Young Quasar Jets Revealed by Dynamic Radio Surveys

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Extragalactic Jets – June 14-18, 2021

Young Quasar Jets Revealed by Dynamic

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CrossMark

Quasars That Have Transitioned from Radio-quiet to Radio-loud on Decadal Timescales Revealed by VLASS and FIRST

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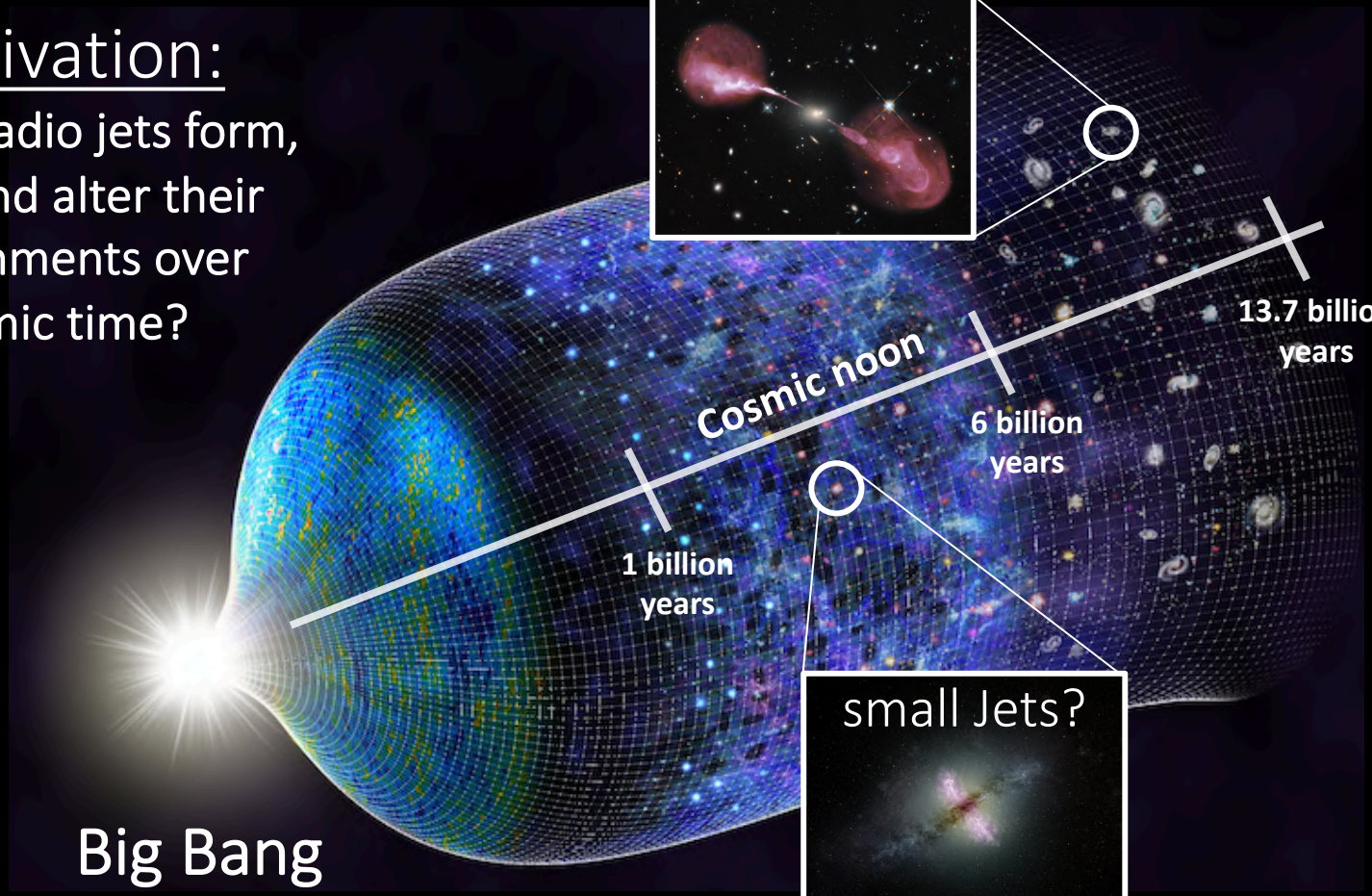
Motivation:

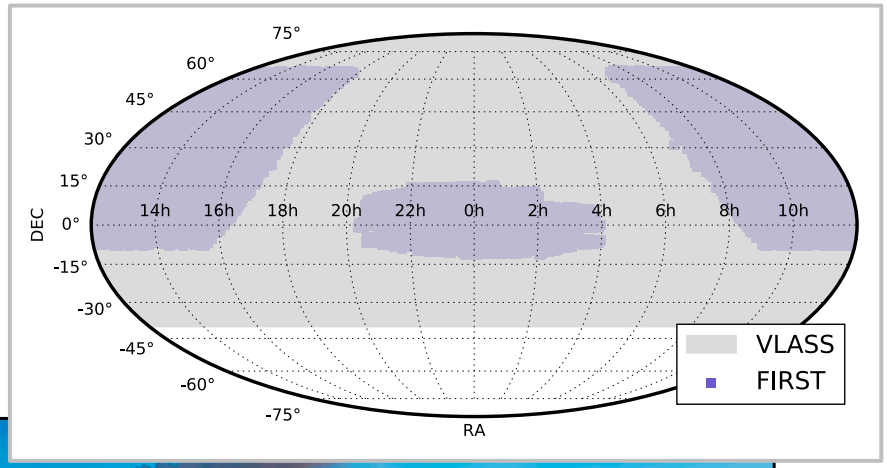
How do radio jets form, grow, and alter their environments over cosmic time?

