The parsec scale of active galactic nuclei

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COST Action MP0905 - Black Holes in a Violent Universe

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1. Introduction

- **Active Galactic Nuclei (AGN)**

Seyfert-Quasars → $L_{optical} \approx 10^{44\text{-}47}$ erg/s

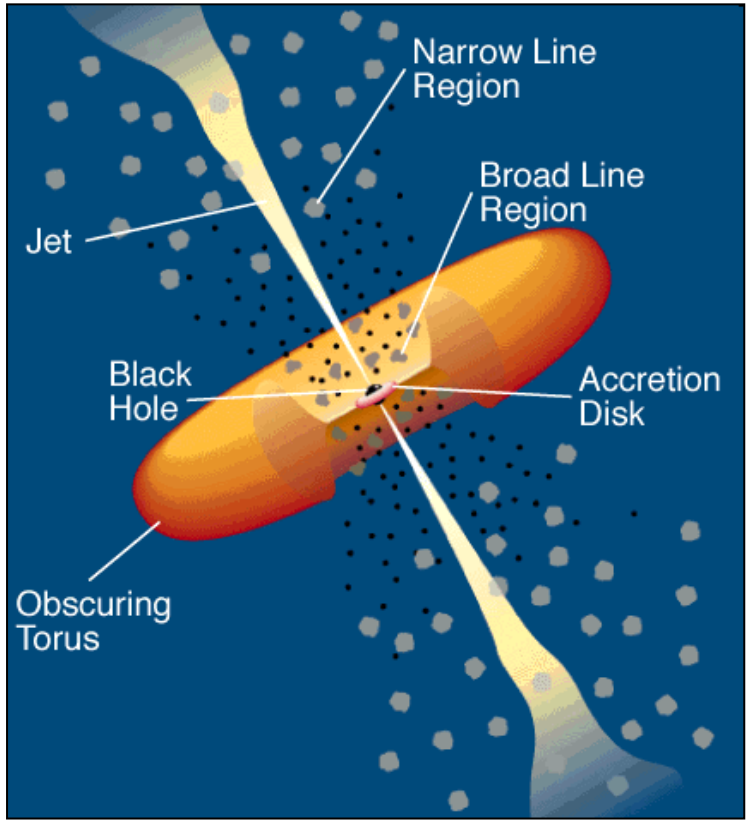
- Broad Line Region (BLR)

Size ≈ (0.1-1) pc ; FWHM ≈ 3000 km/s

- Torus ≈ 10 pc

- Narrow Line Region (NLR)

Size ≈ 100 pc – 4 kpc ; FWHM ≈ 500 km/s



Urry & Padovani (1995)

- Coronal Line Region (CLR)

Near-IR spectroscopy studies

High-ionization emission lines (IP > 100 eV) (e.g. [SiVI] 1.96 μm)

No star formation contribution, only associated to AGN

FWHM ≈ 400-1000 km/s ; size ≈ 30-200 pc

Produced by hard UV- soft Xrays photons or fast shocks

Strong implication to AGN feedback
via outflows of ionized gas
Regulate SF, BH growth

- **Low-Ionization Nuclear Emission Regions (LINERs)**

  Lowest-luminosity AGN → $L_{optical} \approx 10^{42}$ erg/s

  Represent 60% of AGN population in nearby Universe

Intrinsic low luminosity debated:

- Lack of fuelling material around the central SMBH ??

- Non-standard accretion disk ??

- Not being AGN ??

