CLOUDY Workshop, Chiang Mai, Thailand
May, 14th - 25th, 2018

REBORN

RElation Between the structure Of dusty toRus & the geometry of the AGN NLR

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Abstract: We have investigated the different physical properties of the warm absorber and its role in forming the bi-conical shaped Narrow Emission Line Regions (NLR) in AGNs using the photoionization code CLOUDY. We first simulate two gas regions, one along the radial direction of accretion disc i.e. with torus and the other along the axis of symmetry of the BH system (i.e., with only NLR clouds, without the torus). Later we investigate the density & temperature profiles and also the emitted continuum for both regions for different abundances and chemical compositions. By using the pycloudy 3d code, we construct 3D models and obtain the 2D projected images of [OIII] 5007 emission line from the 3D models which shows the geometry of the NLR cloud. We investigate the changes of the NLR by controlling the physical parameter of the dusty torus.

Introduction: AGN are one of the most powerful and luminous objects in the universe, which emit an enormous amount of energy covering the entire electromagnetic spectrum ($10^{40} - 10^{48}$ ergs s^{-1}). According to the current model of AGN there is a central SMBH (~ $10^6 - 10^9$ M_{sun} or more) surrounded by an accretion disk of matter which powers up the AGN. There are some fastly and slowly moving gas clouds called as BLR and NLR respectively as shown in the figure 1. Outside the accretion disk and BLR, a region of thick gas and dust particles resides on a scale of one to few parsec in the radial direction of the disk in the shape of doughnut called as dusty torus (Antonucci 1993). The optical/UV photons coming from the nucleus (disk) absorbed by this dust which is heated to the highest possible temperatures (around 1000-1500 K) and is then re-emitted as thermal radiation in the infrared frequencies. It is also one of the main supply source for matter which eventually falls onto the SMBH. Many models have been developed during the years with the aim of trying to reproduce the mid-infrared spectrum of AGNs.

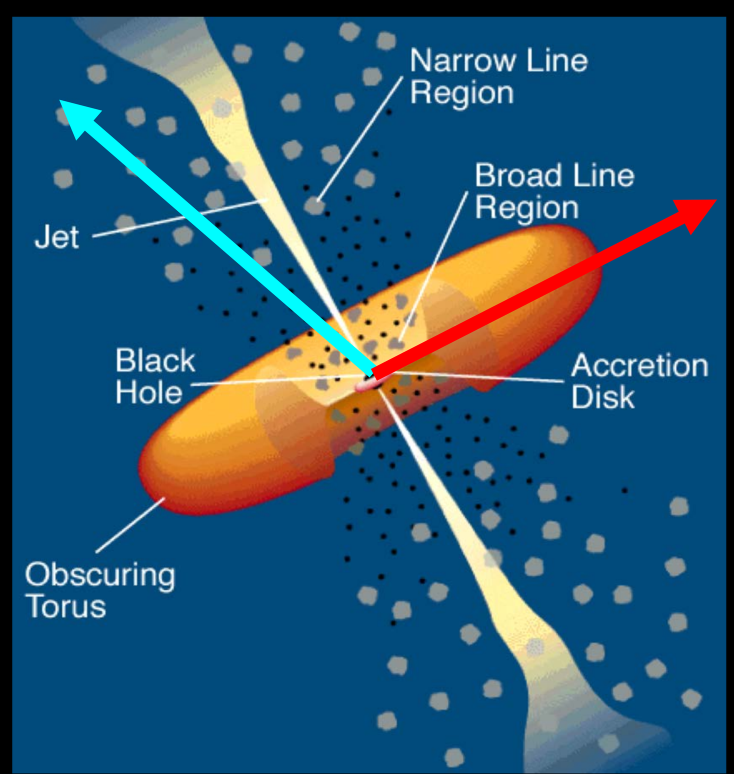

Fig 1. Current AGN model from Urry and Padovani (1995). Cyan arrow shows the cloud without torus, and red arrow shows the cloud with torus

