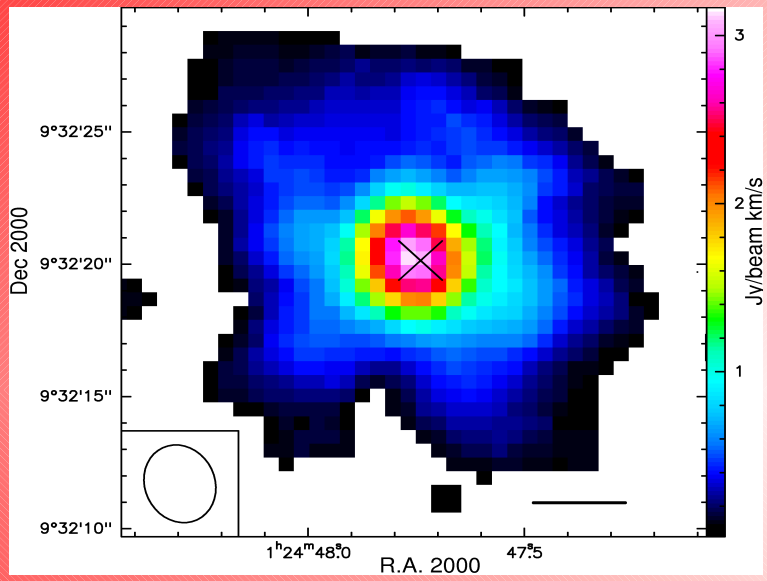
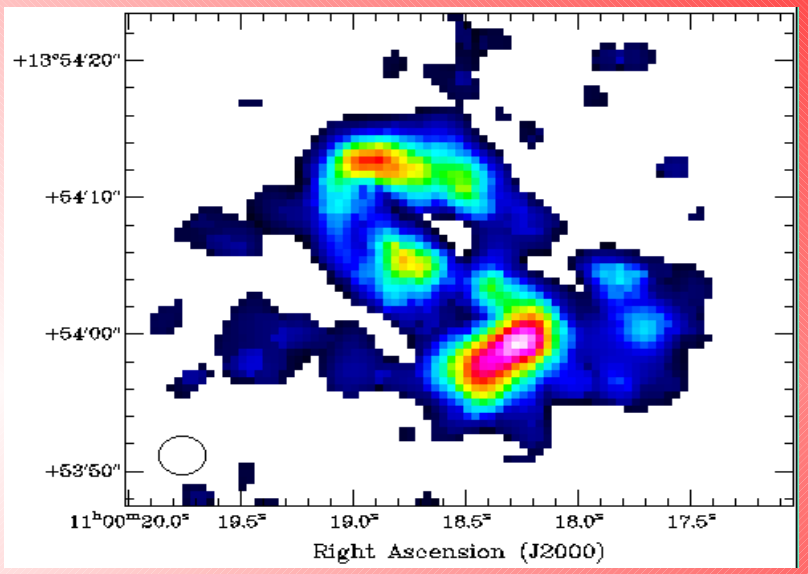
Molecular gas and star formation in early-type galaxies





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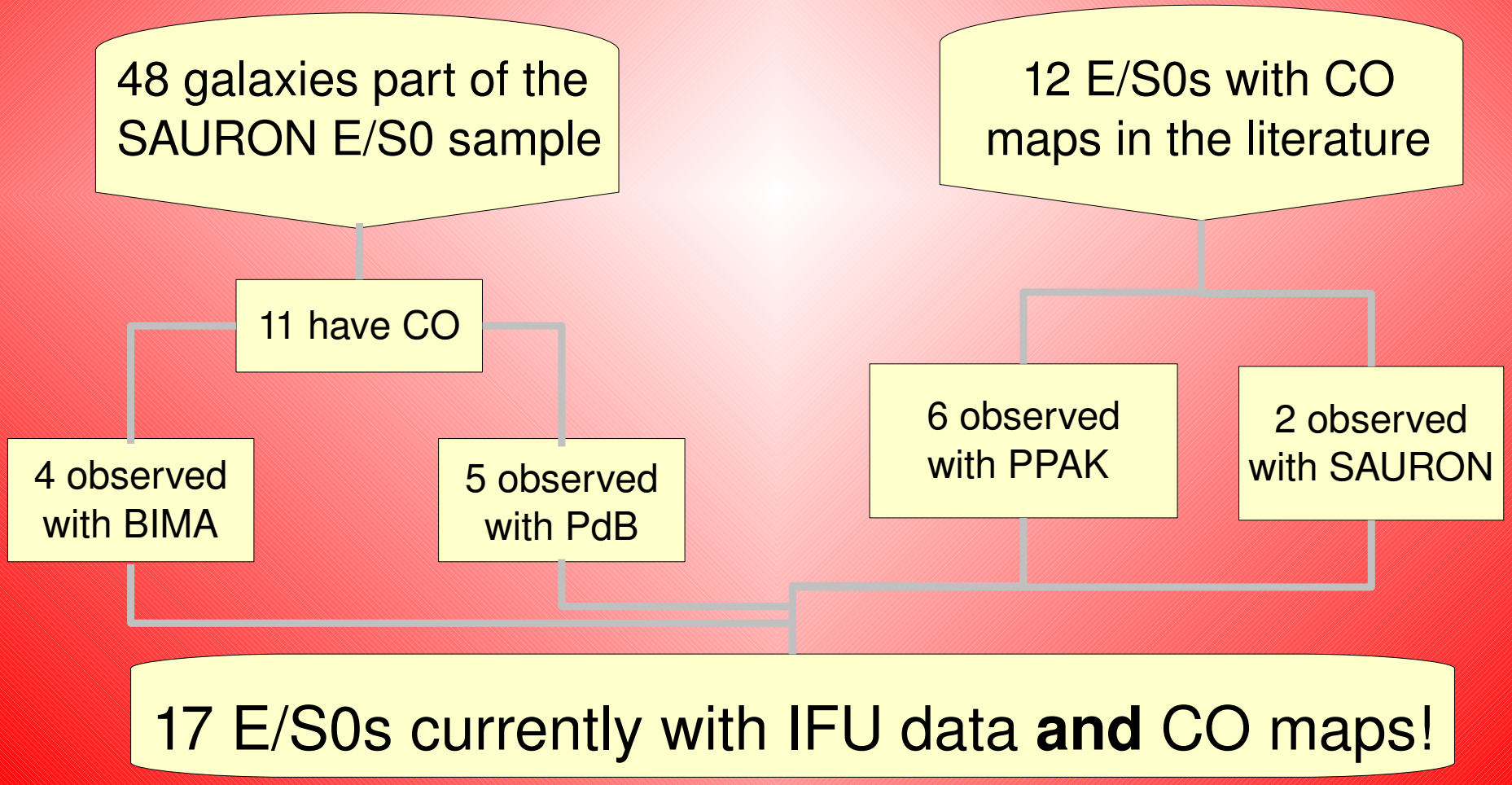
Francoise Combes (Obs. de Paris)

Two main questions

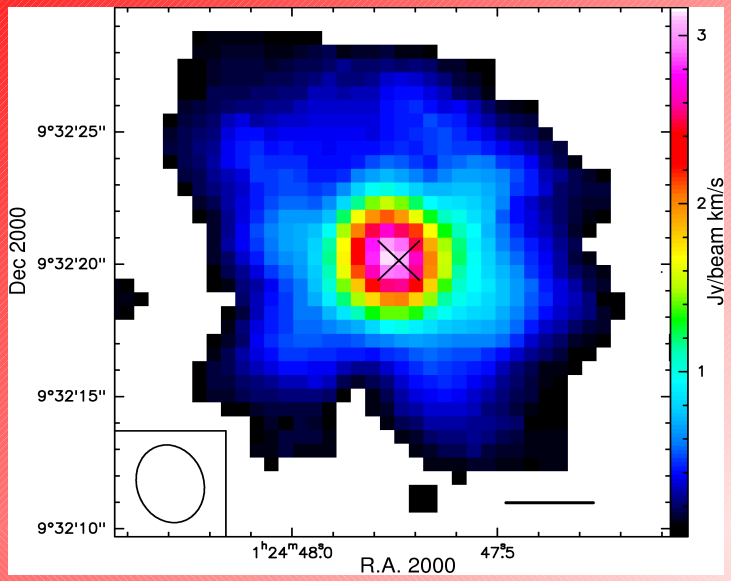
- What is the molecular gas in early-type galaxies doing?
  - Distribution, comparison with ionised gas and stellar populations
- Do early-type galaxies follow the same SF laws and correlations as spirals/starbursts?

