Photometric ages with Gaia
-
Studying the Milky Way disc

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LAMOST

- A 4m telescope with 4000 fibers across a 20 sq deg field of view, taking R ~ 2000 spectra covering approx. 3,500-9000 Å

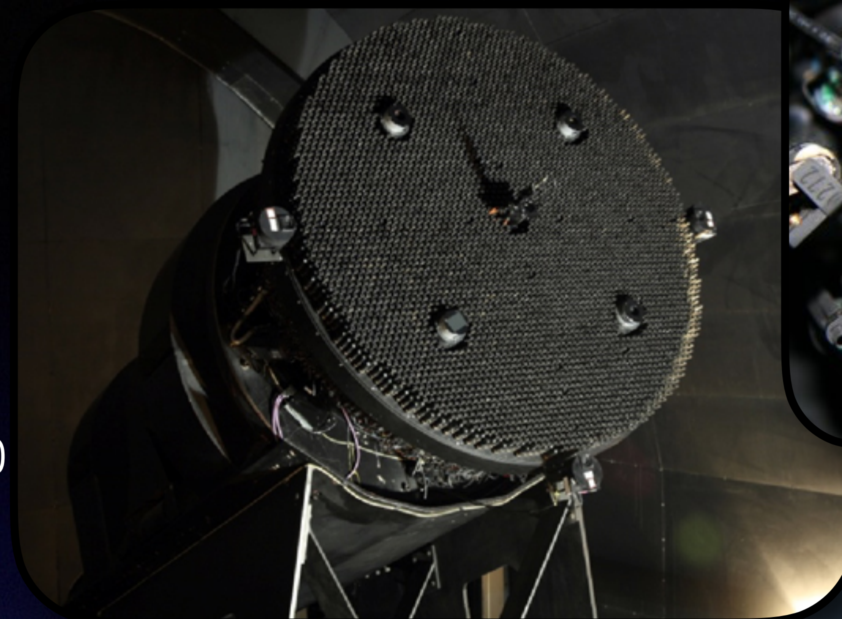
- In 2017 it completed first 5-year survey, obtaining 1M stellar spectra per year, to g ~ 16th
  - 3.9M unique stars with S/N > 20
  - 1.2M unique stars with S/N > 100

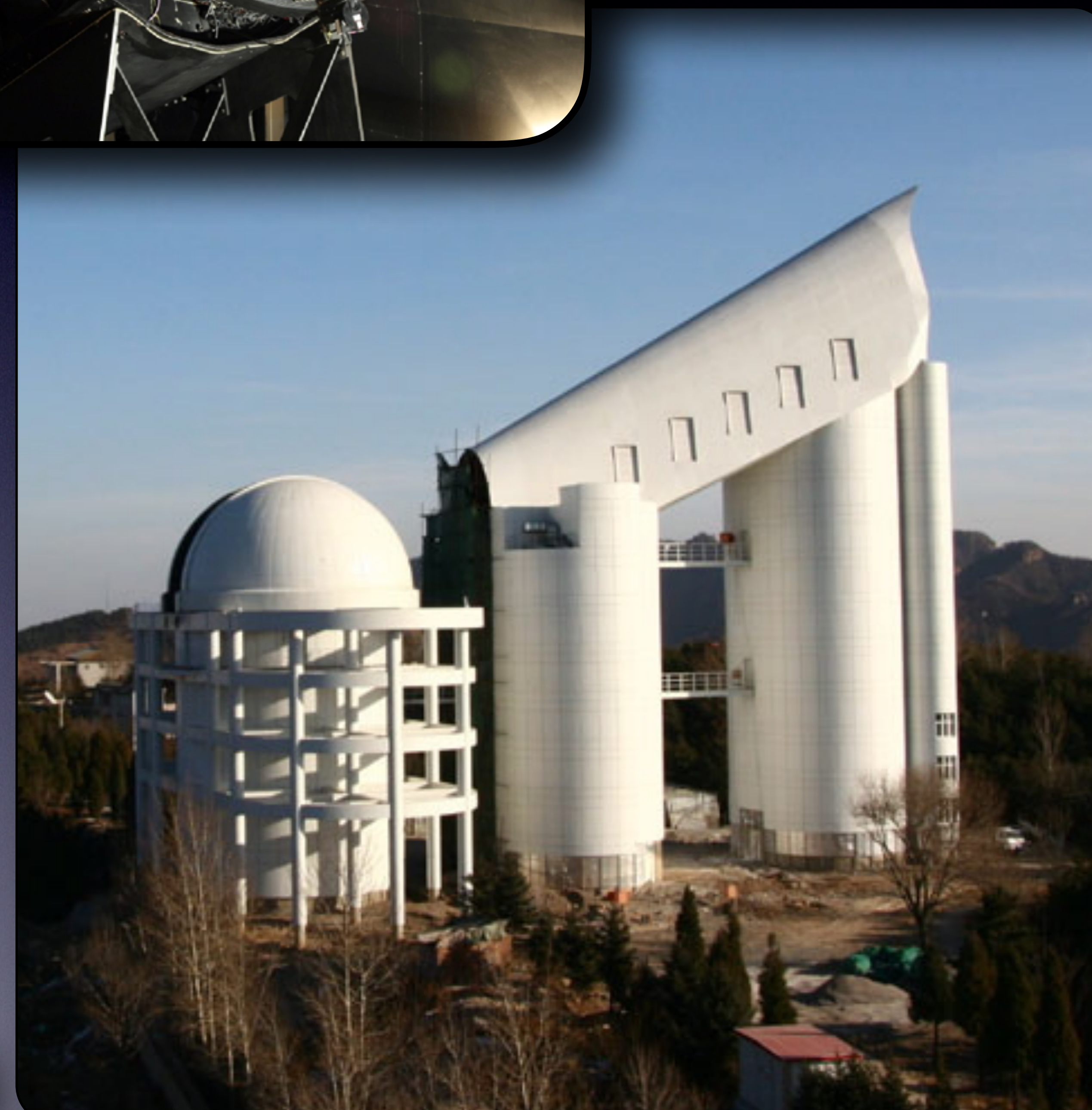
- Latest public data release is DR4, which is ~70% of the current internal release

http://dr4.lamost.org

- There are caveats (e.g. radial velocity offset) but pipelines are improving. Error estimation is now more reliable.

http://dr4.lamost.org/doc/The-warning





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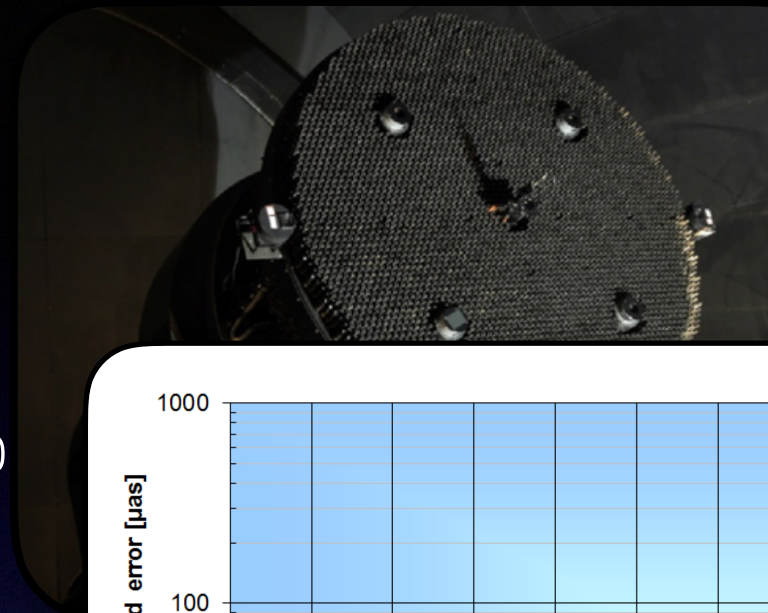
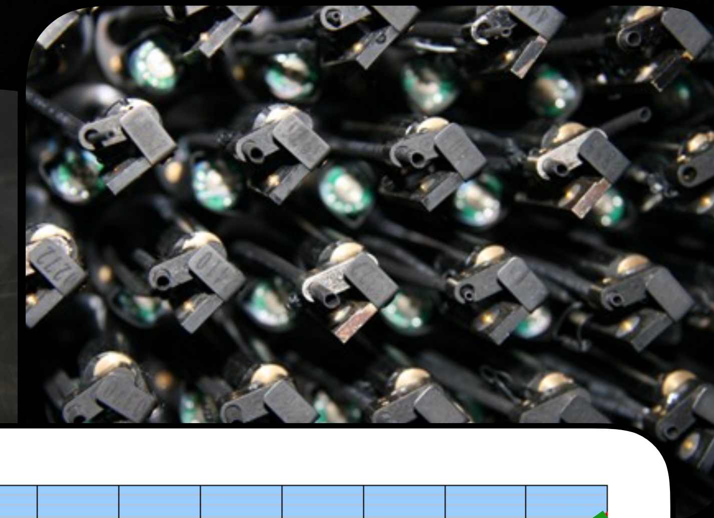
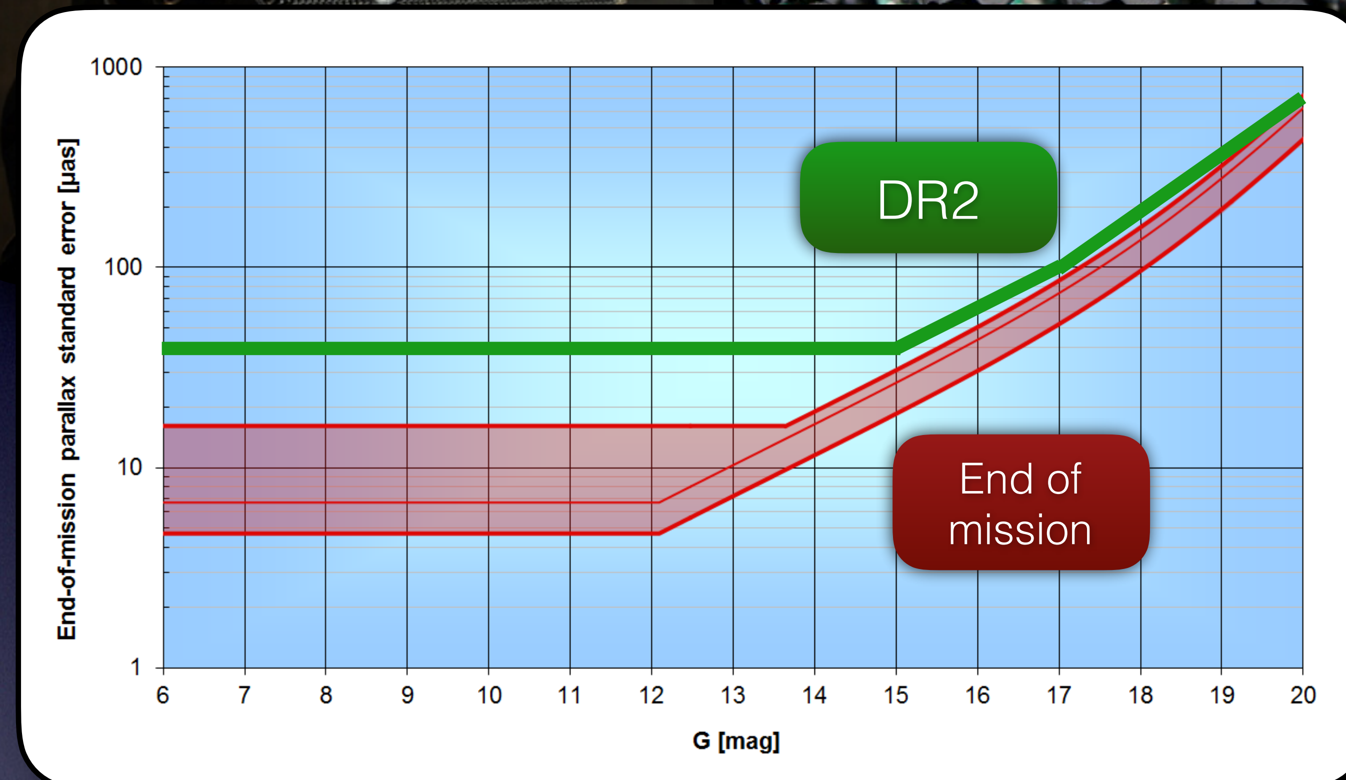
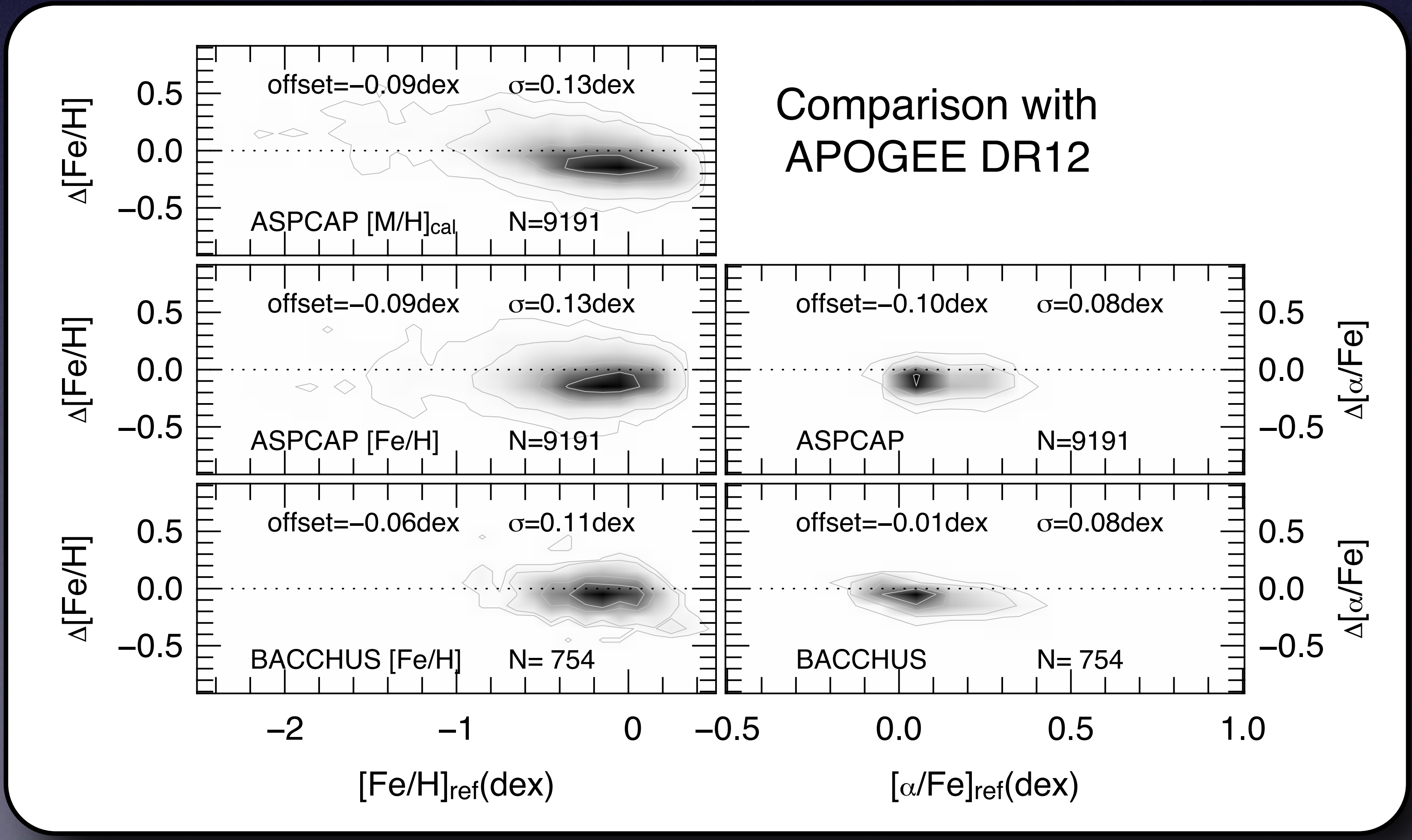






