

塵に埋もれた活動的な超巨大BHと  
銀河のダウンサイジングの起源

IRAS 08572+3915

今西 昌俊

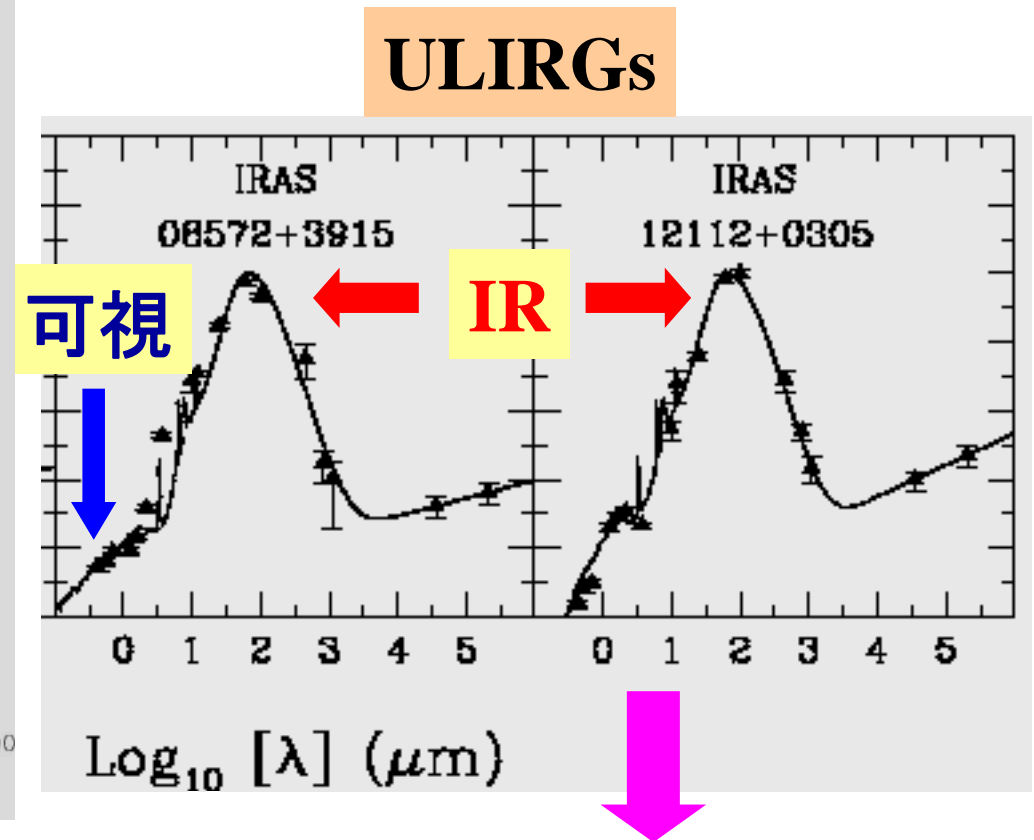
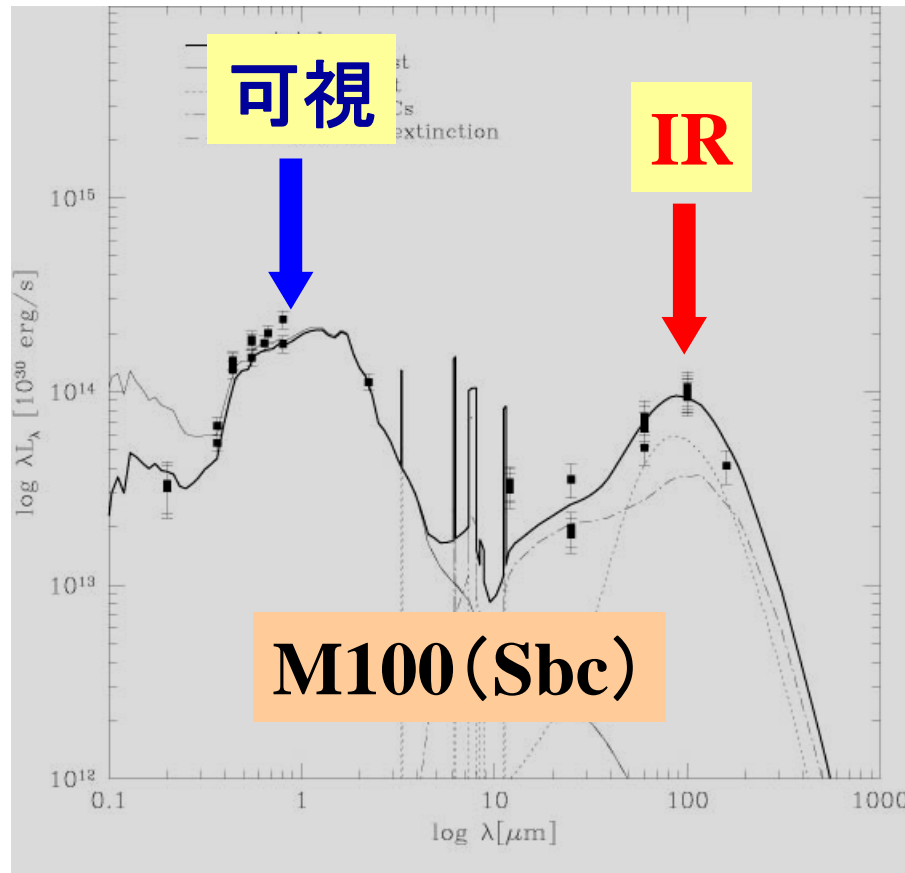
Mrk 231

国立天文台 光赤外研究部

# 超高光度赤外線銀河 (ULIRGs) とは？

赤外線光度=太陽の $10^{12}$ 倍以上

(天の川のような普通の銀河は $10^{10}$ 太陽光度)

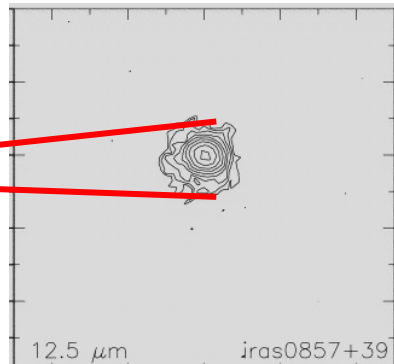


ダストの向こう側に、強力なエネルギー源が存在

# ULIRGs



optical



IR(12um)

Soifer et al. 2000

中心核(<500pc)が  
赤外放射を支配

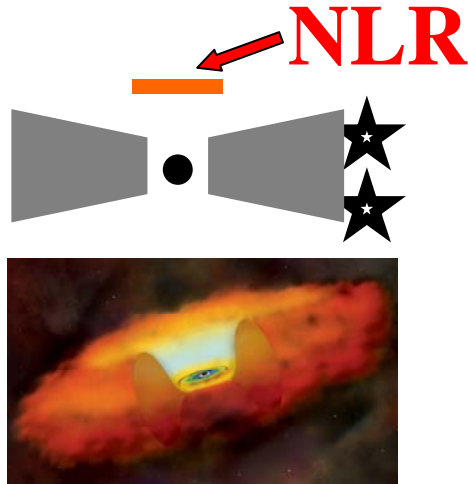


コンパクトな星生成  
or AGN ?



