Stellar and circumstellar spectroscopy in other galaxies

G. C. Sloan
and many others

The Small Magellanic Cloud as seen by *Spitzer* and *Herschel*

GCS affiliations:

Space Telescope Science Institute

Cornell University

Univ of North Carolina at Chapel Hill

Some key players on the team:

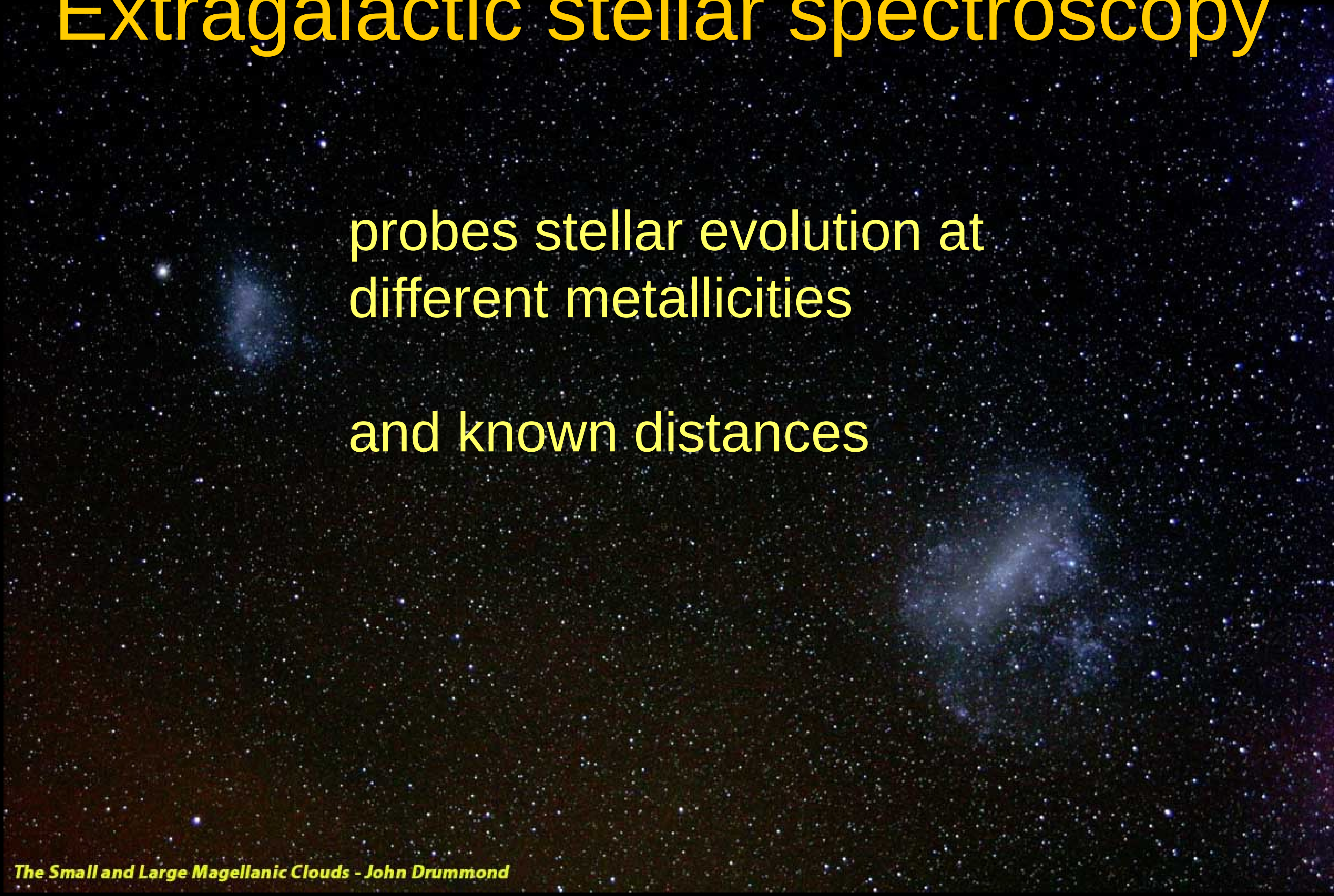
Martha Boyer – STScI
Martin Groenewegen – Roy. Obs. Belgium
Ciska Kemper – ASIAA
Kathleen Kraemer – Boston College
Eric Lagadec – Obs Cote d'Azur
Mikako Matsuura – Cardiff Univ.
Iain McDonald – Univ. of Manchester
Peter Wood – ANU
Albert Zijlstra – Univ. of Manchester

Extragalactic stellar spectroscopy

Extragalactic stellar spectroscopy

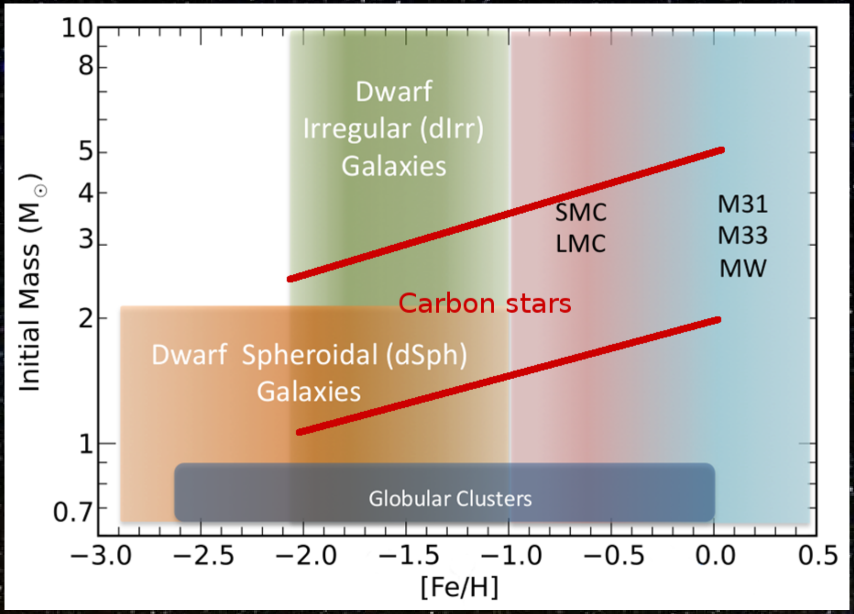
probes stellar evolution at
different metallicities

