



Constraining the Core Structure of Core-Collapse Supernovae

Brandon Barker¹, MacKenzie Warren², Sean Couch¹

¹Department of Physics and Astronomy, Michigan State University, East Lansing, MI 48824, USA

²Department of Physics, North Carolina State University, Raleigh, NC 27695, USA

Introduction

- Observations of core-collapse supernovae (CCSNe) reveal a wealth of information about the dynamics of the supernova ejecta and composition, for example, but tell little of the progenitor star.
- Most 1D explosion models do not accurately treat physics of the core (namely, neutrinos) and require artificial explosions.
- The explosion and its dynamics have been shown to be dominated by the core structure and sensitive to turbulent motions.

Goals

- Make connections between observables of CCSNe and key properties of the progenitor's core.
- Provide a prescription for extracting these core properties from observations

Methods

- Use a new model for driving explosions in 1D [STIR, 1] to simulate 200 progenitors for 5 seconds past collapse.
- Use this as the input to SNEC [2] to run out to 300 days and obtain photometric lightcurves.

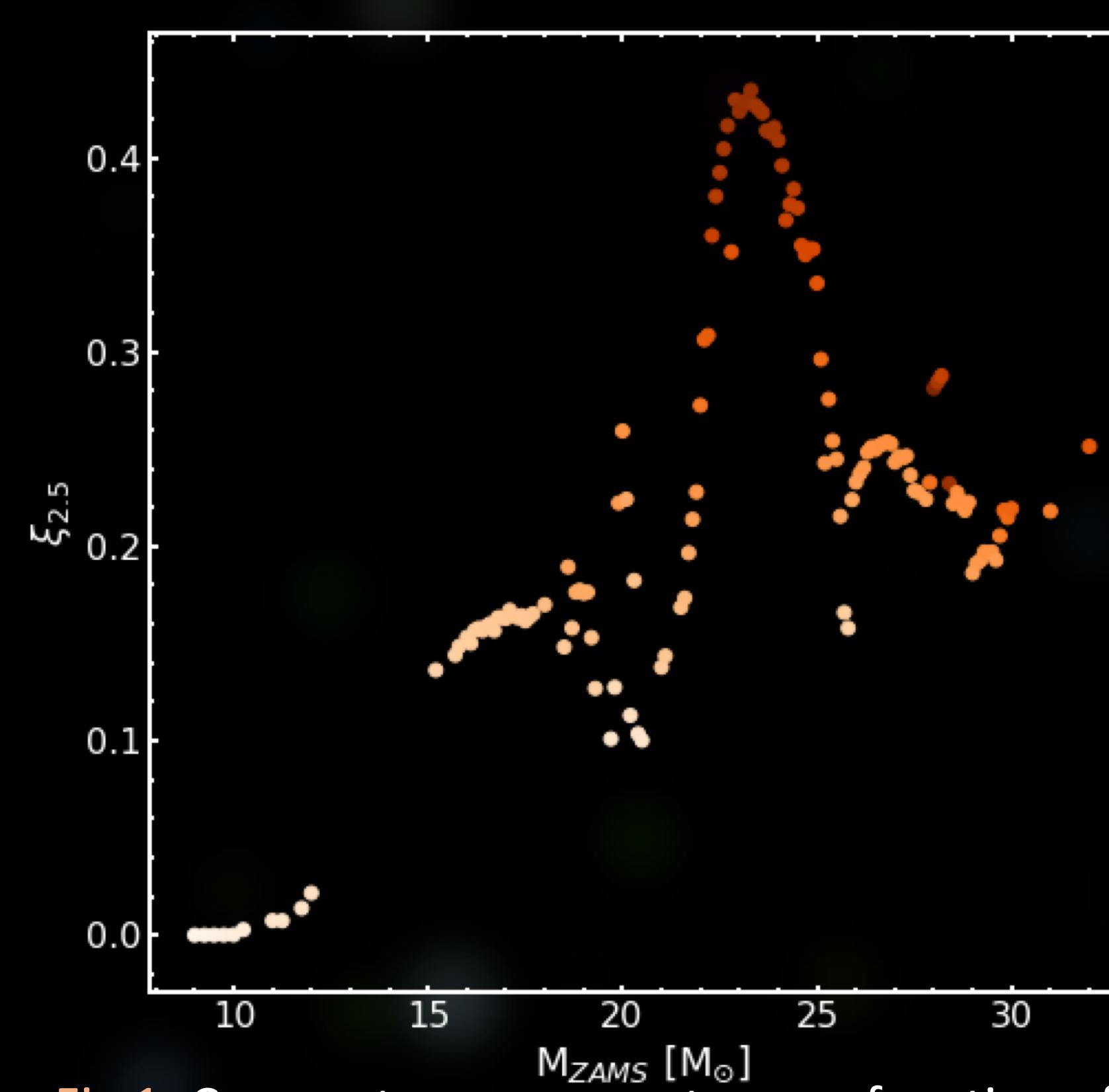


Fig 1: Compactness parameter as a function of progenitor mass, colored by resulting explosion energy.

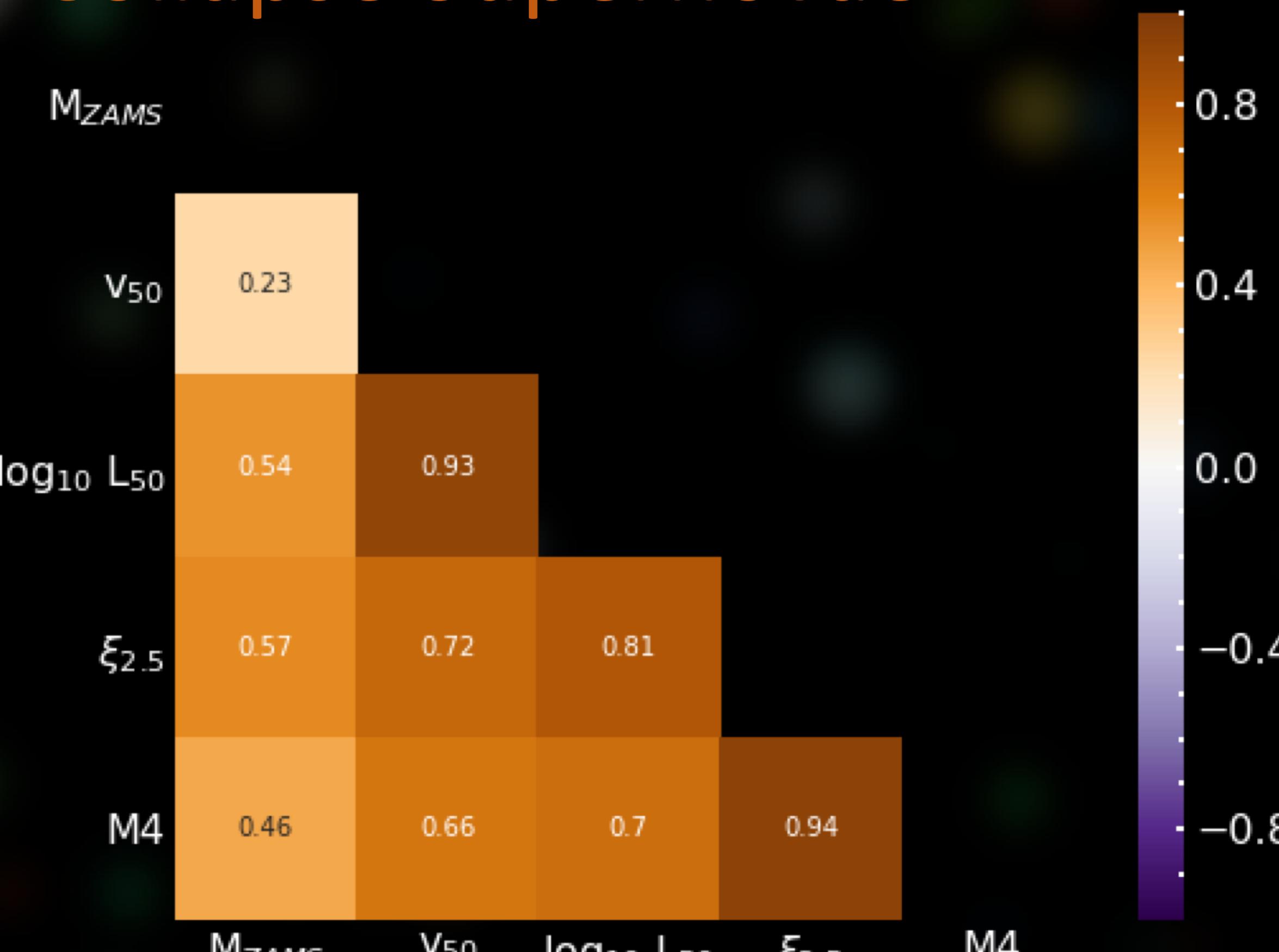


Fig 2: Correlation matrix for various observations and core properties.

