The Star Formation History of the Sagittarius dwarf galaxy and streams

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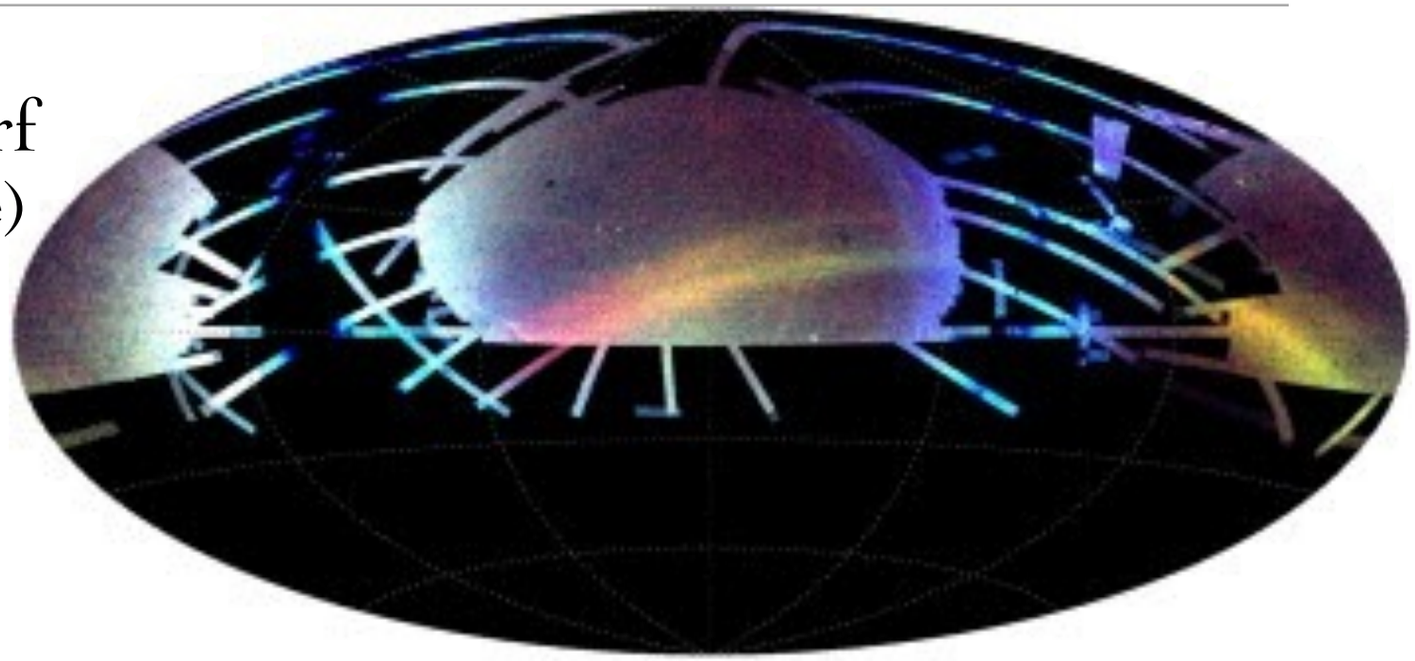
The Sagittarius stream(s)

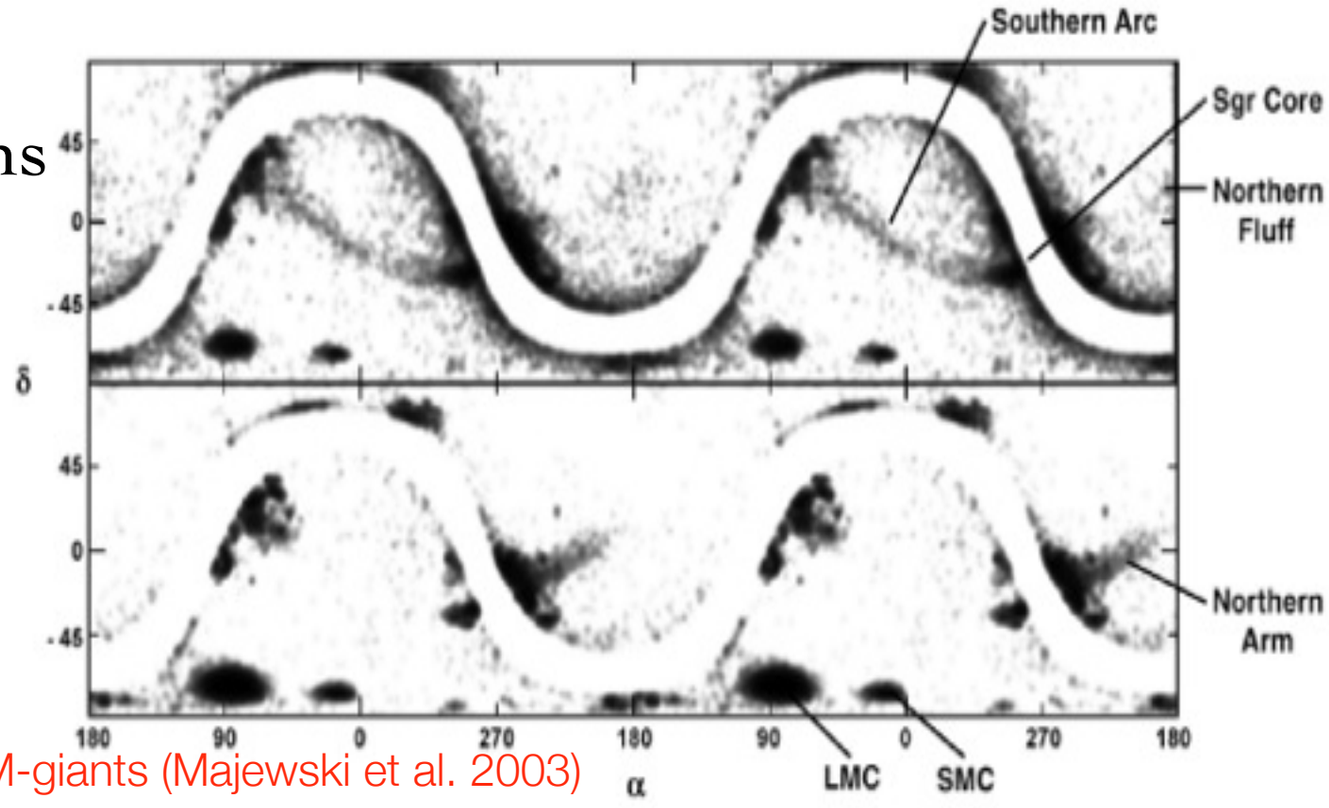
Sgr is a large and luminous dwarf
->Progenitor mass: ~10^9 $M_\odot$ (SMC-like)
->Luminosity: ~ 10^8 $L_\odot$ M_V~-15.2
-> 70% of luminosity in stream

Sgr stream:
->Largest stream in MW halo
->At least 1 full wrap around MW!

