

Radio variability as probe of corona/jet-base origin in RQ AGN

Francesca Panessa



INAF

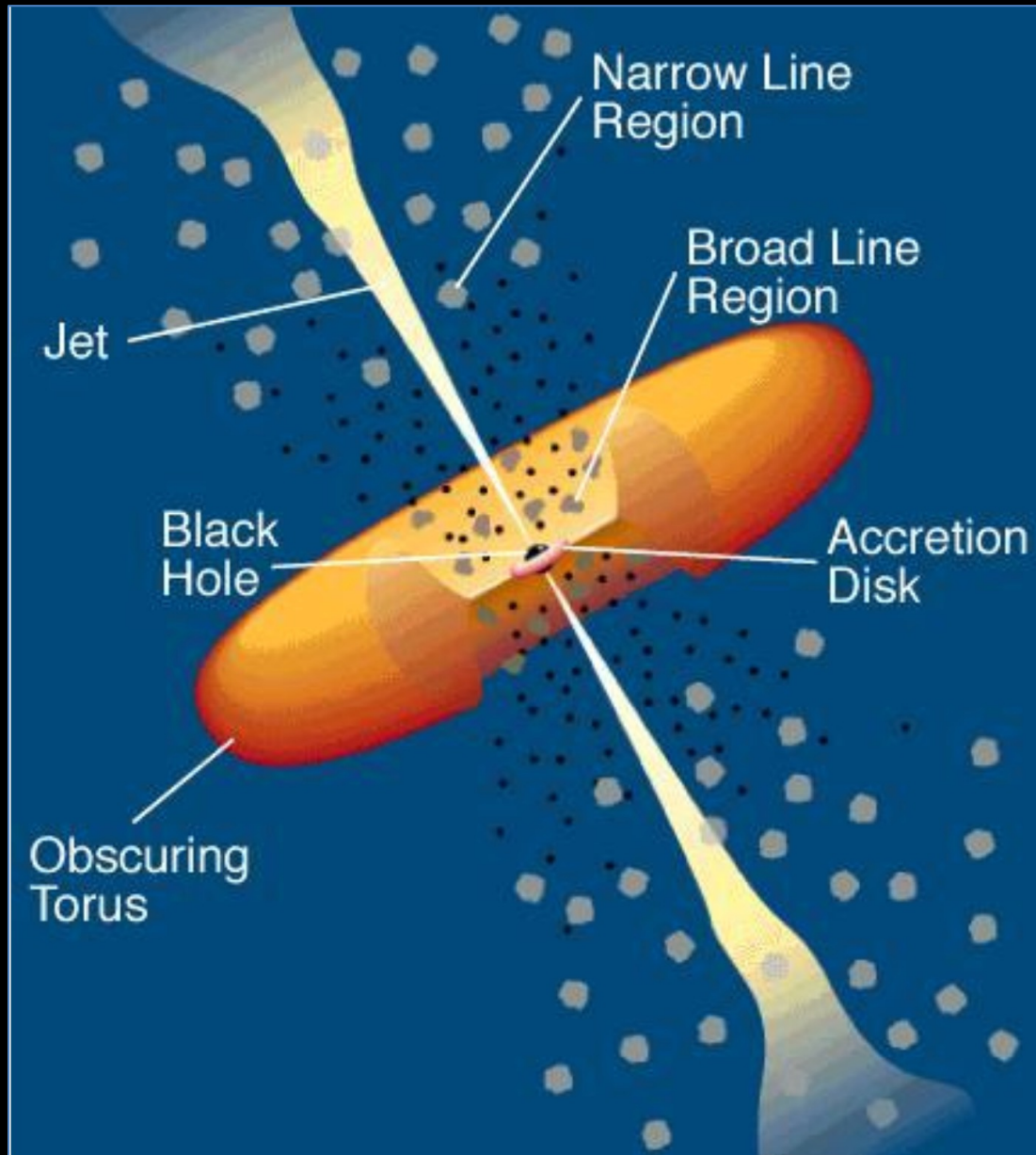
ISTITUTO NAZIONALE
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14–17 set 2026
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Illuminating the Active Universe

Multi-Wavelength and Multi-Messenger
Insights into AGN

THE SUPERMASSIVE BLACK HOLE & THE GALAXY



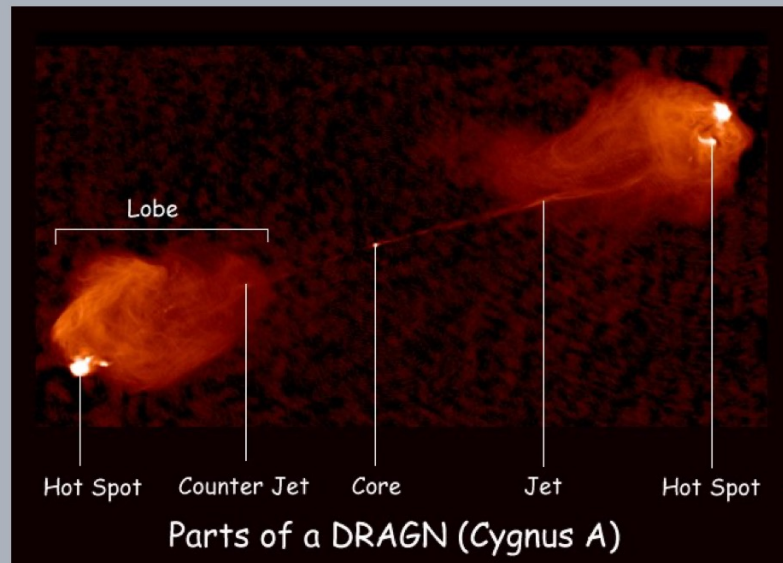
- Accretion disc
- Hot corona
- Wind
- Jet
- Star-formation

→ all radio emitters!

Radio Loud vs Radio Quiet

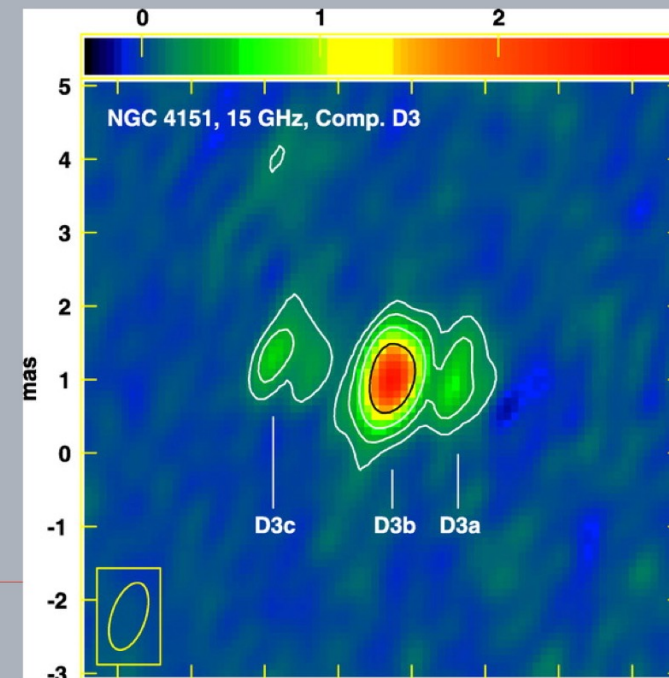
Radio Loud RL:

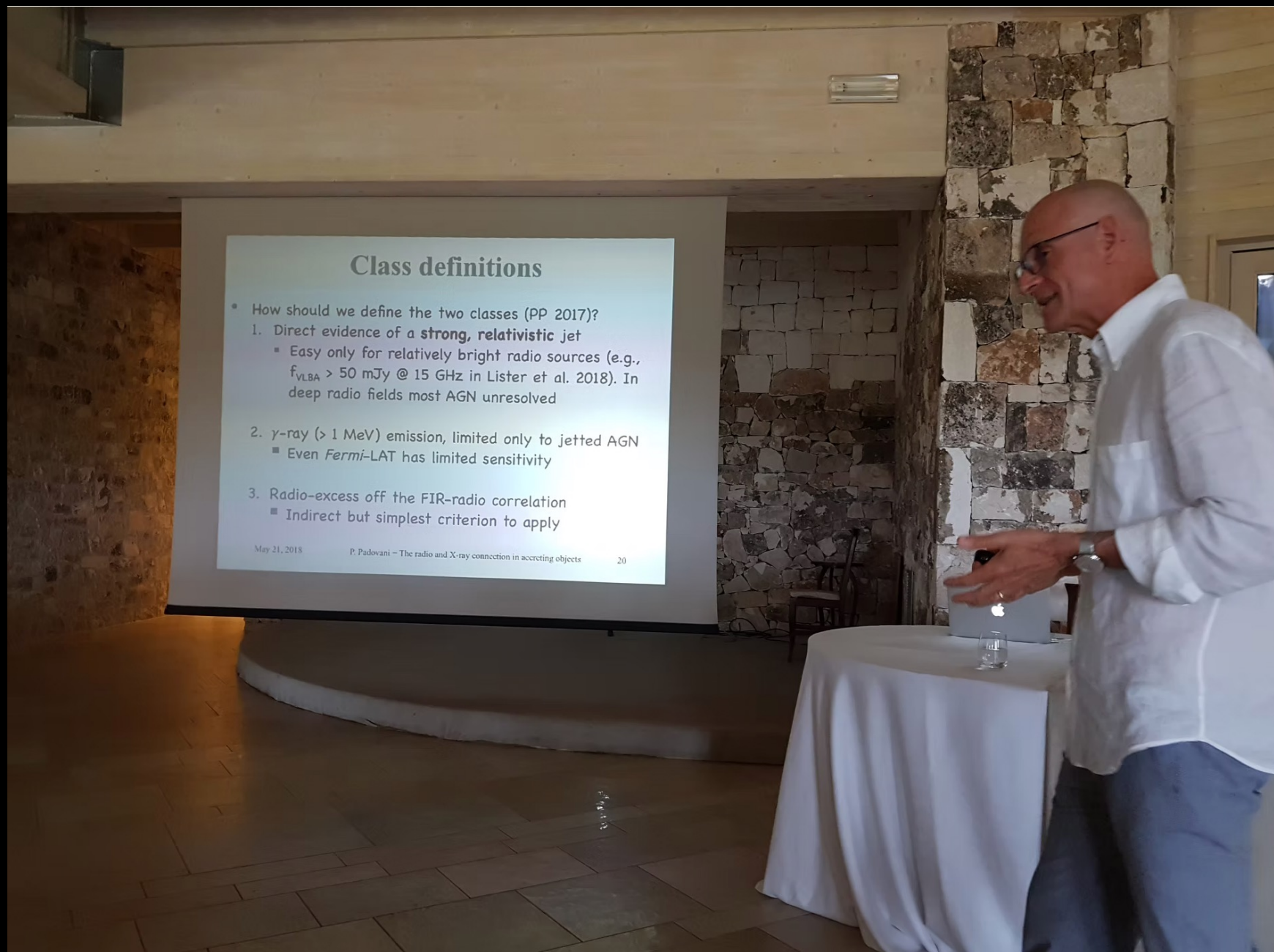
- Large scale radio lobes
- Compact luminous cores often with apparent luminal motions



Radio Quiet RQ:

