

CELESTA

a Catalog of Earth-Like Exoplanet Survey Targets

Colin Orion Chandler¹, Iain McDonald², & Stephen Kane¹

¹San Francisco State University ²Jodrell Bank Centre for Astrophysics



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CELESTA has been accepted for publication in the
Astronomical Journal.

The arXiv release is [here](#), and the files are being hosted
[here](#). An interactive interface will be coming next, so
stay tuned!



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Introduction

CELESTA provides a database of habitable zones as a target selection tool for ongoing and future missions.

Step 1: Aggregate Data

Star catalogs utilized for stellar parameters:

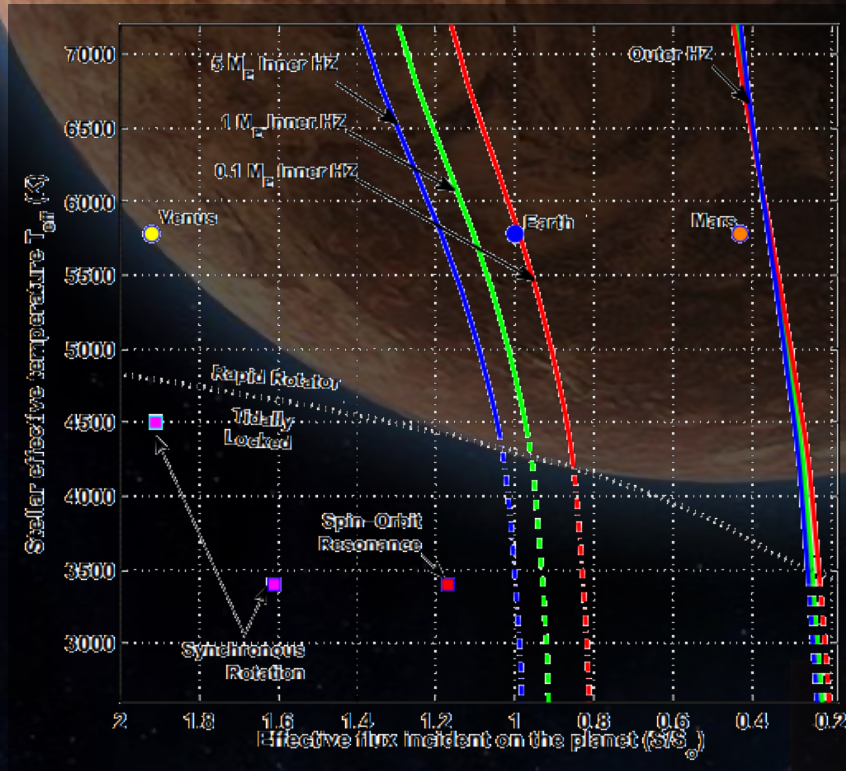
- Hipparcos¹: parallax for distances.
- We created a Stellar Parameter Catalog building upon the work of McDonald et al.³: stellar temperatures and luminosities.
- Kopparapu et al.²: HZ coefficients
- Gaia: future upgrades to CELESTA



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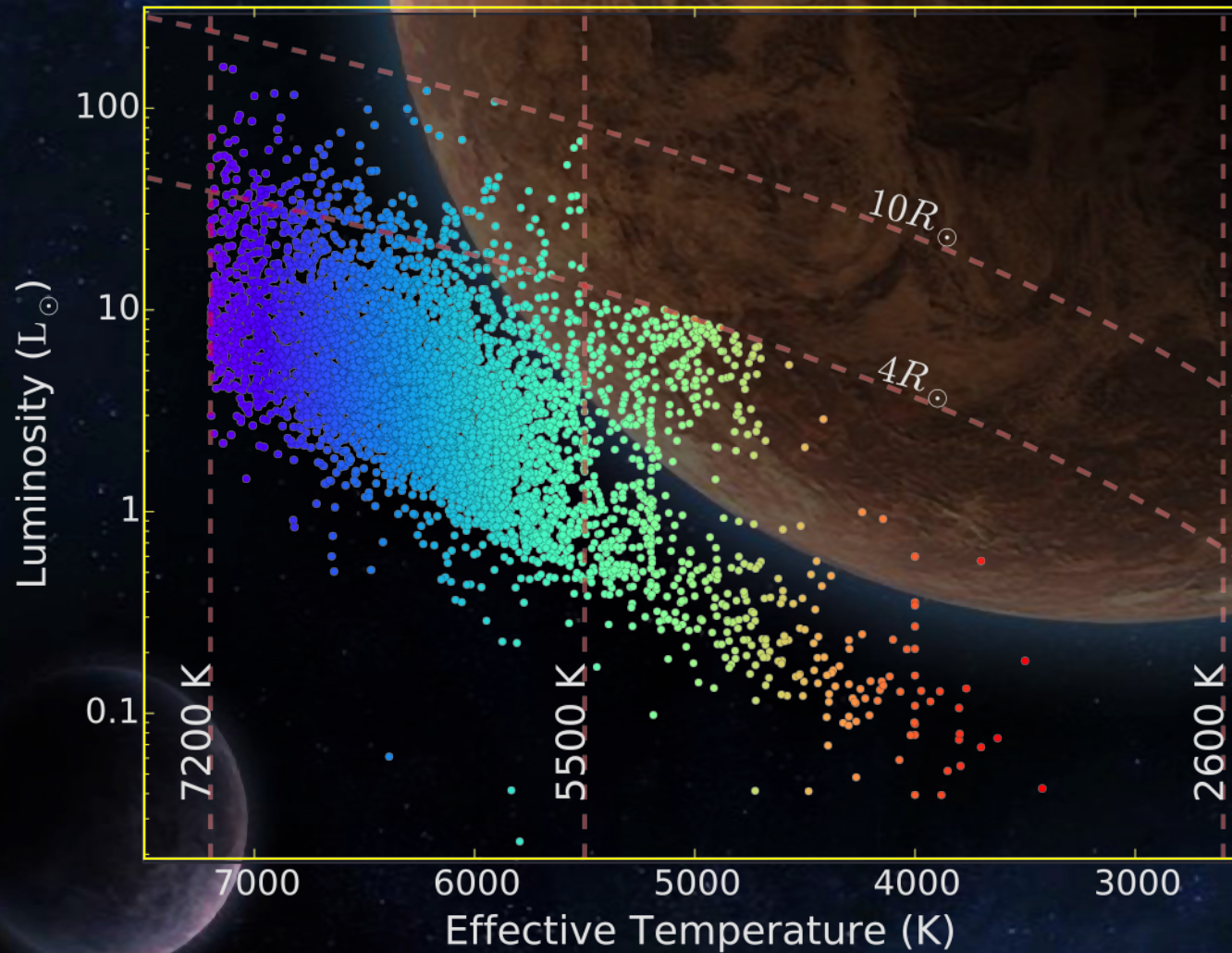
References

