

From seed to supermassive

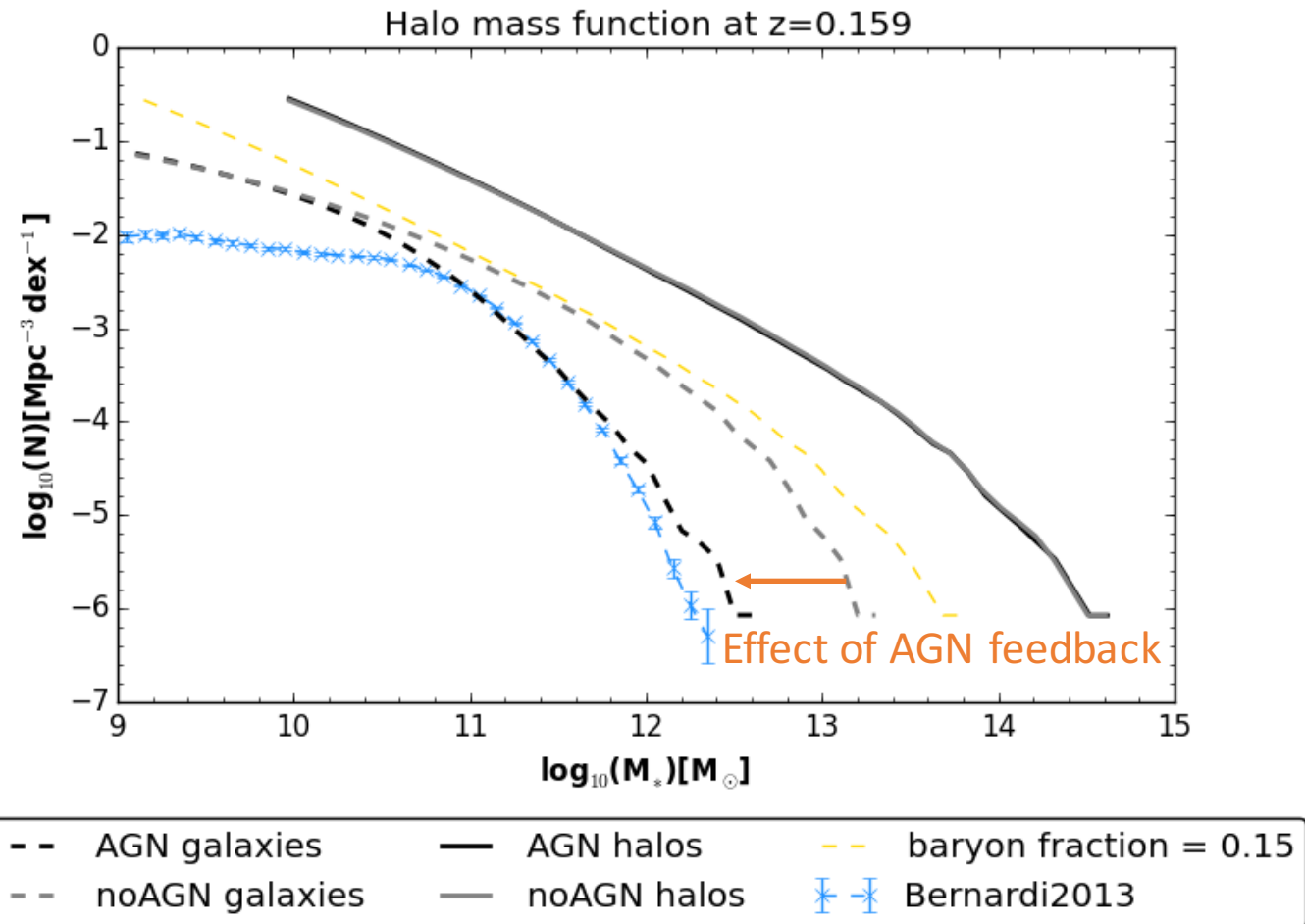
growing high redshift black holes in cosmological simulations

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working with Julien Devriendt and Adrienne Slyz

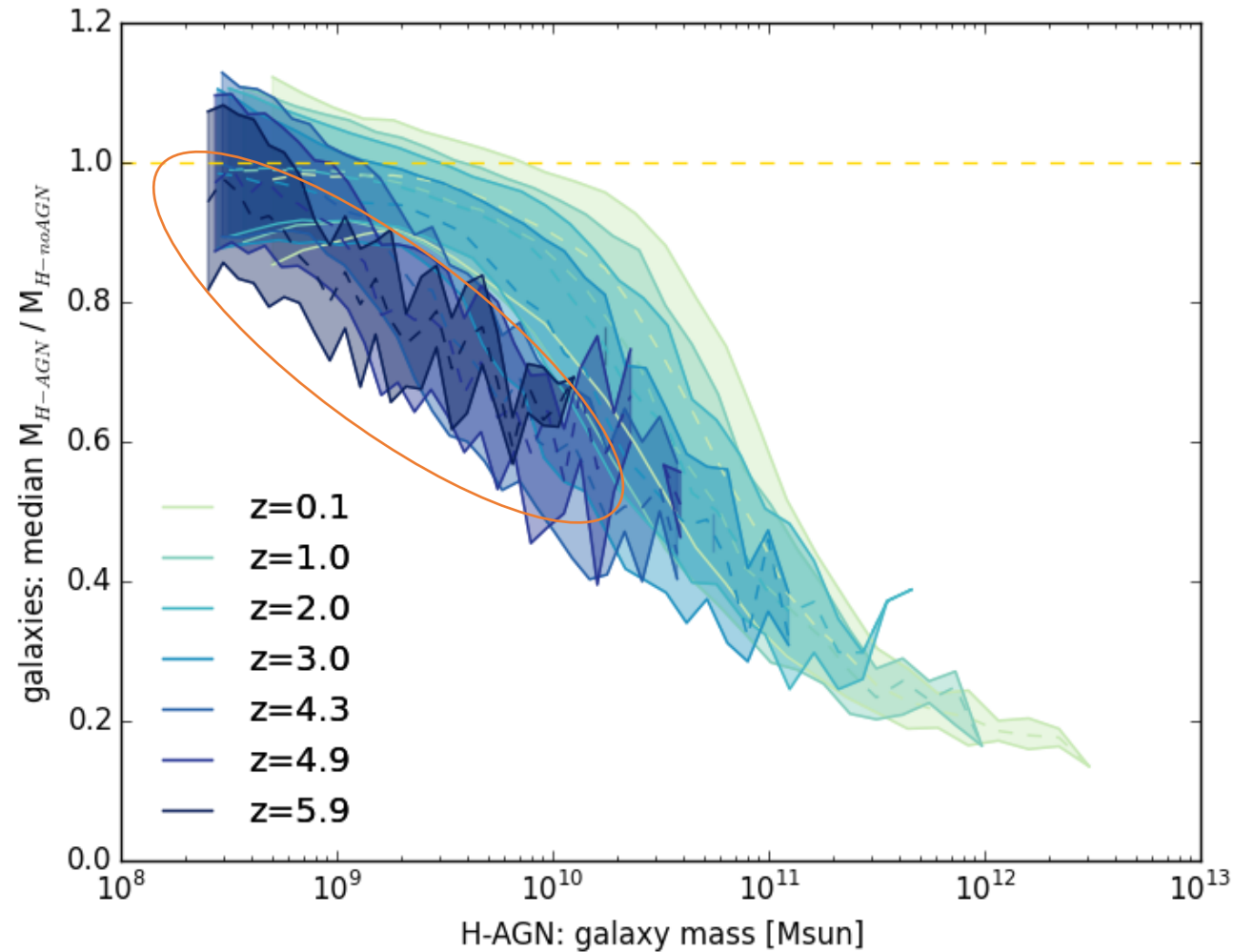
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Feedback from massive black holes is responsible for quenched galaxies in the local universe

