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"Extreme" luminosity decline in $10^{3\text{-}4}$ yrs

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Key question: AGN lifetime

AGN life time: observationally poorly constrained

- ☑ **Total Accretion time scale: $10^{7\text{-}8}$ yr (e.g., Marconi+04)**
- ☑ **One AGN lifecycle: 10^5 yrs?**

(**AGN *flickering*;** Hopkins & Quataert '10; Novak+11; Schawinski+15;
see also ***AGN thermal echo:*** **Schirmer+16; Kawamuro+17**)

How fast do AGN drop its luminosity?

- ☑ **2-3 order of mag in 10^5 yr?**
  (Hanny's voorwerps e.g., Schawinski+10; Keel+12,15,16, see also Sartori's talk)
- ☑ **1 order of mag in 10 yr**
  (changing-look QSO; Tohlin & Osterbrock '76 ;LaMassa+15, Ruan+16 etc.)

It might be highly related to AGN accretion disk state?

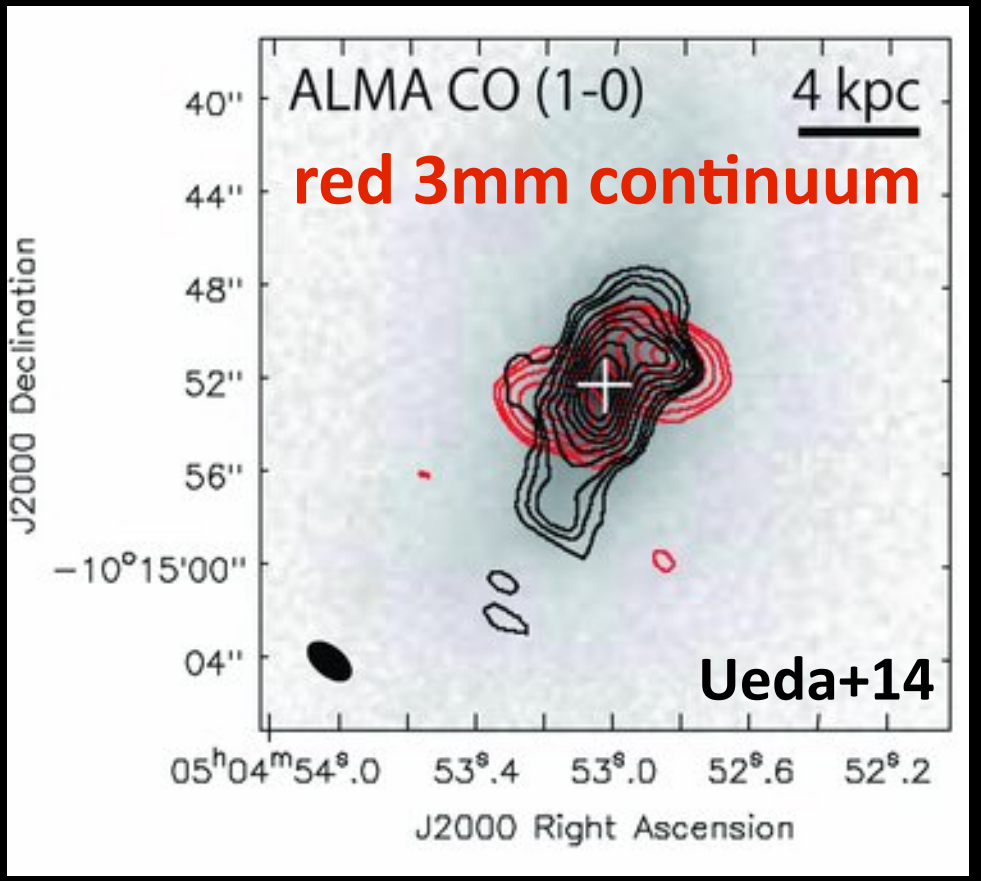
and/or AGN torus environment?

Here I report additional case of extreme variability

Arp 187

Arp187: Merger remnant LIRG (Rothberg & Joseph '04)

