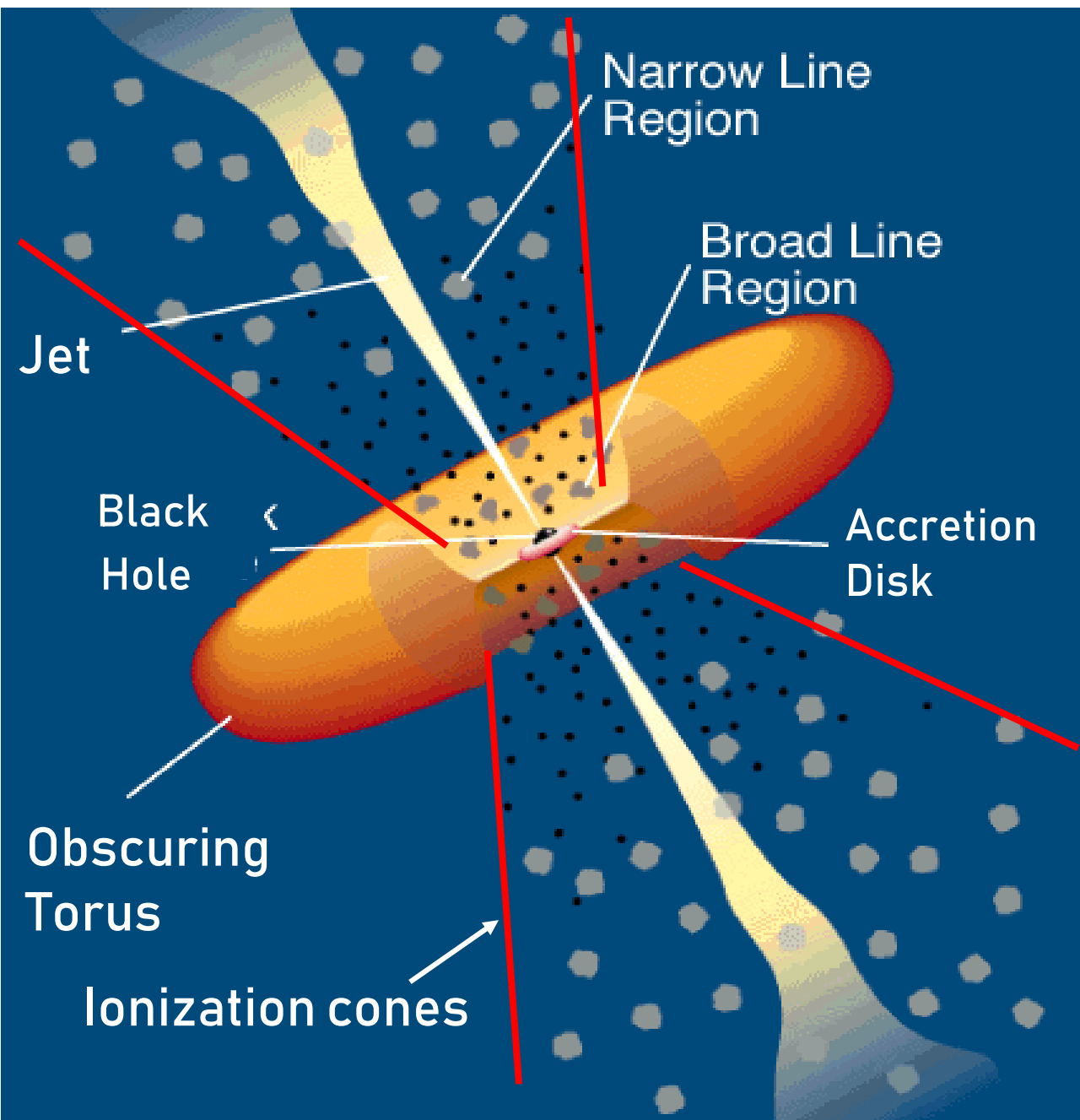


Extended ionized-gas structures in Seyfert 2 galaxy Mrk78

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

Black hole in the center of the most galaxies



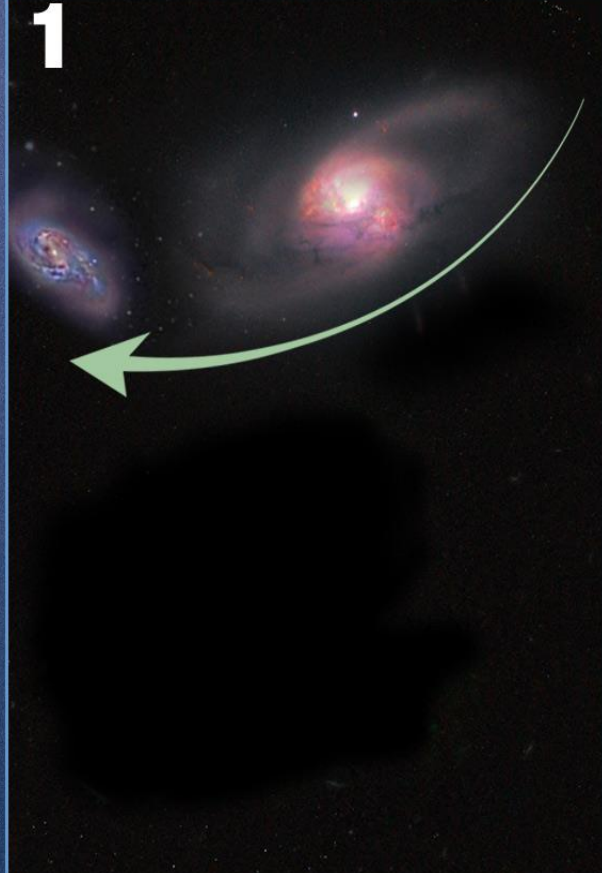
Gas accretion in central regions (e.g., during interaction between galaxies)



