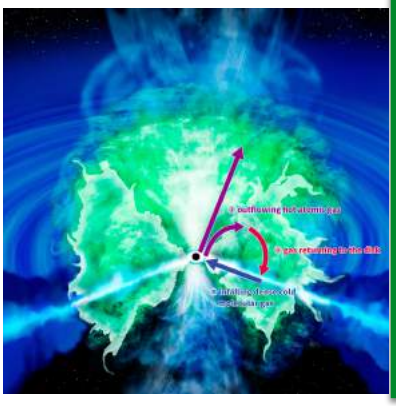
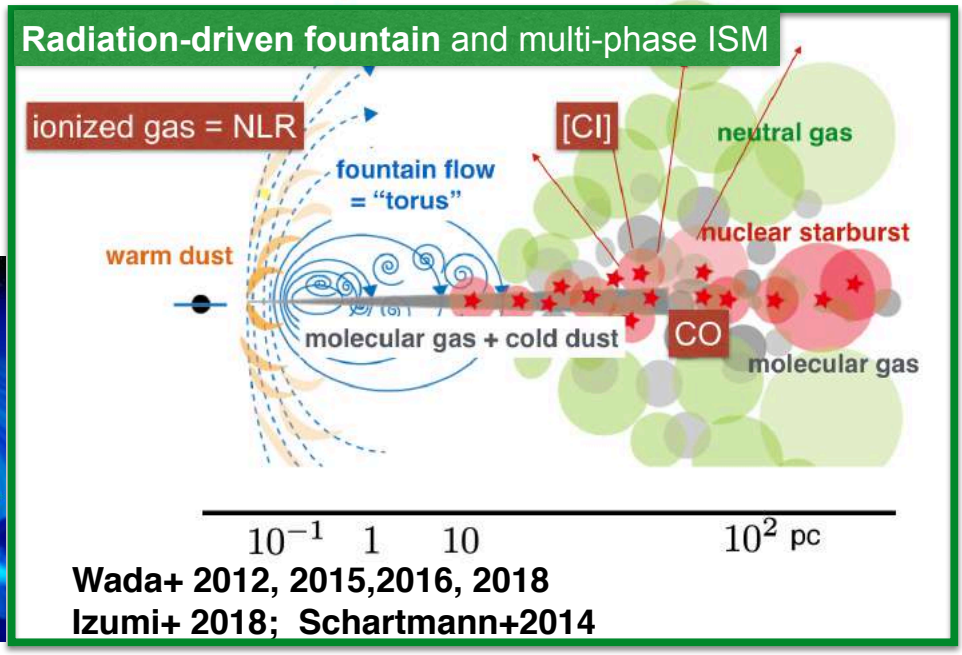
Fountain flows and obscuration by multi-phase ISM

WADA Keiichi
Kagoshima, Japan

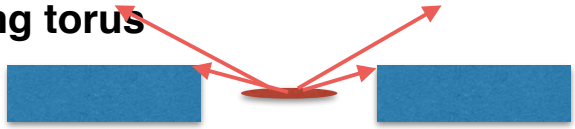




Wada+ 2012, 2015,2016, 2018
Izumi+ 2018; Schartmann+2014

Origin of AGNs obscuration?

receding torus

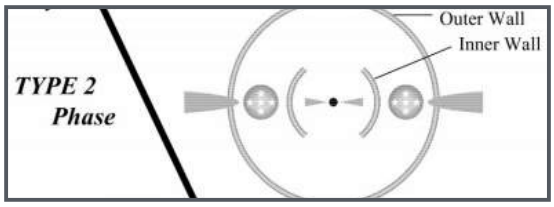


$r_{dust}(L_{AGN})$

$h(L_{AGN})$

Lawrence 1991, Simpson 2005

static walls (shells)

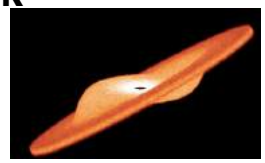


Ohsuga, Umemura (2001)

disk wind

Elitzur, Shlosman (2006)
Nomura+ (2014, 2017)

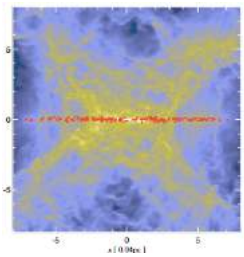
warped disk



http://www.astro.le.ac.uk/

Pringle (1996), Nayakshin (2005)

clumpy stellar wind

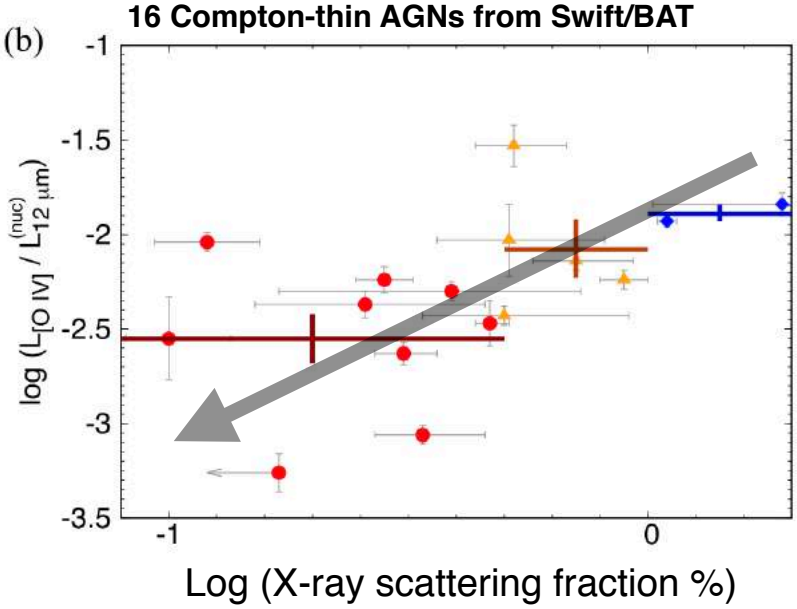


Nayakshin & Cuadra (2007)

