

Active Galactic Nuclei 13

BEAUTY
and the
EAST

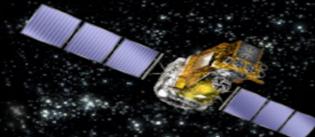
*...when the Super Massive Black Hole ...
has a crush on the galaxy*

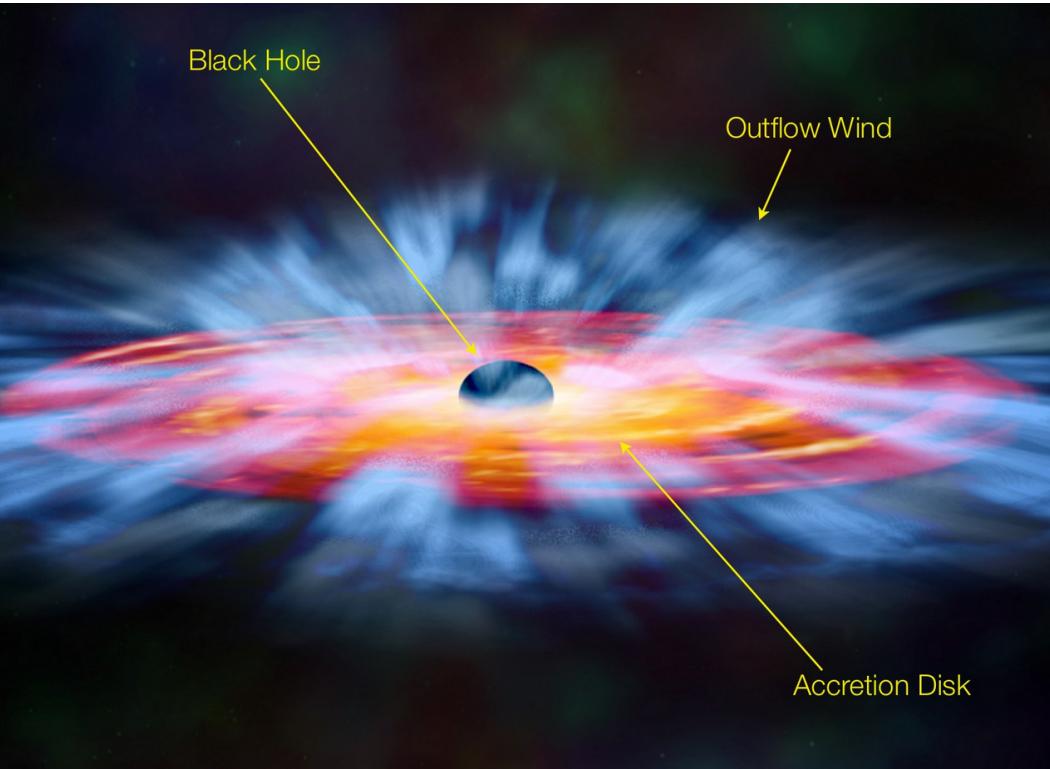
DISC-JET COUPLING in AGN

Francesca Panessa



Institute for Space Astrophysics and Planetology
Istituto di Astrofisica e Planetologia Spaziali



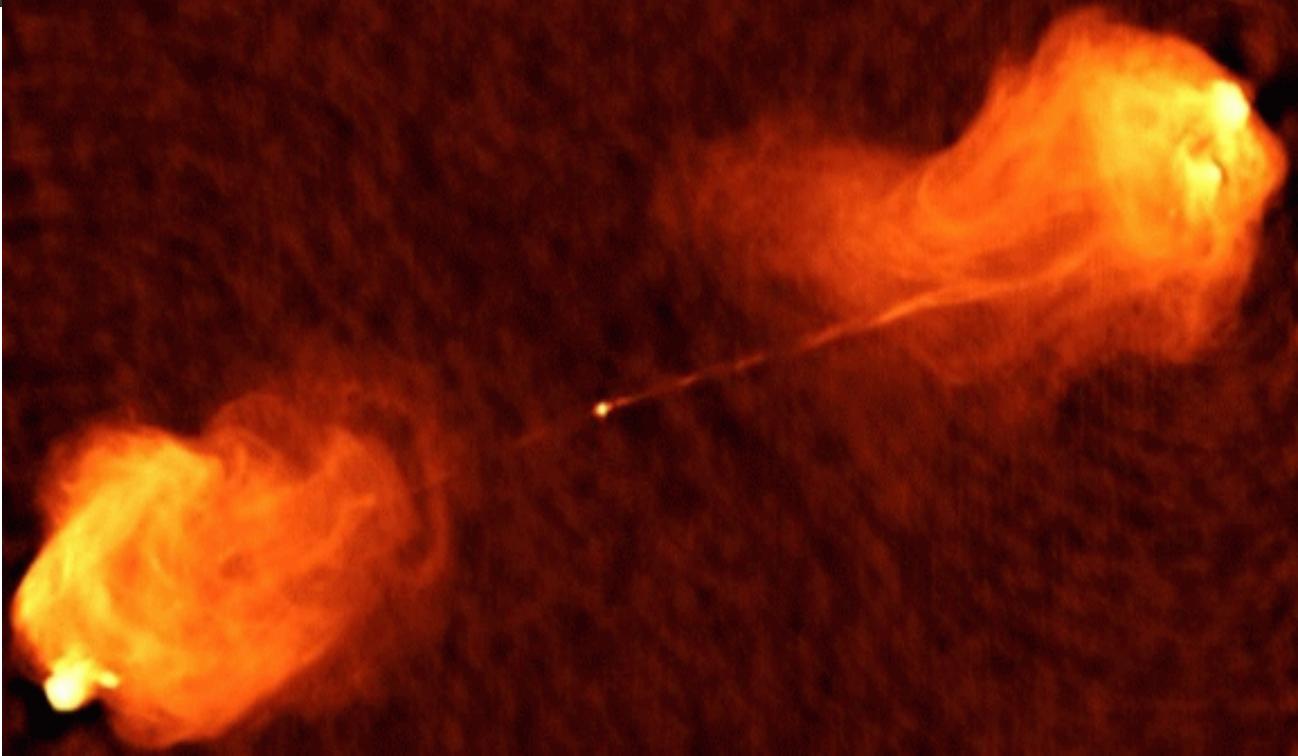


➤ MULTI-FREQUENCY
➤ MULTI SCALE
WINDS





➤ MULTI-FREQUENCY
➤ MULTI SCALE
JETS



JETS and WINDS interplay

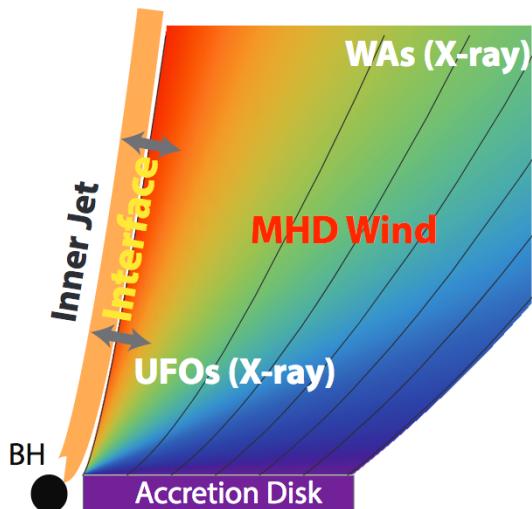
How are jets and winds formed?

Are they a phase of the AGN life?

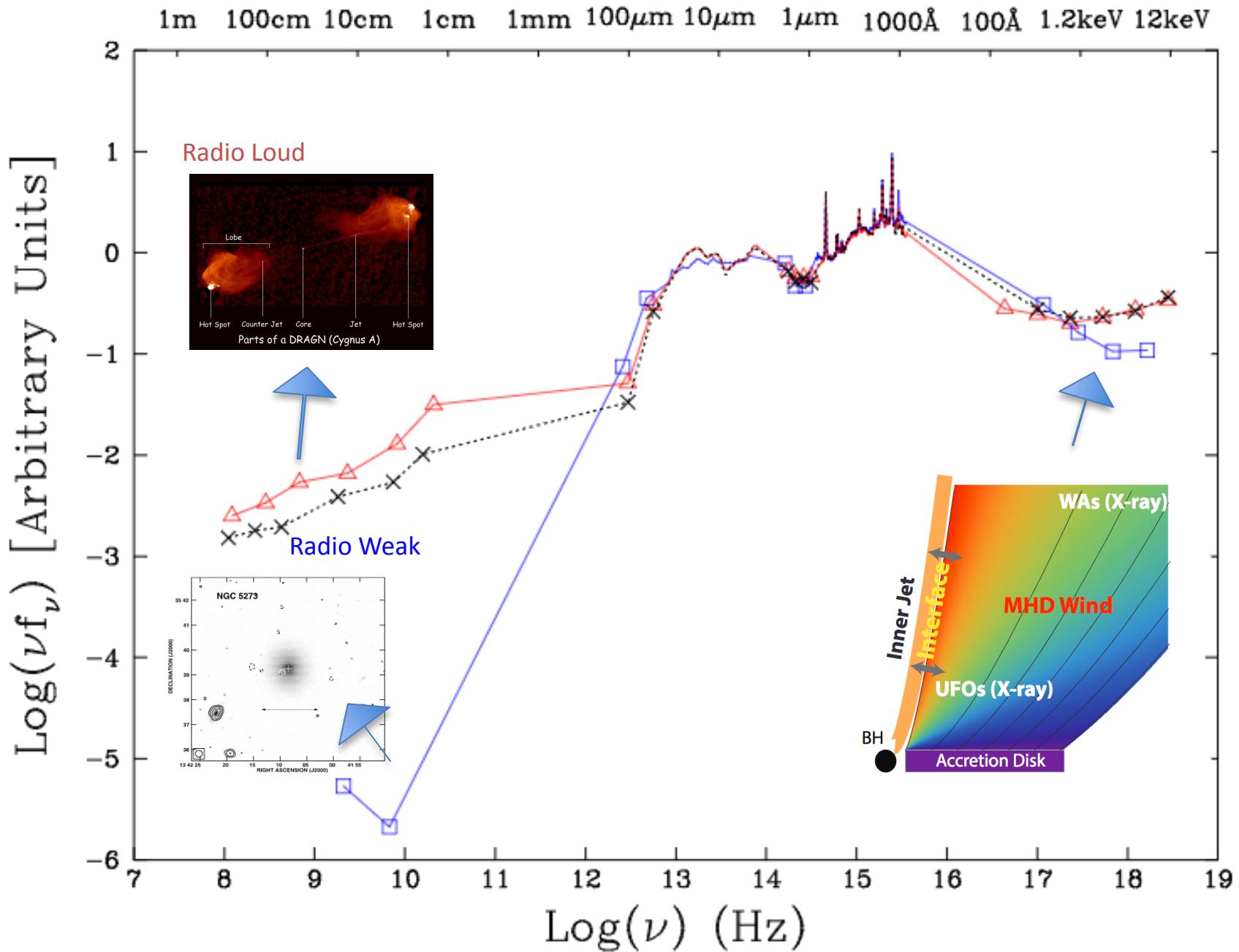
Is the jet and the wind connected to the accretion flow and how?

Does the disk wind collimate the jet?

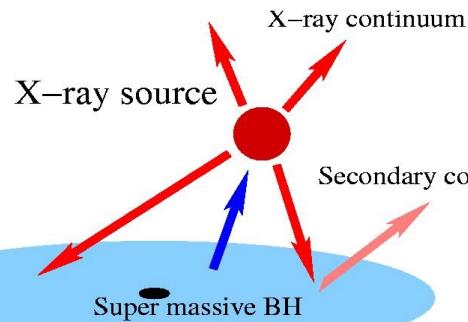
How is the jet and wind feedback acting in galaxies?



