

Extremely Metal-poor Emission-line Galaxy Searched with Subaru/HSC data

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Extremely Metal-Poor strong-line Galaxy (EMPG)

- ✈ - Dominant population in the early universe

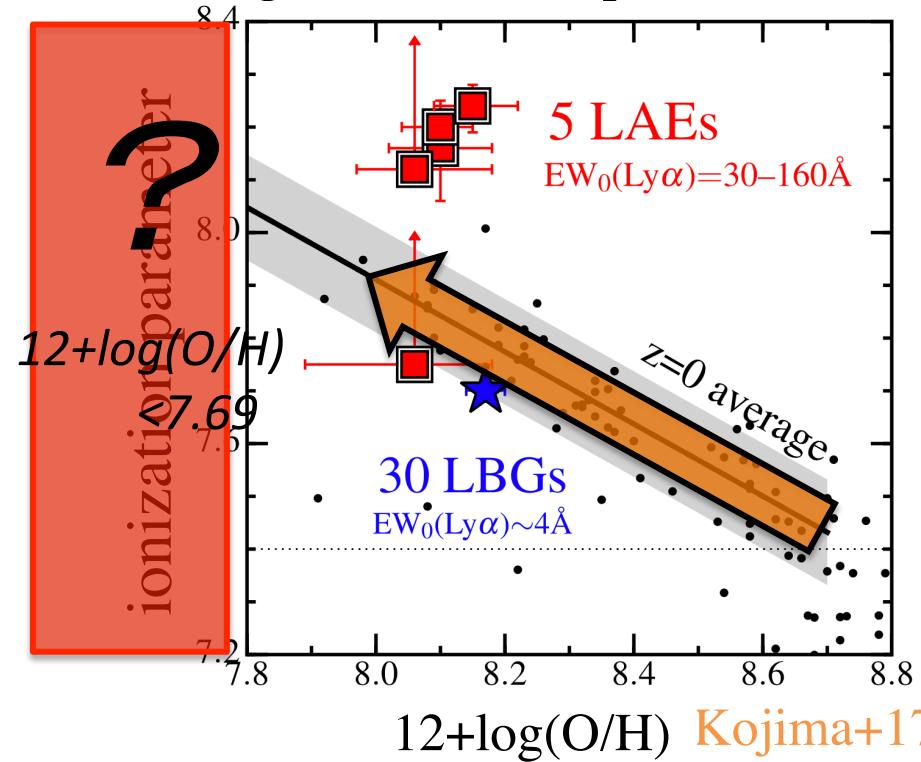
JWST science

def. $12+\log(\text{O/H}) < 7.69$
 $\text{EW}_0(\text{H}\alpha) > 800\text{\AA}$

- Highly ionized → leaking ionizing photons? [Izotov+16b](#)

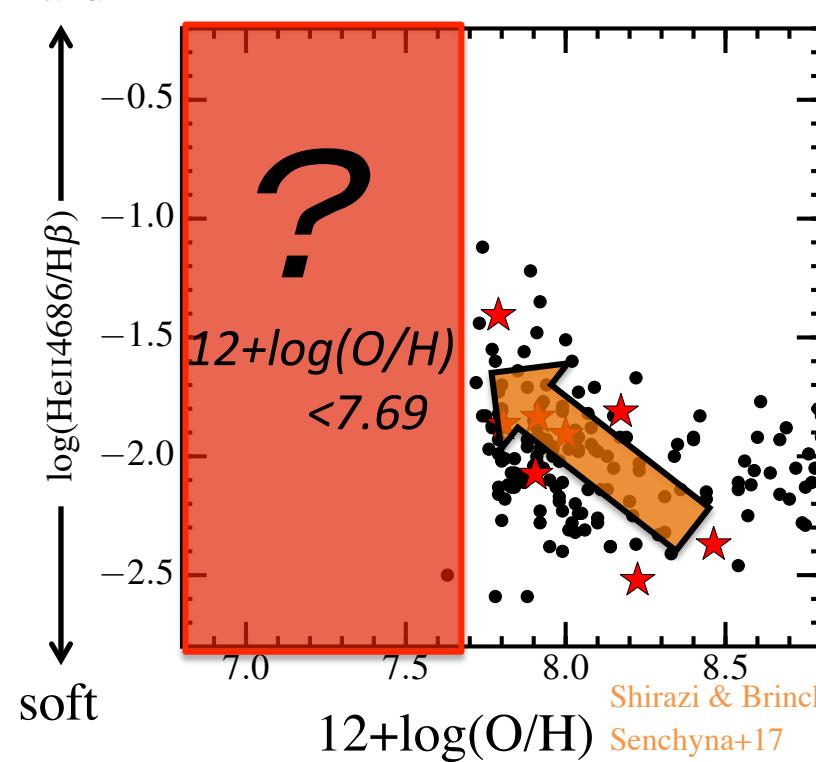
reionize IGM?

high ionization parameter



hard

hard EUV radiation



[Shirazi & Brinchmann 2012](#)

[Senchyna+17](#)

EMPGs ($z < 0.06$) → Intense, hard EUV radiation ?

