

Nearby Galaxies and Stellar Populations

Robert Kennicutt

Institute of Astronomy
University of Cambridge



Outline

- The key questions
- Multi-Great-Observatory science
- Other Legacy/Treasury/Large Project science
- Discussion

Questions and Boundary Conditions

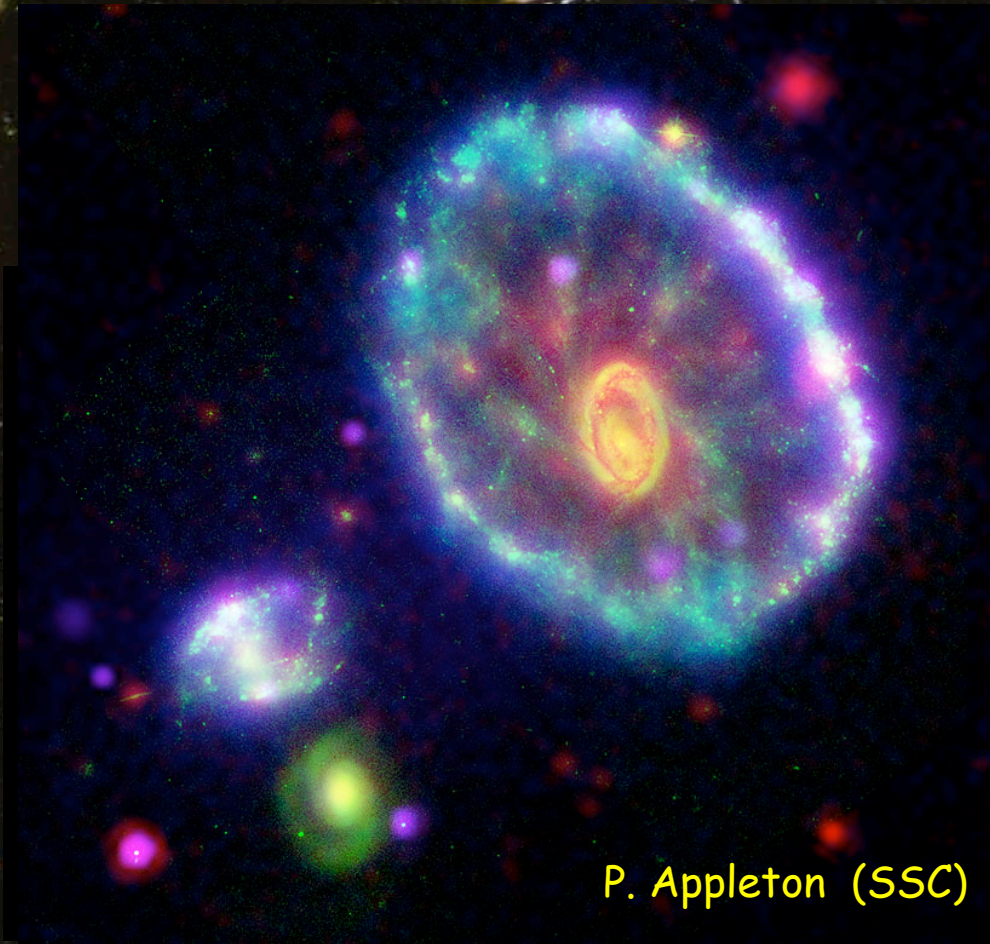
- What are the 3 most important (and least understood) scientific issues within your subject area, and how can we best address them with the Great Observatories?
 - consider GALEX, FUSE, XMM, VLA/ACTA, 8-10m's, SDSS too
- What important scientific issues would profit most from multi-band observations?
- What major future projects are likely to require substantial preparatory observations now?
 - consider leveraging of archival resources too
- What are the top 3 science priorities in your area?

Some Key Questions

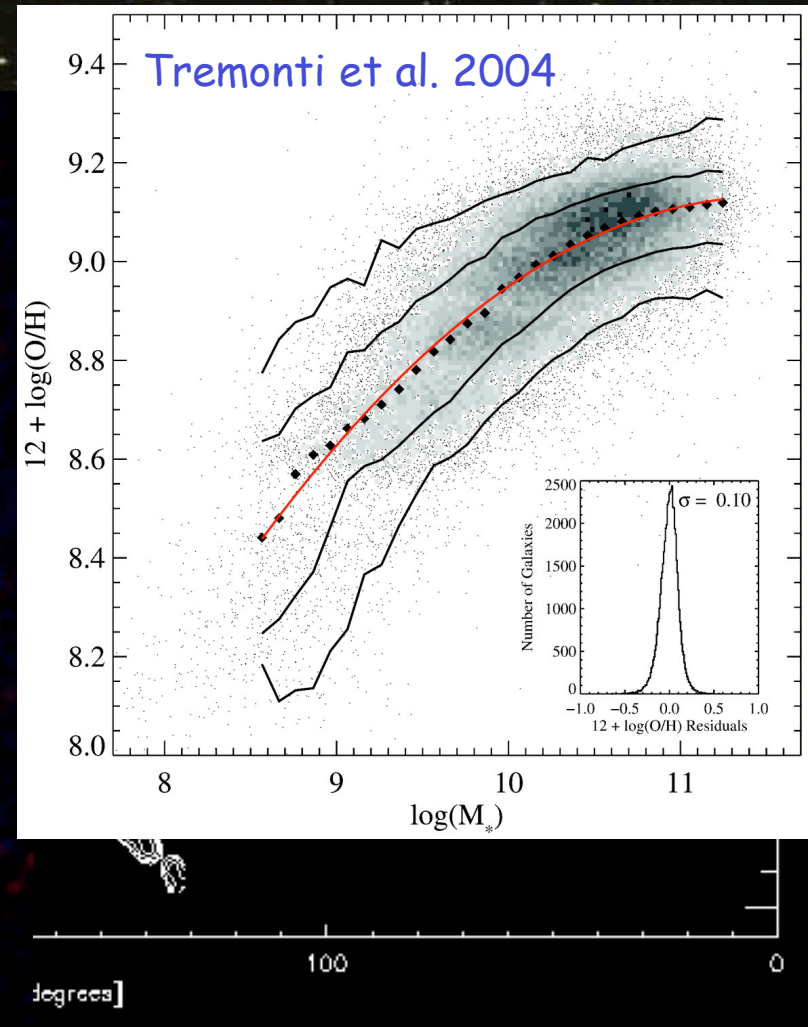
(*cf.* European Strategic Surveys)

- What is the cycling of stars, gas, and dust in galaxies?
- What is the chemical history of the Universe?
- How did the Milky Way form?
- What is the role of black holes in galaxy formation?
- Is the initial mass function of stars universal?

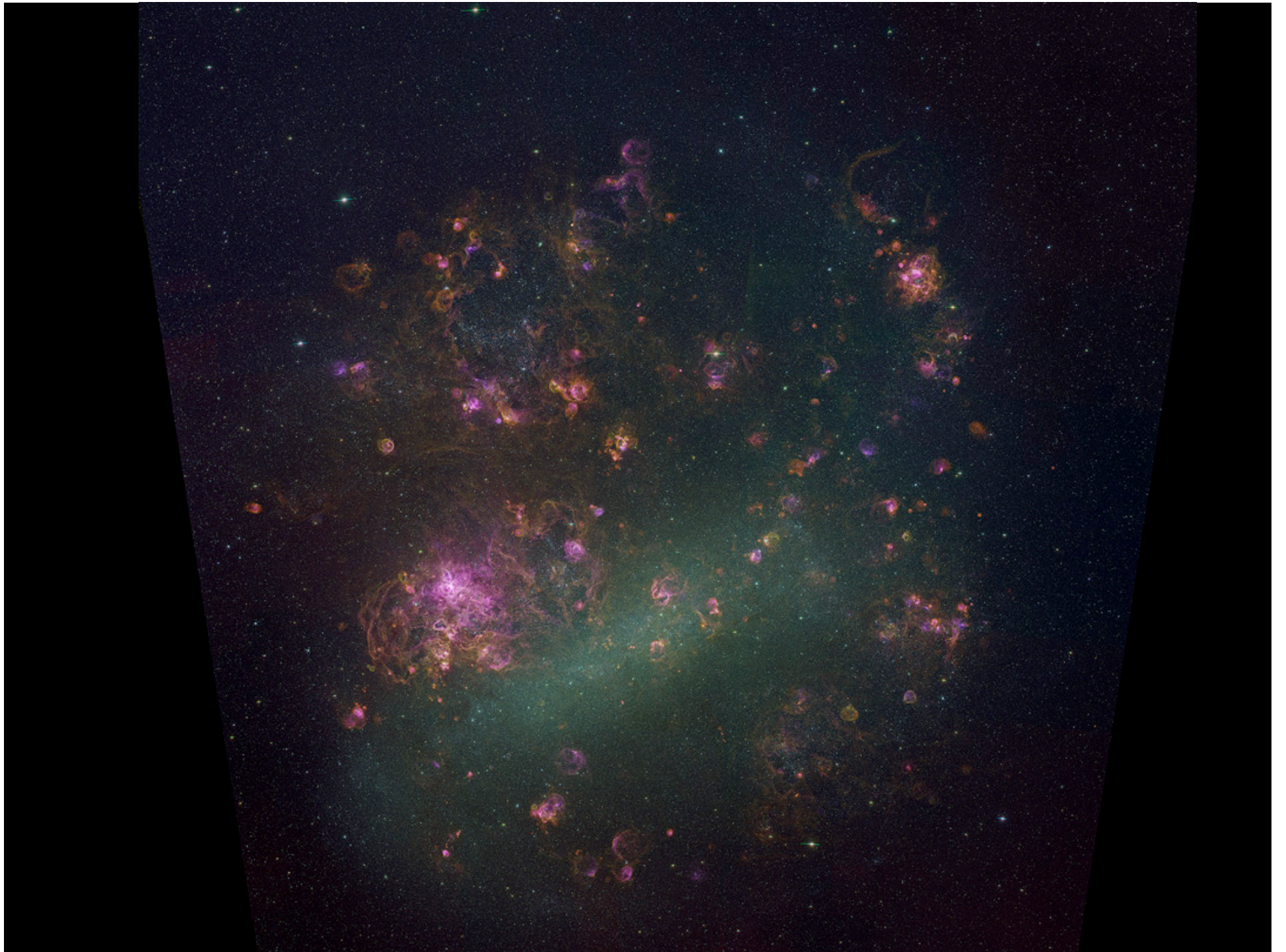
The Big Questions: Independent Paths to Understanding Galaxy Formation/Evolution

