Mapping B0952-0115:

the brightest [CII] emitter at high-z

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R. Maiolino, R. Neri, C. De Breuck, S. Martin Ruiz, J. Wagg,
P. Caselli, T. Nagao, M. Walmsley, F. Walter, M. Meneghetti

ESO Workshop: ``Multiwavelength Views of the ISM in High-redshift Galaxies”
Santiago del Chile, June 29 2011

Why do we care about [CII] emission at high-z?

[CII] ($^2P_{3/2}$-$^2P_{1/2}$) @158 μm

- primarily emitted by PDRs surrounding star forming regions;
- important coolant of the star forming interstellar medium;
- strongest emission line in most galaxies ($L_{[CII]}$ ~ 0.1-1% L_{bol}).

Most promising tool to detect and identify high-z galaxies with mm and sub-mm facilities

First detection at high-z in SDSS1148 at z=6.4

(Maiolino et al. 2005)

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Up to date detected in ~ 20 high-z galaxies

(Maiolino et al. 2005; Iono et al. 2006; Maiolino et al. 2009; Walter et al. 2009; Hailey-Dunsheat et al. 2010; Ivison et al. 2010; Wagg et al. 2010; Stacey et al. 2010; Bertoldi et al. 2010)

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B0952-0115: the brightest [CII] emitter at high-z

(Maiolino et al. 2009)

optical data of B0952-0115

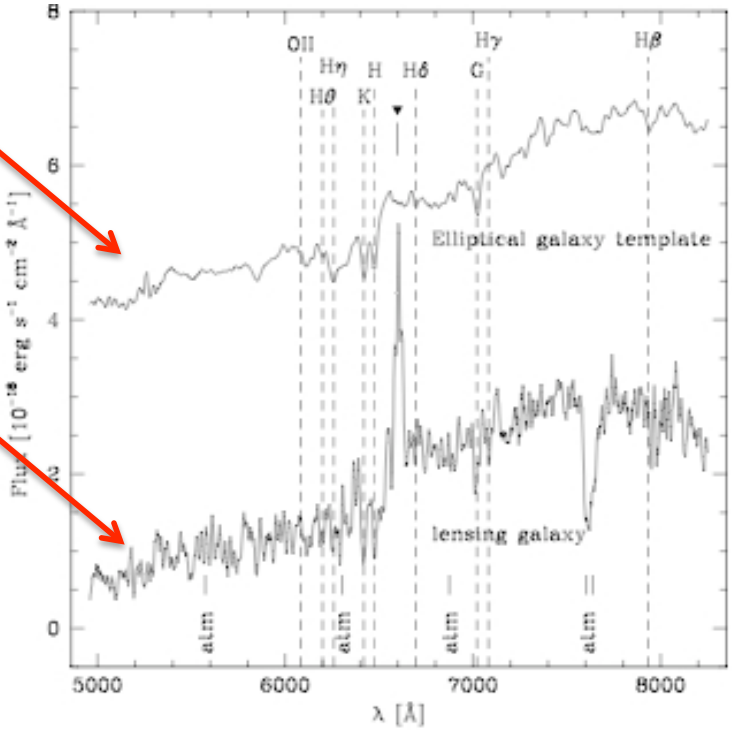
Firstly discovered by McMahon et al. (1992)
and identified as a pair of z=4.5 quasars separated by 0.9”,

then recognized as a lensed galaxy
by a foreground elliptical galaxy at z=0.4.

VLT/FORS1 spectrum

elliptical galaxy template

lensing galaxy spectrum

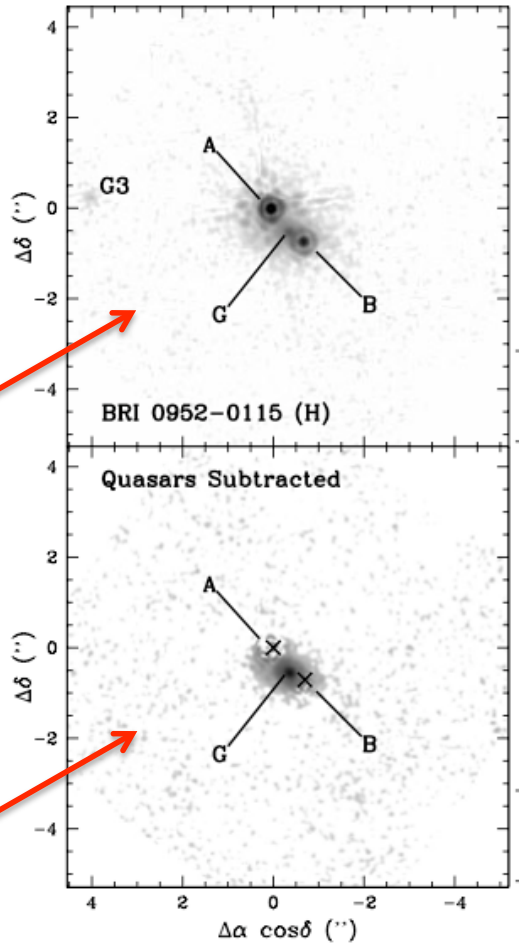


Eigenbrod et al. (2007)

