“Ruling out dark matter interpretation of the galactic GeV excess by gamma-ray data of galaxy clusters”

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From nature, scientific reports 7, 14895 (2017)

Motivation & Background

・ GeV gamma-ray excess around the Milky Way (= our galaxy) can be explained by dark matter annihilation.

・Recently, gamma-ray observation from cluster of galaxies set constraint on the dark matter annihilation cross section.

・There are discussions that the GeV gamma-ray excess from the Mily Way can be explained by pulsar’s emission.

Ref.

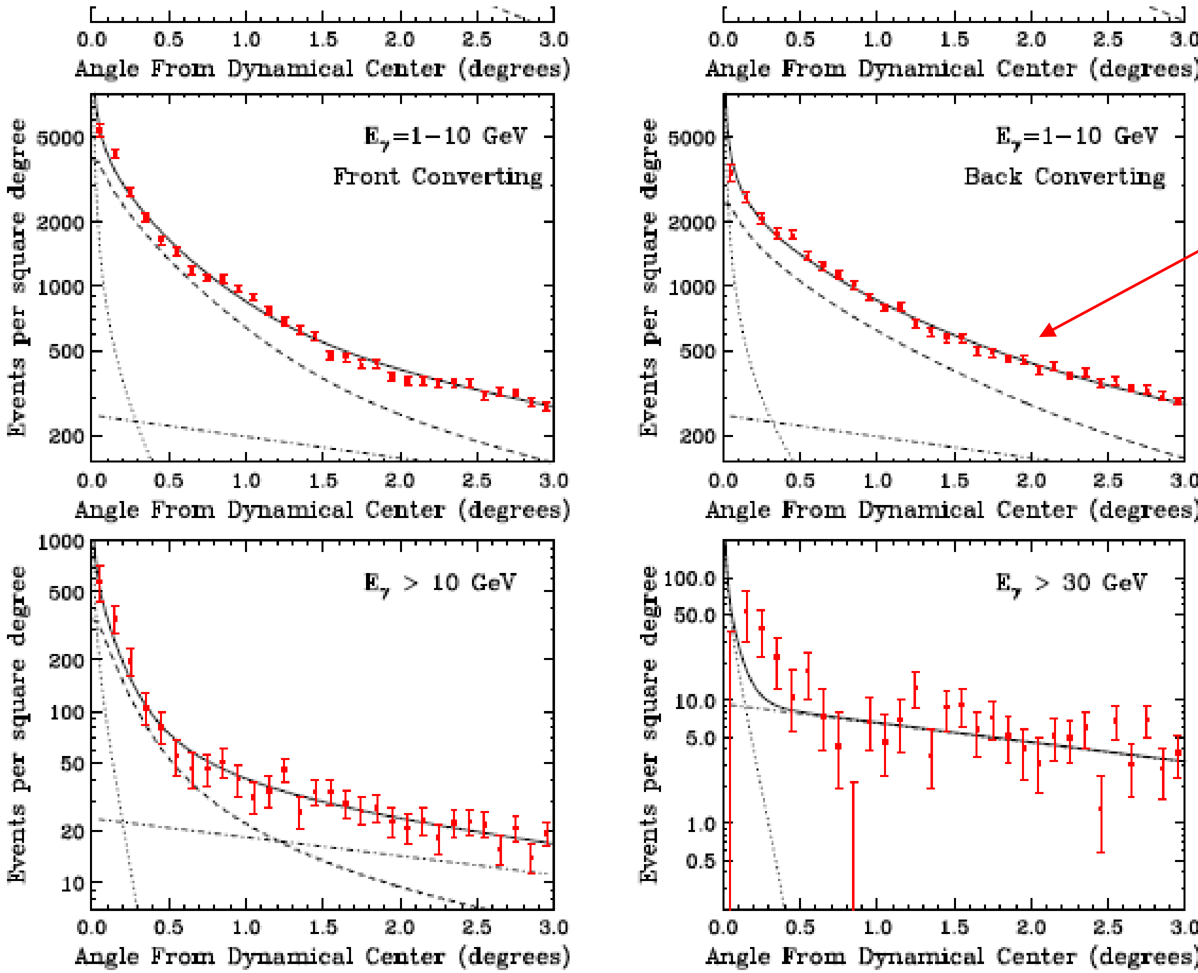


FIG. 1: The angular distribution of gamma rays around the Galactic Center observed by the FGST. In each frame, the dashed line denotes the