Extended ionized-gas structures in Seyfert 2 galaxy Mrk78

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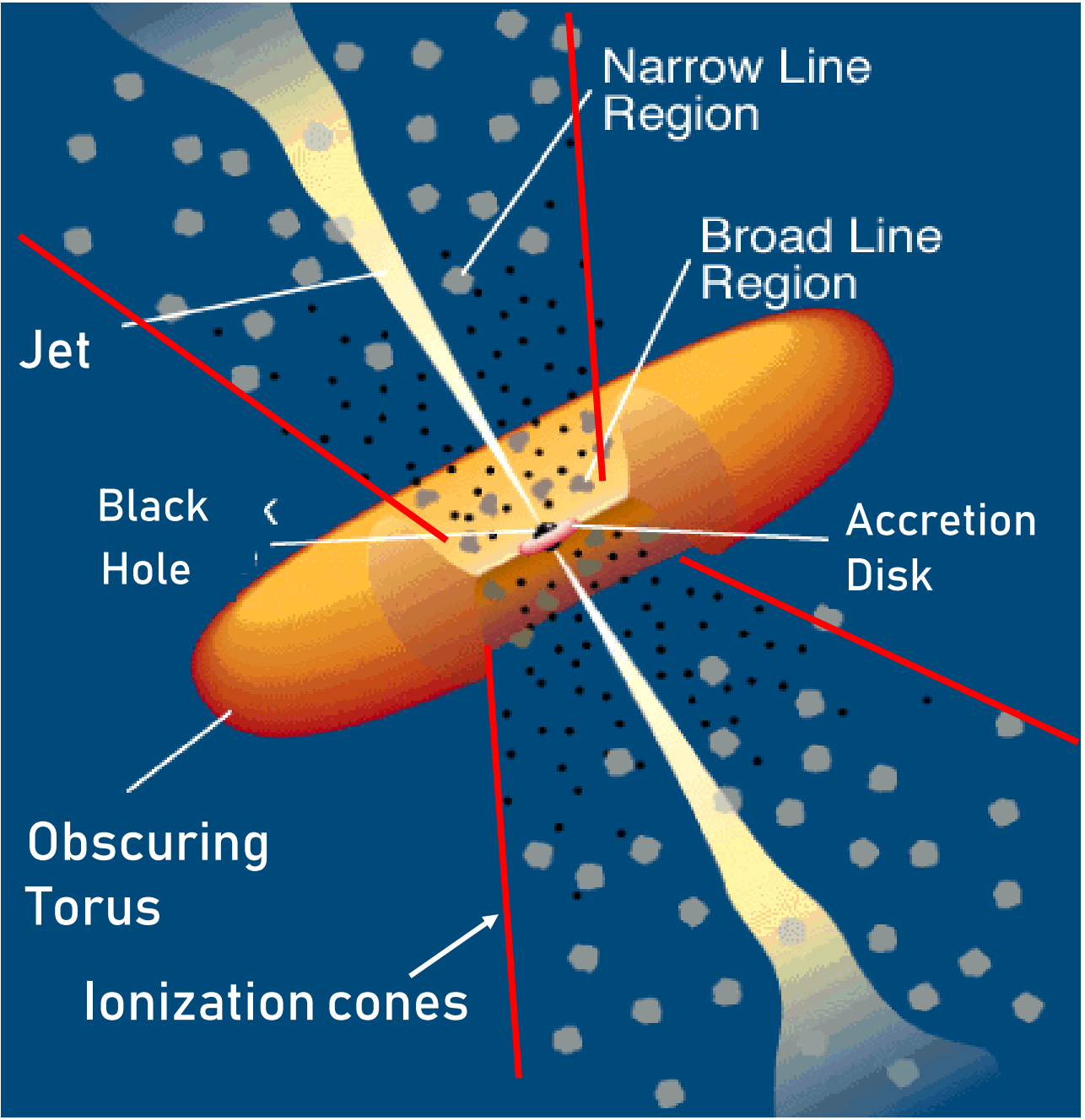
Ural Federal University



What's the origin of active galactic nucleus (AGN) ?

Black hole in the center of the most galaxies

↓

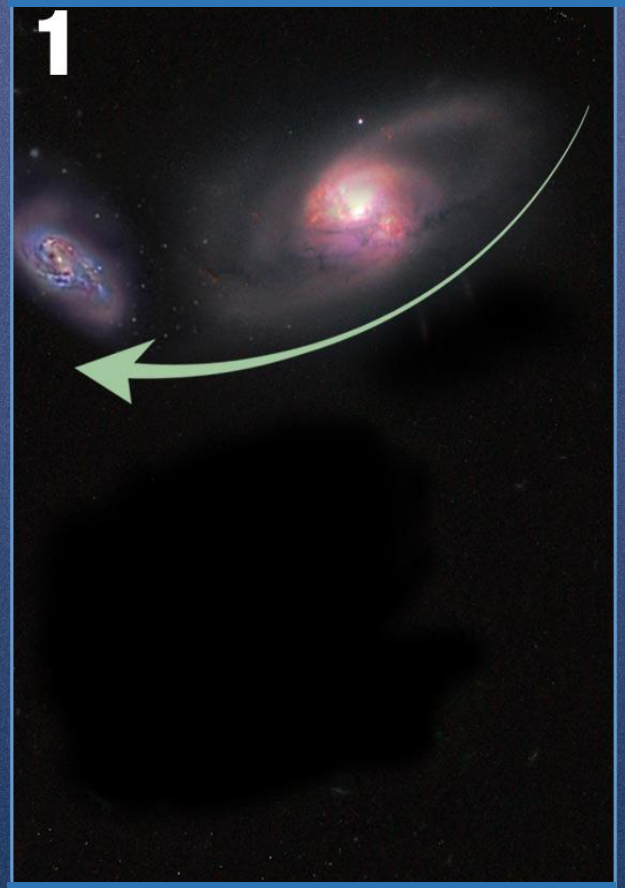
Gas accretion in central regions (e.g.,during interaction between galaxies)

↓

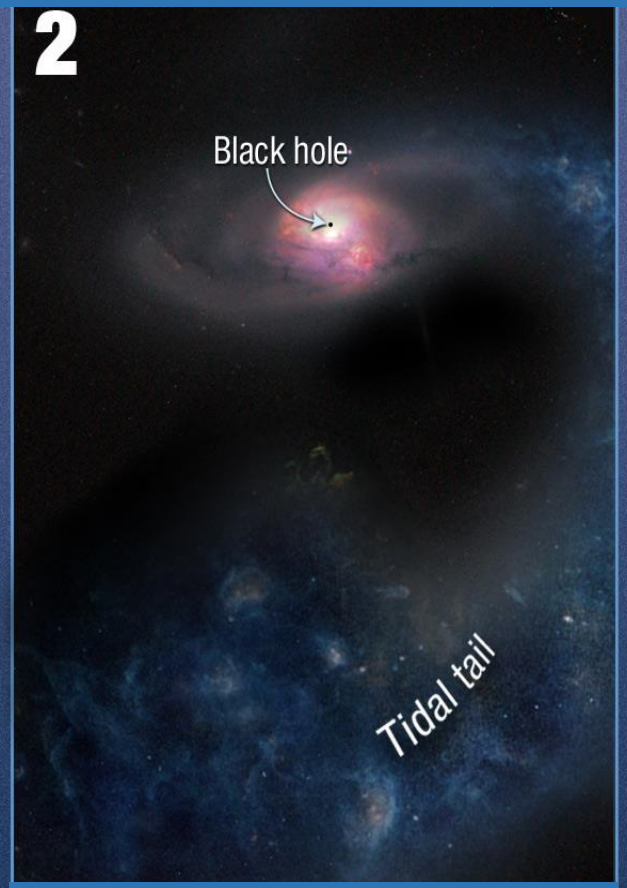
Temporary nucleus activity

How often the activity is manifested and how long does it last?

