

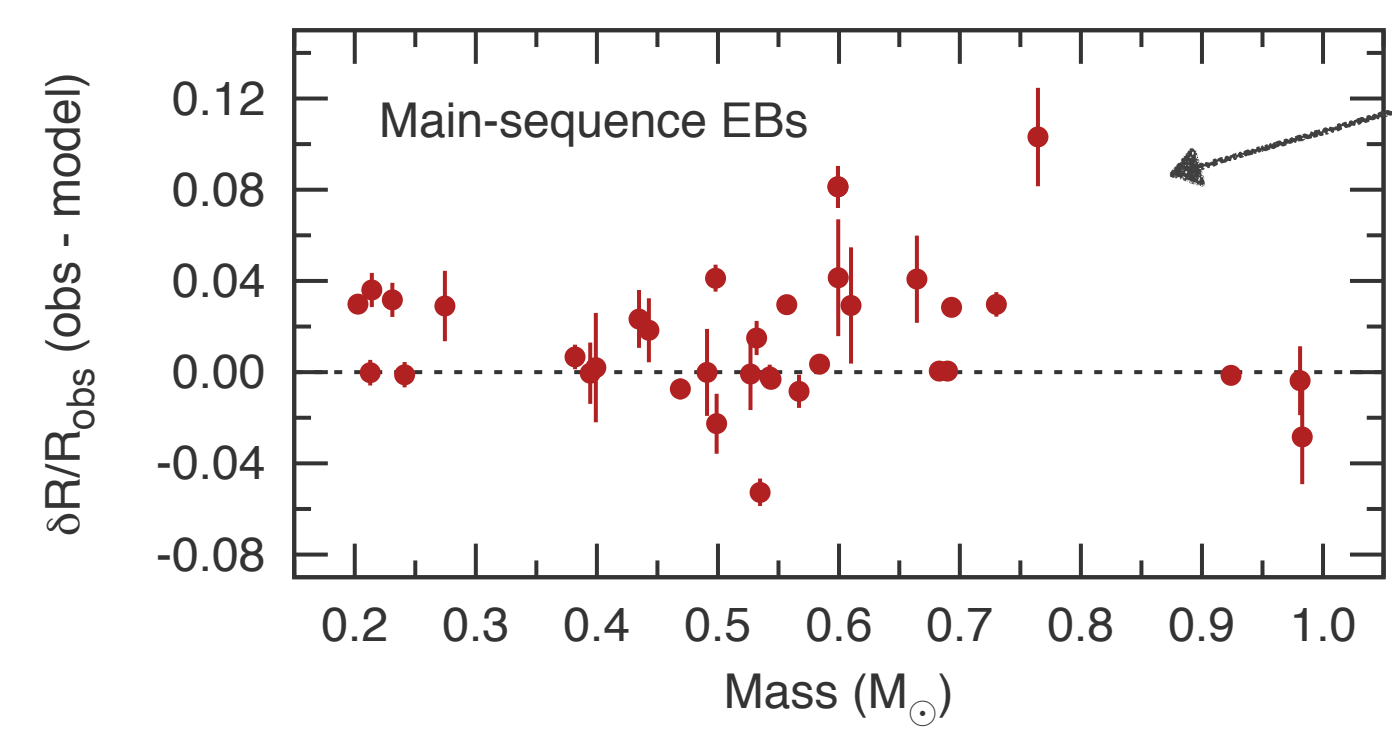
Updating the Dartmouth stellar evolution model grid: Pre-main-sequence models & magnetic fields