Sample:

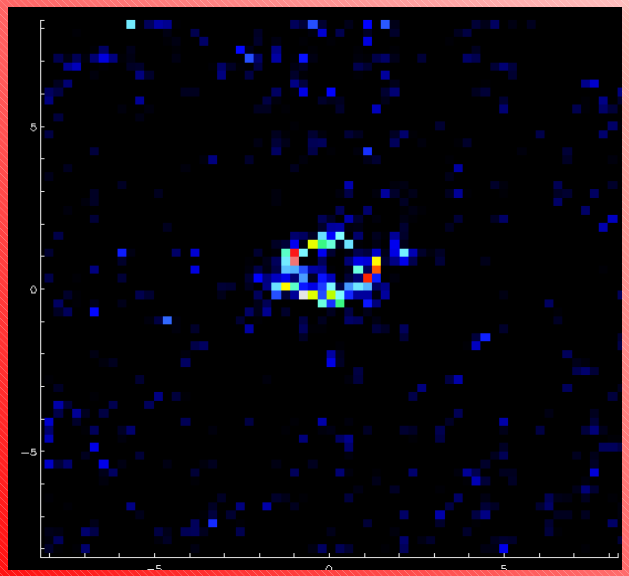
Molecular gas: interferometric CO maps
Star formation: IFU maps, also literature FIR and radio



Molecular gas distributions

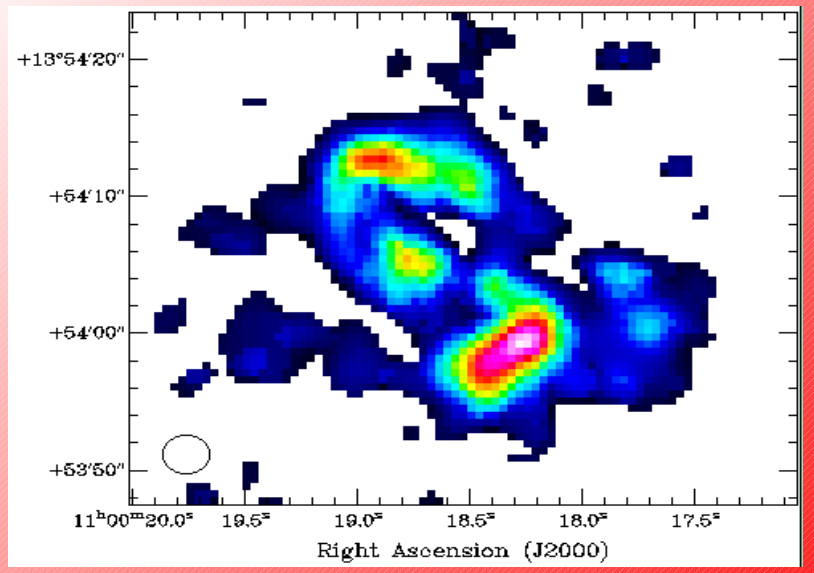


Disk in NGC 524



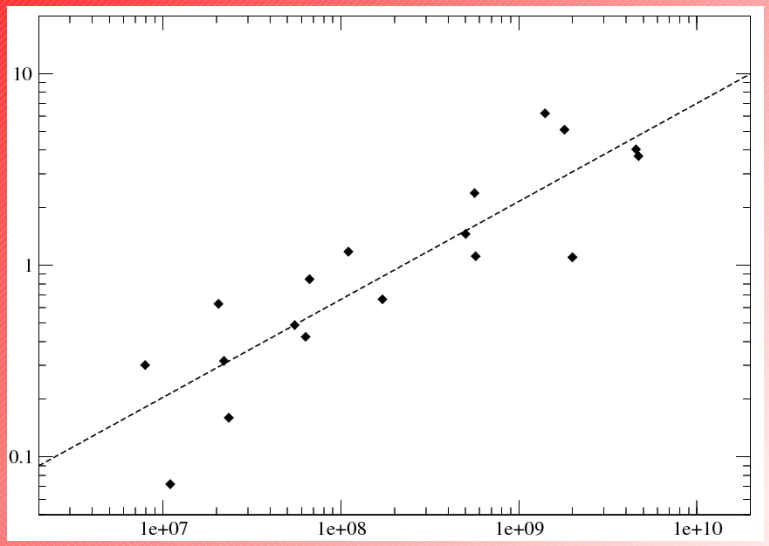
Ring in NGC 4477

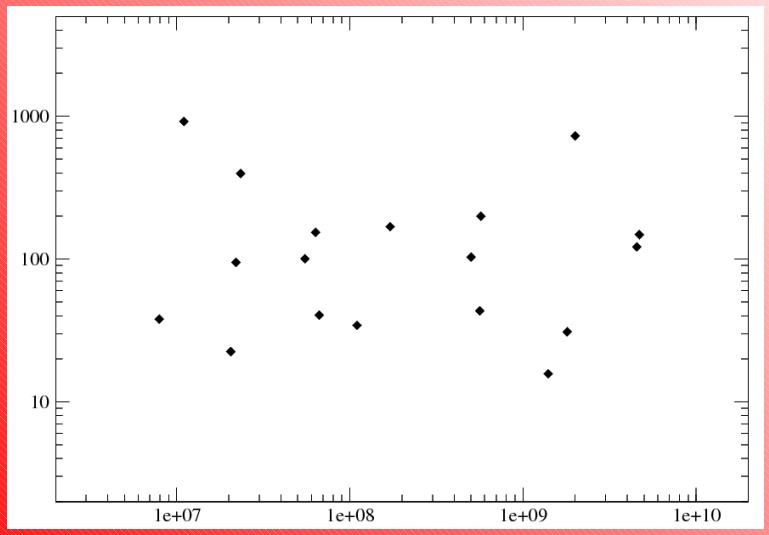
- Central (except merger remnants)
- Disk or ring (one spiral)



Spiral in NGC 3489

Molecular gas distributions





- Central (except merger remnants)
- Disk or ring
- Radial extent depends on mass → relatively constant average surface density

