cGAN を用いた輝線強度マップからのシグナル抽出

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Moriwaki et al. (2020) MNRAS, 496, L54
Moriwaki et al. (2021) ApJL, 906, L1

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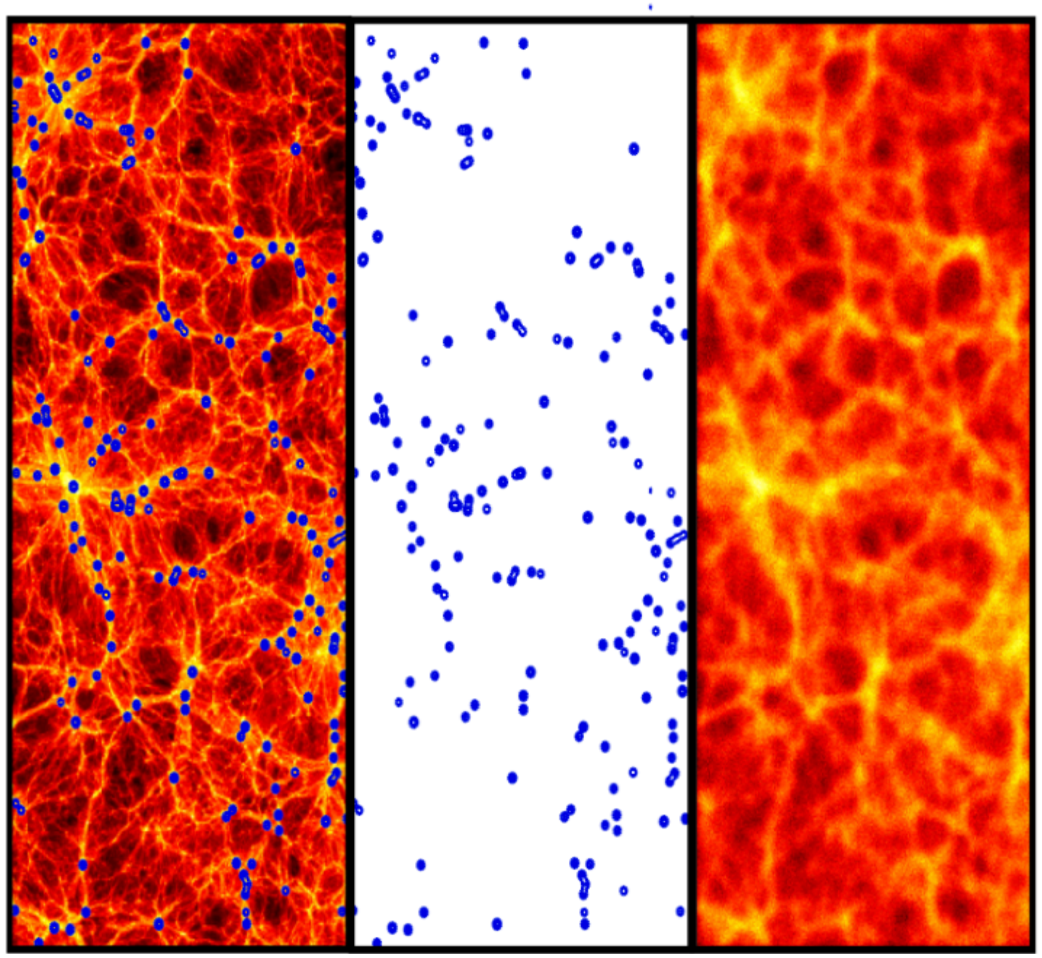
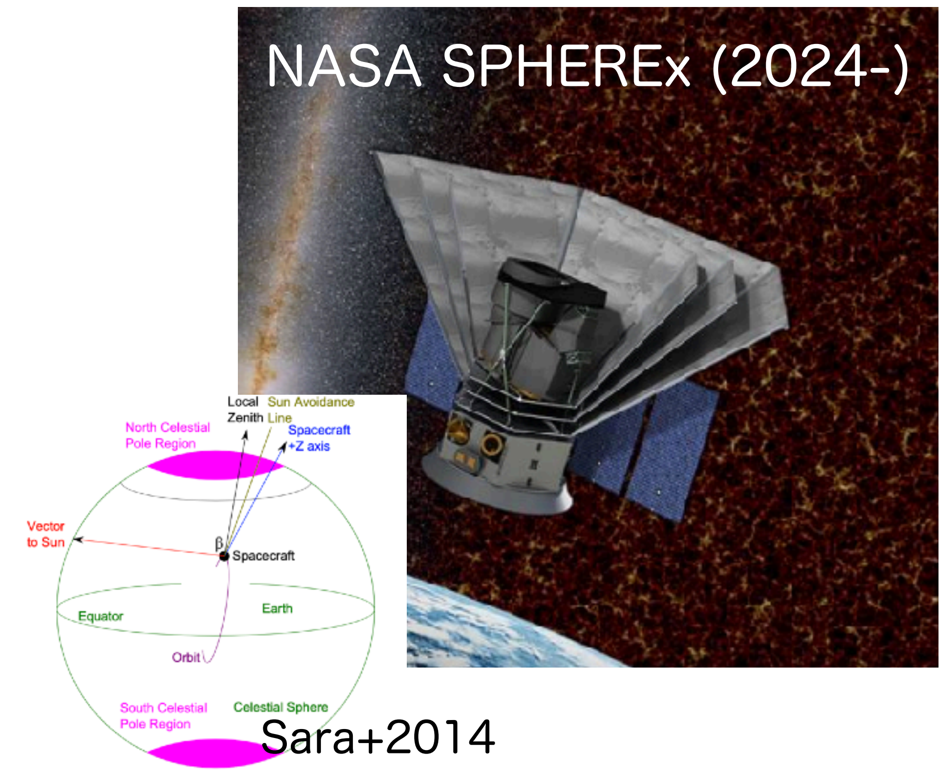
輝線強度マッピング
Line Intensity Mapping Observation:

