Compact Radio Cores in RQ AGNs
A pilot search in the E-CDFS

In collaboration with:

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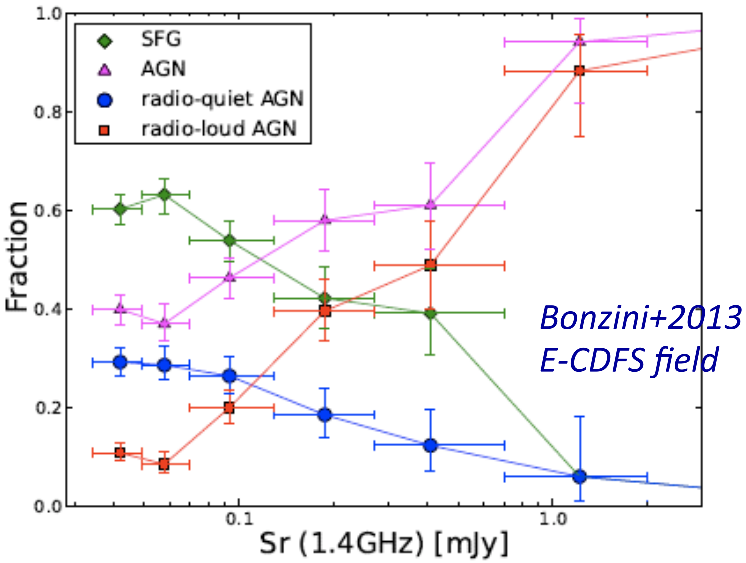
[Maini et al. 2016, A&A Letters, 589, L3]

RQ-AGNs in deep radio surveys



Bonzini+2013
E-CDFS field

RL-AGN: Radio Excess: f.i. q_{24} → **RI AGN**

RQ-AGN: No Radio Excess; AGN signature in MIR or X-ray bands → **RE AGN**

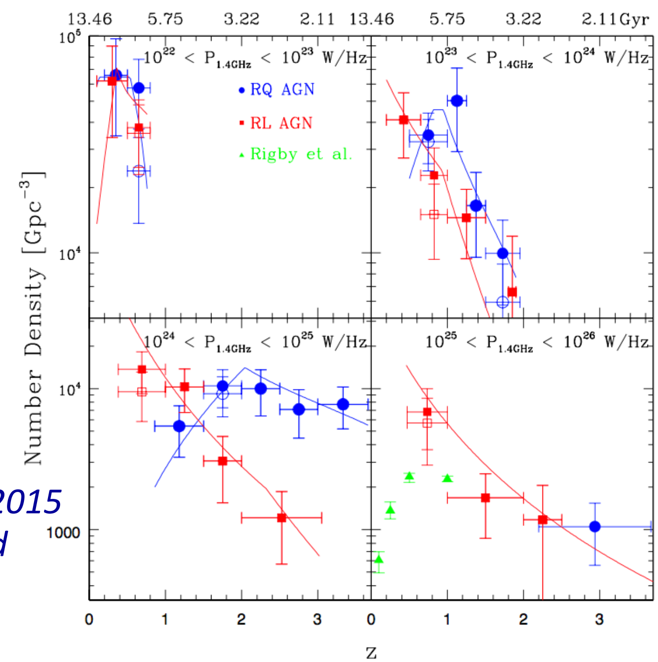
→ **complete view of AGNs/AGN feedback down to RQ regime** (no dust extinction/gas obscuration)

Radio-selected AGN Evolution:

