Indirect detections of DM using Radio and Gamma

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Outline

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2. DM distributions and calculation Setup
3. Signal 1 Inverse Compton from the Galactic Center
4. Signal 2 Synchrotron Radiation from the GC
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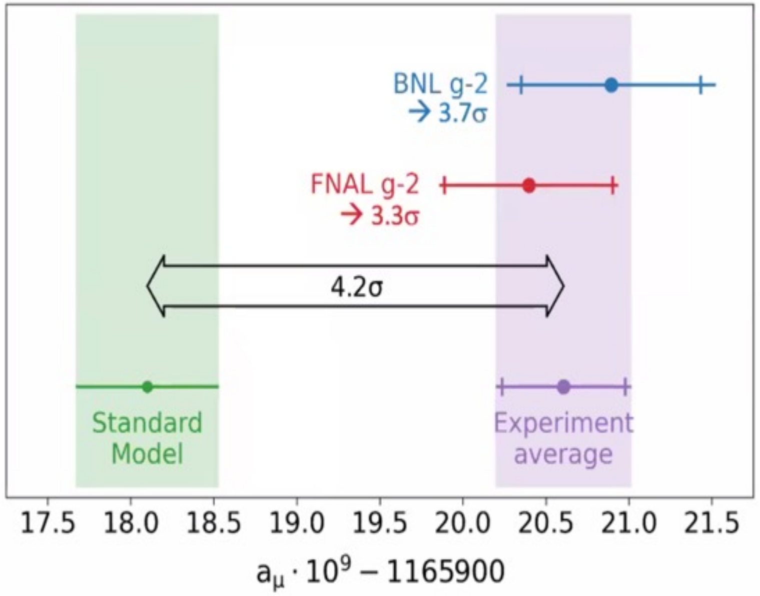
1. Motivation

We have interesting new Hints from Particle Phys



muon g-2 is shifted from the SM prediction

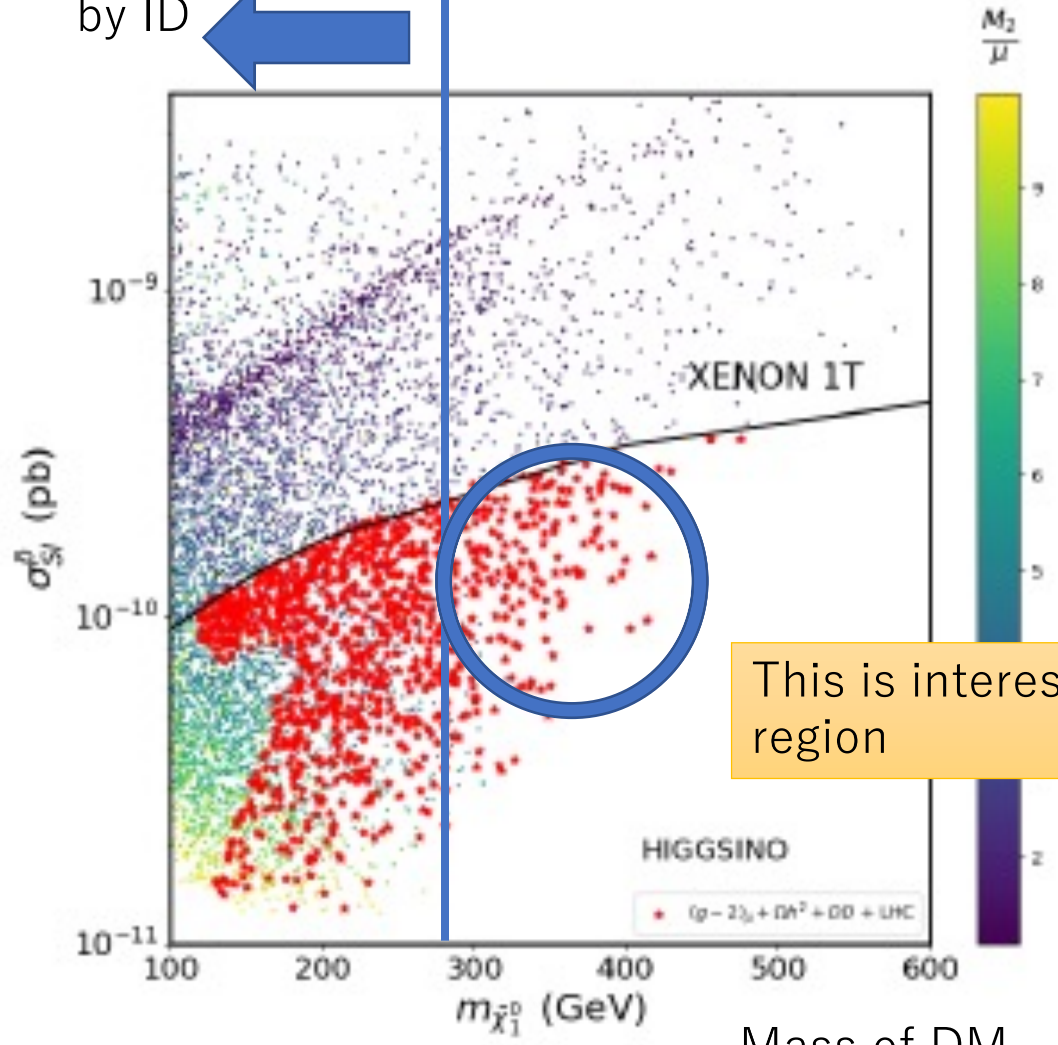
If this excess comes from the SUSY,
the light (200-500GeV) Dark matter is predicted.

On the other hand, there are several constraints from Direct Detection, LHC, Relic density and Indirect Detection(Fermi-Lat).

lighter mass region is disfavored by ID

Red point is higgsino case (with μ g-2, relic, DD and LHC)