Good candidate of AGN feedback study

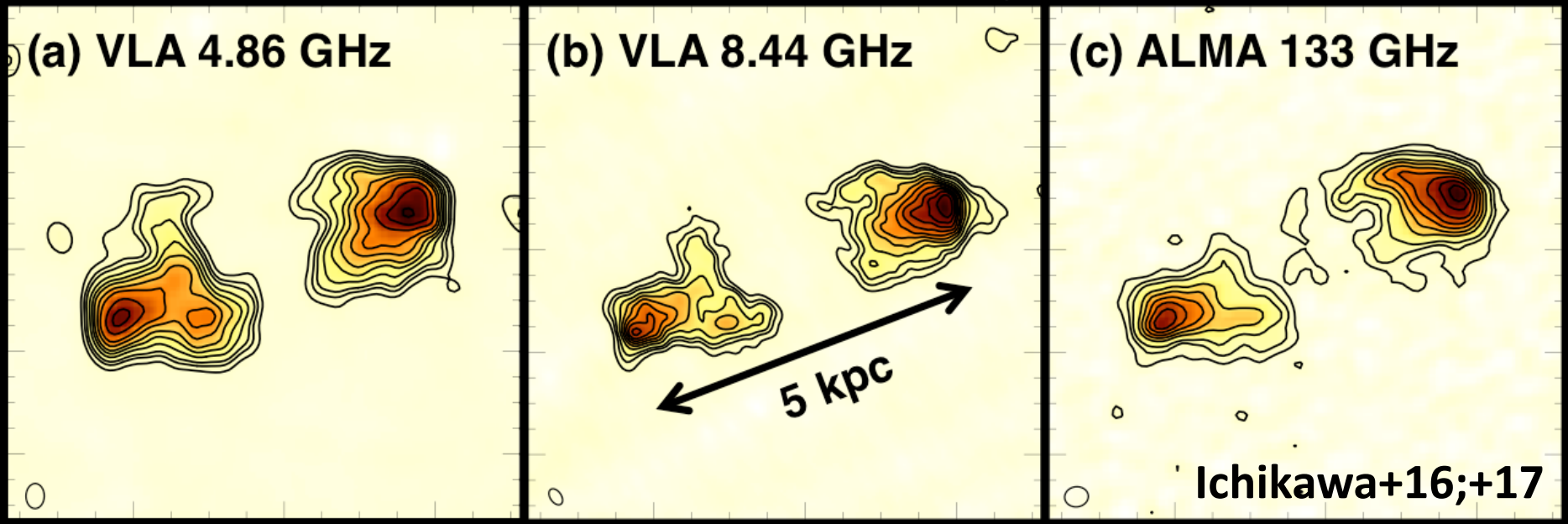


ALMA observations (Ueda+14)

- ☑ CO(1-0) associates with host galaxy K band emission
- ☑ 3mm continuum does not associate with CO(1-0) distributions
- ☑ Some dusty outflow occurs? or radio-jet?

