

ALMA-AGN workshop on Dec 21, 2015  
at NAOJ

# Sudden Death of AGN in Arp 187?

*Ichikawa et al. 2015, PASJ, 281*

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# Key question: AGN lifetime

## Poorly known about AGN lifetime

- ☑ Total Accretion time scale:  $10^{7-8}$  yr (e.g., Marconi+04)
- ☑ One AGN lifecycle:  $10^5$  yrs? (e.g., Novak+11; Schawinski+15)

## How fast does AGN drop its luminosity?

- ☑ 2 order of mag in  $10^5$  yr?

(Hanny's voorwerps e.g., Schawinski+10; Keel+12)

- ☑ 1 order of mag in 10 yr (changing-look AGN; LaMassa+15)

It might be highly related to AGN accretion disk state?  
and/or AGN torus environment?

**Here I report another interesting source**

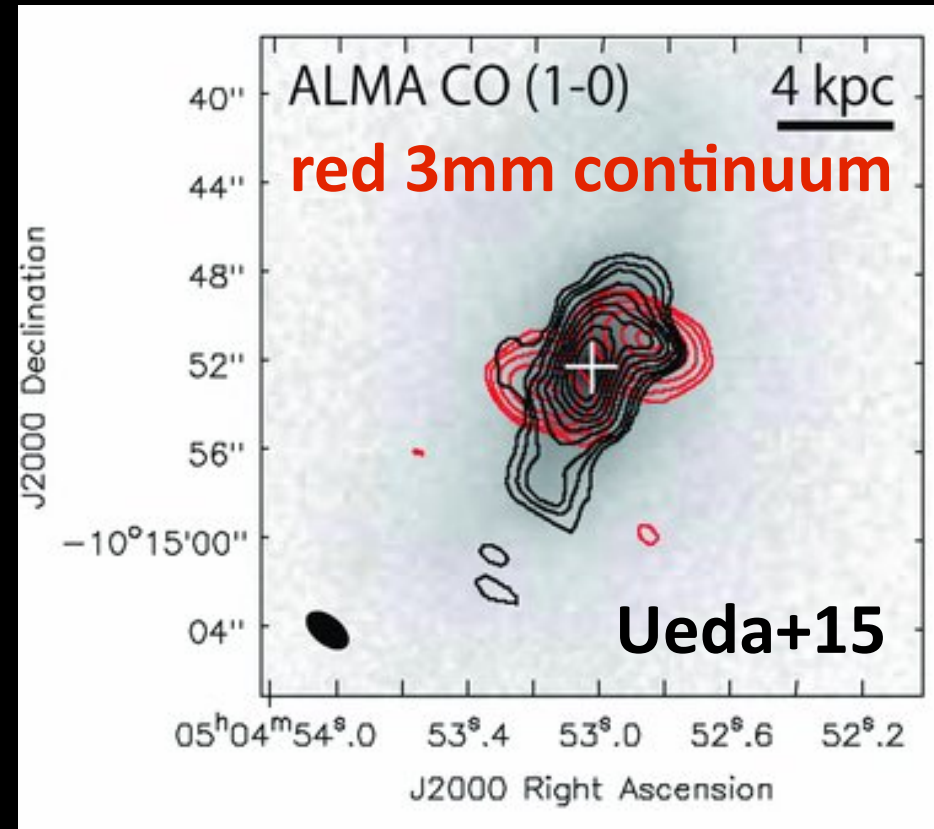
# Arp 187

Arp187: Merger remnant LIRG

Good candidate of  
AGN feedback

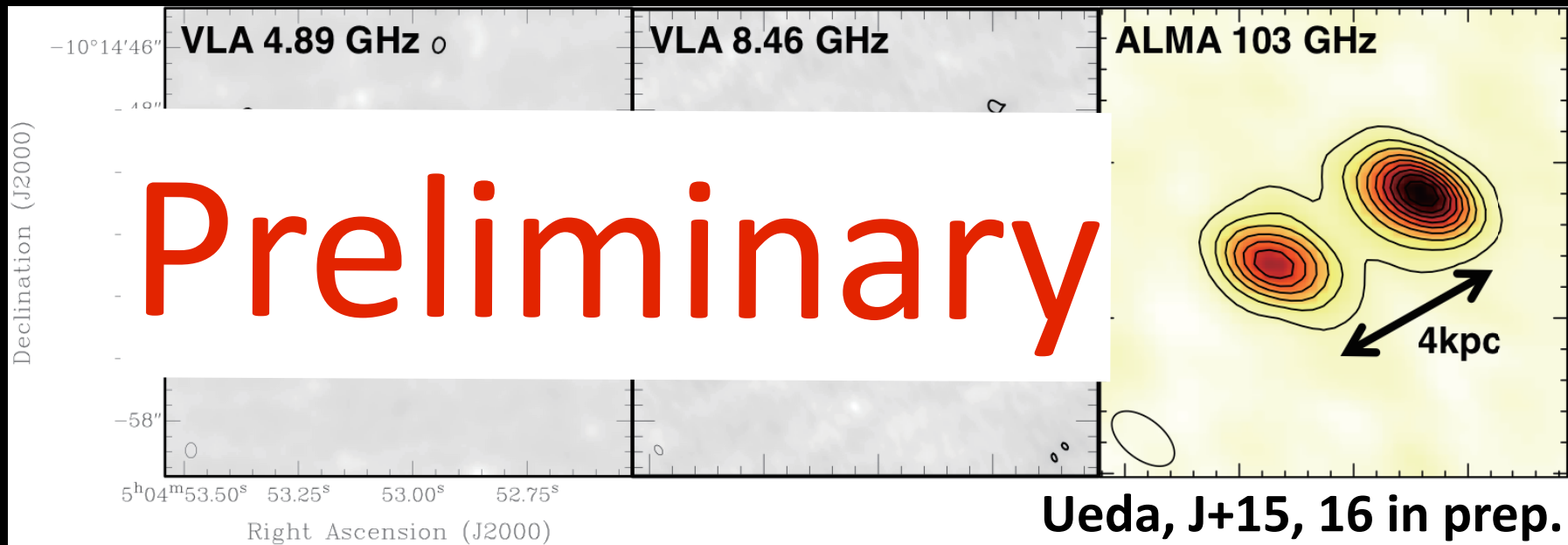
## ALMA observations

- ☑ 3mm does not associate with CO(1-0) distributions
- ☑ Some dusty outflow occurs?