LAMOST chemistry

- Corrado Boeche applied his SP_Ace pipeline to LAMOST, which is based on general curves-of-growth method (Boeche et al. 2018)
- This provides similar precision to the standard LAMOST pipeline (LASP) but with the added benefit of reliable alpha-element abundance to ~ 0.1 dex (NB. alternative data-driven approaches exist, such as Xiang et al. 2017, Ho et al. 2017, Ting et al. 2017)



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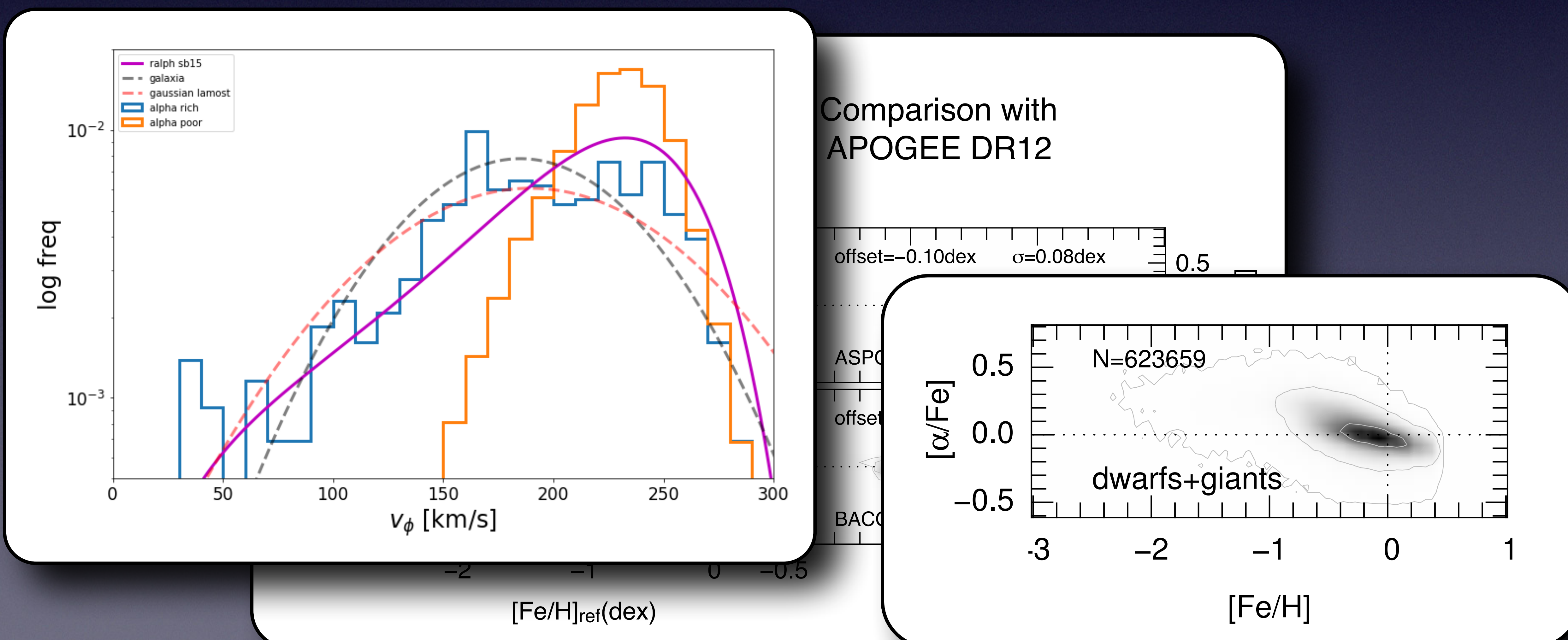
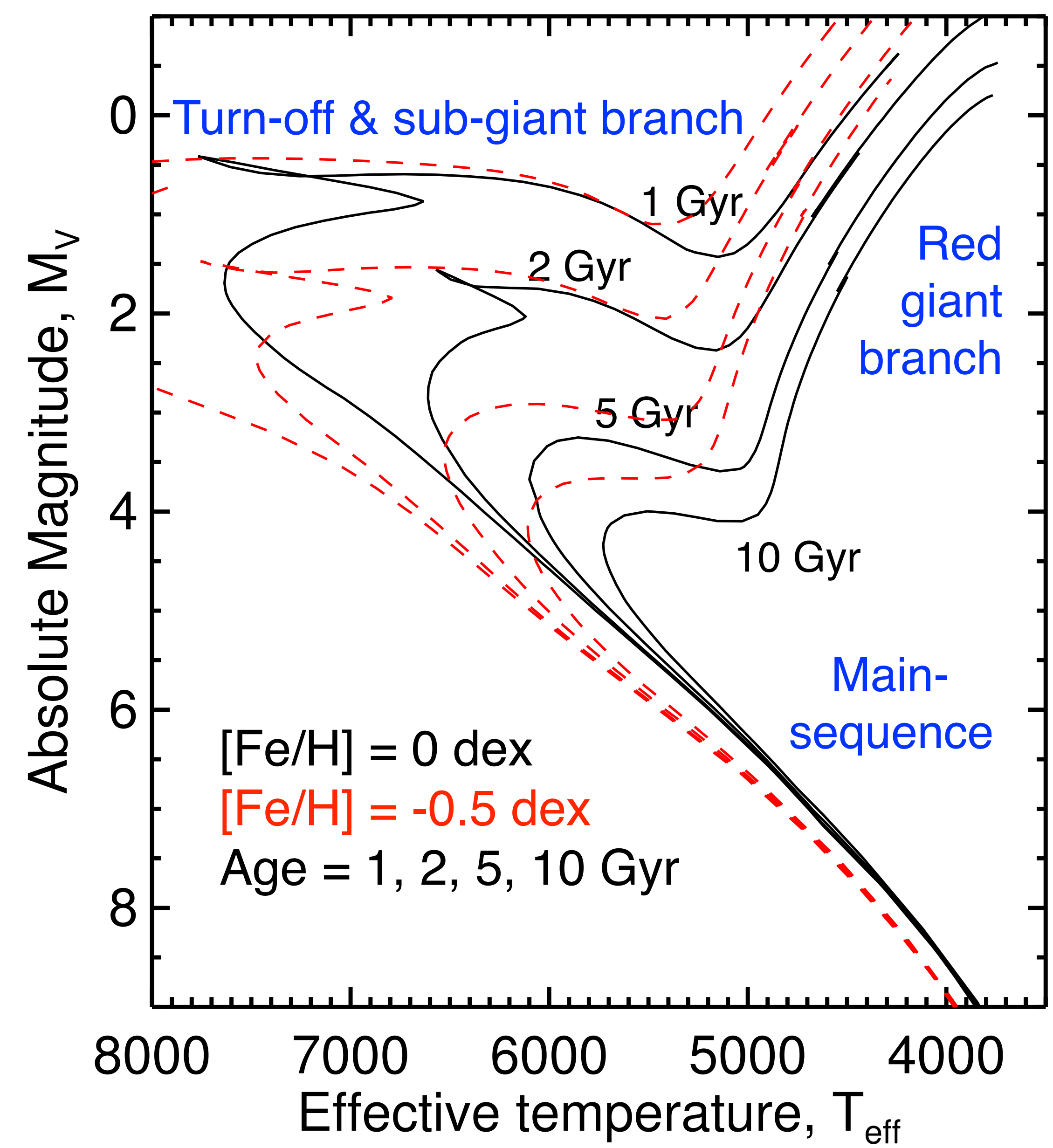


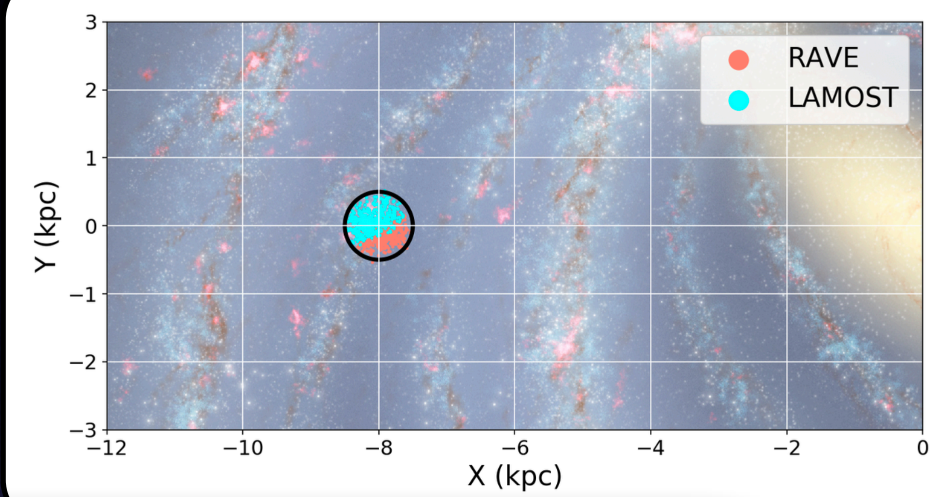
Great survey for ages

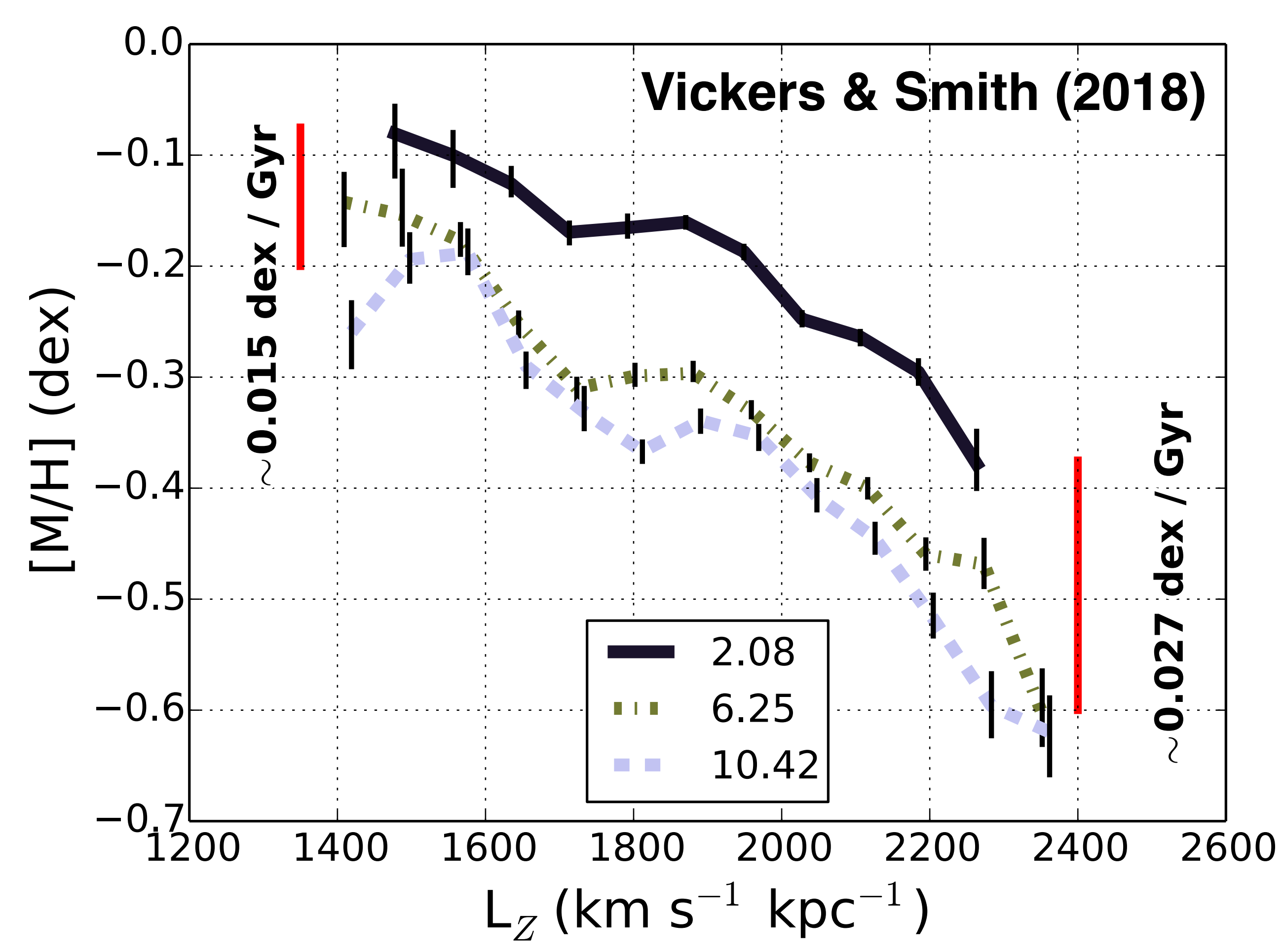
- Gaia+spectroscopy great for ages. Main-sequence stars are difficult, but good prospects for turn-off stars and giants
- Many papers using ages, such as Xiang et al. 2017, Sanders et al. 2018, Wu et al. 2018, etc…
- Paper analysing the dynamics and chemistry of the disc, using 125k stars (Vickers & Smith 2018)