Direct detection Cross-section

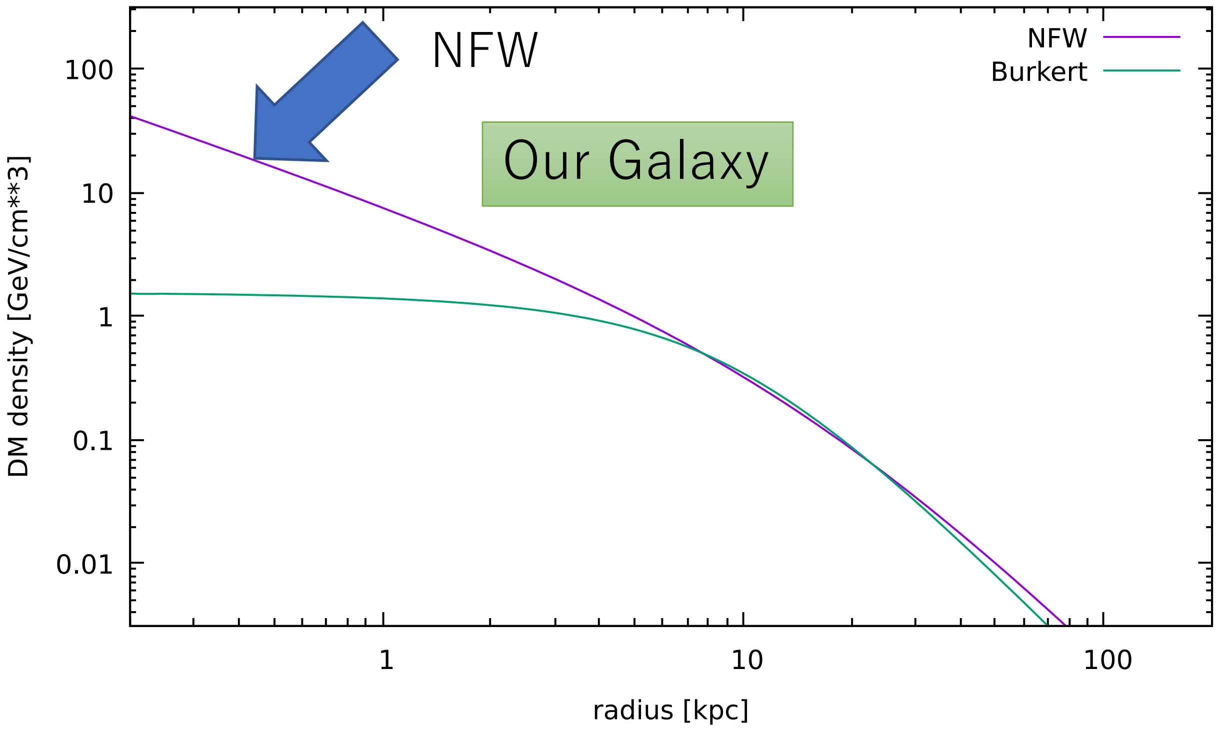


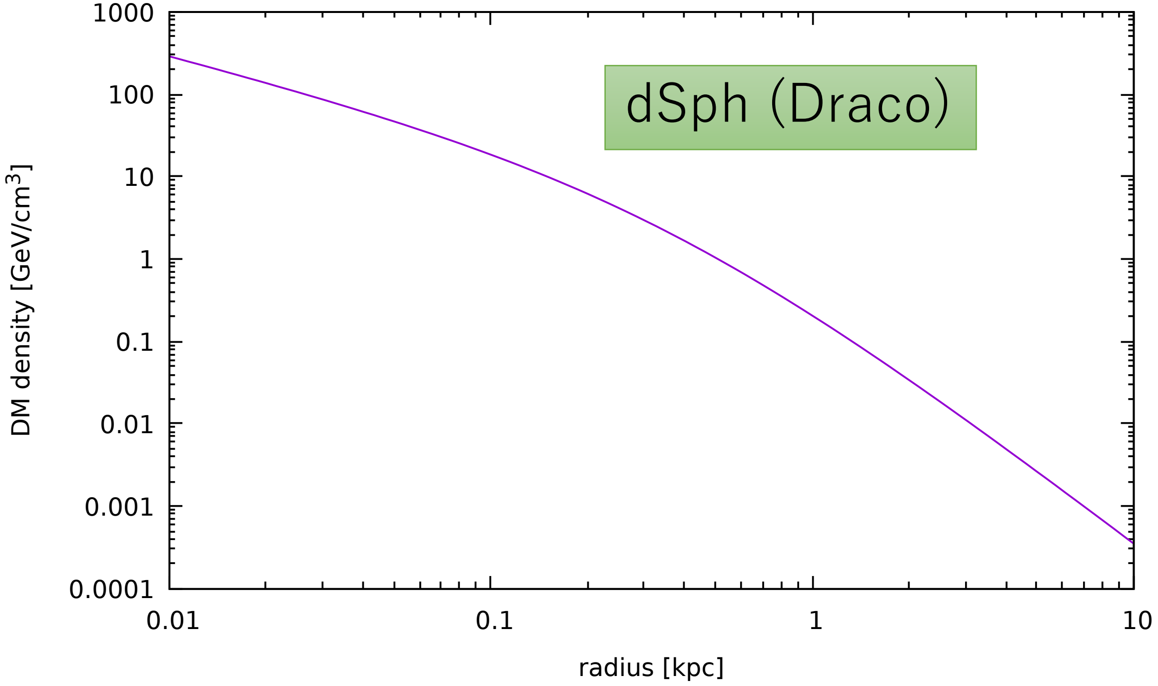
This is interesting region

Mass of DM

arXiv:2103.13403v1

2. DM distribution and setup



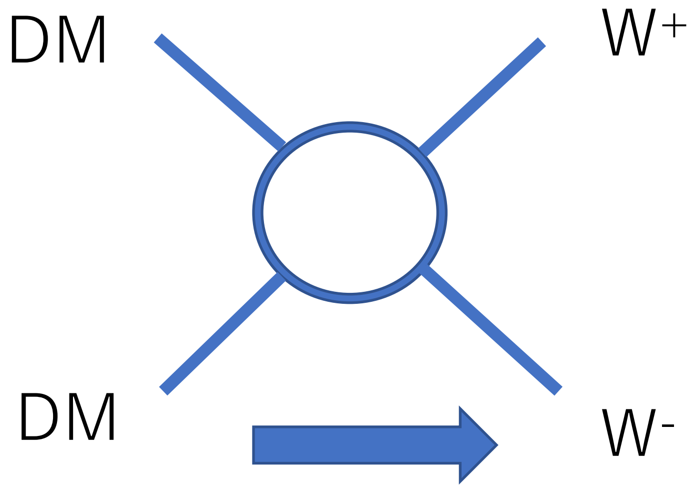


DM distribution could be a cored or cuspy profile.
We adopt a simple
NFW profile(inner slope γ=-1) assuming
$<\sigma v> = 3*10^{-26}$ cm^{3}s^{-1} and
DM mass=500GeV (conservatively)

In order to calculate the diffusion effect, gamma ray and synchrotron flux, we use the Darksusy 6.2.5 and RX-DMFIT Master (JCAP09(2017)027).

Branching Ratio and Diffusion effect

Dark Matter annihilates to SM particles.
We assume that DM annihilate into W^+W^-
(Branching fraction is assumed 100%)
since Bino-like DM is disfavored.



