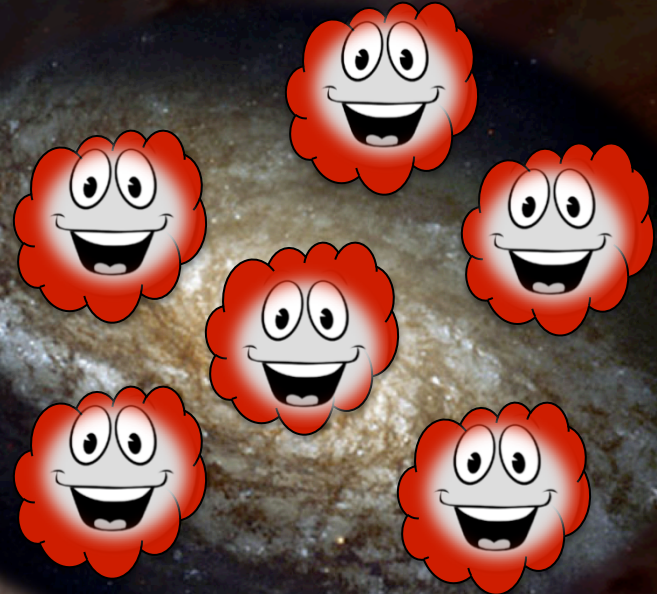


Isolated HII Regions: Star Formation in the Sub-Threshold Regime



Jessica Werk

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University of Michigan Studying at Columbia University as a
Non-Degree-Seeking Visiting Scholar

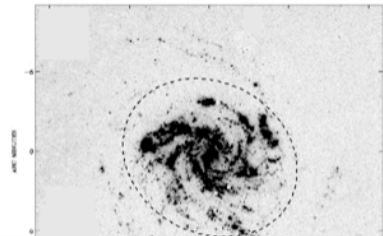
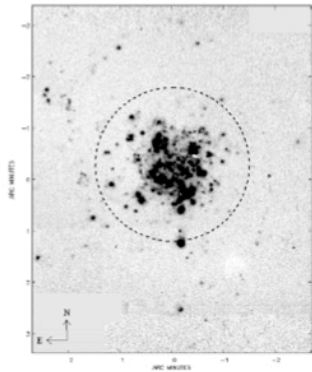
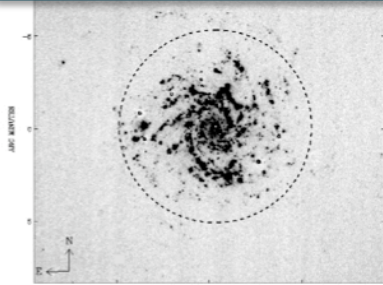
Thesis Advisor: Mary Putman, Columbia University

Co-Advisor: Gerhardt Meurer (JHU)

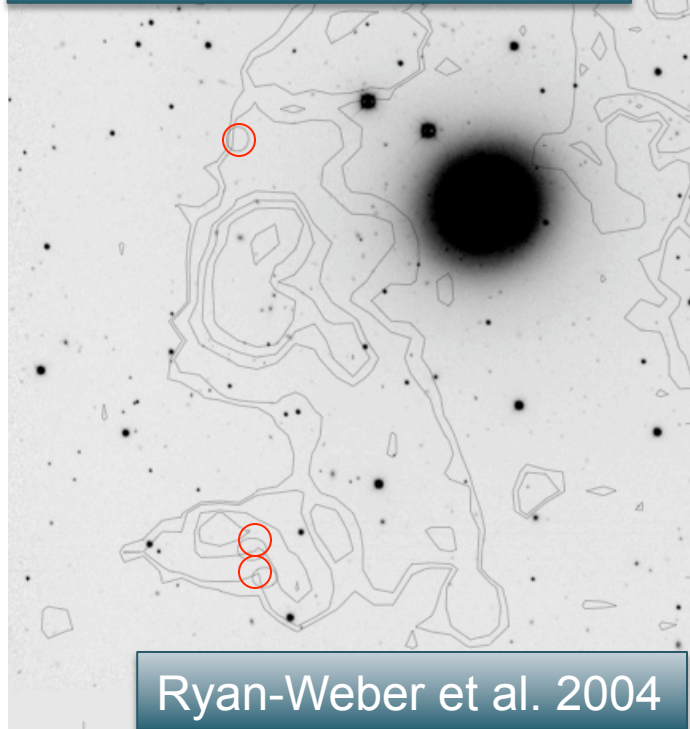
Contributors: The SINGG Team

HII Regions Beyond Typical Thresholds

Part of extended spiral structure:

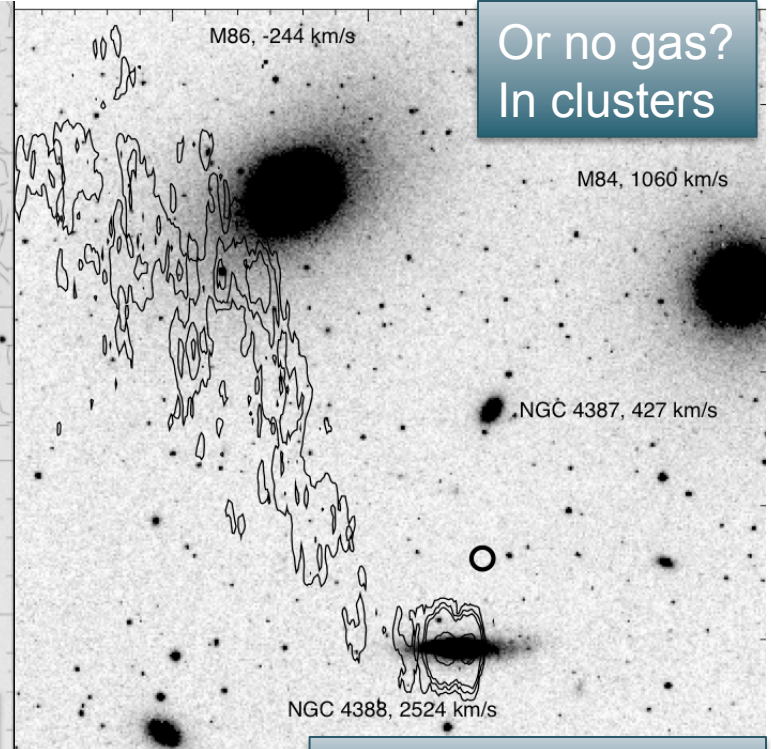


Isolated, in stripped HI Gas



Ryan-Weber et al. 2004

Or no gas?
In clusters



Gerhard et al. 2002

Ferguson et al. 1998;
Bland-Hawthorn et al. 1997;
Martin and Kennicutt 2001

ESO 1.5m, LBVR

Broadening the View of Outer Star Formation: XUV Clusters

GALEX

Thilker et al. 2007:
Roughly 30% of
galaxies have XUV
disks (commonplace!)