Disc evolution with LAMOST+Gaia

- Combine Gaia with LAMOST/RAVE to estimate ages for 125k stars (Vickers & Smith, 2018, ApJ)
- Probe the chemo-dynamical evolution of the disc, looking at inside-out formation, heating and bulk flows
- Investigate radial migration through machine learning





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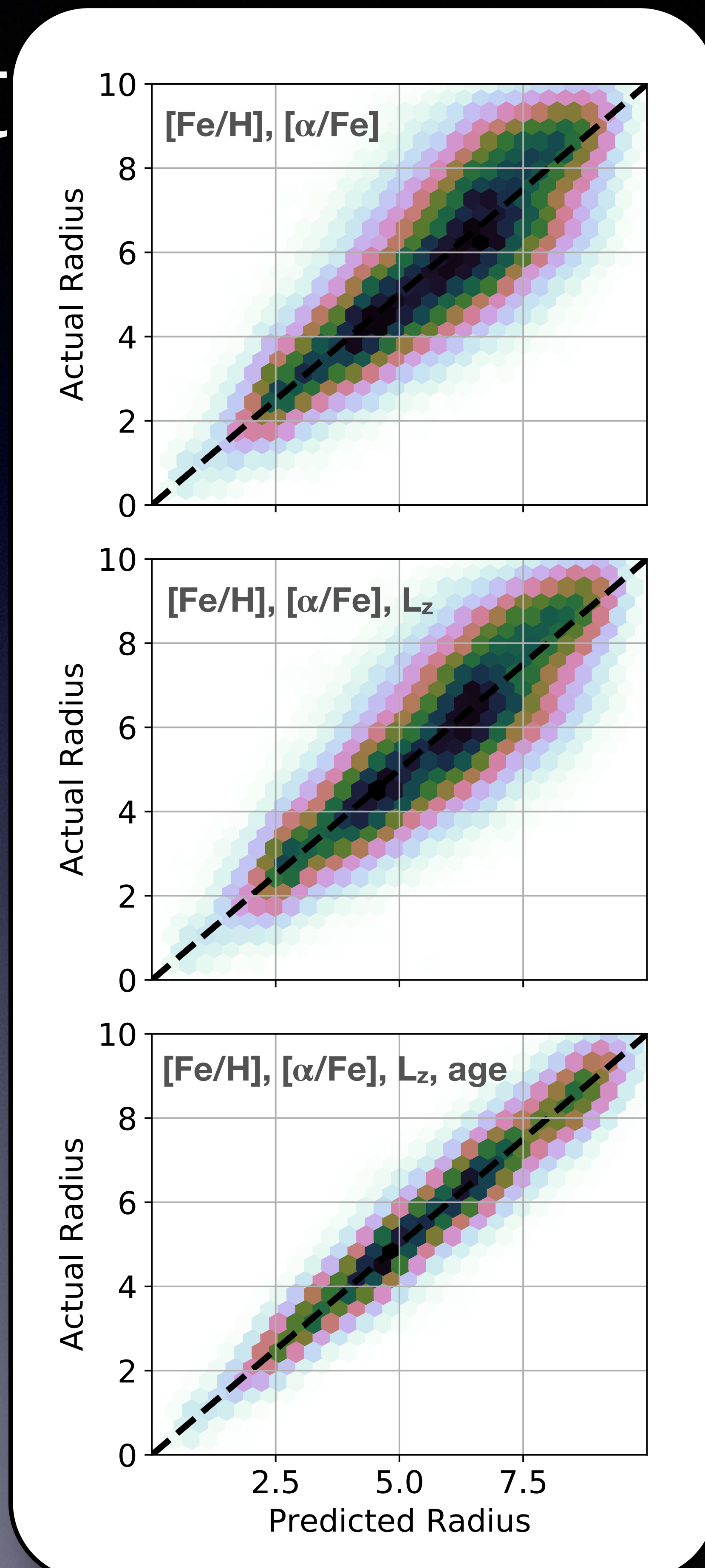
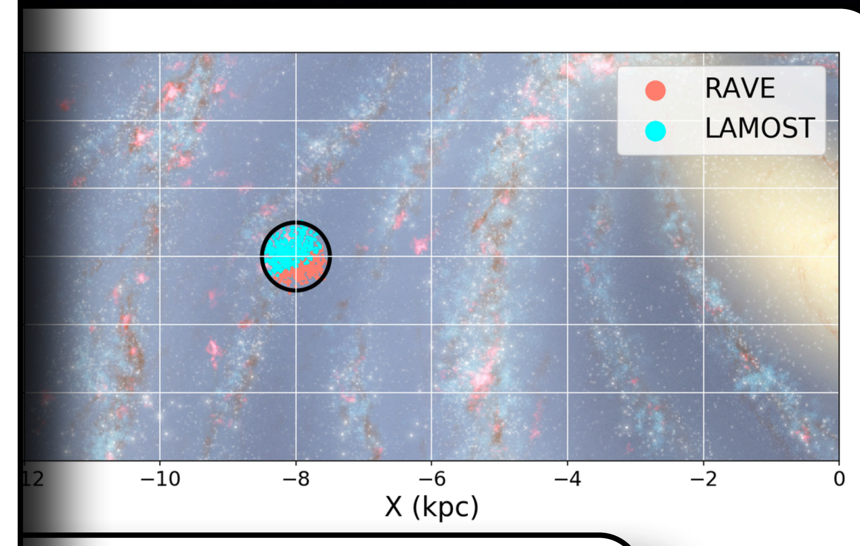
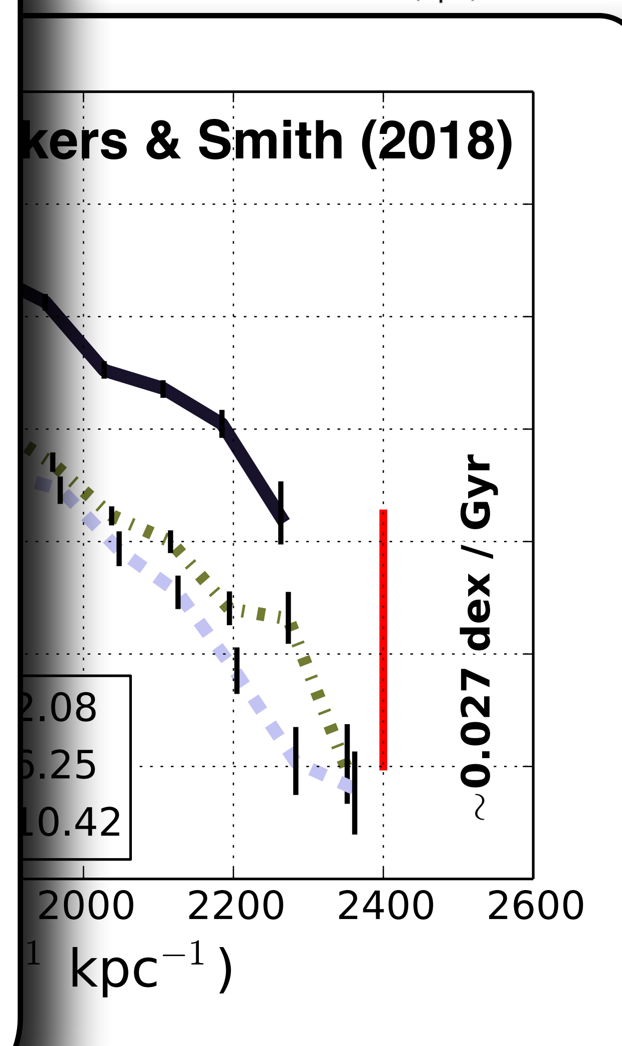
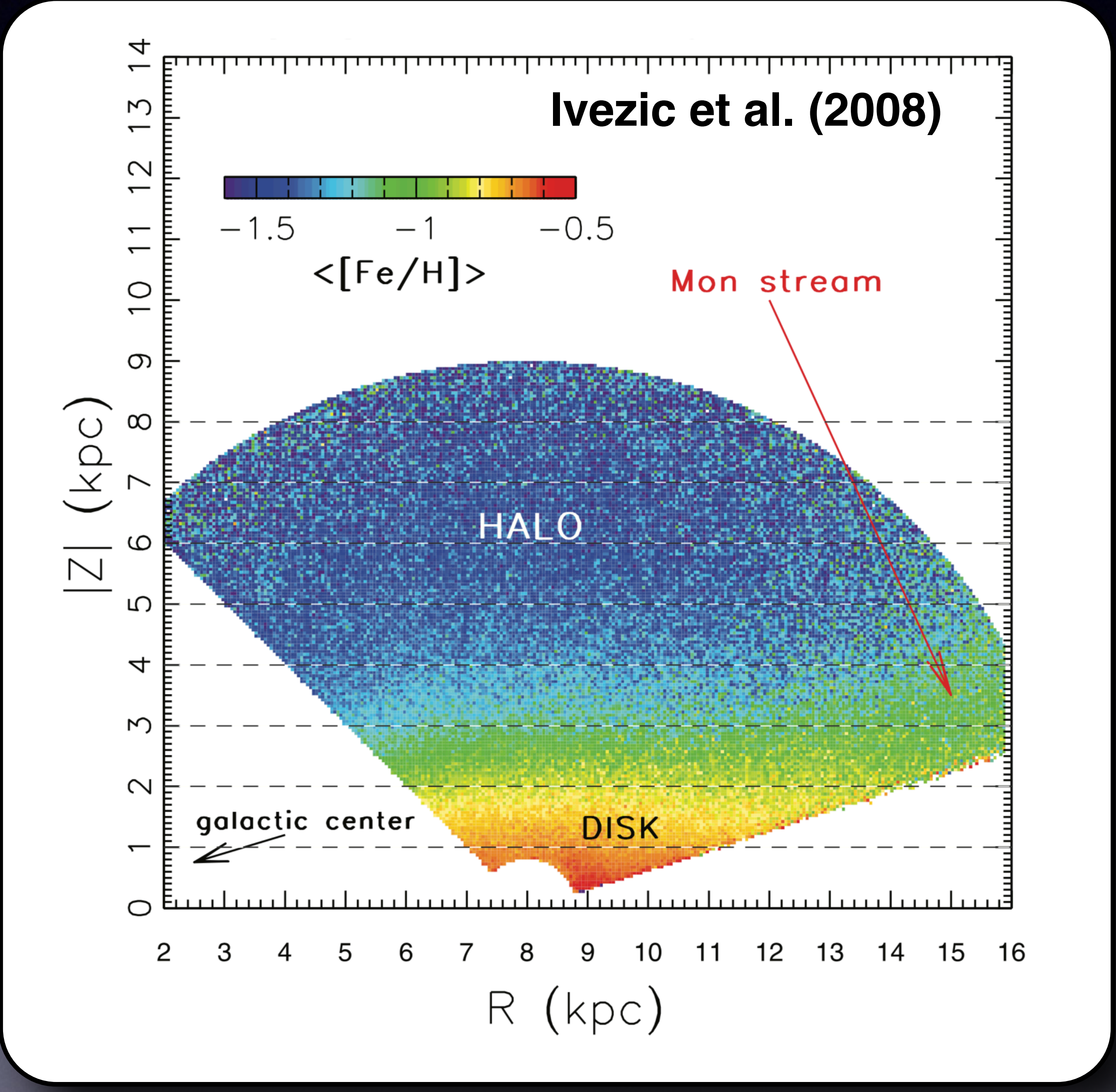






Can we avoid spectroscopy?

