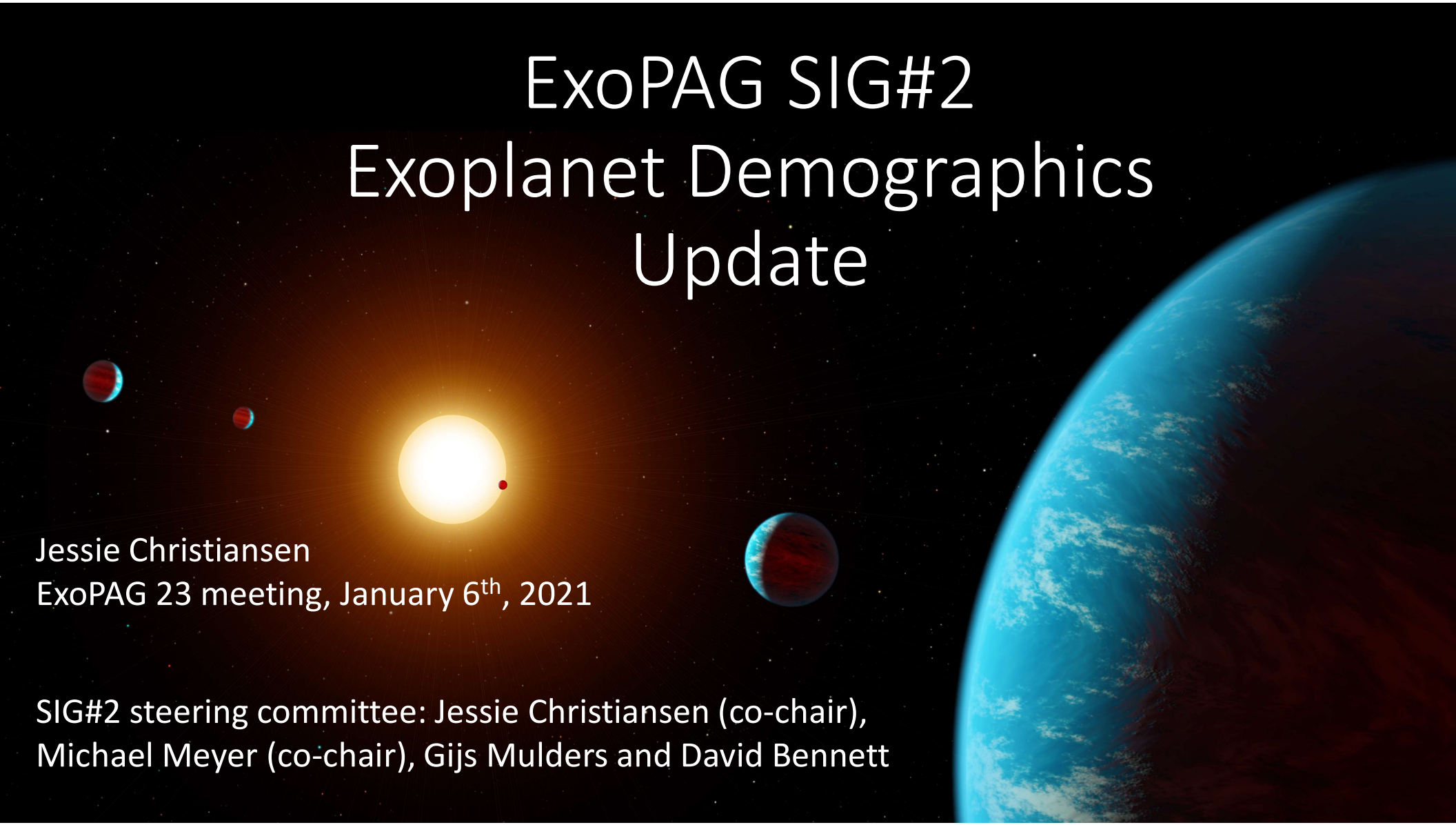
ExoPAG SIG#2
Exoplanet Demographics Update