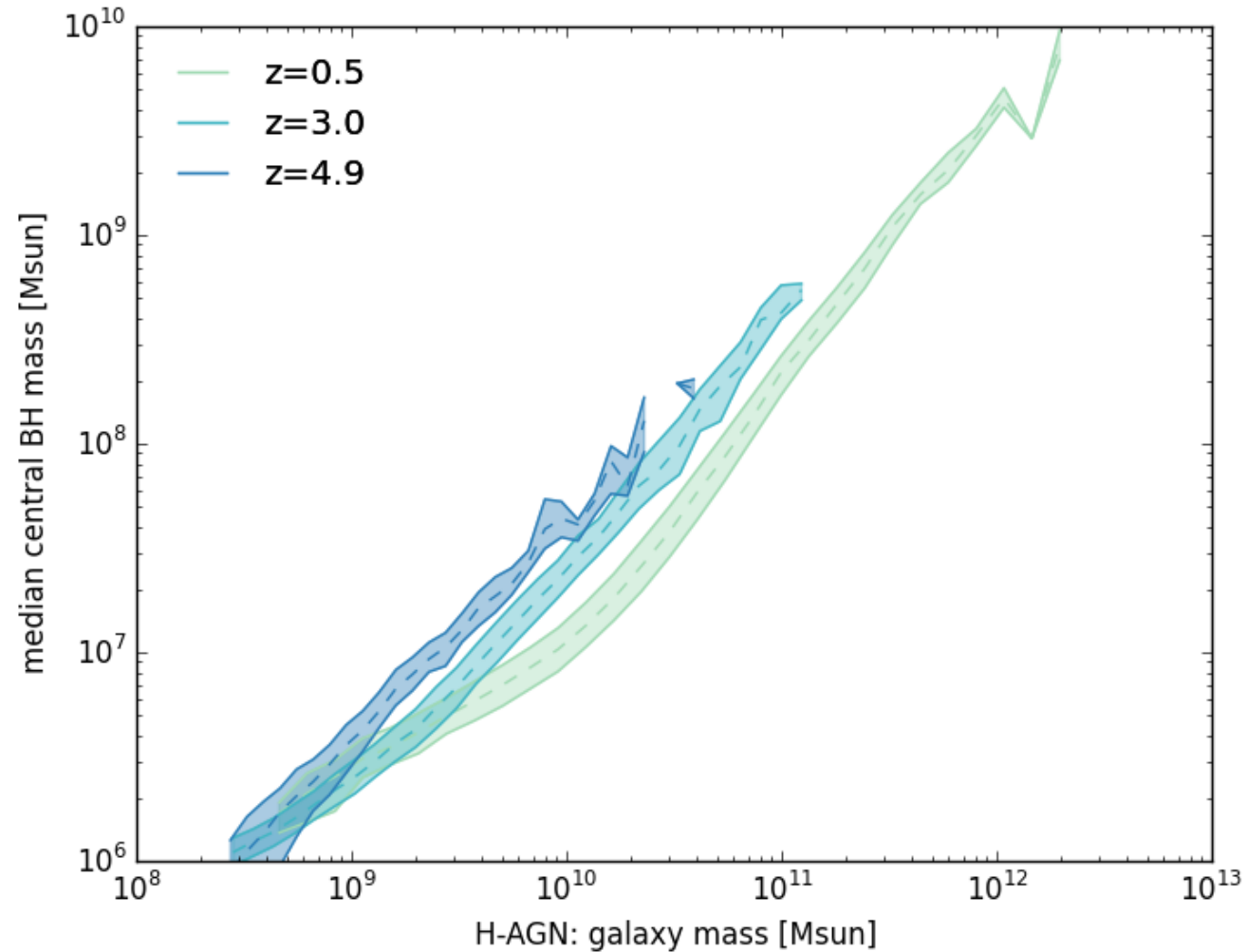


Data from the HORIZON-AGN & HORIZON-noAGN simulations: Dubois et al 2014, Welker et al 2015, Volonteri et al 2016, Kaviraj et al 2016, Beckmann et al (in prep)

At $z=6$, massive galaxies are already quenched



Black holes growth precedes galaxy growth



Black holes in cosmological simulation

In HORIZON (Dubois2014,Welker2015,...):

- Seed the BHs at $1E5 M_{\text{sun}}$
- 1kpc resolution
- Grow using Eddington limited Bondi accretion