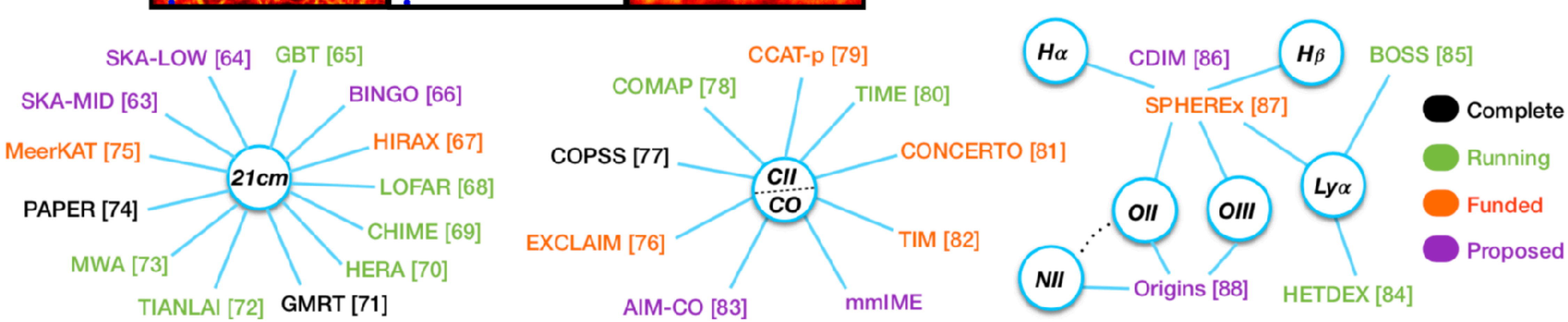
Dore+2014



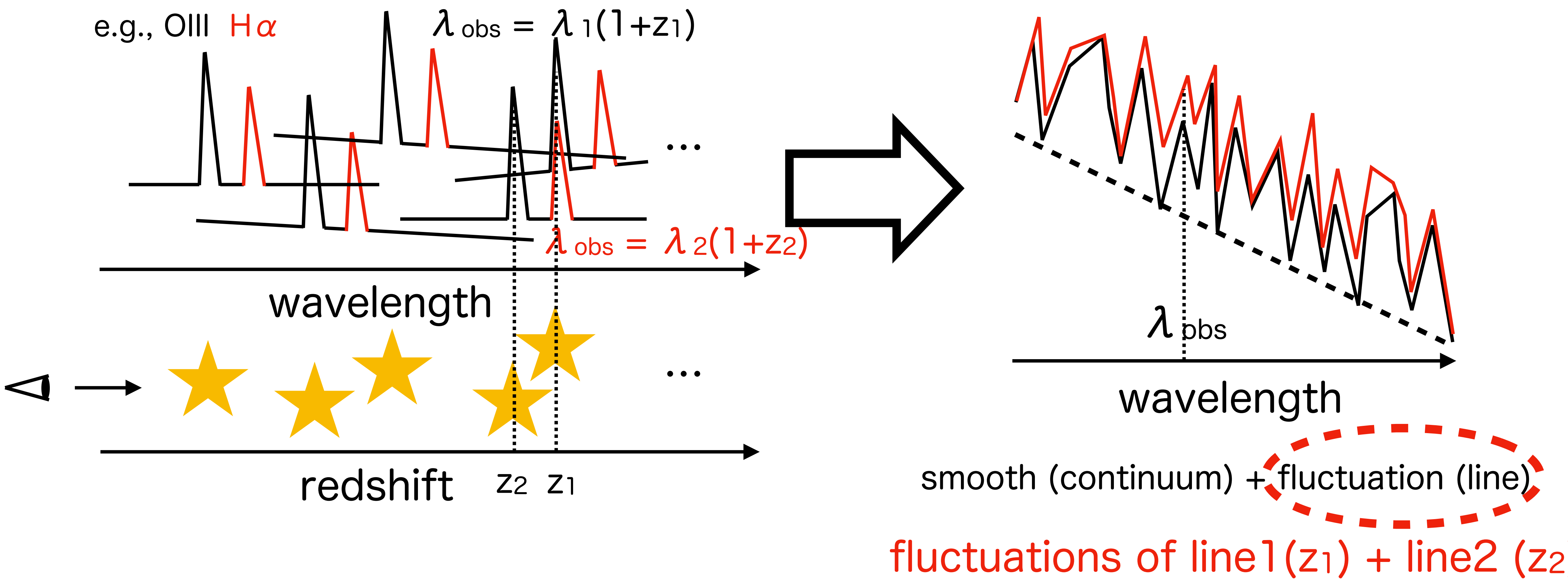


Sara+2014

All-sky survey
+ 200 deg^2 deep survey



Problem: Line Confusion

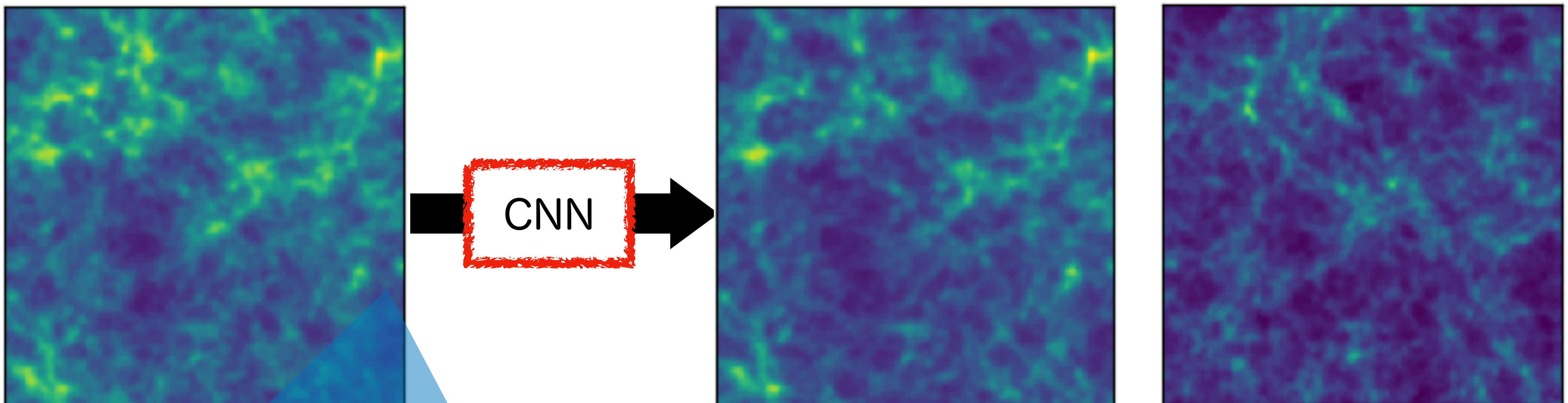


Proposed solutions for line confusion:

- cross-correlation (e.g., Visbal&Loeb10)
- masking (e.g., Gong+14)
- anisotropy of power spectrum (e.g., Gong+14)
- multiple wavelength data (e.g., Cheng+20)