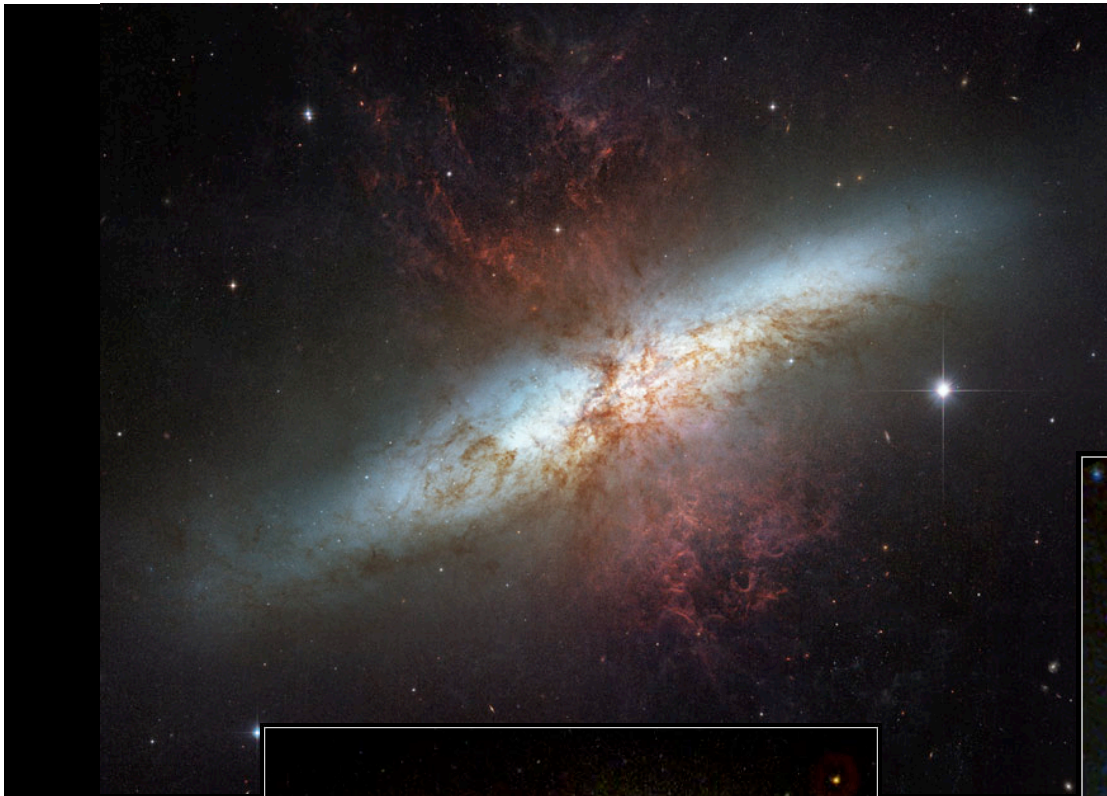


P. Appleton (SSC)



V. Belokurov, IoA SEGUE Team





Galaxy NGC 1512 HST • FOC • NICMOS • WFPC2
NASA, ESA, and D. Maoz (Tel-Aviv University and Columbia University) • STScI-PRC01-16



Ultraluminous Infrared Galaxy HST • NICMOS • ACS
IRAS 19297-0406

NASA, The NICMOS Group (STScI, ESA),
The NICMOS Science Team (Univ. Arizona)
STScI-PRC02-13c

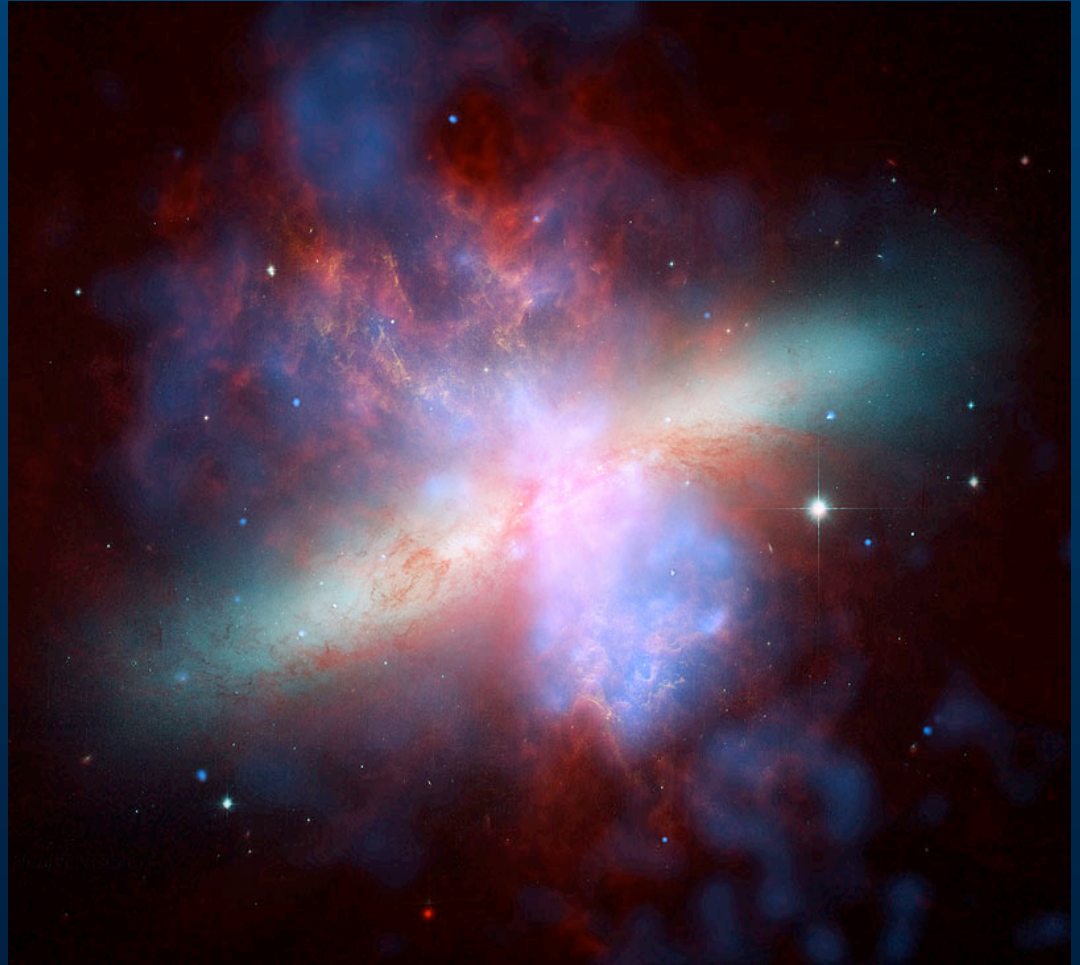
CXO/HST/Spitzer Science

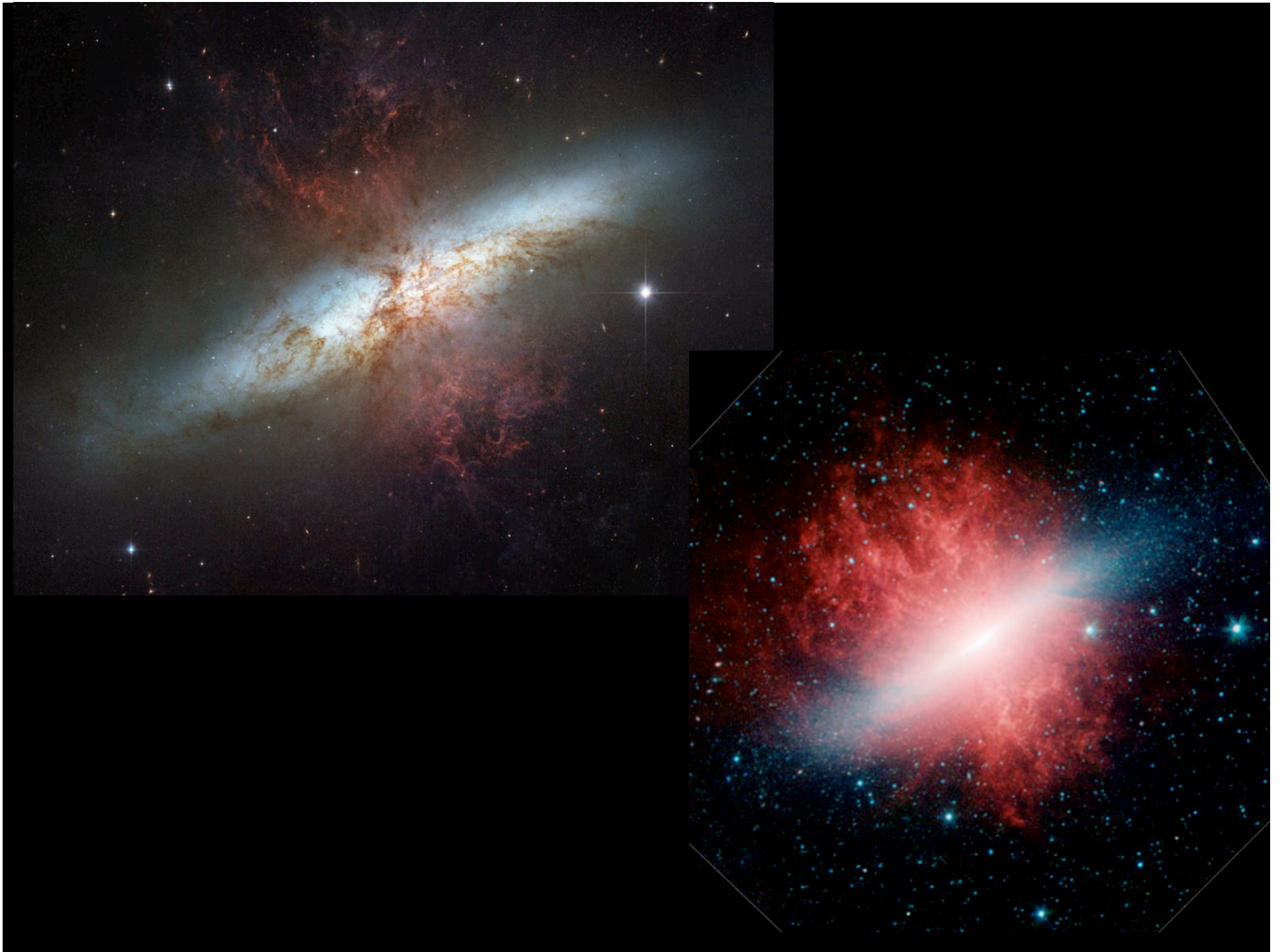
- **Starbursts**
 - star formation, winds, feedback
 - extreme starbursts as galaxy formation laboratories
- **Centers of galaxies**
 - the SF/AGN connection
 - dynamical connections to host galaxies and black holes
- **Galaxy clusters: cycling of baryons, energy**
- **Populations of massive compact objects in galaxies**

CXO/HST/Spitzer Science

Starbursts

- triggering, regulation of SF, bursts
- feedback and galactic winds, superwinds, metal, dust ejection
- central starbursts: the AGN connection
- SF in extreme environments, IMF, abundances, etc





The Starburst Bestiary...

