Characterizing Radio Quiet AGNs

The Role of EMU

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I – Current Picture of AGN Feedback (at z~0)

Clear bimodality in galaxy population

- **Blue galaxies/Star Forming MS**
- **Red Galaxies/Red Sequence**
- **Green Valley/AGN**

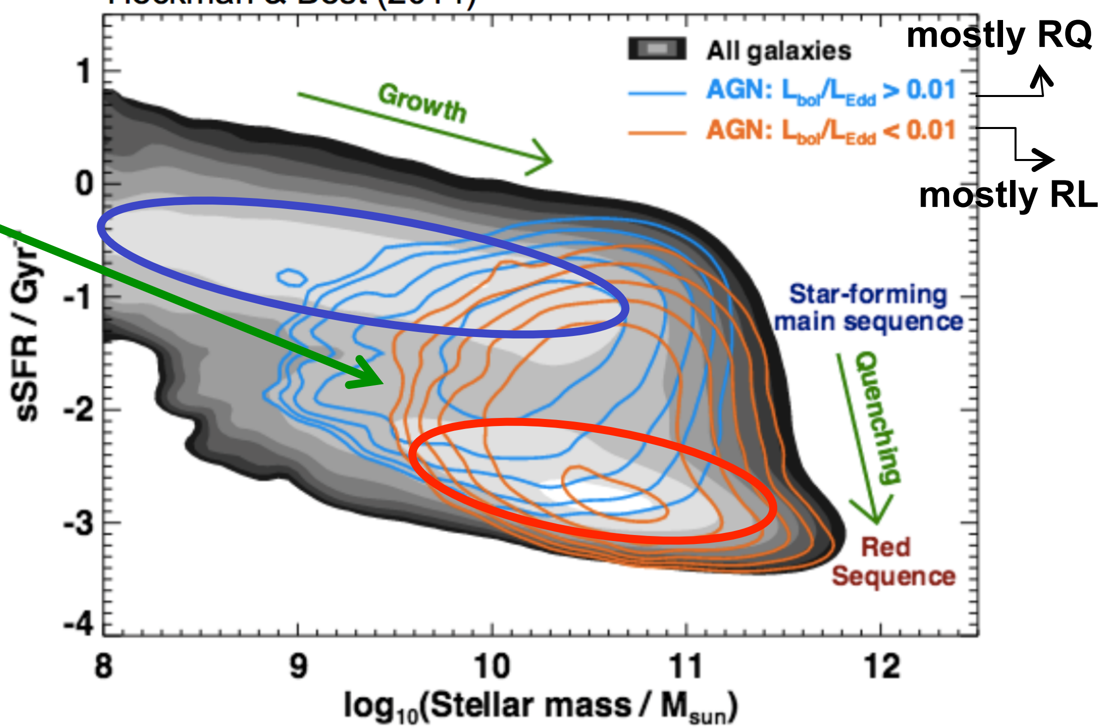
a) QSO-mode feedback:
SF quenching: vigorous BH growth → QSO winds expel gas from galaxy centers

b) Radio-mode feedback:
maintain galaxies "red and dead": radio outflows heat surrounding gas truncating further stellar mass growth

SDSS:
Colour Bimodality: Kauffmann et al. 2003; Blanton et al. 2003; Baldry et al. 2004

SFR/M_* → Brinchmann et al. 2004; Schiminovich et al. 2007

Heckman & Best (2014)

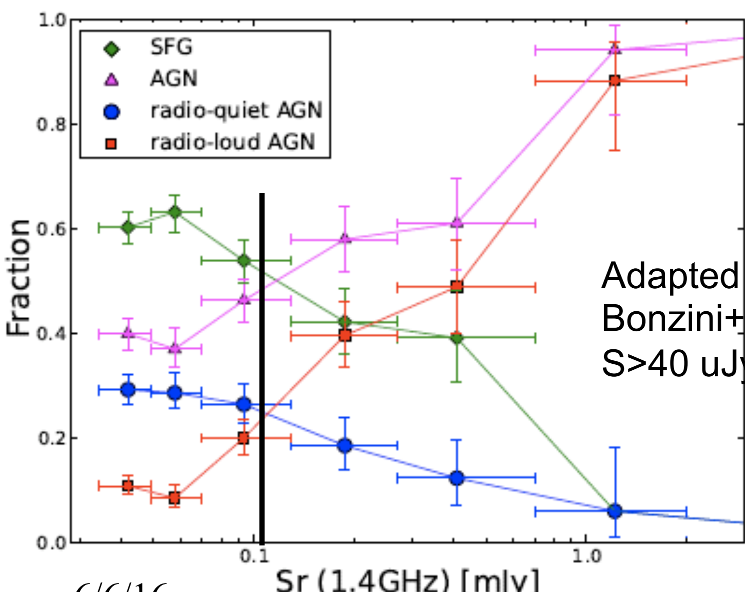


It appears to hold up to z~2, Whitaker et al. (2012)

