

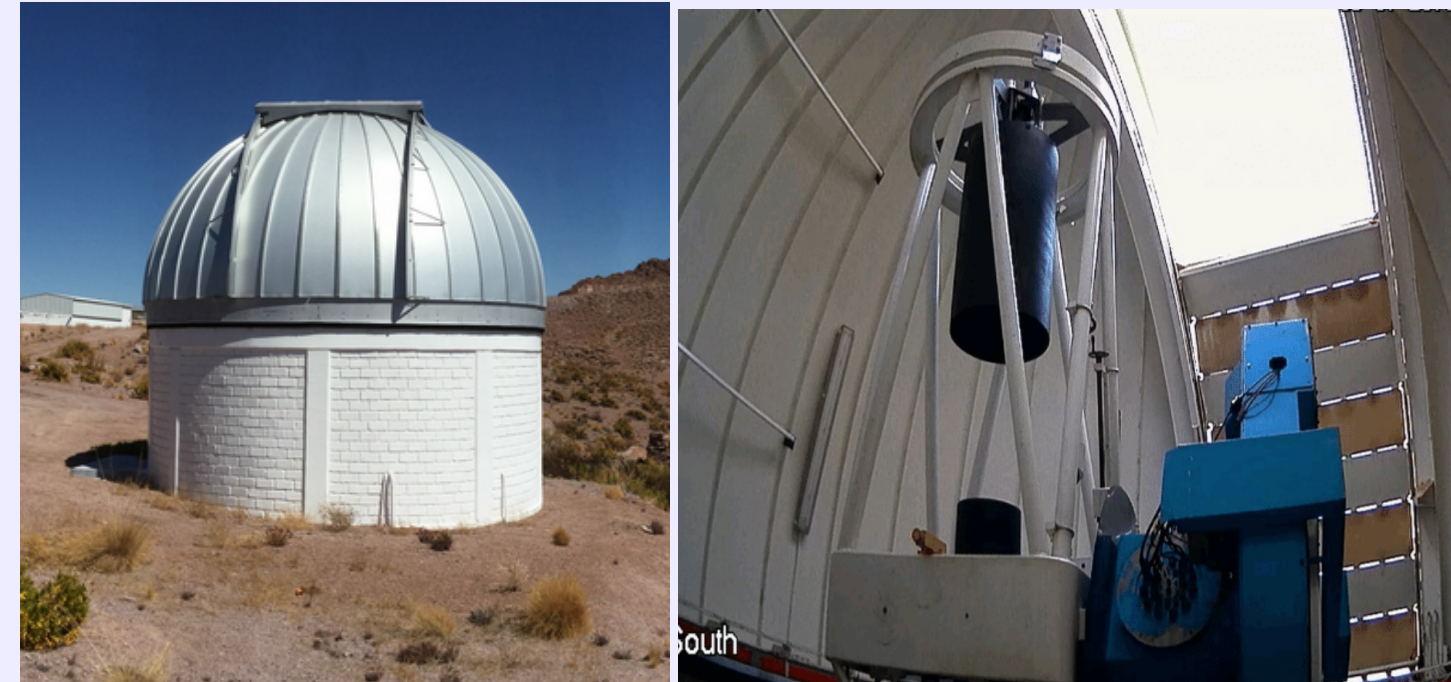


Ionization cones and relativistic jets give us one of the most large-scale example of active galactic nuclei impact on the surrounding gas environment in galaxies and beyond. The study of ionization cones makes it possible to probe intergalactic medium and trace how the luminosity of the nucleus changed over light travel time. We present our recent results for searching of ionized gas clouds emitted in the [O III] beyond stellar disks (EELRs, Extended Emission Lines regions) in different samples of local ($z < 0.03$) Seyfert galaxies. The candidates were found in the frameworks of the TELPERION survey (Tracing Emission Lines to Probe Extended Regions Ionized by Once-active Nuclei) at 1m SARA telescopes. The follow-up spectroscopy was carried out using long-slit and 3D spectroscopic facilities at the 1.6m, 2.5m and 6m Russian telescopes.



