FR-type radio sources COSMOS relation to large-scale environment

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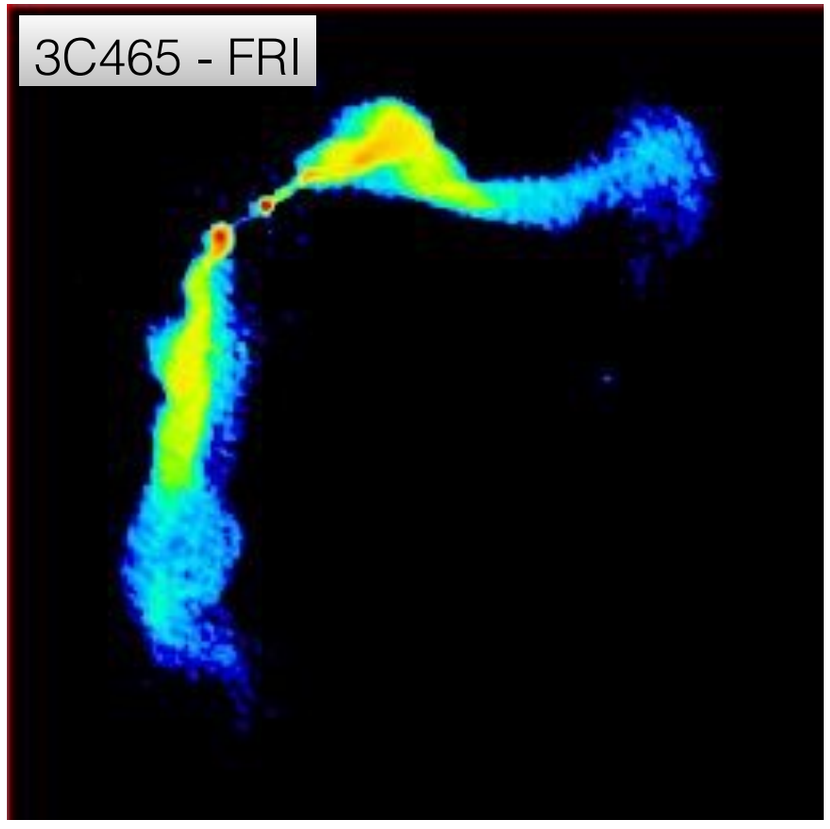
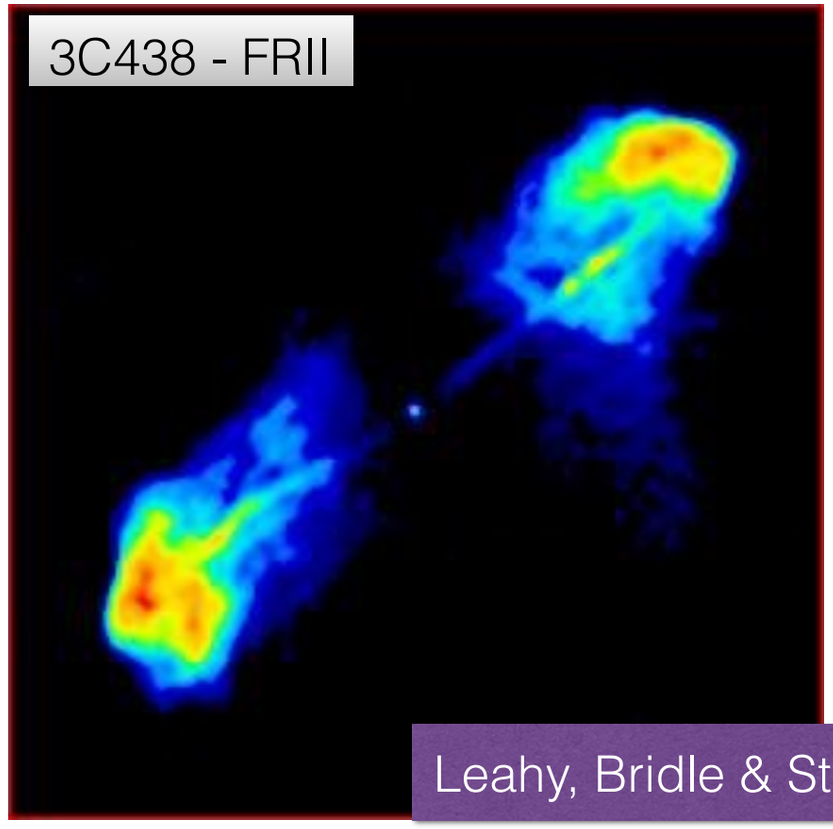
classic FR-type radio sources

- correlation between position of energy deposited and total luminosity (Fanaroff & Riley 1974)