- Faint radio sources
- Emission confined to sub-kpc scale





Class definitions

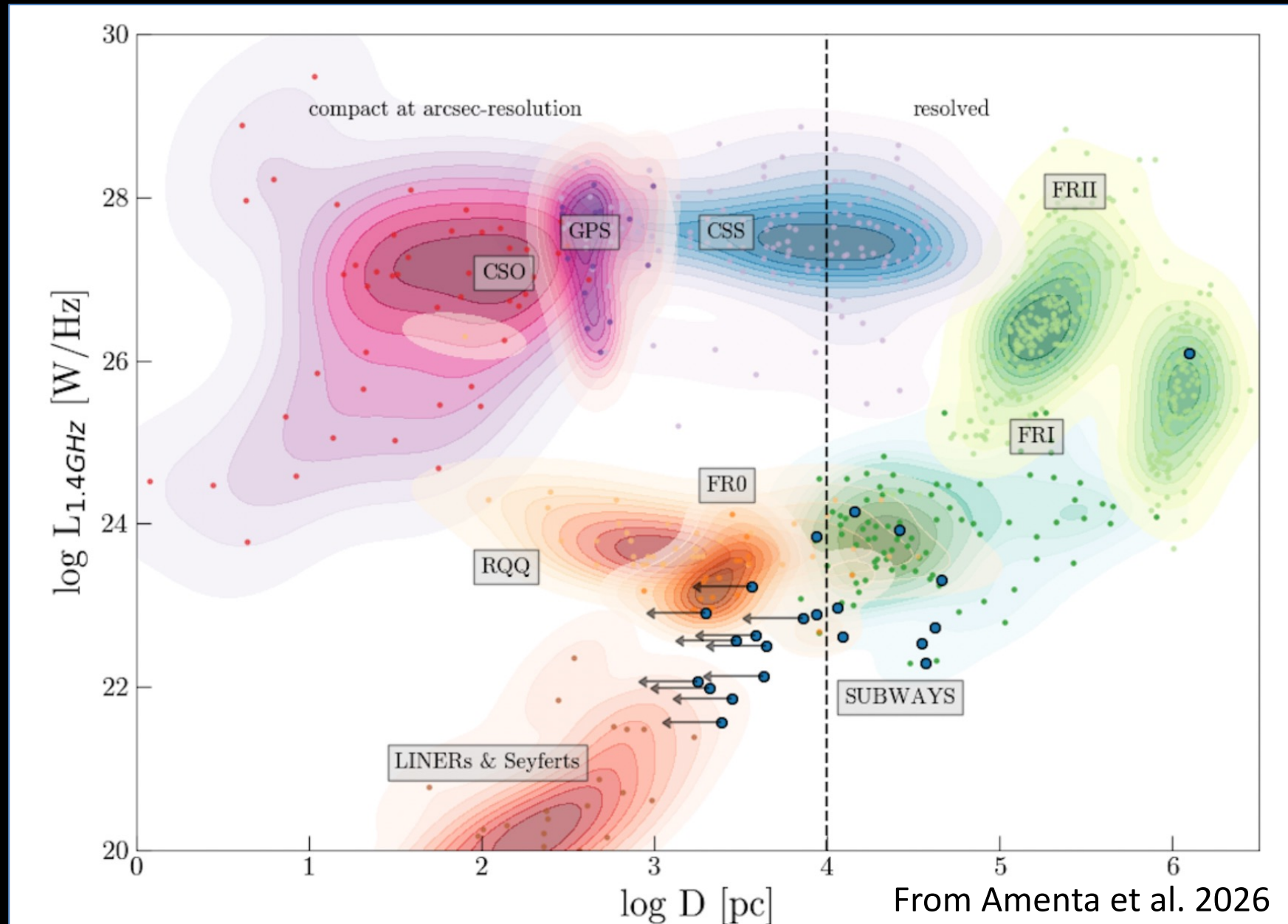
- How should we define the two classes (PP 2017)?
 1. Direct evidence of a **strong, relativistic jet**
 - Easy only for relatively bright radio sources (e.g., $f_{\text{VLBA}} > 50 \text{ mJy @ 15 GHz}$ in Lister et al. 2018). In deep radio fields most AGN unresolved
 2. γ -ray ($> 1 \text{ MeV}$) emission, limited only to jetted AGN
 - Even *Fermi*-LAT has limited sensitivity
 3. Radio-excess off the FIR-radio correlation
 - Indirect but simplest criterion to apply

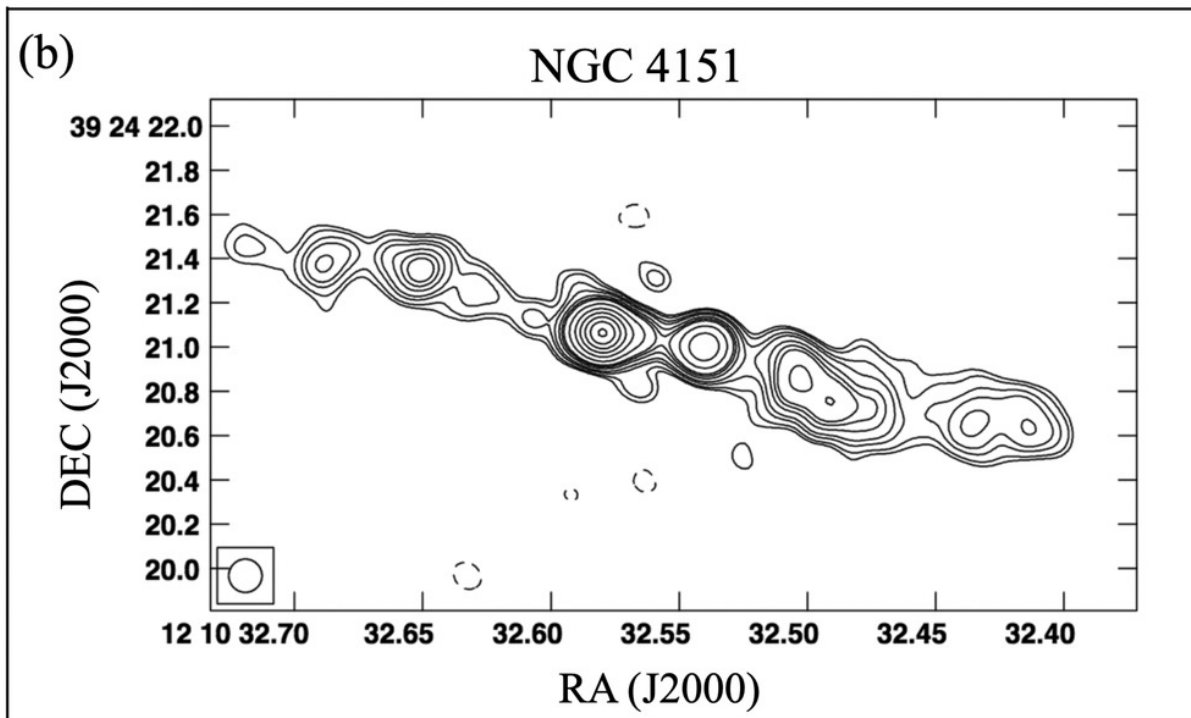
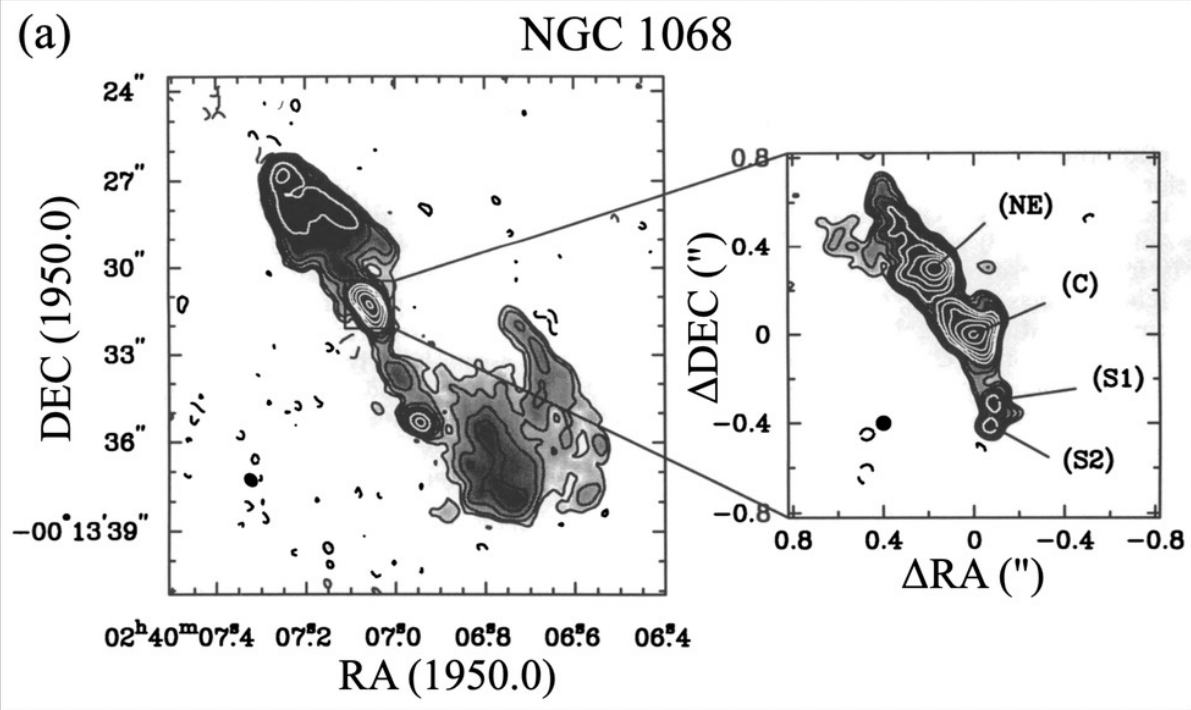
May 21, 2018 P. Padovani – The radio and X-ray connection in accreting objects 20