Telescopes and instruments

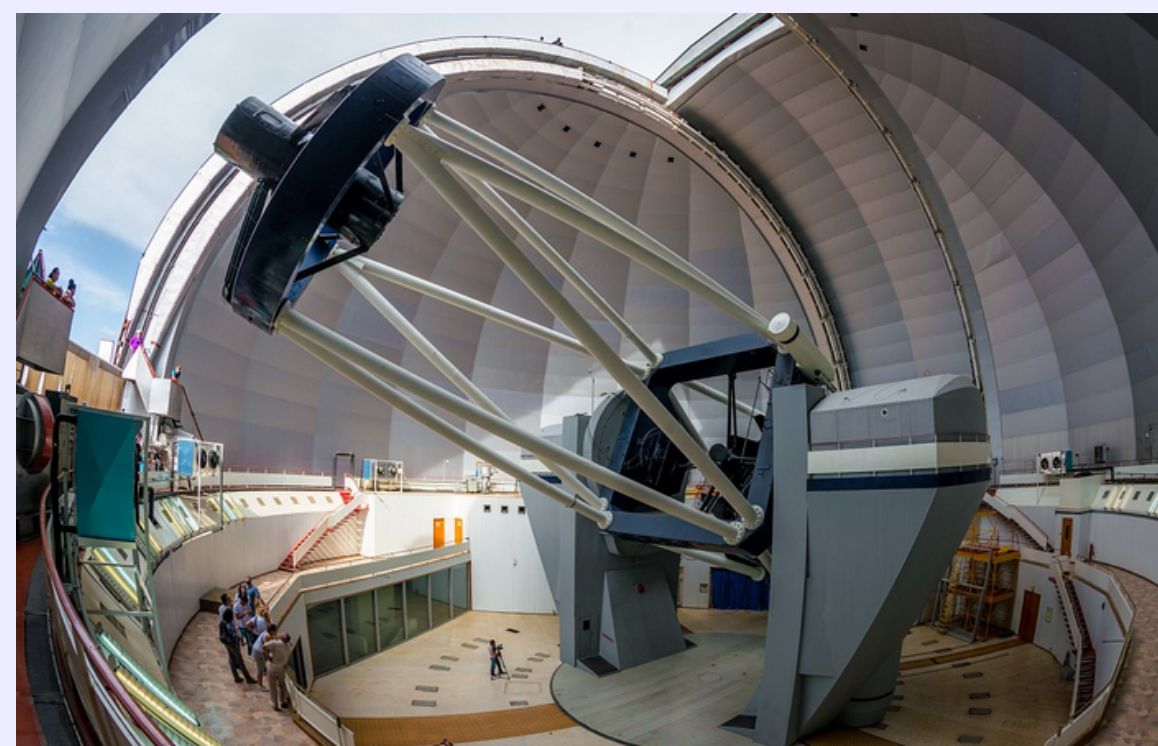
Southeastern Association for Research in Astronomy (SARA) 1-m telescopes at KittPeak & La Palma: search of [O III] redshifted emission with narrow-band filter 510/10 nm



The 2.5m SAI MSU telescope near Kislovodsk (the North Caucasus) with MaNGaL tunable filter photometer:
- Deep emission-line images in ~ 1.3 nm bandpass (the filter is based on low-resolution scanning FPI).



The 6m Big Telescope Alt-azimuth (BTA, the North Caucasus) of the SAO RAS with SCORPIO-1/2 multimode instrument:
- long-slit spectroscopy;
- 3D spectroscopy with scanning Fabry-Perot interferometer (FPI).



