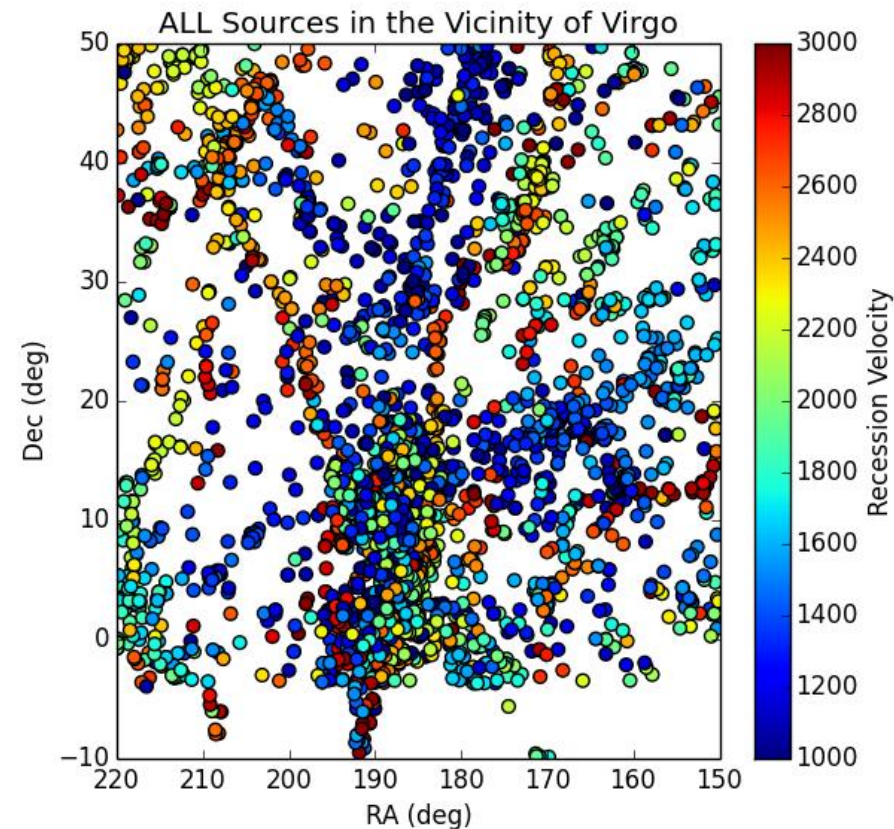
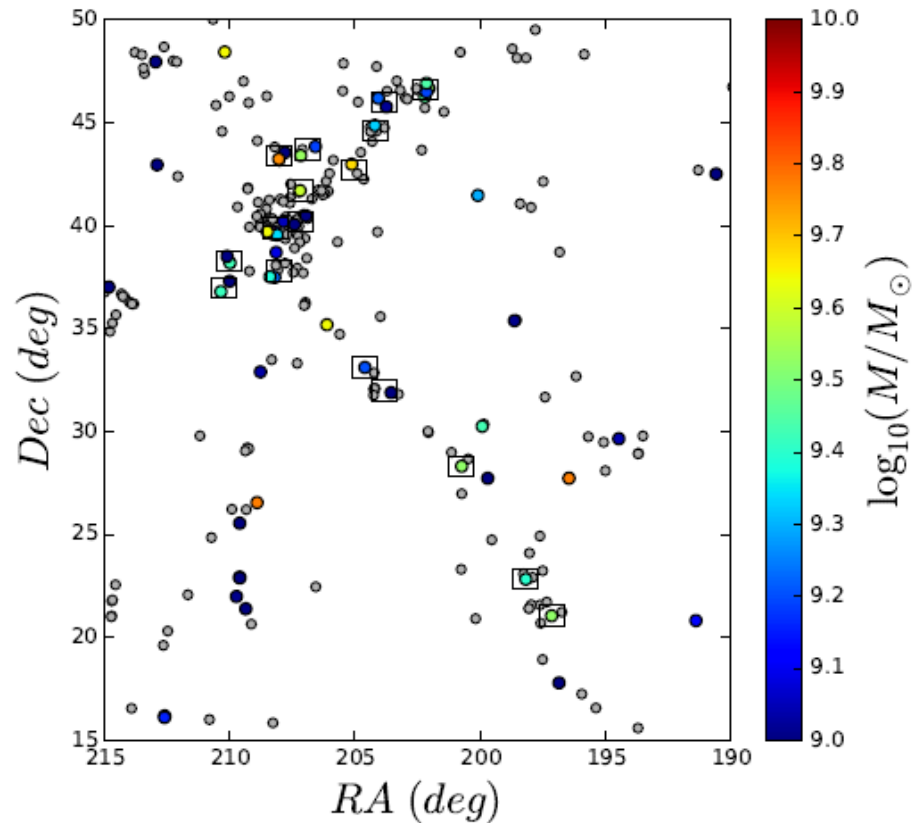


Molecular content of Virgo filament galaxies



The proposals: how much pre-processing in filaments, or groups?

The IRAM-30m proposal: 20 galaxies in the NE filament

Goals: role of environment (ram-pressure or tidal stripping, Strangulation) in filaments falling into Virgo.

Selection: $M^* = 10^9 - 10^{10} M_\odot$, with FIR (IRAS, WISE-22 μm)

→ Comparison with the same range of masses in Virgo and the field

CFHT-proposal: H α with Megacam: no success

Reproposed with NOAO WIYN 0.9m, HDI, 6 nights for 33 galaxies

And also INT 2.5m (Canaries), S. Garcia-Burillo (PI)

Other data: SDSS stellar mass

HI VLA (Chung et al 2009) ALFALFA (Giovanelli et al 2005)

Dust HeVICS (Davies et al 2010), M^* NGVS+WISE (Ferrarese+12)

SFR with Galex, GuVICS (Boselli et al 2011) CFHT Vestige H α

Observations of clusters outskirts

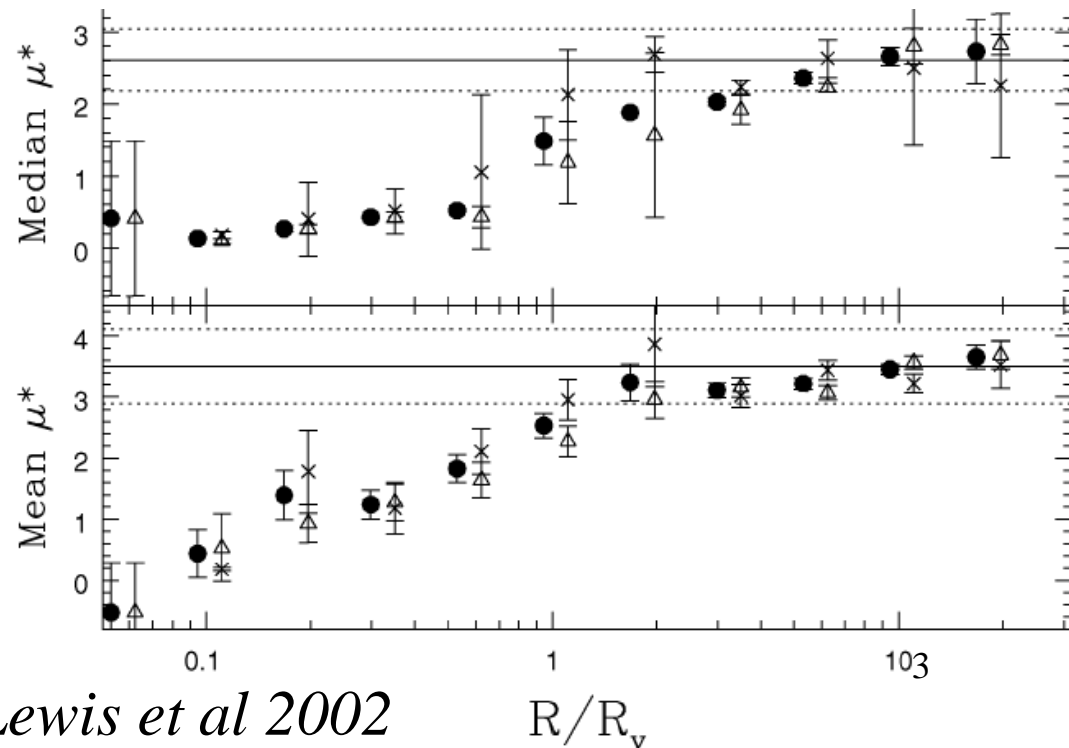
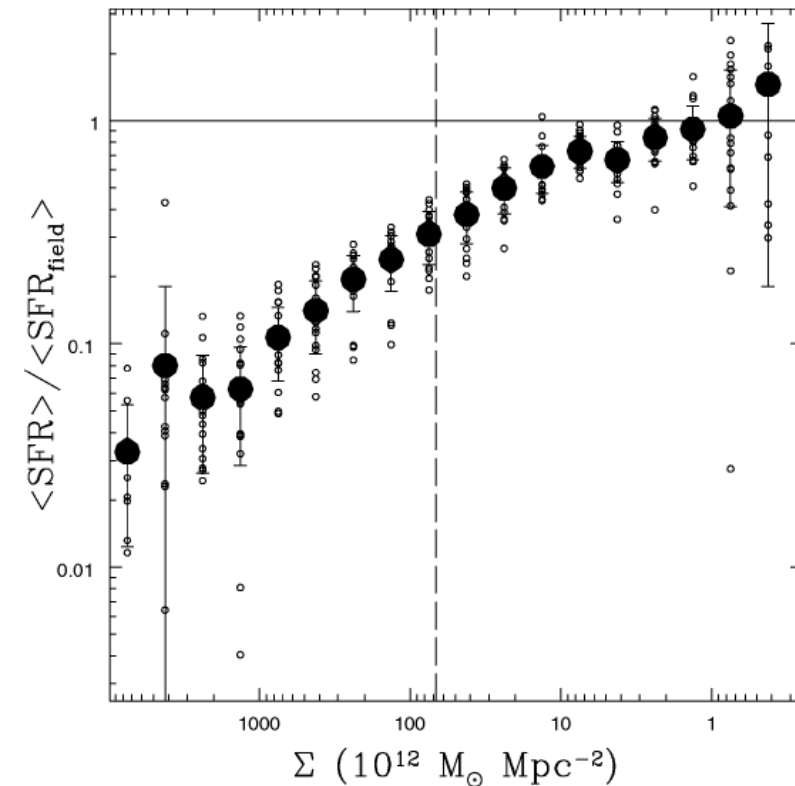
SFR is suppressed in galaxies up to 3-4 virial radii

Lewis et al (2002): 11000 galaxies in 2dF survey

sSFR reaches the field value only 3-5 R_{vir}

$$\mu^* = \text{SFR}/(\text{L}_{\text{cont}}/\text{L}^*) = 0.087 \text{ Wh}\alpha$$

Balogh et al 2004: $\text{WH}\alpha$ depends on surface density, but not environment!



Lewis et al 2002

R/R_v

Model predictions

SFR is suppressed in galaxies up to $5 R_{200}$

In GIMIC simulations with $\log M_{\text{halo}} = 13\text{--}15.2$

~50% of these galaxies have elliptical orbits (not their 1st passage)