shape predicted for the annihilation products of dark matter distributed according to a halo profile which is slightly cuspier than NFW ($\gamma = 1.1$). The dotted line is the prediction from the previously discovered TeV point source located at the Milky Way's dynamical center, while the dot-dashed line denotes the diffuse background described in the text (which, although included in each case, falls below the range of rates shown in the upper four frames). The solid line is the sum of these contributions.

"Possible Evidence For Dark matter Annihilation In The Inner Milky Way From The Fermi Gamma Ray Space Telescope" arXiv: 0910.299

Gamma-ray emission model

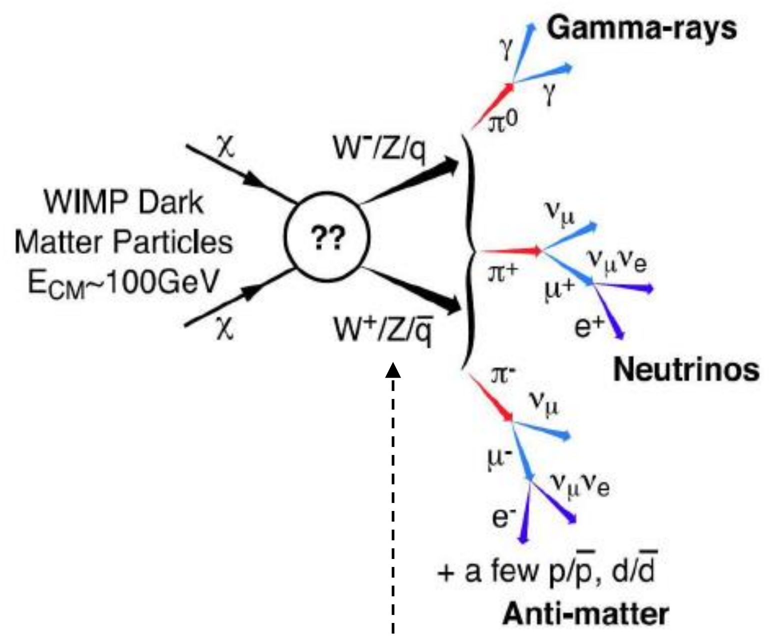
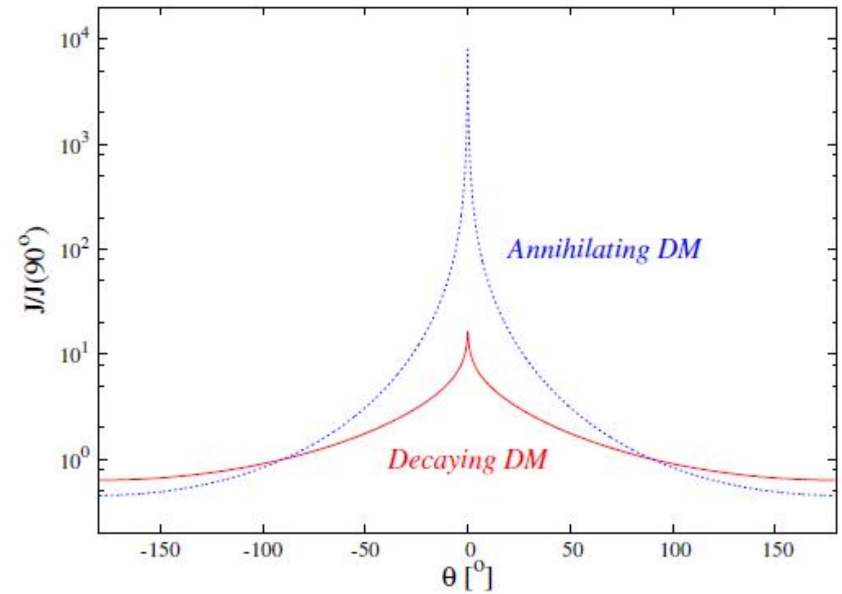


