Dwarf galaxy evolution: clues from nearby groups

Sophia Lianou

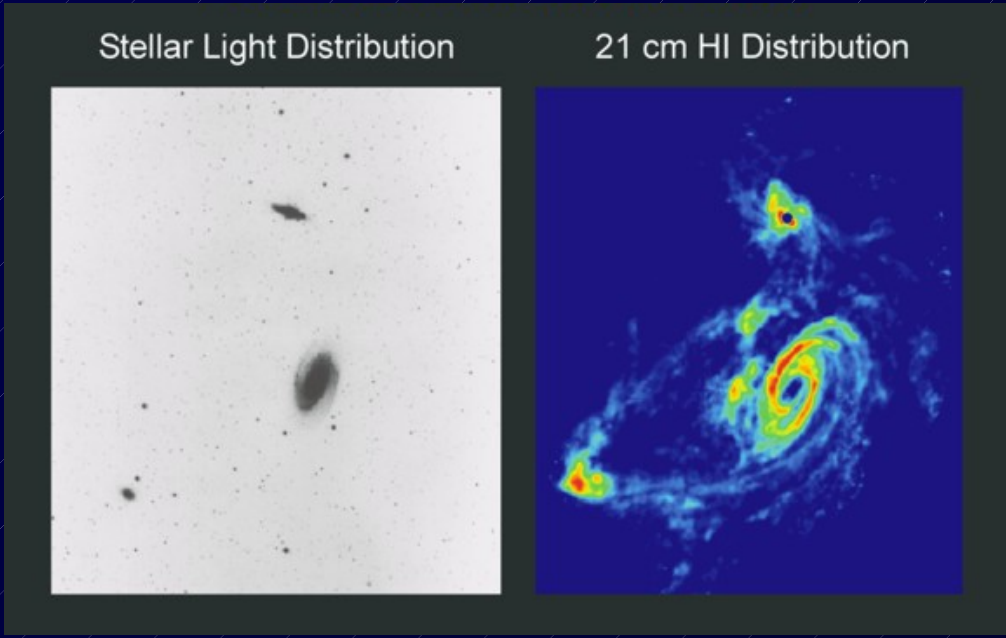
Rm 256, 2nd Floor

PLACES, PAST & CURRENT

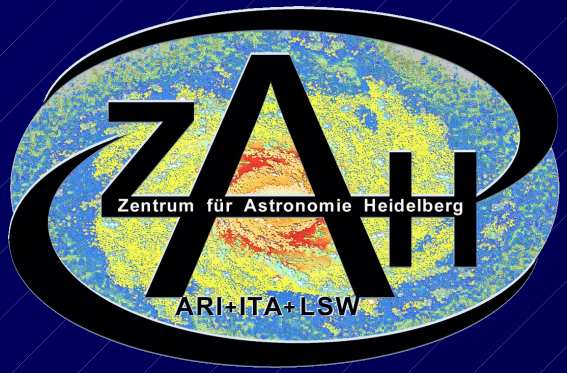
Heidelberg, Germany

with Eva K. Grebel

The interacting M81 group of galaxies



PLACES, PAST & CURRENT



Heidelberg, Germany

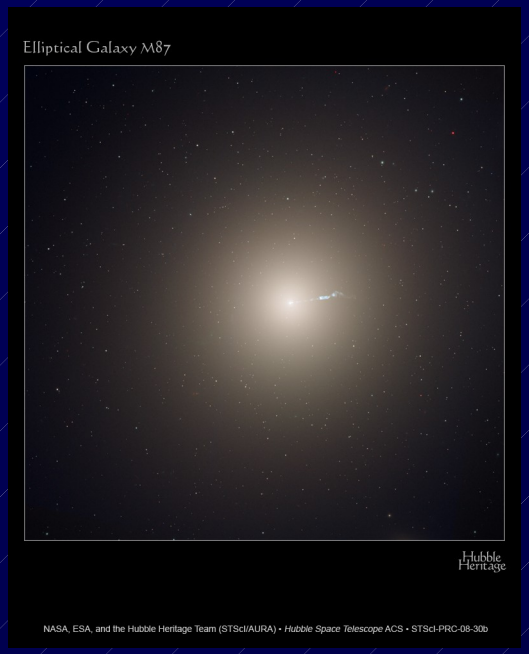
Athens, Greece

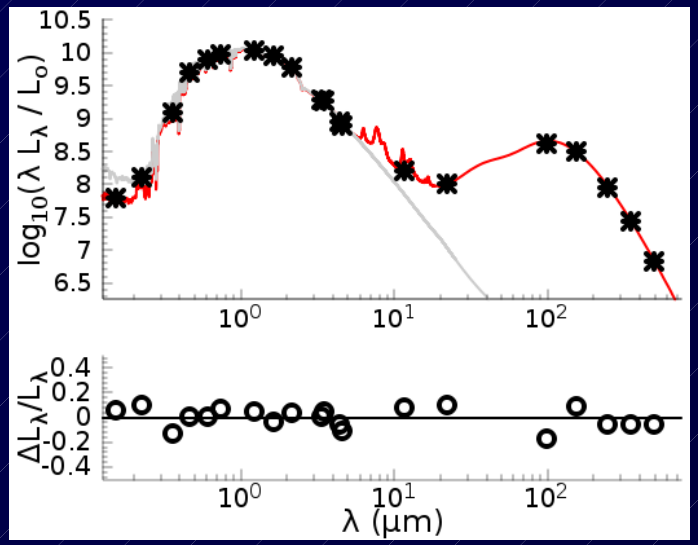
PLACES, PAST & CURRENT

with Manolis Xilouris & Suzanne Madden

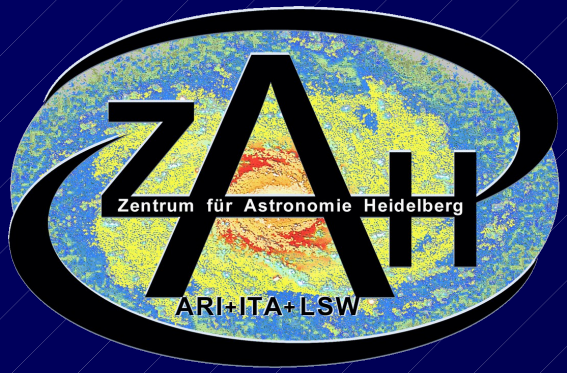
IAASARS

Athens, Greece





PLACES, PAST & CURRENT



Heidelberg, Germany

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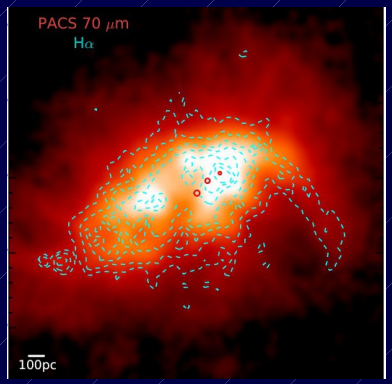
London Ontario, Canada

PLACES, PAST & CURRENT

with Pauline Barmby



I M A G E C U B E @

ASTRO2022B: The origin of the universe

Astronomy 2022B: 2015 Weekly Schedule

Week starting	Topic	Text Chapter*	Notes
Jan. 6	Measuring the universe	2	
Jan. 13	Einstein & spacetime	3	PeerWise intro, in class
Jan. 20	Evolving universe	4	Assignment #1 due
Jan. 27	Receding galaxies	5, workbook	in-class exercise #1
Feb. 3	The hot Big Bang	6, workbook	in-class exercise #5
Feb. 10	Making elements	7, workbook	in-class exercise #4
Feb. 17	Reading Week		
Feb. 24	Course material review		Assignment #2 due
	Midterm (Thursday Feb. 26)		
Mar. 3	Making matter	8, 9	*drop date March 7*
Mar. 10	Gravity & Dark matter	10, 11	
Mar. 17	Acceleration	12, workbook	in-class exercise #2
Mar. 24	Dark energy & structure	13,14	Assignment # 3 due
Mar. 31	Galaxies	16, workbook	in-class exercise #3
Apr. 7	Course material review		
Ap. 11–30	(TBD) **Final Exam**	cumulative	

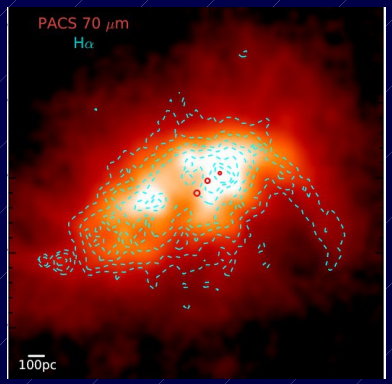
*Number refers to Chapters in *State of the Universe.*

Western UNIVERSITY · CANADA

London Ontario, Canada

PLACES, PAST & CURRENT

with Pauline Barmby & Snantanu Basu



IMAGECUBE@

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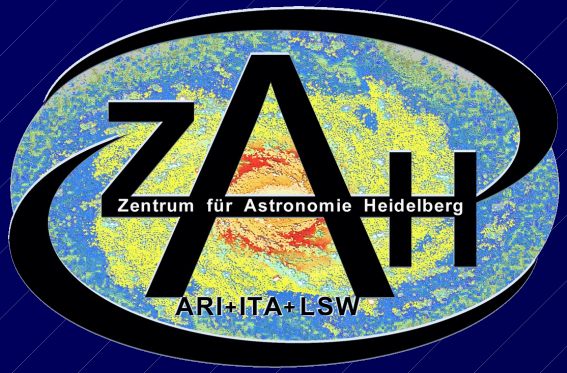
PLACES, PAST & CURRENT