Important for studying halo formation through massive systems
(and in comparison to LG dSph)



SDSS MSTO stars (Belokurov et al. 2006)



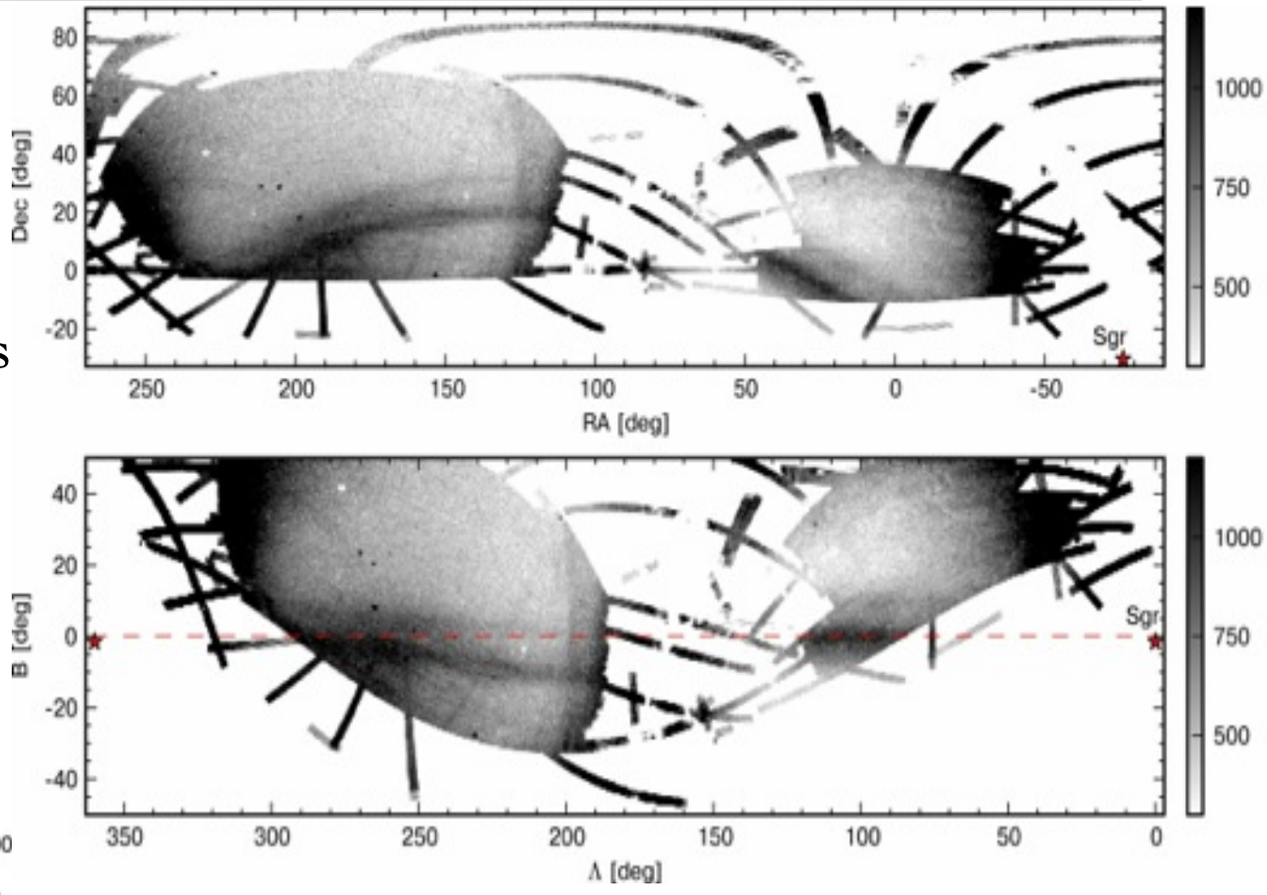
2MASS M-giants (Majewski et al. 2003)

One Sgr stream… or two?

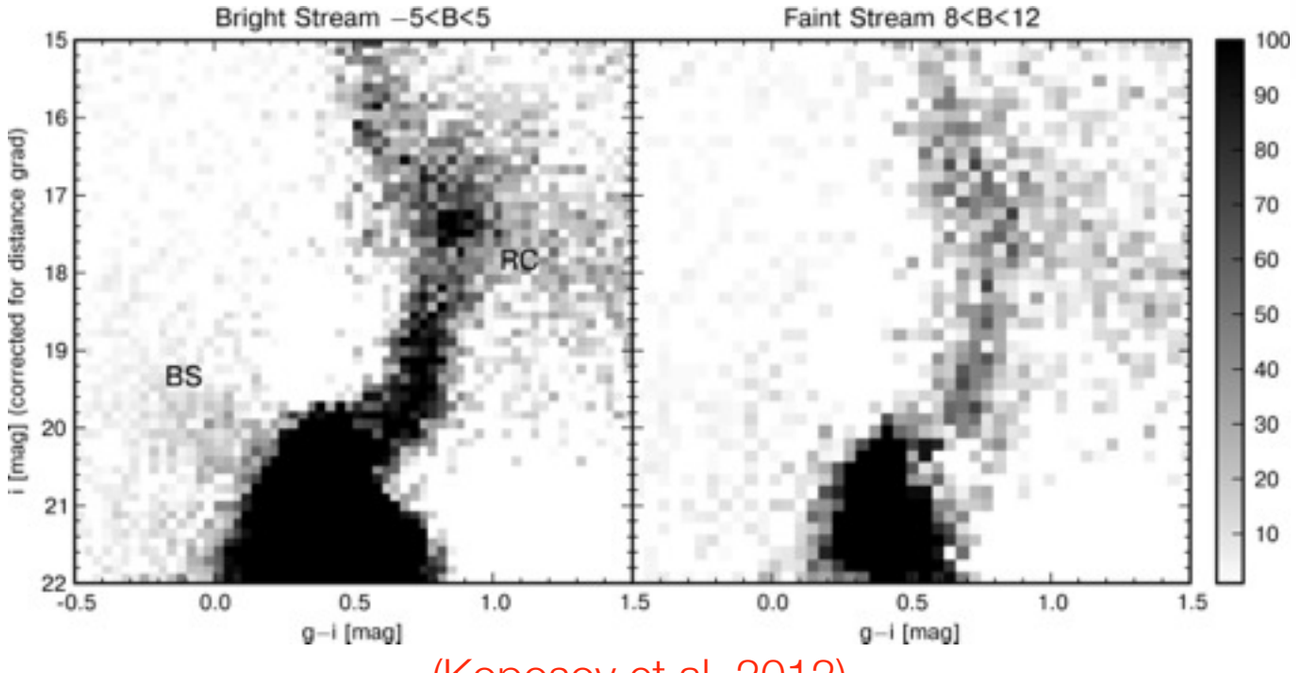
Multiple sequences in Sgr stream!
'bifurcation' in North? Stream split?