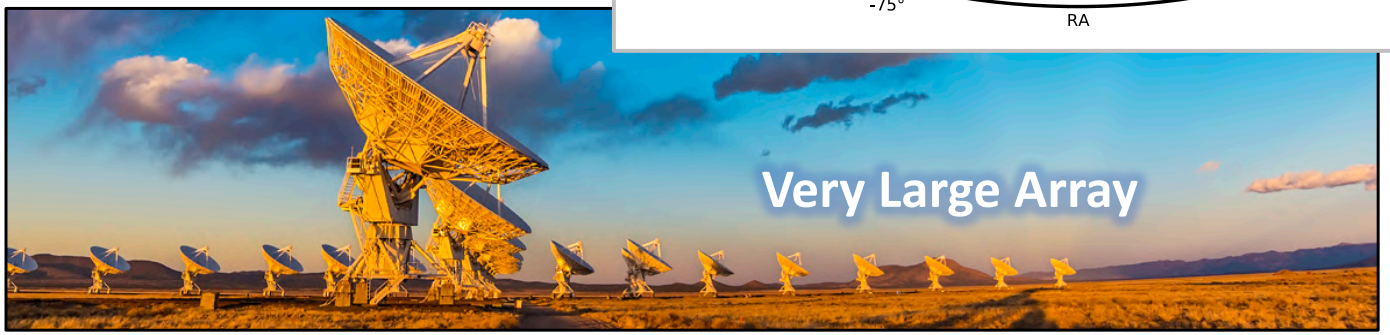


Catching Young Jets with Multi-epoch Radio Data

	ν (GHz)	θ_{FWHM}	Dates	Epochs
FIRST	1.5	5"	1993-2011	1
VLASS	2-4	2.5”	2017-2019†	3

†*Epoch 1*





References:

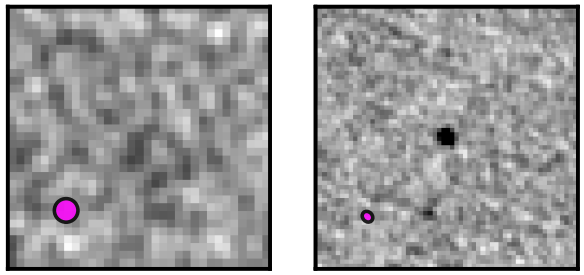
Becker et al. 1995
Helfand et al. 2015
Lacy et al. 2020

Selection Criteria

1

Initial Sample:
2000 variable sources over 3440 deg^2 of VLASS

FIRST VLASS

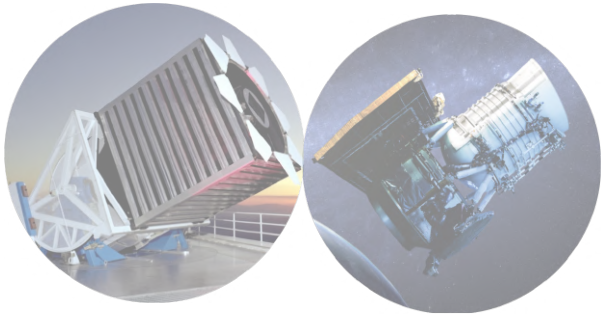


1999 2019

2

Quasar Cross-matching:

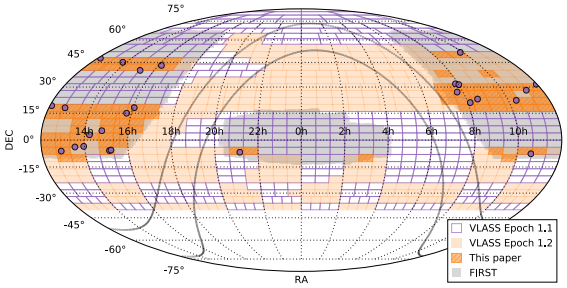
SDSS WISE



Nyland et al. 2020

3

Final sample:
26 newly radio-loud quasars (S_{VLASS} > 3 mJy)