Correlated with galaxy
perturbations

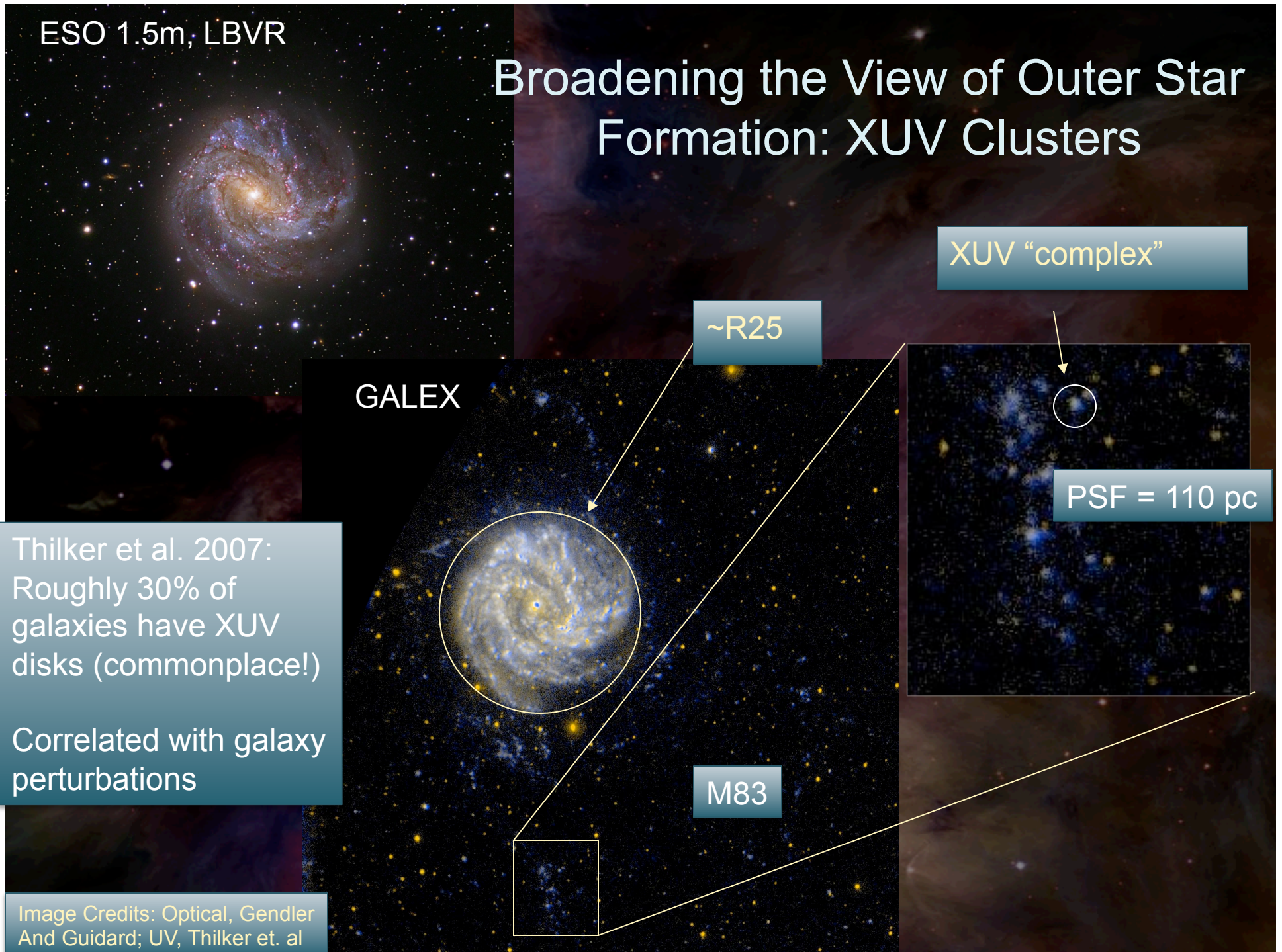
~R25

XUV “complex”

PSF = 110 pc

M83

Image Credits: Optical, Gendler
And Guidard; UV, Thilker et. al



How do Isolated HII Regions fit into and inform a picture of “sub-critical” star formation?

- Systematic search of local ($v \leq 12000 \text{ km s}^{-1}$) gas-rich galaxies using the Survey for Ionization in Neutral Gas Galaxies (SINGG) – massive, young stars in outskirts
- Comparison with deep ($t > 1000 \text{ s}$) GALEX images
- Role of galaxy interactions: a sample of HI Rogues
- Local oxygen enrichment of outer gas based on emission-line spectra
- High-resolution studies of stellar populations with HST

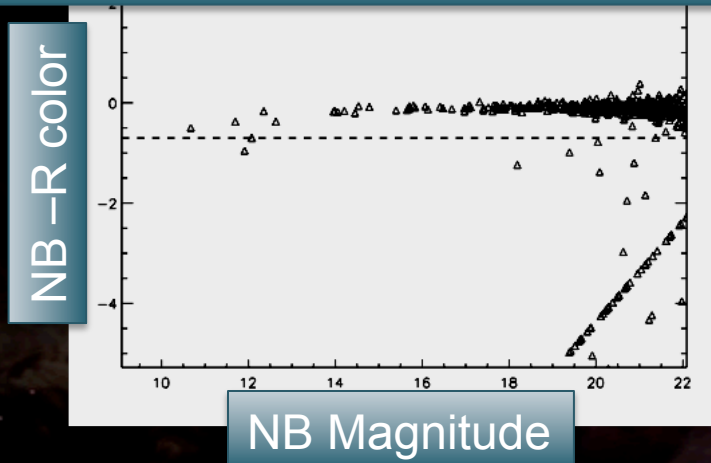
The Nature and Frequency of Isolated Emission-Line Sources in SINGG

SINGG:

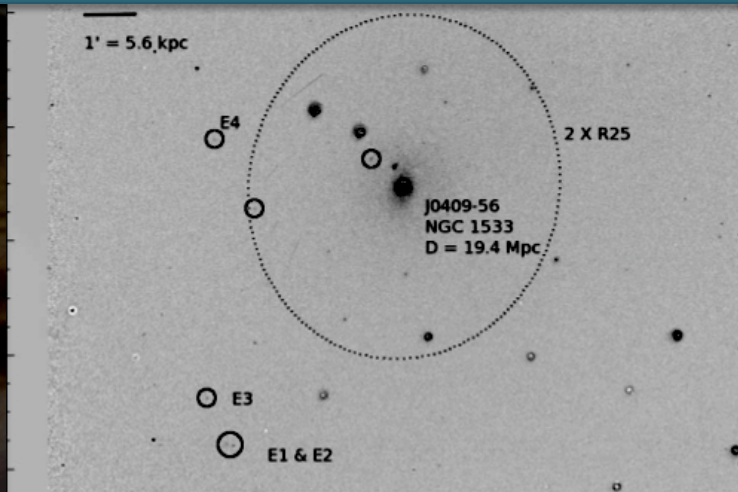
- Selected from HIPASS
- H α and R-band imaging
- 1st Data Release: 93 HIPASS Targets;
Meurer et al. 2006
- 14.7' FOV; $\sim 1.6''$ seeing
- 5σ limiting H α flux for point source:
 1.6×10^{-16} ergs cm $^{-2}$ s $^{-1}$
(at median distance of SINGG
about 1 O7V star)
- Unbiased sample of gas-rich galaxies

An Automated Search for Isolated HII Regions

SExtractor detects sources in NB, R, and Rsub:

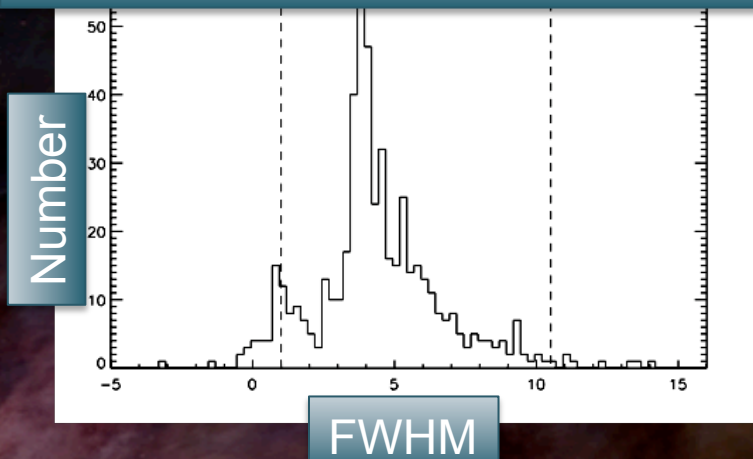


NB - R color cut = $0.7 \sim \text{EW} > 20 \text{ \AA}$

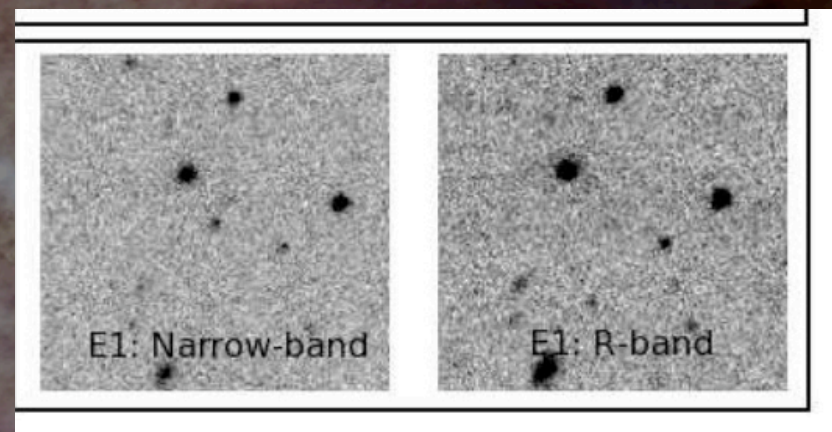


SB cut: Outside two times $\mu_R = 25 \text{ mag arcsec}^{-2}$ elliptical isophote of any of the potential host galaxies in an image.

FWHM (size) cut: $> 1 \text{ pixel}; < 3\sigma \text{ mean}$

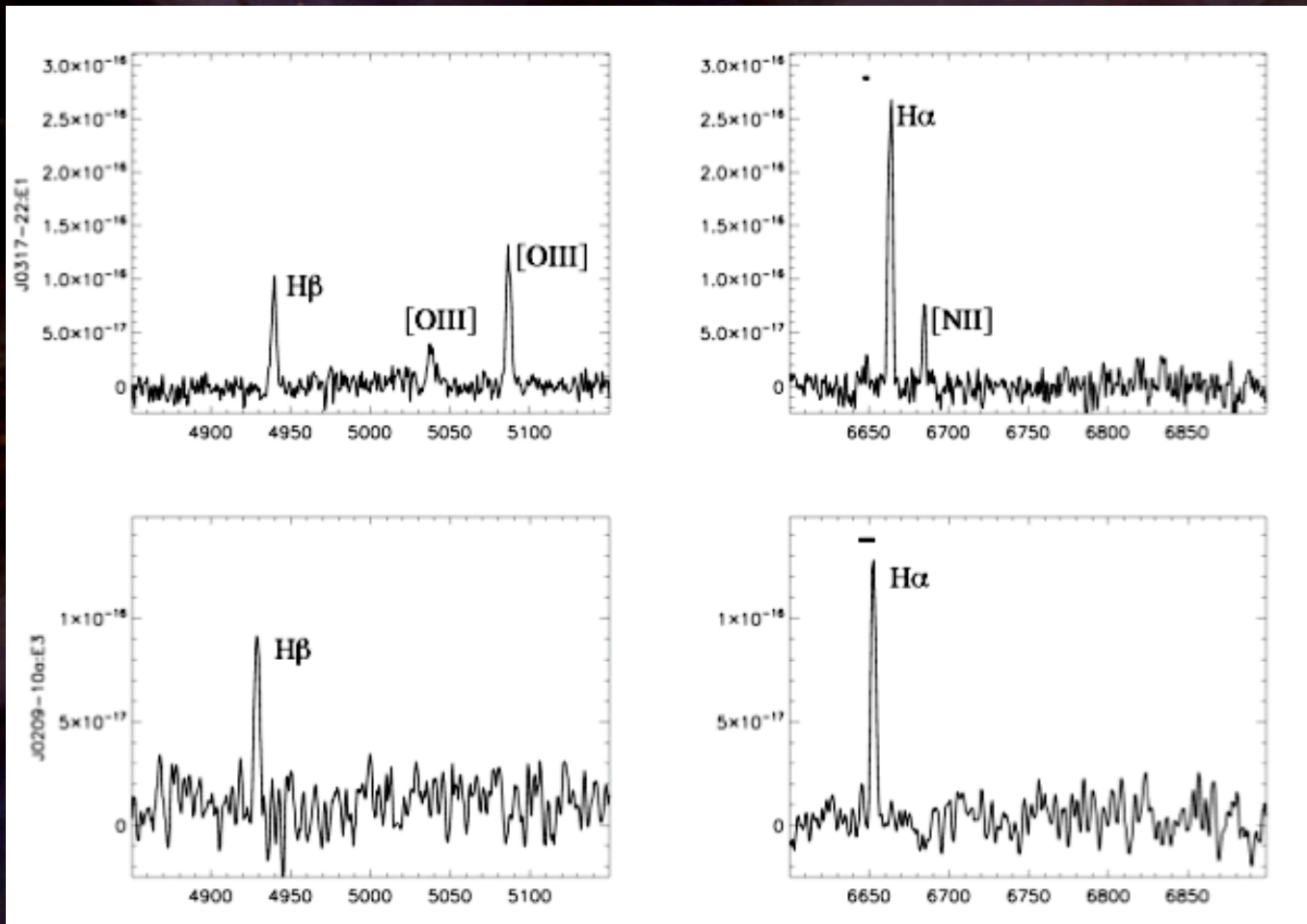


Auto-display image cut-outs of candidates



AND...Spectroscopic Follow-up

Confirms the candidate is an isolated HII region and not a background galaxy ([OIII], [OII], or H β) shifted into the SINGG narrowband filter at a redshift of $\sim 0.3 - 0.8$