Sgr stream can be separated in 2 components
->faint stream: diff distance, simpler populations

Open questions:
->stellar population differences?
->drawn from same progenitor?
->different pericentre passage?



Law & Majewski Sgr stream coordinates

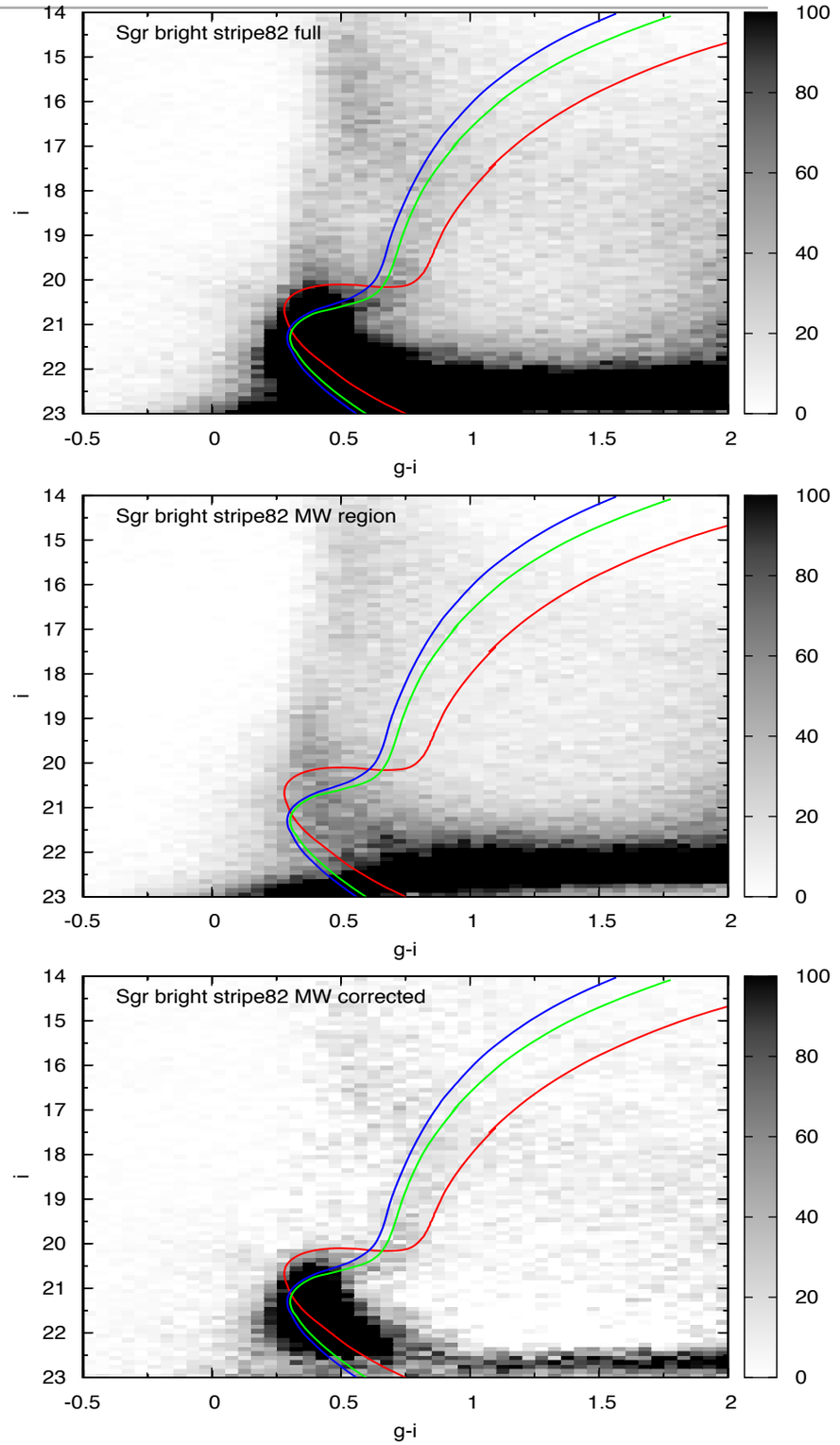


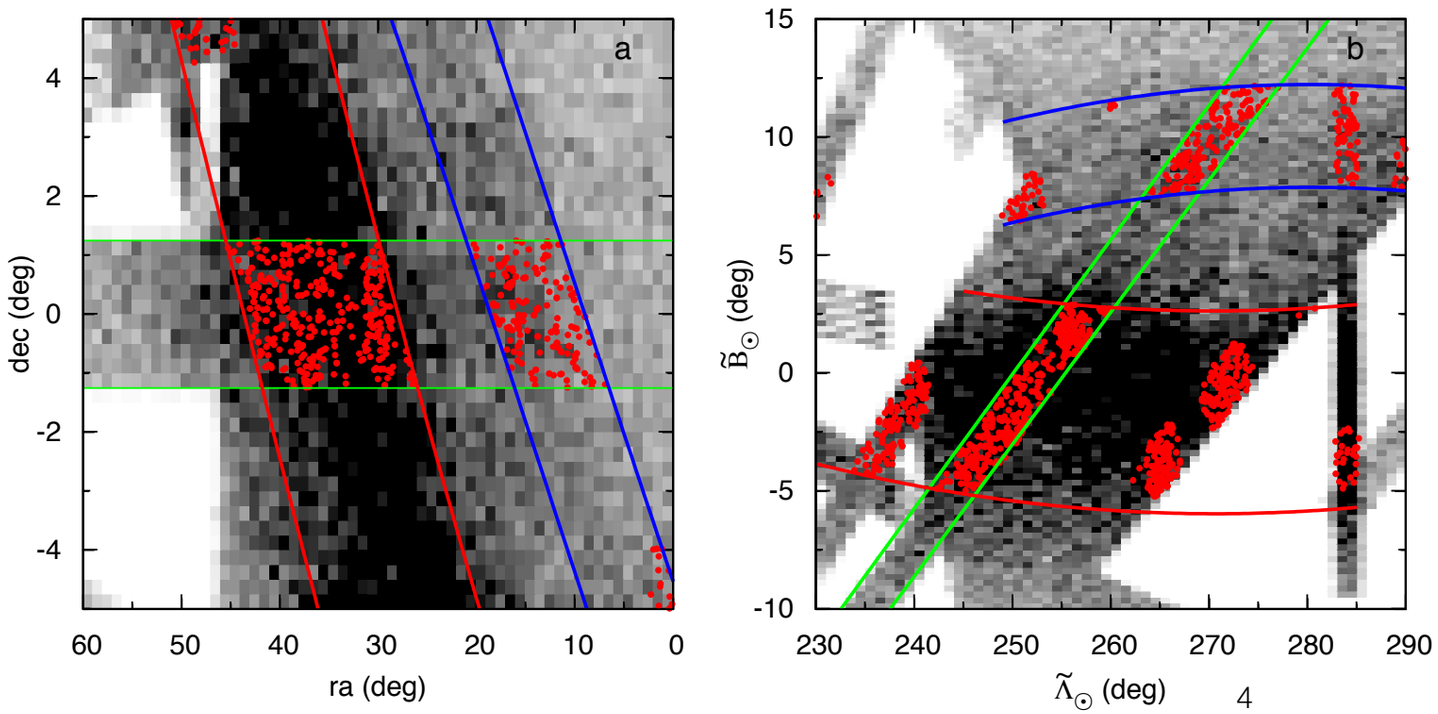
(Koposov et al. 2012)