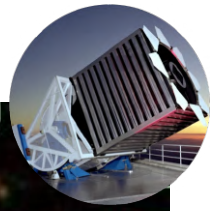


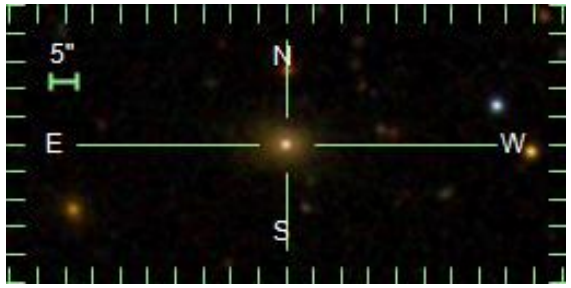
Example SDSS Images and Spectra

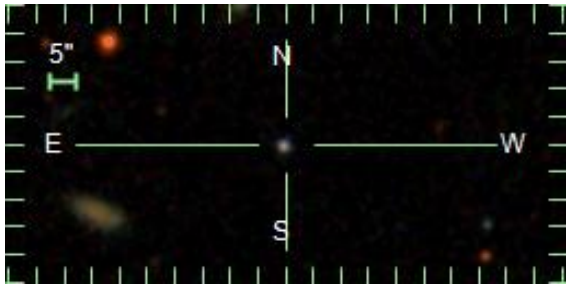
z = 0.2

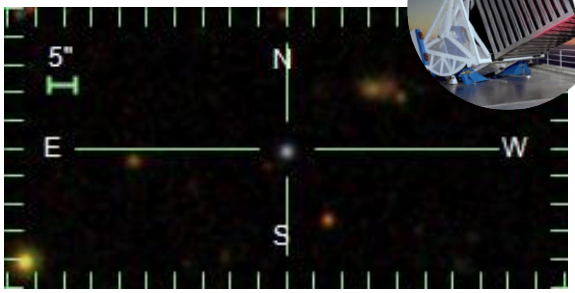
z = 1.6

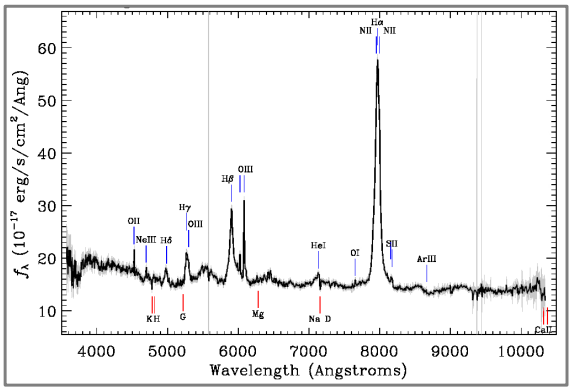
z = 3.2

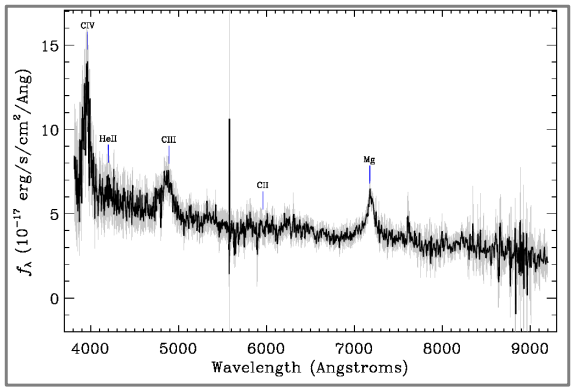


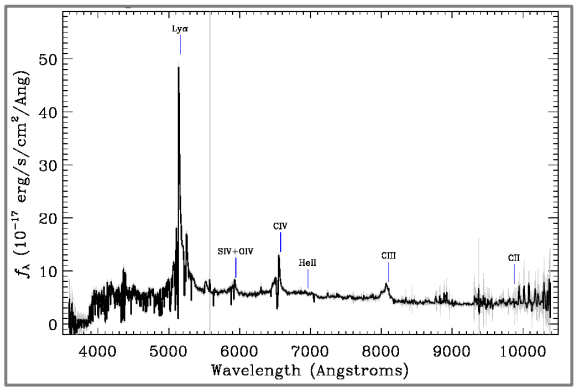










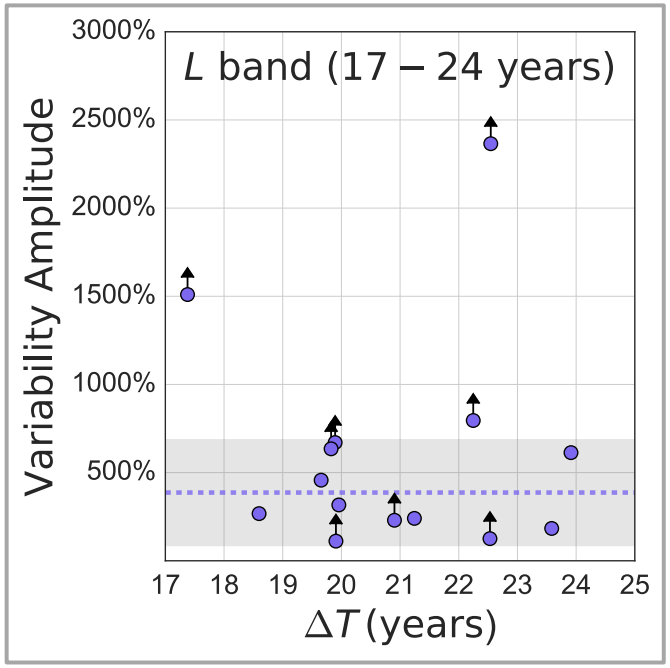


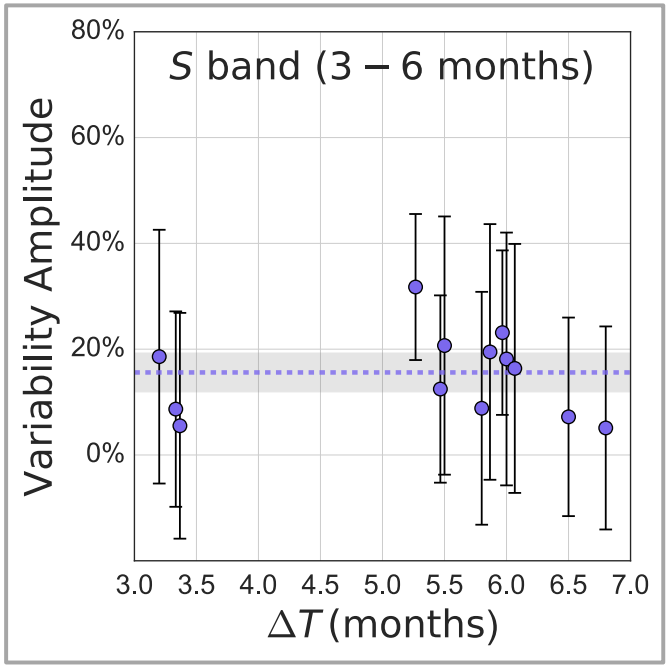
Simultaneous 1-18 GHz VLA Follow-up

- Single-band **variability**
- Radio **spectral shapes**

19A-422 (PI – Hallinan)
20B-329, 20B-459 (PI – Nyland)

