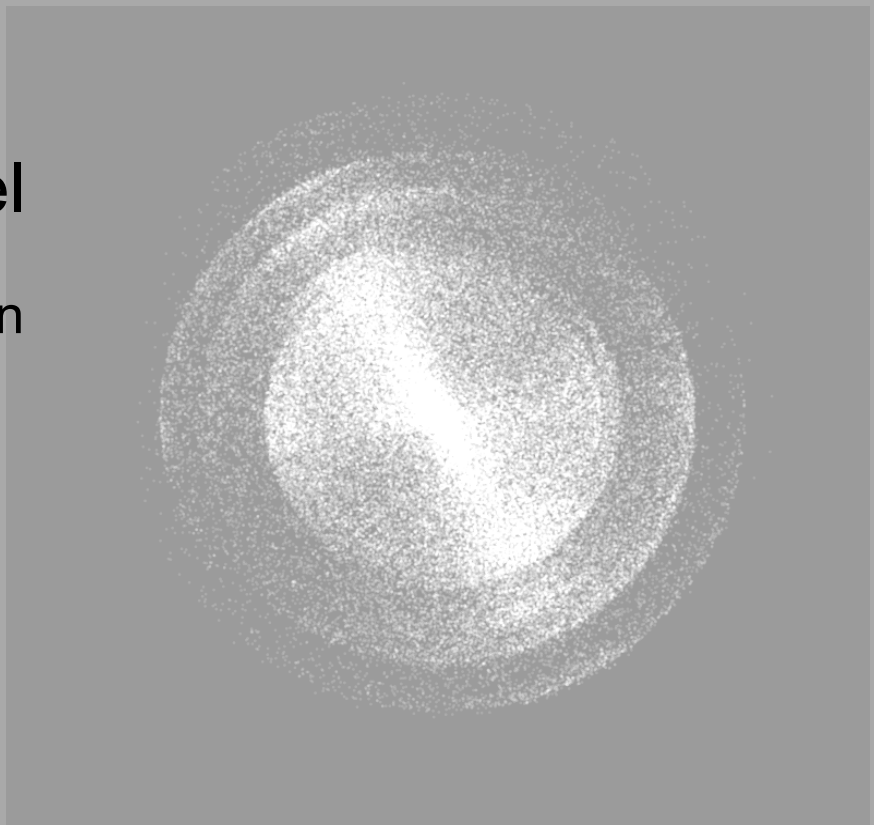
Tidal debris morphology and the orbits of infalling substructures