Magneto-hydrodynamic models
(Tchekhovskoy et al. 2011, Fukumura et al. 2014)



RADIO WEAK AGN



X-rays → a few R_s

Accretion disc

$\text{Log } L_{2-10 \text{ keV}} (\text{erg s}^{-1})$

42

40

38

36

$\text{Log } L_{6 \text{ cm}} (\text{erg s}^{-1})$

34

36

38

40

42

● Sey 1

○ Sey 2

☆ CThic

▲ LLRL

DECINLAT (J2000)

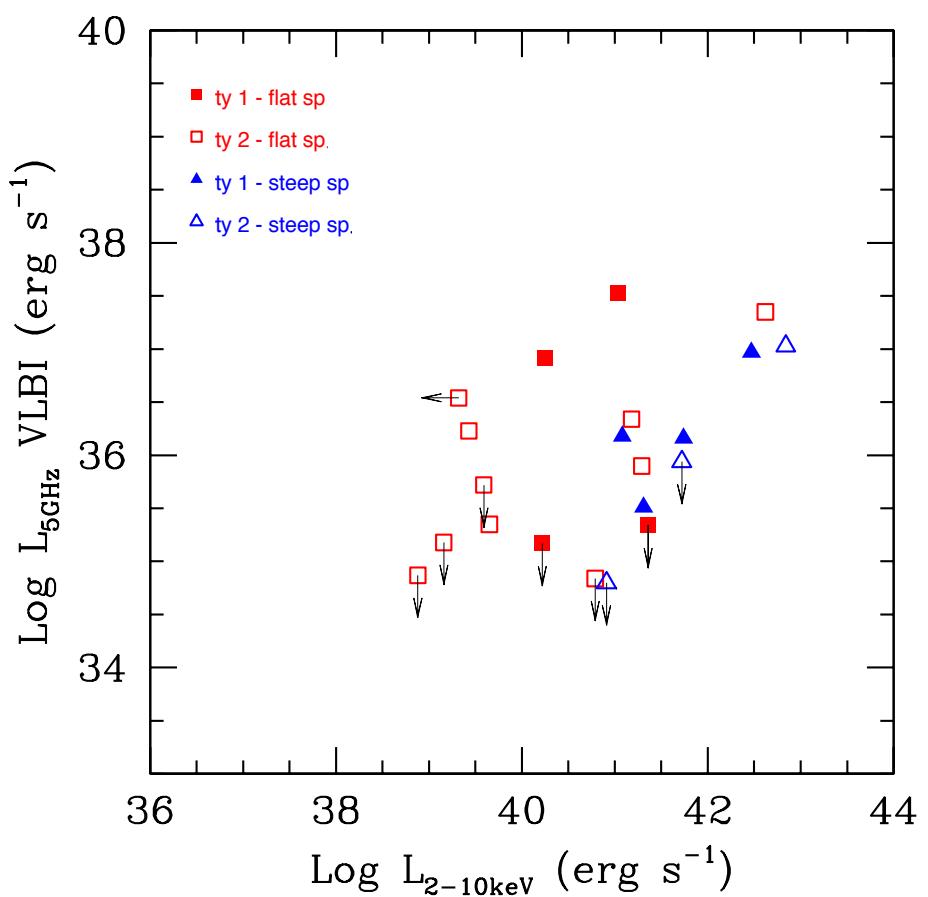
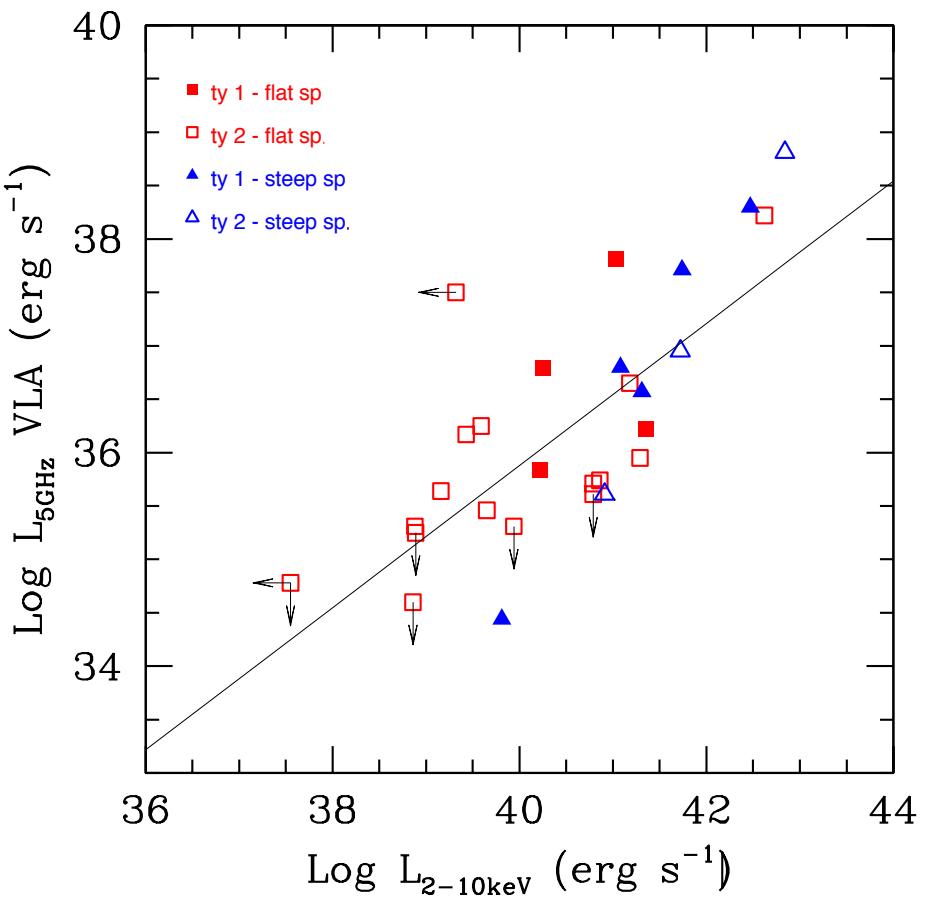
39 24 23
22
21
20
19
18

12 10 32.8 32.6 32.5 32.4

VLA

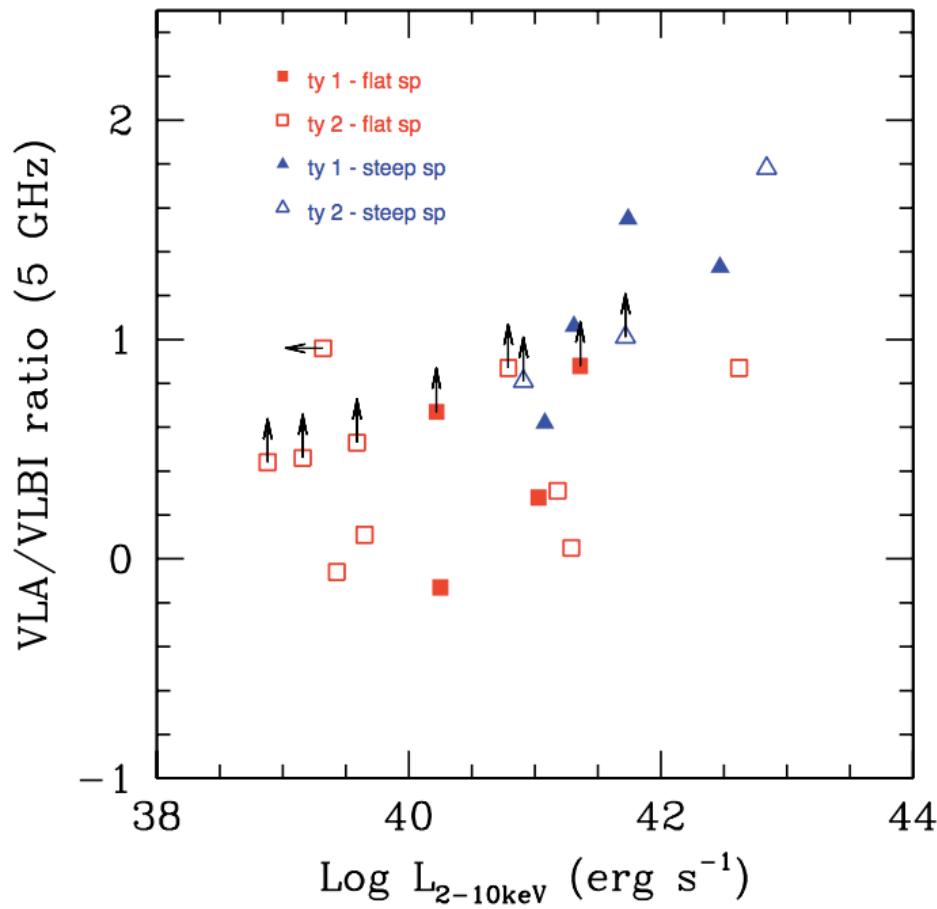
VLA → tens of pc up to kpc scales

DISK-JET COUPLING



No significant correlation at VLBI sub-pc scales

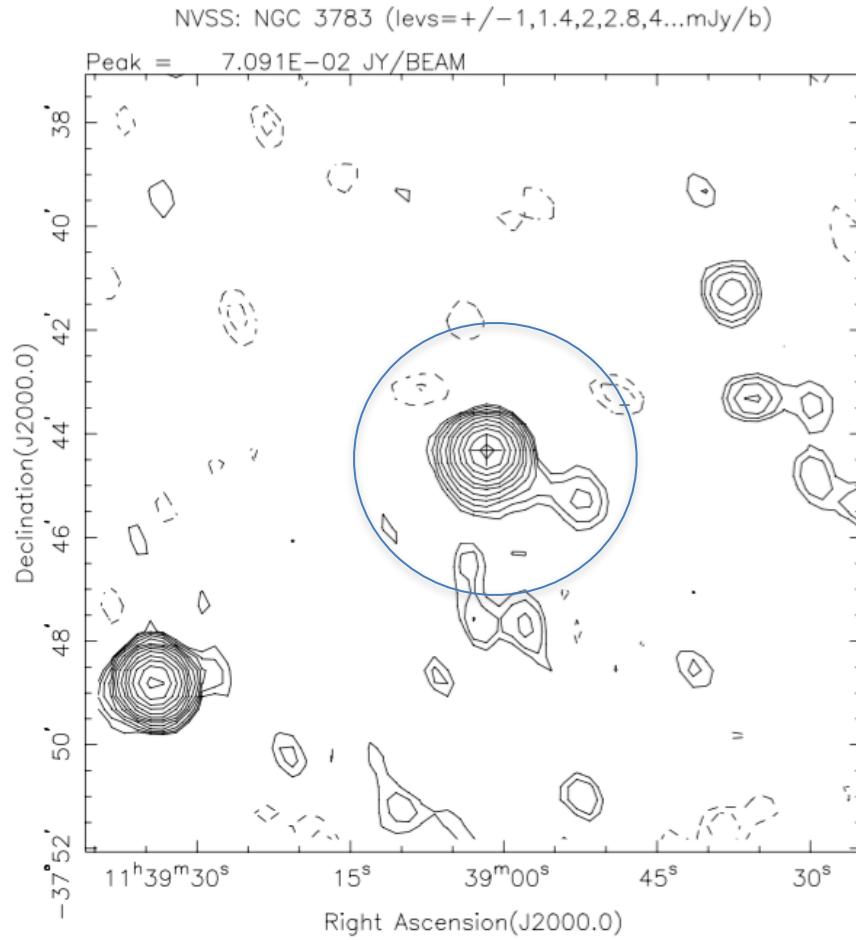
DISK-JET COUPLING



Most of the VLA emission is resolved out!!! → VARIABILITY or RADIO-QUIET-QUIET???

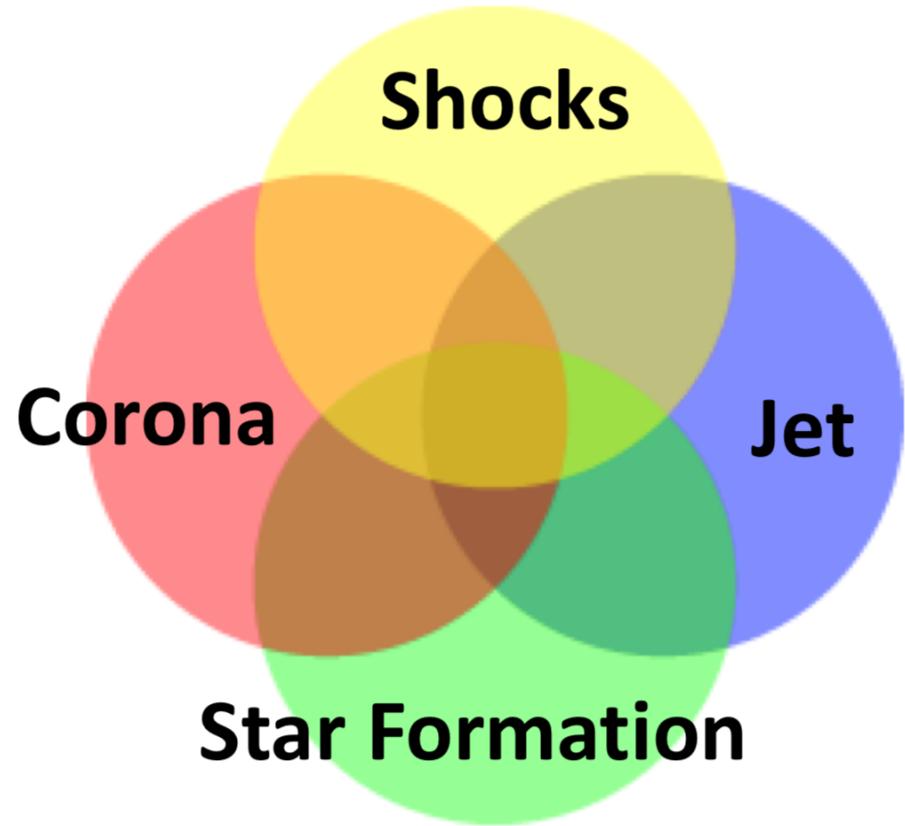
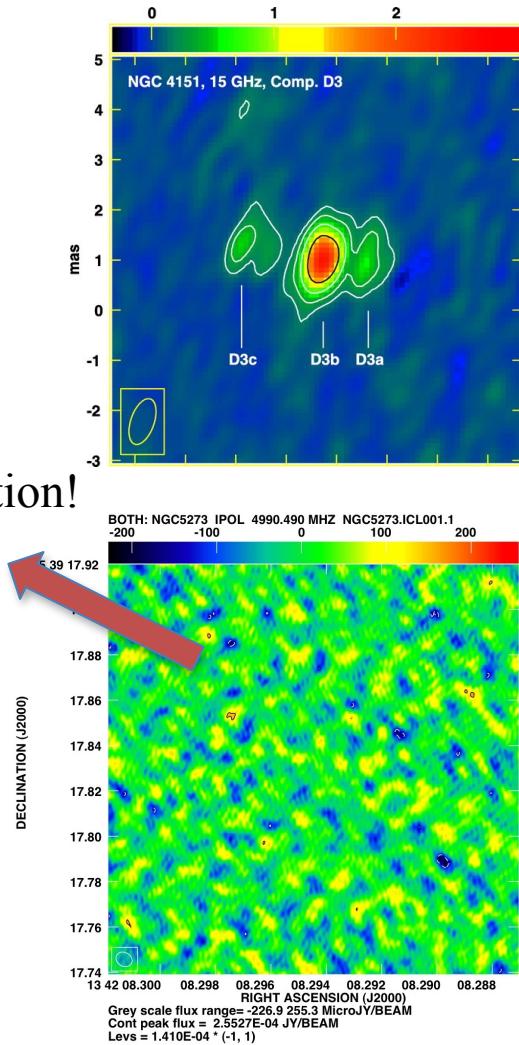
RADIO EMISSION from OUTFLOWS IN RADIO WEAK

Is this thermal or non
thermal? Jet or outflow?



