(Rev)AMP: update methods for stellar parameter estimation

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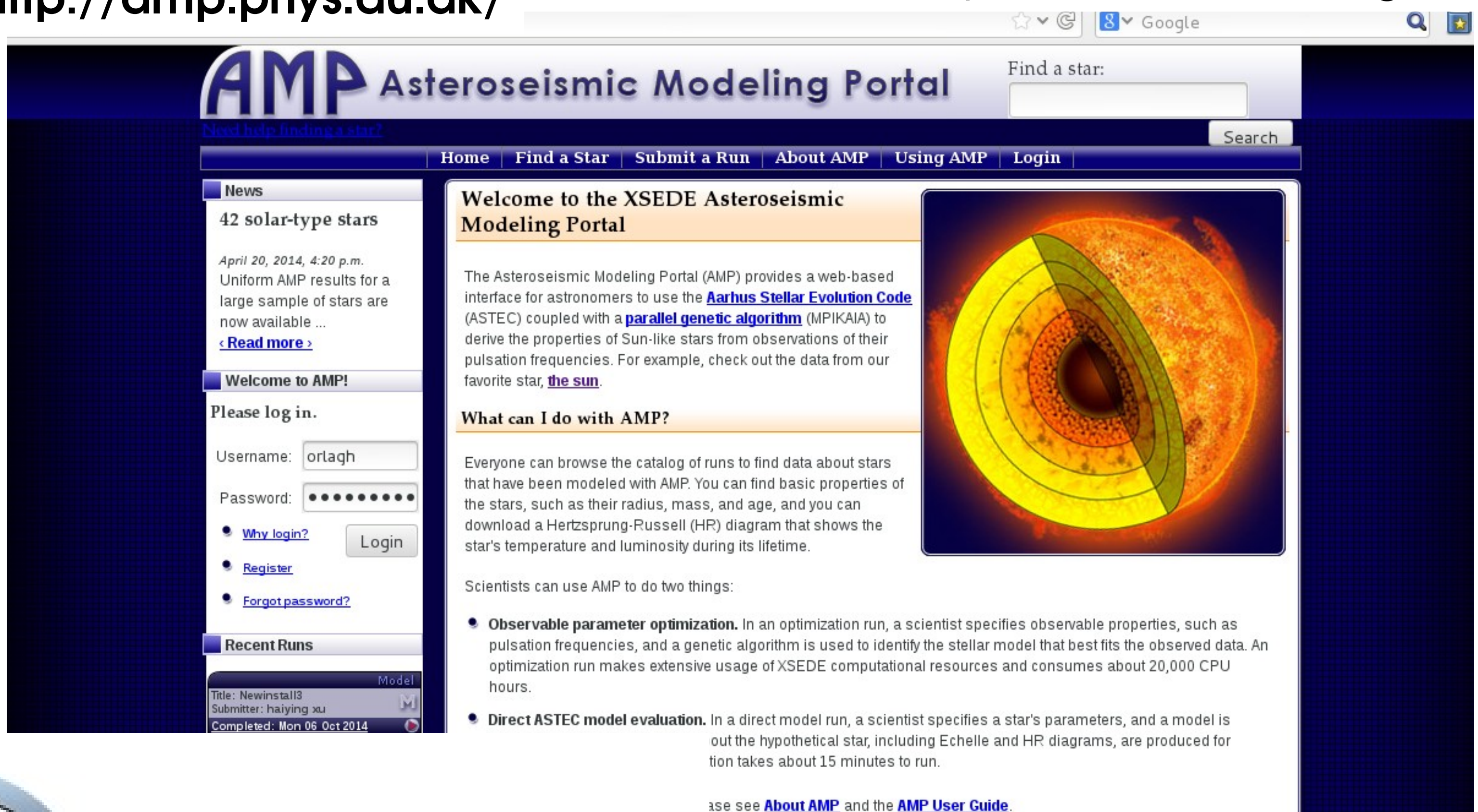
http://amp.phys.au.dk/

