AKARI
infrared observations of interstellar dust in nearby starburst galaxies
「あかり」による近傍スターバースト銀河のダストの赤外線観測

M.Yamagishi (Nagoya Univ.)

H.Kaneda, D.Ishihara (Nagoya Univ.),
T.Onaka, I.Sakon (Tokyo Univ.), T.Suzuki (NAOJ)

Kaneda et al. 2009 , Yamagishi et al. in prep

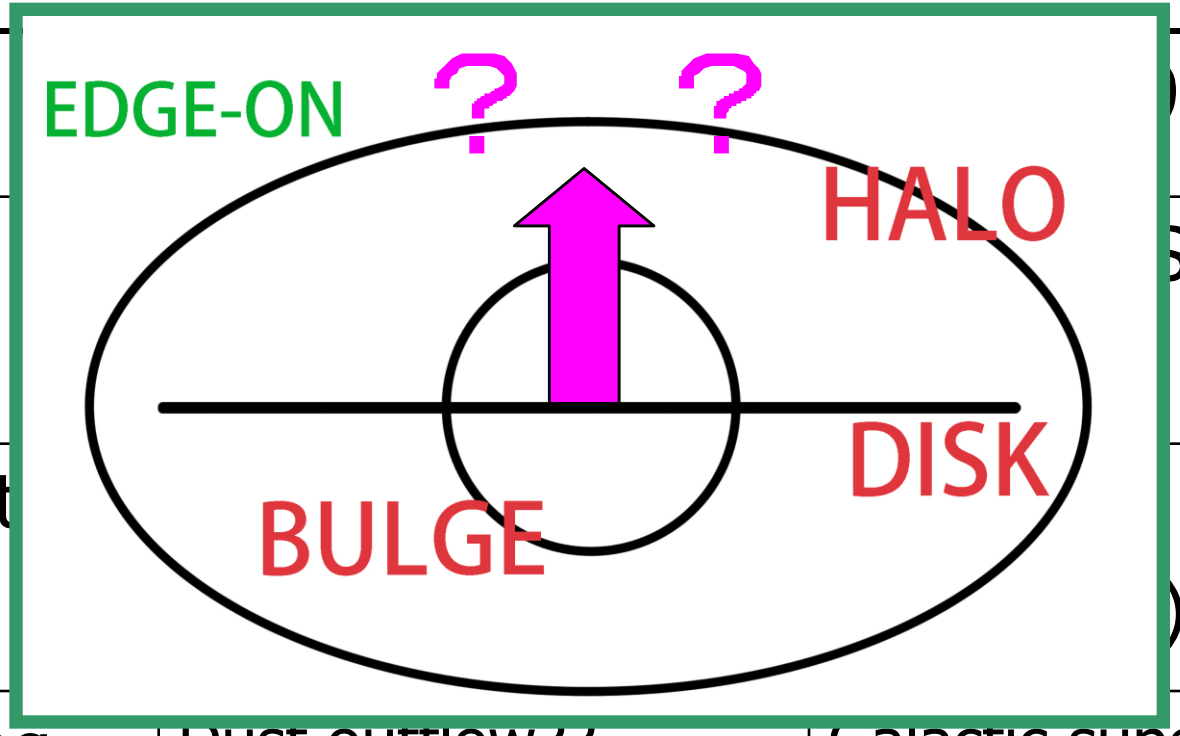
Contents

- Introduction of Starburst galaxies
  - NGC 253 & NGC 3079
- Observation of NGC 253
- Observation of NGC 3079
- Compare NGC 253 with NGC 3079

NGC253 & NCG3079

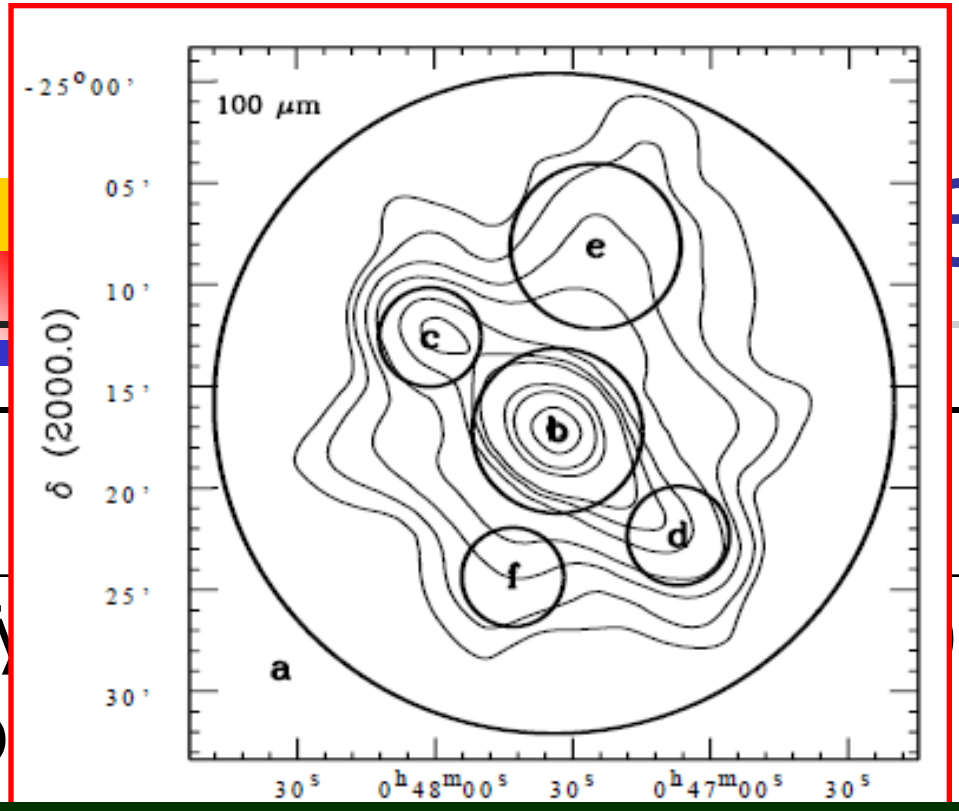
	NGC253	NGC3079
Type, Distance	Edge-on, SAB(s)c, 3.5Mpc	Edge-on, Sbc, 15Mpc
Classification	Starburst	Seyfert2 (Starburst)
Interesting phenomenon	Dust outflow?? (Radovich et al.2001)	Galactic superwind (Cecil et al.2001 etc)

