

For PFS AGN Town Meeting 2024

# Fact Sheets on PFS-SSP-GE and -GO

Based on

Greene et al. (2022): *arXiv:2206.14908 (GE)*

*Takada et al., 2014, PASJ, 66, R1 (CO)*

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# PFS Parameters

# PFS parameters

Taken from <https://pfs.ipmu.jp/research/parameters.html>

| Prime Focus Instrument                  |   |                       |
|---|---|-----------------------|
| Field of view                           | ~1.38 deg (hexagonal - diameter of circumscribed circle)                  |                       |
| Field of view area                      | ~1.25 deg <sup>2</sup>  |                       |
| Input F number to fiber                 | 2.8   |                       |
| Fiber core diameter <sup>(1)</sup>      | 127 μm (1.12 arcsec at the FoV center, 1.02 arcsec at the edge)           |                       |
| Positioner pitch                        | 8 mm (90.4 arcsec at the FoV center, 82.4 arcsec at the edge)             |                       |
| Positioner patrol field                 | 9.5 mm diameter (107.4 arcsec at the FoV center, 97.9 arcsec at the edge) |                       |
| Fiber minimum separation <sup>(2)</sup> | ~30 arcsec  |                       |
| Fiber configuration time                | ~60-120 sec. [TBC]  |                       |
| Number of fibers                        | Science fibers  | Fixed fiducial fibers |
|   | 2394  | 96                    |
| Fiber density                           | ~2000 deg <sup>-2</sup> / ~0.6 arcmin <sup>-2</sup>                       |                       |
| Number of A&G camera <sup>(3)</sup>     | 6   |                       |
| Field of view of A&G camera             | ~5.1 arcmin <sup>2</sup> per one camera                                   |                       |
| Sensitivity of A&G camera               | r'~20.0 AB mag for S/N~30 (100) in 1 (10) sec. exposure                   |                       |

# PFS parameters

Taken from <https://pfs.ipmu.jp/research/parameters.html>

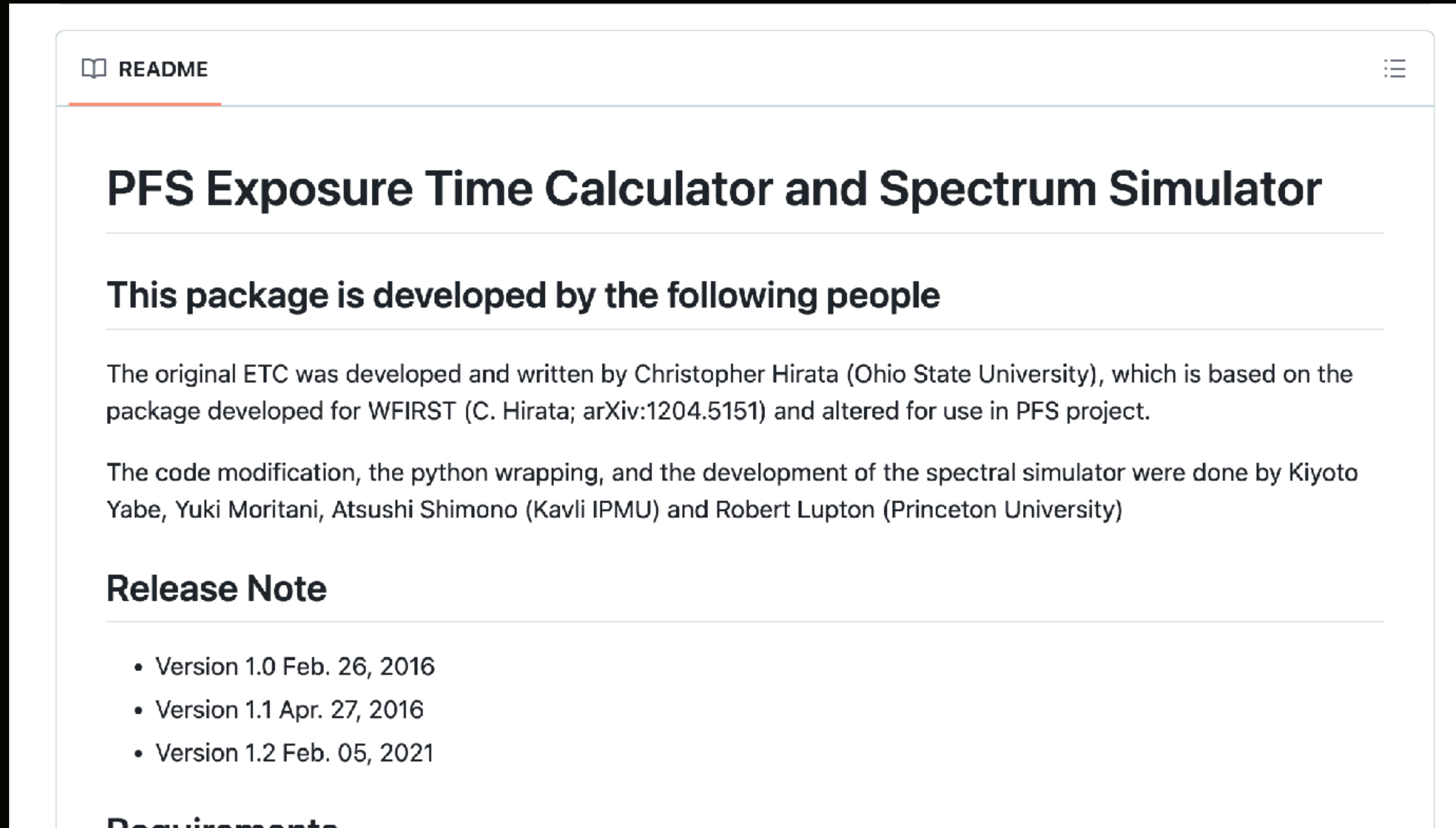
| Spectrograph                           |               |               |               |                |
|--|---------------|---------------|---------------|----------------|
| Spectral arms                          | Blue          | Red           |               | NIR            |
|  |               | Low Res.      | Mid. Res.     |                |
| Spectral coverage                      | 380 - 650 nm  | 630 - 970 nm  | 710 - 885 nm  | 940 - 1260 nm  |
| Dispersion                             | ~0.7 Å/pix    | ~0.9 Å/pix    | ~0.4 Å/pix    | ~0.8 Å/pix     |
| Spectral resolution                    | ~2.1 Å        | ~2.7 Å        | ~1.6 Å        | ~2.4 Å         |
| Resolving power                        | ~2300         | ~3000         | ~5000         | ~4300          |
| Spectrograph throughput <sup>(4)</sup> | ~52% (@500nm) | ~52% (@800nm) | ~47% (@800nm) | ~35% (@1100nm) |