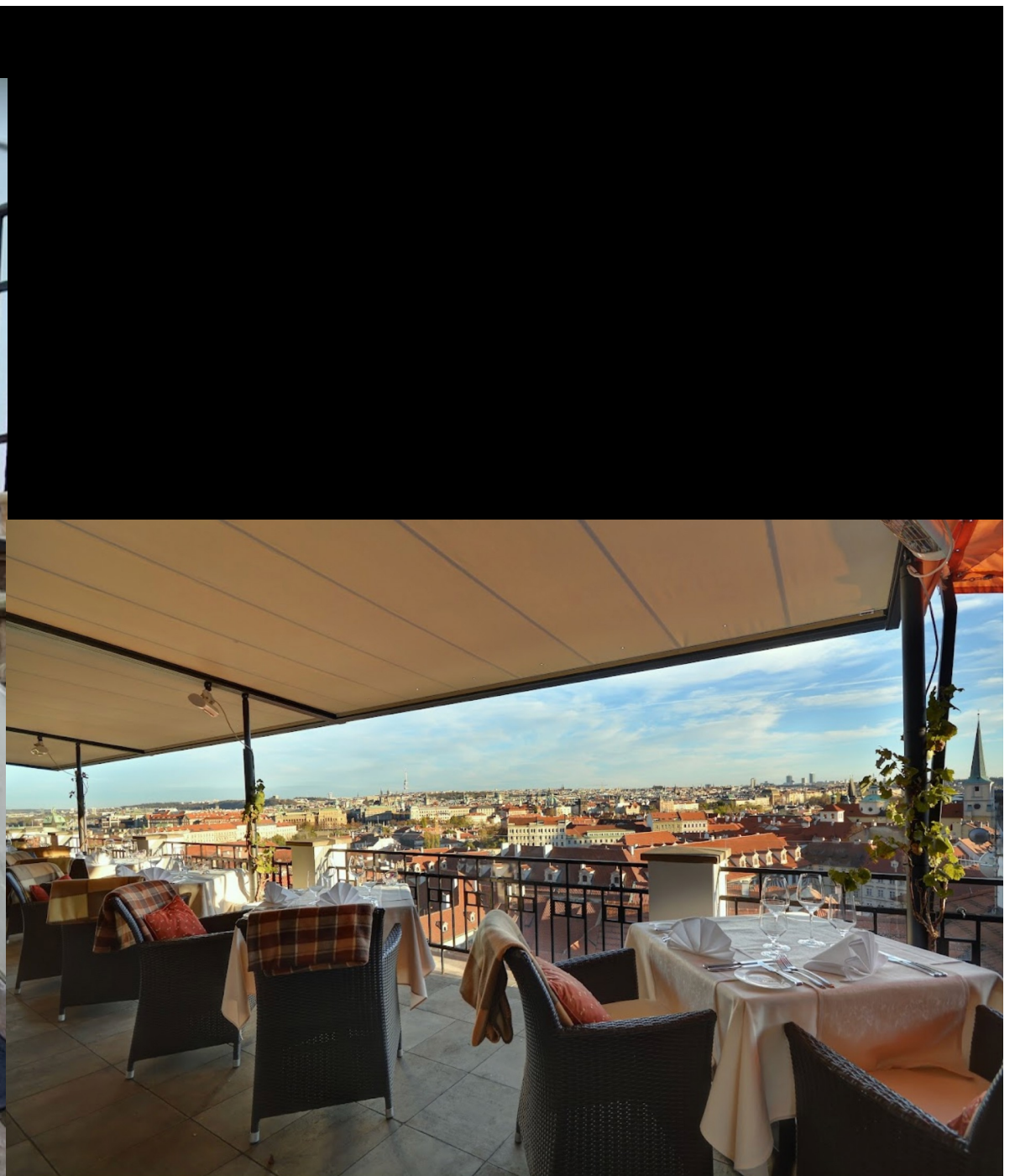
...and never forget:
the “radio-loud/ra-
dio-quiet” classes are
obsolete, misleading, and
inappropriate



AGN: from non-JETTED to JETTED







EAS, Prague, 2017



Puglia, 2018

The origin of radio emission from radio-quiet active galactic nuclei

Francesca Panessa ^{1*}, Ranieri Diego Baldi ^{2,3}, Ari Laor³, Paolo Padovani ⁴, Ehud Behar³
and Ian McHardy²

The central nuclei of galaxies, where supermassive black holes (SMBHs) are thought to reside, can experience phases of activity when they become active galactic nuclei (AGNs). An AGN can eject winds and jets and produce radiation across the entire electromagnetic spectrum. The fraction of the bolometric emission in the radio spans a factor of approximately 10^5 across the different classes of AGNs. The weakest radio sources, radio-quiet (RQ) AGNs, are typically 1,000 times fainter than the radio-loud (RL) AGNs, and represent the majority of the AGN population. In RQ AGNs, the absence of luminous jets allows us to probe radio emission from a wide range of possible mechanisms: star formation, AGN-driven wind, free-free emission from photoionized gas, low-power jets and the innermost accretion disk coronal activity. All these mechanisms can now be probed with unprecedented precision and spatial resolution, owing to the current and forthcoming generation of highly sensitive radio arrays.

CAMERA DEI DEPUTATI
VENERDI' 5 LUGLIO 2019 - ORE 10.00

Ricerca & Sviluppo

PREMIO SPARLAMENTO

Premio assegnato al
dott. Paolo Padovani, astronomo

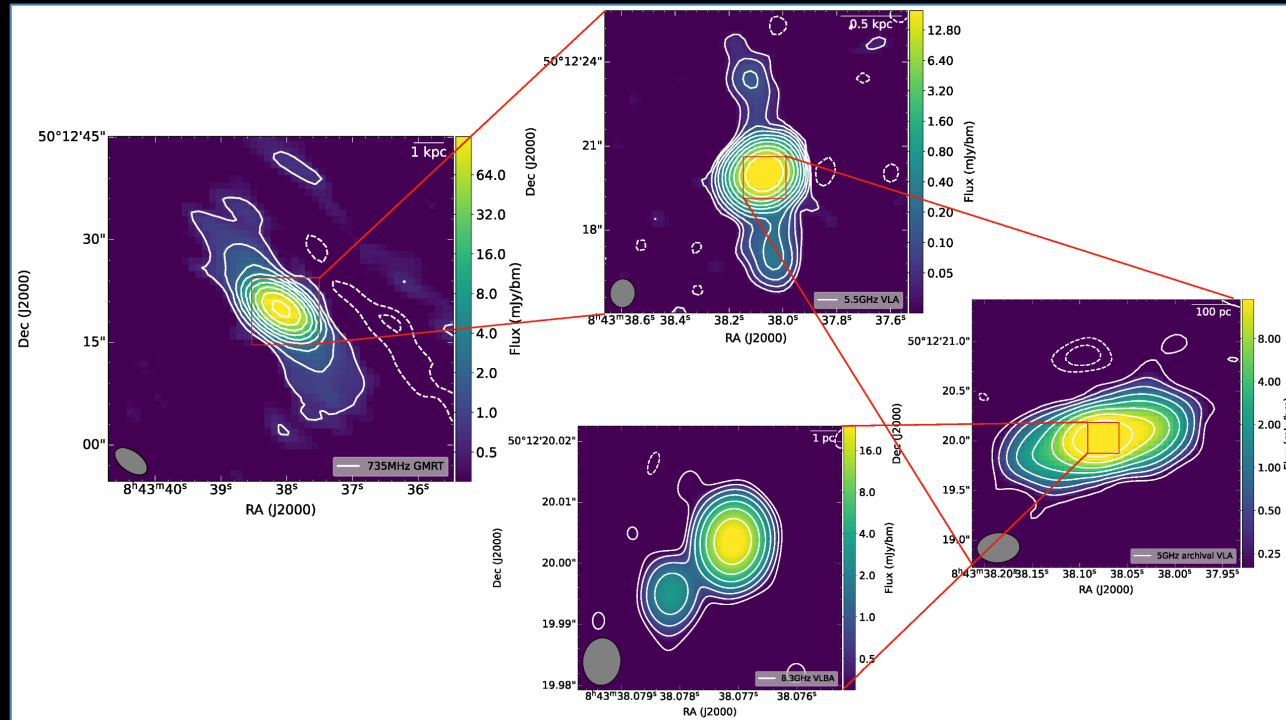
Seguirà Conferenza:
"Neutrini da buchi neri massicci:
una nuova finestra sull'Universo"

con la partecipazione di:
prof. Nicolò D'Amico, presidente INAF, prof.ssa Ginevra
Trinchieri, presidente SAlt. Sono previsti interventi di
parlamentari e membri del Governo

Con la collaborazione di Luca Fornaciari,
esperto e professionista della fotografia astronomica

