ALMAで迫るmm波帯系外銀河背景放射の起源

ALMA Census of Faint 1.2 mm Sources down to 0.01 mJy: Extragalactic Background Light and Dust-poor high-z Galaxies

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(c) NAOJ

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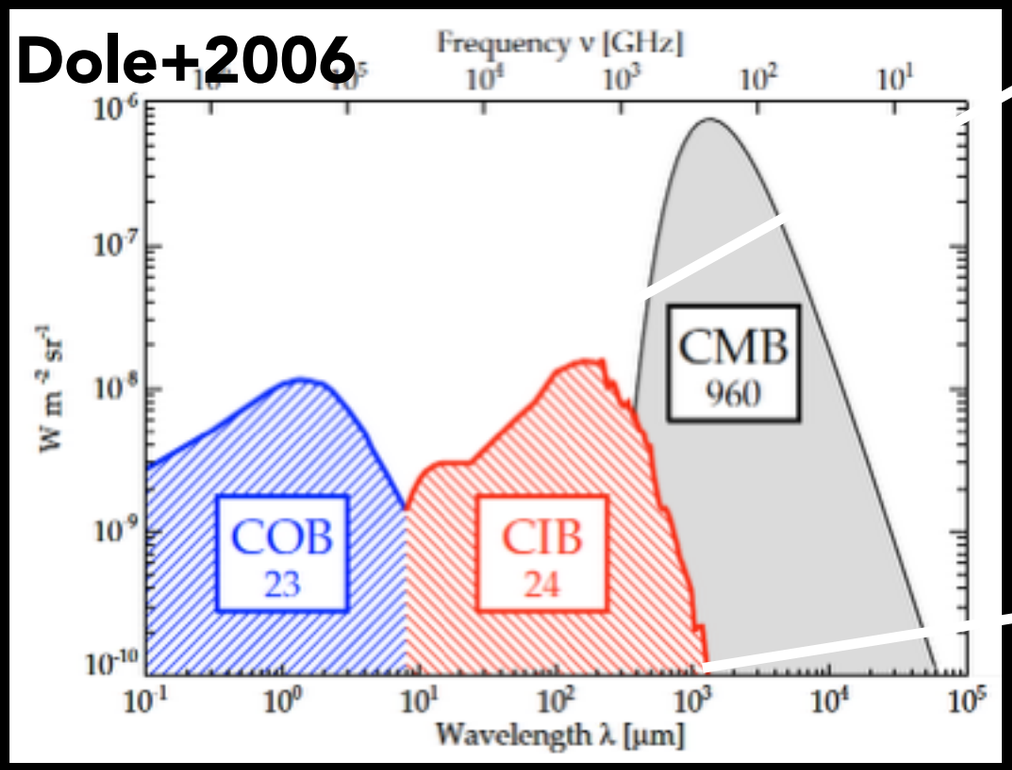
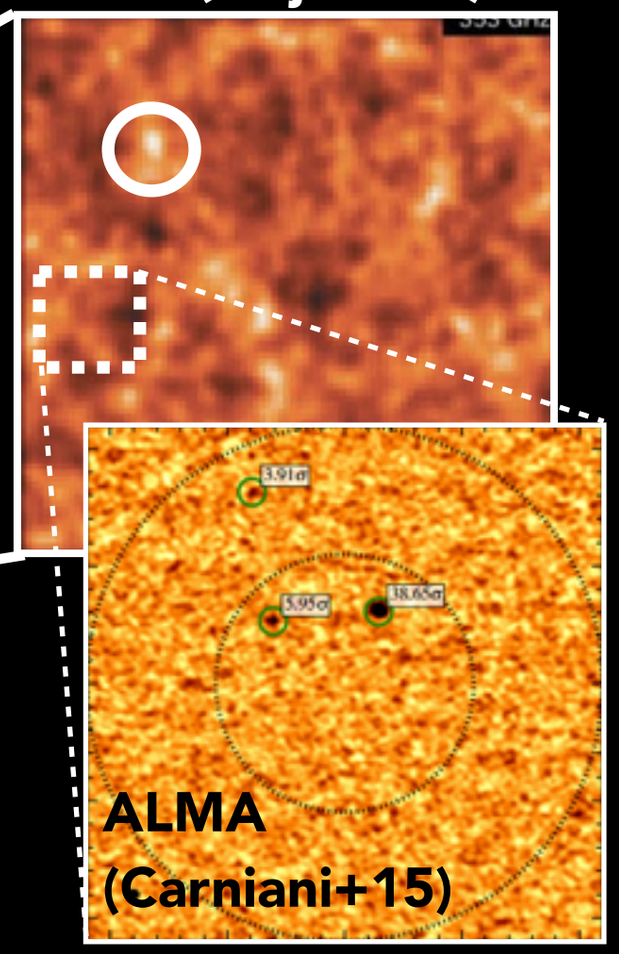
系外銀河背景光 (EBL)





サブミリ銀河(SMGs)

~1.0 – 10mJy

~10% (e.g., Scott+12)

暗いALMA天体

~0.1 – 1.0 mJy

~60% (Hatsukade+13, Ono+14, Carniani+15)

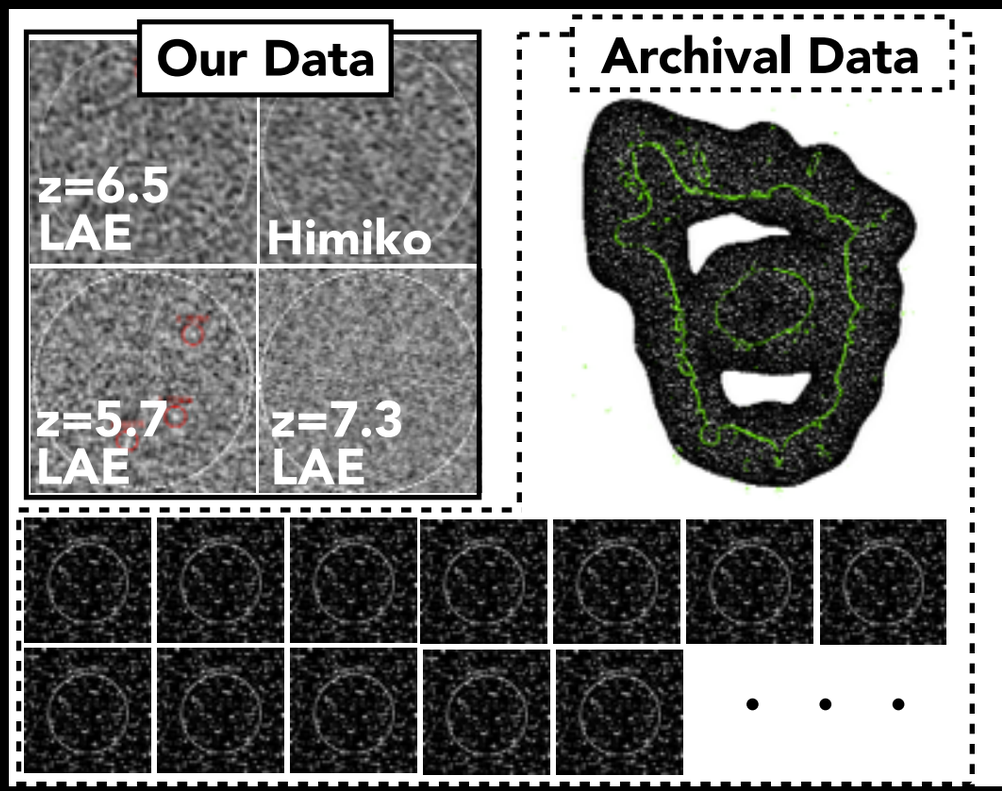
背景光に寄与する全ての成分はいまだ明らかになっていない..

