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A Survey for Dual Megamasers

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A Tale of Two Maser Species

OH Megamasers

- Pumped with FIR photons.
- Relatively high temperatures $\sim$ 160 K
- Large column densities
- Emission extends over some hundreds of parsecs across.

H_2O Megamasers

- Collisionally pumped
- Higher temperatures $\sim$ 300 K
- Yet higher densities, pressures
- Emission very compact: on parsec-scale.

Lonsdale Hypothesis (2002)

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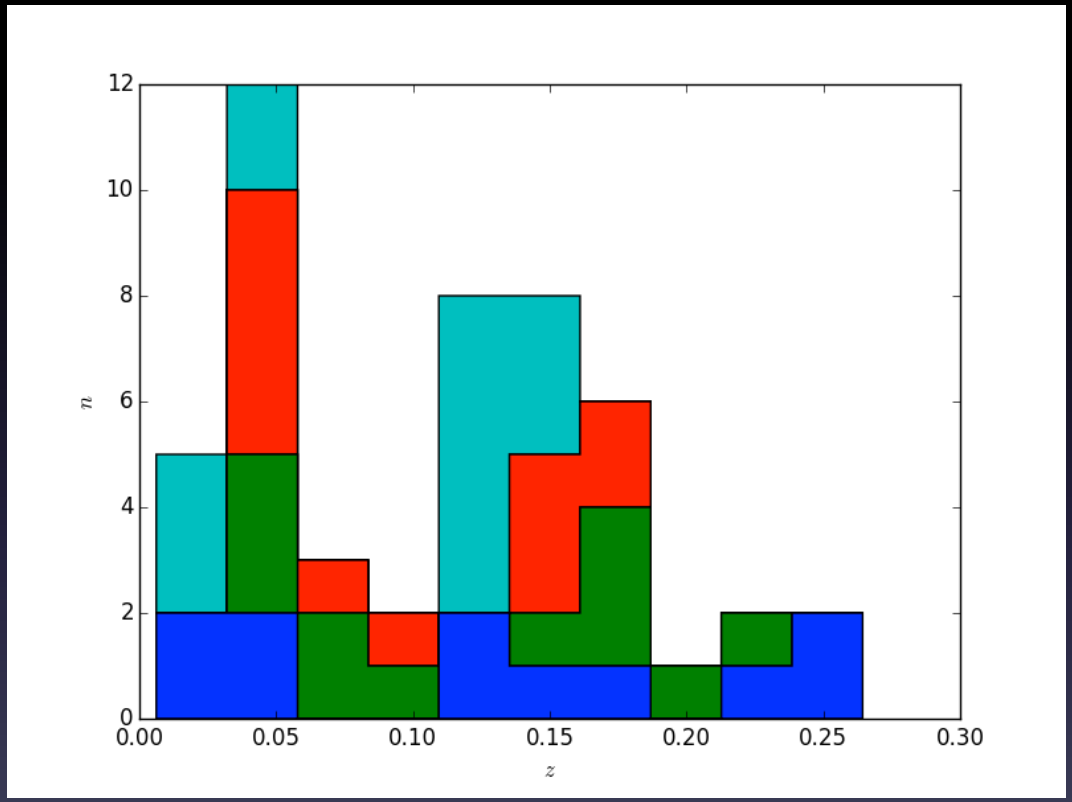
Previous Studies:

- ~ 4000 galaxies searched for water, 150 detections
- ~ 500 galaxies searched for OH, 120 detections

Our Survey:

- Observed ~45 confirmed OH megamaser hosts for 22 GHz water (taken from Tarchi et al. 2011)
- Sources observed for 30, 40 or 60 minutes

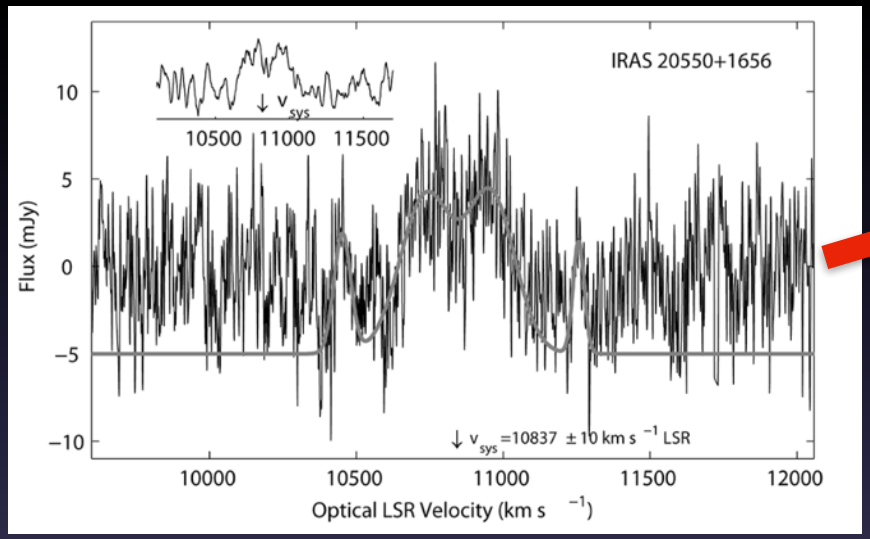
The Sample



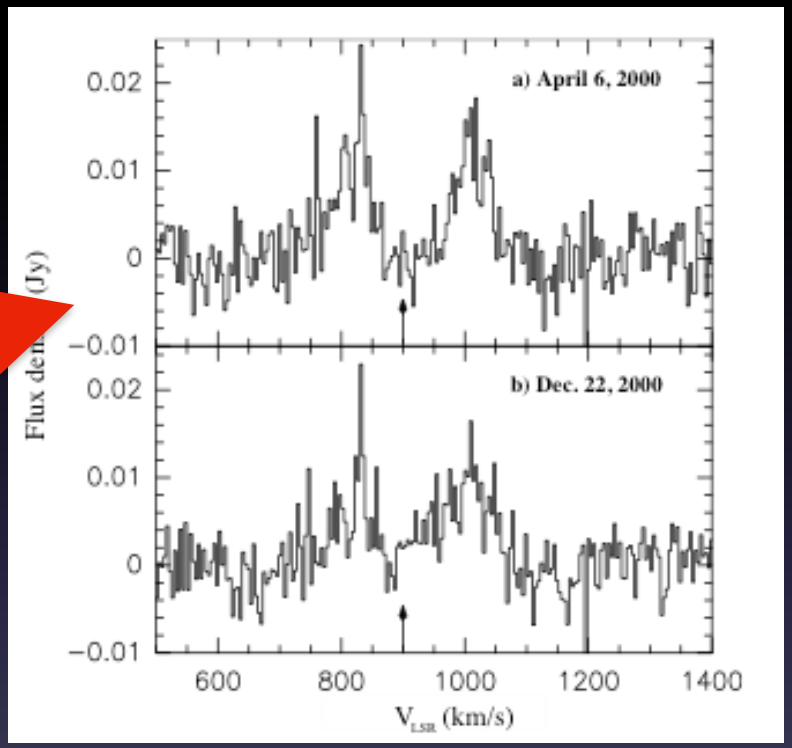
Blue - SEYFERT AGN
Green - LINER AGN
Red - HII Nuclei
Cyan - no NED classification

II Zw 96

Previous tentative detection (Wagner 2013)

