

THE HOST GALAXY OF FRB 121102

PULSAR ASTRONOMERS VENTURE OUTSIDE THE MILKY WAY

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and many others

Tendulkar, Bassa et al 2017, ApJL, 834, 7
Bassa, Tendulkar et al 2017, arxiv 1705.07698 (in review)

IF I TAKE ONE MORE STEP IT'LL
BE THE FARTHEST AWAY FROM
HOME I'VE EVER BEEN

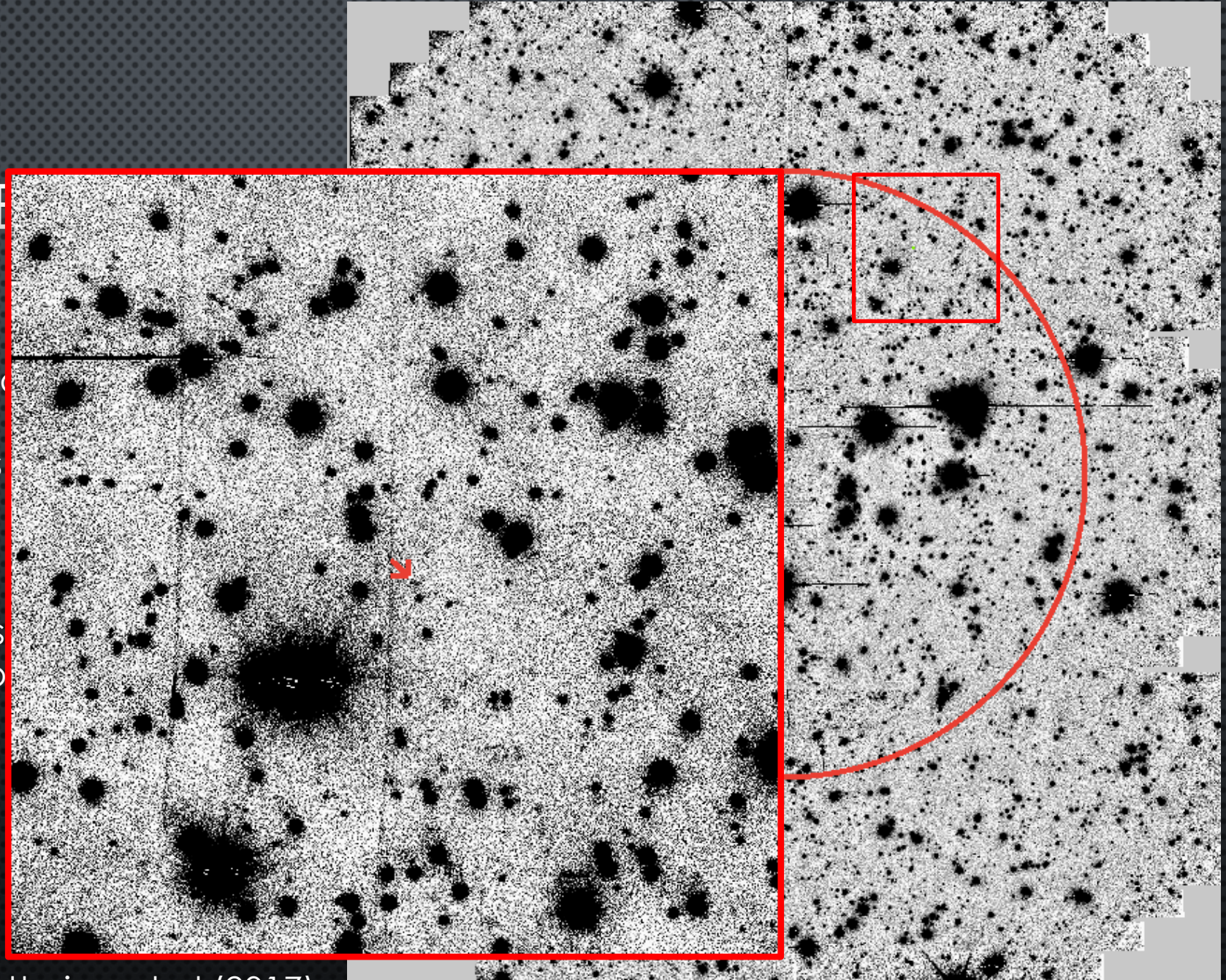


Layout what is known

Put it in perspective

Raise questions about unknowns

FRB 121102 FIELD



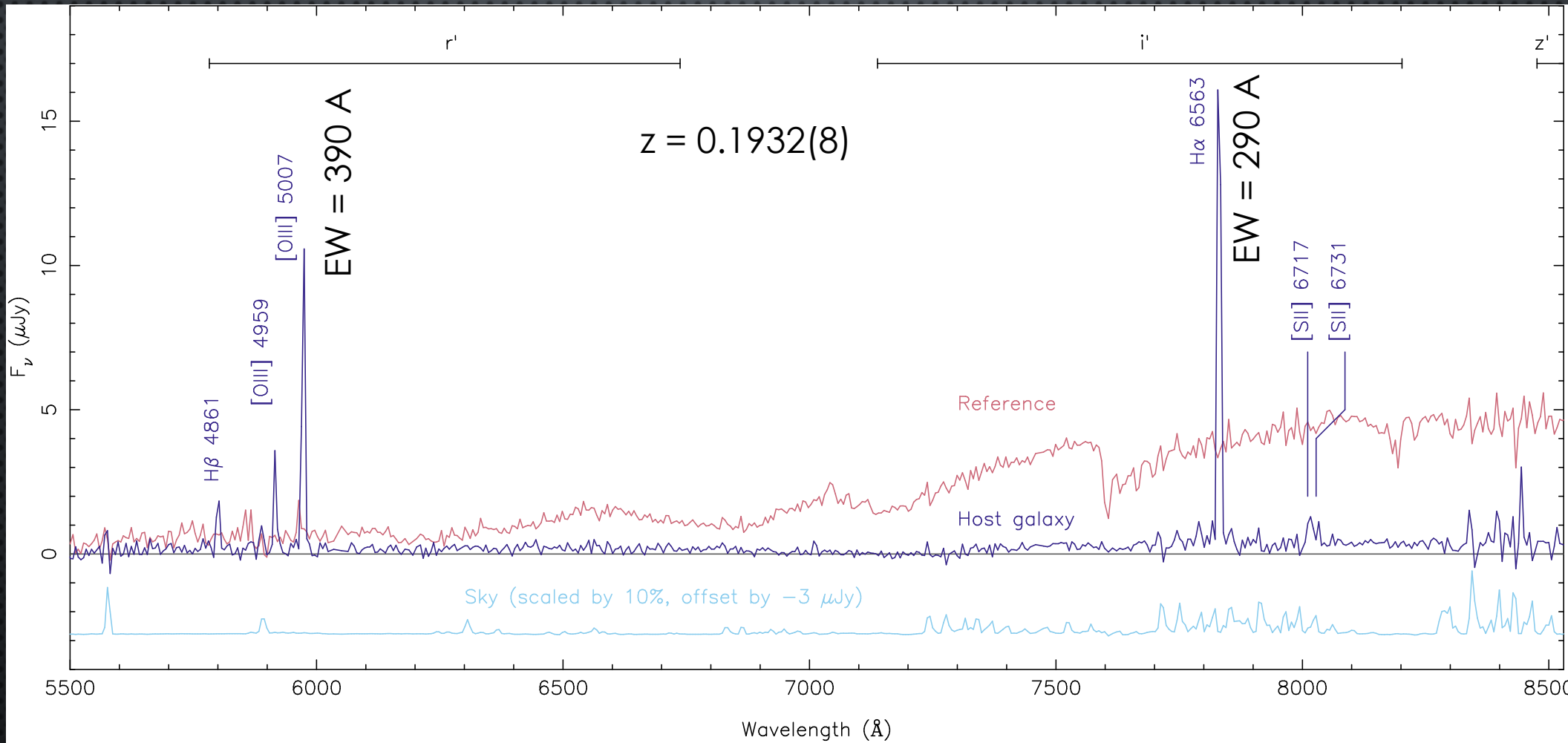
Localization! Localization! Localization!

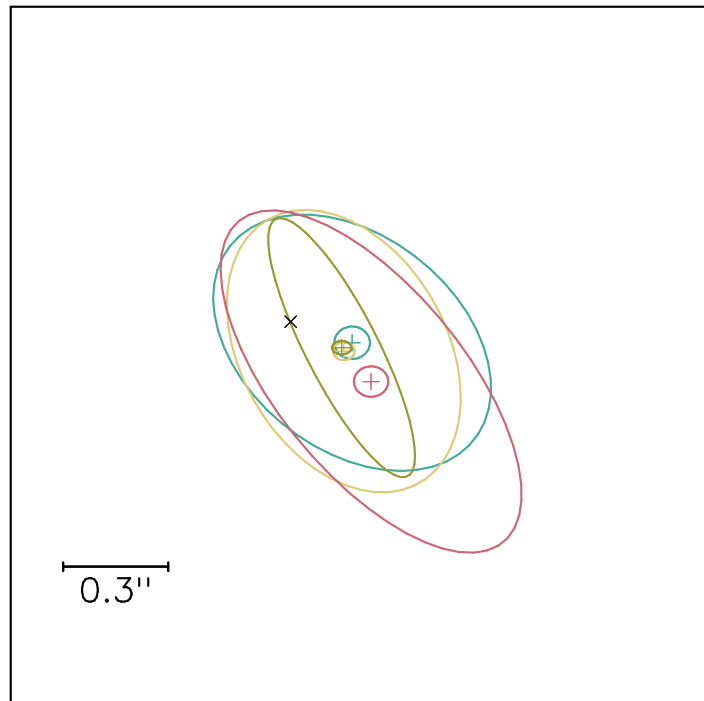
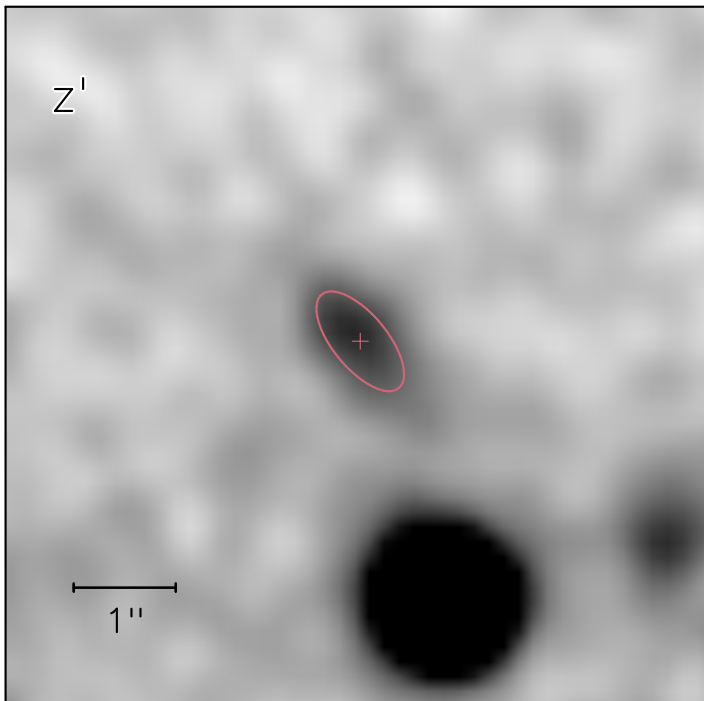
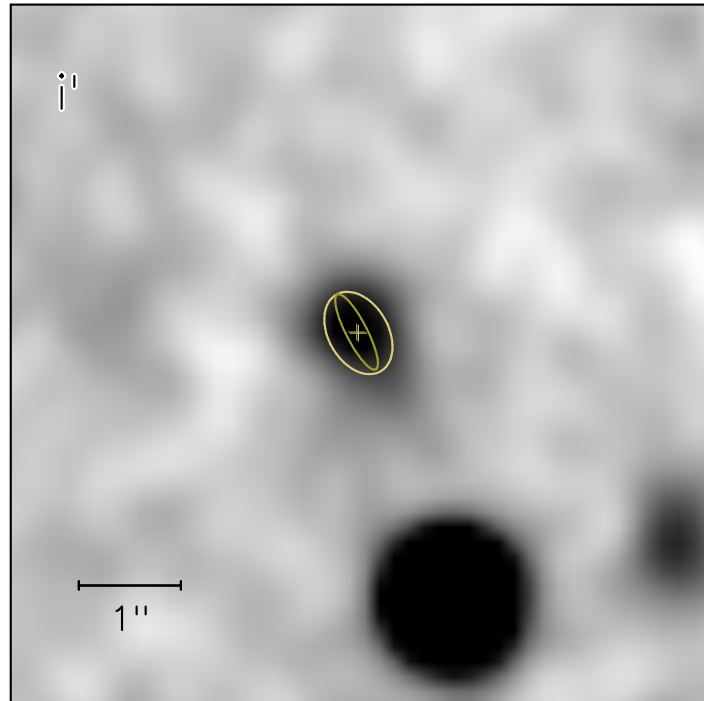
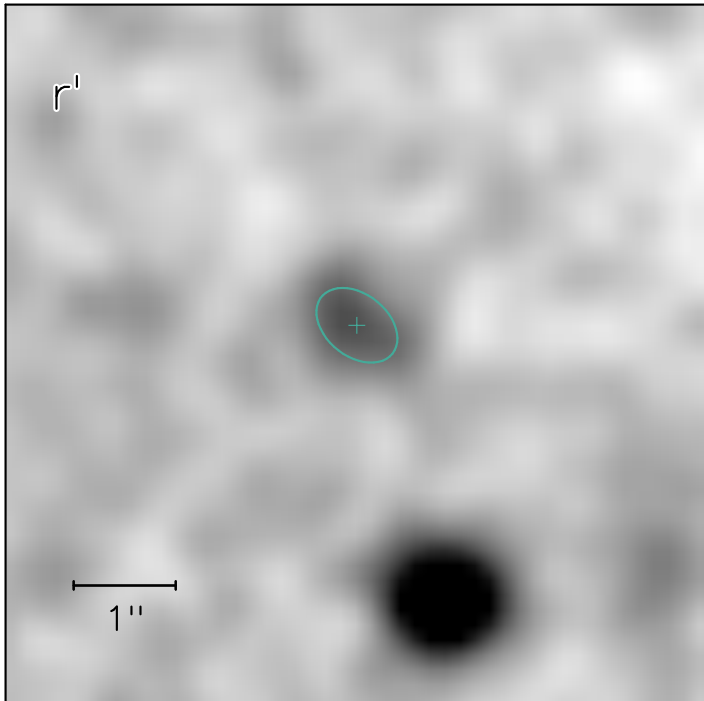
Lots and lots of potential hosts

