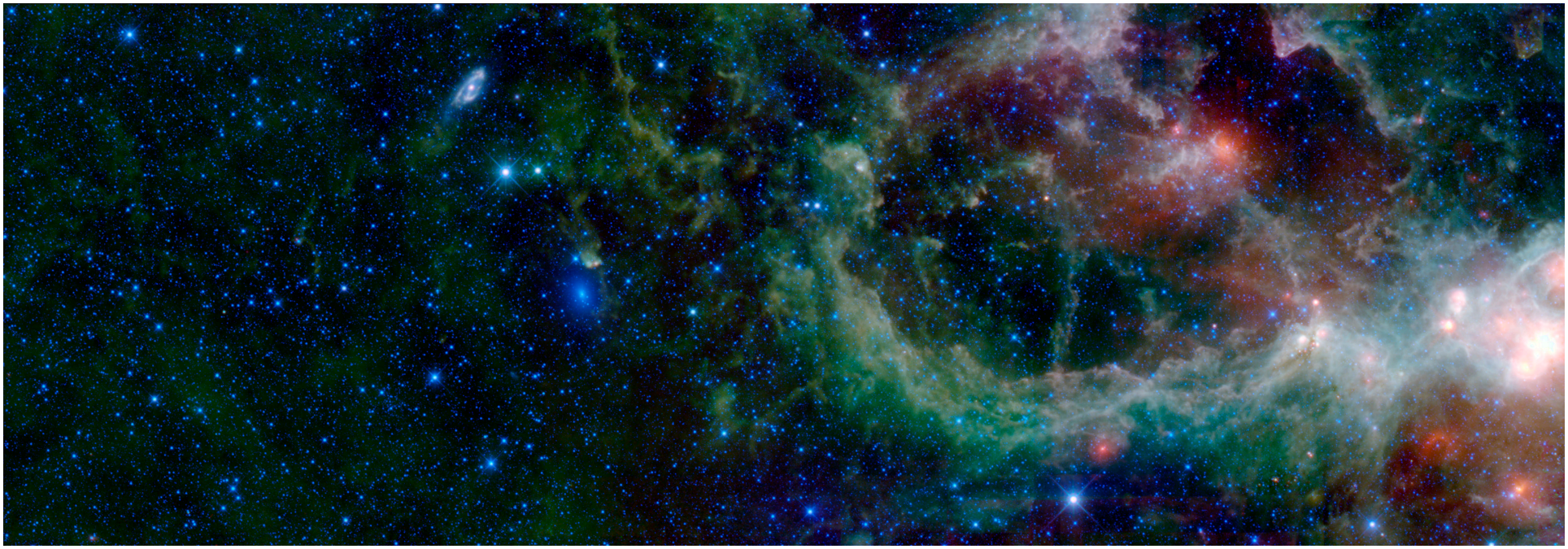
WISE Discovery of Low-metallicity **Blue Compact Dwarf Galaxies**



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IPAC, Caltech

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Lin Yan (IPAC)
Peter Eisenhardt (JPL)
Adam Stanford (UC Davis)
Ned Wright (UCLA)
Andrew Blain (Leicester)
Yanling Wu (Mars & Co)
Roberto Assef (JPL)

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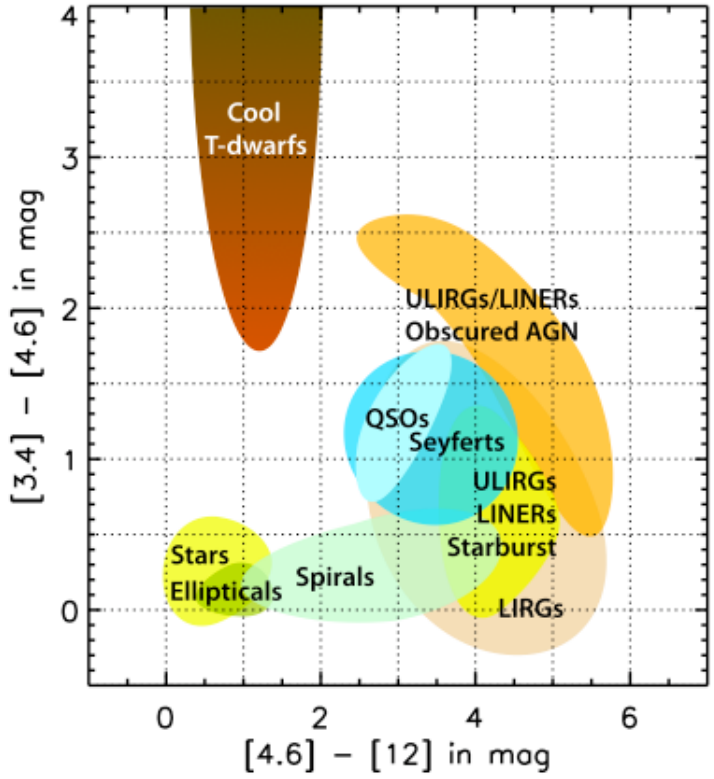
Carrie Bridge (Caltech)
Dominic Benford (GSFC)
Jingwen Wu (JPL)
Frank Masci (IPAC)
Sara Petty (UCLA)
John Moustakas (UCSD)
Brandon Swift (UA)