Metcalfe, Creevey, Christensen-Dalsgaard 2009



Observables - Parameters

INPUT

- Frequencies
- Atmospheric params
- Diameters
- Distance

OUTPUT

- Mass
- Radius
- Age
- Luminosity...
- + uncertainties/correl

Method

- GA combination of encoded params: 126 x ($Y_i Z_i M\alpha$)
- Evolution track + oscillations, optimization Dn, n0
- Comparison of freq ratios* by 'Chi2' (using cov mat)

$$\chi^2 = (x - x_M)^T C^{-1} (x - x_M)$$

- Comparison of other input params 'Chi2'
- Save output and 'fitness'
- GA recombination by 'mutations' and 'evolution' to determine next 126 combinations (200 gen. Total)

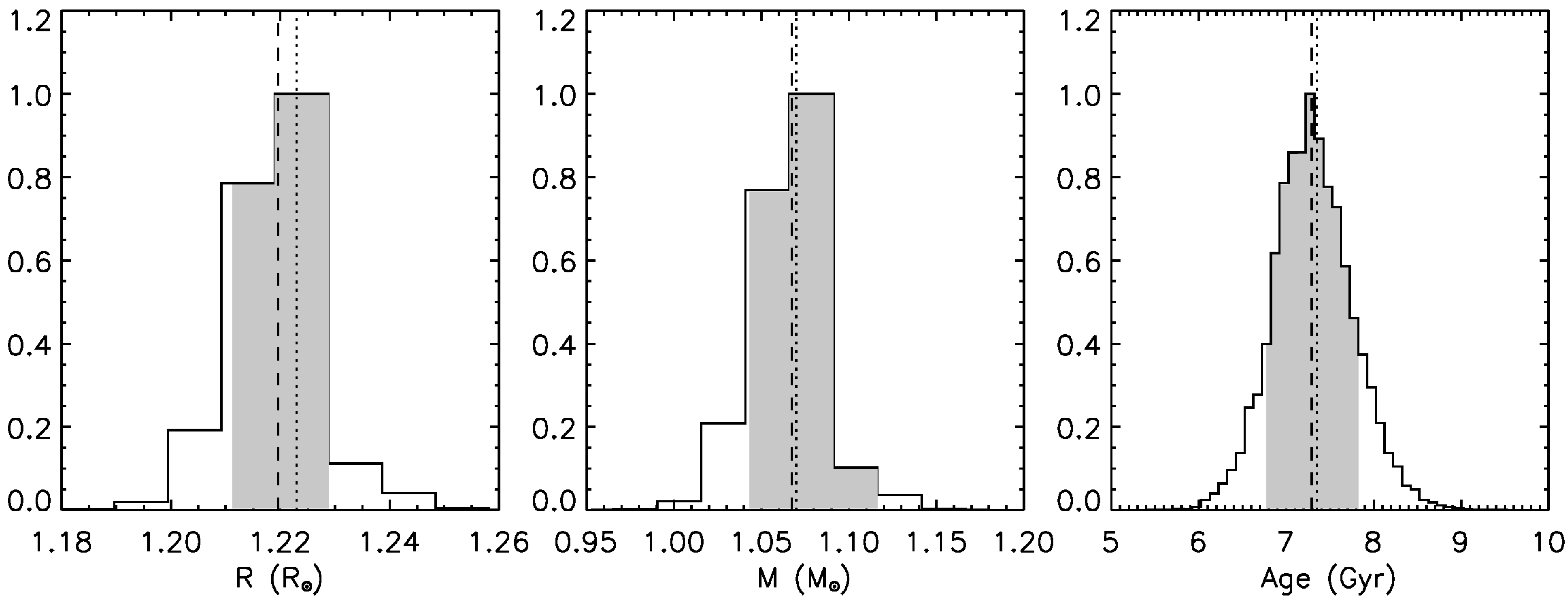
* or individual frequencies, or mix of both