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Athens, Greece

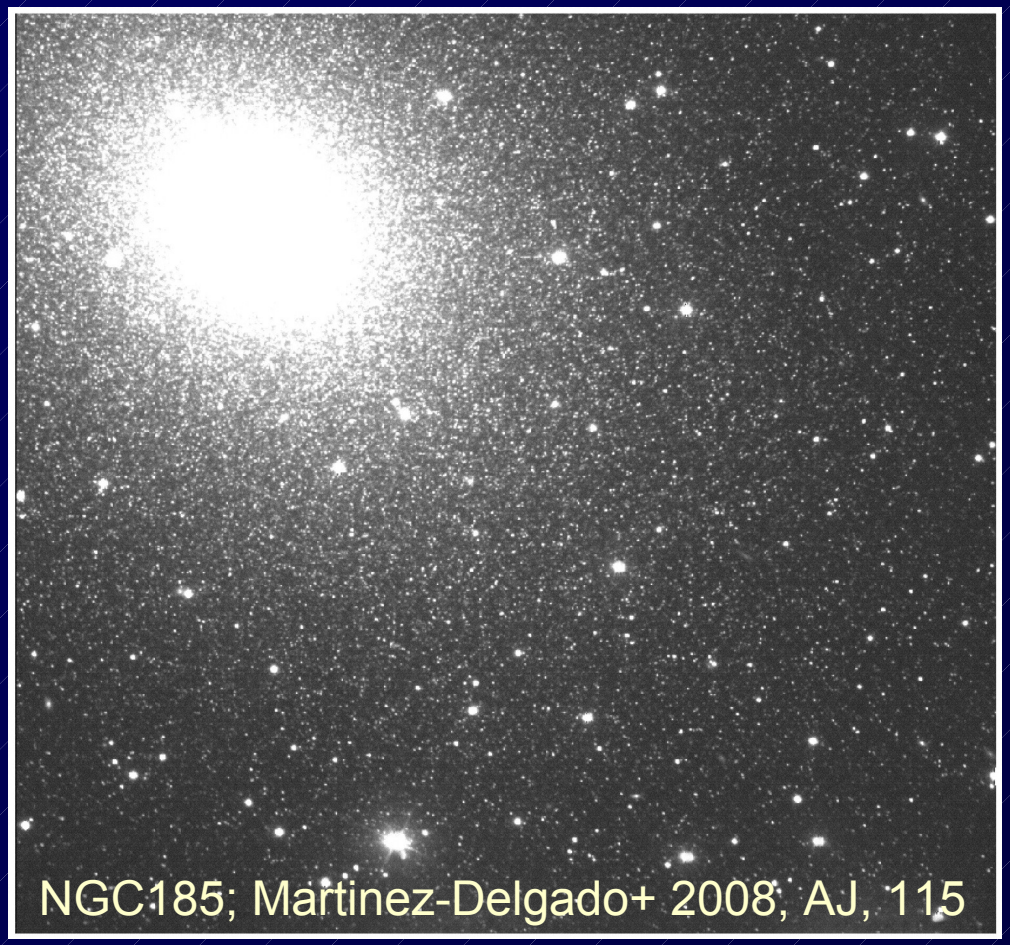
London Ontario, Canada

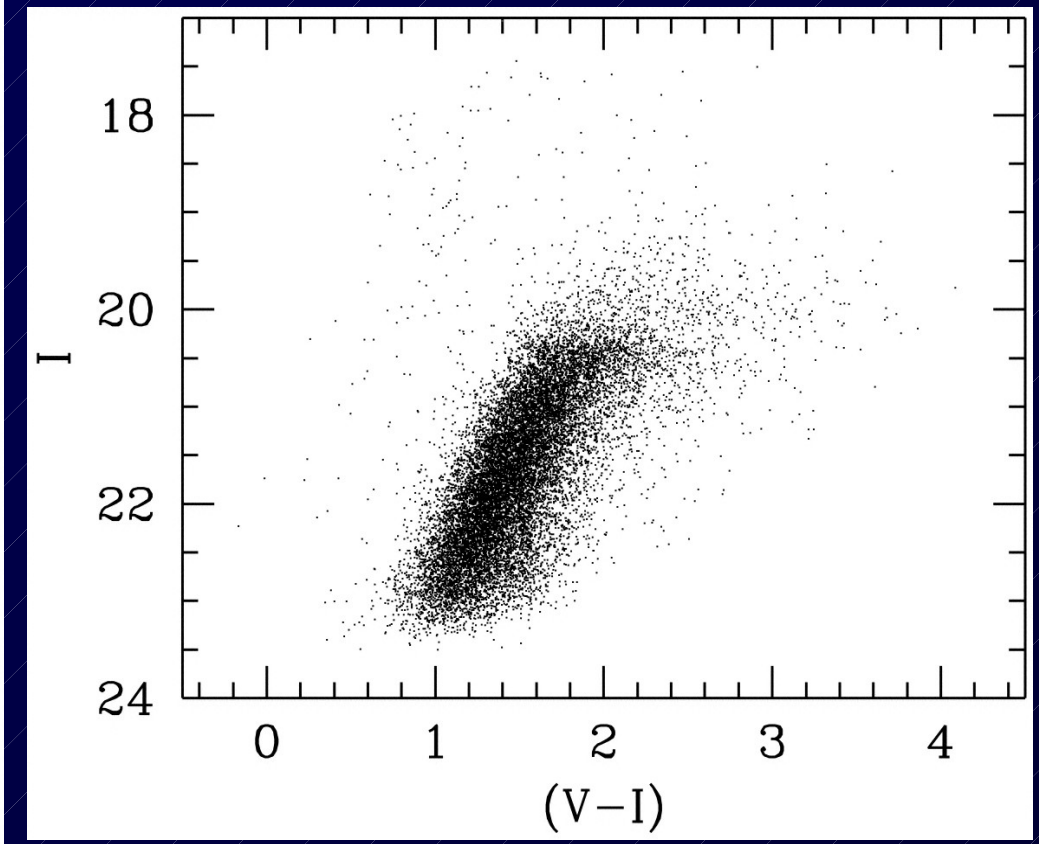
DustPedia – Suzanne Madden
NUAGES @ LFEMI

Dwarf galaxies

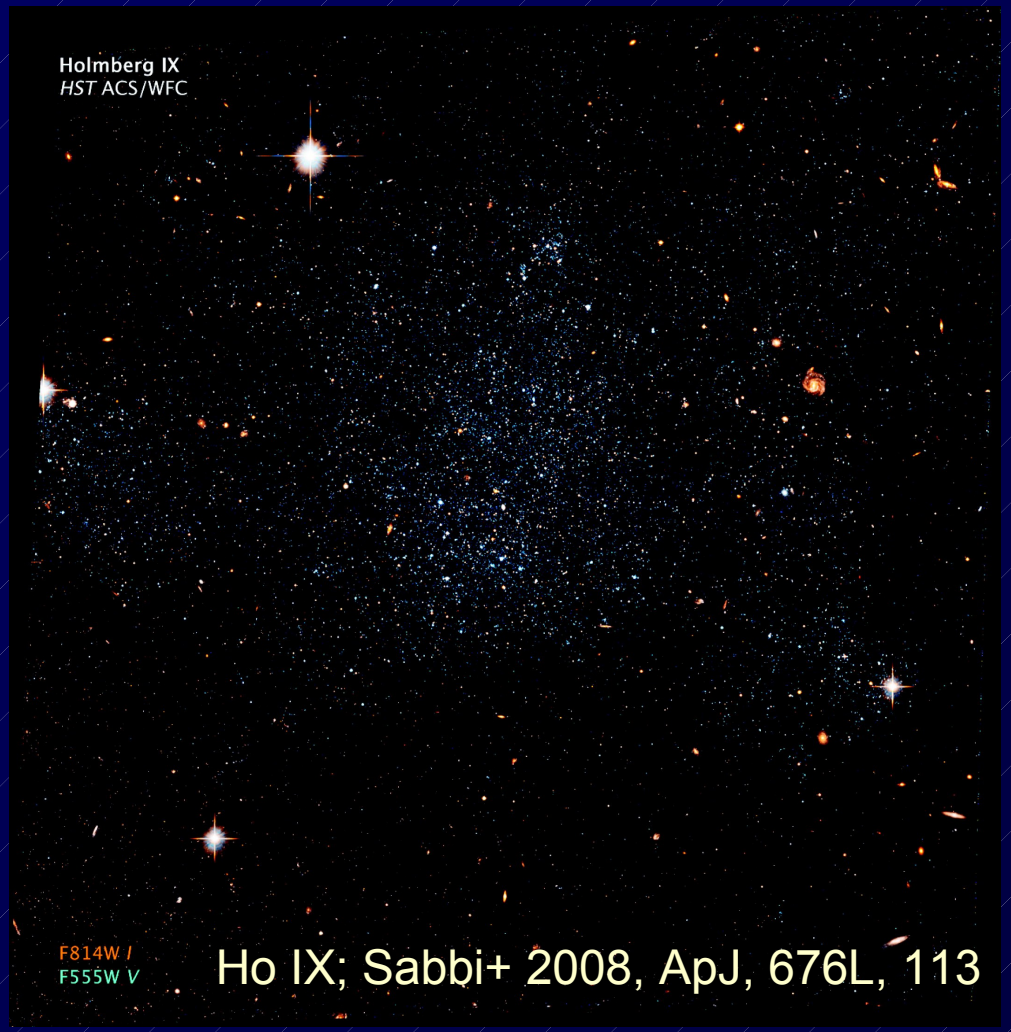
- What is a dwarf galaxy?
- What are the main drivers of dwarf galaxy evolution?
- Is the overall environment that dwarf galaxies live in that plays the dominant role in shaping their observed properties?
- Are processes intrinsic to dwarfs the same or more dominant?

Early-type dwarfs: *gas-poor,* no *on-going star formation activity*
(dwarf ellipticals; dwarf spheroidals; ultra faint dwarf spheroidals ...)

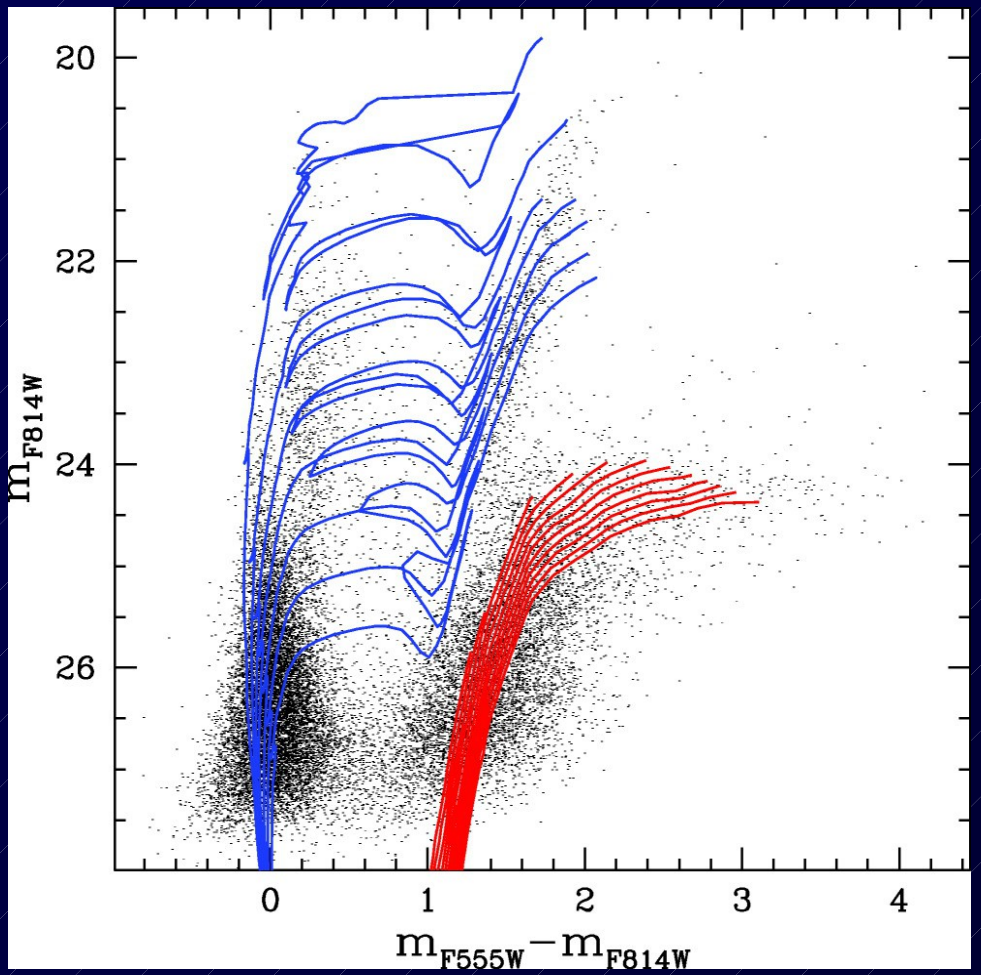

NGC185; Martinez-Delgado+ 2008, AJ, 115



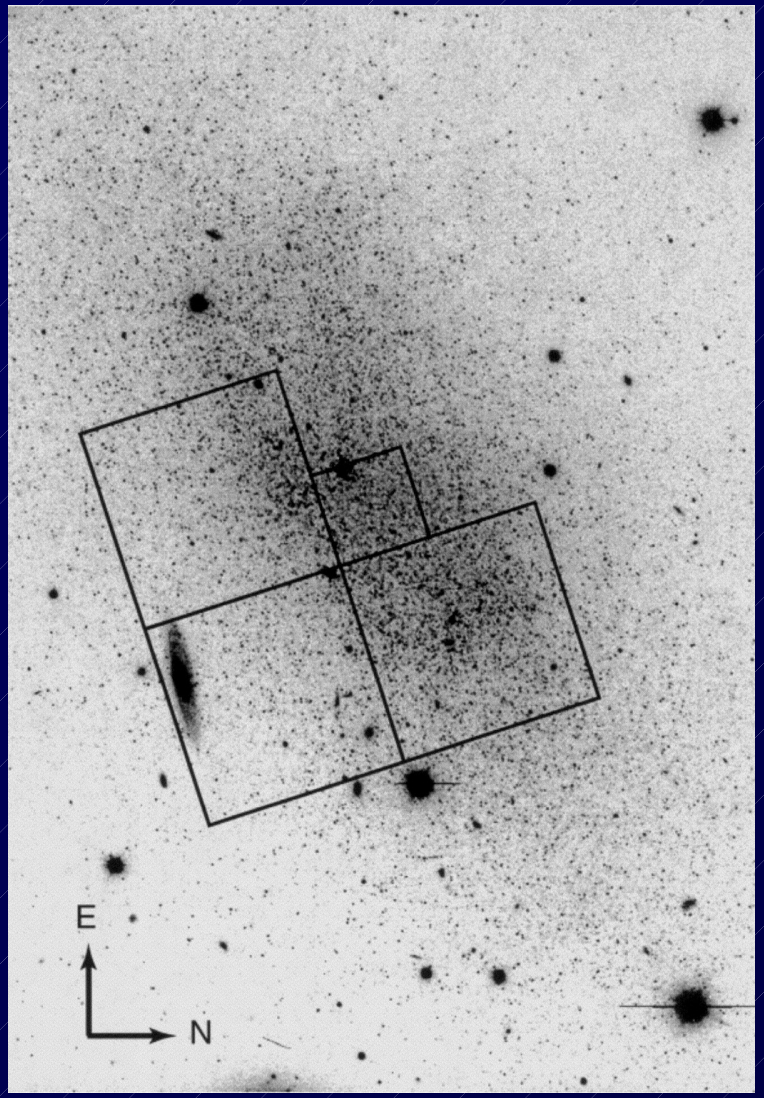
Late-type dwarfs: *gas-rich, on-going star formation activity*
(dwarf irregulars / blue compact dwarfs / tidal dwarf galaxies ...)

