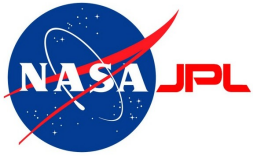
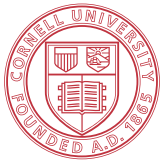
Exoplanet Mission Science Yield Modeling

Rhonda Morgan and Dmitry Savransky





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Goals

What we'd like

are specific, verifiable predictions as to what will be discovered by a given exoplanet imaging system

What we can reasonably expect

are expectation values of a small number of science yield metrics with (hopefully) defensible errorbars

- We must be able to describe the **range** of potential science yields. This means either:
  - Placing absolute bounds on the values of metrics (incredibly hard)
  - Describing the distributions of the metrics (still pretty hard)
- In trying to describe the distributions of science yield metrics, you can either try to directly calculate the moments of the distributions, or take a Monte Carlo approach

Motivating a Monte Carlo Approach

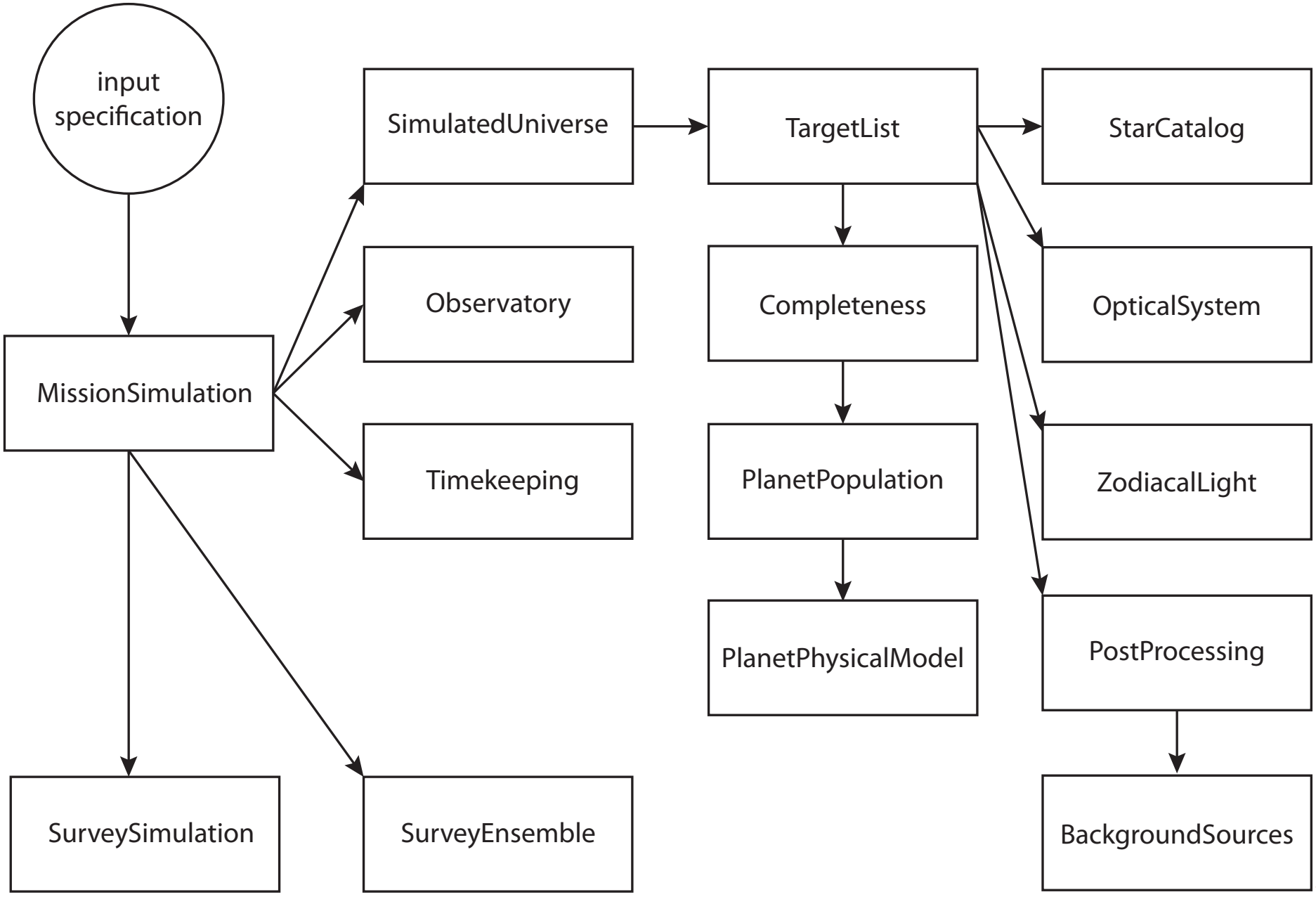
- There are a lot of semi-autonomous pieces that go into a science yield prediction
- It is difficult to predict *a priori* which assumption will be the one that limits the yield
- Different people care most about different things
- It is very difficult to build dynamic constraints into analytical modeling tools