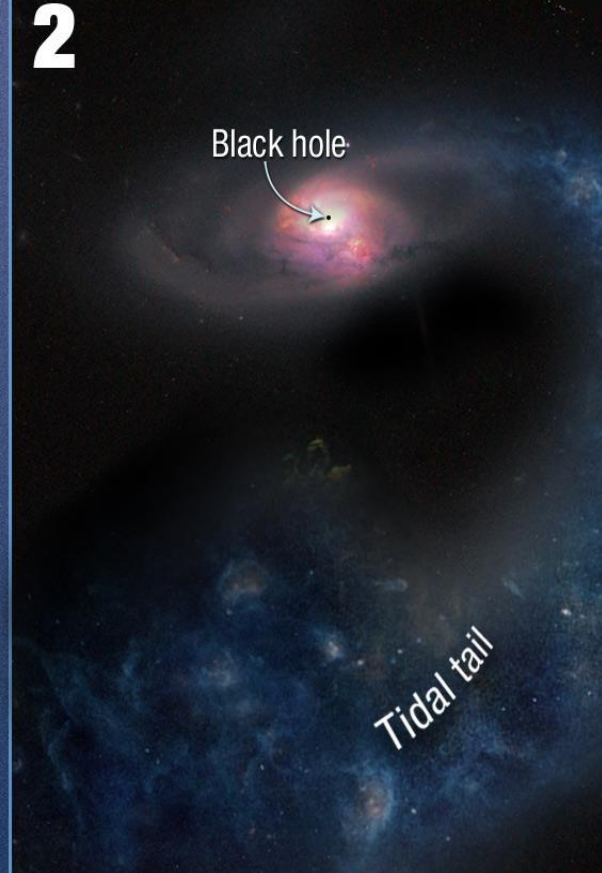
Temporary nucleus activity

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

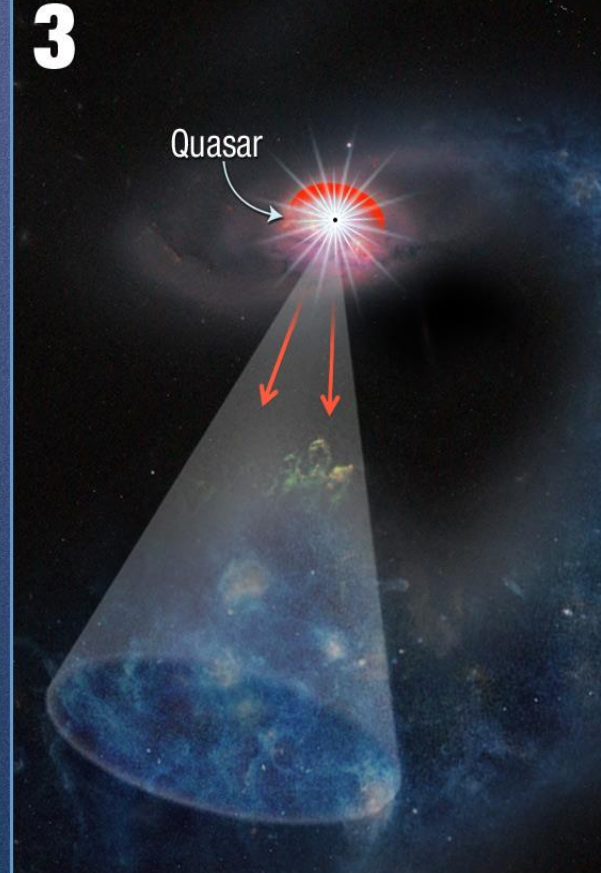
Hanny's Voorwerp Object



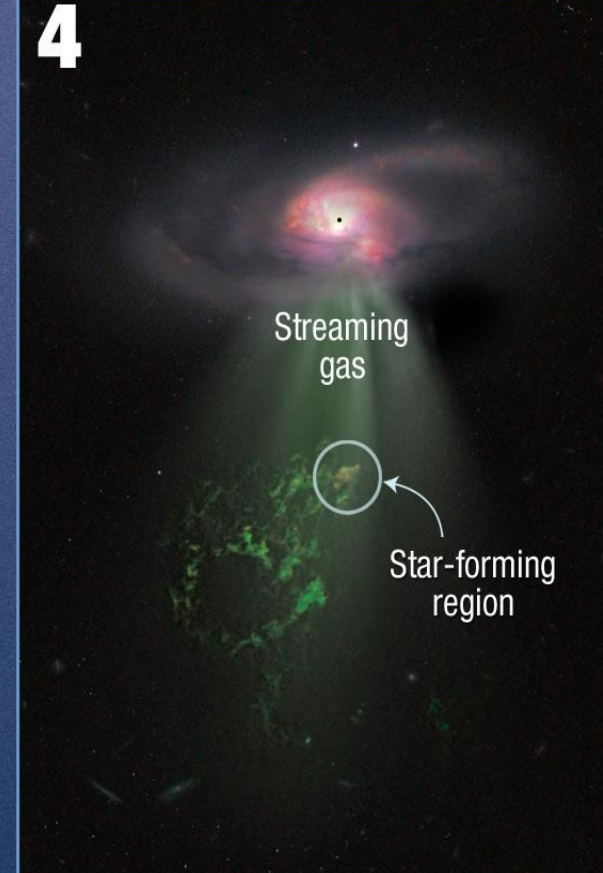
Interaction with nearby galaxy



Off-plane tidal tail



Part of the structure is in the ionization cone



Observable extended emission-line region

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**

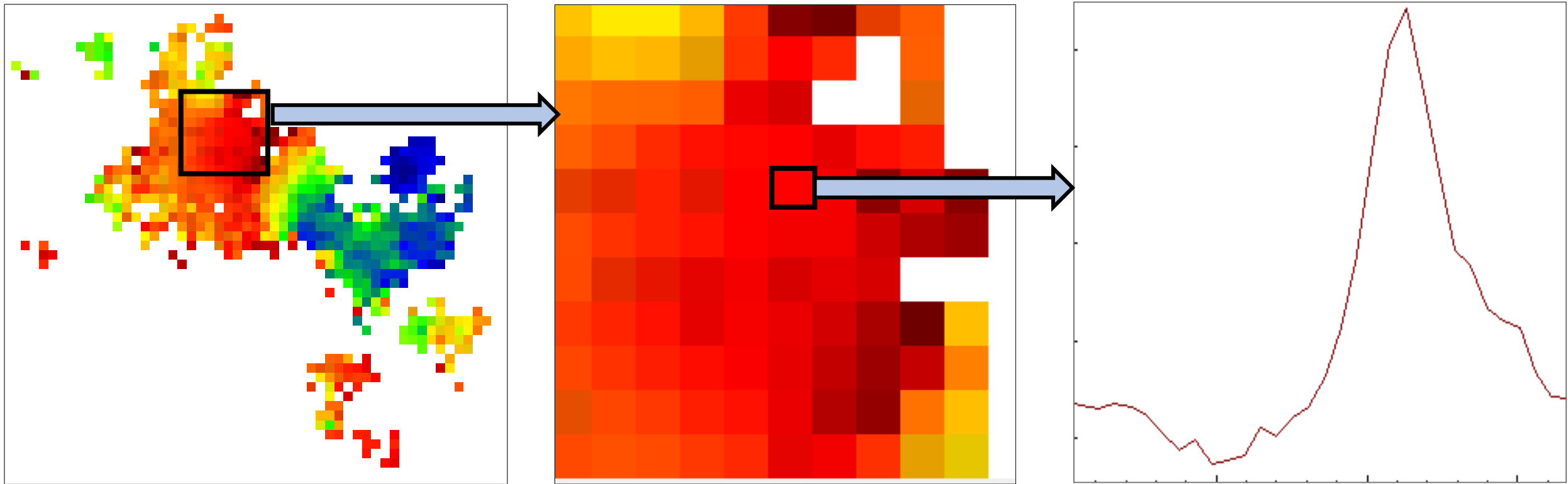
Observations at the 6-m Russian telescope

- 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)



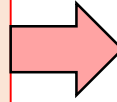
Analysis of IFP 3 D spectroscopy data

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

$$V_{obs}(r, PA) = V_{sys} + V_{rot}(R(r)) \frac{\cos(PA - PA_0) \sin i}{(1 + \sin^2(PA - PA_0) \tan^2 i)^{1/2}}$$

$$R(r) = r(1 + \sin^2(PA - PA_0) \tan^2 i)^{1/2}$$

i – inclination of orbits

PA_0 – kinematics major axis position angle

V_{rot} – rotation velocity

V_{sys} – nucleus velocity (systematic velocity)

