

Uncertainties in pre-supernovae stellar models

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Mesa IV:
Paxton+, Farmer 2017

SNII LC
PPISN/PISN
+ more

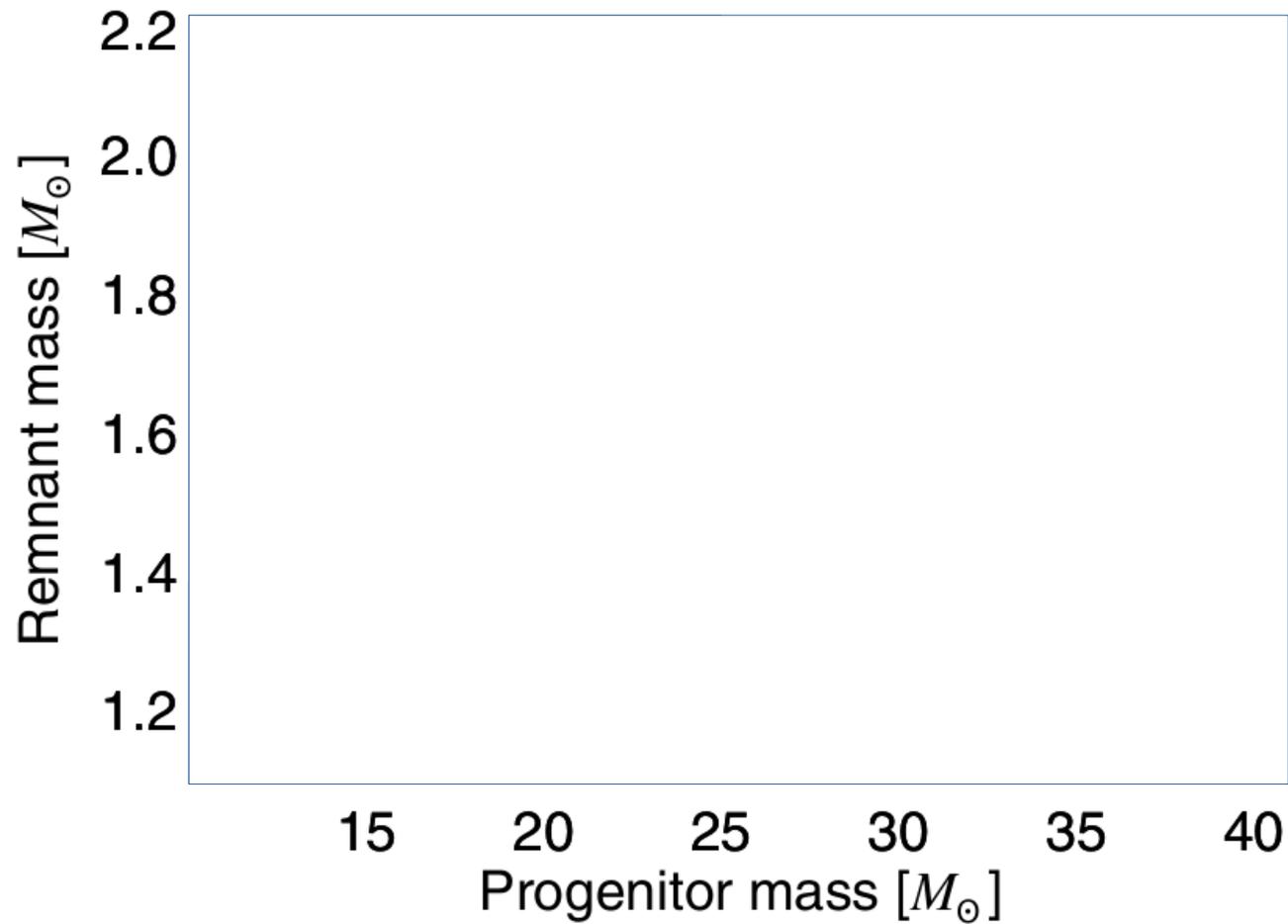
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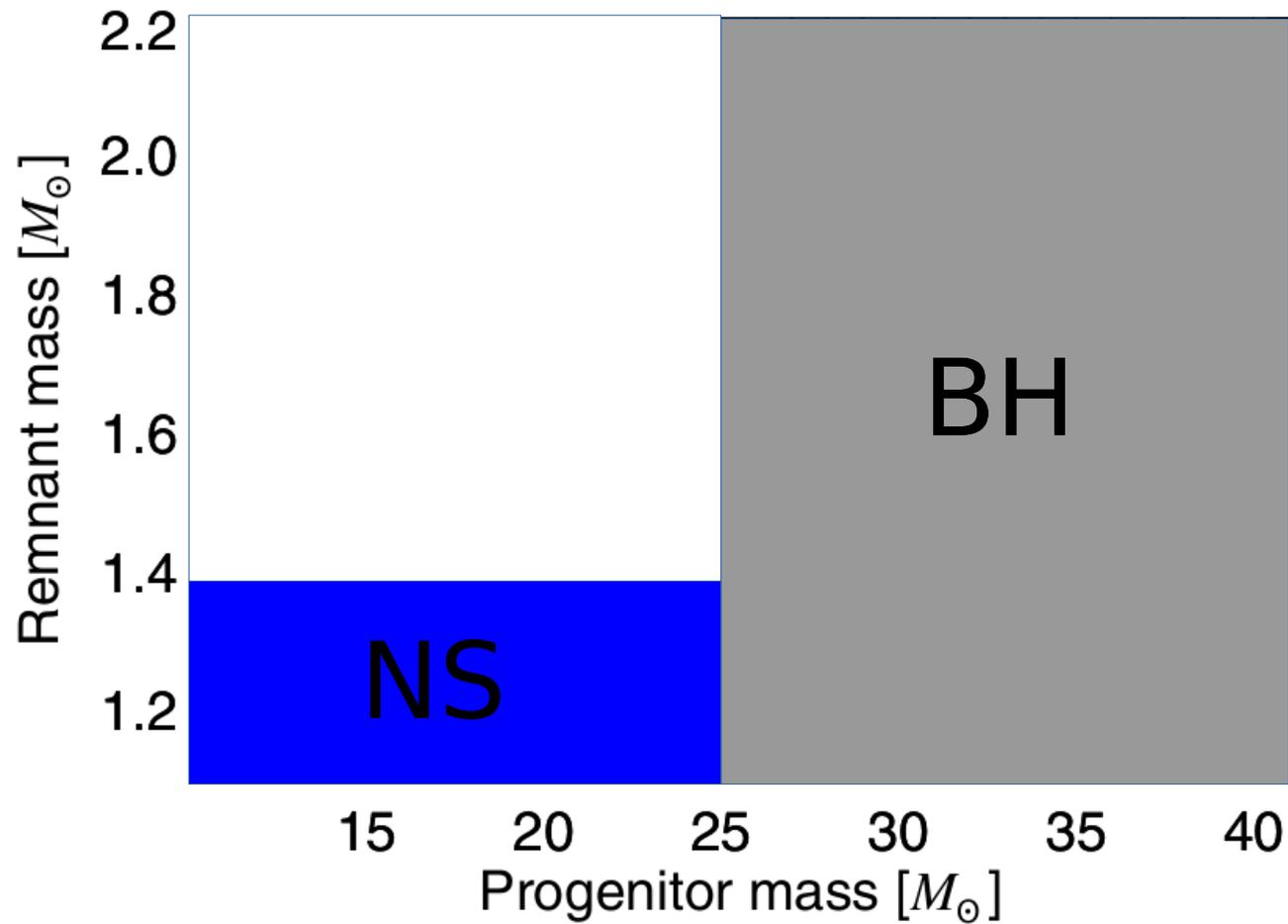