THE DOMINANT AGN POPULATION: RADIO FAINT

non
detection!



Amy Kimball's courtesy

Table 5. Imaging results. Columns: (1) Target name; (2) Frequency band; (3) Image noise rms; (4) Integrated flux density (μJy); (5) Peak flux density ($\mu\text{Jy beam}^{-1}$); (6) Deconvolved source size (arcsec); (7) Source position angle (deg); (8) & (9) Detected source position (hh:mm:ss and $^{\circ}:\!':\!''$). Uncertainties are included in parenthesis

Target (1)	Band (2)	σ_{image} (3)	F_{total} (4)	F_{peak} (5)	
NGC0676	L	89	...	<267	
	C	18	...	<54	
	X	10.5	...	<31.5	
	Ku	9	...	<27	
NGC1058	L	32	...	<96	
	C	11	...	<33	
	X	9	...	<27	
	Ku	9	...	<27	
NGC2685	L	36	...	<108	
	C	11	...	<33	
	X	9	...	<27	
	Ku	9.5	...	<28.5	
NGC3185	L	27	2570(290)	...	
	C	16	3240(160)	...	
	X	14	668(47)	...	
	Ku	10	...	<30	
NGC3486	L	34	...	<102	
	C	10.5	...	<31.5	
	X	8.5	...	<25.5	
	Ku	9	...	<27	
NGC3941	L	30	320(70)	221(30)	1.5
	C	11	46(16)	54(9)	
	X	12	...	<36	
	Ku	14	...	<42	
NGC4477	L	44	210(76)	209(42)	
	C	10	91(15)	72(7)	
	X	9	67(7)	84.0(4.5)	
	Ku	8	61(9)	93(7)	
NGC4639	L	27.5	353(55)	303(28)	
	C	10	404(17)	393(10)	
	X	9	488(15)	477(9)	
	Ku	8	586(13)	610(8)	
NGC4698	L	38	150(53)	119(33)	$<0.78 \times 0.58$
	C	10	238(17)	241(10)	$<0.21 \times 0.15$

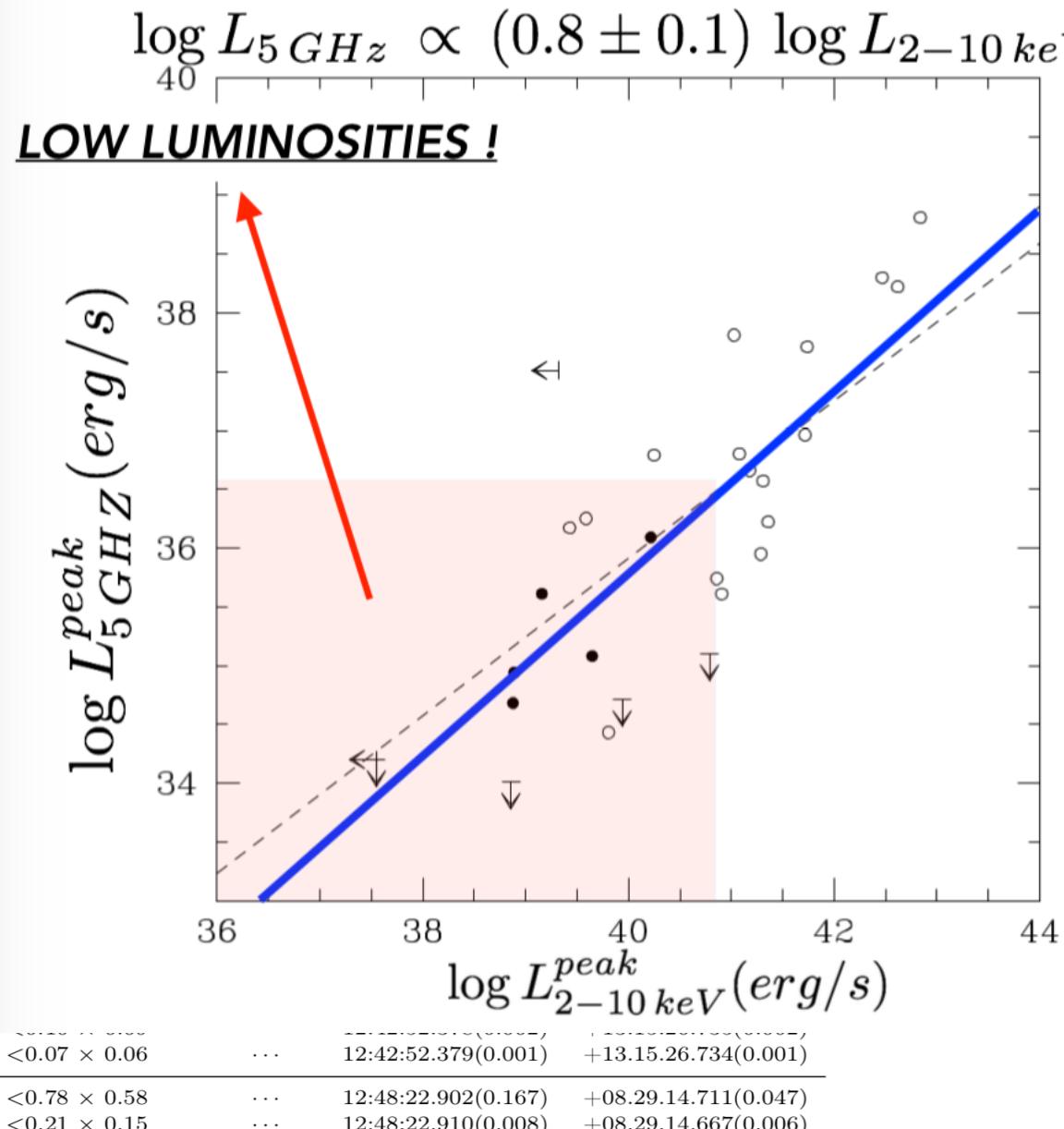
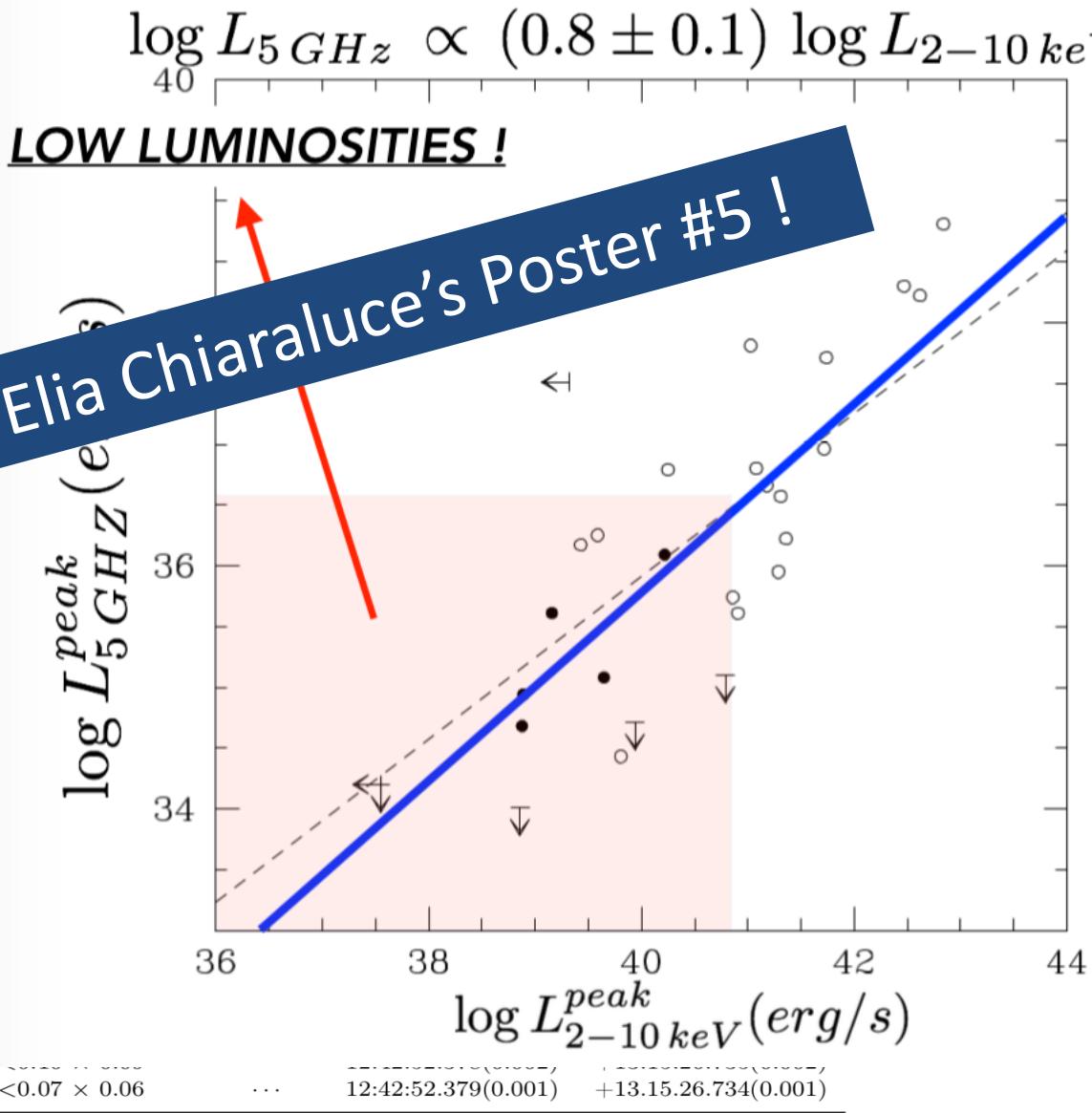
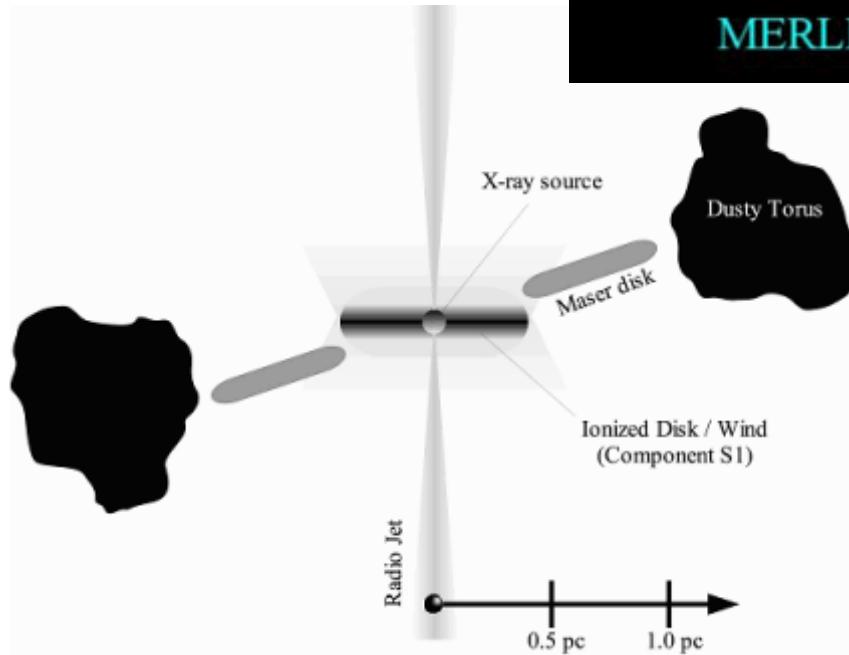
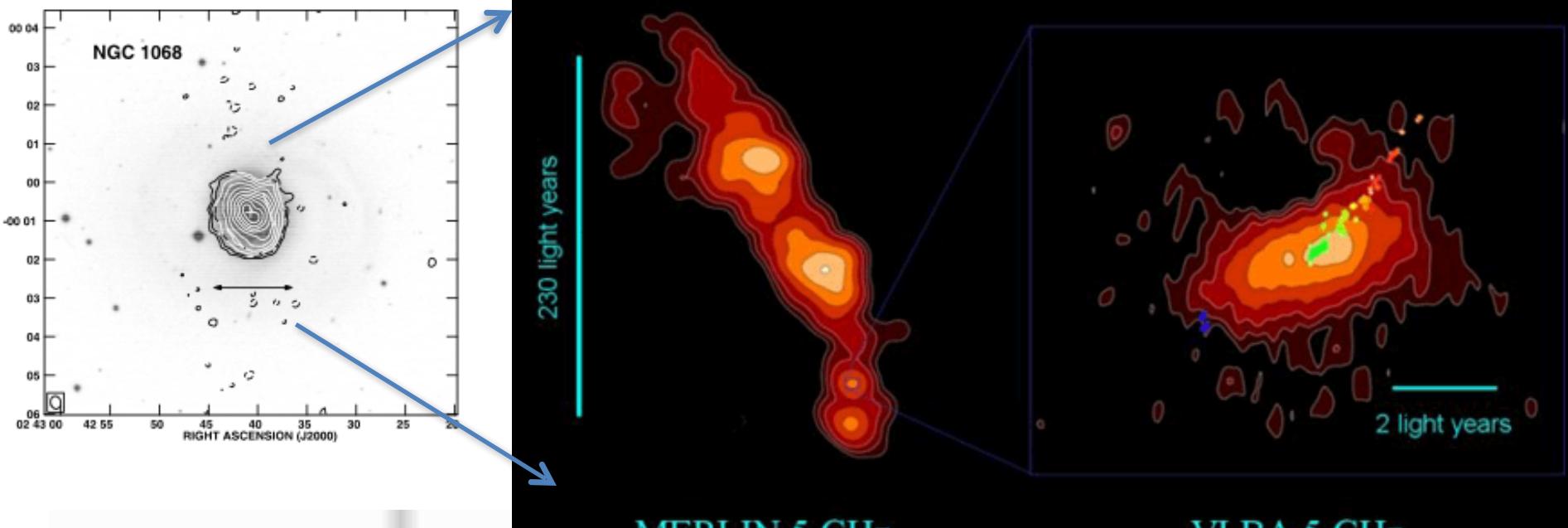


