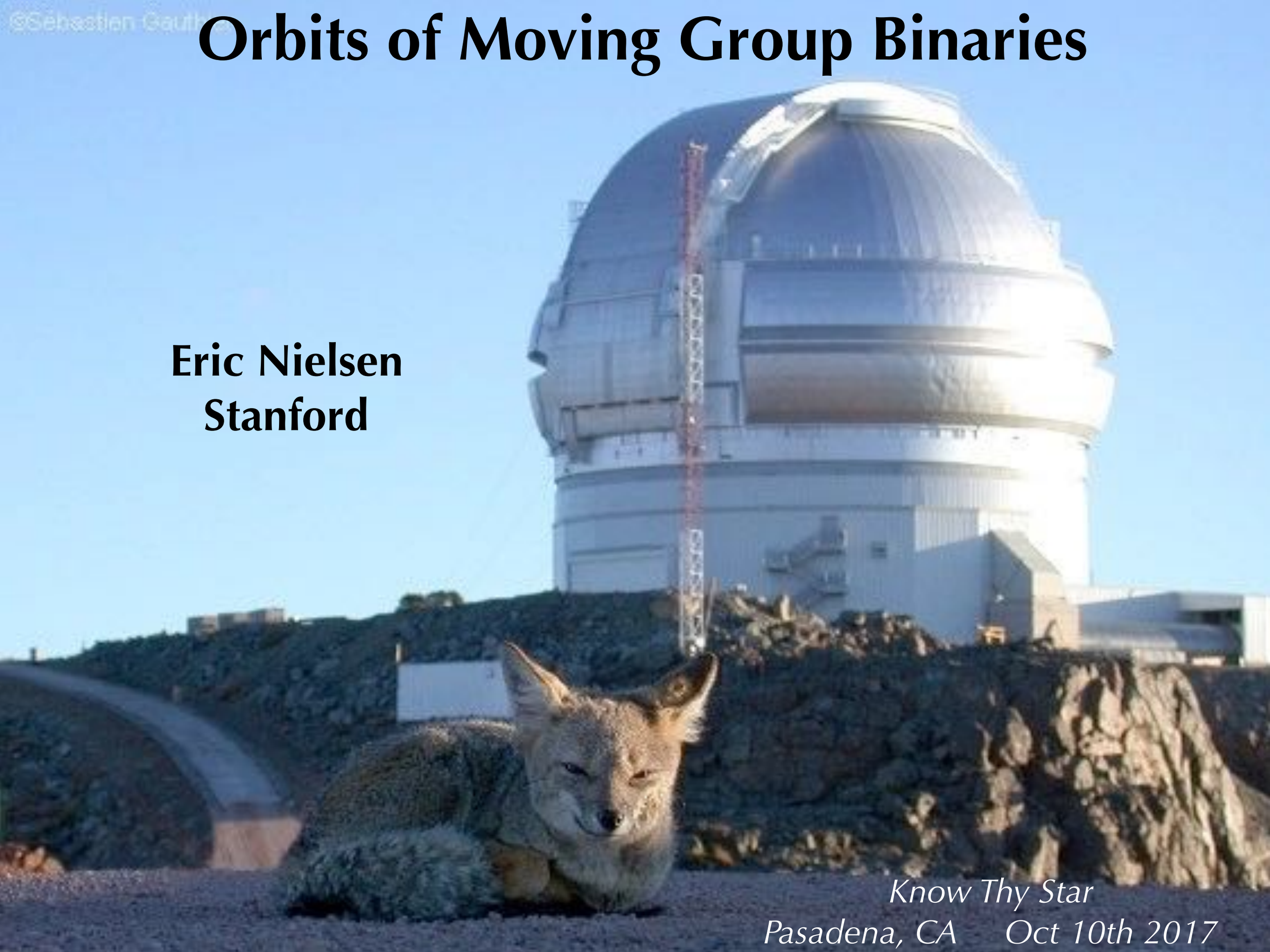
Orbits of Moving Group Binaries

Eric Nielsen
Stanford



Know Thy Star
Pasadena, CA Oct 10th 2017

OMG Binaries

Eric Nielsen
Stanford

Know Thy Star
Pasadena, CA Oct 10th 2017

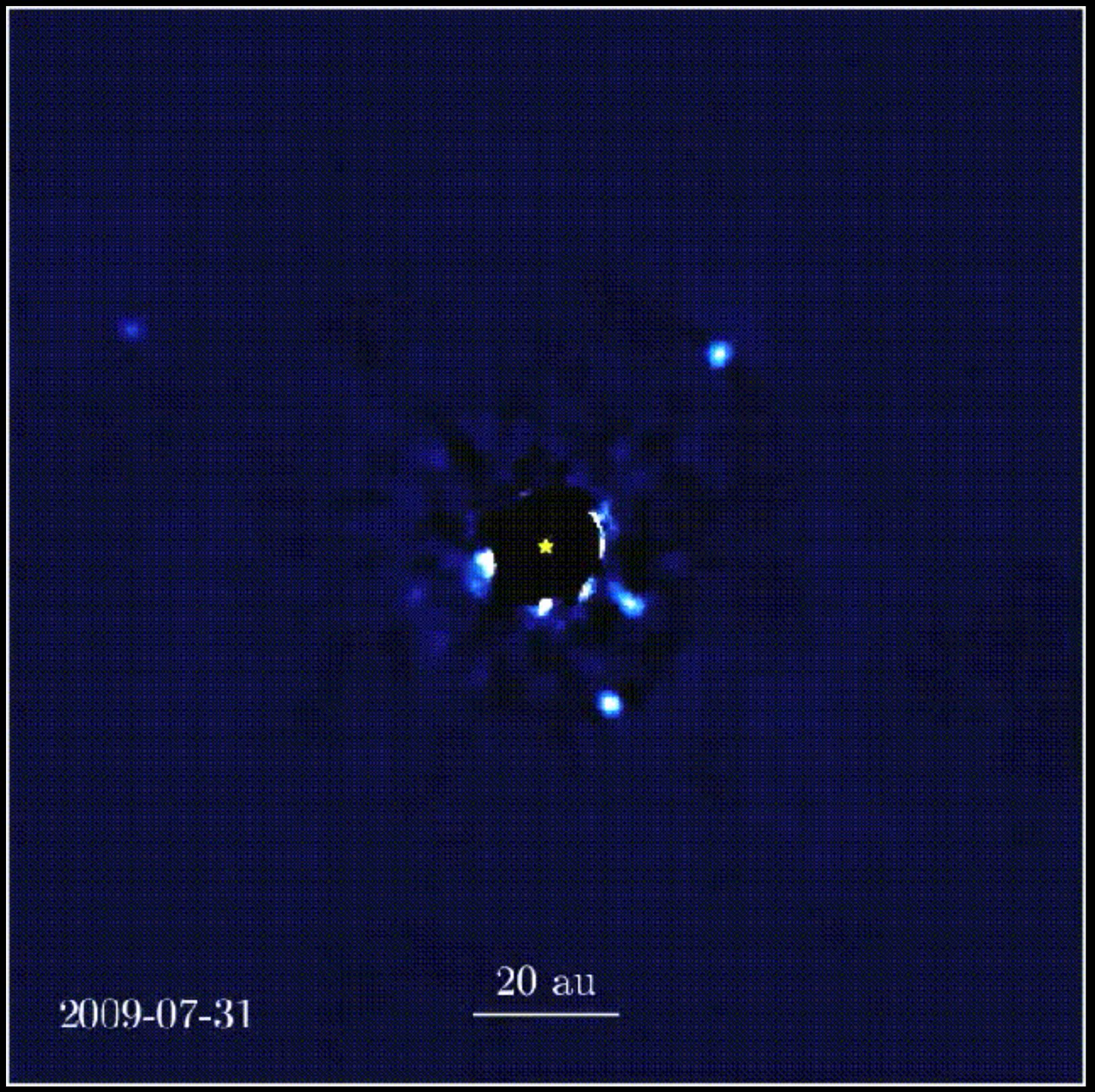
Team OMG Binaries

Eric Nielsen — KIPAC/Stanford
Rob De Rosa — UC Berkeley
Jason Wang — UC Berkeley
Quinn Konopacky — UCSD
Alexandra Greenbaum — University of Michigan
Mike Ireland — Mount Stromlo Observatory
Peter Tuthill — University of Sydney
Sarah Blunt — Caltech
Kimberly Ward-Duong — Amherst
Franck Marchis — SETI Institute
Ian Czekala — KIPAC/Stanford
Blaine Lomberg — SAAO
Michael Gully-Santiago — NASA K2 Office
BJ Fulton — University of Hawaii

And the GPIES science team

Image from Stefan Binnewies / Josef Pöpsel / Capella Observatory

HR 8799: Exoplanets in Motion



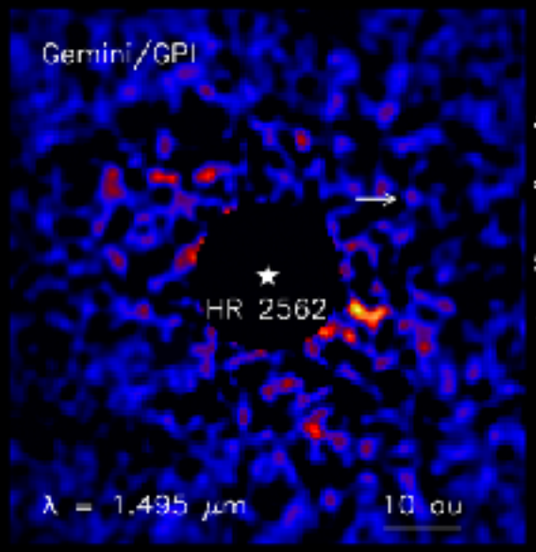
Movie from Jason Wang and Christian Marois

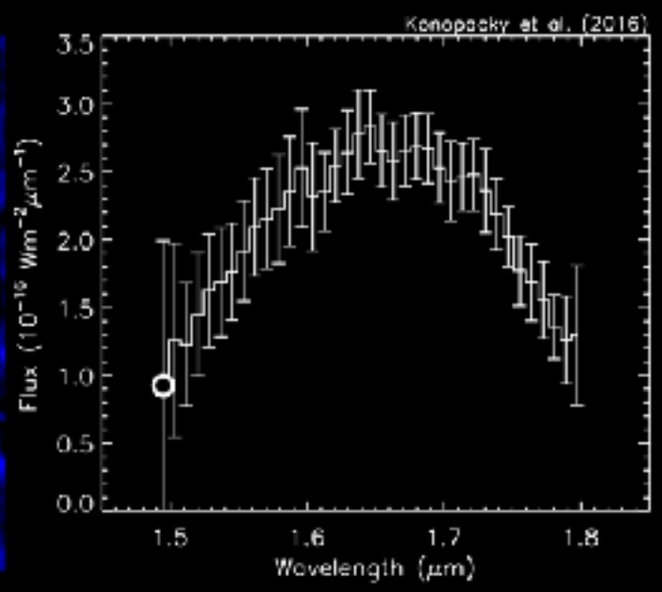
The GPI Team (a subset)

Jonathan Aguilar, S. Mark Ammons, Pauline Arriaga, Etienne Artigau, Vanessa Bailey, Travis Barman, Steve Beckwith, Sebastian Bruzzone, Joanna Bulger, Ben Burningham, Adam S. Burrows, Eric Cady, Christine Chen, Eugene Chiang, Jeffrey K. Chilcote, Rebekah I. Dawson, Robert J. De Rosa, Ruobing Dong, René Doyon, Zachary H. Draper, Gaspard Duchêne, Thomas M. Esposito, Daniel Fabrycky, Michael P. Fitzgerald, Katherine B. Follette, Jonathan J. Fortney, BJ Fulton, Benjamin Gerard, James R. Graham, Alexandra Z. Greenbaum, Pascale Hibon, Sasha Hinkley, Lea Hirsch, Justin Hom, Andrew Howard, Tara Hufford, Li-Wei Hung, Patrick Ingraham, Rebecca Jensen-Clem, Mara Johnson-Groh, Paul Kalas, Quinn Konopacky, David Lafreniere, James E. Larkin, Samantha Lawler, Eve Lee, Jinhee Lee, Michael Line, Bruce Macintosh, Jerome Maire, Franck Marchis, Mark S. Marley, Christian Marois, Brenda C. Matthews, Stanimir Metchev, Max Millar-Blanchaer, Caroline V. Morley, Katie M. Morzinski, Ruth Murray-Clay, Eric L. Nielsen, Andrew Norton, Rebecca Oppenheimer, David W. Palmer, Rahul Patel, Jenny Patience, Marshall D. Perrin, Charles Poteet, Lisa A. Poyneer, Laurent Pueyo, Roman R. Rafikov, Abhijith Rajan, Julien Rameau, Fredrik T. Rantakyrö, Emily Rice, Malena Rice, Patricio Rojo, Jean-Baptiste Ruffio, M. T. Ruiz, Dominic Ryan, Maissa Salama, Didier Saumon, Dmitry Savransky, Adam C. Schneider, Jacob Shapiro, Anand Sivaramakrishnan, Inseok Song, Rémi Soummer, Sandrine Thomas, Gautam Vasisht, David Vega, J. Kent Wallace, Jason J. Wang, Kimberly Ward-Duong, Sloane J. Wiktorowicz, Schuyler G. Wolff, Joe Zalesky, Ben Zuckerman

