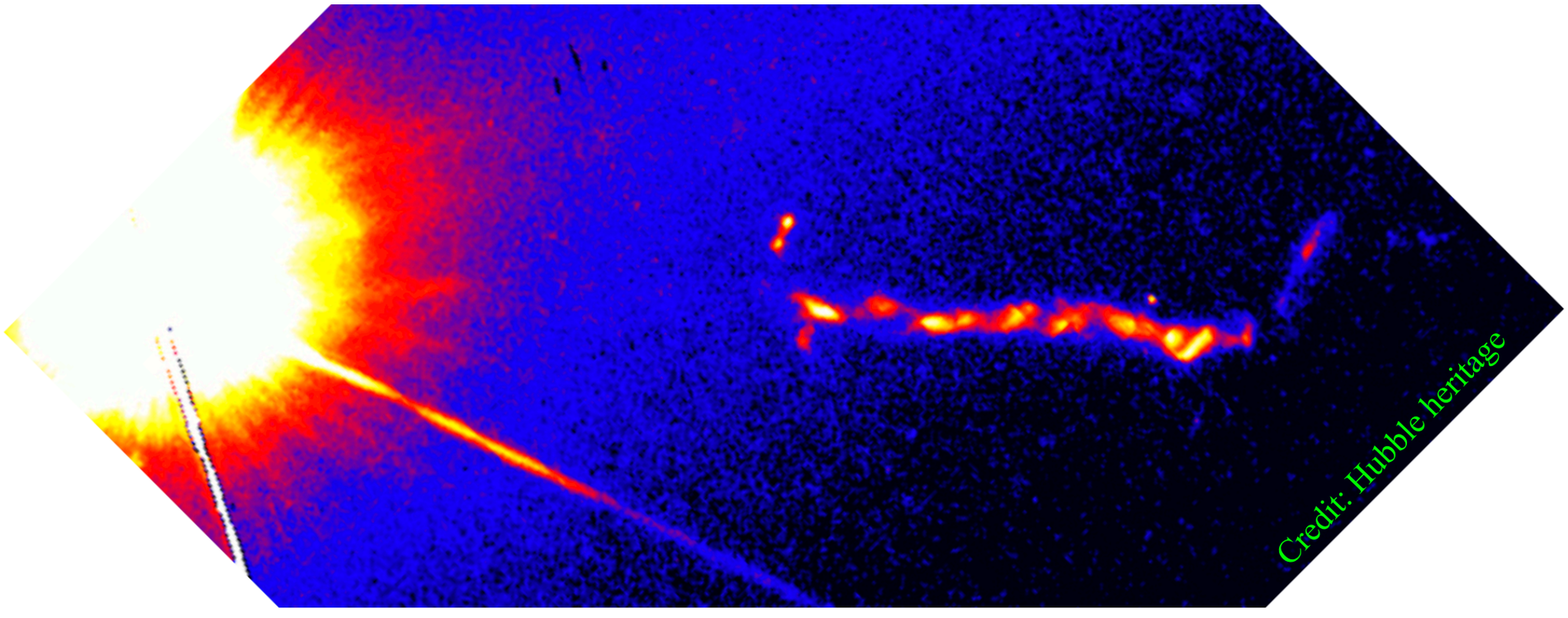
On the Origin of Relativistic Jets: 2020s & Beyond

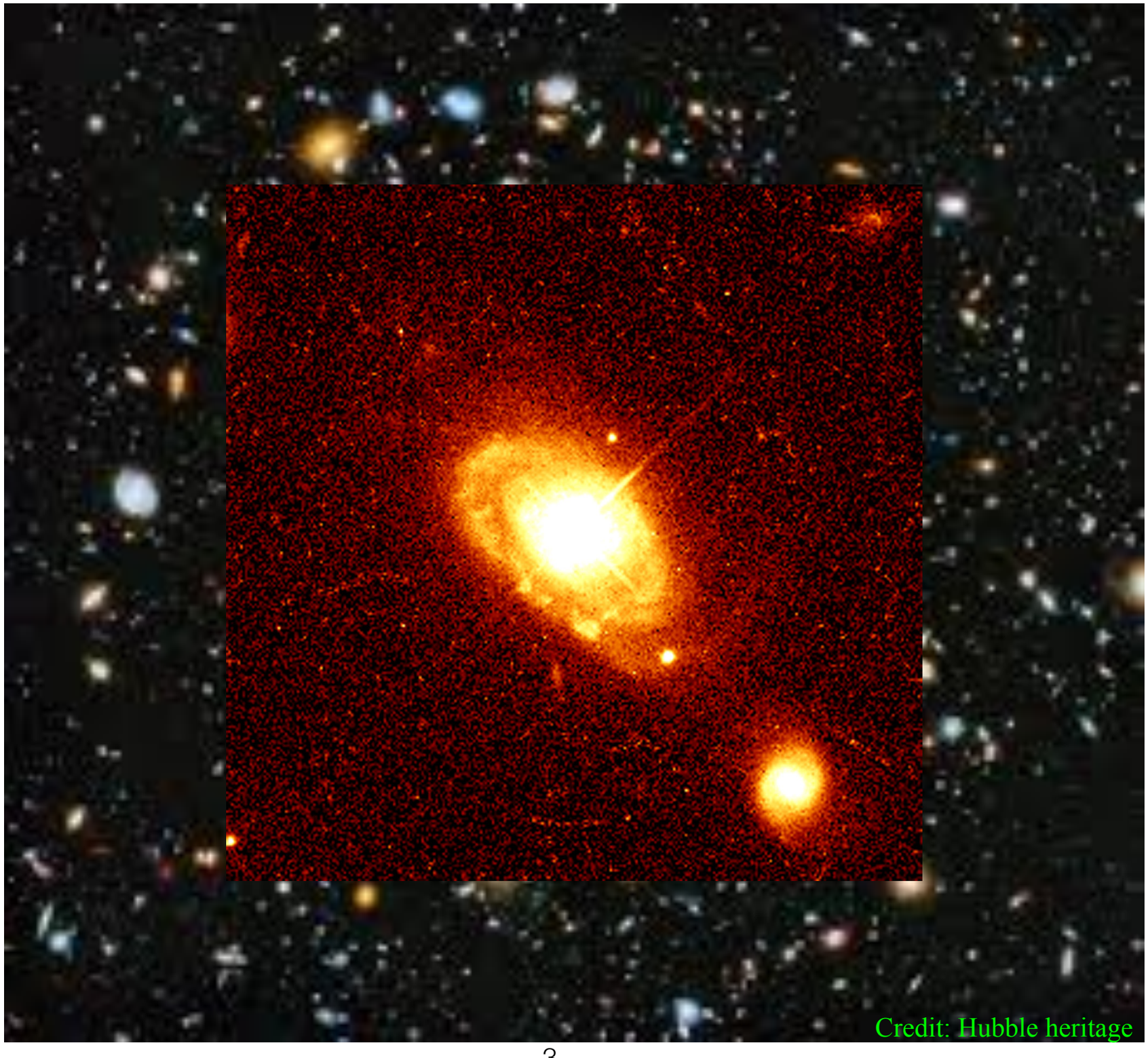


V. S. Paliya (DESY, Germany), F. Prada, E. Perez,
R. Garcia-Benito, A. Alberdi (CSIC, Spain), A. Dominguez (UCM, Spain)

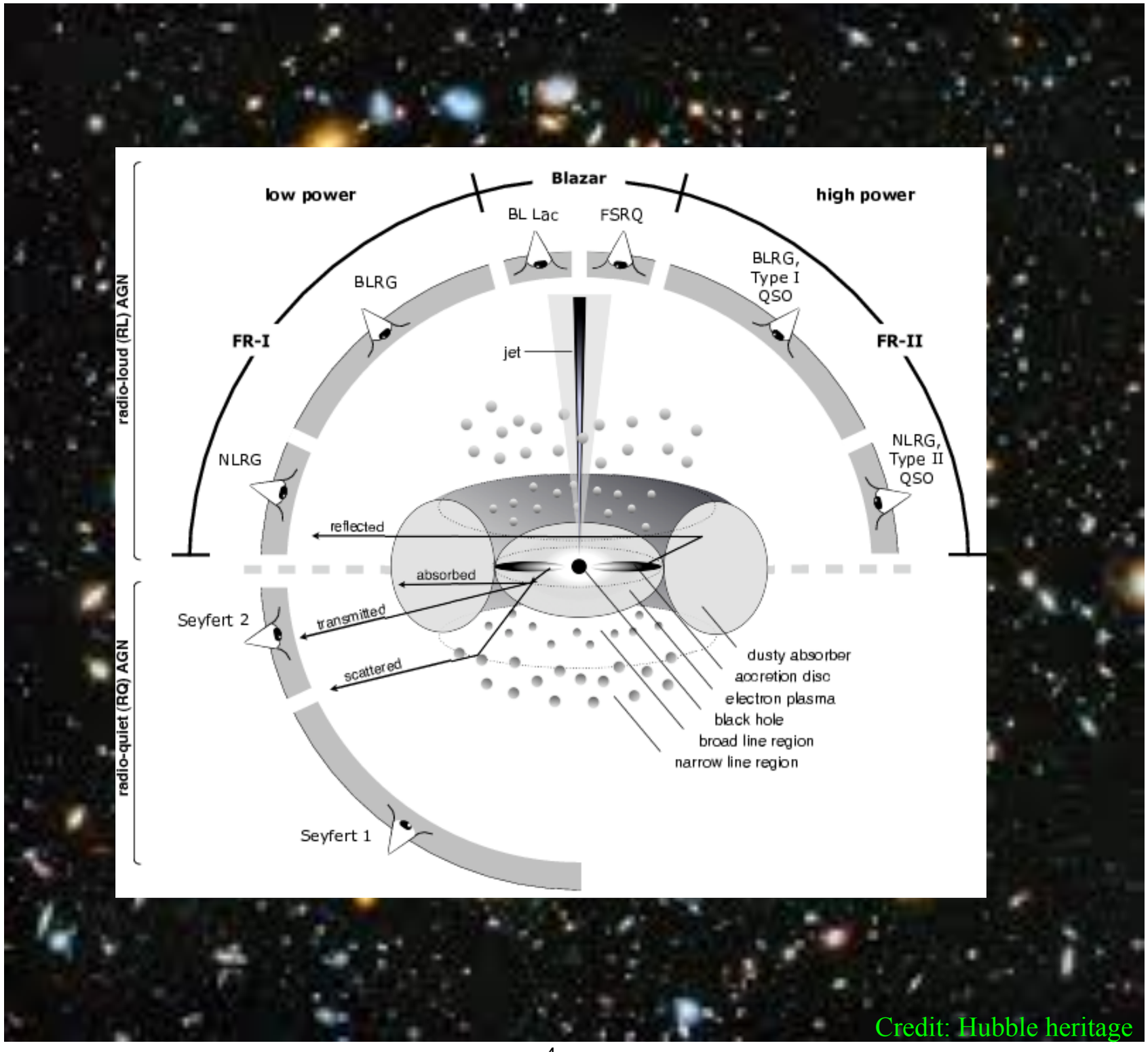
MAAT workshop (5/5/2020)