HST image

Lensed galaxy at z=4.5

foreground galaxy at z=0.4

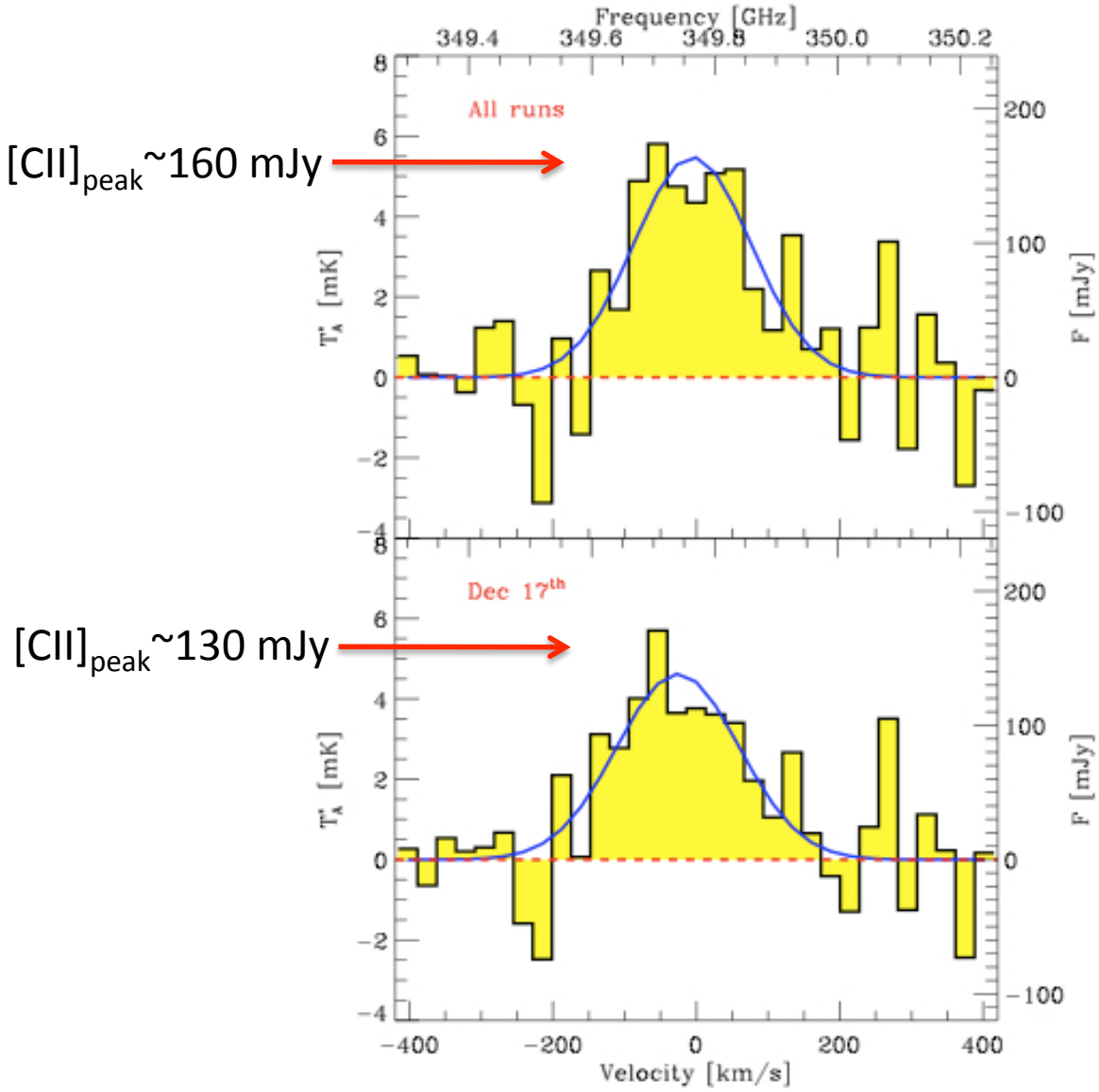


(Lehar et al. 2000)

