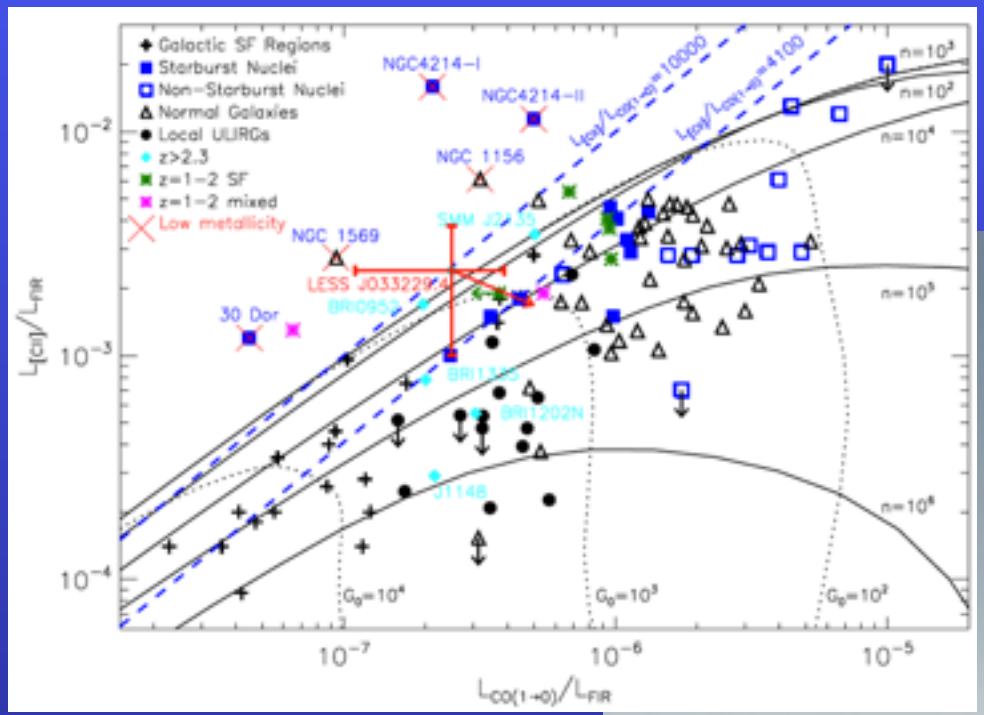
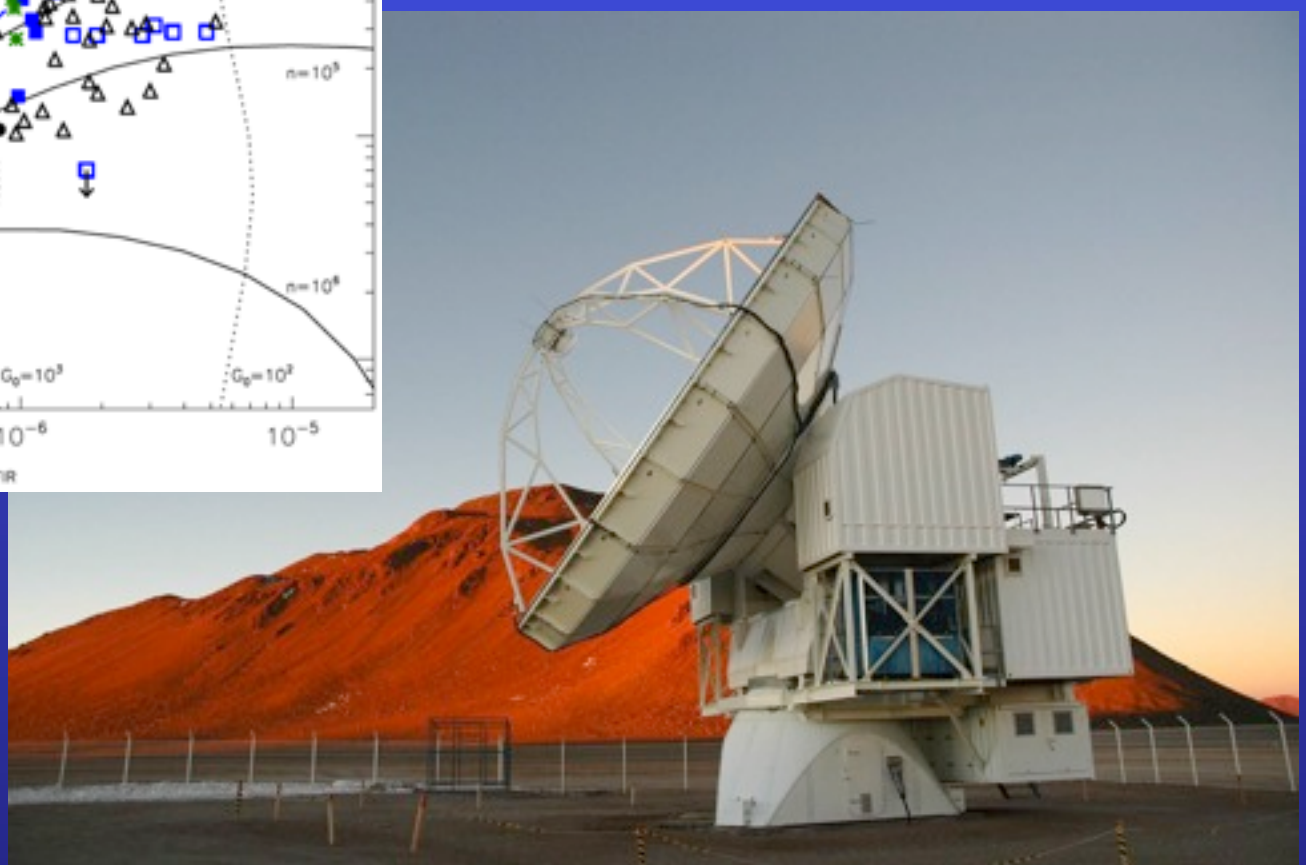
Enhanced [CII] emission in the highest redshift galaxies: low metallicity?





