Who is who ?

From the heaven of concepts to the hell of observations

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- **Conceptual definition(s) of exoplanets/brown dwarfs**
- **What observables fit a given definition ?**
- **The hell of real observations**
- **Conclusion : what solution(s) for an impossible task ?**

Do we need a definition ?

No

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But, people use to make statistics

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==> we need criteria to build samples

Tentative physical definition

Problem:

There exist objects phenomenologically close to, but perhaps conceptually different from exoplanets: brown dwarfs.

Tentative convention (Baraffe et al. 2010):

- **planet** = formed by **accretion in a circumstellar disc** of dust+gas (But what about interstellar wanderers?)

- **brown dwarf** = formed by **gravitationnal collapse** in a gas cloud

Result :

- A planet should have a central core made of heavy elements from the dust disc
- A brown dwarf may have less heavy elements, depending on the initial cloud composition

Tentative physical definition

But then a question arises:

How to know the formation scenario of an object?

The formation movie is inobservable.

Tentative answer: rely on present observables, e.g. mass.

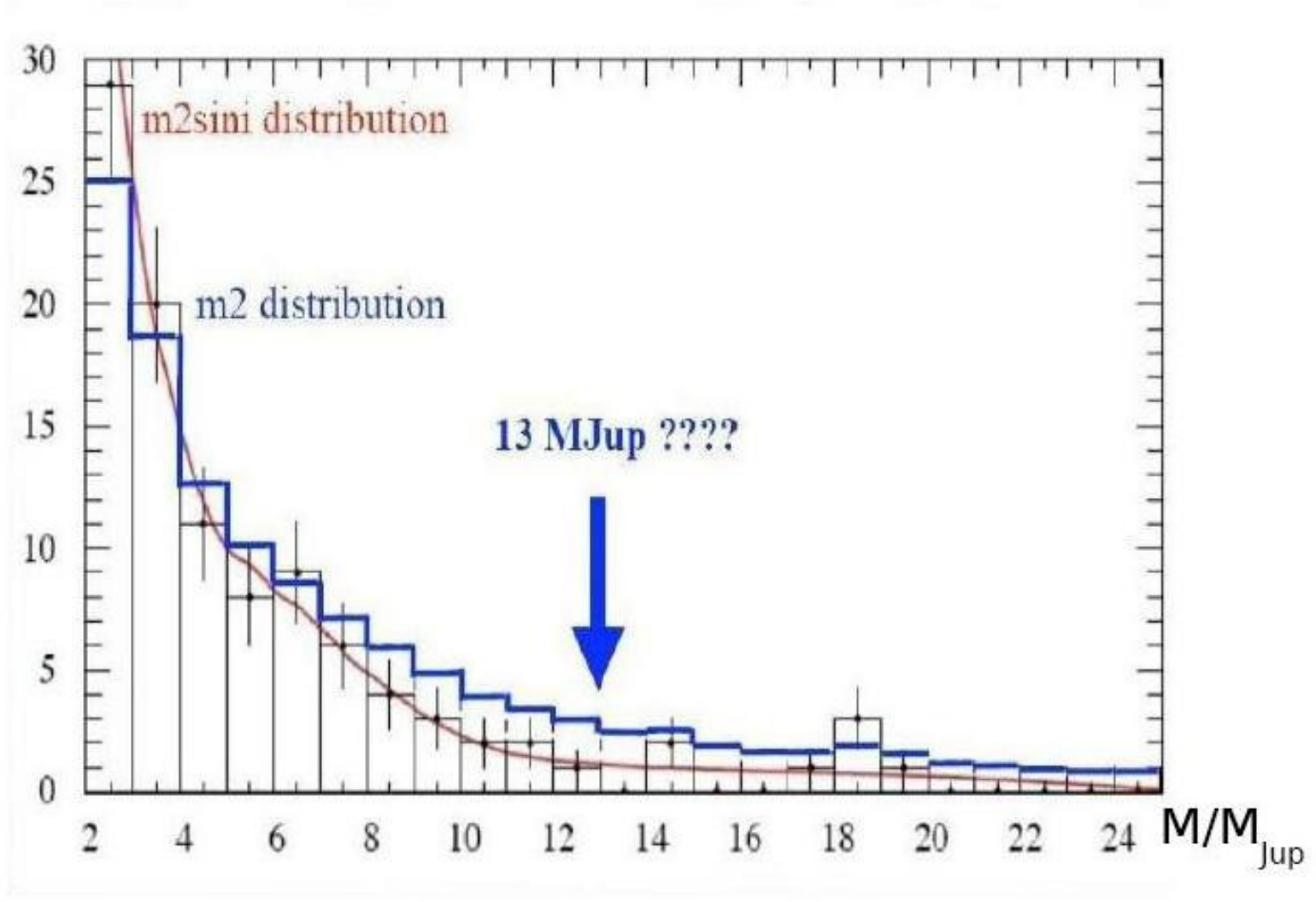
Until recently:

$M > 13\ M_{jup}$ ==> central nuclear reactions

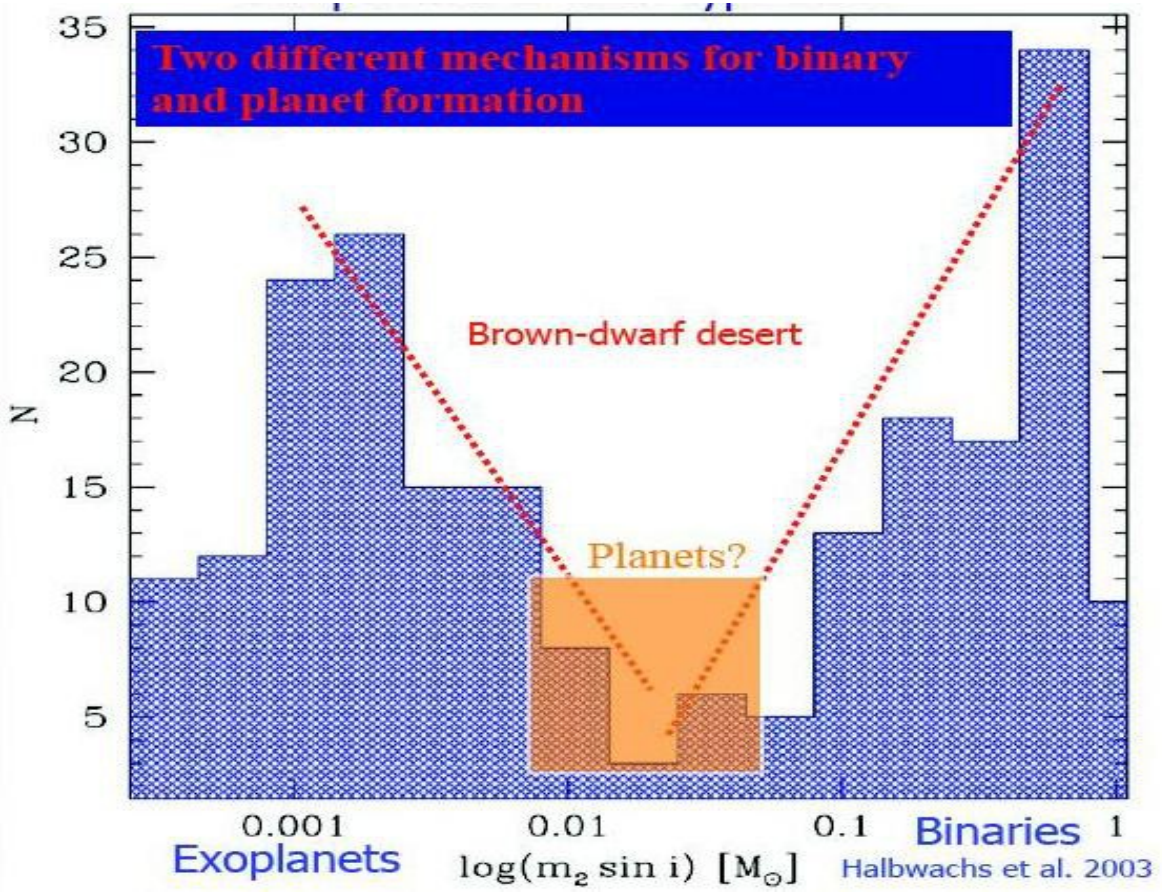
==> (arbitrarily) not a planet

But: nothing prevents initial accretion with a final mass $>13\ M_{jup}$

==> **$<13\ M_{jup}$** not a good criterion



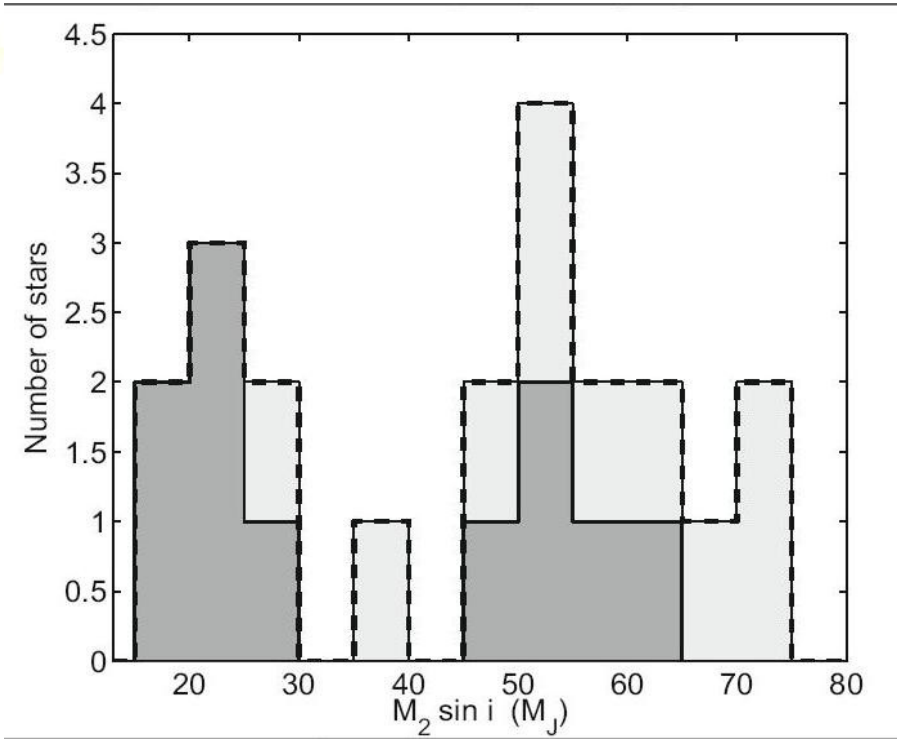
(Udry et al. 2010)



(Udry et al. 2010)