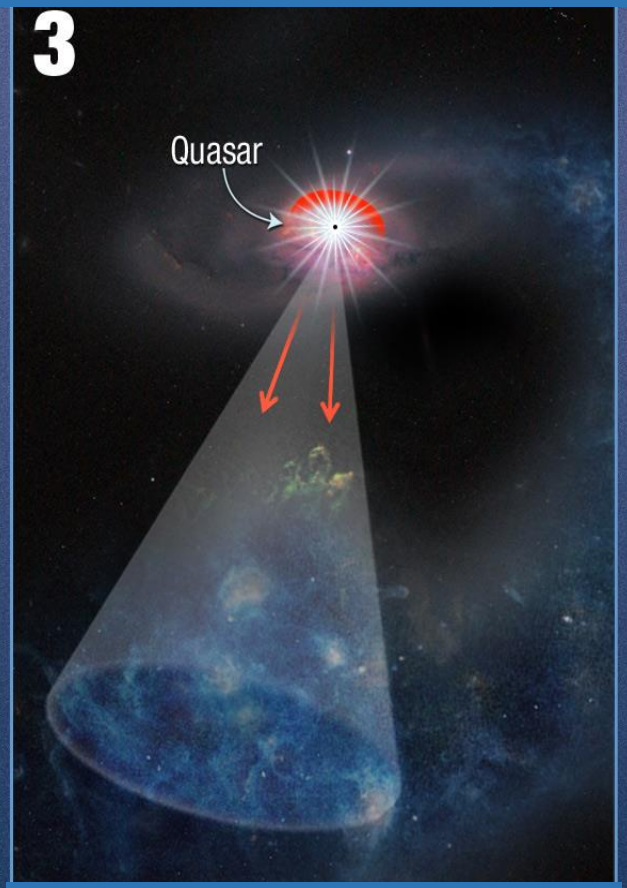
Hanny's Voorwerp Object



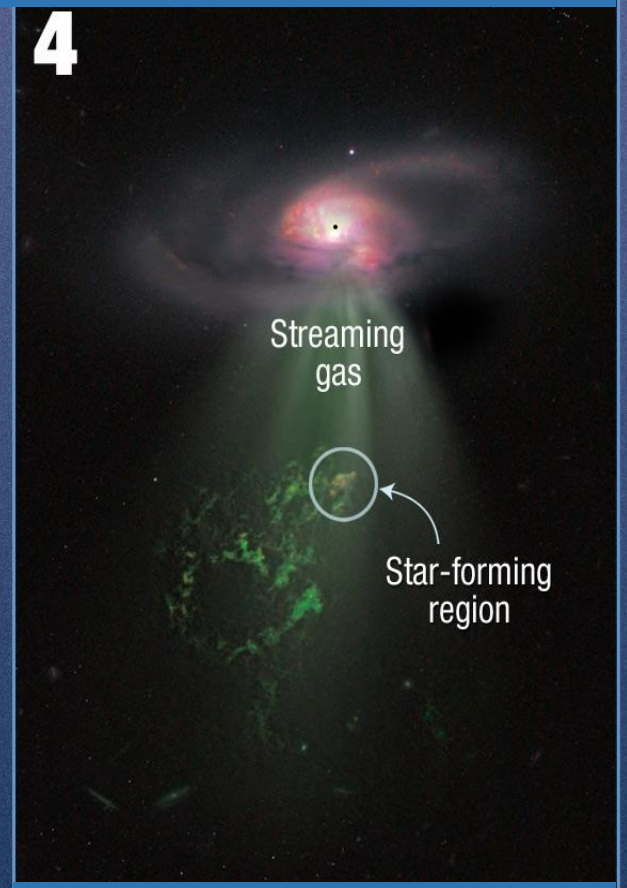
Interaction with nearby galaxy



Off-plane tidal tail



Part of the structure is in the ionization cone



Observable extended emission-line region

*Hanny's Object

Objectives

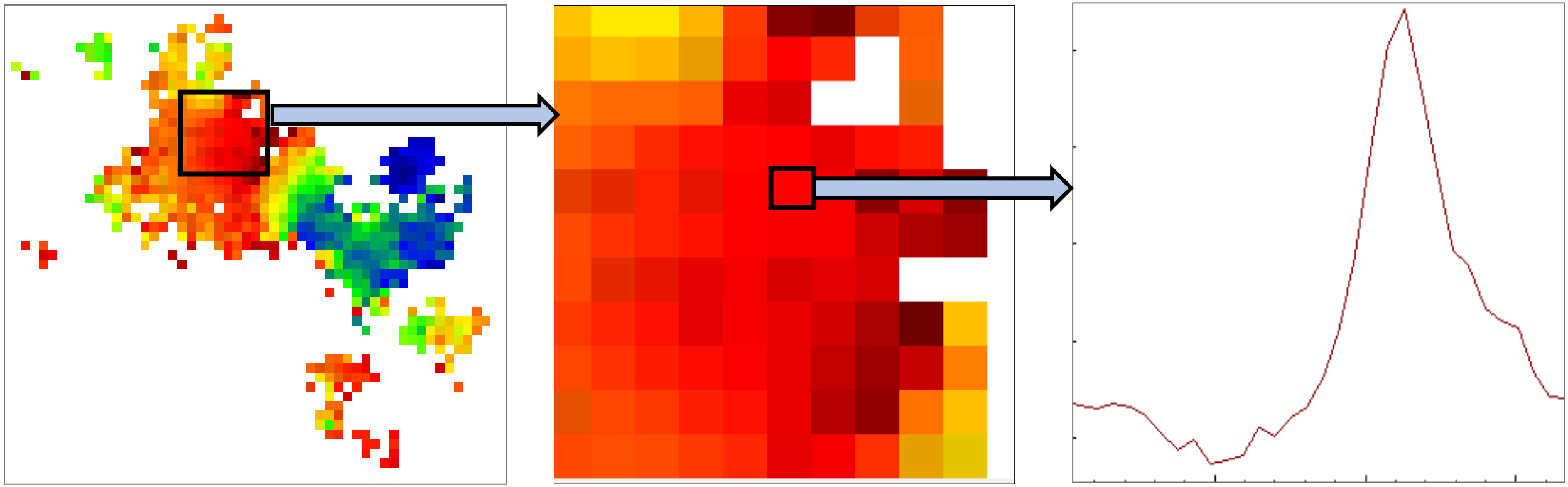
- search of the Extended Emission Lines Regions (EELR) (>10 kpc) around AGN host
- determination of EELR clouds kinematics and parameters of ionization
- understanding of the EELR clouds' origin

Observations at the 6-m Russian telescope

- 3 D spectroscopy with the scanning Fabry-Perot Interferometer (FPI) with SCORPIO-2
  (Afanasiev & Moiseev, 2011)
- long-slit spectroscopy with SCORPIO-2
- 3 D spectroscopy with Integral-field Multi-Pupil Field Spectrograph
  (Afanasiev et al, 2001)

Analysis of IFP 3 D spectroscopy data

Data cube – each pixel has its own spectrum



Disc circular rotation model

Divide velocity field into elliptical rings 1.5” wide

In each ring observed radial velocity distribution is fitting by disc circular rotation model

$$Vobs(r, PA) = Vsys + Vrot(R(r)) \frac{\cos(PA - PA0) \sin i}{(1 + sin^2(PA - PA0) tan^2 i)^{1/2}}$$

$$R(r) = r(1 + sin^2(PA - PA0) tan^2 i)^{1/2}$$

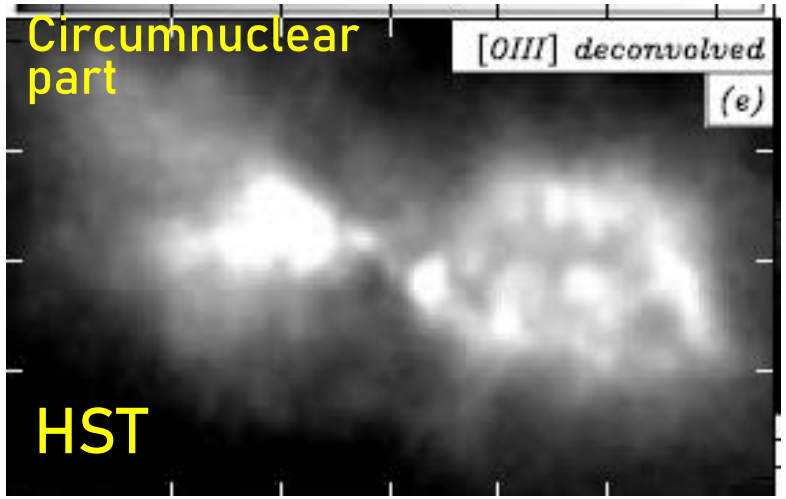
i – inclination of orbits
PA_0 – kinematics major axis position angle
Vrot – rotation velocity
Vsys – nucleus velocity (systematic velocity)
r – distance from the nucleus