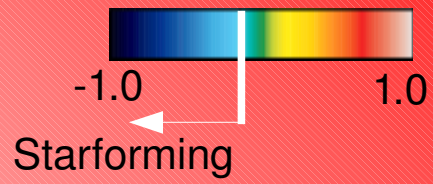
Molecular and ionized gas

<u>IFU maps of OIII/Hβ emission-line ratio.</u>

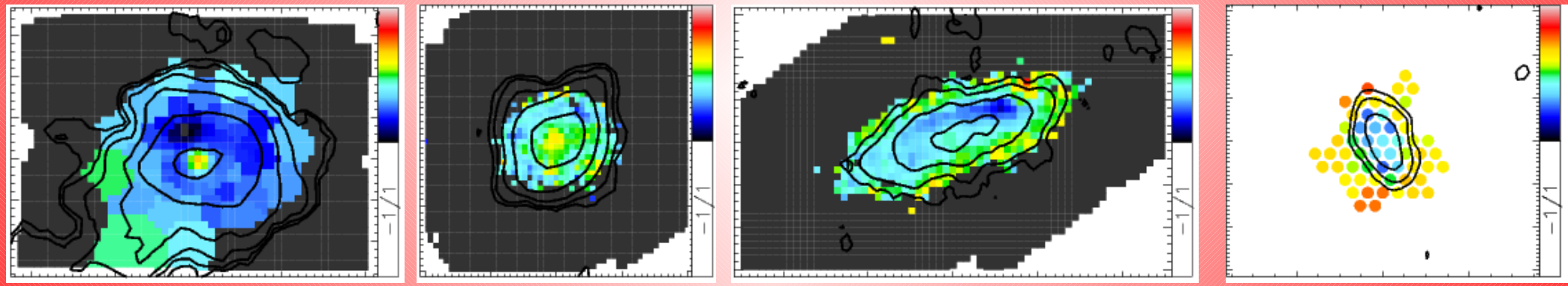
Use this ratio ratio to diagnose star formation:

log(OIII/Hβ) < –0.2 → ionisation attributable to star formation

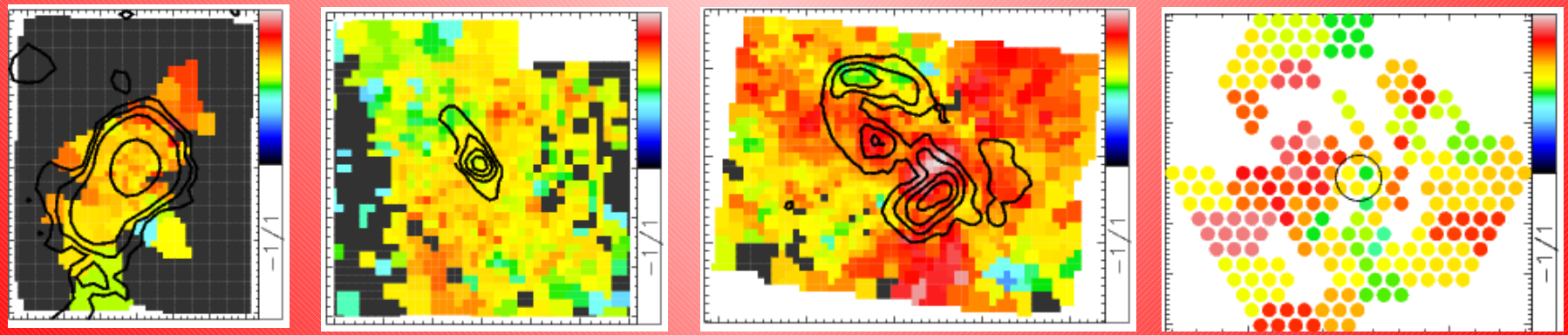
log(OIII/Hβ) > –0.2 → ionisation dominated by other source



4 star forming galaxies:



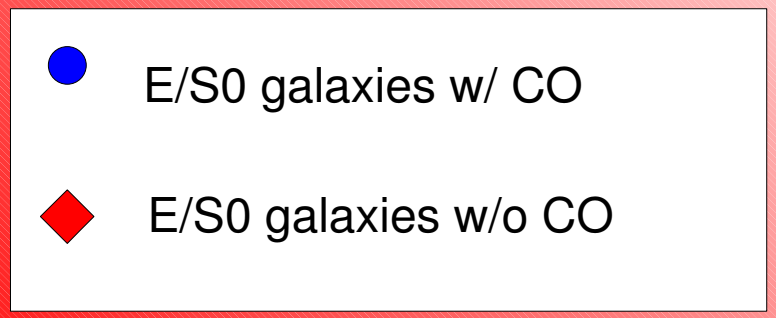
4 not star formation dominated galaxies:

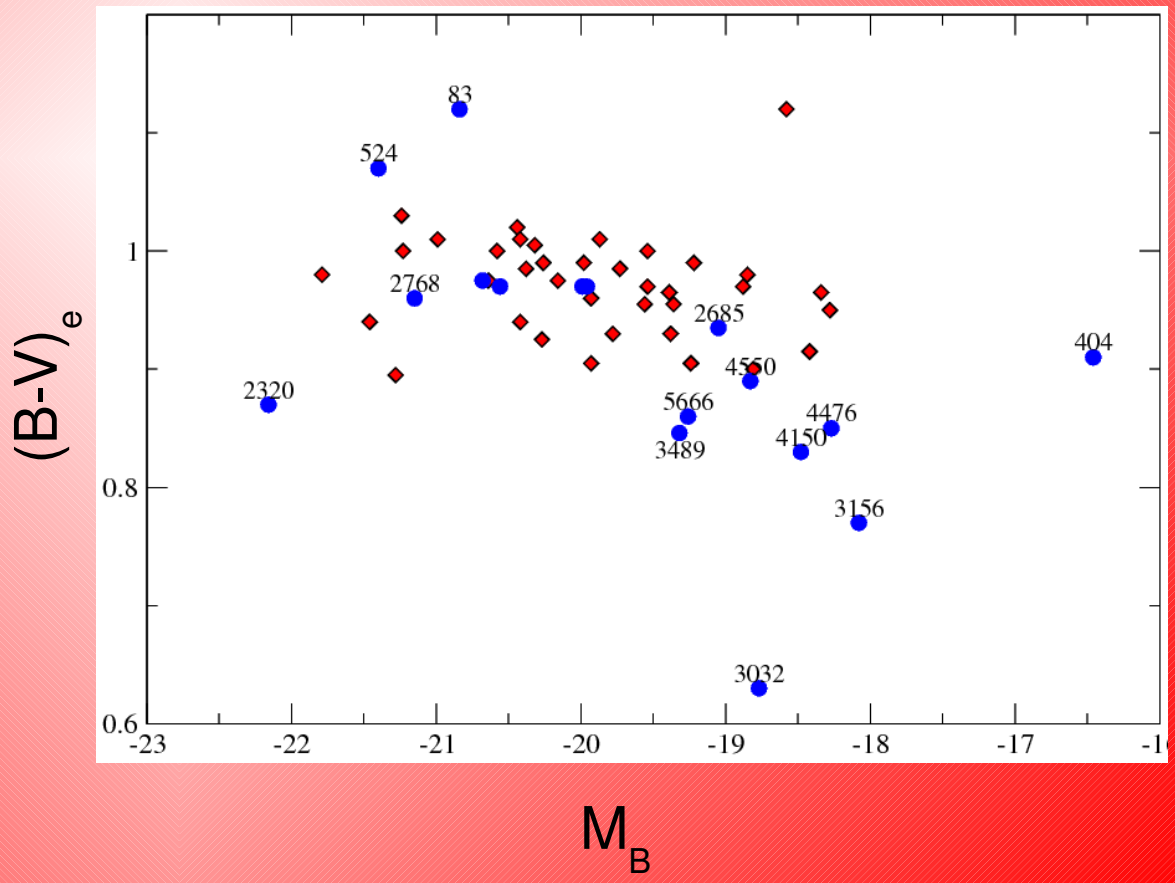


Molecular gas and stellar populations

- 3 diagnostics: optical color, NUV-V color and absorption linestrengths
- 1) Optical color:

8/17 galaxies to the blue side of the red sequence → must have young stellar populations



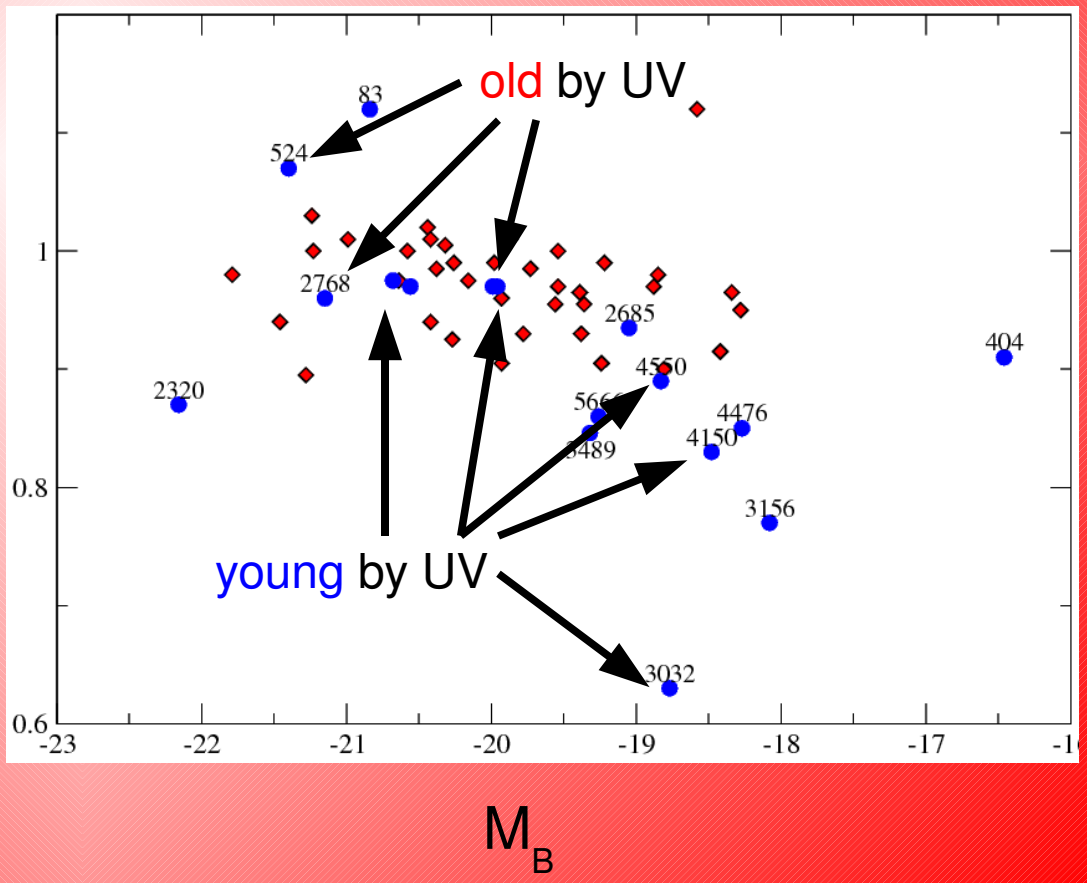


Molecular gas and stellar populations

- 3 diagnostics: optical color, NUV-V color and absorption linestrengths
- 1) Optical color
- 2) NUV-V color:

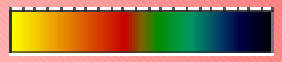
Reveals central young pop in 2 optically red galaxies.

BUT- 3 other E/S0s with molecular gas show no young stars in UV....