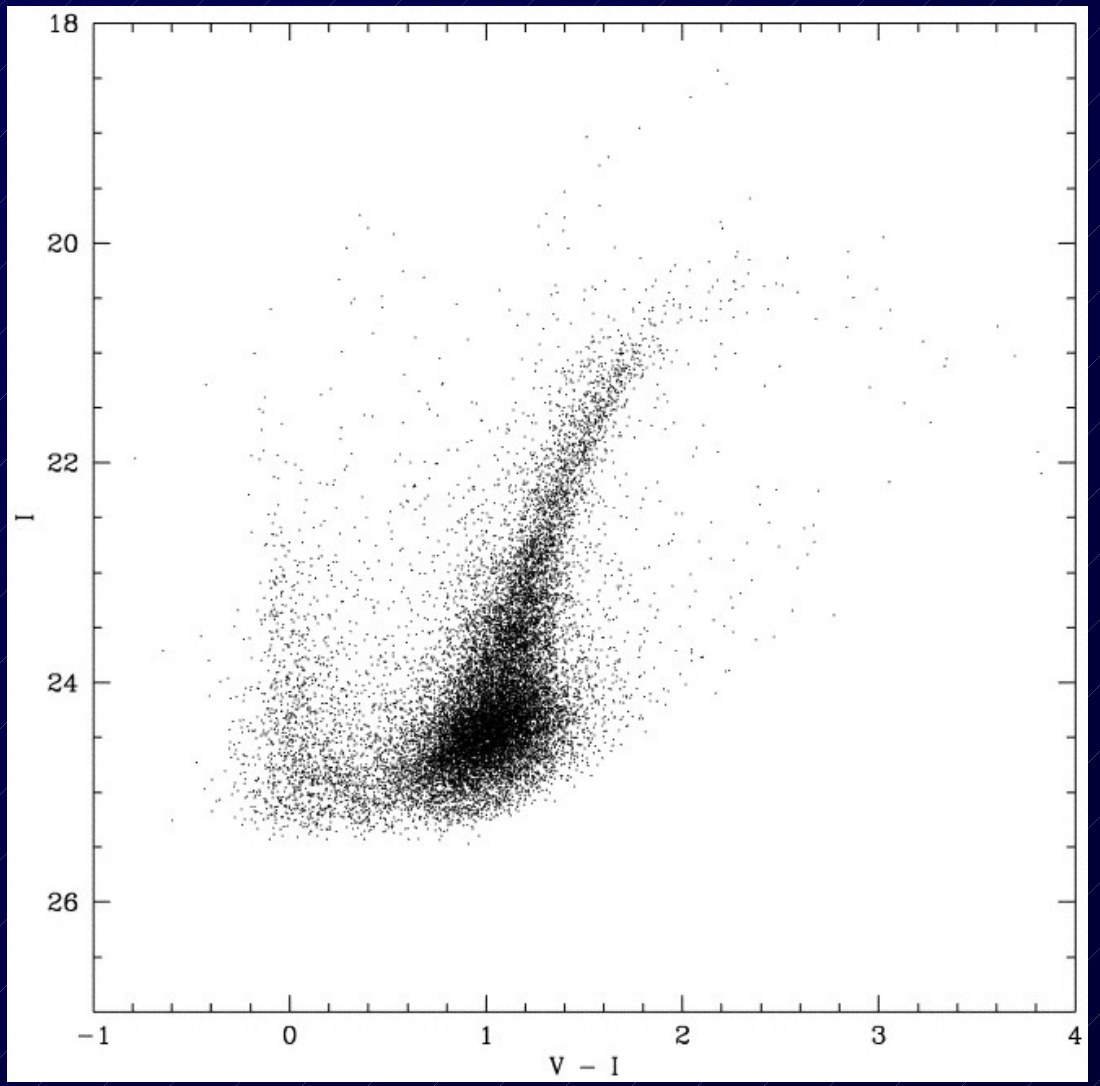


Ho IX; Sabbi+ 2008, ApJ, 676L, 113

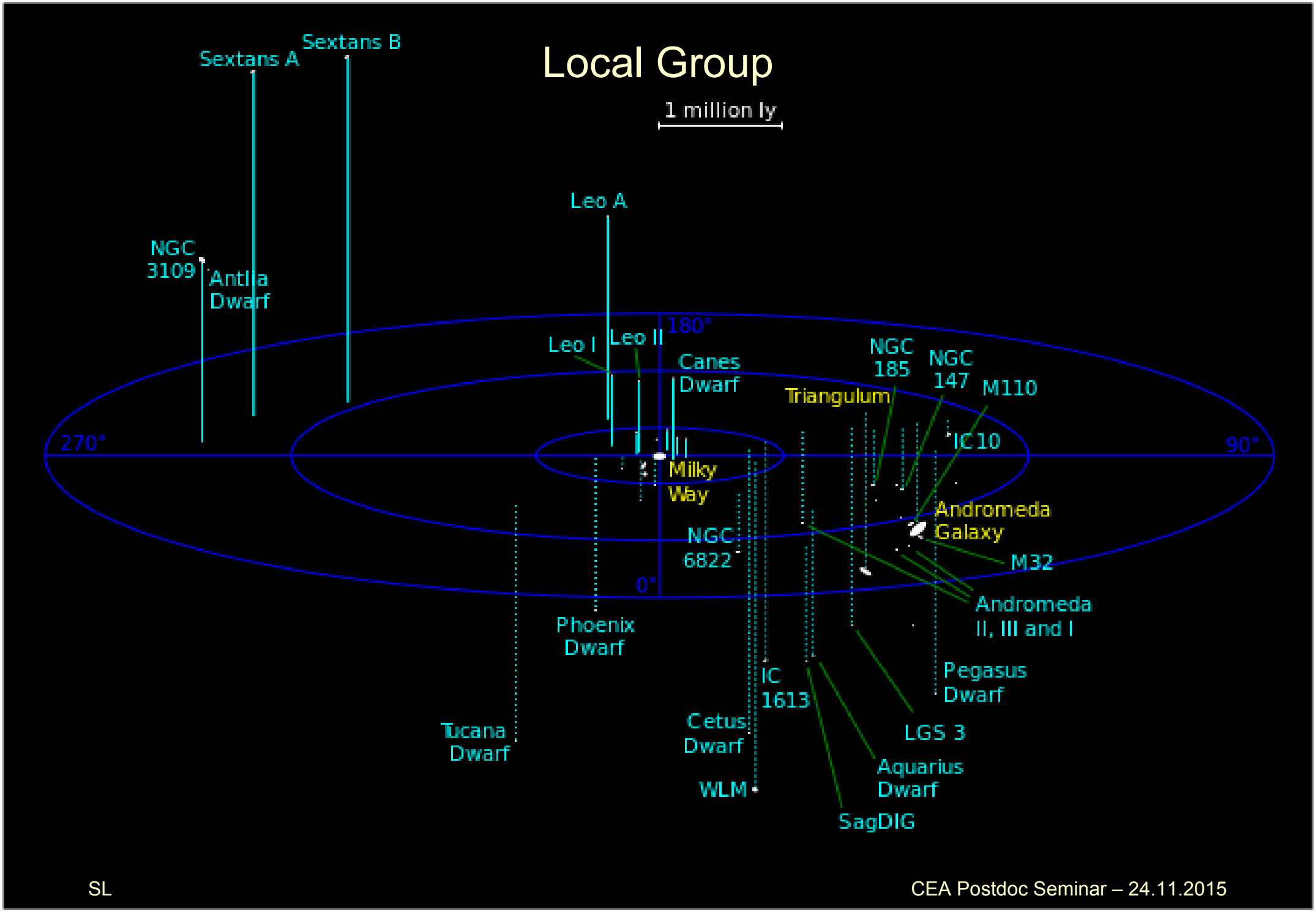


Transition-type dwarfs: *properties in between*

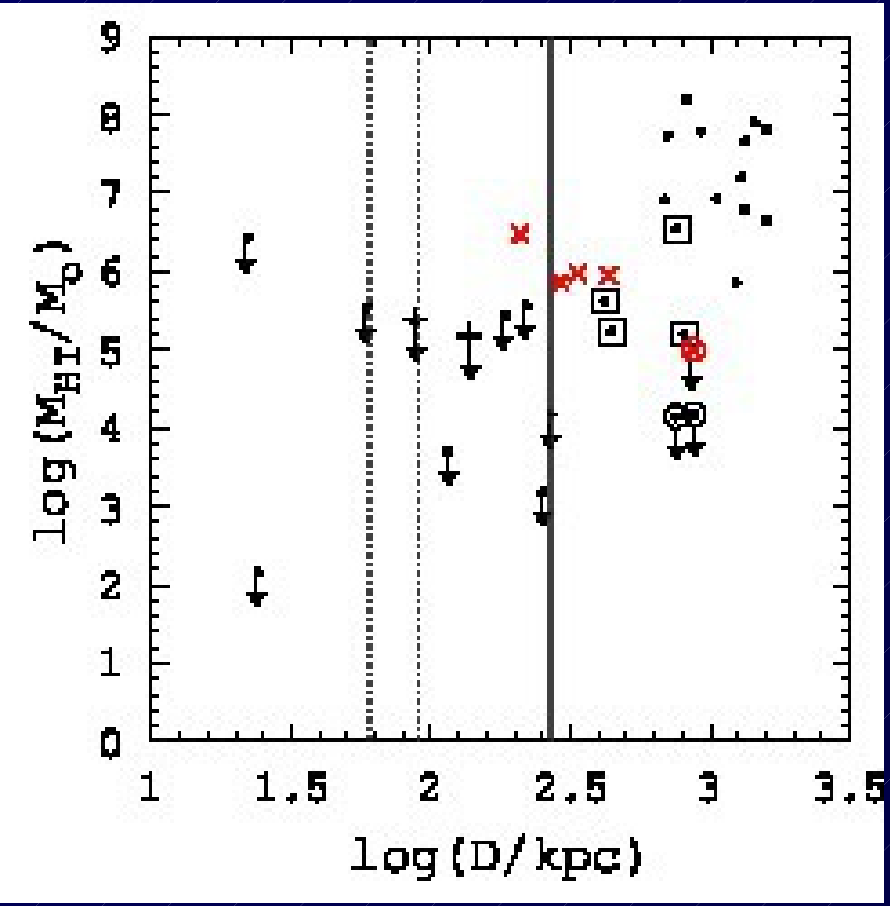




Pegasus dwarf; Gallagher+ 1998, AJ, 115


Local Group
1 million ly
Sextans A
Sextans B
Leo A
NGC 3109
Antlia Dwarf
180°
Leo I
Leo II
Canes Dwarf
NGC 185
NGC 147
M110
Triangulum
270°
90°
IC 10
Milky Way
Andromeda Galaxy
NGC 6822
M32
0°
Andromeda II, III and I
Phoenix Dwarf
IC 1613
Pegasus Dwarf
Tucana Dwarf
Cetus Dwarf
LGS 3
Aquarius Dwarf
WLM
SagDIG

Morphology-distance relation for Sculptor group dwarf galaxies

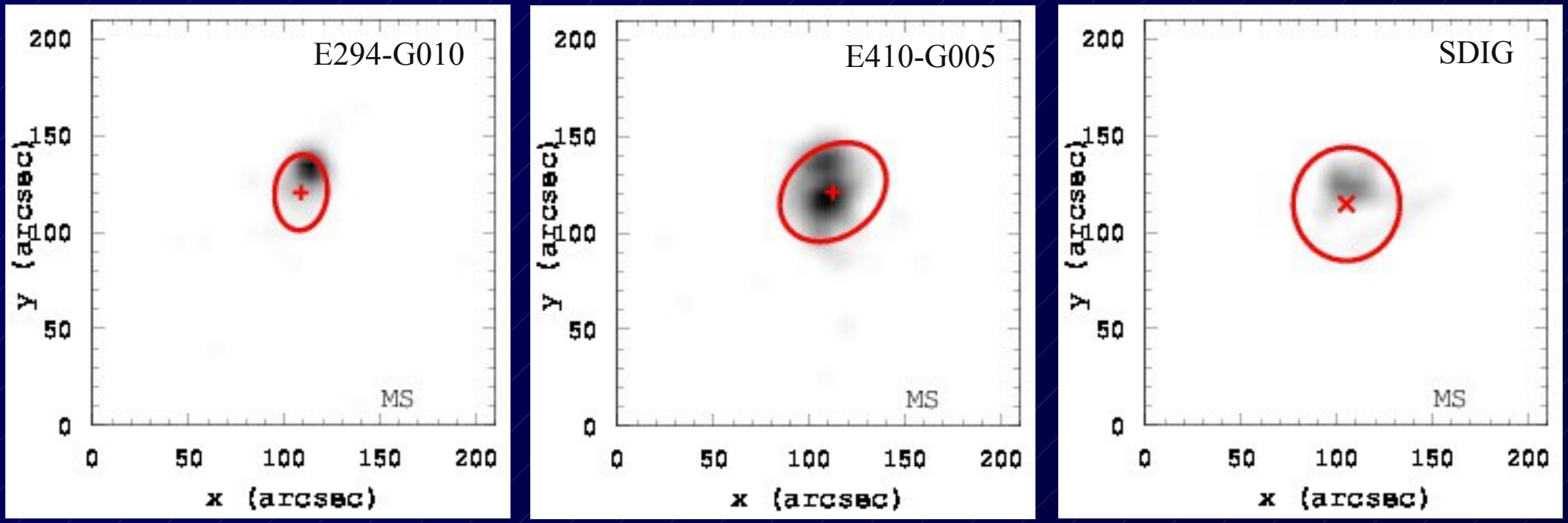


- Some of the Local Group dwarfs along with the Sculptor group dwarf sample in the HI mass versus distance from the primary galaxy
- Transition-type dwarfs fall in the “right” place, i.e. beyond the virial radius of their corresponding primary galaxy
- The sole dwarf spheroidal in the sample an exception to the relation