Arp 187: VLA observations

VLA 5, 8.5 GHz show bimodal jet lobes



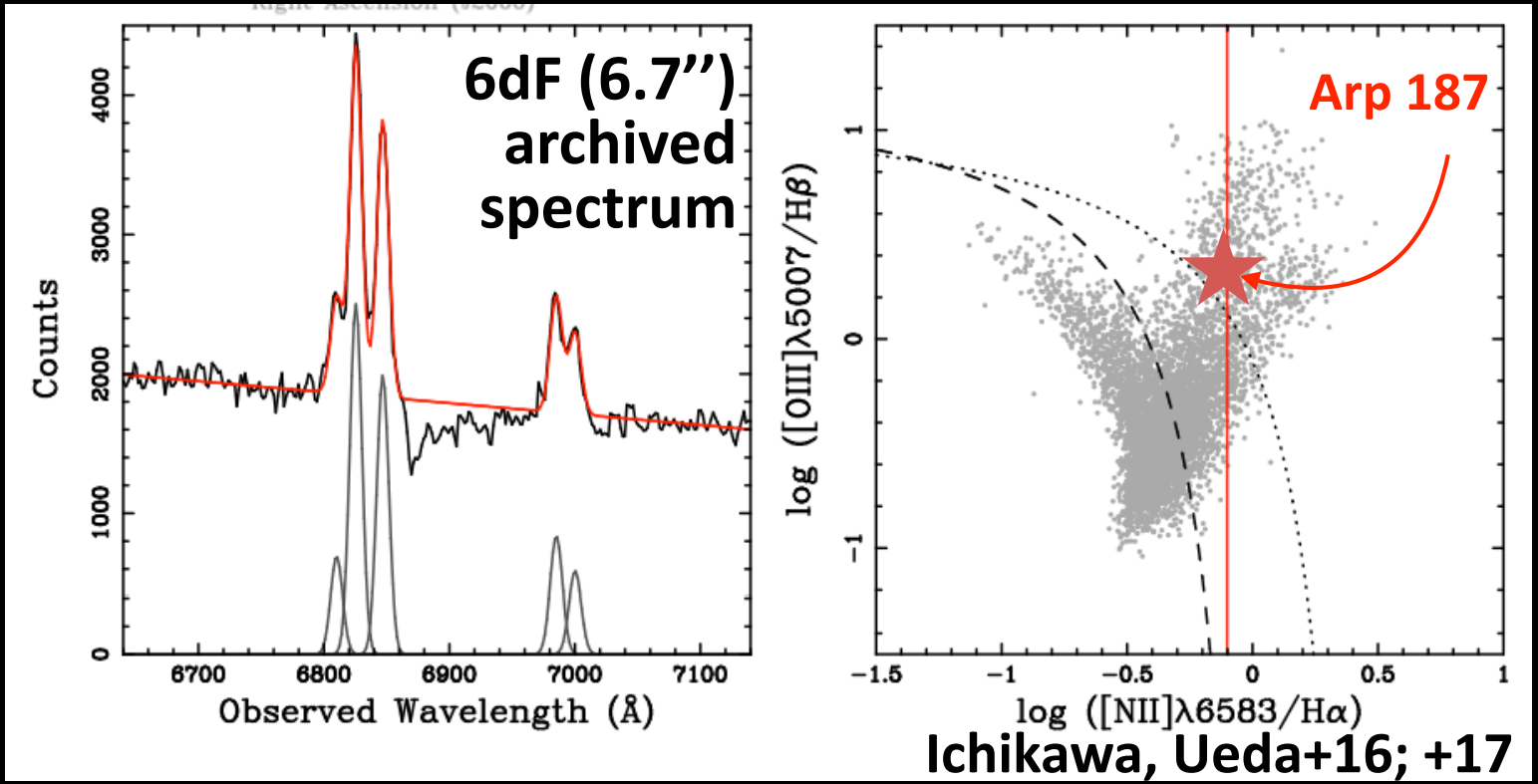
Jet properties

- ☑ Both lobes show spec index α=-1 => synchrotron jet
- ☑ jet kinetic age: 6×10^4 yr (jet angle=90° w/ v=0.1c)
- ☑ **jet core seems absent (f_{5GHz} < 210 μJy)**

=> current AGN activity might be silent?

Optical spectrum = NLR activity (~ kpc)

BPT diagram: NLR (probably) exists



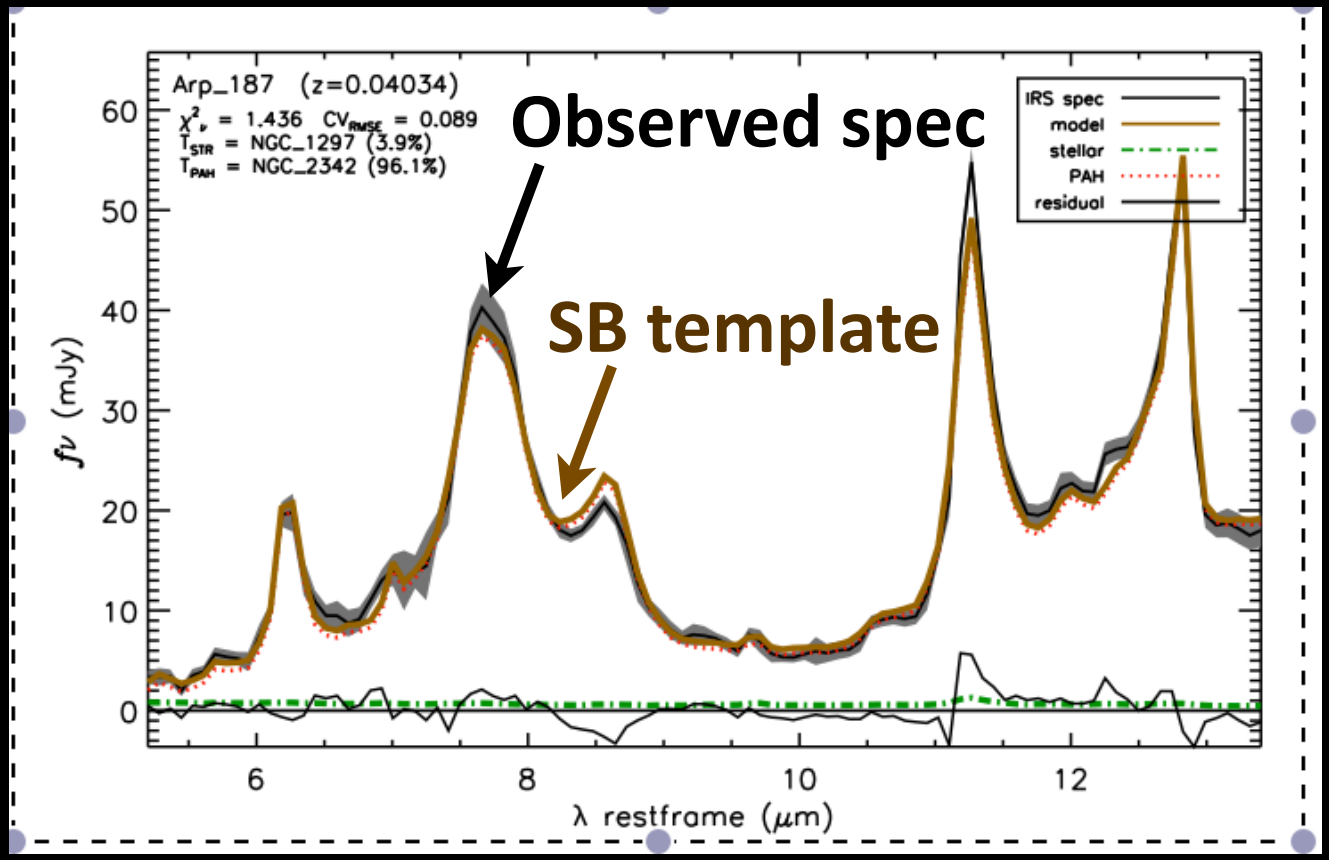
Optical properties: suggest Seyfert class luminosity