Then we get the source term

$$Q(E,\vec{r}) = \frac{<\sigma v> \rho_\chi^2(\vec{r})}{2M_\chi^2}\frac{dN}{dE}(E,\vec{r})$$

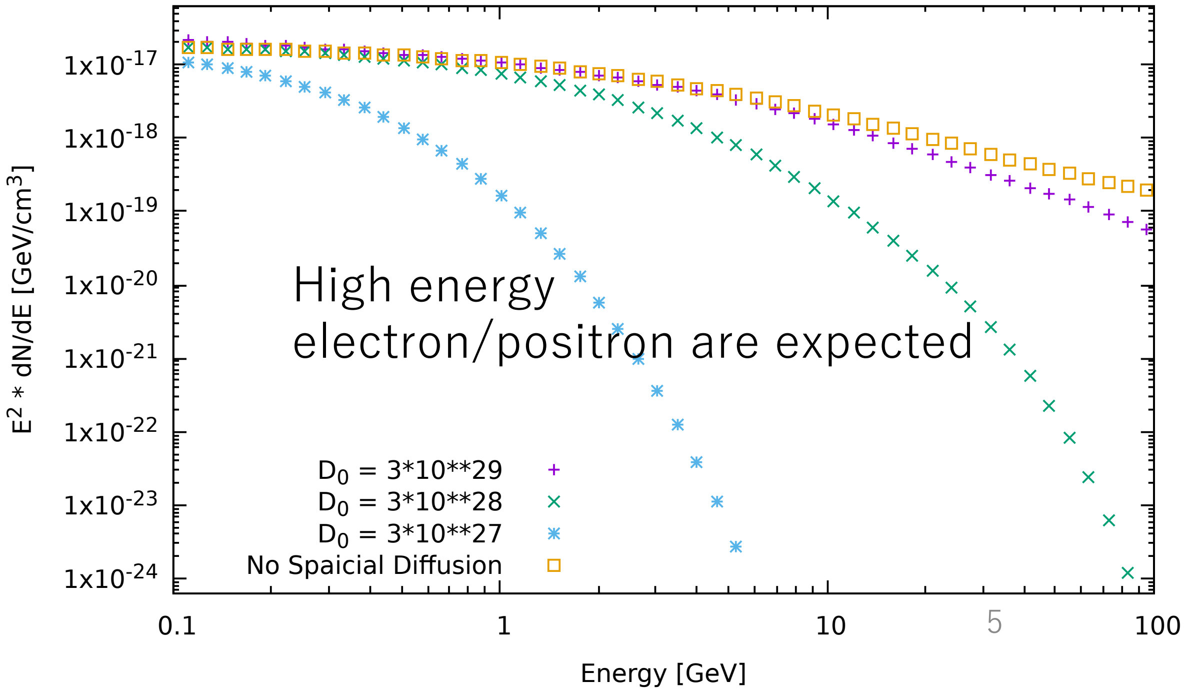
and by solving the Diffusion Equation,
we obtain the equilibrium electron density.

We assume the Diffusion coefficient as

$$D(E) = D_0 E^\gamma$$

and γ =0.3, D_0 =3*10^28 for our GC .

- e^+/e^- Energy distribution with diffusion effect



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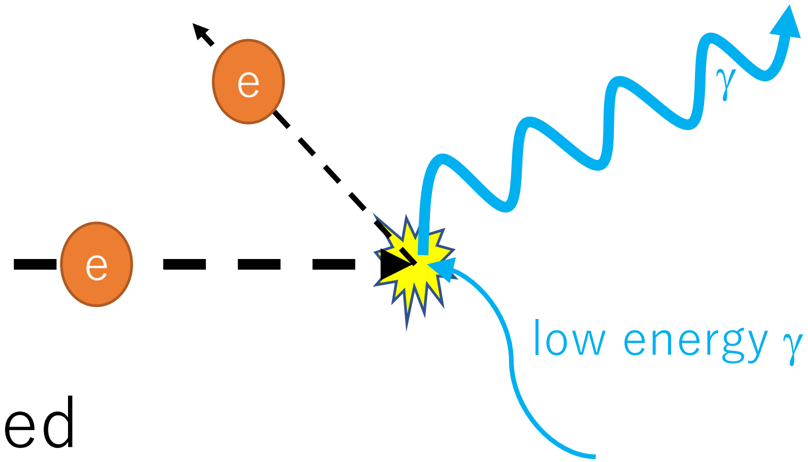
Inverse Compton Scattering process

(1) High energy electron/positron
produced by annihilation of DM
(2) low energy photon (usually 2.7K CMB)
gets high energy from electron,
change into gamma ray.
The energy of outgoing photon is enhanced
($E_{out} \sim E_{int}\ \gamma_{electron}^2$)



The Spectral Energy Distribution by IC scattering
is calculated by
1,Calculating Electron density by solving Diffusion Equation
2,Folding it and IC power(→emissivity)
3,Taking line of sight integral and solid angle integral