mm data of B0952-0115

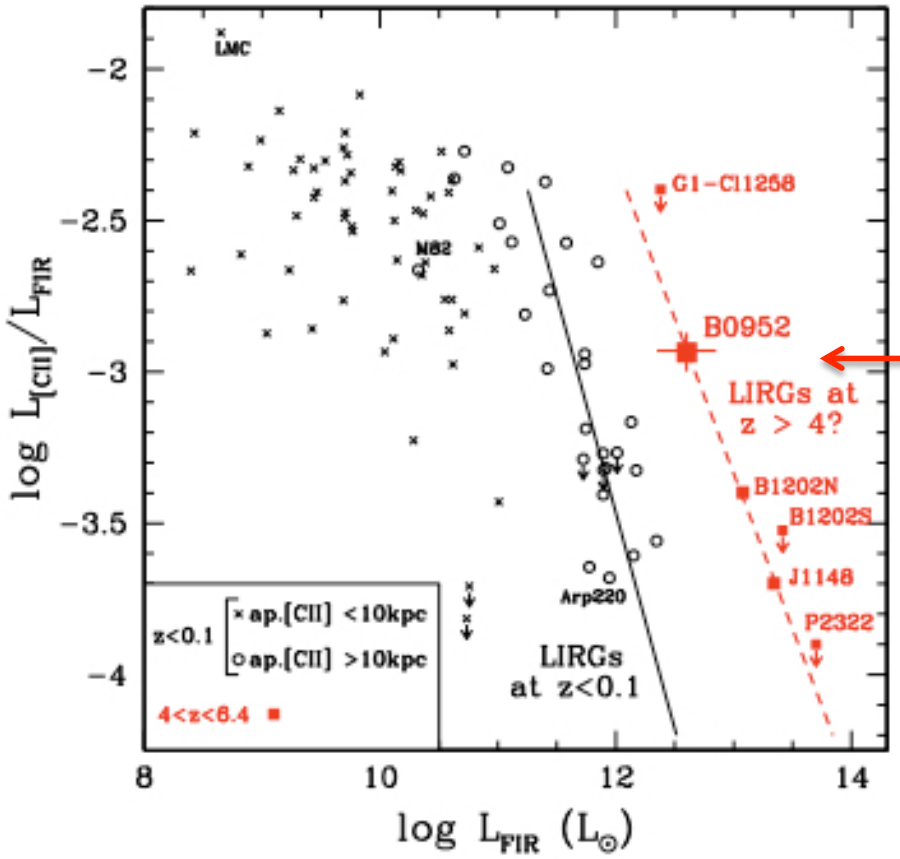
APEX

- 5 h on the source
- Bandwidth ~ 900 km/s
- R ~ 30 km/s
- FWHM ~ 200 km/s



(Maiolino et al. 2009)

[CII] emission enhancement at high-z



$$L_{FIR} \sim 4 \times 10^{12} L_{sun}$$

$$\log \frac{L_{[CII]}}{L_{FIR}} \sim -3.0$$

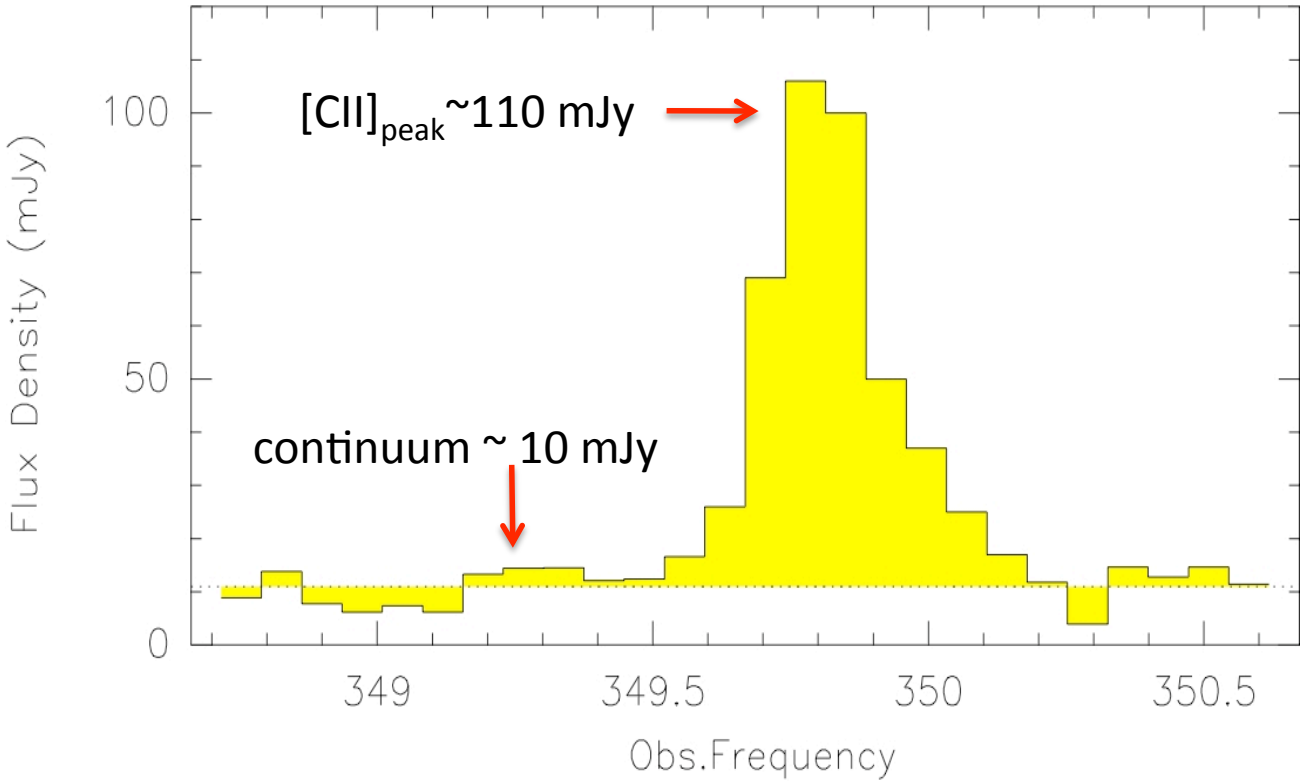
$$\frac{L_{[CII]}}{L_{FIR}} \text{ ULIRGs @ } z > 4 \quad > \quad \frac{L_{[CII]}}{L_{FIR}} \text{ LIRGs @ } z < 0.1$$

(ref. C. De Breuck's talk)

