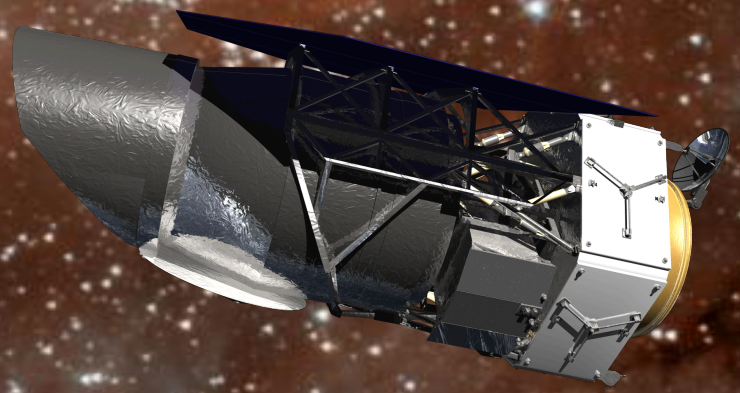
Investigating the gas and dust content of our Galaxy at high resolution — What a WFIRST Galactic Plane Survey can tell us

Sean J. Carey
Spitzer Science Center /
IPAC / Caltech



Advertisement – Spitzer Last Call

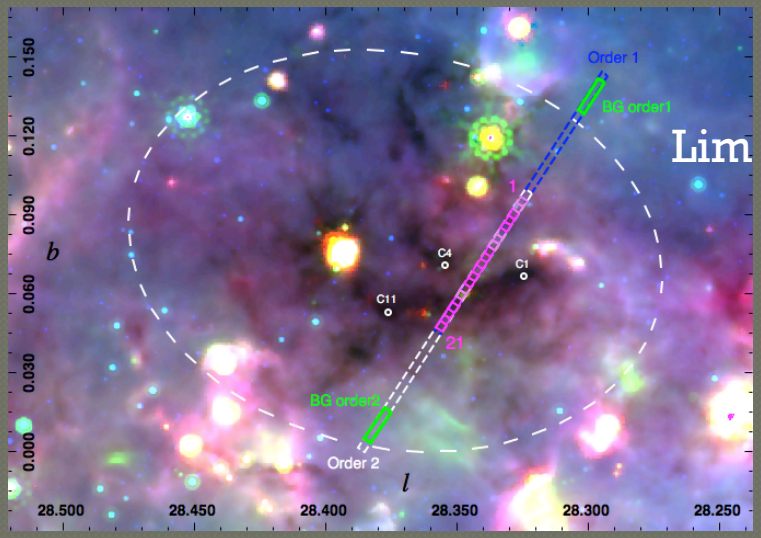
- Spitzer Cycle 13 released
- New Frontier Legacy (>2000 hr) category
- Letters of intent (>500 hr) due 24 March
- **Proposals due 08 June**
- 14000 hours available over 2 years
- 2000 of the 14000 hours in three DDT calls (Feb 2017, Aug 2017, Mar 2018)

Low Latitude Survey with WFIRST

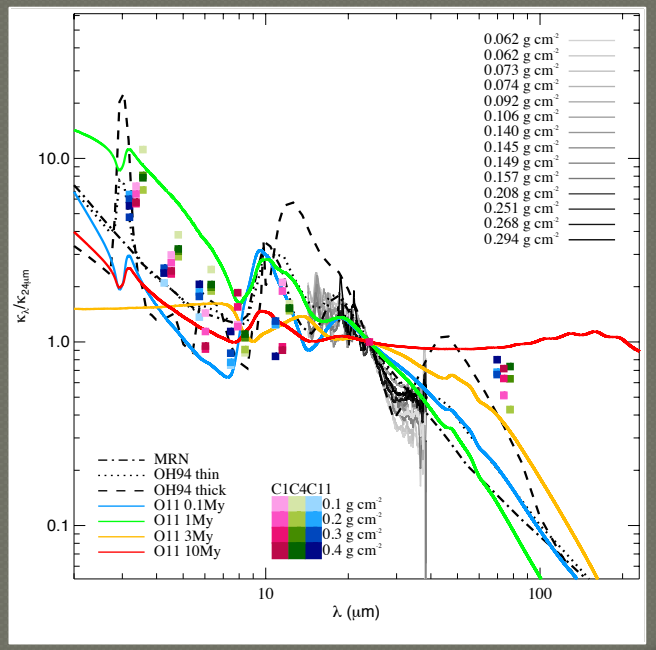
- Some large swath of Galactic plane
  - Most of the action is within $|b| < 1°$, $|l| < 60°$
  - Nearby Star Forming Regions
  - Will see the entire Galaxy at fantastic resolution
    - **0.11 arcsec = 1100 AU at 10 kpc**
  - Confusion limited observations of Galactic plane in days
- Measure Structure of Galaxy
- Examine Star Forming regions on large scales and in detail at same time
- Extinction mapping of Galaxy
- Evolved Stellar Population
- Supernova Remnants, Dust Shells, Outflows, ….