NGC253 & NCG3079



Type, Distance		Sbc,
Classificat		
Interesting phenomenon	Dust outflow?? (Radovich et al.2001)	Galactic superwind (Cecil et al.2001 etc)

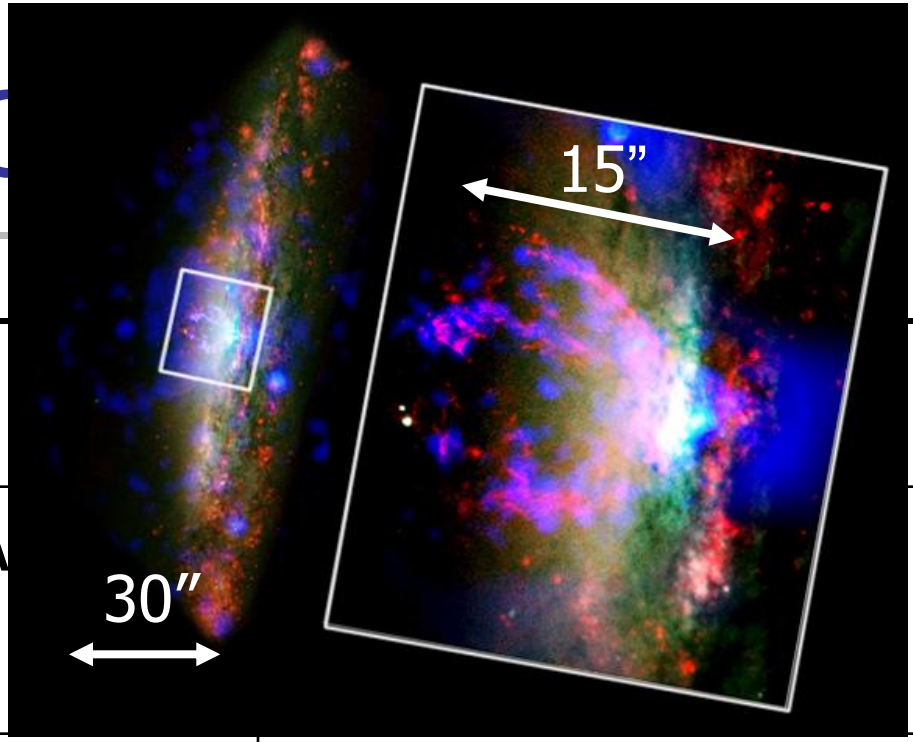
3079



		NGC3079
Ty D		c, Edge-on,Sbc, 15Mpc
		Seyfert2 (Starburst)
Interesting phenomenon	Dust outflow?? (Radovich et al.2001)	Galactic superwind (Cecil et al.2001 etc)

Radovich et al. 2001 IRAS 100um
But ! This is an effect of saturation.
(Melo et al.2002)

NGC253 & NC



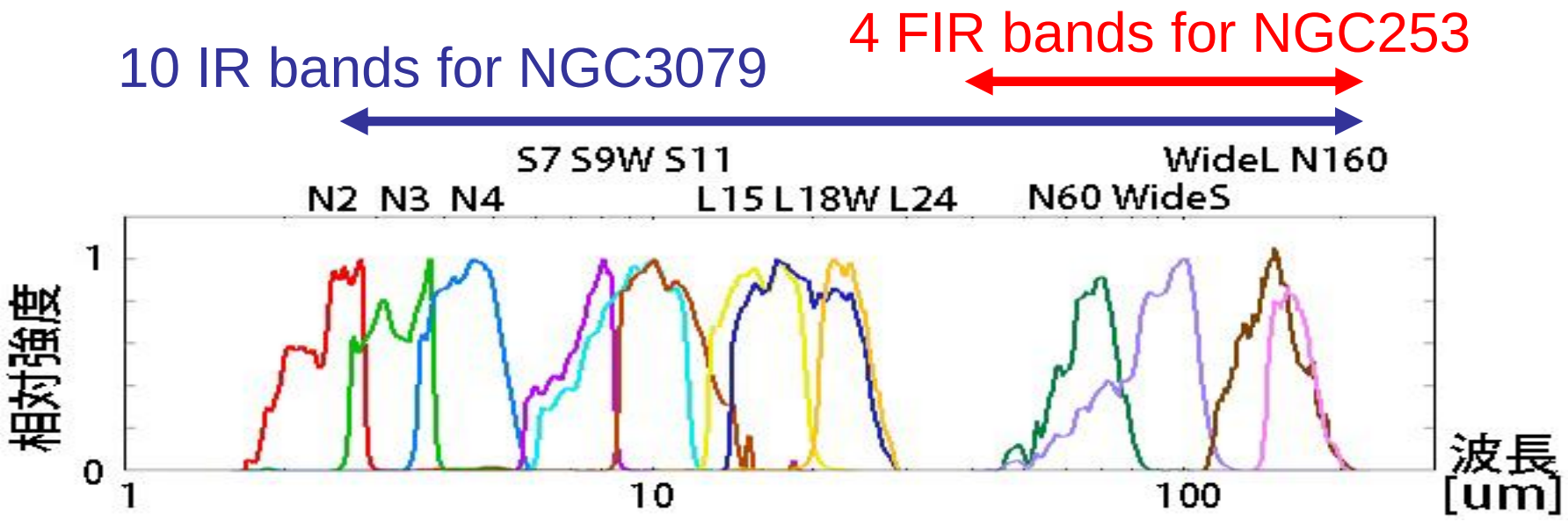
Red：Hα, Green：I band,
Blue：X-ray

http://chandra.harvard.edu/photo/2003/ngc3079/

	NGC253	
Type, Distance	Edge-on,SA 3.5Mpc	
Classification	Starburs	
Interesting phenomenon	Dust outflow?? (Radovich et al.2001)	Galactic superwind (Cecil et al.2001 etc)