Post-processing

- GA Optimal model from 4 independent runs
  - Frequencies, ratios, radius, ...
- Full evolution of GA recorded
- Uncertainties by two methods:
  - Chi2 limit
  - Likelihood
- Mean parameters $\langle \boldsymbol{P} \rangle$, $\boldsymbol{\sigma}$ and (mod'd) optimal model $\boldsymbol{P}_{OPT}$
- Use as final results or starting point for refinement or exploration of other physics

Likelihood

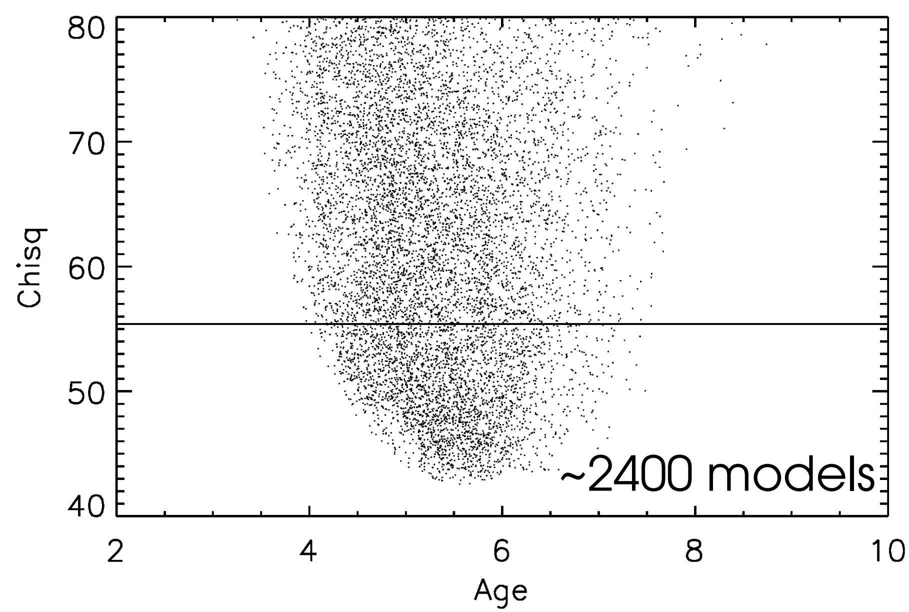
Creevey, Metcalfe, et al. In prep



$$\mathcal{L} = \mathcal{L}_{\rm seis} \cdot \mathcal{L}_{\rm T_{eff}} \cdot \mathcal{L}_{\rm [M/H]}$$

Chi2 limit

- Filter by complementary constraints (2sigma, for ex)
- Determine degrees of freedom
- Calculate confidence interval limit for 95%
- Determine range of parameters, e.g. Rmin Rmax, for all models within criteria
- If one model way out, ignored, otherwise use (max-min)/4 as sigma.



