Lyra

Self-interacting dark matter:
What dwarf galaxies can teach us about our Universe

THALES A GUTCKE

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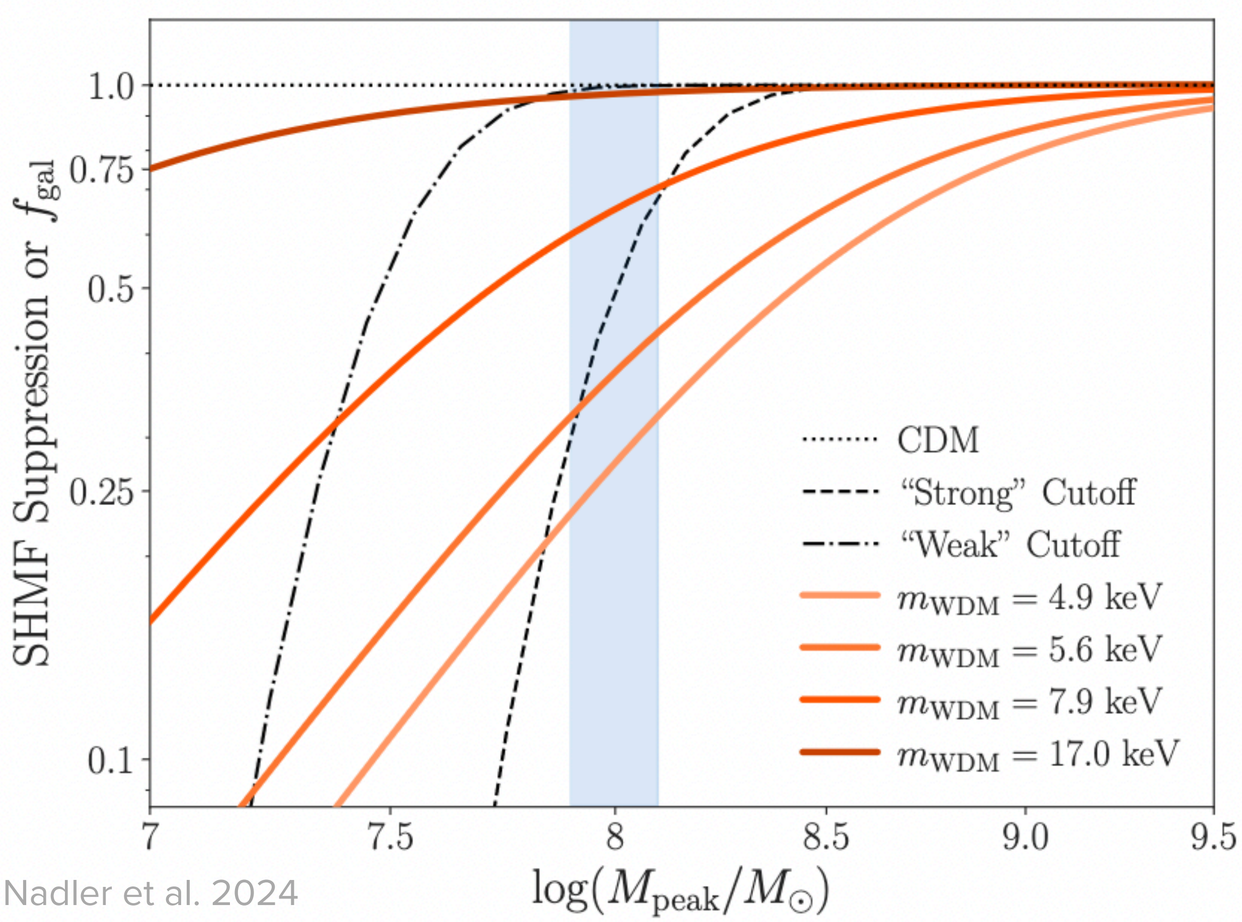
RELEVANCE OF DWARF GALAXIES FOR DARK MATTER RESEARCH

- One of the tightest **constraints on dark matter** models
- Cusp - core question at the centers of dwarf galaxies
- Constrains **feedback** models
- **Smallest dwarfs** might provide the tightest constraints

WHICH DWARFS CONSTRAIN DM BEST?



Nadler et al. 2024

EXPLOSION OF DWARF GALAXY RESEARCH BEYOND THE LOCAL GROUP

Until now:

- <100 dwarfs known fainter than M_V > -10
- Almost all associated with galaxy/cluster

Now:

- DESI - detection
- DECam - detection
- HST/JWST - follow up
- EUCLID - detection

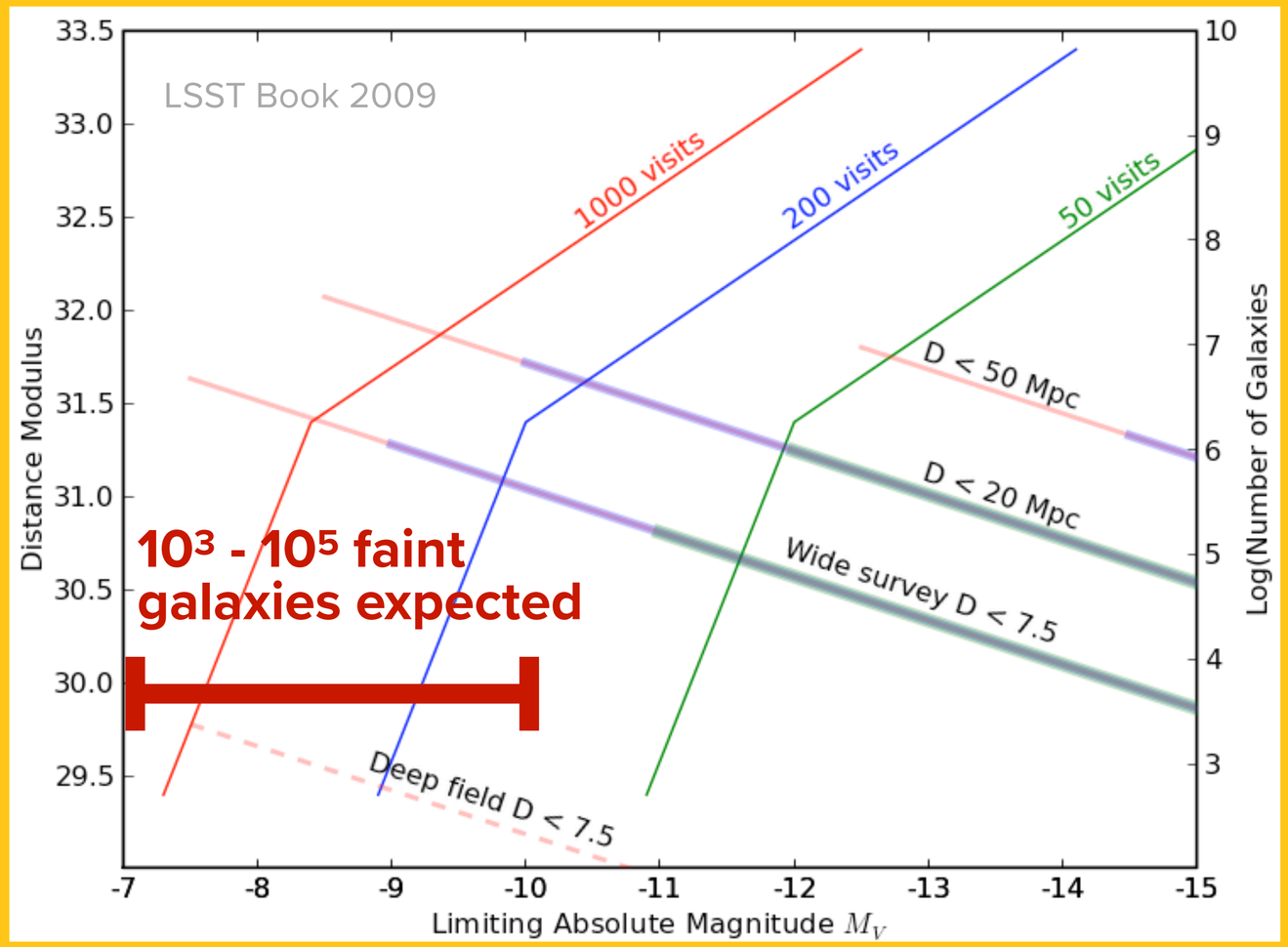
Soon:

- 4MOST - follow up
- Vera Rubin Observatory / LSST - detection
- Roman telescope

Future:

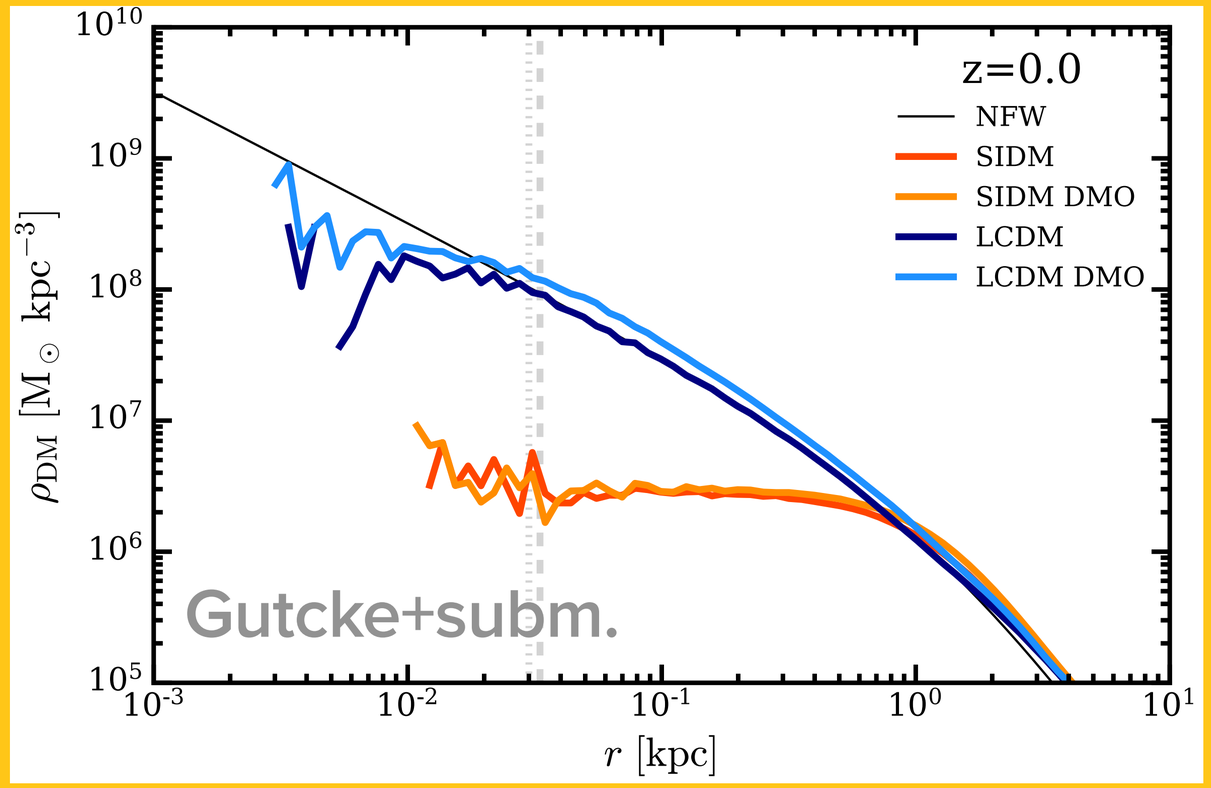
- Wide-field spectroscopic telescope
- Arrakhis satellite