- Spectroscopy is extremely useful, but it is also expensive
- For many years people have been estimating metallicities from photometry, most-effectively through the uv-excess (e.g. Ivezic et al. 2008)
- If we can estimate metallicities, why can we not estimate ages?!
- Use subset with ~10% ages from Vickers et al. (2018) to train a random forrest regression tool to calculate ages from photometry



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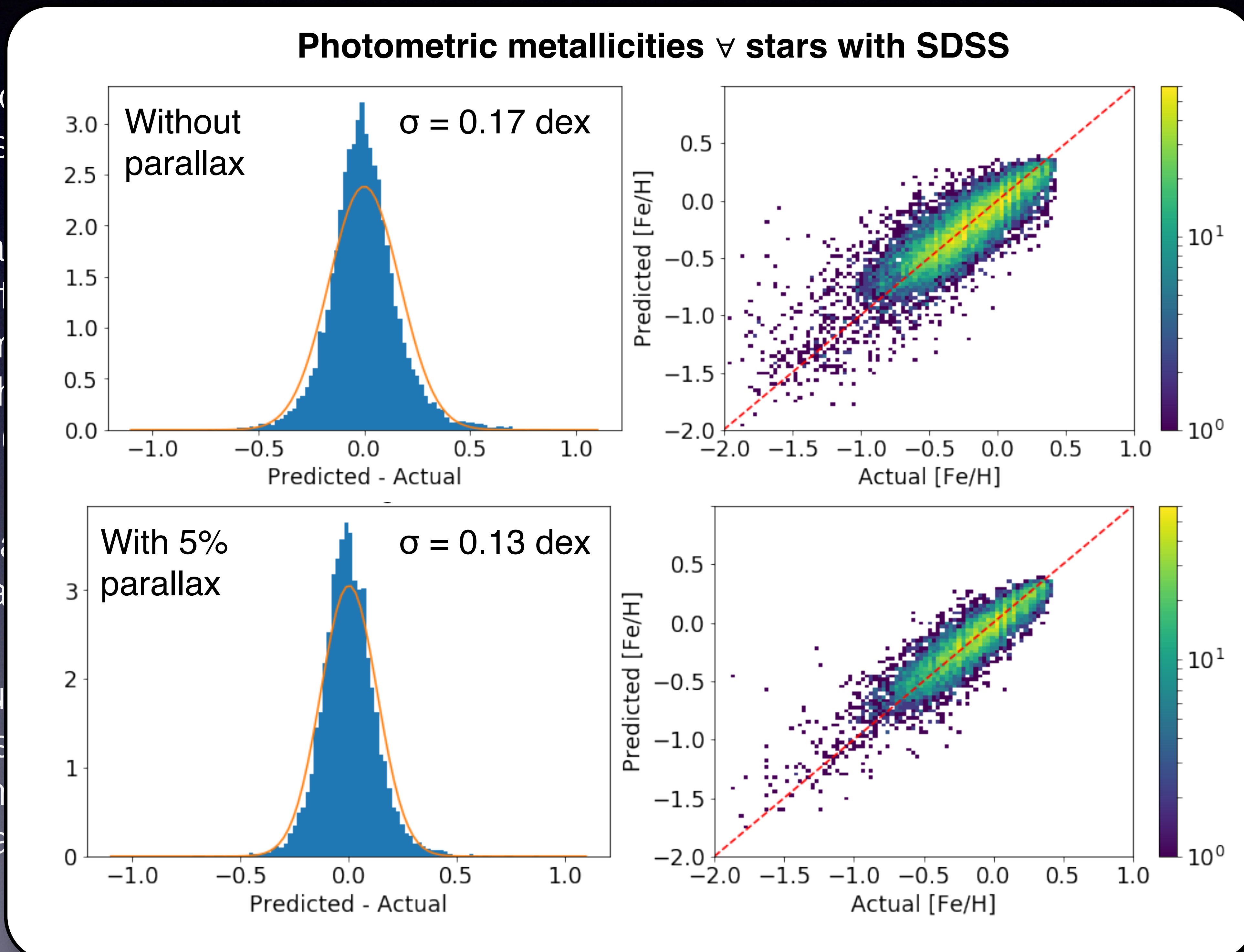

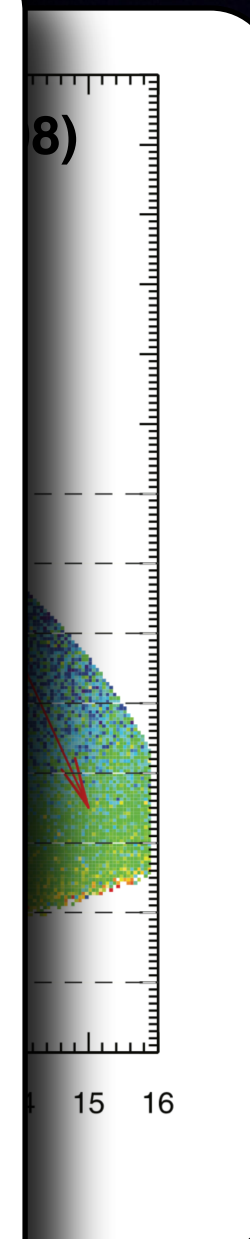

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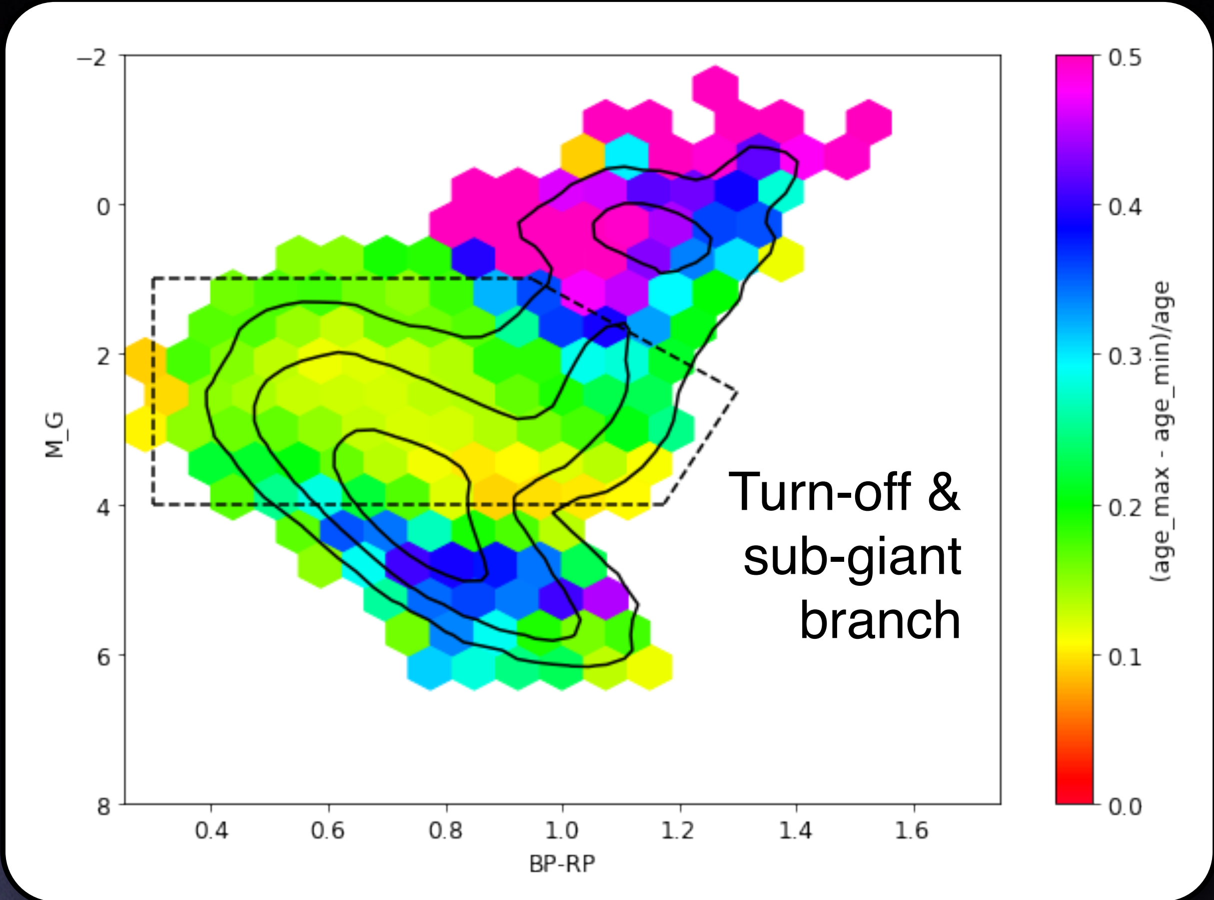