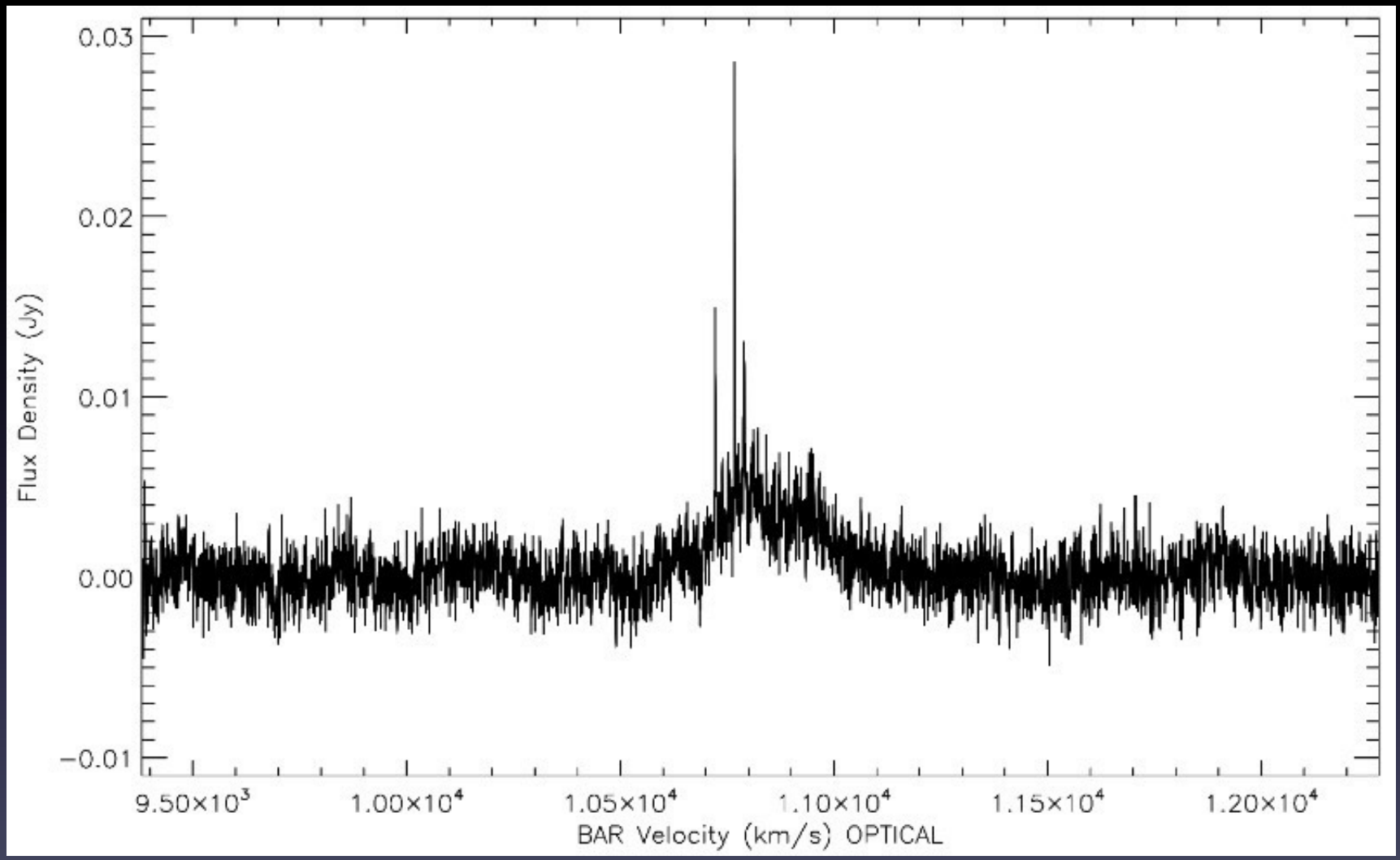


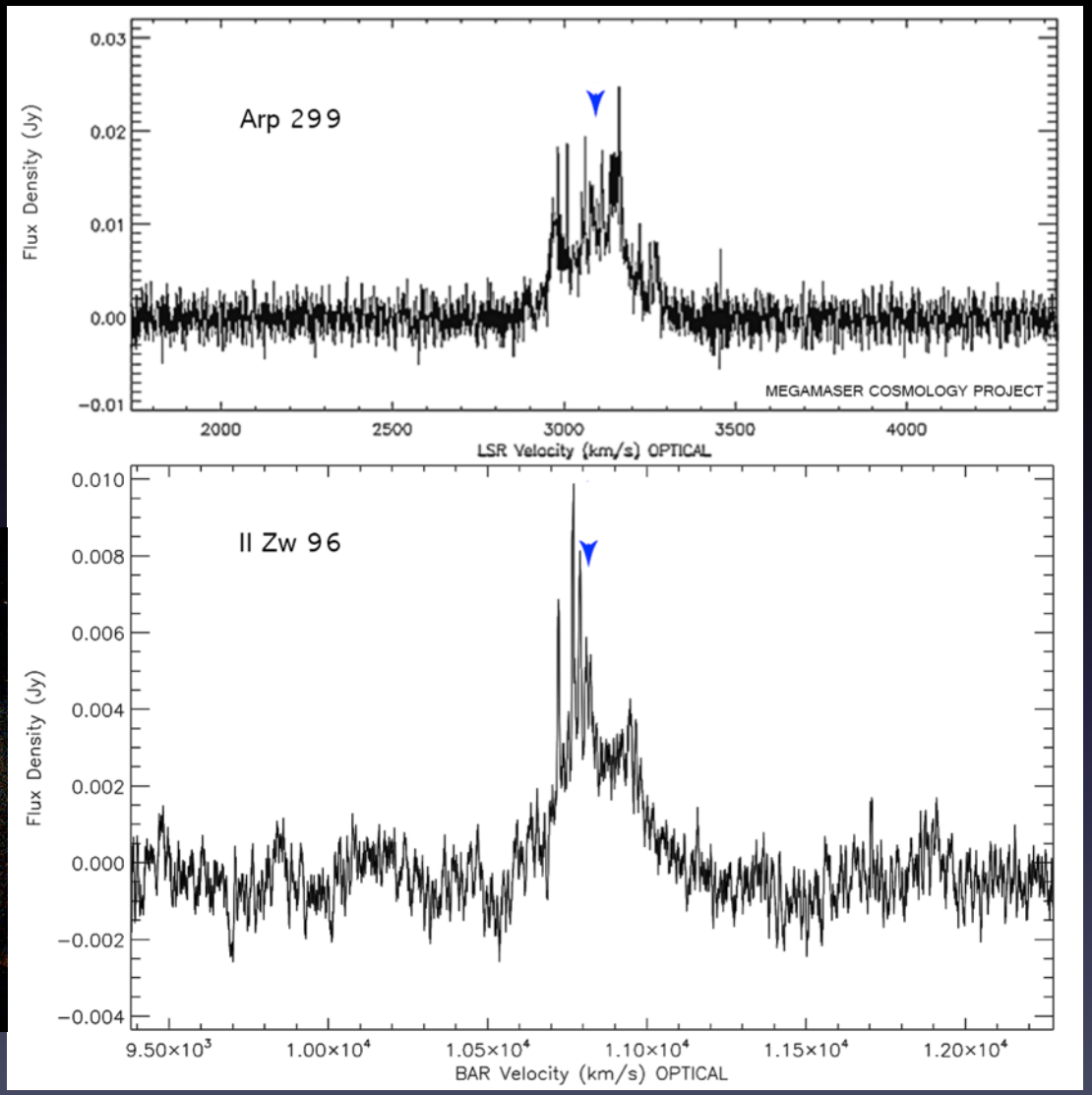
?