GEHRs

SSCs

HII galaxies

ELGs

CNELGs

W-R galaxies

BCGs

BCDs

LIGs, LIRGs

ULIGs, ULIRGs

LUVGs, UVLGs

nuclear starbursts

circumnuclear starbursts

clumpy irregular galaxies

Ly- α galaxies

E+A galaxies

K+A galaxies

LBGs

DRGs

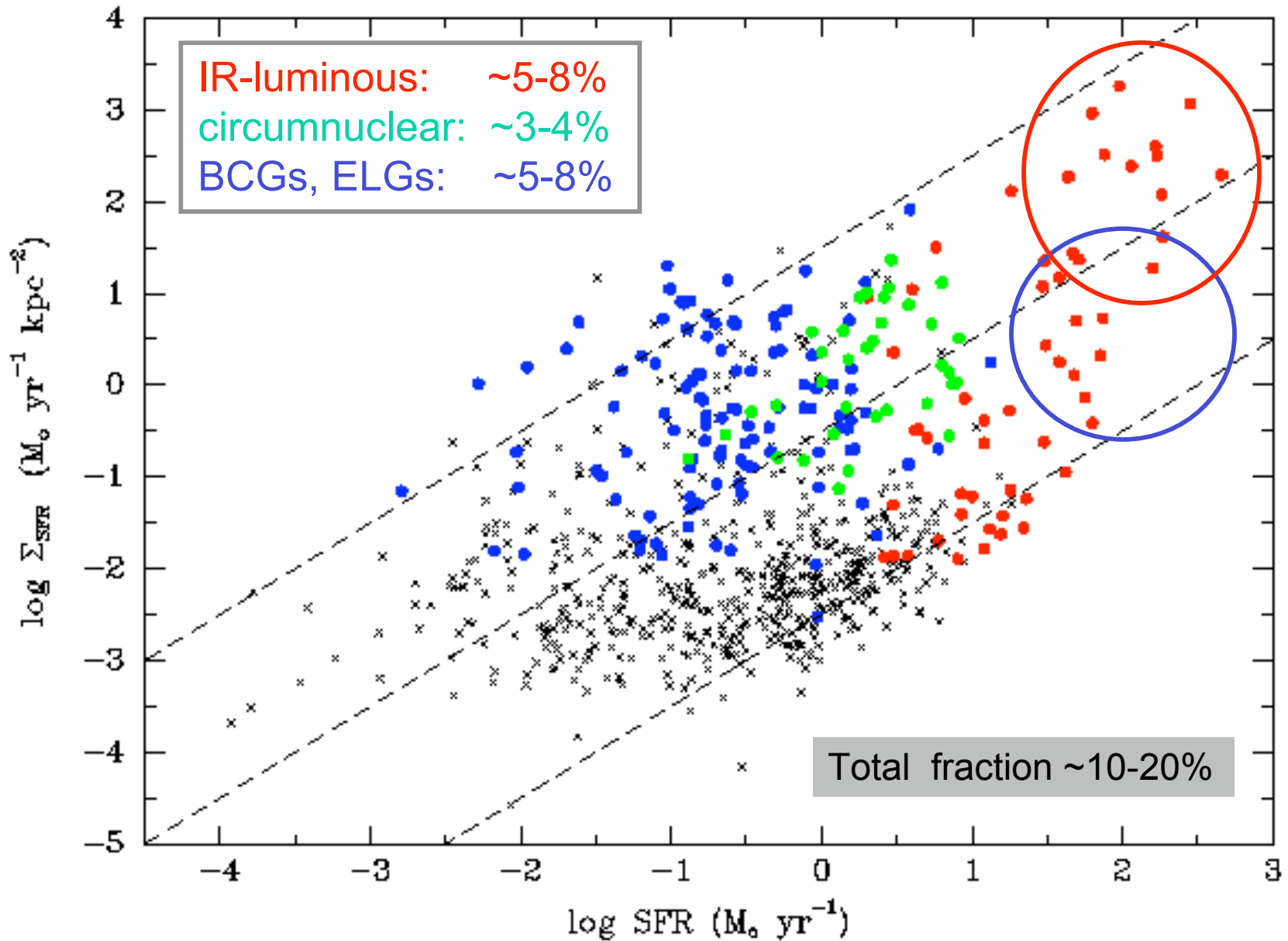
EROs

SCUBA galaxies

extreme starbursts



Contributions to the global star formation budget



Starbursts: Key Observations

- Coupling of wind properties to SFR, SF concentration, host galaxy properties— scaling laws for feedback?
- **Triggering and Fueling**
 - gas flows, timescales
 - role of interactions
 - regulation of SFR in extreme environments
- **Evolution**
 - transformation from dust embedded to UV-luminous phases
 - coupling of central starburst vs AGN activities
- **Clustering of star formation**
- **IMF in starbursts**

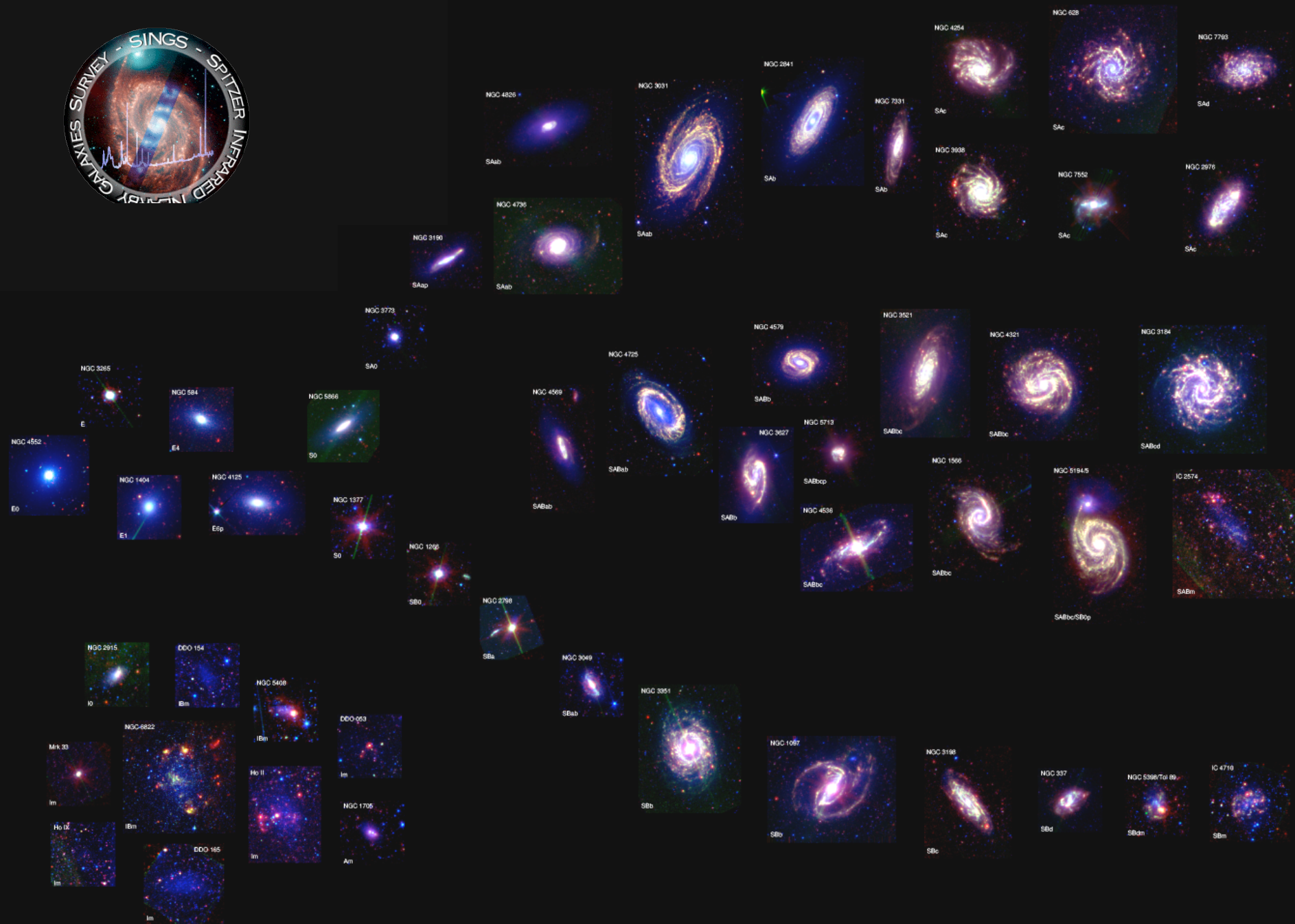
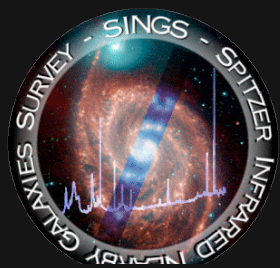
Individual Legacy/Treasury Large Projects

