DUVET: Resolved direct metallicity measurements in the outflow of starburst galaxy NGC 1569

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MNRAS, accepted

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(DUVET) = Deep near-UV observations of Entrained gas in Turbulent galaxies

Цель: сравнить металличность истечений с металличностью газа, действительно ли идёт вынос металлов?

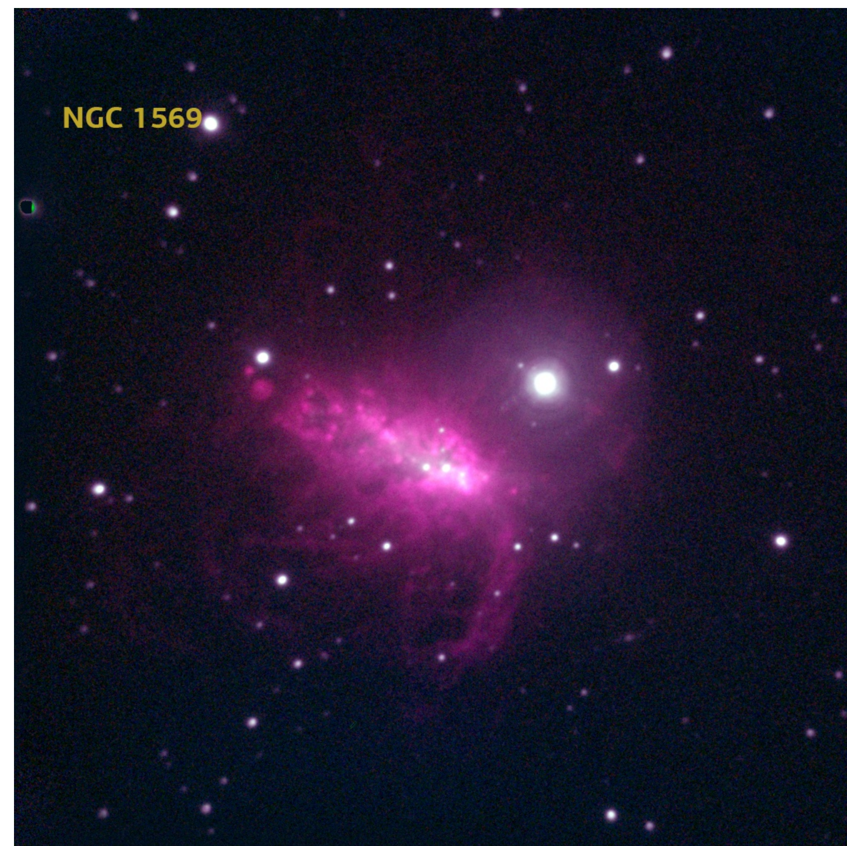
metal-loading factor:

? η - mass-loading

$$\zeta = \frac{Z_{\rm out}}{Z_{\rm ISM}}\frac{\dot{M}_{\rm out}}{\rm SFR}.$$

Chisholm + 2018 (COS, абсорбции): l*ow and high-mass galaxies have outflow Z 10-50 and 2.6 times larger than their ISM*
Но Cameron + (2021) получил прямым методом по эмиссиям для Mrk 1486 это отношение 1.6) – в два раза меньше, чем по COS.

to galaxy NGC 1569. NGC 1569 is a well-studied, nearby Mpc, Tully et al. 2013), low metallicity (12+log(O/H) = 8.19, nicky & Skillman 1997), low mass (log($M_\star/M_\odot$ = 8.6, Leroy 2019), starburst galaxy. It has two supermassive star clusters that formed after a period of high star formation approximately rs ago (Hunter et al. 2000). Hα emission shows a complex re around the SSCs, with filaments and bubbles suggesting a feedback driven outflow (Heckman et al. 1995; Westmoquette 2007). Analysis of the H I kinematics suggests a mass loading cold gas in the wind of $\dot{M}_{\rm out}$/SFR ∼ 3 (Johnson et al. 2012;