Jessie Christiansen
ExoPAG 23 meeting, January 6th, 2021

SIG#2 steering committee: Jessie Christiansen (co-chair), Michael Meyer (co-chair), Gijs Mulders and David Bennett

SIG vs SAG

Science Analysis Group (SAG)

- Performs analysis and reports findings to address a specific ExEP issue
- Once the findings are reported, the SAG is closed out
- Short timescale (~1 year)

Science Interest Group (SIG)

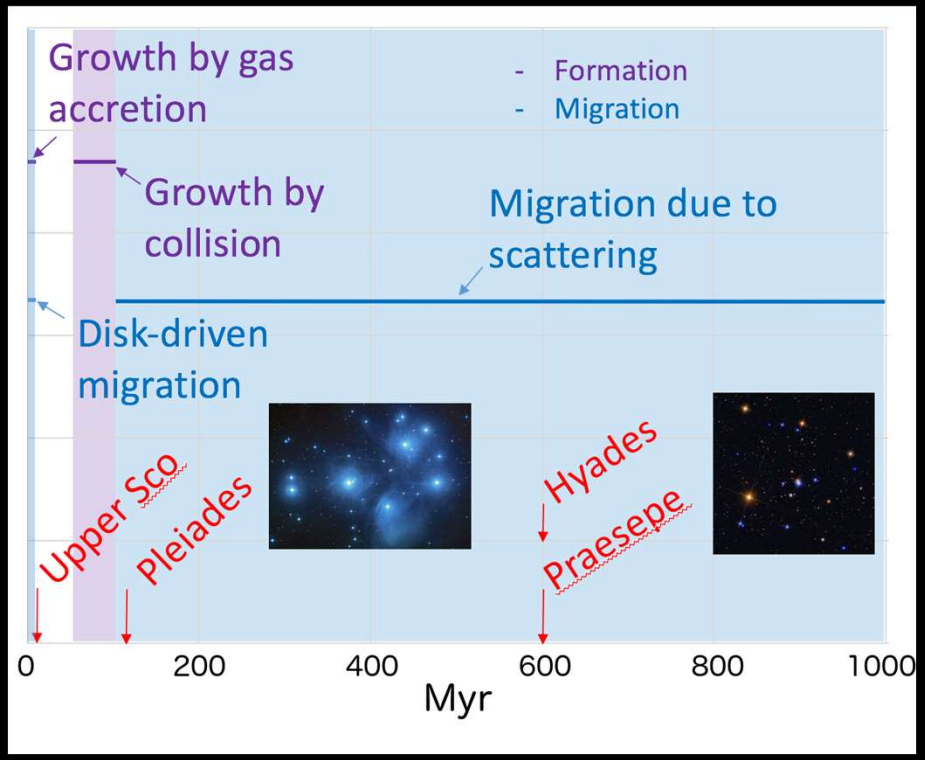
- Addresses longer-term community interests
- Single, well-defined area of interest
- Longer term groups (2+ years)

Motivation – scientific

Broad, open questions in exoplanets, including:

- What is the dependence of exoplanet formation on the natal environment and host star?
- What are the mechanisms and timescales for planet formation and migration?
- What drives the evolution and diversity in the resulting exoplanet systems?