Also, many radio counterparts
Few weak X-ray sources (Scho

Optical Spectrum

- Incredibly bright emission lines! – high SFR – EELG
- *r* & *i* bands dominated by [OIII] and H α , *z* band is continuum





Gemini Observations (Oct-Dec 2016)

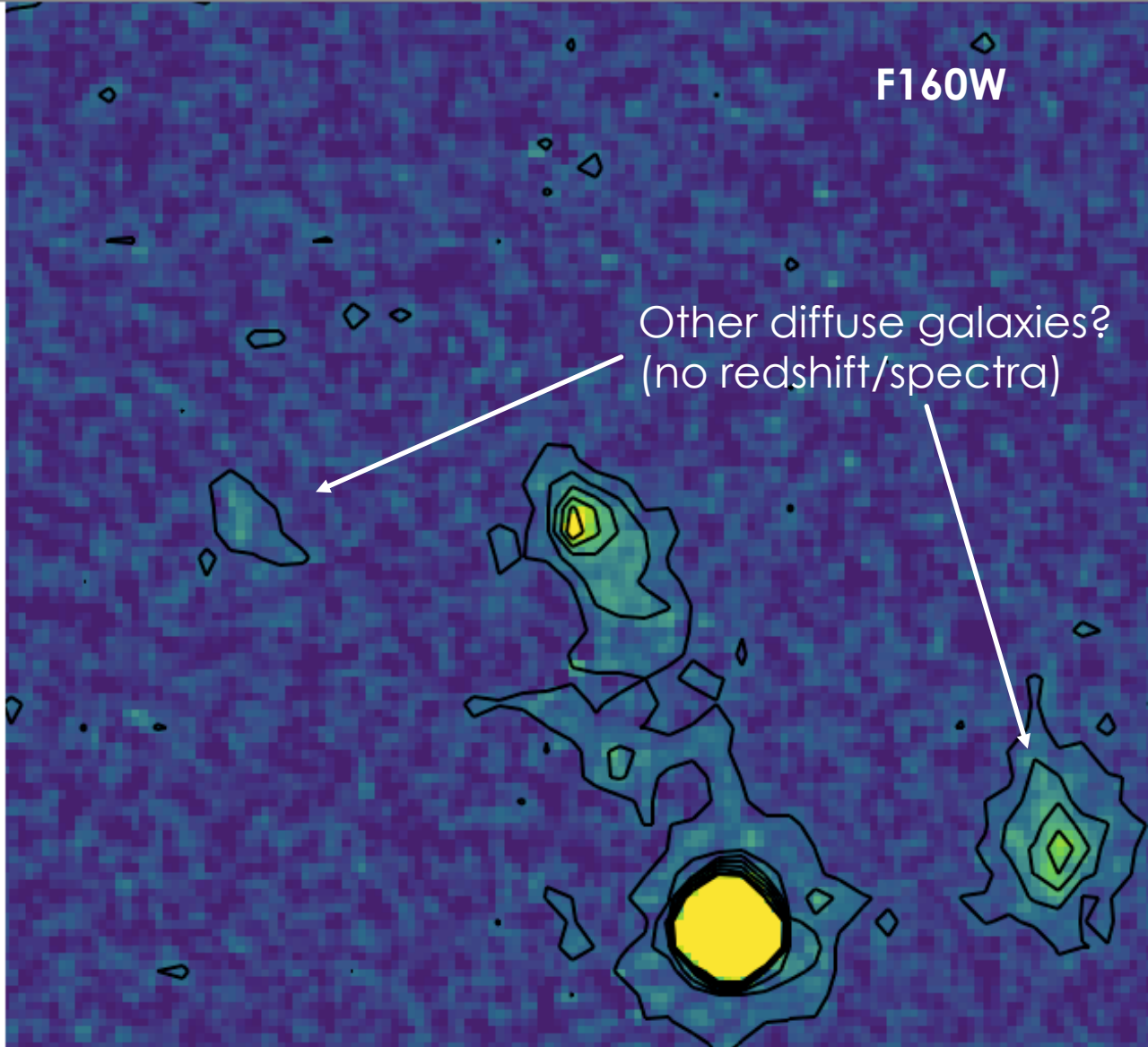
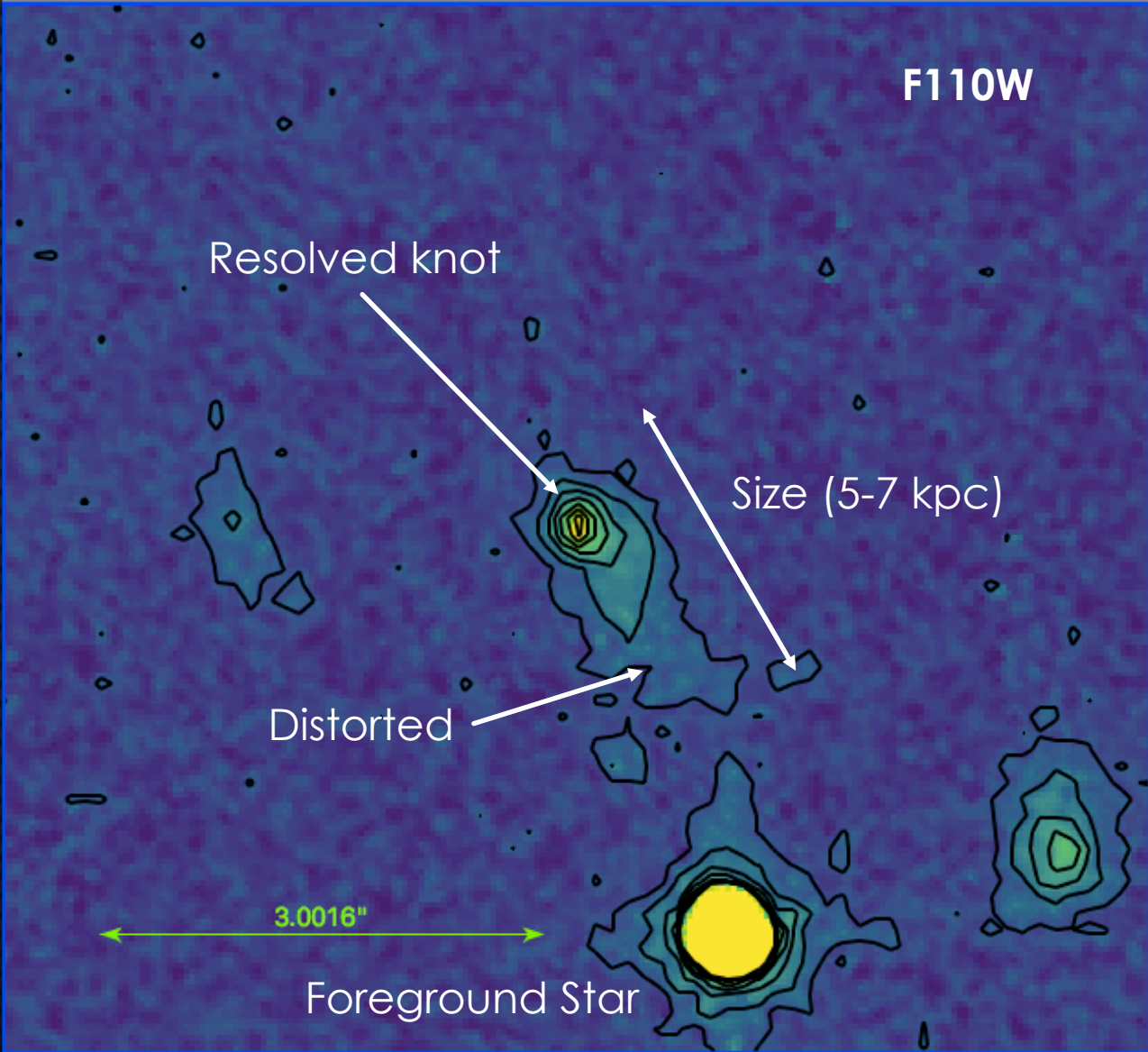
→ Dwarf galaxy