Spitzer Legacy, Large Projects

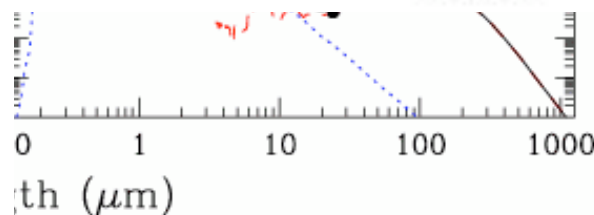
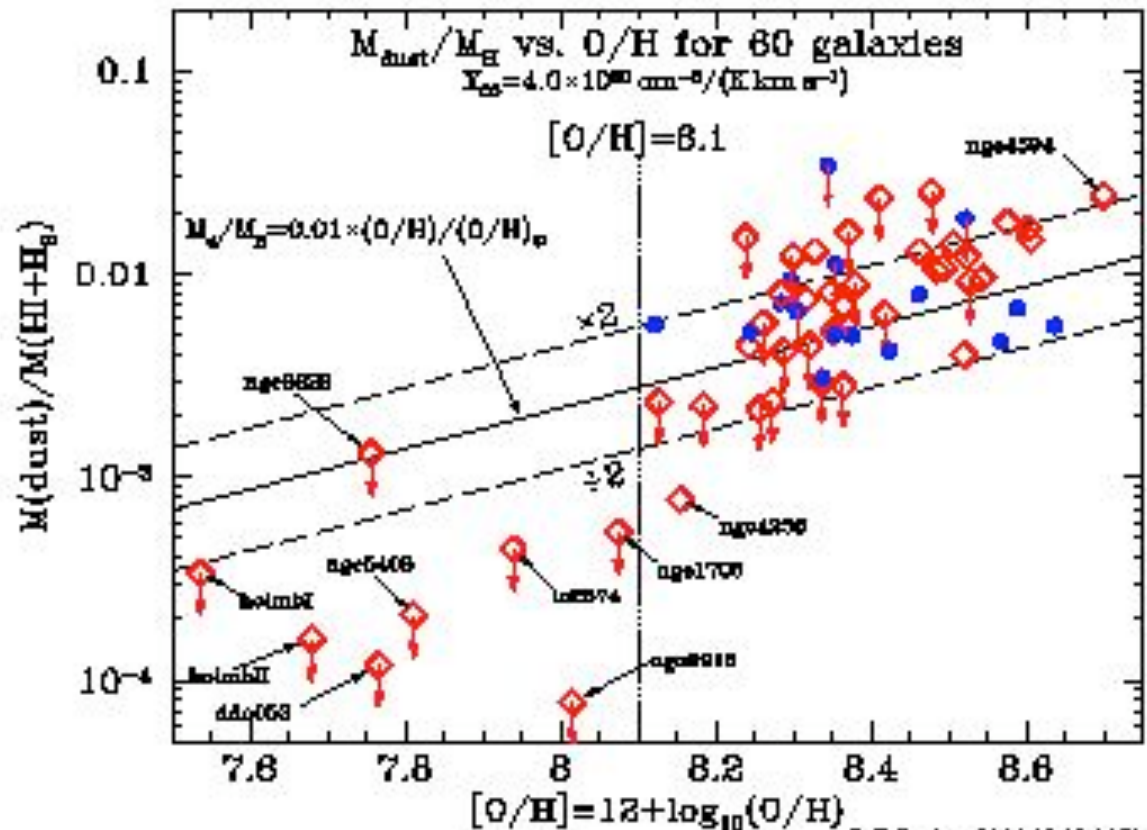
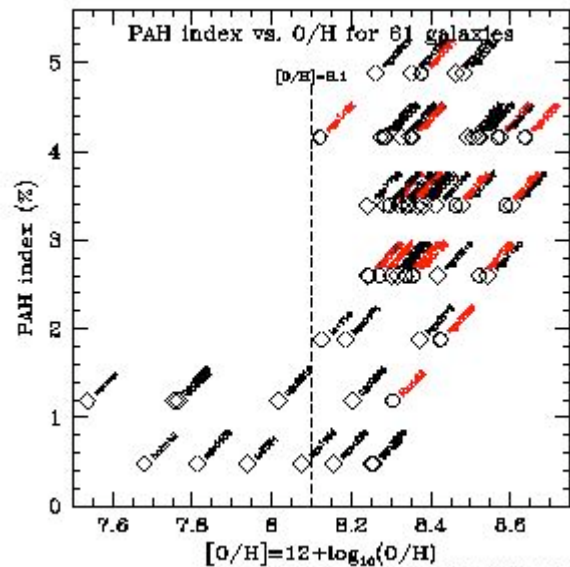
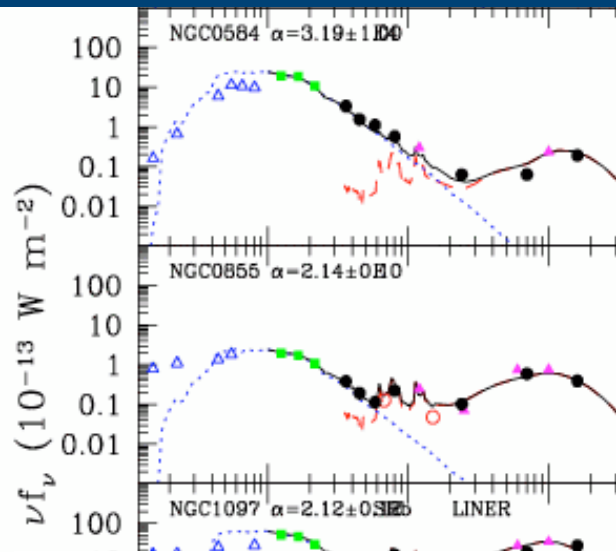
- SINGS (UV \rightarrow radio for 75 galaxies)
- SAGE (LMC) + SMC survey
- QUEST (quasars, ULIRGs)
- ULIRG spectra (Armus et al)
- SSGSS (Sloan, GALEX, Spitzer)

HST Legacy, Large Projects

- H_0 Key Project (distances, stellar/cluster pops)
- Nuker survey (centers, black holes)
- ACS Virgo cluster survey
- M31 halo surveys
- UV spectra of clusters, galaxies nuclear
- ACS Nearby Galaxy Survey Treasury (ANGST)

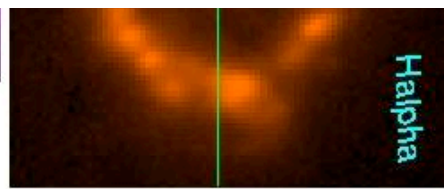
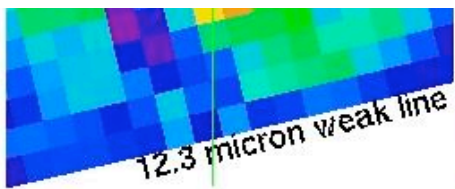
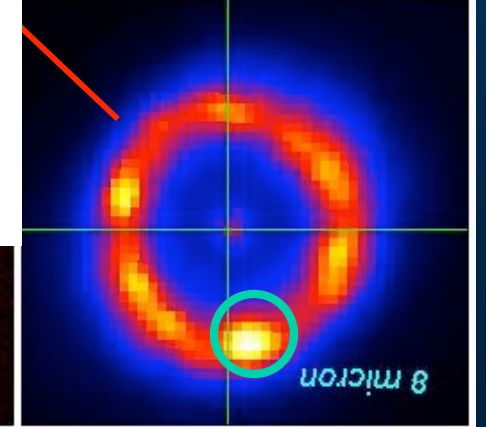
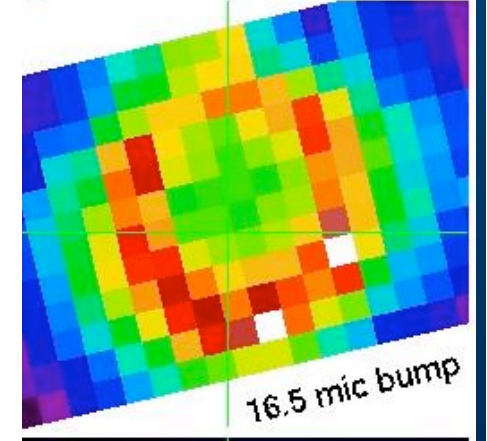
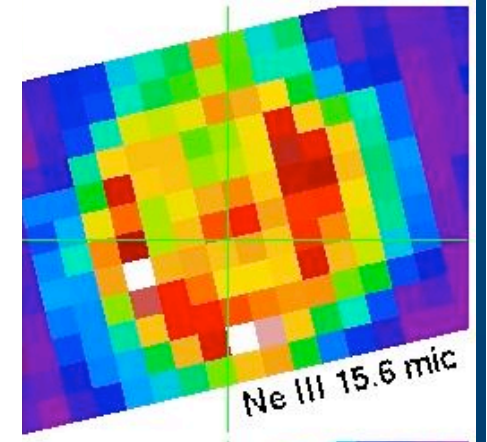
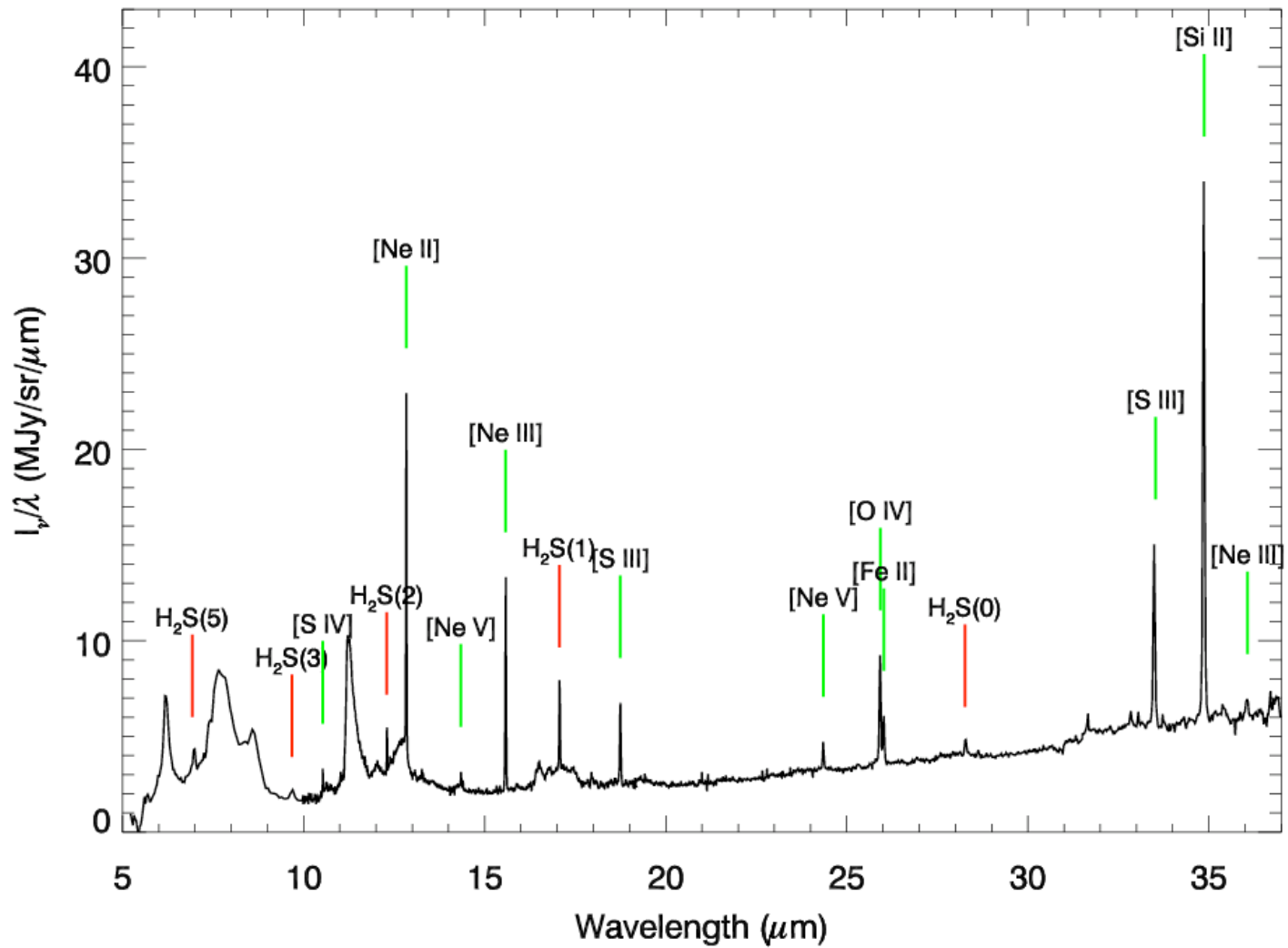


