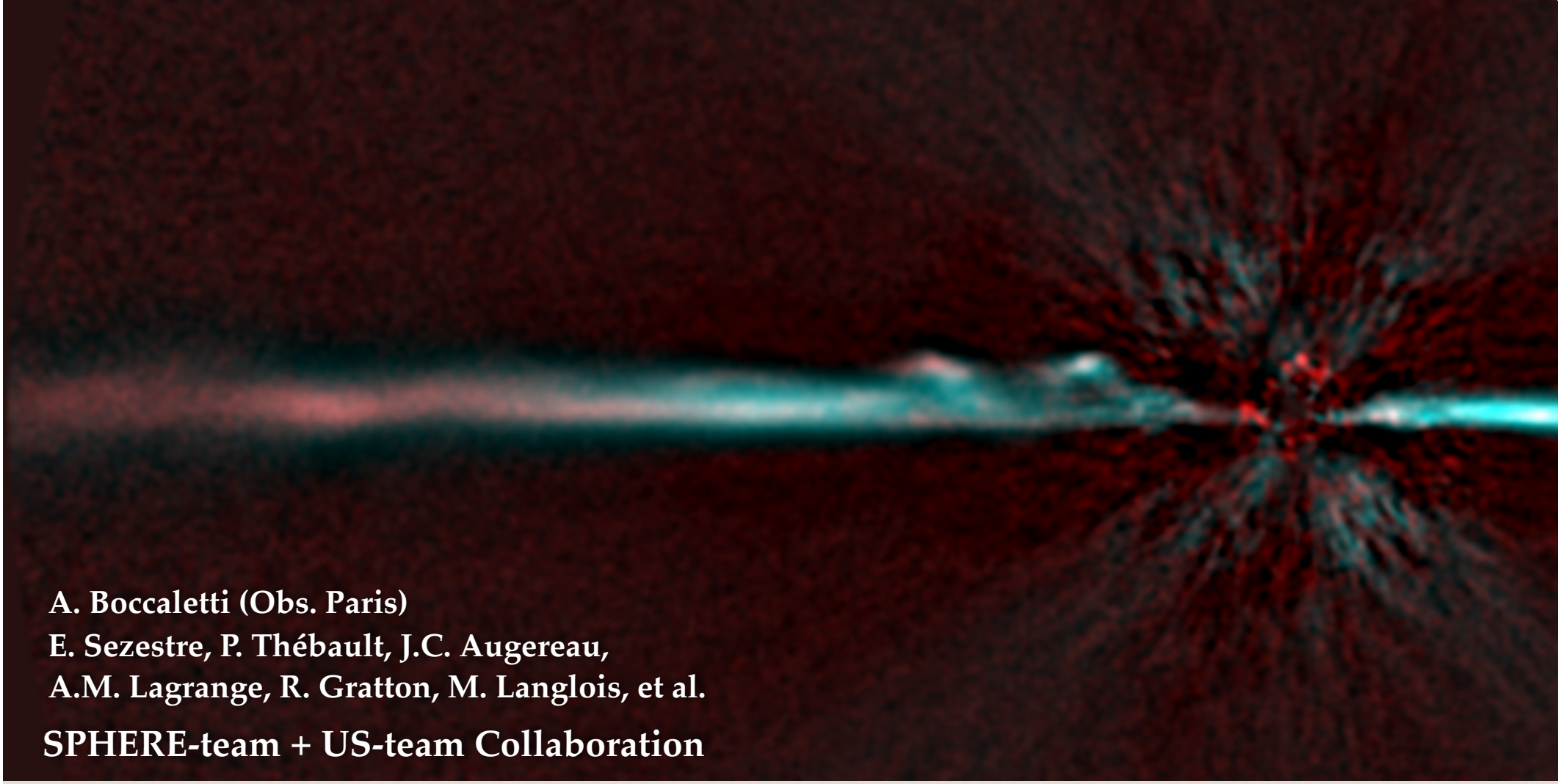


A. Boccaletti (Obs. Paris)
E. Sezestre, P. Thébault, J.C. Augereau,
A.M. Lagrange, R. Gratton, M. Langlois, et al.

SPHERE-team + US-team Collaboration

Observations of fast moving structures in the debris disk of AU Mic

A possible case of star-planet interaction at large orbital distances

SPHERE

High contrast imaging at visible and near IR

- extreme Adaptive Optics
- coronagraphy
- differential imaging

SPHERE
Spectro-Polarimetric High-contrast Exoplanet REsearch

1st light : May 4th, 2014

Opérations : Feb. 2015

SPHERE @ VLT - Apr. 2014

IPAG Institut de Planétologie et d'Astrophysique de Grenoble

LAM Laboratoire d'Astrophysique de Marseille

l'Observatoire de Paris — LESIA

INAF Istituto Nazionale di Astrofisica