Some are pre-processed

in groups, but most

of them **suffer**

ram pressure

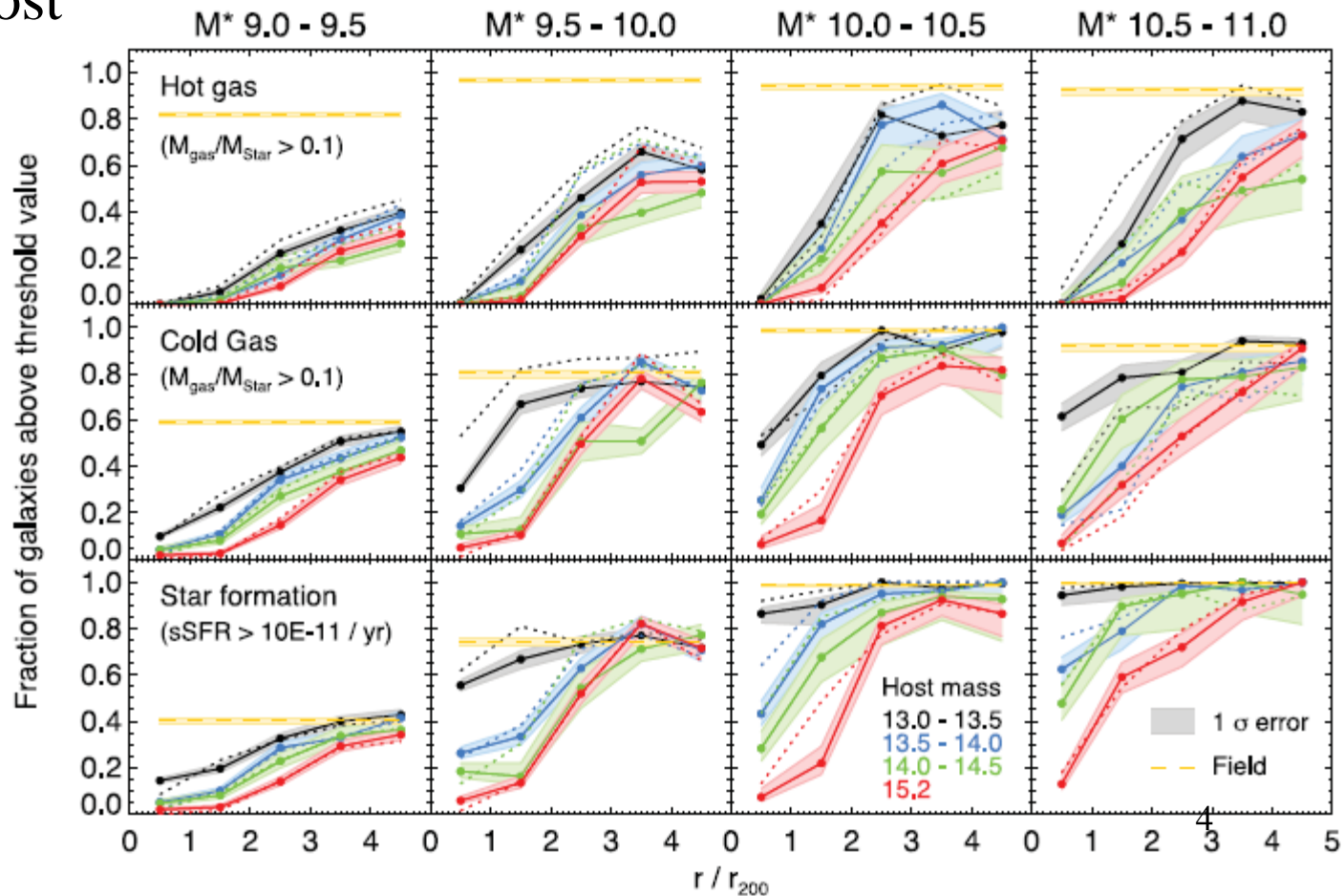
in filaments,

even if they

co-flow with

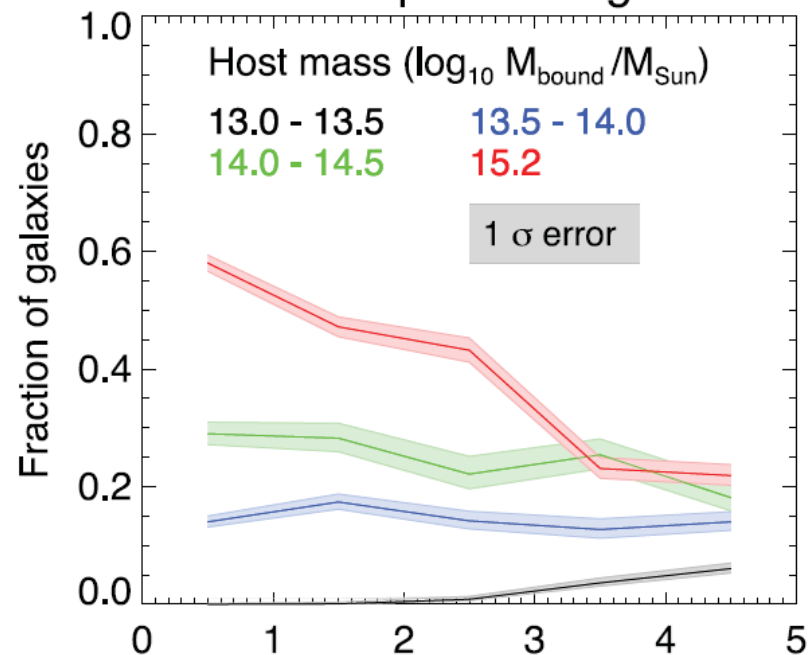
them

(100x field)

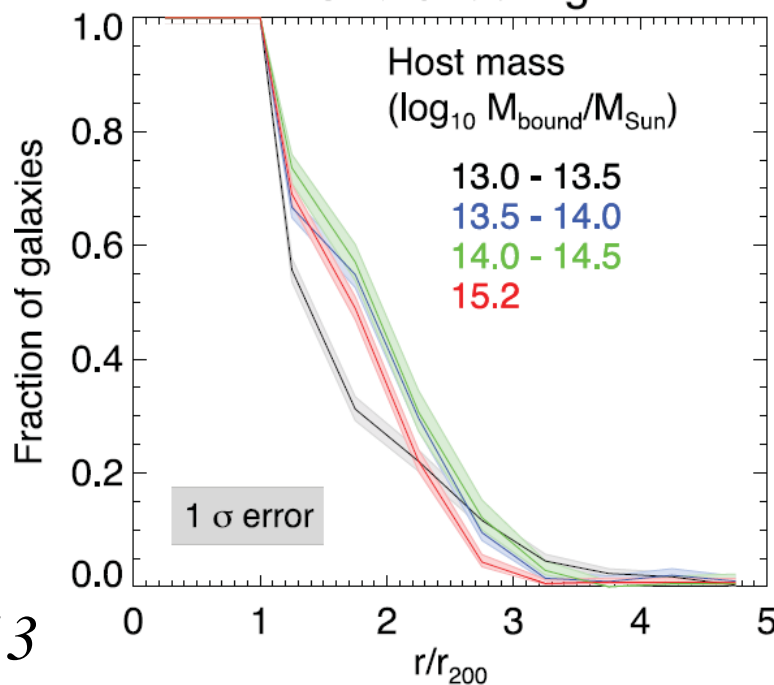


Causes

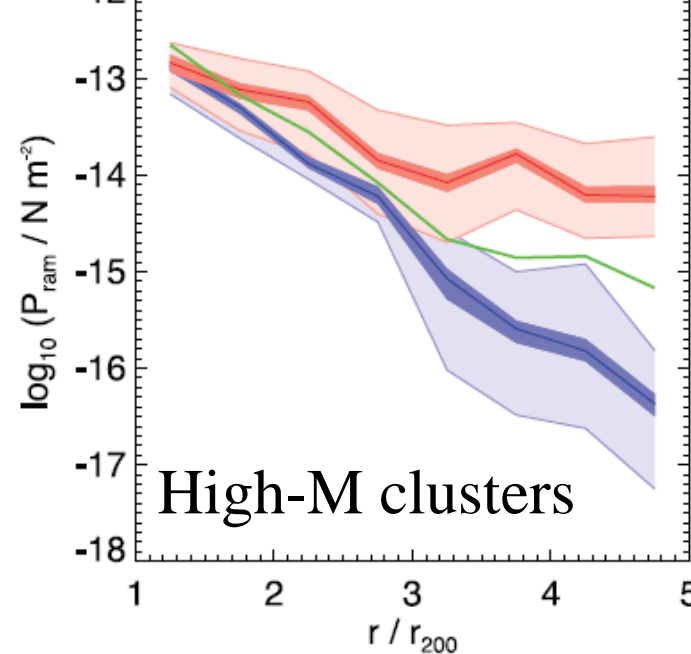
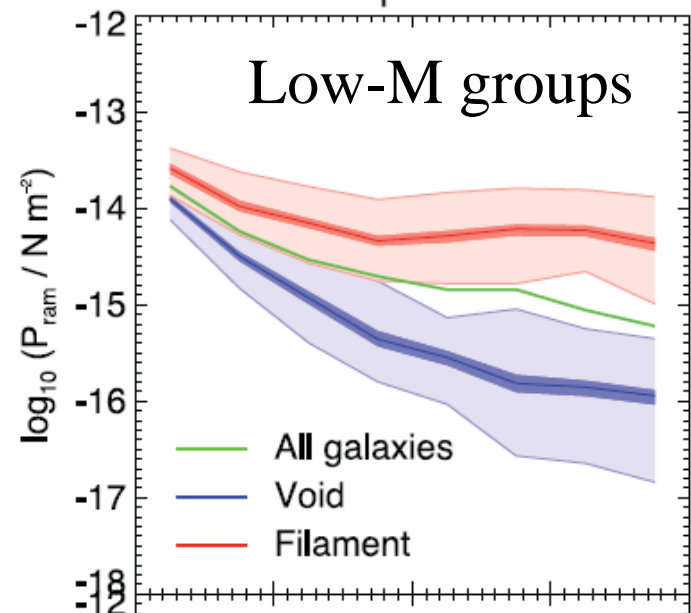
Pre-processing