DWARF GALAXIES WITH RUBIN

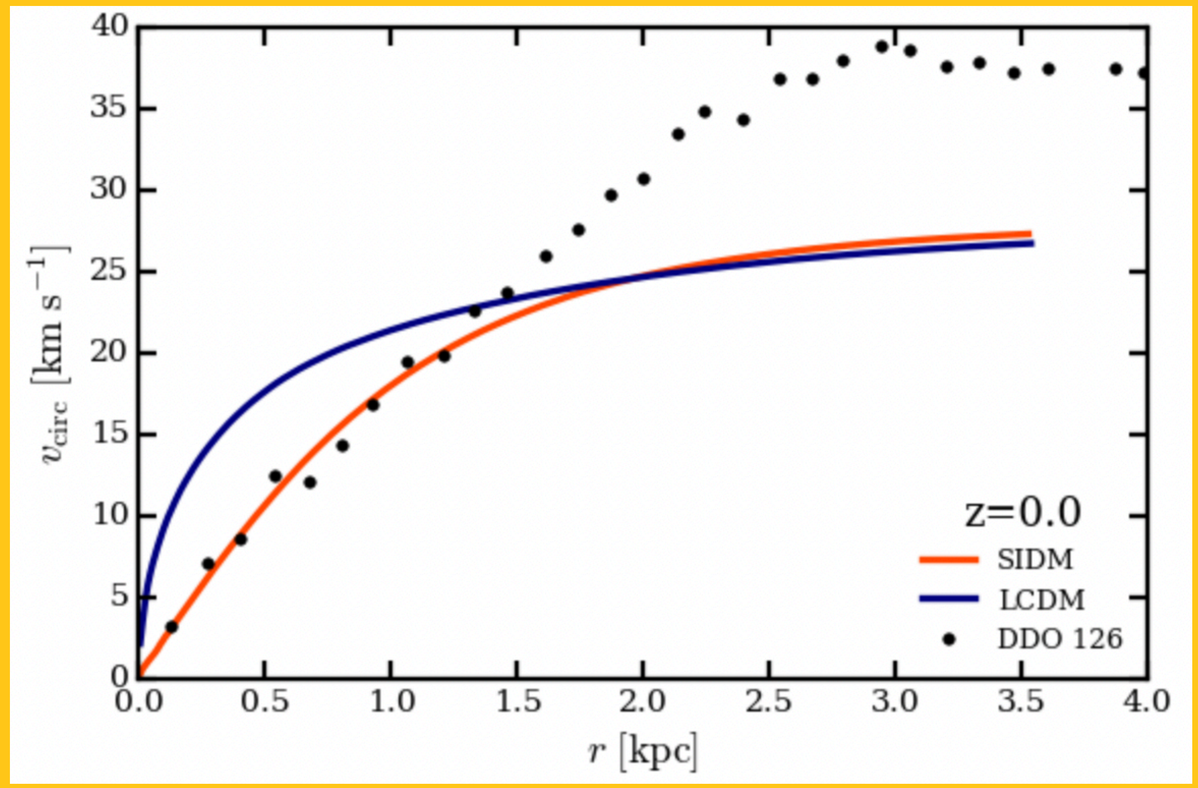


DM DENSITY PROFILE AND ROTATION CURVE

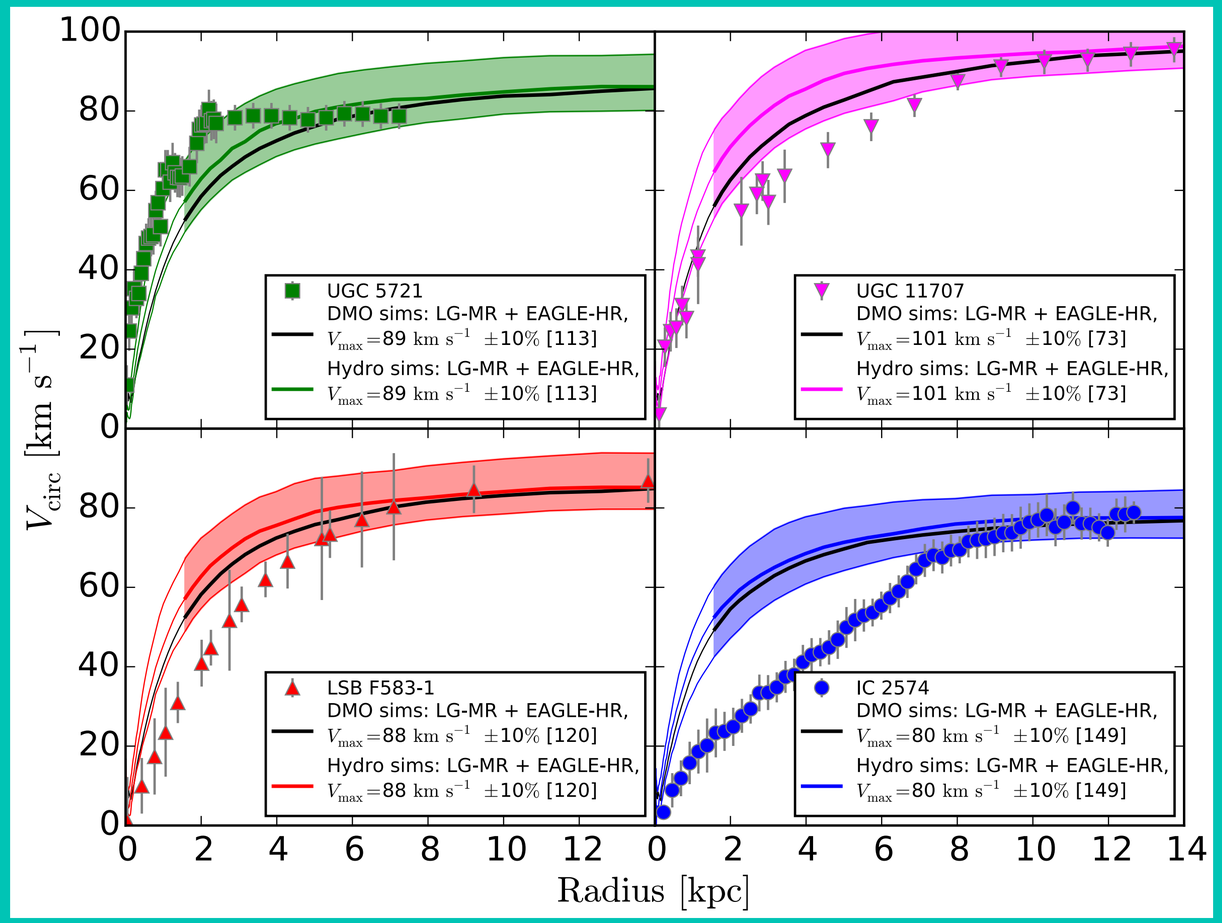
DM profiles at z=0



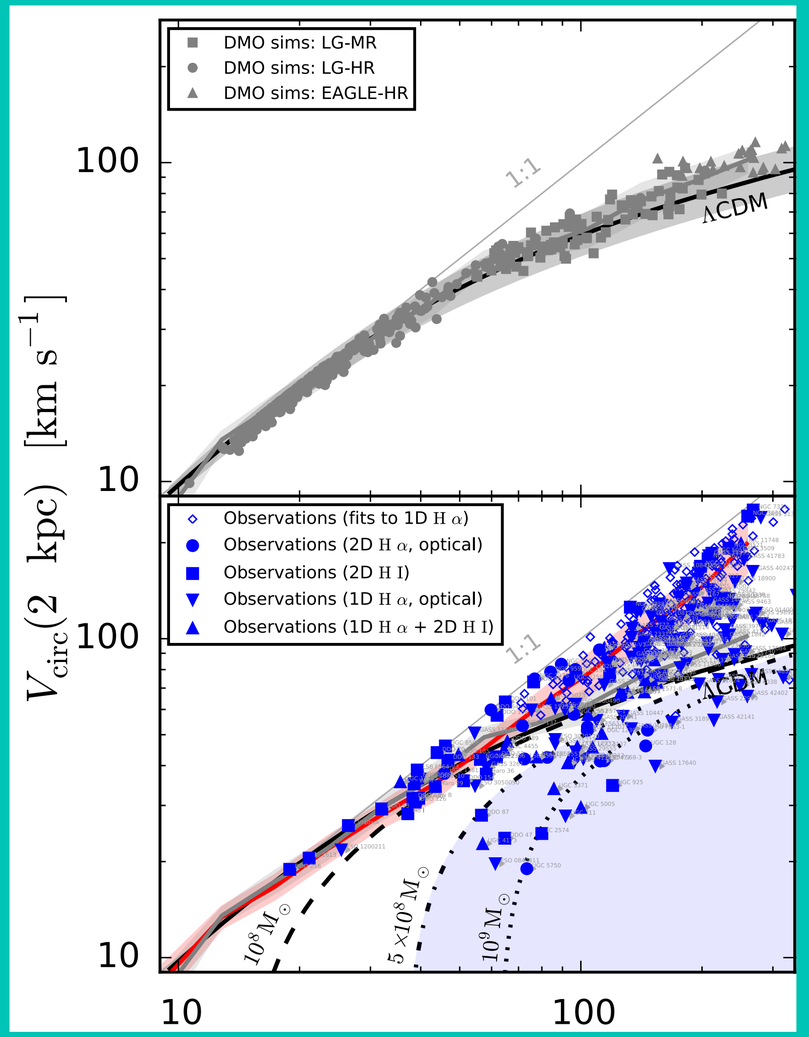
Rotation curves



DIVERSITY OF DWARF GALAXIES



Oman et al. 2022

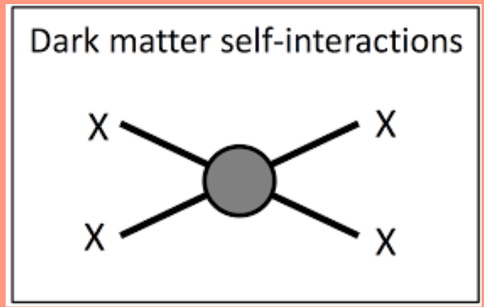


All flat

Some flat, some peaked

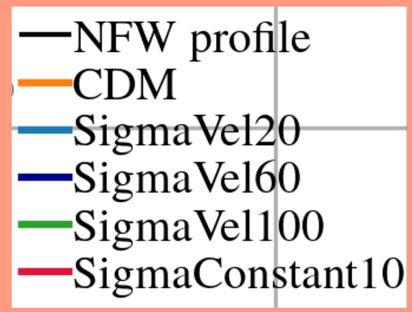
SELF – INTERACTING DARK MATTER (SIDM)

- Proposed interaction between dark matter particles
  - Requires invoking a new gauge boson
  - Allows scattering or annihilation of dark matter

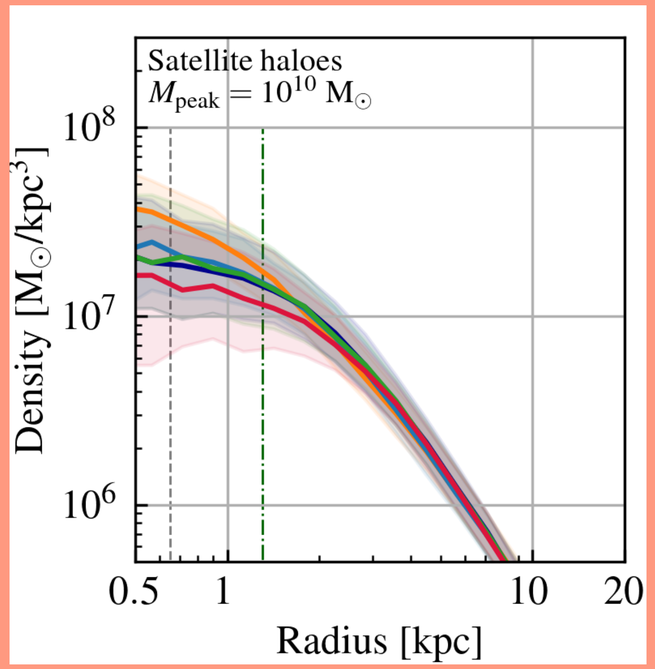


- Most common parameter is the scattering cross section
  - Now often includes a velocity dependency

- Mostly testing as dark matter-only
  - Need to study with baryonic physics!



