The Evolution of the IMF of Star Clusters

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Contents

Why Study the IMF?

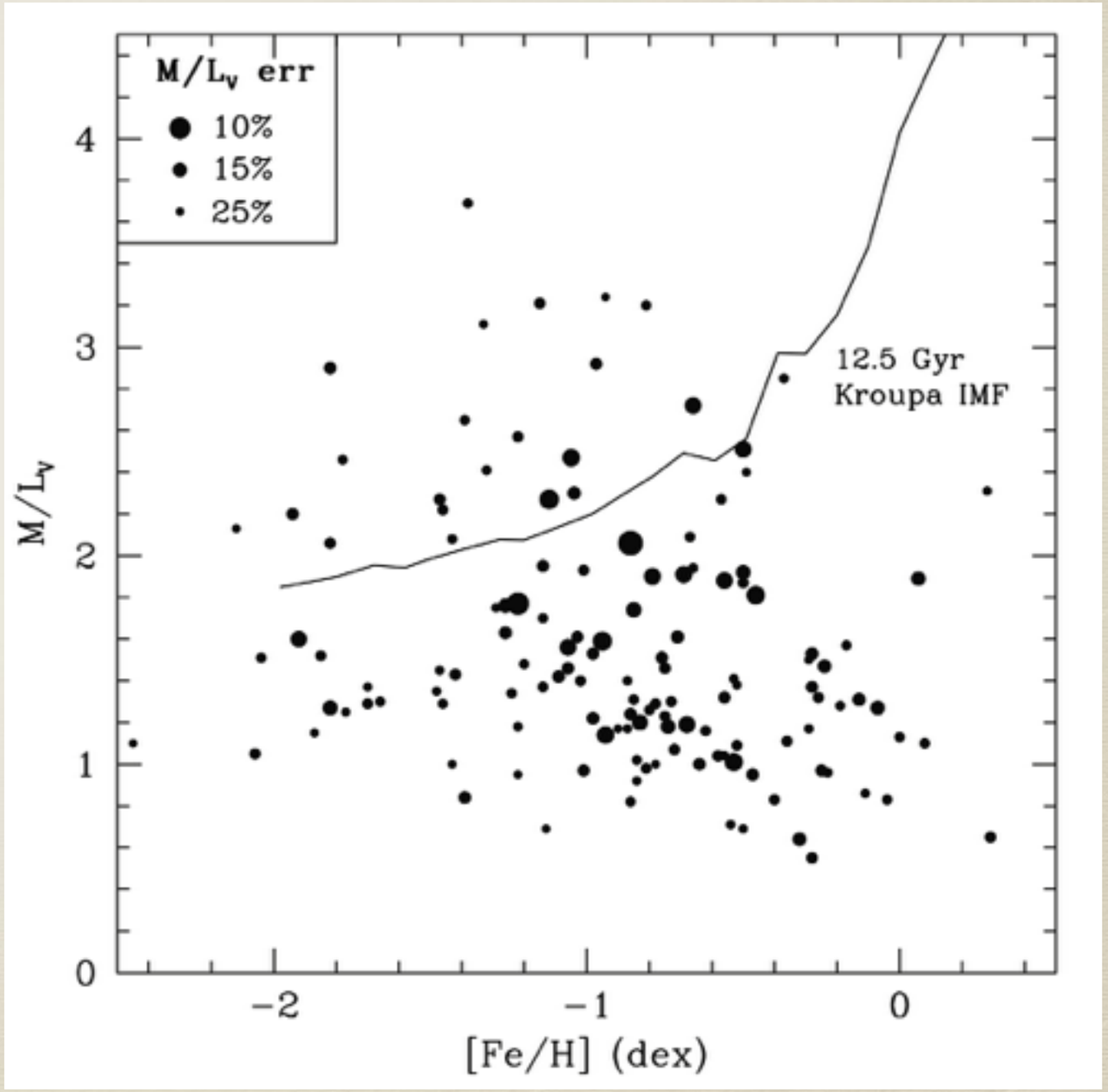
- the initial mass function (IMF) is defined as the number of stars per unit volume per unit logarithmic mass
- describes initial masses of a stellar population
- is it universal?
- influences most observable properties
- variations could provide insights into stellar formation processes

