The gamma-ray signature of an early matter-dominated era

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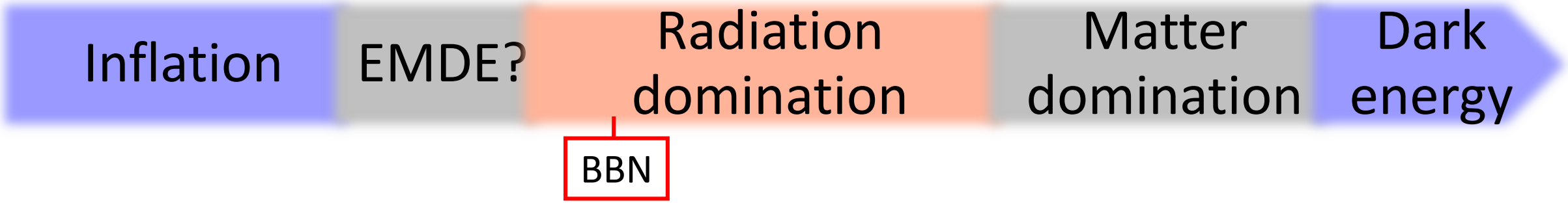
An early matter-dominated era (EMDE)

Possible domination by a pressureless fluid during the first second after inflation



Driven by unstable heavy relic such as

- Dark mediator
- String moduli fields
- Inflaton

History prior to BBN is largely unconstrained.

EMDE and thermal dark matter

Decaying relic sources radiation, diluting DM.

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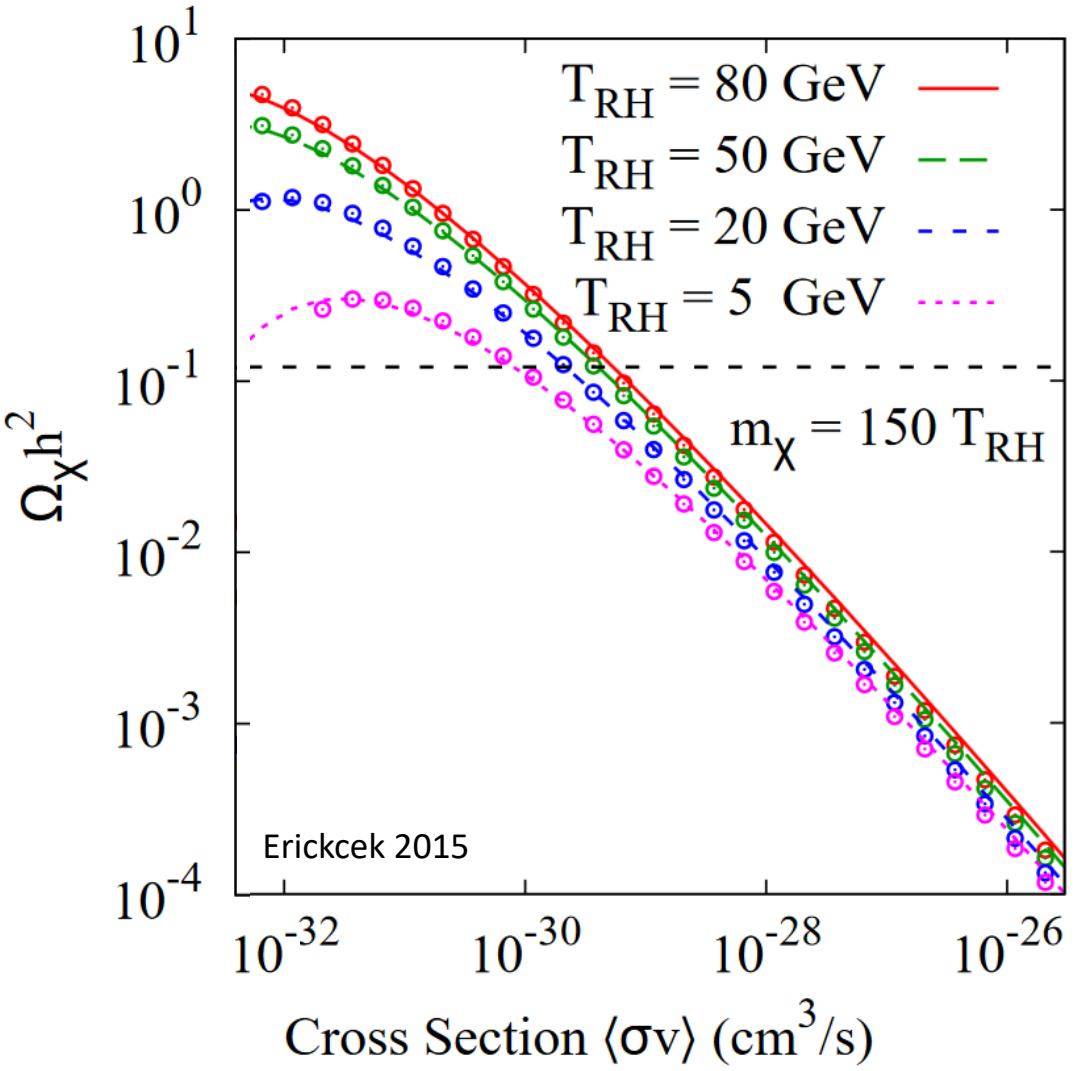
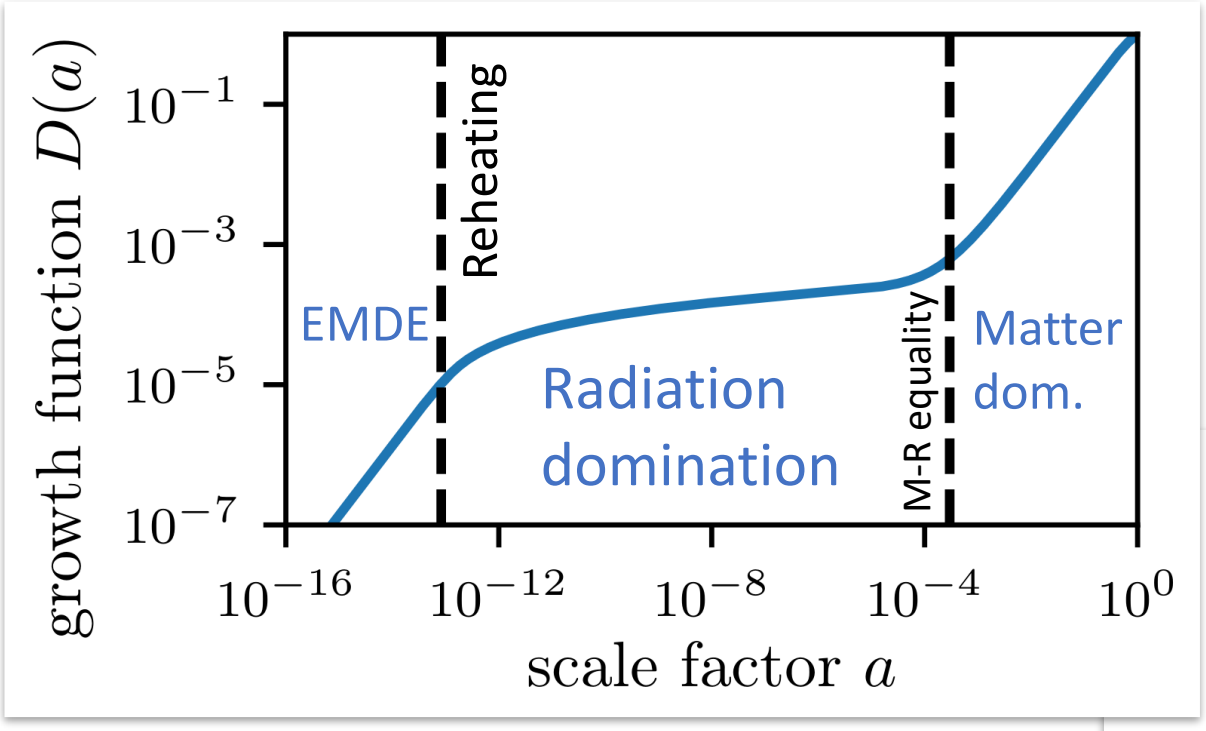
Need smaller cross section for correct relic abundance