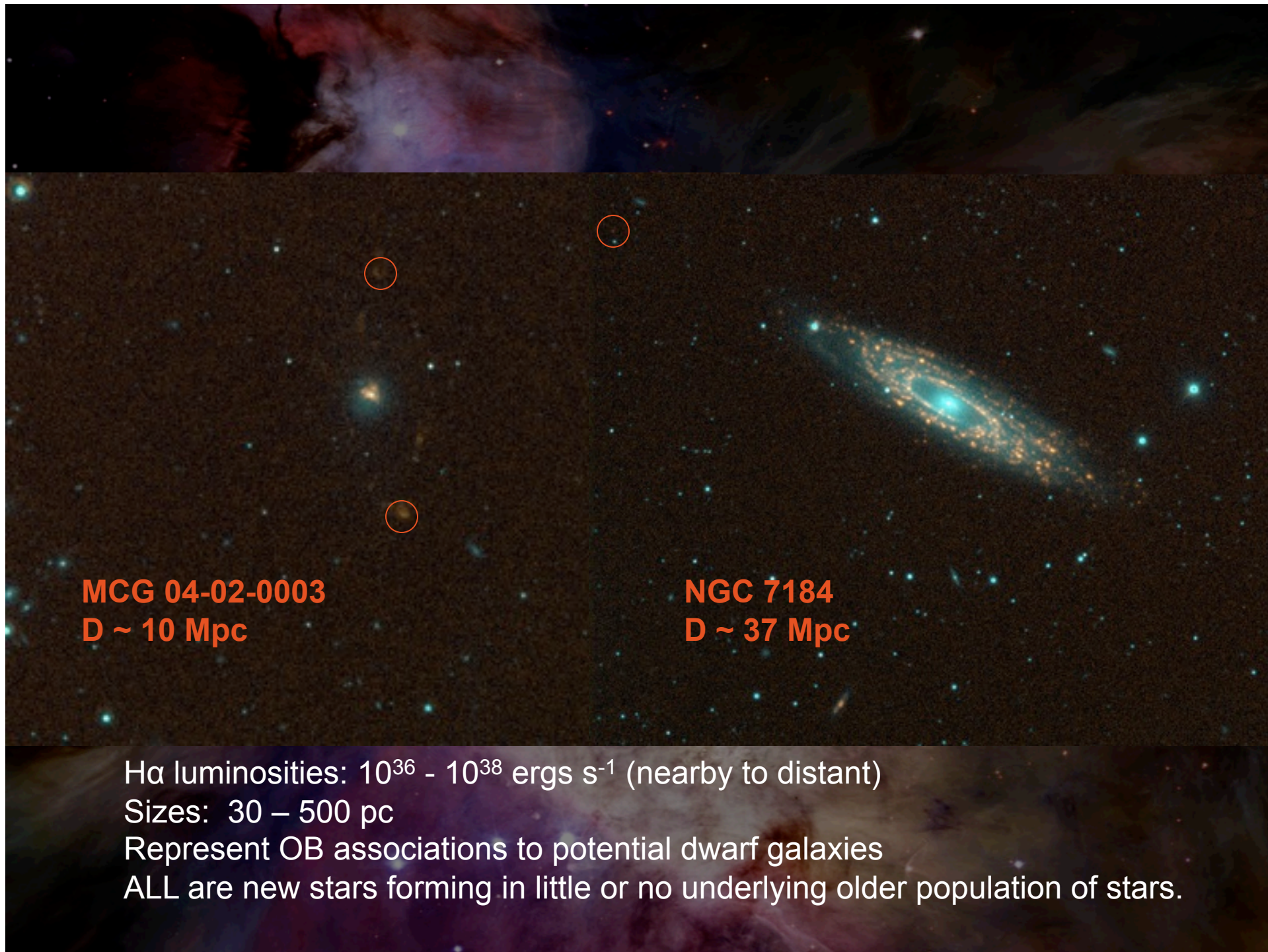
Isolated HII Regions in SINGG

ESO 481-G017
D ~ 55 Mpc

NGC 1512/10
D ~ 10 Mpc

NGC 1533
D ~ 21 Mpc

HCG 16
D ~ 50 Mpc



MCG 04-02-0003
D ~ 10 Mpc

NGC 7184
D ~ 37 Mpc

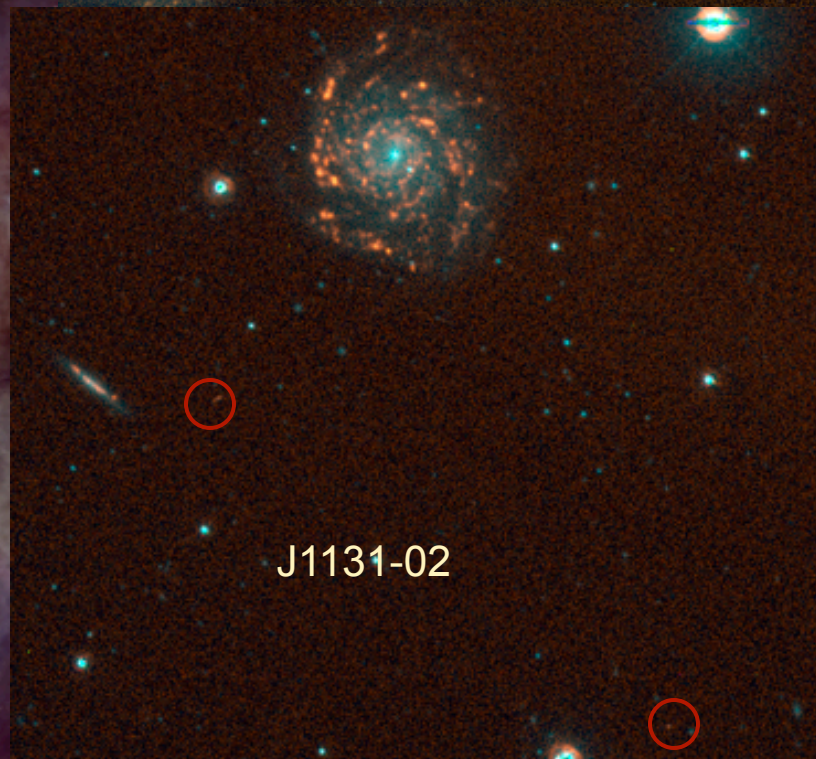
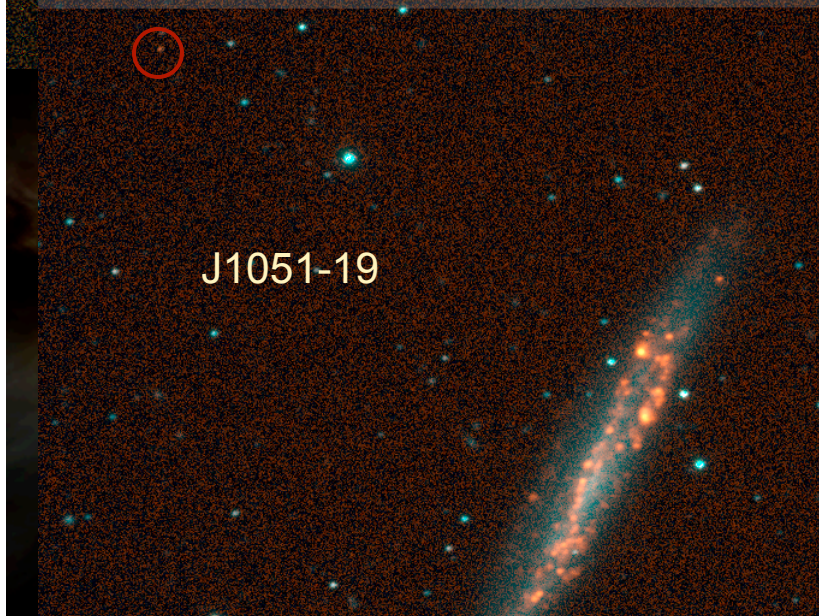
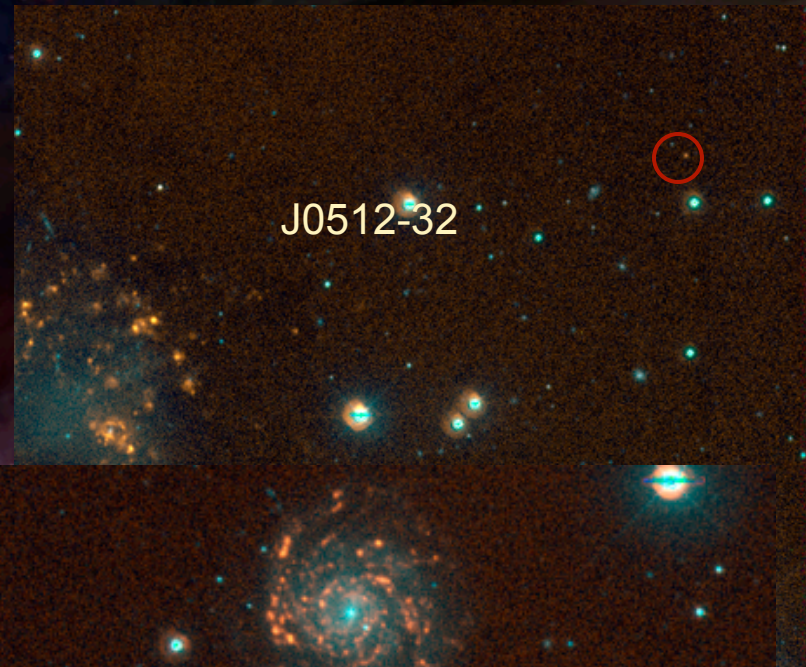
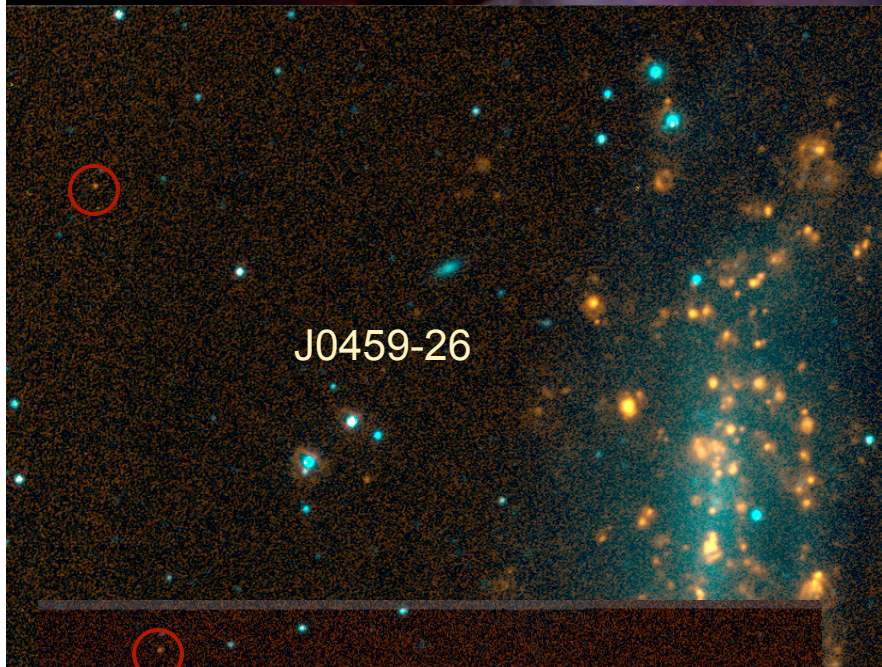
H α luminosities: 10^{36} - 10^{38} ergs s $^{-1}$ (nearby to distant)