FIG. 1: gamma-ray production scheme for DM annihilation. Reproduced from [12]. If the DM particles self-



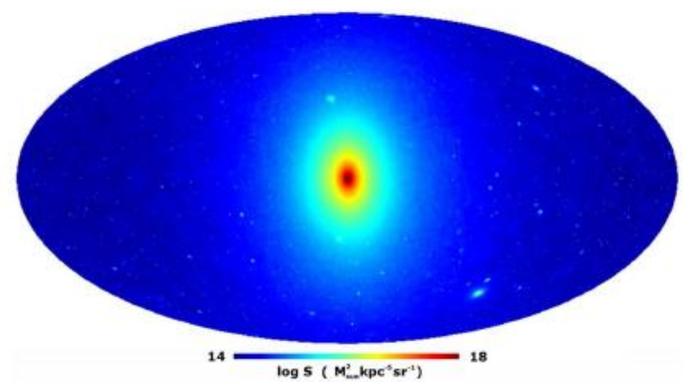


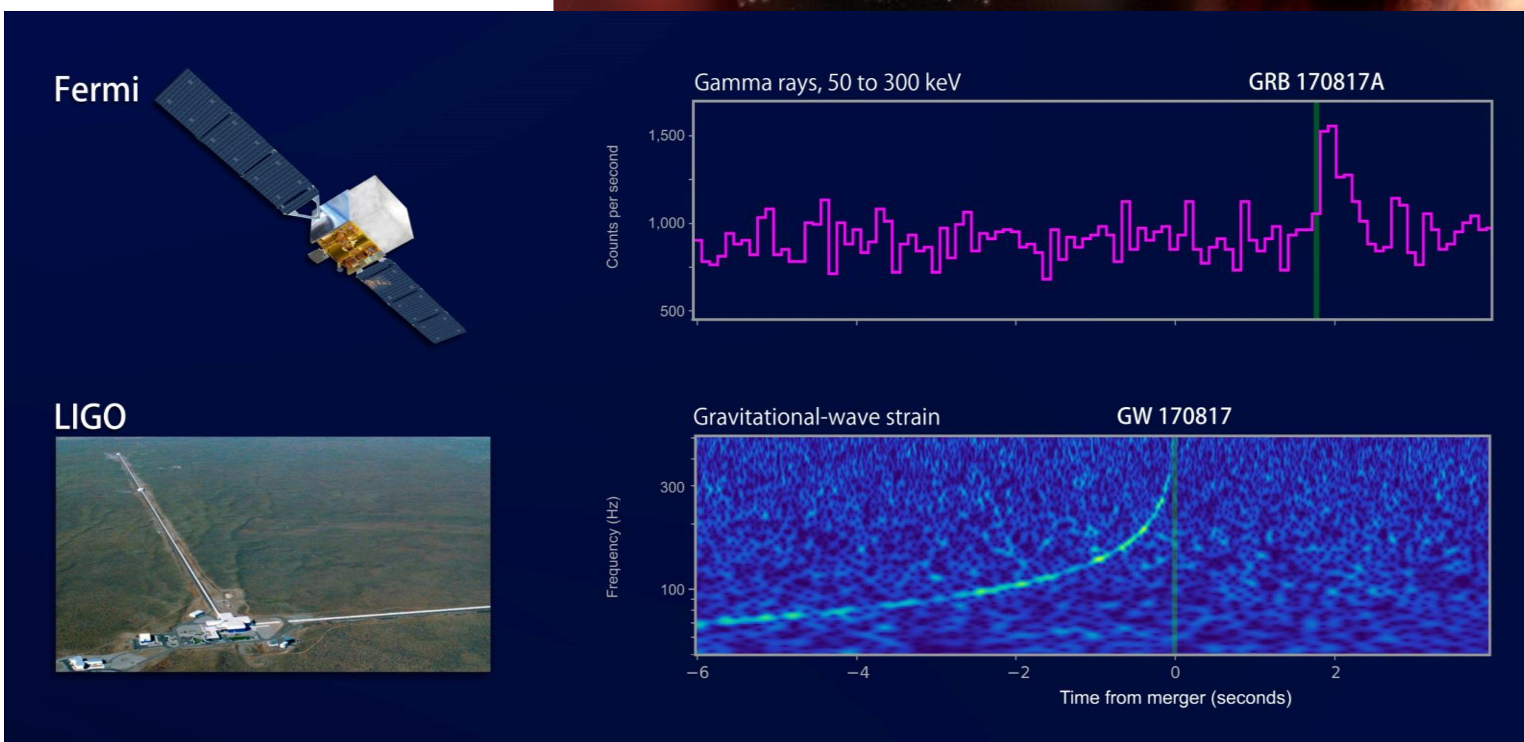
FIG. 3: Simulated gamma emission from an annihilating