→ FRB not at optical center

→ r and i band centers shifted

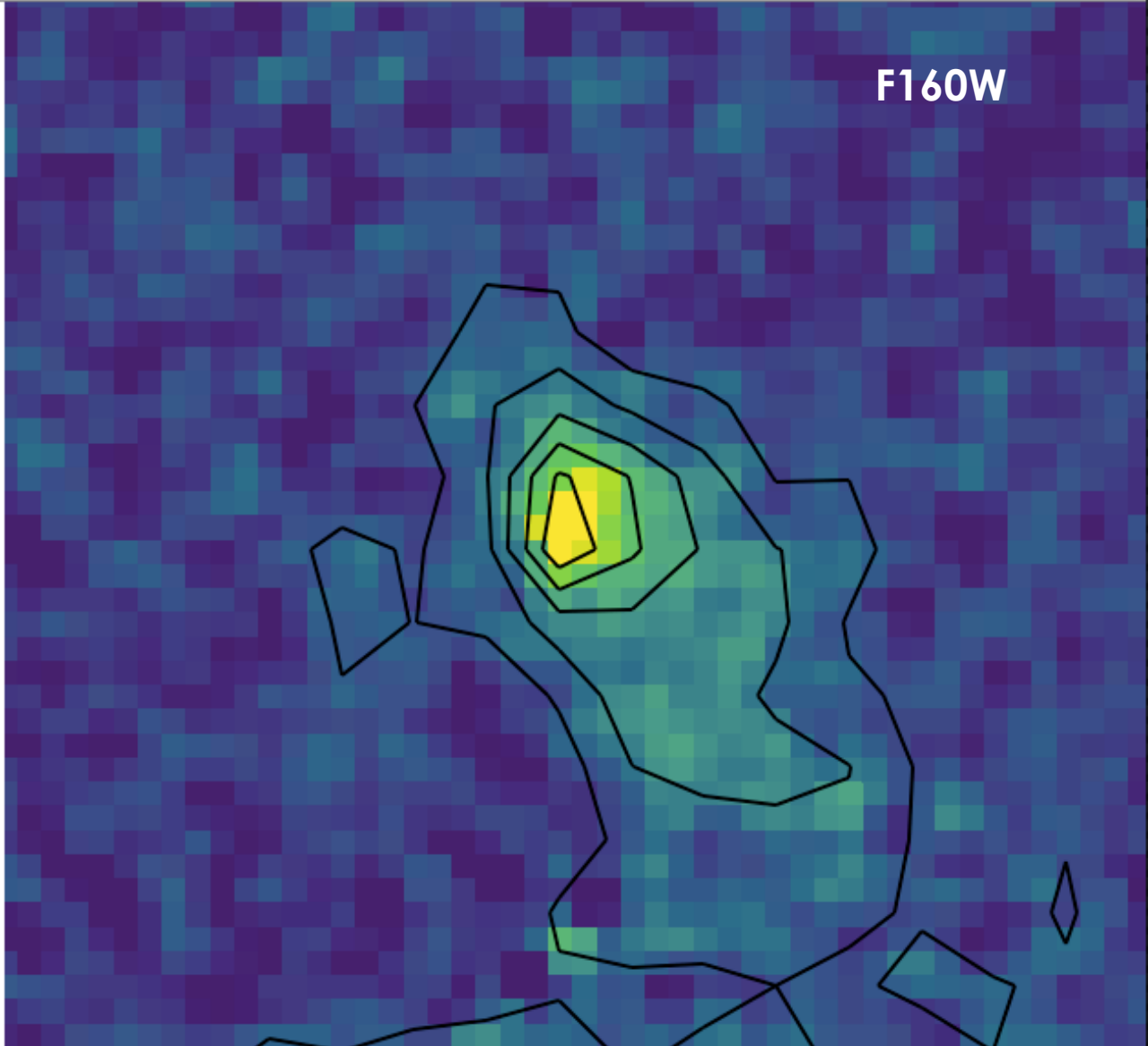
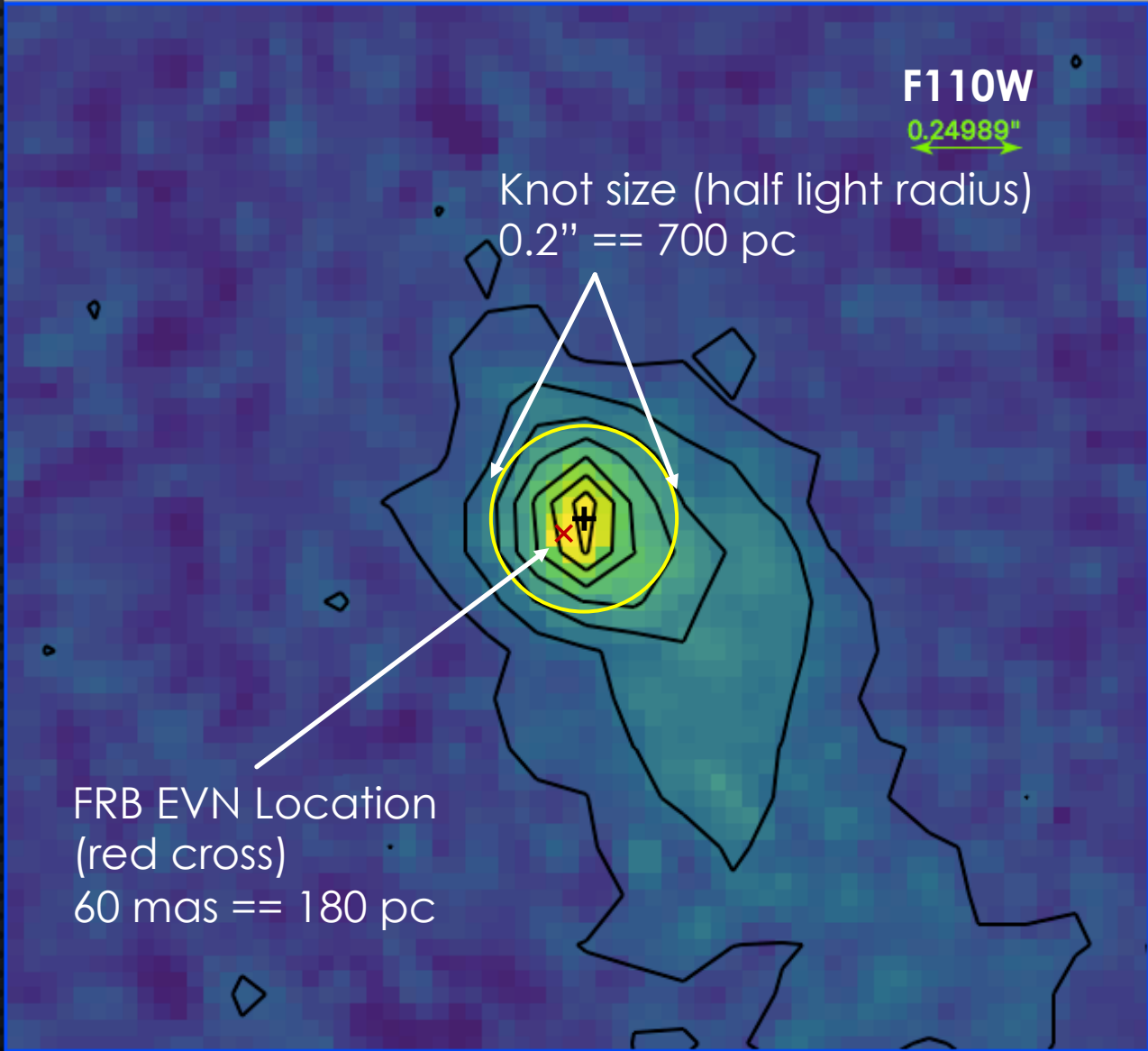
→ Bright knot of star formation?

HST WFC3 Infrared Observations



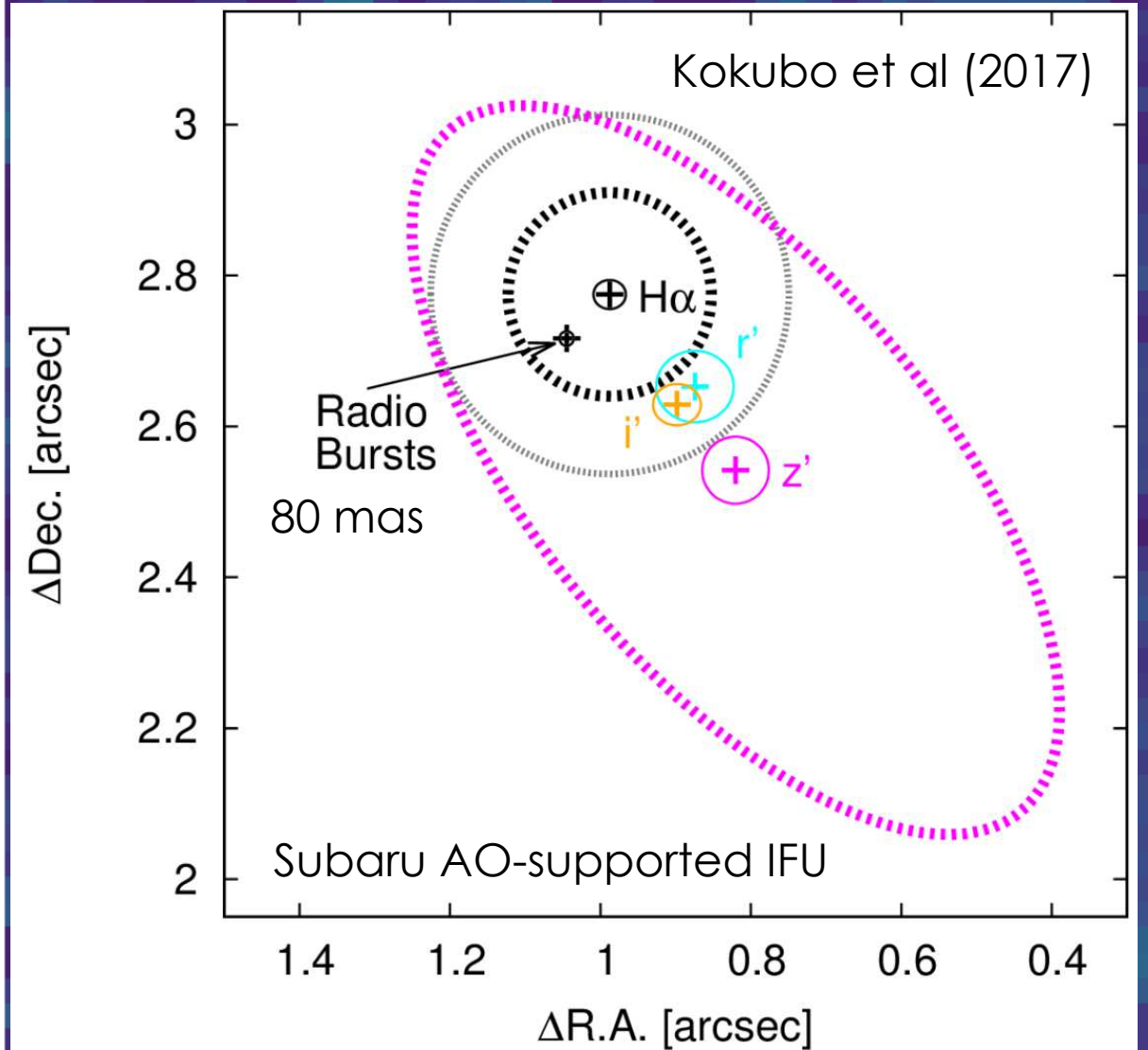
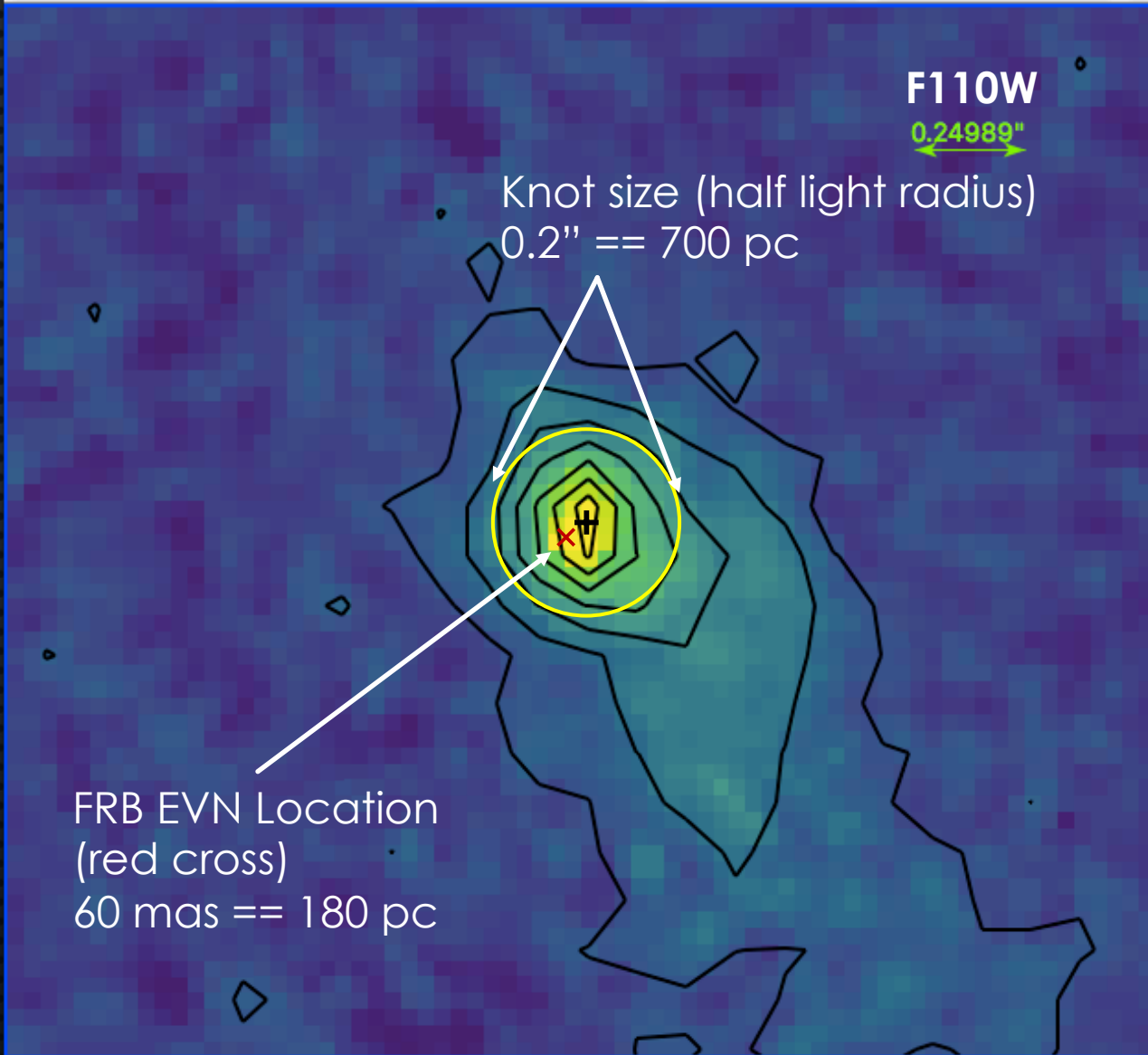
Bassa et al (2017)