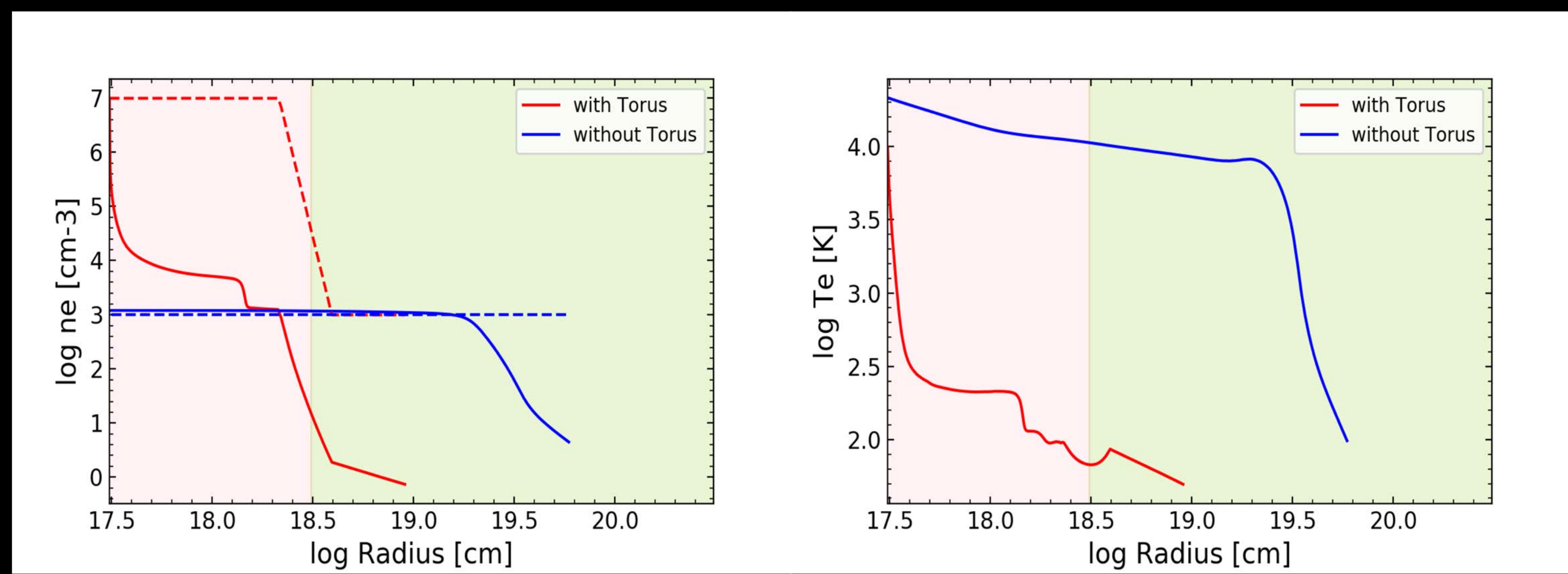

Fig 2. Hydrogen (dashed lines) and electron number density (solid lines) profiles as a function of distance from the source (Left panel). Right panel shows electron Temperature profiles. Colors indicate two different model: one model along the accretion disk (red) which have dusty torus, and the other model perpendicular to the accretion disk (blue) which only have low density region.