Interesting things to learn about dust in ISM

- Study extinction law variations in detail
- Carriers of Diffuse Interstellar Bands
- Transition from interstellar grains to proto-planetary grains

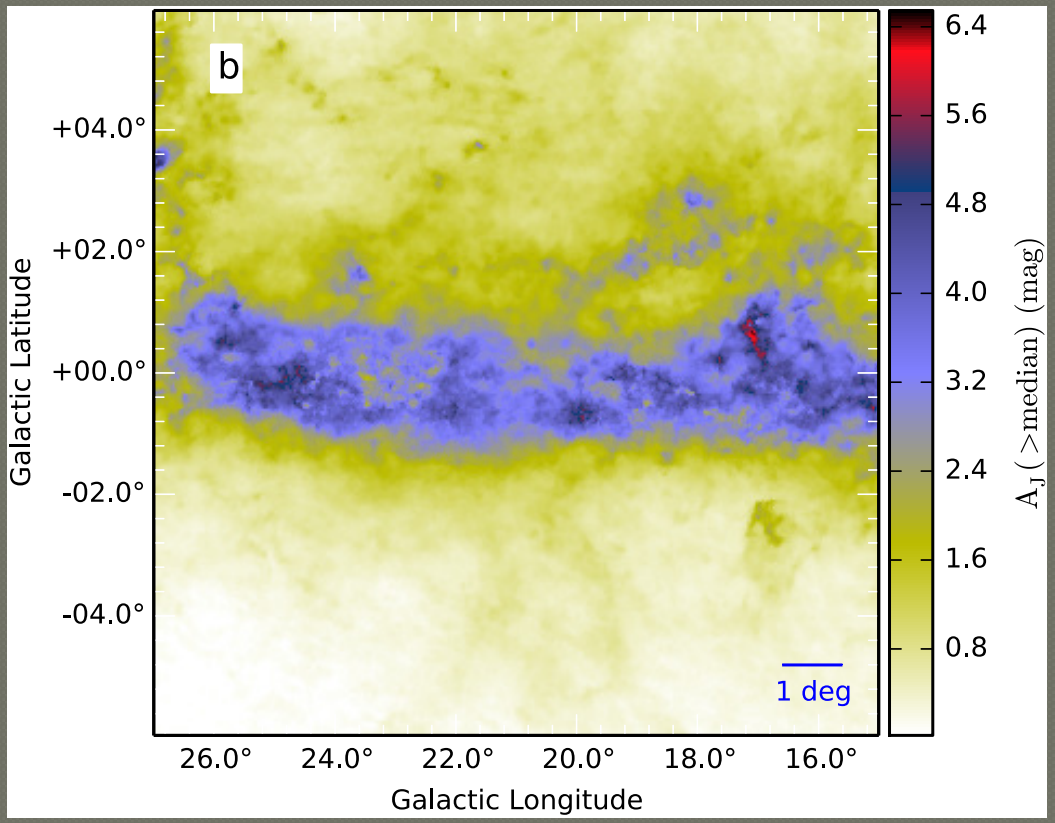


Lim et al. (2016)



Extinction Mapping

- Color excess method, many variants using NIR J, H, K
- Resolution (~3 arcmin) and depth (A_V~ 20) limited by depth of data (2MASS)
- WFIRST has potential to resolve molecular cloud cores (0.1 pc) throughout Galaxy