Out proposal: use CNN

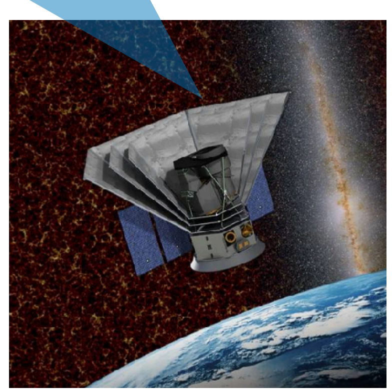
Our Proposal:
Use Convolutional Neural Network (CNN)



Observation @ 1.5μm
(Hα + OIII)

Hα (z = 1.3)

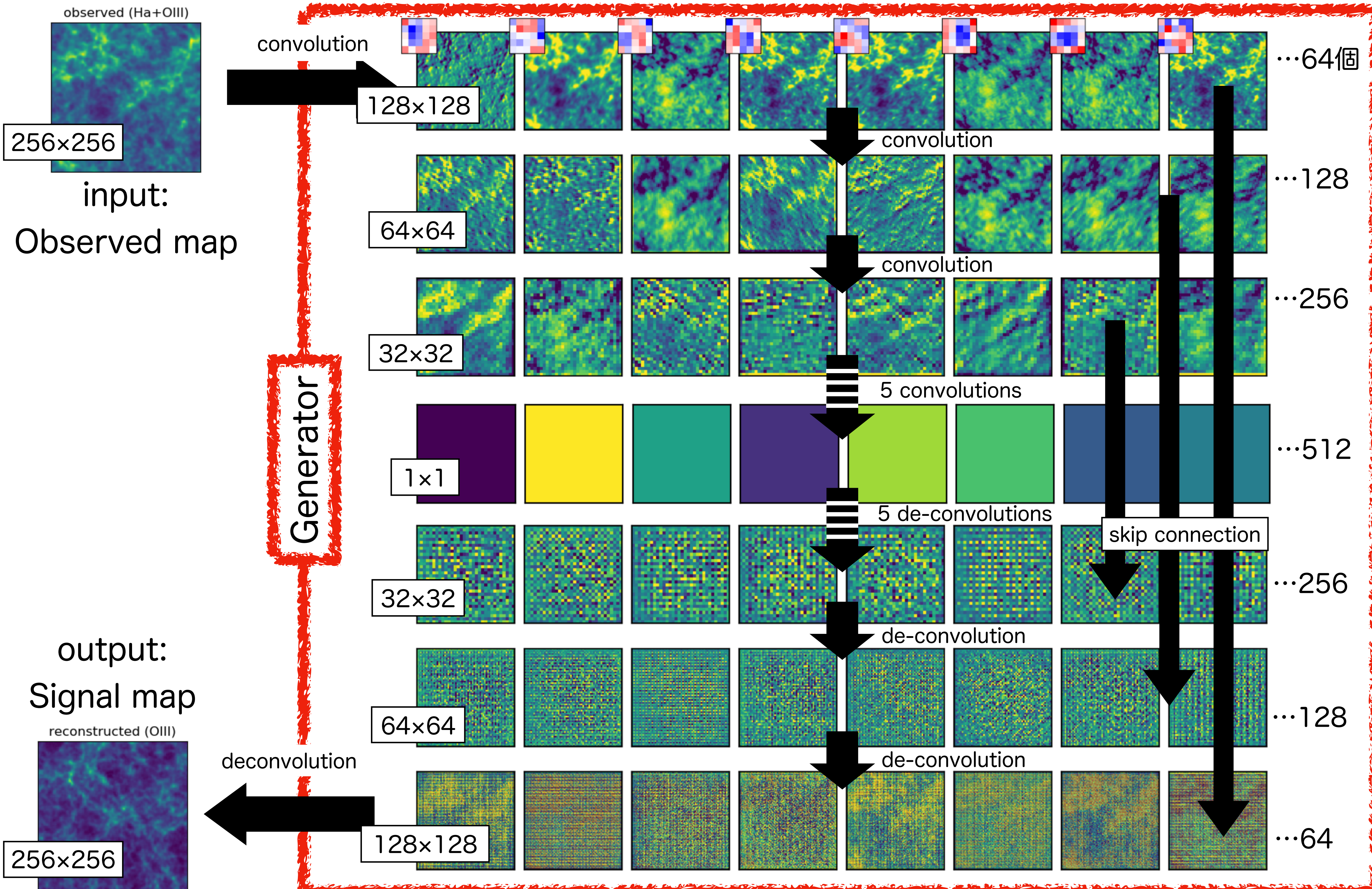
[OIII] (z = 2.0)