RL-AGN: z_{peak} at ~0.5-1
RQ-AGN: z_{peak} at 0.5-2

→ **High-z dominated by RQ AGN & by RQ AGN related feedback ?**

Padovani+2015
E-CDFS field



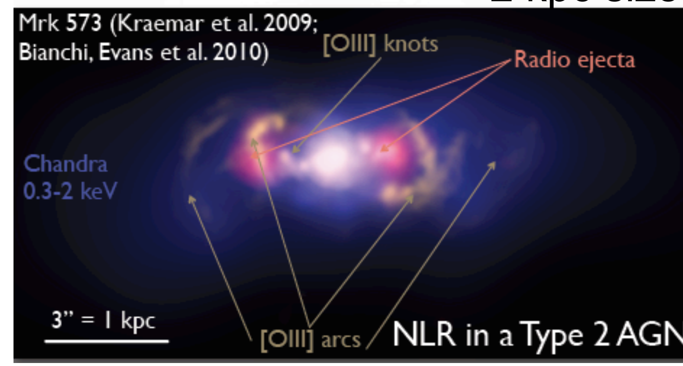
Origin of Radio Emission in RQ AGNs

What triggers radio emission in RQ AGNs?

- **pure SF in the host galaxy?**
- **SF and AGN related emission do co-exist?**
- **Incidence of embedded AGN radio cores?**
- **Fraction of AGN-driven radio emission?**

- **Mechanism responsible for AGN-driven radio emission?**
- **Is there any associated jet-feedback?**

<2 kpc size



→ Resolved (VLBI-scale) radio imaging of RQ AGN cores

Wide-field VLBI imaging:

GOODS-N@EVN:
Garrett +2001; Chi+2013; Radcliffe+2016

E-CDFS@VLBA: Middleberg+2011

LH@VLBA: Middleberg+2013

Targeted VLBI observations of RQ-AGNs:

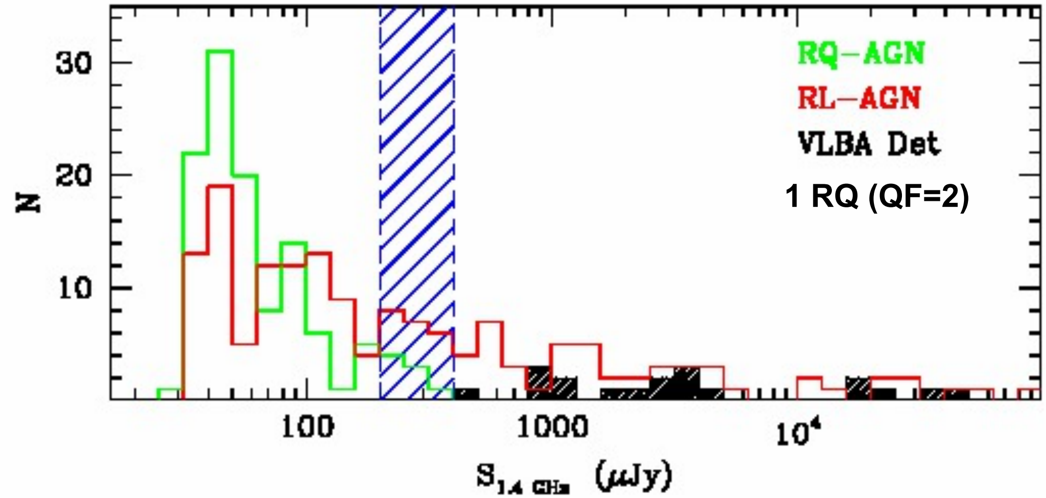
COSMOS@VLBA: Herrera-Cruiz+2016

E-CDFS@LBA: Maini, IP, et al. 2016

E-CDFS: LBA follow-up of RQ AGNs

Why E-CDFS: S_{lim} ~ 37 uJy/b; 0.32 deg^2
First with complete & reliable RQ-AGN classification (Bonzini et al. 2013)

Why LBA: Decl. ~ -28 deg
challenging for VLBA
(El. ~20^o on average)
→ detections >400 uJy



Pilot study to probe LBA feasibility:

→ Brightest flux interval: 200-400 uJy
→ 4 RQ AGN (50%) with secure classification (QF=3), point-like
→ 4 RL-AGN (20%) with same flux and redshift distribution **(z~1-3)**