Astronomical Observatory of Padova

ONERA The French Aerospace Lab

LAGRANGE

Universiteit van Amsterdam

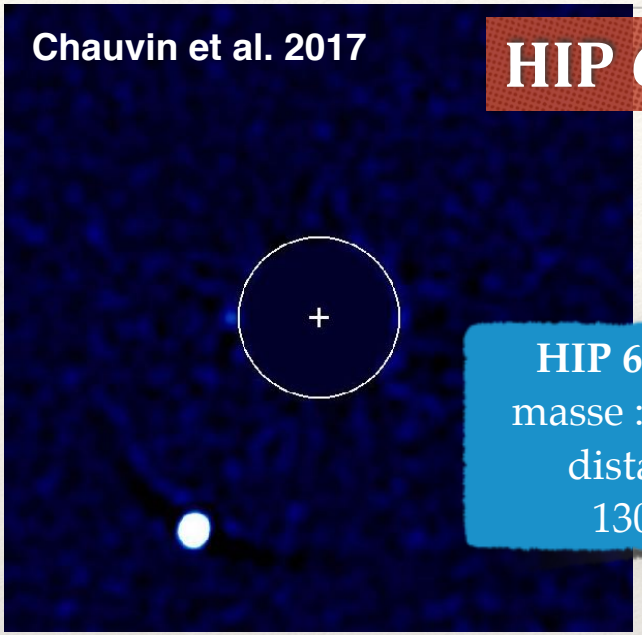
ETH zürich

ASTRON

Observatoire de Genève Fondé en 1772

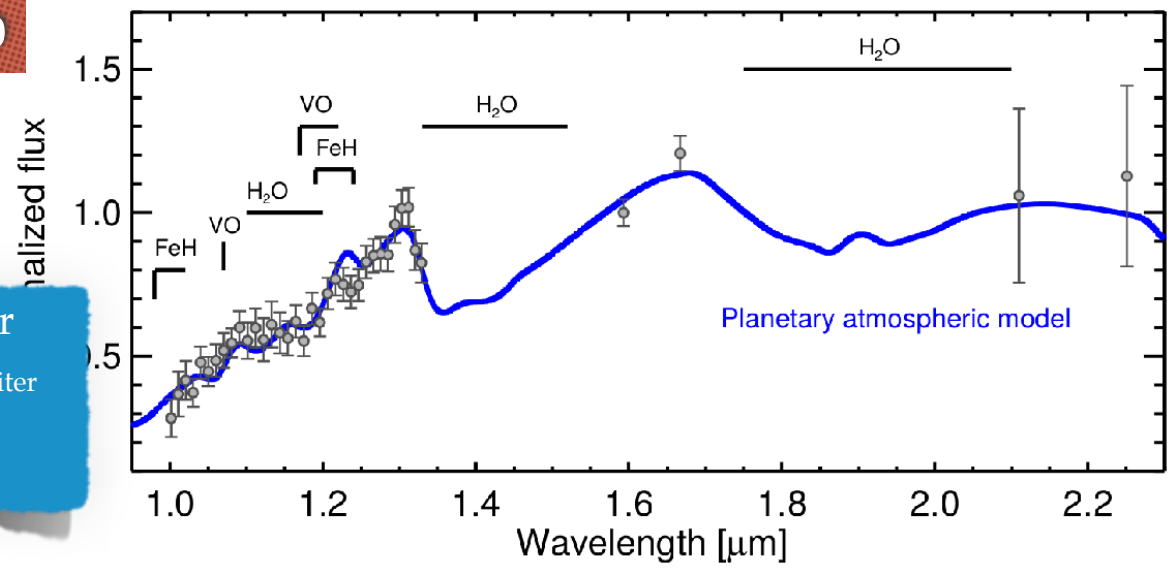
ESO

Discoveries of super-Jupiter planets

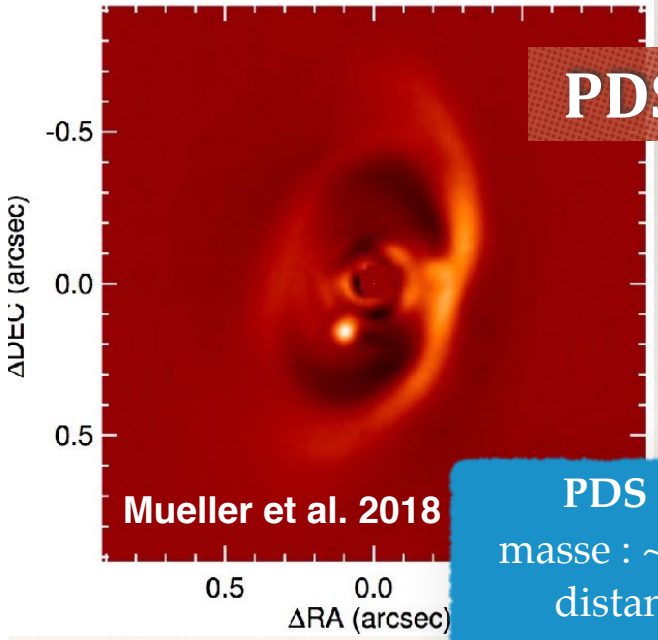


HIP 65426 b

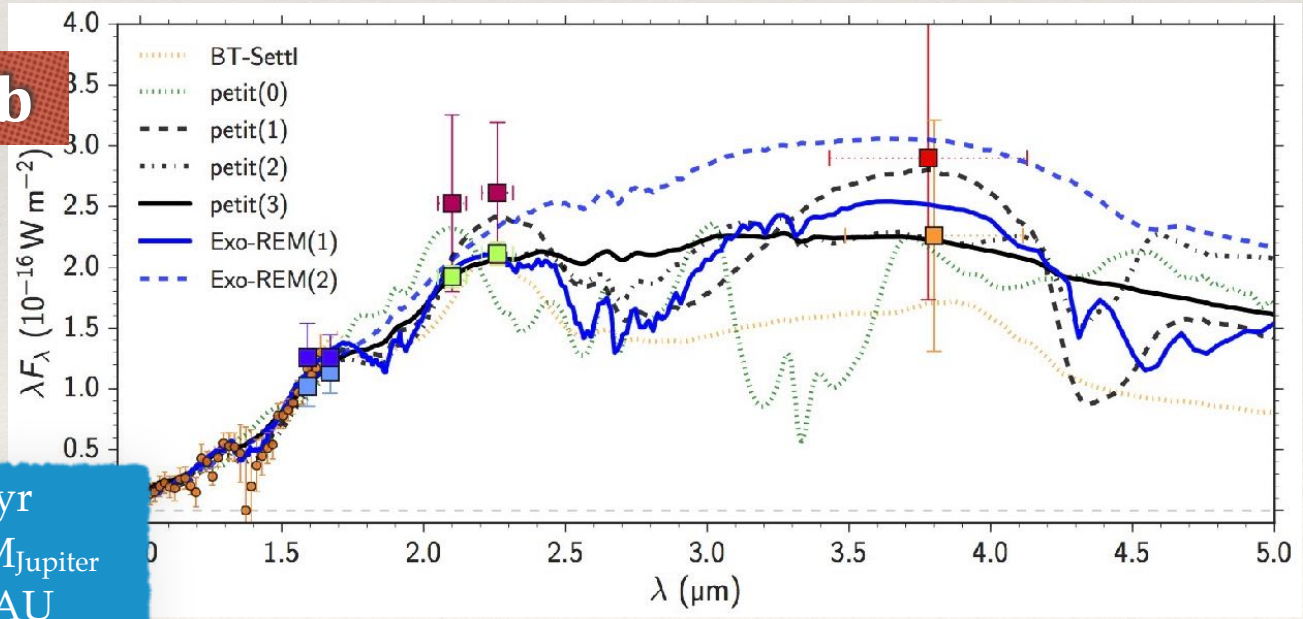
HIP 65426 : 17 Myr
masse : ~ 6 -12 $M_{Jupiter}$
distance : 92 AU
1300 - 1600 K



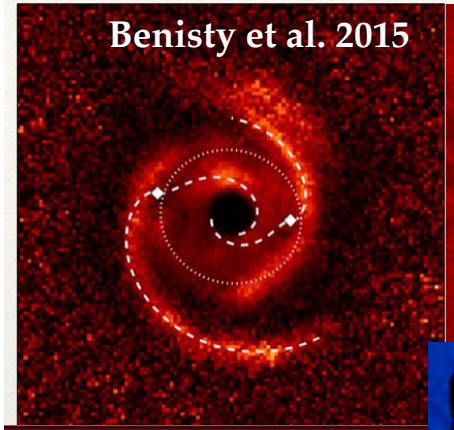
PDS 70 b

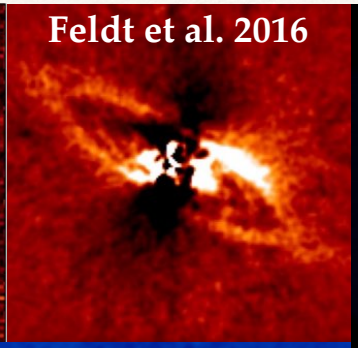


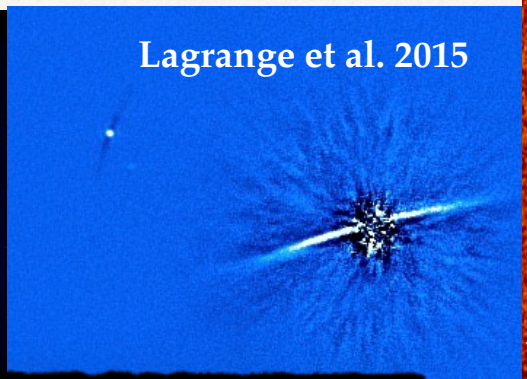
PDS 70: 5 Myr
masse : ~ 2 -17 $M_{Jupiter}$
distance : 22 AU
1000 - 1600 K

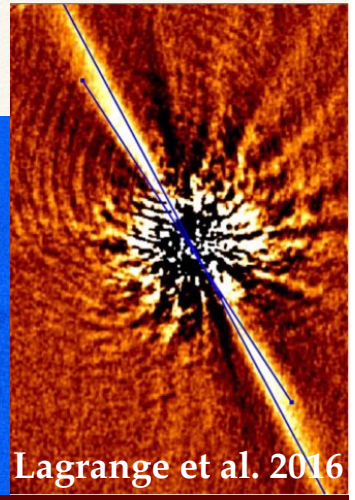


Harvest of disks !









Many Structures !