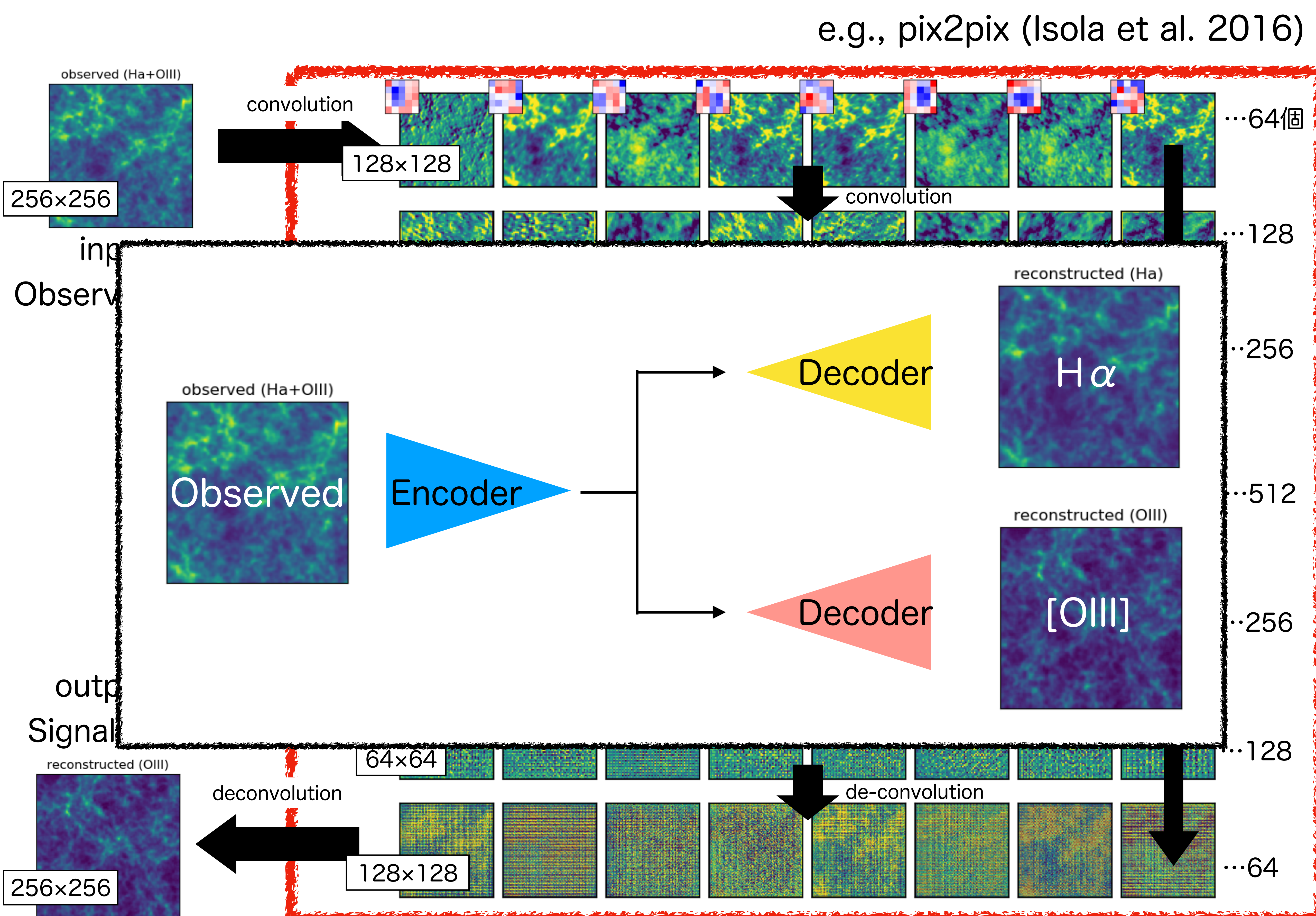


SPHEREx (2024~)

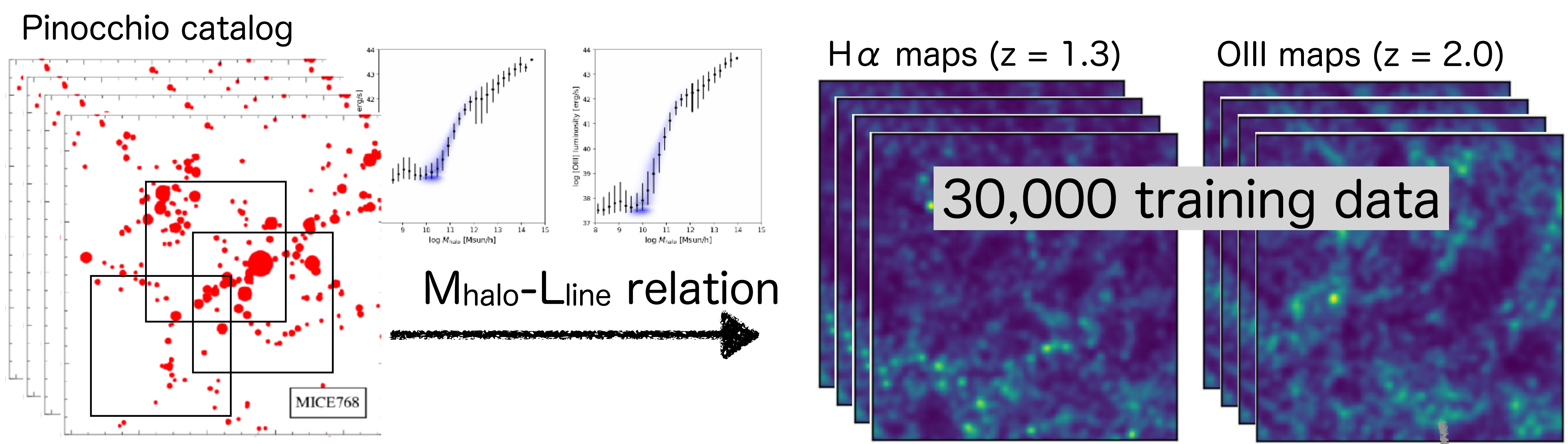
- survey area (deep): ~200 deg^2
- resolution: 6”, R = 40
- 0.75μm - 5μm
- $z_{H\alpha}$ = 0.1 - 6.6, z_{OIII} = 0.5 - 9.0, $z_{Ly\alpha}$ > 5

e.g., pix2pix (Isola et al. 2016)