Table 5. Imaging results. Columns: (1) Target name; (2) Frequency band; (3) Image noise rms; (4) Integrated flux density (μJy); (5) Peak flux density ($\mu\text{Jy beam}^{-1}$); (6) Deconvolved source size (arcsec); (7) Source position angle (deg); (8) & (9) Detected source position (hh:mm:ss and $^{\circ}:\!':\!''$). Uncertainties are included in parenthesis

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	X	9	...	<27	
	Ku	9	...	<27	
NGC2685	L	36	...	<108	
	C	11	...		
	X	9	...		
	Ku	9.5	...		
NGC3185	L	
	C	1	
	X	1.4	668(47)	...	
	Ku	10	...	<30	
NGC3486	L	34	...	<102	
	C	10.5	...	<31.5	
	X	8.5	...	<25.5	
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NGC 1068
Gallimore et al. 2004

MERLIN emission: **low power jet**

VLBA emission: free-free emission from the **hot X-ray corona – wind from molecular wind?**

NGC 4051

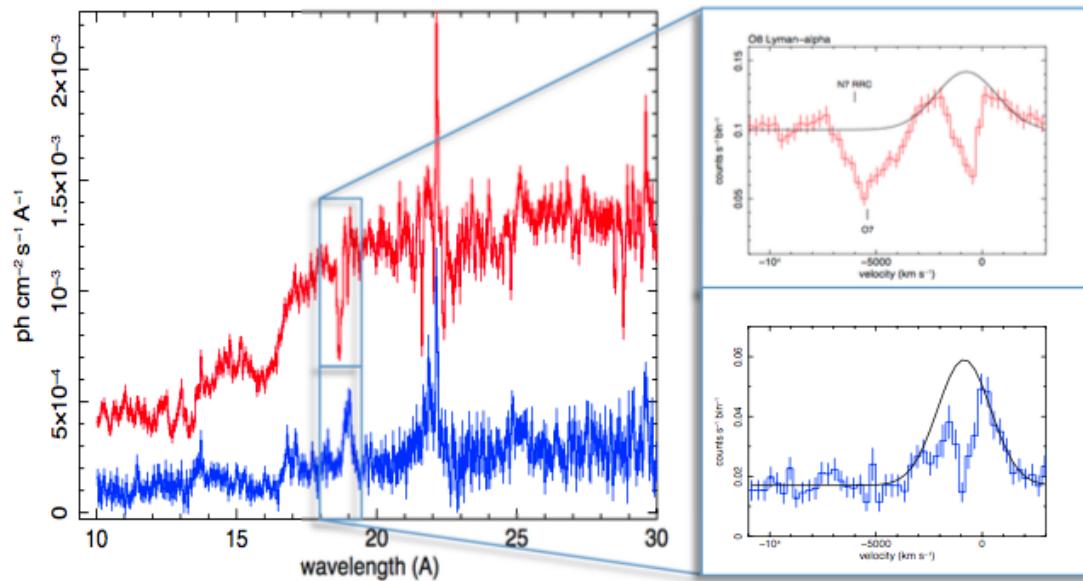
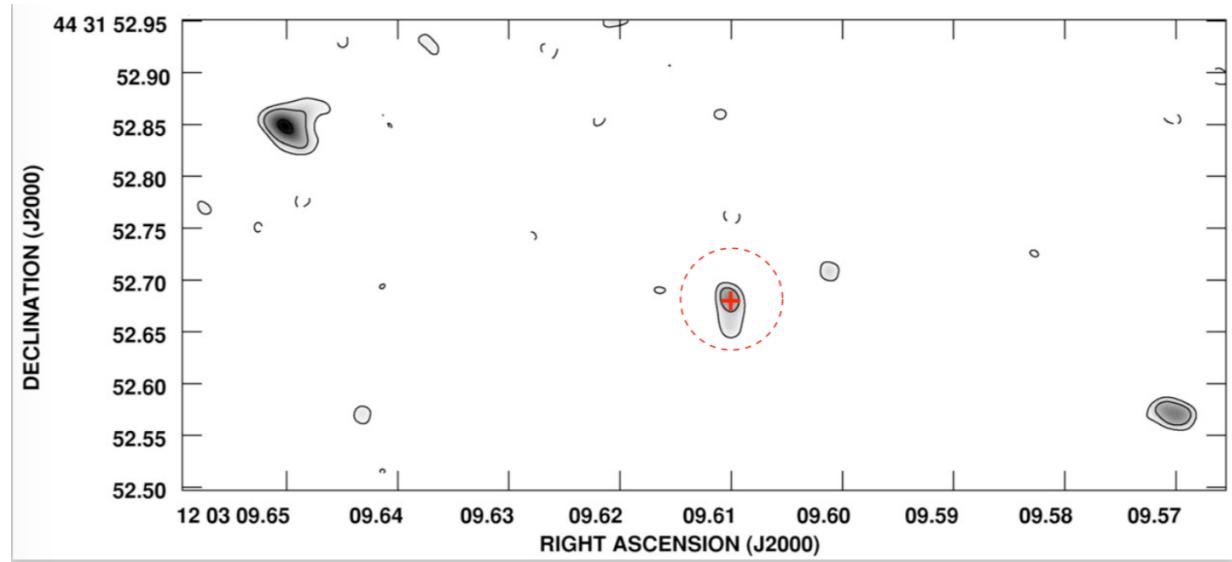


Fig. 3: (Left) Athena+ simulated (~ 1 ks) soft X-ray spectrum of the Seyfert 1 galaxy NGC 4051 expected from a shocked outflow

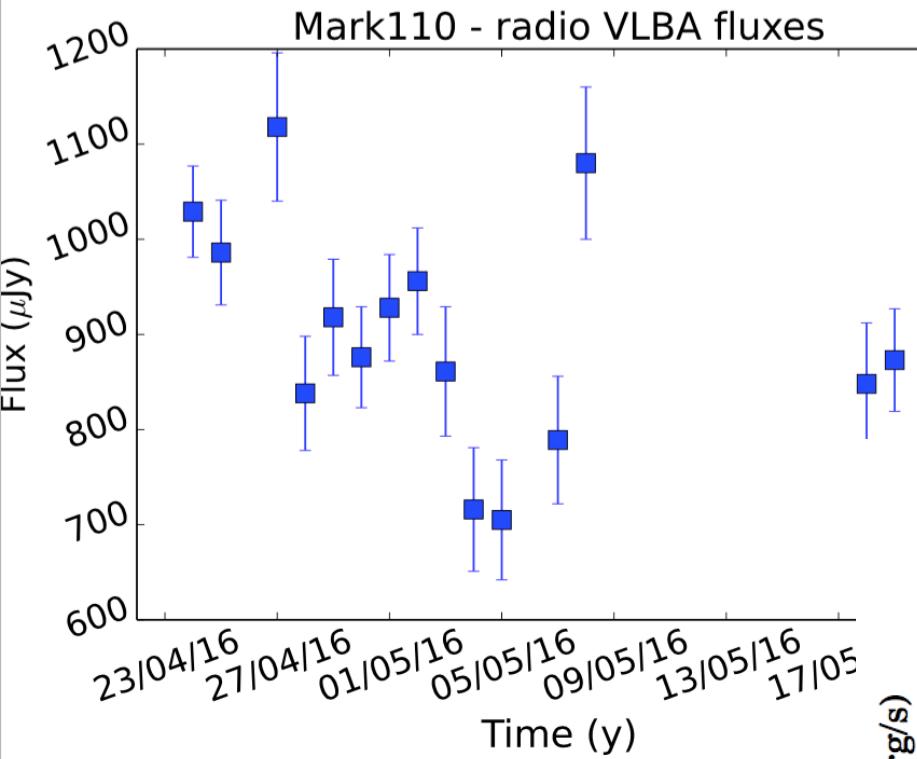
post-shock region of radius ~ 0.3 pc (Pounds and Vaughan 2011)

Giroletti & Panessa 2009



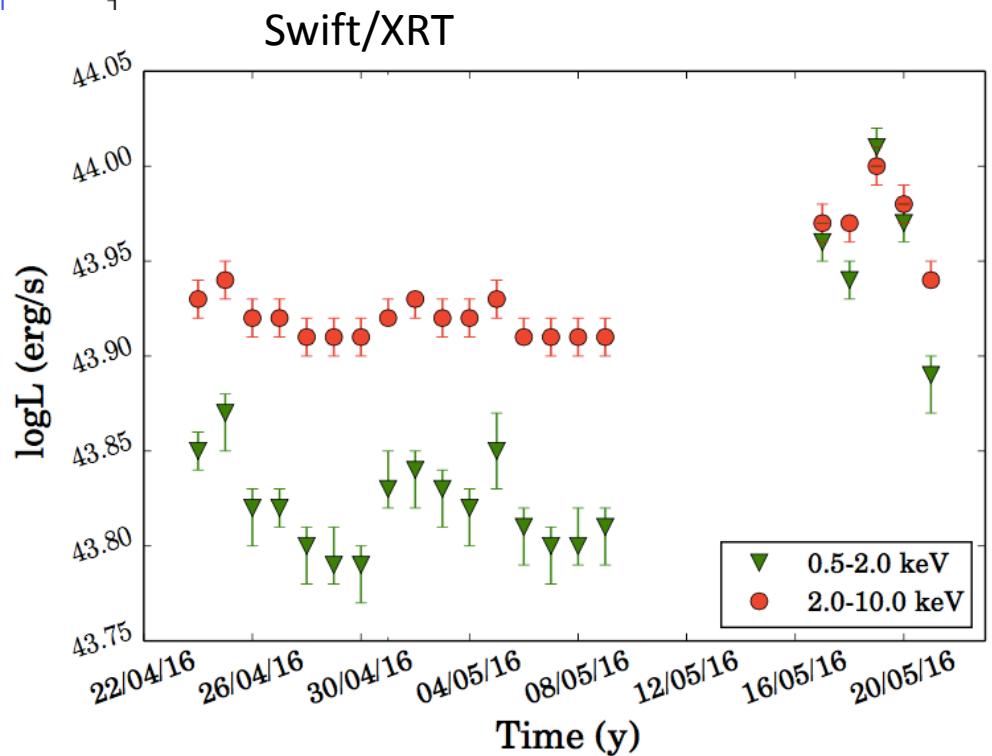
Radio linear size < 0.31 pc

SIMULTANEITY - VLBI monitoring of a RQ AGN!



No conclusive on time lags

Evidence of variability at VLBI (millarcseconds) scales!

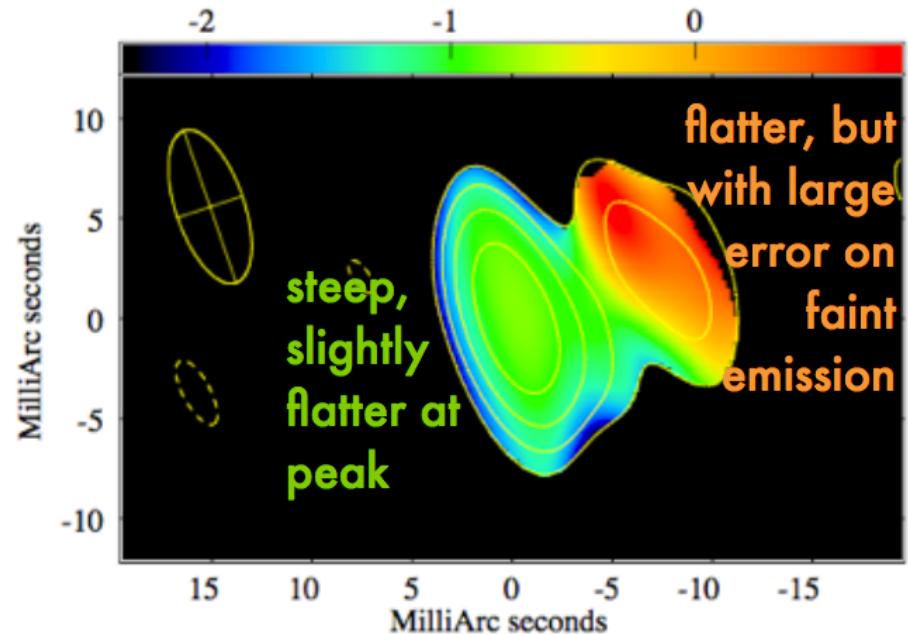
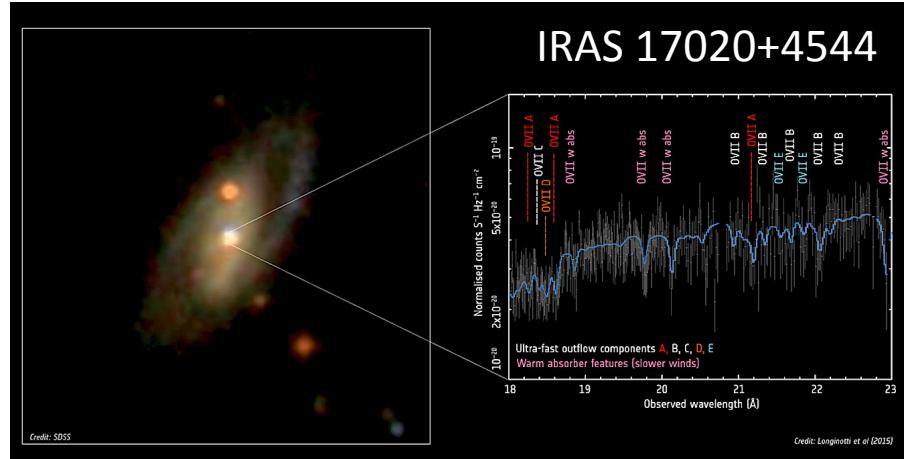


