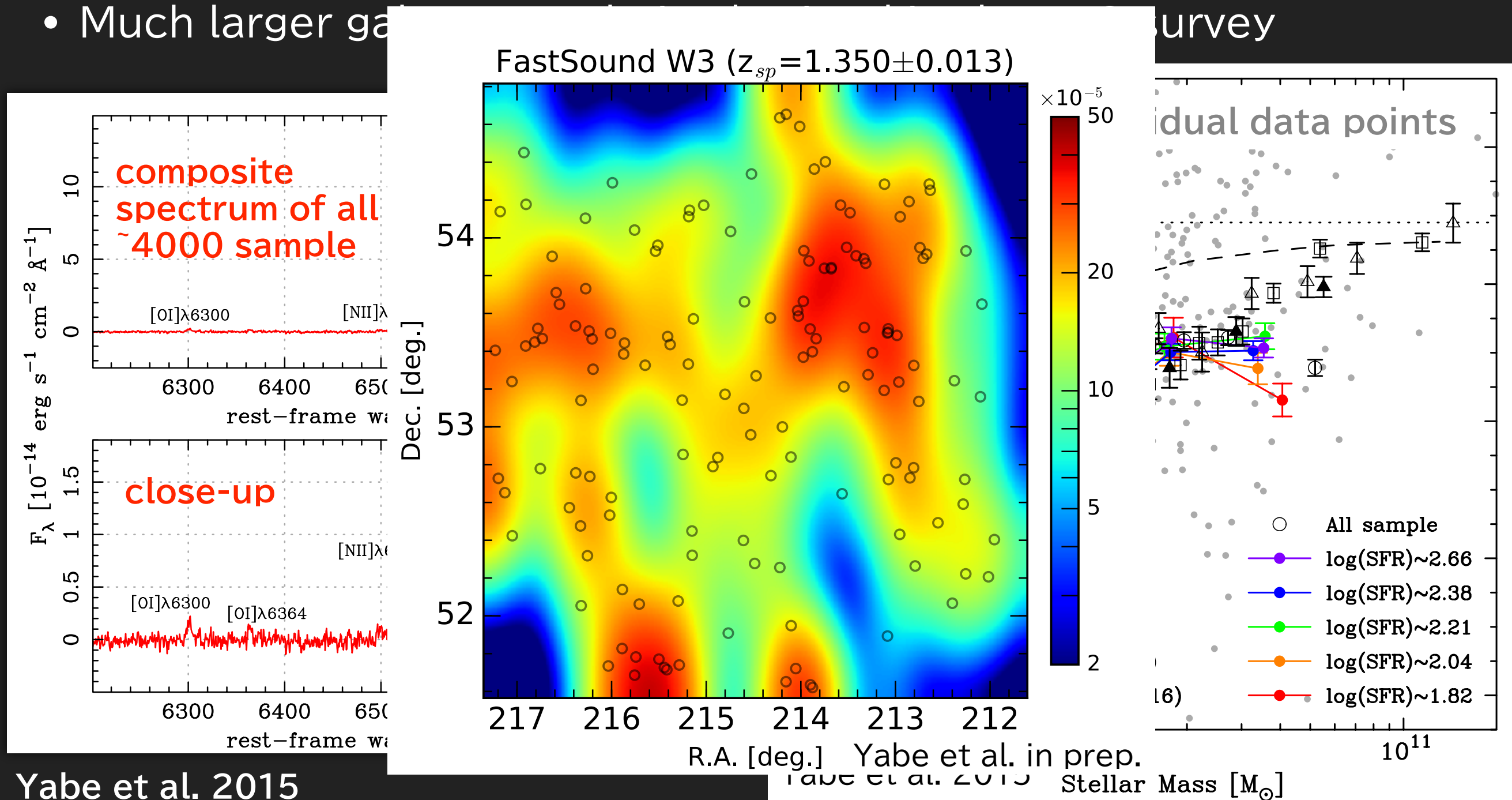
- Target selection for emission line galaxies
 - Basically, color selected sample
 - Improvement of the color selection is on-going
- 4M emission line galaxies will be detected in total



- Survey strategy
 - 2 visits for the same field
 - 15 min. (450 sec. \times 2) in each visit
 - Strategy of the tiling of FoVs is currently under discussion

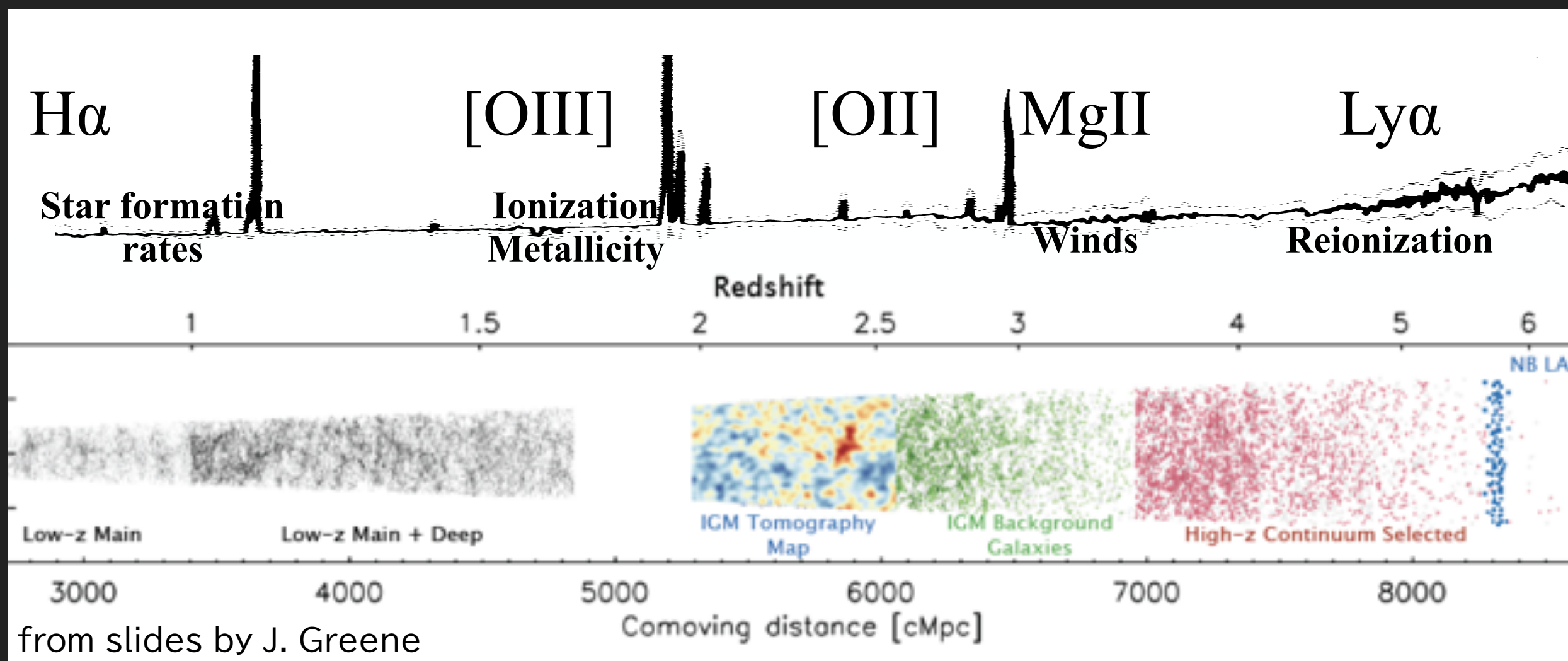
Too shallow for galaxy science?

- Probably, NO
- We (at least I) have experience of FastSound (FMOS SSP)
 - ▶ On-source exp. time is ~ 30 min.
 - ▶ We wrote (and will) science papers on galaxy science
- Much larger galaxy sample



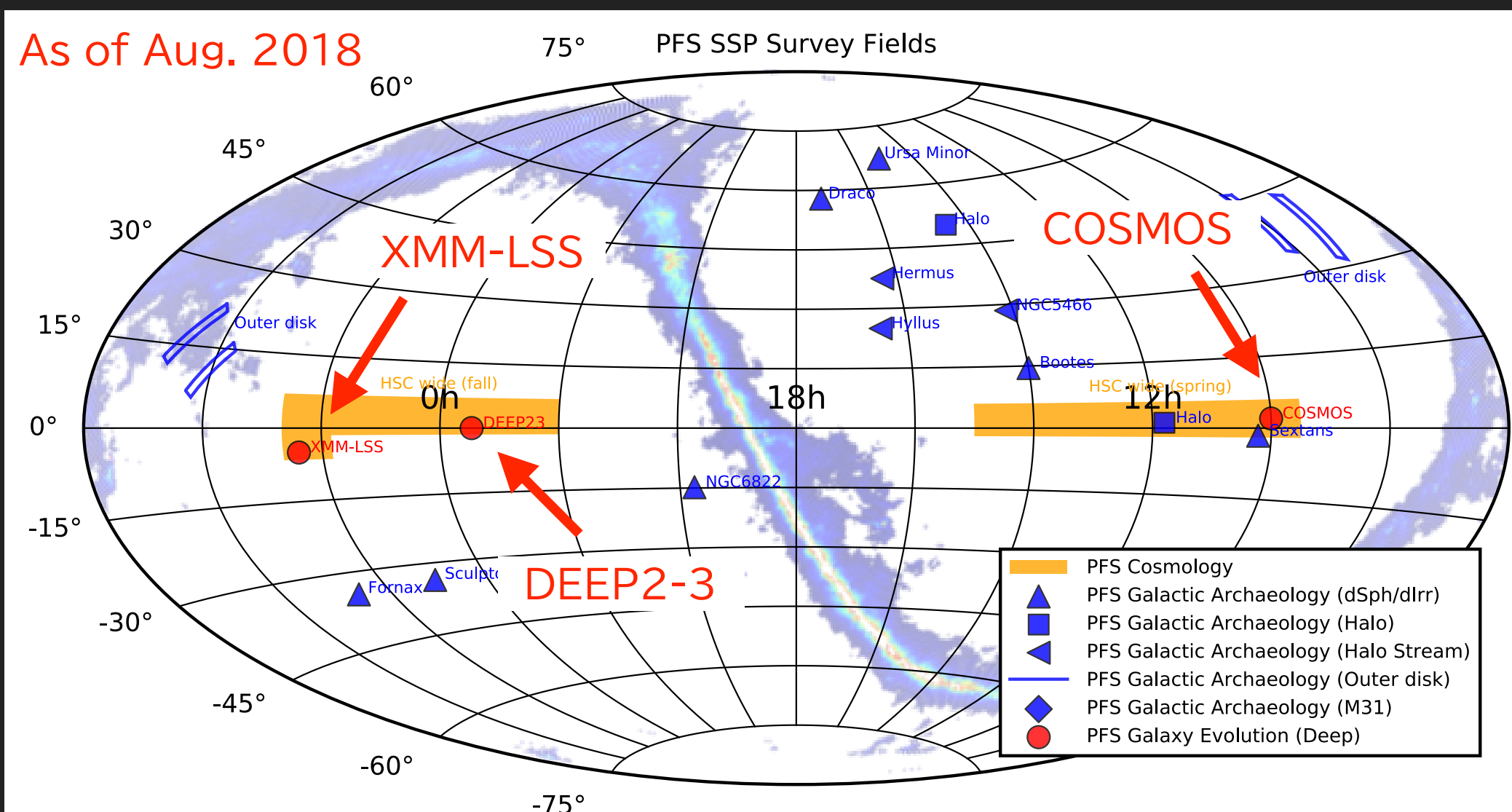
PFS SSP survey: Galaxy/AGN Evolution

- Scientific goals:
 - ▶ Charting mass assembly within the cosmic web (from $z \sim 7$ to $z \sim 1$)
- Targets:
 - ▶ \sim Magnitude limit sample at $0.7 < z < 2$
 - ▶ Galaxies at $z = 2 - 2.5$ for IGM tomography
 - ▶ Galaxies at $z > 3$ and LAEs@ $z = 2.2, 5.7, 6.6$
 - ▶ All in $\sim 15 \text{ deg}^2$ of HSC-D with U-band and NIR/Spitzer coverage