Degeneracy between DM properties and EMDE widens field of viable dark matter models (e.g. binos)

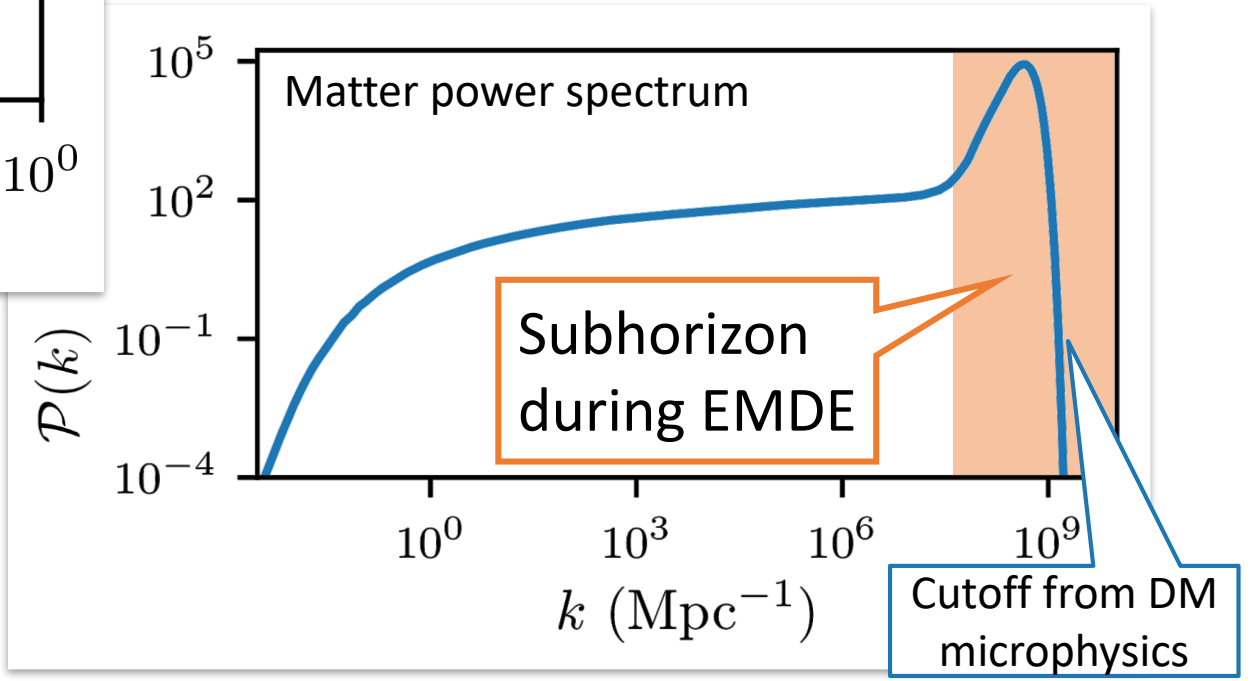


Can we detect smaller cross sections?

EMDE and density fluctuations



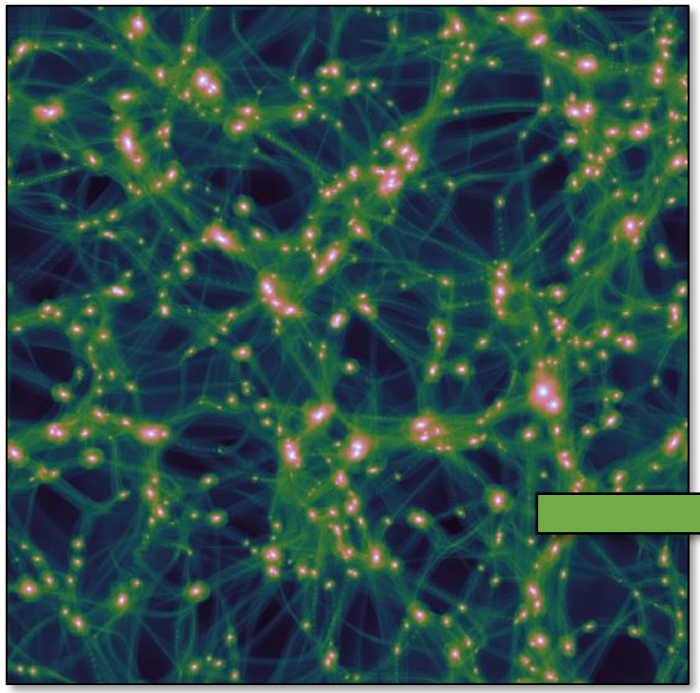
Subhorizon matter density fluctuations grow rapidly when pressureless fluids dominate.