Spectrum of B0952-0115

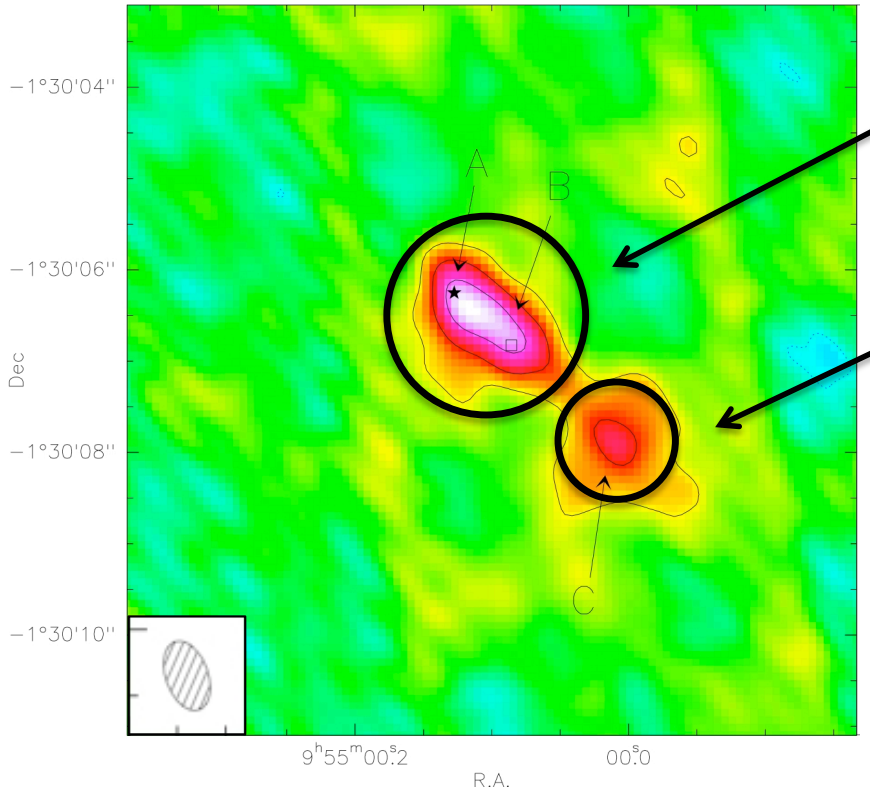
PdBI

- 7 h on the source
- Bandwidth ~ 1600 km/s
- Beam: 1.1” x 0.7”
- R ~ 60 km/s
- FWHM ~ 250 km/s



Imaging of B0952-0115

PdBI observations reveal a surprisingly complex structure!



REGION A + B
extended emitting region

REGION C
compact component

Contours levels at 2.5 σ

(1 σ = 1.7 Jy km/s^{-1} beam^{-1})

Beam = 1.1” x 0.7”

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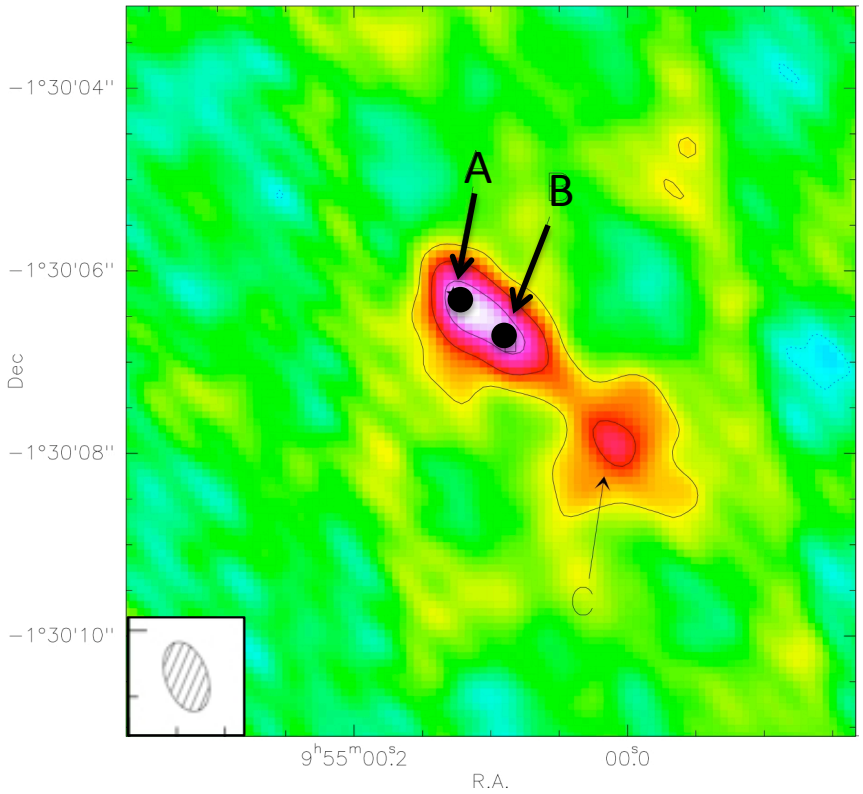


Beam = 1.1” x 0.7”

