Dark Matter Annihilation in and around the First Galaxy Halos

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TAUP 2015, Torino

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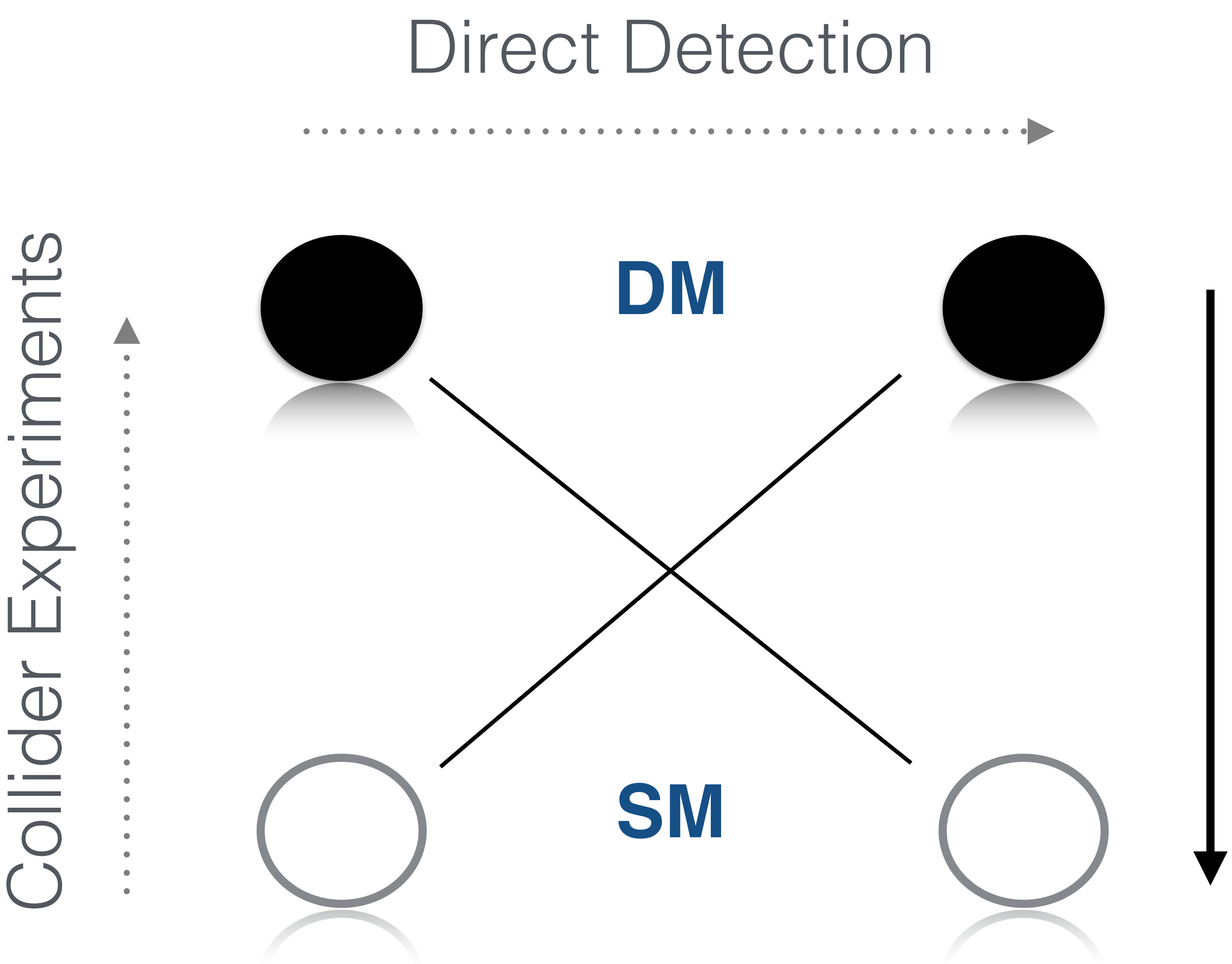
Indirect Dark Matter Searches