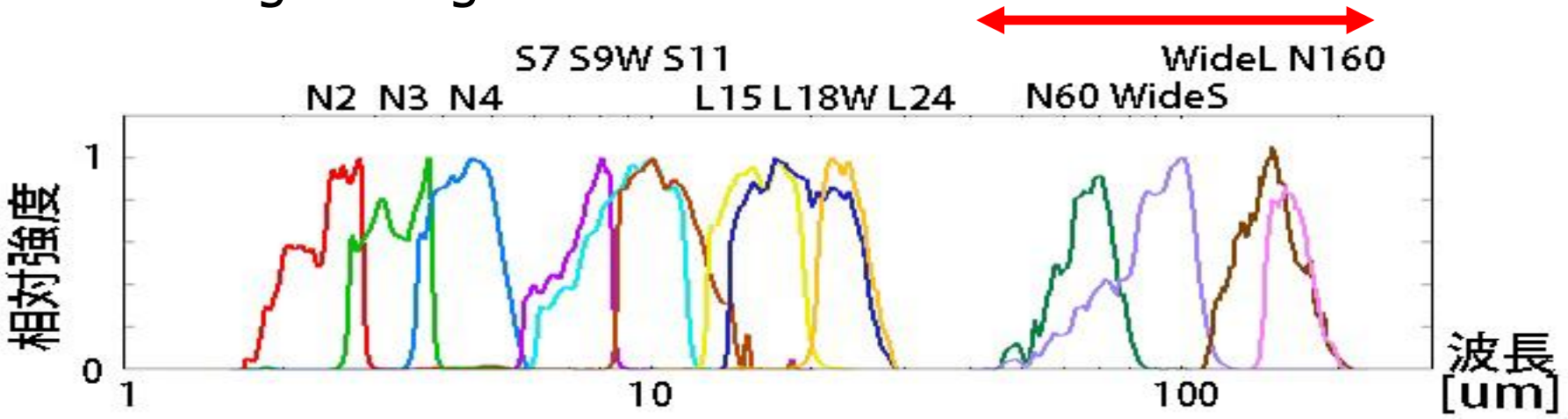
AKARI satellite

- Launched in on Feb 21,2006 (UT)
- 13 photometric bands(2-180um)
- Now in phase 3 II



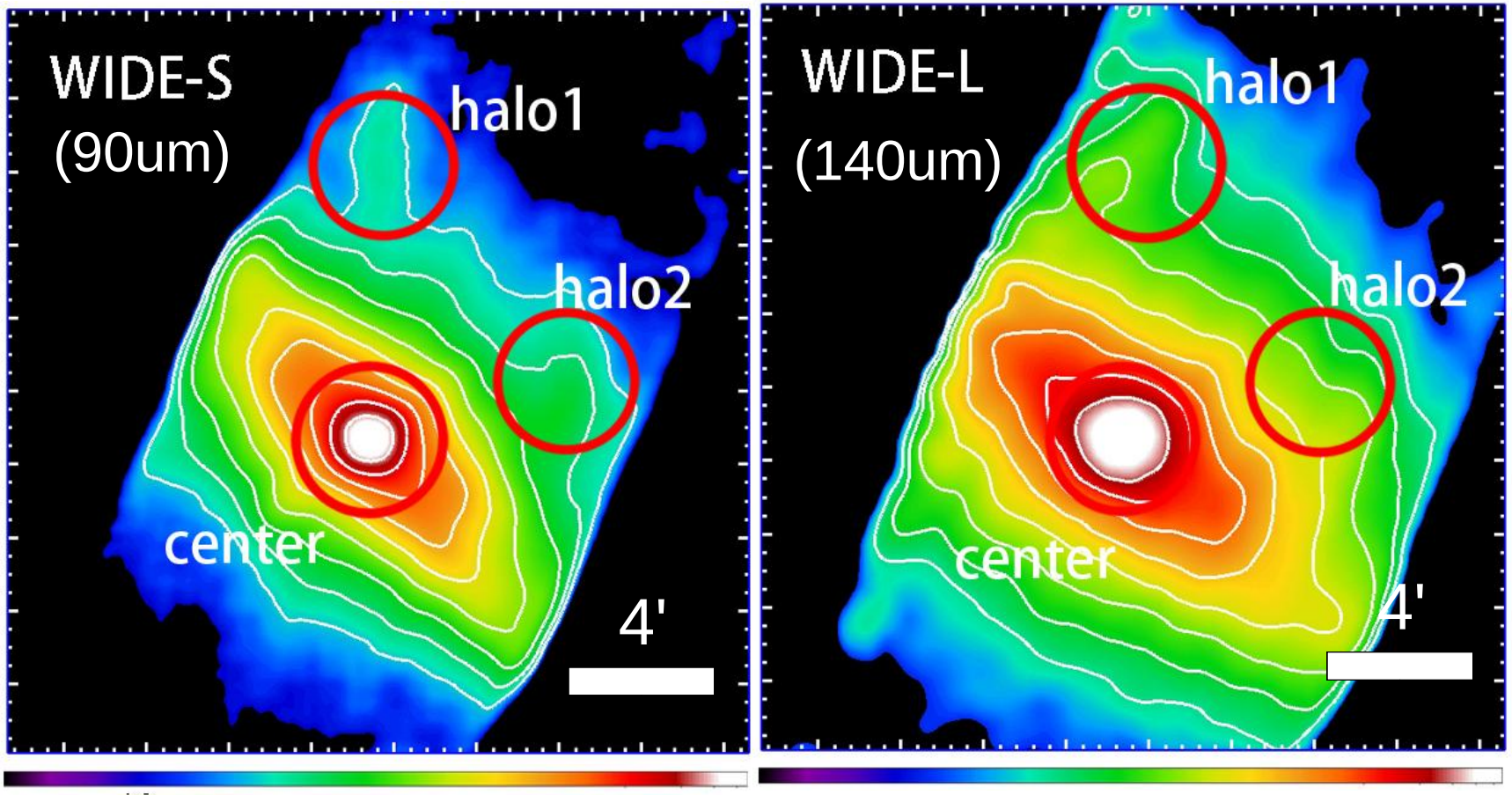
Observation of NGC253

- Instrument : FIS (Far-Infrared Surveyor)
  - 4 photometric bands (65,90,140,160um)
- Observation AOT : FIS01(CDS mode)
- Date : 2007 Jun 21
- We did not use narrow band images (65,160um) because of the ghost signals.

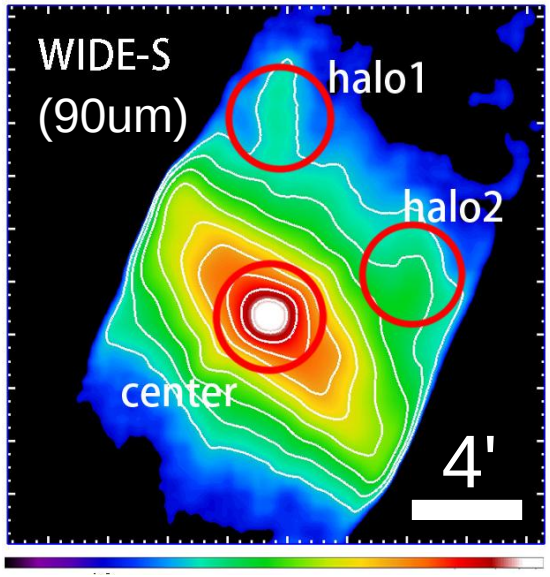


FIR emission

We detected FIR dust emissions in the halo of NGC 253.



