Influence of the AGN activity on ionized gas clouds in narrow-line regions of AGNs
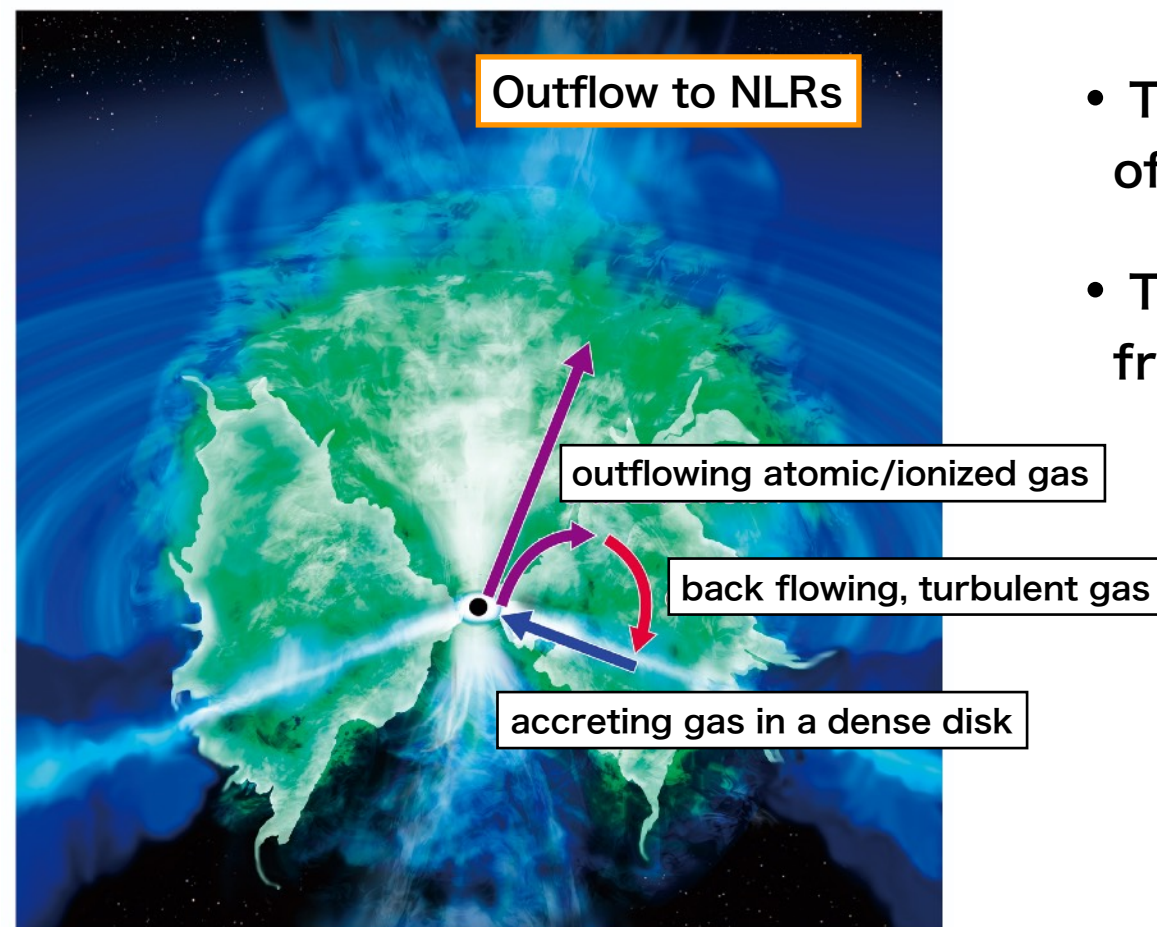
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The formation and structure of narrow-line region

- The co-evolution of galaxies and SMBHs

  - A $M_{\rm BH}$ correlates closely with a $M_{\rm bulge}$, indicating the coevolution of galaxies and SMBHs. (Kormendy & Ho 2013) ➡️ **Why and how this relation has arisen ?**

  - Narrow-line regions (NLRs) in AGNs play an important role in investigating an influence of the SMBH activity on its host galaxies.

    How the structure of NLRs is? How NLRs have been formed and evolved?

- The radiation-driven fountain model (Wada 2012, Wada et al. 2018)

An image of the fountain model (Izumi et al. 2018; credit: NAOJ)

Labels in image: Outflow to NLRs; outflowing atomic/ionized gas; back flowing, turbulent gas; accreting gas in a dense disk

- The fountain model explains the formation and maintenance of the nuclear torus structure.