Single-band Radio Variability



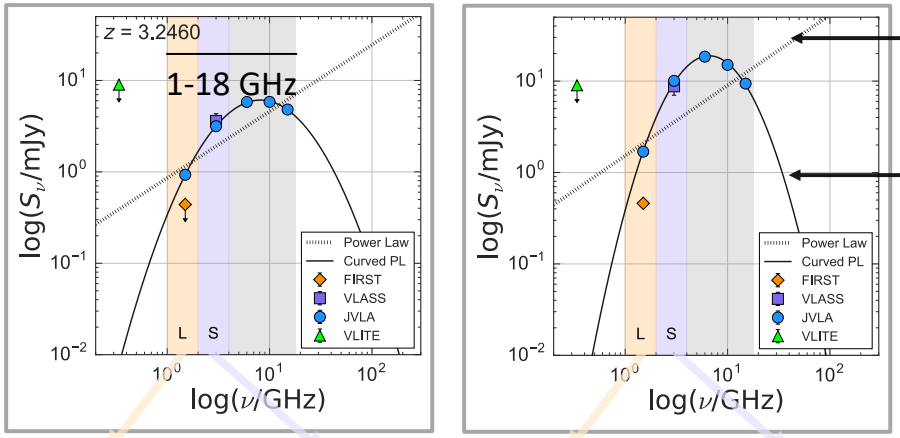


Variability amplitudes and timescales → intrinsic radio AGN variability

Nyland et al. 2020

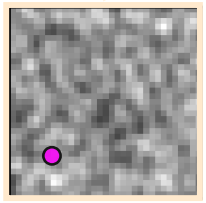
Radio Spectral Shapes

Nyland et al. 2020

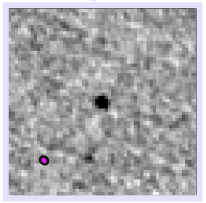


Power-law model doesn't fit

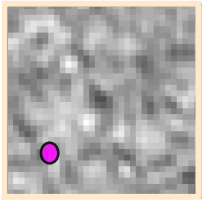
Curved power-law model fits!



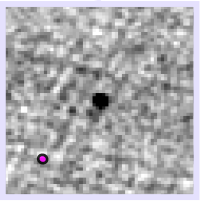
FIRST



VLASS



FIRST



VLASS

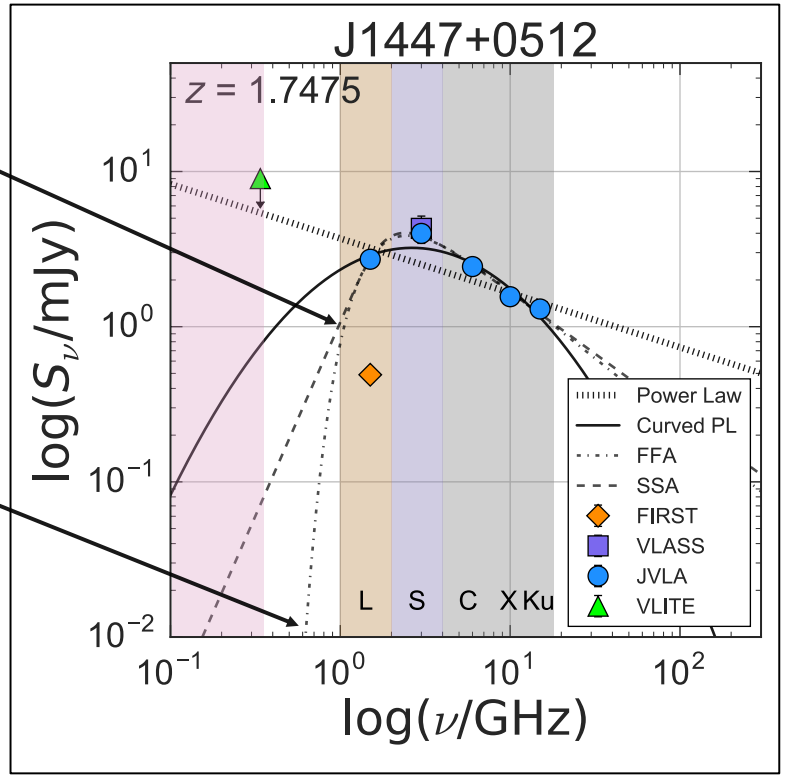
Peaked spectra consistent with absorbed and compact jets

Origin of the Absorption?