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Motivation

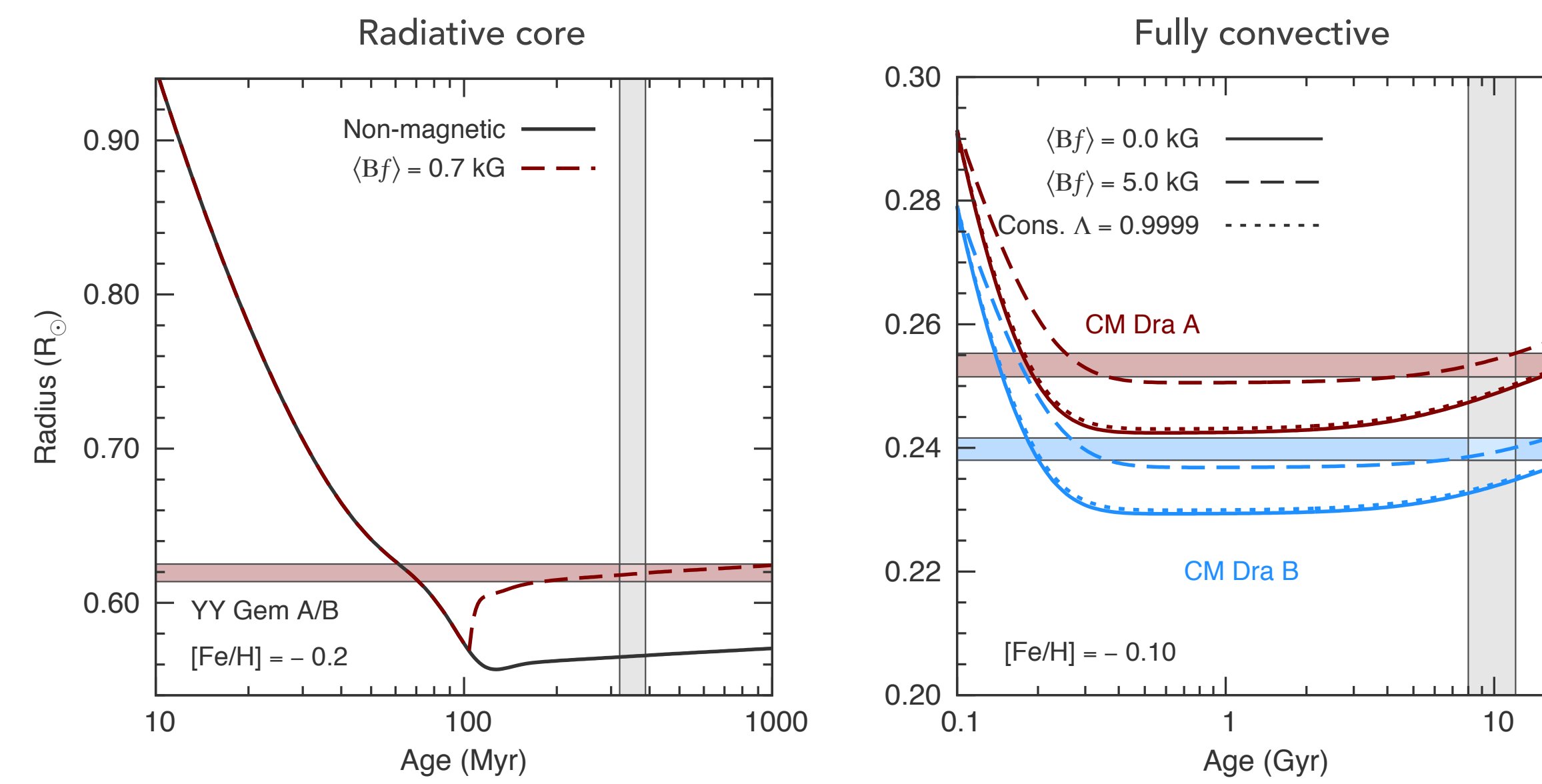
There is strong evidence indicating stellar evolution theory is unable to accurately predict fundamental properties of main-sequence (MS) and pre-MS low-mass stars.^{1, 2, 3}



Tendency for models to under-predict observed radii.