MESA

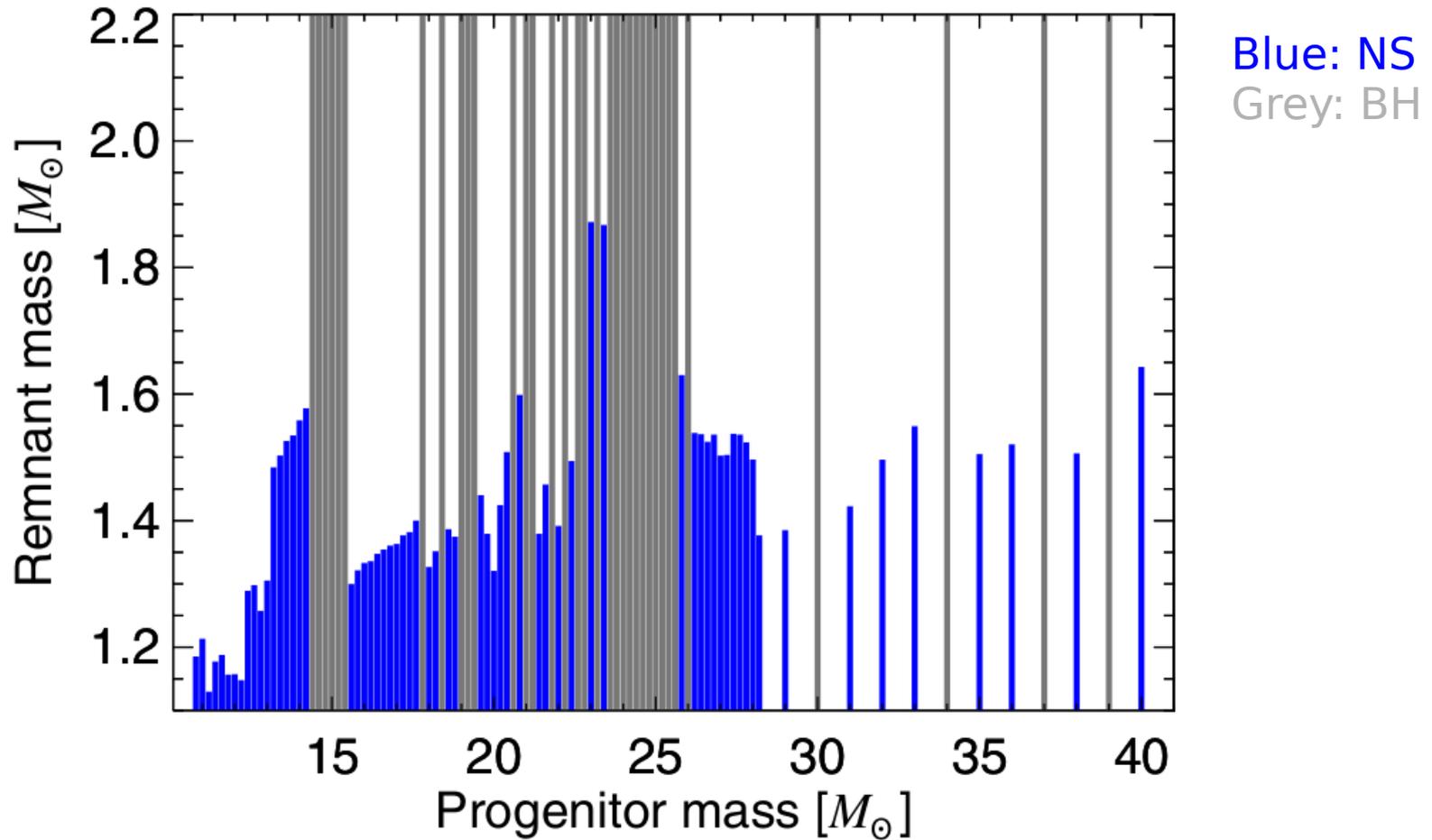
Final fate of a star



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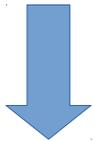
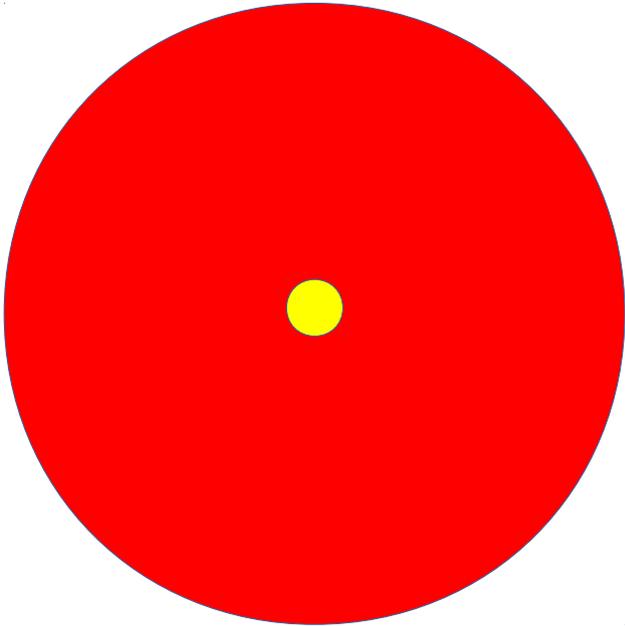
Final fate of a star



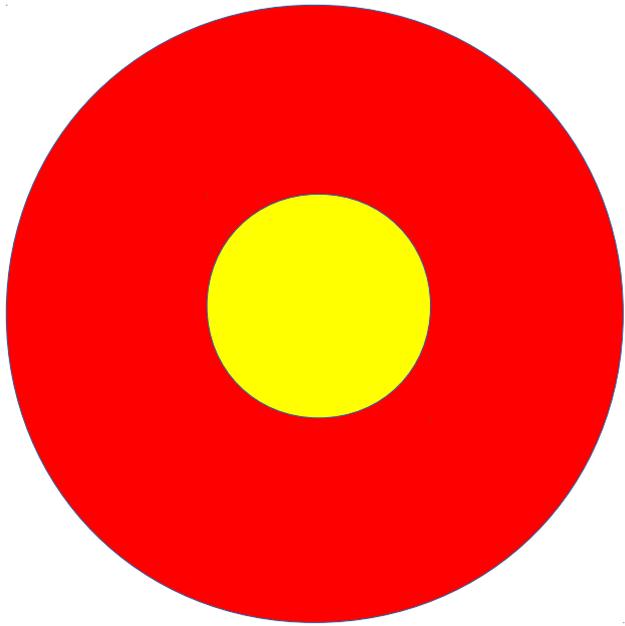
Pejcha & Thompson 2015

Also: Ugliano+ 2012, O'Connor & Ott 2013, Müller+ 2016, Sukhbold+ 2016, 2017, Ertl+ 2016

Compactness



NS

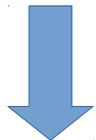
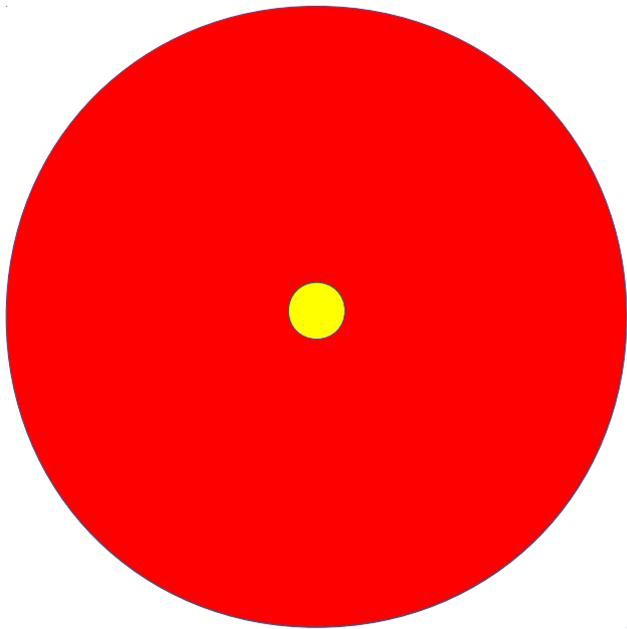


BH

*Not to scale

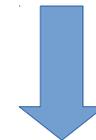
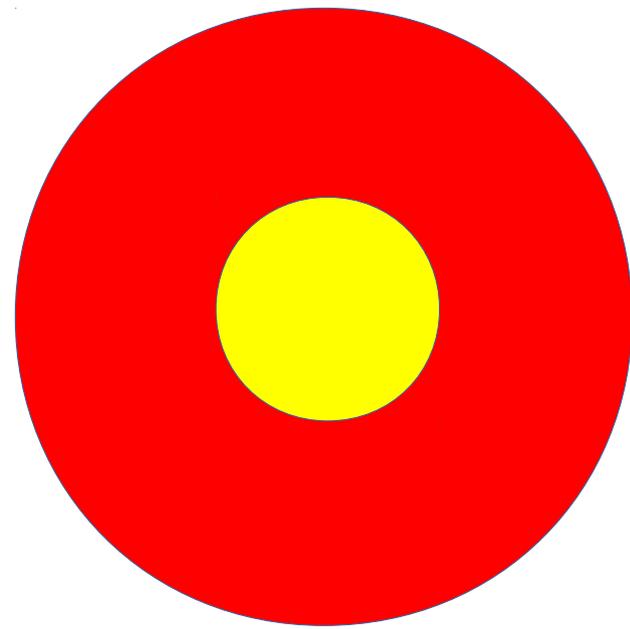


Compactness



NS

$$\xi_M = \frac{M / M_{\odot}}{R(M_{\text{bary}} = M) / 1000 \text{ km}} \Big|_{t=t_{\text{bounce}}},$$