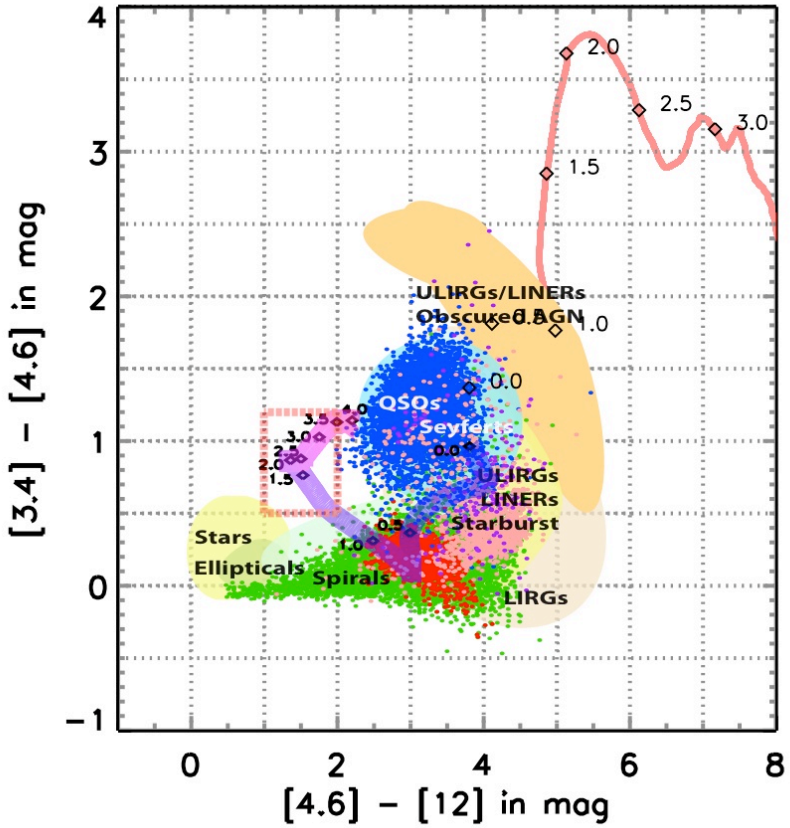
Griffith, Tsai, Stern, et al. 2011, ApJL
Tsai et al. in preparation

WISE Color-Color Plot

Where are the extreme luminous IR galaxies?

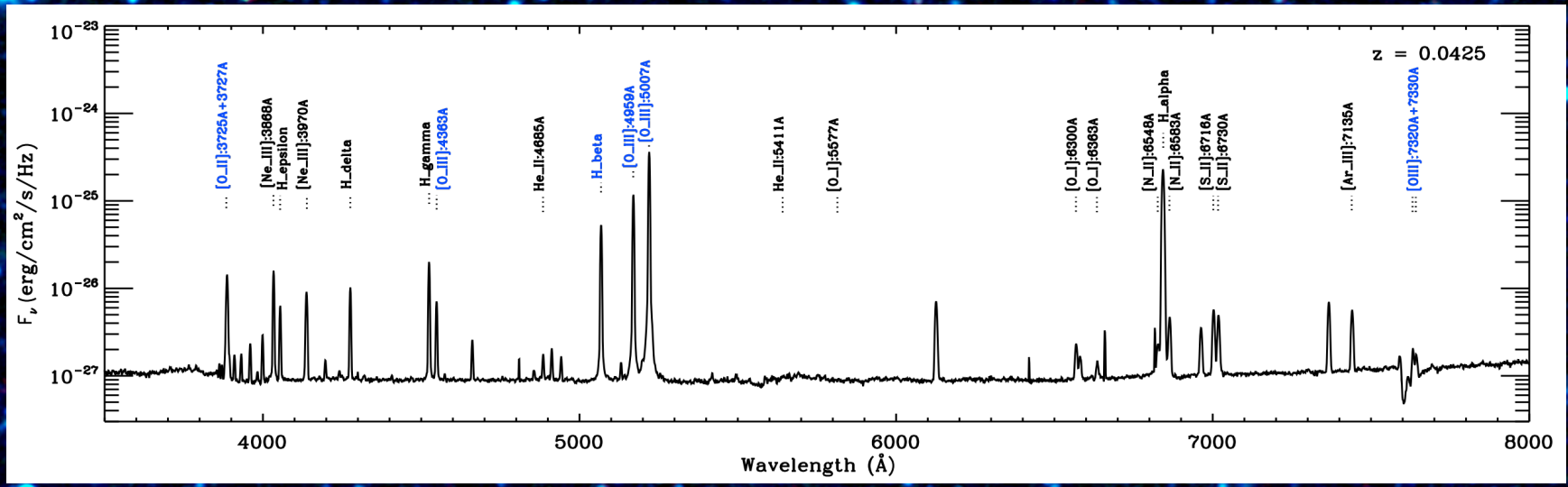


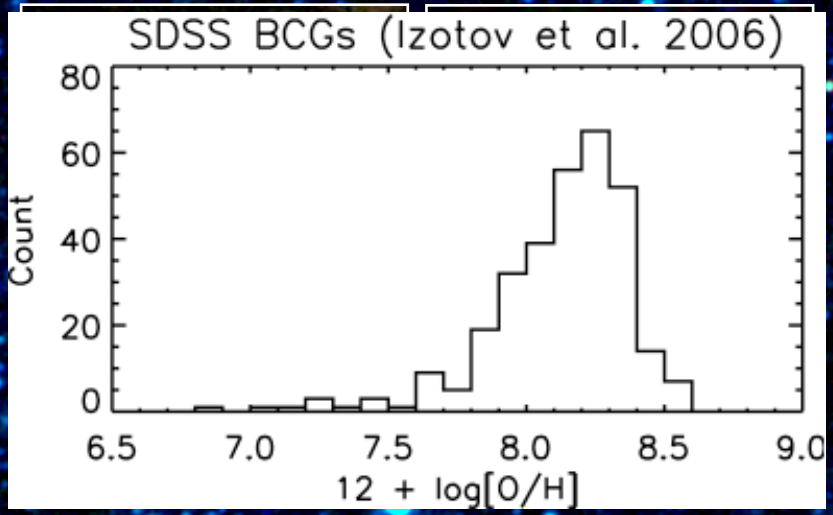
Wright, …, Tsai et al. 2011



W1702+18

First Low Metallicity BCD Discovered by WISE





- 8th mag (870 mJy) source at 22 microns
- 18th mag Optically
- z=0.0425
- Metallicity ~ 1/10 of Solar value
- SFR ~ 11.4 $M_\odot$/yr
- **The results of a systematic search on DR7 data support this esitmate (Morales-Luis et al. 2011)**