Sizes: 30 – 500 pc

Represent OB associations to potential dwarf galaxies

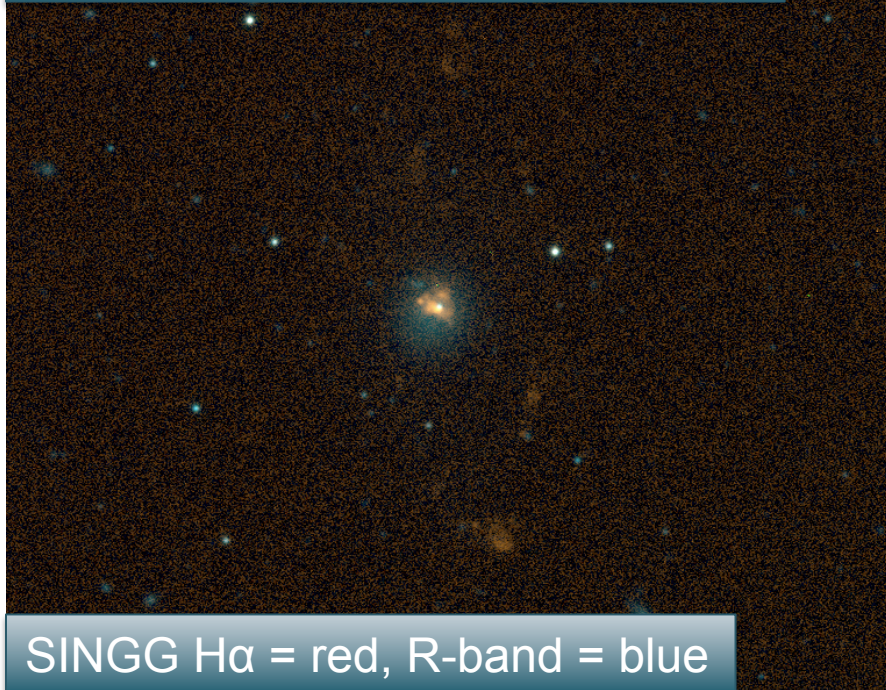
ALL are new stars forming in little or no underlying older population of stars.