Panessa et al. in preparation
McHardy et al. in preparation

RADIO LOUD AGN

JET AND OUTFLOW COEXISTENCE

→ Ultra fast outflows in 27% of 26 Radio-Loud AGN sample (Tombesi et al. 2014)



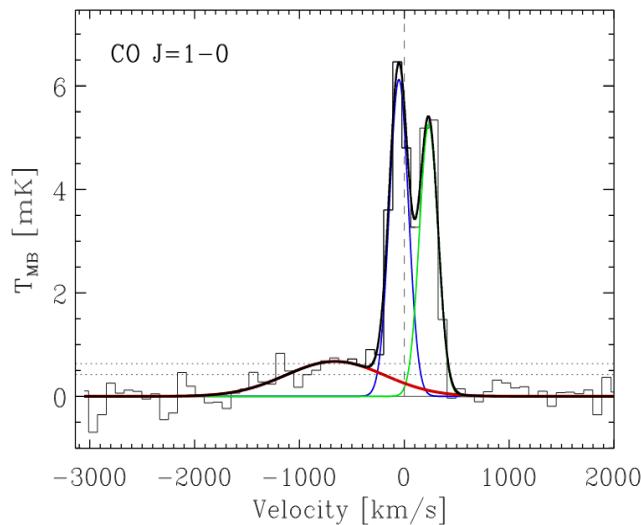
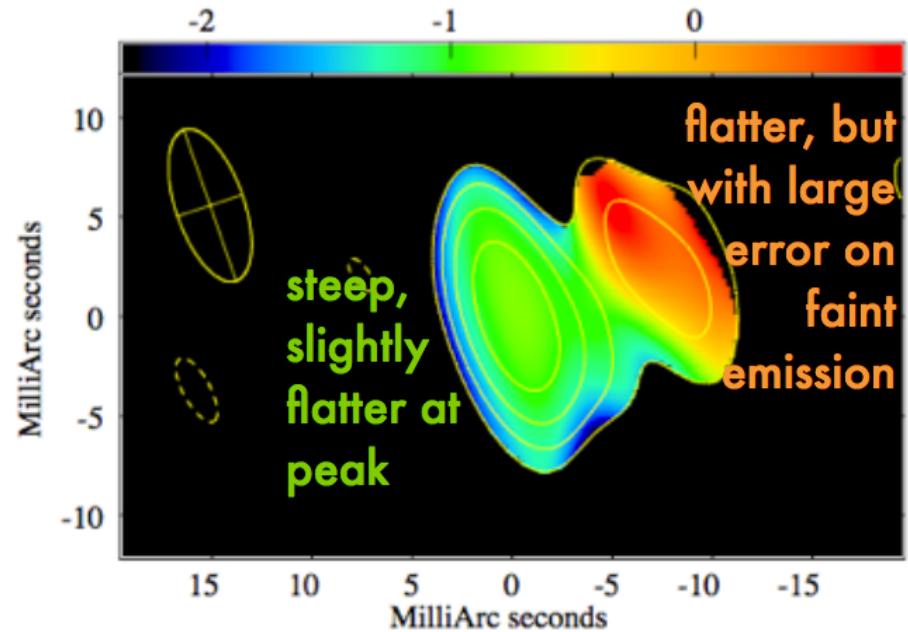
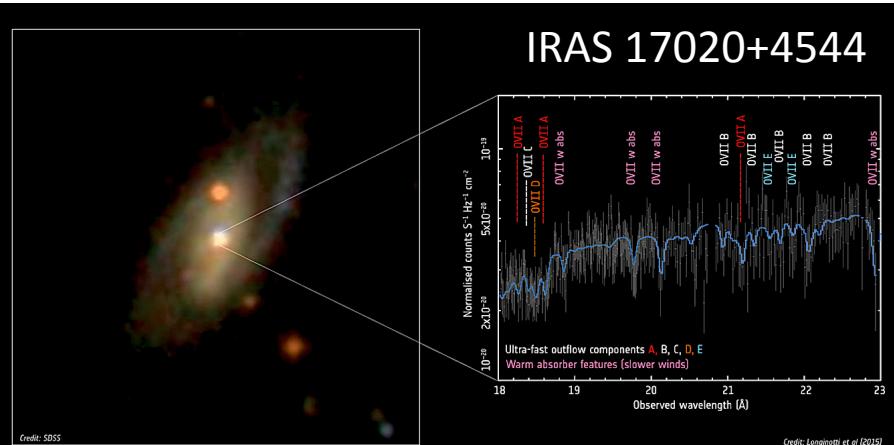
Longinotti et al. 2015, ApJL

Giroletti et al. 2017

- ✓ VLBA Observations in 2000 and 2014
- ✓ Compact bright core plus a secondary fainter component at 1.2'
- ✓ Steep spectral index indicates synchrotron spectrum (magnetic fields)
- ✓ Elongated jetted structure /outflow at ~10 pc scale moving at $v \sim 0.1c$

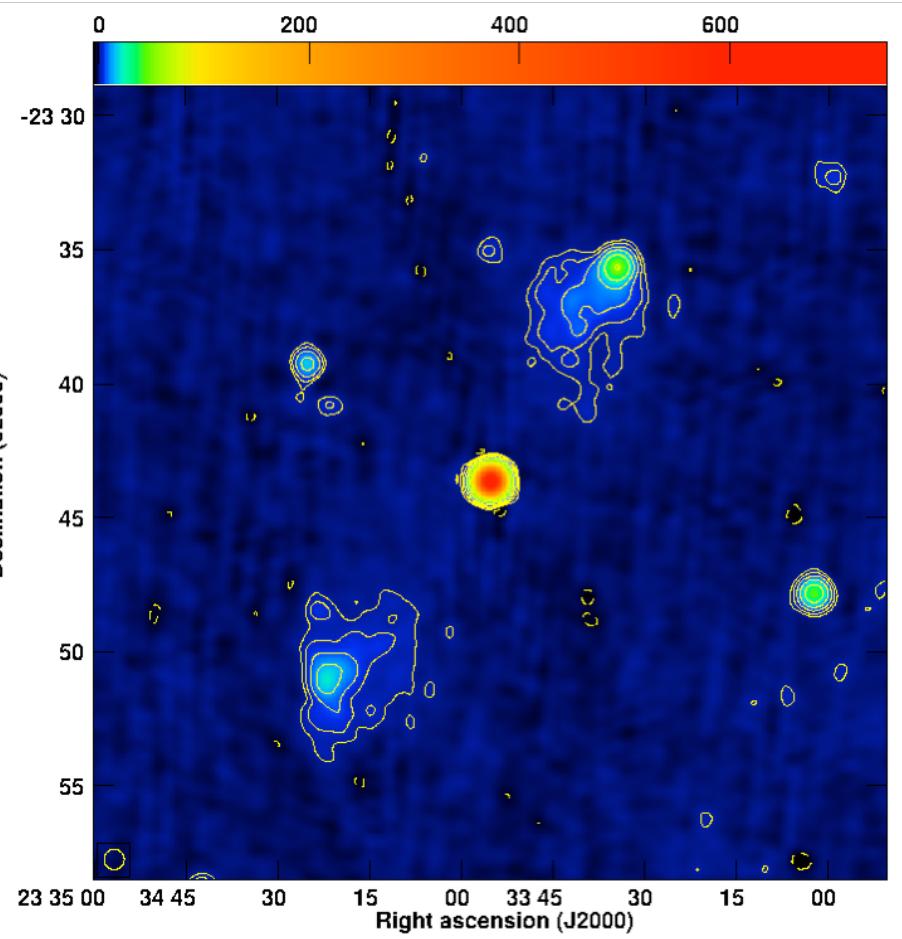
→ Possible connection with X-ray outflow?