# Arp 187: VLA observations

VLA 5, 8.5 GHz show bimodal jet lobes

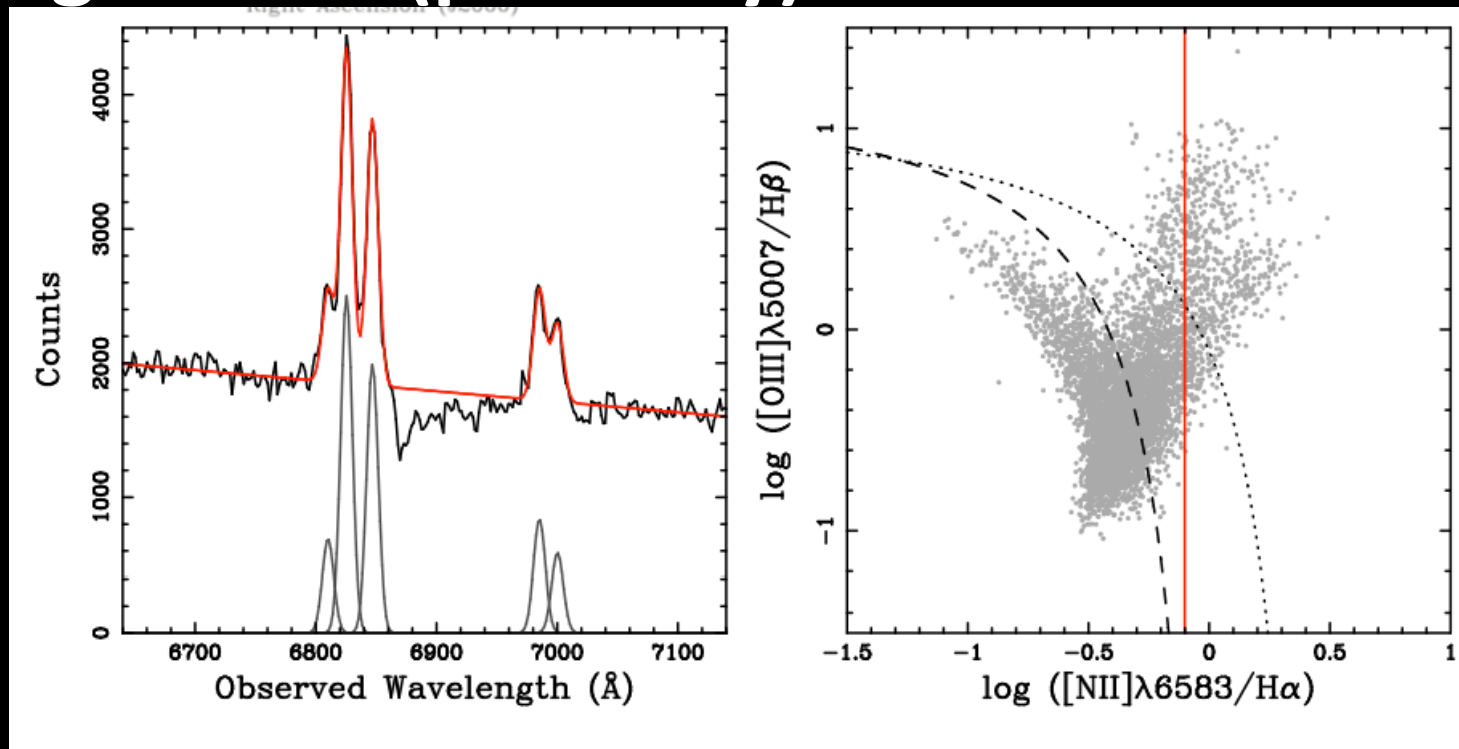


## Jet properties

- ☑ Both lobes show spec index  $\alpha = -1 \Rightarrow$  synchrotron jet
- ☑ jet kinetic age:  $6 \times 10^4$  yr (jet angle =  $90^\circ$  w/  $v = 0.1c$ )
- ☑ **jet core seems absent ( $f_{5\text{GHz}} < 210 \mu\text{Jy}$ )**