$\lambda=0.38-1.26\mu\text{m}$ ,  $R=2300-5000$

Mid-Resolution ( $R\sim 5000$ ) is designed for achieving GA science (observing stars and alpha-elements), while GE+CO would use mainly low-res. mode (Takada+14)

**PFS tools**

# PFS Exposure Time Calculator (ETC)



The image shows a screenshot of a GitHub README page. At the top left, there is a book icon followed by the word "README". At the top right, there is a hamburger menu icon. The main heading is "PFS Exposure Time Calculator and Spectrum Simulator". Below this, there is a section titled "This package is developed by the following people". The text describes the development history, mentioning Christopher Hirata (Ohio State University) as the original developer, and Kiyoto Yabe, Yuki Moritani, Atsushi Shimono (Kavli IPMU), and Robert Lupton (Princeton University) as contributors to the current version. A "Release Note" section follows, listing three versions: Version 1.0 (Feb. 26, 2016), Version 1.1 (Apr. 27, 2016), and Version 1.2 (Feb. 05, 2021). The "Requirements" section is partially visible at the bottom.

README

## PFS Exposure Time Calculator and Spectrum Simulator

### This package is developed by the following people

The original ETC was developed and written by Christopher Hirata (Ohio State University), which is based on the package developed for WFIRST (C. Hirata; arXiv:1204.5151) and altered for use in PFS project.

The code modification, the python wrapping, and the development of the spectral simulator were done by Kiyoto Yabe, Yuki Moritani, Atsushi Shimono (Kavli IPMU) and Robert Lupton (Princeton University)

### Release Note

- Version 1.0 Feb. 26, 2016
- Version 1.1 Apr. 27, 2016
- Version 1.2 Feb. 05, 2021

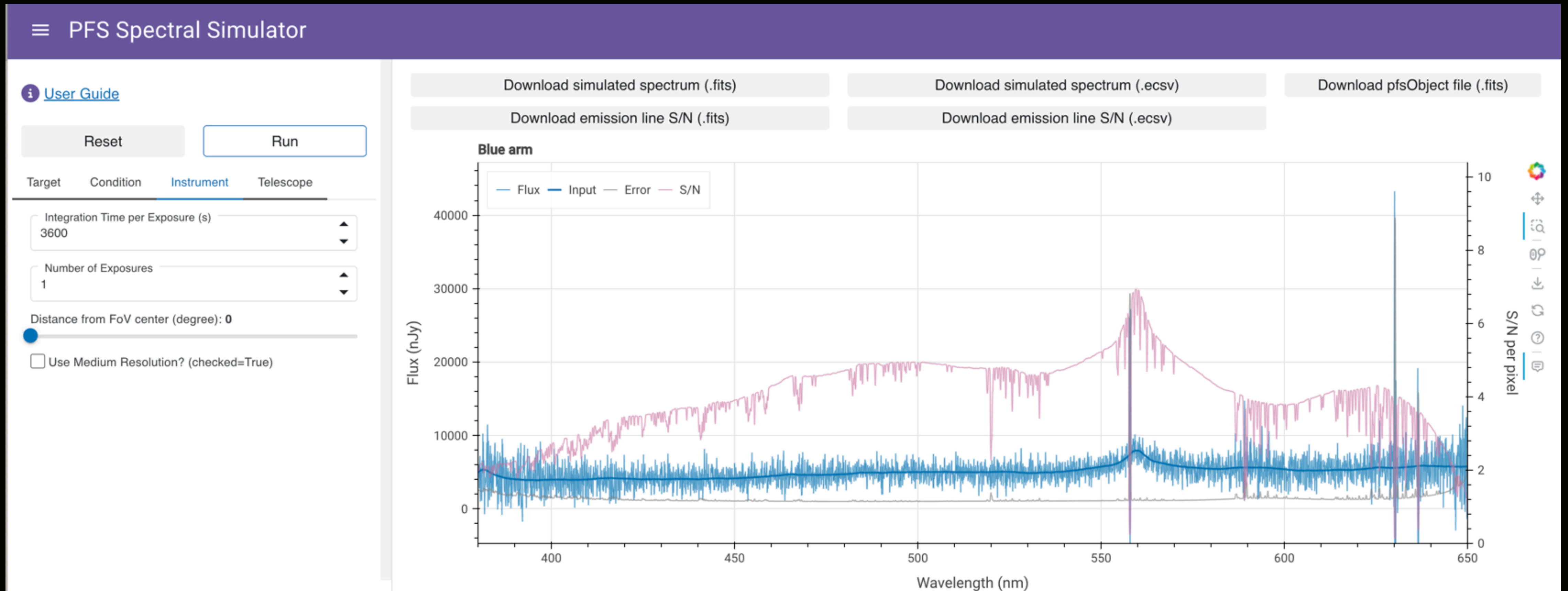
### Requirements

[https://github.com/Subaru-PFS/spt\\_ExposureTimeCalculator](https://github.com/Subaru-PFS/spt_ExposureTimeCalculator)