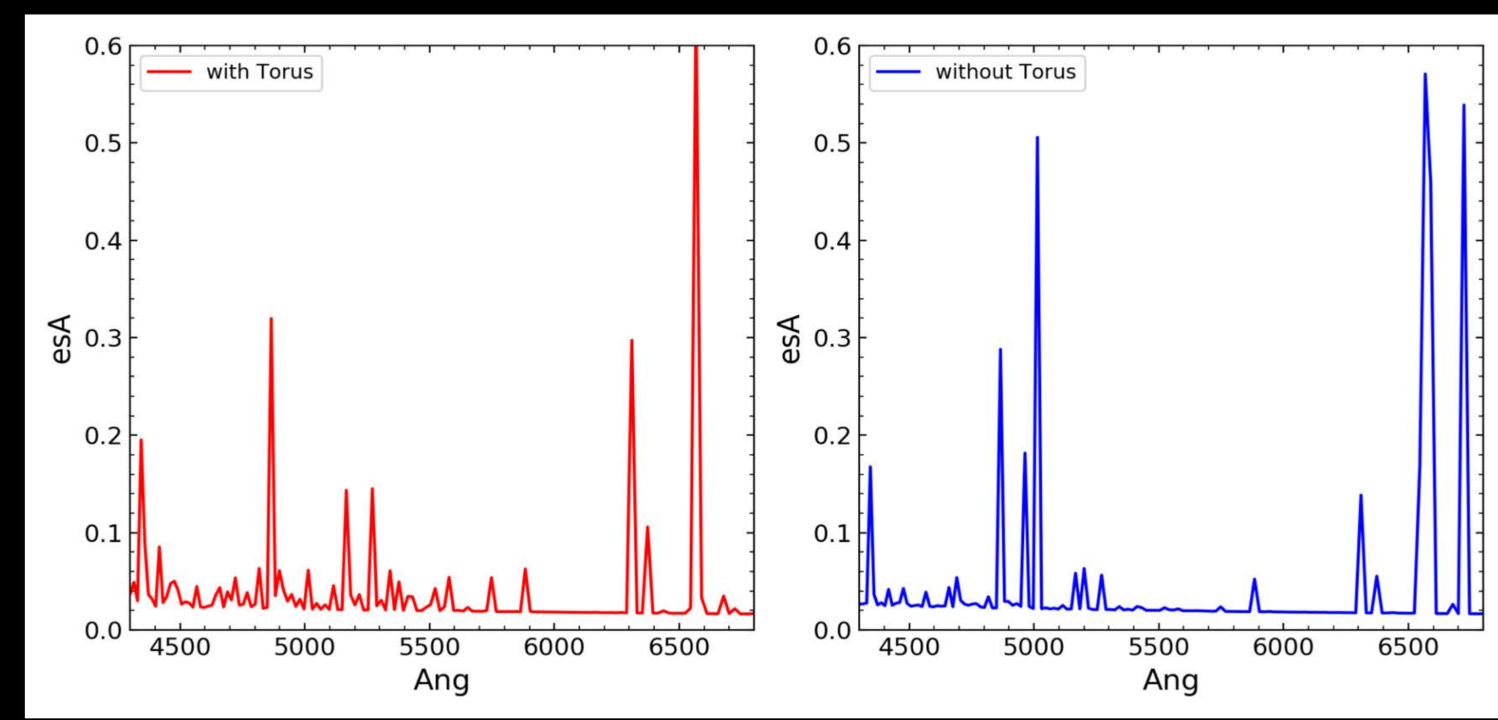

Fig 3. Emitted spectra of two different cloud models. Color code is same as Fig 2.

Results & Discussion

- Our aim was to set different n_H values for different regions outside the BLR, lying at different angle and check the temperature profile.
- We have used the inbuilt AGN table as the incident radiation fileld from the code
- Gas cloud along the radial direction (without the torus) has n_e comparable to the NLR and shows strong [OIII] 5007 emission line, while the model with torus has weak [OIII] emission.
- Using pycloudy 3D, we modeled the 3D shape of NLR by simulating several gas clouds at different direction. By changing the physical properties of the dusty torus (e.g., inner radius, thickness) , we obtain different [OIII] images which represent the geometry of the NLR.
- The size of the NLR grows and it's shape becomes more spherical as the inner radius of the torus increases (Fig. 4).
- The shape of NLR becomes narrower as the thickness of the torus increases (Fig. 5), but the size of the NLR does change as much as in Fig 4.