Overshooting

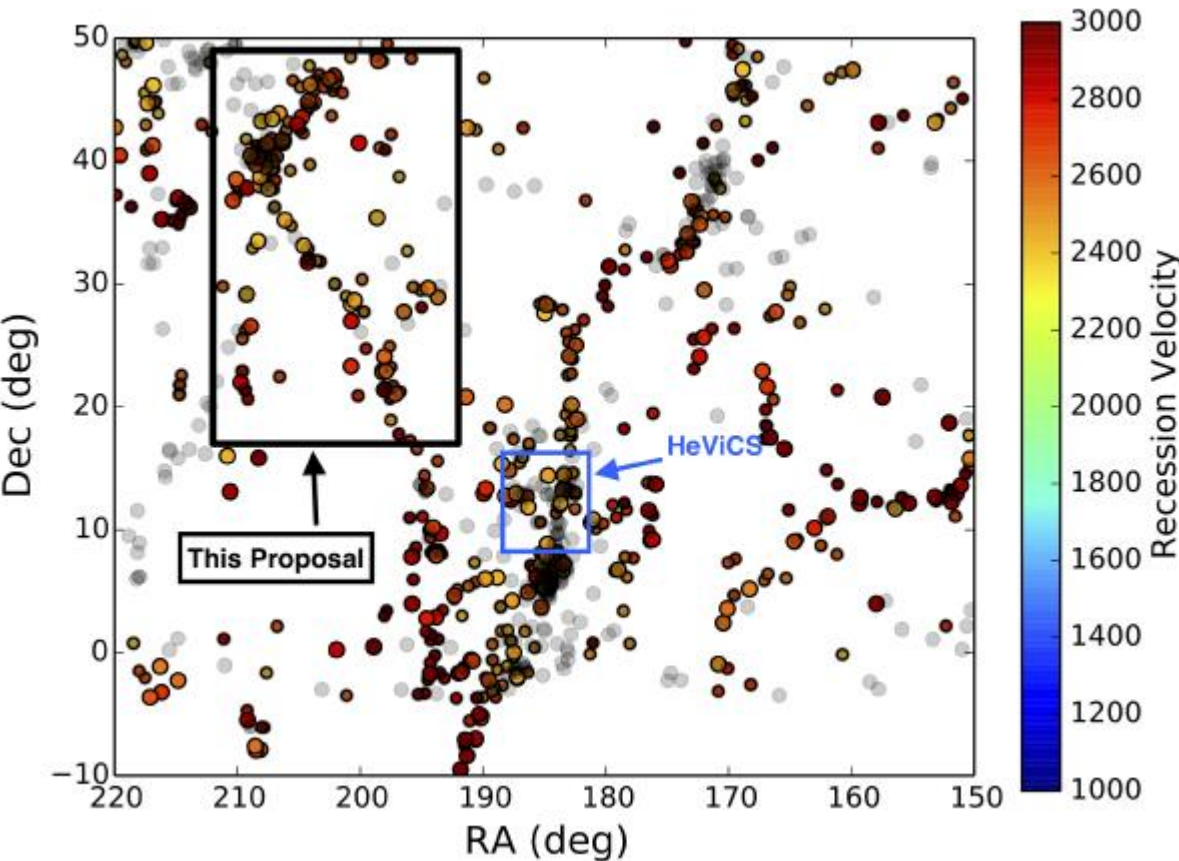


Ram pressure



Filament Selected

HeViCS: Herschel key-project, CO observations by
Pappalardo et al 2012

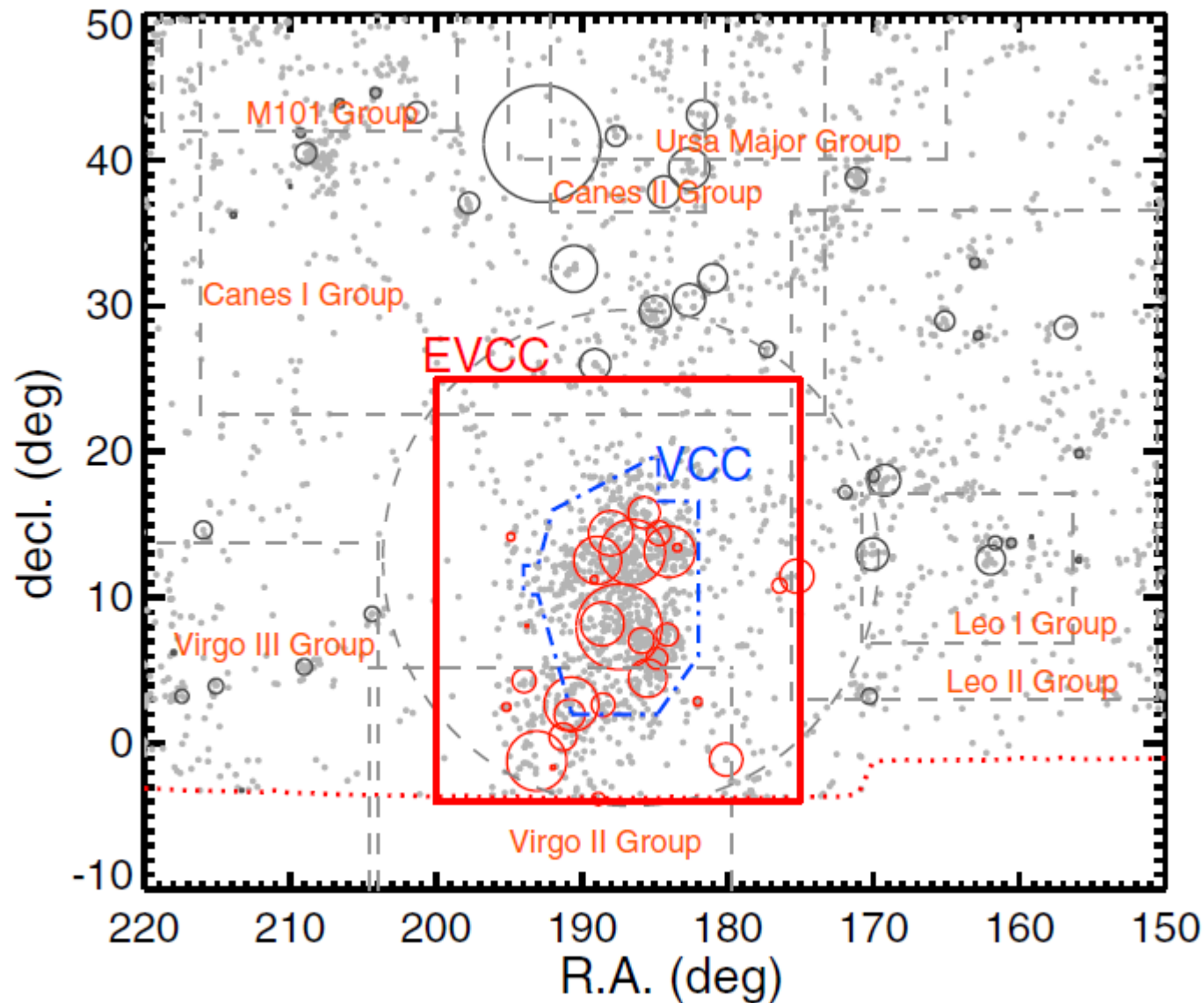


All WISE-22 μ -detected
For $V < 2400$ km/s, grey

Our sample
 $2400 < V < 3000$ km/s

Beyond EVCC 3.5 R_{vir}
Kim et al 2014

EVCC Kim et al 2014



$725^{\circ 2}$

60.1 Mpc^2

5.2 times
the VCC

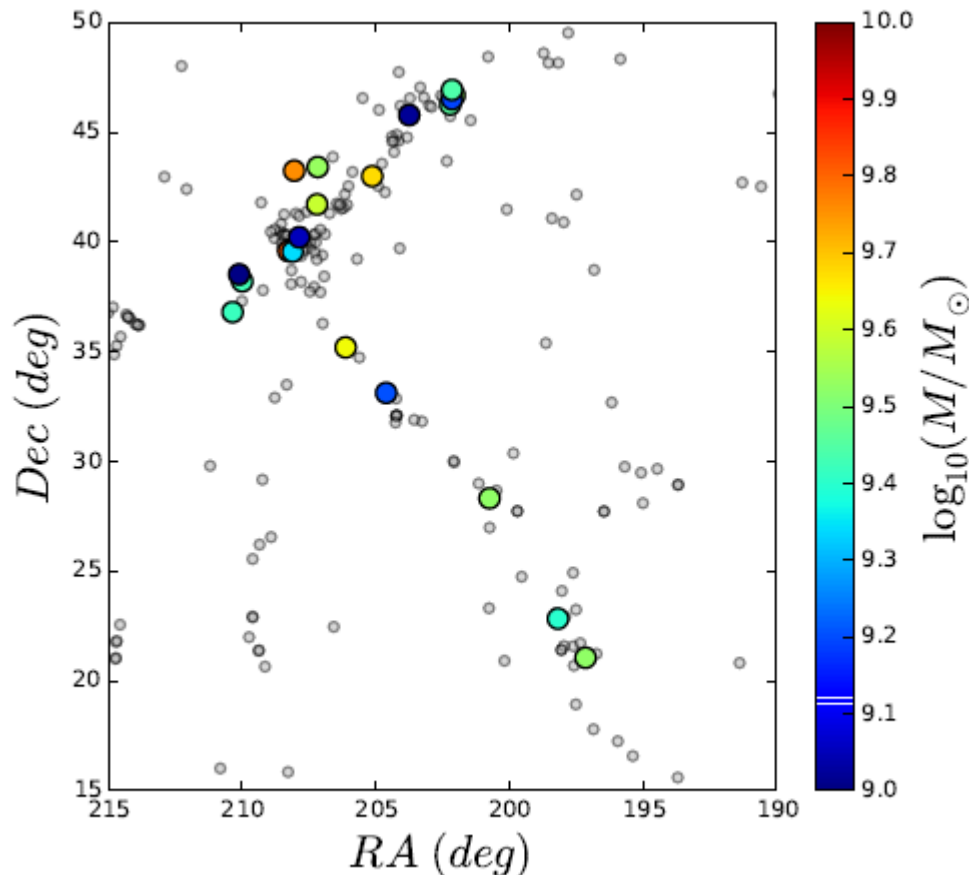
2971 galaxies
SDSS ugriz

Filament Selected

Our selection, coded in stellar mass: $M^* = 10^9 - 10^{10} M_\odot$

Below: problem of metallicity to detect CO

Above: Morphological quenching

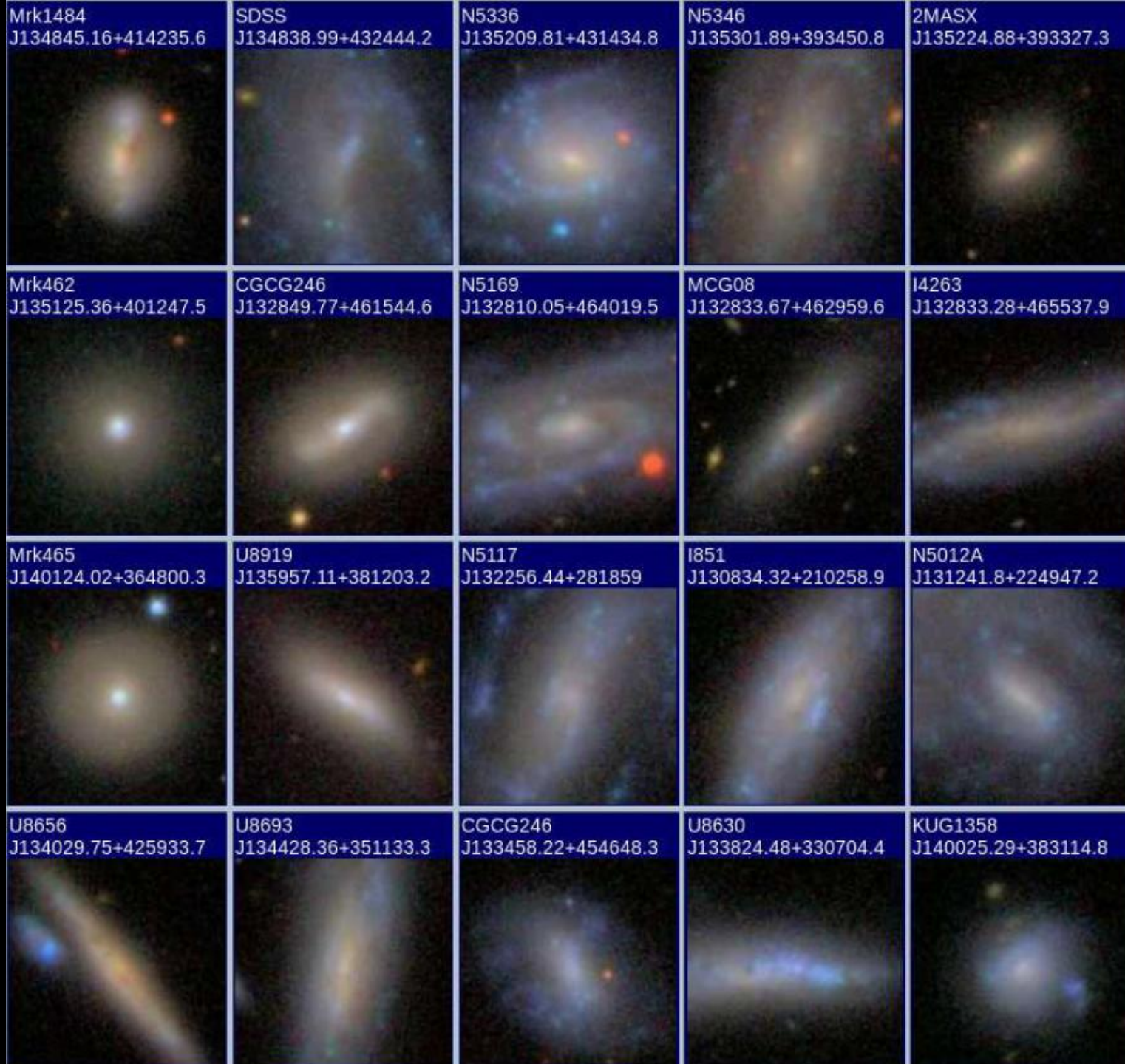


All WISE-22 μ -detected
Not selected: grey

Our sample
 $2400 < V < 3000$ km/s
 $M^* = 10^9 - 10^{10} M_\odot$

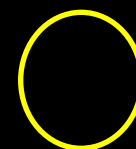
Extend 7 R_{vir} , 20Mpc

HI often available



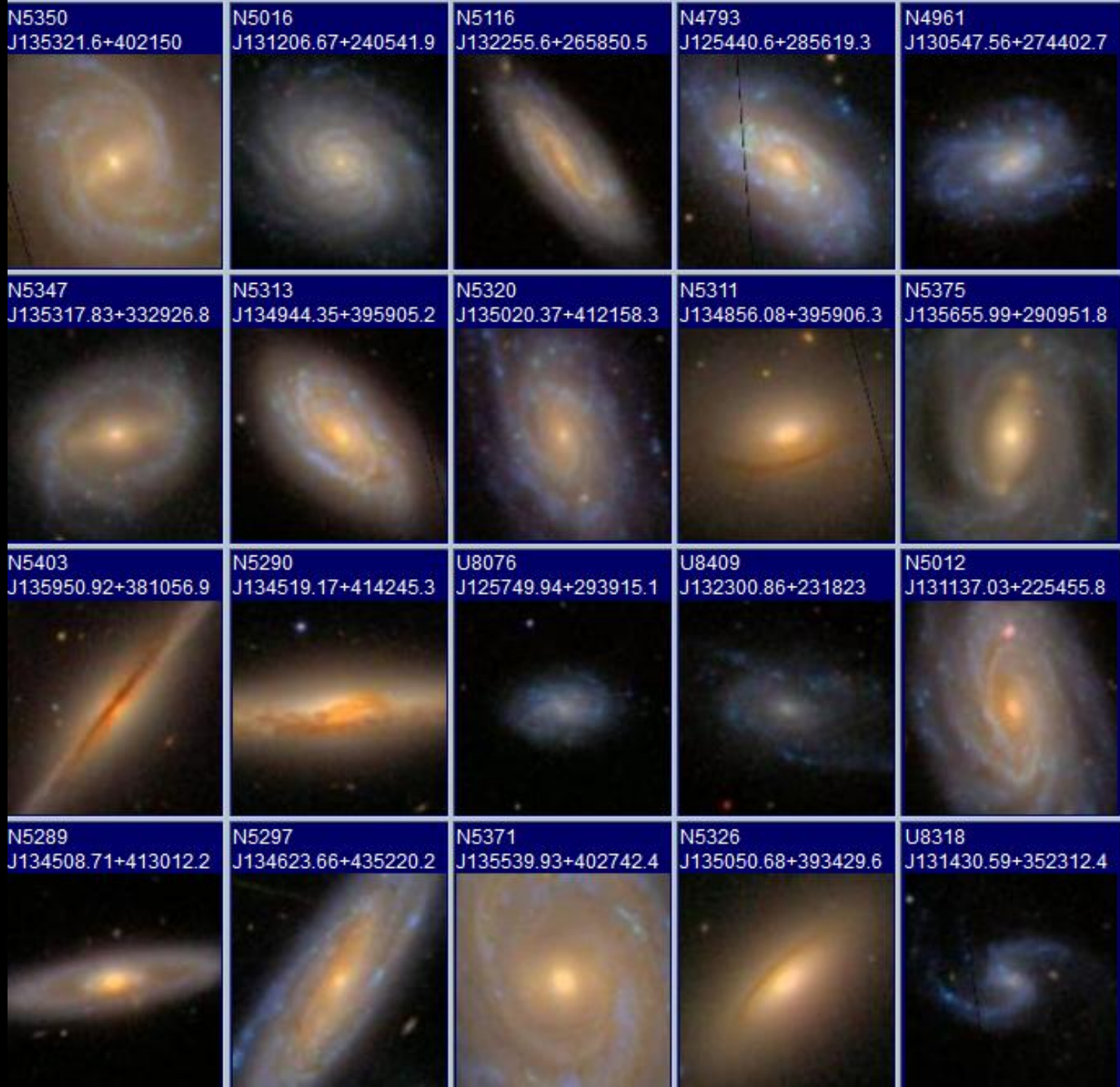
Box
50''