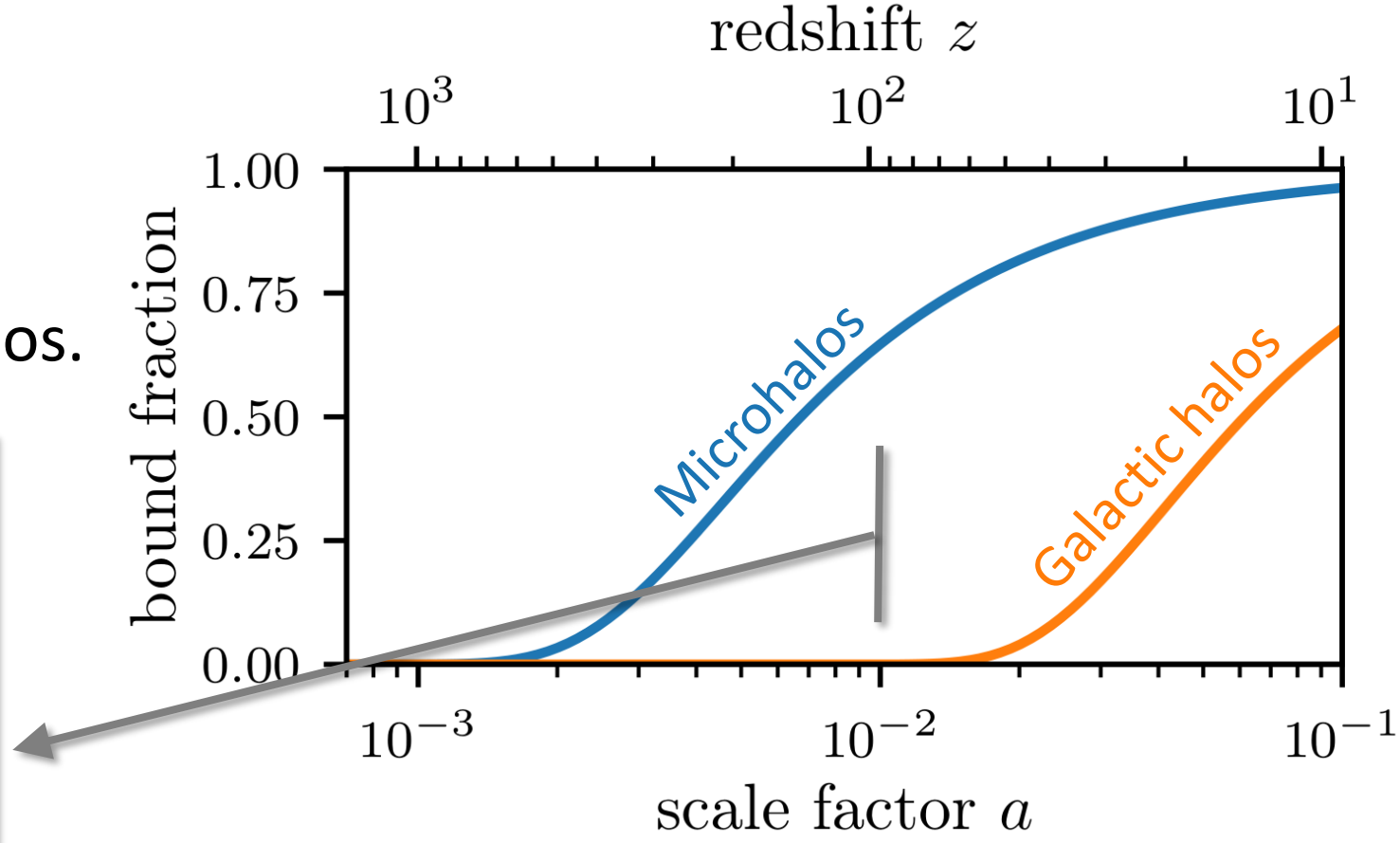
An EMDE enhances small-scale fluctuations.

Microhalos

Due to EMDE, most dark matter is in superdense sub-earth-mass microhalos.



1.5 parsec (comoving)

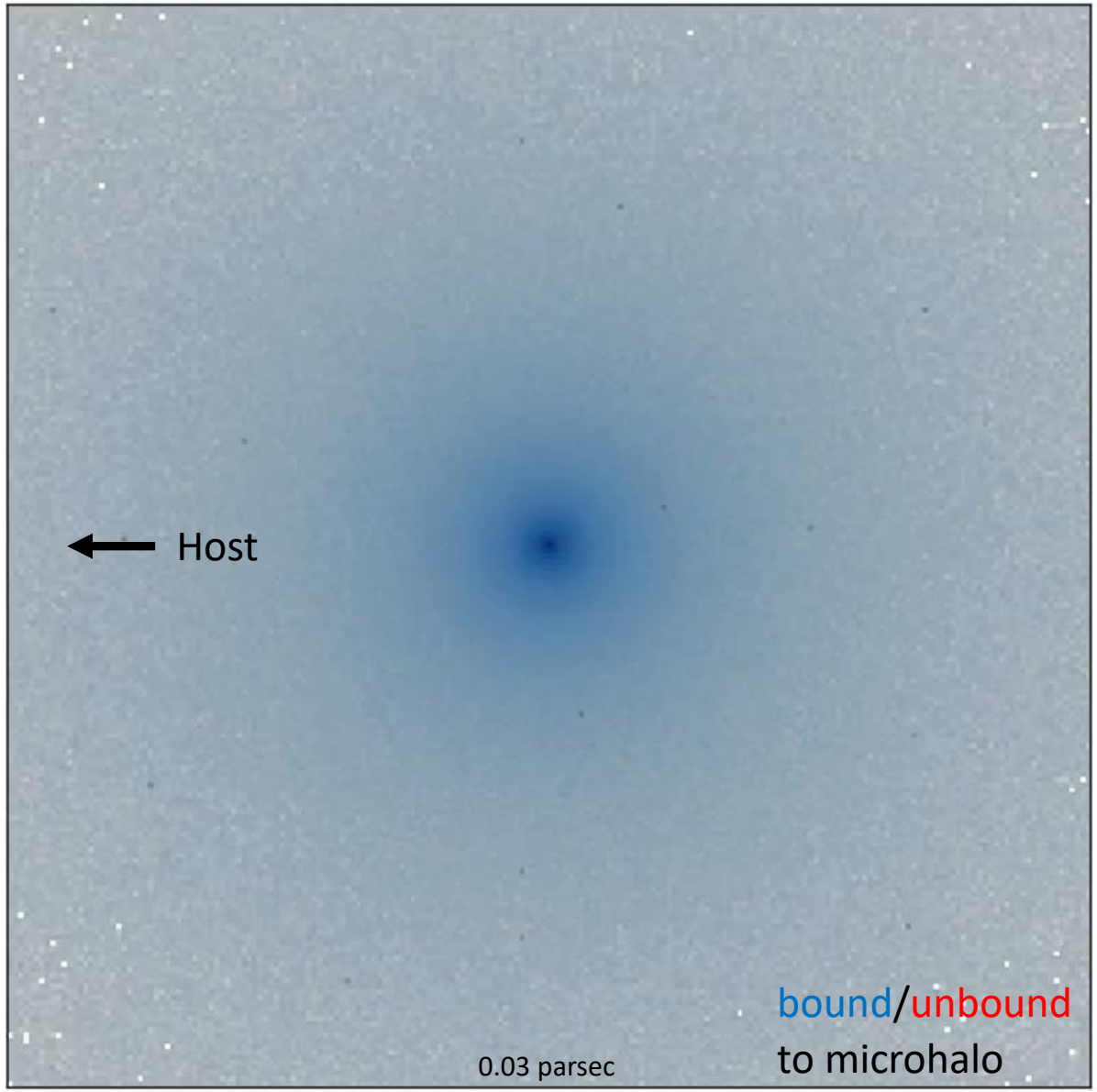


Dramatically enhanced annihilation signal!