- **Estimated (0.004 Extremely metal poor galaxies (1/12 soloar) per deg^2 (Kniazev et al. 2003) or ~ 165 over whole sky (r < 17.77)**

General Properties of BCD's

- Low luminosity M_B > -18.0
- Compact sizes < 1 kpc
- Strong emission line spectra
- blue optical colors (U – B ~ –0.6)

SBS 0335-05E

Credit: Thuan et al 1997

z = 0.0134
M_B = -17.1
Z ~ 1/50 Z_sun
W1 = 14.54 Vega
W2 = 12.52
W3 = 7.62
W4 = 5.04

Zwicky 18

Credit: HST/NASA/ESA.

z = 0.0025
M_B = -15.4
Z ~ 1/50 Z_sun
W1 = 15.40 Vega
W2 = 14.79
W3 = 11.43
W4 = 7.84

Active vs Passive – The BCD Dichotomy

Hirashita & Hunt Framework (2004)

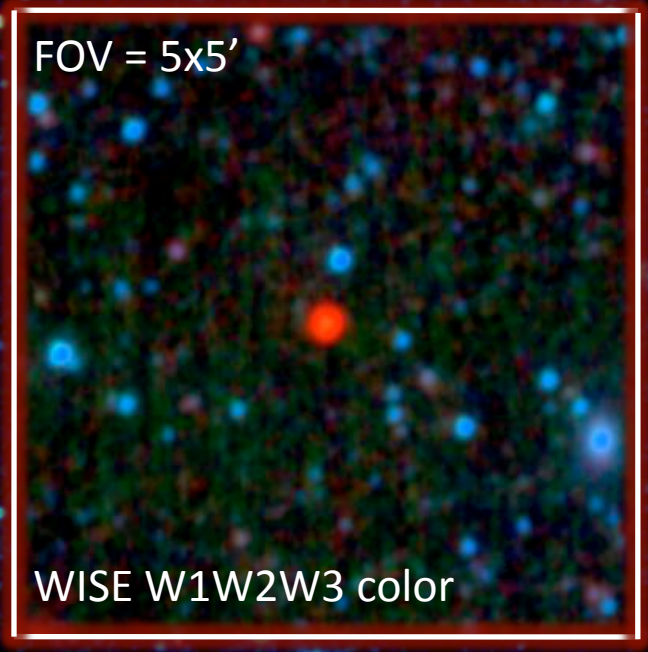
Active

- Host super star clusters
- Compact star formation regions < 50 pc
- High gas density > 500 cm^3
- Rich H_2 content
- Large dust optical depth
- High dust temperature

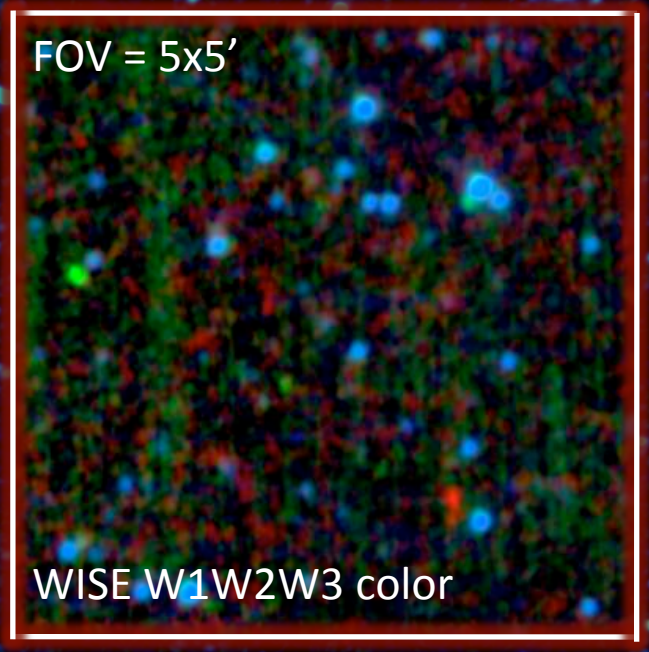
Passive

- Lack super star clusters
- Diffuse star formation regions > 100 pc
- lower gas density < 100 cm^3
- Poor H_2 content
- Lower dust temperature

SBS 0335-05E



Zwicky 18

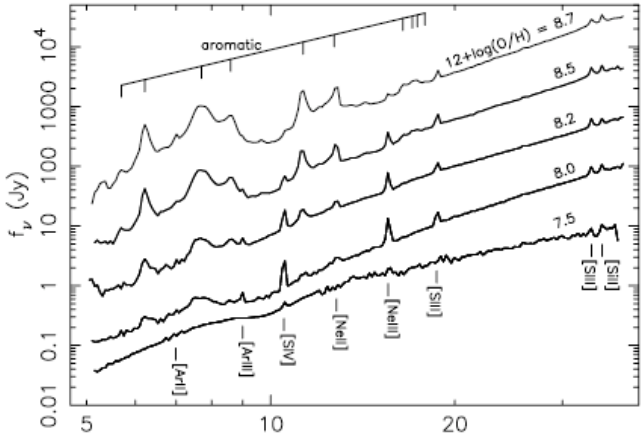


How Can These Blue Little Things Be Red?