spirals

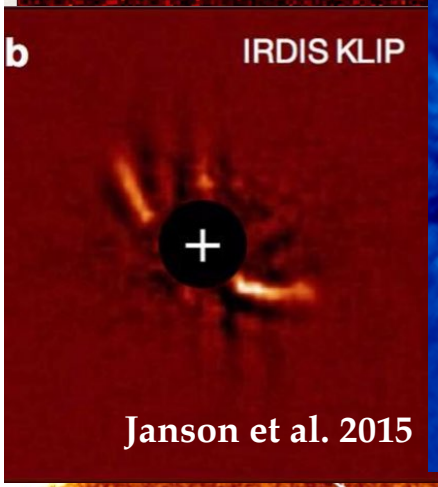
rings

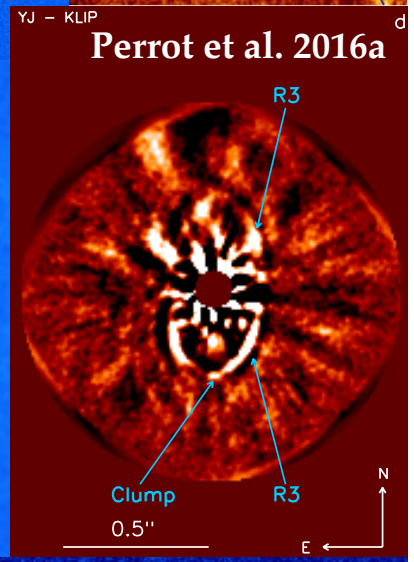
gaps

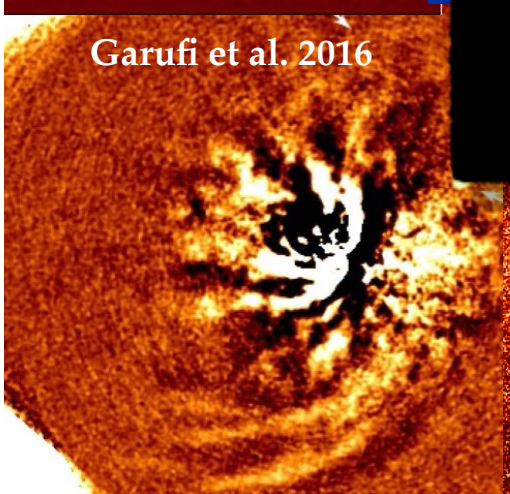
shadows

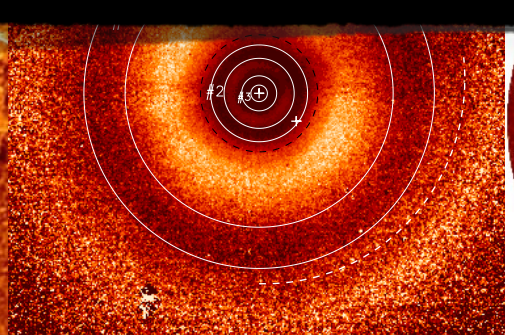
clumps

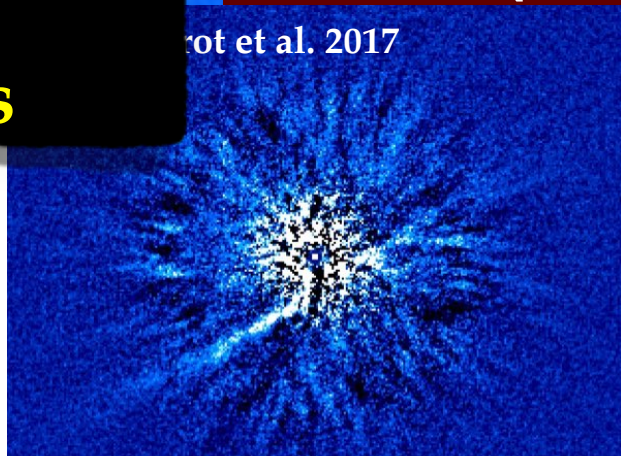
asymmetries



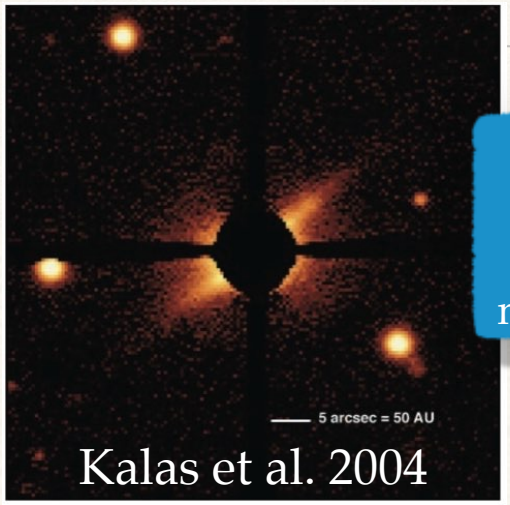






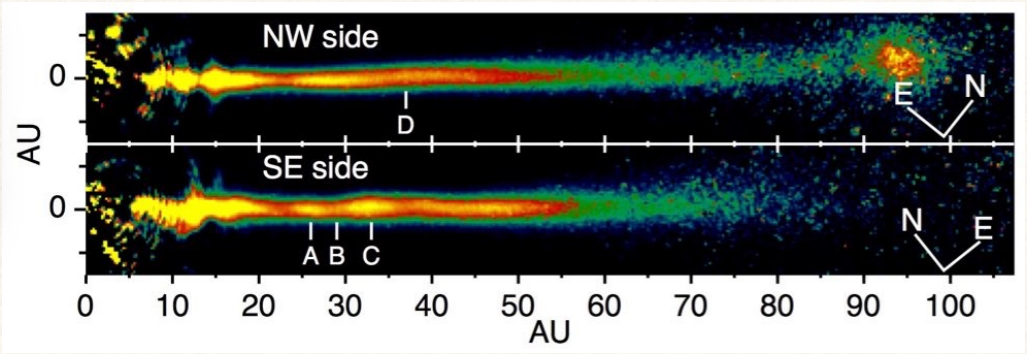


AU Microscopii

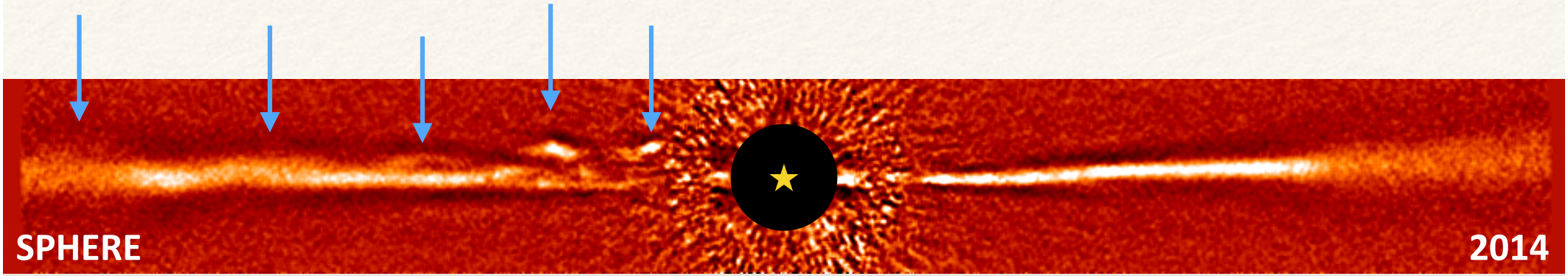


Kalas et al. 2004

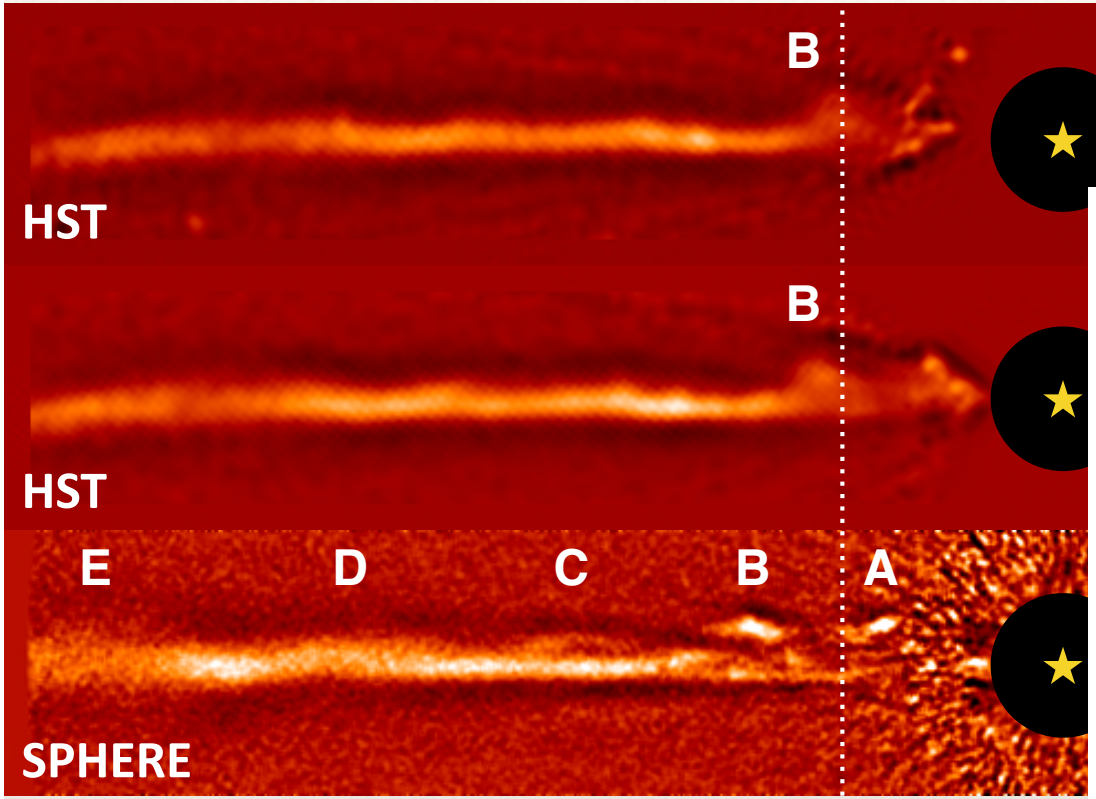
M1Ve
d=9.94pc
BPMG : 23+/- 3Myr
most active nearby M star