Synchrotron self absorption (SSA)

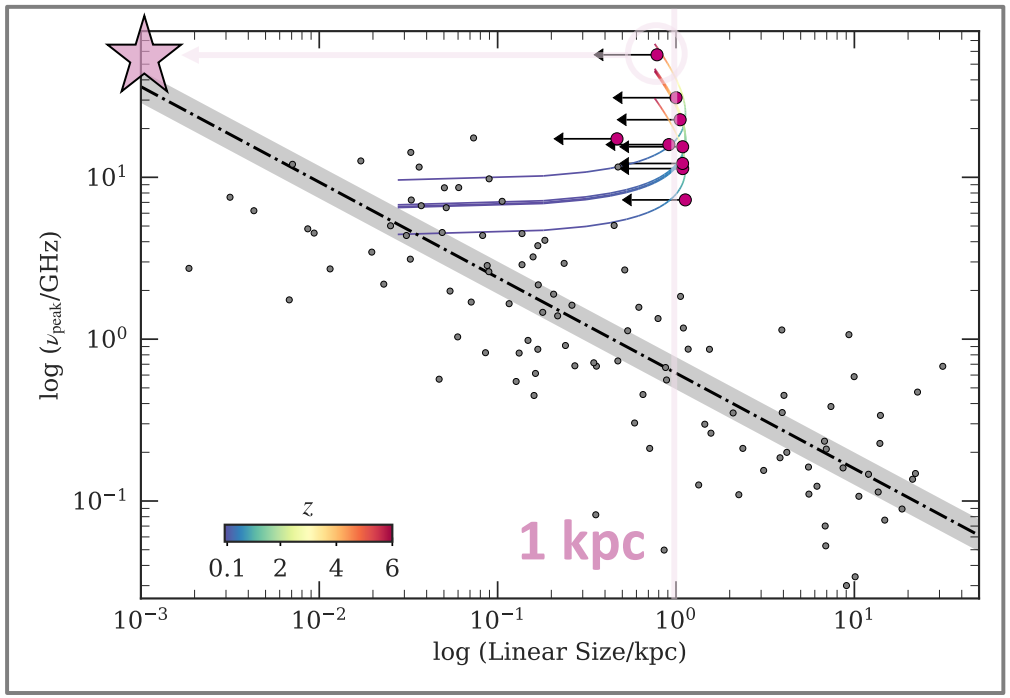
Free-free absorption† (FFA)

†Possible sign of jet-ISM interaction



Deep sub-GHz data needed to separate SSA/FFA

Size Constraints from Turnover-size Relation



Consistent with sub-kpc jets launched decades ago

Radio AGN Life Stages

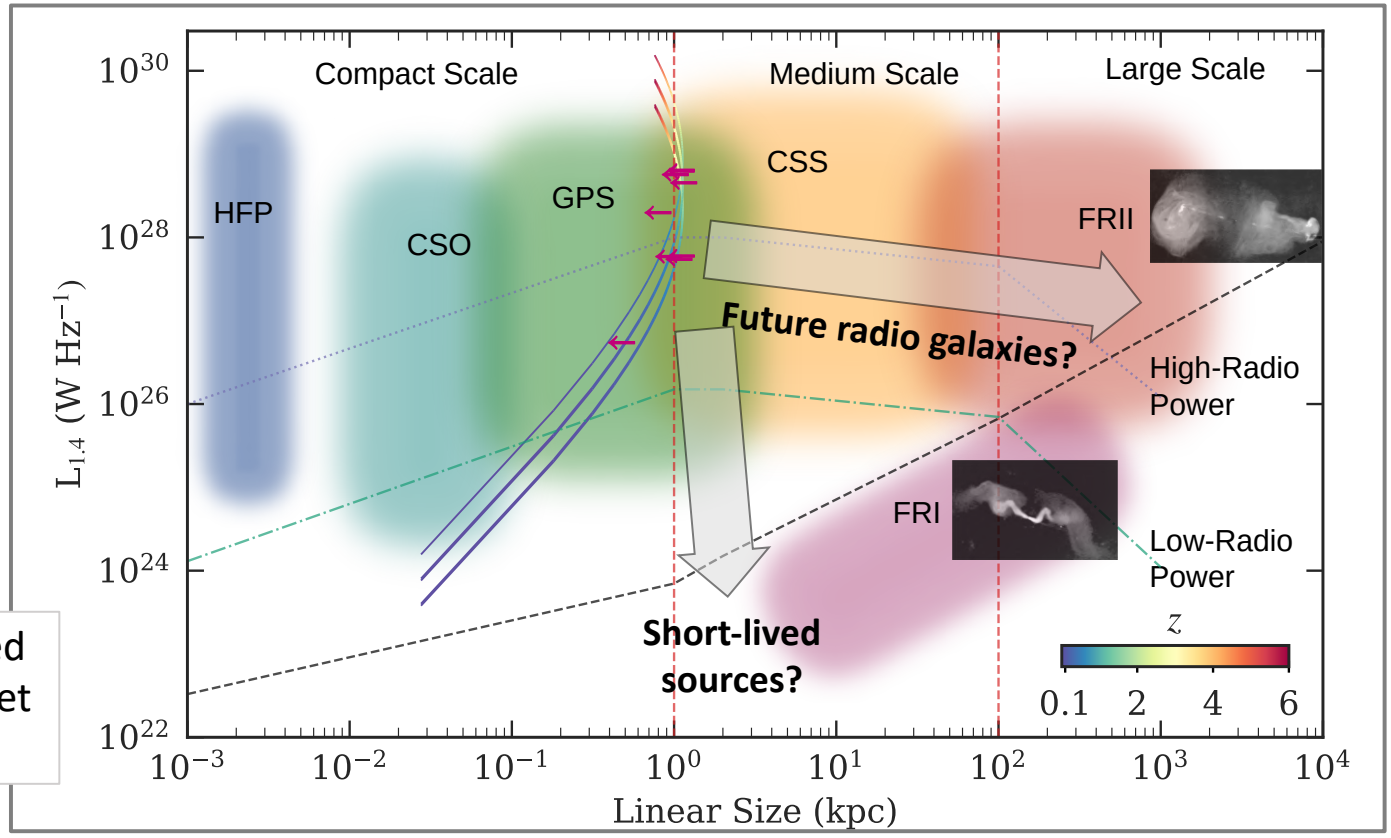
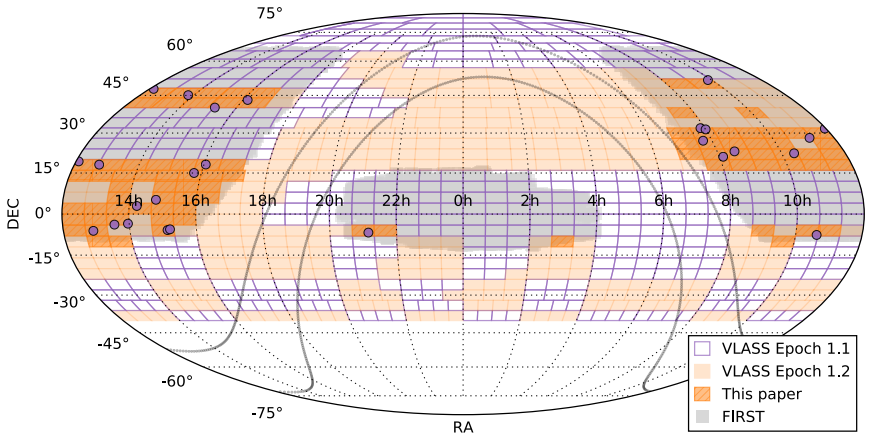