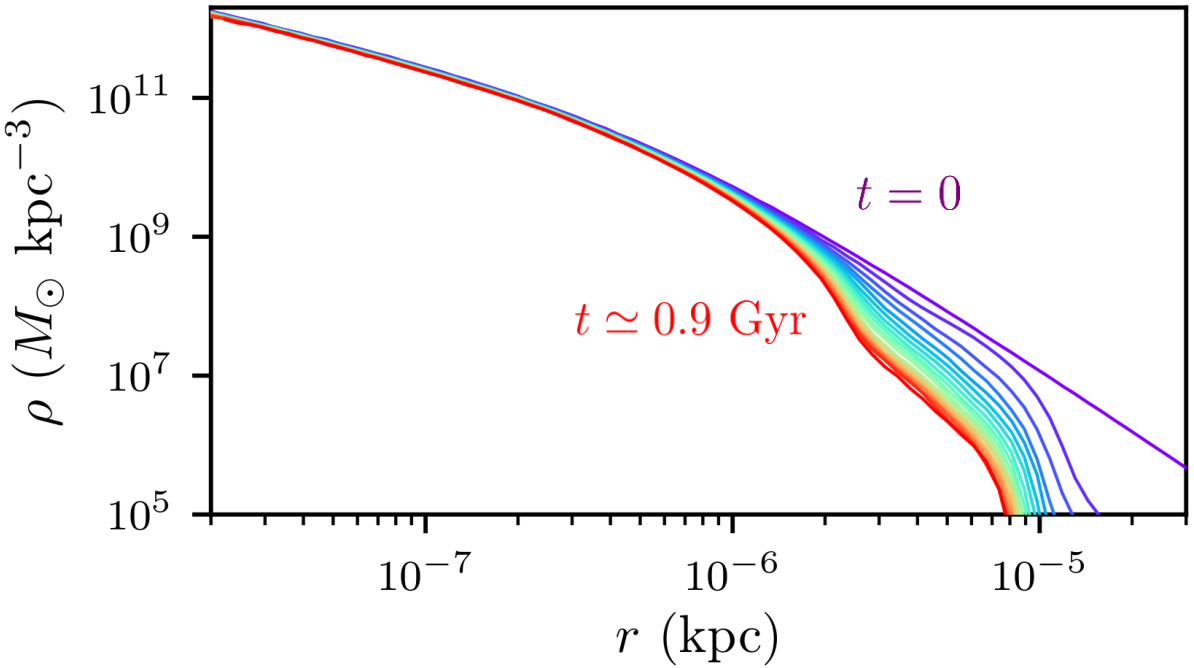
Do microhalos survive inside galactic halos?

Possible “hole” in annihilation signal near centers of systems?

Simulating tidal stripping



N-body microhalo in orbit about analytic potential (dSph halo)