Beams
CO(1-0)
22''



CO(2-1)
11''





Box
100''

Beams
CO(1-0)
22''

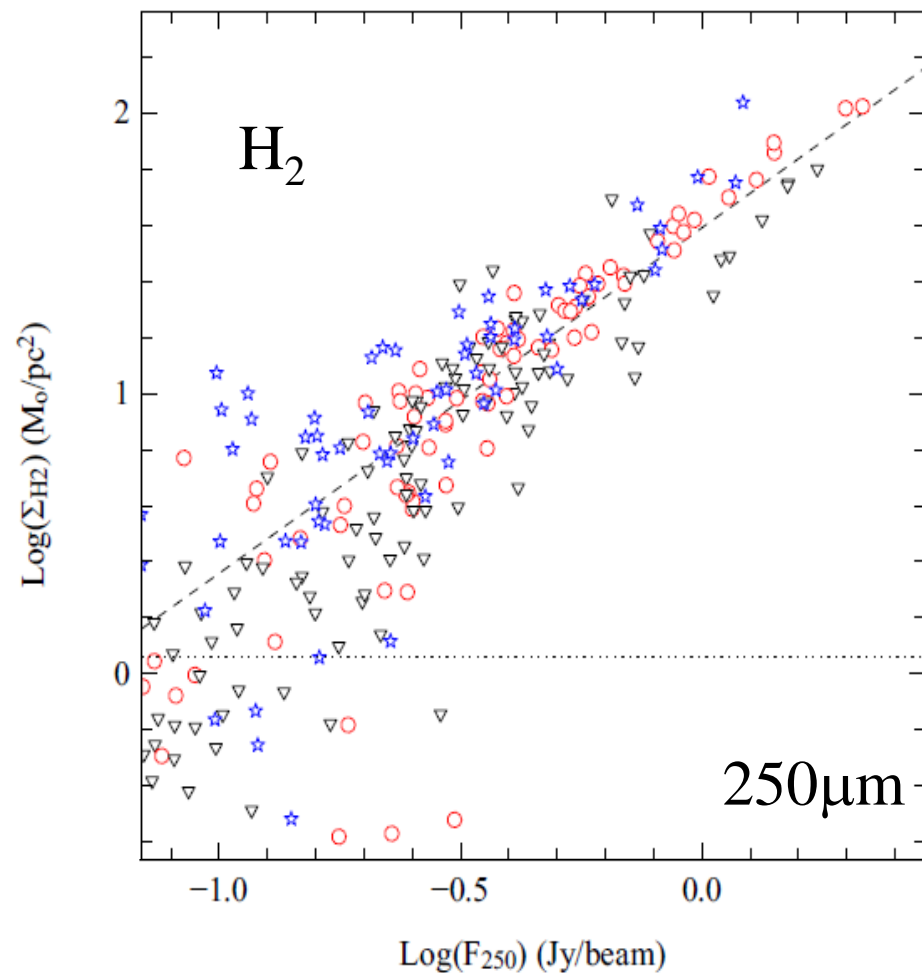


CO(2-1)
11''

