Direct and indirect detections of heavy wino-like dark matter

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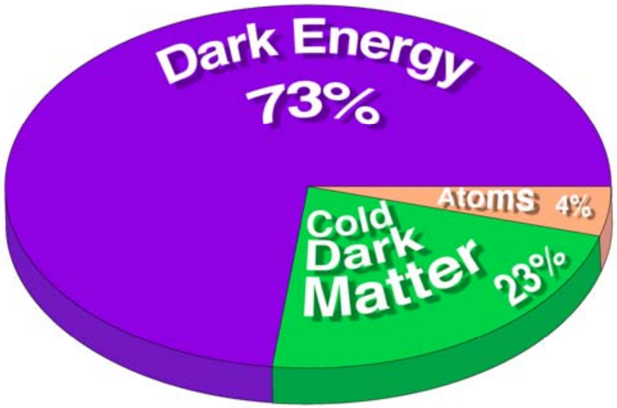
Dark Matter Abundance

Results from recent cosmological observation

Mean density of matter and baryon

$\rho_M \approx 2.9 \times 10^{-6}$ GeV/cc

$\rho_B \approx 4.6 \times 10^{-7}$ GeV/cc



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Existence of non-baryonic (cold) dark matter

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Constituent of dark matter = **Beyond SM Physics**

Wino-like dark matter

Many candidates (neutralino, gravitino, Axion, LKP, etc)

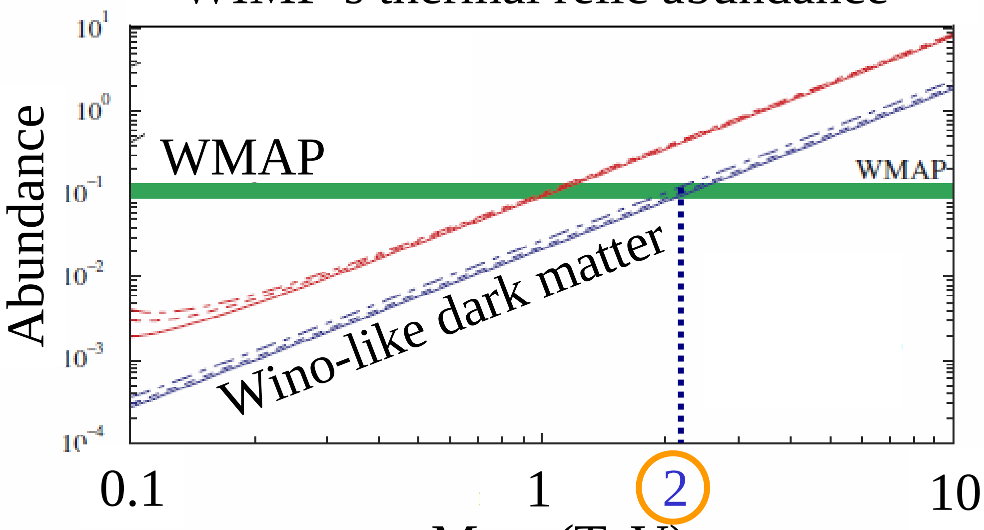
Among those →

neutralino in Minimal SUSY SM

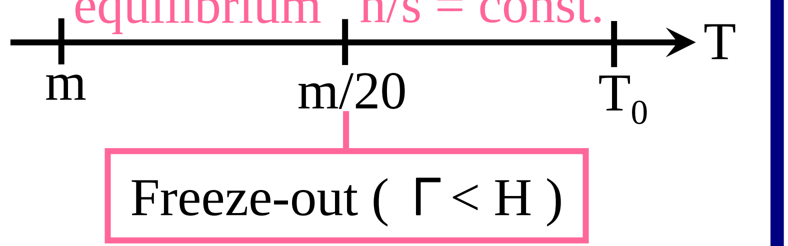
$$\tilde{\chi}^0 = Z_{01}\tilde{B} + Z_{02}\tilde{W} + Z_{03}\tilde{H}_d + Z_{04}\tilde{H}_u$$

Wino-like dark matter (super-partner of neutral weak boson)
(realized in anomaly mediation, Split SUSY)

WIMP's thermal relic abundance



Profumo, Yaguna (2005)