PFS SSP survey: Galaxy/AGN Evolution

- Scientific goals:
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PFS SSP survey: Galaxy/AGN Evolution

”Current” plan of target sample

Total area: 14.5 deg²

sample	redshift	mag / flux limit	exp. time (hours)	number	description
low-z (main)	$0.7 < z < 2$	J~23	2	~230,000	main component
low-z (deep)	$0.7 < z < 2$	J~22.5	12	~14,000	deep component
high-z (IGM)	$2.1 < z < 3.5$	g~25, y~24	6-12	~44,000	IGM tomography
very high-z	$3.5 < z < 7.0$	y~24.5	6	~22,000	very high-z
LAE	$z=2.2, 5.7, 6.6$	$L(\text{Ly}\alpha) \sim 3\text{-}5 \times 10^{42}$	3-12	~15,000	LAEs
AGN	various	various	various	~10,000	AGN

- The total observing time is 70 nights (including weather factor)
- A single pointing is observed in 40-50 hours

PFS SSP survey: Galaxy/AGN Evolution

“ISM properties”

Metallicity

Ionization diagnostics

PFS SSP survey: Galaxy/AGN Evolution

Build-up of “red sequence”

Velocity dispersion

Number density of post-
star burst galaxies

PFS SSP survey: Galaxy/AGN Evolution

Outflow velocity as a function of SFR

SFR vs. Environment

All these properties as a
function of “environment”

PFS SSP survey: Galaxy/AGN Evolution

Tomographic reconstruction of 3D gas distribution using $\text{Ly}\alpha$ forest (Lee et al. 2014)

HI 21 cm cross-
correlation to LAEs at $z > 6$

PFS SSP survey: Galaxy/AGN Evolution

AGN science

TABLE 1
TARGET SELECTION AND OBSERVING STRATEGY IN THE GE SURVEY FIELD

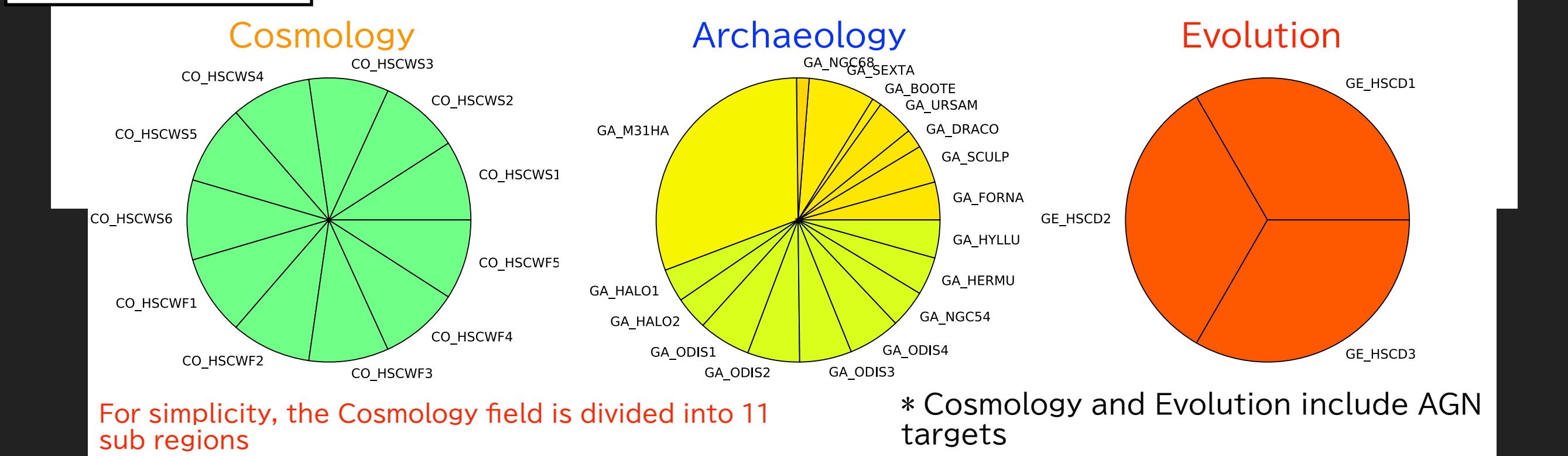
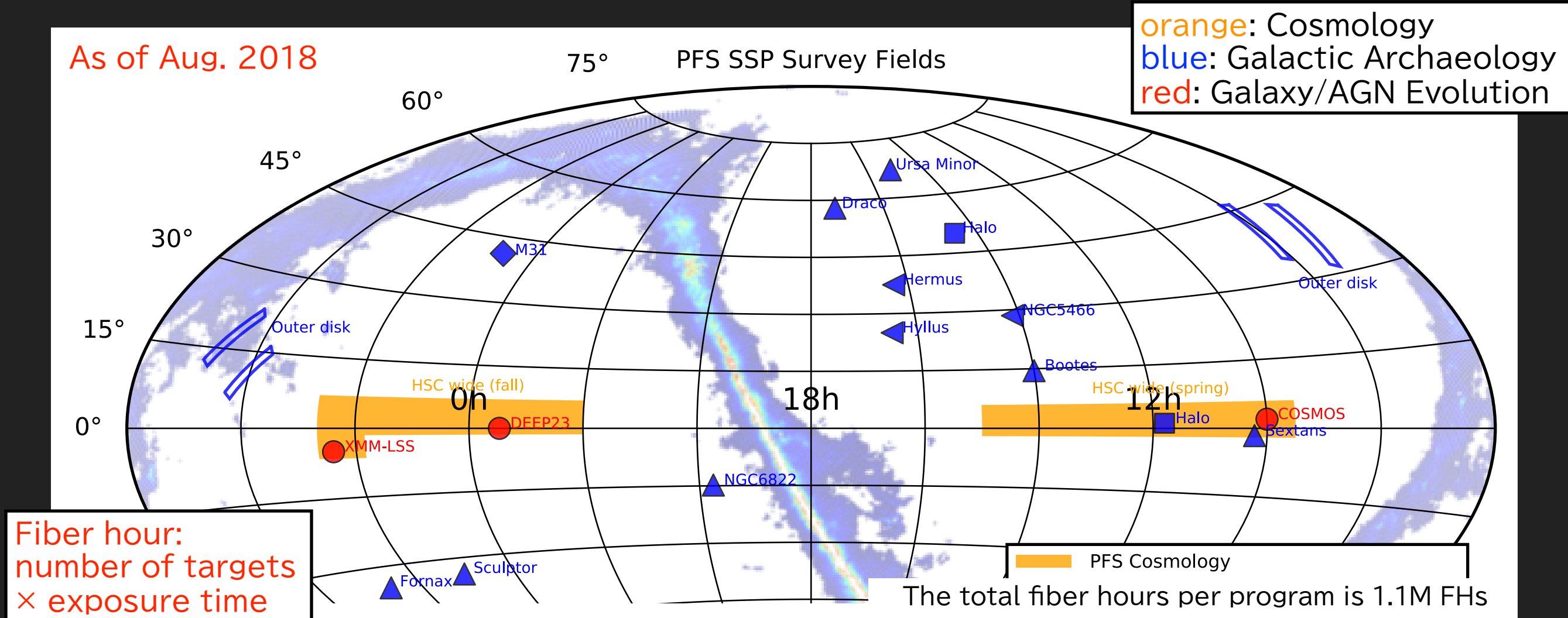
Target (1)	Selection (2)	$N_{\text{AGN}}^{\text{total}}$ (3)	N_{AGN} (4)	N_{fiber} (5)	T_{exp} (6)	$N_{\text{fiber}}T_{\text{exp}}$ (7)
BL/X-ray AGNs	CLAUDS/HSC/UKIRT/X-ray					
$0.5 < z < 2.0$	$i_{\text{AB}} < 22.5$	2,000	500	1,000 (0.5)	1	
	$22.5 < i_{\text{AB}} < 23.3$	1,000	500	1,000 (0.5)	2	7,000
	$23.3 < i_{\text{AB}} < 24.0$	1,000	500	1,000 (0.5)	4	
$2.0 \leq z < 4.0$	$i_{\text{AB}} < 22.5$	600	600	1,200 (0.5)	1	
	$22.5 < i_{\text{AB}} < 23.3$	500	500	1,000 (0.5)	2	8,000
	$23.3 < i_{\text{AB}} < 24.0$	600	600	1,200 (0.5)	4	
$4.0 \leq z < 6.0$	$i_{\text{AB}} < 24.0$	400	400	800 (0.5)	4	3,200
$6.0 \leq z$	$z_{\text{AB}} < 25.0$	10	10	100 (0.1)	5	500
SMGs	HSC/SCUBA-2 $f_{850\mu\text{m}} > 8 \text{ mJy}$	100	100	500 (0.2)	4	2,000
Radio AGNs	HSC/FIRST detection	2,000	200	250 (0.9)	3	750
XMP AGNs	HSC NB excess	...	a few	1,000 (0.001)	2	2,000
IMBHs	HSC variability	30	30	300 (0.1)	2	600
RM project	COSMOS/VVDS variability	...	300	300 (1.0)	0.5×30	4,500
Total						28,550

NOTE. — Columns (1) target; (2) selection method; (3) total number of AGNs expected in 15 deg²; (4) number of AGNs we aim to observe; (5) number of requested fibers (the number in parenthesis represents the expected success rate of AGN identification, i.e., $N_{\text{AGN}}/N_{\text{fiber}}$); (6) exposure time (hr); (7) fiber hours.