- ¹ <http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=1989-062B>
- ² Kopparapu, R.K. et al., 2014. Habitable Zones around Main-sequence Stars: Dependence on Planetary Mass. *Astrophysical Journal Letters*, 787(2), p.L29.
- ³ McDonald, I., Zijlstra, A.A. & Boyer, M.L., 2012. Fundamental parameters and infrared excesses of Hipparcos stars. *Monthly Notices of the Royal Astronomical Society*, 427(1), pp.343-357.
- ⁴ <http://sci.esa.int/gaia/55638-artist-impression-of-gaia>

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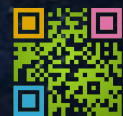


Star Selection

- Stellar temperature: 2,600 K to 7,200 K.
- Error in parallax: <30 % for analysis
- Main-sequence (MS) branch stars, chosen by radii.



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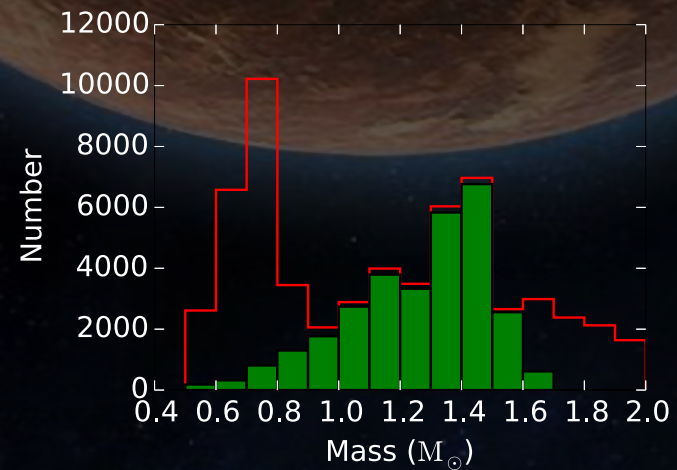
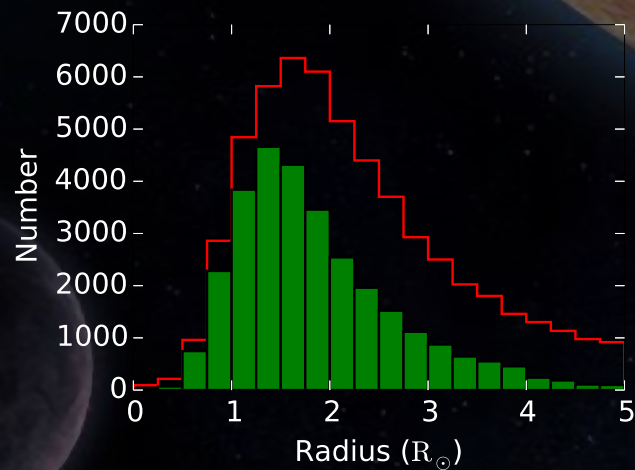
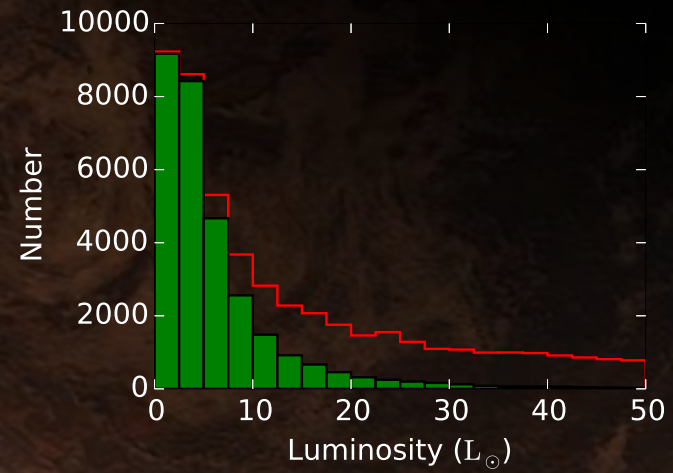
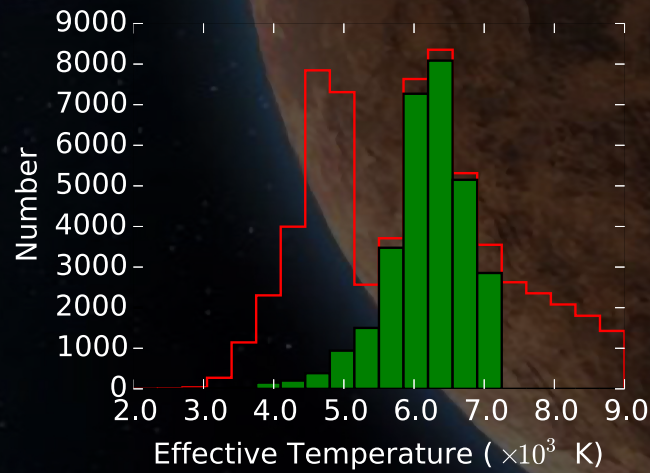