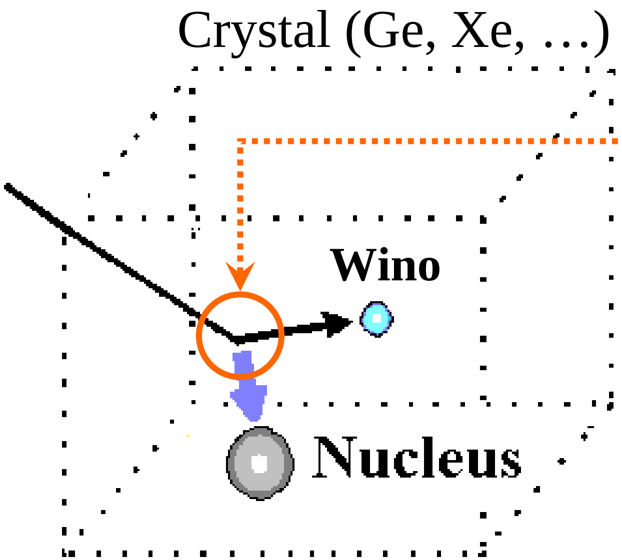


Purpose of my talk

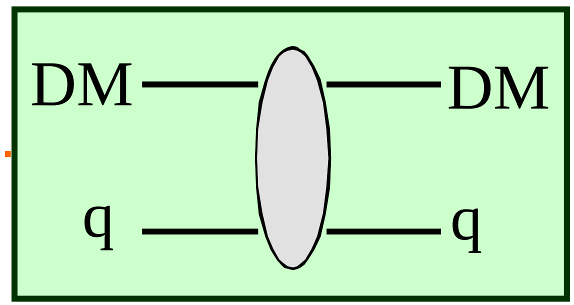
Signatures of heavy Wino-lilke DM in direct and indirect (e^+, γ) detection mesurments.

Direct detection

Our solar system moves in the halo, many dark matters passes thorough the earth's surface. Dark matter will be detected by observing nuclear recoil after DM-nucleus scattering.

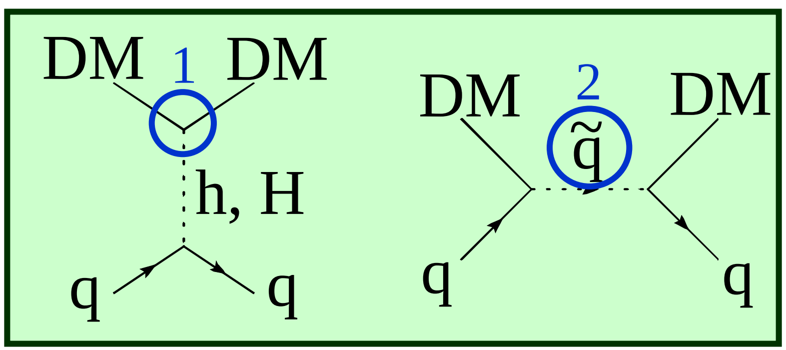


Detection rate ∝ Scattering cross section



Scattering cross section of Wino-like DM

At tree level



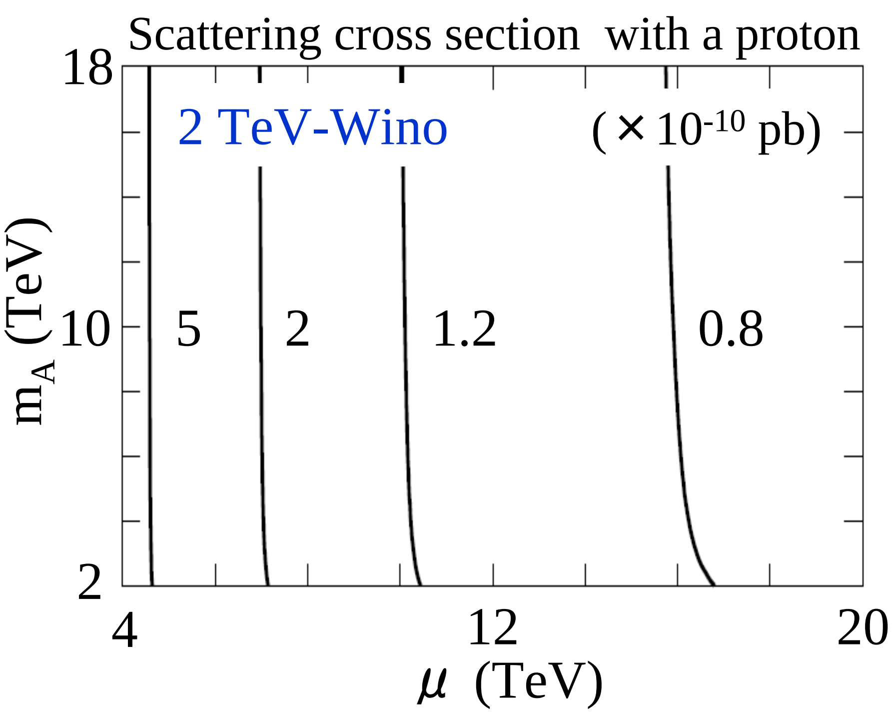
For spin-independent int.

