Some properties of the distribution of long period comets

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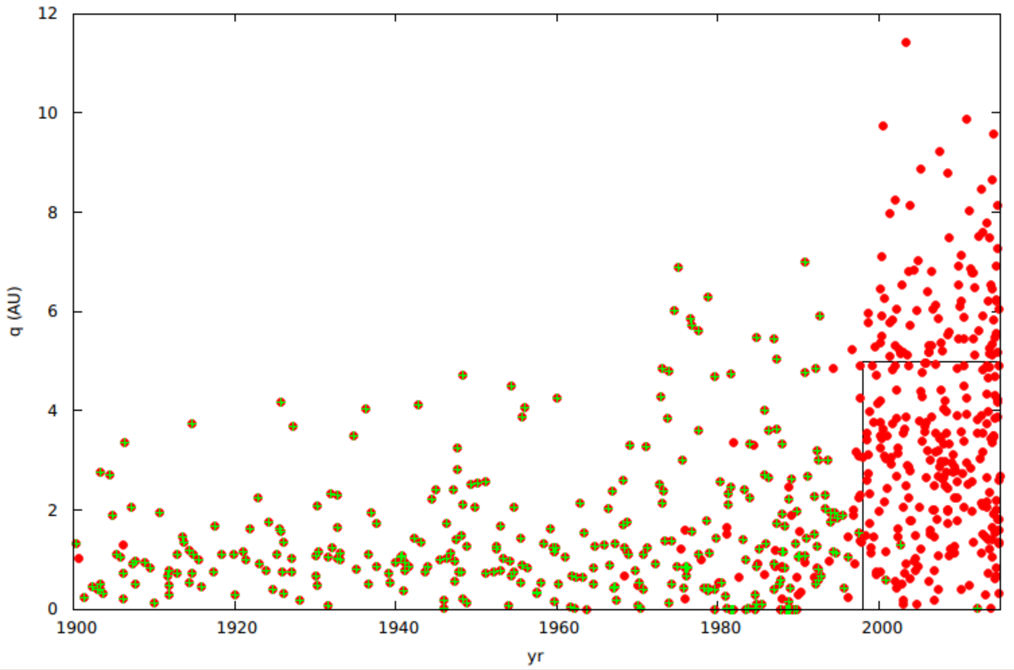
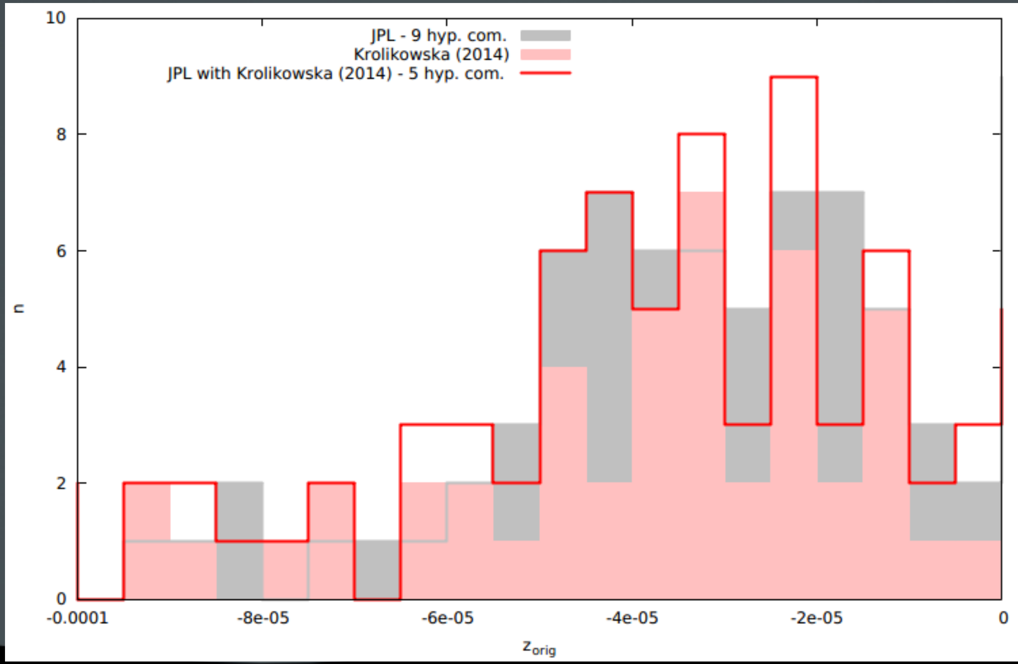
EPSC-2015, Nantes, September 27th – October 2nd 2015