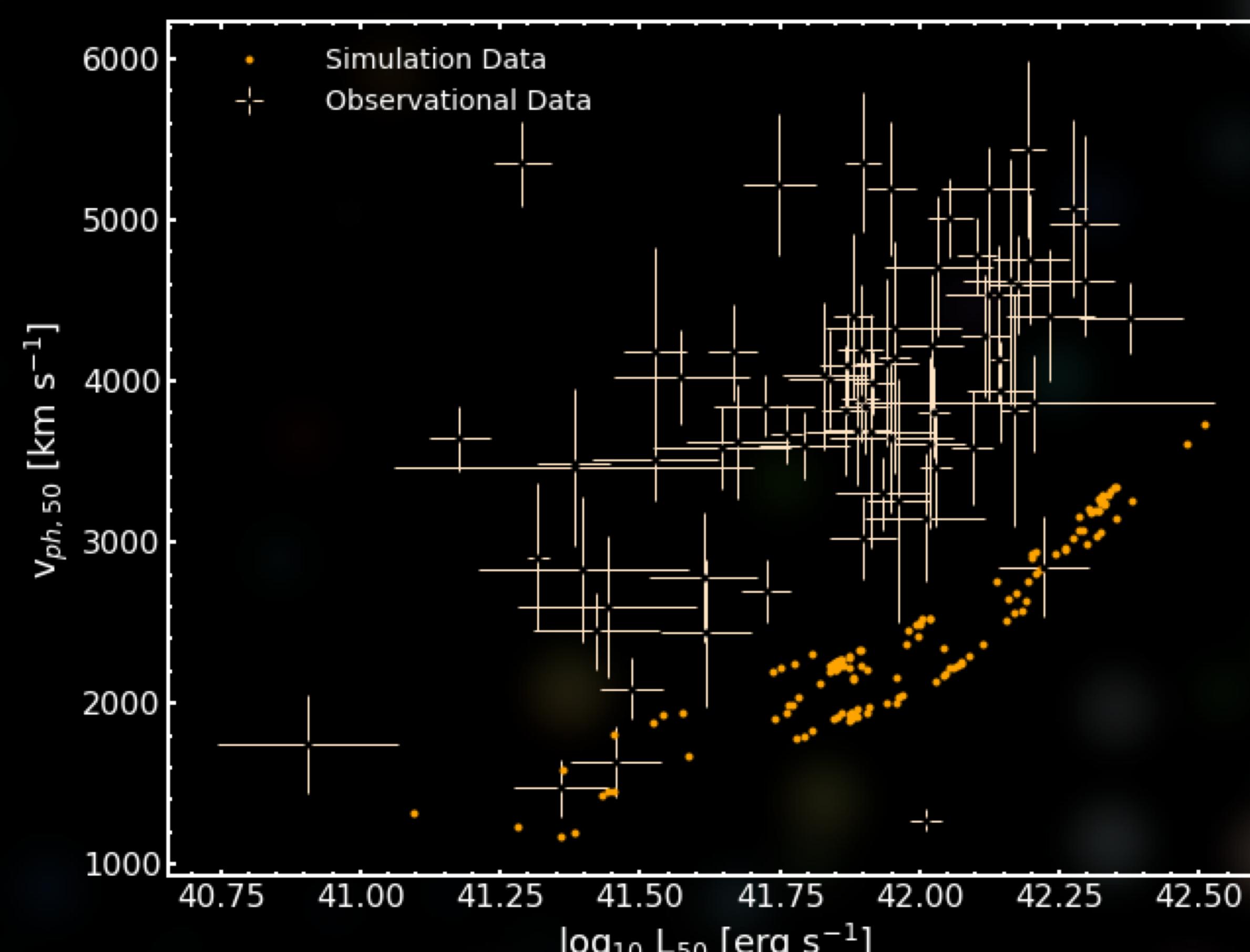


Fig 3: Photospheric velocity vs plateau luminosity (at day 50) for observations (crosses) [3] and simulation data (dots).