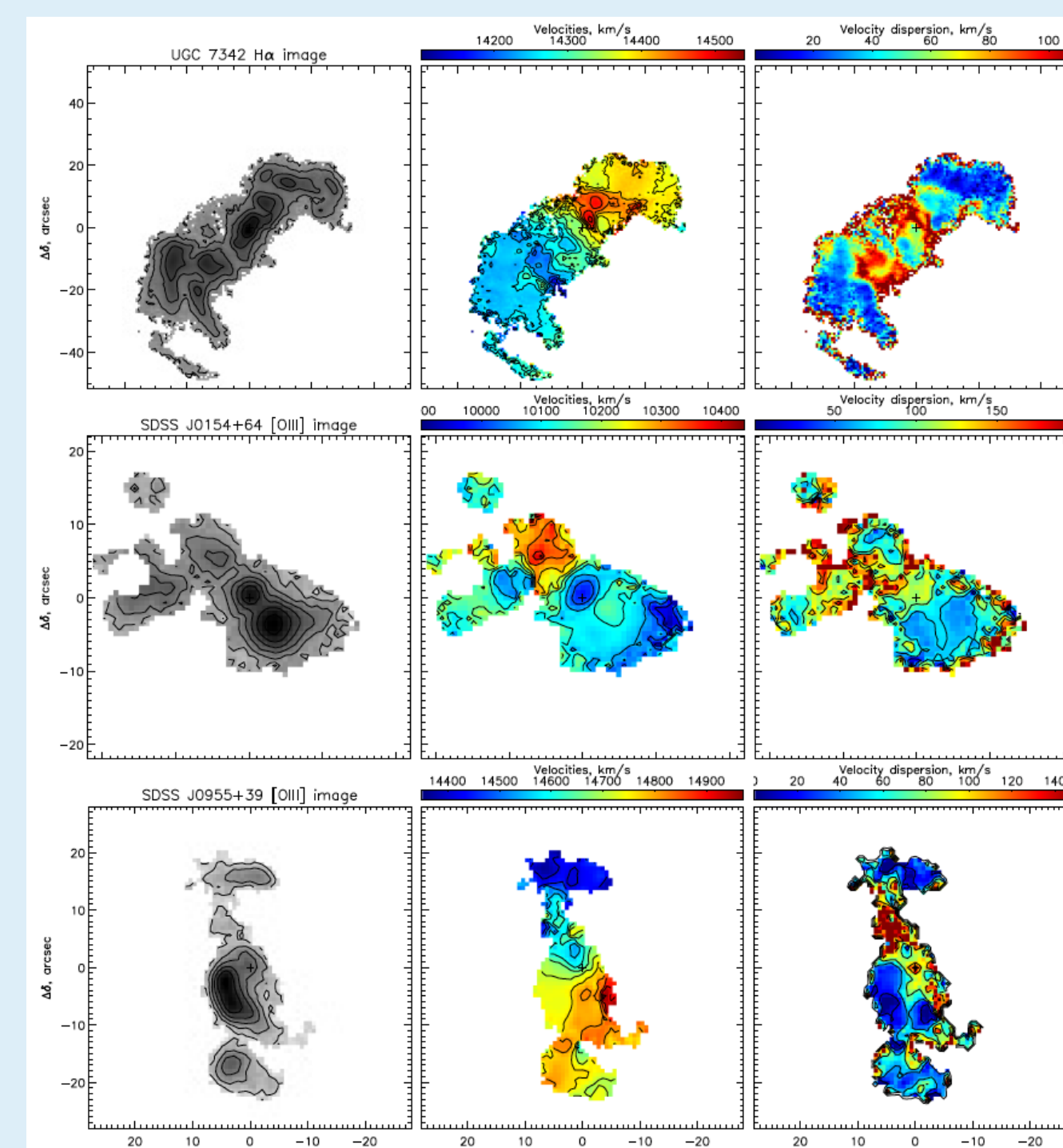
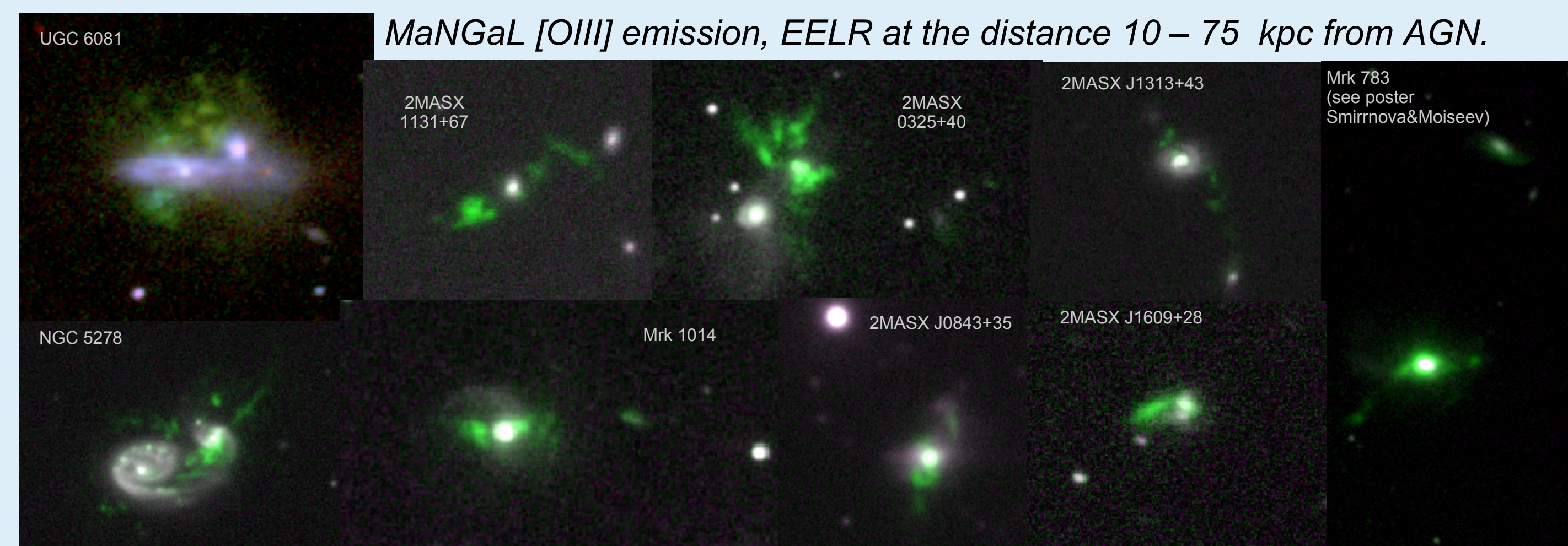
The 1.6m telescope of Sayan Observatory, Siberian Branch of the Russian Academy of Sciences with ADAM low-resolution long-slit spectrograph



The description of all used instruments developed in SAO RAS Laboratory of Spectroscopy and Photometry of Extragalactic objects:
https://www.sao.ru/hq/lsvo/devices_eng.html