HST WFC3 Infrared Observations (Zoom-In)

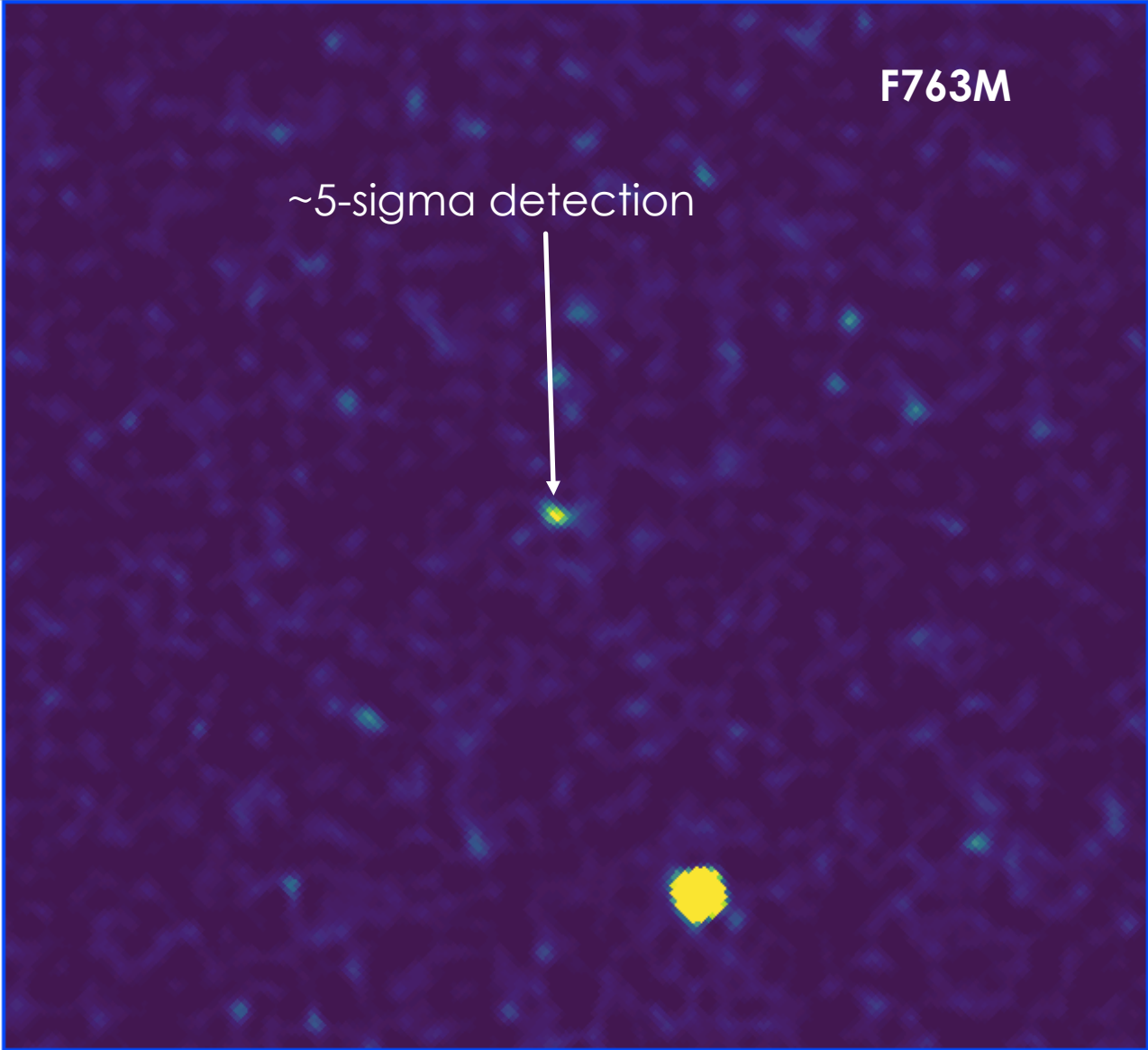
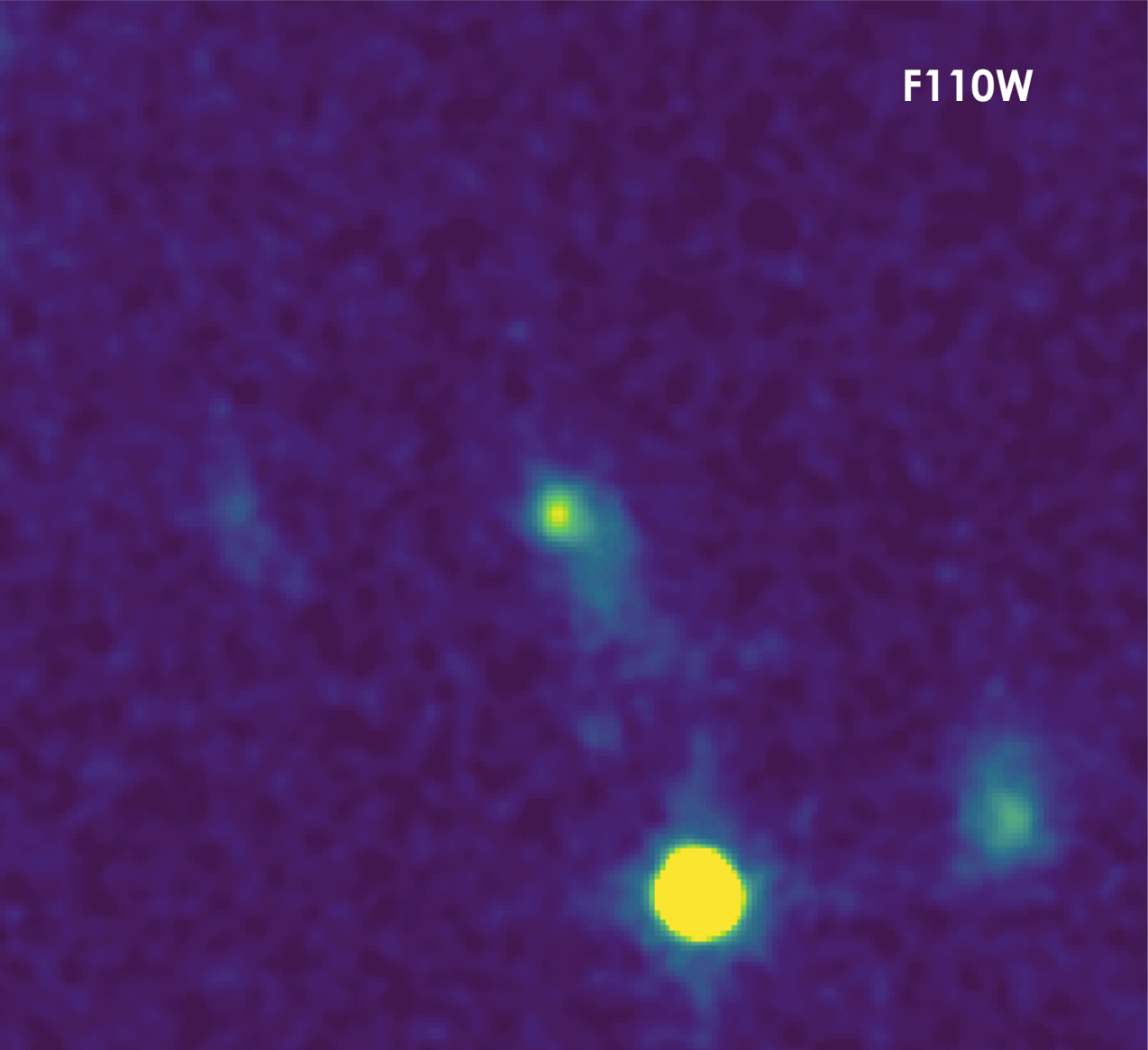


Bassa et al (2017)