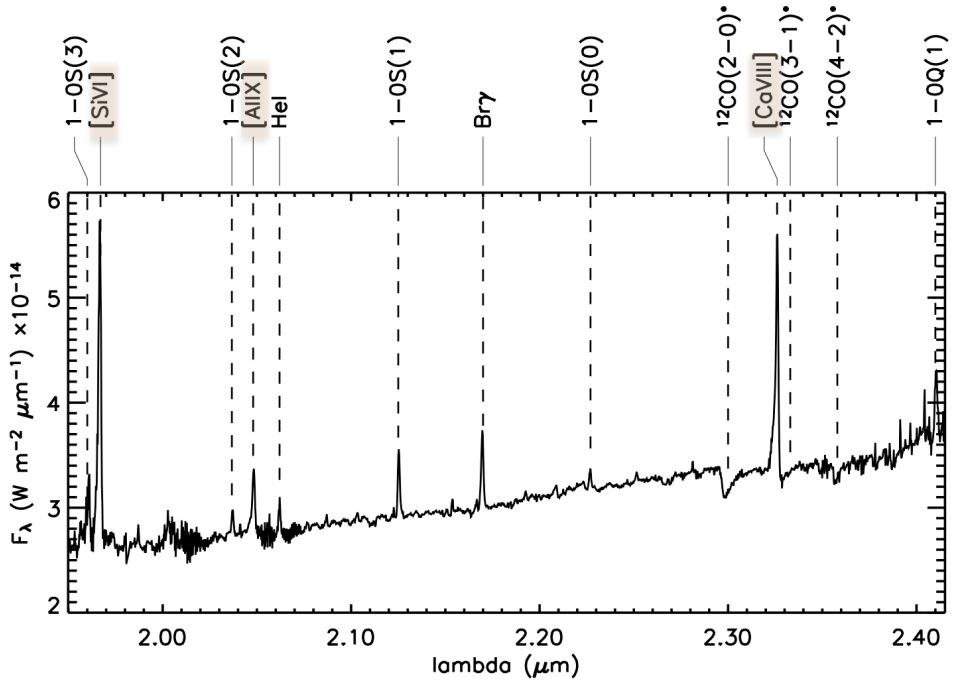
1. If LINERs low-power AGN

- High-ionization coronal lines:

[Si VI] 1.96μm

[Al IX] 2.04 μm

[Ca VIII] 2.32 μm



Nuclear spectrum of Circinus Galaxy (Sy2)
Mueller-Sánchez et al. (2006)

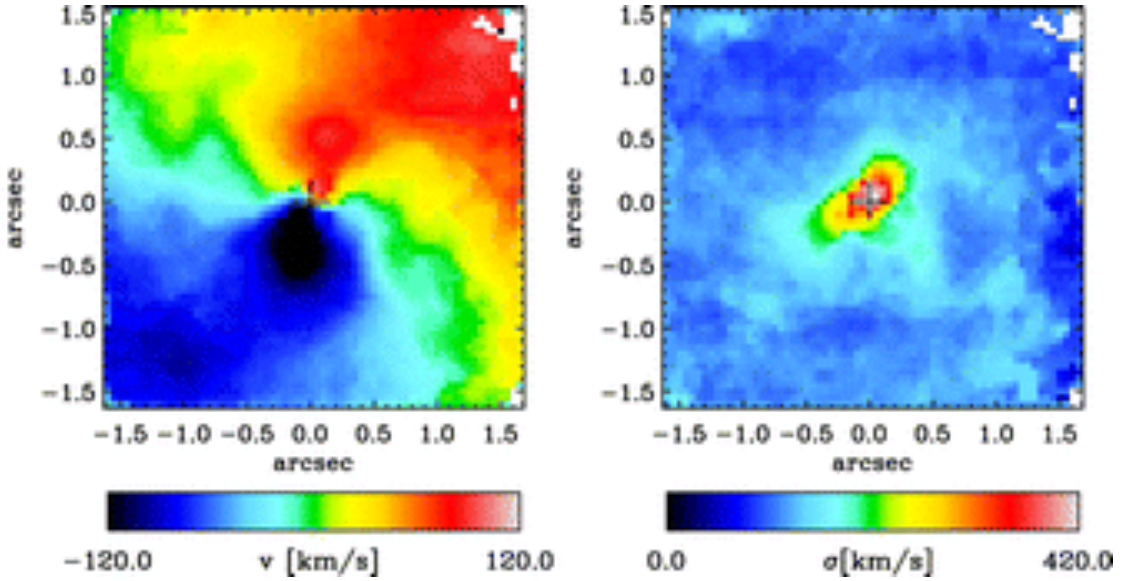
- Geometrically-thick,

  rotating H_2 gas disk

  turbulence, winds → torus

  $\sigma / V_{rotation} > 1$

Features seen in near-IR high spatial resolution studies of Seyfert galaxies



Velocity (left), velocity dispersion (right) maps of CenA
Neumayer et al. (2007)

2. If LINERs have non-standard accretion disk

- non-standard ionizing spectrum lacking hard photons to produce coronal lines
- no gas outflows → release of gravitational energy?