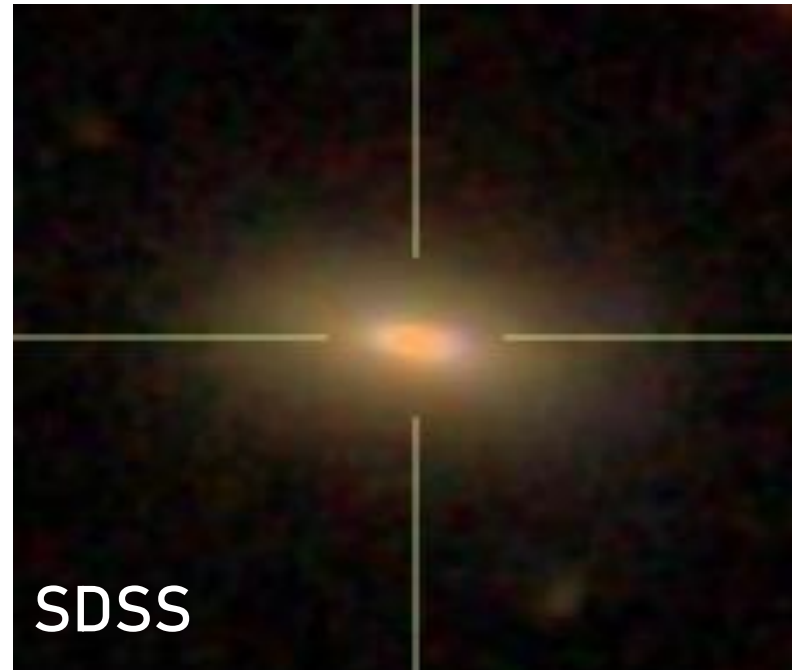
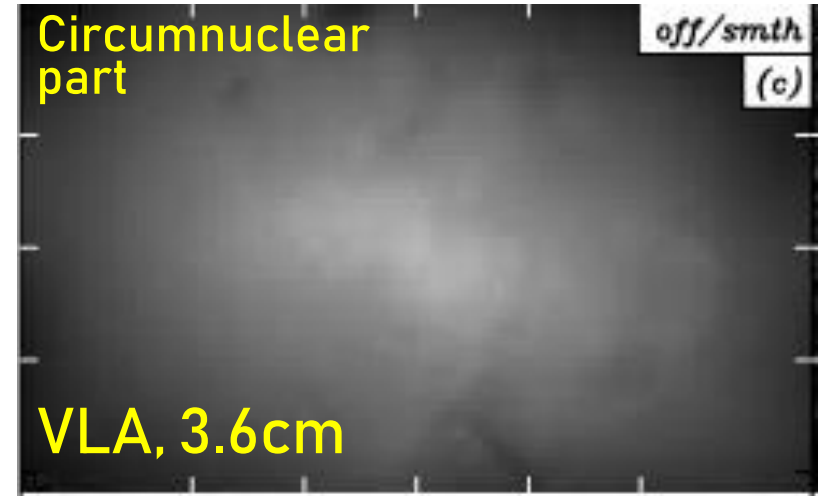
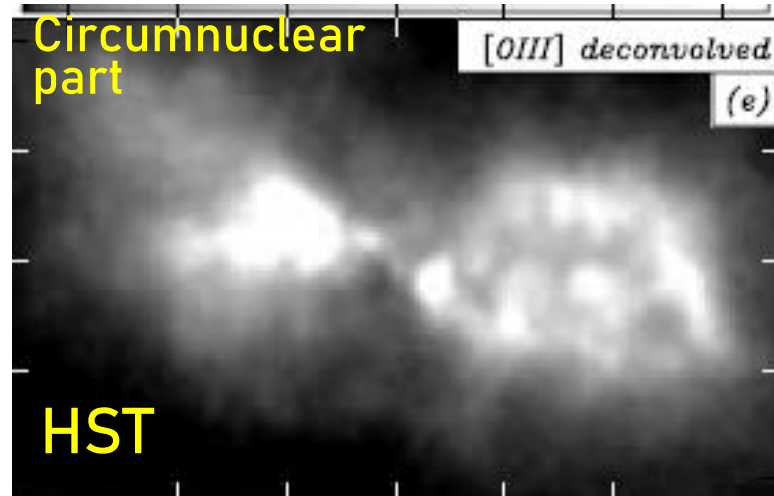
r – distance from the nucleus

Mrk78

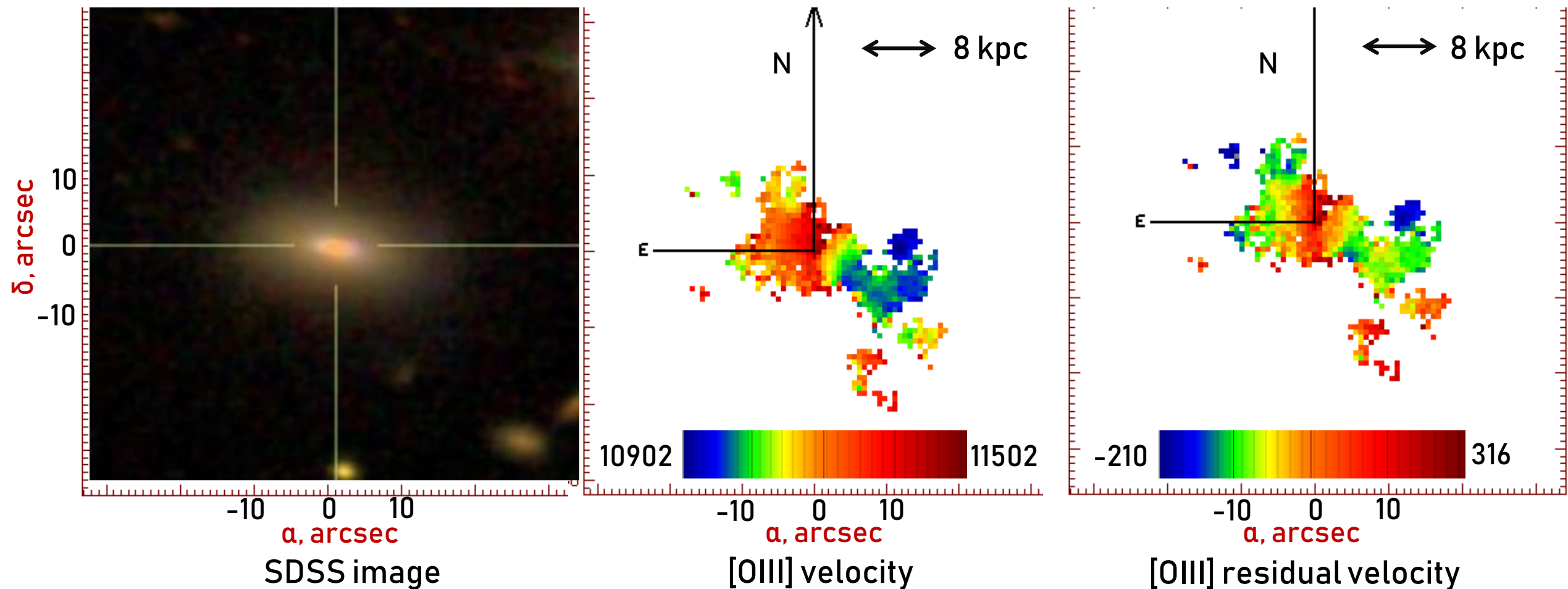
- Type: Seyfert 2
- Center: $\alpha=7\text{h}42\text{m}41\text{s}$
 $\delta=+65^{\circ}10'38''$
- Distance: $z=0.03715$
- Scale:
0.803 kpc/arcsec.