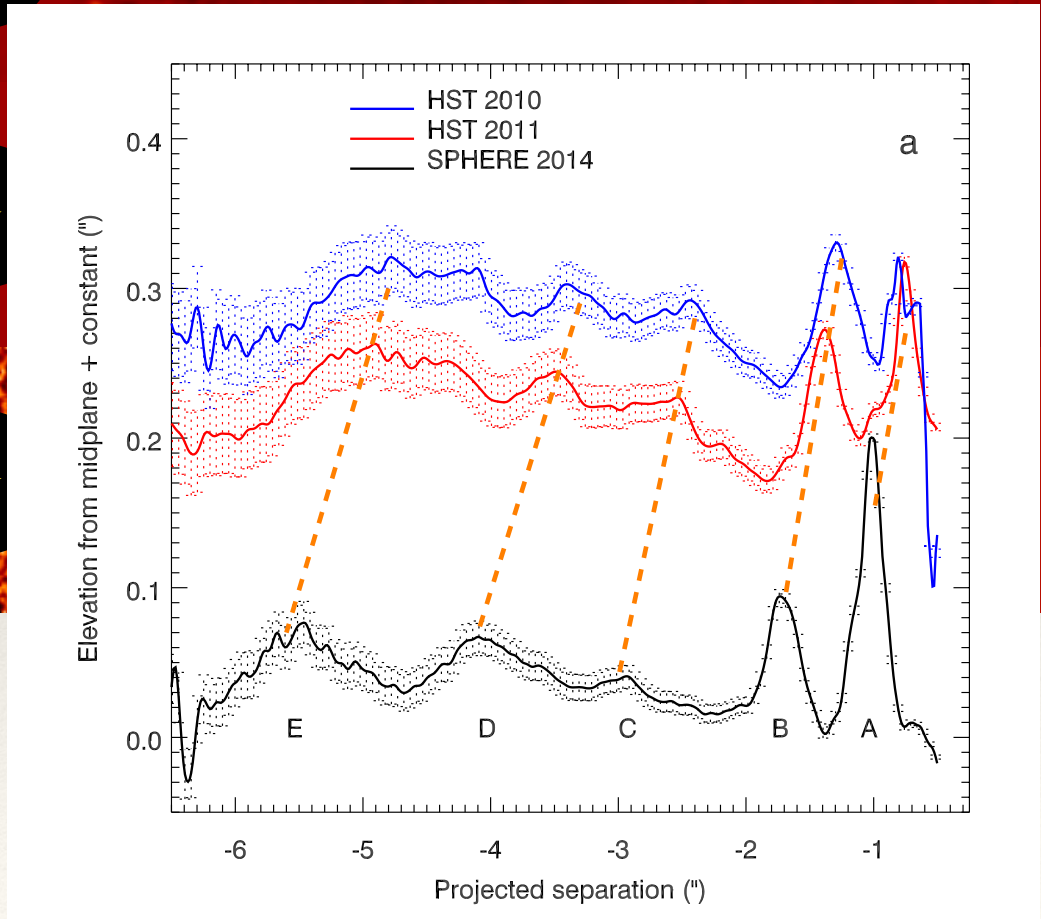


Krist et al. 2005



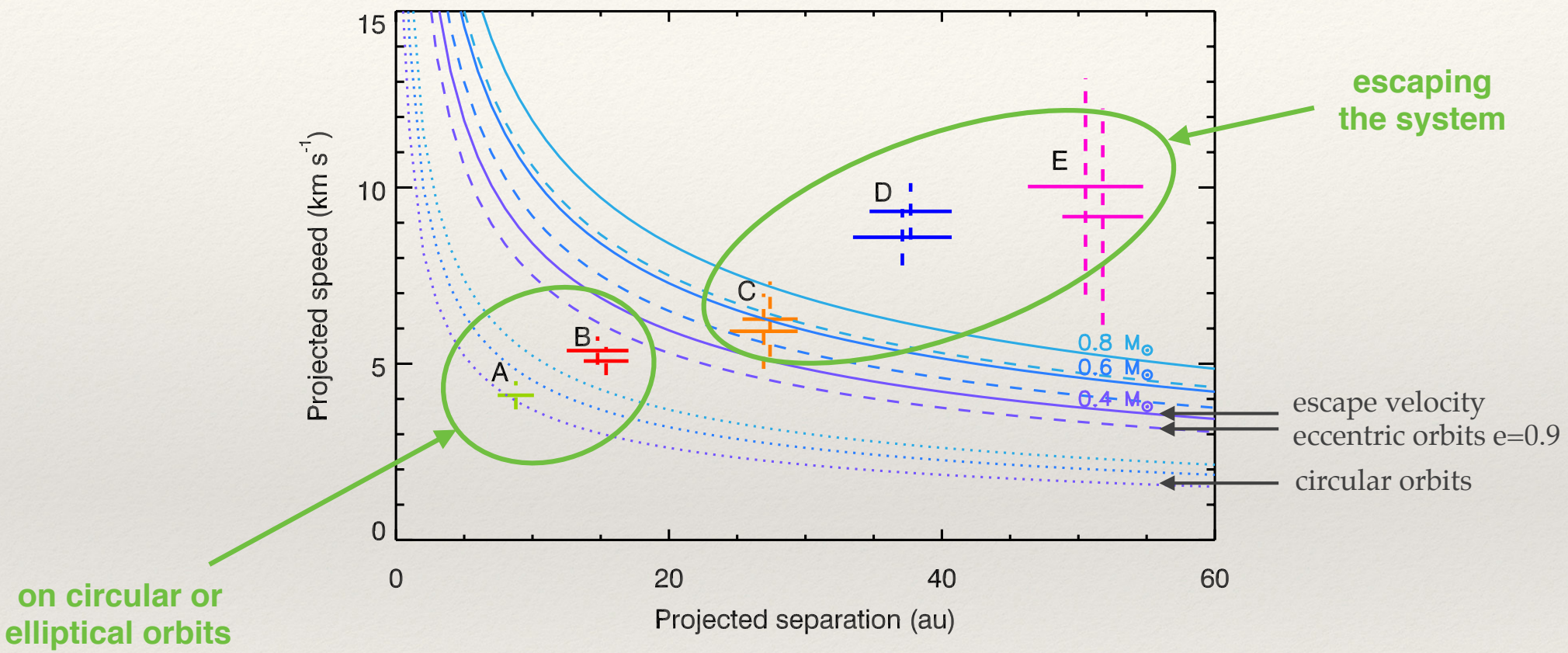
Discovery of fast moving structures

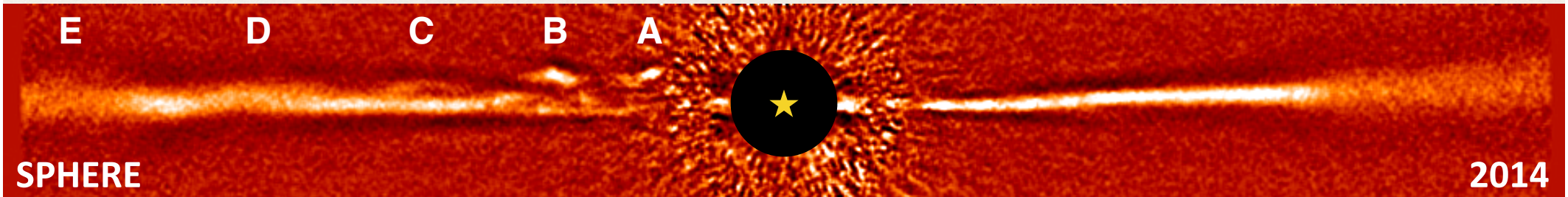




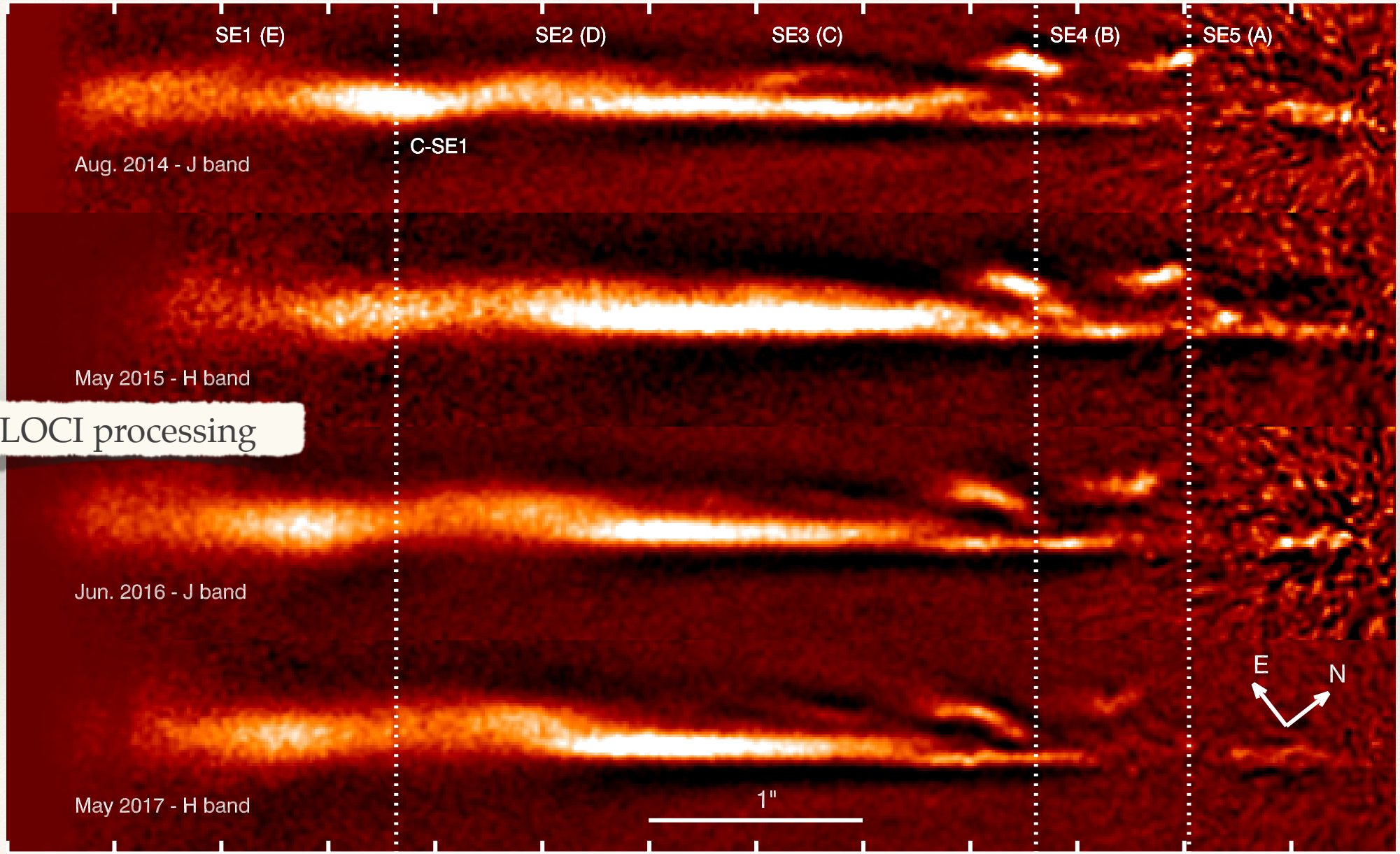
Boccaletti et al. 2015

Discovery of fast moving structures

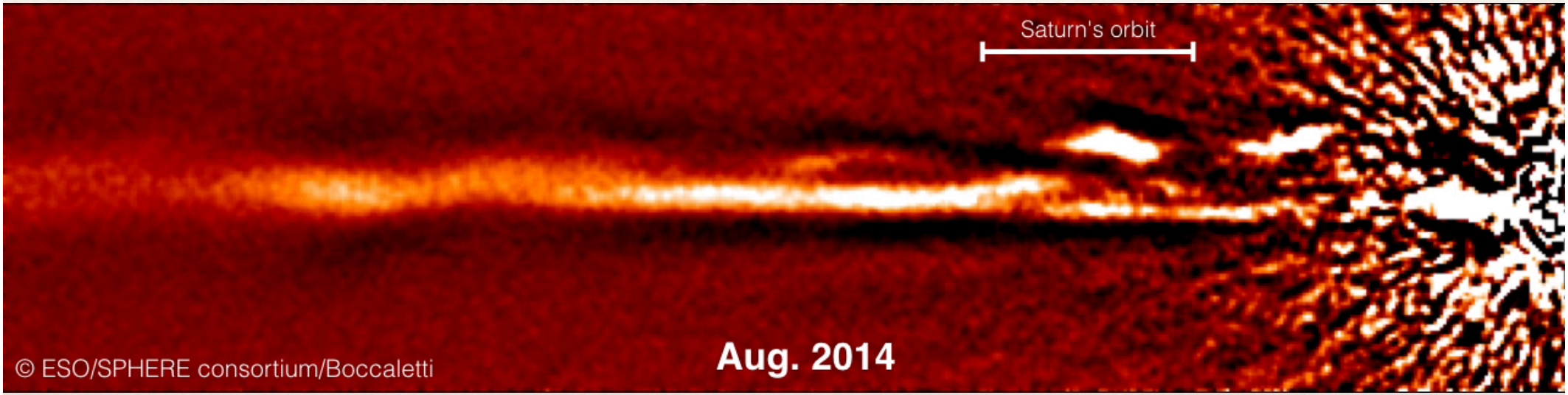




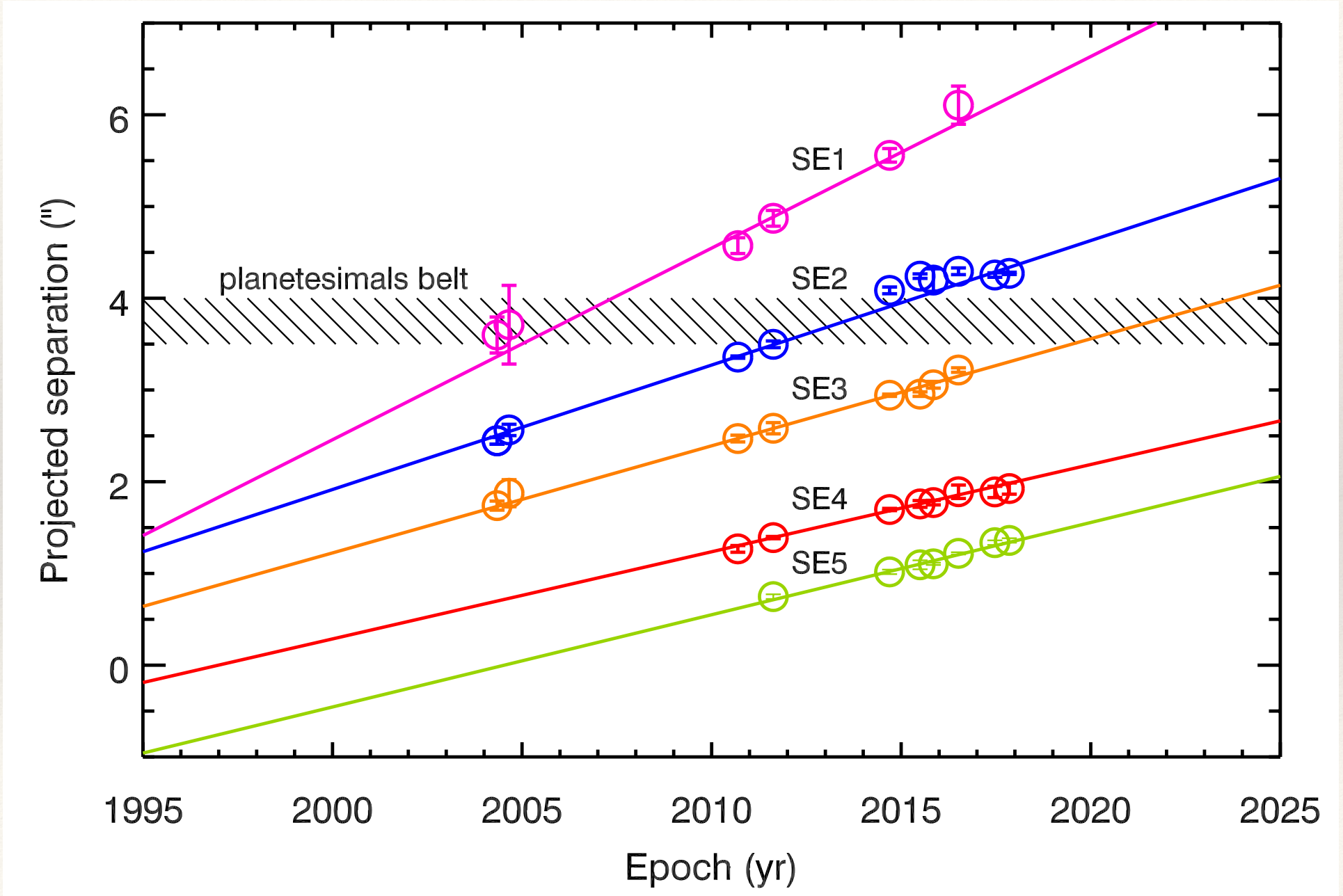
The southeast side: close up



The southeast side: close up

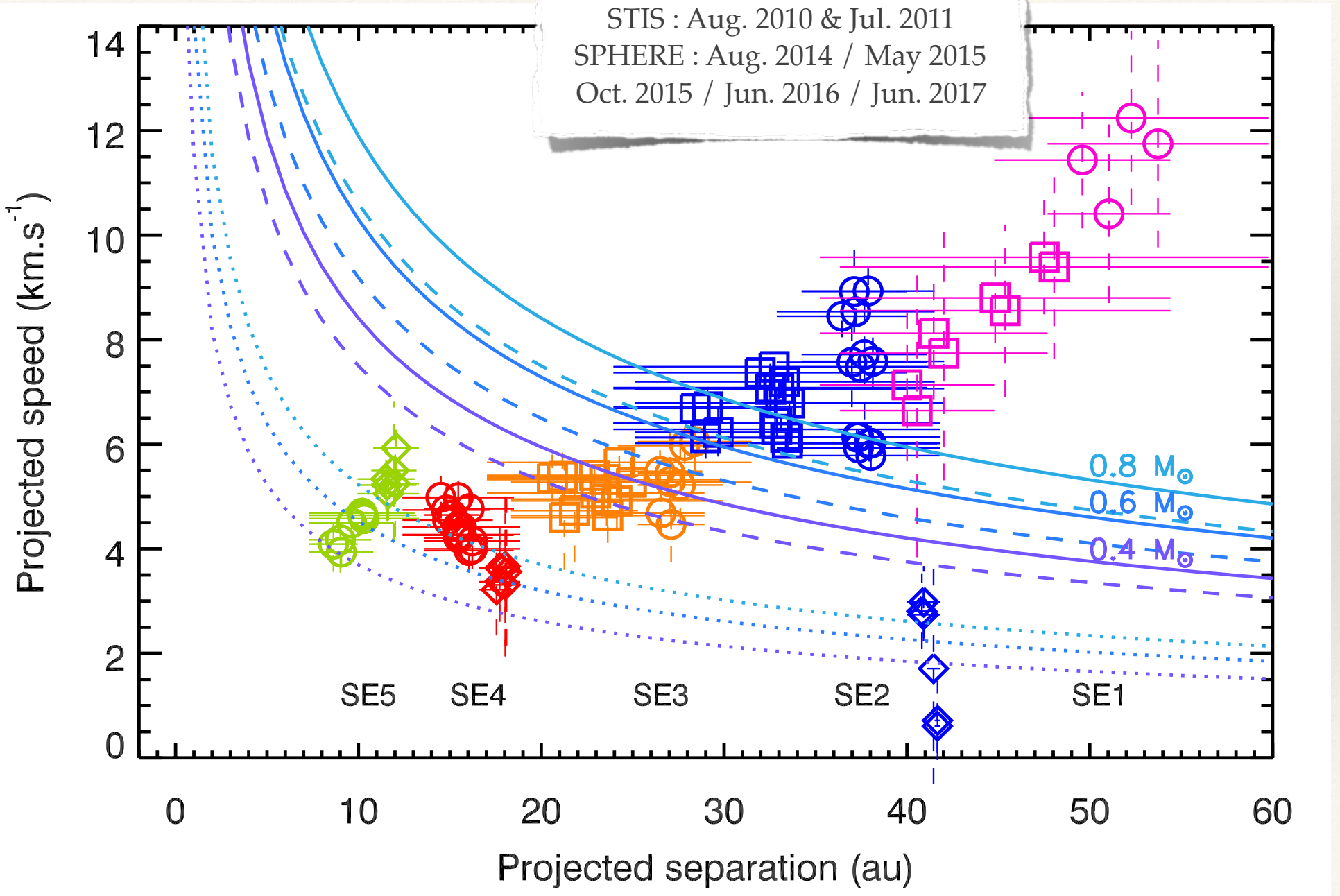


Evolution in time



Projected speeds