and known distances



The Small and Large Magellanic Clouds - John Drummond

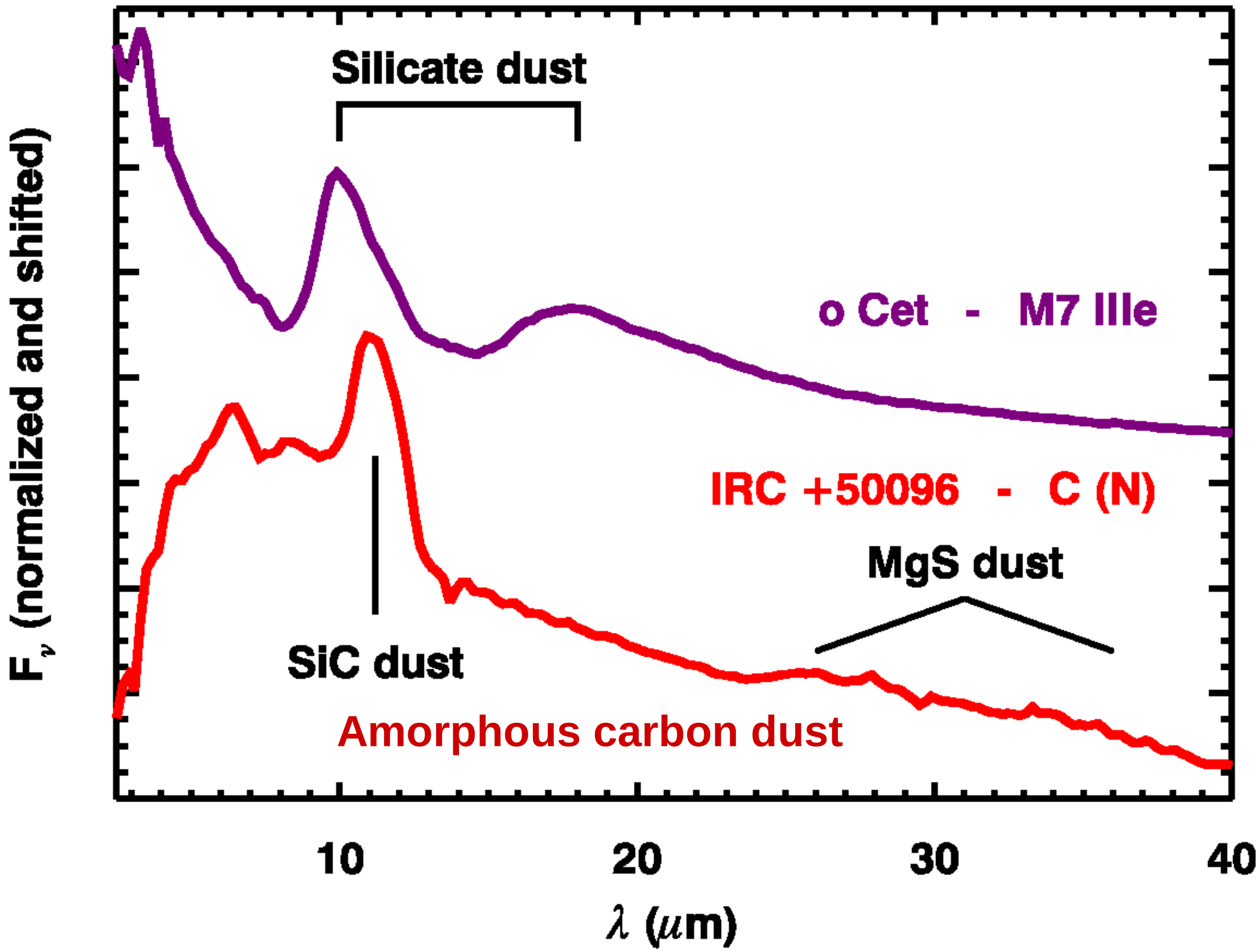
Extragalactic stellar spectroscopy



Credit: Martha Boyer

The Small and Large Magellanic Clouds - John Drummond

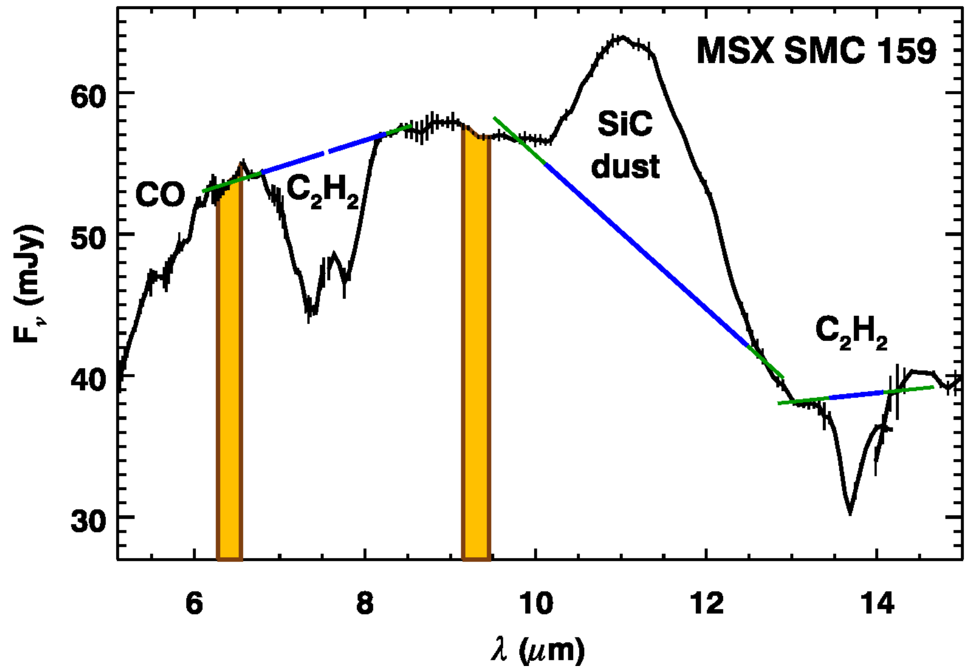
Dust on the AGB



Magellanic carbon stars

Many IRS papers:

Sloan et al. (2006)
Zijlstra et al. (2006)
Matsuura et al. (2006)
Buchanan et al. (2006)
Lagadec et al. (2007)
Leisenring et al. (2008)
Sloan et al. (2008)
Gruendl et al. (2008)
Matsuura et al. (2014)
Sloan et al. (2014)
Sloan et al. (2016)



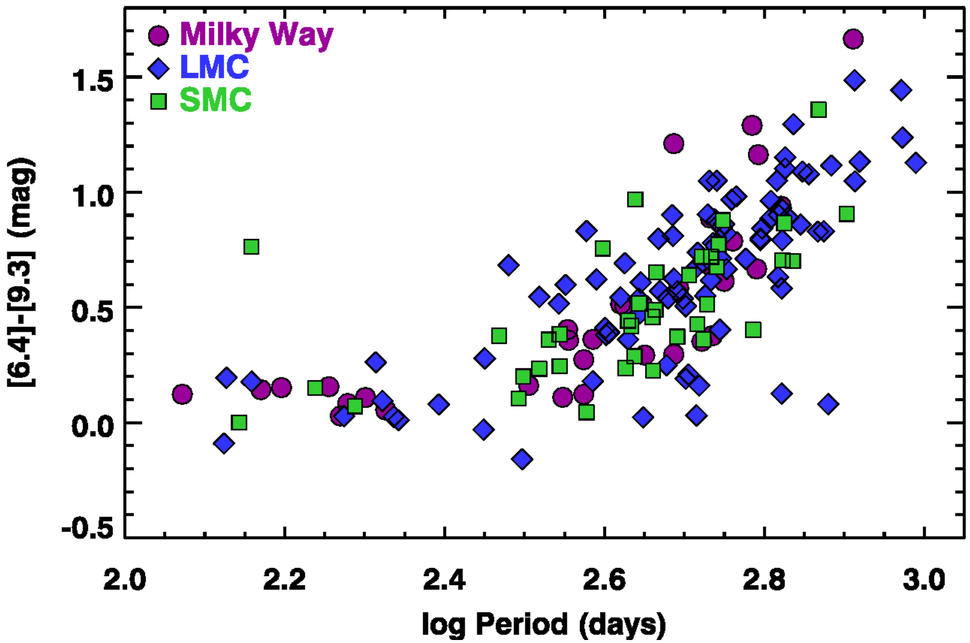
Carbon-rich AGB sample:

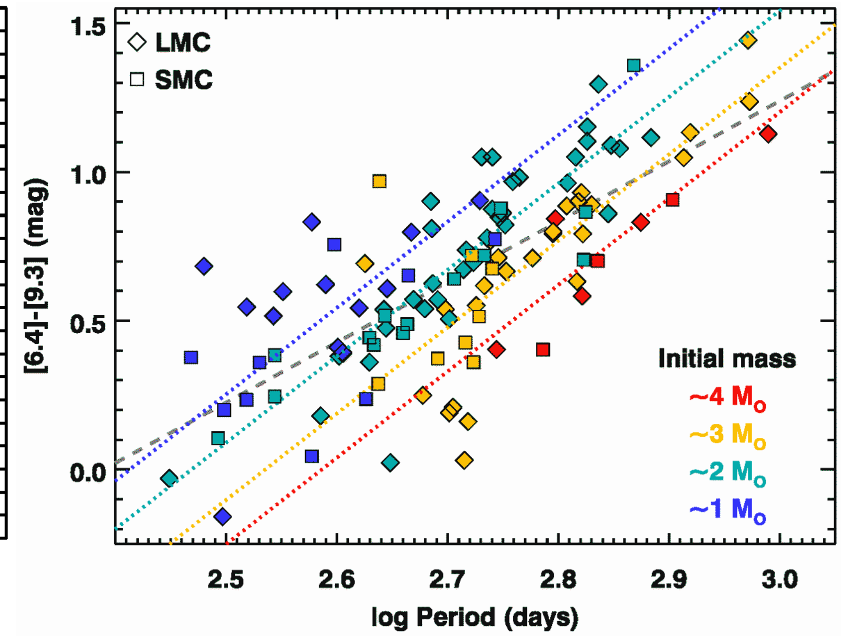
144 in LMC

40 in SMC

(and 42 in Galaxy)

Carbon-rich dust and metallicity





For carbon stars, longer pulsation periods mean more dust

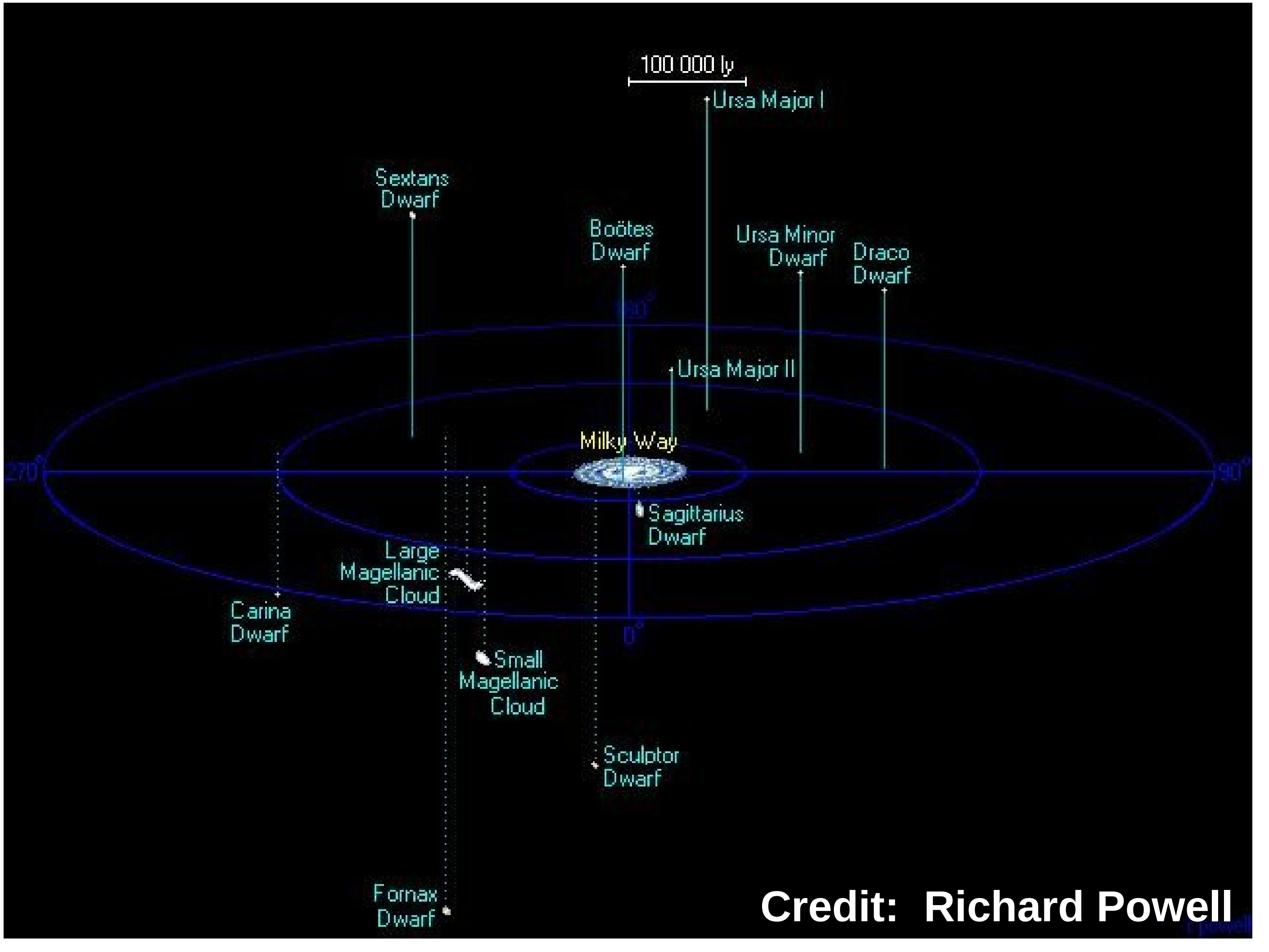
But carbon-rich dust production doesn't depend on metallicity!