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

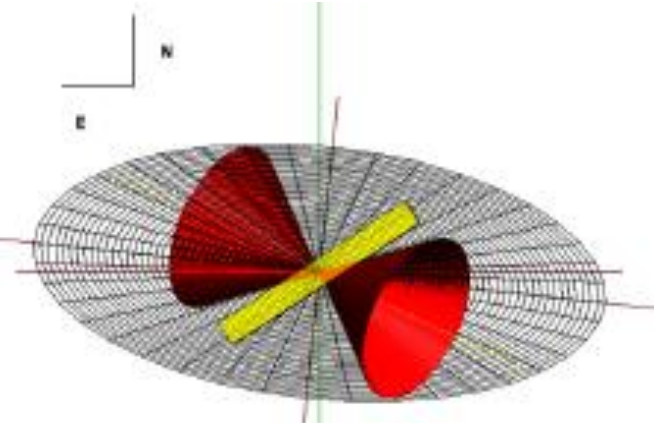
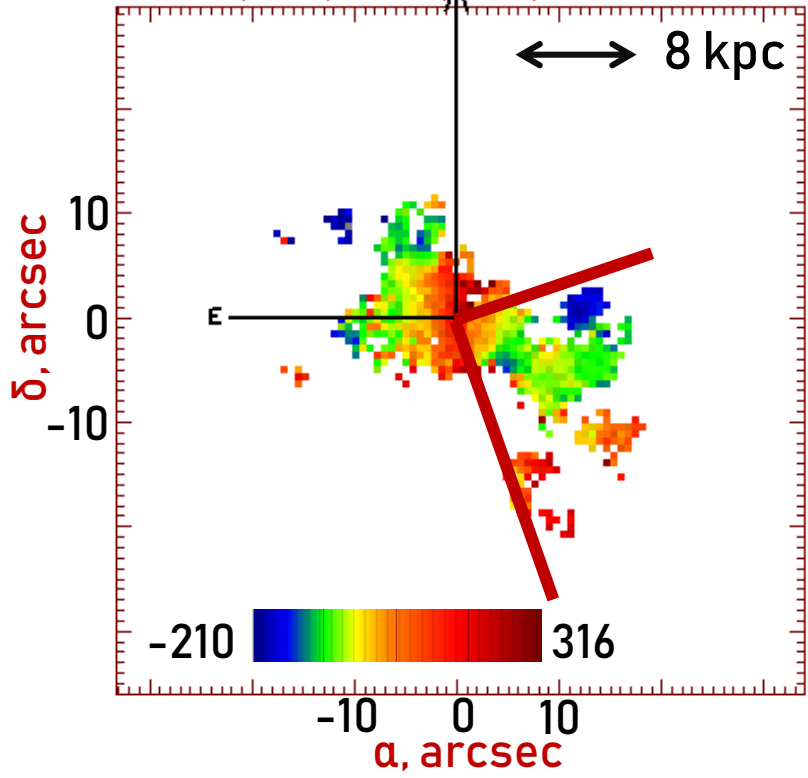
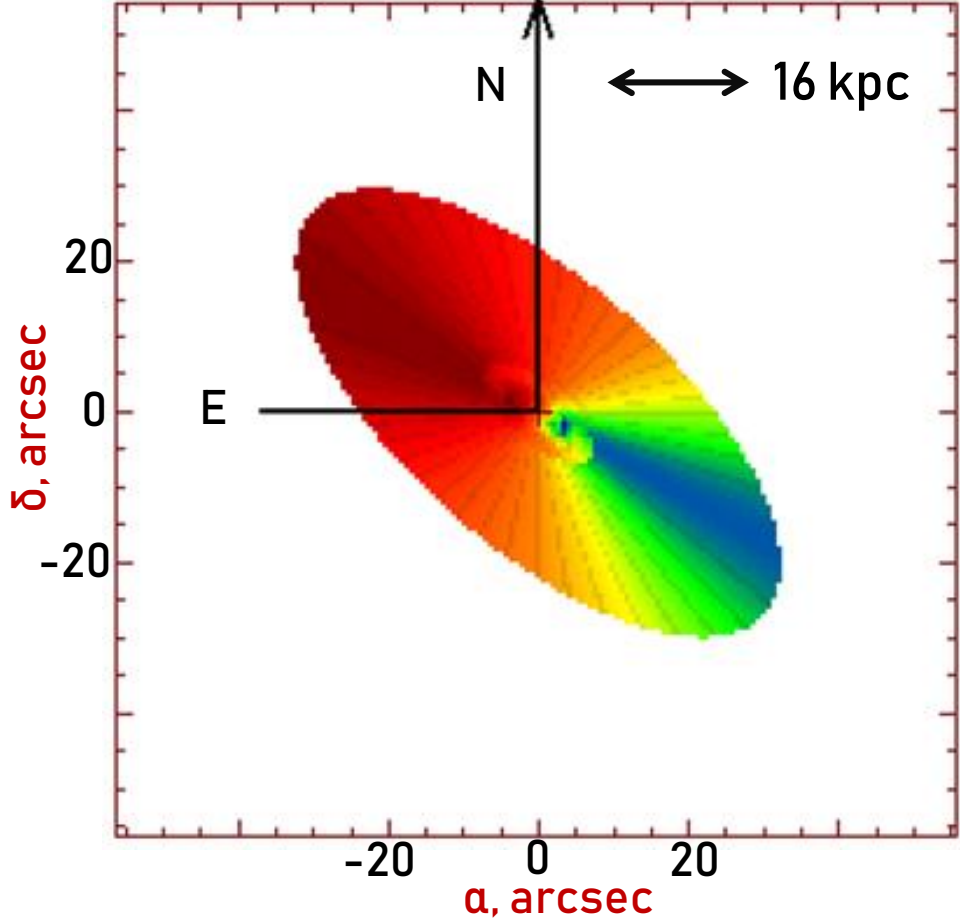