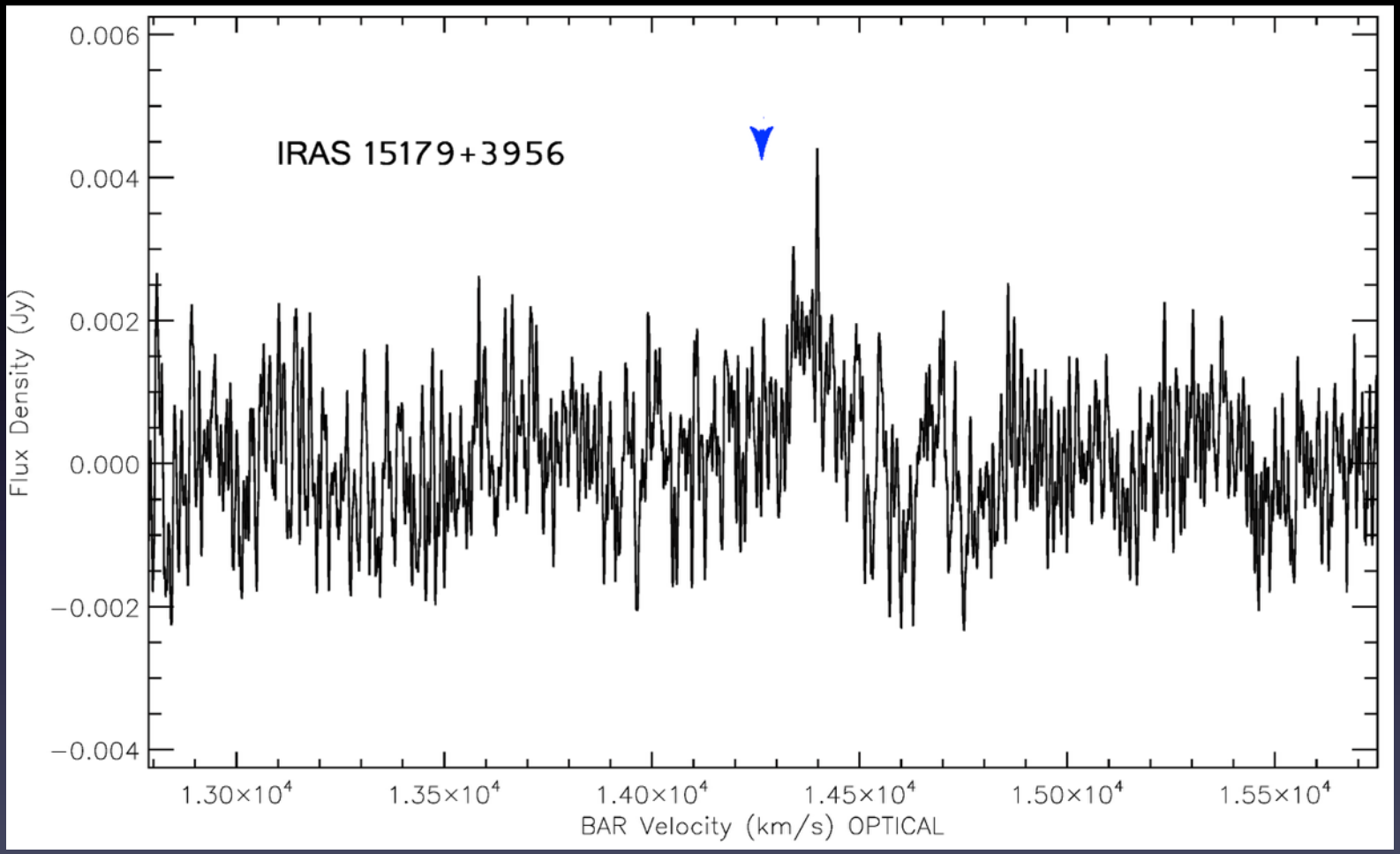


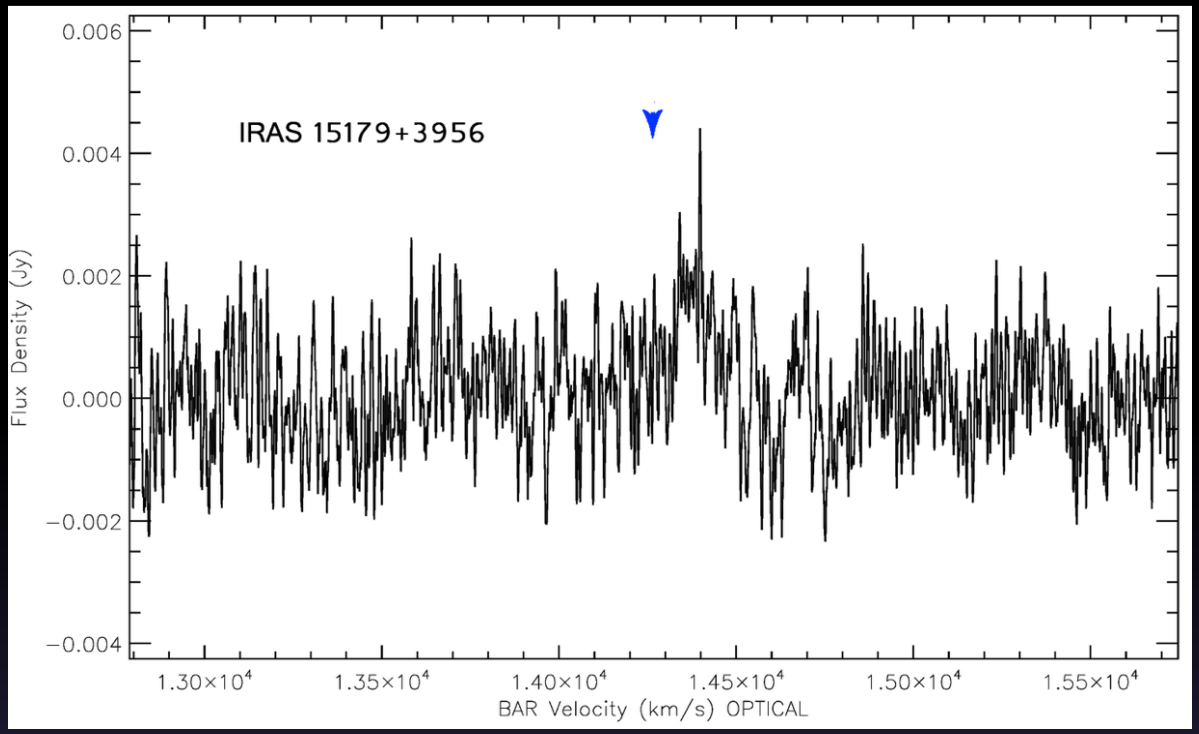
II Zw 96
Wagner (2013)

NGC 2146
Tarchi et al. 2002


0.03
0.02
0.01
0.00
−0.01
Flux Density (Jy)
9.50×10³
1.00×10⁴
1.05×10⁴
1.10×10⁴
1.15×10⁴
1.20×10⁴
BAR Velocity (km/s) OPTICAL


Arp 299
Flux Density (Jy)
0.03
0.02
0.01
0.00
−0.01
2000
2500
3000
3500
4000
LSR Velocity (km/s) OPTICAL
MEGAMASER COSMOLOGY PROJECT
II Zw 96
Flux Density (Jy)
0.010
0.008
0.006
0.004
0.002
0.000
−0.002
−0.004
9.50×10³
1.00×10⁴
1.05×10⁴
1.10×10⁴
1.15×10⁴
1.20×10⁴
BAR Velocity (km/s) OPTICAL