The universe is full of galaxies

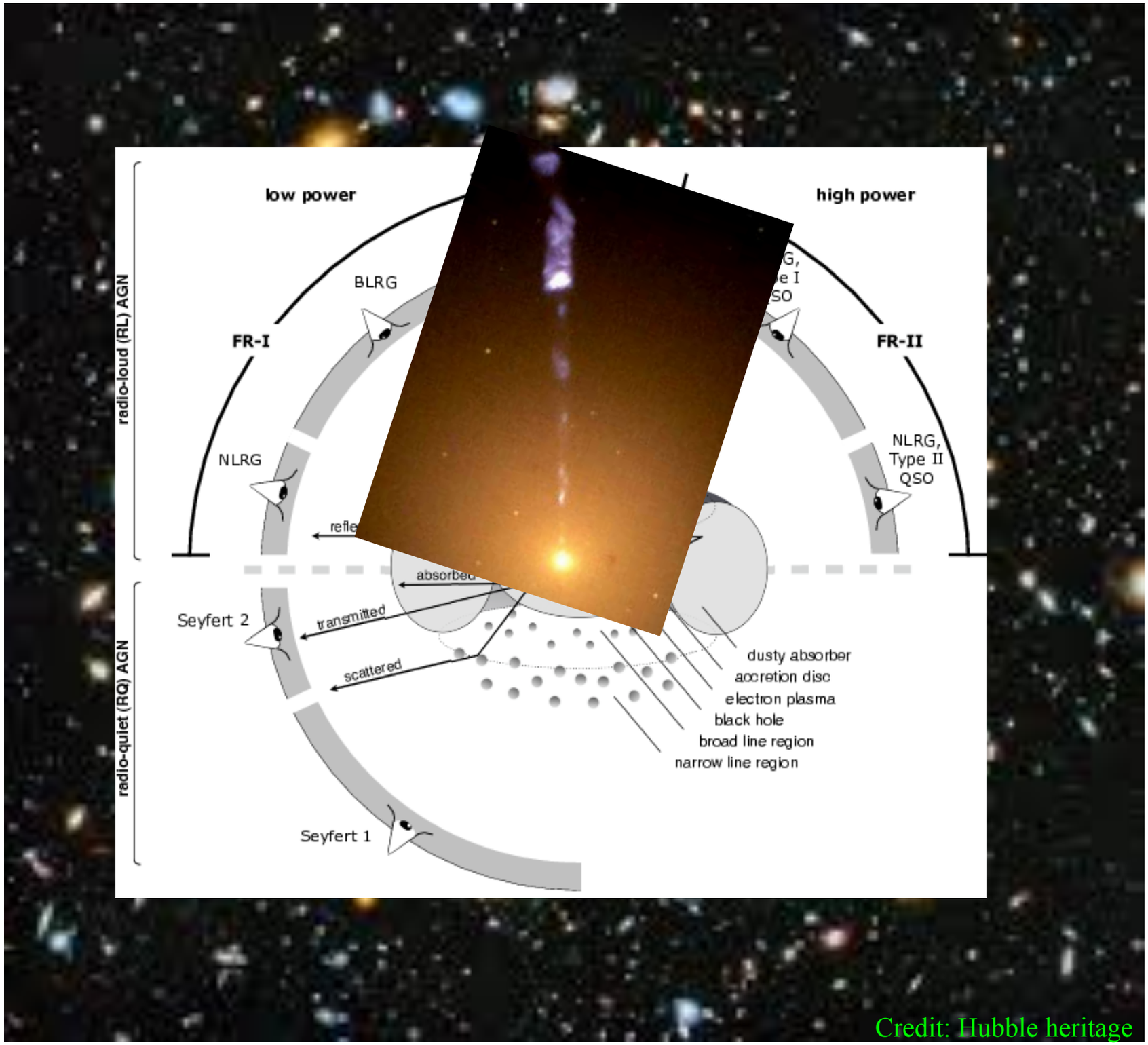
1 in ~100 galaxies hosts an active nucleus



AGN: Quasars/Seyferts; Type 1/Type 2; radio-loud/radio-quiet; blazars

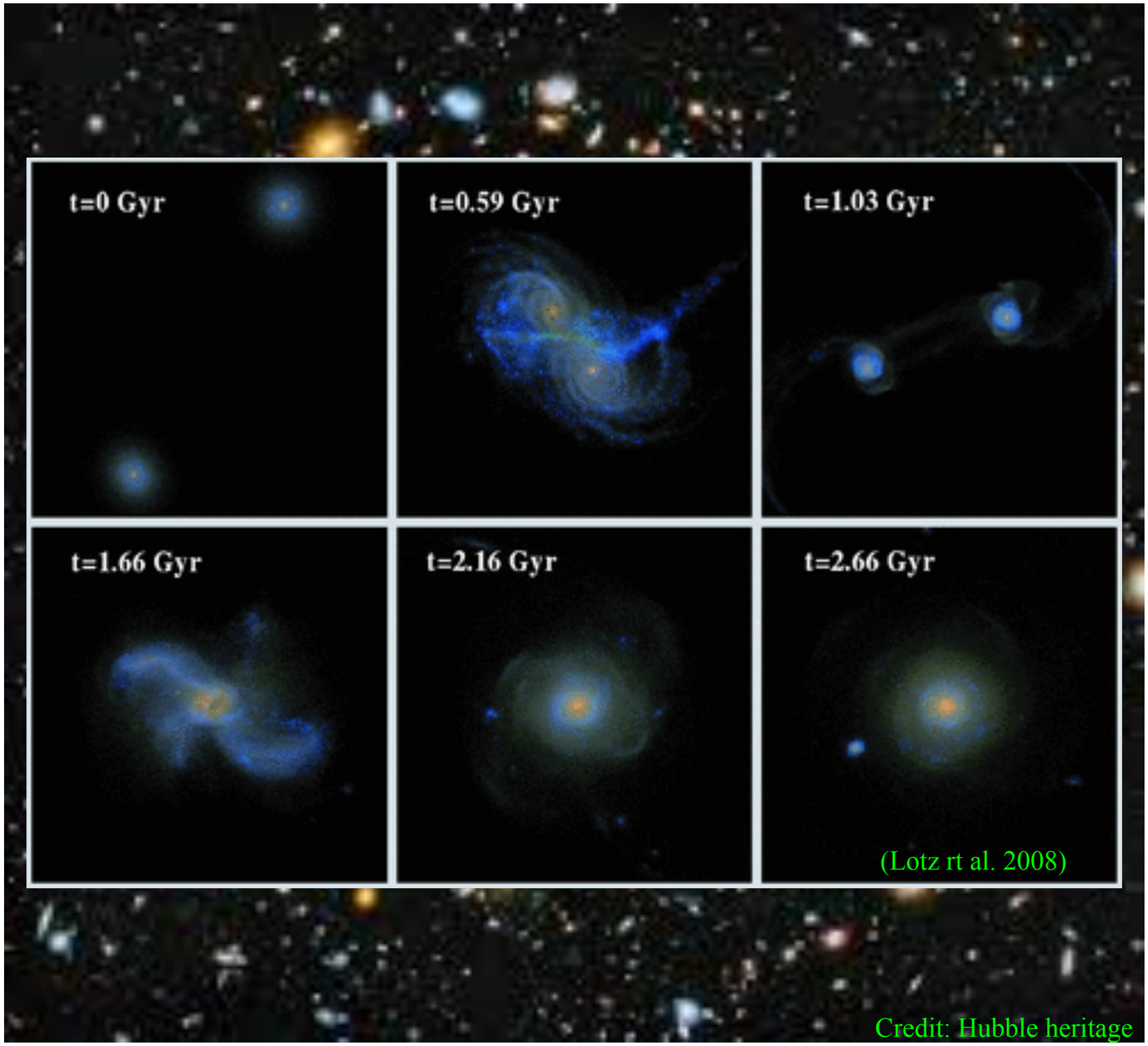


1 in ~300 AGNs hosts bi-polar relativistic jet: a very rare phenomenon! **Origin?**