David Hendel

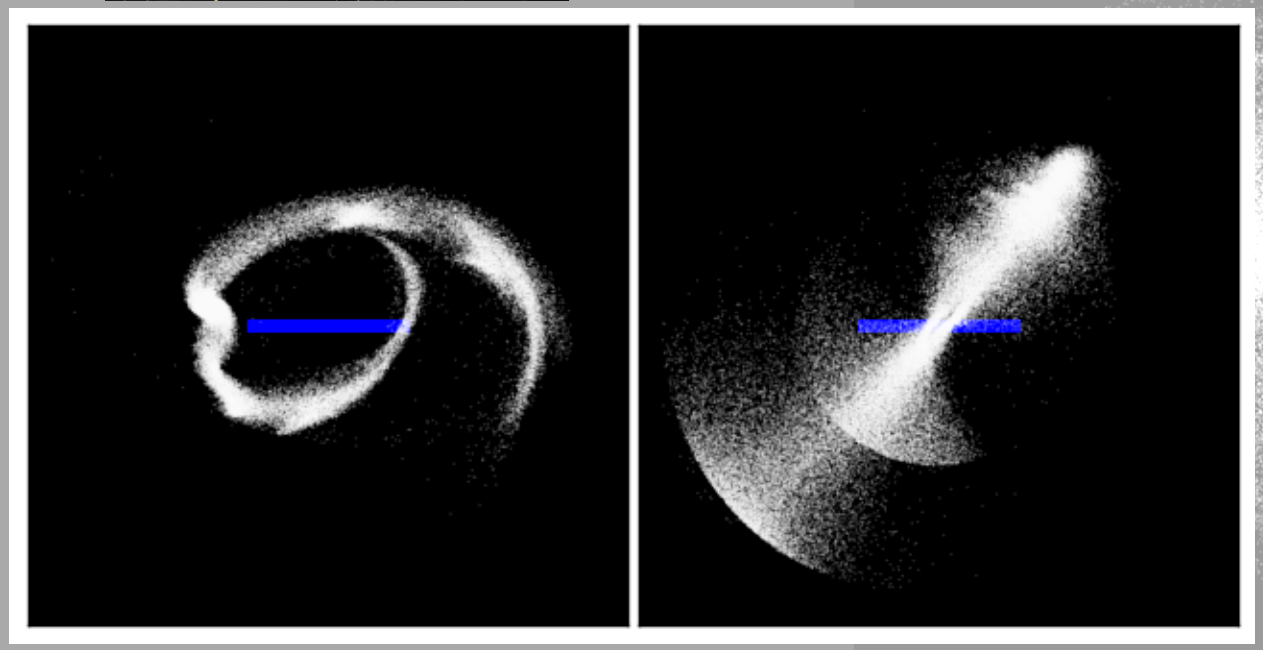
Kathryn Johnston

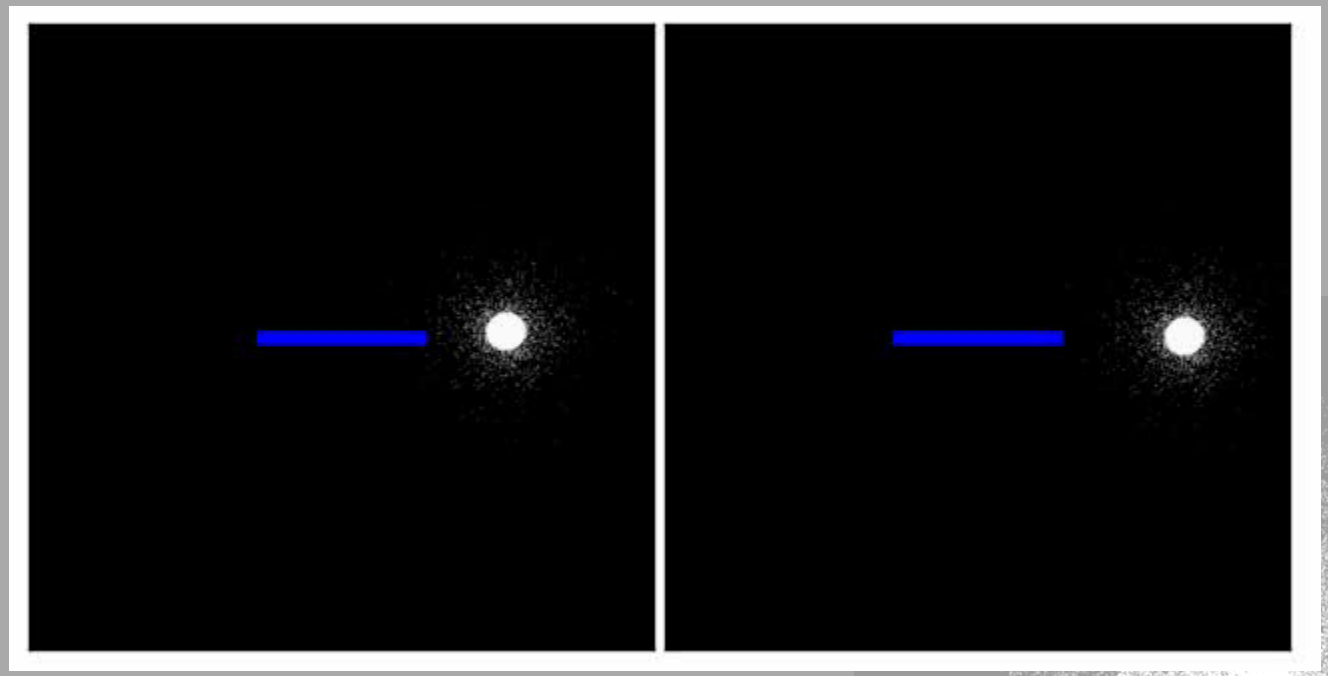


Debris morphology

Martinez-Delgado et al. 2008

Duc et al. 2015





$J/J_{circ}=0.9$ $J/J_{circ}=0.1$