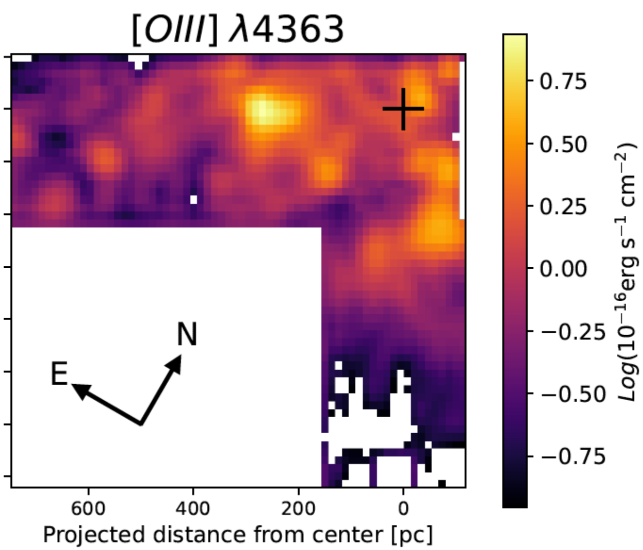


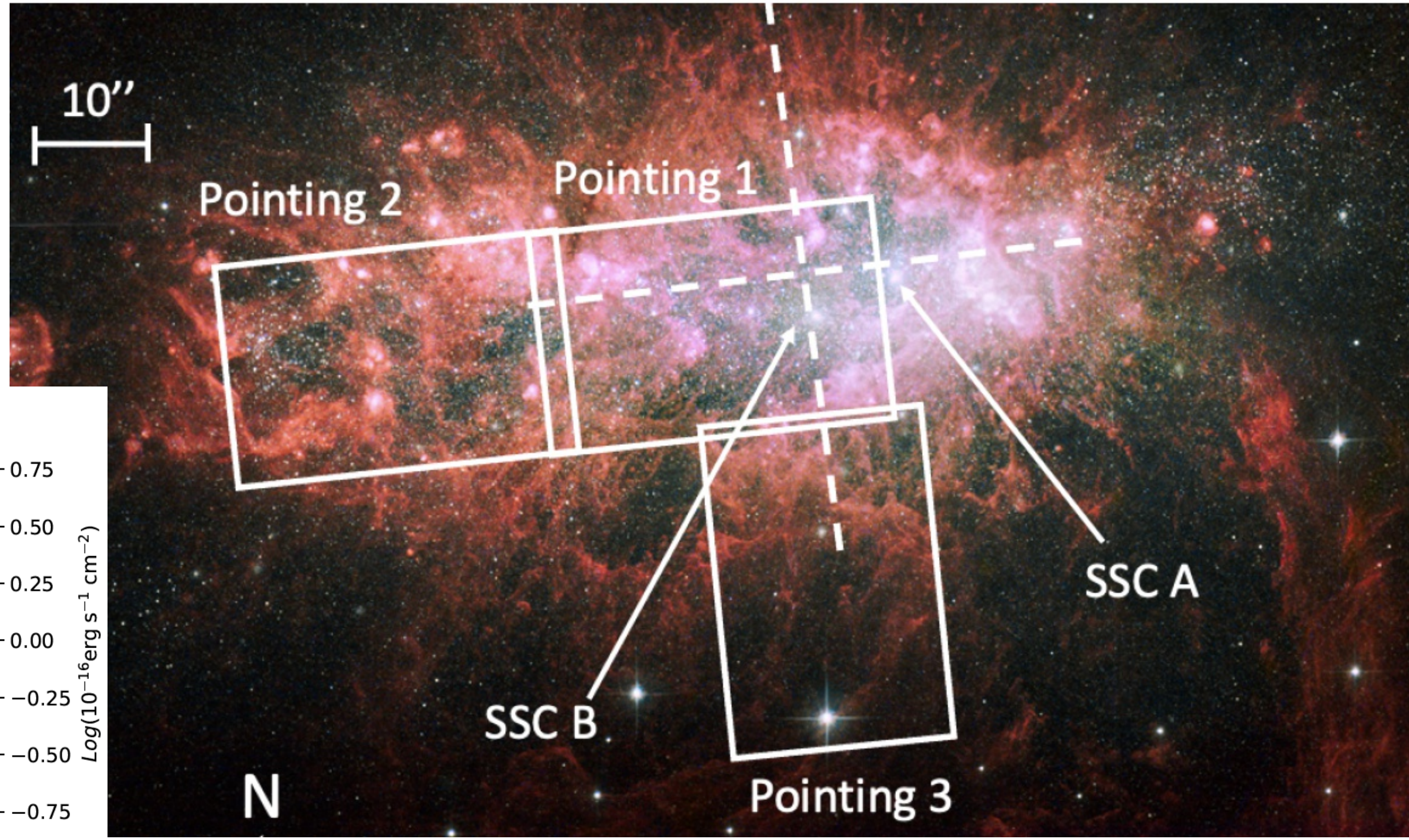
MaNGaL (Moiseev + 2020)