現状可能な限りのALMAデータ(Field+Cluster)を集め、0.1 mJy以下含めた背景光放射起源に迫る

データ選択

データ : ALMA Band 6 & 7

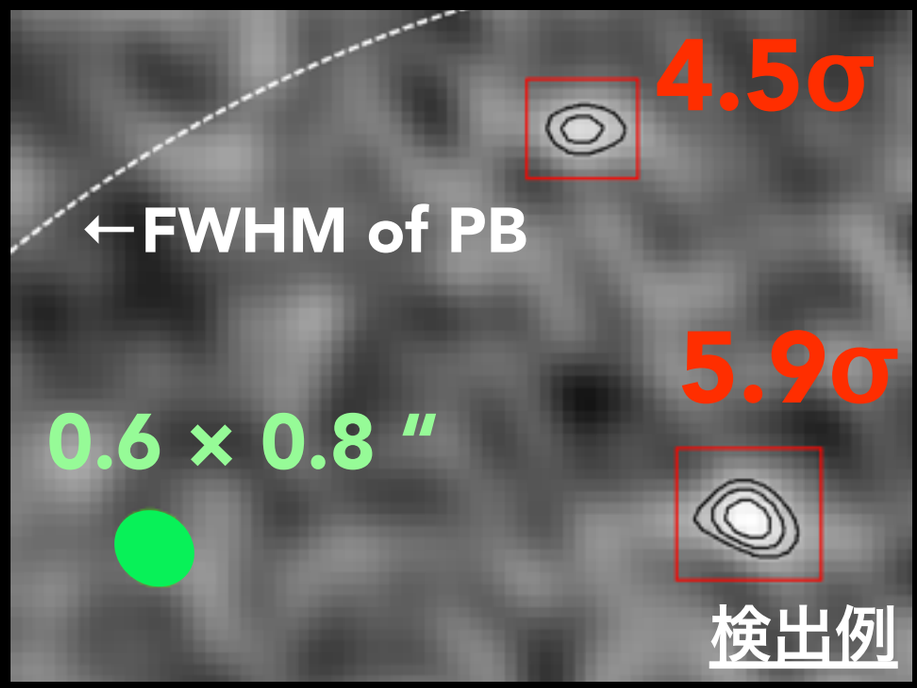
我々が所有する世界的に最深データ
+
全公開アーカイブデータ
(2011/12 - 2015/3)



- 深さ < 0.1 mJy
- 明るすぎる天体を含まない

計51maps (~100視野相当)
r.m.s ~ 8.5 - 100 uJy
天体数 : 89

* Mass model made with GLAFIC (see Ishigaki+15)



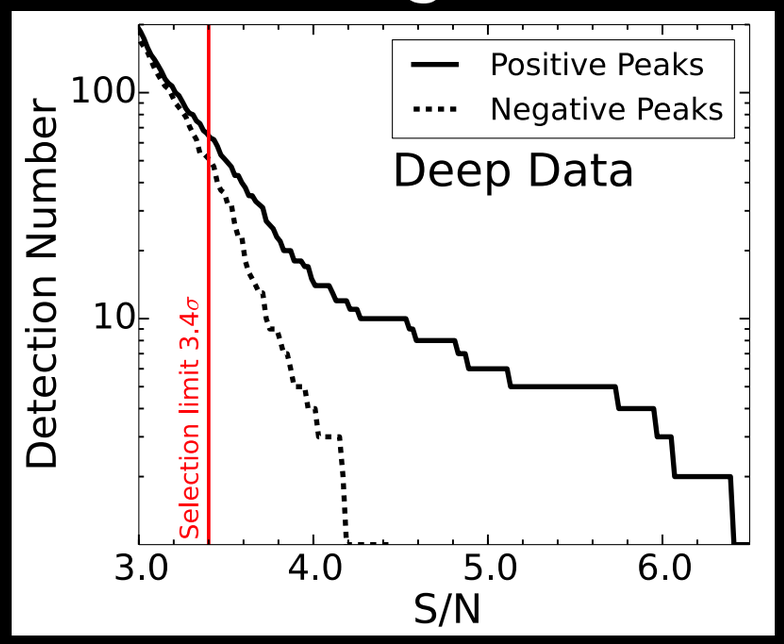
データ解析

背景光への寄与 -> 個数密度を正しく求める.

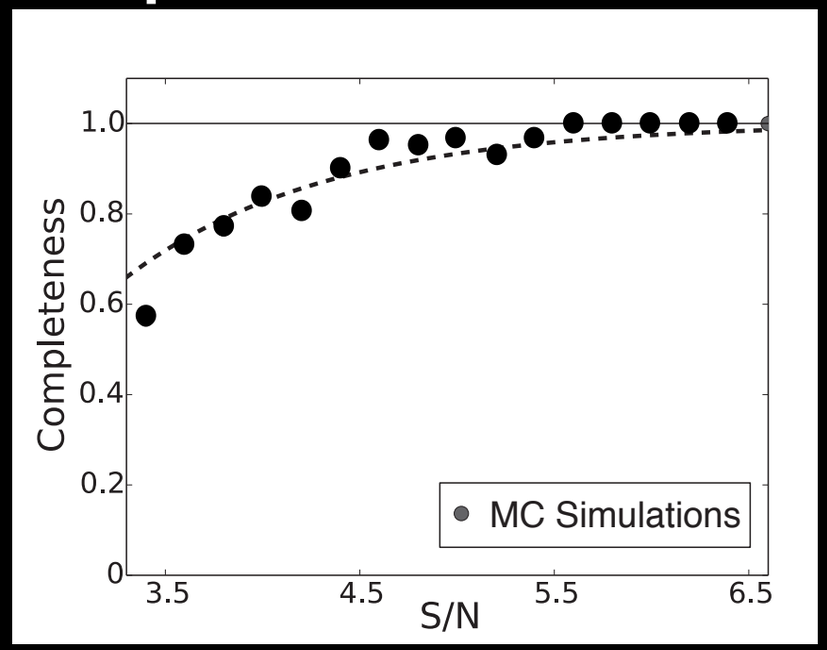
$$N_{eff} = \frac{1 - R_S(S/N)}{C(S/N)}$$