A proposed solution

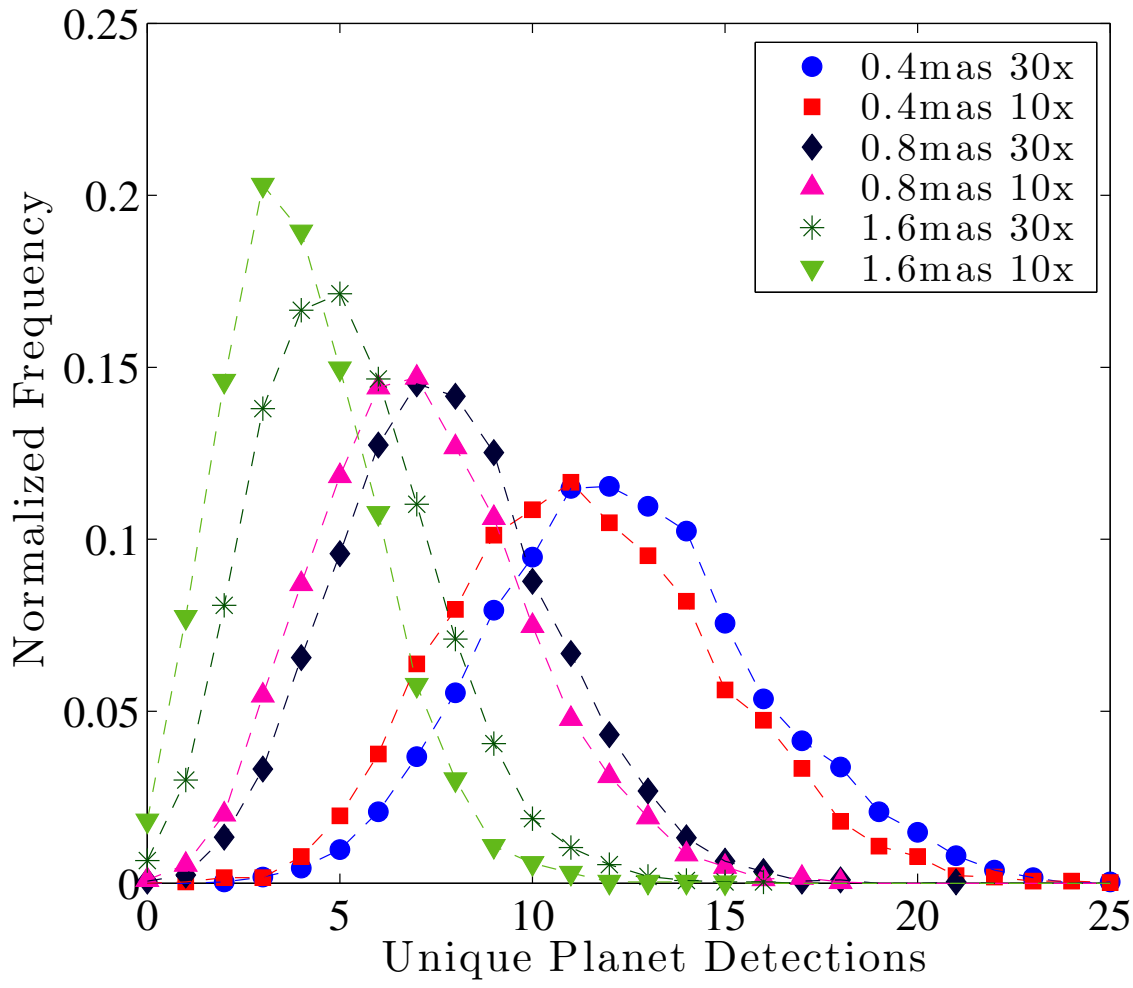
Create a software architecture where every model component can be independently upgraded/changed