3. If LINERs are a quiescent, no turbulent AGN state

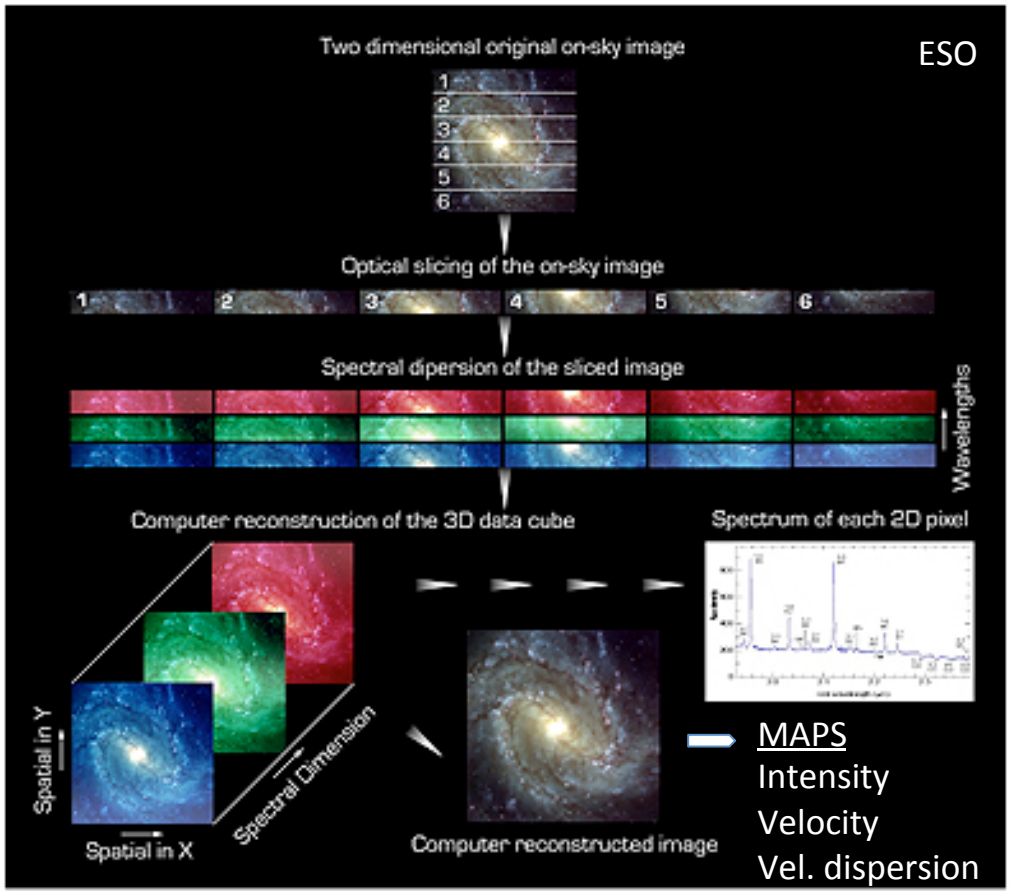
- geometrically-thin, rotating H_2 disk with low σ
- no thick torus can be maintained

2. Observations

- **Integral Field Spectroscopy (IFS)**

  LINERs innermost region

  Near-IR high spatial resolution



SINFONI instrument

("Spectrograph for INtegral Field Observation in the Near-Infrared")

VLT UT4, Paranal Observatory (Chile)

Near-diffraction limit, adaptive optics

K band (1.95-2.45 μm)

Pixel scale 100 mas, FoV 3"x 3"

Resolve spatial scale ≈ 10 pc

Nuclear gas kinematics & distribution (100 pc)