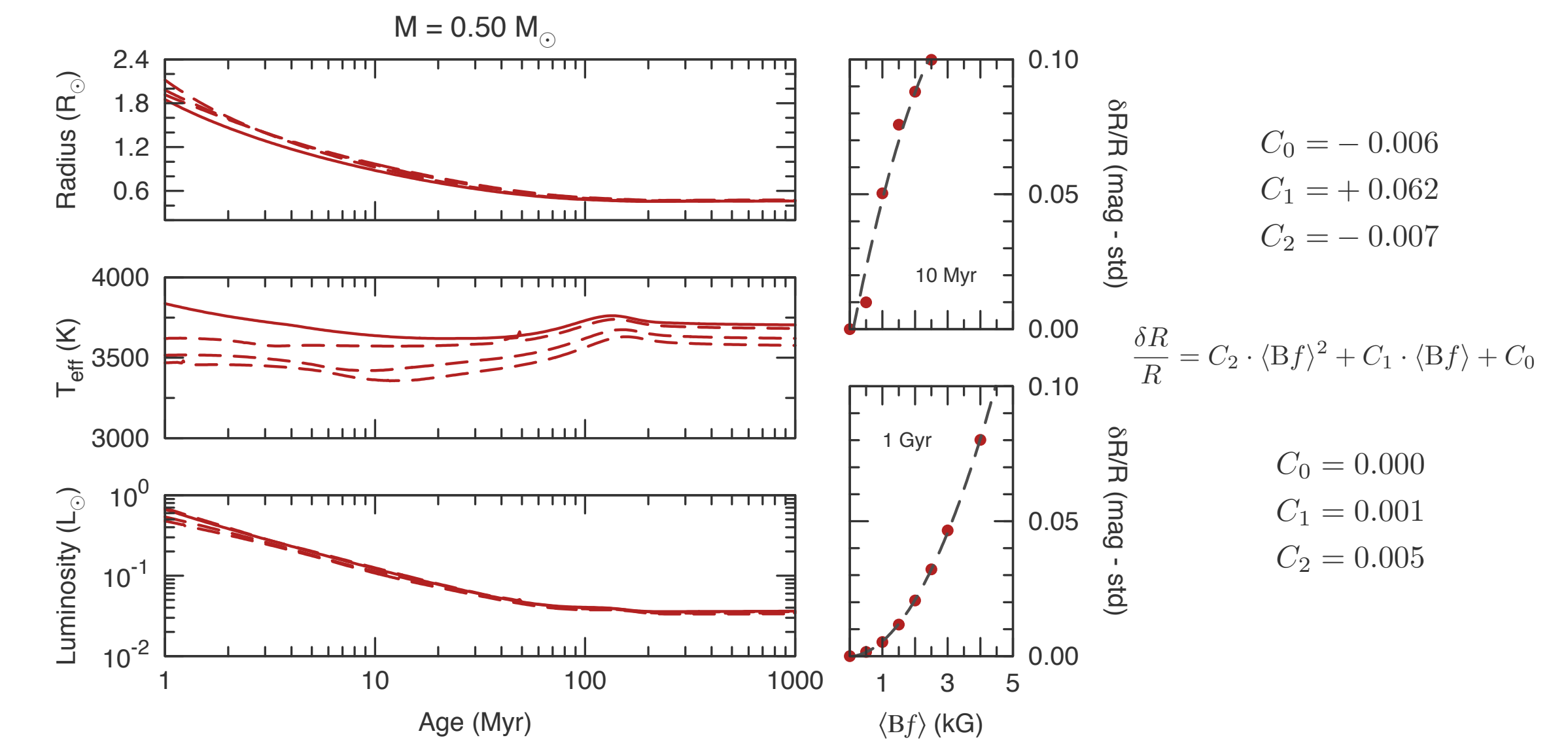
Interplay between magnetic fields and convection (magneto-convection) is often cited as the explanation.⁴ Magnetic fields can stabilize a fluid against convection, or even draw energy from convective flows. But, does magneto-convection actually have an observable influence on stellar structure?

Stellar models with magneto-convection included have been developed and implemented with mixed success.^{4, 5, 6, 7}