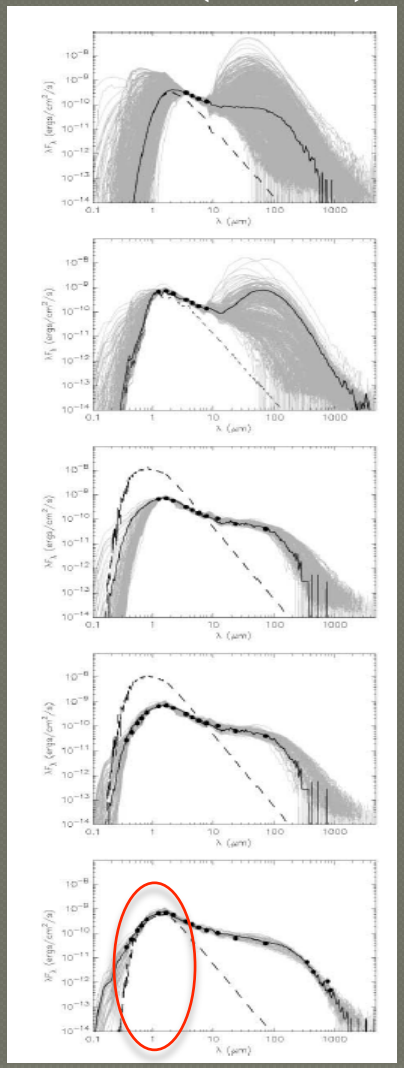


Juvela et al. (2015)

Constraining and Characterizing the Galactic Population of Young Stars with WFIRST

See Poster # 22, R. Paladini

AA Tau (Class II)



IRAC

JHK + IRAC

JHK + IRAC + MIPS 24 μm + MIPS 70 μm

UBVRI + JHK + IRAC + MIPS 24 μm + MIPS 70 μm

UBVRI + JHK + IRAC + MIPS 24 μm + MIPS 70 μm + sub-mm

Robitaille et al. 2007

WFIRST can break model degeneracies for tens of thousands of YSO SEDs !

Modeling of Protostars -- Roberta

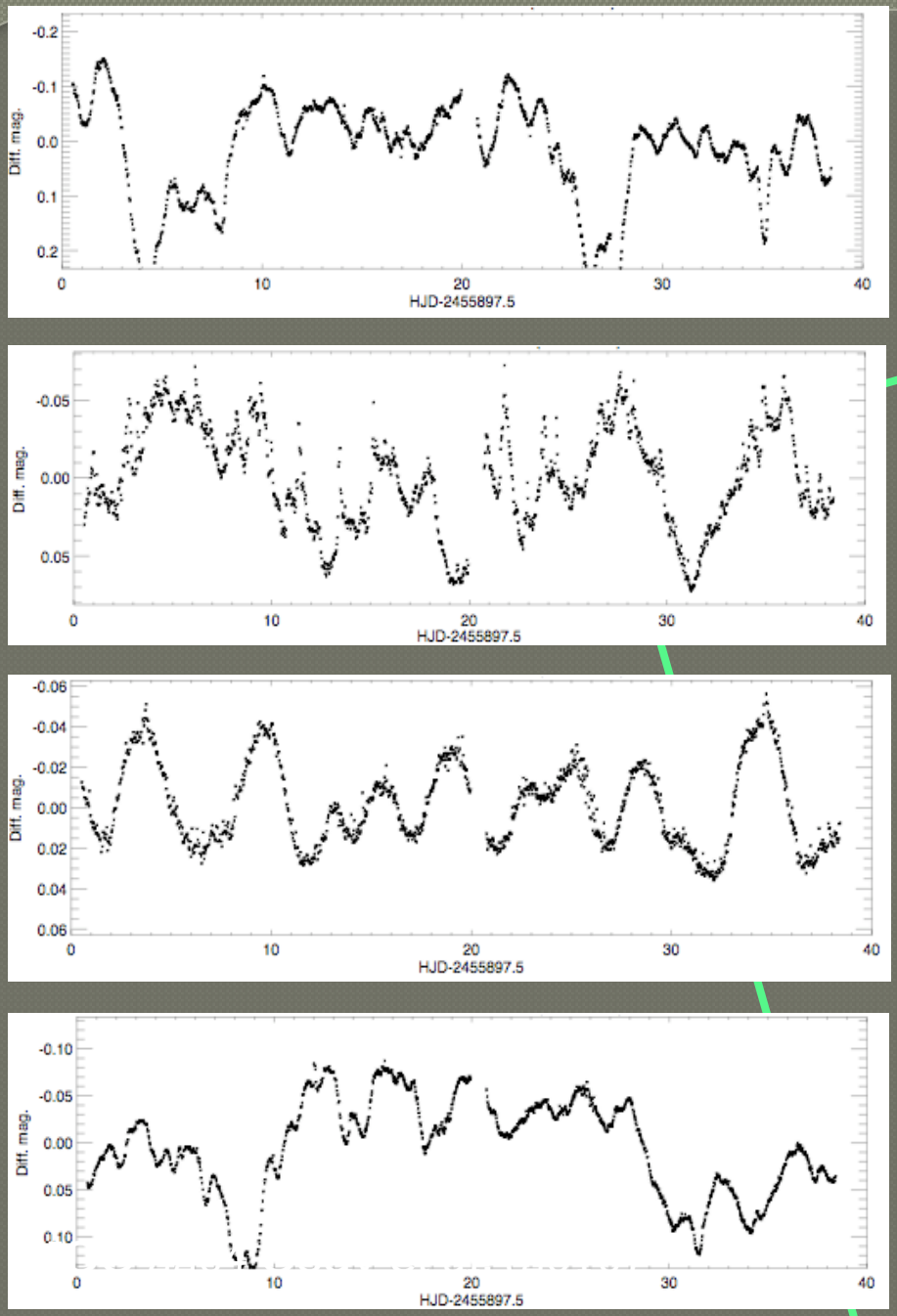
- Roberta's excellent material goes here