=> Similar picture in other simulations such as Illustris (Vogelsberger2014,Sijaki2015), Eagle (Schaye2015) and massive black II (Khandai2014)

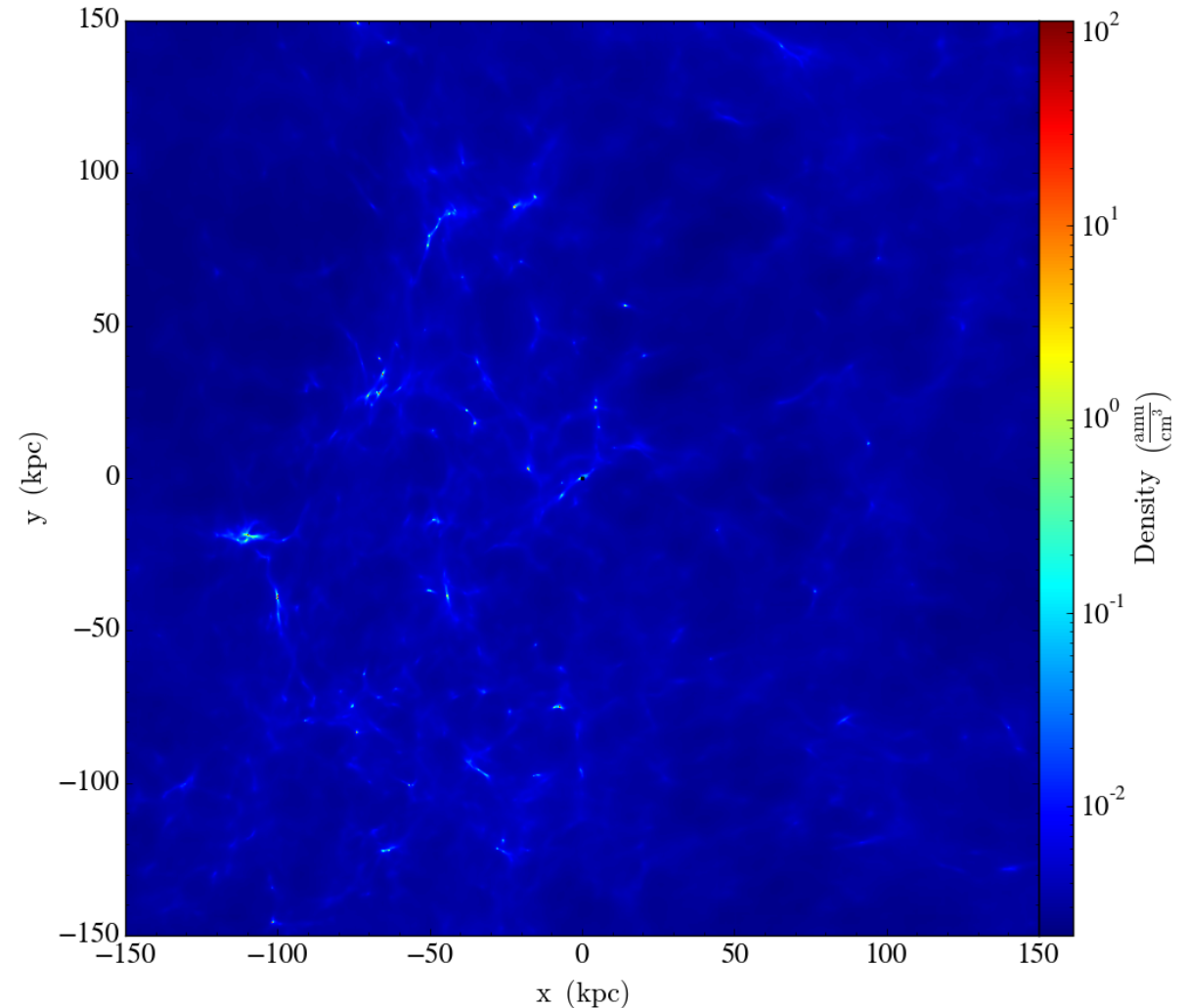
Where do these black holes physically come from?