# PFS Spectral Simulator

<https://pfs-etc.naoj.hawaii.edu/etc/app>

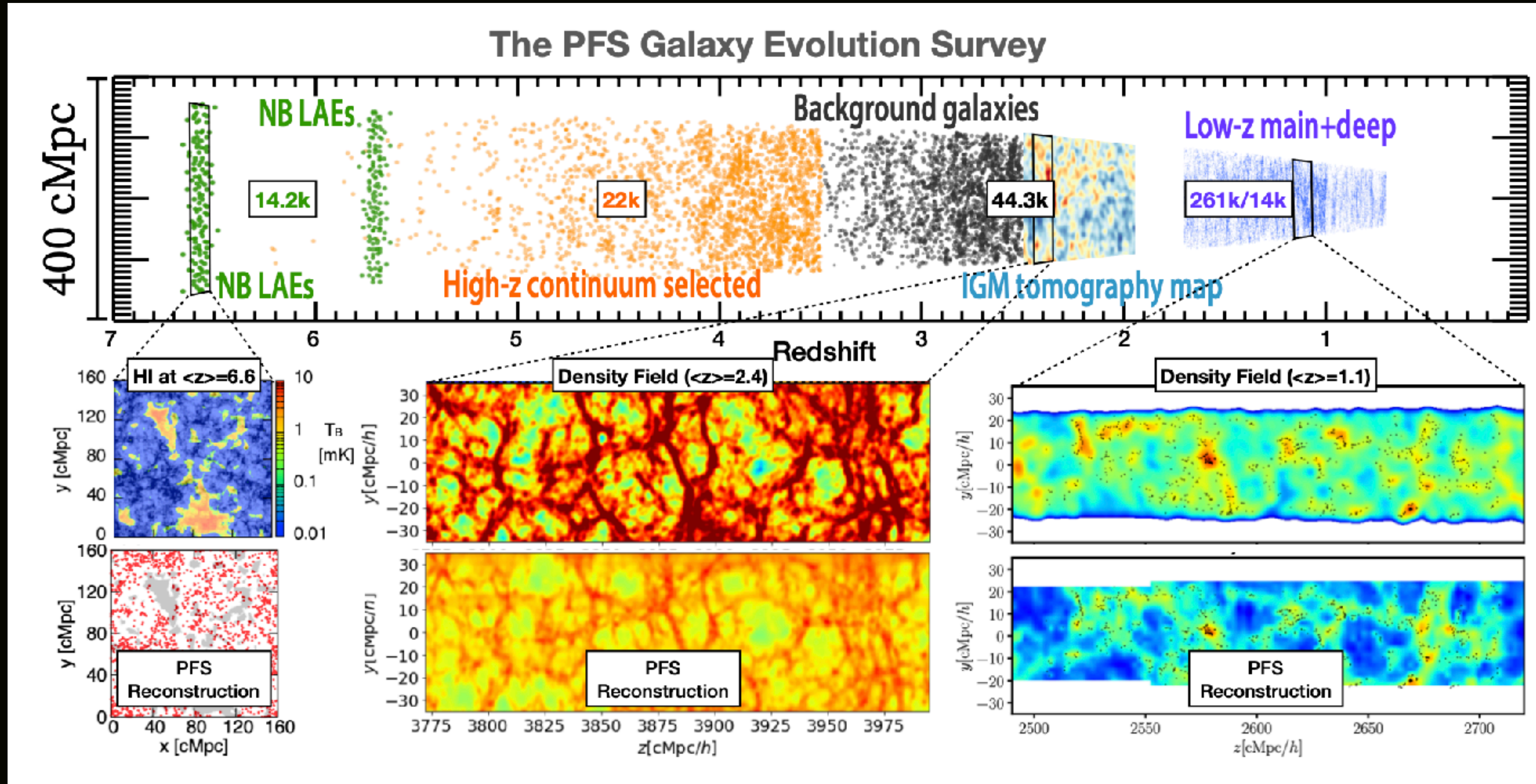
Web-based interface



**PFS-GE (Greene et al. 2022)**



# SSP-GE sample in one slide



1. Continuum-selected galaxies at  $0.7 < z < 2$  ( $\sim 270$ k sources)
2. IGM tomography map with background galaxies at  $2.1 < z < 3.5$  ( $\sim 31$ k sources)
3. LBGs at  $z = 3.5 - 7$  (22k sources) and LAEs at  $z = 2.2, 5.7, 6.6$  ( $\sim 15$ k sources)  
+ AGN (4.2k sources)

# SSP-GE sample and selection cut

Total: ~350k galaxies

**Table 1.** Galaxy samples and depths

| Type      | Redshift range | Selection  | Exp. Time (hrs) | # of spectra ( $\times 10^3$ ) |
|-----------|----------------|--|-----------------|--------------------------------|
| Continuum | 0.7 – 2        | $y, J < 22.8$  | 2, 12           | 261, 14                        |
| IGM       | 2.1 – 3.5      | $y < 24.3, g < 24.7$                                 | 6, 12           | 30.3, 14                       |
| LBG       | 3.5 – 7        | $y < 24.5$   | 6               | 22                             |
| LAE       | 2.2, 5.7, 6.6  | $L_{Ly\alpha} > 3 \times 10^{42} \text{ erg s}^{-1}$ | 3, 6, 12        | 7.4, 4.5, 2.8                  |
| AGN-GE    | 0.5 – 6.0      | various (see text)                                   | 1 – 5           | 4.2                            |

1. Continuum-selected galaxies at  $0.7 < z < 2$  (~270k sources)
2. IGM tomography map with background galaxies at  $2.1 < z < 3.5$  (~31k sources)
3. LBGs at  $z=3.5-7$  (22k sources) and LAEs at  $z=2.2, 5.7, 6.6$  (~15k sources)  
+ AGN (4.2k sources)

# Galaxy target table

Total: ~350k galaxies

Table 3. Full Target Table

| Redshift range     | Selection   | Exp. Time (hrs) | Targets PFS FOV | Sampling rate (%) | # of spectra ( $10^3$ ) | Fiber khrs |
|--------------------|---|-----------------|-----------------|-------------------|-------------------------|------------|
| Continuum-selected |   |                 |                 |                   |                         |            |
| $\lesssim 1$       | $i < 23$  | 2               | 6100            | 40                | 24                      | 48         |
| 0.7 – 1            | $y < 22.5 + z_{\text{ph}}$                        | 2               | 11900           | 50                | 58                      | 116        |
| 1 – 2              | $y > 22.5 + z_{\text{ph}}$<br>$+ J < 22.8$        | 2               | 11800           | 70                | 81                      | 162        |
| 0.7 – 2            | $y < 22.8 + z_{\text{ph}}$                        | 12              | 1220            | ...               | 12                      | 144        |
| Tomography         |   |                 |                 |                   |                         |            |
| 2.1 – 2.5          | $y < 24.3 + z_{\text{ph}}$                        | 6               | 8300            | 22                | 18                      | 108        |
| 2.5 – 3.5          | $y < 24.3 + z_{\text{ph}}$<br>$+ g < 24.2$        | 6               | 770             | 90                | 6.8                     | 41         |
| 2.5 – 3.5          | $y < 24.3 + z_{\text{ph}}$<br>$+ 24.2 < g < 24.7$ | 12              | 1800            | 65                | 11.5                    | 138        |
| LAE                |   |                 |                 |                   |                         |            |
| 3.5 – 7            | $y < 24.5 + z_{\text{ph}}$                        | 6               | 2500            | 74                | 18                      | 108        |
| 2.2                | $\log L_{Ly\alpha} > 42.5$                        | 3               | 770             | 80                | 6.0                     | 18         |
| 5.7, 6.6           | $\log L_{Ly\alpha} > 42.7$                        | 6               | 470             | 80                | 3.7                     | 22         |
| 5.7, 6.6           | $\log L_{Ly\alpha} = 42.5-42.7$                   | 12              | 290             | 80                | 2.3                     | 28         |

Why  $z < 2$ ?

to cover 4000Å break  
=> crucial for  
stellar-mass, SFR

Minimum exposure: 2hr (Main-continuum selected)

Maximum exposure: 12 hrs (Deep-continuum selected, faint back ground galaxies for IGM at  $z=2.5-3.5$ , faint LAE at  $z=5.7, 6.6$ )