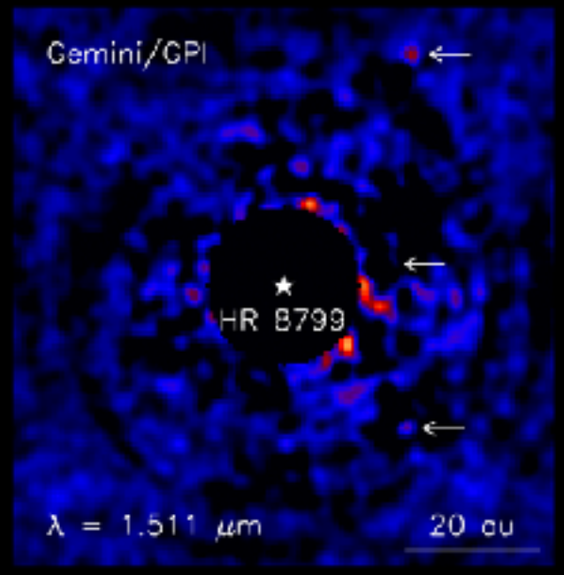
GPI and Friends

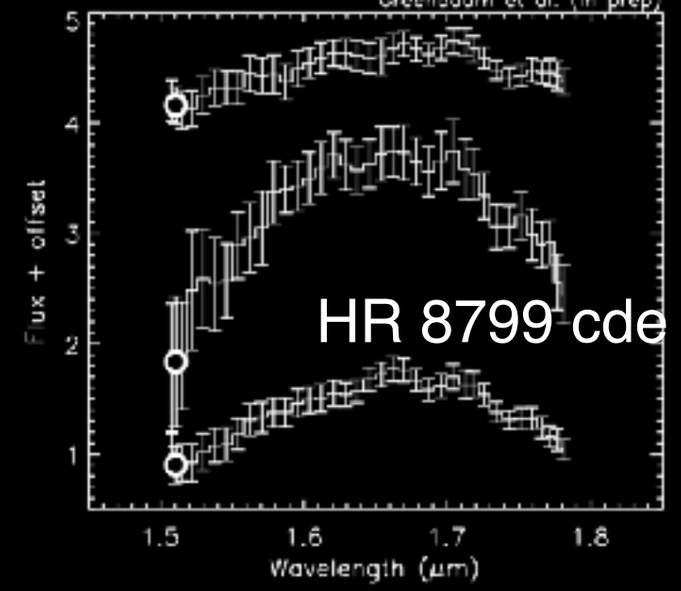
Brown Dwarfs and Planets with GPIES

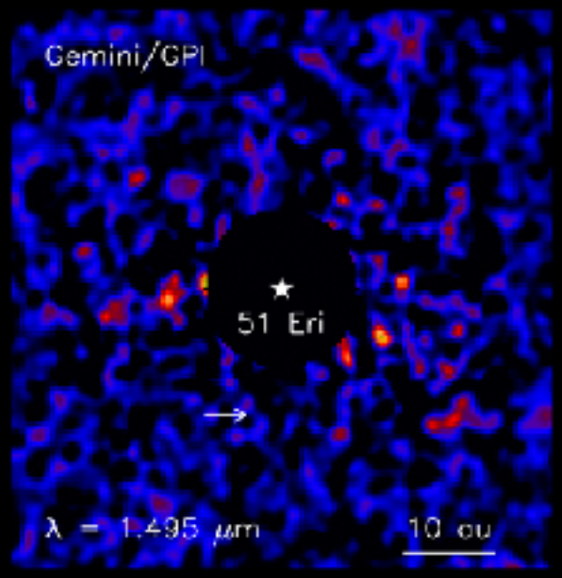


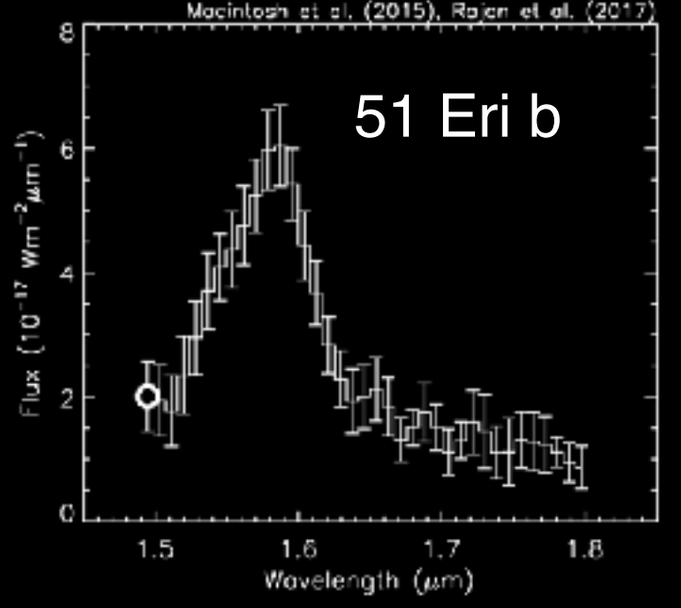


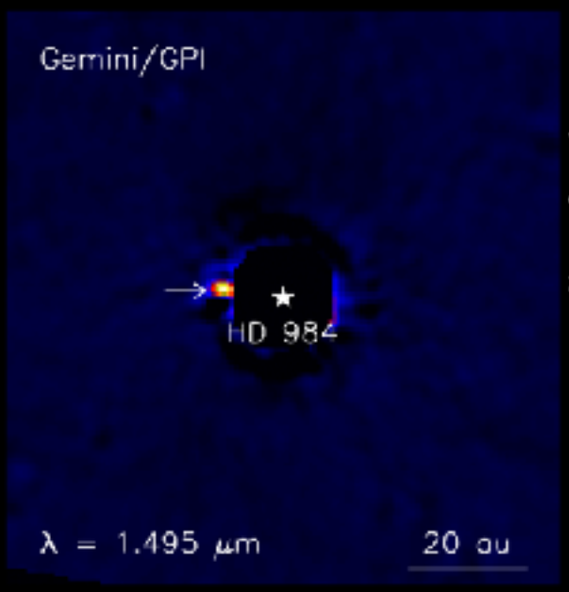
HR 2562 B

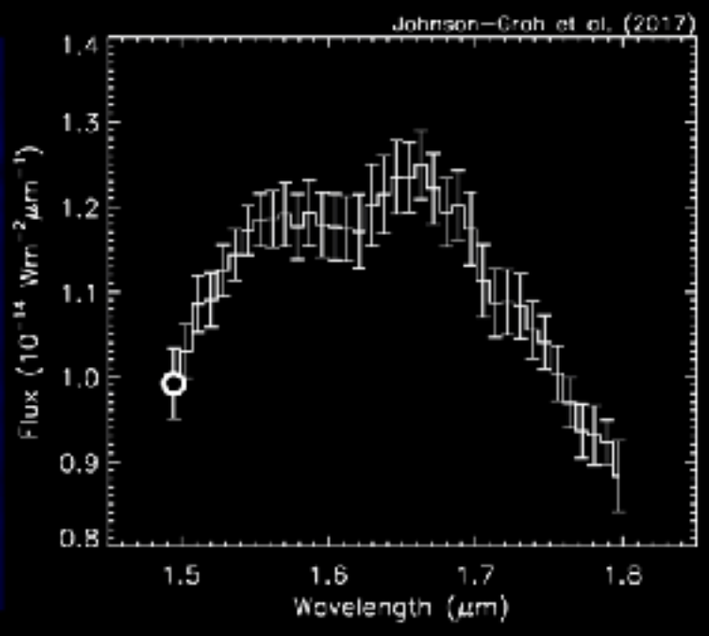




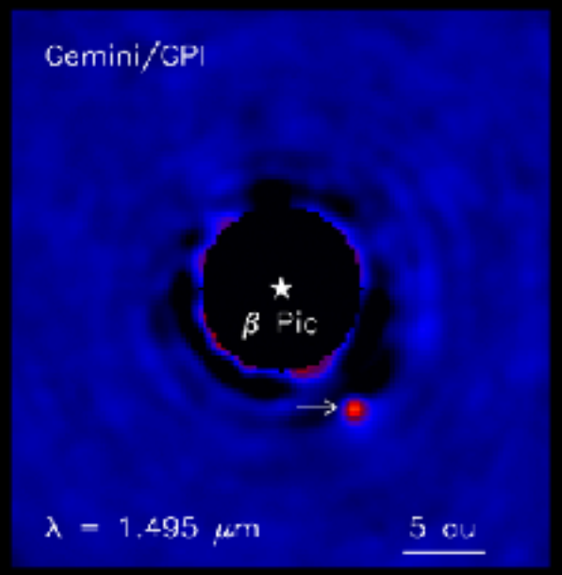


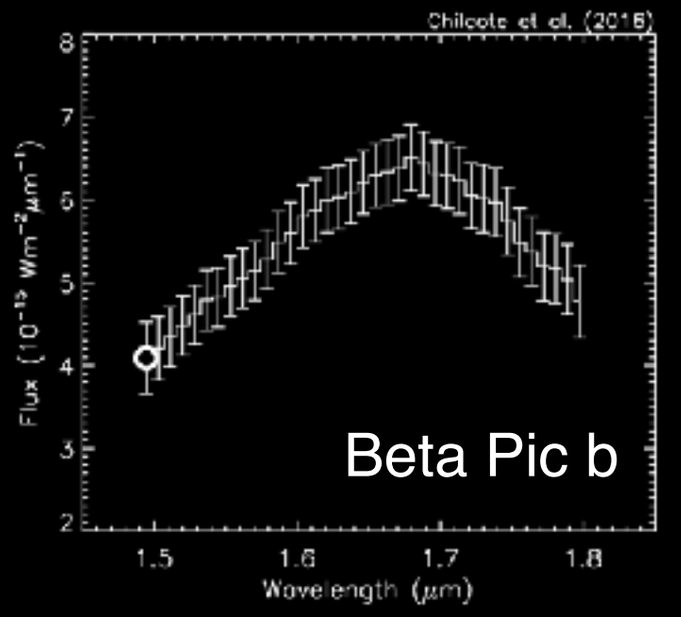




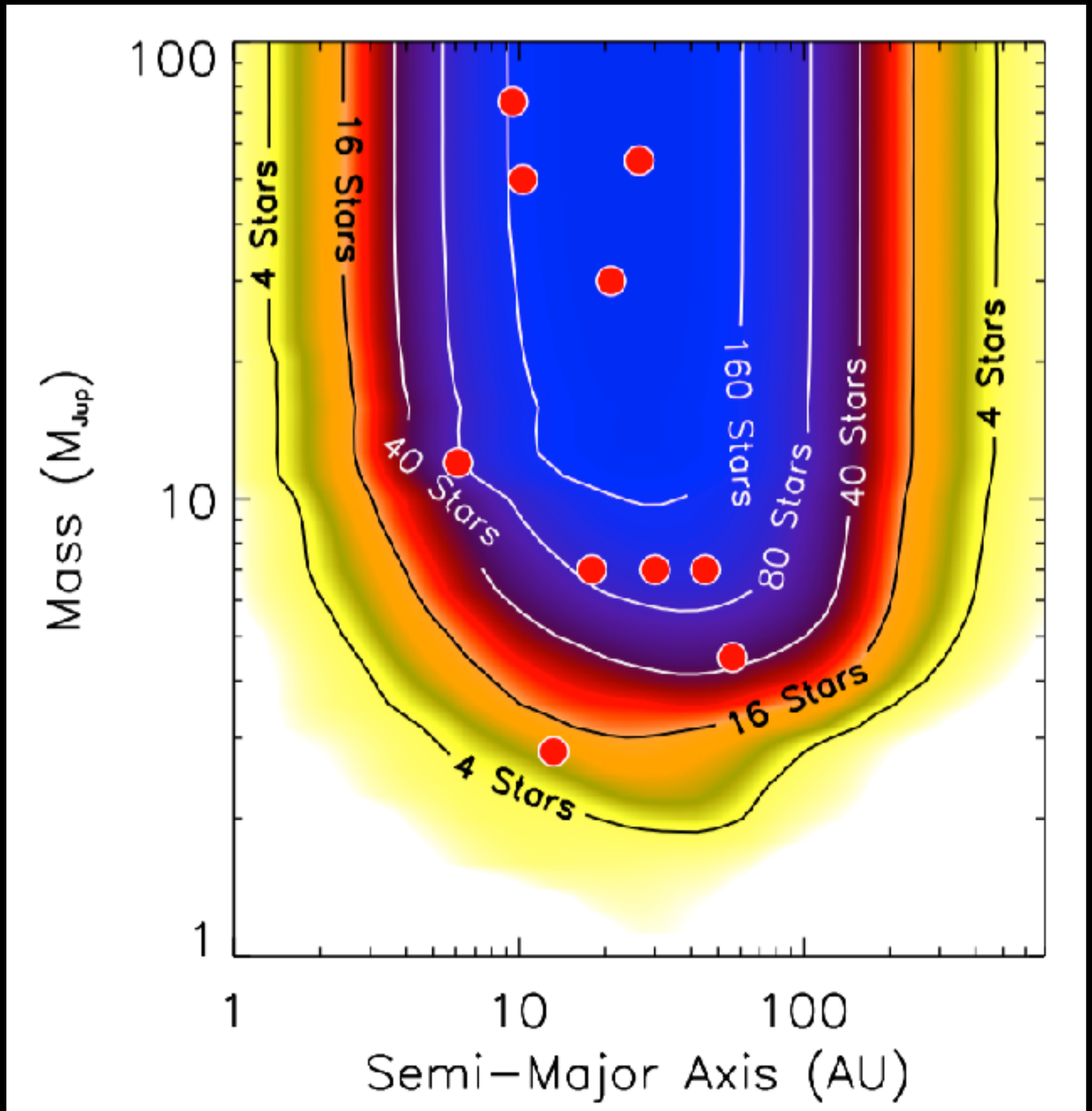


HD 984 B