Luminosity Ratio between [O IV] 25.89 μm Line and Nuclear Continuum 12 μm as a Diagnostic for "Buried" AGNs

Satoshi Yamada[1], Yoshihiro Ueda[1], Atsushi Tanimoto[1], Taiki Kawamuro[2], Masatoshi Imanishi[2,3], and Yoshiki Toba[1,4]

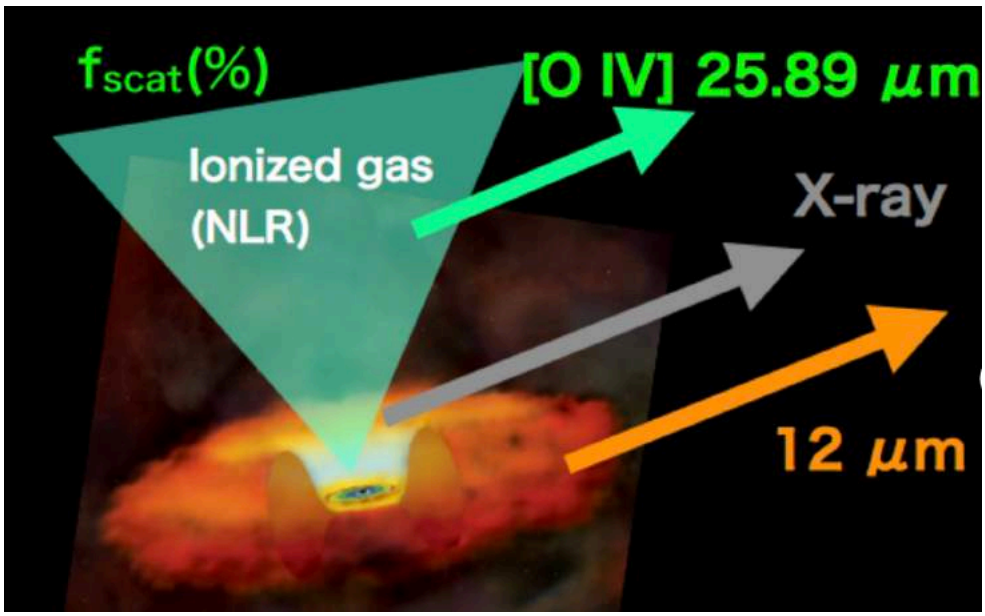
16 Compton-thin AGNs from Swift/BAT



[OIV]/ 12 μm smaller for
more obscured objects

Yamada, et al. 2019

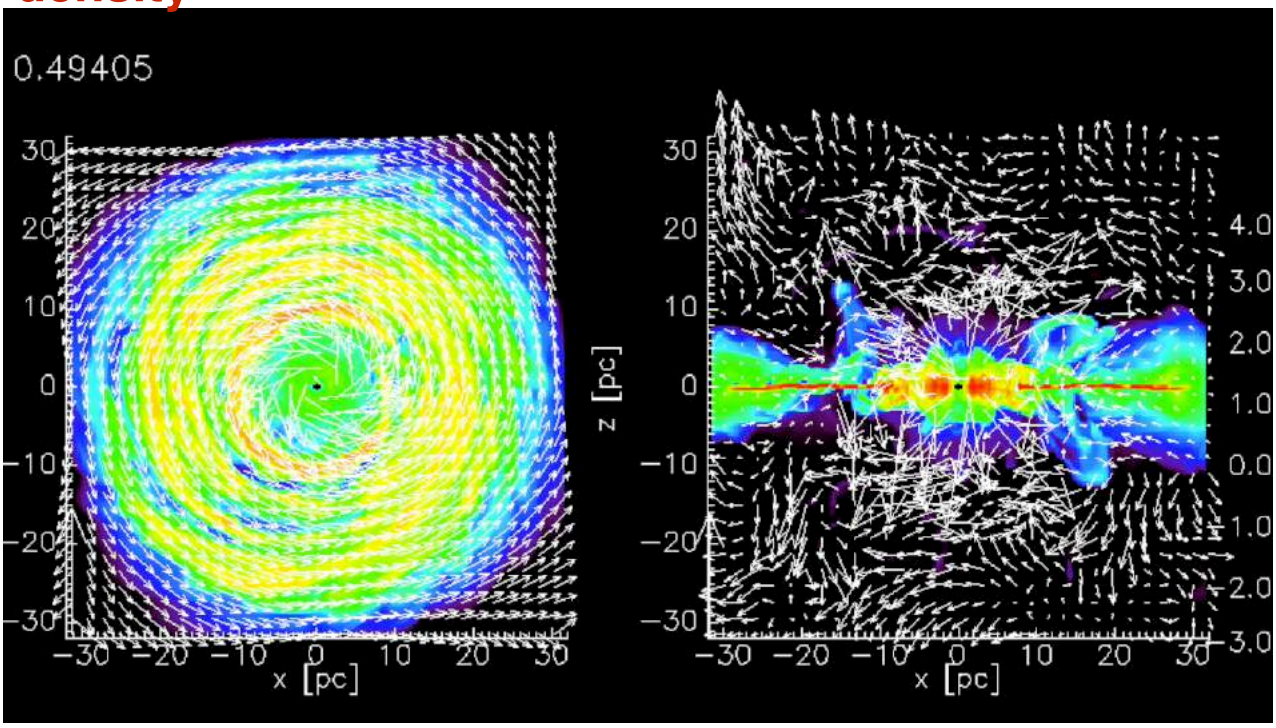
Yamada + 2019



More obscured, smaller opening angle, therefore smaller $L_{[OIV]}$ & smaller X-ray scattering fraction