Rs (S/N): 偽天体確率
C (S/N): コンプリートネス

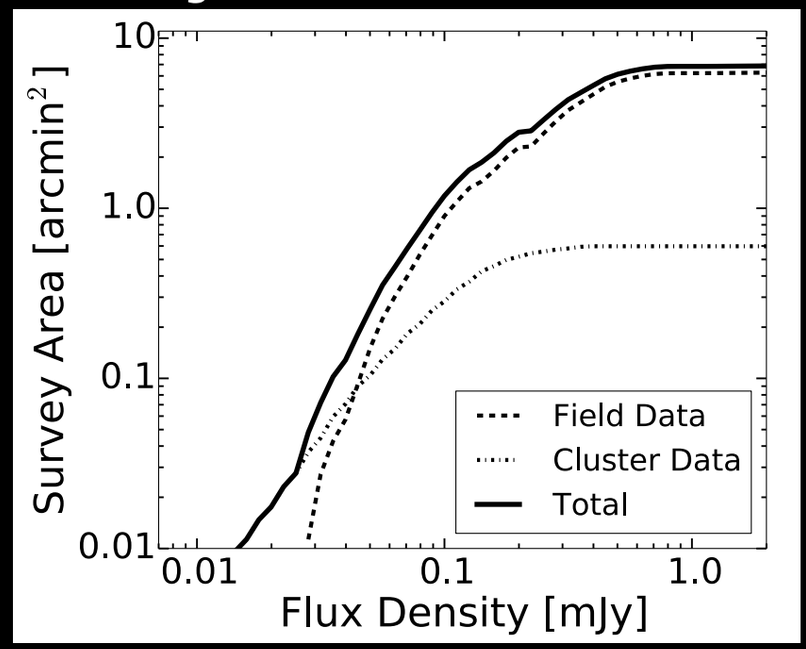
Positive & Negative Peaks



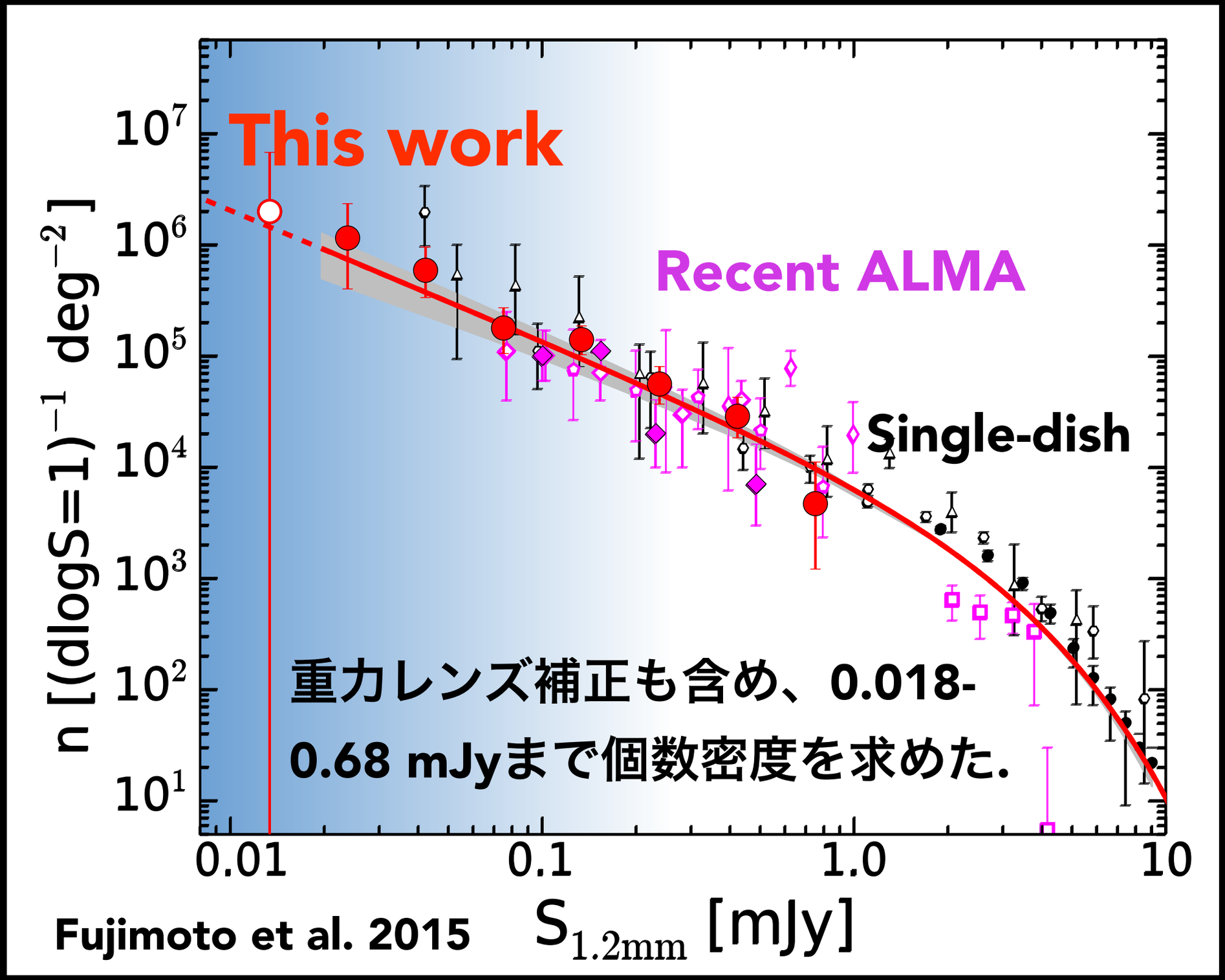
Completeness



Survey Area



個数密度 @ 1.2 mm


This work
Recent ALMA
Single-dish
重力レンズ補正も含め、0.018-
0.68 mJyまで個数密度を求めた.
n [(dlogS=1)$^{-1}$ deg^{-2}]
10^7
10^6
10^5
10^4
10^3
10^2
10^1
0.01
0.1
1.0
10
$S_{1.2mm}$ [mJy]
Fujimoto et al. 2015

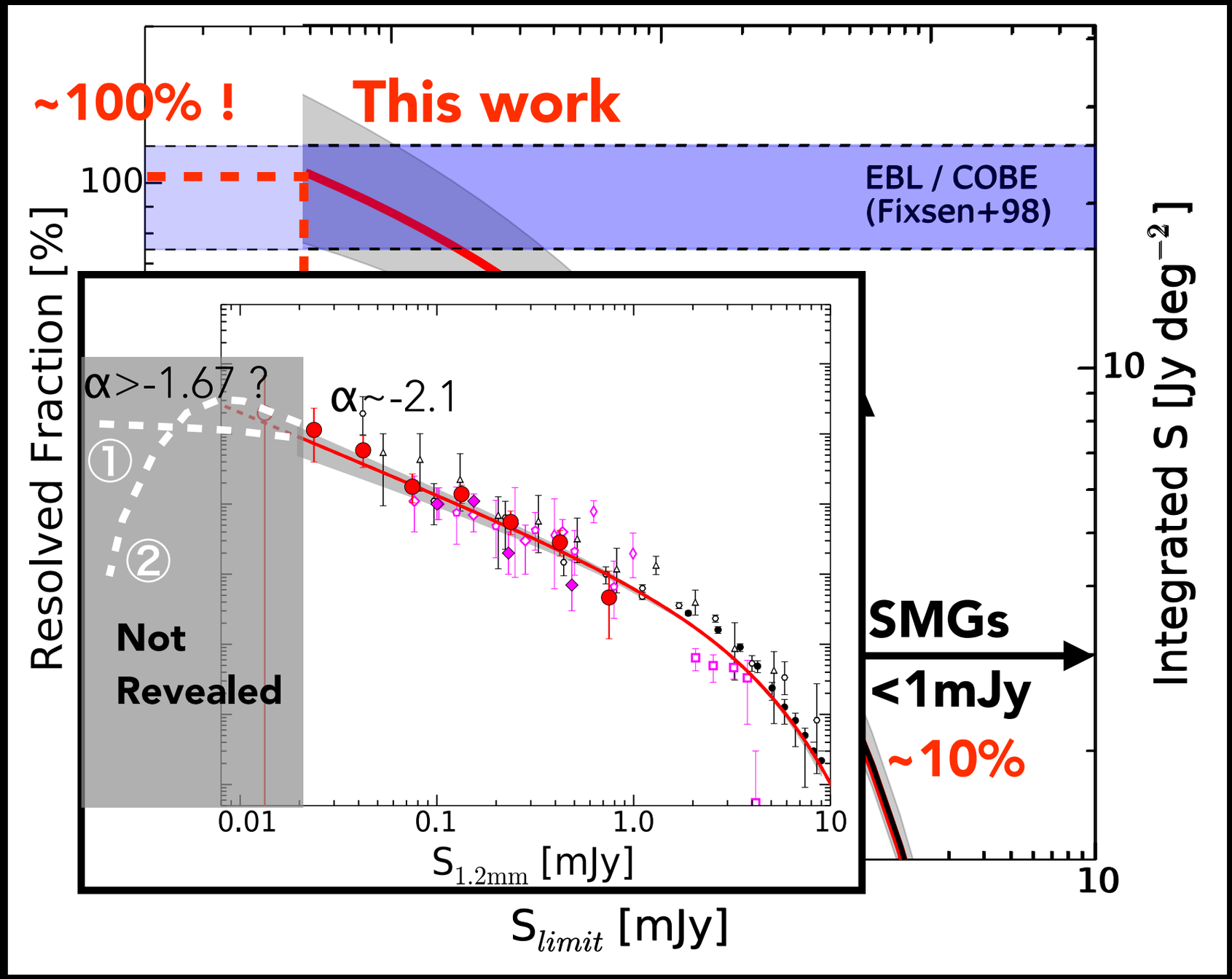
Resolve the EBL

- Almost fully (104±30%) resolve the EBL
- < 0.01 mJy sources might be negligible