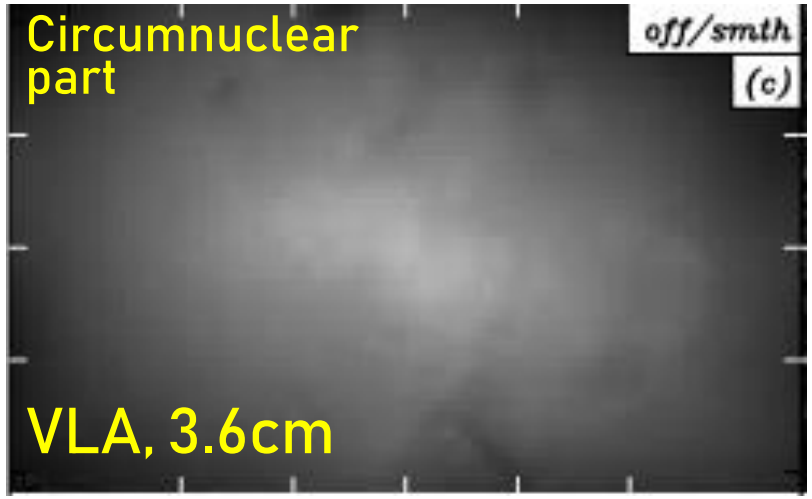
Mrk78

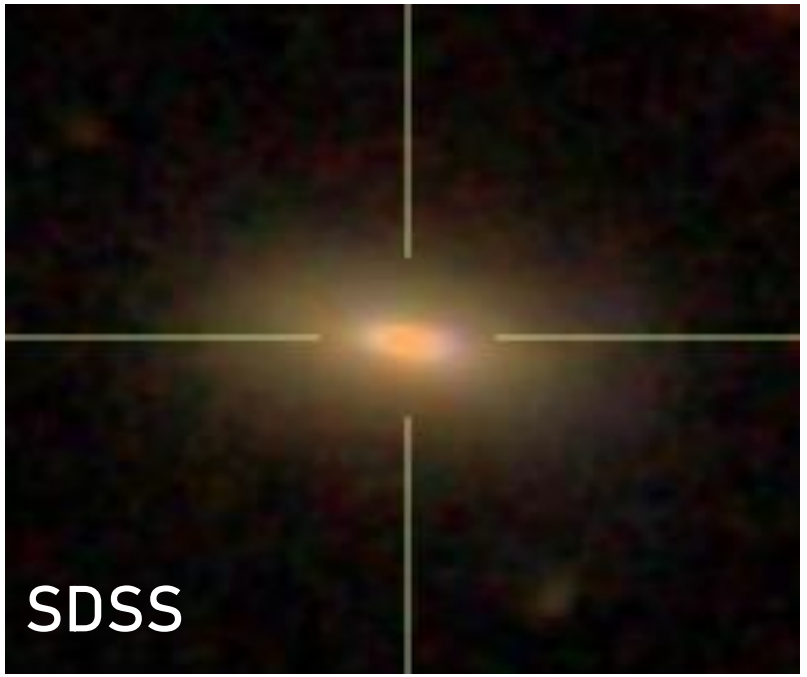
- Type: Seyfert 2
- Center: α=7h42m41s δ=+65°10’38”
- Distance: z=0.03715
- Scale: 0.803 kpc/arcsec.

Spectral observations: weak emission 13 kpc away from the nucleus (Afanasiev & Sil’chenko, 1991)

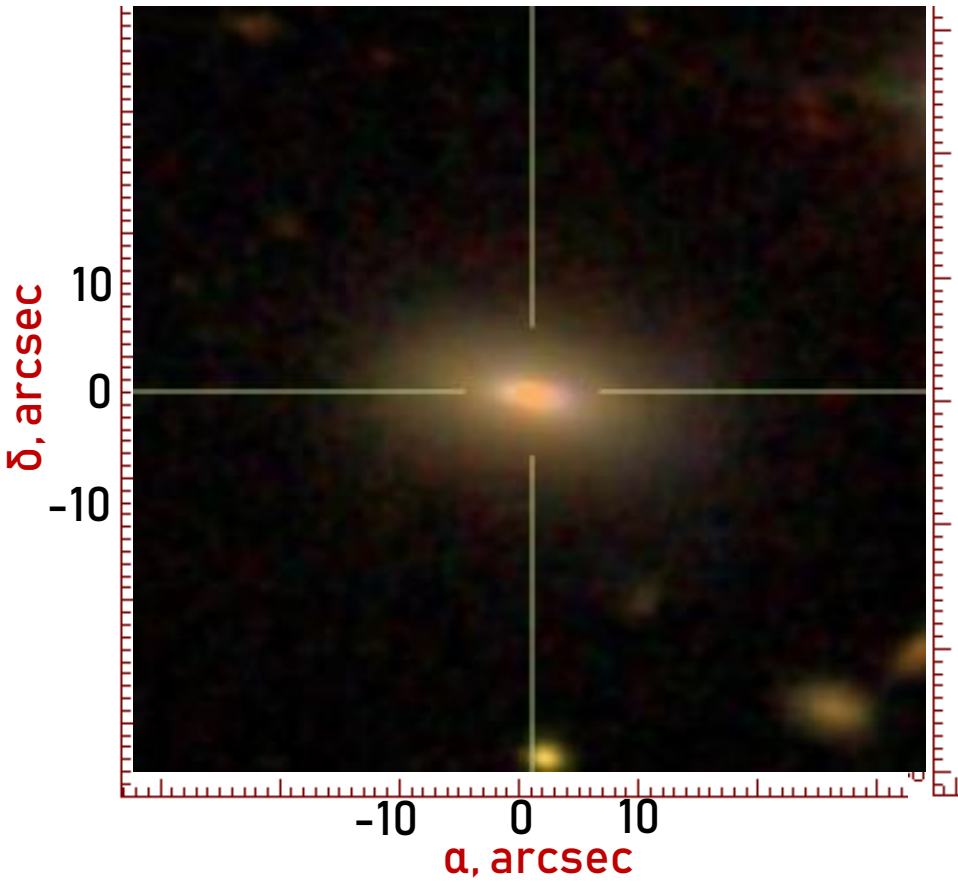
Assumption of the presence of EELR clouds from SDSS image (Keel et al., 2012)



