New Migration Model

Effects of Saturation, Cooling and Irradiation

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Grenoble, October 2012

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Content

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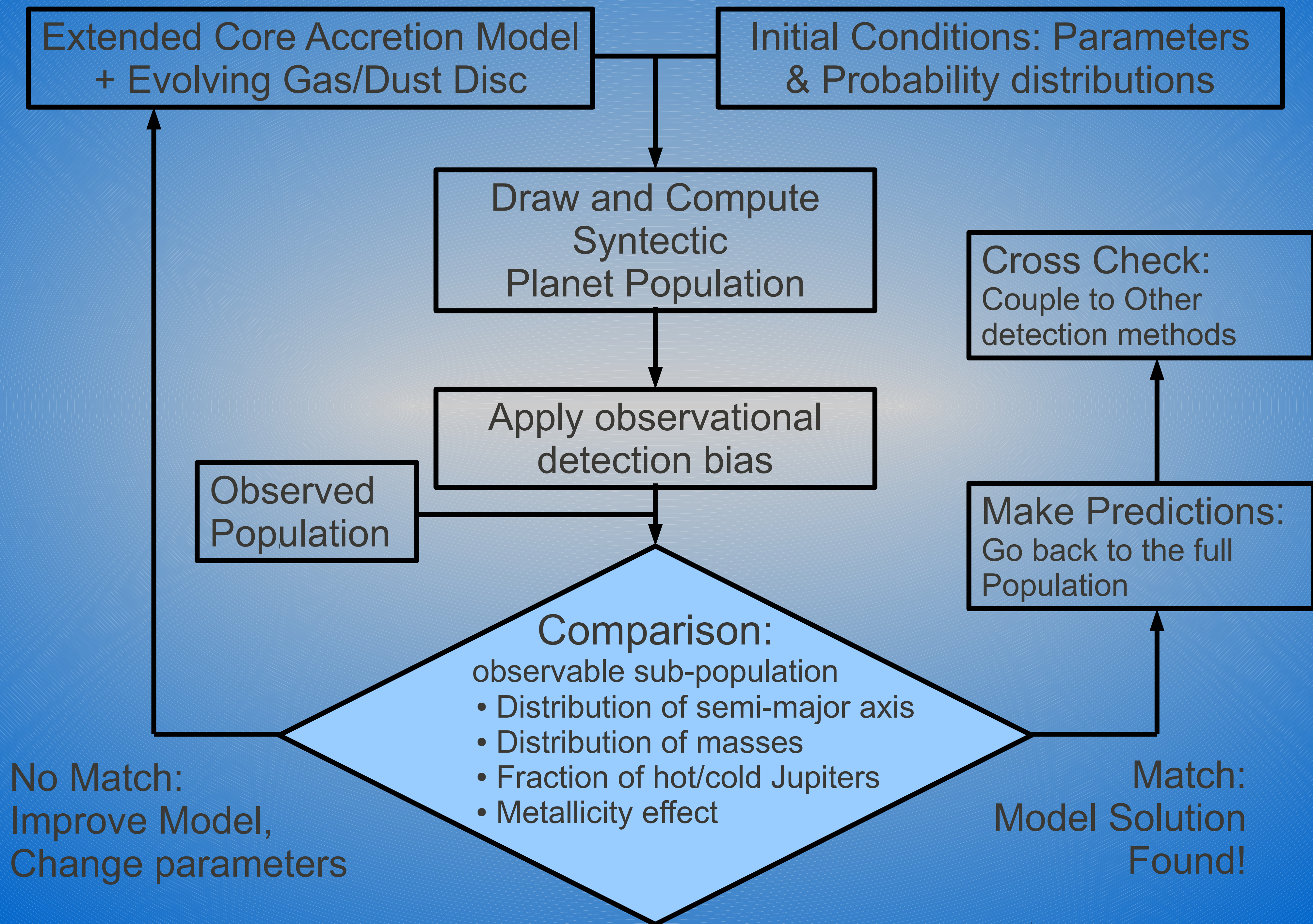
What is Planet Population Synthesis

Aim: Model unobservable Planet Formation as simple as possible but still realistic:

- *Link of disc observations to planet populations*
- *Input: Distributions of observable quantities*
- *Output: Population of thousands of planets with semimajor axis, mass, luminosity, planet radius*
- *Compare with other populations, synthetic or observed*