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Stellar Distribution after Star Selection

- Red outlines indicate Stellar Parameter Catalog population
- Green bars are stars contained in CELESTA



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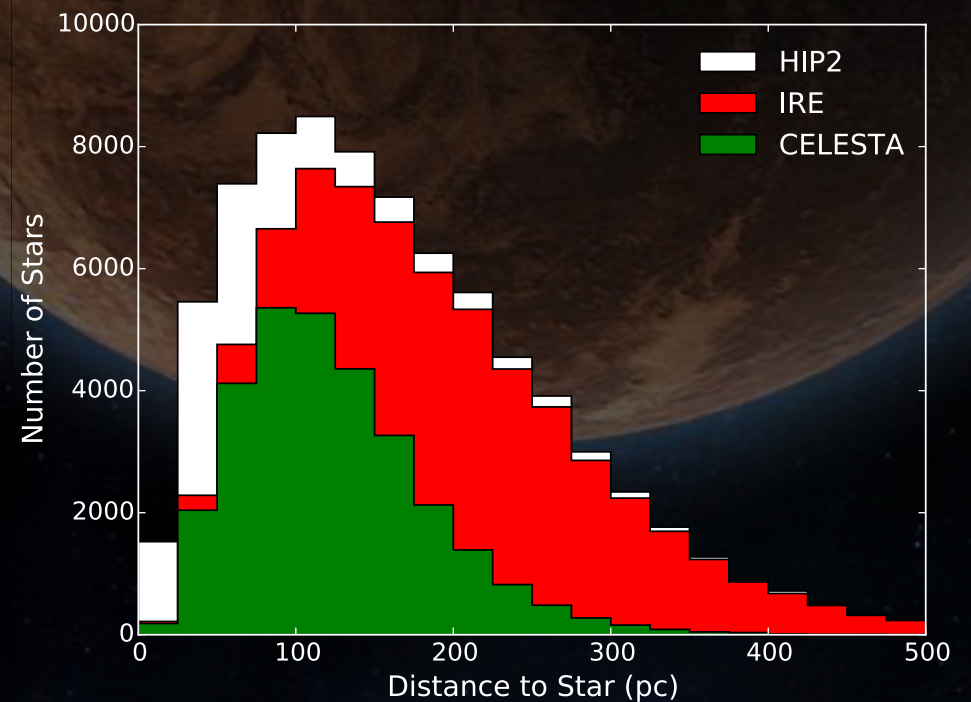
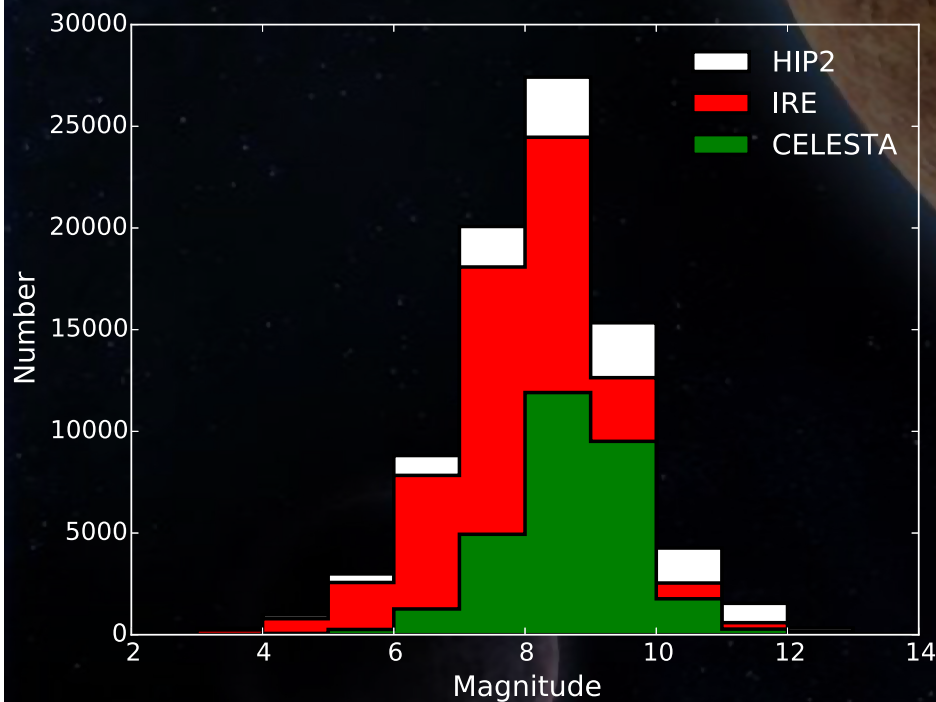