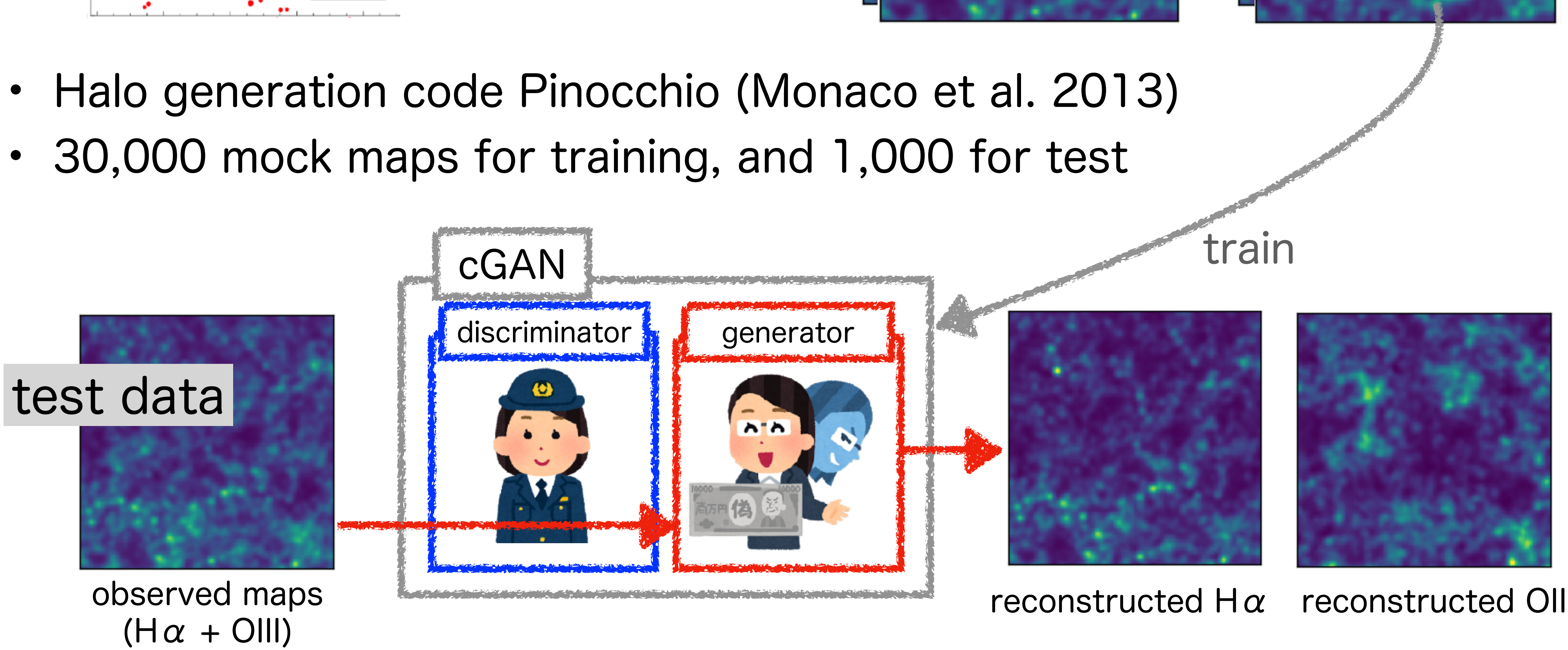



e.g., pix2pix (Isola et al. 2016)
observed (Ha+OIII)
256×256
convolution
128×128
…64個
convolution
…128
…256
…512
…256
…128
64×64
de-convolution
…64
deconvolution
128×128
reconstructed (OIII)
256×256
observed (Ha+OIII)
Observed
Encoder
Decoder
Decoder
reconstructed (Ha)
H α
reconstructed (OIII)
[OIII]