here, the model expects bb/ττ/μμ/ee .... but I do not investigate more

From arXiv: 0912.382

Fermi Gamma-ray Space Telescope

Recently, they "collaborate" with the Gravitational Wave event

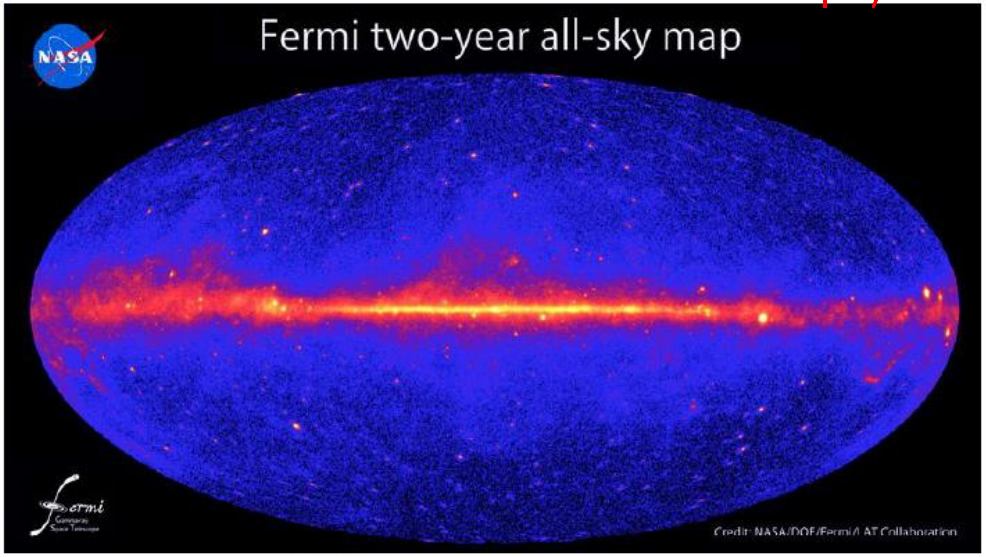


Fermi Gamma-ray Space Telescope

- Fermi = LAT + GBM
- LAT = "GeV" Gamma-ray Space Telescope
  (20 MeV ~ >300 GeV)

Complement to IACT (air chelenkov telescope)

Cape Canaveral, Florida



1873 sources
Abdo+, ApJS submitted
arXiv:1108.1435

T. Mizuno et al.

Back to the paper .

・ They combine gamma-ray emission model of direct emission & in-direct emission

e-e+ from the dark matter annihilation process interact with thermal e-e+ and emit gamma-ray

・ They searched (used the data) cluster of galaxies which has large density (mass) and smaller gamma-ray flux limited observed by Fermi.

➡ It seems, cluster of galaxies of "A2877" and "Fornax" are selected here.