UV --> FIR SED Maps of Galaxies



B. F. Drake 2005.08.08.1950

M51, Composite Spectrum



Sheth et al, in preparation

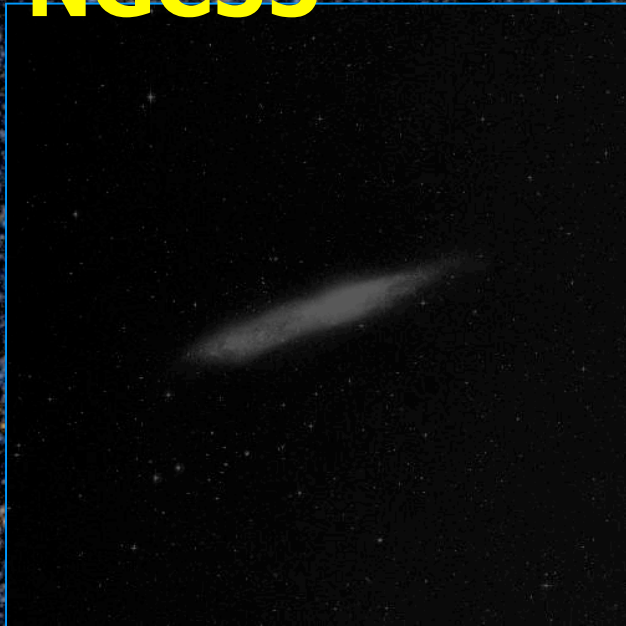
ACS Nearby Galaxy Survey Treasury (ANGST)

- Recover SFH of Local Volume
- Provide Rich General Purpose Archive

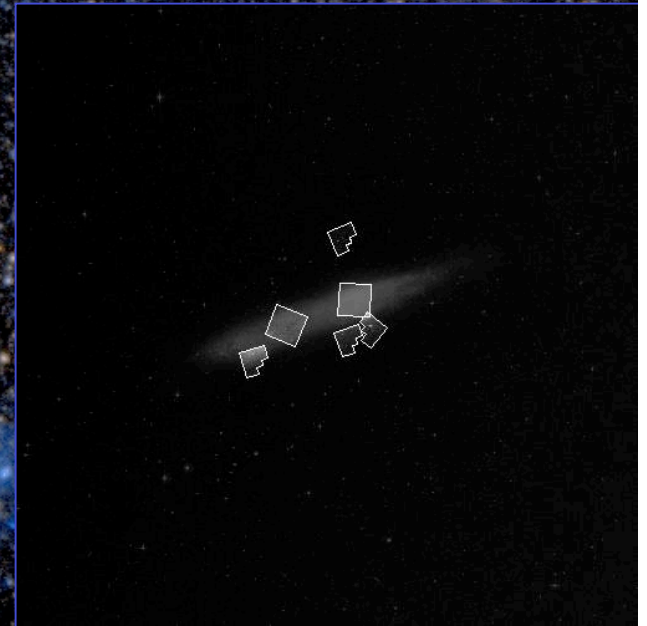
- 295 Orbits
- 45 New Galaxies + 14 Archival
- Volume limited sample
($|b| > 20$, $D < 3.5 \text{ Mpc}$, cone out to M81 & Sculptor)
- Captures 99% of Past & Current SF
- 3 Filters for all galaxies with $M_B < -13.5$

ACS Nearby Galaxy Survey Treasury (ANGST)

NGC55

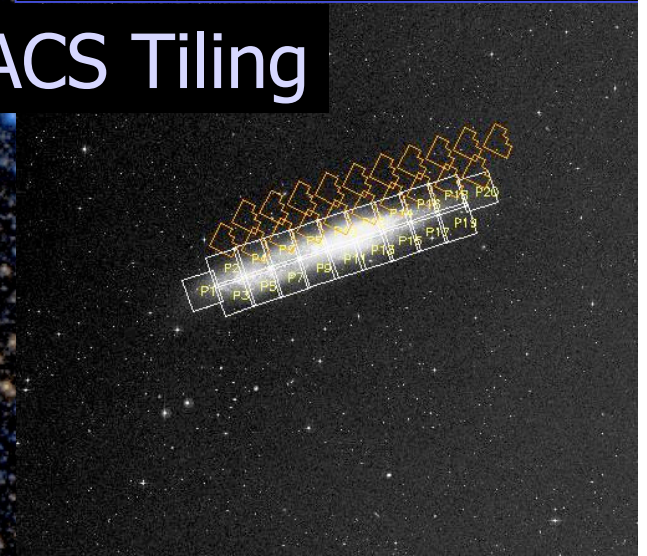


Existing HST Data



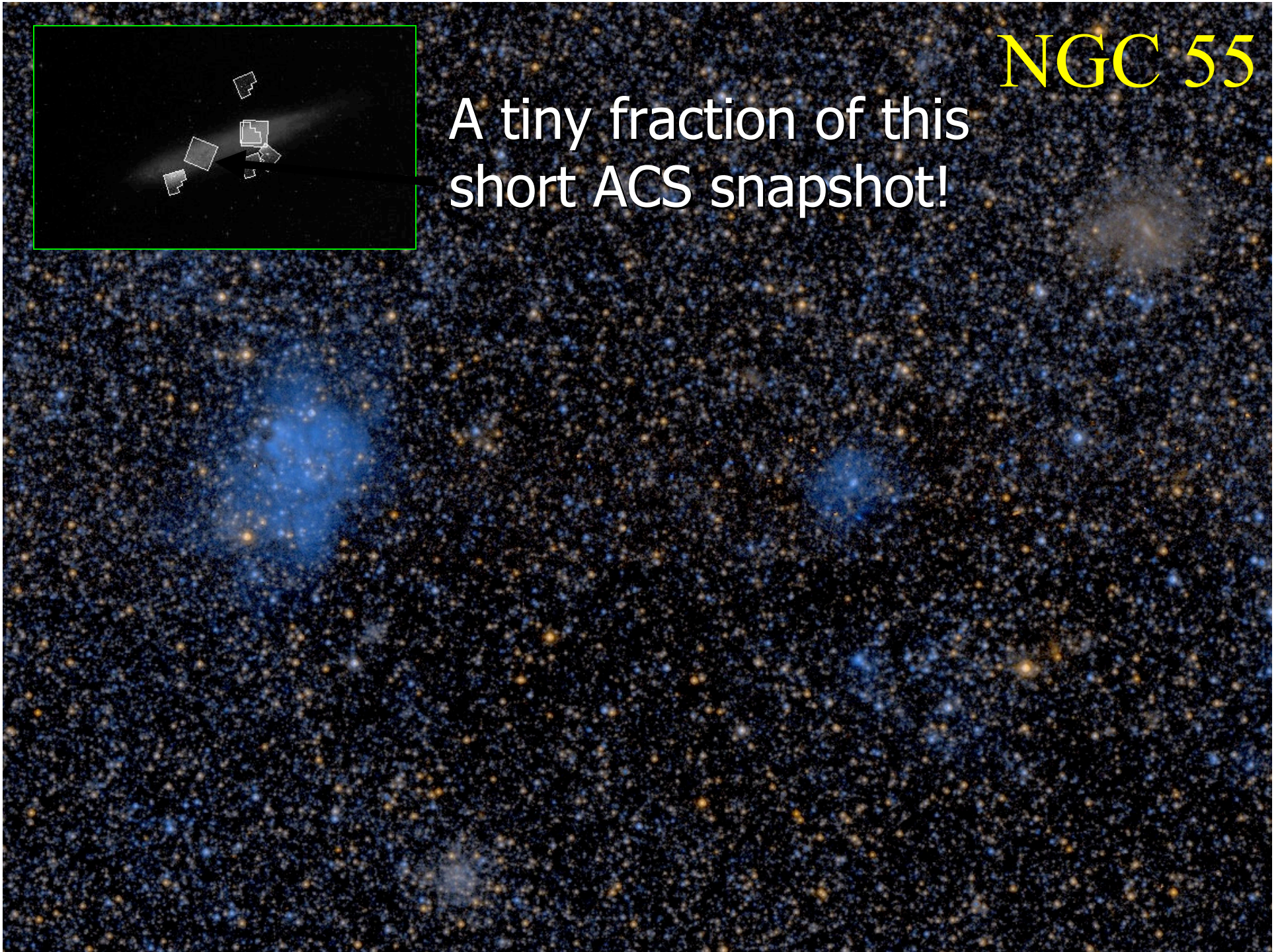
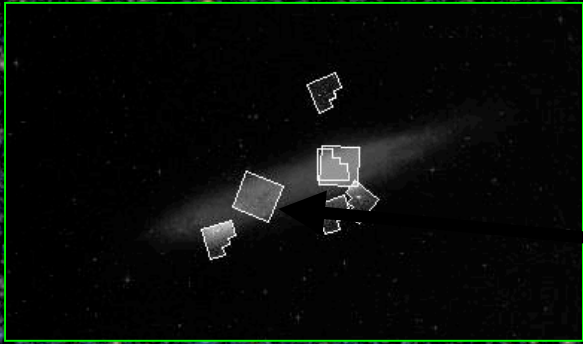
Proposed ACS Tiling

1. Galaxies tiled in 3 filters
2. Volume limited sample of galaxies out to ~ 4 Mpc
3. 1 deep field to reach below HB
4. 295 Orbits (cut from 552)