PFS SSP survey: Galaxy/AGN Evolution

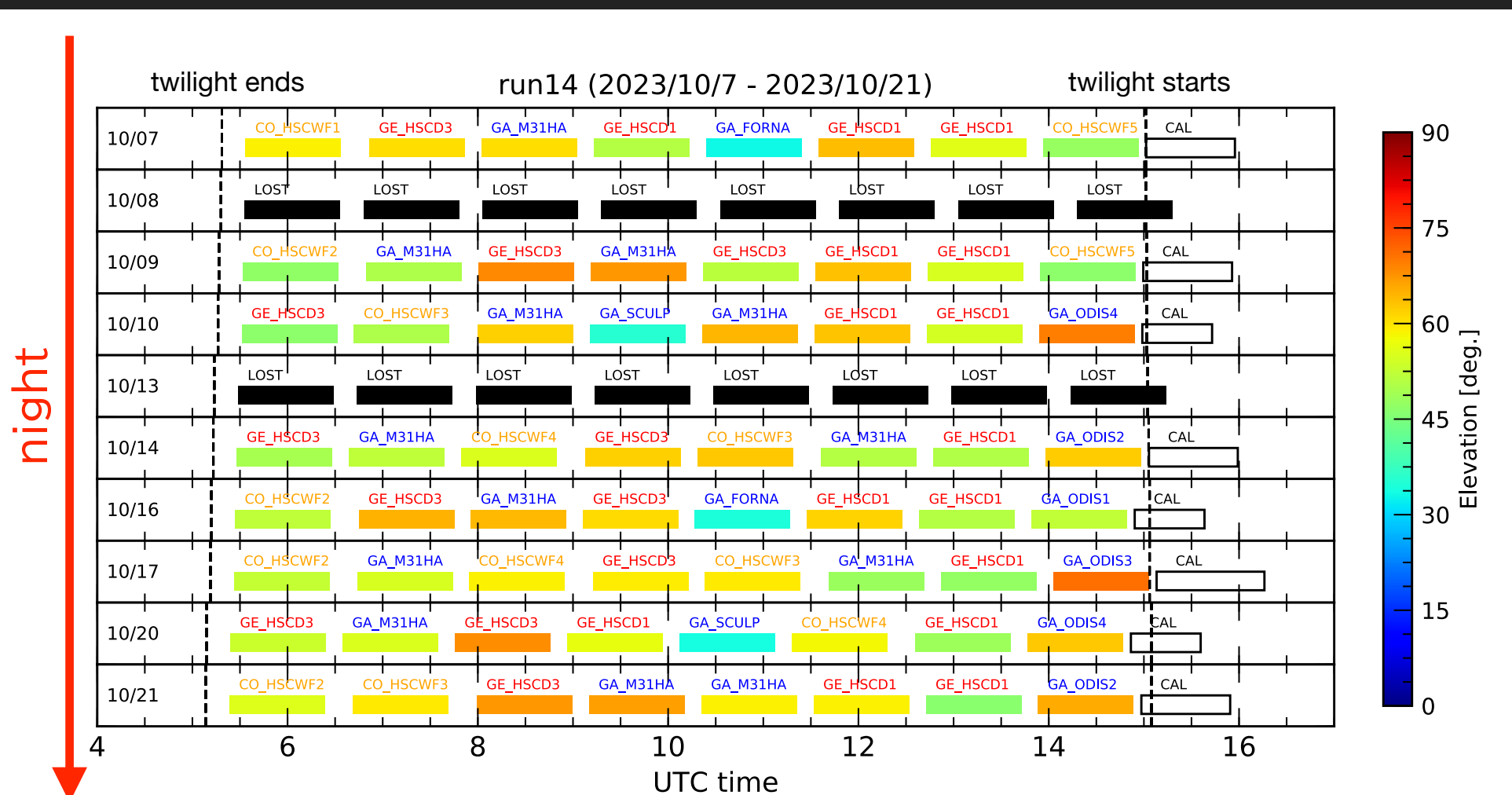
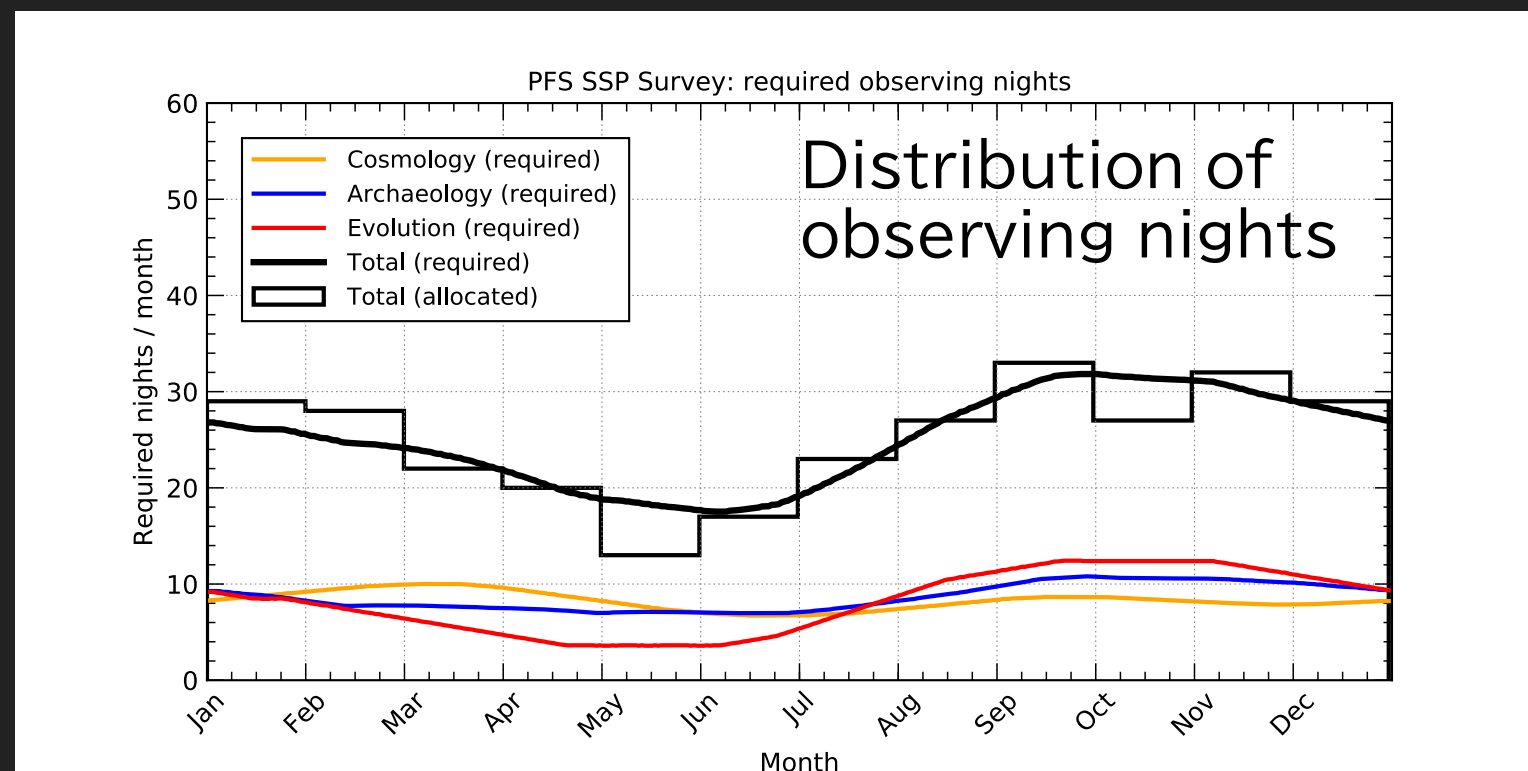
- The current plan does not necessarily include everything...
 - ▶ Low-mass emission line galaxies such as $H\alpha$ /[OIII] emitters at low redshift
 - ▶ Clusters are not target so much (cf. we expect >30 clusters@ $z=1-2$ with $M_{\text{halo}} > 10^{14} M_{\text{sun}}$)
 - ▶ Time domain science
- We are welcome to include additional sample if it makes the proposal stronger

PFS survey planning and simulations



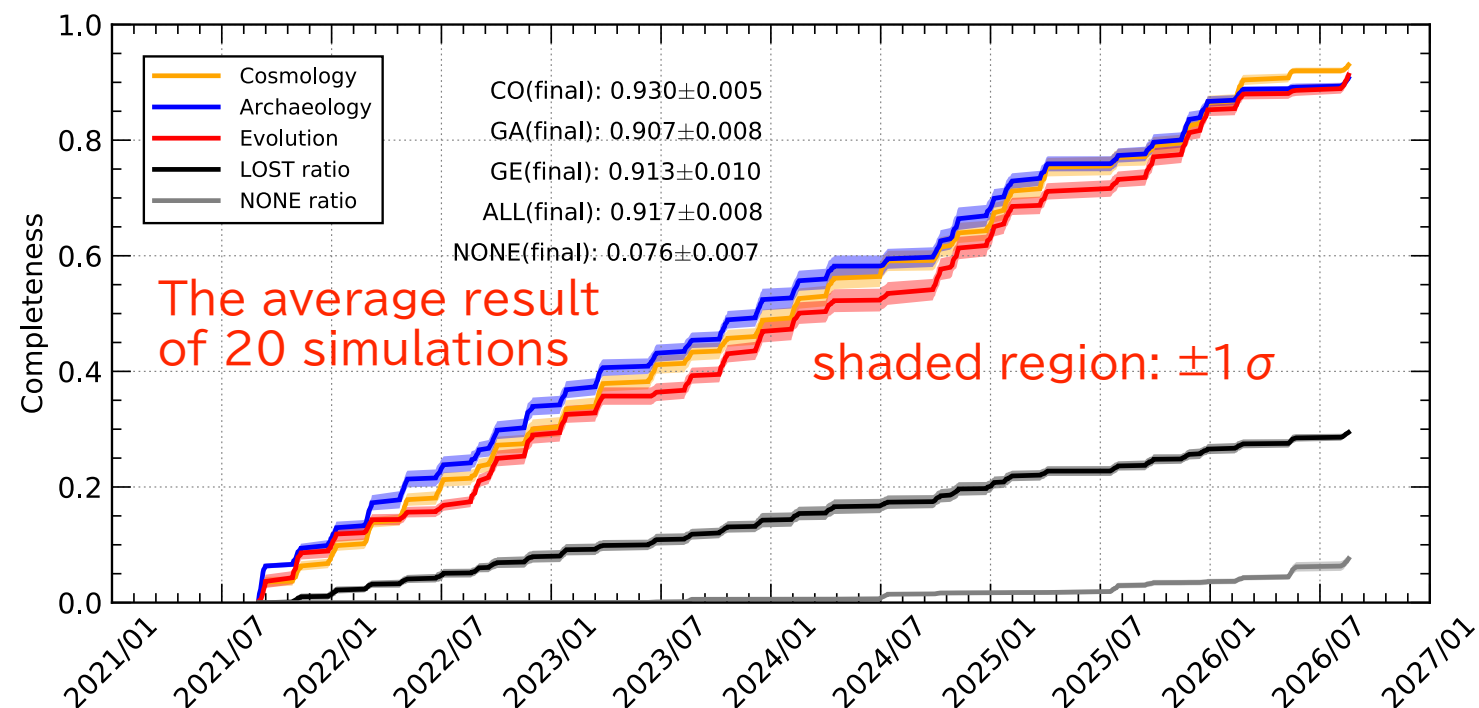
PFS survey planning and simulations

- For an ideal case of night allocation, we simulate the actual observing nights
 - Sep. 2021 - Sep. 2026
 - 1 PFS run = 10 dark/gray nights
 - 30 runs in total (=300 nights)
 - Weather factor = 0.7