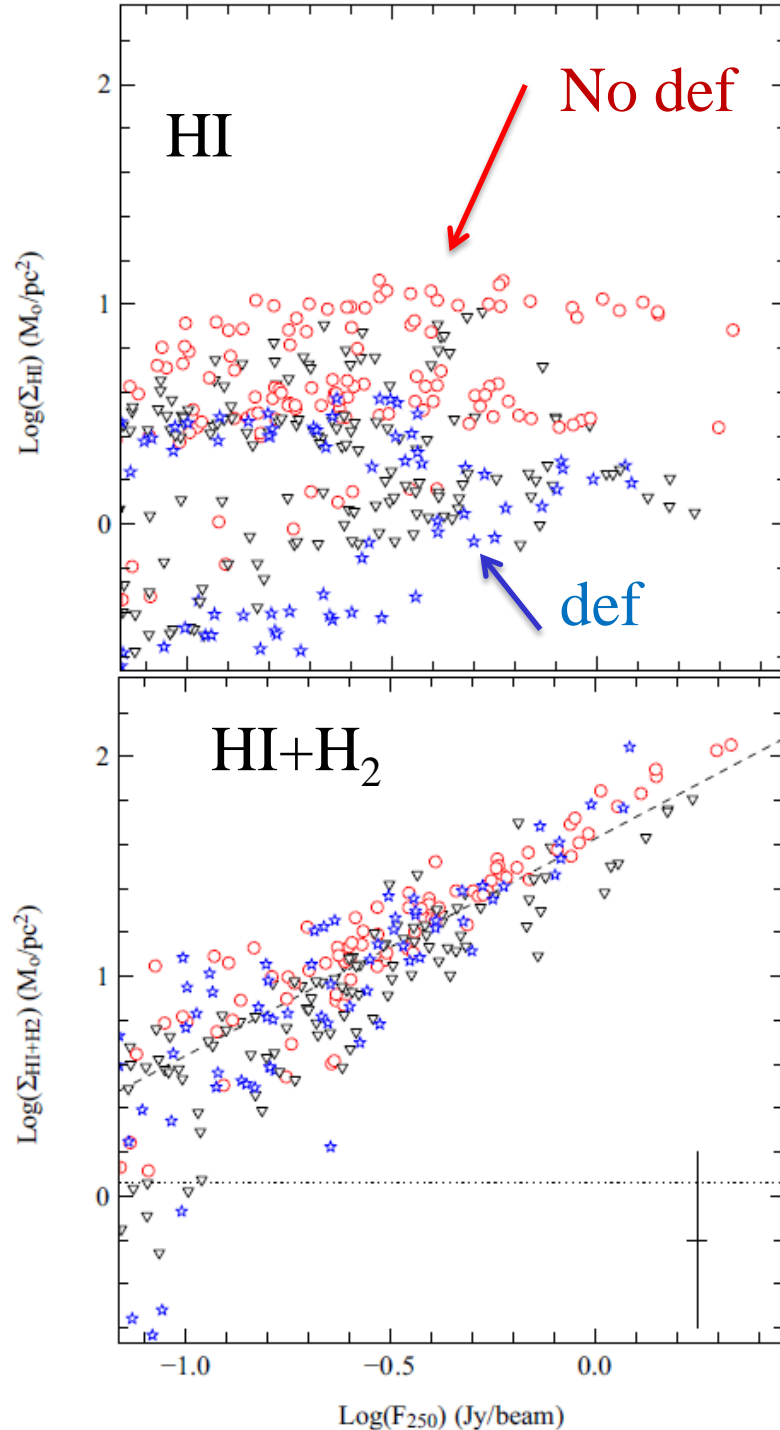


In Virgo, HI-deficiency

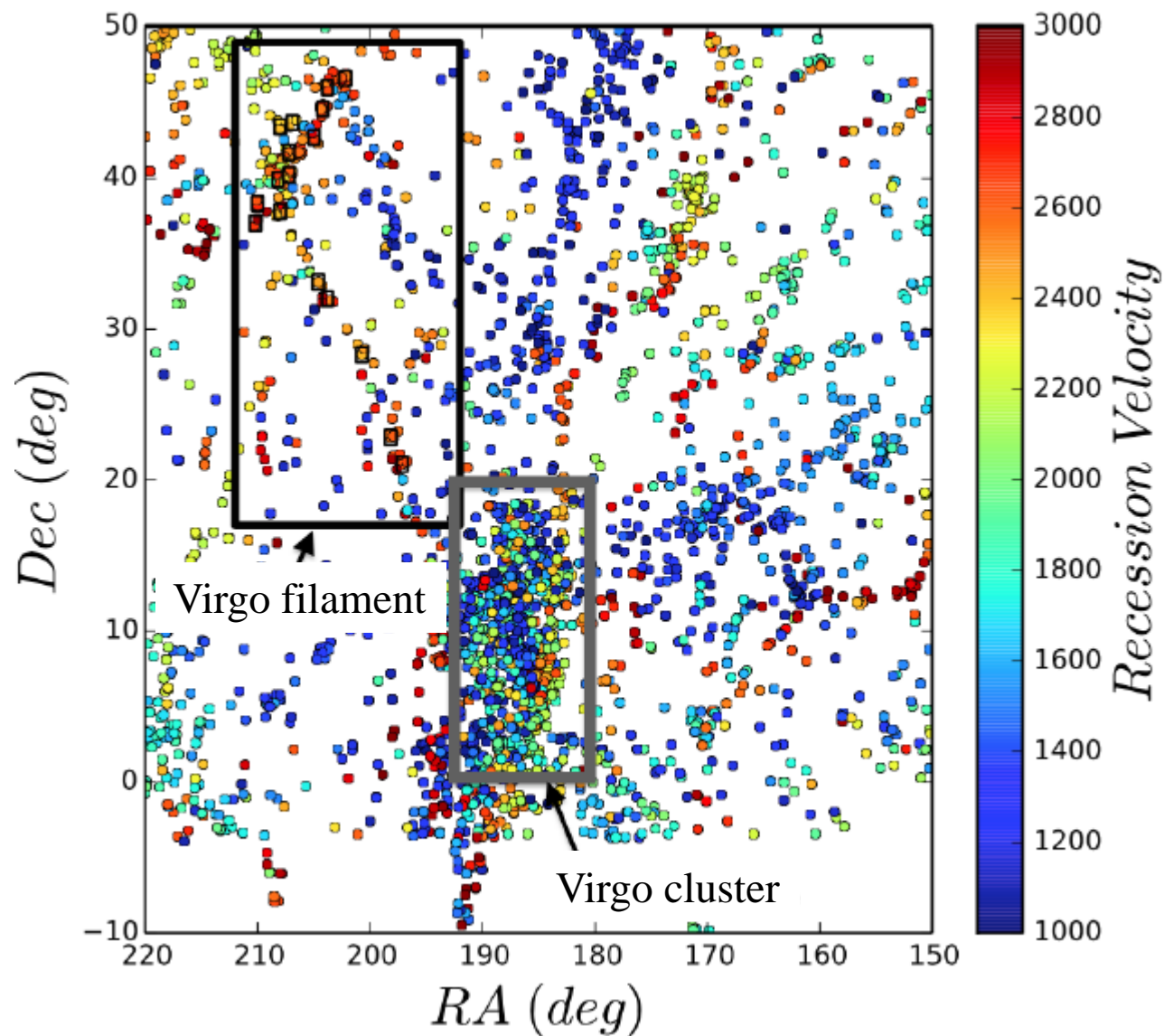
H₂ deficient in the center



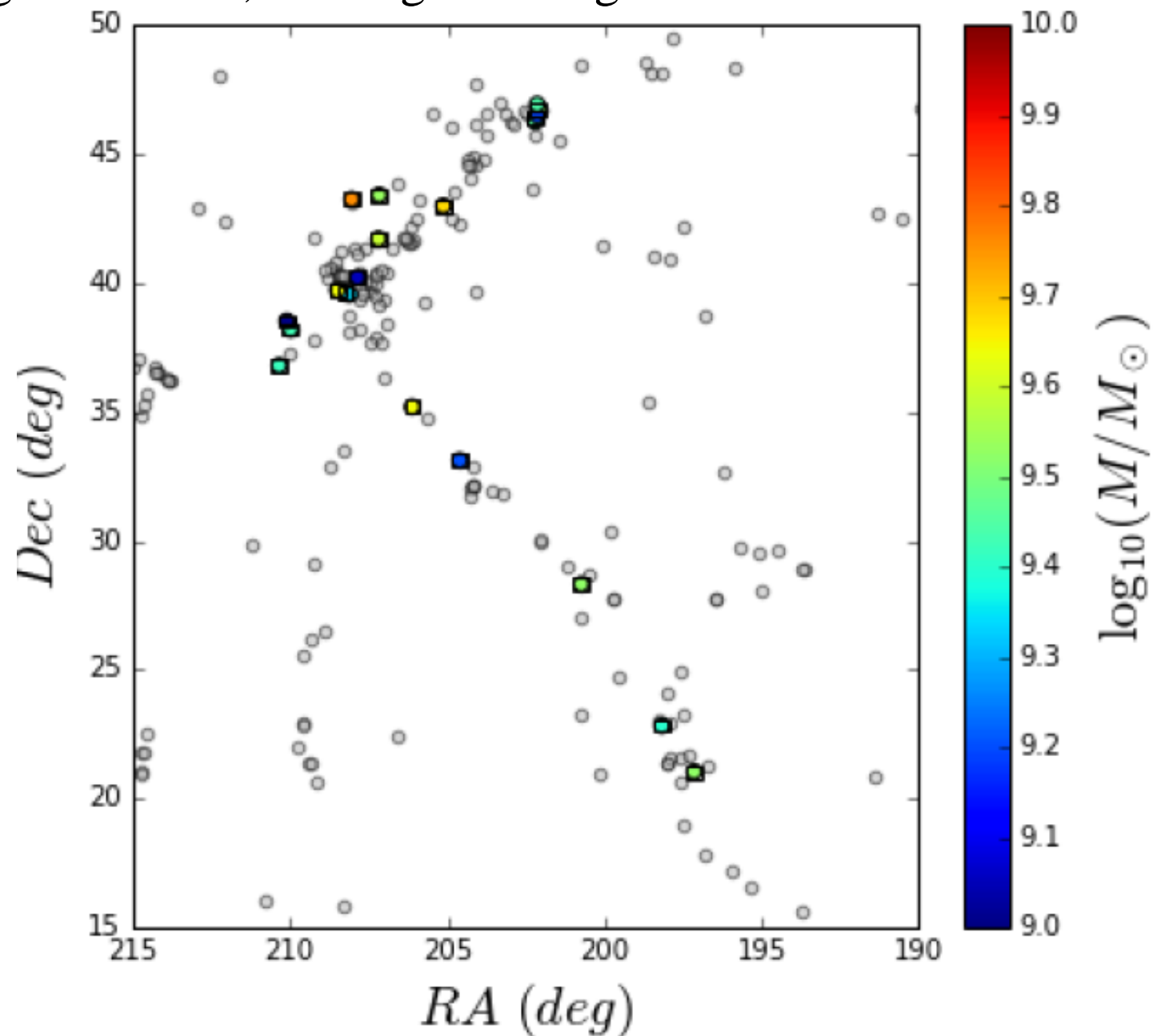
Pappalardo et al 2012



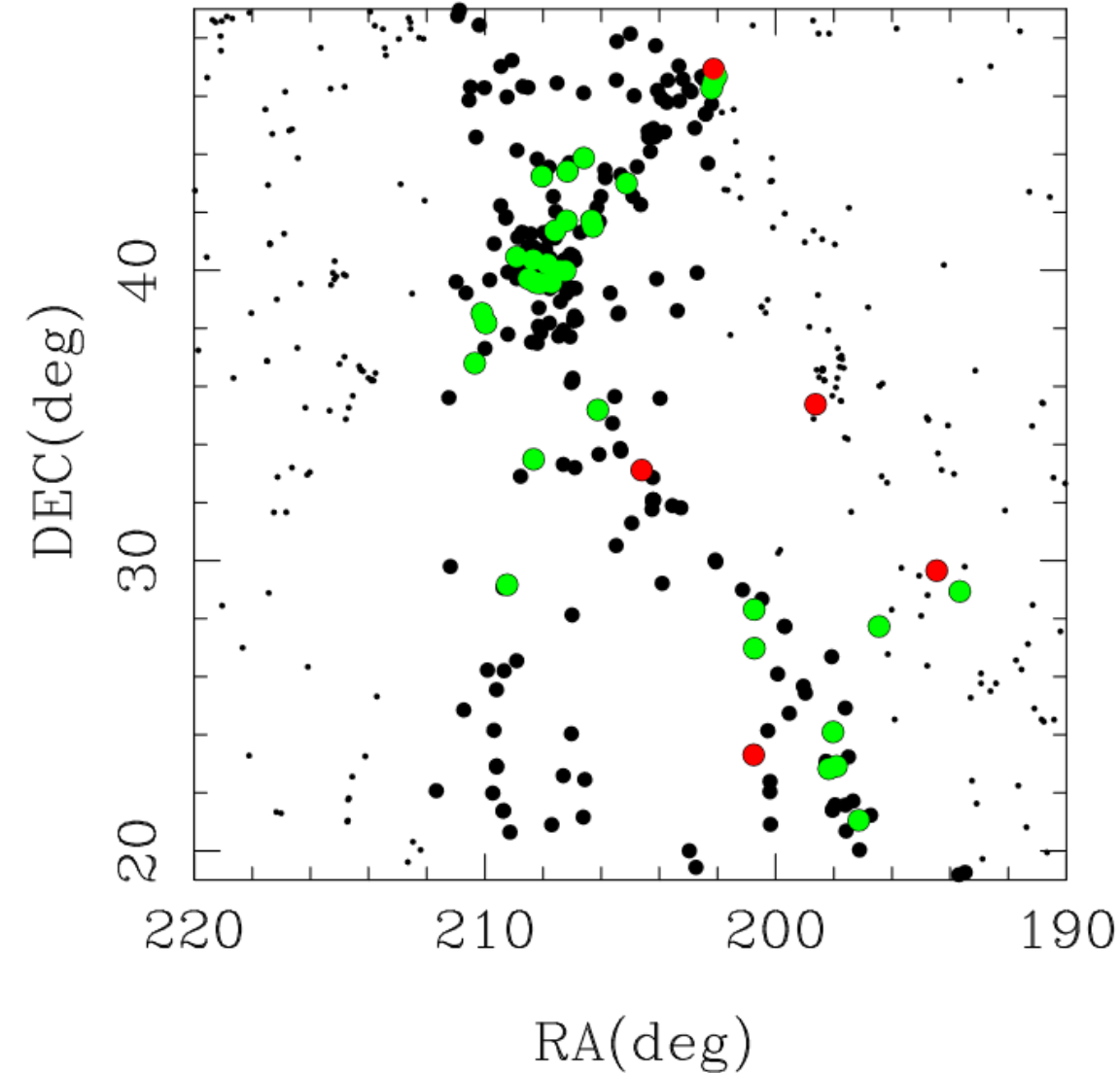
Virgo filaments, flowing into Virgo cluster



Virgo filaments, flowing into Virgo cluster



Overview of CO results so far



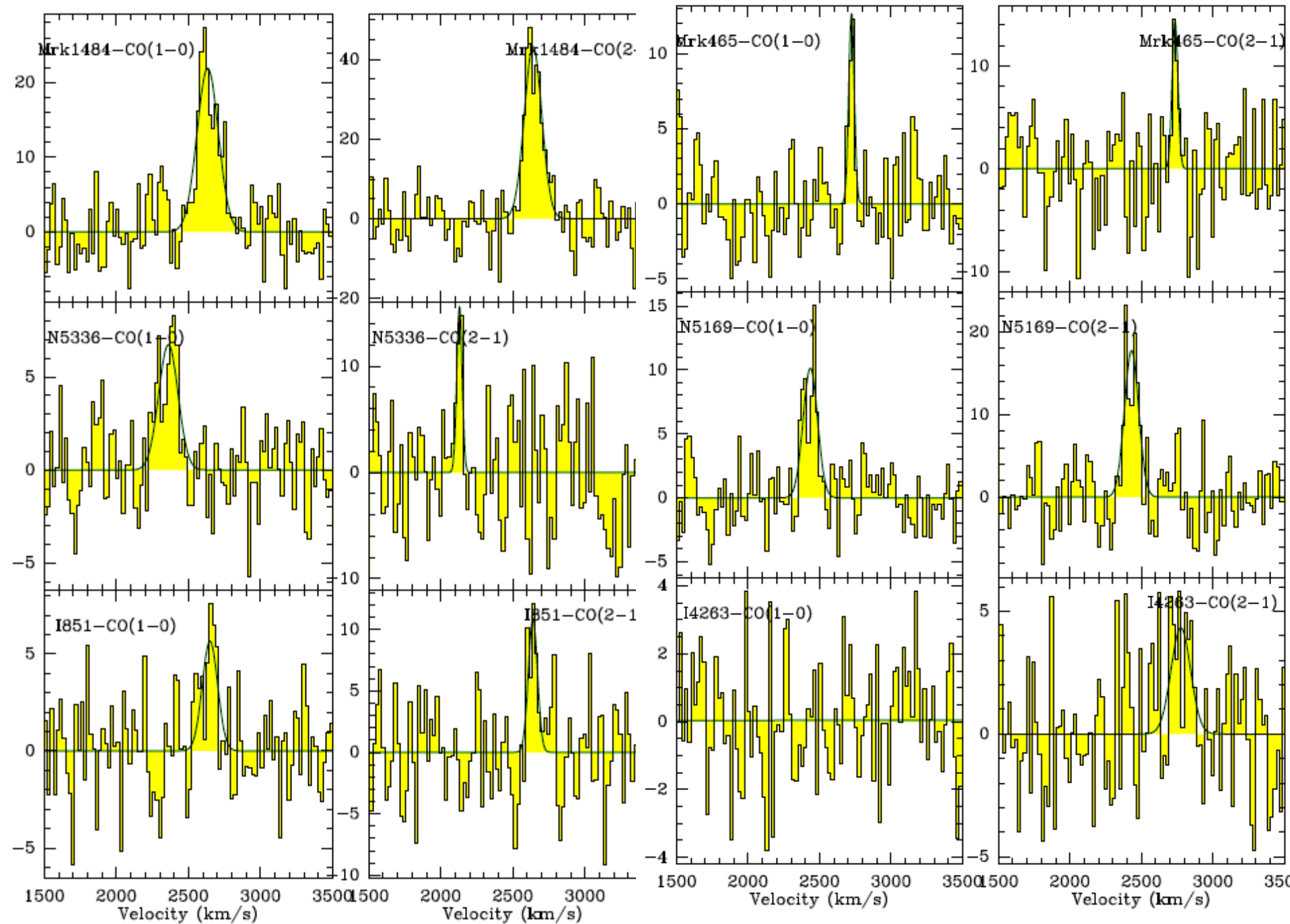
Green: detections

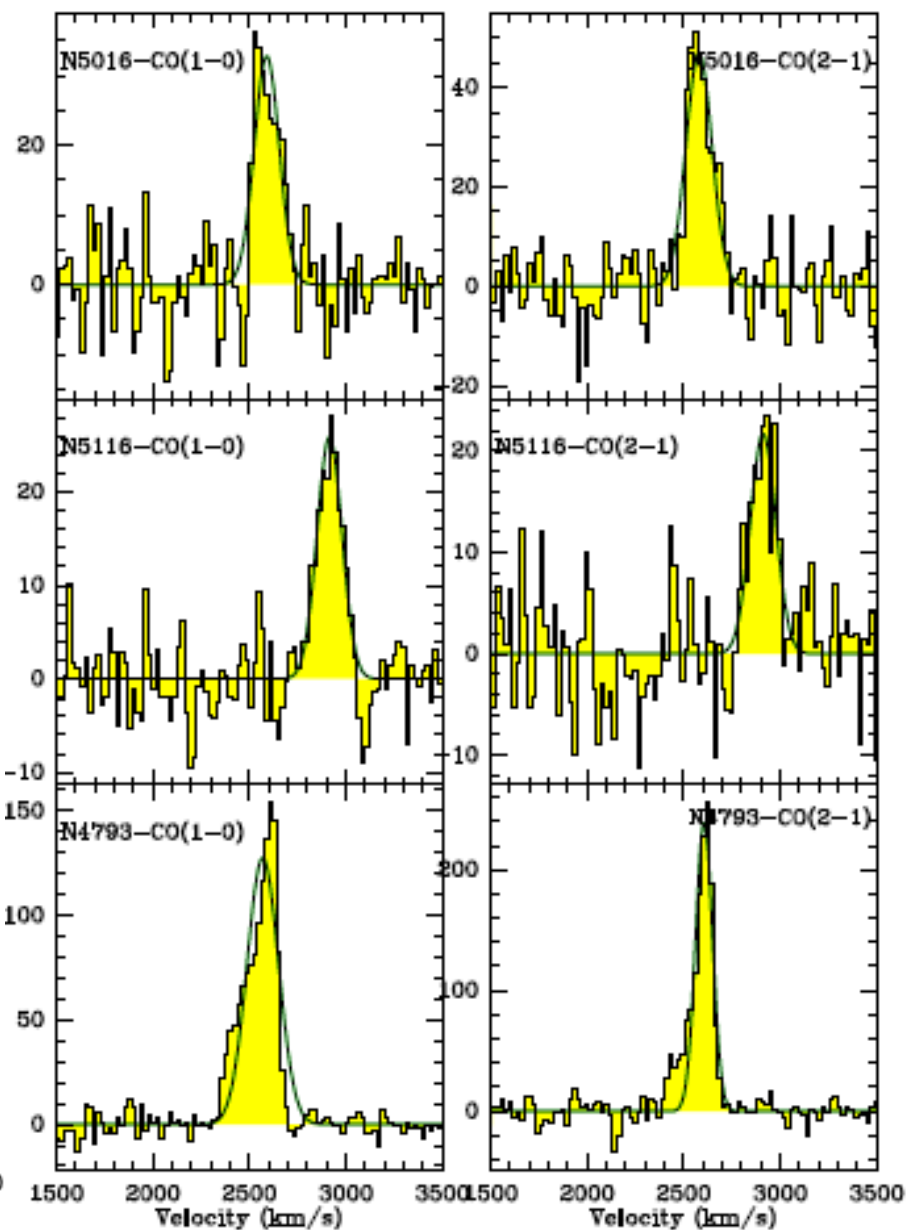
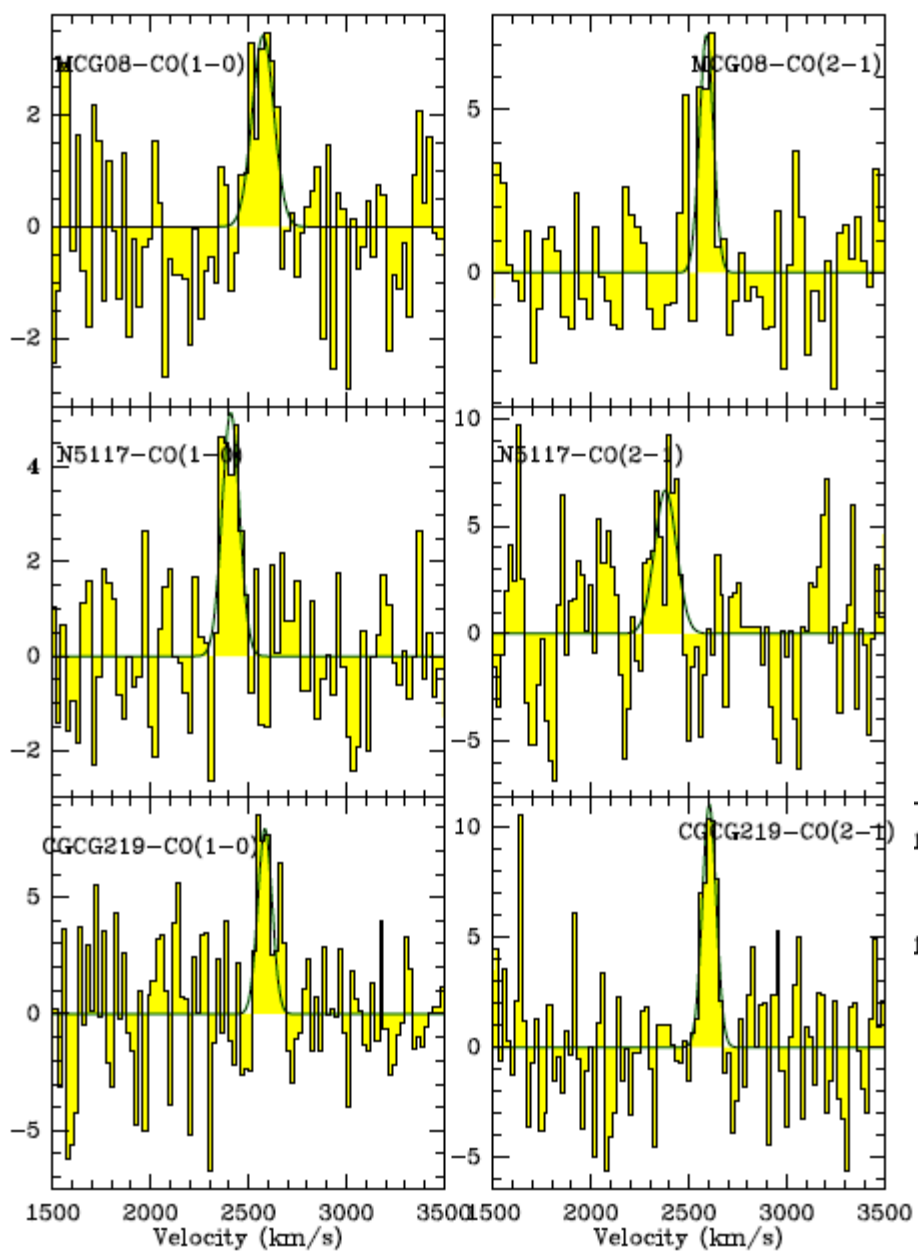
Red: upper limits