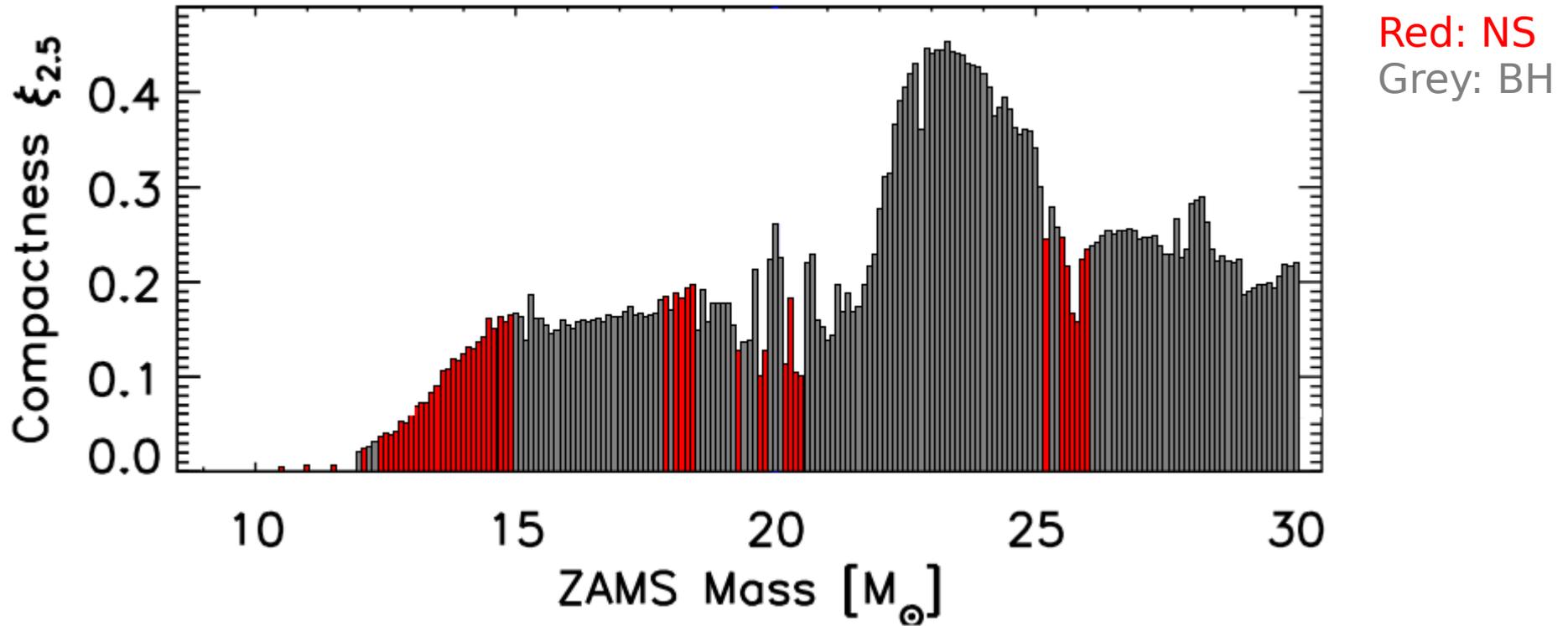


BH

*Not to scale



Compactness

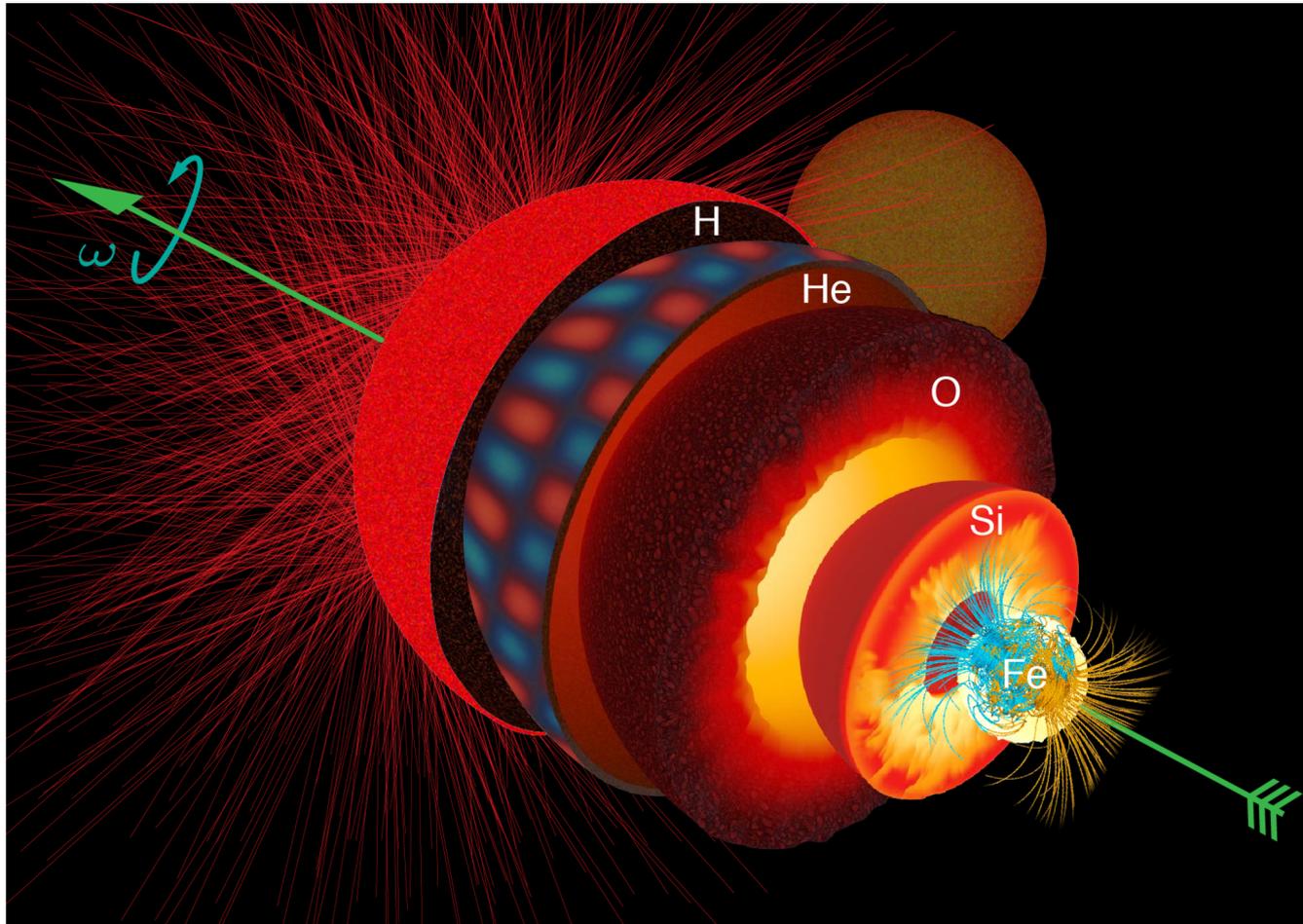


Compactness still isn't the complete picture

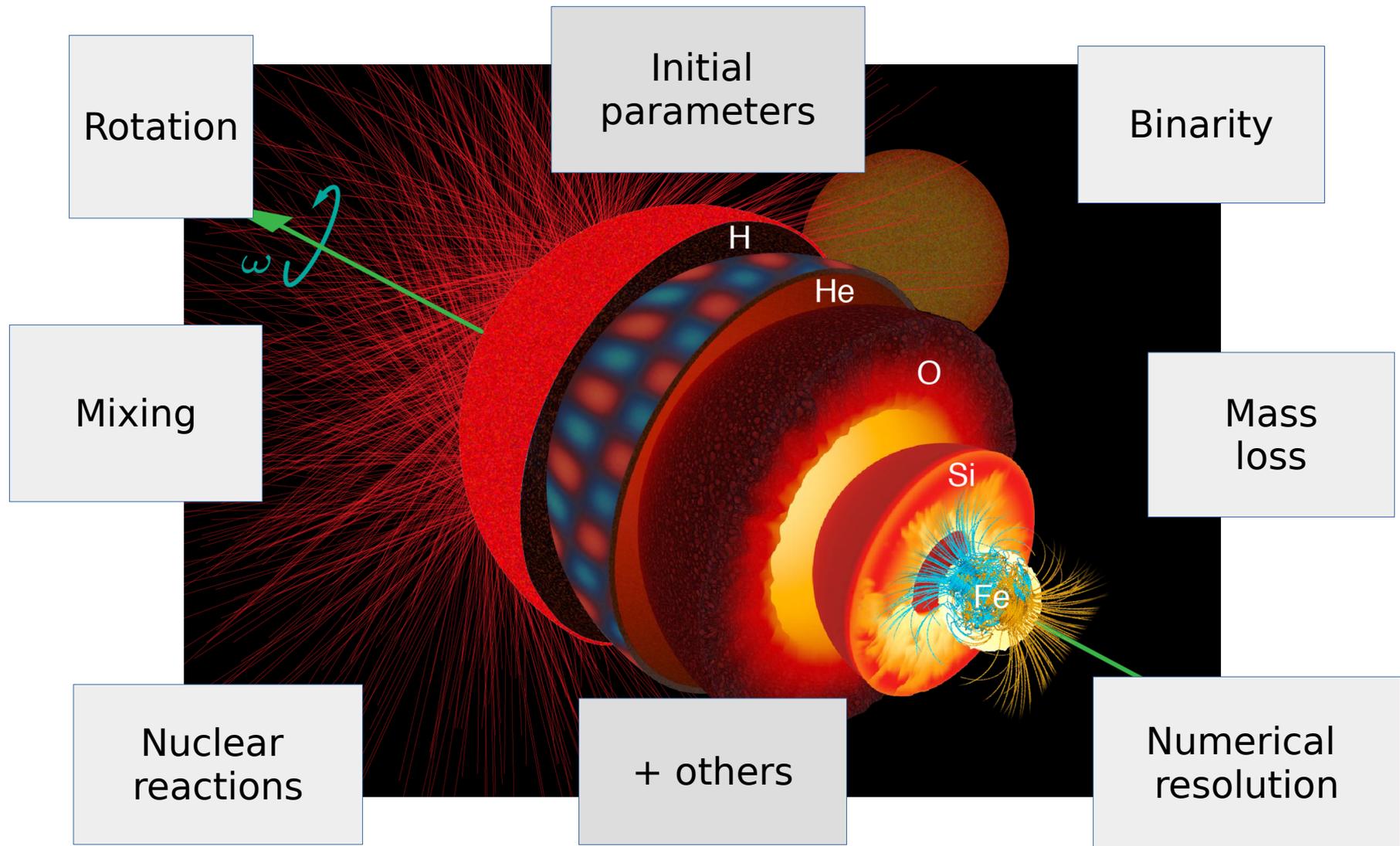
Ertl+2016



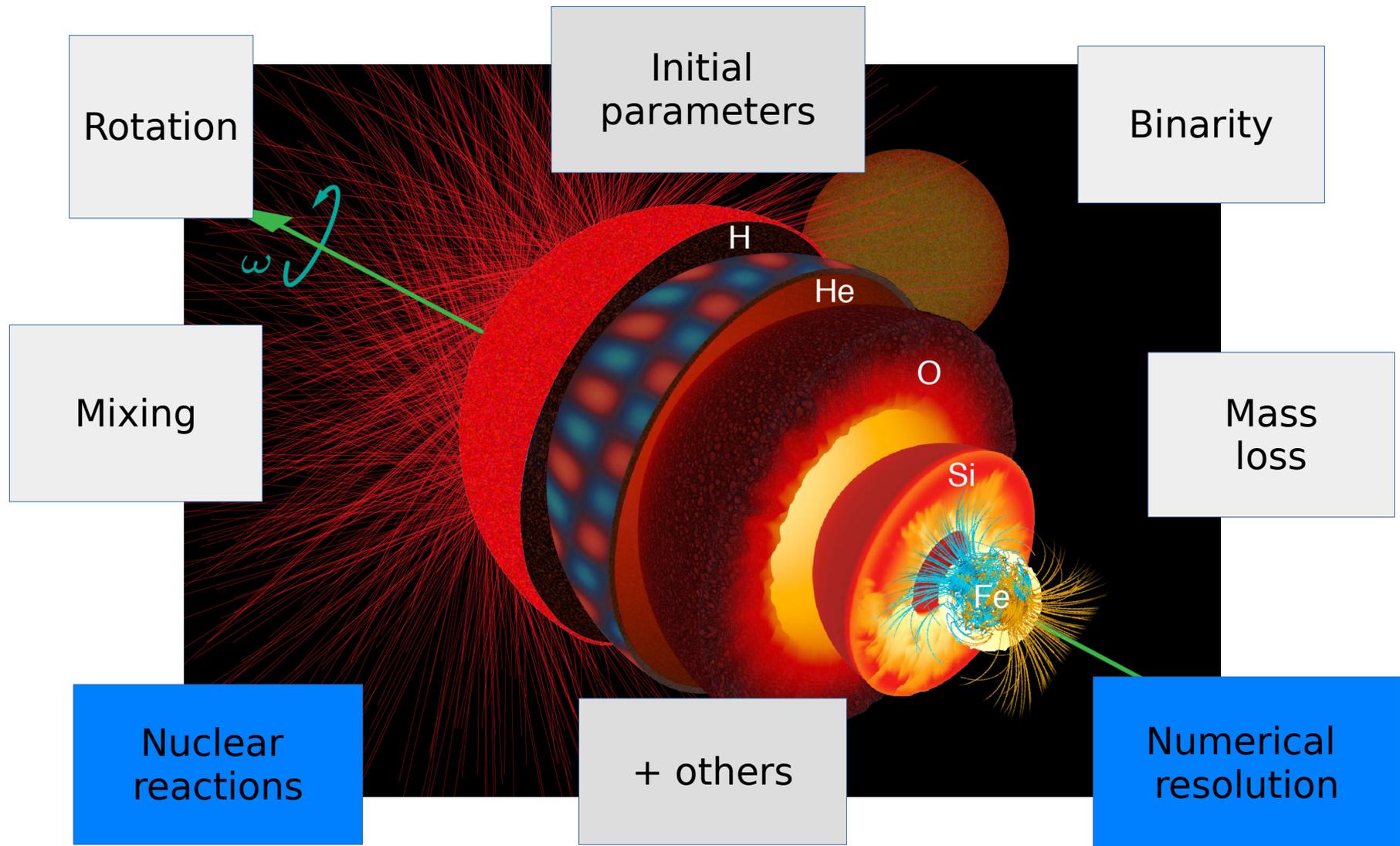
What sets the compactness?