SEEDING MODELS

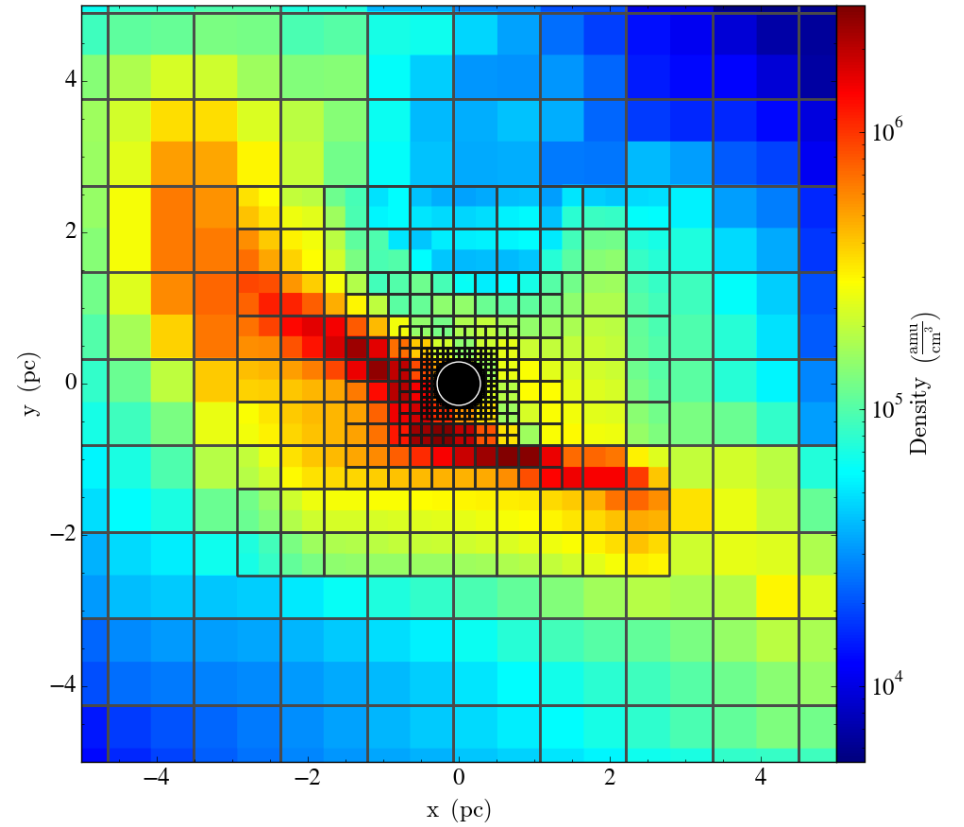
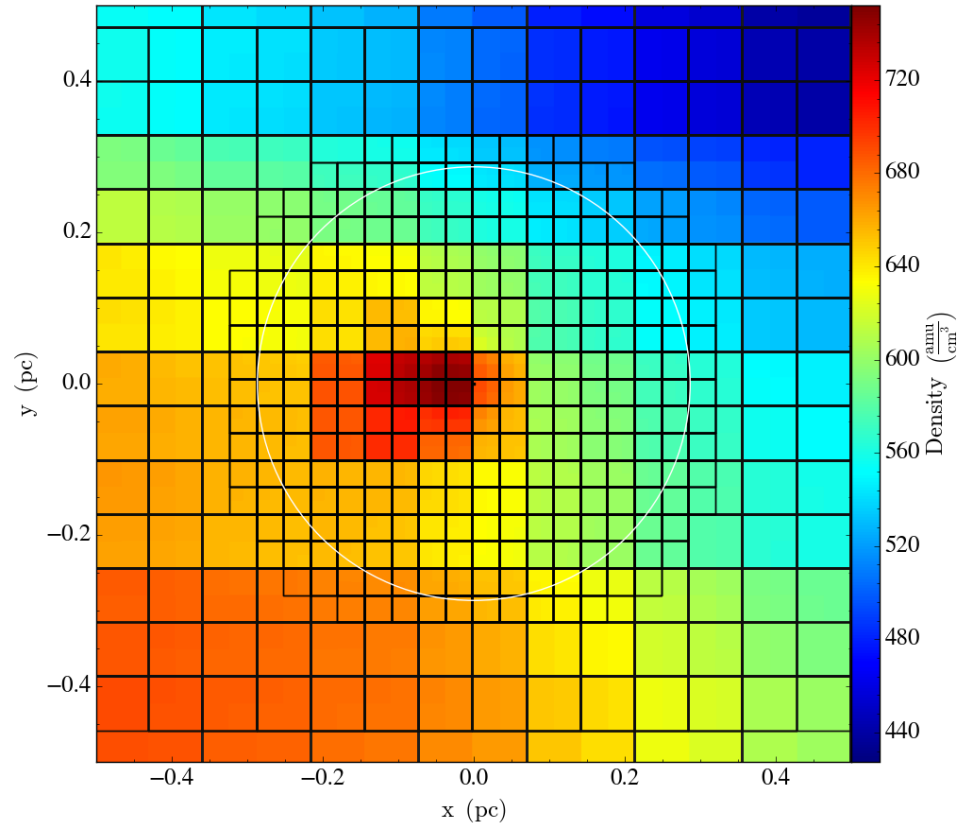
- **Direct Collapse:** 10^5 M_{sun} seeds, needs metal free gas and radiating neighbours (Begelman2006,Latif2013,Habouzit2016)
- **Runaway cluster collapse:** 10^3 - 10^4 M_{sun} seeds (Omukai2008,Devecchi2009,Katz2015)
- **Stellar mass seeds:** 1-100 M_{sun} , (Haiman2000, Freyer2001,Alvarez2009,Heger2003)

Bridging the gap from seed to supermassive

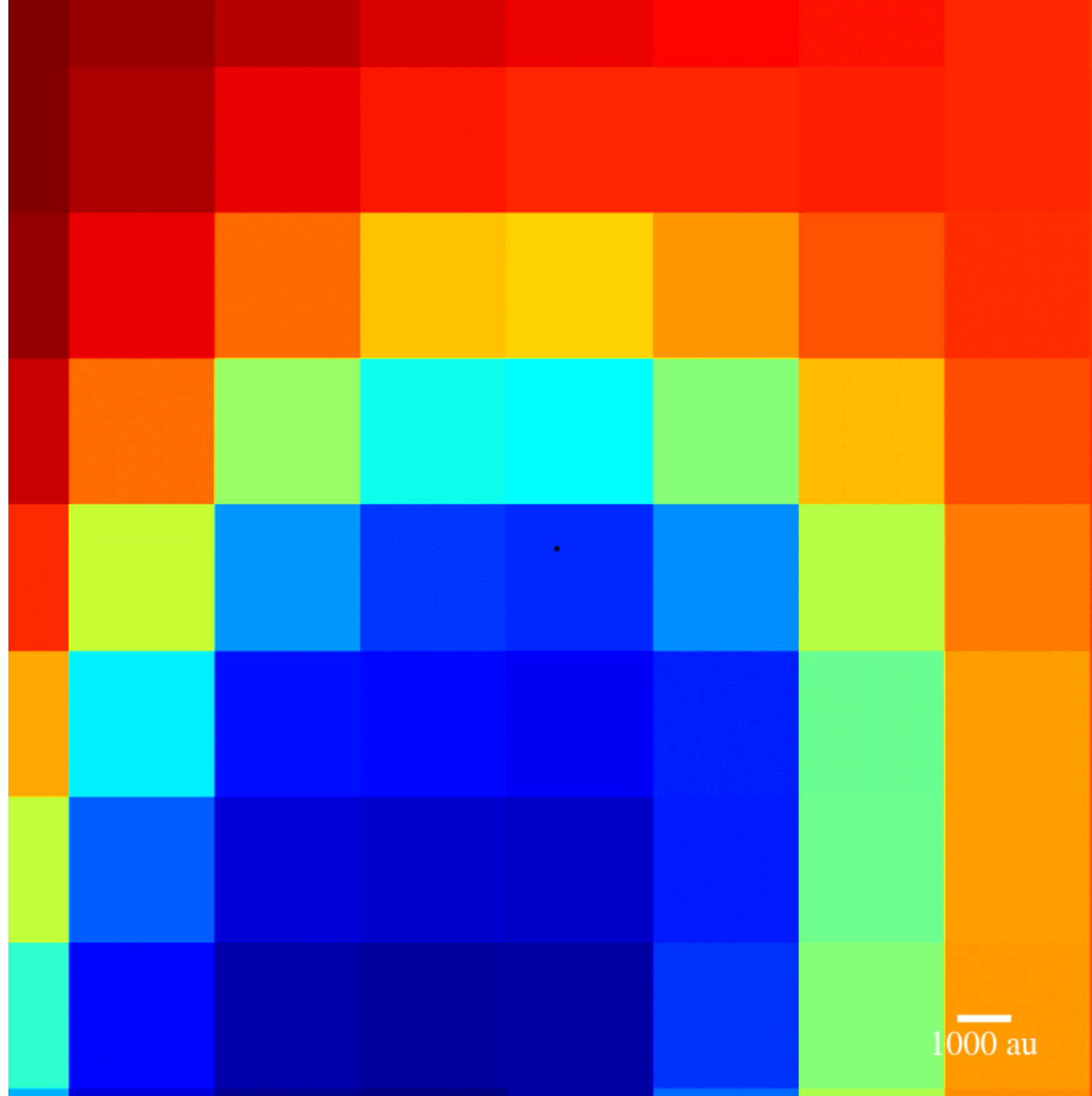
- stellar mass seed (260 M_{Sun})
- a cosmological context (1Gpc box with 5 Mpc zoom region)
- high resolution ($\Delta x=0.01$ pc)
- run to redshift 6
- AMR hydro (RAMSES)