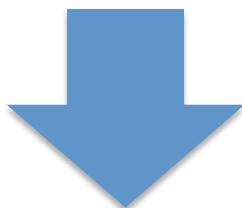
Advantages of this study ① (data depth)

[Prev.]

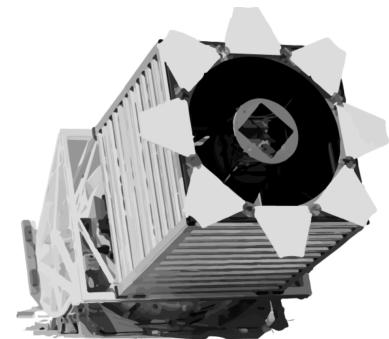
SDSS (Sloan Digital Sky Survey)

e.g., Izotov+12
Sanchez-Almeida+16

$i_{\text{limit}} \sim 21 \text{ mag}$



$\sim 5\text{--}7 \text{ mag deeper}$



SDSS

[This work]

Subaru/HSC SSP data

$i_{\text{limit}} \sim 26\text{--}28 \text{ mag}$

$M_* = 10^4\text{--}10^6 M_{\odot}$

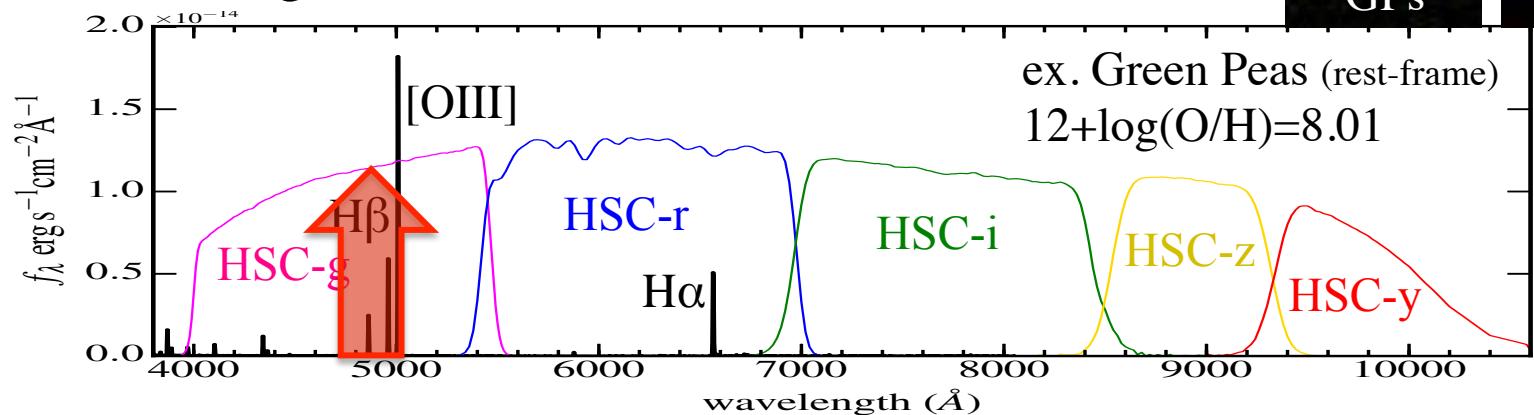


→ We'll find EMPGs that cannot
be discovered in the SDSS data

Advantages of this study ② (selection)