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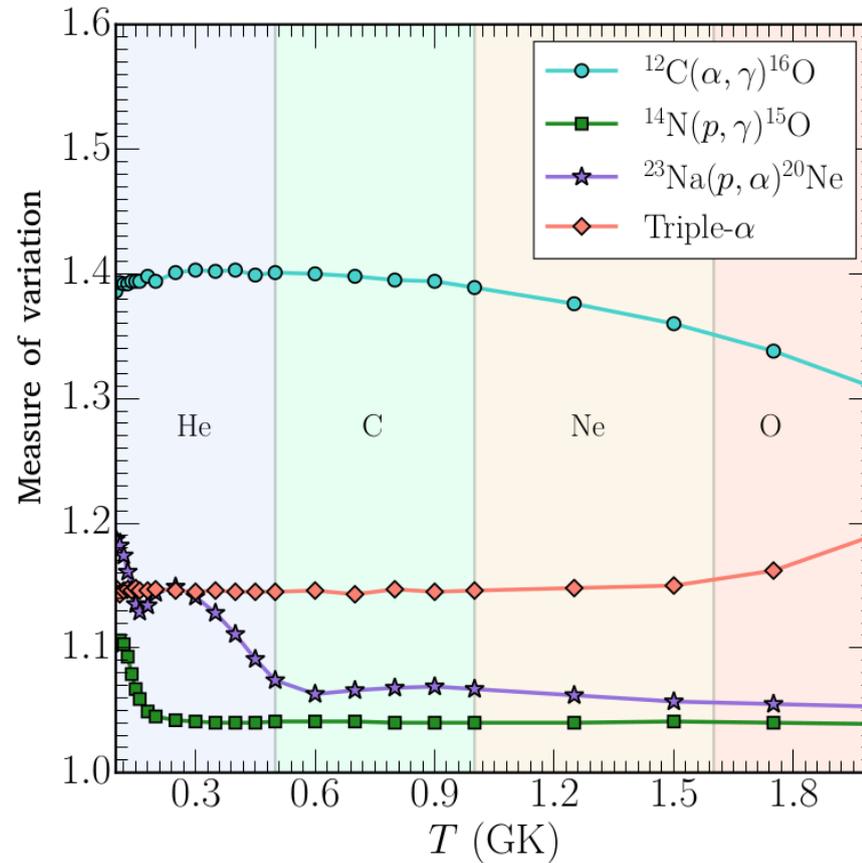


What sets the compactness?