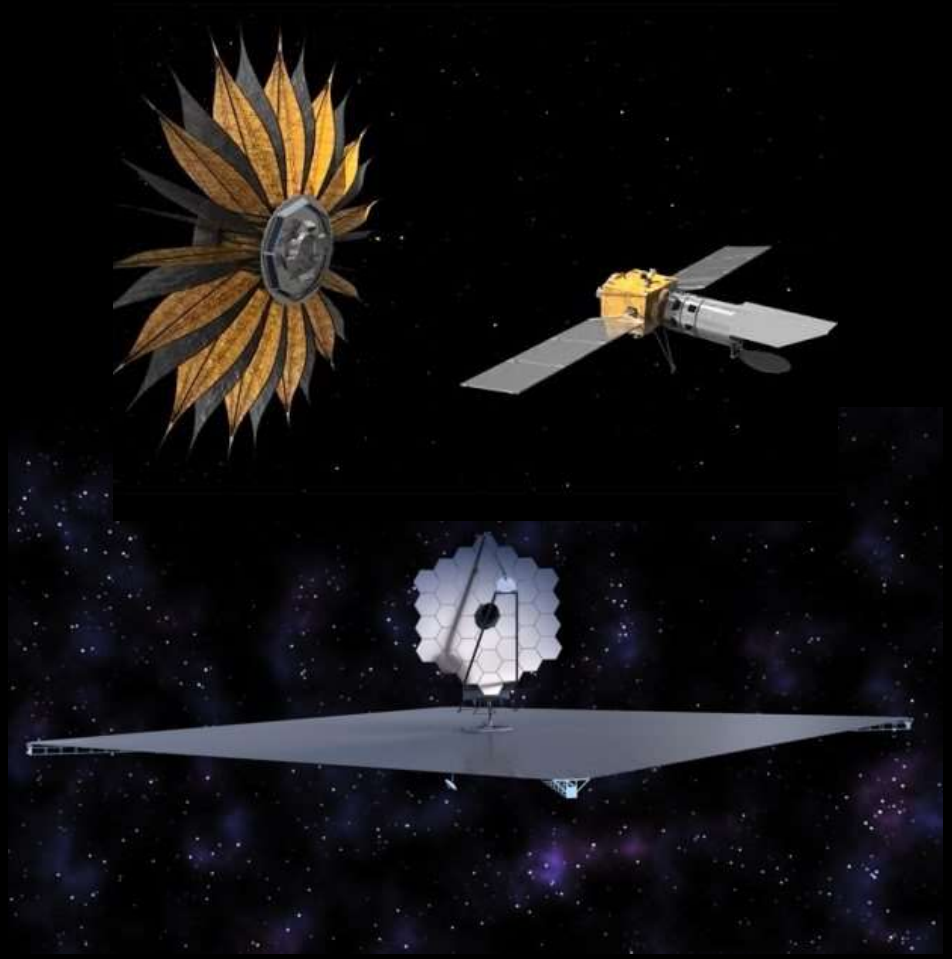
- How can the observation and theory communities best work together to answer these questions?



Motivation – programmatic

NASA's Decadal Flagship Mission Studies

- Three (Origins, HabEx and LUVOIR) have significant exoplanet science drivers (with various weightings compared to general astrophysics)
- LUVOIR and HabEx have agreed to use the SAG#13 occurrence rates so their yield predictions are on an equal footing
- These studies (and future mission planning) would be benefited by occurrence rates addressing a broader parameter space



Our goals

To extend the SAG#13 work over a wider parameter space, by, e.g.:

(i) Bringing together groups in the community to discuss their cross-technique and cross-population results

(ii) Identifying the overlaps between the parameter space from different studies, and what is needed to enable meta-studies

(iii) Curating a demographics "gap list" and analyzing the need for a public demographics repository

(iv) Facilitating a Kepler data challenge across multiple teams in the community with controlled inputs

(v) Members prepared an Astro2020 white paper outlining a road map for furthering the census of exoplanets

(vi) Hosted a demographics mini-symposium at ExoPAG 21 (which ultimately became the Exoplanet Demographics conference with 500+ attendees)

Demographics ‘Gap List’