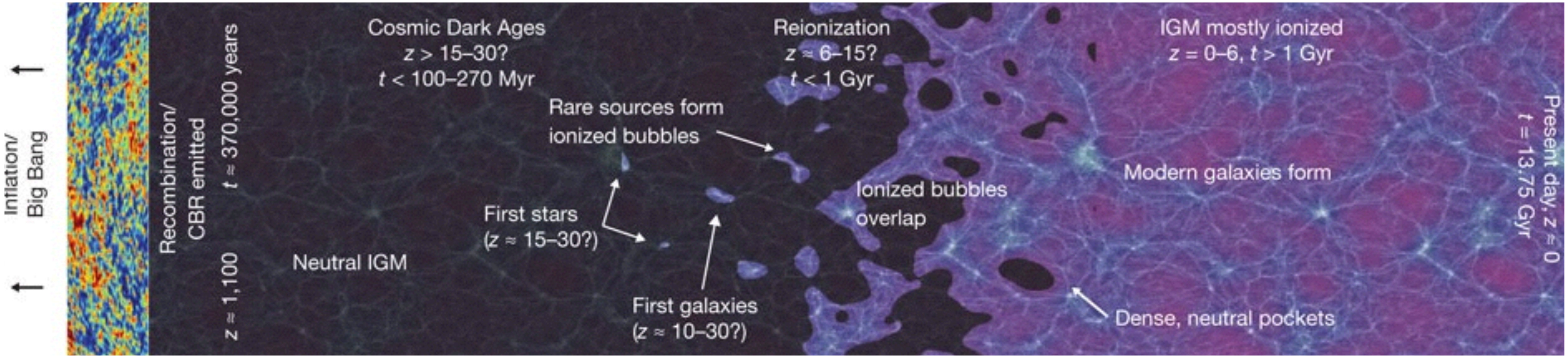
Indirect Detection

- Look for effects from standard model annihilation products
- i.e. particle excess from high DM density regions or cumulative, global signals

High Redshift Searches

- Heating and ionisation from DM annihilation products may alter the evolution of the IGM which could subsequently be detectable through measurements of the 21-cm line emission

- Search during the Cosmic Dark Ages* and Era of Reionisation



* See poster by Cassandra Avram "Dark Matter Annihilation During Early Cosmic Times"

DM Annihilation and the IGM

DM annihilates

IGM is modified through additional heating and ionising component from DM

Change in 21-cm global signal and power spectrum

DM Annihilation and the IGM

DM annihilates

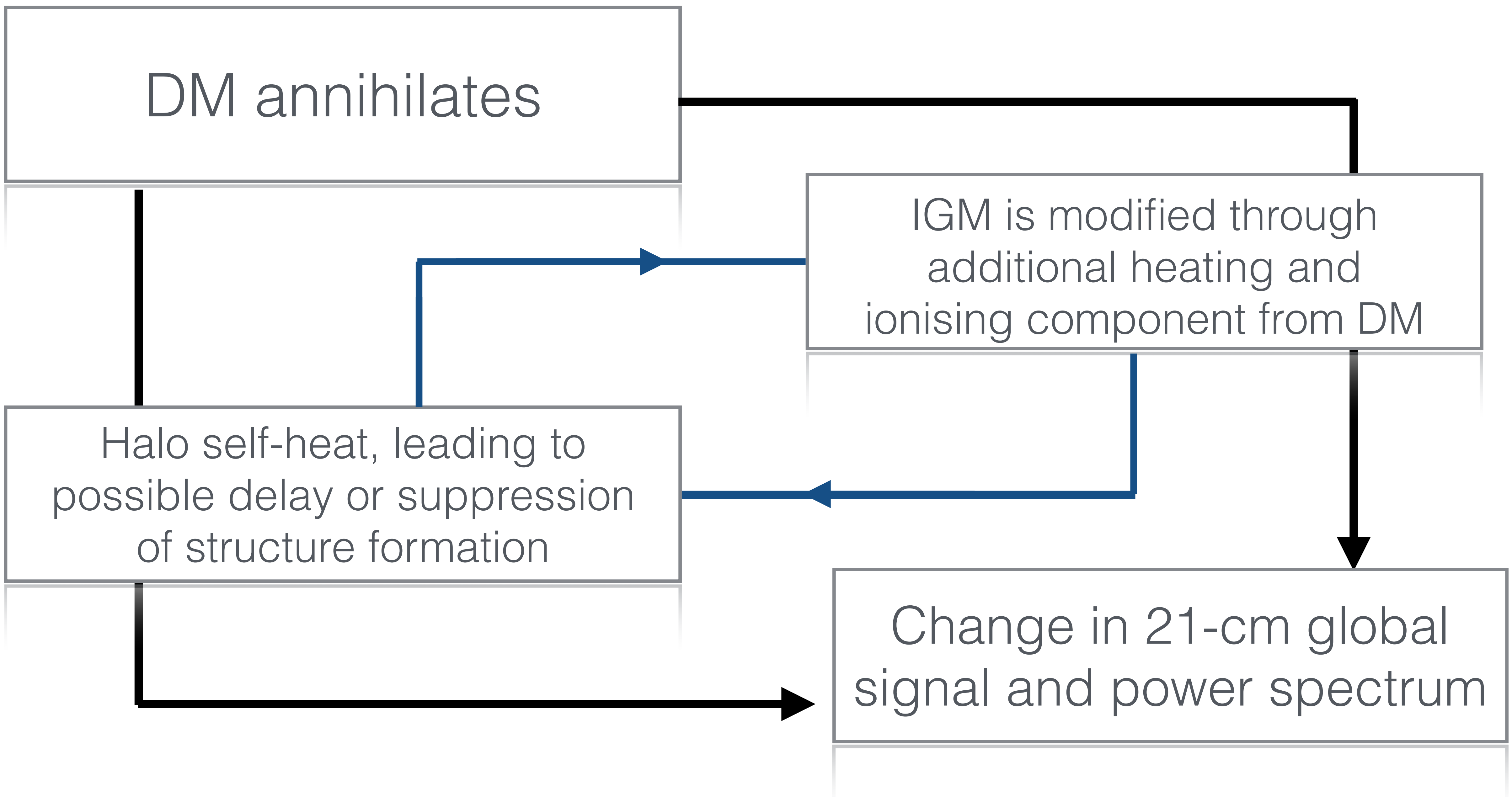
Astrophysical uncertainties can create degeneracies between a possible DM signal and standard phenomenology.