✈ Select with broad-band photometry excess

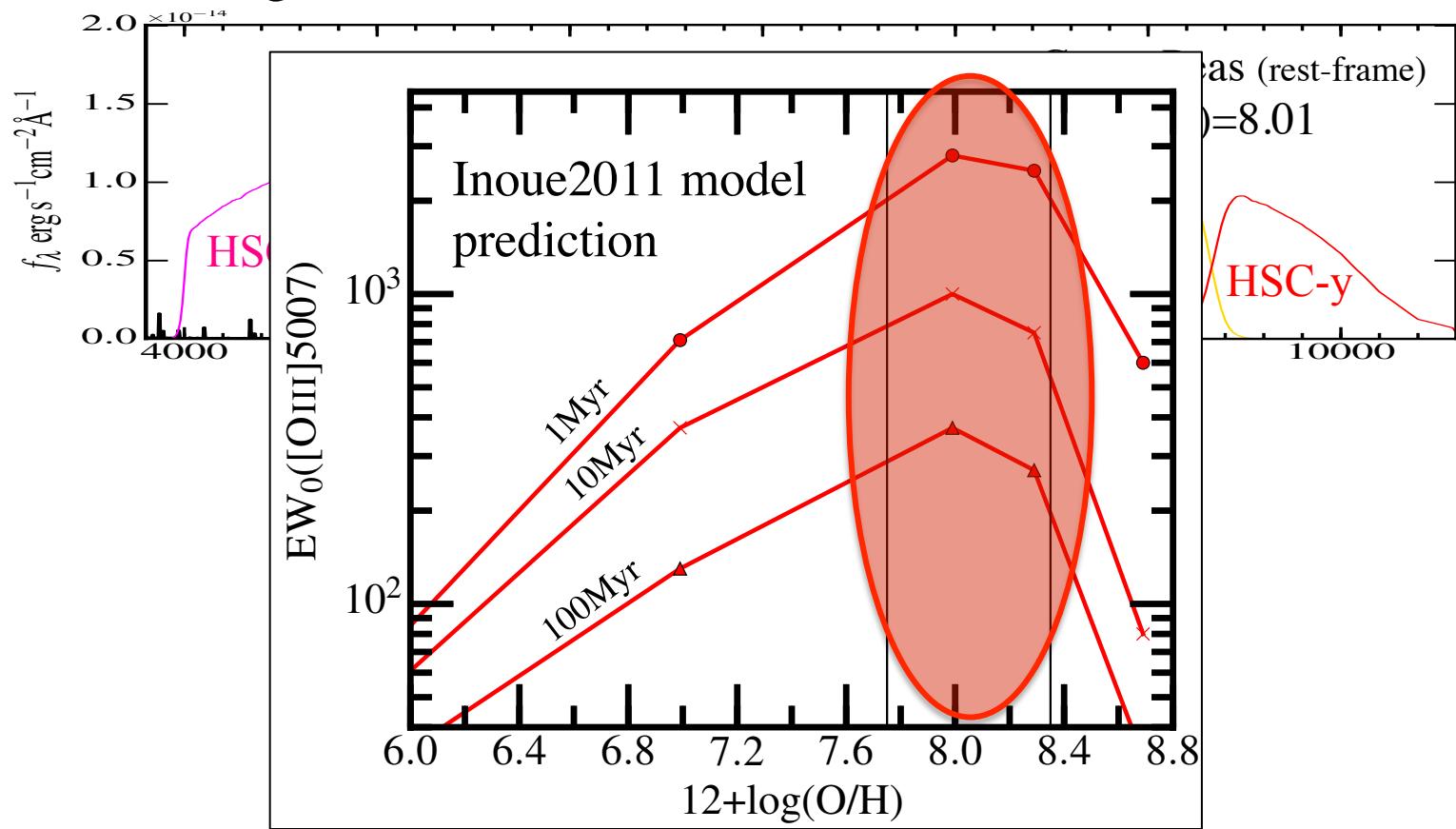
[Prev.] Very strong [OIII]5007Å (GPs/BBs)



Advantages of this study ② (selection)

✈ Select with broad-band photometry excess

[Prev.] Very strong [OIII]5007Å (GPs/BBs) → Bias to $12+\log(\text{O/H}) \sim 8.0$

