Is a virialized CGM required for the formation of thin galactic discs?

(main paper: Stern+ 2021, ApJ, 911, 88)

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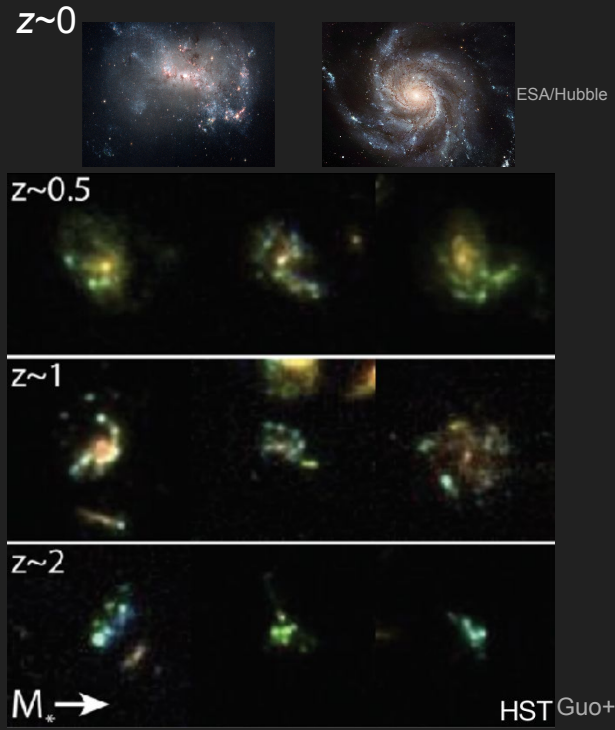
In SF galaxies, rotating thin discs dominate at high masses and late times. ***Why?***