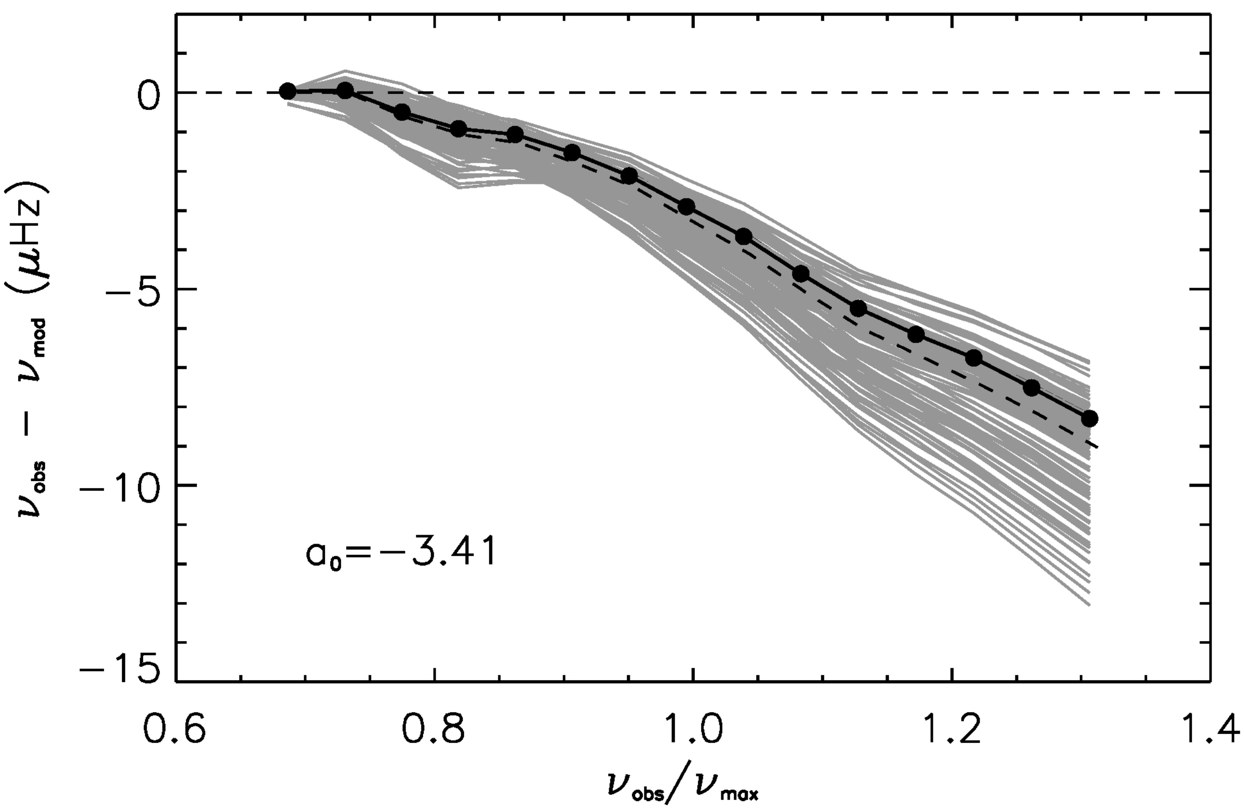
Sun

Creevey, Metcalfe, et al. In prep

	AMP_1	AMP_2	AMP_3	AMP_4	$\langle P \rangle$	σ
R ($R_\odot$)	1.002	1.003	1.003	1.010	1.001	0.009
M ($M_\odot$)	1.01	1.01	1.01	1.03	0.995	0.031
Age (Gyr)	4.59	4.38	4.41	4.69	4.54	0.28
Z_i	0.019	0.021	0.020	0.024	0.017	0.002
Y_i	0.266	0.281	0.278	0.282	0.265	0.023
α	2.16	2.24	2.24	2.30	2.12	0.12
L ($L_\odot$)	0.96	0.99	0.99	1.00	1.00	0.04
$\log g$ (dex)	4.441	4.439	4.439	4.442	4.439	0.004
χ^2	1.047	0.968	0.995	1.058		

Sun

Creevey, Metcalfe, et al. In prep



Advantages

- Automatic, requires input ascii file (freq + ..)
- Full exploration of parameter space for 1 set of physics
- Simple implementation of core ovrsht and diffusion (1/0)
- "Fast" =
  - local implementation 24-36hours MS (4x20cpu, but 4 stars simult!)
  - AMP < 1 day MS/sG (4x127cpu)
- Currently configured with AMP, to be configured with MESA
- GA evolution logged