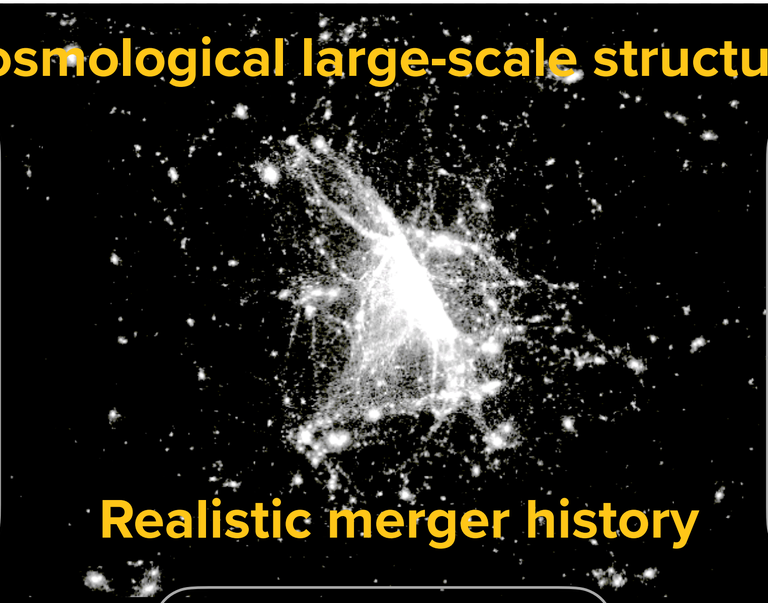
Correa et al. 2022



THE Lyra MODEL

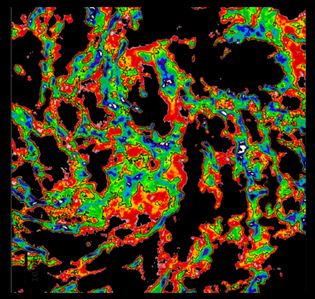
Model (Gutcke+2021)
built within AREPO code