質量降着している活動的な  
超巨大ブラックホール

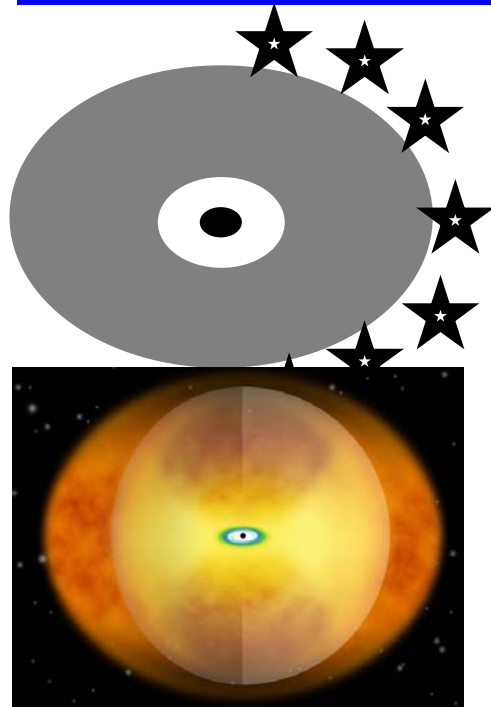
# ULIRG中のAGNは埋もれている



トーラス状のダストに  
隠されたAGN

Sy2

可視光線分光で検出できる

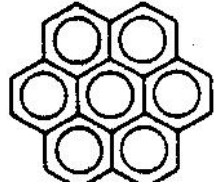


ULIRGは、大量のガス/ダストを  
中心核に持つ

埋もれたAGNは検出が困難

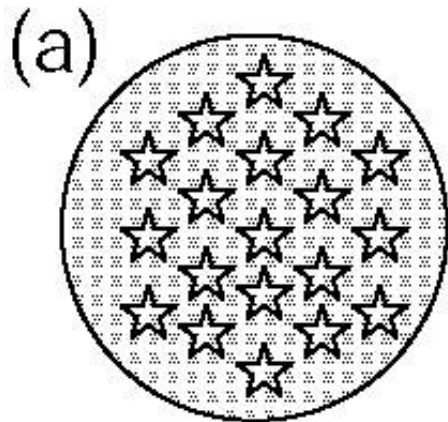
70% ULIRGs = non-Sy

# PAH

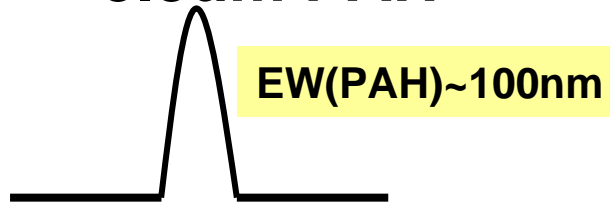


- ・PAHは、SBのPDRで励起
- ・AGNの近傍では破壊される

## 星生成(SB)

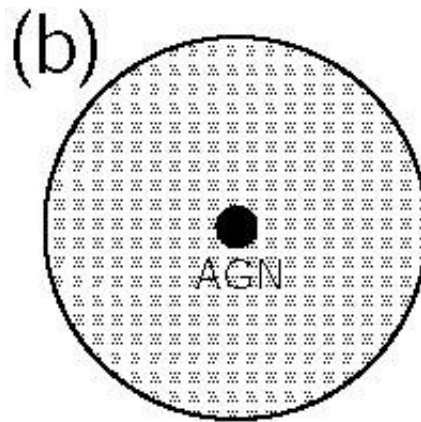


3.3 $\mu$ m PAH

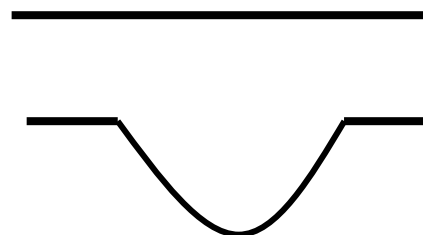


EW: 等価幅

## 埋もれたAGN

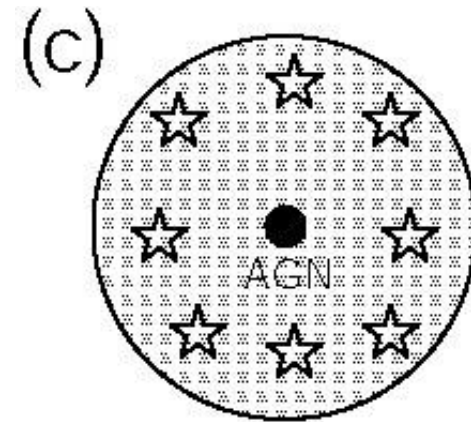


featureless



3.4 $\mu$ m/3.1 $\mu$ m

## 共存



EW(PAH) << 100 nm



# 3-4 $\mu\text{m}$

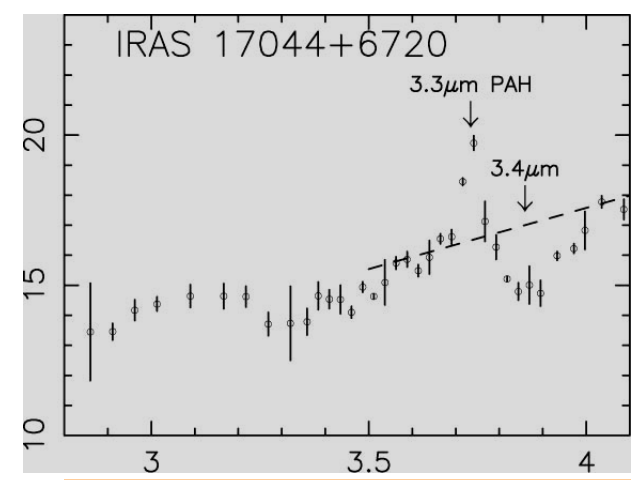
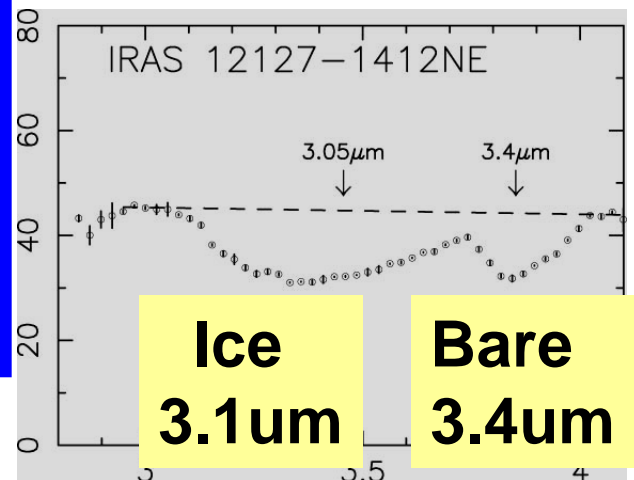
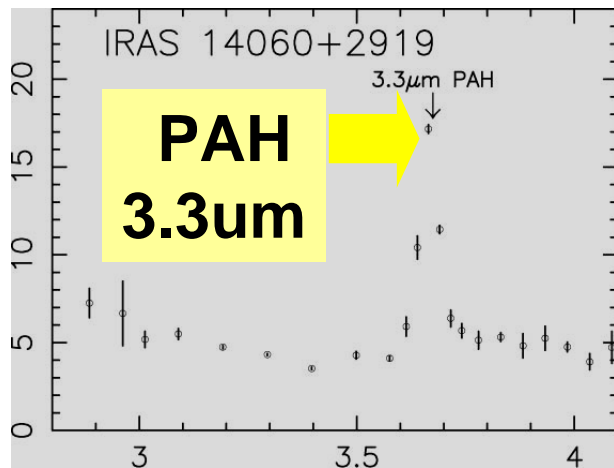
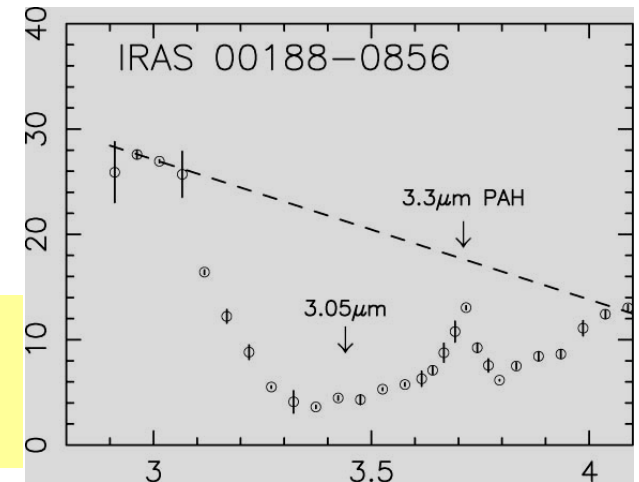
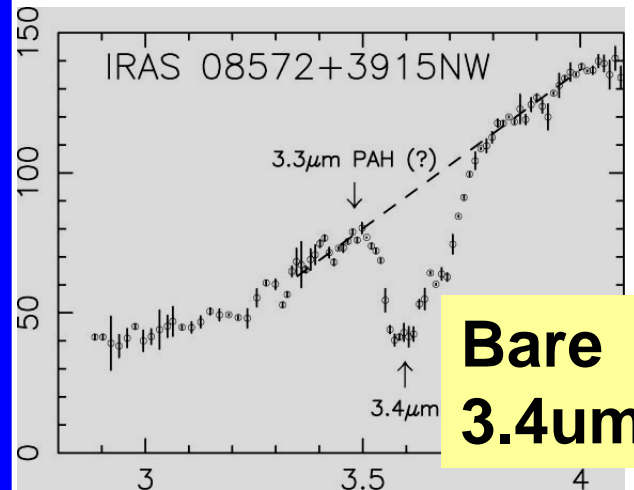
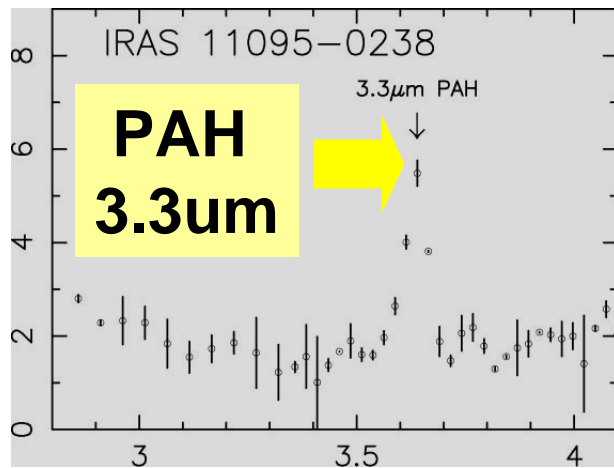


Subaru

星生成 (SB)

埋もれた AGN

AGN/SB 共存

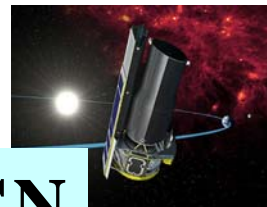


PAH strong

吸収 strong

小さなEW(PAH)