Dust mass in the halo



R = 2 ’ (~ 2kpc)

$$B_{\rm dust} = A\nu^{\beta}B_{\nu}(T)$$

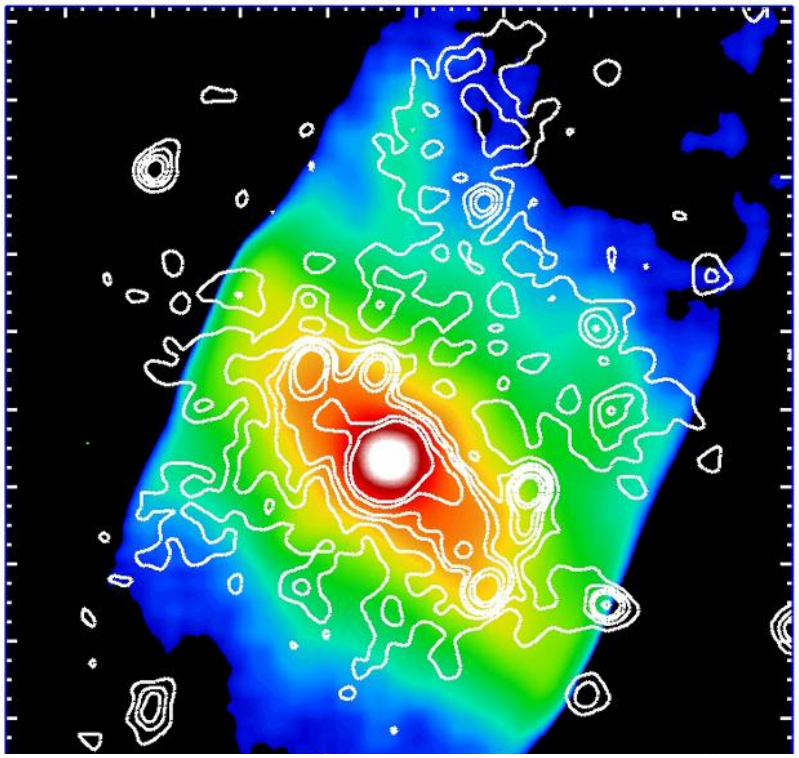
$$M_{\rm dust} = \frac{\frac{4}{3}\pi a^3\rho}{\pi a^2 Q(\nu)}\frac{F_\nu D^2}{B(\nu,T)} = \frac{F_\nu D^2}{\kappa_\nu B(\nu,T)}$$

- Emissivity power-low index beta = 1, mass density = 3g/cm^3 and dust size 0.1um are assumed.
- We adopt the grain emissivity factor given by Hildebrand 1983.

- halo1 :Td = 20K, Md = 1.1×10^6 Msun
- halo2 : 23K, 9.1×10^5 Msun

Other results

90um + X-ray contour



Dust emissions is correlated with X-ray emission.

B: optical G: HI 21cm R: X-ray

HI gas also extends to the halo.

Sputtering timescale

How long does the dust survive without sputtering?
Does the dust escape from the galactic potential?

- Draine & Salpeter 1979:

$$t_{sput} \sim 10^6 \left(\frac{a}{um}\right)\left(\frac{n_H}{cm^{-3}}\right)^{-1} [yr]$$

→ 4-30 Myr.

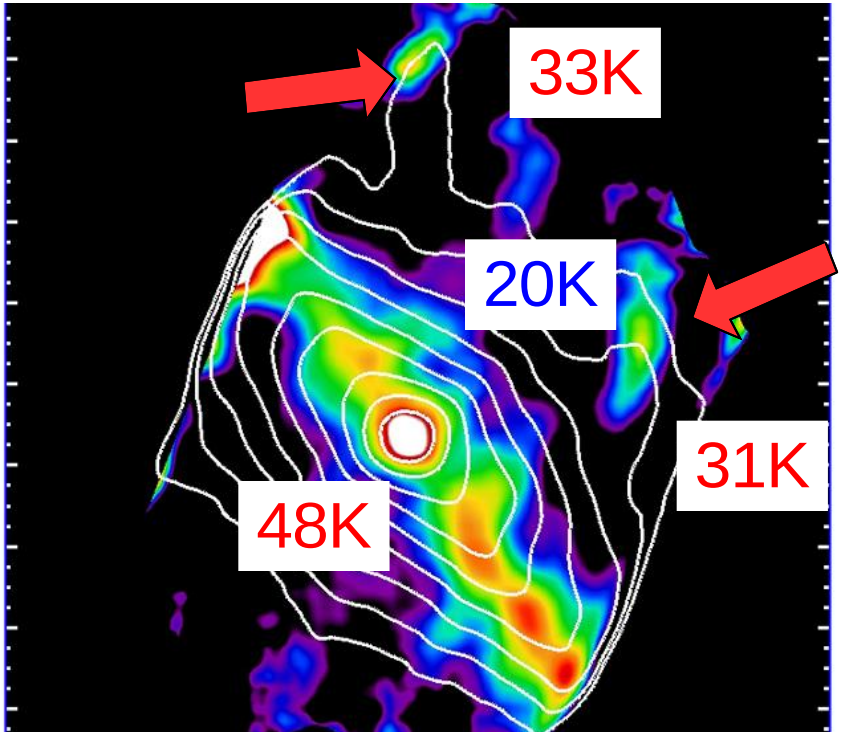
(Bauer et al. 2008)

- 300-2000 km/s is required to travel up to 9kpc in this timescale.

