# Unveiling the population of dual- and lensed- AGNs at sub-arcsec separations with Gaia

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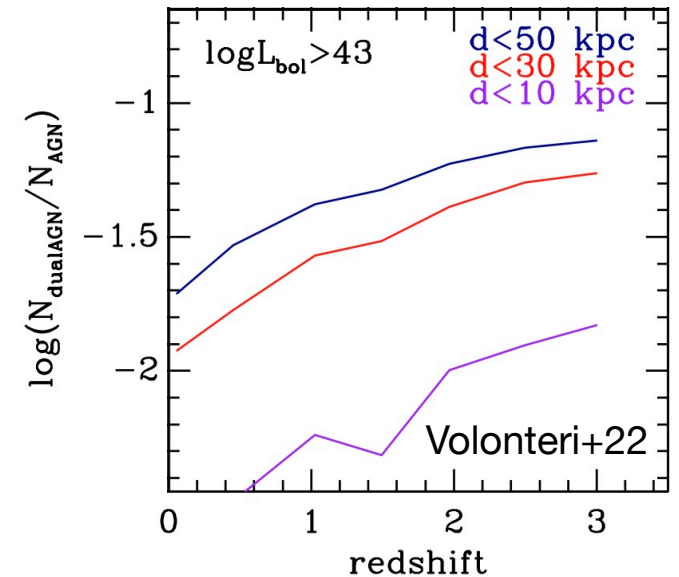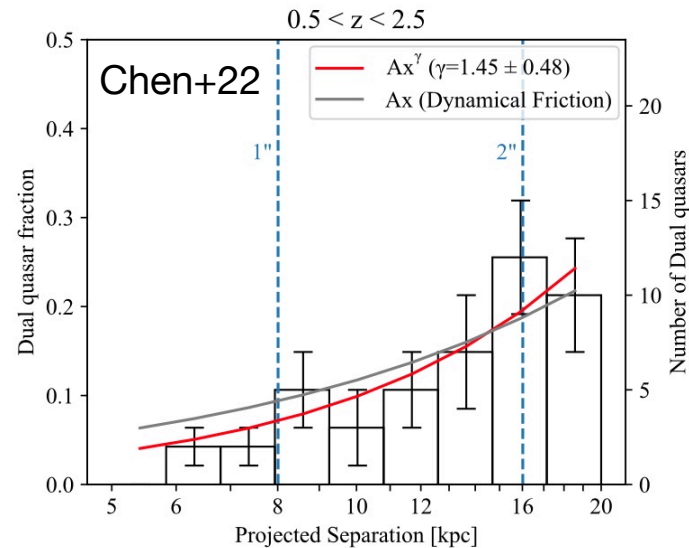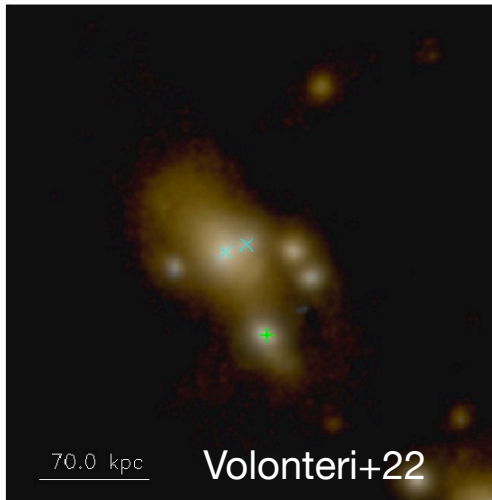In collaboration with M. Volonteri, P. Rosati, Rubinur K., S. Carniani, I. Montoya Arroyave
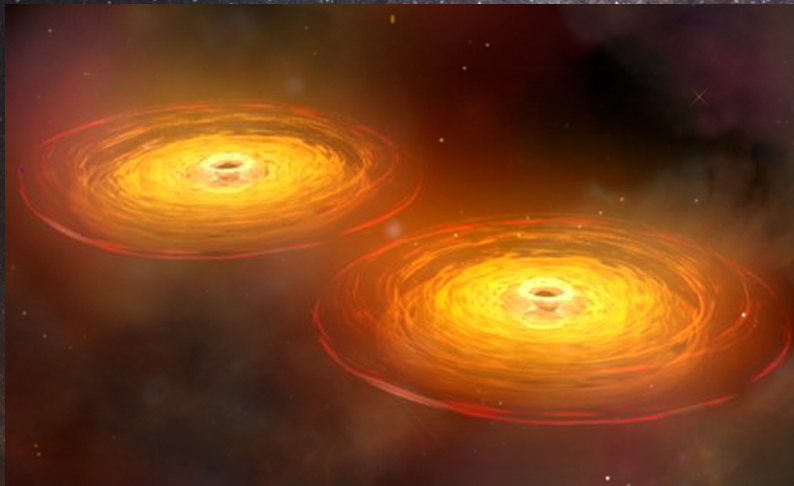
Hierarchical merging

Widespread population of Multiple SMBHs in the same host galaxy

Long timescales, ~kpc separations

Large fraction to produce **dual AGNs**

Important to:

    1. test the models: separations, mass ratios, luminosities, redshift evolutions.....

    2. study the processes driving to the final merger

    3. parent population of the GW-emitting systems
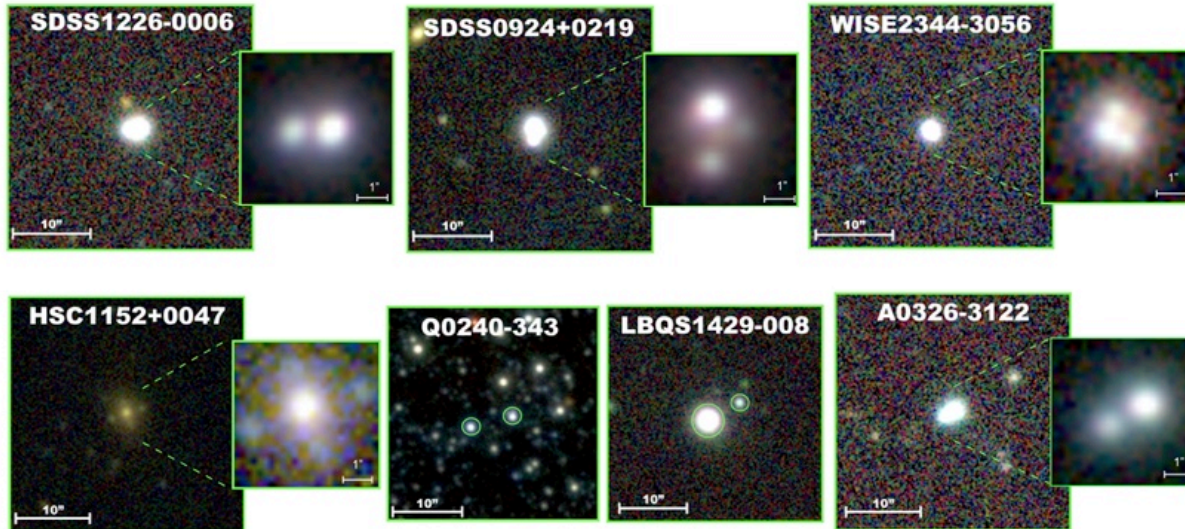
Current status of observations