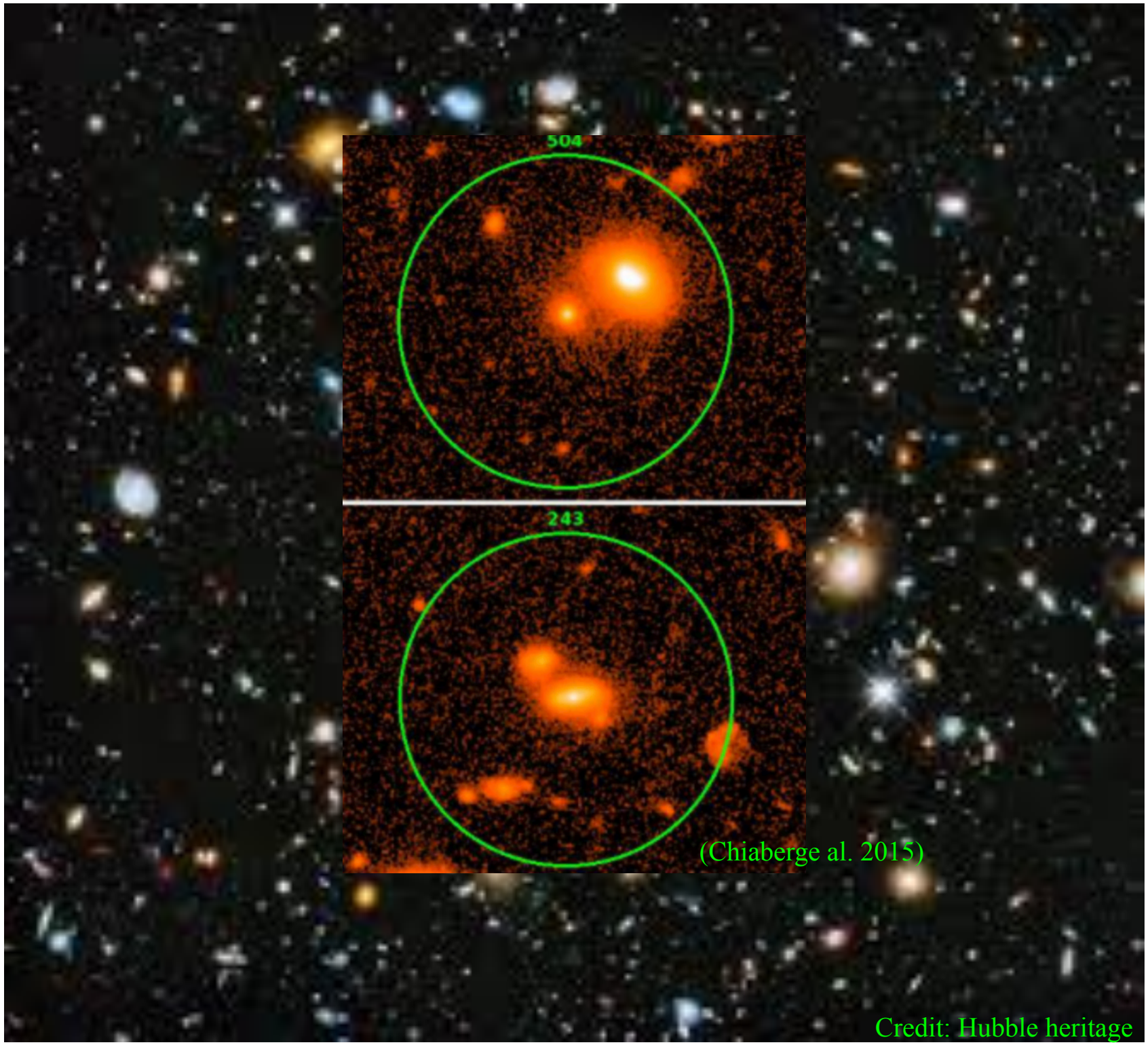
Jets are ubiquitously associated with massive elliptical galaxies

Ellipticals are formed via galaxy mergers



Mergers trigger AGN activity (Jets?)

Studies of ‘evolved’, Type 2, radio-loud quasars support this hypothesis (e.g., Chiaberge et al. 2015)



The missing link?

- Find ‘young’ AGNs hosting relativistic jets
- Find Type 1 AGNs (to observe the innermost regions)
- Find systems with low jet power (so that underlying host galaxy can be studied)
- Find ‘interacting’ systems
- Altogether, find young, type 1 AGN with weak jets and study their host galaxy environments

The Narrow-Line Seyfert 1 Galaxies

- ‘young’ AGNs ✔ (e.g., Mathur 2000)
- Type 1 AGNs ✔
- Do they have jets?

The Narrow-Line Seyfert 1 Galaxies

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- Type 1 AGNs ✔
- Do they have jets? ✔ A few are detected in the γ-ray band with the *Fermi* Large Area Telescope: unambiguous confirmation for the presence of jets closely aligned to our line of sight

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],

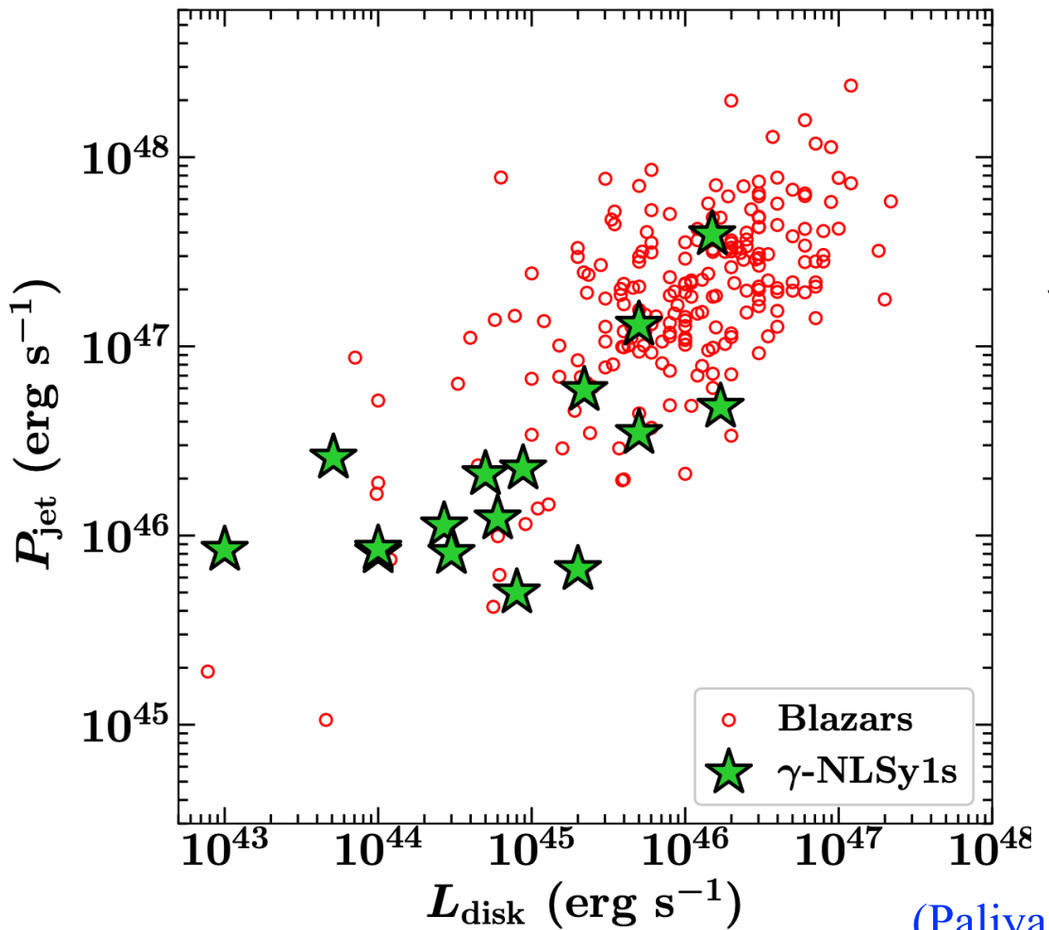
The Astrophysical Journal Letters, 853:L2 (6pp), 2018 January 20 https://doi.org/10.3847/2041-8213/aaa5ab