Need to study the stellar content of Sgr!

Photometric stream samples

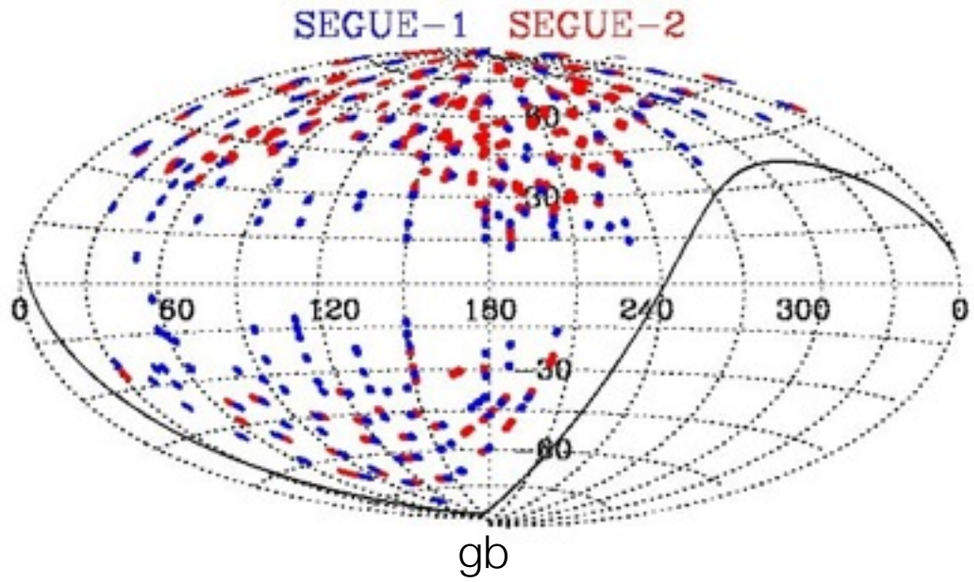
SDSS Stripe 82 photometry
-> single epoch and deep co-add-> photometric completeness
-> Sgr based on **Λ**,B selection (Law & Majewski model)
-> MW foreground correction using Galactic-mirrored fields (same l, inverse b)
-> Distance gradient correction using distances from Koposov et al. 2012