Tree level diagrams are highly suppressed by the M_{SUSY} scale (1 mixings , 2 squark mass , …) for heavy Wino-like DM.

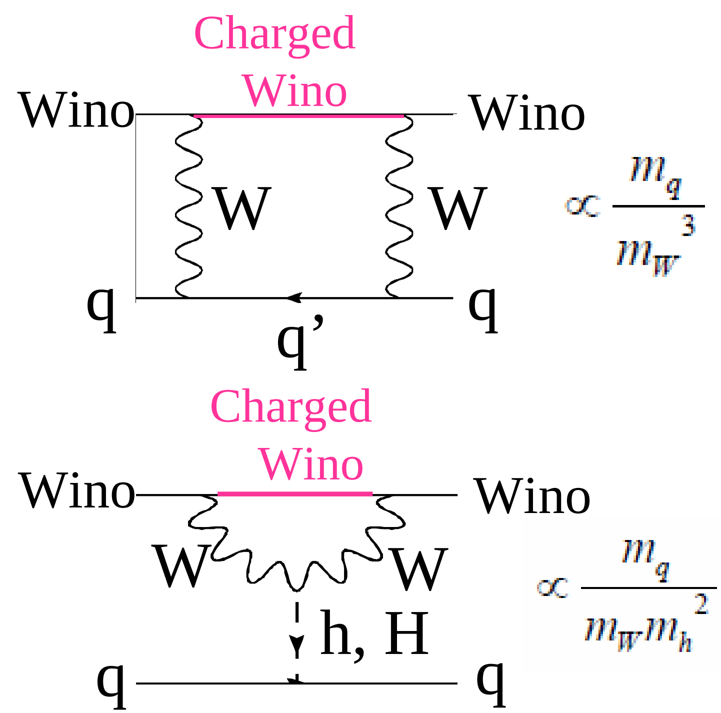
Scattering Cross section at 1-loop

J.Hisano, S.M, M.Nojiri and O.Saito (2004)

At 1-loop level, there are some diagrams which are not suppressed by M_{SUSY}.



$\sigma_{\chi P} \sim 10^{-10}$ pb. (Dominant contribution comes from 1-loop diagrams.)
Present bound from CDMSII ~ 10^{-6}pb.
The dependence of m_A is very small when the pseudo-scale is heavy enough.

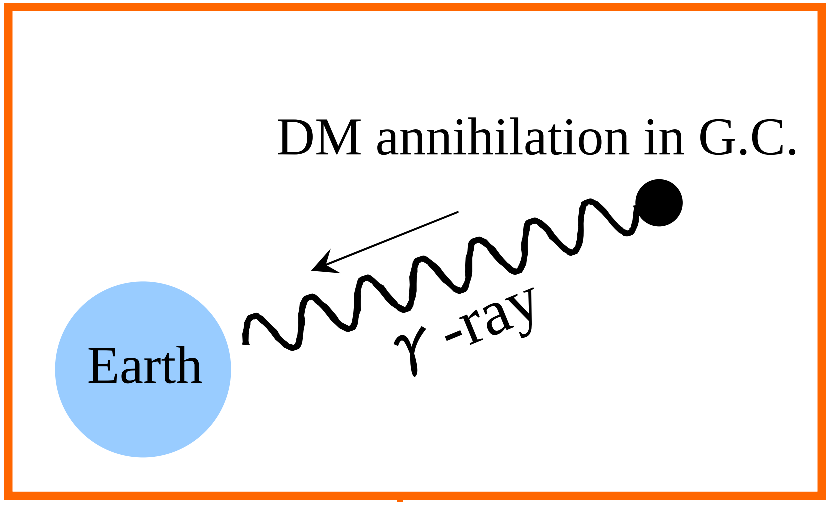


In these diagrams, no vertex suppressions. Intermediate charged Winos are almost On-shell, and no dependence of Wino's mass.

