Morphology Distribution of Compact Group Galaxies

By

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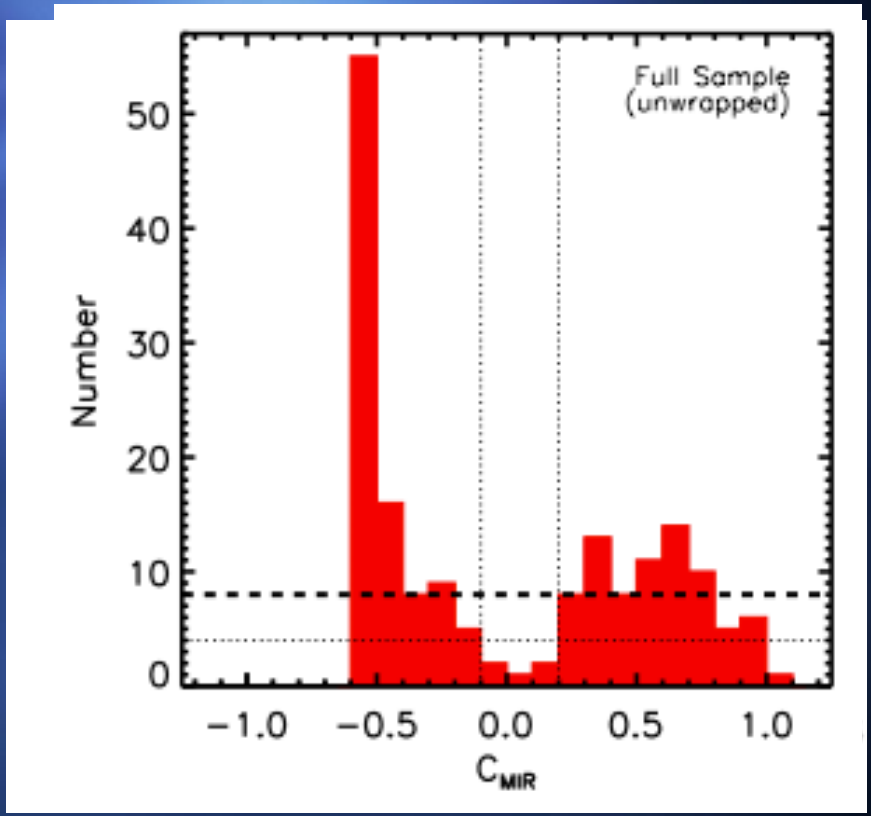
What are Compact Groups?

- Similar environment to the early universe
  - High Number Density and Low Velocity → strong tidal forces
- Dynamically bound systems
  - Short time scales due to merging
- Our Compact Groups (CG) can be broken up into two subsections:
  - Hickson Compact Groups (HCG)
  - Redshift Survey Compact Groups (RSCG)

HCG 92

Star formation in CG

- Star formation in this extreme environment
  - IRAC looked at PAH* emission as a tracer of warm dust and SF
- Gap in MIR colors between gas rich and gas poor galaxies
  - Indicating a short crossing time
- The canyon region is where where the number distribution of galaxies falls less then half of the median
- Walker 2010 found that the canyon is distinct characteristic of CG

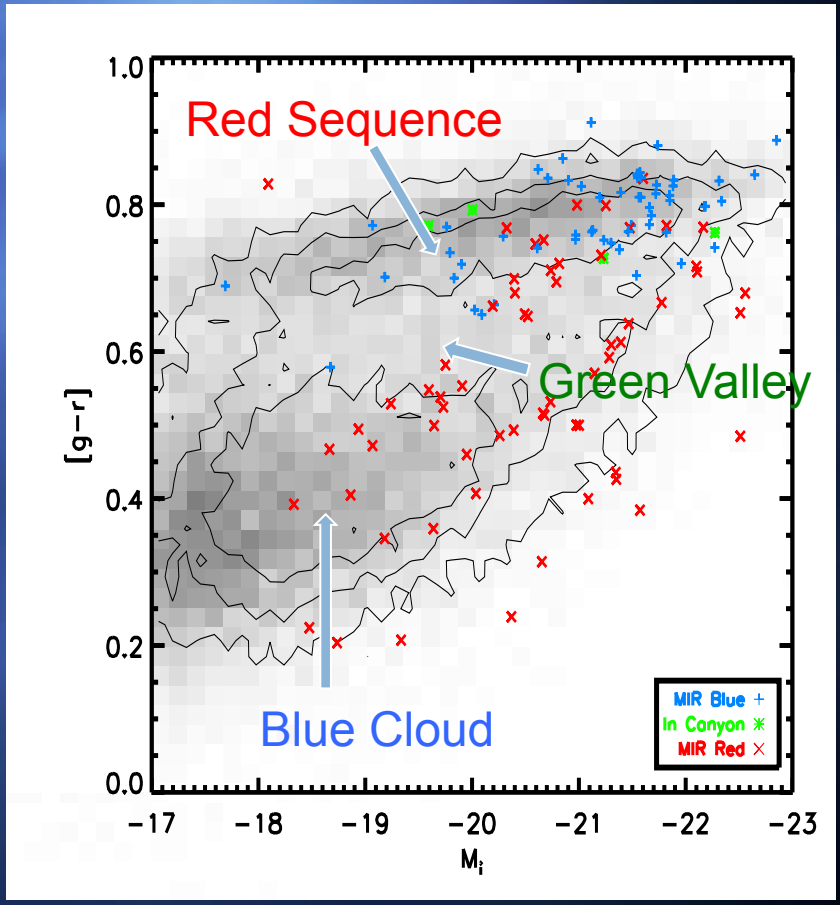


Walker et al. 2012

*PAH=polycyclic aromatic hydrocarbon

Compact Groups in Optical

- 3 regions in optical
  - Red Sequence
    - Mainly ellipticals (red stars)
  - Blue Cloud
    - Mainly spirals (blue stars)
  - Green Valley
    - Transition of blue stars dying off and galaxy becoming redder
    - Short crossing time~ lifetime of blue stars
- Did not find a connection in the canyon to GV
- CGs do not show the same trend as field galaxies (contours)
  - CGs don't show characteristics of the blue cloud or green valley

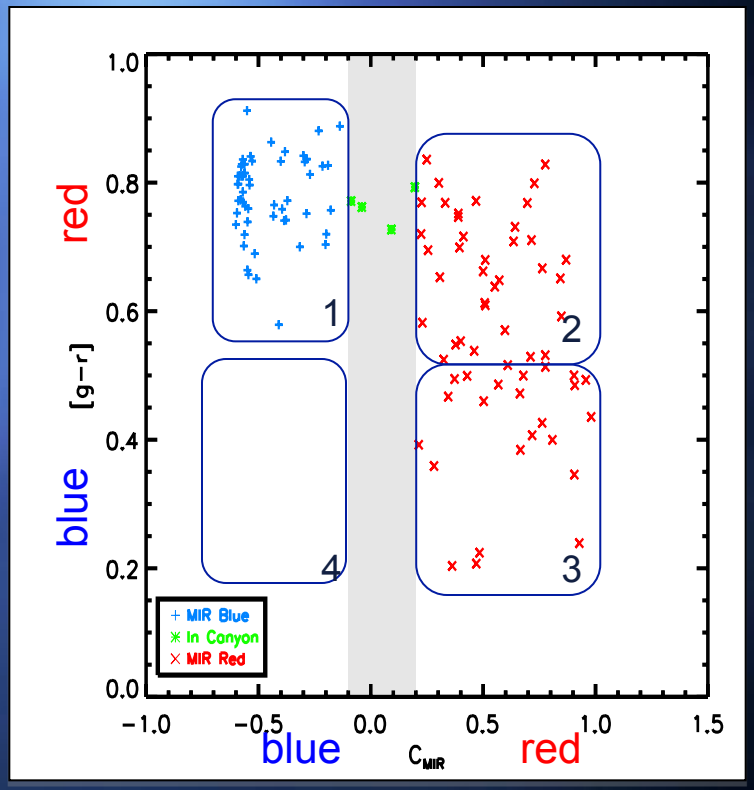


Optical vs. Mid-IR (Optmir)

- When comparing the optical and MIR we gain insight on star formation in CGs
- Larger population of optically red galaxies than blue

1.	Blue MIR + Red Opt → "Red and Dead"
2.	Red MIR + Red Opt → "Dusty"
3.	Red MIR + Blue Opt → "Current SF"
4.	Blue MIR + Blue Opt → "SF Recently ended"

- Large spread in MIR red

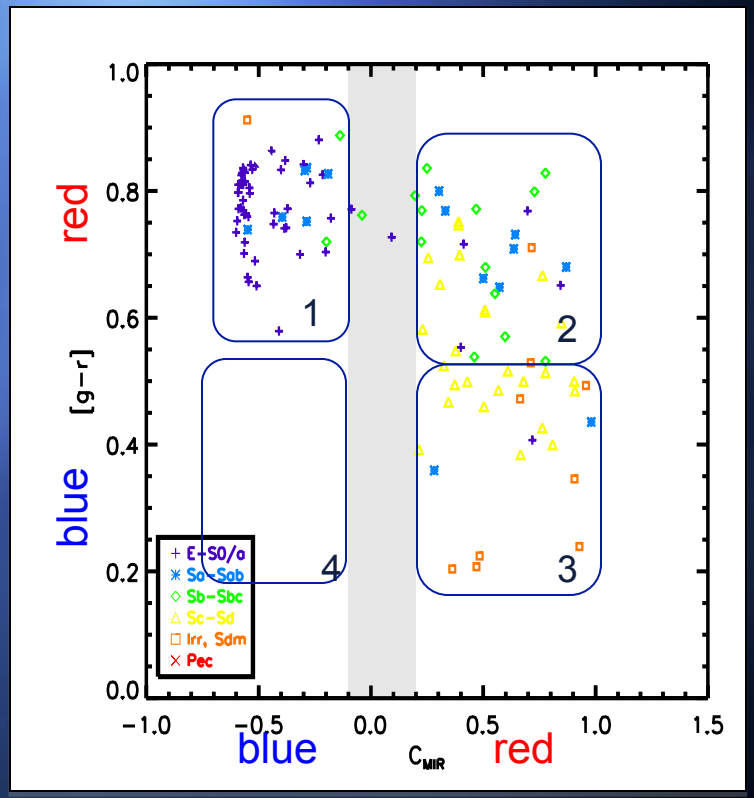


Morphology from NED

- When comparing the optical and MIR we gain insight on star formation in CGs
- Larger population of optically red galaxies than blue

1. Blue MIR + Red Opt → "Red and Dead"
2. Red MIR + Red Opt → "Dusty"
3. Red MIR + Blue Opt → "Current SF"
4. Blue MIR + Blue Opt → "SF Recently ended"

- Large spread in MIR red
- Morphology only indicates spirals and ellipitcals
- With current morphology, no ties between type and location



Why should we care?

- Similar environment to the early universe
- More than just elliptical and spiral, WISE can indicate activity in the galaxies
- The evolution of galaxies and how they interact
- Snapshots of different points of merging in groups
- Final result is galaxy mergers, indication of how large elliptical galaxies form?

HCG 44

Science Questions

- How do WISE classifications compare to NASA/IPAC Extragalactic Database (NED) and the literature?
- How does activity affect where galaxies fall in the "Optmir" plot?
  - Does this give insight on stages of star formation?
- Does this give an indication on the types of galaxies in the "Green Valley?"
  - Are they a transition from blue cloud to red sequence?
- Compact groups have strong tidal forces, how does this effect the HI gas in and in between the galaxies?

