Nearby Galaxies ISDT

Summary of Key Program Concepts

ISDT Convenors

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with thanks to

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Inspired by Jessica's slide…

Star and planet formation

Stars

Exoplanets

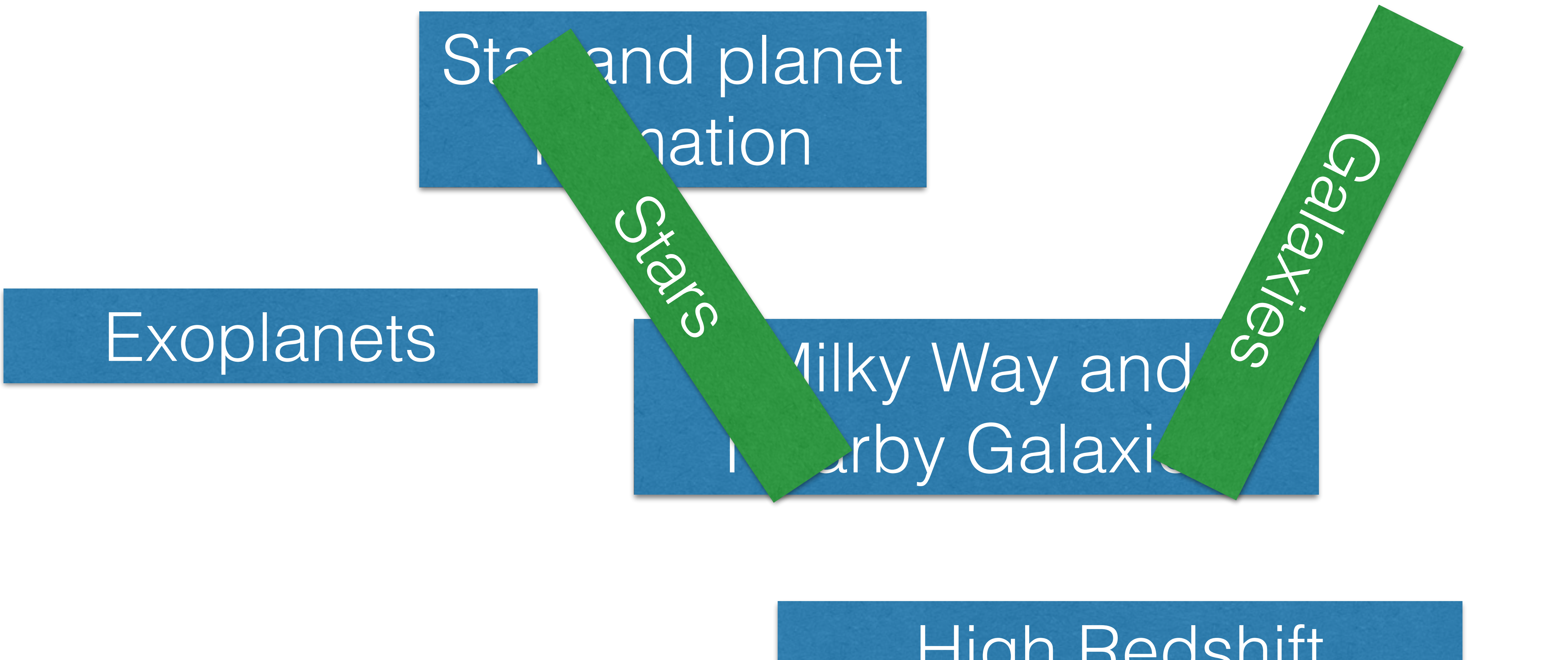
Milky Way and Nearby Galaxies

Galaxies

High Redshift Galaxies