Collaborators

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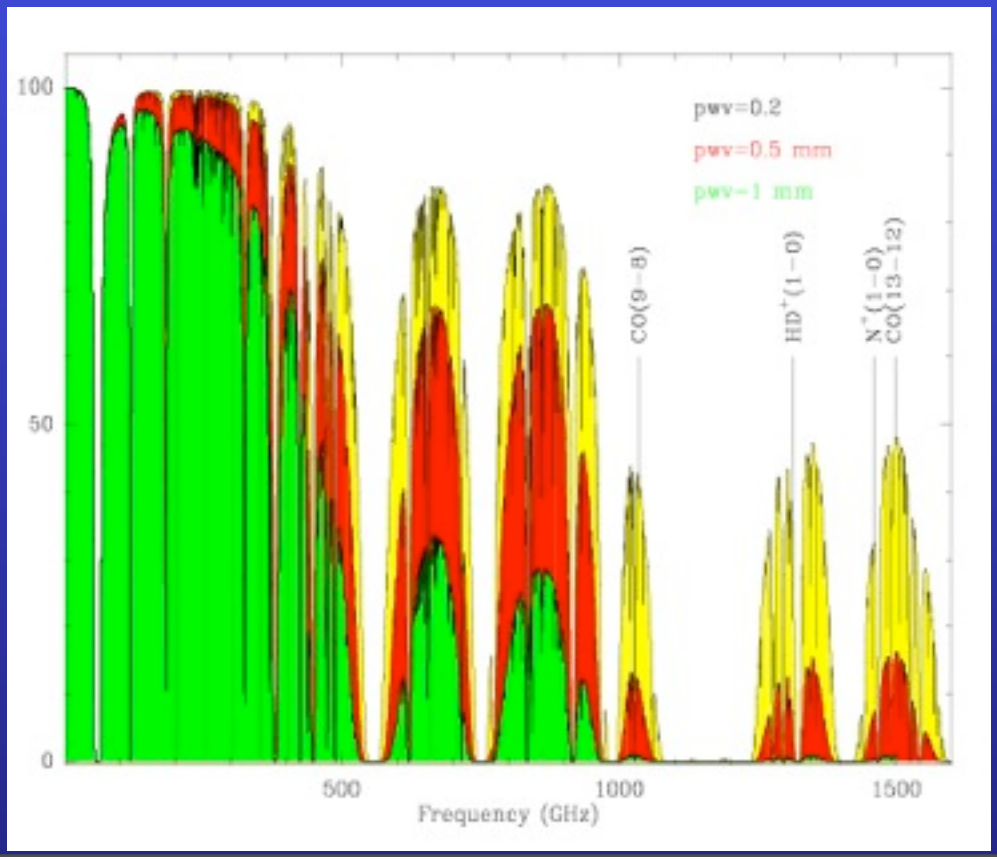
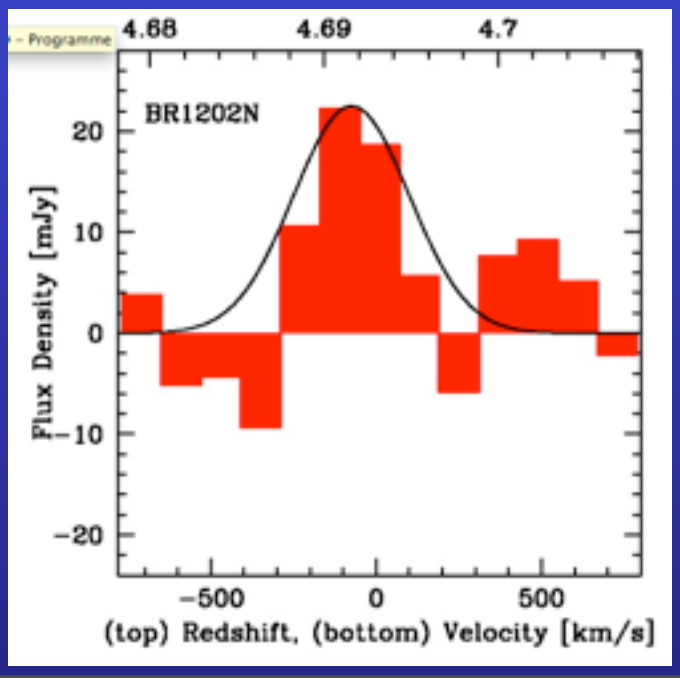
High redshift [CII] lines