HCG 59

Data

- 33 Compact Groups (CGs) [129 galaxies]
  - Chosen from Hickson Compact Group (HCG) and Redshift Survey Compact Group (RSCG) catalogs

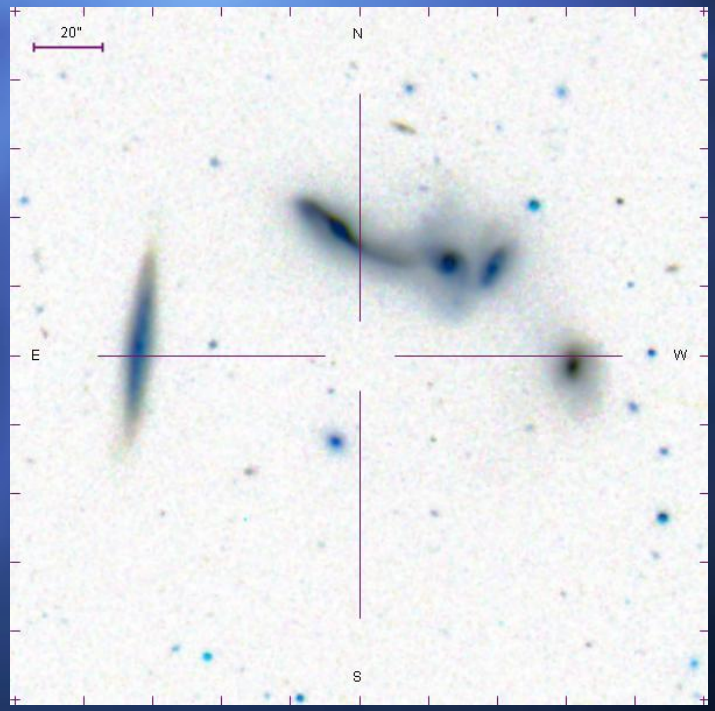
- HCG:
  - Palomar Sky Survey
  - Isolation
  - Magnitude limited
  - Compactness
- RSCG:
  - Minimum redshift
  - Other selection criteria similar to HCG

Selection criteria included CGs that have both Spitzer and Sloan data available

WISE Data

- Use WISE point source catalog
- Cores of galaxies point sources
  - Determining spatial extent of galaxies is difficult
- Use bands 3.4, 4.6, and 12 μm

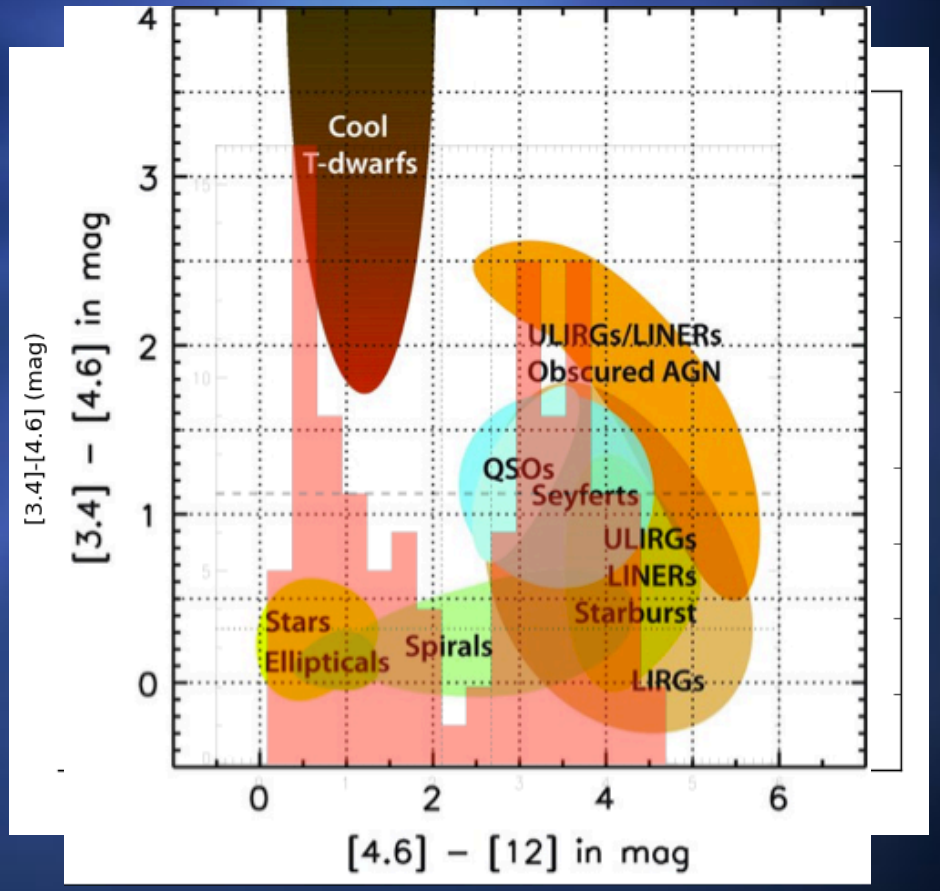
HCG 56



SDSS image with WISE point source catalog

Our findings

- A lot more than just spirals and ellipticals
  - We see the activity of the galaxies
- A wide spread in [4.6]–[12] but a narrow band in [3.4]–[4.6]
- We also see a gap in the wise data, falls around spiral regions, separating active and inactive galaxies



Comparison With NED

Main Catalog:

-de Vaucouleurs et al. 1991

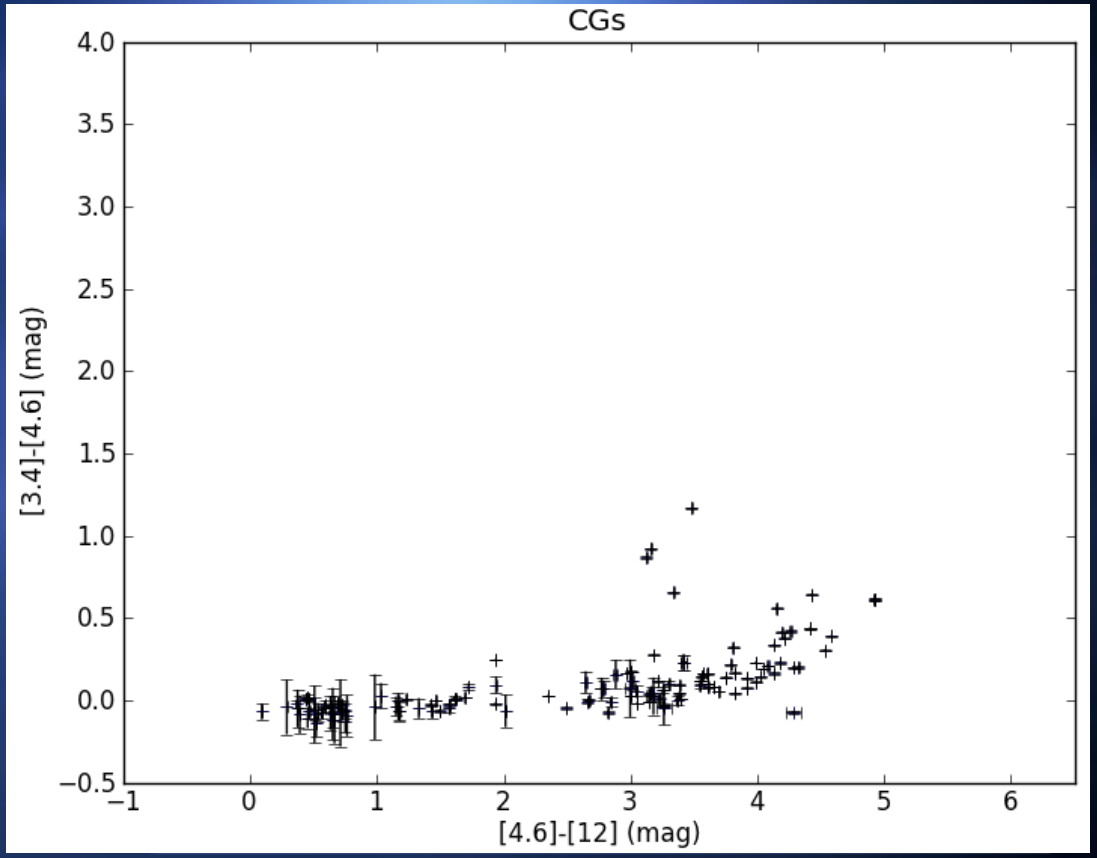
- Similar to Hubble's identification process