R.S.V.P. sparlamento.info@gmail.com

RQ AGN



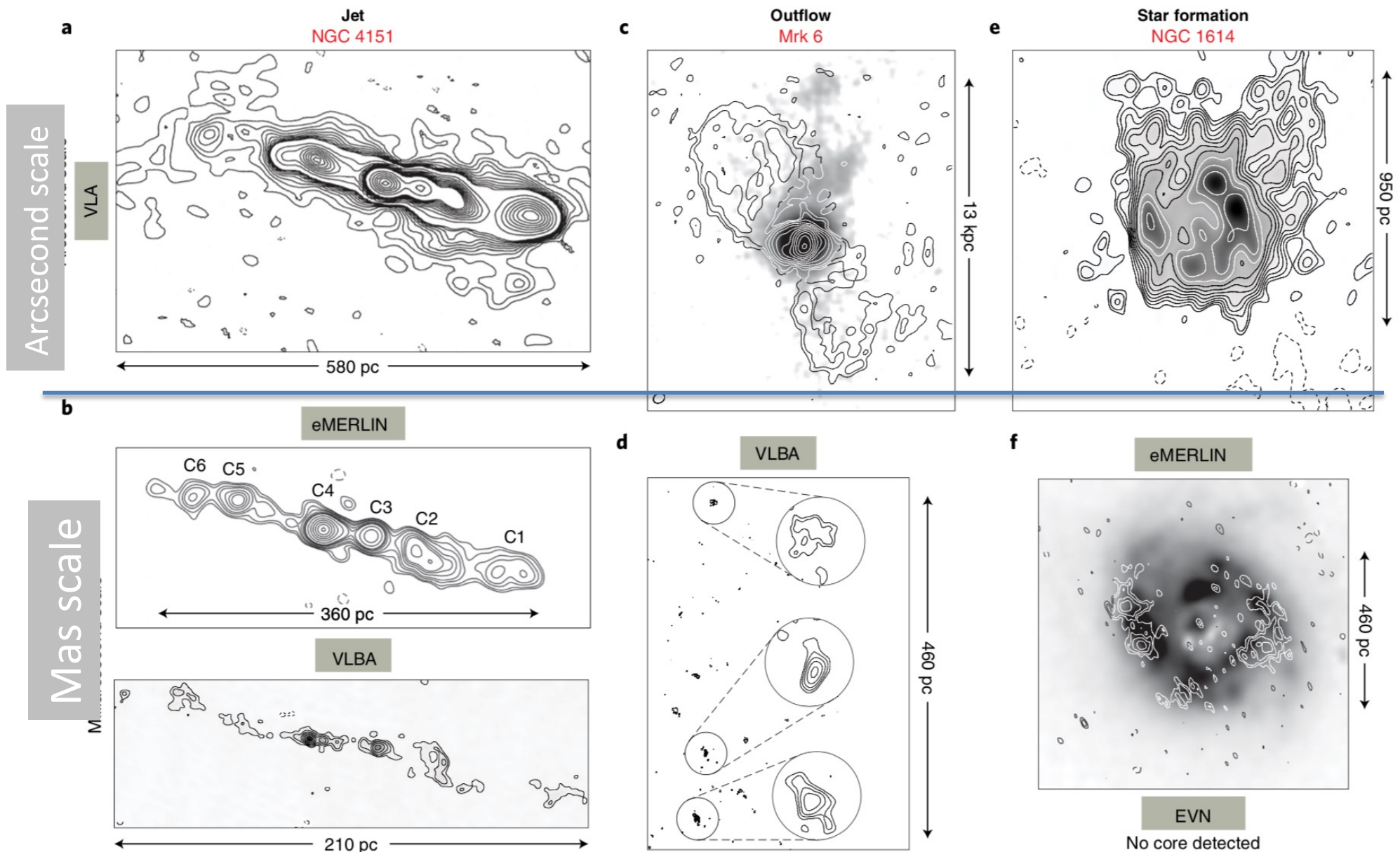
Kharb & Silpa 2023

High detection rate of “RQ AGN” at

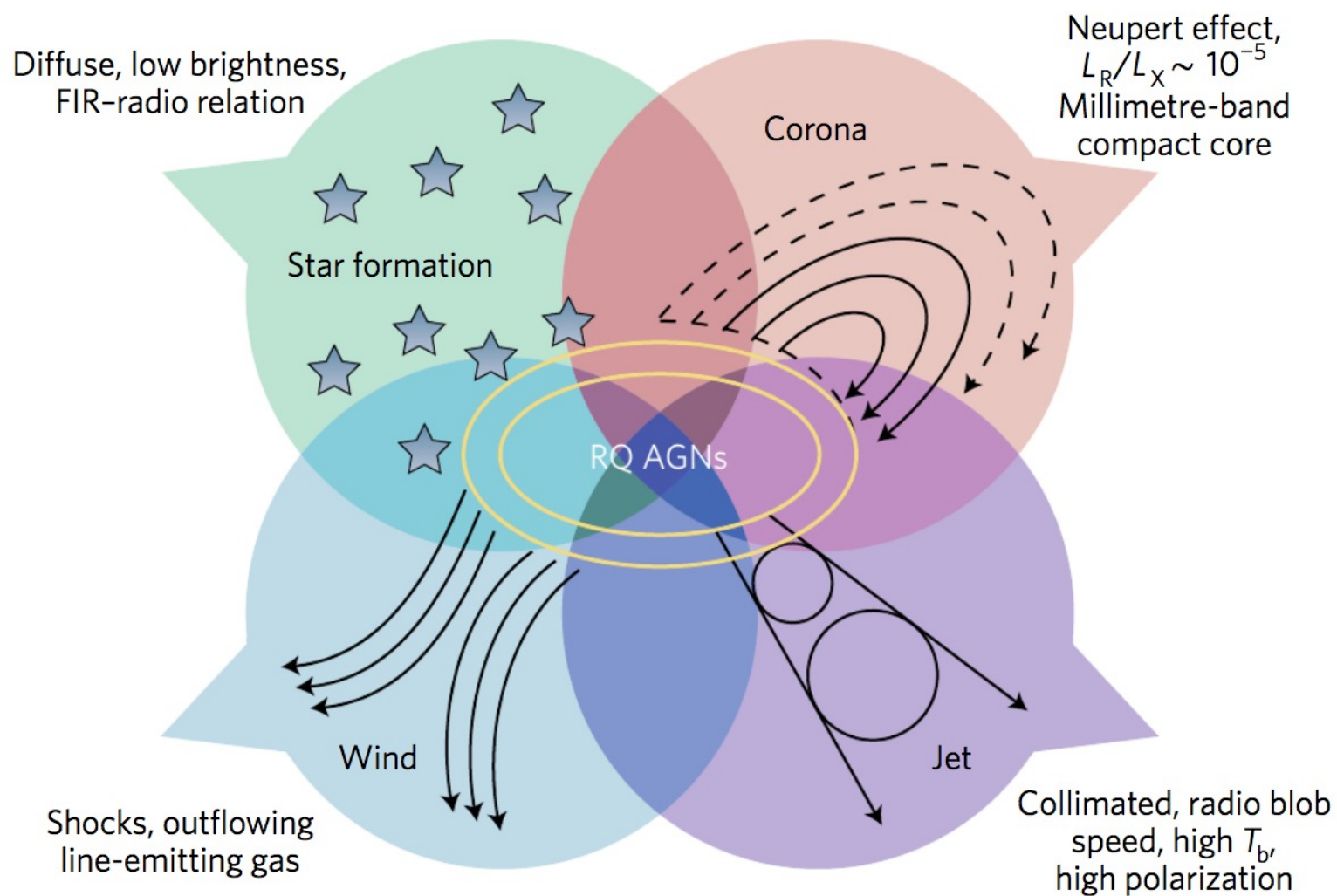
- ✓ all frequencies
- ✓ all scales
- ✓ all Eddington ratios
- ✓ all redshifts

Njeri et al. 2026, Cheng et al. 2025, Magno et al. 2025, Kondapally et al. 2023, Wang et al. 2023a, Wang et al. 2023c, Fischer et al. 2022, Whittam et al. 2021, Nyland et al. 2020, Panessa et al. 2019, Nyland et al. 2016, Padovani et al. 2015, Panessa & Giroletti 2013, Padovani et al. 2011, Giroletti & Panessa 2009, Leipski et al. 2006, Nagar et al. 2005, Nagar et al. 2002, Ulvestad & Ho 2001, Blundell & Rawlings 2001, Kukula et al. 1998, Ulvestad et al. 1995, Kellermann et al. 1989

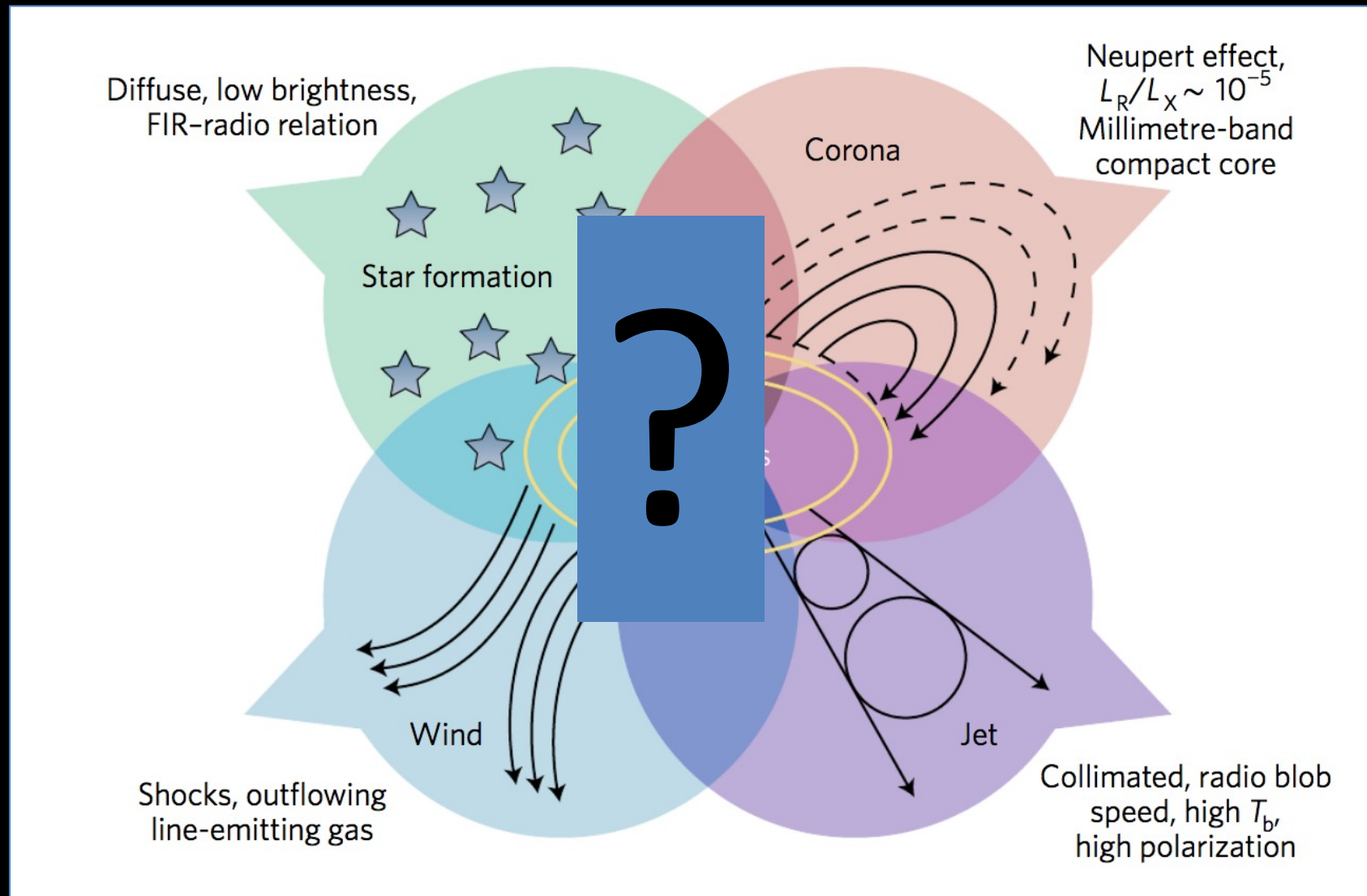
The radio emission in RQ AGN



Physical mechanisms



Radio VARIABILITY in RADIO QUIET AGN



Radio VARIABILITY in RADIO QUIET AGN

Typical variability of 10-20%

Wrobel 2000 ; Anderson & Ulvestad 2005 ; Barvainis et al. 2005 ; Mundell et al. 2009 ; Bell et al. 2011 ; Doi, Asada & Nagai 2011 ; King et al. 2013 ; Baldi et al. 2015 ; Behar et al. 2020 ; Williams et al. 2020, Panessa et al 2022, Petrucci et al. 2023, Hernandez-Garcia et al. 2026, Bruni et al. 2026

Radio VARIABILITY in RADIO QUIET AGN

Core Flux Variations → rule out stationary diffuse starburst models

VLA 8.4 GHZ MONITORING

High-frequency VLA monitoring of low-luminosity Seyfert galaxies revealed core flux density variations by factors of 1.5–2 on month-to-year timescales (Wrobel 2000, see also Mundell et al. 2009)

Parsec-Scale Cores → compact non-thermal synchrotron engines

VLBA PARSEC RESOLUTION

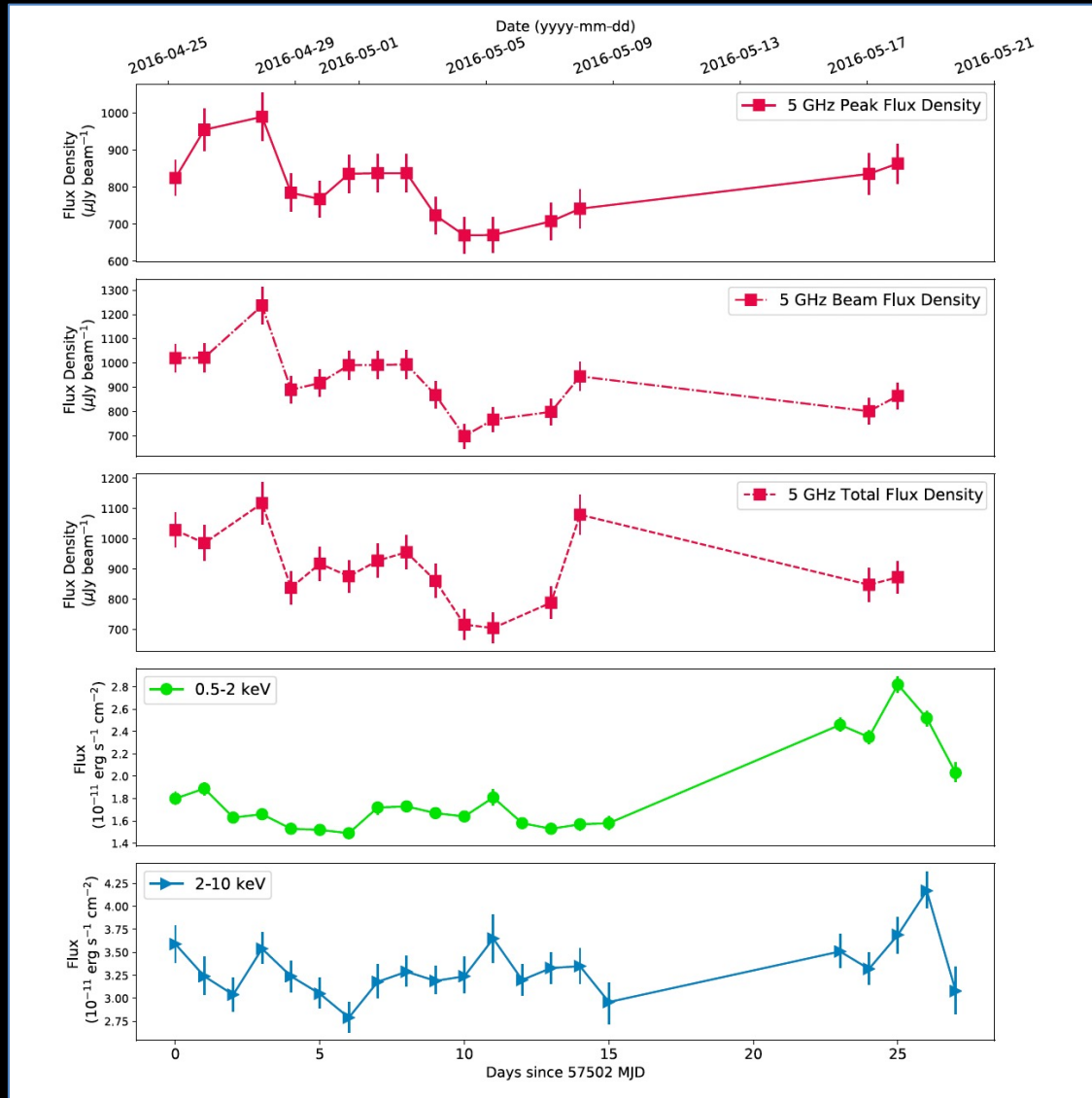
High-resolution VLBA imaging detected sub-parsec core variability along with high brightness temperatures, confirming that radio-quiet cores originate from (Anderson & Ulvestad 2005).