Assume initial mass ~ current luminosity

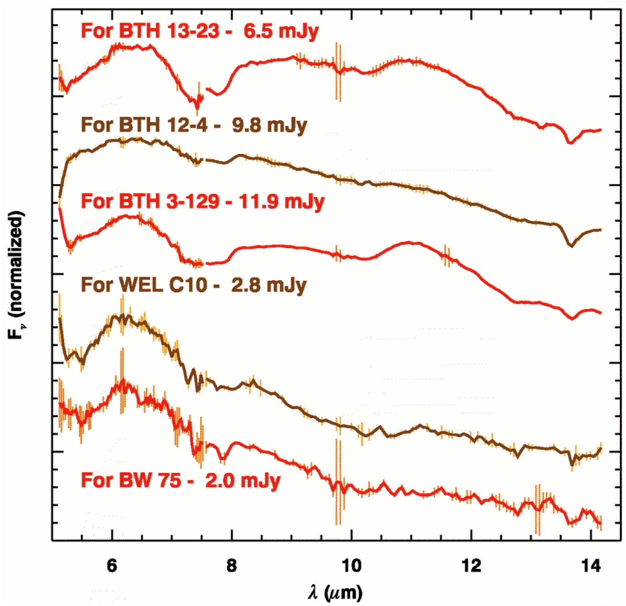
Mass explains width of dust-period relation

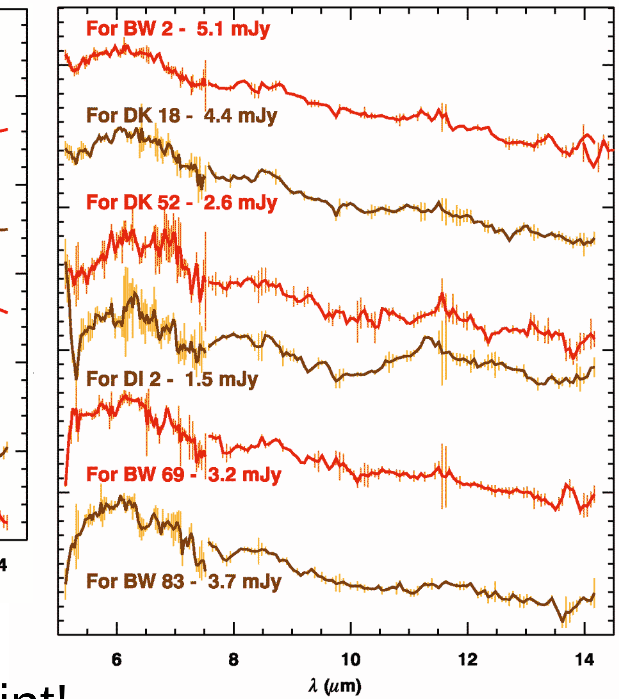
(Sloan et al. 2016)

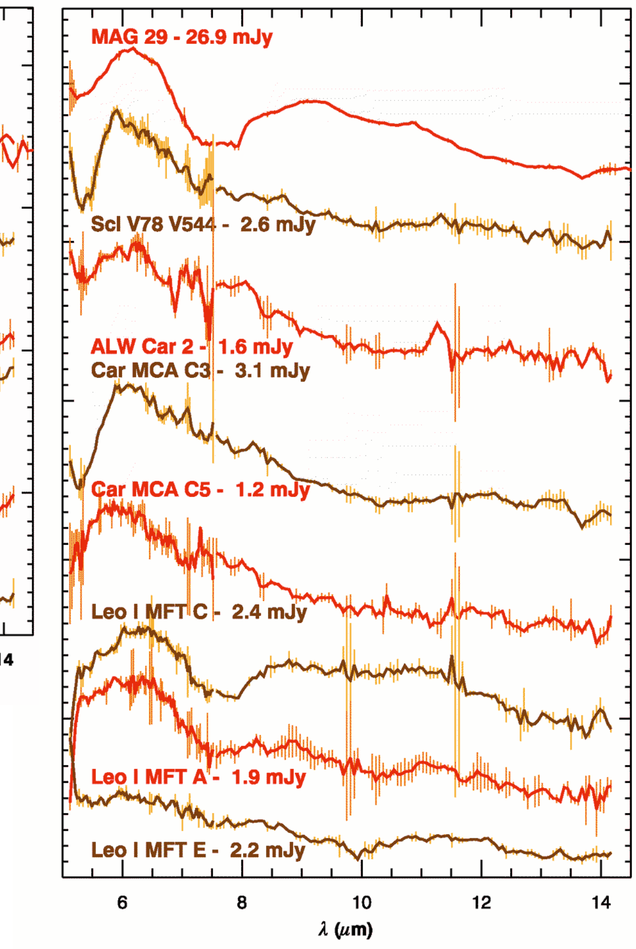
The Milky Way System



Local Group spectra

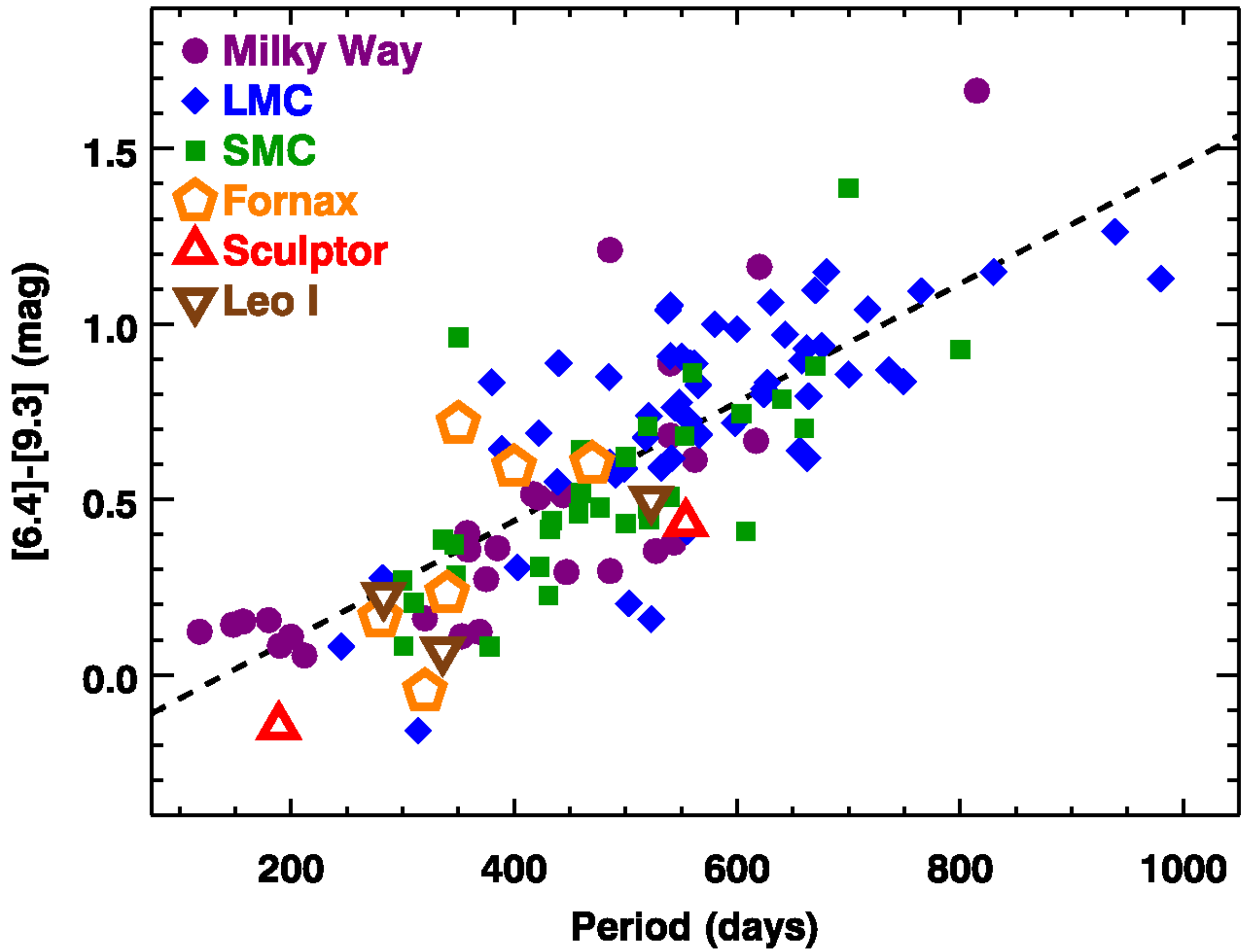






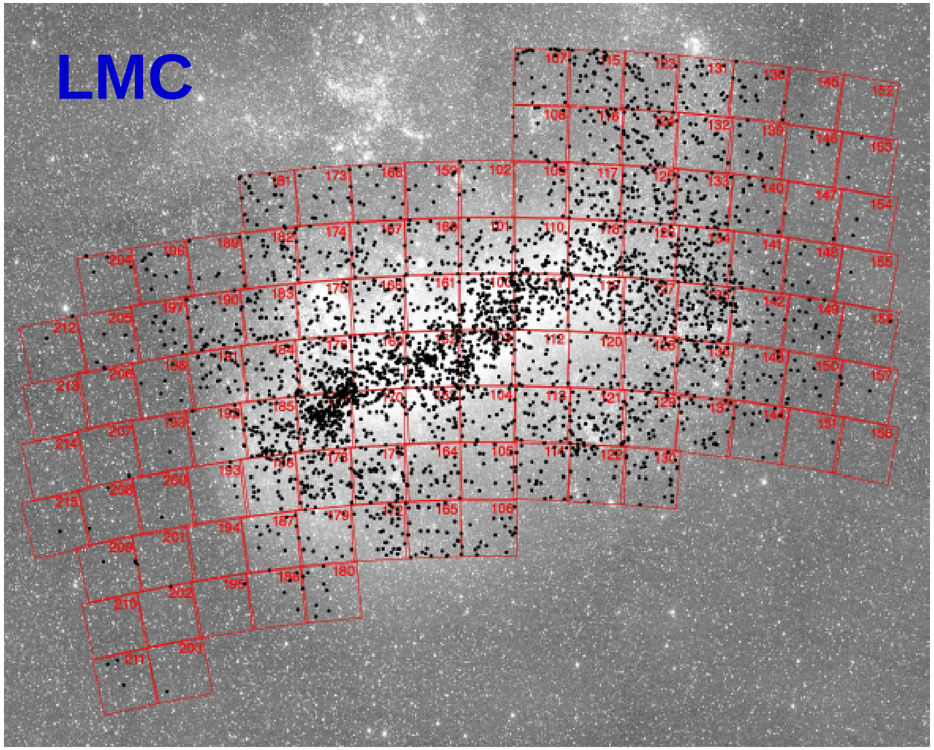
- These targets are faint!
- Need **Cornell's** optimal extraction algorithm (***Lebouteiller et al. 2010, 2011***)
- Extracted spectra publicly available: http://cassis.sirtf.com