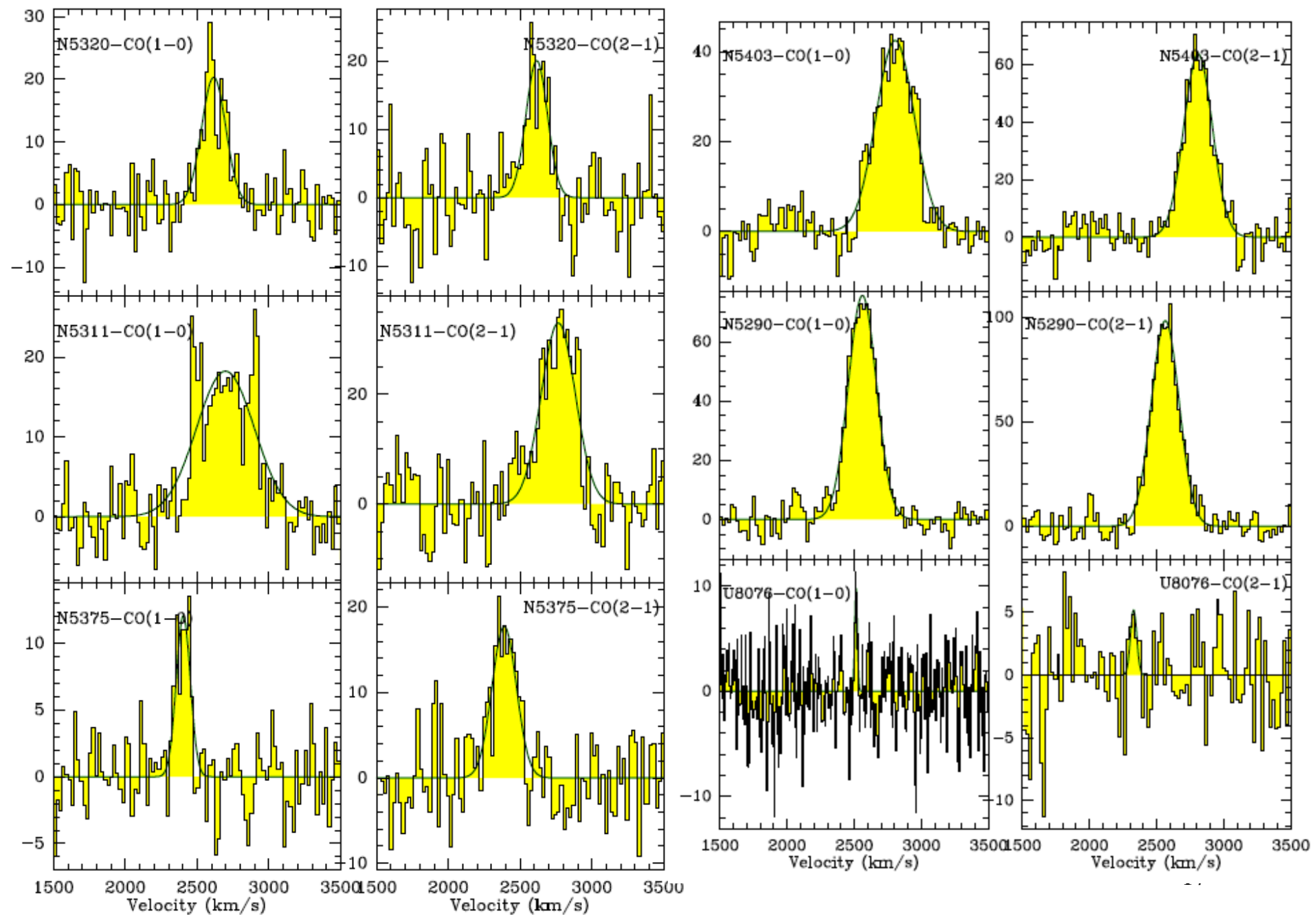
Black: not observed

From 0.3 to 21 Kkm/s

Almost 100 of dynamics



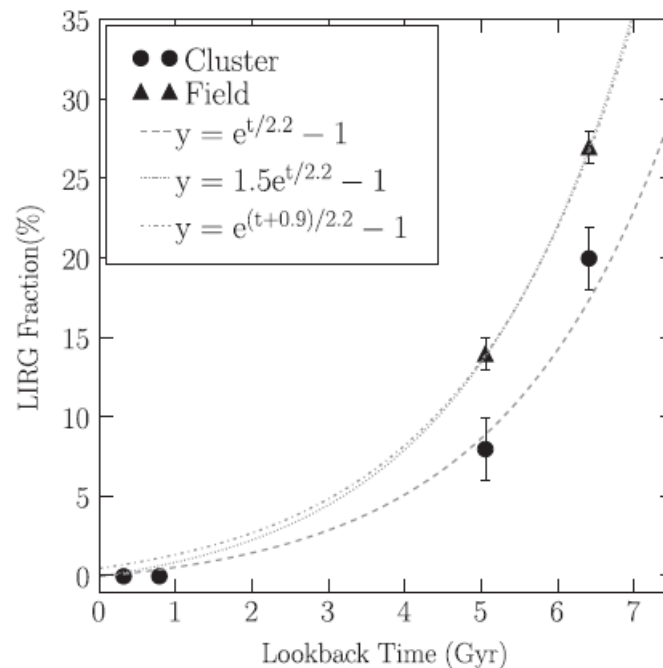
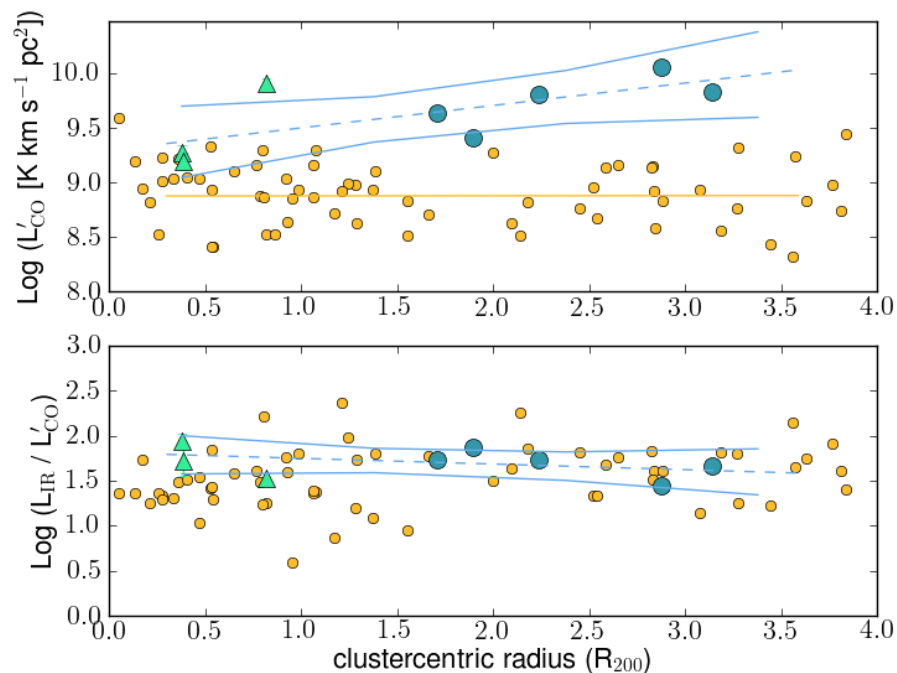
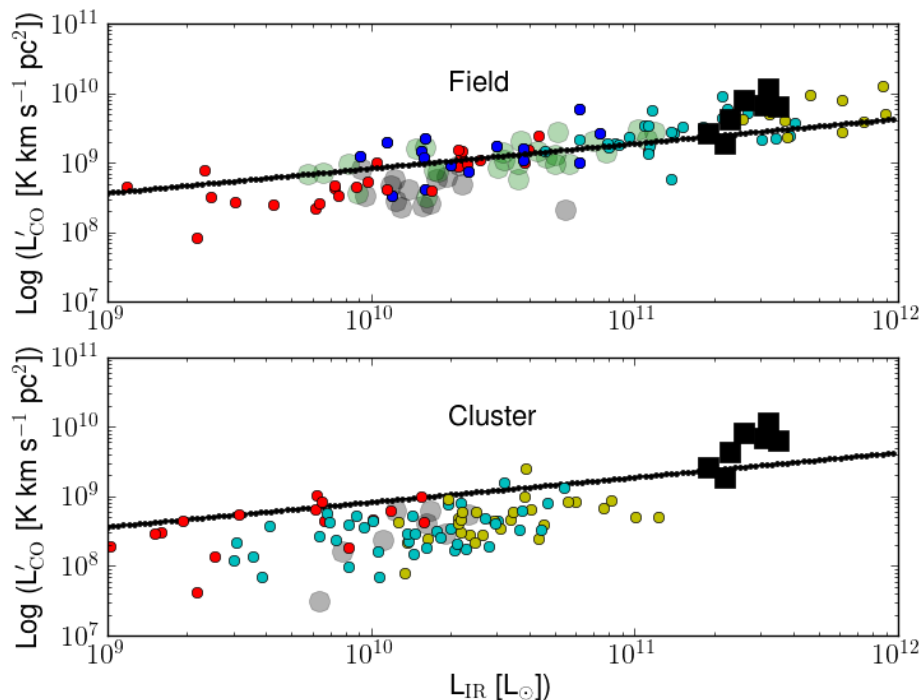