Cosmological large-scale structure



Realistic merger history

Multi-phase ISM

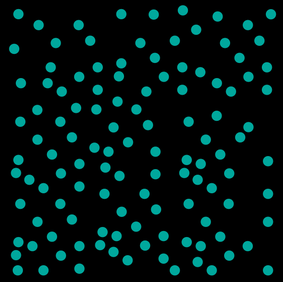


Molecular clouds

Individual stars

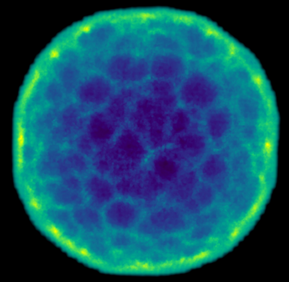
follow IMF

Metal seeding



in PopIII halos

Resolved



supernovae

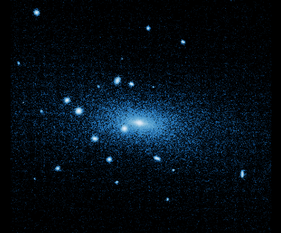
Discrete

Fe Si C H Mg He O N

chemical yields

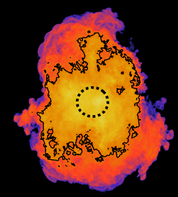
Emergent features

Star clusters



Clustered SNe

SN-driven outflows

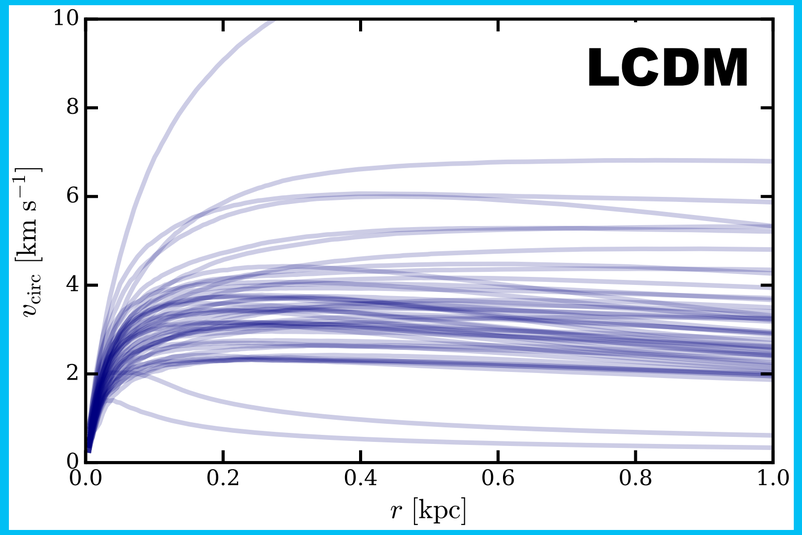