- A few systems in the local universe
- Distant (z>0.5) systems at large separations
- Only 4 systems at z>1 and $\delta < 8$ kpc

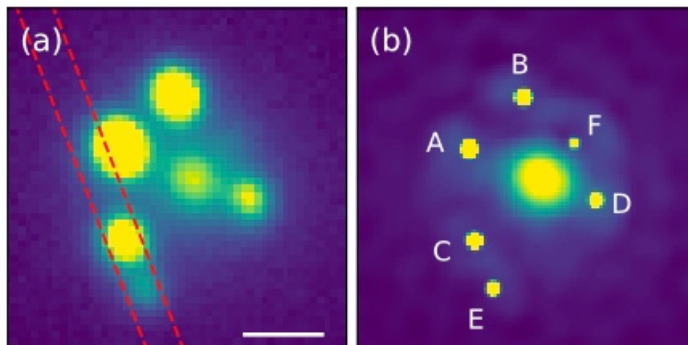NGC6240 $\delta \sim 1.5"$

Fabbiano+20
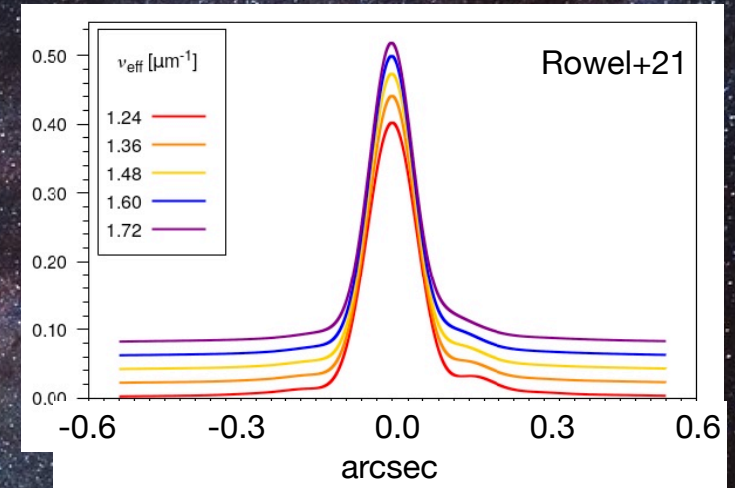
Chen+22
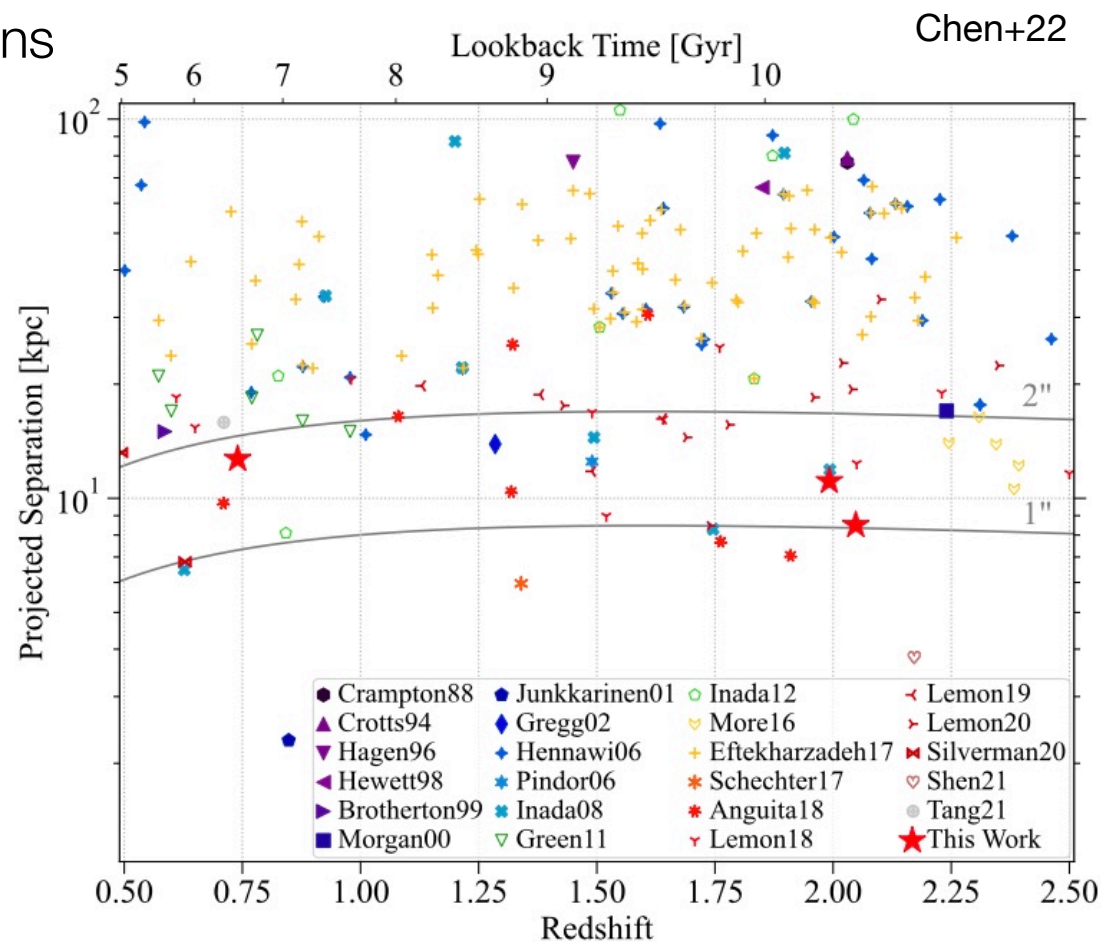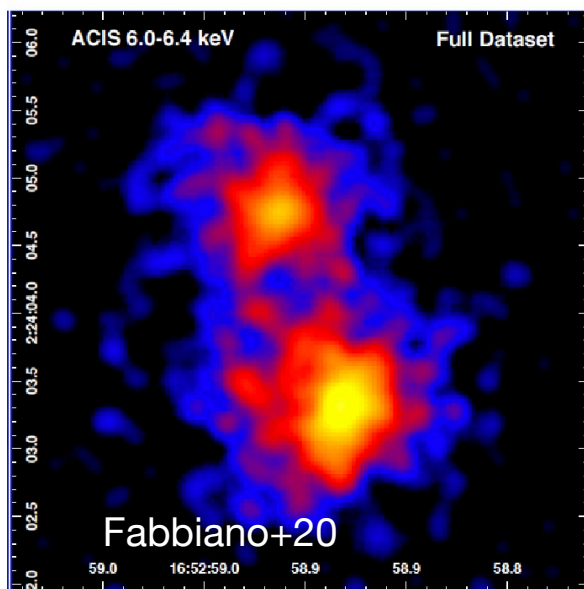
Lensed AGNs