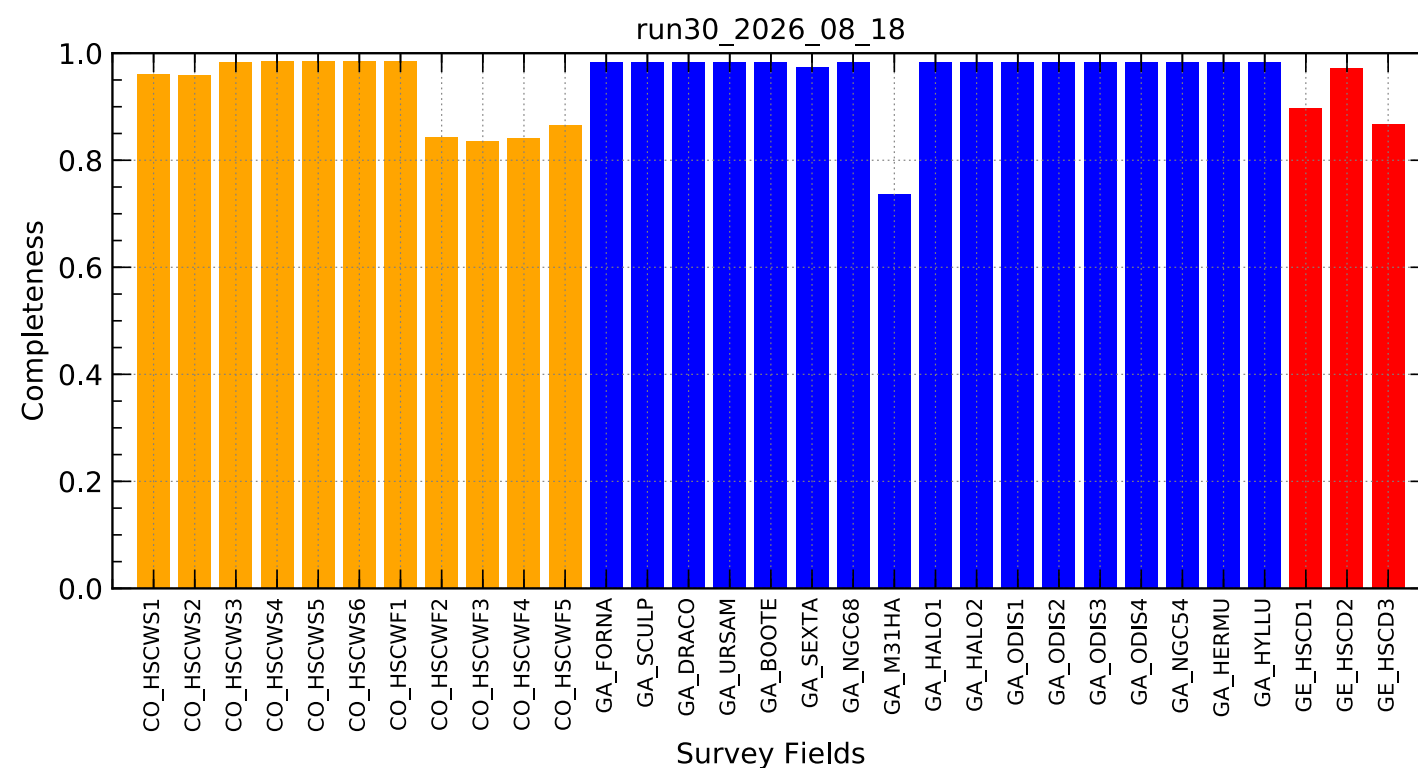
- 1-hour obs. blocks
- An observable target field assigned to each observing block is selected by "score":
 - Remaining fiber hours
 - Visibility
 - WG progress

PFS survey planning and simulations



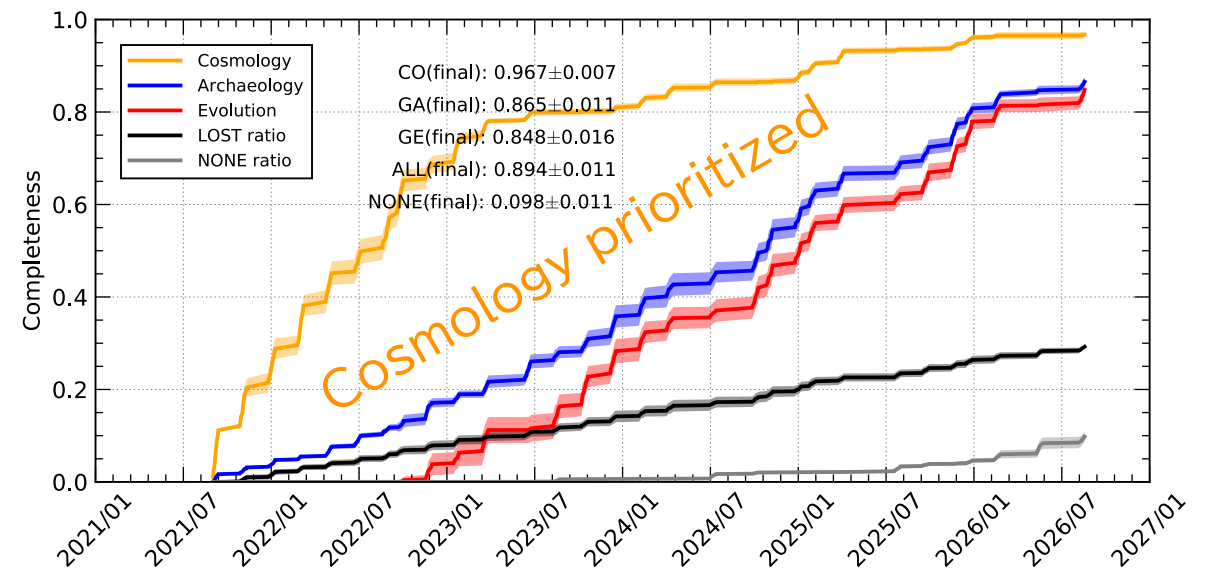
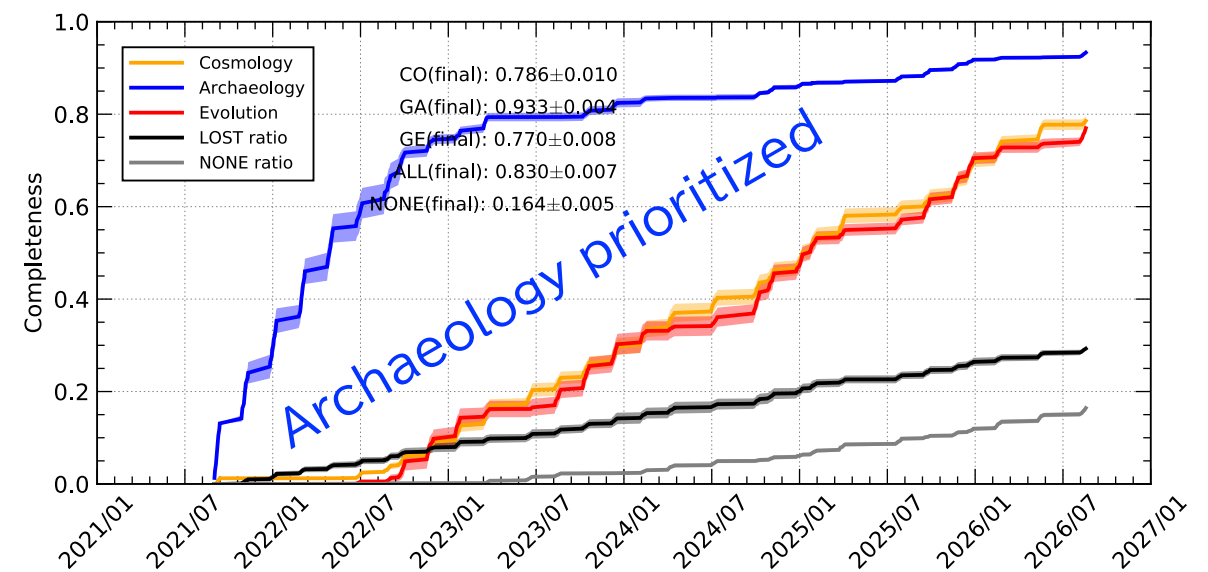
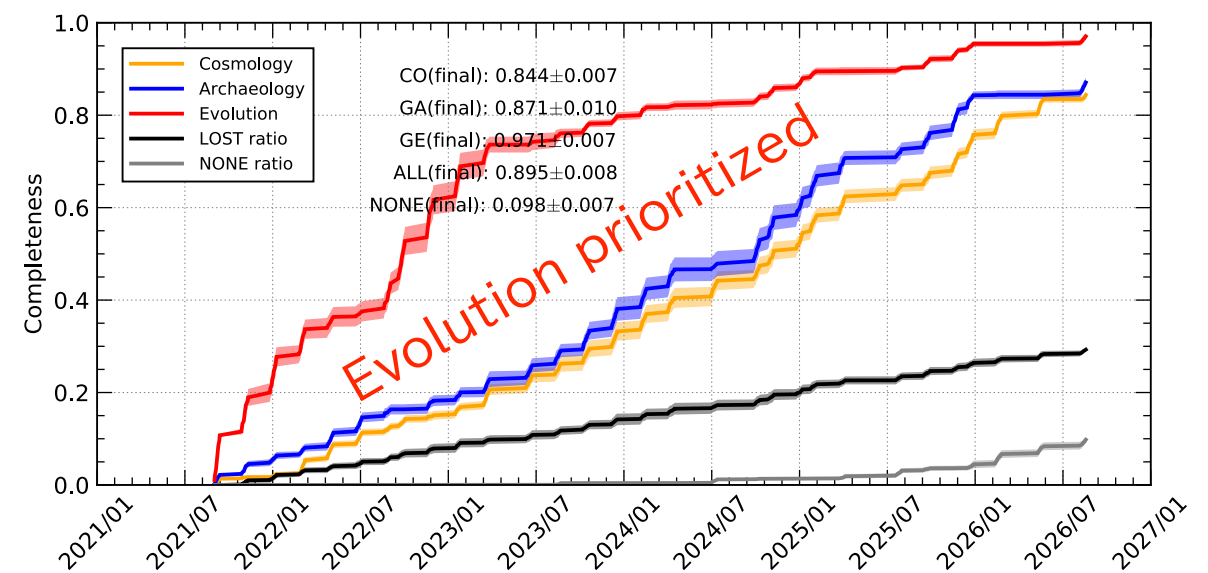
Running 20 simulations by changing nights lost due to bad weather