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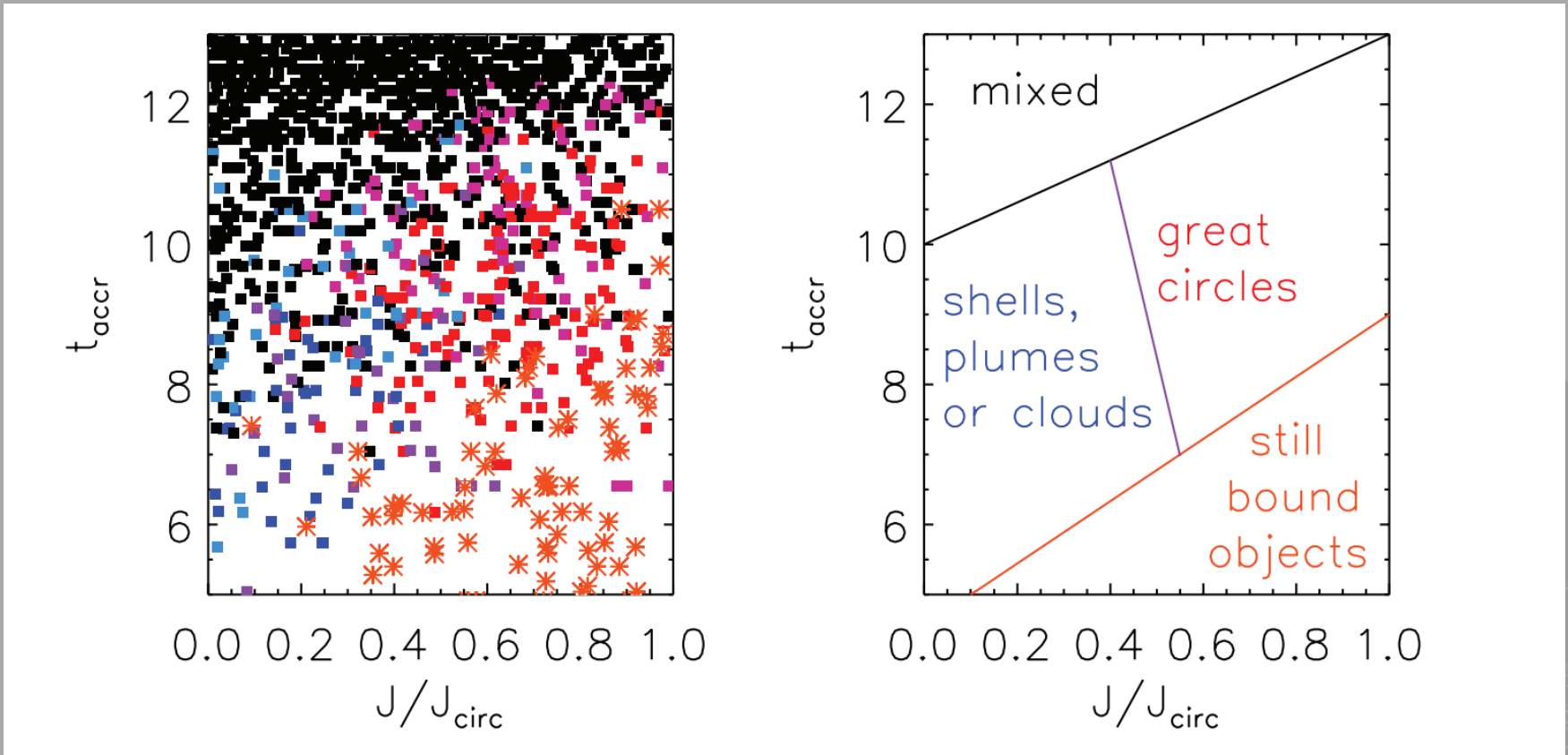
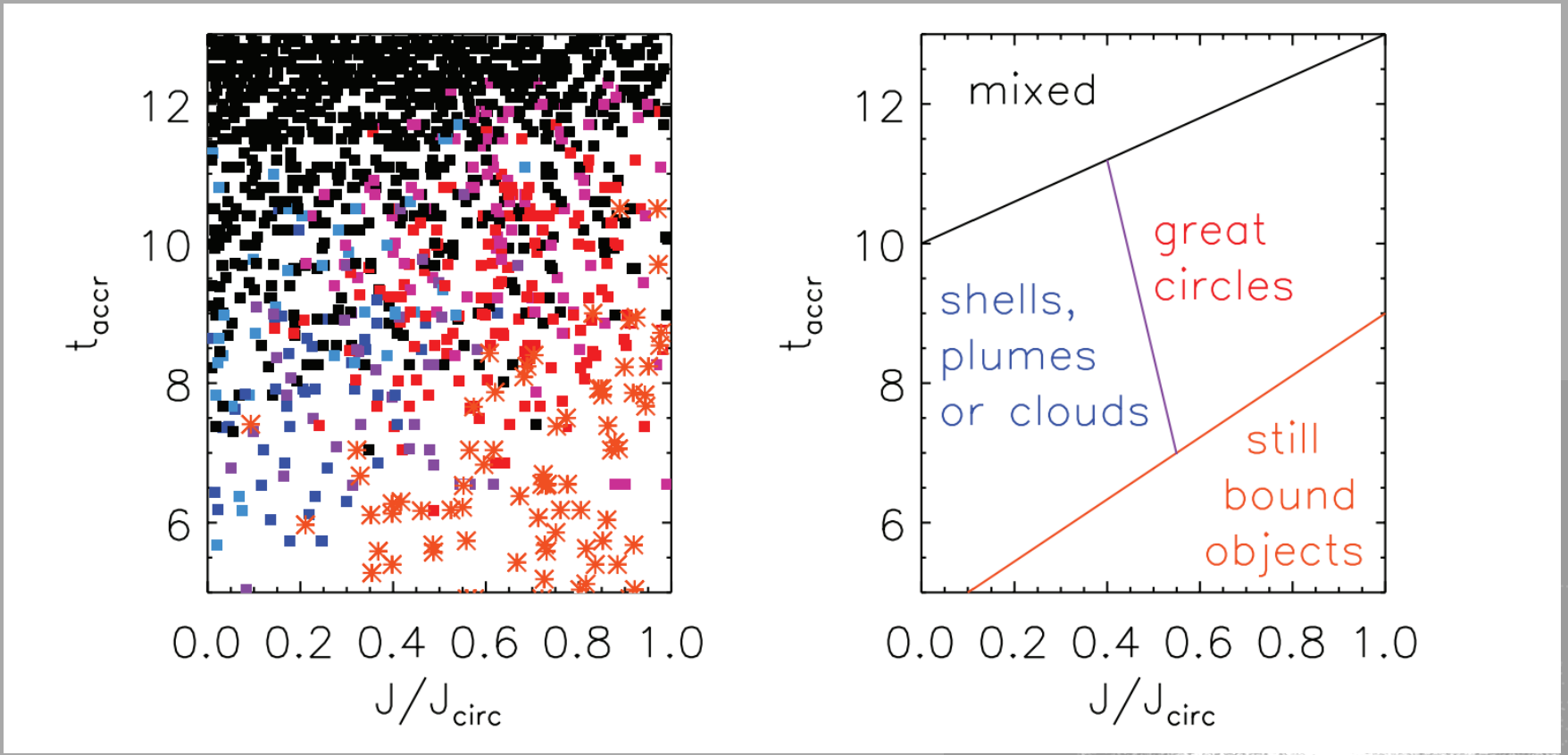
Influences on morphology



Johnston et al. 2008

Morphology = f(t,j)