Cosmology

Inspired by Jessica's slide…



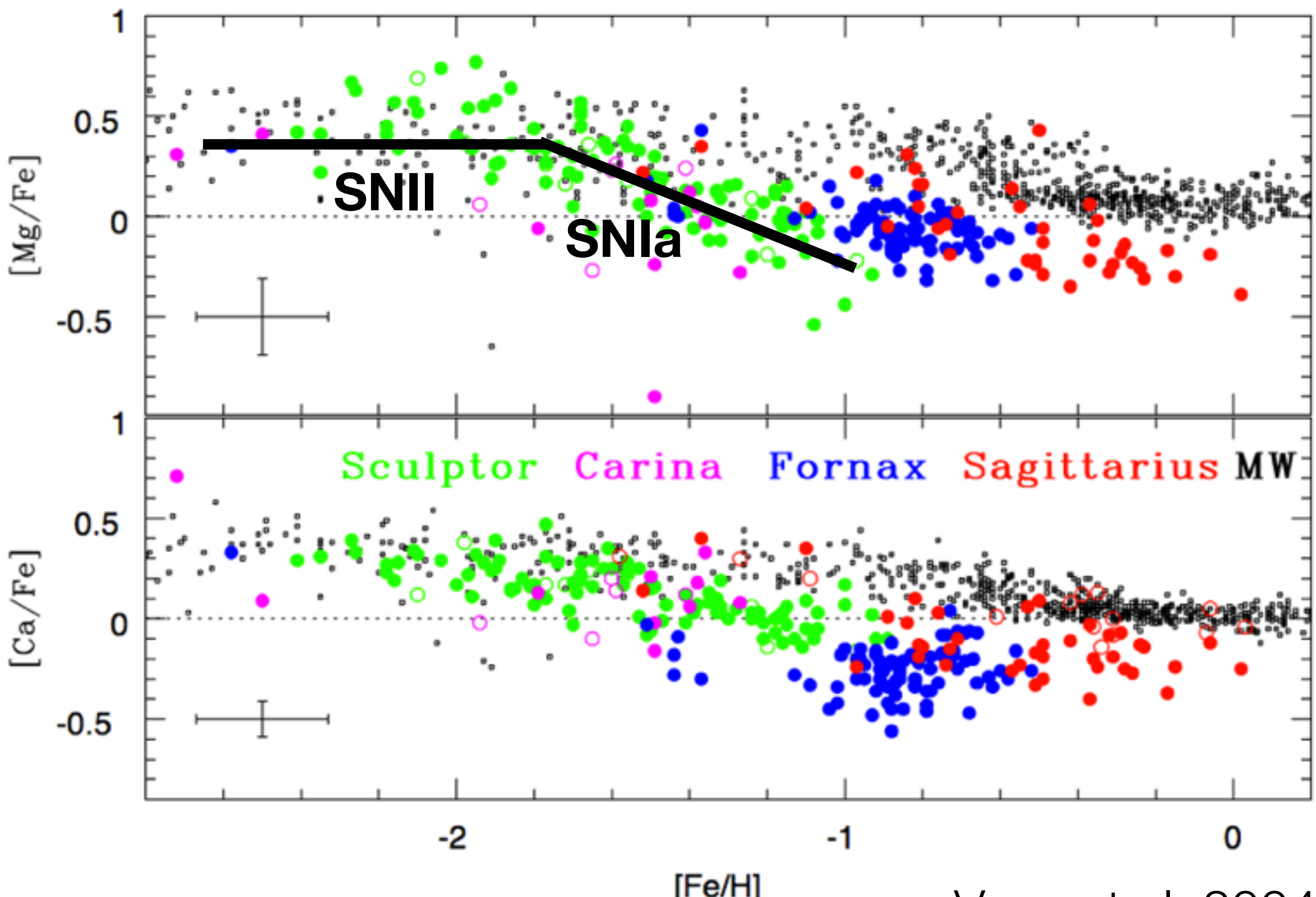
~40+ members with
very diverse interests

Key Program Concepts

- “Working titles”
  - 1. The formation of L* galaxies as probed by the detailed chemical evolution of the oldest stars
  - 2. Building the stellar mass of galaxies
  - 3. The mass and shape of dark matter halos