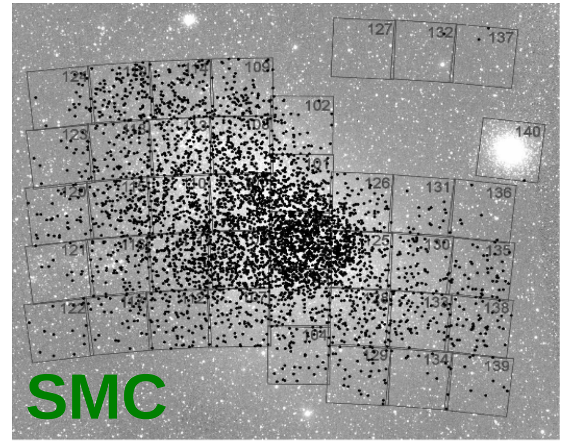
Dust and metallicity, Take 2



(Sloan et al. 2012)

Thank you, gravitational lensing





OGLE III fields and Cepheids
(Soszynski et al. 2008, 2010)

OGLE III and Magellanic Variables

LMC and **SMC**: Soszynski et al. (2009, 2011)

There's also ***MACHO***

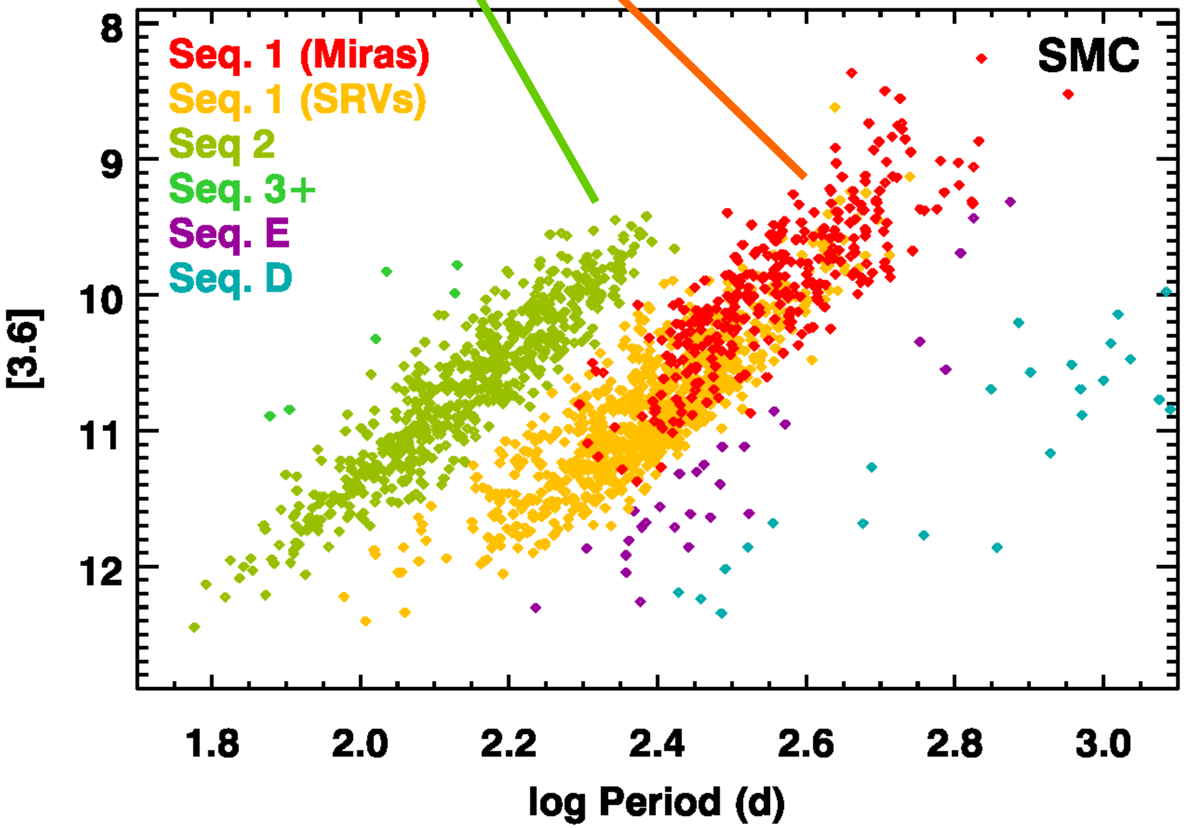
Pulsation modes in AGB stars

Fundamental mode

First overtone mode

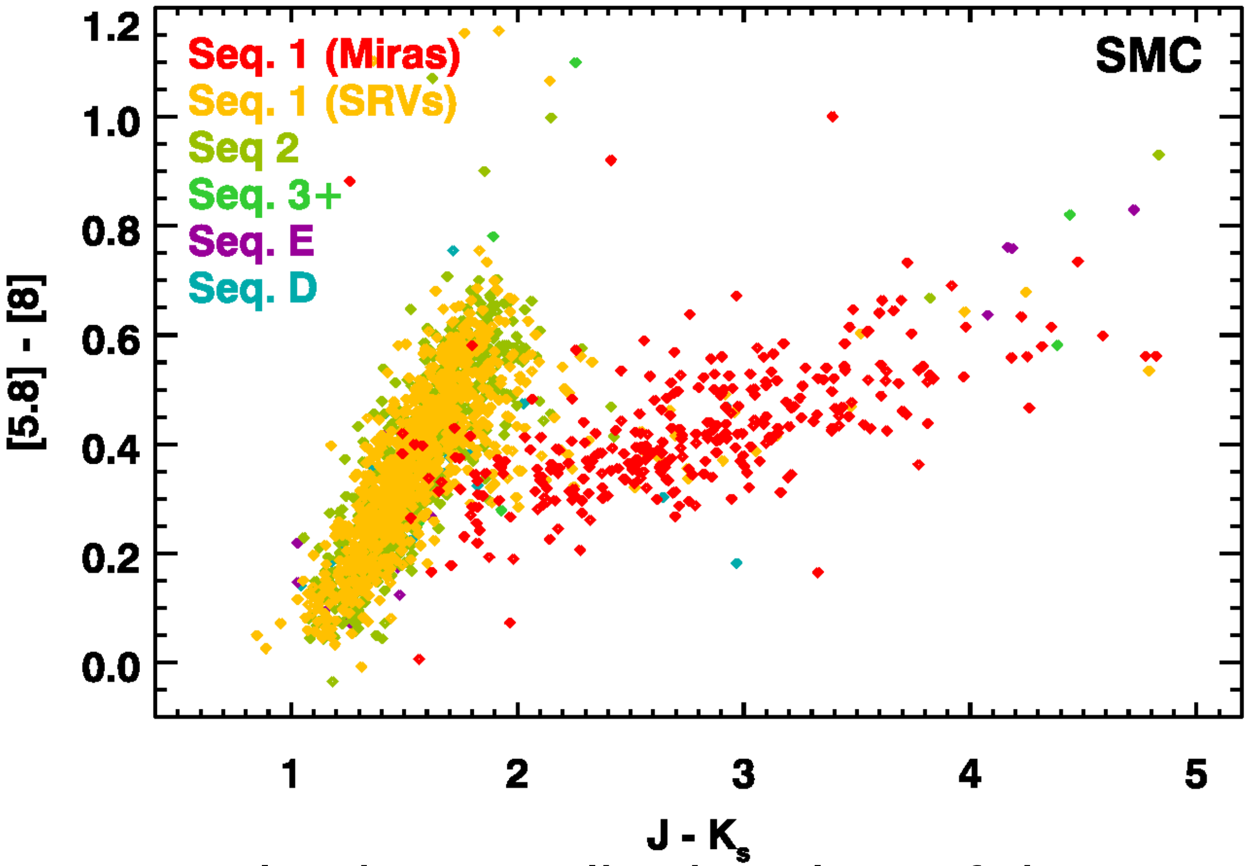
Larger amplitude

Smaller amplitude



(Sloan et al. 2015)

Pulsation and carbon-rich dust



Large pulsation amplitude = lots of dust

But OGLE misses the most embedded stars

(Sloan et al. 2015)

Wide-field Infrared Survey Explorer

WISE

2009 Dec – launched

2010 Sep – exhausted cryogens

NEOWISE

NEO = Near Earth Object

2011 Feb – ordered to hibernate

NEOWISE-R

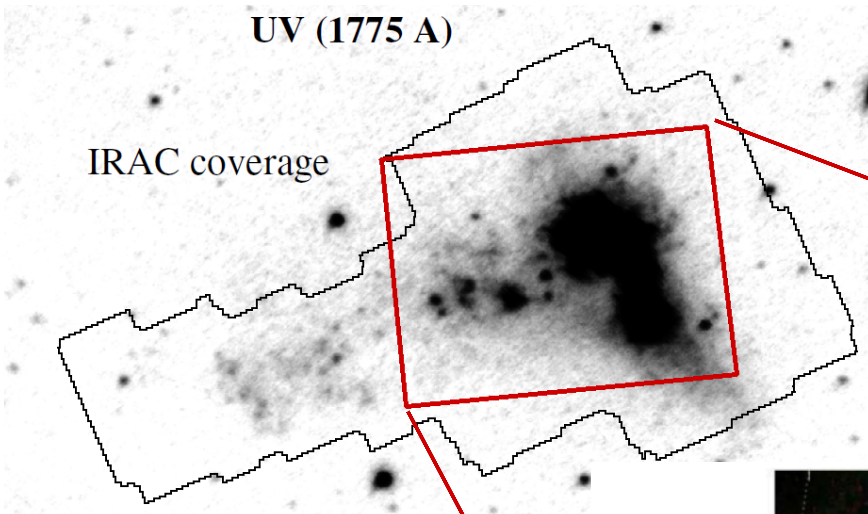
2013 Dec – R = reactivated

(Mainzer et al. 2014)

New epoch every 6 months!