Quasar Core Variability → radio variability is pervasive across RQQs

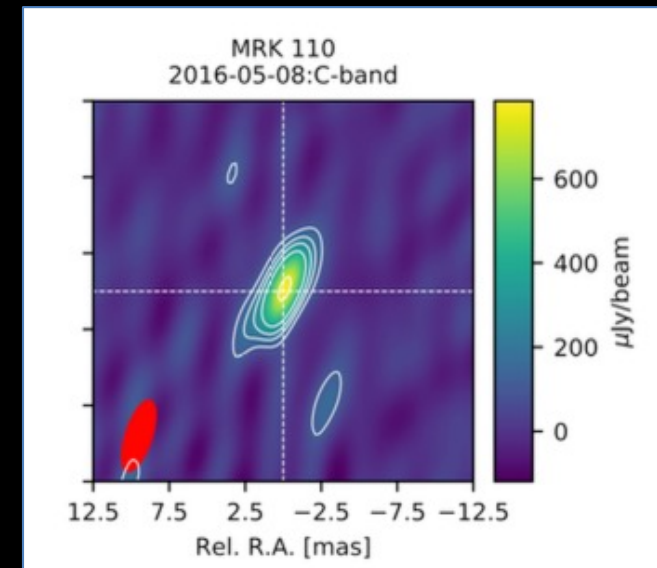
MULTI-EPOCH RQQ SURVEY

A systematic multi-epoch survey of optically selected radio-quiet quasars uncovered significant flux changes in 30%–50% of targets, demonstrating that (Barvainis et al. 2005).

Milli-arcsecond daily variability in RADIO QUIET AGN



Mrk 110 – NLSy1
Extremely RQ



→ radio region $< 180 R_s$

Coronal or low power jet emission?

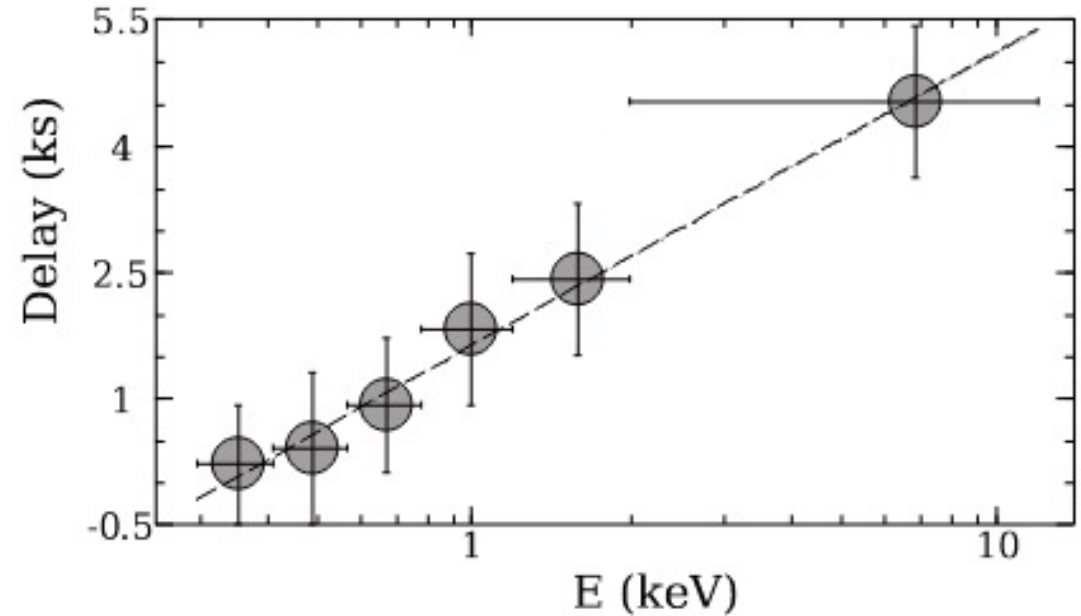
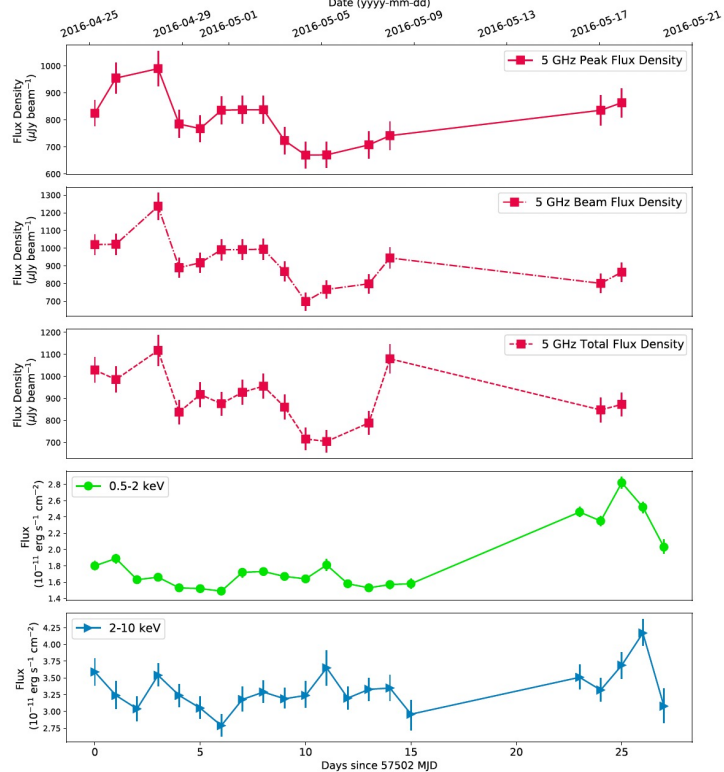
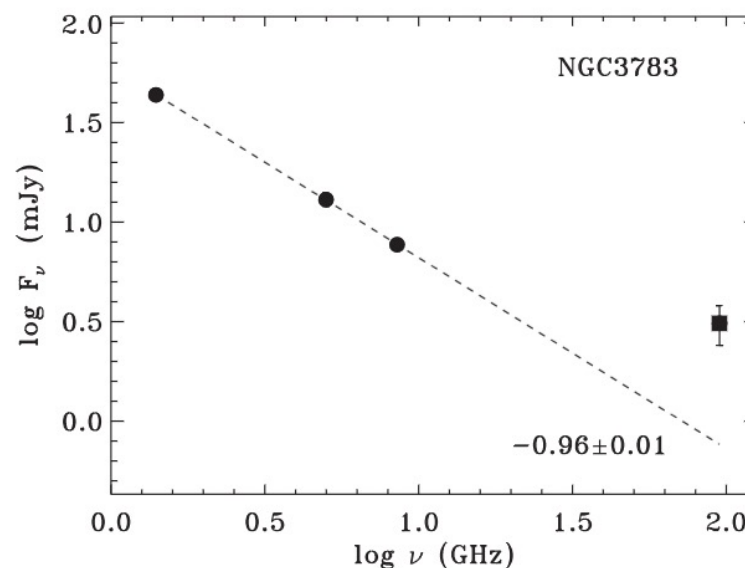
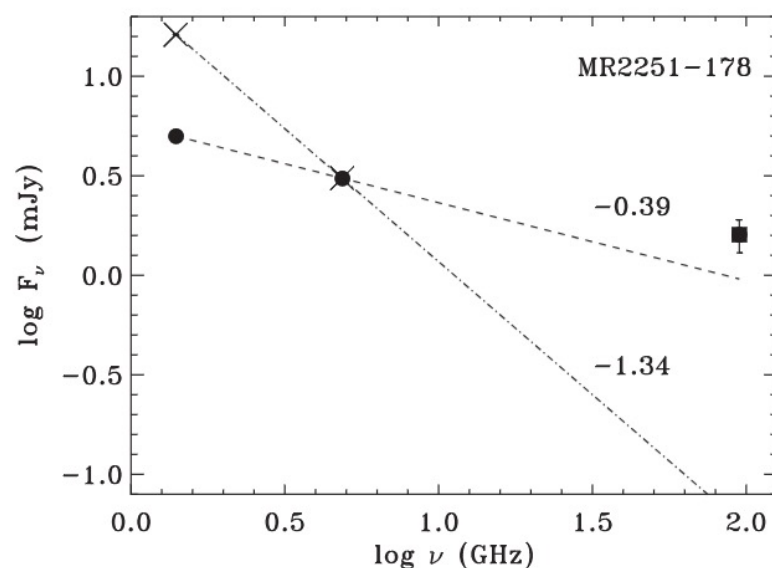


FIG. 3.— Energy dependence of lag between the light curves of energy 0.2 – 0.3 keV and higher energies.

The energy dependent delay can be modeled as due to the effect of Comptonization in a hot plasma confined within 10 Schwarzschild radii of the black hole

