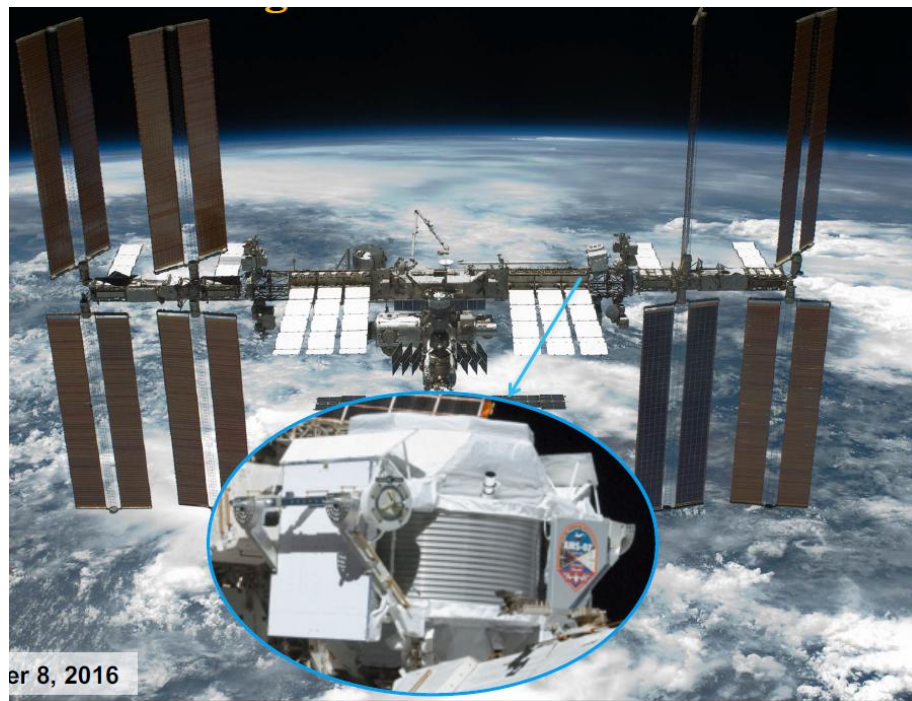


# LD2DM AND THE AMS-02 POSITRON EXCESS



Vikram Rentala

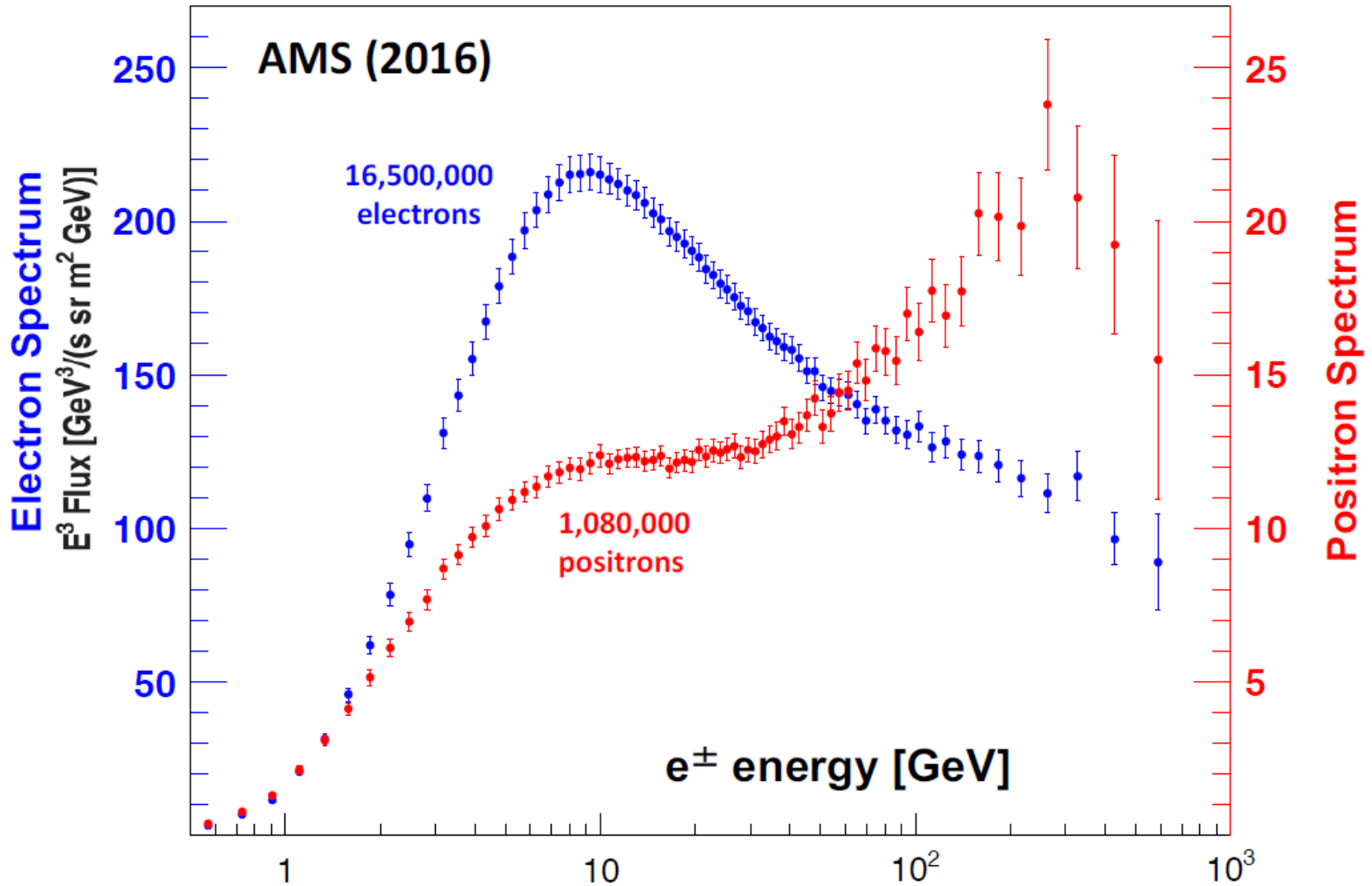
Indian Institute of Technology Bombay

(w J. Buch and P. Ralegankar)