IRAS 15179+3956
0.006
0.004
0.002
0.000
−0.002
−0.004
Flux Density (Jy)
1.30×10^4
1.35×10^4
1.40×10^4
1.45×10^4
1.50×10^4
1.55×10^4
BAR Velocity (km/s) OPTICAL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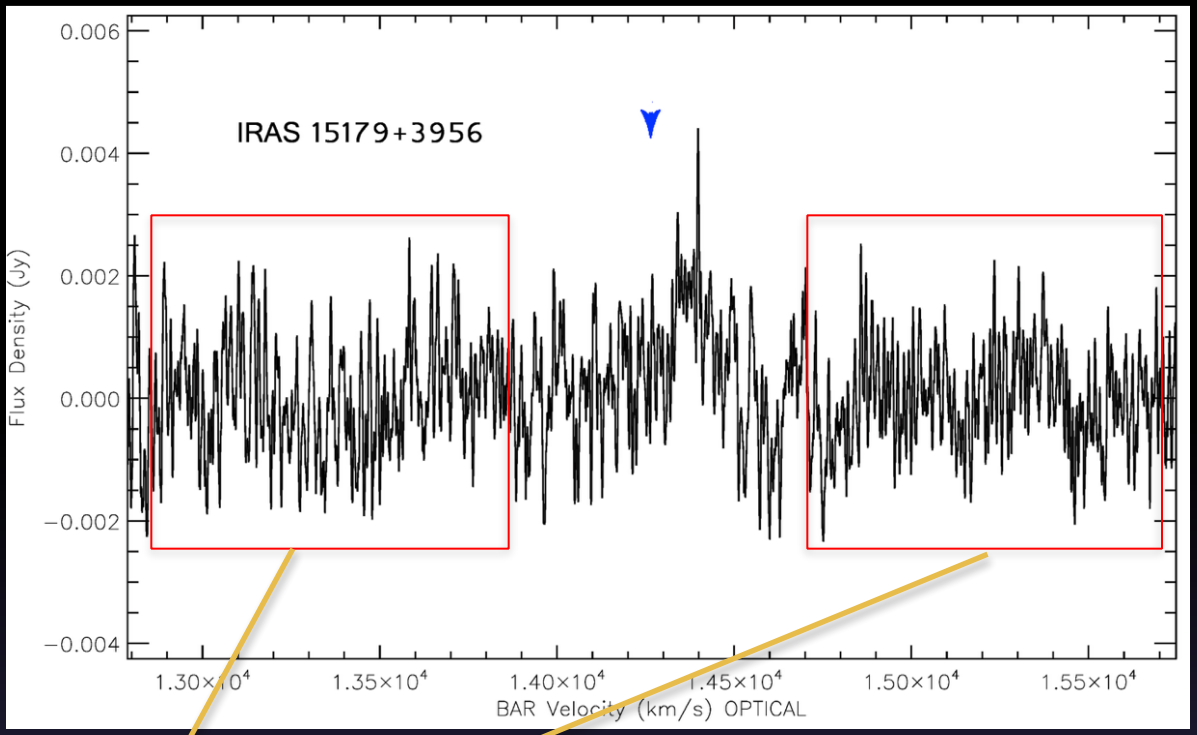
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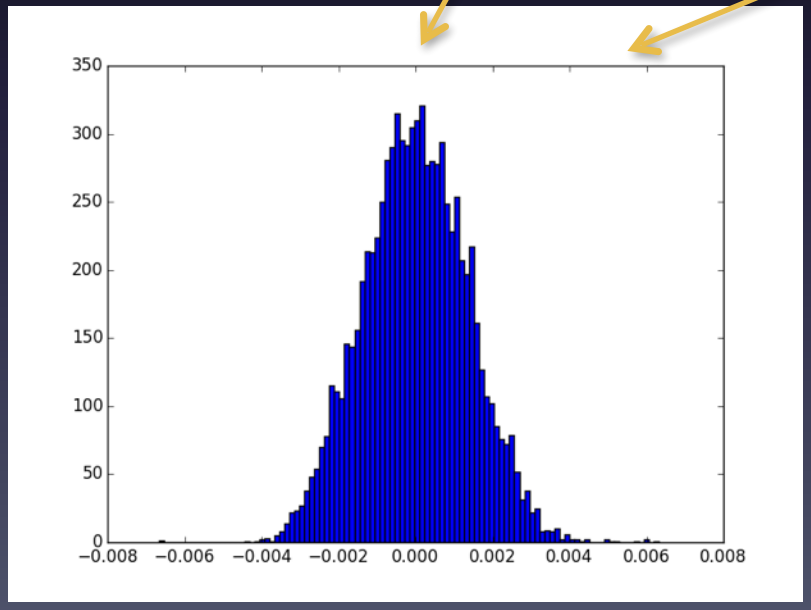
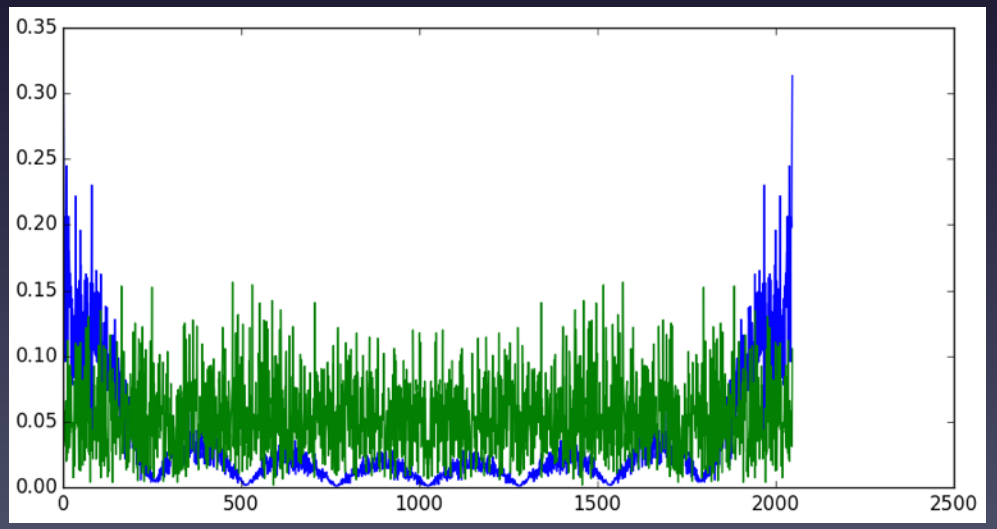
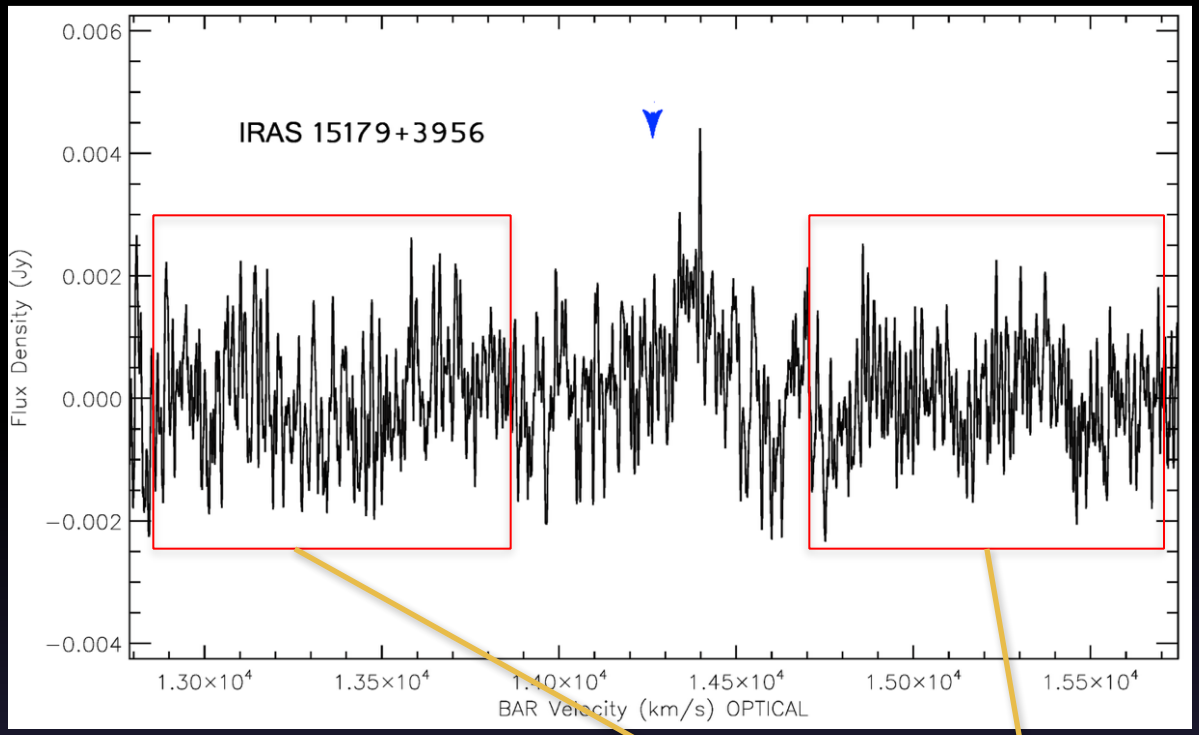

350
300
250
200
150
100
50
0
−0.008
−0.006
−0.004
−0.002
0.000
0.002
0.004
0.006
0.008