# AGN Target table

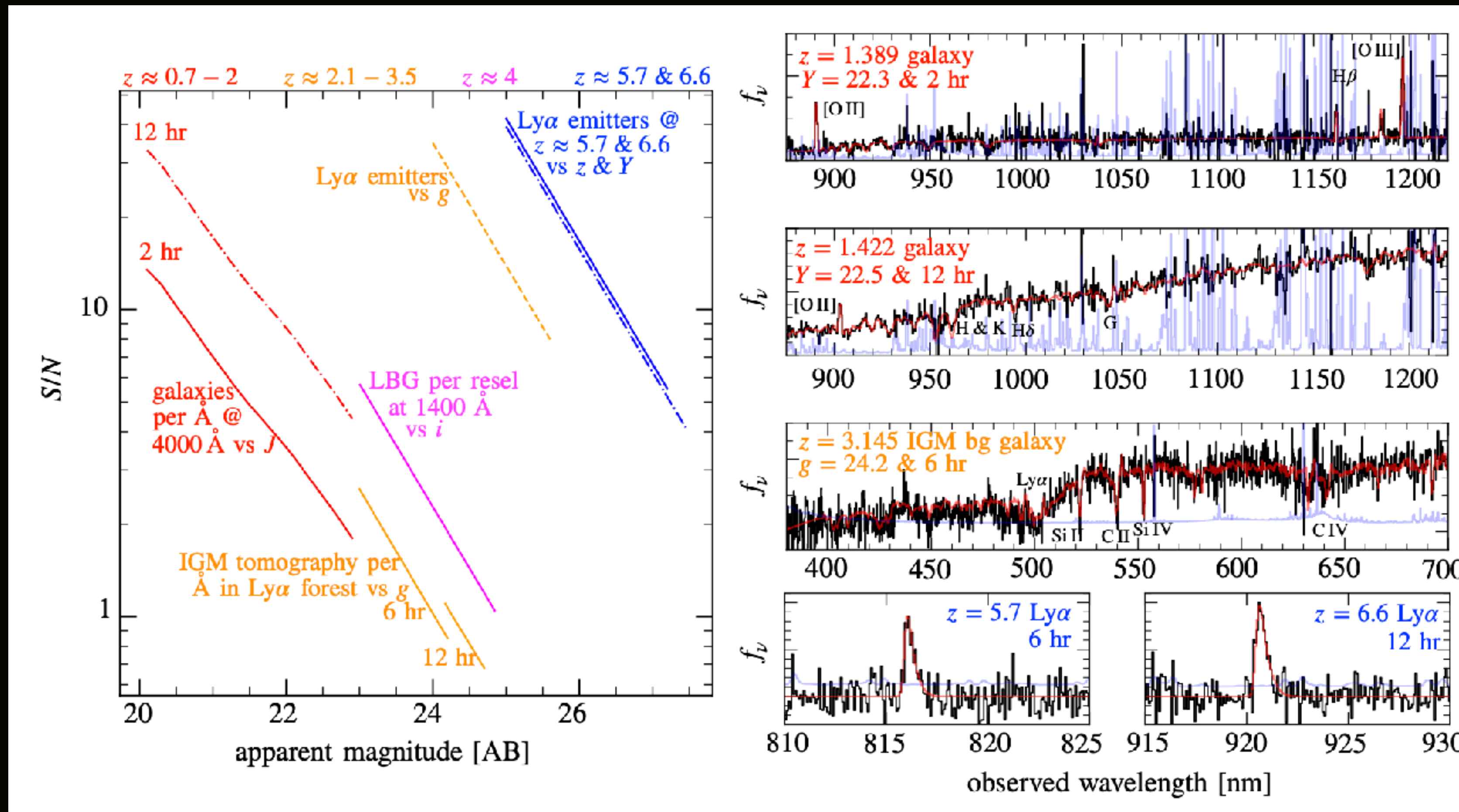
For GE, 6k sources

| Targets                   | Selection                          | $N_{\text{AGN}}^{\text{total}}$ | $N_{\text{AGN}}$ | $N_{\text{fiber}}$ | $T_{\text{exp}}$ | $N_{\text{fiber}}T_{\text{exp}}$ |
|---------------------------|------------------------------------|---------------------------------|------------------|--------------------|------------------|----------------------------------|
| Galaxy Evolution          |                                    |                                 |                  |                    |                  |                                  |
| BL candidates ( $z < 4$ ) | CFHT $u - \textit{Spitzer}$ colors | 5,700                           | 3,000            | 6,000 (0.5)        | 1 – 4            | 15,000                           |
| BL candidates ( $z > 4$ ) | HSC – <i>Spitzer</i> colors        | 500                             | 500              | 1,000 (0.5)        | 4 – 5            | 4,500                            |
| X-ray sources             | <i>Chandra</i> , <i>XMM-Newton</i> | 10,000                          | 2,000            | 2,000 (1.0)        | 4 – 5            | 9,000                            |
| Sub-mm galaxies           | SCUBA-2 w/ ALMA counterparts       | 300                             | 300              | 1,000 (0.3)        | 5                | 5,000                            |
| Radio galaxies            | FIRST                              | 200                             | 200              | 300 (0.7)          | 3                | 900                              |
| IMBH candidates           | HSC flux variability               | 30                              | 30               | 300 (0.1)          | 2                | 600                              |
| <b>Total</b>              |                                    |                                 | <b>6,030</b>     | <b>10,600</b>      |                  | <b>35,000</b>                    |
| Cosmology                 |                                    |                                 |                  |                    |                  |                                  |
| BL candidates ( $z > 4$ ) | HSC colors                         | 15,000                          | 15,000           | 30,000 (0.5)       | 0.5              | 15,000                           |
| X-ray sources             | <i>eROSITA</i>                     | 1,700                           | 1,700            | 1,700 (1.0)        | 0.5              | 850                              |
| Mid-IR sources            | WISE 22 $\mu\text{m}$              | 1,000                           | 1,000            | 1,500 (0.7)        | 0.5              | 750                              |
| Radio galaxies            | FIRST                              | 20,000                          | 1,500            | 1,700 (0.9)        | 0.5              | 850                              |
| Lensed quasar candidates  | HSC shapes                         | 100                             | 100              | 1,100 (0.1)        | 0.5              | 550                              |
| <b>Total</b>              |                                    |                                 | <b>19,300</b>    | <b>36,000</b>      |                  | <b>18,000</b>                    |

Several selection criteria, basically with multi-wavelength cross-matching (IR, X-ray, sub, radio) or variability