==> 30 M_{jup}

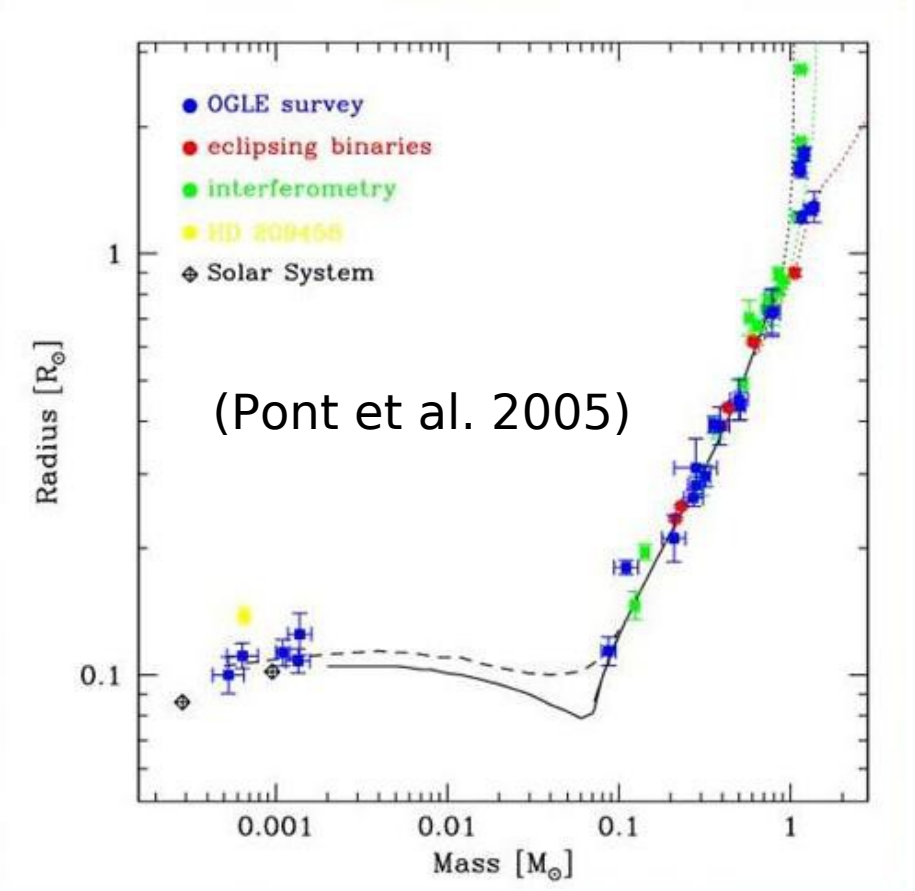
better limit



(Sahlmann et al. 2011)

