

# Dark matter:

## *From PAMELA to CDMS and Back*

Hao Zhang

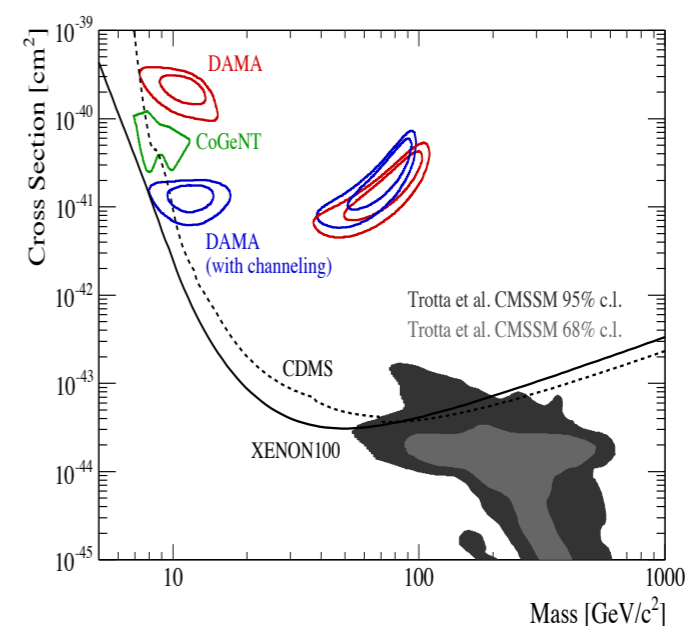
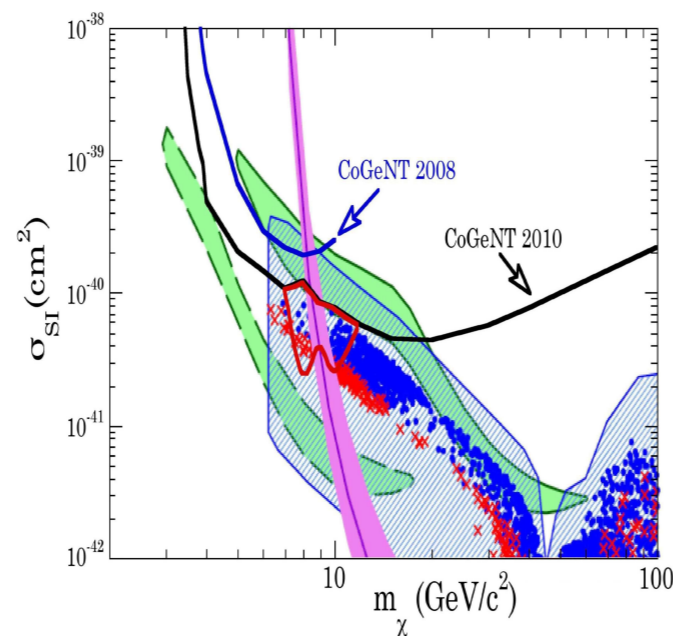
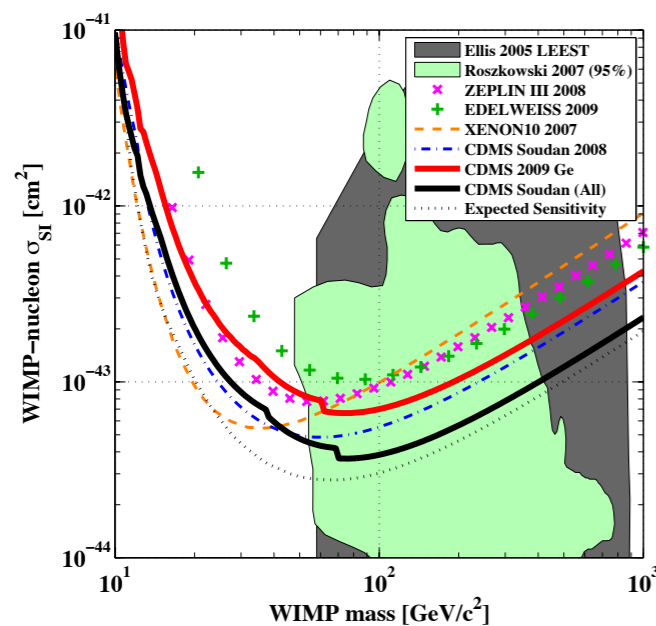
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In Collaboration with Qing-Hong Cao, Ian Low and Gabe  
Shaughnessy, arXiv:0912.4510 and 1005.xxxx



# Motivation

- Recently, we have some new results from dark matter direct detection experiments.