An example of fountain flow and formation of a “torus-like” structure

density



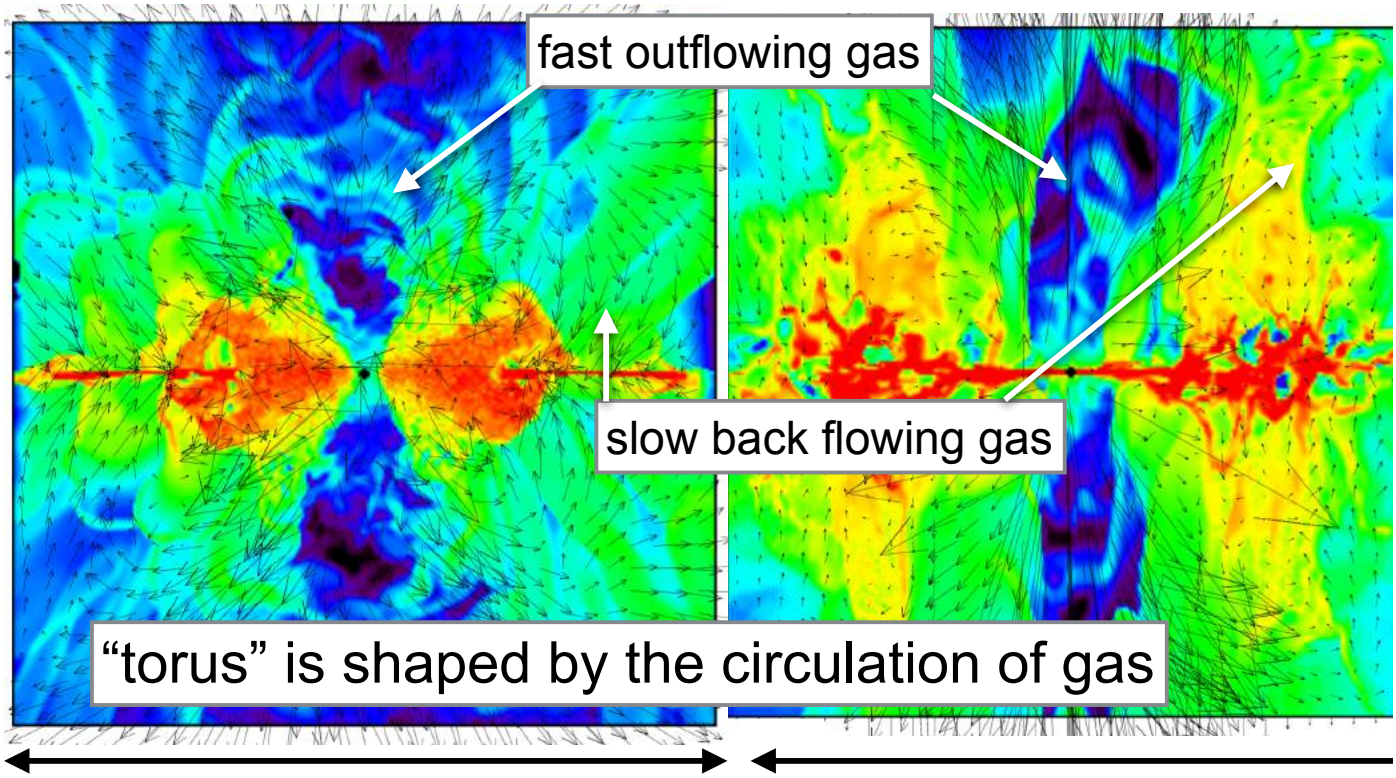
Wada (2012)