Spiniello+18

Lemon+22

- very rare: f ~10^{-4}

- cosmological parameters through variability

- dark-matter substructures

- host galaxies

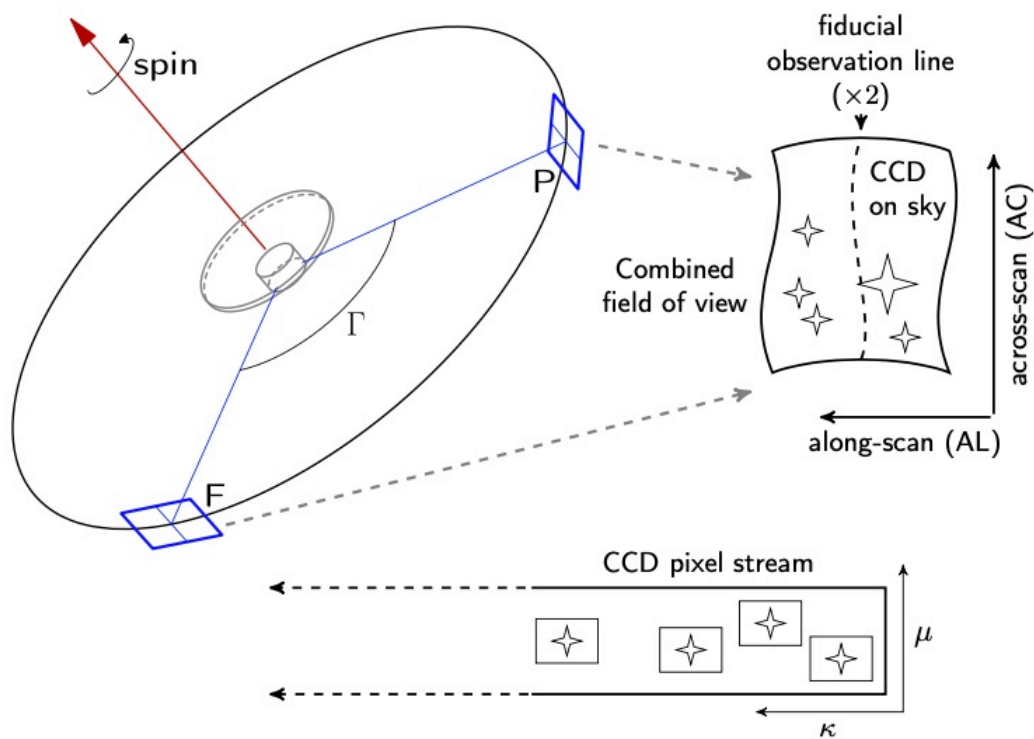- inner structure of the AGN through microlensing

- lensing galaxy

e.g. Treu & Ellis 2015

Looking for dual/lensed AGNS with Gaia

- All-sky survey
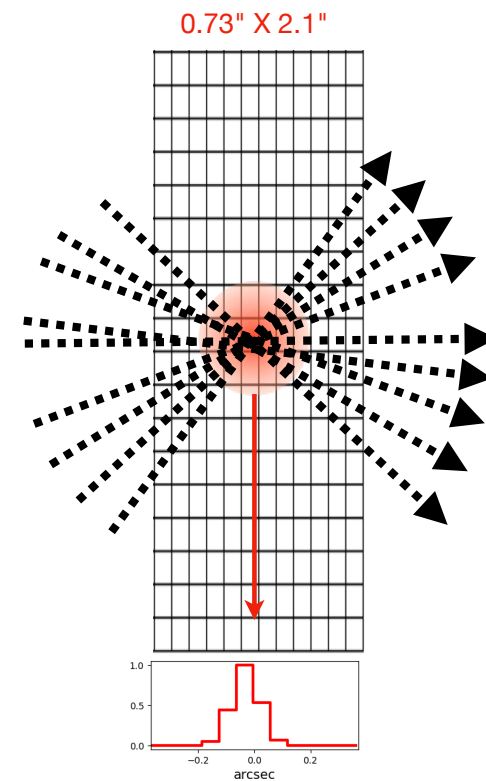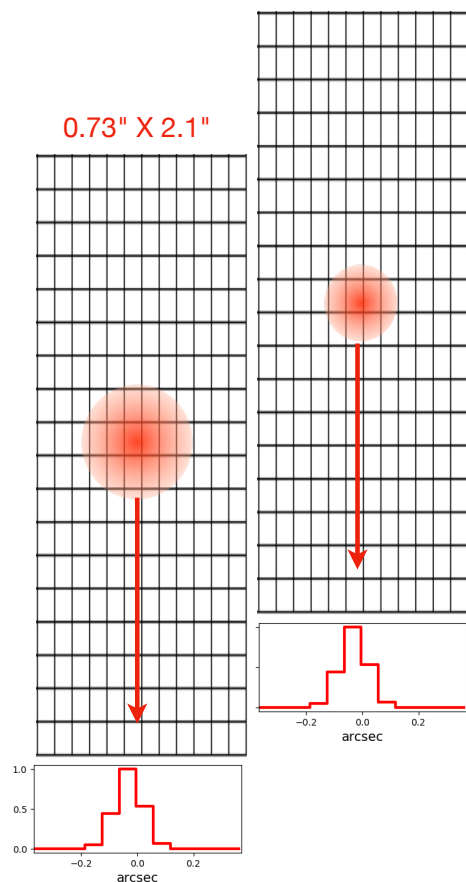- EDR3: 1.5 G sources
- PSF ~ 0.11"
- G<~20.5
- BP & RP

Rowel+21

ν_{eff} [μm^{-1}]