Indirect detection using γ & e^+

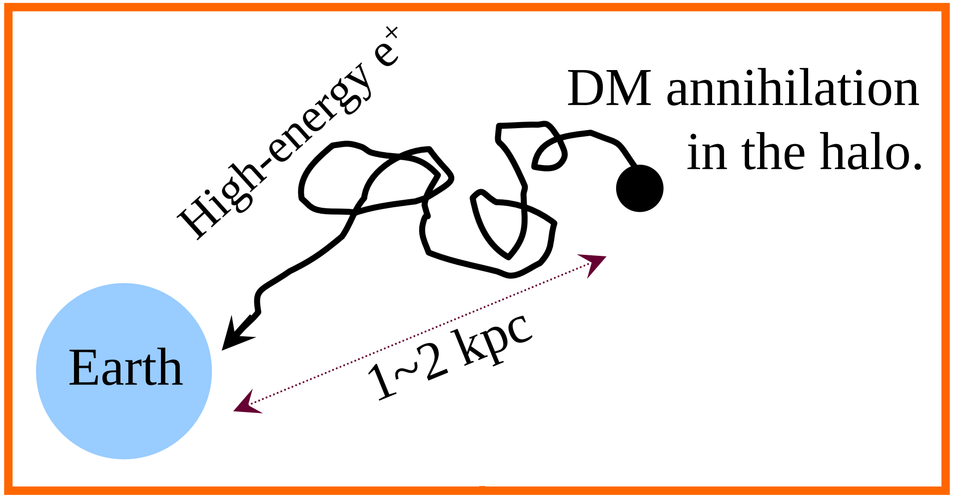
Dark matter will be detected by observing γ or e^+ produced in the galactic halo.

Gamma-ray from DMs



High energy gamma-ray is produced from dark matter annihilations.
The gamma-ray is dominantly coming from the direction of the galactic center if the dark matter profile has a cuspy structure.

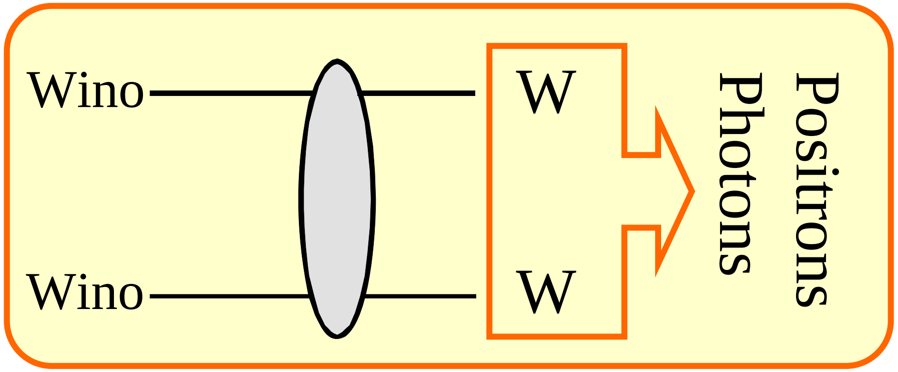
Positrons from DMs



e^+ do not travel in straight line, the signal is observed as the Positron excess in cosmic rays.
e^+ is absorbed and loses its energy by the propagation in ISM. The flux at earth mostly originates within a few kpc.