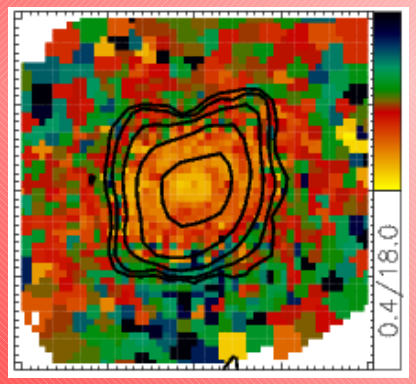


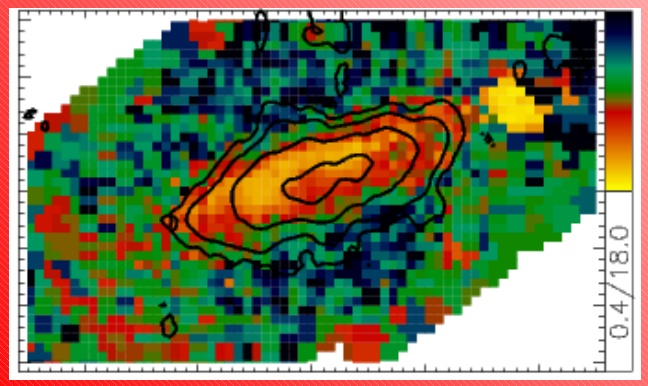
Molecular gas and stellar populations

- 3) Absorption linestrength → stellar population ages via SSP models

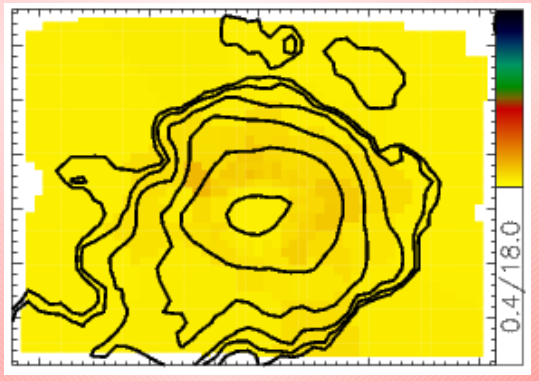
0.4 Gyr  18 Gyr

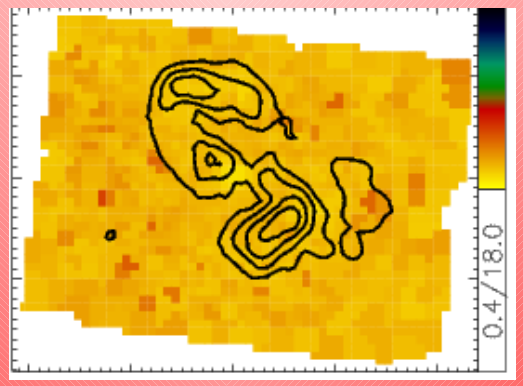
Locally young



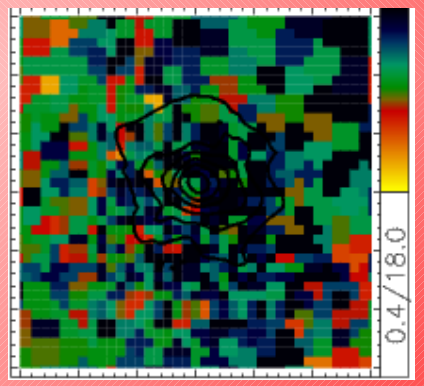


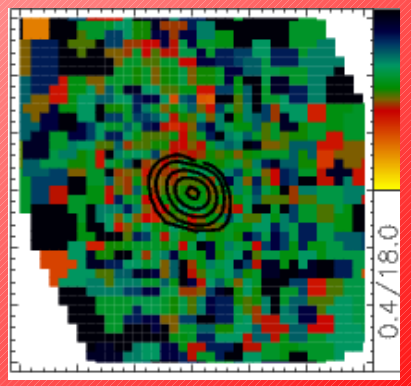
Globally young





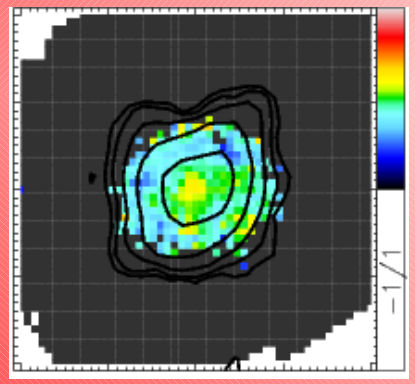
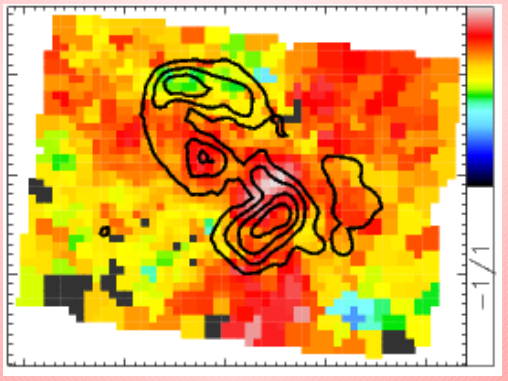
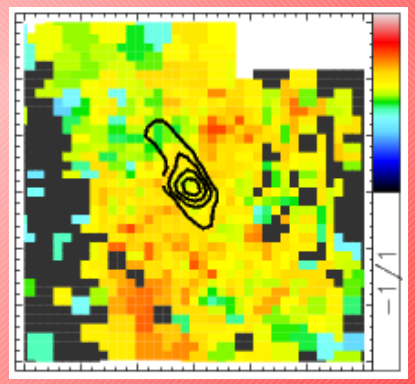
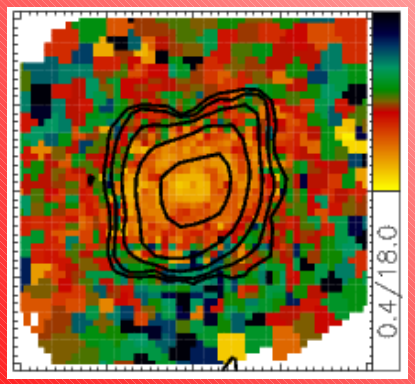
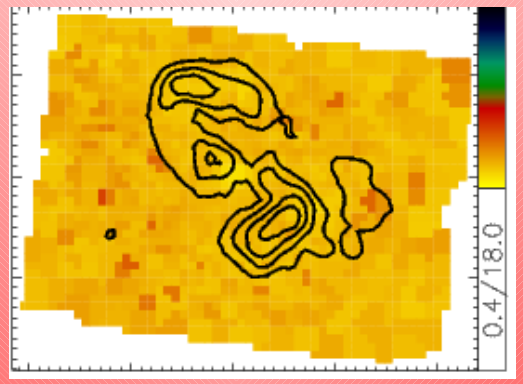
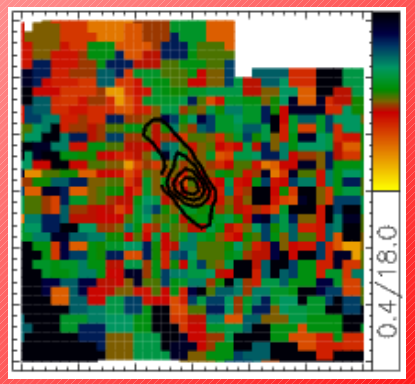
Old





Different stages of evolution

- 3 types:

Definitely star forming:	Post-starburst:	Not star forming:
-star-forming ionisation	-other ionisation	-other ionisation
-young stars	-young stars dominate	-old stars
		
		
9/17	4/17	4/17

SF tracers in E/S0s

- Goal: test if star formation follows same correlations/laws as in spirals/starbursts
- Problem: SF tracers may be significantly contaminated

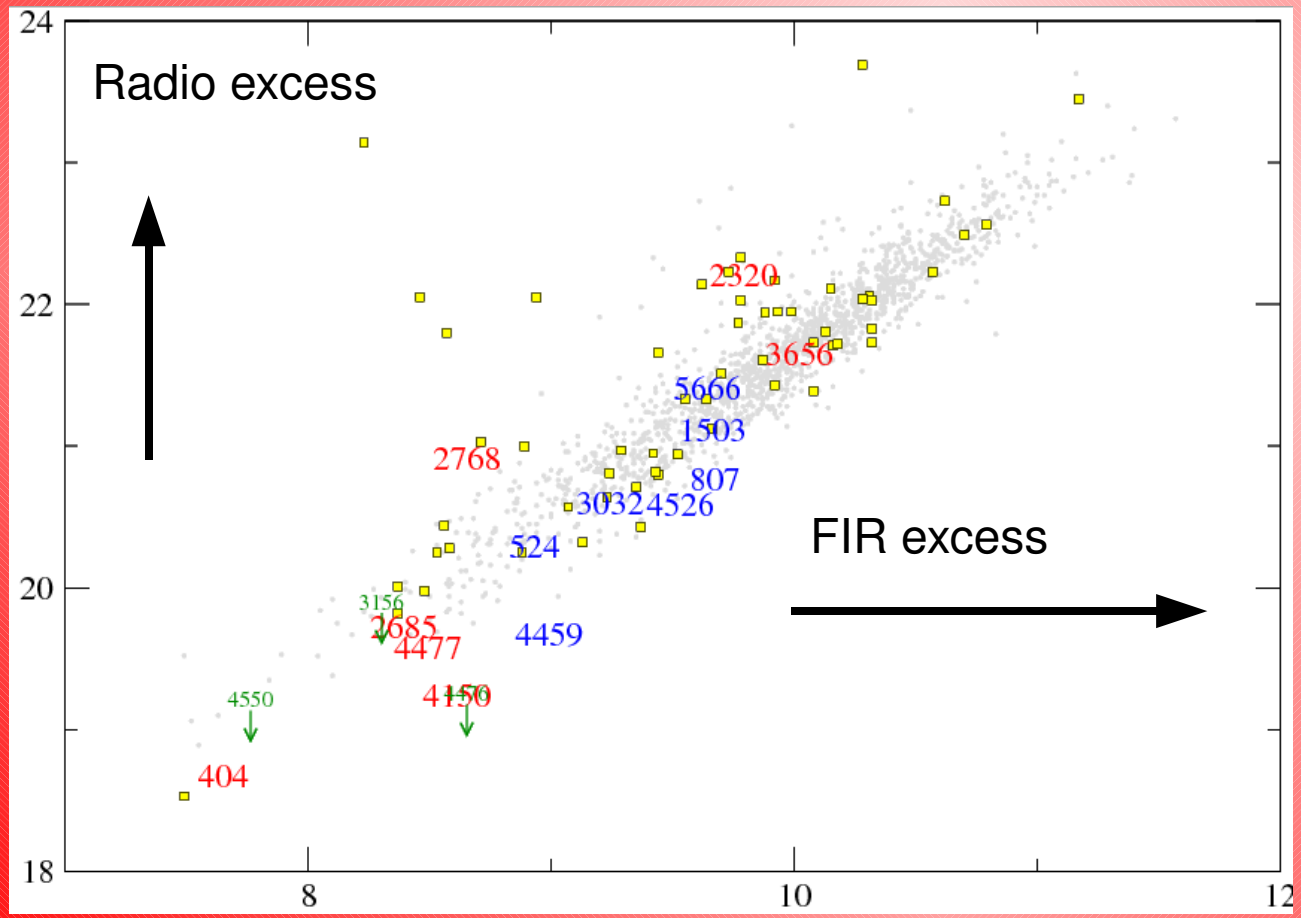
Radio
-contribution from AGN
-magnetic field in E/S0s different than spirals?