The observed "new" long period comets

- The Horizons (JPL) system is used to compute the original orbital energy z_{orig}=-1/a_{orig} (i.e. at 150 AU from the Sun before the observed perihelion) of observed long-period comets until June 1st, 2015.
- When available, the original orbital energy is taken from Krolikowska (2014).
- The flux of "new" comets (z_{orig}> -10^{-4} AU^{-1}) with a total magnitude H < 11 and q < 5 AU is considered as complete from 1998 : 4.29 com · year $^{-1}$.





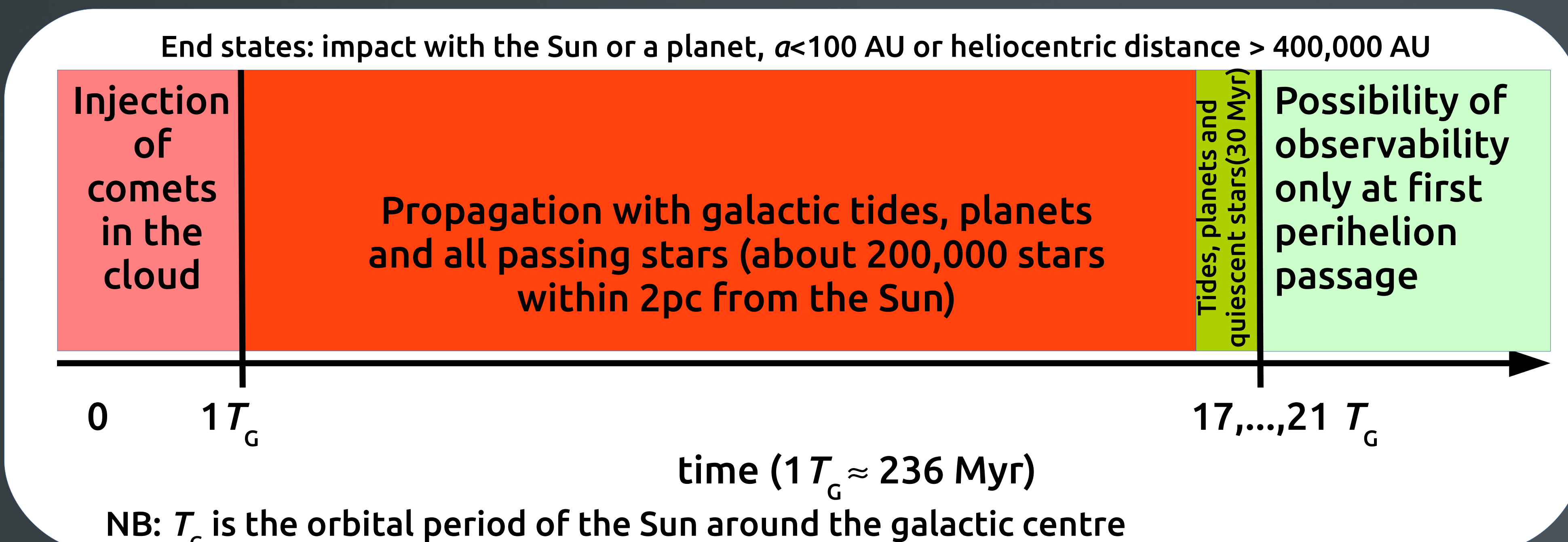
Initial conditions and simulations

Initial conditions:

10^7 comets randomly chosen with the following uniform distributions:

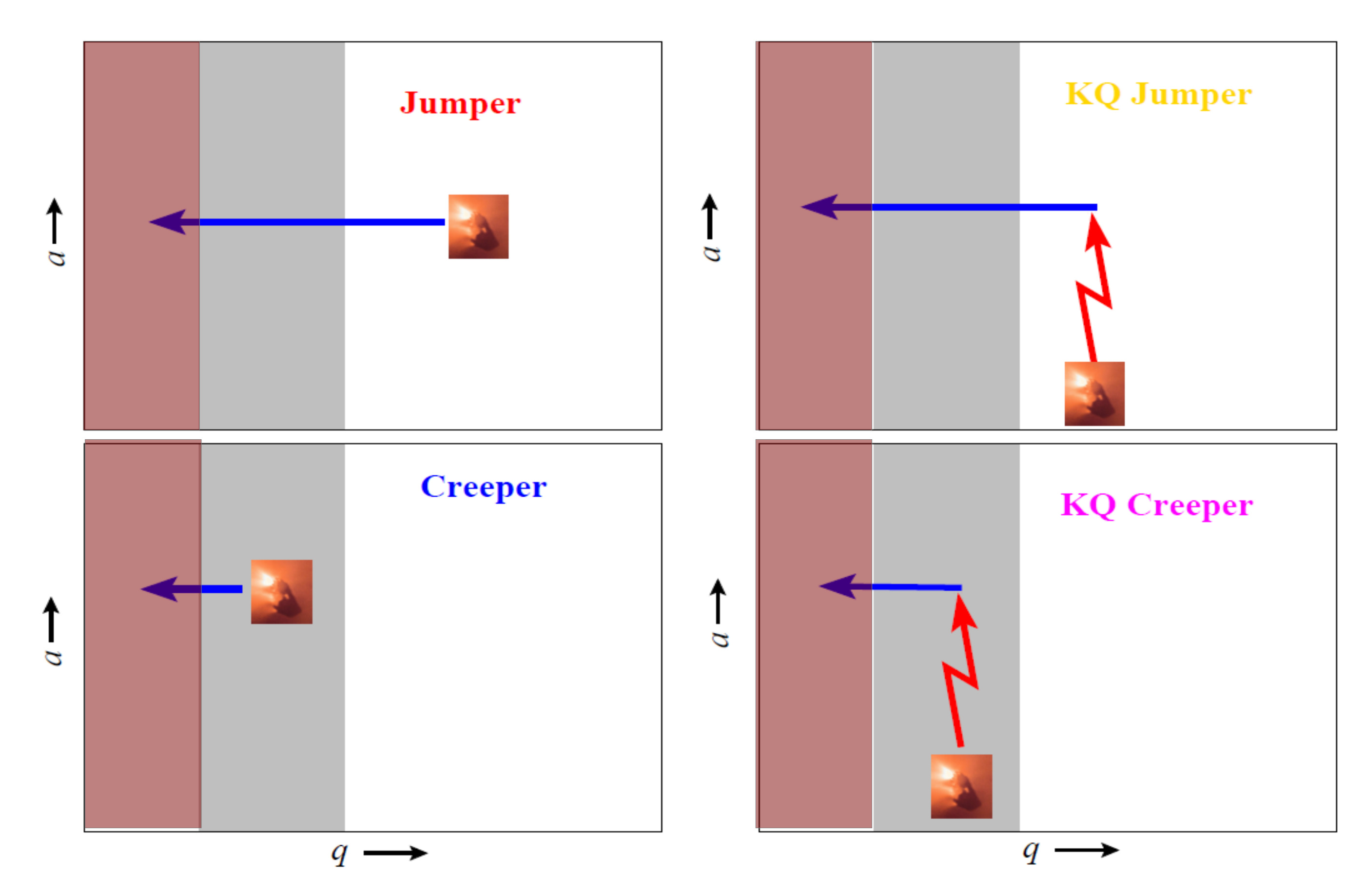
- perihelion distance *q* between 15 and 32 AU
- ecliptical inclination *i* between 0° and 20°
- orbital energy for semi-major axis *a* between 1,100 and 50,000 AU
- uniform distribution of M, ω and Ω between 0° and 360°.