Fig adapted from Patil et al. 2020

Implications for Galaxy Evolution

Sky density:
4 x 10^{-3} deg^{-2} → period of occurrence = 10^5 yr



Nyland et al. 2020

Episodic, short-lived jets common at z = 1-3 →
Jet-ISM feedback?

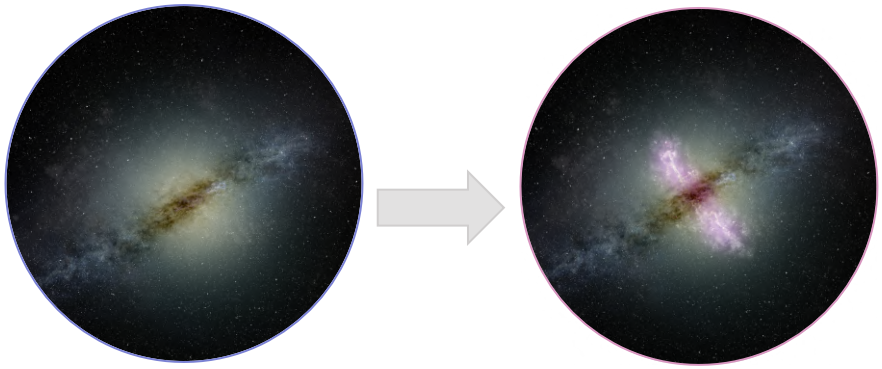
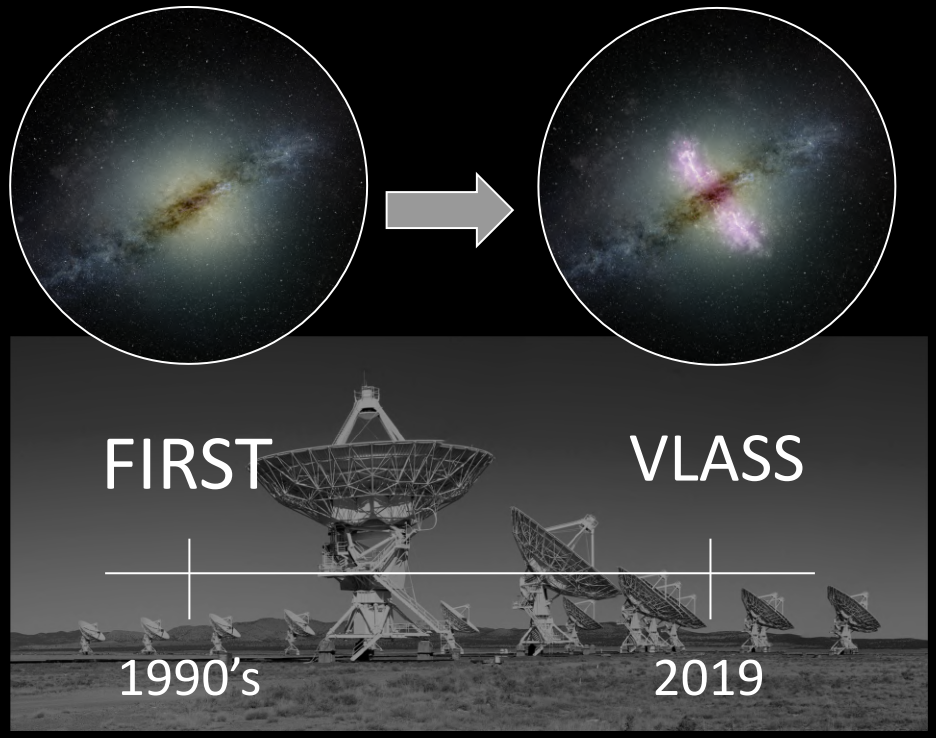


Image credit: Sophia Dagnello; NRAO/AUI/NSF

On-going and Future Work

- Continued radio SED monitoring (VLA)
- Milliarcsecond-scale imaging (VLBA)
- X-ray accretion state/morphology (new Cycle 22 *Chandra* data)
- Optical variability, host properties (new ground-based data, *HST*?)
- ISM content and conditions (ALMA?)

