γ線スカイサーベイと銀河団カタログを用いたダークマターシグナルの探査

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Gamma-ray survey

The gamma-ray sky survey by Fermi Gamma-ray Space Telescope

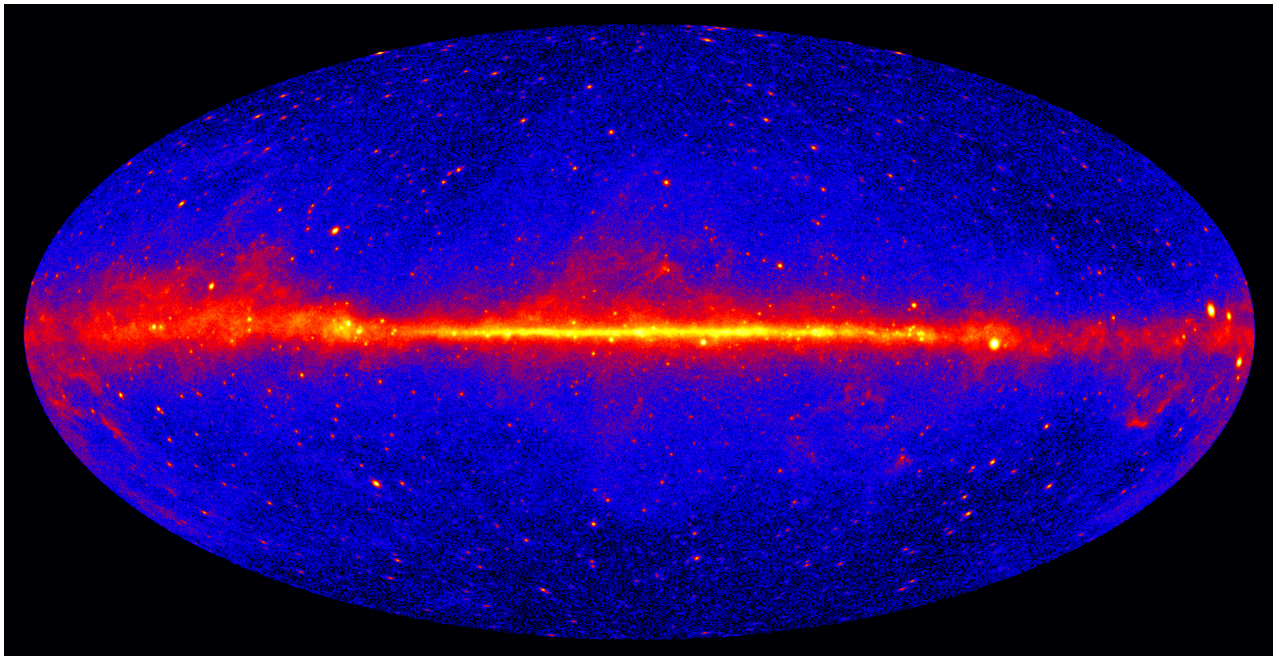


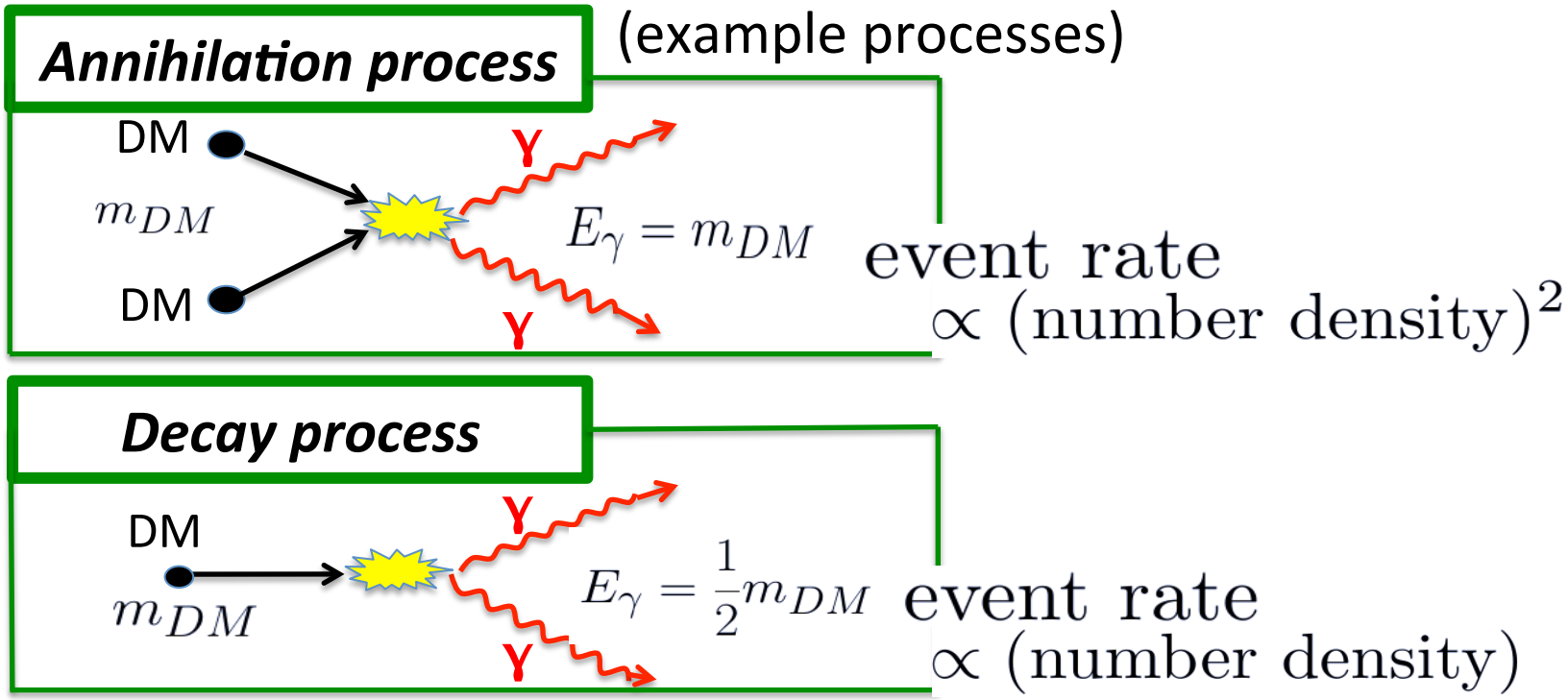
Image Credit: NASA/DOE/Fermi LAT Collaboration

Extragalactic Gamma-ray Background(EGB)

…remains of the total measured gamma-ray emission after the subtraction of the resolved sources and of the diffuse Galactic foregrounds.