Planet Population Synthesis: Principles

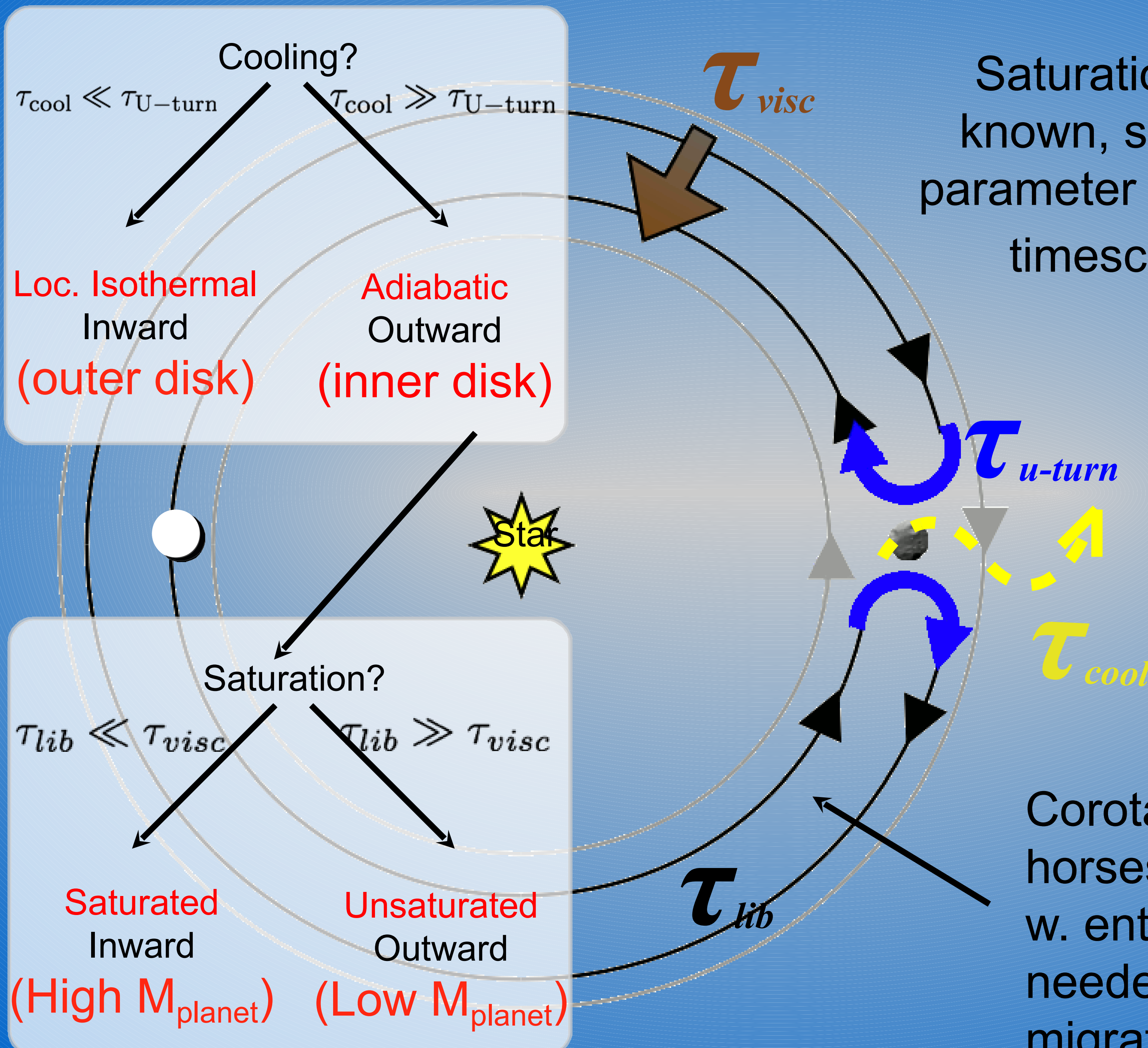


Formation Model

Our model consists of:

- *Core accretion paradigm*
- *Evolving α-disc (1+1 D)*
- *Evolving hydrostatic structure of planet envelope (1D)*
- *Migration of the planet*
- *Single core per disc (at the moment)*

Migration regimes and timescales



Saturation mass not really known, so included scaling parameter f_{visc} at the viscous timescale to change the saturation mass

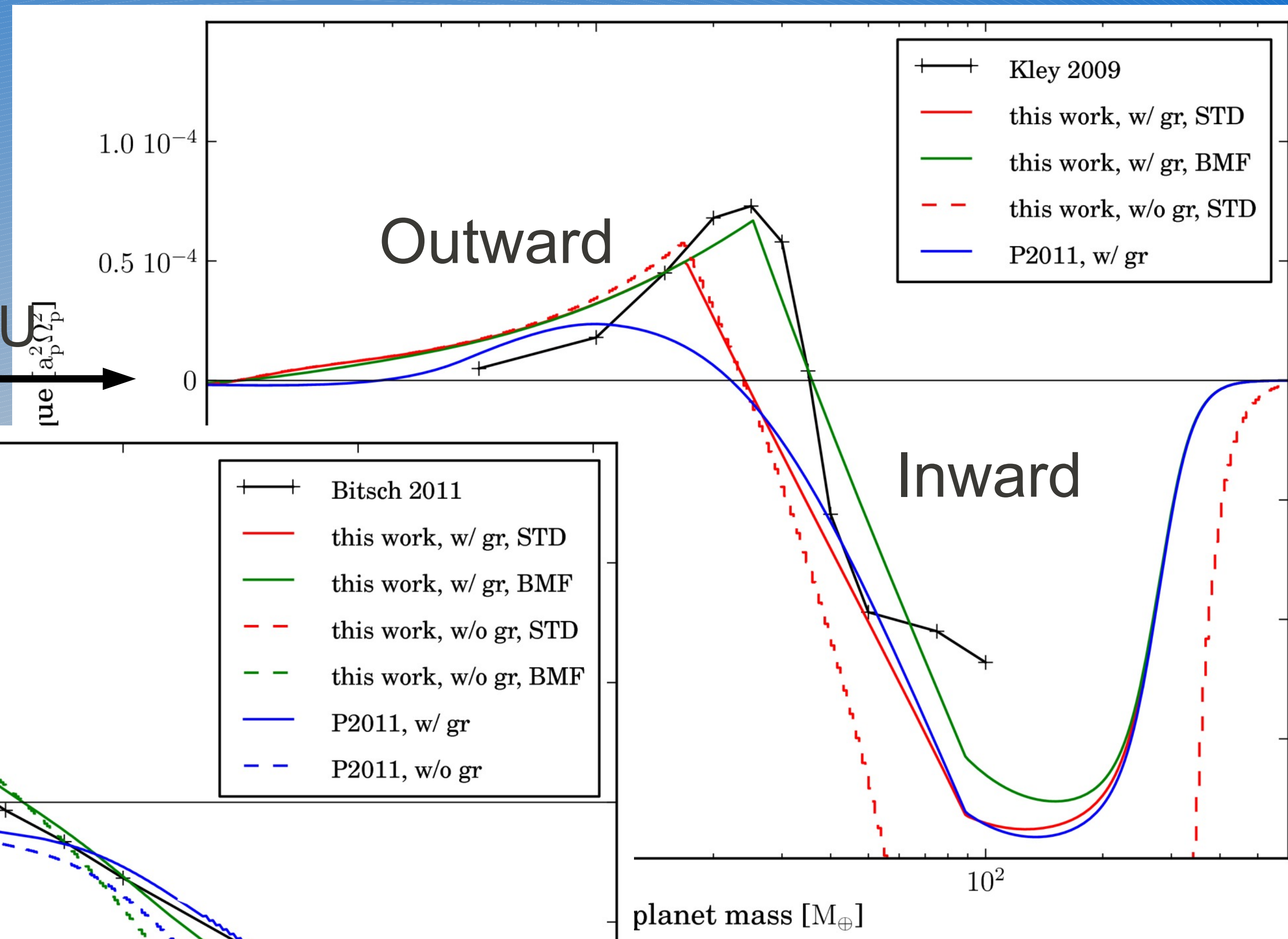
Different thermodyn. regimes
→ different density distributions
→ different migration rates