How to Study the IMF

- field stars in the stellar neighbourhood
- difficult to obtain robust empirical measurement
- need some knowledge of star formation history
- estimations/assumptions have to be made
  - impacts greatly on the resulting IMF
- globular clusters (GCs)
  - interplay between dynamics and stellar evolution
    1. the stellar IMF itself
    2. details of stellar evolution
    3. dynamical evolution in the Galactic tidal field
  - no dark matter

Observations

- Strader et al. (2011)
- mass-to-light of 163 M31 GCs
- metal rich GCs deviate strongly from model IMF
- concluded that a shallower mass function is required



Project Outline

- parameterised model for present day mass function
- includes the effects of stellar evolution and dynamics:
  - evolution according to specific IMF
  - coupling to (static) dynamical models for GCs with different mass components
  - multi-mass King models
- predictions for the observed velocity dispersion and half-light radii
- compared with observational data (Strader et al. 2011)

Method: Stellar Evolution

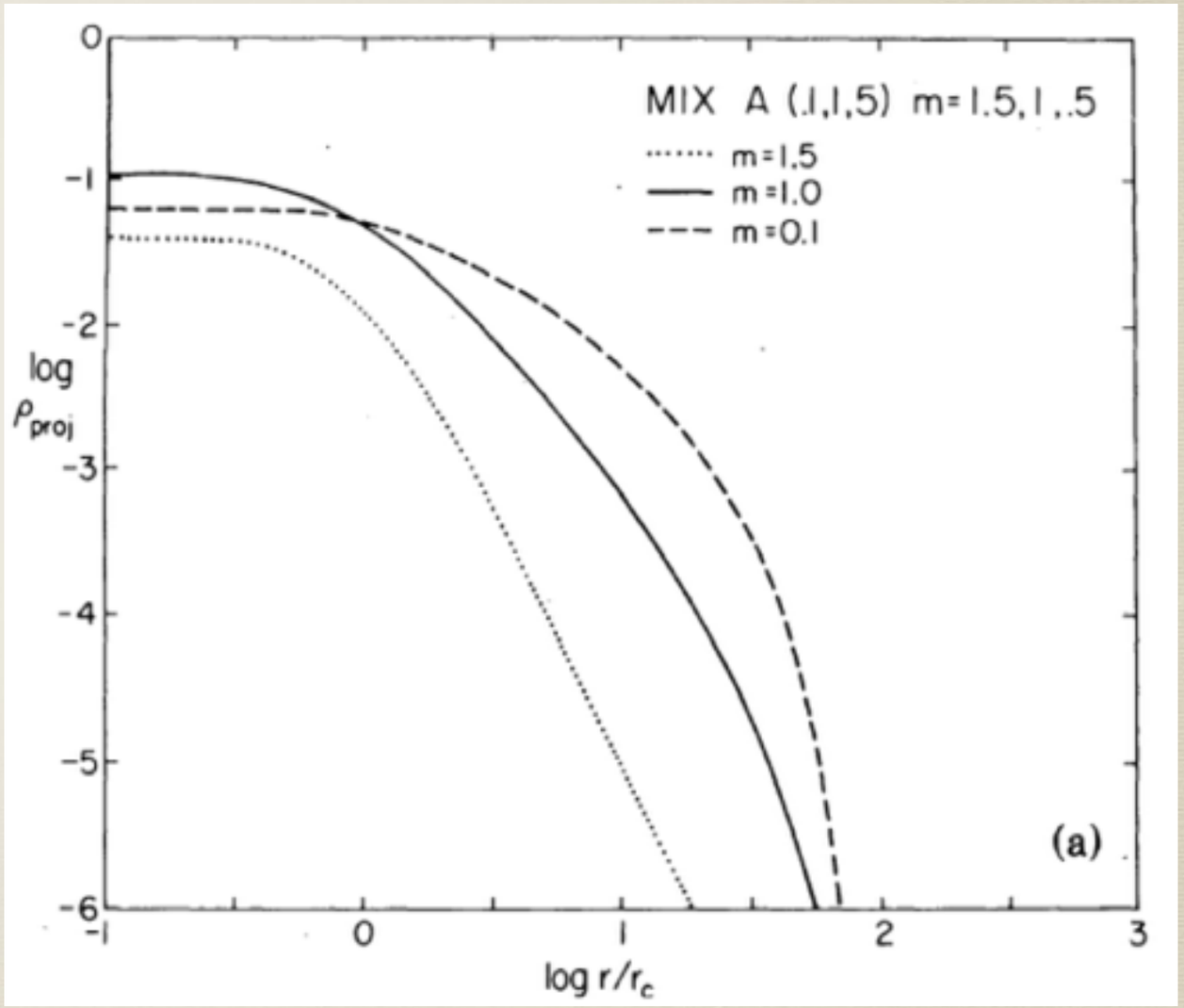
- 10,000 stars: $0.2 - 100 M_\odot$
- SSE code (Hurley, 2000)
- 11 metallicities: Fe/H between -2 and 0
- stellar mass function:

$$\frac{dN}{dm} = \begin{cases} A m^{-\alpha_1} & m_1 < m < m_2 \\ B m^{-\alpha_2} & m_2 < m < m_3 \end{cases} \qquad \alpha_1 = 0 \qquad \alpha_2 = 2.35$$

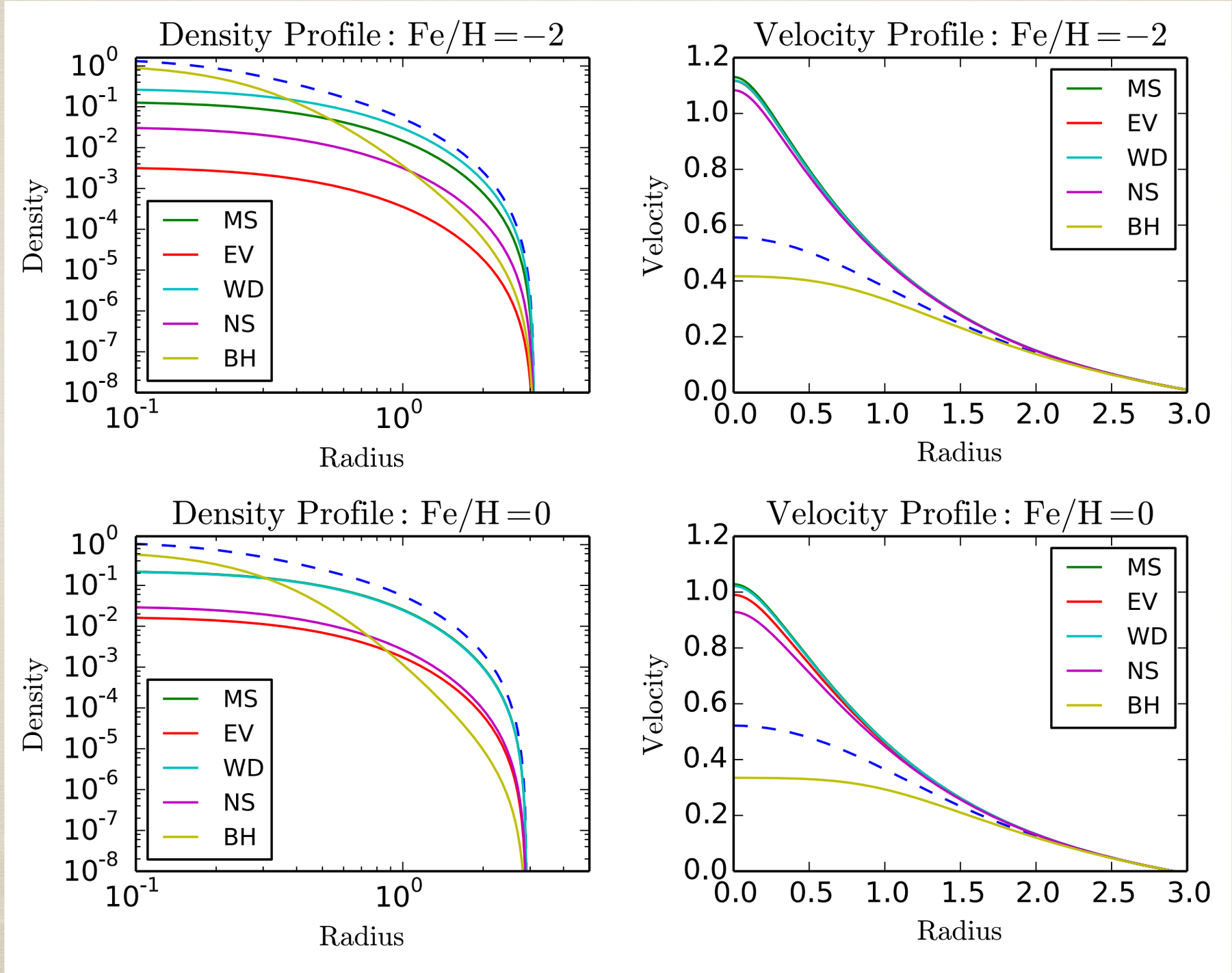
- quicker than N-body simulation
- not concerned with following the stars
- statistical characterisation of underlying physics