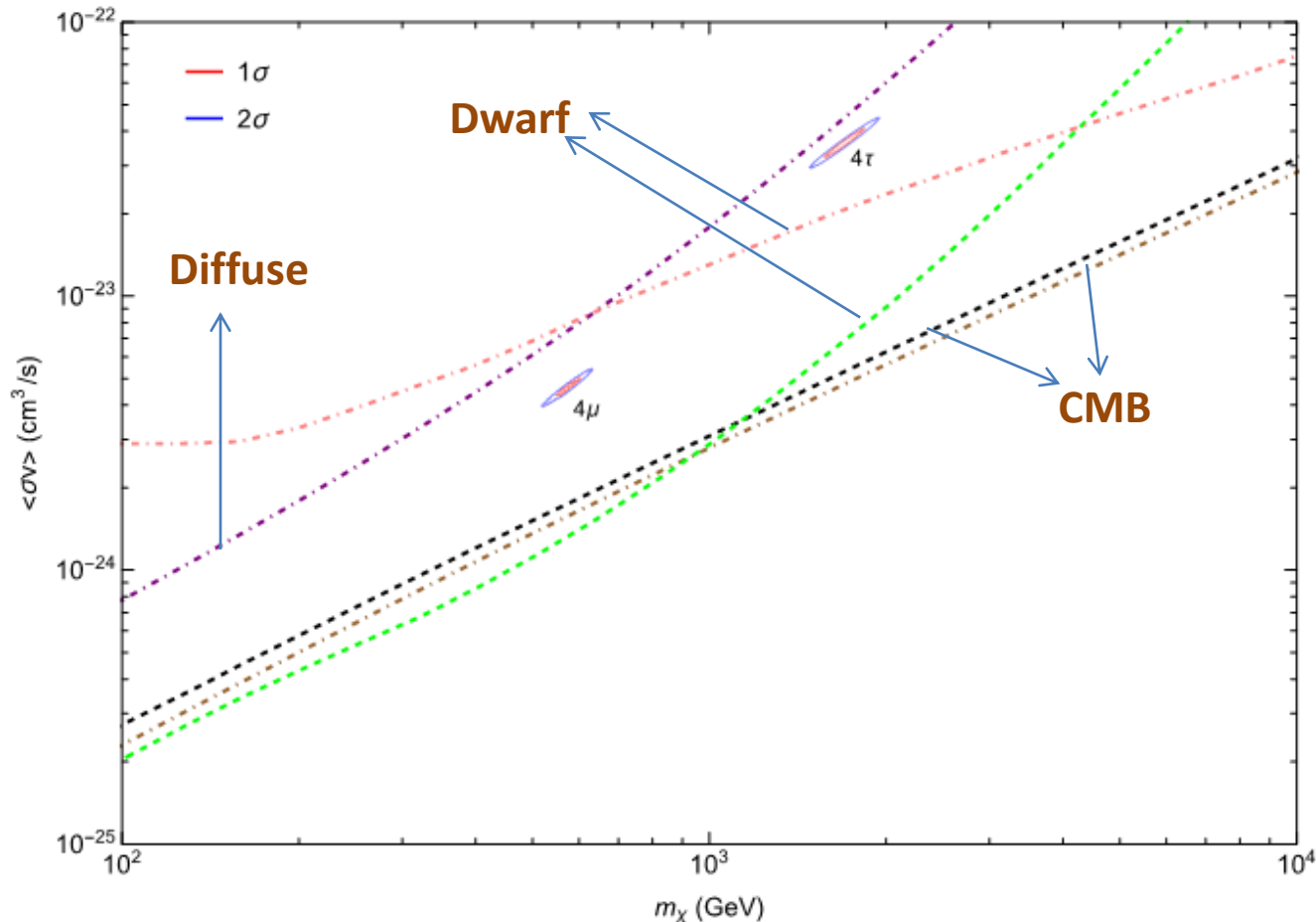
hep-ph/1609.04821



# AMS-02 positron spectrum

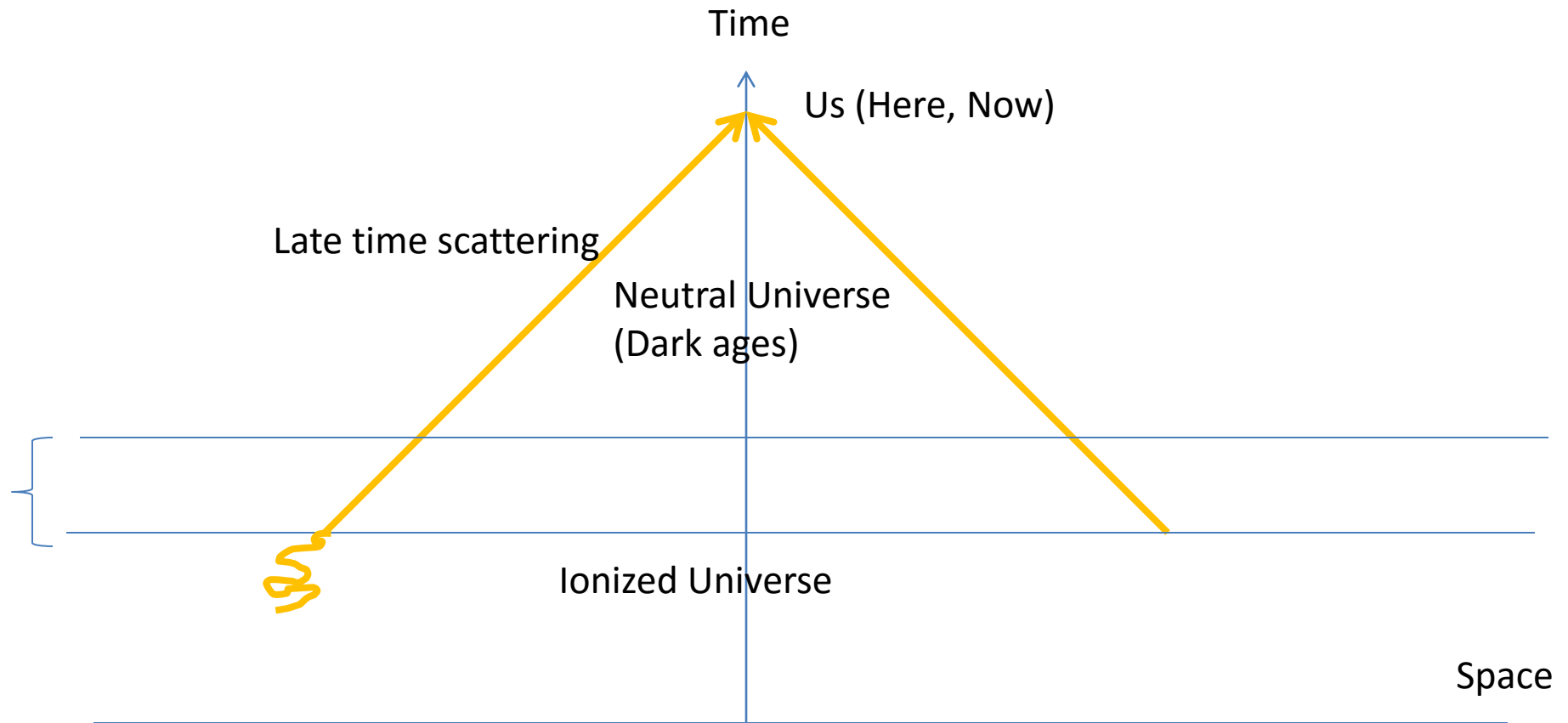


# Best fit cross-section and mass and constraints



Caveats for CMB bounds: Assuming s-wave (velocity independent) cross-section and standard evolution of relic abundance  $\sim (1+z)^{-3}$

# CMB annihilation constraints



# Summarizing the Problem

Mass of DM to explain positron excess  $\sim 1$  TeV

Cross-section needed to explain the positron excess

$$\langle \sigma v \rangle \sim 3 \times 10^{-23} \text{ cm}^3 \text{ s}^{-1}$$

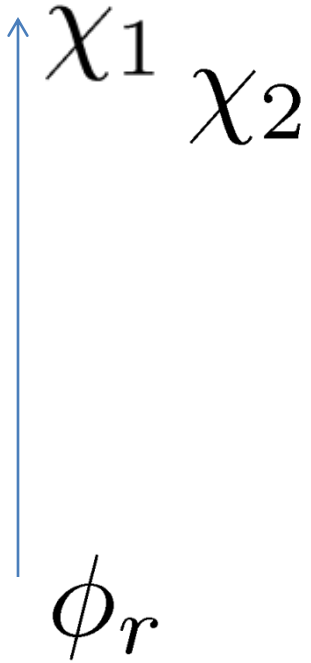
- Ruled out by CMB bounds
- Relic abundance too small – trying to solve this problem with Sommerfeld enhancement makes the CMB bound problem even worse

**How do we reconcile an  
annihilating dark matter  
interpretation of the AMS-02  
positron excess with the CMB  
constraints?**

**LD2DM scenario**  
**(Late decaying 2 component dark matter)**

# Basic particles

Mass



# Basic particles

Mass

$\chi_1$   
 $\chi_2$

$$\sigma(\chi_1\chi_1 \rightarrow \phi_r\phi_r)v = 3 \times 10^{-26} \text{ cm}^3 \text{ s}^{-1}$$

$$\sigma(\chi_2\chi_2 \rightarrow 4\mu)v = 3 \times 10^{-23} \text{ cm}^3 \text{ s}^{-1}$$