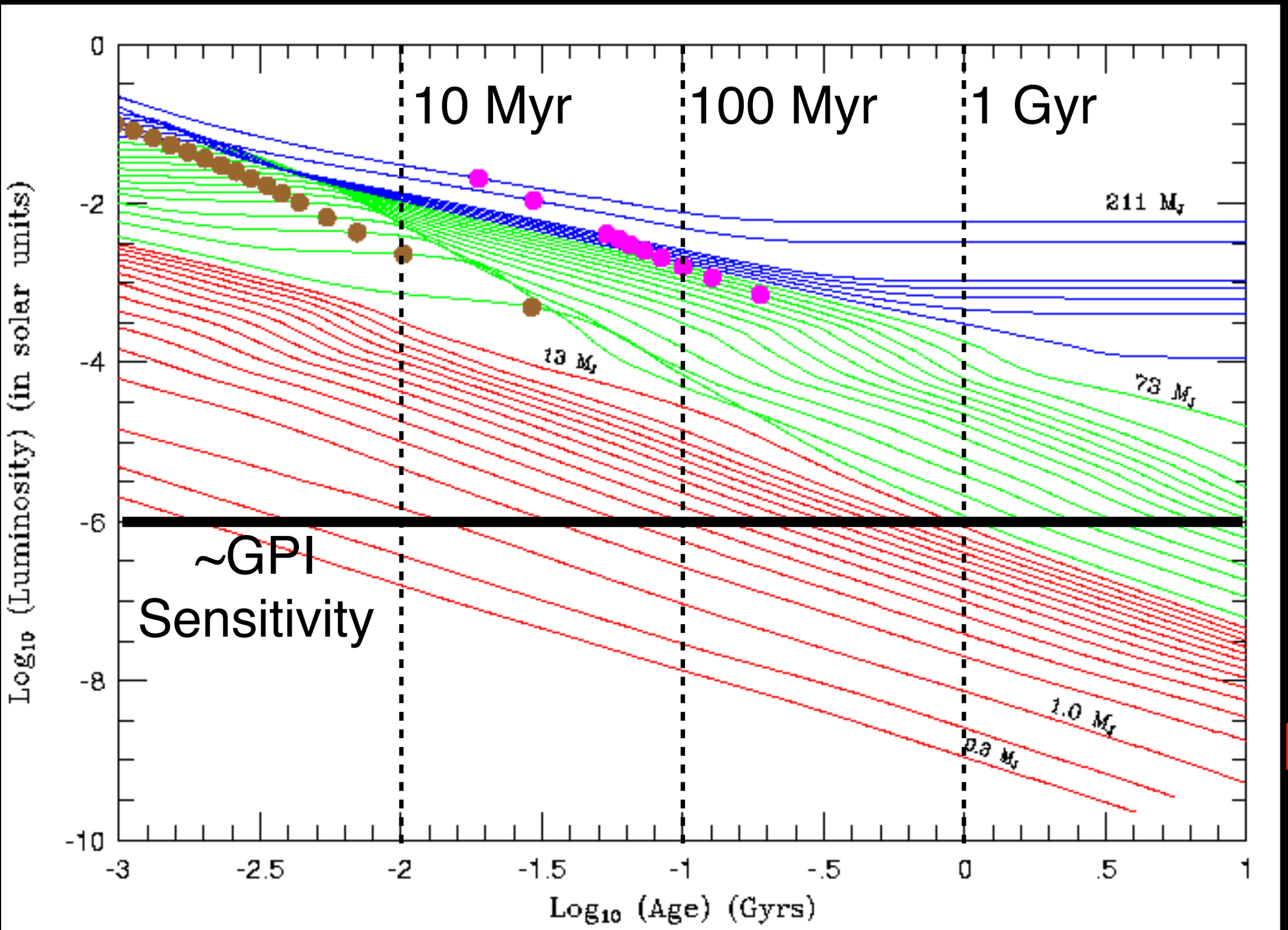




GPIES Completeness and Detections



Luminosity Models

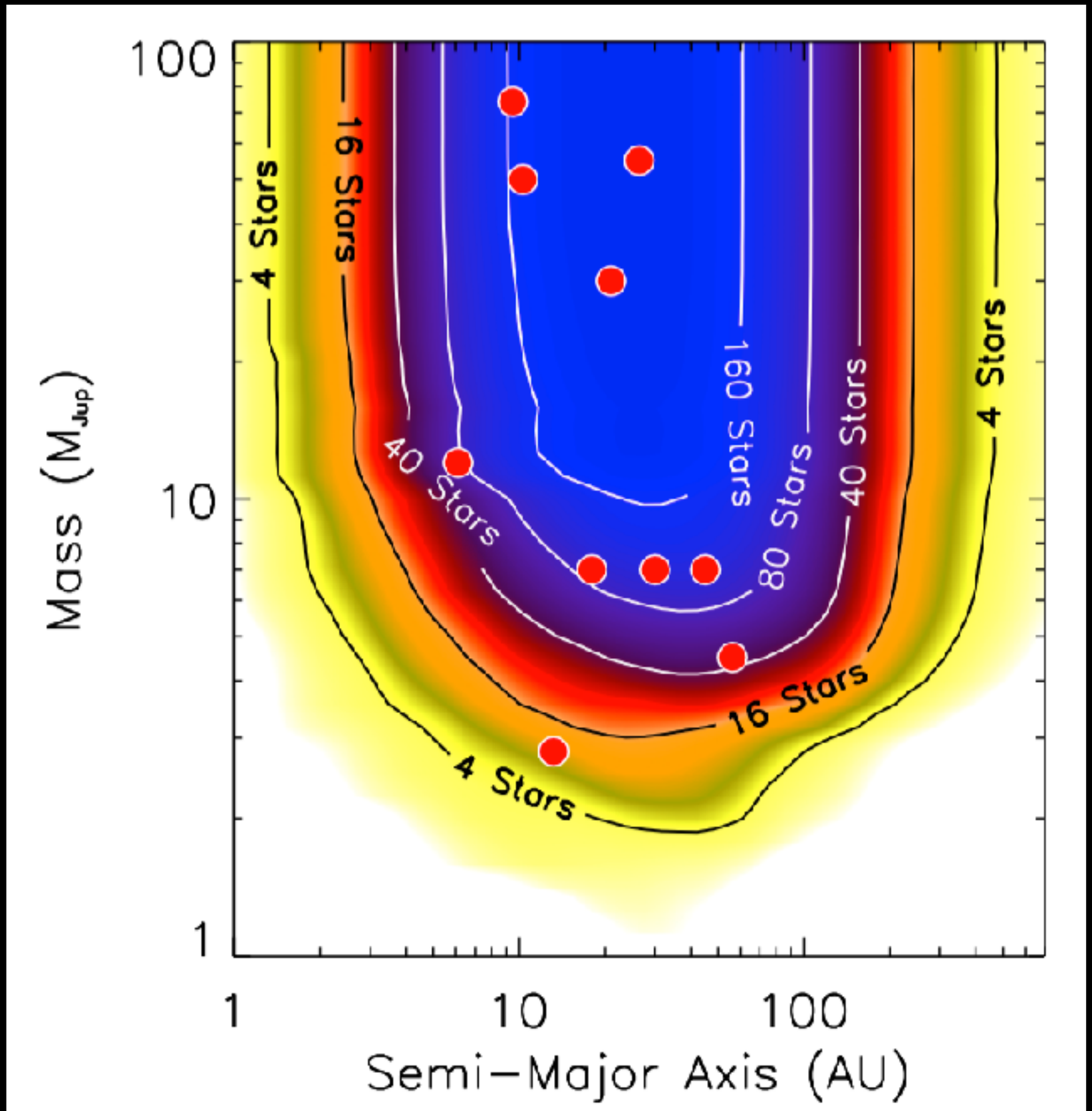


Stars

Brown Dwarfs

Planets

GPIES Completeness and Detections



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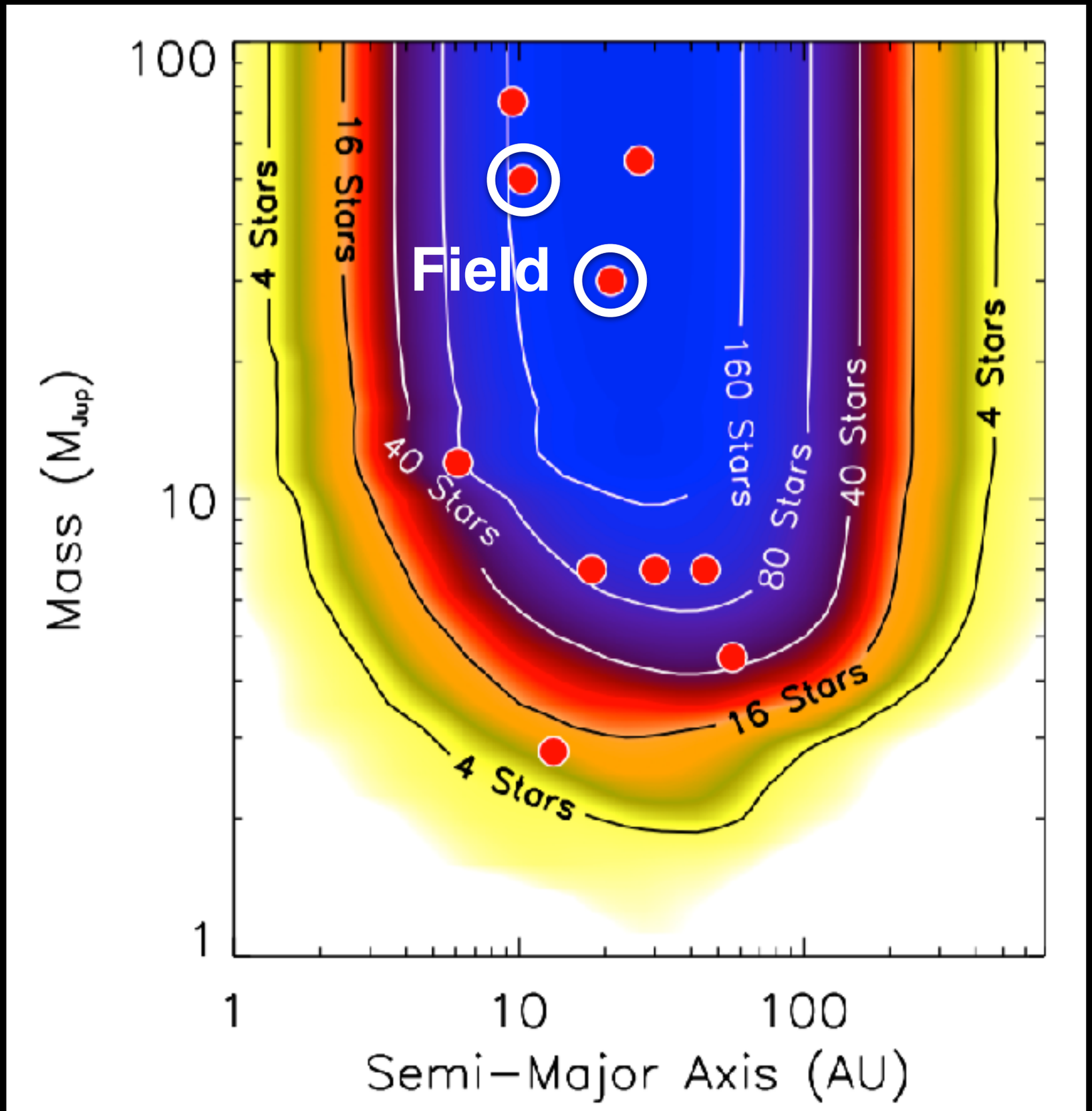

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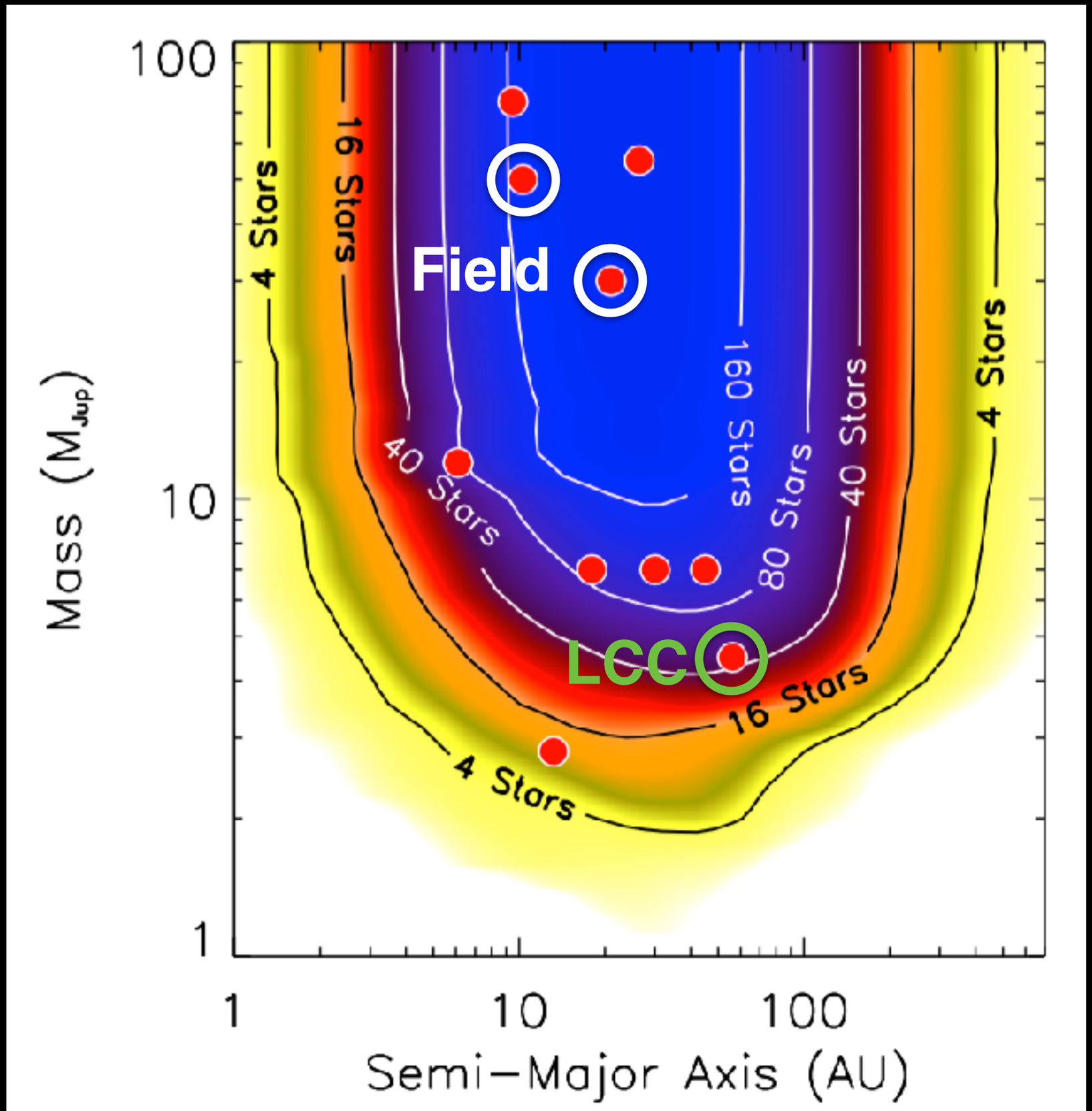

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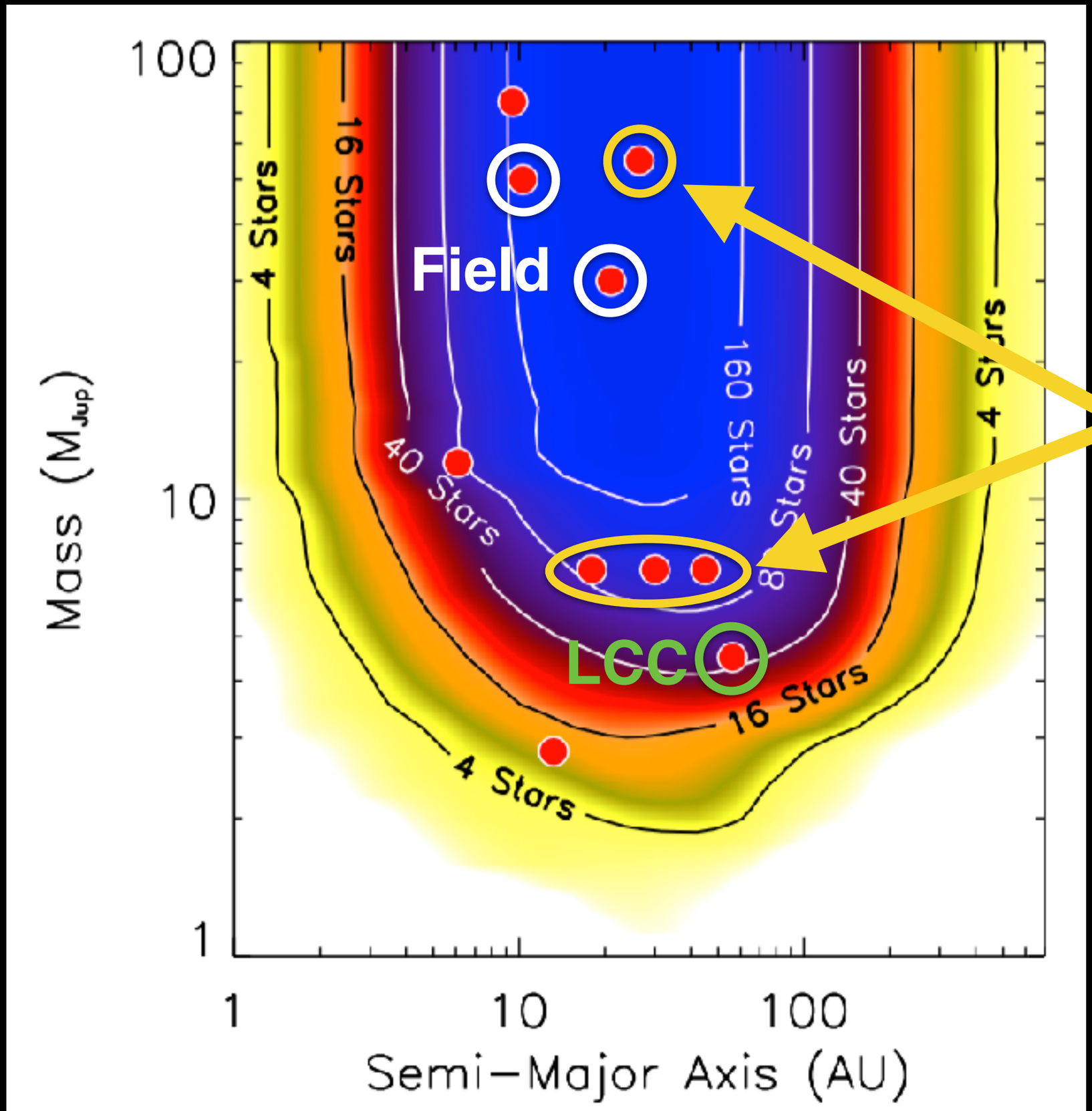