Gas in Star Forming Regions

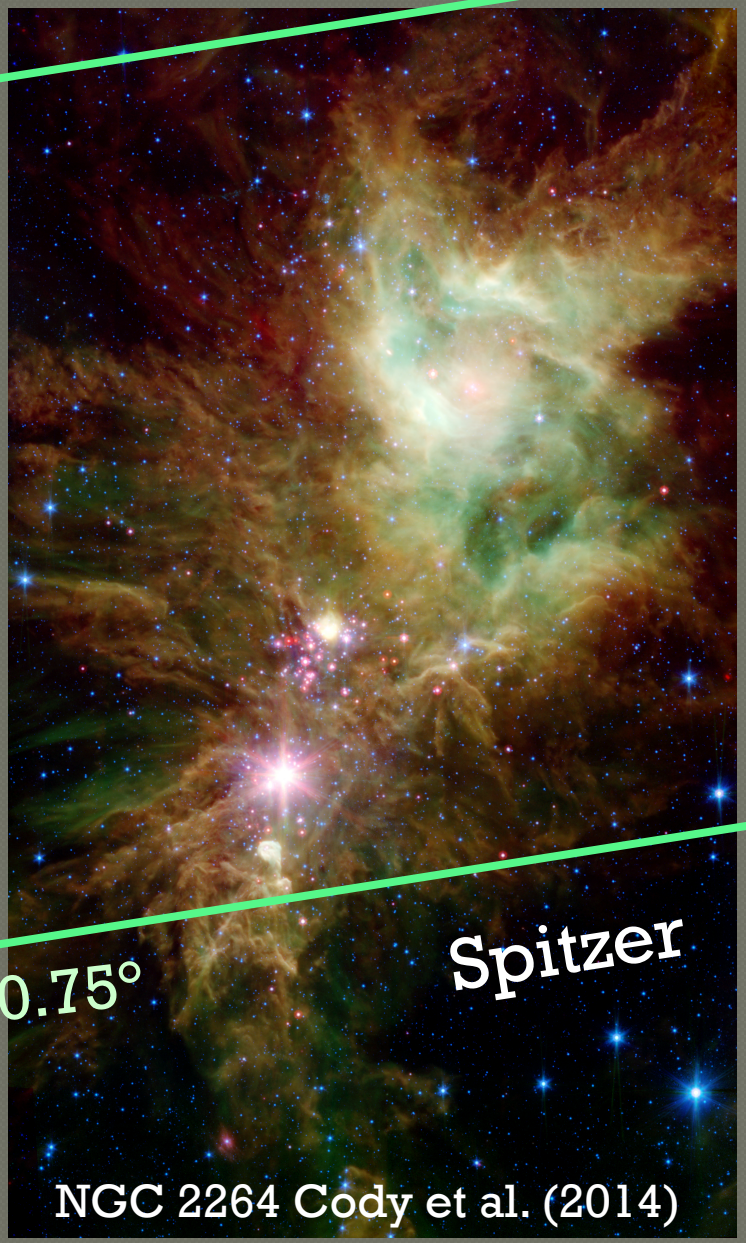
- Morphology of diffuse emission will be interesting
- Accretion indicators: Hα (0.656 μm) and Paβ (1.282 μm) will require grism to be have bluer cutoff
- H_2 (2.12 μm) indicating outflows will require grism to be redder