Gamma-ray emission from DM

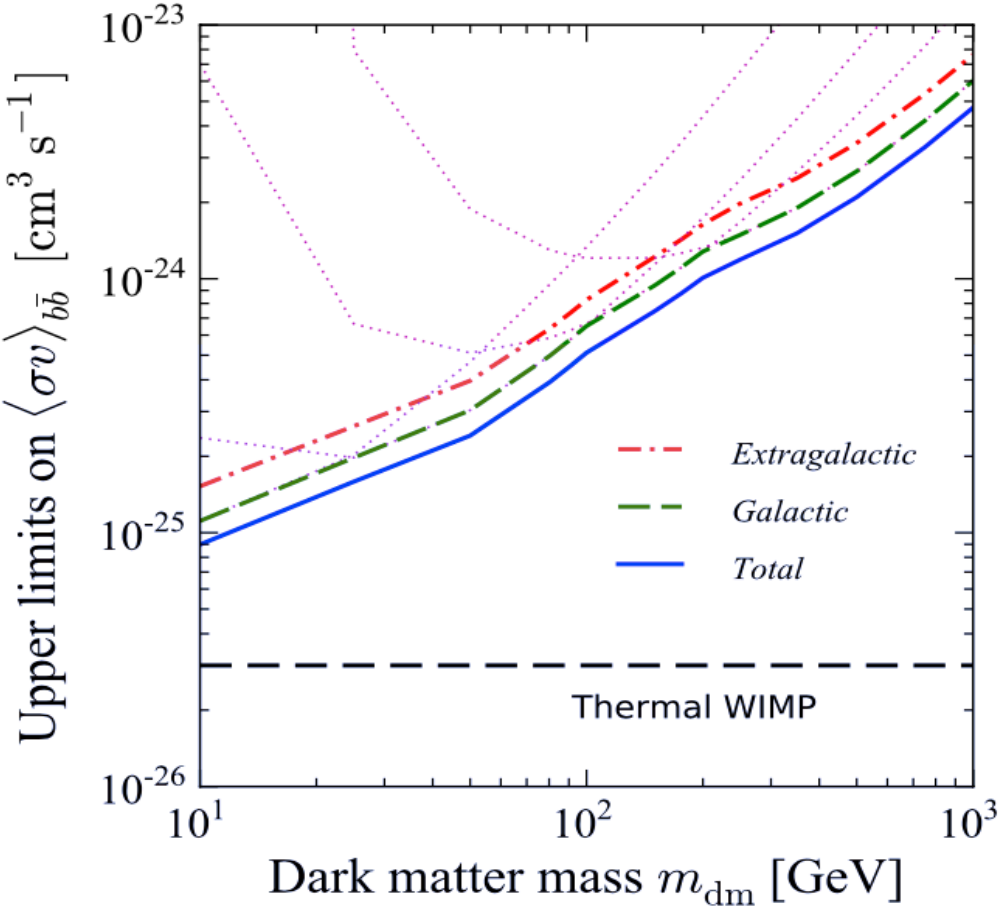
If dark matter mass is around GeV order...



From gamma-ray sky survey and theoretical prediction,
dark matter properties can be restricted.

Previous Work

S. Ando, E. Komatsu（2013）



Observational data :
gamma-ray background
by Fermi GRST sky survey

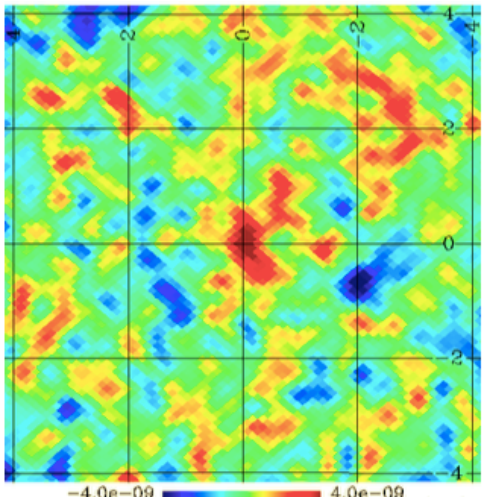
Theoretical estimation :
halo mass function :EPS
annihilation process

$$\langle \sigma v \rangle \lesssim 10^{-25} (\mathrm{cm}^3/\mathrm{s})$$

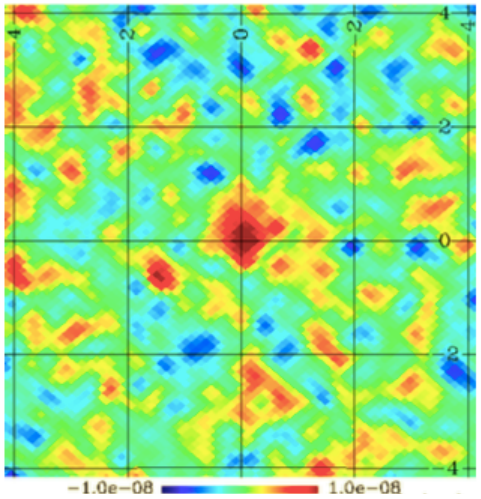
(at dark matter mass of 10GeV)

Cross-Correlation between Fermi Map and Catalogs of Clusters (previous work)