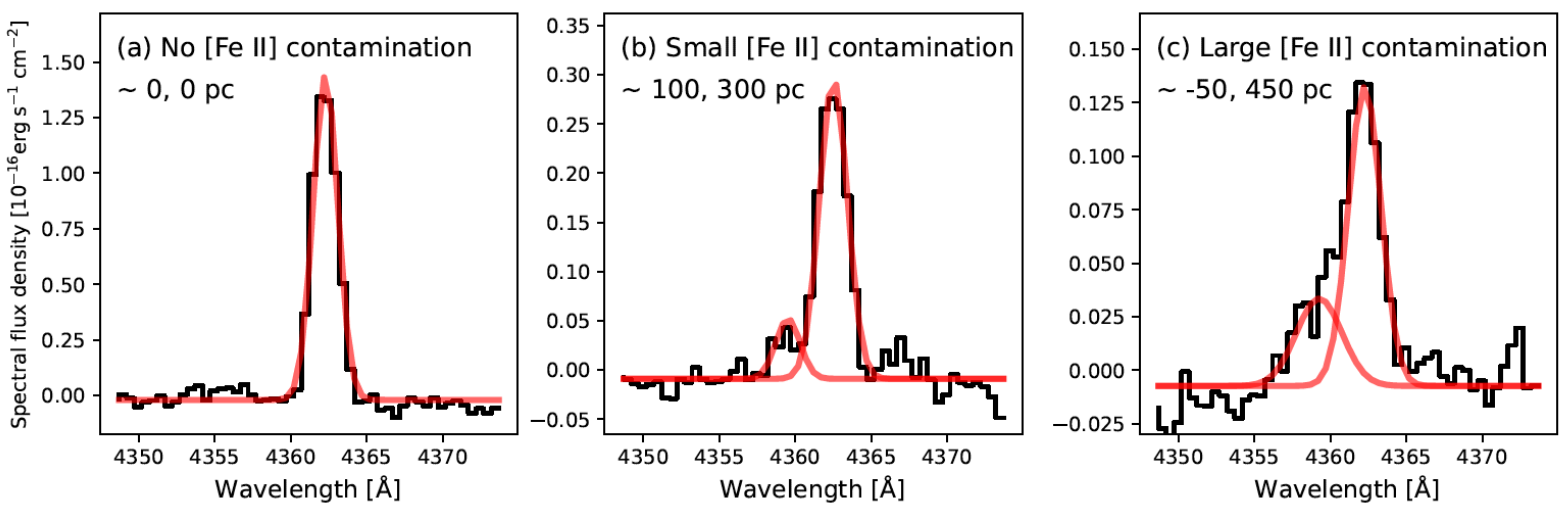
Семинар VOLGA 10/04/2024, Моисеев

Keck/KCWI, seeing 1.2''
3 field 20x33'',
final spaxel 3x3: 0.87''
3600-5130A,
R~2000