- ☑ detections of [OI]6300, Ha, [NII], [SII], [OIII], Hb
- ☑ [NII]/Ha = 0.8, located at composite or AGN
- ☑ log $L_{[OIII]}$ =42.5, => log ($L_{2\text{-}10keV}$ /erg s^{-1}) = 44.3 (e.g., Ueda, KI+15)

mid-IR = torus activity (<10 pc)

Spitzer/IRS (w/4.5''): SB dominant spectra

=> AGN torus emission (<10pc) is faint



☑ $L_{12um} < 1.5\times10^{42}$ erg s^{-1} => $L_{2\text{-}10keV} < 2.8\times10^{42}$ erg s^{-1}

=> $L_{14\text{-}195keV} < 5.9\times10^{42}$ erg s^{-1}

(see also Gandhi+09; Asmus+15; Ichikawa+12, +17a)

X-ray (= electron corona << 0.1 pc)

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)

=> $L_{14\text{-}195keV} < 4.7\times10^{43}$ erg s^{-1}

=> consistent w/IR upper limit: $L_{14\text{-}195keV} < 5.9\times10^{42}$ erg s^{-1}

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

☑ Not listed in the catalog (Voges+99)

=> $L_{0.5\text{-}2keV} < 8.8\times10^{42}$ erg s^{-1}

=> consistent w/IR upper limit: $L_{0.5\text{-}2keV} < 2.0\times10^{42}$ erg s^{-1} (Γ=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-H2, and/or Chandra is crucial

BH mass of Arp 187

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

☑ L_{Kband} => $M_{stellar} = 1.3\times10^{11}\ M_{sun}$ w/$n_{sersic} \sim 4$ (Rothberg & Joseph '04)

=> $M_{stellar} \sim M_{bulge}$

=> **$M_{BH} \sim 7\times10^{8}\ M_{sun}$** (Kormendy & Ho 2013)

Upper limit of λ_E :

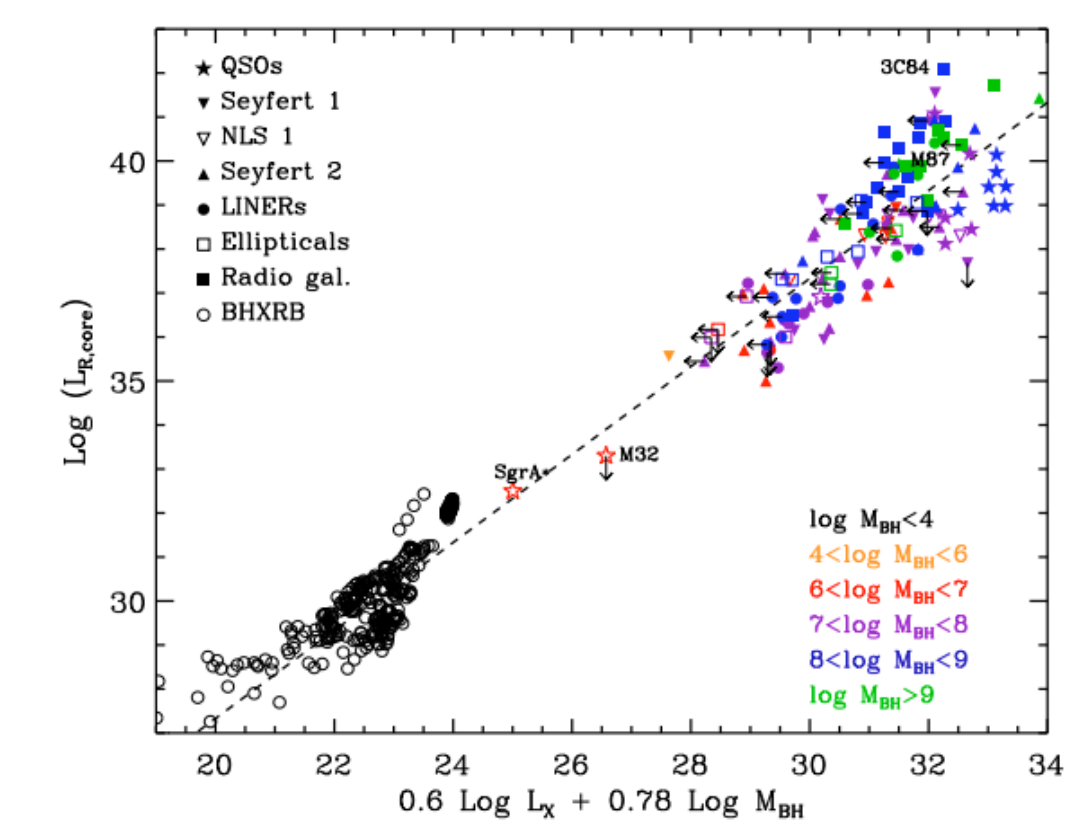
☑ $L_E = 8.4\times10^{46}$ erg s^{-1}, $L_{bol} < 8.4\times10^{43}$ erg s^{-1}

=> **$\lambda_E < 10^{-3}$**

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

BH fundamental plane

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



Merloni+03
Heinz+03
Yuan+14

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

☑ **$L_{2\text{-}10keV} < 4 \times 10^{39}$ erg s^{-1}** (see Gultekin+09; Yuan & Cui '05)