Red symbols: Sculptor group dwarfs
Black symbols: Local group dwarfs

(Lianou+ 2013, A&A, 550, A7)

Off-center local sites of star formation

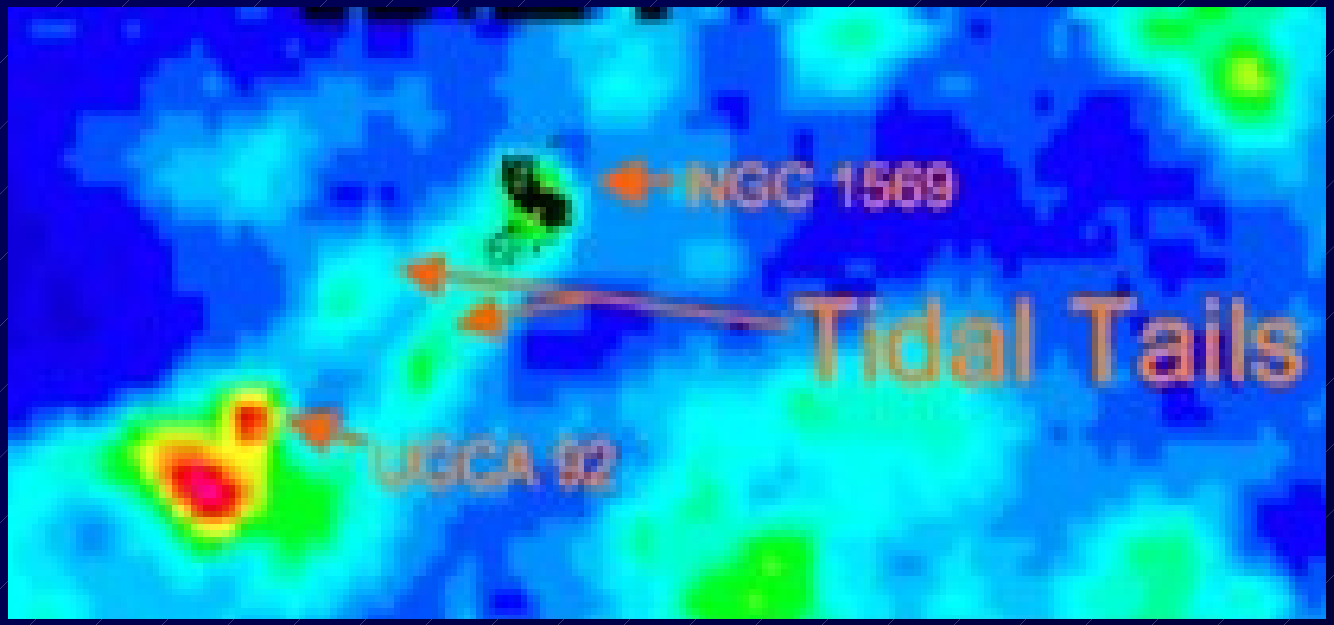


(Lianou & Cole 2013, A&A, 549A, 47; Lianou+ 2013, A&A, 550, A7)

- Transition-types have similar behavior with the dwarf irregulars
- Local Group analogues: Sextans A; IC 1613; DDO216; Fornax

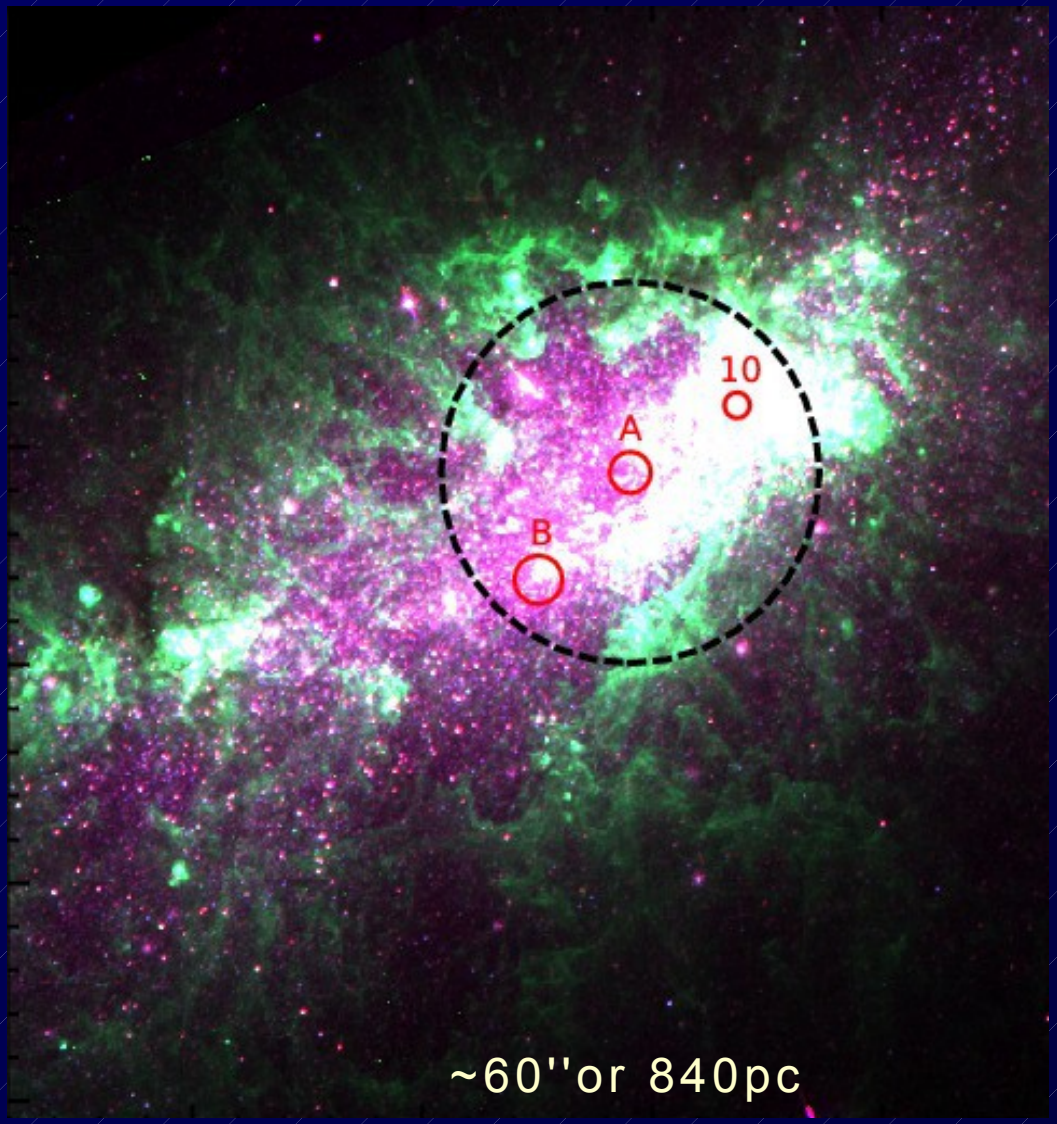
  (Dohm-Palmer+ 1997; Cole+ 1999; Gallagher+ 1998; Stetson+ 1998)

NGC1569 member of IC342 group environment



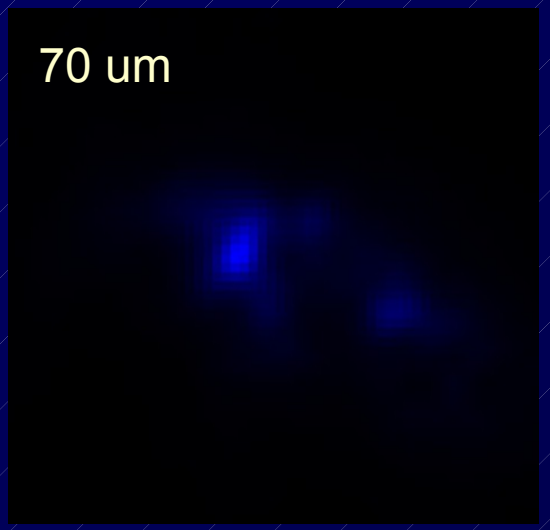
Jackson+ 2011; Stil & Israel 2002; Johnson 2013

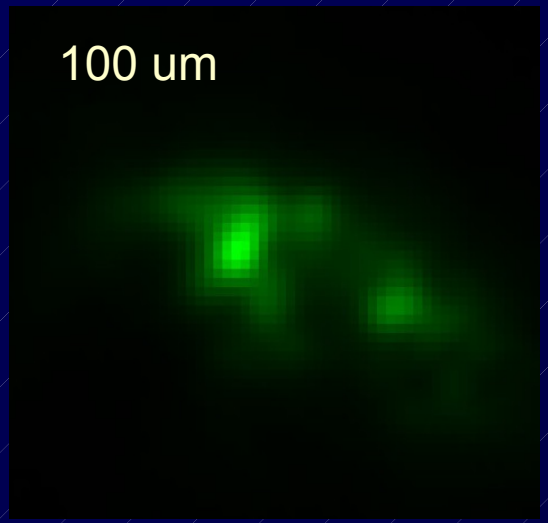
Extreme super star cluster formation impacting ISM

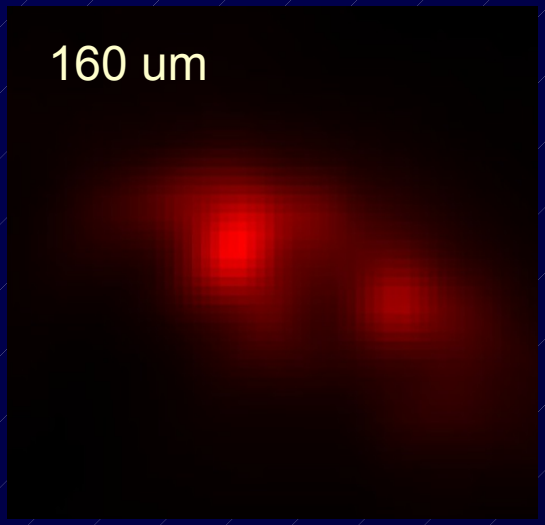


- 2 super star clusters & many compact populous star clusters, as in LMC (Hunter+ 2000; Anders+ 2004)
- Typically have:
  $L_V \sim 10^6$-$10^7\ L_\odot$
  $M_\star > 10^5\ M_\odot$
  $r_{eff} \sim 5$pc
- Younger counterparts to old Galactic globular clusters

PACS & SPIRE, as well as UV-to-MIR ancillary data

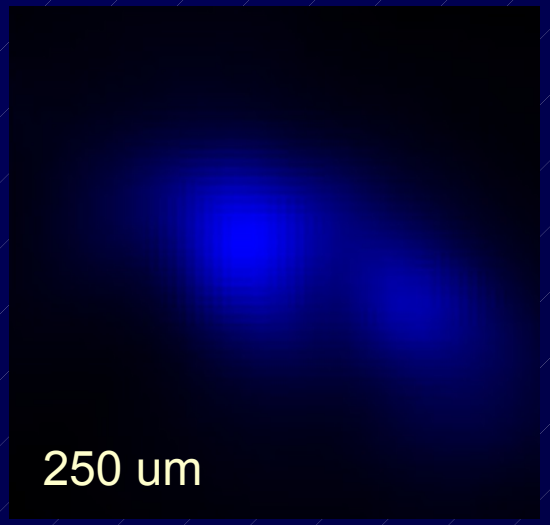


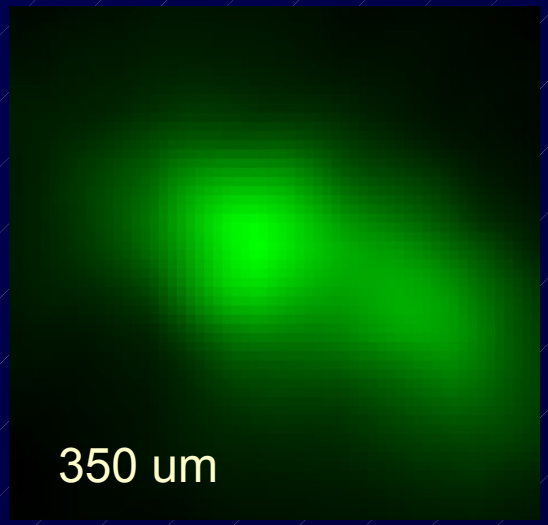


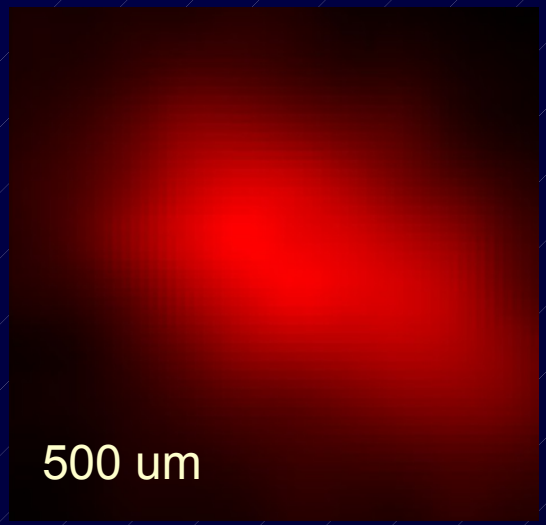


Dwarf Galaxy Survey

(Madden+ 2013; Remy-Ruyer+ 2013)