REGION A+B

Fit with a two-point source model

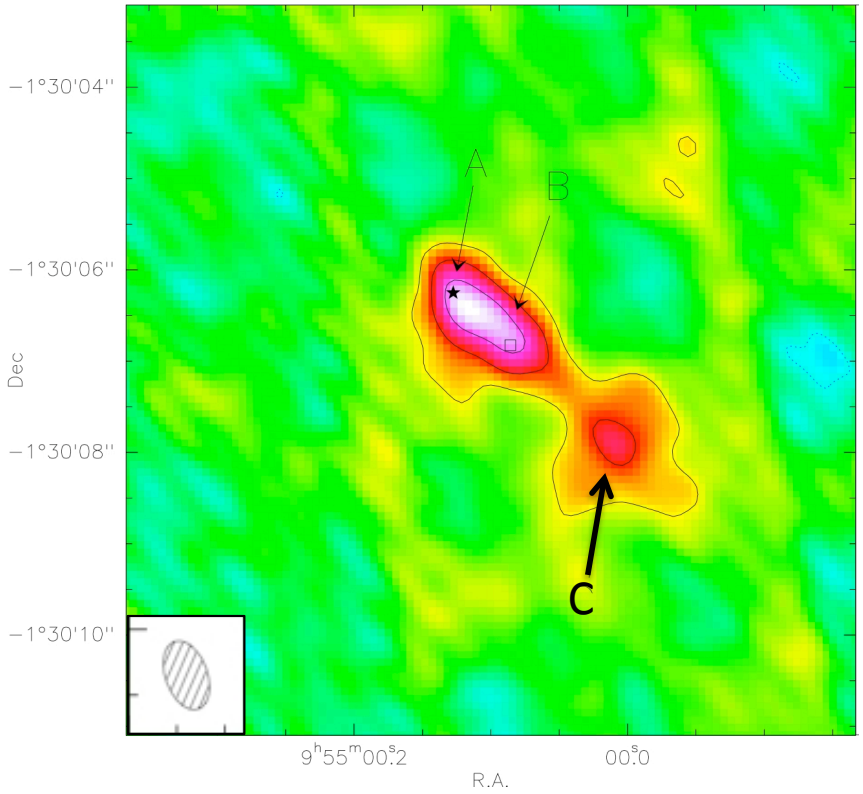
0.9” separation of the components A and B

(excellent agreement with Lehar et al. 2000)

We can not distinguish A and B
since the angular resolution of PdBI data
(beam = 1.1” x 0.7”)
is comparable with their separation

Imaging of B0952-0115

PdBI observations reveal a surprisingly complex structure!



Beam = 1.1” x 0.7”

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Fit with a two-point source model

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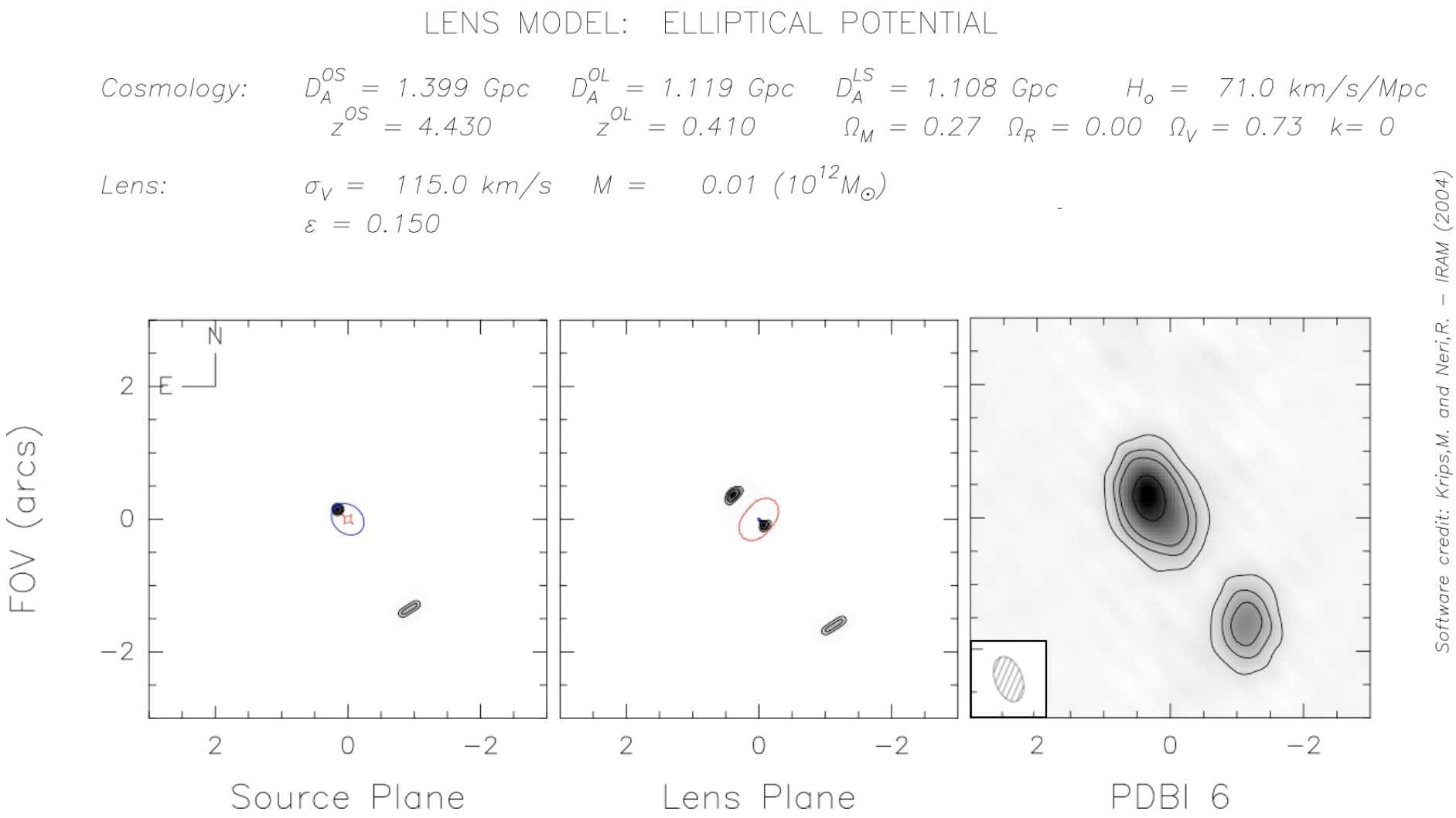
Region C