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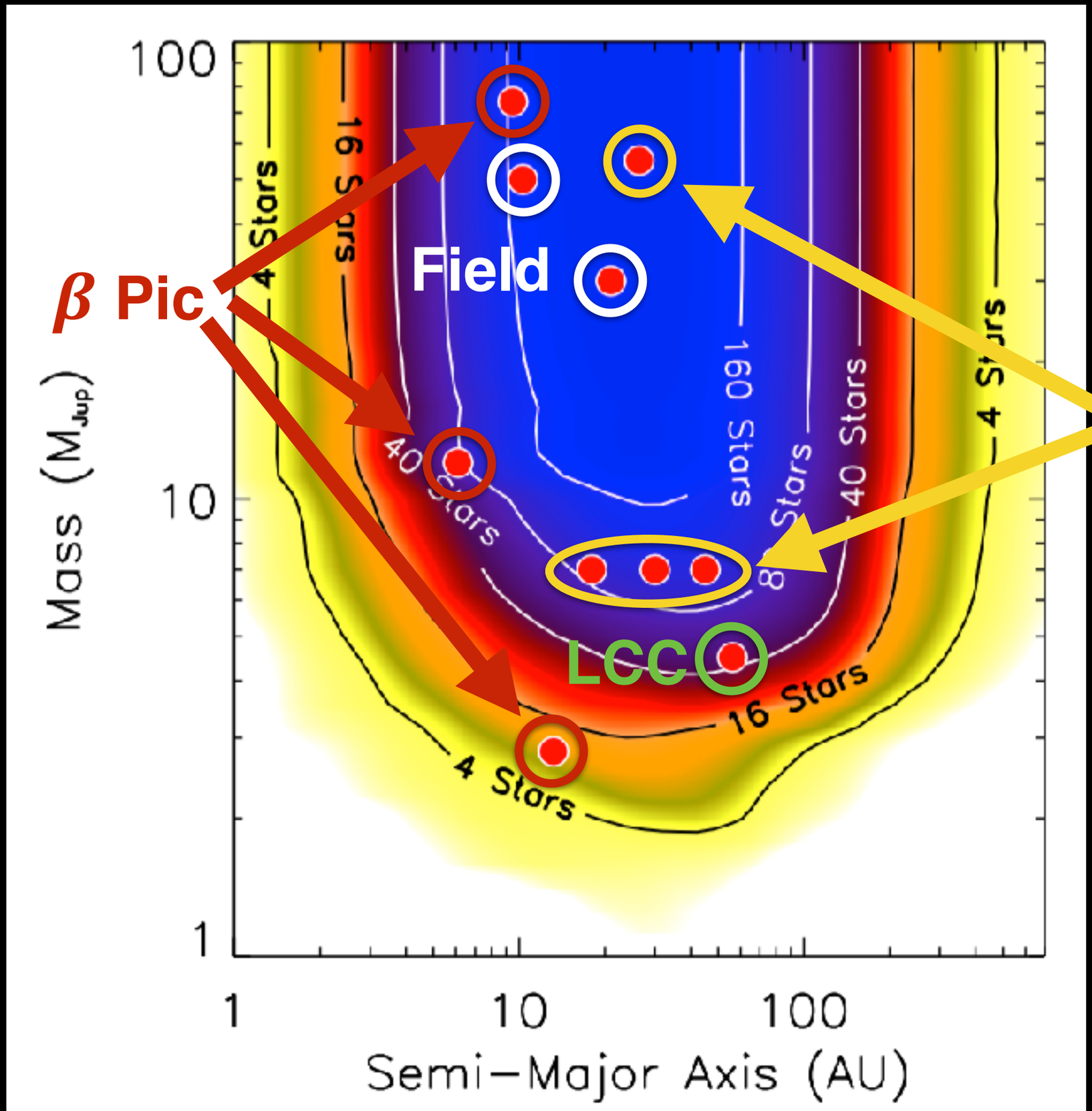
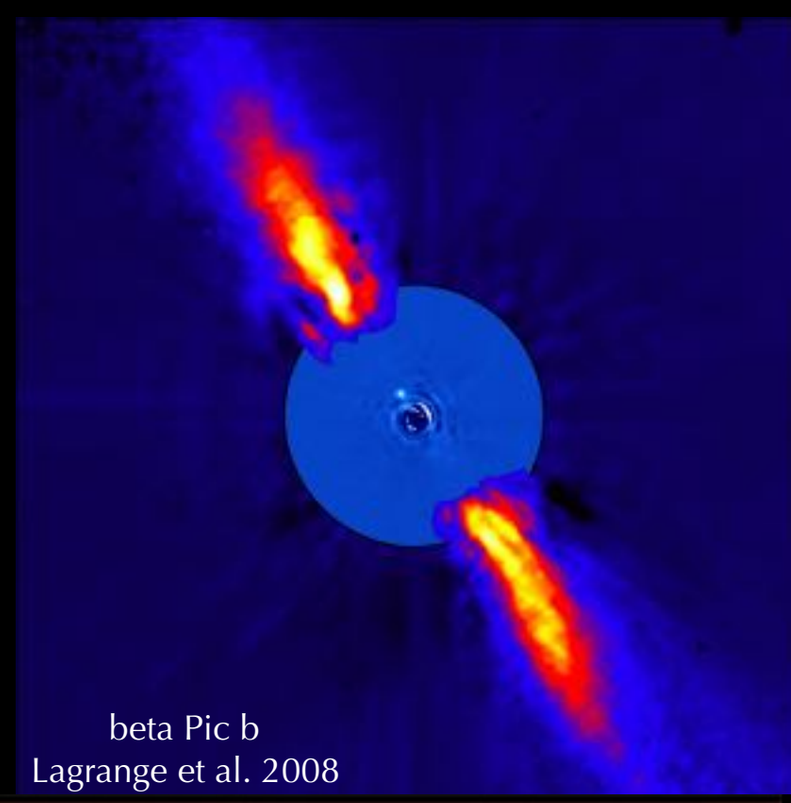
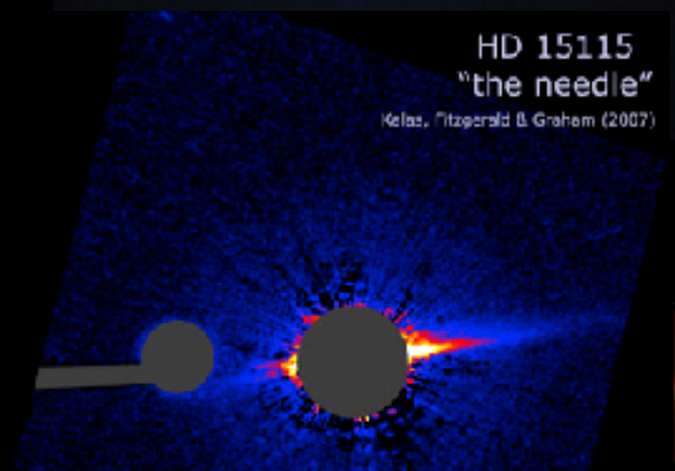
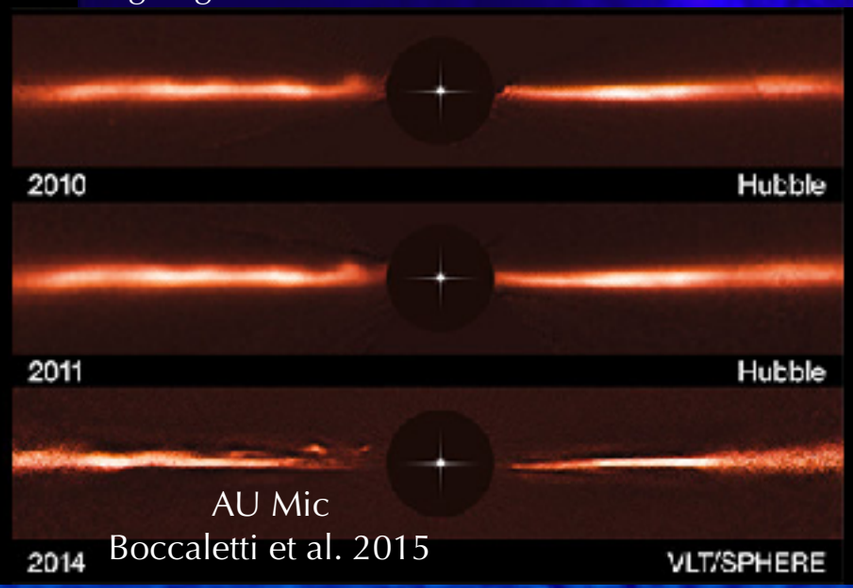
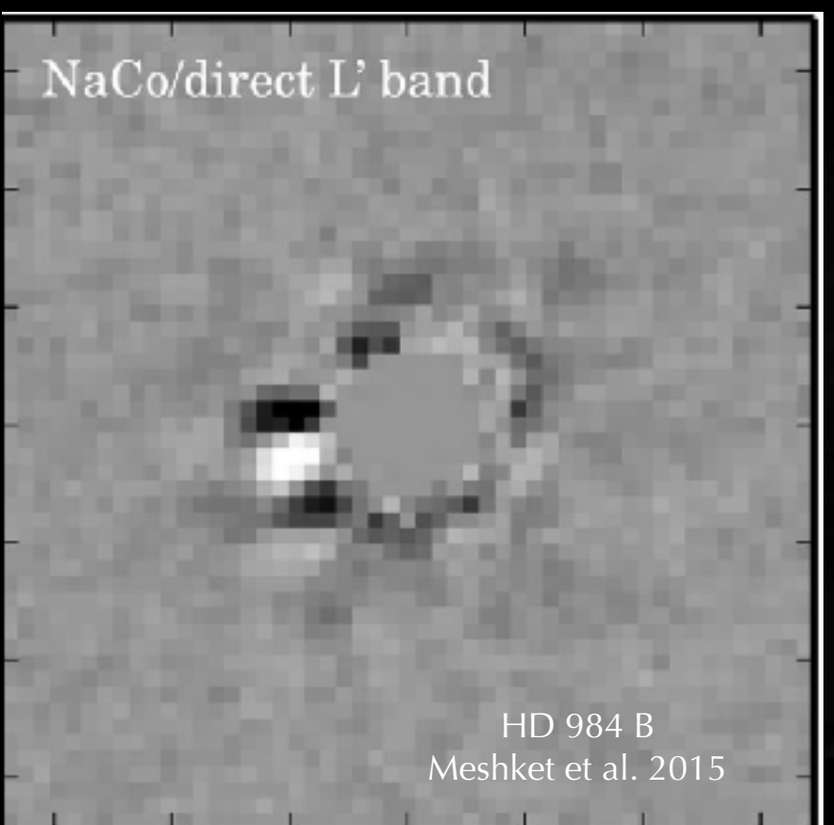


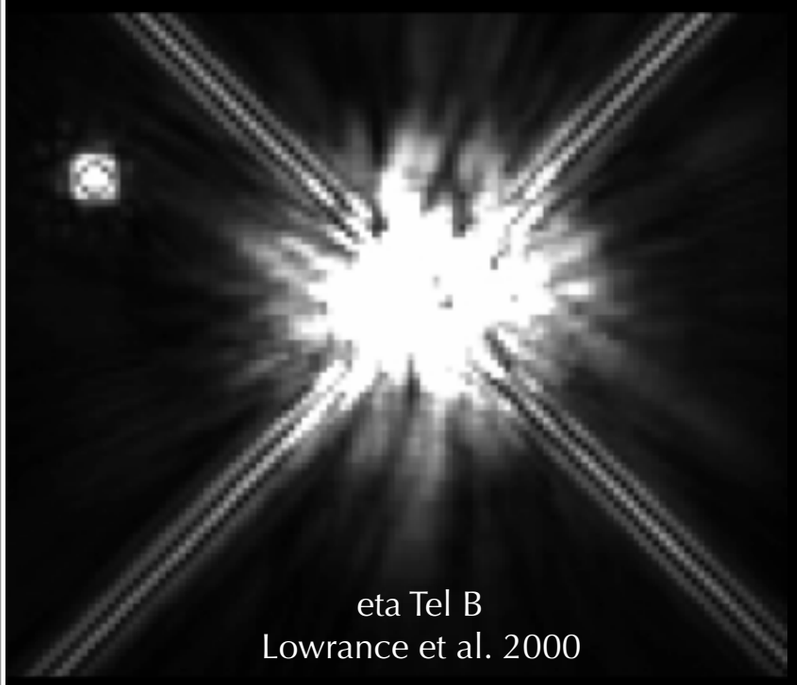
The Age of the β Pic Moving Group

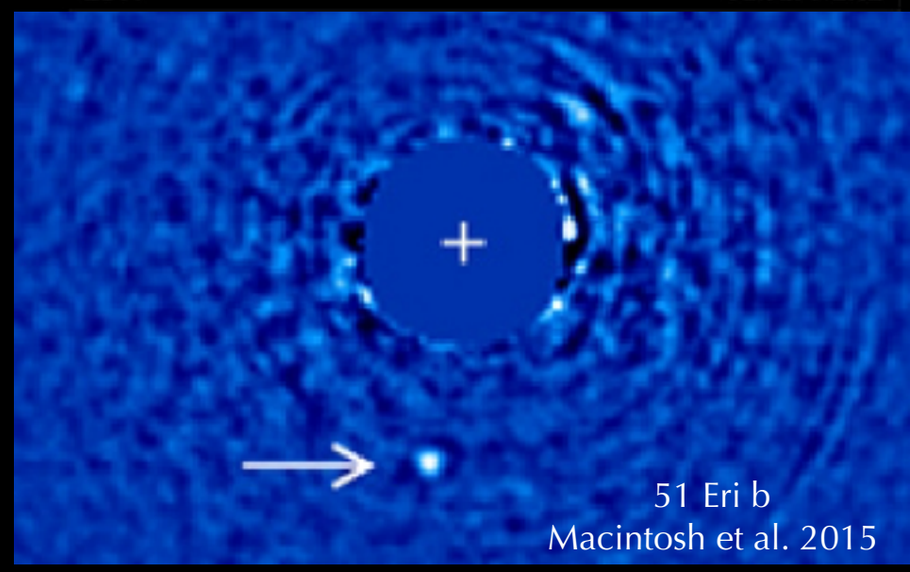












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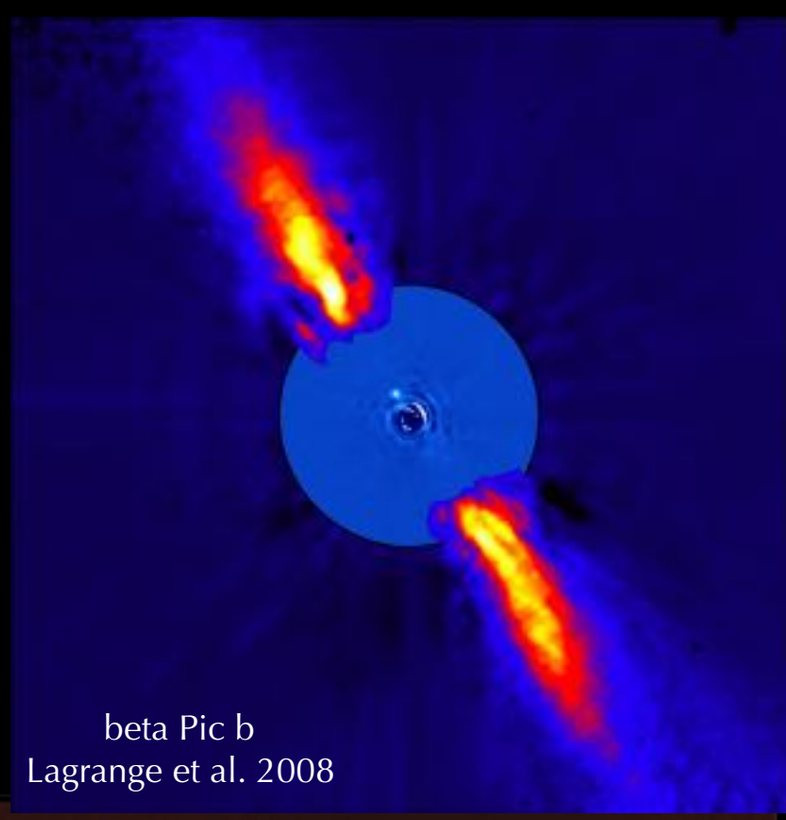
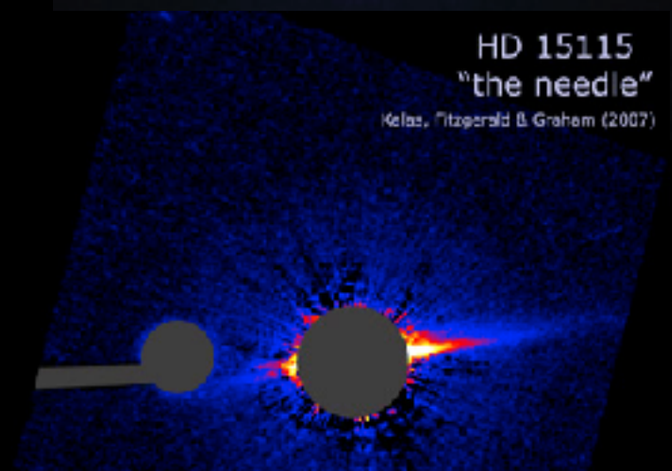
24 ± 3 Myr — Bell et al. 2015
26 ± 3 Myr — Nielsen et al. 2016