0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
500
1000
1500
2000
2500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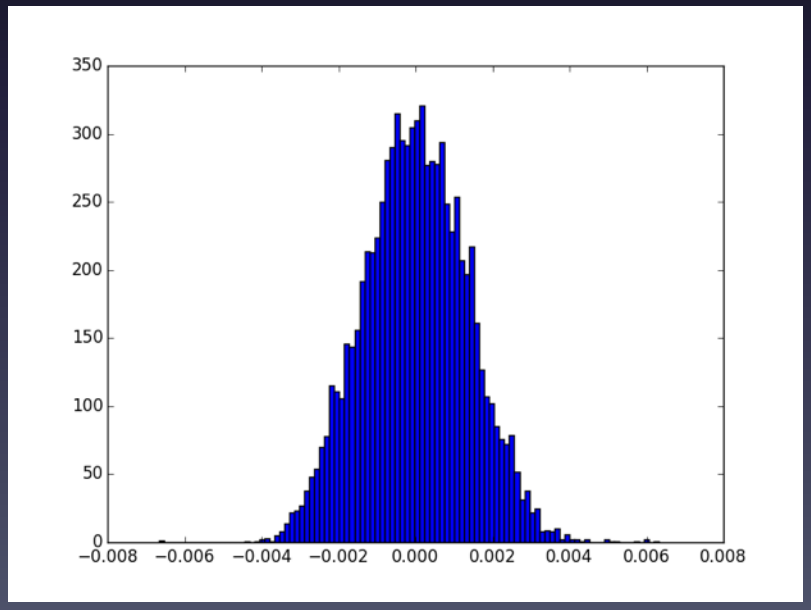
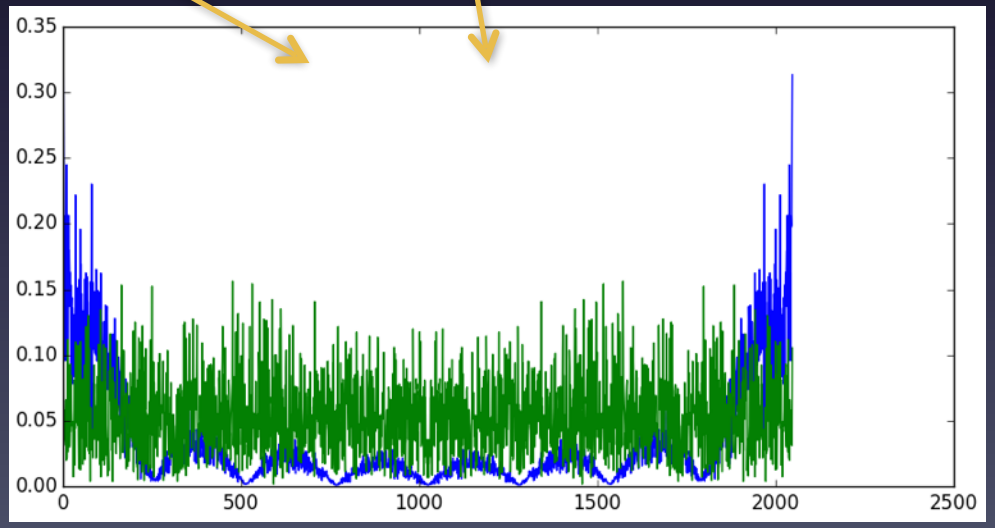
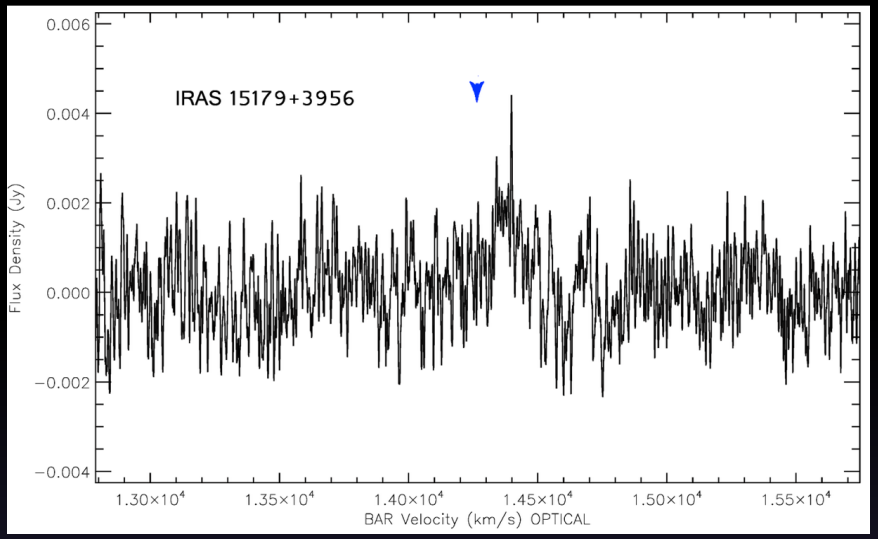
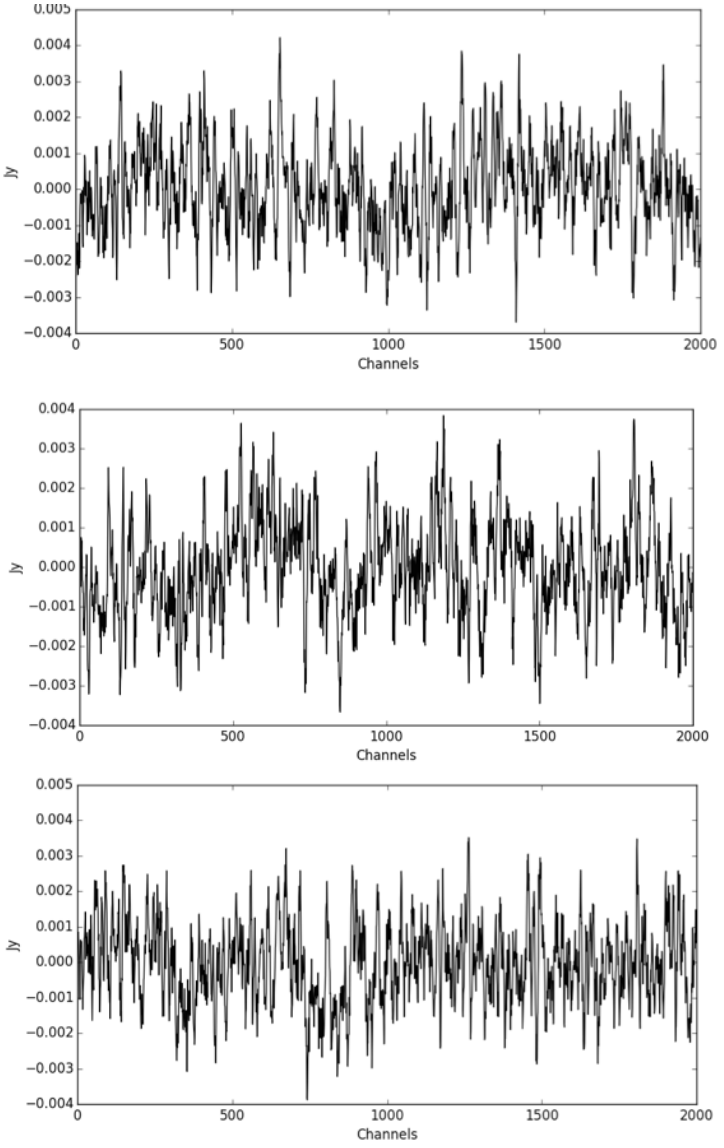

350
300
250
200
150
100
50
0
−0.008
−0.006
−0.004
−0.002
0.000
0.002
0.004
0.006
0.008