# SN as a function of mag

With 6 hrs, we can obtain spectra (SN>2/bin) of LBG down to  $i_{AB} = 24$  mag

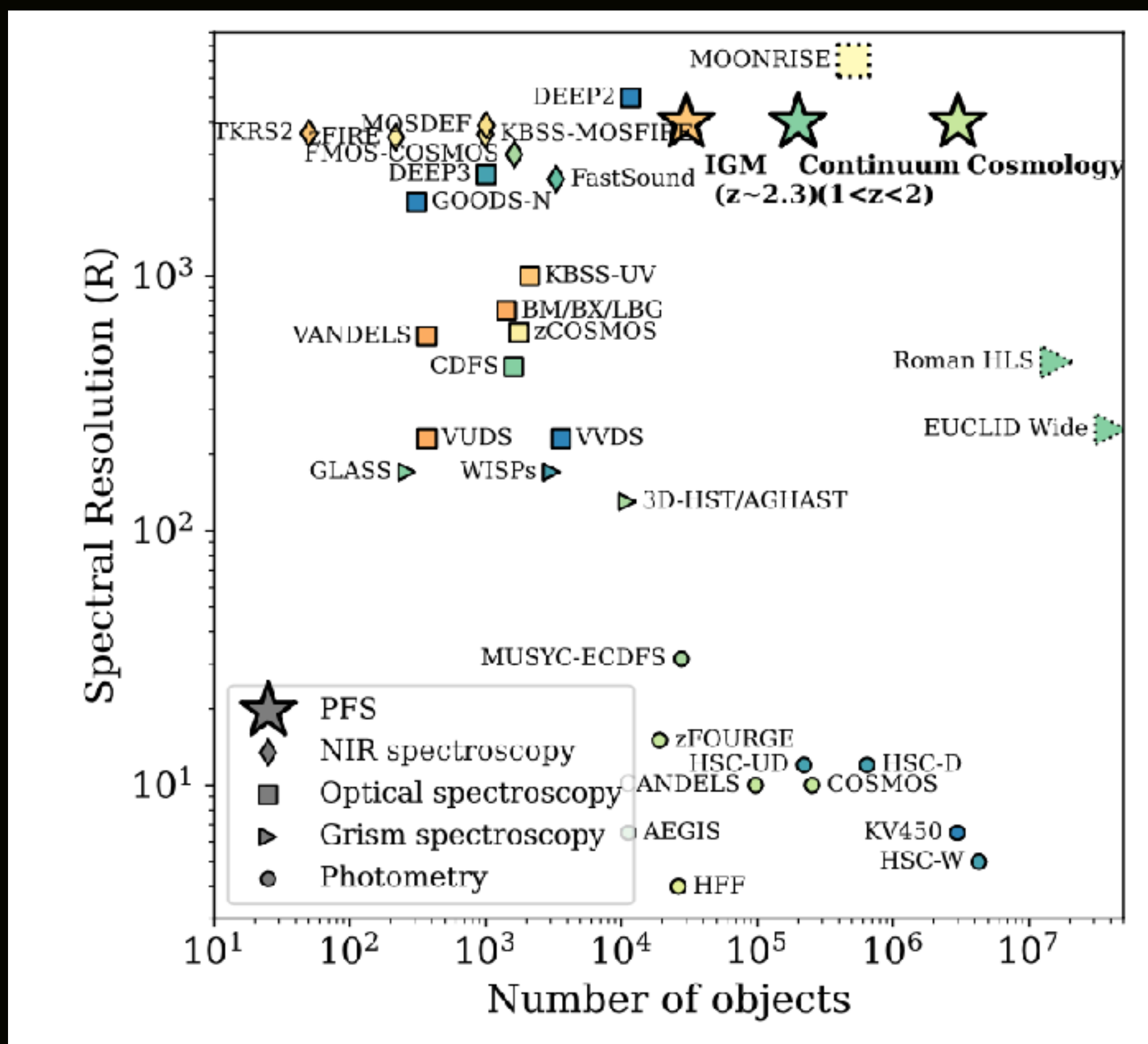


Minimum exposure: 2hr (Main-continuum selected)

Maximum exposure: 12 hrs (Deep-continuum selected, faint back ground galaxies for IGM at  $z=2.5-3.5$ , faint LAE at  $z=5.7, 6.6$ )

# Spectral Resolution and Numbers

No specific resolution in the main text, but figure tells  $R=3000-5000$   
 Matched with expected resolution by PFS



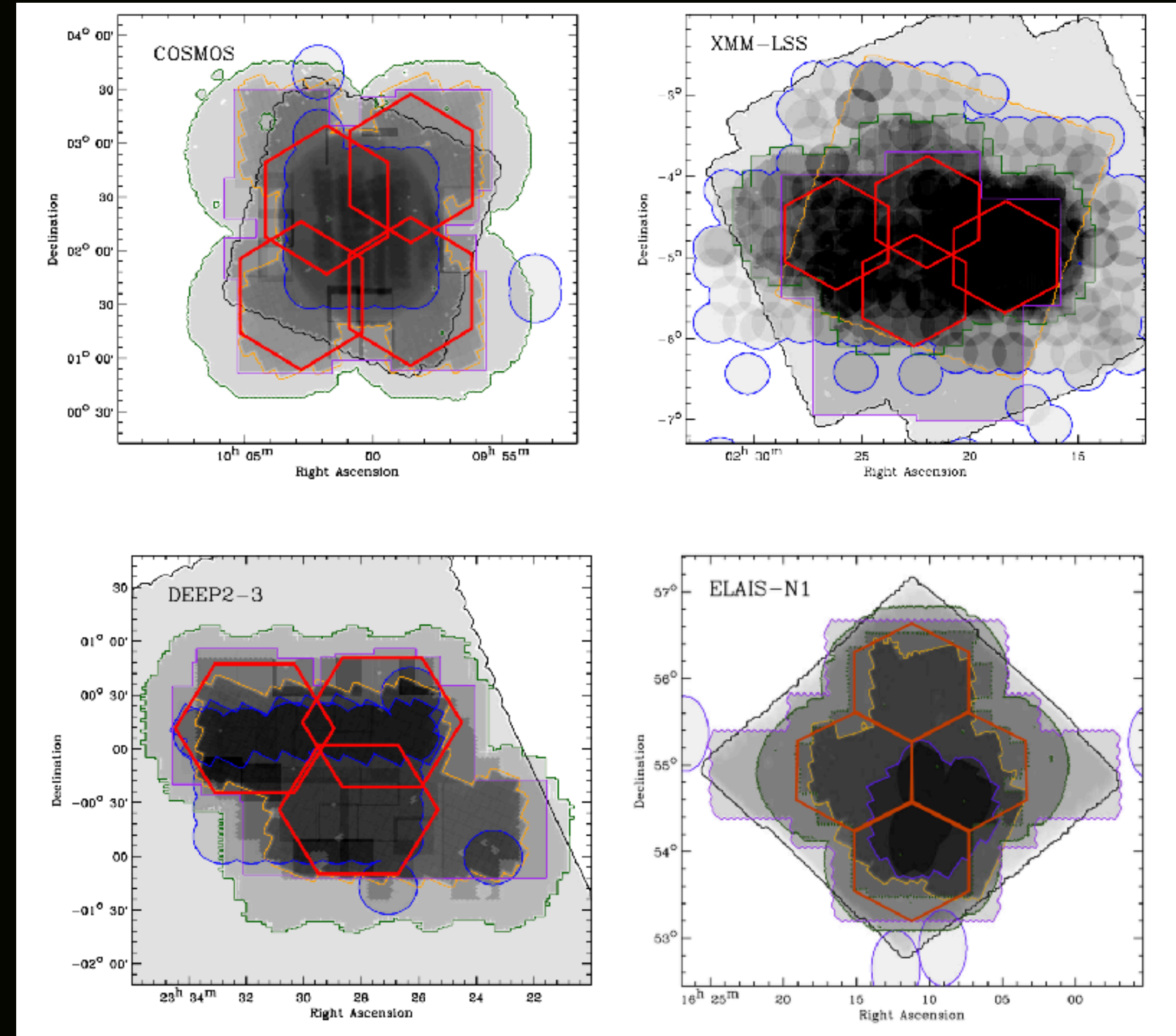
From <https://pfs.ipmu.jp/research/parameters.html>