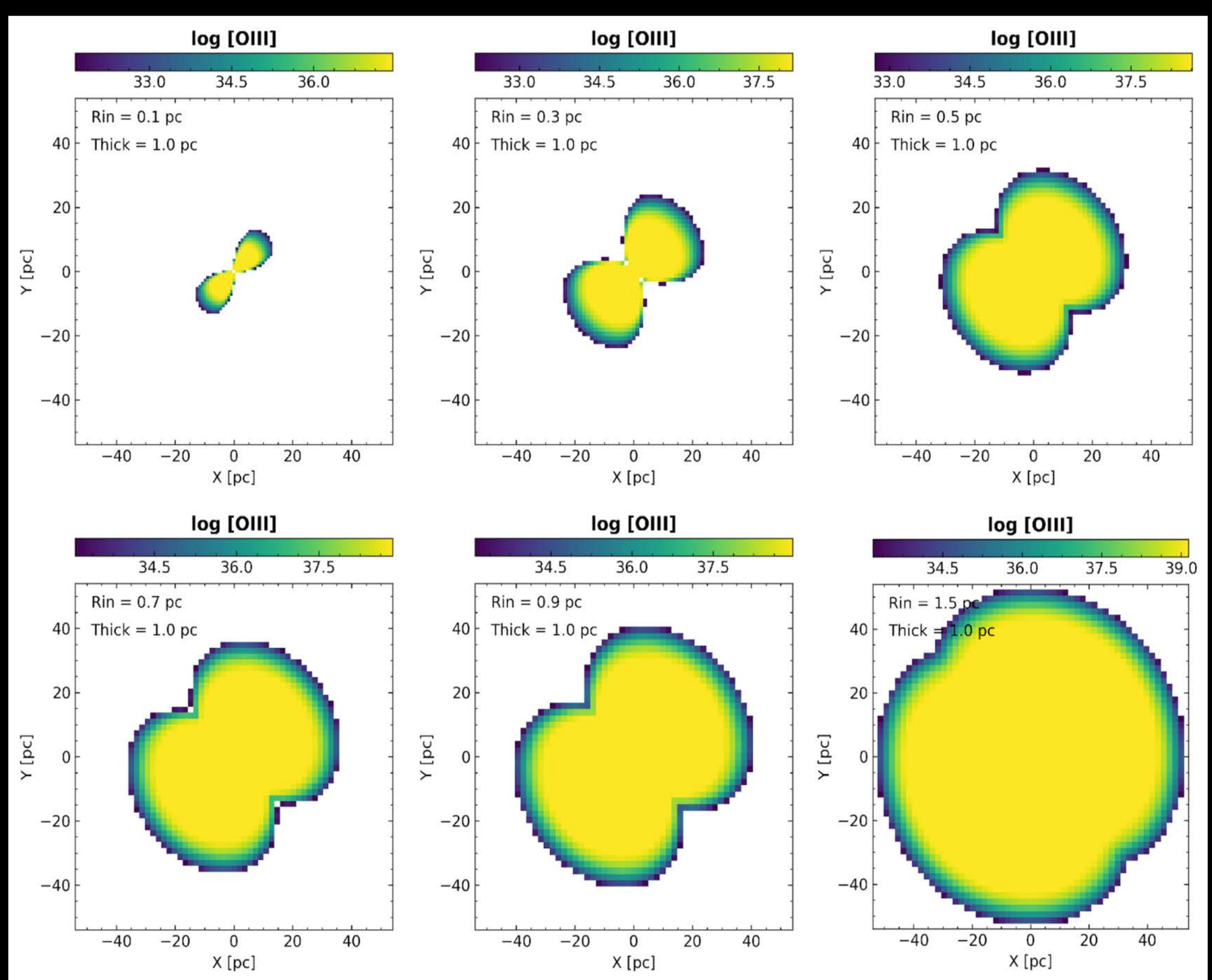

Fig 4. Projected 2D [OIII] images with different inner radius of dusty torus. We increased inner radius from 0.1 pc (upper panel, 1st column) to 1.5 pc (lower panel, 3rd column).