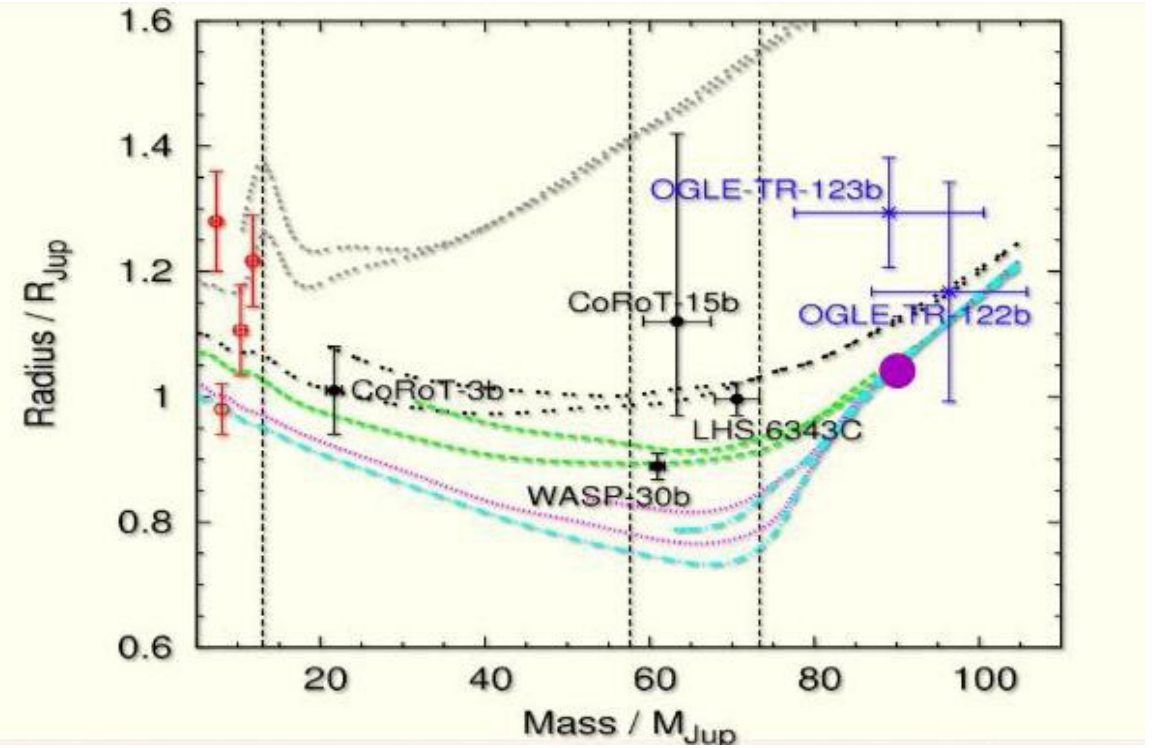
Physical definition: new mass criterion

The mass-radius relation also