NLS1 galaxies and their place in the universe, Padova, April 2018

Multi-λ Properties of Radio-loud Narrow-Line Seyfert 1 Galaxies

S. Komossa, Bonn

- intro: radio-loud (RL) NLS1s
- X-ray properties, disc & jet
- γ –rays with Fermi
- IR: SF vs jets
- optical: hosts,
  BH masses,
  spectroscopy,
  outflows
- case studies: 1H0323+342, RXJ2314+2243

NLS1s are AGN with extreme multi-wavelength properties

THE SPECTRA OF NARROW-LINE SEYFERT 1 GALAXIES[1]

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Received 1985 January 2; accepted 1985 April 9

ABSTRACT

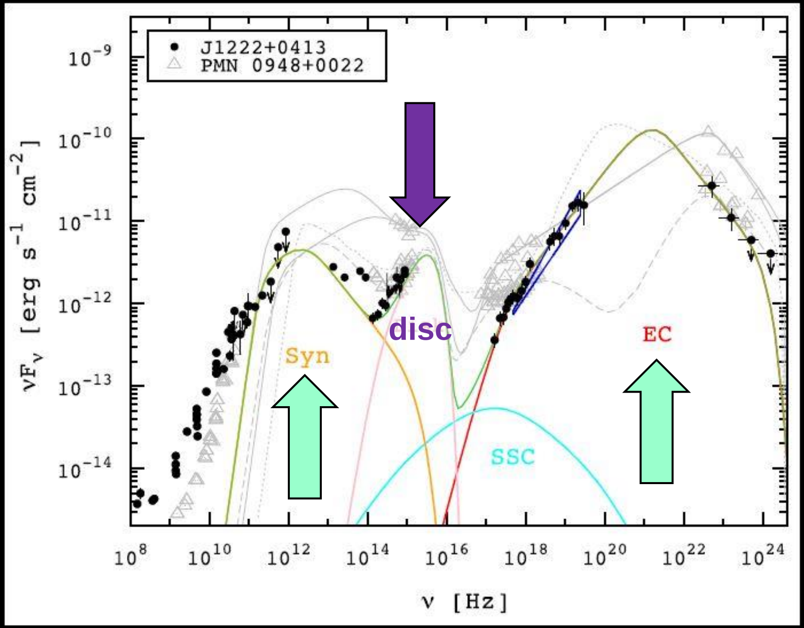
Measurements are presented of a group of active galactic nuclei with all the properties of Seyfert 1 or 1.5 galaxies, but with unusually narrow H I lines. They include Mrk 42, 359, and 1239 (previously studied by other authors) as well as Mrk 493, 766, 783, and 1126. One other somewhat similar object, Mrk 1388, is also included in the discussion; measurements of its spectrum have been published elsewhere. For these objects, narrow-line widths, relative intensities of the emission lines, etc., are all similar to those in other Seyfert 1 galaxies. Some, in particular Mrk 493 and Mrk 42, have relatively strong Fe II emission; in others, especially

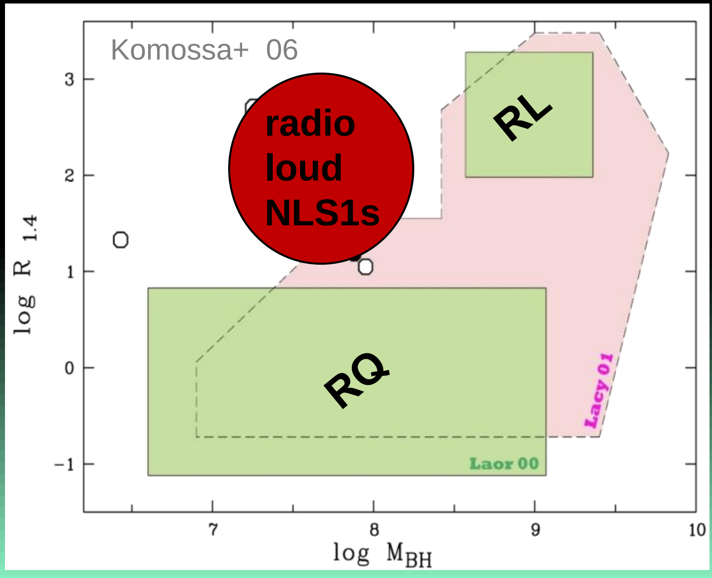
→ provide important insights on drivers & physics of AGN

radio properties of NLS1s – astrophysical context

- **new probe of jet-disc coupling :**
  - *both* components in SED
  - in new regime, different from classical blazars, and on *shorter* timescales

→ jet formation & acceleration





[e.g., Komossa+ 06, Yuan+ 08, Foschini 11]

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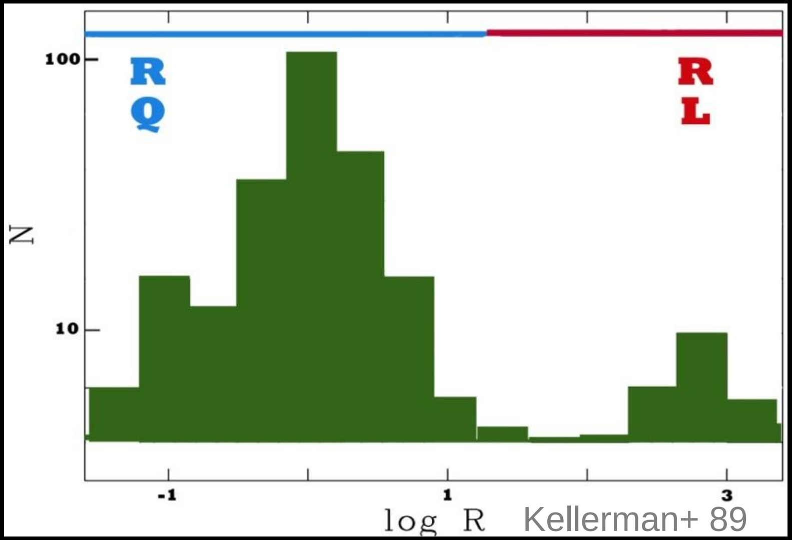
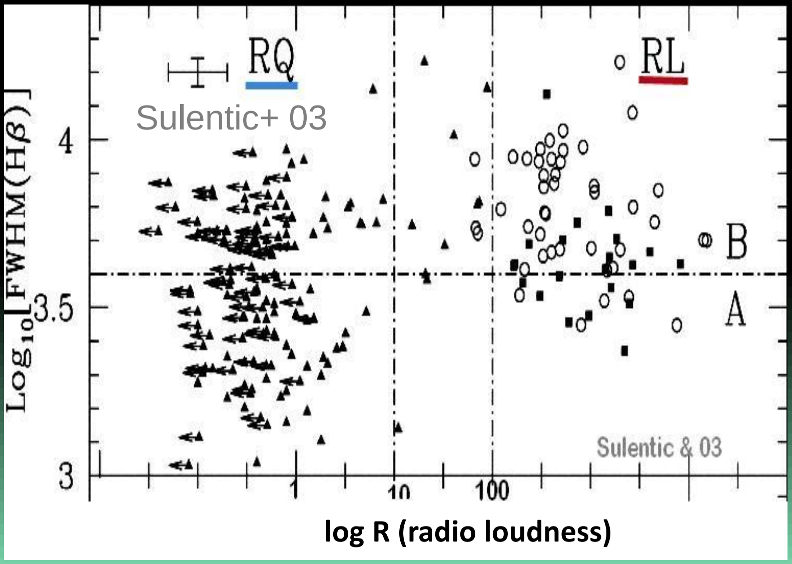
- **RL-RQ bimodality**
  (historically: RLness & NLS1ness /FeII-ness at opposite ends of EV1)

→ **driver(s) of radio-loudness** (role of spin, BH mass, large-scale environment)

- new probe of NLS1 physics, new test of NLS1 (orientation) models

[e.g., Komossa+ 06, Yuan+ 08, Foschini 11]





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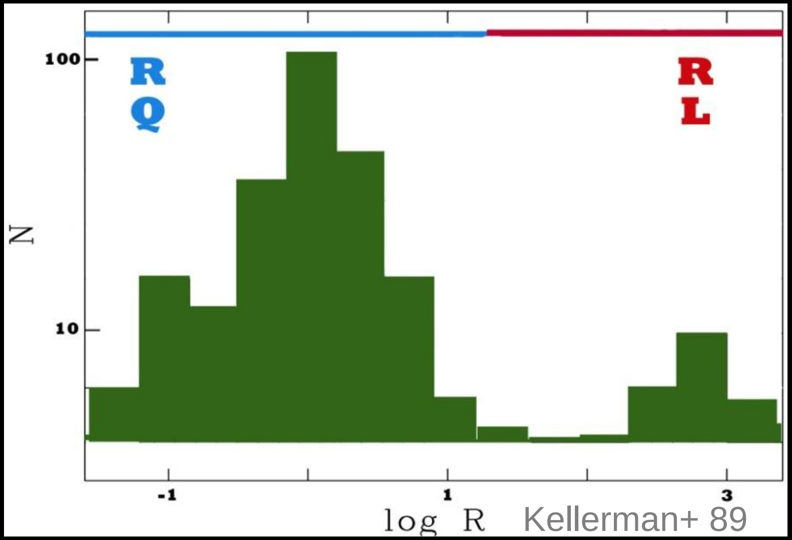

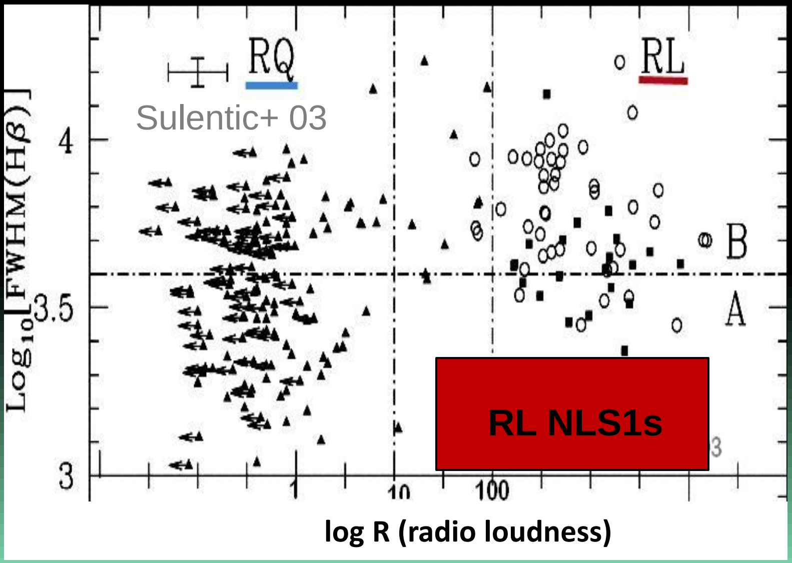

radio properties of NLS1s – 1st systematic studies

- almost unexplored territory, pre-2005; except for ~3-4 RLs

THE ASTRONOMICAL JOURNAL VOLUME 109, NUMBER 1 JANUARY 1995

RADIO PROPERTIES OF NARROW-LINED SEYFERT 1 GALAXIES

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Received 1994 June 3; revised 1994 September 13

ABSTRACT

We have observed seven narrow-lined Seyfert 1 (NLS1) galaxies and one high-ionization Seyfert 2 galaxy

compact, low radio power (radio-quiet)

radio properties of NLS1s – 1st systematic studies

- almost unexplored territory, pre-2005; except for ~3-4 RLs

→ first systematic search for radio-loud NLS1 galaxies ($R = f_{1.4\mathrm{GHz}} / f_{4400}$)
based on all known NLS1s in VeronQC, cross-matched with FIRST, NVSS, SUMSS, WENSS, PMN, 87GB, and PKS radio surveys

~tripled # of known RL-NLS1s
(formally: NL type 1 <u>quasars</u>!)