E-CDFS: LBA follow-up of RQ AGNs

Observations: from March 2014 to March 2015, 51.5 hours in total

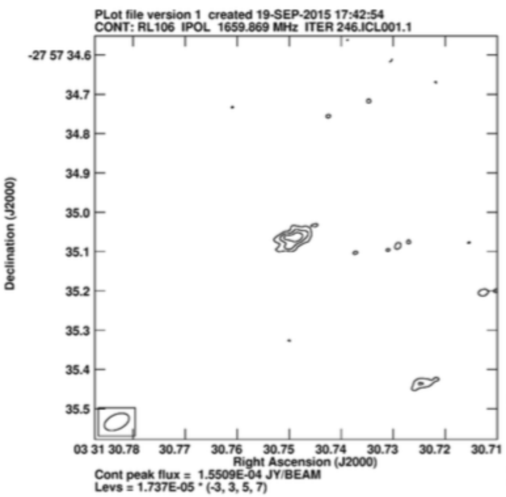
Run	Date	t_{Obs} (hrs)	ν_{Obs} (GHz)	BW (MHz)	Antennas	Target(s)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
A	09/03/2014	9.5	1.666	64	AK, AT, Cd, Ho, Mp, Pa	RQ26
						RL106
						RL728
B	04/06/2014	11	1.650	32	AT, Cd, Mp, Pa, Ti	RQ174
						RQ851
C	26/11/2014	12	1.410	64	AK, AT, Cd, Ho, Pa, Ti	RL183
						RL287
D	30/03/2015	10	1.410	64	AT, Cd, Ho, Mp, Pa	RQ851
E	31/03/2015	9	1.410	64	AT, Cd, Ho, Mp, Pa	RQ76

Data from Run C discarded

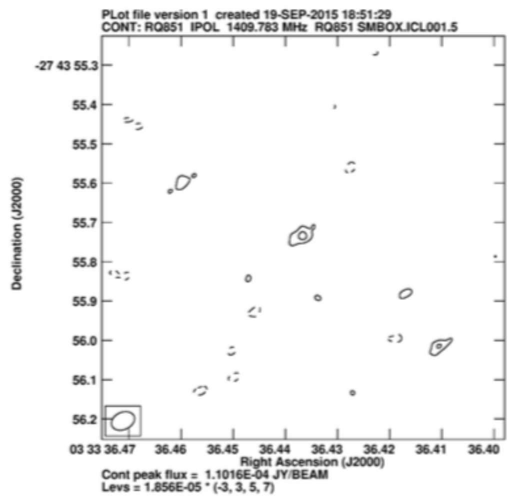
→ 2 RL-AGN and 4 RQ-AGN successfully observed
→ 1 RL-AGN and 2 RQ-AGN detected (50%)