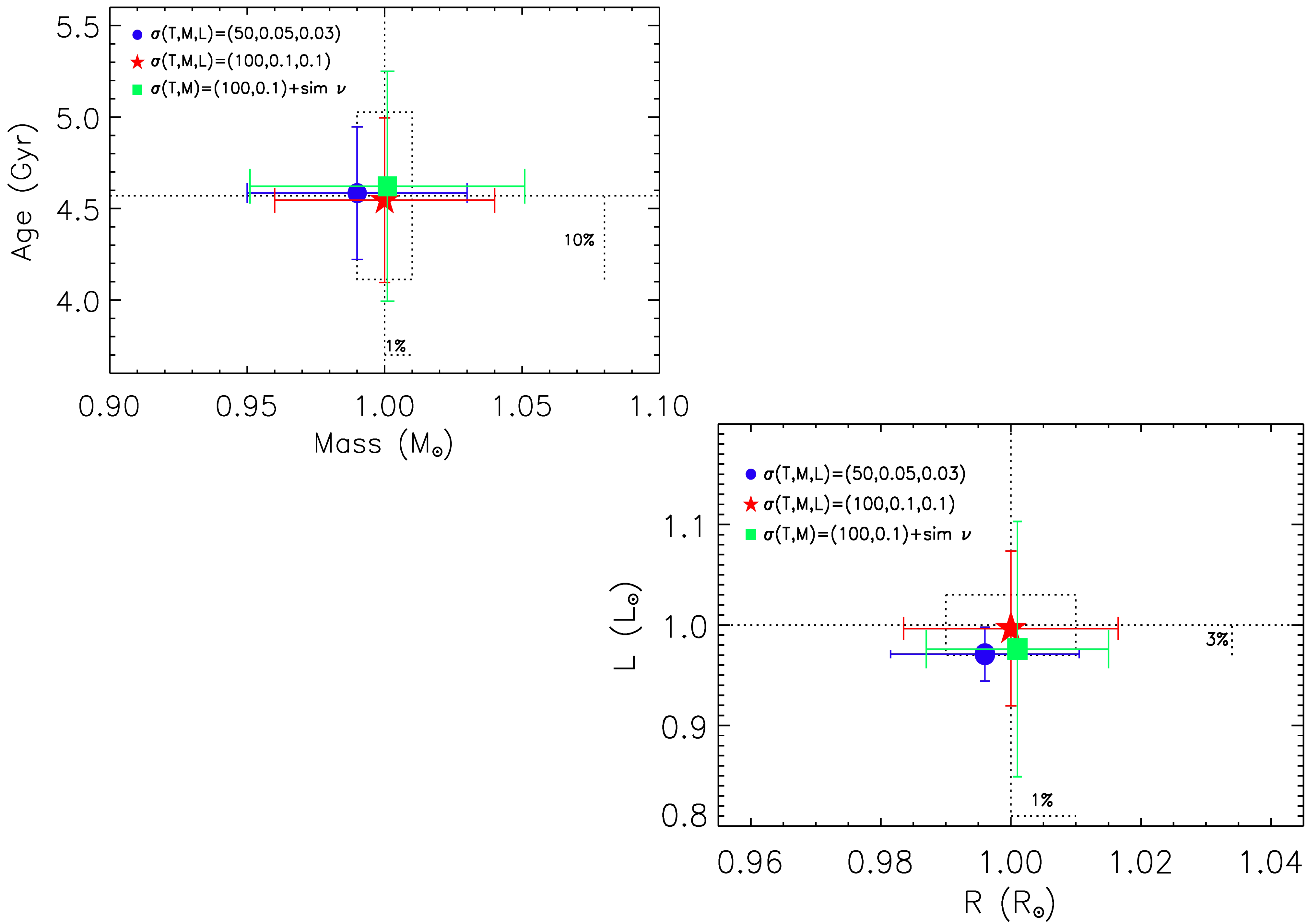
Disadvantages

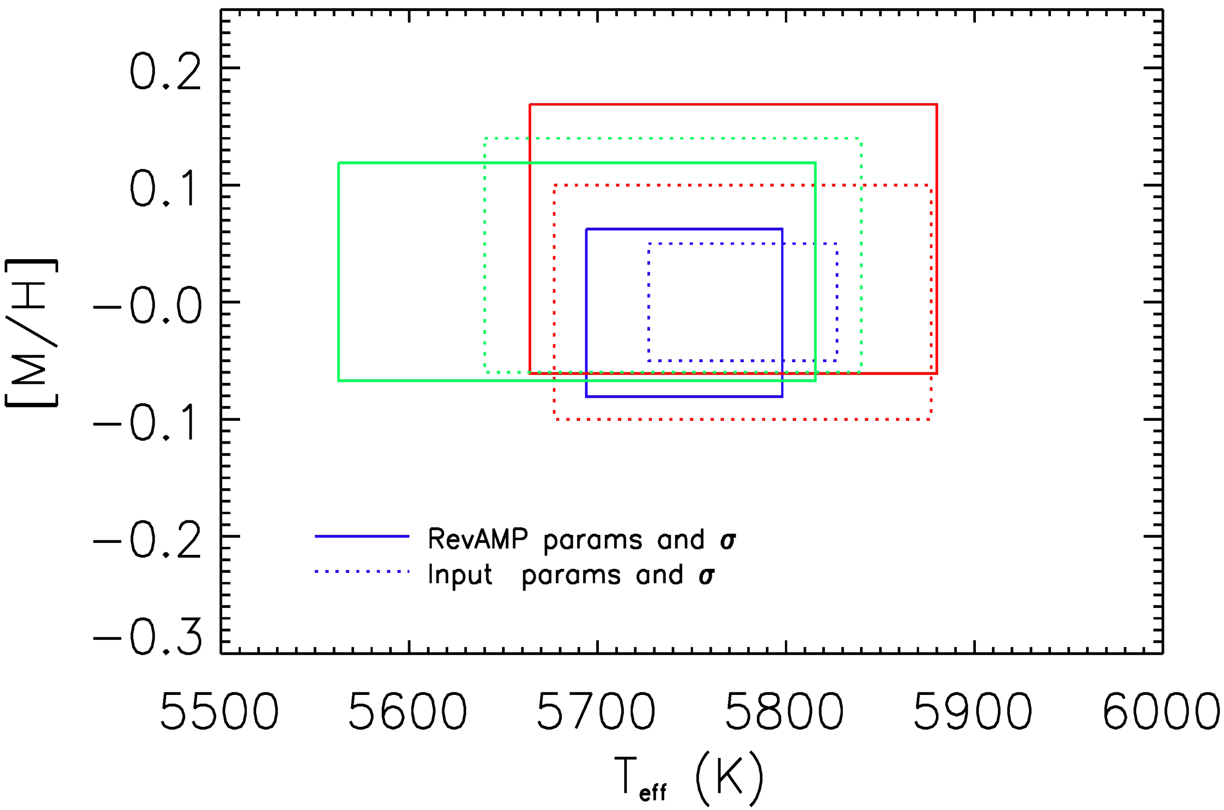
- Require matching lowest frequency to ~1-2 mu Hz (H&H2)
- Changing more physics, more difficult but mesa
- "black-box" ish, but algorithm easy to modify (F77)
- "Long" so important to monitor runs (but robotic with shell scripts)