3. Results

- **Three LINERs with IR high spatial resolution:**

  NGC 1097, NGC 1052, NGC 3169

1. No coronal lines present ➡ no photons E > 130 eV generated !!!

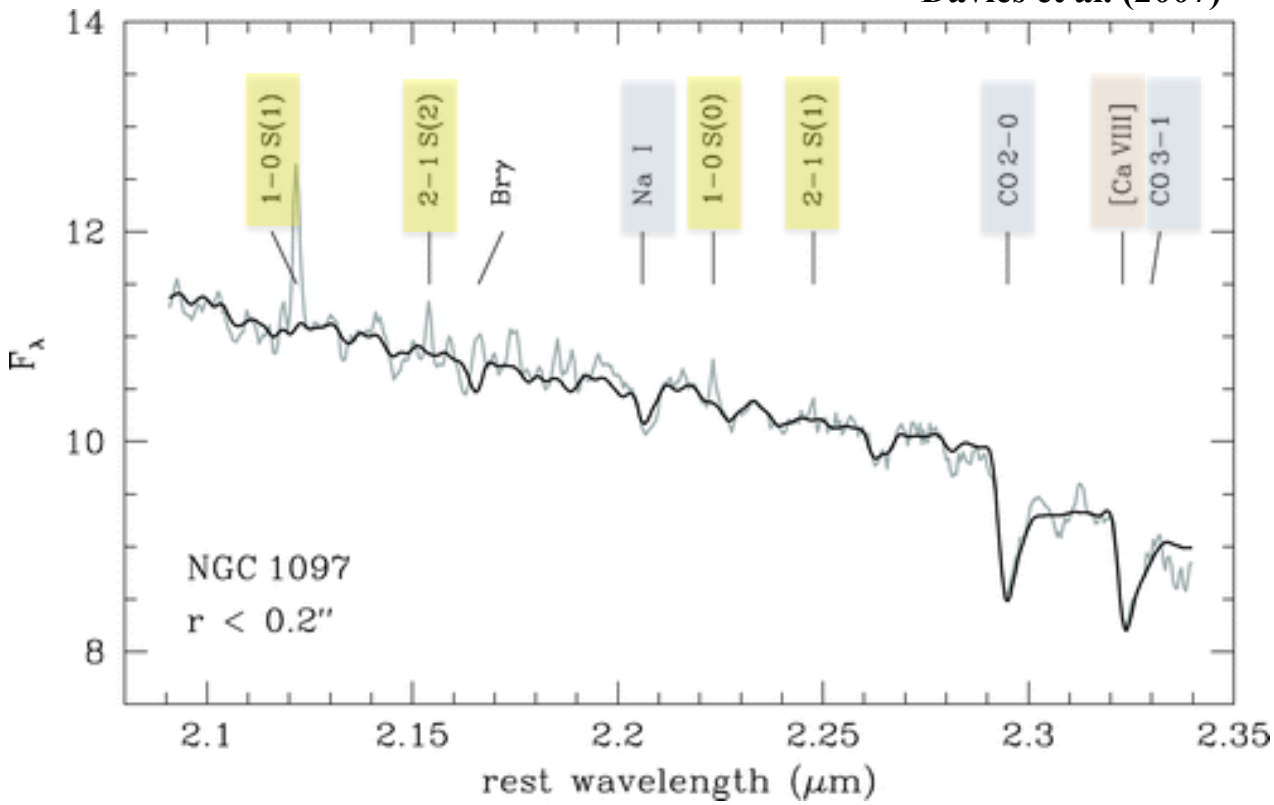
— Stellar continuum

Coronal line

Stellar absorption

H_2 gas emission

Davies et al. (2007)



2. H_2 gas kinematics in central 100 pc dominated by rotation

low velocity dispersion ⇒ thin rotating disk !!!