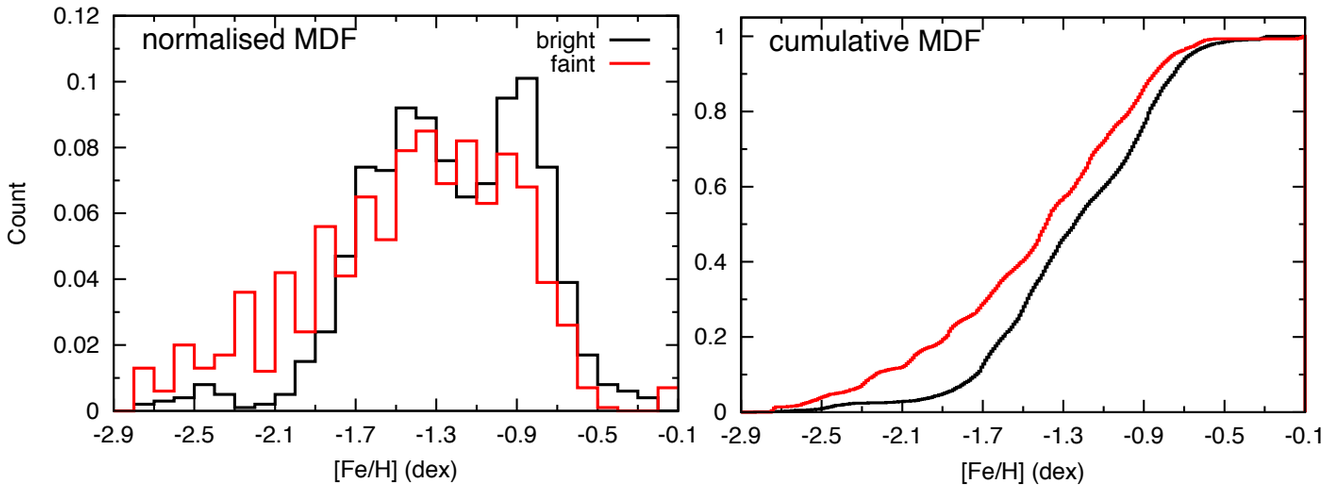


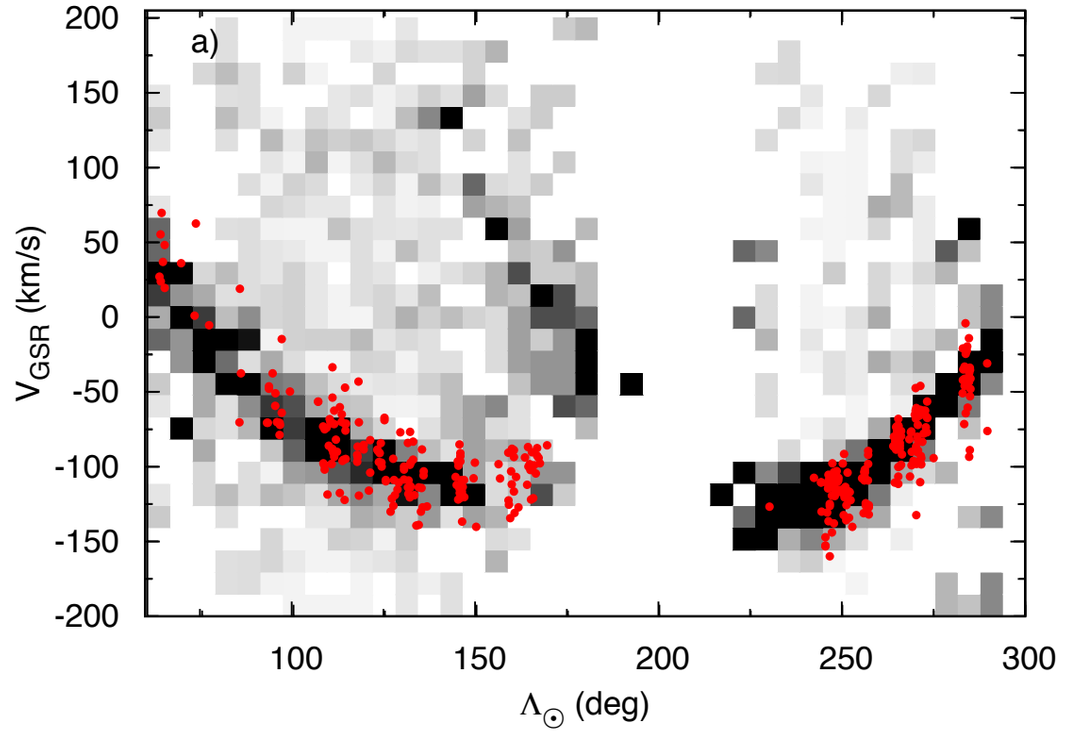
Spectroscopic stream samples

Spectroscopic sample from SDSS/SEGUE
-> atmospheric parameters (log g, log T_{eff})
-> radial velocities
-> metallicity [Fe/H]
-> average α-element abundance [α/Fe]



Select Sgr based on:
-> spatial location
-> radial velocity
-> distance
-> select only giants (log g<3)



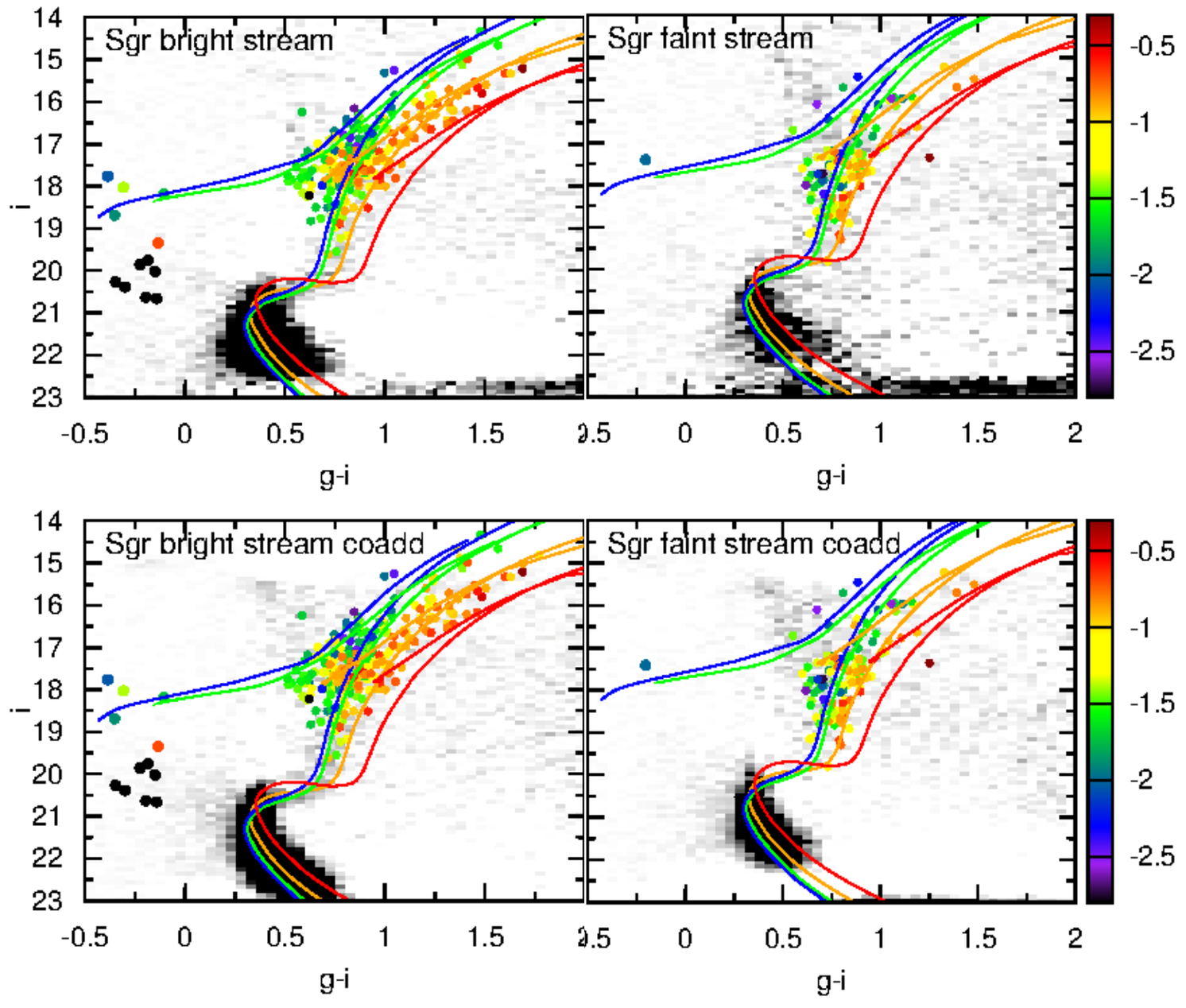


Bright and faint streams

Combination of spectroscopy and photometry shows clear stellar population picture

MSTO:
extended distribution: multiple populations
faint stream shows simpler CMD
-> simpler stellar populations

RGB:
Bright stream bi-modal extended MDF
Faint stream more metal-poor
->lacks strong metal-rich ([Fe/H]>-0.9) component