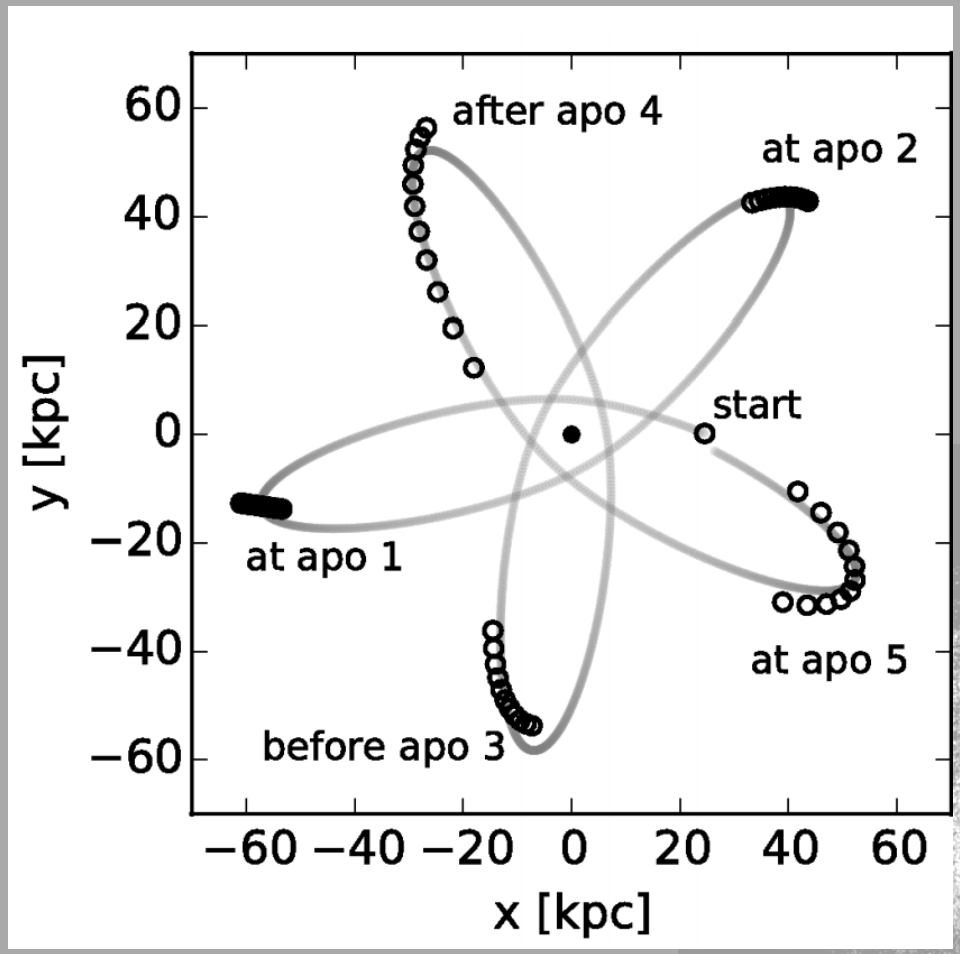
Influences on morphology



Johnston et al. 2008

Morphology = f(M,m,E,L,Φ(M,z),t…)

A simple toy



Vary only E

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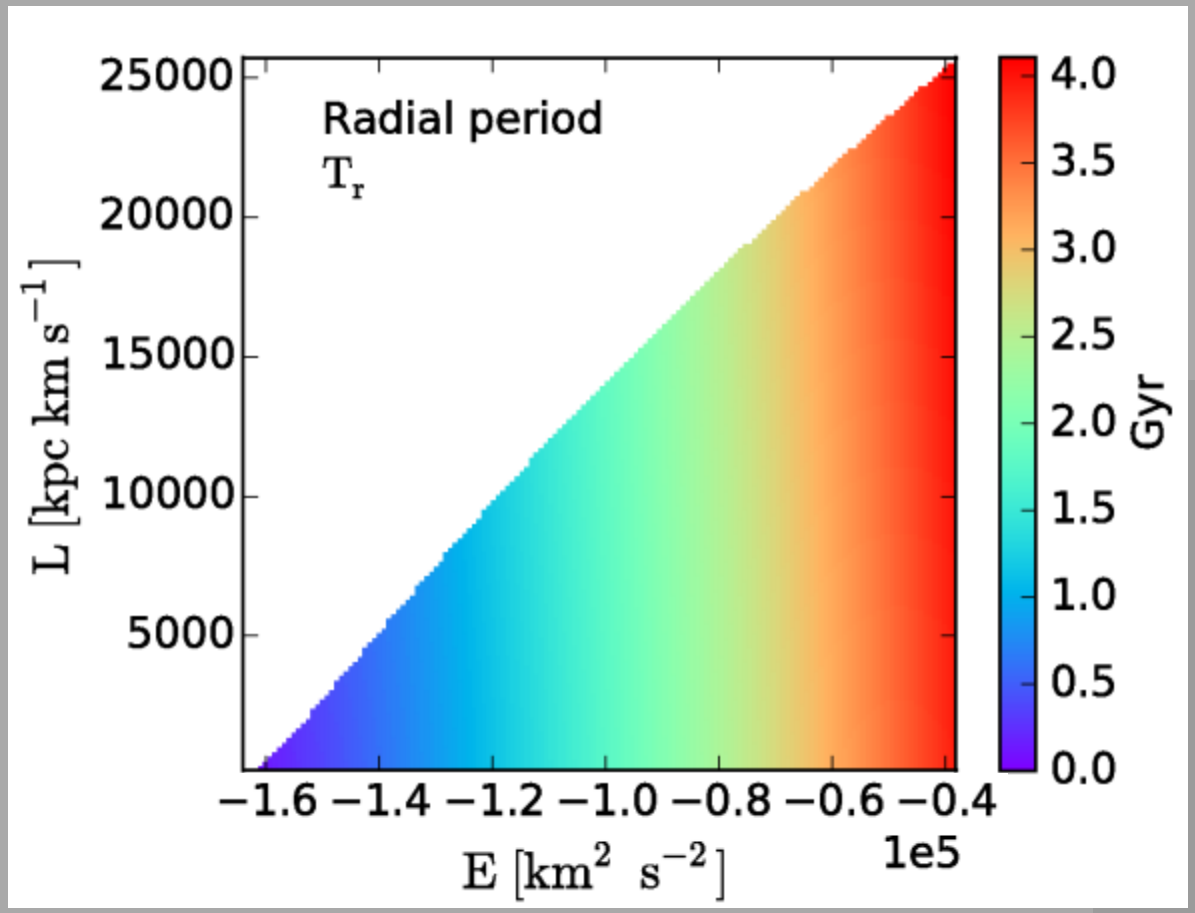
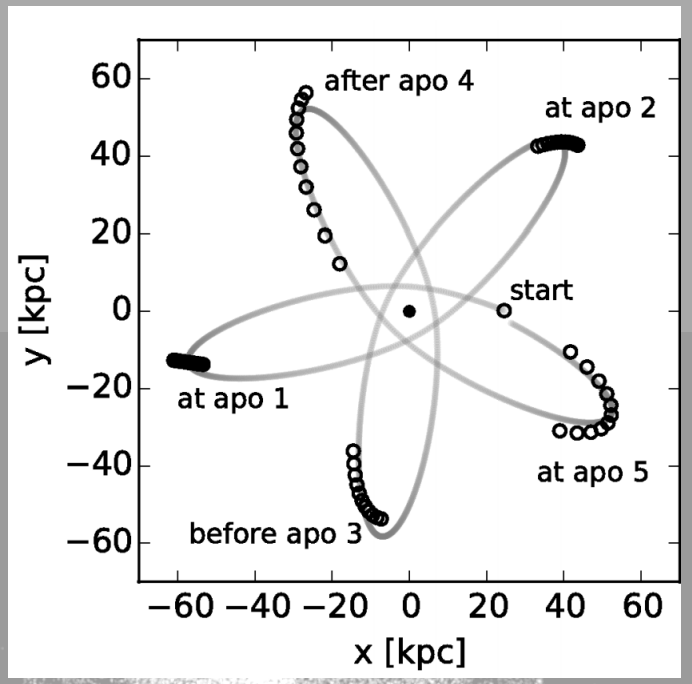
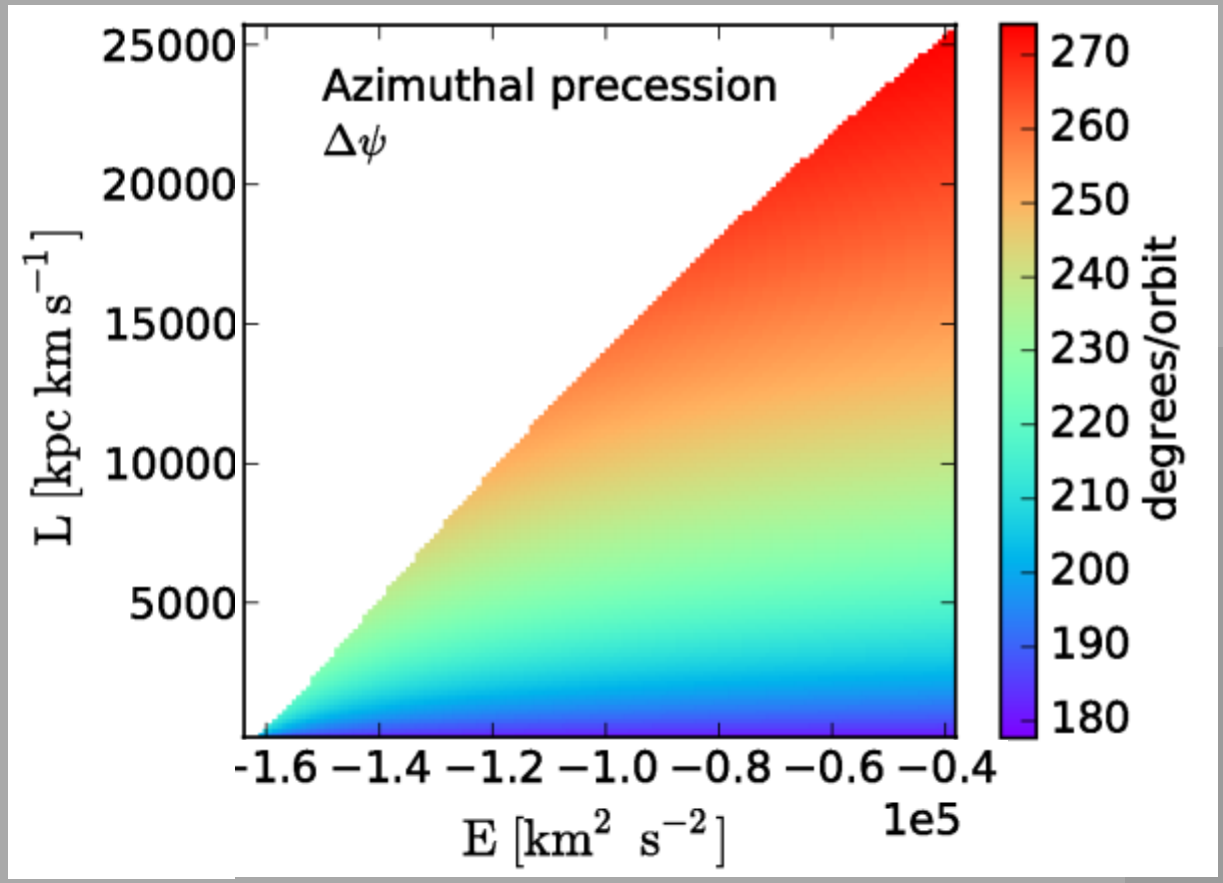
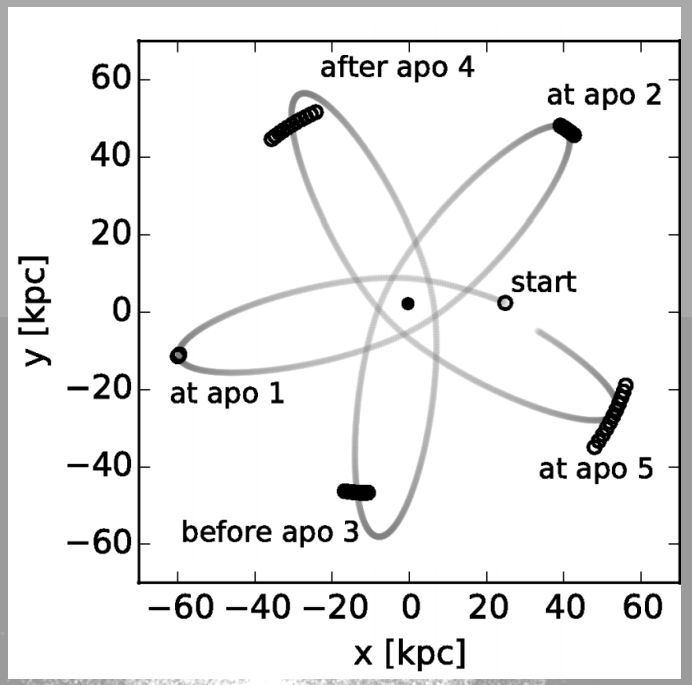
A simple toy