PA=84°

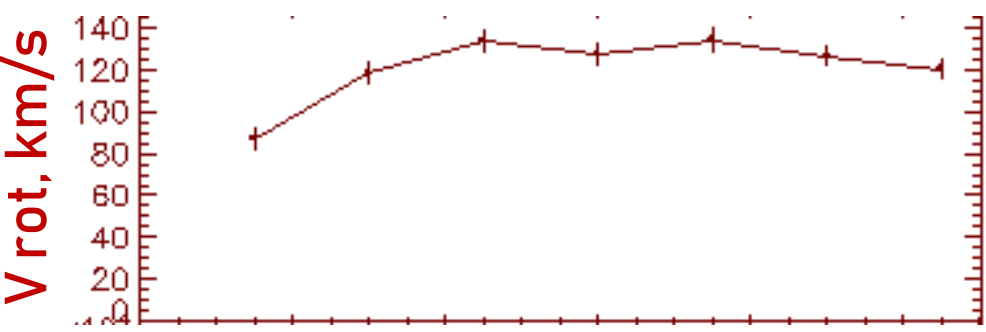
$i=64^\circ$

Scale: 0.7 arcsec/pix

$V_{\text{sys}}=11159.0$ km/s

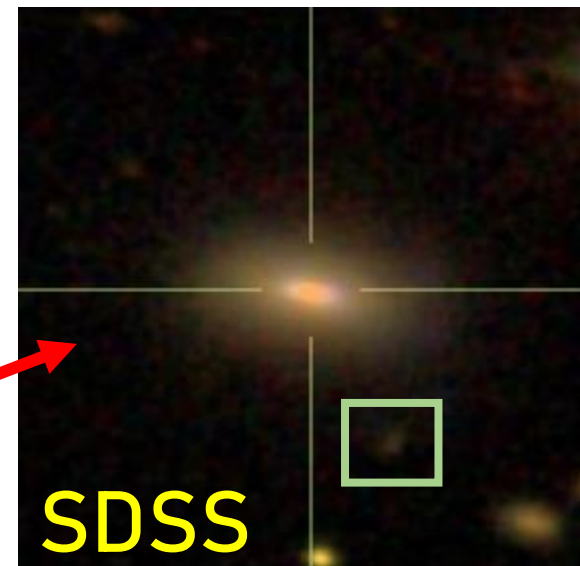
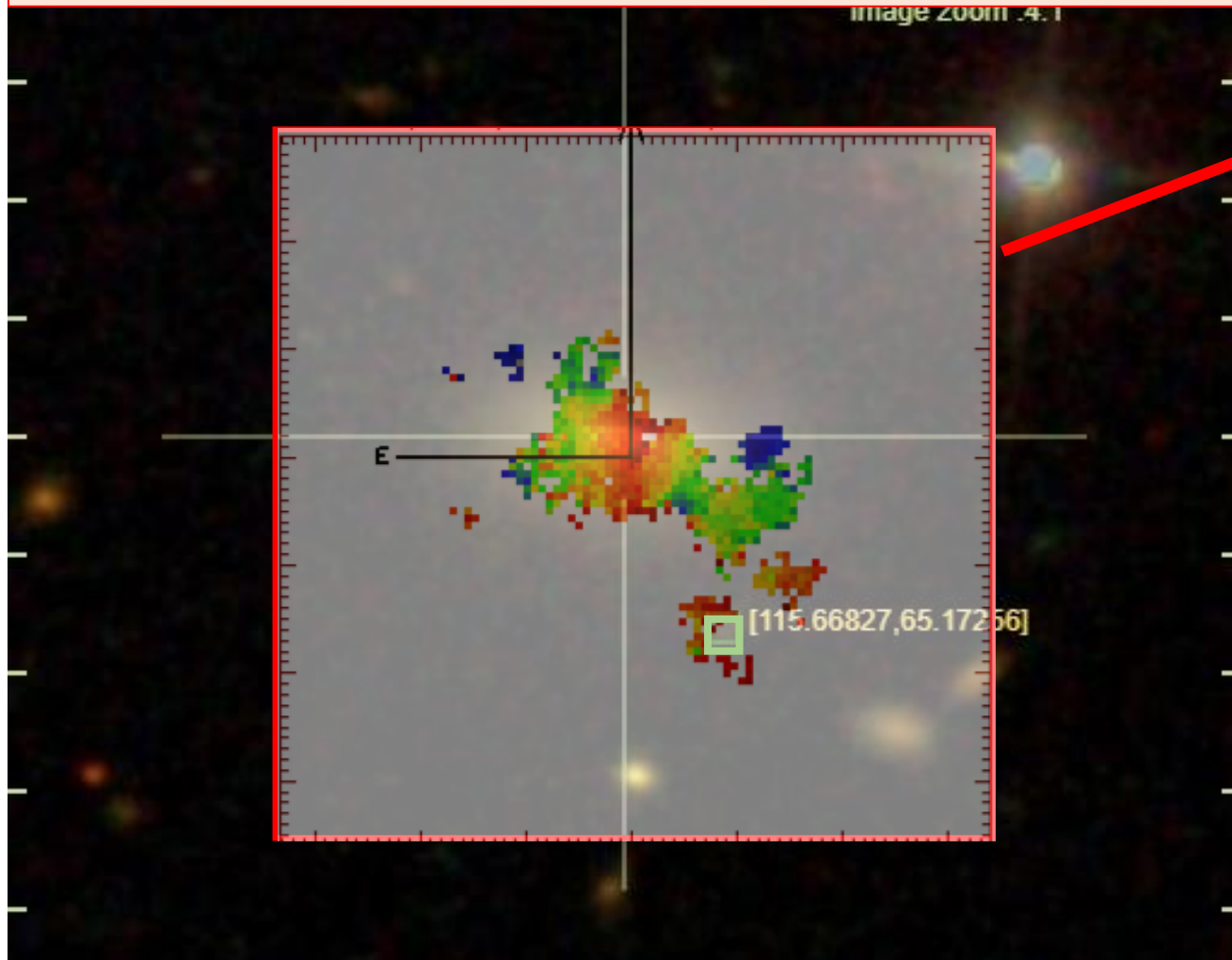


T.C.Fischer et al., 2011

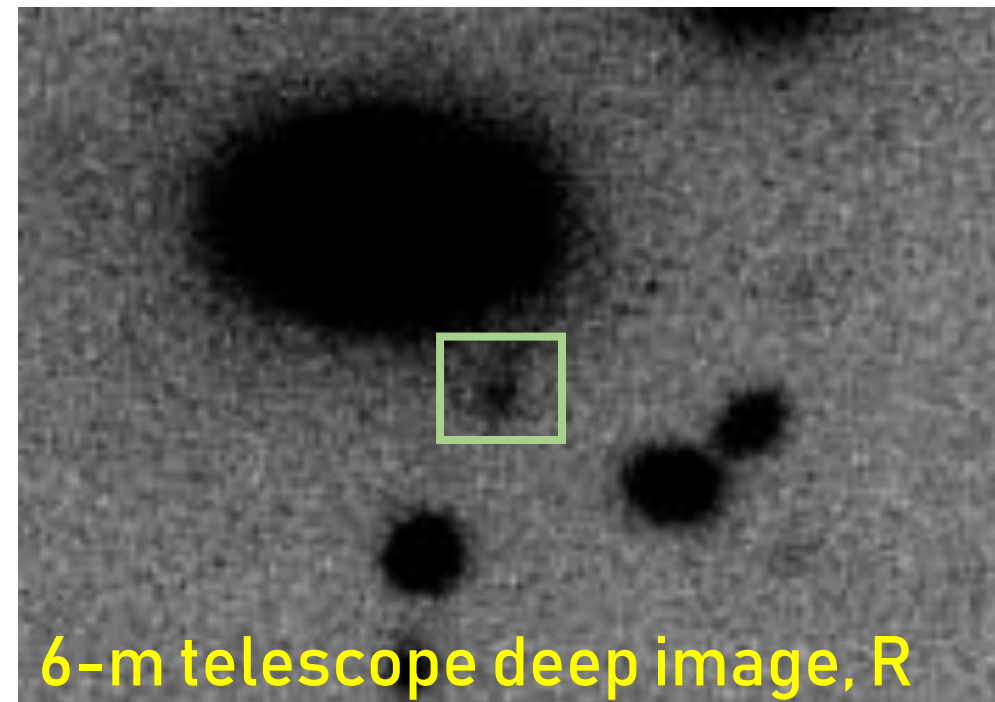


- Jet-clouds interaction – central regions' gas residual velocity ~ 300 km/s
- Off-plane gas structures – residual velocity $\sim 250-300$ km/s.
- Ionized by AGN – structures are in ionization cones.
- Structures' distance from the nucleus – ~ 11 kpc and ~ 12 kpc