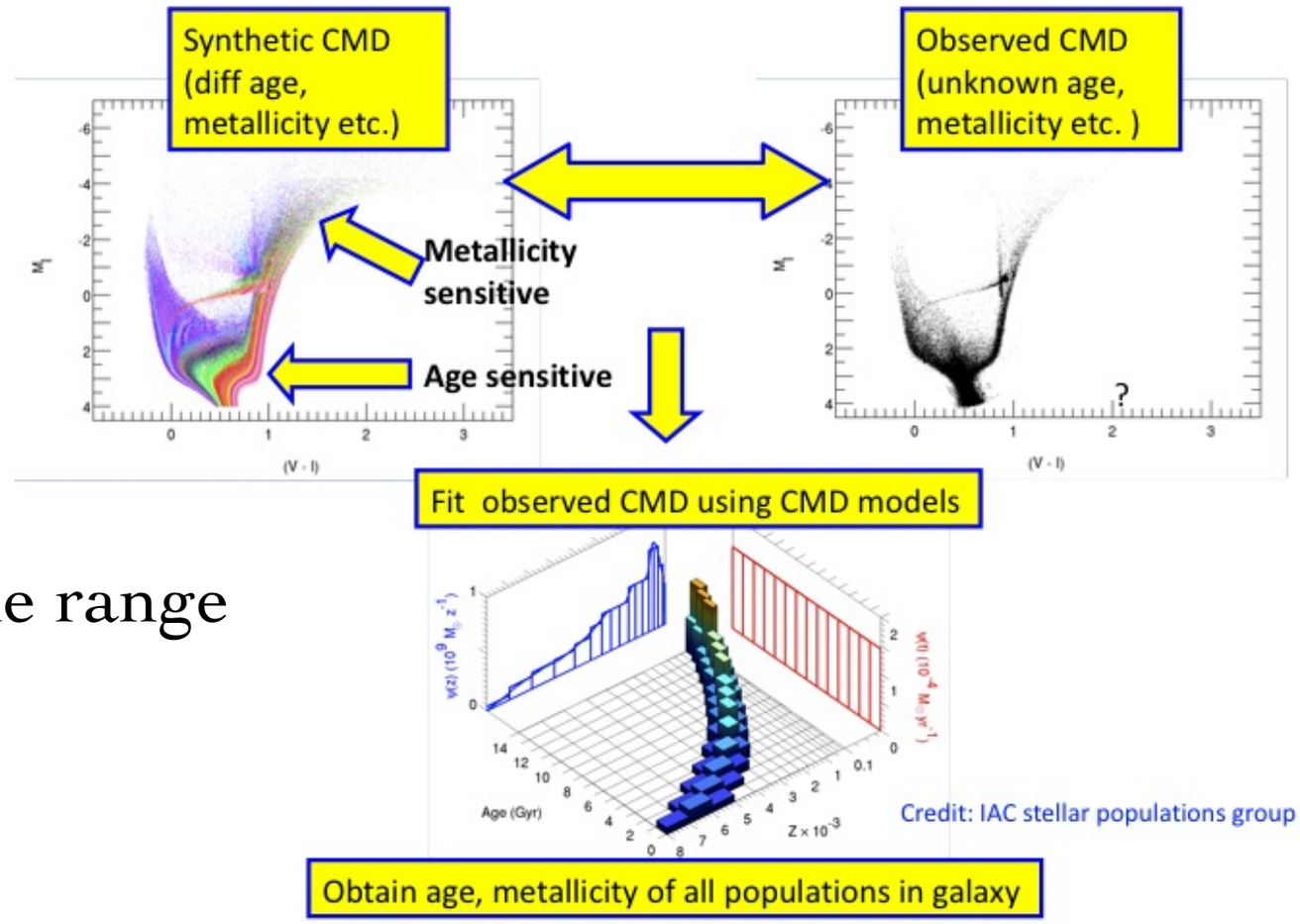


Combining all pieces: the SFH

Combine photometry and spectroscopy directly to constrain ages

Construct synthetic CMD's
-> arbitrary age, [Fe/H], [α/Fe]
-> different isochrone sets
-> photometric completeness

Construct synthetic MDFs
-> extract stars with similar magnitude range
-> bin in [Fe/H]
-> convolve with Gaussian



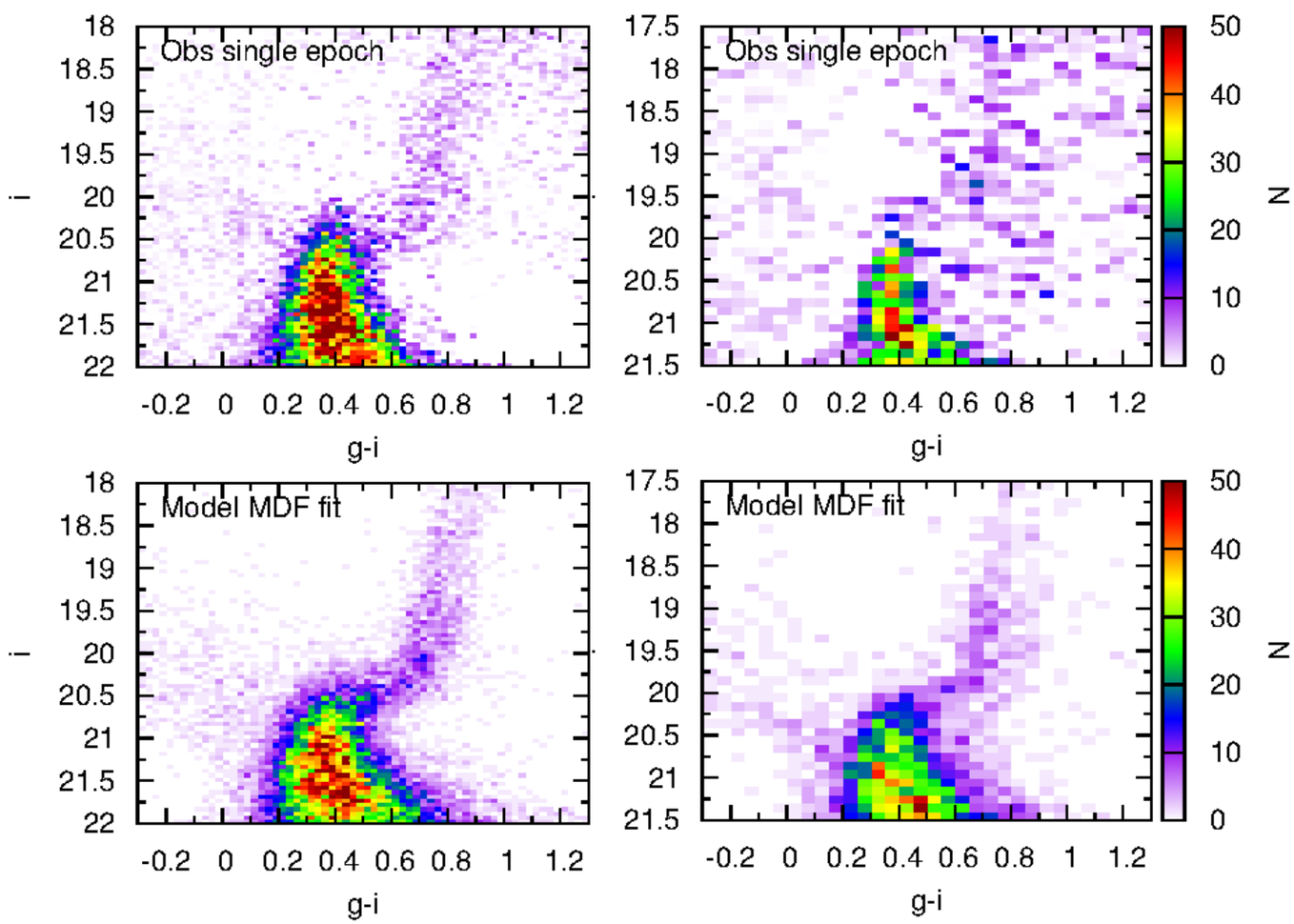
SFH using MSTO photometry (age sensitive) and RGB MDF (direct metallicity)
(de Boer et al 2012)