Method: Dynamics

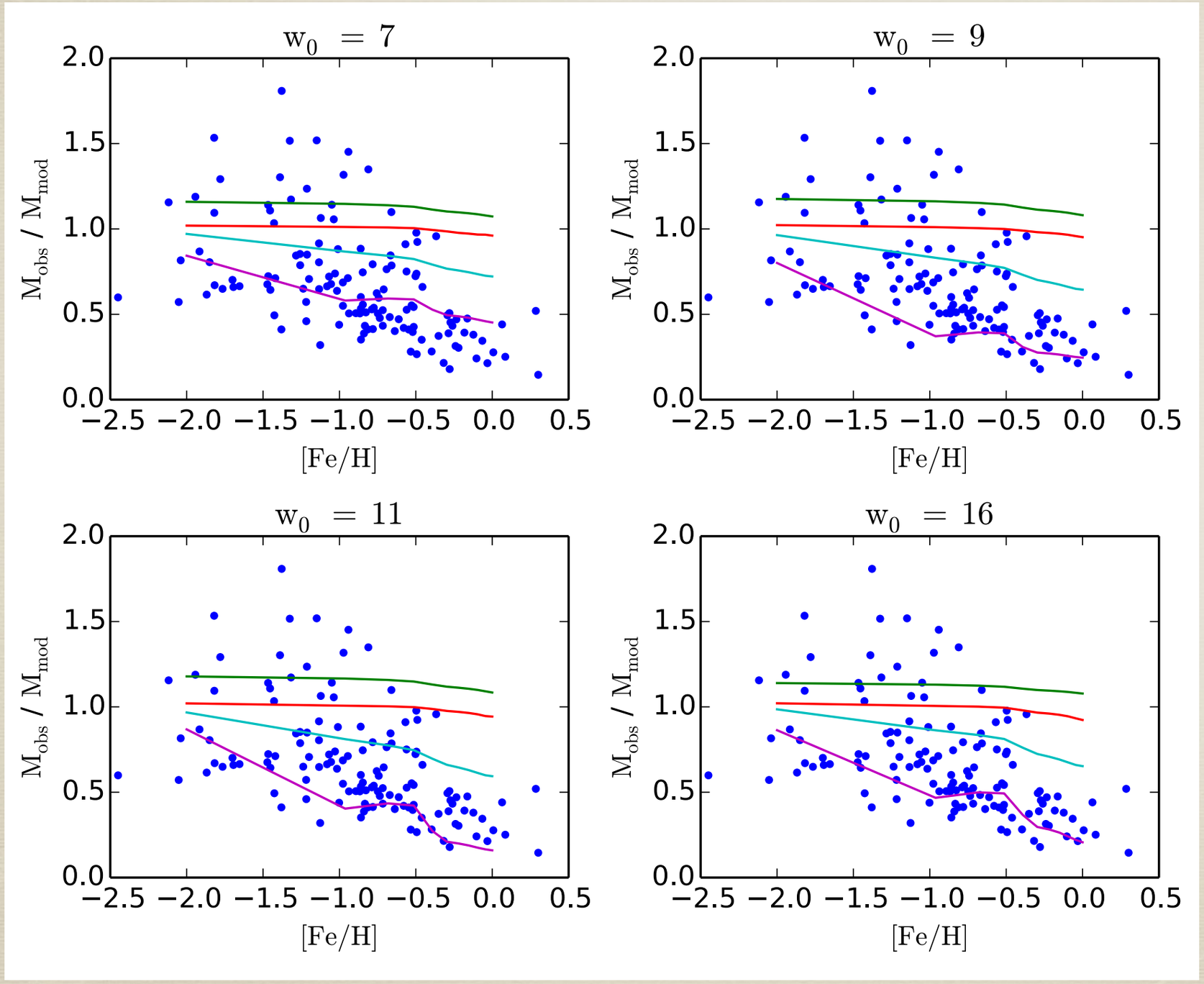
- Gunn & Griffin 1979
- see Douglas' first lecture for details
- multi mass models
  - retention fraction of remnants
  - energy equipartition
  - mass segregation
- double power law
  - preferential loss of low mass stars
  - mimics effects of dynamical evolution