# AGN diagnostic: Optical

AGN signs: NLR (probably) exists

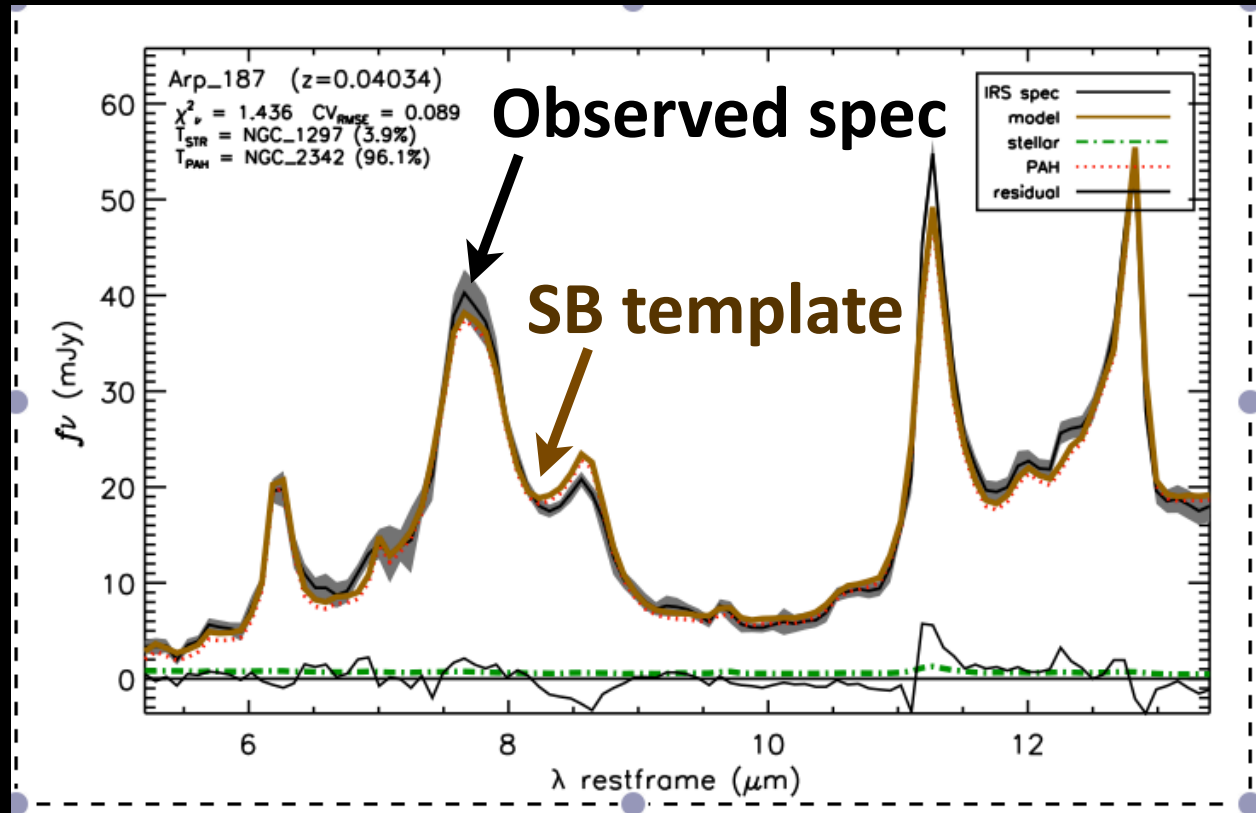


**Optical properties: typical Seyfert luminosity**

- ☑ detections of [OI]6300, H $\alpha$ , [NII], [SII], [OIII], H $\beta$ ?
- ☑ [NII]/H $\alpha$  = 0.8, located at composite or AGN
- ☑  $L_{[\text{OIII}]} = , \Rightarrow L_{2-10\text{keV}} = 1.2 \times 10^{43} \text{ erg s}^{-1}$  (e.g., Ueda, Hashimoto, KI+15)

# AGN diagnostic: Infrared

Spitzer/IRS (w/4.5'') shows that AGN torus (<10pc) is faint



IR properties: SB emission is dominant

☑  $L_{12\mu\text{m}} < 1.5 \times 10^{42} \text{ erg s}^{-1} \Rightarrow L_{2-10\text{keV}} < 2.8 \times 10^{42} \text{ erg s}^{-1}$   
 $\Rightarrow L_{14-195\text{keV}} < 5.9 \times 10^{42} \text{ erg s}^{-1}$   
(see Gandhi+09; Ichikawa+12)

# AGN diagnostic: X-ray

No previous deep X-ray observations for this target

## Swift/BAT all-sky survey (E=14-195 keV)

☑ Not listed in the catalog (Baumgartner+13)

=>  $L_{14-195\text{keV}} < 4.7 \times 10^{43} \text{ erg s}^{-1}$

=> consistent w/IR upper limit:  $L_{14-195\text{keV}} < 5.9 \times 10^{42} \text{ erg s}^{-1}$

## ROSAT all-sky survey (E=0.5-2 keV)

☑ Not listed in the catalog (Voges+99)

=>  $L_{0.5-2\text{keV}} < 8.8 \times 10^{42} \text{ erg s}^{-1}$

=> consistent w/IR upper limit:  $L_{0.5-2\text{keV}} < 2.0 \times 10^{42} \text{ erg s}^{-1}$

( $\Gamma=1.9$ ; e.g., Brightman+13)

## Not located in the XMM-slew survey region

Suzaku obs. (AO-10) was awarded, but not completed

=> Obs. w/ NuSTAR, ASTRO-H, and/or Chandra is crucial

# BH mass of Arp 187

Using  $M_{\text{BH}} - M_{\text{bulge}}$  relation, we estimate  $M_{\text{BH}}$ .