EXOSIMS

Savransky and Garrett (2015); `https://github.com/dsavransky/EXOSIMS`



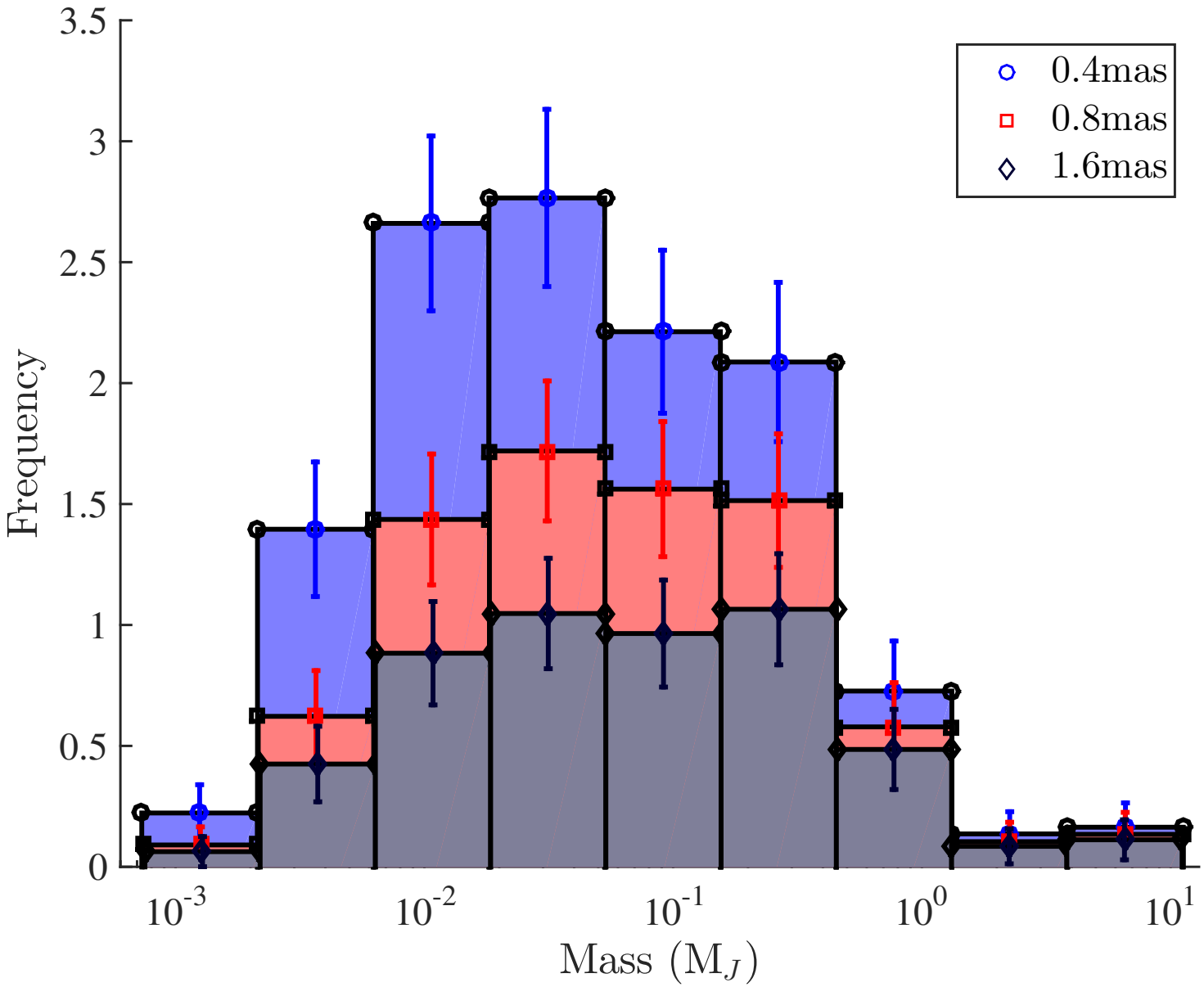
What it Does



What it Does **Not** Do:

Prevent garbage in/garbage out

Additional Metrics are Trivial to Add



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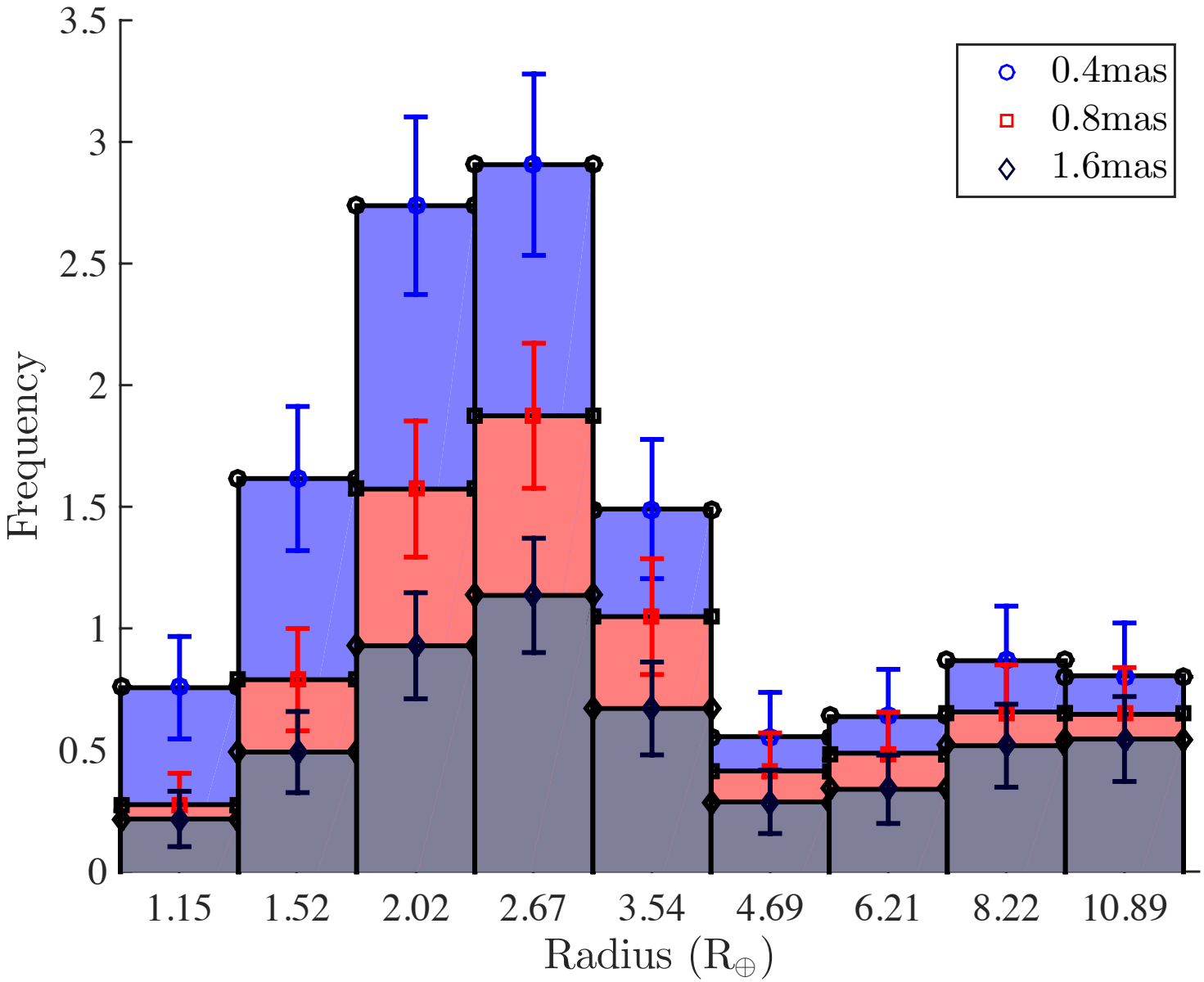