Zoom-within-Zoom



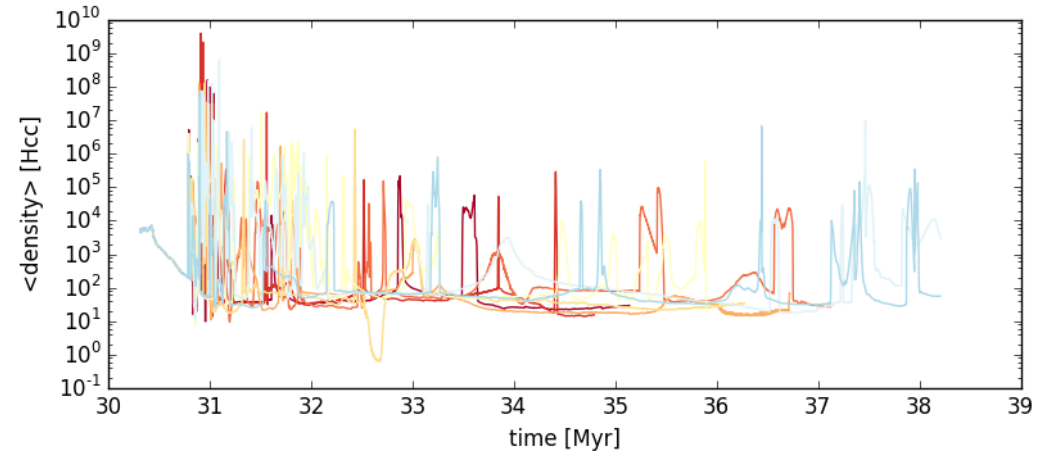
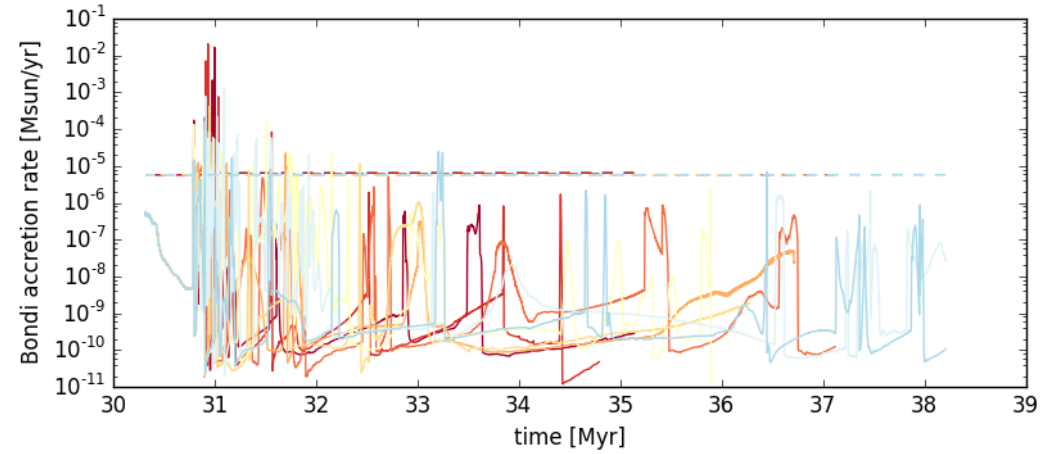
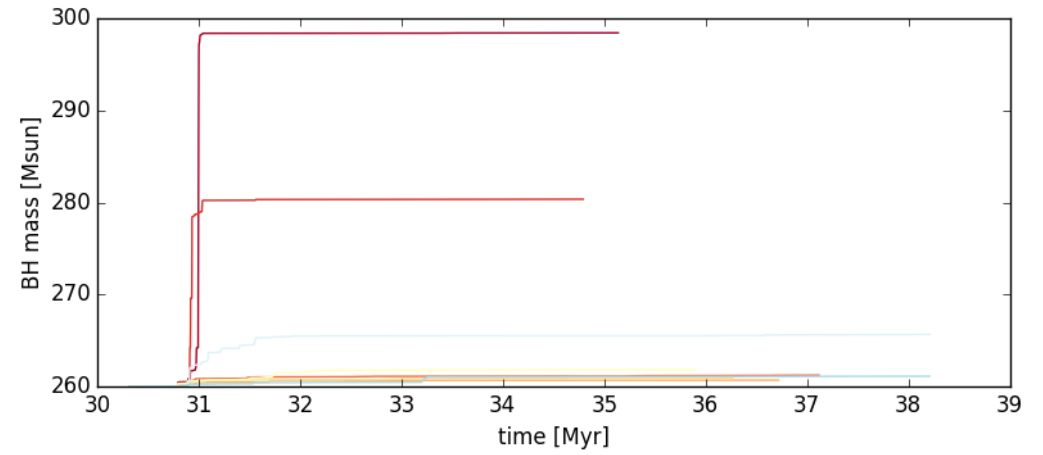
Density