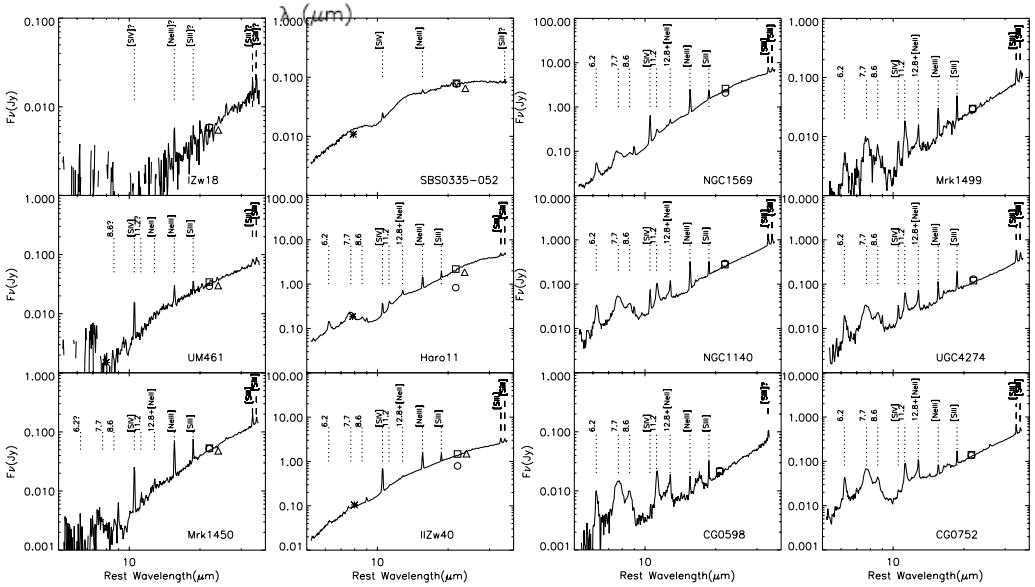
- PAH strength decreases with metallicity in star forming galaxies
  (Engelbracht et al. 2008)

- No PAH feature, no Silicon absorption in low-Z BCDs – (almost) pure thermal dust emission
  (Wu et al 2006)

- Small, hot dust are responsible for the MIR mission
  (Dale et al. 2001)



Engelbracht et al. 2008

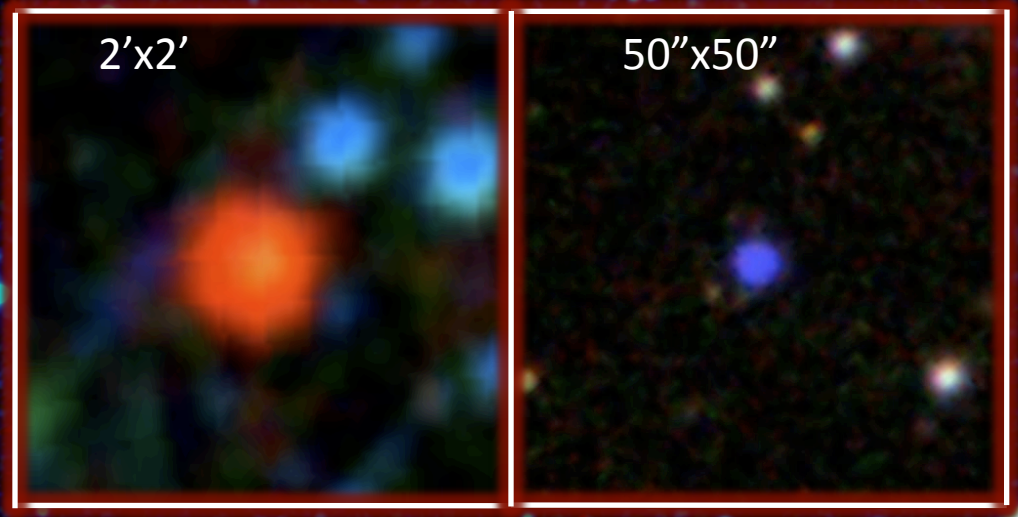


Metallicity ->

Wu et al. 2006

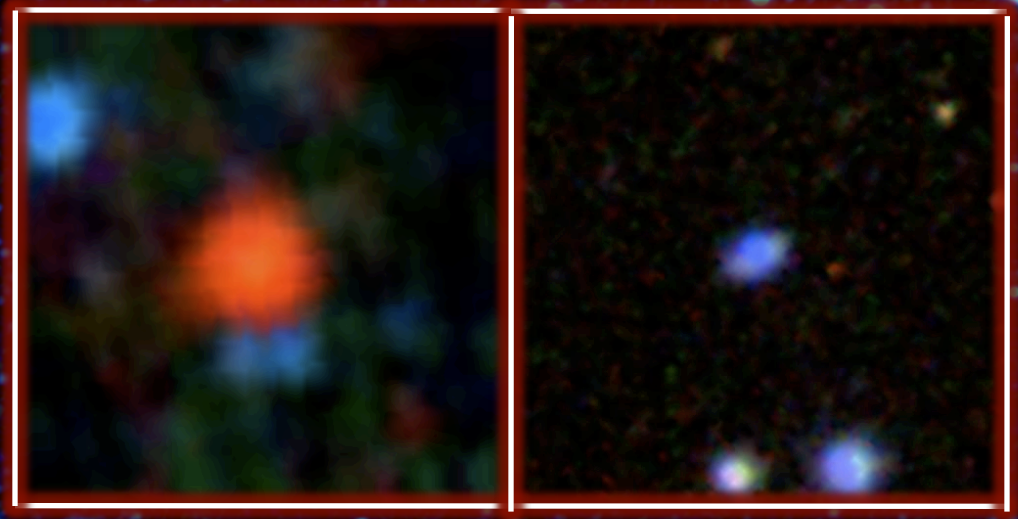
The First WISE Discovered "active" BCDs

W1702+18



z = 0.0425
M_B = -18.3
Z ~ 1/10Z_sun
W1 = 14.25 (Vega)
W2 = 12.02
W3 = 7.58
W4 = 4.95
SFR* = 11.4 M_sun/yr