Threshold singularity of annihilation cross section

Important quantity for indirect detections



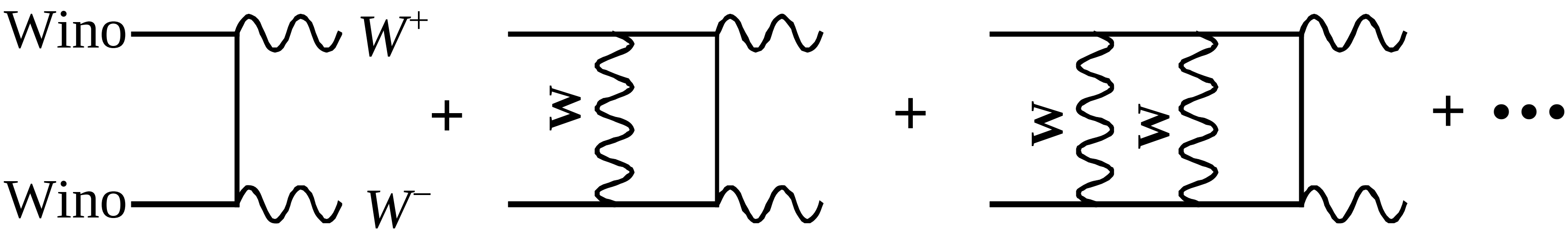
Simple perturbative calculations of the annihilation cross section are broken down due to the threshold singularity !!

Threshold singularity appears due to the degeneracy between wino & charged wino

. We have to consider highr order diags !!

Resummation of ladder diagrams

Resummation



$A_0 \sim \alpha_2$

$\sim A_0 \frac{\alpha_2 m}{m_W}$

$\sim A_0 \frac{\alpha_2^2 m^2}{m_W^2}$

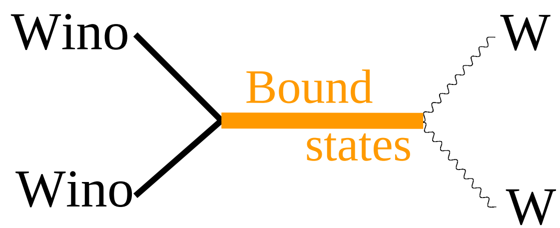
Diagrams have an additional factor $\alpha_2 m / m_W$ for each weak gauge boson exchange.

Resonant annihilation cross section of heavy wino-like DM

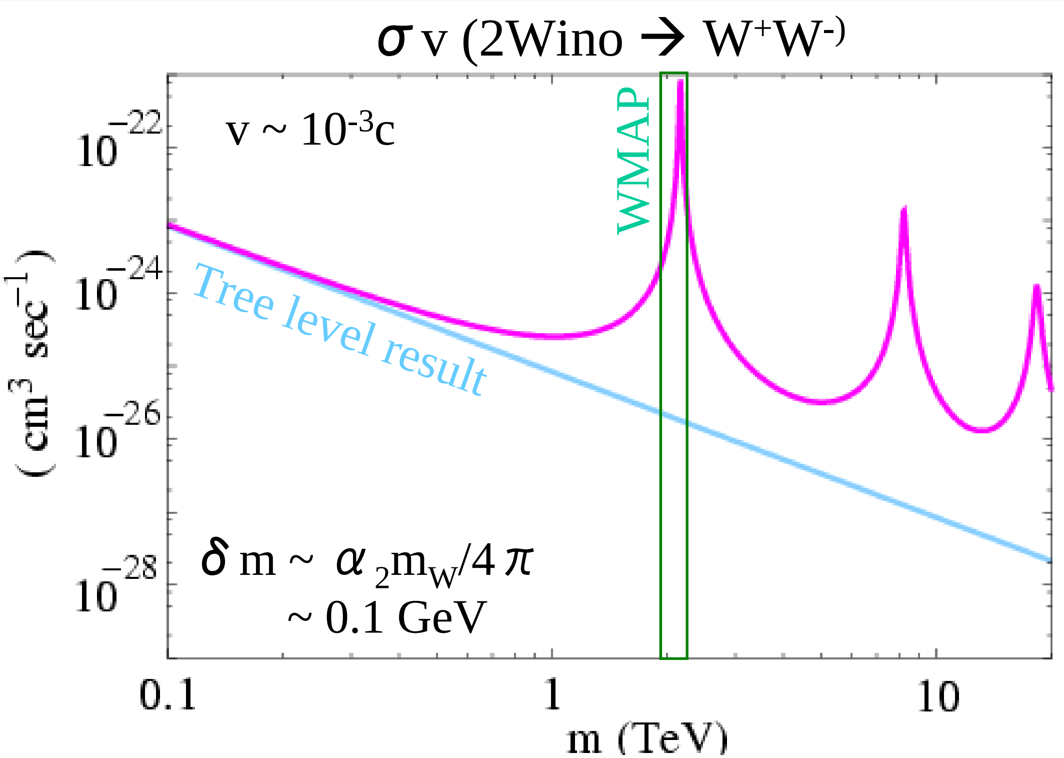
Resummation of ladder diagrams

= existence of the long range force induced by W boson exchange. (Yukawa interaction)

Binding states composed by Wino & charged Wino pair appear when Wino is heavy.