Upper limits on the dark-matter annihilation cross section

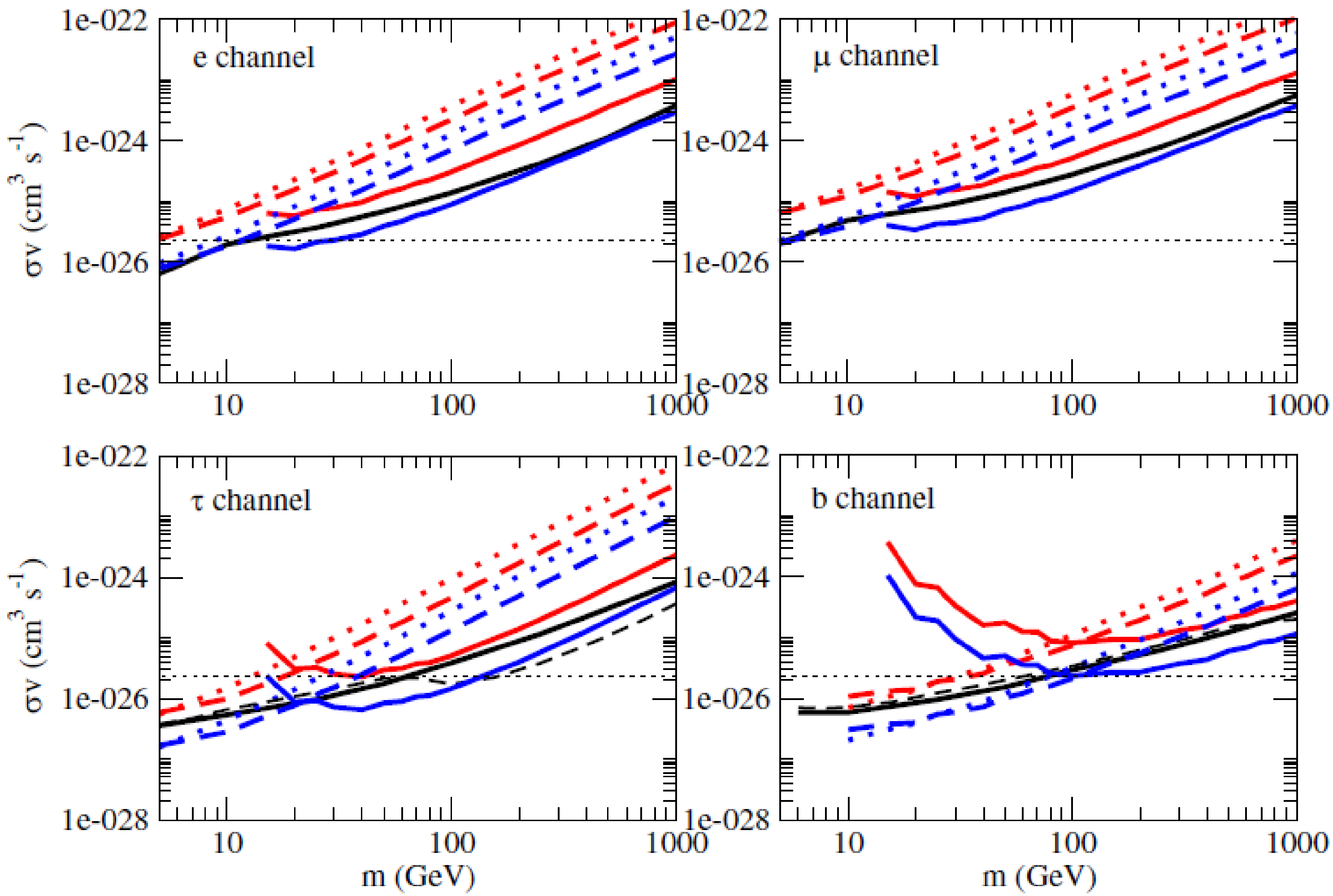


Figure 1. The upper limits of the annihilation cross section for 4 channels. The lines in red and blue represent the limits based on the data from A2877 and the Fornax cluster respectively (dotted line: $E_0 = 0.5$ GeV; dashed line: $E_0 = 1$ GeV; solid line: $E_0 = 10$ GeV). The black solid lines and dashed lines represent the upper limits of the annihilation cross section based on the Fermi-LAT data of the Milky Way dwarf spheroidal satellite galaxies[6,7]. The black dotted lines represent the thermal relic cross section $<\sigma v> = 2.2 \times 10^{-26}\,\mathrm{cm}^3\,\mathrm{s}^{-1}$[36].