IGM is modified through additional heating and ionising component from DM

Energy from DM annihilation may also change early structure formation though "self-heating" halos

Change in 21-cm global signal and power spectrum

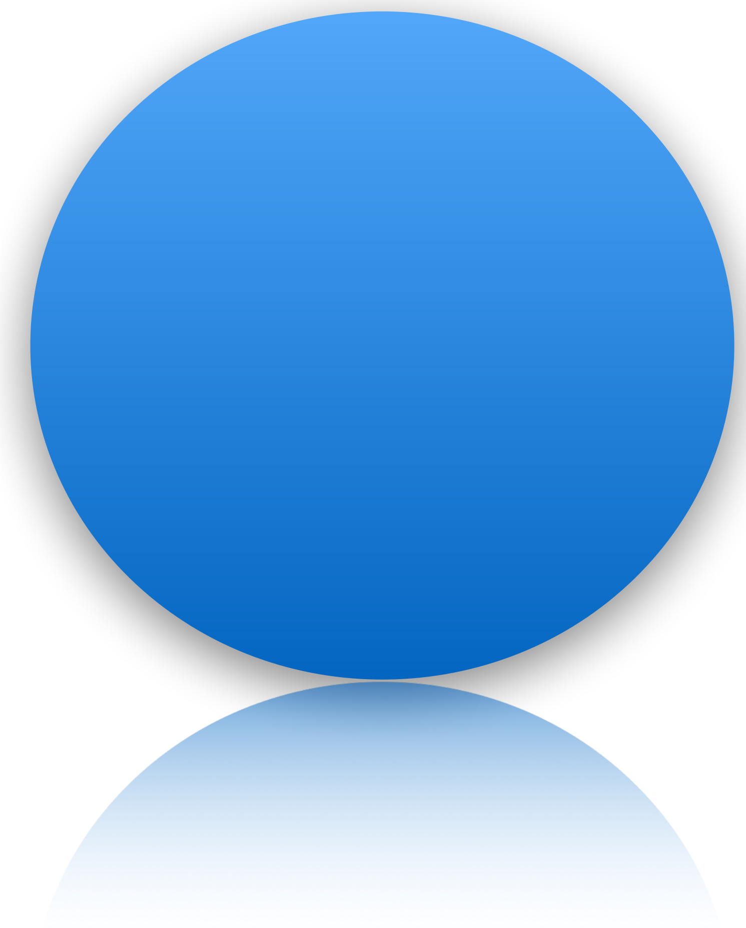
…with Modification of Structure Formation



Self-heating Halos

Requires:

- Dark Matter halo model
- Dark Matter particle model
- Energy Transfer scheme
- Compare gravitational binding energy of the gas of the halo to the energy transferred from DM annihilation over the Hubble time



also see Schon et al MNRAS, 2015

DM Particle Model

- Consider a SUSY neutralino type candidate, self-annihilating to standard model particles.