Radial period
T_r
25000
20000
15000
10000
5000
L [kpc km s^{-1}]
−1.6 −1.4 −1.2 −1.0 −0.8 −0.6 −0.4
1e5
E [km^2 s^{-2}]
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Gyr


after apo 4
at apo 2
start
at apo 1
at apo 5
before apo 3
60
40
20
0
−20
−40
−60
y [kpc]
−60 −40 −20 0 20 40 60
x [kpc]

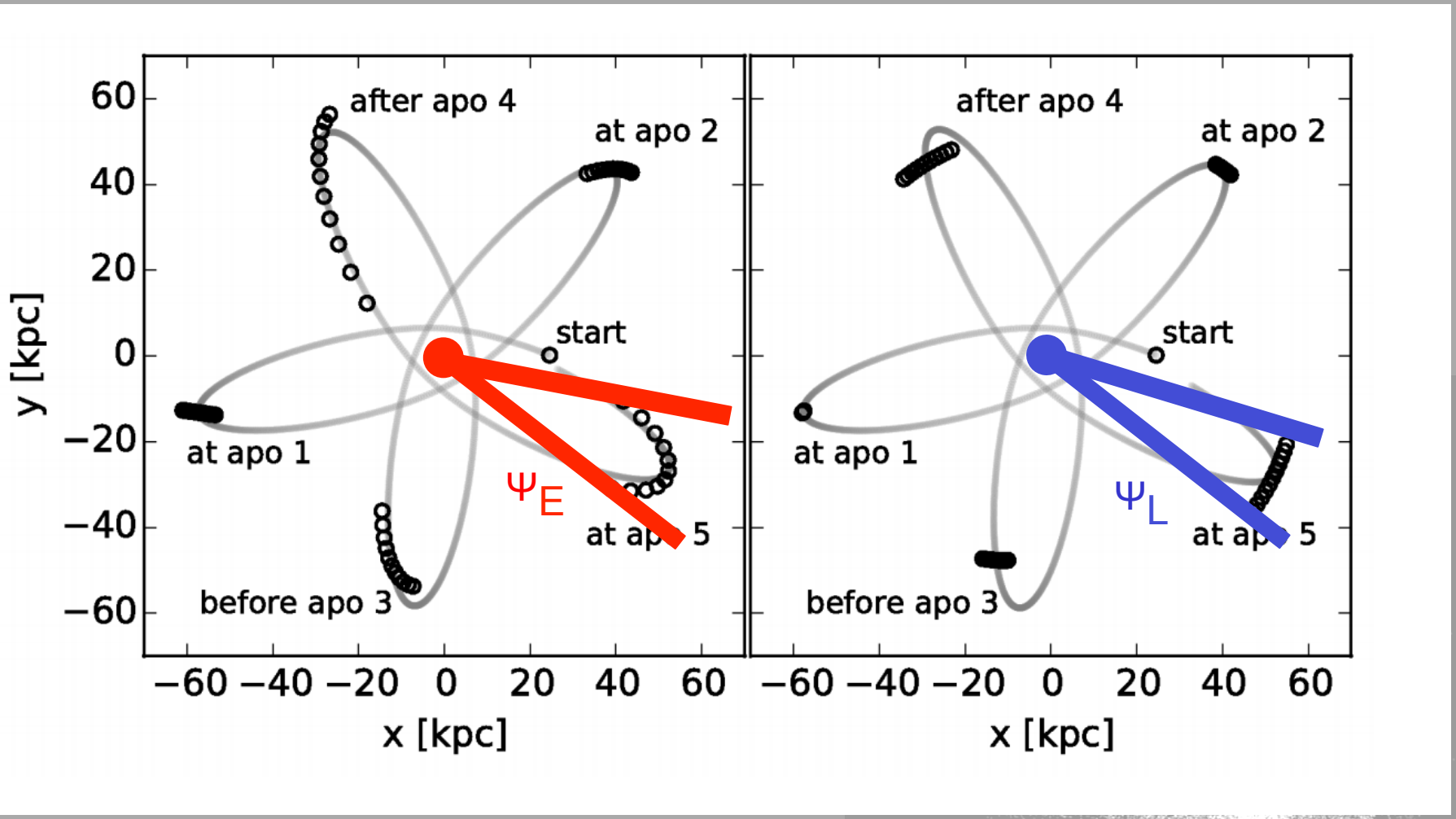
A simple toy





vary only L

A working definition



Shells ≡ $\Psi_L > \Psi_E$

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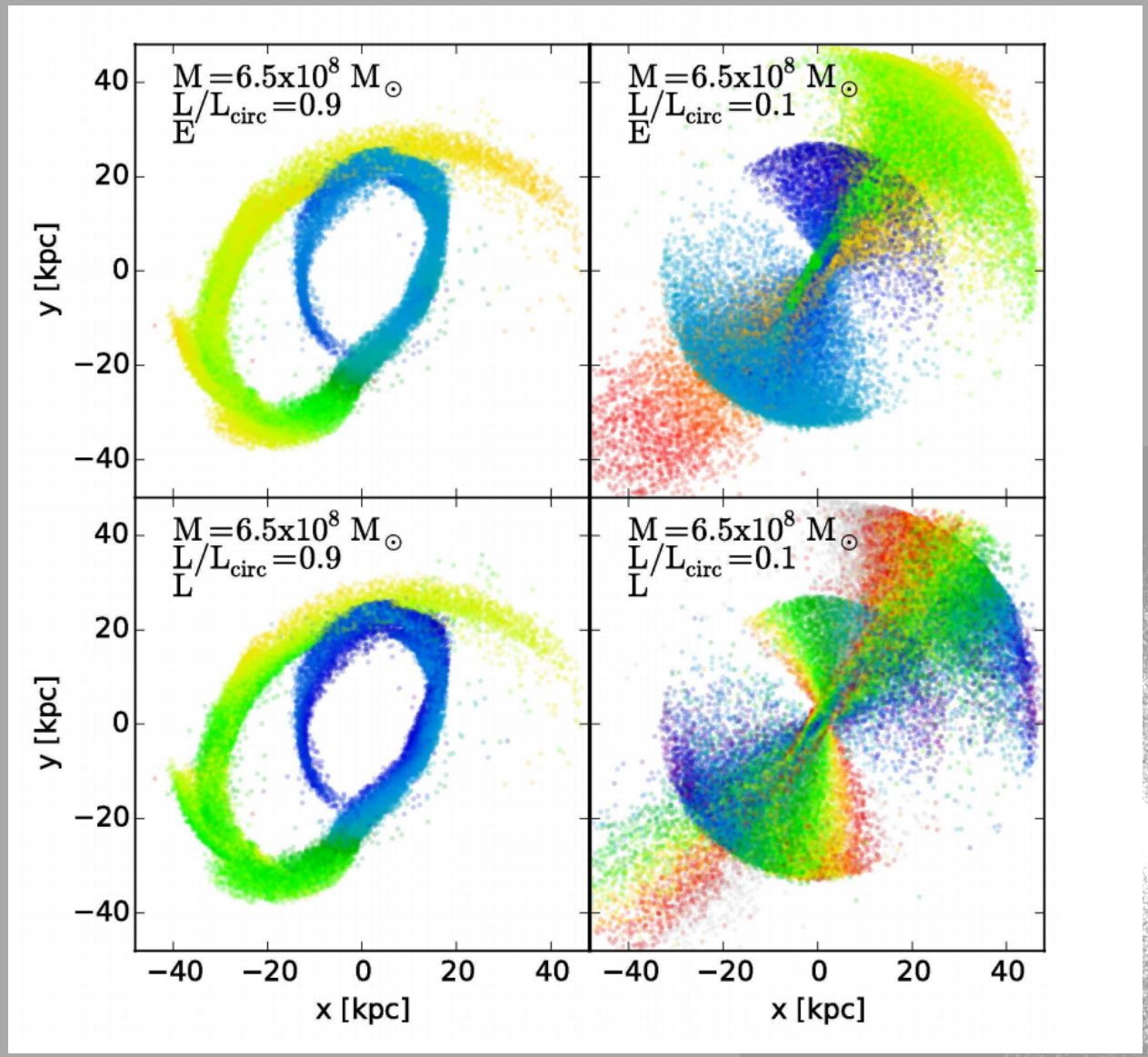

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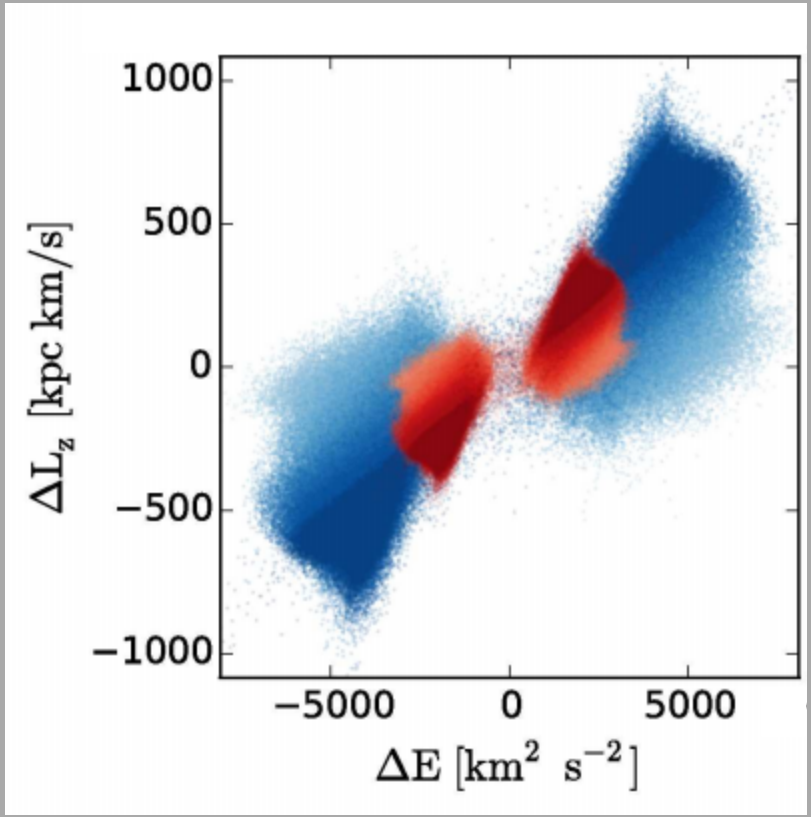
Calculating the angles