1. The formation of L* galaxies as probed by the detailed chemical evolution of the oldest stars

- e.g., alpha element abundance pattern

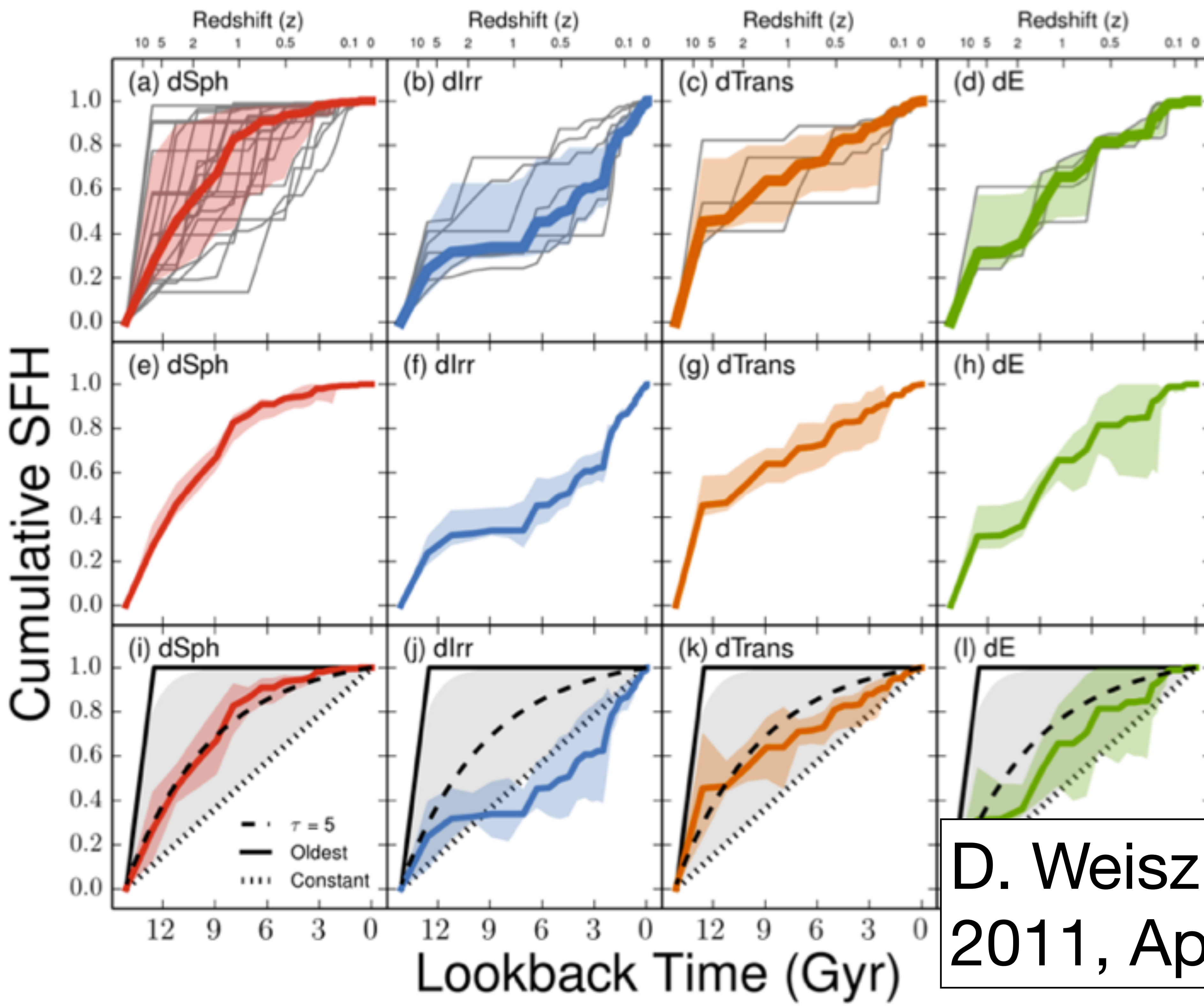


Venn et al. 2004

The formation of L* galaxies as probed by the detailed chemical evolution of the oldest stars