$\sigma/V_{rotation} \approx$ 0.3 ; NGC 1052; 0.2 ; NGC 3969; 0.8 ; NGC 1097

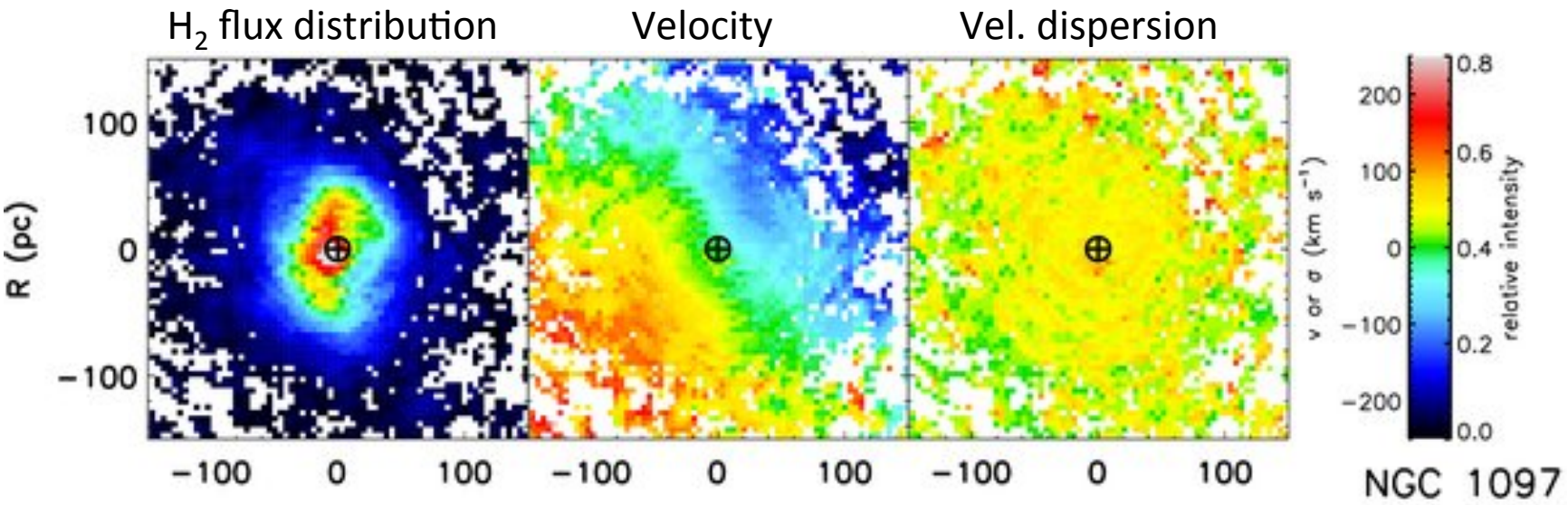
$\sigma/V_{rotation} \approx 1.5$ Seyferts

Inner spiral H_2 gas inflow: NGC 1097, NGC 1052?

3. Abrupt increase in H_2 vel. dispersion towards center (30 pc)

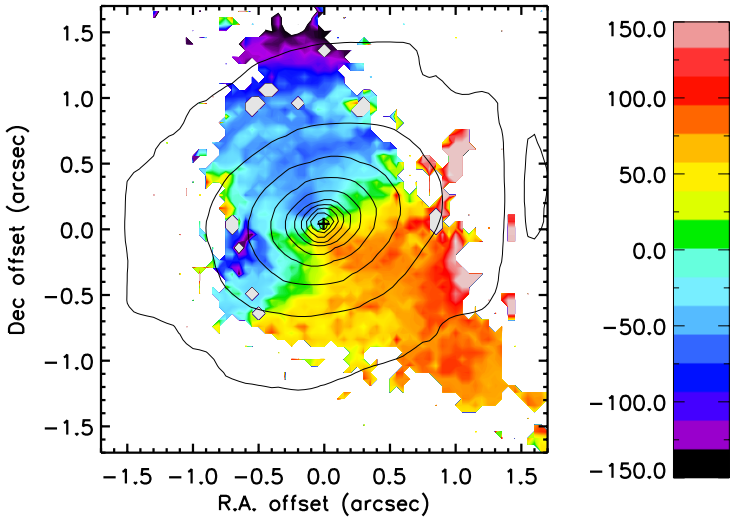
$\sigma/V_{rotation} \geq 1$ ⇒ Disk becoming turbulent as in Seyfert !!!