→ test of orientation effects in NLS1s.
esp.: *if BH masses same as in BLS1s, and NLS1s preferentially pole-on, than expect <u>more</u> RL NLS1s than BLS1s !*

THE ASTRONOMICAL JOURNAL VOLUME 109, NUMBER 1 JANUARY 1995

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THE ASTRONOMICAL JOURNAL, 132:531–545, 2006 August

RADIO-LOUD NARROW-LINE TYPE 1 QUASARS

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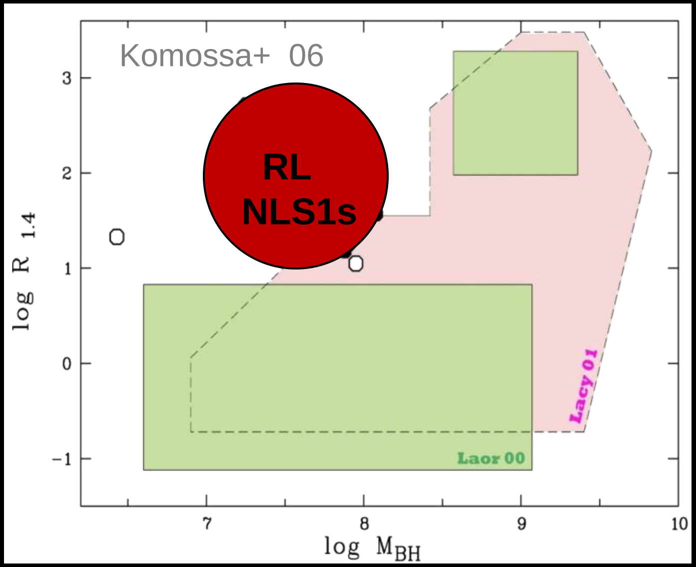
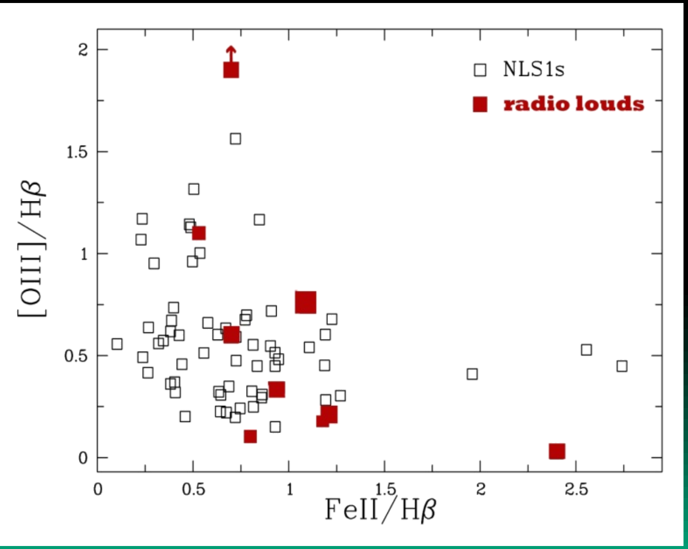
ABSTRACT

We present the first systematic study of (non-radio-selected) radio-loud narrow-line Seyfert 1 (NLS1) galaxies. Cross-correlation of the Catalogue of Quasars and Active Nuclei with several radio and optical catalogs led to the

radio properties of NLS1 galaxies

- only 2.5% very RL   (R>100)
  while 14% of BL-AGN vRL
- 7% RL (R>10)   )*
- low BH masses, despite RLness
- high FeII, despite RLness
- high L/L_{edd}
- ~70% CSS
- ~30% blazars (flat/inverted spectra
  high var)





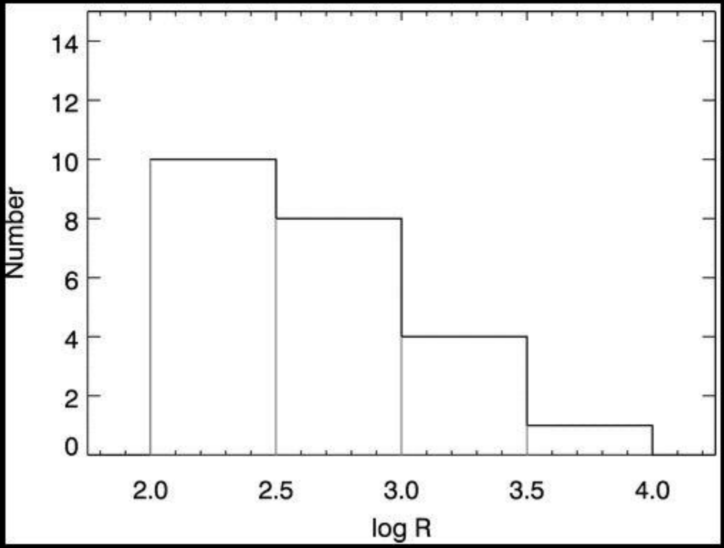
[Komossa+ 06]

)* recent studies; e.g. 6% radio-loud (6dFGS, Chen+18), 4% (SDSS, Cracco+ 16), 5% radio detections (DR12, Rakshit+17)

very radio-loud NLS1 galaxies

- 23 NLS1s @ R>100

- several of these show properties like
  blazars:
  flat or inverted radio spectra,
  large-amplitude flux and spectral
  variability, compact radio cores,
  high variability brightness
  temperatures,
  enhanced optical conti emission,
  flat X-ray spec and blazar-like SEDs

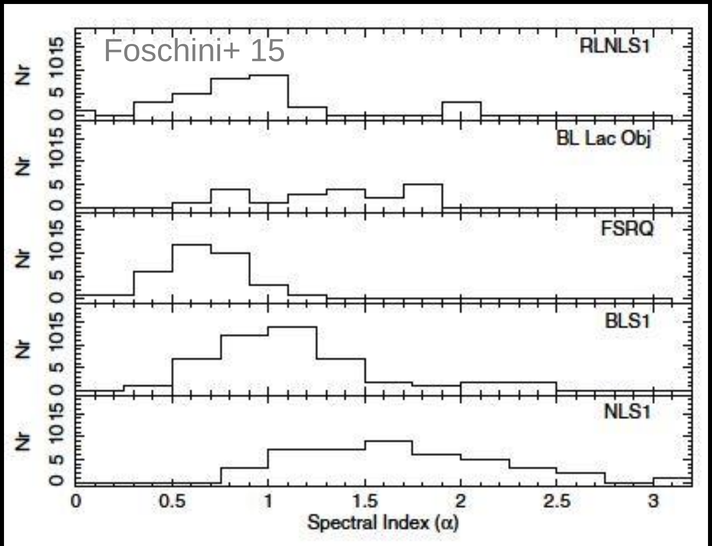


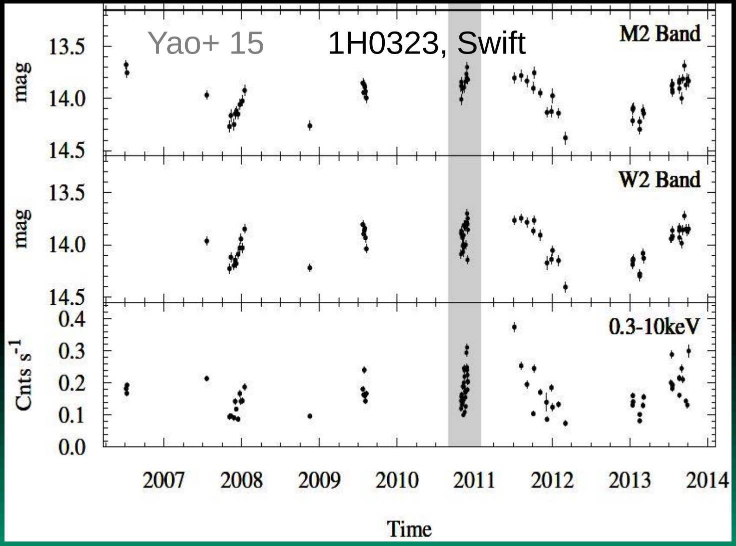
[Yuan, Zhou, Komossa, + 08]

- last decade: radio-imaging (VLBI) and radio-monitoring of RL NLS1s → review talk

X-ray properties of radio-loud NLS1s

- 0.3-10 keV X-ray spectra (42 sources):
  < Γ > = -2.0 (F15)
  -2.7 RQ NLS1
  -1.6 FSRQs
- 0.1-2.4 keV (ROSAT)
  < Γ > = -2.4 (K06)
  < Γ > = -2.4 (Y08)





[Foschini+ 15, Komossa+ 06, Yuan+ 08]

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- 0.1-2.4 keV (ROSAT)
  $<\Gamma> =$ -2.4 (K06)
  $<\Gamma> =$ -2.4 (Y08)
- XMM & NuStar: „soft excess“ (disc) & pl (corona or jet)
- Fe line only in 1H0323
- rapid variability on timescales down to hrs -- disk, jet
- UV & X correlated in 1H0323

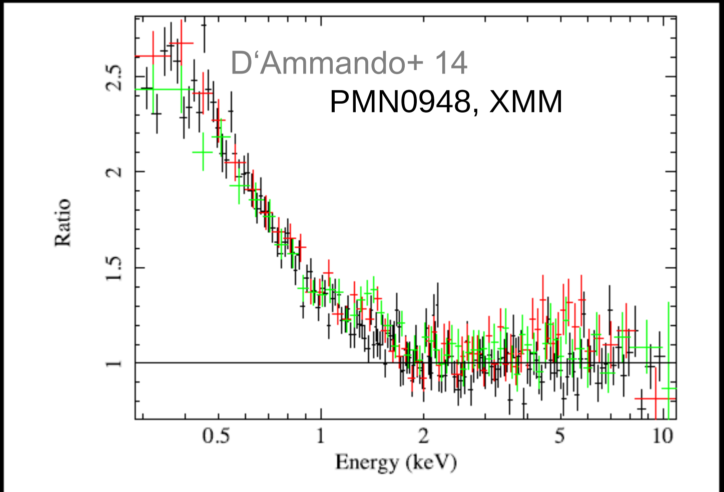
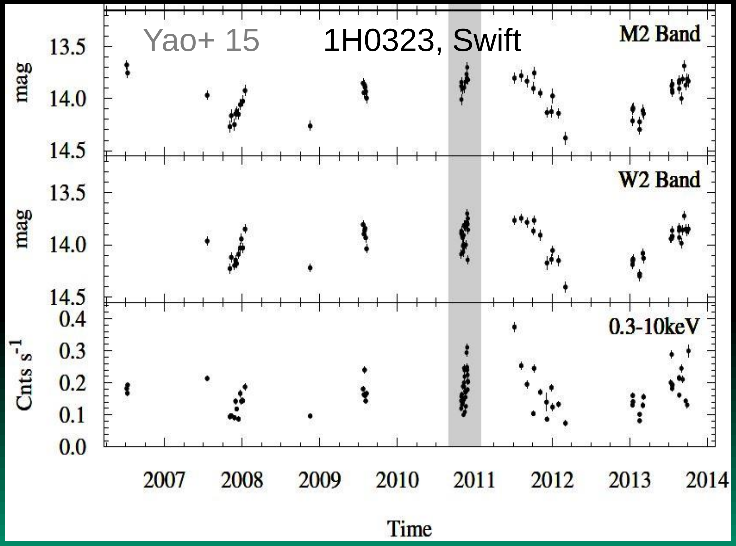


Figure 2. *XMM–Newton* EPIC pn (black), MOS1 (red) and MOS2 (green) data shown as a ratio to a power law with $\Gamma = 1.48$.



[Foschini+ 15, Komossa+ 06, Yuan+ 08; Gallo+ 06, de Rosa+ 08, Abdo+ 09, D`Ammando+ 12, 14, Paliya+ 13, 14, Orienti+ 15, Yao+15, Kreikenbohm+ 16, Land+ 17, Kynoch+18, Larsson+ 18, Yang+ 18, ...]

γ–ray discovery of NLS1 galaxies

The Astrophysical Journal, 707:L142–L147, 2009 December 20
doi:10.1088/0004-637X/707/2/L142

RADIO-LOUD NARROW-LINE SEYFERT 1 AS A NEW CLASS OF GAMMA-RAY ACTIVE GALACTIC NUCLEI

A. A. Abdo[1,2], M. Ackermann[3], M. Ajello[3], L. Baldini[4], J. Ballet[5], G. Barbiellini[6,7], D. Bastieri[8,9], K. Bechtol[3], R. Bellazzini[4], B. Berenji[3], E. D. Bloom[3], E. Bonamente[10,11], A. W. Borgland[3], J. Bregeon[4], A. Brez[4], M. Brigida[12,13], P. Bruel[14], T. H. Burnett[15], G. A. Caliandro[16], R. A. Cameron[3], P. A. Caraveo[17], J. M. Casandjian[5], C. Cecchi[10,11], Ö. Çelik[18,19,20], A. Chekhtman[1,21], C. C. Cheung[1,2], J. Chiang[3], S. Ciprini[11], R. Claus[3], J. Cohen-Tanugi[22], J. Conrad[23,24,56], S. Cutini[25], C. D. Dermer[1], F. de Palma[12,13], E. do Couto e Silva[3], P. S. Drell[3], R. Dubois[3], D. Dumora[26,27], C. Farnier[22], C. Favuzzi[12,13], S. J. Fegan[14], W. B. Focke[3], L. Foschini[28,57], M. Frailis[29], Y. Fukazawa[30], P. Fusco[12,13], F. Gargano[13], N. Gehrels[18,31,32], S. Germani[10,11], B. Giebels[14], N. Giglietto[12,13], F. Giordano[12,13], M. Giroletti[33], T. Glanzman[3], G. Godfrey[3], I. A. Grenier[5], J. E. Grove[1], L. Guillemot[34], S. Guiriec[35], M. Hayashida[3], E. Hays[18], D. Horan[14], R. E. Hughes[36], G. Jóhannesson[3], A. S. Johnson[3], W. N. Johnson[1], M. Kadler[19,37,38,39], T. Kamae[3], H. Katagiri[30], J. Kataoka[40], M. Kerr[15], J. Knödlseder[41], M. Kuss[4], J. Lande[3], L. Latronico[4], F. Longo[6,7], F. Loparco[12,13], B. Lott[26,27], M. N. Lovellette[1], P. Lubrano[10,11], A. Makeev[1,21], M. N. Mazziotta[13], W. McConville[18,32], J. E. McEnery[18,32], C. Meurer[23,24], P. F. Michelson[3], W. Mitthumsiri[3], T. Mizuno[30], C. Monte[12,13], M. E. Monzani[3], A. Morselli[42], I. V. Moskalenko[3], S. Murgia[3], P. L. Nolan[3], J. P. Norris[43], E. Nuss[22], T. Ohsugi[30], N. Omodei[4], E. Orlando[44], J. F. Ormes[43], V. Pelassa[22], M. Pepe[10,11], M. Persic[6,45], M. Pesce-Rollins[4], F. Piron[22], T. A. Porter[46], S. Rainò[12,13], R. Rando[8,9], M. Razzano[4], L. S. Rochester[3], A. Y. Rodriguez[16], F. Ryde[24,47], H. F.-W. Sadrozinski[46], R. Sambruna[18], A. Sander[36], P. M. Saz Parkinson[46], J. D. Scargle[48], C. Sgrò[4], P. D. Smith[36], G. Spandre[4], P. Spinelli[12,13], M. S. Strickman[1], D. J. Suson[49], G. Tagliaferri[28], H. Takahashi[30], T. Takahashi[50], T. Tanaka[3], J. B. Thayer[3], J. G. Thayer[3], D. J. Thompson[18], L. Tibaldo[5,8,9], O. Tibolla[51], D. F. Torres[16,52], G. Tosti[10,11], A. Tramacere[3,53], Y. Uchiyama[3], T. L. Usher[3], V. Vasileiou[19,20], N. Vilchez[41], V. Vitale[42,54], A. P. Waite[3], P. Wang[3], B. L. Winer[36], K. S. Wood[1], T. Ylinen[24,47,55], M. Ziegler[46]
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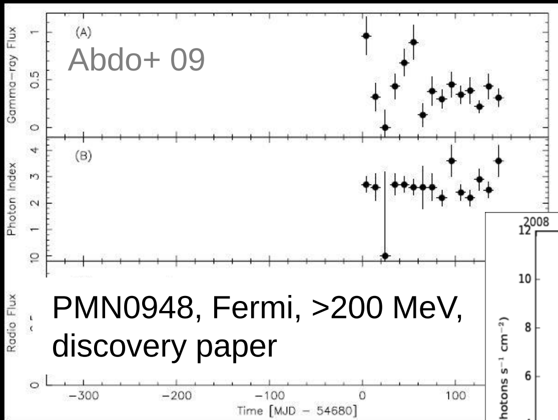
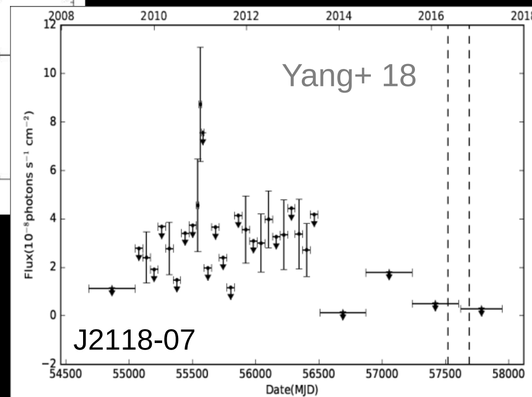
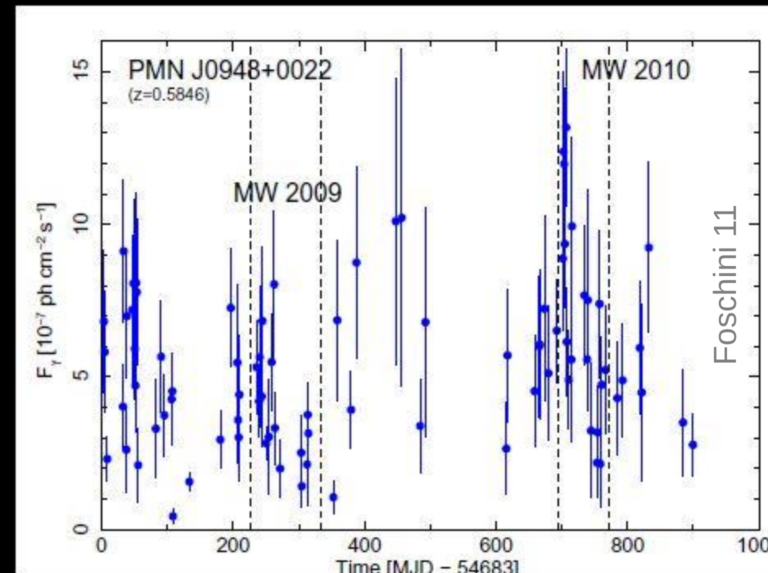
and
G. Ghisellini[28], L. Maraschi[28], and F. Tavecchio[28]