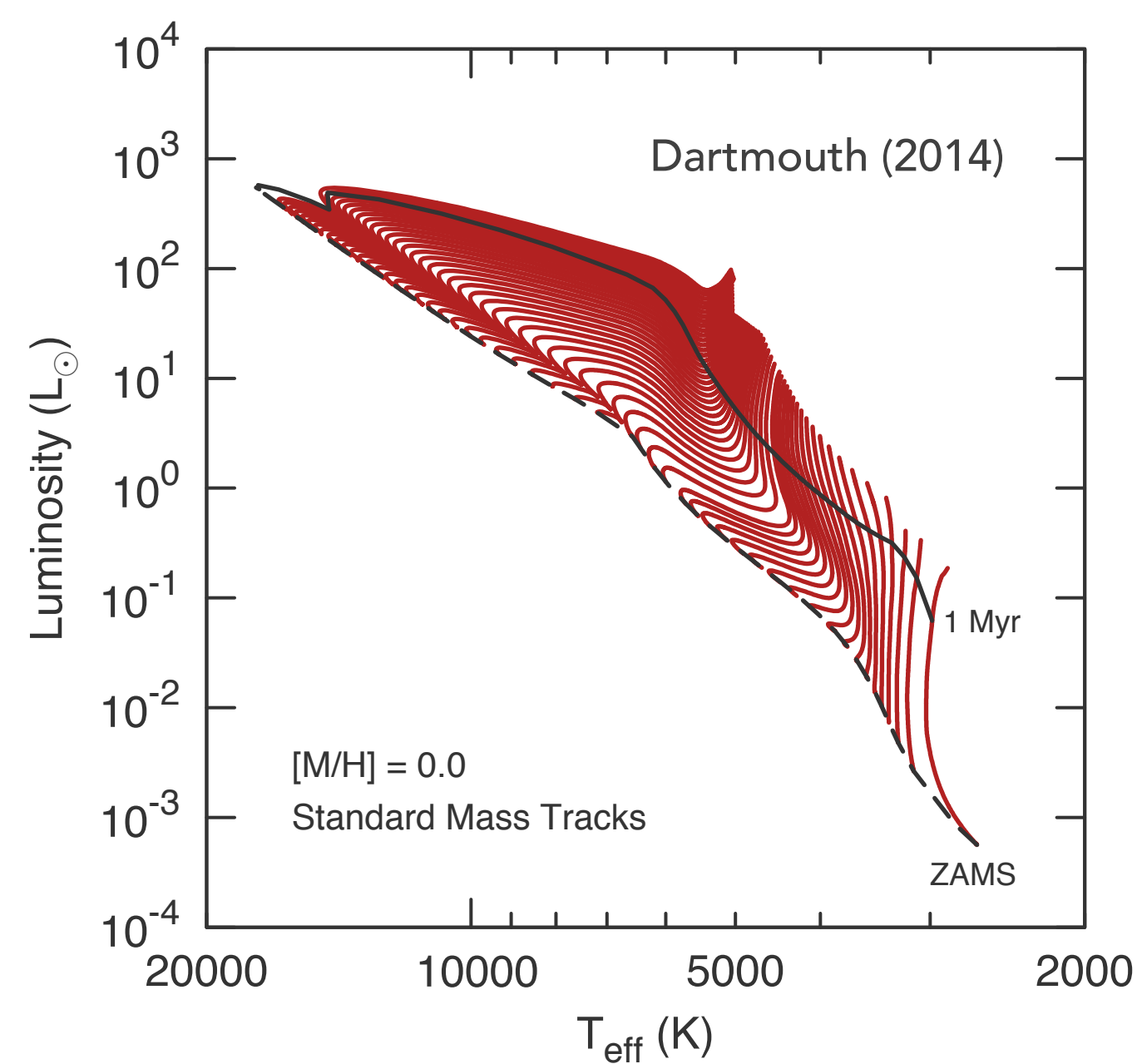


Models for stars with radiative core require seemingly realistic magnetic field properties,^{5, 6} but models of fully convective stars need interior fields strengths in excess of 1 MG. Such fields are likely to be unstable to buoyant rise.⁷

It is still not clear whether magnetic fields influence stellar interior structure. Models must be applied in a wide variety of situations to validate their predictions, necessitating the development of a grid.