5-35  $\mu\text{m}$

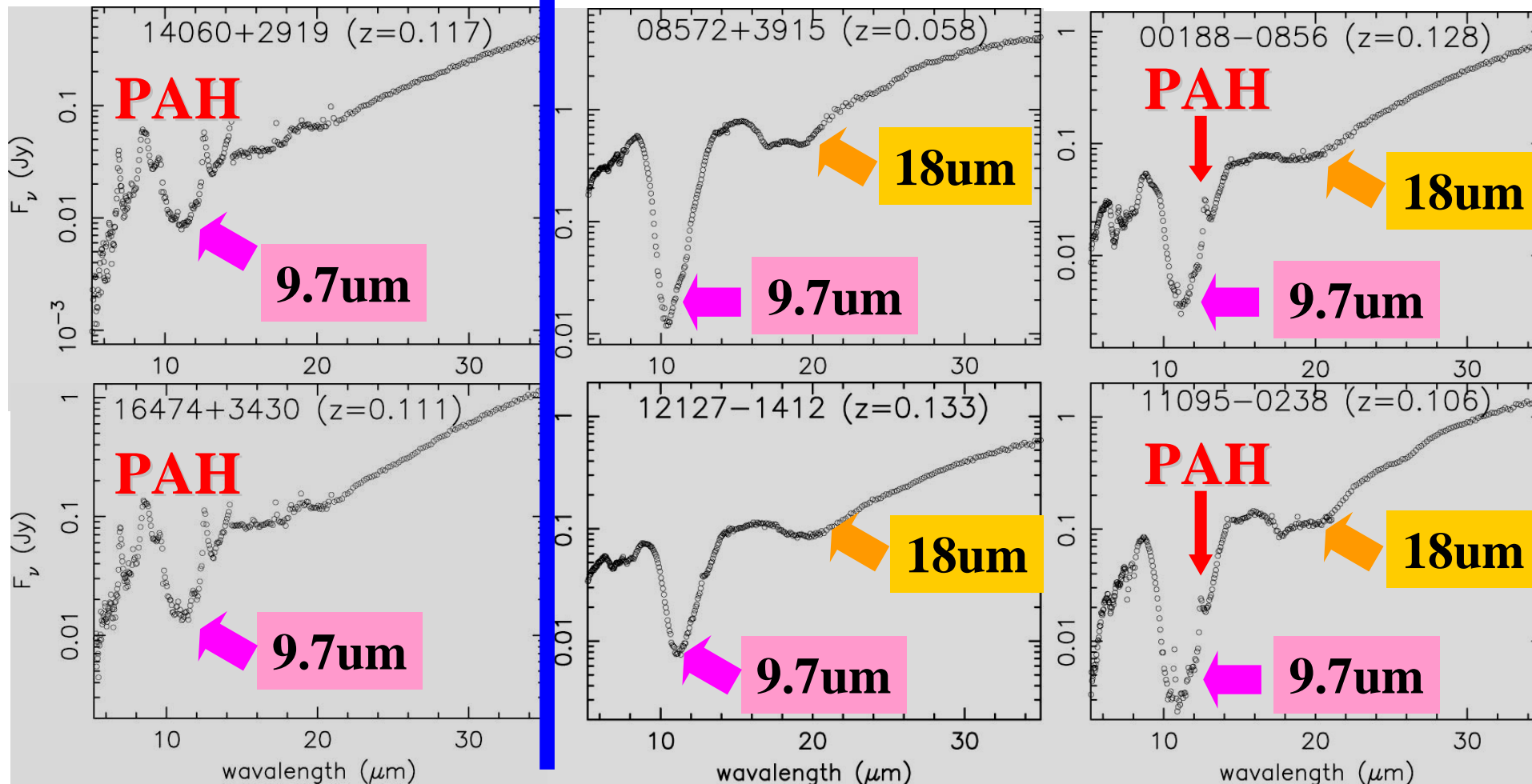


Spitzer GO1  
PI今西

星生成

埋もれたAGN

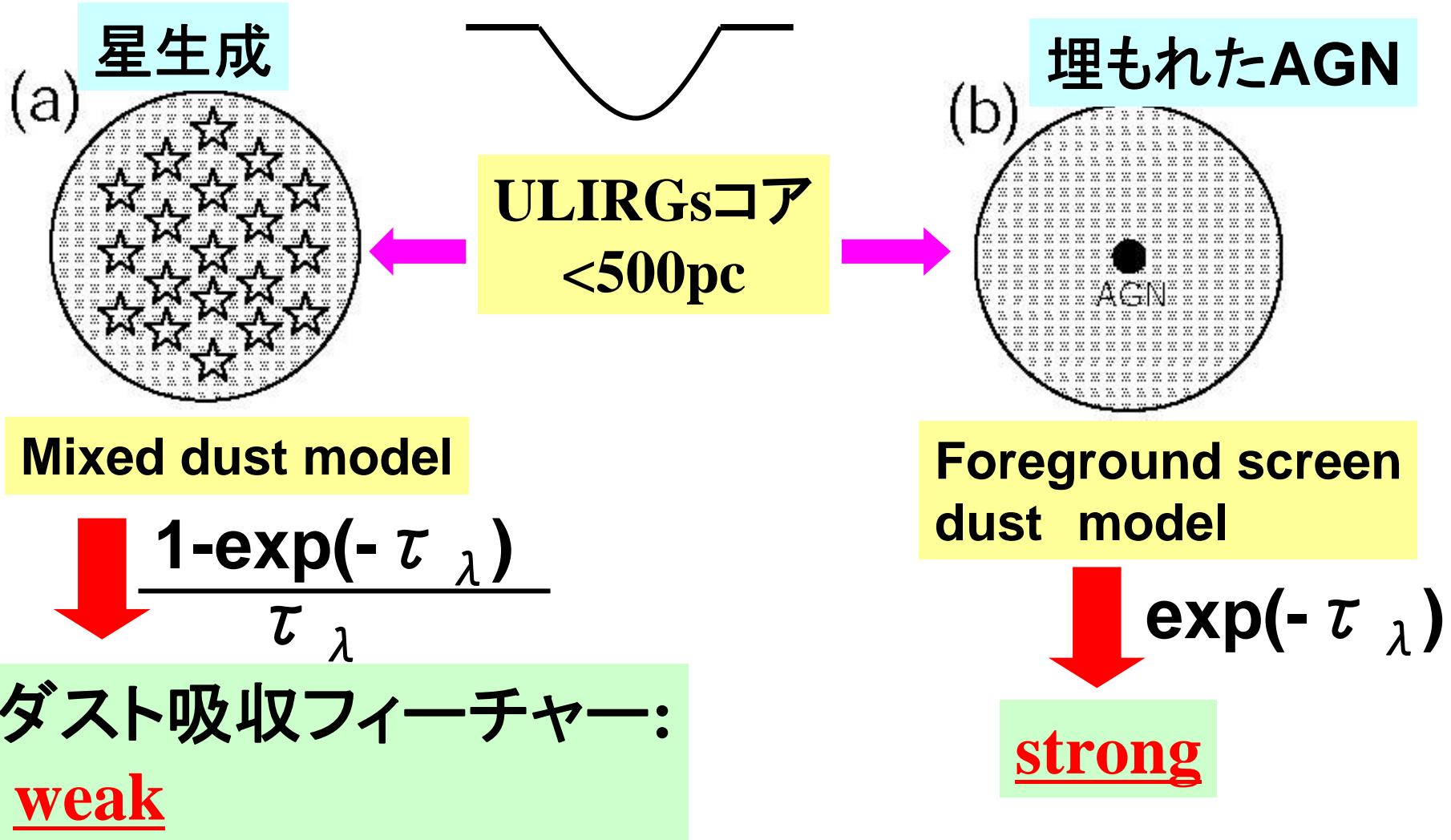
共存



PAH strong

PAH weak  
Silicate吸收 strong

## 2. エネルギー源とダストの空間分布



$$\text{Tau}(3.1) < 0.3 \quad \text{Tau}(9.7) < 1.7$$

$$\text{Tau}(3.4) < 0.2 \quad (\text{Imanishi \& Maloney 2003 ApJ 588 165})$$



3-4  $\mu\text{m}$

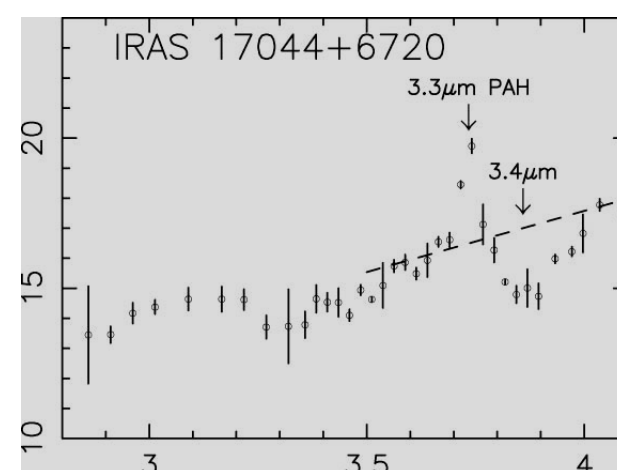
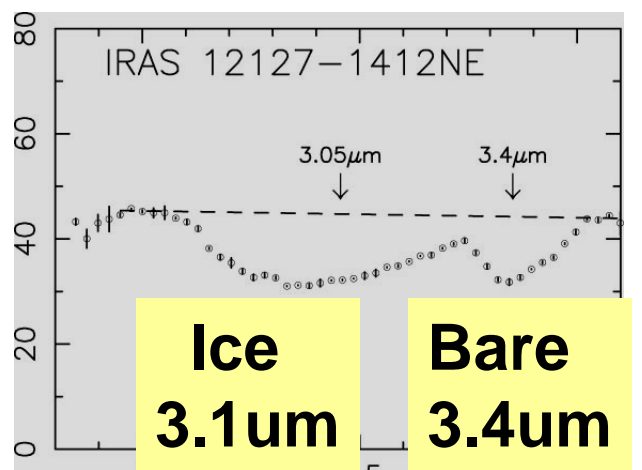
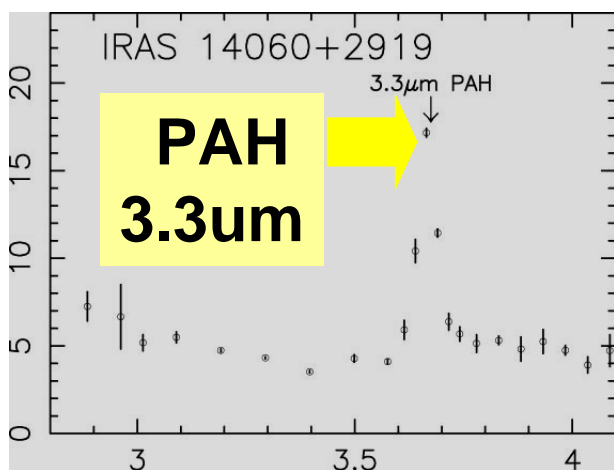
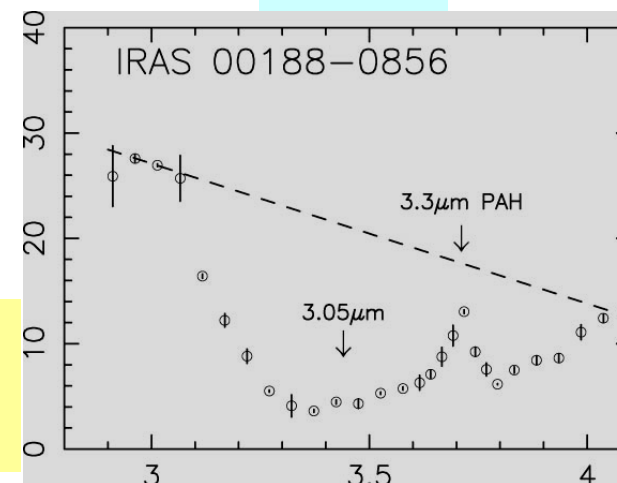
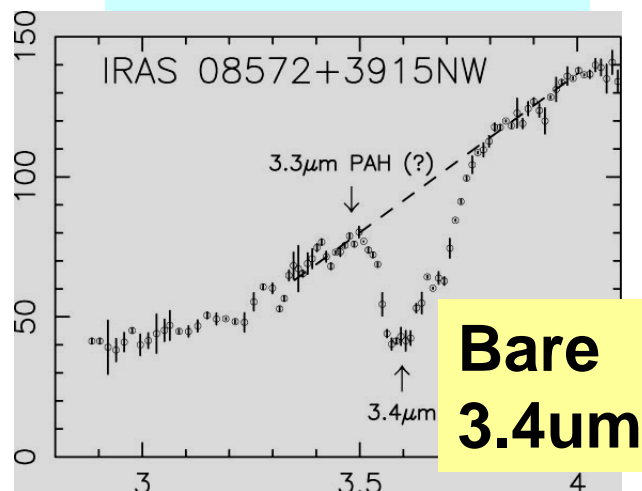
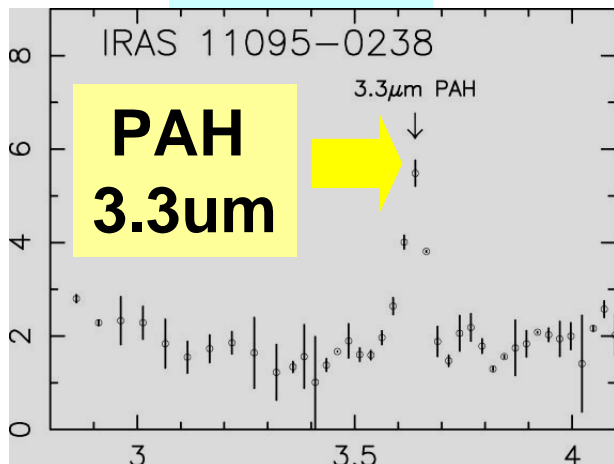