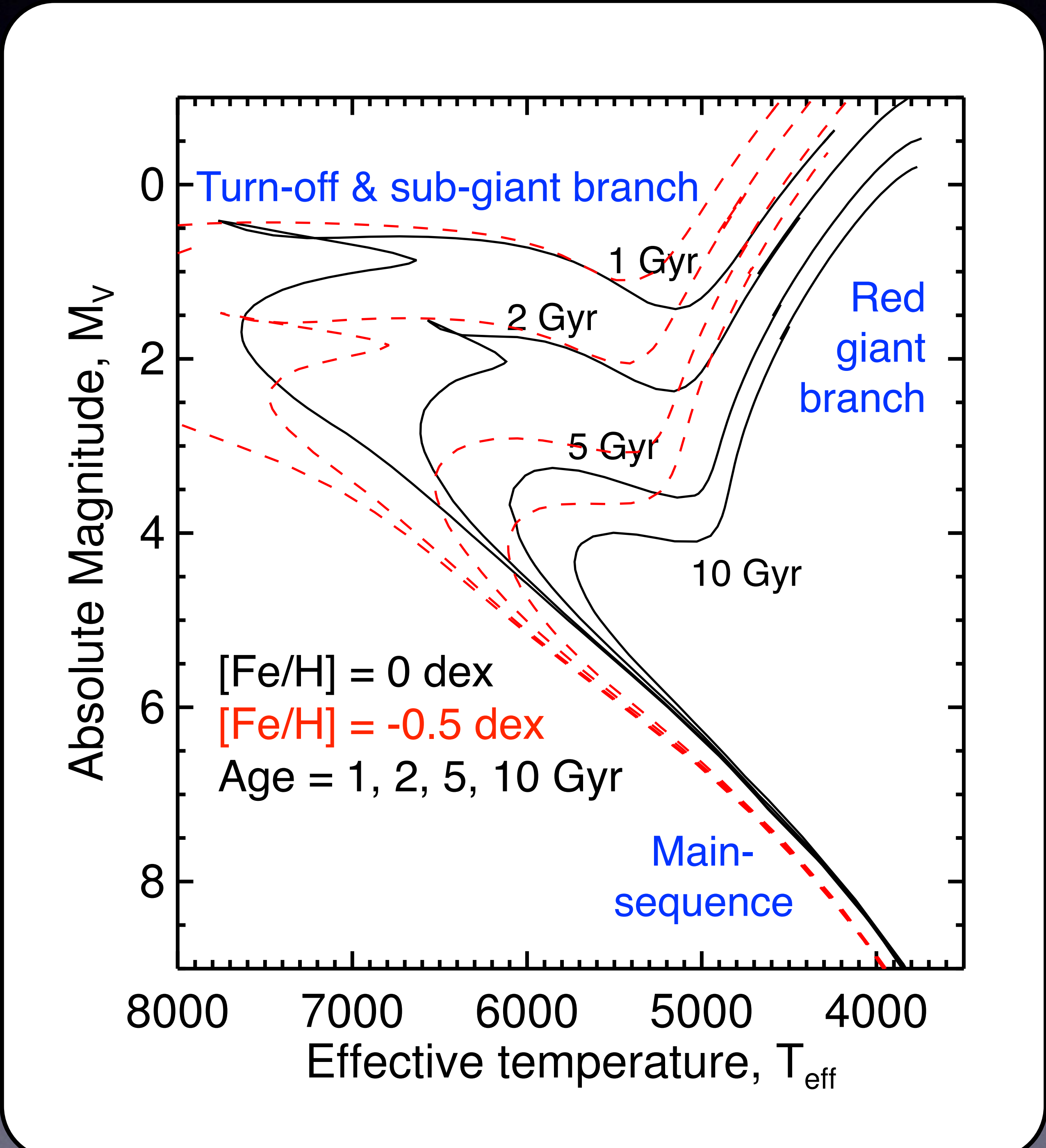

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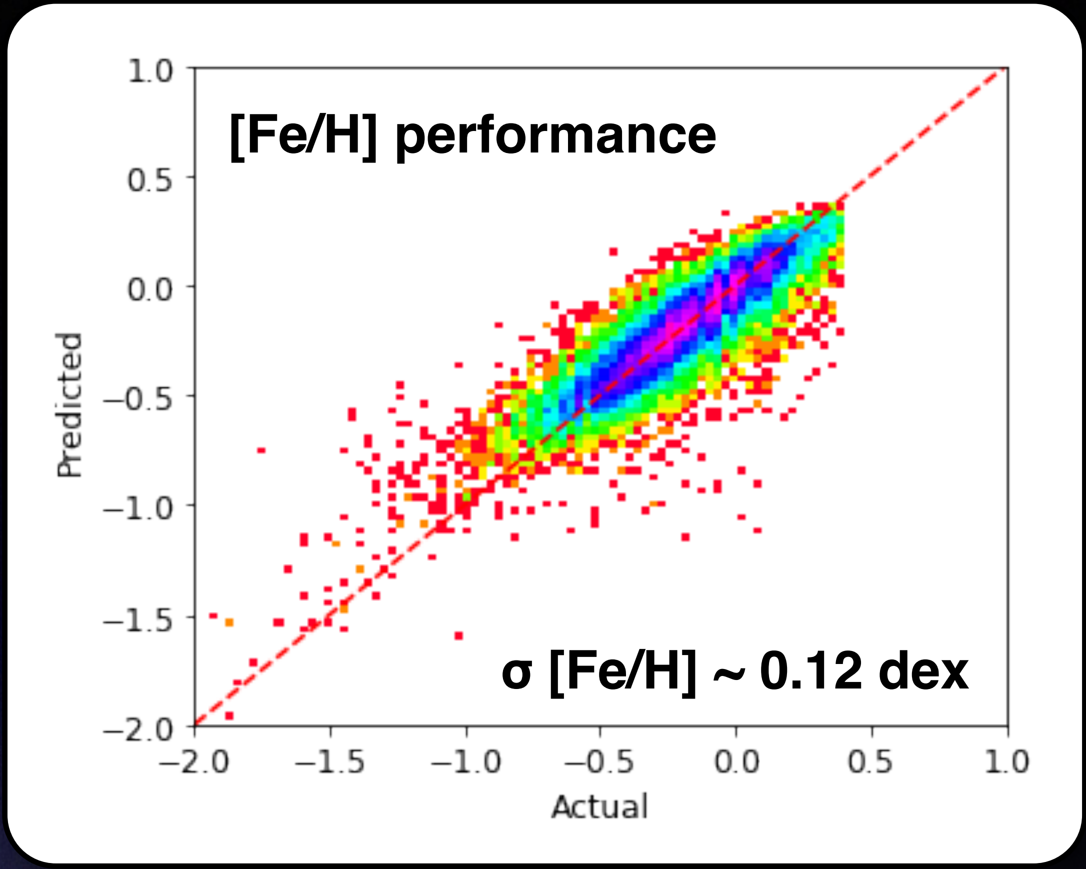
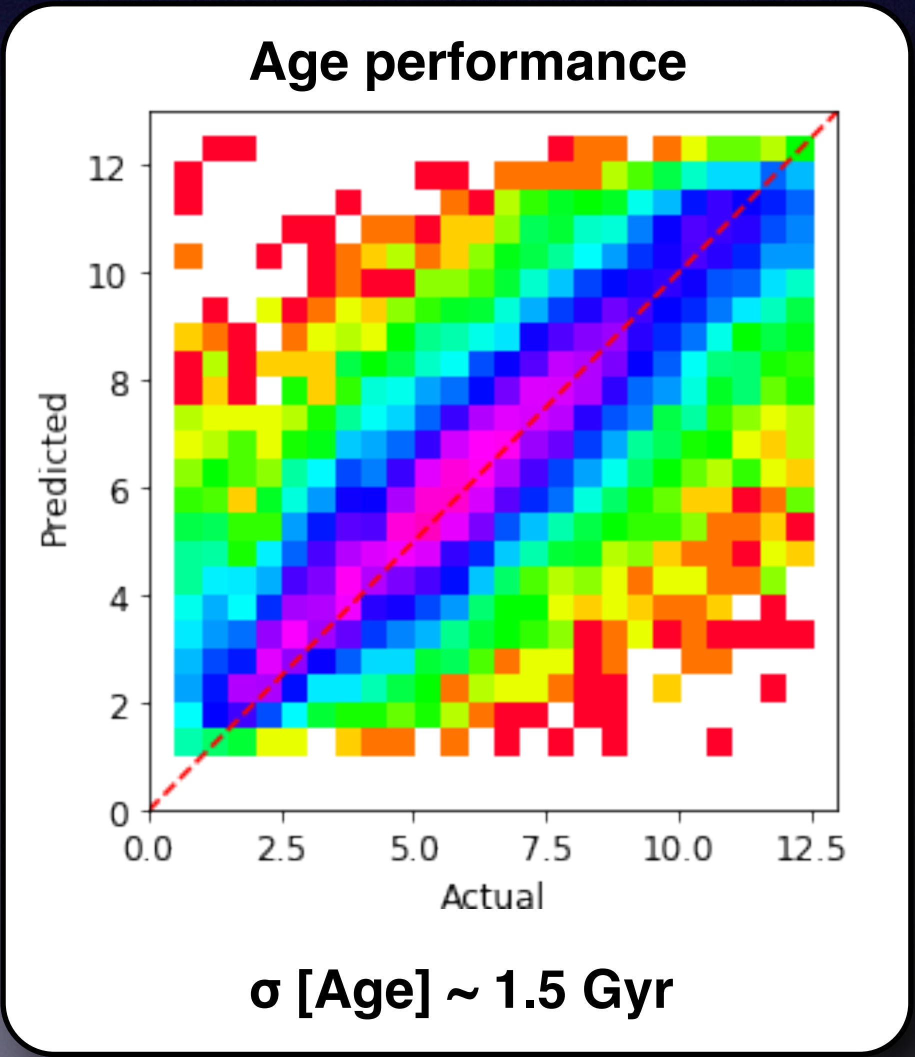
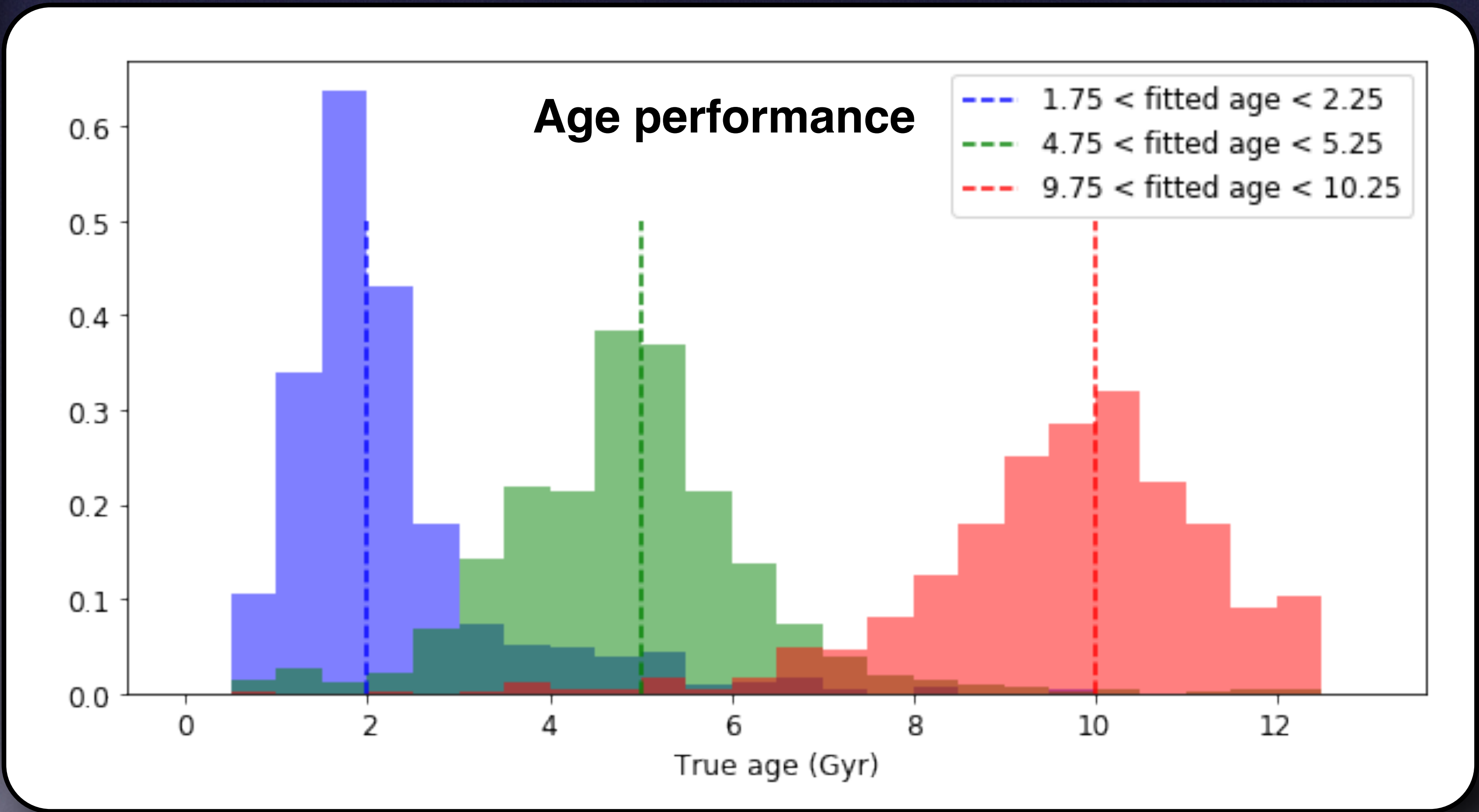
How well can we recover metallicities and ages?

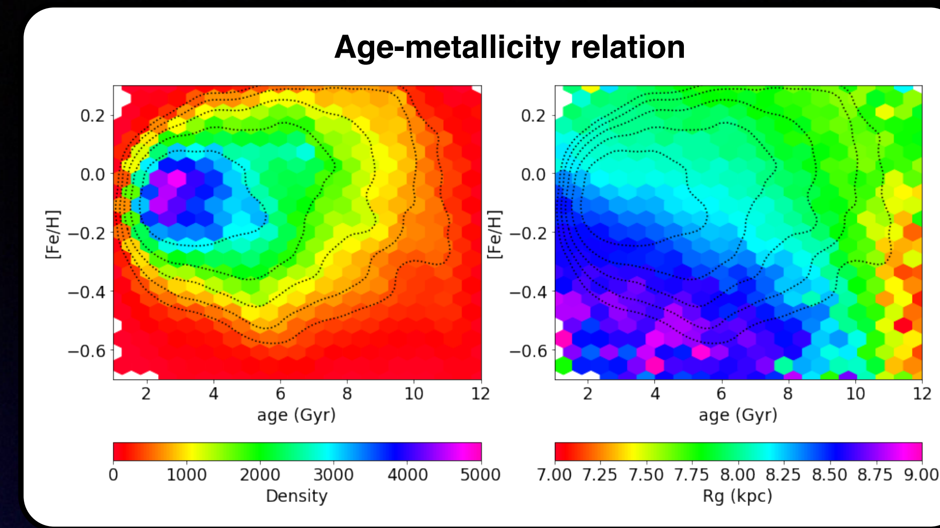


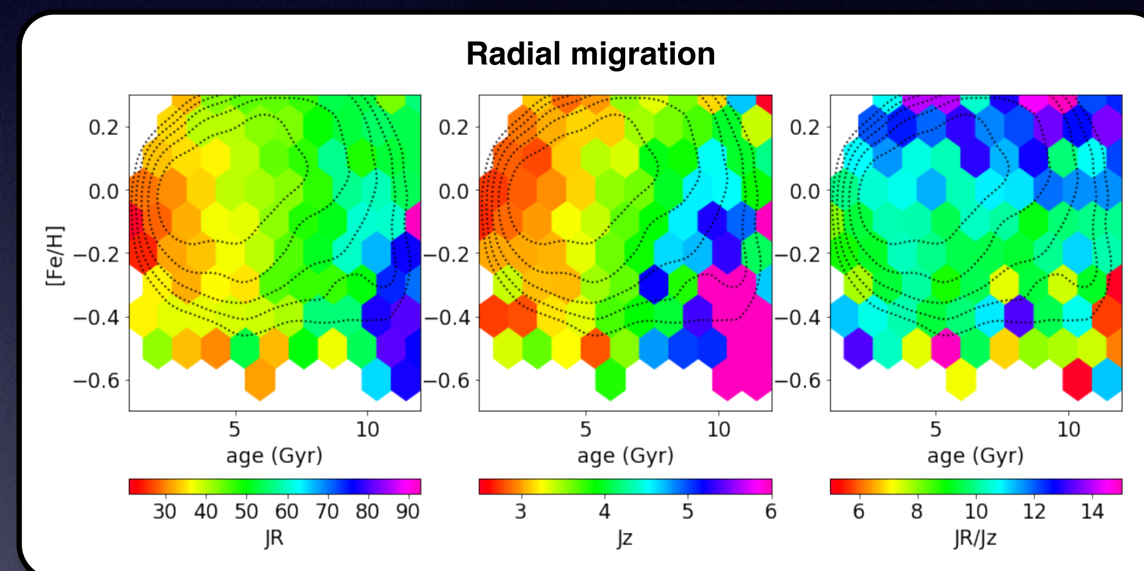


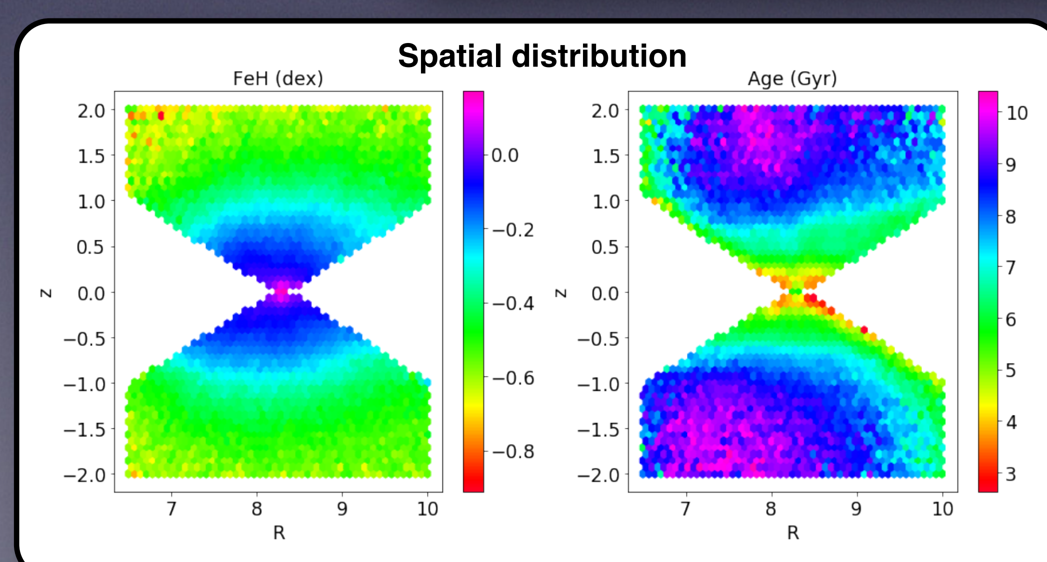


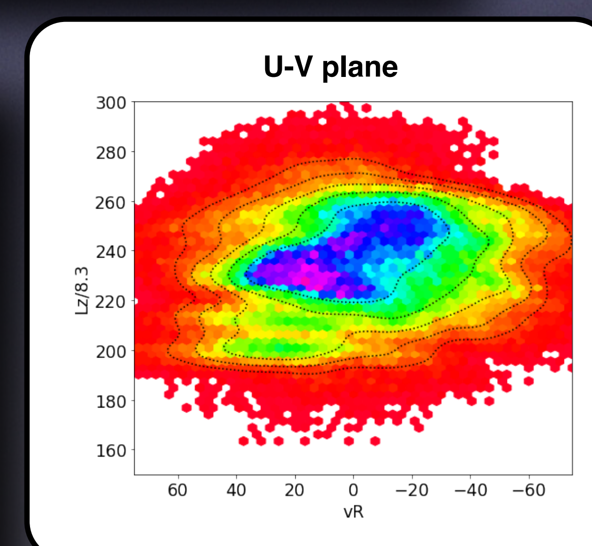
Applications

- Using all-sky GALEX data gives us around 2 million turn-off stars with good ages (SDSS gives ~6M)
- If we want 6D phase-space we can cross-match GALEX and Gaia's onboard spectrograph RVS, giving around 0.5 million stars
- Other avenues not discussed here include the phase-space snail (more prominent in younger stars) & substructures in action space