1.24
1.36
1.48
1.60
1.72

arcsec

Gaia observing strategy

- G = 16-20:
  no images
  1D light profile

- Multiple scans
  different directions

0.73" X 2.1"

0.73" X 2.1"

Brown 2021

Resolving near-by sources

"Distant" sources ($\delta \sim 0.7"$)
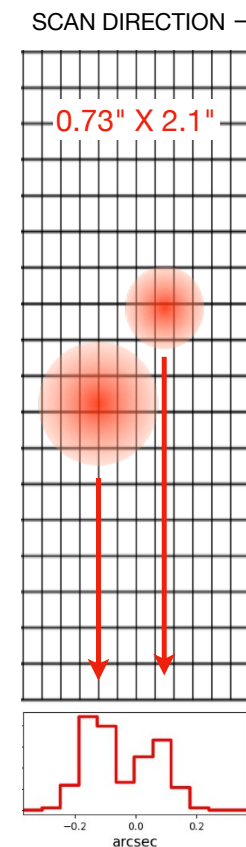
0.73" X 2.1"

Gaia Multi Peak (**GMP**) technique

0.73" X 2.1"

fraction of scans showing a multiple peak:
`ipd_frac_multi_peak`

Threshold: 8-10%

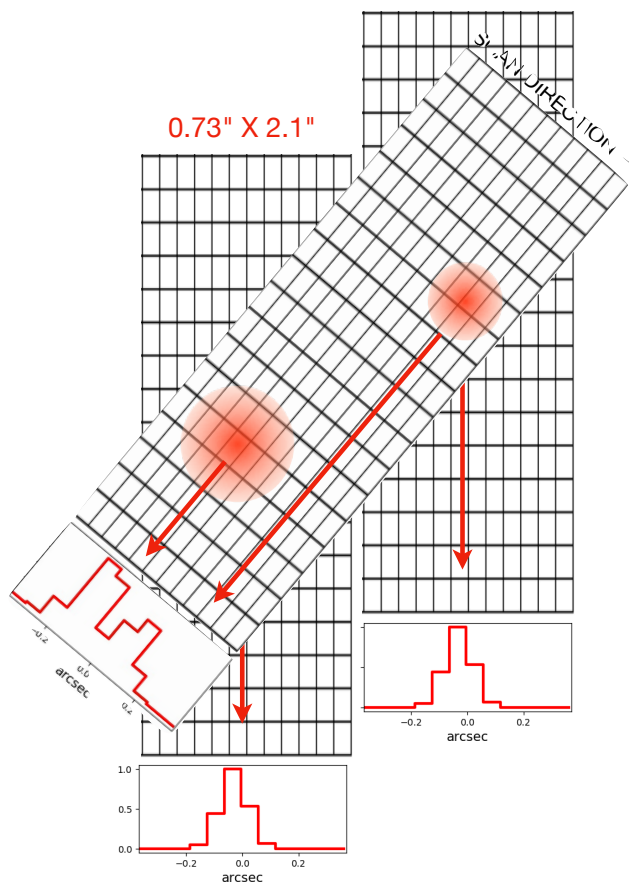several hundreds candidates
About 0.1% of the AGNs

Two entries in the catalog: "*Separated*"

Nearby sources ($\delta \sim 0.2"$)

SCAN DIRECTION →

0.73" X 2.1"

0.73" X

"*Unseparated*"

Resolving near-by sources

"Distant" sources ($\delta \sim 0.7$")
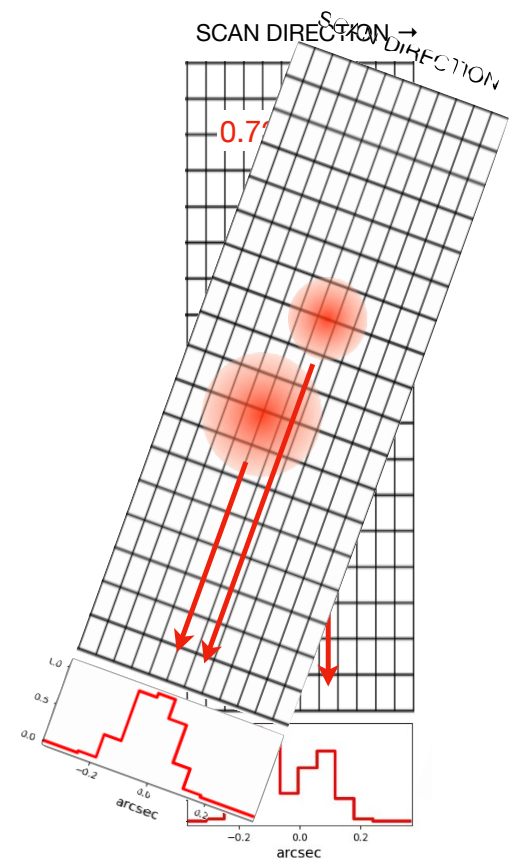
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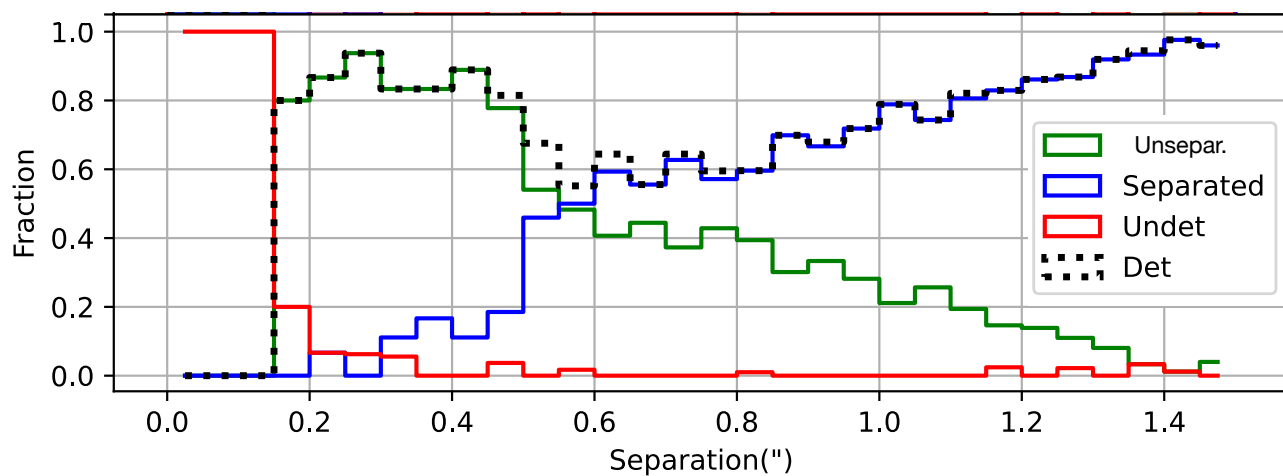several hundreds candidates
About 0.1% of the AGNs