M_BH = 10^7 Msun

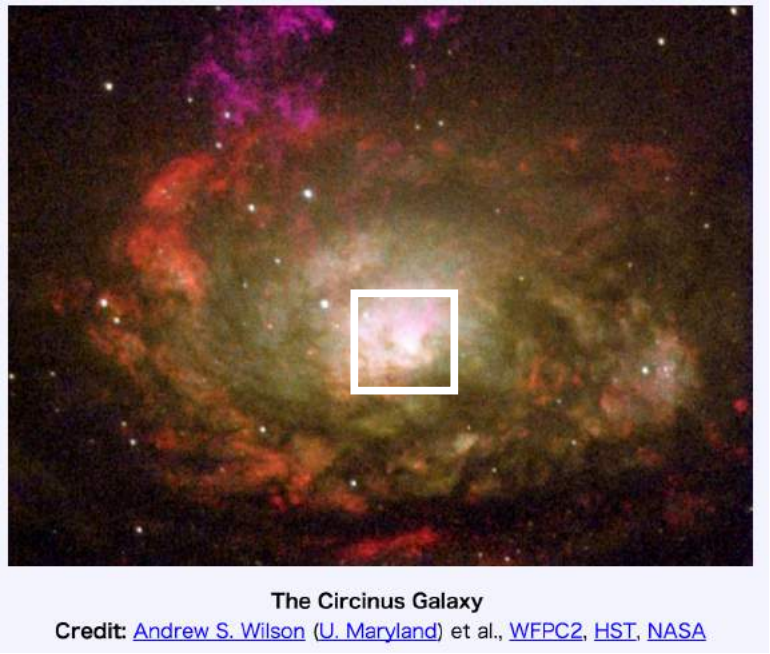
w/o supernova feedback

M_BH = 10^6 Msun

with supernova feedback



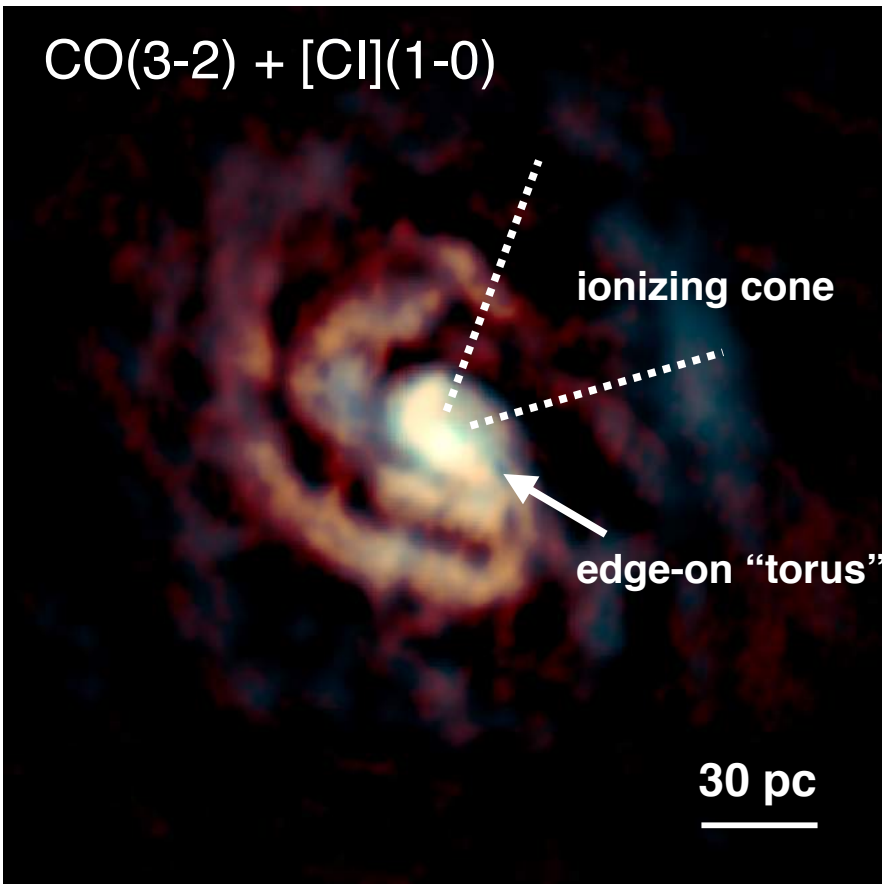
Circinus galaxy (Sy2 at 4Mpc)



The Circinus Galaxy
Credit: Andrew S. Wilson (U. Maryland) et al., WFPC2, HST, NASA

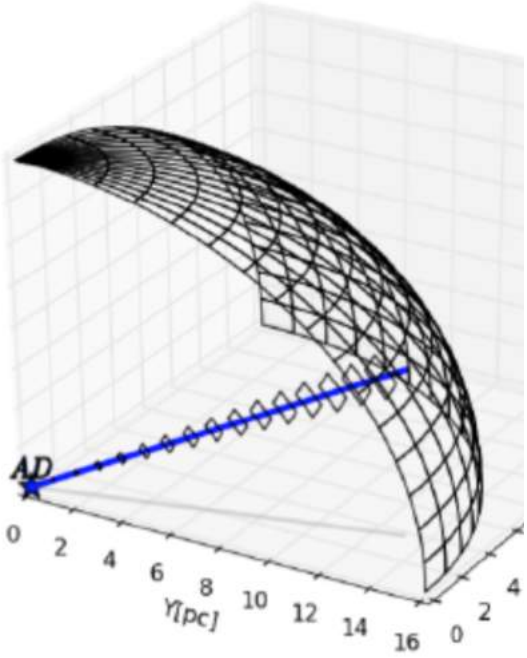
yellow: i-band
red: Hα

ALMA Cycle 4 Observations (Band 7 + 8)



Izumi, KW+2018

pseudo-3D radiative transfer for emissions from ionized gas (i.e. only radial propagation is solved with **CLOUDY (Ferland 2017)**)



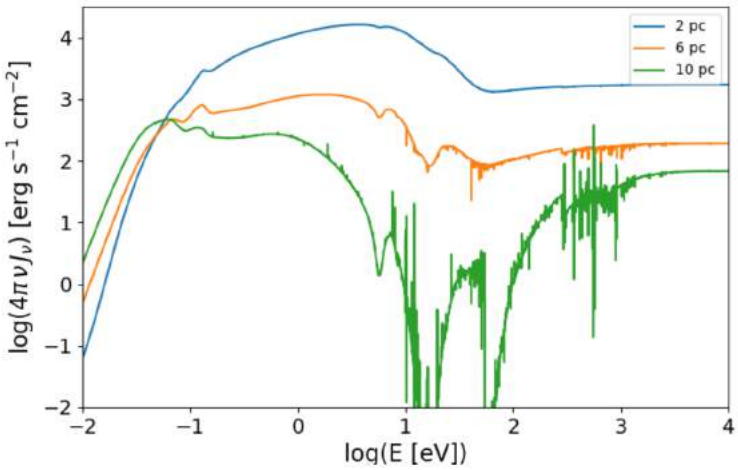
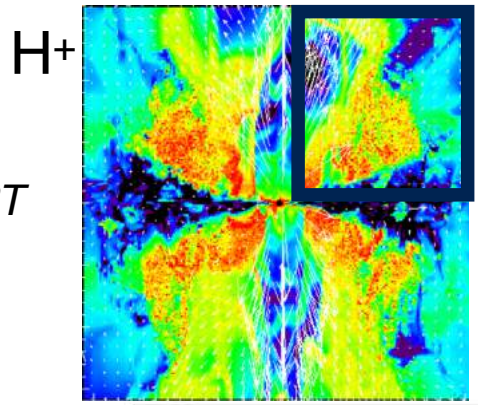


Figure 5. Radial change of SEDs at $r = 2, 6$, and 10 pc from the center along a ray of $\theta = 40°$ from the rotational axis.