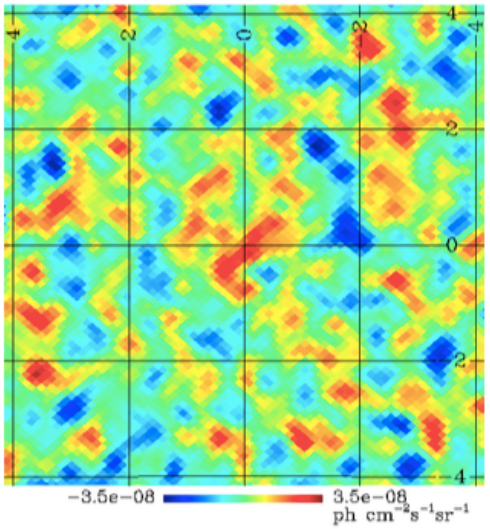
WHL12 (N=39668)



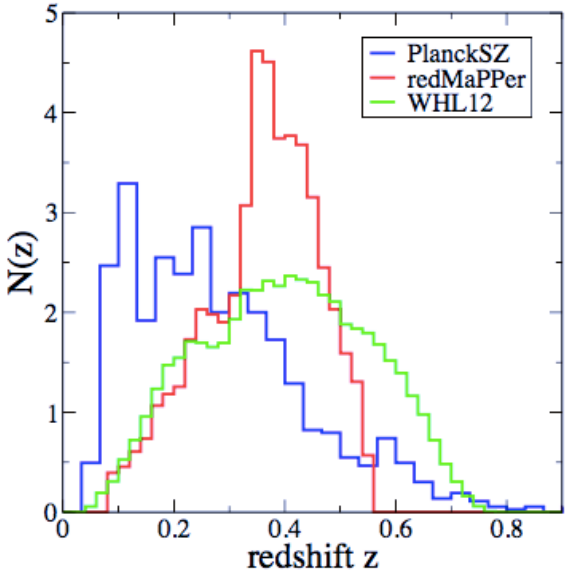
redMaPPer (N=26350)

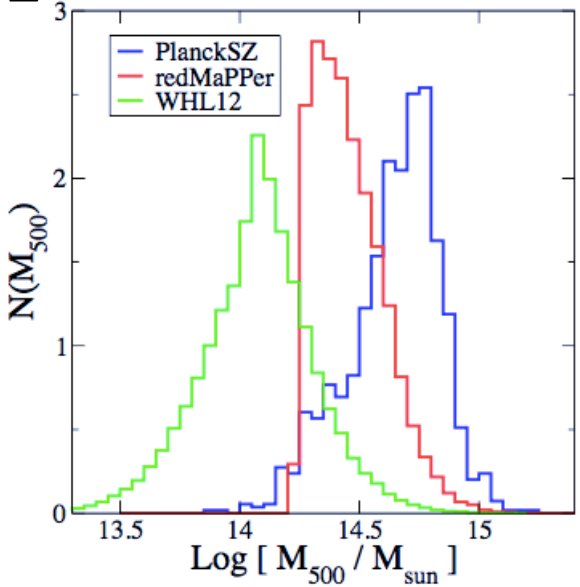


PlanckSZ (N=1653)



(1～10GeV)





Branchini et al.(2017)

In this work

In this work...

- Fermi GRST gamma-ray sky survey
- **HSC（Hyper Suprime-Cam）cluster catalog**

HSC cluster catalog (CAMIRA catalog)

Observation

HSC

redshift and *position* of each cluster

+ ・mass assumption : 10^14Msun

Fermi GRST

distribution of the gamma-ray intensity

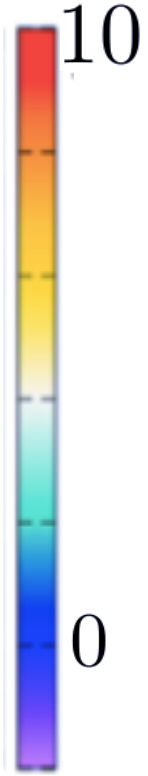
↓

obtain number count of gamma-ray photons at each cluster position with redshift.