$$\checkmark L_{\text{Kband}} \Rightarrow M_{\text{stellar}} = 1.3 \times 10^{11} M_{\text{sun}} \text{ w/n}_{\text{sersic}} \sim 4$$

$$\Rightarrow M_{\text{stellar}} \sim M_{\text{bulge}}$$

$$\Rightarrow \mathbf{M_{\text{BH}} \sim 7 \times 10^8 M_{\text{sun}}} \text{ (Kormendy \& Ho 2013)}$$

Upper limit of  $\lambda_E$  :

$$\checkmark L_E = 8.4 \times 10^{46} \text{ erg s}^{-1}, L_{\text{bol}} < 8.4 \times 10^{43} \text{ erg s}^{-1}$$

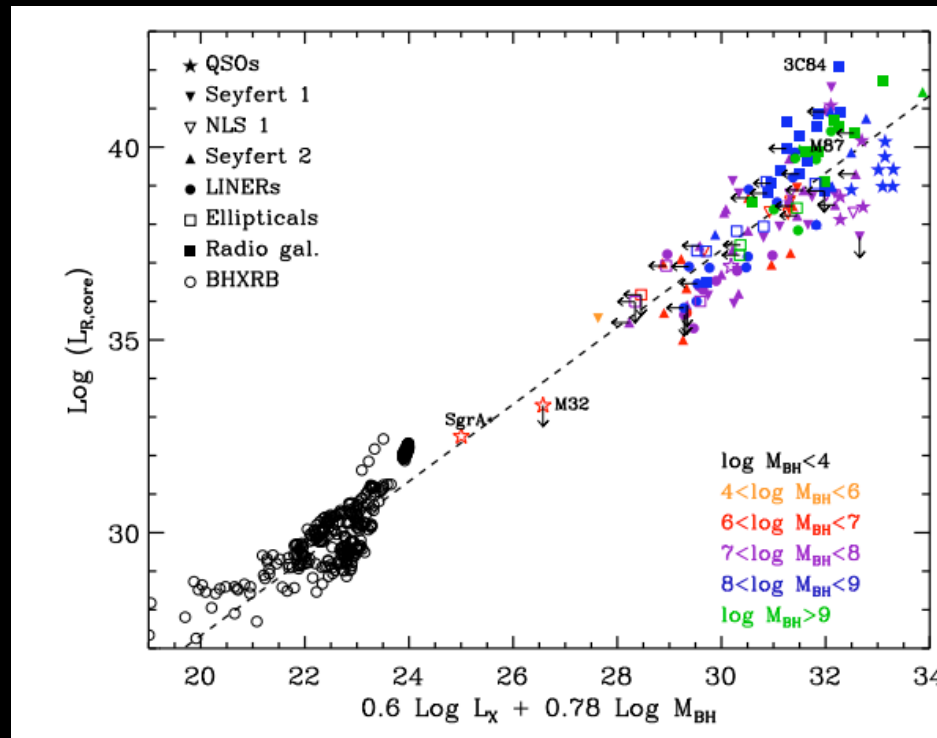
$$\Rightarrow \mathbf{\lambda_E < 10^{-3}}$$

**Disk is now ADAF state?** (Ichimaru '77, Narayan & Yi '94)



# BH fundamental plane

If you have either two values of  $L_{5\text{GHz (core)}}$ ,  $L_{2-10\text{keV}}$ ,  $M_{\text{BH}}$ , then you can estimate the final one.



Merloni+03  
Heinz+03  
Yuan+14

Upper limit of  $L_R$ , and  $M_{\text{BH}}$  are given, then

$$\checkmark L_{2-10\text{keV}} < 4 \times 10^{39} \text{ erg s}^{-1}$$

(see Gültekin+09; Yuan & Cui '05)