morphology

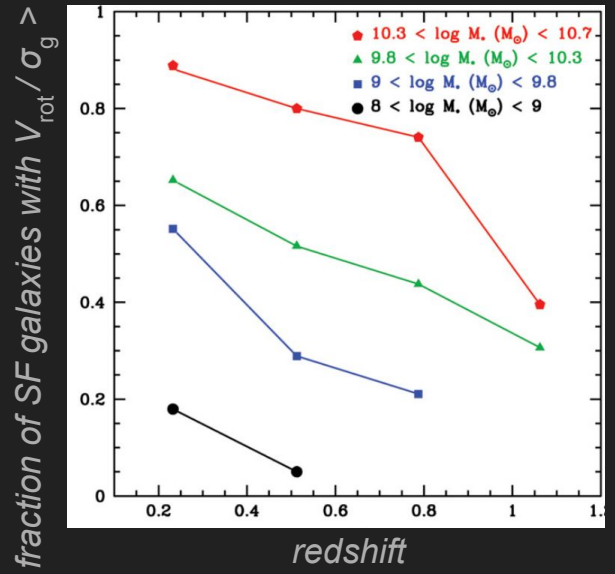


ESA/Hubble

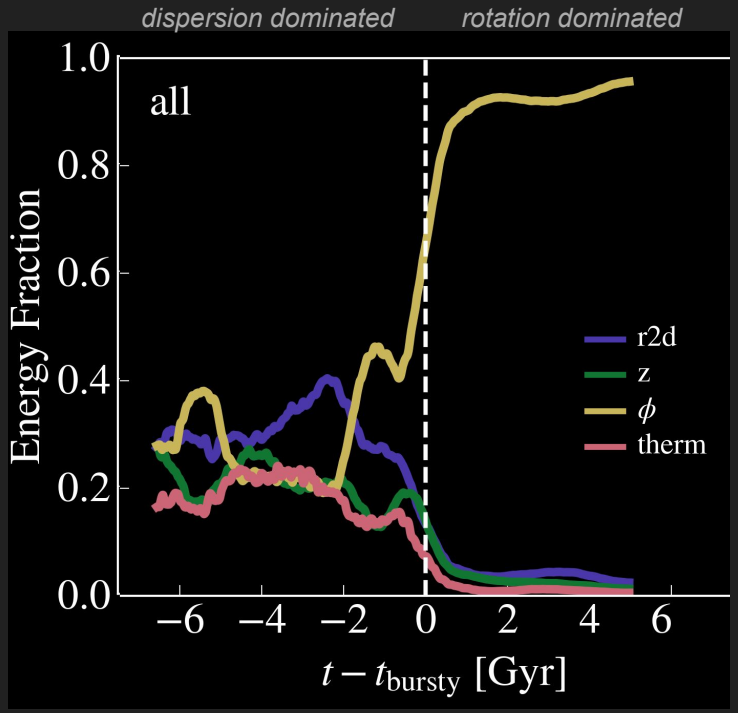
Guo+ 2015

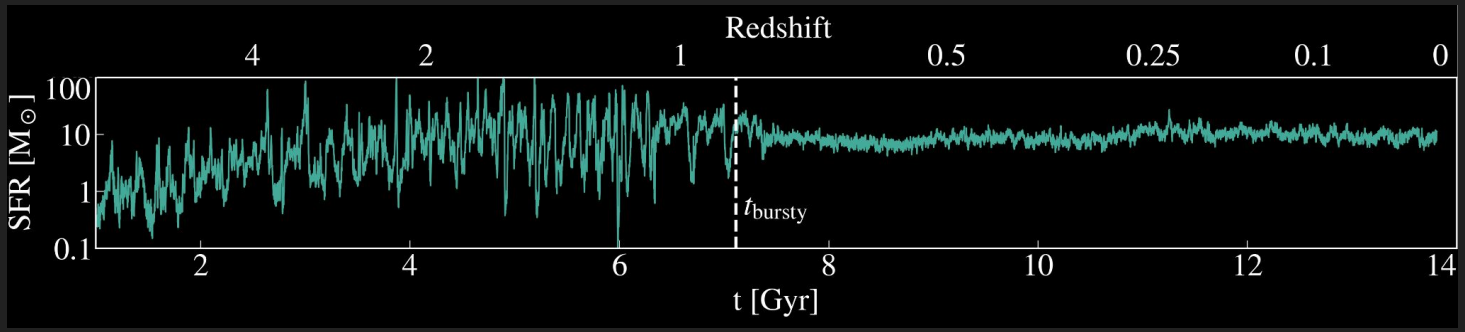
kinematics

Kassin+ 2012



Alex's talk: in FIRE, *disc settling* simultaneous with transition from bursty to steady star formation.
What drives these transitions?



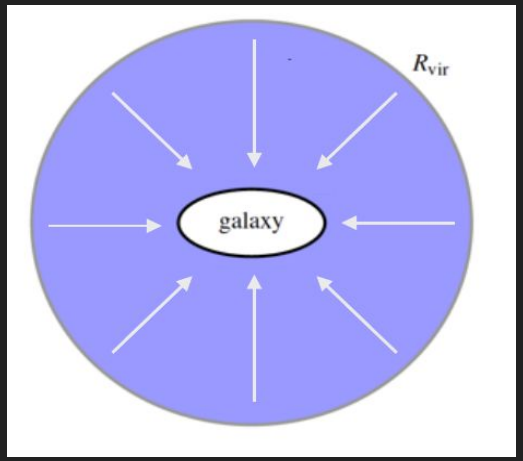


Could CGM 'virialization' (Rees, Ostriker, White, Silk, Dekel, Birnboim, …) be required for the formation of thin star-forming disks?

$M_{halo} < 10^{11} – 10^{12}\ M_{\odot}$

rapid cooling of hot gas ($t_{cool} < t_{ff}$)