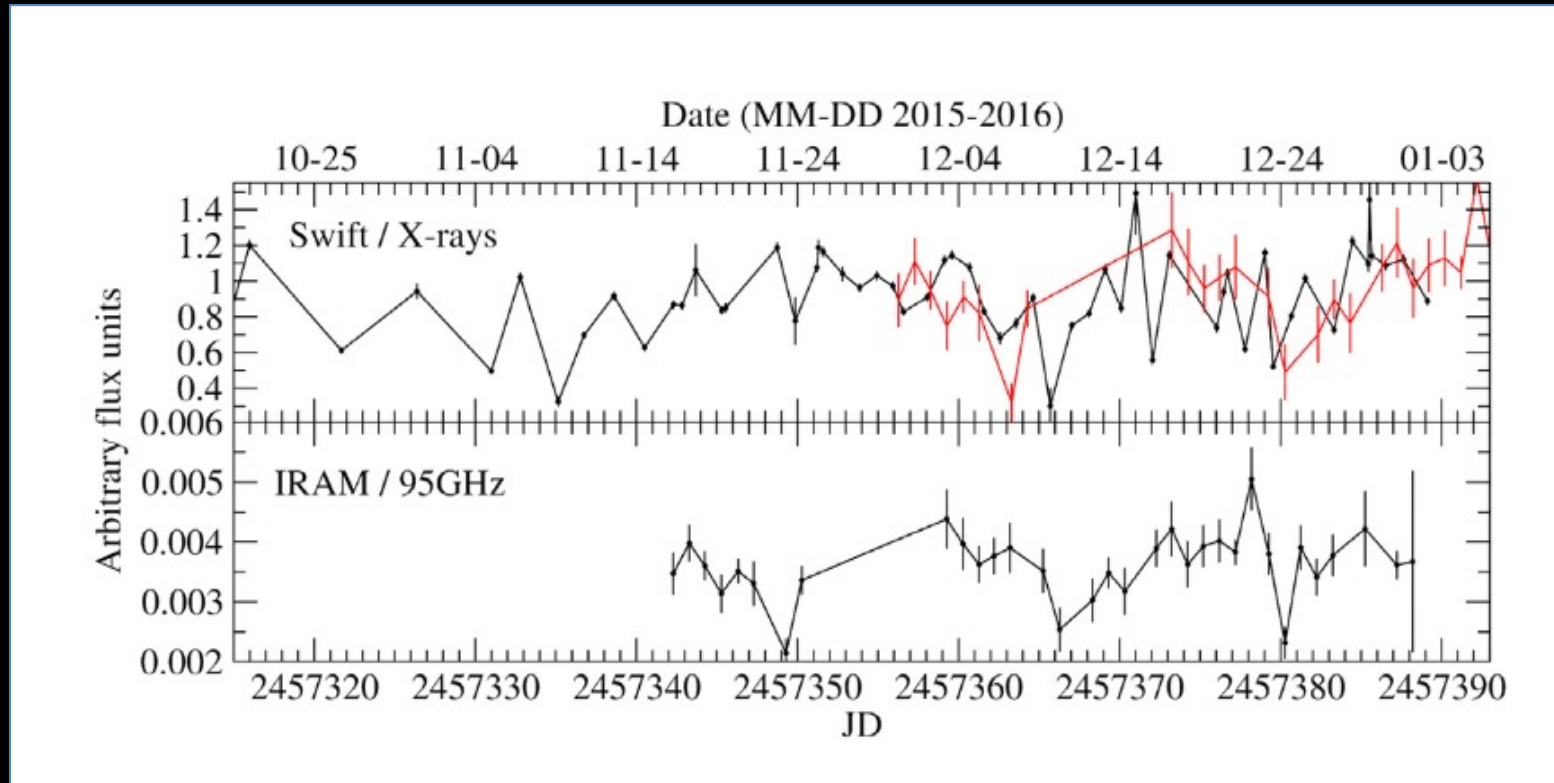
Discovery of millimetre-wave excess emission in radio-quiet active galactic nuclei

Ehud Behar,^{1★} Ranieri D. Baldi,¹ Ari Laor,¹ Assaf Horesh,² Jamie Stevens³
and Tasso Tzioumis³ 2015



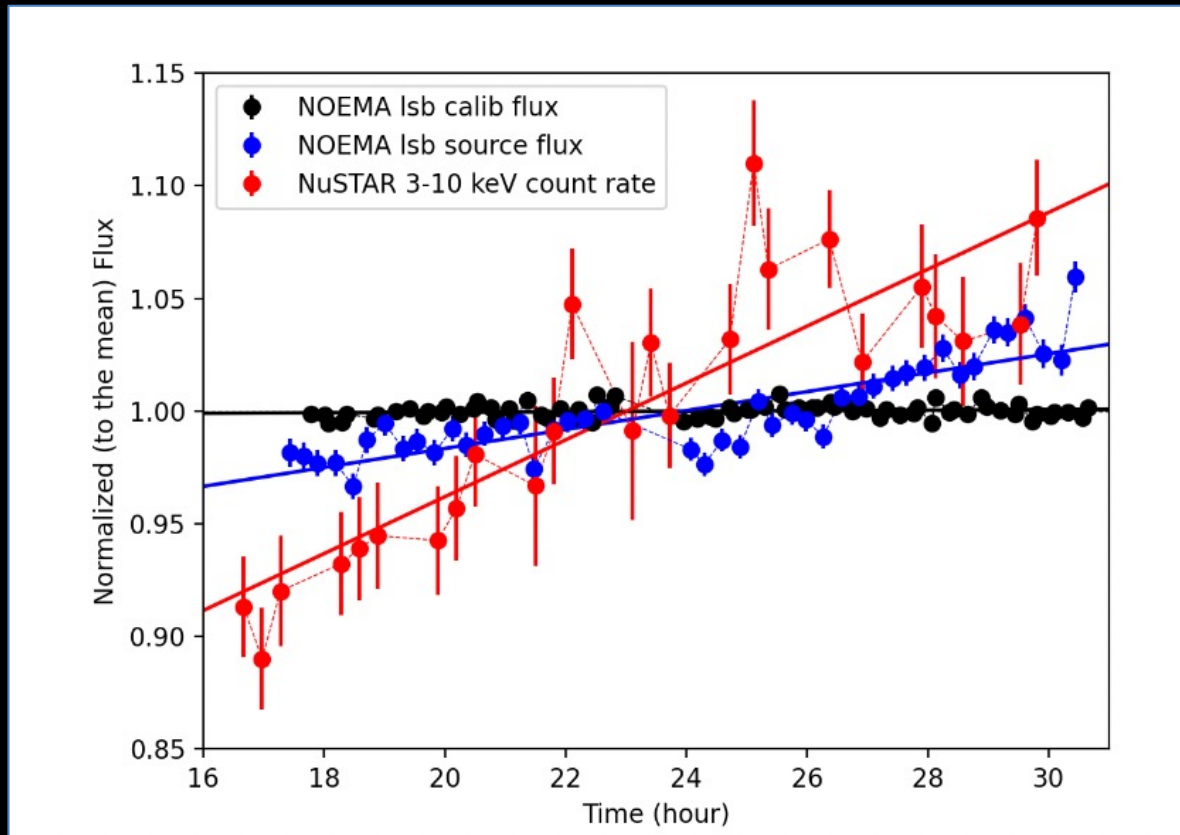
Simultaneous mm-wave and X-ray monitoring of RQ AGN
features a promising method for understanding accretion disc
coronal emission

Corona versus Jet Ejections



Identified tight coronal coupling: mm-wave flares often accompany or follow hard X-ray heating events, strongly favoring a magnetically dominated corona over extended relativistic shocks

Magnetized accretion coronae

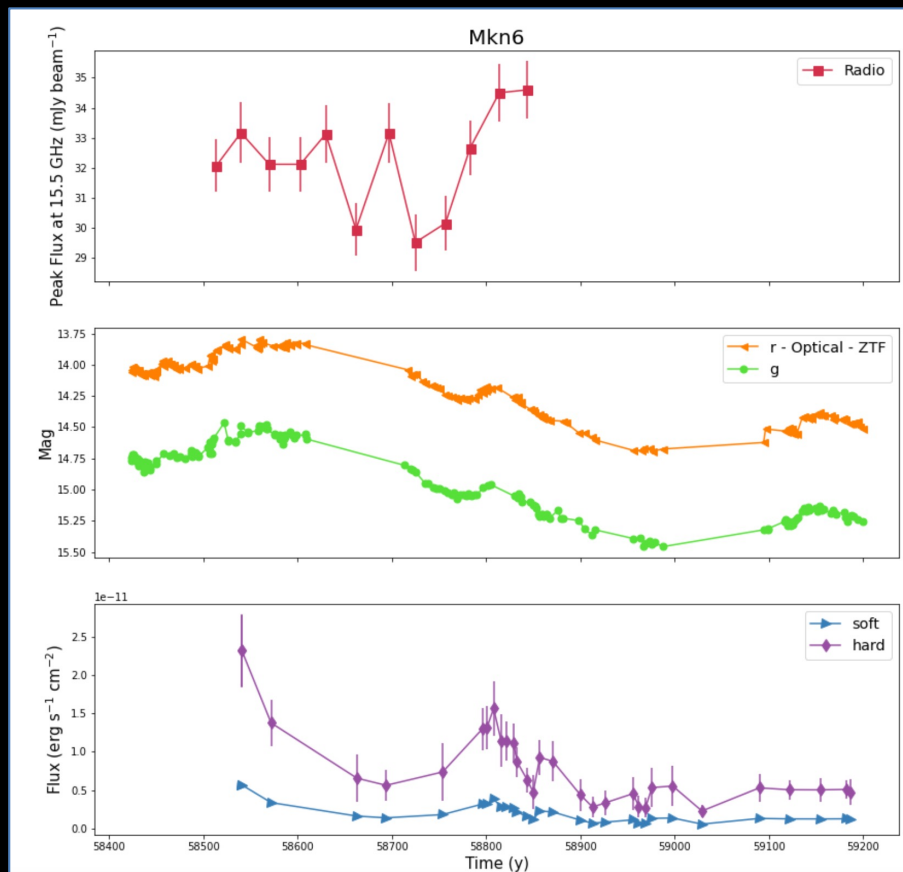
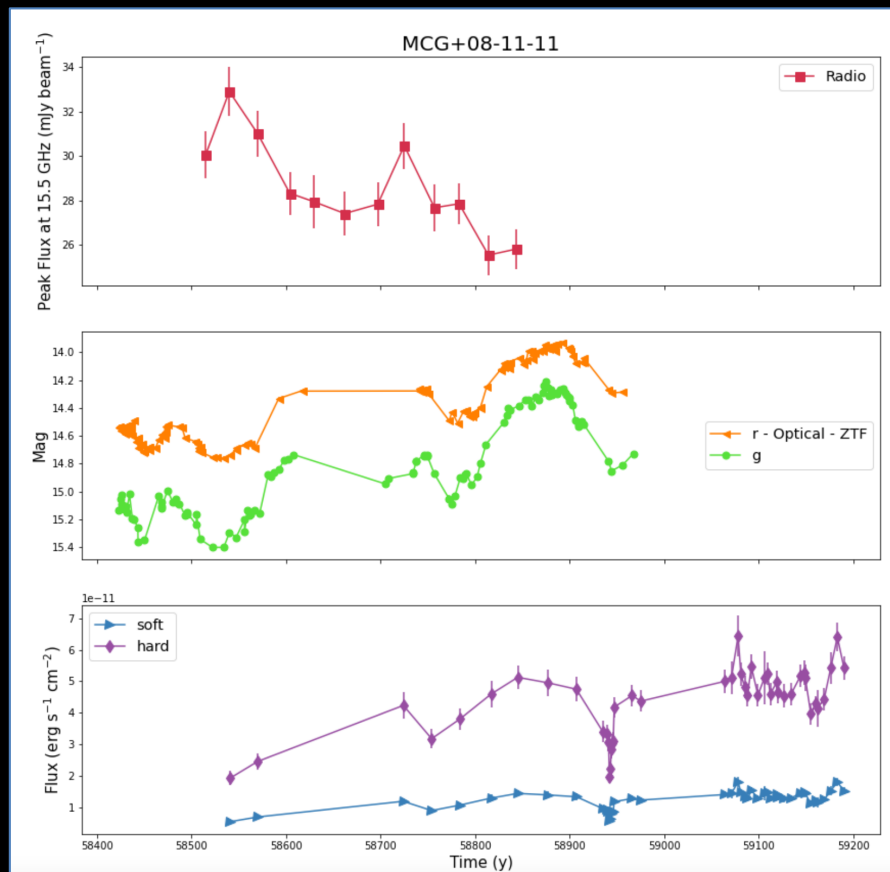


Magnetic reconnection events in magnetized accretion coronae, explains correlated radio/X-ray transitions without needing classical relativistic jets