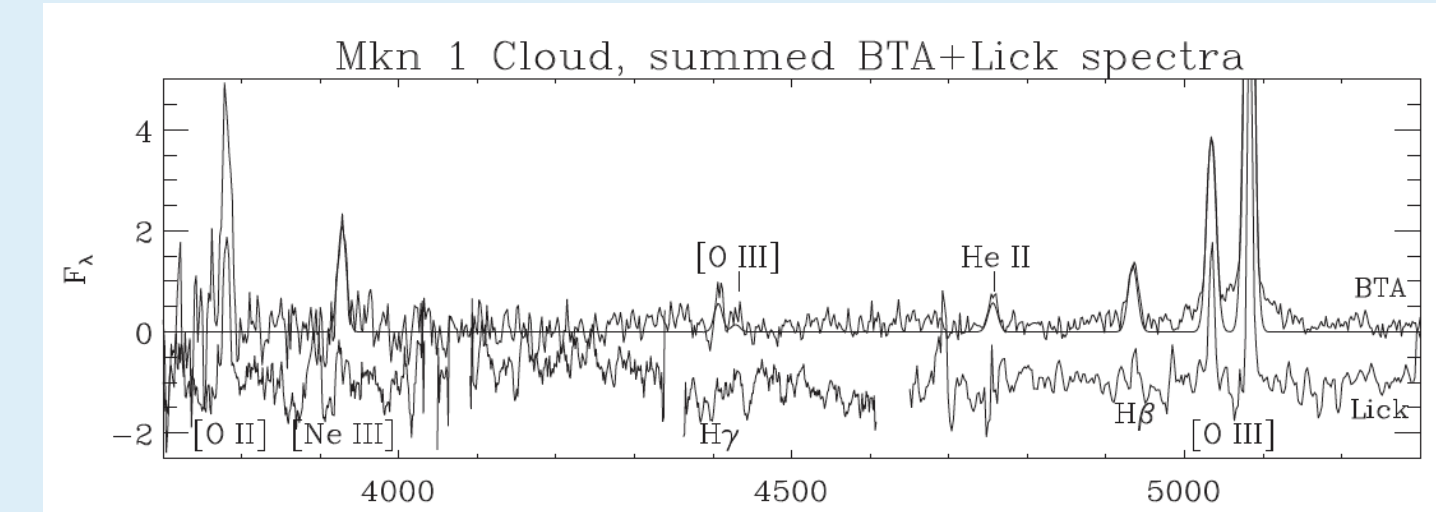
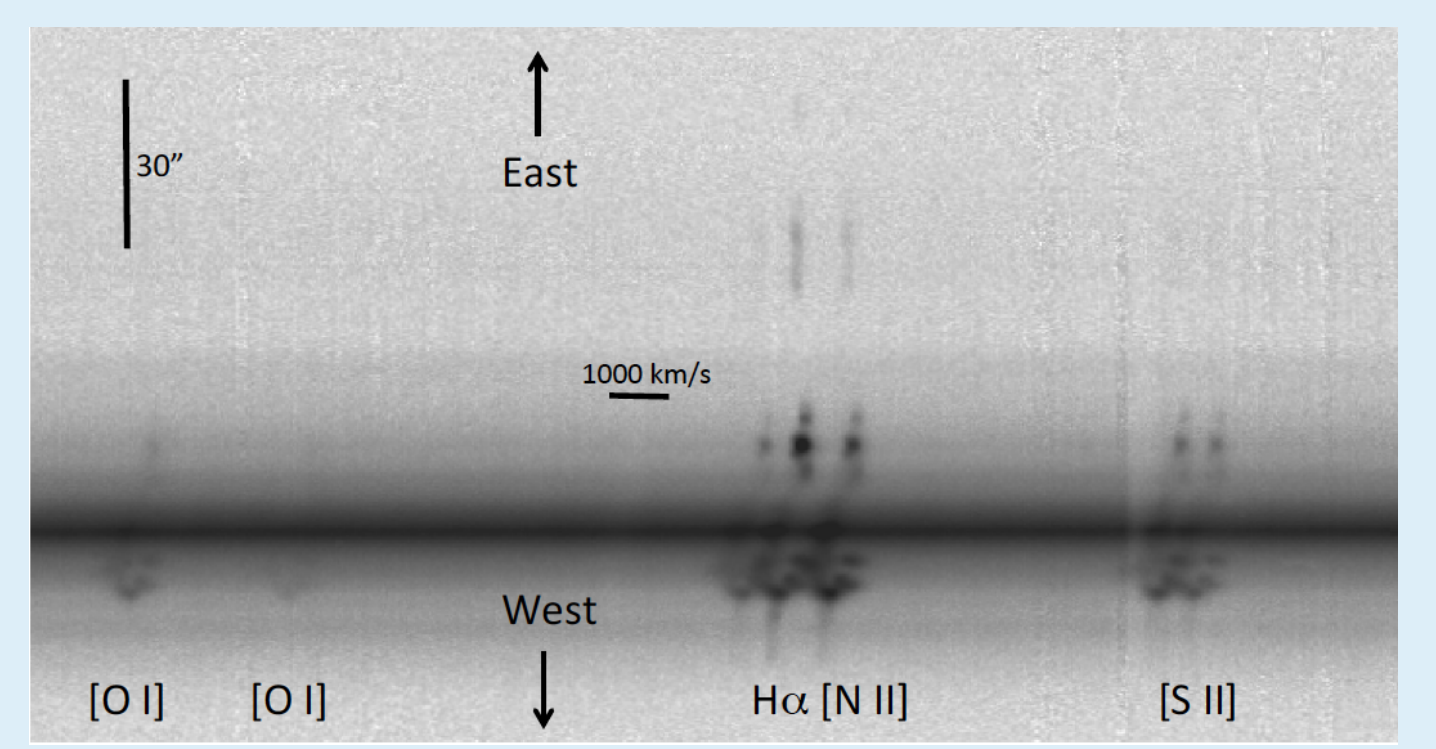