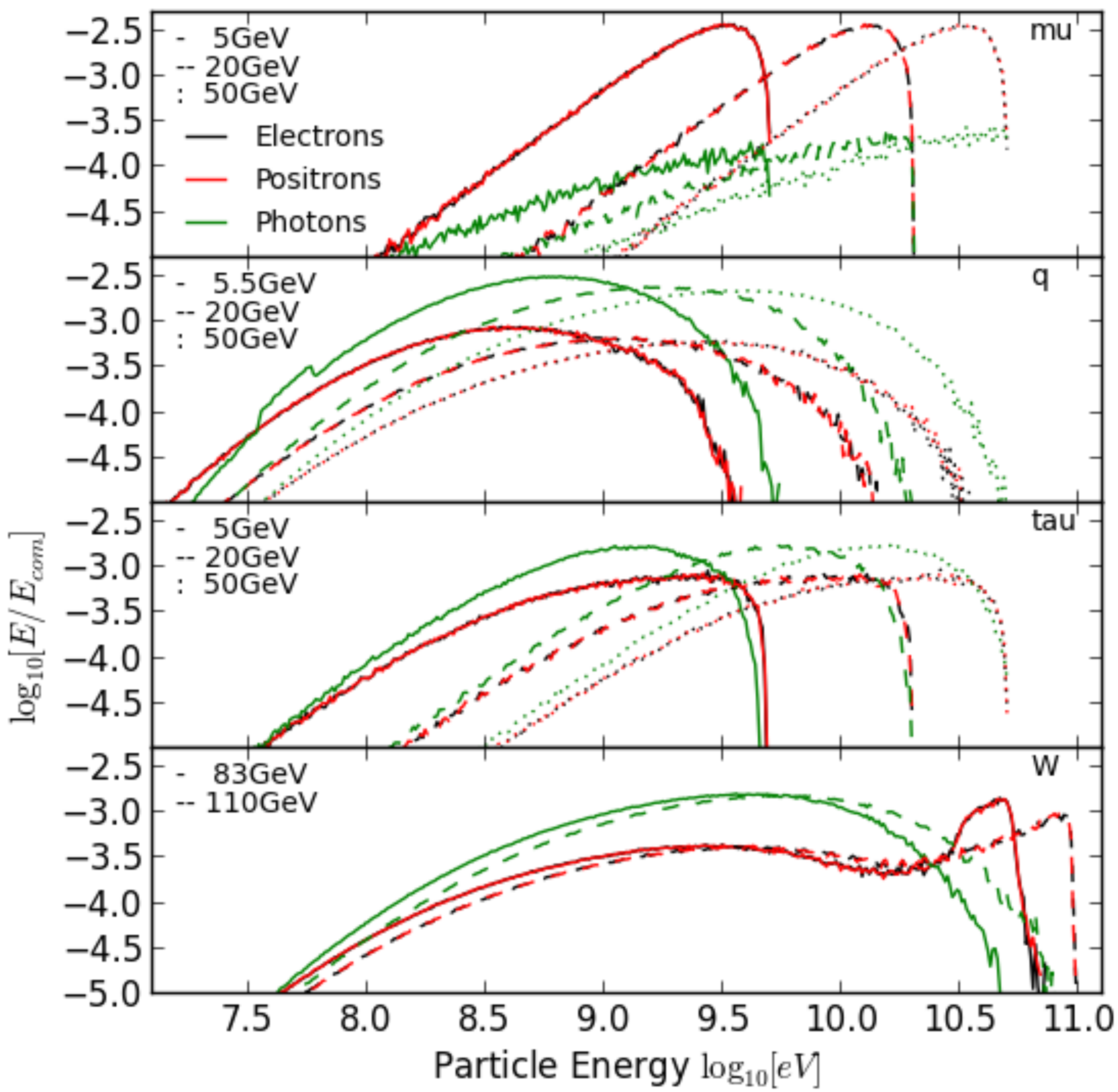
$$P_{dm} = \frac{c^2}{m_{dm}} < \bar{v\sigma} > \rho_{dm}^2$$

- Assume weak-interaction cross-section

- Use an electron/positron proxy in PYTHIA to simulate annihilation to either muon, quark, W or tau

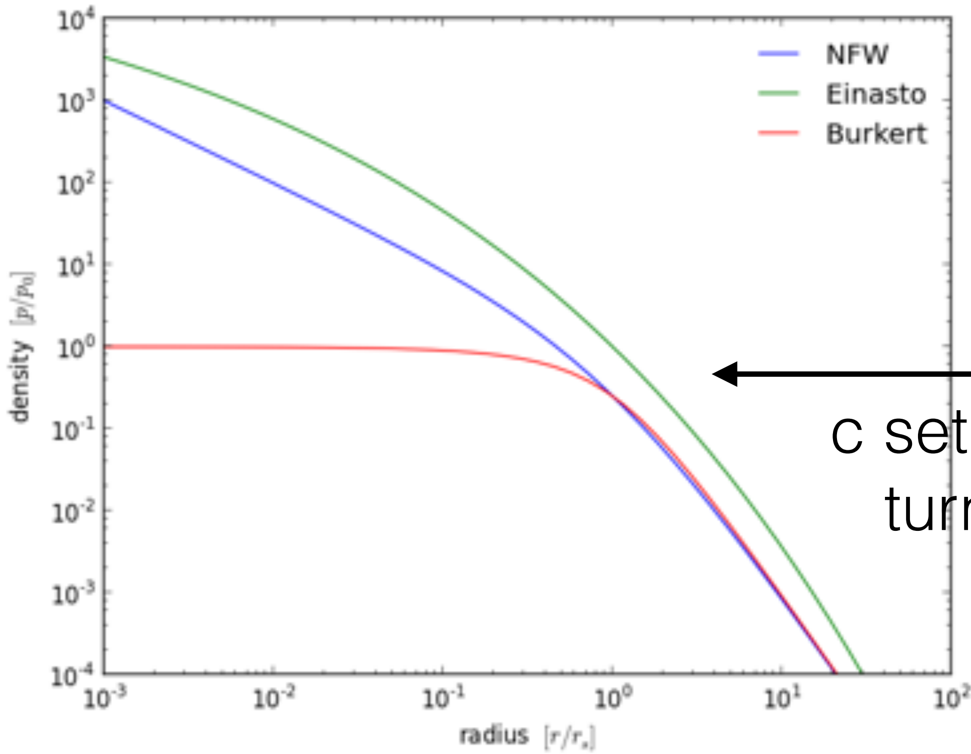
- Annihilation products are allowed to decay until only electrons, positron and photons remain