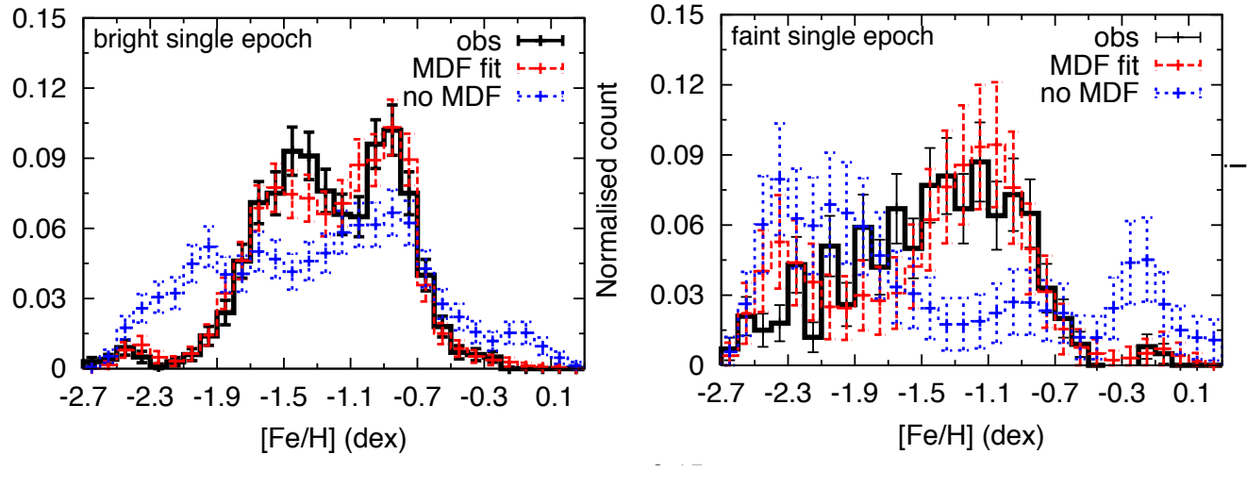
Fitting the SFH

Fit single-epoch as well as deep co-add
Fit with and without spectroscopy

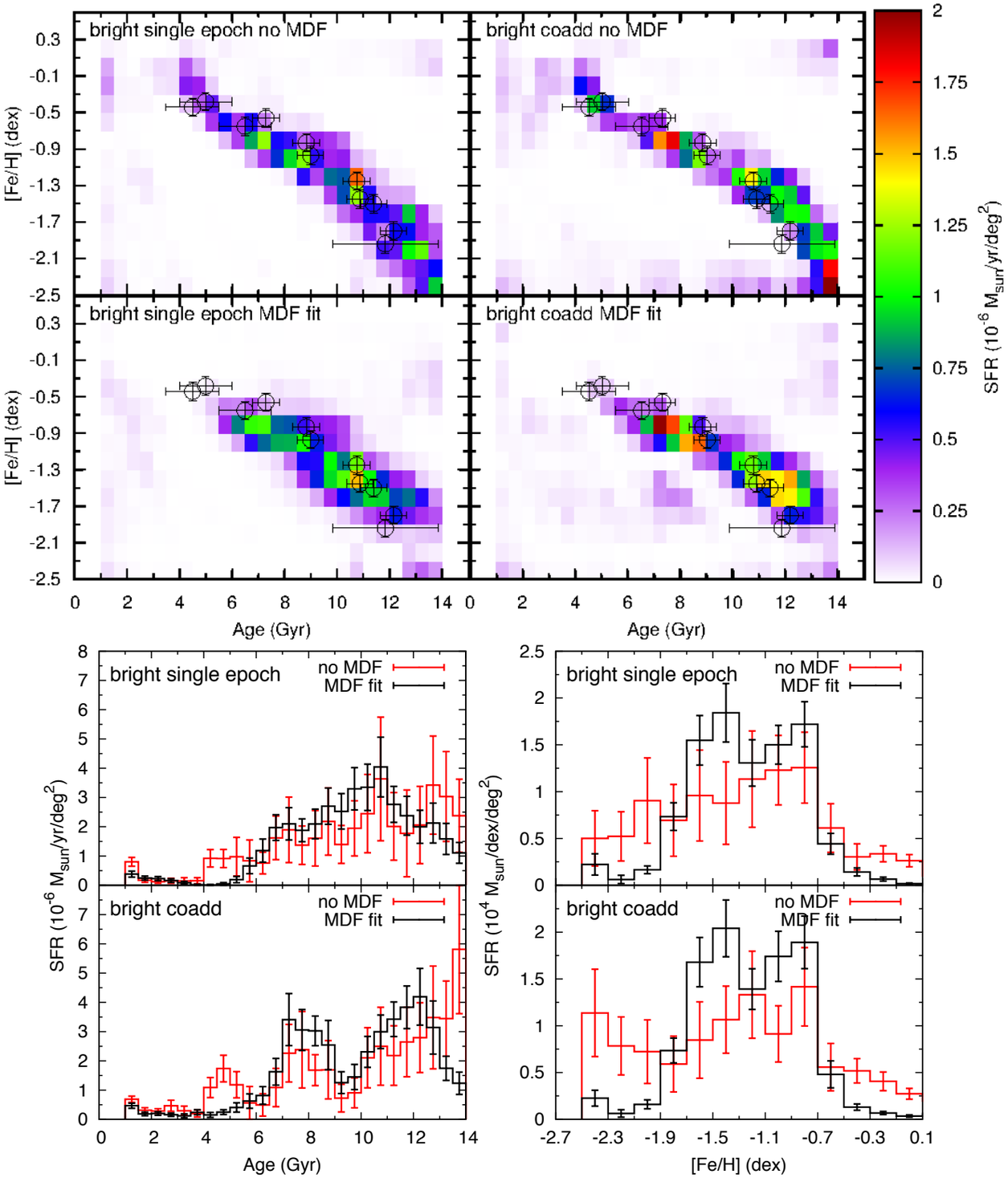
Sensible residuals, models reproduce CMD
->overall small residuals (<3 sigma in most bins)
->blue stragglers (g-i<0) fit as young population
->small amount of positive residuals
MW subtraction not perfect?