→ *free-falling CGM*

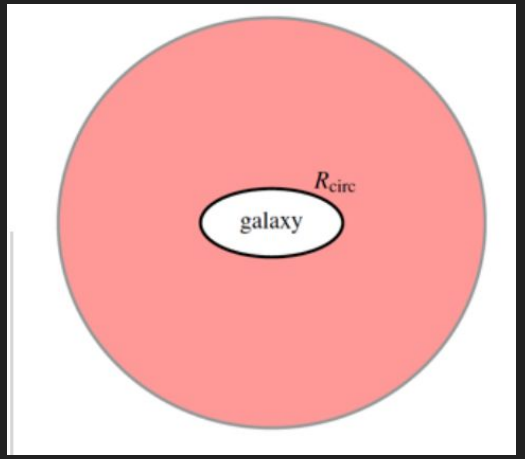


***qualitative** change in galaxy inflows and outflows*

$M_{halo} > 10^{11} – 10^{12}\ M_{\odot}$

slow cooling of hot gas ($t_{cool} > t_{ff}$)

→ *quasi-static CGM*



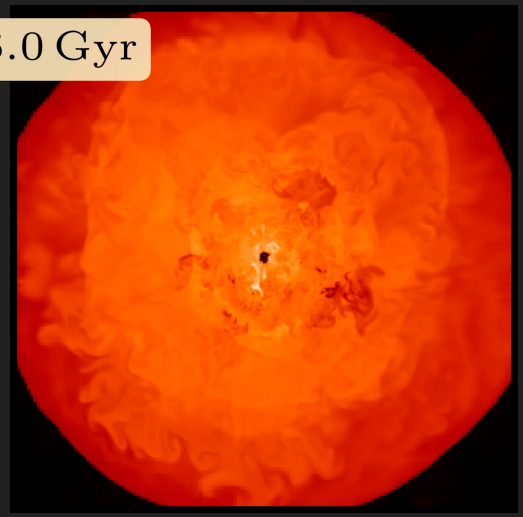
Recent updates to CGM virialization theory

The effect of (stellar) feedback on CGM virialization

$M_h = 10^{11}\, M_\odot$, $t_{cool} < t_{ff}$

Fielding +2017

$M_h = 10^{12}\, M_\odot$, $t_{cool} > t_{ff}$



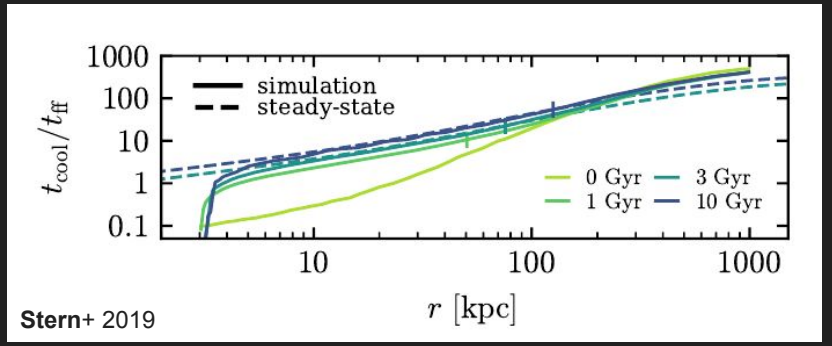
transition from dynamic CGM with transient hot phase to time-steady, quasi-static hot phase (Fielding+2017, see also van de Voort +2016)

Radial dependence of CGM virialization

*t_{cool}/t_{ff} expected to **increase outwards** in CGM, with normalization increasing with halo mass*