Propagation:



5 different final times between 4.02 and 4.96 Gyr => as if we had modelled the evolution of 5×10^7 comets.

The four observable classes



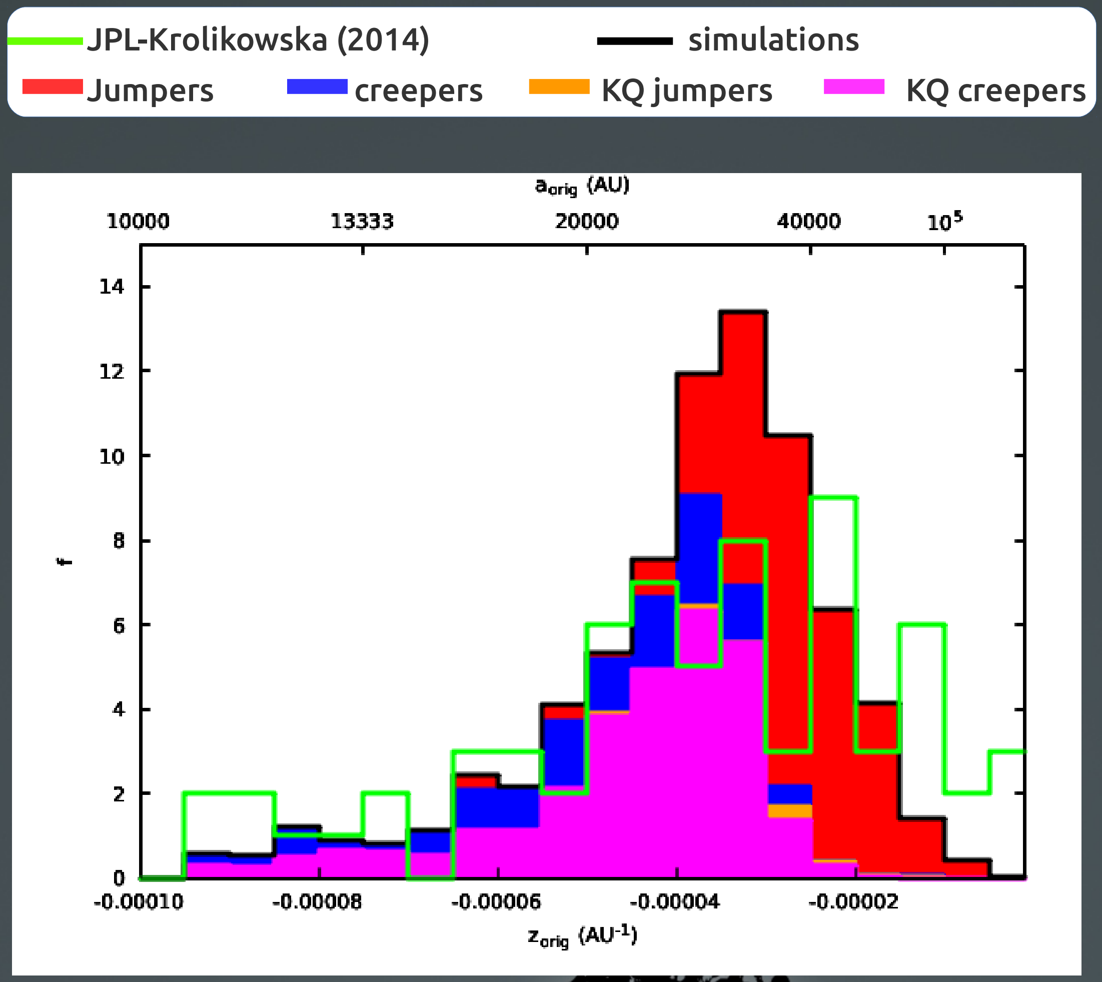
Observable region

Jupiter-Saturn barrier (5 < *q* < 15 AU)