Two entries in the catalog: "*Separated*"

"*Unseparated*"

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GMP sensitivity vs. separation

stellar pairs in dense stellar fields observed with HST

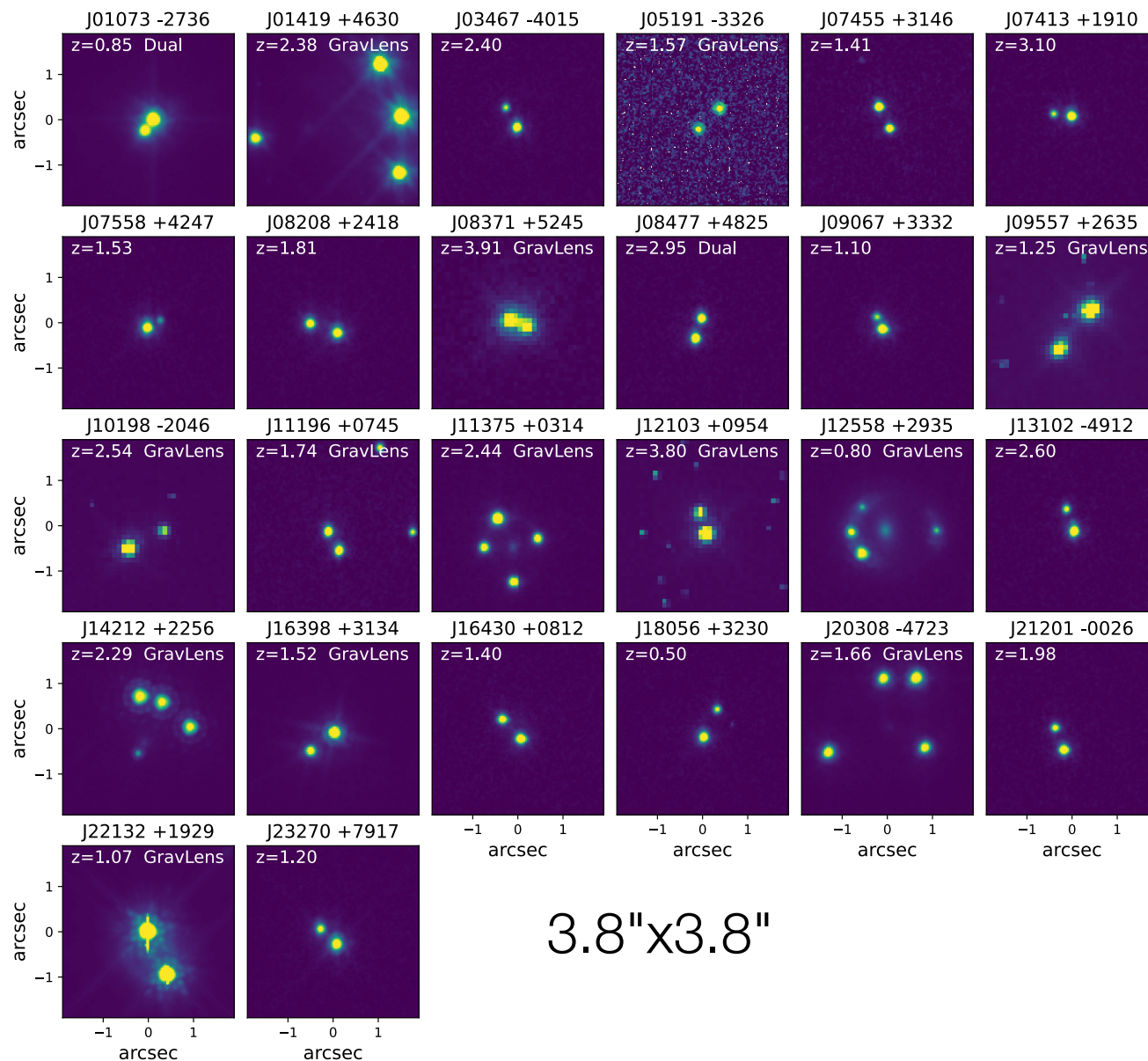0.15" < sep <0.7"