-Incompleteness

-Classified galaxies based on the color-color

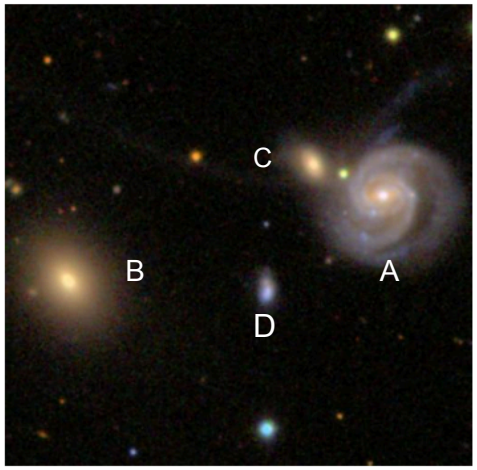
-Took into account errors

-Found 2 QSOs, 2 Seyferts, Starbursts, ULIRGS/LINERS, and LIRGS



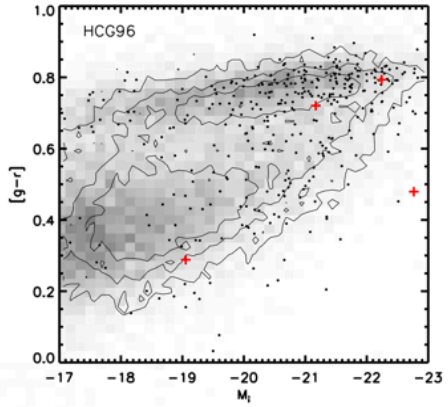
HCG 96

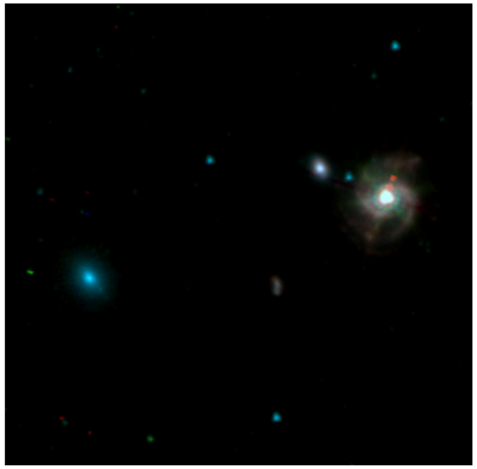
- 4 Member Galaxies



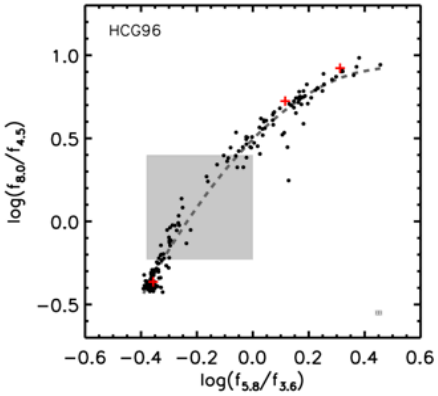
SDSS image

Optical

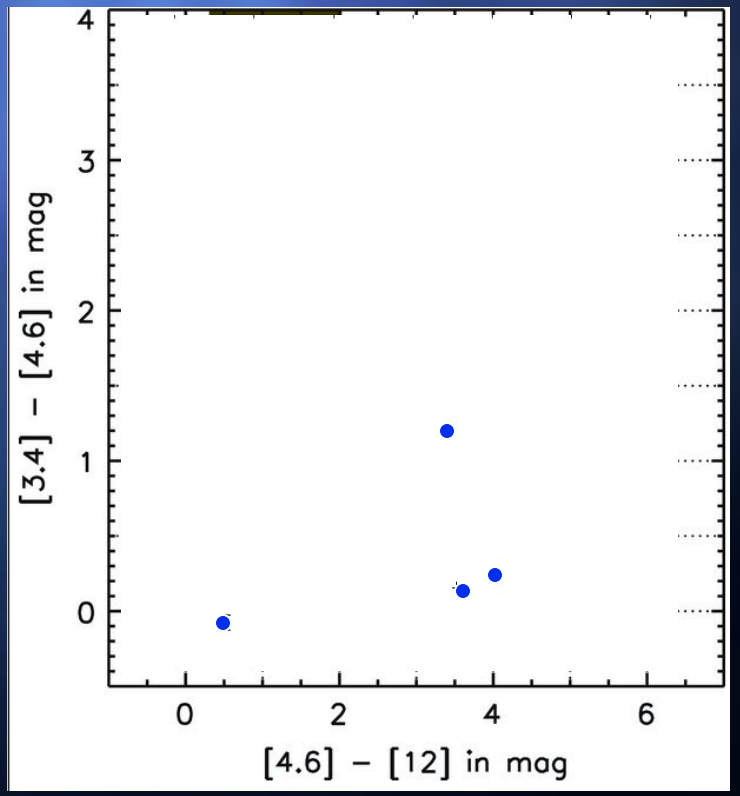



Spitzer 3-color image

MIR

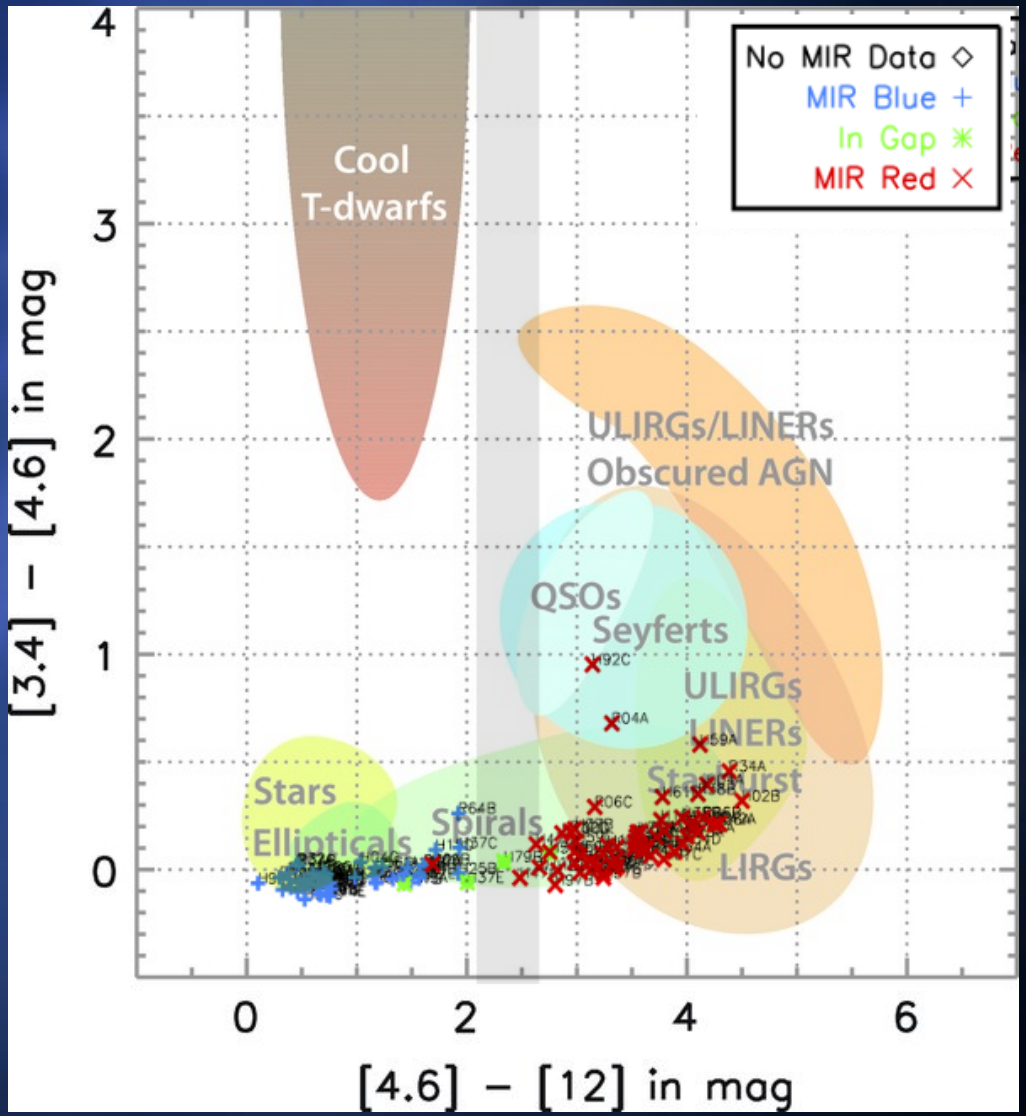


Member	NED ID	ID
A	SA	QSO
B	SAB0	Elliptical
C	S	Spiral/LIRG
D	N/A	Starburst



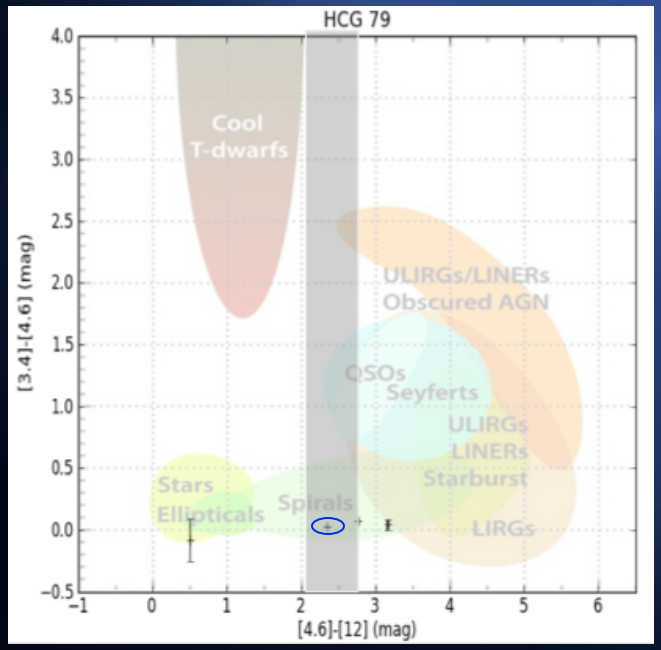
Connection with Spitzer

- Colors correspond to location in Spitzer MIR plot
  - Red (warm dust/PAHs) is mostly in the active starforming region
  - Blue is mainly spirals and ellipticals → inactive
- Canyon
  - We only see one MIR canyon galaxy falling in our canyon (H79B)



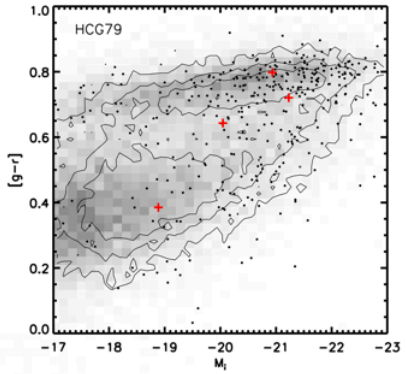
HCG 79 (canyon)

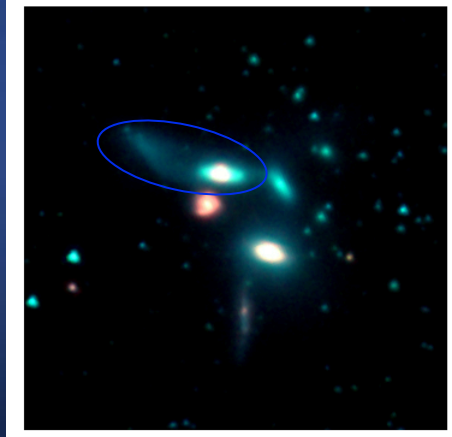
- H79B consistently falls in the under dense (canyons) regions of both plots
- Nothing extremely unusual in optical and MIR, besides a cold tidal tail
- Besides canyon, nothing unusual in wise