presents a, fuzzy, break at ~25 - 80 M_{jup}



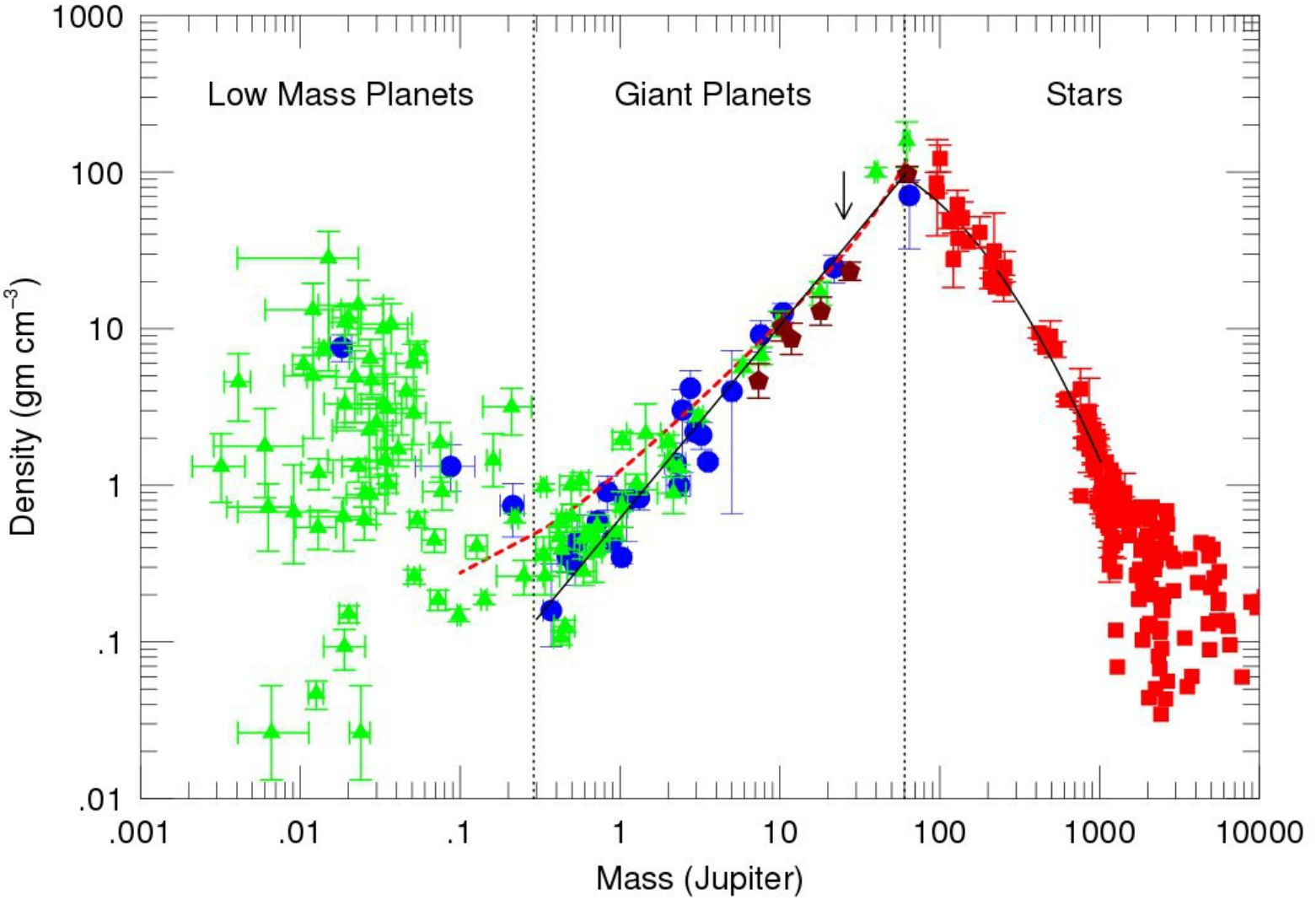
(Pont et al. 2005)