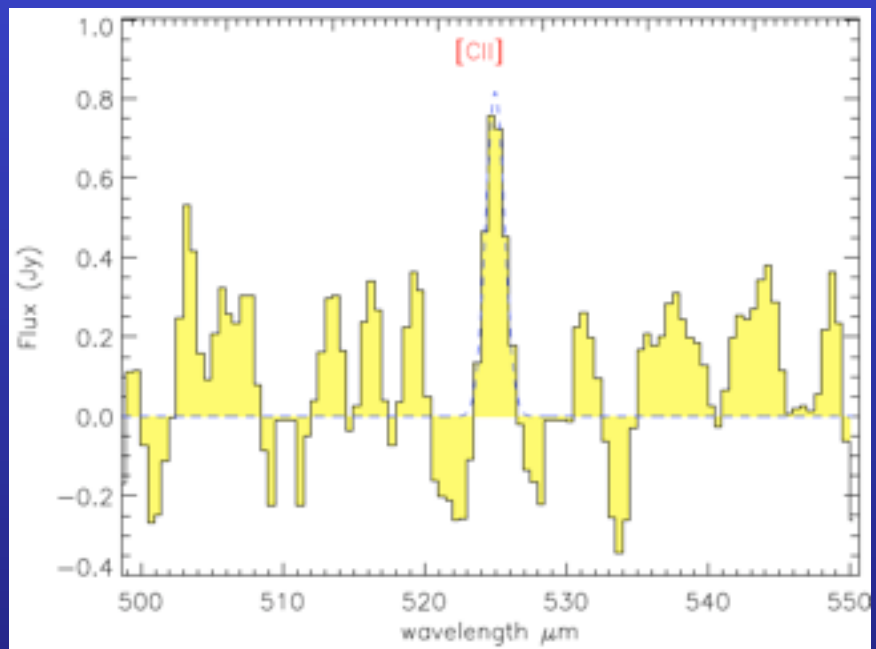
- The higher the redshift, the better the atmospheric transparency, with notable gaps.
- Early attempts unsuccessful.
- First detection a z=6.4 with IRAM 30m in QSO SDSS1148+5251.



High redshift [CII] lines

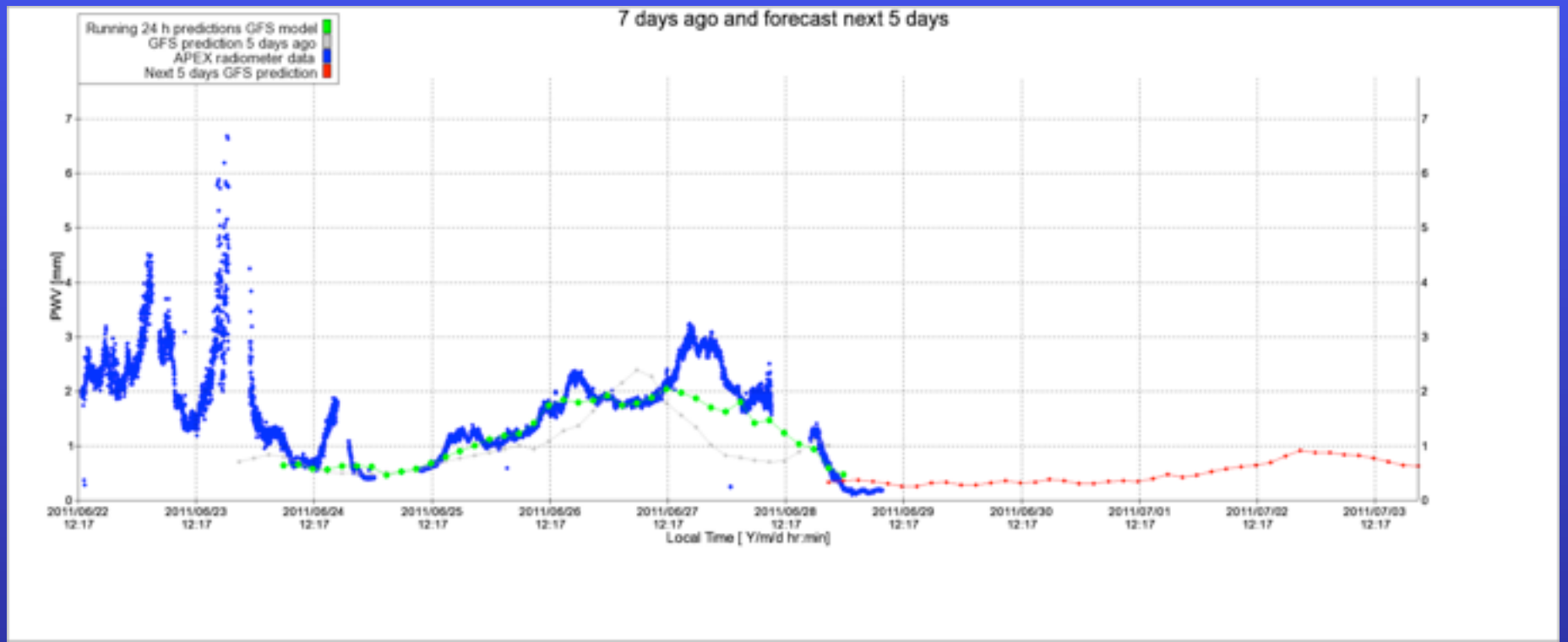
- ZEUS @ CSO has shown that [CII] is quite ubiquitous with 12/13 sources detected at 1<z<2 (see Gordon Stacey's talk).
- Two detections with SMA (Iono et al 2006) and Herschel (Ivison et al 2010).
- Four z>4 detections with APEX.