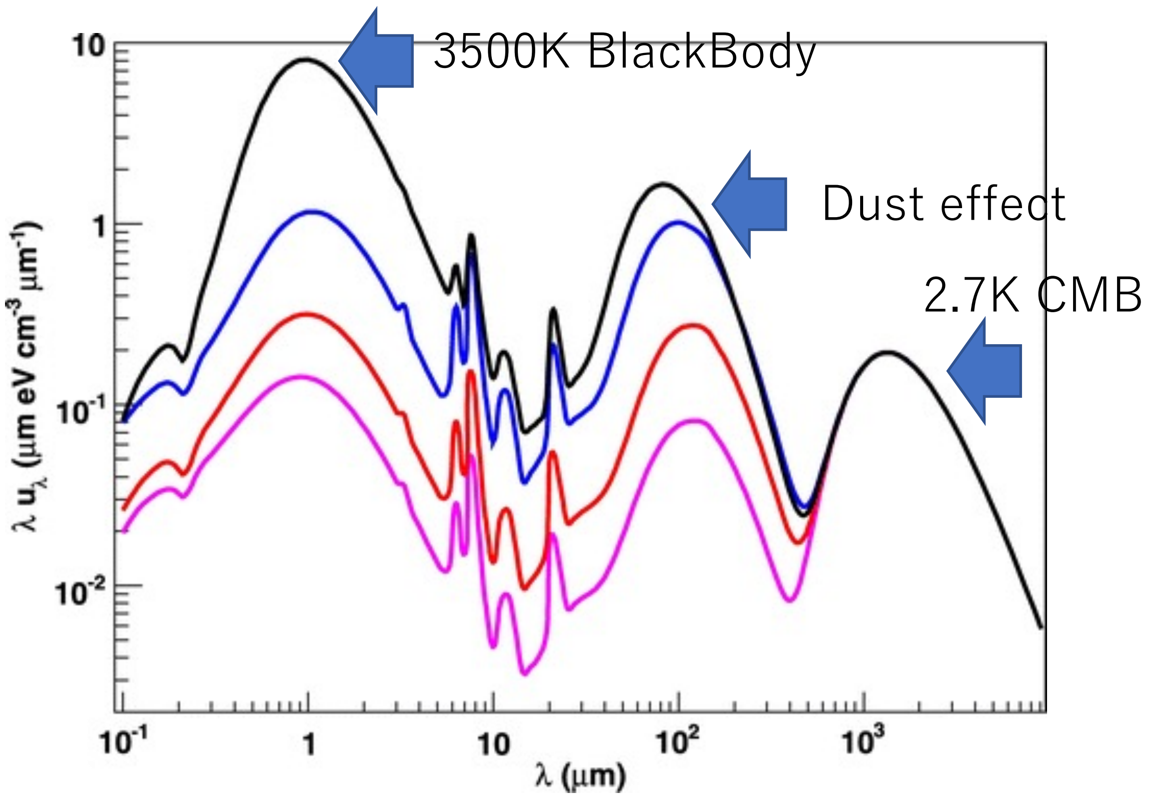
Radiation Fields in the GC

The right figure shows the spectral energy distribution of the MilkyWay Interstellar Radiation Field
The Black line corresponds to the SED of radiation field at Radius R =0 (GC.)

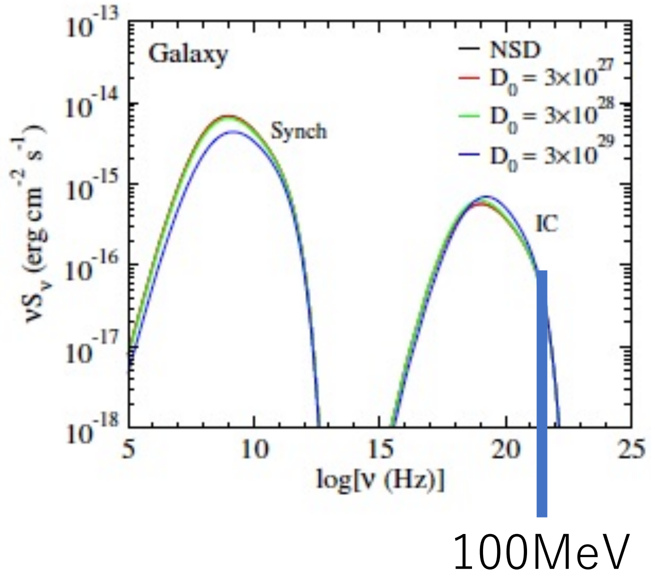
Main component of radiation field in the inner Galactic region is the emission by star.

we approximate the luminosity profile in the Galactic Center region by normalized ~3500K Black Body spectrum and CMB.

IC signal is generally expected around 10MeV assumed that CMB is main component of photon.
Photon energy and signal intensity increases if the starlight is taken into account

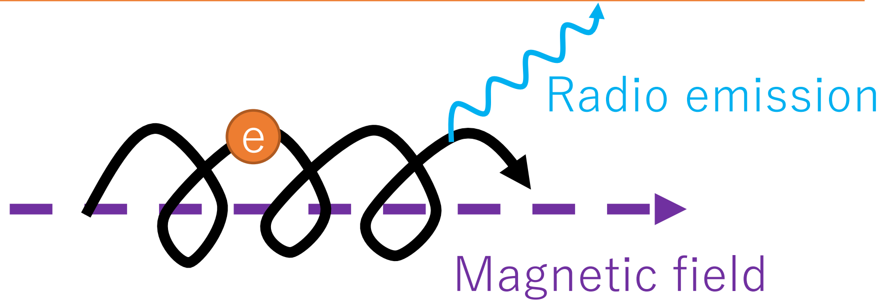


arXiv0804.1774



arXiv1705.09384

Synchrotron Radiation process



When charged particle travels
in the presence of magnetic field,
its path is bended and emit Radio Frequency light.

The strength of magnetic field strongly affect the synchrotron emission.