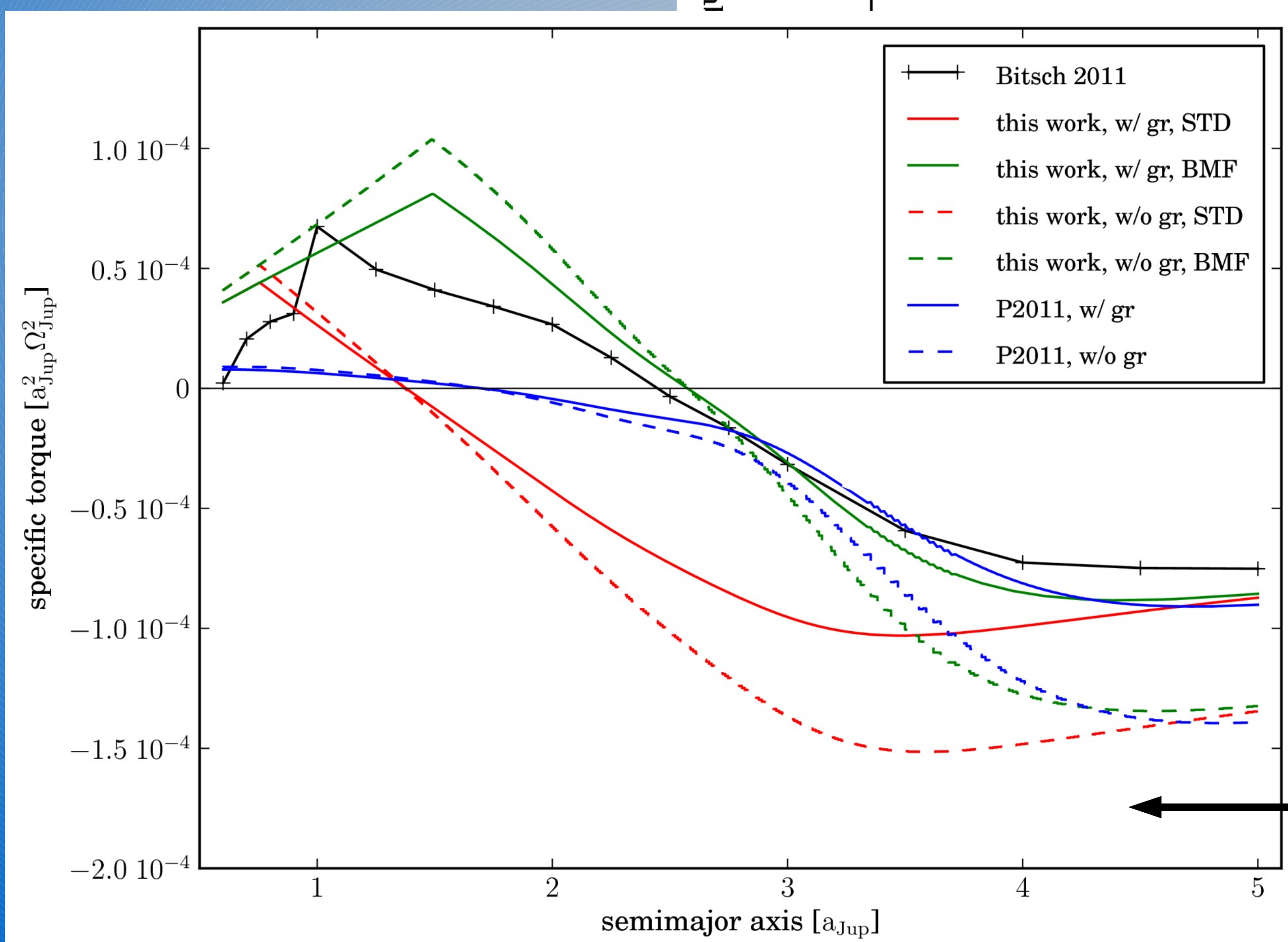
Corotation region: horseshoe orbits w. entropy gradient: needed for outward migration