Solutions without MDF prefer more metal-poor SFH





SFH of bright Sgr stream



SFH shows tight sequence in age-[FeH] plane
->stars formed in well-mixed, homogeneously enriched medium.

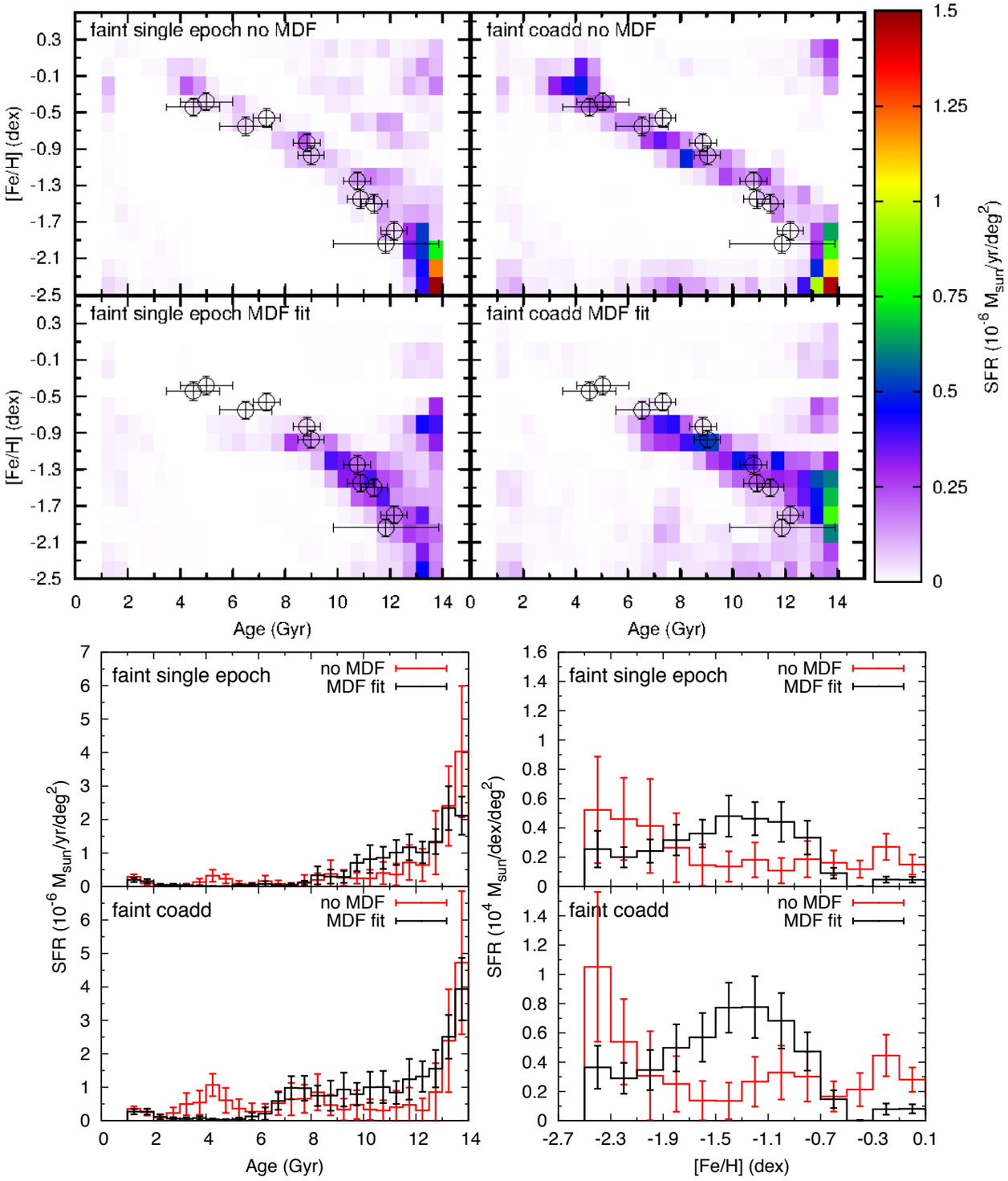
Similar results single-epoch and co-add photometry
-> MDF adds meaningful constraints on SFH

Sequence consistent with age and metallicity of GCs associated to Sgr
-> stream stars drawn from same population mix as Sgr

Change of slope at age 11-13 Gyr, consistent with Sgr alpha-element knee (de Boer et al. 2014)
->supernovae Ia started contributing to abundance pattern 1-3 Gyr after start of star formation.

Star formation rate drops sharply at 5-7 Gyr
-> related to infall of Sgr into the MW?

SFH of faint Sgr stream



Same tight sequence as in bright stream
-> Sgr dwarf is progenitor of the faint component as well as the bright one

Lower S/N of the stream results in the presence of more anomalous populations
->metal-rich populations likely fit to red MW stars

Faint stream composed of simpler population mix than the bright stream
-> consistent with CMD morphology

Sequence dominated by old (>8 Gyr) metal poor stars
->stream drawn from more pristine Sgr population mix
->stripped earlier? from the outskirts?

Earlier pericentre passage of the stream?

Conclusions

First detailed quantitative study of the Sgr trailing stream

Sgr SFH of both components show a tight sequence in the plane of Age vs [Fe/H]
->star-formation and enrichment proceeded in a similar fashion for each part of the bifurcation.
->star-formation within Sgr took place in a well-mixed medium, homogeneously enriched in metals over 8 Gyr.

Comparison to Sgr GCs:
->both streams are consistent with Sgr populations
->Sgr dwarf is progenitor of the faint component as well as the bright one

Star formation rate drops rapidly around 5-7 Gyr ago
->could be caused by the infall of Sgr into the MW, coinciding with stripping of gas

Faint stream composed of simpler stellar population mix than the bright stream
-> dominated by old metal poor stars
-> lacking strong metal-rich component found in the bright stream MDF.

Faint stream likely produced by material stripped earlier and from the outskirts of Sgr.