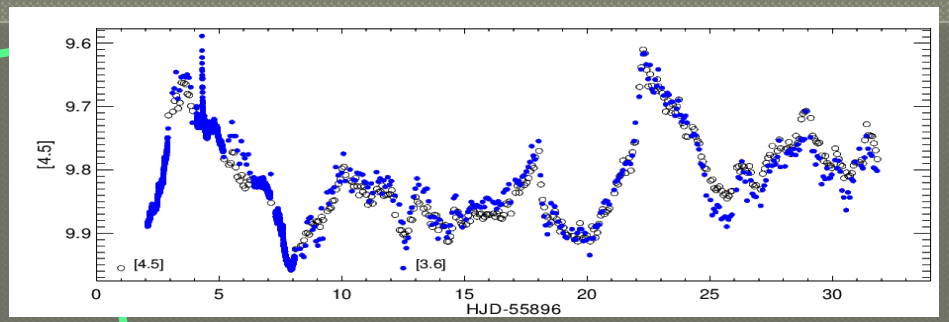
Protostellar Variability

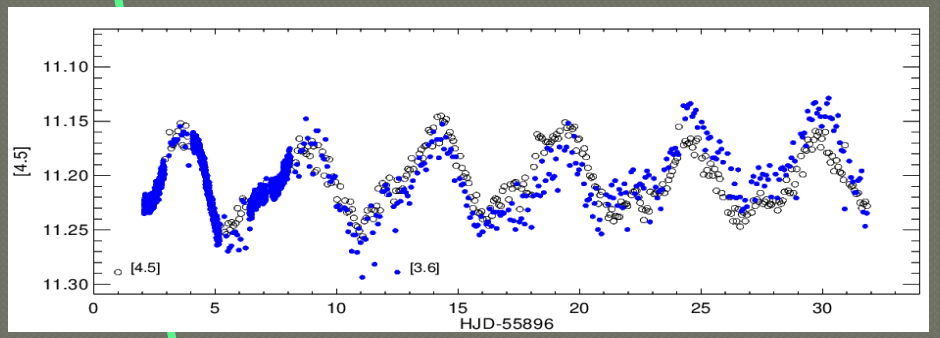
- CoRoT, Spitzer, K2 monitoring of star forming regions have provided a wealth of high quality light curves in the visible and mid-IR
- WFIRST monitoring of star forming regions will provide considerably more information on accretion, disk structure and protostellar activity
- Trick will be being able to classify and model observed light curves

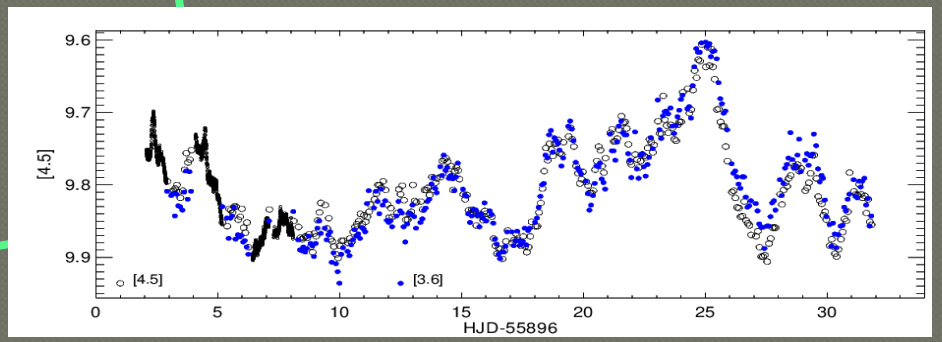

0.1 mag
Diff. mag.
HJD-2455897.5
0.1
0.1
0.1
40d

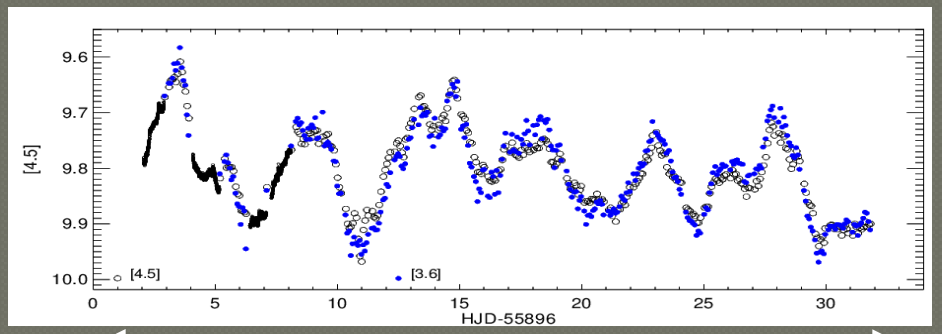

NGC 2264 Cody et al. (2014)
0.75°
CoRoT


0.75°
Spitzer
NGC 2264 Cody et al. (2014)