| Spectrograph                           |               |               |               |                |
|--|---------------|---------------|---------------|----------------|
| Spectral arms                          | Blue          | Red           |               | NIR            |
|  |               | Low Res.      | Mid. Res.     |                |
| Spectral coverage                      | 380 - 650 nm  | 630 - 970 nm  | 710 - 885 nm  | 940 - 1260 nm  |
| Dispersion                             | ~0.7 Å/pix    | ~0.9 Å/pix    | ~0.4 Å/pix    | ~0.8 Å/pix     |
| Spectral resolution                    | ~2.1 Å        | ~2.7 Å        | ~1.6 Å        | ~2.4 Å         |
| Resolving power                        | ~2300         | ~3000         | ~5000         | ~4300          |
| Spectrograph throughput <sup>(4)</sup> | ~52% (@500nm) | ~52% (@800nm) | ~47% (@800nm) | ~35% (@1100nm) |

Considering the Mid-Resolution mode is for GA science, primal choice for GE should be  $R \sim 3000$  in Red arm

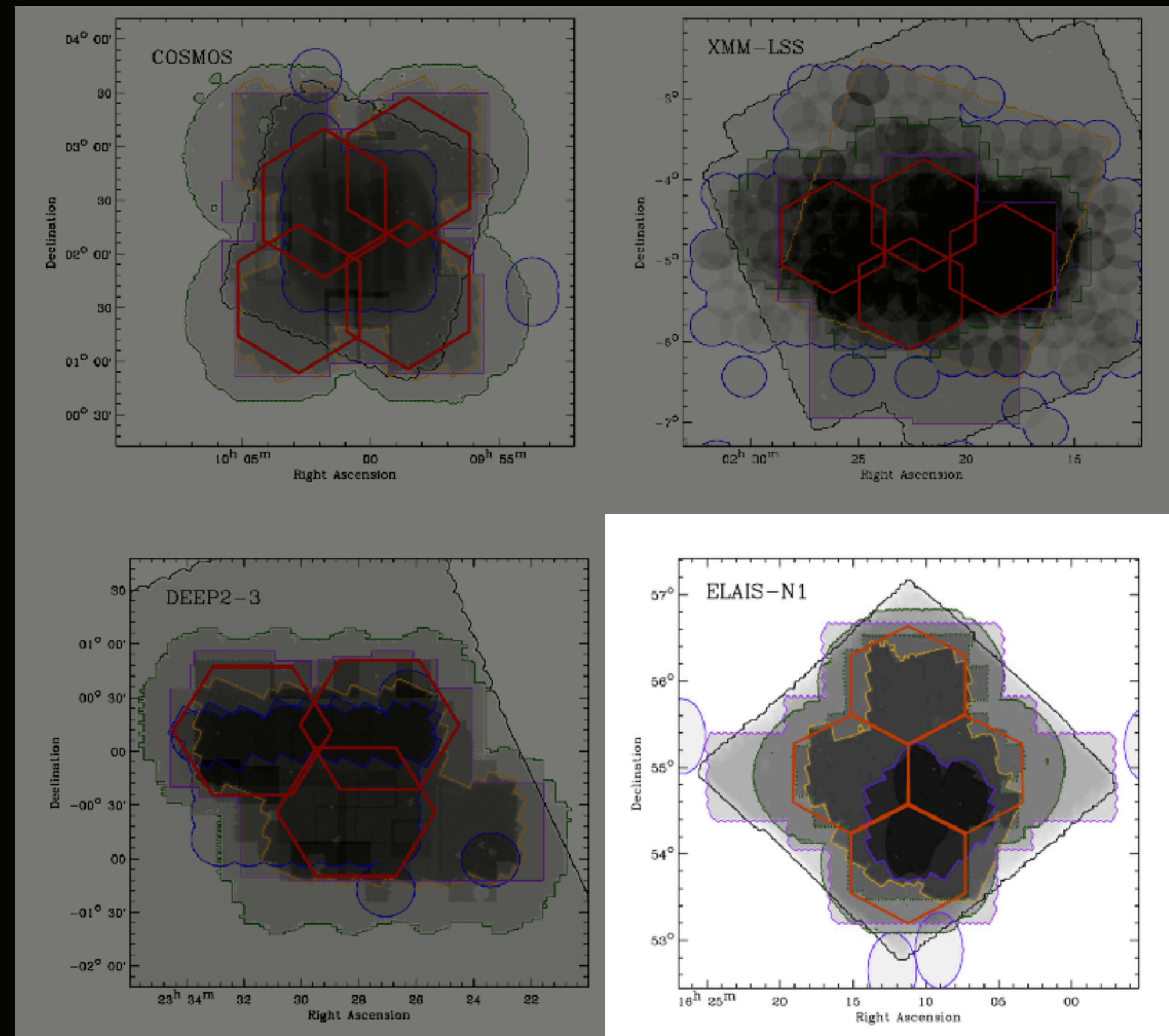
# Survey fields: COSMOS, XMM-LSS, DEEP2-3, and ELAIS-N1

Selected from the HSC Deep Field, 12.3 deg<sup>2</sup> w/ NIR bands



# Survey strategy

During SSP year1, ELAIS-N1 will be observed



What are the remaining priority?