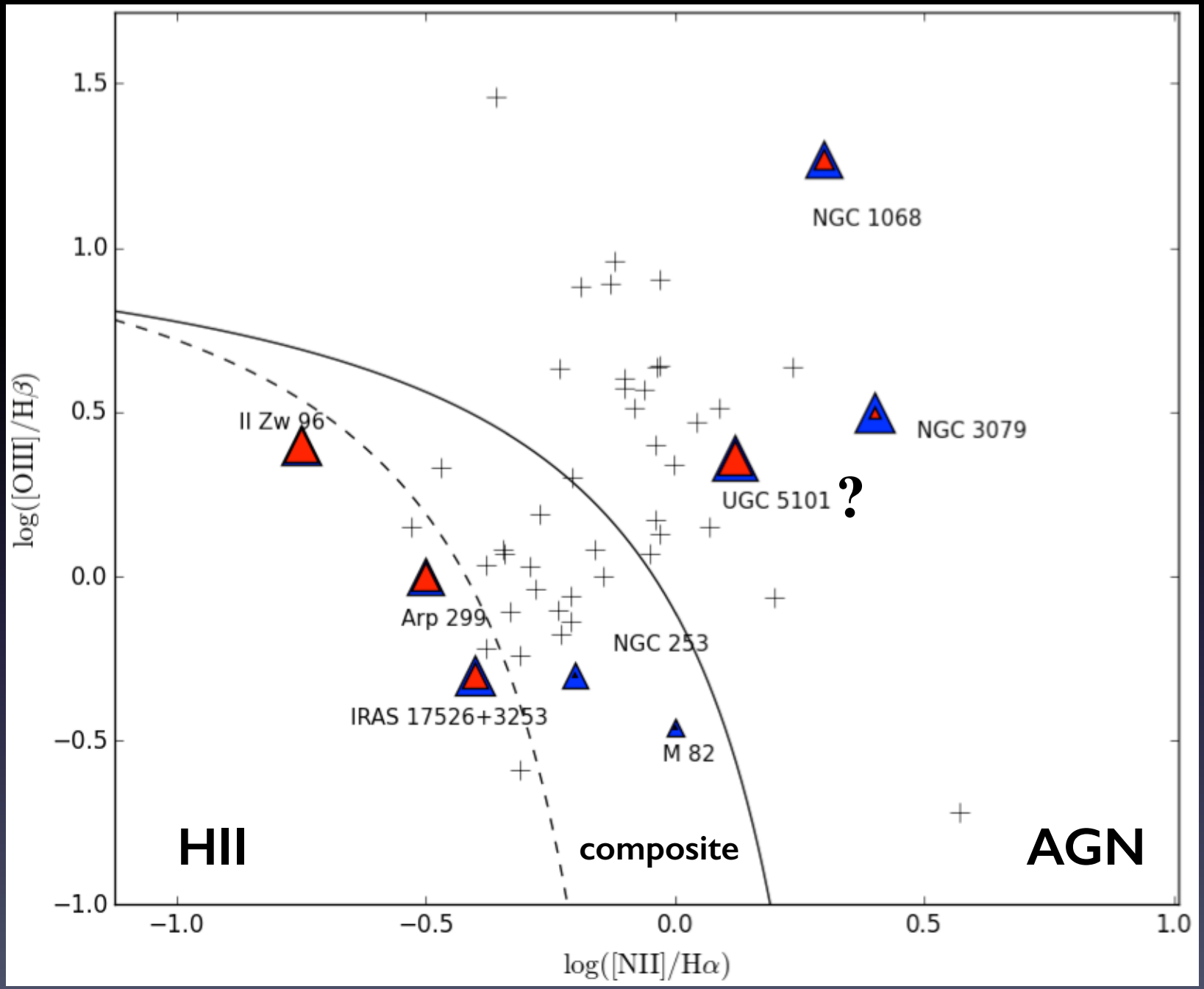

0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
500
1000
1500
2000
2500

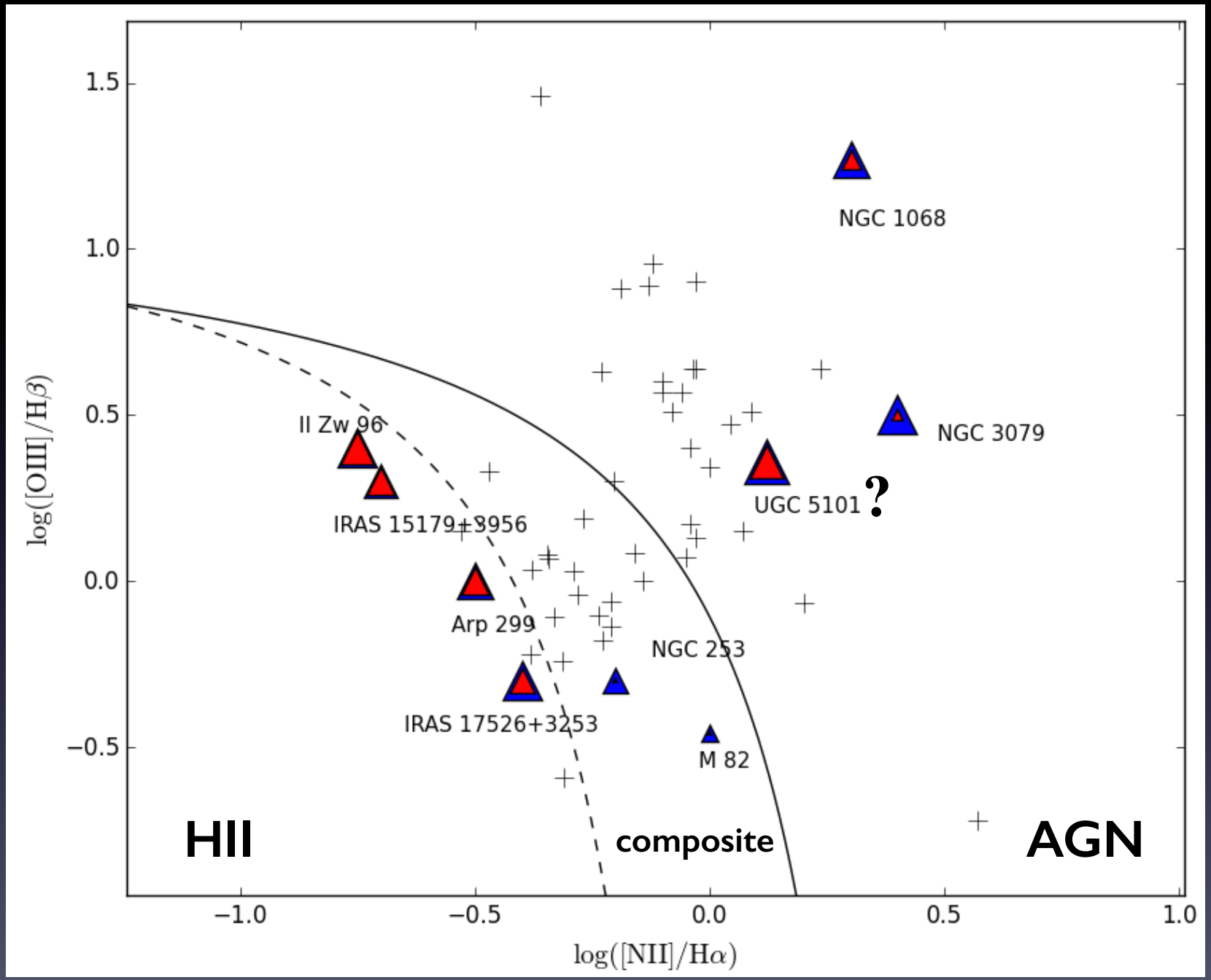


- In 100,000 such simulated spectra, only 966 realized a single point with a amplitude as high as the observed spectrum
- ~2.8 sigma detection