Images of two data

Fermi map + *cluster positions* (sample)

- **cluster position**



Stack the gamma-ray intensity at HSC clusters position

↓

obtain the gamma-ray intensity from these clusters

Stacked image

Stack the gamma-ray intensity map around each cluster

the center of each cluster

photon count

preliminary

Stacked Image for Fermi Map

Stacked images obtained from random rotation at each cluster position

variable : γ-ray energy

0.5～1GeV　　1～3GeV　　5～10GeV

Stacked Image for Fermi Map

Stacked images obtained from random rotation at each cluster position

variable : redshift

redshift : 0.1～0.3　　0.3～0.6　　0.6～1.1

Stacked Image

Stacked images obtained from random rotation at each cluster position

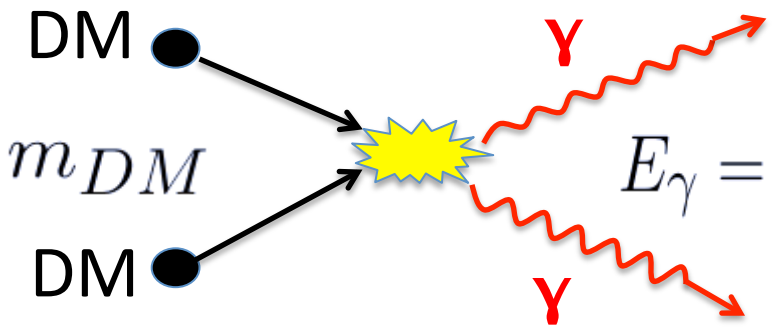
variable : richness

richness : top 500 top 1000 top 2000

Set up for the model

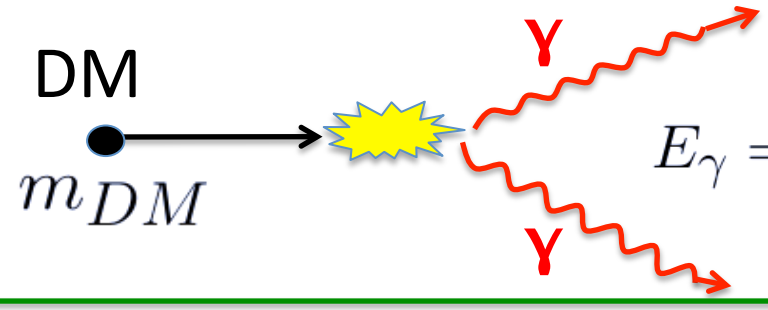
Assuming the two simple processes.

Annihilation process



$$\text{event rate} \propto (\text{number density})^2$$

Decay process



$$\text{event rate} \propto (\text{number density})$$

Gamma-ray intensity from one cluster

ANNIHILATION

- Adopting the *NFW profile* for clusters
- Fixing a cluster mass to *10^14Msun*

$$I_{ann}(E_{obs}, z) = \langle \sigma v \rangle \int \left(\frac{\rho^{NFW}}{m_{\rm DM}} \frac{\Omega_{\rm DM}}{\Omega_m} \right)^2 dV$$

generated number of photons per unit time

$$\frac{1}{4\pi d_L^2} \times \frac{\exp(-\tau(E_{obs}, z))}{}$$

gamma-ray attenuation

1 / (luminosity distance)^2

Gamma-ray intensity from one cluster

DECAY

- Adopting the *NFW profile* for clusters
- Fixing a cluster mass to *10^14Msun*

$$I_{dec}(E_{obs}, z) = 2P \int \frac{\rho^{NFW}}{m_{\rm DM}} \frac{\Omega_{\rm DM}}{\Omega_m} dV \times \frac{1}{4\pi d_L^2} \times \frac{\exp(-\tau(E_{obs}, z))}{}$$