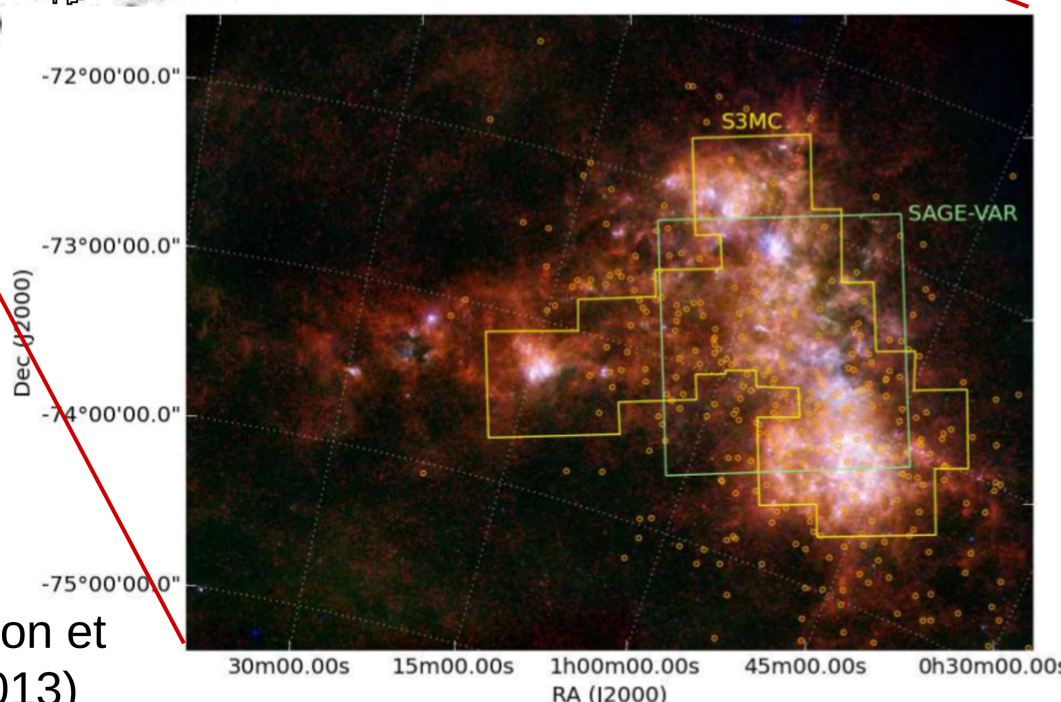
8 epochs now on IRSA

Spitzer imaging of the SMC



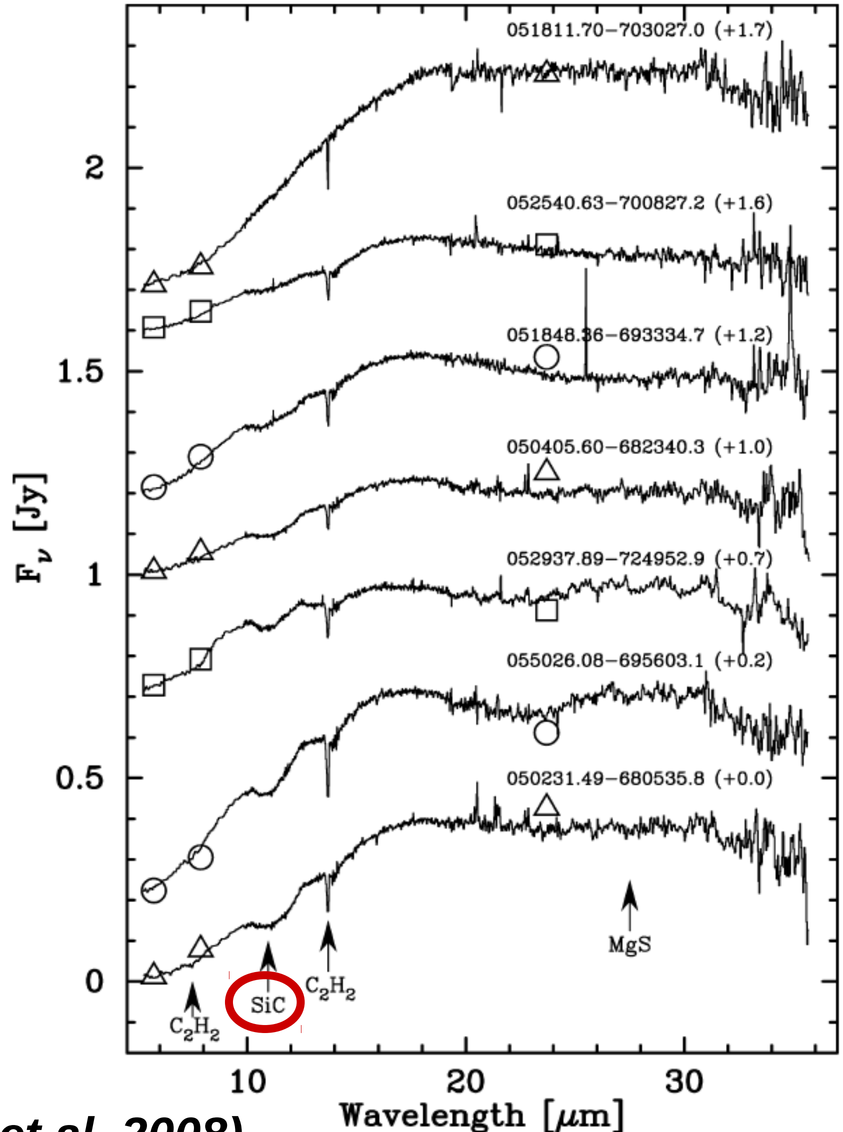
2 30-sq.-deg. surveys
2008 Jun, Sep
2 more epochs coming
2017 Aug, Nov

5 more epochs
in the core
2005, 2010-11



Images adapted from Gordon et al. (2011), Meixner et al. 2013)

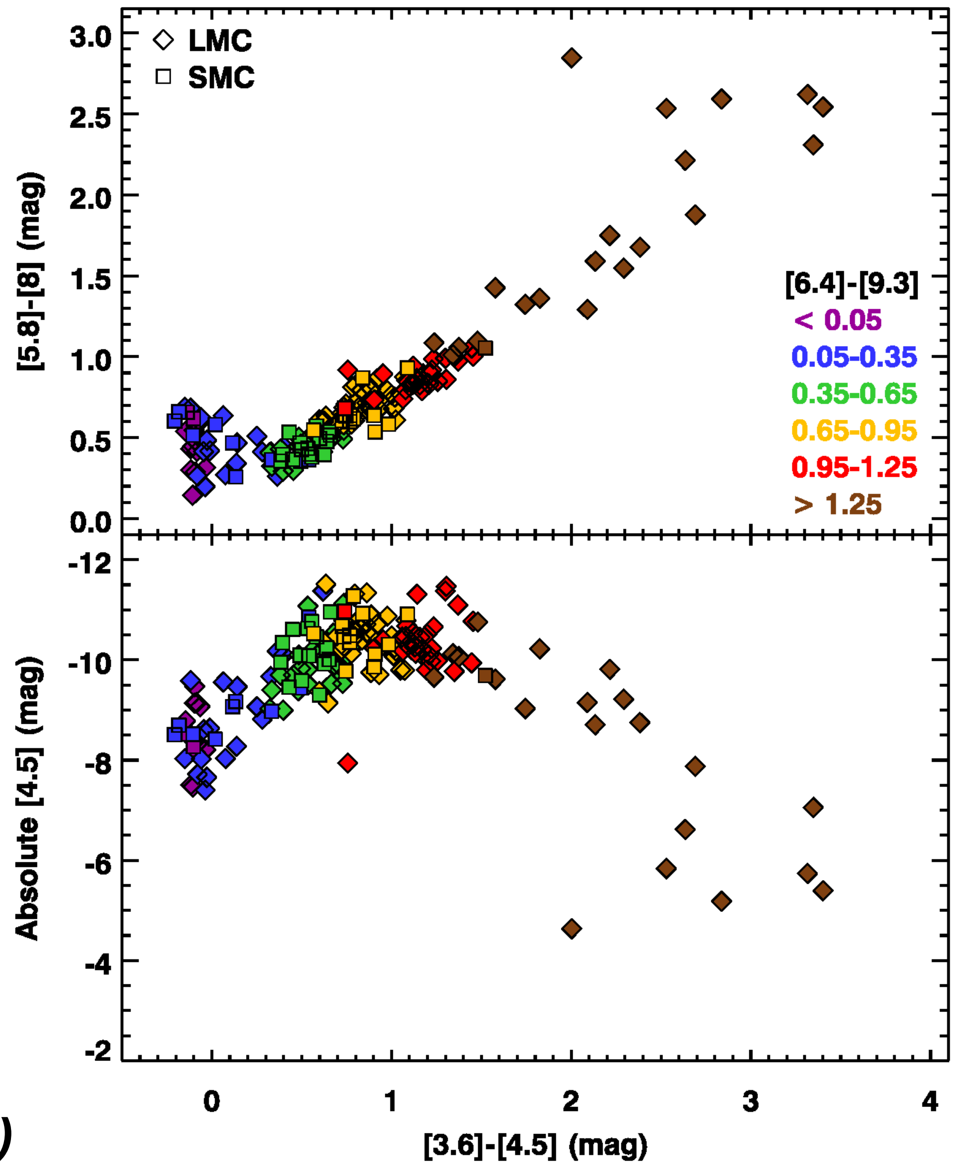
Extremely red objects in the LMC



SiC in absorption!