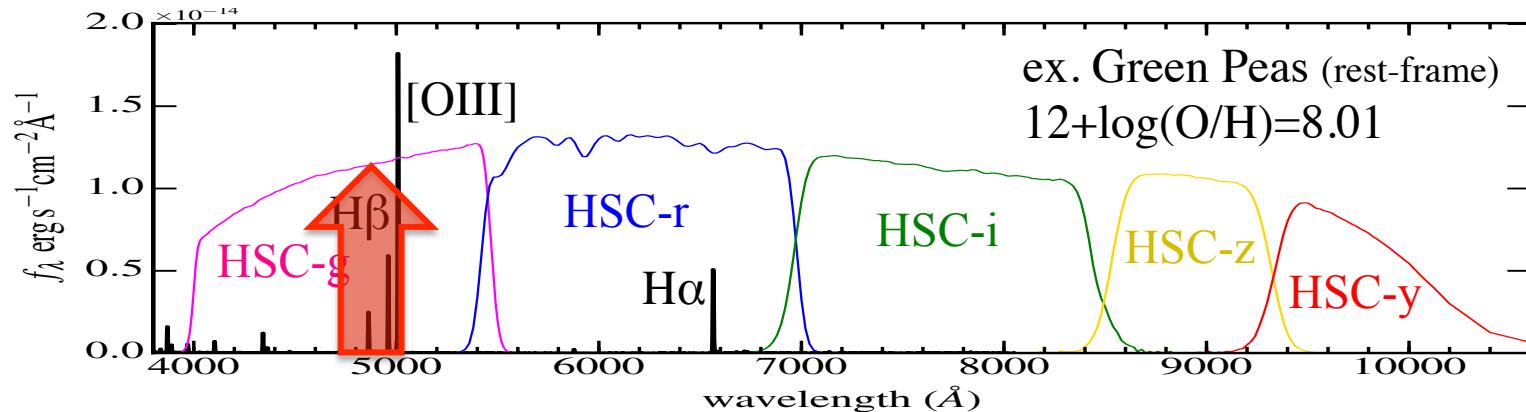


The selection based on a strong [OIII] is successful (GP/BB)
but **not ideal to reach $12+\log(\text{O/H}) < 7.0$** .

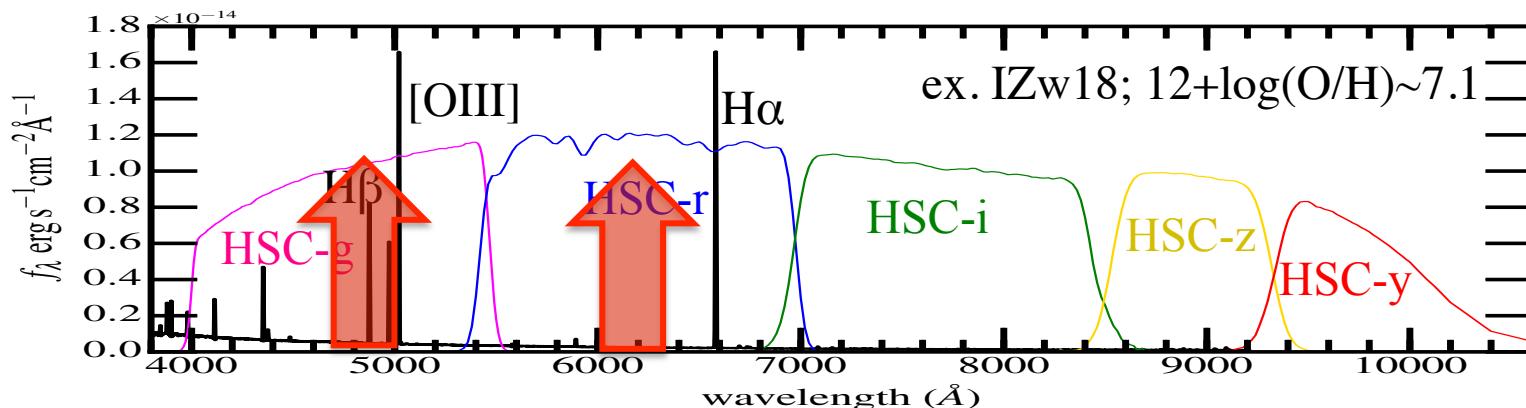
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[Prev.] Very strong [OIII]5007Å (GPs/BBs) → Bias to $12+\log(\text{O/H})\sim 8.0$



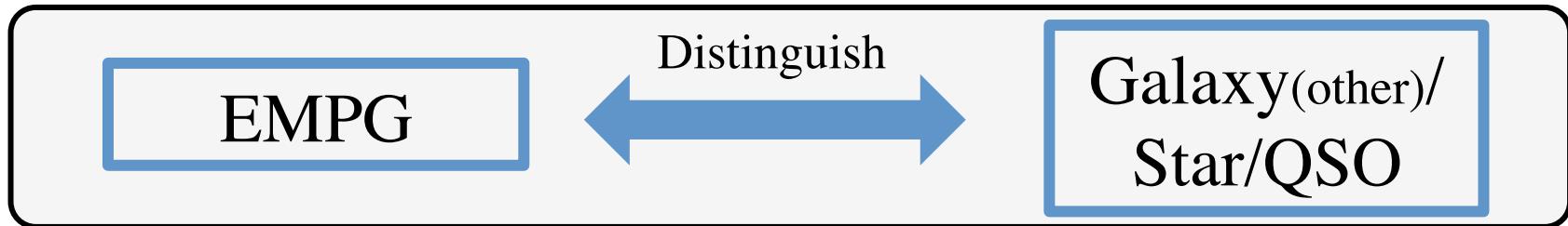
[This work] Multiple lines + blue cont. → Down to $12+\log(\text{O/H})<7.0$!!