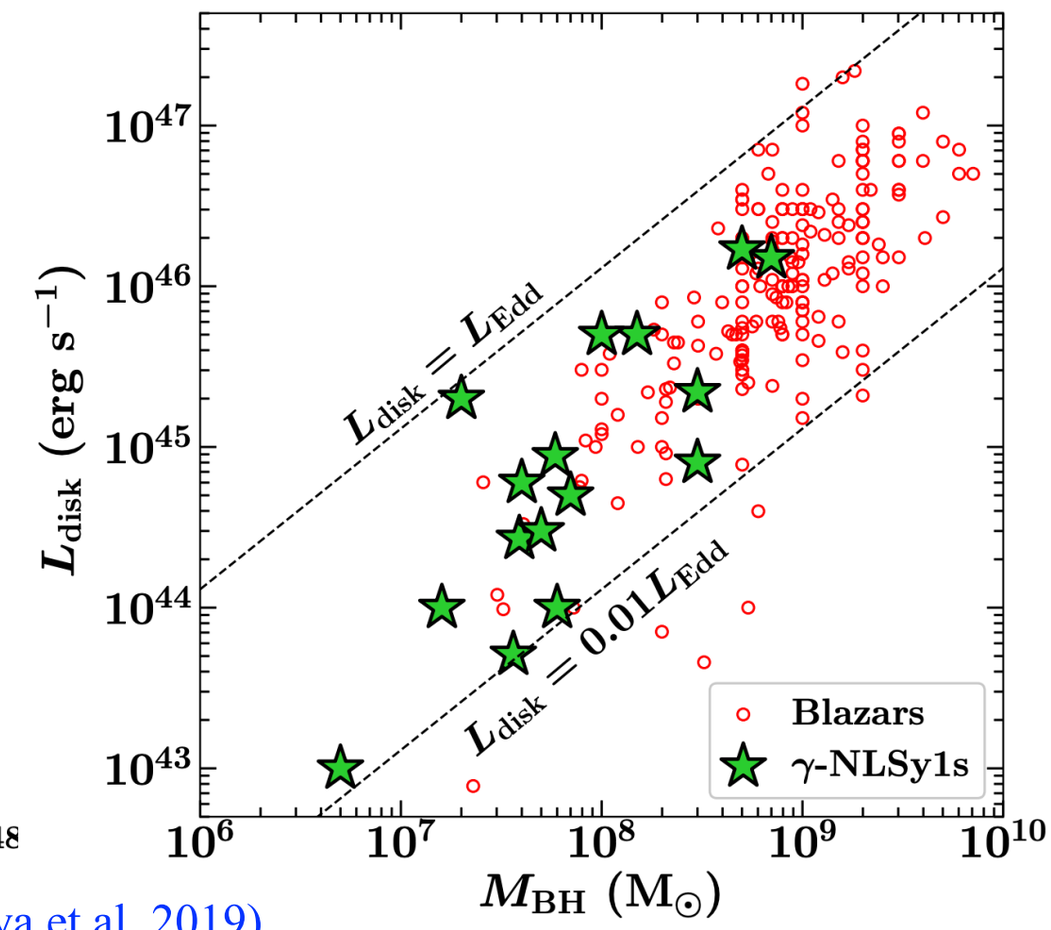
Gamma-Ray-emitting Narrow-line Seyfert 1 Galaxies in the Sloan Digital Sky Survey

Vaidehi S. Paliya[1], M. Ajello[1], S. Rakshit[2,3], Amit Kumar Mandal[2], C. S. Stalin[2], A. Kaur[1], and D. Hartmann[1]

The Narrow-Line Seyfert 1 Galaxies

- Followup studies have revealed that γ-ray detected NLSy1 galaxies host relatively low-power jets and powered by low-mass black holes compared to blazars





(Paliya et al. 2019)

The missing link?

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- Find systems with low jet power ✔

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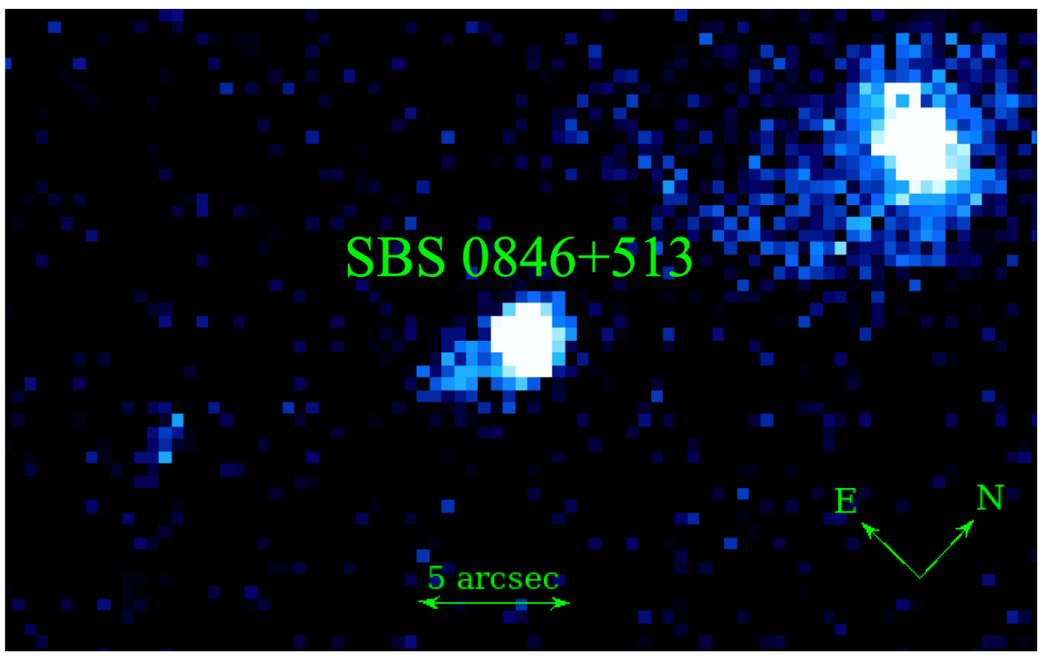
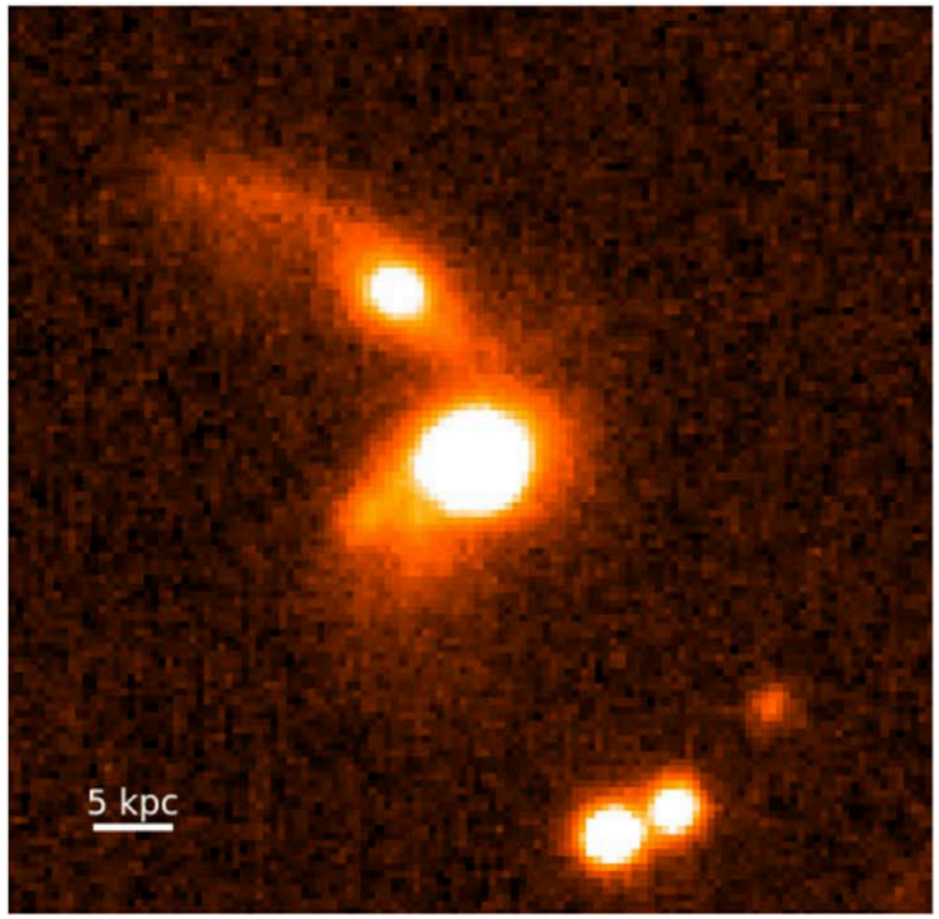
- Interacting systems ✔





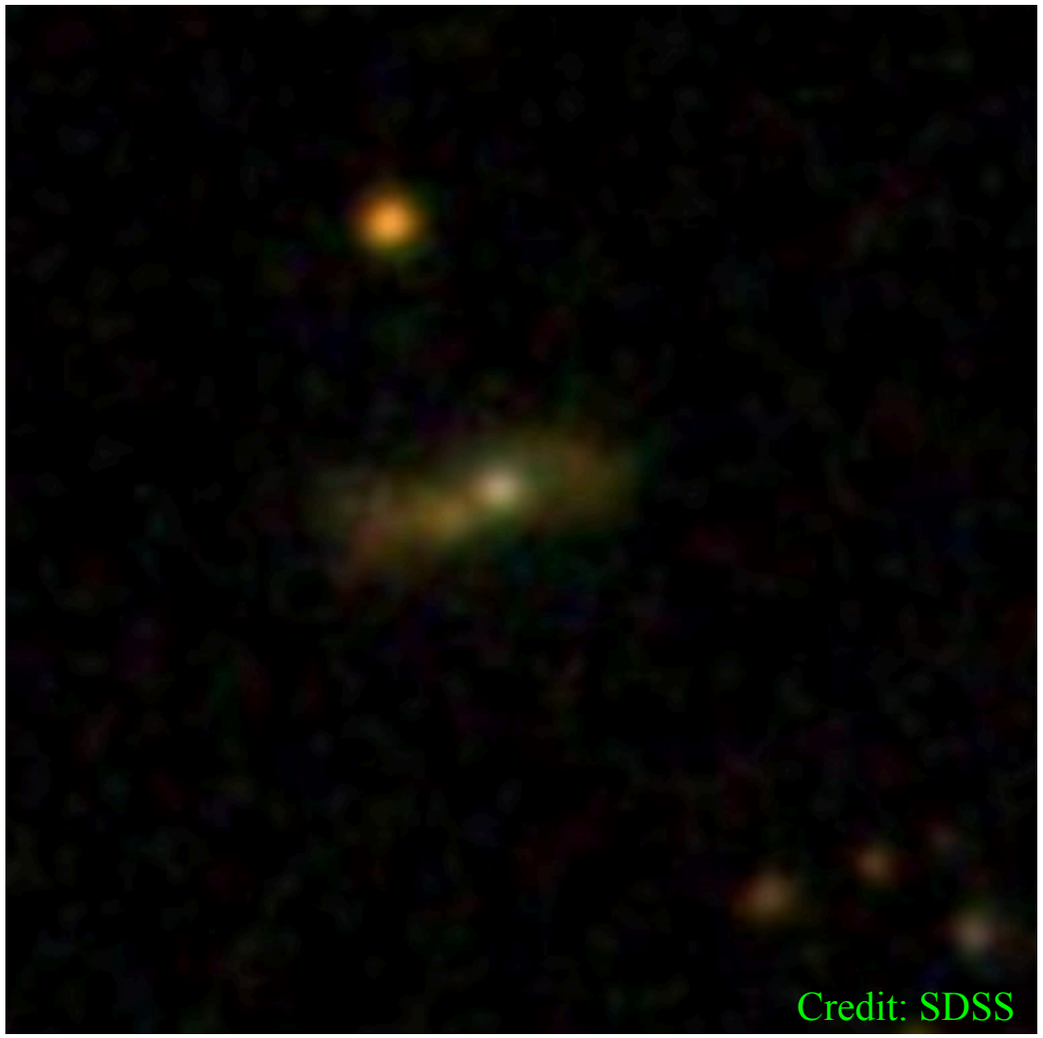
(Berton et al. 2019)