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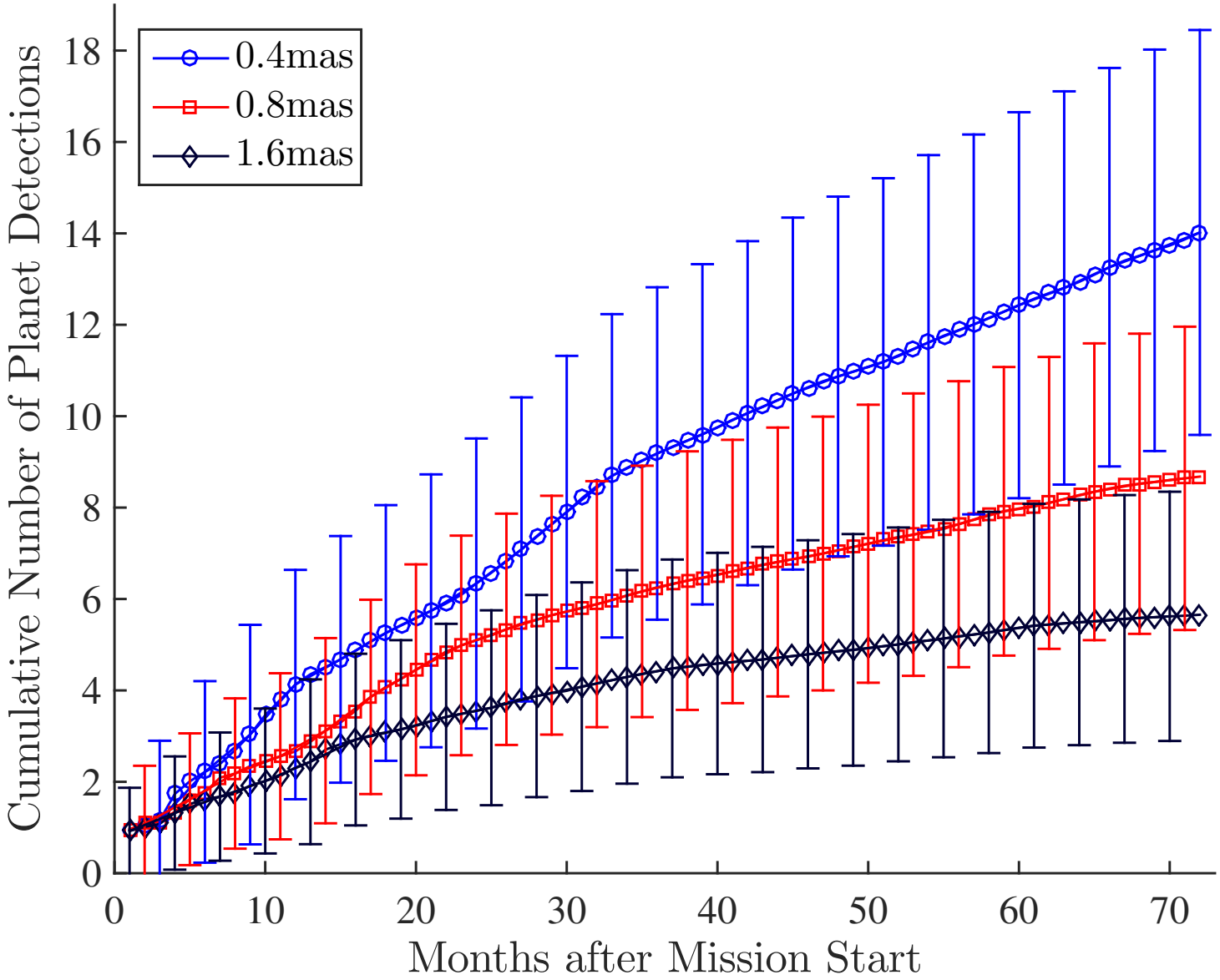