We assumed magnetic field strength

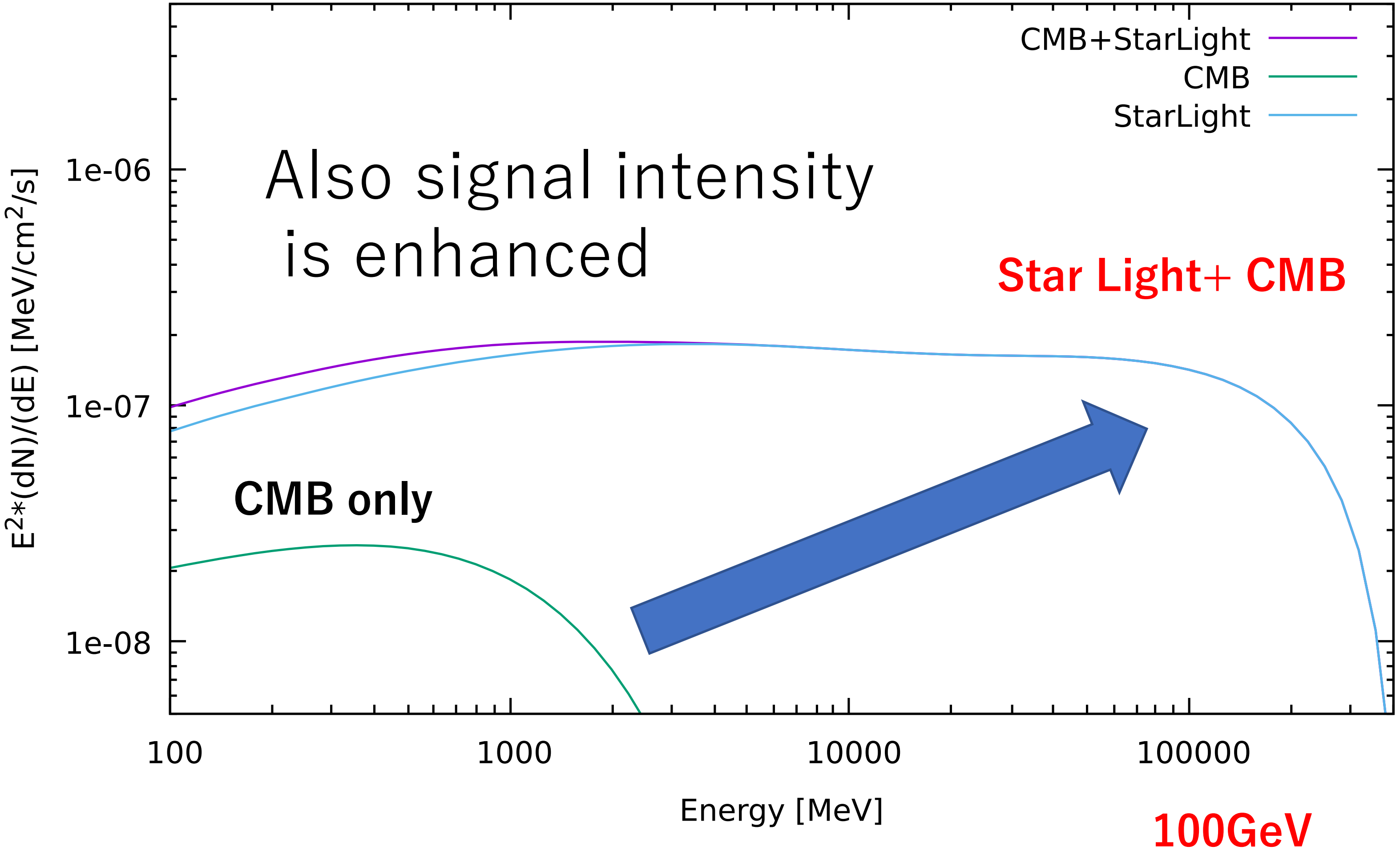
1mG for Galactic Center

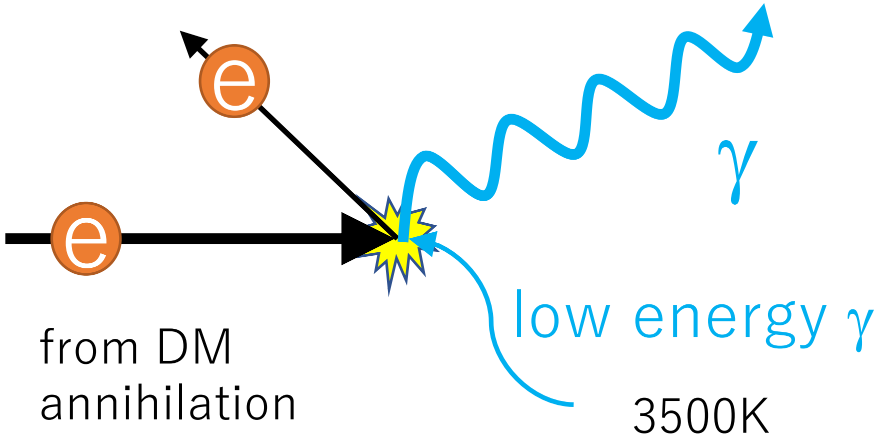
1μG for dSph. ← Necessary for discussion.

3. Signal of IC from the GC

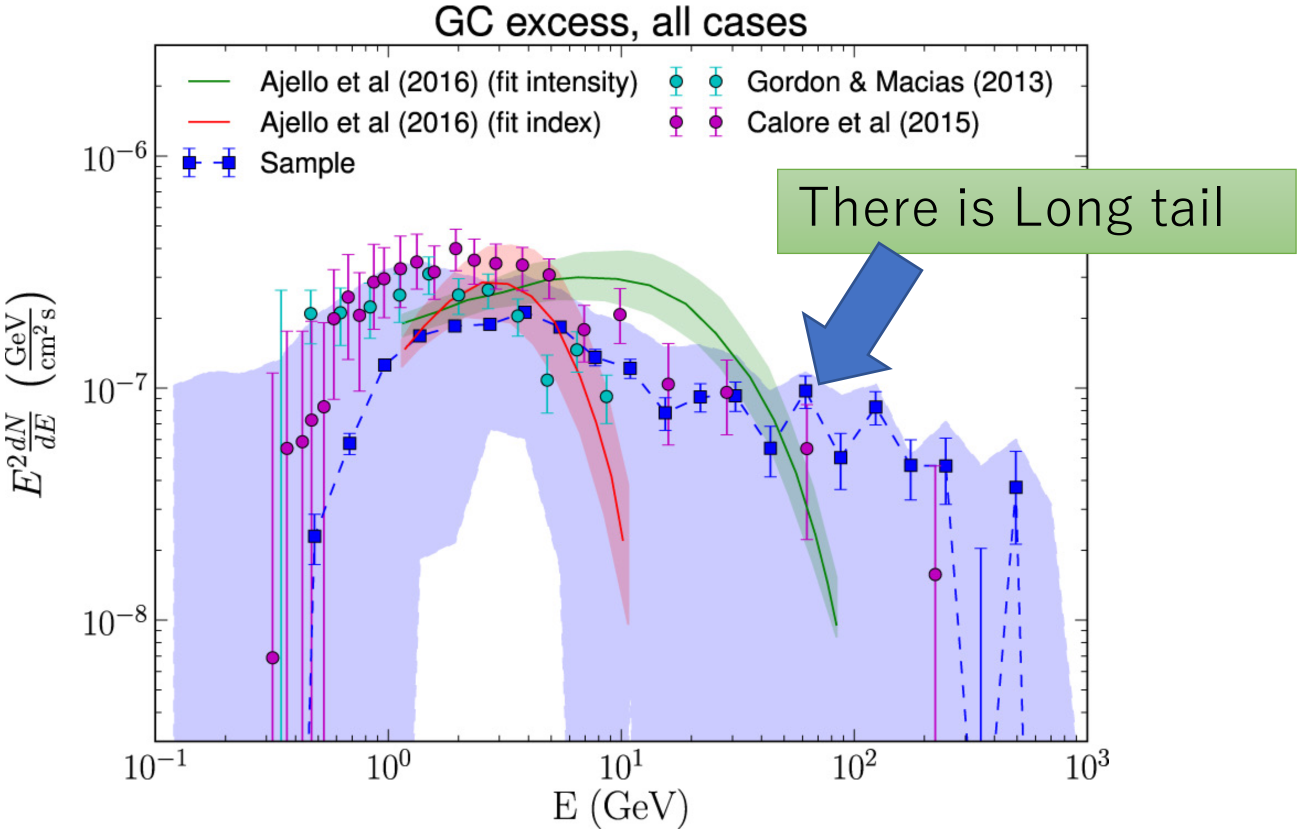
Emitted photon energy extends to about **100GeV**

Our Result





Fermi excess ?