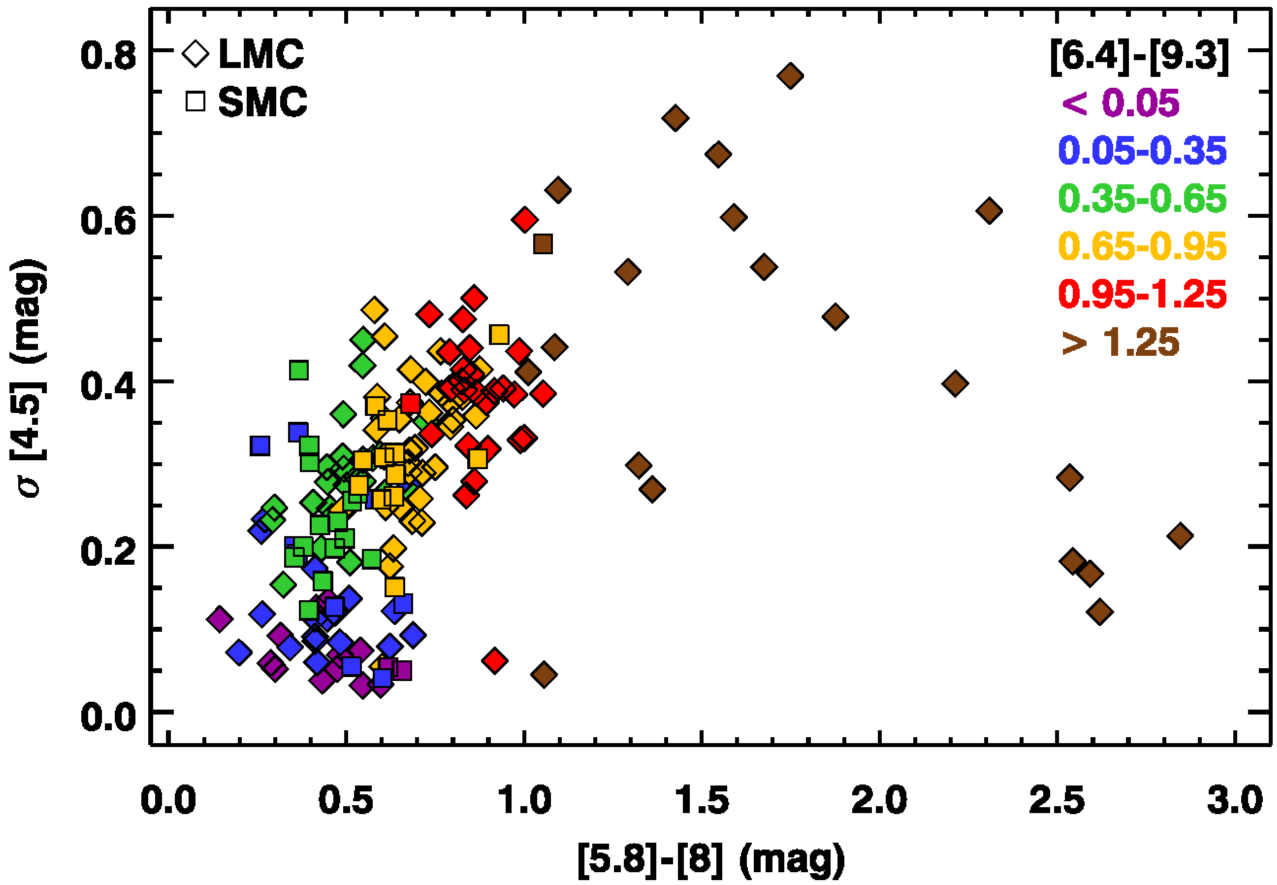
(Gruendl et al. 2008)

From AGB to post-AGB



(Sloan et al. 2016)

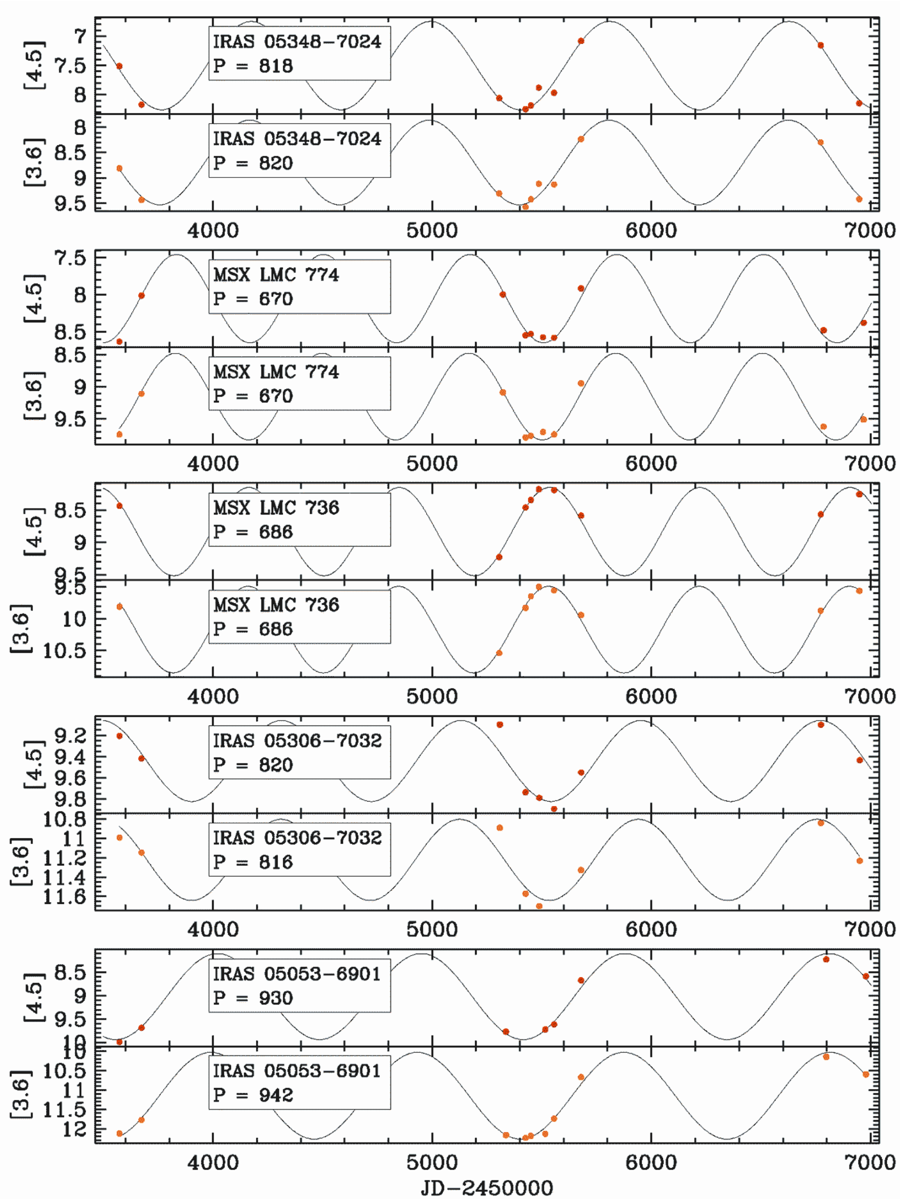
New pulsation amplitudes



Reddest stars are evolving off of the AGB

(Sloan et al. 2016)

Sparse sampling of light-curves



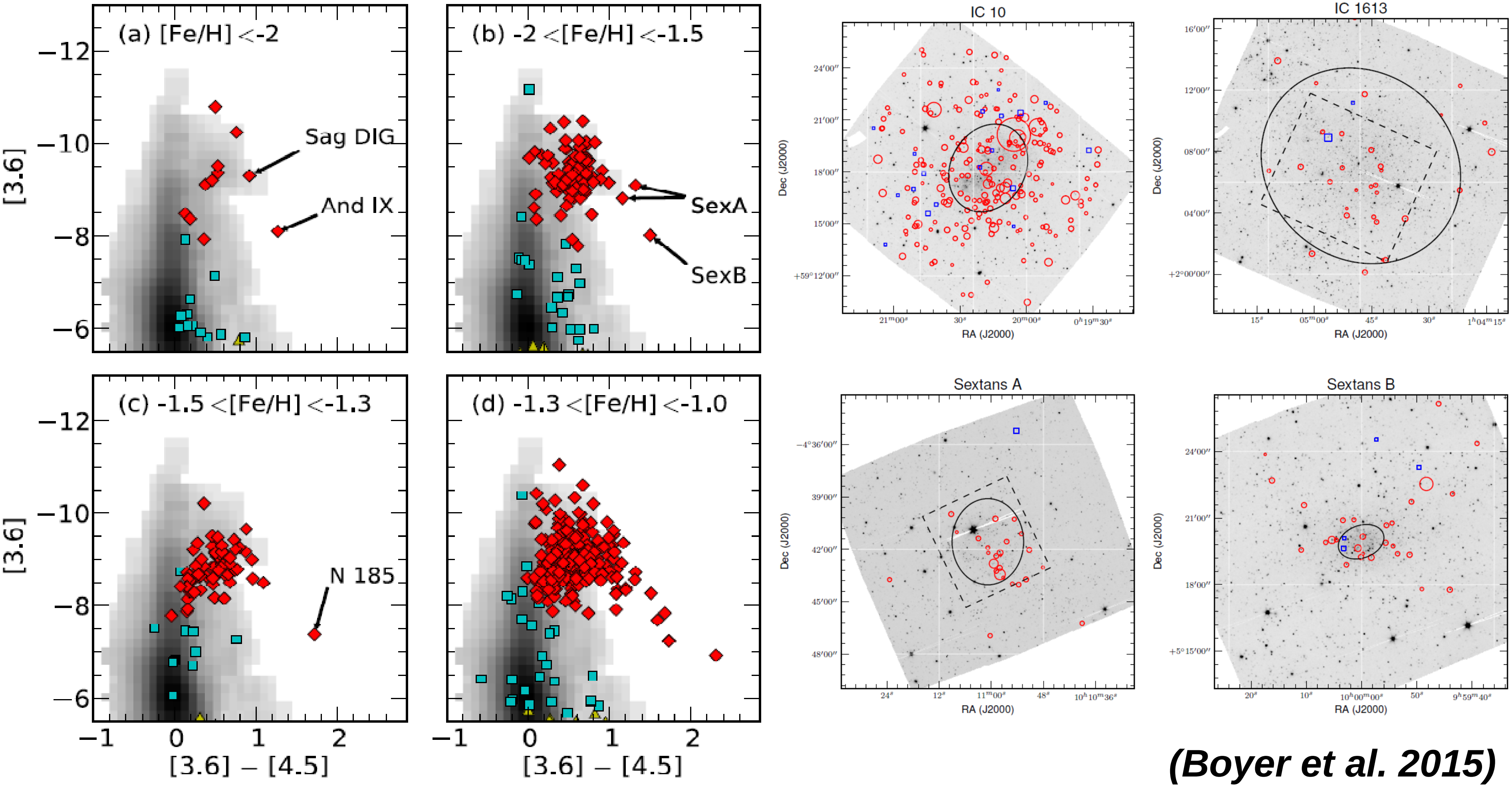
Test concept with IRS sample

Five new periods, all deeply embedded sources

Compared to published periods, 86% agree within 5%

(Sloan et al. 2016)