W0801+26



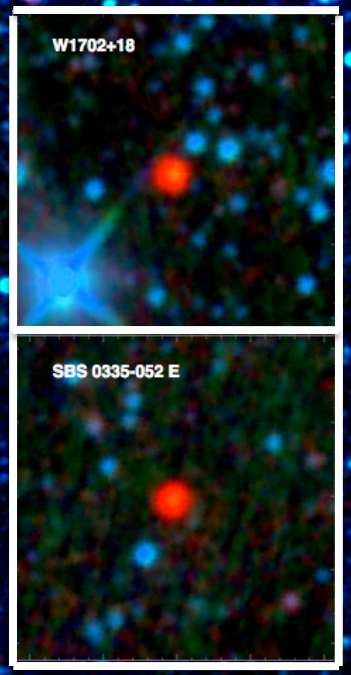
z = 0.0260
M_B = -16.8
Z ~ 1/10 Z_sun
W1 = 15.03 (Vega)
W2 = 12.96
W3 = 8.23
W4 = 5.38
SFR = 2.5 M_sun/yr

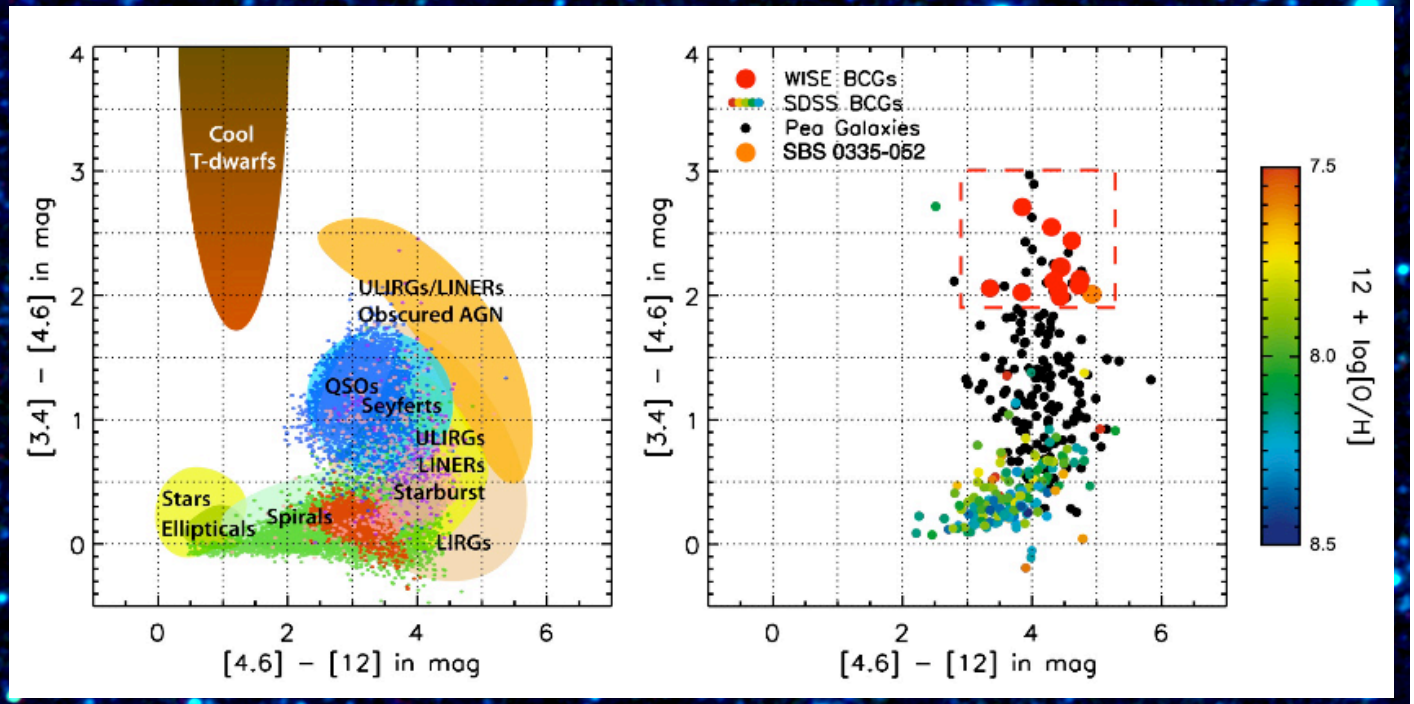
WISE w1w2w3 SDSS color

Griffith, Tsai, Stern et al. 2011

Hunt for Red BCDs

Inspiration



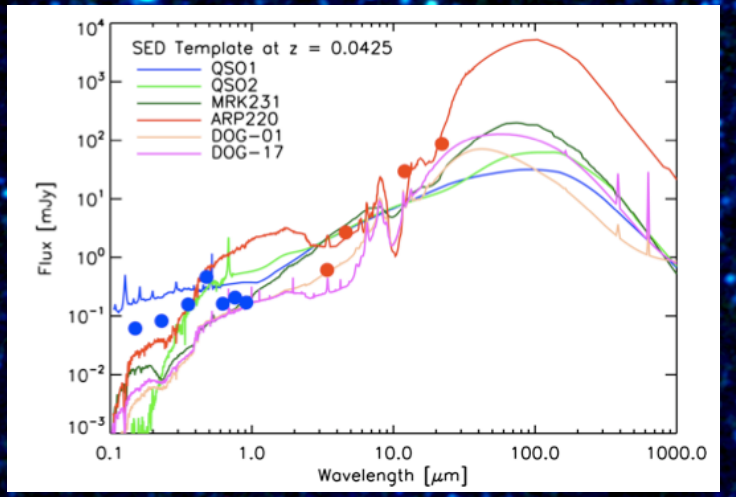


Work in progress –

So far, we have optical spectroscopic follow-up on 33 (out of total 109) WISE BCD candidates, and

~ 40% are confirmed BCDs

We are requesting more high quality optical spectroscopic data to complete the BCD confirmation over the remainder of candidates