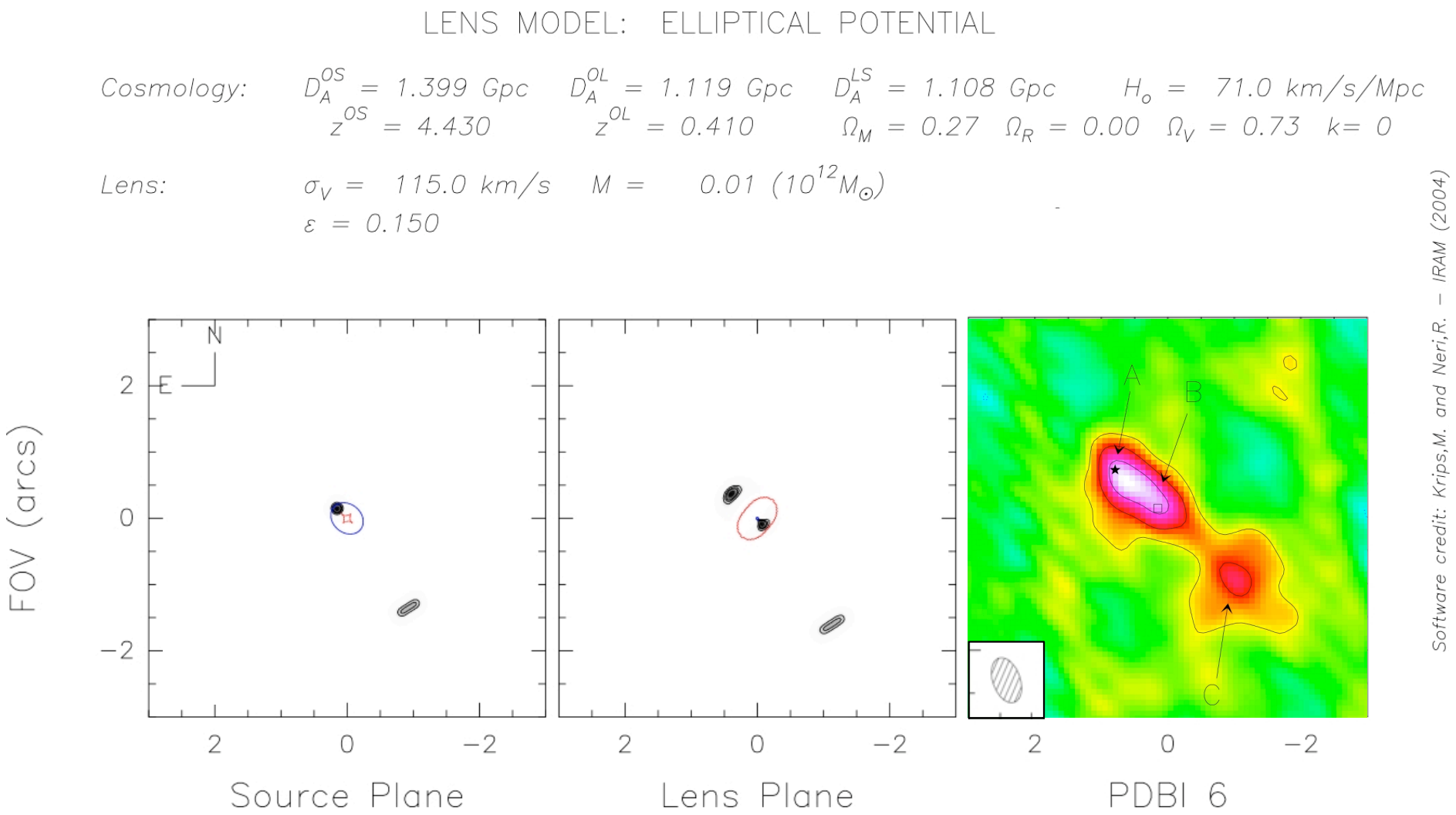
It has not been detected with HST, possibly because of its low surface brightness which makes it undetectable in the optical.