We can achieve $>90\%$ completeness for each science WG

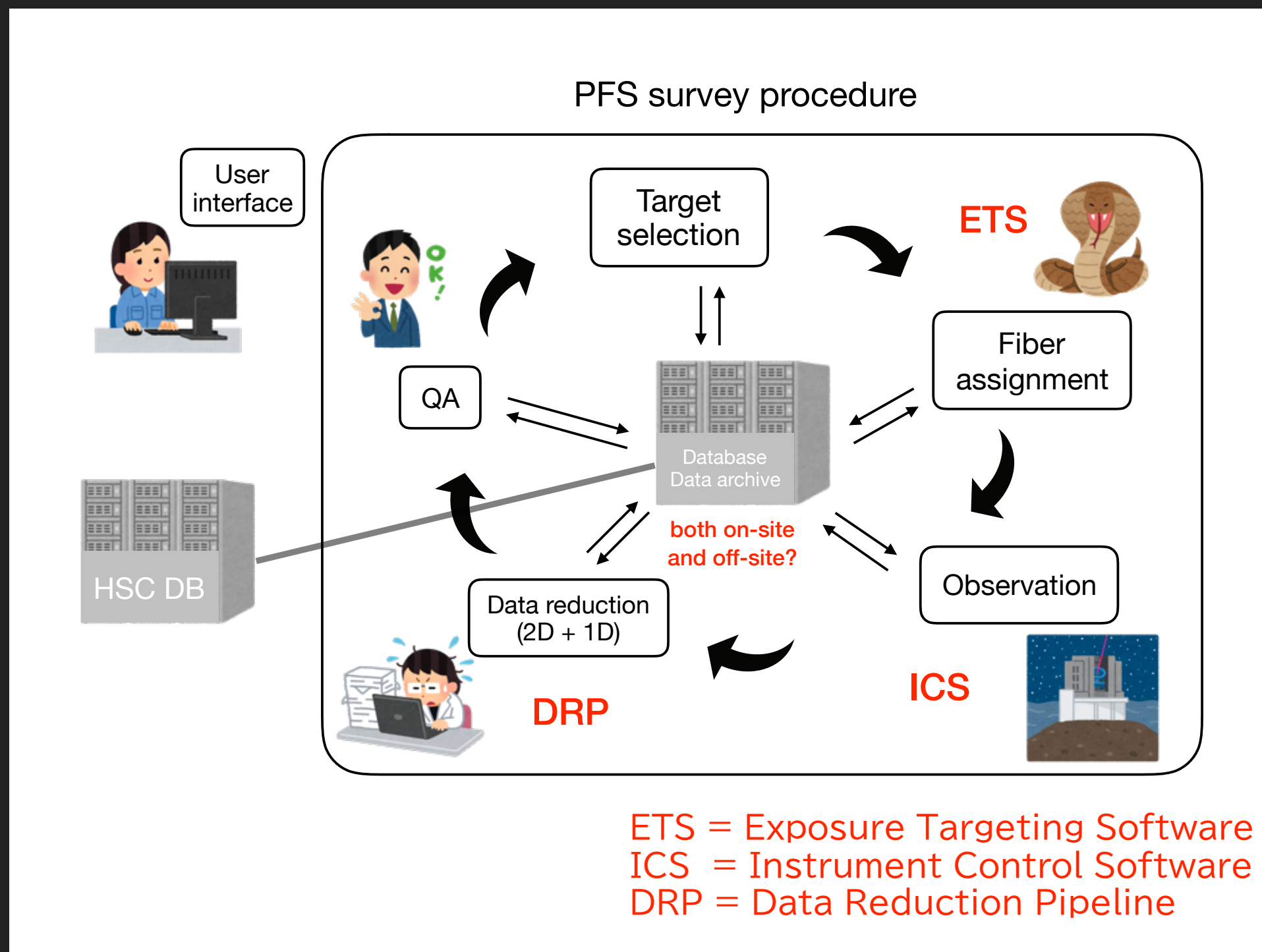


Low completeness in a part of "CO fall fields", "GA M31", "GE XMM-LSS and DEEP23" because they are in crowded R.A.

- Using a set of weights [w_{CO} , w_{GA} , w_{GE}] for the score, the progress of a specific science program can be controlled
- Strategy will be discussed in the collaboration with being led by "survey integration team"
- We want to maximize the scientific outputs from the survey, but how to evaluate/quantify the output?

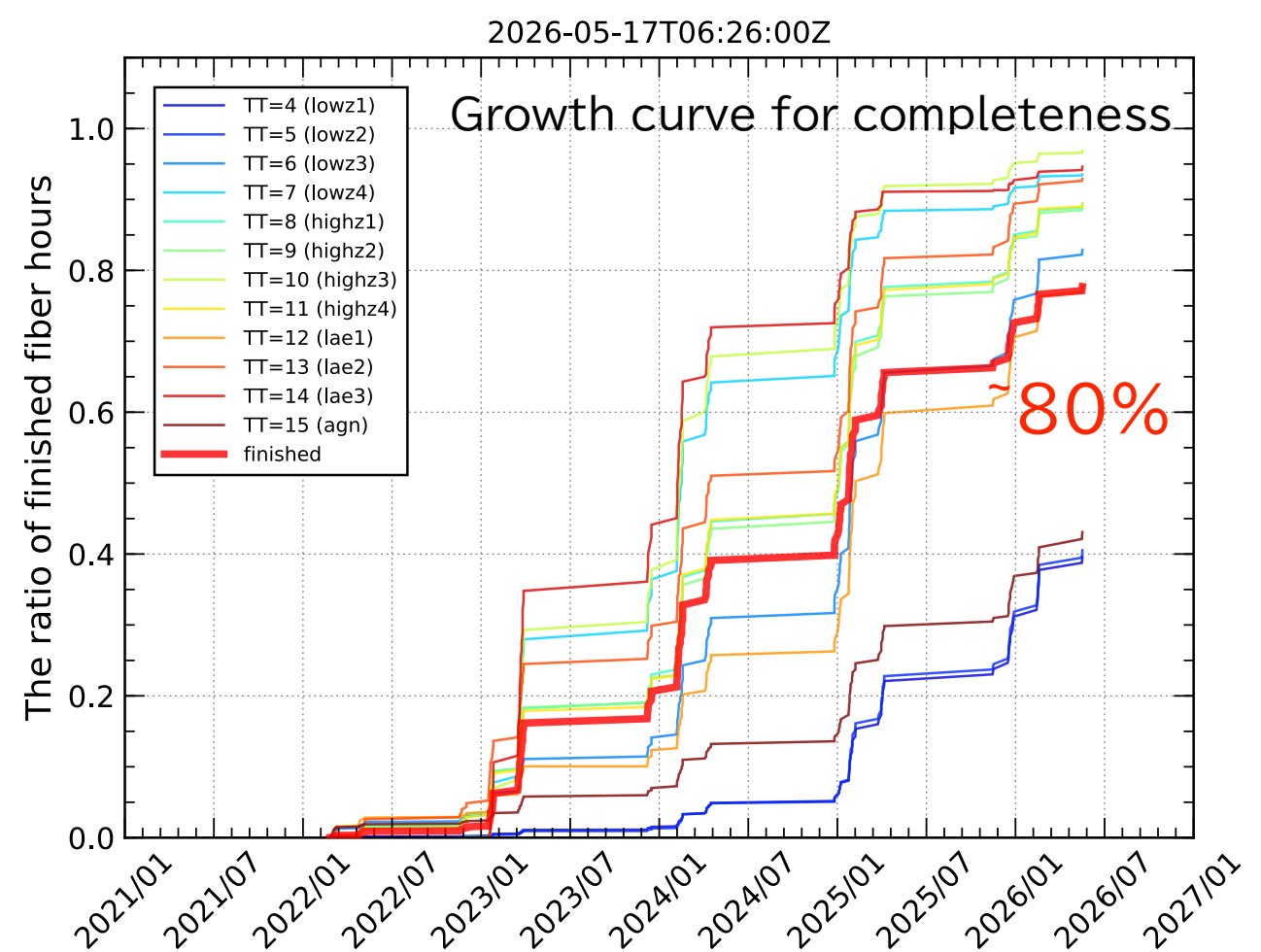
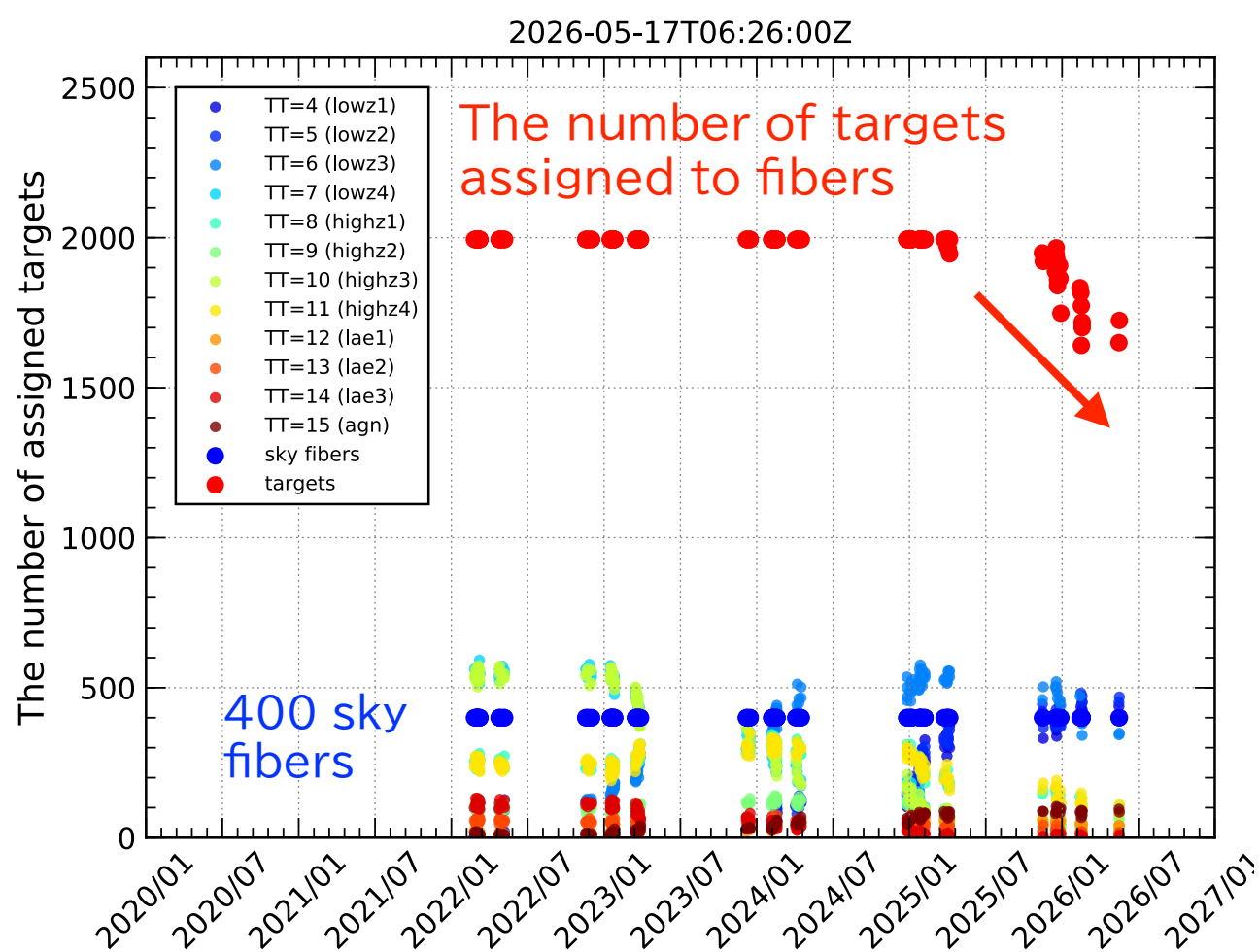
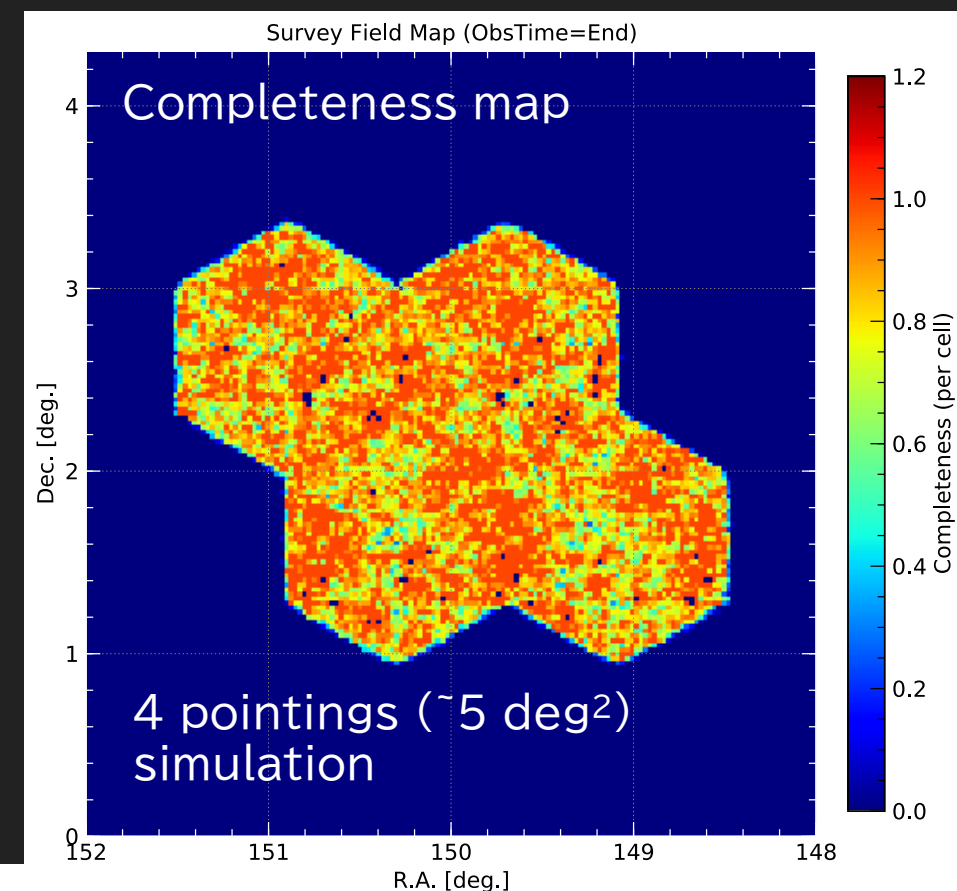