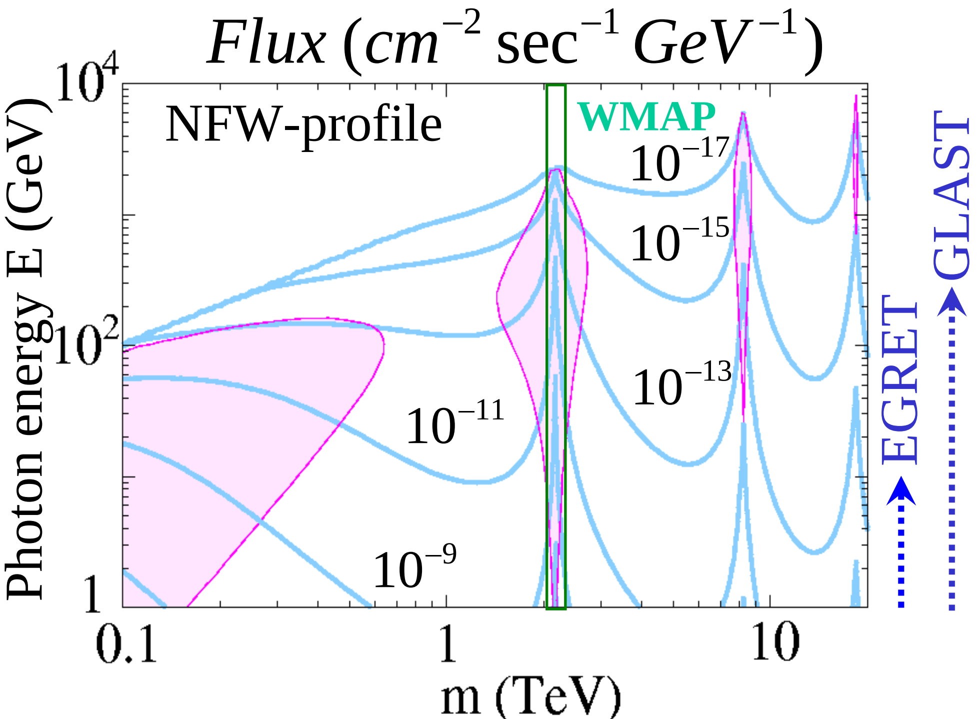
Binding Energy is Almost 0!!



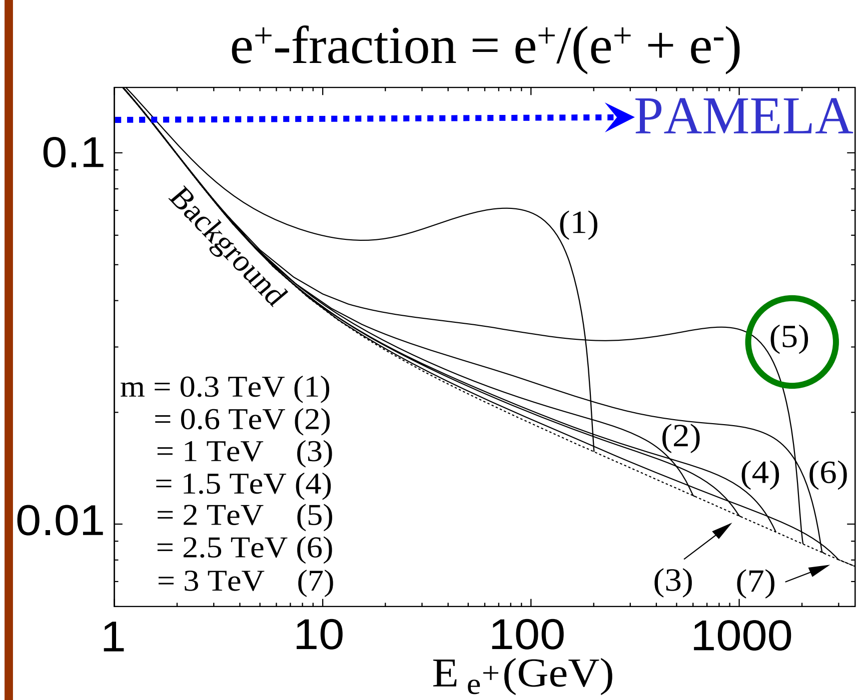
J.Hisano, S.M, M.Nojiri (2003, 2004)

γ -ray & e+ fluxes

In indirect detection, strong signals from Wino-like DM annihilation are expected due to the resonant annihilation.