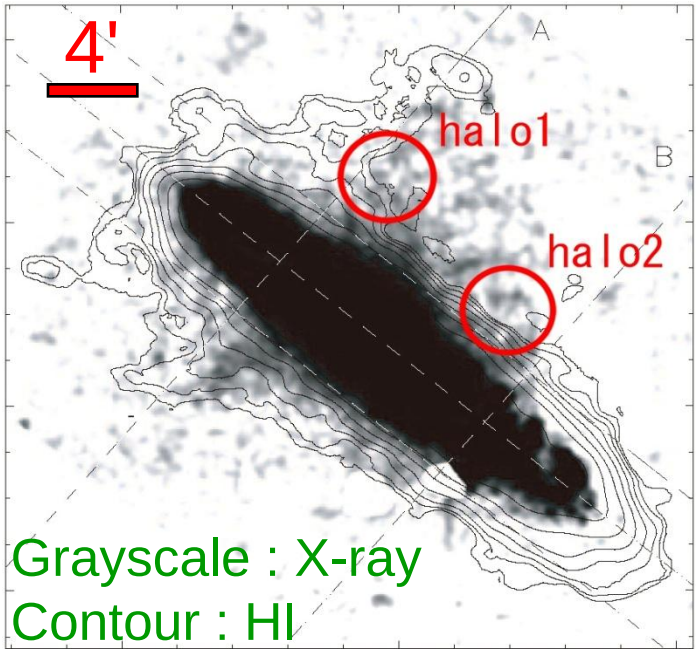
- Escape velocity :280 km/s (Heesen et al.2009)

Temperatures of the dust

90/140um + 90um contour



Temperatures of the dust are getting higher in the halo!

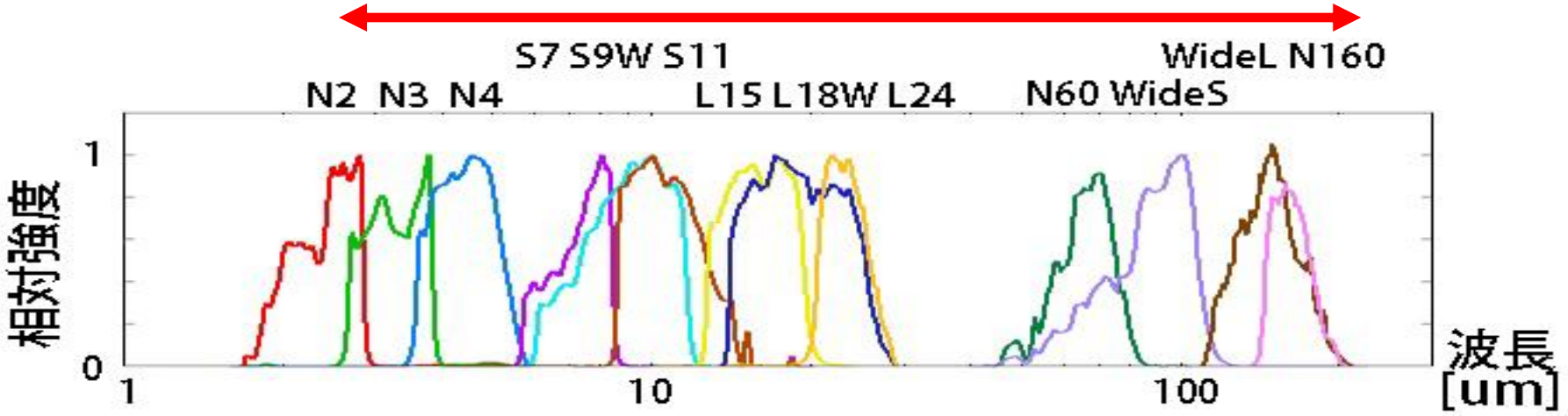


Boomsma et al. 2004 + regions

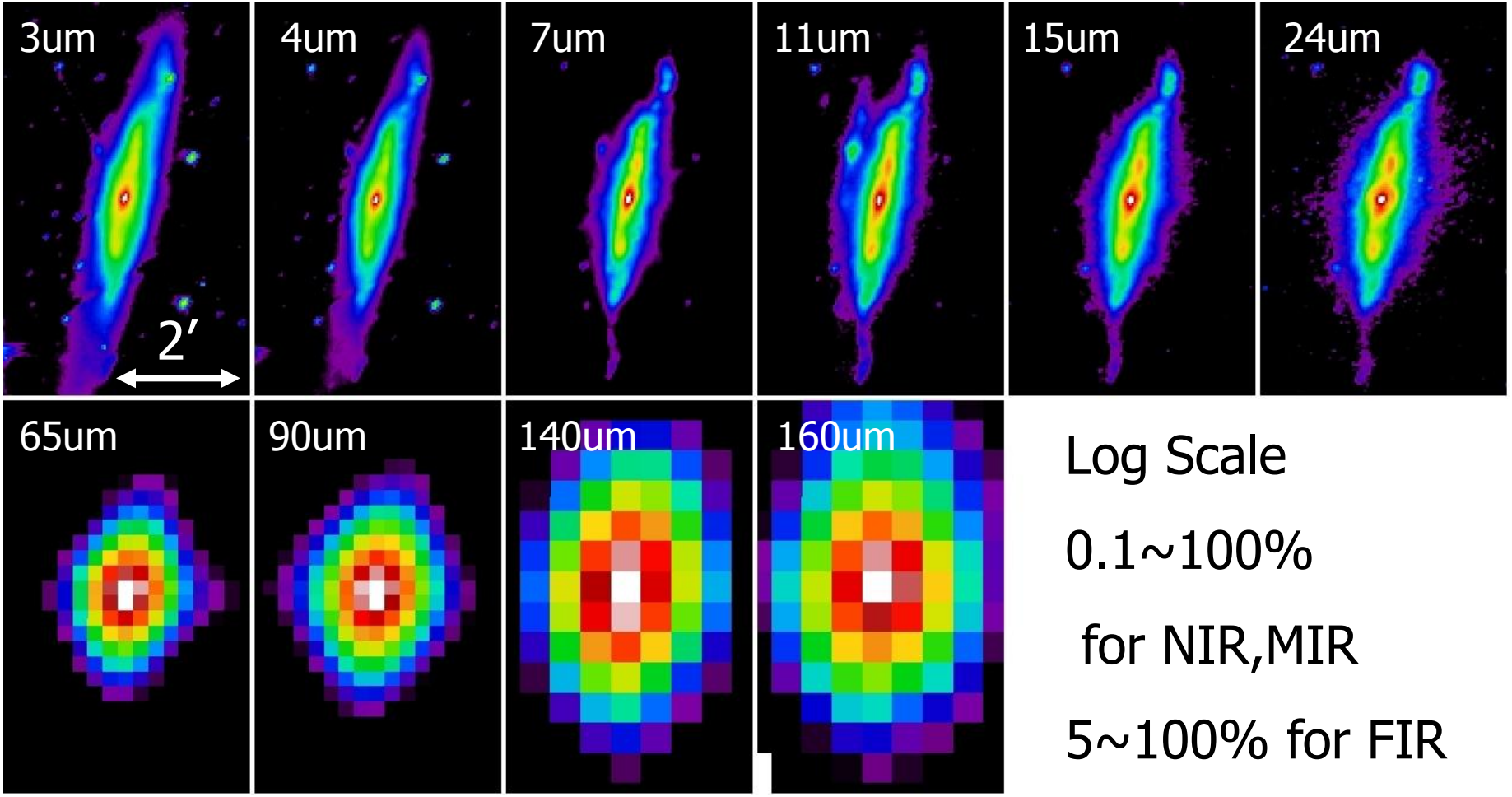
Interaction between X-ray superwind and HI clouds ?