SDSS image

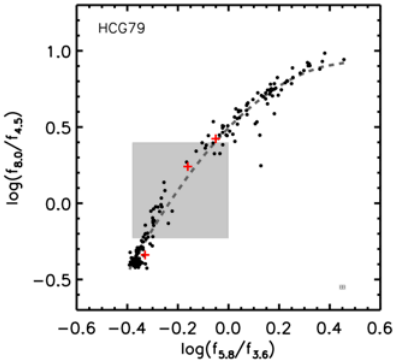
Optical

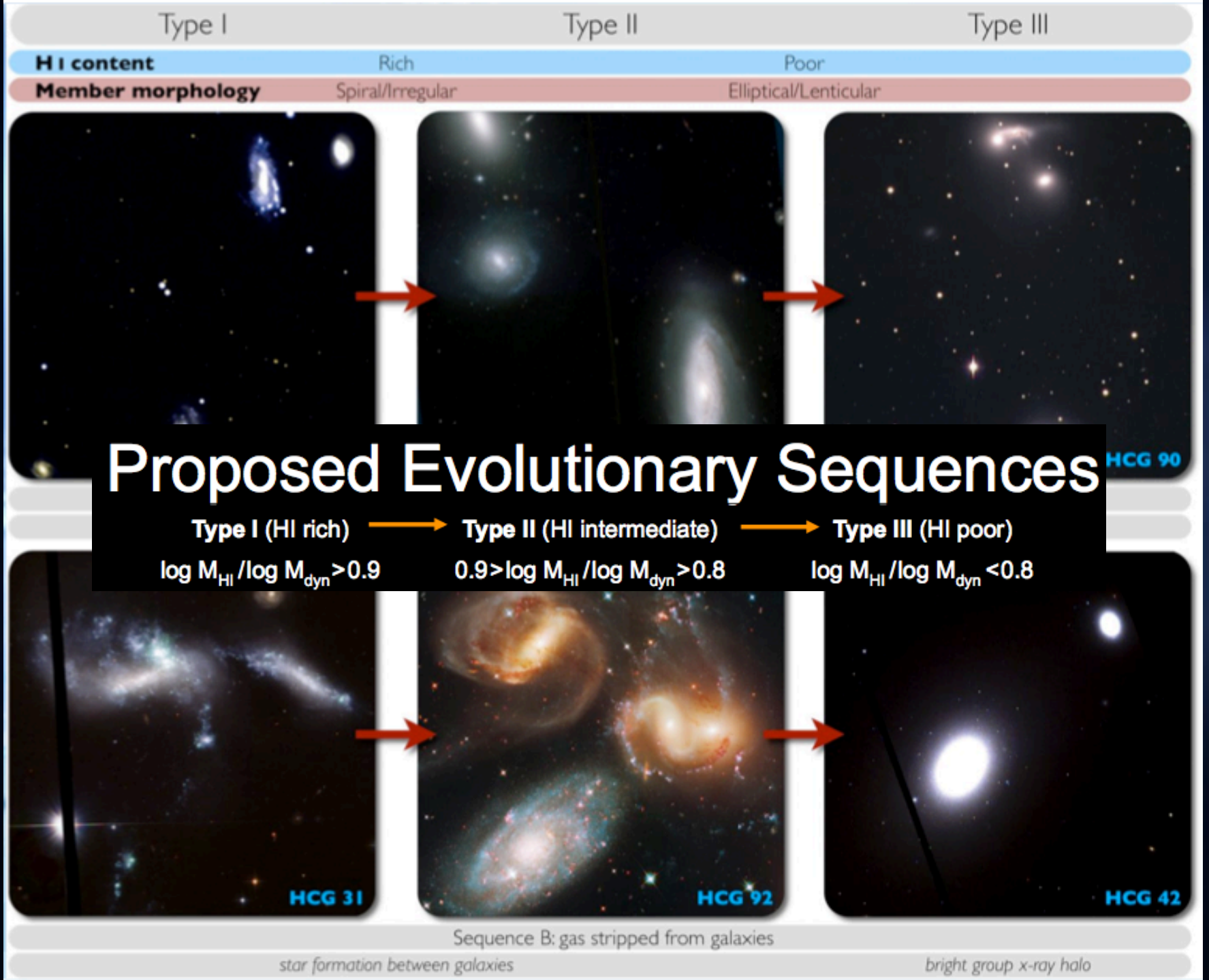




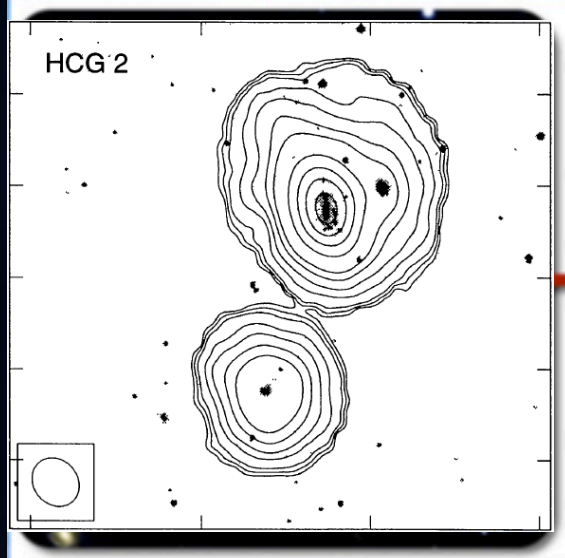
Spitzer 3-color image

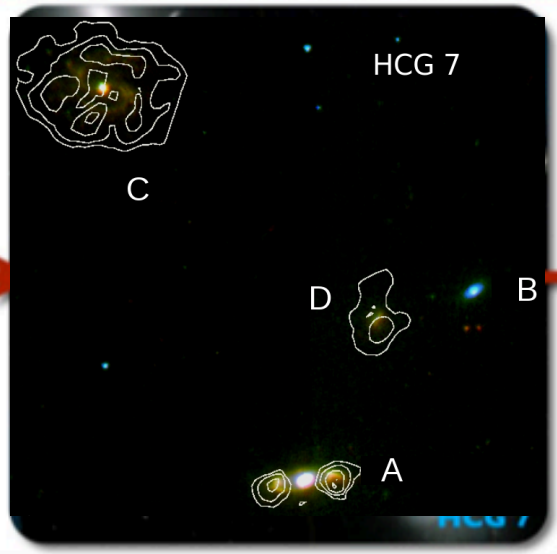
MIR

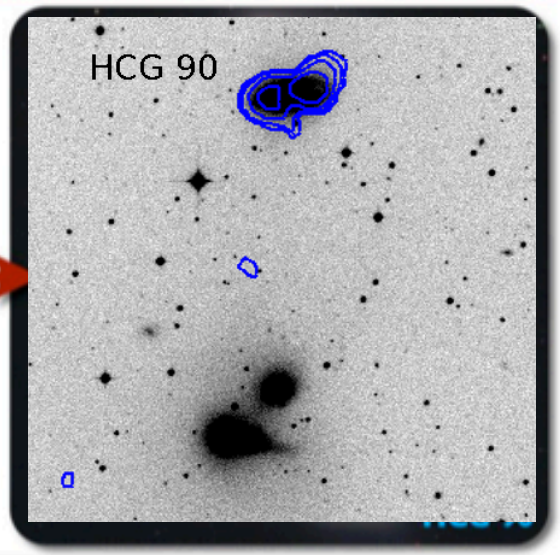



Type I
Type II
Type III
H I content
Rich
Poor
Member morphology
Spiral/Irregular
Elliptical/Lenticular
HCG 90
Proposed Evolutionary Sequences
Type I (HI rich)
Type II (HI intermediate)
Type III (HI poor)
log M_HI /log M_dyn >0.9
0.9>log M_HI /log M_dyn >0.8
log M_HI /log M_dyn <0.8
HCG 31
HCG 92
HCG 42
Sequence B: gas stripped from galaxies
star formation between galaxies
bright group x-ray halo

	Type I	Type II	Type III
H I content	Rich		Poor
Member morphology	Spiral/Irregular		Elliptical/Lenticular

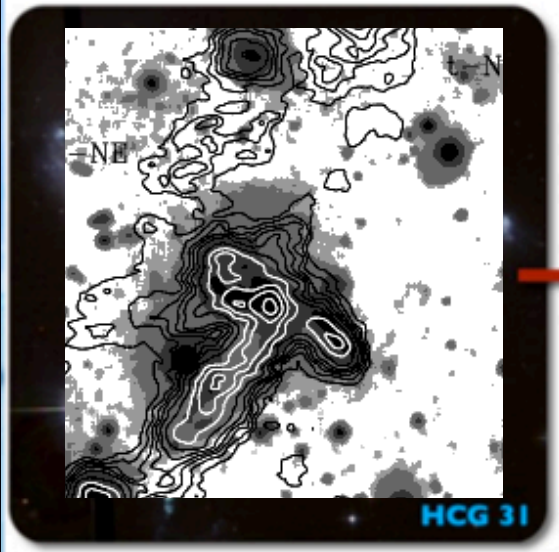


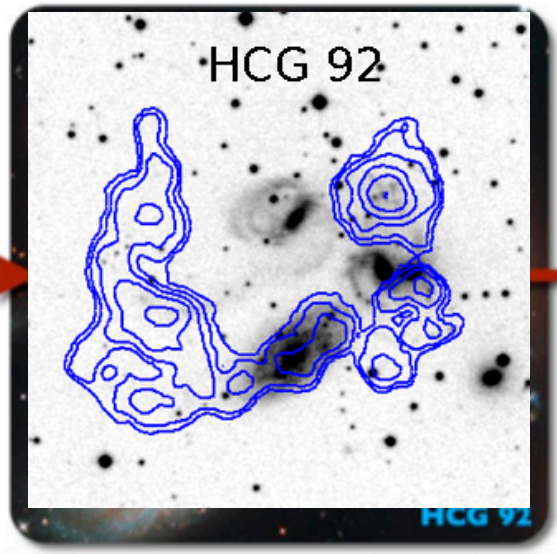


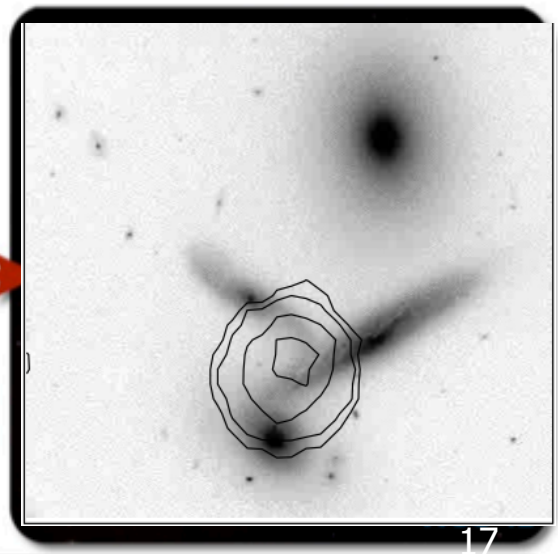


Sequence A: gas contained in galaxies

star formation within galaxies — *no/faint group x-ray halo*







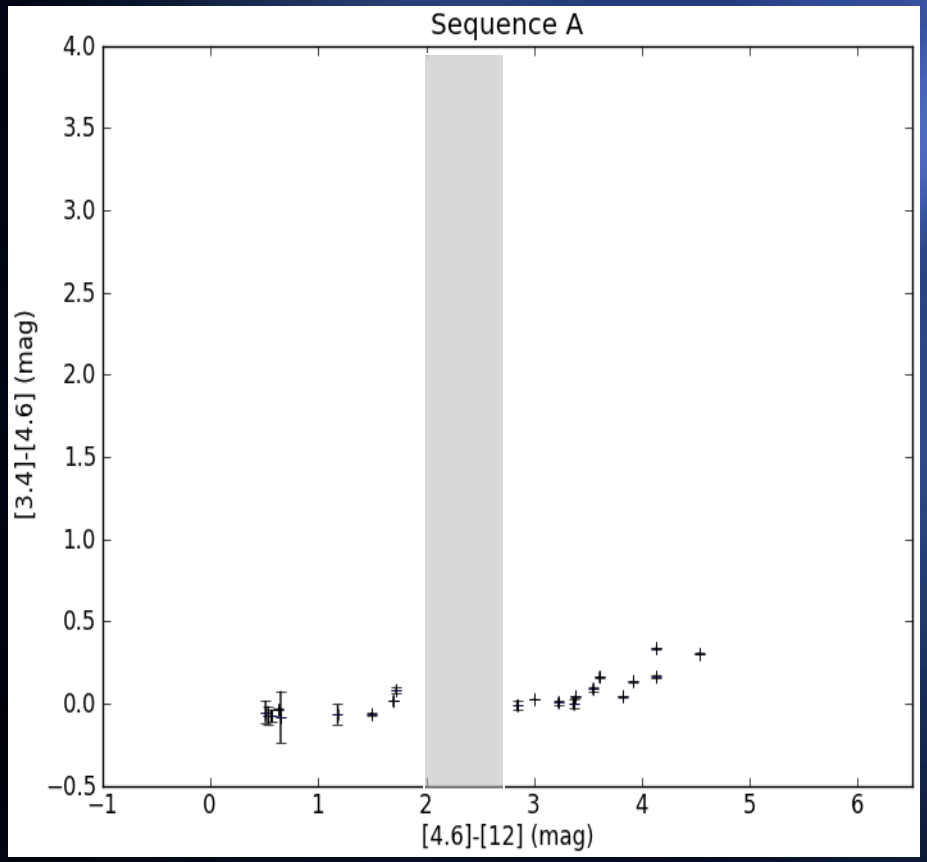
Sequence B: gas stripped from galaxies

star formation between galaxies — *bright group x-ray halo*

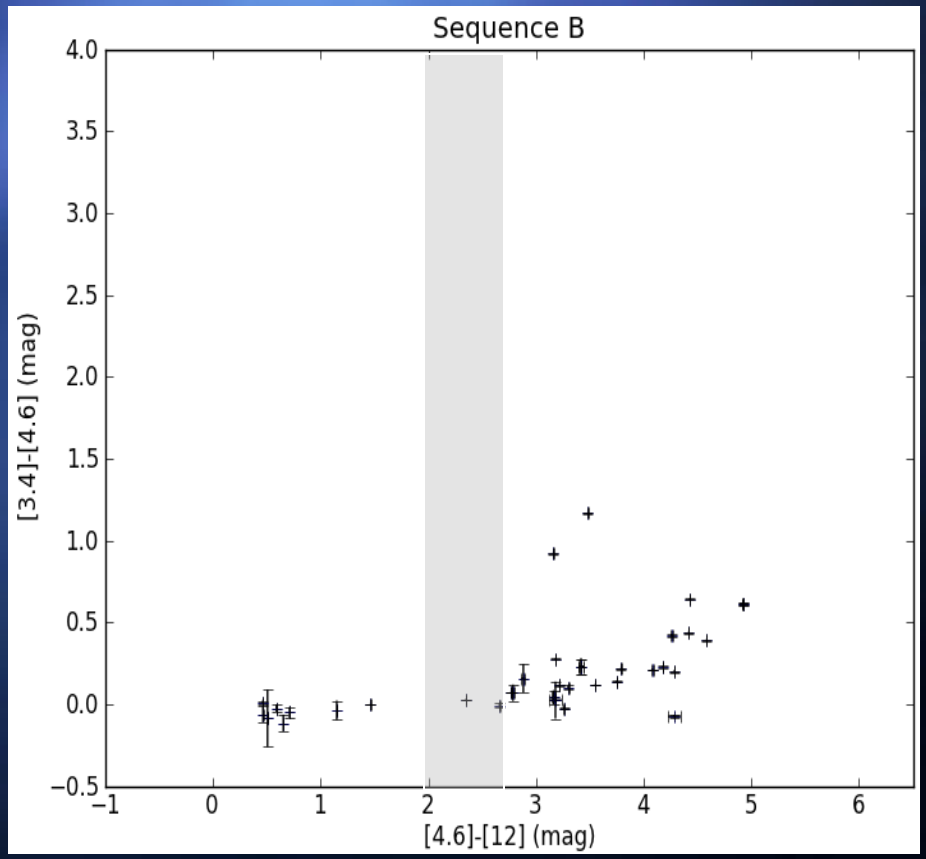
HI connection?