II - The promise of next-generation radio surveys

- **Open Issues:**
  - Any significant QSO-mode feedback ass… -L RQ-AGN?
  - What is the incidence of galaxy-s… ode AGN/feedback in the RQ population?
  - Can we better constrain d… jet-mode AGNs?
  - **How AGN feedb… evolves with look-back time?**

Next-generation (radio) surveys



Adapted from Bonzini+2013
S>40 uJy

uJy-level RC surveys can trace SFG, RL and RQ AGNs

RQ-AGN ~860/deg^2 !

→ **complete view of SF and AGN activity & feedback to high-z and down to RQ regime**

Not affected by dust extinction/gas obscuration

II – Characterizing the Radio AGN Population

Fine characterization of RQ AGN and their hosts across look-back time → panchromatic approach is key

- **Source redshifts**: spectroscopy + multi-band photometry
- **AGN/SFG & RL/RQ AGN separation**
  mid/far IR colors (WISE+Herschel) + X-ray (eROSITA)
- **AGN classification**: HEG (Seyfert/QSO) vs LEG (Liners, ETS)
  High S/N optical spectra (BPT diagnostic, TAIPAN, GAMA)
- **Host galaxy properties (**mass, bulg/disk, color, stellar population, dust, gas, etc.)
- **Environment**

Multi-band Information - 2020

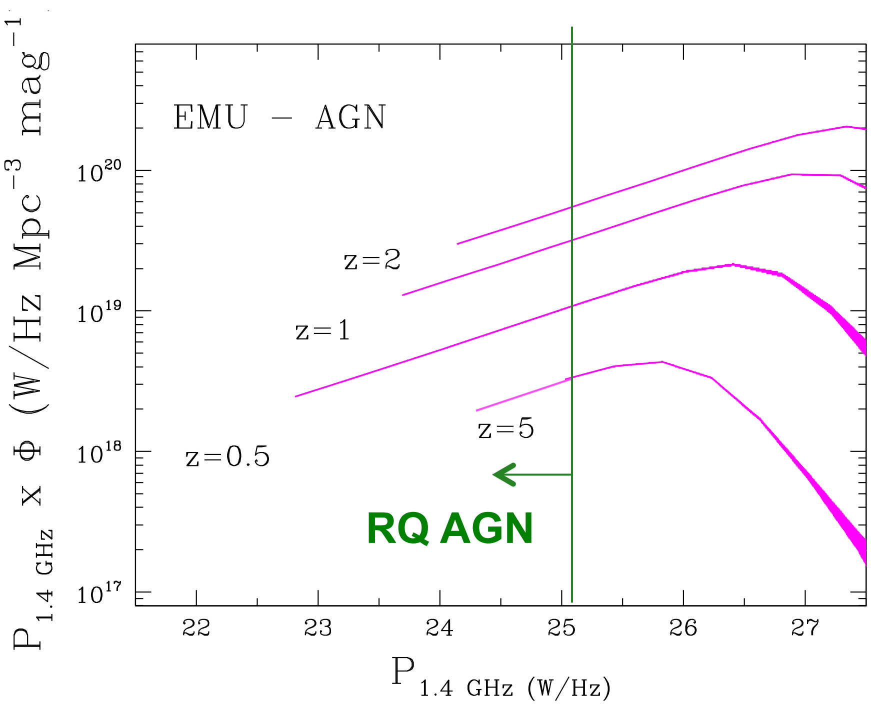
SKA Tier	Observatory /Survey Name	Area (deg^2)	Wavelength Bands	Limiting Mag. or flux[a]	Data Release Date
All-sky	ALL*WISE*[a]	42,195	3.4, 4.6, 12, 22 μm	70 μJy	2013
All-sky	PanSTARRS[b]	31k	g, r, i, z, y	$r < 24.0$	2020[b]
All-sky	LSST[c]	20k	u, g, r, i, z, y	$r < 27.5$	2020
All-sky	VISTA-VHS[d]	20	Y, J, H, K	$K < 20.0$	2011+
All-sky	*eROSITA*[e]	$\sim$ 42k	0.5 – 10 keV	$\sim 10^{-14}$ erg cm^{-2} s^{-1}	2018
All-sky	*EUCLID*[f]	15k	0.55 – 2.0 μm+spec.	$YJH < 24$	2020+
All-sky	TAIPAN[g]	20k	0.37 – 0.87 μm spec.	$R < 17.5$	2015
All-sky	4MOST[h]	15-20k	0.39 – 1.05 μm spec.	$r < 22$	2019+
All-sky	MOONS[i]	15k	0.8 – 1.8 μm spec.	(TBD)	2019+
Wide	H-ATLAS[j]	570	70 – 500 μm	$S_{250\mu m} > 44.5$ mJy	2015
Wide	DES[k]	5000	g, r, i, z, y	$r < 25$	2017
Wide	VISTA-Viking[d]	1500	Y, J, H, K_s	$K_s < 21.2$	2012
Wide	VST-ATLAS[d]	4500	u', g', r', i', z'	$r' < 22.2$	2016
Wide	VST-KIDS[d]	1500	u', g', r', i'	$r' < 24.2$	2016
Wide	PanSTARRS Deep[b]	1200	0.5 – 0.8, g, r, i, z, y	$g < 27.0$	2020
Deep	SCUBA2[l]	1/6	450/850 μm	$S_{850\mu m} > 3.5$ mJy	????
Deep	HerMES[m]	1...270	70 – 500 μm	$S_{250\mu m} > 3.8...64$ mJy	2016
Deep	SERVS[n]	18	3.4, 4.6 μm	~ 2 μJy	2013
Deep	VISTA-VIDEO[d]	12	Z, J, H, K_s	$K_s < 23.5$	2016
Deep	LSST (deep drilling)[o]	38.4	(some of) u, g, r, i, z, y	$r < 30$	2020
Deep	UltraVISTA[d]	0.73	Y, J, H, K_s, NB	$K_s < 25.6$	2016
Deep	DES[k]				