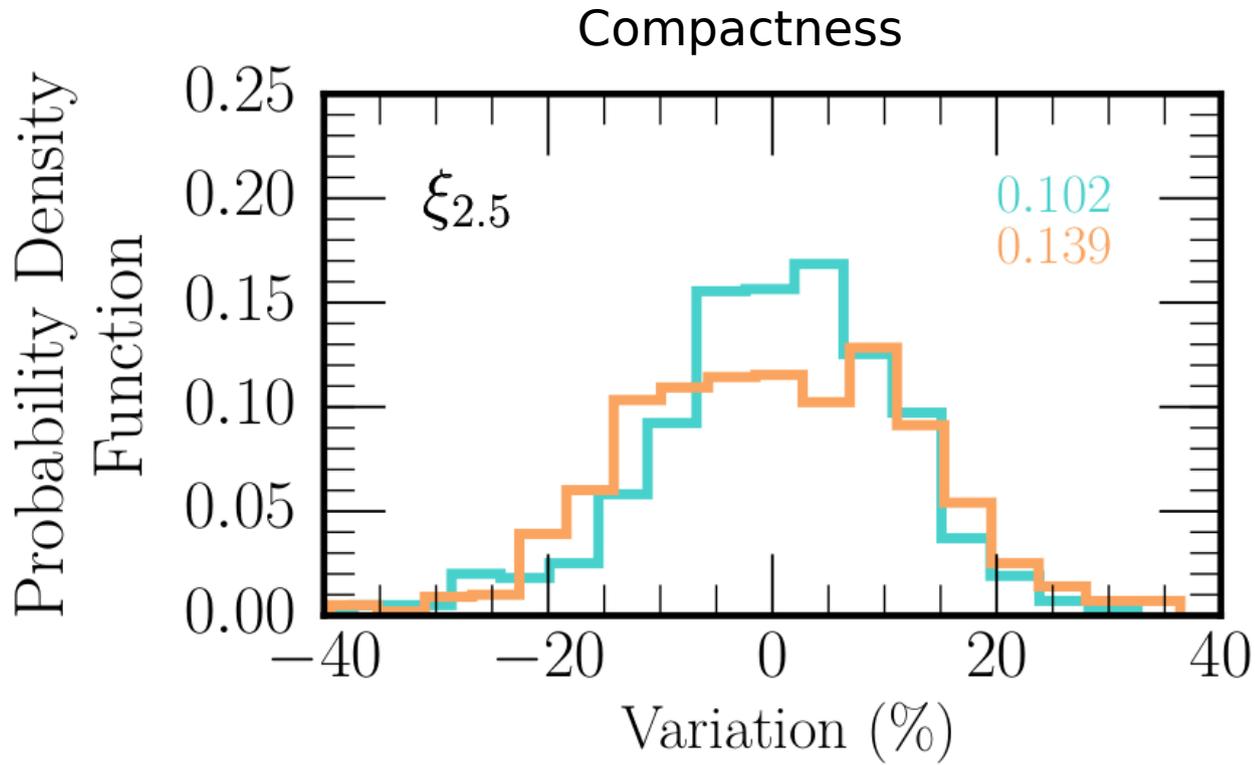


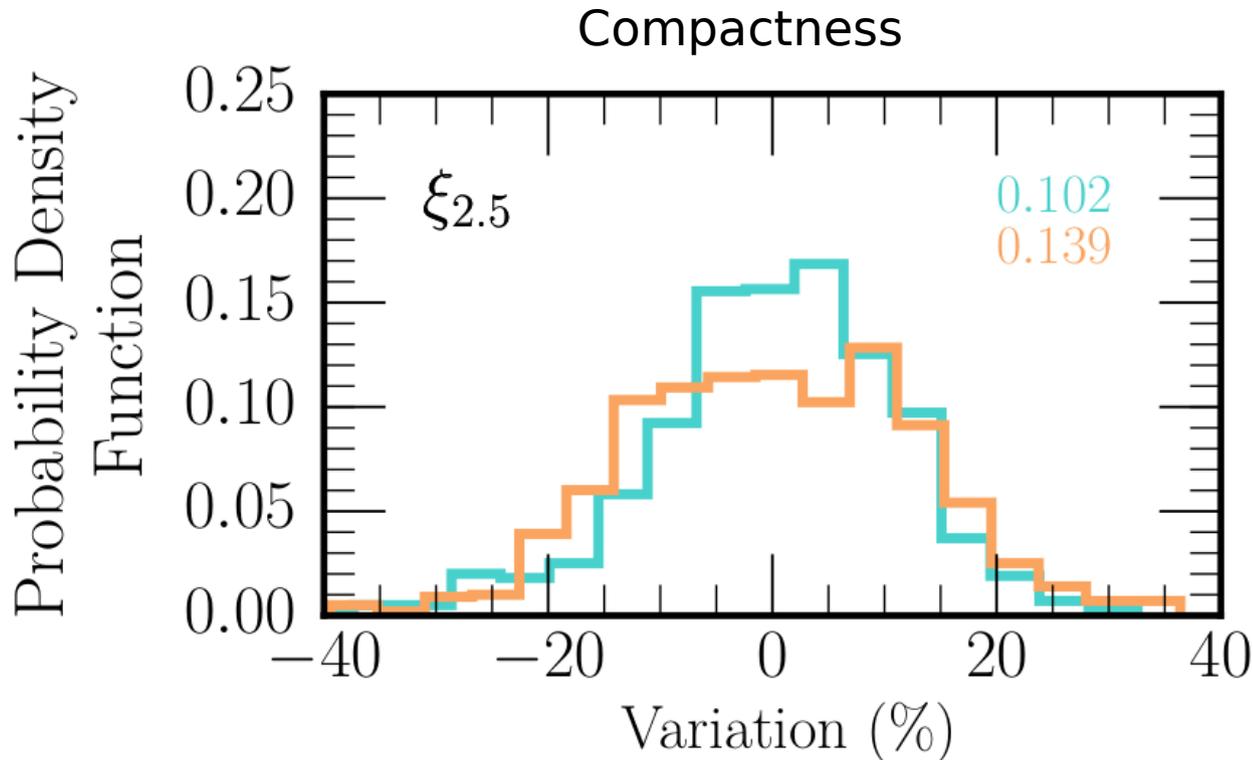
Nuclear physics

Fields+, Farmer 2017



Uncertainty in a rate varies with temperature

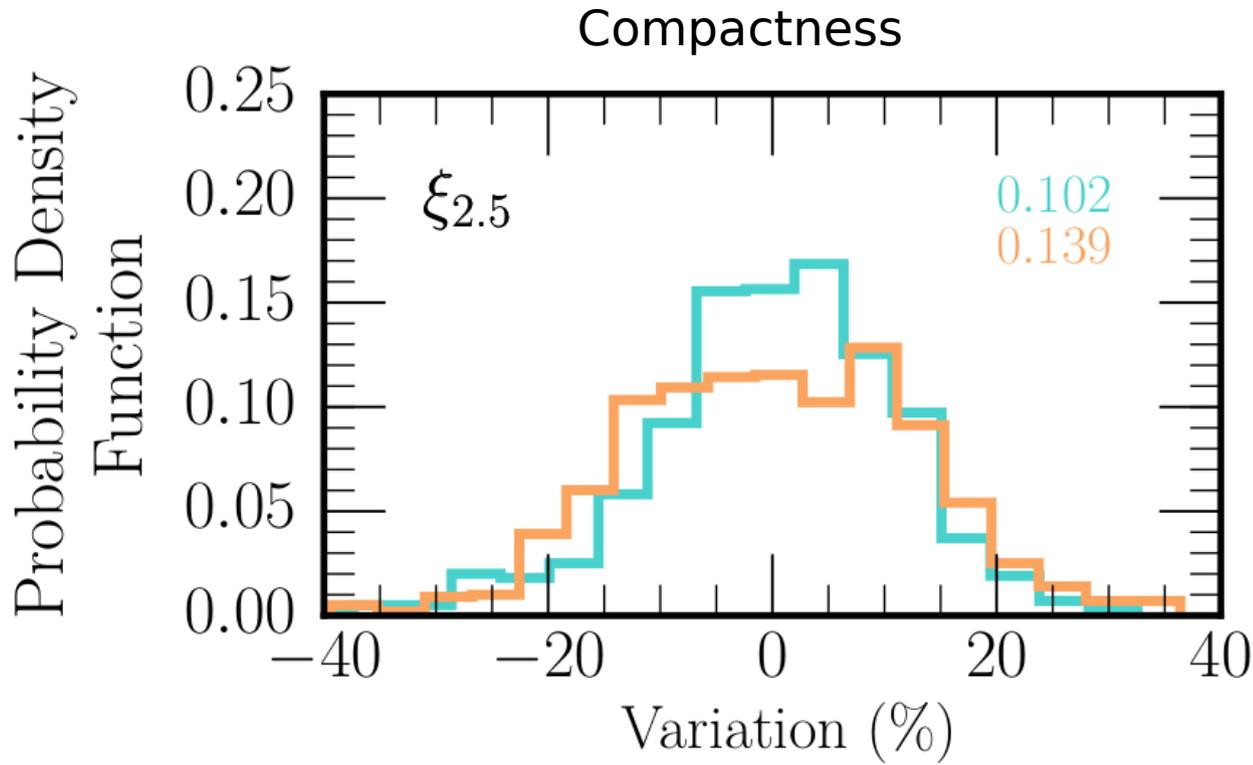




~20% variations just from uncertainties in the things we can measure in a lab

Nuclear physics

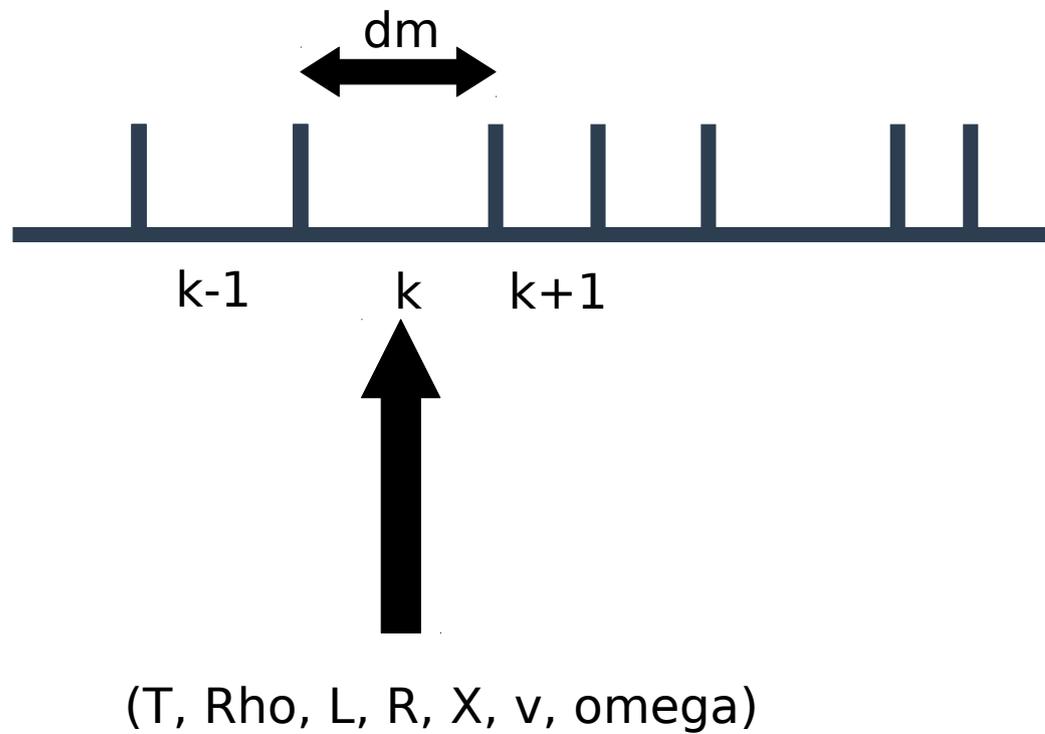
Fields+, Farmer 2017



Key rates:
12C→160, 14N→150, 15N→160, 3 α

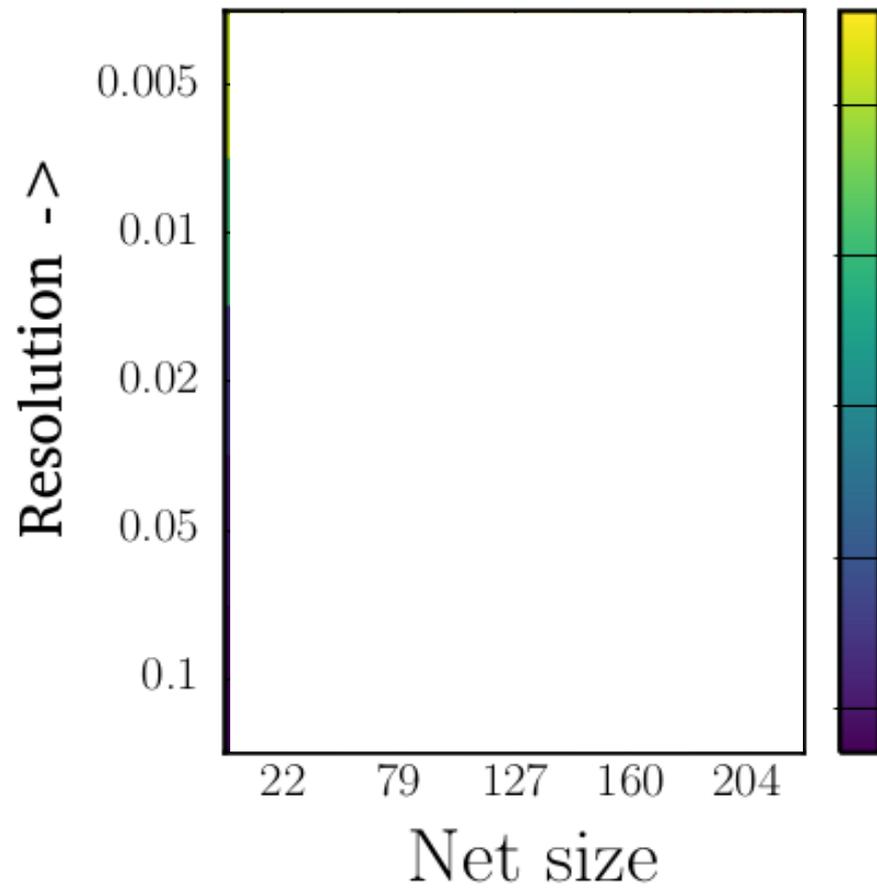
Also: West+2013, Cyburt+2016, Fields+ 2016, Rauscher+ 2016, Nishimura+ 2017, Harris+ 2017