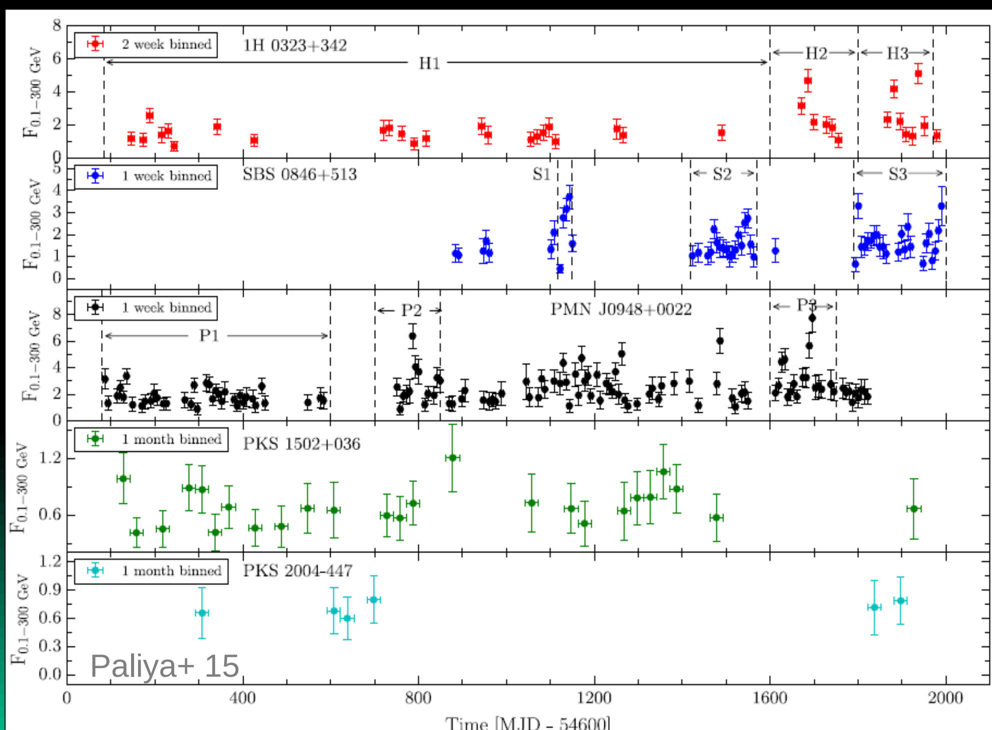
We report the discovery with *Fermi*/LAT of γ-ray emission from three radio-loud narrow-line Seyfert 1 galaxies: PKS 1502+036 ($z = 0.409$), 1H 0323+342 ($z = 0.061$), and PKS 2004−447 ($z = 0.24$). In addition to PMN J0948+0022 ($z = 0.585$), the first source of this type to be detected in γ rays, they may form an emerging new class of γ-ray active galactic nuclei (AGNs). These findings can have strong implications on our knowledge about relativistic jets and the unified model of the AGN.

γ–ray discovery of NLS1s









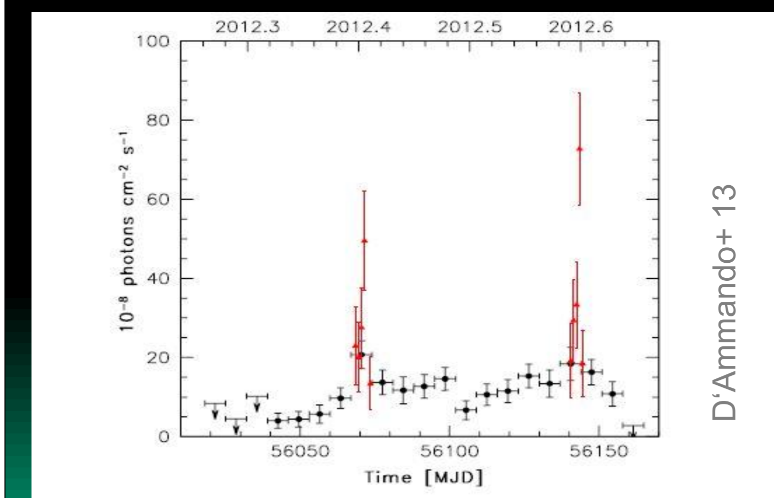


Figure 1: *Fermi*-LAT (E > 100 MeV) light curve of SBS 0846+513 obtained during 2012 April 1 - August 28 with 7-day (black circles) and 1-day (red triangles) time bins.

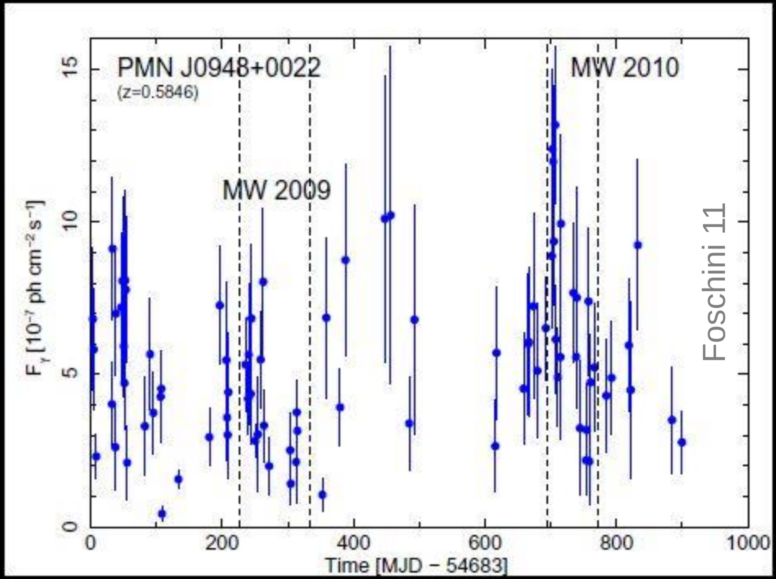
radio-loud NLS1s: γ–rays

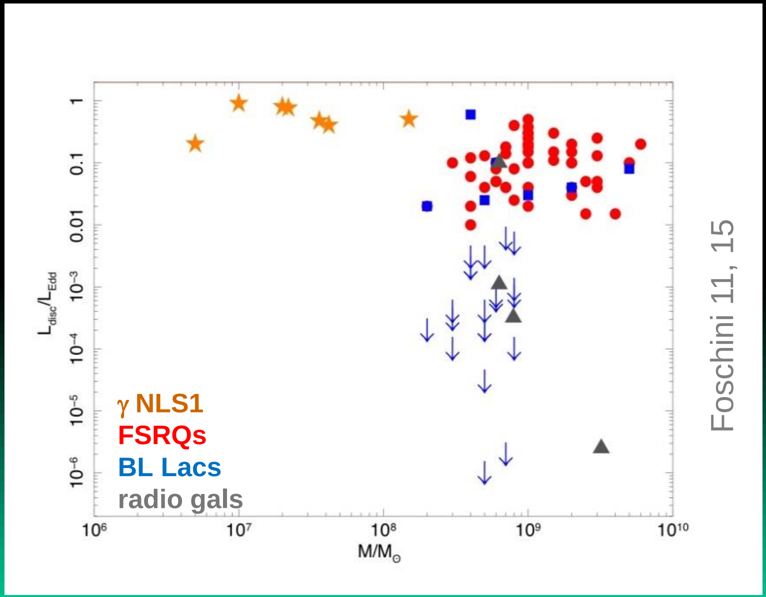
- *Fermi-LAT* detection of several RL NLS1s in γ–rays for the 1st time
- repeat & rapid flaring, Δt ~ 3-30d
- high (isotropic) luminosities, up to L_{peak}~10^{48} erg/s (PMN0948+0022)

→ established NLS1s as a new group of γ-ray emitting AGN;
re-confirmed their blazar nature,
presence of (relativistic) jets

- ongoing MW campaigns

[discovery papers: Abdo+ 09ab, Foschini 11, D'Ammando+ 12, 15, Yao+ 15b, Paliya+ 18, Yang+ 18]





γ–ray emitting NLS1 galaxies*

galaxy	coordinates	redshift	RLness	γ–ray discovery
PMN0948+0022	094857.32 +002225.5	0.585	350	Abdo+ 09a
1H0323+342	032441.19 +341045.9	0.063	50*	Abdo+ 09b
PKS1502+036	150506.48 +032630.8	0.409	1550	
PKS2004-447	200755.18 -443444.3	0.24	1710	
SBS0846+513	084957.98 +510829.0	0.584	1450	D'Ammando+ 12
FBQSJ1644+2619	164442.53 +261913.2	0.145	450	D'Ammando+ 15
SDSSJ1222+0433	122222.55 +041315.7	0.966	3230	Yao+ 15
SDSSJ2118+0732	211852.96 -073227.5	0.26	920	Yang+18, Paliya+18
SDSSJ0932+5306	093241.1 +530633.3	0.60		Paliya+18
SDSSJ0958+3224	095820.9 +322401.6	0.53		
SDSSJ1421+3855	142106+385522	0.49		
TXS 1518+423	152039.61 +421108.9	0.48		3FGL (id as NLS1 by P18)
PMN J2118+0013	211817.40 +001316.80	0.46		3FGL (id as NLS1 by P18)