Hβ emission line
-contribution from other ionising sources (AGN, pAGB stars)
-unknown extinction

FIR
-contribution from other heating sources (AGN, pAGB stars)
-different dust content?

SF Correlations

- 1) Radio vs. FIR



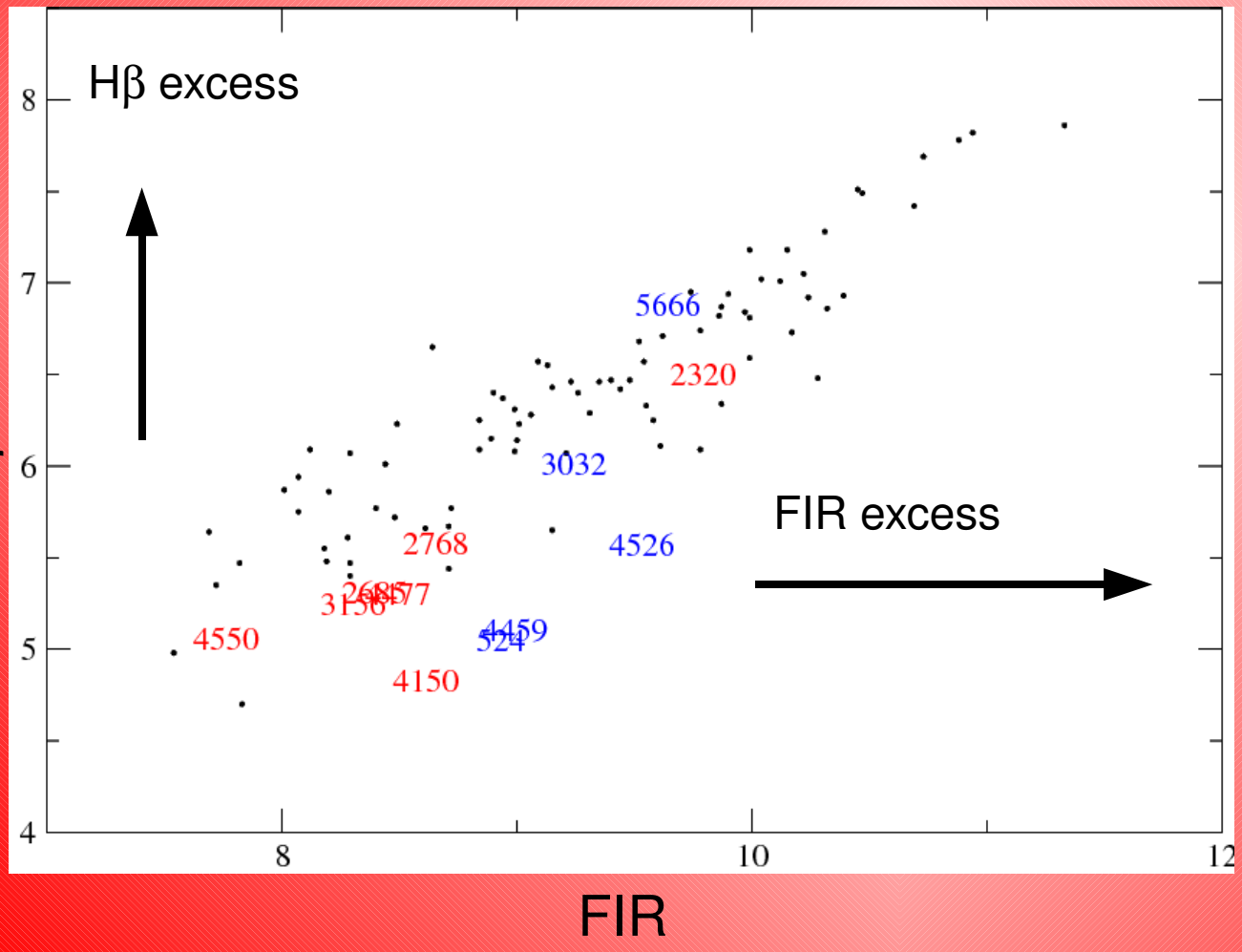
- 2 radio excess galaxies → identifiable as AGN

-3 FIR excess galaxies → ?

-E/S0s tend to lie to the FIR excess (or radio deficient) side of the relation (other than AGN)

SF Correlations

- 2) Hβ vs. FIR



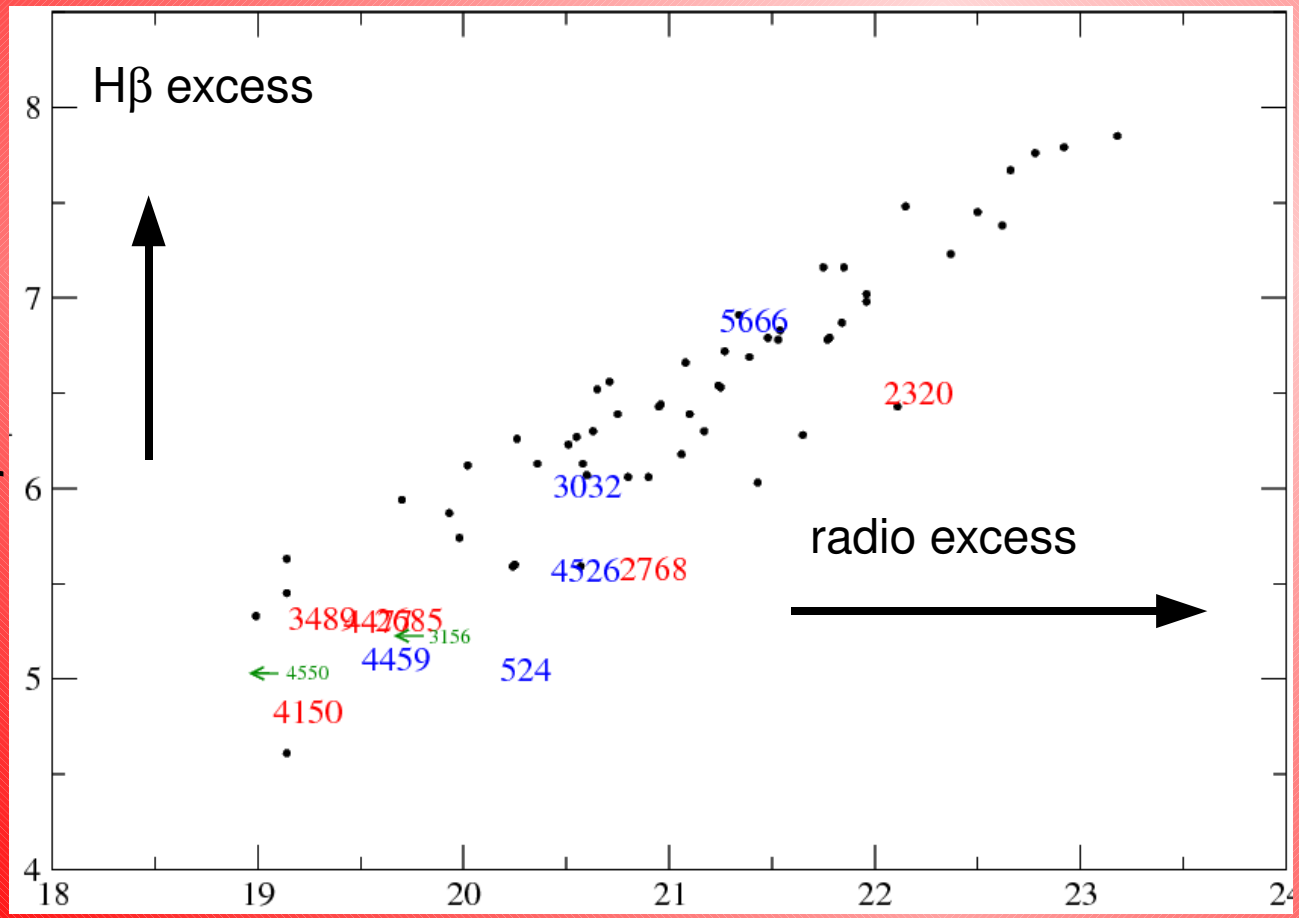
- no true Hβ excess galaxies

-4 FIR excess galaxies → ?