PFS survey planning and simulations

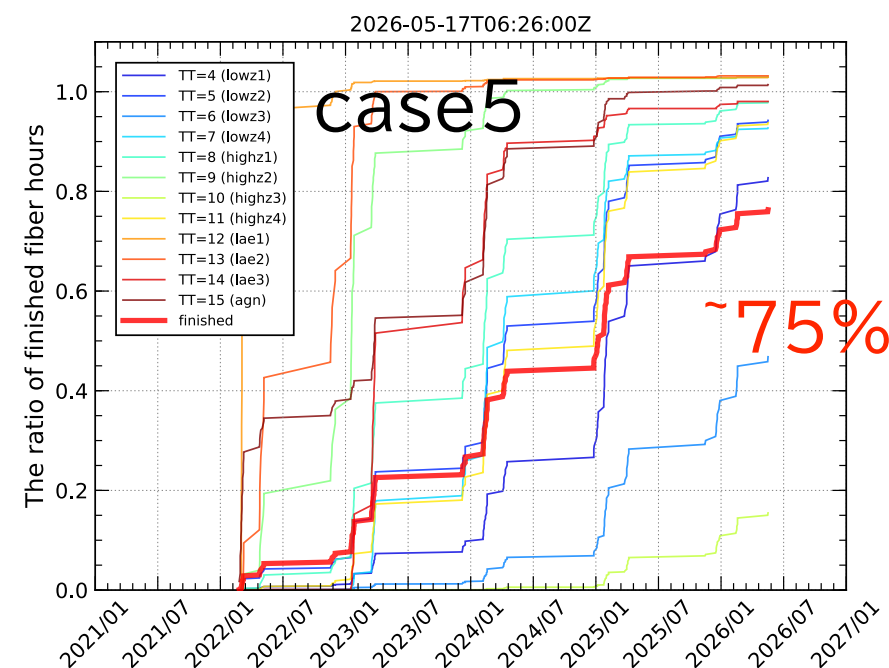
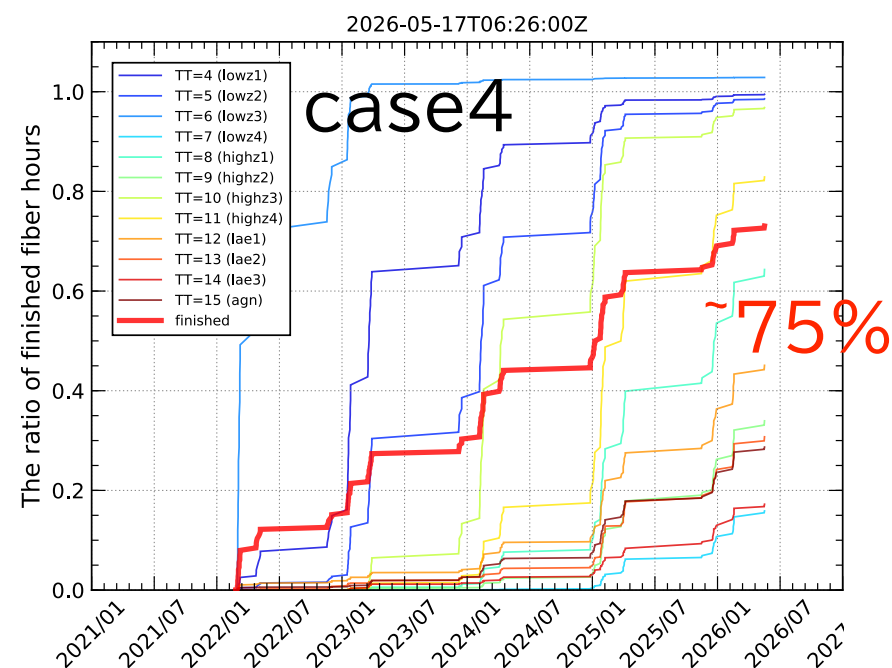
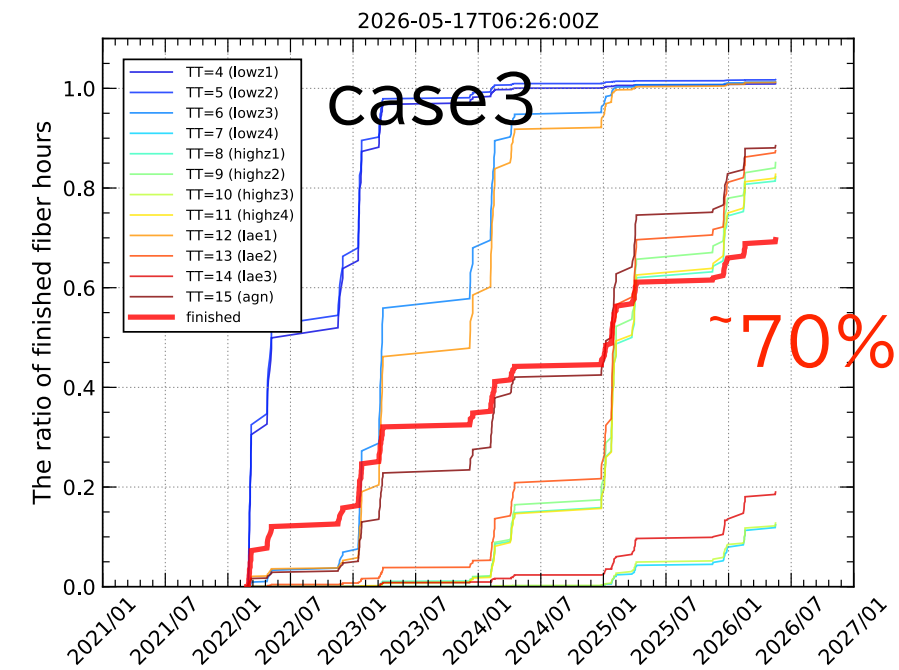
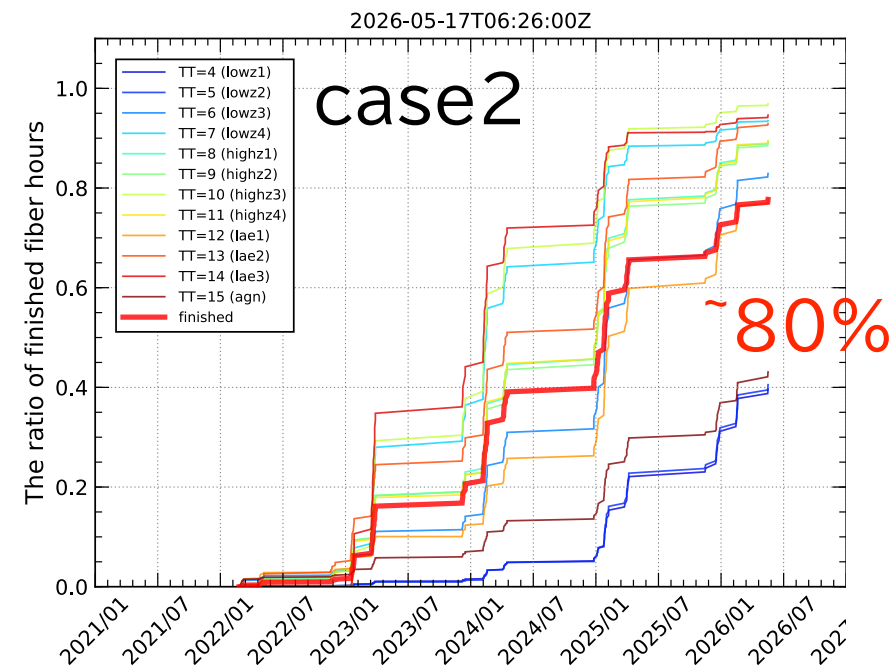
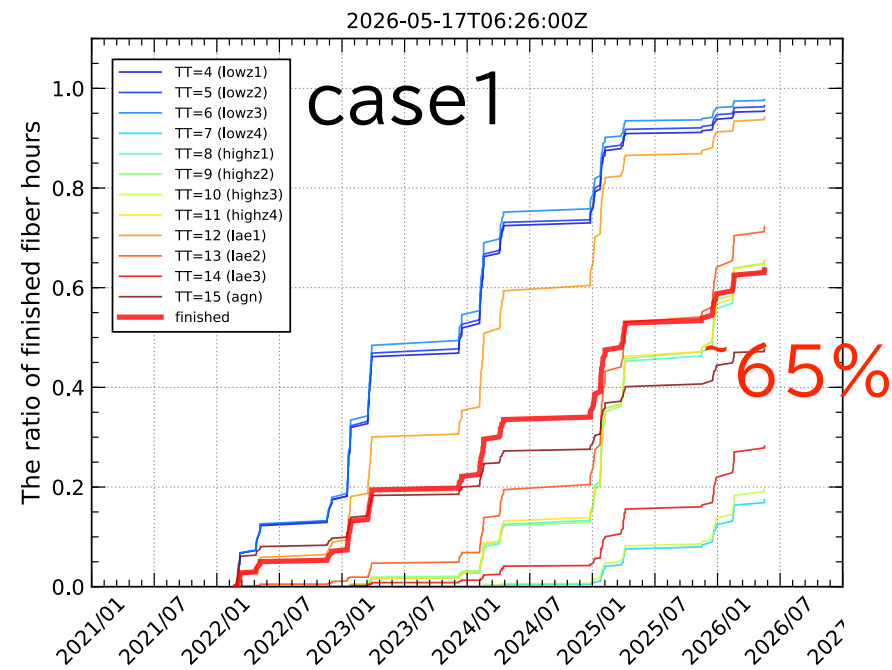