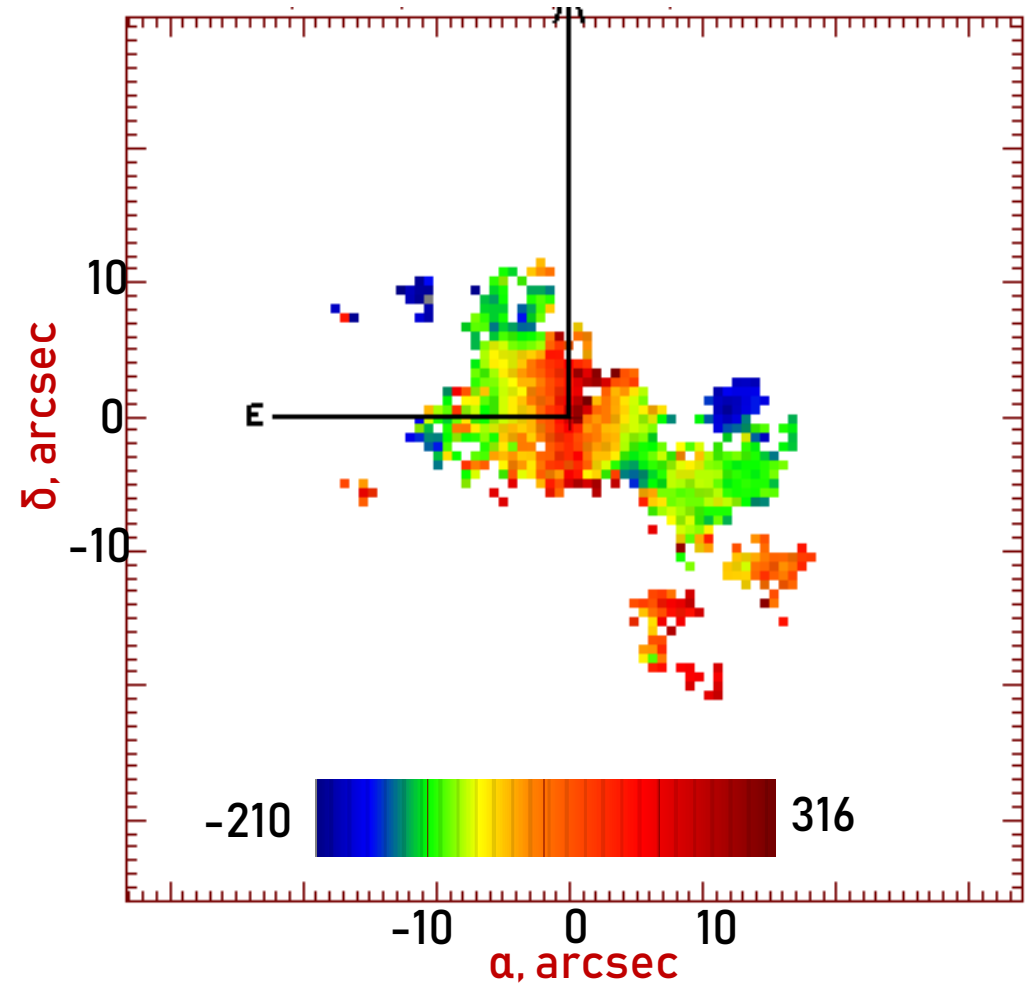
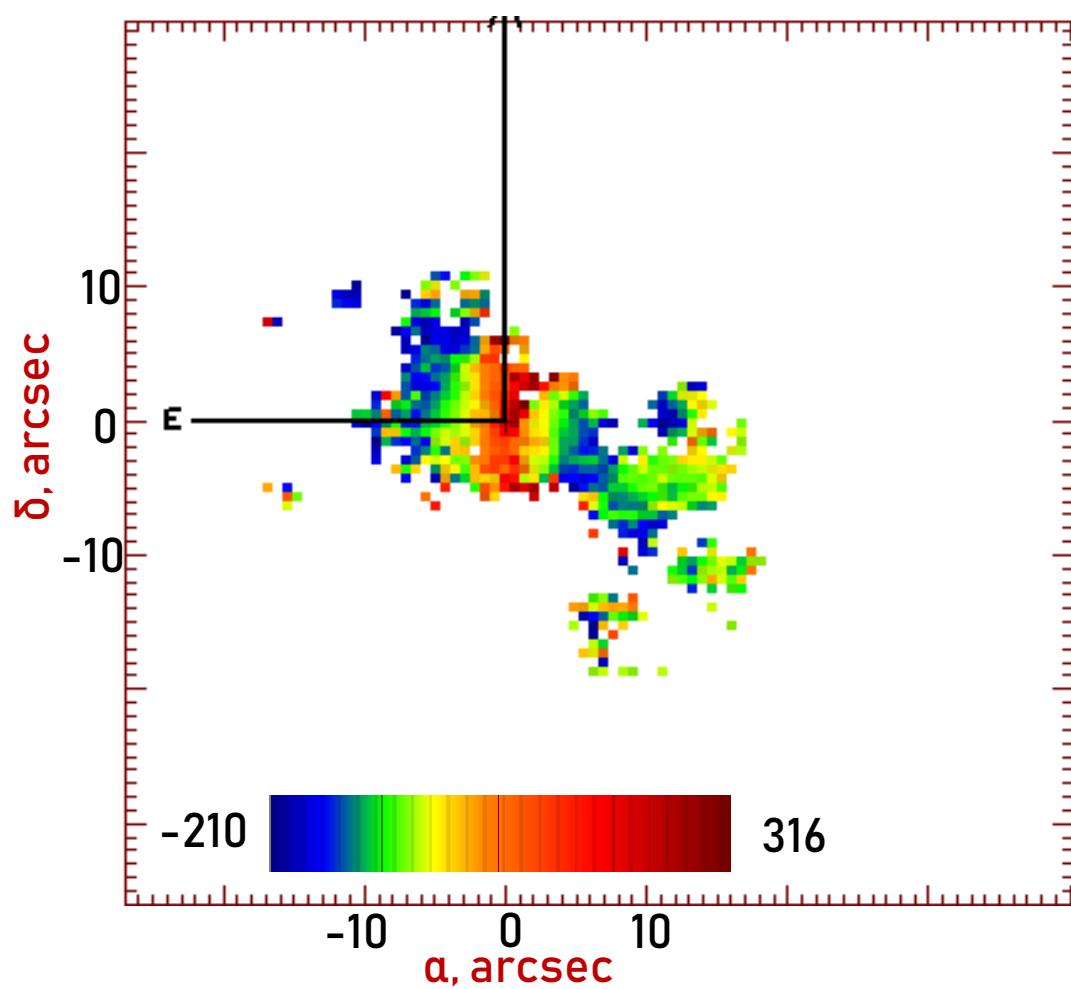
Possible satellite marked with a square 