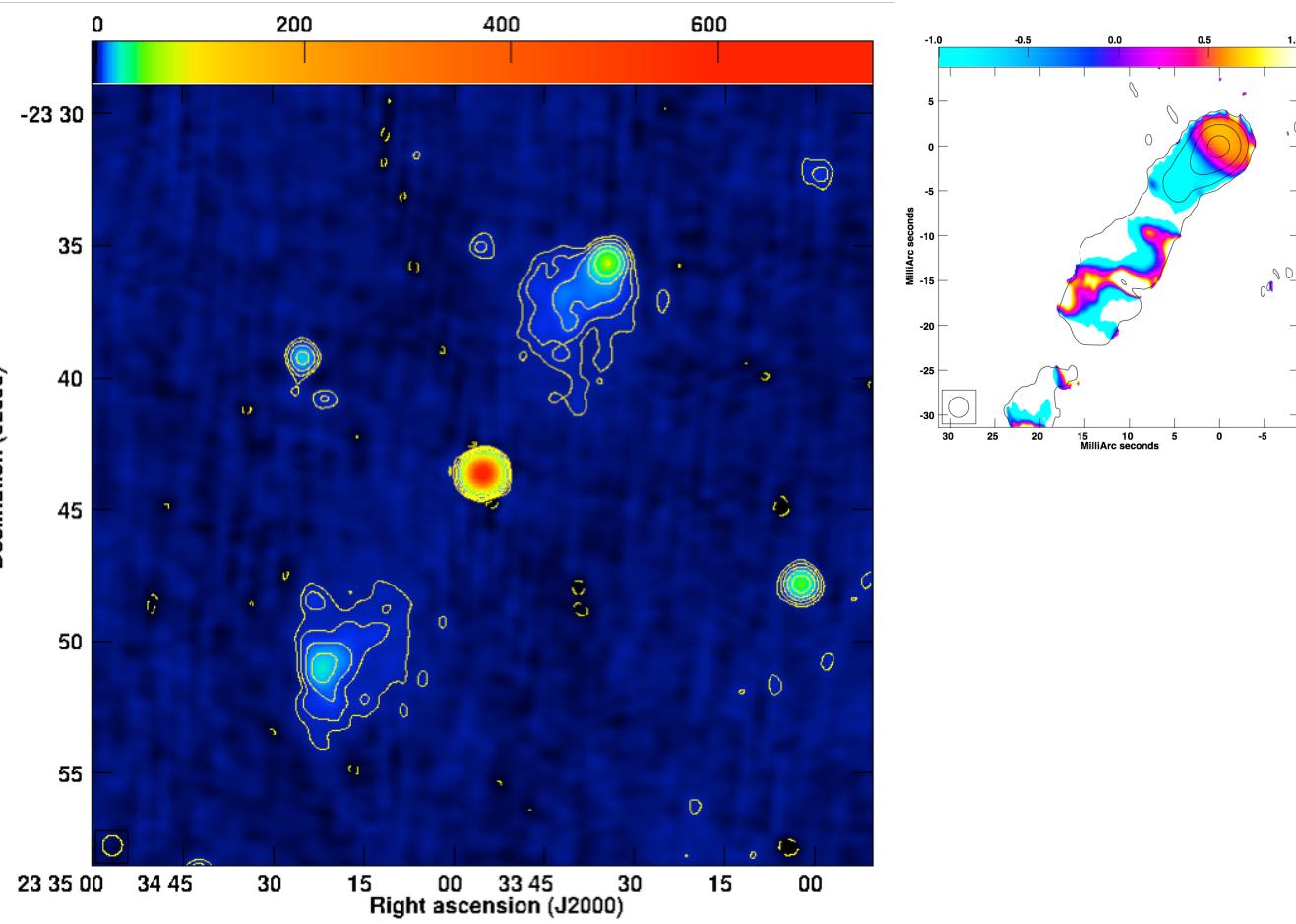
JET AND OUTFLOW COEXISTENCE

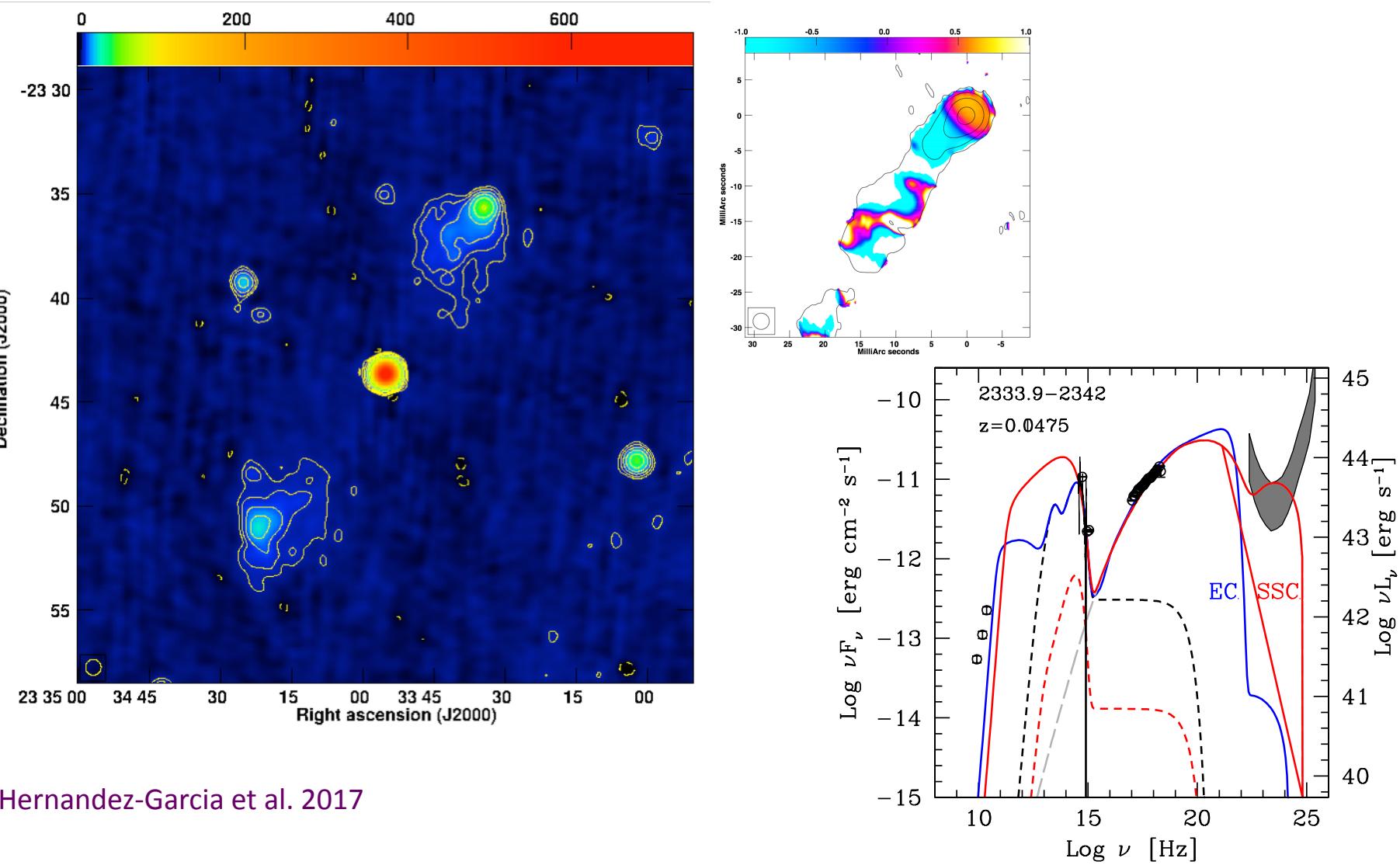


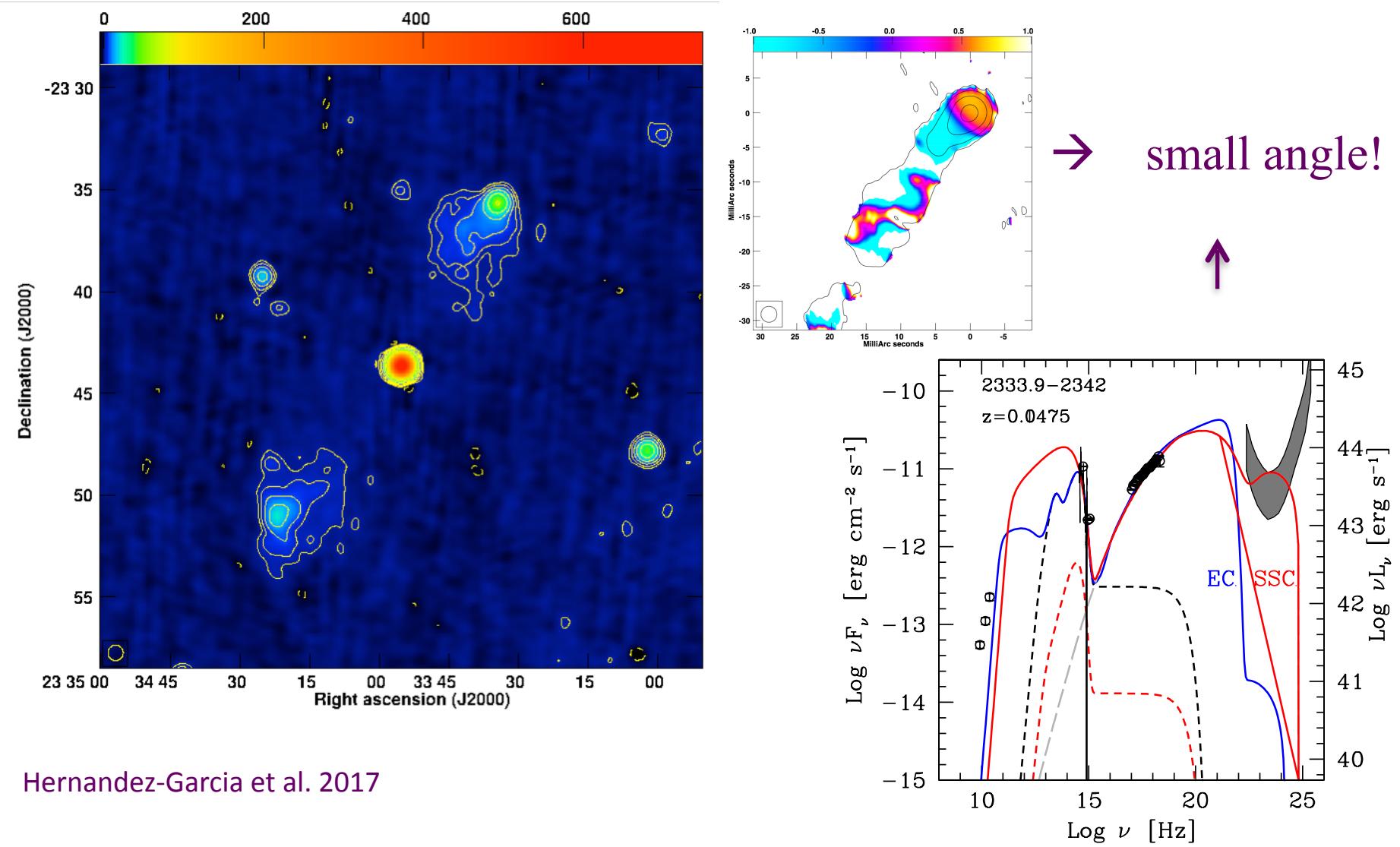
CO(1-0) line spectrum (LMT)
→ V ~ -660 km/s

.



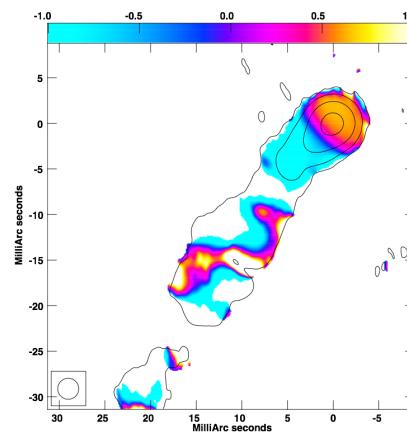
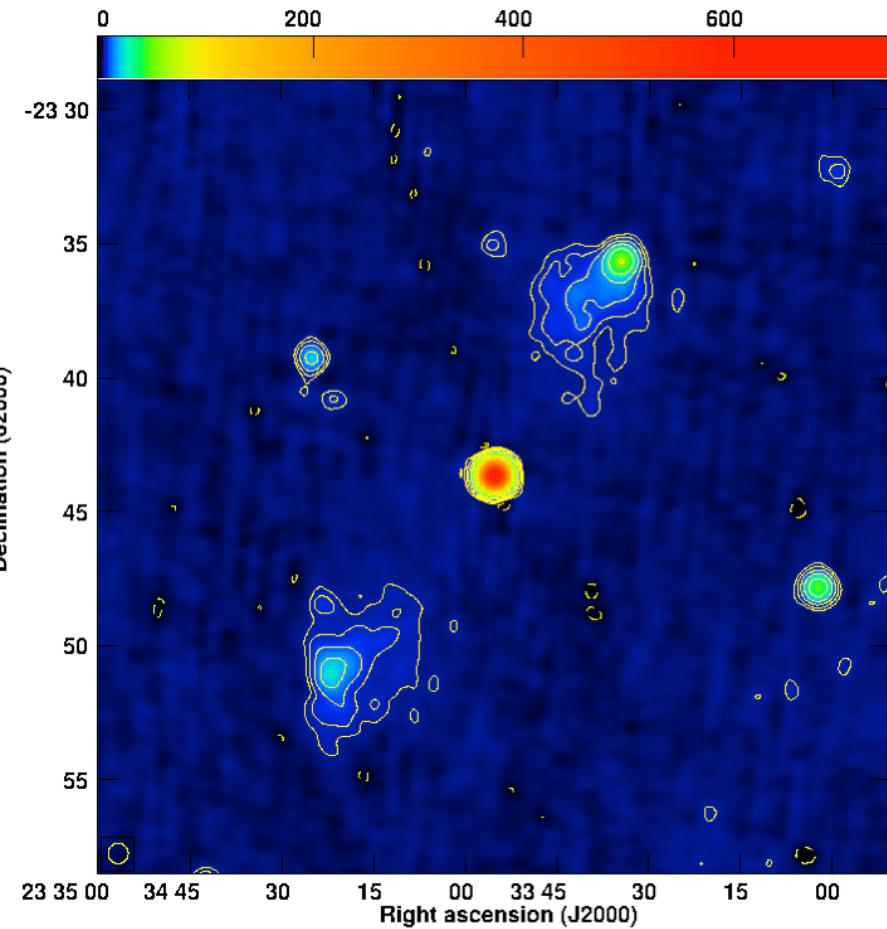




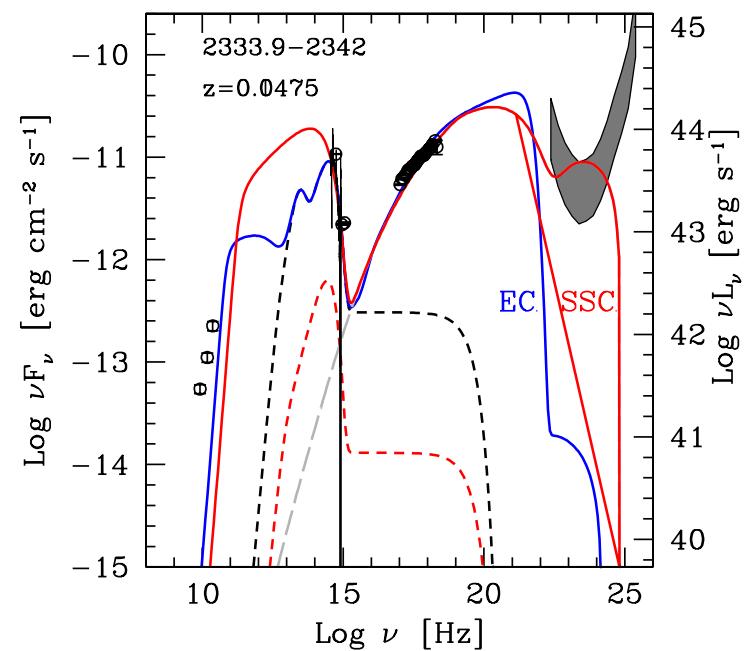


THE REACTIVATING NUCLEUS OF PBC J2333.9-2343

from giant radio galaxy to blazar!



→ small angle!



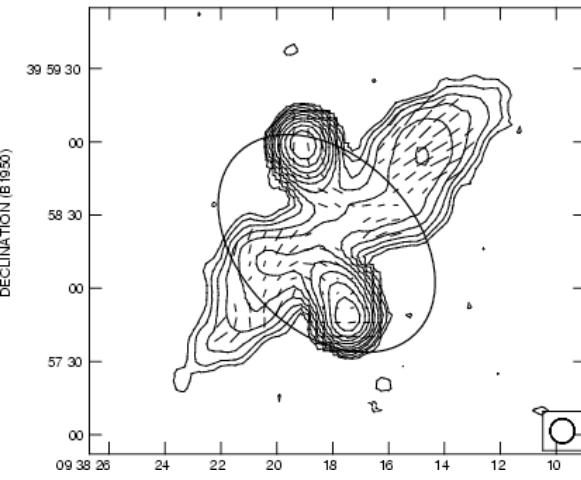
AGN RESTARTING ACTIVITY

Schoenmakers et al. 2000

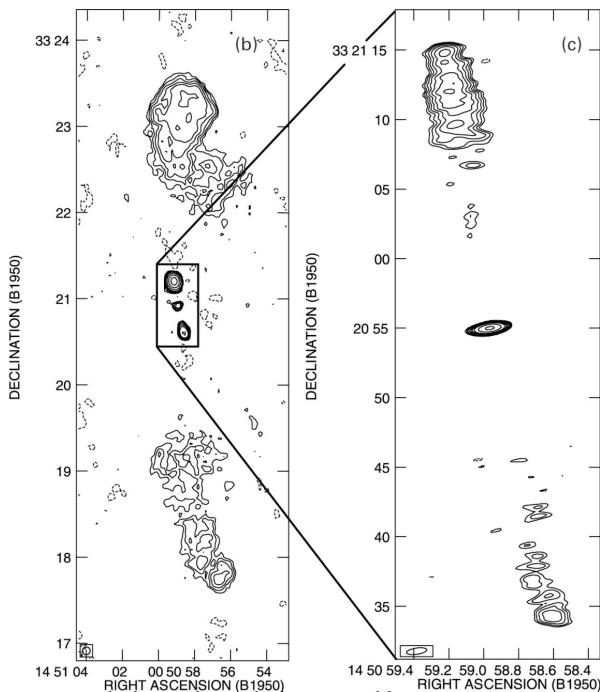
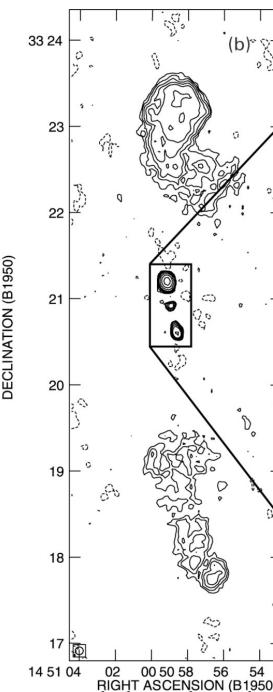
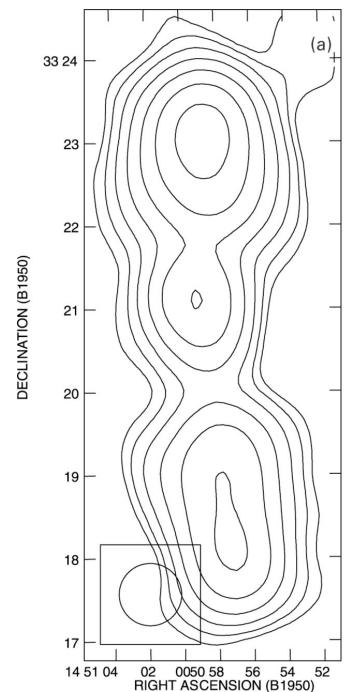
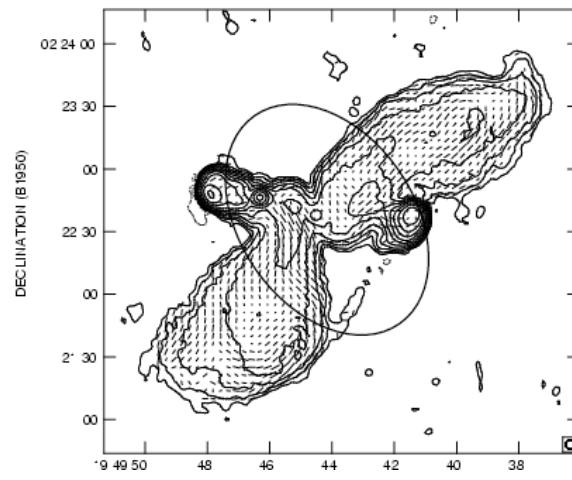
AGN ARCHEOLOGY!