$$r_{\rm tide} = \left(\frac{m}{3M(R_p)}\right)^{1/3} R_p = sR_p$$

$$e_s = 2r_{\rm tide}\left.\frac{\partial\Phi}{\partial R}\right|_{R_p}$$

$$l_s = \sigma R_p + 2V_p r_{\rm tide} = (\sqrt{3}+2)sL$$

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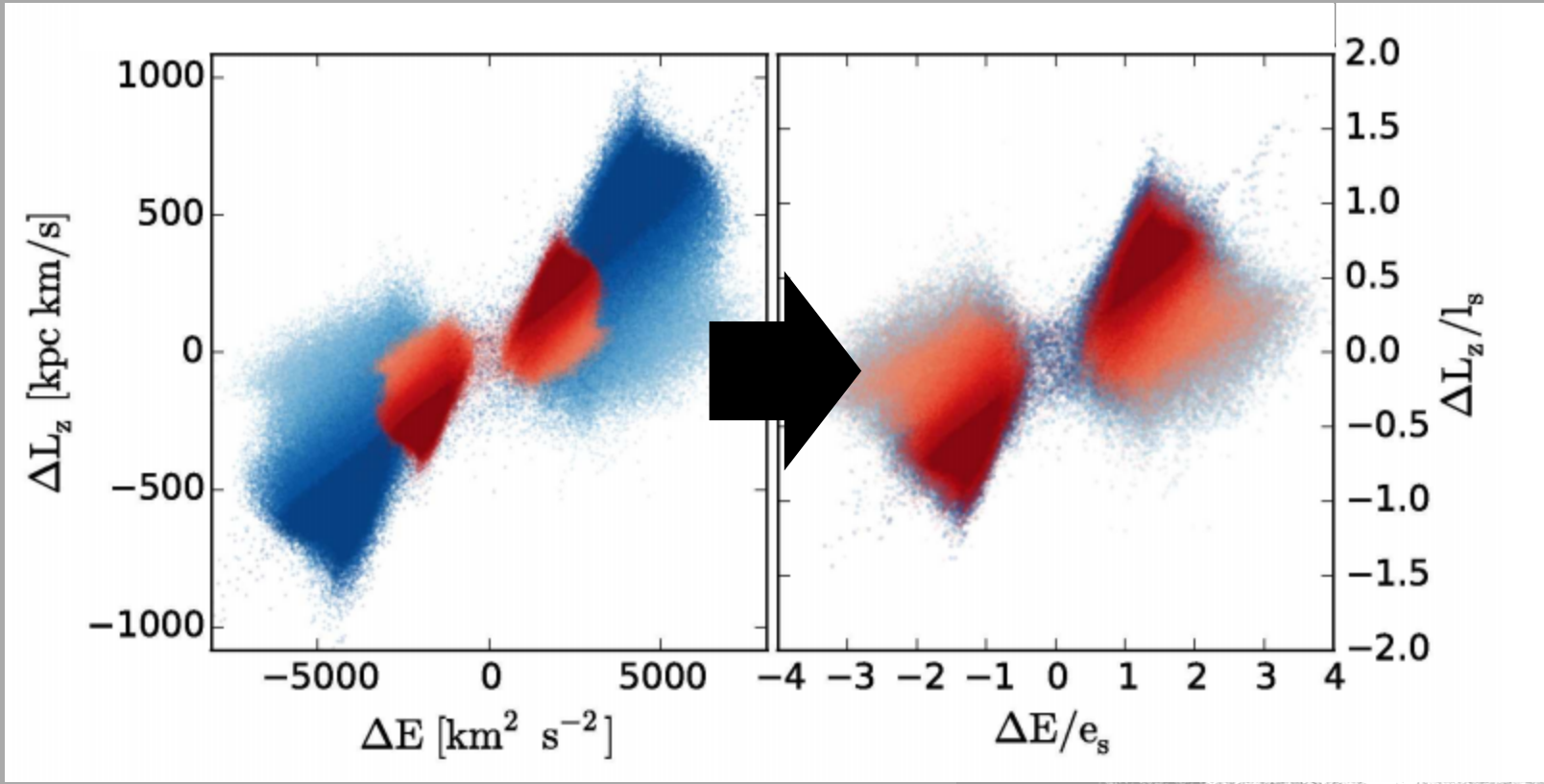
Calculating the angles



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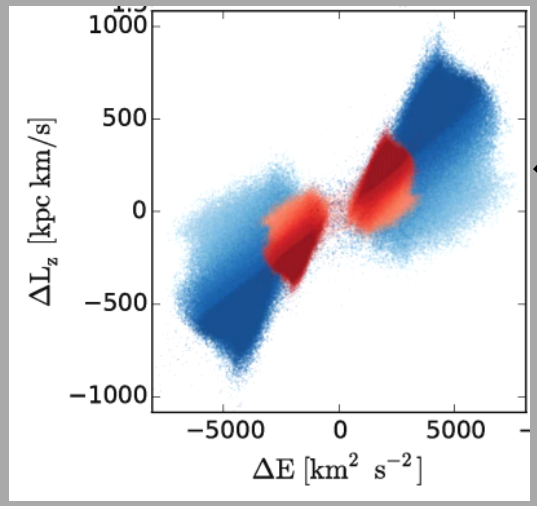
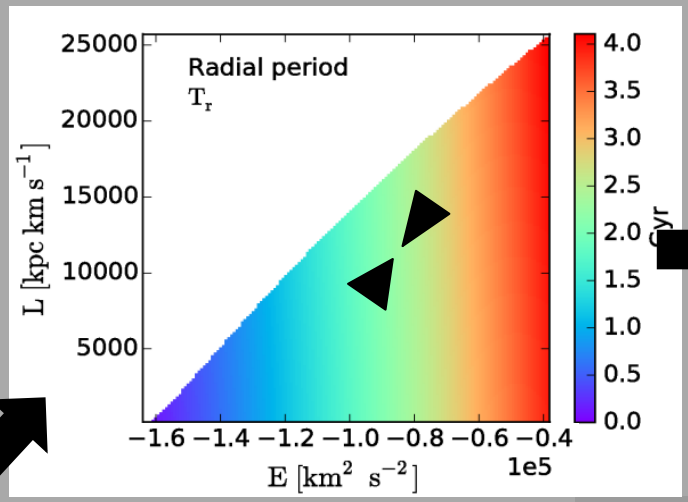
Calculating the angles