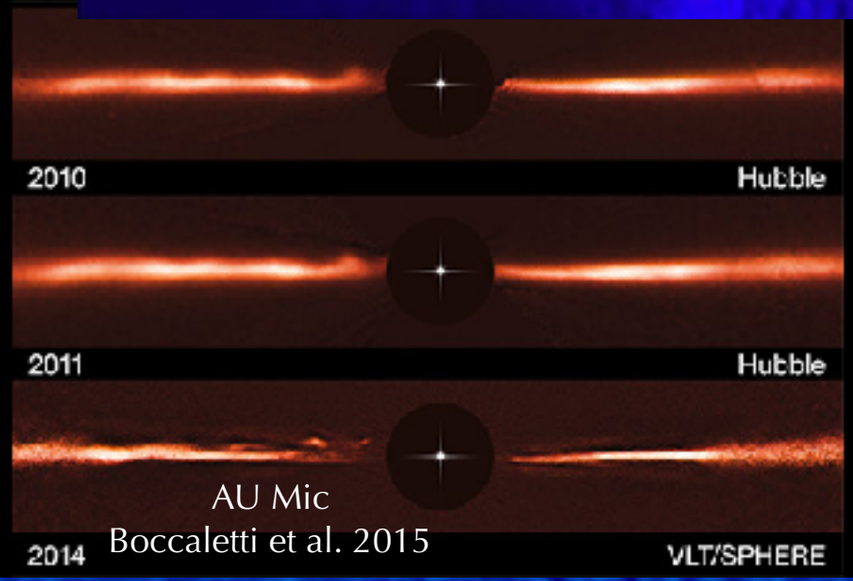
HD 181327
Schneider et al. 2014



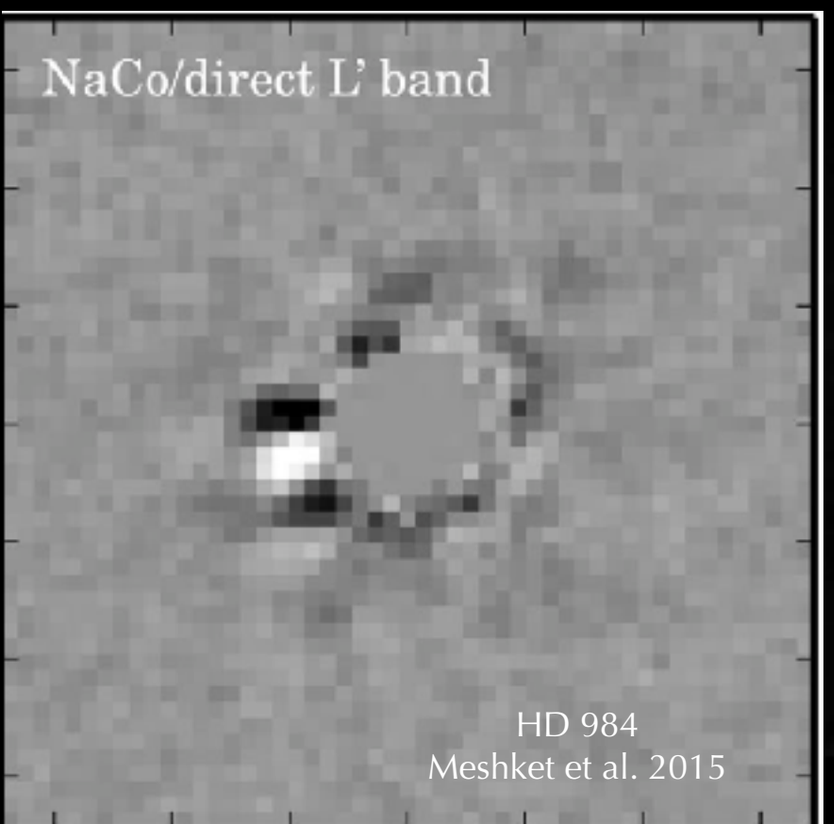
beta Pic b
Lagrange et al. 2008



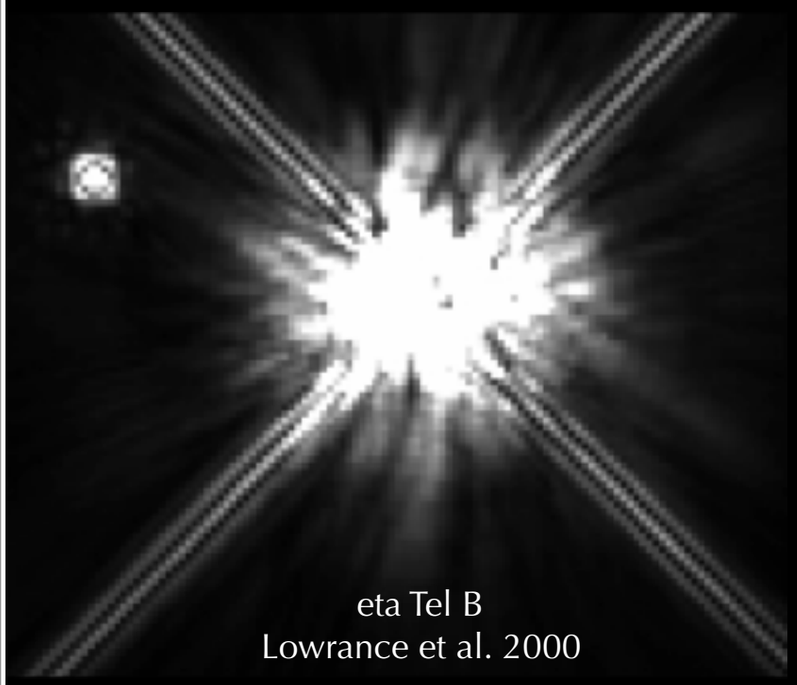
HD 15115
Kalas et al. 2007



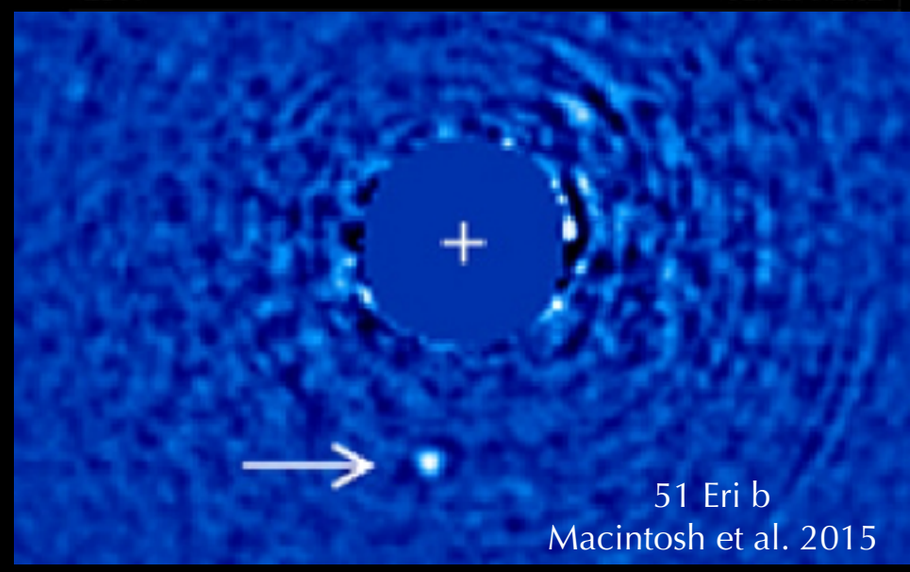
AU Mic
Boccaletti et al. 2015



HD 984
Meshket et al. 2015



eta Tel B
Lowrance et al. 2000



51 Eri b
Macintosh et al. 2015

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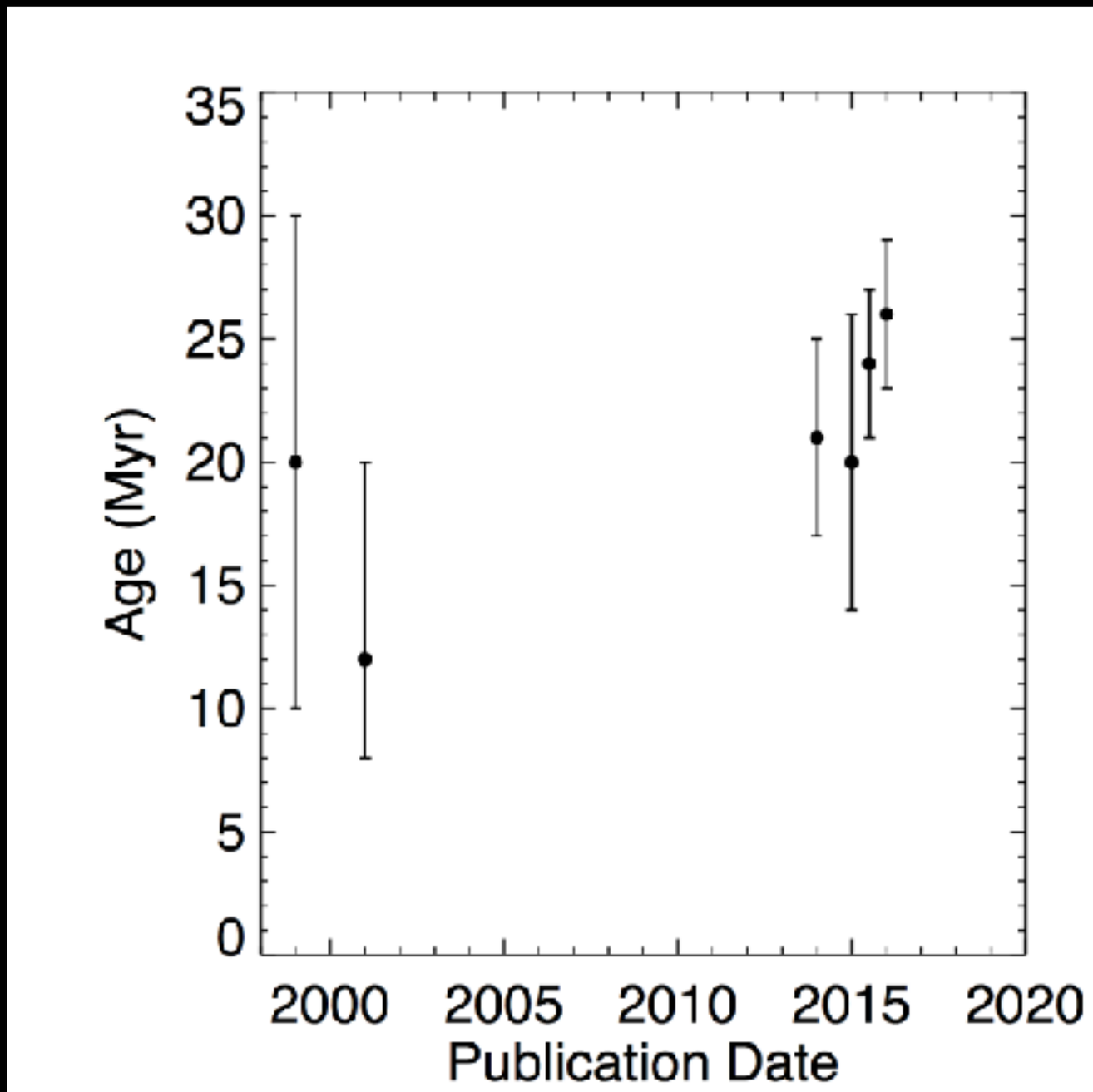

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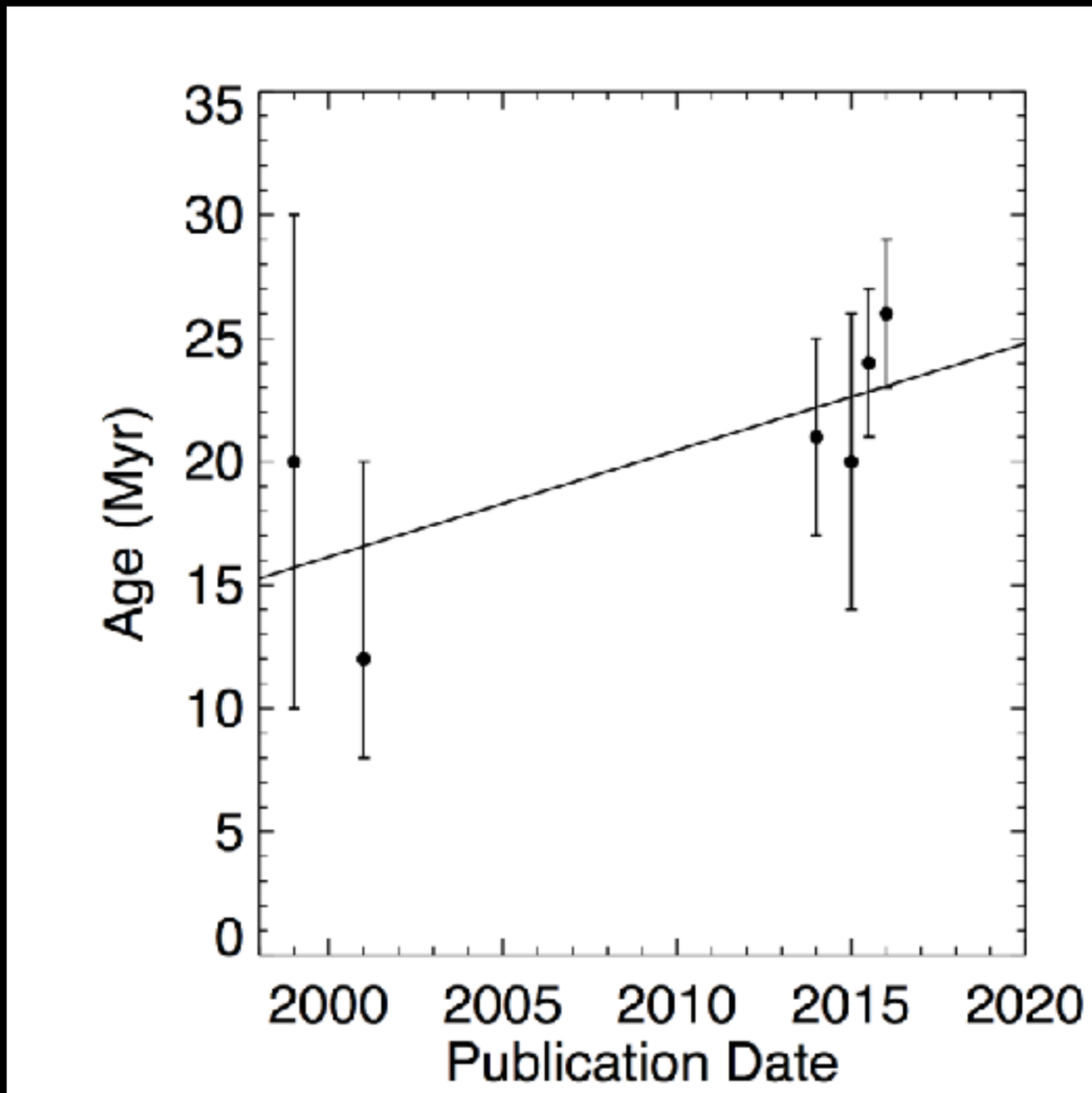