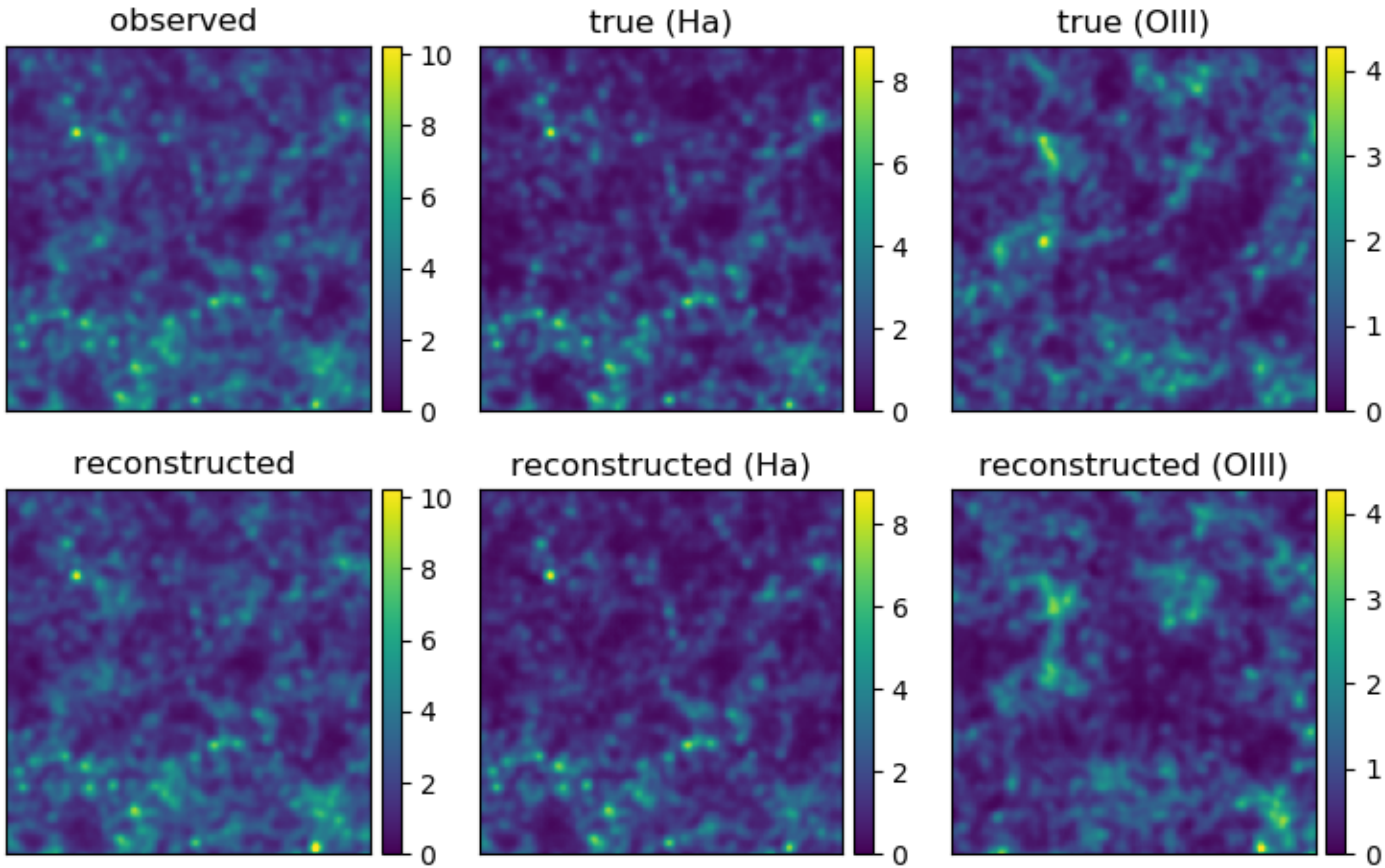
Training & Test



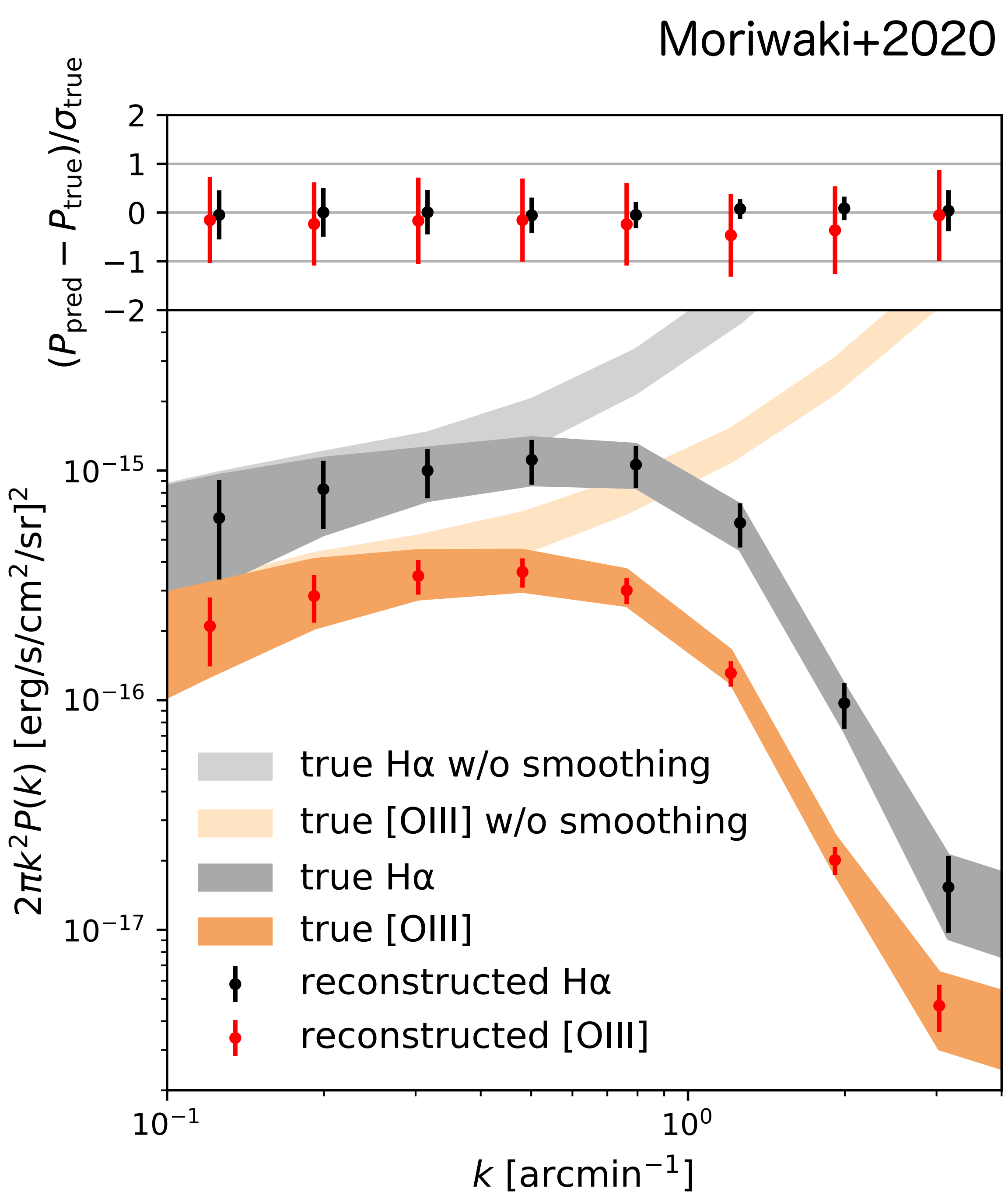
- Halo generation code Pinocchio (Monaco et al. 2013)
- 30,000 mock maps for training, and 1,000 for test