* detected at high significance & published in main journals; [see Foschini 11, Liao+ 15, D'Ammando+ 17, Miller+ 17 for some further candidates]

radio-loud NLS1s: SEDs

- double-humped structure like blazars, high Compton dominance

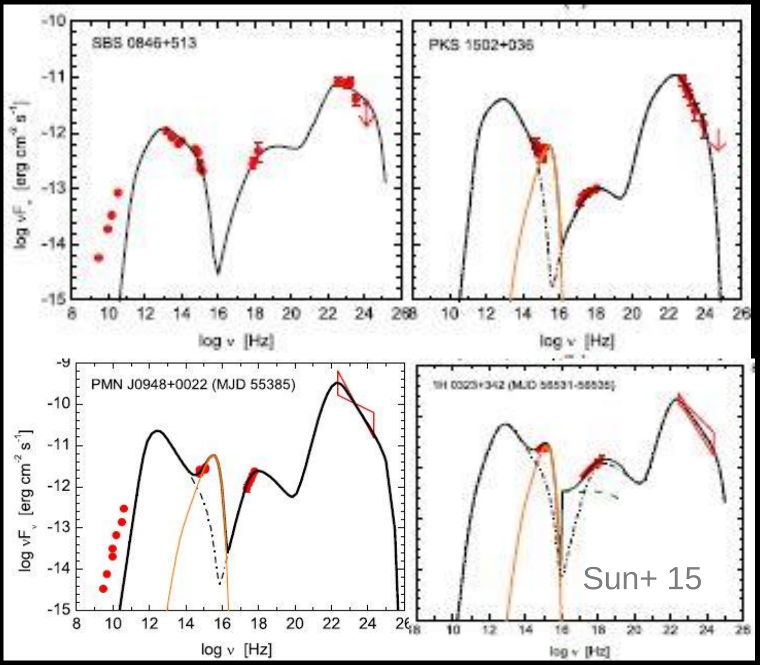
- plus acc disc in most cases

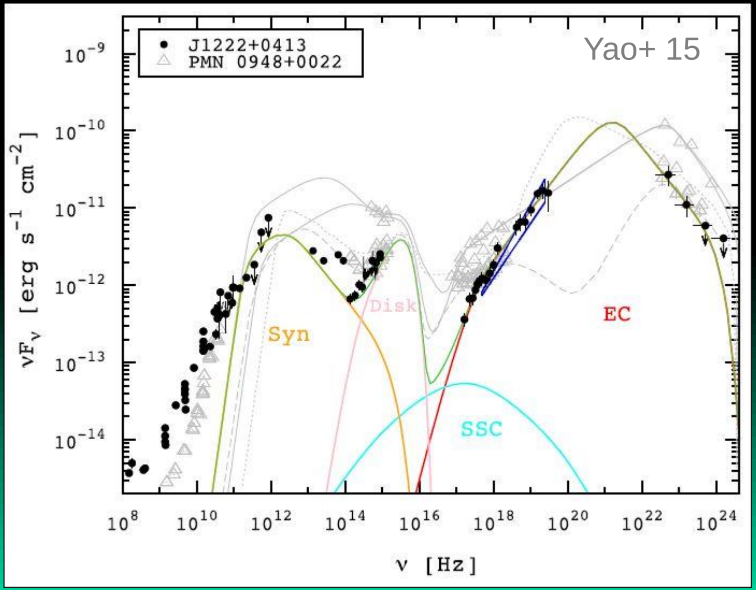
  γ-NLS1s well modelled by one-zone leptonic jet models with external Comptonization (EC)

- site of γ-ray formation in 1H0323 inside BLR, EC from acc disk

- lower jet powers, sim to FSRQs & BL Lacs, when scaled by mass, $M^{1.4}$; or even lower

[e.g., Abdo+ 09abc, D‘Ammando+ 12-16, Foschini+ 11,12, 15, Paliya+13, 14, 18, Zhang+ 13, Sun+14, 15, Yao+15a, Orienti+ 15, Komossa+ 15, Yang+18, Kynoch+ 18, ...]





radio-loud NLS1s in the IR: jets vs SF

- rapid & intraday NIR variability (WISE) of several γ-NLS1s

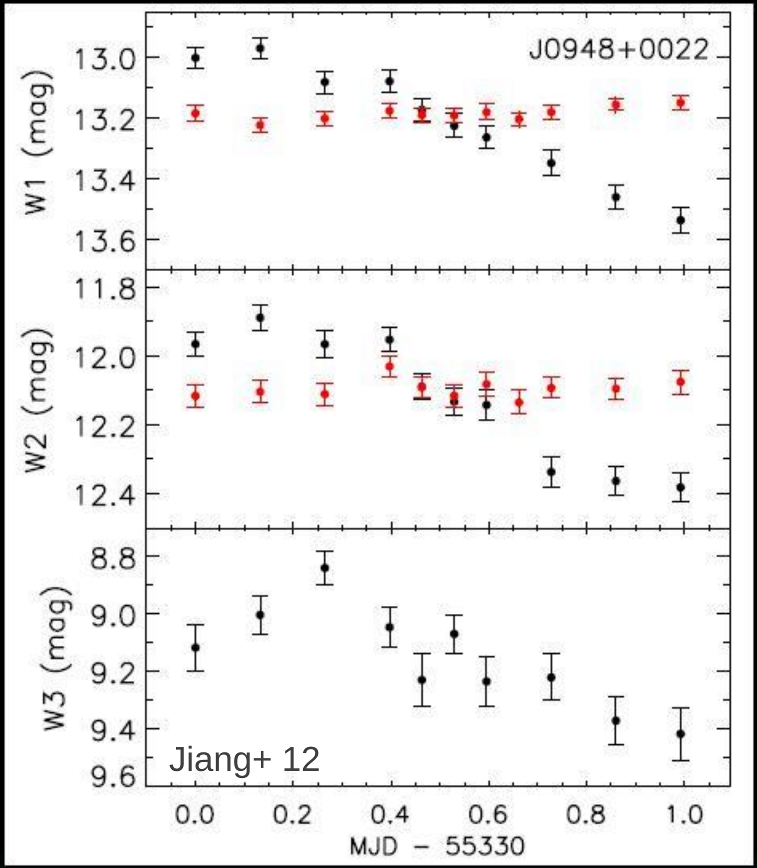
  - implies size < 10^{-3} pc
  - smaller than torus, consistent with base of jet

- radio-detected NLS1s more variable than non-detected ones

[Abdo+ 09c, Jiang+ 12, Yao+ 15, Yang+ 18; Rakshit+ 17]

- radio-IR relation:
  - majority of RL-NLS1s are powered by jets [K06, C15]
  - while sometimes SB contributes /dominates [C15]

[Komossa+06, Caccianiga+ 15]



radio-loud NLS1s: optical properties
host galaxies

- what do we expect ?

- nearby BLS1s: spirals , BL QSOs: ellipticals & mergers
- nearby NLS1s: spirals , NL QSO1s: ellipticals & mergers ?

- RL NLQSO1s: ellipticals & mergers ?
  plus some discs

)* Sy: M > 23, quasars: M<23

Interlude: radio-quiet-NLS1 host galaxies

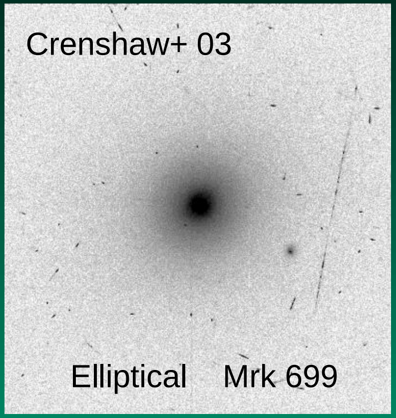
nearby (z<0.04-0.07) NLS1s show

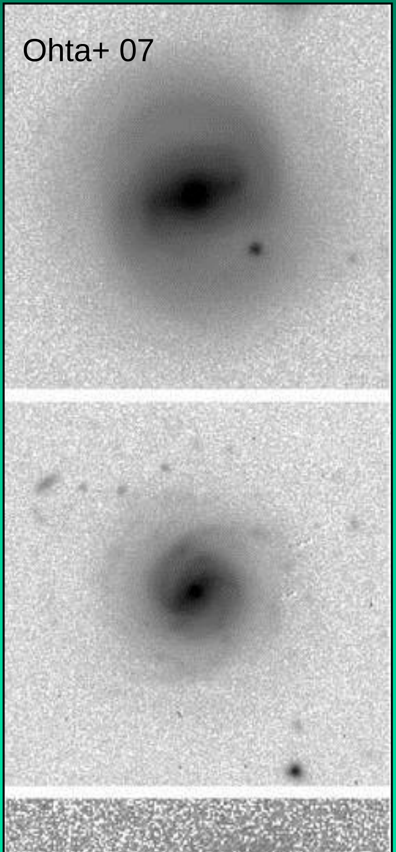
- no excess companions
- no evidence for recent mergers
- a higher fraction of bars; & nuclear dust-spirals & stellar rings than BLS1s (C03-sample[13NLS1]: 65% of NLS1 spirals have bars, 25% of BLS1 spirals have bars; z<0.04. O07-sample [50NLS1]: ~60-70% NLS1 have bars, ~40-70% BLS1 have bars)

→ no merger-induced accretion, but bar may play a role (secular processes) in fuelling

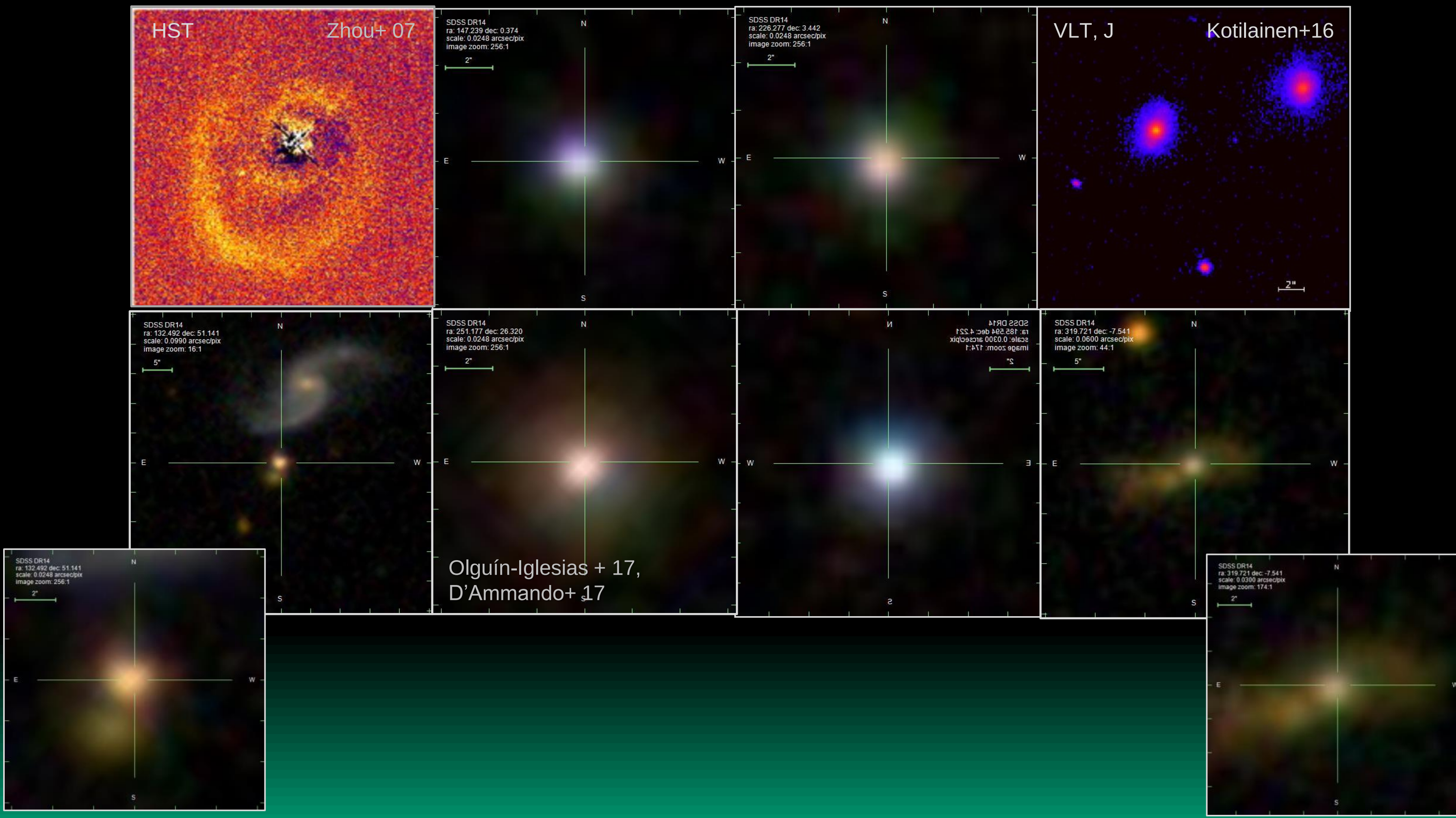
note: most hosts of more distant/luminous NLS1s/Q1s, and radio NLQ1s *not yet known* [majority likely ellipticals & mergers, like in BLQ1s]

[e.g., Krongold+ 00, Crenshaw+ 03, Deo+ 06, Ohta+ 07, Ryan+ 07, Orban de Xivry+ 11, Mathur+ 12, Xu+ 12, ...]