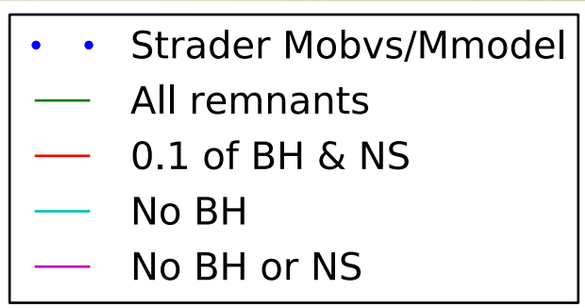


Method: Dynamics

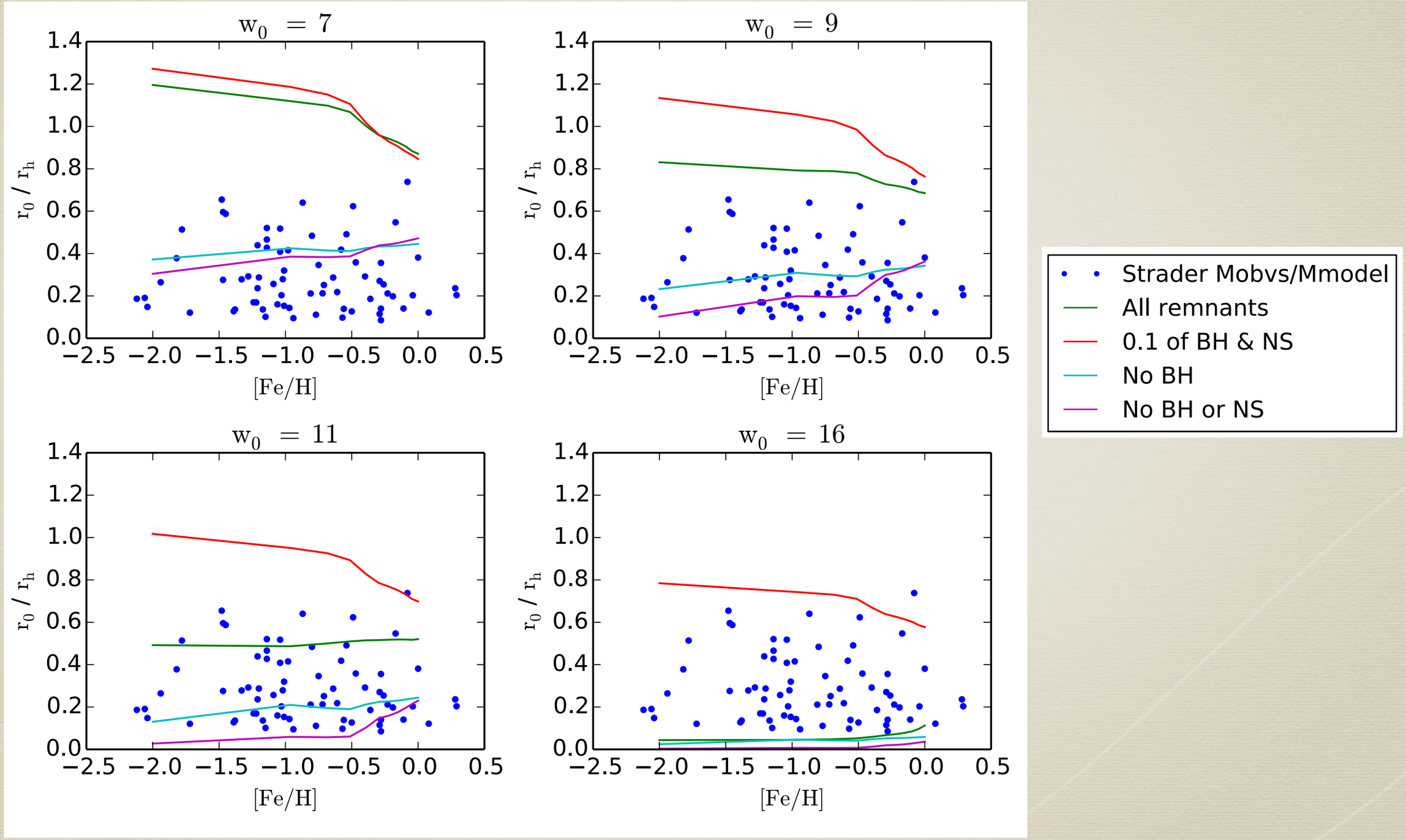


Mass vs Metallicity

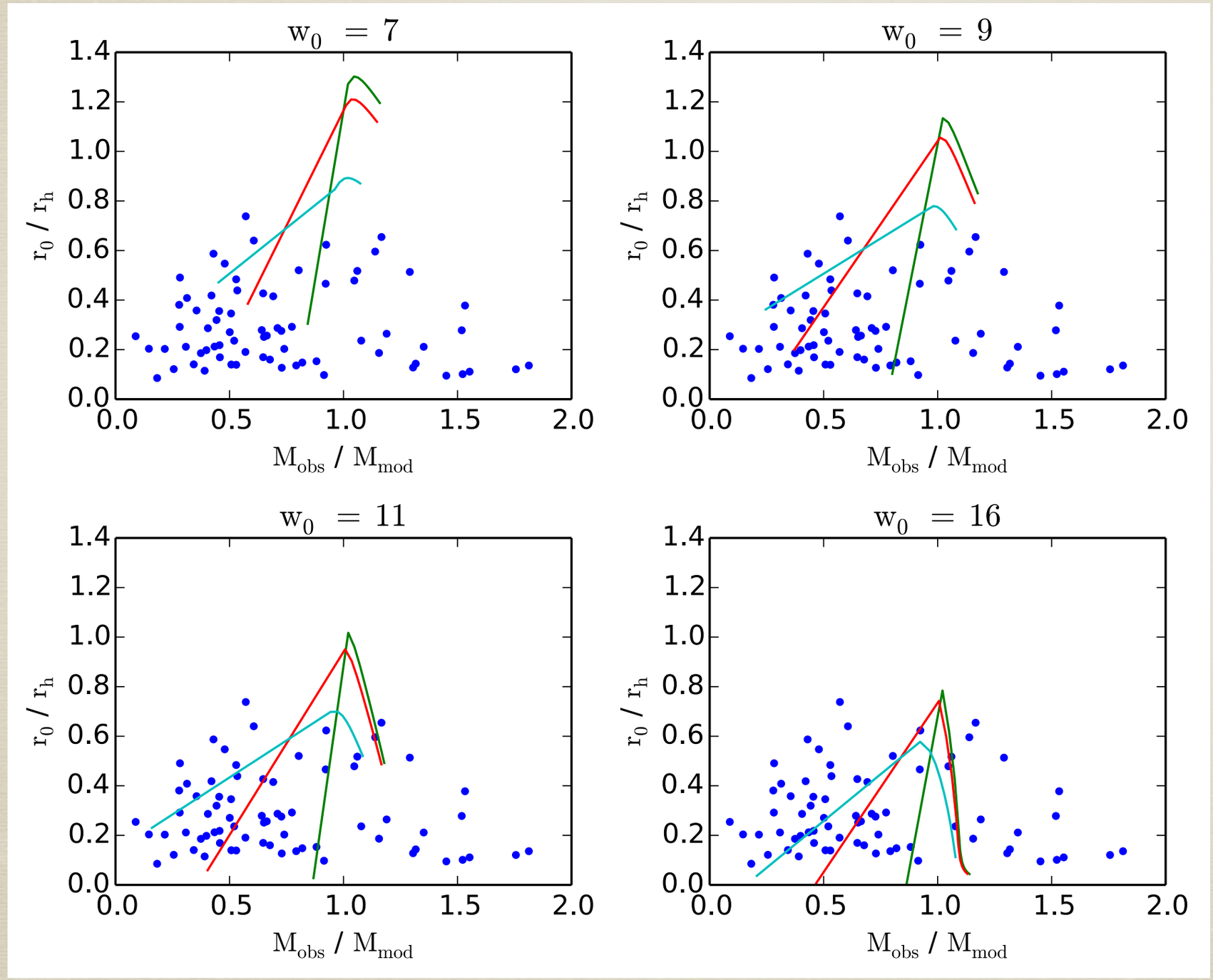


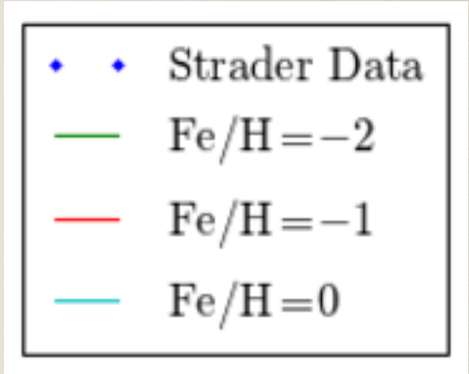


Radius vs Metallicity



Radius vs Mass





Key Results (so far…)

1. For clusters without NS and without BH: the dynamical mass derived from evolved stars of a mass segregated cluster (M_dyn) depends on metallicity, in that M_dyn is lower, and this effect is stronger at high Z.
2. Adding BH has a large effect on the derived M_dyn, in that the value is higher, and closer to the real value. NS also increase the derived M_dyn, but not by as much.

Summary

- preliminary investigation
- seeking alternative explanation to discrepancy between observations and expected M/L values of M31 GCs
- explored effects of using different:
  - central concentrations, i.e. w0 values
  - metallicities
  - remnant retention fractions
- changing the retention fraction greatly impacts the observed GC mass values
- including this effect would go some way to reconciling the discrepancy Strader found, without the need to make changes to the IMF
- further investigation will take place!