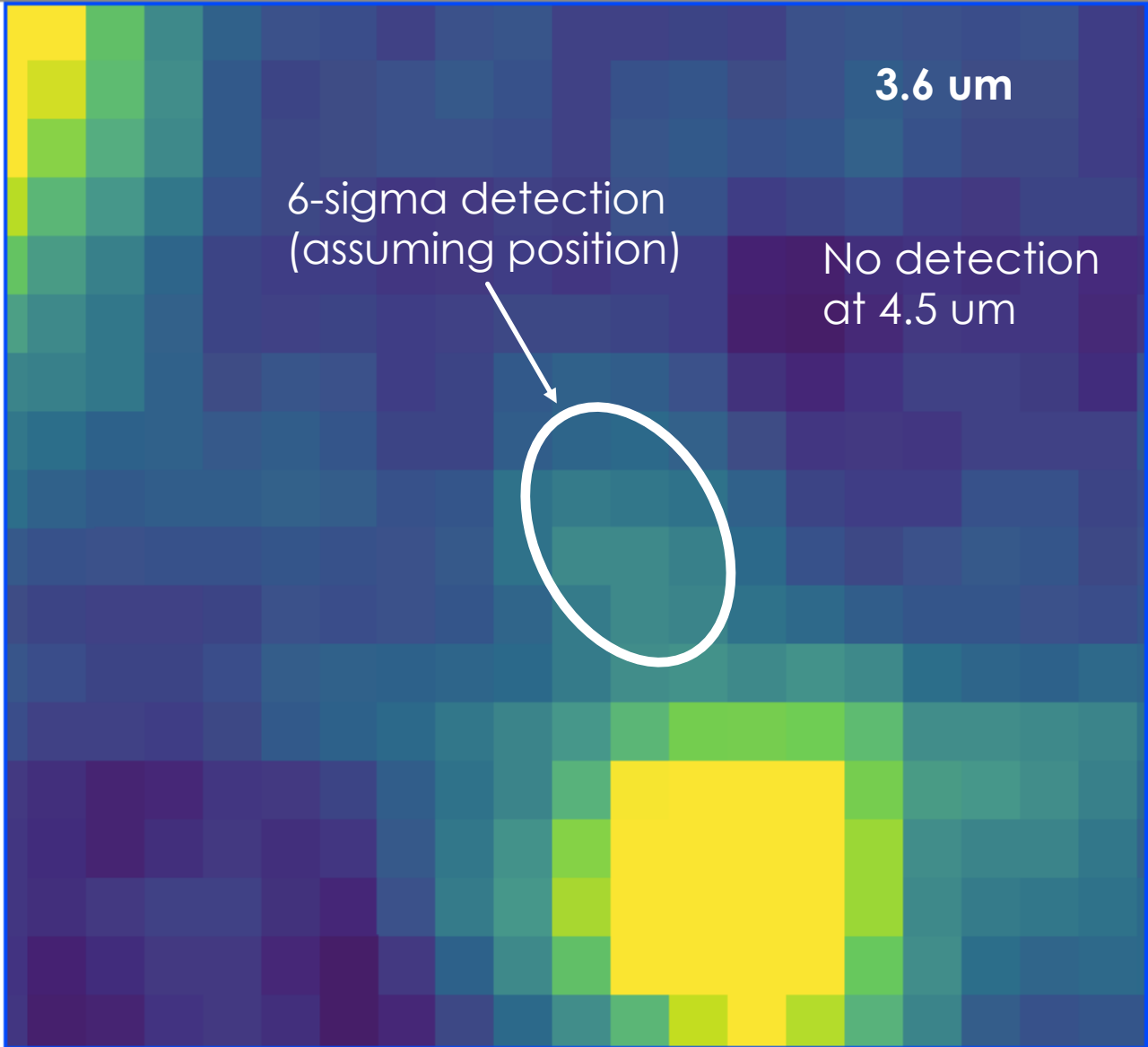
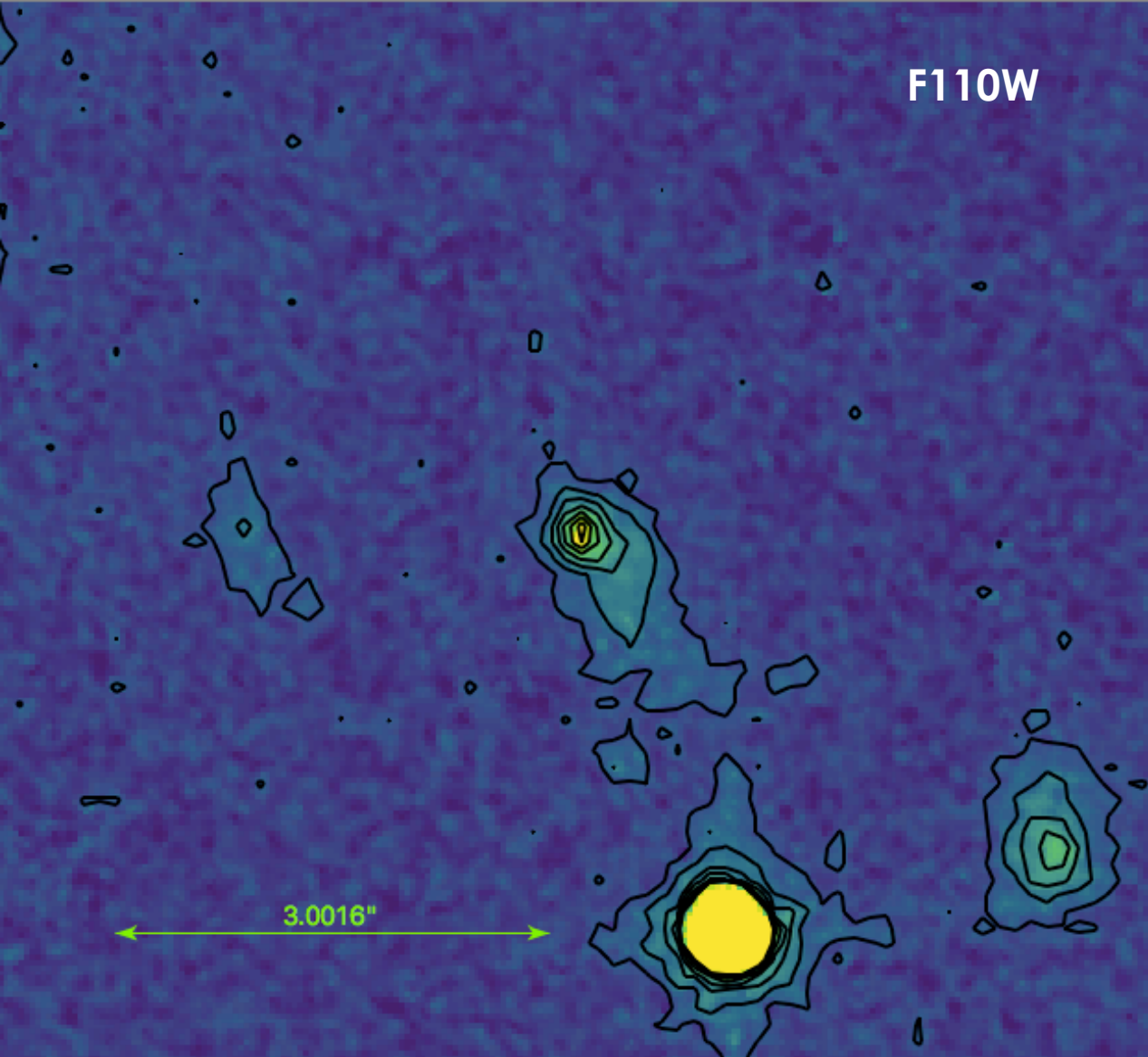
HST WFC3 Infrared Observations (Zoom-In)



HST WFC3 redshifted H α observation



Spitzer Observations



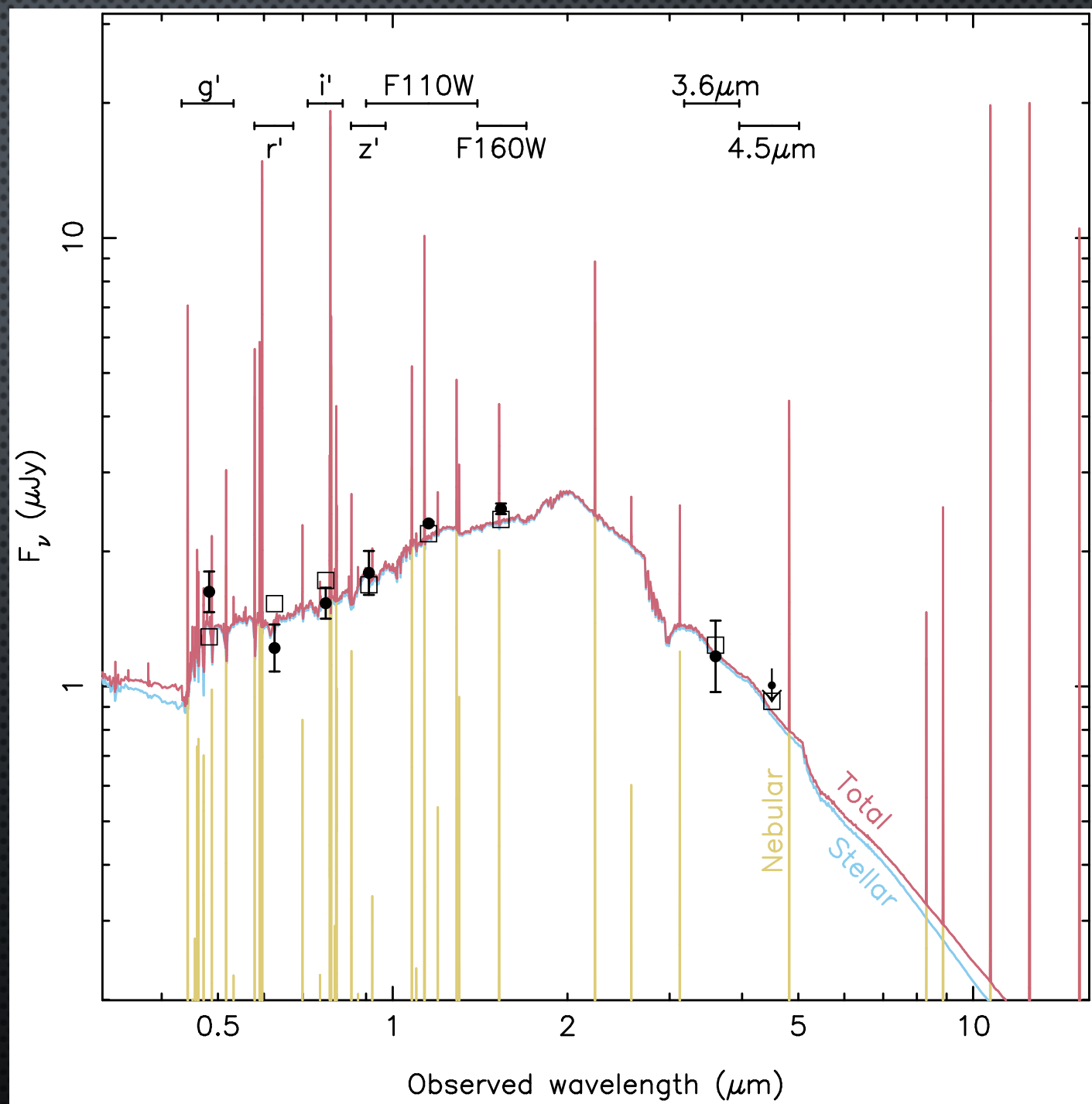
SED Fitting

Used CIGALE code for SED fitting
(Serra et al 2011)

Very low extinction (expected)

$M_{\star} = (1.3 \pm 0.4) \times 10^8 M_{\odot}$
 $M/L \sim 0.6 M_{\odot}/L_{\odot}$

Star formation rate: $0.13(4) M_{\odot} \text{ yr}^{-1}$
From H α : $0.23 M_{\odot} \text{ yr}^{-1}$