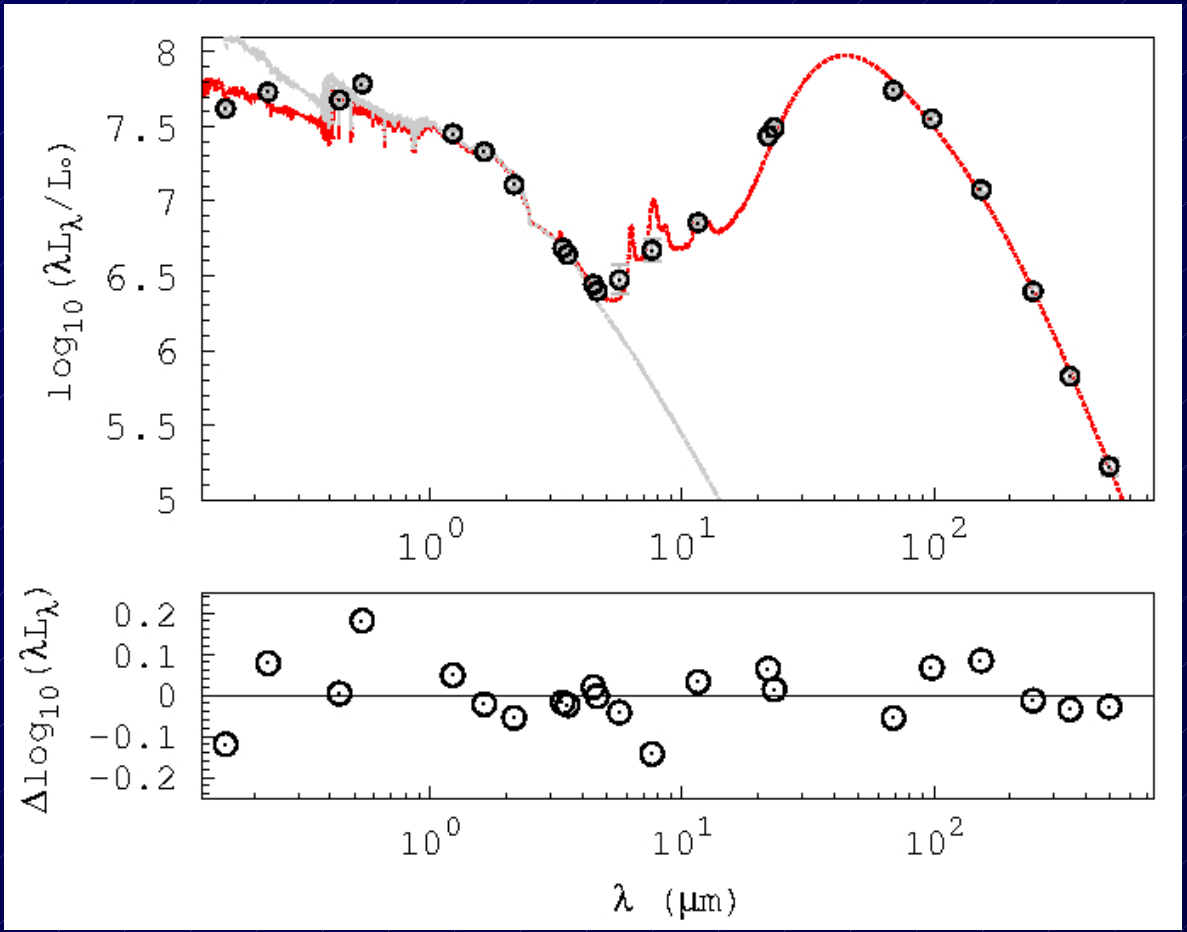






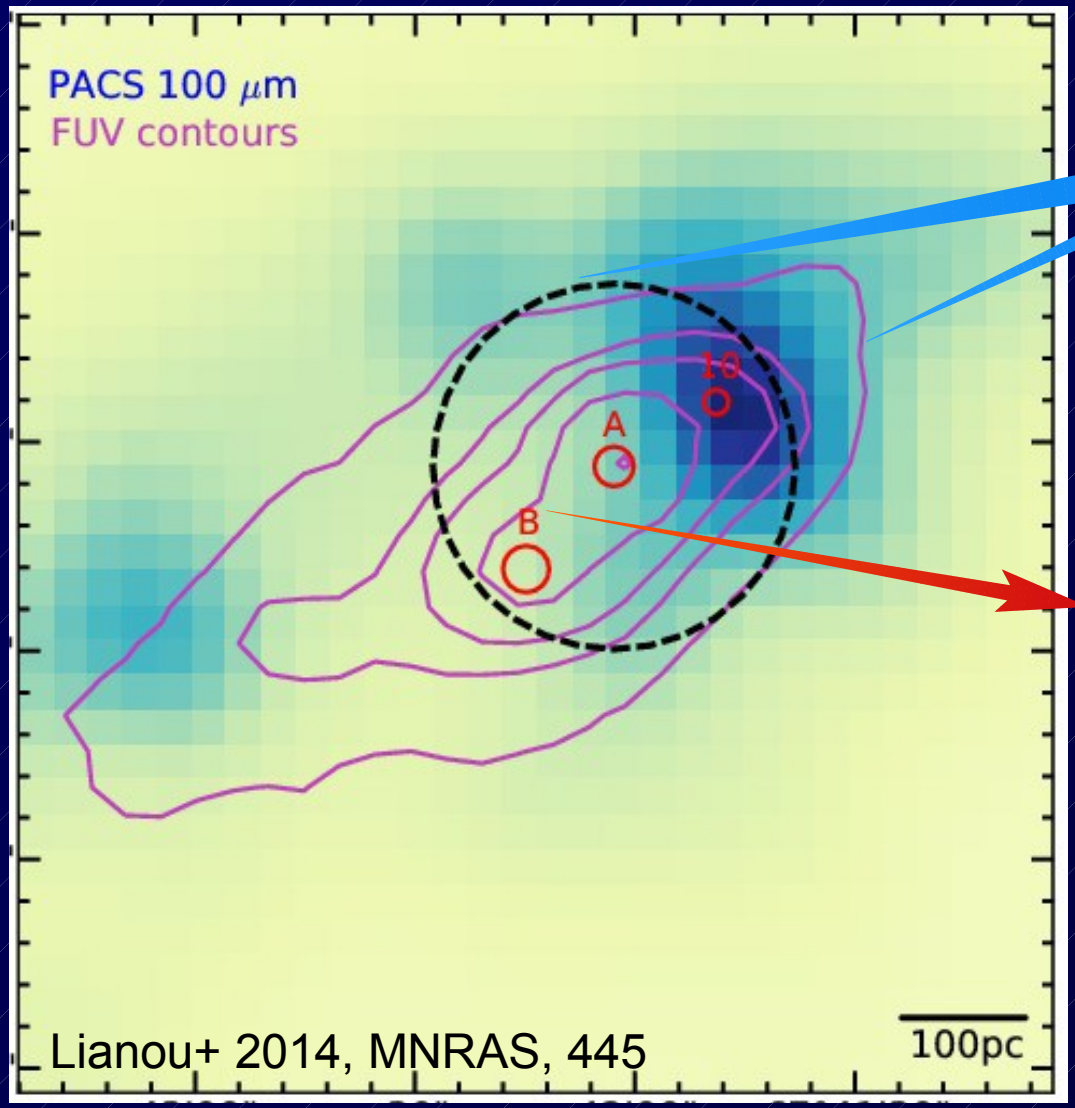
Main body
120" x 120"
1.7x1.7 kpc^2

Modeling the Spectral Energy Distribution



- Pixel-by-pixel (300pc)
- Cavity vs starburst
- Magphys modeling (da Cunha+08)
- Image processing with imagecube (Lianou, Barmby & Taylor 15)