FRI or edge darkened
$r_{hotspots} / r_{total} < 0.5$

FRII or edge brightened
$r_{hotspots} / r_{total} > 0.5$





Leahy, Bridle & Strom

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FR dichotomy - literature

1. FRIIs brighter radio luminosity than FRIs (e.g. Gopal-Krishna & Witta 2001 @ $z < 0.5$, Vardoulaki+10 @ $z \sim 1$), in contrast with Gendre+13 @ $z < 0.3$
2. FRIIs mainly high-excitation, FRIs mainly low-excitation radio galaxies (e.g. Kauffmann et al. 2008, Best & Heckman 2012)
3. FRIs on denser environments than FRIIs (e.g. Gendre+13, Zirbel 1997 @ $z < 0.5$, Castignani+14 @ $z > 0.5$)

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motivation

does appearance matter?

what is the dependence of radio structure to physical properties:

1. size of radio source (*L-D*)
2. energetics (Eddington ratio from X-rays)
3. environment (X-ray groups - kpc, density fields - Mpc)

Vardoulaki+ to be subm.

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motivation

does appearance matter?

what is the dependence of radio structure to physical properties:

1. size of radio source (*L-D*): FRIIs > FRIs > COM/FR0
2. energetics (Eddington ratio from X-rays): no dichotomy
3. environment (X-ray groups - kpc, density fields - Mpc)

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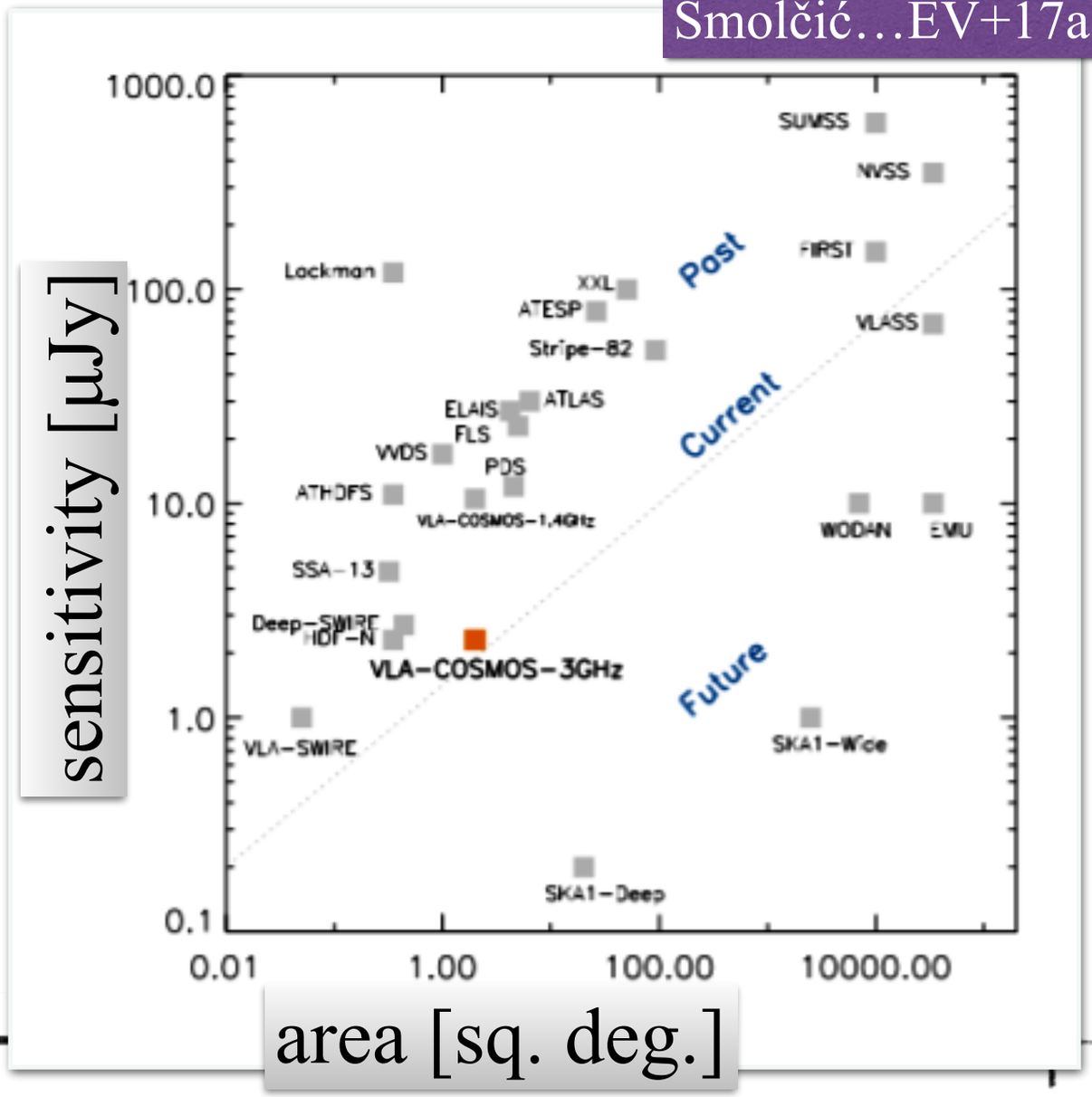
JVLA COSMOS