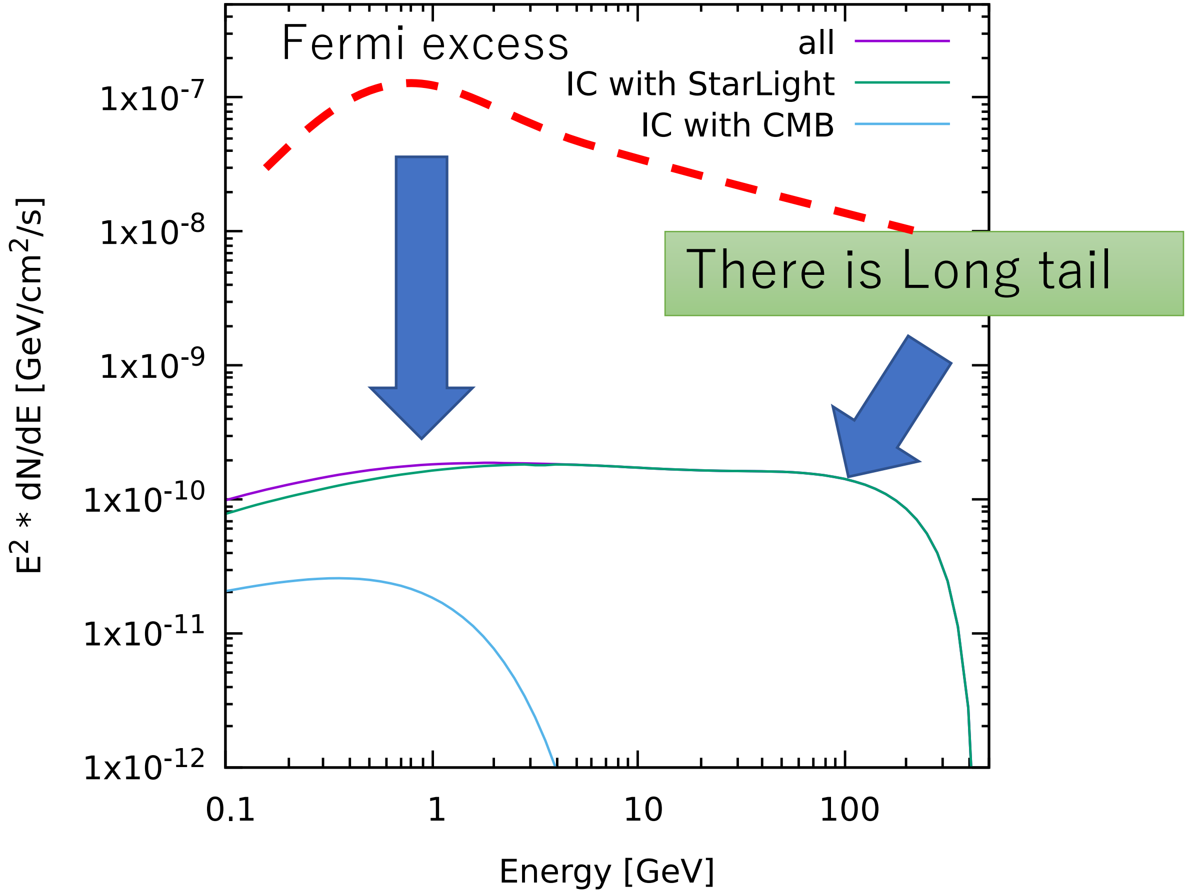
GeV -100 GeV excess is reported from Fermi-Lat spectrum.

Many explanations are proposed.

DM ~ 30GeV?
SuperNova?
AGN 300years ago?