1. [pink box] : DM signals > back ground (when NFW-profile is used)
2. Some part of WMAP region are already excluded from EGRET observation.
3. GLAST will cover all WMAP region (γ -ray signal depends on DM profile)



1. Positron fraction is ~ 0.035 for 2 TeV Wino.
2. In this calculation, the boost factor is not used.
3. Large excess from B.G.

J.Hisano, S.M, M.Nojiri, O.Saito (2004,2005)

J.Hisano, S.M, O.Saito, M.Senami (2005)

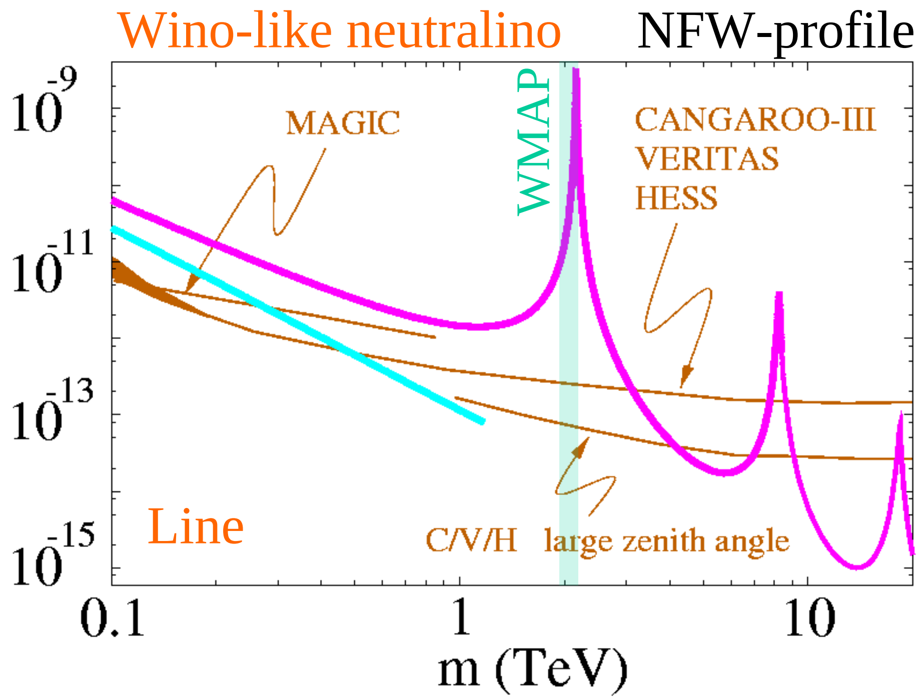
Summary

We study the signatures of heavy (TeV) wino-like dark matter in direct and indirect detection measurements.

In direct detection, some 1-loop diagrams significantly contribute to the collision cross section between Wino and proton, though the tree level ones are highly suppressed. The cross section is about 10^{-10} pb.

In indirect detections using gamma-rays and positrons, strong signals are expected due to the threshold singularity in the cal. of the annihilation cross section.
In the gamma ray measurements, the large flux comes from the galactic center (if the dark matter profile has a cuspy structure.)
In the positron measurements, the large positron excess in cosmic rays is expected than its expectation (B. G.).