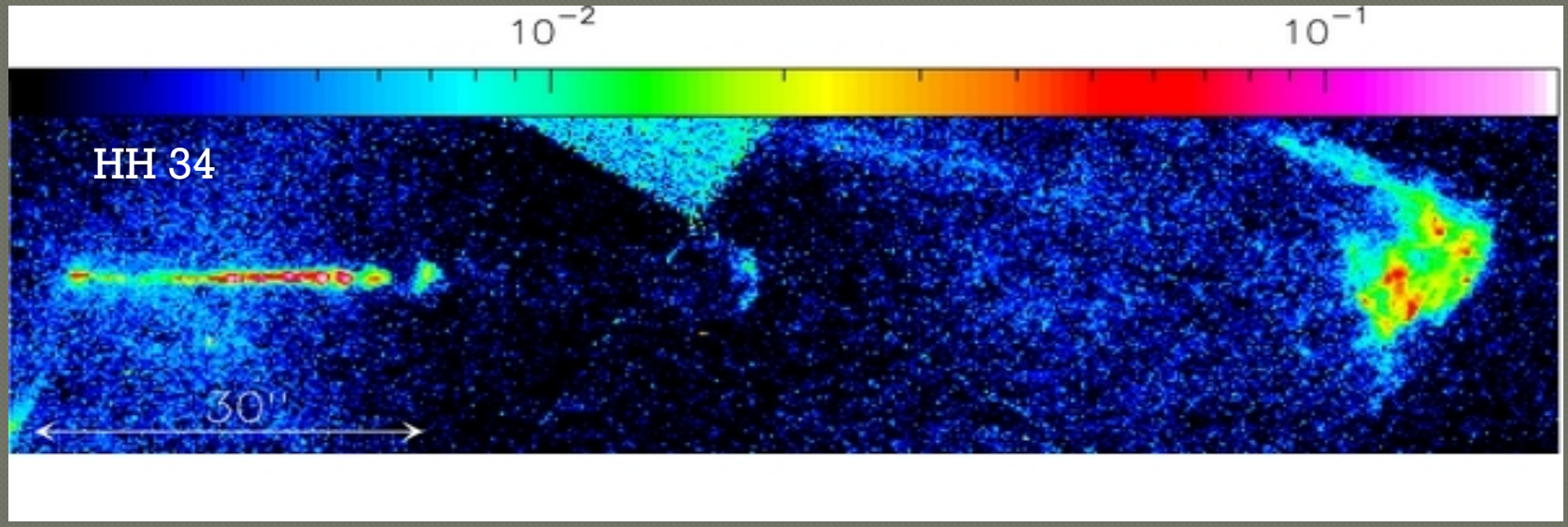

[4.5]
[3.6]
HJD-55896
0.1


[4.5]
[3.6]
HJD-55896
0.1


[4.5]
[3.6]
HJD-55896
0.1


[4.5]
[3.6]
HJD-55896
0.1
30d

Motion of HH Objects

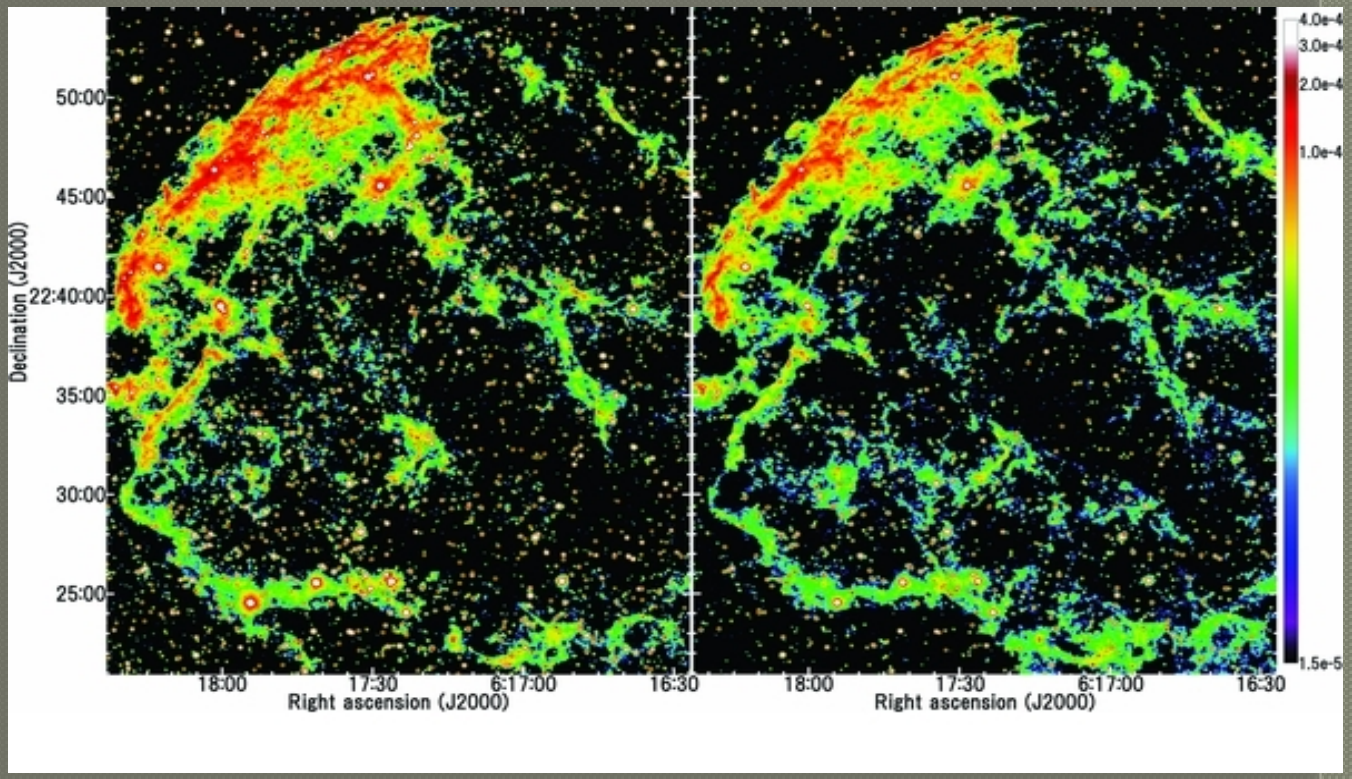


- Time history of outflows for entire star forming regions
- Identification and proper motion measurement of distant HH objects using improved astrometry of WFIRST
- Would require early epoch

Raga et al. (2012)

Supernova Remnants

- Ideally map 1.257 and 1.644 μm [Fe II] lines as well as 2.12 μm H_2 1-0 S(1) line
- Morphology of shock fronts
- Identify SN Remnants in Galactic plane from morphology of features in broad-band surveys



1.257 μm 1.644 μm