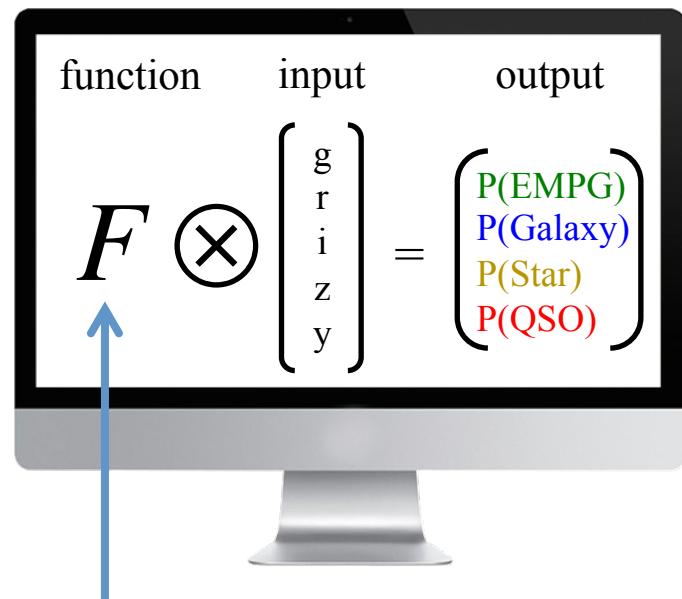
Problem: complex color → Solved by Deep Learning!

EMPG selection by Deep Learning

✈ Basic idea is...



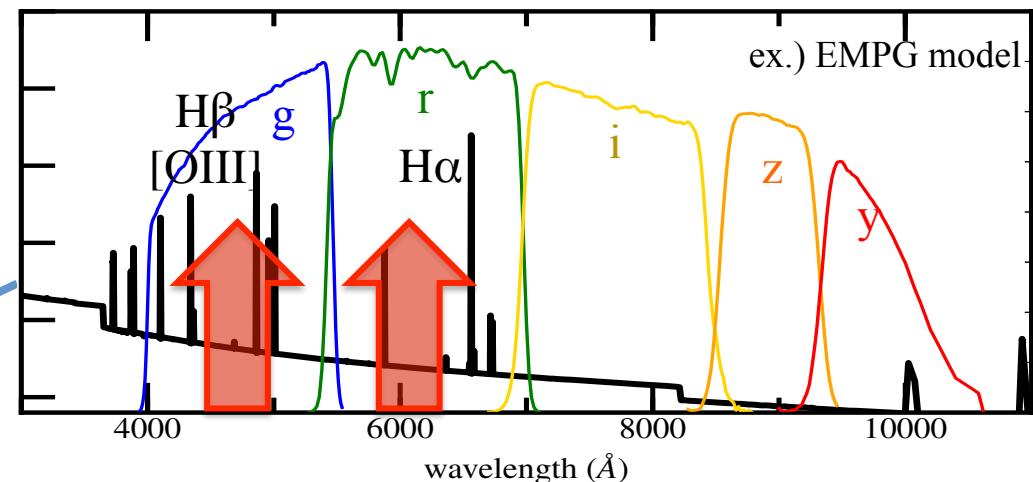
Classifier ← Deep Learning



Trained with SED models
(optimized)

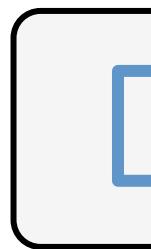
SED models ($30,000 \times 4$)

<i>Beagle</i>	Chevallard & Charlot 2016
<i>Stellar model</i>	Castelli & Kurucz 2004
<i>QSO composite</i>	Selsing et al. 2016