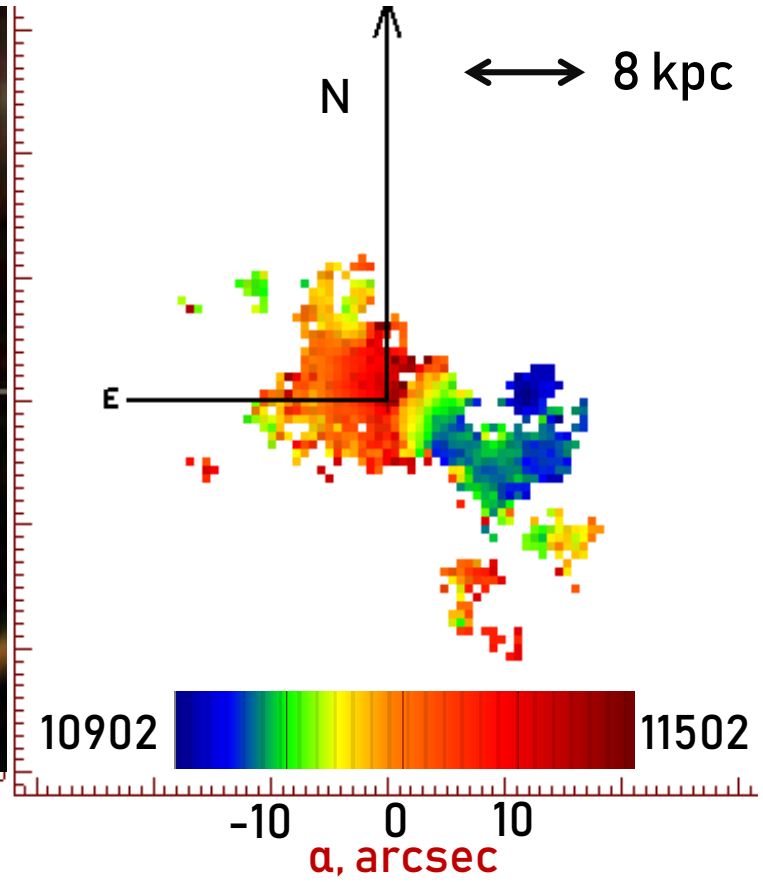




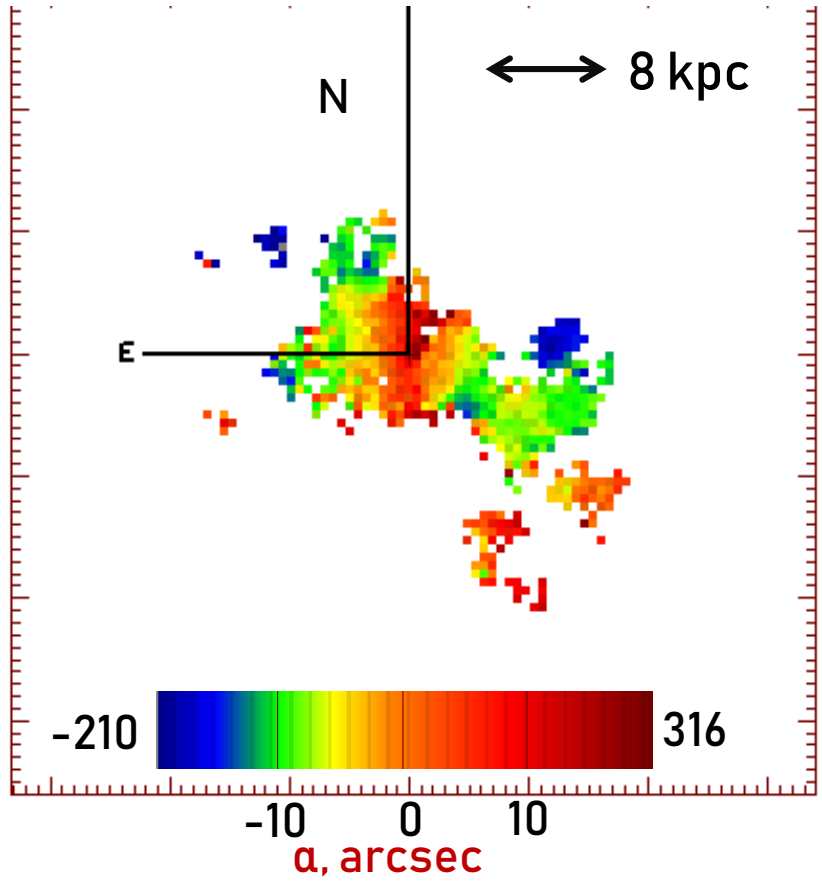
Current results. 3 D spectroscopy



SDSS image



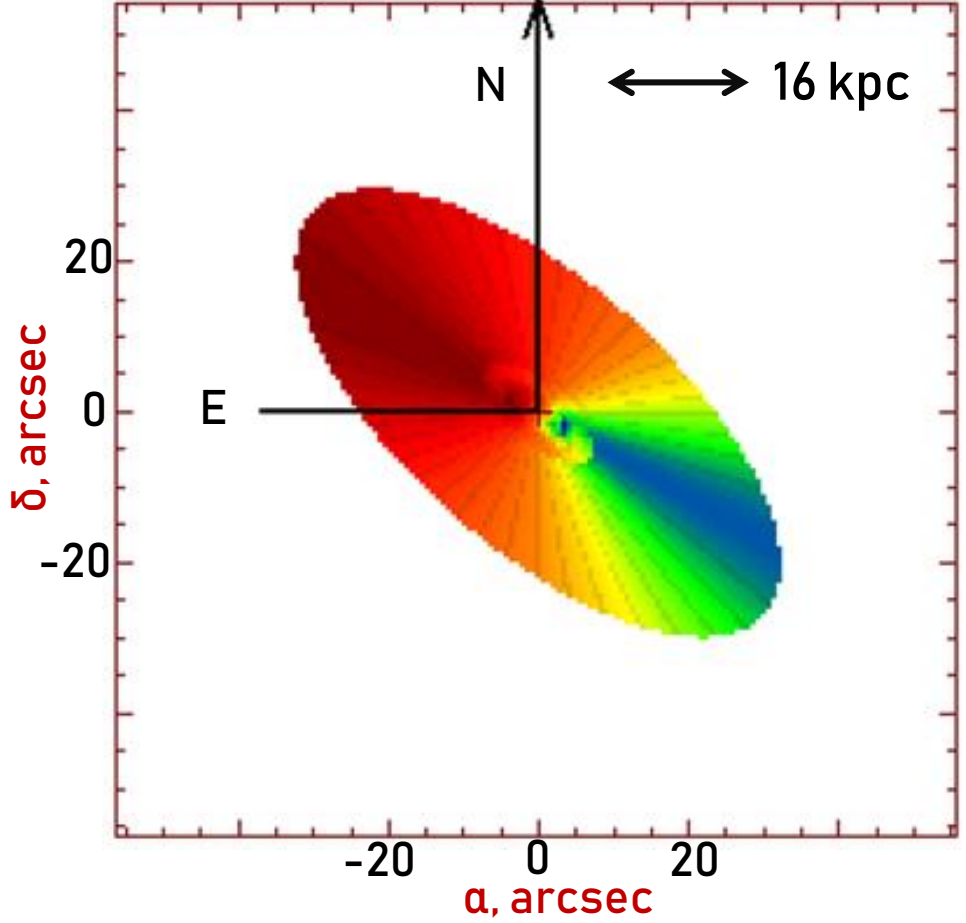
[OIII] velocity

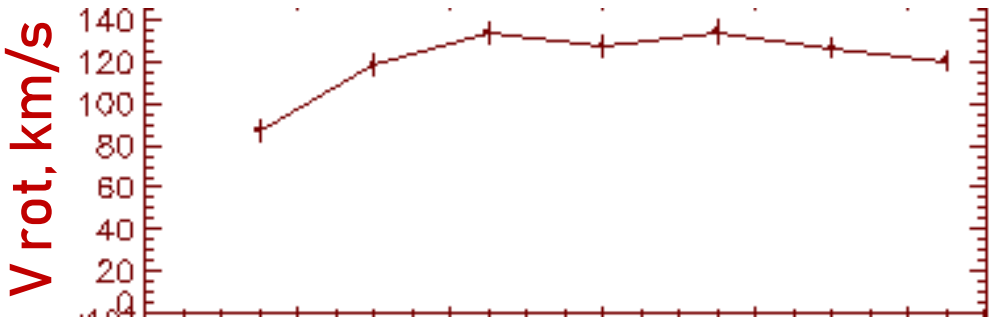


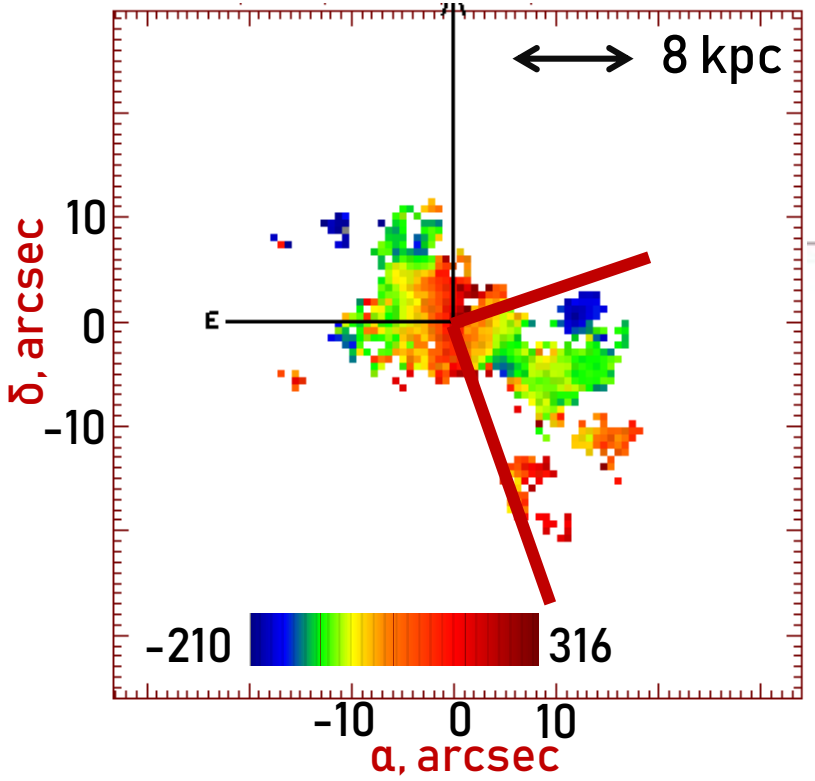
[OIII] residual velocity

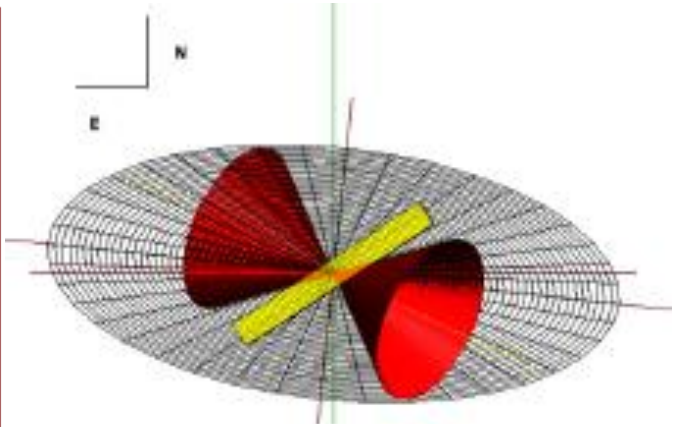
PA=84° i=64° Scale: 0.7 arcsec/pix

Vsys=11159.0 km/s