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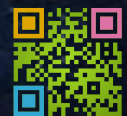


Tri-Catalog Comparison

- Comparing CELESTA selected stars to source catalogs
- HIP2 is the revised Hipparcos Catalog (van Leeuwen 2007)
- IRE is the Stellar Parameters Catalog



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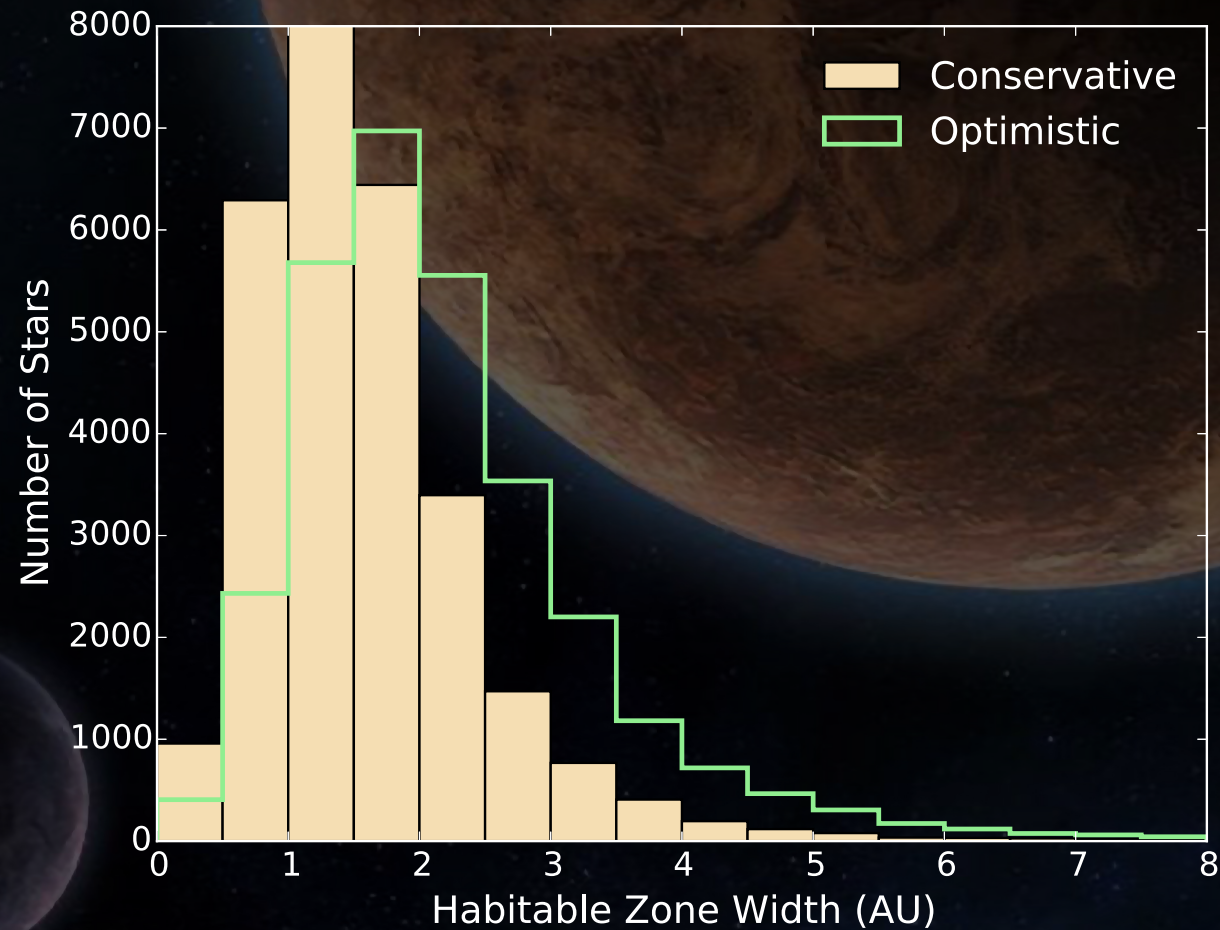


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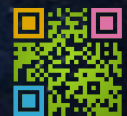