Учёт перекопа в 5007



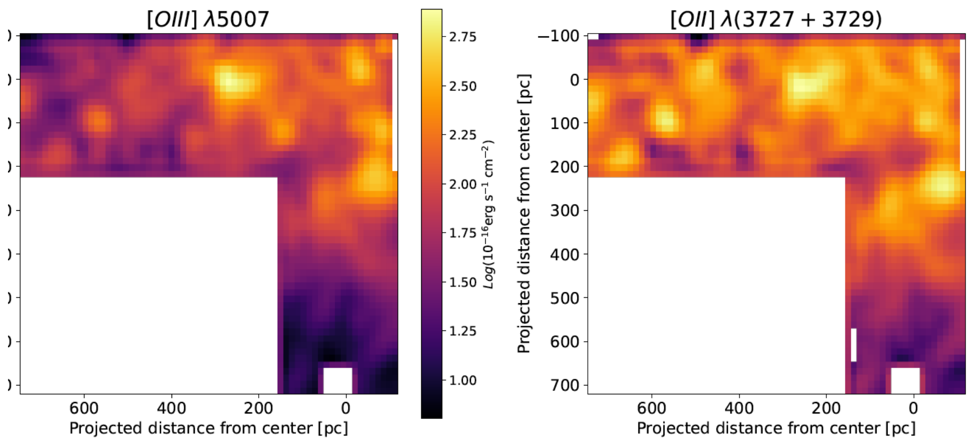




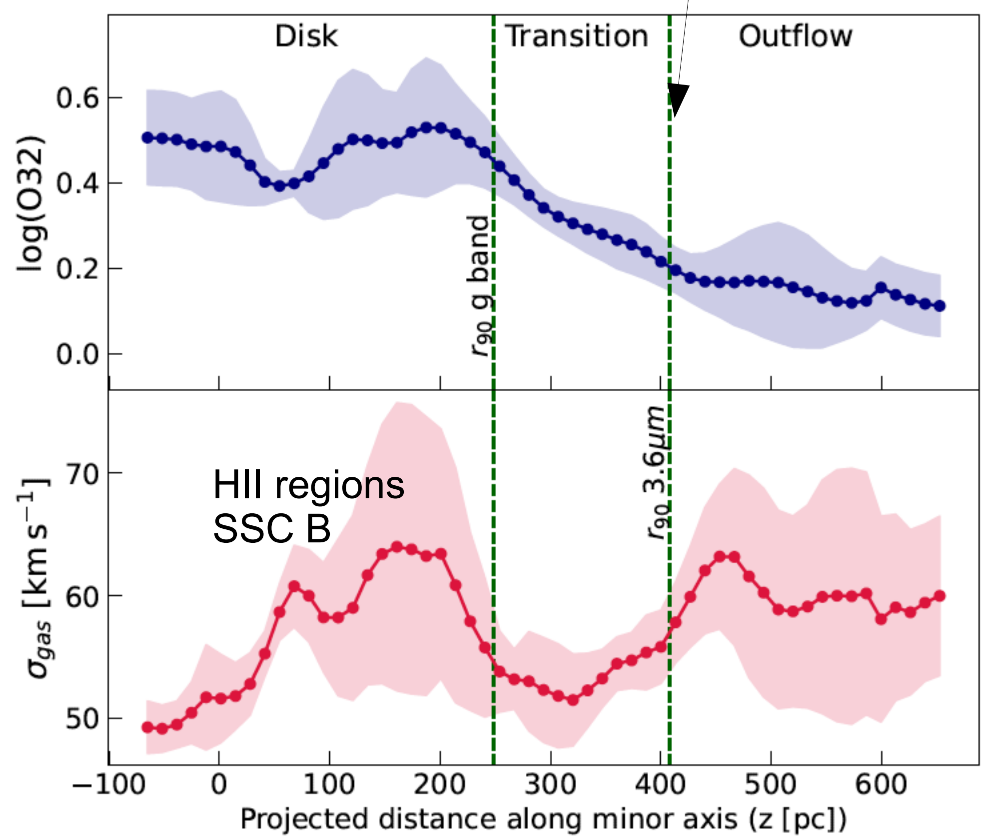
Семинар VOLGA 10/04/2024, Моисеев

FeII – может влиять и на Te и на Z !

Континуум - pPXF или константа для малого S/N
A_V(MW)=1.85
Поглощение в N1569 Hβ/Hγ; A_V=1.2 (disk), 1.5 (outflow)
Профили - однокомпонентные
Выделение диска (звездного) – по g-sdss и Spitzer/IRAC 3.6 mu- граница по малой оси
Ионизационный параметр O32=[OIII]50007/[OII]3727,29