ACS : Apr. & Jul. 2004
STIS : Aug. 2010 & Jul. 2011
SPHERE : Aug. 2014 / May 2015
Oct. 2015 / Jun. 2016 / Jun. 2017



Model of dust expelled from a parent body

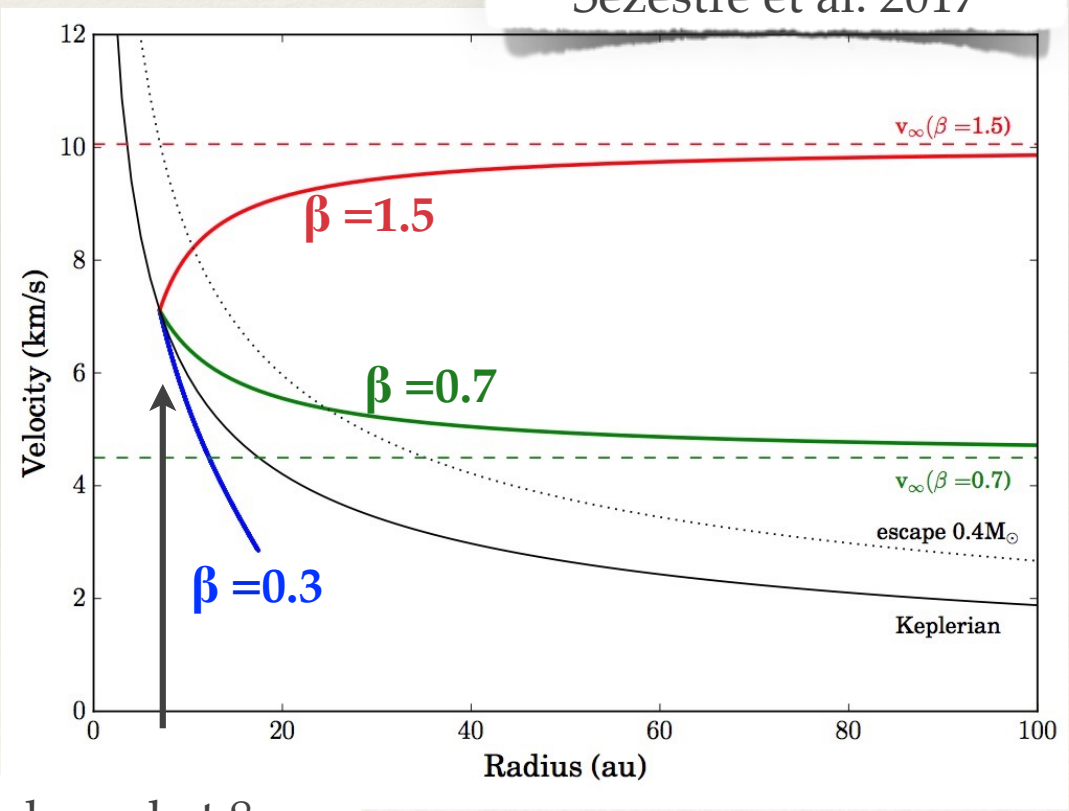
- developed by E. Sezestre, J.-C. Augereau
- assume the motion of features corresponds to a motion of dust particles (not a wave pattern)
- need an asymmetric process => parent body : static / rotation
- trajectories determined by R_0 and β

$$\beta = \frac{\|F_{SW}\| + \|F_{PR}\|}{\|F_{grav}\|} = \beta_{SW} + \beta_{PR}$$