NB : KQ for Kaib and Quinn (2009)

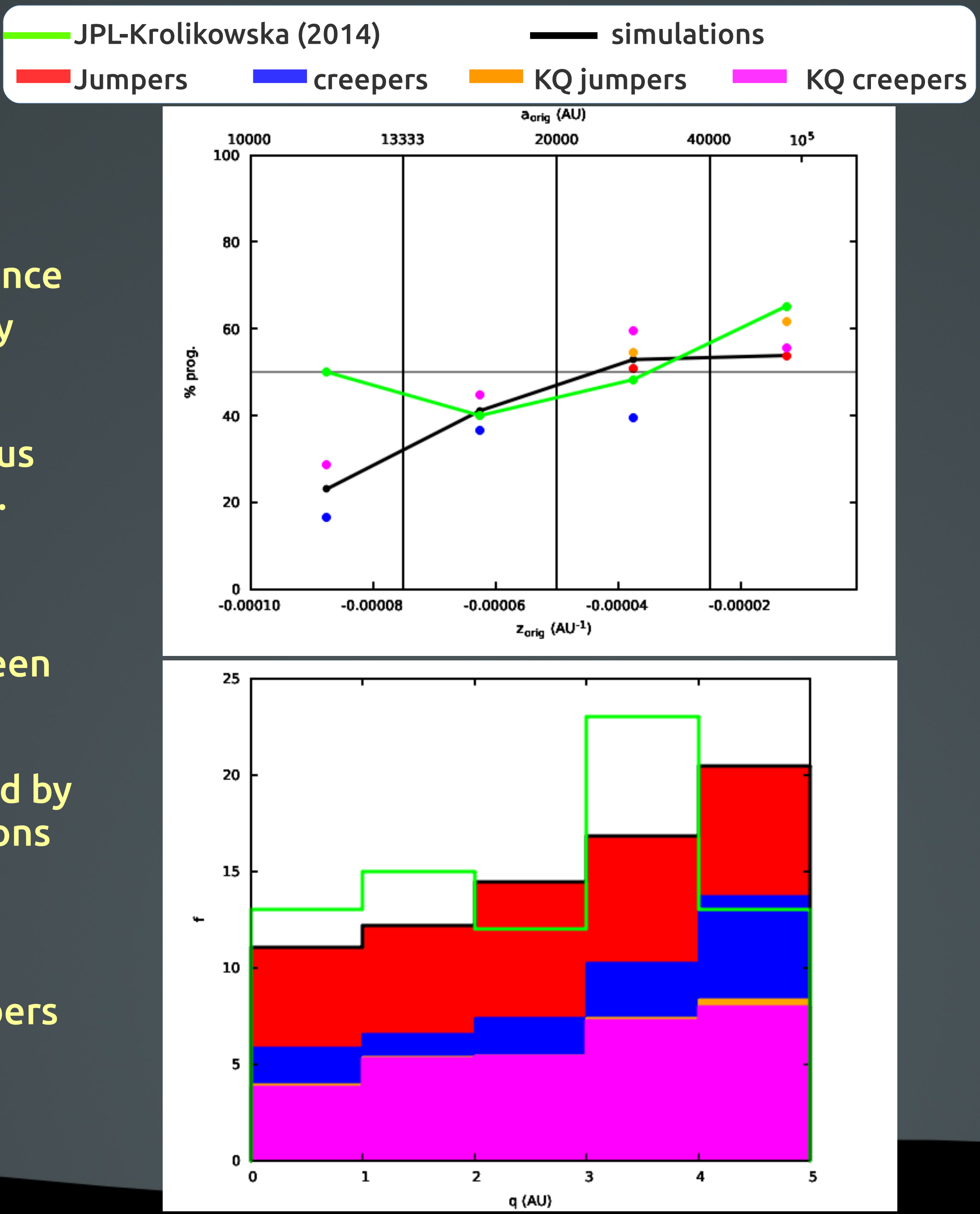
The observable comets : q < 5 AU
The Oort peak