Specific Torque Comparison

Comparison with
- 3D radiative hydrodynamic simulations
- Paardekooper ea. 2011

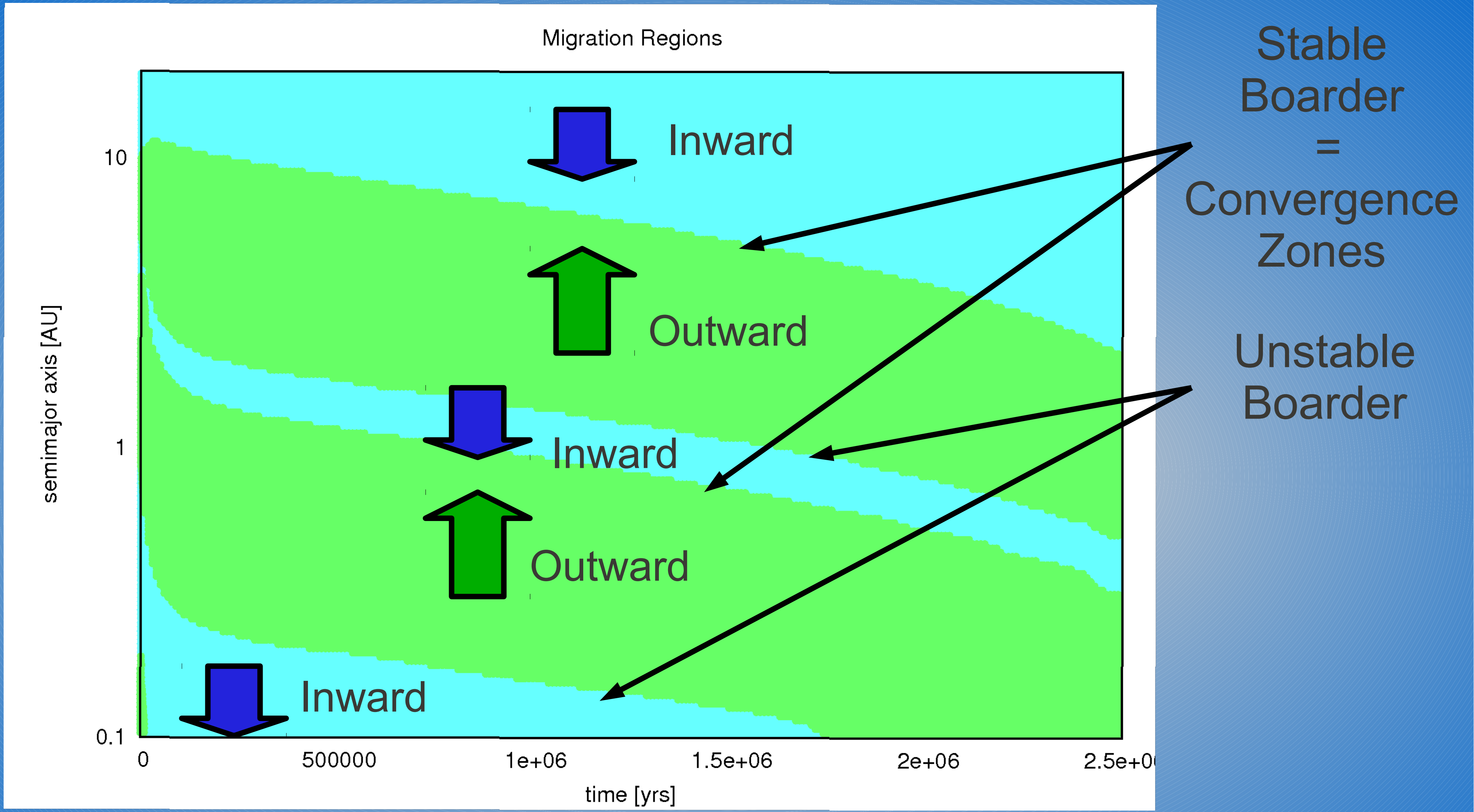
Different masses at 5.2 AU





Different semimajor axes, 20 Earth masses

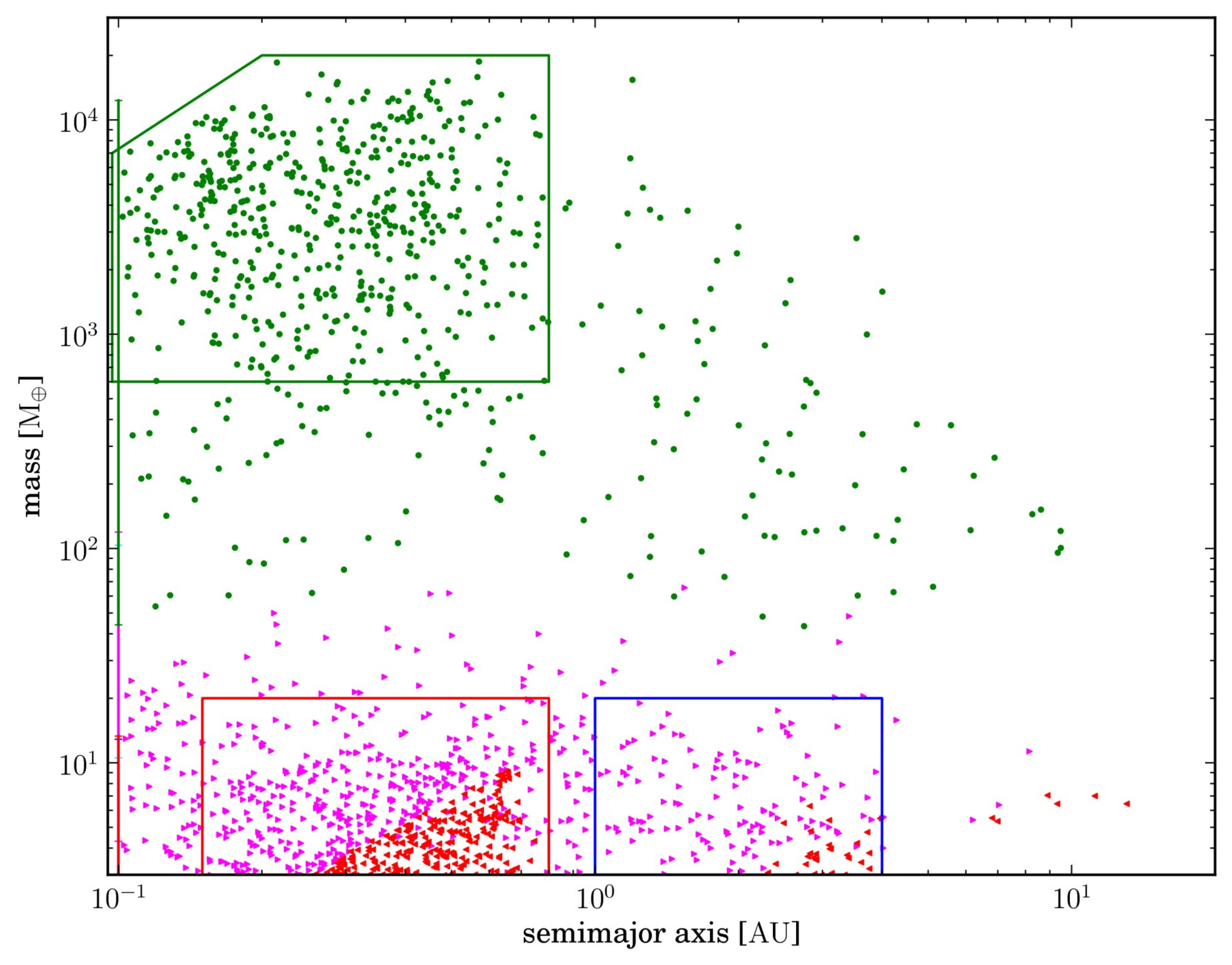
Convergence Zones



Unsaturated Migration:

Direction of migration only depends on slopes of temperature and surface density profiles

Synthesis I



10000 Initial Conditions