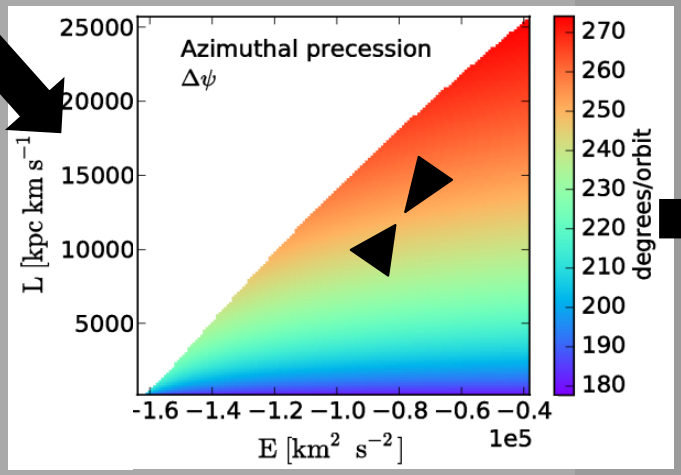
E, L, Φ, M, m





∫dt → Ψ_E

predict
classification



∫dt → Ψ_L

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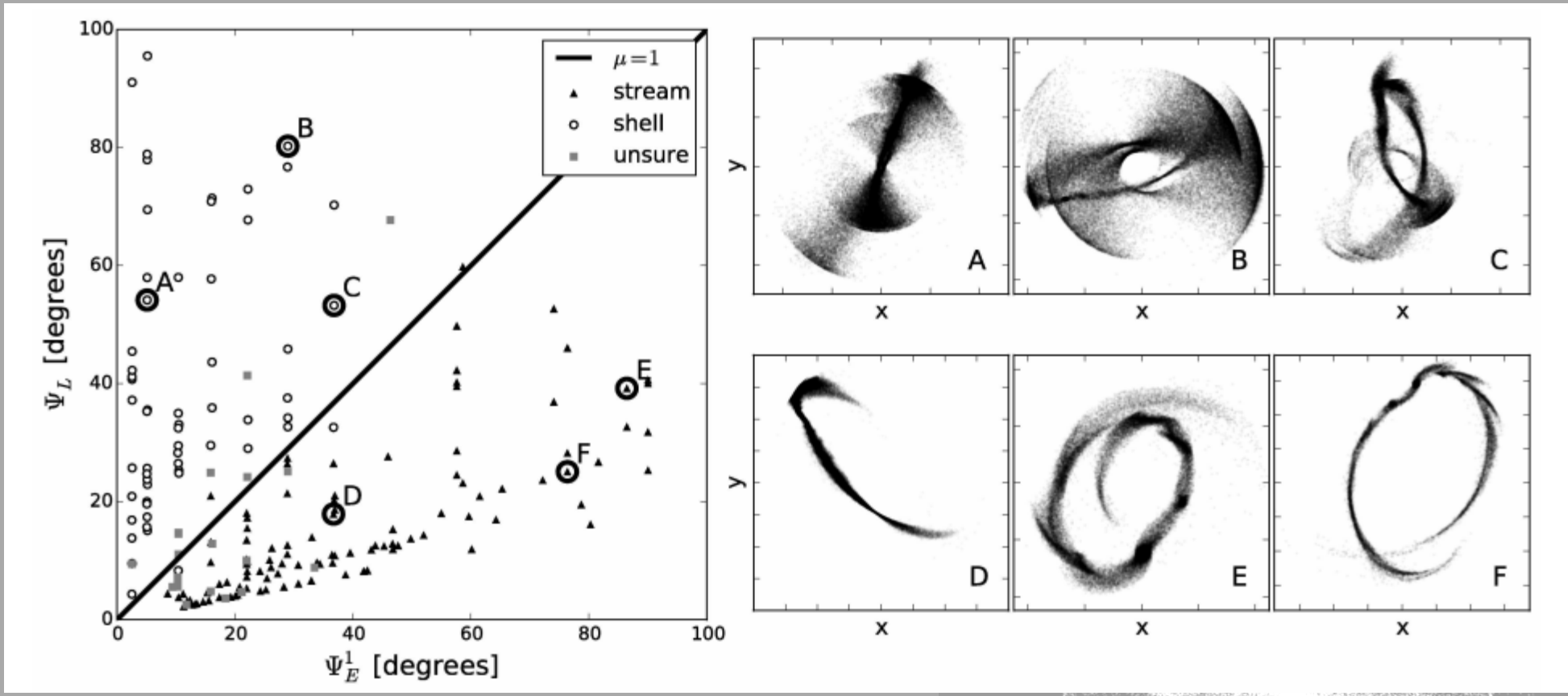
Does it work?



Sequence of decreasing μ ≡ Ψ_L / Ψ_E

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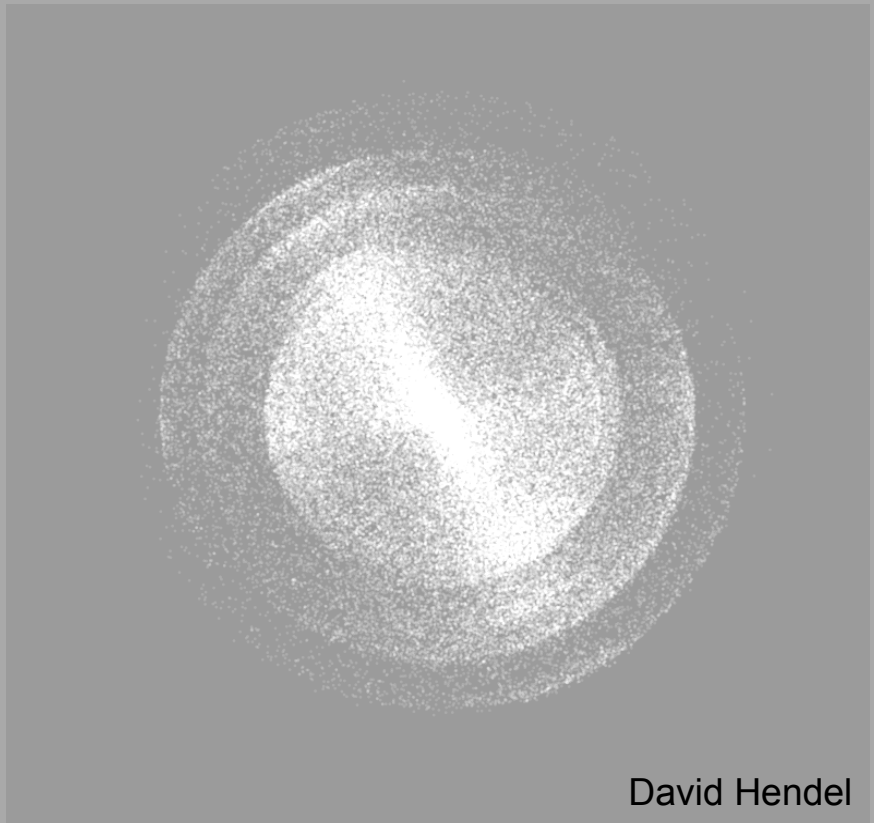
If you think we can understand the effects of …

- Cosmology
- Triaxiality
- Orientation
- Surface brightness
- Environment
- Stars vs. DM
- Dynamical friction
- Host mass growth
- Multiple simultaneous mergers
- more?

we can have some fun!



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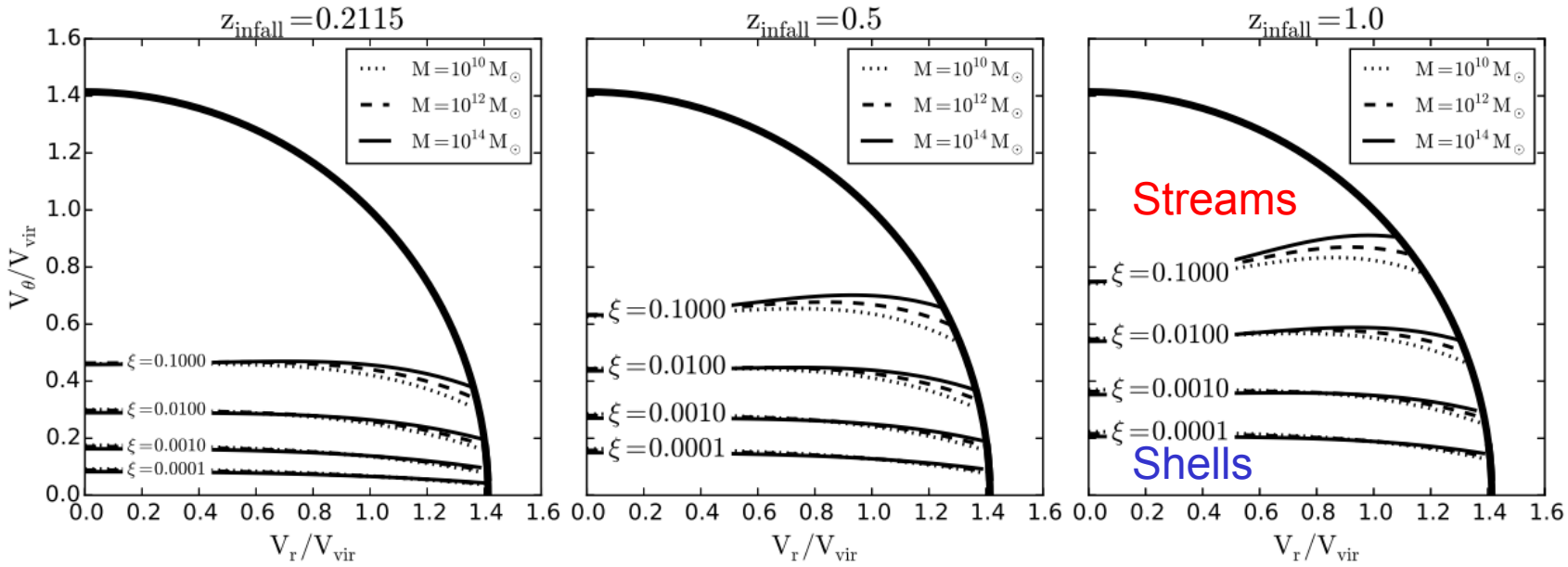
A probe of infall