-mostly lie to the FIR excess/Hβ deficient side of the relation

SF Correlations

- 3) Hβ vs. radio



- no true Hβ excess galaxies

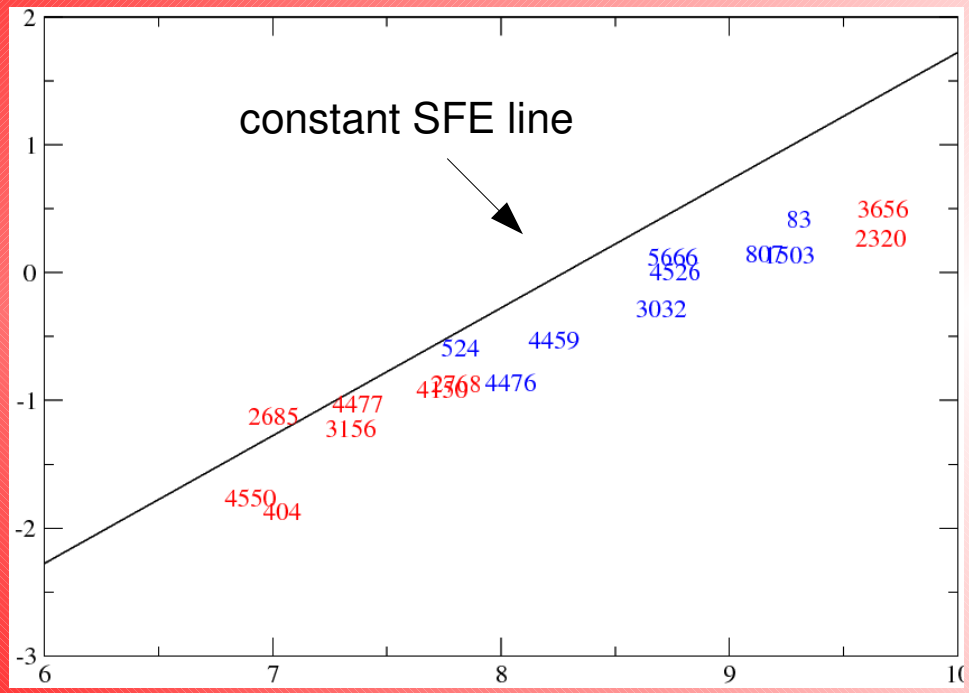
- 2 AGN are radio-excess

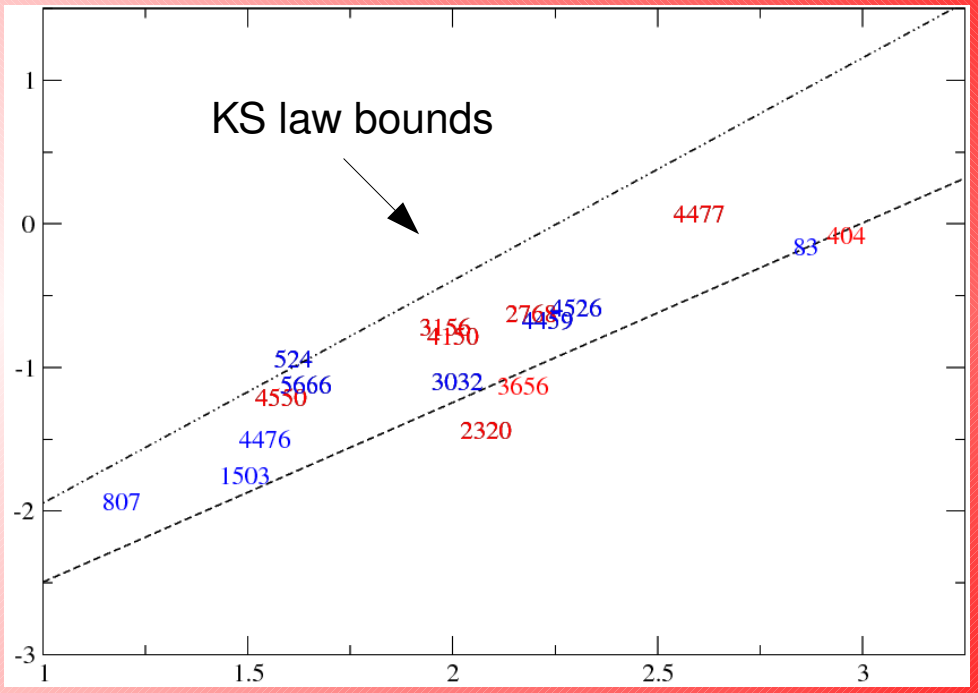
-2 others Hβ deficient

-most lie to the FIR excess/ Hβ deficient side of the relation

SF laws

- 1) FIR-based



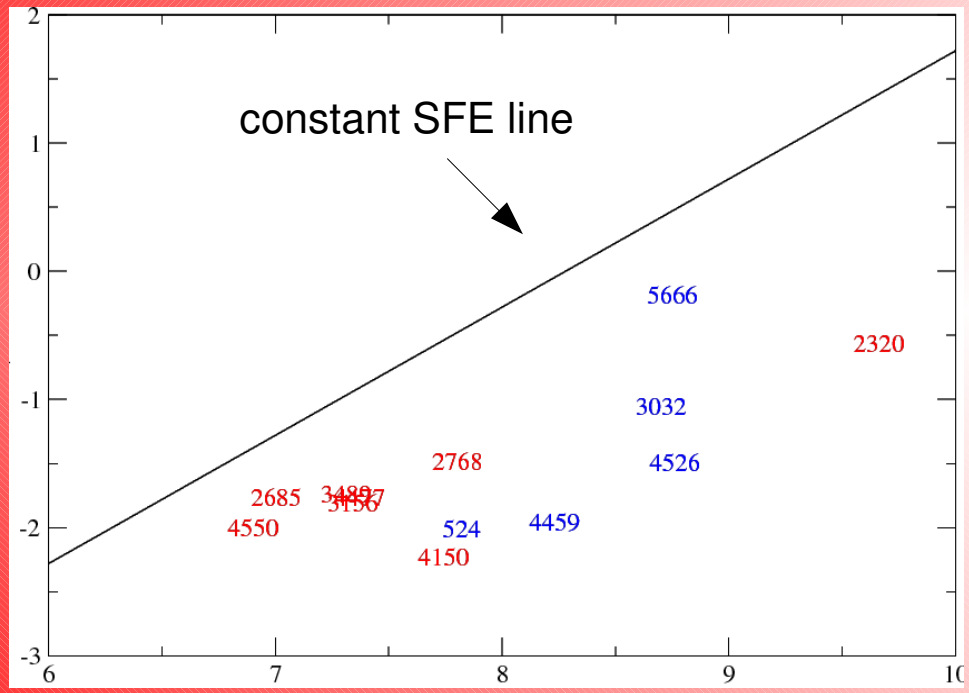


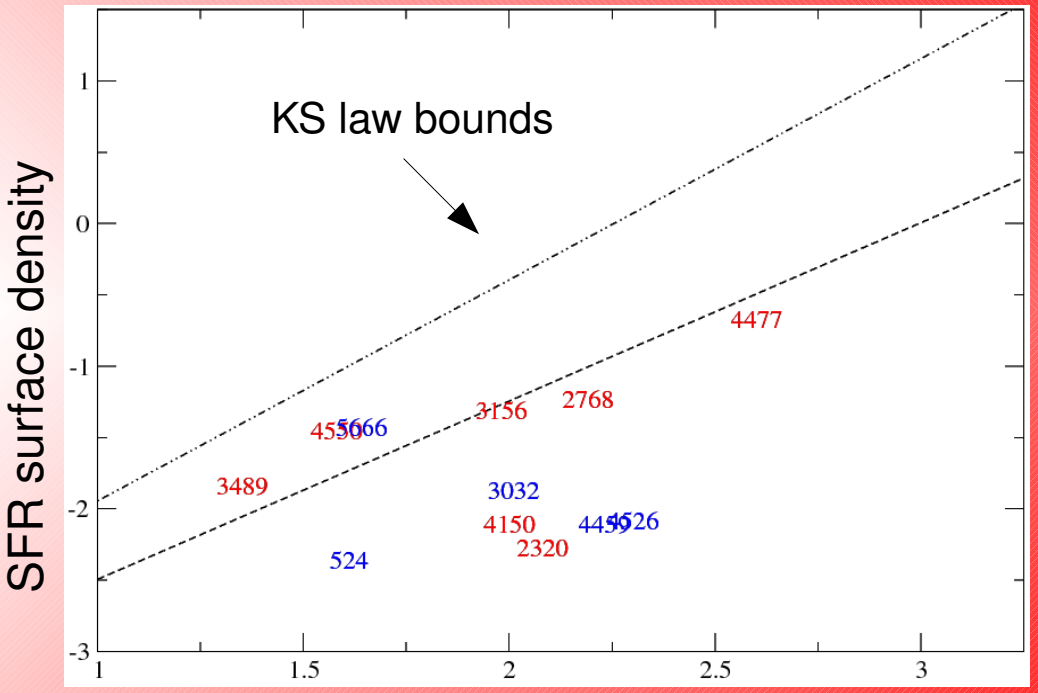
-Very good FIR-H_2 mass correlation, but slope < 1

-Almost all galaxies within KS law bounds

SF laws

- 2) Hβ-based