Repeating the observing cycle with connecting to each component

- Targets
 - ▶ Galaxy/AGN evolution survey
 - ▶ 12 different sample components
 - ▶ COSMOS galaxy catalog
 - ▶ ~40 hour-visits per pointing
- The number of galaxies assigned to fibers per visit decreases slightly in the end of the survey
- The (fiber-hour-base) completeness reaches ~80%



- Different prioritization leads to different results
- How do we optimize the prioritization?
 - ▶ Maximize the total survey completeness?
 - ▶ Minimize the target-to-target variation?



Further tests and discussion are now on-going

How to be involved with the collaboration?

- We discuss how to get involve this project later
- New science cases to make the survey stronger are welcome
- Detailed process to call for additional targets is currently under discussion
 - ▶ Is the science case interesting?
 - ▶ Is the science case feasible?
 - ▶ Does it fit with the story of the proposal?
 - ▶ Does it fit with the current survey plan?
- If you have some thoughts, please let us (PFS people) know
- We have prepared some tools for your idea

ETC and spectral simulator

- The project office presents information on the baseline of performance
 - ▶ summarizing the instrument throughput and the expected sensitivity and presenting them on our official website (<https://pfs.ipmu.jp>)
 - ▶ providing a package of exposure time calculator (ETC) and spectral simulator on GitHub

The screenshot shows the GitHub repository page for Subaru-PFS / spt_ExposureTimeCalculator. The repository has 59 commits, 5 branches, 3 releases, and 3 contributors. The latest commit is 9cbfc73 on Jul 21. The repository is currently on the master branch. The commit history shows several updates, including ignoring machine-generated files, writing the medium resolution arm as spectrograph 3, updating the datamodel to v1.0, and updating the README.

Subaru-PFS / spt_ExposureTimeCalculator

59 commits 5 branches 3 releases 3 contributors

Branch: master New pull request Create new file Upload files Find file Clone or download

kiyoyabe committed on GitHub Merge pull request #13 from Subaru-PFS/ticket/kiyoyabe20160703 Latest commit 9cbfc73 on Jul 21

bin	Ignore machine-generated files	4 months ago
config	Write the medium resolution arm as spectrograph 3	4 months ago
datamodel @ cf38363	Updated version of datamodel to v1.0	4 months ago
example	README updated	4 months ago
src	fixed #11	2 months ago

https://github.com/Subaru-PFS/spt_ExposureTimeCalculator

PFS performance

5 σ sensitivity for 1-hour exposure

Spectral arm	Wavelength range [nm]	Throughput [%]	Continuum sensitivity [AB mag]		Line sensitivity [10 ⁻¹⁷ erg/s/cm ²]	
			mean	representative	mean	representative
Blue	380 - 450	14.9	22.0	22.1	2.9	2.8
	450 - 550	24.5	22.4	22.5	1.5	1.4
	550 - 650	23.9	22.1	22.2	1.5	1.3
Red	630 - 750	29.1	22.2	22.5	1.2	1.0
	Low res. 750 - 850	30.1	22.0	22.4	1.1	0.9
	850 - 970	27.8	21.6	22.1	1.2	0.9
	710 - 775	26.4	21.6	21.8	1.3	1.1
	Mid. res. 775 - 825	28.4	21.6	21.8	1.1	1.0
	825 - 885	27.3	21.5	21.7	1.2	1.0
NIR	940 - 1050	17.9	20.9	21.5	2.0	1.3
	1050 - 1150	19.5	21.0	21.4	1.6	1.2
	1150 - 1260	17.1	20.9	21.3	1.5	1.2

Sensitivity:

Continuum ~22 AB

Line ~10⁻¹⁷ erg/s/cm²

*1 Here a point source is assumed

*2 For continuum, 3-pix binning along spec. direction is applied

*3 The representative value at the wavelength free from OH line

*4 The average value in the wavelength window

*5 Seeing FWHM of 0.8 arcsec. is assumed

<https://pfs.ipmu.jp/research/performance.html>

PFS survey simulator

- The simulator is open for the collaboration
- Python + Jupyter notebook running on a remote server

https://pfs.ipmu.jp/jupyter-spt/notebooks/example/example_end-to-end_simulation.ipynb

PFS account is required

If you are interested, please let us know

```

jupyter PFS survey simulations - end-to-end simulations - GE - fiducial si... Last Checkpoint: 8 minutes ago (unsaved changes) Logout
File Edit View Insert Cell Kernel Help Python 2
In [12]: %matplotlib inline
%load_ext autoreload
%autoreload 2

import sys, os
import matplotlib.pyplot as plt
import scipy as sp
from pfsurveywin import run_sim

sim = run_sim.SurveySim()

sim.set_param('hostname', hostname)
sim.set_param('port', port)
sim.set_param('dbname', dbname)
sim.set_param('dbuser', dbuser)
sim.set_param('dbpasswd', dbpasswd)
sim.set_param('survey_config', dir_name_config + 'ideal_evolution_survey')
sim.set_param('programid', 2)
sim.set_param('exptime', 3600.)
sim.set_param('exptime_min', 1200.)
sim.set_param('sim_name', 'ideal_ge_case2')
sim.set_param('log_dir', dir_name_log)
sim.set_param('fig_dir', dir_name_figure)
sim.set_param('pos_center_init', (151.2, 2.5))
sim.set_param('pos_angle_init', 0)
sim.set_param('nax_iter', 1)
sim.set_param('operation', 'fixed')
sim.set_param('qa_mode', 'exptime')
sim.set_param('ets_algorithm', 'ets')
sim.set_param('ets_assigner', 'draining')
sim.set_param('seeing', 0.8)
sim.set_param('noon', 0.0)
sim.set_param('dith_scale', 30.0)
sim.set_param('nax', 400)
sim.set_param('nax', 30)
sim.set_param('do_fov_plot', 0)
sim.set_param('do_map_plot', 1)
sim.set_param('xmin_sf', 148.0)
sim.set_param('xmax_sf', 152.0)
sim.set_param('dx_sf', 0.025)
sim.set_param('ymin_sf', 0.0)
sim.set_param('ymax_sf', 4.3)
sim.set_param('dy_sf', 0.025)
sim.set_param('vmin_sf', 0.0)
sim.set_param('vmax_sf', 30.0)
sim.set_param('writefits', False)
sim.set_param('quiet', True)

sim.run()

The autoreload extension is already loaded. To reload it, use:
%reload_ext autoreload
Connection to pfs ge survey_sim_201807 ... ok
Resetting QA Finished ...
Resetting OneFiber ...
Resetting pfsArrObj ...
Resetting pfsArr ...
Resetting Exposure ...
Resetting pfsConfigFiber ...
Resetting pfsConfig ...
Resetting Tile ...
Resetting pfsObject ...
Checking ETS package ...
Initializing ETS package ...
Elapsed_time: 2157.0[sec]

Out[12]: 0

```

PFS survey simulator

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- Python + Jupyter notebook running on a remote server

https://pfs.ipmu.jp/jupyter-spt/notebooks/example/example_end-to-end_simulation.ipynb

PFS account is required

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sim.set_param('dbname', dbname)
sim.set_param('dbuser', dbuser)
sim.set_param('dbpasswd', dbpasswd)
sim.set_param('survey_config', dir_name_config + 'ideal_evolution_survey')
sim.set_param('programid', 2)
sim.set_param('exptime', 3600.)
sim.set_param('exptime_min', 1200.)
sim.set_param('sim_name', 'ideal_ge_case2')
sim.set_param('log_dir', dir_name_log)
sim.set_param('fig_dir', dir_name_figure)
sim.set_param('pos_center_init', (151.2, 2.5))
sim.set_param('pos_angle_init', 0)
sim.set_param('nax_iter', 1)
sim.set_param('operation', 'fixed')
sim.set_param('qa_mode', 'exptime')
sim.set_param('ets_algorithm', 'ets')
sim.set_param('ets_assigner', 'draining')
sim.set_param('seeing', 0.8)
sim.set_param('noon', 0.0)
sim.set_param('dith_scale', 30.0)
sim.set_param('nax', 400)
sim.set_param('nax', 30)
sim.set_param('do_fov_plot', 0)
sim.set_param('do_map_plot', 1)
sim.set_param('xmin_sf', 140.0)
sim.set_param('xmax_sf', 152.0)
sim.set_param('dx_sf', 0.025)
sim.set_param('ymin_sf', 0.0)
sim.set_param('ymax_sf', 4.3)
sim.set_param('dy_sf', 0.025)
sim.set_param('vmin_sf', 0.0)
sim.set_param('vmax_sf', 30.0)
sim.set_param('writefits', False)
sim.set_param('quiet', True)

sim.run()