-> 1) Flattening

2) Truncation

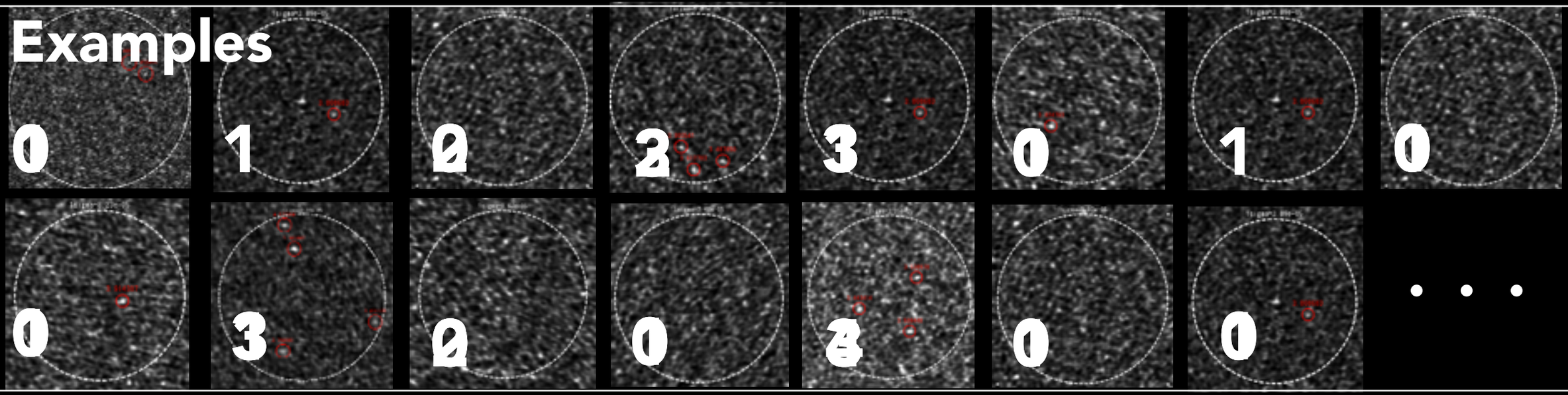
below 0.01 mJy



What are the faint ALMA sources ?

1. Statistical Approach: Clustering Analysis

Examples



Field-to-Field Scatter = Poisson error + Galaxy Bias

Counts-in-Cells

$$b_g^2 \approx \frac{\sigma_N^2 - \bar{N}}{\bar{N}^2 \sigma_V^2(z)}$$

(e.g., Robertson+10)