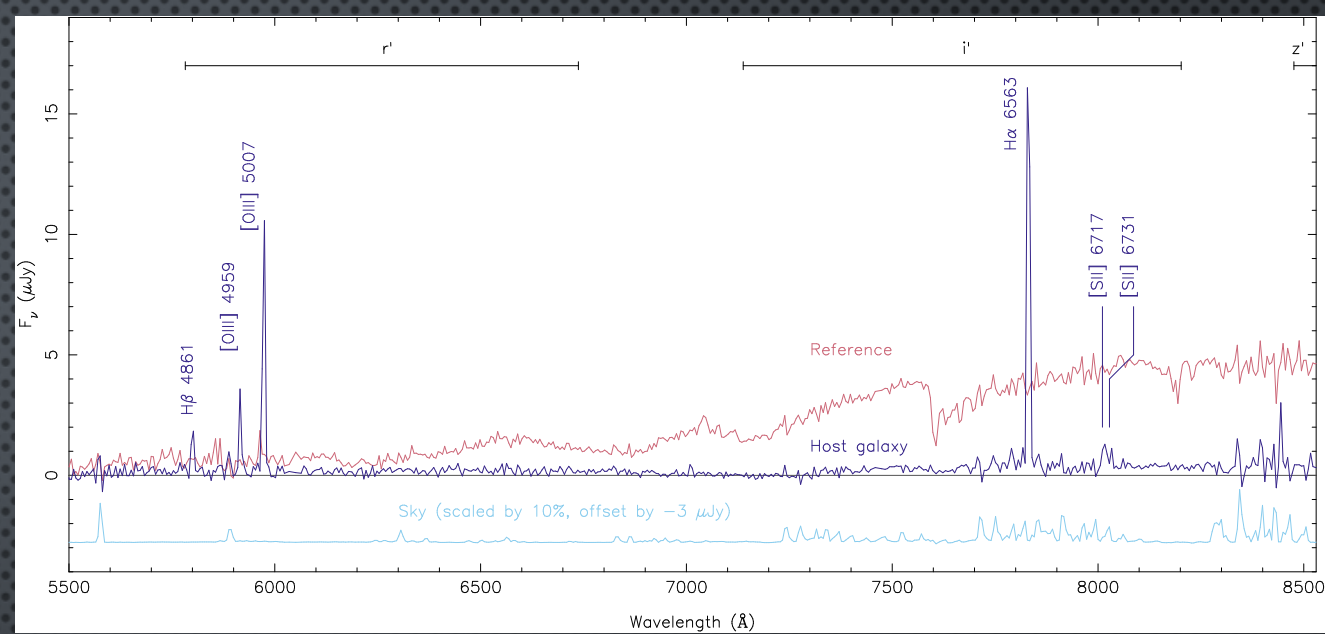


Metallicity Update

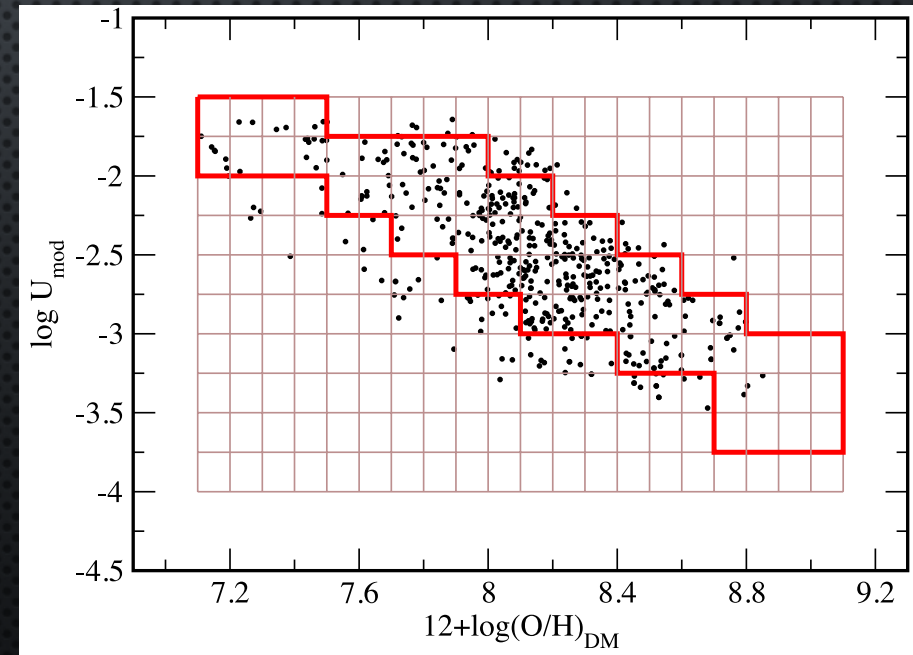
Metallicity needs line ratios, ideally multiple ionization states of Oxygen
~~[OII] 3727, [OIII] 4363, [OIII] 5007~~
~~[NII] 6584, [SII] 6717+6731 (+ H α , H β)~~

HII-CHI-mistry code for metallicity fitting
(Perez-Montero 2011)
-- Uses empirical relations between ionization parameter ($\log U$) and metallicity.

$$12 + \log_{10}([\text{O}/\text{H}]) = 8.0 \pm 0.1$$



Tendulkar et al (2017)



Perez-Montero (2014)

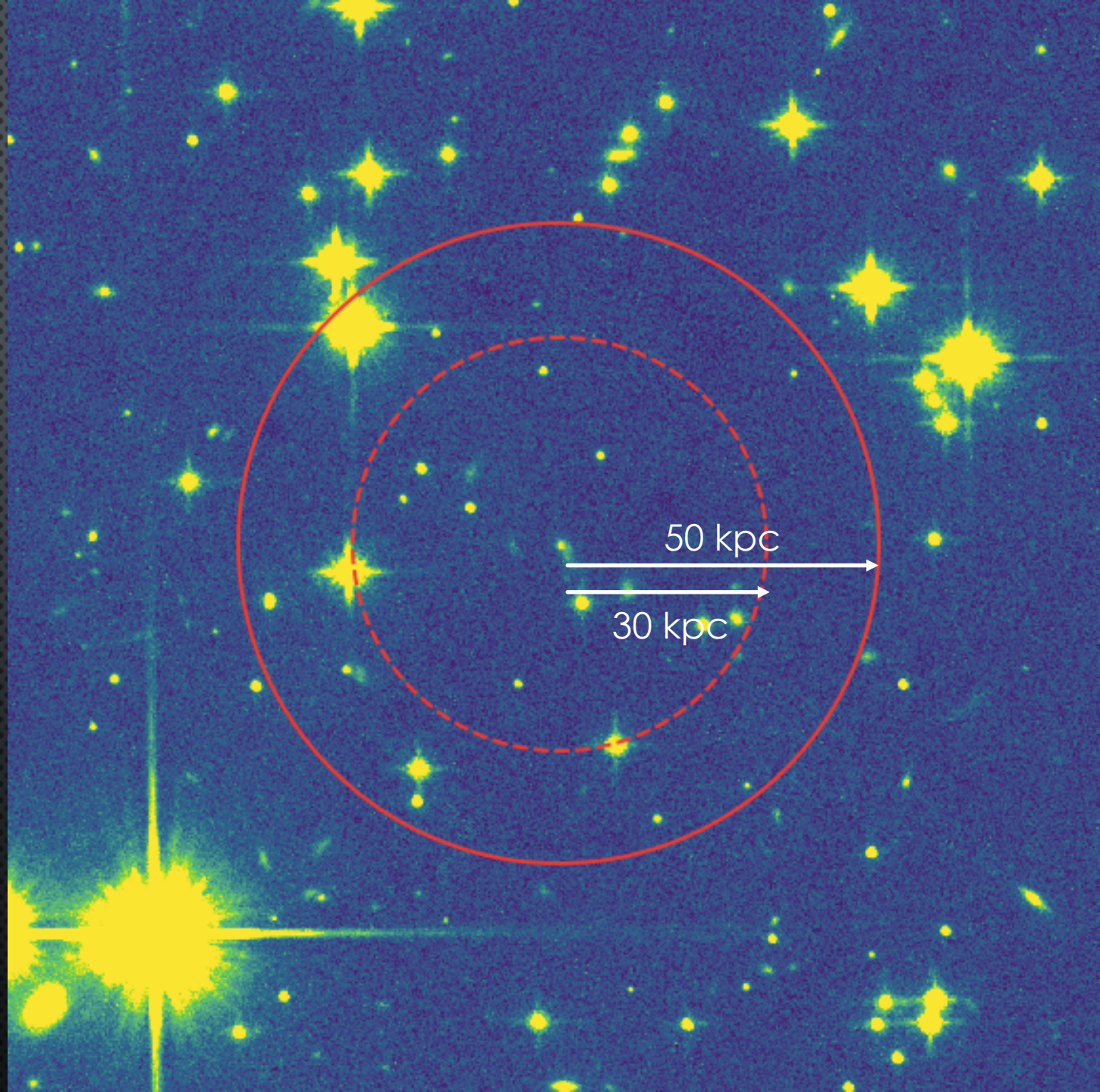
Clustering?

Count objects within 0.15 mag & 50 kpc (15.5") of FRB 121102

31 control patches around the image

At 50 kpc: Equivalent

At 30 kpc scale: 1- σ overdensity(?)