- VLA-COSMOS Large Survey @ 3 GHz (Smolčić+17)
- ~2.6 deg^2
- median *rms* ~ 2.3 μJy/beam
- 0.75 arcsec resolution
- 10830 radio sources above 5σ
- multi-λ coverage (Laigle+16)
- counterpart association (Smolčić+17b)

Smolčić…EV+17a



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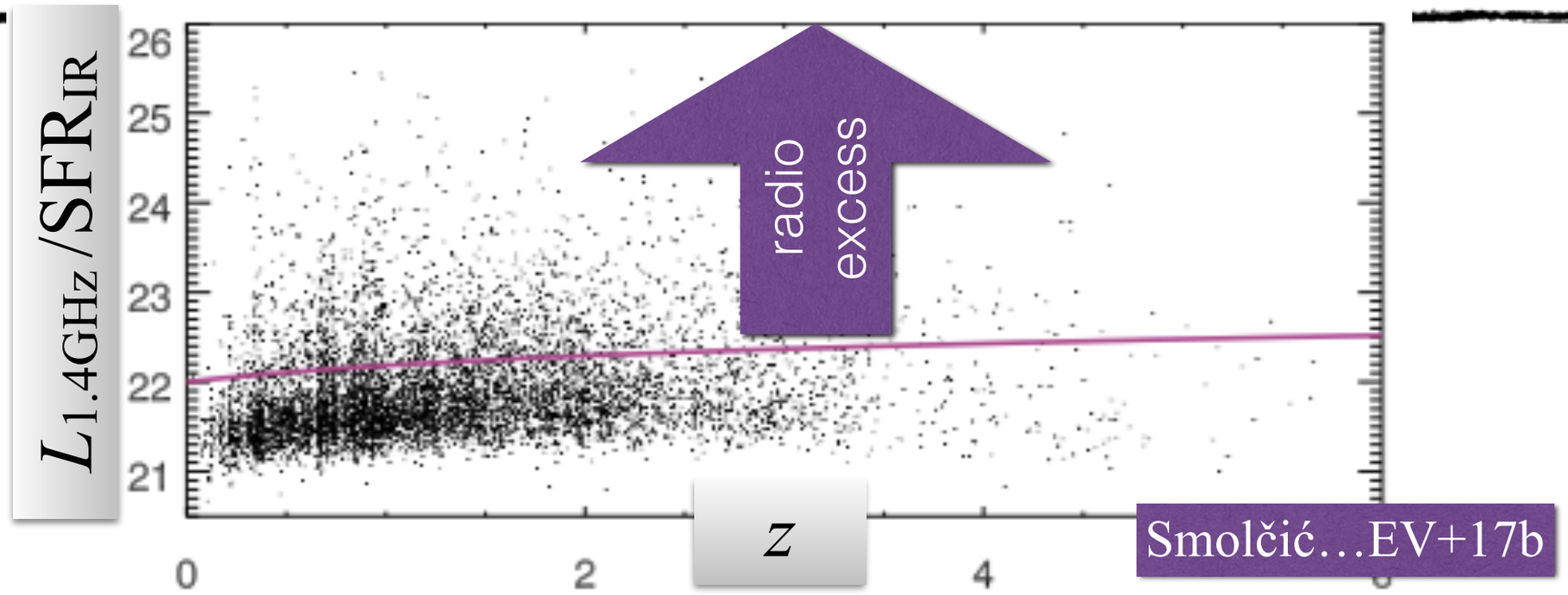
sample selection

Our sample:

- **42** FRIIs & **87** FRIs, visually classified from VLA-COSMOS 3-GHz mosaic (Smolčić+17α)
- **1810** radio excess objects (COM AGN), excluding FRIs & FRIIs (but missing low-L_{rad} AGN below 3σ)
- crossmatch with photometric (Laigle+16) & counterpart catalogues (Smolčić+17b)
- **$0.03 < z < 4.6$, $z_{med} \sim 1$**