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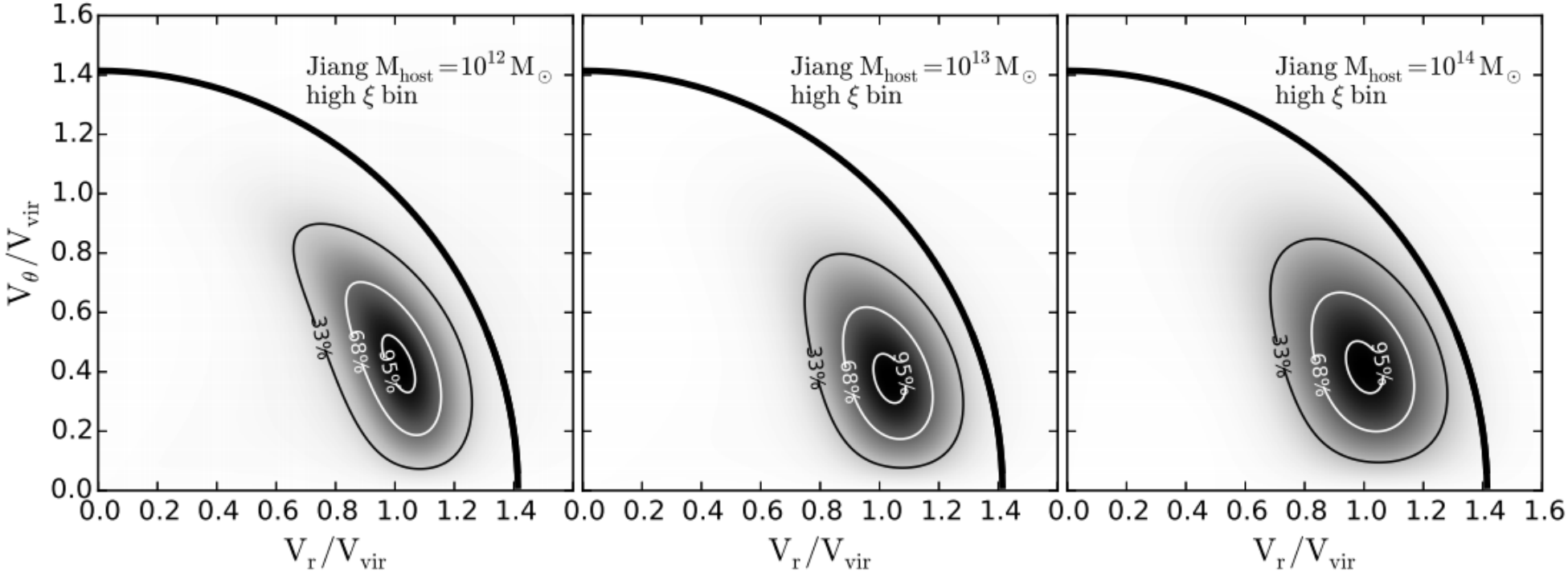
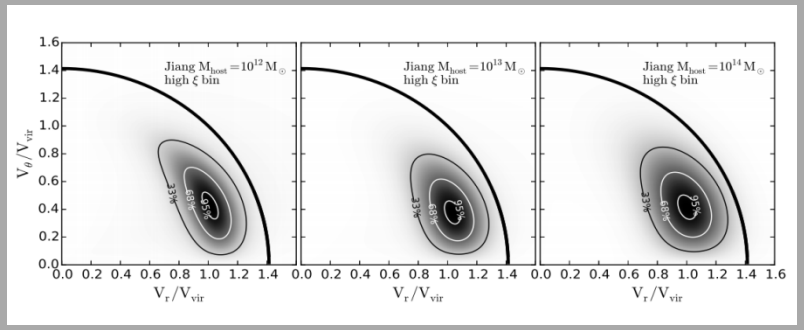
A probe of infall



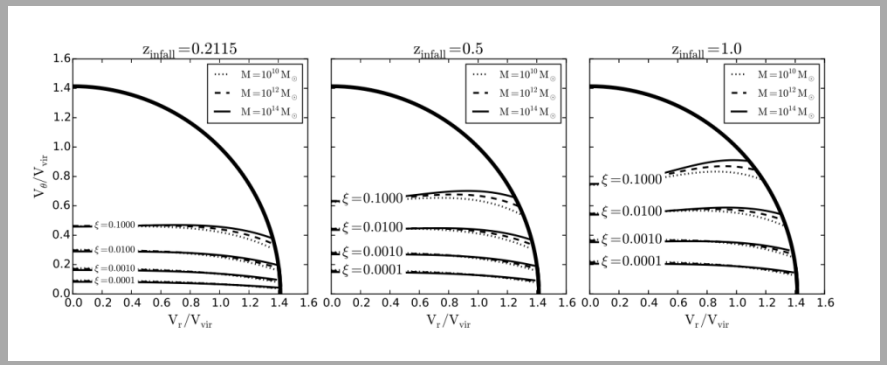
$$N_{\rm shell}(M) = \int_{z_{\rm min}}^{z_{\rm max}} \int_{\xi_{\rm min}}^{\xi_{\rm max}} \int_{V_\theta=0}^{\sqrt{V_{\rm esc}^2 - V_r^2}} \int_{V_r=0}^{V_{\rm esc}} \frac{{\rm d}N_m}{{\rm d}\xi {\rm d}z} \times$$

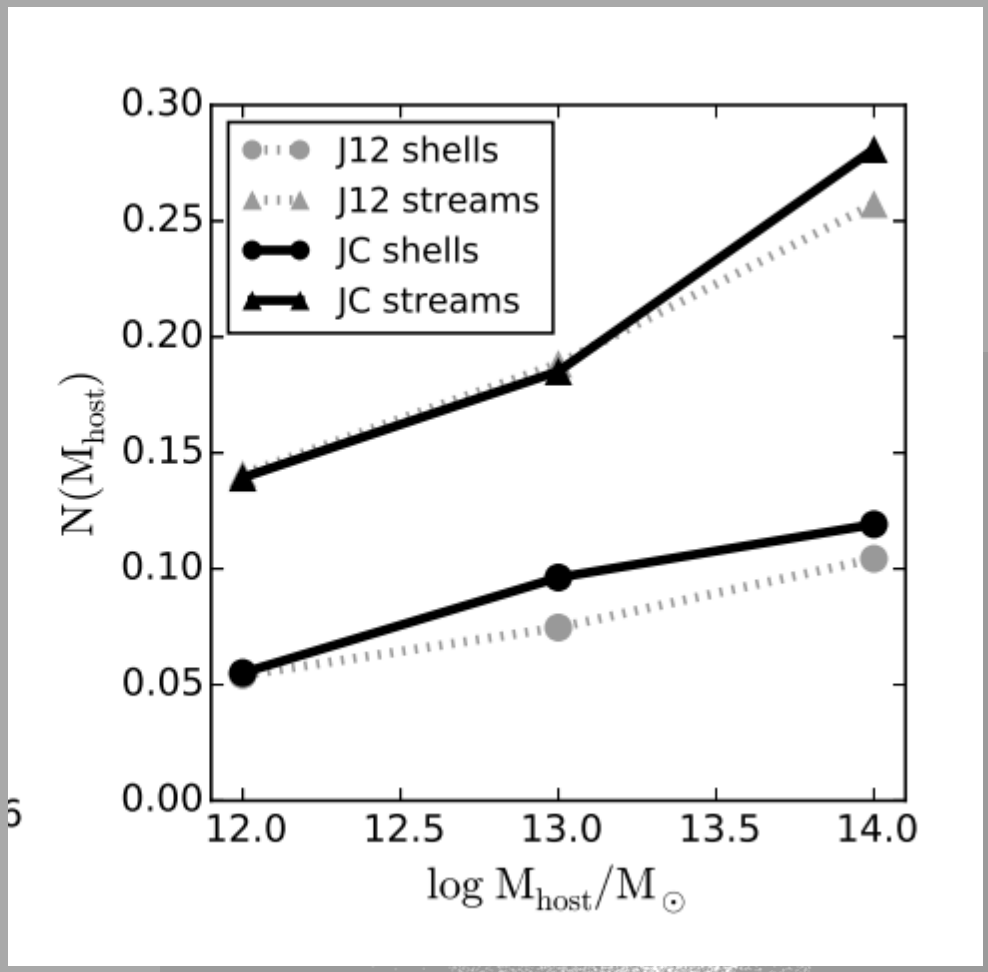
$$\mathrm{P}(V_r, V_\theta \mid \xi, M, z)\mathrm{H}(\mu - \mu_t){\rm d}V_r{\rm d}V_\theta{\rm d}\xi{\rm d}z.$$

A probe of infall



+





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Summary

- A more holistic view of tidal debris structures
- Access to new dimensions of the accretion history
- Measure infall distributions and debris frequencies!