- Simulation (data are weighted in order to have 4.29 com · yr with q < 5 AU) :
  - Class repartition :
    - Jumpers: 41.4%
    - Creepers: 17.8%
    - KQ Jumpers: 1.3%
    - KQ Creepers: 39.5%
    - The median initial semi-major axis is 2,500 AU
- Observation/Simulation
  - Good fit for the a_{orig} < 25,000 AU
  - Need better orbit determination for higher semi-major axis
- For this simulation the initial population should contains 9 · 10^{11} comets with H < 11.



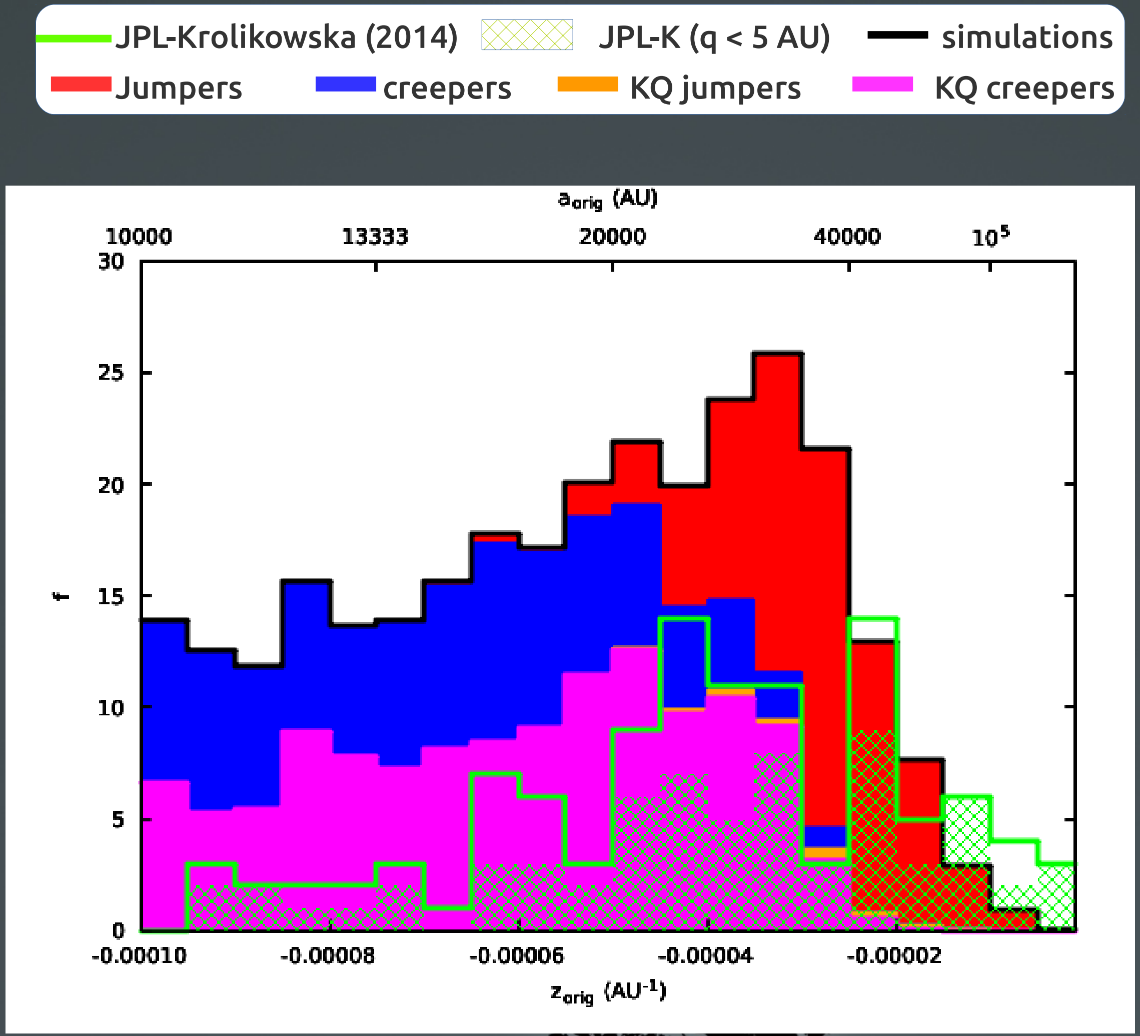
The observable comets : q < 5 AU
Inclination and perihelion distributions