# What is happening in Arp 187?

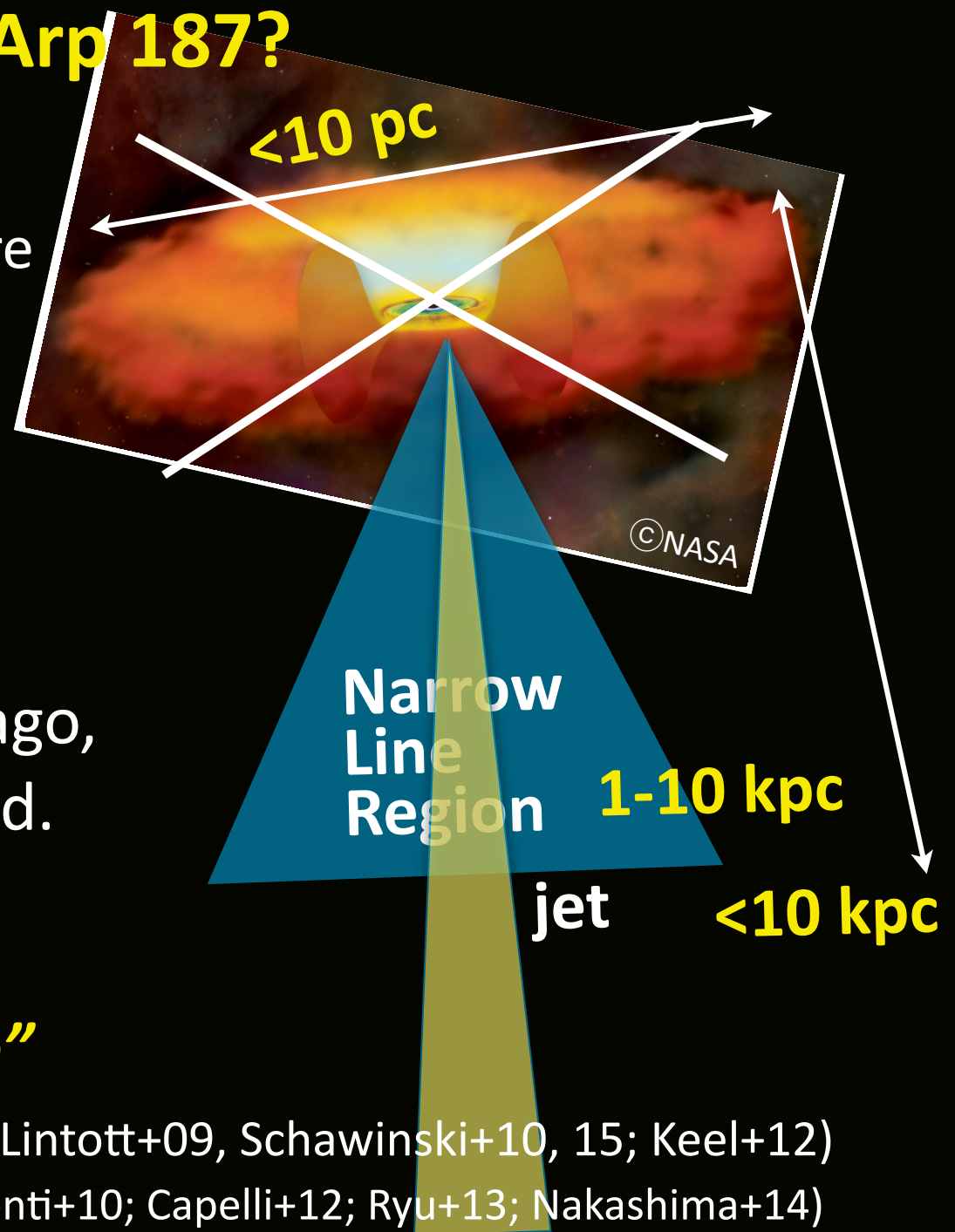
- ☑ Signs of NLR, jet (> kpc)
- ☑ Absence of torus, radio core (<10 pc scale)

FYI; dust torus cools <1yr  
(Ichikawa+16, in prep.)