Injected Particles

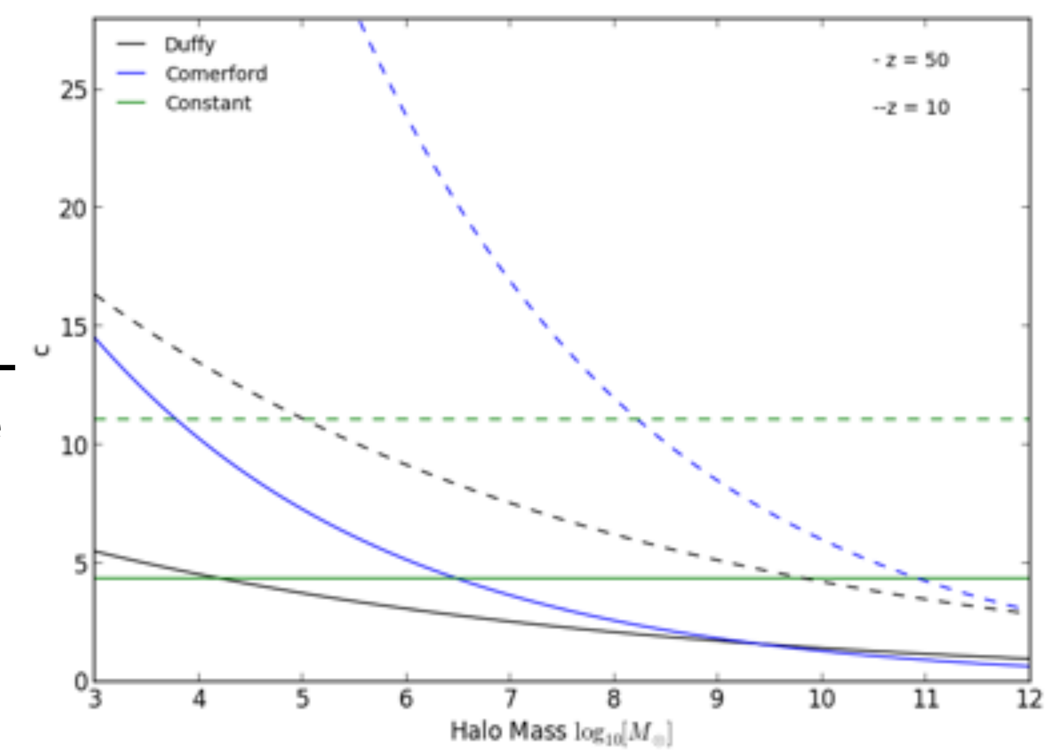


DM Halo Model

Compare cusp (NFW, Einasto) and core (Burkert) density profiles, with different mass-concentration relations.



c sets profile turn-over



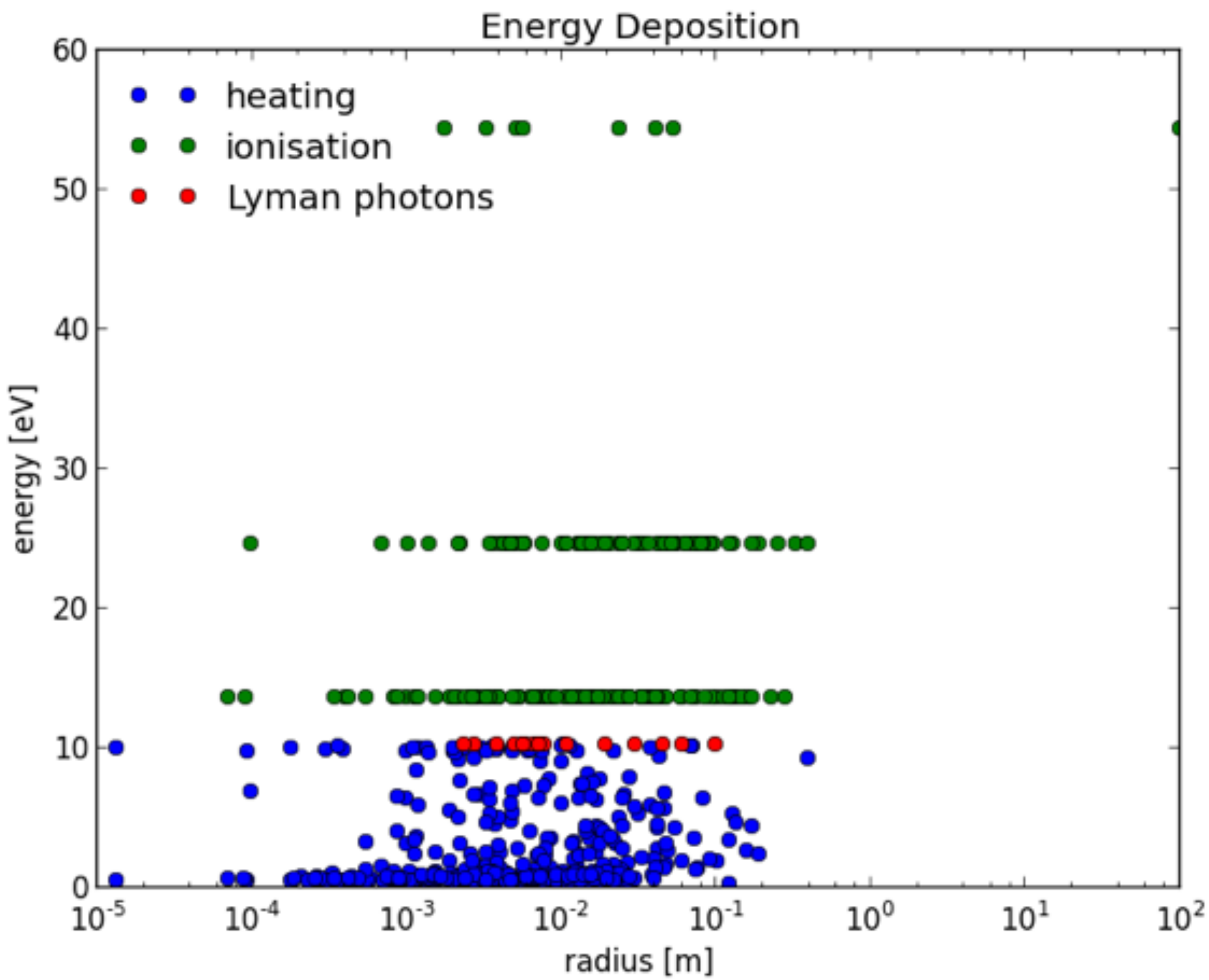
Central density paramount to total energy produced through annihilation