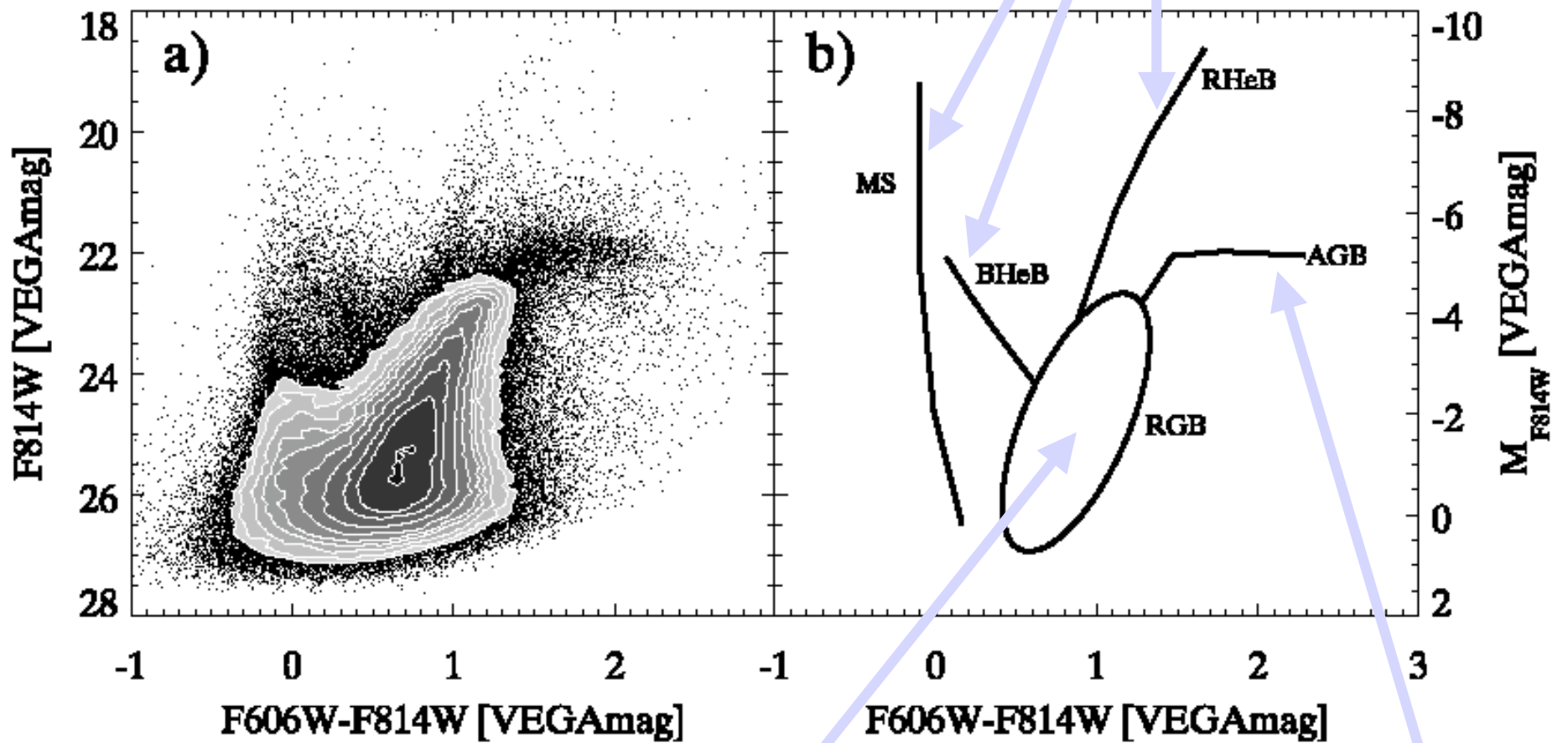


NGC 55

A tiny fraction of this
short ACS snapshot!



>250,000 stars in a single ACS snapshot



NGC 55

Old
($\sim 10^{10}$ yrs)

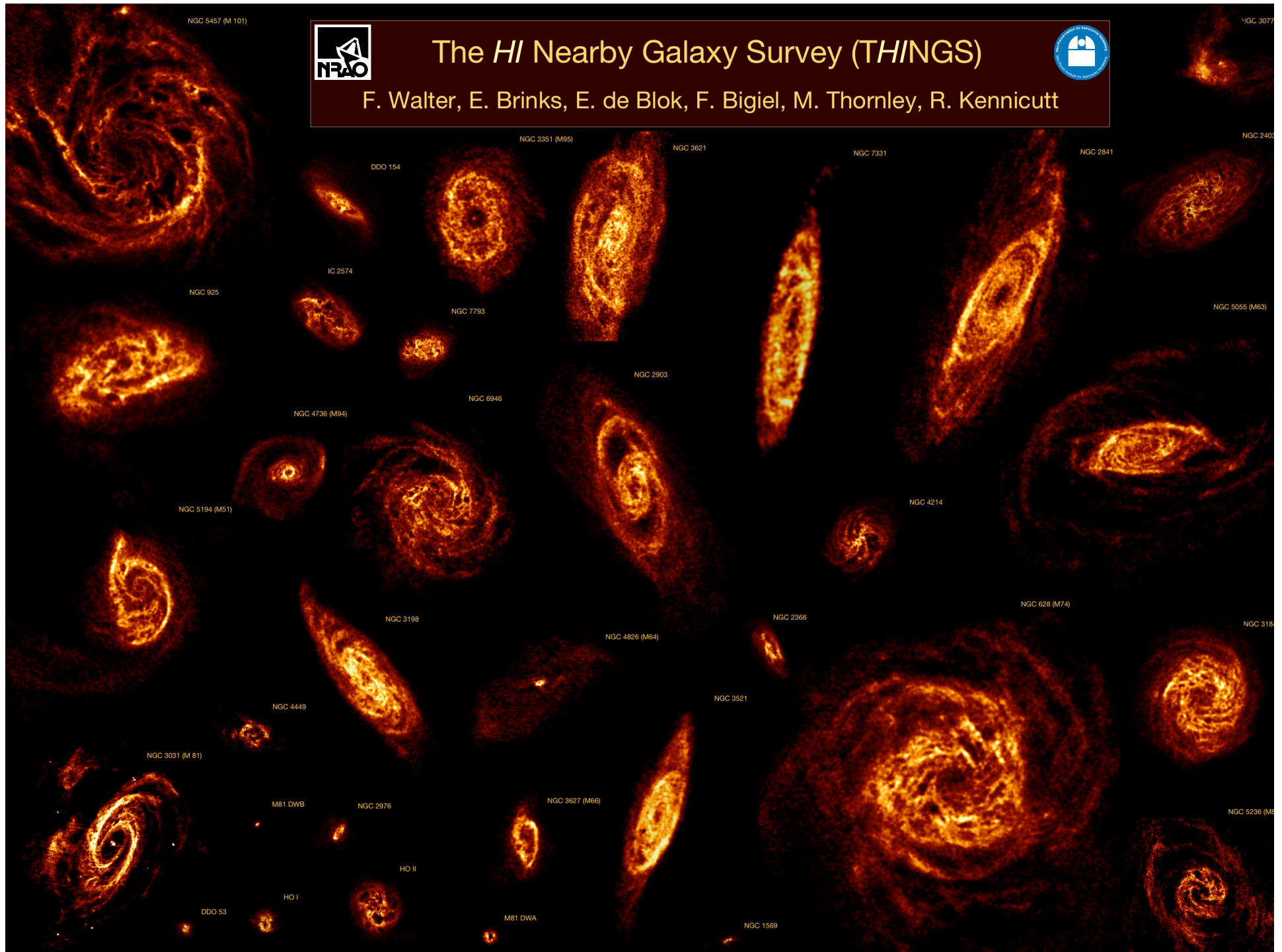
Intermediate
($\sim 10^9$ yrs)