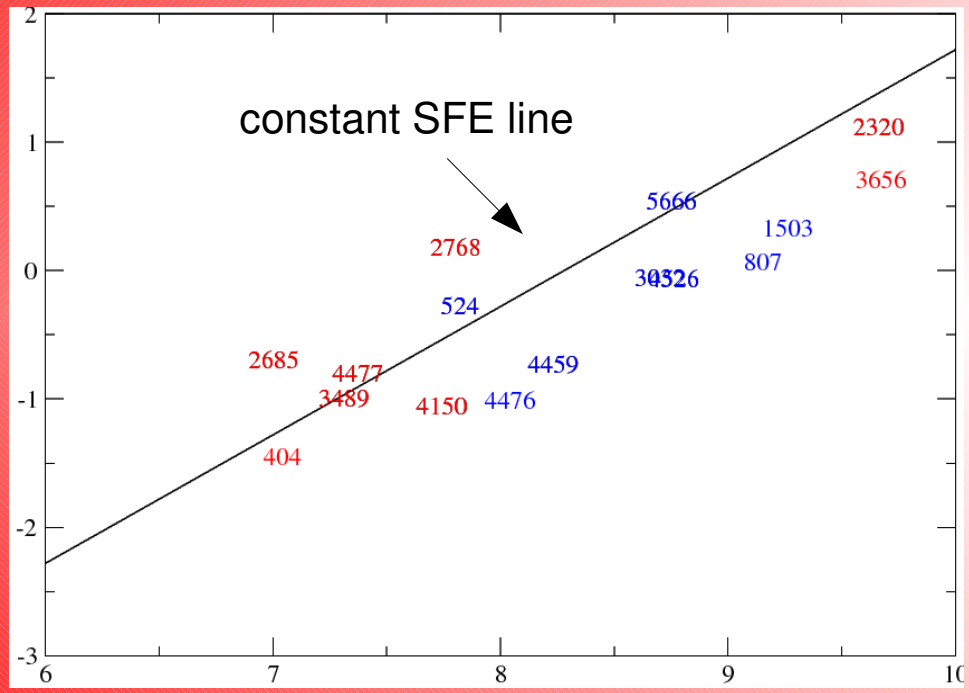


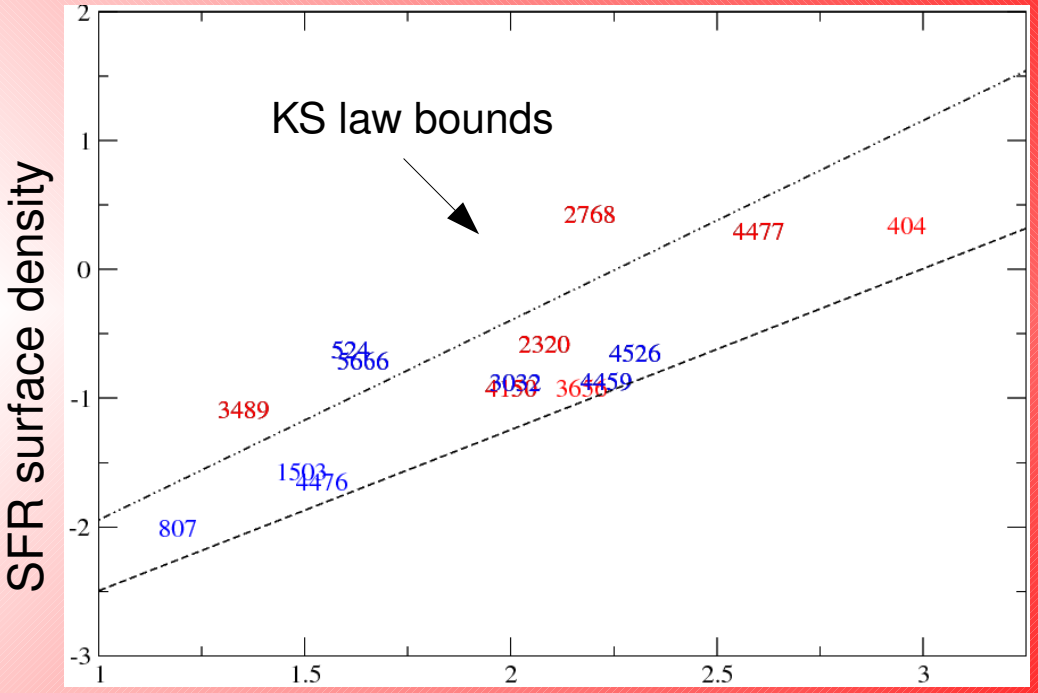


-SFRs far too low → significant extinction

SF laws

- 3) Radio-based





-Decent radio-H_2 mass correlation, despite radio AGN

-Galaxies mostly within KS law bounds

Conclusions

- Despite many potential contaminants, early-type galaxies roughly follow SF correlations and laws
  - Hβ too weak
  - FIR excess galaxies
  - Can other ionisation sources act like star formation?
- Three types of E/S0s with molecular gas:
  - Star forming
  - Post-starburst
  - Not or inefficently star forming