Monthly monitoring of Hard X-ray selected AGN

AMI 15 GHz Light Curves

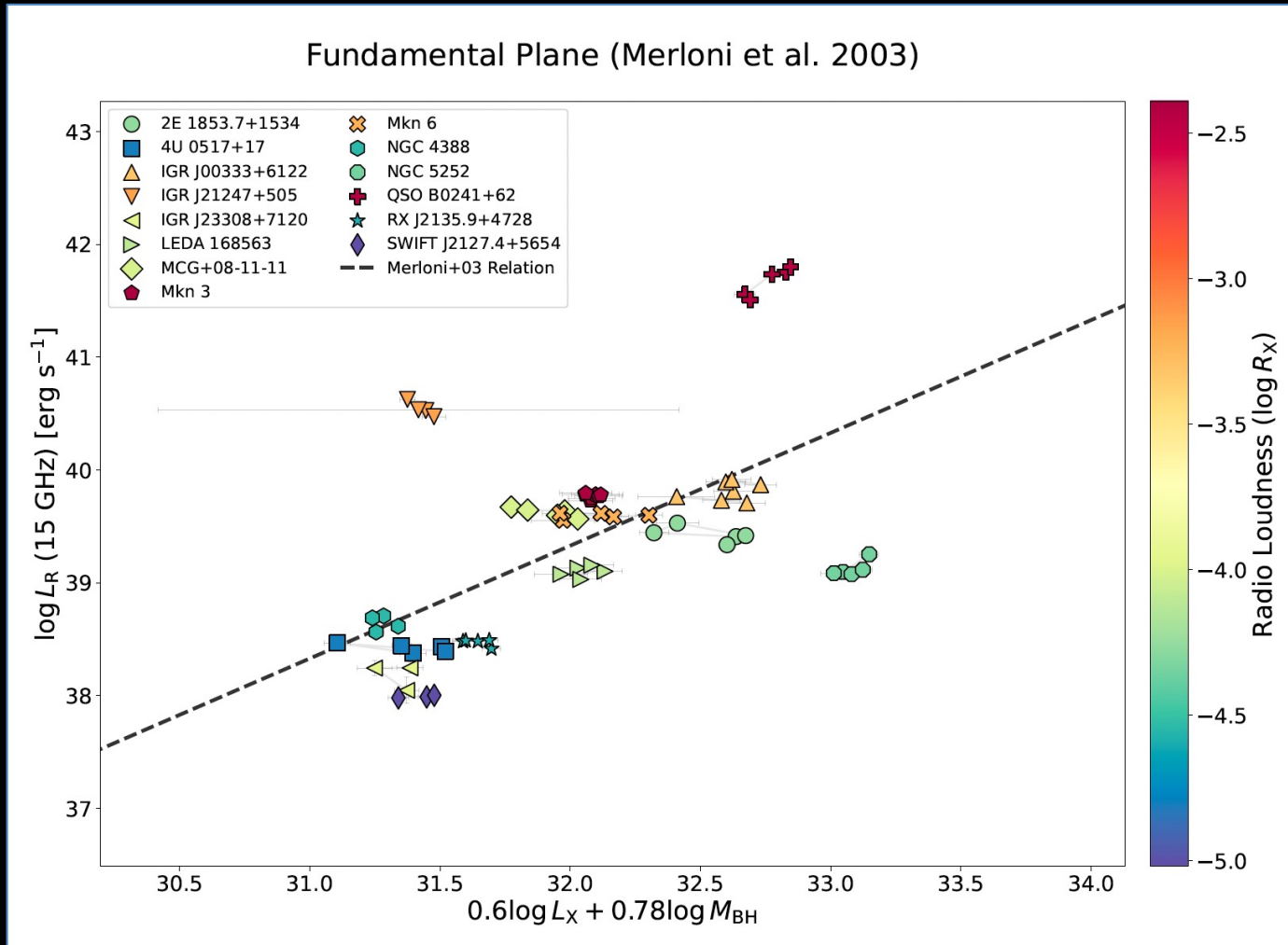
Hernandez-Garcia, Panessa et al. 2026



Variability fractions 10% (4–23%) - Long-term fluctuations dominate

*Core-dominated origin at 15 GHz
→ compact jet base or a magnetized corona*

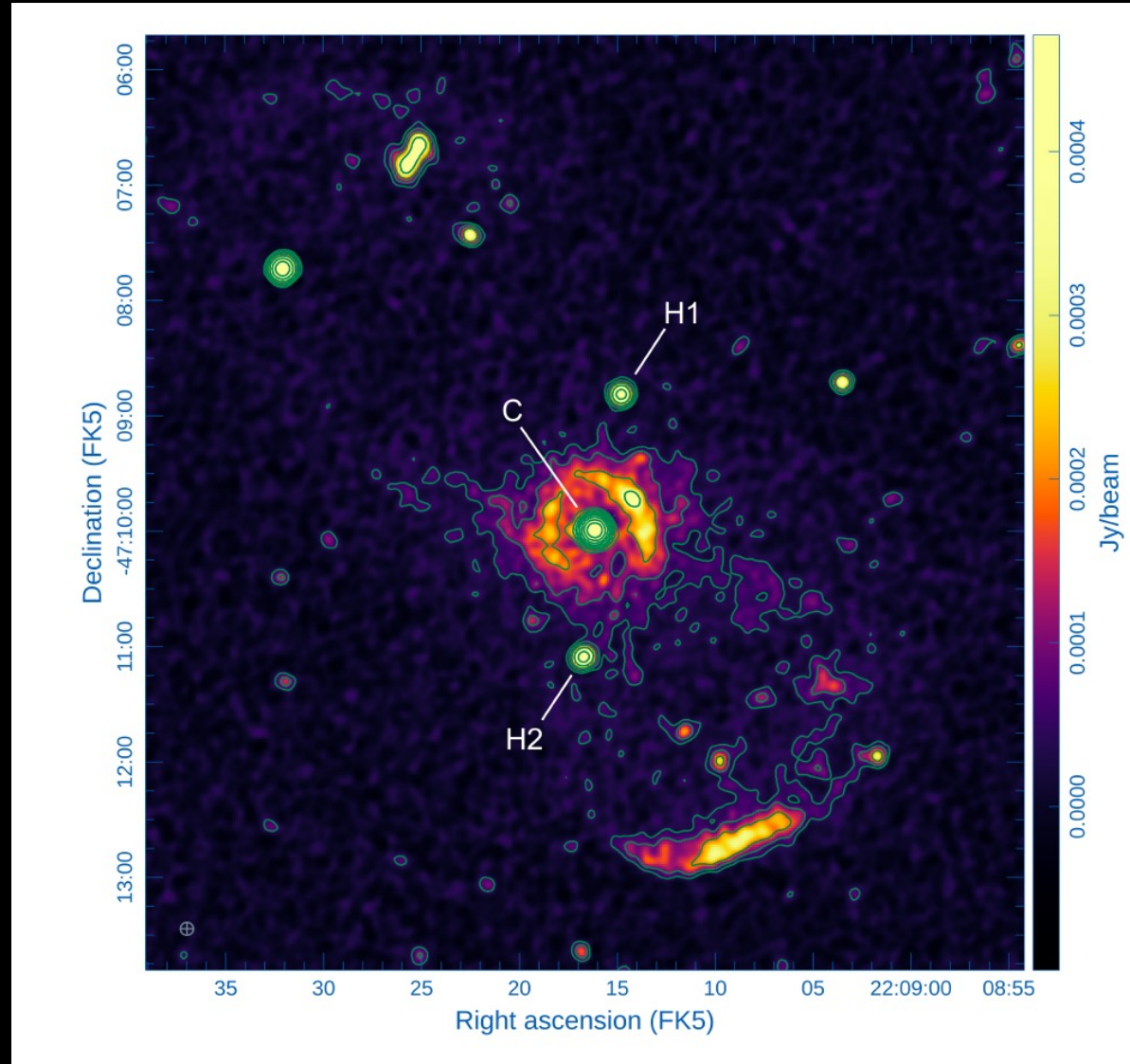
Quasi simultaneous Fundamental Plane for BH Activity



Variability-induced dispersion accounts for
only 3% of the total scatter

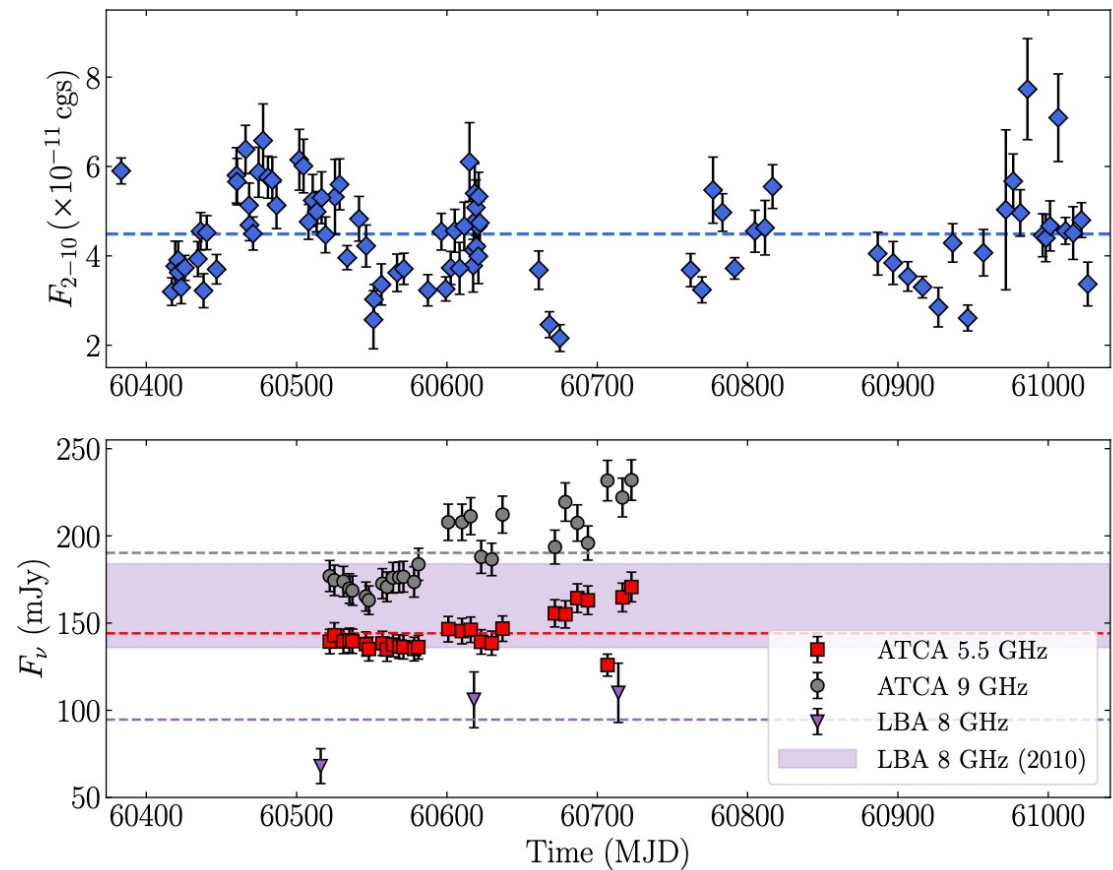
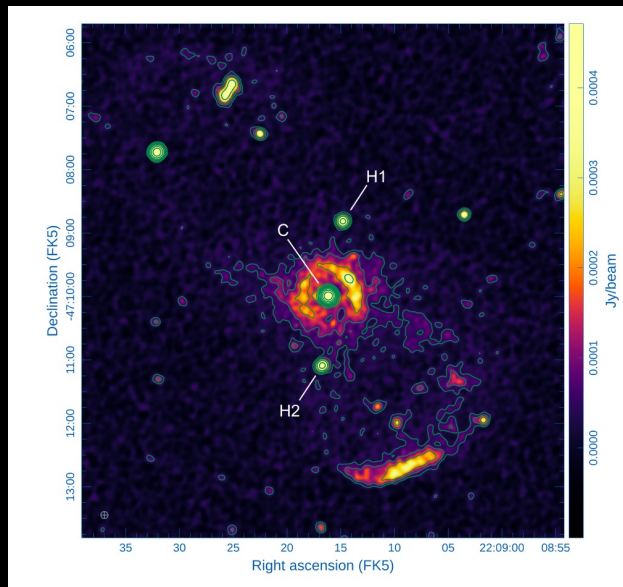
Symmetric kiloparsec-scale radio knots in NGC 7213