90% светимости звездного диска

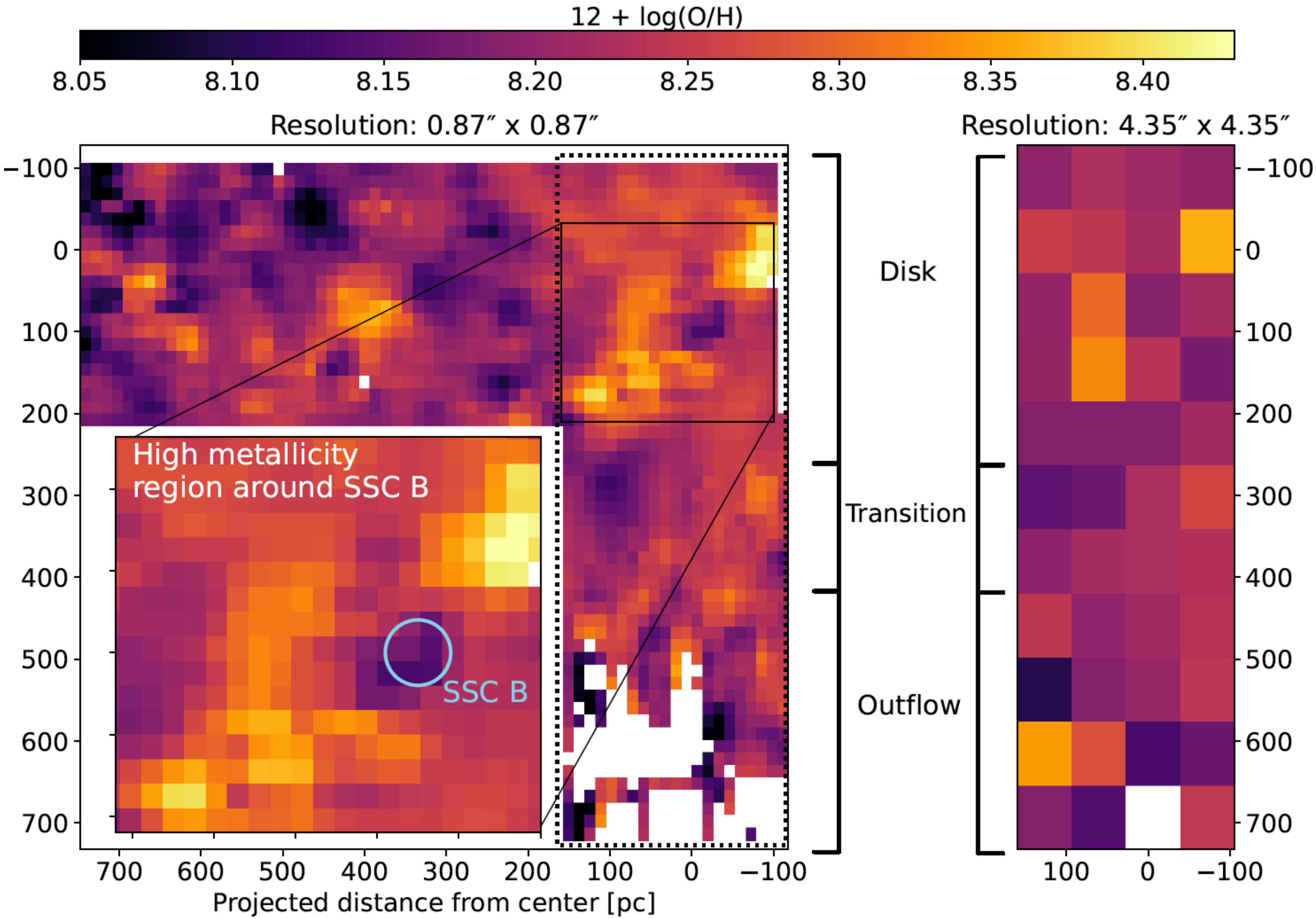


supermassive star cluster (SSC)
Так как нет [OI], то Te([OIII]) по 4363/5007 и:

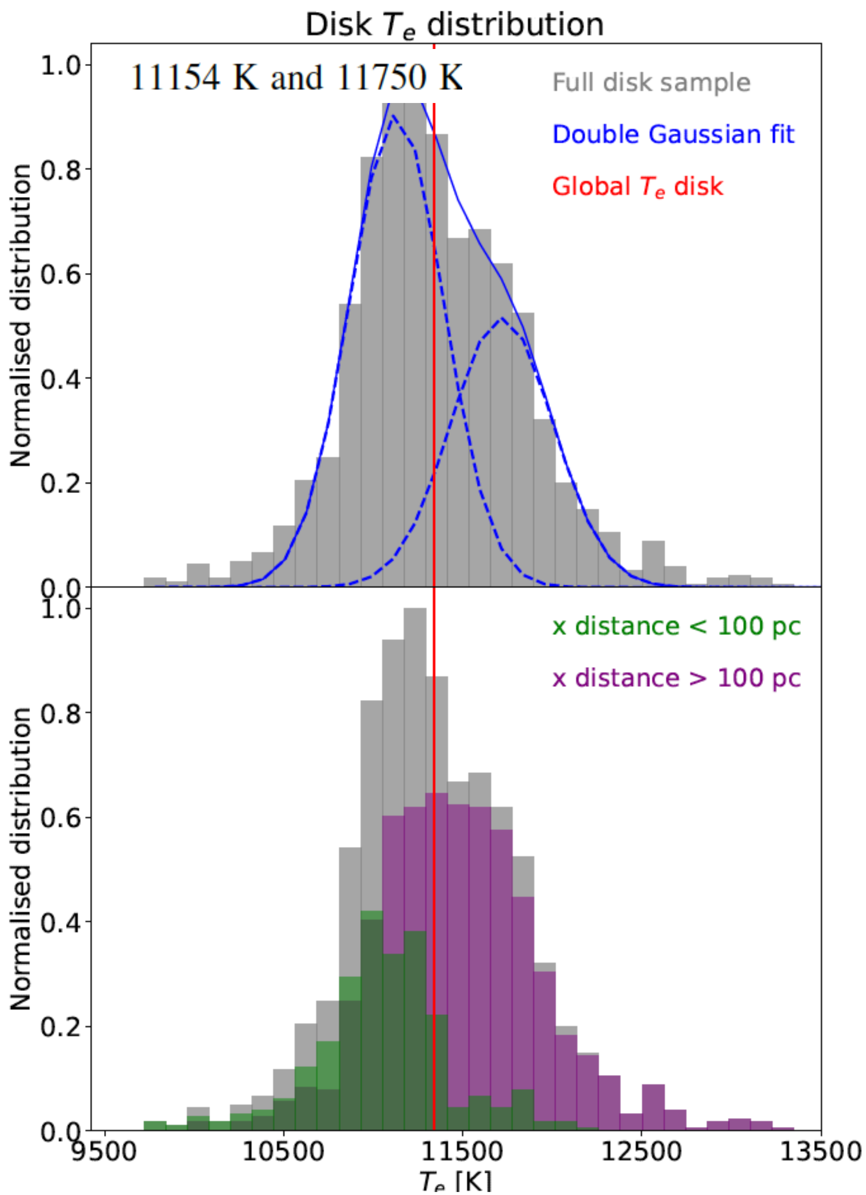
$$T_e([\text{O II}]) = 0.7 \times T_e([\text{O III}]) + 3000. \quad (2)$$