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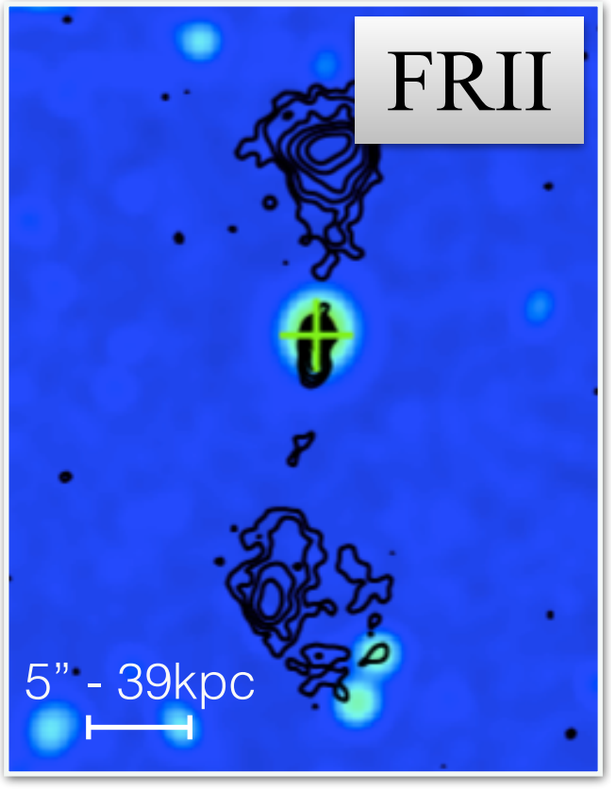
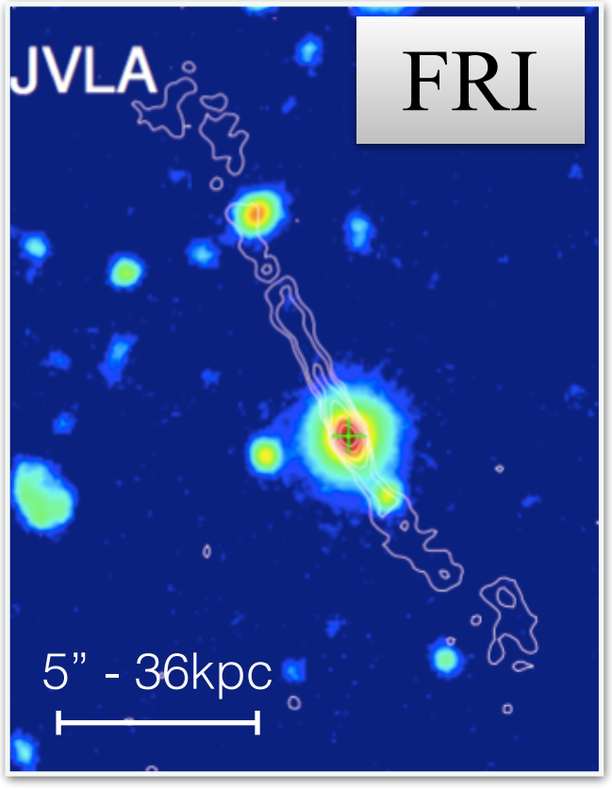
radio classification

based on radio structure at 3 GHz (visual inspection)

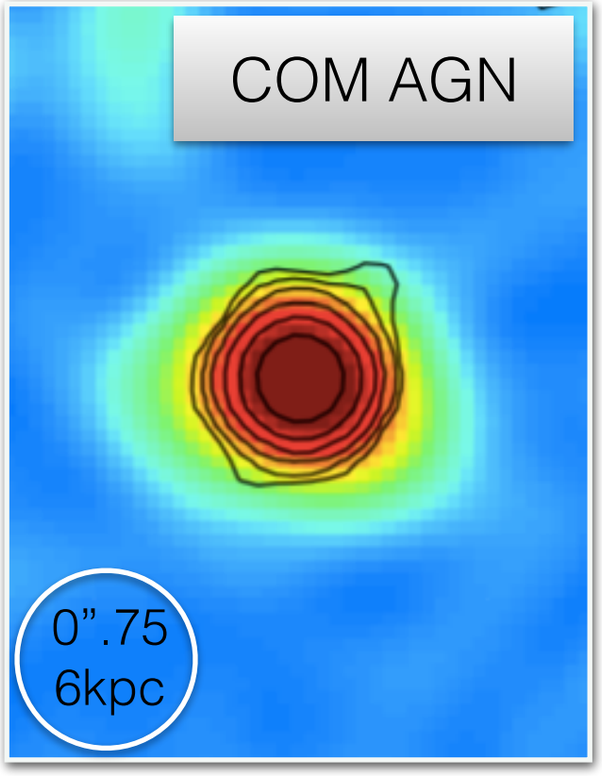




contours 3GHz (JVLA)
background near-IR (Ultra-VISTA)

automatic classification (in prep.)