Observations of EELRs: images, spectra, velocity fields



Results of scanning FPI 3D spectroscopic observations, from left to right: images in the emission lines, line-of-sight velocity and velocity dispersion.

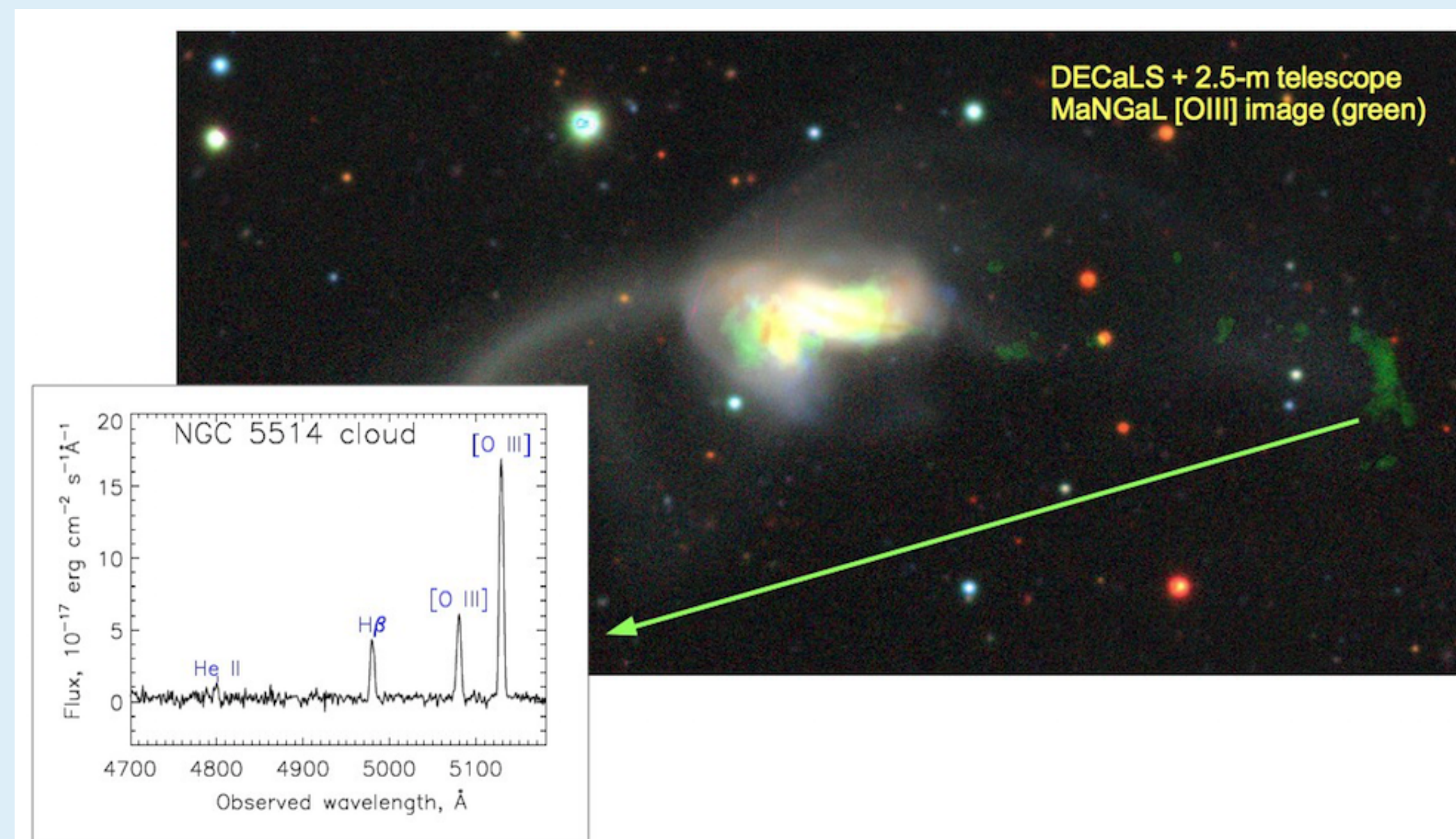
Long-slit spectrum of the central regions of NGC 5514 (BTA/SCORPIO-2). The section at red wavelengths shows the patchy elliptical traces of an expanding shell west of the nucleus (Keel et al. 2022).