First Order Energy Transfer

- High energy injected particles' interactions with gas is non-trivial and dependent on the density, ionisation, temperature and species of the gas
- Create electromagnetic cascades with numerous secondary particles
- As a first order approach we calculate the energy loss of the primary particle as it travel through the halo and consider an absorption fraction of the secondary particles.

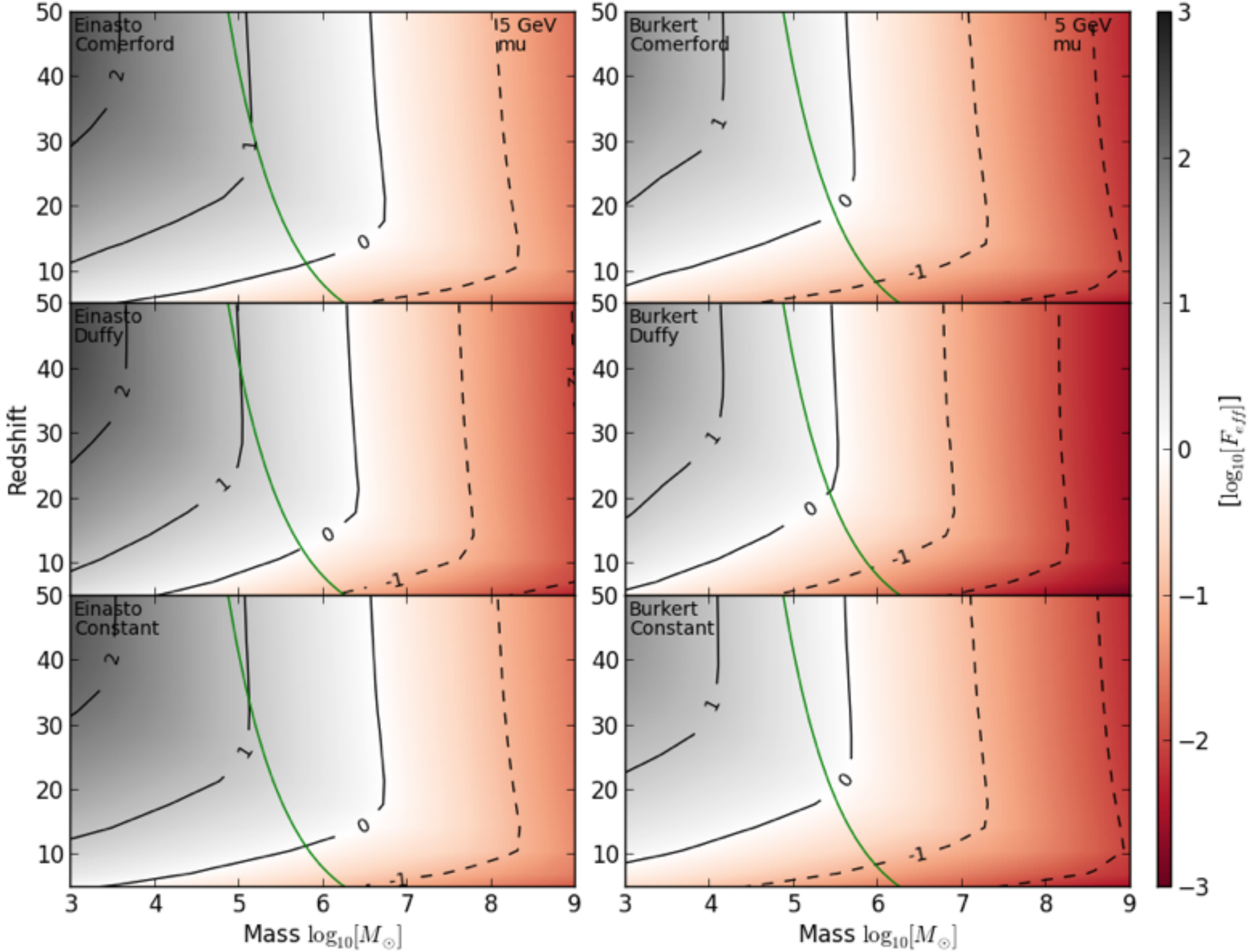
$$F_{eff} = \frac{U_{dm}(M,z)}{U_g(M,z)} T(M,z) f_{abs}$$