Dust emission in the central starburst

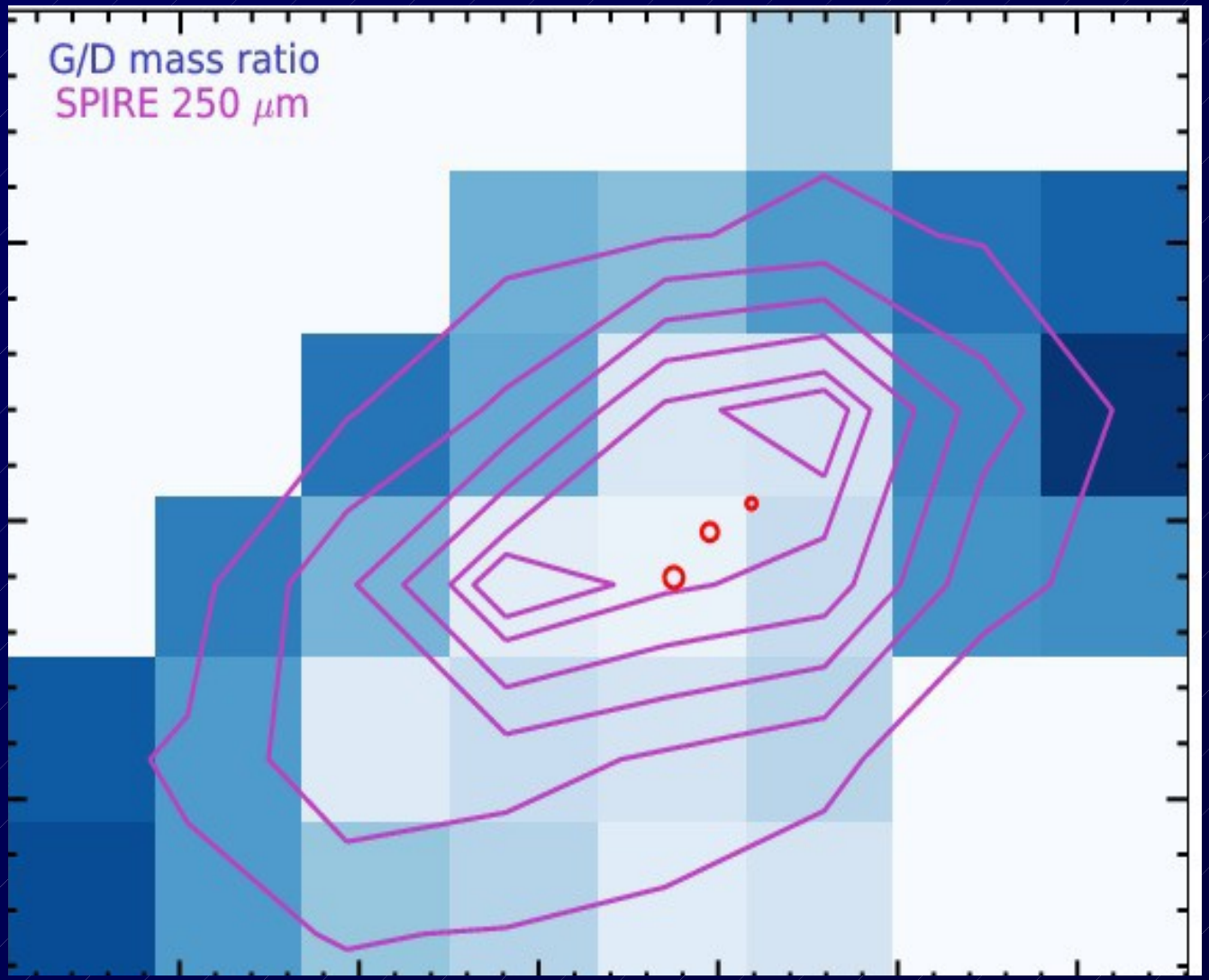


Dust emission knots in the periphery of the cavity coinciding with HII regions

Low dust emission around super star clusters

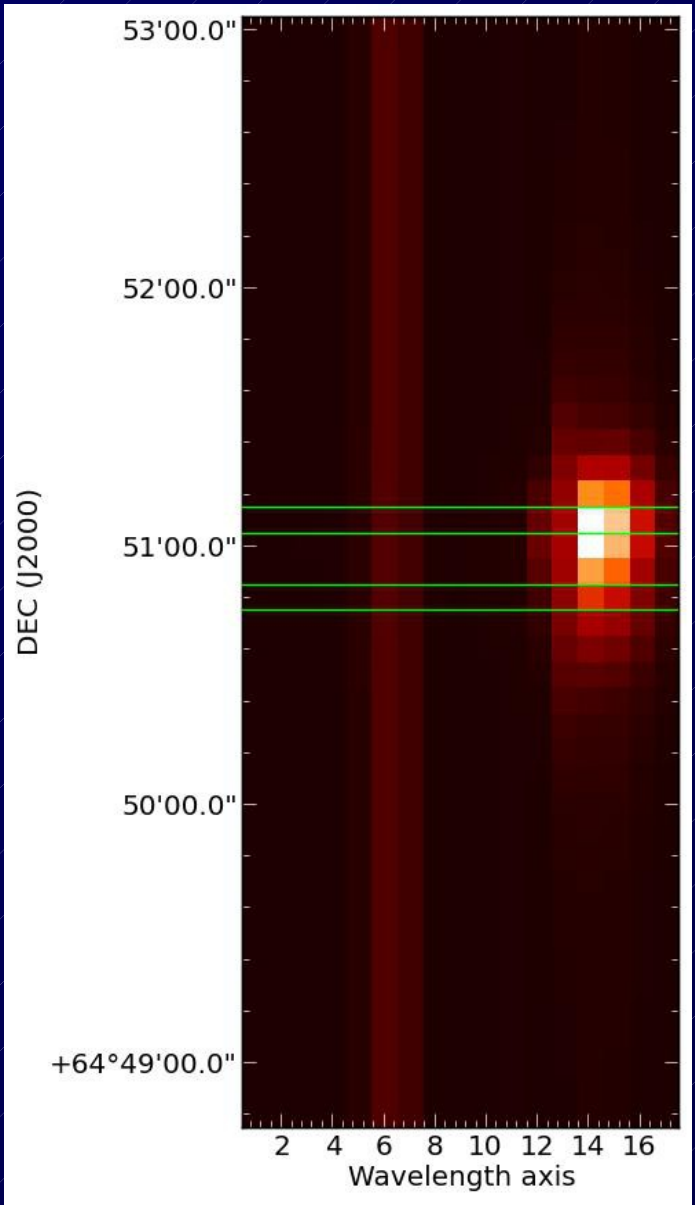
- Cavity's dust mass is 12% that of the central starburst
- Central starburst has $Md \sim 4 \times 10^4 M_\odot$

Gas-to-Dust mass ratio distribution



- G/D ranges: 0.6–4.9 x10^3
- Lowest in cavity

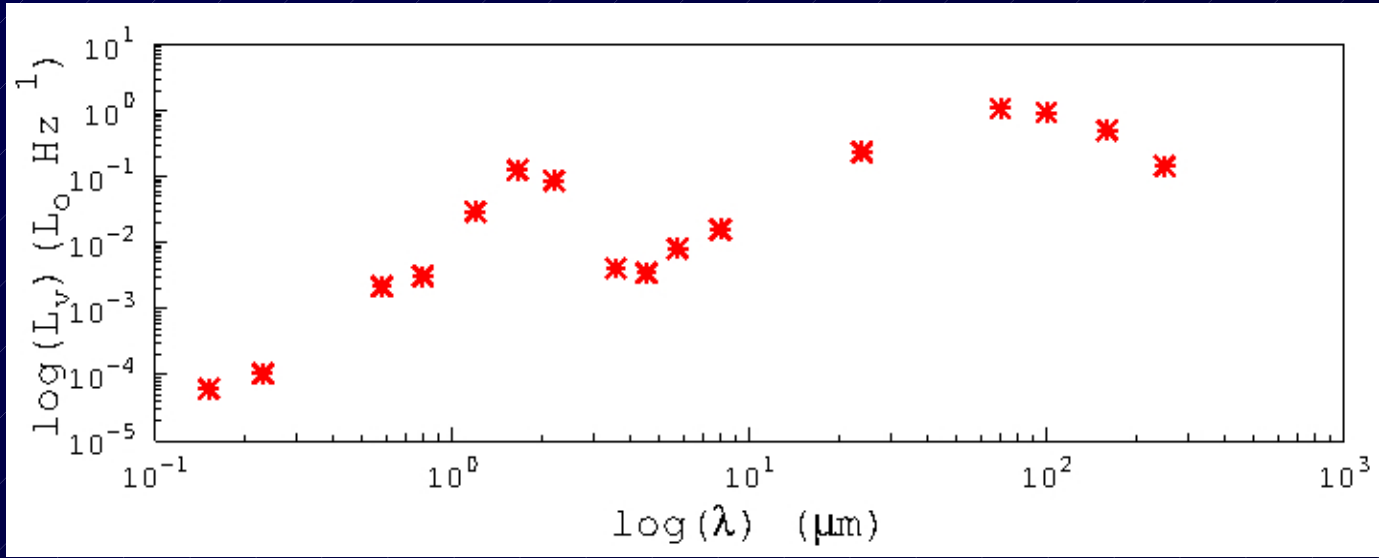
IMAGECUBE @ Western



http://sophiathl.github.io/imagecube/

Lianou, Barmby & Taylor 2015, in prep.

- Python package affiliated with Astropy
- Automates image processing
- Delivers datacube and pixel-by-pixel SEDs



DustPedia

A Definitive Study of Cosmic Dust in the Local Universe

- Funded under FP7 → http://dustpedia.com/index.php
- 6 institutes in 5 countries:

Jonathan Davies Cardiff University (CU) UK	Maarten Baes Ghent University (UGent) Belgium	Simone Bianchi INAF-Osservatorio Astrofisico di Arcetri (INAF) Italy	Antony Jones Universite Paris Sud (PSUD) France	Suzanne Madden Service d'Astrophysique (CEA) France	Manolis Xilouris National Observatory of Athens (NOA) Greece

DustPedia

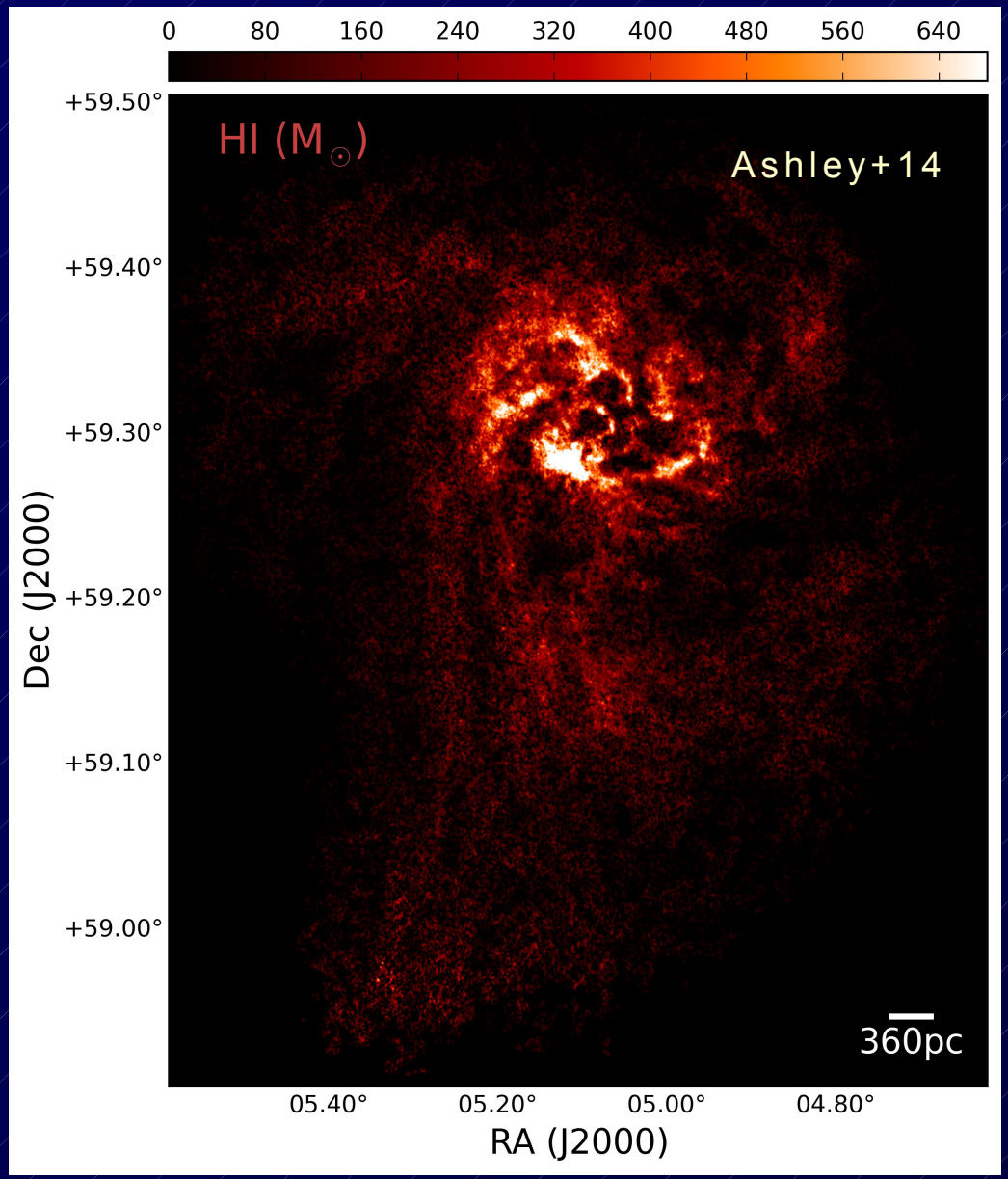
A Definitive Study of Cosmic Dust in the Local Universe

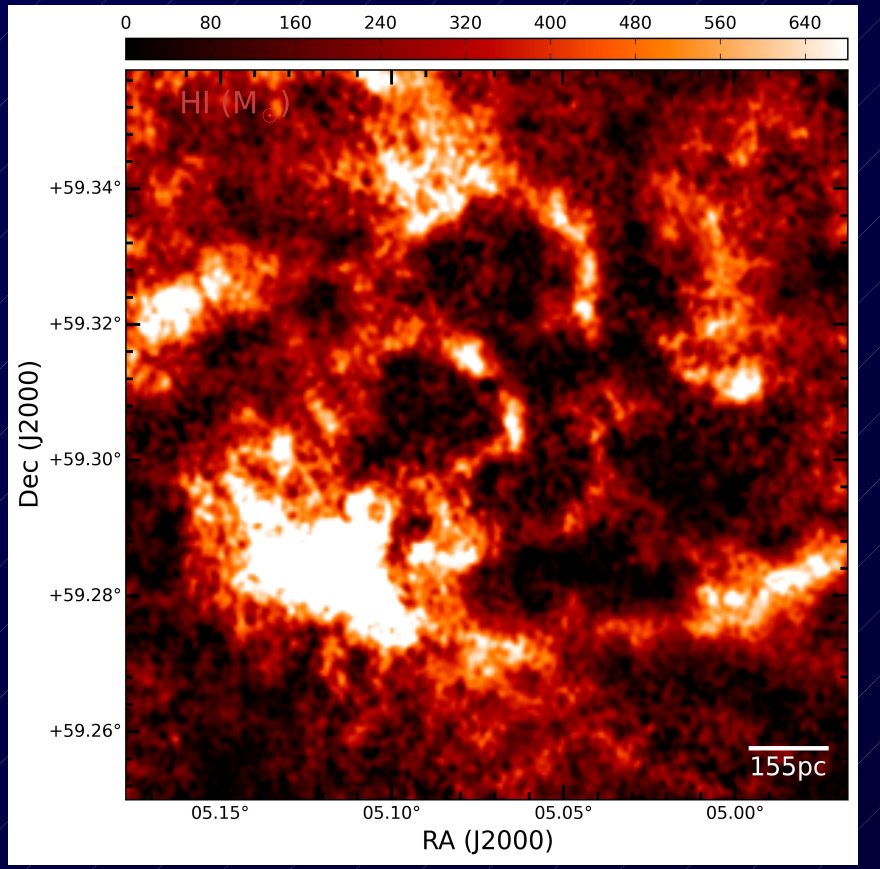
- Sample of ~3000 galaxies WISE-ly selected at 3.4μm
- Out to a distance of 40Mpc
- With sizes larger than 1'