E-CDFS: Radio core detections

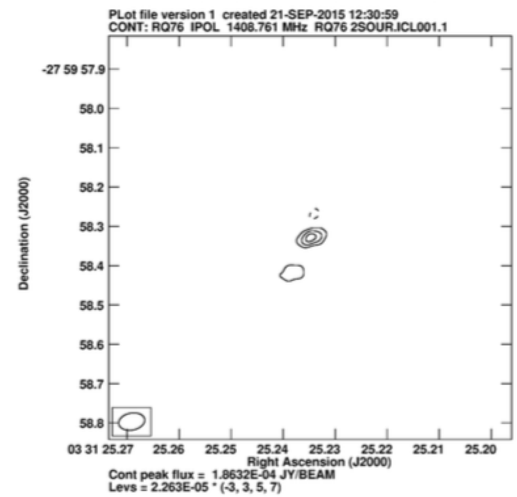
RL106



RQ851



RQ76



E-CDFS: Radio core detections

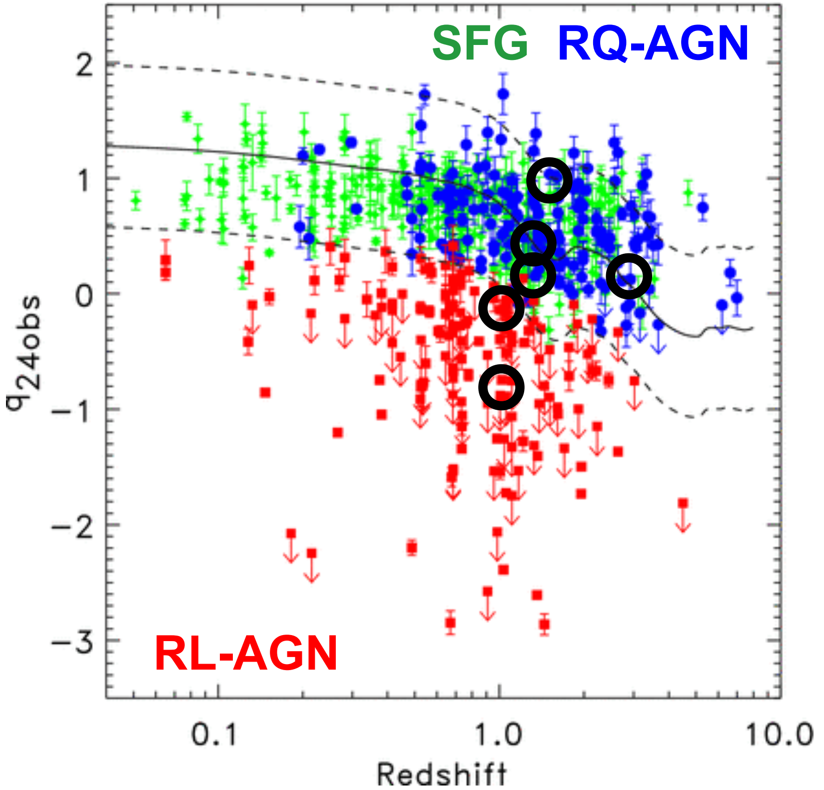
Target	S_{VLBI} (μJy)	S_{VLBI}/S_{VLA}	r.m.s. (μJy/beam)	K-corr.[a] $L_{1.4GHz}$ ($\times10^{23}$ W/Hz)	Restoring beam (mas^2)	T_B ($\times10^4$ K)	z	Linear Scale (pc)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
RQ26	$\lesssim 157$	$\lesssim$ **0.49**	52	...	...	...	1.59[b]	...
RL106	155 ± 29	0.43 ± 0.08	17	**6.6** $\pm$ 1.2	$\sim 67 \times 38$	2.7 ± 0.5	1.06[c]	$\lesssim 544 \times 308$
RL728	$\lesssim 109$	$\lesssim$ **0.33**	36	...	...	...	1.08[b]	...
RQ174	$\lesssim 125$	$\lesssim$ **0.42**	42	...	...	...	2.85[c]	...
RQ851	110 ± 26	0.50 ± 0.12	20	**9.7 ± 2.3**	$\sim 62 \times 44$	2.5 ± 0.6	1.35[d]	$\lesssim 521 \times 370$
RQ76	186 ± 36	0.69 ± 0.14	23	**17.2 ± 3.3**	$\sim 67 \times 43$	4.0 ± 0.8	1.38[b]	$\lesssim 564 \times 362$

- rms ~ 20-50 uJy/b → 1 RL-AGN and 2 RQ-AGN detected (50%)
- resolution ~60x40 mas^2 → All unresolved on ~500x300 pc^2 scales
- S_{VLBI}/S_{VLA} ~ 40-70% (<30-50% for undetections)
- RQ detections →similar/ larger S_{VLBI}/S_{VLA} fractions than RL
- 1.4 GHz core radio powers ~5-20 10^{23} W/Hz (>100x compact HII regions)
- T_B ~ 10^4 K → ν^{YSN} >100-300 SN/yr; ν^{SNR} >10-30 SN/yr (Kewley et al. 2000)