Reference :

WIMP (dark-matter) annihilation cross section

It is estimated from cosmological theory together with current observation result by assuming thermal equilibrium and so on . . .

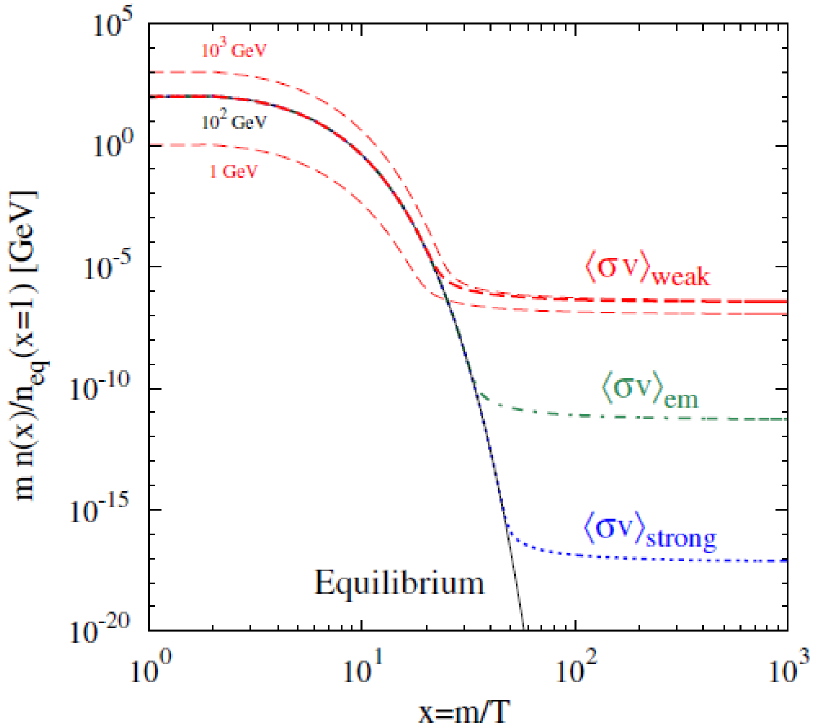


FIG. 1 (color online). Evolution of the cosmological WIMP abundance as a function of $x = m/T$. Note that the y axis spans 25 orders of magnitude. The thick curves show the WIMP mass density, normalized to the initial equilibrium number density, for different choices of annihilation cross section $\langle\sigma v\rangle$ and mass m. Results for $m = 100$ GeV are shown for weak interactions, $\langle\sigma v\rangle = 2 \times 10^{-26}$ cm^3 s^{-1}, (dashed red), electromagnetic interactions, $\langle\sigma v\rangle = 2 \times 10^{-21}$ cm^3 s^{-1} (dot-dashed green), and strong interactions, $\langle\sigma v\rangle = 2 \times 10^{-15}$ cm^3 s^{-1} (dotted blue). For the weak cross section the thin dashed curves show the WIMP mass dependence for $m = 10^3$ GeV (upper dashed curve) and $m = 1$ GeV (lower dashed curve). The solid black curve shows the evolution of the equilibrium abundance for $m = 100$ GeV. This figure is an updated version of the figure which first appeared in Steigman (1979) [11].