CEA's contribution:

- Spatial and global ISM studies for resolved galaxies
- Hierarchical Bayesian technique to model their SED
- To compare SEDs with different physical properties

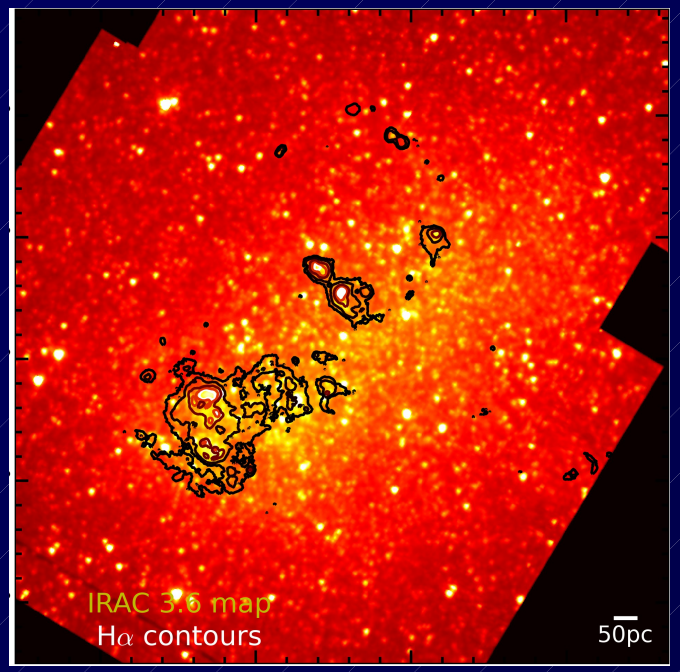
IC10 member of our Local Group

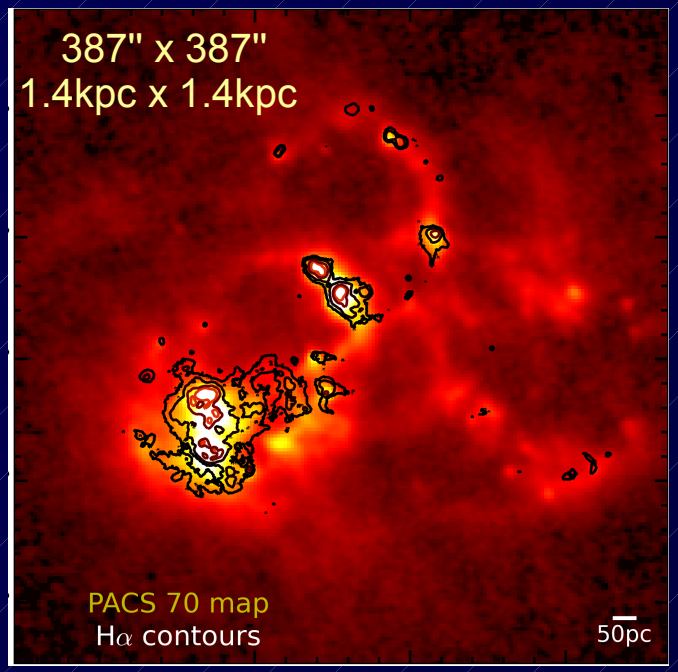


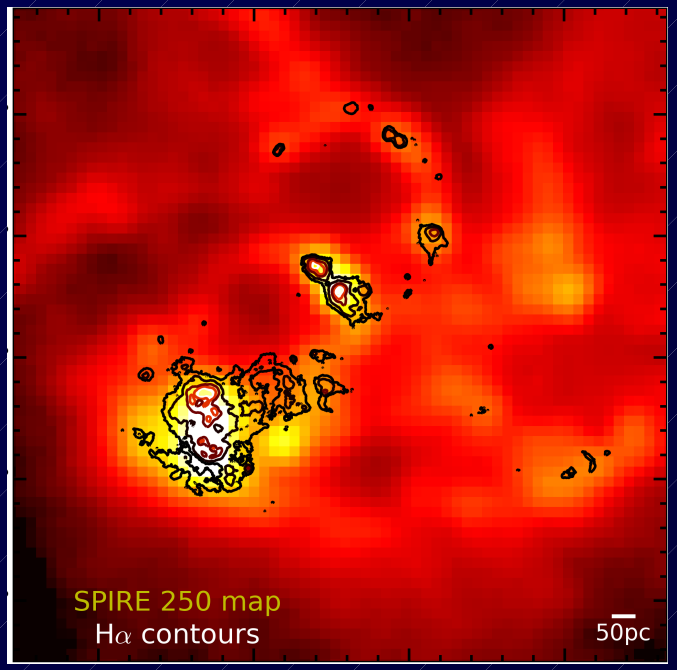


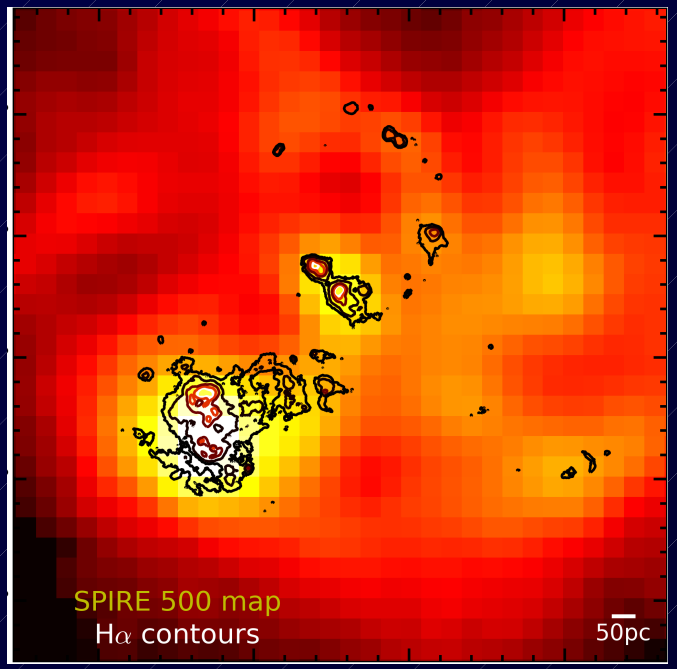
- HI rich & extended (Ashley+2014)
- signs of interaction (Nidever+2013)
- star-cluster bursting (Hunter+2001)

PACS & SPIRE & UV-to-MIR









Several dust emission knots

Hierarchical Bayesian Spectral Energy Distribution Model

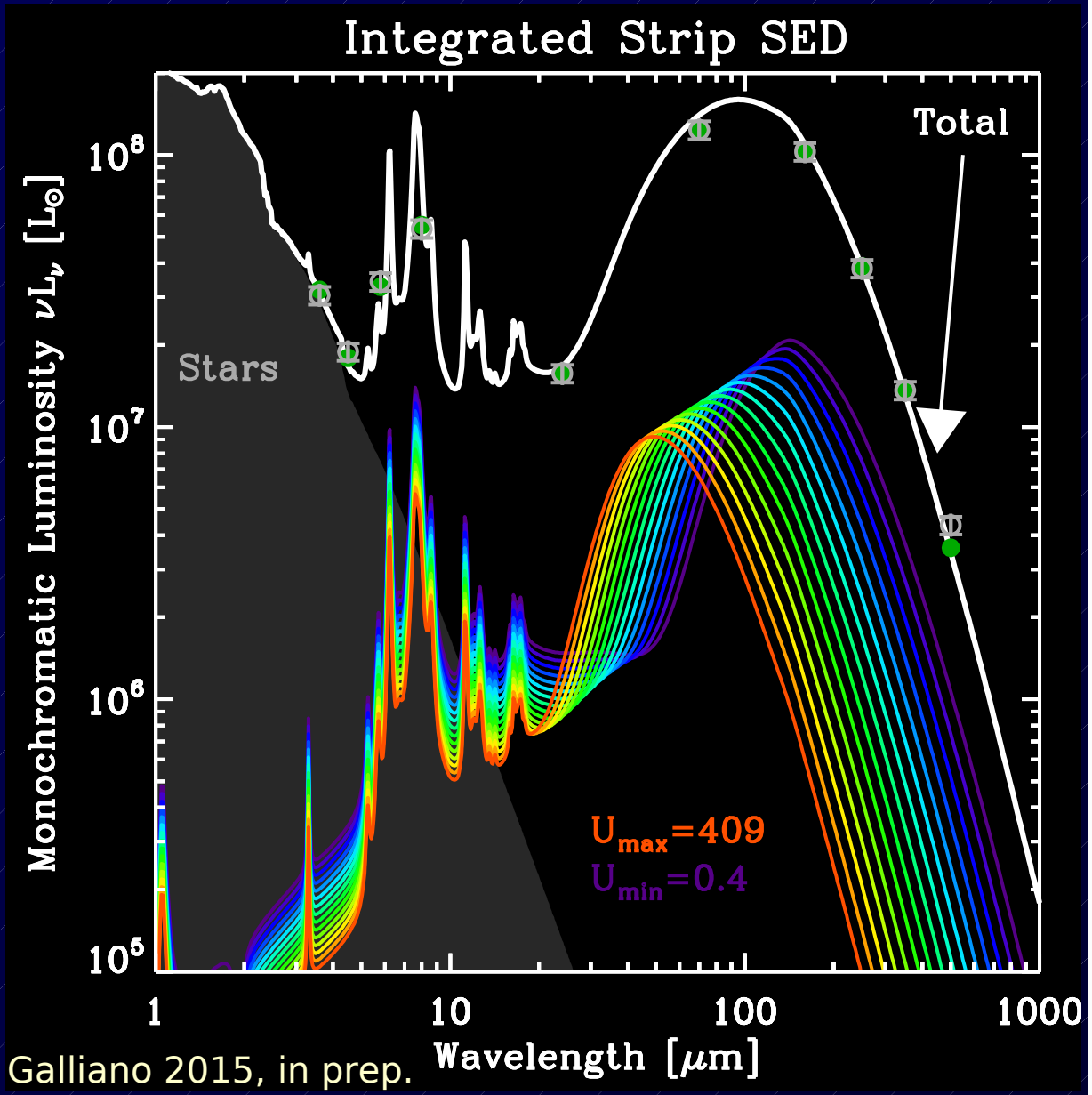
1) Stellar continuum: old stars

2) Distribution of dust conditions:

- Heating intensity, U (U=1 for the Galactic diffuse ISM):

$$M_{\rm dust} \propto U^{-\alpha}$$

- Other main Parameters: total dust mass and PAH fraction

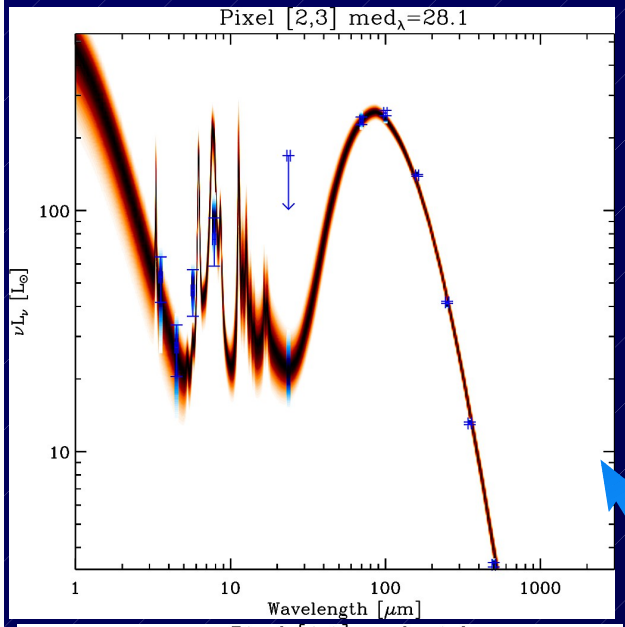


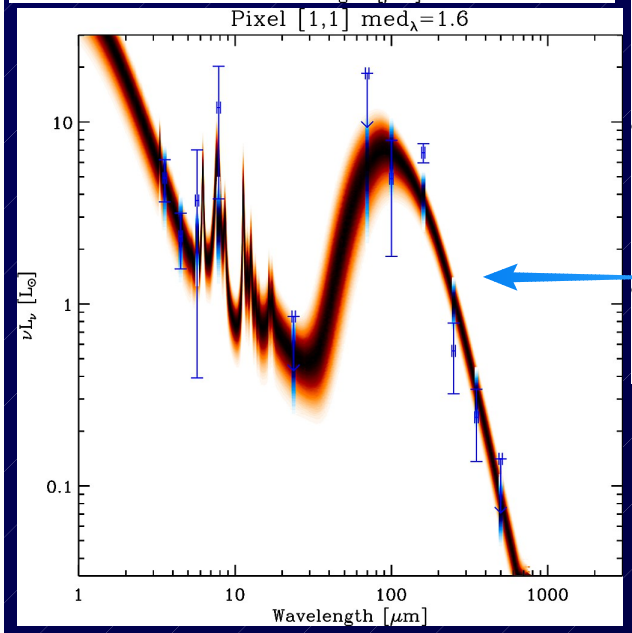
Galliano 2015, in prep.