``Lensing scenario''



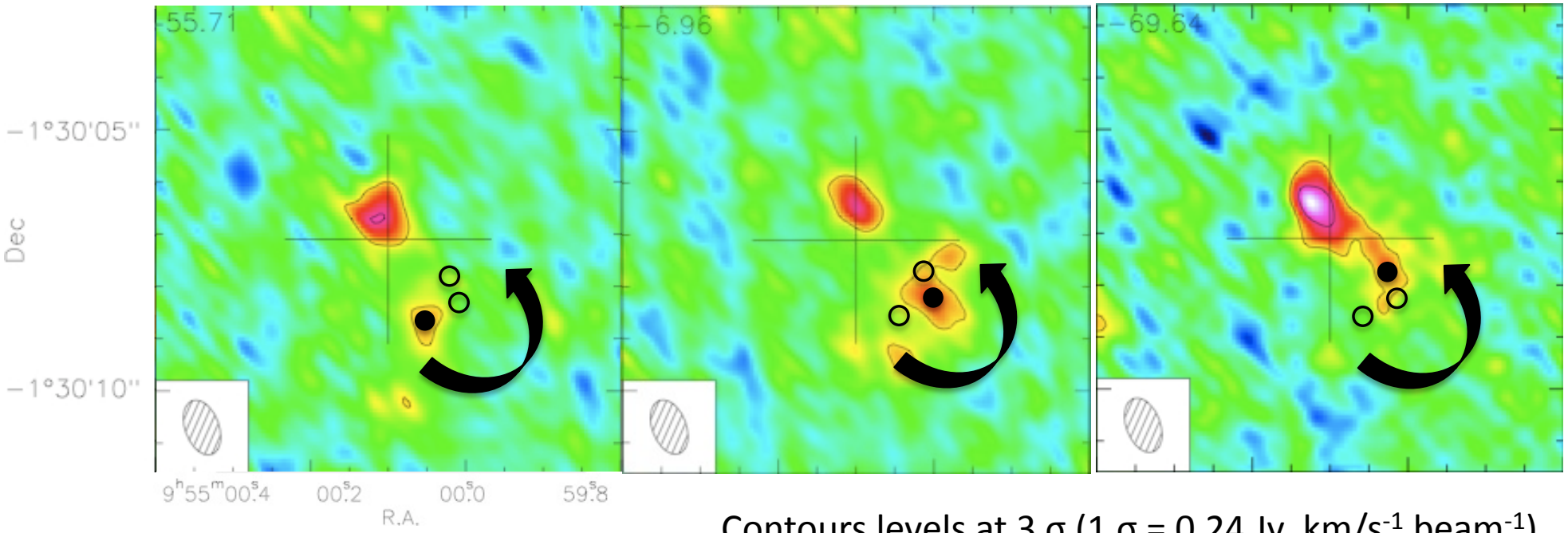
magnification factor $\mu \sim 4$

``Lensing scenario''



magnification factor $\mu \sim 4$

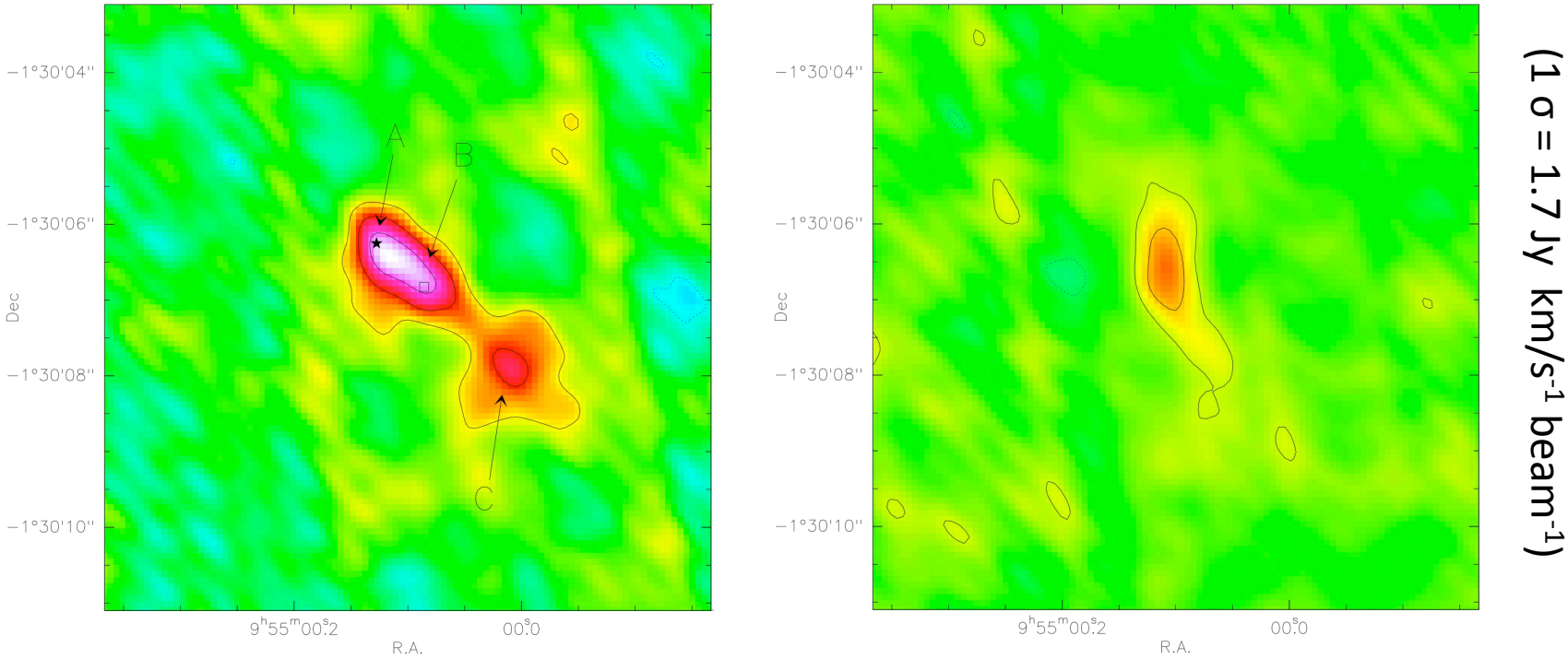
``Merging scenario''



Contours levels at 3 σ (1 σ = 0.24 Jy km/s^{-1} beam^{-1})

Region C may be a companion star forming galaxy
in the phase of merging with region A+B.