EMPG selection by Deep Learning

→ Basic



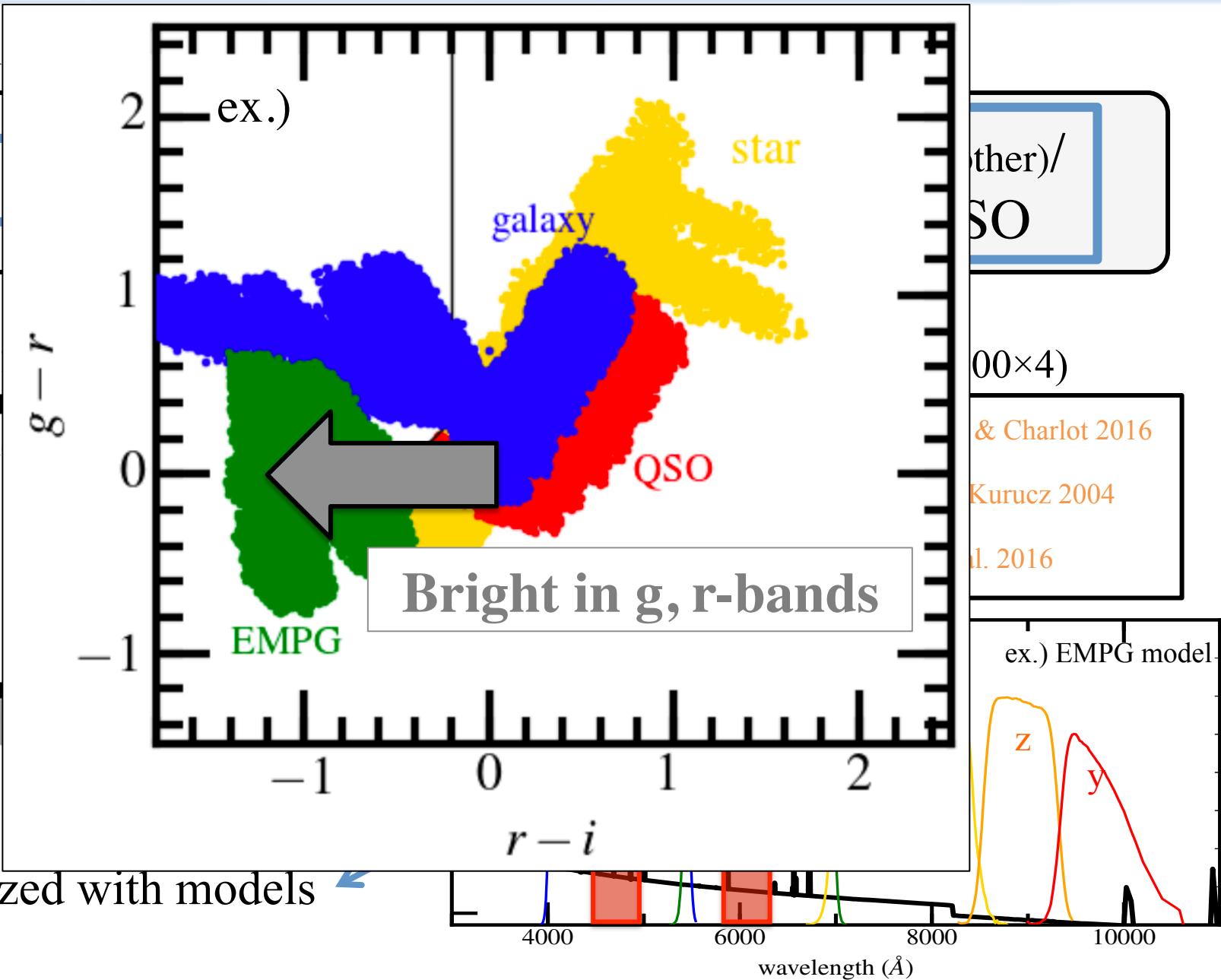
Classification

function

F



Optimized with models



Test our method with SDSS data (w/spectrum)

SDSS Data

Total: 935,042 objects

✗: Not deep, ○: w/spectra



← Apply our method

13 candidates

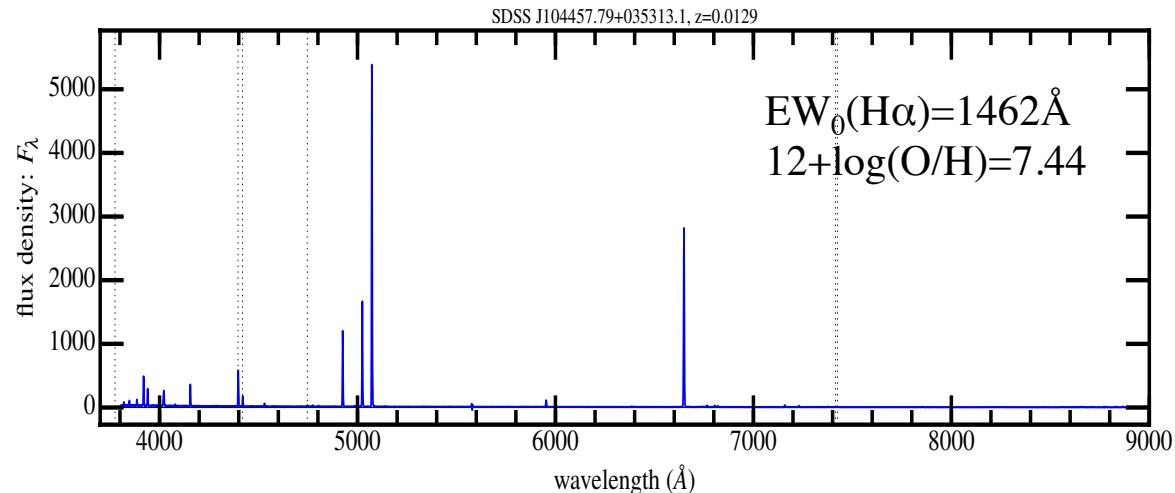
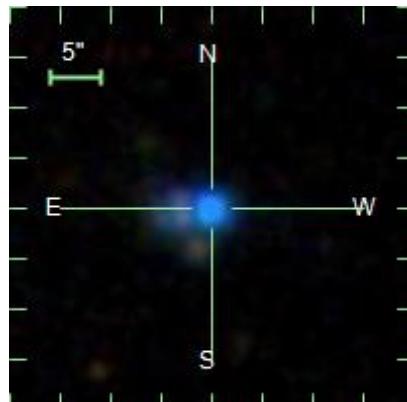