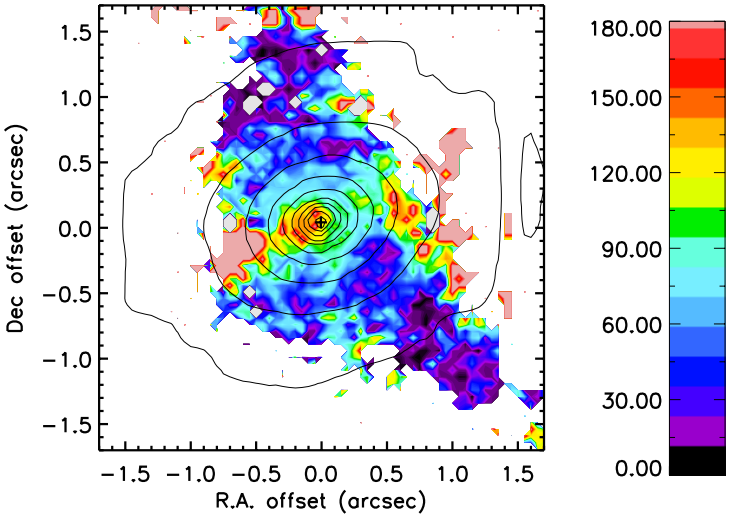
Hicks et al. (2009)



NGC 1052

Mueller-Sánchez et al. (in prep.)

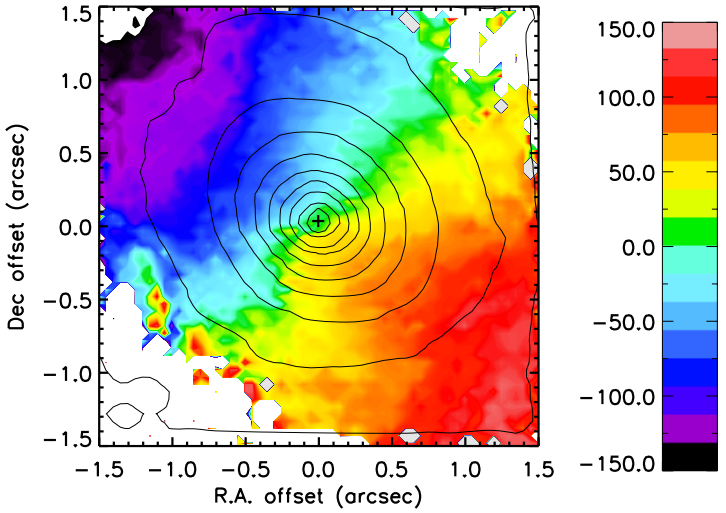


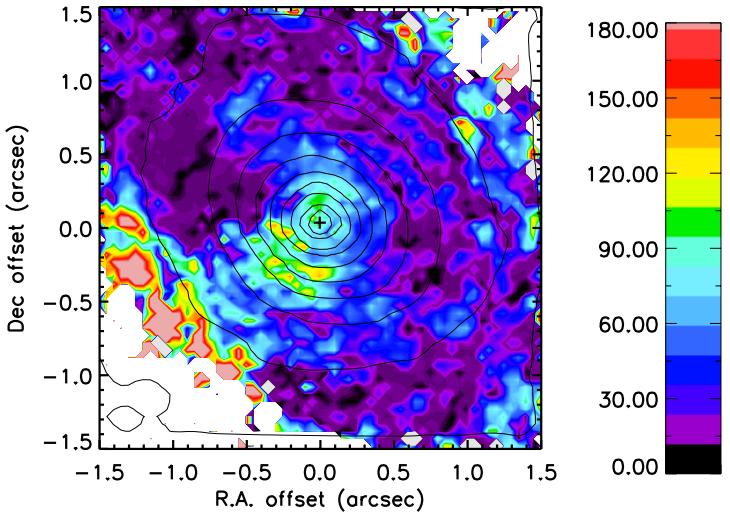


Velocity

Vel. dispersion

NGC 3169





4. Conclusions

- **High resolution near-IR spectroscopic study of 3 LINERs**

  1. No presence of coronal lines → non-standard AGN ionizing continuum ???

  2. H_2 rotating thin disk → can LINERs sustain a torus ???

  3. σ increase towards center → disk becomes turbulent in the central 30 pc ???

- **Better statistics needed**

  Extend studies to 5 more LINERs → SINFONI proposal submitted

  Selection criteria:

  - Bright (to use AO), near (d<30 Mpc), accessible from Paranal

  - Host early-type galaxies: avoid confusion with SF in H_2 kinematics analysis

  - Secure AGN: X-ray core counterpart in 2-10 keV Chandra images
  radio core

  - Similar distances to Seyferts studied with SINFONI: guarantee comparison of same physical region


Thank you!