- This model suggests that high-density gas clouds are supplied from the inner part to outer NLRs through outflows.

  We investigated the properties of ISM in NLRs to check the expectation of the fountain model.

Systematic investigation of the NLR gas density

- The electron density as a function of the location in the BPT diagram

Data

- 135,000 nearby galaxies (z < 0.32) from SDSS MPA-JHU catalog

- star-forming: 94,794 objects, type2 AGN: 17,511 objects and composites: 23,284 objects selected by BPT diagrams
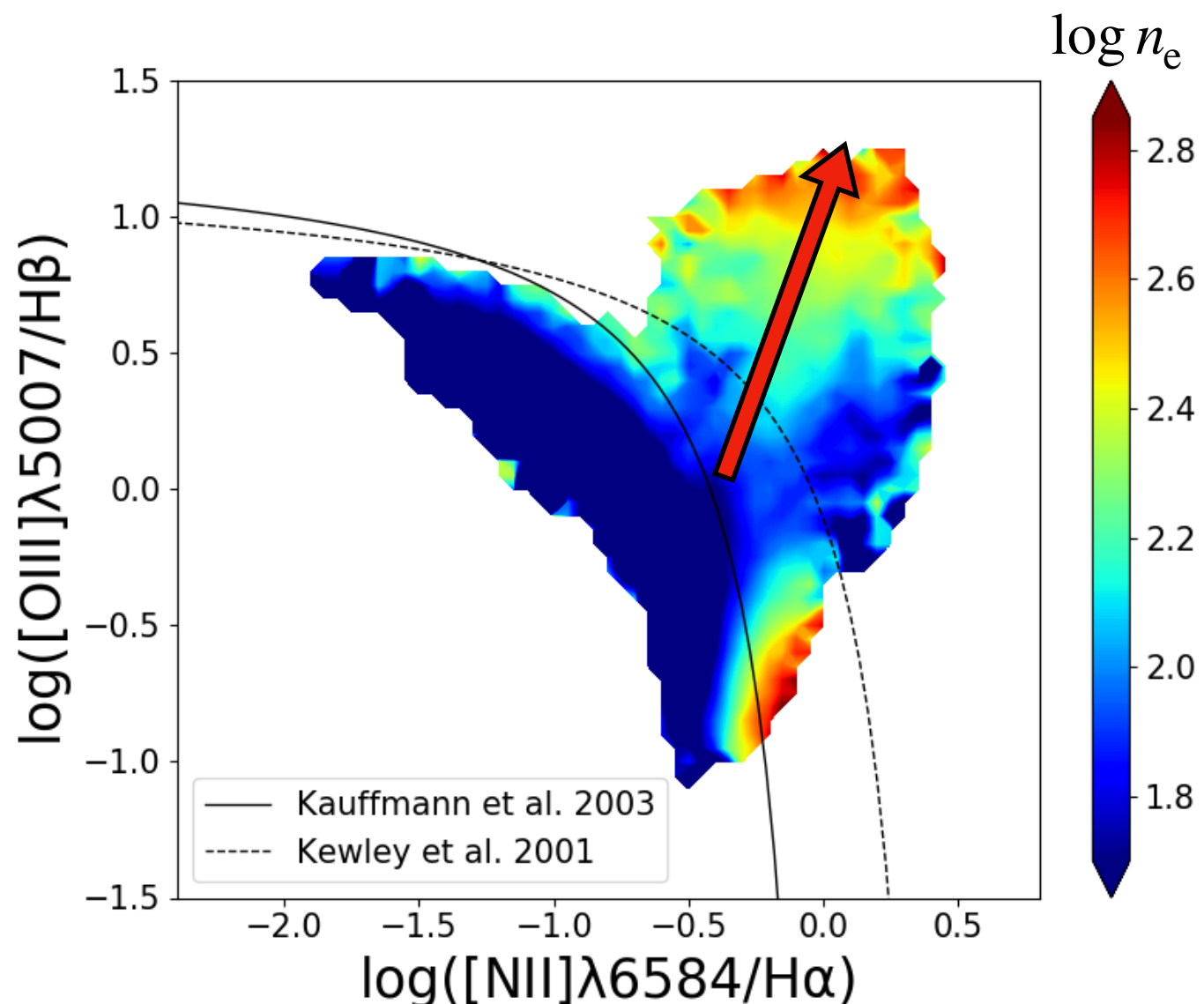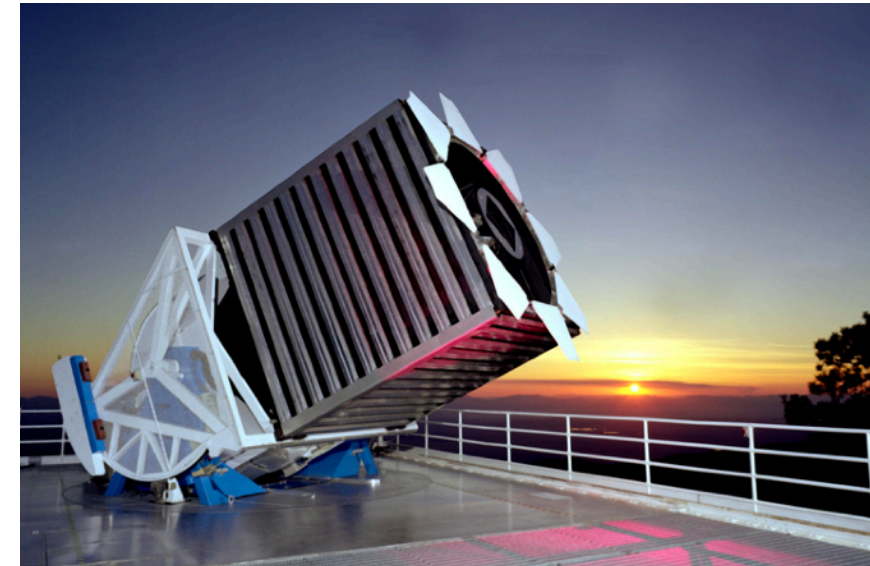
Results