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Spatial distribution

- Using Gaia+Galex can probe the extended solar neighbourhood
- When looking at ages can see clear flaring and/or stubby thick disc

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- If we want 6D phase space we ca... Ga... giv...
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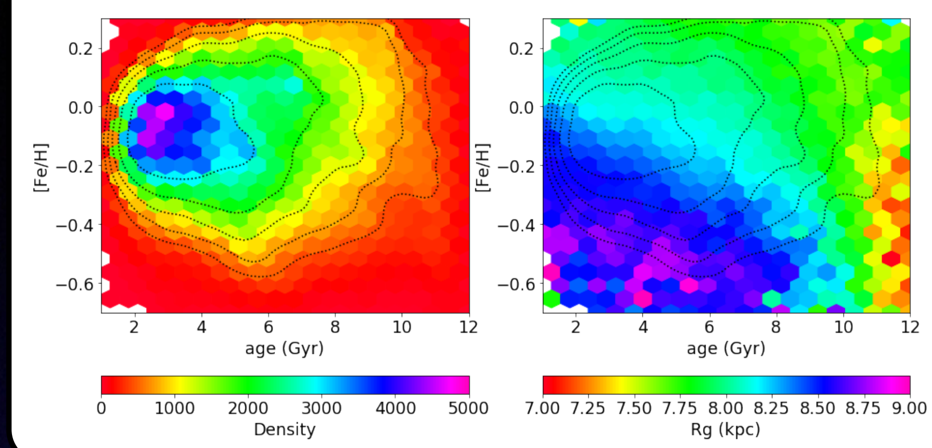
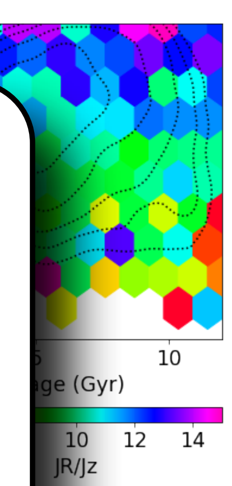
Age-metallicity relation



Radial migration



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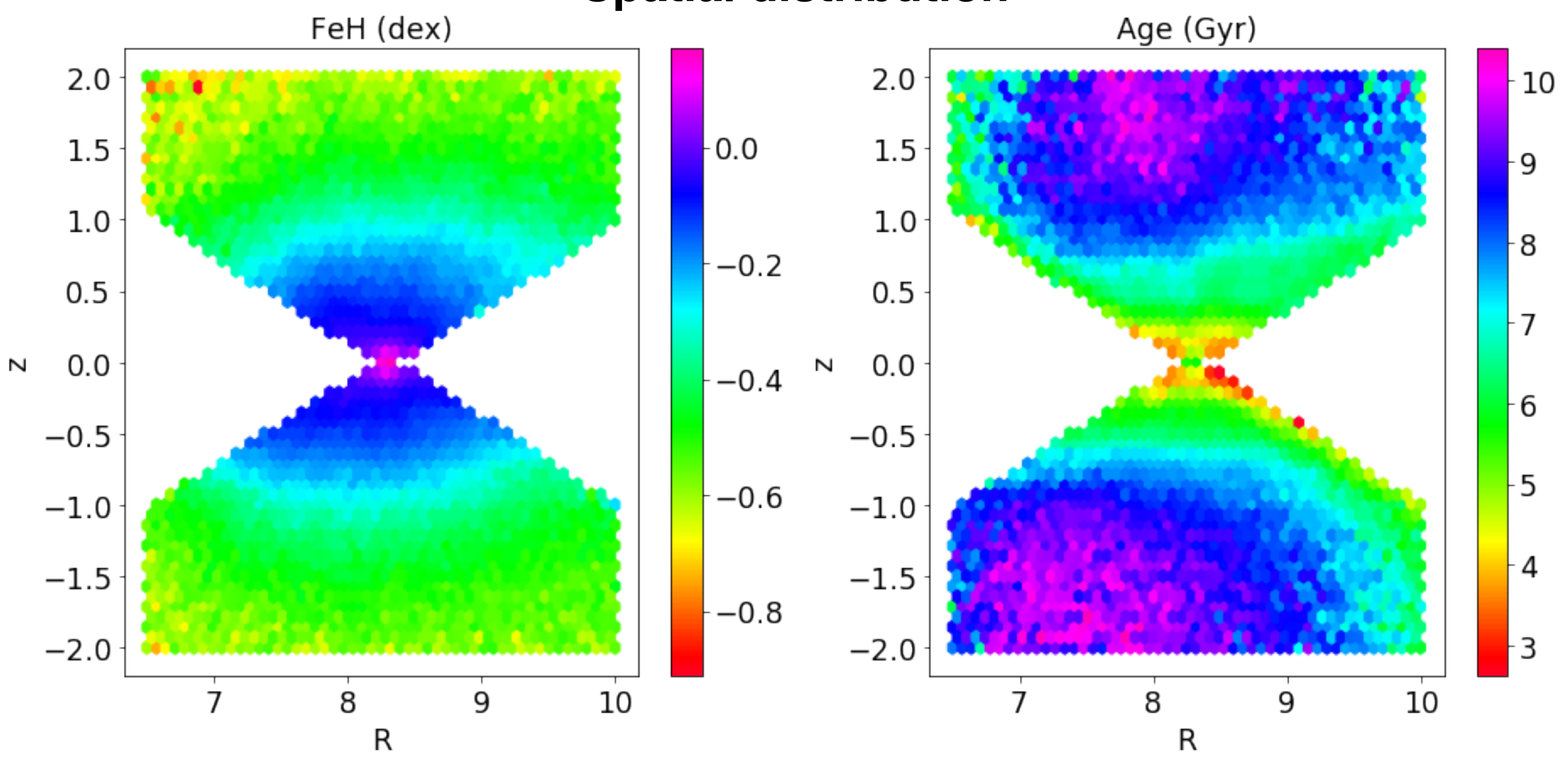
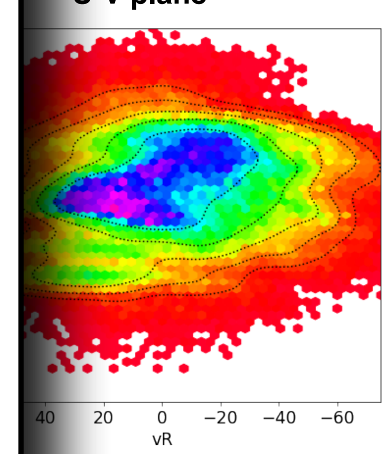


U-V plane



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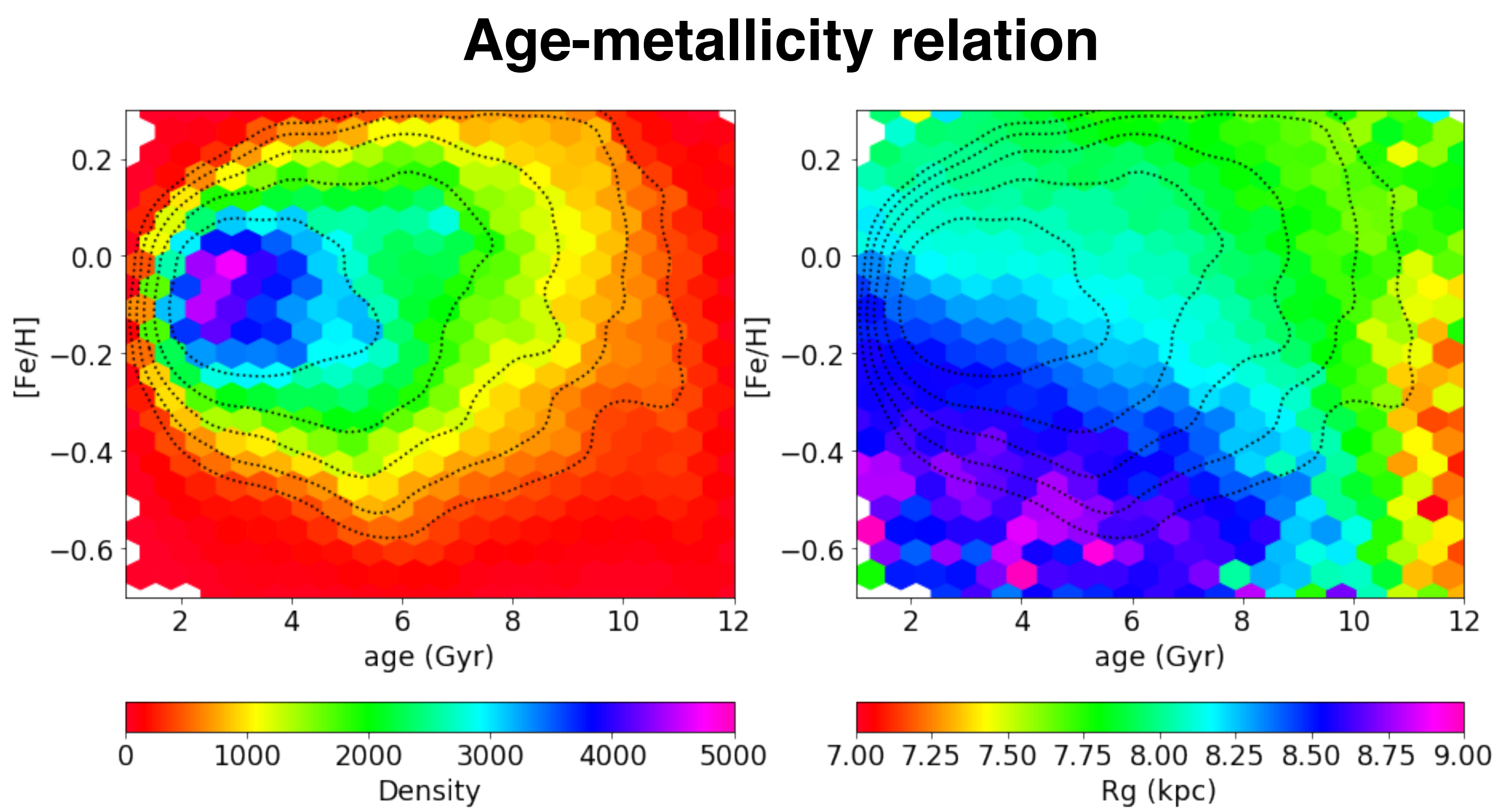
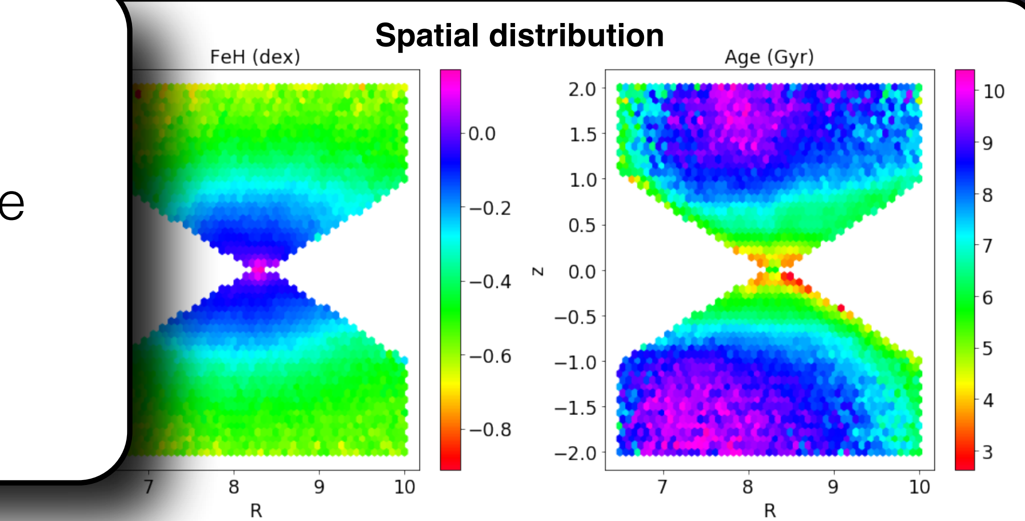
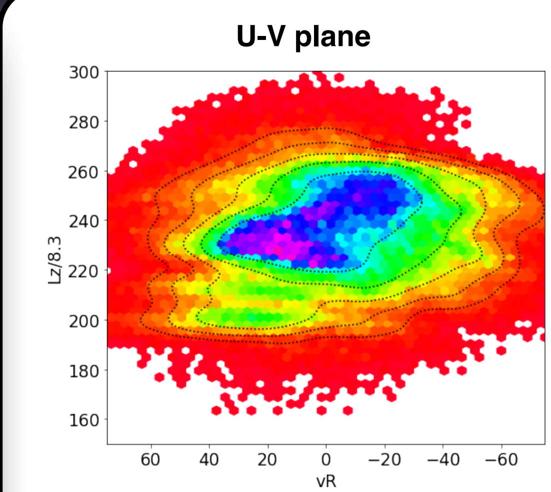
- Other avenues not discussed



Age-Metallicity relation

- By plotting the guiding centre radii we can see the effects which work to broaden this relation.