Intrinsic Dispersion Measure

Bright H α emission from a very small region

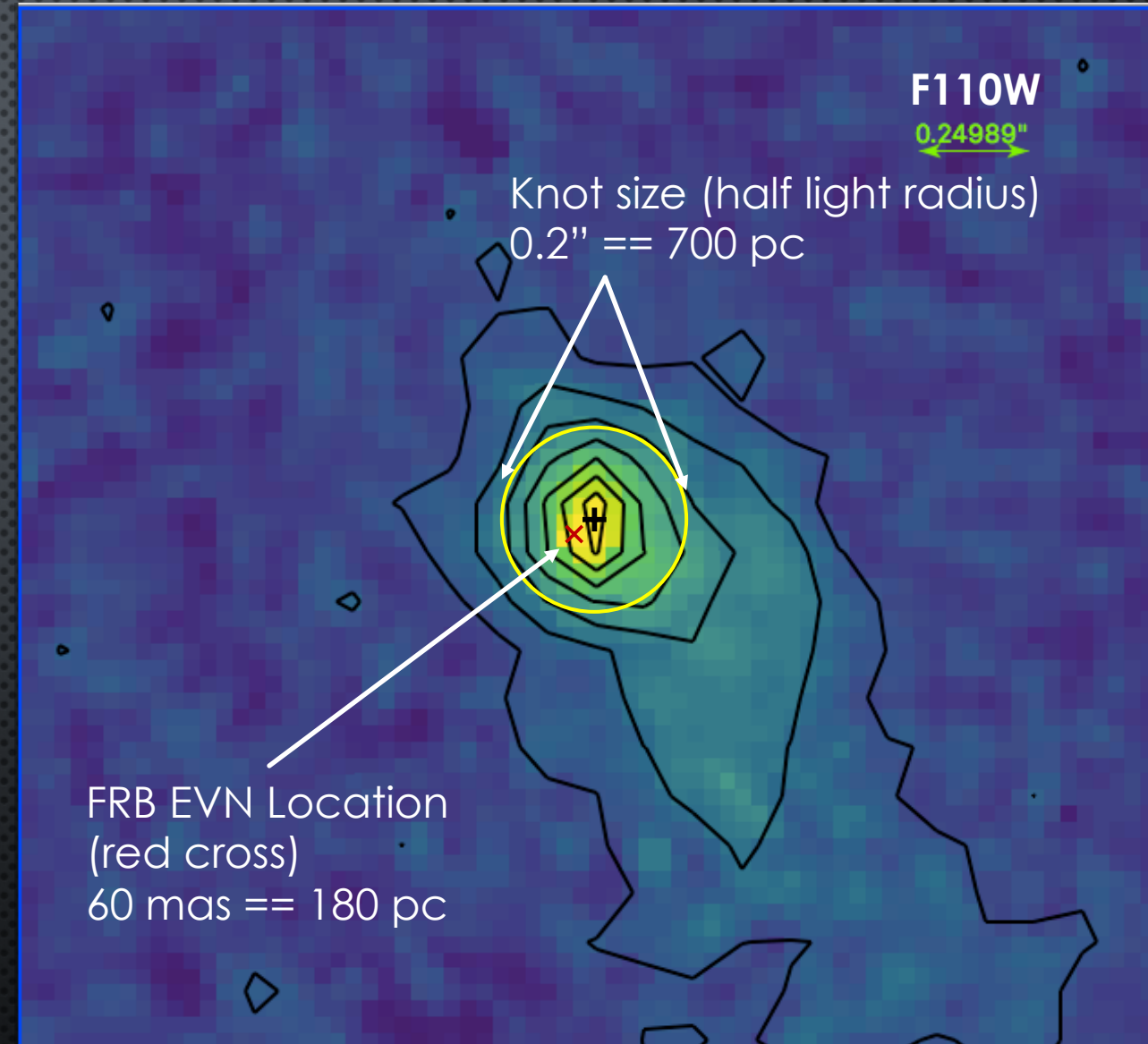
→ A very high emission measure

$$EM = \int n_e^2 ds$$

→ DM contribution $\leq 590 \text{ pc/cm}^3$

But $55 \leq DM_{\text{host}} \leq 225 \text{ pc/cm}^3$

Edge of the knot? Clumpy gas?



Summary of Properties

Size $\sim 5\text{--}7$ kpc (disturbed)

Mass $\sim 10^8 M_{\odot}$

Star formation rate $\sim 0.2 M_{\odot} / \text{yr}$

Metallicity $\approx 8.0 \pm 0.1$

SF Region ~ 700 pc in radius!

FRB offset by ~ 200 pc

Extreme emission line galaxy (EELG)

At 30 kpc scale: $1\text{-}\sigma$ overdensity(?)

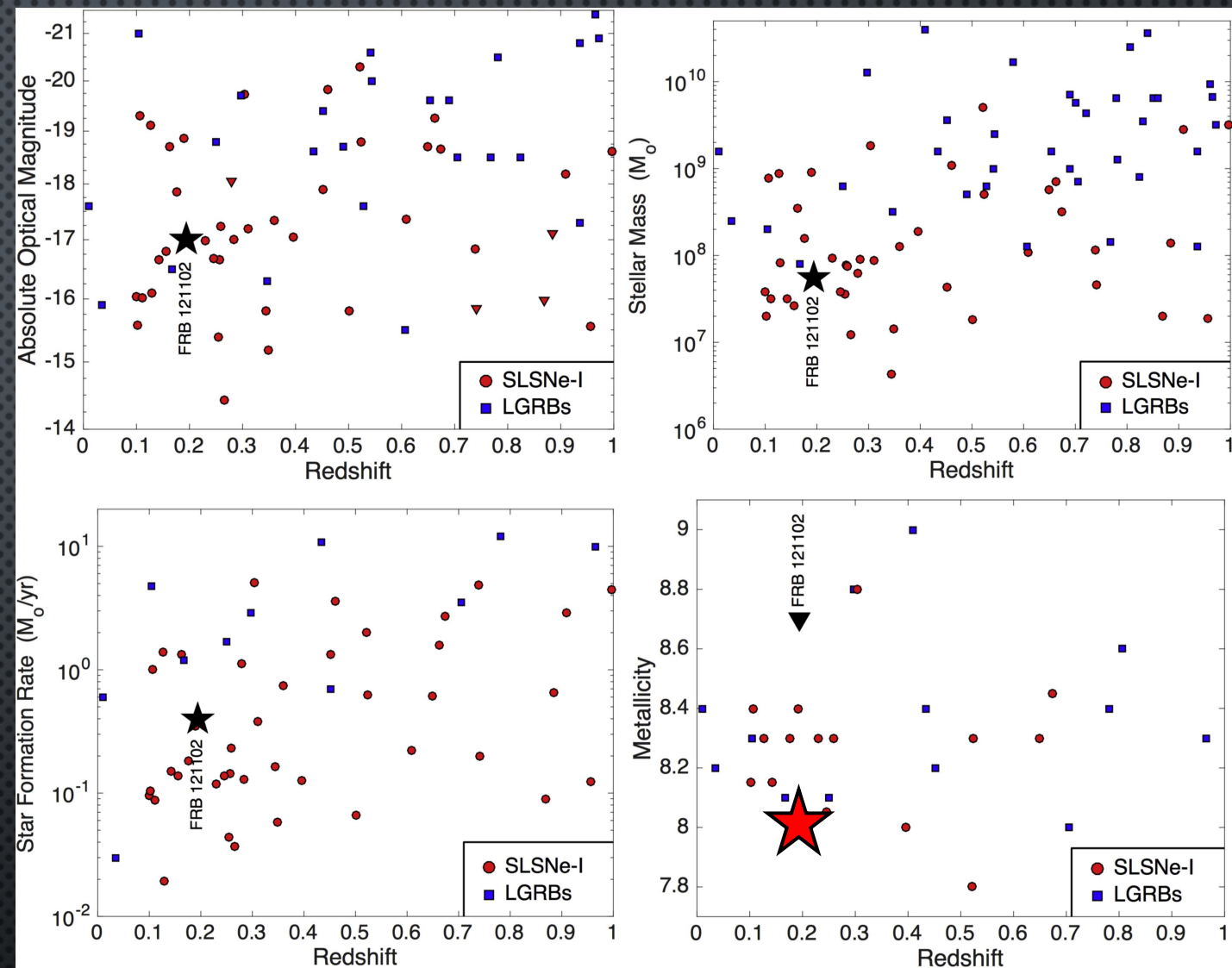
Comparing to other galaxies

Size $\sim 5\text{--}7$ kpc (disturbed)

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Metallicity ≈ 8.0



Metzger et al (2017)

Comparing to other galaxies

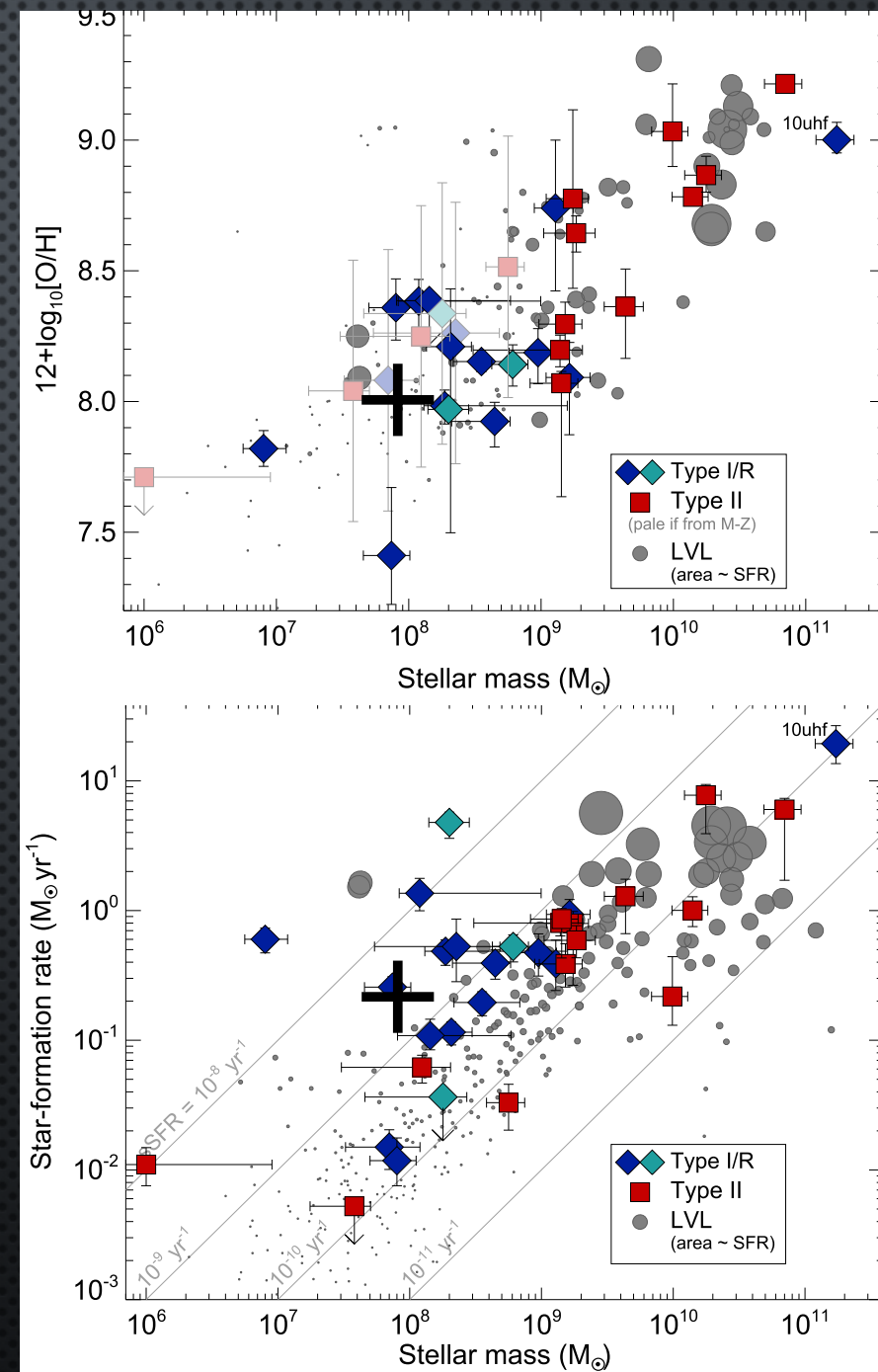
Size $\sim 5\text{--}7$ kpc (disturbed)

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Star formation rate $\sim 0.2 M_\odot / \text{yr}$

Metallicity ≈ 8.0

Perley et al (2016)