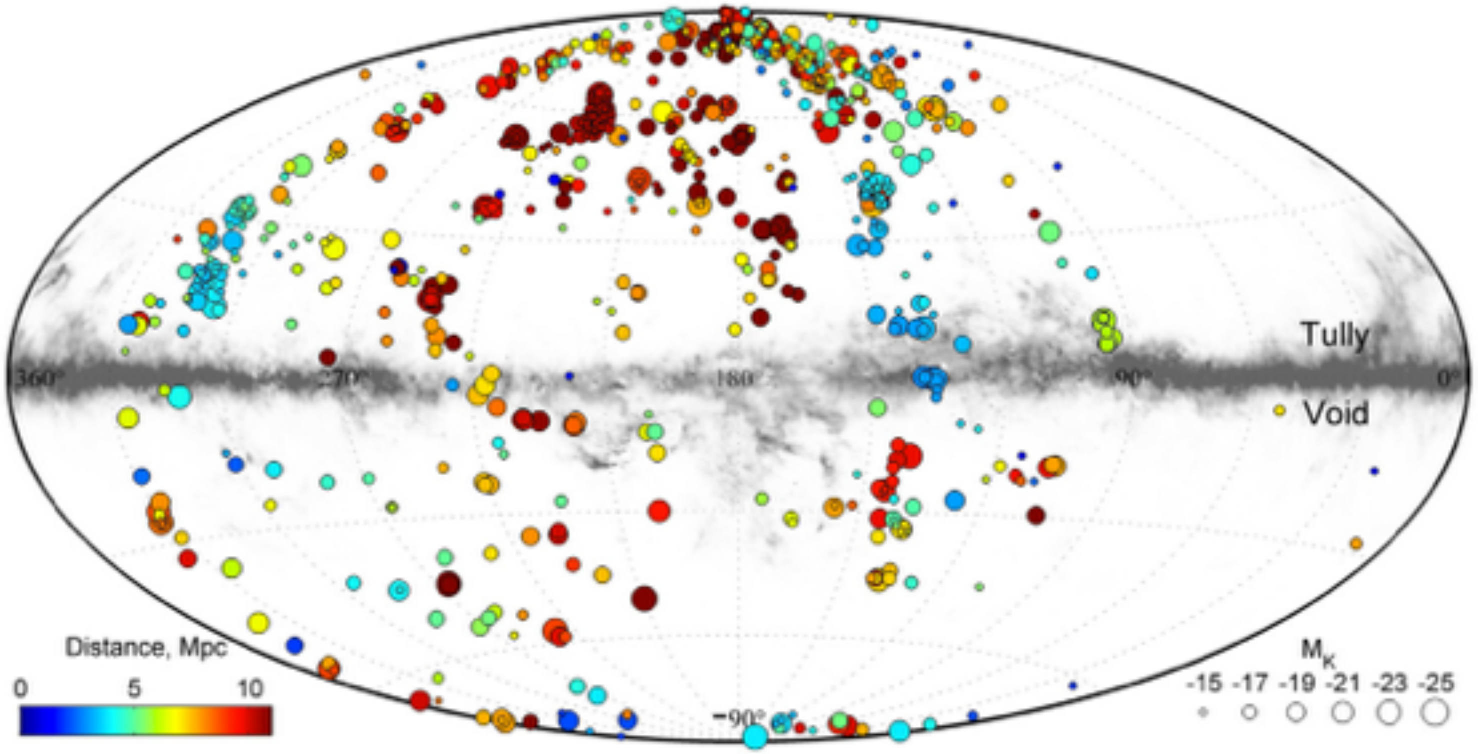
- Key Instrument for TMT:
  - HROS (perhaps NIRES), operating somewhere between 30K - 100K
  - MOS capabilities very useful, but detailed studies of wavelength coverage vs resolution vs Nobjects needs to be developed
- Key Capability with respect to existing telescopes:
  - Faint stars; objects currently only observed with Keck at moderate resolution observable with TMT at high resolution
  - i.e. for studies of the Milky Way, focus on areas/subcomponents/structures that are not well probed by current instrumentation
  - Outer halo, distant stellar streams, dwarf galaxies (especially those with very few bright stars)
  - Other Local Group (Local Volume?) galaxies
    - e.g. the differential chemical evolution of the subcomponents of L* galaxies in the Local Group
- Key reason for being Key:
  - Individual exposures probably reasonably long, and large samples required
  - Target selection important: culmination of program requiring ancillary data on smaller (ie 10m-class) telescopes