(Anderson et al. 2011)



New mass-density-radius distribution
(Hatzes & Rauer 2015)

arxiv.org/1506.05097



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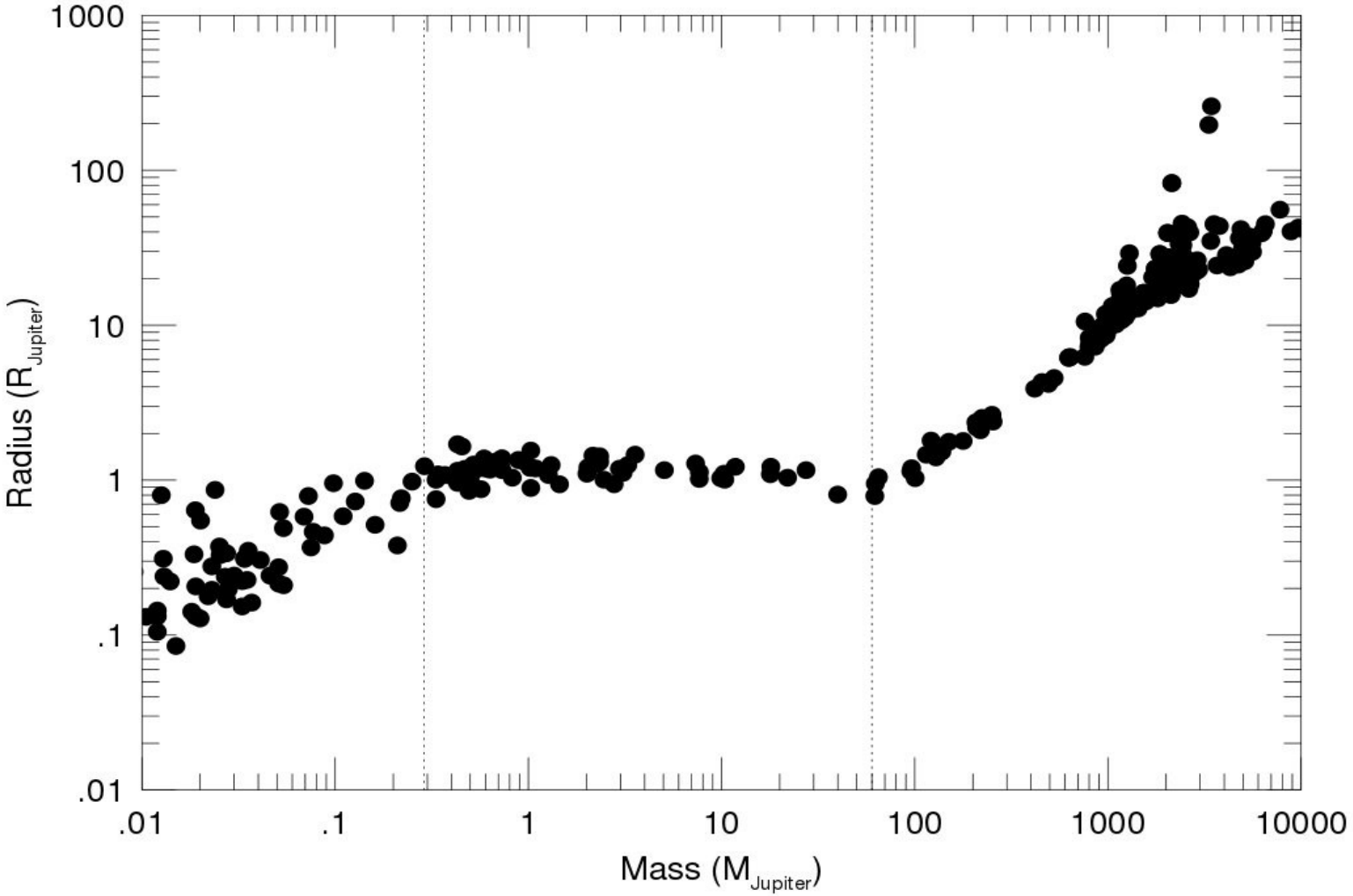