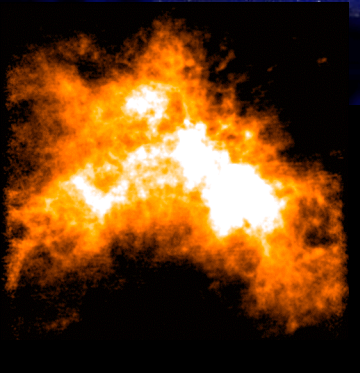
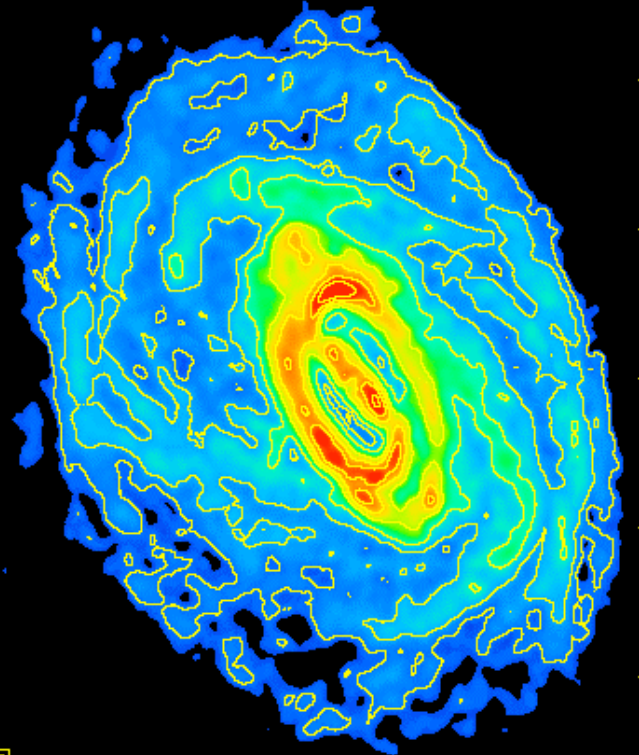
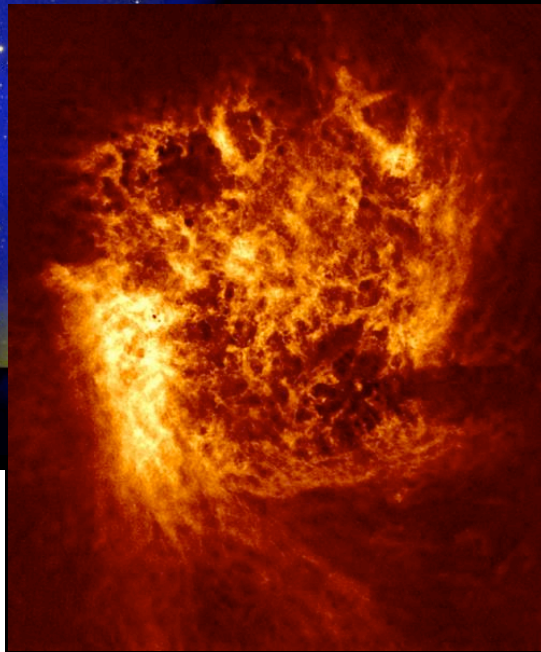
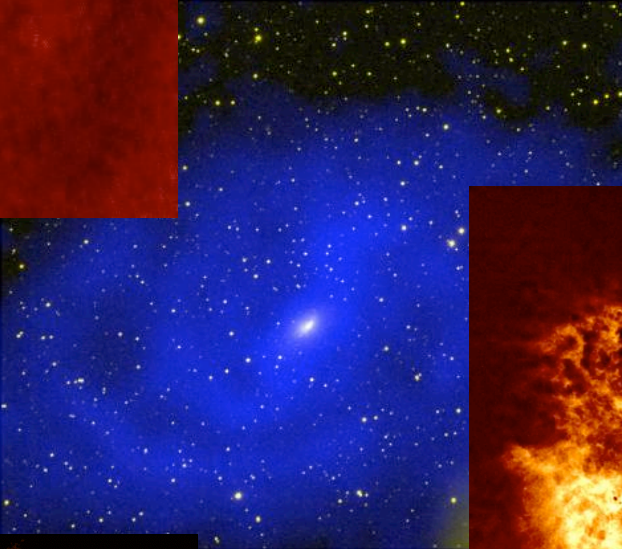
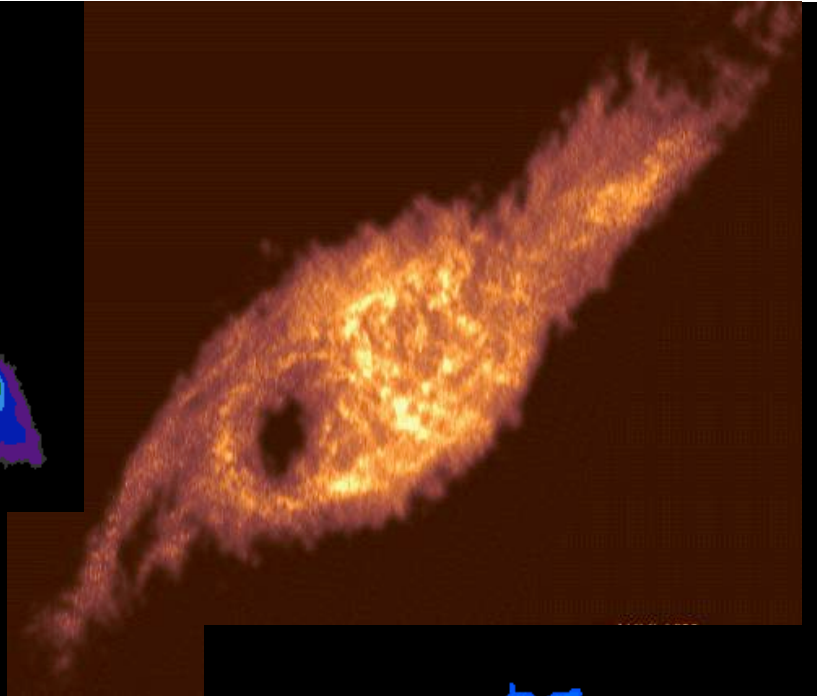
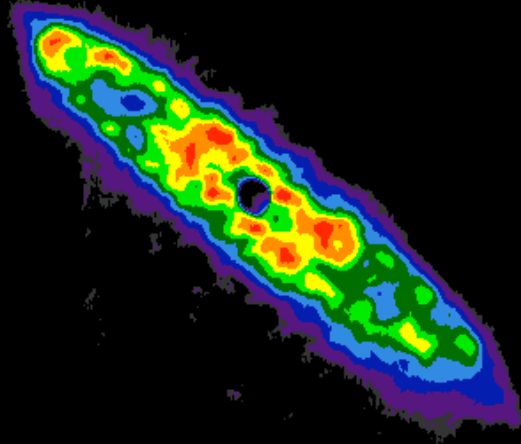
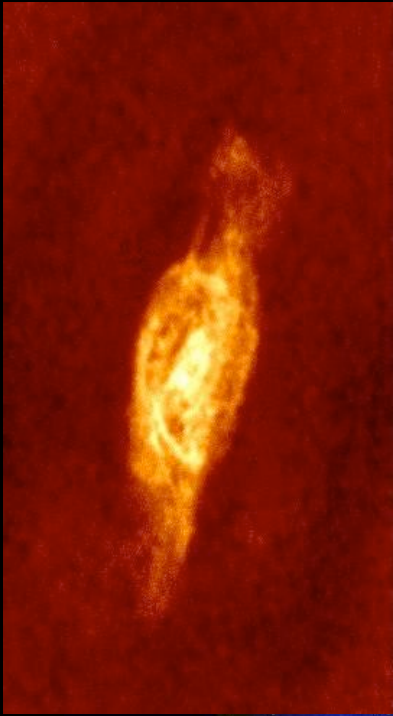


The *HI* Nearby Galaxy Survey (*THINGS*)



F. Walter, E. Brinks, E. de Blok, F. Bigiel, M. Thornley, R. Kennicutt





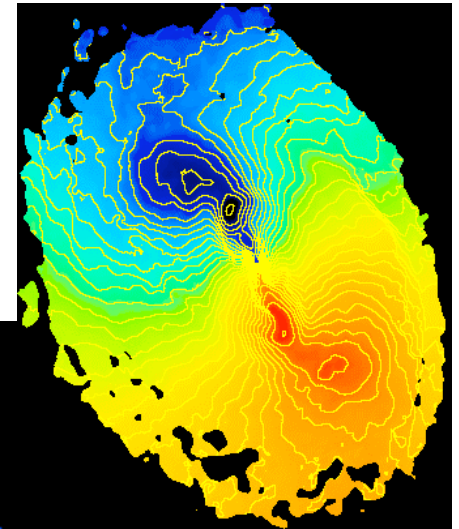
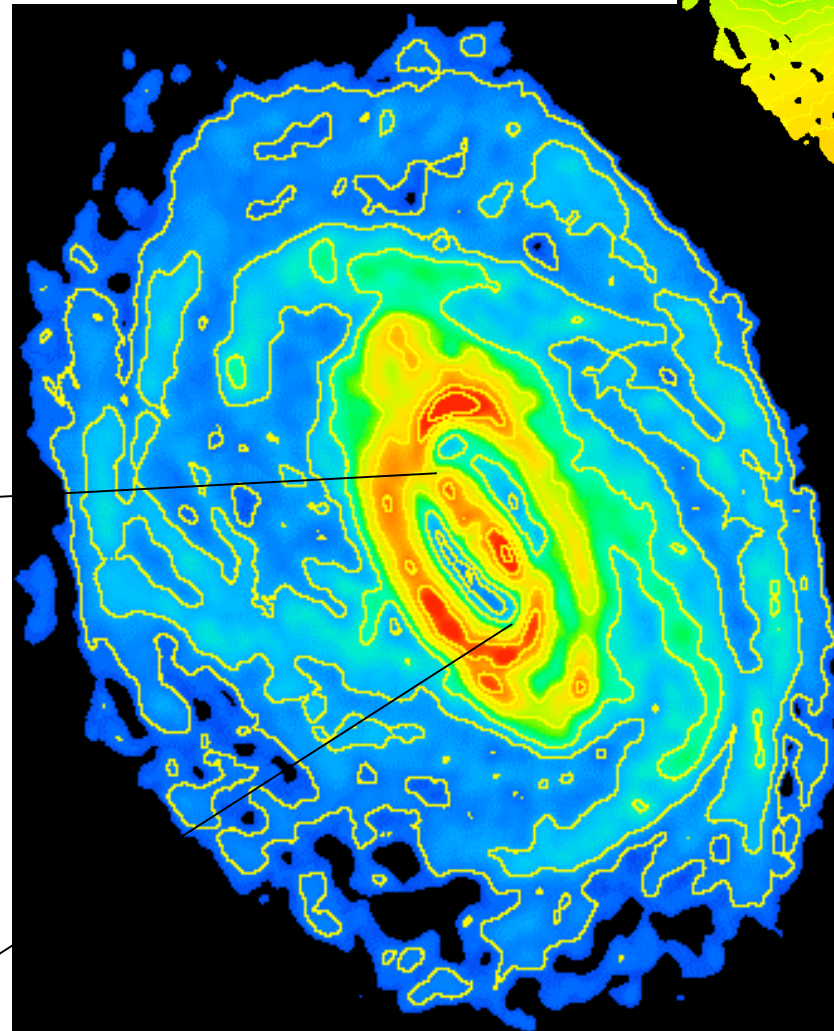
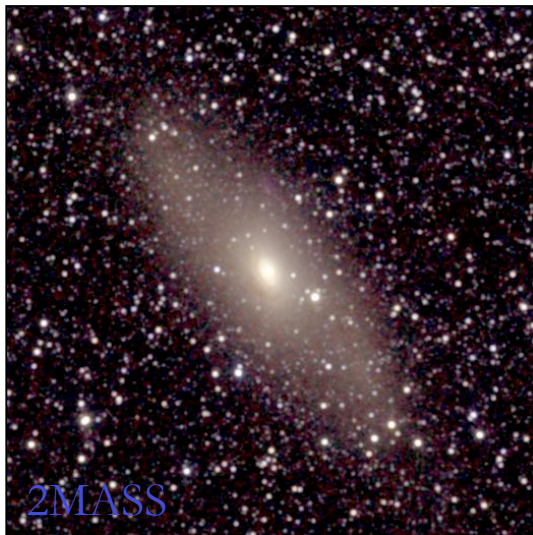
The Circinus Galaxy