Observation of NGC3079

- Instrument : IRC (InfraRed Camera) + FIS
  - 10 photometric bands
    (3,4,7,11,15,24,65,90,140,160 um)
- Observation AOT : IRC02,FIS01
- Date : 2007 April 30 & May 1



10 band images



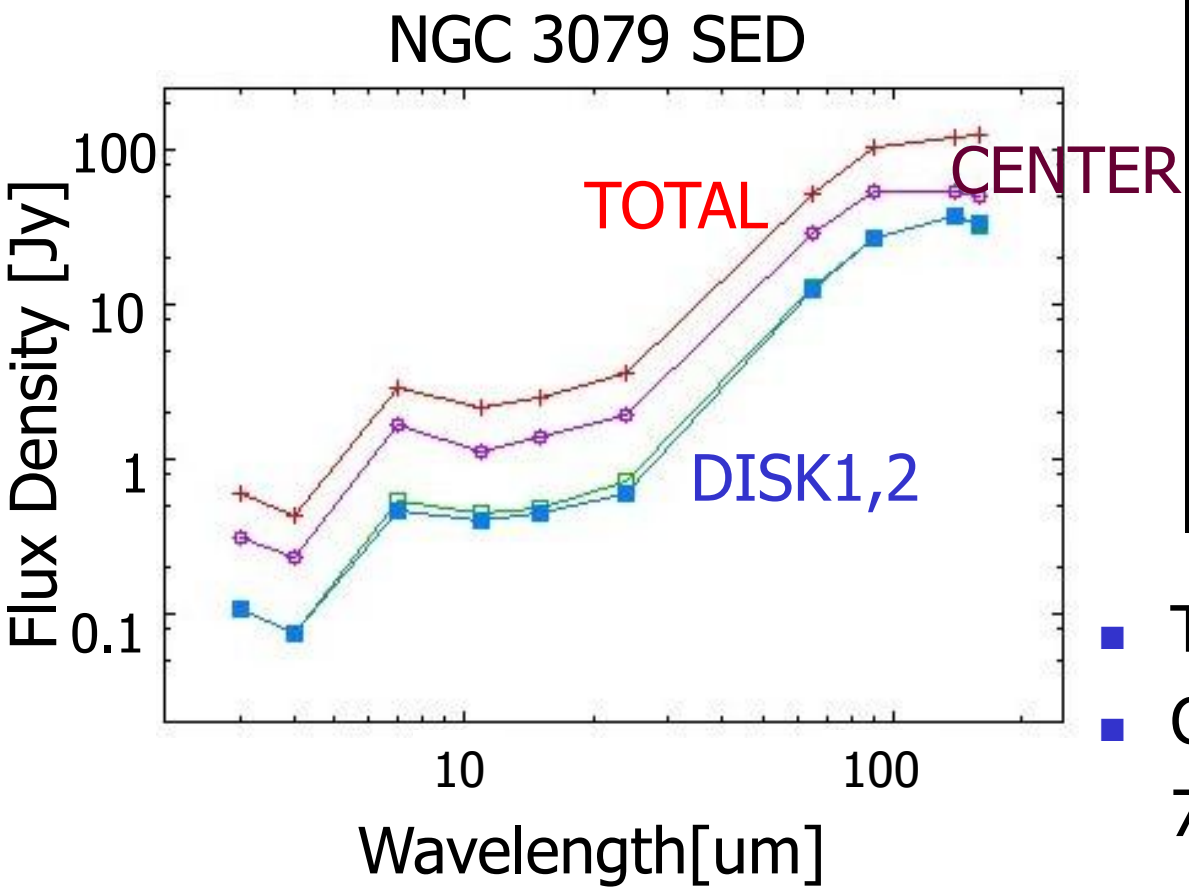
Log Scale

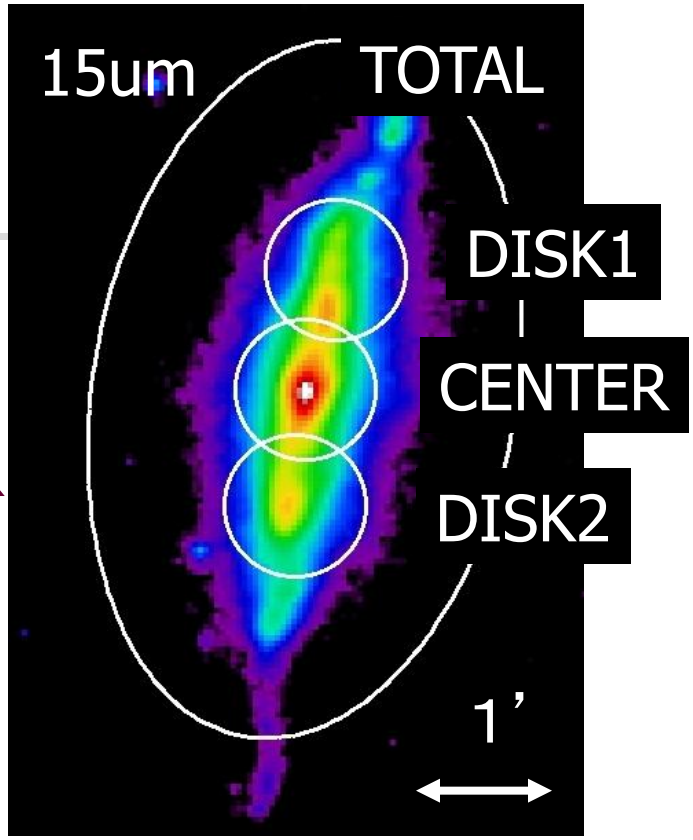
0.1~100%

for NIR,MIR

5~100% for FIR

SED