T.C.Fischer et al., 2011

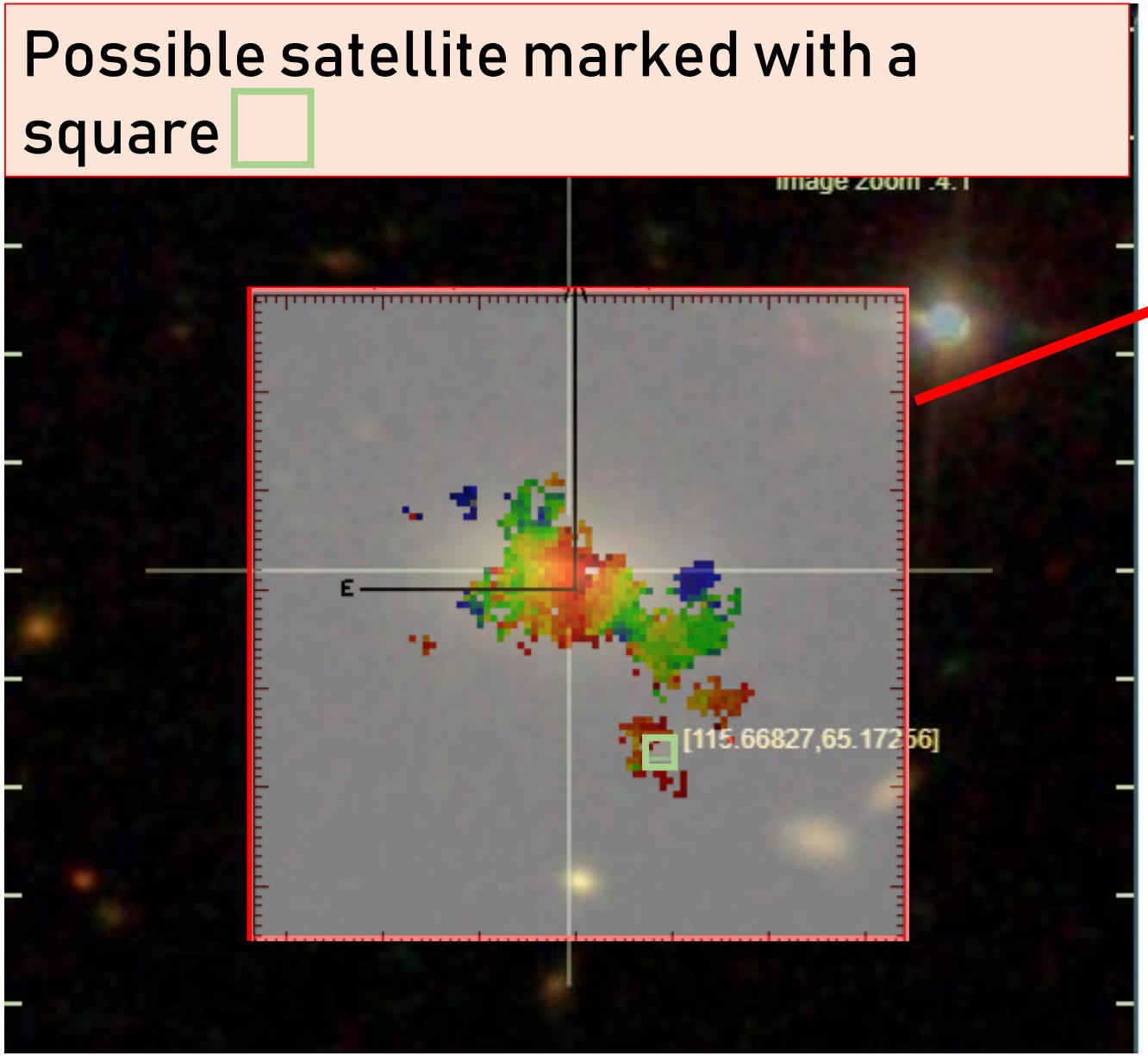
Jet-clouds interaction – central regions' gas residual velocity ~ 300 km/s

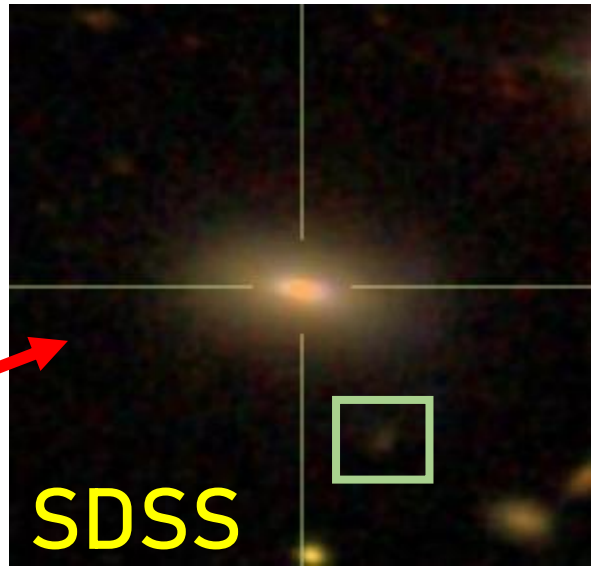
Off-plane gas structures – residual velocity ~ 250-300 km/s .

Ionized by AGN – structures are in ionization cones.

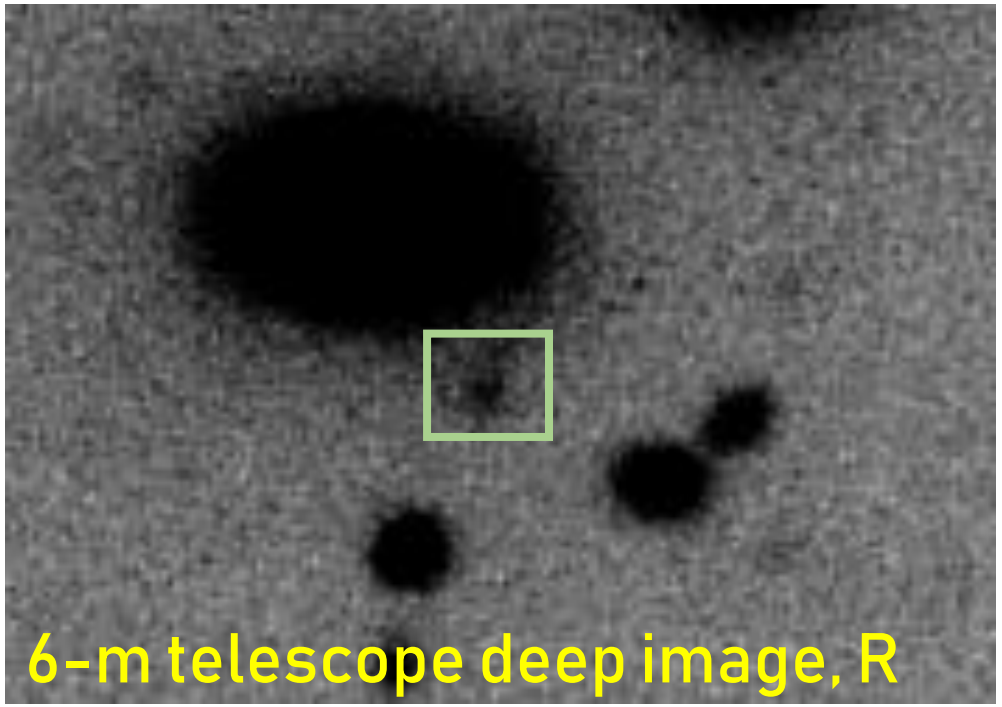
Structures' distance from the nucleus – ~11 kpc and ~12 kpc