E-CDFS Target Properties

E-CDFS: 650/883 sources classified as RQ/RL AGNs or SFG

Original Classification
Bonzini et al. 2013



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Based on new multi-band analysis,
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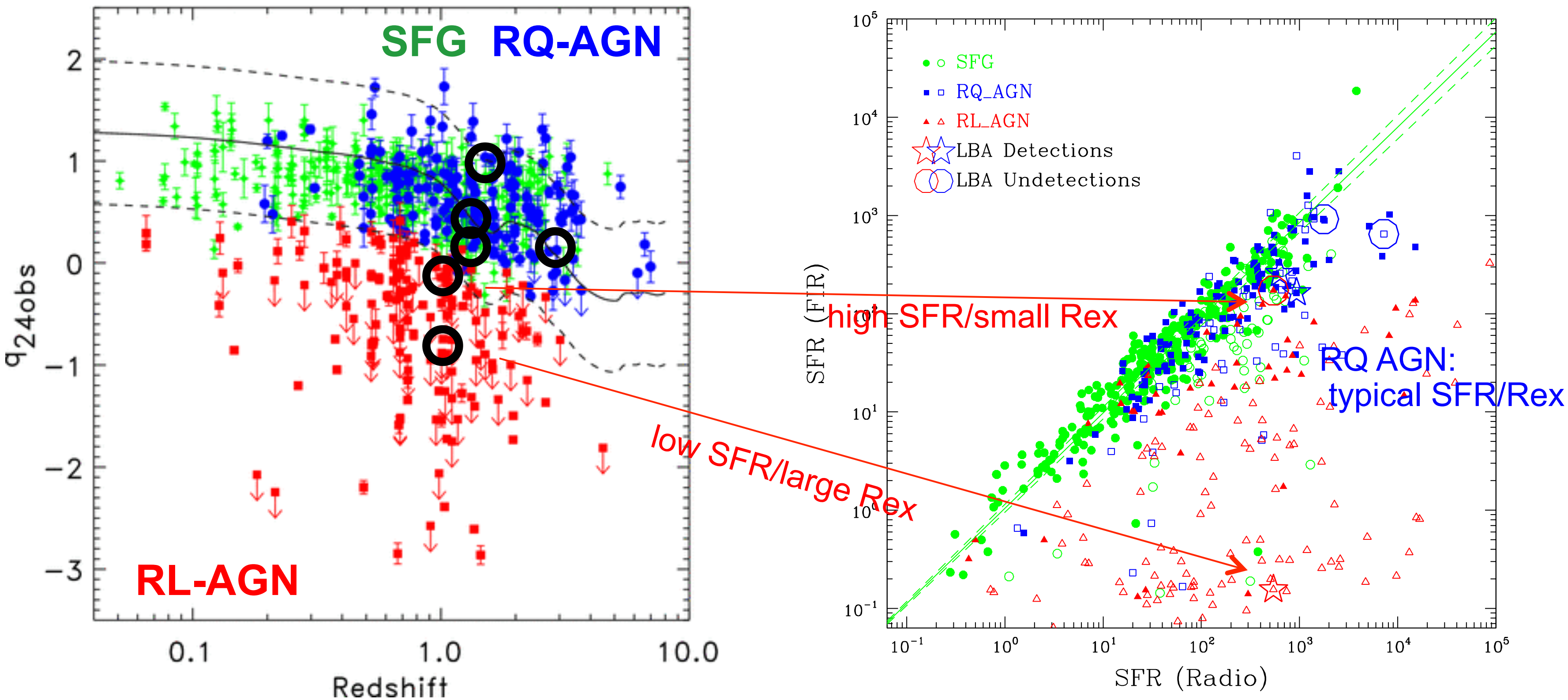
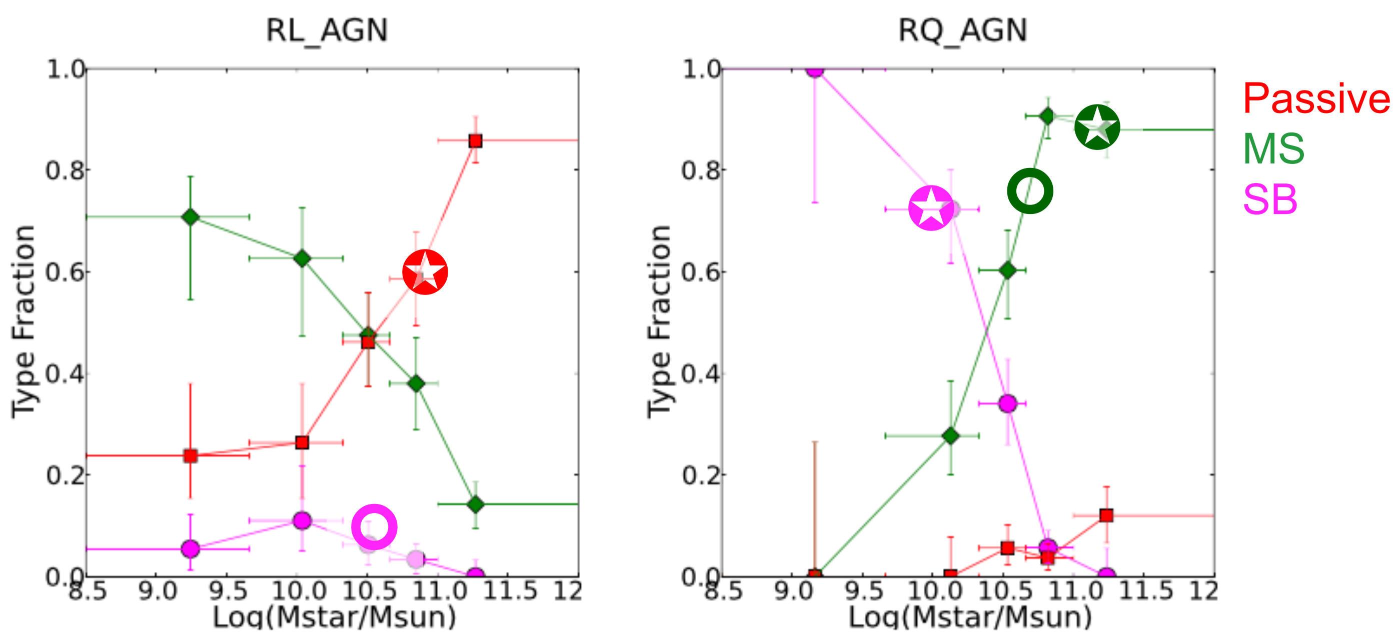