$$\Gamma(\chi_1 \rightarrow \chi_2 + \phi_r)^{-1} > 380,000 \text{ years}$$

$\phi_r$

# Timeline in the LD2DM scenario

**Time**

**Dominant dark matter species**

**Relevant process**

Today

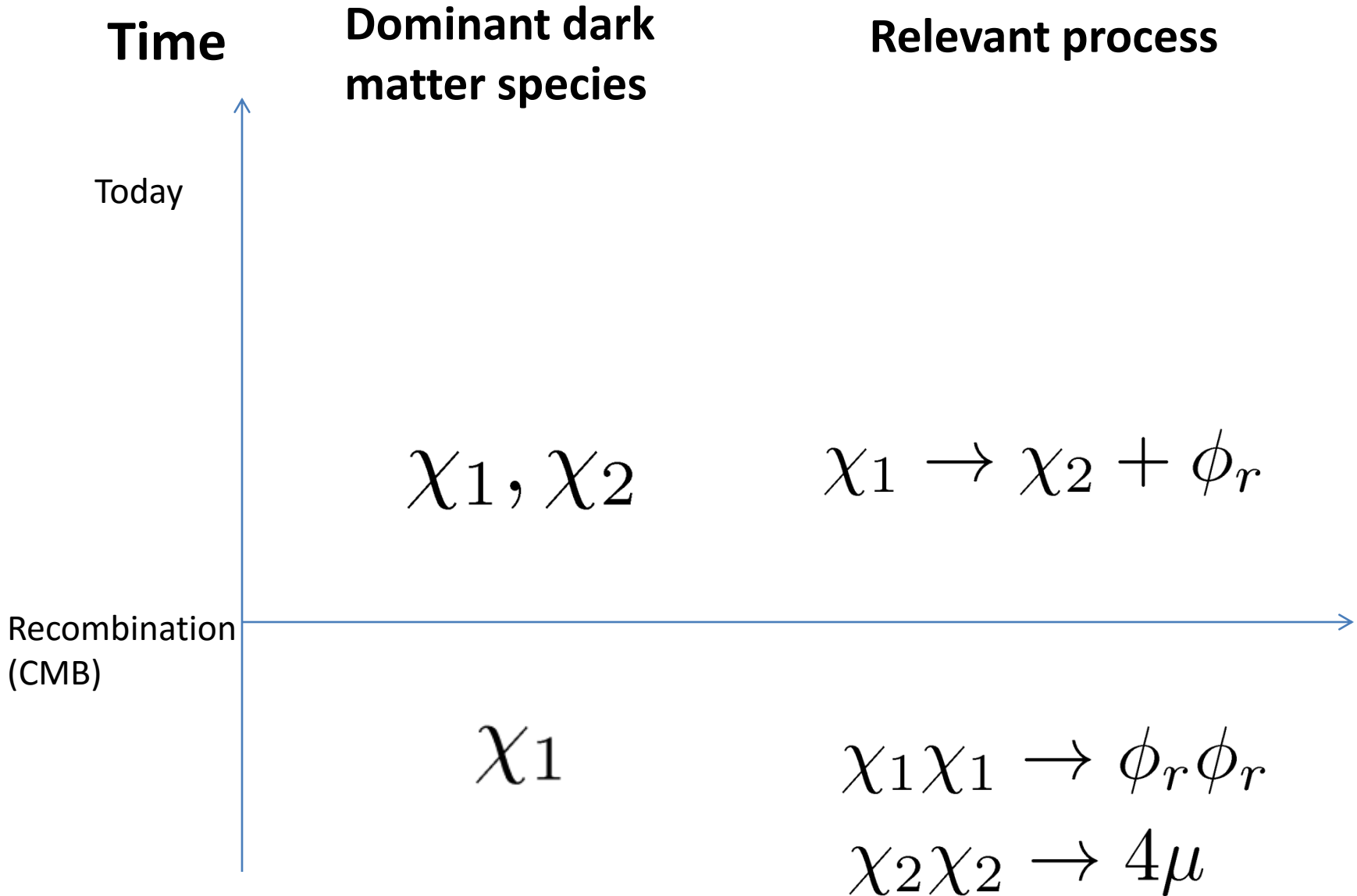
Recombination  
(CMB)