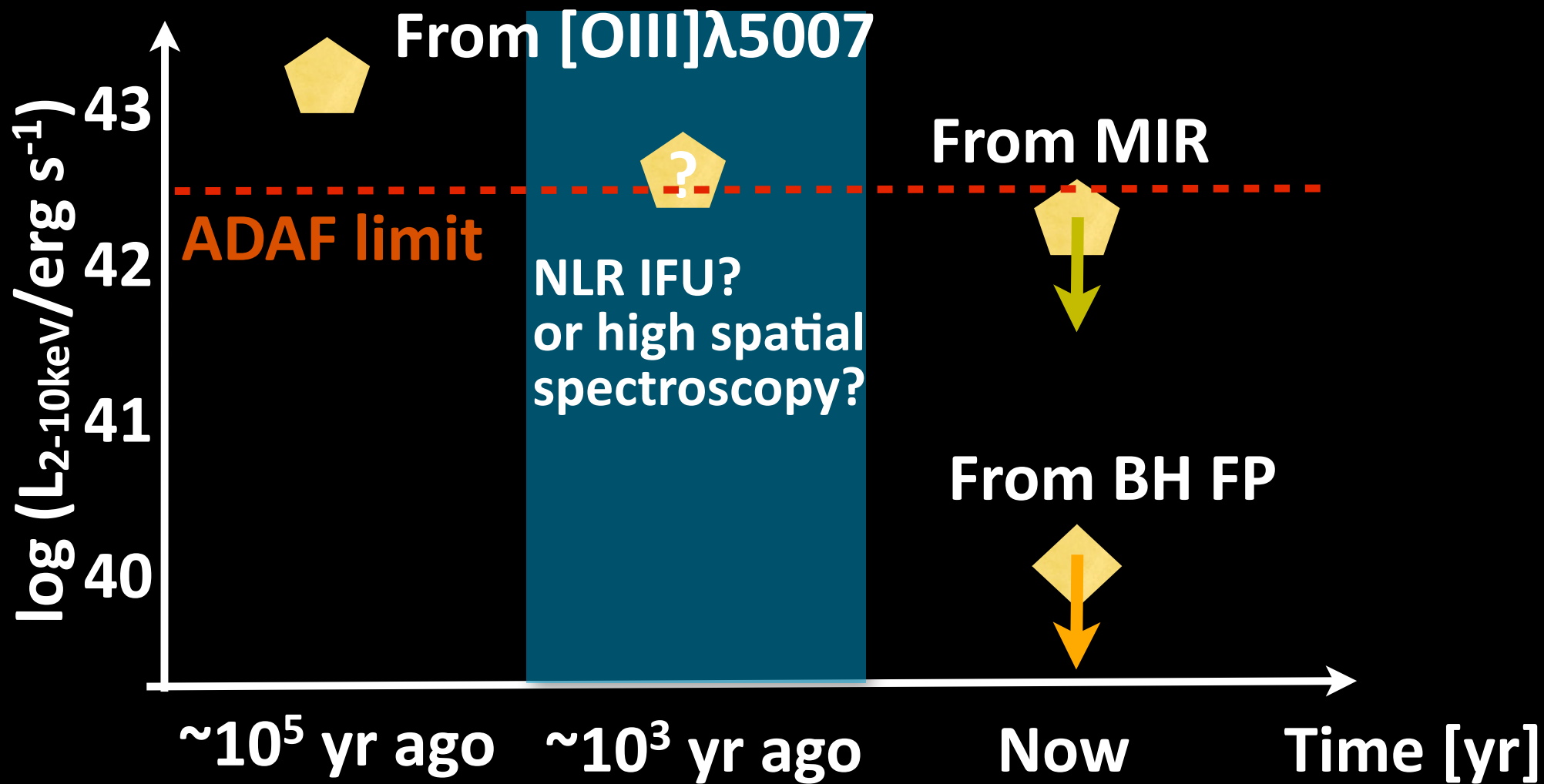
AGN “was” active  $\sim 10^5$  yr ago,  
but currently AGN “is” dead.