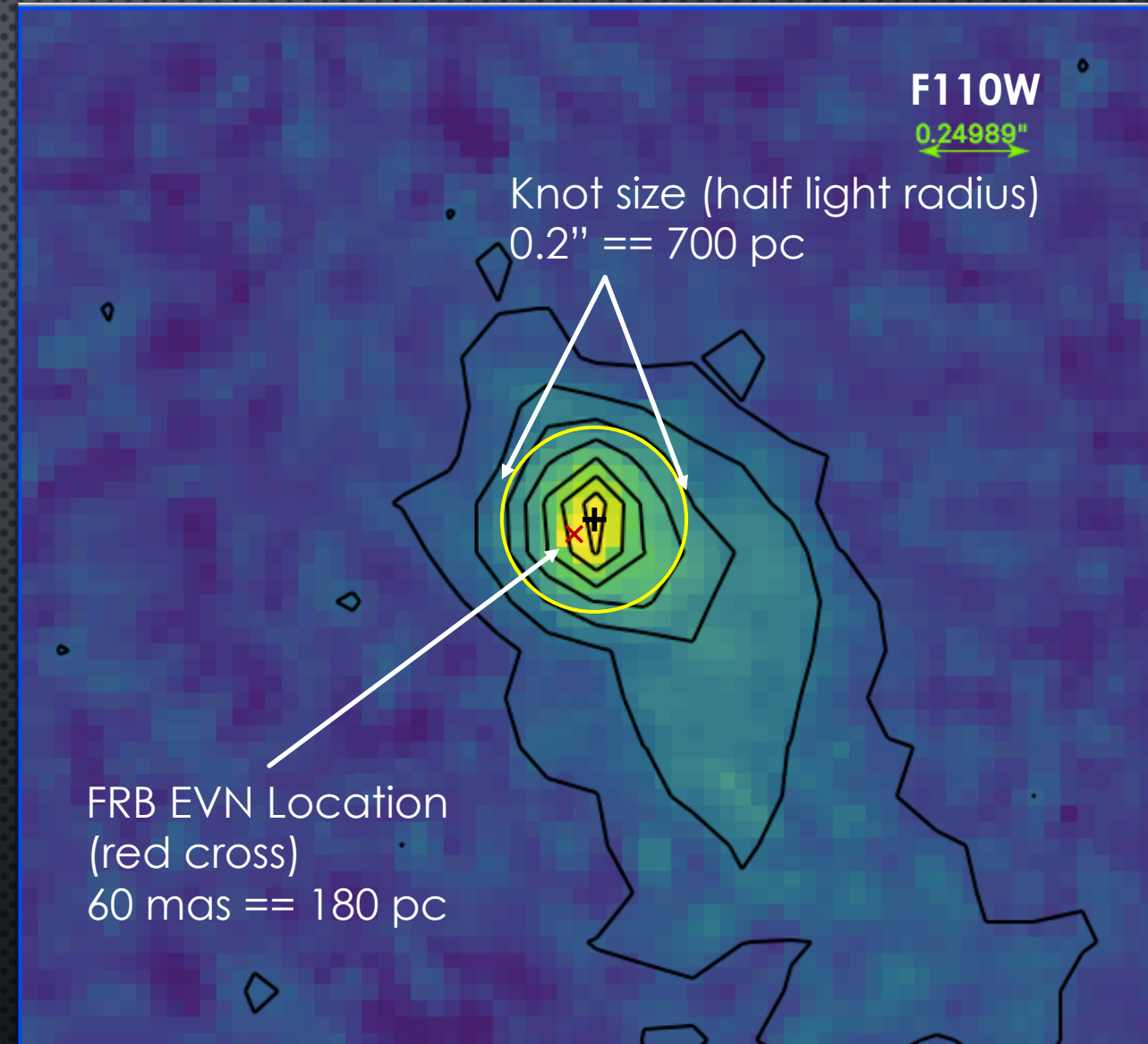
Why is the SF Region so big?

The half light radius is 700 pc!

Giant Molecular Clouds up to 300 pc have been observed.

Unresolved clump of GMCs?

High strehl AO with 8–10m class telescope might help.



Is there an AGN?
What is the radio source?

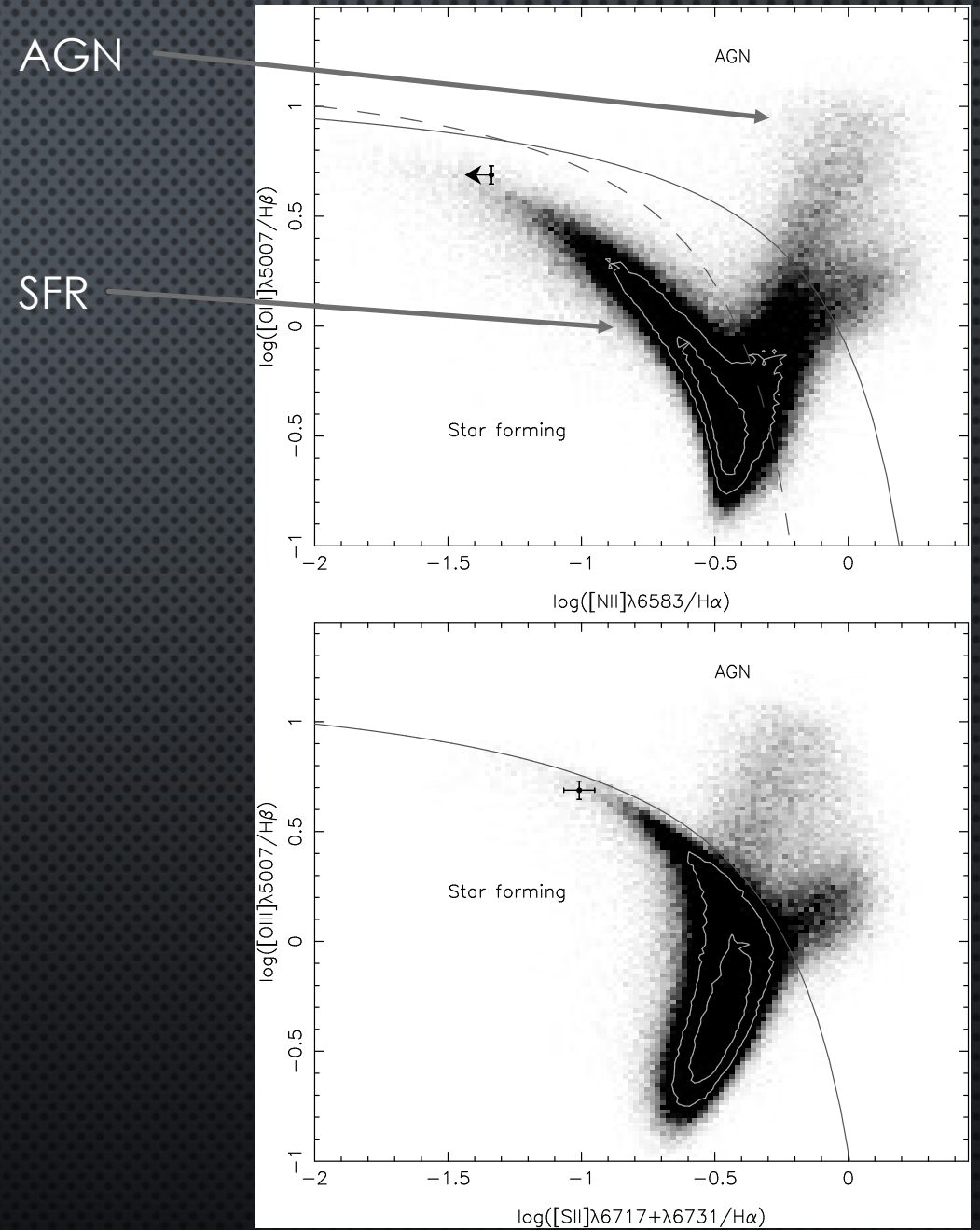
BPT DIAGRAM

(Baldwin Philips & Terlevich)

Line ratios diagnostic of AGN/SF

Lies in SF region

- BUT!
- Not very well calibrated for dwarfs
 - BH may be inactive



Is there an AGN? What is the radio source?

Jury is still out on the rate of occurrence of IMBHs in dwarf galaxies

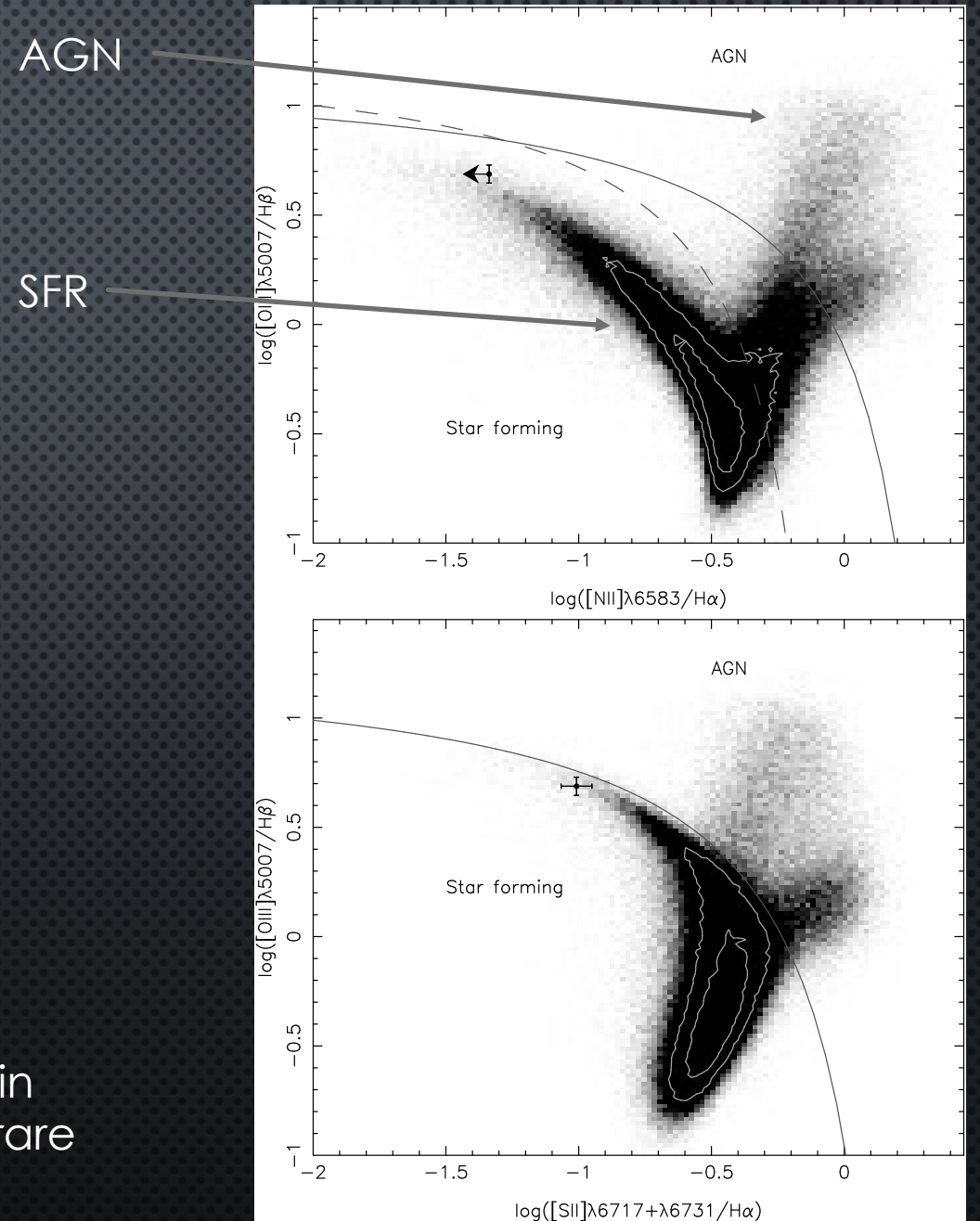
Only 0.5% of dwarf galaxies show AGN signatures in optical (Reines et al 2013)

Stacked X-ray images show excess (Mezcua et al 2016)

Many reasons to expect IMBHs (Silk 2017)

NOT CONCLUSIVE

But radio sources in galaxies are also rare (Eran's talk)



Following up future FRBs

IF FRBs are in dwarfs:

At $z = 1$ ($DM_{\text{excess}} \sim 1000$)

$m_{\text{AB}} = 28$ mag

Dwarfs are faint!

SLSNe redshifts are measured from the SLSNe, which are much brighter.

LGRBs often have bright afterglows.

Here, we have to depend on the galaxy.

This work took 9 hours of Gemini + 3 orbits of HST + 200 ks Spitzer

How do we follow up 100s of FRBs?

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Extreme emission line galaxy (EELG)

At 30 kpc scale: $1\text{-}\sigma$ overdensity(?)

Consistent with the hosts of LGRBs and SLSNe-I
but single data point