Subaru

星生成

埋もれたAGN

共存



PAH **strong** (星生成):  
ダスト吸収 **weak**

PAH **weak** (AGN):  
Dust吸収 **strong**

5-35  $\mu\text{m}$



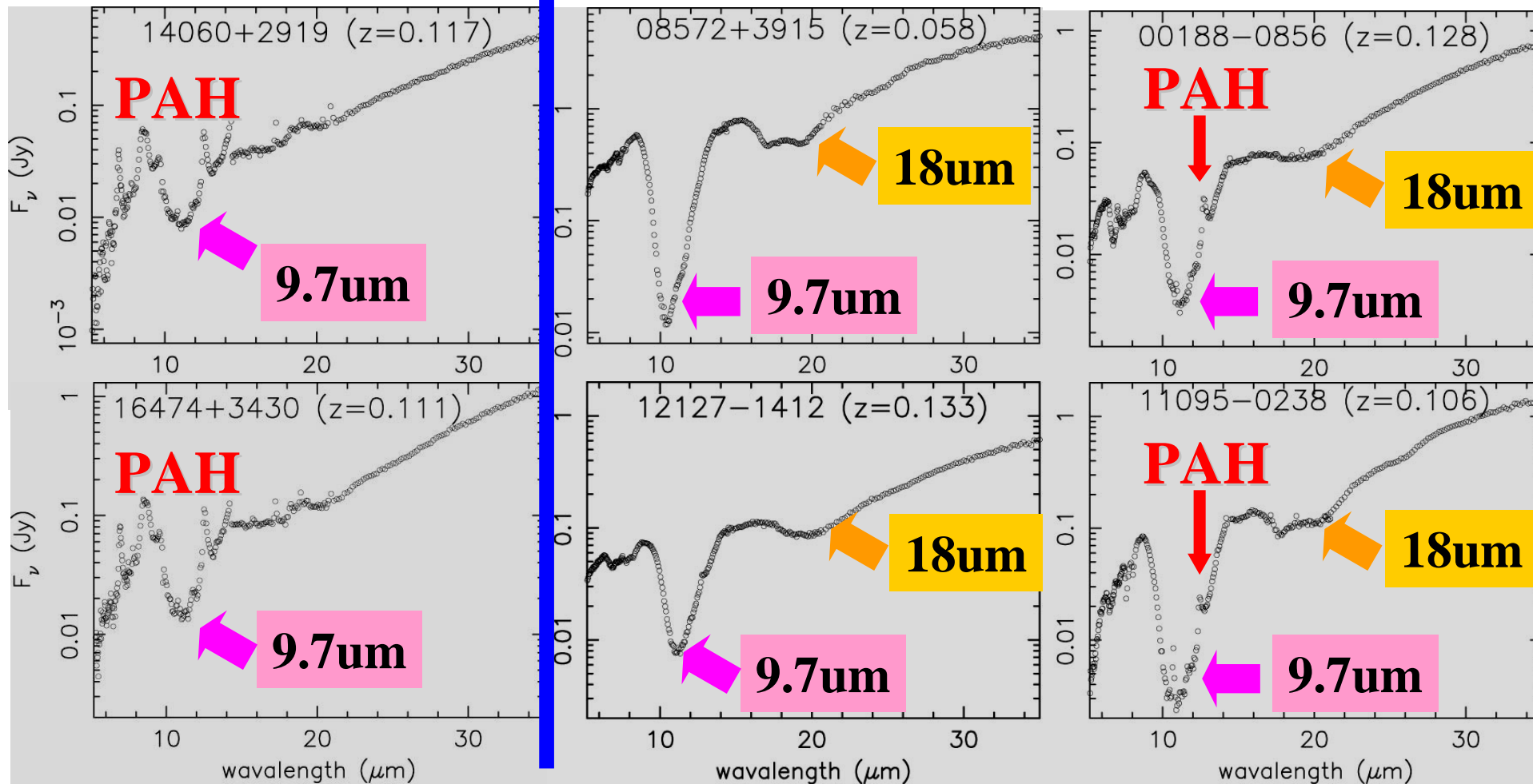
Spitzer

GO1  
PI今西

星生成

埋もれたAGN

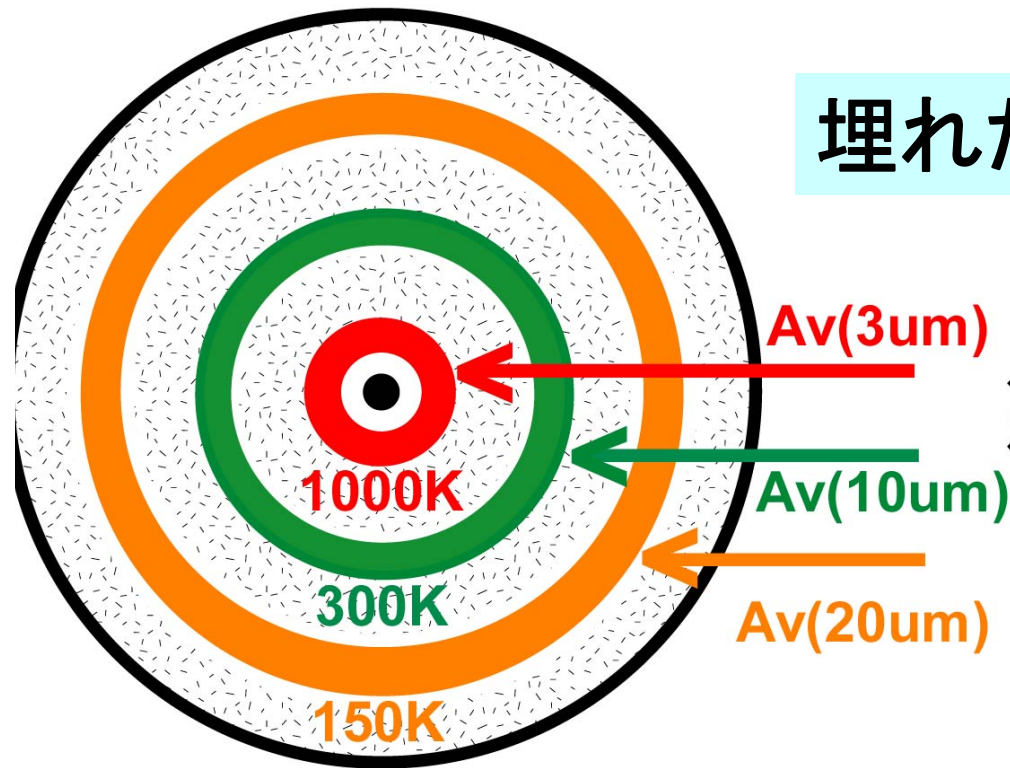
共存



**PAH strong :**  
**Silicate吸收 weak**

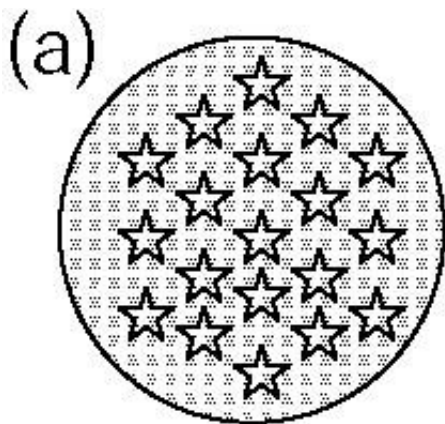
**PAH weak:**  
**Silicate吸收 strong**

### 3. ダストの強い温度勾配



埋れたAGN

$$A_v(3\mu\text{m}) > A_v(10\mu\text{m}) > A_v(20\mu\text{m})$$

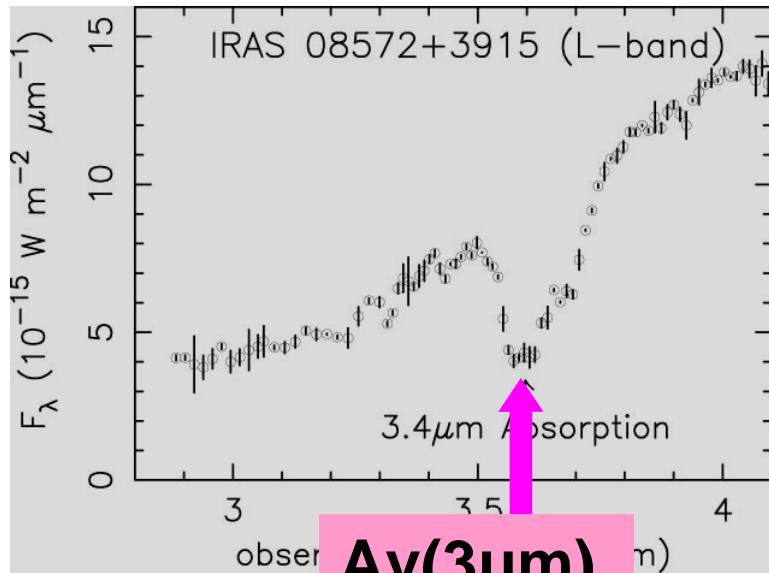


dust in  
host  