*→ implies a **characteristic scale** in the system:*

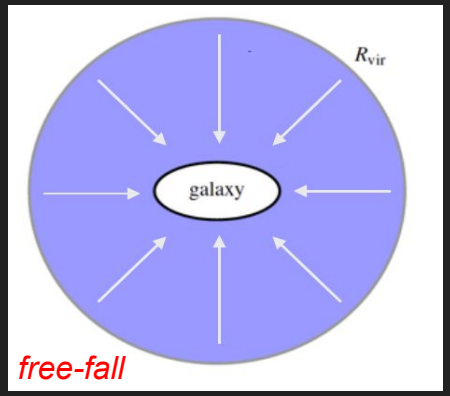
$$R(t_{cool} = t_{ff}, M_{halo})$$

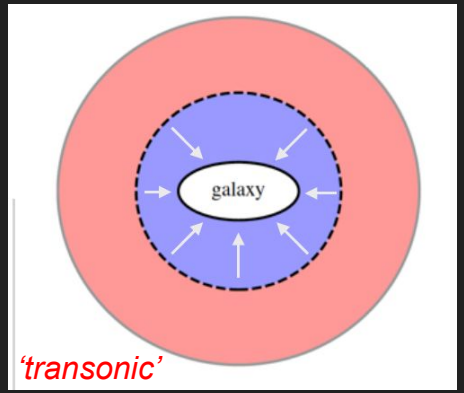


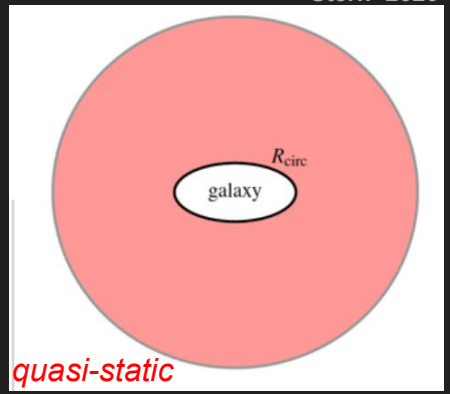
Stern+ 2019

*… and a **third** CGM regime:*

Stern+2020







low mass, $R(t_{cool}=t_{ff}) > R_{vir}$

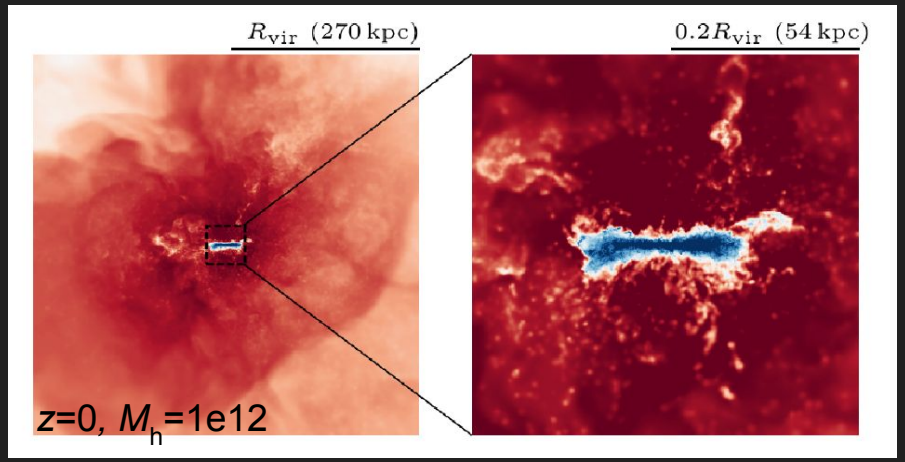
intermediate, $0.1R_{vir} < R(t_{cool}=t_{ff}) < R_{vir}$

high mass, $R(t_{cool}=t_{ff}) < 0.1\ R_{vir}$

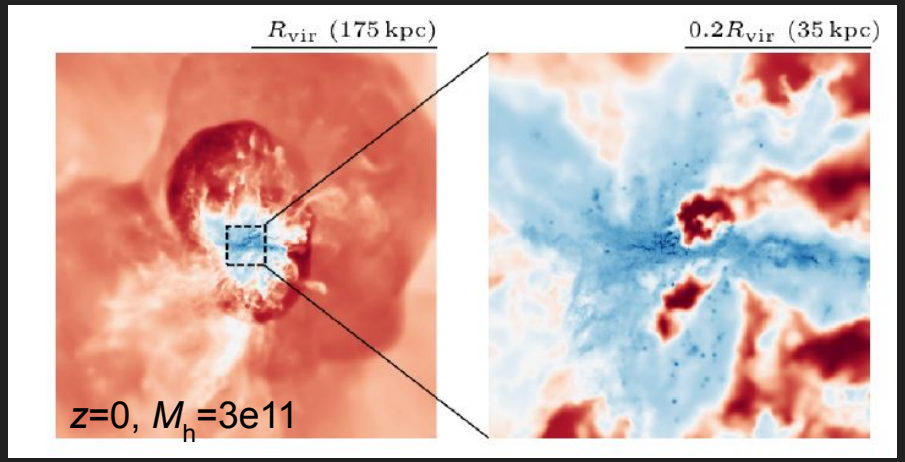
Are these three CGM regimes realized in cosmological simulations?