TXS 2116-077

- A narrow-line Seyfert 1 galaxy (Rakshit et al. 2017)

- A flat radio spectrum, variable γ-ray emission (Yang et al. 2018), so the presence of a beamed jet is confirmed

- Low-resolution SDSS image exhibits some interesting morphology



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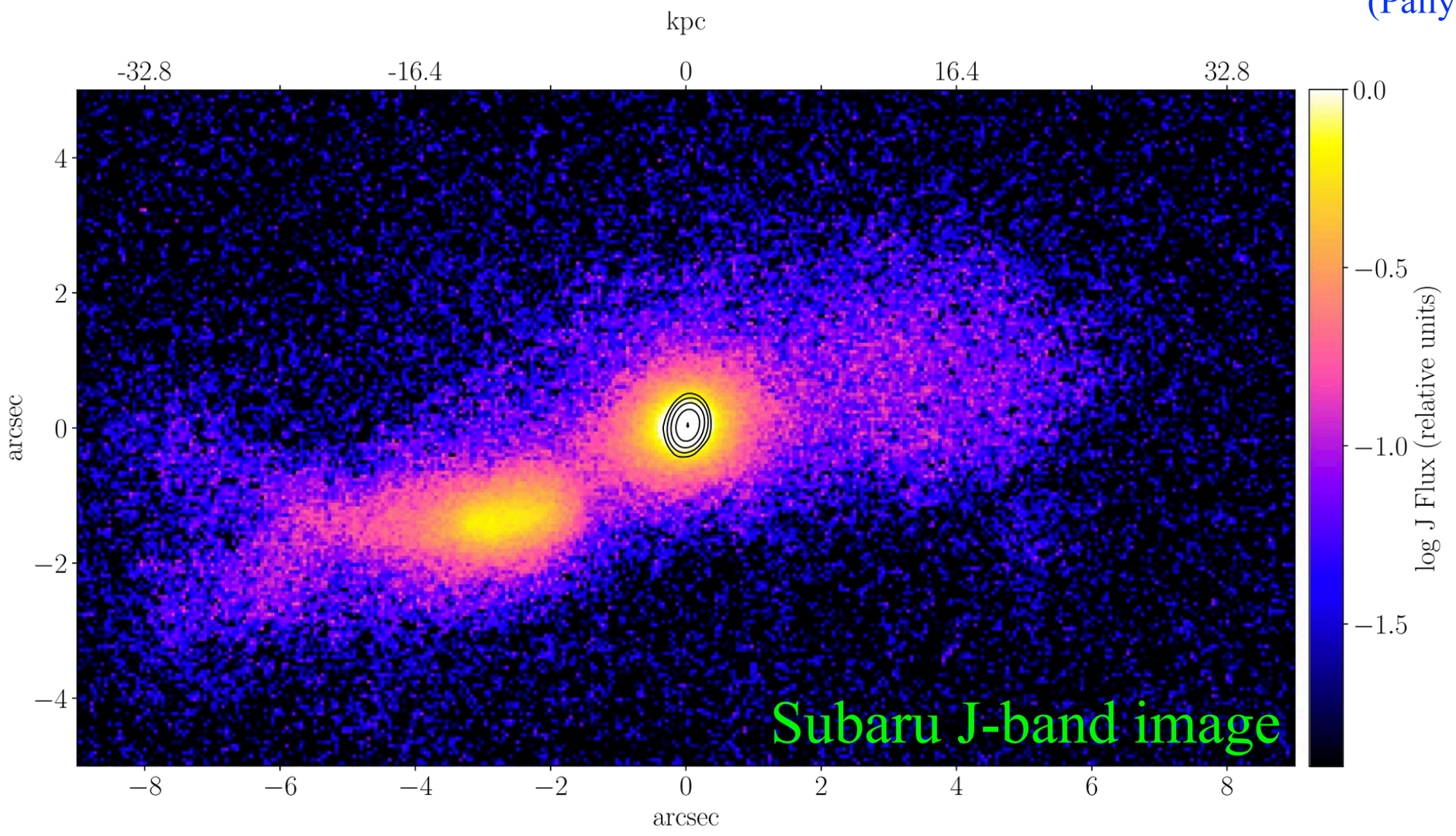
(Paliya et al. 2020)

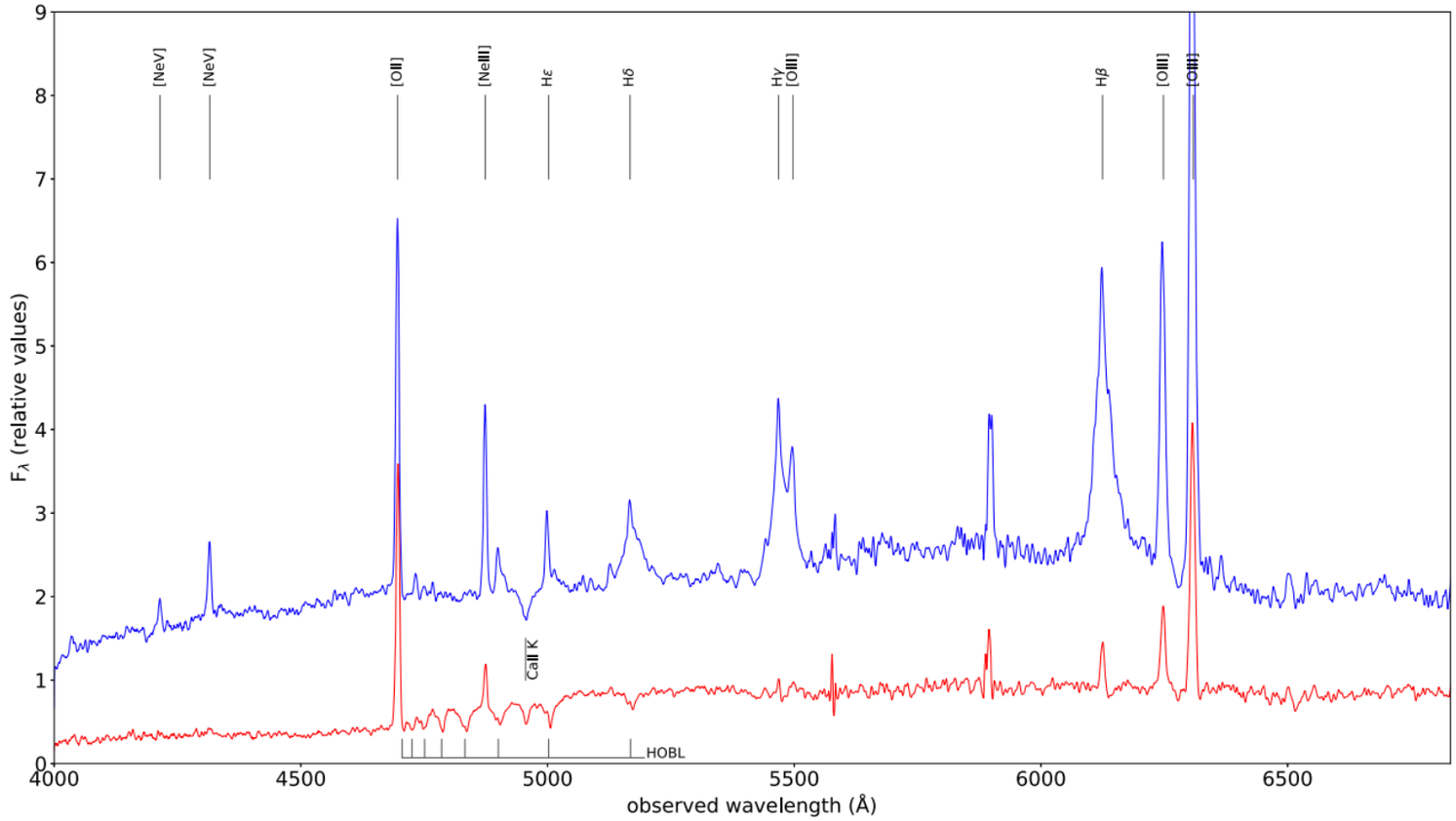


- A galaxy merger hosting a γ-ray emitting relativistic jet

- GALFit modeling suggests both to be late-type galaxies with pseudo bulges, aligned with the hypothesis that NLSy1s are ‘young’ AGNs

TXS 2116-077

(Paliya et al. 2020)