[CII] vs continuum emission

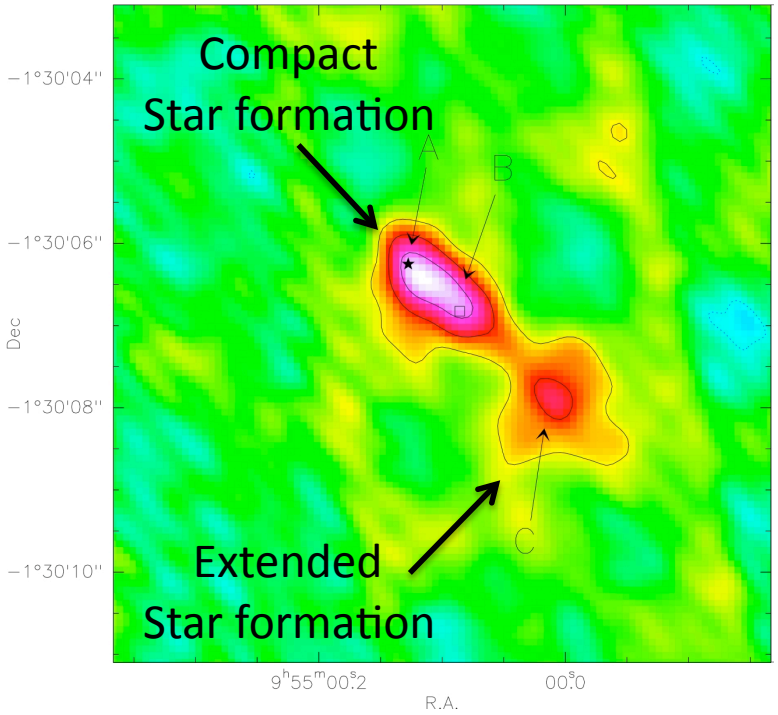


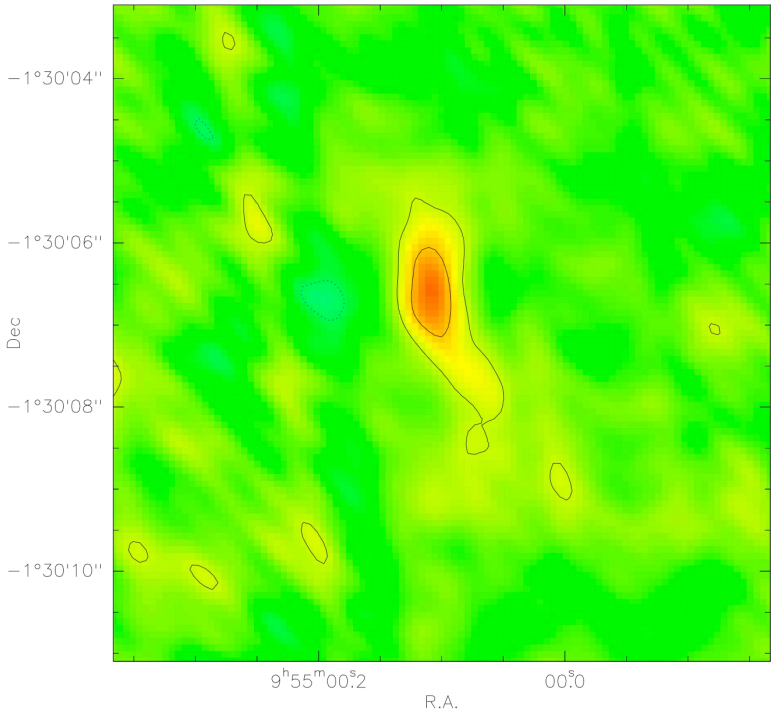
Contours levels at 2.5 σ
(1 σ = 1.7 Jy km/s^{-1} beam^{-1})

The ratio of [CII] over continuum emission is sensitive to the ionization parameter, the metallicity, and dust content of the star forming region.

(Maiolino et al. 2009; Rubin et al. 2009; Hailey-Dunsheath et al. 2010; Stacey et al. 2010; De Breuck et al. 2011)

[CII] vs continuum emission





Contours levels at 2.5 σ
(1 σ = 1.7 Jy km/s^{-1} beam^{-1})

$$\frac{[CII]}{FIR_{A+B}} < \frac{[CII]}{FIR_{C}}$$

Conclusions

Results from PdBI imaging of B0952-0115:

- surprisingly complex structure
  (extended emission region A+B plus a second more compact component C);

- ``lensing'' and ``merging'' scenario;

- continuum and [CII] emission maps differ in morphology and extension.

Higher sensitivity and angular resolution
are required to confirm these intriguing results.

Time request for ALMA Early Science