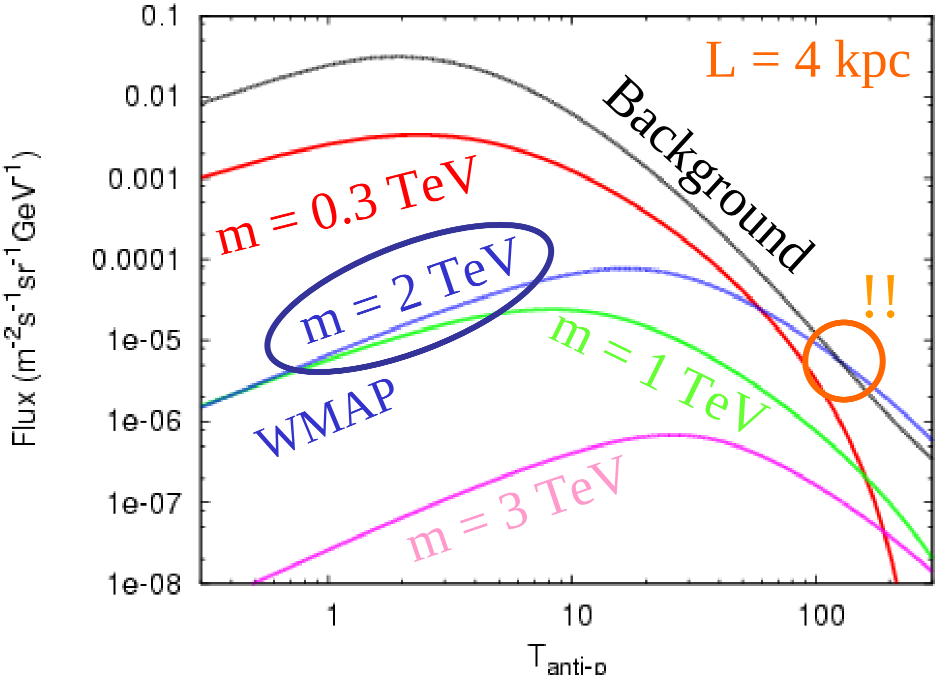
Line gamma-ray flux (Wino-like DM)

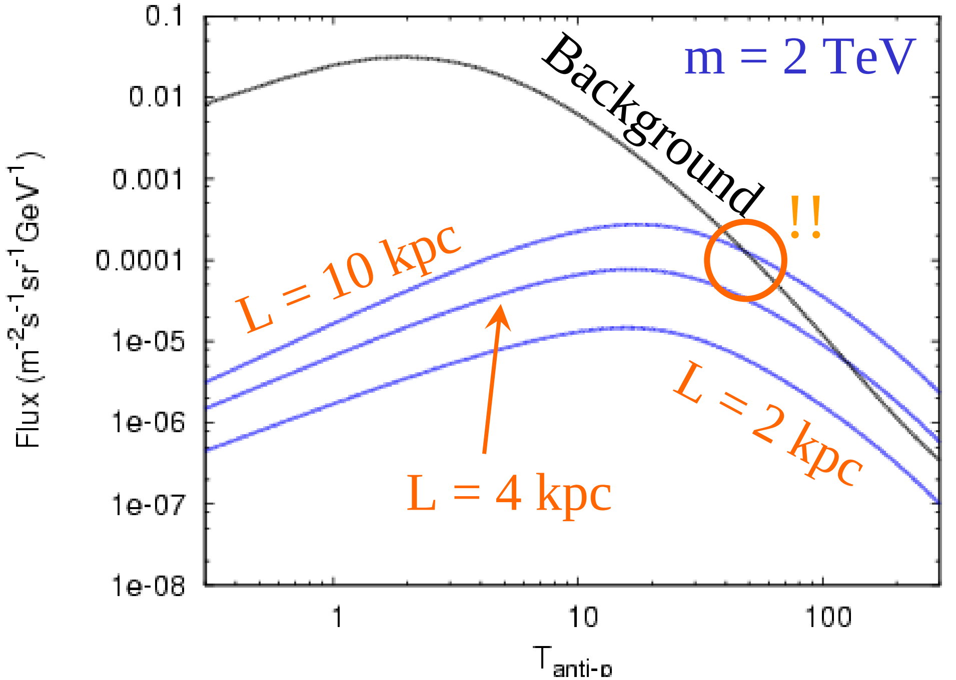


J.Hisano, S.M, M.Nojiri, O.Saito (2004,2005)

Anti-proton flux (Wino-like DM)

J.Hisano, S.M, O.Saito, M.Senami (2005)





When m ~ 2 TeV, Signal > Background
due to the resonant enhancement of threshold singularity.

The spectrum of the background is described by the power law at the high-energy.

→

When the signal from the DM annihilation is large enough,
we can find the deviation from the law.

Please note that the signal has large ambiguities coming from the parameter L