radio excess objects



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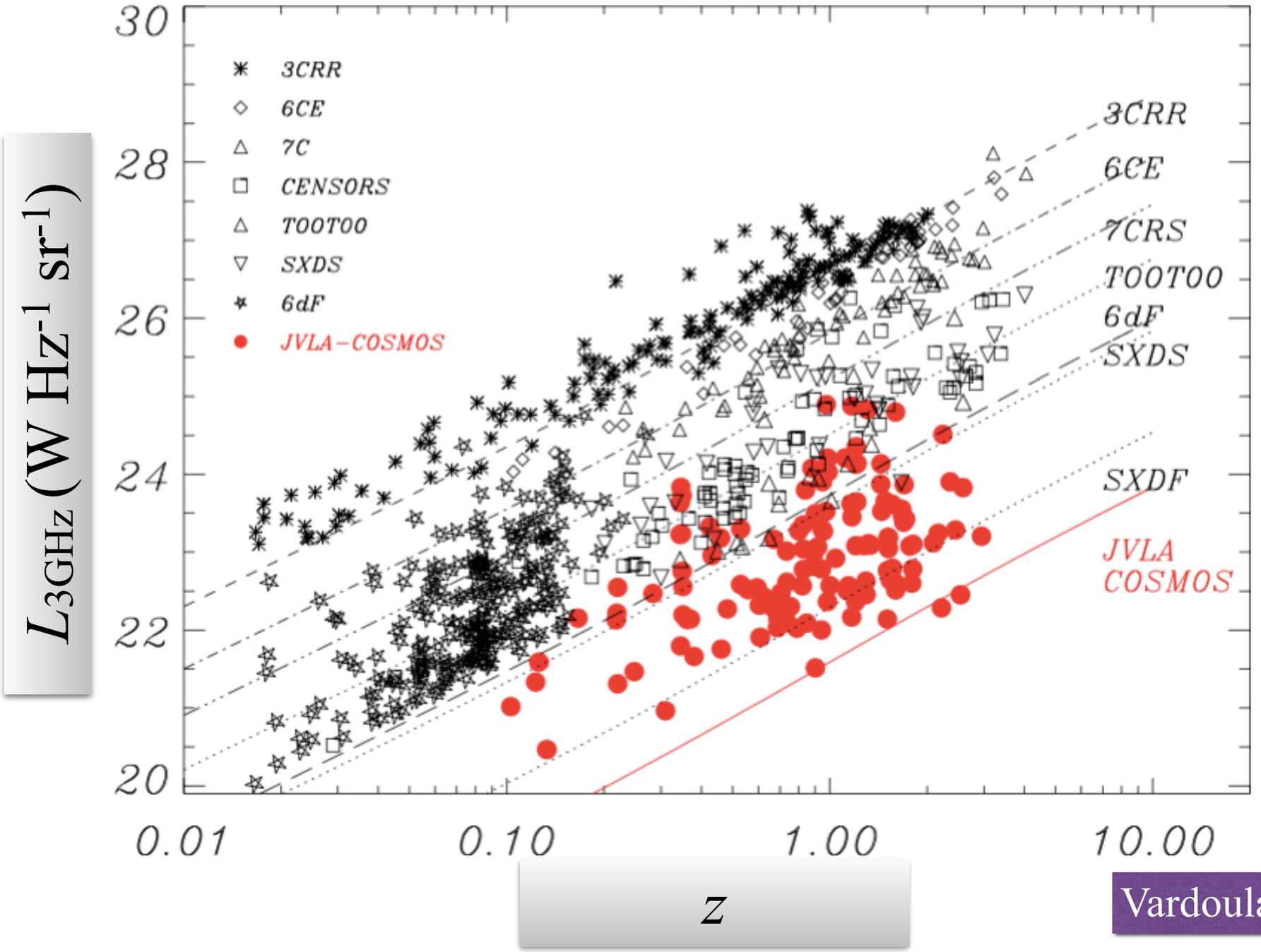
FRs v brighter samples



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FR v environment

➡<u>kpc-scale: X-rays groups</u>

- FRIs at outskirts of X-ray groups for $z > 0.5$ (kpc-scale) - infalling?
- FRII radio structure more disturbed in the centre of group (kpc-scale)

➡<u>Mpc-scale: density fields</u>

- FRIs & FRIIs at similar density environments at $z < 2$ (Mpc-scale)