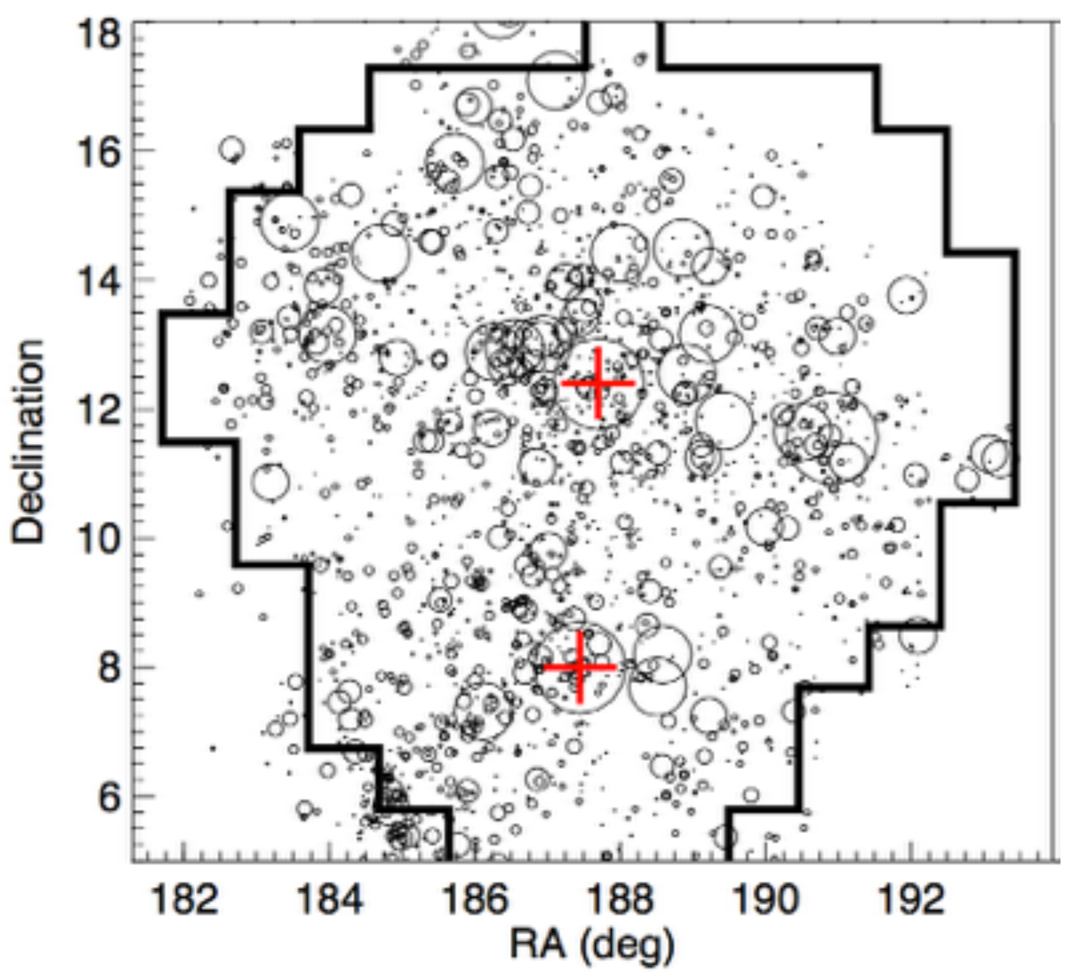
2. Building the stellar mass of galaxies