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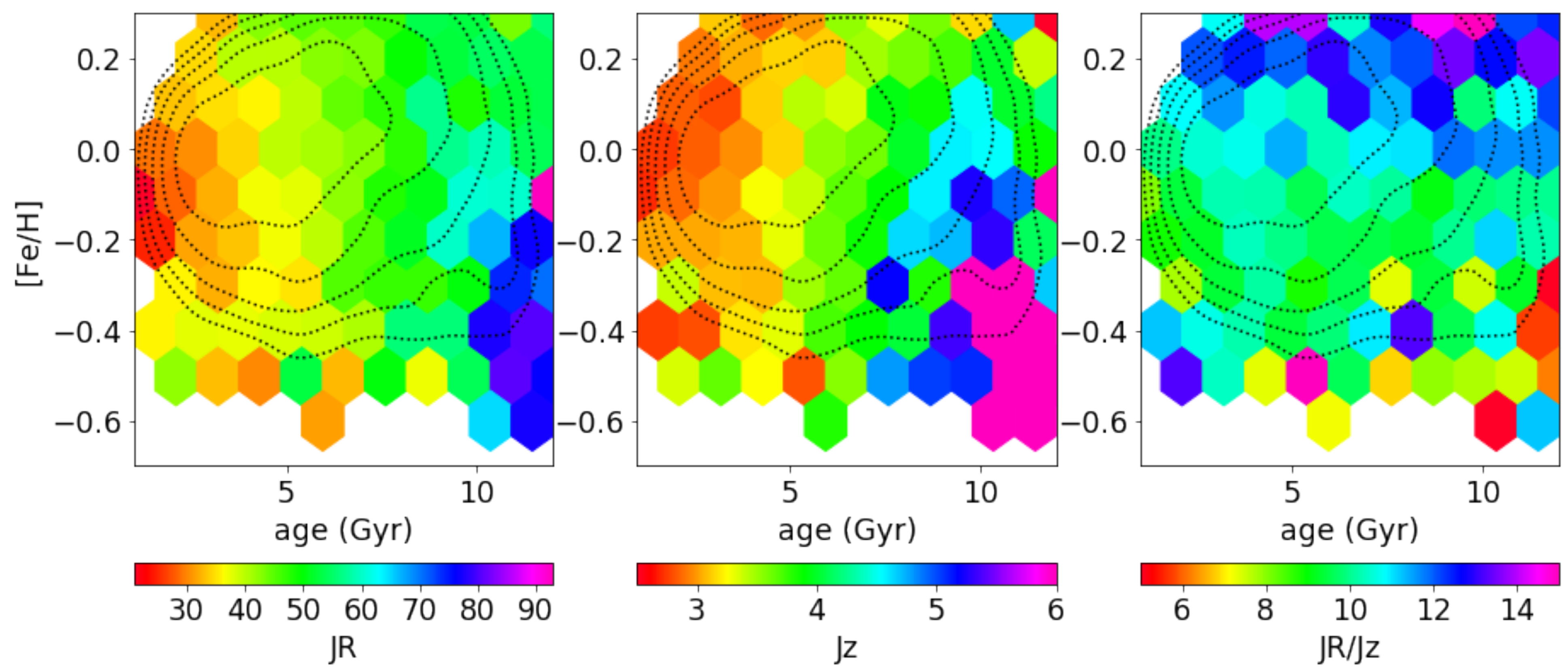
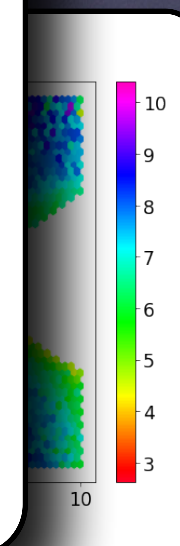
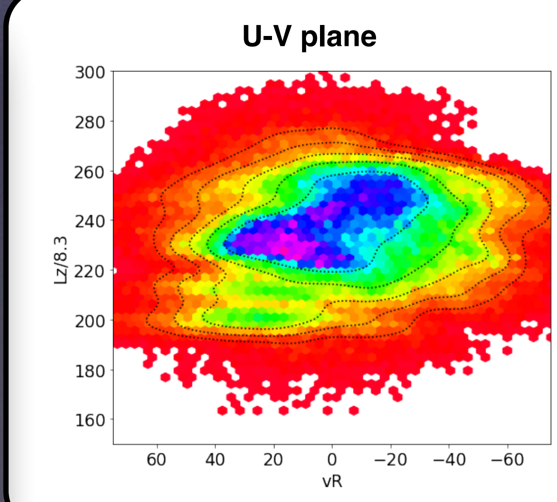


Radial migration

- Here we show the age-metallicity plane for stars with R_g = 7 kpc.
- As expected, older stars are hotter in both J_R and J_z.
- However, plotting the ratio shows that the (probable) migrated stars have high values of J_R/J_z. Is this because migration preferentially occurs for stars with proportionally smaller J_z?





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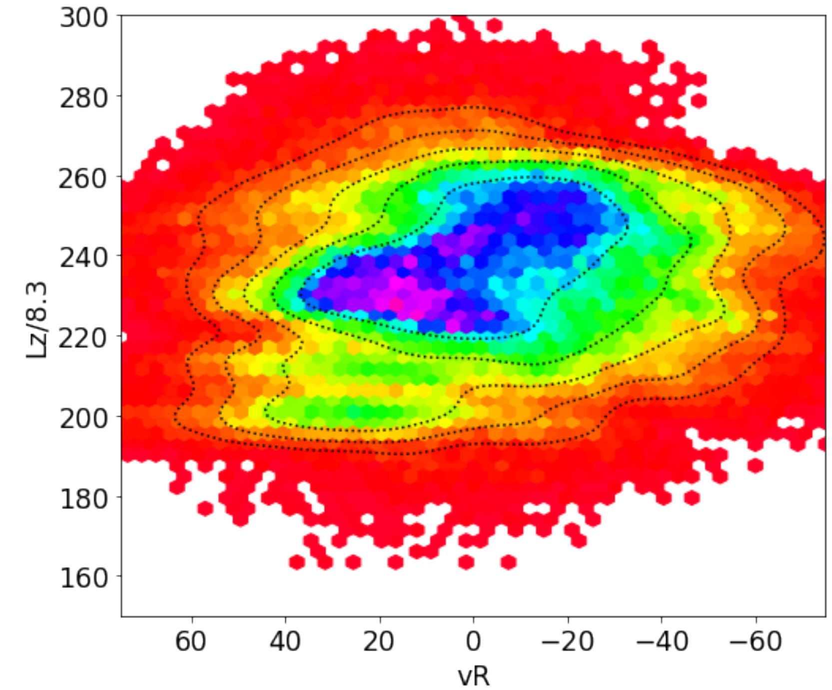
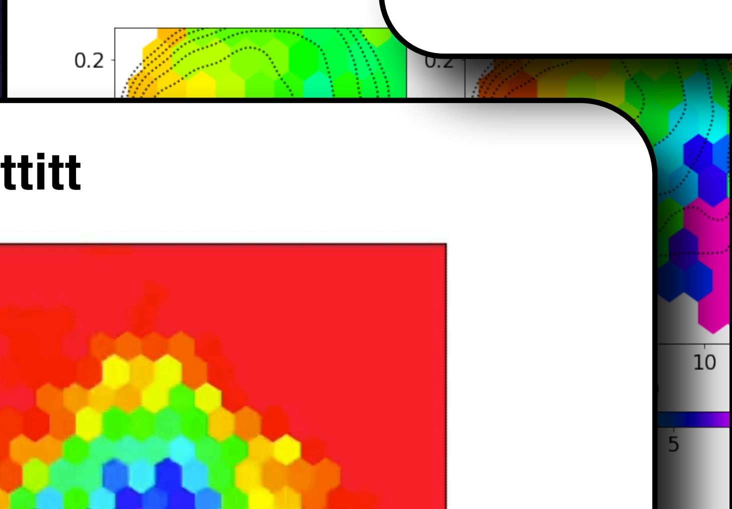
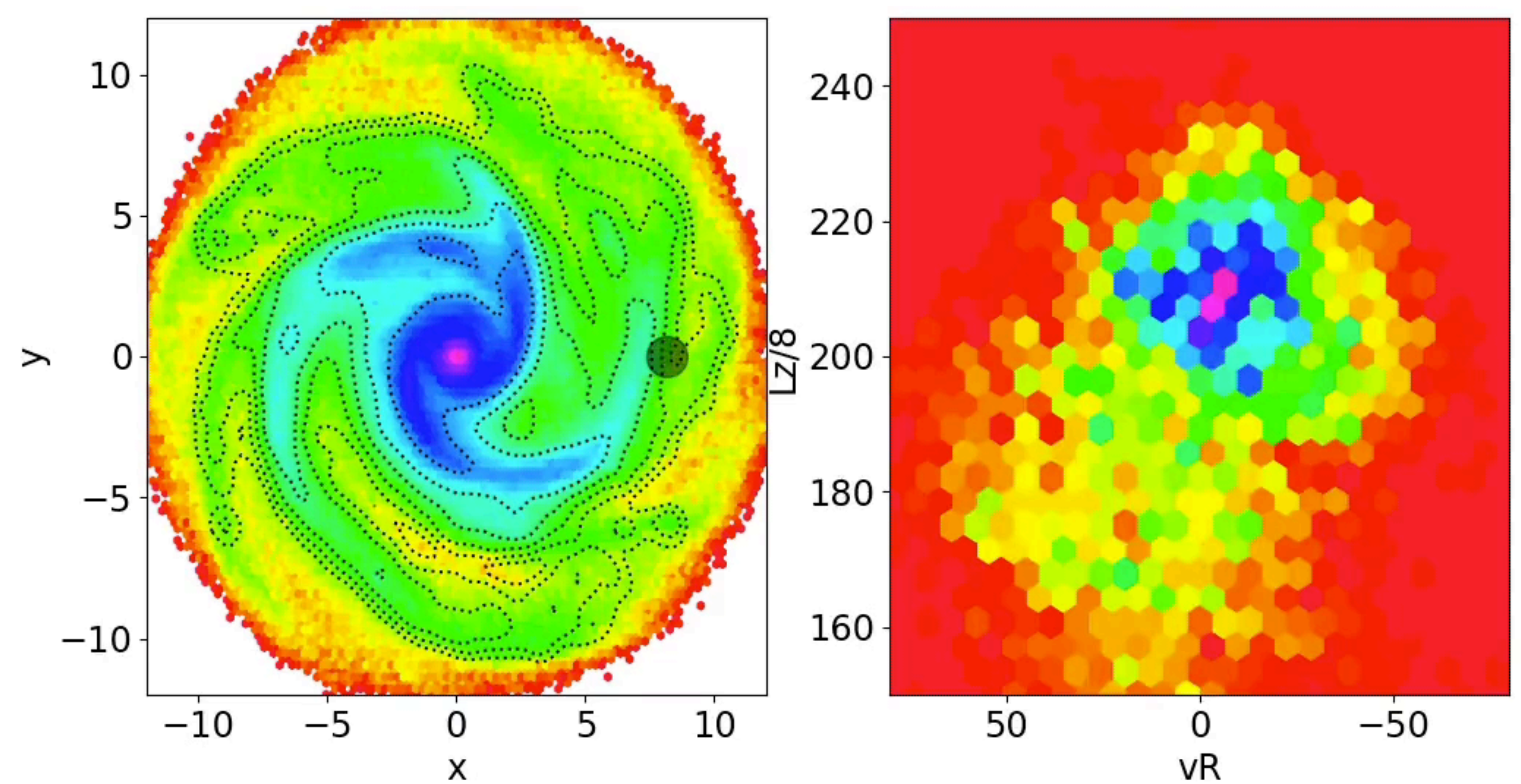