Applications

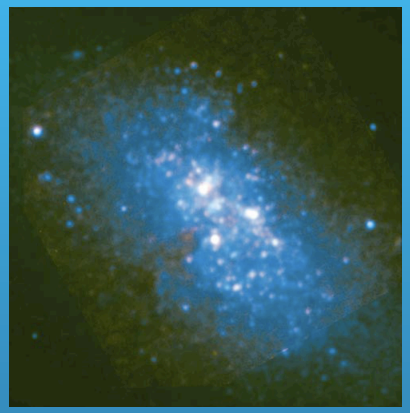
- Local laboratories for studying dust properties and star formation processes in low metallicity environments, (analog to high z galaxies)

  (only few successful direct measurements of [O/H] in galaxies beyond z = 1.5: Hainline et al 2009, Yuan & Kewley 2009, Finkelstein et al. 2011, Rigby et al 2011, Wright et al. 2011)
- Host of Super Star Clusters
- Host of Super Massive Black Holes?

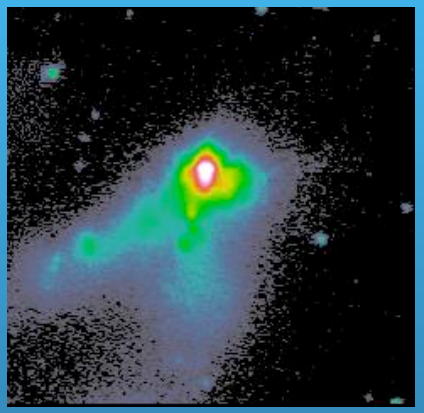
Super Star Clusters

- SSCs are compact massive star clusters with luminosities a few orders of magnitude brighter than globular clusters
- Bright, young, massive (10^5–10^6 M_{Sun}), and compact (with in few pc^3)
- They are likely (90%) to survive though the relaxation time (Johnson 2009*)
- Star formation and evolution processes in the cluster effect further star formation, thus all stars have to form in a short time
- They are formed with high star formation rate (SFR) and high formation efficiency (SFE)

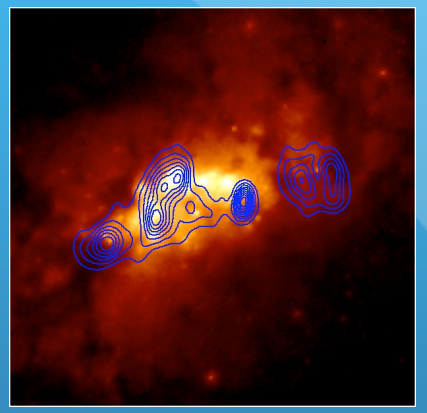
SSCs in Blue Compact Dwarfs



NGC5253, optical and NIR
Turner et al. 2003

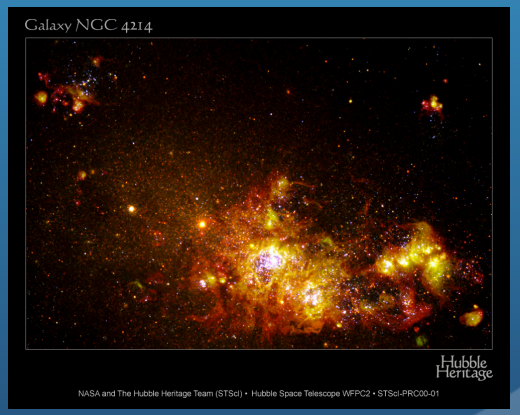


IIZw 40, optical
Beck et al. 2002



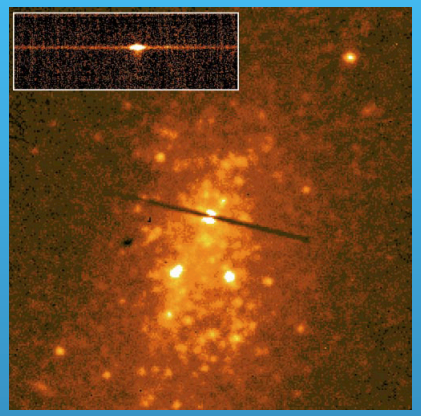
He 2-10, I band
Kobulnicky & Johnson 1999