$$\beta_{SW} \propto \frac{\dot{M}_\star V_{SW}}{M_\star s}$$

$$\beta_{PR} \propto \frac{L_\star}{M_\star s}$$

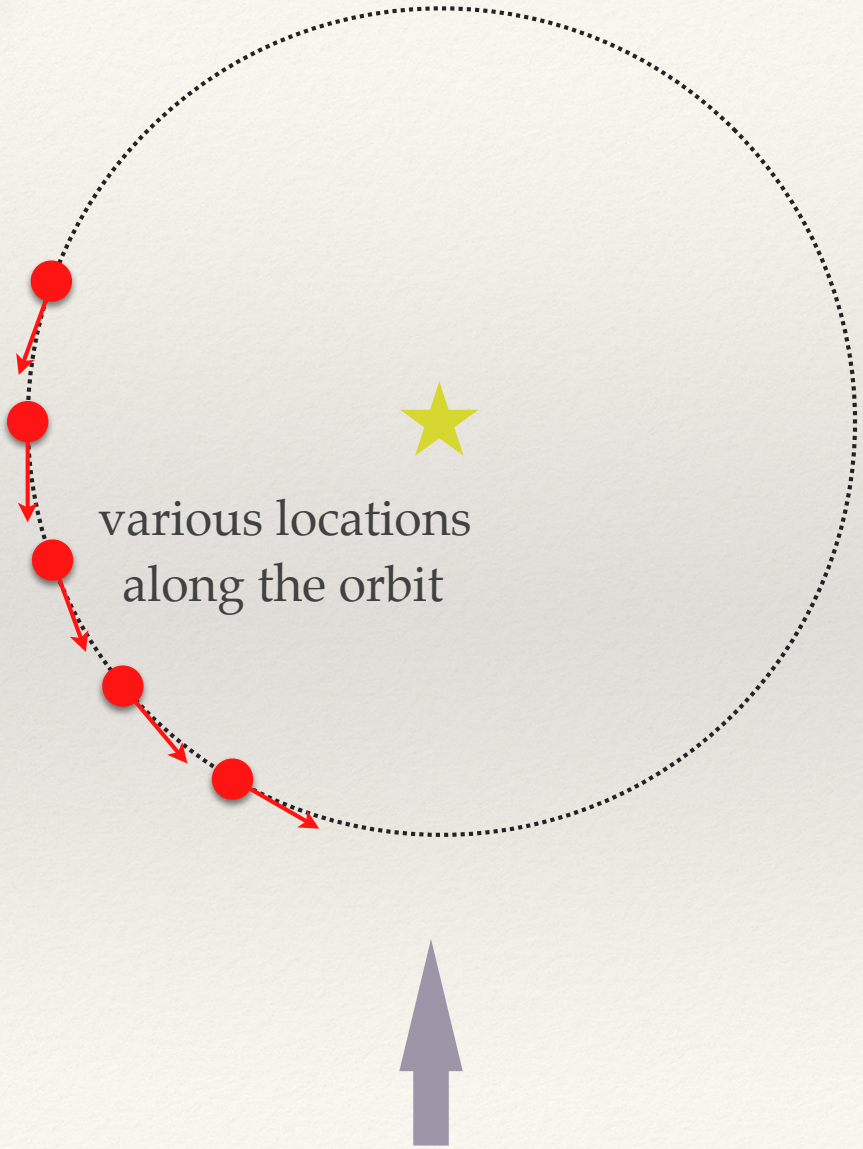
Sezestre et al. 2017



particle released at 8 au

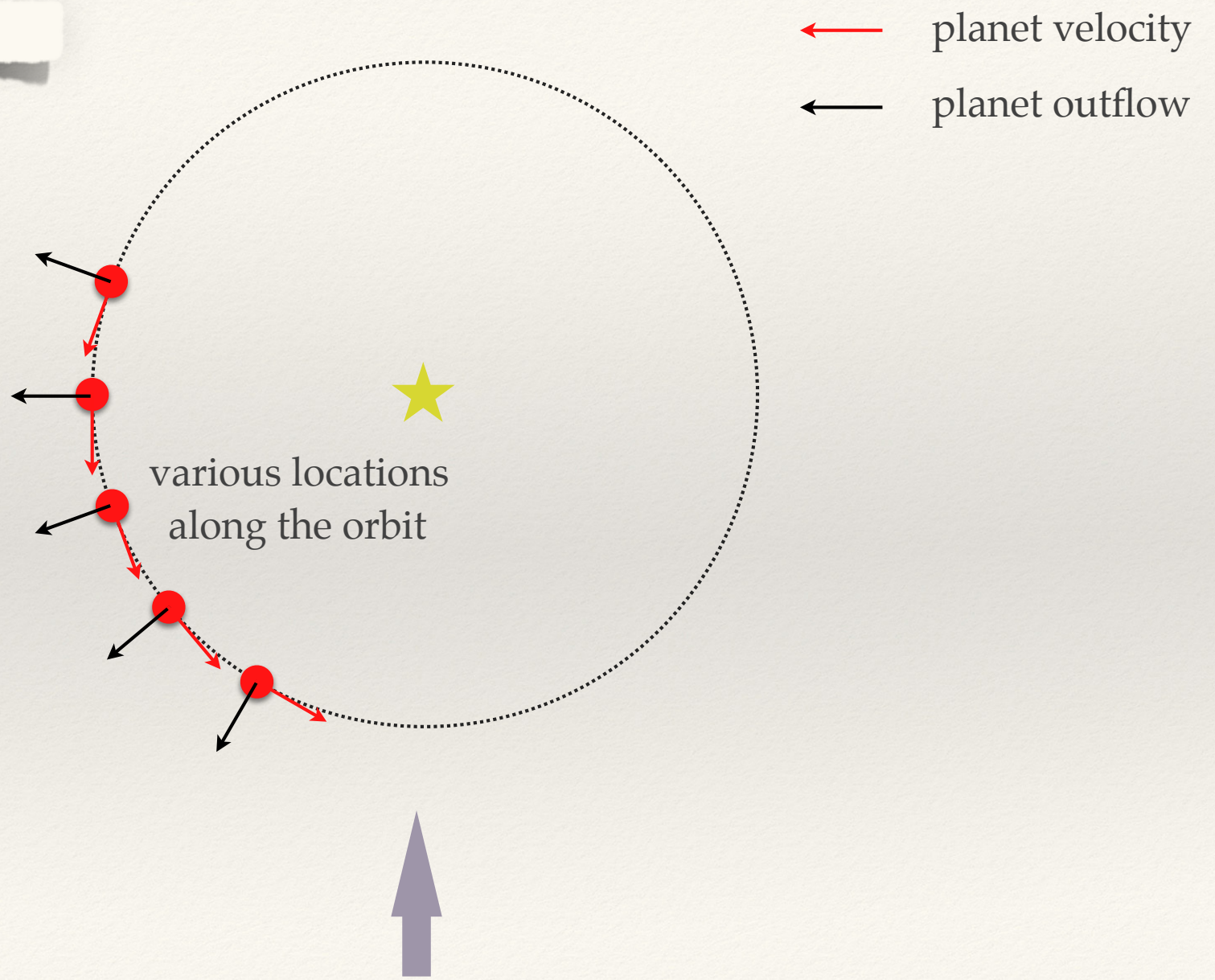
stellar flares + emitting object

Just a sketch !



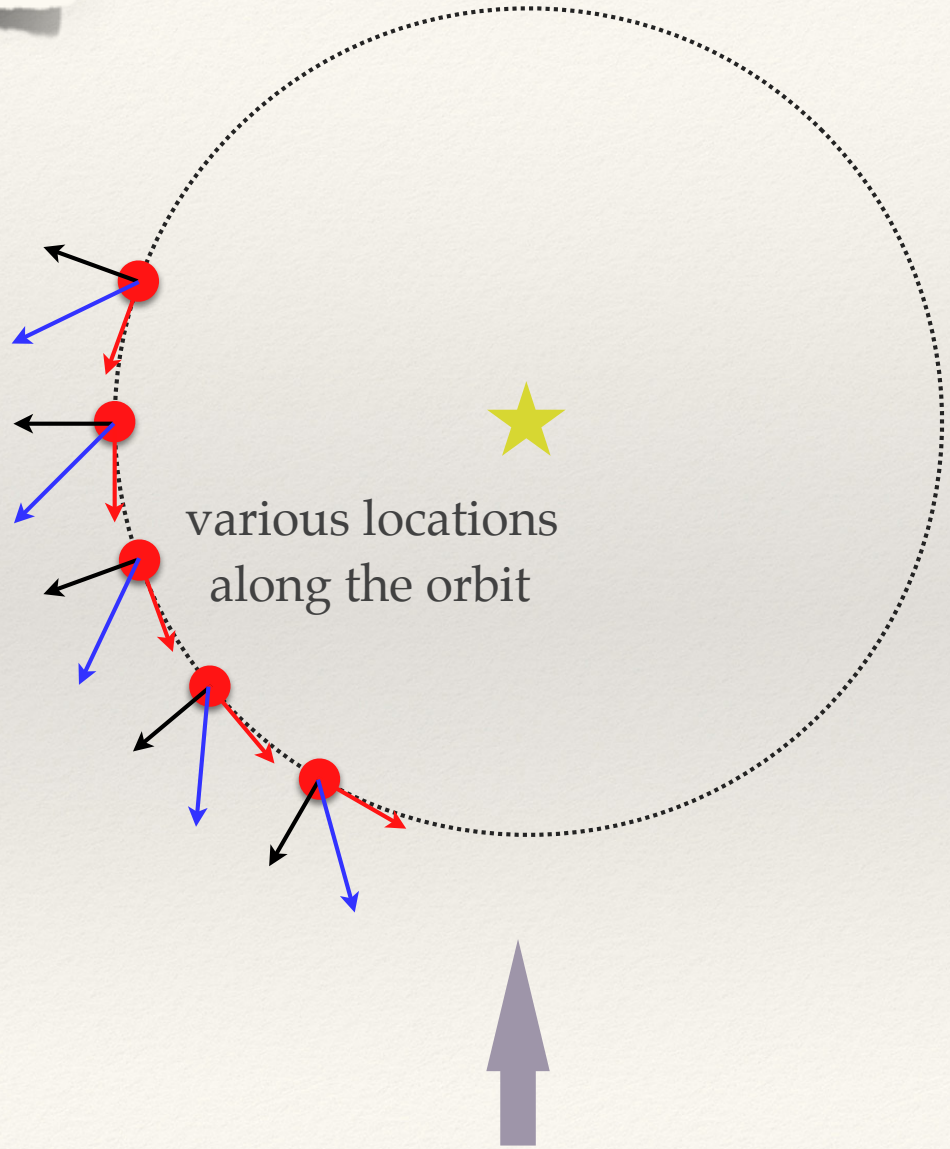
stellar flares + emitting object

Just a sketch !



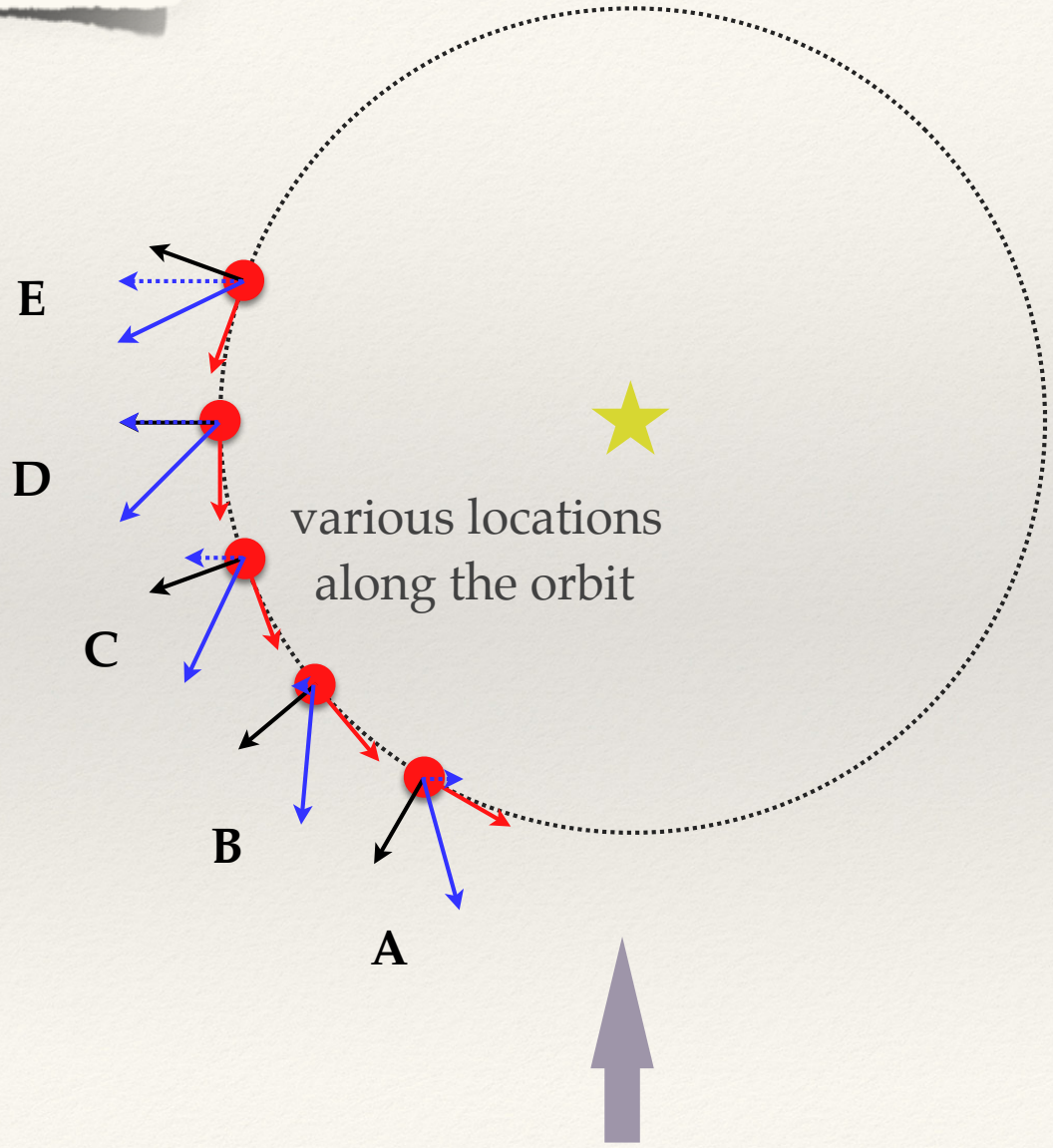
stellar flares + emitting object

Just a sketch !



stellar flares + emitting object

Just a sketch !