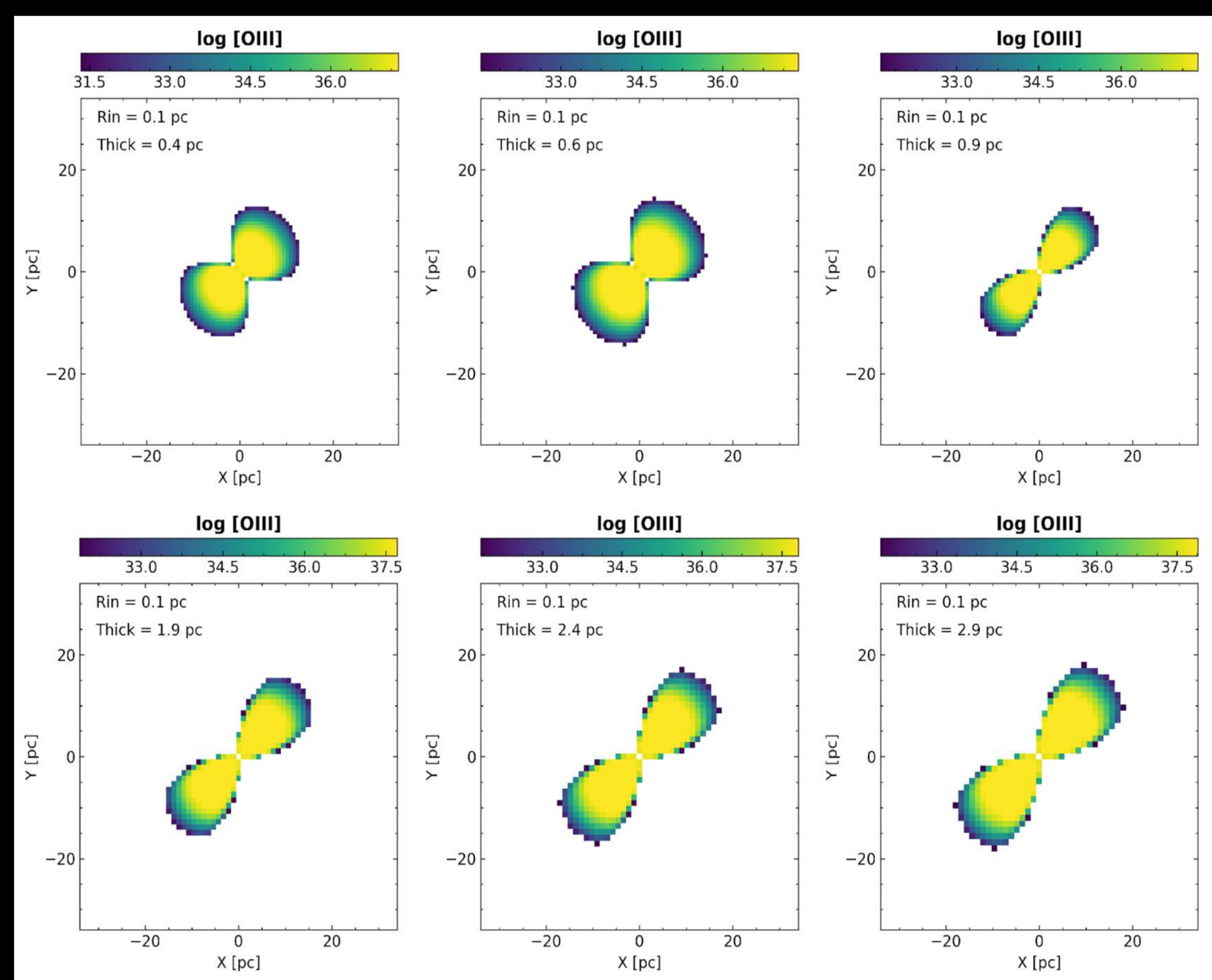

Fig 5. Projected 2D [OIII] images with different thickness of dusty torus. We increased the thickness of the torus from 0.4 pc (upper panel, 1st column) to 2.9 pc (lower panel, 3rd column)