X-shaped radio-sources

3C 223.1



3C 403



Double-double radio-sources

Dennett-Thorpe et al. 2002

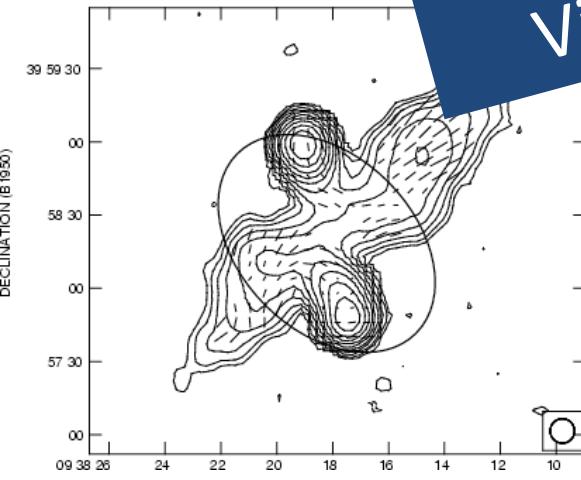
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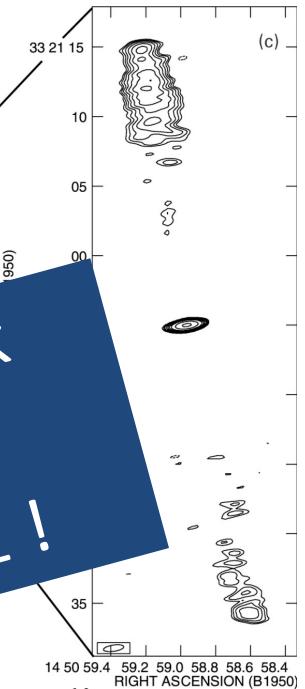
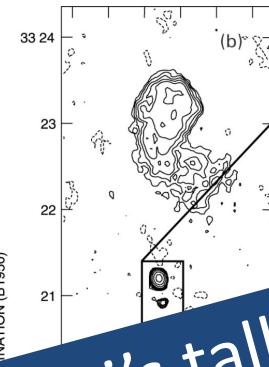
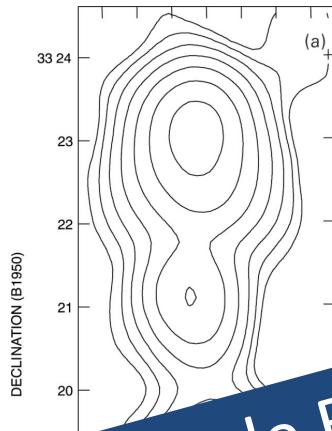
AGN ARCHEOLOGY!

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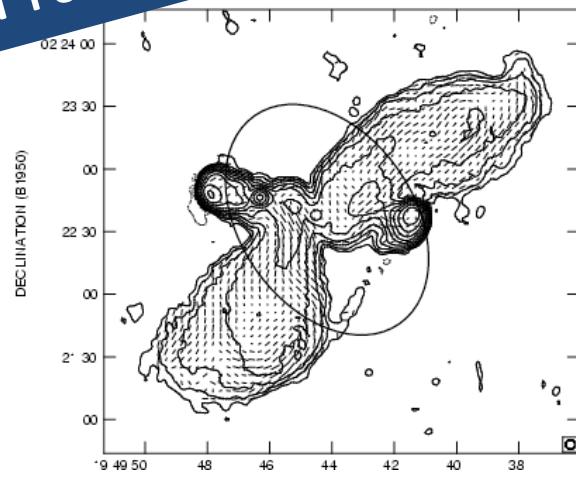


Please listen to Gabriele Bruni's talk
and
Visit Francesco Ursini's Poster #31 !



Double-double radio-sources

3C 403



Dennett-Thorpe et al. 2002

NLR

BLR

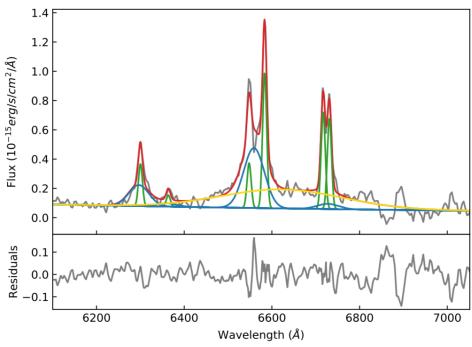
Outflow

Total

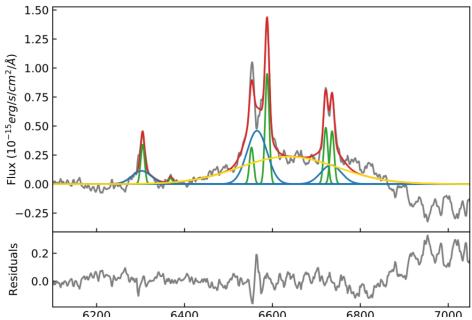
SPM, Mexico

Variations in the broad lines

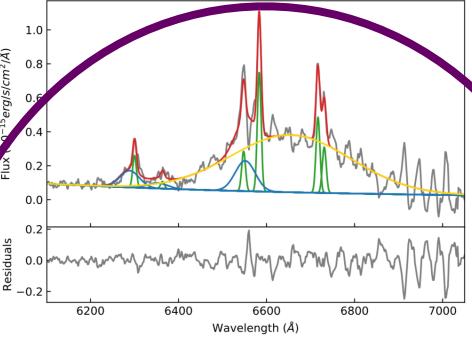
2009



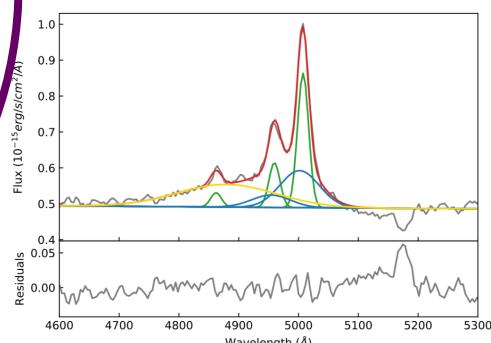
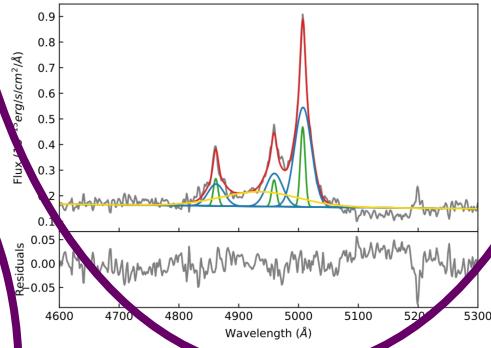
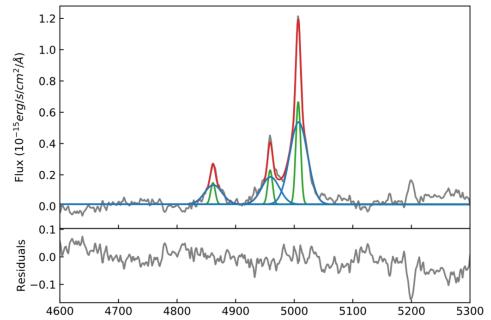
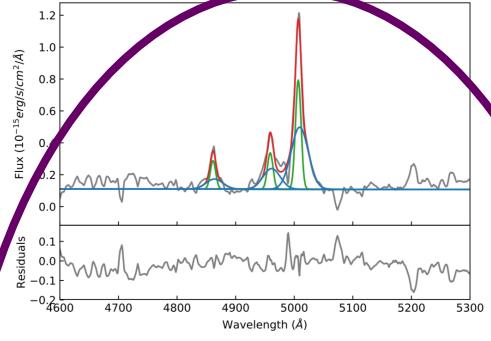
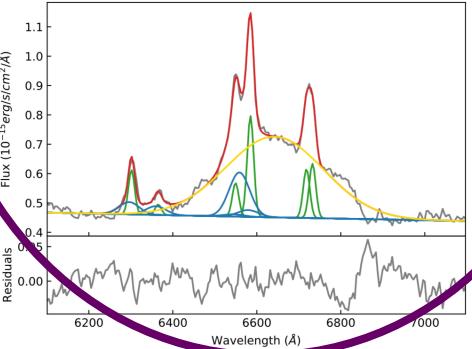
2015



2016



2016



NLR

BLR

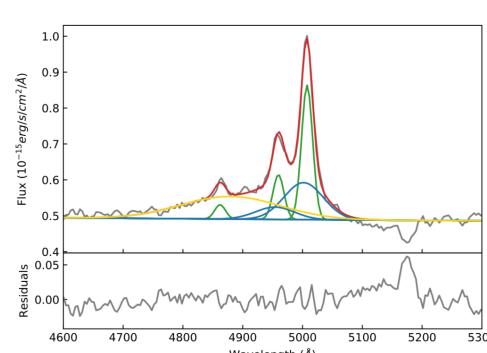
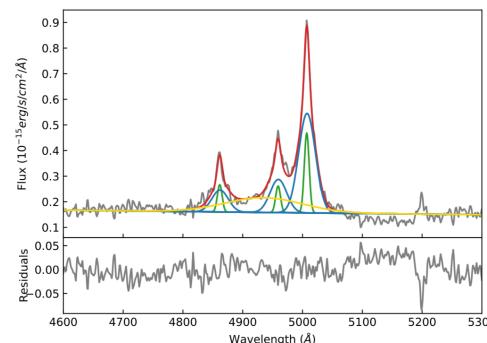
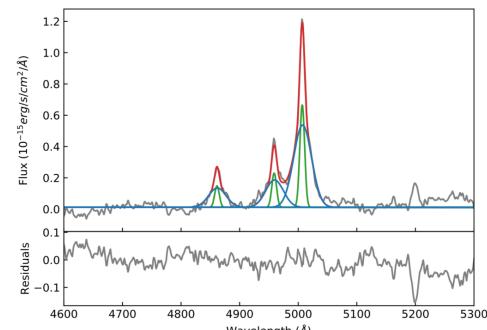
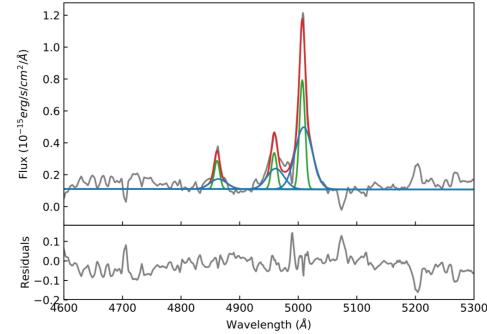
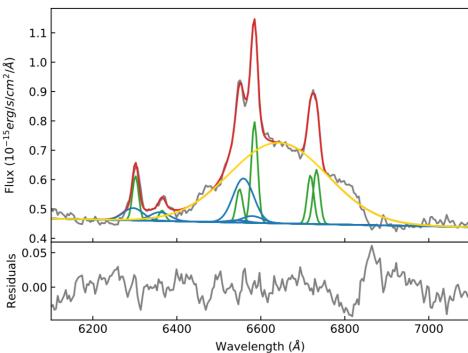
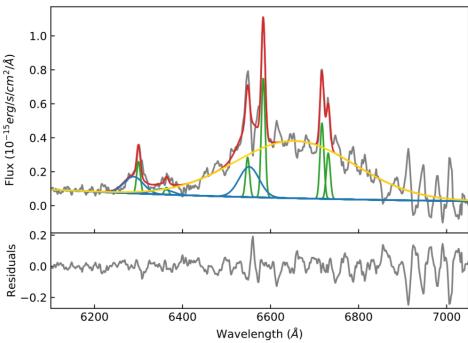
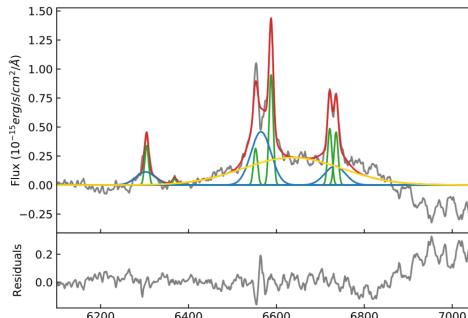
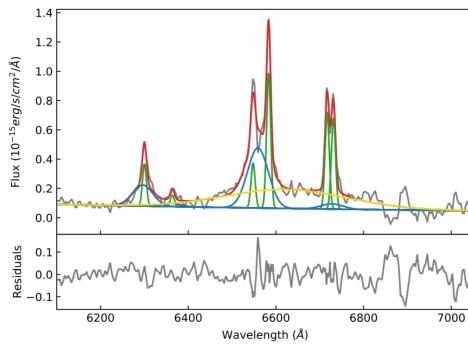
Outflow

Total

Brodened component
in all narrow lines

→ Large scale (NLR)
outflow!