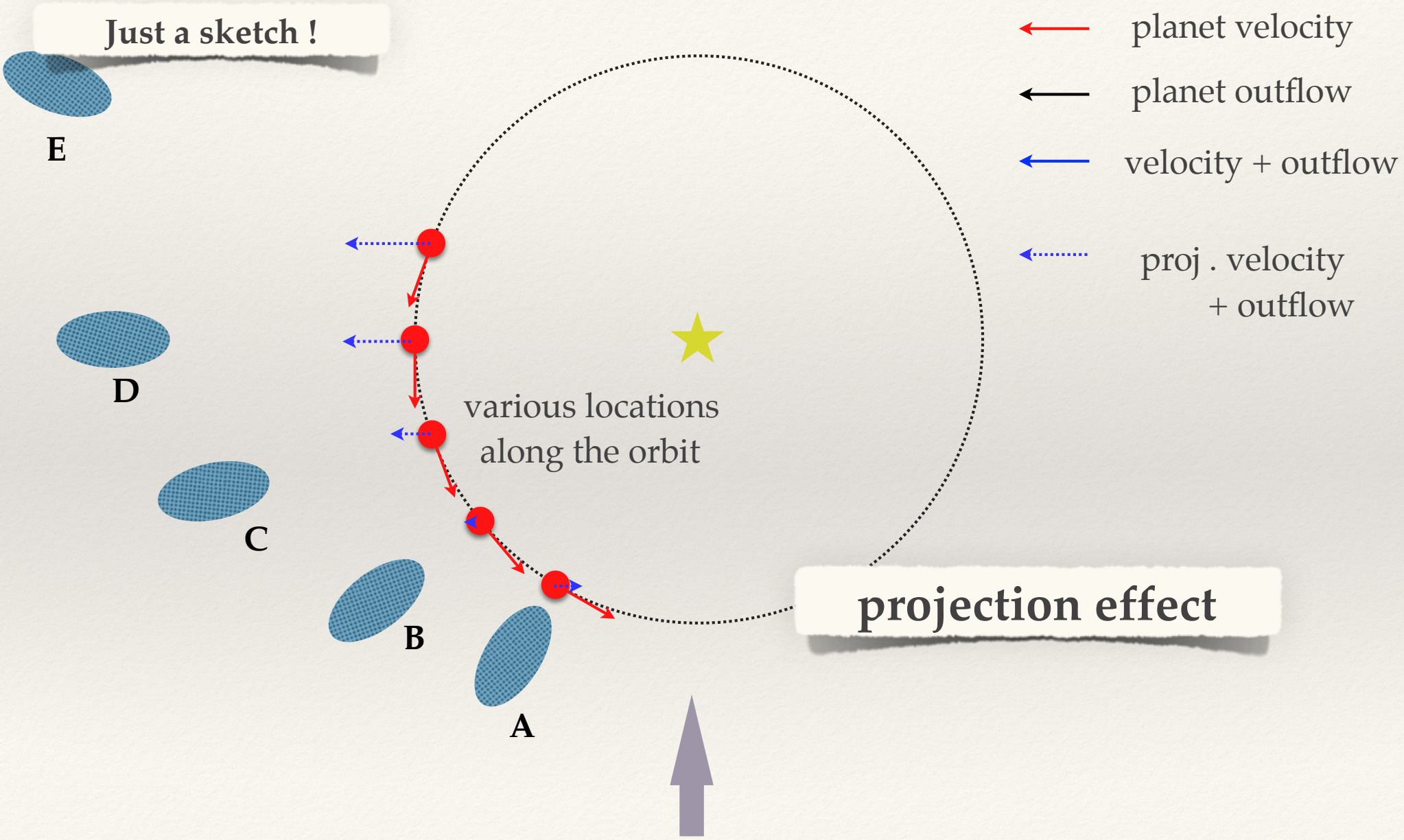
planet velocity

planet outflow

velocity + outflow

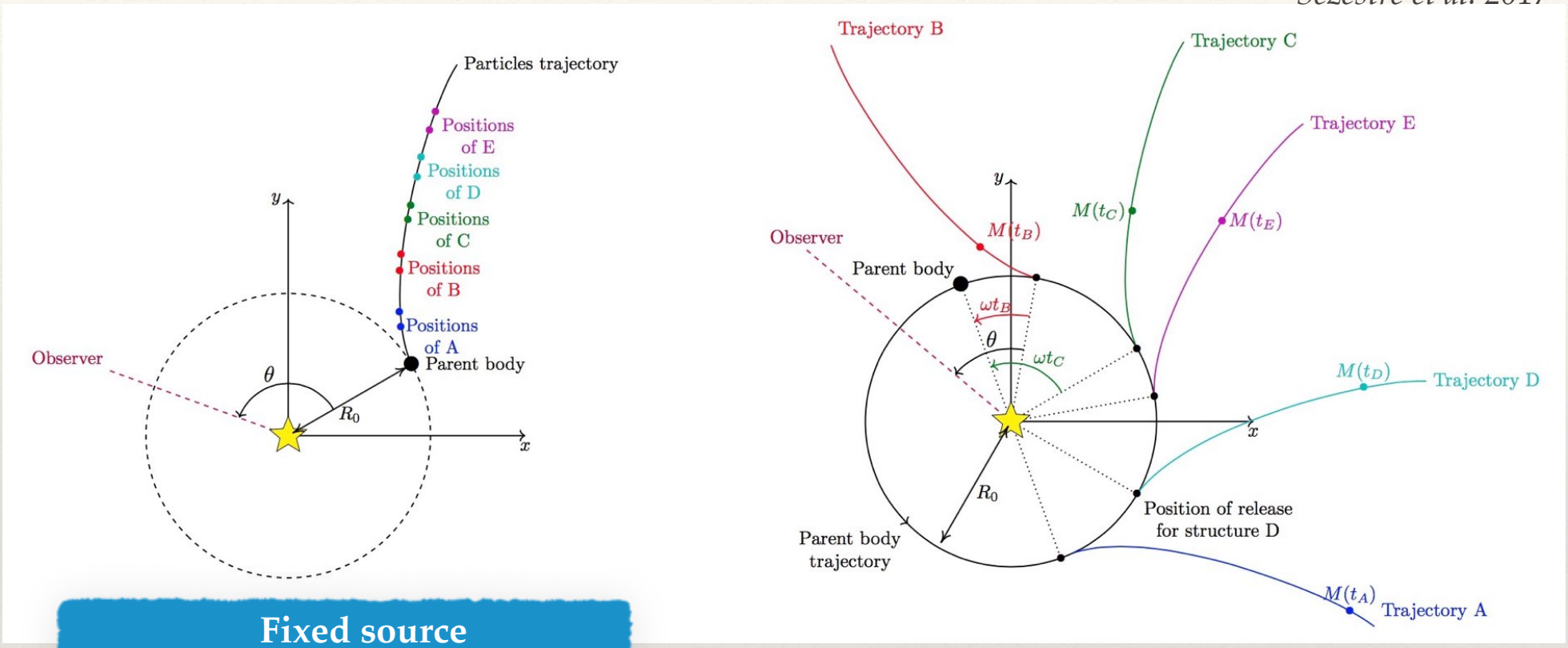
proj . velocity
+ outflow

stellar flares + emitting object



A more accurate model

Sezestre et al. 2017



Fixed source

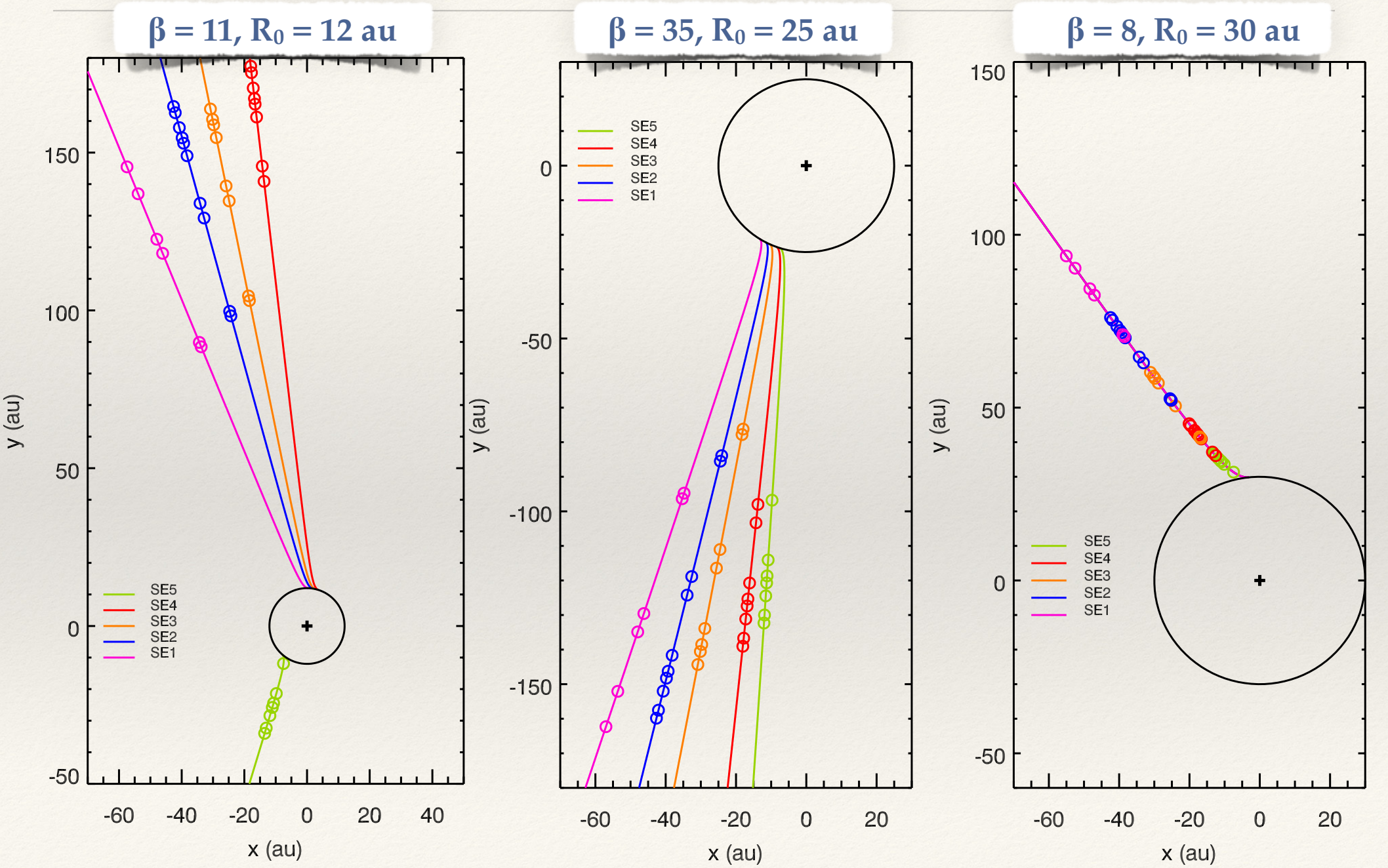
- periastron of giant collisions (Kral et al. 2014)
- avalanche (also giant collisions) (Chiang & fung 2017)