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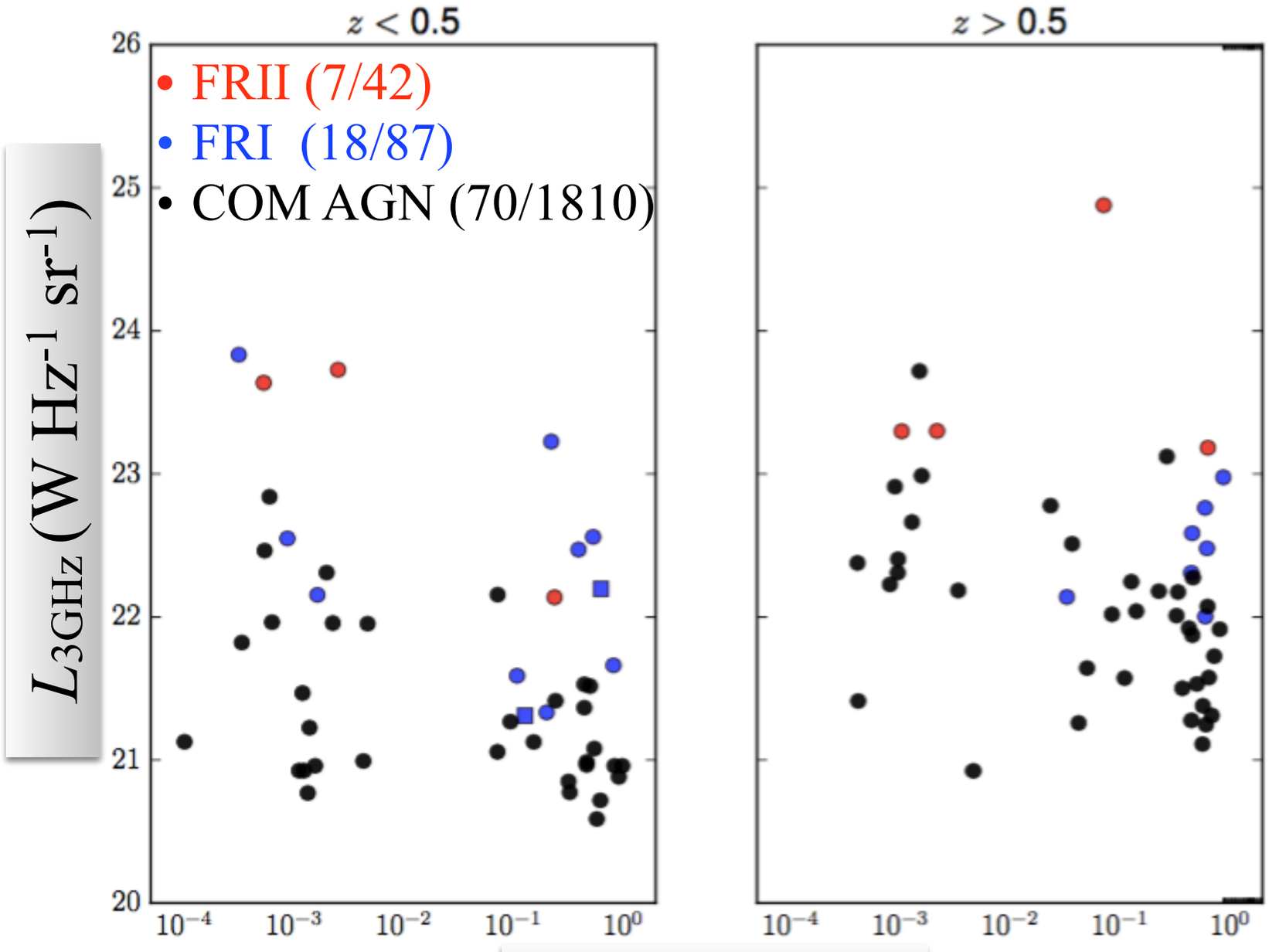
FR v environment: kpc-scale

X-ray groups from George+11



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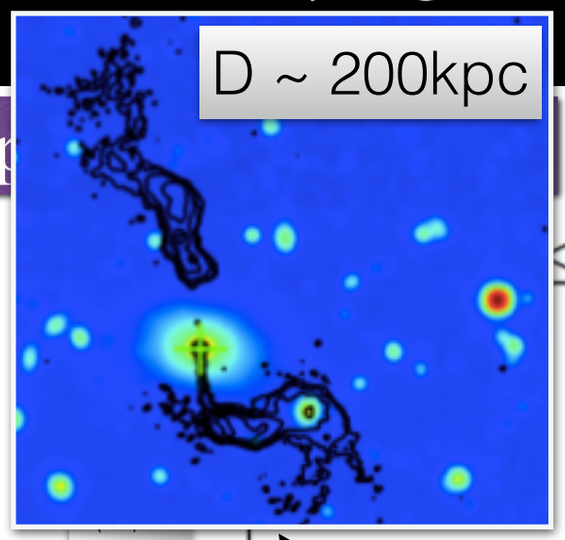
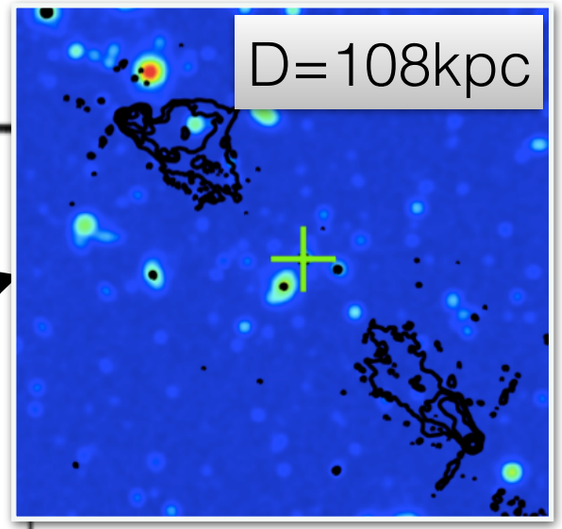
FR v environment: kpc-scale