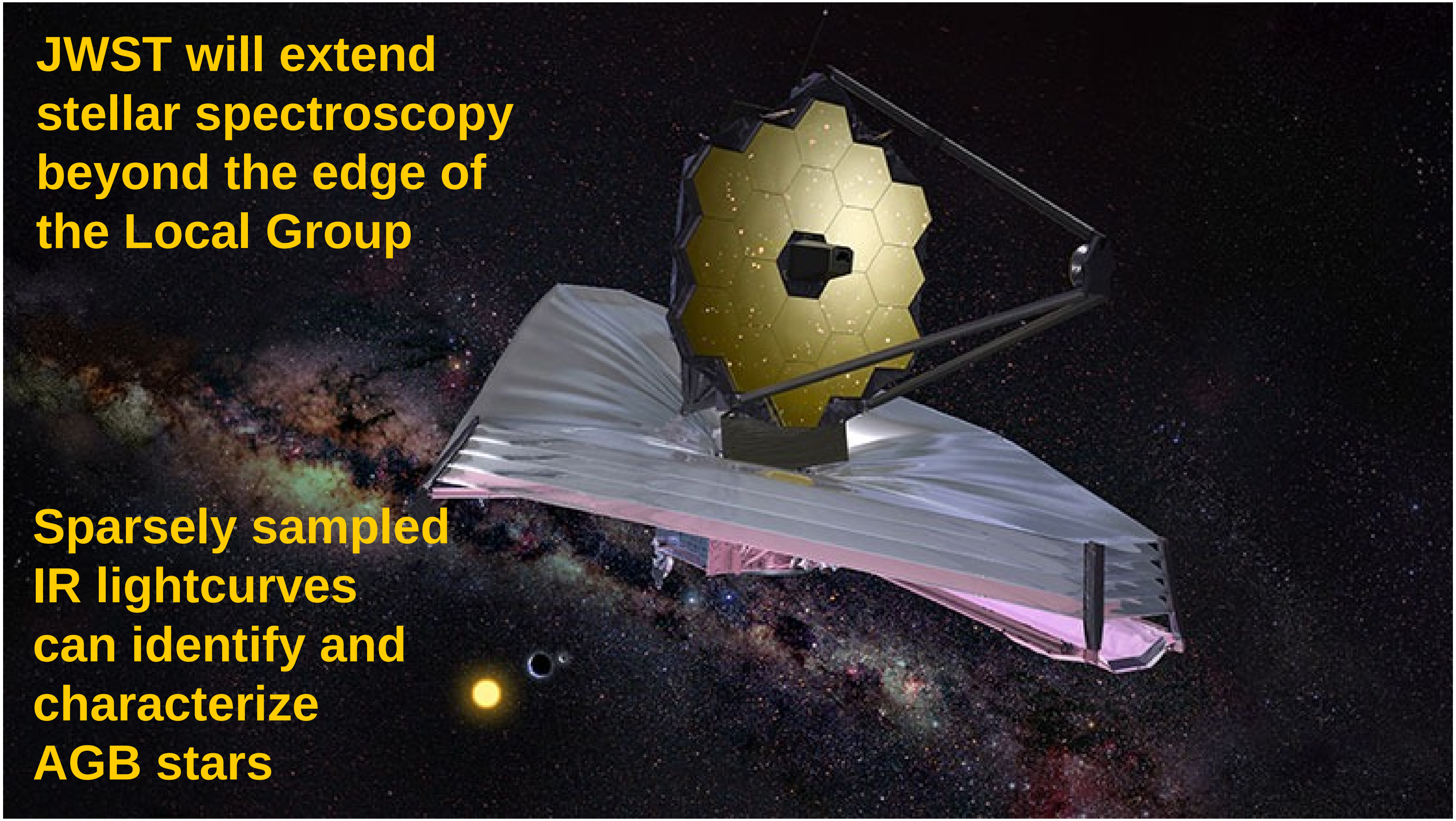
DUSTiNGS



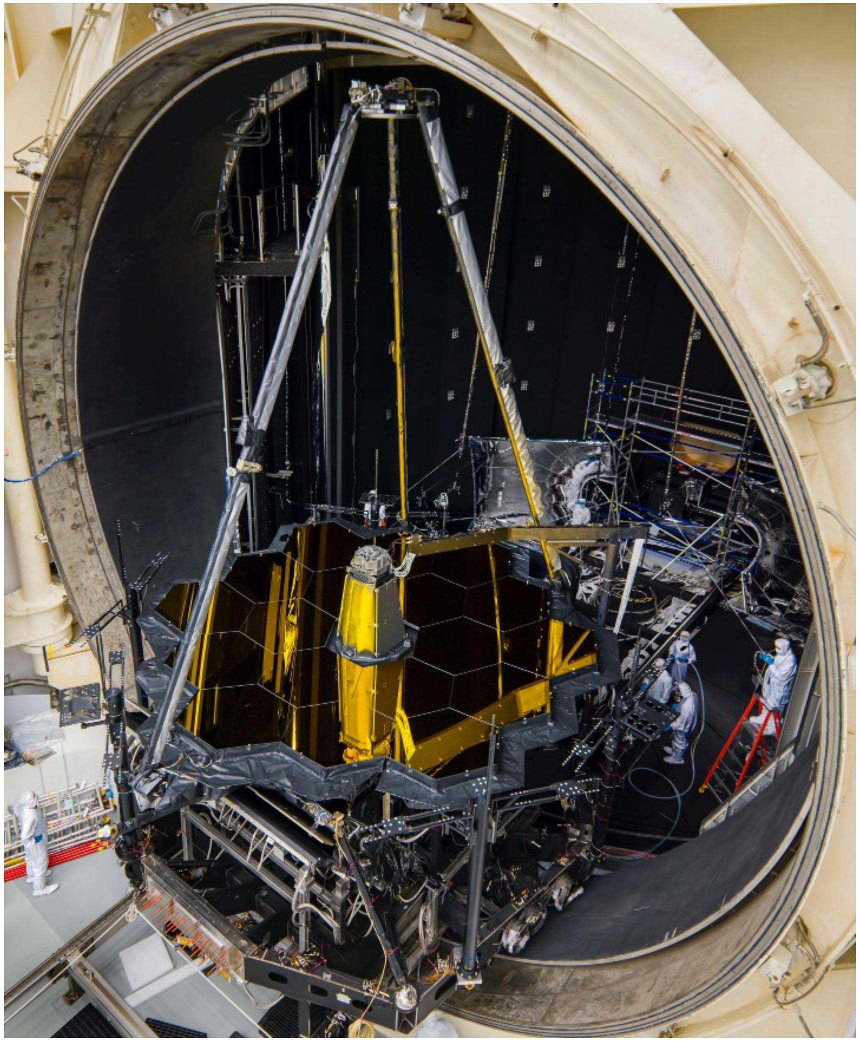
(Boyer et al. 2015)