- For the groups that had HI contour data, we plotted Sequence A and Sequence B

Sequence A

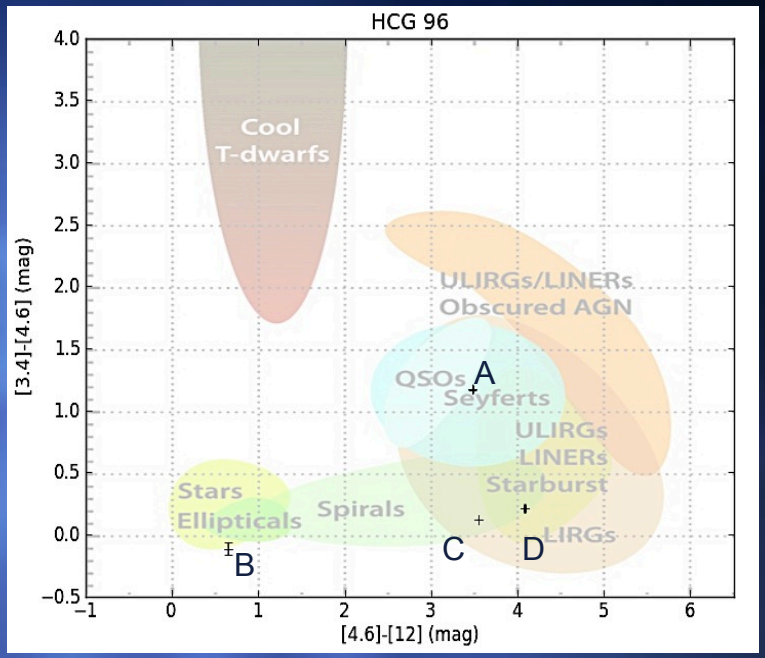


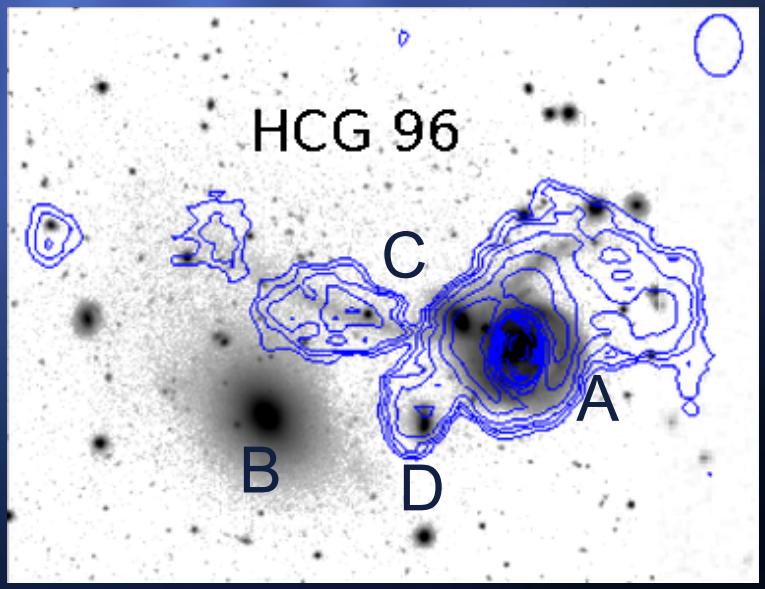
Sequence B



HI connection?

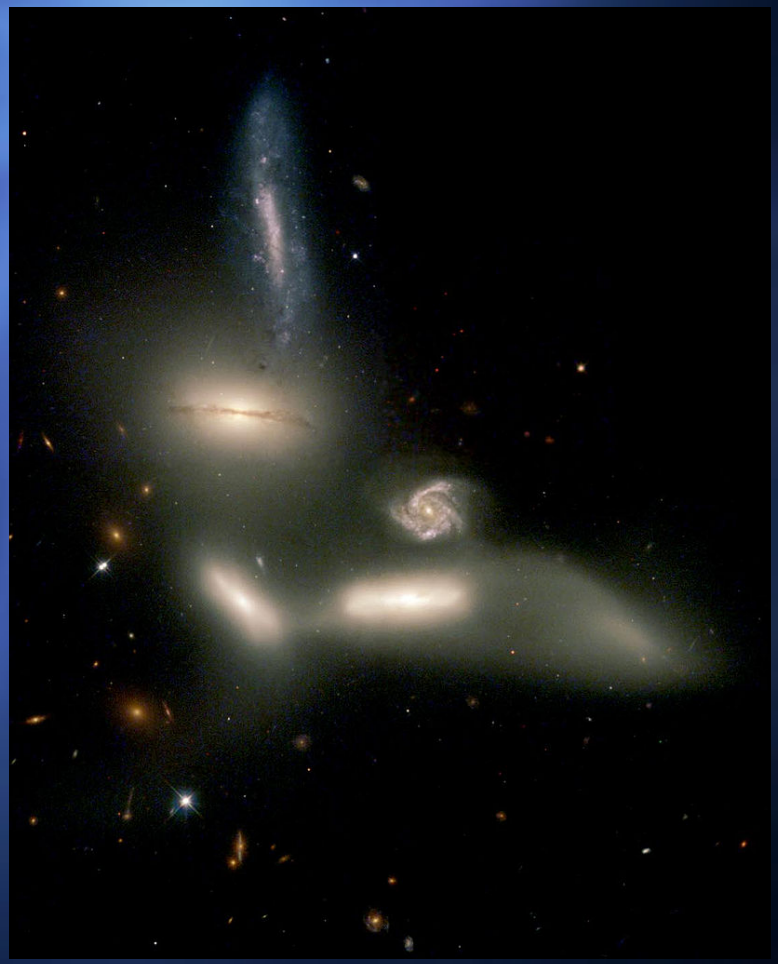
- In one of the galaxies (H96A) we see a significant correlation between HI and location in WISE
  - The location seems to be correlated to the amount of HI in the galaxy
- Oversaturation in MIR image
- In the evolutionary sequence this group is classified as Sequence B, Type II group





Our conclusions

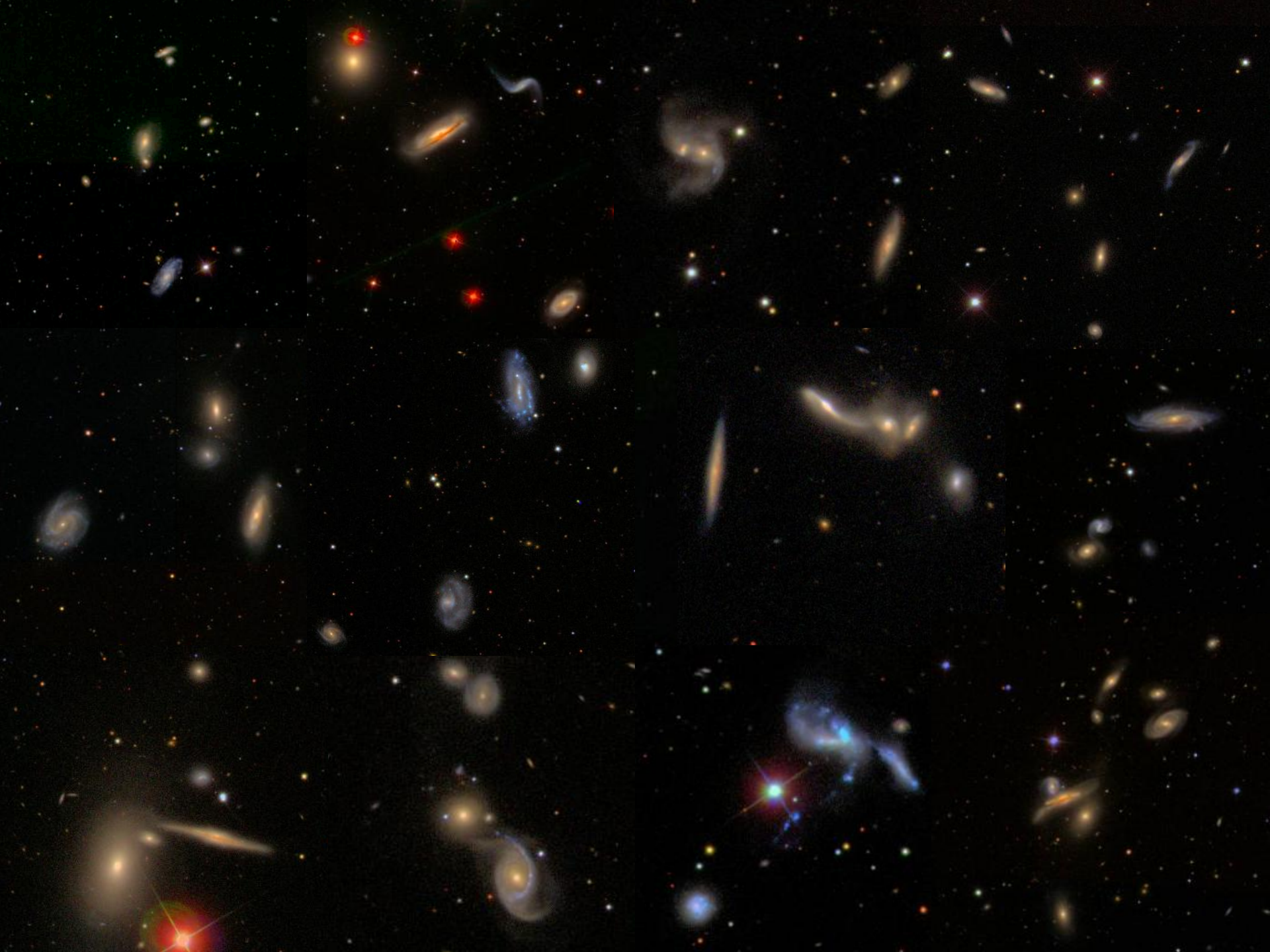
- Classified galaxies based on activity
  - Better than photometric plates
- Compared to NED
  - A systematic identification
  - Identified QSOs
- Identification of canyon galaxies
  - Smaller canyon region needed?
- Correlation between HI content and activity of CGs in WISE morphology



HCG 79

References

- Walker, L. M., Johnson, K. E., & Gallagher, S. C. et al. 2012, AJ, 143, 69
- Hickson, P. 1982, *ApJ*, 255, 382
- Barton E., Geller M., Ramella M., Marzke R. O., da Costa L. N., 1996, *AJ*, 112, 871
- Johnson, K. E., Hibbard, J. E., & Gallagher, S. C. et al. 2007, *AJ*, 134, 1522