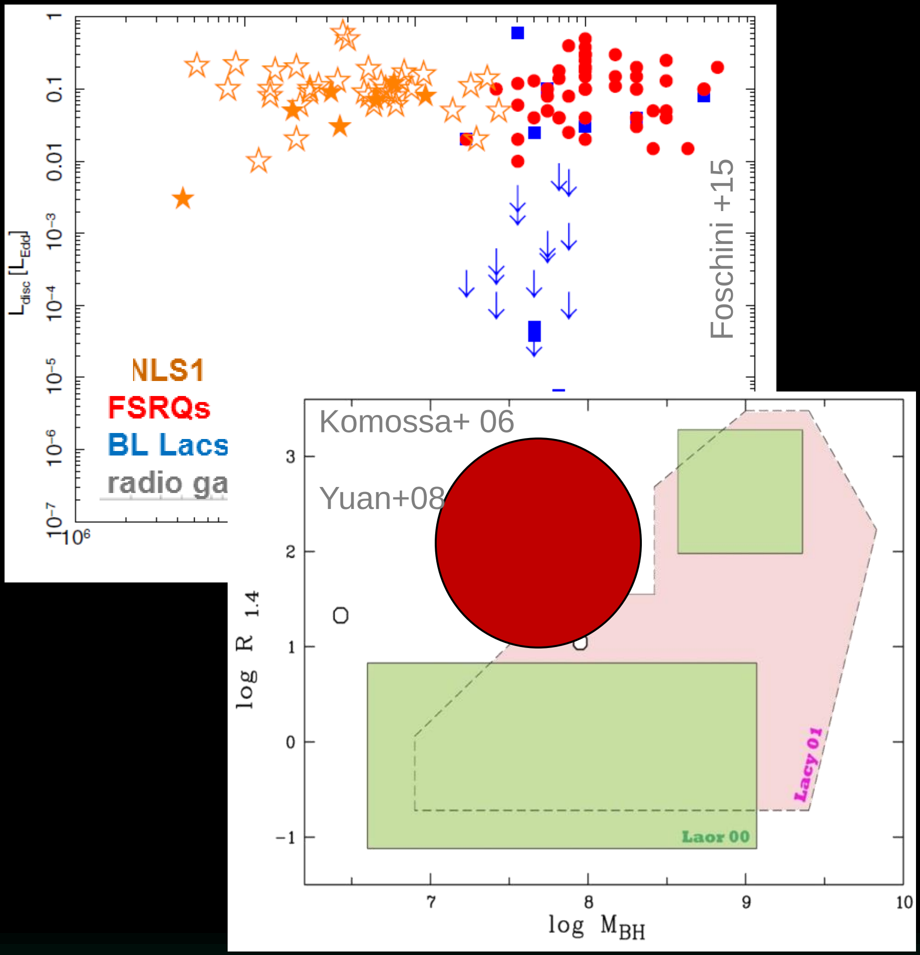




γ–ray emitting NLS1s: host galaxies

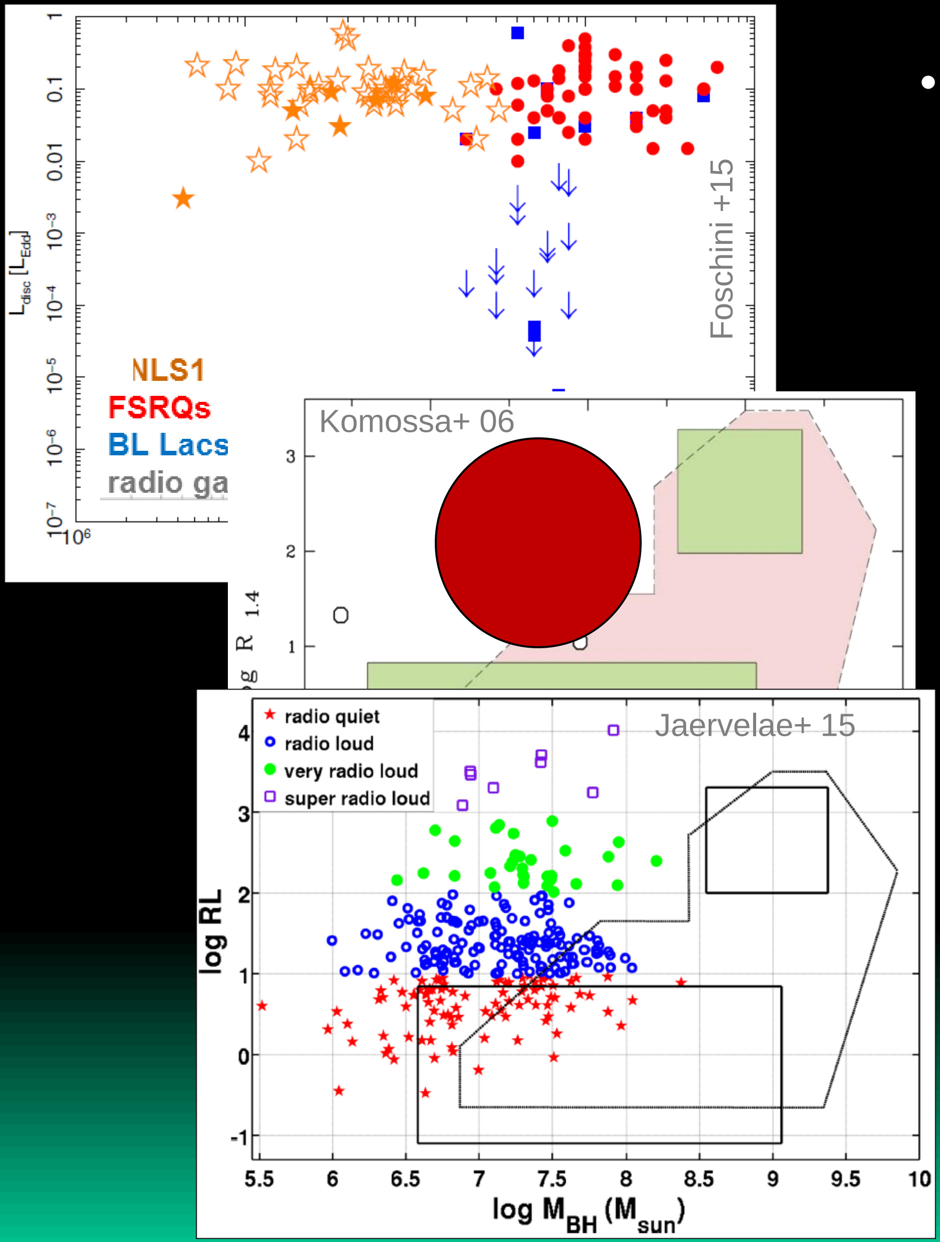


radio-loud NLS1s: BH masses



- how well can we measure BH masses ?

radio-loud NLS1s: BH masses



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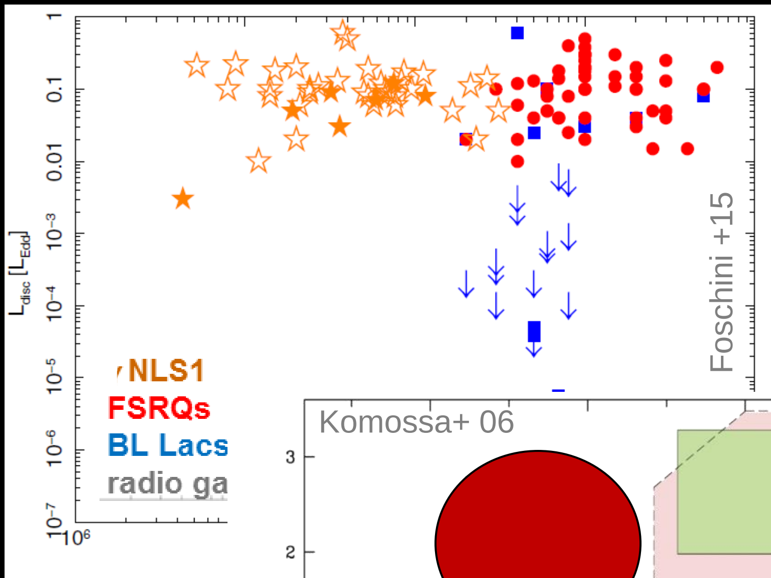
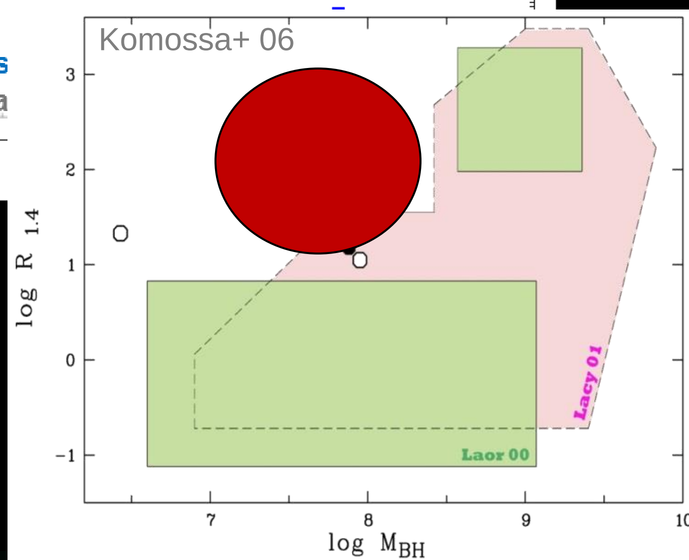
radio-loud NLS1s: BH masses





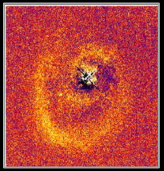
- how well can we measure BH masses ?

→ different methods for BH mass estimation:
- virial estimates from single-epoch spectra (with or without projection effects; f)
- rev. mapping: (only one)
- spectropolarimetry (only one)
- X-ray variability: excess variance, or PSD break frequency (only one)
- SED modelling
- host-BH scaling relations

do RLs in particular, or all NLS1s, have higher BH masses than implied from width(Hβ) estimates ?

→ most of these point to low BH masses

example 1: **1H0323+342 – BH mass estimates**



optical

- single-epoch, broad Hβ: 10^7 M_{sun}
- broad Pα, Hβ: 2 10^7 M_{sun}

- rev mapping (f=1): 6 10^6 M_{sun}
  (f=6): 3 10^7 M_{sun}

optical-UV

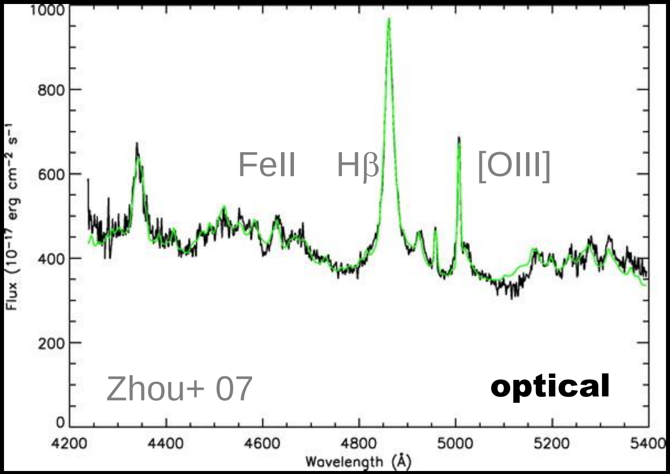
- SED modelling: 10^7 M_{sun}

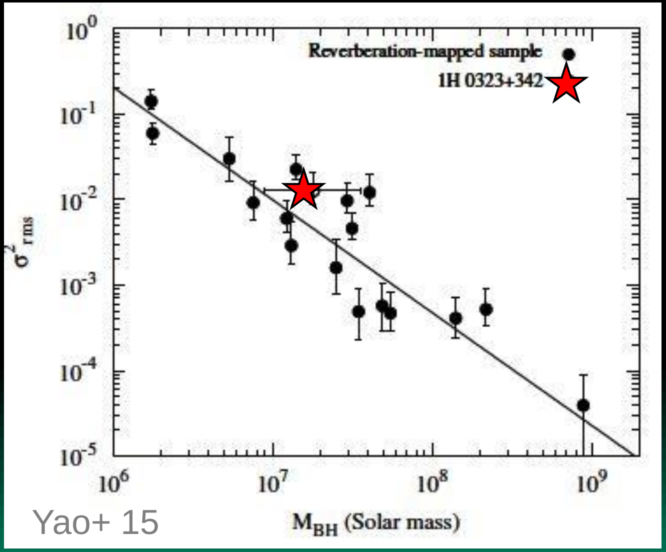
NIR-optical

- host magnitude: $10^{8.2-8.6}$ M_{sun}

X-rays

- X-ray excess variance: 10^7 M_{sun}
- break frequency of PSD: 10^7 M_{sun}
  → confirms low mass, M~10^7 M_{sun}





[in order listed: Zhou+07, Landt+17, Wang+ 16, Abdo+09, Leon-Tavares+ 14, Yao+ 15, Pan+ 18]

example 2: **PKS1502+03 – BH mass estimates**

optical-UV

- single-epoch, broad Hβ: 4-6 10^6 M_{sun}
- MgII: 10^7 M_{sun}

optical-UV

- SED modelling: 2 10^7 M_{sun}
  4.5 10^7 M_{sun}
  2 10^8 M_{sun}
  < few 10^7 M_{sun}

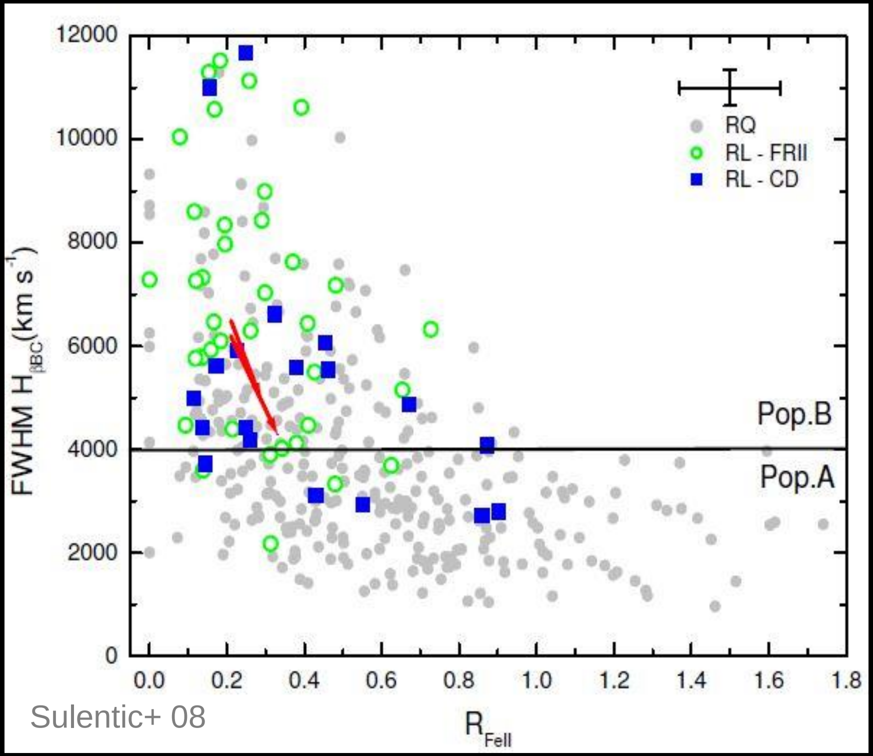
→ most estimates on order few 10^7 M_{sun}