- High and Low Yi initial chemical composition (no Z diff)

Next steps

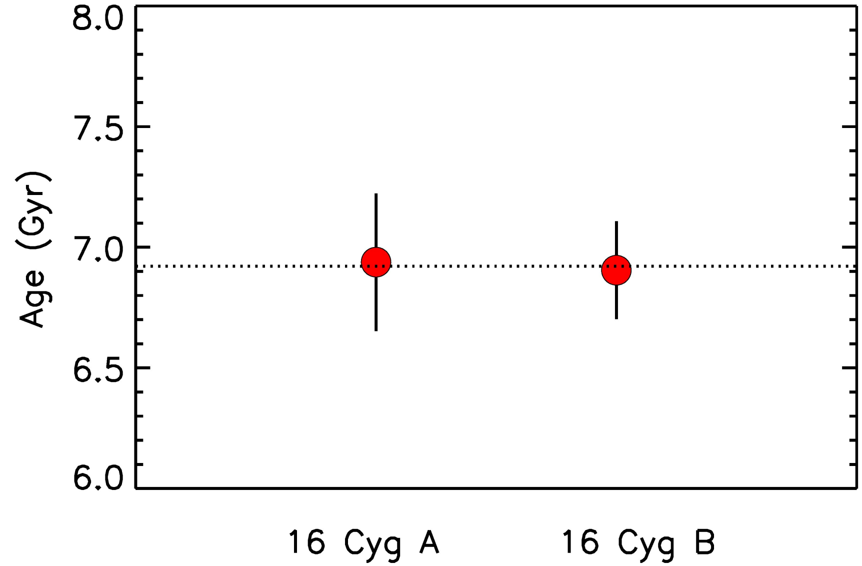
- Rerun H&H again
- MESA implementation
- Tests on fixing of base frequency
- Tests on limiting Yi
- Uncertainties -> f77 (currently offline IDL)