Habitable Zone Width Distribution

- Conservative zones necessarily cluster to narrower zones



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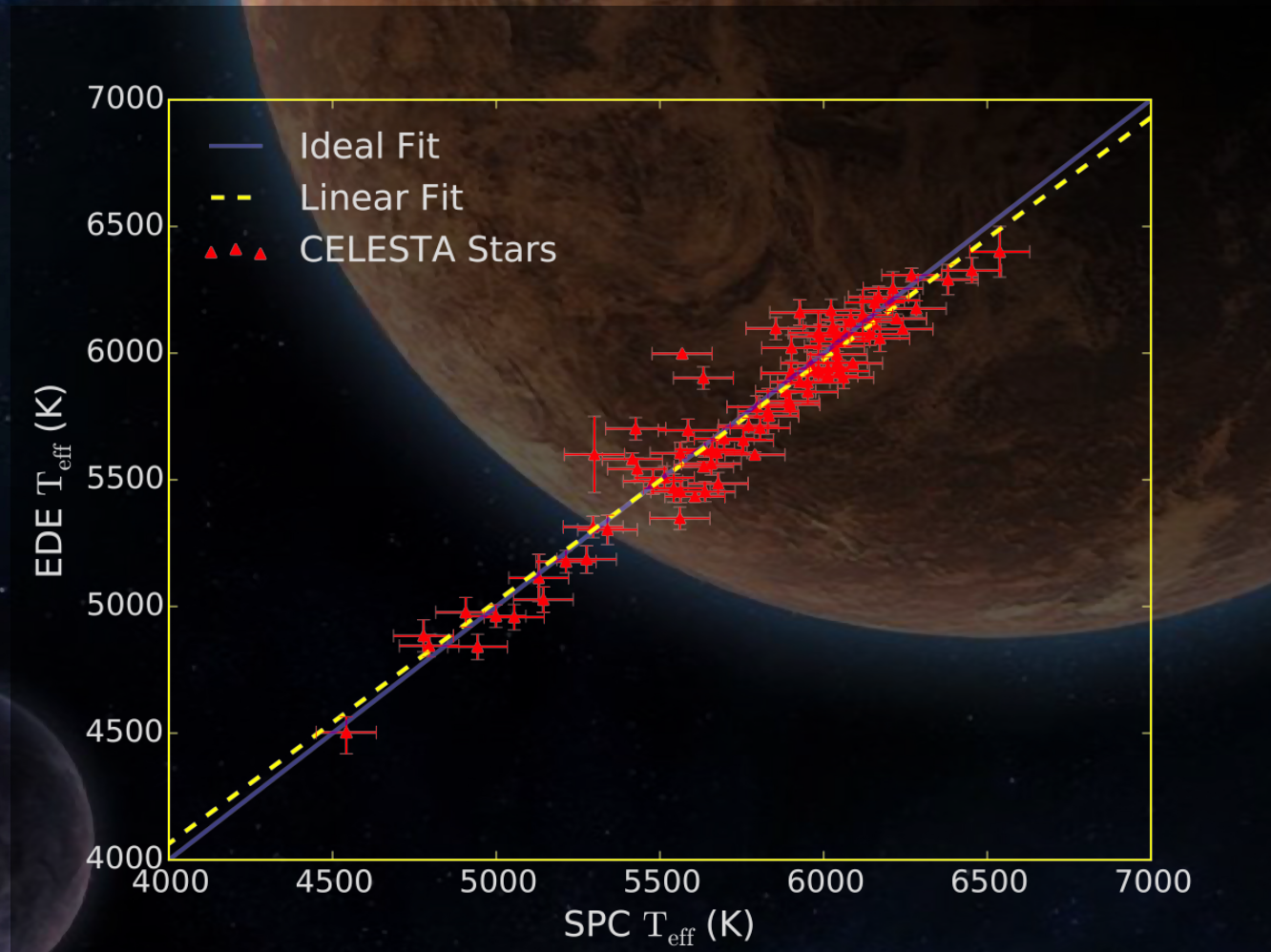


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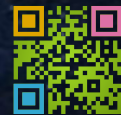


Determining Uncertainty in Temperature

- Comparison of CELESTA to EDE (<http://www.exoplanets.org>)
- Uncertainty in CELESTA temperature: ± 100 K.