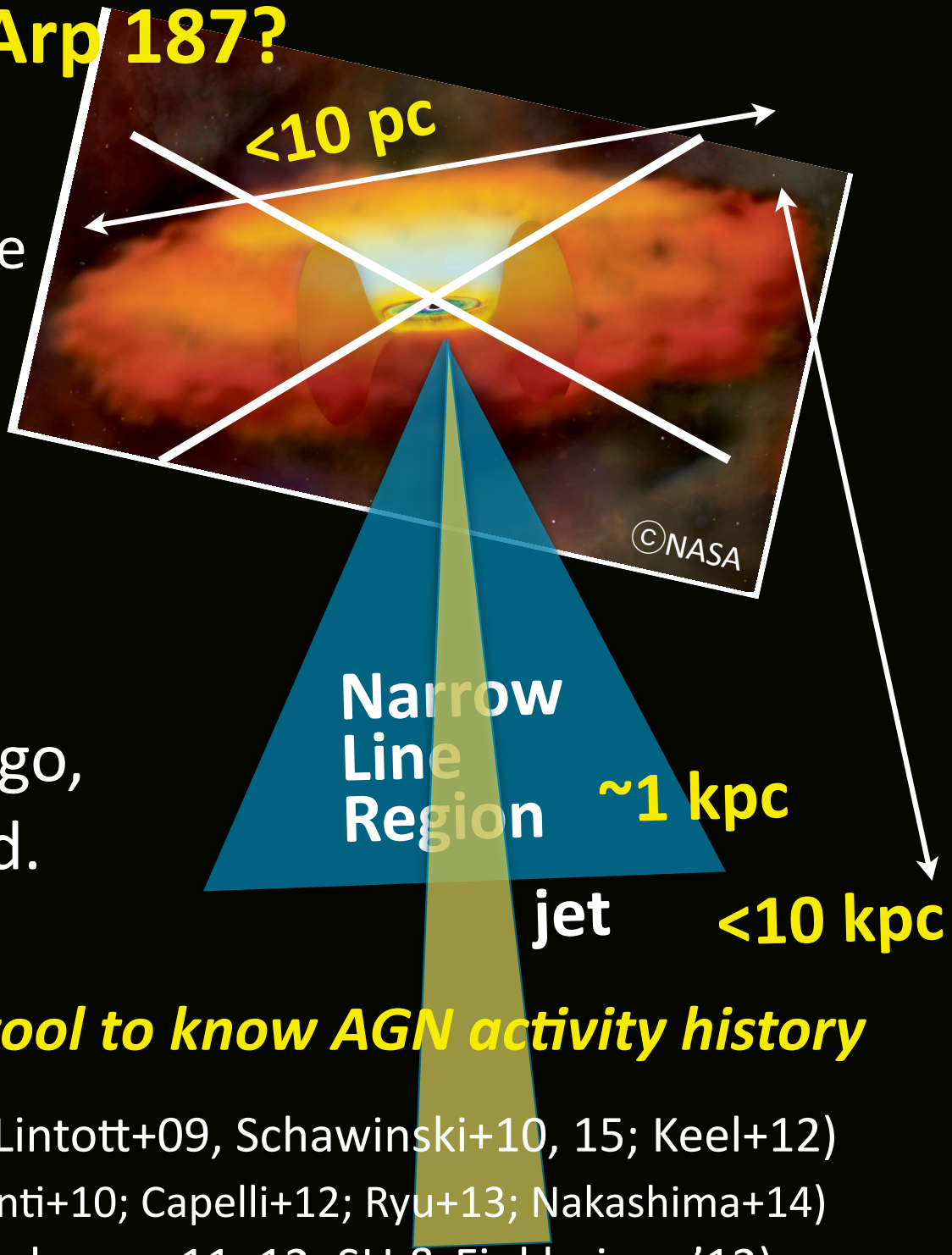
What is happening in Arp 187?

☑ Signs of NLR, jet (> kpc)

☑ Absence of torus, radio core (<10 pc scale)

FYI; torus cools down in <100 yr (KI & Tazaki ’17)