Specific survey strategy is not made public yet.



# Available photometries

**CLAUDS u:**  $u_{AB} \sim 27$  mag

**HSC grizy:** ( $i_{AB} \sim 28$  mag at COSMOS and  $i_{AB} \sim 26.5$  mag at remaining 3 fields)

**HSC NBs:** NB387, 816, 921 (+additionally NB387/527/718/973 at COSMOS)

**UKIRT J+K:**  $J_{AB} \sim 23.5$ ,  $K_{AB} \sim 23.2$  mag

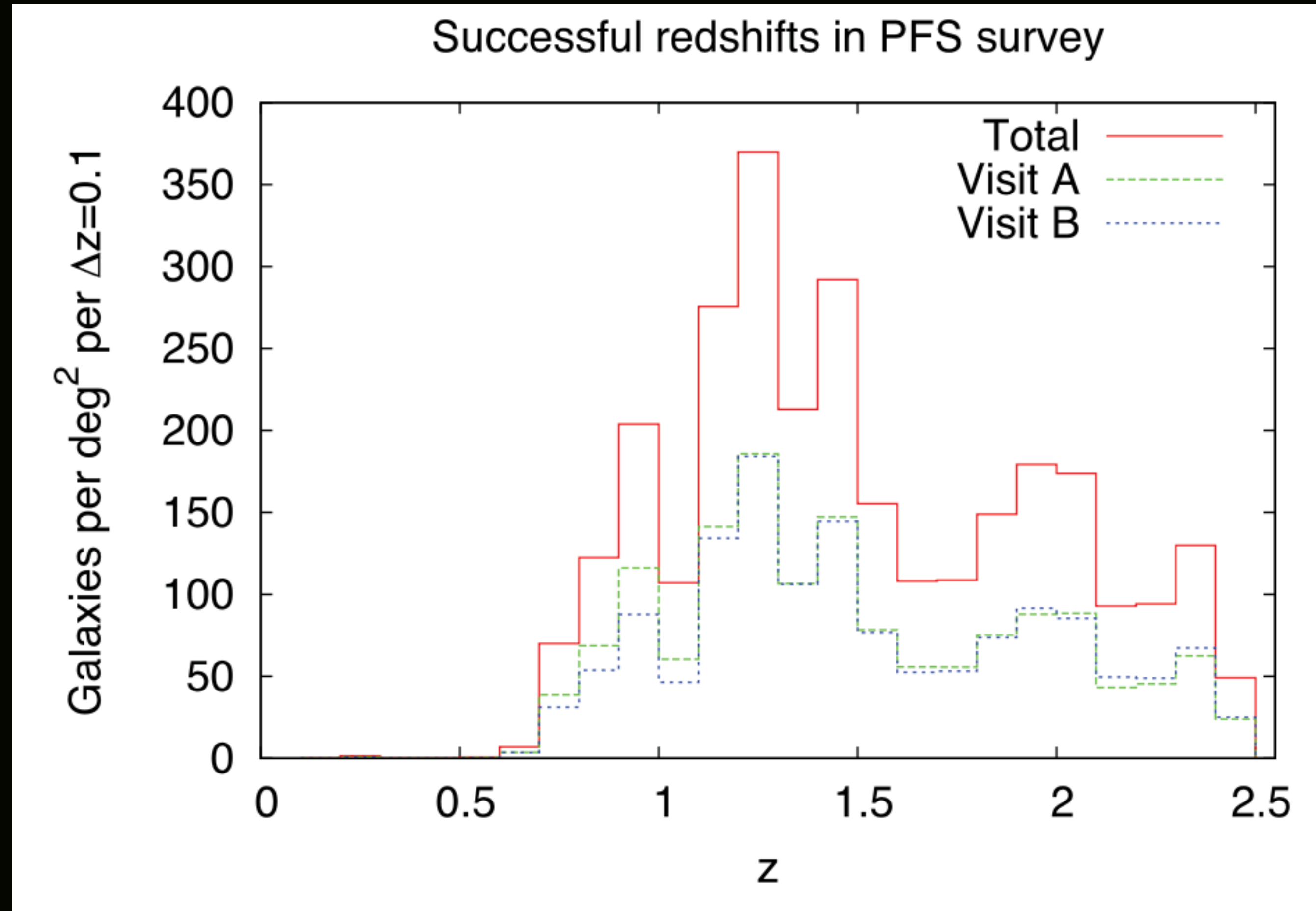
**Spitzer IRAC 3.6+4.5um:** 23.7 and 23.3 mag each

u2k catalog combining all photometries (except NBs) above is under construction?