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



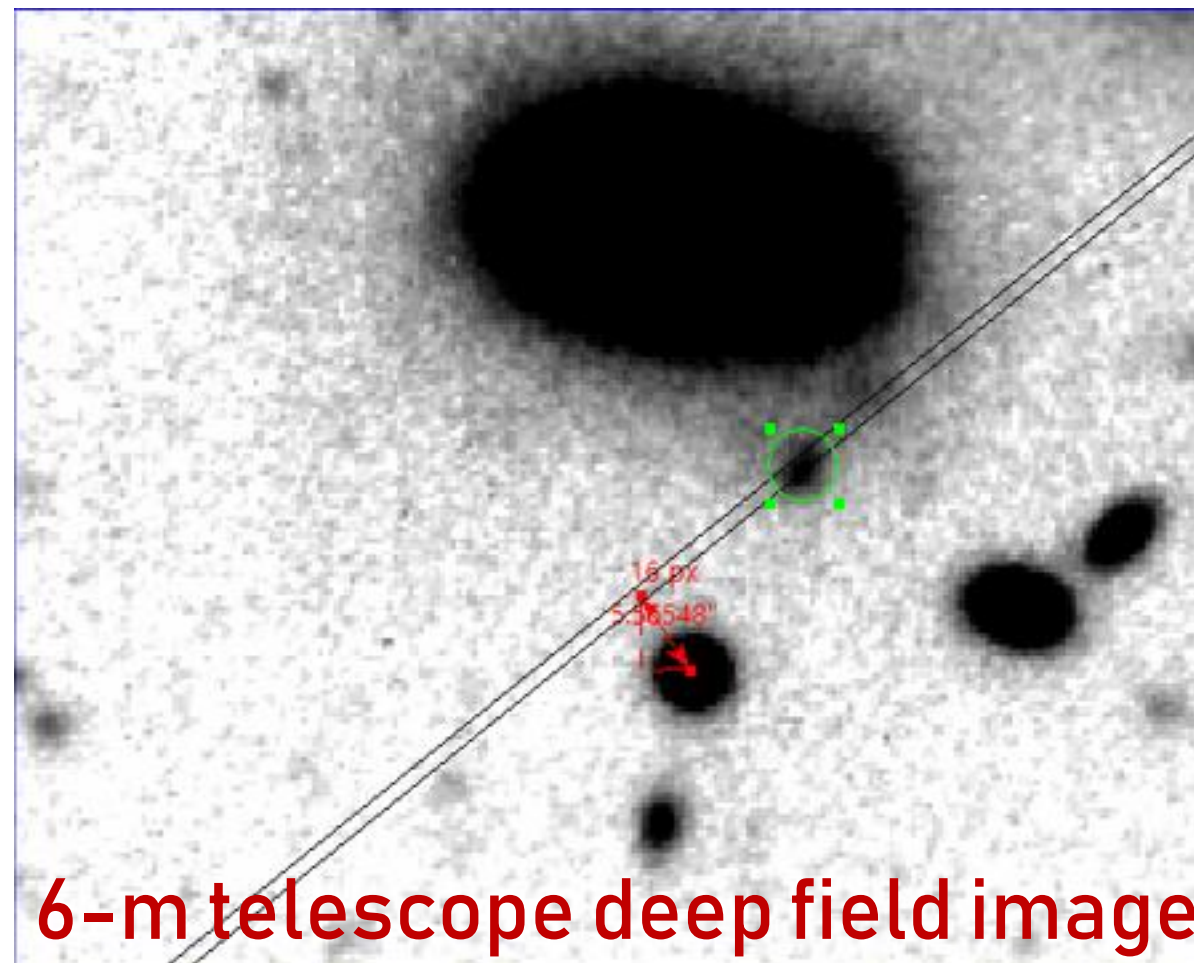
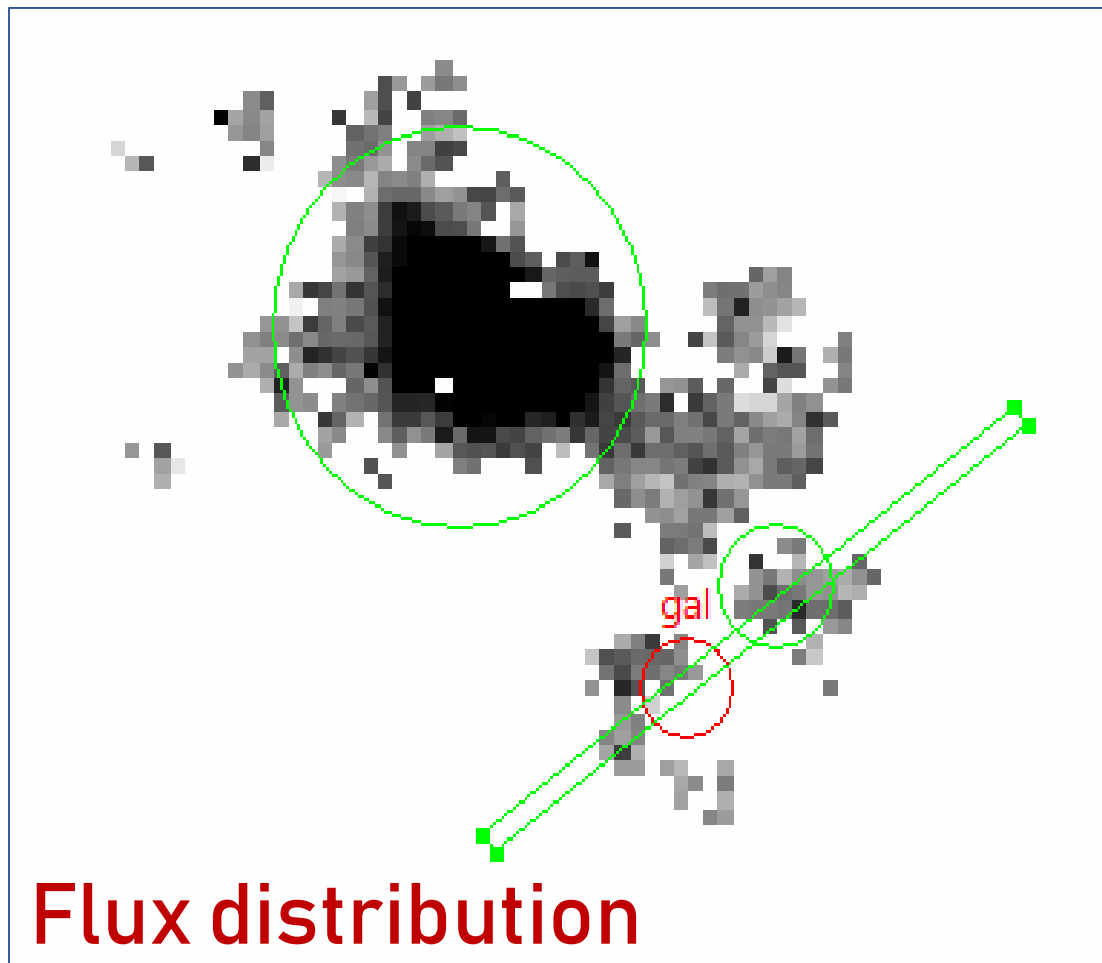
Model selection



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



Current results. Long-slit spectroscopy

- Observed emission lines:

$H\beta$, [O III] $\lambda\lambda$ 4959,5007, [N II] $\lambda\lambda$ 6548,6583, $H\alpha$,
[S II] $\lambda\lambda$ 6717,6731

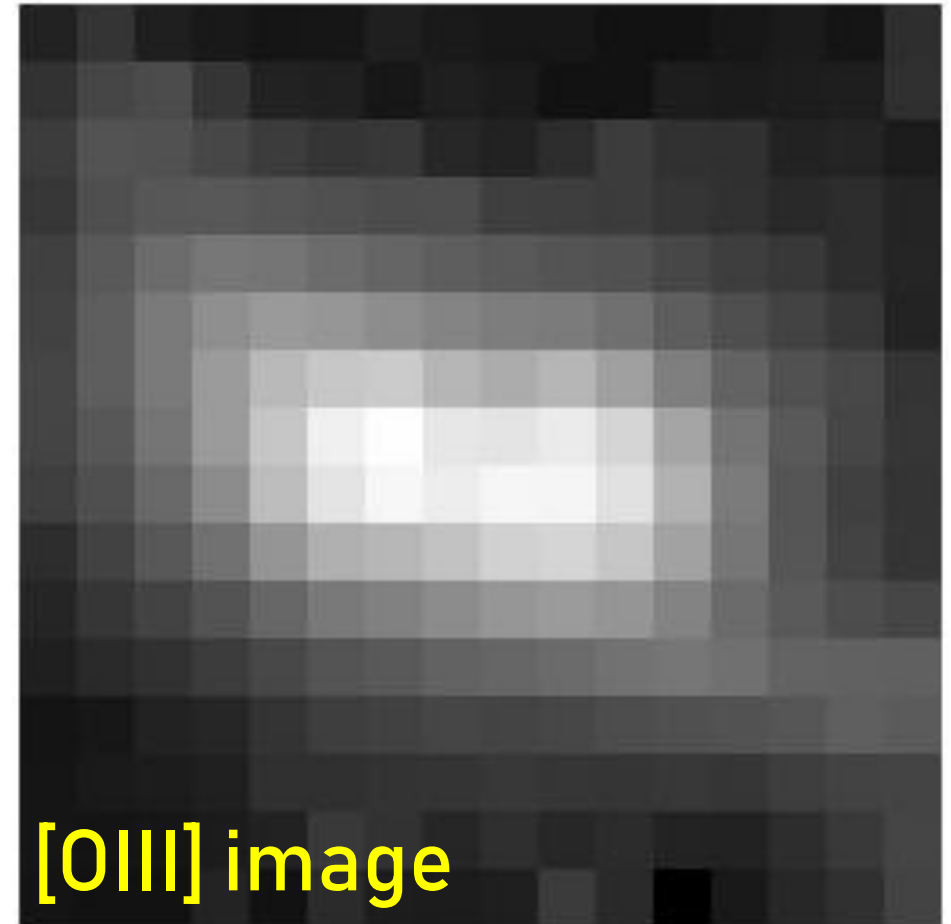
- 4 ([S II]) < S/N < 32 ([O III])
- Observed Mrk 78 distance: $z=0.037$
- Observed dim galaxy distance: $z=0.308$

It is distant background galaxy.