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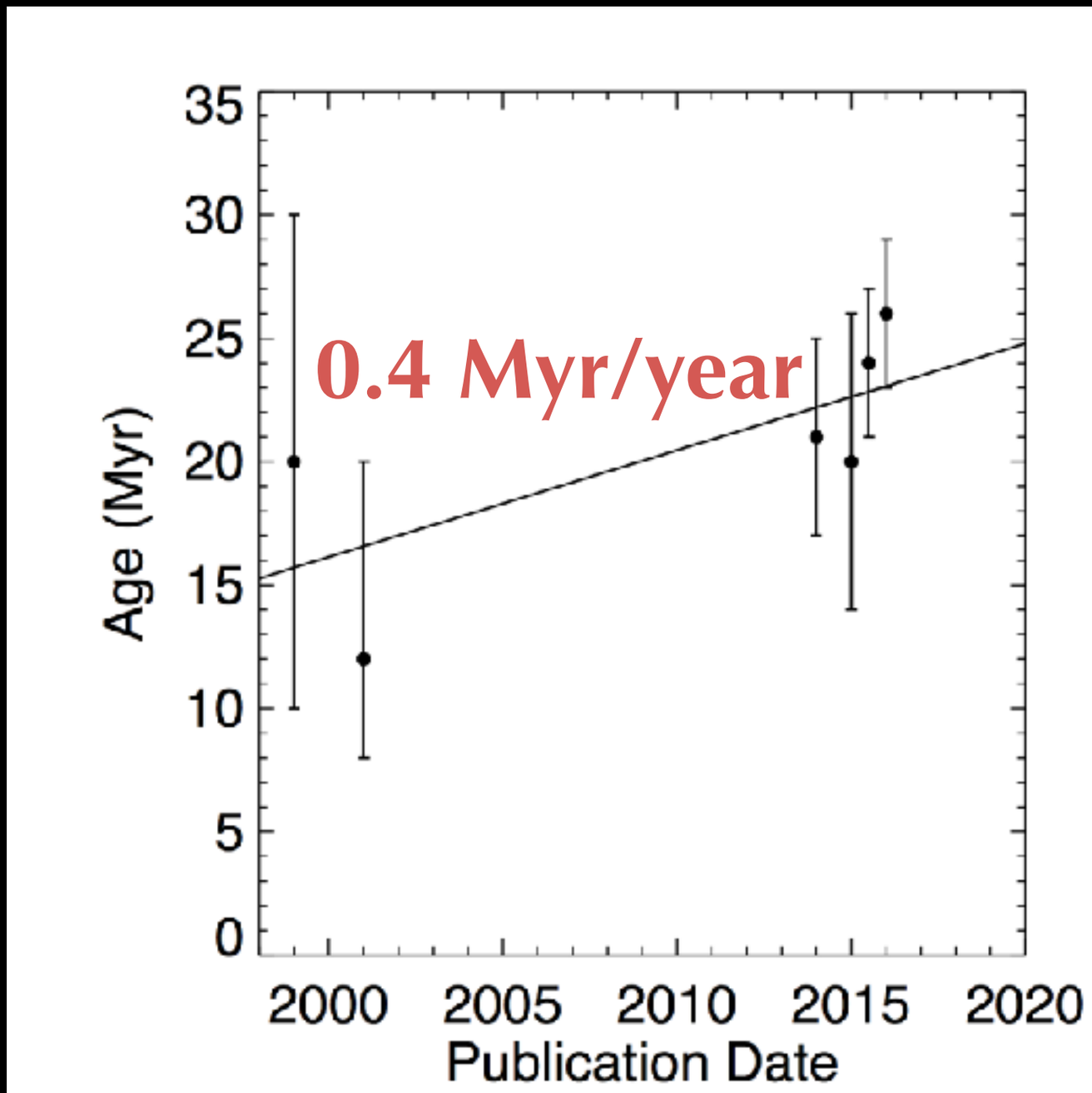
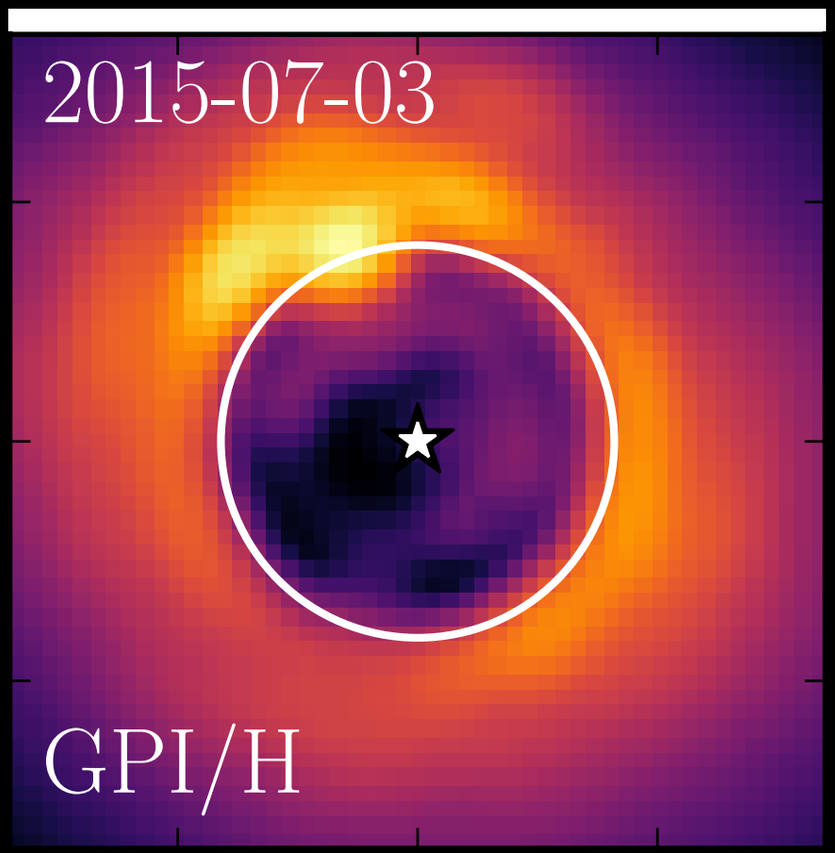
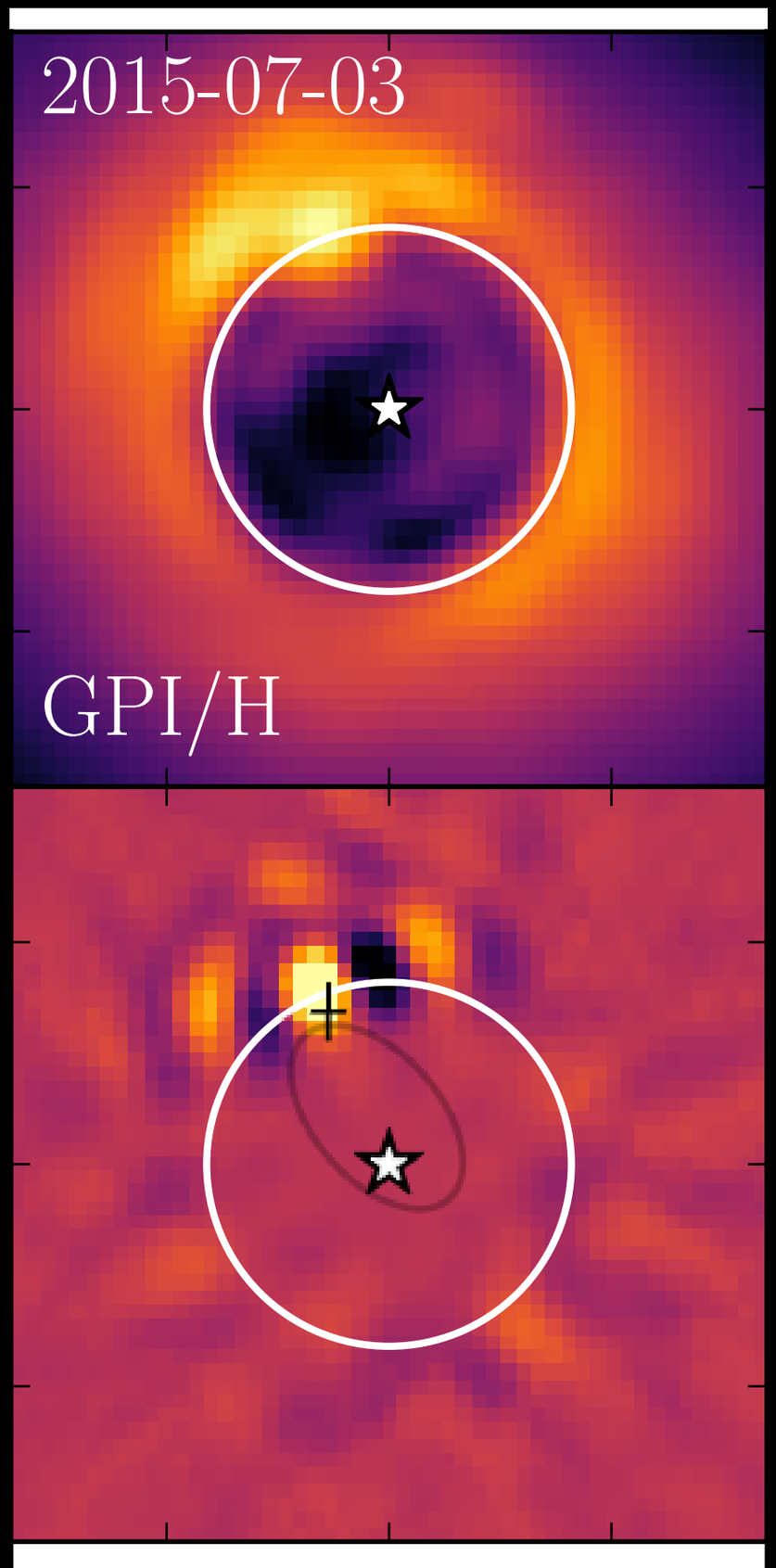