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Upper limit ratio:

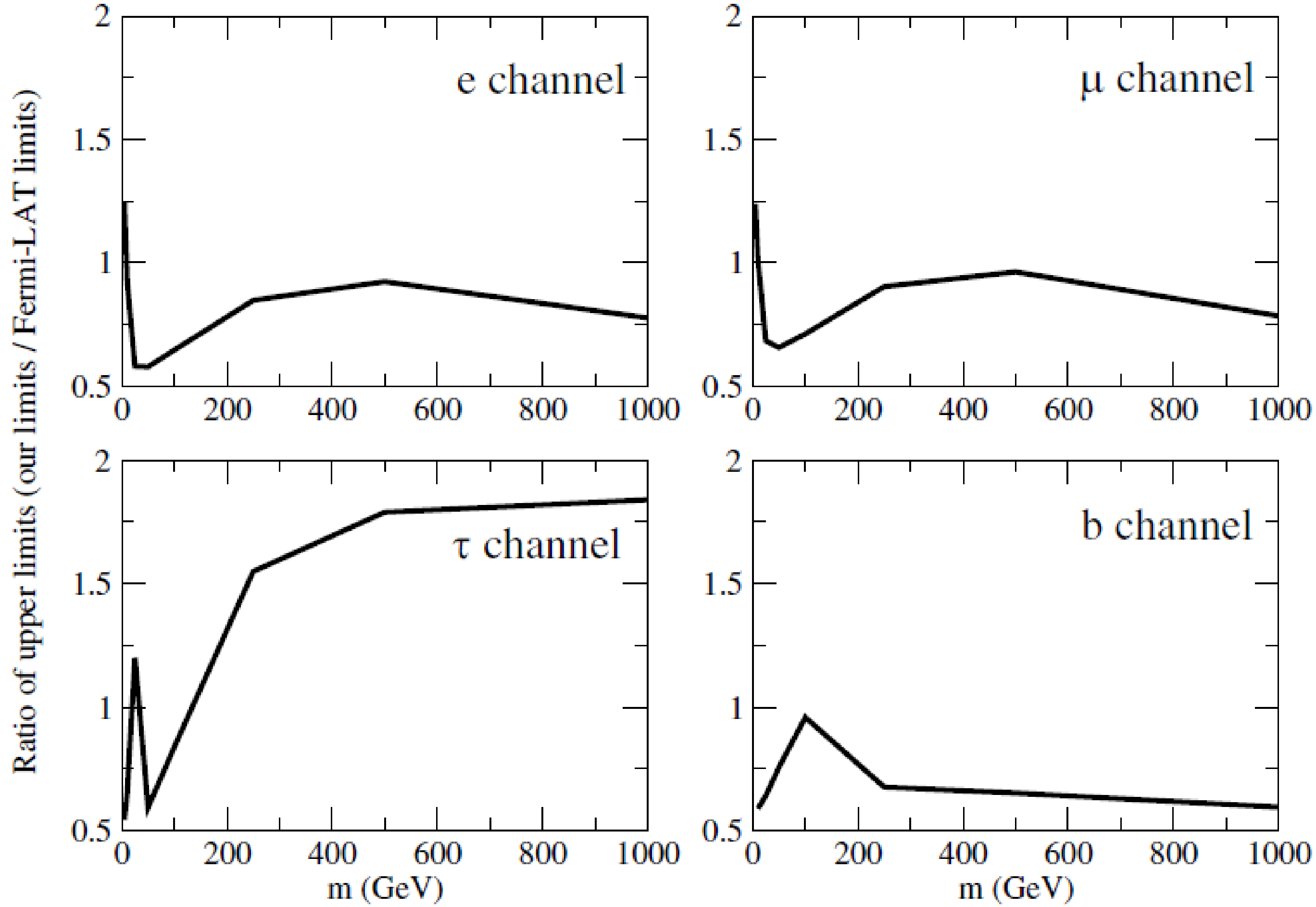

Figure 2. The ratio of the upper limits of the annihilation cross section obtained in this study to the Fermi-LAT upper limits in[6,7] for 4 channels.

cross section if the gamma-ray excess around galactic center is due to dark matter annihilation