for unseparated sources
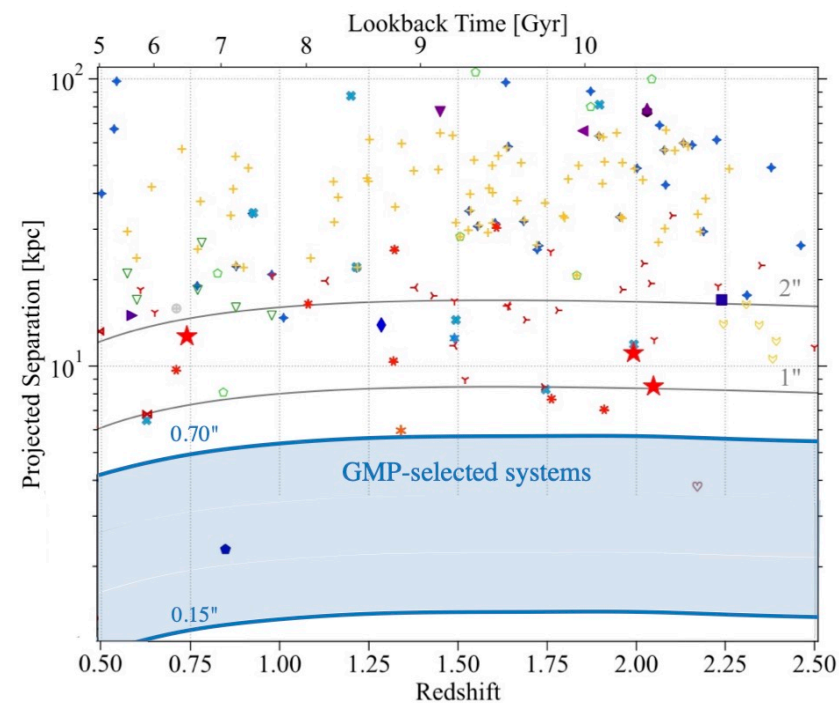
HST images

26 GMP-selected AGNs in the archive

- all show multiple components

- 13 known lensed systems
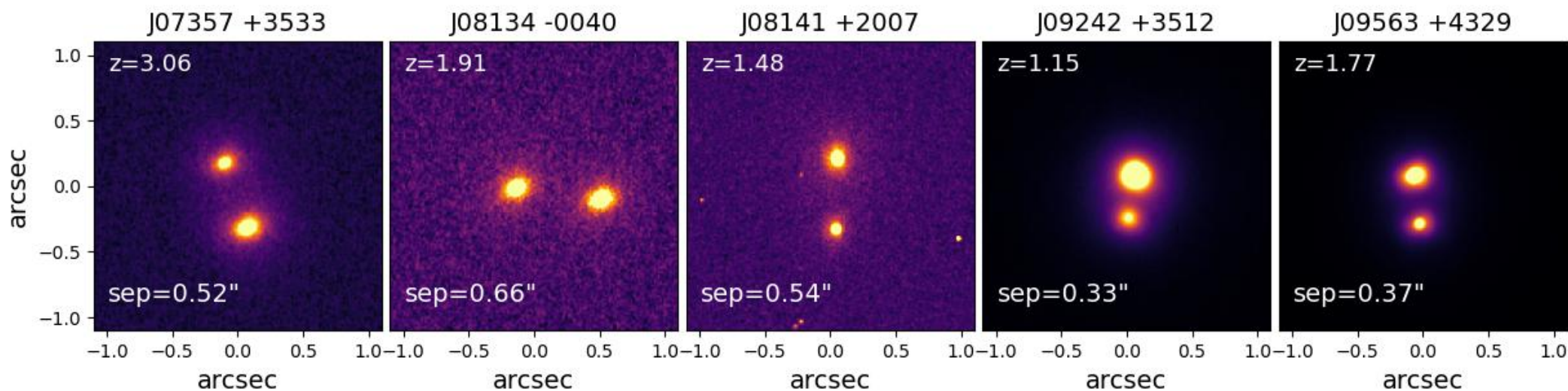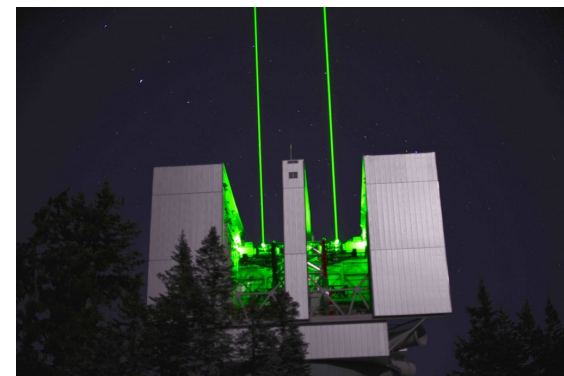- 2 known dual systems
- 11 previously unclassified:
  - $\langle \delta \rangle = 0.53"$

Biased sample

3.8"x3.8"

High-resolution AO imaging at LBT

Unbiased sample of GMP-selected AGNs

separations: 0.33"-0.66"

2.2"x2.2"
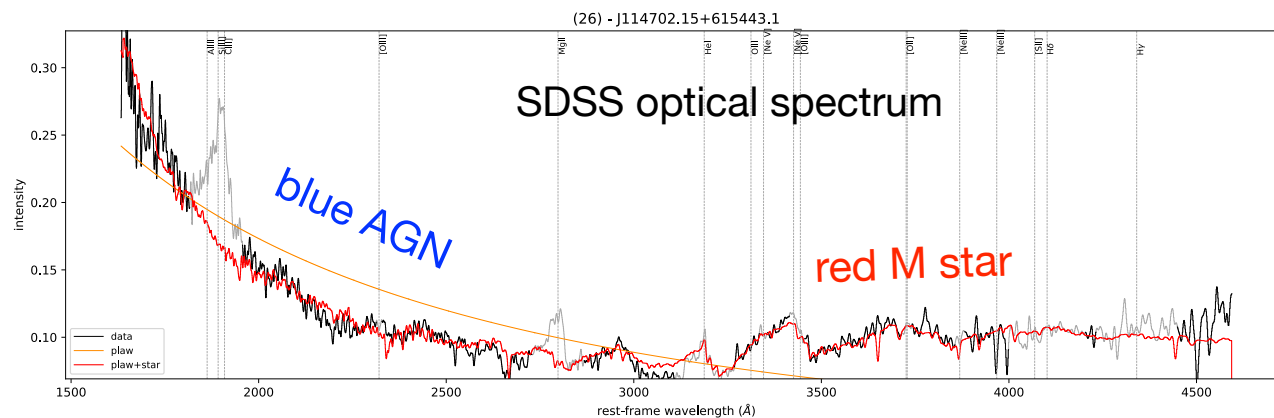
(observations on-going)
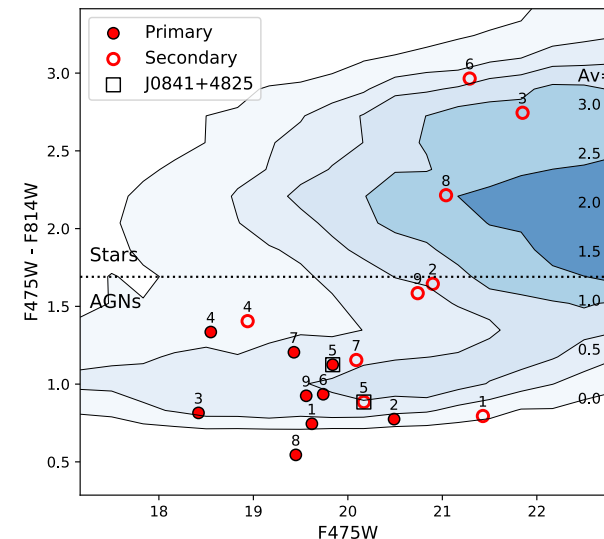
Nature of the GMP-selected systems