b_g: galaxy bias σ_V: matter variance

σ_N: dispersion of source counts

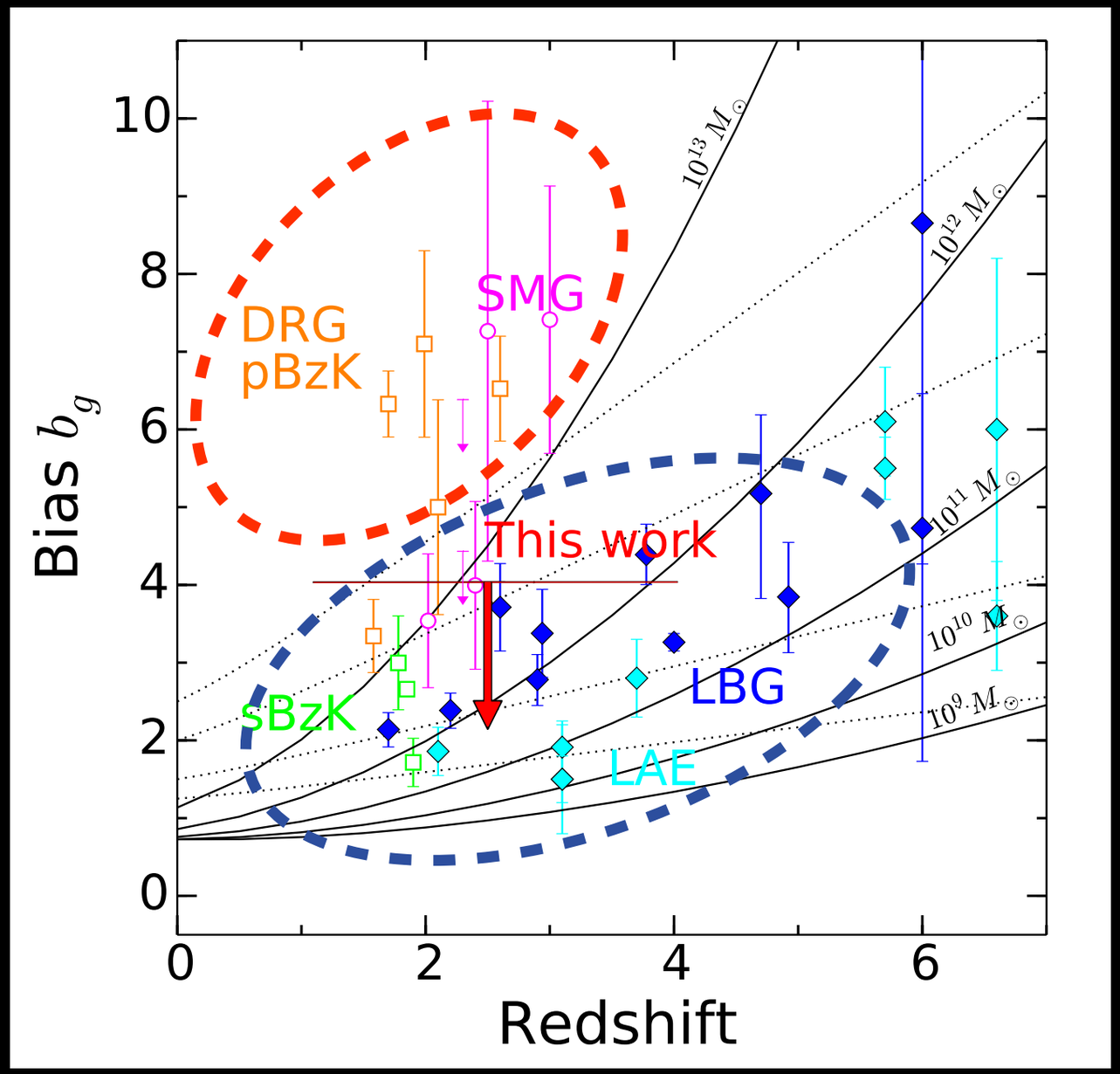
N: mean source counts

Faint ALMA Sources

$b_g < 4.1$

(ΛCDM->) $M_{DH} < 8 \times 10^{12}\ M_{sun}$

1. Statistical Approach: Cluster Analysis

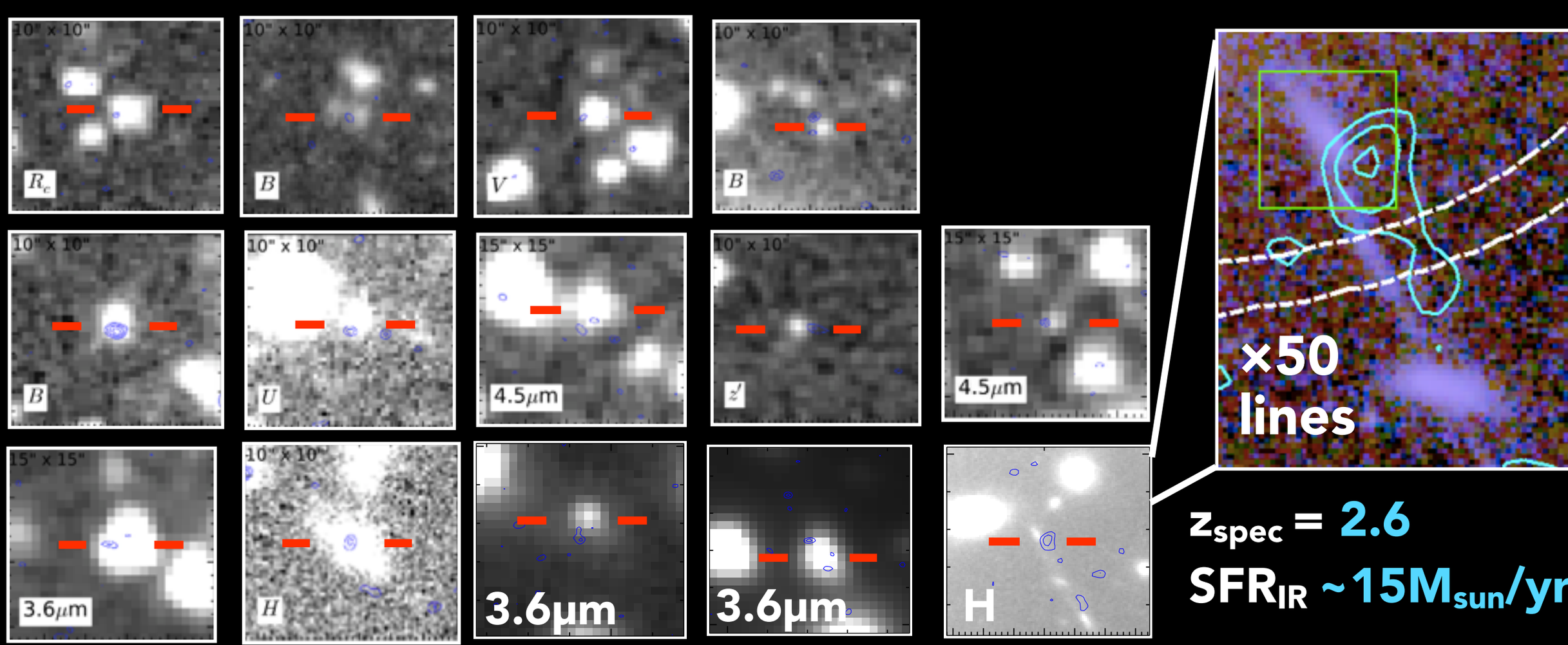


- Faint ALMA Sources
  $b_g < 4.1$
- SMGs / DRGs / pBzK
  $b_g \sim 5 - 7$
- sBzK / LBGs / LAEs
  $b_g \sim 2 - 3$

Faint ALMA Sources = sBzK, LBGs, LAEs?

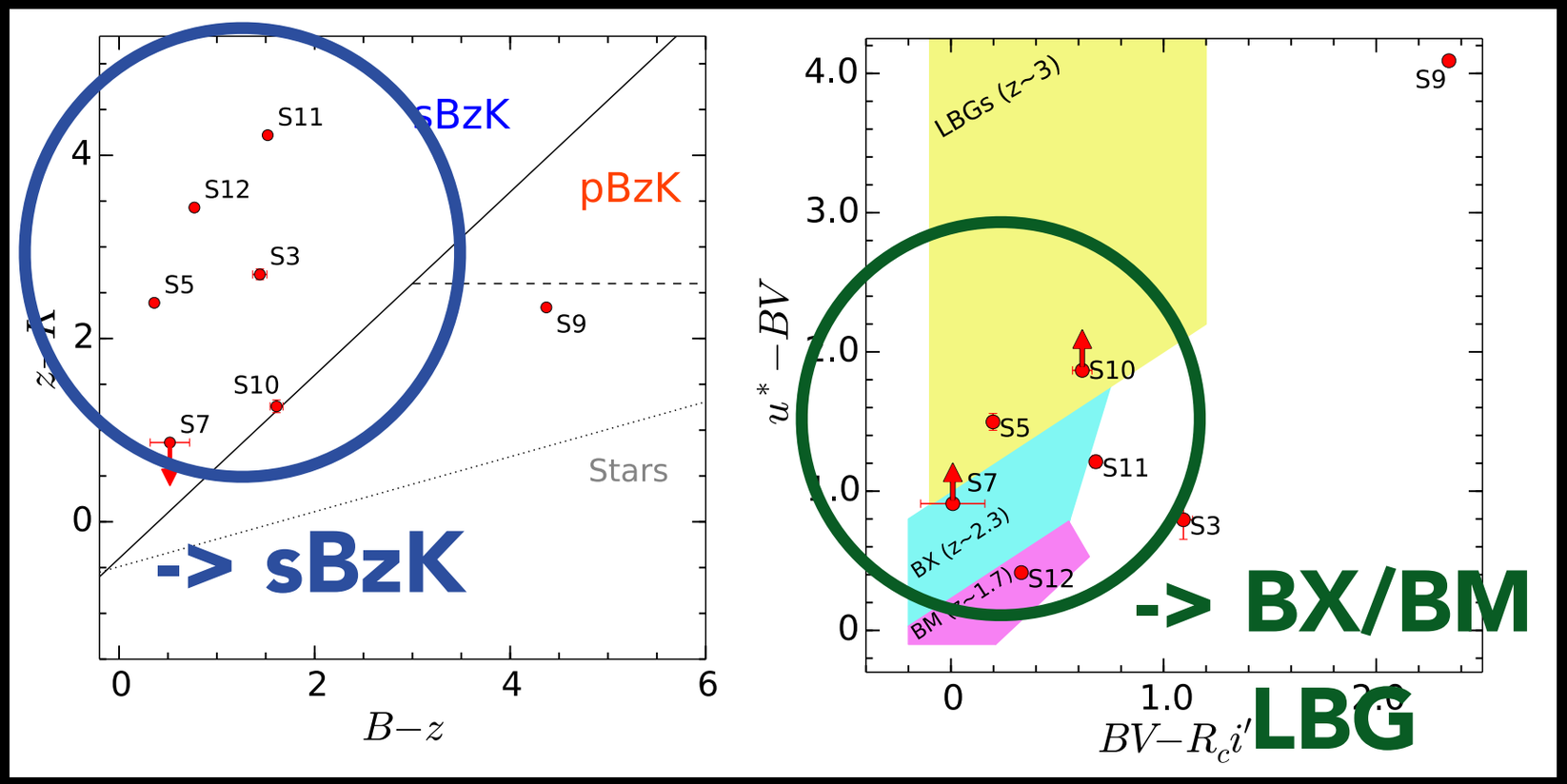
2. Individual-basis Approach: Optical Counterparts

- Optical counterparts in SXDS, A1689 with rich multi-wavelength data
- 14/26 Sources (~54%) have optical counterparts