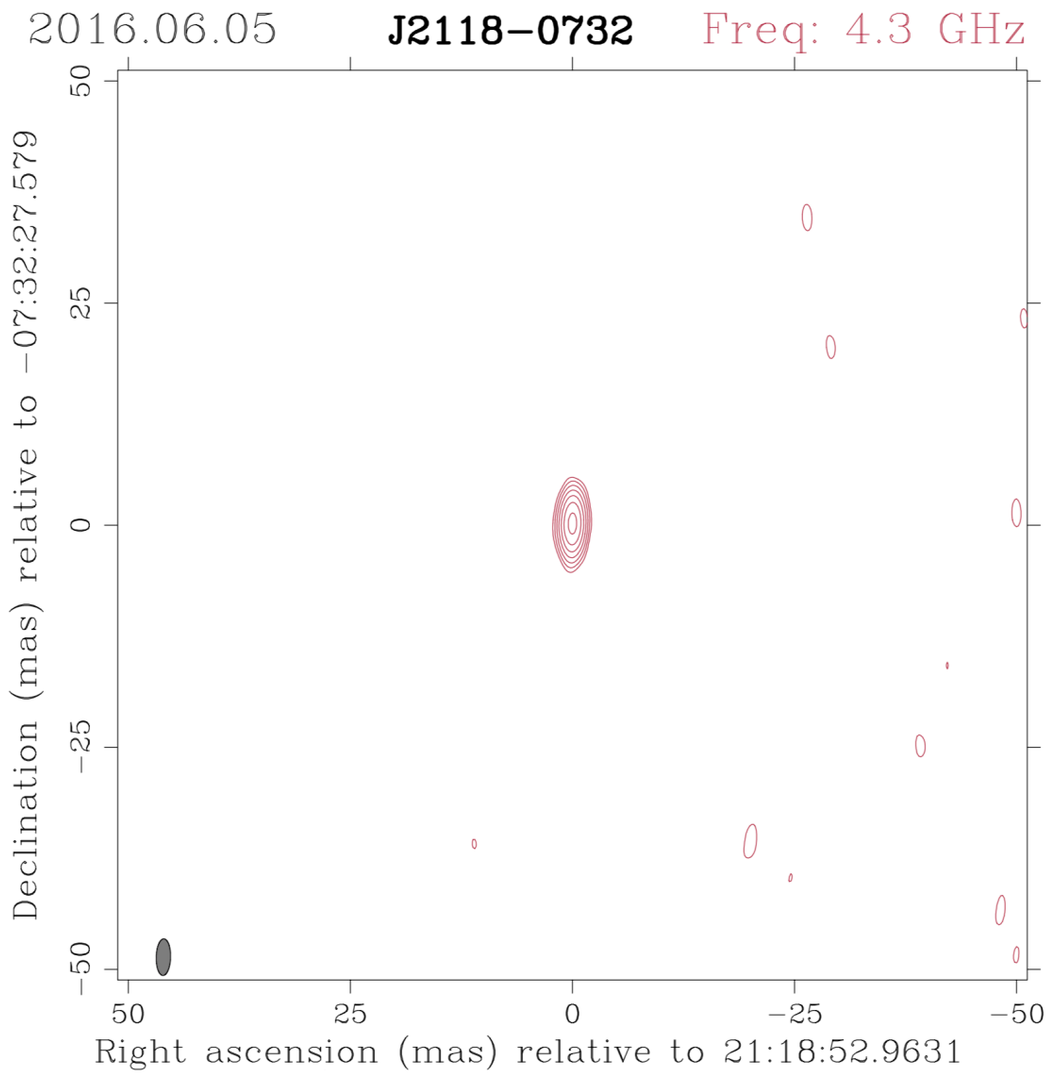


- Merger spectroscopically confirmed with GTC-OSIRIS+WHT-ISIS

- Can we somehow determine whether the jet is triggered due to merging activity? What about the merging environment?

TXS 2116-077

- High-resolution VLBA observations revealed a compact jet
- Unresolved down to mili-arcsec scales
- Computed the upper limit of the jet length from the VLBA beam size
- Assuming a jet velocity of 0.1c, kinematic age of the jet is derived as $T_{jet} \leq 15$ kyr



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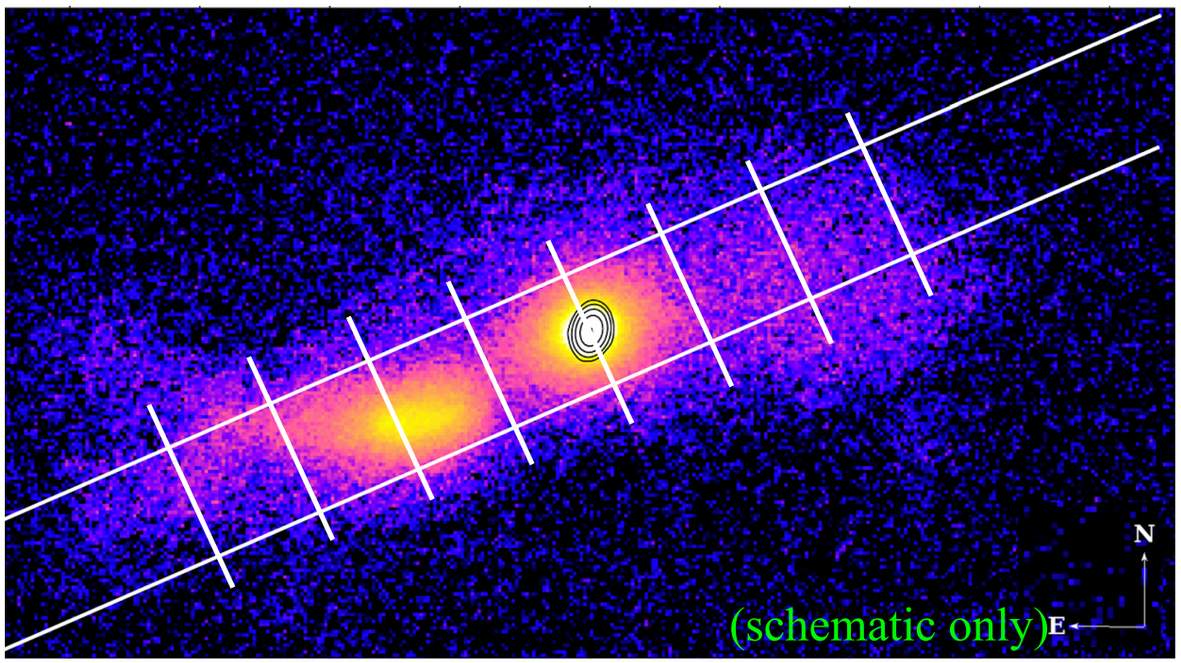
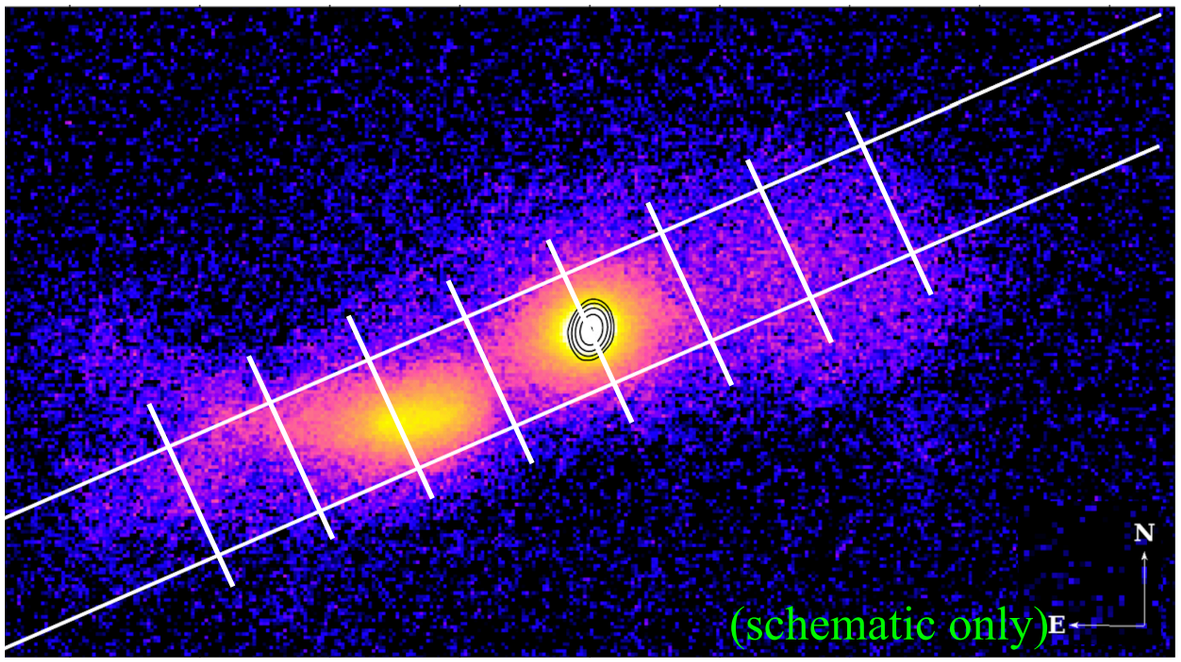
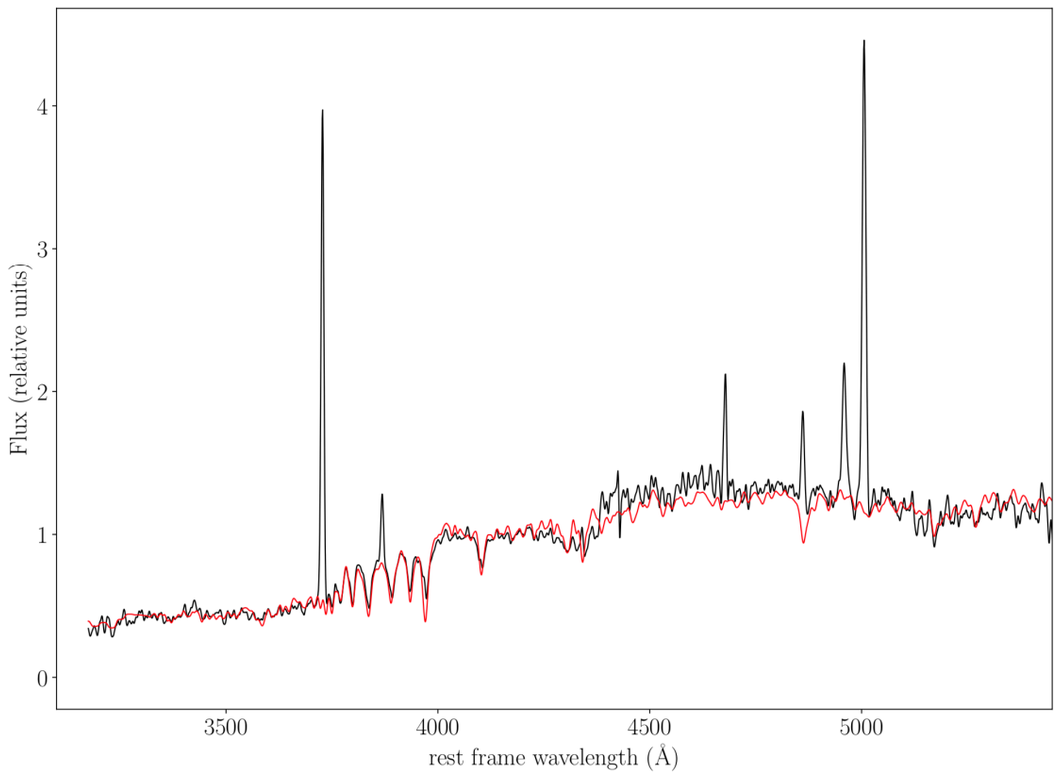