Prandoni & Seymour 2015

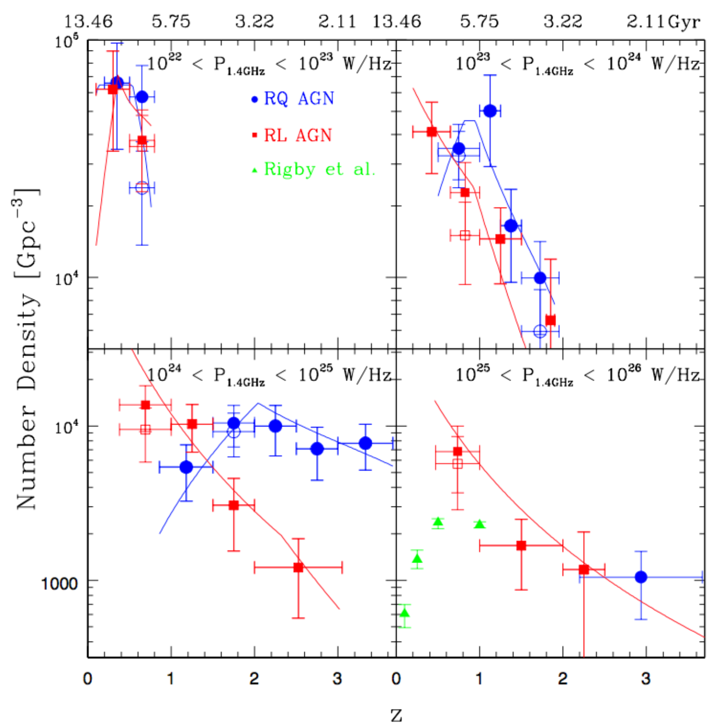
II - Radio-AGN Evolution – EMU Perspectives

ASKAP/EMU: all-sky survey to similar sensitivity as current deep fields
➔ huge statistics at all epochs: **RL AGN ~ 18x10^6**   **RQ AGN ~ 13x10^6**

→ **Evolution of low-L AGNs (incl. RQ AGN) poorly constrained**
→ **high-L tail of (RQ/RL) LF vs z & all environments**



SKADS Simulations (Wilman et al. 2008)