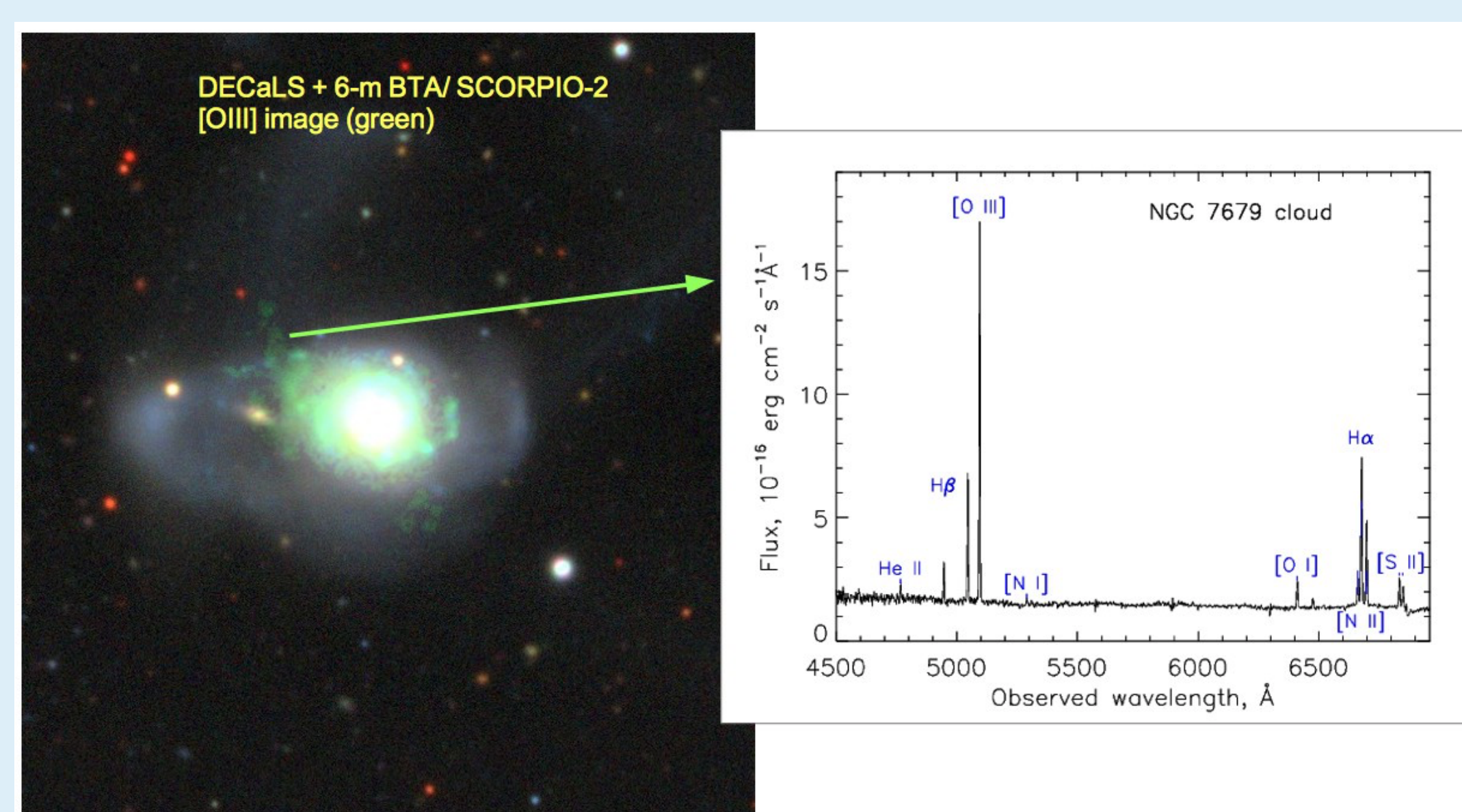
The spectrum of EELR near Mrk 1 (Knese et al. 2020)

Distant [O III] Clouds around Luminous and Hibernating AGN (Keel et al. 2022)

EELRs have been searched for in a complete luminosity-limited sample of nearby AGN ($M < -20$, $z < 0.03$) selected from Véron-Cetty & Véron (2010). Among 111 objects, the ionized gas systems far from the nucleus (25-75 kpc) were found in NGC235 and NGC5514. Energy budgets suggest that the AGN in NGC 5514 has faded by >3 times over the past 0.25 Myr years. Also, giant (up to 10 kpc) ionization cones inside galactic disks were found in 4 galaxies (IC1481, ESO362-G08, NGC5514, and NGC7679). Together with earlier surveys, this strengthens that pattern of kinetically quiescent distant EELRs occurring almost solely in interacting or merging systems. We see them in $\approx 10\%$ of the galaxies with tidal tails. Here, the gas leaves the plane of the main stellar disk. Or, on the contrary, we observe the gravitational capture of the outer matter that fell into the radiation cone of the active nucleus.