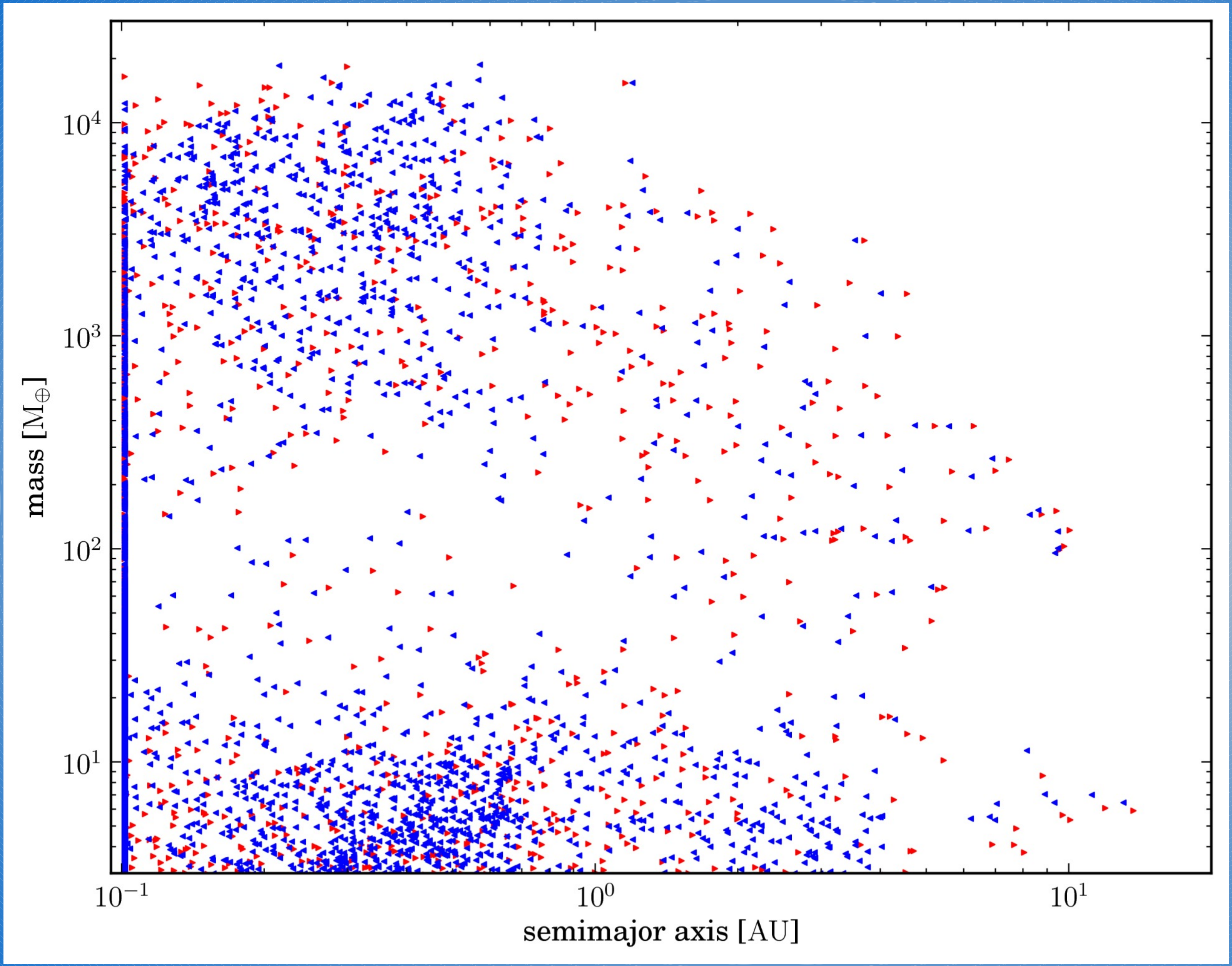
Varying in surface density, dust-to-gas radio photo-evaporation initial position and starting time

New migration model (f_{visc} = 0.55)

Regimes:
unsaturated
Saturated
Type II

Basic statistics:
55% “hot” planets, 45% “cold” planets, 13% “massive” planets, 4% “hot,massive” planets

Synthesis II



10000 Initial Conditions

In surface density, dust-to-gas radio photo-evaporation initial position and starting time