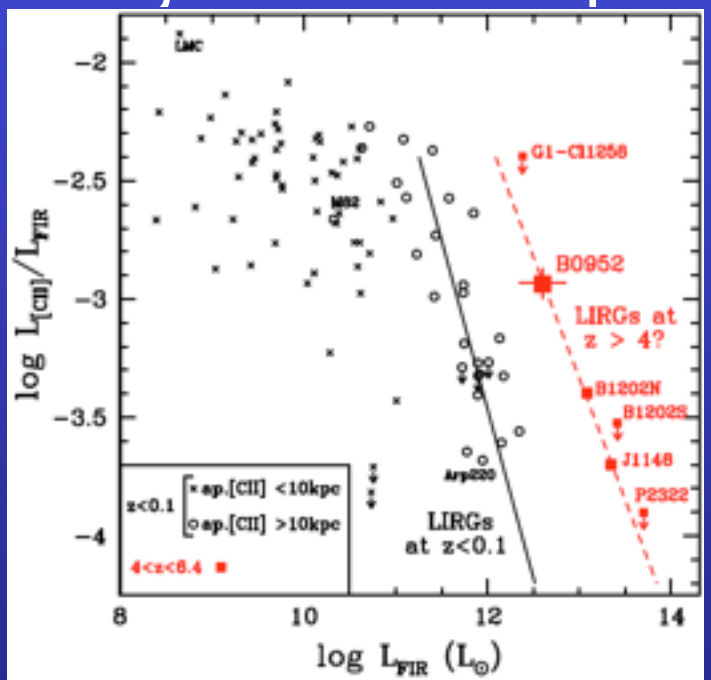
APEX last week

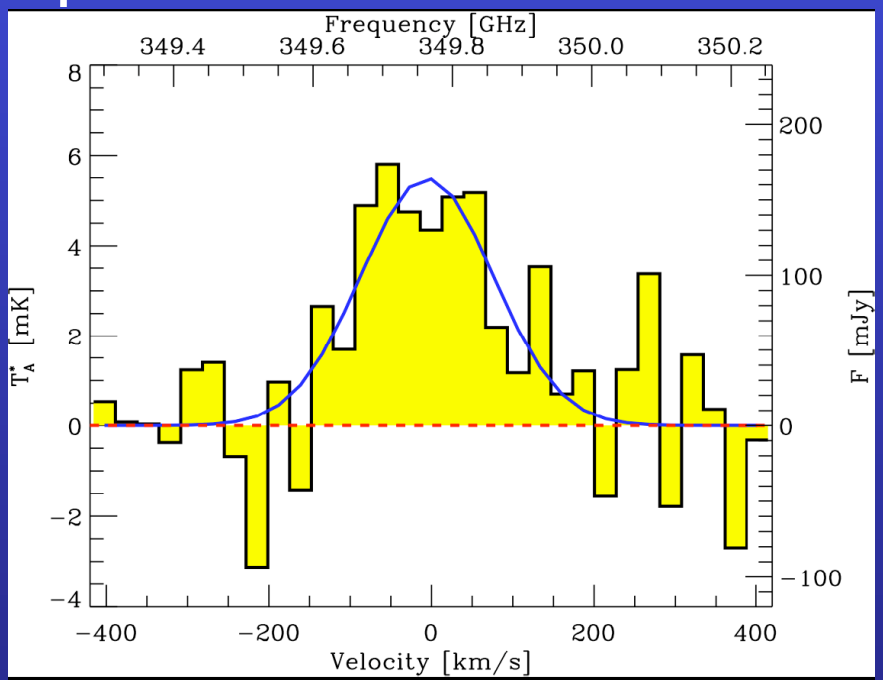
Today's PWV forecast for Chajnantor



BRI0952-0115 (z=4.43)

- 1st APEX/SHFI detection of broad extragalactic line.
- Confirmed with SMA and IRAM PdBI, see Simona Gallerani's talk.
- Lensing amplification μ=2.5 to 8.
- Brighter than expected compared to local ULIRGs.

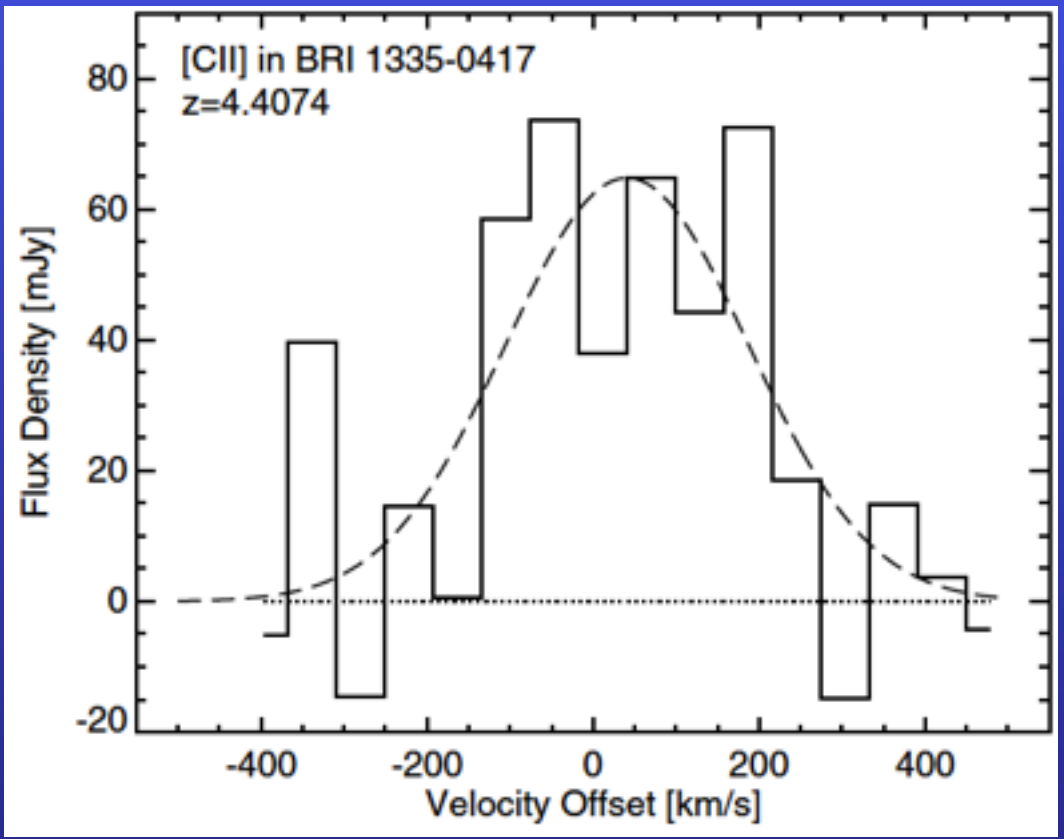




Maiolino et al. 2008

BRI1335-0417 (z=4.41)