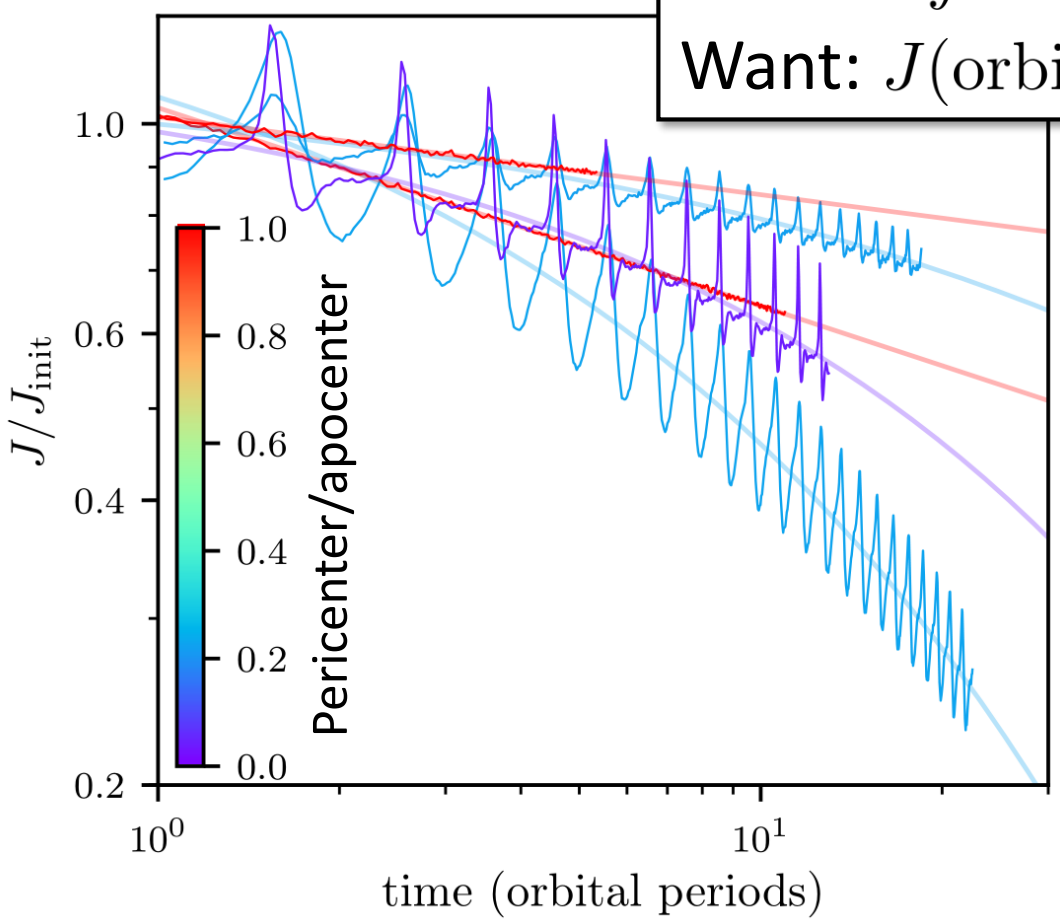


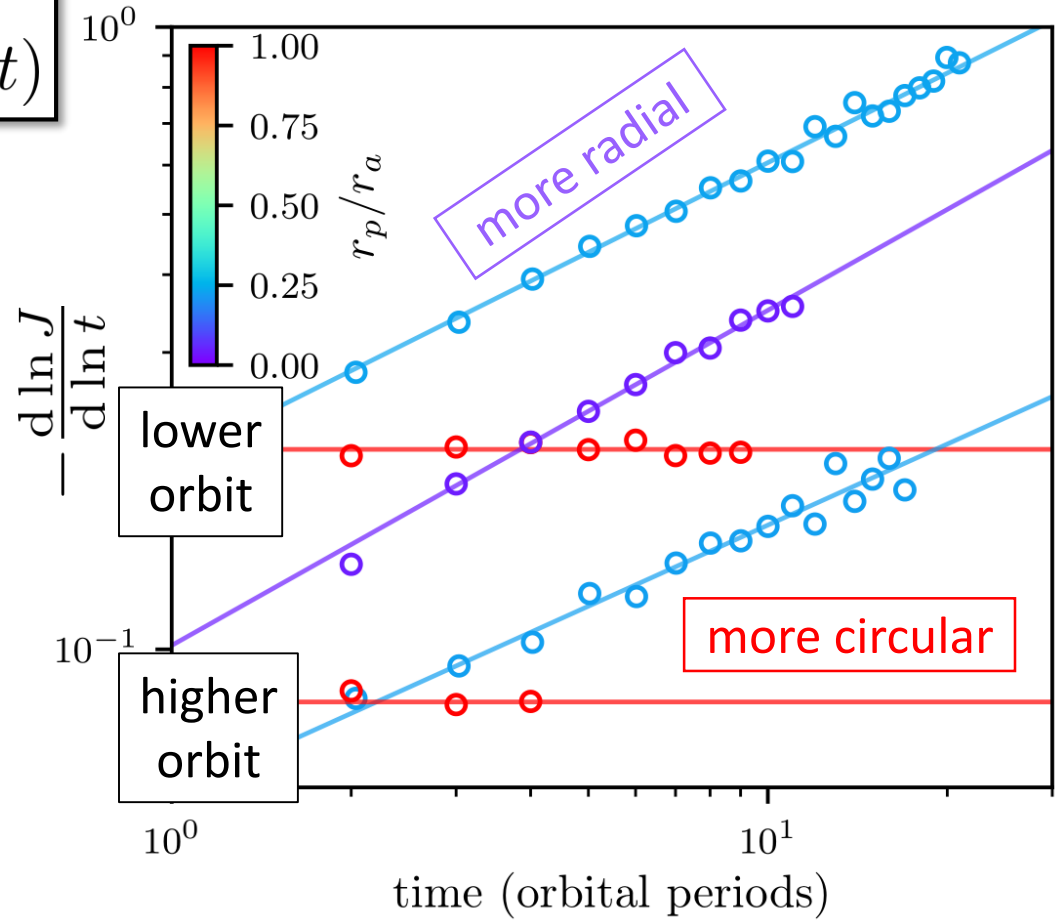
Outer reaches are stripped, but the central density profile is largely unscathed.