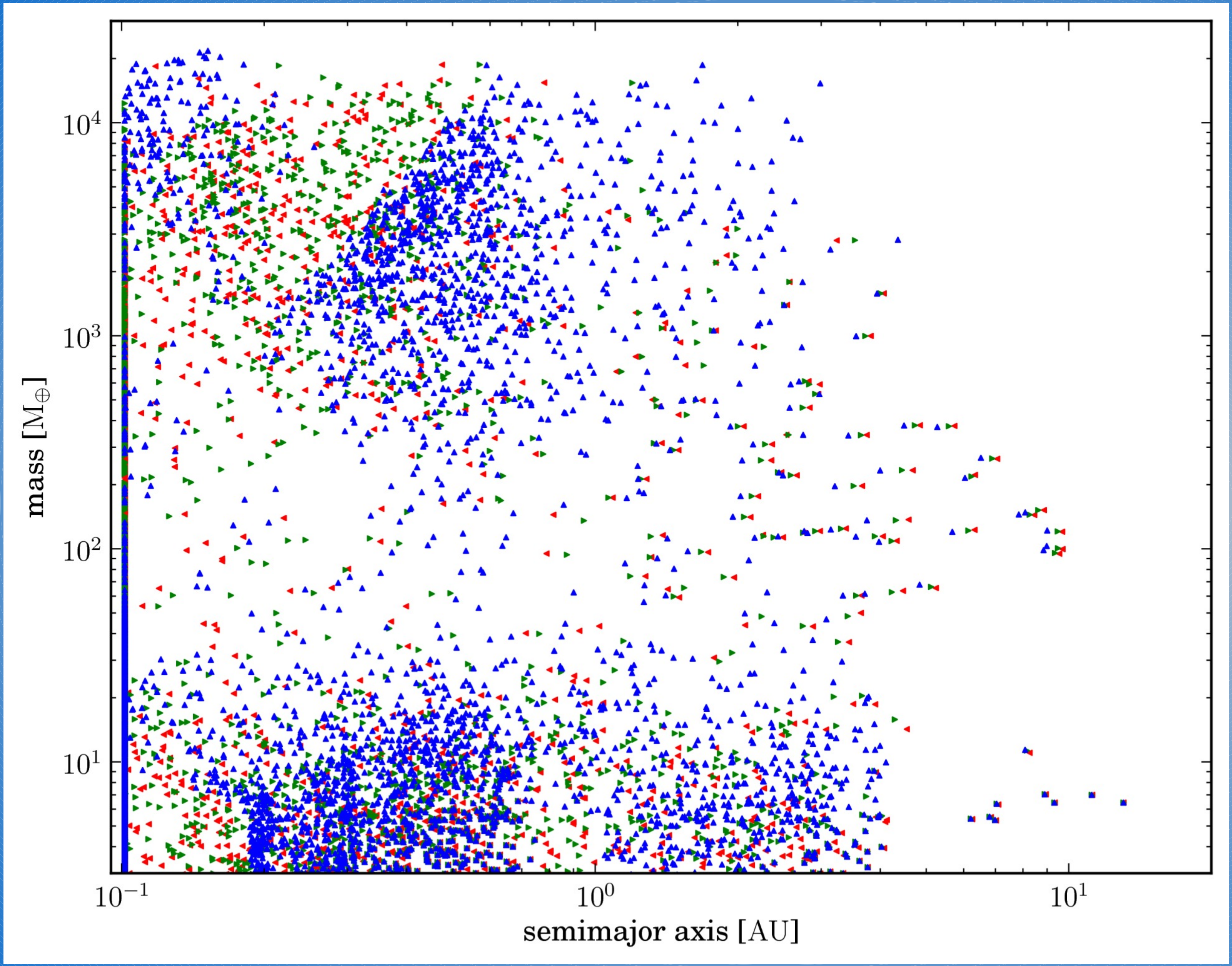
Old unreduced migration model (f1=1.0)

(Tanaka et al 2002)

Colors:
New model
Old model

Basic statistics:
80% “hot” planets, 20% “cold” planets, 8% “massive” planets, 2.7% “hot,massive” planets