- Unlensed quasar with LFIR=$3 \times 10^{13} L_{Sun}$.
- Most luminous [CII] line to date with $L_{[CII]}=1.6 \times 10^{10} L_{Sun}$
- Gas rich merger with SFR of a few 1000 M_{Sun}/yr?

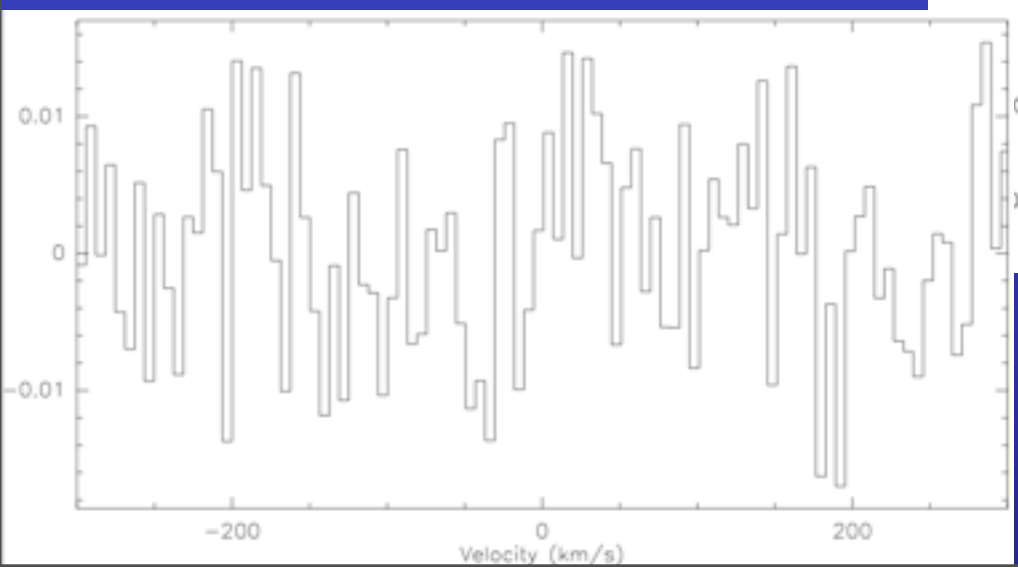


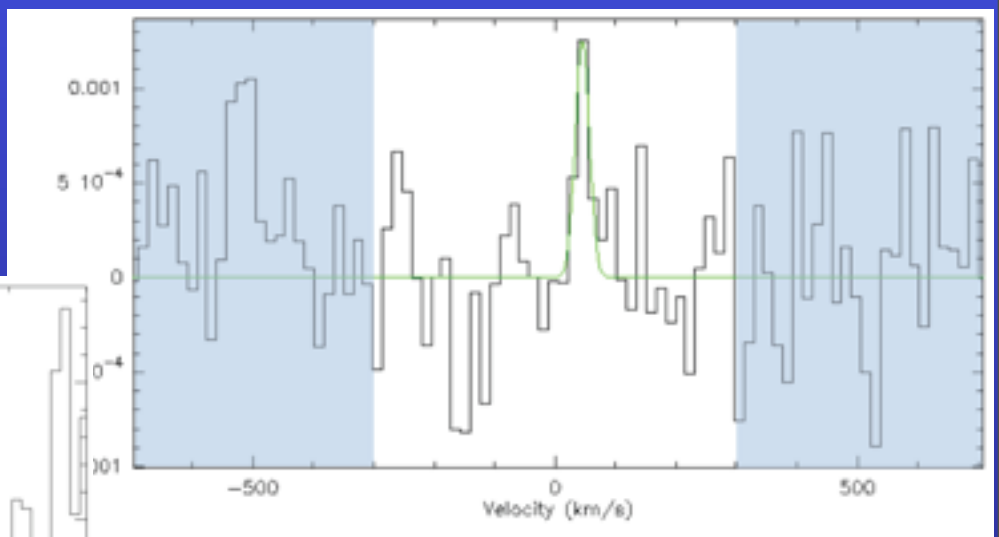
Wagg et al. 2010

Non-detections

- Cosmic Eye at z=2.8 observed with FLASH.
- GDSn4em at z=5.553 (candidate pop III galaxy).
- Both deep integrations (~30h total time) push the APEX instruments to (or beyond) their limits.