Examples of SINGG $z \sim 0.3$ Emission-Line Galaxies

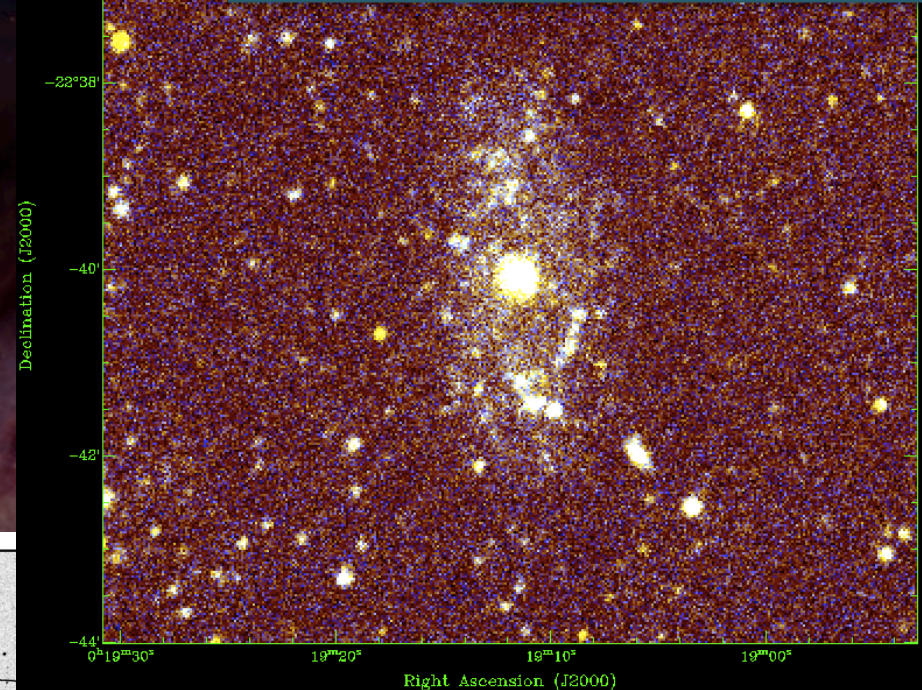


Isolated HII Regions Associated with XUV emission

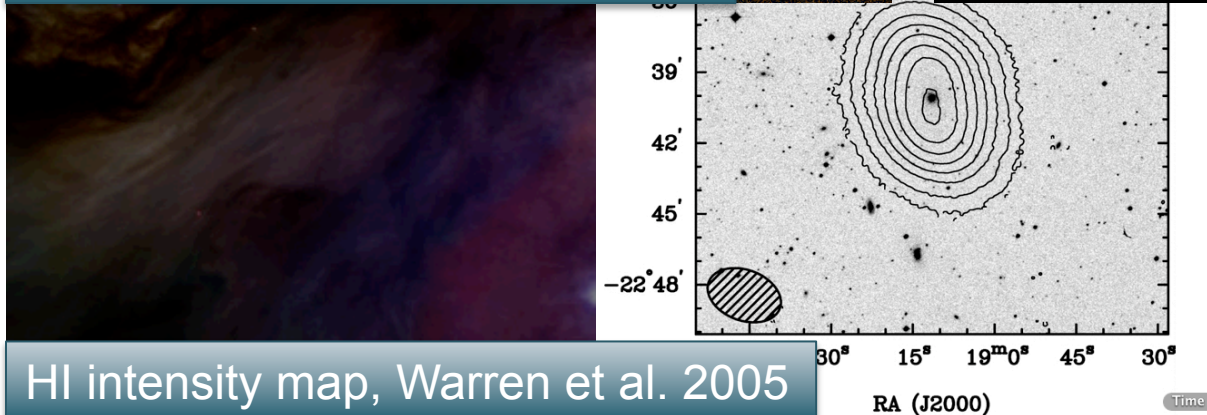
HIPASS J0019-22; MCG-04-02-03



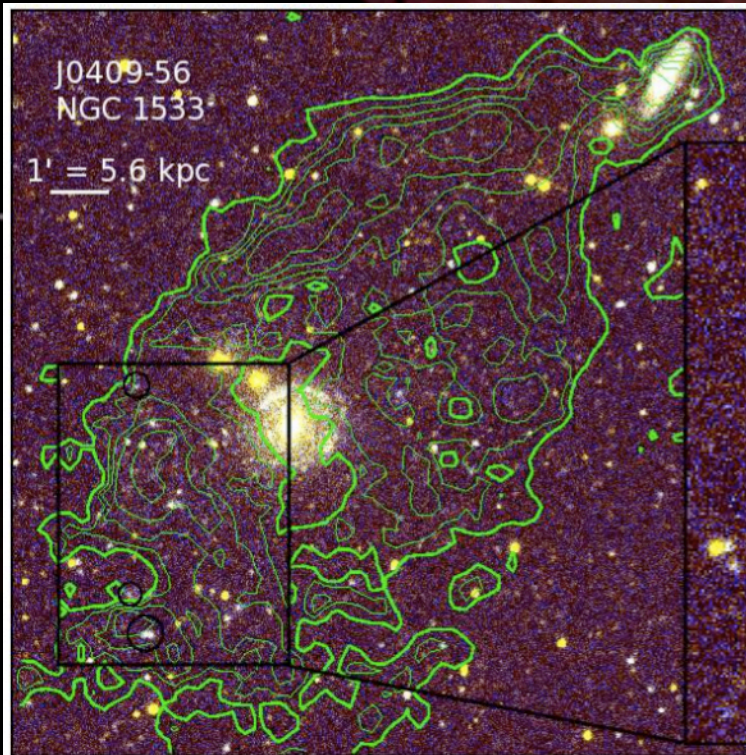
GALEX FUV = blue, NUV = yellow



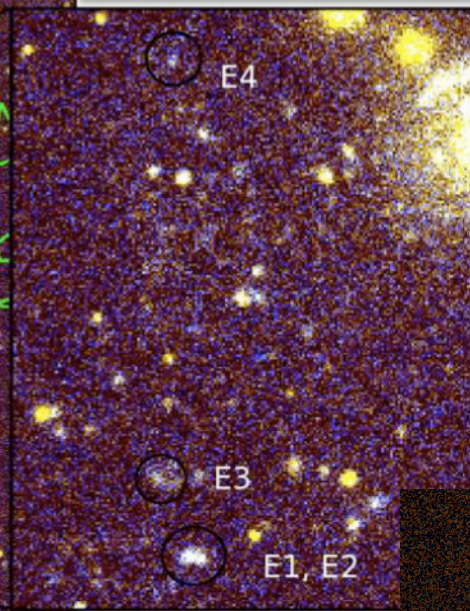
SINGG H α = red, R-band = blue



Searched GALEX archive for images with exposure times > 1000s
Found IHIs via position matching
3 systems with IHIs have GALEX data