Numerical resolution



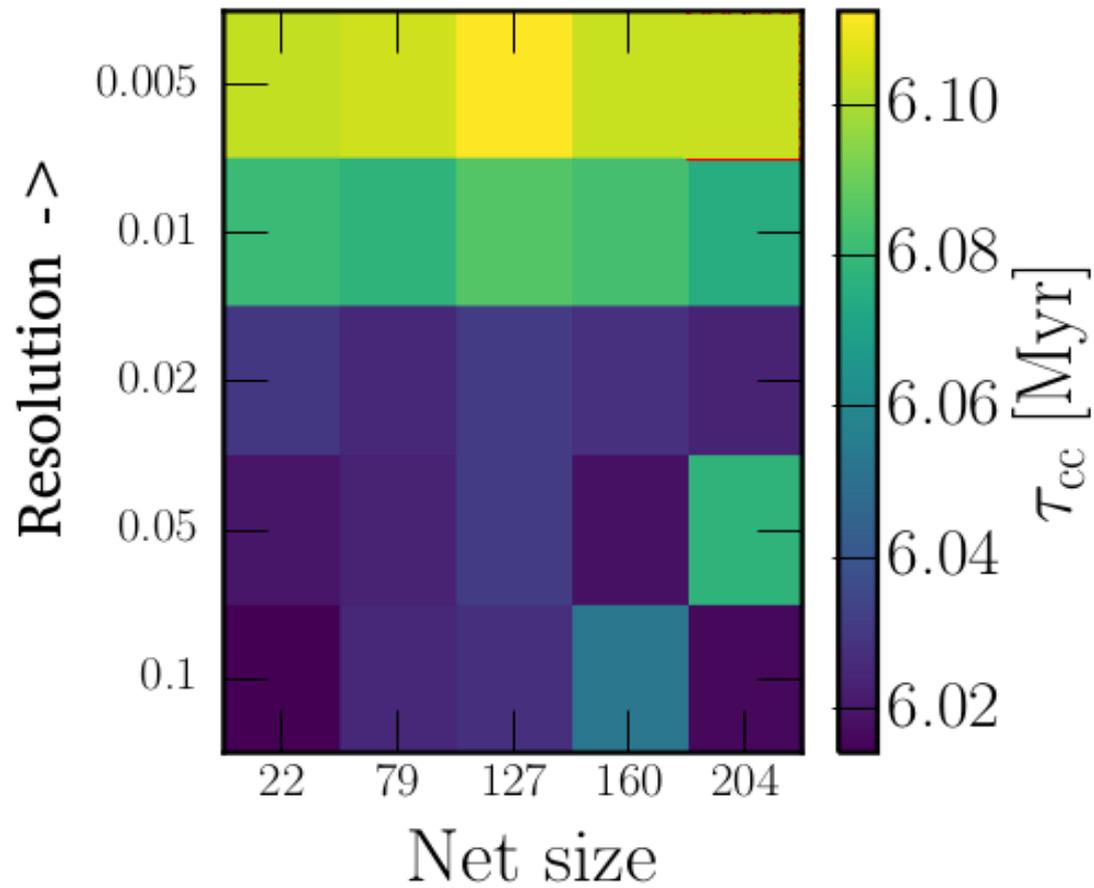
Numerical resolution

Farmer+ 2016



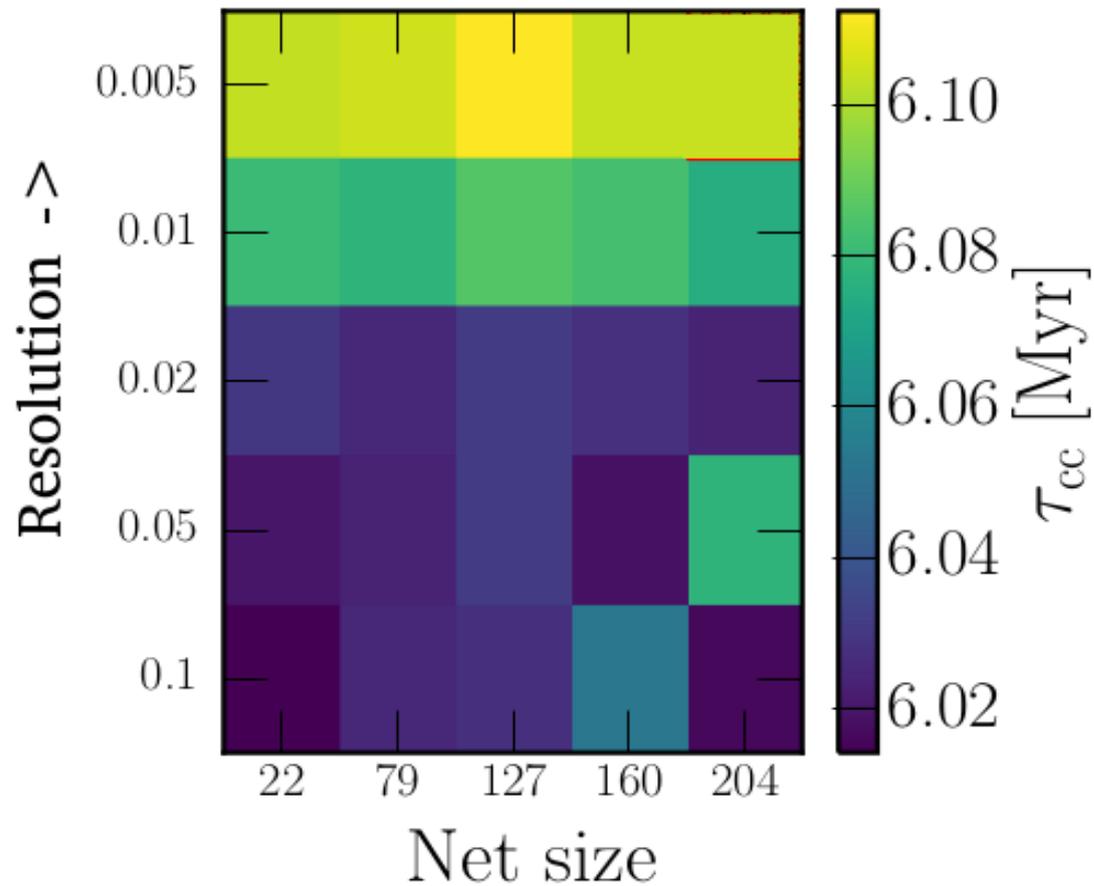
Numerical resolution

Farmer+ 2016



Numerical resolution

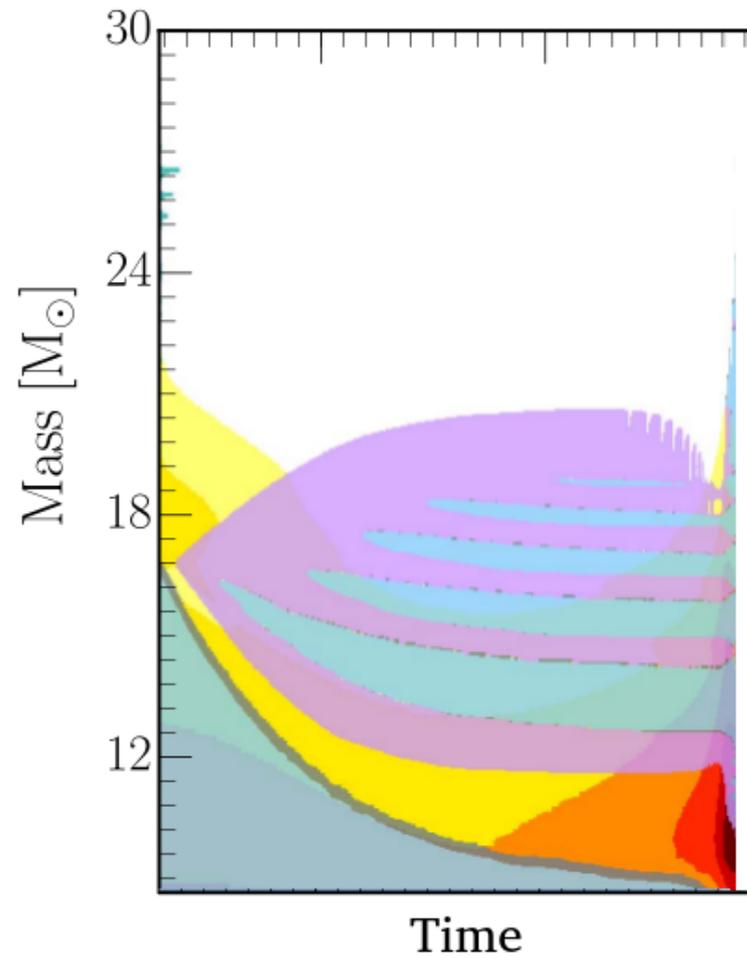
Farmer+ 2016



Stellar lifetime depends on spatial resolution

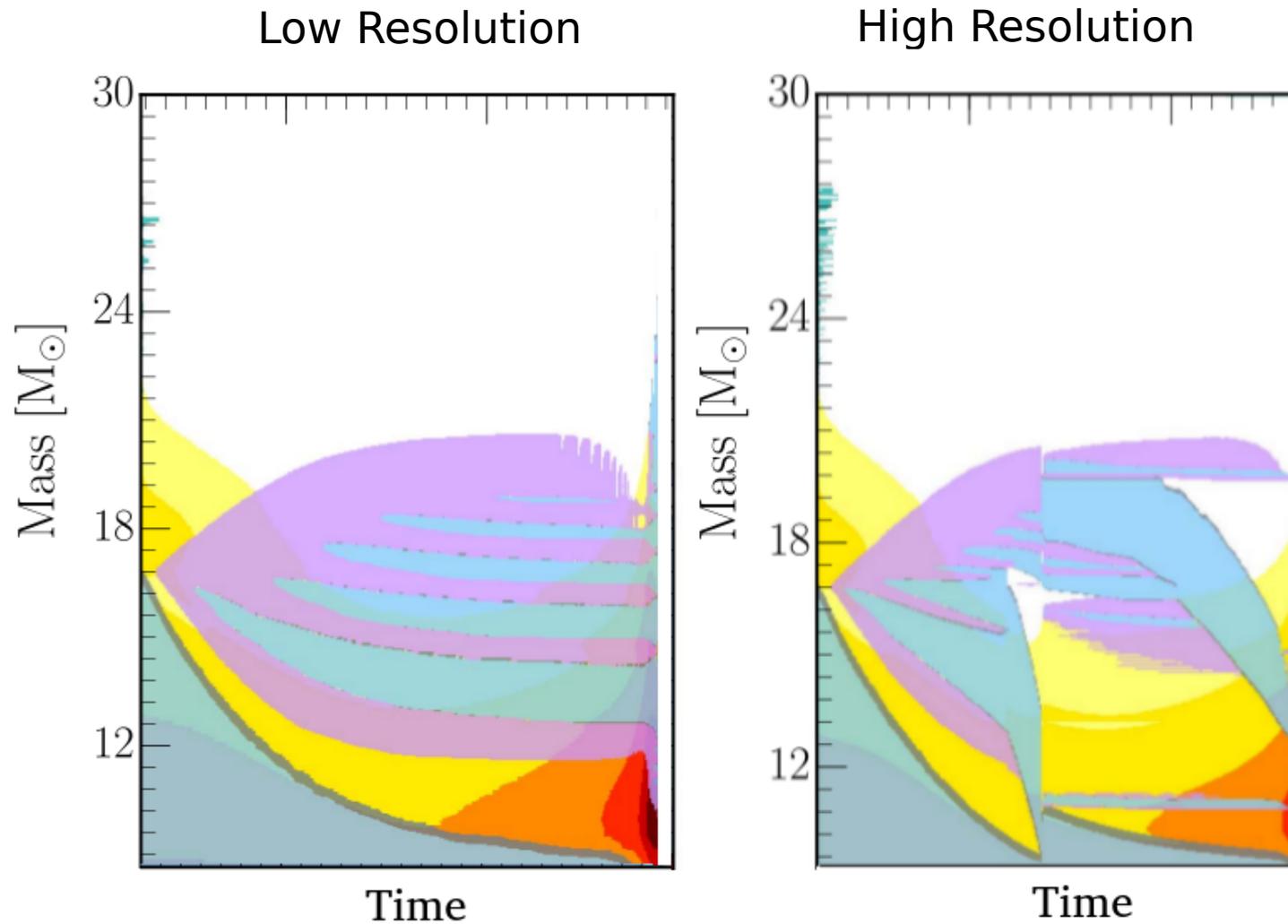
Numerical resolution

Farmer+ 2016



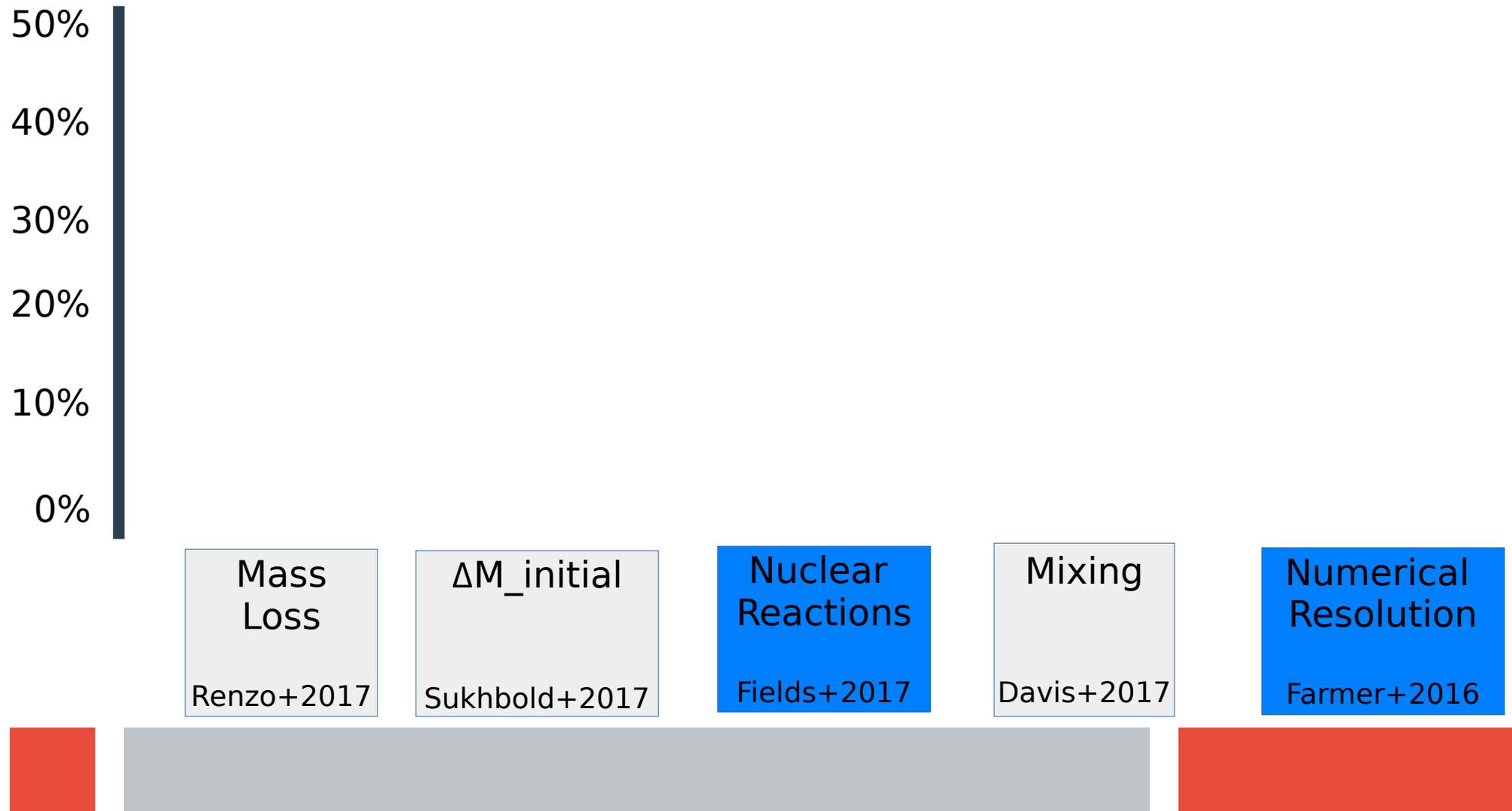