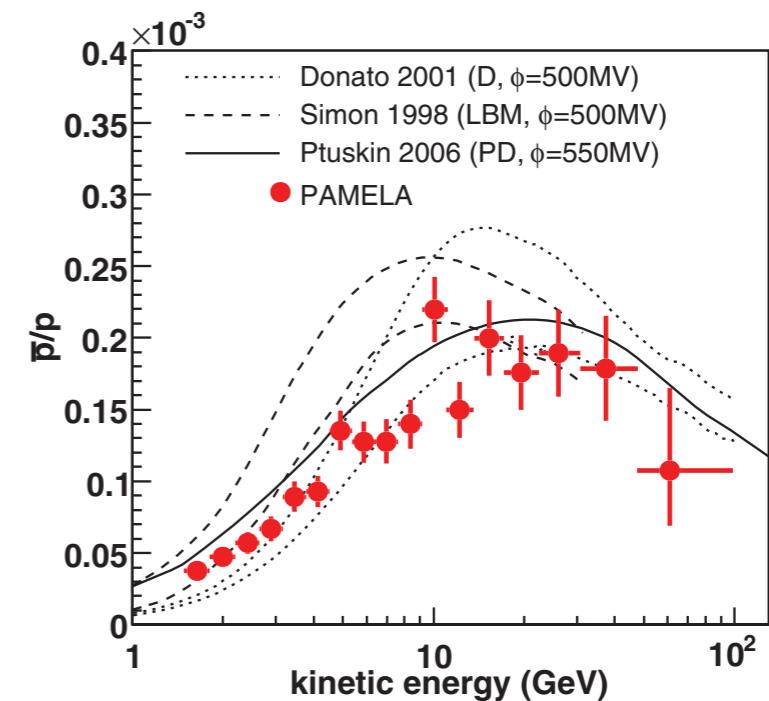
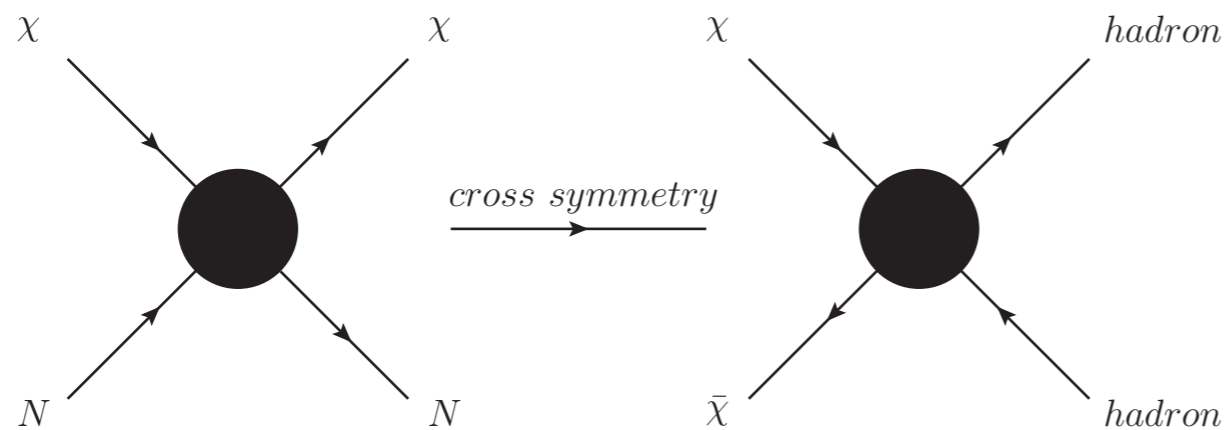


- The CDMS collaboration reported an observation of two signal events with a 77% confidence level. (CDMS collaboration, Science 26 March 2010: Vol. 327. no. 5973, pp. 1619 - 1621)
- The CoGeNT group announced an excess of events at low energies. (CoGeNT collaboration, arXiv:1002.4703)
- The XENON experiment also published their new result. (XENON Collaboration, arXiv:1005.0380)



# Motivation

- The crossing symmetry tells us: if the cross section of DM --- nucleon elastic scattering is non-zero, we will also have a non-zero DM annihilation into hadron final state.

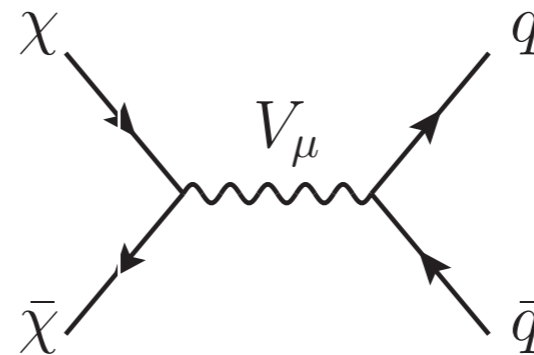
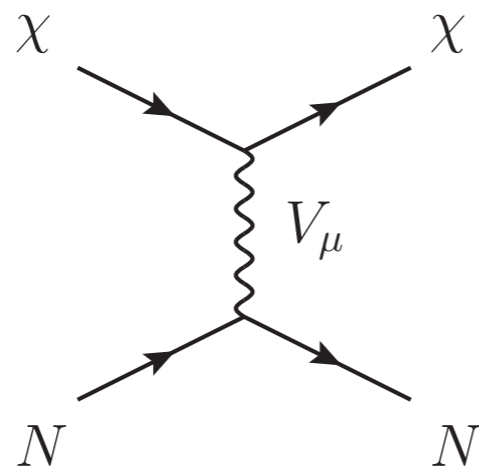


- It could be constrained by the PAMELA antiproton spectrum. (Phys. Rev. Lett, 2009(102)051101)
- A constraint to the boost factor!