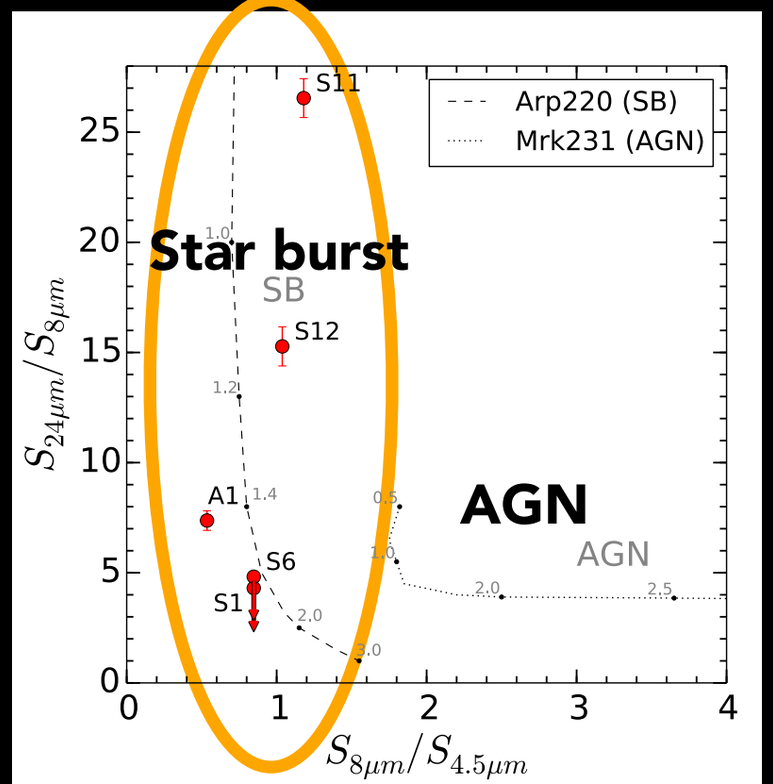


Photometric Properties

Bzk & LBG Selection



AGN or SB ?

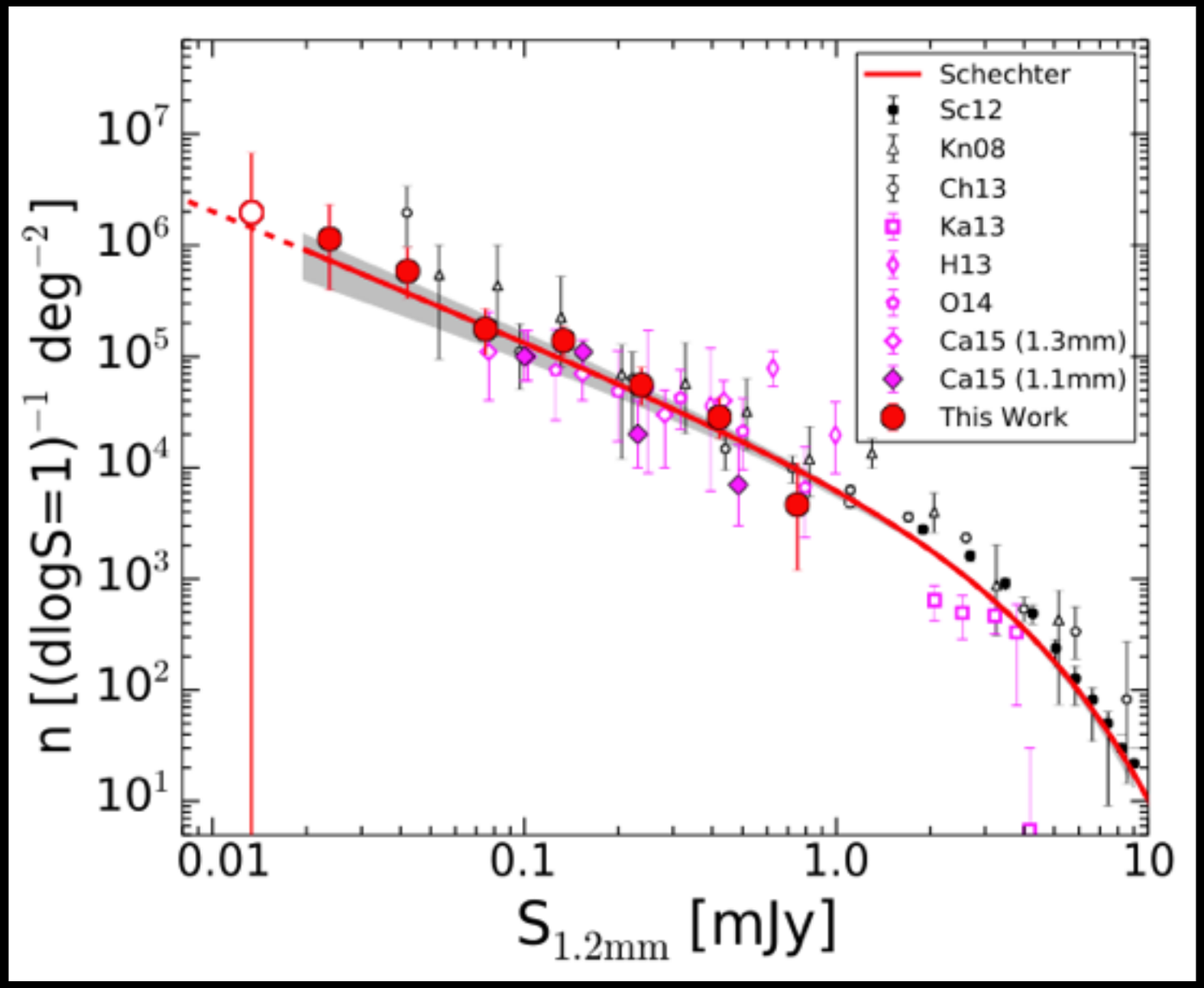


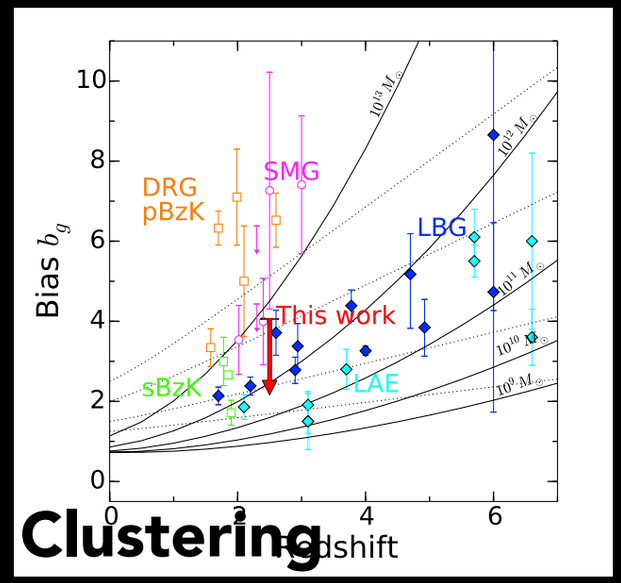
Faint ALMA Sources = sBzK / LBG(BX/BM)

- Clustering (Statistical)
- Opt. Counterparts (Individual)

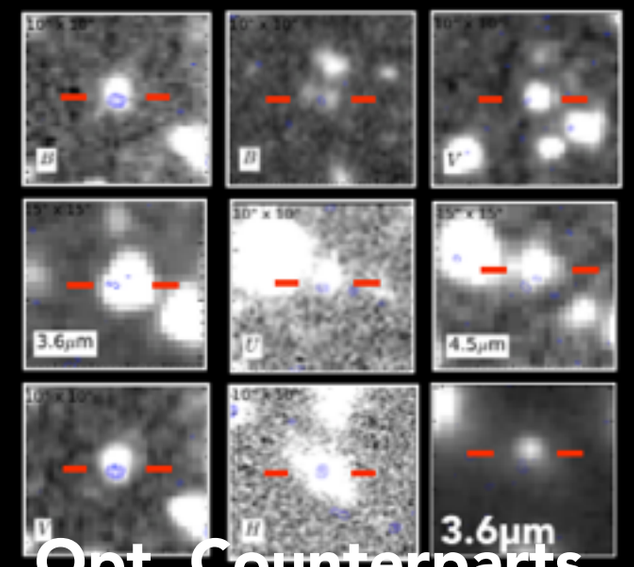
Faint ALMA Sources (~50%) ↓ Optically Selected SFGs