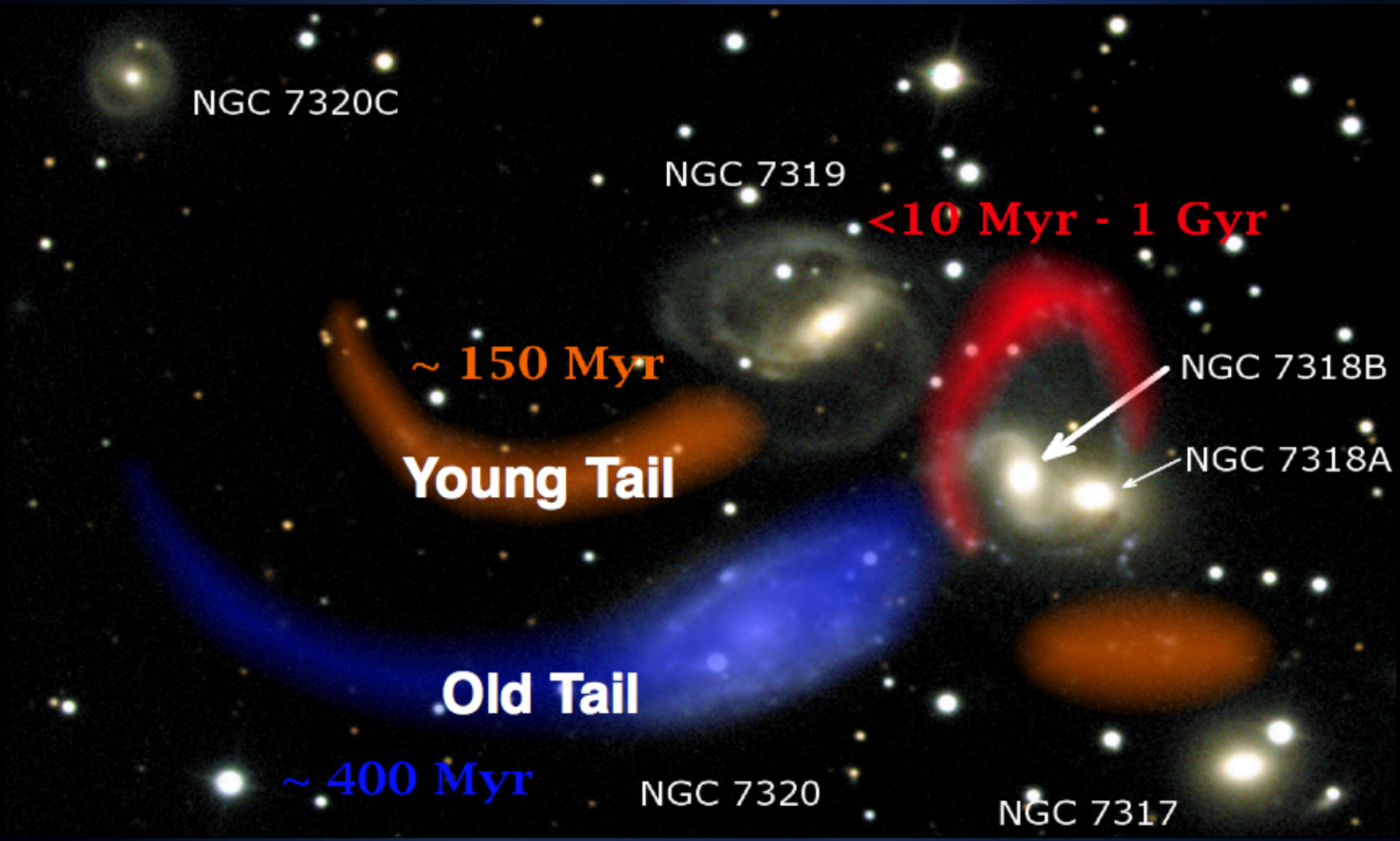
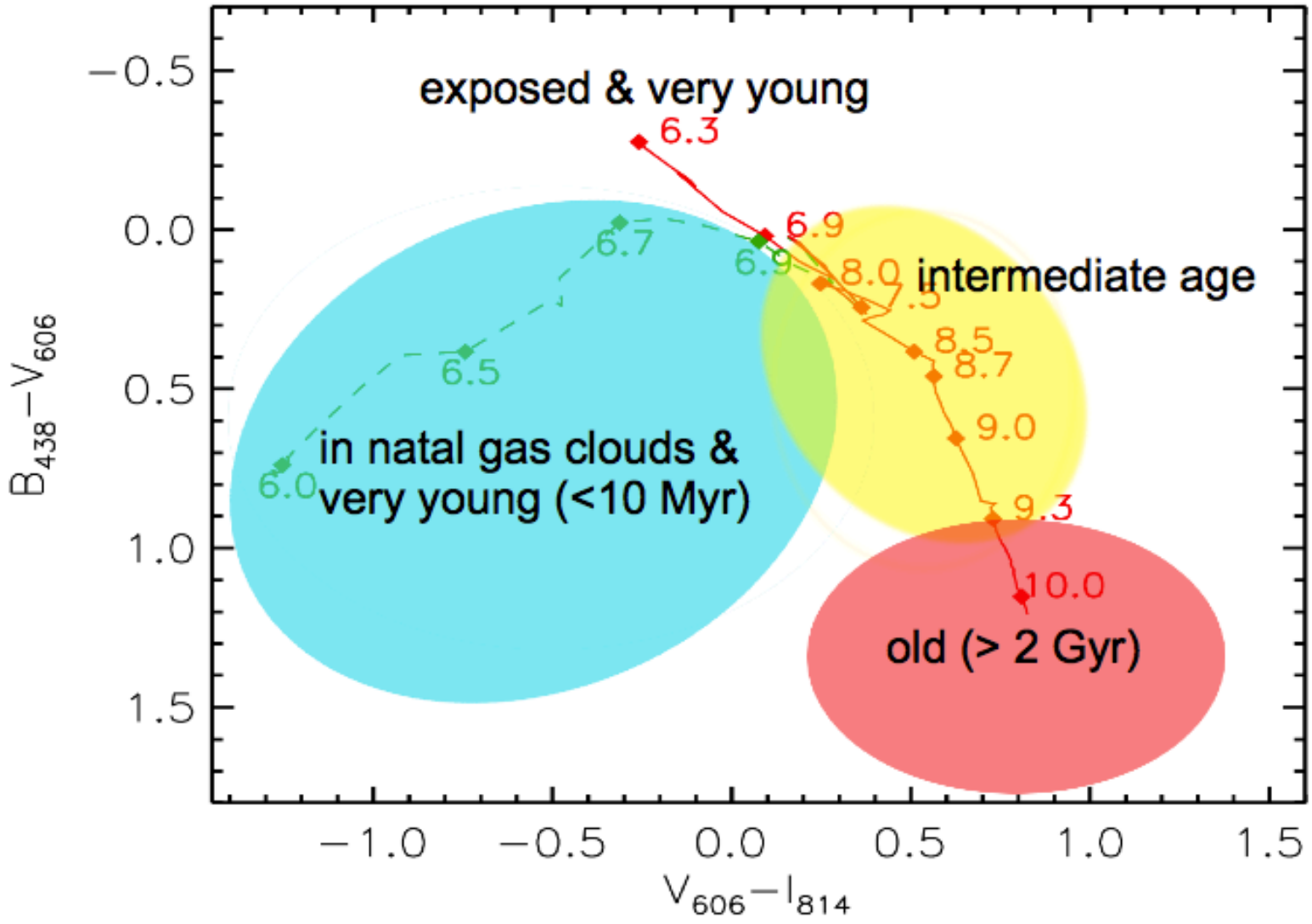


Image: N.A.Sharp/AURA/NOAO/NSF

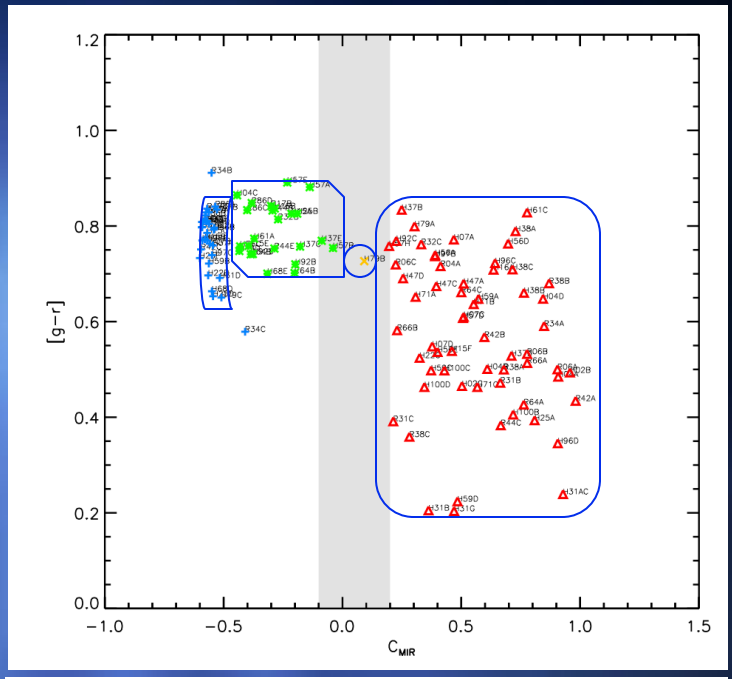
Age Estimation

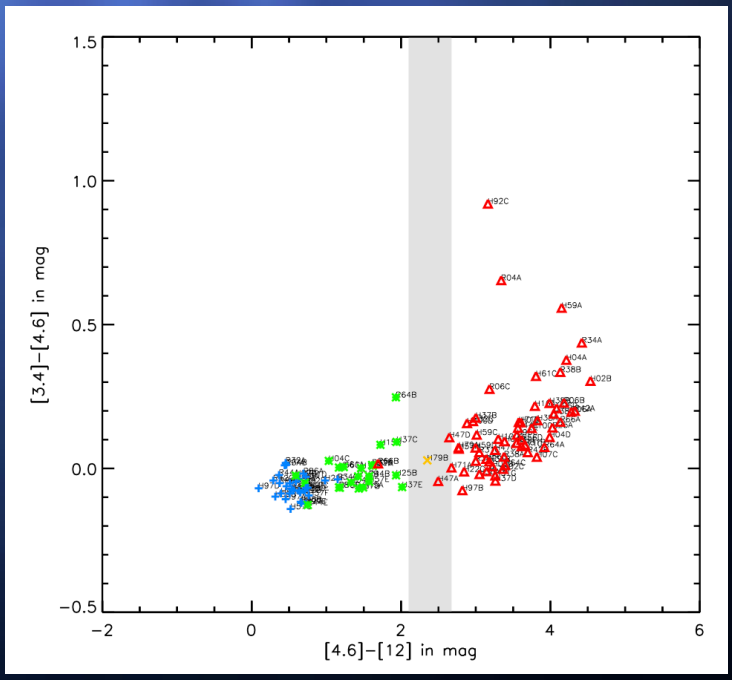


Evolutionary track based on stellar synthesis models from Marigo et al. (2008)

Connection to canyon galaxies

- Looking at the Optical-MIR plot we can group 4 regions
- Want to see if there is a connection to location in wise color-color plot
  - Does location in optmir indicate underlying properties of the galaxy type or vise versa?
- There is a trend similar to the curve in the MIR
- Not a one-to-one mapping