arXiv1704.03910

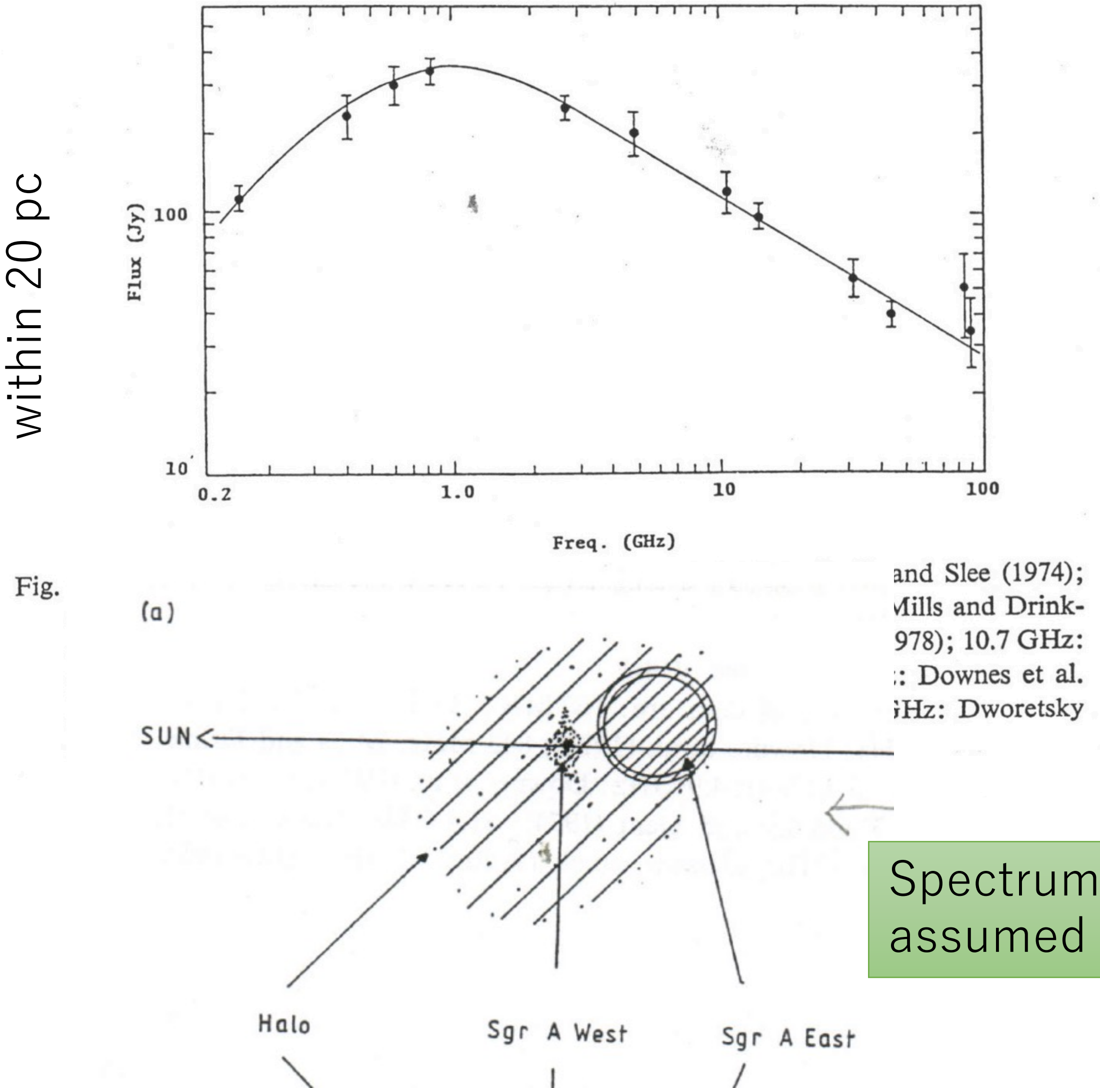
Our Result of IC spectrum



Unfortunately,
2 to 3 orders discrepancy
There are many BG/Photons in the GC

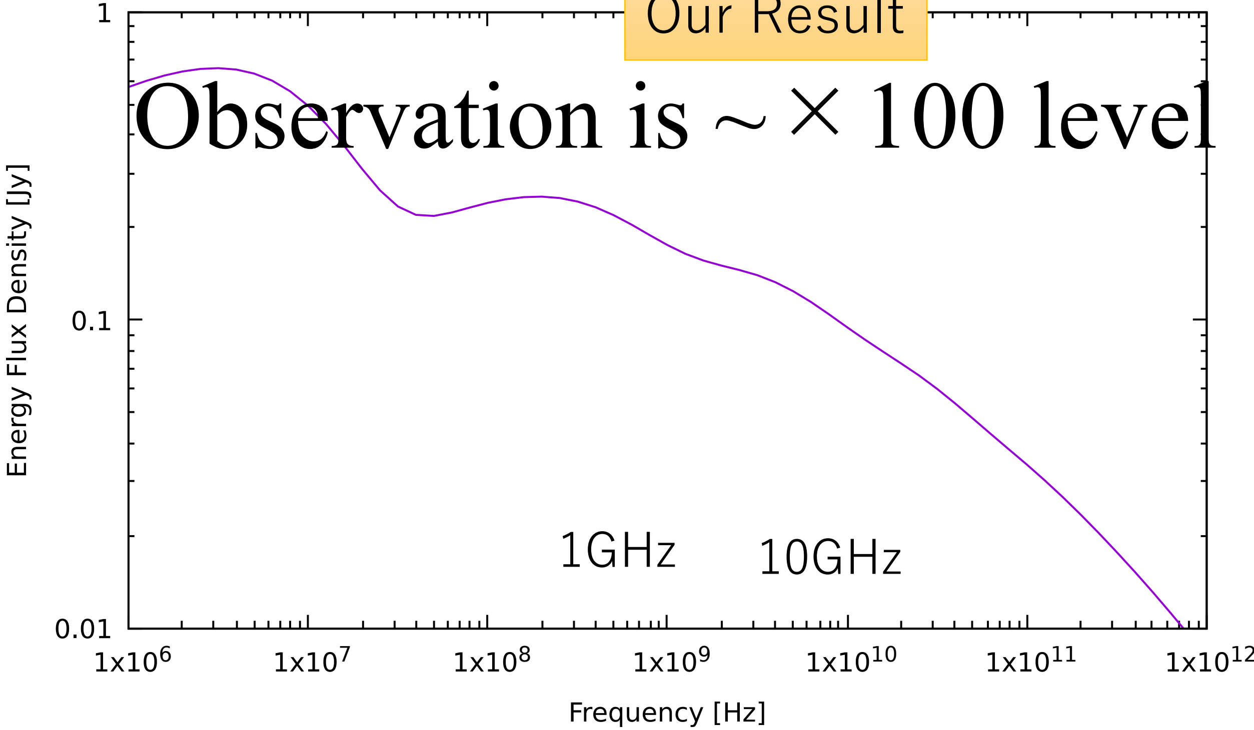
4. Signal of Radio Emission from the GC

Flux integrated within 20 pc



Our Result

Observation is ~× 100 level



Spectrum from Halo is assumed for signal

The GC is too noisy to observe DM!!

5. Signal of Radio Emission from Dwarf Galaxy(dSph)

Dwarf Galaxy(dSph) :

Draco is used

Distance 76kpc
Radius 220pc
M 1.1*10^7 Msun
Fe/H = -1.93 ← Maybe related SN

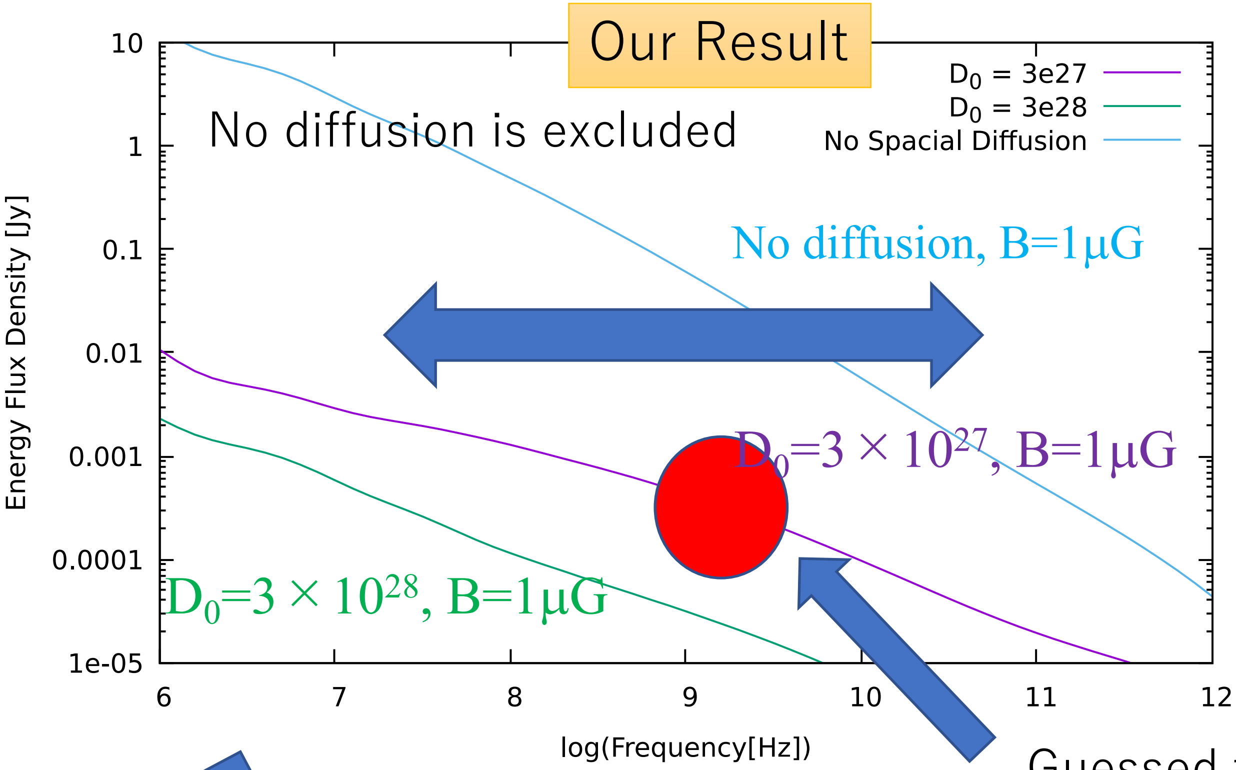
B=1 μ G

The other dSph are calculating Now.