← Check the answers with spectra

6 EMPGs / 7 MPGss

Our selection → **Successful**

One example of EMPGs



Apply our method to the HSC-SSP data

HSC data

(Survey area; $\sim 300 \text{ deg}^2$; $i_{\text{lim}} \sim 26-28$)

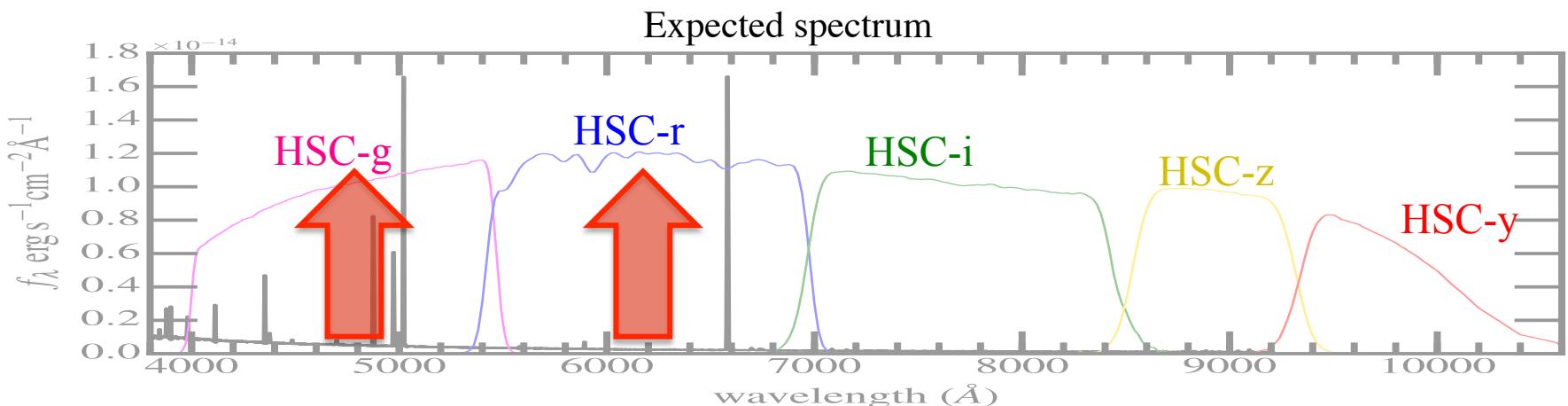
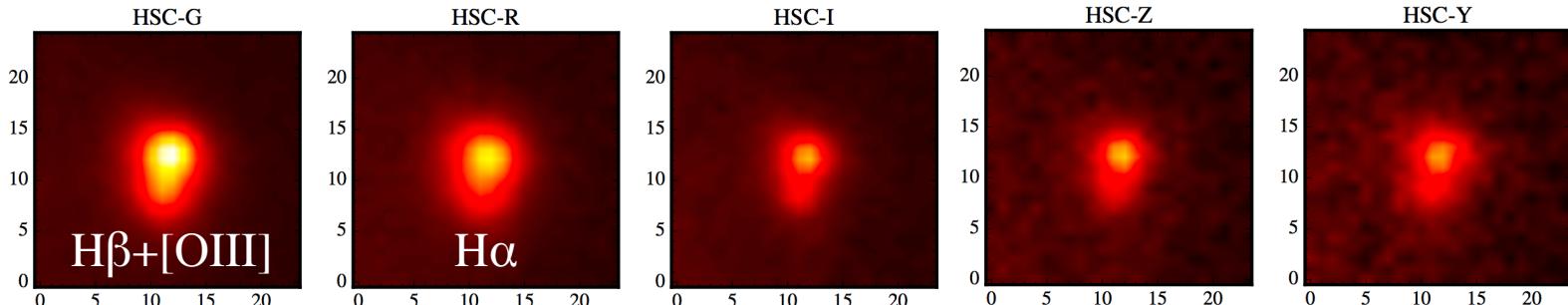


← apply our method

8 candidates

($\rightarrow \sim 40$ expected when HSC-SSP is completed)