galaxy

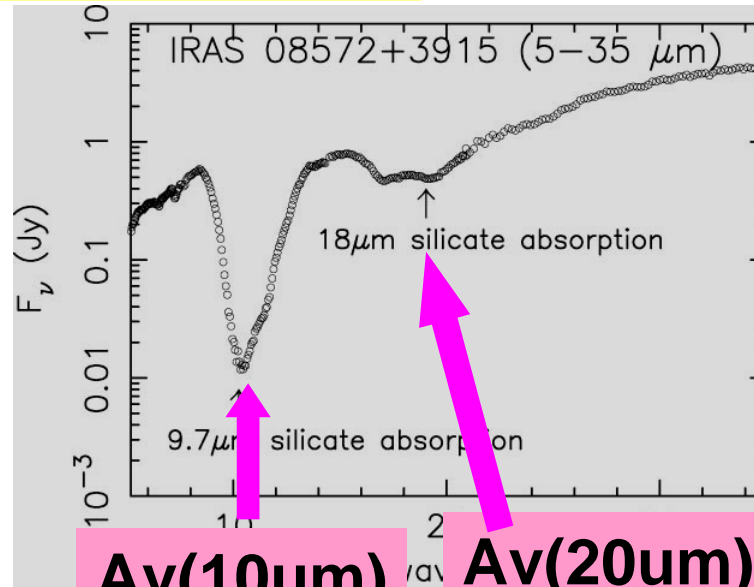
星生成

$$A_v(3\mu\text{m}) \leq A_v(10\mu\text{m}) \leq A_v(20\mu\text{m})$$

# ダスト温度勾配をどう検出？

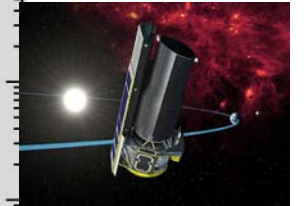


**Av(3um)**  
~110mag



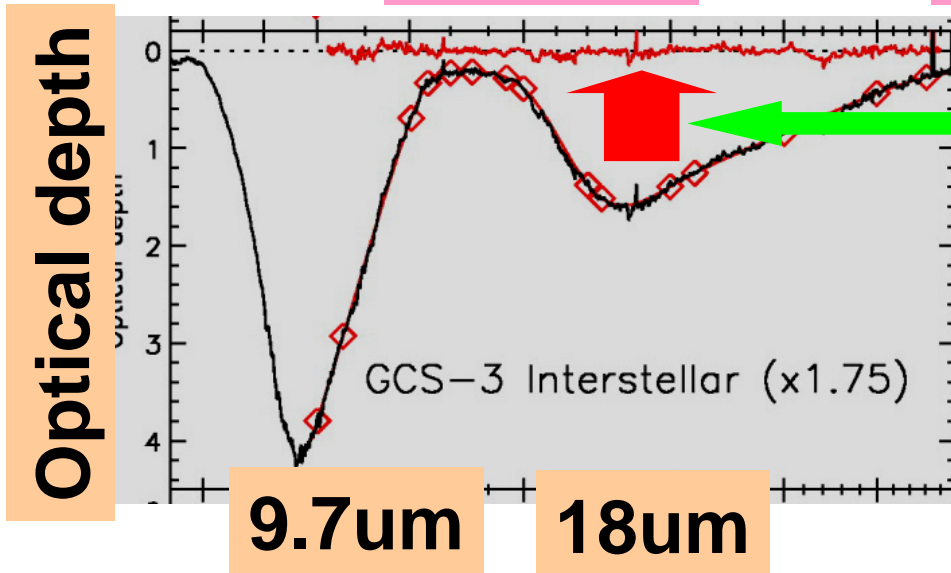
**Av(10um)**  
~40mag

**Av(20um)**  
~20mag



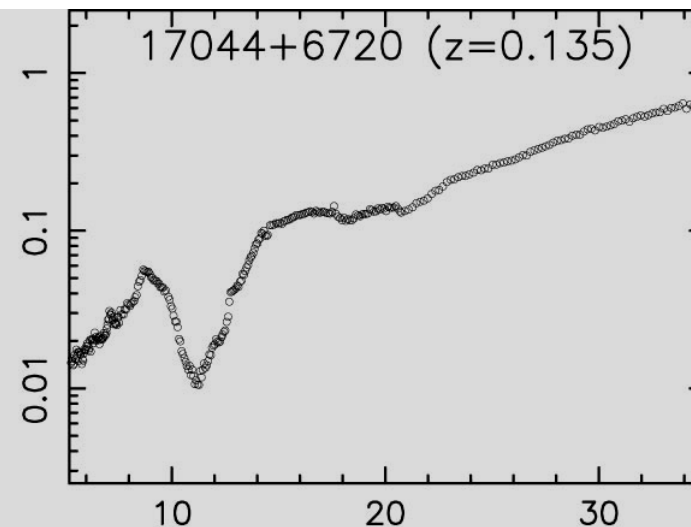
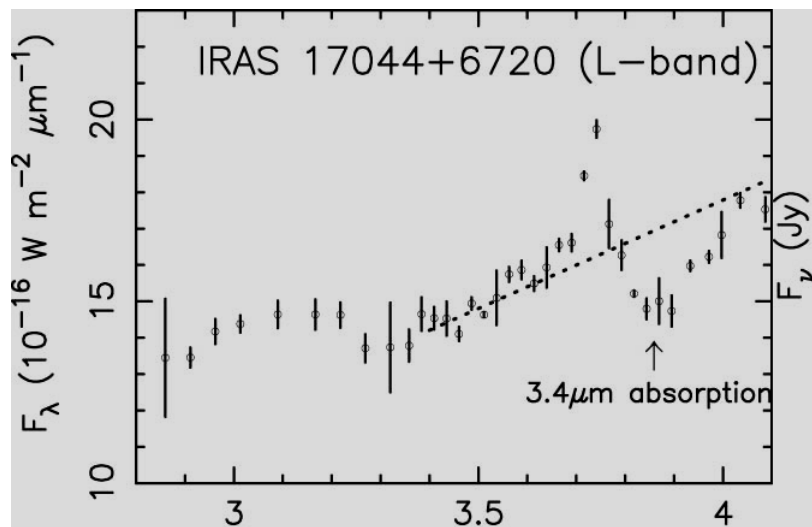
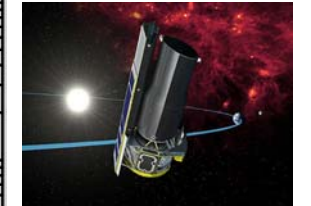
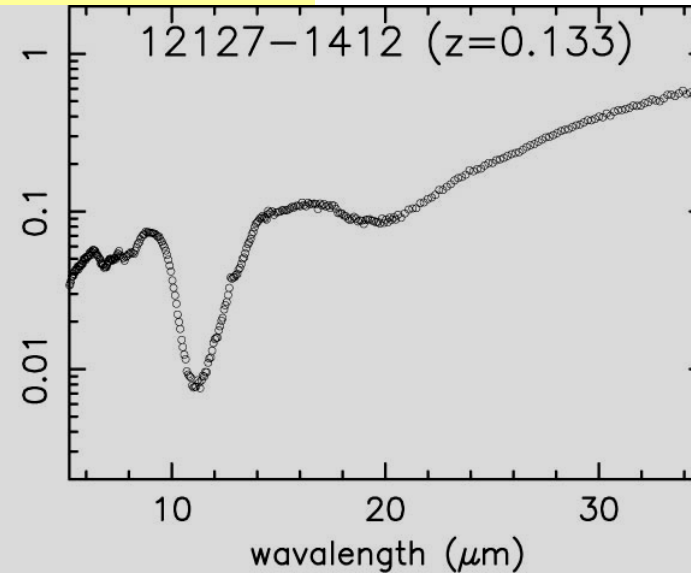
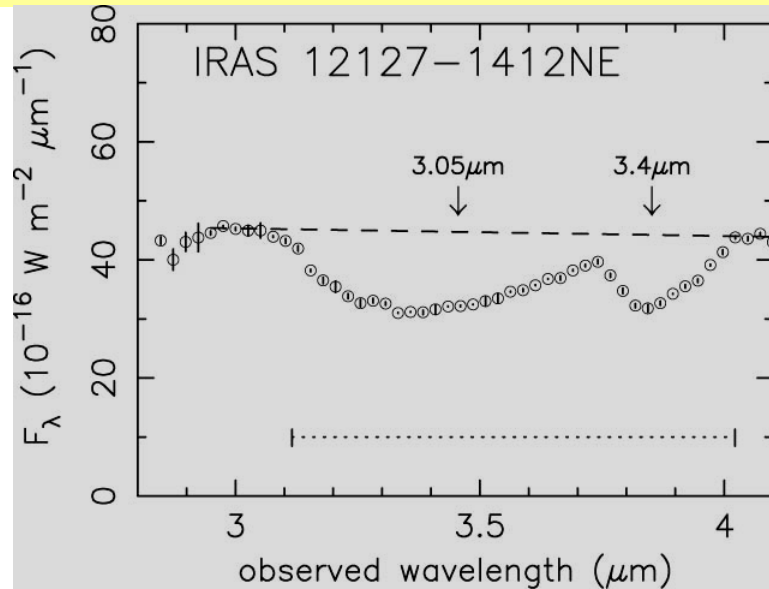
Subaru

Spitzer