GPI Detection of V343 Nor AaAb



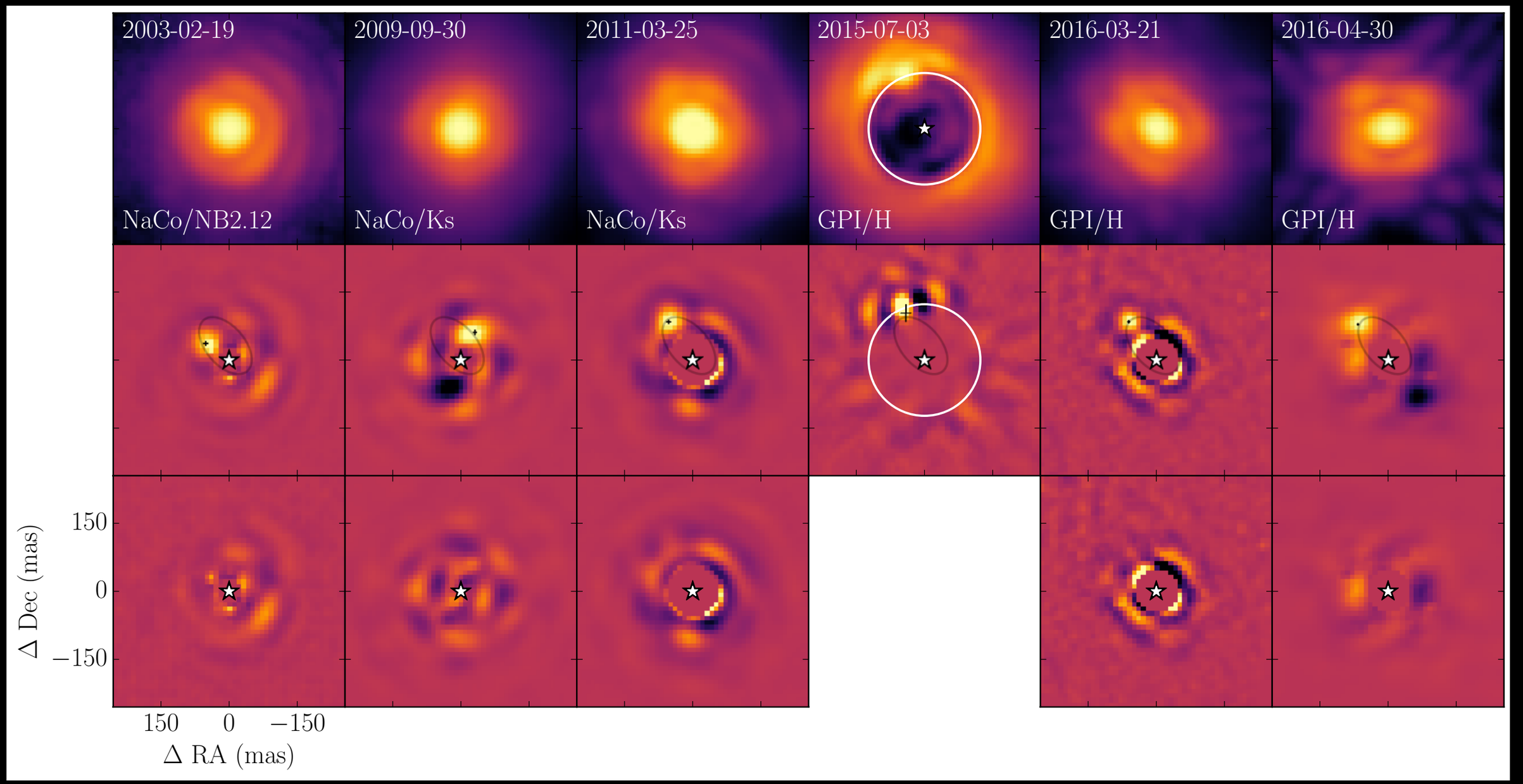
Nielsen et al. 2016

GPI Detection of V343 Nor AaAb



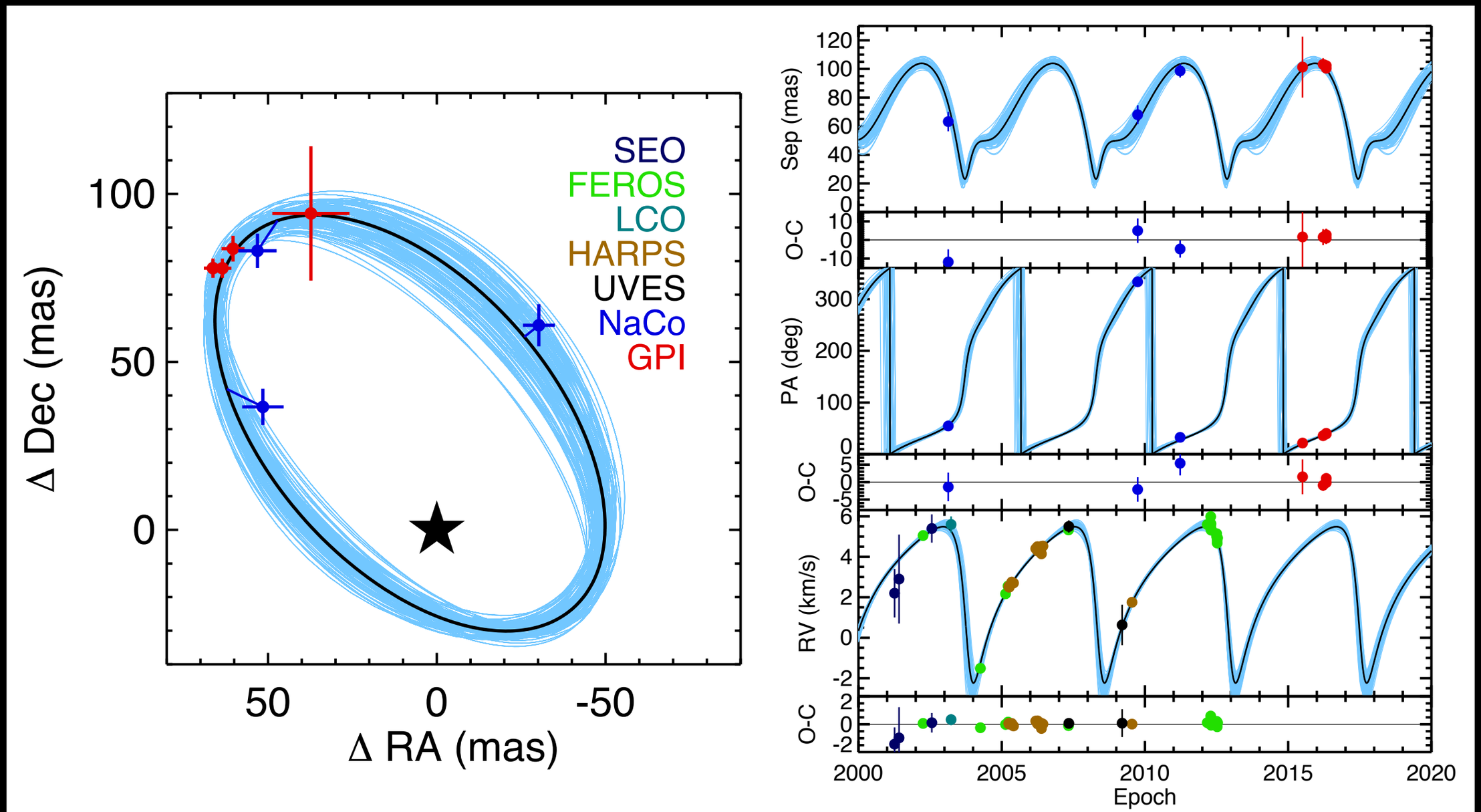
Nielsen et al. 2016

Astrometric Monitoring of V343 Nor AaAb



Nielsen et al. 2016

Dynamical Mass Measurement



Nielsen et al. 2016

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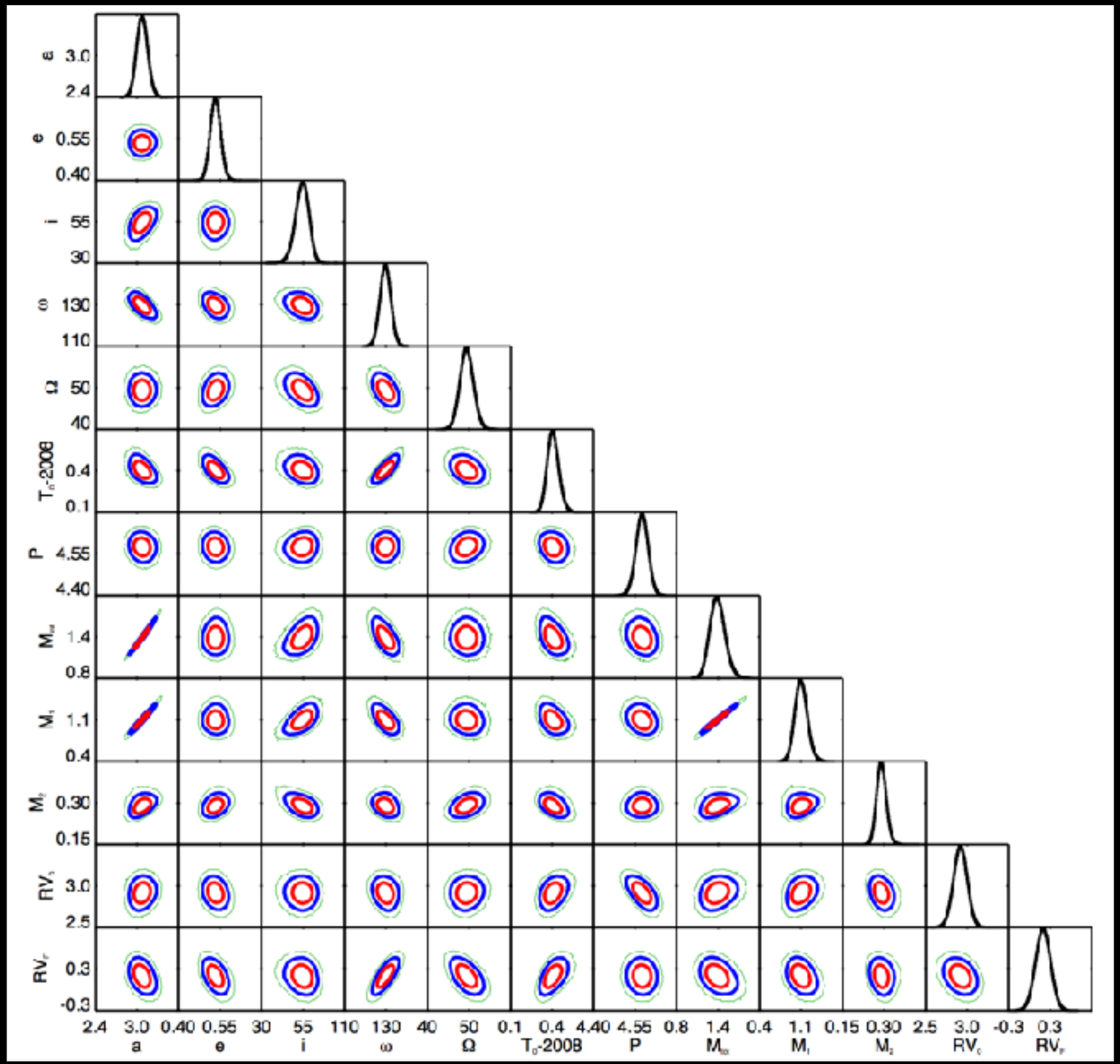
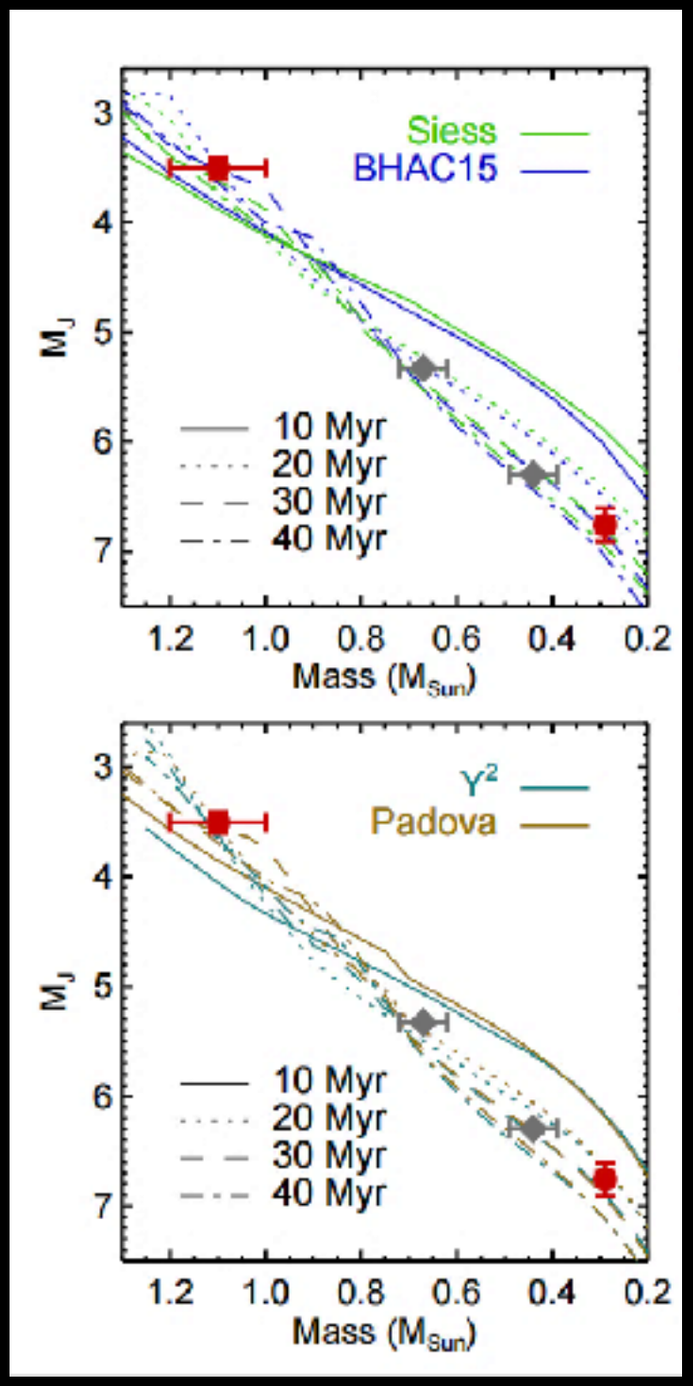


Nielsen et al. 2016

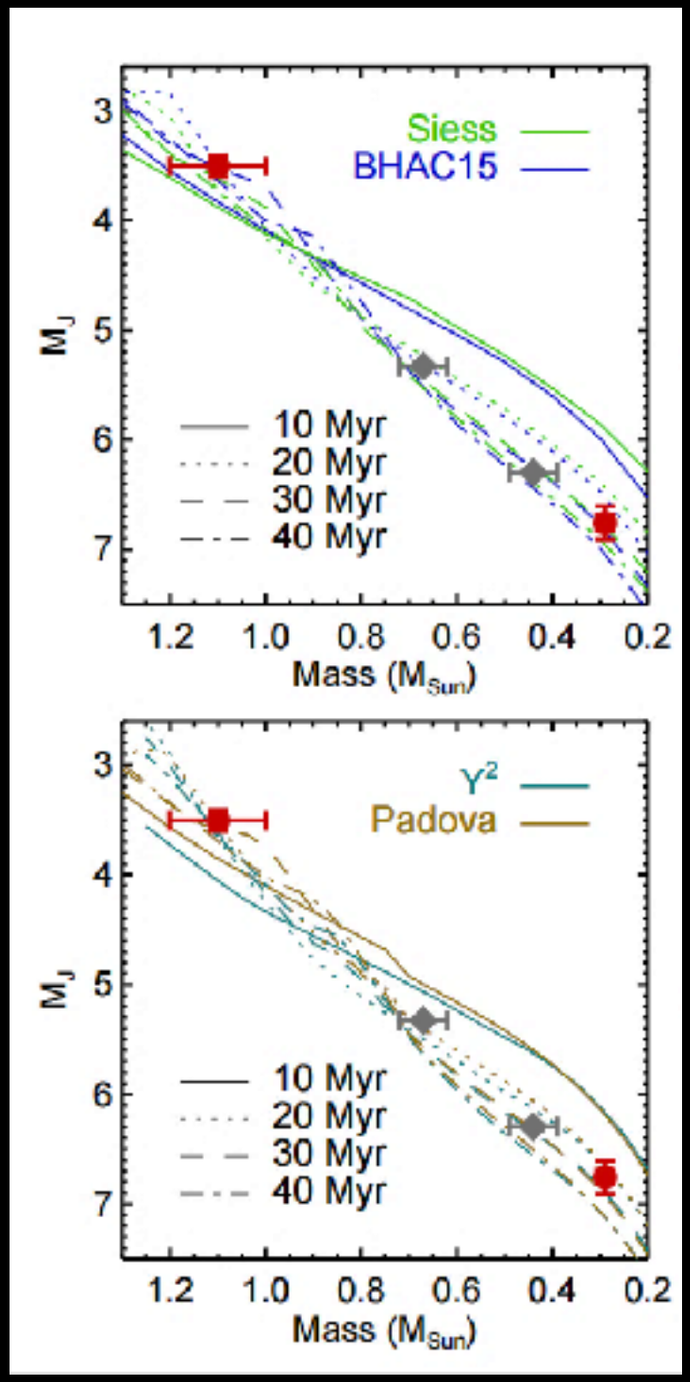
Age of the beta Pic moving group

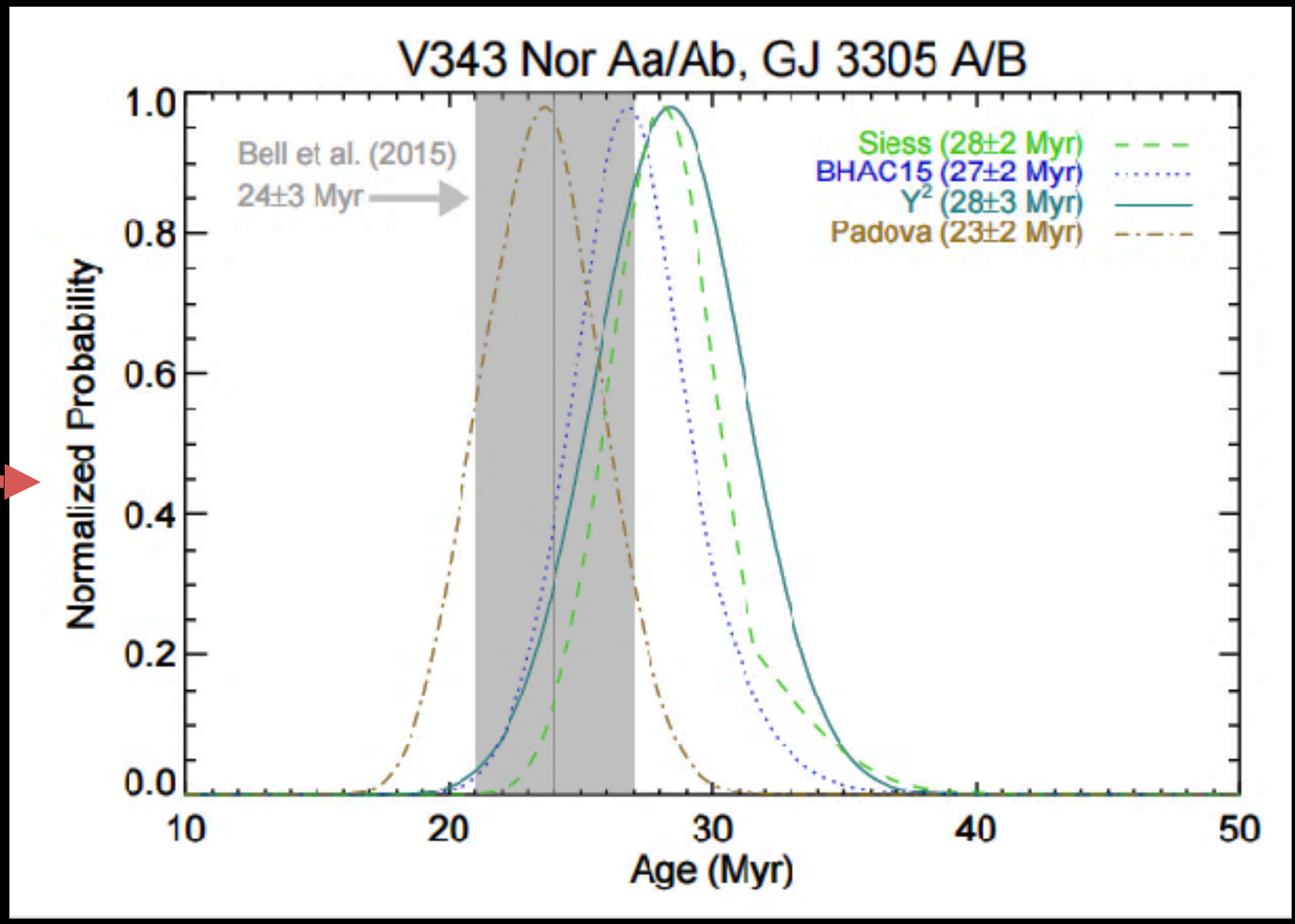


GJ 3305: Montet et al. 2015
V343 Nor: Nielsen et al. 2016

Age of the beta Pic moving group

Measured Luminosity and Mass + Stellar Evolution Model → Stellar Age





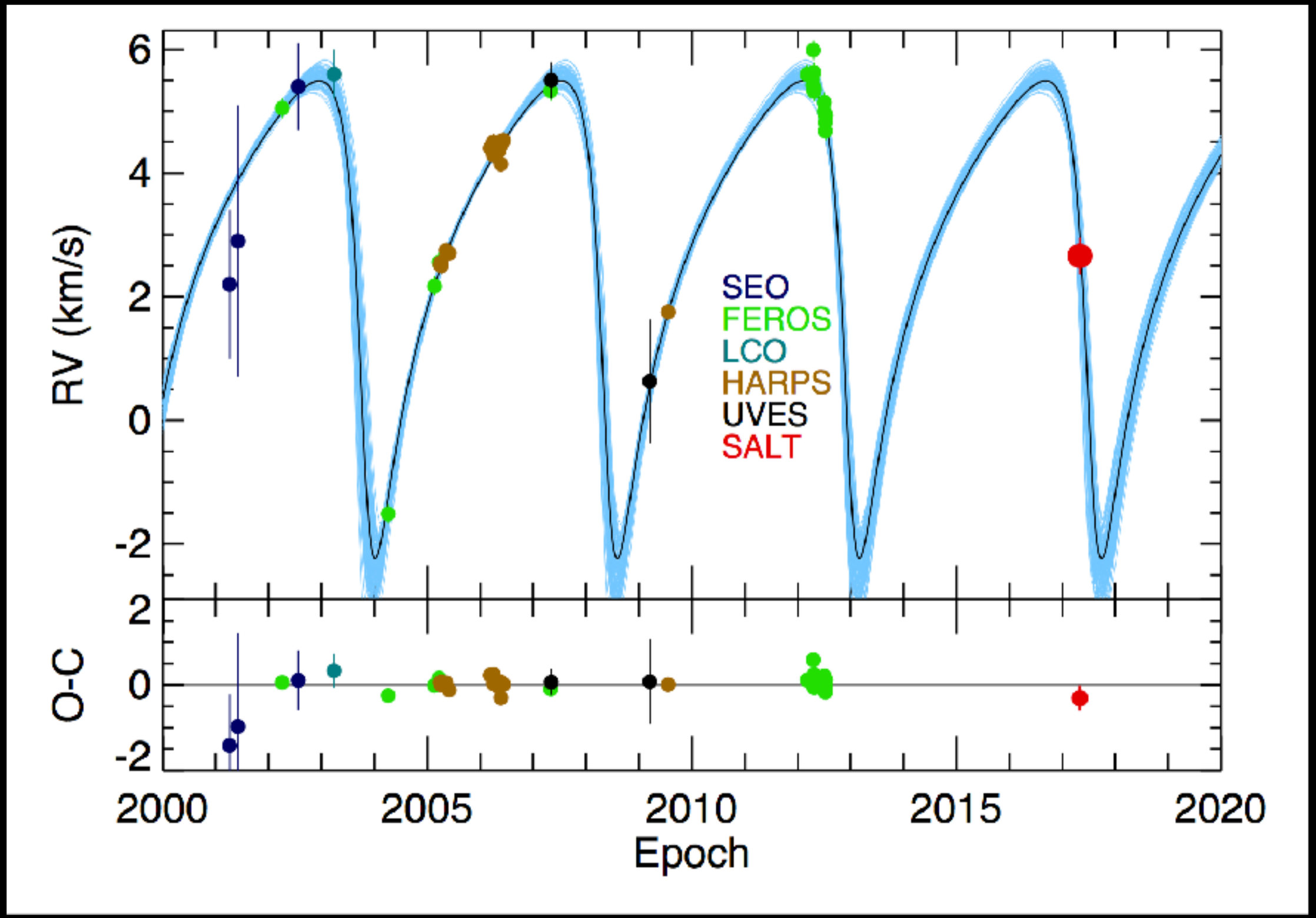
GJ 3305: Montet et al. 2015

V343 Nor: Nielsen et al. 2016

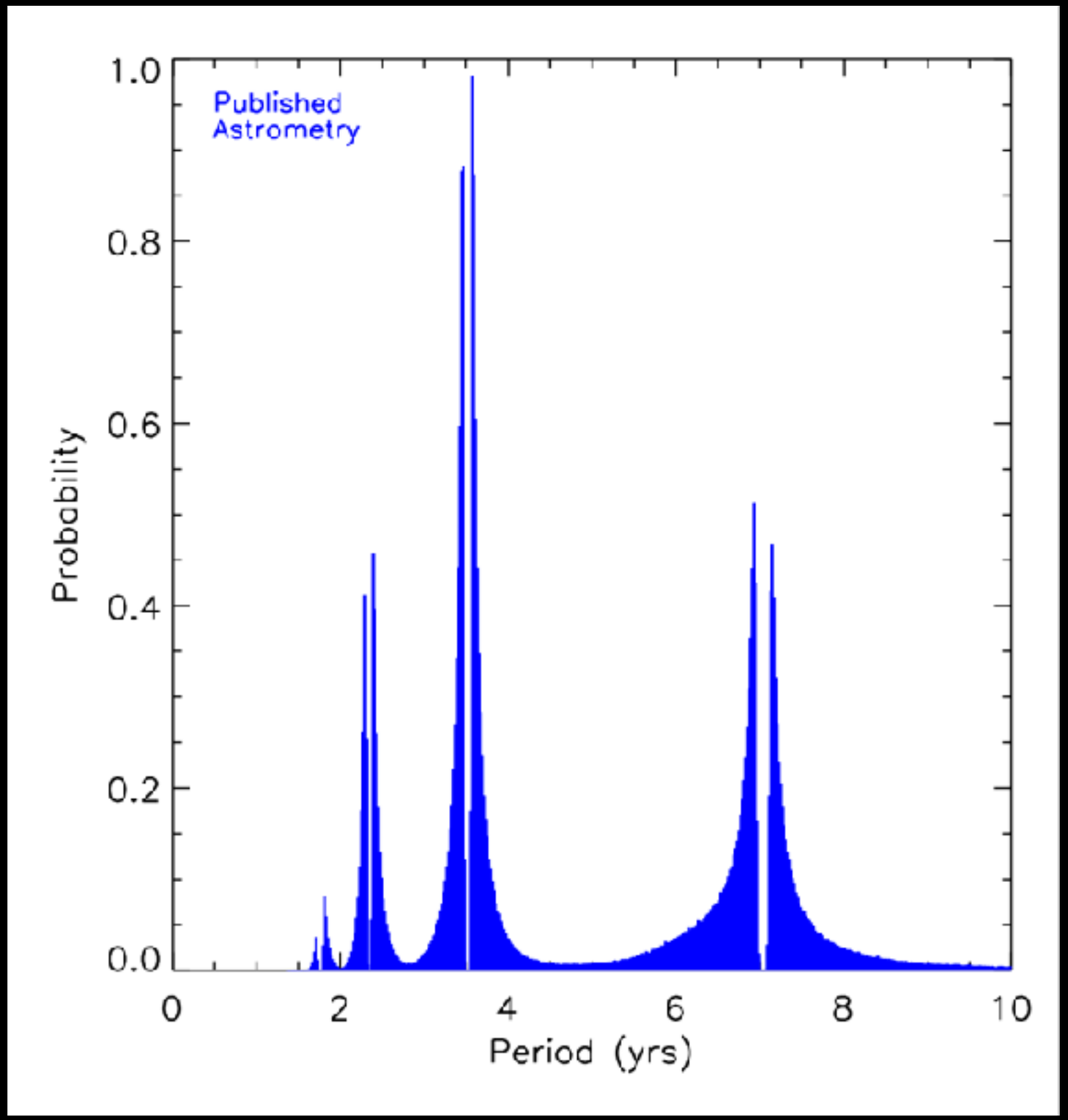
The Future of OMG Binaries

- GPI Imaging and NRM program
- APF RV velocity monitoring program
- SALT-HRS RV monitoring program
- Utilize archival imaging and spectroscopic observations