Summary





Clustering



Opt. Counterparts

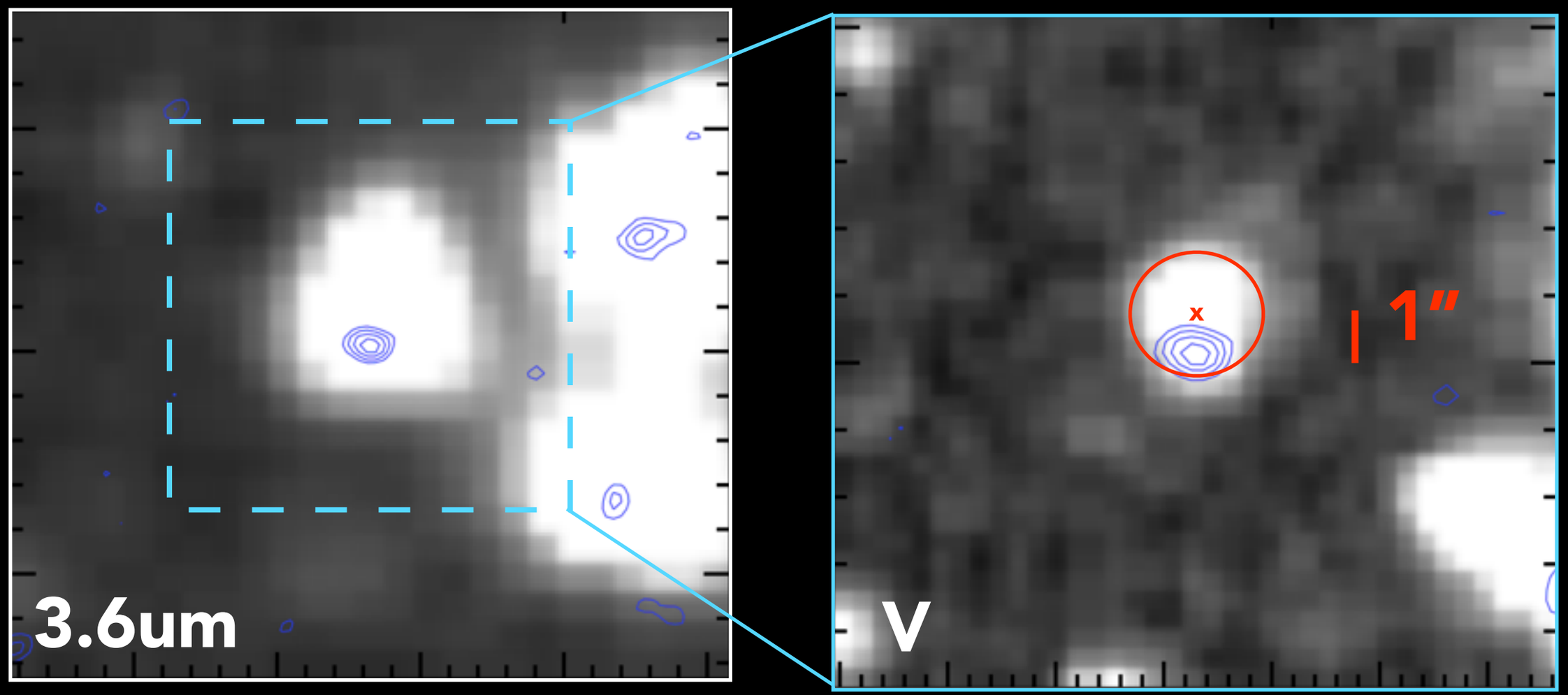
- **Largest ALMA Dataset (89 sources: down to ~ 0.01 mJy)**
- **Number Counts -> Resolve ~ 100% of EBL -> Flat/Trunc ?**

What are Faint ALMA Sources ?

50% -> Opt. Selected SFGs (Clustering & Opt. Counterparts)

ALMAの位置測定精度 (PAA)

0.1″ < PAA = Calibrator + Dish Distance < beam size (~1.0″)