2 *Spitzer* epochs in 50 Local Group dwarf galaxies

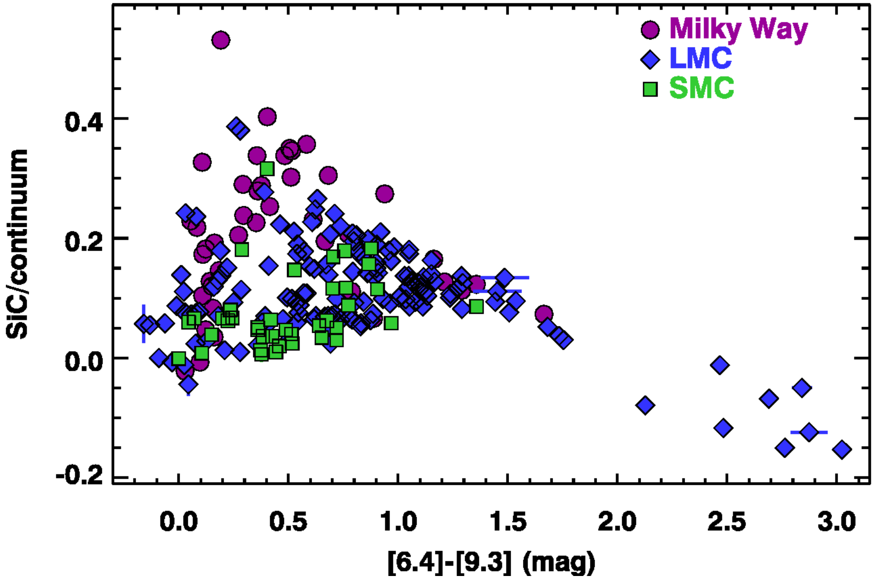
Lessons for the future

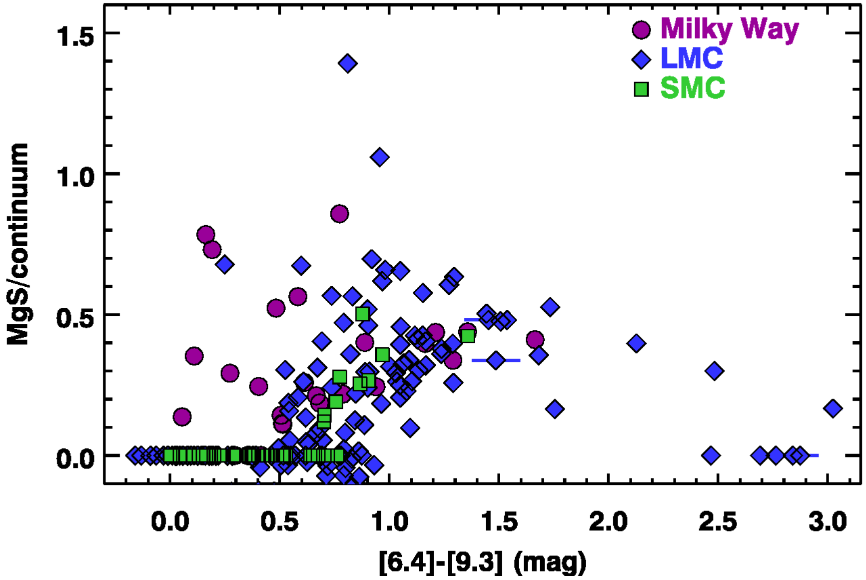


And the future is almost now



SiC and MgS in C-rich shells



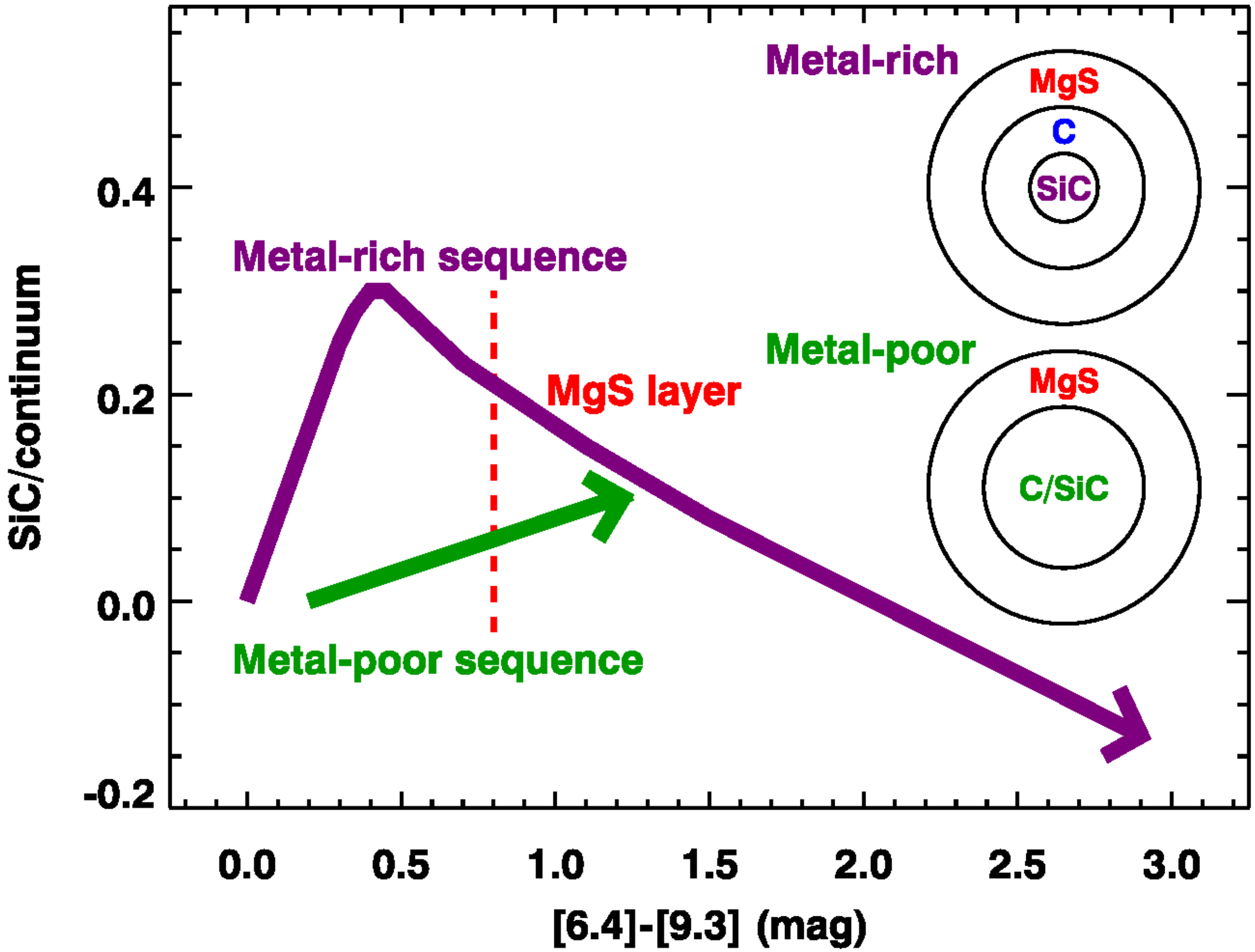


As dust shells grow redder

- SiC strength rises, then falls
- Reddest sources have SiC in absorption!
- MgS rises as SiC falls

(Sloan et al. 2016)

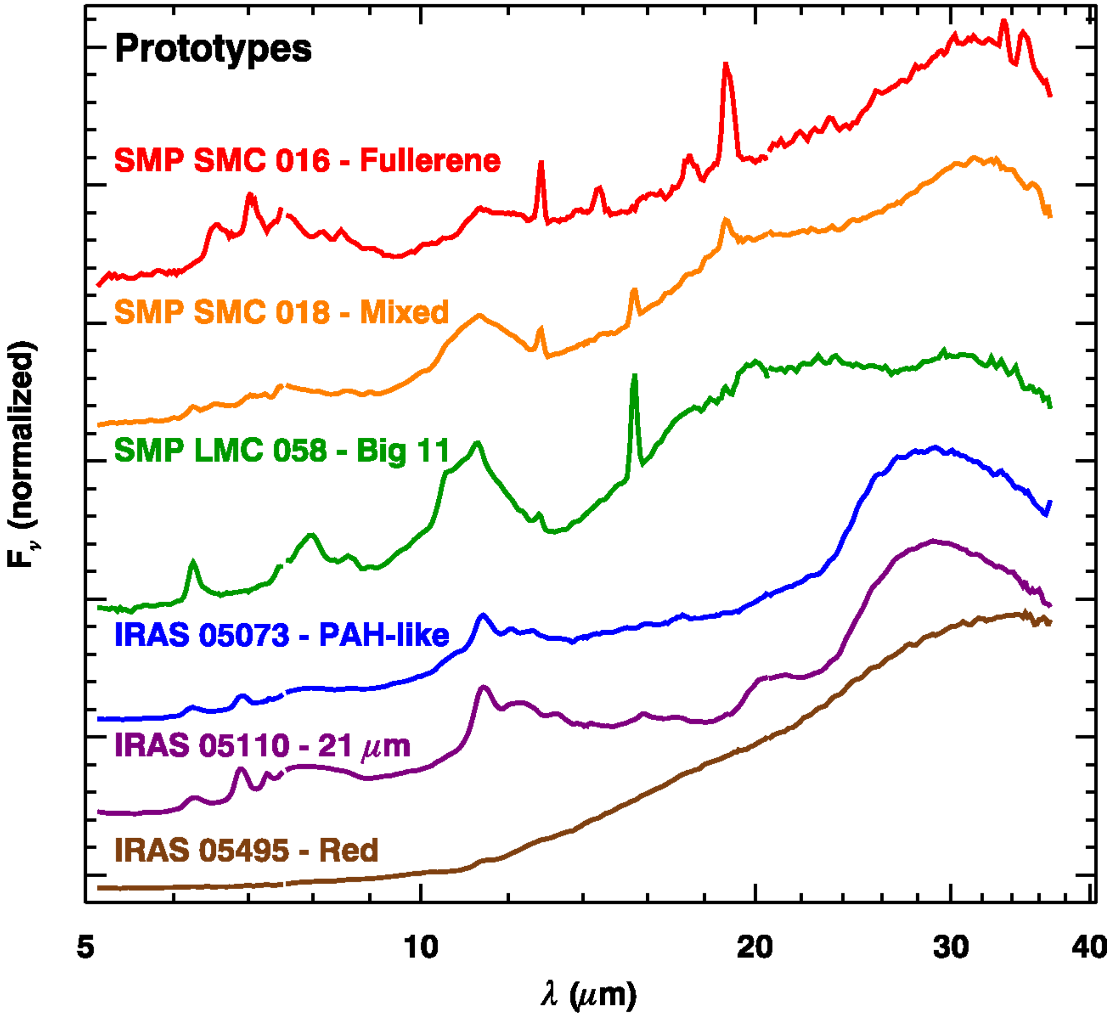
Grain layering



After ***Lagadec et al. (2007)*** and ***Leisenring et al. (2008)***

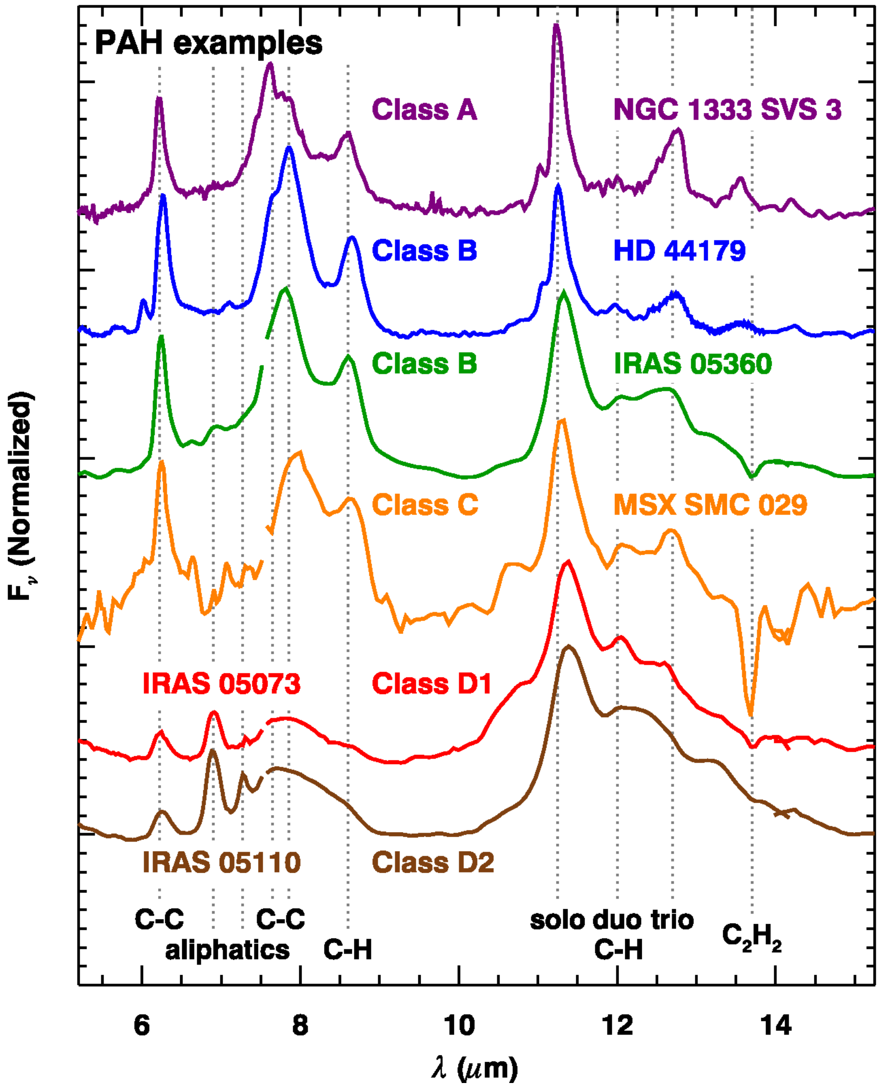
(Sloan et al. 2016)

Carbon-rich post-AGB spectra



(Sloan et al. 2014)

Class D PAHs in PNe



New class of PAH emission

Introduced by
Matsuura et al. (2014)

Unusual PAH profiles at
8 and 11-14 μm