Possible satellite marked with a square

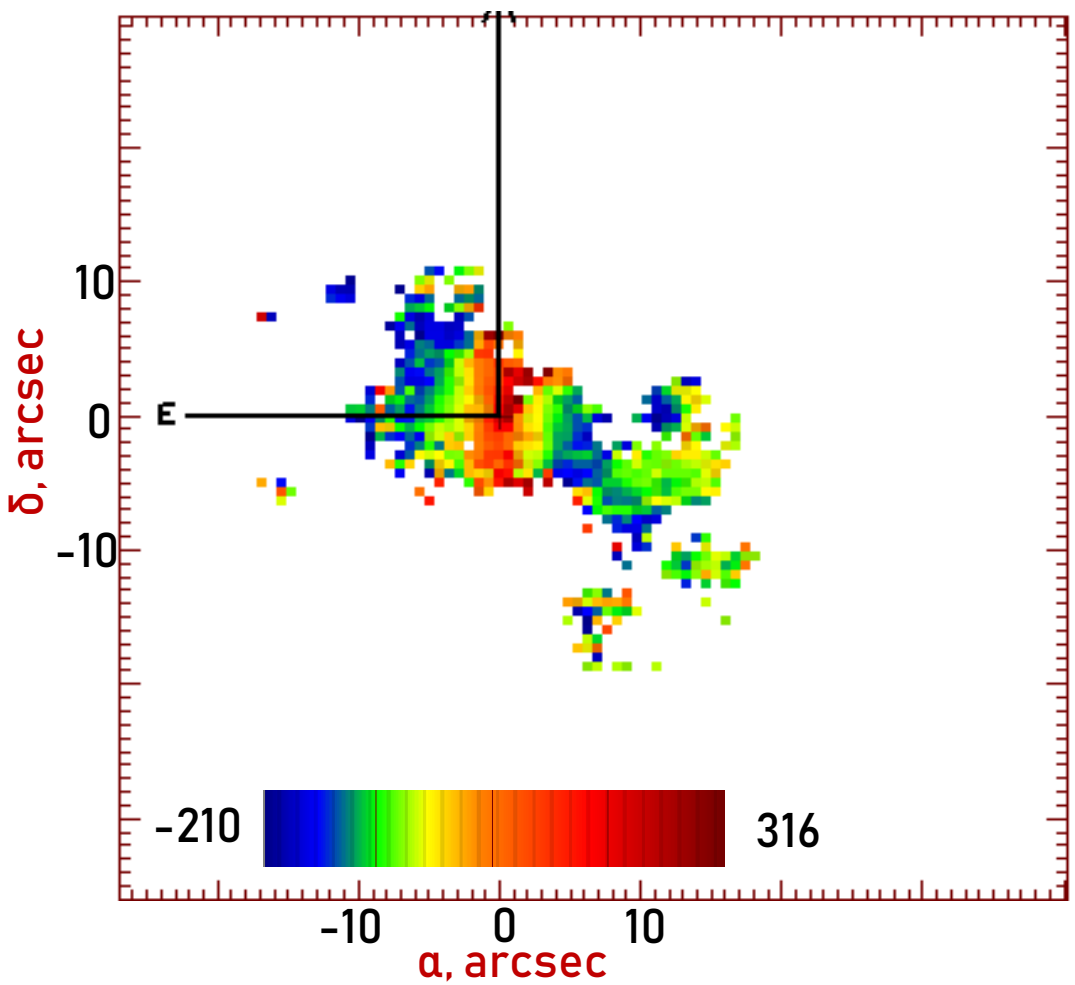


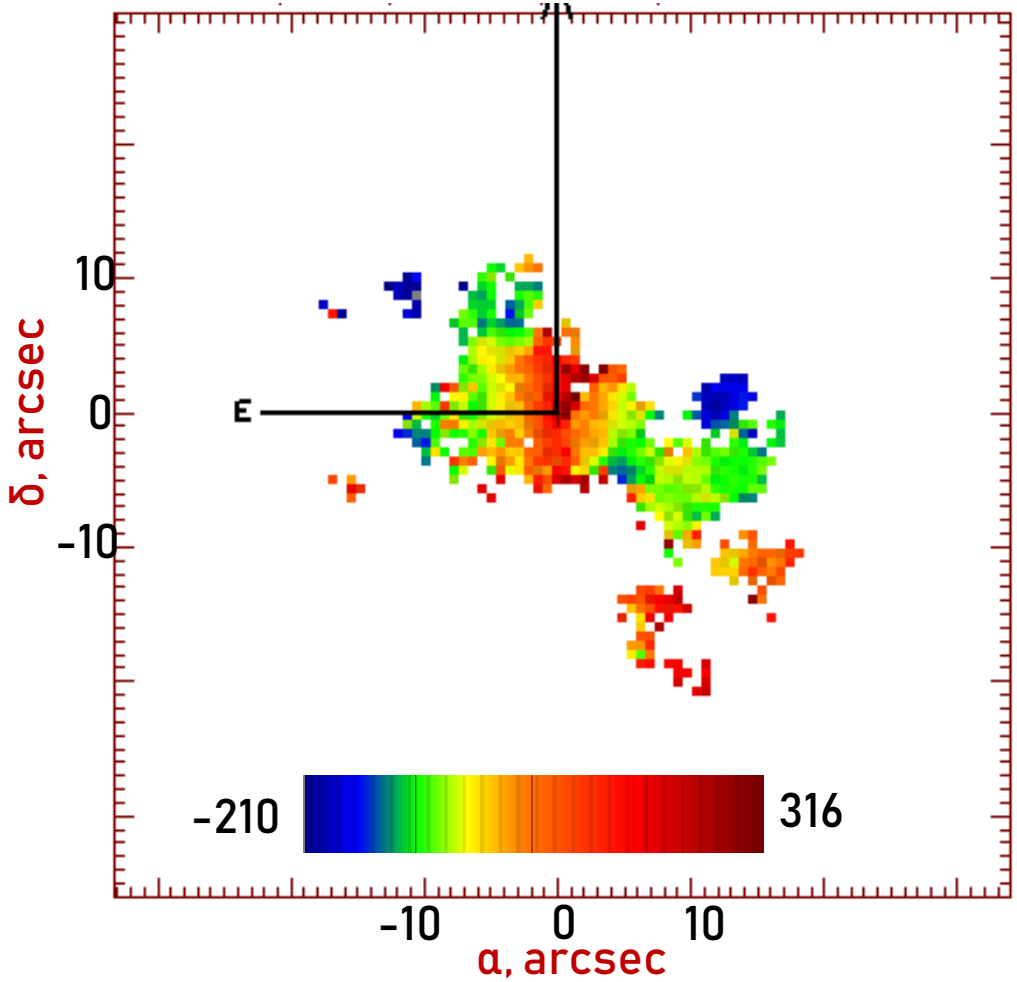


ra	115.66822
dec	65.17262
type	GALAXY
u	24.25
g	22.38
r	21.44
i	21.10
z	20.87



Model selection

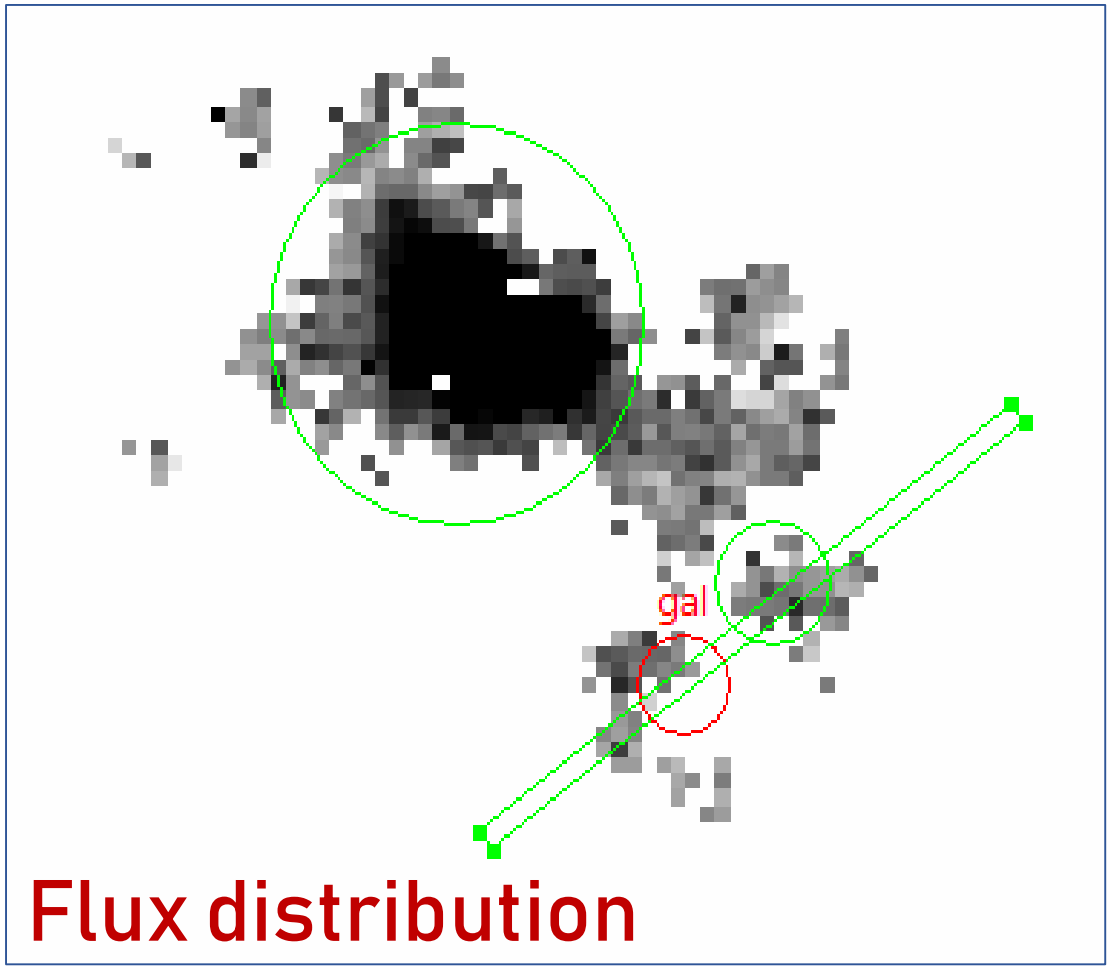




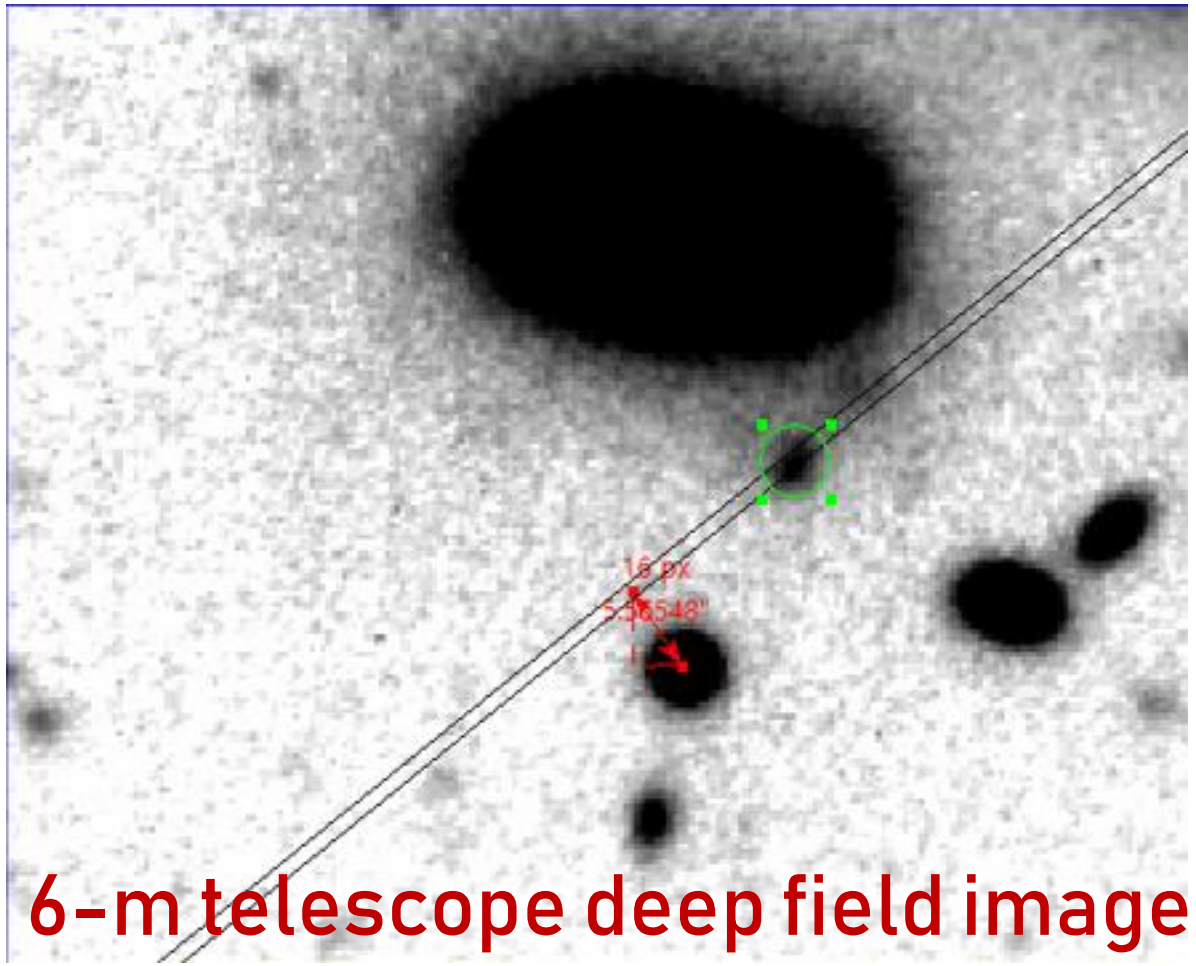
Probably, there are clouds out of the stellar disk but in the same plane and above stellar disk