Synthesis III



10000 Initial Conditions

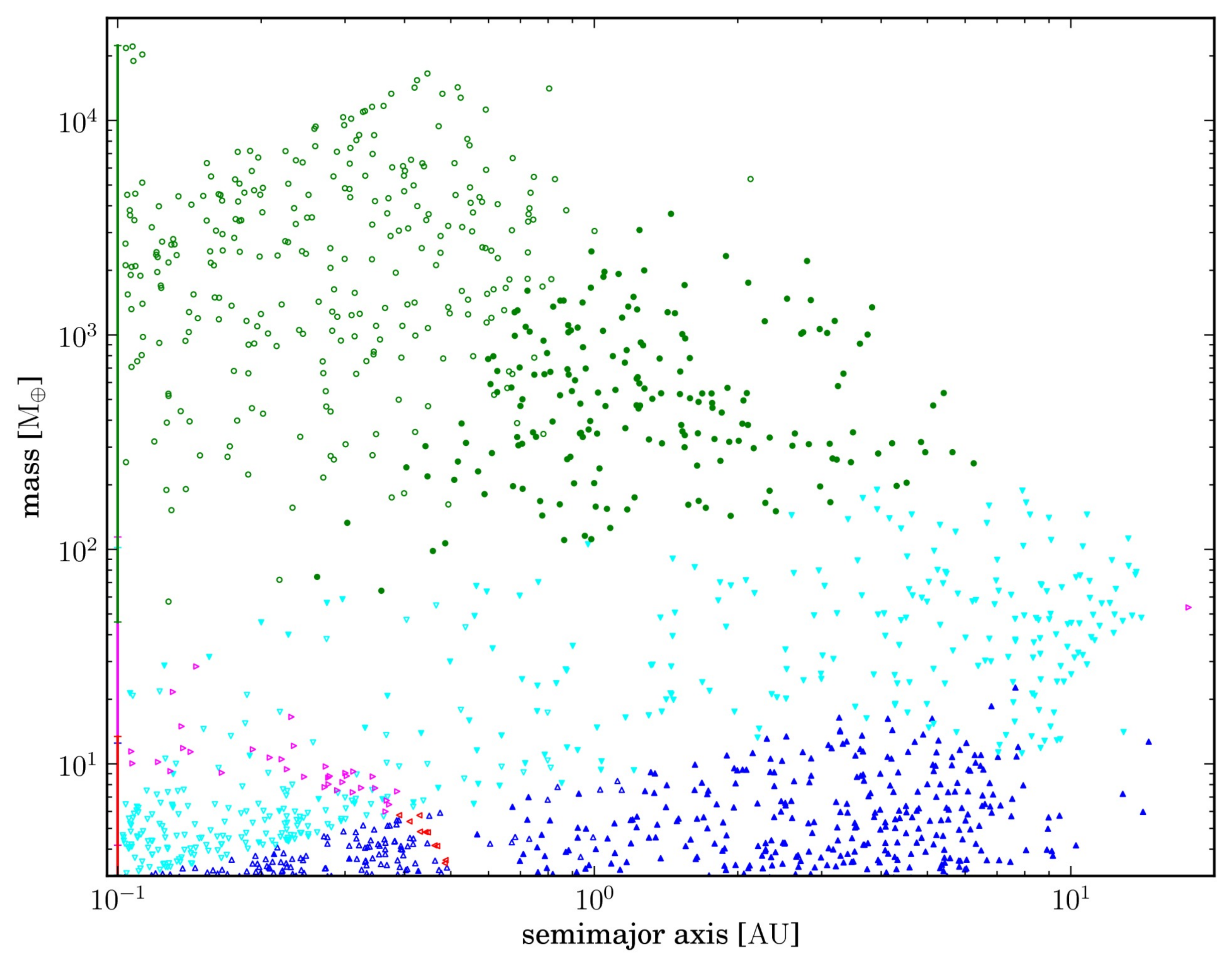
In surface density, dust-to-gas radio photo-evaporation initial position and starting time

Different saturation masses

Colors:
f_{visc} = 1.0
f_{visc} = 0.55
f_{visc} = 1/8

Basic statistics:
1.0: 60% “hot” planets, 40% “cold” planets, 11% “massive” planets, 4.5% “hot,massive” planets
1/8: 35% “hot” planets, 65% “cold” planets, 19% “massive” planets, 1.4% “hot,massive” planets

Synthesis IV



10000 Initial Conditions

In surface density, dust-to-gas radio photo-evaporation initial position and starting time

Irradiated disc (f_{visc} = 0.55)

Regimes:
unsat. lociso.
sat. lociso.
unsat. adia.
sat. adia.
Type II

Basic statistics:
69% “hot” planets, 31% “cold” planets, 10% “massive” planets, 3.8% “hot,massive” planets

Conclusions

3 convergence zones in our disc model where planets stay and only migrate slowly inwards on the disc evolution (viscous) timescale. Solving the type 1 timescale problem!

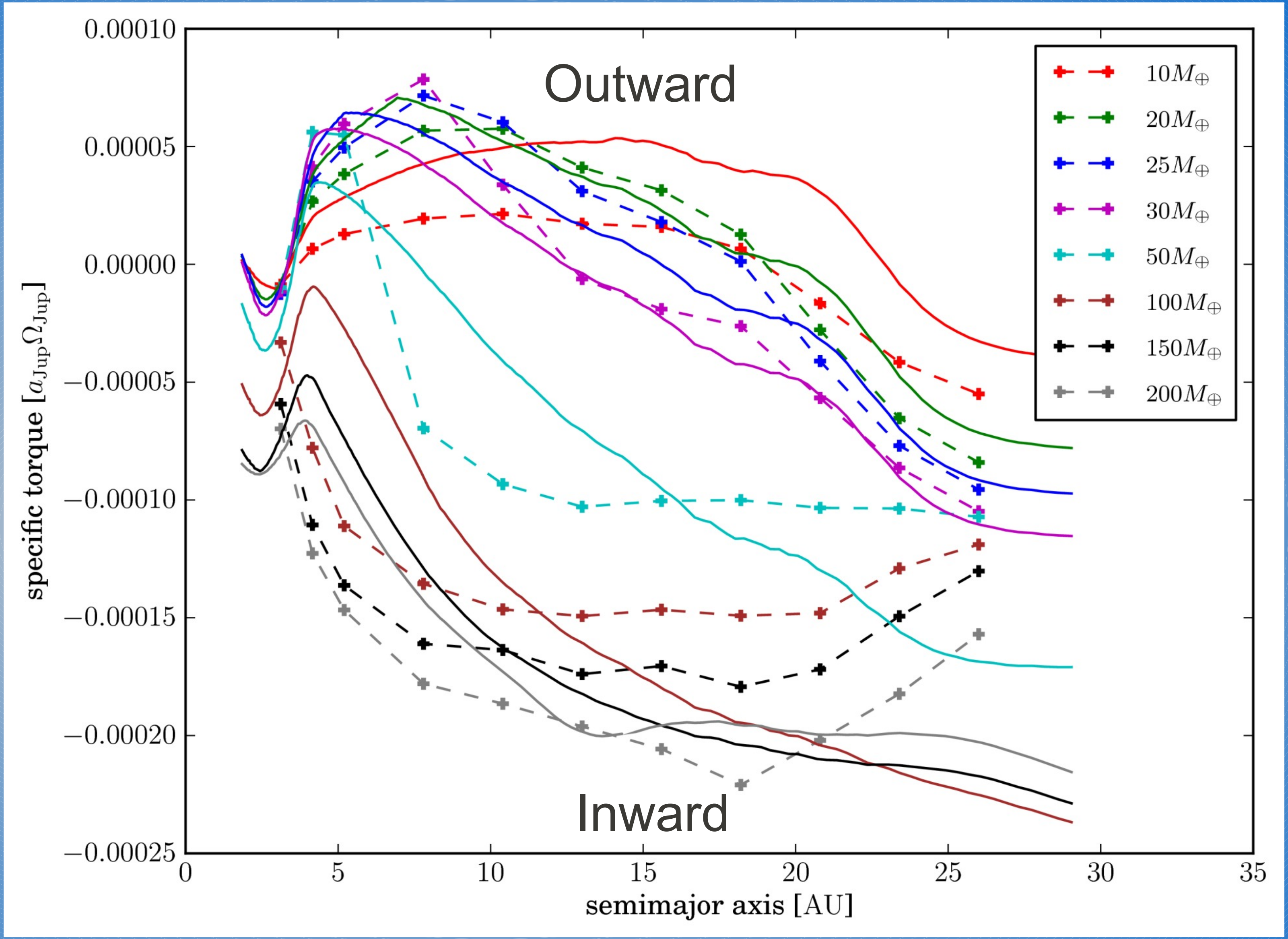
Could be a place where massive cores can form out of smaller bodies