One example



Spectroscopy for 5 out of the 8 EMPG candidates

✈ Magellan/LDSS3 + MagE

PI: M. Rauch 2018/6/12-13

$$\lambda=0.32\text{--}0.90\mu\text{m}$$

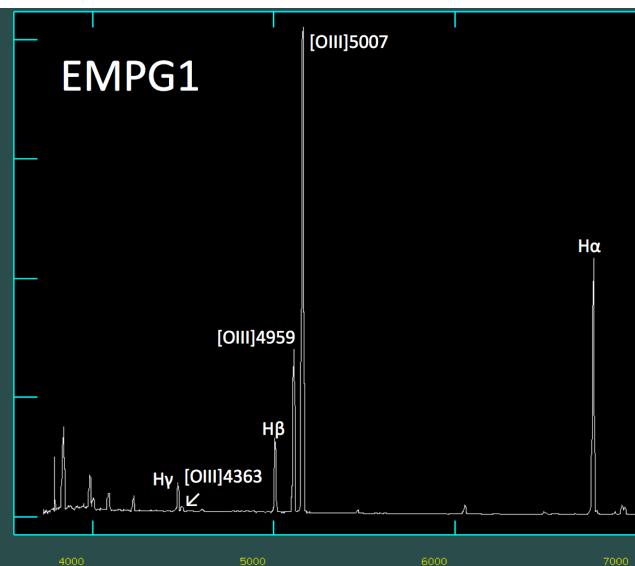
$\lambda=0.31-1.00\mu m$
 $R=4100$



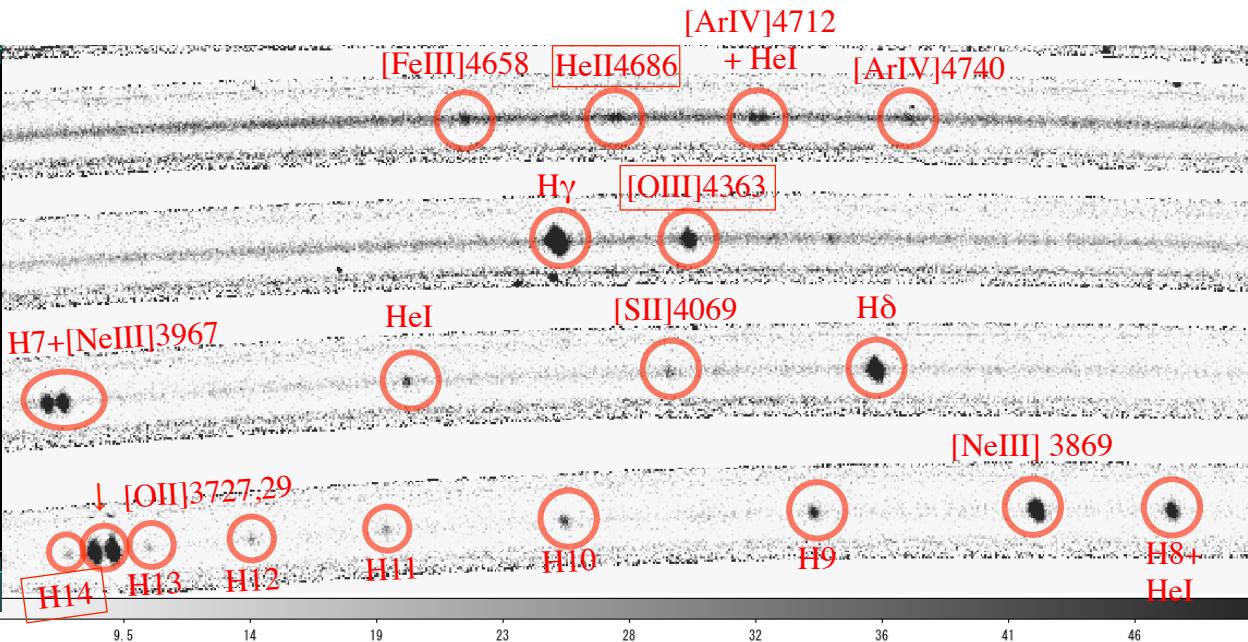
Carnegy

- ✈ 5 candidates { 3 – Real galaxies w/ strong lines
 2 – Contaminants

Example 1-hour exp.



LDSS3 (1D spec)



MagE (blue side of 2D spec)

Summary:

Extremely Metal Poor Galaxy (EMPG) Survey

Q. EMPG → Intense, hard EUV radiation?

Wide, deep imaging data
(Subaru/HSC-SSP)

+

Deep Learning
(DNN)

- * HSC data → 8 EMPG candidates selected
 - Spectroscopy for 5 out of the 8

- * Three (out of the 5) are real galaxies w/ strong lines
 - Further analysis on going...