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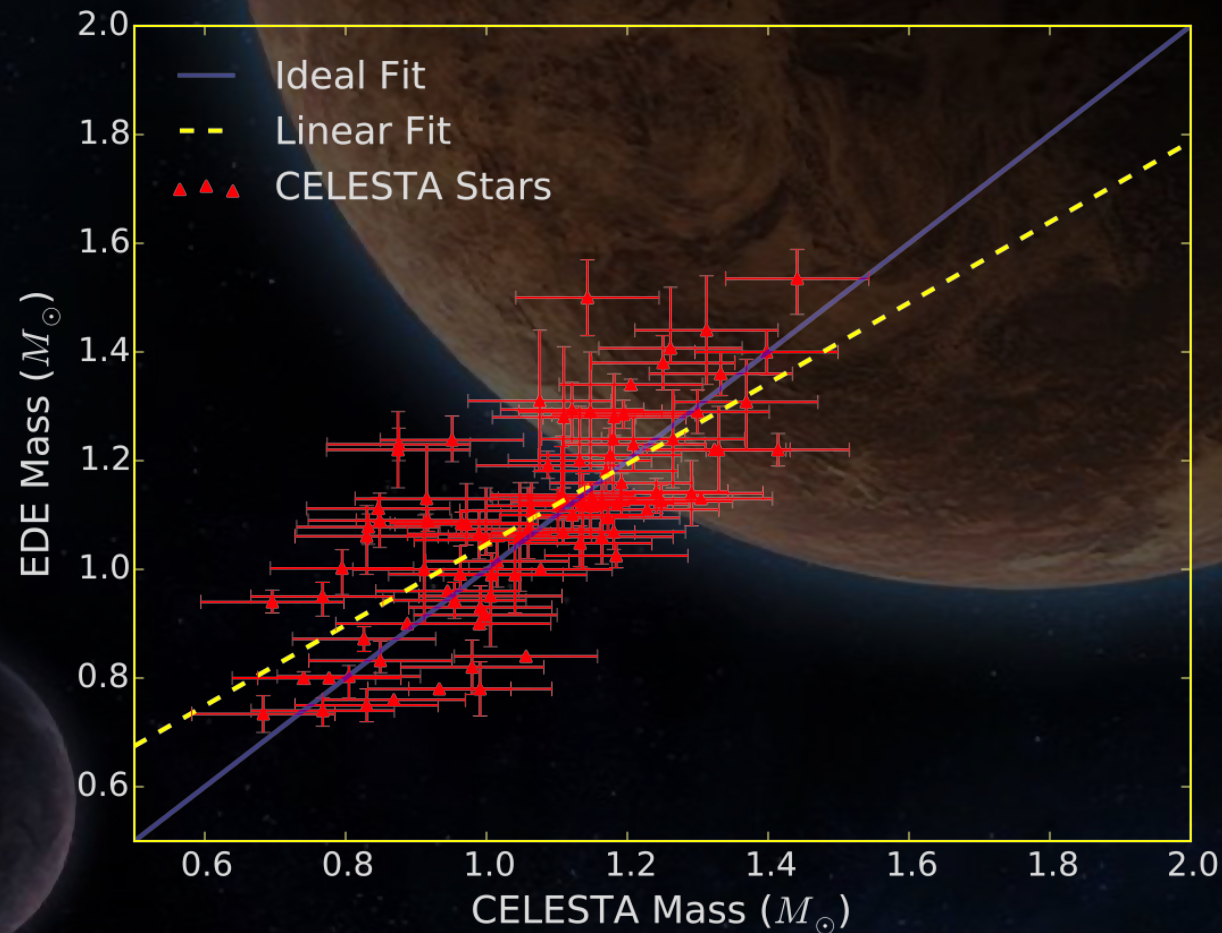


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Determining Uncertainty in Mass

- Comparison of CELESTA to EDE (<http://www.exoplanets.org>)
- Uncertainty in CELESTA mass: $\pm 0.10 M_{\odot}$.



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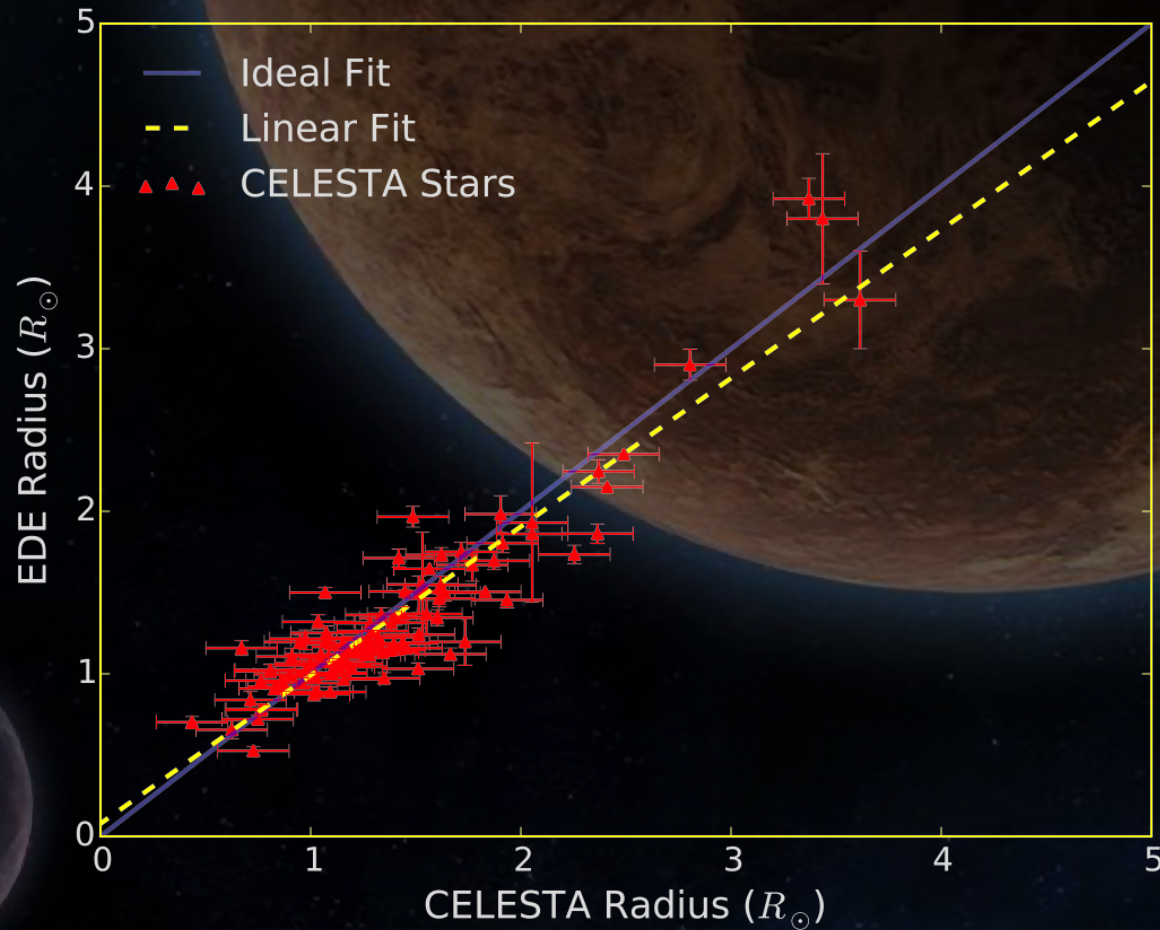