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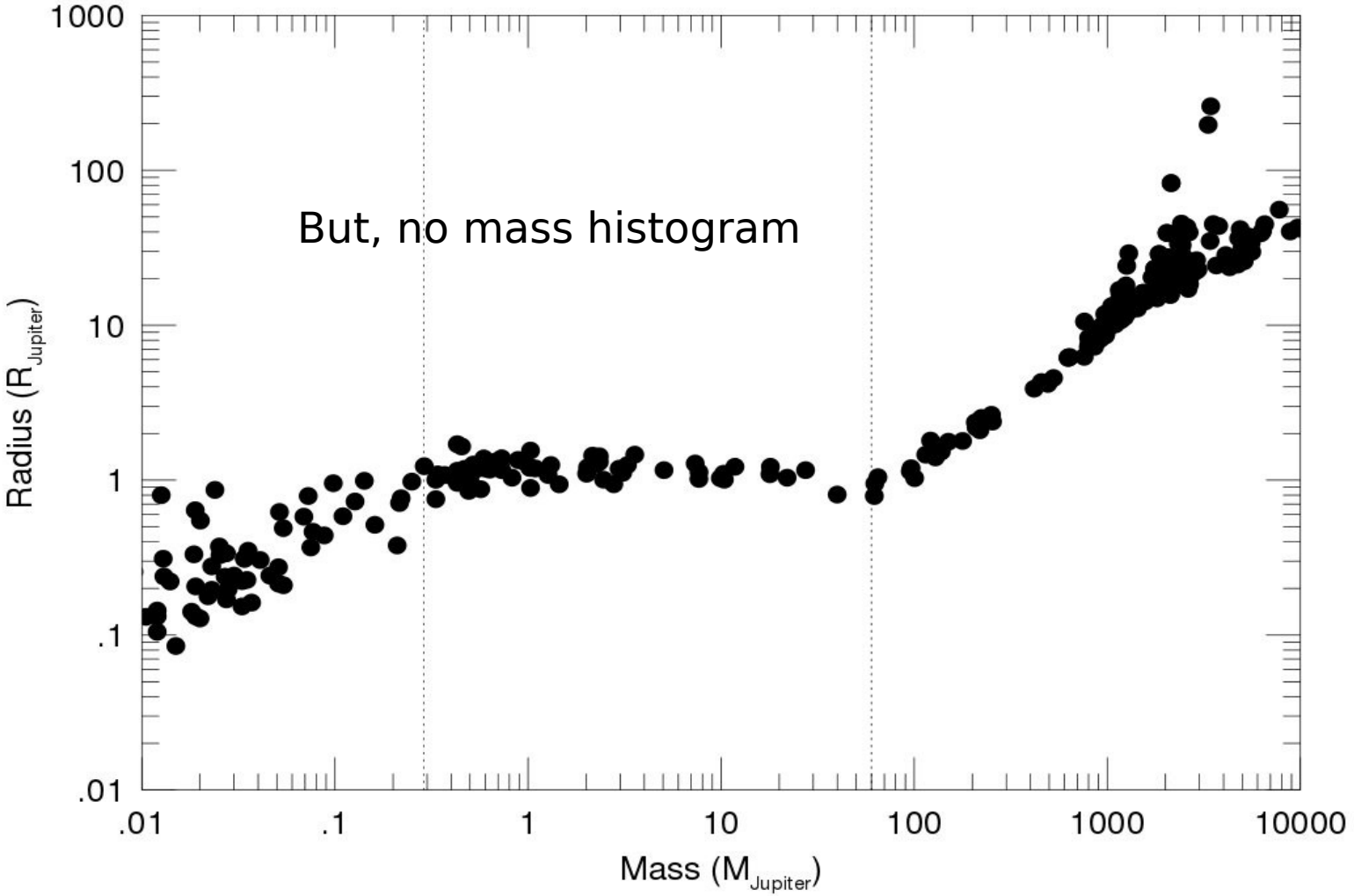