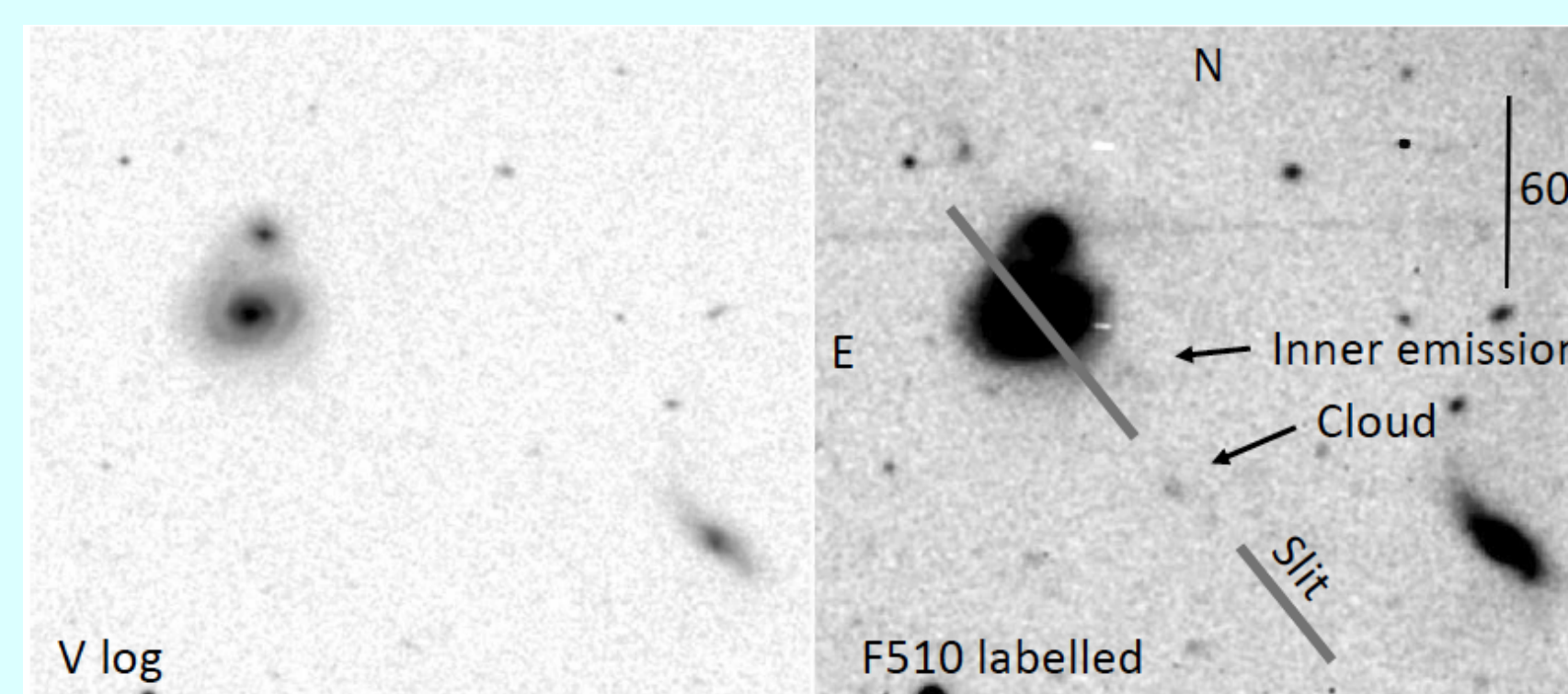
NGC 5514: the green color shows the emission distribution in the [O III] line according to the 2.5m/MaNGaL observations. The gas illuminated by the AGN is visible far beyond the disks of galaxies inside the tidal arm. The box shows the spectrum of clouds obtained at the 6m BTA. The [O III] and He II lines confirm the gas ionization by the active nucleus.