Chance AGN/star alignment: ~30%

    1. stellar density

    2. colors

    3. random alignment of Gaia sources

    4. deconvolution of total (ground-based) spectra

AGN/AGN ~ 70%

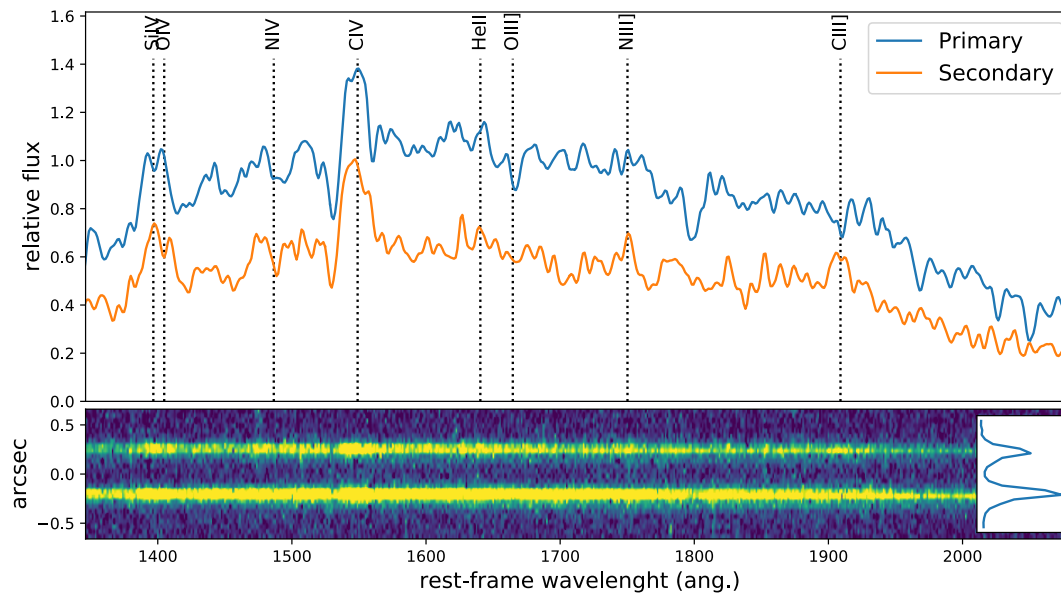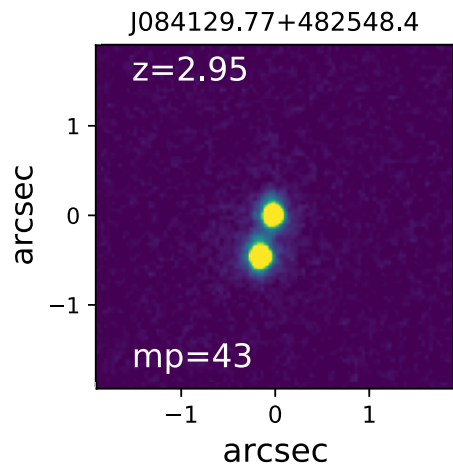- mostly dual

A confirmed dual AGN

STIS

J084129.77+482548.4
z=2.95
mp=43

arcsec

ed dual AGN:

edshift

- Different spectrum
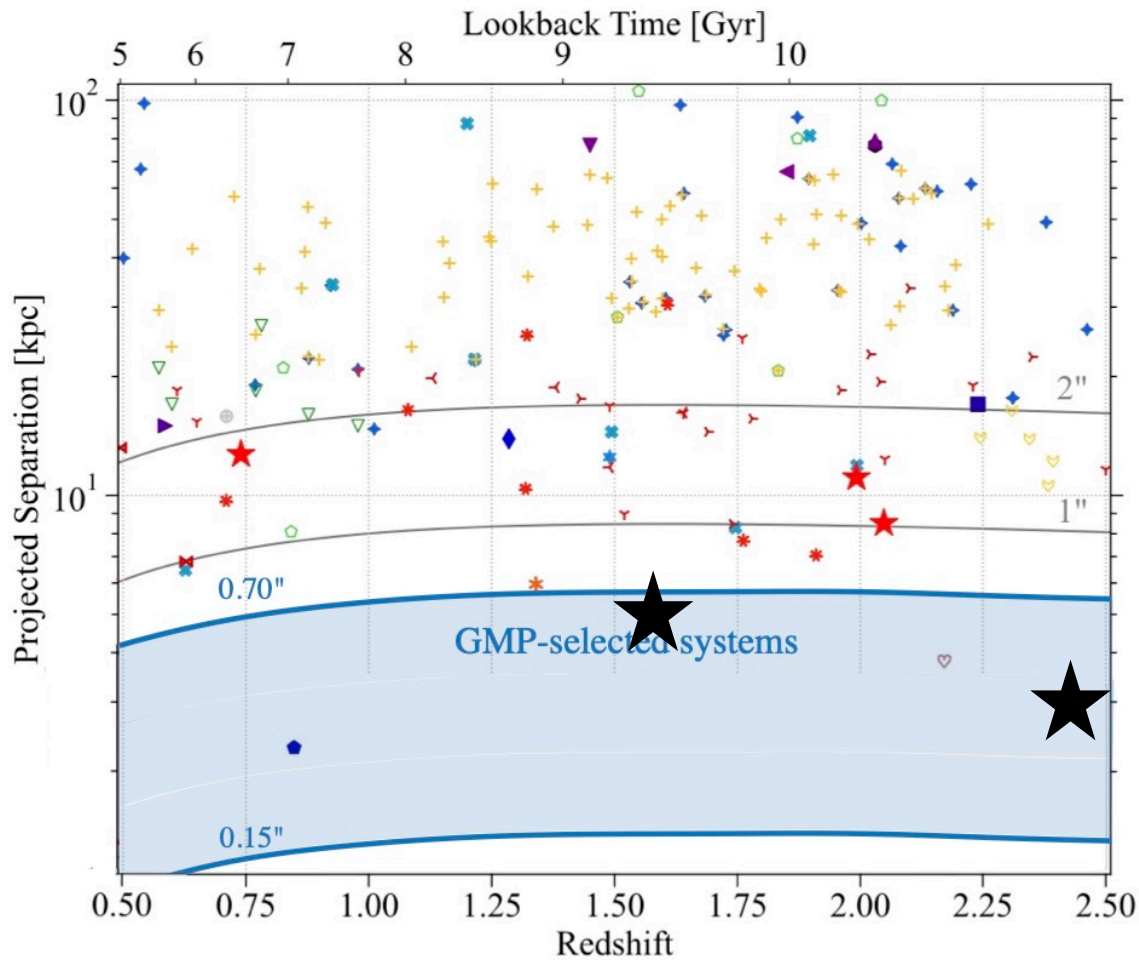
- Δt ~ 2 days

ility timescale:
days

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High-resolution AO IFU spectroscopy at Keck