- We extracted optical spectra from 8 different parts along the long-slit

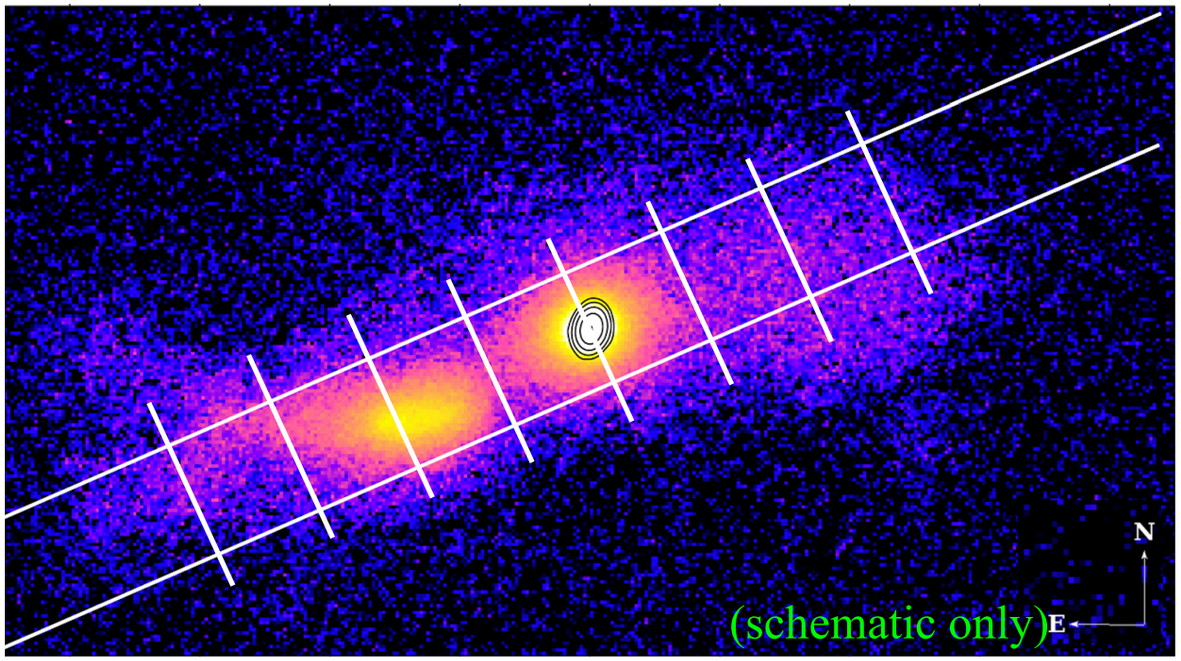
TXS 2116-077

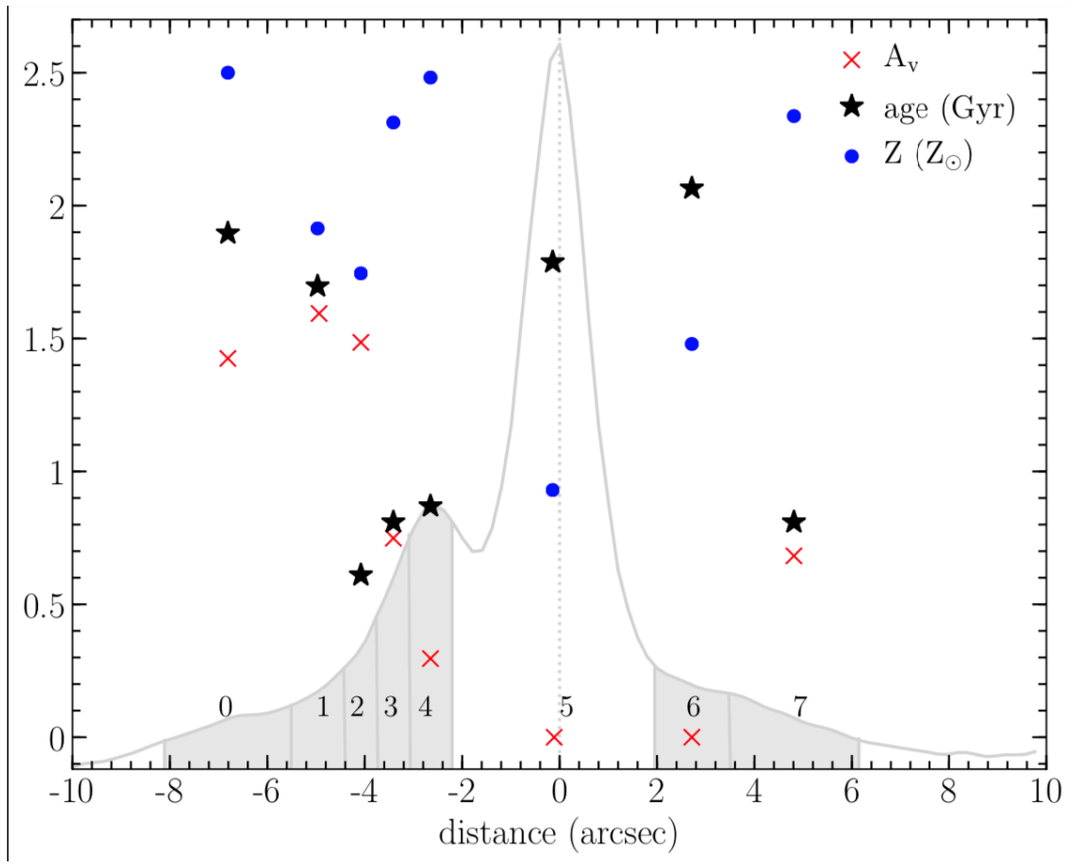




- We extracted optical spectra from 8 different parts along the long-slit
- Carried out stellar population synthesis masking emission lines