$\chi_1$

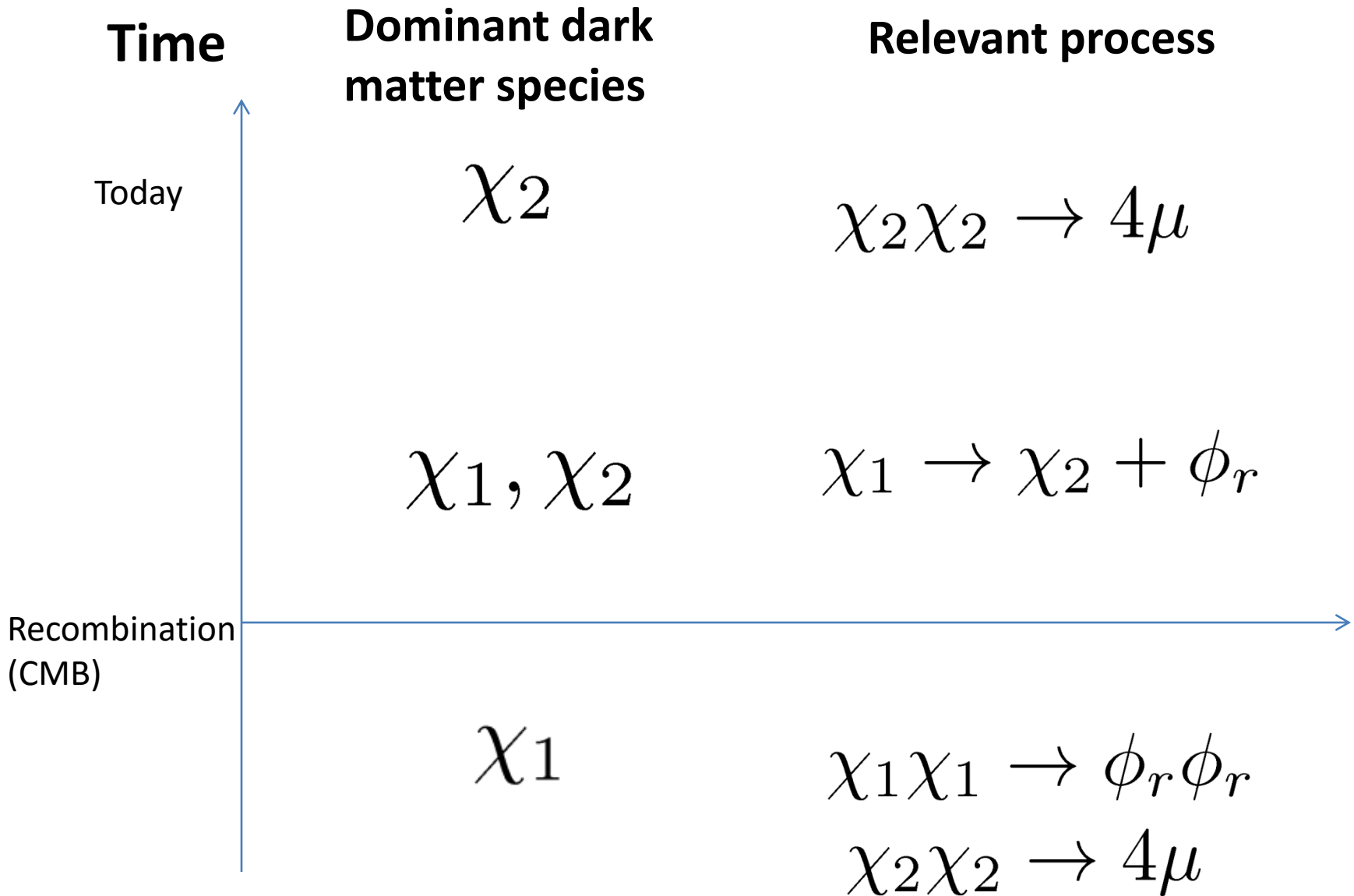
$\chi_1\chi_1 \rightarrow \phi_r\phi_r$

$\chi_2\chi_2 \rightarrow 4\mu$

# Timeline in the LD2DM scenario



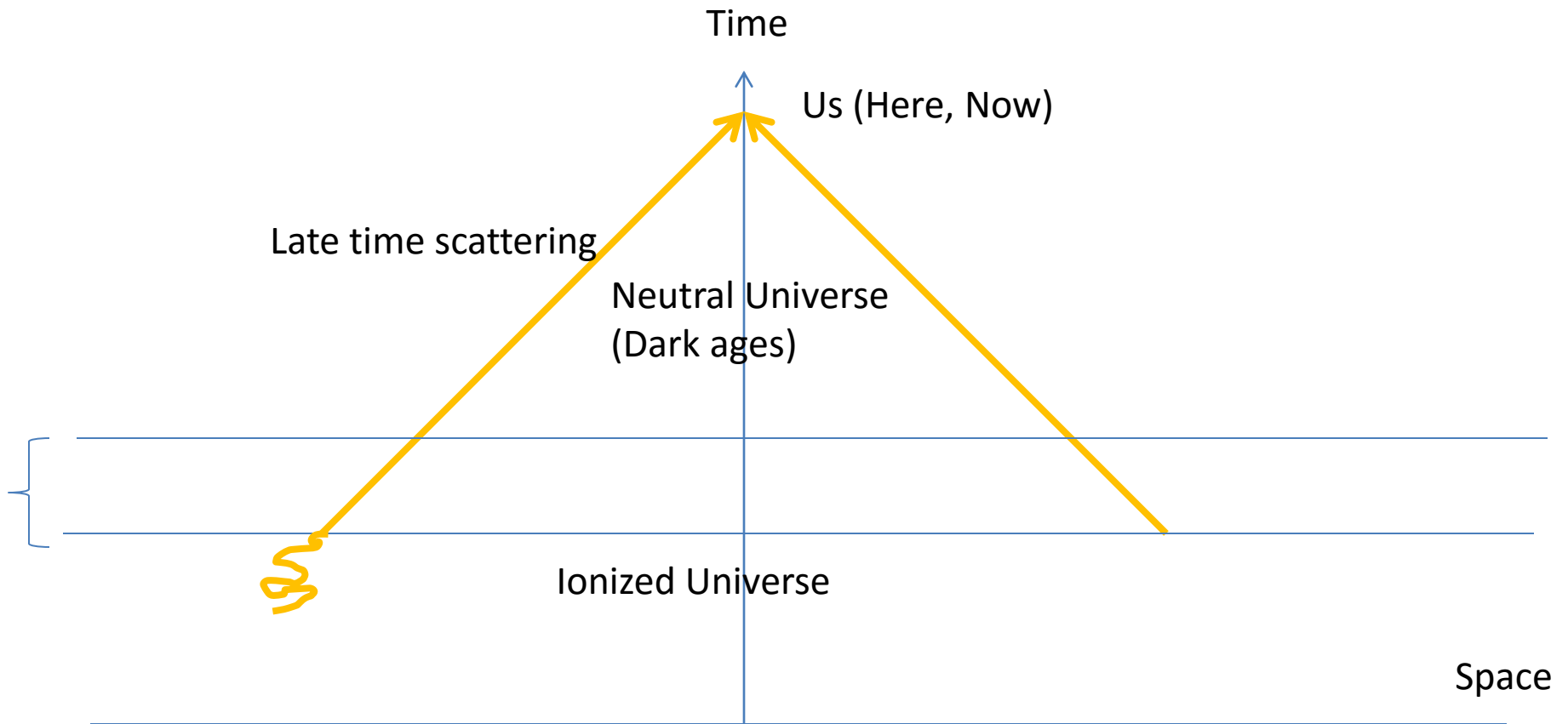
# Timeline in the LD2DM scenario



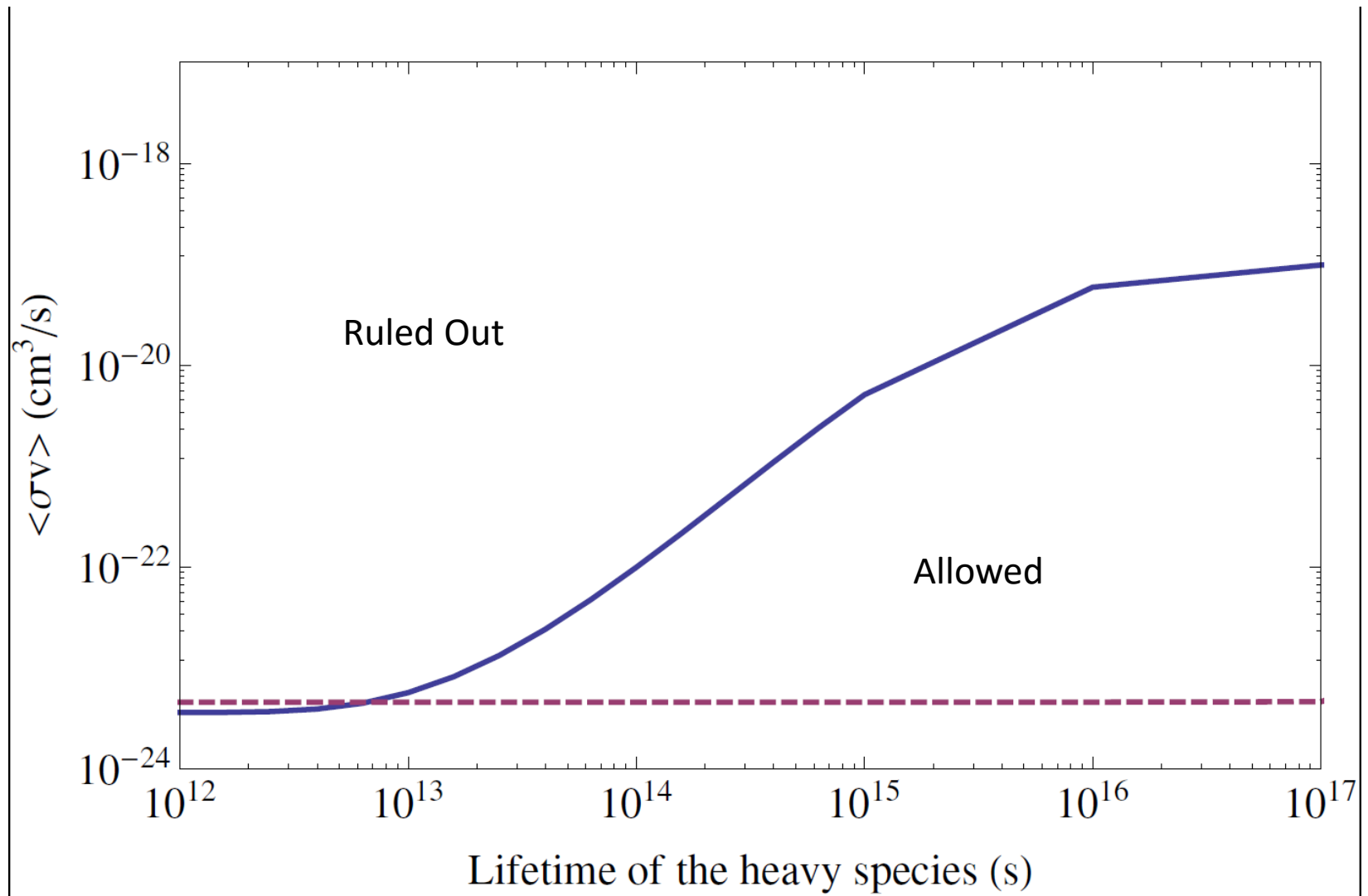
# Constraints on LD2DM scenario

- From CMB constraints on late time annihilations
- From structure formation

# Late time annihilation constraint



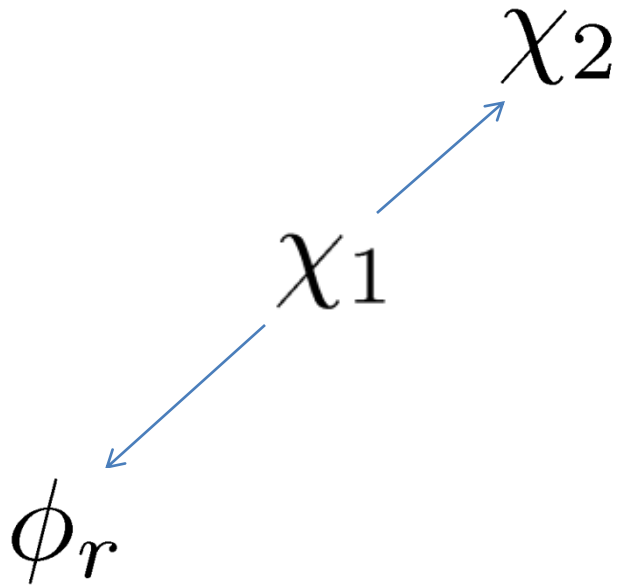
# Late time annihilation constraint



(based on codes by Slatyer,1211.0283)