- Gas in NLRs of AGNs is denser than that in HII regions of star-forming galaxies.

- NLRs with a higher AGN activity are characterized by a higher electron density.

### Consistent with the fountain model

Subaru PFS

PFS allows us to extend our sample to $z \sim 1$.

It will be possible to examine the evolution of the relation between the properties of NLRs and AGN activities.

The property of spatially resolved NLRs
- The Mapping Nearby Galaxies at the Apache Point Observatory (MaNGA) survey

• An electron density as a function of the location in the "spatially resolved" BPT
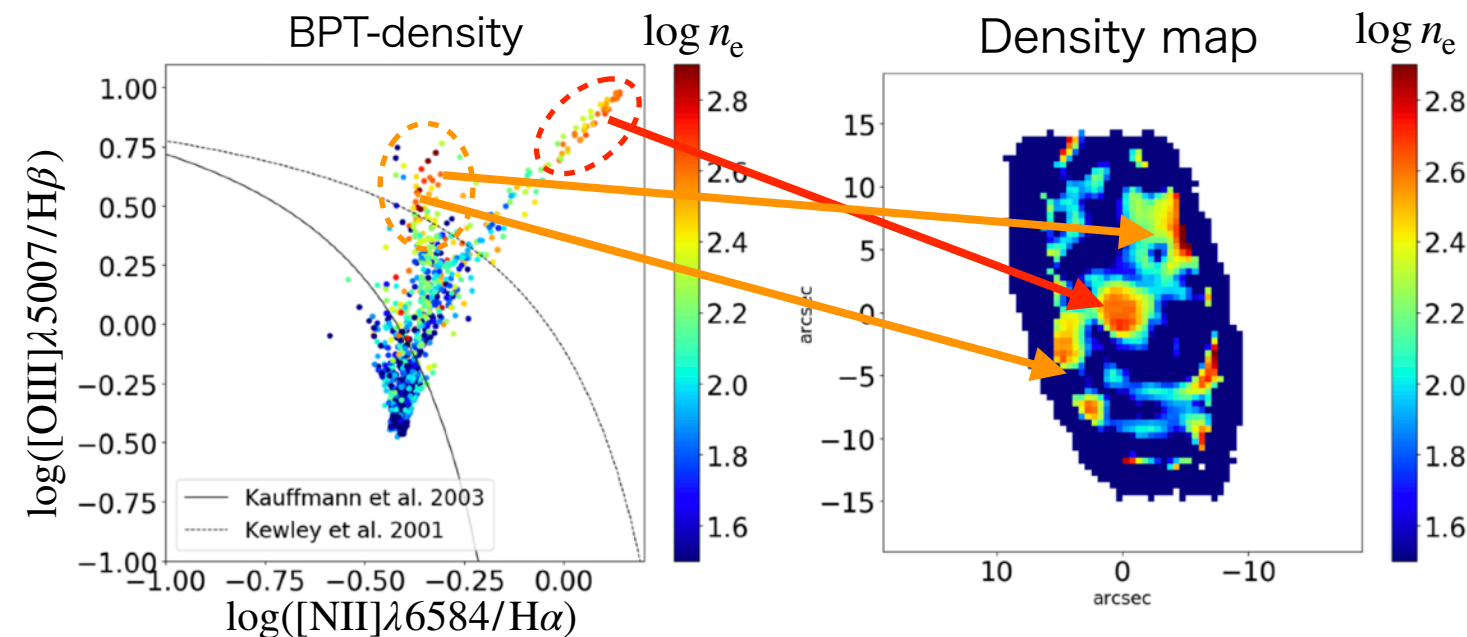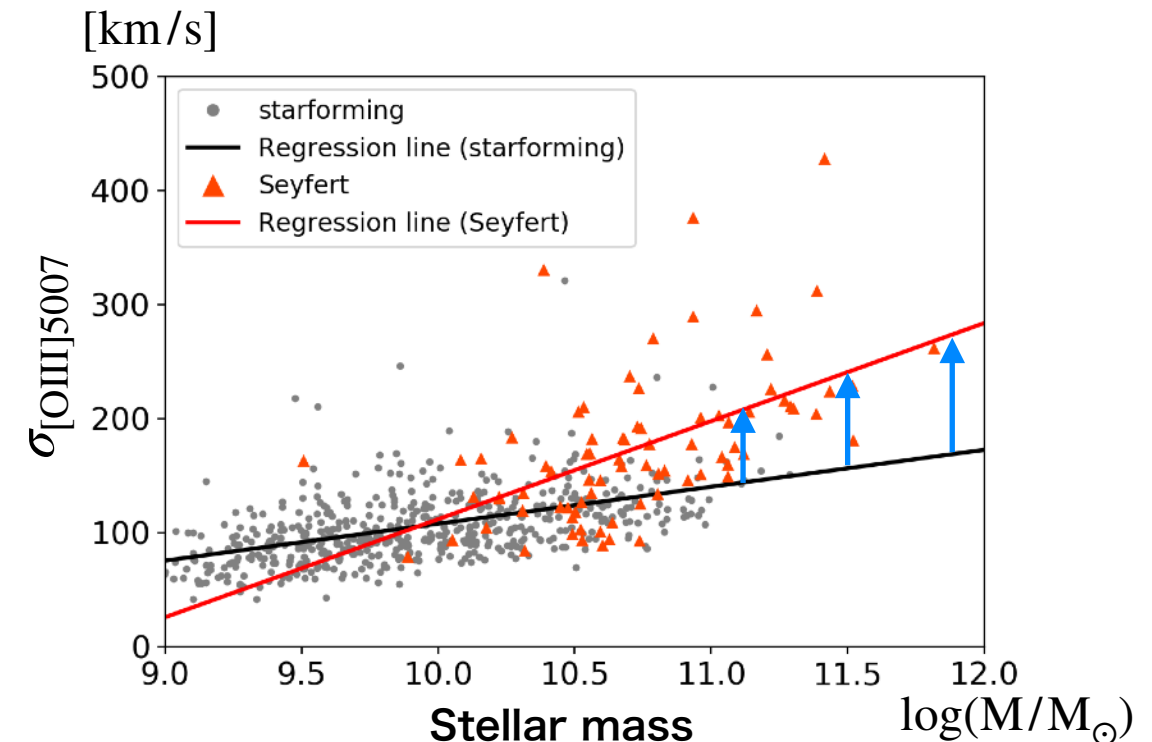

The density map in some Seyfert galaxies shows a biconical feature with dense gas, indicating that high density gas is supplied from the nucleus through outflows.

• The relation between velocity dispersion and stellar mass

The regression line for a distribution of Seyferts is steeper than that of star-forming galaxies. The result suggests that the ISM in NLRs is influenced by an acceleration mechanism like an AGN driven outflows ("the fountain flow").

Subaru FOCAS-IFU

• FOCAS can detect fainter lines such as [OIII]4363.

➡ We will be able to estimate physical conditions in more detail, such as temperature of ionized gas.
➡ The formation mechanism of NLRs will be examined more conclusively through comparisons with the fountain model directly.