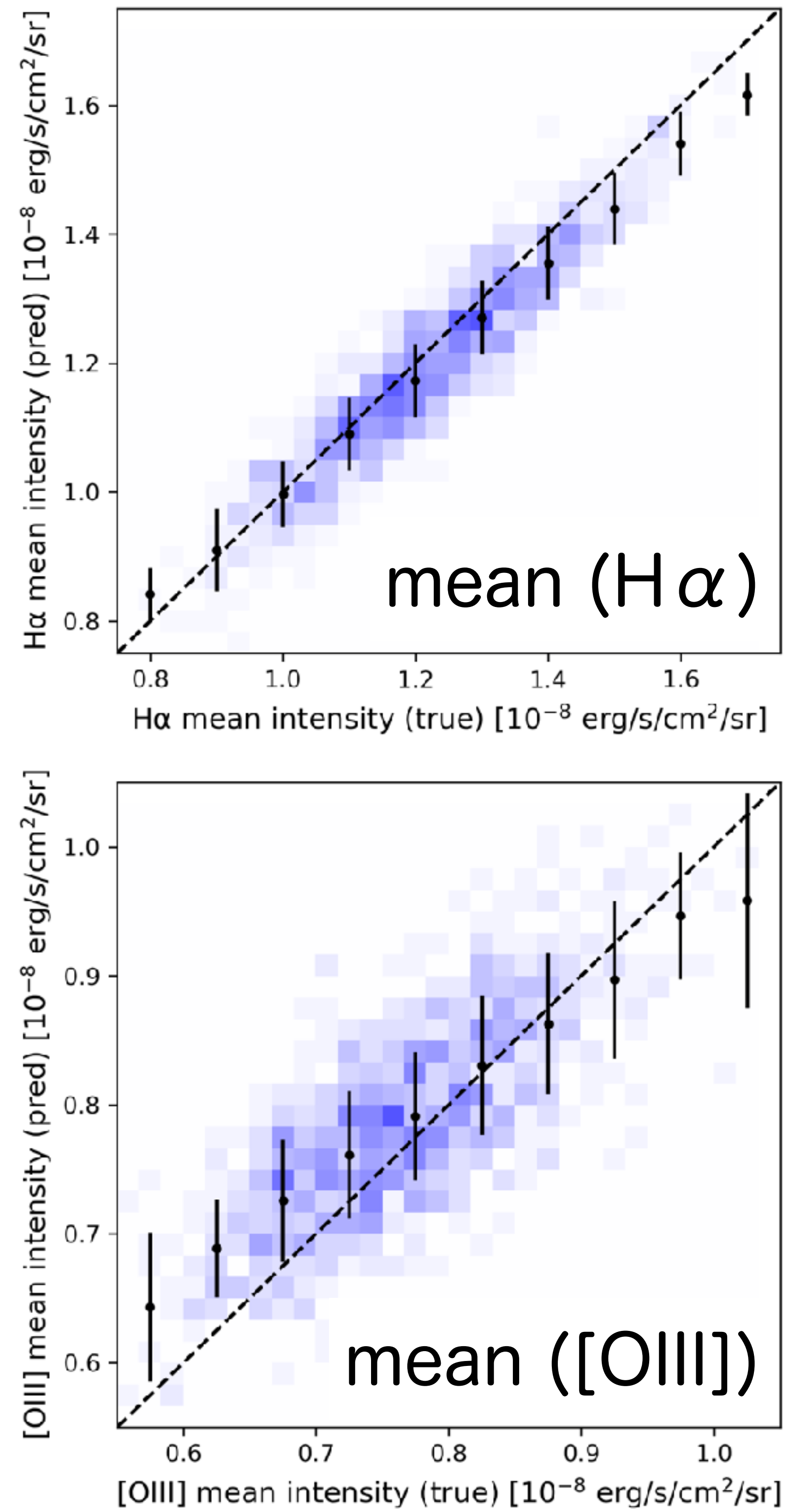


Results

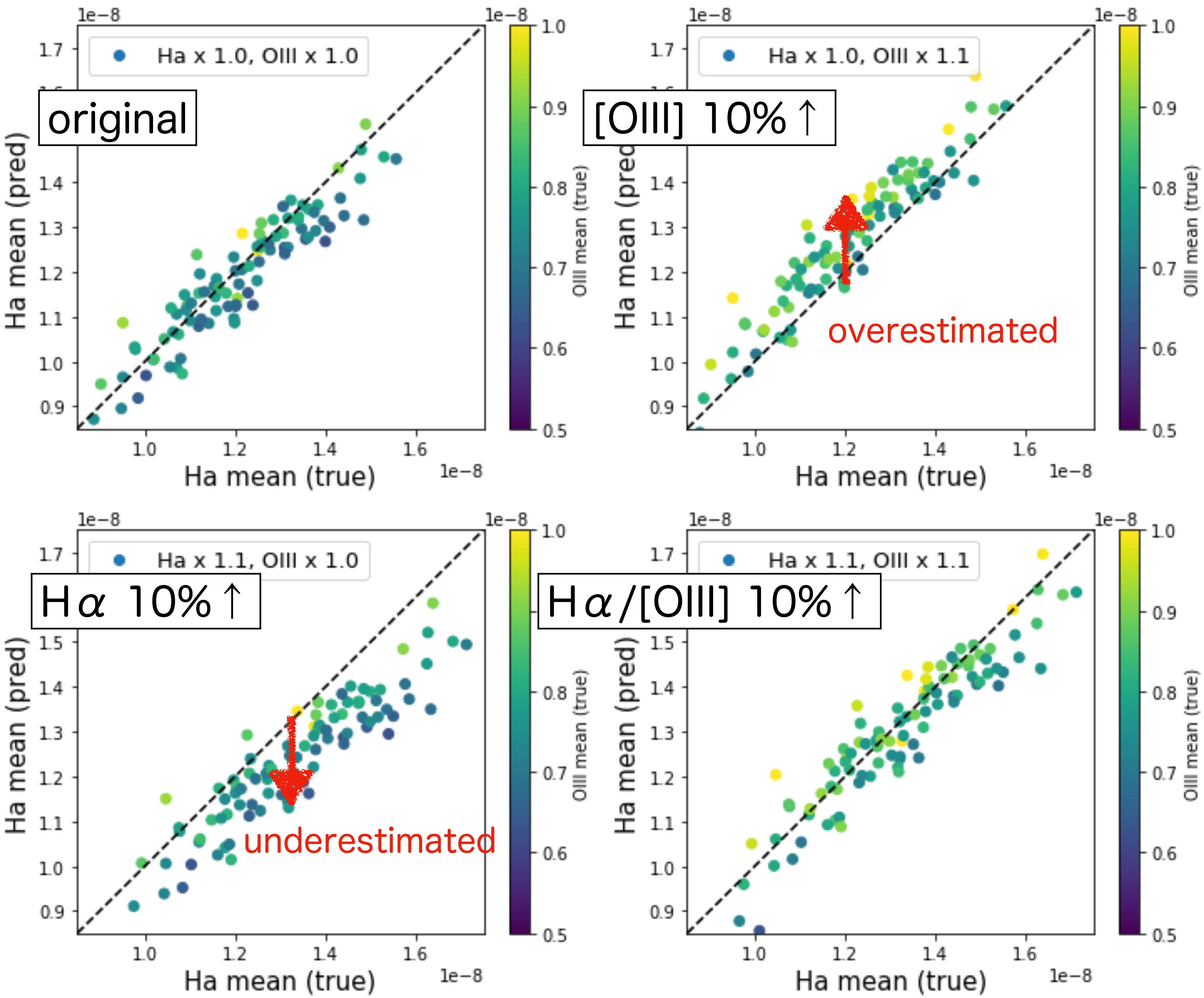

observed
true (Ha)
true (OIII)
reconstructed
reconstructed (Ha)
reconstructed (OIII)
0
2
4
6
8
10
0
2
4
6
8
0
1
2
3
4