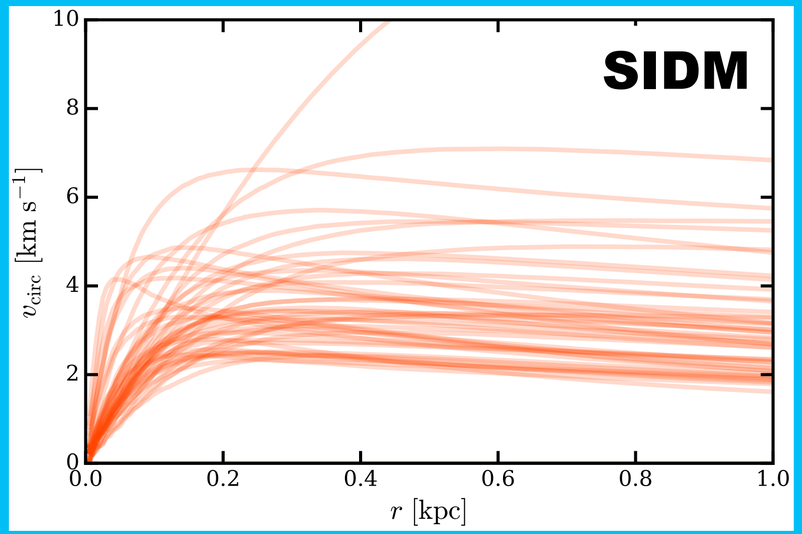
Realistic CGM

DIVERSITY OF ROTATION CURVES WITH SIDM

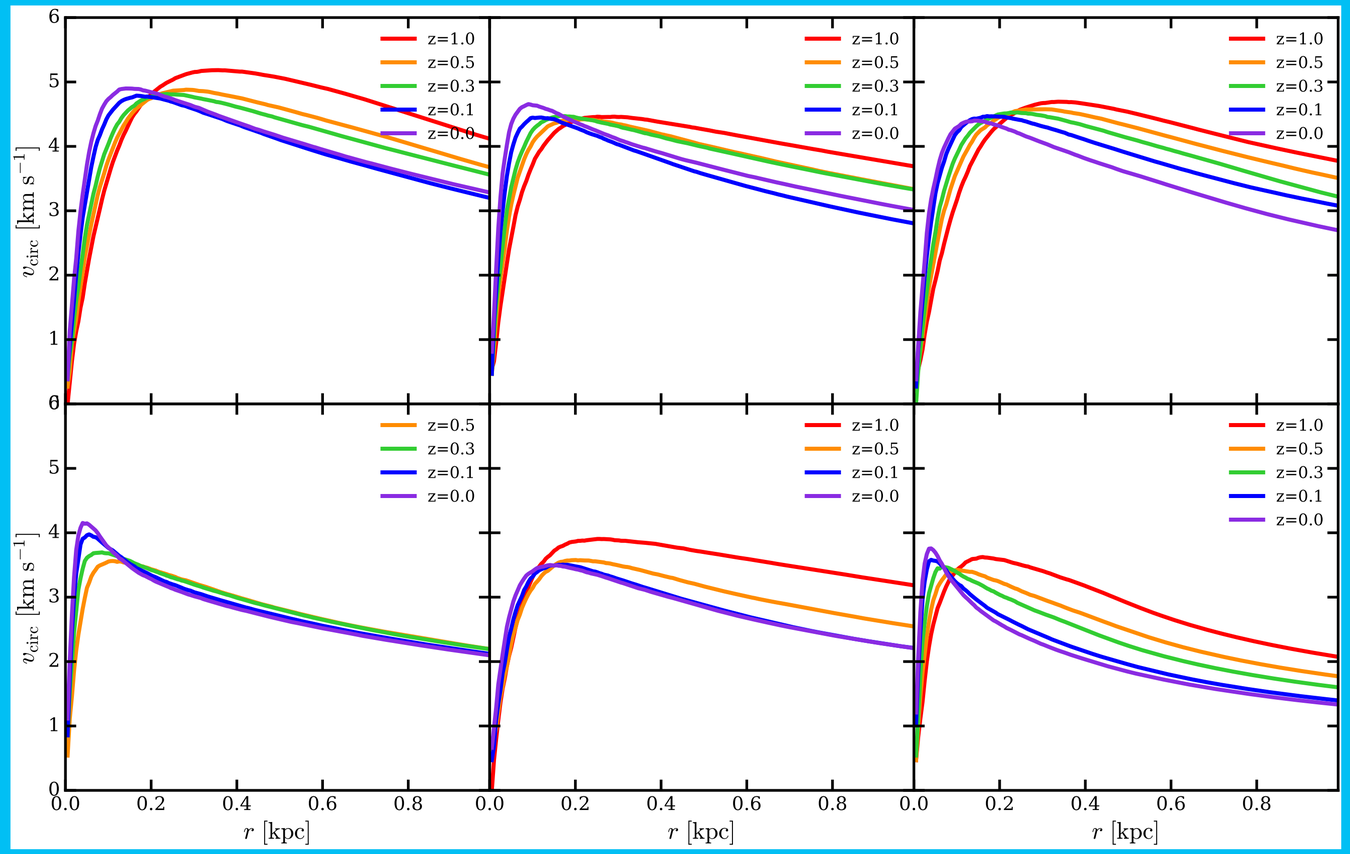
All flat

Some flat, some peaked





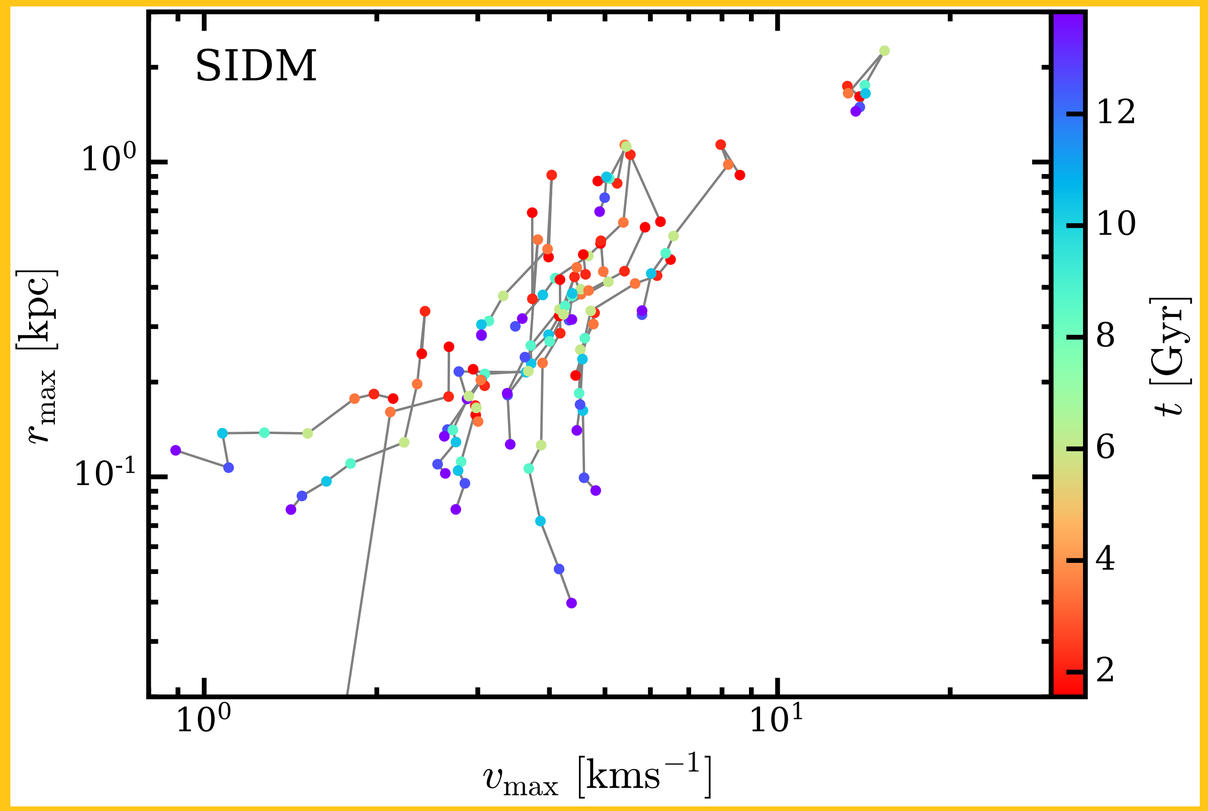
Core-collapsing subhalos



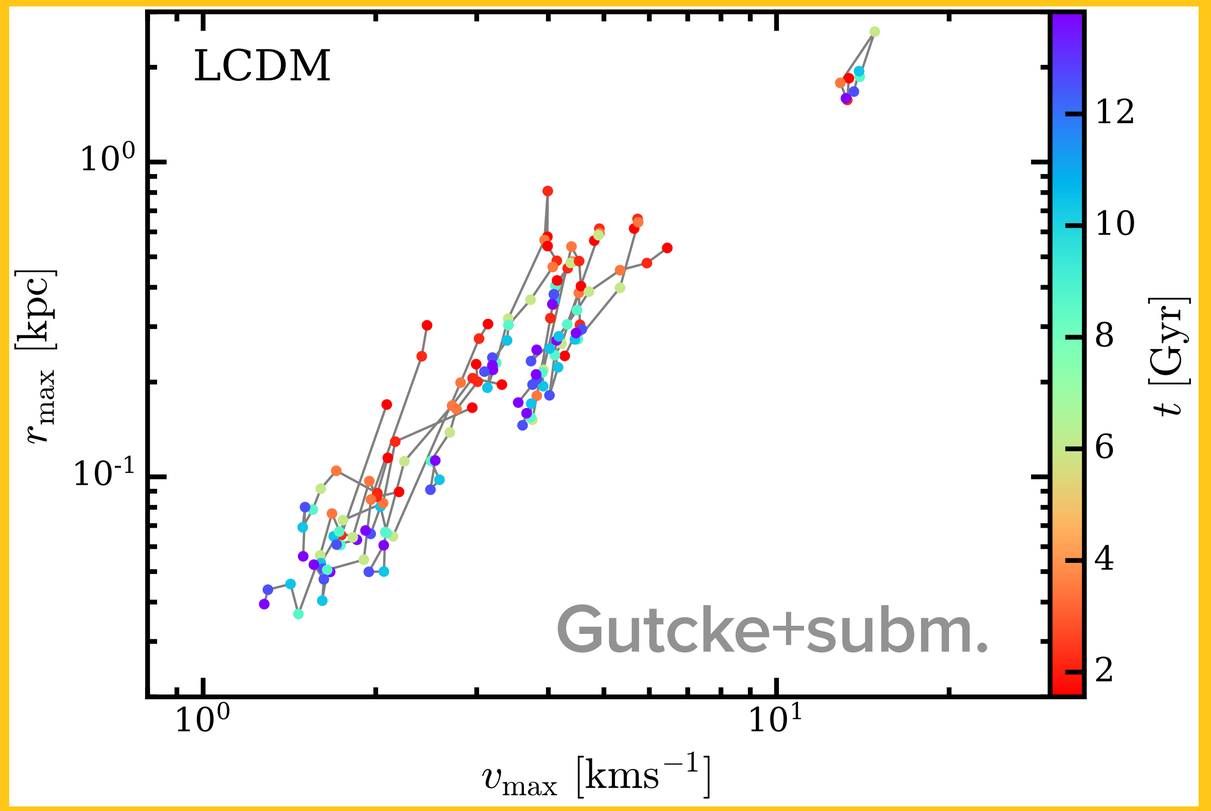
Gutcke+subm.

CORE-COLLAPSED SATELLITES

SIDM

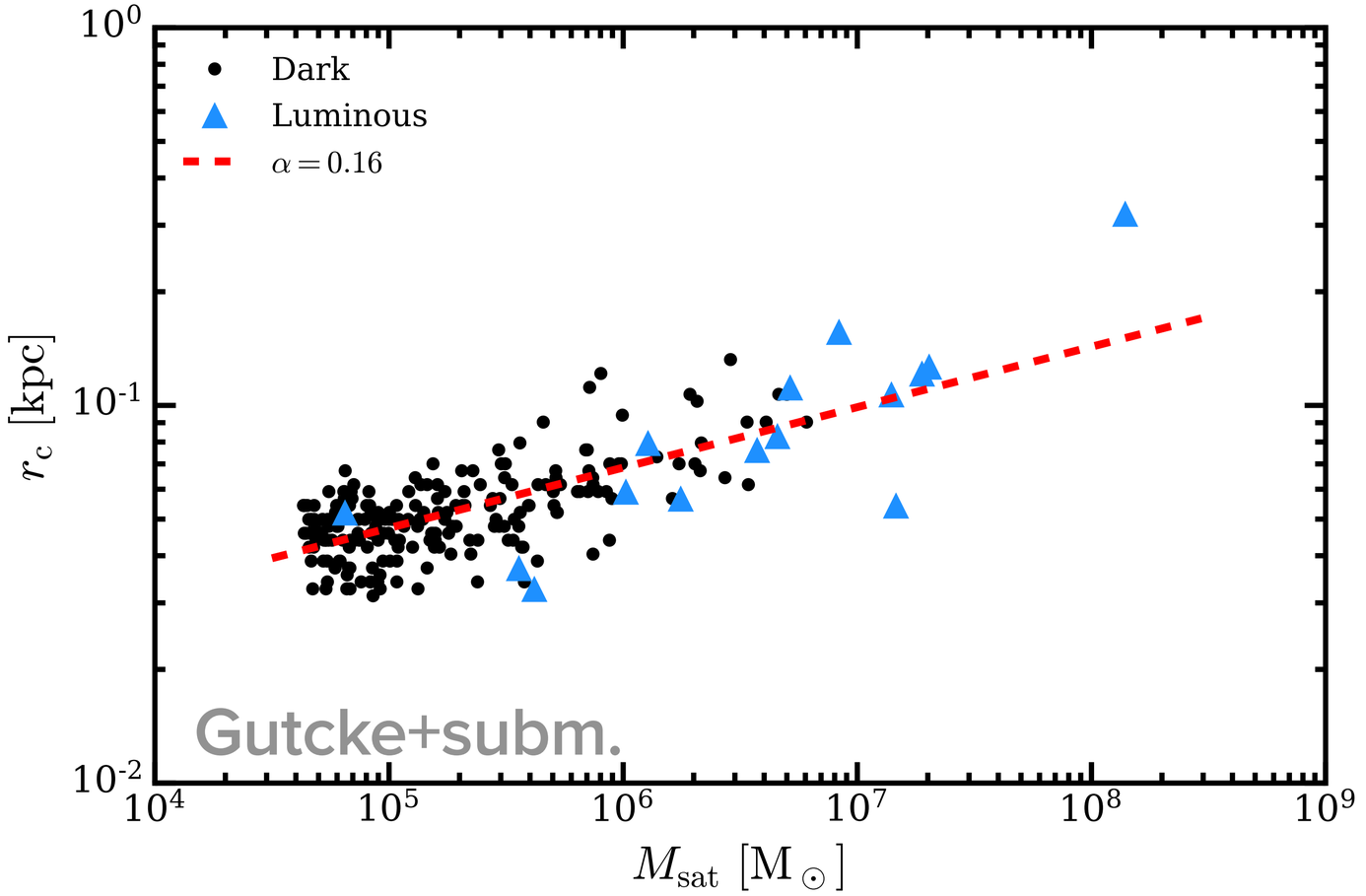


LCDM



CORE SIZES IN SATELLITES

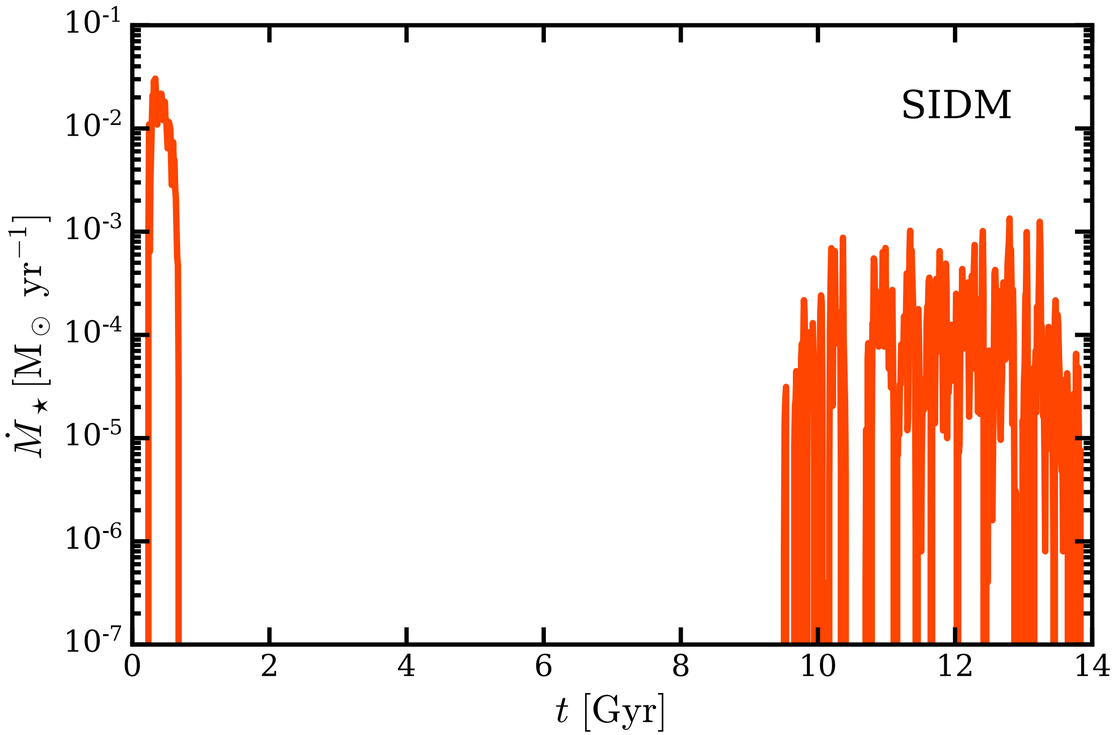
Power law relation between core size and dynamical mass