New Code for Energy Transfer

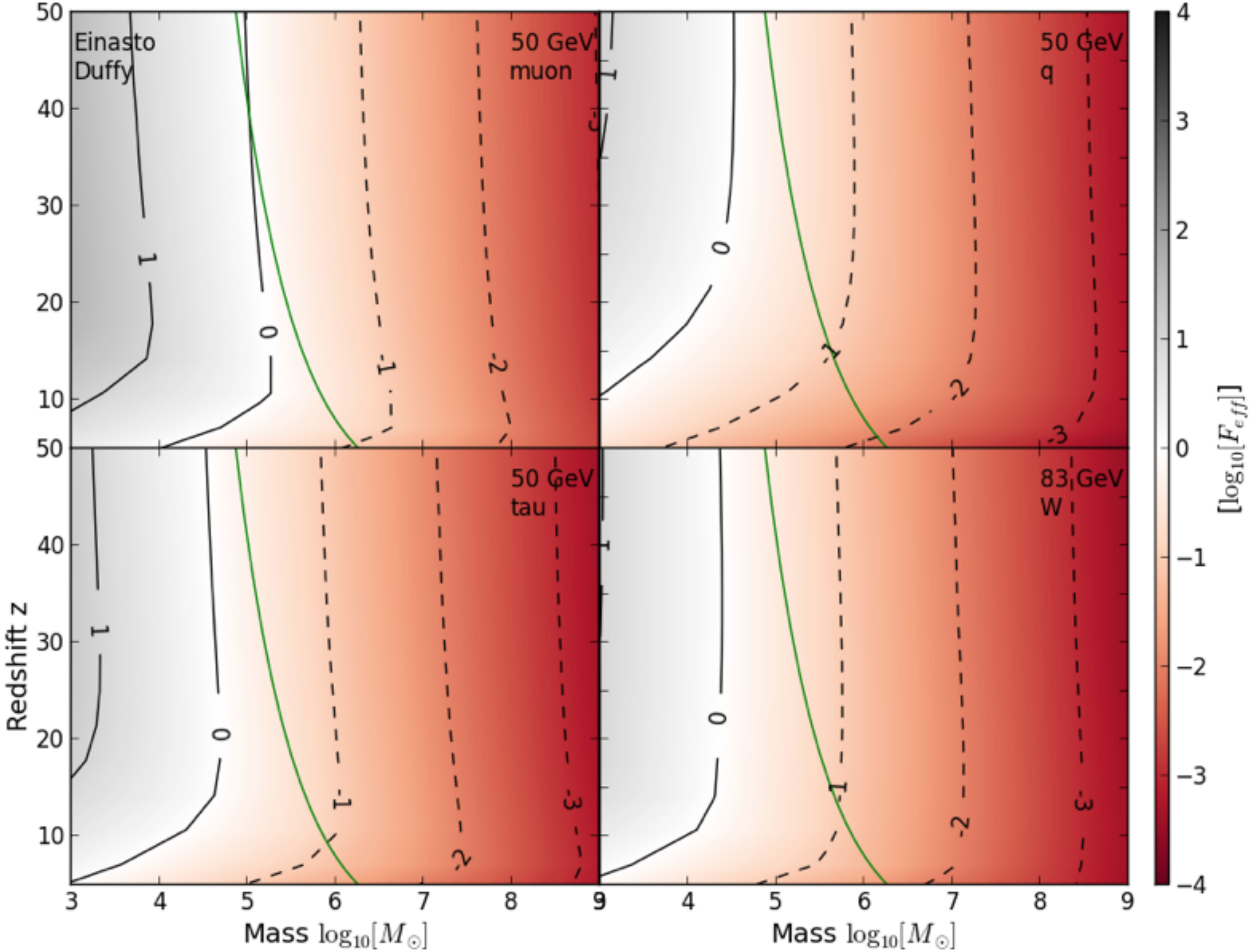


Update code for future work, to allow full realisation of electro-magnetic cascades in non-uniform gas density fields.