→ BH masses near upper end of NLS1 distribution, but lower end of blazars

statistical argument, based on very small fraction of RLness: no projection effects in high BH mass systems [K06]

[in order listed: Yuan+ 08, Komossa+ 18, Abdo+09, Paliya+ Stalin 16, Calderone+ 13, D‘Ammando+ 16]

radio-loud NLS1s: optical spectroscopy
FeII emission

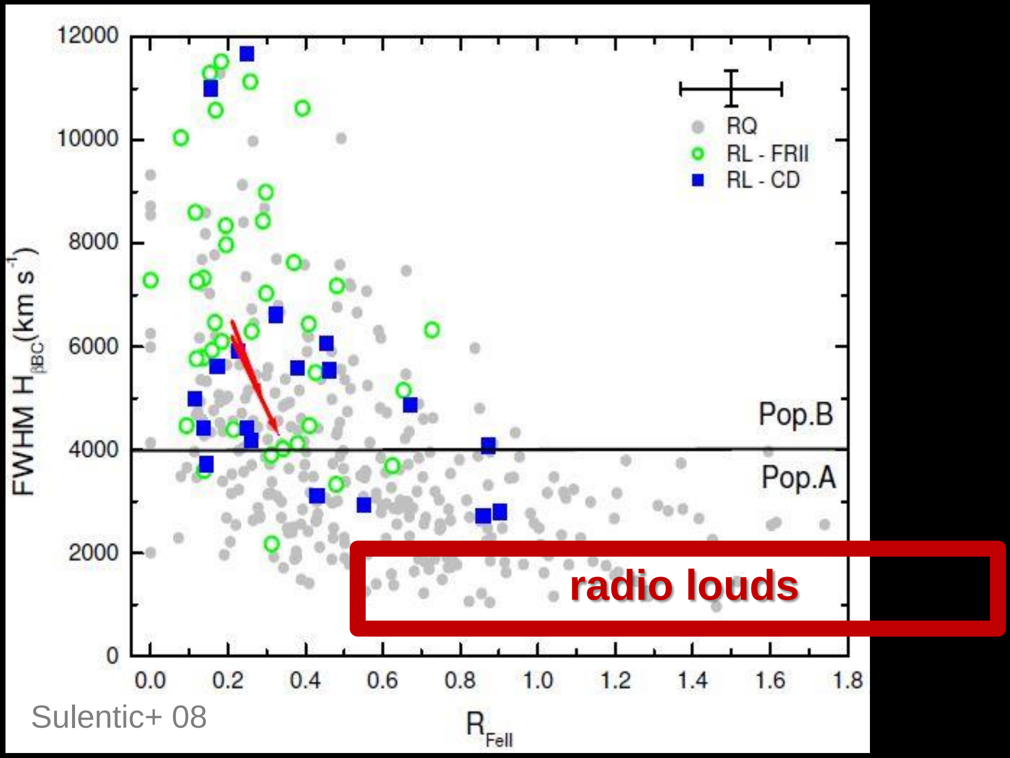


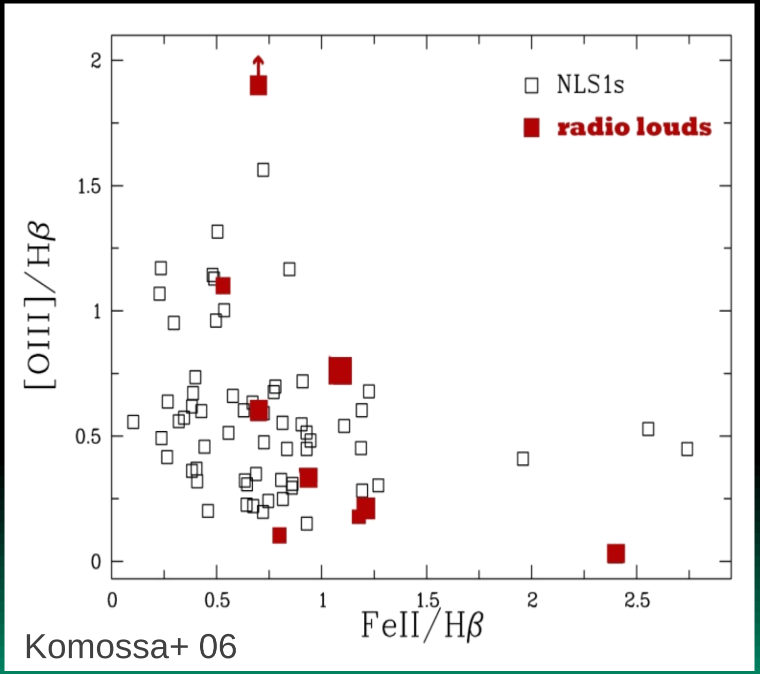
radio-loudness & *FeII*ness at opposite ends of AGN correlation space.

where are the *radio-loud* NLS1s located ?

[Sulentic+ 08]

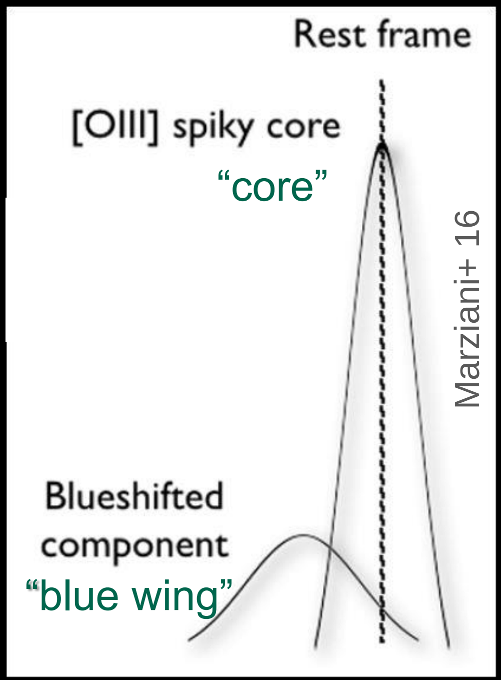
radio-loud NLS1s: optical spectroscopy
FeII emission





[Sulentic+ 08; Komossa+ 06, Yuan+ 08, Berton+ 16; two outliers which lack FeII: PKS2001 (Oshlack+01, Gallo+ 06); SDSSJ2118 (Yang+ 18, Paliya+ 18)]

radio-loud NLS1s: optical spectroscopy
[OIII] emission and (extreme) outflows



[OIII]5007 profile complexity comes in two types:

(1) presence of „blue wings“ -- very common

(2) „blue outliers“: sources with *whole* [OIII] core (&wing) component blueshifted [Zamanov+02]

- radio-quiet BLS1s: few [OIII] outflows (at low z) [K08]
- radio-quiet NLS1s: 16% [OIII] outflows („blue outliers“; v>150 km/s) [K08]
- radio-loud NLS1s: ~17-23% [Y08,B16,K18]
- γ NLS1s: highest fraction of [OIII] complexity, 43% (3/7) [OIII] outflows [B16]

[Komossa+ 08, Berton+ 16, Komossa+ 18]

case study: RXJ2314.9+2243 (extreme blue wing)

- radio-loud NLS1 (z=0.17)
- possible γ–ray detection (Foschini, priv. com. 14; Miller+ 17), var.
- (but) steep radio spectrum, α=-0.7 (*Effelsberg*)

- luminous IR (LIRG)
- very steep UV spectrum, but no evidence for optical reddening
- flat, variable X-ray spect (*Swift*)
- → SED likely dom by non-thermal emi (X: corona; IR-UV: synchro)

- very broad & blueshifted (v=1260 km/s) [OIII]5007 emission → strong outflow
- → a case of strong AGN-induced feedback in local universe ?
- → low-z equivalent of a similar pop emerging now at higher z

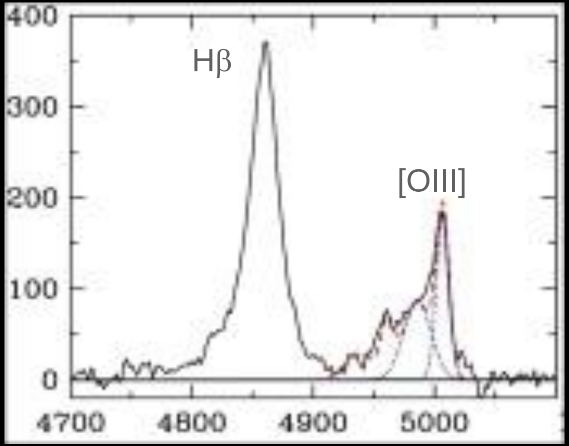
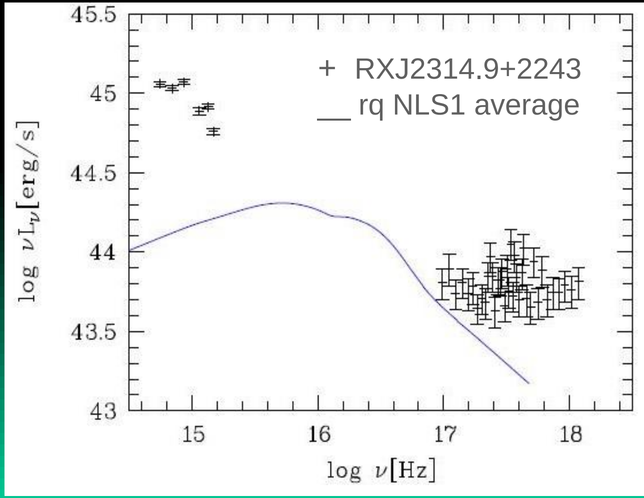


Table 1. Radio measurements of RXJ2314.9+2243 performed with the Effelsberg 100m telescope. Not all frequencies ν were observed at all dates. RX J2314.9+2243 was also detected during the NVSS at 1.4 GHz with a flux density of 19±1 mJy.

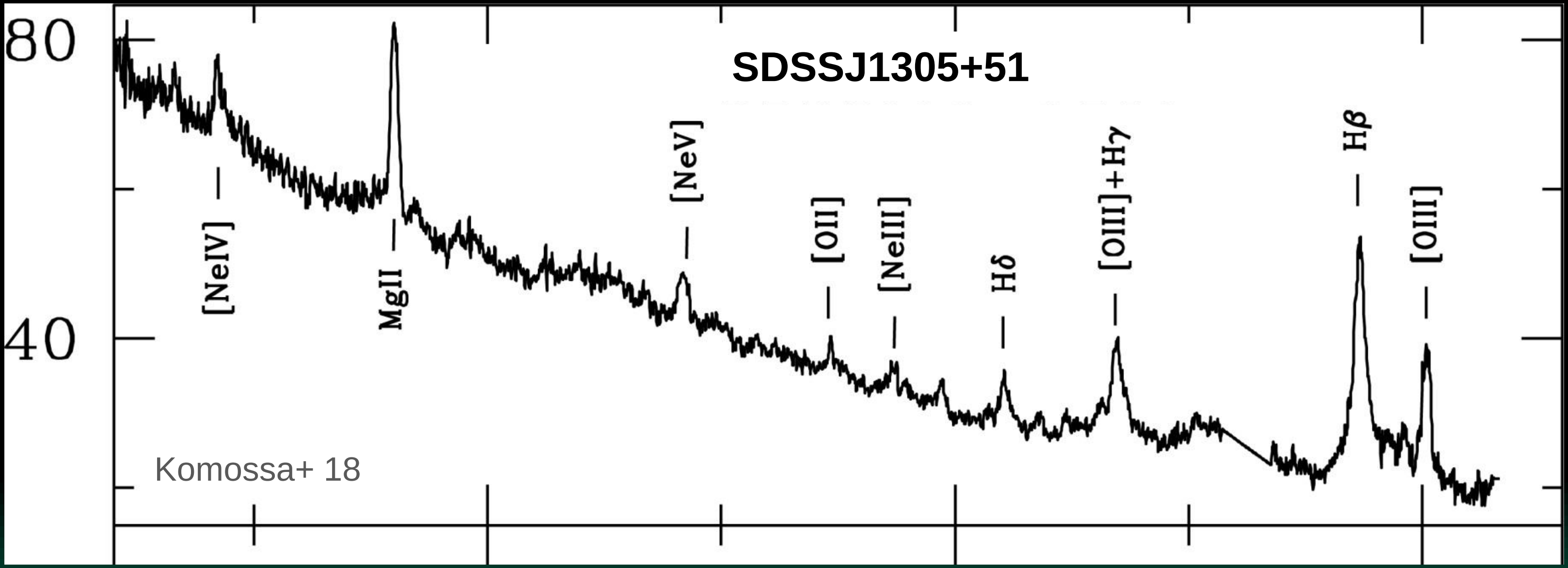
ν [GHz]	flux density [mJy] 2013 Feb 03	2013 Feb 09	2013 July 7	2013 July 23	2014 Oct 18	2014 Oct 31
2.64	–	14 ± 3	12 ± 2	–	–	–
4.85	7 ± 1	7 ± 1	9 ± 2	7 ± 2	10 ± 2	8 ± 2
8.35	5 ± 1	5 ± 1	5 ± 1	5 ± 1	6 ± 1	5 ±
10.45	–	–	< 17	–	< 56	< 56
14.60	–	–	–	–	< 27	< 28
43.00	–	–	< 56	–	< 158	< 96