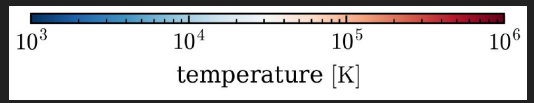
Yes! quasi-static versus 'transonic' CGM in FIRE

hot outer CGM hot inner CGM



hot outer CGM cool inner CGM

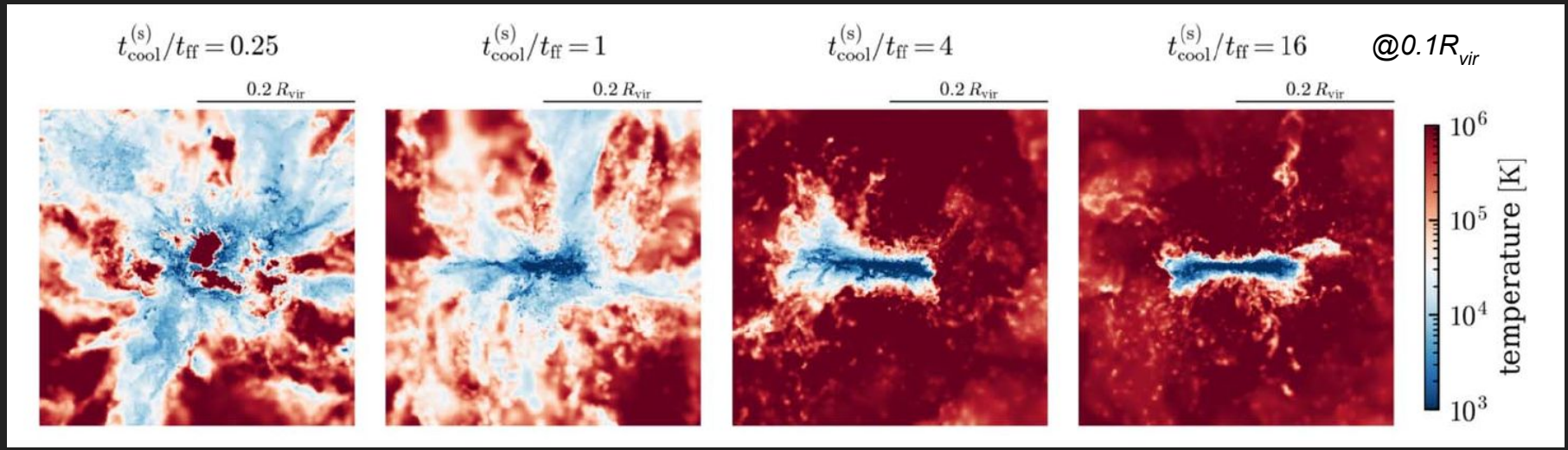




Stern et al. (2021)