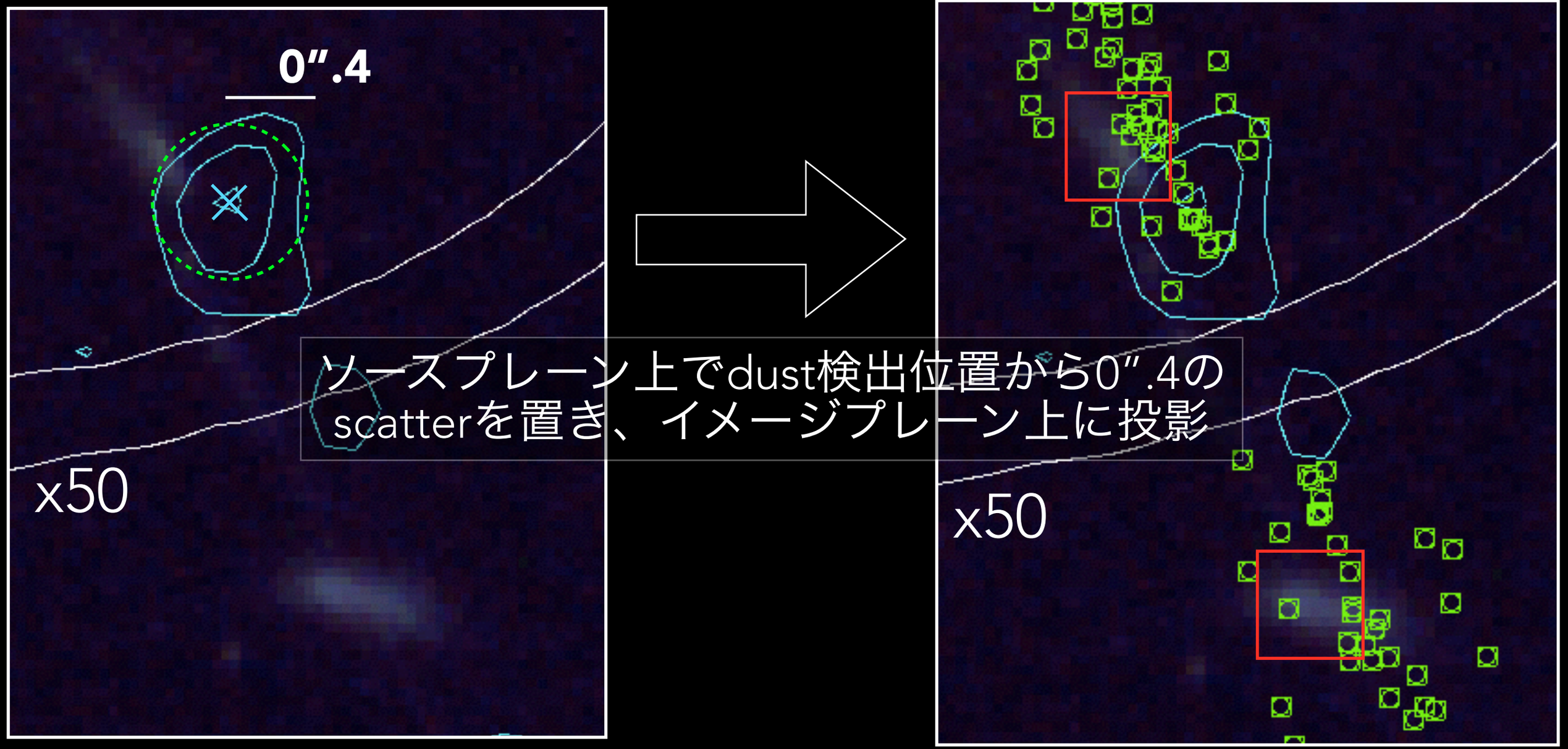


15″x15″

10″x10″

UV/dust領域の位置オフセット

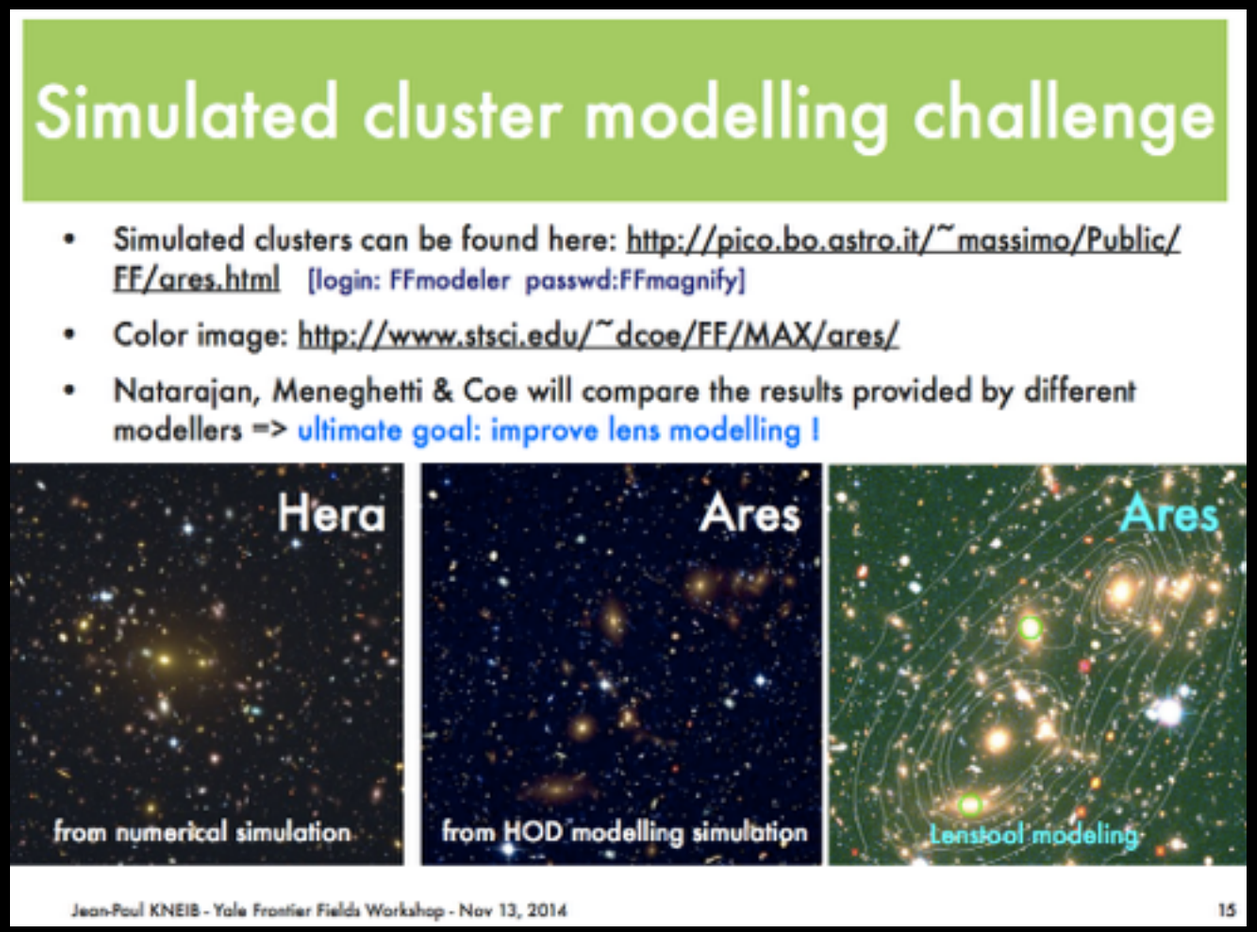
Chen et al. 2014: ALESS天体(SMG)をHSTで観測
-> 典型的に0”.4のscatter

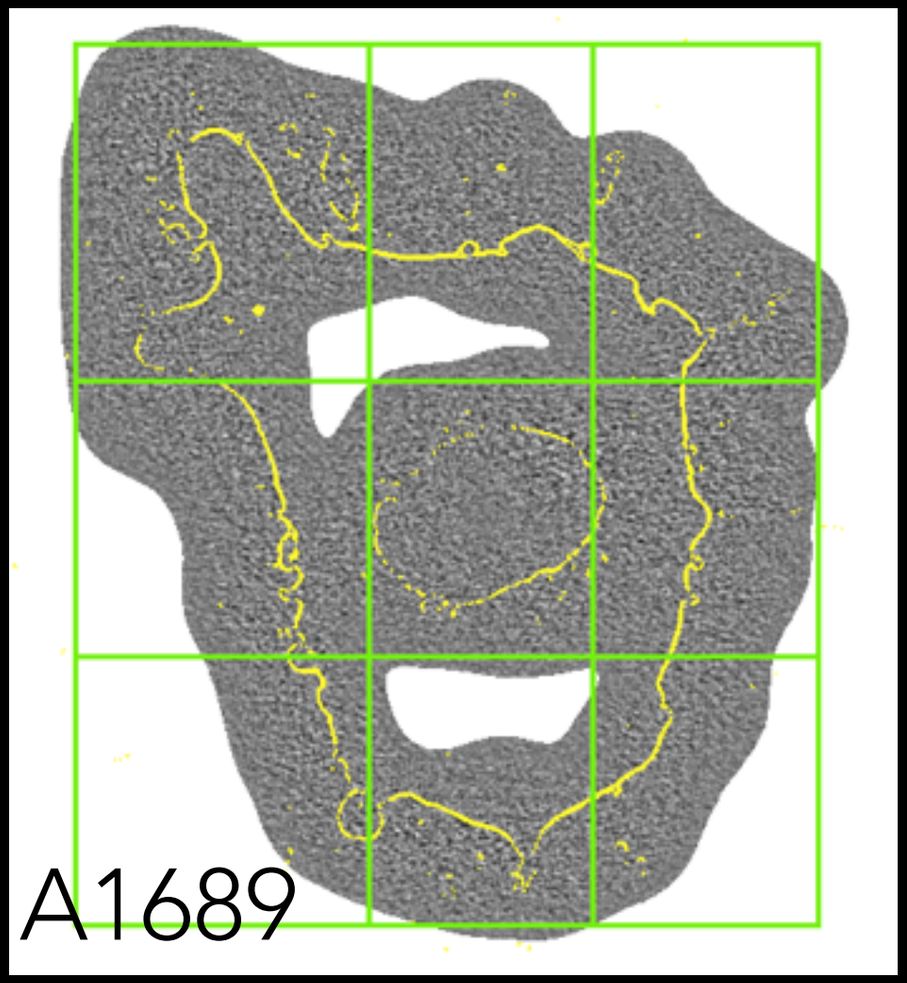


A1689領域で見つかった暗いALMA天体の例

Mass Model

Multiple image: Diego+14
Optical Catalog: Diego+10
Software: GLAFIC (Oguri 10)





Mass model uncertainty is reported ~ 20-30%.

*Ishigaki won the first prize in this challenge.