X-ray group





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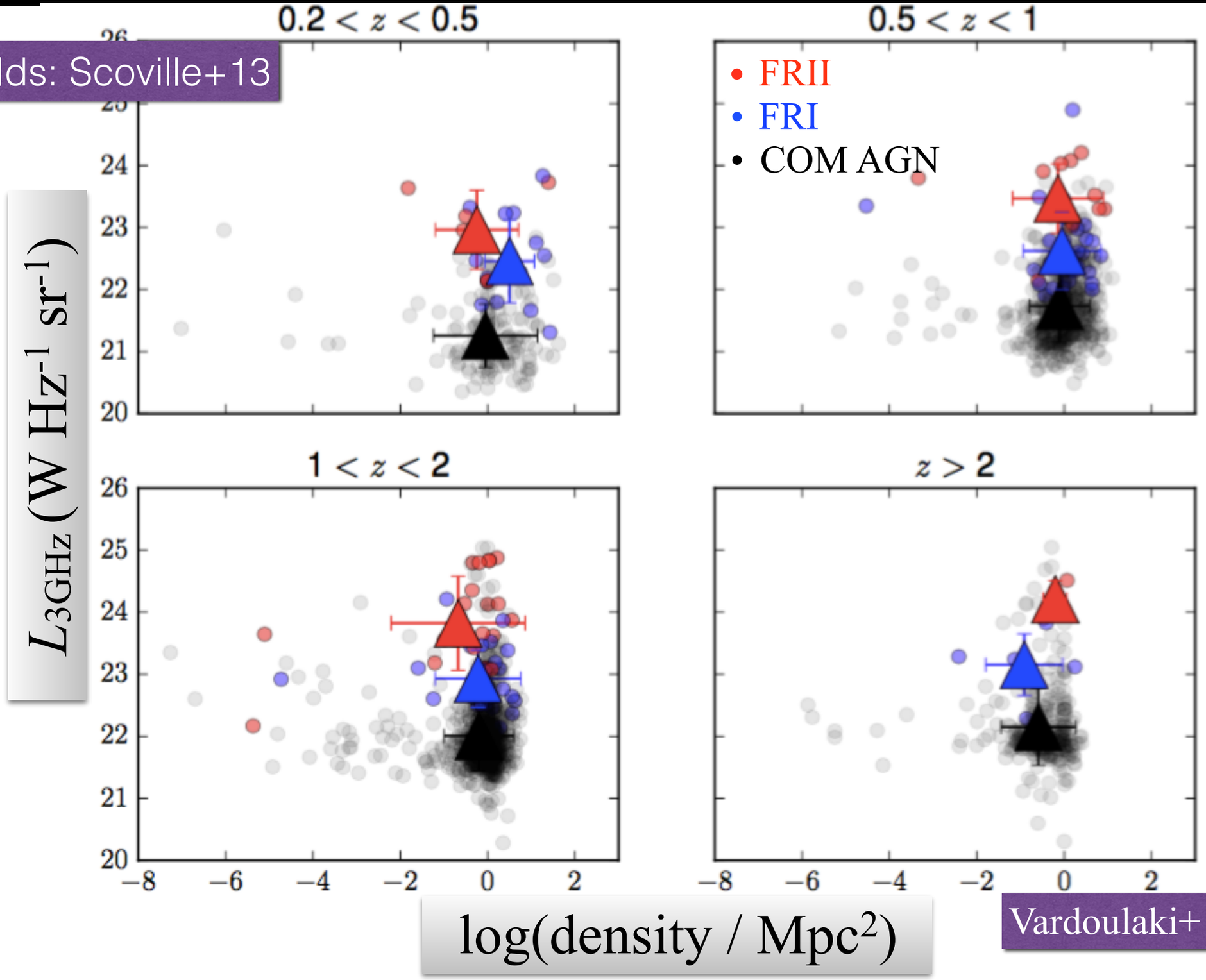
FR v environment: Mpc-scale

density fields: Scoville+13



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FR v environment - literature

1. FRIs at richer environments than FRIIs at $z < 0.5$ (408-MHz, Zirbel 1997)
2. FRIs at richer environments than FRIIs at $z < 0.3$, but significant overlap between classes (CoNFIG sample, mixed frequency selection, Gendre+13)
3. majority of FRIs at higher density environments contrary to FRIIs at $1 < z < 2$, agrees with local studies: Mpc-scale environments of FRIs and FRIIs undergo a different evolution (COSMOS 1.4-GHz, Castignani+14) & FRIs more efficient in finding groups at high-z

This study:

1. FRIs & FRIIs in JVLA-COSMOS: similar density environments (Mpc-scale) on average
2. FRIIs more disrupted in the centre of groups; FRIs at outskirts of groups @ z >0.5 (kpc-scale), and no correlation with disrupted structure; are FRIs more efficient in finding groups at high-z?