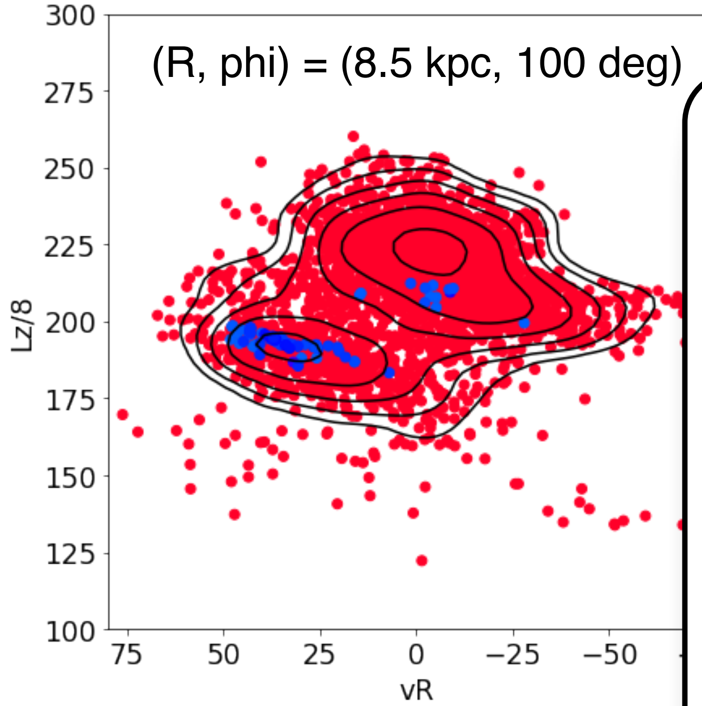


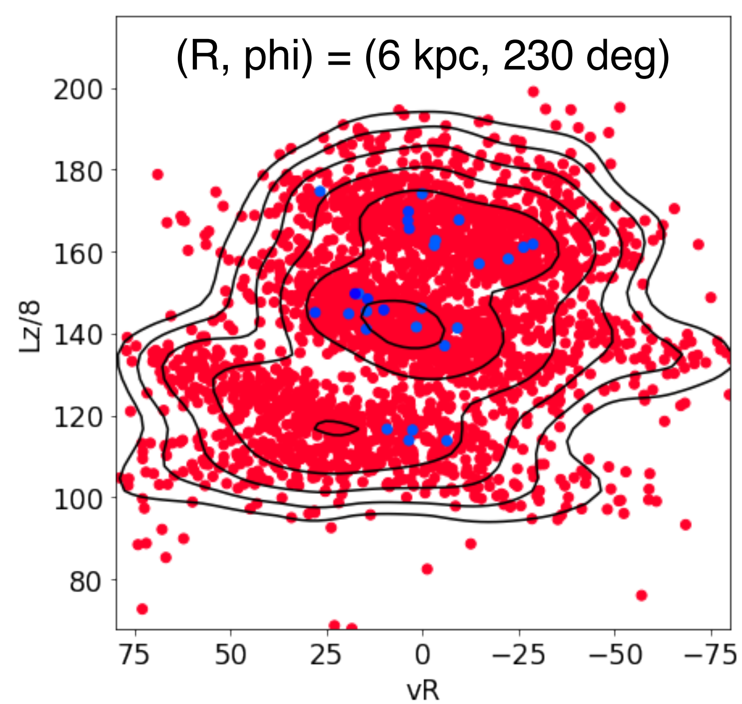
Simulation from Alex Pettitt

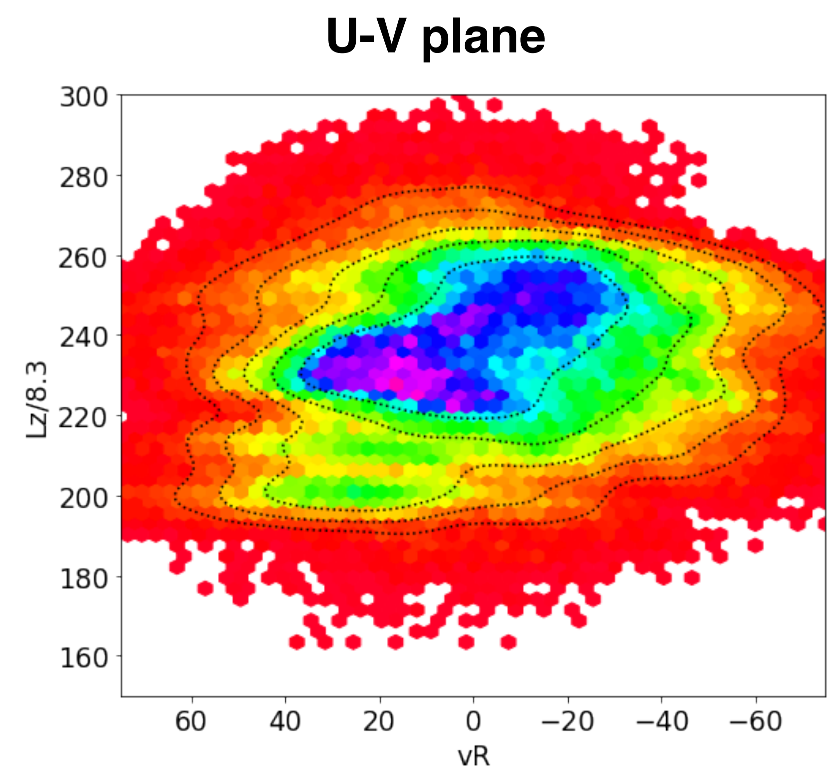


U-V plane

- Vertex deviation and complex substructure
- Spirals are able to match overall structure, but how much of substructure too?
- Hercules stream seems to bifurcate, showing signature in age but not [Fe/H]







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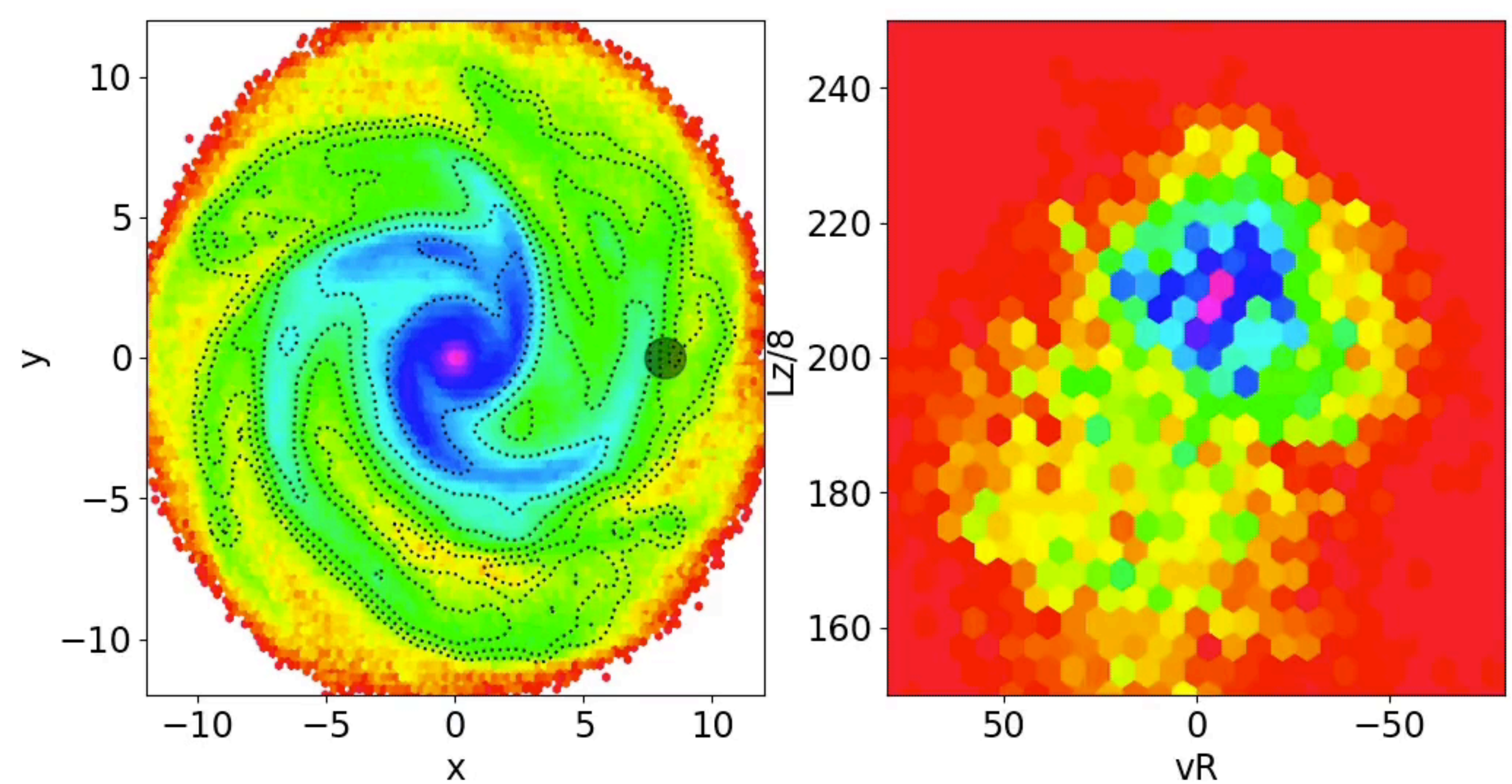

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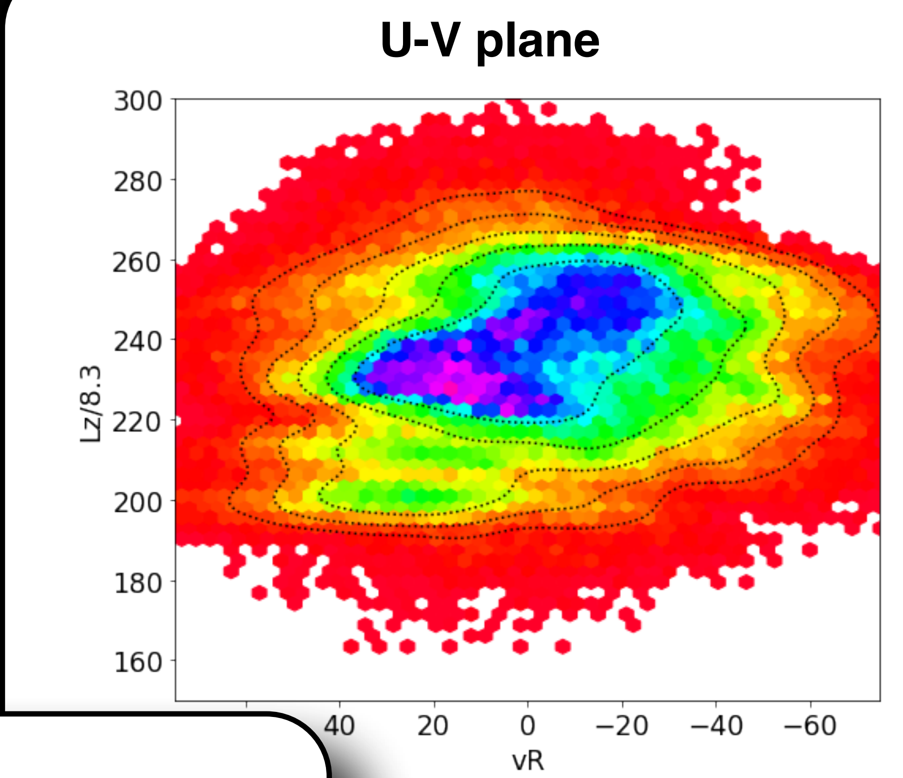
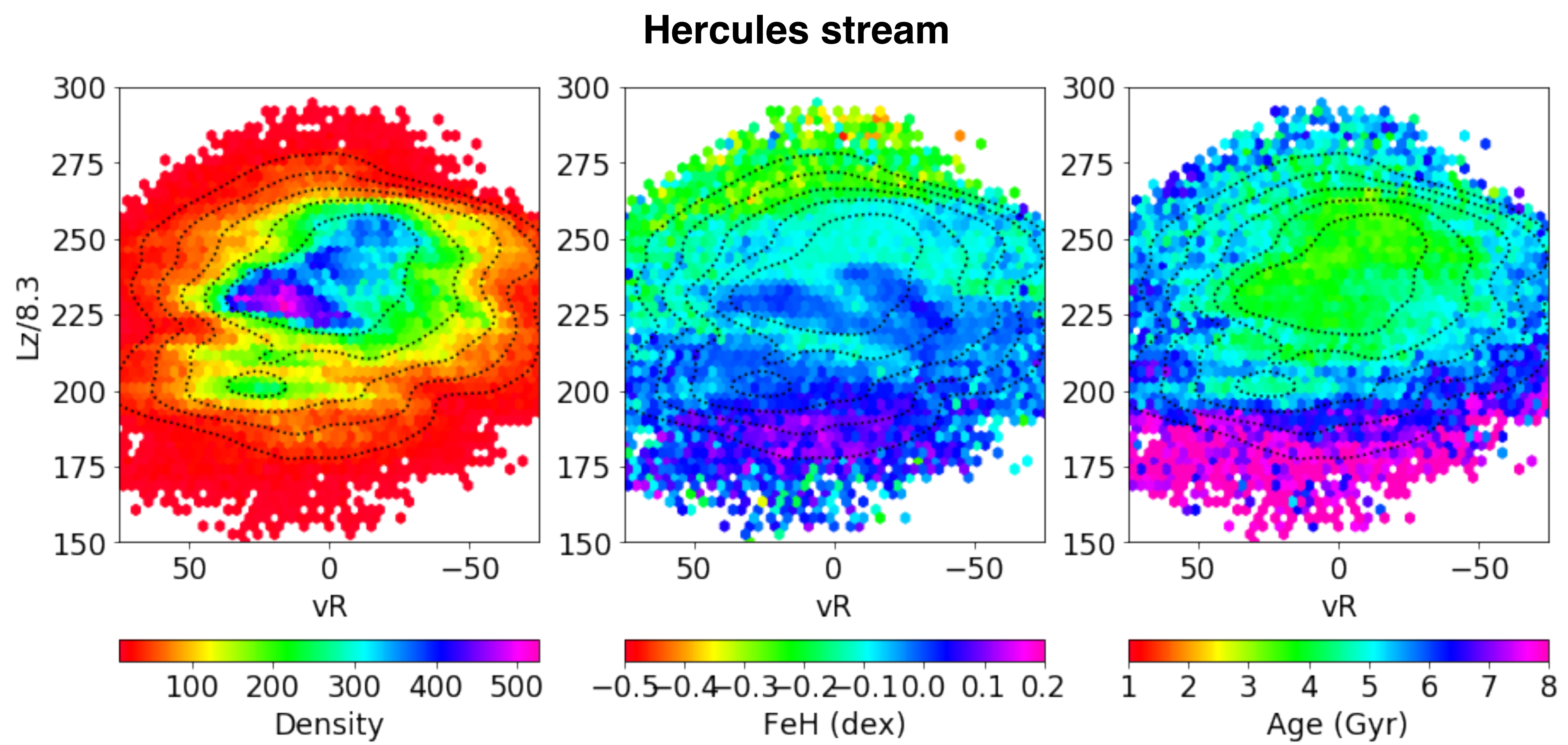
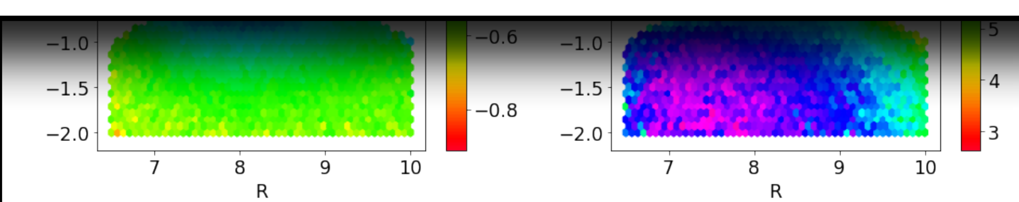




in action space



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LAMOST-2

- 5-year survey from Oct 2018 to Jun 2023. Continuation of LAMOST-1 survey, but with new medium resolution component.
- R ~ 7,500 for two windows: 496-533 nm (Mg Triplet, metal lines) & 630-680 nm (Halpha, Li). Aim to get ~20 elemental abundances.
- Med-res: ~2 million stellar spectra (for G < 15) and ~0.2 million stars with time-domain spectra (60 epochs for G < 14)
- Time-domain science: Variable stars and exo-planet host stars (Kepler/K2 & TESS), star clusters, nebula regions (HII regions, SNR, PNe, etc), field binaries.