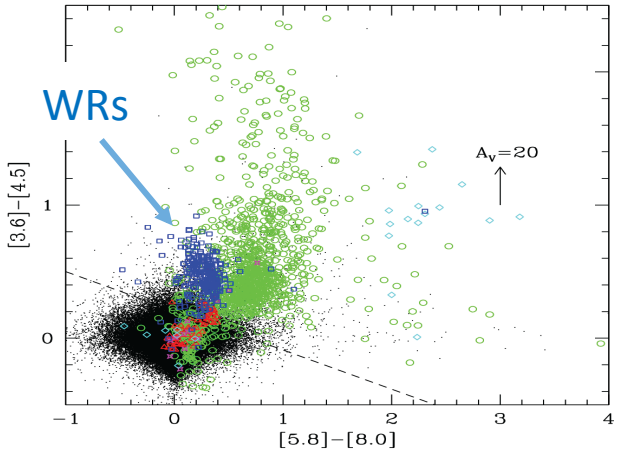
IC 443: Kokusho et al. (2013)9

Towards Completeness of the Galactic Population of Evolved Massive Stars with WFIRST/WFI

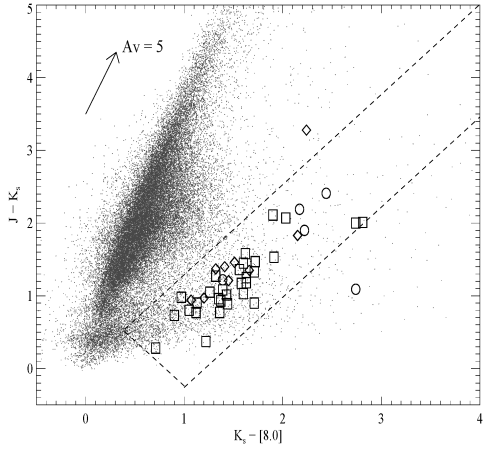
Poster 20: P. Morris, S. van Dyk, J. Mauerhan, G. Morello, A. Marston

The known **Wolf-Rayet and LBV** population in the MW is 45% - 95% low compared to empirical estimates → average lifetimes from evolutionary models in galaxies (at varied metallicity) are uncertain by up to factor 10.

GLIMPSE CCD



2MASS+GLIMPSE CCD



Our team developed a successful method to use 2MASS and GLIMPSE **broad-band colors + ground-based spectroscopy to reveal reddened WRs, LBVs.** ~20% added to the known population so far.