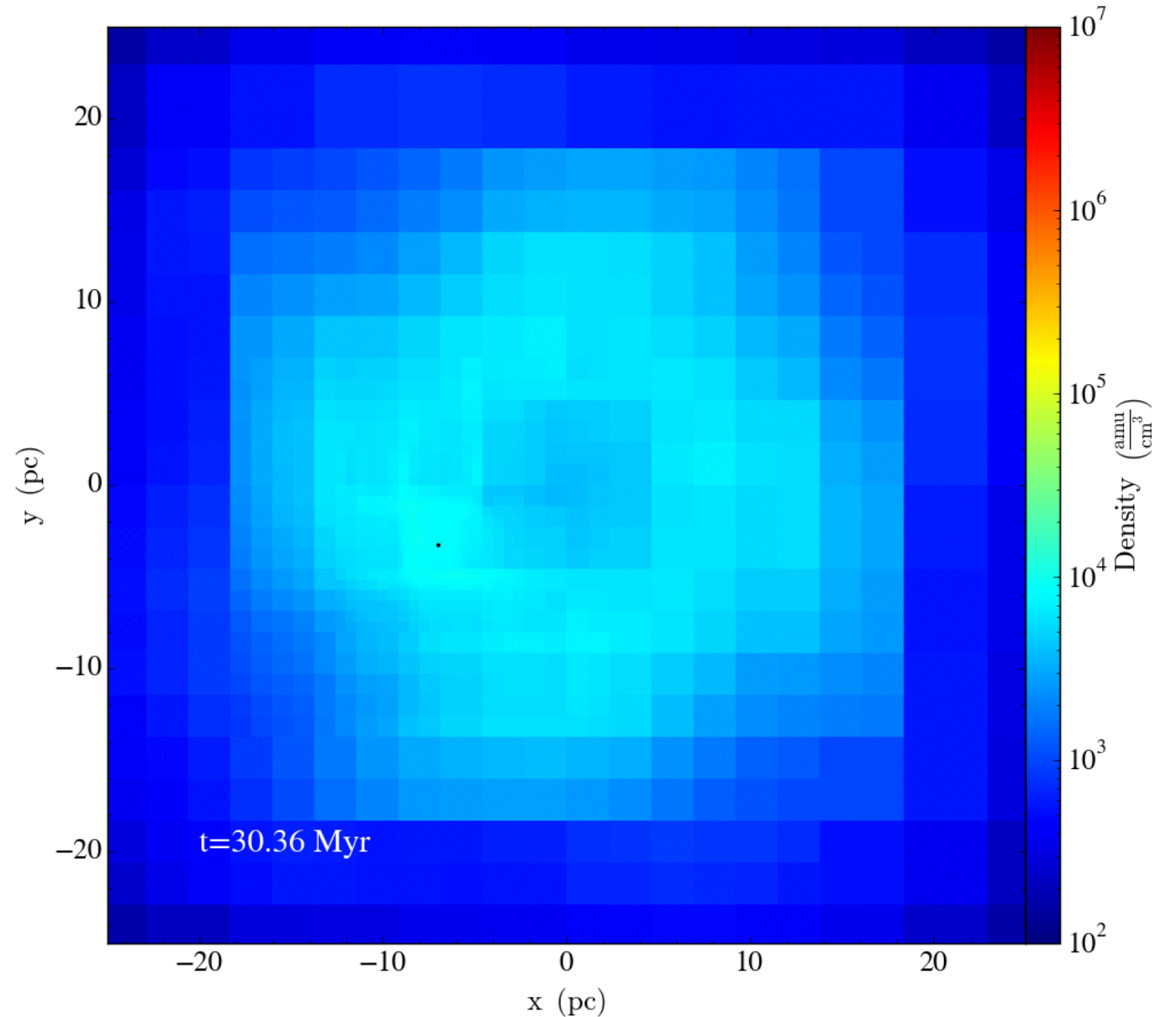
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RESULTS