**ダスト温度勾配**

# ダスト温度勾配を示すULIRGs



強い吸収フィーチャー ⇒ ダスト温度勾配も示す

# 赤外線観測の結果

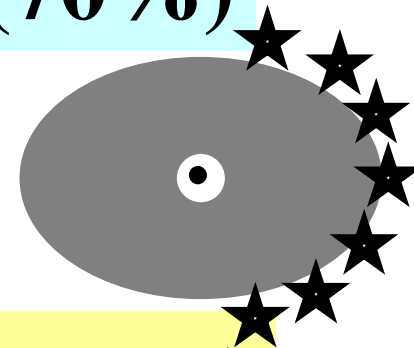
近傍( $z < 0.15$ )

Subaru:  
36天体

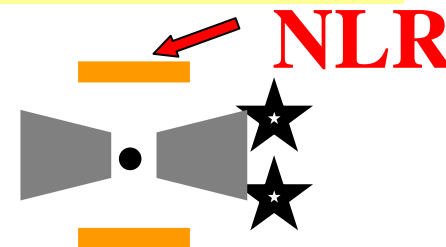
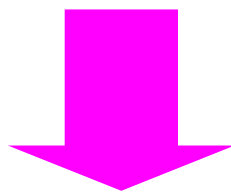
Spitzer:  
GO1 35天体  
GTO 13天体

OpticalでNon-Seyfert型のULIRGs(70%)

↳ 強力な埋もれたAGN = 30-50%

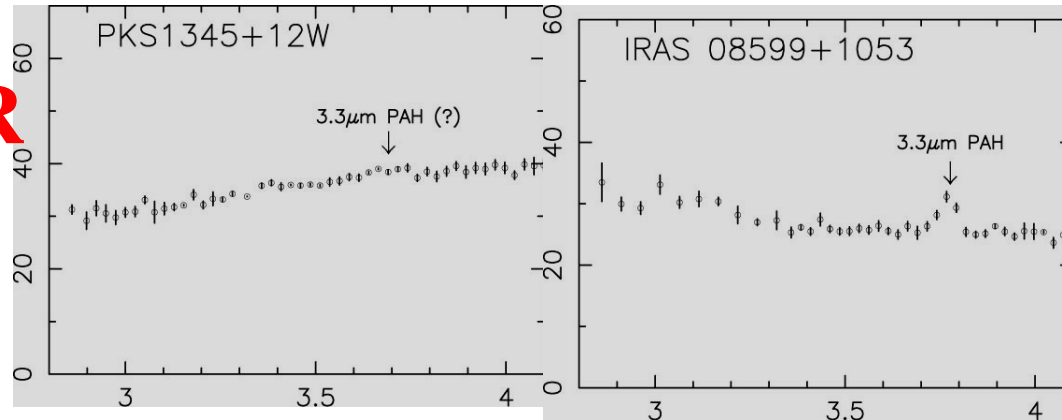
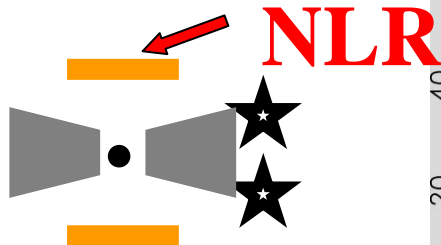


30% ULIRGs = optical Sy (AGN + torus)

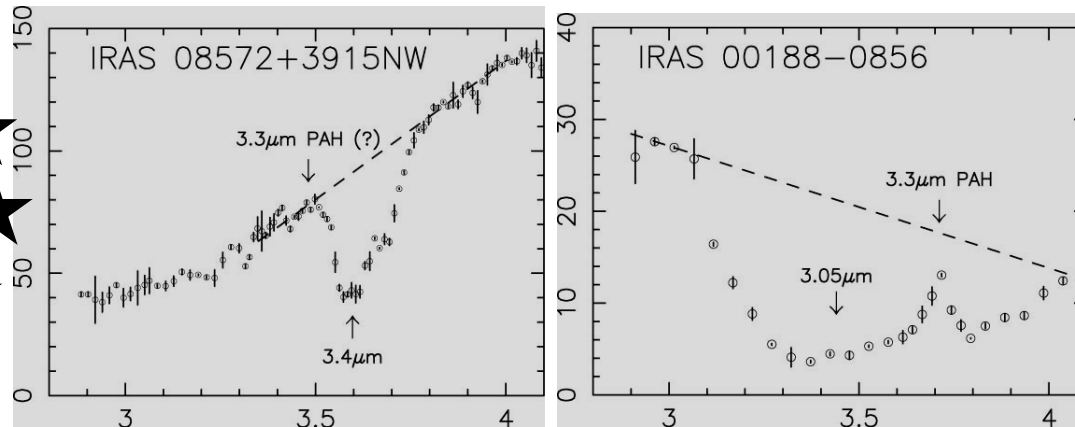
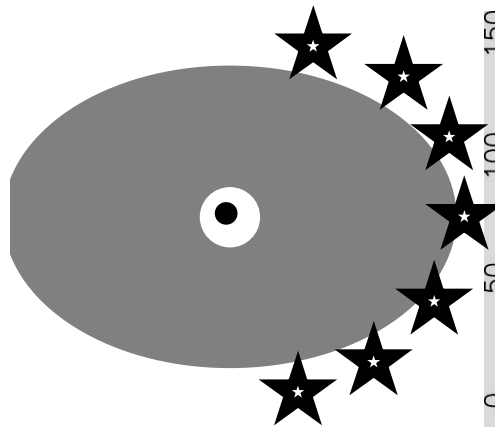