Microhalo annihilation rate

$$\Gamma \propto J \equiv \int \rho^2 \mathrm{d}V$$

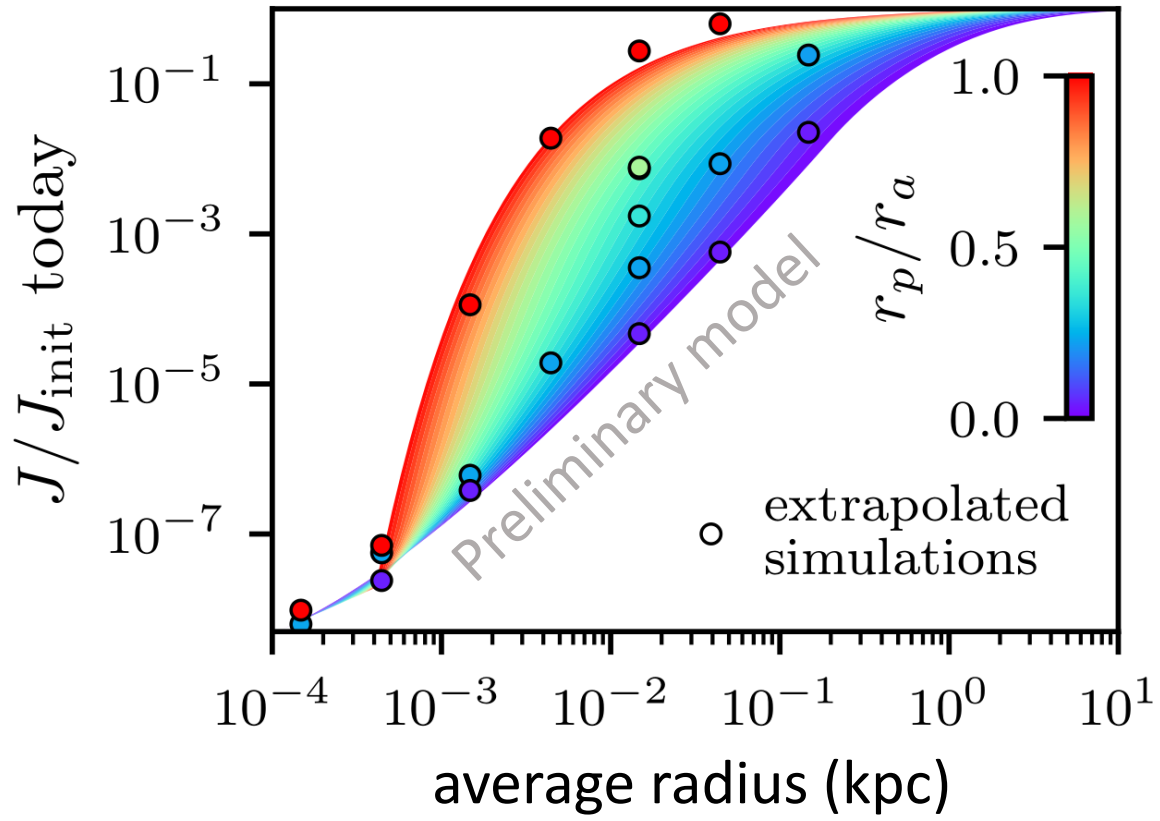
Want: $J(\mathrm{orbit}, t)$





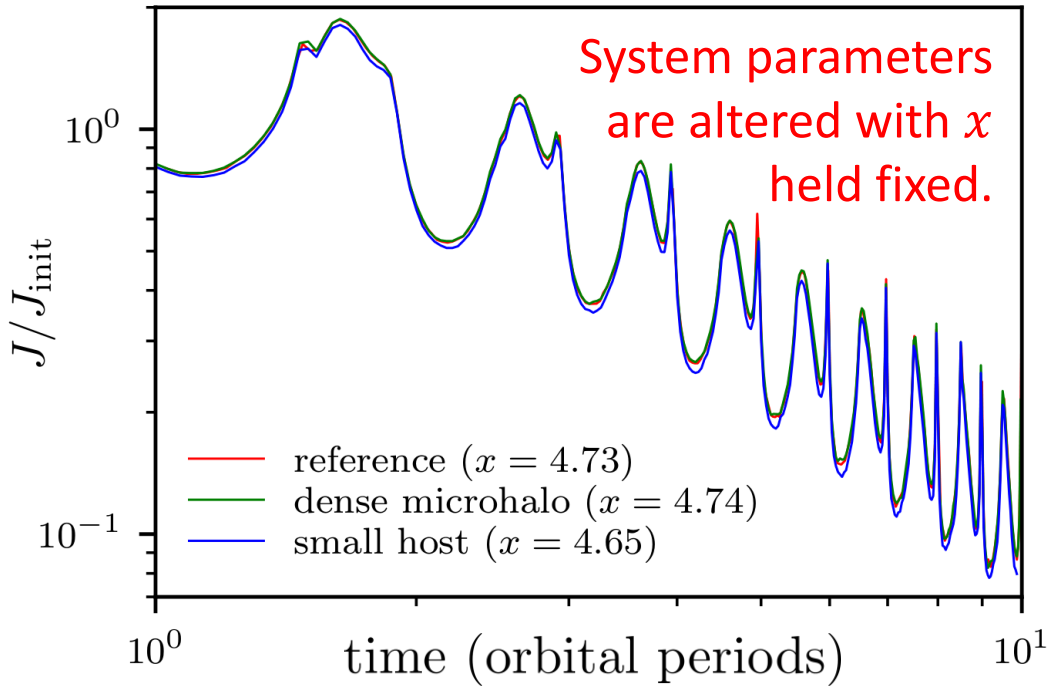
Modeling J(orbit)

Model for Draco dSph and typical microhalo from one EMDE scenario:



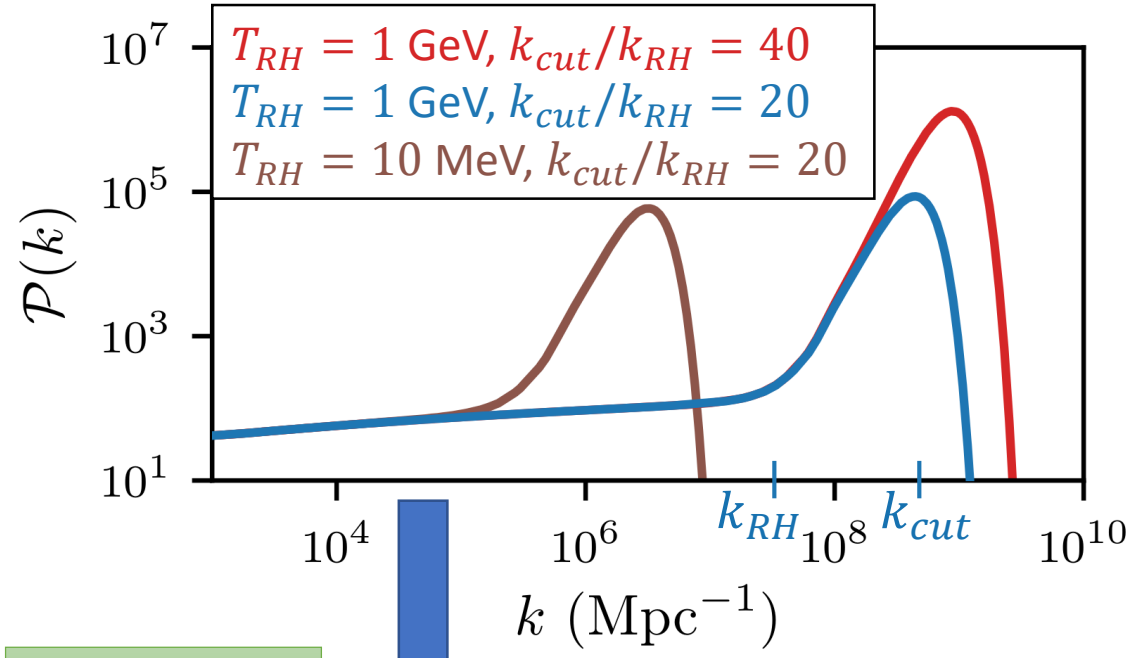
Generalize to arbitrary host-microhalo system:

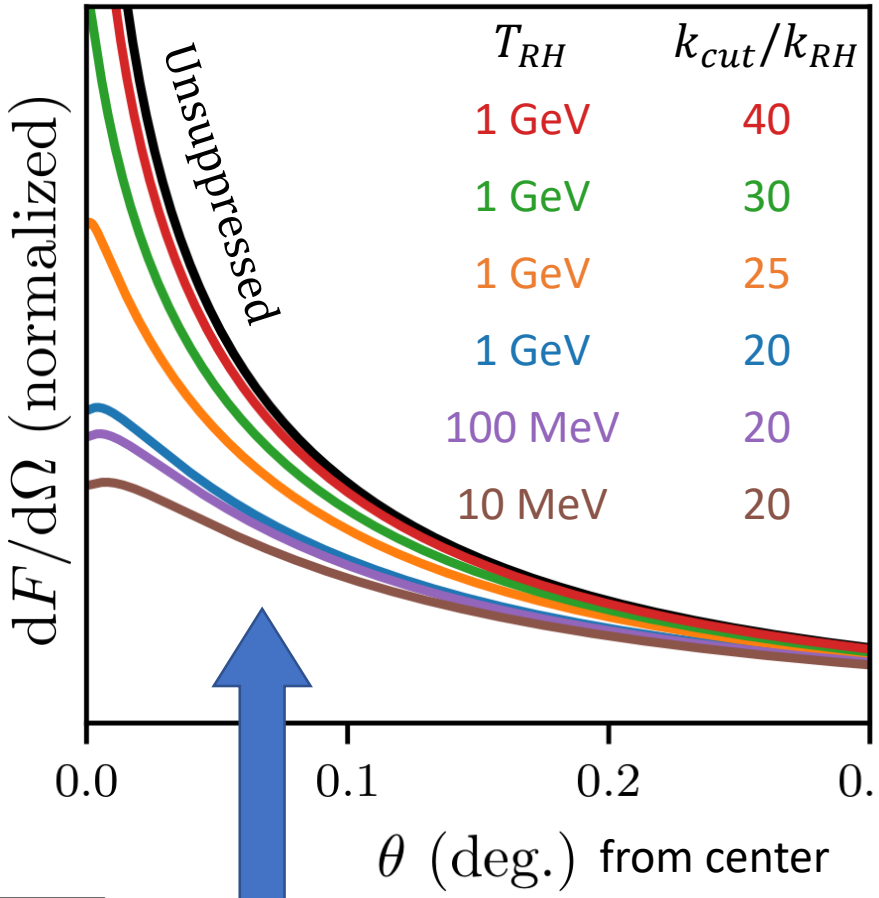
$$\text{radius } r \to x \propto \frac{\text{binding energy}}{\text{energy injected/orbit}}$$