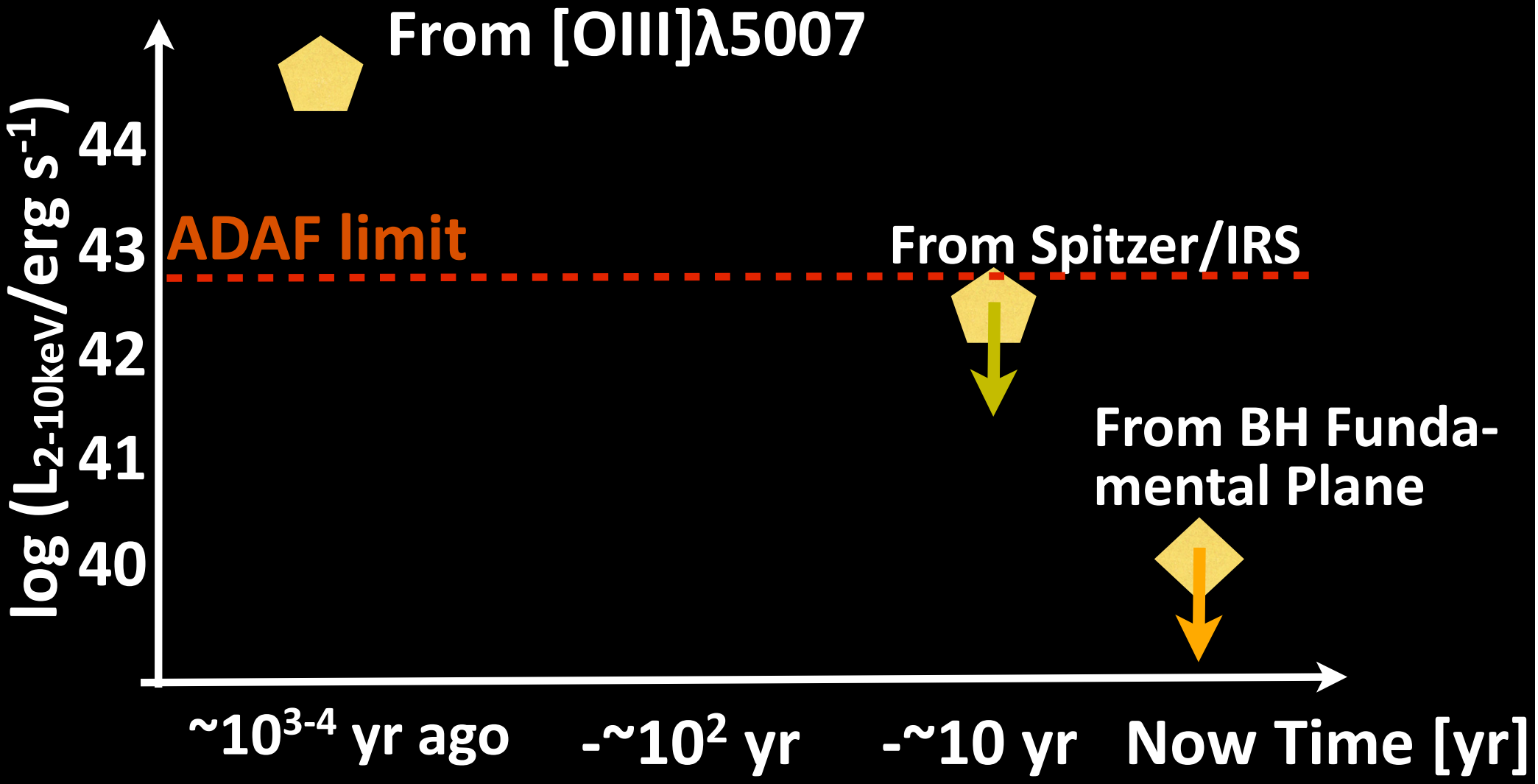
AGN “was” active ~10^4 yr ago, but currently AGN “is” dead.