Summary



Nyland et al. 2020

Radio jets may "switch-on" over *human timescales*

Multi-epoch radio surveys catch newborn jets!

Short-lived jets common at z=1-3 → jet-ISM feedback?

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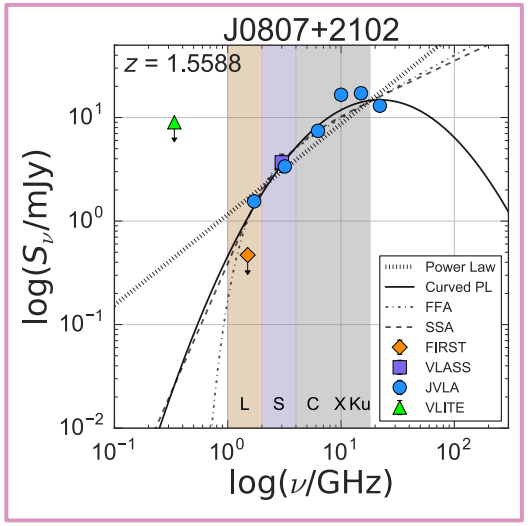
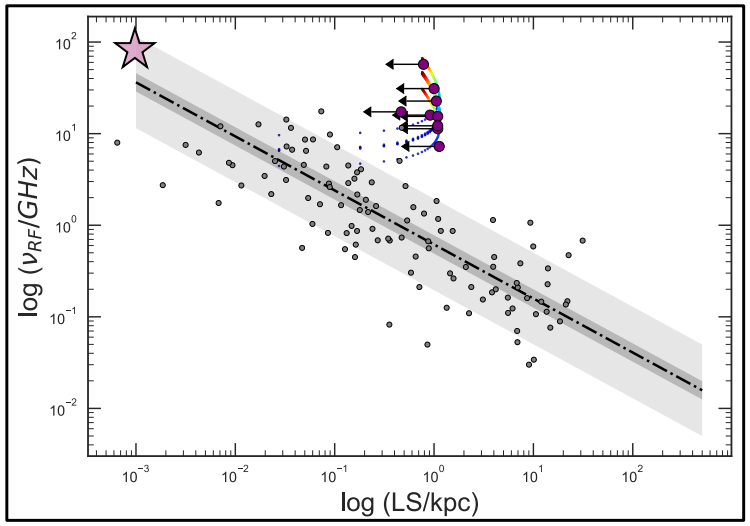
Extra Slides

Turnover-Size Relation: Age Constraint Example



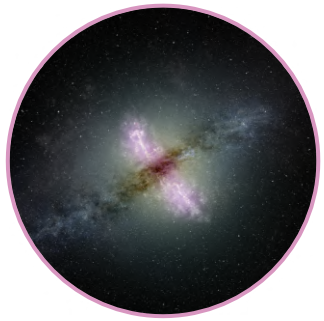
Spectral peak: 15 GHz
(= 40 GHz in restframe)



Size estimate: ~1-10 pc

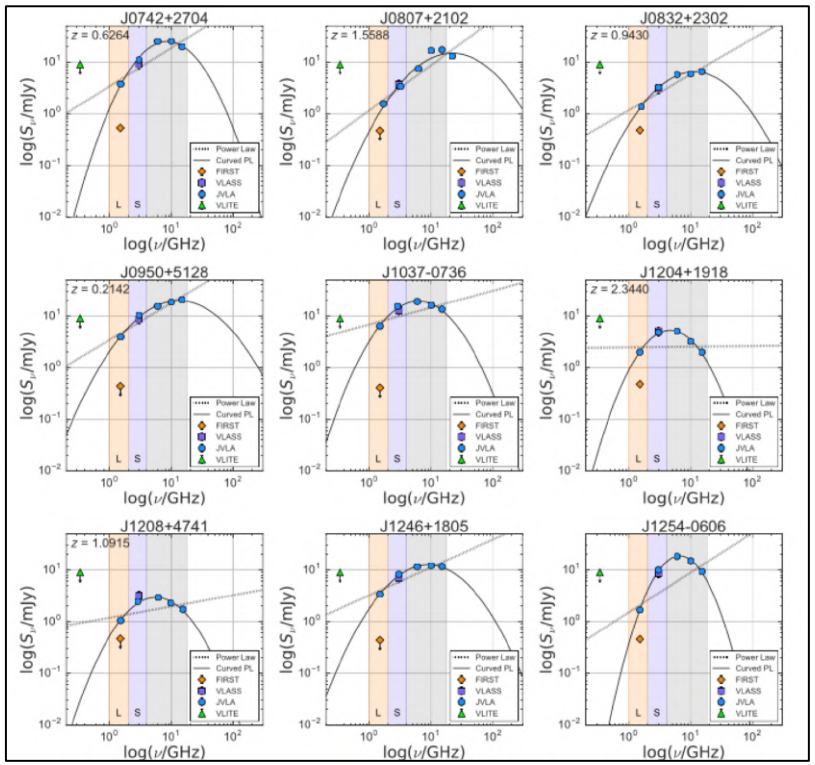
Velocity: 0.1c (assumed)