Field-Cluster comparison

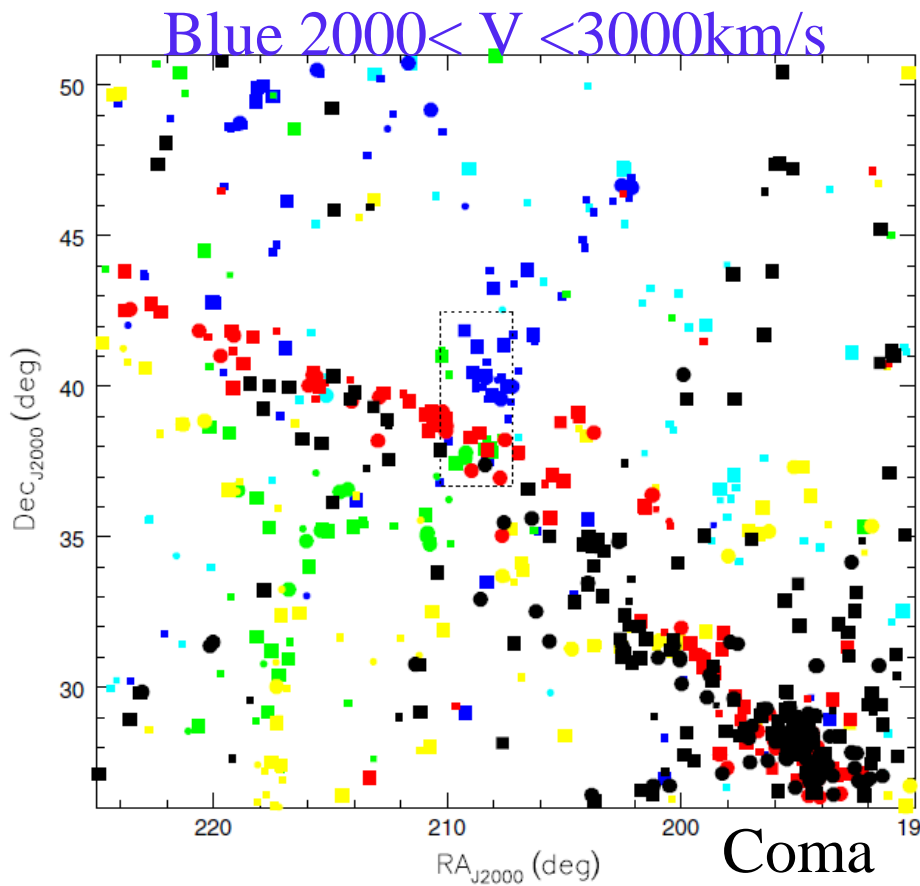
The LIRG fraction falls exponentially (Finn et al 2010)

At some z , galaxies are not yet quenched



N5353/4 group

In the Local Super-Cluster, $2.1 \cdot 10^{13} \text{Mo} = \text{HCG 68}$, $M/L_R = 105$
Less evolved dynamically, no superluminous systems, SF activity

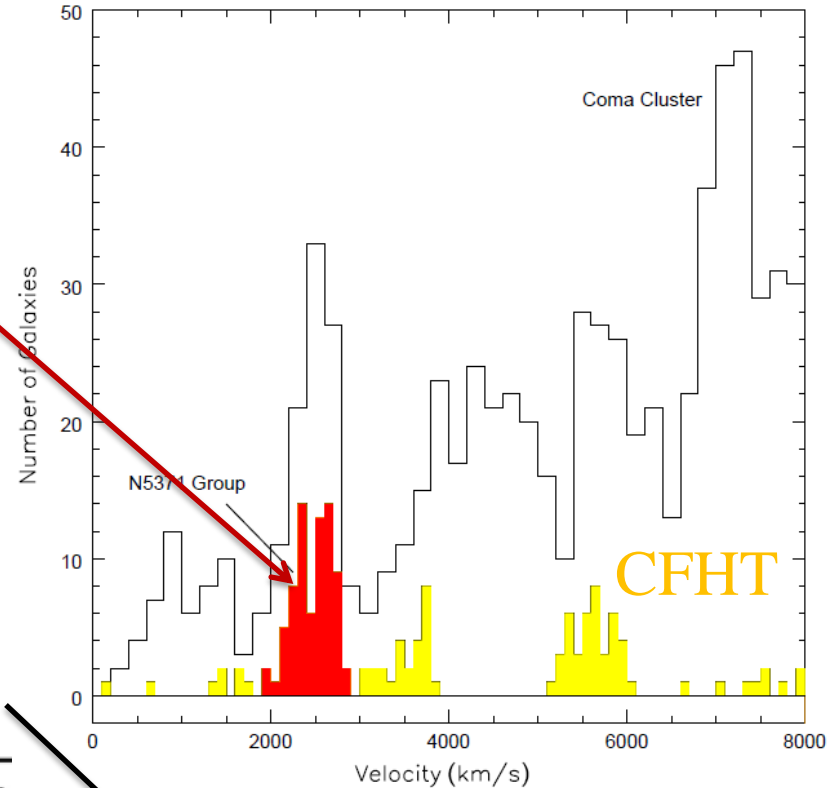
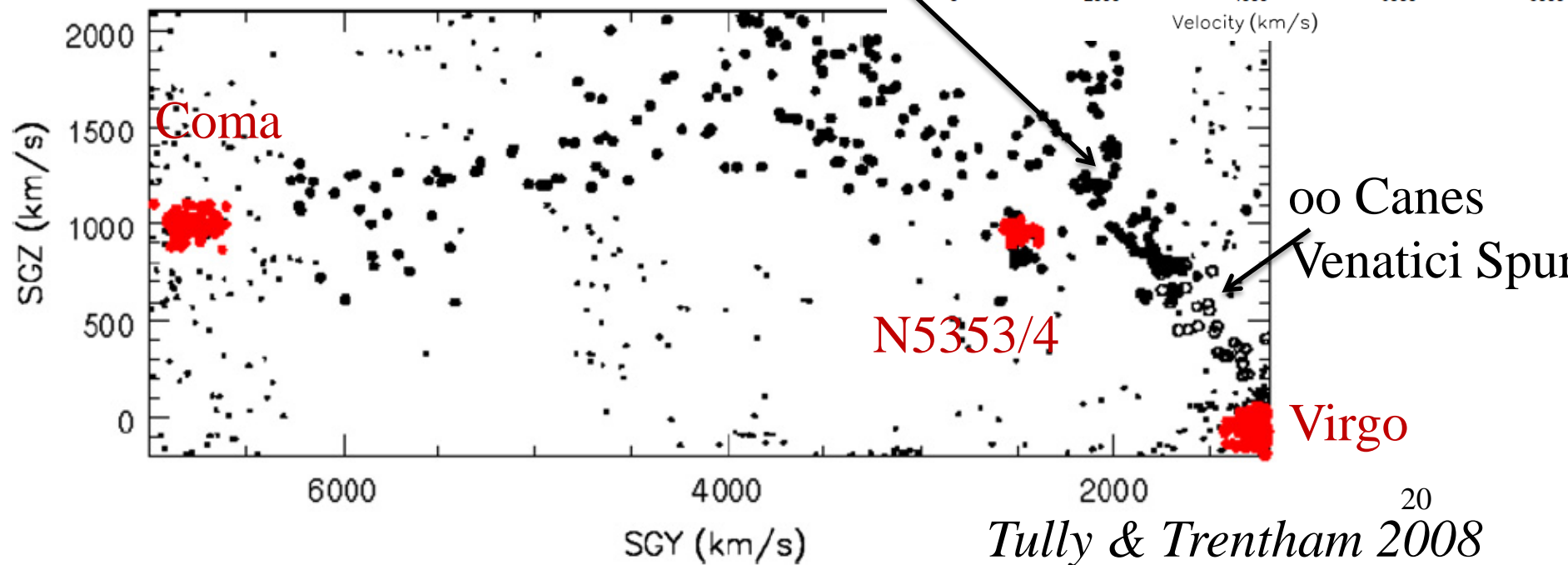


Tully & Trentham 2008

N5353/4 group

$$-300 < \text{SGX} < 1200 \text{ km/s}$$

Filament

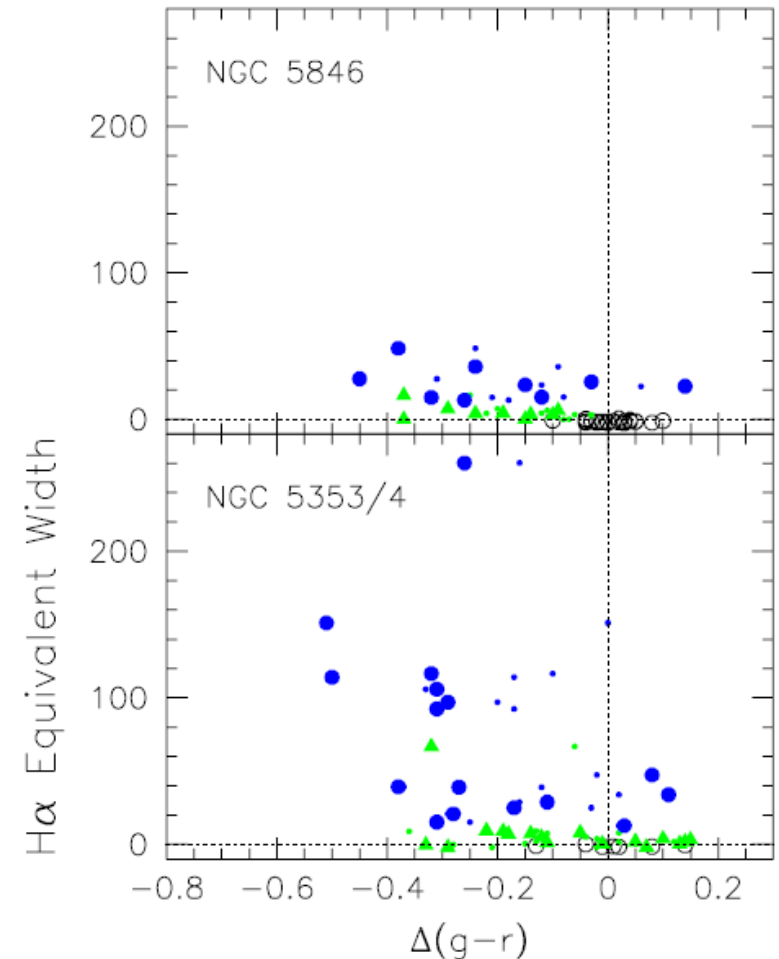
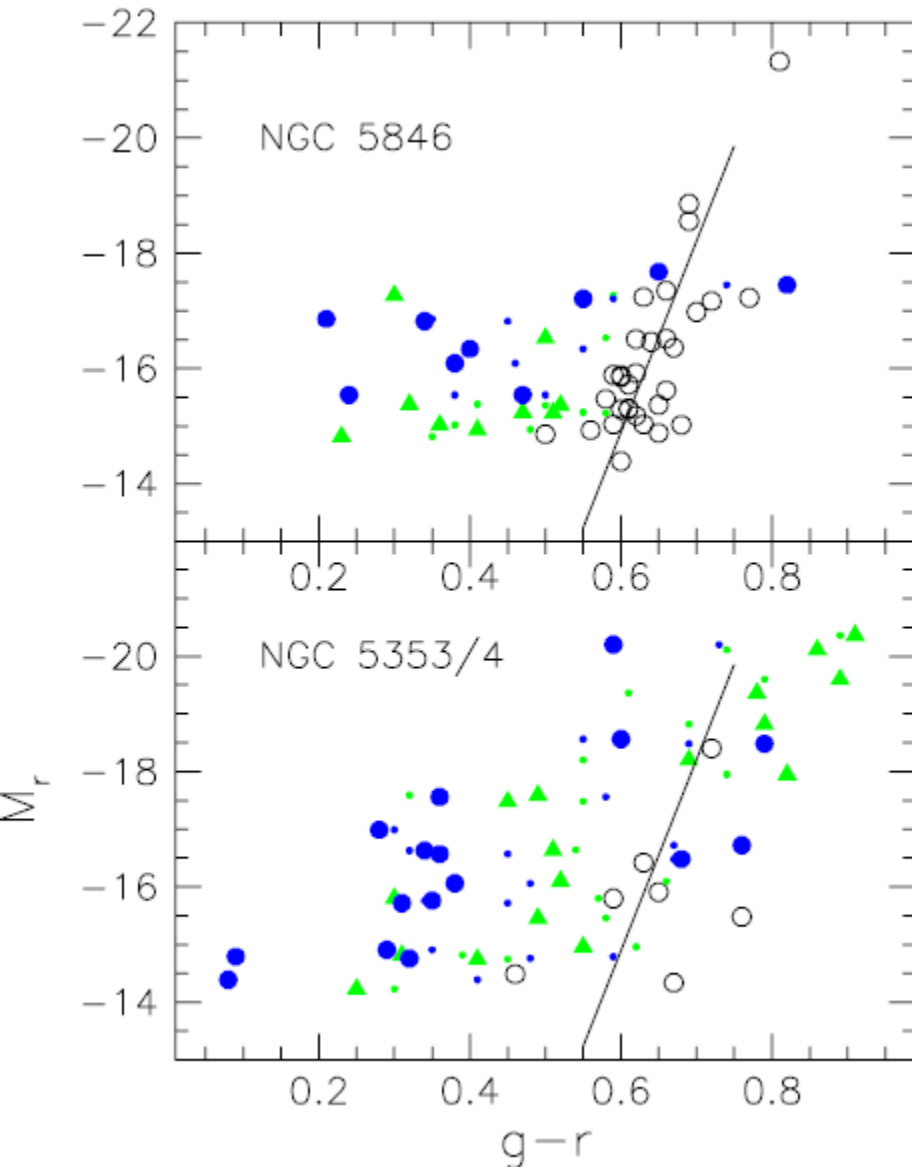