- Simulations :
  - isotropy for a_{orig}> 20,000 AU, clear preference for retrograde orbits otherwise (caused by creepers comets)
  - Slight increase of observable comets versus perihelion distance coming from creepers.
- Observation/simulations
  - Good agreement with observations between 13,000 AU and 40,000 AU.
  - Discrepancy on the edges, might be caused by small statistics or poor orbit determinations (on z_{orig})
  - Perihelion distribution is consistent with simulations but again small statistic numbers makes rigorous comparison hazardous.



LPC with $q < 10$ AU Oort peak

- Simulations (data are weighted in order to have 4.29 com · yr with $q < 5$ AU) :
  - Class repartition :
    - Jumpers: 25.4%
    - Creepers: 31.0%
    - KQ Jumpers: 0.8%
    - KQ Creepers: 42.8%
    - 67% have a_{orig} < 25,000 AU (25% for $q < 5$ AU)
    - The median initial semi-major axis is 2,300 AU.
- Observation/Simulations
  - Huge increase of comets with a_{orig} < 25,000 AU. Not detected yet by observations even if a small trend is observed: 40% of observed comets have a_{orig} < 25,000 AU, they were 33% considering comets with q < 5 AU.



LPC with $q < 10$ AU
Inclination and perihelion distributions

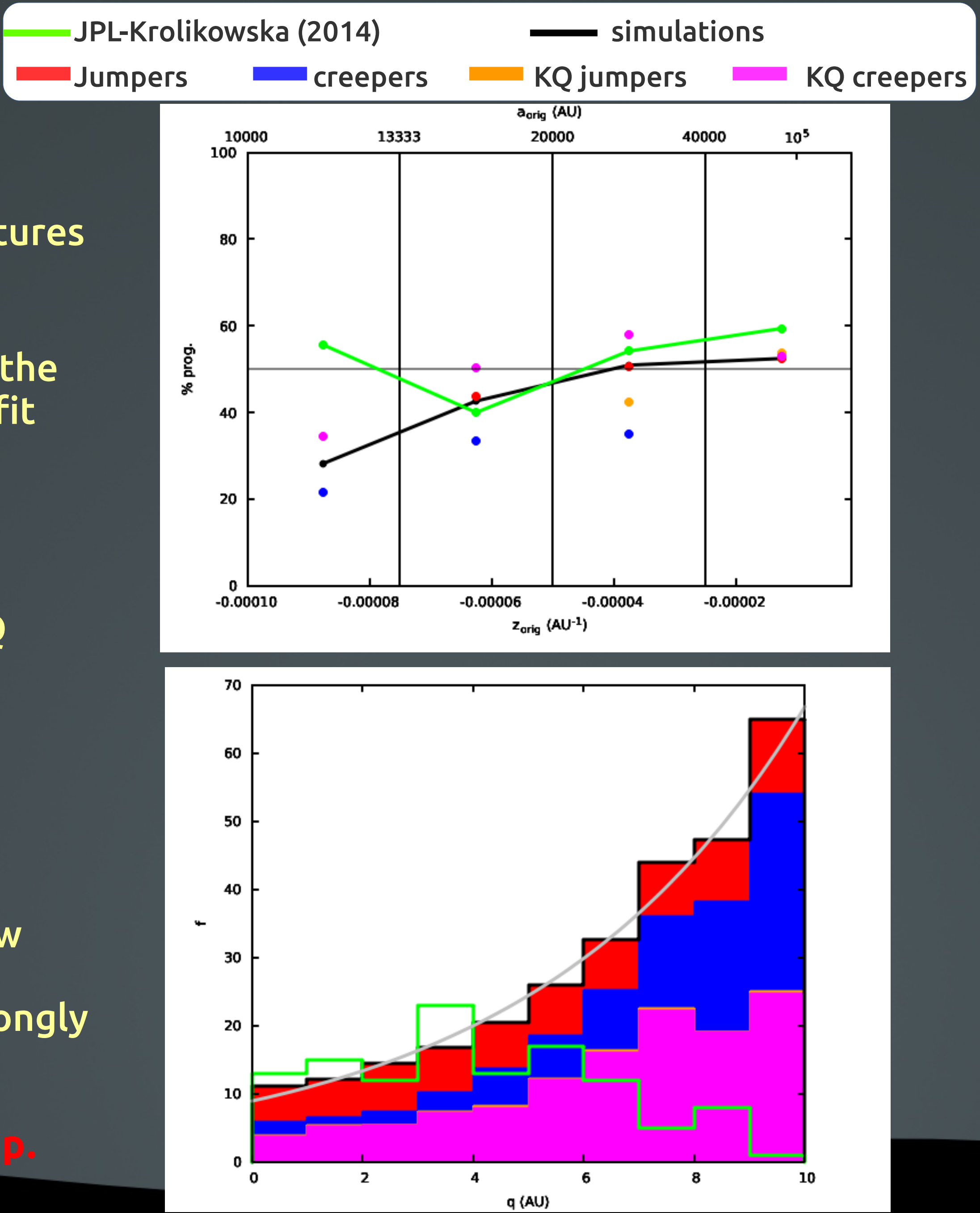
- **Simulations :**
  - The inclination vs z_{orig} shows the same features as for comets with $q < 5$ AU
  - The number of LPC per AU increases with the perihelion distance according to the best fit law:

$$n \propto 1.22\ (\pm 0.01)^{q}$$

  - This increase comes from creepers and KQ creepers, but not from jumpers.

- **Observation/simulations**
  - a majority of prograde comets for a_{orig}<13,333 AU is still present in the observations but the data are still very few
  - From q>5 AU observations seem to be strongly incomplete

future observations by survey will help.



Conclusions

- The flux of observed new LPC with $q < 5$ AU is well reproduced by our simulations :
  - more than 60% of this comets were already in the Jupiter-Saturn region at their previous perihelion passage
- For $a_{ori} < 20{,}000$ AU comets are preferentially retrograde, and no preference otherwise from our sim. Observations show a preference of prograde for $a_{ori} > 40{,}000$ AU but need a better orbit determination for these orbits.
- The number of comets with $H < 11$ in the initial population is about $9 \cdot 10^{11}$, and for $H < 6.5$ it is about $3.6 \cdot 10^{11}$ (number consistent with Brasser and Morbidelli, 2013)
- Considering new LPC with $q < 10$ AU, our sim. show that :
  - The number of New LPC per year and per perihelion distance unit increases as $n \propto 1.22^{q}$
  - 75% of the comets were in the Jupiter-Saturn region at their previous perihelion passage
  - 67% of comets have $a_{ori} < 25{,}000$ AU.

Need for observations to complete the flux beyond 5 AU in order to confirm the trend observed in the simulations.