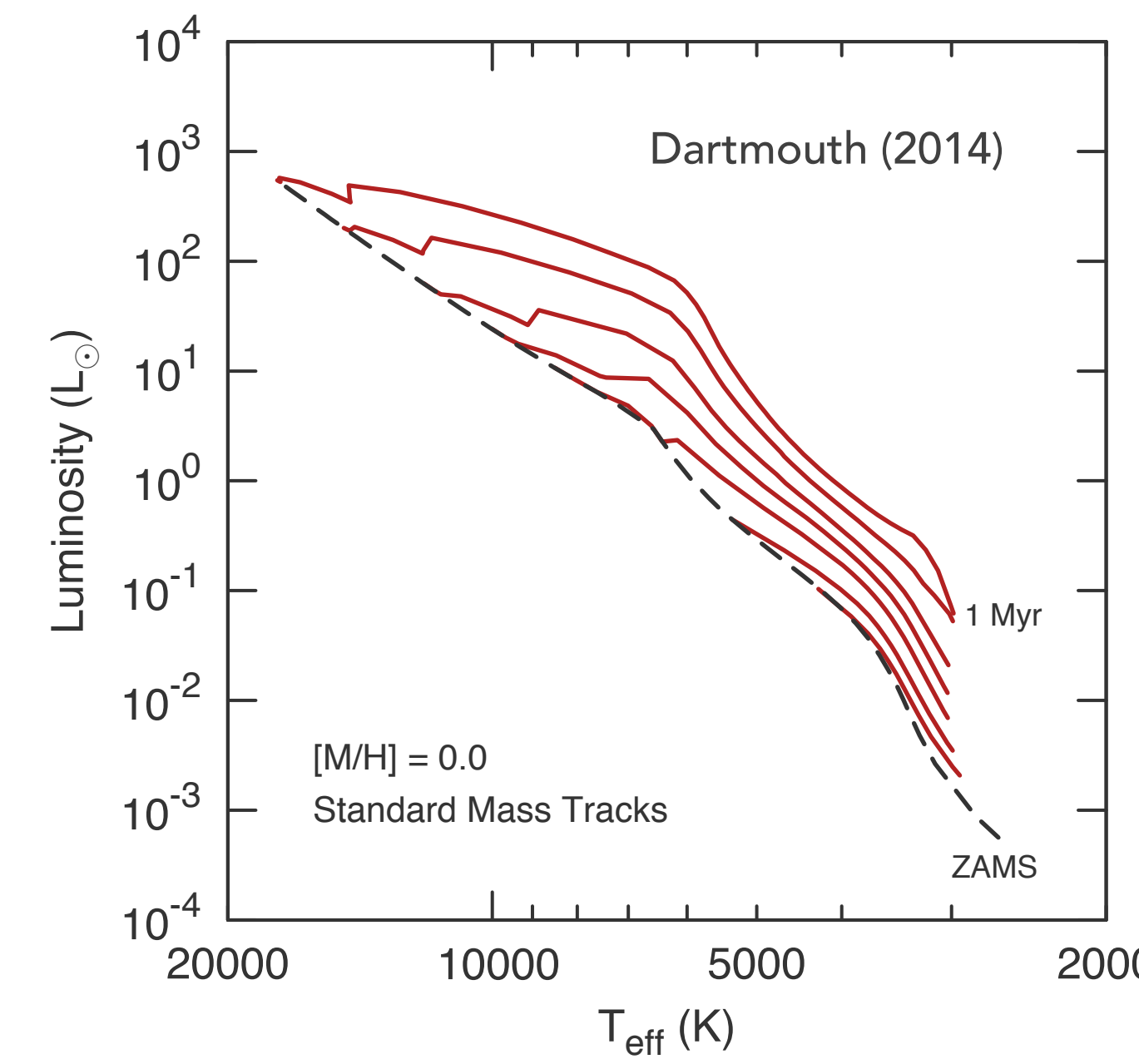


Greatest sensitivity to magneto-convection is along the pre-MS at an age of around 10 Myr. Therefore, it is advantageous to not just cover the MS, but to extend the grid to the pre-MS.