Current results. Long-slit spectroscopy

Slit position



Flux distribution



6-m telescope deep field image

Current results. Long-slit spectroscopy

- Observed emission lines:

  Hβ, [OIII]λλ4959,5007, [N II]λλ6548,6583, Hα, [S II]λλ6717,6731

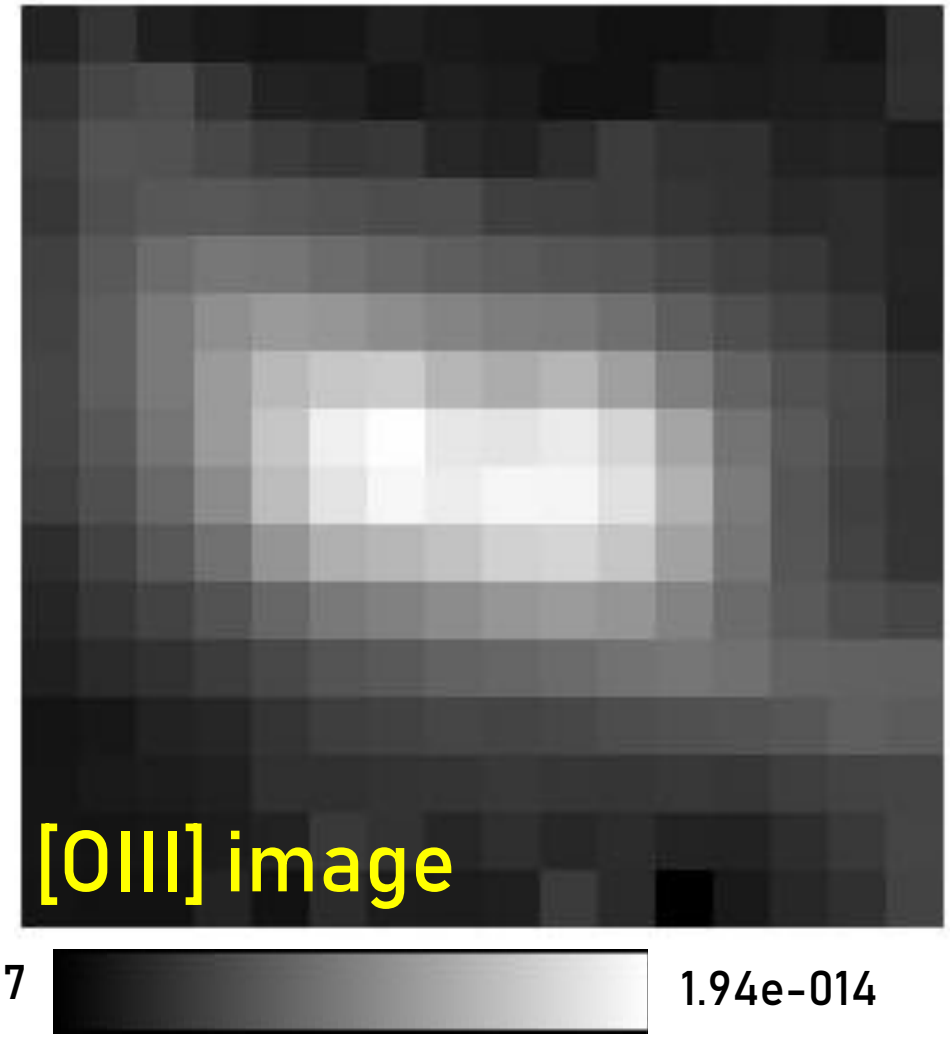
- 4 ([S II]) < S/N < 32 ([OIII])
- Observed Mrk 78 distance: z=0.037
- Observed dim galaxy distance: z=0.308