Cosmic Eye

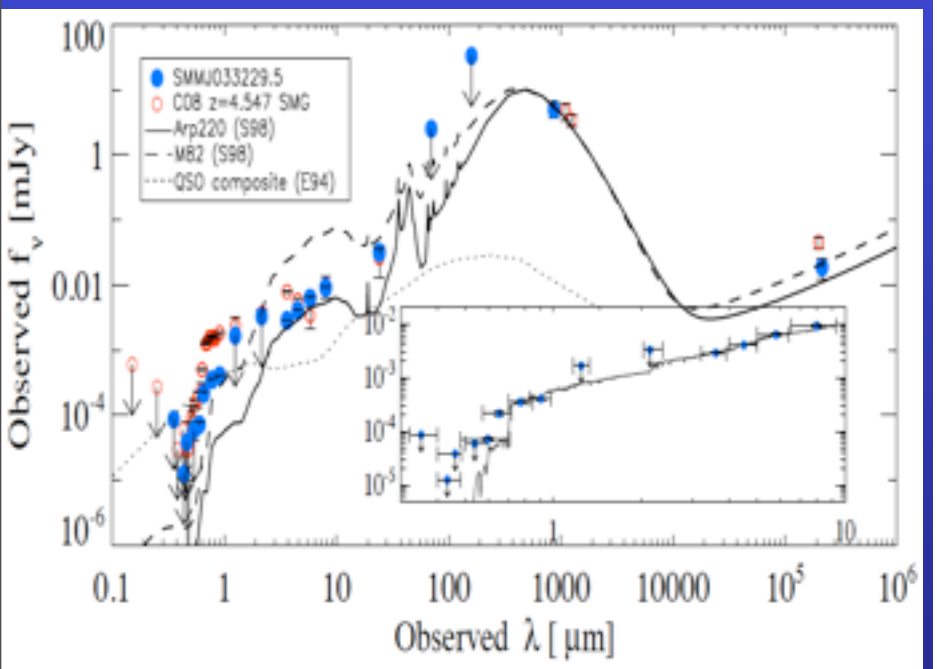


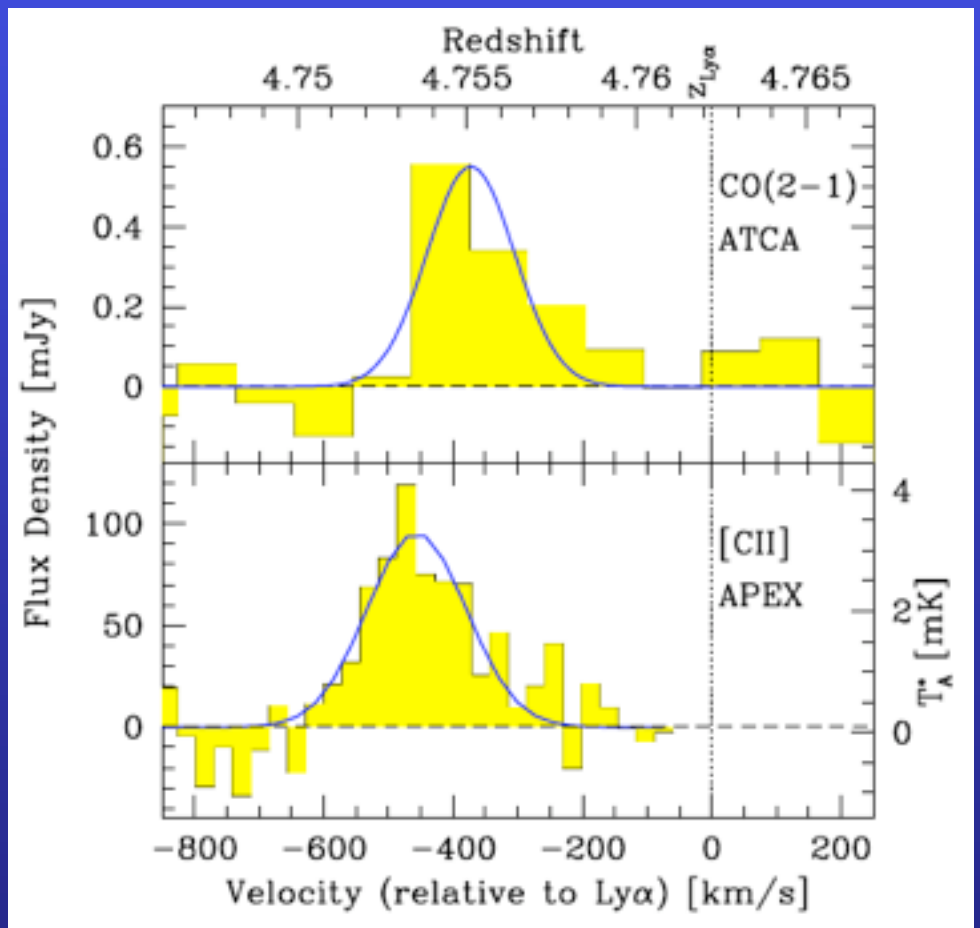


GDSn4em

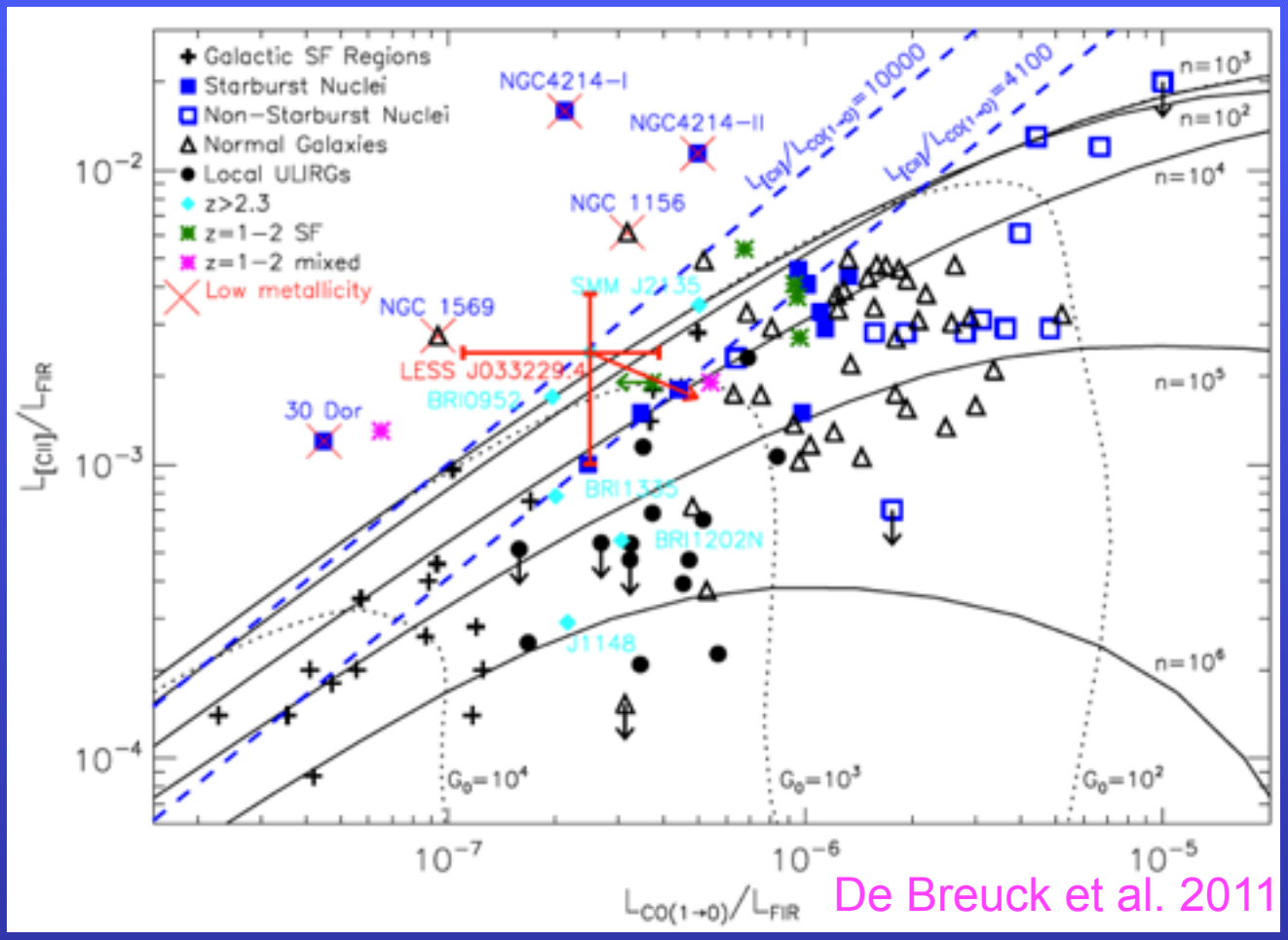
LESS J033229.4-275619 (z=4.76)

- Discovered from LABOCA ECDFS Submm Survey.
- One of the highest redshift SMGs known.
- Hosts a Compton-thick AGN, contributing <30% of far-IR luminosity.