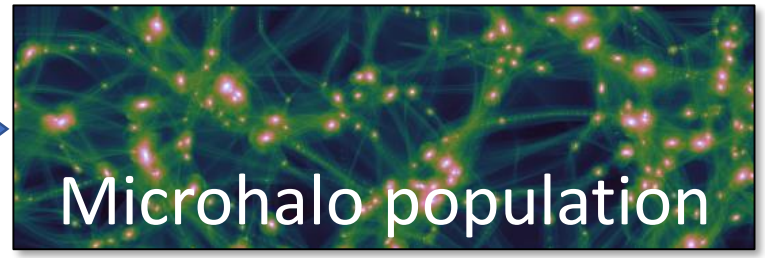
Emission profile

Find annihilation profile from Draco dwarf for various parameters T_{RH}, k_{cut}/k_{RH}



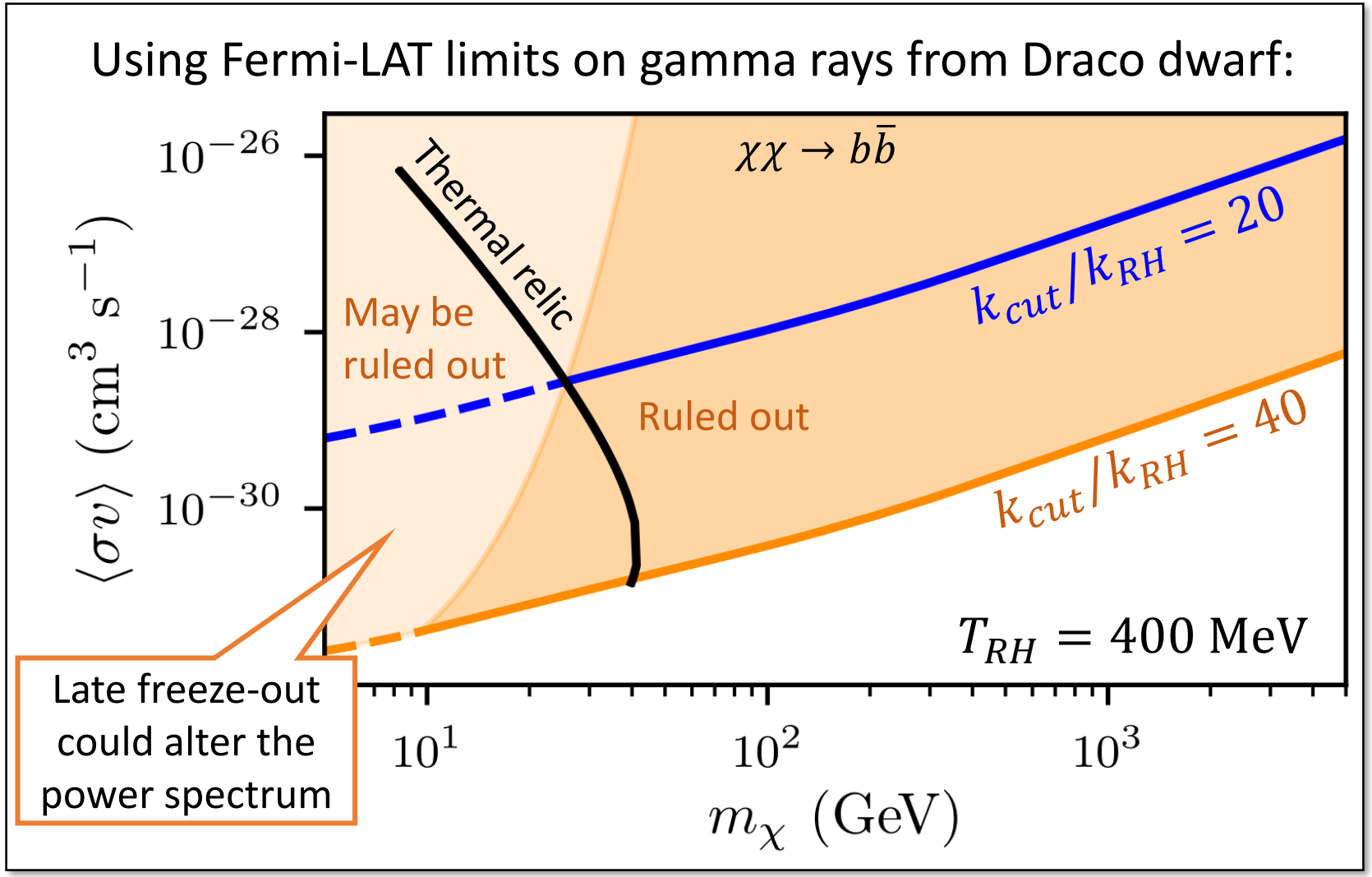


Delos, Bruff, Erickcek 2019 (forthcoming)