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Determining Uncertainty in Radius

- Comparison of CELESTA to EDE (<http://www.exoplanets.org>)
- Uncertainty in CELESTA radius: $\pm 0.17 R_{\odot}$.



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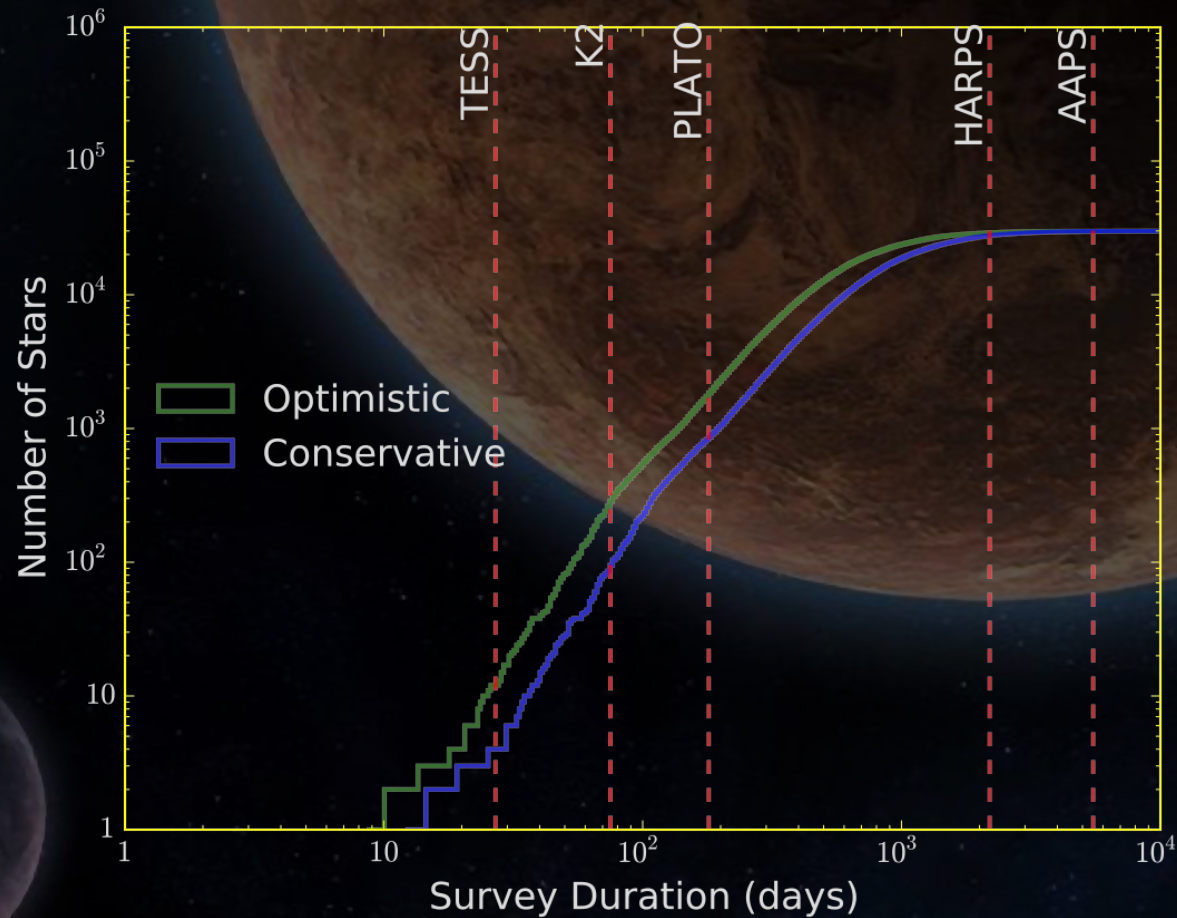


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Application: "ROI"

- CELESTA is as an input catalog for target selection with current and upcoming exoplanet surveys.
- Transit and radial velocity (RV) survey sensitivity to planets within the HZ increases as the survey duration increases.



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CELESTA: What's Next?