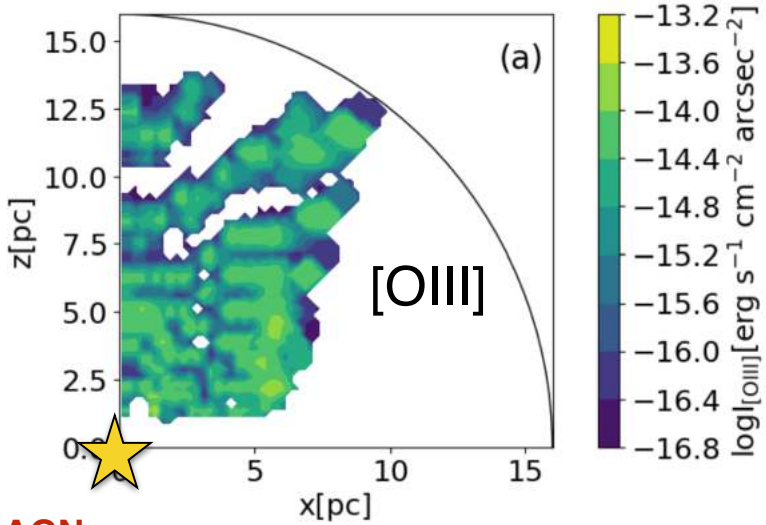
KW, Yonekura, Nagao (2018)