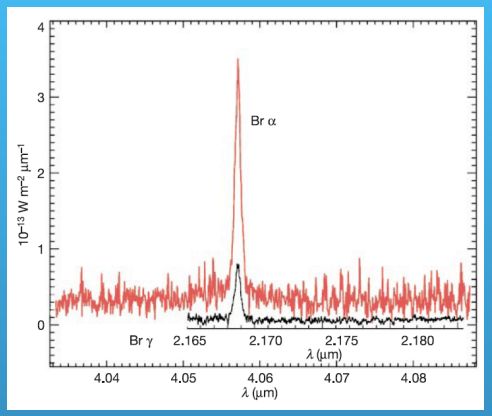
NGC1569, HST optical



NGC4214, HST optical

From SSC to IMBH

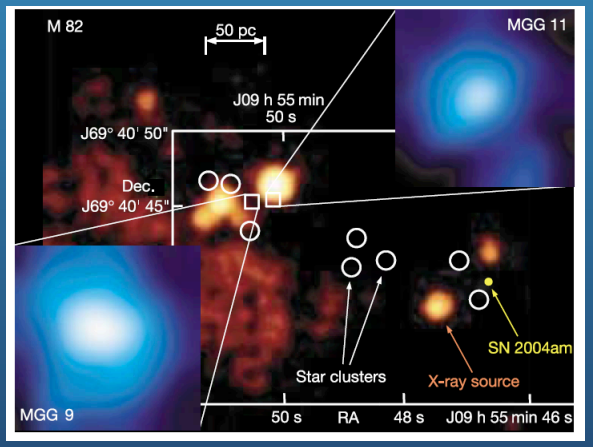


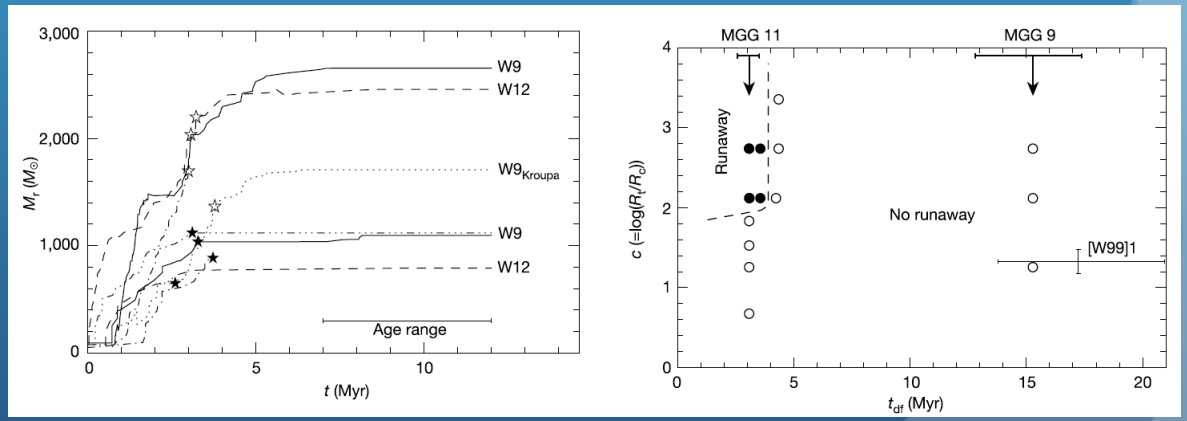


Run-away collisions of O stars
->
Intermediate Mass Black Holes (IMBHs)

NGC5253 - Turner et al (2003, Nature)

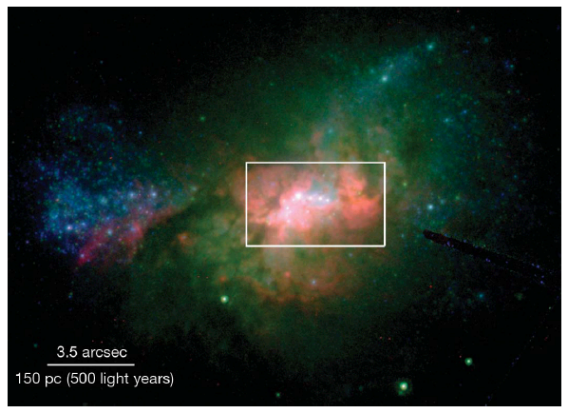
IMBH in M82



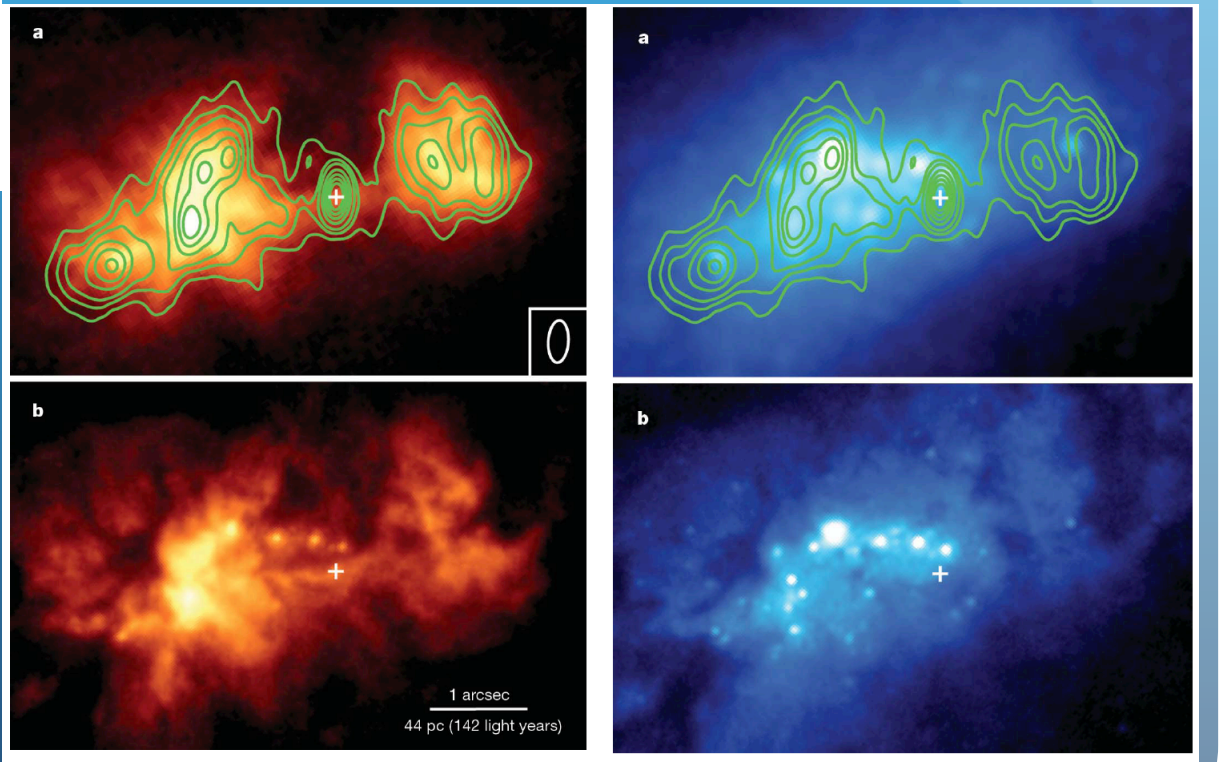


Portegles Zwart et al (2004, Nature)