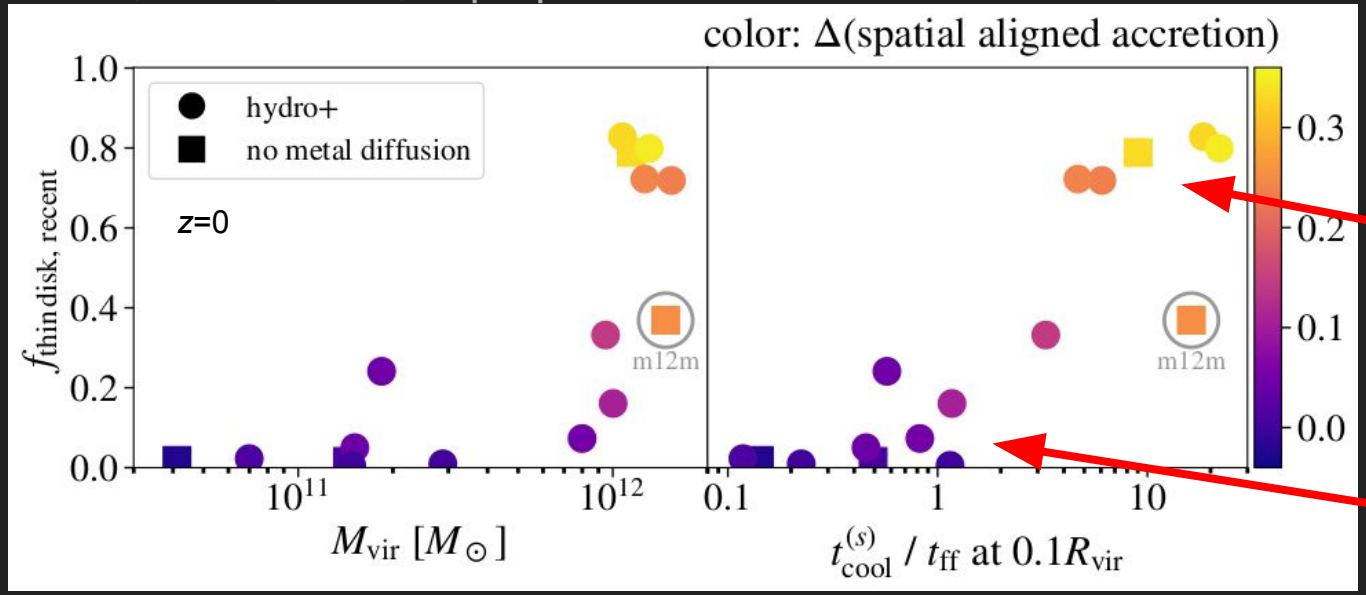
Transition from transonic to quasi-static CGM ('Inner CGM Virialization')

z = 1 → *z* = 0



M_h(z=0)=1e12, **Stern**+ 2021

Hafen, **Stern**, et al., in prep.



thin disk galaxies have virialized inner CGM

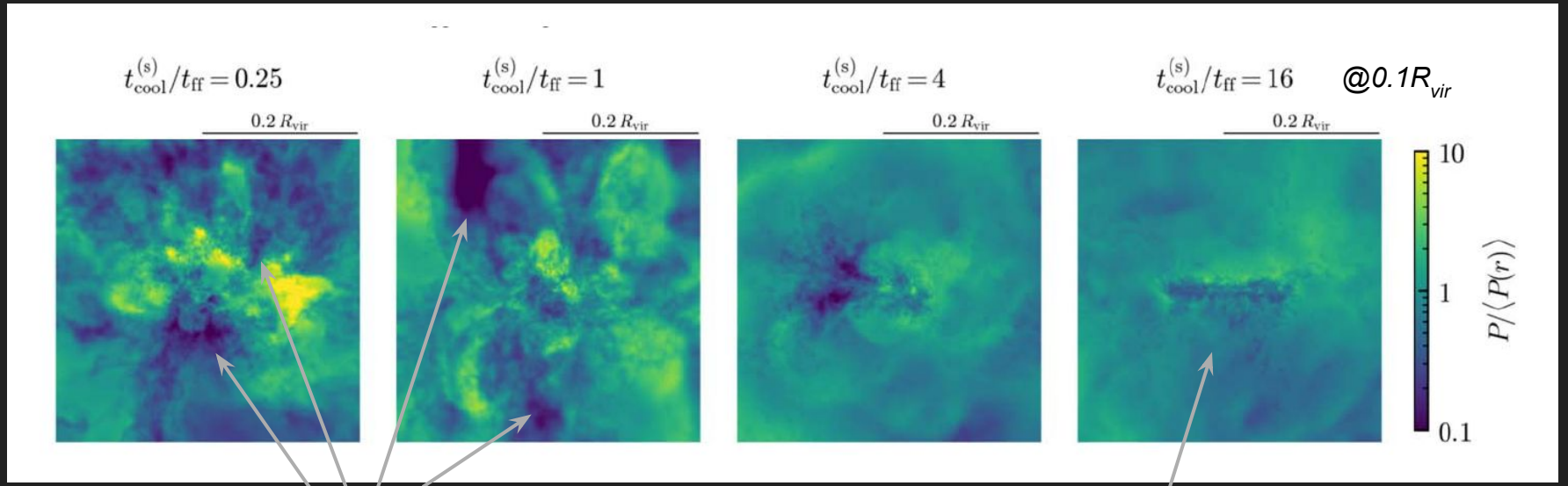
galaxies without thin disks have non-virialized inner CGM