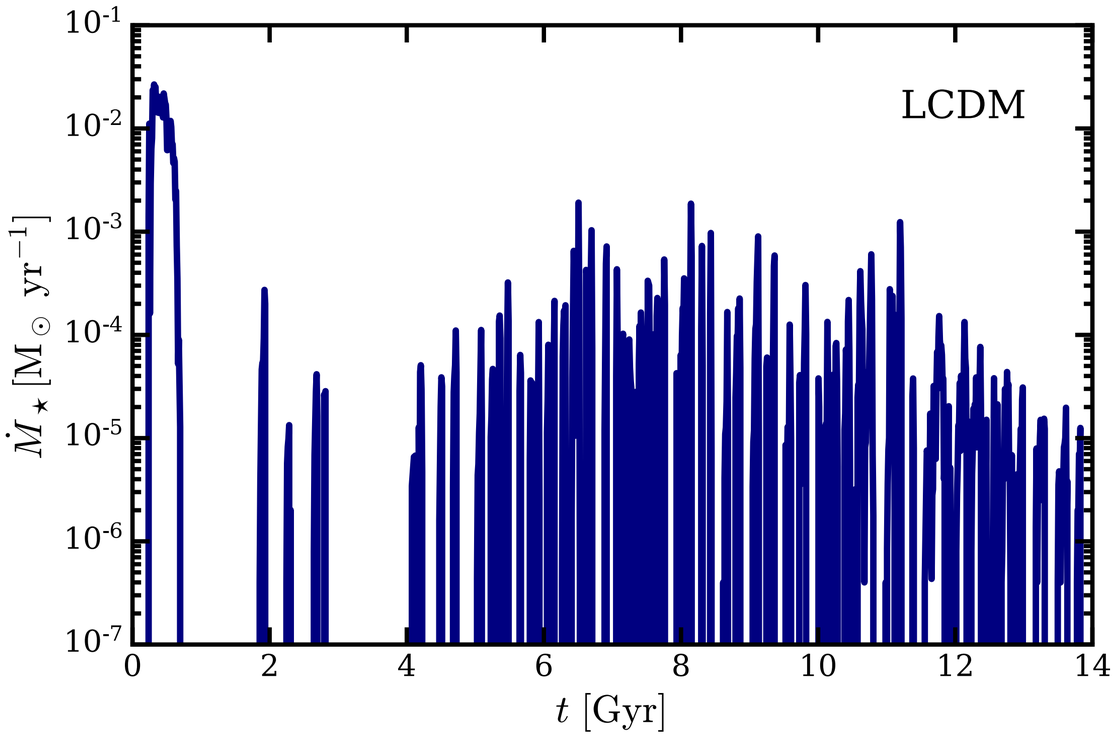


LOOKING AT THE CENTRAL GALAXY

STAR FORMATION HISTORY IS DELAYED

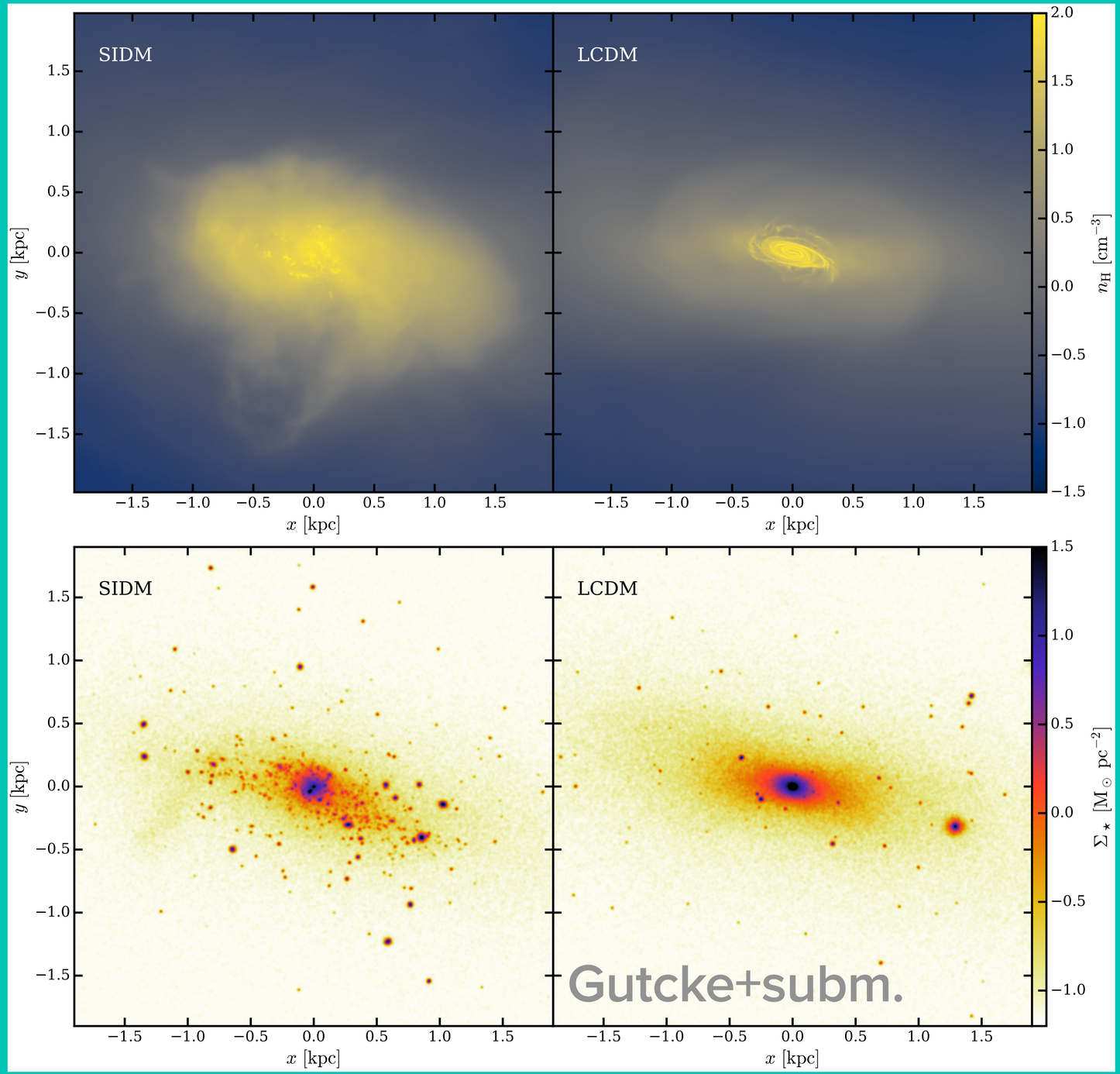
Gutcke+subm.