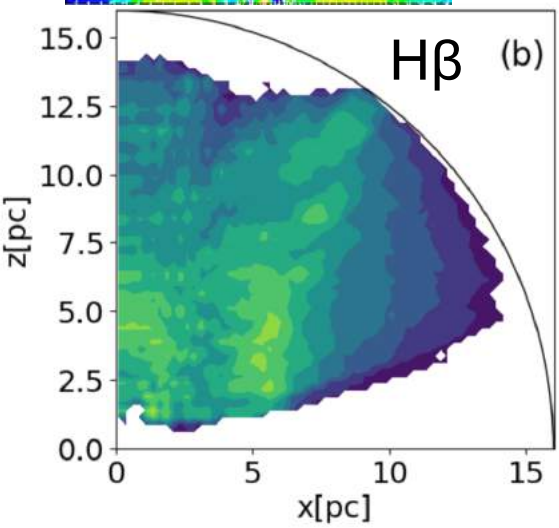
Origin of NLR = outflowing ionized gas

Fountain model *+ multi-dimensional RT using* ***Cloudy (Ferland 2017)***



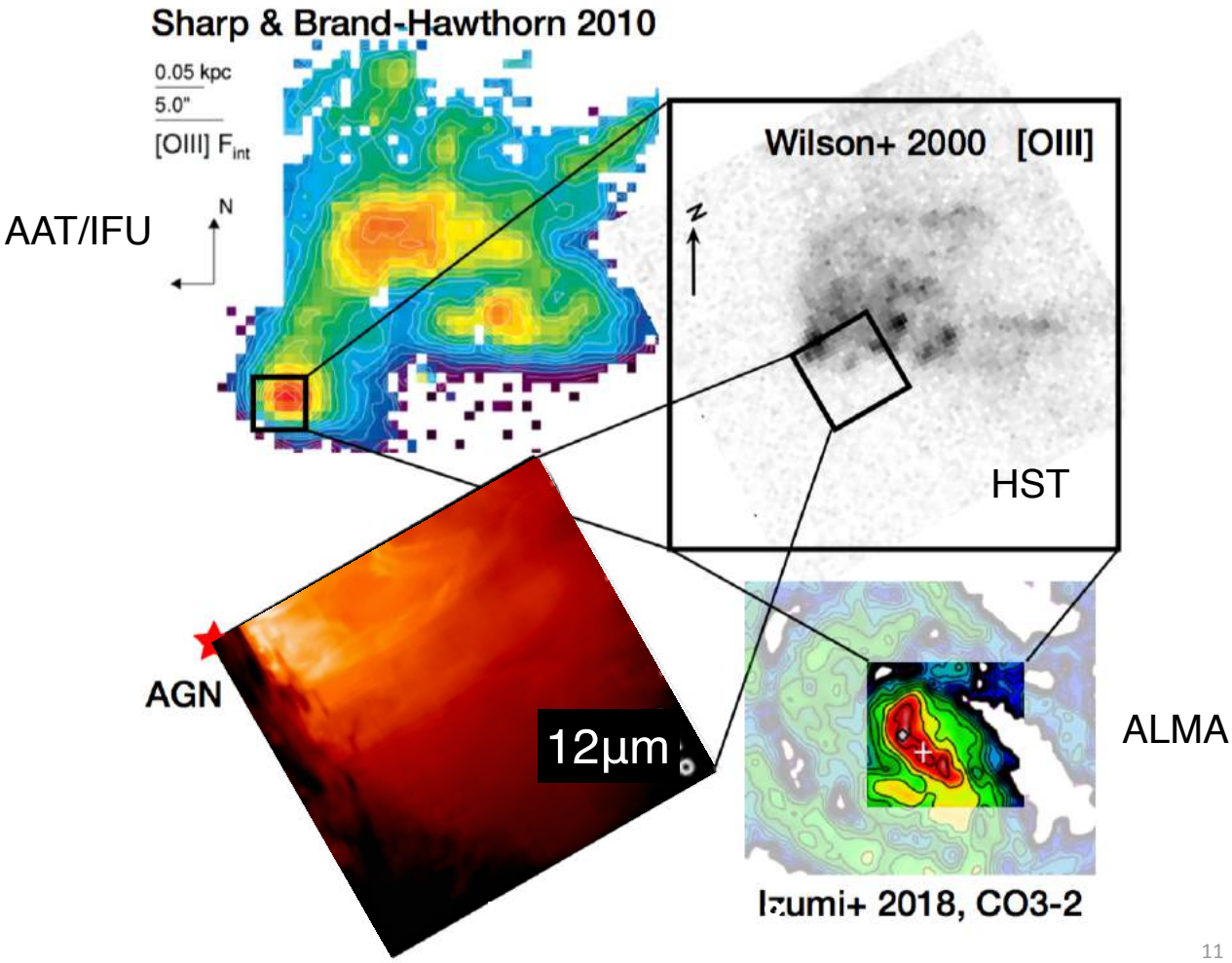
Edge-on view



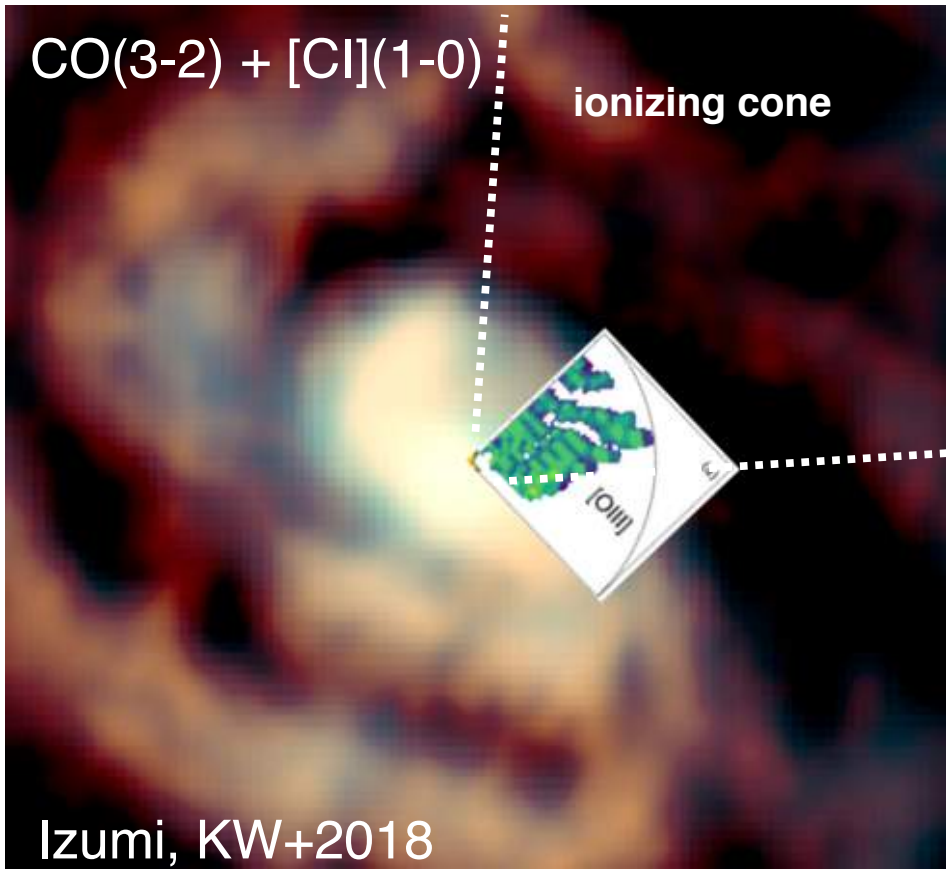


AGN

KW, Yonekura, Nagao (2018)



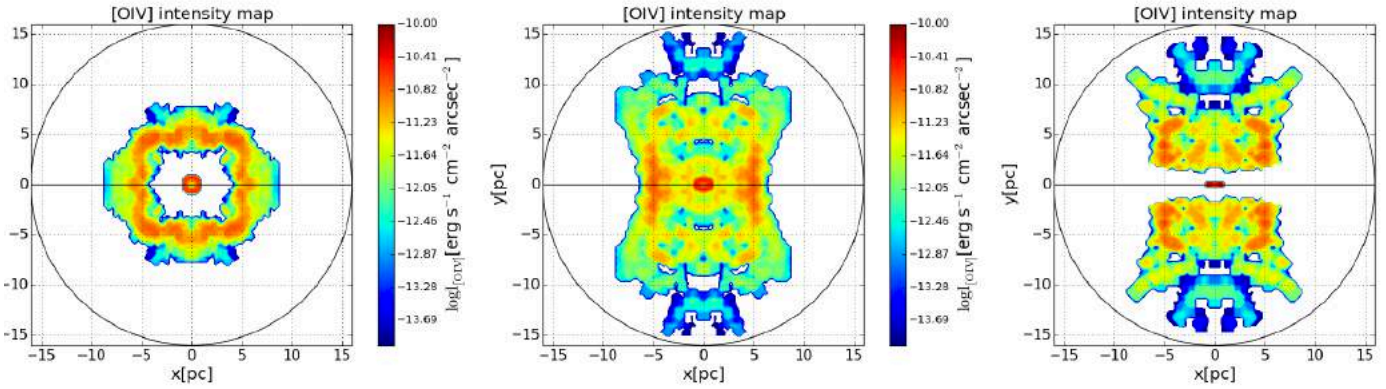
Multi-phase gas in central ~ 100 pc



Fountain model** + multi-dimensional RT using **Cloudy (Ferland 2017)