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

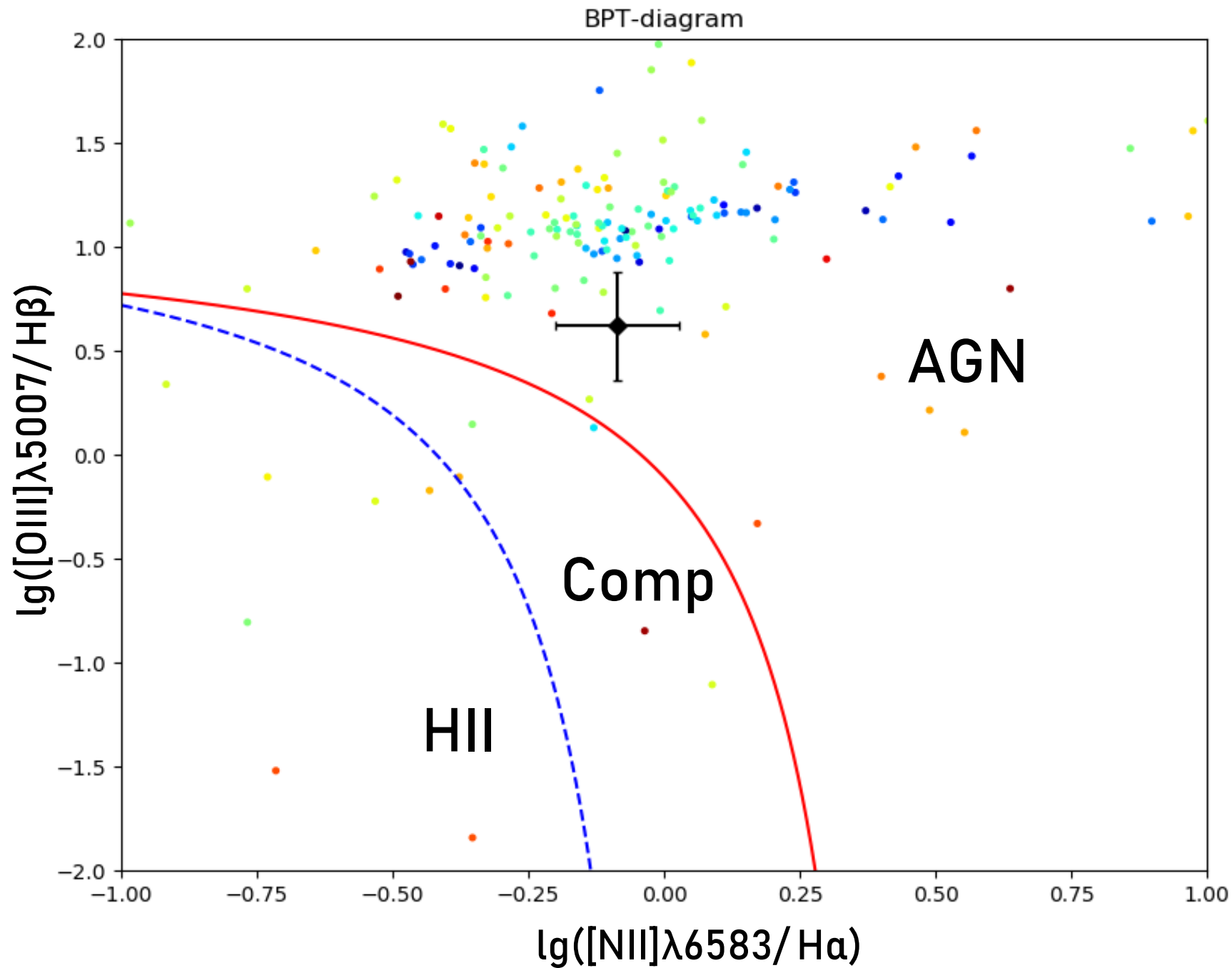
- Field size: 16x16 pix²
- Scale: 1 arcsec/pix
- Field-of-view centered at the nucleus

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



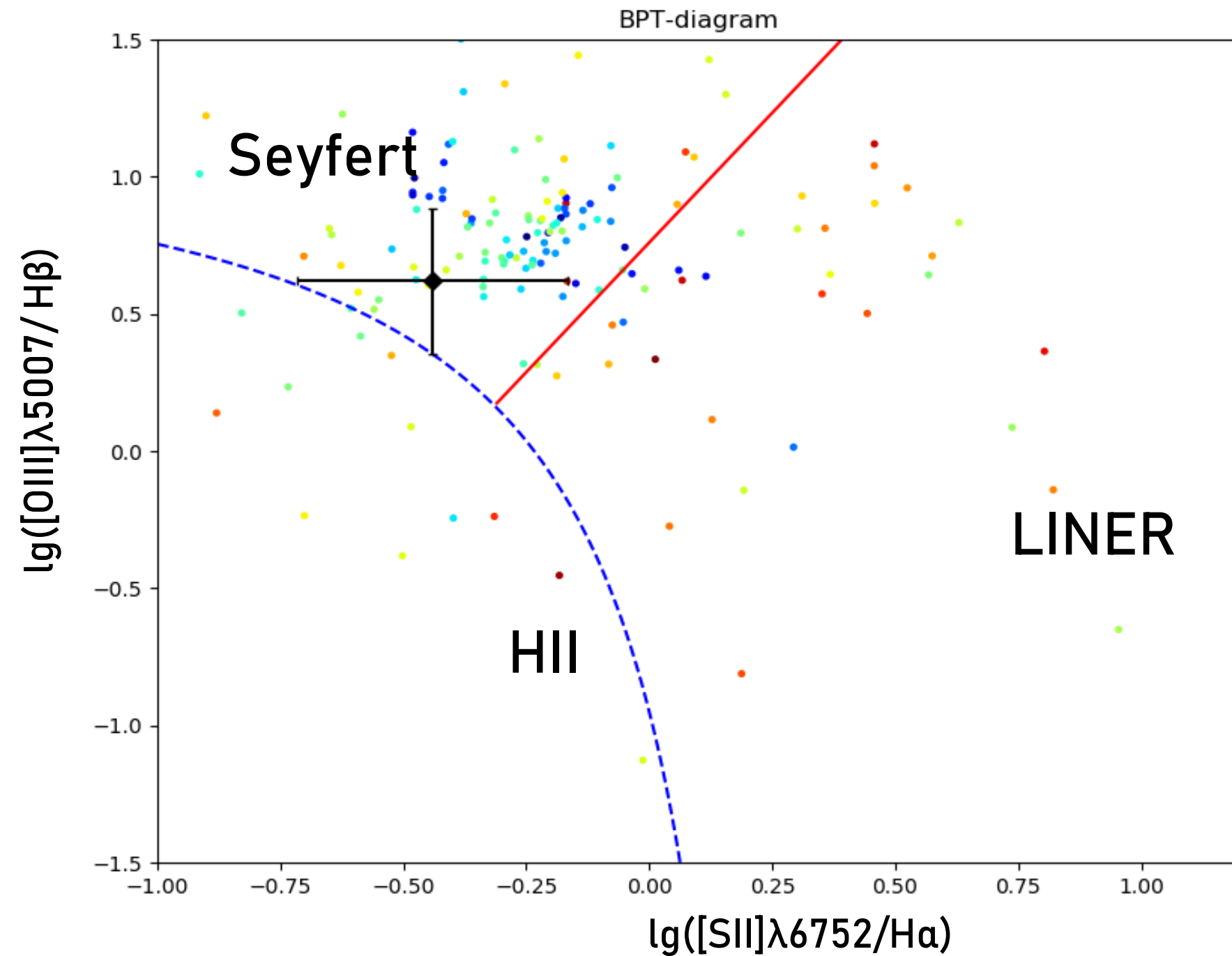
1.27e-017

1.94e-014



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 ~ 12 kpc 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!