D. Weisz et al. 2011, ApJ, 739, 5

Karachentsev et al. 2004, 2013





Ferrarese et al. 2012

- Key questions probe questions relating to **Galaxy Evolution**
- How does the build up of stellar mass through time vary between
    - low and high mass galaxies?
    - satellites and centrals?
    - quenched and unquenched galaxies?
    - early and late type galaxies?
- How quickly does the group or cluster environment shut off star formation on average?
- etc etc etc etc etc

Building the stellar mass of galaxies

- Key Instrument for TMT:
  - IRIS
- Key Capability with respect to existing telescopes:
  - Faint stars, diffraction limit
  - Pushing AO corrections into the optical very helpful
  - Mid-IR observations could be useful for better characterizing AGB stars
- Key reason for being Key:
  - Systematic survey is absolutely essential to answer driving science questions regarding populations of galaxies e.g. at what epoch do quenched galaxies become quenched? (NOT: at what epoch does KKR25 become quenched?)
  - Representative sample spanning all major parameters of interest likely numbers in the hundreds
  - Multi-band (2) photometry required per target, but individual exposures are long
  - Targets must have complementary wide field imaging from small (~10m) facilities

NGC3379, E galaxy @ 11Mpc

Name	r (arcsec)	Σ_K (mag arcsec^{-2})	K_{lim}	Time (secs)	
R_e	30	17.0	25.7	282	**AGB**
$3R_e$	90	19.3	28.5	47200	**HB**
R_{tot}	190	22.5	31.6	∞	
K (1 hour)	—	—	27.9	3600	

3. The mass and shape of dark matter halos

Jeans Eqn
$$\frac{1}{\nu}\frac{d}{dr}(\nu\bar{v_r^2}) + 2\frac{\beta\bar{v_r^2}}{r} = -\frac{GM(r)}{r^2}$$

where $\beta(r) \equiv 1 - \bar{v_\theta^2}/\bar{v_r^2}$

Useful number:
PM = 200 microarcsecs/yr (Vt/100km/s) (100kpc/D)

Tangential velocity of LG satellites (D<=1000kpc)
=>PM ~ tens of microarcsecs/yr

Tangential velocity dispersion of MW satellites ~1 - 10 km/s?
=> PM ~2 - 20 microarcsecs/yr (much easier for closer satellites)

- Measure the orbits of the Milky Way (and Local Group) satellites —> masses of the MW and M31 dark matter halos, especially at large radius
- Measure the internal orbits of stars in the MW satellites —> inner mass profiles of the dark matter (sub)halos

Building the stellar mass of galaxies

- (Joint interest with Cosmology)
- Key Instrument for TMT:
  - IRIS
- Key Capability with respect to existing telescopes:
  - Faint stars, diffraction limit for crowded fields
  - Ability to measure net motion of a system or dispersion within a system scales as 1/root(N) —> provides largest gain over (e.g.) HST
  - Observations spaced out over decade(s)…keep IRIS in working order!!!
- Key reason for being Key:
  - Multi-epoch observations are essential
  - Systematic survey of relatively large number of satellites (spanning luminosity i.e. probe impact of baryons on DM profiles)
  - In early years, precision will be similar to HST (proposals to use HST as "first epoch")
  - Over first decade or so, precision will begin to greatly exceed that of HST
  - Deep imaging of dwarfs also useful for other science (esp. stellar populations)

Summary

- Majority of stellar / stellar populations science is currently conducted at optical wavelengths
  - the next decade will see a transition away from this, but learning curve is required
- IRIS is the key first light instrument
- Interest also in using MOS capabilities of IRMS and WFOS, although not developed to key program status yet
- **HROS** is a key early light capability that will have a big impact on the science of this ISDT
- Large amount of ground-work to enable some of these ideas
  - target selection for chemical abundance studies with HROS —> MOS spectroscopy on wide field facilities at low/intermediate wavelengths
  - determination of a “representative sample” of Local Volume galaxies requires systematic and homogeneous structural analysis of thousands of objects
  - HST and Gaia will have (continue to have) a profound effect on our understanding of the MW prior to first light of TMT