Evidence of a confined weak jet and recurrent nuclear activity



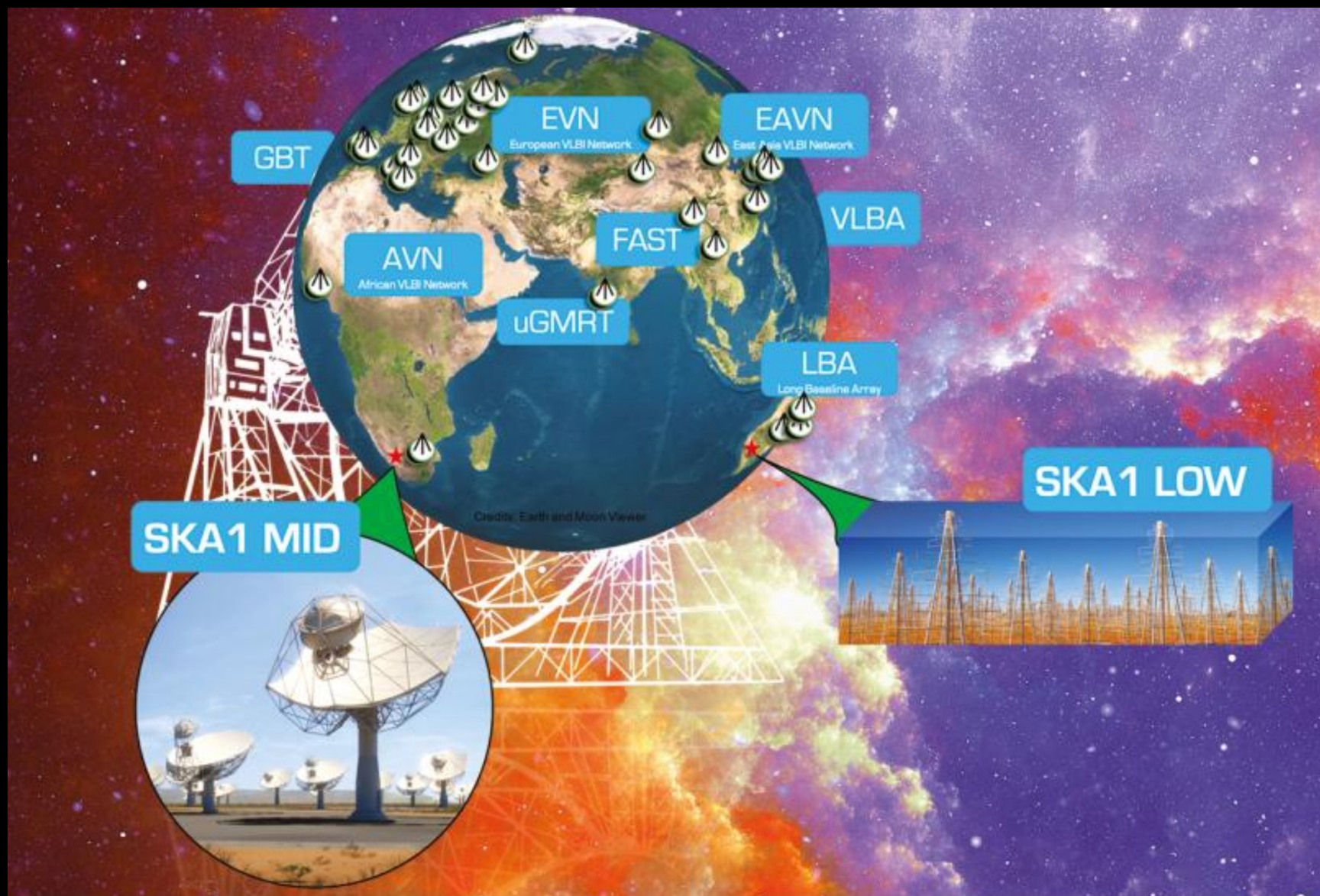
Symmetric kiloparsec-scale radio knots in NGC 7213

High-frequency radio variability originates in the innermost jet region



VLBI with the SKA

Science Working Group



SKA-VLBI: Resolution and Sensitivity



The SKA, integrated into global VLBI networks (EVN, LBA), will surpass current constraints:

- ✓ **Resolution:** Sub-milliarcsecond (< 0.5 mas in Band 5b).
- ✓ **Sensitivity:** μJy -level per beam, enabling comprehensive population surveys.
- ✓ **Frequencies:** Continuous coverage from 0.35 to 15.4 GHz (Bands 1, 2, 5a, 5b).

It successfully isolates the sub-parsec core from diffuse host galaxy emission.

Astrophysics > Astrophysics of Galaxies

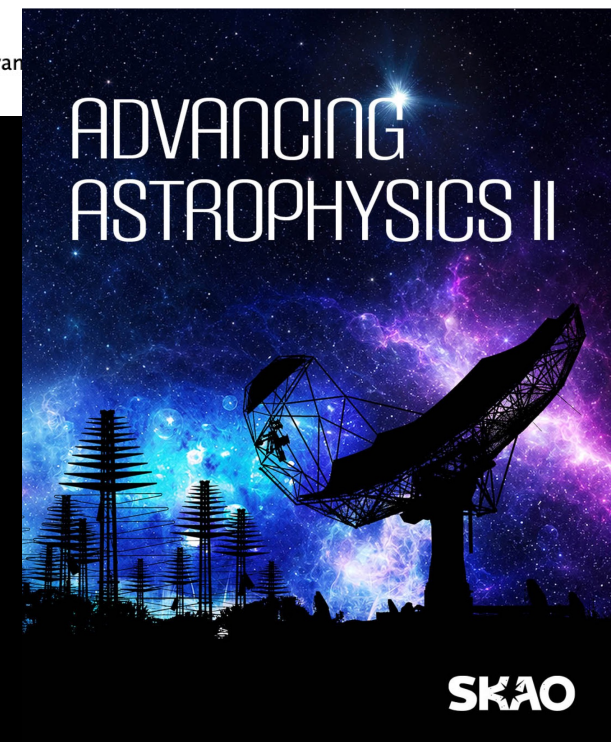
[Submitted on 29 Jun 2026]

The SKA-VLBI Perspective on Radio-Quiet AGN

Francesca Panessa, Tao An, James Petley, Ailing Wang, Ranieri Diego Baldi, Ehud Behar, Emmanuel Bempong-Manful, Gabriele Bruni, Ning Chang, Sina Chen, Lang Cui, Filippo D'Ammando, Marcello Giroletti, Magdalena Kunert-Bajraszewska, Sibasish Laha, Ari Laor, Ian McHardy, Eileen Meyer, Monica Orienti, Miguel Pérez-Torres, Isabella Prandoni, Claudio Ricci, David R. A. Williams-Baldwin, Zsolt Paragi

The accretion-ejection mechanism in Active Galactic Nuclei (AGN) remains a central open problem in astrophysics, tied to the role of AGN feedback in galaxy formation and evolution. Radio-quiet AGN dominate the observed AGN population. Lacking luminous jets, their radio emission traces a rich set of processes spanning the host galaxy kpc scales down to the vicinity of the supermassive black hole: star formation, AGN-driven winds and shocks, free-free emission from photo-ionized gas, low-power jets, and coronal activity close to the inner accretion disk. The Square Kilometre Array (SKA) will probe these processes across a wide frequency range with unprecedented sensitivity, wide-field survey capability, and, critically, high-resolution VLBI imaging. Flux, spectral, and polarization monitoring will constrain dynamics and environmental coupling, while mapping nuclear regions on sub-pc to kpc scales will disentangle compact cores from host emission, resolving the diversity of radio activity across accretion regimes and jet powers from the local Universe to the cosmic dawn. At the full AA4 deployment, the SKA-MID phased into global VLBI arrays will deliver sub-milliarcsecond imaging and μJy sensitivity over 0.35--15\,GHz, enabling the first population-level census of radio-quiet AGN nuclei. Earlier AA* operations will support pilot studies of the brightest nearby systems.

Comments: Published in Advancing Astrophysics with the SKA II (AASKAII), 2026 ([arXiv:2606.20366](https://arxiv.org/abs/2606.20366)). Report-no: AASKAII/Panessa01. Advancing transformative scientific advances that will be enabled by the SKA telescopes



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The
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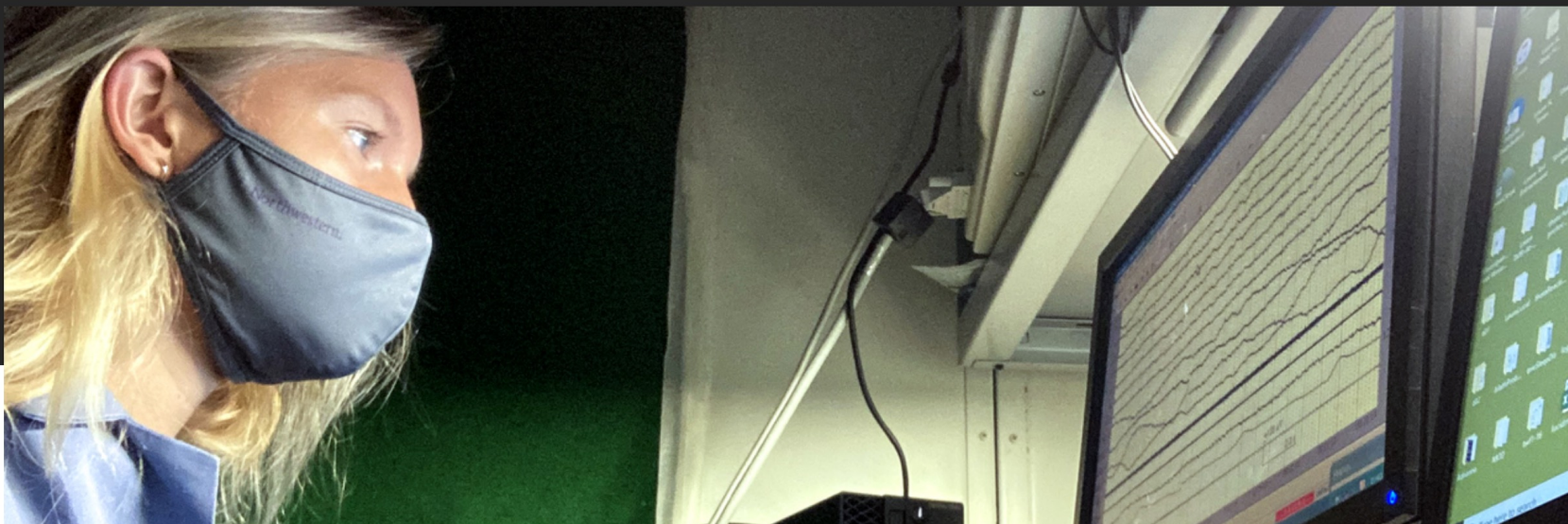
Science

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Scientists entered people's dreams and got them 'talking'

Dreaming experiments involved real-time conversations between sleepers and scientists

18 FEB 2021 · BY [SOFIA MOUTINHO](#)



«Paolo Padovani: what's in a name?»

Thank you