It is called **“AGN light echo”**

see Hanny’s Voorwerp ( $10^{4-5}$  yr ago; Lintott+09, Schawinski+10, 15; Keel+12)  
or the galactic center (500 yr ago; Ponti+10; Capelli+12; Ryu+13; Nakashima+14)  
or Fermi bubbles study ( $10^6$  yr ago; Zubovas+11, 12; SU & Finkbeiner ’12)



# AGN Luminosity drops of Arp 187



$L_{\text{AGN}}$  has decreased at least  $10-10^3$  times in  $\sim 10^5$  yr

# Summary: witnessing the death of AGN

Arp 187 is a LIRG w/ interesting properties

☑ NLR, jet lobe (w/ age  $\sim 10^5$  yr) exist

☑ torus, jet core is absent

=> AGN “was” active but “is” dead

$L_{\text{AGN}}$  has decreased at least  $10\text{-}10^3$  times in  $\sim 10^5$  yr

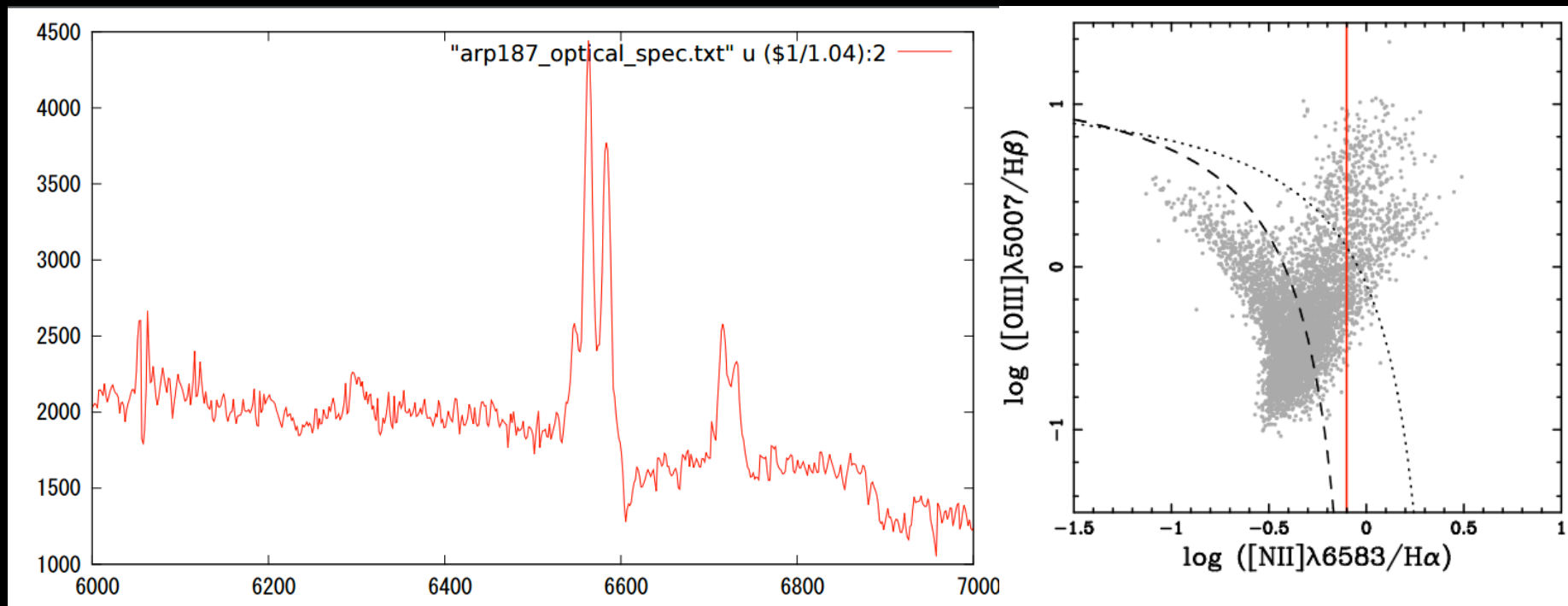
## Sudden ( $=10^5$ yr) Death of AGN in Arp 187

CSO may be good candidates which have similar properties with Arp 187

# Appendix

# AGN diagnostic: Optical

AGN signs: NLR probably exists



## Optical properties

- ☑ detection of [O I]6300, H $\alpha$ , [N II], S II
- ☑ [N II]/H $\alpha$  = 0.8, located at composite or AGN
- ☑  $L_{[\text{O III}]}$  = ,  $\Rightarrow L_{2-10\text{keV}} = 1.2 \times 10^{43} \text{ erg s}^{-1}$  (e.g., Ueda+15)