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take home

FR radio sources in JVLA-COSMOS v environment:

- kpc-scale environment:
  - ✳FRIs at outskirts @ z > 0.5 - infalling?
  - ✳FRIs & FRIIs found at all distances from group centre @ $z < 0.5$
  - ✳FRIIs more disrupted at centre of group
- Mpc-scale environment: FRIs & FRIIs similar density environments at $z < 2$ - similar evolution?

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conclusions

- aims

1. study radio structure of radio AGN in JVLA-COSMOS & relate to physical properties & environment

- sample:

1. 42 FRIIs, 87 FRIs, 1810 COM AGN from VLA-COSMOS Large Survey @ 3 GHz (Smolčić+17)

- methods

1. radio classification: visual inspection
2. environment from X-rays groups (kpc-scale) & density fields (Mpc-scale)

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conclusions

does appearance matter?

physics matters

➡ ***FRI & FRII differences cannot be attributed to environment:***

no clear dichotomy at low flux densities (down to several tens of μJy @ 3 GHz)

- results (soon in Vardoulaki+to be subm.)

1. FRIIs are small, radio faint, and have disrupted structures at centre of group
2. FRIs not at centre of X-ray groups for $z > 0.5$
3. FRI & FRII similar density environments @ $z < 2$ given the density fields

- other projects

1. automatic classification based on physical properties and multi-wavelength approach + case studies
2. IR/radio relation in COSMOS (high-z) and at local Universe v environment

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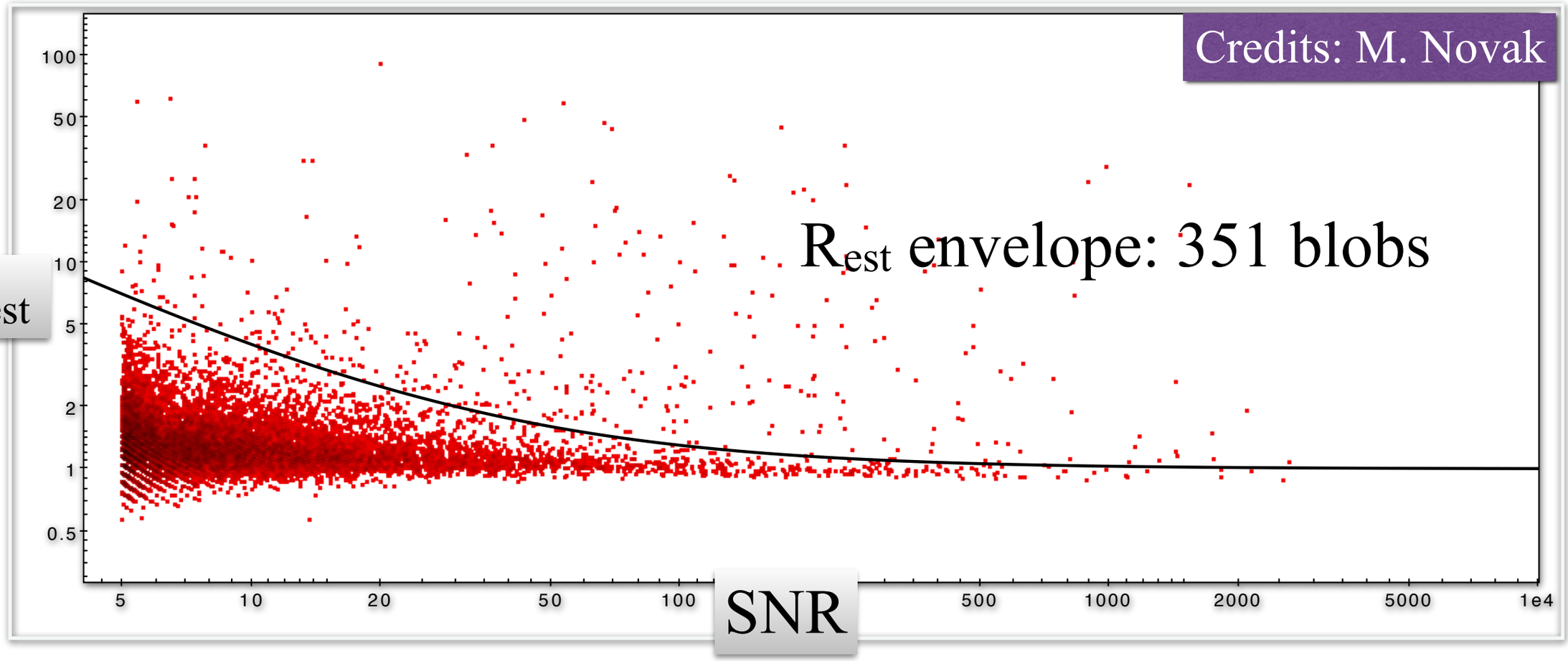
FR sample selection

- 127 known extended sources from VLA COSMOS 1.4 GHz (Schinnerer+10)
- 351 blobs high S/N ratio: $R_{EST}>1+30/SNR$ (BLOBCAT; Hales+12)



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