TXS 2116-077



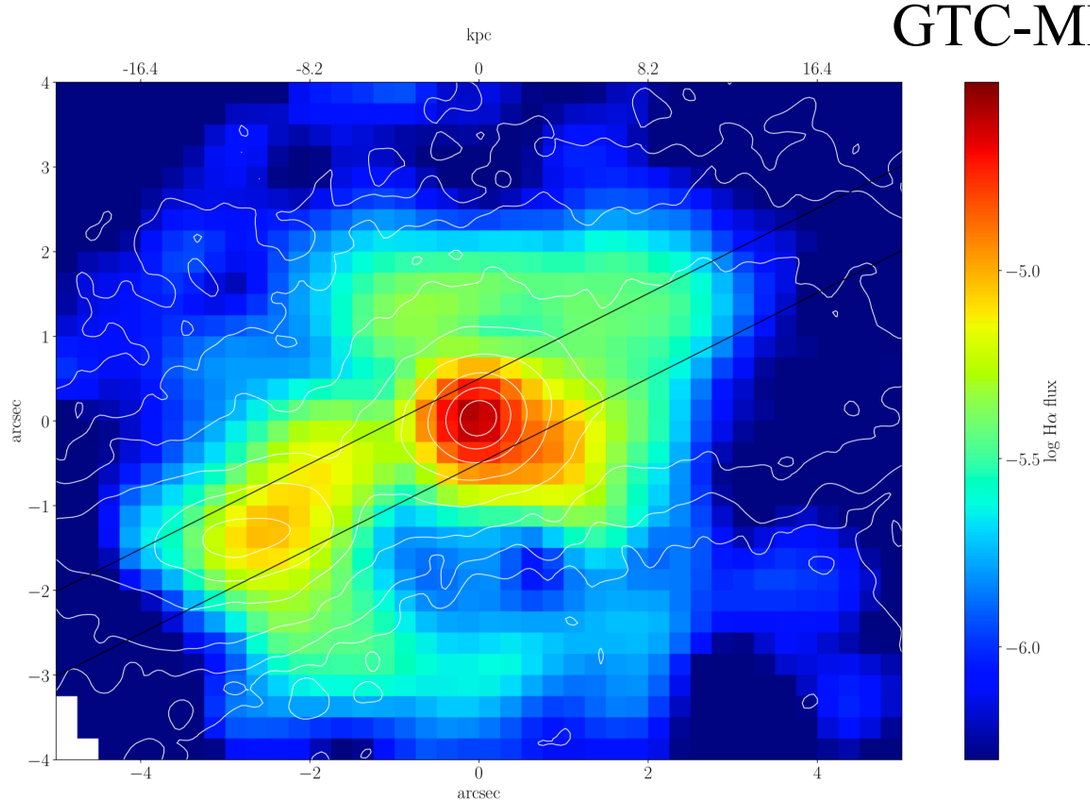


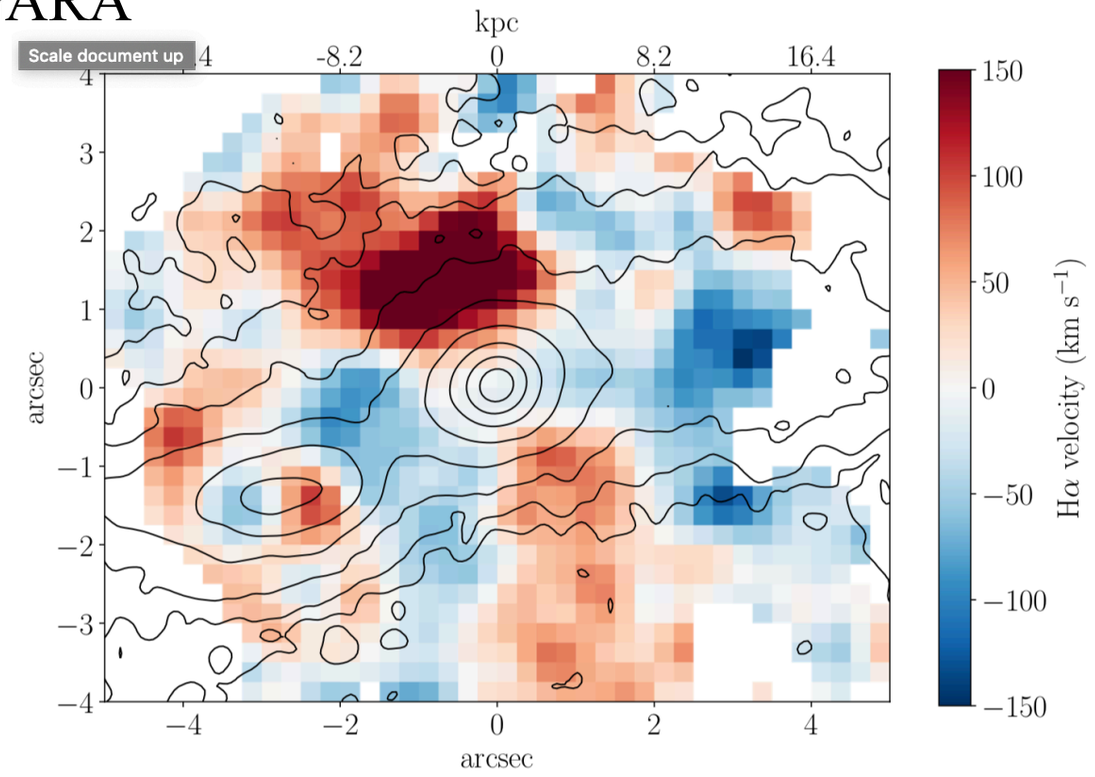
- Estimated extinction, metallicity, stellar population age giving a merger timescale of ~0.5-2 Gyr (consistent with simulations)

- Comparing the jet kinematic age with the merger timescale indicates the **jet to be considerably younger than the merger**

Merging Environment

GTC-MEGARA



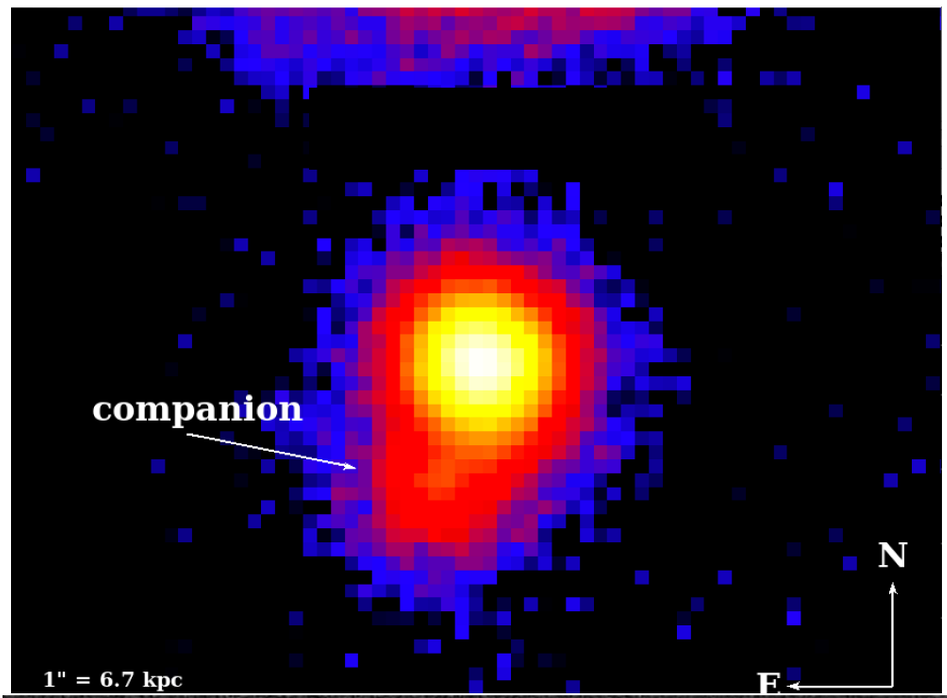


- The Hα flux map reveals a ring surrounding the jet and extends to SW of the γ-NLSy1
- The Hα velocity map shows complex patterns: a turbulent environment due to shocks
- But, MEGARA has a limited wavelength coverage (~7200-8700 A)
- We need an IFU at GTC covering a broad wavelength range to develop a 3D map of the merging system parameters

What next!

- Interesting results obtained so far demand a deeper investigation

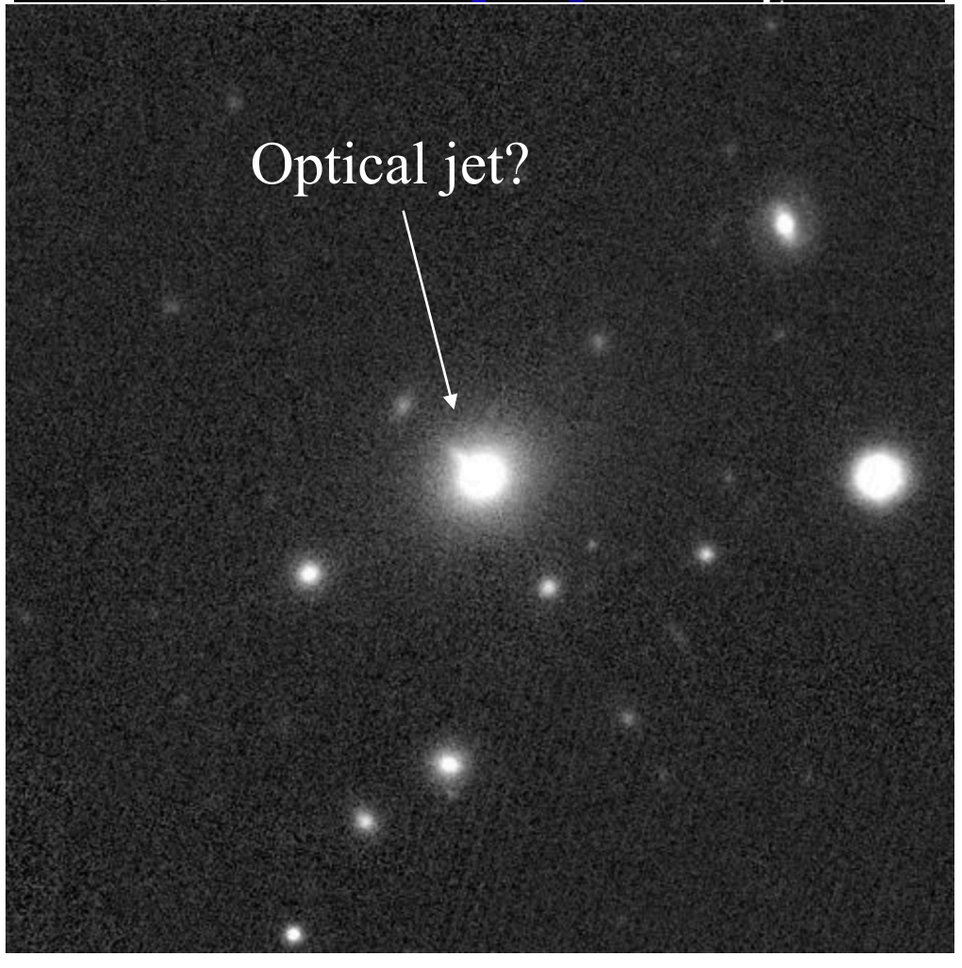
- IFU observations hold the key to reveal the merging environment and jet triggering mechanisms



- Until MAAT is ready, we will try to study more γ-ray emitting jets with GTC-OSIRIS

- Most of the known such systems are in the northern-hemisphere (due to SDSS)

- Having MAAT at GTC would be invaluable to explore the origin of relativistic jets



!!Thank you!!