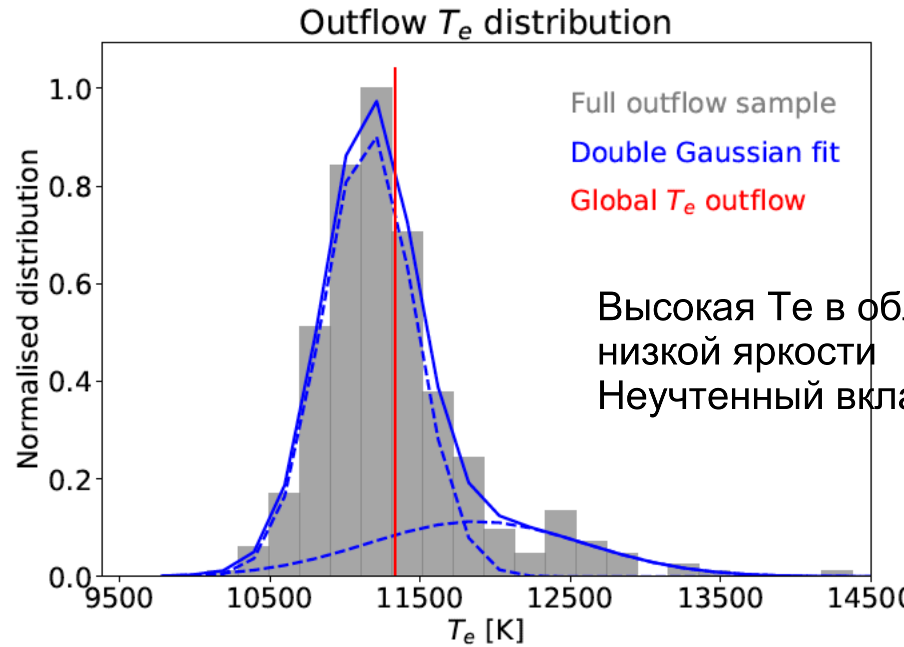
We measure a mean $T_e([\text{O III}])$ value of 11,408 K with a standard deviation of 515 K in our entire field of view and a mean $T_e([\text{O II}])$ of 10,986 K with standard deviation of 360 K. We note that this correlation is based on observations of HII regions and that there is a large scatter (Rogers et al. 2021). Future work with broader

[O/H]: прямой метод по 3727/Hβ + 5007/Hβ



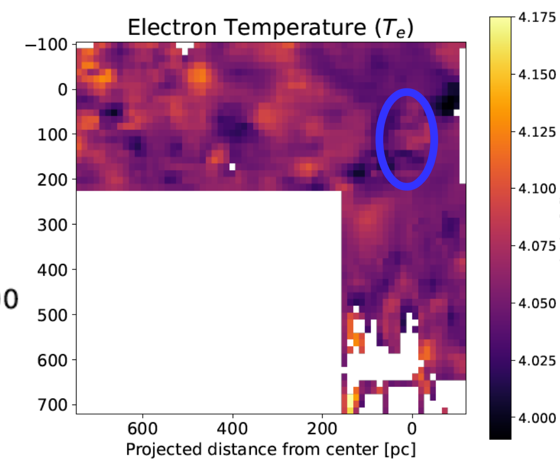
Median ne(3737)=43 cm-3, but in SSC B n_e=1300