SBMH in found in BCD



He 2-10
Z = 0.00292
M_{BH} ~ 2 x 10^6 M_{sun}

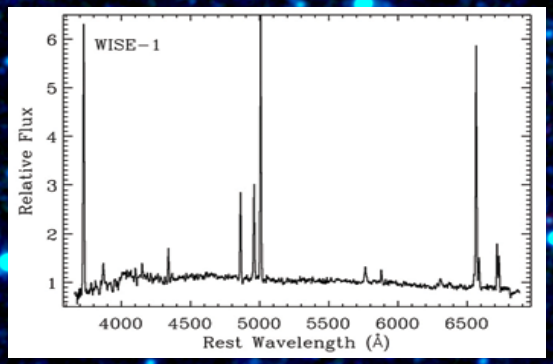


Contours: VLA 3.5 cm
Cross: X-ray source
(2.7 x 10^{39} erg/s)
Images:
HST B+I+Hα (top)
Paα image (left)
K band (top right)
I band (bottom right)

Reines et al (2011, Nature)

In progress

- Optical spectroscopic follow-up
  - Keck, Palomar, SOAR
  - NOAO/UA Summer Camp
    by John Moustakas (UCSD), Brandon Swift (UA)



NOAO Newsletter Sept 2011

- HI follow-up
- And other multi-wavelength follow-up
  - Submm, radio, high contrast imaging…

Summary

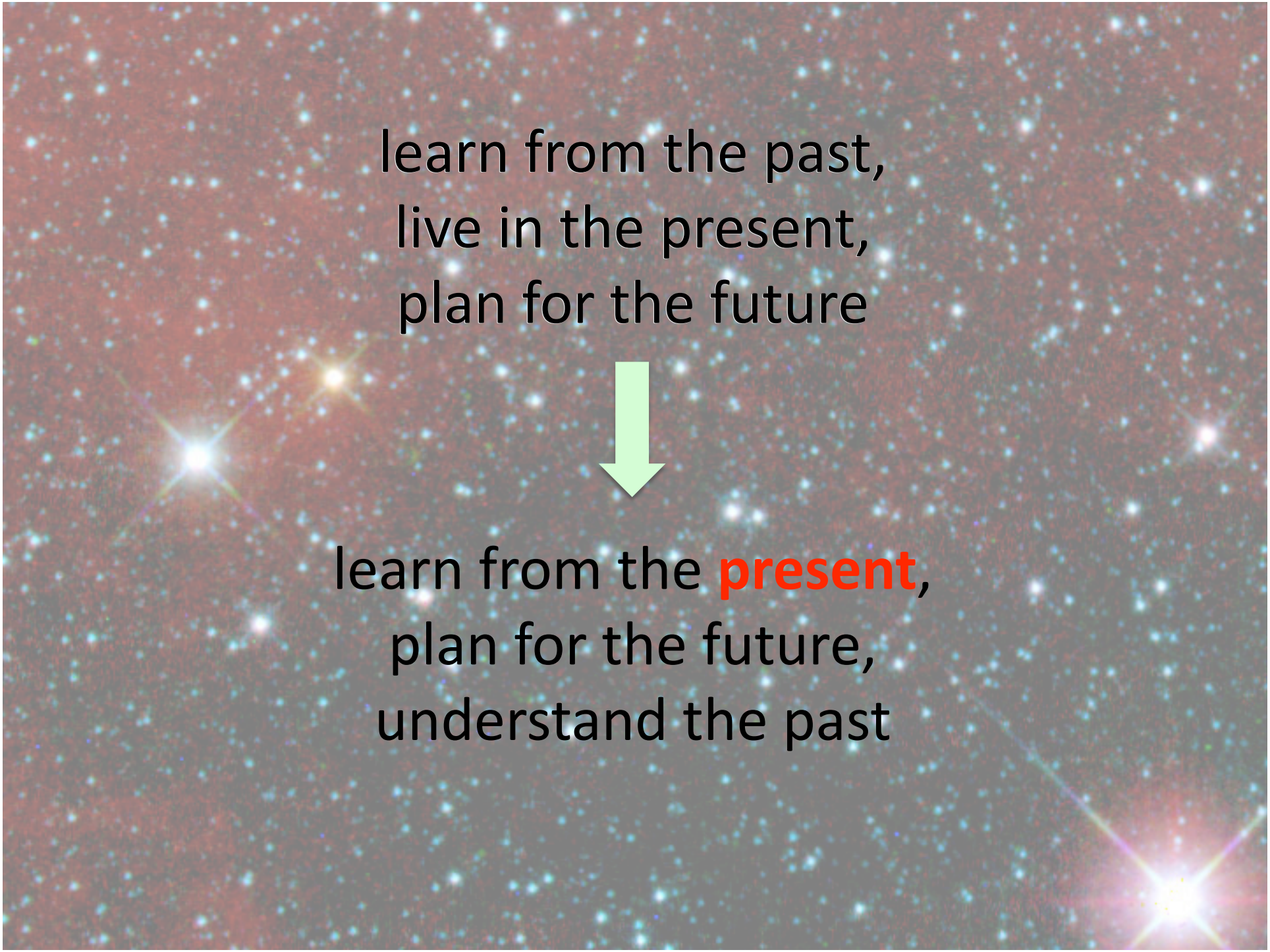
- WISE is an efficient instrument for identifying active BCD's

- Pre-WISE only 10's of low metallicity BCD's known, WISE will add at least double the sample

- WISE all sky capabilities will allow for complete samples of active BCD's to be constructed and used to study evolution

- Important applications of these low-Z BCDs
  - Stellar components, extinction, molecular gas, dust…
  - Super star cluster studies under low extinction
  - SMBHs in BCDs
  - Potential study subjects for HST/JWST, ALMA, CCAT..

- Local laboratories for studying dust properties and star formation processes in low metallicity environments, (analog to high z galaxies)


learn from the past,
live in the present,
plan for the future
learn from the present,
plan for the future,
understand the past