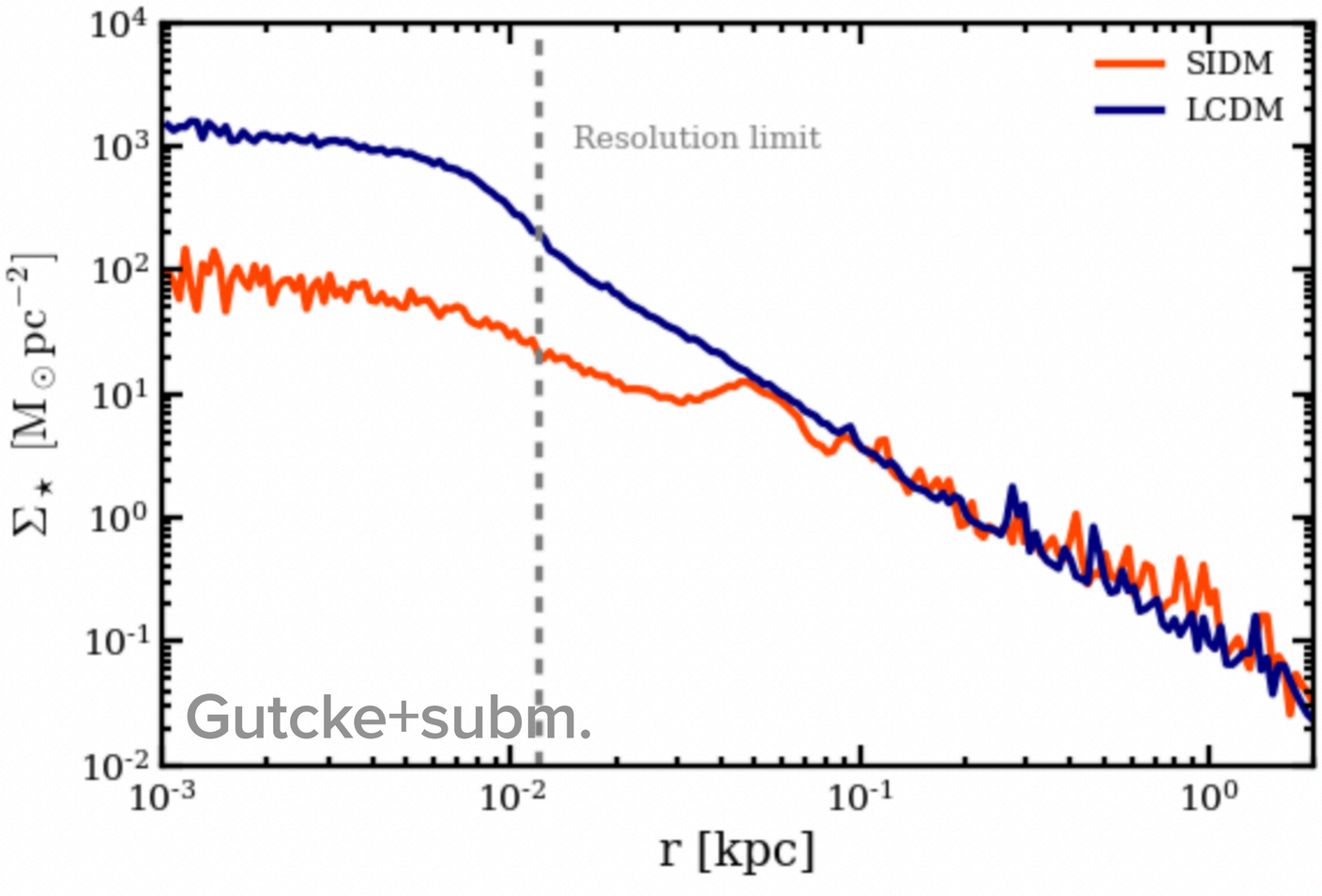
EFFECT OF SIDM ON GAS AND STARS

- Flatter core region allows gas to be extended
- Star formation occurs in various star forming regions
- Star clustering likely over-estimated to due lack of 2-body evaporation

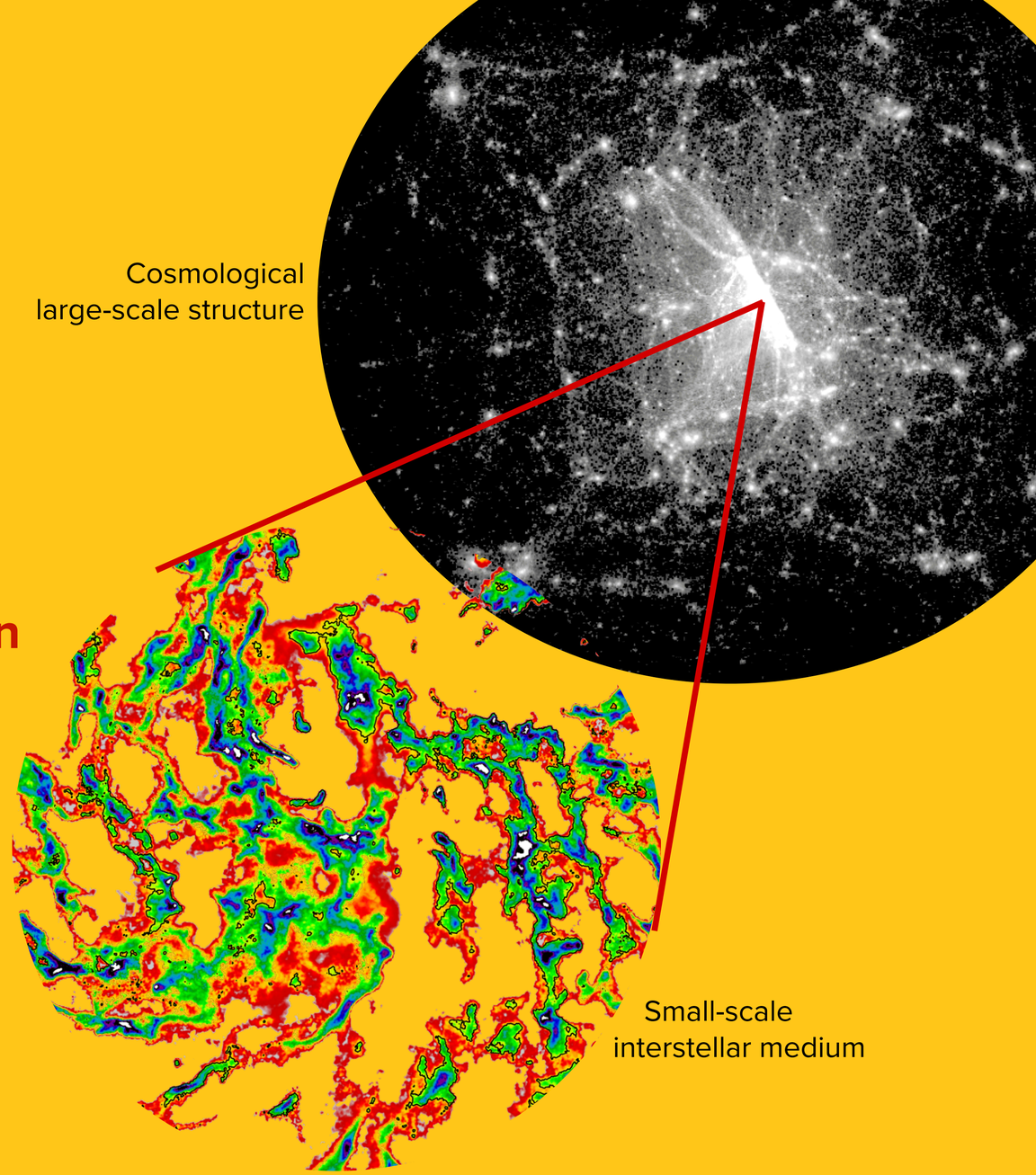


STELLAR SURFACE DENSITY

Observable reduction of stellar density in central region



SUMMARY



Lyra brings together small scale baryonic physics and the cosmological context providing a **novel testing ground for SIDM**

- Highly timely in light of **dwarf galaxy data explosion**
- Provides much needed spatial details to **constrain DM while including baryonic physics**

Model developments are ongoing

Let me know if you would like to **collaborate**!

NHFP NASA Hubble Fellowship Program

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