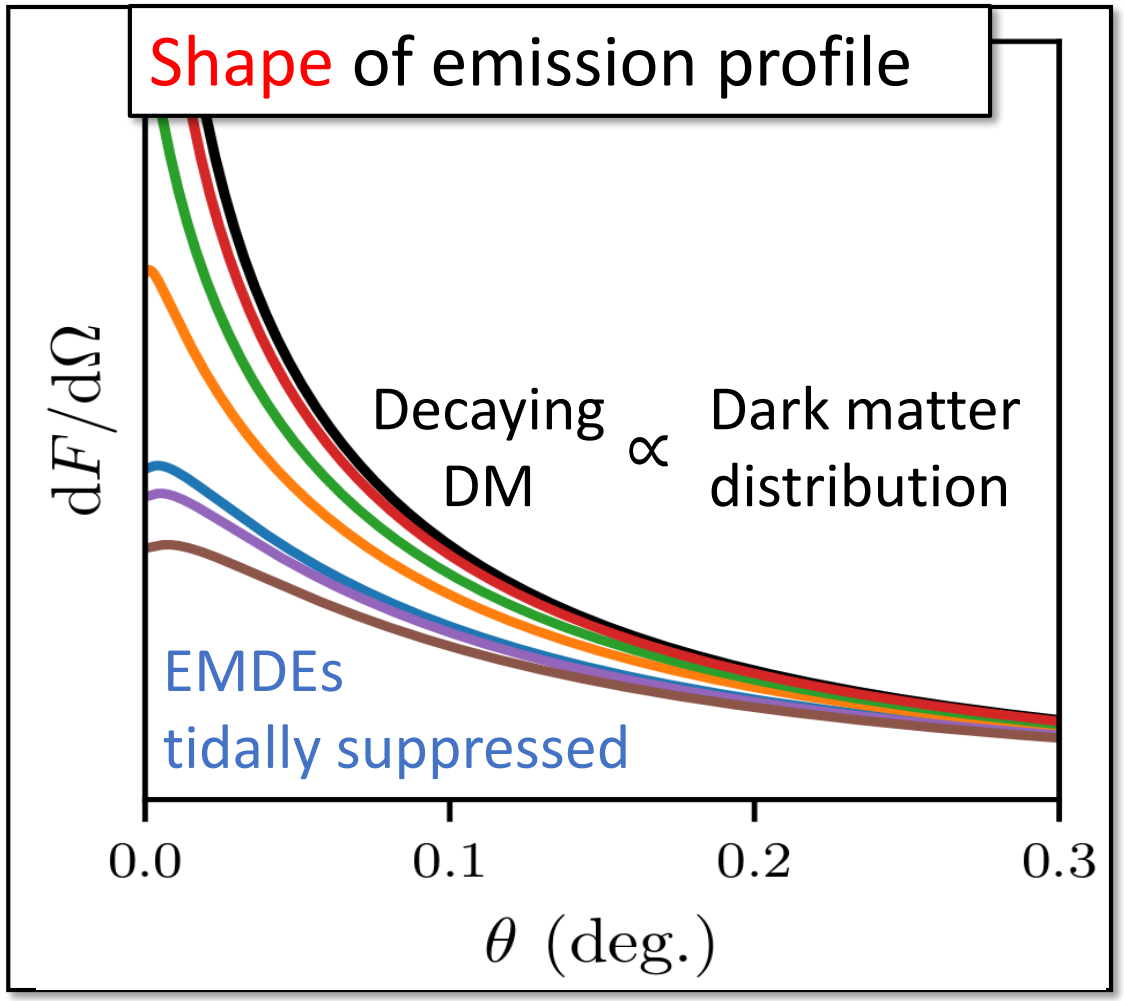
J(orbit) model; Orbital distribution

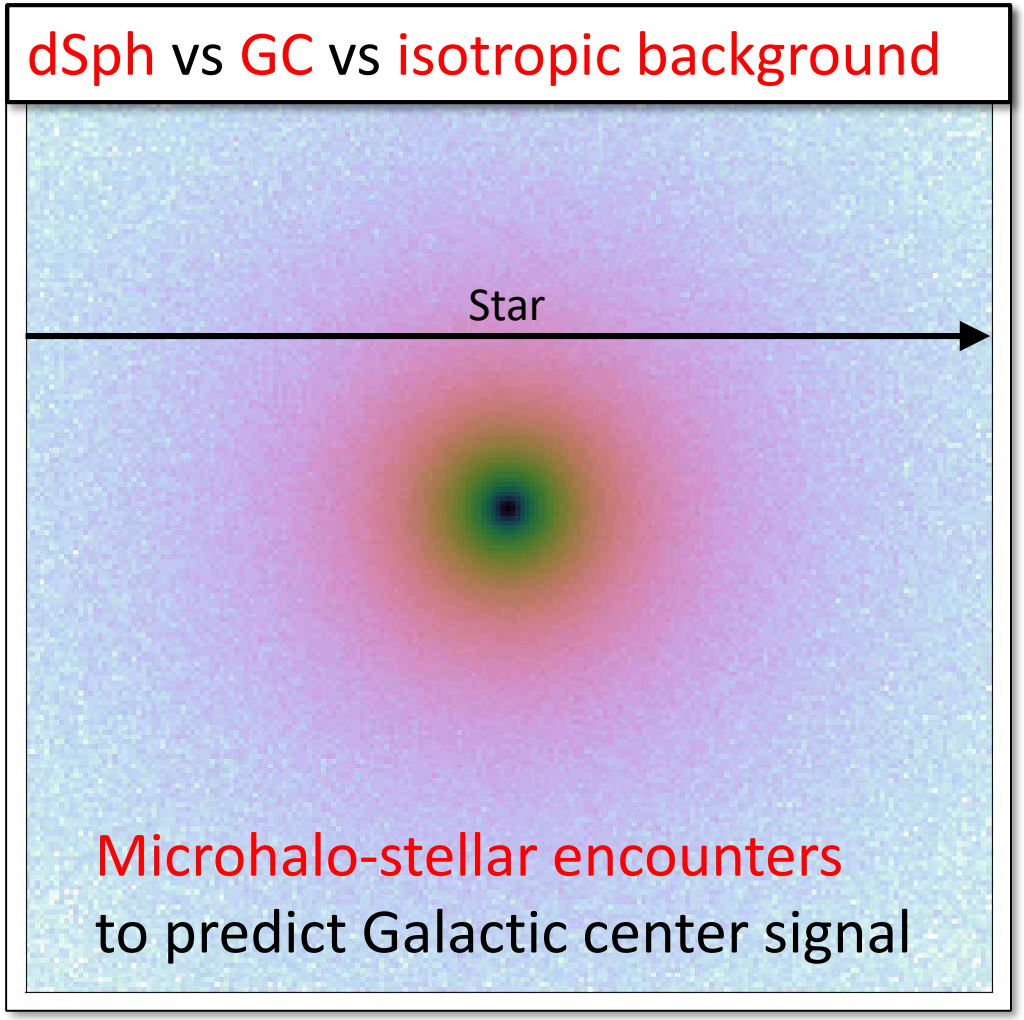
Constraining EMDEs



More to come!

Distinguishing between scenarios





Summary

- EMDE enhances small-scale density fluctuations → most DM in microhalos
- Tidal stripping model from N-body simulations
- Tidal stripping determines emission profile from DM annihilation due to microhalos
- Emission profile → constraints on thermal DM freezing out during EMDE