[OIV] 26 μm based on the Circus galaxy model (Wada 2016)

pole-on i = 45° edge-on

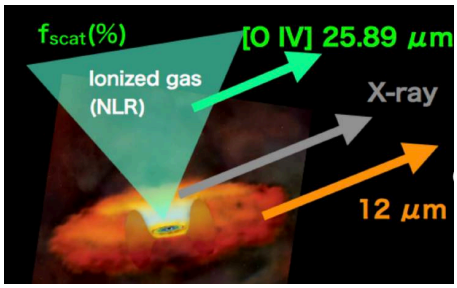


Nagatomo (graduation thesis, 2019)

Original radiation-hydro simulation is full-3D, but 1/8 region is used with Cloudy.

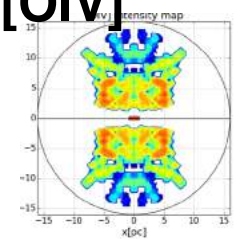
The fountain model follows the observational trend?

$L_{[OIV]}/L_{12\,\mu m} \sim 10^{-3}$
implies that Circinus's nucleus is deeply buried.

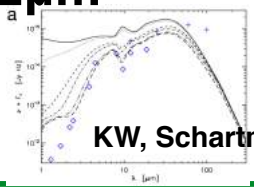


Fountain model

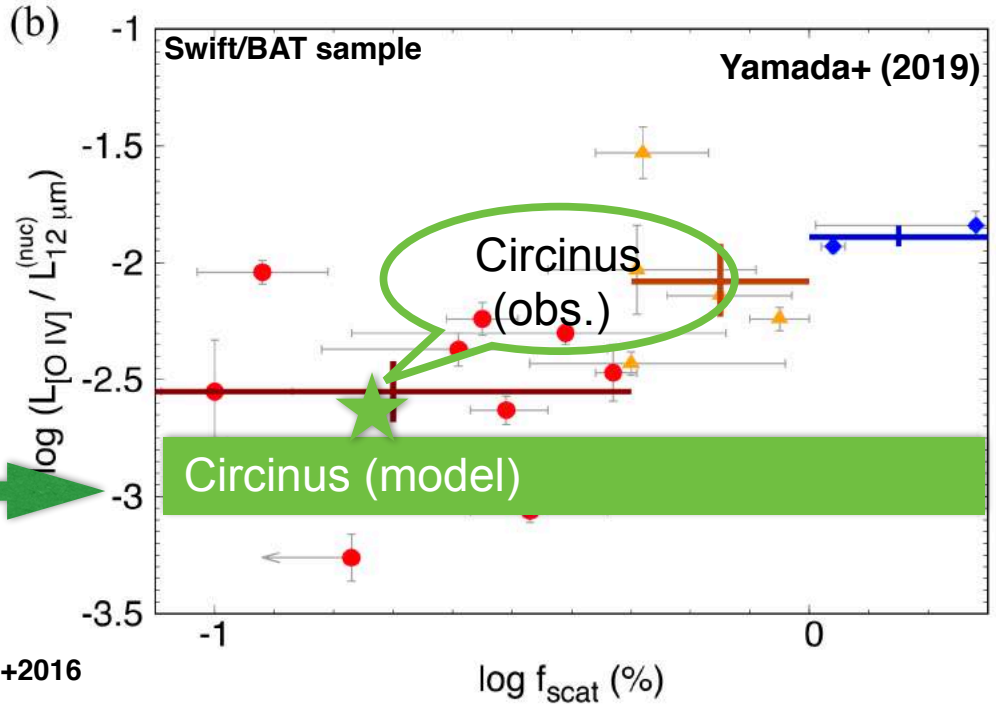
[OIV]



12μm



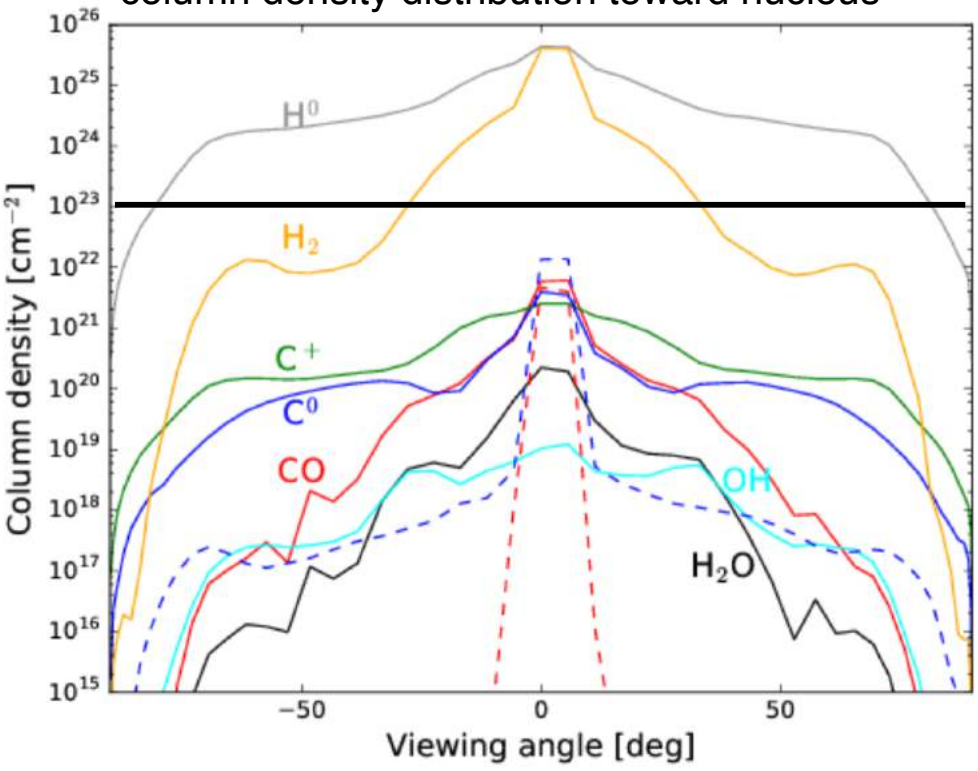
KW, Schartmann+2016



Circinus nuleus is “buried”.