Thank you!

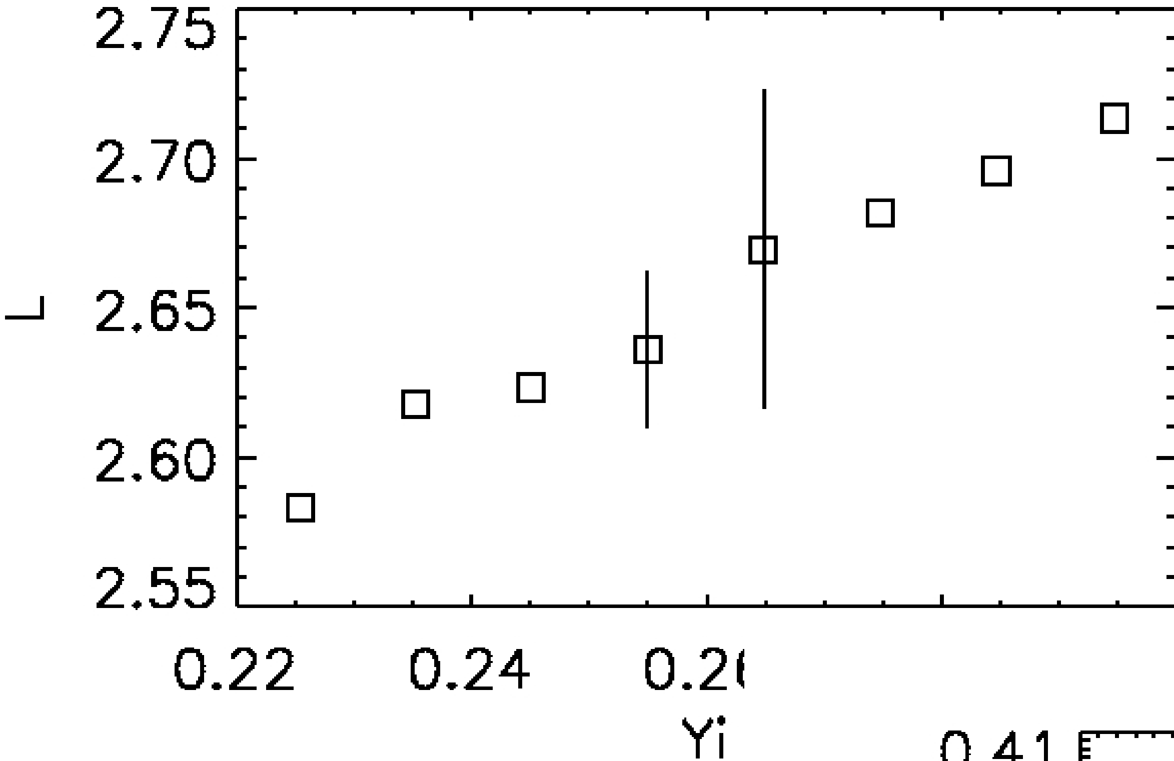

σ(T,M,L)=(50,0.05,0.03)
σ(T,M,L)=(100,0.1,0.1)
σ(T,M)=(100,0.1)+sim ν
10%
1%
Age (Gyr)
Mass (M⊙)
5.5
5.0
4.5
4.0
0.90
0.95
1.00
1.05
1.10
σ(T,M,L)=(50,0.05,0.03)
σ(T,M,L)=(100,0.1,0.1)
σ(T,M)=(100,0.1)+sim ν
3%
1%
L (L⊙)
R (R⊙)
1.1
1.0
0.9
0.8
0.96
0.98
1.00
1.02
1.04