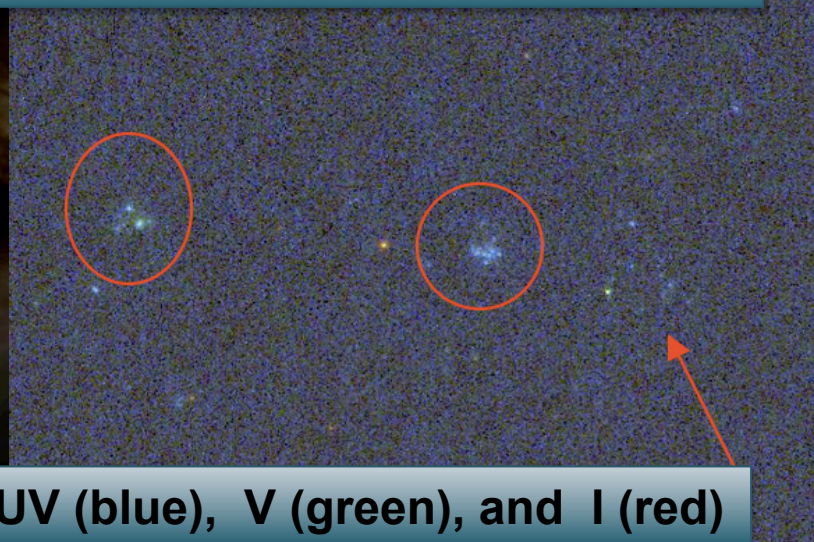


GALEX FUV = blue, NUV = yellow

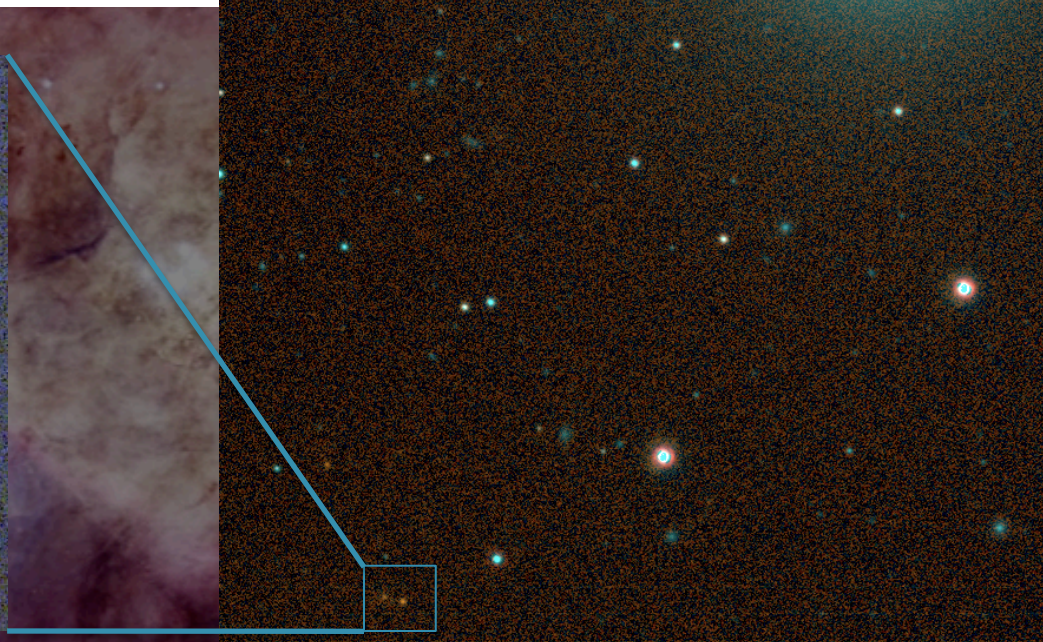


SINGG H α = red, R-band = blue

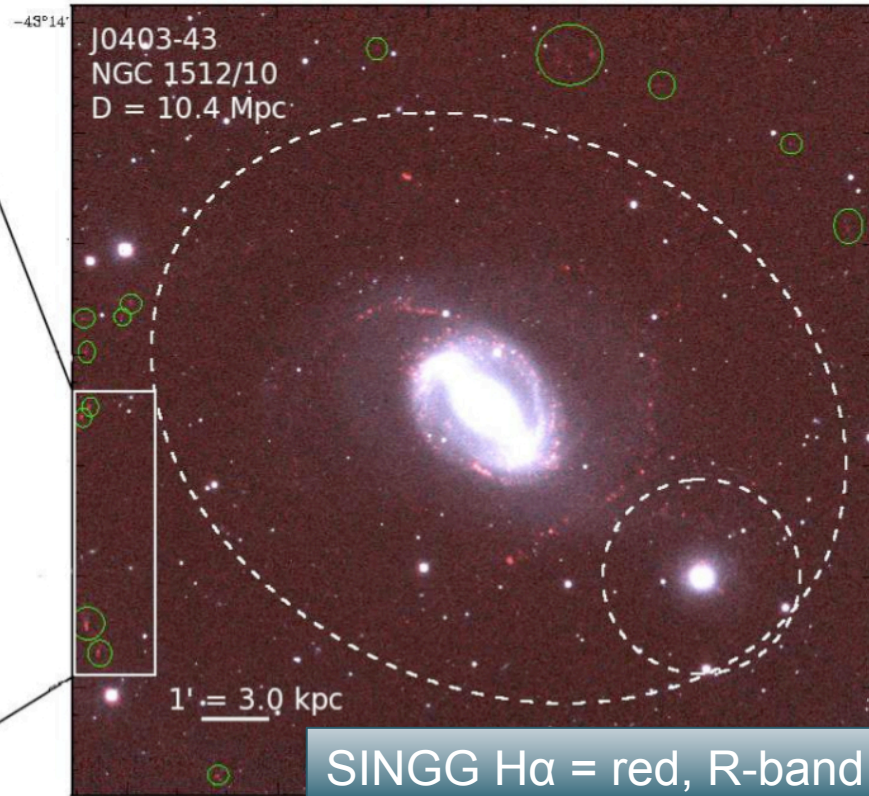
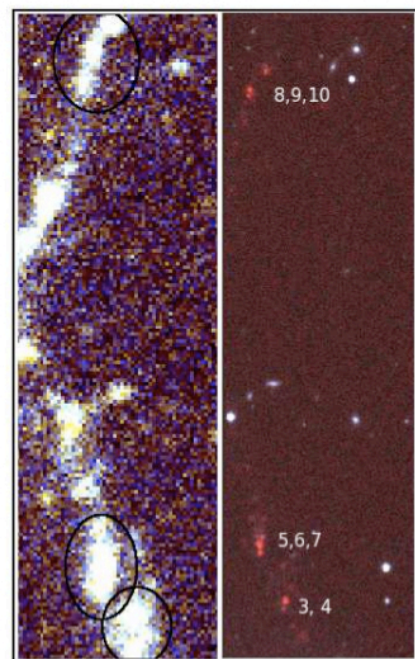
Werk et al. 2008: HST HRC images



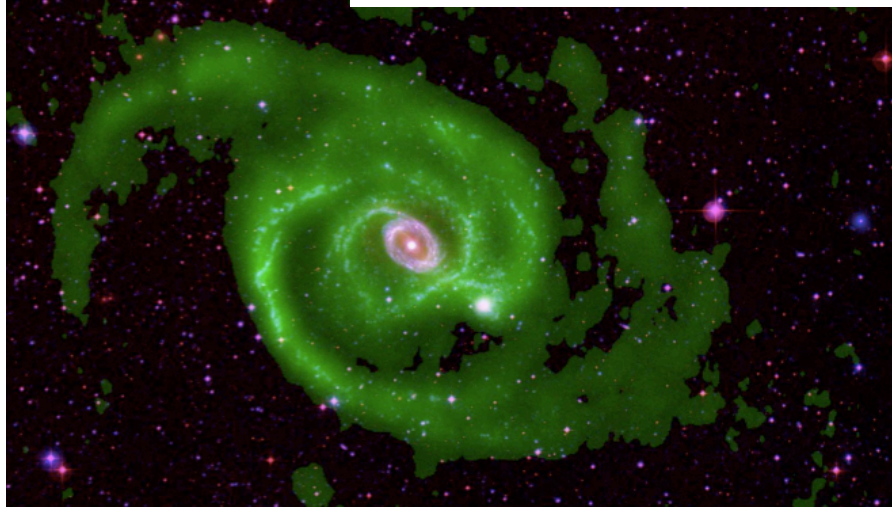
UV (blue), V (green), and I (red)