Simulated Spectra




NGC 1068
NGC 3079
UGC 5101
?
II Zw 96
Arp 299
NGC 253
IRAS 17526+3253
M 82
HII
composite
AGN
log([OIII]/Hβ)
log([NII]/Hα)
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.0
−0.5
0.0
0.5
1.0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NGC 3079
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IRAS 15179+3956
Arp 299
NGC 253
IRAS 17526+3253
M 82
HII
composite
AGN
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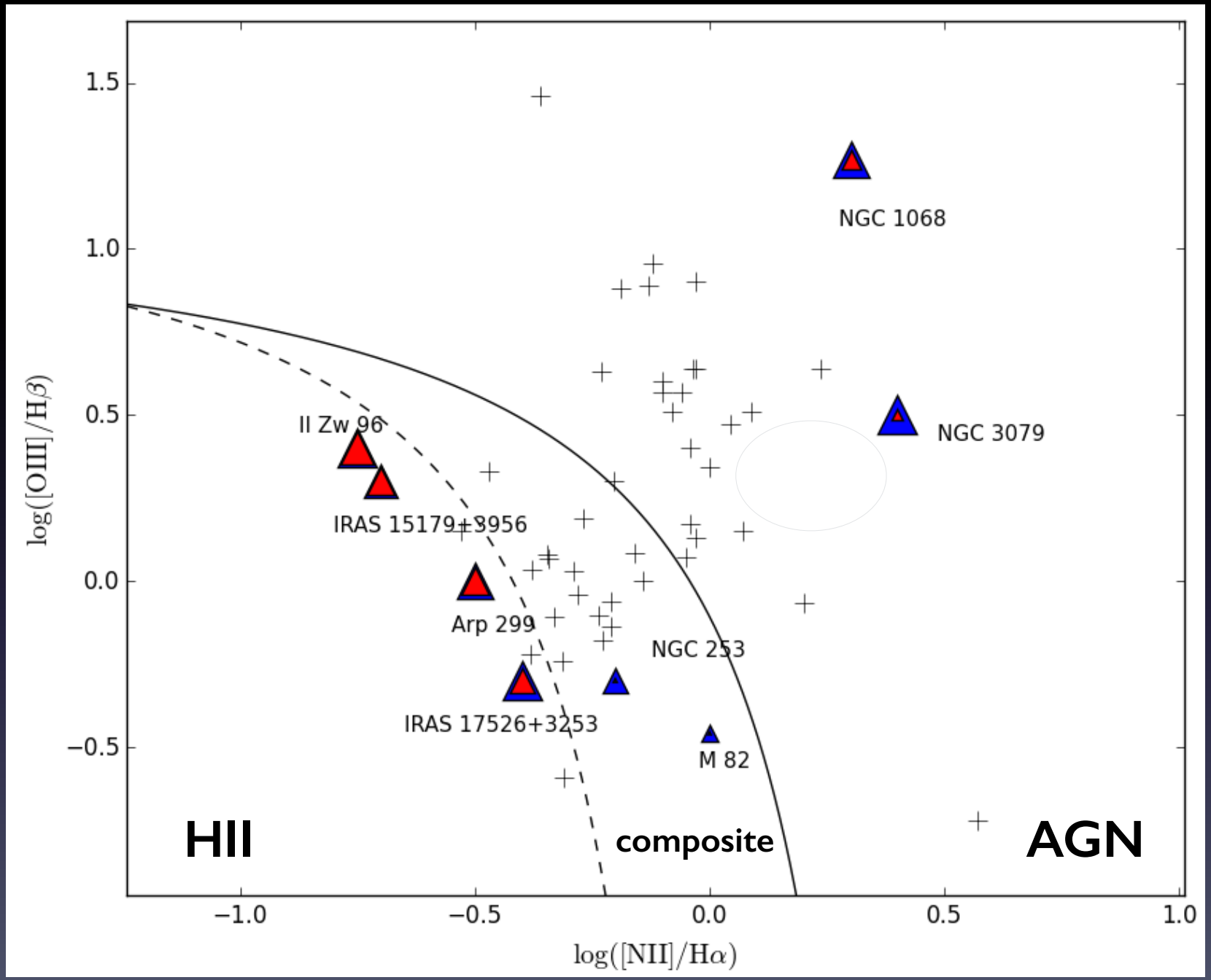
log([NII]/Hα)
1.5
1.0
0.5
0.0
−0.5
−1.0
−0.5
0.0
0.5
1.0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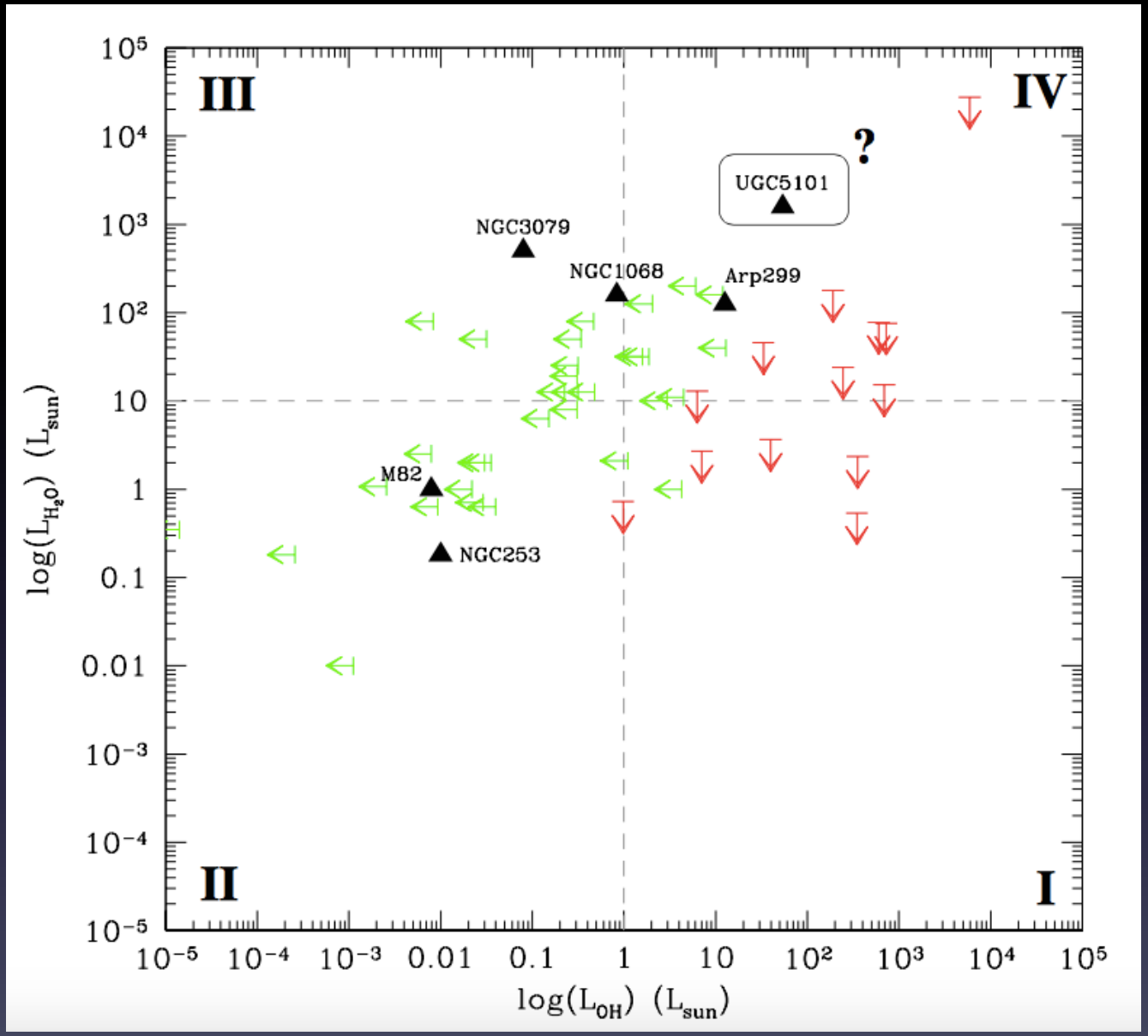
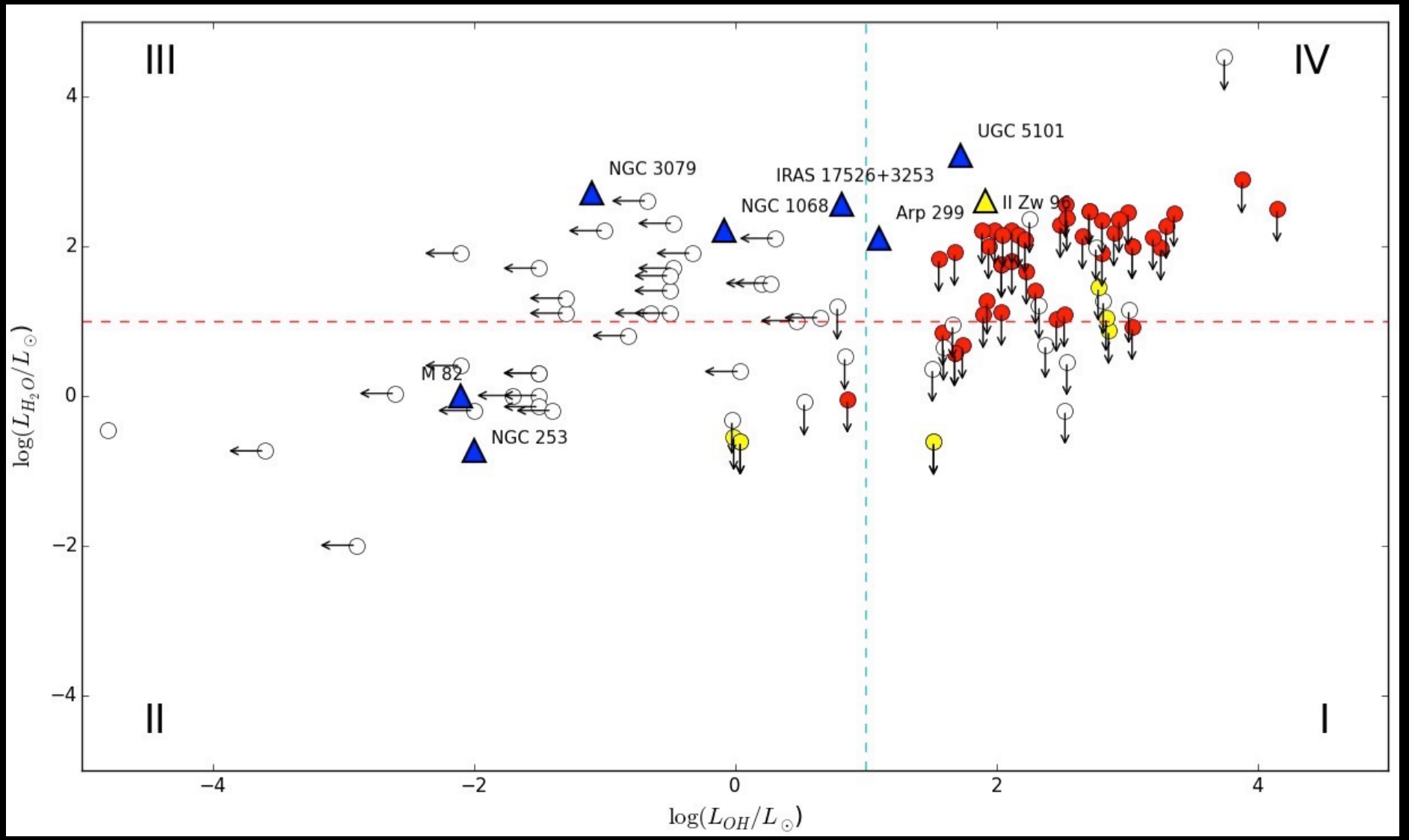
1.5
1.0
0.5
0.0
−0.5
−1.0
−0.5
0.0
0.5
1.0