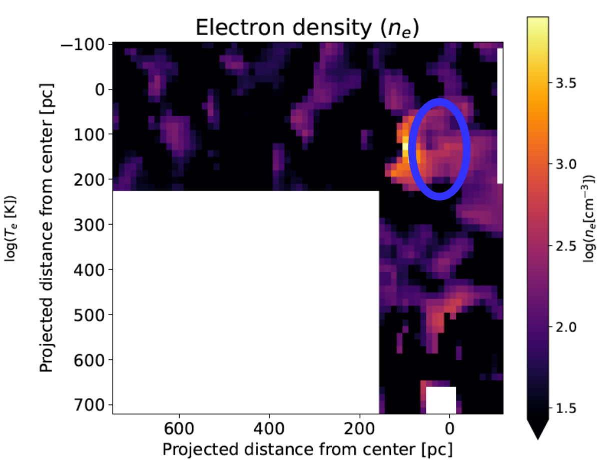




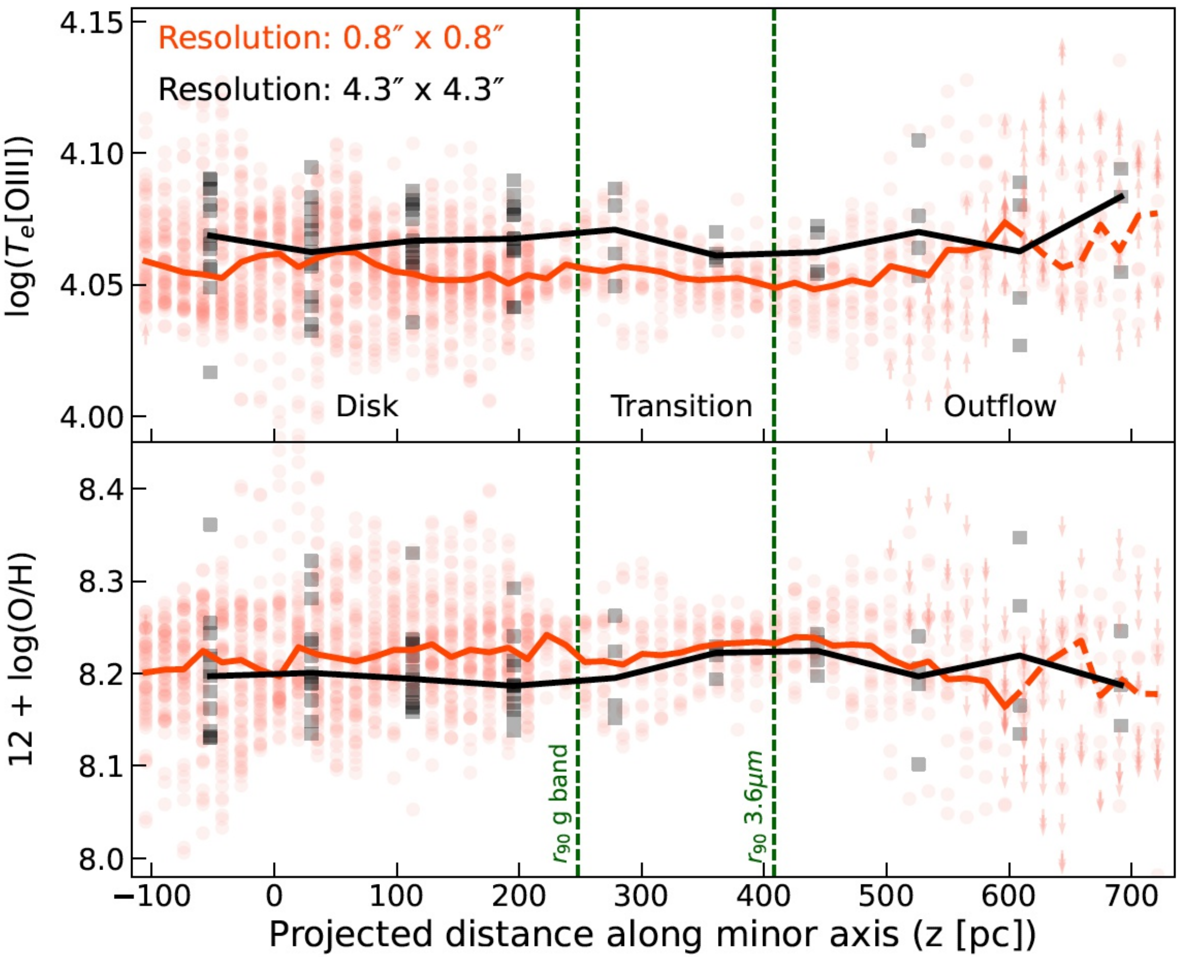
Высокая Te в областях низкой яркости
Неучтенный вклад FeII?

Global Te=11 420 K – по суммарным потокам [OIII]/[OII]
Понижение Te в SSC-B





Истечение: n_e=26-83 cm-3 – сильно ниже, чем в ULIRGs



В согласии с моделями:

Recently, Vijayan et al. (2023) carried out box-simulations of supernovae-driven winds which include metallicity effects on the outflow. They included a range of metallicities in the simulation and showed a result with 0.2 $Z_\odot$, which is appropriate for comparison to NGC 1569. The shape of the simulated metallicity profile in Vijayan et al. (2023) depends on the gas phase and the initial metallicity of the galaxy. For the warm ionized gas, the profile will be steeper for lower metallicity galaxies. The profile for galaxies with Z_{ISM} = 0.2 $Z_\odot$ goes from Z_{ISM} in the midplane to ~1.1 Z_{ISM} at distances of ~1 kpc from the midplane. NGC 1569 has a metallicity of ~0.25 $Z_\odot$. Considering error bars in our metallicity profile for NGC 1569 it is consistent with the results in Vijayan et al. (2023).