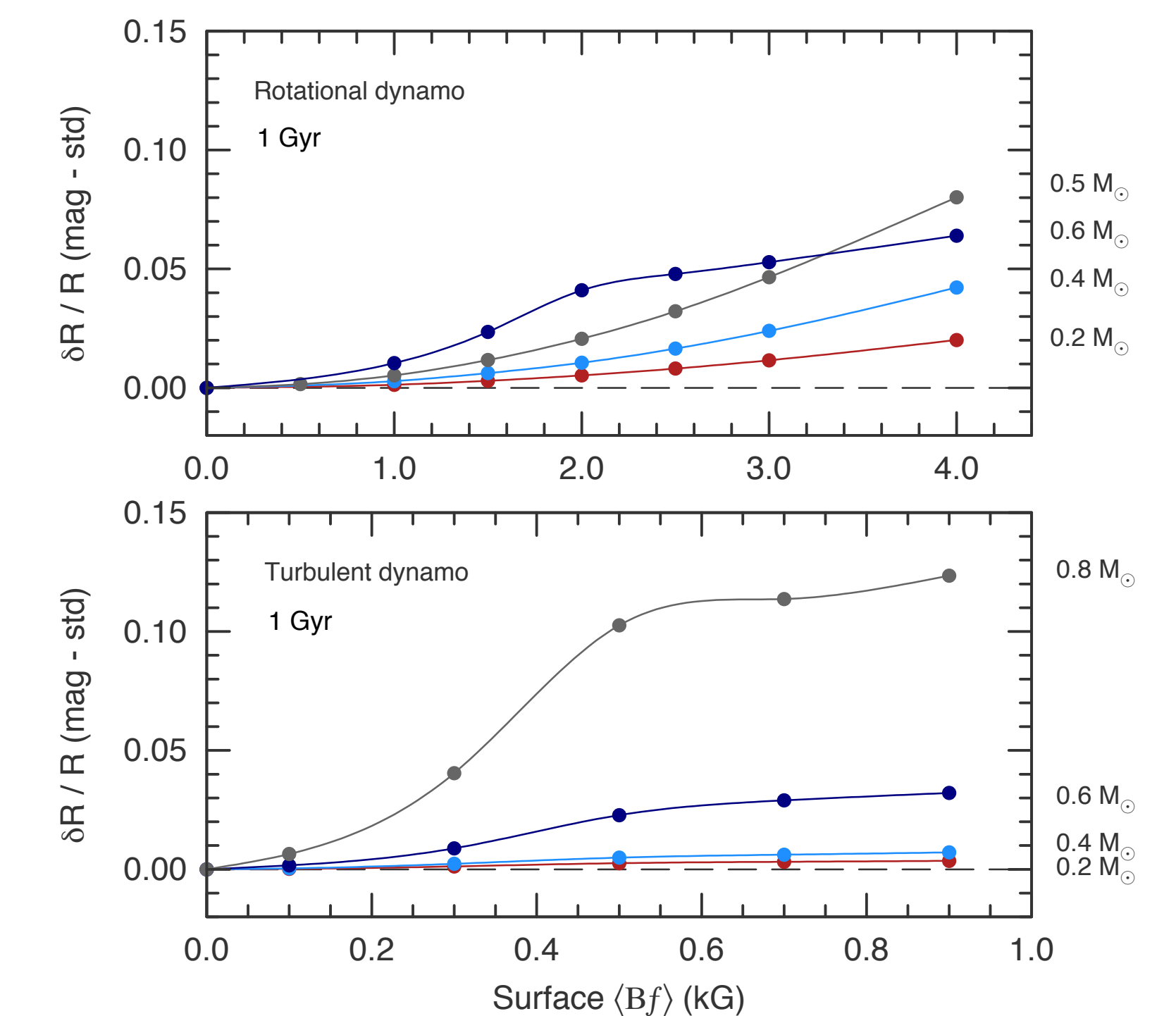
Extending grid to pre-MS

- Added deuterium burning
- Atmosphere matched at a higher τ
- Masses from 0.08 up to 5.0 M_{\odot}
- Mass resolution of 0.02 M_{\odot}
- Isochrone ages from 1 – 250 Myr
- Age resolution of 0.1 Myr to 20 Myr
- Metallicity from -0.5 dex to +0.5 dex