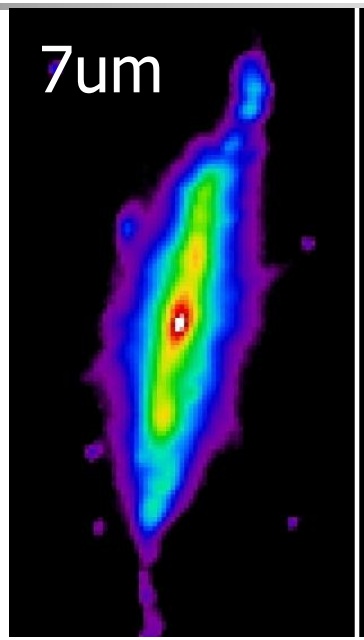


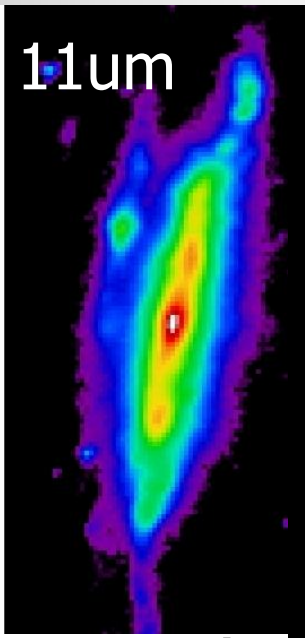


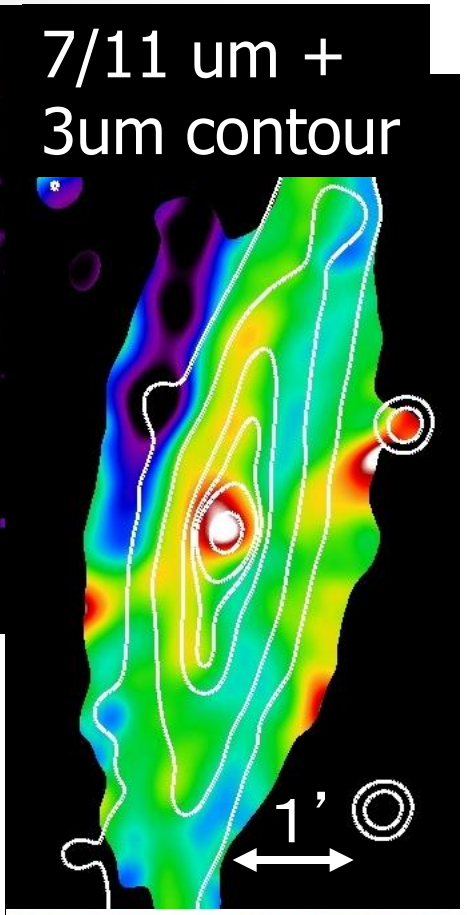
- TOTAL: F_{FIR} ~ 100Jy
- CENTER:
  7um emission is strong

7,11um PAH

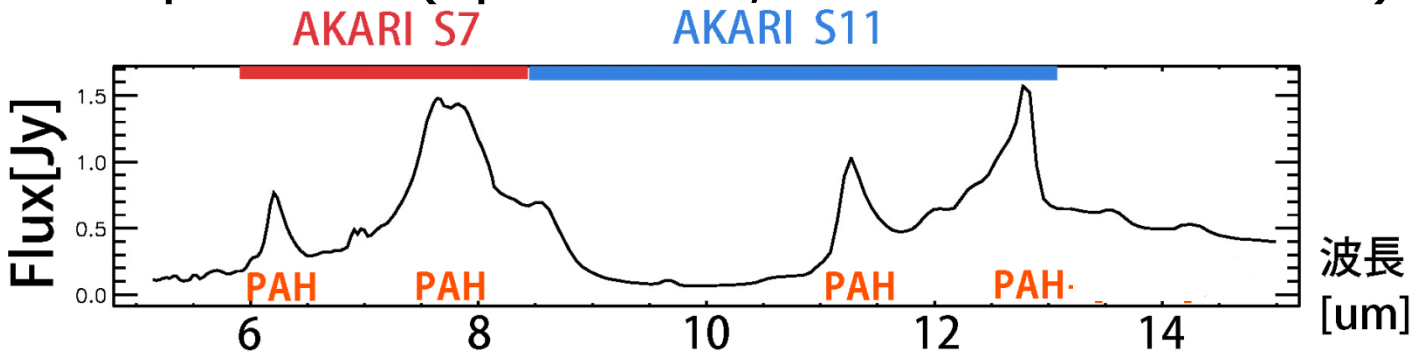
- Emissions from PAH are dominant at 7,11um bands.
- 7/11um ratio varies with location.







MIR spectrum (Spitzer IRS,Weedman et al. 2005)