“AGN light echo” is powerful tool to know AGN activity history

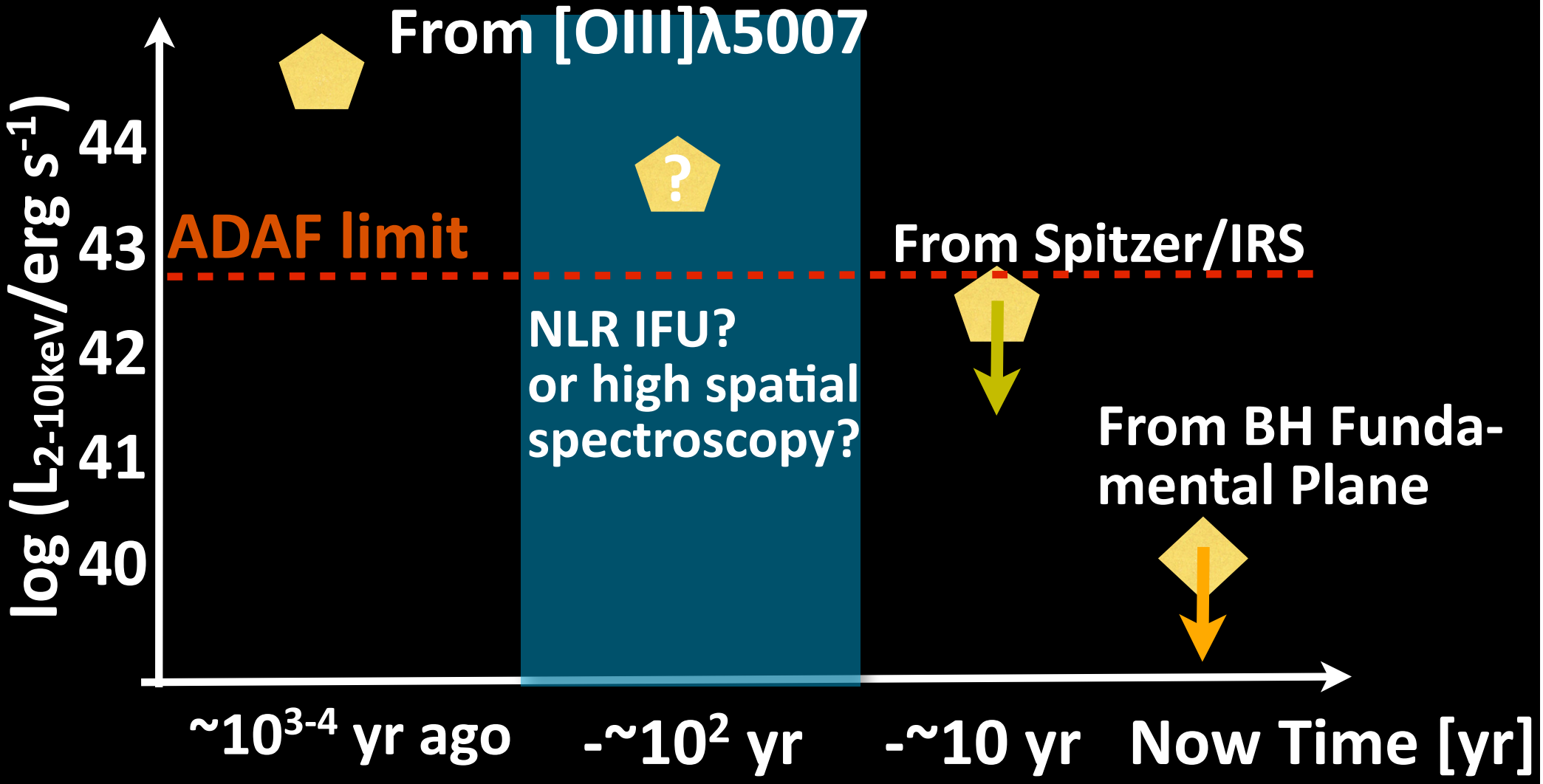
see Hanny’s Voorwerp ($10^{4\text{-}5}$ yr ago; Lintott+09, Schawinski+10, 15; Keel+12)
or the galactic center (500 yr ago; Ponti+10; Capelli+12; Ryu+13; Nakashima+14)
or Fermi bubbles study (10^6 yr ago; Zubovas+11, 12; SU & Finkbeiner ’12)