Numerical resolution

Farmer+ 2016

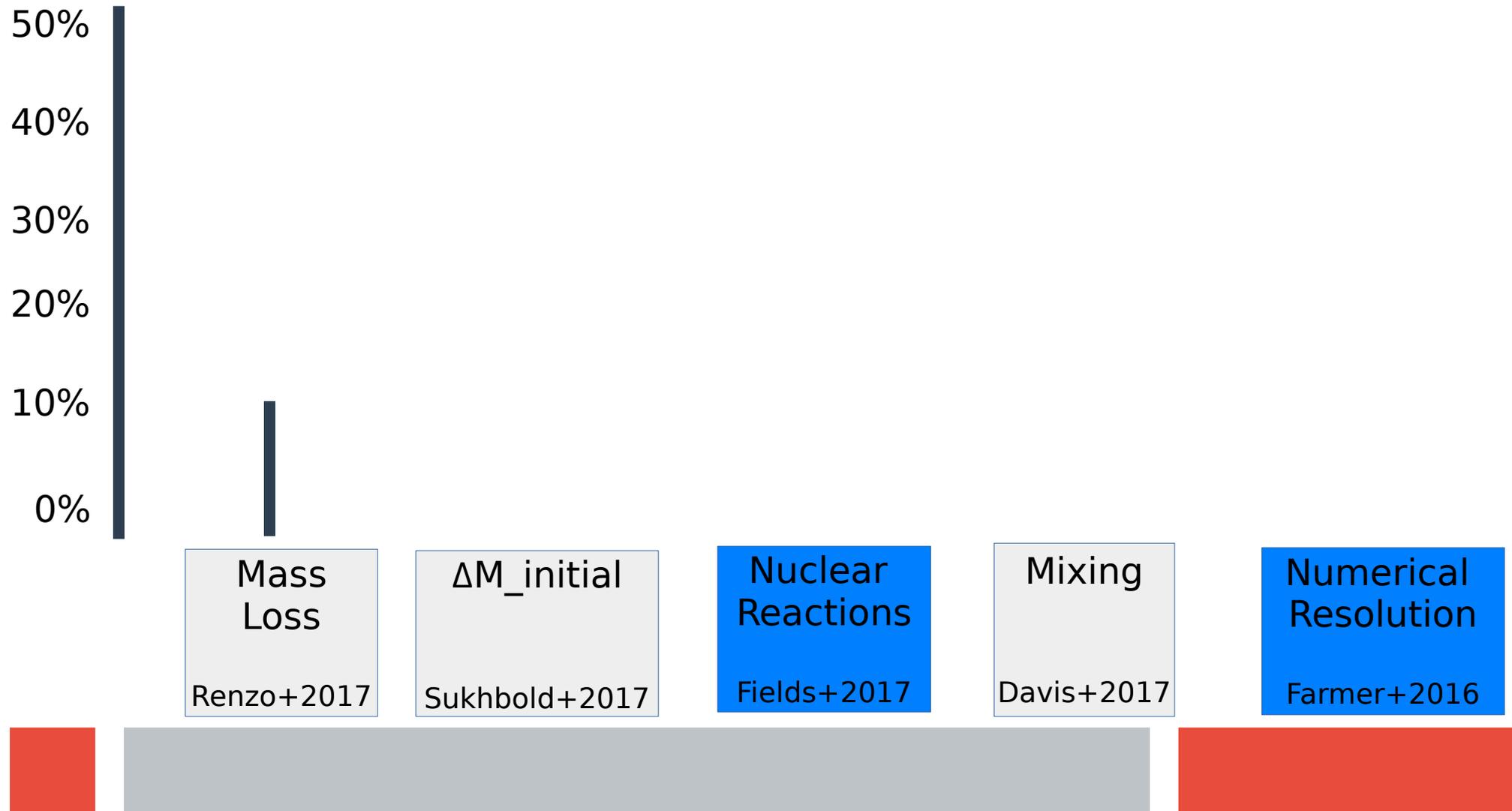


Numerical resolution changes the effective strength of semiconvection

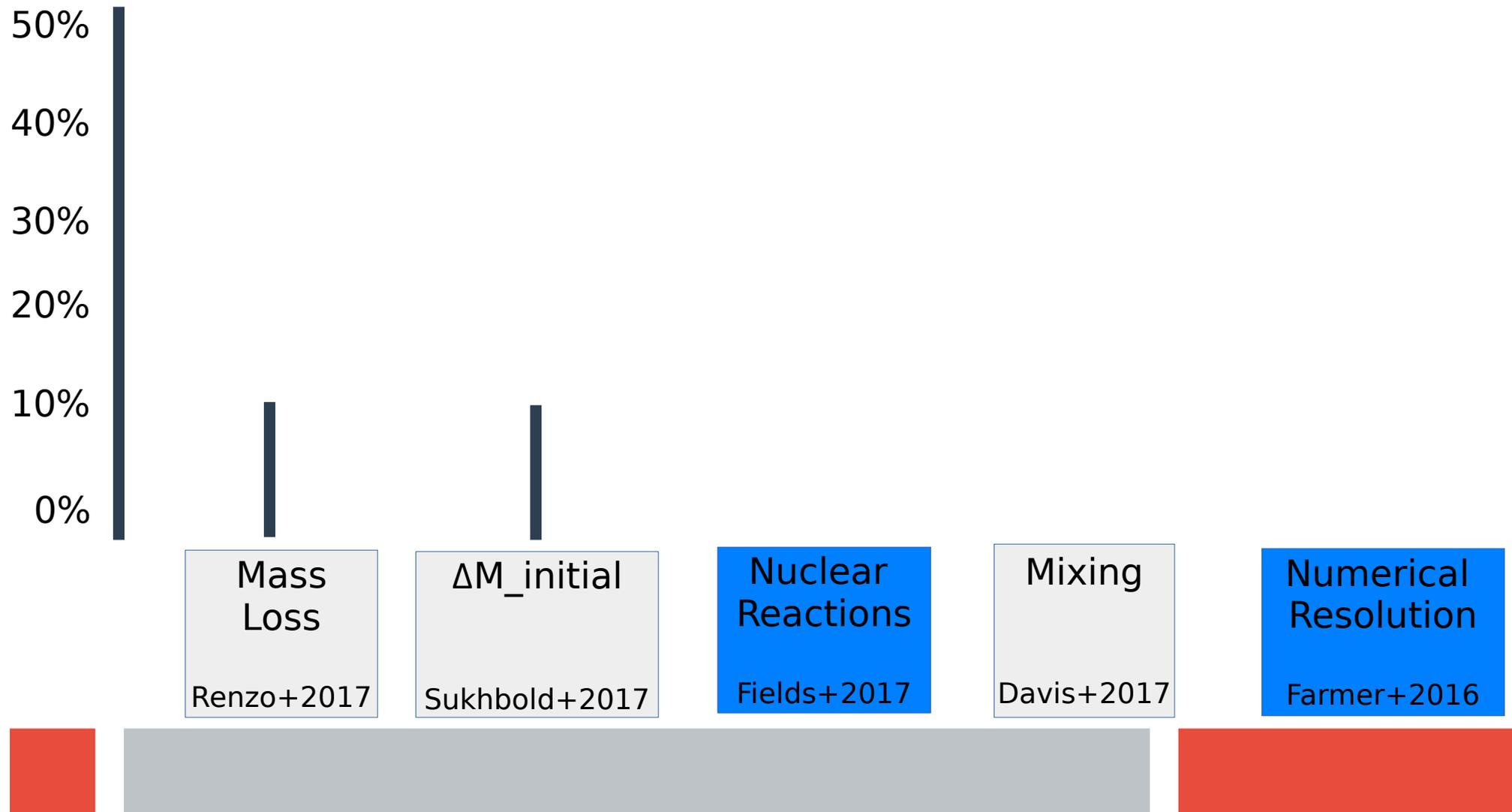
Variations in compactness



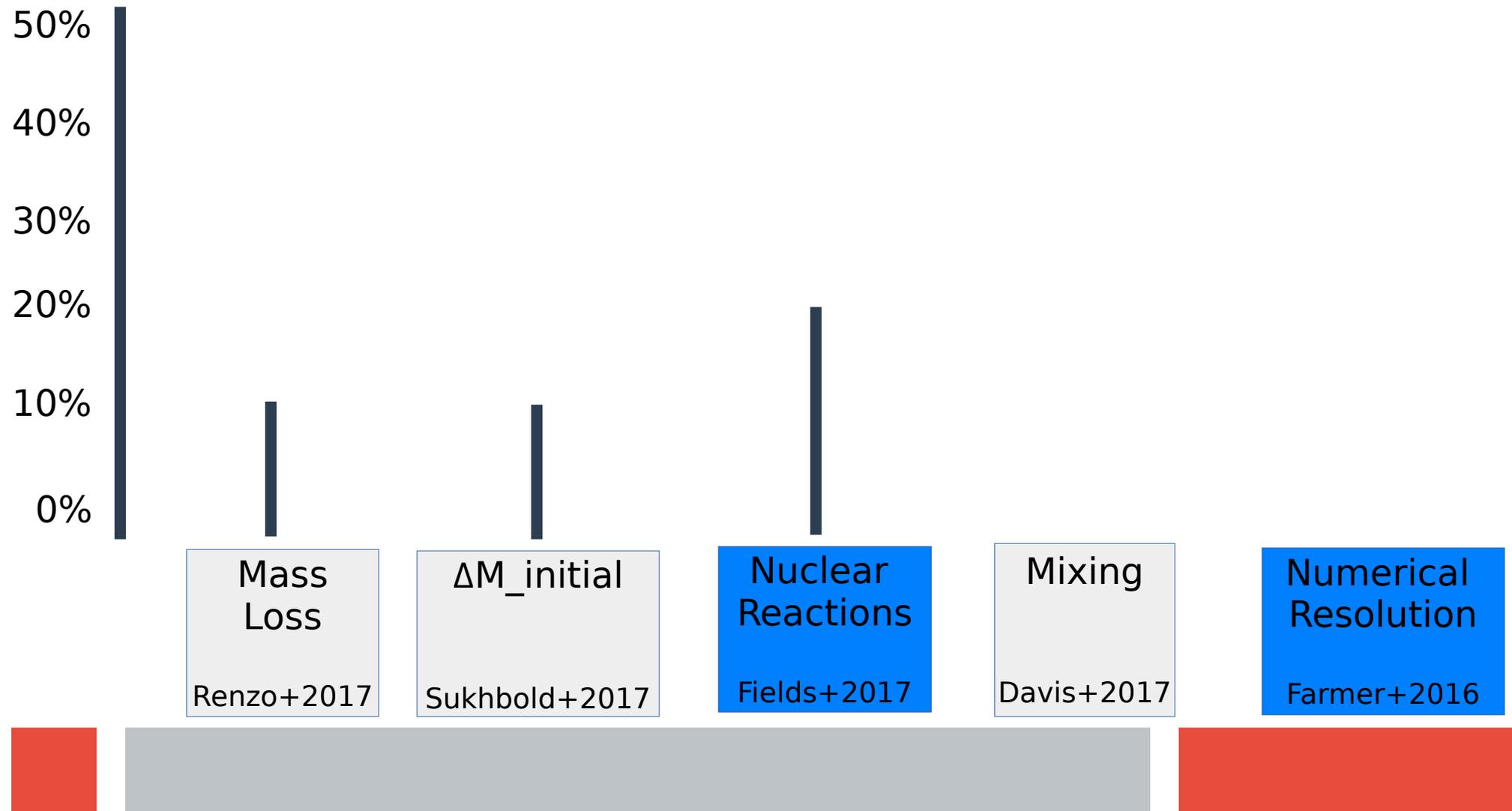
Variations in compactness



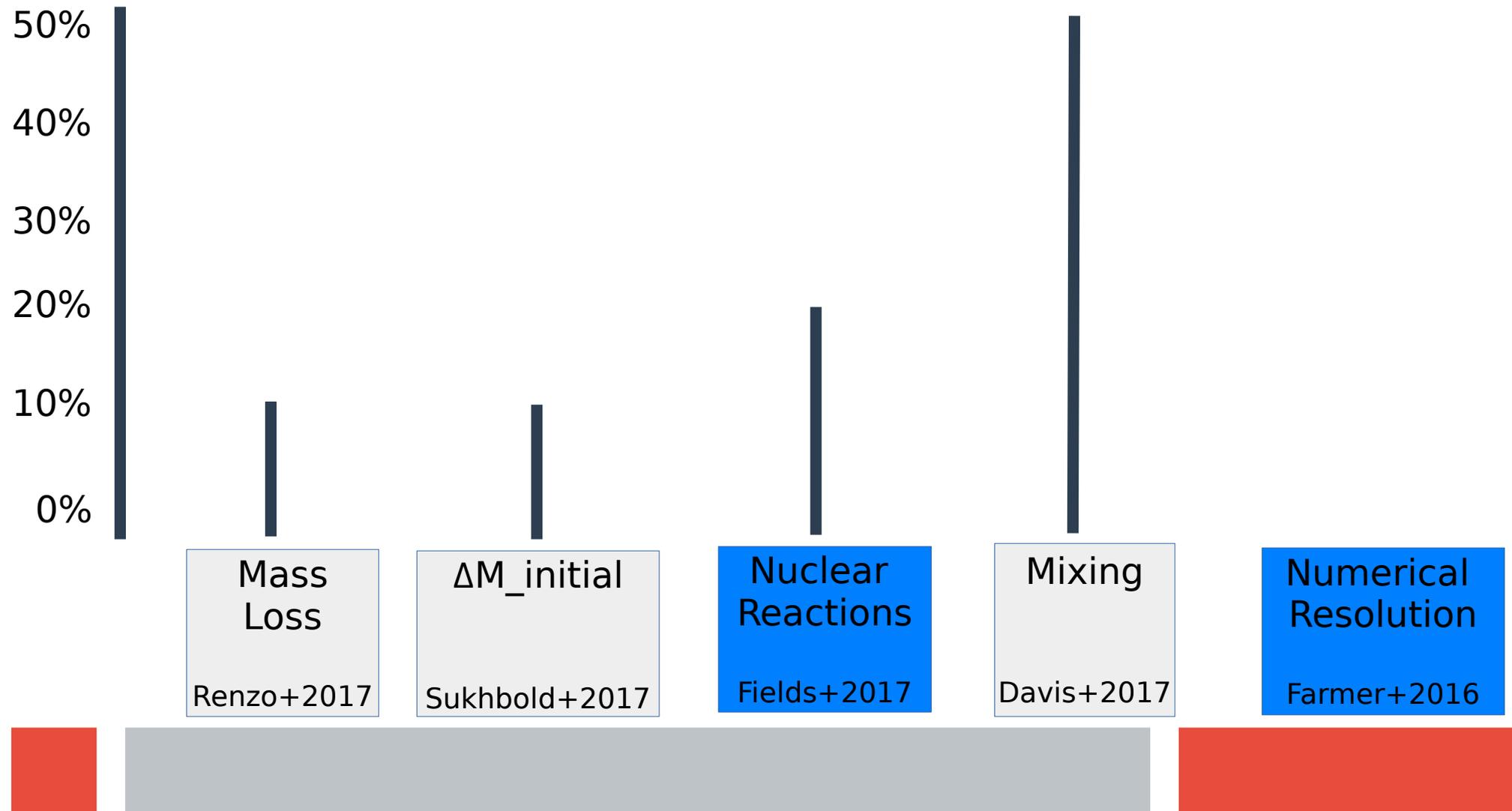
Variations in compactness



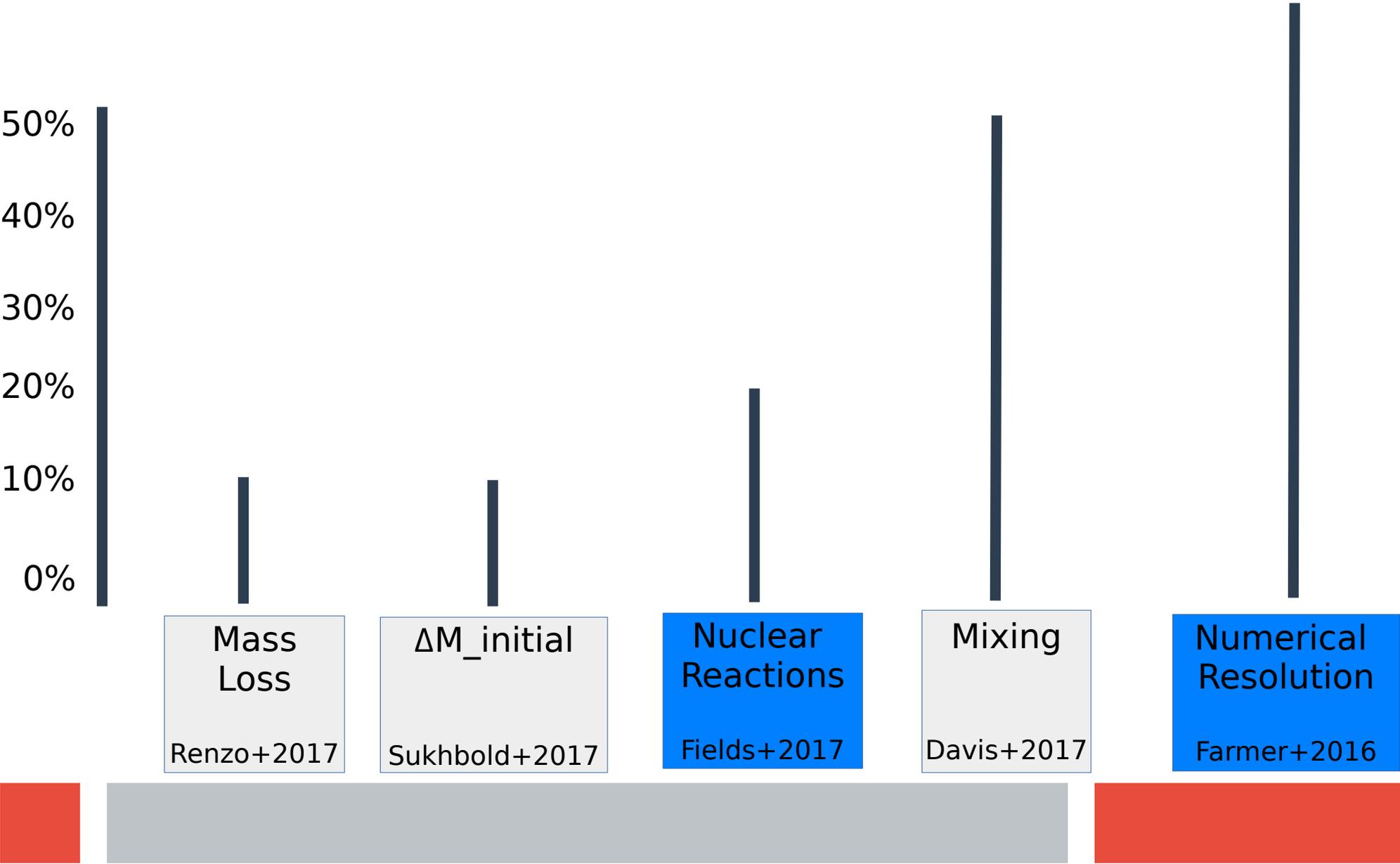
Variations in compactness



Variations in compactness



Variations in compactness



Summary

- **Many parts of stellar evolution modelling have uncertainties in them**
- **Small changes can lead to “branches” in the evolution**
- **Begun to quantify their effect**
 - Nuclear reactions ~20%
 - Spatial Resolution ~50%
 - Correlations between terms?

Final state is determined by more than a star's initial mass & metallicity