...2 sigma variability

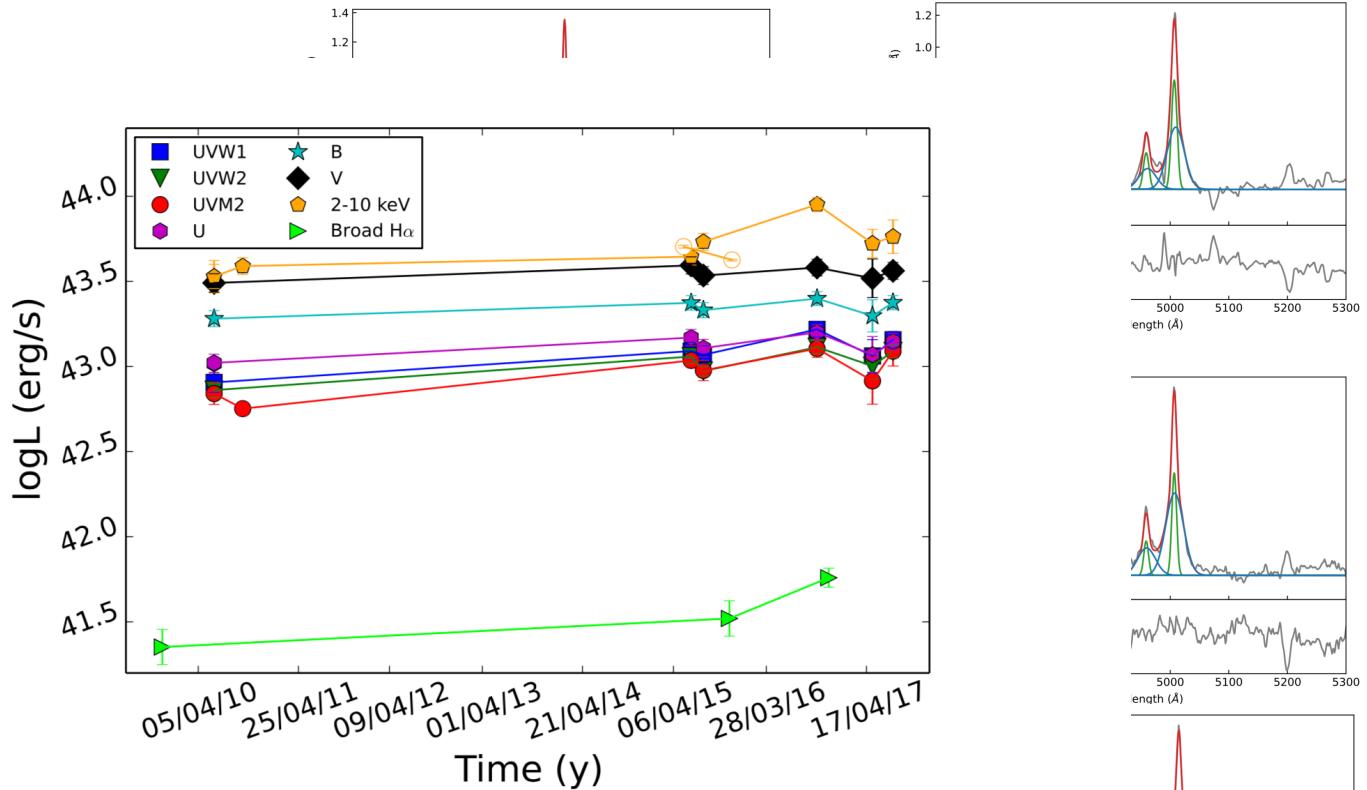


NLR

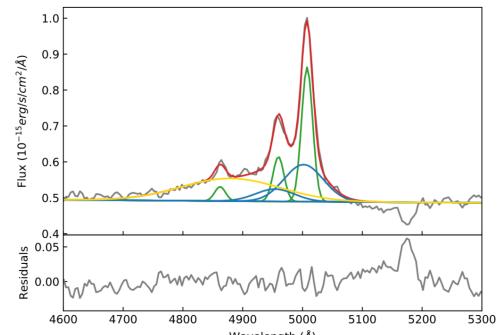
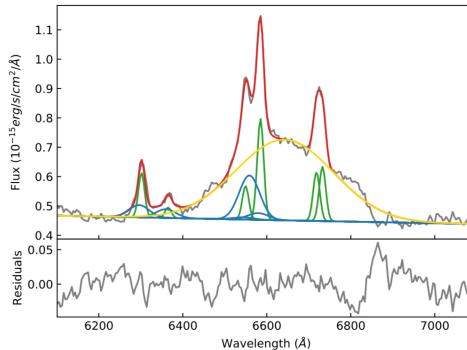
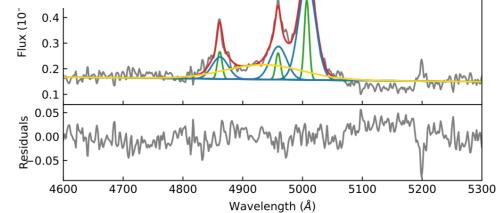
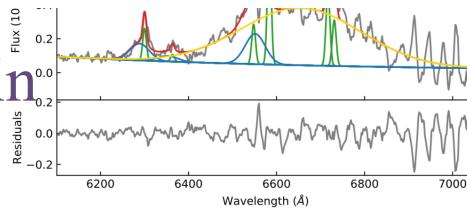
BLR

Outflow

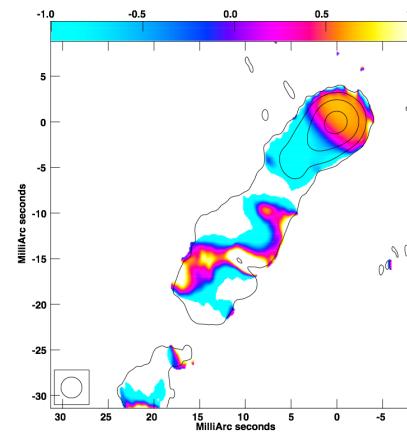
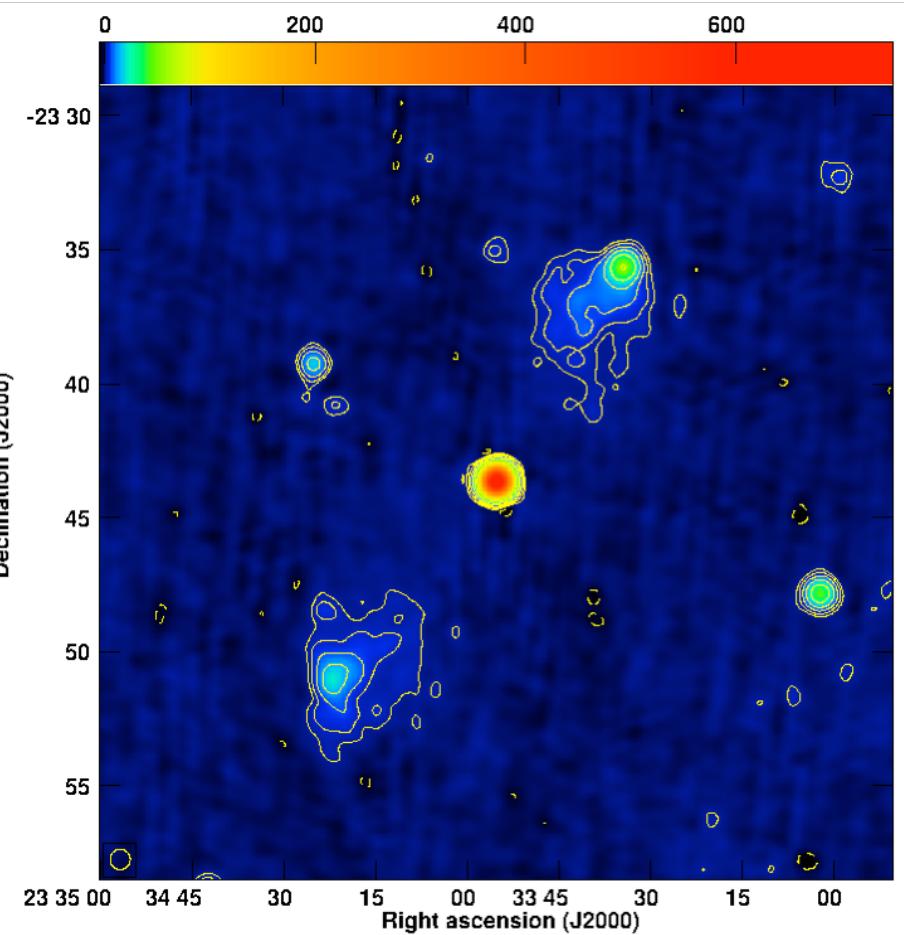
Total



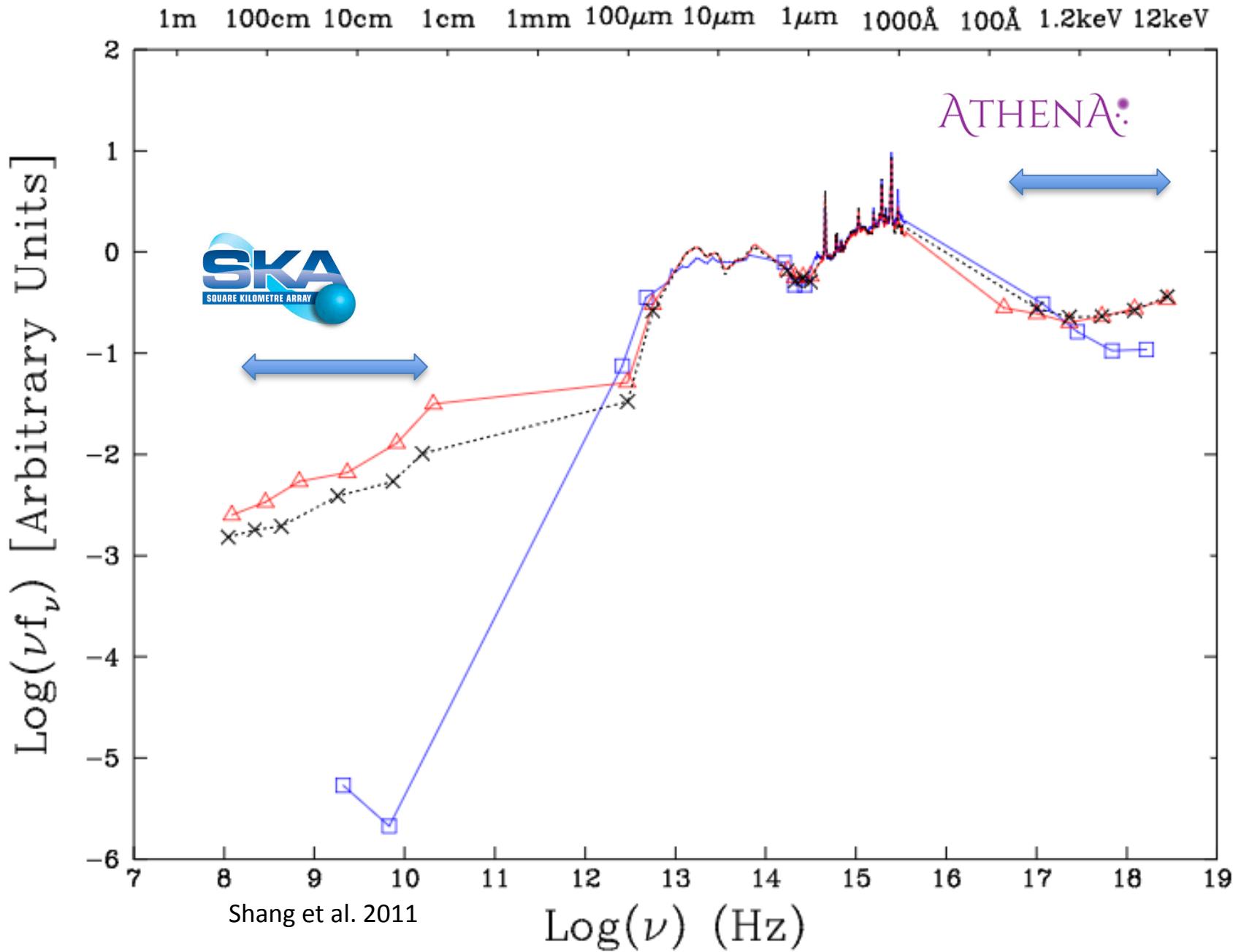
...that follow variations in
X-rays and opt-UV
continuum



JET and CLOUDS in the blazar-candidate PBC J2333.9-2343



- Change in the BLR: variability in the optical broad components →
Jet powering the ionization of the AGN
- First time of a wind in a blazar?



Thank you!



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