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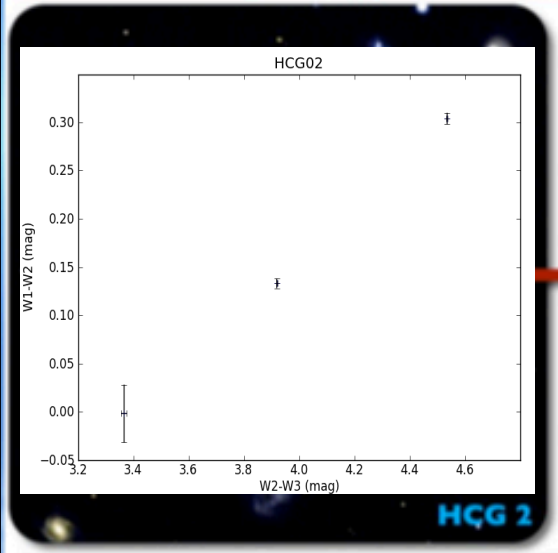
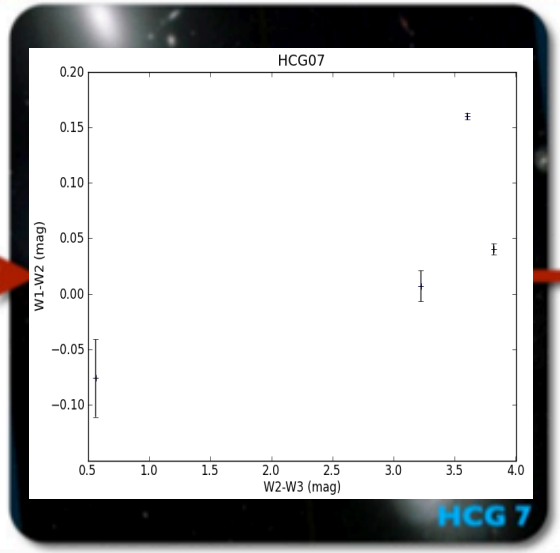
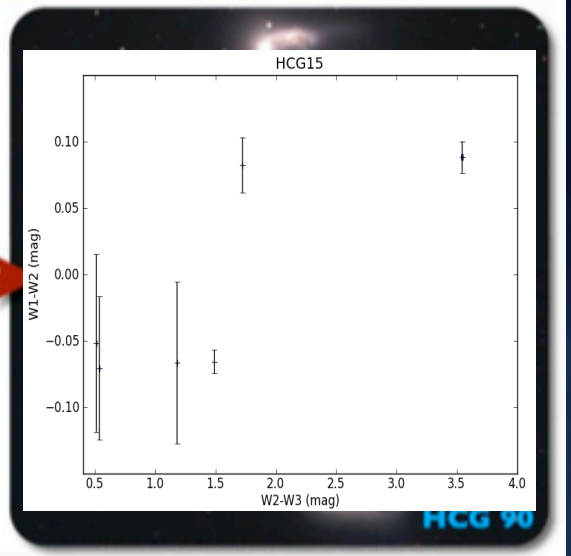
H I content	Rich		Poor
Member morphology	Spiral/Irregular		Elliptical/Lenticular

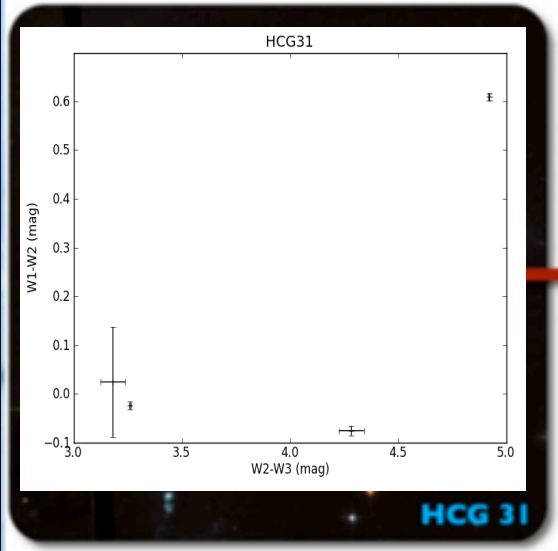


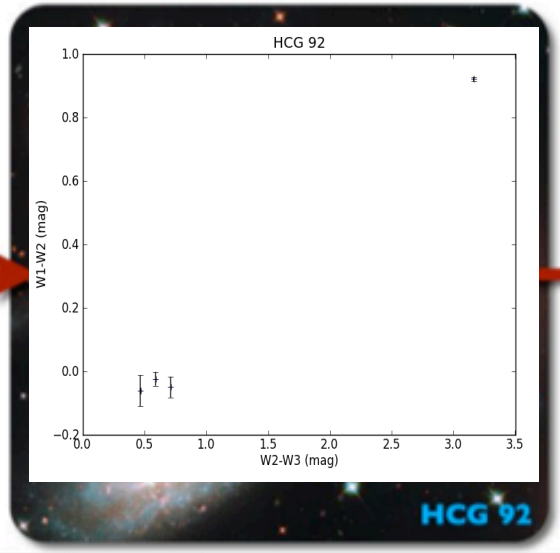


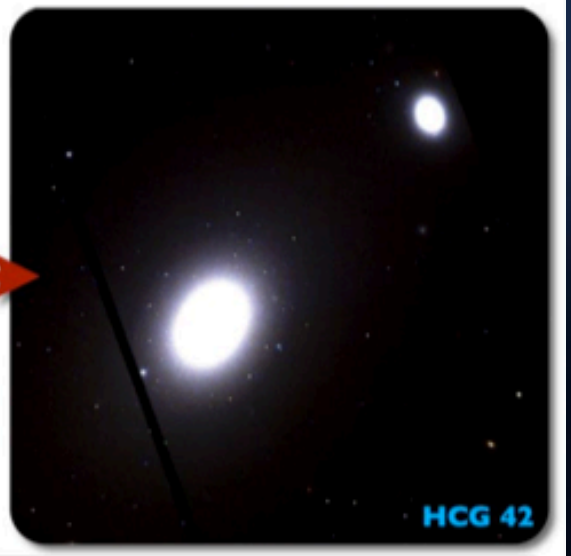


Sequence A: gas contained in galaxies

star formation within galaxies — *no/faint group x-ray halo*







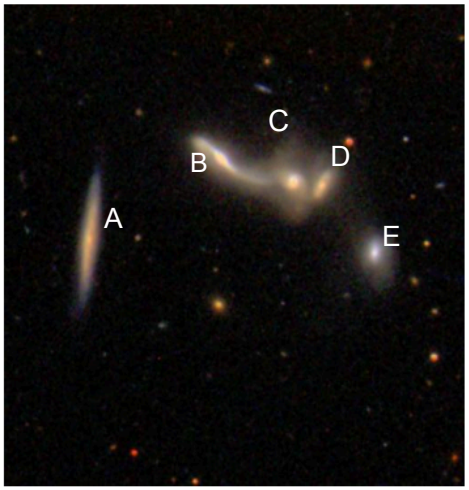
Sequence B: gas stripped from galaxies

star formation between galaxies — *bright group x-ray halo*

HCG 56

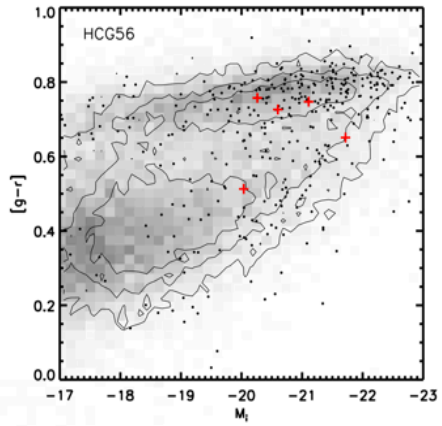
- 5 Member Galaxies

Member	NED ID	ID
A	S	Spiral
B	Seyfert	Seyfert
C	S0	Elliptical
D	SA	Spiral/LIRG
E	SB0	Spiral



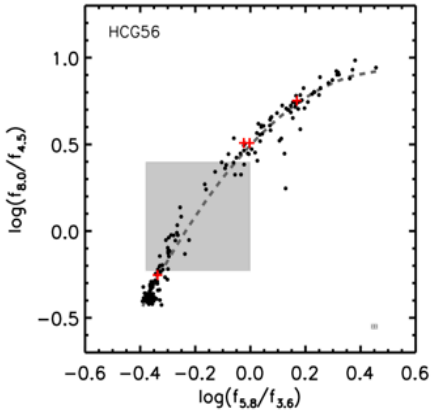
SDSS image

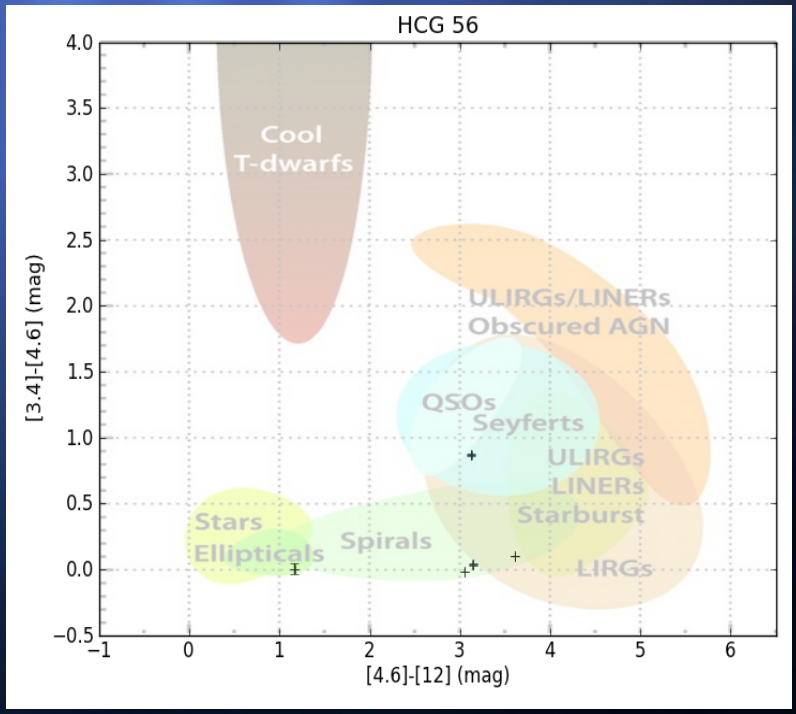
Optical



Spitzer 3-color image

MIR

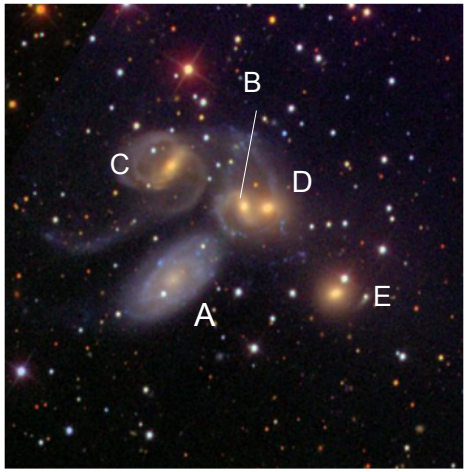




HCG 92

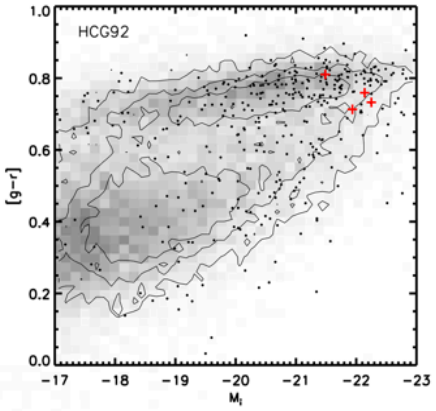
- 4 Members Galaxies
- 1 foreground galaxy