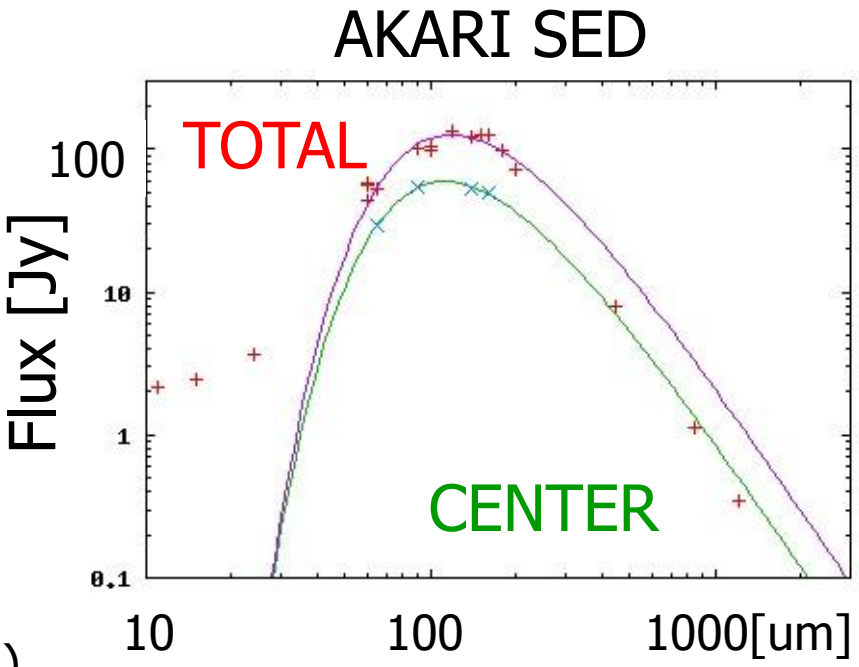
Gas/dust ratio

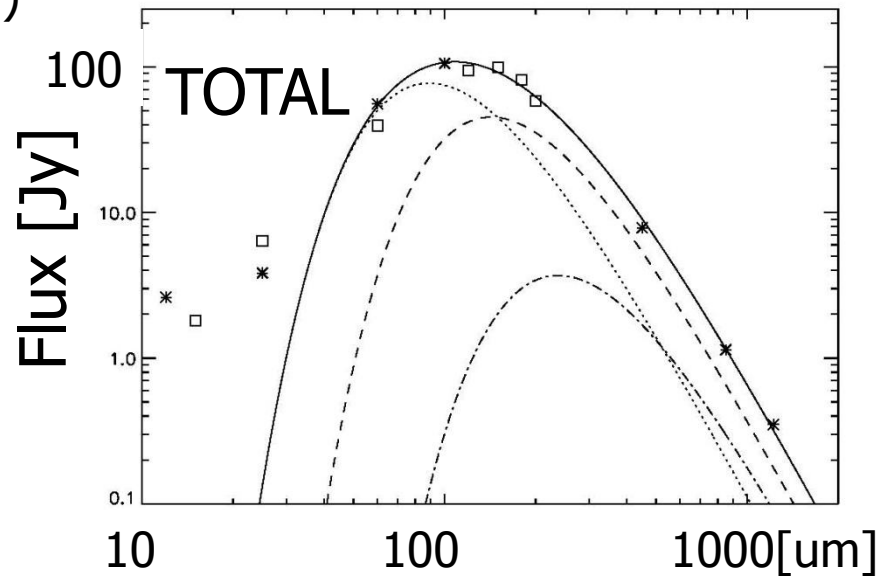
<TOTAL>

- Tdust = 31K, 1 component (β=1)
  Tdust = 32,20,12K, 3 components
  (β=2, Klass & Walker 2002)
- Mdust = 1.4×10^7 Msun
- Mgas=6×10^9Msun(Scoville et al. 1985)
- Gas to dust mass ratio ~ 500

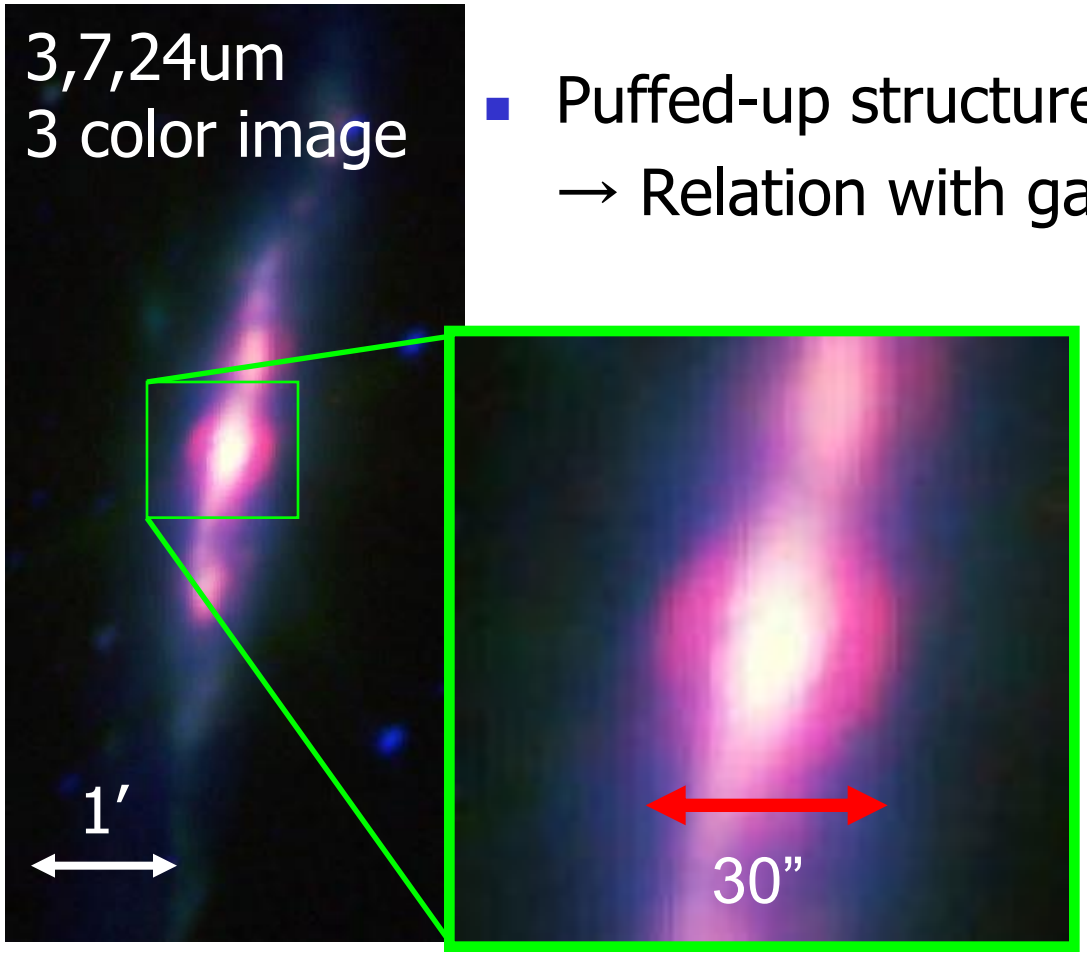
<CENTER>

- Tdust = 33K (β=1)
- Mdust = 5.6×10^6 Msun
  Mgas = 5×10^9 Msun
  (Koda et al. 2002)
- Gas to dust mass ratio ~ 1000





Relation with center activity



- Puffed-up structure at galactic center
  → Relation with galactic superwinds?

Compare NGC253 with NGC3079

CENTER Region	Dust [Msun]	Gas [Msun]	Gas/dust ratio	FIR Luminosity [Msun]
NGC253	8.3×10^6	6.7×10^8	80	5.8×10^9
NGC3079	5.6×10^6	**5×10^9**	**1000**	4.6×10^9

Kaneda et al. 2009, Koda et al. 2002, Nicholas & Judith 1990, Scoville et al. 1985

- R=2kpc
- Not so much differences in dust mass and FIR luminosity.
- Huge amounts of gas in NGC3079, resulting in unusually high gas/dust.

Summary

- We observed NGC253 & 3079 with AKARI.

<NGC253>

- We detect FIR dust emissions in the halo.
- There are high-temperature regions in the halo.

<NGC3079>

- 7/11um ratio varies with location.
- Possible relationship between galactic superwinds and puffed-up structure of 24um image.
- Gas to dust mass ratio is very large .

  → Early evolutionary stages of ISM? There are large amounts of gas which is not linking to star formation. Active star formation will occur in future?