Results: statistics

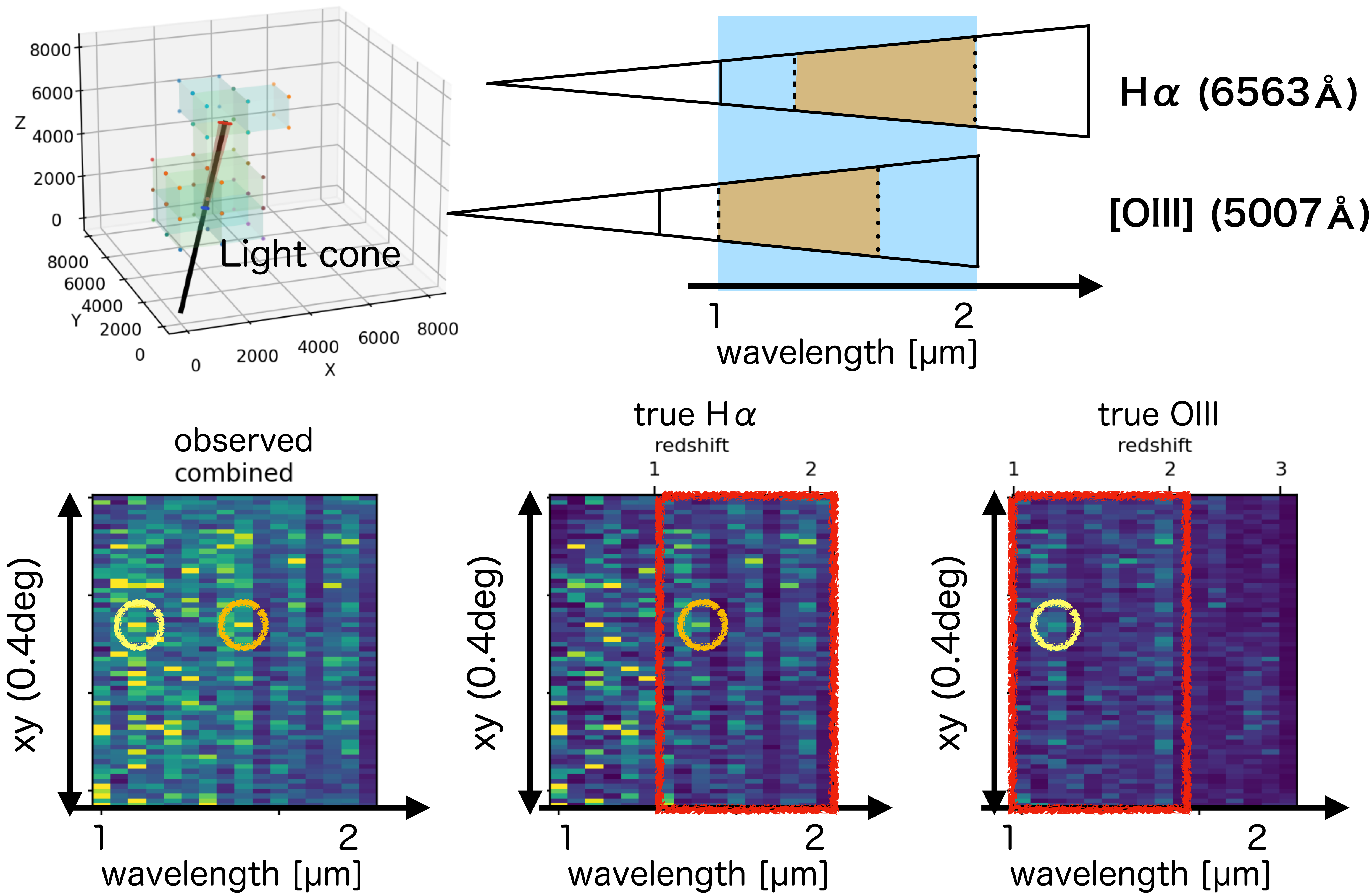




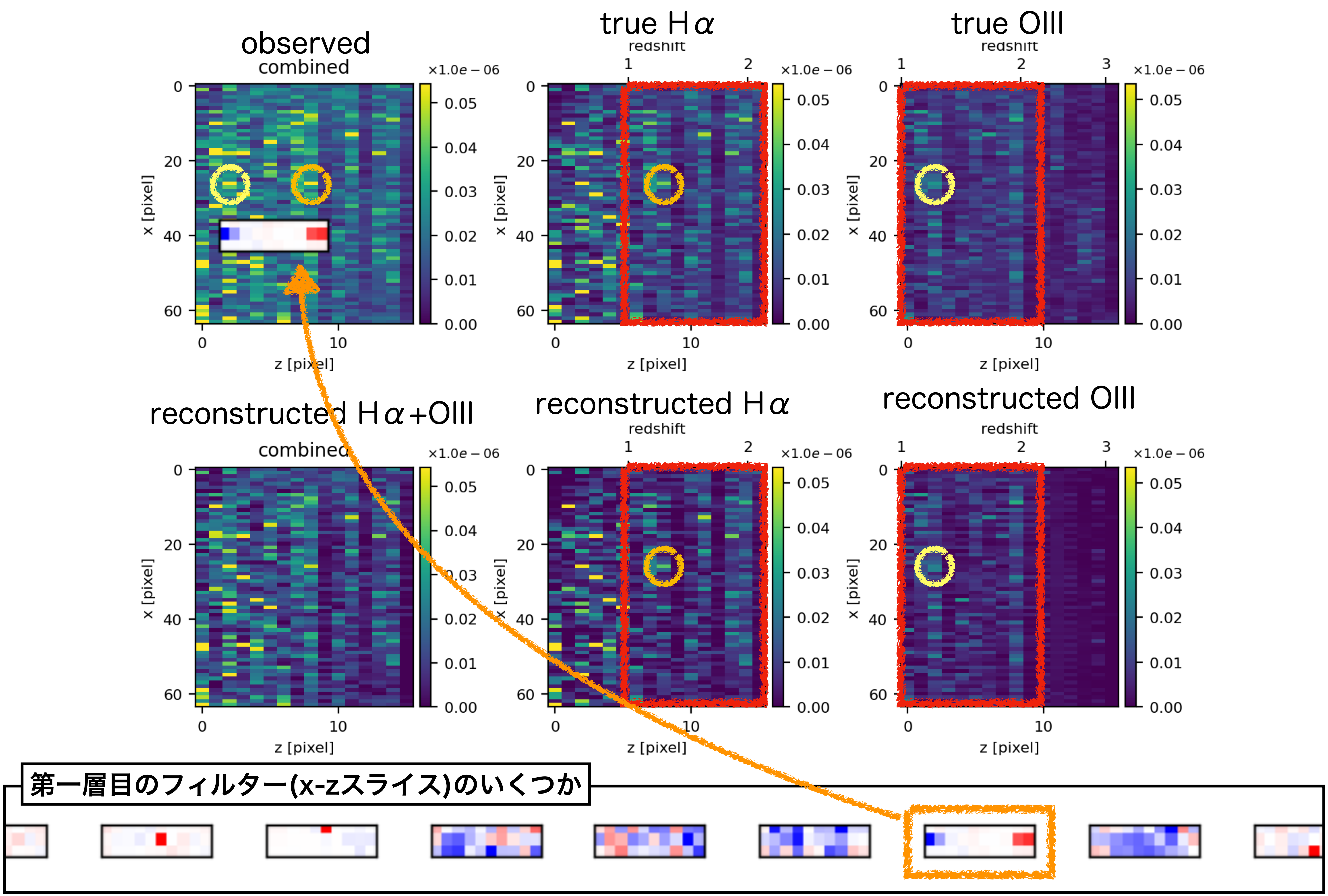
Results: Test Error



3-dimensional CNN



Results


observed
combined
true Hα
redshift
true OIII
redshift
reconstructed Hα+OIII
combined
reconstructed Hα
redshift
reconstructed OIII
redshift
x [pixel]
z [pixel]
×1.0e − 06
第一層目のフィルター(x-zスライス)のいくつか

Summary

- Line confusion is a serious problem in line intensity mapping (LIM) observations.

- We develop a cGAN to solve the line confusion problem and to remove observational noise in LIM on map base: peak positions and statistics are reasonably reconstructed.

- Three-dimensional (spatial × spectral) LIM data can also be analyzed with cGAN.

- The reconstructed maps can be used for
  - astronomical/cosmological parameter estimation,
  - cross-correlation analysis,
  - follow-up observations,
  - environmental effect study, etc.