P : decay rate

generated number of photons per unit time

1 / (luminosity distance)^2

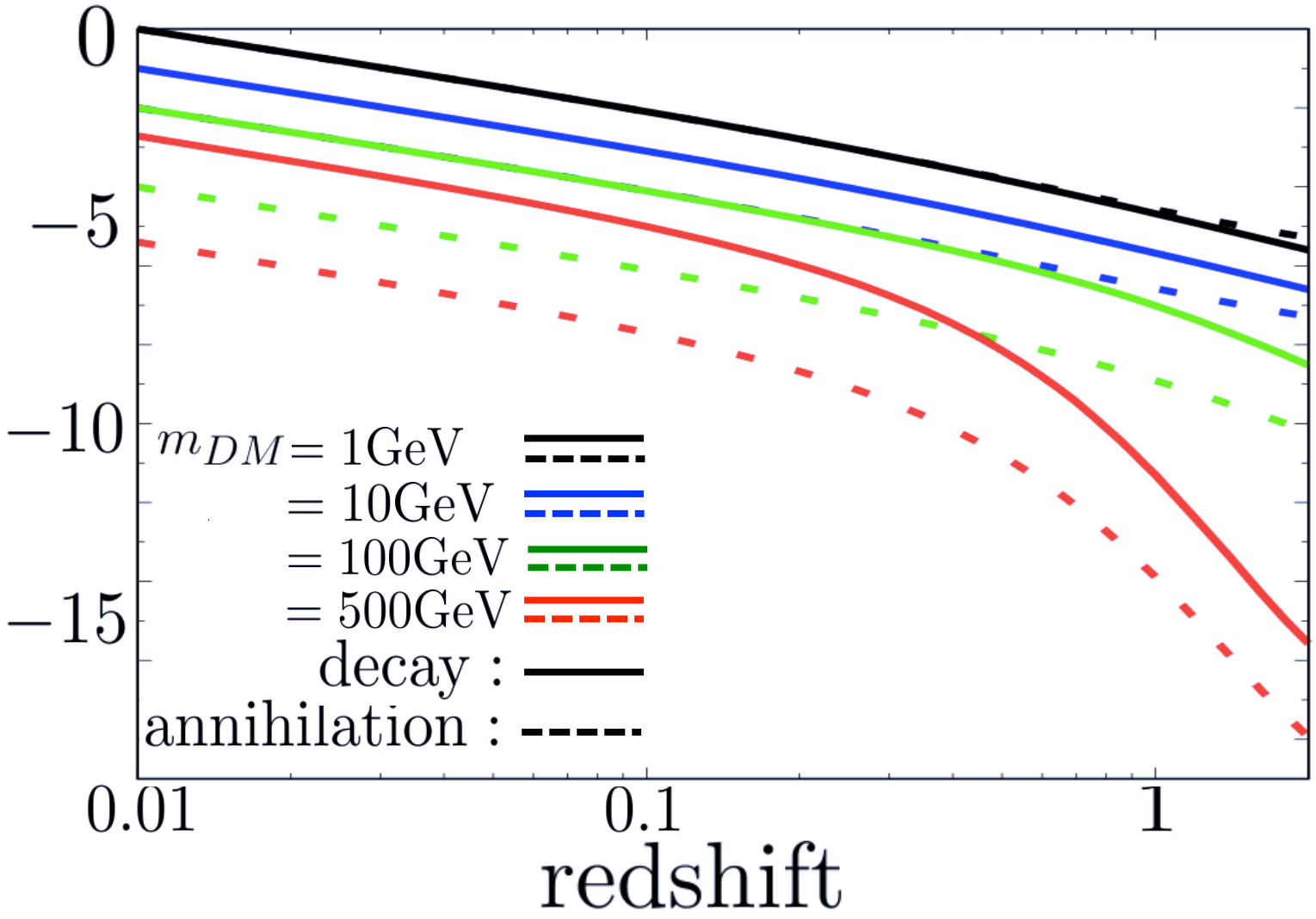
gamma-ray attenuation

redshift dependence of gamma-ray intensity from one cluster

$\log(I_{ann}/I_{ann}(z=0.01, m_{\rm DM}=1{\rm GeV}))$

or

$\log(I_{dec}/I_{dec}(z=0.01, m_{\rm DM}=1{\rm GeV}))$



Result

Upper limit on **annihilation cross section** and **decay rate**

dark matter mass(GeV)

Summary

- ✔ The gamma-ray intensity at a cluster position and random position are not significantly different. We need to analyze the signal more precisely.
  - inaccuracy of evaluation for galactic gamma-ray foreground
  - underestimation for spread of signals from clusters

- ✔ More clusters in future HSC will be expected which enable us to distinguish the models (annihilation or others).