Motivating Example: Population vs. Planet Model

- Population describes distributions of parameters and occurrence rates
- Model describes derived quantities and mappings between parameters (albedo/phase, mass/radius, etc.)

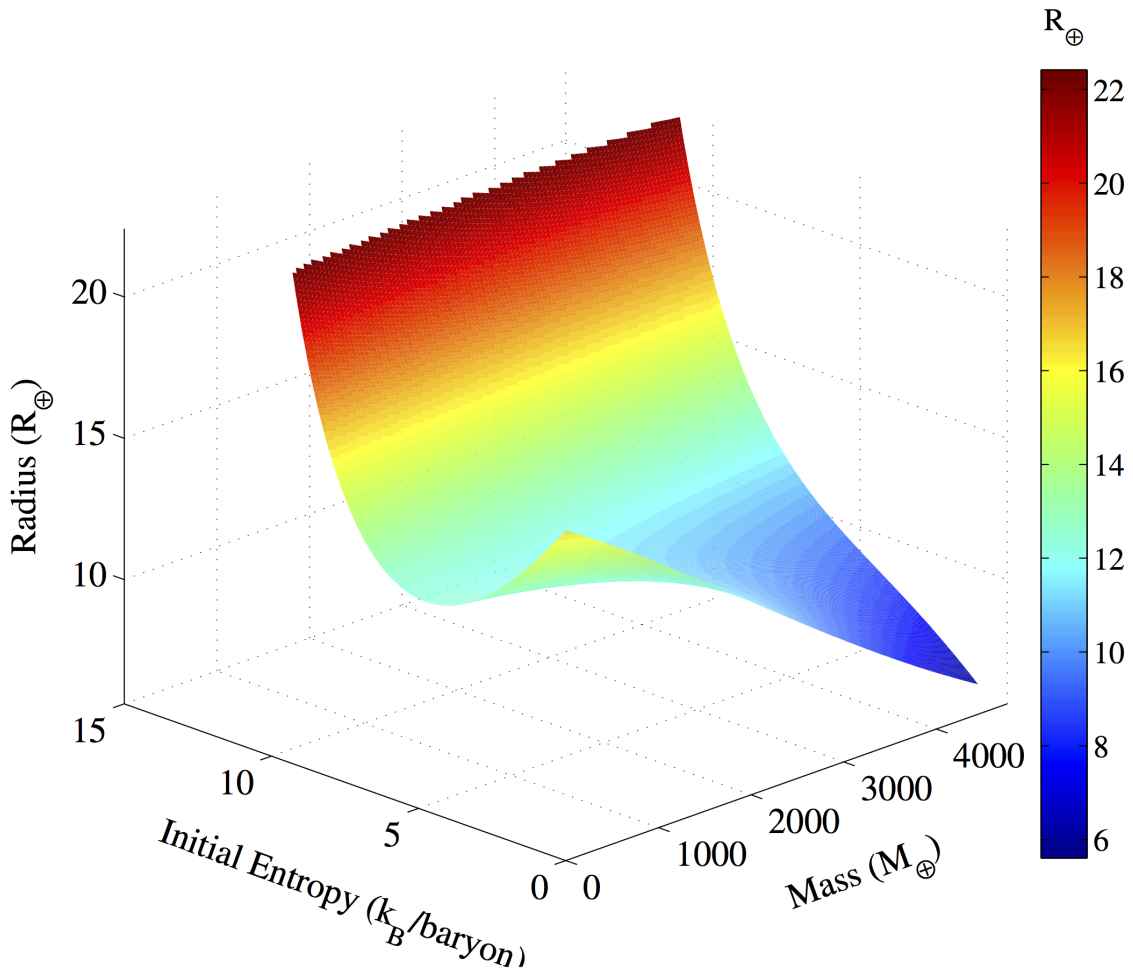

Figure: Mass-radius relationship from Spiegel and Burrows (2012).