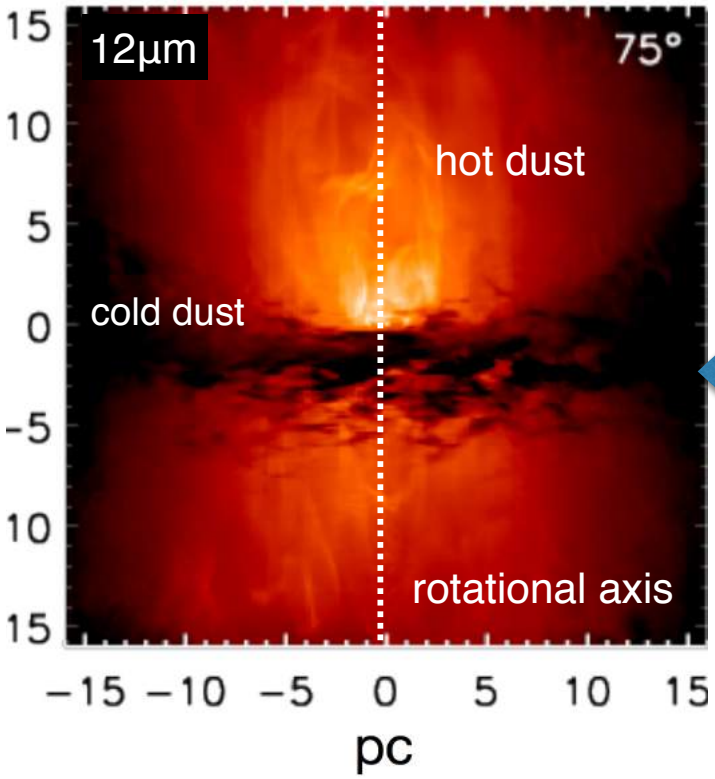
for $N_H = 10^{23}$ cm^{-2}
f_obs ~ 0.8 ⟶ f_scat should be small

column density distribution toward nucleus

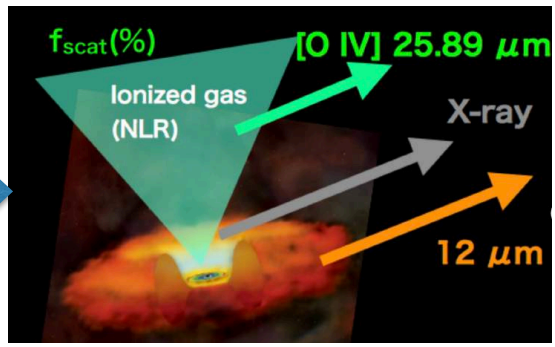


KW, Schartmann, Meijerink (2016)

MID IR does NOT come from “torus”: What [OIV]/12μm means?



?



KW, Schartmann, & Meijerink (2016)

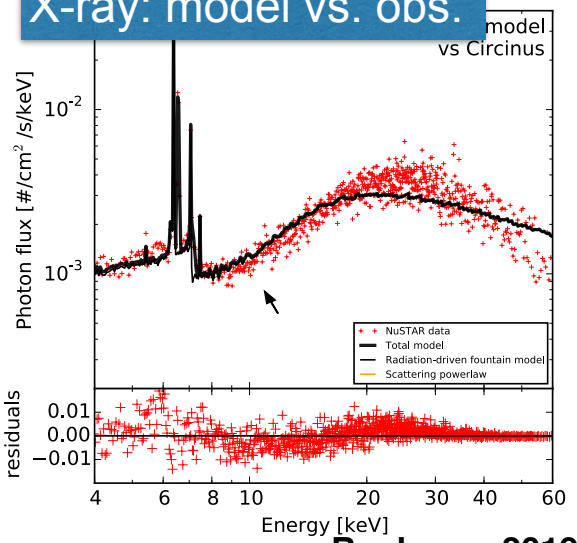
Summary & future plan

A fountain model is consistent with the observational trend of [OIV]/12μm in Circinus. But the reason is not clear.

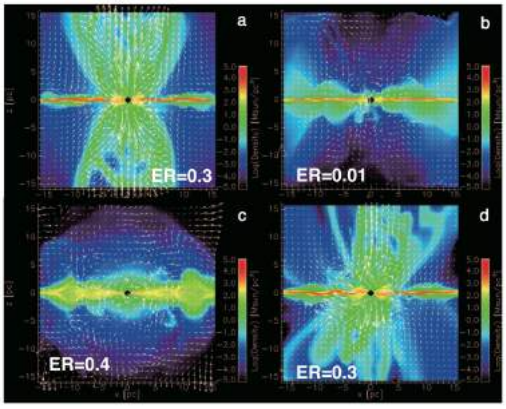
1. X-ray SED in the fountain model => f_scat

2. How do [OIV]/12μm ratios change in various fountain flows whose structures depend on M_BH & L_AGN?

X-ray: model vs. obs.



Buchner+ 2019



Wada 2015