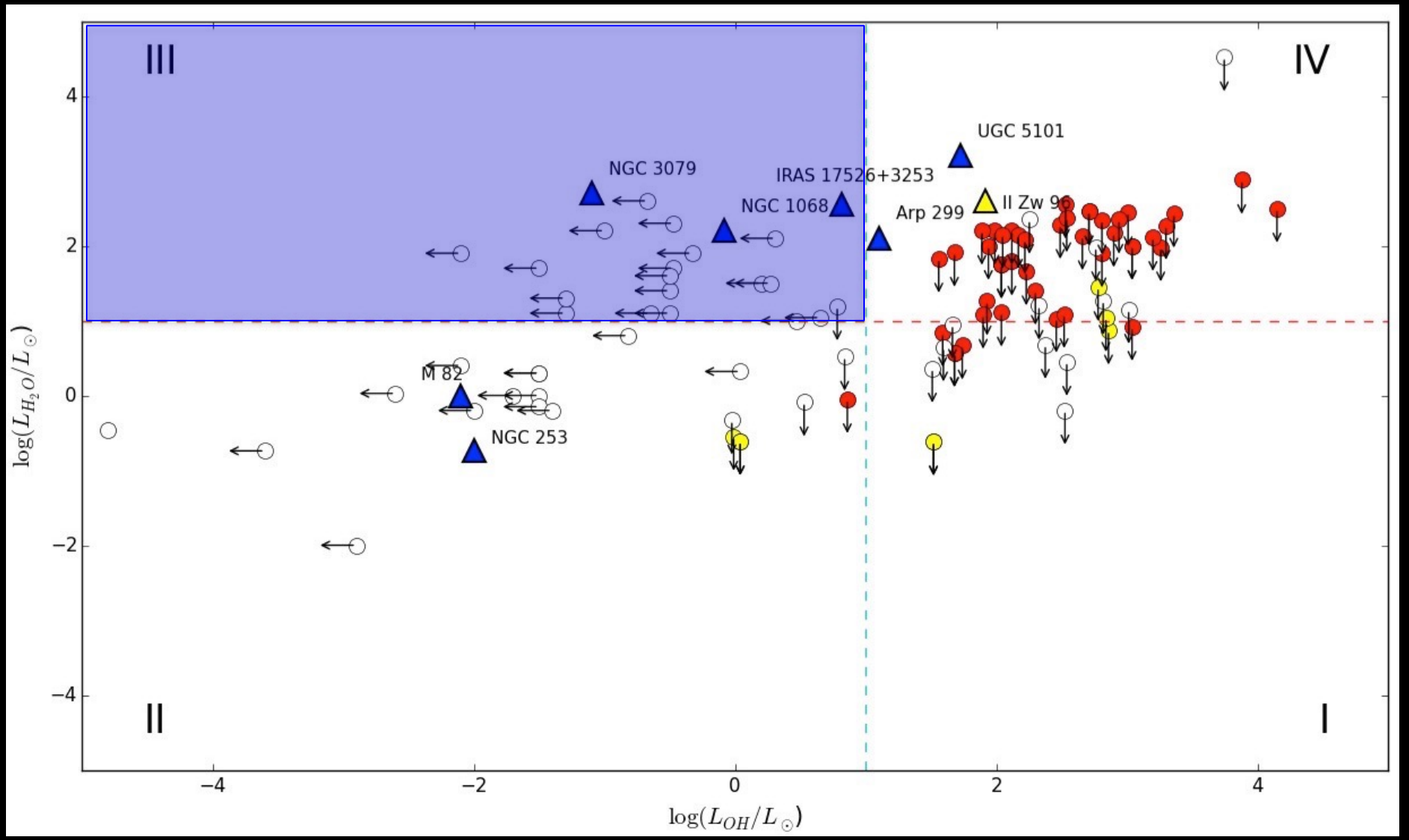
from Tarchi et al. (2011)

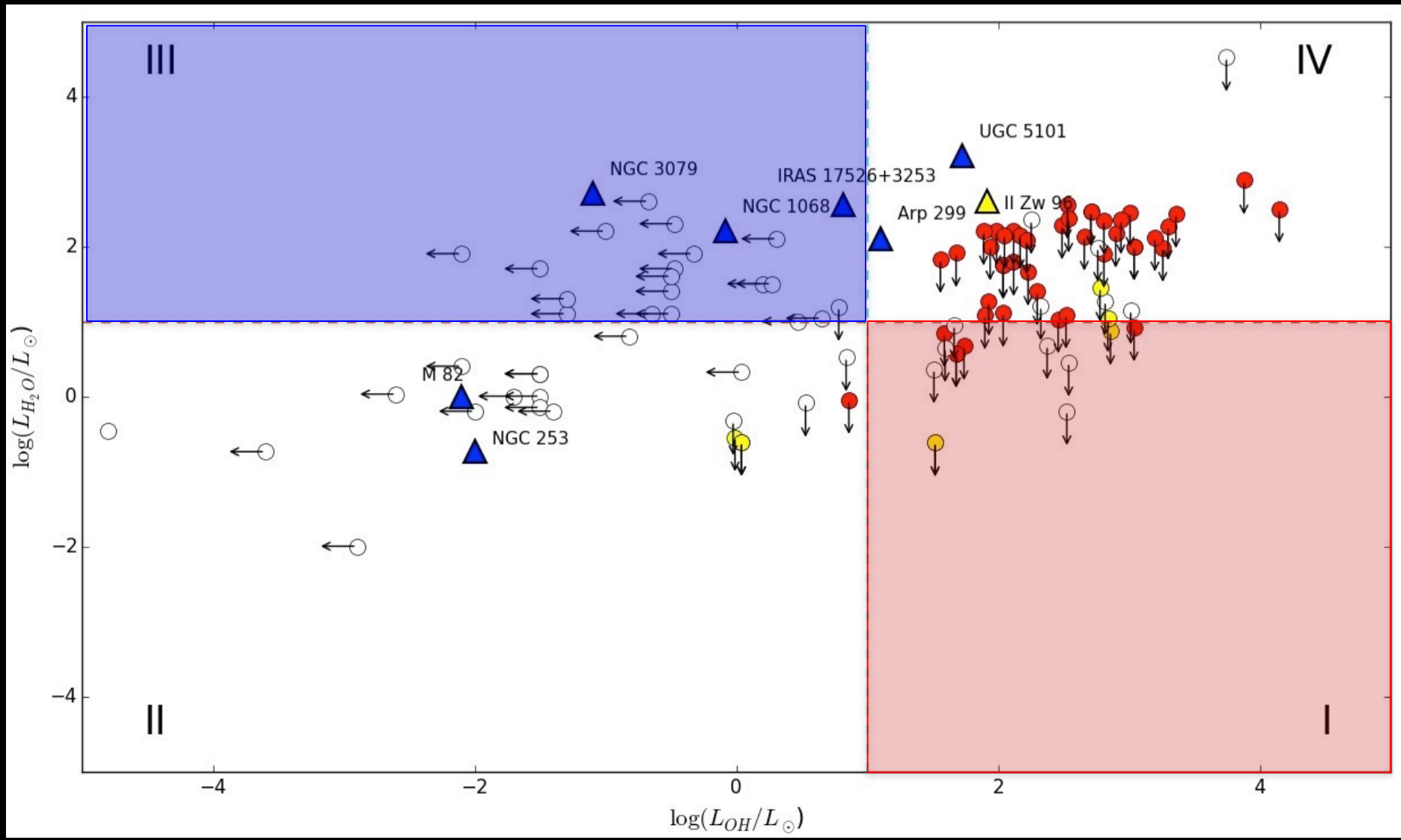


Blue - dual OH and H2O hosts (previous so this study)

Red - sources observed in this study and never previously observed

Yellow - sources previously observed but re-observed in this study


III
IV
II
I
UGC 5101
NGC 3079
IRAS 17526+3253
NGC 1068
Arp 299
II Zw 96
M 82
NGC 253
4
2
0
−2
−4
−4
−2
0
2
4
$\log(L_{H_2O}/L_\odot)$
$\log(L_{OH}/L_\odot)$


III
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4
2
0
−2
−4
−4
−2
0
2
4
$\log(L_{H_2O}/L_\odot)$
$\log(L_{OH}/L_\odot)$

Survival Analysis

- Question: Are OH kilomasers in H2O megamaser hosts really more luminous than H2O kilomasers in OH megamaser hosts?

- **Survival analysis between QI and QIII.** Treat detection limits and detections as censoring and fatalities respectively.
- Two analysis with different weightings for non-detections: **p = 0.0896, p = 0.0863.** So the difference in kilomaser luminosities is **marginally significant.**

Conclusions

- Surveyed **~ 45 OH megamaser hosts** for 22 GHz H2O emission
- We confirm (> 8σ) a previously tentative water detection toward **II Zw 96**
- A **tentative** detection toward **IRAS 15179+3956**
- We confirm for the first time a **marginally significant lack** of H2O kilomasers among OH megamaser hosts.