See Suzuki-san's talk

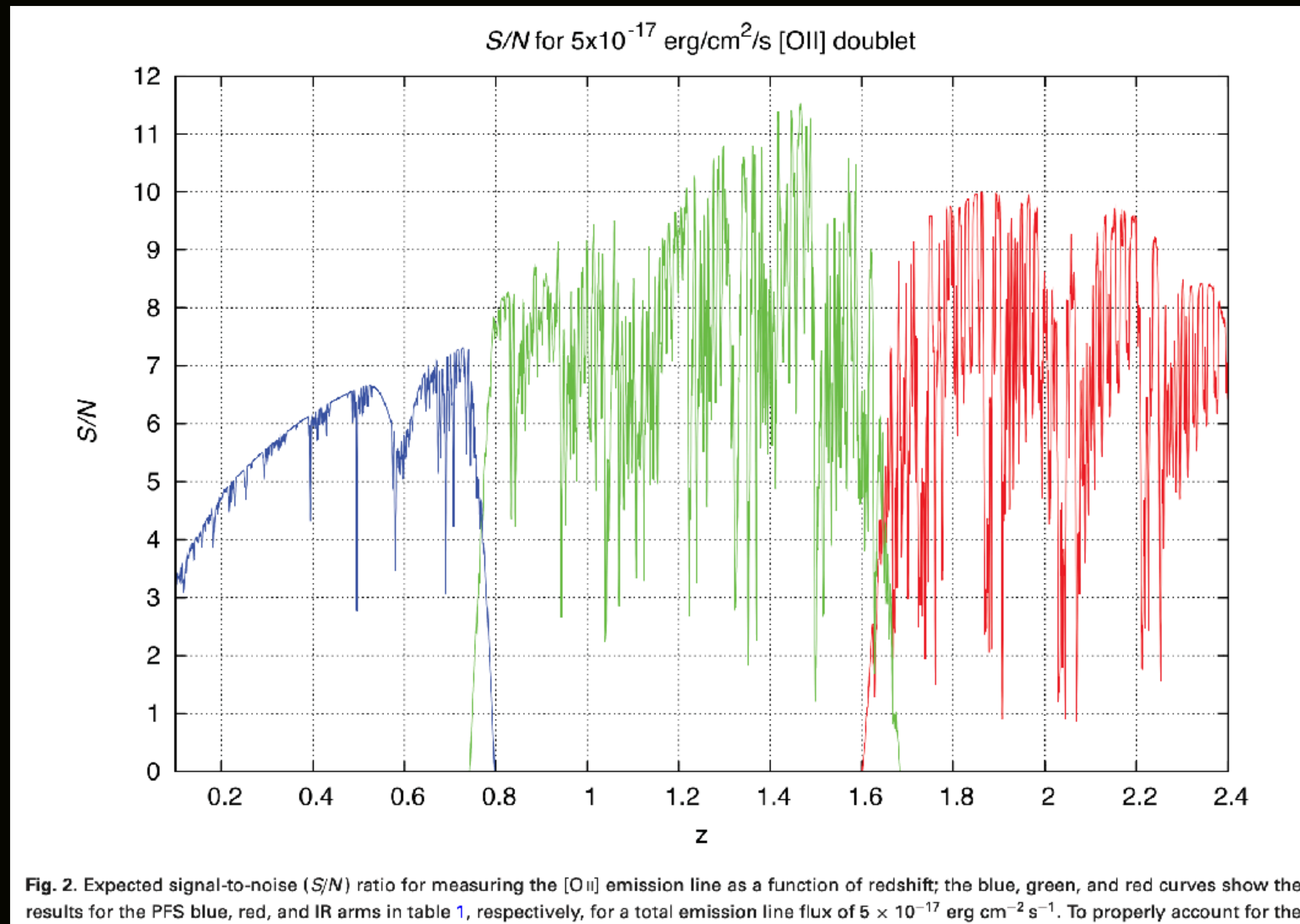
**PFS-CO (Takada et al. 2014)**

# SSP-CO sample in one slide



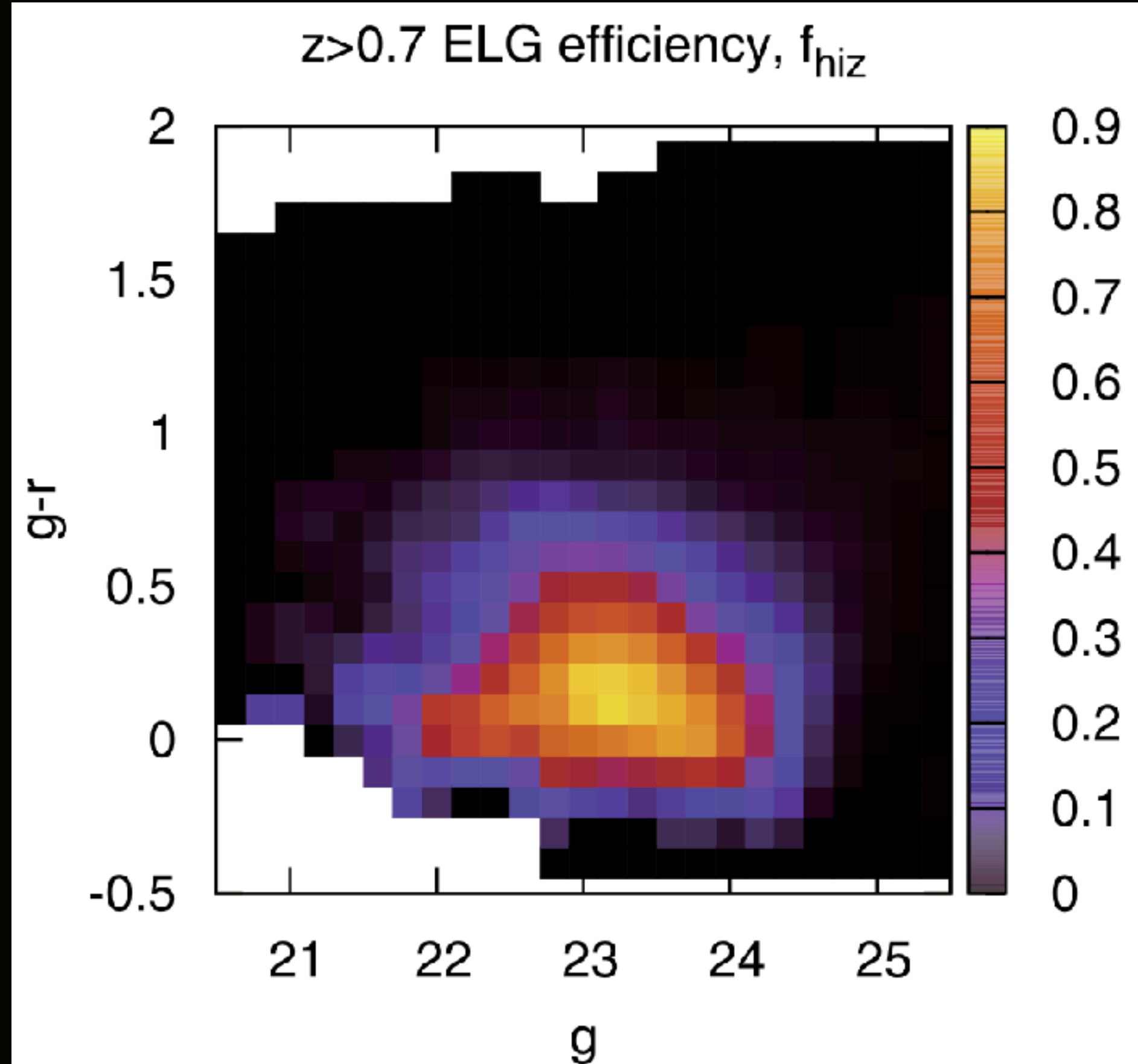
- HSC-Wide 1100 deg<sup>2</sup> , 2 visits/FoV, 15min exp per visit.
- [OII] emitters at red-arm => 0.6<z<2.4
- ~150/z-bin(delta z=0.1)/deg<sup>2</sup> => 150\*18\*1100~ 3 million sources

# SSP-CO sample in one slide



- Depth (15min):  $f_{[\text{OII}]} = 5 \times 10^{-17}$  erg/s/cm<sup>2</sup>, SN > 8 for [OII] (lower SN for continuum)

# Sample selection: [OII] emitter at $0.8 < z < 2.4$



$$22.8 \leq g \leq 24.2 \quad \text{AND} \quad -0.1 < g - r < 0.3$$
$$\text{AND NOT } (g > 23.6 \quad \text{AND} \quad r - i > 0.3).$$

-  $g-r$  is blue ( $g-r < 0.3$ ) & no break at  $g$  and  $r$  (No Balmer/4000Å break)