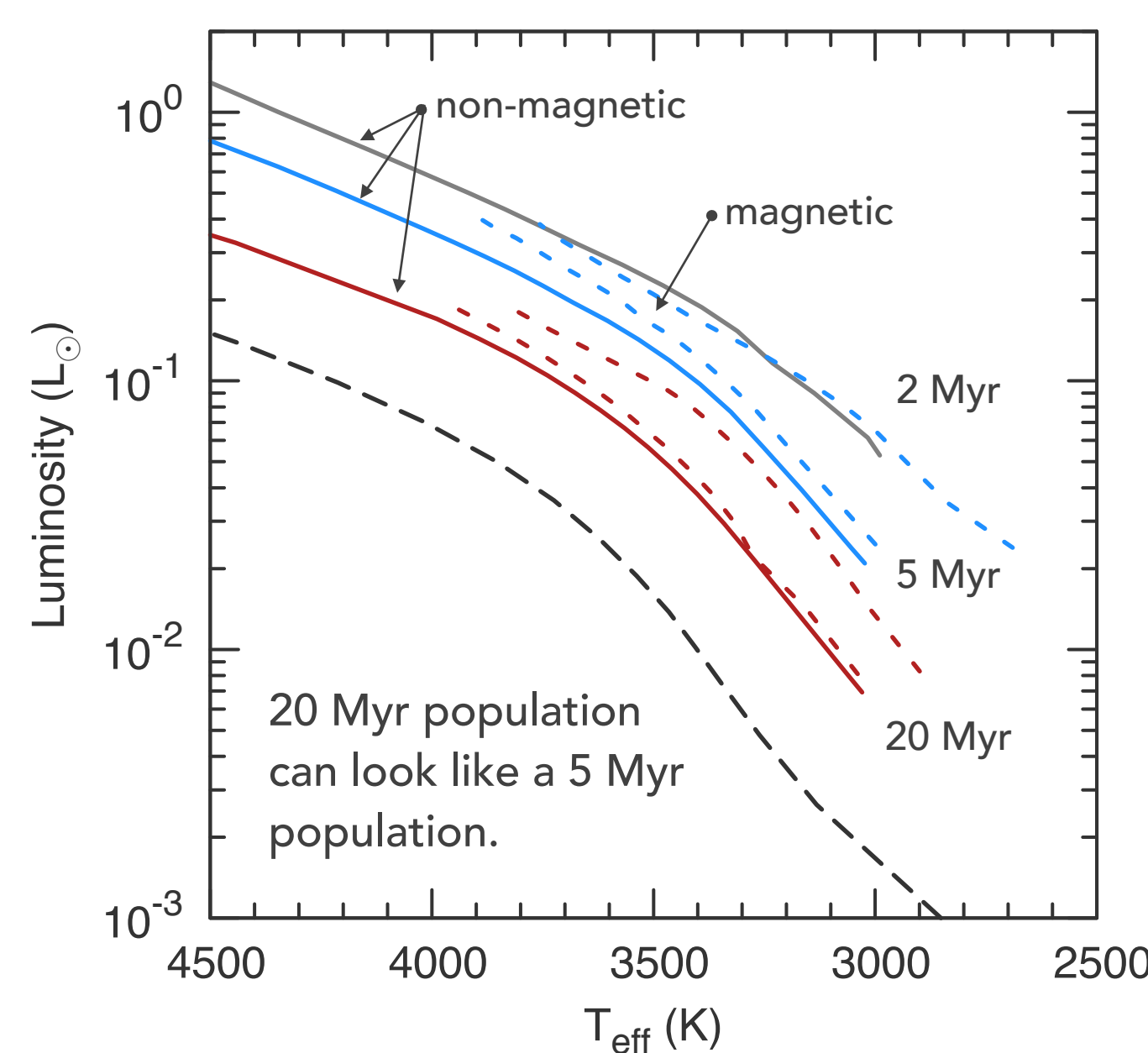
Magnetic model grid

- Rotational + turbulent “dynamo”
- Masses from 0.1 up to 1.2 M_{\odot}
- Mass resolution of 0.05 M_{\odot}
- Range of near-solar metallicities
- Different grids for pre-MS and MS
- Surface magnetic field strengths
- Turbulent: 0.1, 0.3, 0.5, 0.7, 0.9 kG
- Rotational: 1.0, 1.5, 2.0, 2.5, 3.0, 4.0 kG



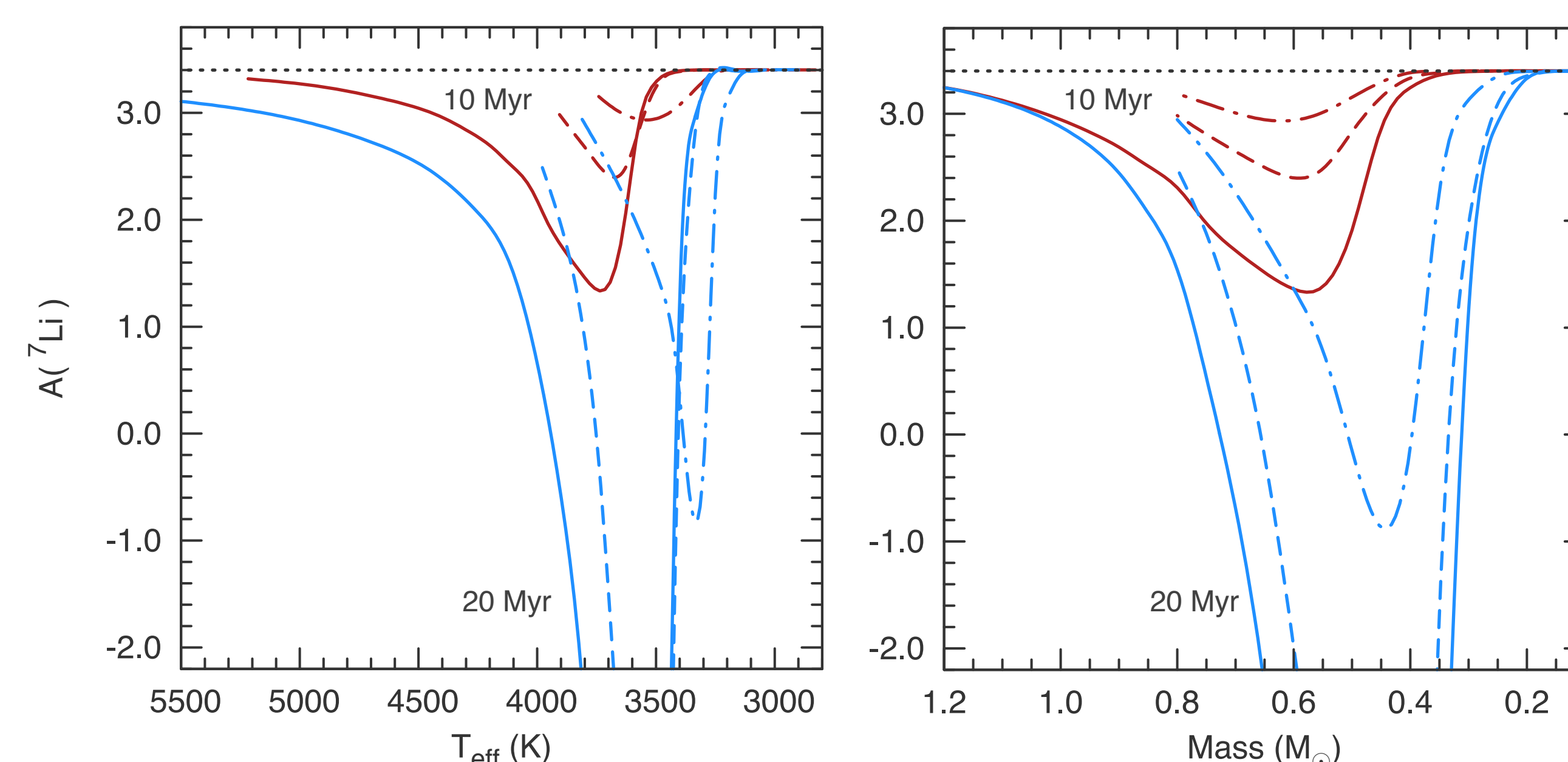
Magnetic Isochrones

Isochrones developed with constant magnetic field strength from pre-MS to MS.