ULIRGs全体の  $> 50\%$  = 強力なAGN

# 視線方向のダスト吸収: Non-Sy >> Sy2



**Sy2:  
吸収  
weak**



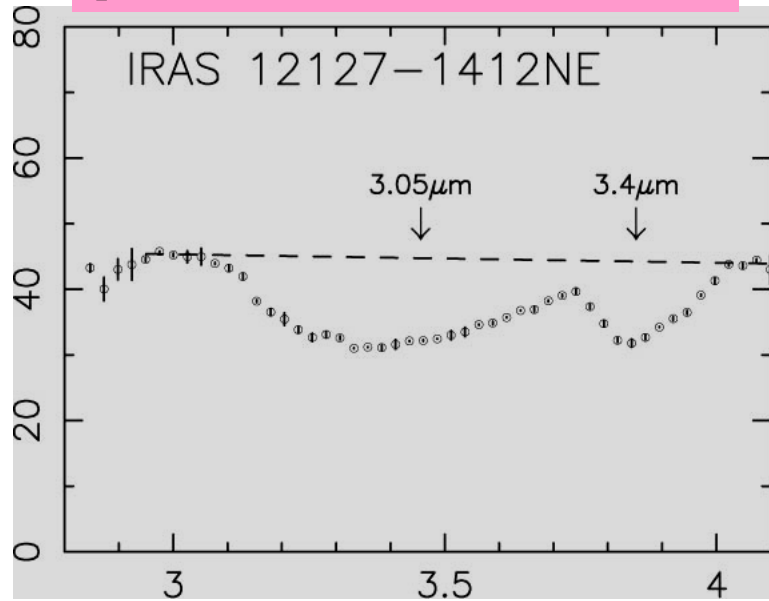
**Non-Sy:  
strong**

**L(吸収補正後のAGN) ~ L(IR) すると**

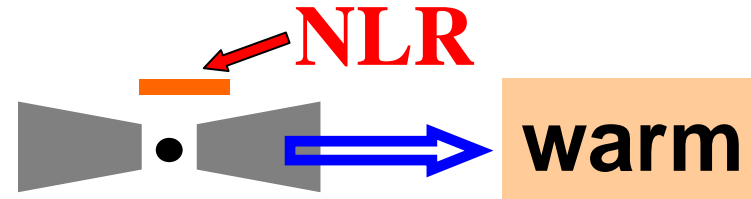
**中心核のダスト量: Non-Sy >> Sy2**

# 埋もれたAGN: warm/cool ULIRGsで検出

pure 埋もれたAGN



$F_{25}/F_{60}=0.16$ (cool)



ダストの  
柱密度大

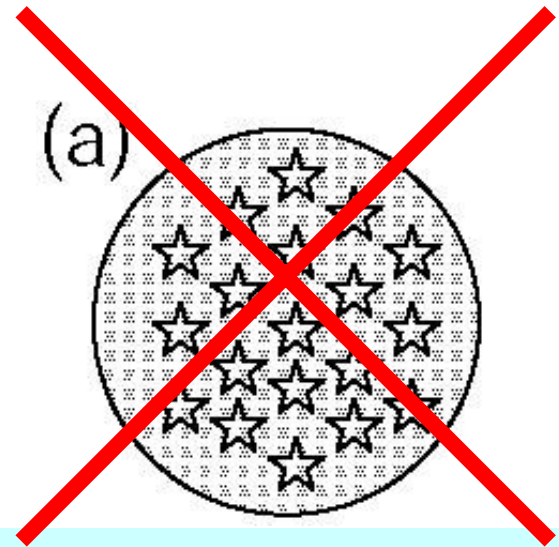
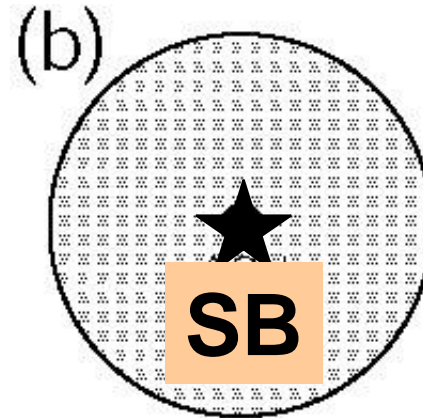
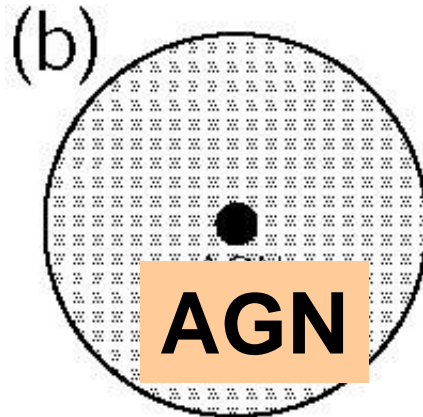


cool な赤外の色

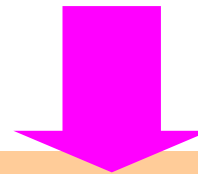
cool  $\neq$  starburst



# 不定性



例外的に中心集中した星生成 (SB)



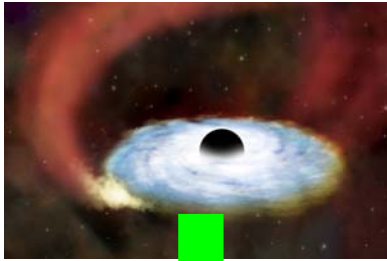
表面輝度が非常に高い必要

$\gg 10^{13} L_{\text{sun}} / \text{kpc}^2$  (SB max)

極端なSB?

## 確認観測の必要性

埋もれたAGN or 極端なSB ?

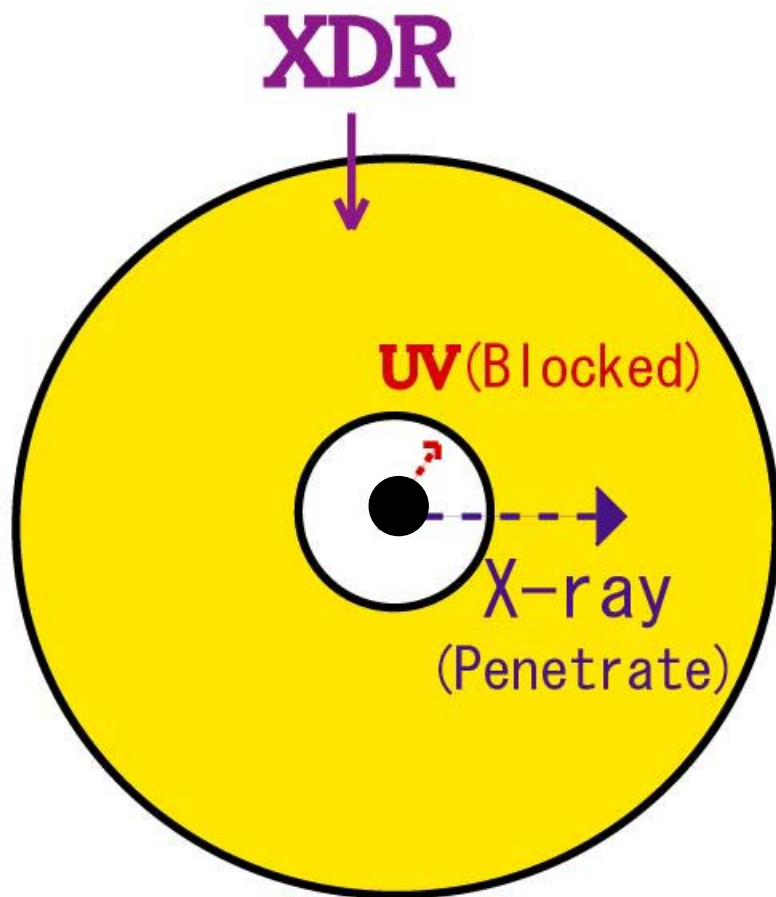


X-ray : AGN  $\gg$  any SB

ULIRGs中に埋もれたAGNのほとんどは  
Compton thick ( $N_H > 10^{24} \text{ cm}^{-2}$ )