Member	NED ID	ID
A	SA	X
B	SB	Spiral
C	SB	QSO
D	E2	Spiral
E	N/A	Elliptical



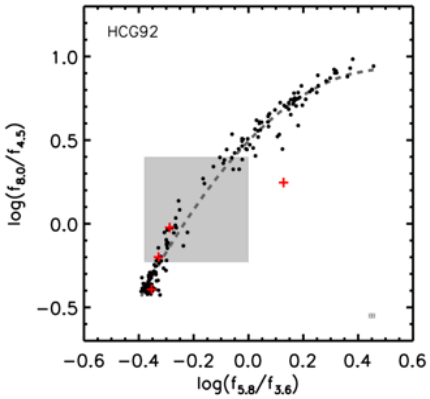
SDSS image

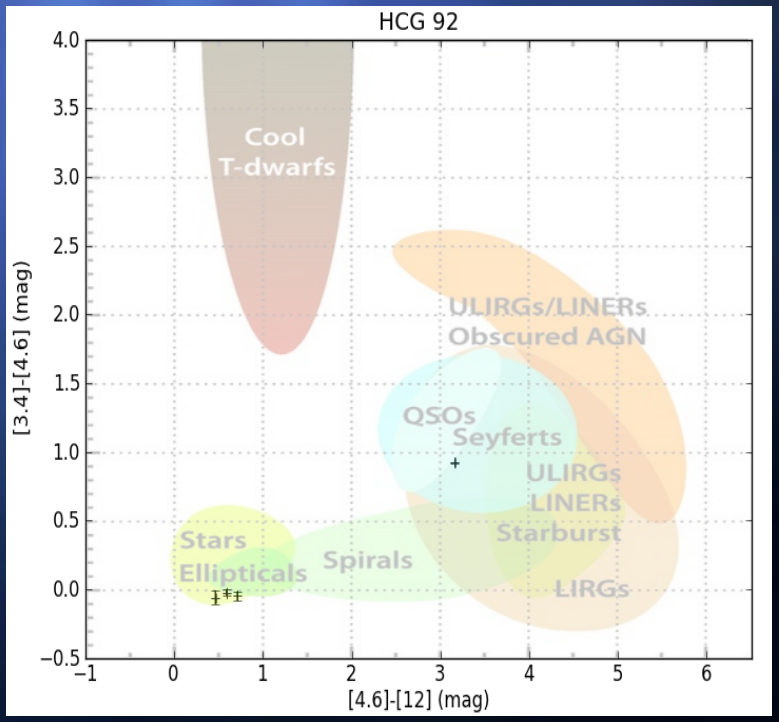
Optical



Spitzer 3-color image

MIR

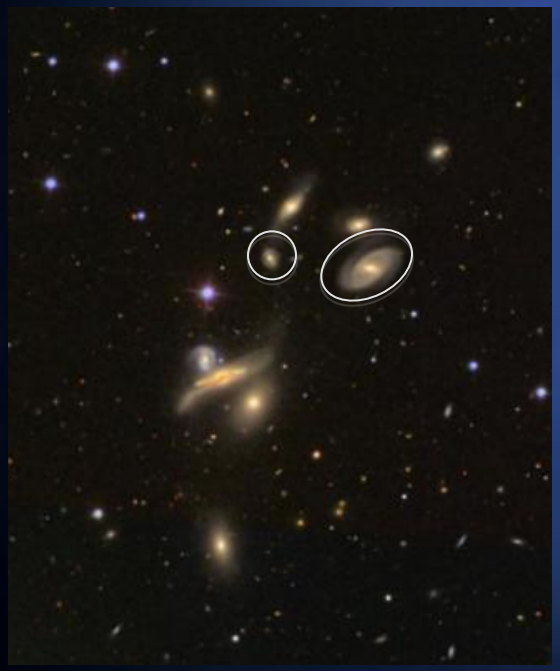




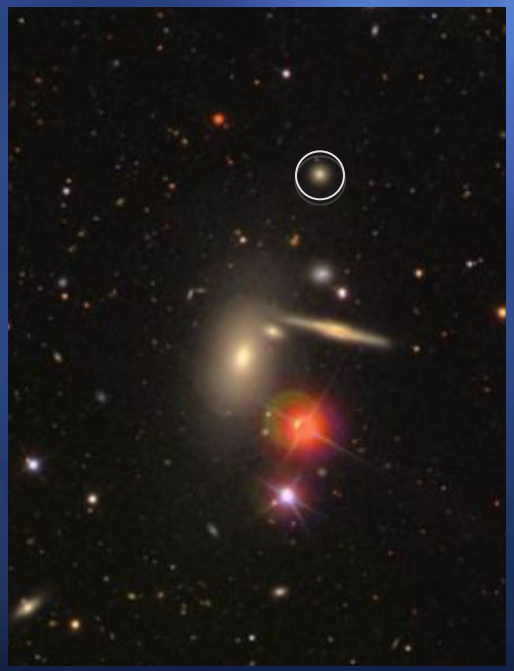
Galaxies in Canyon

- HCG 79B, HCG 57B, HCG 37E, HCG 57H

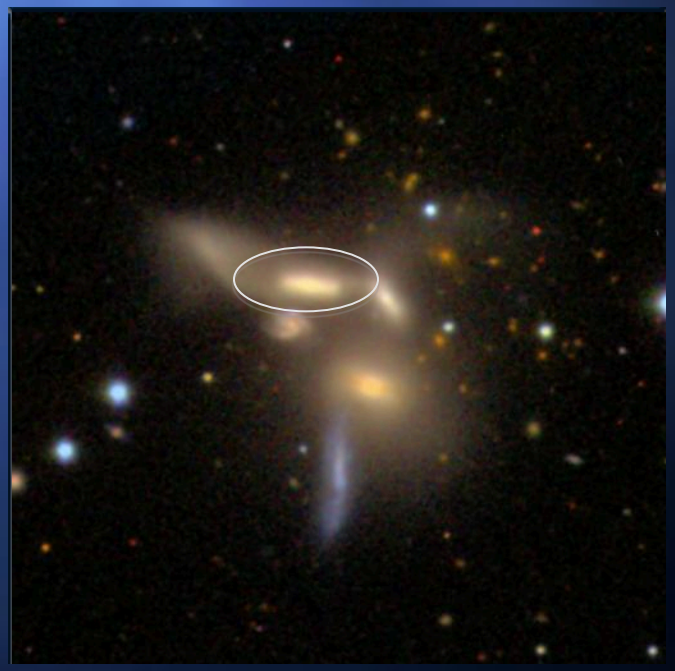
HCG 57



HCG 37

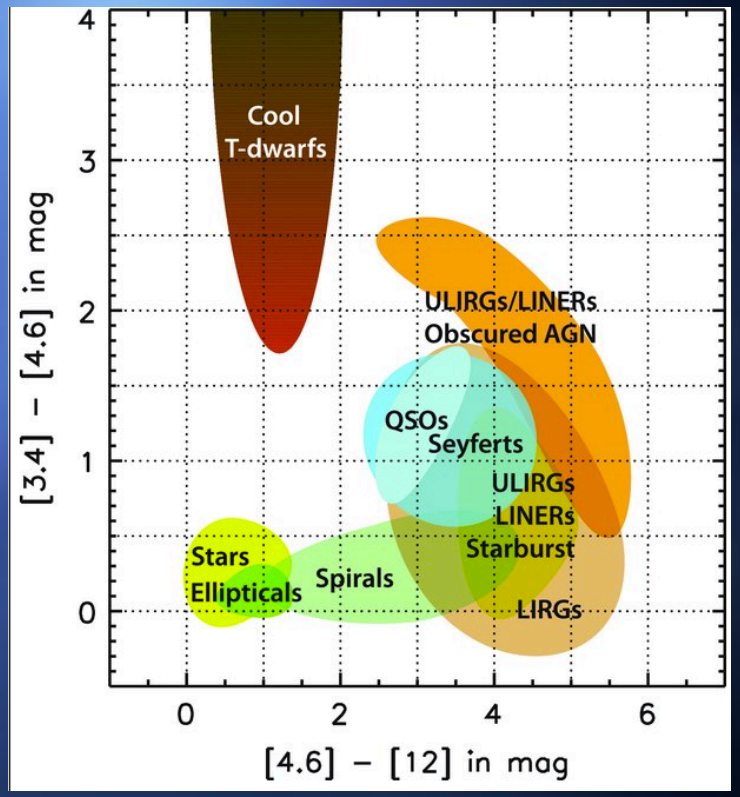


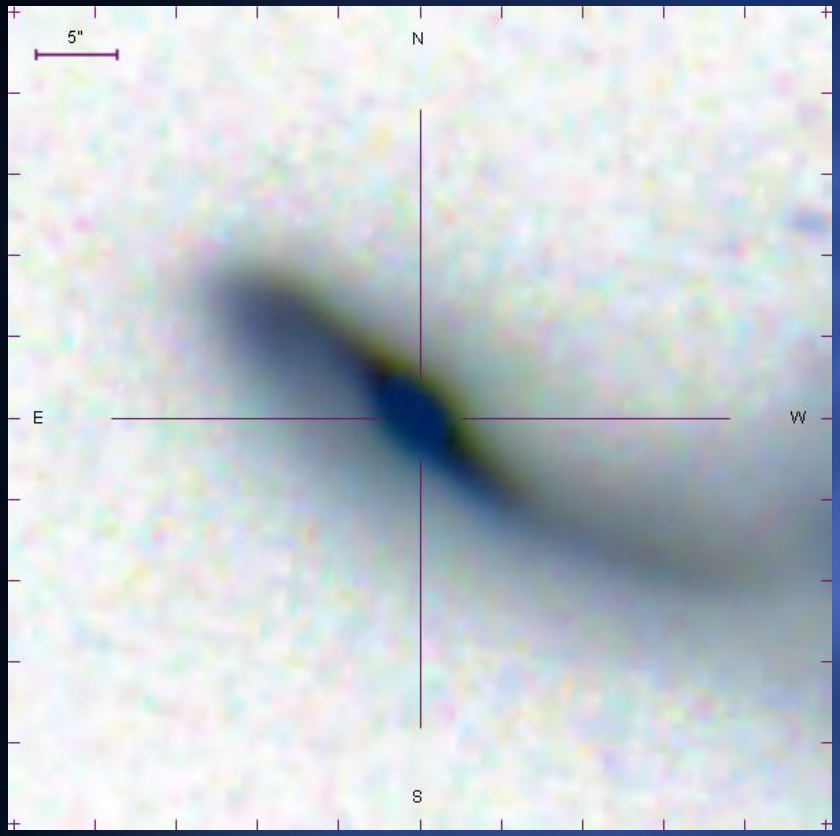
HCG 79

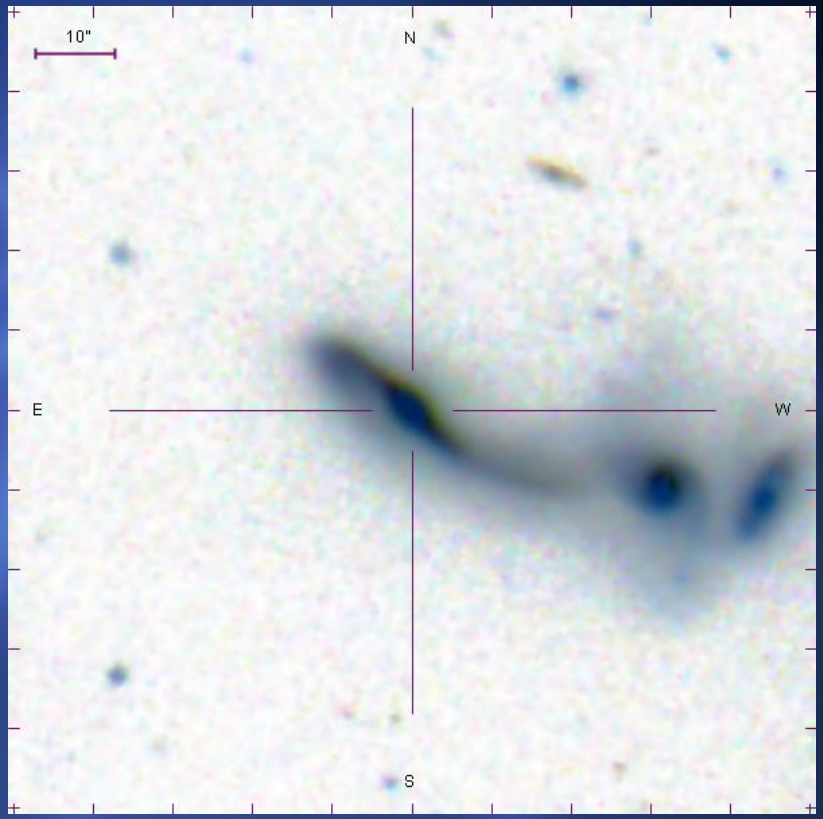


The Project

- Using WISE data to see where group members fall in the specified regions
  - Using 33 groups from Walker et al. 2012 survey
- Science Questions:
  - How does morphology affect where galaxies fall in the "Optmir" plot?
    - Does this give insight on stages of star formation?
  - Does this give an indication on the types of galaxies in the "Green Valley?"
    - Are they a transition from blue cloud to red sequence?
- .




5"
N
E
W
S


10"
N
E
W
S