The autoreload extension is already loaded. To reload it, use:
%reload_ext autoreload
Connection to pfs ge survey_sim 201807 ... ok
Resetting QA Finished ...
Resetting OneFiber ...
Resetting pfsArrObj ...
Resetting pfsArr ...
Resetting Exposure ...
Resetting pfsConfigFiber ...
Resetting pfsConfig ...
Resetting Tile ...
Resetting pfsObject ...
Checking ETS package ...
Initializing ETS package ...
Elapsed_time: 2157.0[sec]

Out[12]: 0
  
```


PFS survey simulator

- The simulator is open for the collaboration
- Python + Jupyter notebook running on a remote server

https://pfs.ipmu.jp/jupyter-spt/notebooks/example/example_end-to-end_simulation.ipynb

PFS account is required

If you are interested, please let us know

```

In [12]: %matplotlib inline
%load_ext autoreload
%autoreload 2

import sys, os
import matplotlib.pyplot as plt
import scipy as sp
from pfsurveywin import run_sim

sim = run_sim_surveywin()

sim.set_param('hostname', hostname)
sim.set_param('port', port)
sim.set_param('dbname', dbname)
sim.set_param('dbuser', dbuser)
sim.set_param('dbpasswd', dbpasswd)
sim.set_param('survey_config', dir_name_config + 'ideal_evolution_survey')
sim.set_param('programid', 2)
sim.set_param('exptime', 3600.)
sim.set_param('exptime_min', 1200.)
sim.set_param('sim_name', 'ideal_ge_case2')
sim.set_param('log_dir', dir_name_log)
sim.set_param('fig_dir', dir_name_figure)
sim.set_param('pos_center_init', (151.2, 2.5))
sim.set_param('pos_angle_init', 0)
sim.set_param('nax_iter', 1)
sim.set_param('operation', 'fixed')
sim.set_param('qa_mode', 'exptime')
sim.set_param('ets_algorithm', 'ets')
sim.set_param('ets_assigner', 'draining')
sim.set_param('seeing', 0.8)
sim.set_param('noon', 0.0)
sim.set_param('dith_scale', 30.0)
sim.set_param('masky', 400)
sim.set_param('ncol', 30)
sim.set_param('do_fov_plot', 0)
sim.set_param('do_map_plot', 1)
sim.set_param('xmin_sf', 140.0)
sim.set_param('xmax_sf', 152.0)
sim.set_param('dx_sf', 0.025)
sim.set_param('ymin_sf', 0.0)
sim.set_param('ymax_sf', 4.3)
sim.set_param('dy_sf', 0.025)
sim.set_param('vmin_sf', 0.0)
sim.set_param('vmax_sf', 30.0)
sim.set_param('writefits', False)
sim.set_param('quiet', True)

sim.run()

The autoreload extension is already loaded. To reload it, use:
%reload_ext autoreload
Connection to pfs ge survey_win 201807 ... ok
Resetting QA Finished ...
Resetting OneFiber ...
Resetting pfsArrObj ...
Resetting pfsArr ...
Resetting Exposure ...
Resetting pfsConfigFiber ...
Resetting pfsConfig ...
Resetting Tile ...
Resetting pfsObject ...
Checking ETS package ...
Initializing ETS package ...
Elapsed_time: 2157.0[sec]

Out[12]: 0
  
```

Set parameters

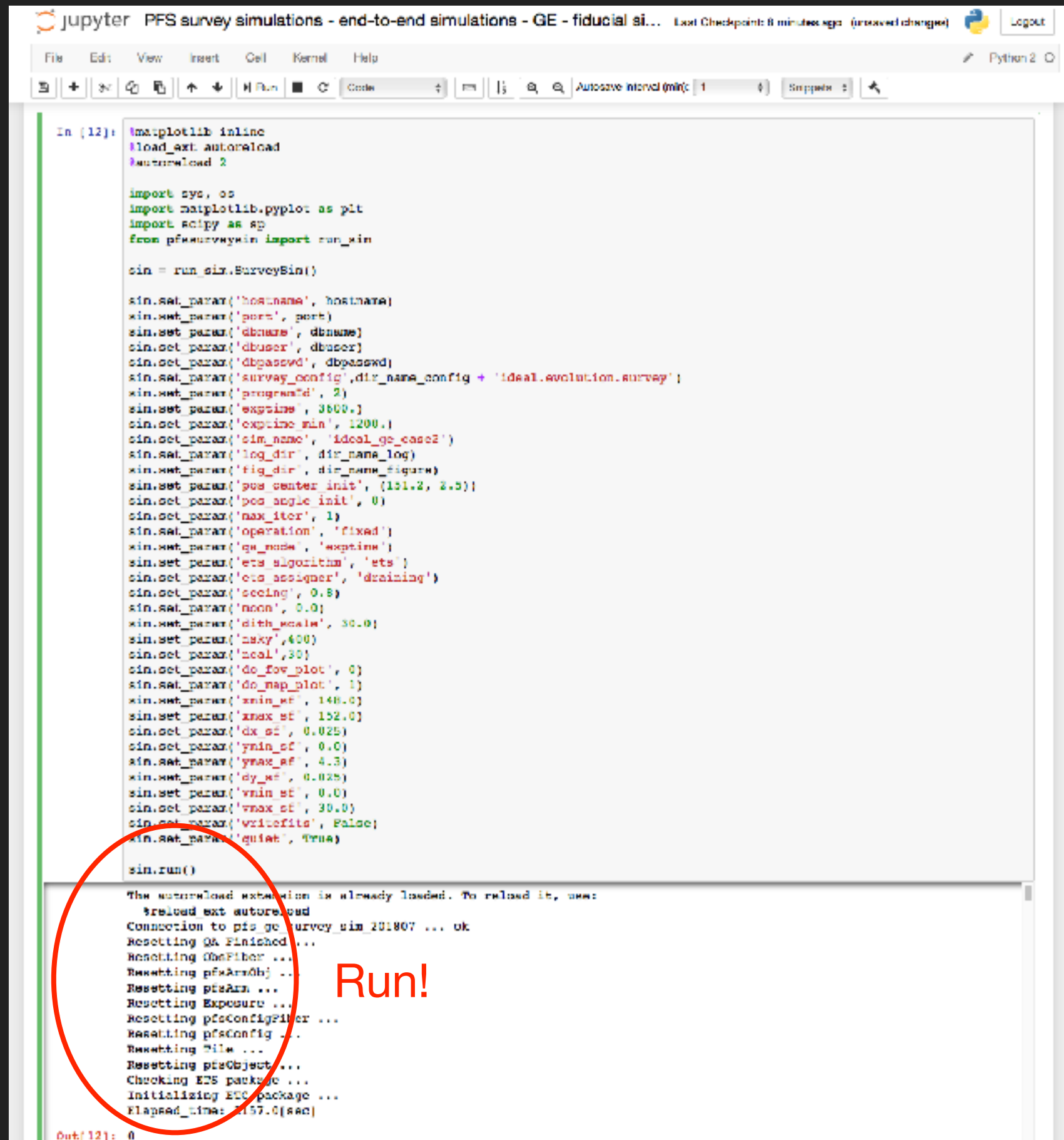
PFS survey simulator

- The simulator is open for the collaboration
- Python + Jupyter notebook running on a remote server

https://pfs.ipmu.jp/jupyter-spt/notebooks/example/example_end-to-end_simulation.ipynb

PFS account is required

If you are interested, please let us know



```

jupyter PFS survey simulations - end-to-end simulations - GE - fiducial si... Last Checkpoint: 8 minutes ago (unsaved changes) Logout
File Edit View Insert Cell Kernel Help Python 2
In [12]: %matplotlib inline
%load_ext autoreload
%autoreload 2

import sys, os
import matplotlib.pyplot as plt
import scipy as sp
from pfsurveywin import run_sim

sim = run_sim.SurveySim()

sim.set_param('hostname', hostname)
sim.set_param('port', port)
sim.set_param('dbname', dbname)
sim.set_param('dbuser', dbuser)
sim.set_param('dbpasswd', dbpasswd)
sim.set_param('survey_config', dir_name_config + 'ideal_evolution_survey')
sim.set_param('programid', 2)
sim.set_param('exptime', 3600.)
sim.set_param('exptime_min', 1200.)
sim.set_param('sim_name', 'ideal_ge_case2')
sim.set_param('log_dir', dir_name_log)
sim.set_param('fig_dir', dir_name_figure)
sim.set_param('pos_center_init', (151.2, 2.5))
sim.set_param('pos_angle_init', 0)
sim.set_param('nax_iter', 1)
sim.set_param('operation', 'fixed')
sim.set_param('ga_mode', 'exptime')
sim.set_param('ets_algorithm', 'ets')
sim.set_param('ets_assigner', 'draining')
sim.set_param('seeing', 0.8)
sim.set_param('noon', 0.0)
sim.set_param('dith_scale', 30.0)
sim.set_param('nax', 400)
sim.set_param('nax', 30)
sim.set_param('do_fov_plot', 0)
sim.set_param('do_map_plot', 1)
sim.set_param('xmin_sf', 148.0)
sim.set_param('xmax_sf', 152.0)
sim.set_param('dx_sf', 0.025)
sim.set_param('ymin_sf', 0.0)
sim.set_param('ymax_sf', 4.3)
sim.set_param('dy_sf', 0.025)
sim.set_param('vmin_sf', 0.0)
sim.set_param('vmax_sf', 30.0)
sim.set_param('writefits', False)
sim.set_param('quiet', True)

sim.run()

The autoreload extension is already loaded. To reload it, use:
%reload_ext autoreload
Connection to pfs ge survey_sim 201807 ... ok
Resetting QA Finished ...
Resetting OneFiber ...
Resetting pfsArrObj ...
Resetting pfsArr ...
Resetting Exposure ...
Resetting pfsConfigFiber ...
Resetting pfsConfig ...
Resetting Tile ...
Resetting pfsObject ...
Checking ETS package ...
Initializing ETS package ...
Elapsed time: 2157.0[sec]

Out[12]: 0
  
```

Summary

- PFS SSP survey
 - ▶ Cosmology survey
 - ✓ $\sim 1400 \text{ deg}^2$ of the HSC-wide fields
 - ✓ Precise measurement of cosmological parameters and constraint on the neutrino mass hierarchy
 - ✓ Competitiveness to other large surveys
 - ▶ Galaxy/AGN Evolution survey
 - ✓ $\sim 15 \text{ deg}^2$ of the HSC-deep fields
 - ✓ Understand how galaxies form and evolve along the cosmic large scale structure
 - ✓ Many science cases have been discussed so far
- Survey planning and simulation are on-going
- Some tools have been provided for your own science