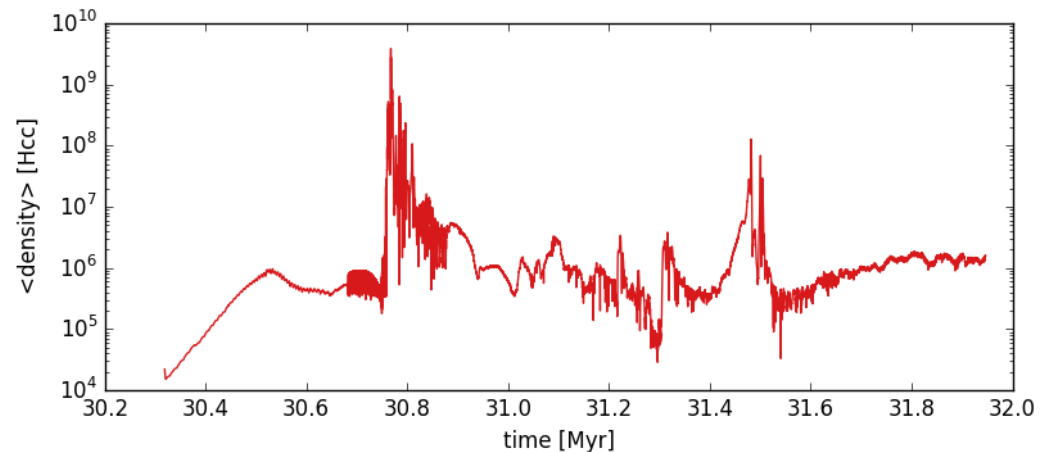
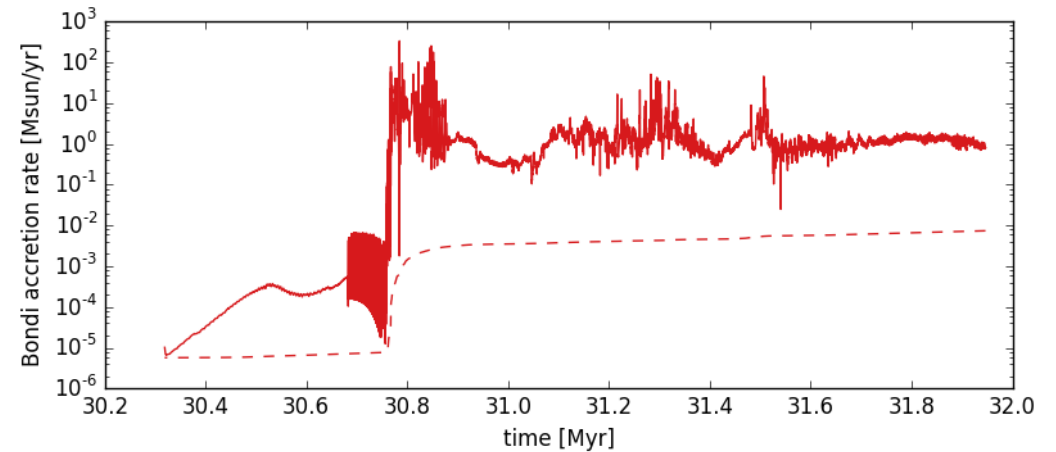
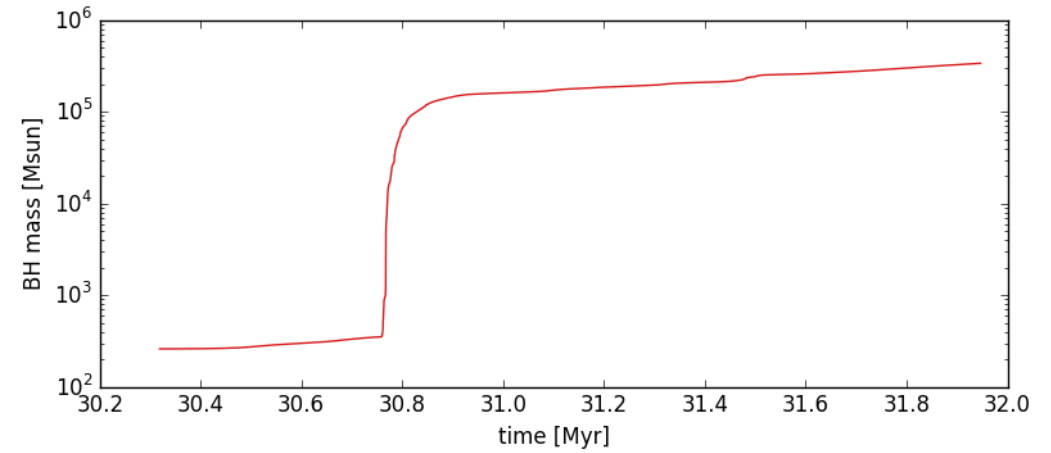
A test case: an isolated disc