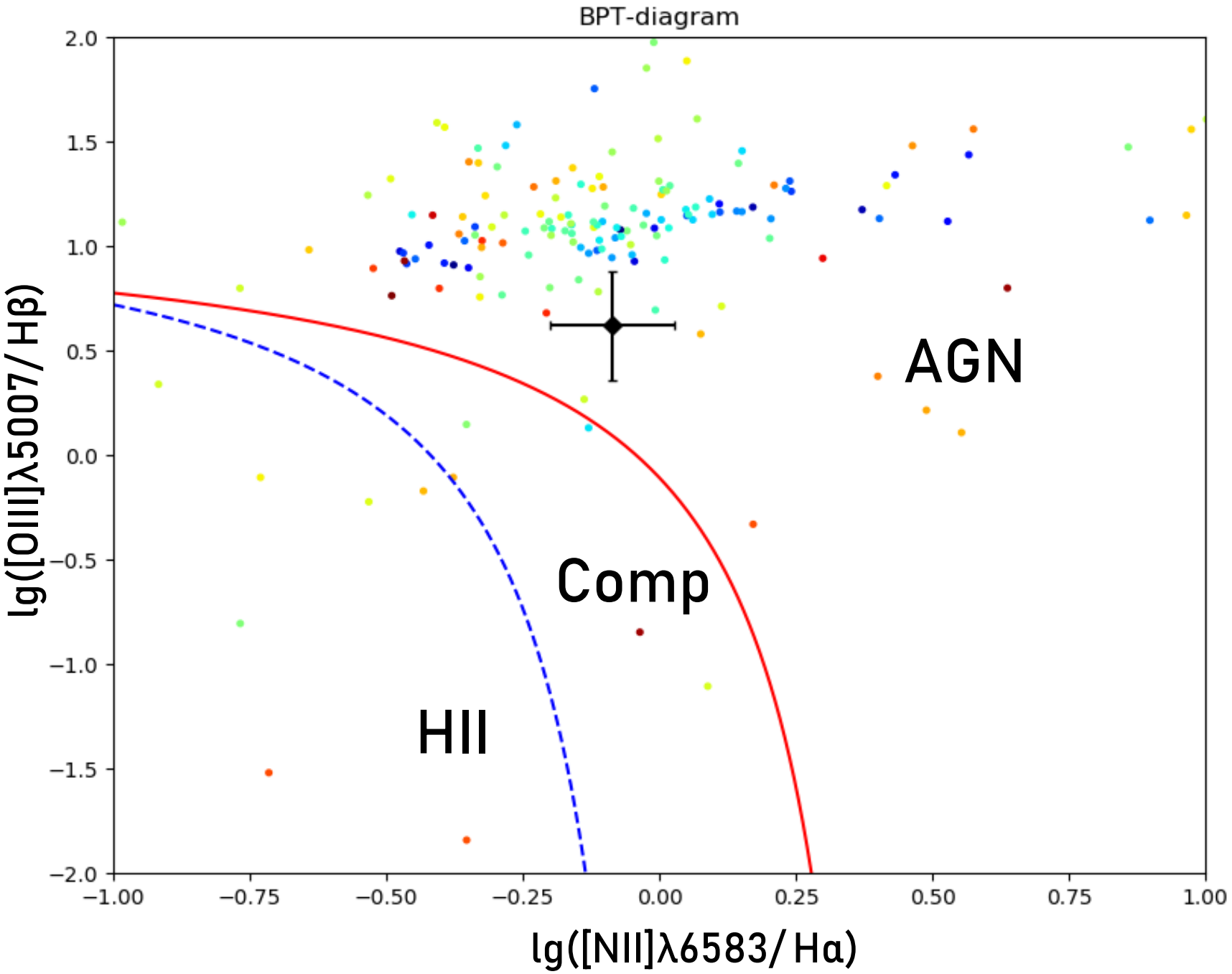
  It is distant background galaxy.

3 D spectroscopy with Integral-field Multi-Pupil Field Spectrograph

- Field size: 16x16 pix^2
- Scale: 1 arcsec/pix
- Field-of-view centered at the nucleus

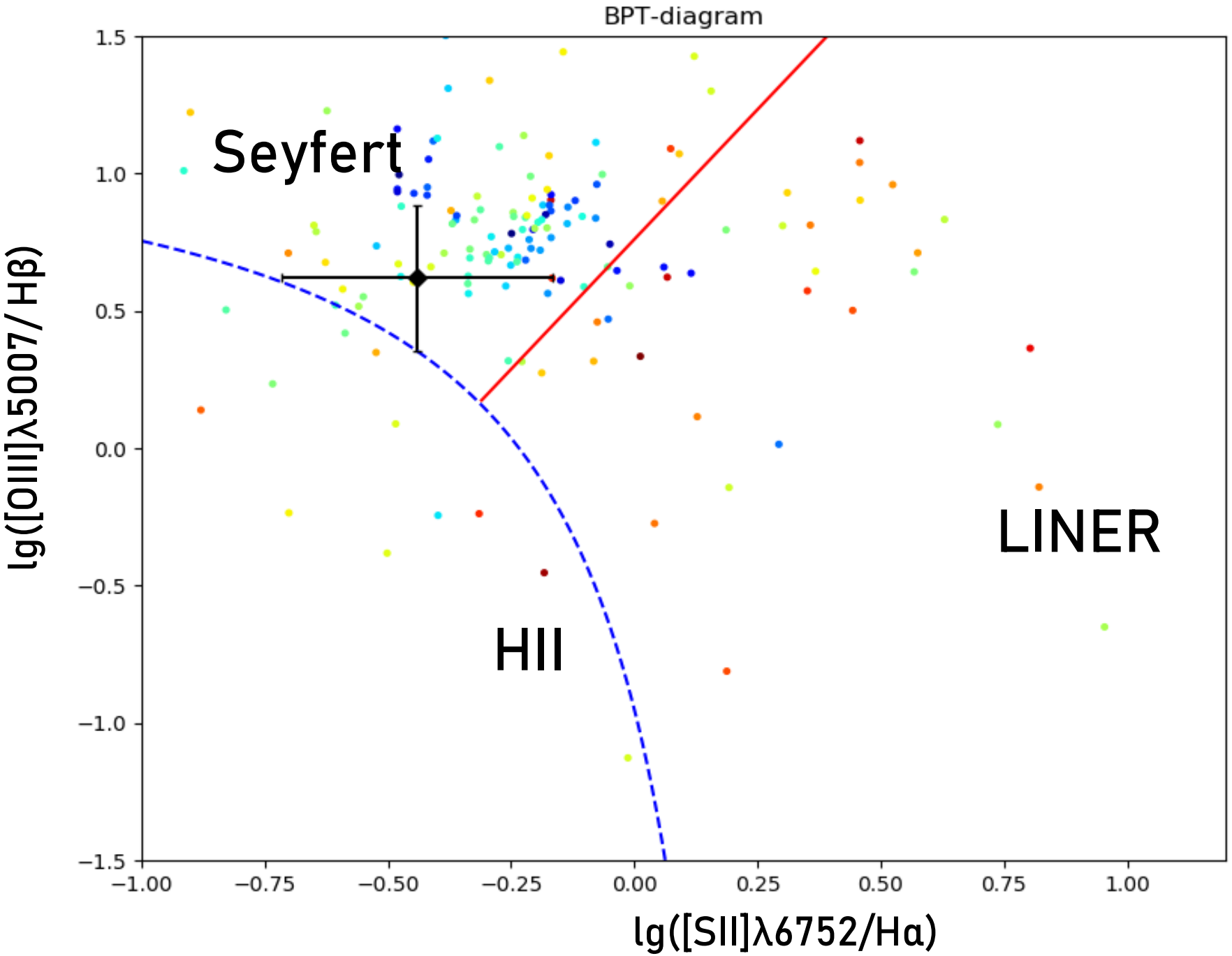
Now we can compare ionization state of the circumnuclear gas and ionization state of the off-plane structures





Optical diagnostic diagram: Baldwin, Phillips & Terlevich, 1981

Separated branches: Kewley et al.,2006



Optical diagnostic diagram: Baldwin, Phillips & Terlevich, 1981

Separated branches: Kewley et al.,2006

Conclusion

1. There are ionized by AGN gas structures laying at the distance ~12kpc apart from Mrk 78 nucleus;
2. Probably, there are not only off-plane gas structures but also structures out of the stellar disk;
3. The source of external gas accretion is unknown, we have not found any signs of the galaxy interaction with environment.

Thank you for attention!