Effects of saturation getting important: Our simulations show that you lose most planets because in saturation they migrate fast inward into the star

Preliminary Work

Comparison with
- 3D radiative hydrodynamic simulations
- 3 AU to 27 AU
- 10 to 200 M_{earth}

Fitted 5 parameters to 88 datapoints



Basic statistics:
51% “hot” planets, 49% “cold” planets, 14% “massive” planets, 3.1% “hot,massive” planets

Preliminary Work

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- 3D radiative hydrodynamic simulations
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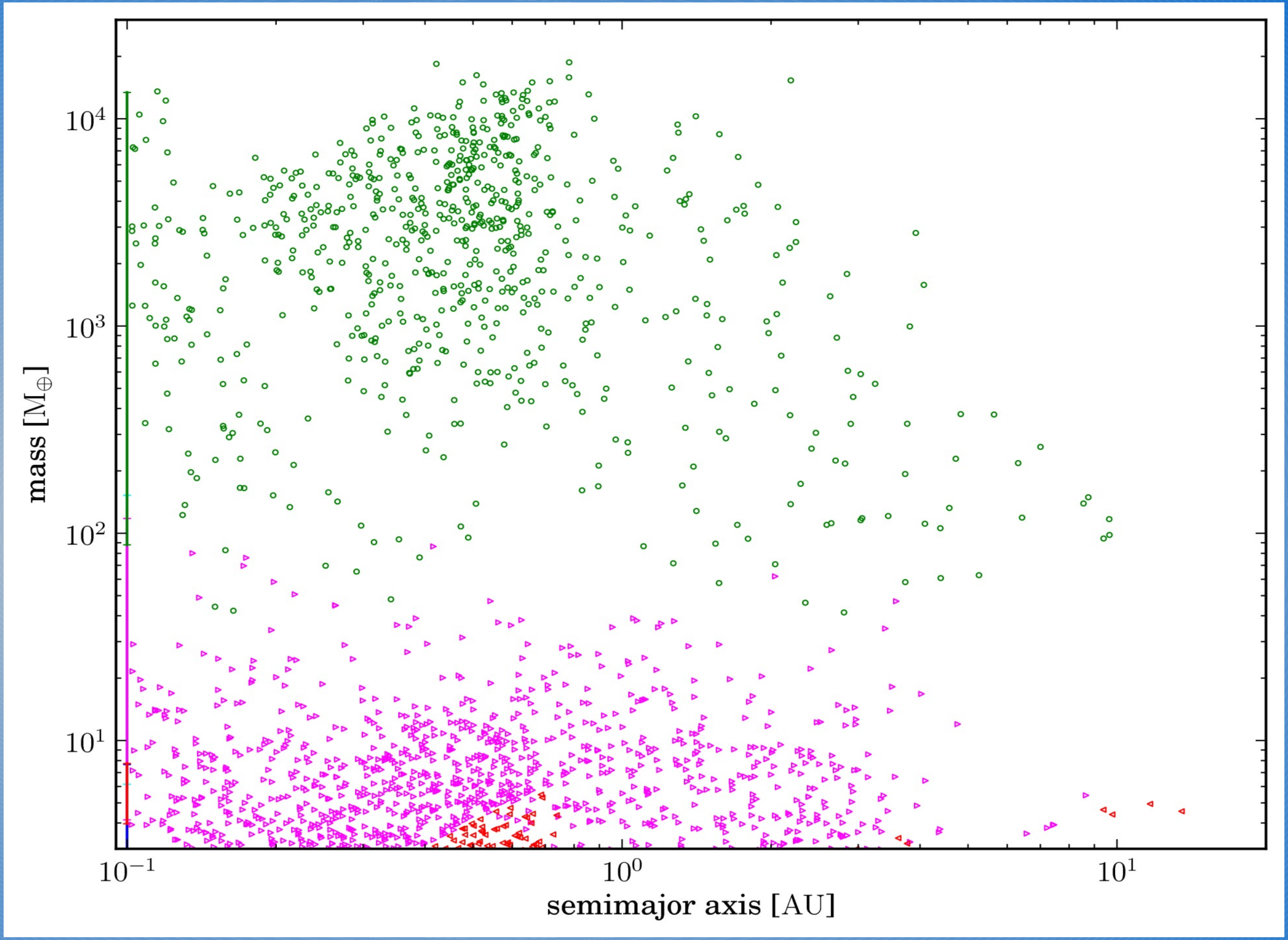
- 10 to 200 M_{earth}

Fitted 5 parameters to 88 datapoints



Basic statistics:
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