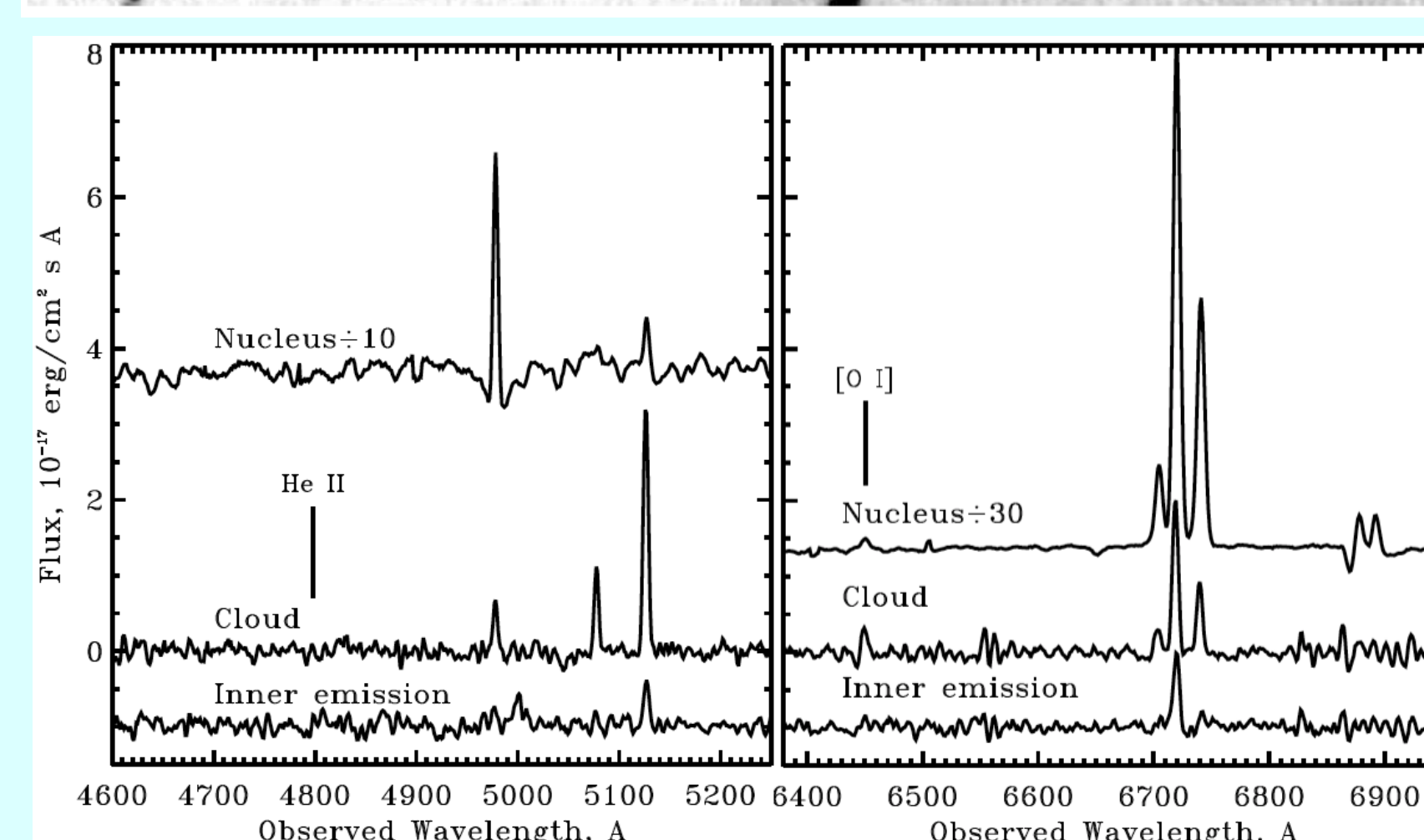
The same for NGC 7679, whereas the images in [O III] emission line was conducted the BTA/SCORPIO-2 narrow-band filter. The AGN illuminates the gas inside the galaxy.

EELRs in a strongly-interacting and merging galaxy sample (Keel et al., MNRAS, submitted)

We improve the statistic of occurrence of EELRs ionized by extant or recently-faded active AGN in the sample of 198 galaxies in 92 strongly interacting or merging galaxy systems selected from SDSS GalZoo sample (Darg et al. 2010). Among these, three have EELRs extended beyond 10 kpc in projection from the nucleus detected in previous studies. We identify a single new distant emission region, projected 35 kpc from UGC 5941. Our optical spectrum does not detect He II, but its strong-line ratios put this in the same class as securely-characterized EELR clouds. The nucleus of UGC 5941 is dominated by recent star formation, preventing detection of any weak ongoing AGN. Overall counts of distant EELRs in this and the previous TELPERION samples give incidence 2–5% depending on galaxy and AGN selection, 20-50 times higher than the Galaxy Zoo EELR survey with its higher surface-brightness threshold and much larger input sample. AGN in interacting and merging systems have an increased detection rate $12 \pm 6\%$, while none are detected around noninteracting AGN.



On- and off-band 1m SARA images showing the [O III] cloud detected near UGC 5941.



Diagnostic sections of the BTA long-slit spectrum of UGC 5941 and its associated emission cloud.

References

Darg D.W. et al. 2010, MNRAS, 401, 1552

Keel W. et al. 2022, MNRAS, 510, 4608

Knese E.D., et al. 2020, MNRAS, 496, 1035

Véron-Cetty M.-P. & Véron P. 2010, A&A, 518, id.A.10