AGN Luminosity drops of Arp 187



L_{AGN} has decreased at least $10^{3\text{-}4}$ times in ~$10^{3\text{-}4}$ yr

AGN Luminosity drops of Arp 187



L_{AGN} has decreased at least 10^{3-4} times in ~10^{3-4} yr

Summary: witnessing the death of AGN

Arp 187 is a LIRG w/ interesting properties

☑ NLR (w/ age~$10^{3\text{-}4}$ yr), jet lobe (w/ age~10^{5} yr) exist

☑ torus, jet core emission is absent

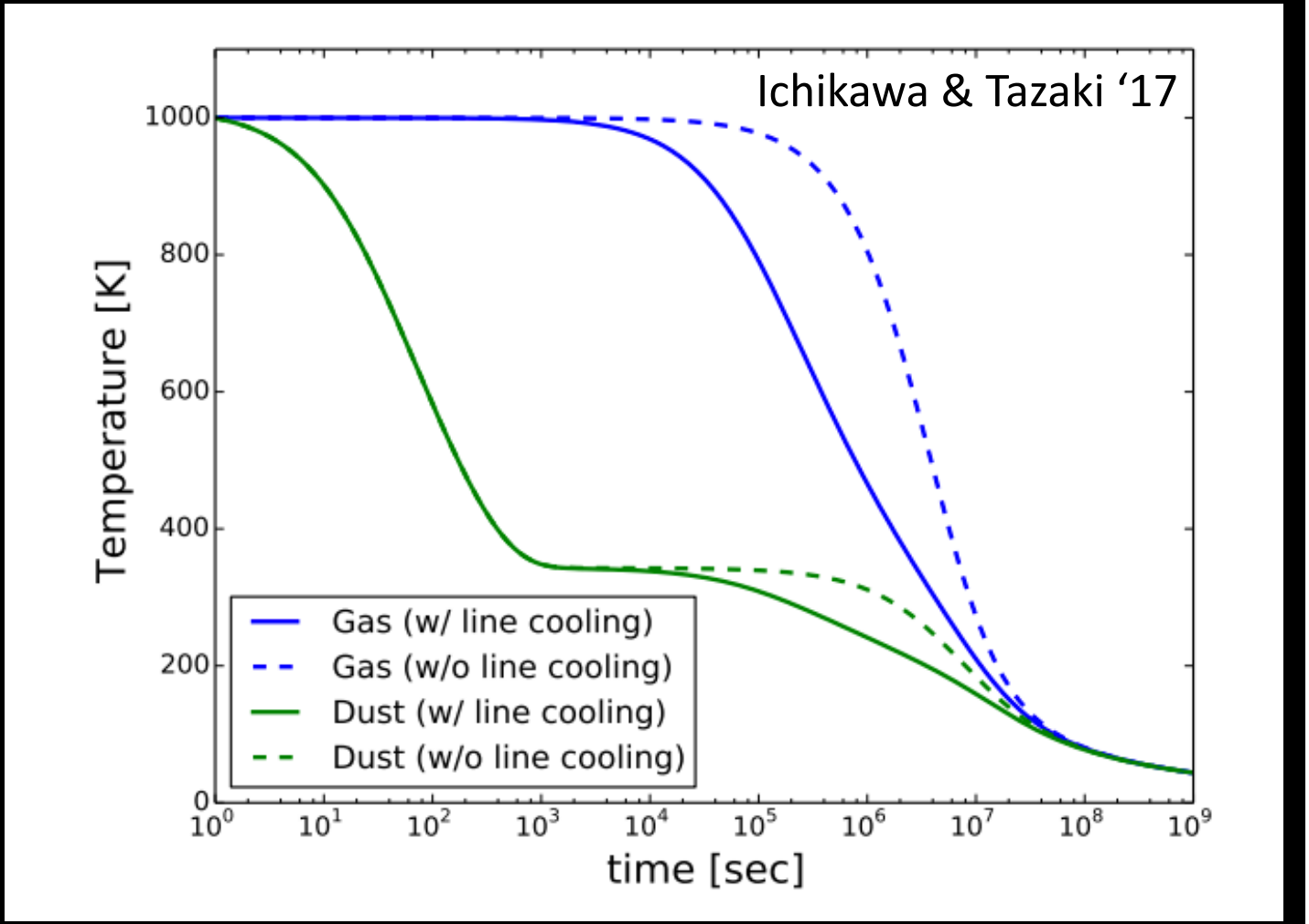
=> AGN "was" active but "is" dead

L_{AGN} : go downs at least $10^{3\text{-}4}$ times in ~$10^{3\text{-}4}$ yr

Sudden (=$10^{3\text{-}4}$ yr) Death of AGN in Arp 187 with "extreme" L decline (3-4 orders)

Appendix

Torus cools down in 10-100 yrs



dust clump energy Eq.

$$\frac{dE_{c,d}}{dt} = -4\pi R_c^2 \langle Q_c \rangle_T \sigma_{\rm SB} T^4 + \int_{V_{\rm clump}} n_g \Gamma_{\rm g-d} dV \quad (13)$$

Torus cools down in 10-100 yrs

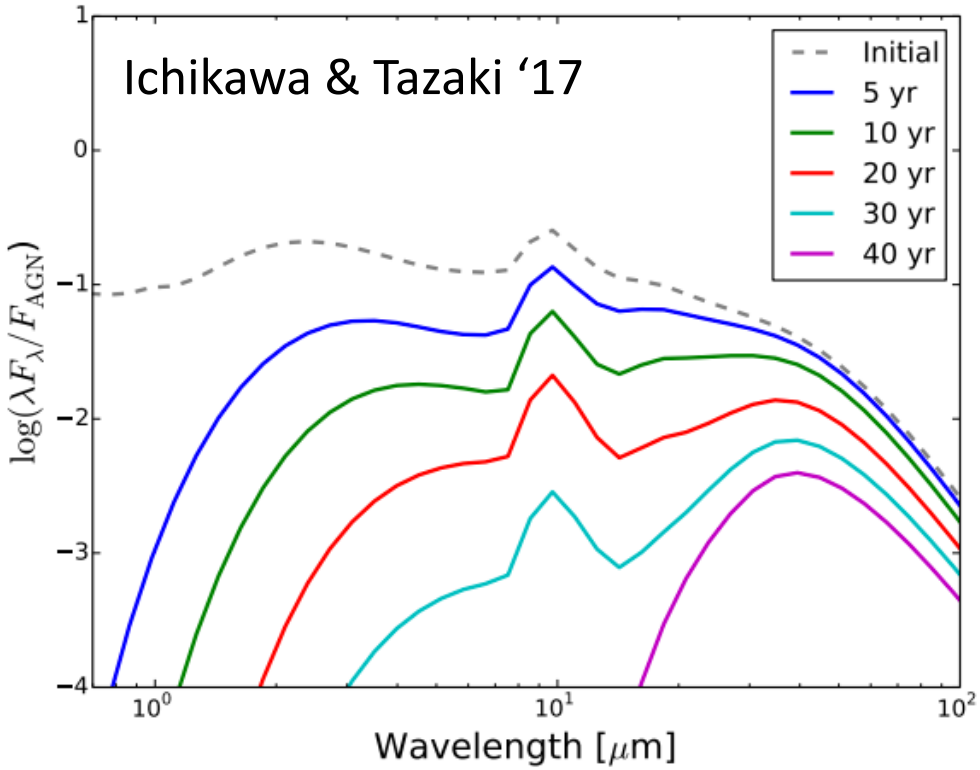


Figure 2. Time evolution of dust torus SED around dying AGN whose initial luminosity before the quenching is 10^{45} erg s^{-1}. The dashed line represents the SED under the radiative equilibrium temperature structure.