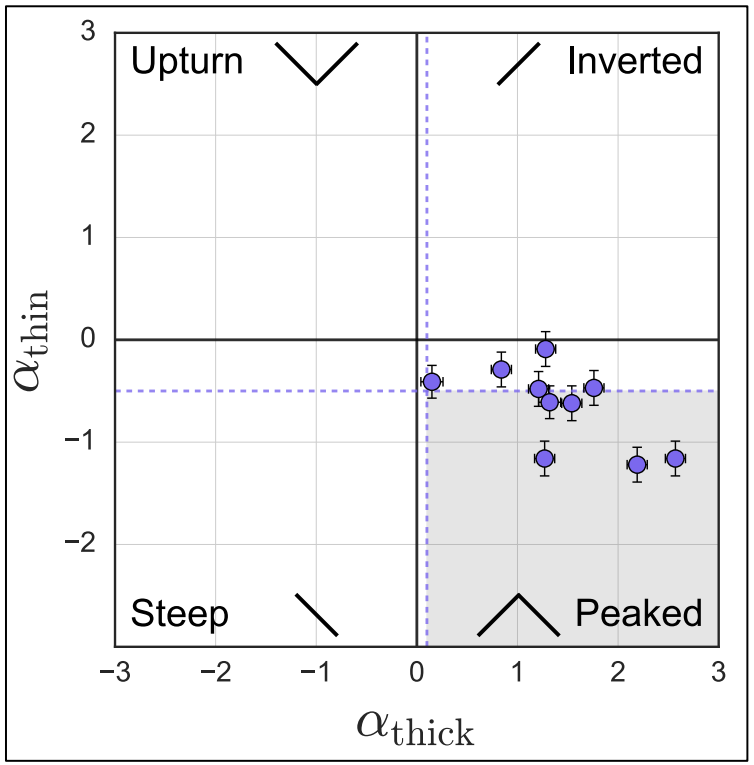
Age: t=d/v ~30-300 yr



Young Jet!

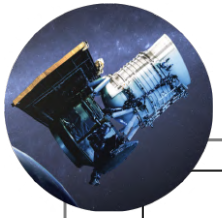
Radio Spectral Shapes



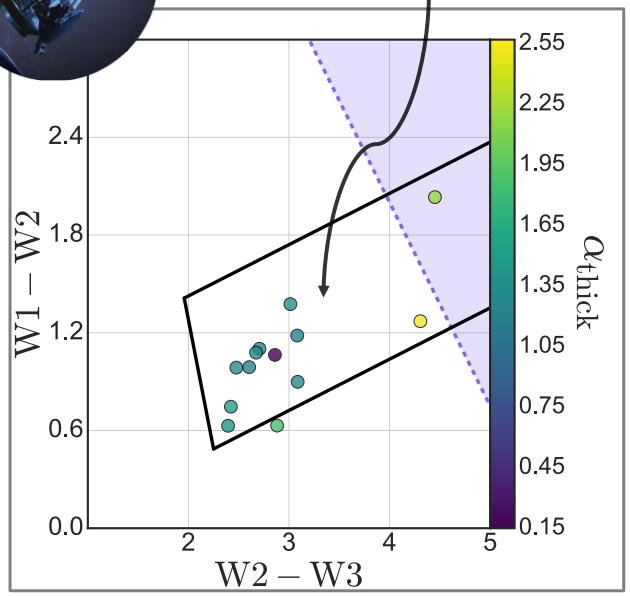


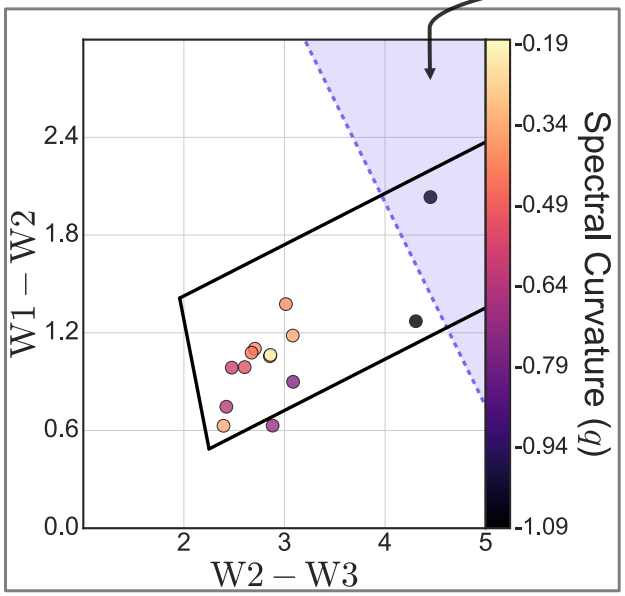
Nyland et al. 2020

Connection with Quasar Reddening (and Mergers?)



Infrared AGN "wedge" (Matteos et al. 2012)





Heavily obscured, luminous AGN (Lonsdale et al. 2015)

Free-free absorption in dusty quasars with compact jets?

More information on host galaxies needed!

Nyland et al. 2020