ECDFS Field: 0.3 deg^2 – Padovani+ 2015

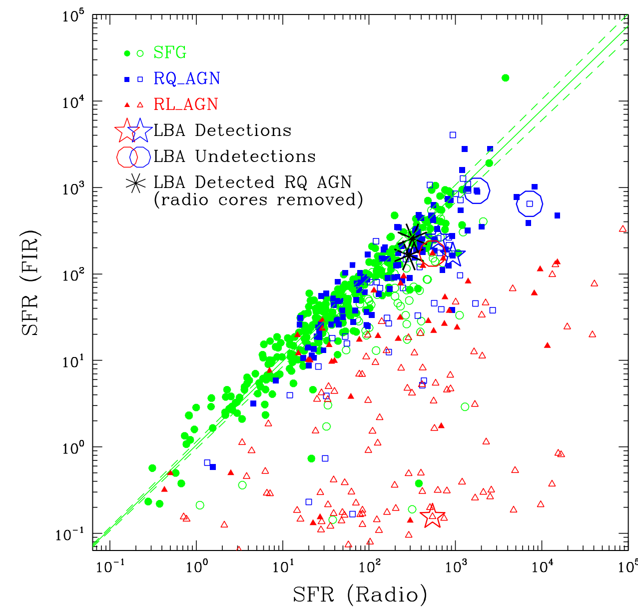
I. Prandoni

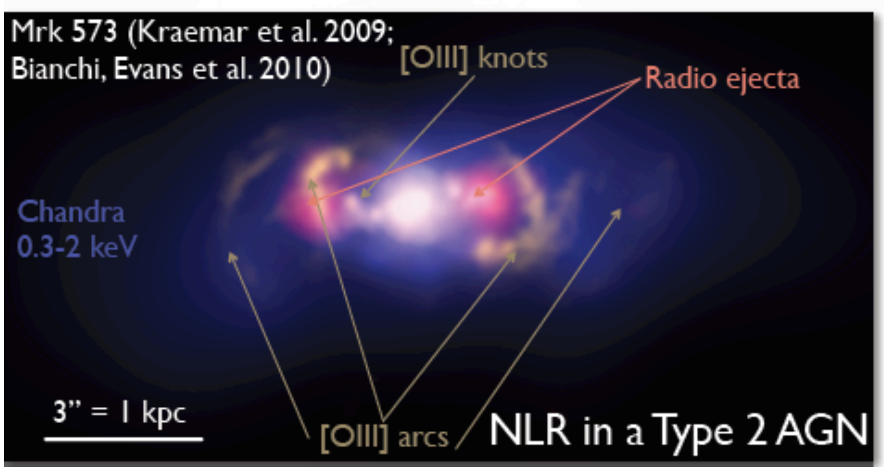
II - Origin of Radio Emission in RQ AGNs

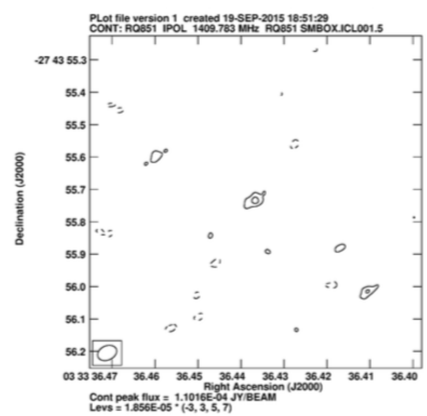
- **What triggers radio emission in RQ AGNs?**

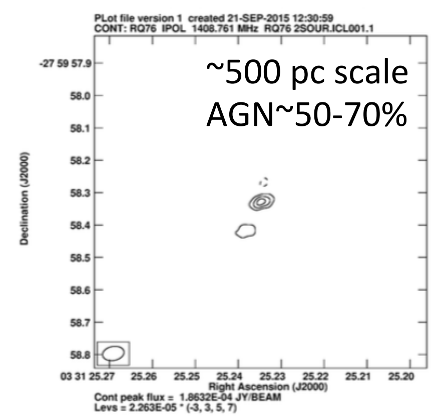
- pure SF in the host galaxy?
- **SF and AGN related emission do co-exist?**
- **AGN Contribution fraction?**
- Synchrotron radiation from mildly relativistic mini-jets?
- magnetic coronal activity (analogy with XRBs)?

- What is the incidence of jet-induced feedback?