Continued Monitoring of V343 Nor



Taking Data on New Binaries



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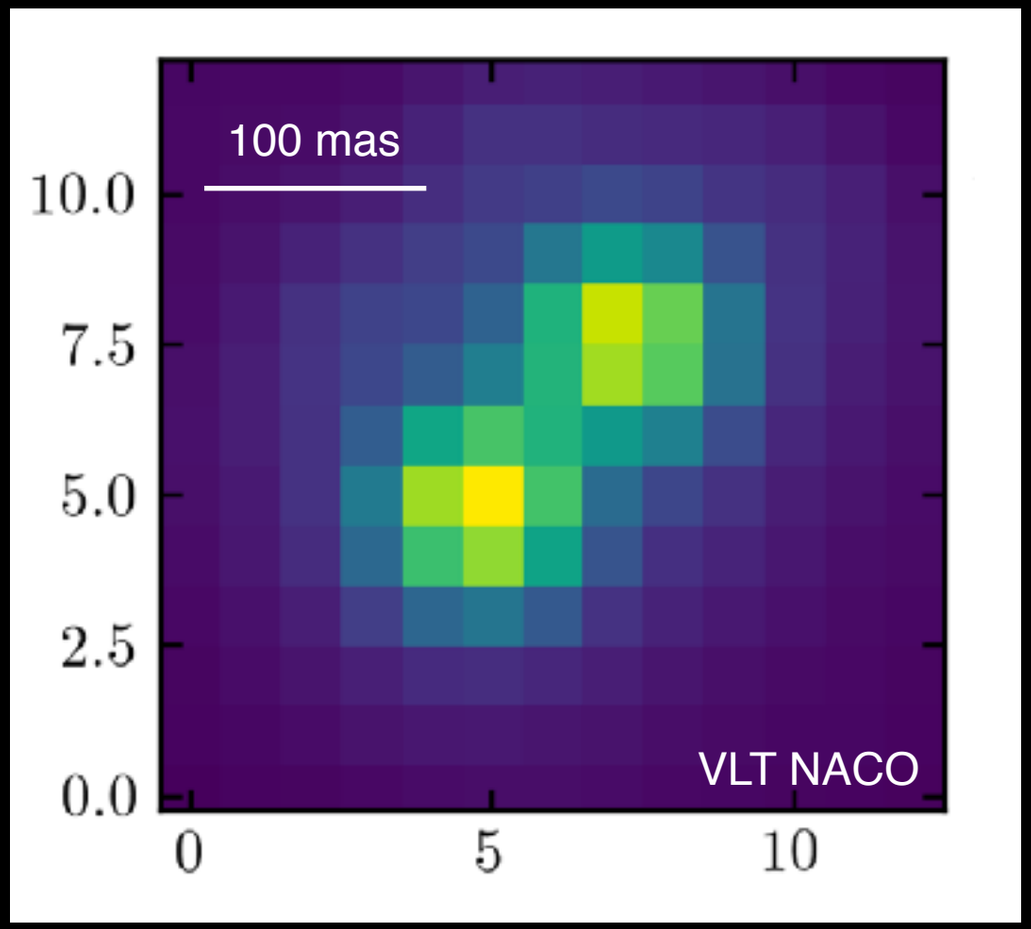

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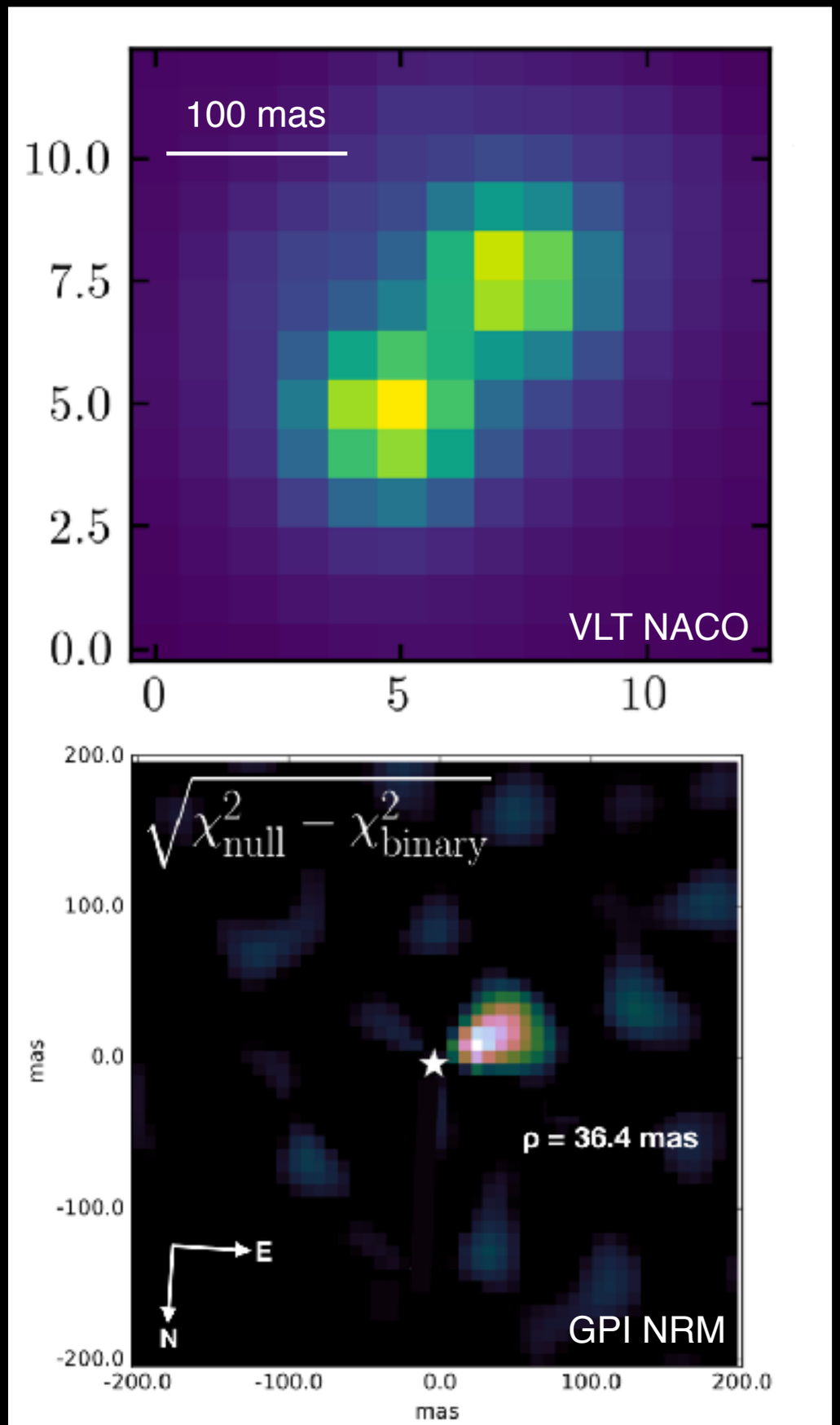
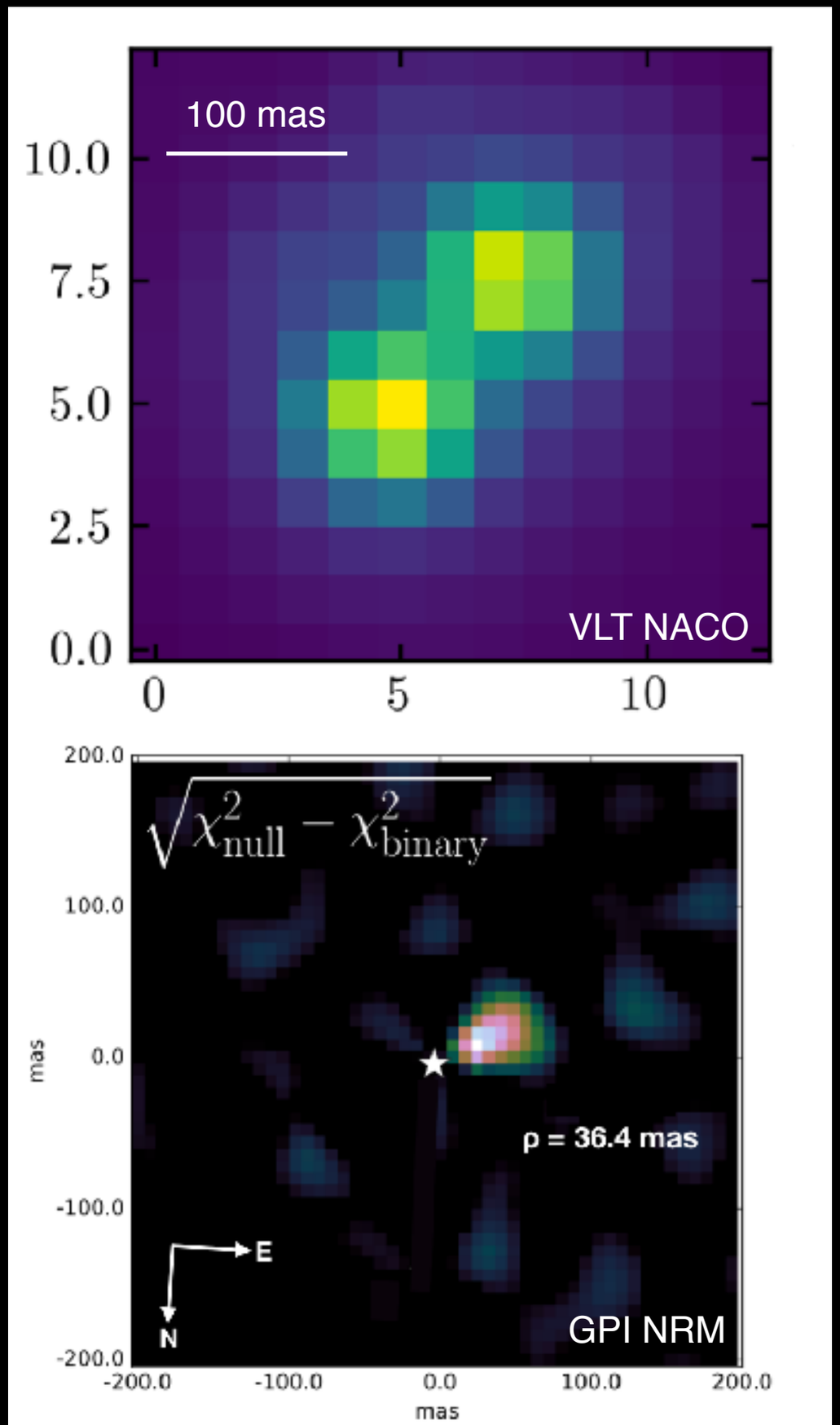
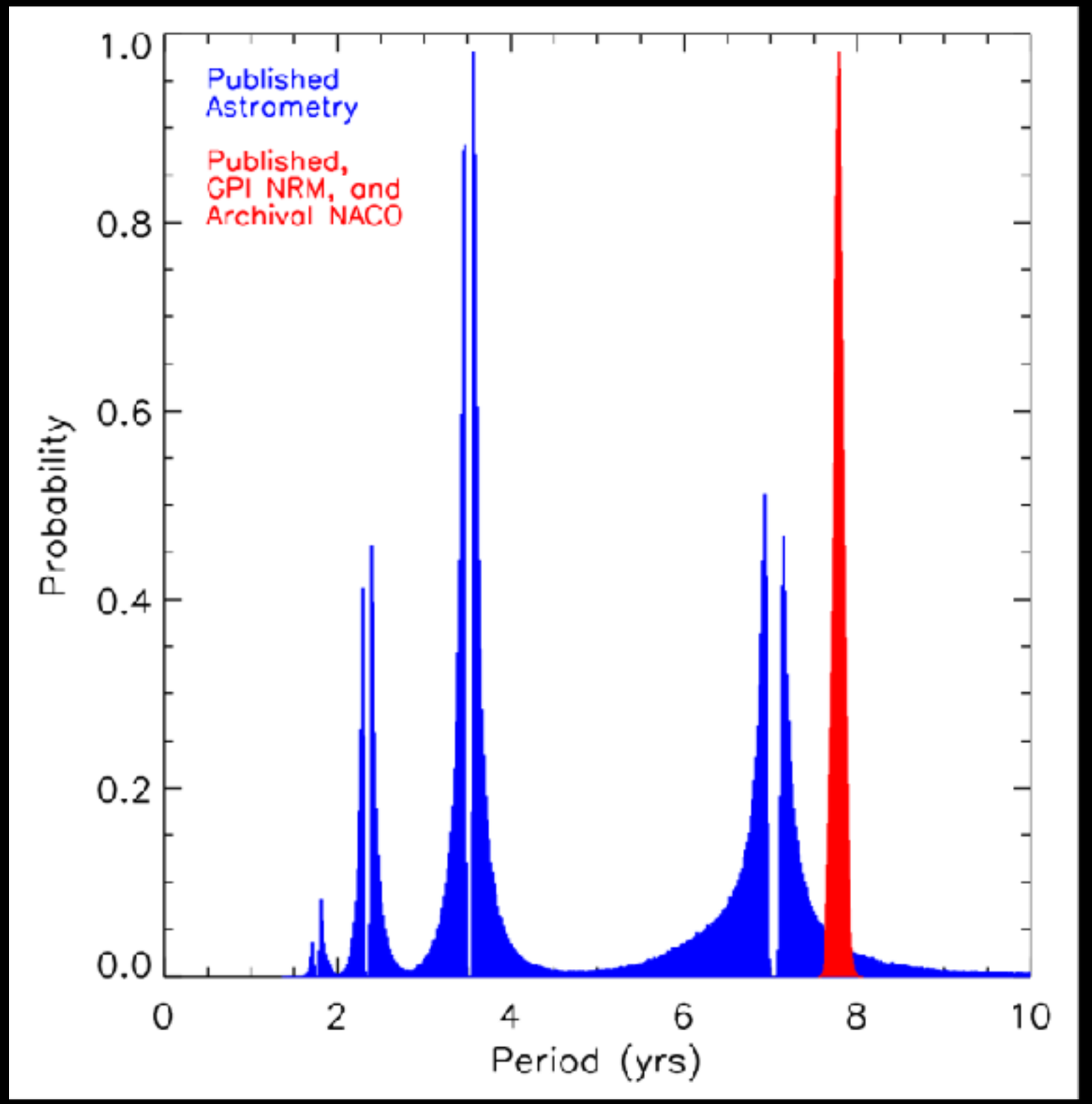


Taking Data on New Binaries





Conclusions

Ages are vital for characterizing substellar companions detected by direct imaging

Most detected companions are in moving groups

Resolved spectroscopic binaries give us model-dependent ages of their parent moving groups

OMG Binaries is ongoing, stay tuned for more results