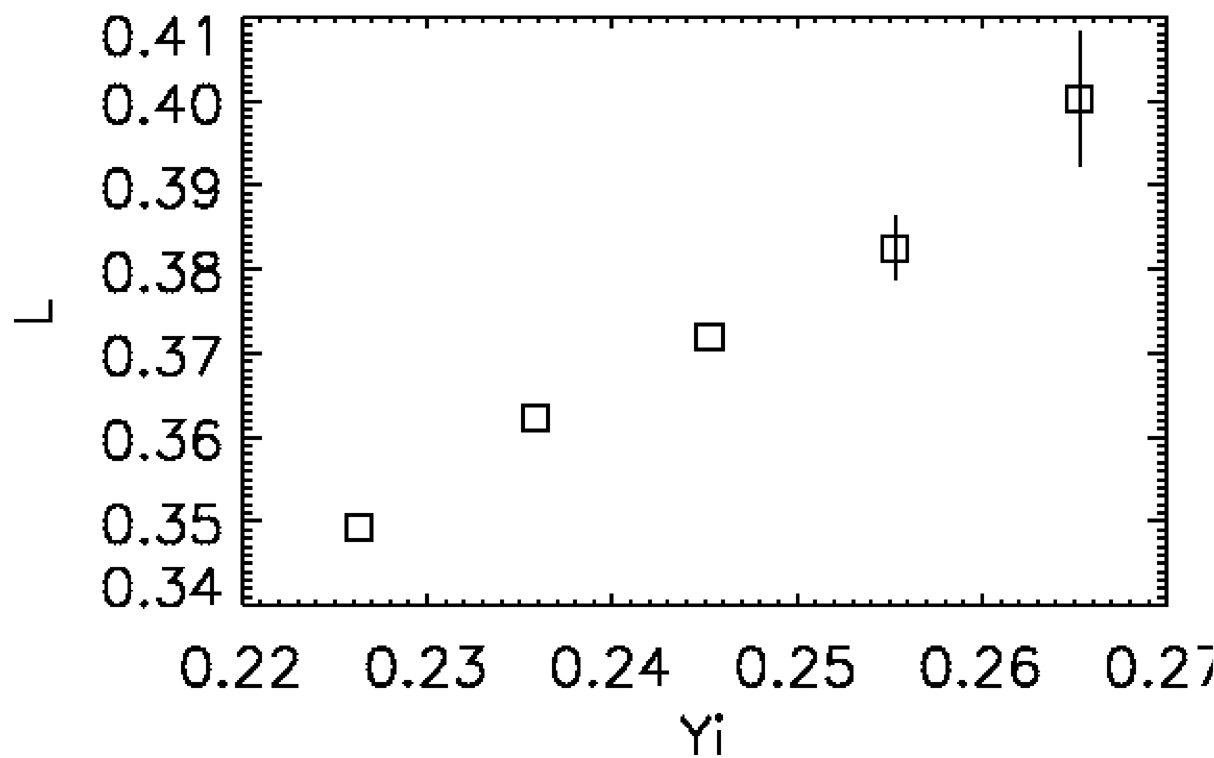
0.2
0.1
−0.0
−0.1
−0.2
−0.3
[M/H]
RevAMP params and σ
Input params and σ
5500
5600
5700
5800
5900
6000
T eff (K)



8.0
7.5
7.0
6.5
6.0
Age (Gyr)
16 Cyg A
16 Cyg B



2.75
2.70
2.65
2.60
2.55
L
0.22
0.24
0.26
Yi



0.41
0.40
0.39
0.38
0.37
0.36
0.35
0.34
L
0.22
0.23
0.24
0.25
0.26
0.27
Yi