orbiting source

- planets/ planetesimals /
- disk feature

- grid of models R_0 and β, θ, 5 release dates

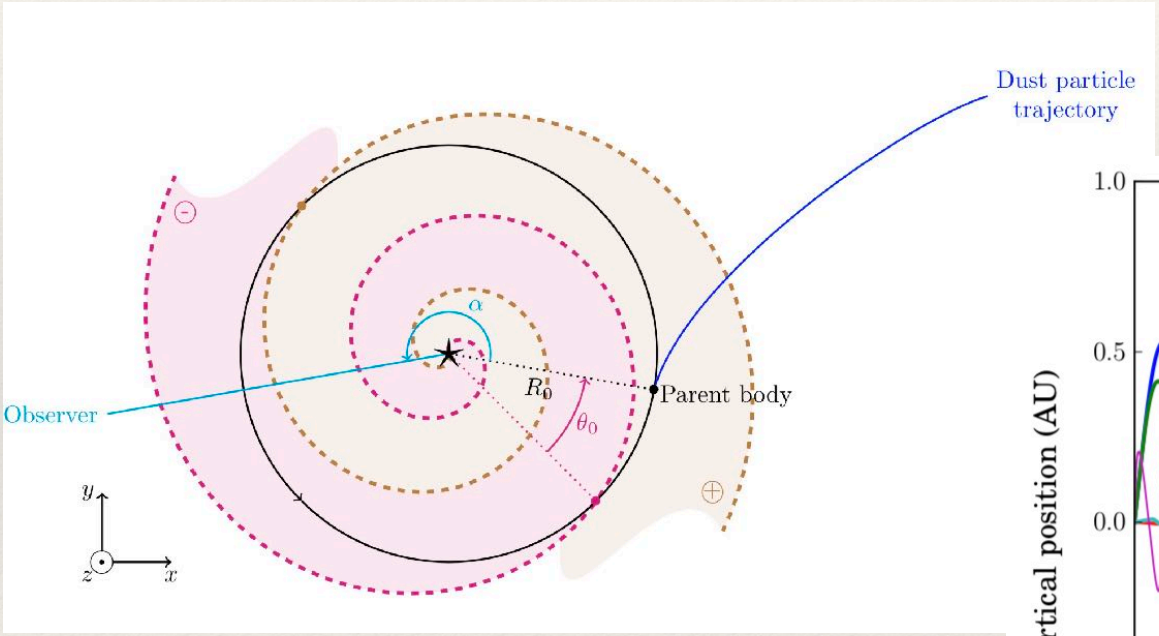
A more accurate model

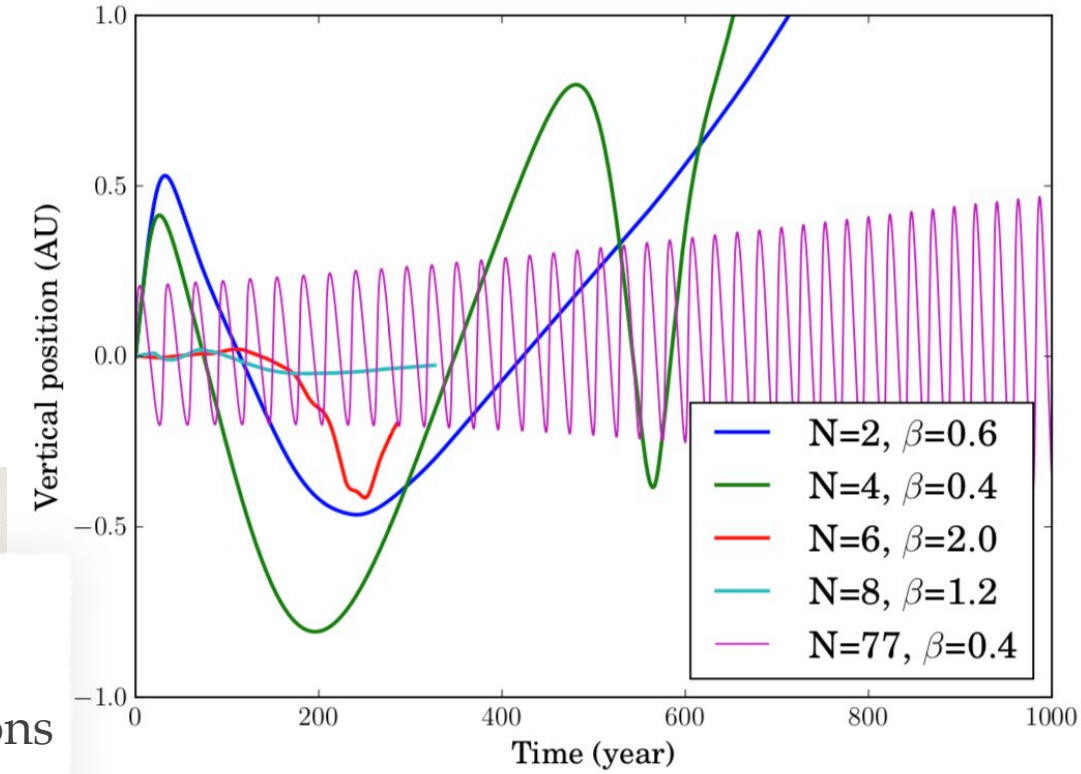


What about ondulations?

- grains can be charged (SW ions/e-)
- AU Mic has an intense magnetic field (2kG)
- at large distance F_Lorentz is vertical
- Parker spiral => magnetic field inversion => oscillation of grains around the midplane

Sezestre et al. 2016

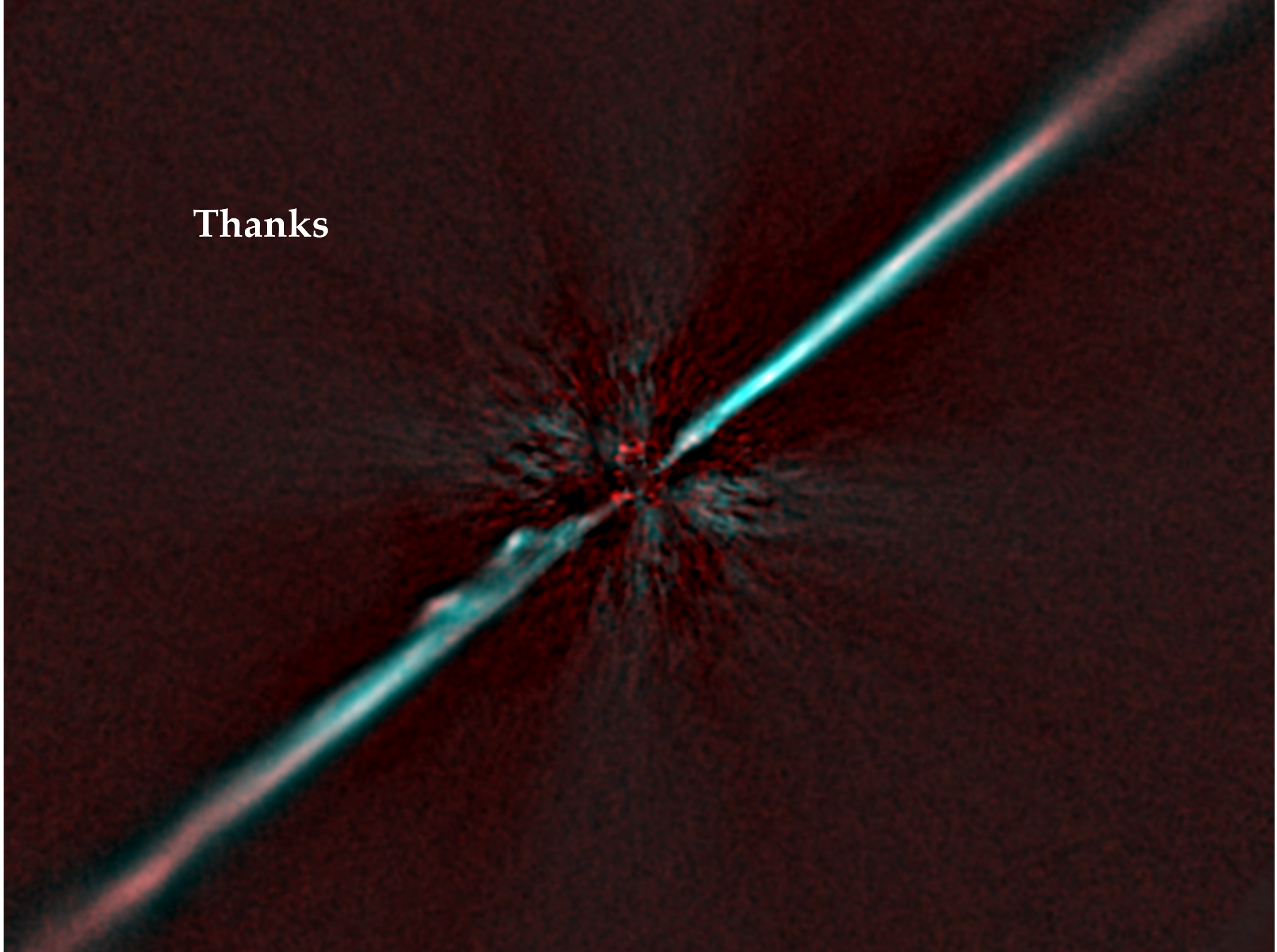




preliminary results:
- conditions to form arches is in contradiction with dynamical simulations
- arches size too small

Conclusions …

- Evidence of **dust clumps moving** at high velocity across the AU Mic disk midplane
- trajectories can be explained by interaction between the **mass loss/stellar wind** and a source of dust
- the source can be either **static or orbiting** around the star
- How the dust is released from this source is still unconstrained
- **magnetism** is a good candidate to explain the **vertical motion** but more modeling required


Thanks