A test case: an isolated disc

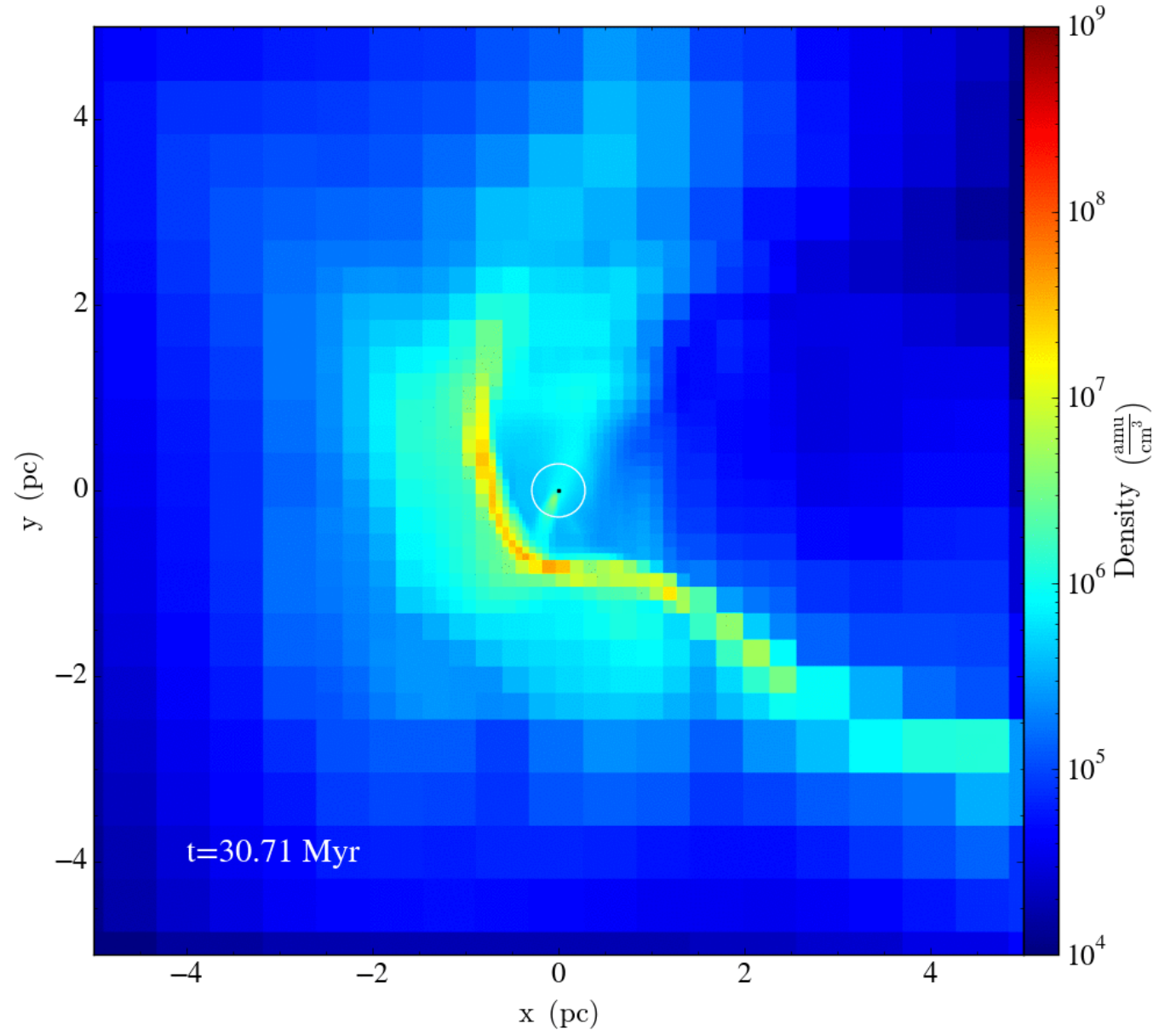


A test case: an isolated disc with a drag force

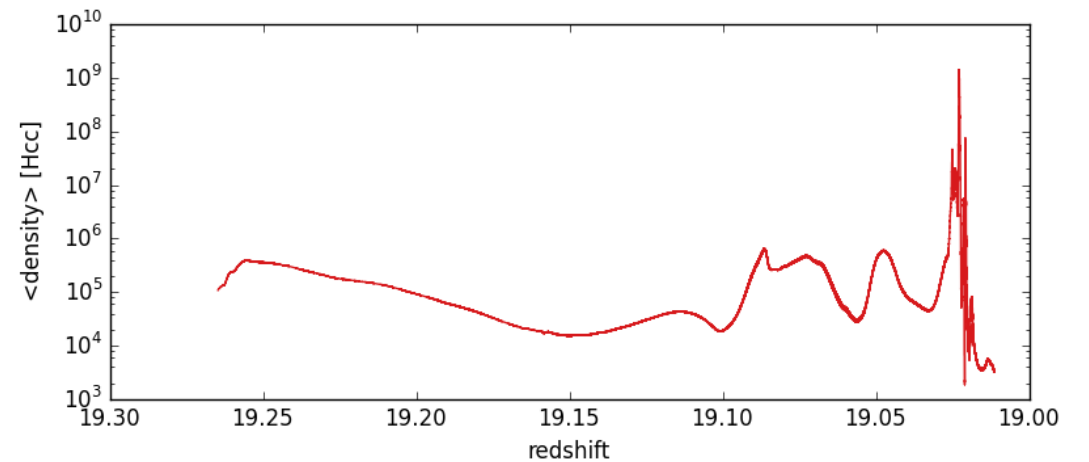
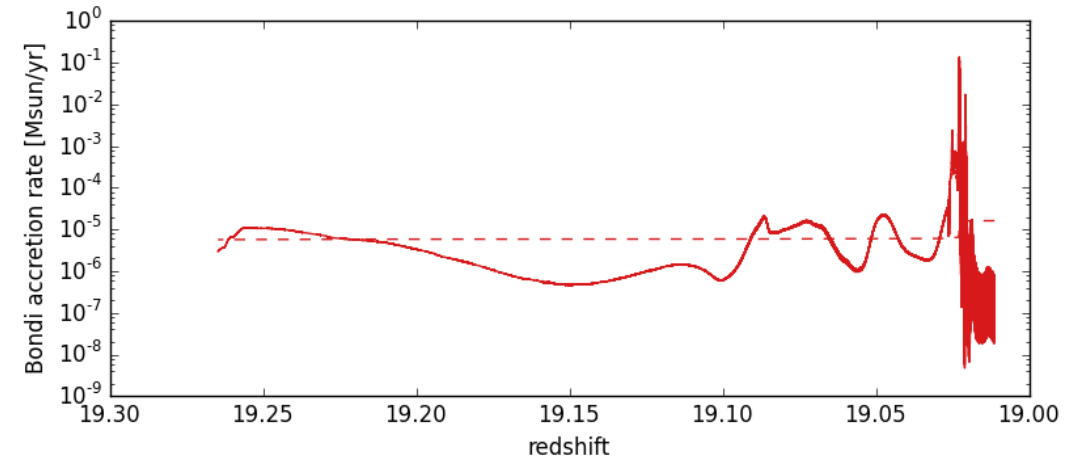
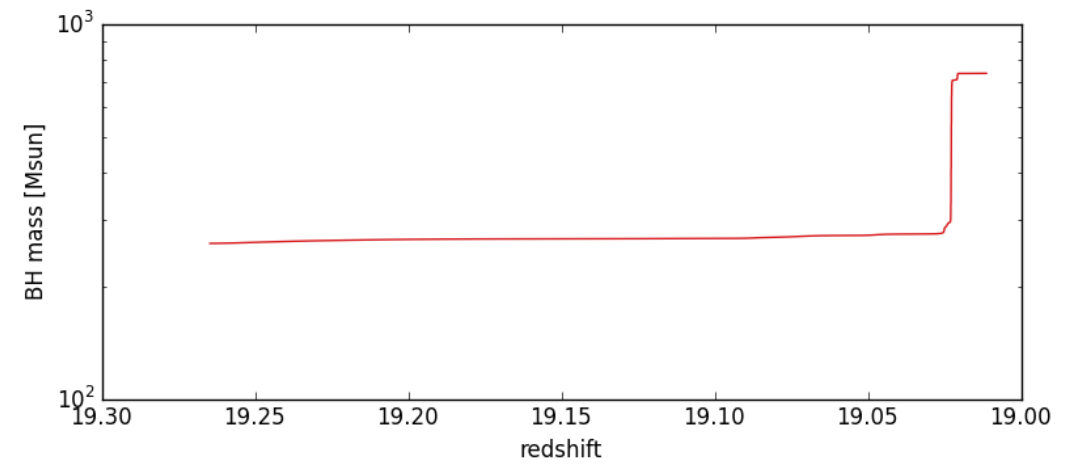


Drag force following Ostriker1999 &
Chapon2013

A test case:
an isolated disc
with a drag force



SNEAK PEEK: The cosmological simulation



Thank you