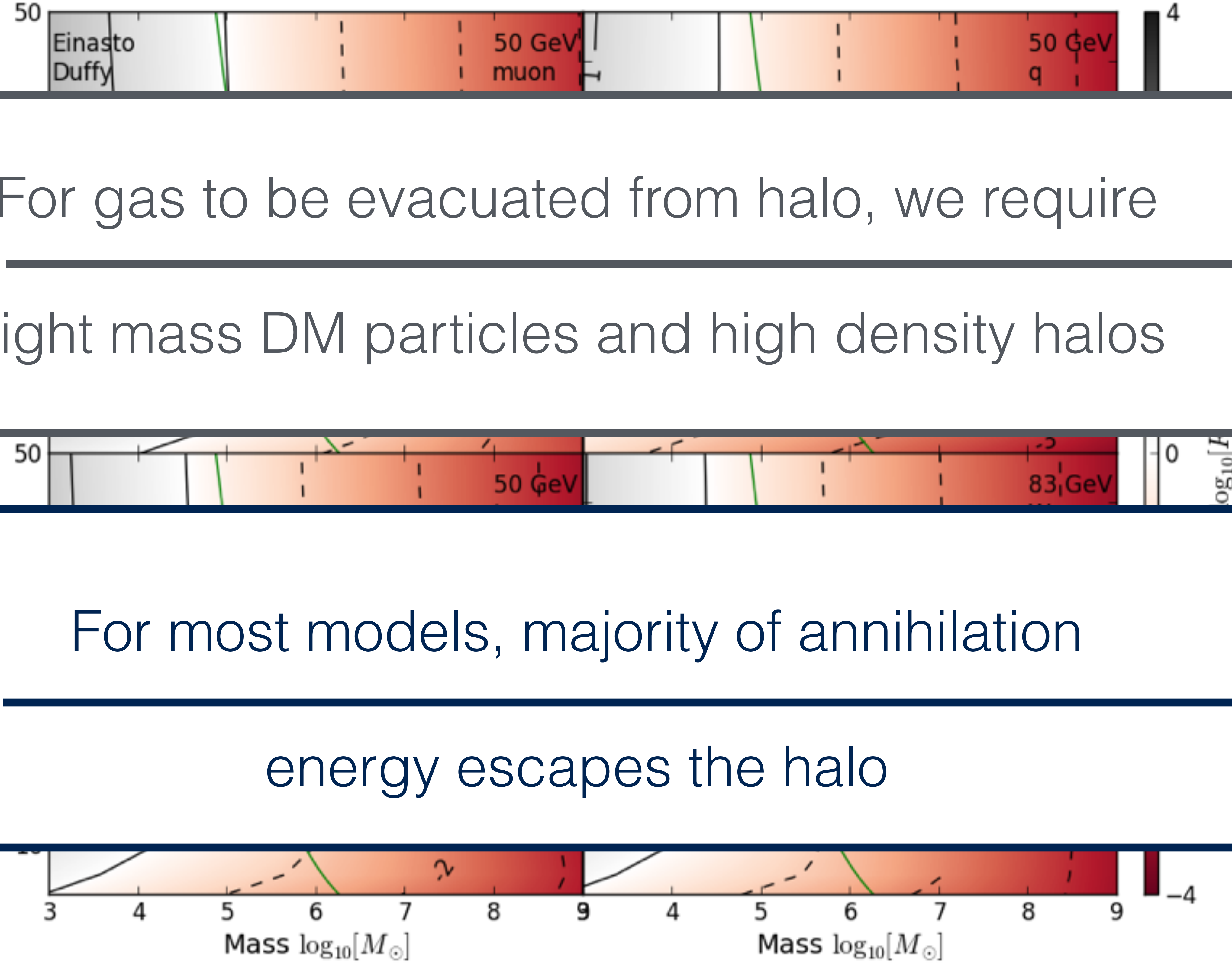
Self-heating Halos



Self-heating Halos



Self-heating Halos



For gas to be evacuated from halo, we require → light mass DM particles and high density halos

For most models, majority of annihilation → energy escapes the halo

Future Work

Self-heating efficient in Halo, star-formation is suppressed

Self-heating in-efficient in Halo

Energy from DM annihilation escapes halo into circum-galactic medium.

As the halo cools, gas becomes denser and heating from DM annihilation increases in efficiency

Use updated energy transfer code to model gas in CGM and evolving halo with DM heating to look for further potential modification in standard structure formation

Conclusions

- There exists a parameter space for which DM annihilation may suppress star formation at high redshift in small halos

- Direct observation at these high redshifts is difficult but modification of star-formation maybe detectable through the 21-cm signal

- Follow up calculations (using an updated energy transfer code) of the energy deposited into the CGM and modification of the gas during the evolution of the halo are planned

- Thank you for your time!