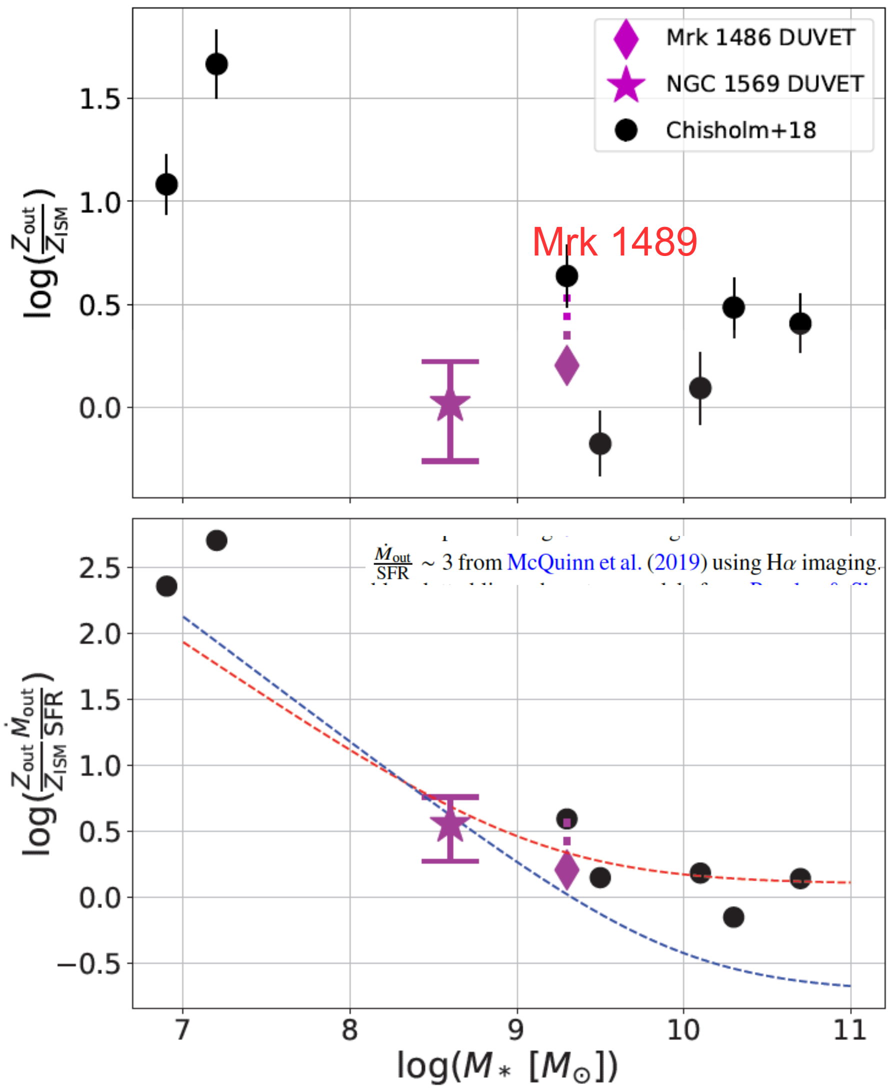


Figure 9. Top panel: Z_{out}/Z_{ISM} as a function of $M_\star$. The magenta star shows the result of this work for NGC 1569. The magenta error bars show the two most extreme values depending on what regions we consider as ISM and outflow. The black dots show the results from Chisholm et al. (2018) where they measured Z_{out} from absorption lines and Z_{ISM} using the direct method. The magenta diamond shows the result from Cameron et al. (2021) for Mrk 1486 using the direct method for Z_{out} and Z_{ISM}. The magenta diamond is connected to the Chisholm et al. (2018) measurement for the same galaxy with a magenta dotted line. Bottom panel: $(Z_{out}/Z_{ISM}) \times (\dot{M}_{out}/SFR)$ as

<Zout/ZISM>=1, по крайним значениям:0.6-1.6

Даже с этим учётом, - согласие с более массивными галактиками, тренд от M* не подтверждается

Мелкомасштабные вариации Te (15-100 pc) не влияют на результат

Работа удвоила число галактик с прямыми оценками отношения металличностей Zout/ZISM :)

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*От меня: жаль, что не рассматривается кинематика и Z**