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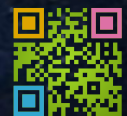
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Next Step: Online Presence

- Framework for interactive analysis
- Vectors = unlimited resolution
- Can update data automatically



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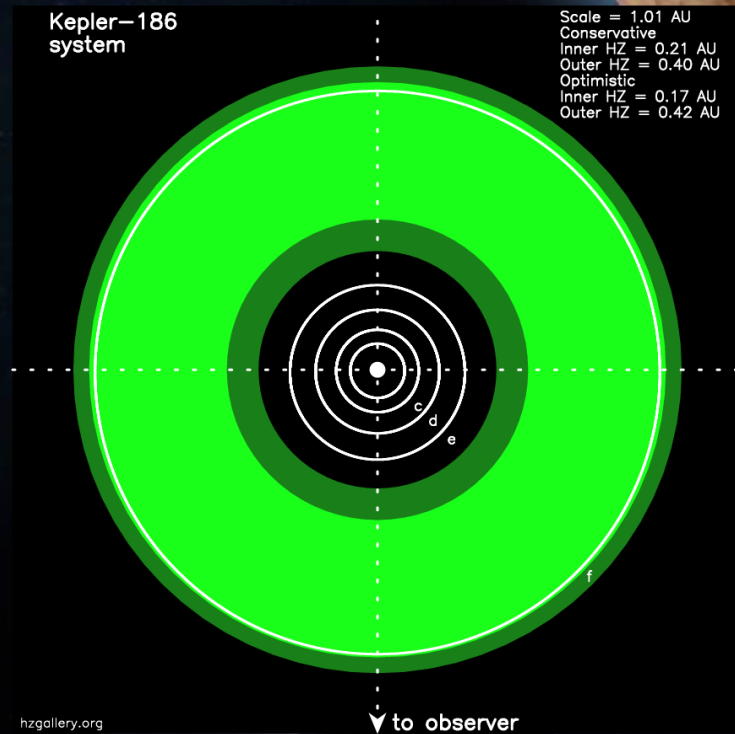
The Habitable Zone Gallery

Stephen Kane¹, Dawn Gelino², Colin Orion Chandler¹

¹San Francisco State University ²NASA/Caltech

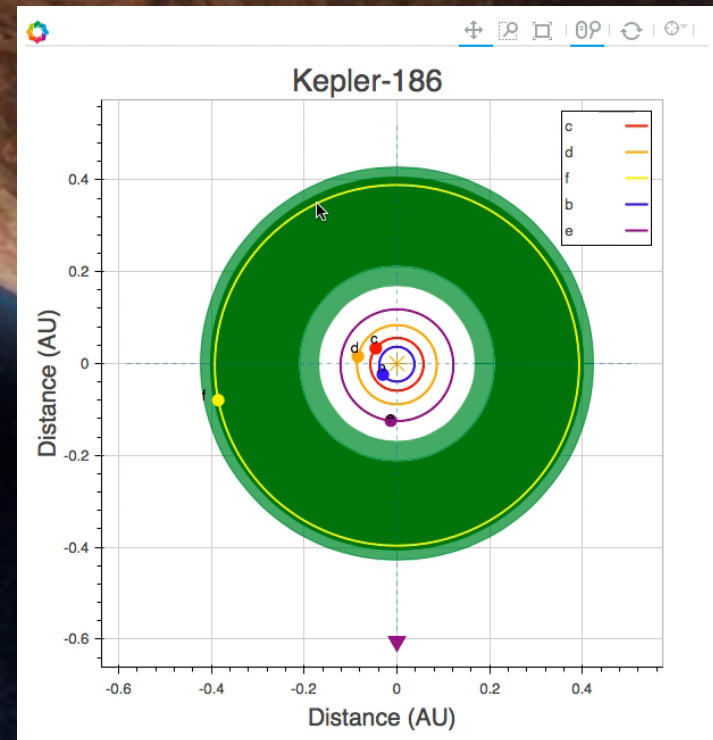
Static Image

- Kepler-186 from the Habitable Zone Gallery¹
- Image format: PNG



Interactive Environment

- Kepler-186 with interaction
- Standalone HTML file requires no special software.
- Entire gallery of HTML files generated in < 2 minutes.



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References

¹<http://hzgallery.org>



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Conclusions

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What CELESTA Does Now

- Provides HZ distances for 37,000 bright, nearby stars
- Computes the orbital periods for Earth-like exoplanets in those zones
- Calculates stellar parameters (temperature, luminosity, mass, radius)
- Estimates uncertainties by comparing predictions with the EDE (www.exoplanets.org)
- Determines the number of CELESTA HZs probed for a given survey duration
- Available for download now at <http://celesta.info>

What is coming

- Interactive online edition
- Bidirectional integration with www.hzgallery.org
- Ability to specify mission parameters (e.g. survey duration, area on sky, magnitude)
- Real-time stellar parameter uncertainty updates with www.exoplanets.org
- Framework for astrometric updates derived from Gaia data

CELESTA Wish-List

- Linkage with additional sources (e.g. M-Dwarf catalogs, Hypatia¹, SIMBAD)
- 3D Interactivity
- Eccentricity effects integration
- Venus Zone calculations
- Ability to utilize other climate/HZ models in calculations²

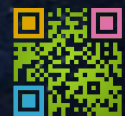
References

¹ <http://physics.sfsu.edu/~nhinkel/hypatia.html>

² Requested feature.



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