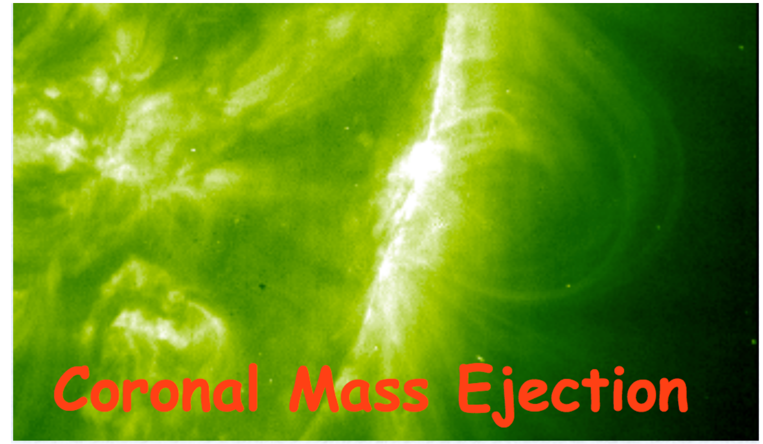


ECDFS – Maini, IP+ 2016

II - Origin of Radio Emission in RQ AGNs

•**What triggers radio emission in RQ AGNs?**

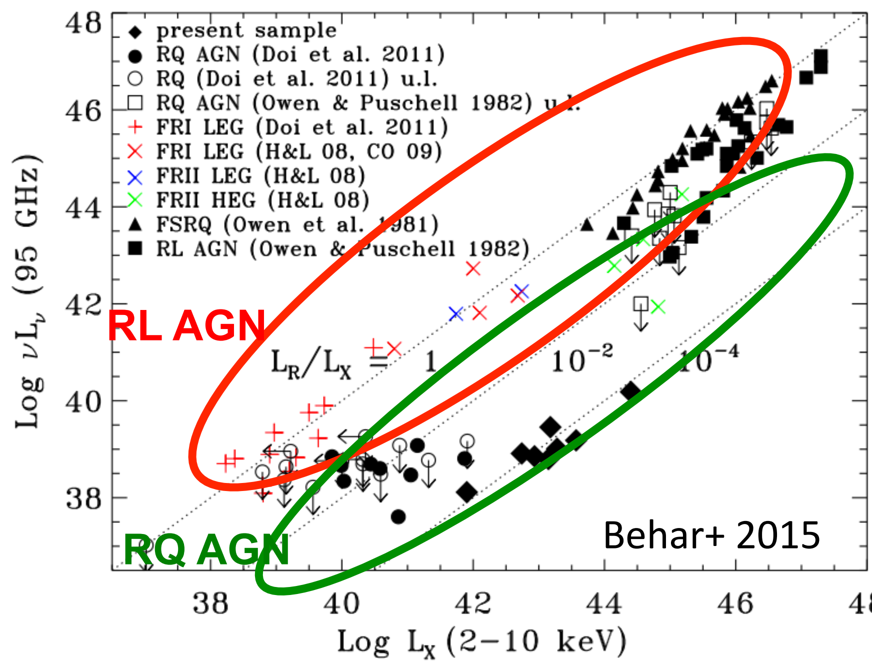
- pure SF in the host galaxy?
- SF and AGN related emission do co-exist?
- AGN Contribution fraction?
- **Synchrotron radiation from mildly relativistic mini-jets?**
- **magnetic coronal activity (likewise CMEs in stars (XRBs)?**



BH fundamental plane (Wong et al. 2016)
L_{radio} – L_x correlation if there is fundamental connection between accretion and radio activity

can be used to test underlying physics:

- **L_{radio} / L_x ~ 1 for RL AGN**
- **L_{radio} / L_x ~ 10^{-5} for coronal emission**



- **Is there a RL/RQ AGN dichotomy?**

II - Origin of Radio Emission in RQ AGNs

The role of EMU:

- **L_{radio} – L_x relation and AGN fundamental plane:**
  location of different classes of RQ AGN (Seyfert, QSO, radio luminosity, etc) on L_{radio} – L_x relation, **and redshift dependence**
  → underlying physics of AGN-related radio emission; dichotomy?
  – For a local sub-sample: BH masses can derived from e.g. broad line (H_{beta}) fitting → study AGN fundamental plane on statistical grounds

- **Disentangling AGN from SF contribution in RQ AGNs:**
  ~20000 RQ AGN @ z<0.01 (10" = 2 kpc)
  allows first systematic statistical studies + selection of sub-samples for higher resolution follow-up (higher frequency or VLBI)

Summary

Deep radio surveys → valuable dust-extinction/gas-obscuration-free tool to study **AGN activity and related feedback up to high redshifts and down to RQ regime**

Deep All-sky surveys like EMU → ample statistics at *all* redshifts & wide-area/ extensive multi-band information will allow to fully exploit EMU

- **z~0:** allows detailed multivariate studies: SDSS-like but including radio properties among the parameters under study (NVSS and FIRST too limited)
  → crucial for issues that arise mainly at radio-band, like e.g. RL/RQ dichotomy, the origin of radio emission in RQ AGN, etc.
  → crucial when radio-band provide essential information, like e.g. AGN fundamental plane

- **z>>0:** allows to probe **evolution of AGN activity and feedback at low radio luminosities**, still poorly constrained in both its two modes.

Early Science → exploratory study in the GAMA fields:

~5000 RQ AGN expected with S>500 uJy

~3000 at z<0.4 (spectroscopy completeness)

bulge/disk decomposition
BPT diagnostics
star, gas, dust components

THANKS!