[Komossa+ 15]

radio-loud NLS1s: optical properties
(extreme) outflows

- four radio-loud NLS1s with high-velocity ionized gas outflows, seen in several emission lines



[Komossa, Xu, Wagner 18]

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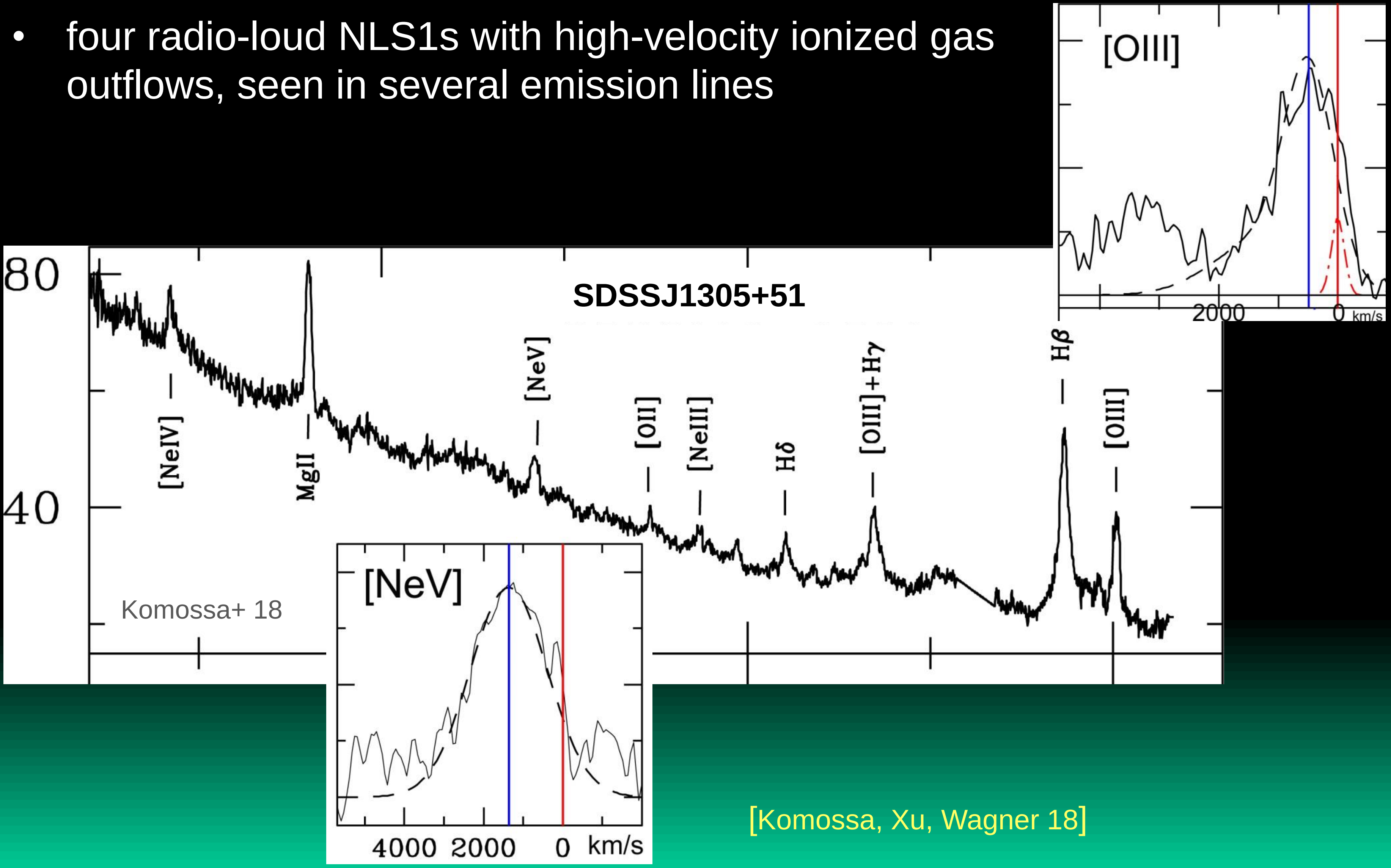


[Komossa, Xu, Wagner 18]

radio-loud NLS1s: optical properties
(extreme) outflows

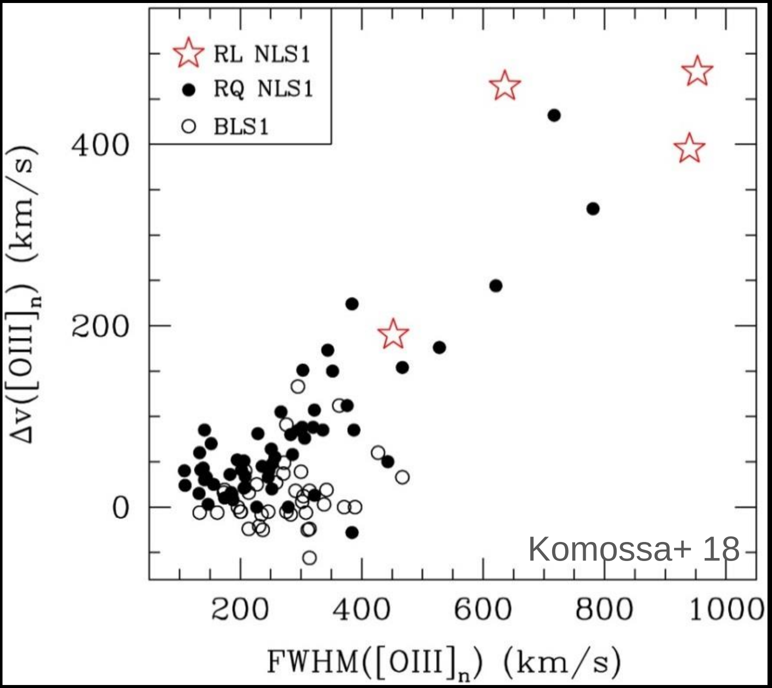
- extreme velocities, up to
  v_c = 2450 km/s in [NeV]
  v_c = 480 km/s in [OIII]
  FWHM (NeV) = 2270 km/s

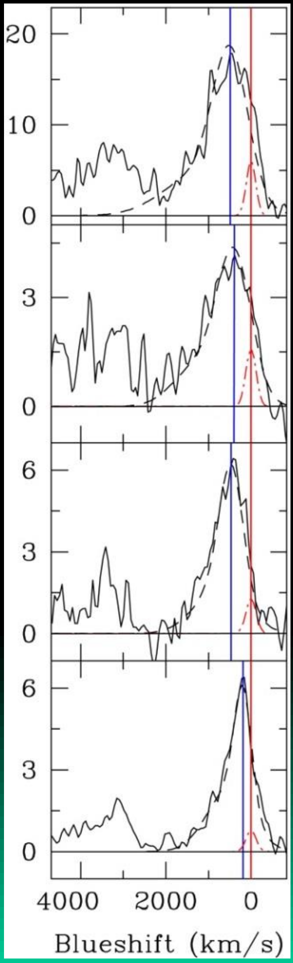
- [OIII] still has core-wing structure:
  v_w = 1280 km/s

- little zero-velocity [OIII]

  → no two-component NLR;
  bulk of NLR in outflow

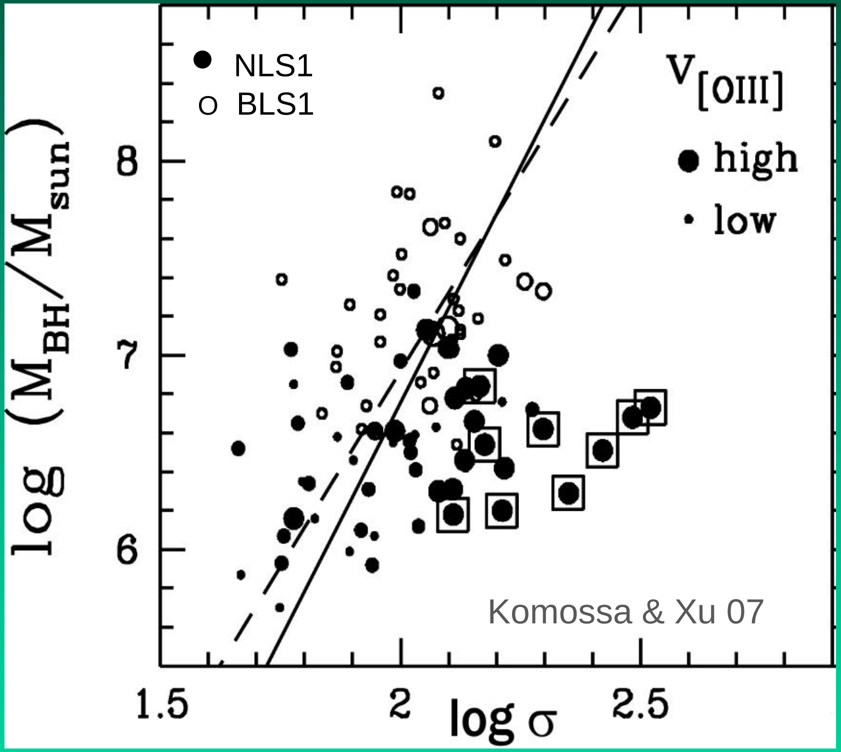
- width-shift correlation

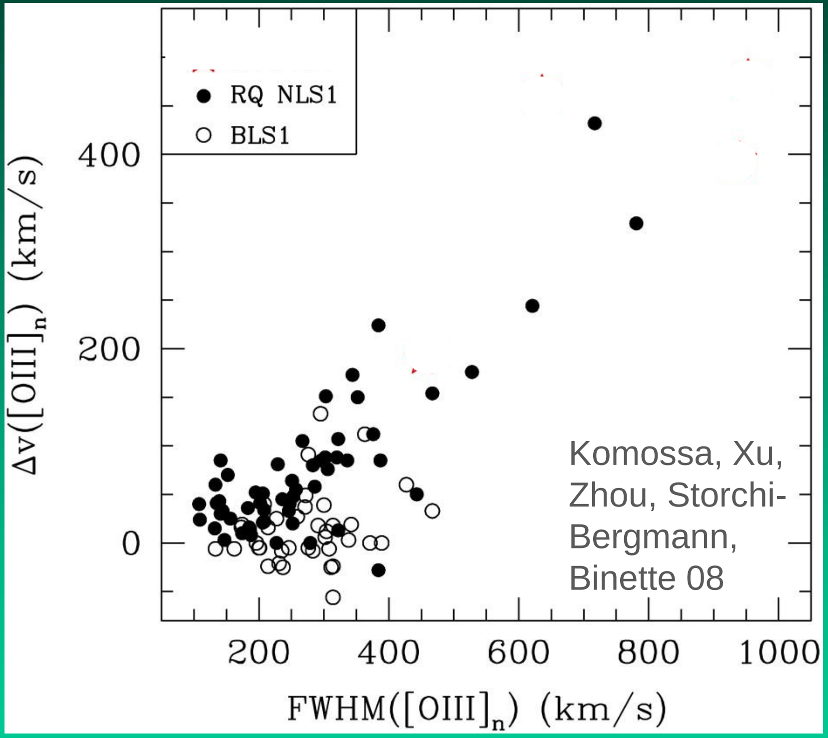




[Komossa, Xu, Wagner 18]

Interlude: (radio-quiet) NLS1 galaxies on the M_{BH}-σ plane, and the problem of [OIII] outflows





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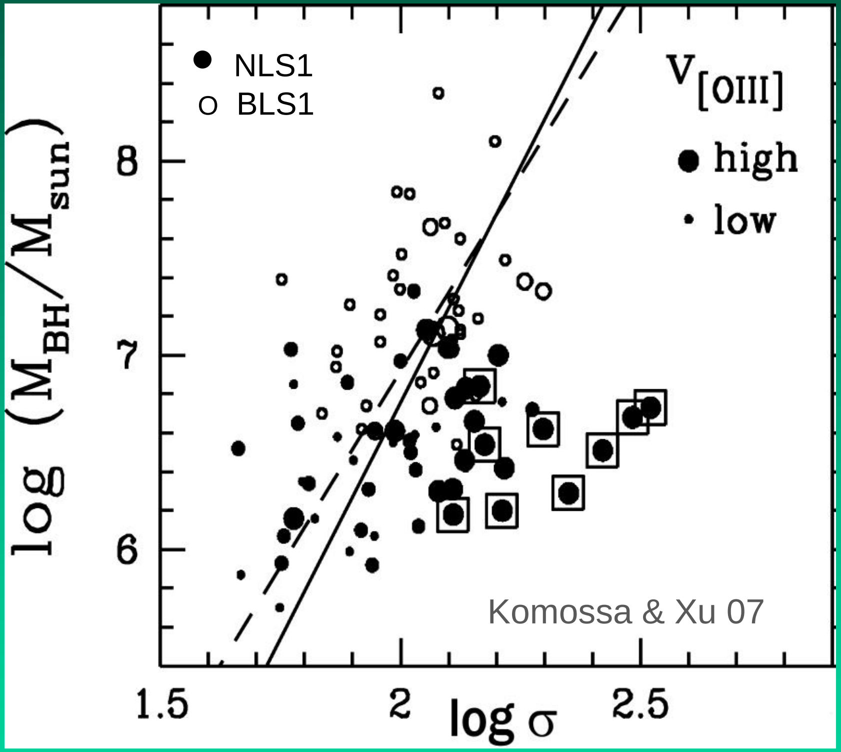