March 20th 2022
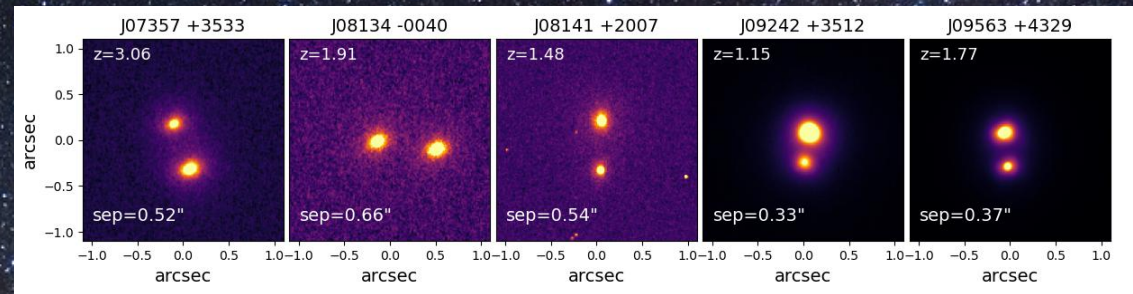
0.05" spaxels
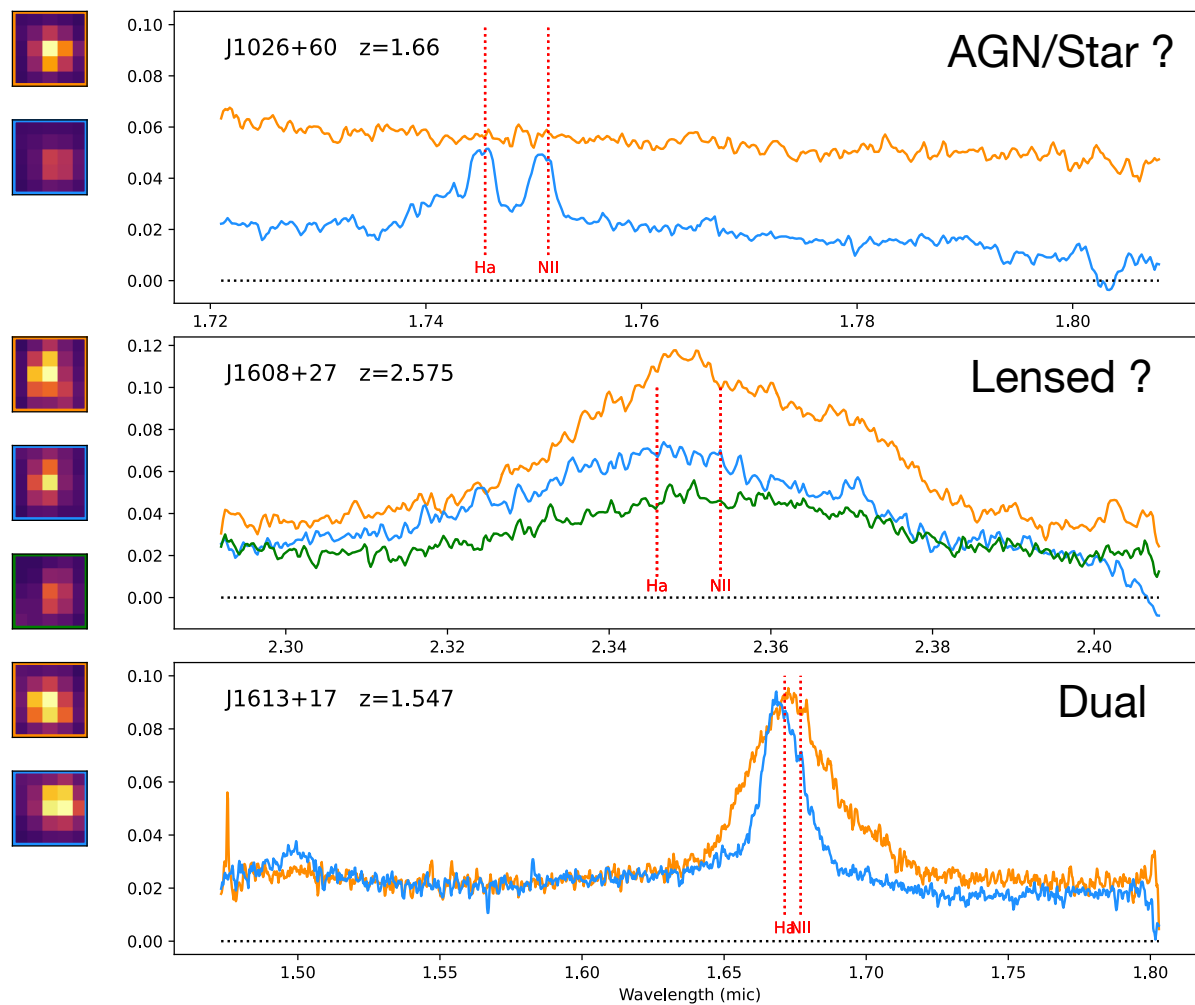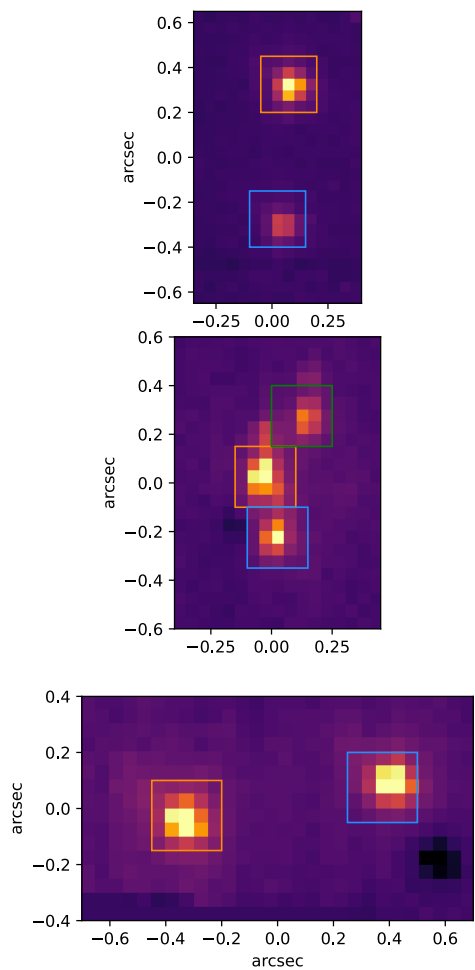
Populating the desert with GMP objects

Future AO observations:

~100 GMP-selected systems with:

1. VLT/MUSE NFM (accepted prop.)
2. VLT/ERIS (GTO times)
3. Keck/OSIRIS (accepted prop.)

Summary

1. GMP very efficient in selecting multiple systems, low contamination

2. Sampling separations $0.15"<\delta<0.7"$, i.e., $1<\delta<5$ kpc @ z>1 , inside the same galaxy

3. 30% AGN/star alignment, 70% AGN/AGN, dominated by dual systems

4. Hundreds of selected systems, many more using Gaia spectrscopy

5. Aim: classify ~100 of them to test the models:

   distribution of separation, luminosity ratios, fraction of dual AGNs...