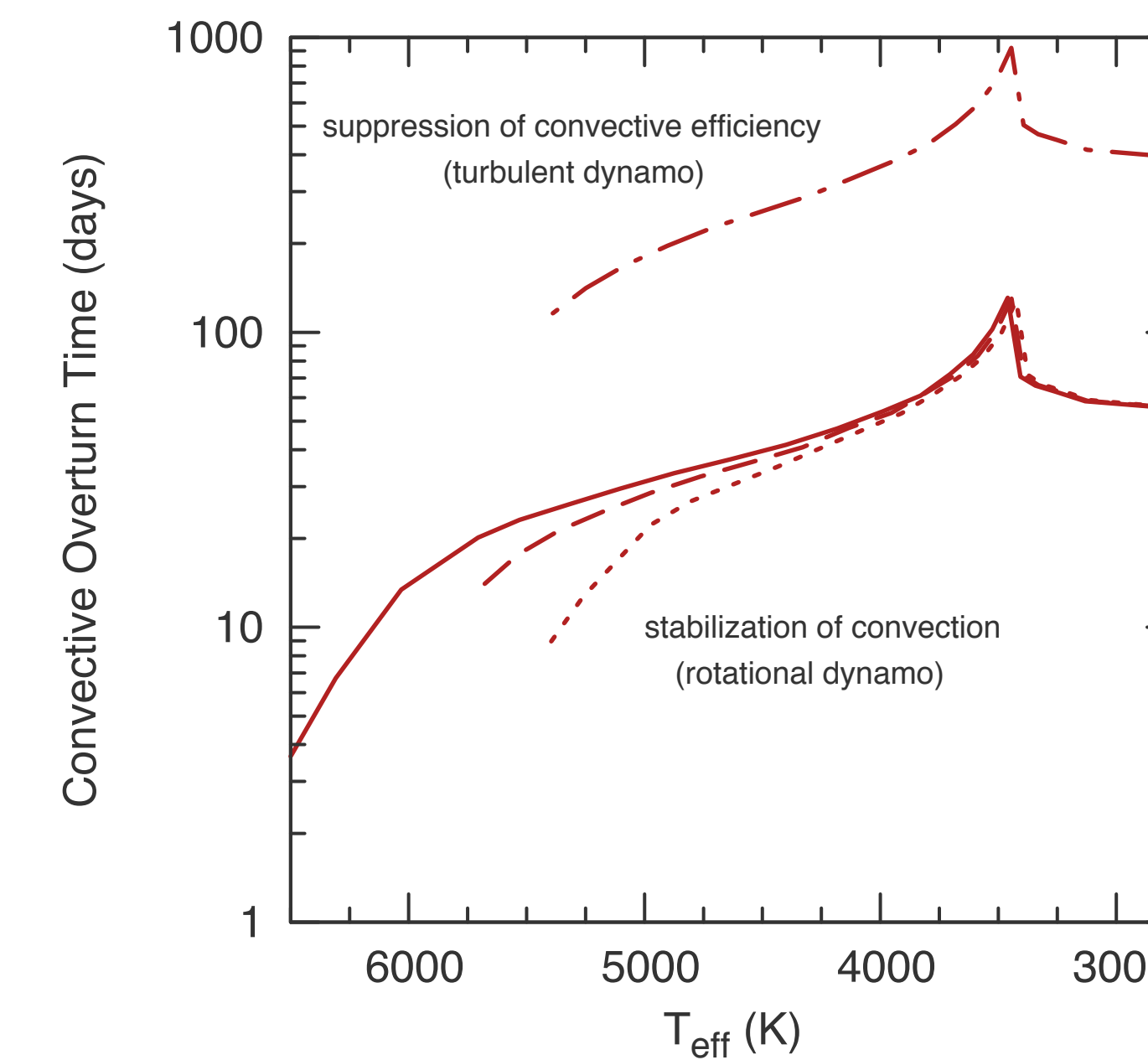
Lithium depletion profiles

Magneto-convection shrinks the convection zone and reduces lithium depletion



Convective overturn timescales

Convective overturn times impacted by magneto-convection on MS.



Future work

Finish the grid and make it publicly available:

- Pre-MS models
 - ▶ Additional mixing lengths
 - ▶ Expand metallicity range
- Magnetic models
 - ▶ Fix numerical instabilities at young ages
 - ▶ Expand metallicity range
- Fuse non-grey atmosphere models with interior code
 - ▶ Dartmouth + MARCS
 - ▶ Incorporate magnetism in atmosphere