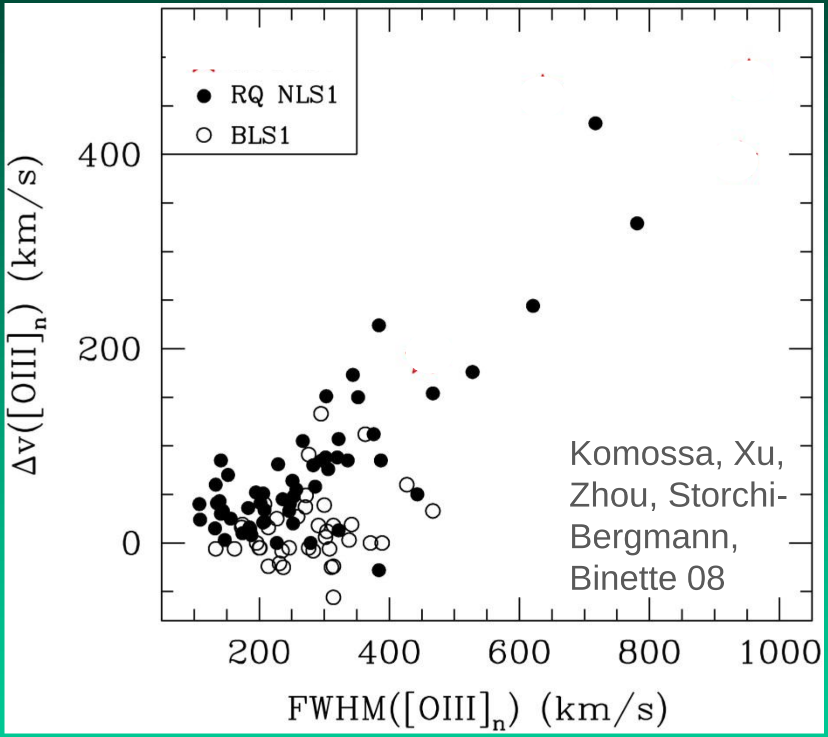

→ BLS1s and NLS1s follow the same M-σ relation (with large scatter), once sources dominated by outflow, [OIII] blue outliers, are removed

→ even blue outliers in [OIII] follow M-σ_*, when FWHM([SII]) is used

radio-loud NLS1s: optical properties
(extreme) outflows

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  v_c = 2450 km/s in [NeV]
  v_c = 480 km/s in [OIII]
  FWHM (NeV) = 2270 km/s
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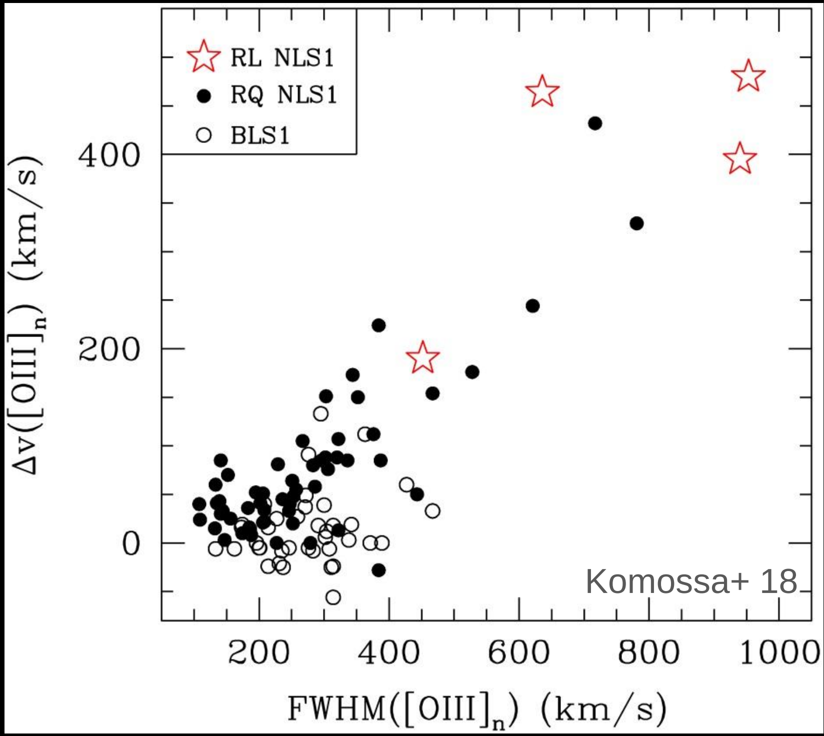
- little zero-velocity [OIII]

  → no two-component NLR;
  bulk of NLR in outflow
- width-shift correlation
  → FWHM([OIII]) no surrogate for σ_*

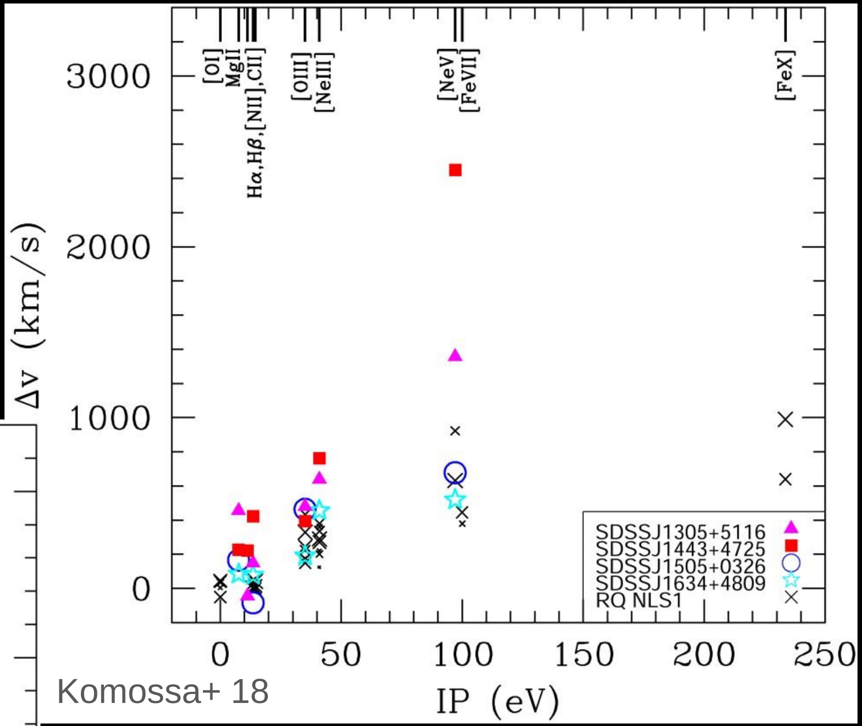
[Komossa, Xu, Wagner 18]

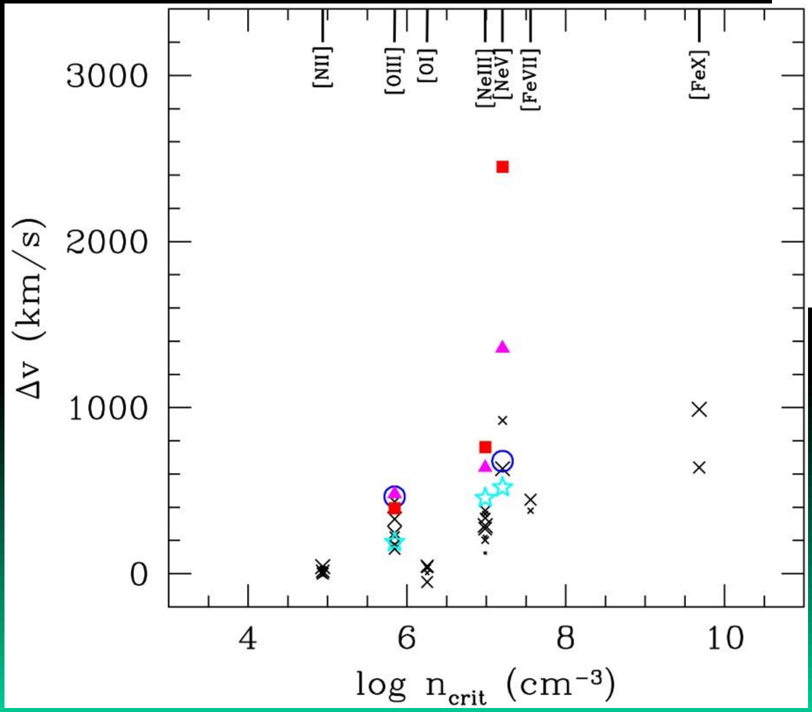


radio-loud NLS1s: optical properties
(extreme) outflows

- ionization stratification
  (or density stratification)

  → large-scale outflow, no *localized* processes





[Komossa, Xu, Wagner 18]

radio-loud NLS1s: optical properties
(extreme) outflows

- BH masses, L_{bol} , L_{Edd}
- jet power P_{jet}, η_{jet}
- Ionized gas mass in outflow

Vestergaard & Peterson 06:

$$M_{BH} = 10^{6.67} \left(\frac{L_{H\beta}}{10^{42}\,\mathrm{ergs}^{-1}} \right)^{0.63} \left(\frac{\mathrm{FWHM}(\mathrm{H}\beta)}{1000\,\mathrm{kms}^{-1}} \right)^{2} \mathrm{M}_\odot$$

$$\eta_{jet} = P_{jet}/L_{Edd}$$

$$L_{H\beta} = \int\int j_{H\beta}\, d\Omega\, dV,$$

$$M_{out} = 6.74\,10^{7} \left(\frac{L_{H\beta}}{10^{42}\,\mathrm{erg\,s}^{-1}} \right) \left(\frac{n}{100\,\mathrm{cm}^{-3}} \right)^{-1} \mathrm{M}_\odot$$

name (1)[a]	log L_{bol} (2)	log $M_{BH,H\beta}$ (3)	L/L_{Edd} (4)	log $M_{BH,MgII}$ (5)	P_{jet} 10^{44} erg/s	η_{jet}	M_{out} 10^{7} M_{sun}
SDSSJ1305+5116	46.5	8.4	0.95	8.1	5.0	0.015	8.7
SDSSJ1443+4725	45.6	7.6	0.79	7.9	6.1	0.11	1.6
SDSSJ1505+0326	44.7	6.8	0.66	7.0	4.3	0.52	0.3
SDSSJ1634+4809	45.4	7.5	0.65	7.1	1.4	0.03	0.3

[Komossa, Xu, Wagner 18]

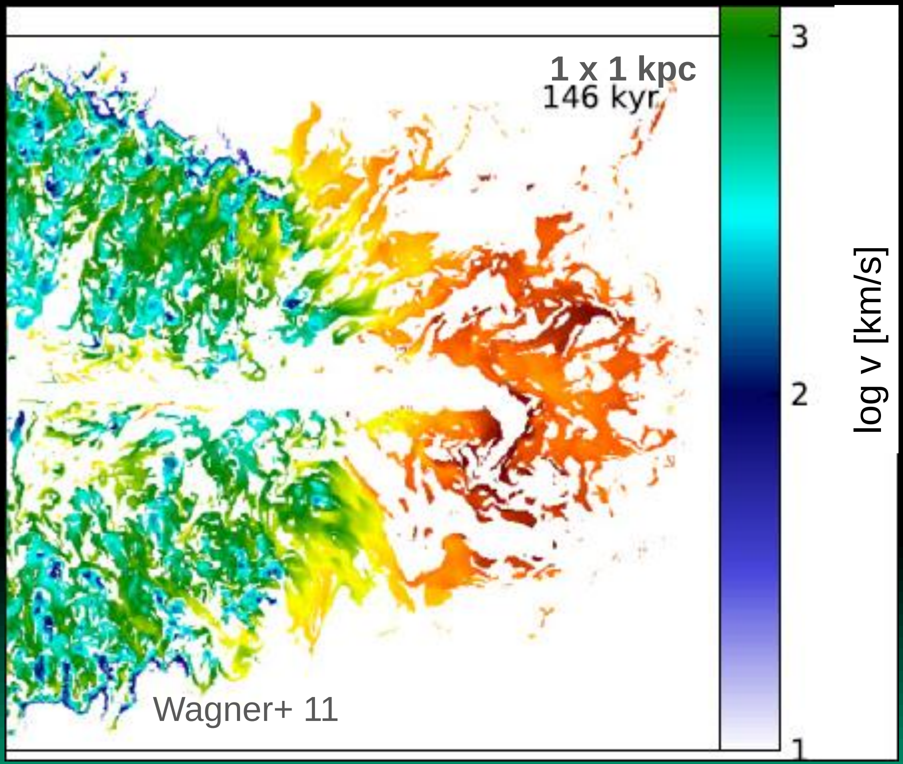
radio-loud NLS1s: optical properties
(extreme) outflows

- driver of the outflow ?
- key constraints from observations:

  - little zero-*v* [OIIII], little exti
  - high *v*, above escape vel
  - width-shift correlation
  - high [NeV]/[OIII] → matter-bounded
  - ionization stratification, *v*-IP

→ no two(velocity)-component NLR, with one at rest
→ bulk of NLR in outflow
→ no localized jet-cloud
→ no rad pressure by dust

- high L/L_{Edd} & powerful jets
  → hydrodyn simulations of large-scale outflows



[e.g., Wagner+ 11, 12, 13, 16, Bieri+ 17, Cielo+ 18]

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[Komossa, Xu, Wagner 18]

- high L/L_{Edd} & powerful jets
  → hydrodyn simulations of large-scale outflows

- high v ← high L_{bol} , high P_{jet}
- fragmented clouds more easily accelerated
- high v → imply **young age** (< few Myr)

consistent with radio-compactness [Gu+15, Berton+ 18]

- ion strat more challenging to understand (early phase of evolution, AGN-driven bubble still evolving; near-nuclear gas more time to accelerate ?)

radio-loud NLS1s: optical properties
(extreme) outflows

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consistent with radio-compactness [Gu+15, Berton+ 18]

Σ: - high-ion lines highly shifted & broadened, so (OIII) widths no suitable substitute for σ_*, - but sources are important laboratories for drivers of large-scale, high-velocity outflows & AGN-induced feedback.