Physical definition: new mass criterion

From previous distributions, nothing special at 30 MJup.

==> New mass limit : 60 Mjup

Problem: around 10-60 M_{jup} the planet/brown dwarf ratio is unknown

i.e. No *a priori* model of their mass spectrum

Brown dwarfs start around 6 M_{jup} (Baraffe et al. 2010)

==> Mass not a good criterion.

Other observables ?

- **Temperature**

  In case of unknown mass (no RV or astrometry, no log-g)

  But, poor mass-age-temperature correlation

  e.g. : DE 0823-49 : M = 28 – 63 M_{Jup} (Sahlman et al. 2015)

- **Beyond bold mass-radius : central heavy elements core**
  - Core present : ==> planet
  - Core absent : ==> brown dwarf

  How to detect a central core ?
  - Tidal effects :

  star-planet or planet-planet interactions different with and without core : ==> different perturbations of the Keplerian motion
  - In the very far future : seismology

- **Orbit**

  For multiple objects, coplaner orbits are indicative of a formation in a dust disk
  ==> rather a planet

- **Composition ?**

- **Others ?**

What to include in a Who's Who ?

For astronomical objects, a Who's Who is a catalog.

Once conceptual definitions and limits of observables are chosen, does a given (candidate) object fit the criteria ?

New problem : uncertainties and error bars.

New problem for a Who's Who (i.e. catalog) : uncertainties in real observations

- Uncertainty ΔM on the mass

  Choice: 1 sigma tolerance (i.e. M = 60 M_{jup} + 1 sigma).

Remark:

Absurdity of sharp mass criterion (60.1 M_{jup} excluded).

e.g. CoRoT-33 b : 62.1 (+2.1, -0.9) Jup (Czismadia et al. 2015)
CoRoT-15 b : 63.3 (+/- 4.1) Mjup (Bouchy et al. 2011)

But no solution.

Other problems

- Ambiguities, wrong diagnosis
  - Radial Velocity:

    2 planets on circular orbits, or 1 planet on eccentric orbit?

    (Anglada-Escudé et al 2011)
  - Image:

    Giant planet or dust cloud around small planet

    (ex. Fomalhaut b) ?

A possible solution

- Modern technology allows large « generous » electronic lists of planet candidates

- Each researcher is to make its own mind and « tick » or « un-tick » her/his preferred planets

Implementation in existing catalogues

The Exoplanet Orbit Database

exoplanets.org

Wright et al.

PASP, 123, 412, 2011

Limited to **M < 24 M_{jup}**

The Extrasolar Planets Encyclopaedia

exoplanet.eu

Defining and cataloging exoplanets

Schneider, Dedieu, Savalle, Le Sidaner, Savalle & Zolotukhin

A&A, 532, A79, 2011 arxiv:1106.0586

Any detection method and **M < 30 M_{jup}**

Later on

- extension to 60 M_{jup}
- Possibility to « un-tick » objects from the catalog

Conclusion

A debate still open

(biased by the emotional content of the word « planet »)

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A recommendation to IAU :

Please, do not set up an official definition of a (exo-)planet