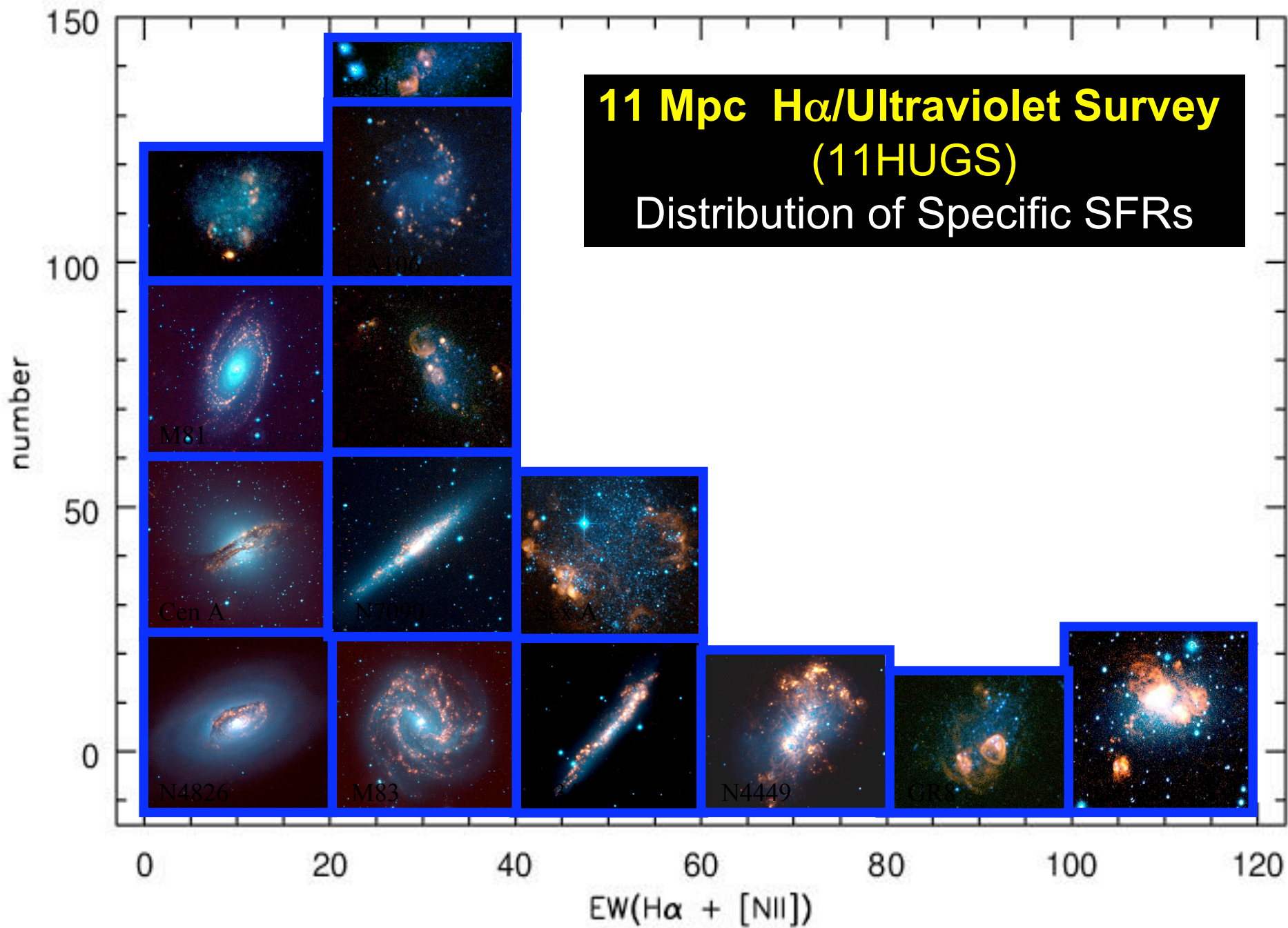
(Jones, Koribalski, Elmouttie & Haynes 1999)

$D = 4.2 \text{ Mpc}$

HI extent $> 70 \text{ kpc}$

$M_{\text{HI}} = 8 \times 10^9 M_{\odot}$



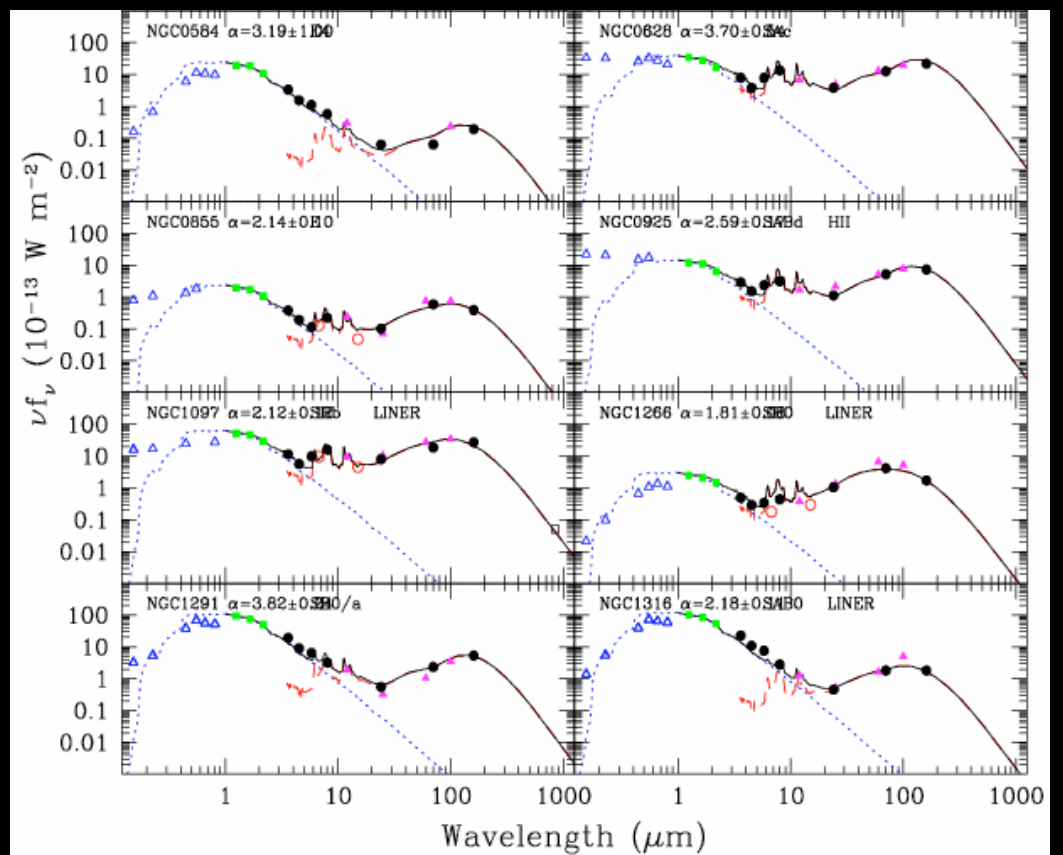


*SINGG: Survey for
Ionization in Neutral-
Gas Galaxies*

M83 = NGC 5236 (Sc)

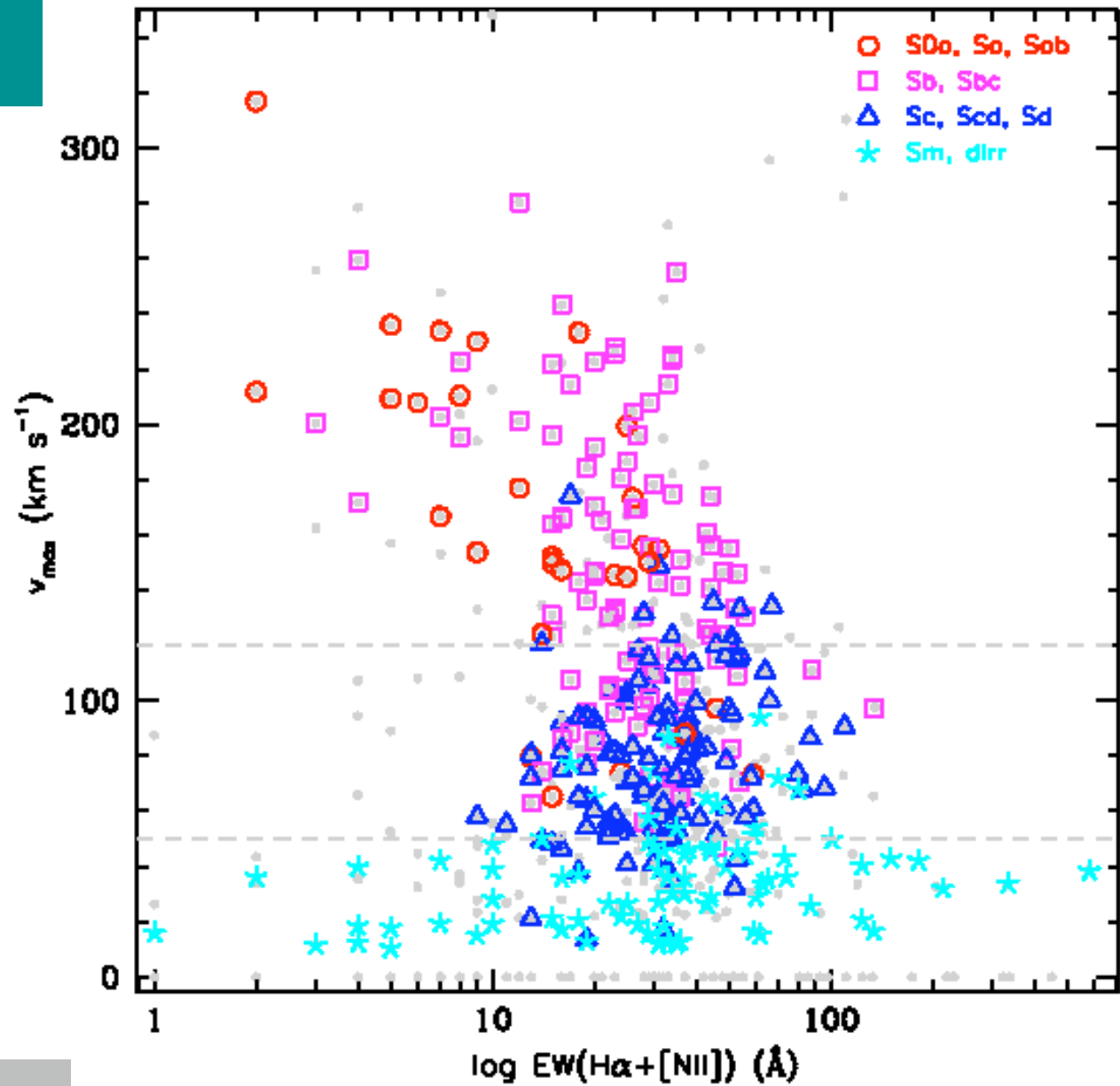


GALEX/Spitzer Synergies





Specific SFR vs Circular Velocity



Parting Thoughts

- Local galaxies hold keys provide detailed fossil reconstructions of the assemblies of gas, spheroids, disks, heavy elements, and central black holes, and in revealing the physical processes driving these assemblies.
- The Great Observatories can make major strides toward understanding the "gastrophysical" processes that trigger and regulate star formation in galaxies (esp. starbursts), and characterizing the local inventory of galaxies and their constituent stellar/cluster populations.