strong relation between stellar kinematics and CGM thermal properties

Why would the virialization of the inner CGM initiate disk settling?

Inner CGM virialization confines galaxy outflows

z = 1 → *z* = 0



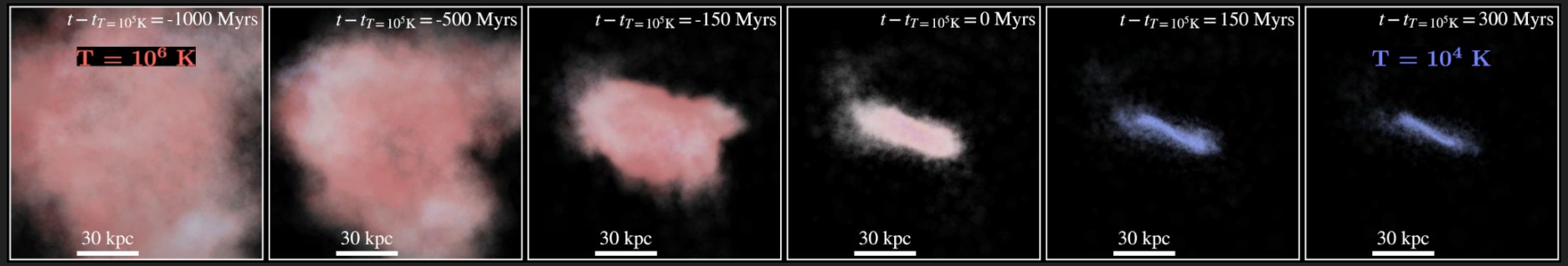
low pressure channels prior to virialization

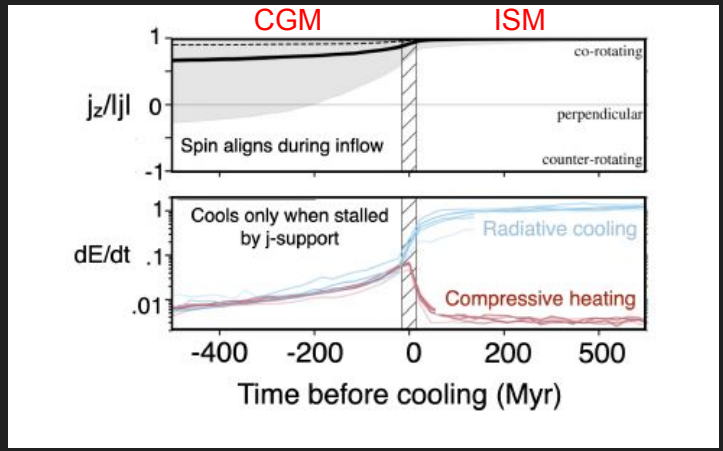
disk confined by ~uniform pressure

***M*$_h$(*z*=0)=1e12, Stern**+ 2021 (cf. Bower+2017)

Inner CGM virialization leads to spin-aligned accretion

time





Hafen, **Stern**, et al., in prep.

Summary

1. *Three* CGM regimes: free-fall, *transonic*, quasi-static

‘Inner CGM virialization’

2. Inner CGM virialization
   - *confines galaxy outflows*
   - narrows angular momentum distribution in galaxy inflows

3. In FIRE, *formation of thin SF disks* simultaneous with inner CGM virialization, supporting a scenario where they are causally linked