**Buch, Ralegankar, VR hep-ph/1609.04821**

# Small scale structure constraint



$$v_k = \frac{\Delta m}{m_1} c,$$

$$v_k < 20 \text{ km s}^{-1}$$

Wang, Croft, Peter, Zentner, Purcell astro-ph/1309.7354  
Peter, Benson astro-ph/1009.1912

$$\implies \Delta m < 0.1 \text{ GeV}$$

# Cosmological implications

## Small scales

- Missing satellite problem
- Too big to fail problem
- Core cusp problem

## Large scales

- Hubble tension
- Effective number of neutrinos
- $\sigma_8$  tension

# Potential future observations

- AMS-02 precision data + anisotropy measurements
- $\chi_1 \rightarrow \chi_2 + \nu$
- 21 cm cosmology and epoch of reionization

# Summary and Conclusions

- Era of AMS-02 precision data could finally resolve the positron anomaly – dark matter or astrophysics?
- LD2DM provides a viable scenario to reconcile annihilating DM with CMB bounds and also explains the relic density
- Several potential cosmological and astrophysical implications!

QUESTIONS, COMMENTS, SUGGESTIONS?



# Basic particles

Mass



$\chi_1$   
 $\chi_2$

$$\sigma(\chi_1\chi_1 \rightarrow \phi_r\phi_r)v = 3 \times 10^{-26} \text{ cm}^3 \text{ s}^{-1}$$

$$\sigma(\chi_2\chi_2 \rightarrow Z'Z' \rightarrow 4\mu)v = 3 \times 10^{-23} \text{ cm}^3 \text{ s}^{-1}$$

$$\Gamma(\chi_1 \rightarrow \chi_2 + \phi_r)^{-1} > 380,000 \text{ years}$$

$\phi_r$

## Toy model

$$\begin{aligned} \mathcal{L}_{\text{int}} = & -\frac{1}{\Lambda} \bar{\chi}_1 \chi_1 \phi \phi^* - ig_\phi (\phi^* \partial^\mu \phi - \phi \partial^\mu \phi^*) Z'_\mu \\ & - ig \bar{\chi}_2 \gamma^\mu \chi_2 Z'_\mu - ig' \bar{\psi}_\ell \gamma^\mu \psi_\ell Z'_\mu + y \bar{\chi}_1 \chi_2 \phi + \text{h.c.} \end{aligned}$$