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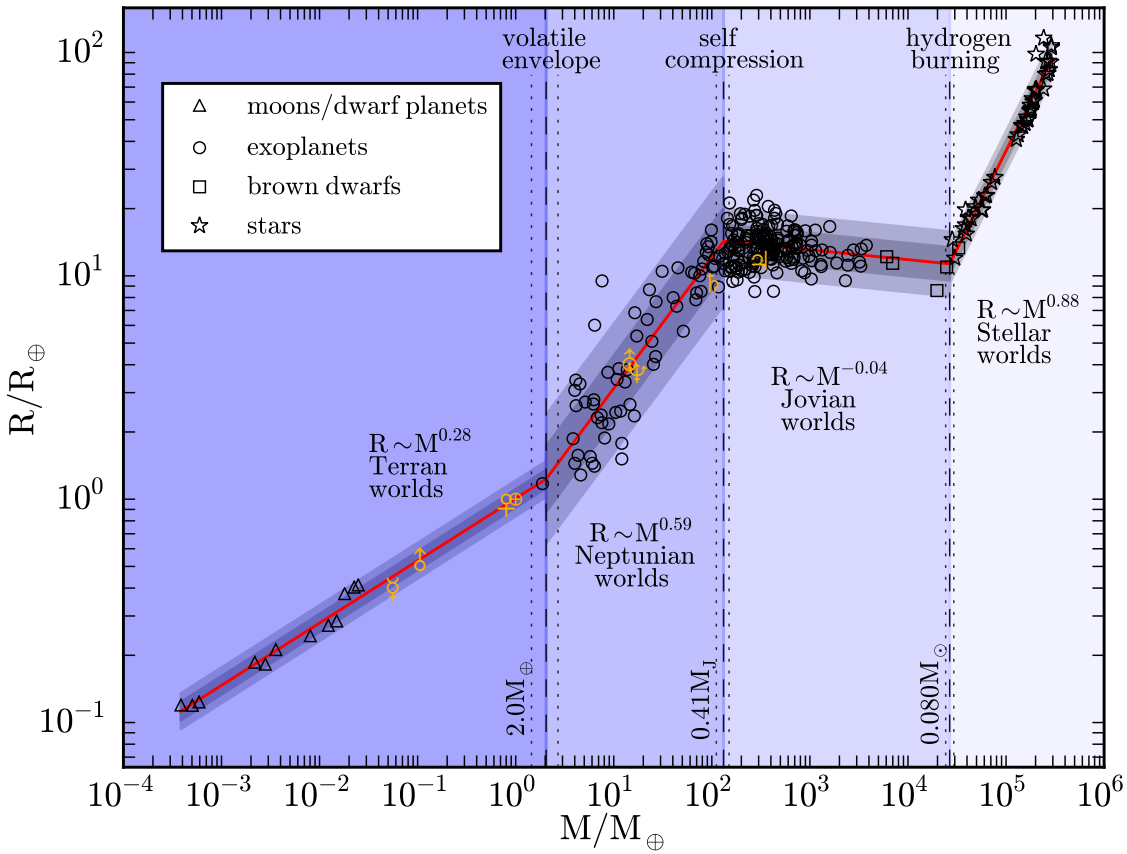

Figure: Mass-radius relationship from Chen and Kipping (2016).

Notes

- Mission Simulation Ensembles are a hugely powerful tool for answering practically any question about mission yields *if you can trust the code*
- Build confidence in simulations by releasing all code, having independent verification, and iterating on all simulation components with subject matter experts
- EXOSIMS is under active development and is continuously being updated
  - Please see `https://github.com/dsavransky/EXOSIMS` - in particular the ICD and as-built documentation
  - Comments and pull requests very welcome