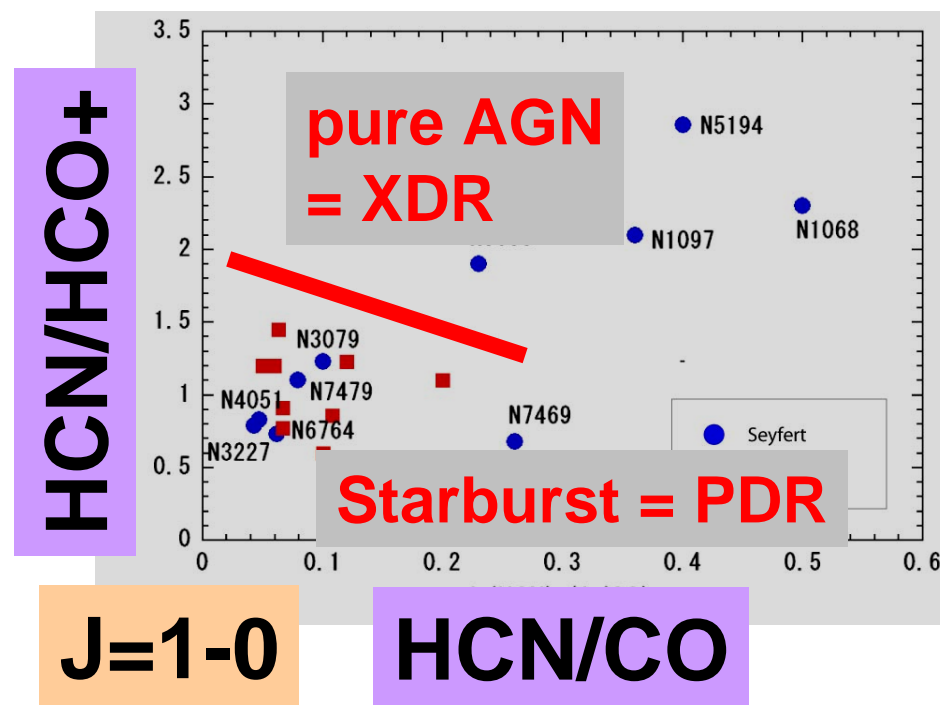
X線で検出するのは非常に困難

# 埋もれたAGNが周囲の星間ガスへ与える影響



Maloney et al.1996

**XDR** : X線で明るいAGN  
の周囲に発達



(Kohno astro-ph/0508420)



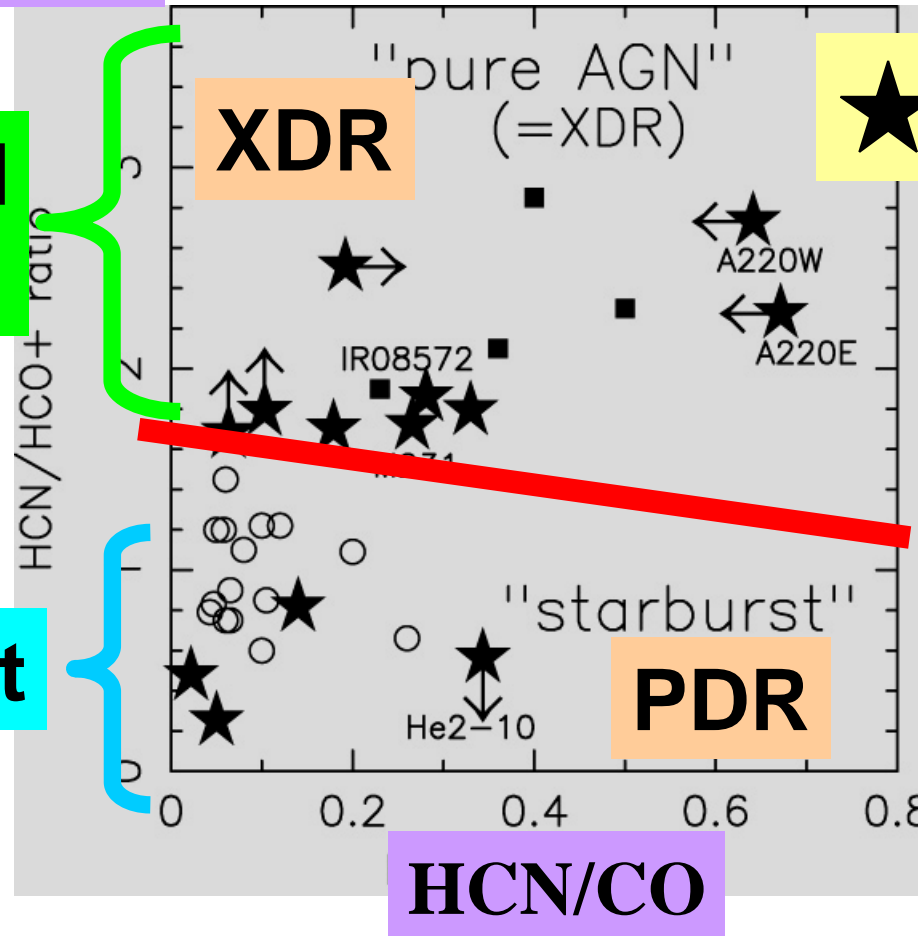
NMA  
(RAINBOW)

HCN/HCO+

IR-buried  
-AGNs

★:(U)LIRGs

IR-Starburst



Imanishi et al. 2006 AJ 131 2888

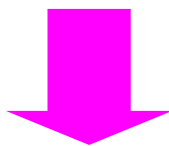
Imanishi et al. 2007 AJ 134 2366

# コメント

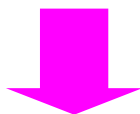
$z > 0.15$



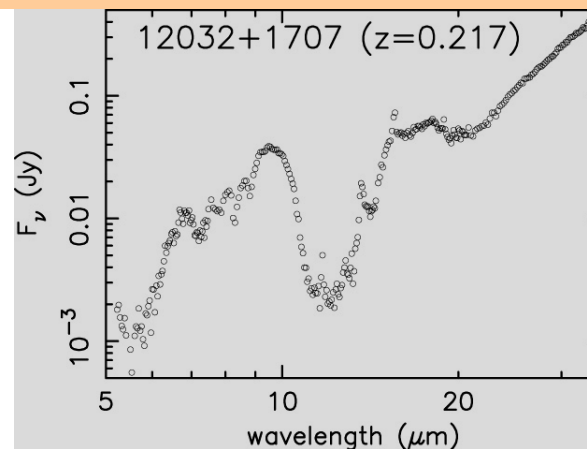
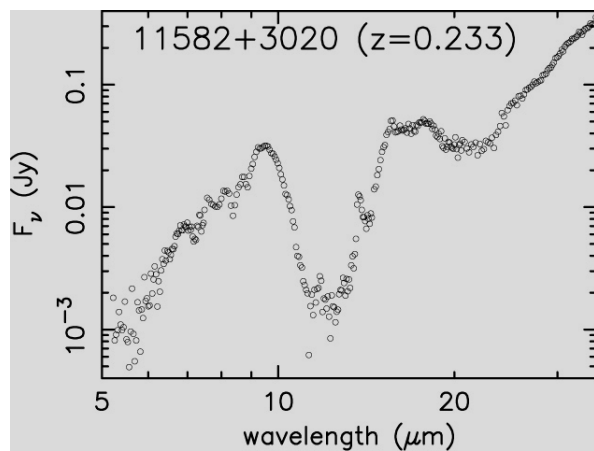
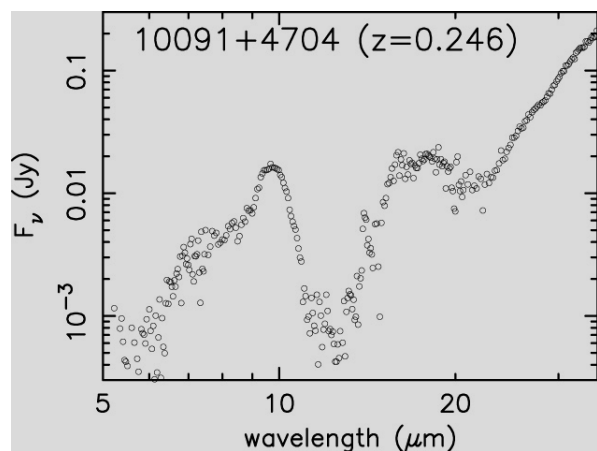
$L_{\text{IR}}$  大きな ULIRG 含まれる



埋もれた AGN は、 $L_{\text{IR}}$  大きいほど増加



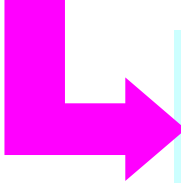
AGN-feedback が 銀河の downsizing 支配?



## まとめ

可視光線でnon-Sy の近傍ULIRGsの30-50%で、  
明るい埋もれたAGNのサイン

埋もれたAGNは、中心核ダストの量が、Sy2 AGNより多い



可視光線Syのサインは、中心核ダストの量に依存  
(AGNが存在するか否かではない)

ミリ波：赤外線の手法の信頼性を確認

Imanishi et al. 2006 ApJ 637 114 (Subaru)

Imanishi et al. 2007 ApJS 171 72 (Spitzer)

Imanishi et al. 2007 AJ 134 2366 (NMA)

終わり