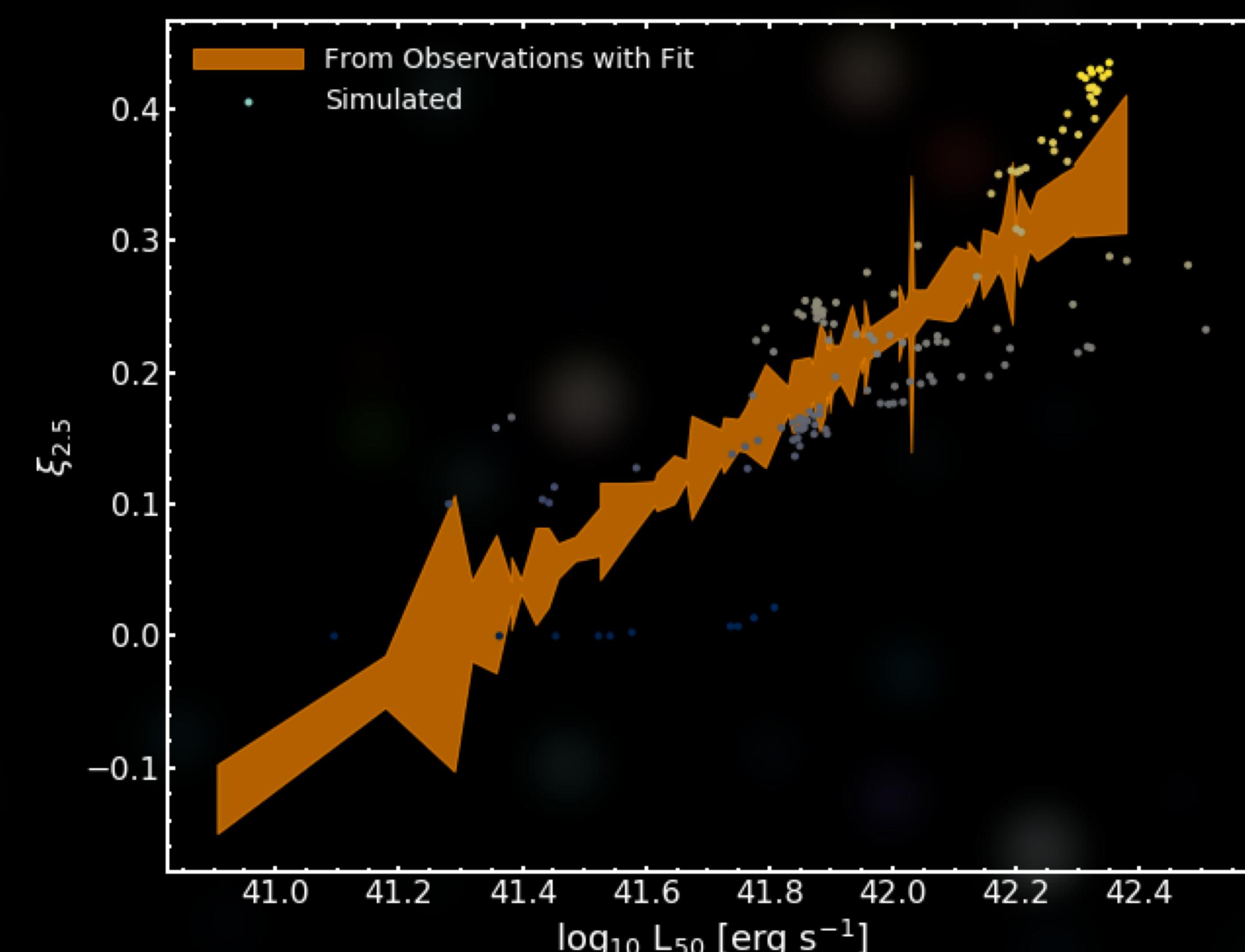
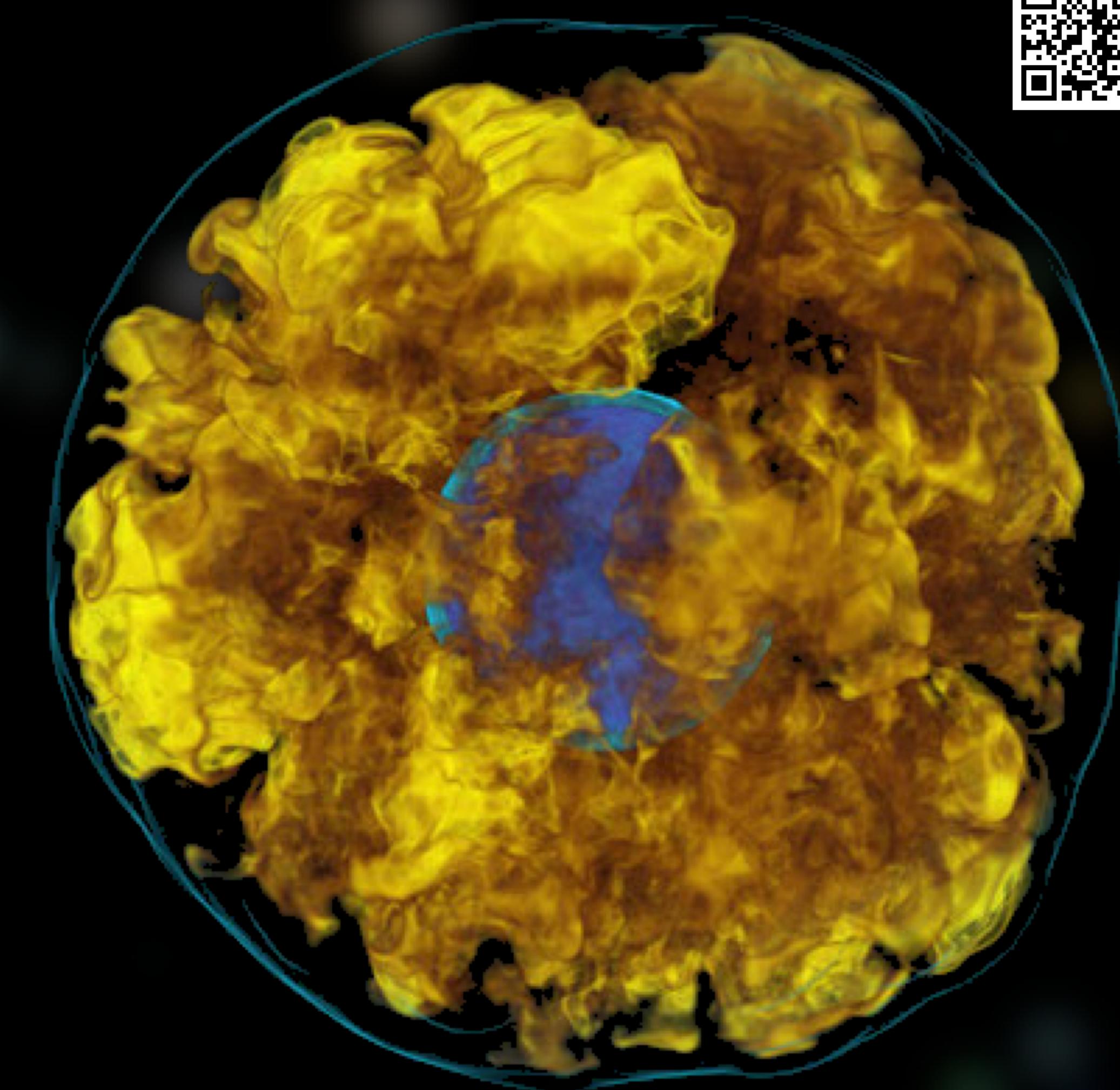


Fig 4: Compactness vs plateau luminosity. Data points are from simulation data and shaded region is compactness extracted from observations.



Conclusions

- Type IIP lightcurve observables are sensitive to properties of the progenitor core.
- We may use observations to put constraints on the supernova progenitor

Future Work

- Include fits for photospheric velocity and iron core mass
- Double down on statistics
- Compare observations to theory (e.g., a Terti plot)
- Extend to synthetic spectra
- Look out for Barker et al 2019 coming soon to a journal near you!

References

1. Couch, S. M., Warren, M. L., & O'Connor, E. P. 2019, arXiv:astro-ph/1902.01340, submitted
2. Morozova, V., Piro, A. L., Renzo, M., et al. 2015, ApJ, 814, 63, doi: 10.1088/0004-637X/814/1/63
3. Gutiérrez, C. P., Anderson, J. P., Hamuy, M., et al. 2017, ApJ, 850, 90

Acknowledgements

Michigan State University University
Enrichment Fellowship
MSU iCER – Computational Resources