dSph FoV	J2000 RA			DEC			Distance arcmin	Flux density mJy	$\langle\sigma_a v\rangle$ 10^{-26} cm^3/s
CAR	06	41	33.5	-50	58	11.7	0.6	0.28 ± 0.05	11.9
CAR	06	41	27.6	-50	59	09.5	1.9	0.30 ± 0.05	12.7
FOR	02	40	00.3	-34	25	07.6	1.8	0.16 ± 0.04	1.1
SCU	01	00	15.0	-33	44	00.3	1.9	0.28 ± 0.06	1.8
BOO	13	58	04.2	12	52	53.6	2.2	0.17 ± 0.05	0.51
HER	16	31	00.2	12	46	48.1	0.8	0.11 ± 0.04	11.7
SEG	02	19	18.7	20	09	13.1	1.4	0.09 ± 0.03	0.27
SEG	02	19	18.0	20	11	39.1	1.2	0.22 ± 0.03	0.66

Table 3. Properties of point-sources located within 2 arcmin from the dSph optical centers. The values of $\langle\sigma_a v\rangle$ have been determined matching the measured flux density with the emission from a WIMP model with $M_\chi = 100$ GeV, $b-\bar{b}$ final state, Einasto DM profile, B_{SFR} and no diffusion, see text.

ATCA (2GHz) JCAP10(2014) 016



Guessed from other dSphs

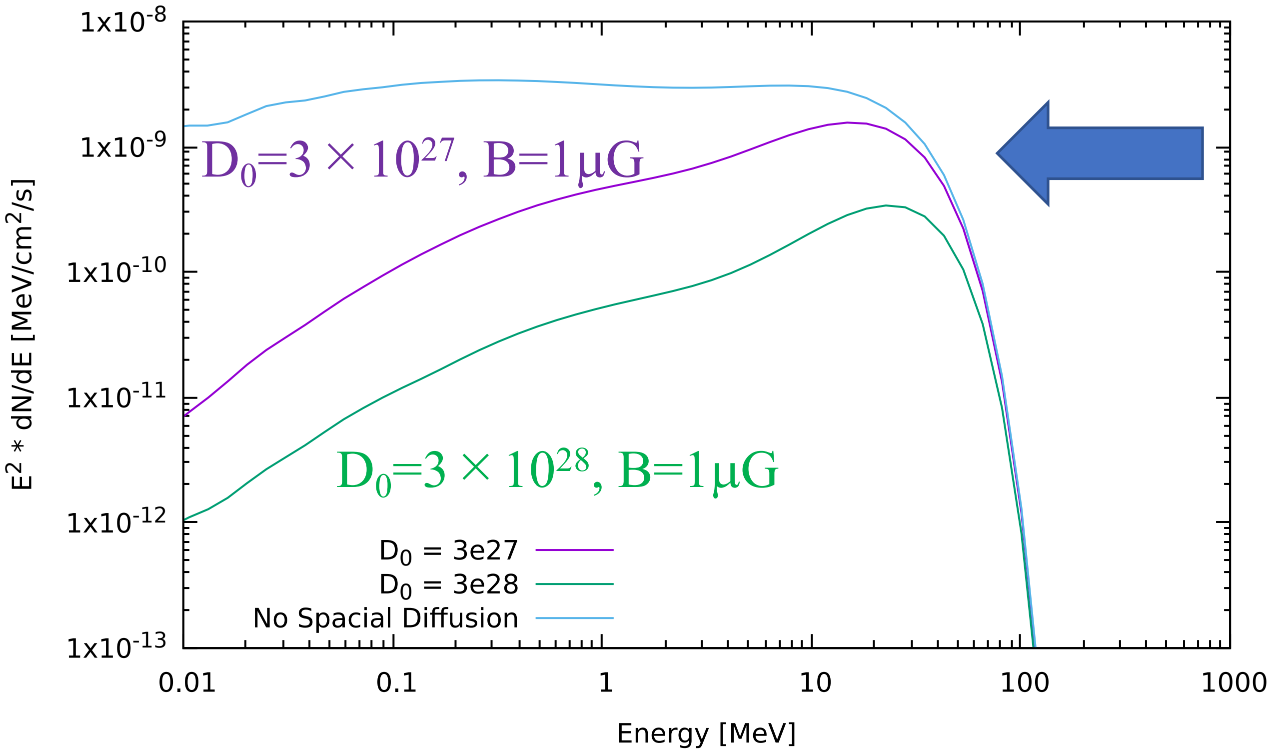
0.1 mJy radio are observed in the other dSphs

the same order?

More data is necessary wide frequency/various dSph

Signal of IC from dSph(Draco)

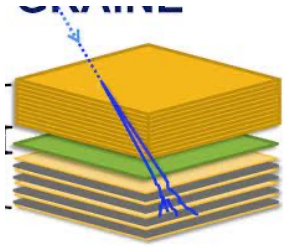
Our Result



Star in dSph is low-activity 2.7K CMB is used for IC
Signal will be enhanced if star effect is included

1000 events / year

MeV/GeV γ ray can be a clear signal, but the observational data are poor.
→ Need (large detector 10 m^2 & long exposure (10^7sec) & high angular resolution (< 1^o))



Emulsion on ISS?

6. Summary

1. muon g-2 and the other constraints give some hints (M=300-500GeV Higgsino DM)

2. IC γ from DM in the GC has hard spectrum upto 100GeV
   But intensity is too small(1-0.1%) comparing observed Fermi-Lat excess

3. SR signal from the DM in the GC is also smaller than the observed data (1% level)

4. SR signal in Dwarf is tantalizing, but there are many uncertainties (B, D, distributions)
   Wide wavelength measurements are crucial
   for various Fe/H Dwarfs.

5. We discuss about MeV –GeV γ signal. Need large area / high angular resolution
   detector (like Emulsion)