E-CDFS: Target Properties

Based on new multi-band analysis, including Herschel PACS data [Bonzini et al. 2015]



Host types/M_{star}:

- RL AGN det. → Passive
- RL AGN u.l. → SB

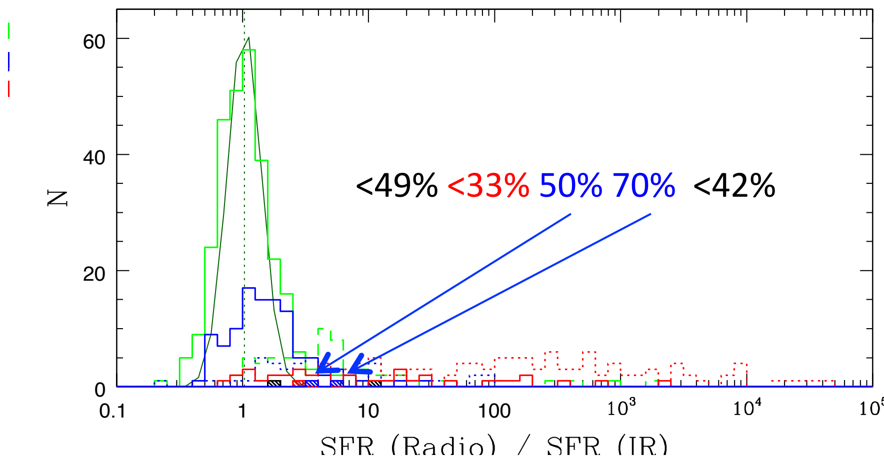
$L_X \sim 10^{43}$ erg/s

- RQ-AGN det. → 1 MS + 1 SB
- RQ-AGN u.l. → MS

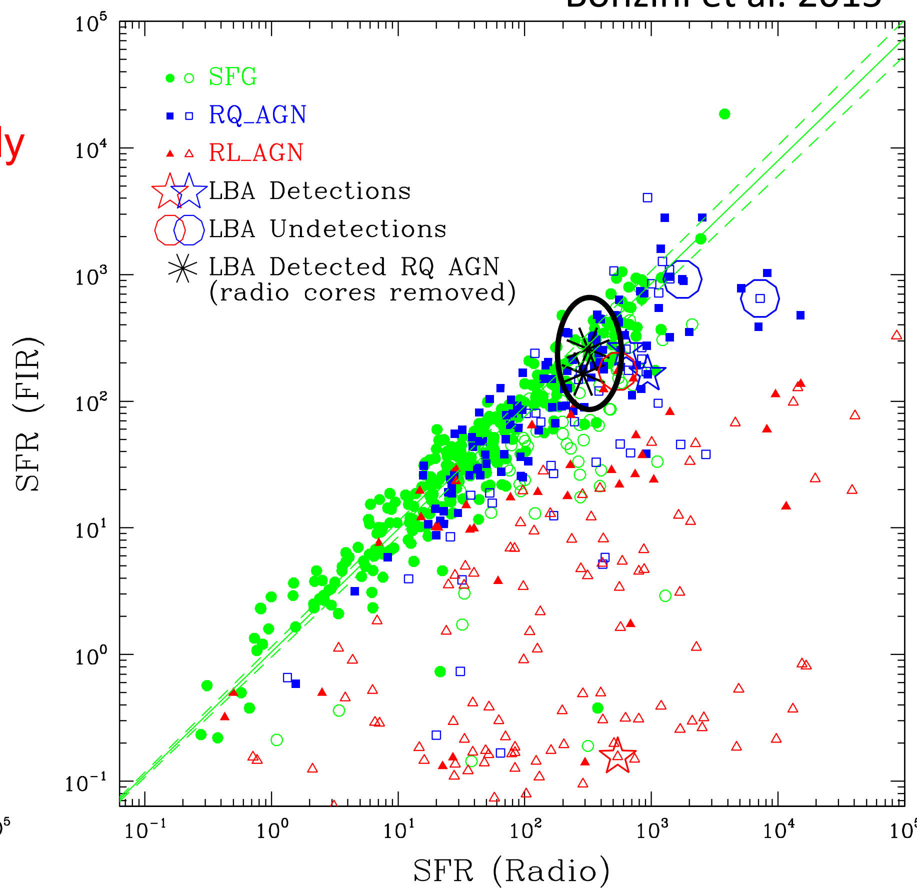
E-CDFS: Target Properties

RQ-AGN: Composite Radio Emission

→ When removing cores RQ-AGN nicely fit on the RC/FIR SFR correlation
(we are likely accounting for all AGN-related radio emission)



Bonzini et al. 2015



Conclusions & Future Perspectives

- **E-CDFS** pilot LBA study: 2/4 (50%) or 2/5 (40%) RQ AGN detected
- Re-analysis of **GOODS-N**: 2/13 (15%) RQ AGN detected (but not deep enough)

➔ Evidence of radio cores in (at least a fraction) of RQ AGN

What's next:

- Extending the search for VLBI cores in E-CDFS (20 RQ >100 uJy)
- Analysis of upcoming EVN data for the GOODS-N (1-4 uJy rms expected) in connection with eMERGE project (200 mas @ 1.4 GHz and 50 mas resolution @ 5.5 GHz) → **trace small-scale jets, if present**