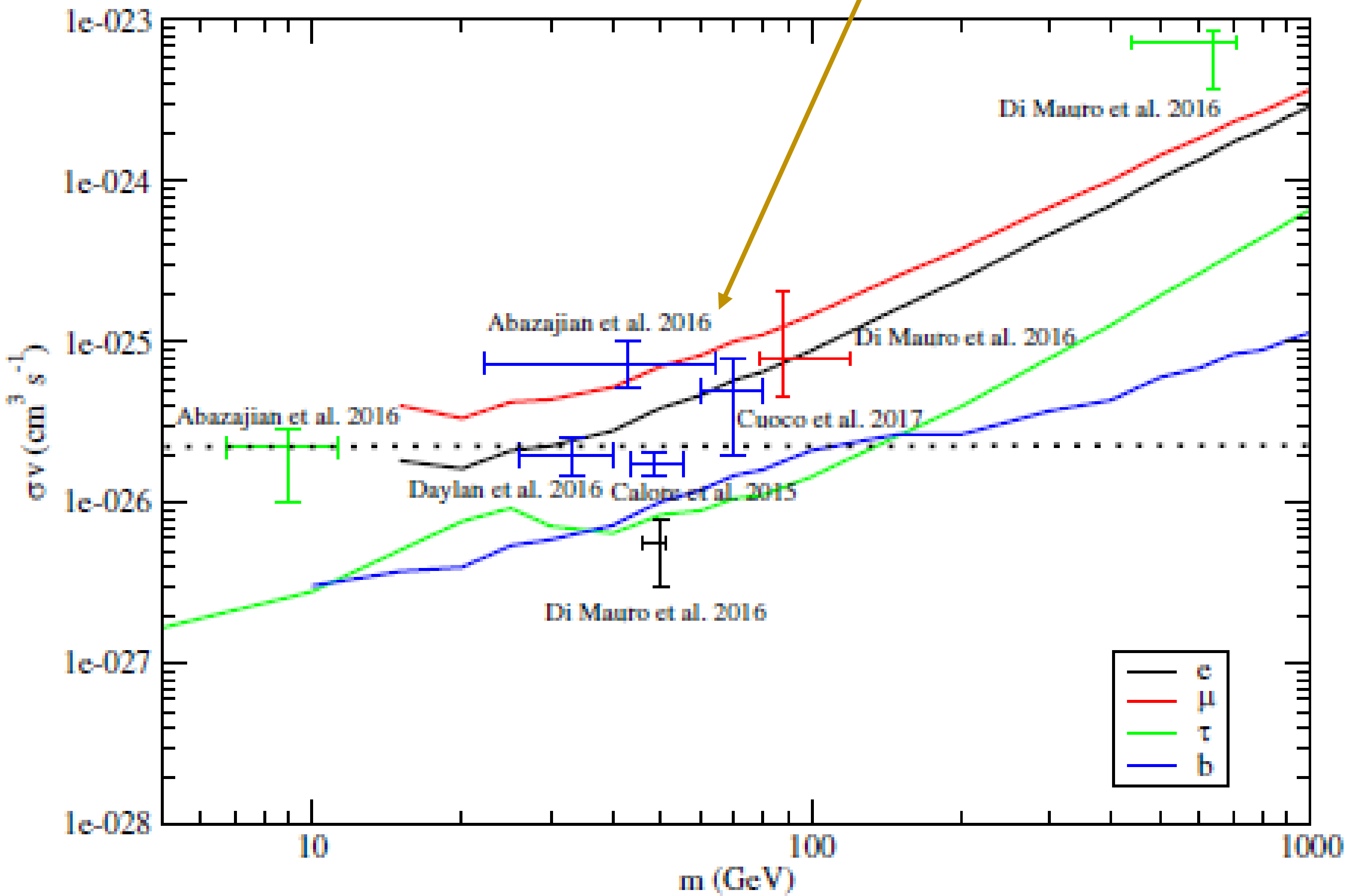

Figure 3. The solid lines represent the upper limits of the annihilation cross sections for the e^+e^-, $\mu^+\mu^-$, $\tau^+\tau^-$ and $b\bar{b}$ channels. The data points with 1 σ error bars are the results obtained in[2,4,5,38,39] for the dark matter interpretation of the GeV excess and positron excess. Here, different colors of solid lines and data points represent different annihilation channels. The dotted line is the thermal relic cross section.

Summary

・ They have tighter constraints on the dark matter mass from A2877 and Fornax

・The result favors the scenario of the mass of dark matter is larger than 1 TeV.