NGC 1512 / 1510



SINGG H α = red, R-band = blue



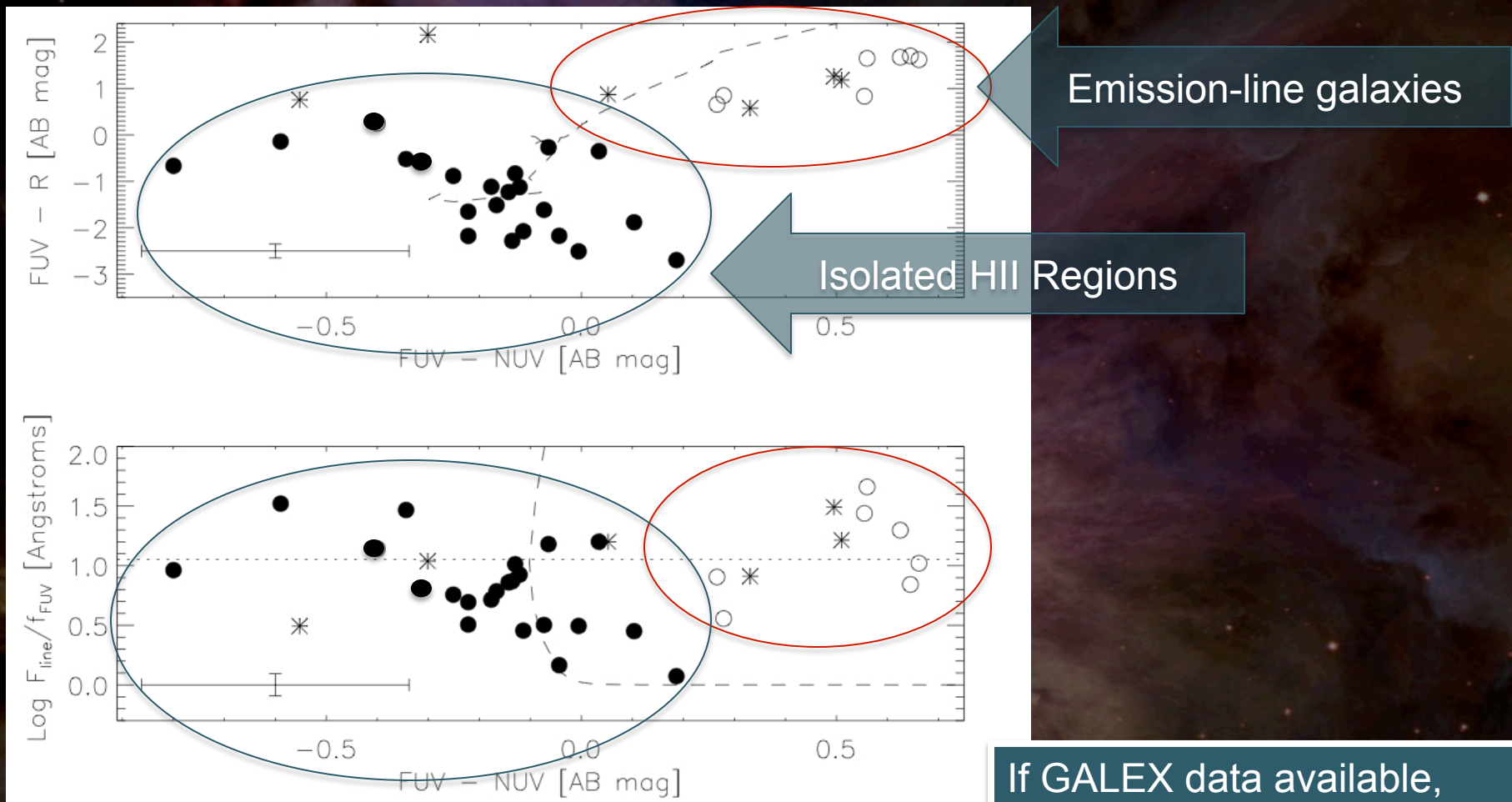
HI map: Koribalski and Lopez-Sanchez, submitted

NUV (blue) + H I (green) + R (red)



GALEX FUV = blue, NUV = yellow

GALEX, SINGG colors



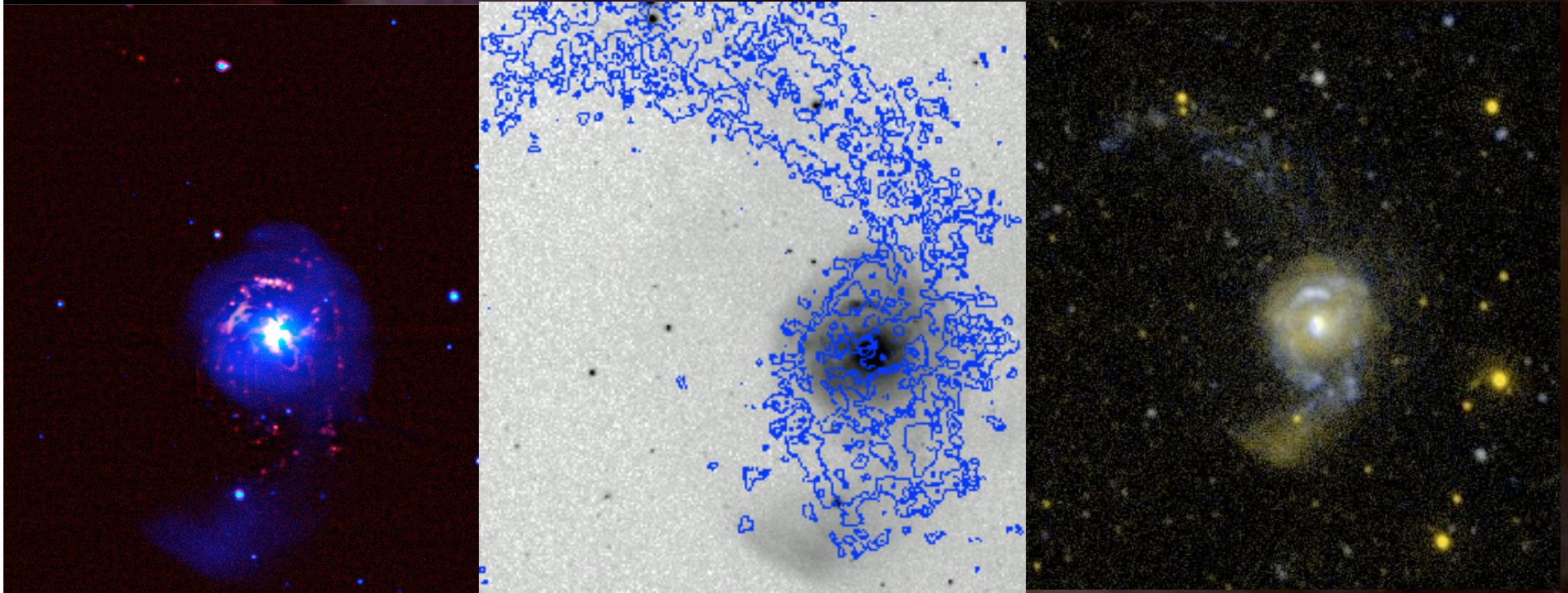
If GALEX data available, follow-up spectroscopy is unnecessary for confirmation of Isolated HII Region.

Main Results

- ~10% of nearby gas-rich galaxies have isolated HII regions
 - Total search area = 4.0 deg^2 (168 Å deg^2); 89 SINGG galaxies with $\text{FOV} > 2 \times R_{25}$; 8 systems w/ IHIIIs
- Isolated HII regions associated with XUV emission (Type 1 morphologies; when GALEX data available)
- Isolated HII regions associated with interactions/disturbed HI morphologies

What's Next?

Careful Cross-Comparisons between H α and UV



Additional 14 HI Rogues with IHIs
imaged in H α and R with MDM 2.4-m

with available HI maps and GALEX data

Implications for thresholds or lack thereof in low surface brightness regime...

Oxygen Abundances of Outer, Low-Density Gas

Enrichment level of gas sheds light on nature of outer, “sub-threshold” star formation

Multislit spectra
for 14 rogues with
ELdots + NGC 1533 and
NGC 2915

Oxygen abundances via
R23 method of outer
gaseous material
compared to within galaxy

NGC 2915:
Isolated HII regions:
 $12 + \log (O/H) = 8.25$
Central HII regions:
 $12 + \log (O/H) = 7.9$