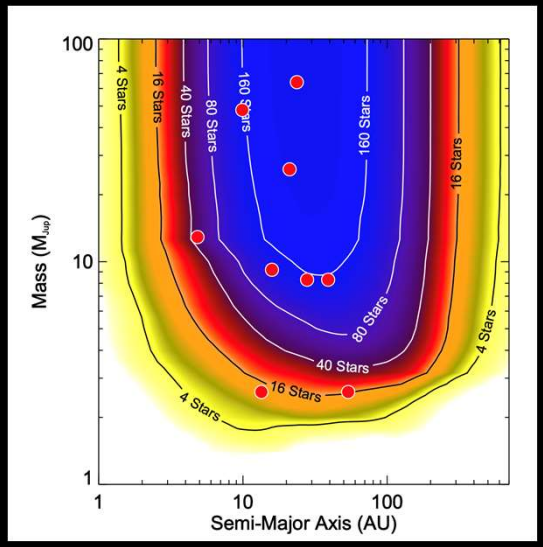
What is needed to extend demographics calculations to wider orbits?

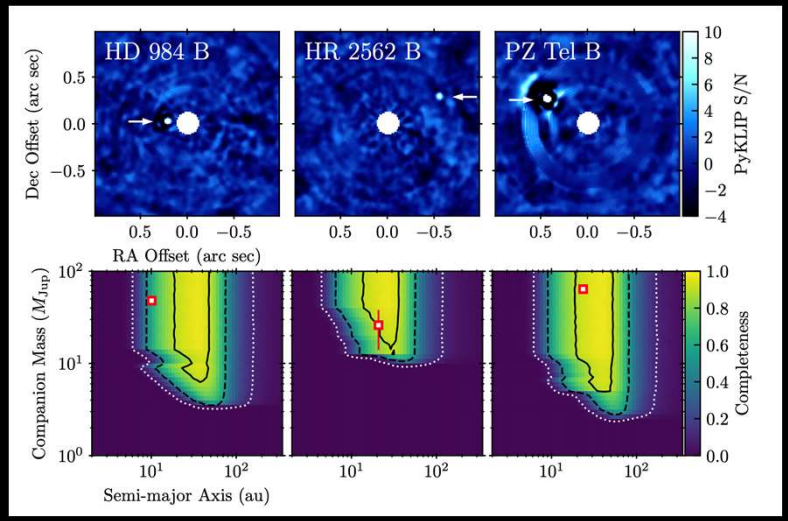
There are data available

- Published RV survey results (e.g. Mayor+2011, Tuomi+2019)
- Publicly available RV data (e.g. HARPs/SERVAL, CPS (Keck, Lick))
- Microlensing (e.g. Suzuki+2018, UKIRT survey data)
- GPIES first-half sample (e.g. Nielsen+2019)

But that’s only ***part*** of the necessary information

- Individual detection efficiencies for targets – sometimes not published, sometimes lost
- Understanding the stellar selection criteria





Demographics ‘Gap List’

Incorporating physics

- Need to start incorporating stability/dynamics in multi-planet systems
- Internal composition physics in the joint mass/radius/period distribution to capture the mass/composition distribution

Producing completeness and reliability estimates for updated transit surveys (K2, TESS)

Recomputing mission yields (Gaia, WFIRST, HabEx/LUVOIR)

Multiplicity (stellar AND planetary) – effects on detection efficiencies

Public Demographics Database

An open-source database for exoplanet demographics products
(modelled on the success of Kepler)

- For each detection technique, recommend a set of standard products in standard formats
- As model-independent/close to the data as possible
  - Keep in native parameters (radius, mass, mass-ratio)
  - Model assumptions (mass-radius relation to translate transit survey results to radial velocity space, luminosity function to translate microlensing results, etc)
- Include stellar meta-data (why selected, detections vs. non-detections)
- Allow for flexibility of grid (e.g. radius/period) choices, as compared to prescribing a set grid
- To do: prepare a report presenting the analysis above to the ExoPAG

Kepler Data Challenge

The plan:

- To use the Kepler d data sets to construct a synthetic planet p s a prescribed (but secret!) underlying planet