More star formation: CMD

Black circles: no SFR

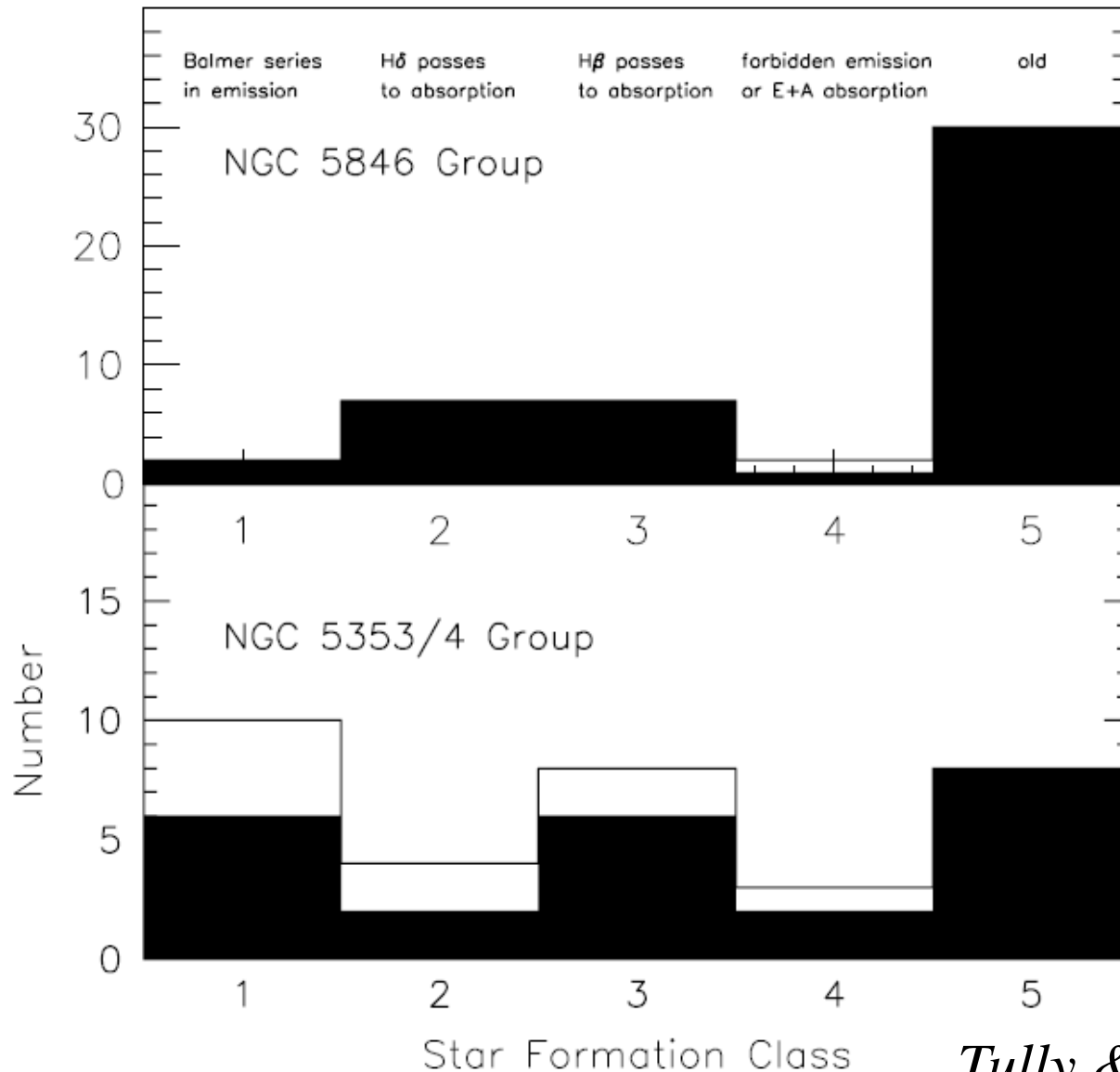
Green triangles: modest SFR

Blue circles: Vigorous SFR



Tully & Trentham 2008

Star formation evolution



Filled: types earlier than Sa

Empty: all types

Although dwarfs are mostly dE, they are actively forming stars in N5353/4 group

Dwarfs play the role of markers of evolution

Other filaments

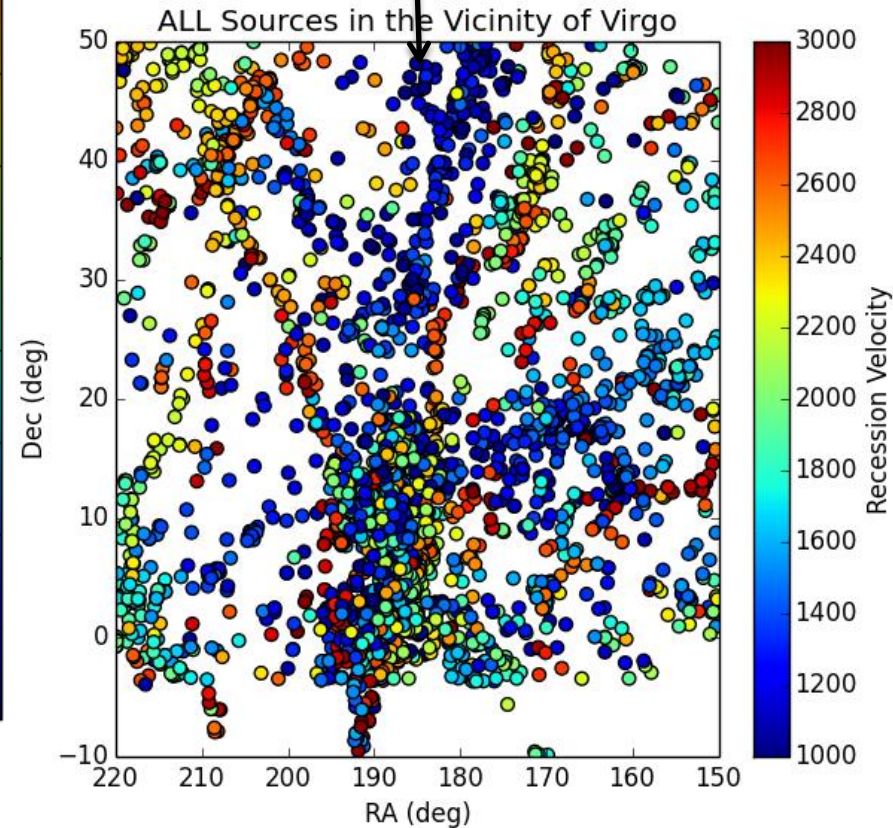
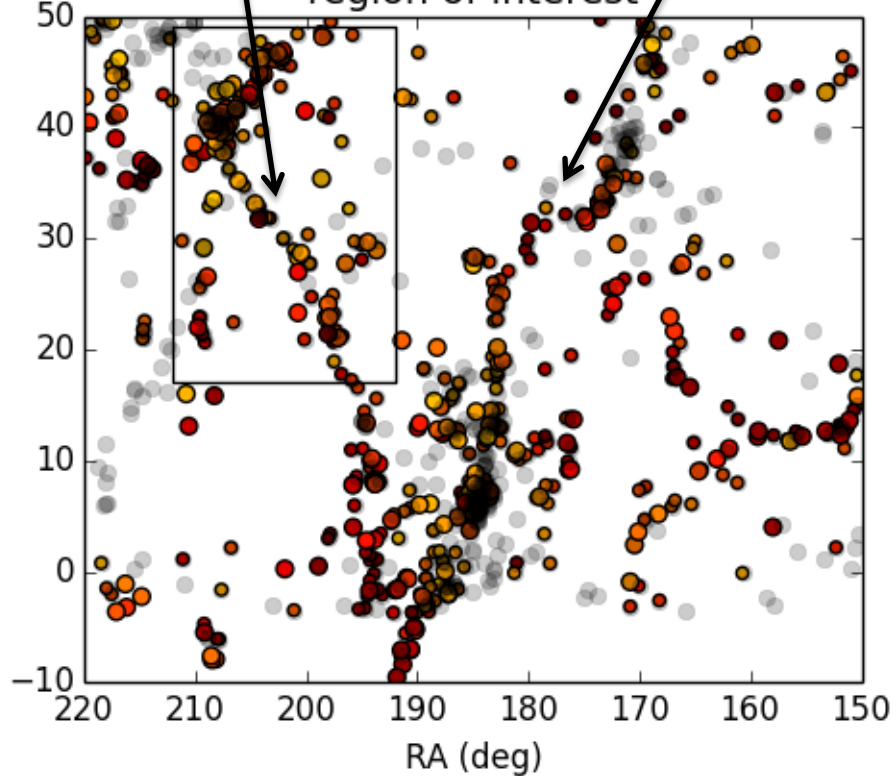
Filament 1

Filament 3

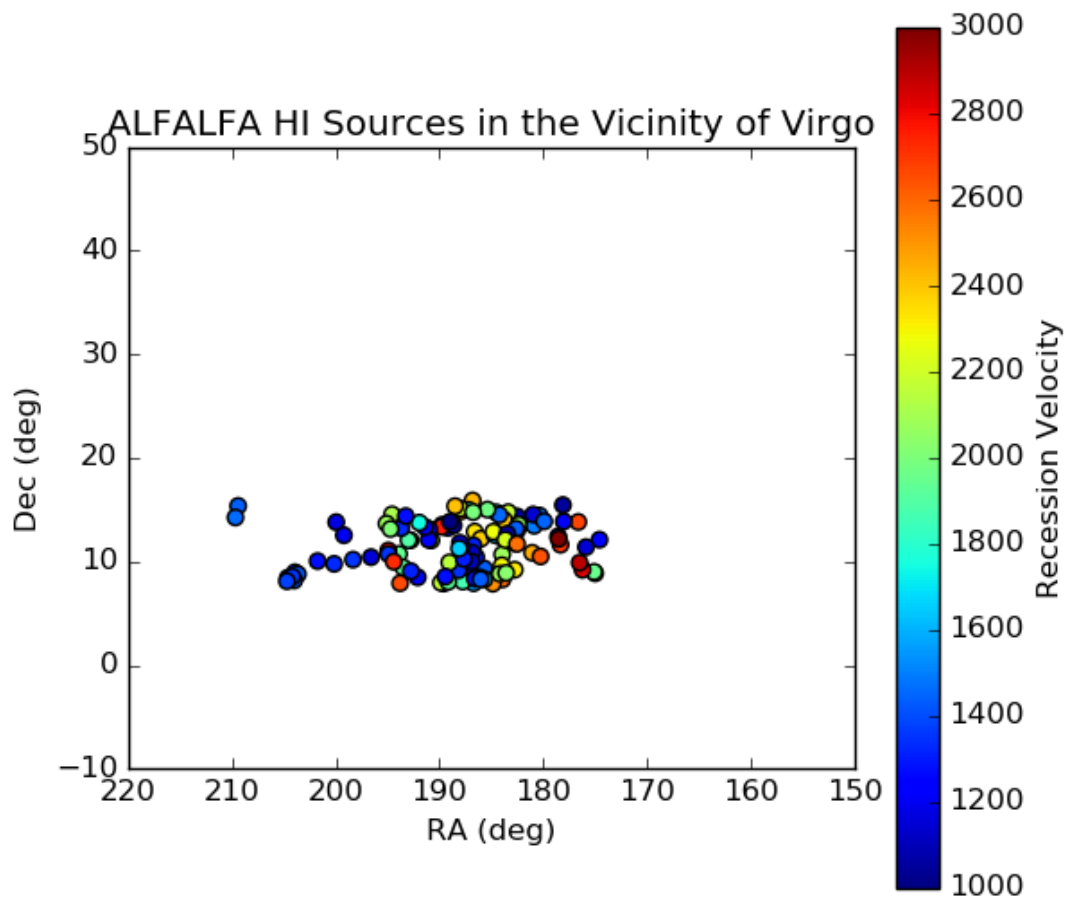
Filament 2

$V \sim 1200$ km/s

region of interest



Ancillary data



HI from
Alfalfa

Other CO data

Essentially Filament 2 ($\sim 1200 \text{ km/s}$) 14 galaxies observed in CO
4 in Filament 3 \rightarrow Statistics of ~ 60 galaxies

Search for filament 3 in the extension of 8 hours?

Young et al (1995) Amherst survey
Braine, Combes et al (1993) IRAM
Sage (1993)
Casoli et al (1998) IRAM
HERACLES, IRAM CO(2-1)
ATLAS^{3D}, Young et al (2011) IRAM
BIMA-spectro