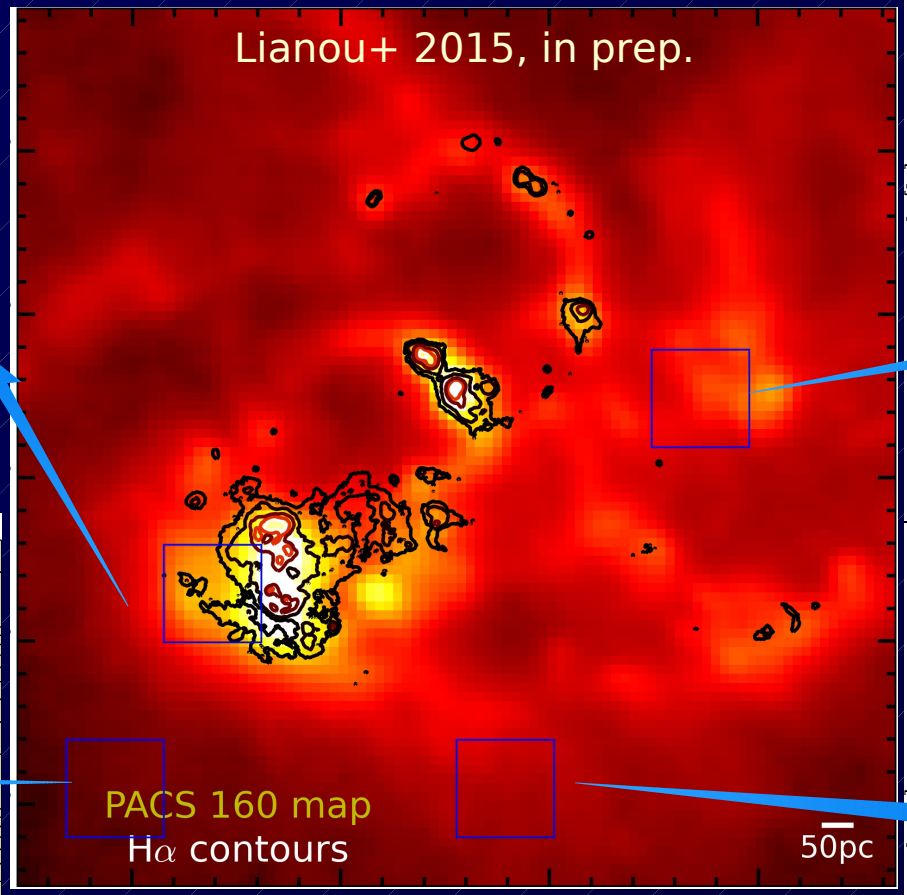
Hierarchical Bayesian:
modeling, a consistent view of the entire dataset, even low S/N data will be statistically meaningful, by solving for the distribution of parameters (hyperparameters).

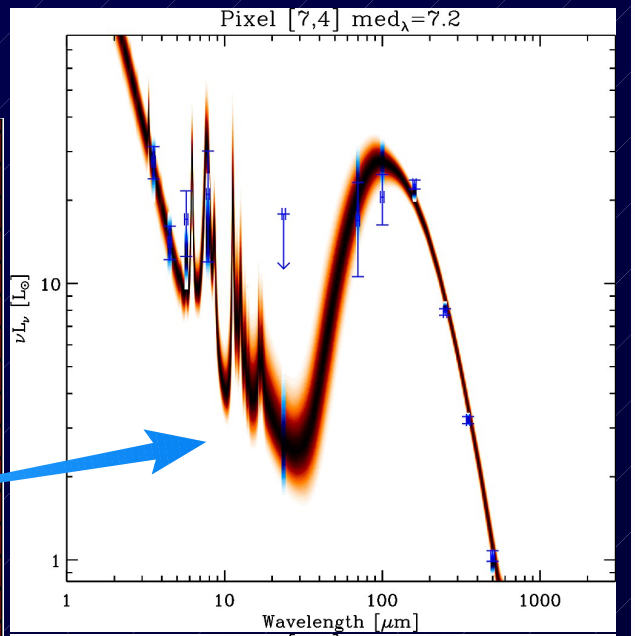
$$\underbrace{p(x|Obs)}_{\text{posterior}} \propto \underbrace{p(Obs|x)}_{\text{likelihood}} \times \underbrace{p(x)}_{\text{prior}}$$

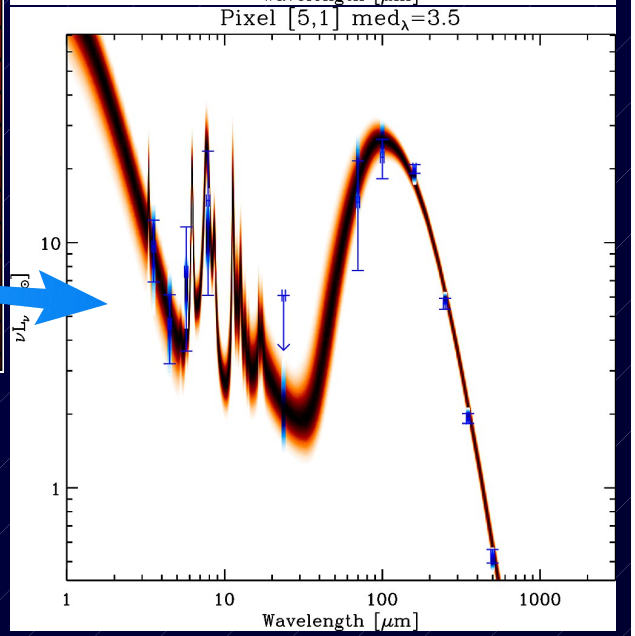
SEDs on 150pc-scale pixel



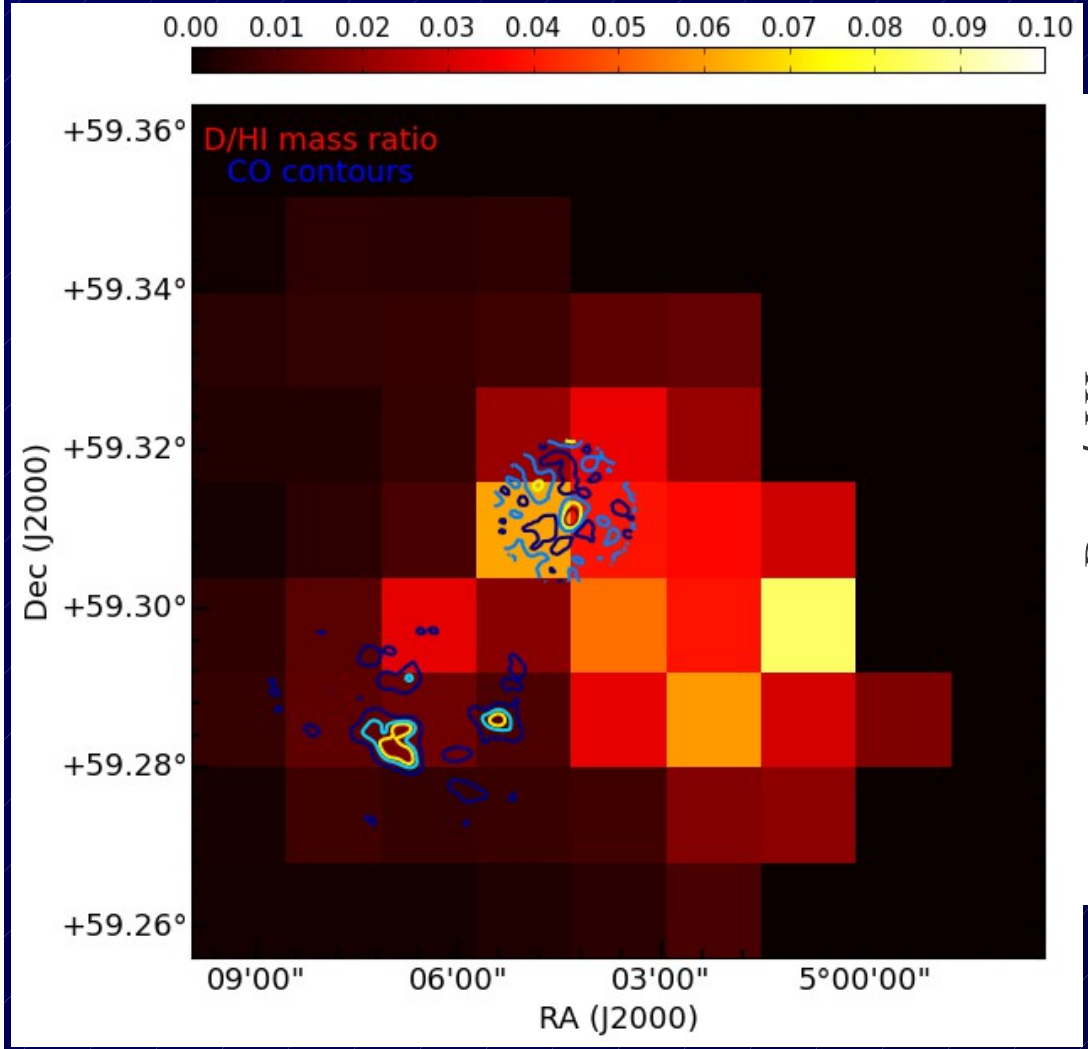


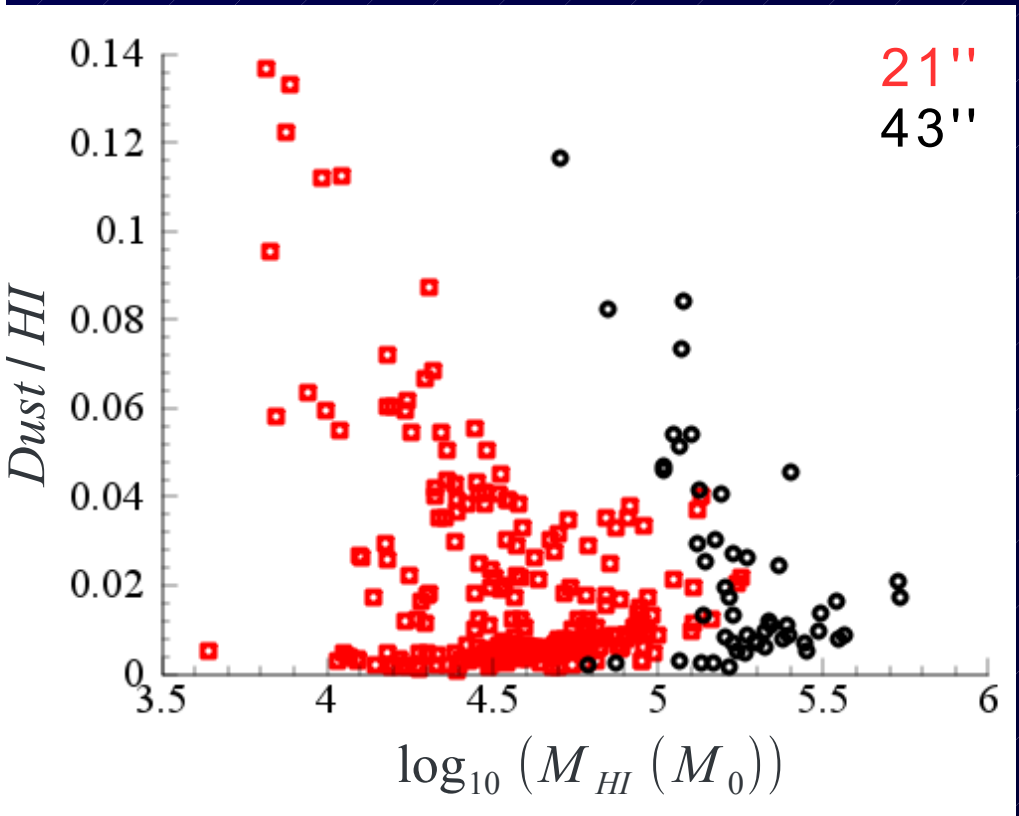






Dust-to-HI mass ratio: highest in HI-deficient regions





Pixels with lower HI mass as compared to the dust mass – other than in HI cavities, hints to CO-dark gas? (Madden+1997) – or showing a variation in dust and gas?

DustPedia

A Definitive Study of Cosmic Dust in the Local Universe

- Sample of ~3000 galaxies WISE-ly selected at 3.4μm
- Out to a distance of 40Mpc
- With sizes larger than 1'

CEA's contribution:

- Spatial and global ISM studies for resolved galaxies
- Hierarchical Bayesian technique to model their SED
- To compare SEDs with different physical properties