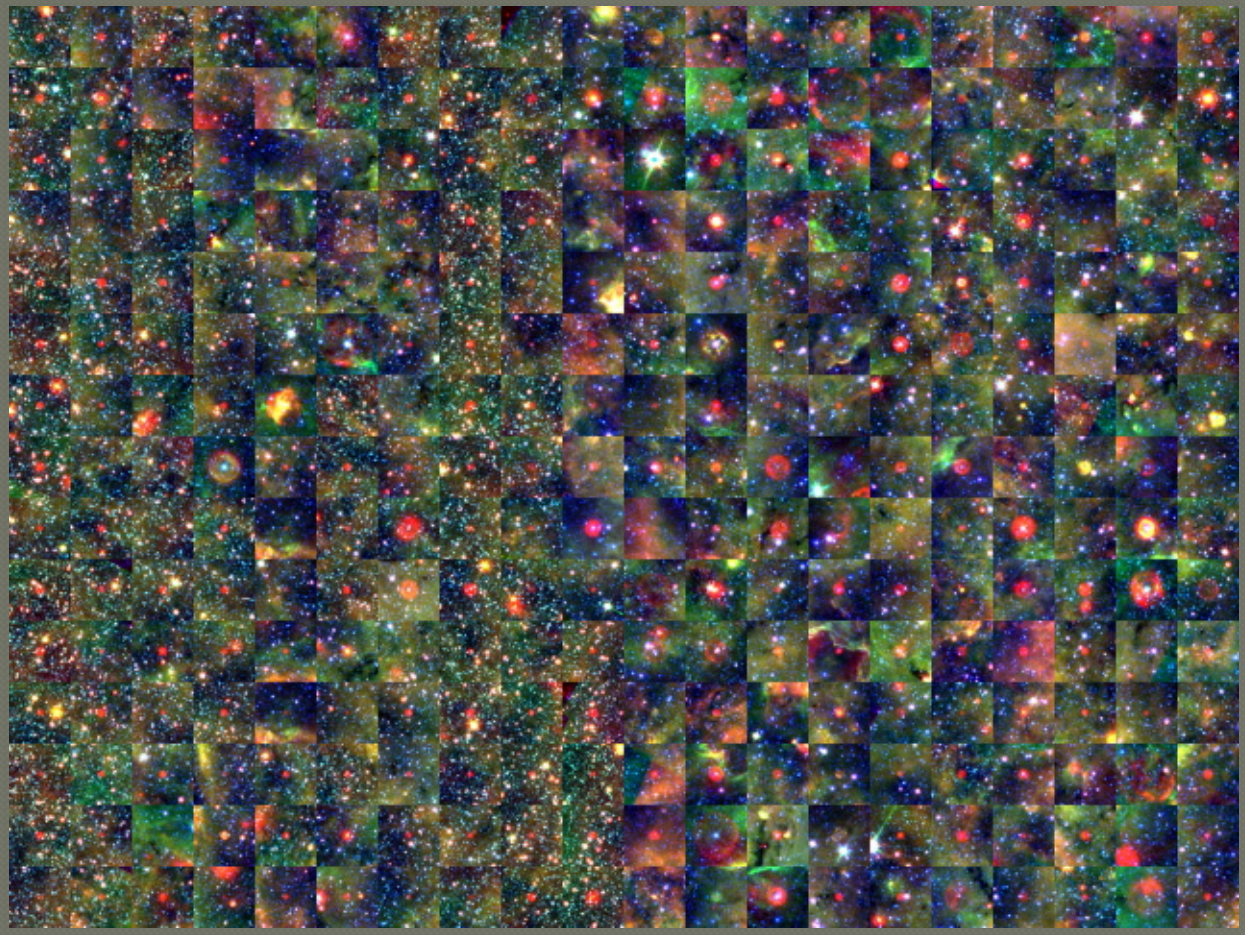
The method is limited by confusion, population degeneracies (e.g. Ae/Be stars) → **Completeness is uncertain**.

Population degeneracies may be lifted (→ completeness better estimated) by

- A WFI survey of the Galactic Plane *unbiased,* using YZJHF filters. (K desirable).
- A machine learning method under development, exploiting massive star SED shapes vs other vermin.

Evolved Stars Shells

- Blind searches can yield interesting results – MIPSGAL bubbles
- Find gas/dust shells around massive and low mass evolved stars



Montage courtesy of N. Flagey

Summary

- Lots of value in low latitude survey
  - Large areas can be mapped efficiently
- Serendipity and statistics are key
- Galactic science would benefit from extension of grism in red and blue directions
  - Personal preference is redder
  - Optimal telescope background not necessary
  - Complex regions will be interesting data reduction challenge with grism
- Narrow band filters would be grand (H_2 2.12 μm, Hα)