LESS J033229 in [CII]/FIR vs. CO/FIR

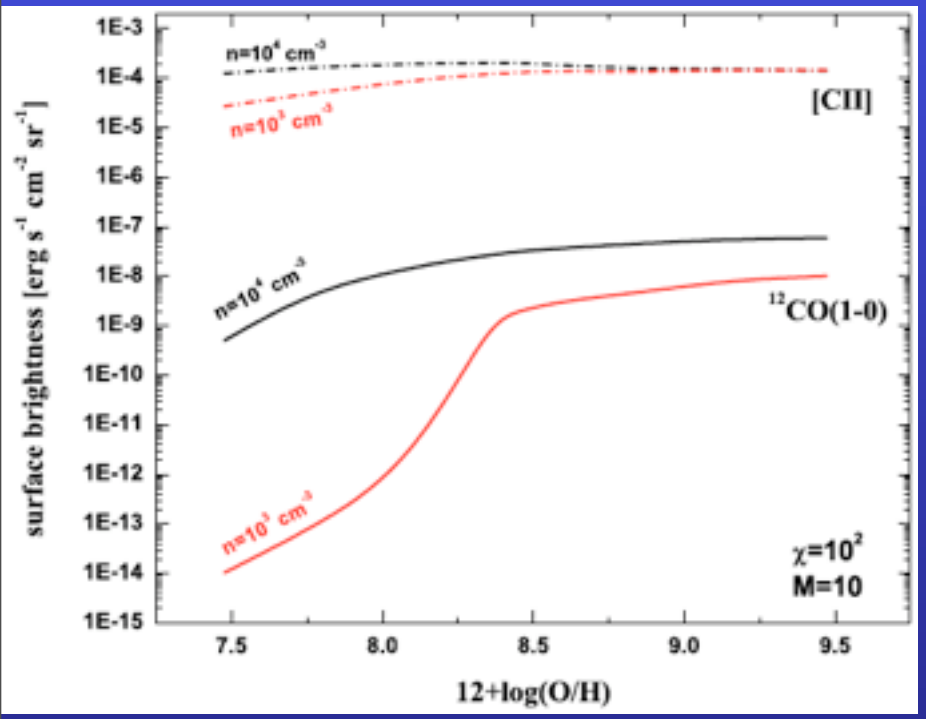


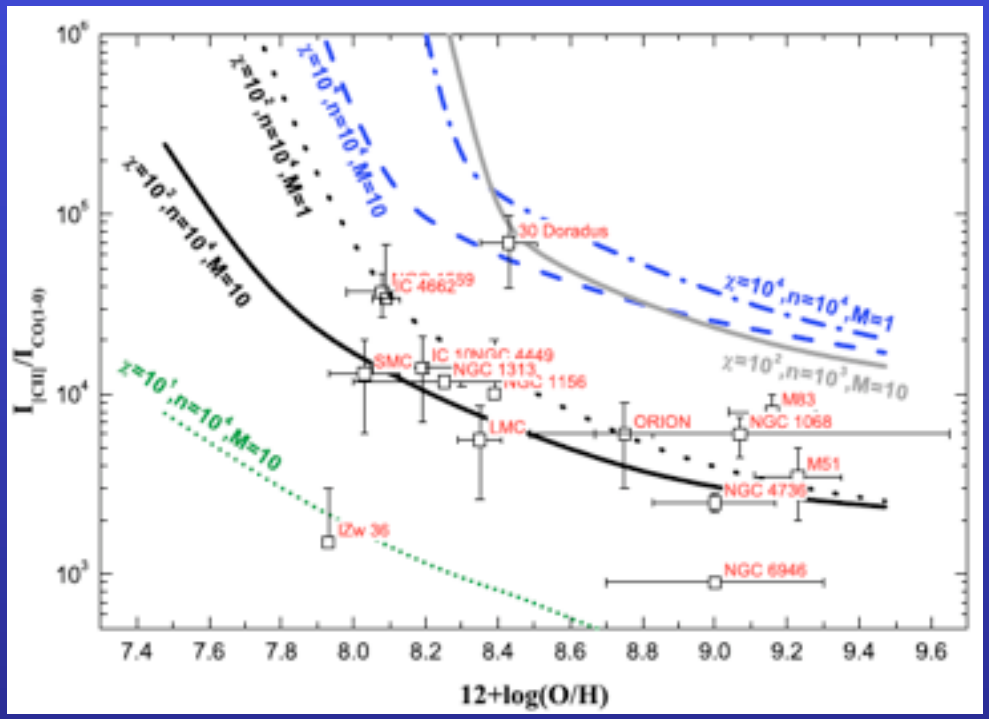
De Breuck et al. 2011

- $L_{[CII]}/L_{CO(1-0)} \approx 10^4$ factor 2-3 higher than other sources.
- Uncertainty dominated by L_{FIR}, but parallel to models.
- Near boundary of PDR models, close to low Z objects.

Low metallicity & spherical PDR models

- $L_{[CII]}/L_{CO(1-0)}$=10000 to 70000 commonly found in low metallicity galaxies.
- Cannot be explained with solar metallicity plane-parallel slab PDR models ⇒ requires spherical PDR models.

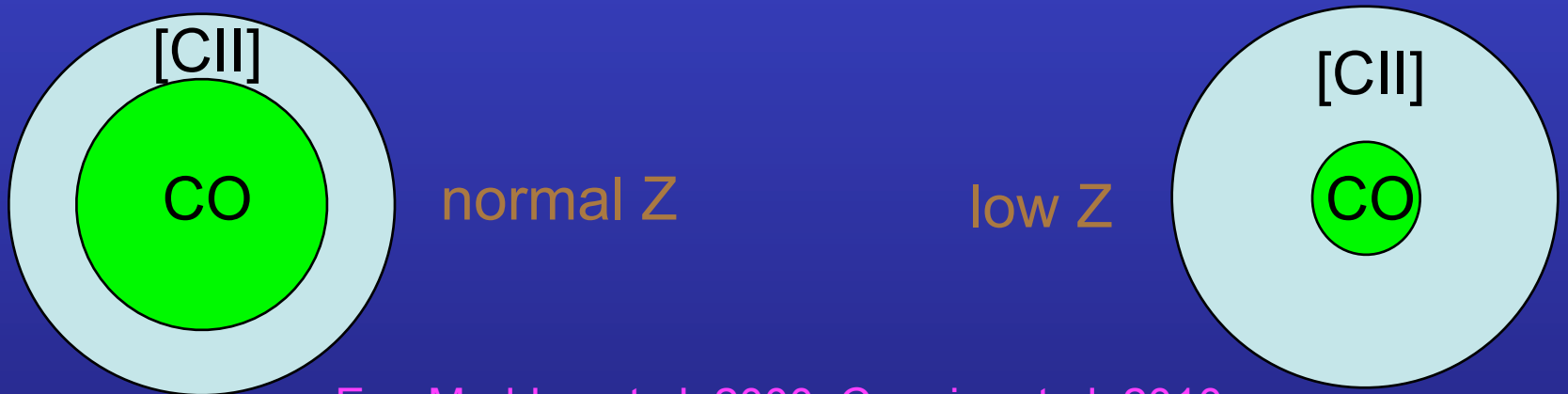




E.g. Bolatto et al. 1999, Röllig et al. 2006, ...

Enhanced [CII] in LESS J033229

- Reduced dust abundance ⇒ less dust shielding allows FUV photons to penetrate deeper ⇒ decreases L_{FIR} and CO core sizes & increase [CII] emitting regions as photons travel a larger volume of clouds.
- [CII] region may also contain self-shielded H_2 ⇒ boost H_2 to CO conversion factor X_{CO} by up to 100 times.
- Very high redshift may imply lower metallicity.



E.g. Madden et al. 2000, Cormier et al. 2010, ...

What is the best ISM mass tracer?

- $M(H_2)$ derived from CO $=1.6 \times 10^{10}$ Msun.
- Atomic mass derived from [CII]$=1.0 \times 10^{10}$ M_{sun}.

$\Rightarrow$ CO may be missing a significant fraction of the ISM!

Conclusion: [CII] will not only be brighter in low metallicity environments, but it also provides a more reliable mass tracer. This is particularly important when observing z>4 galaxies.