# An Example

- Dirac Fermion dark matter.
- Vector boson mediator.
- Vector boson mediator also talks to the SM quarks.
- Contribution to SI direct detection.

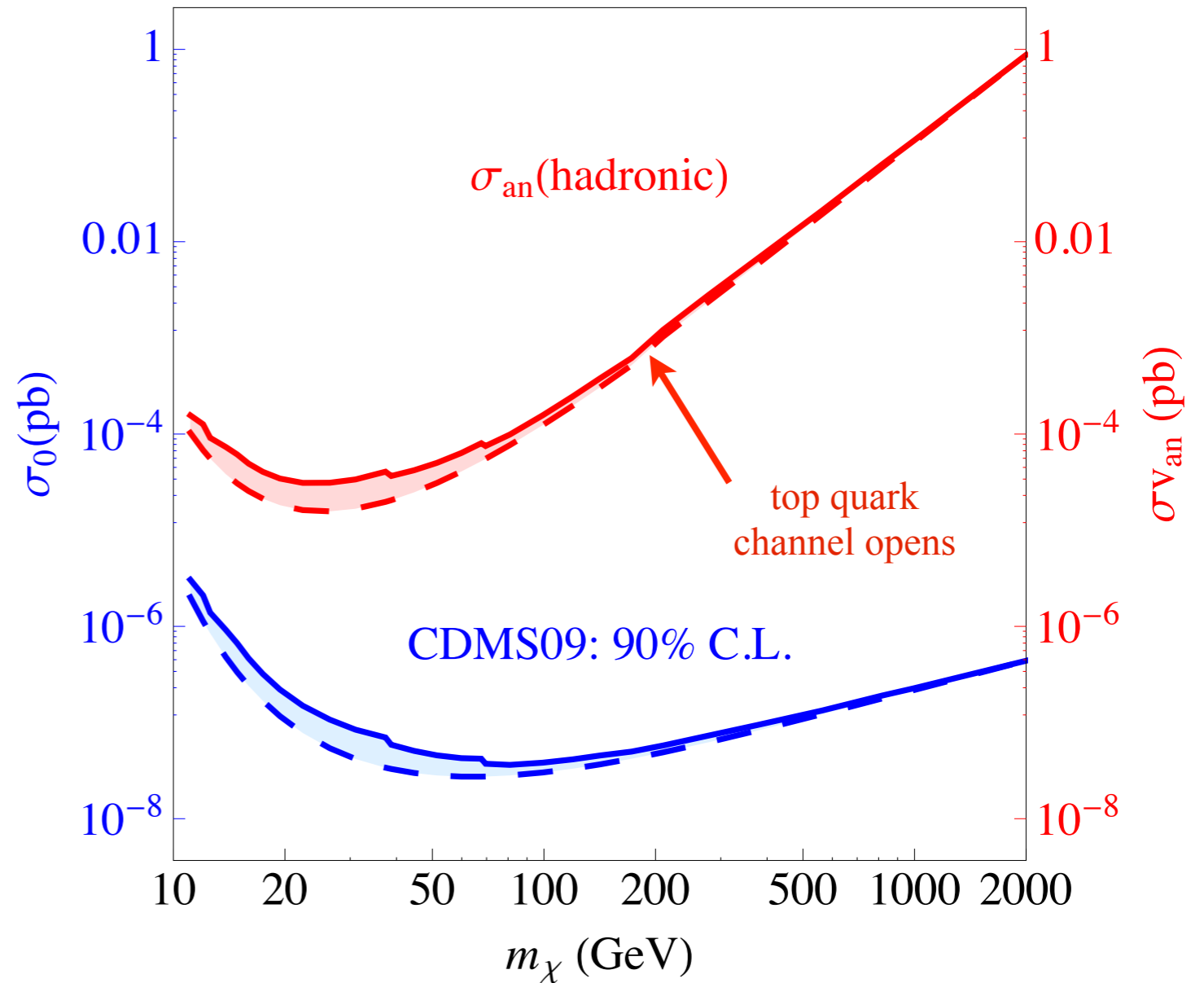


# An Example

- When the mediator is heavy enough, we are going to use the effective operator

$$\frac{G}{\Lambda^2} \bar{\chi} \gamma^\mu \chi \bar{q} \gamma_\mu q$$

- Observed 90% C.L. of the latest CDM result and the CDMS expected sensitivity



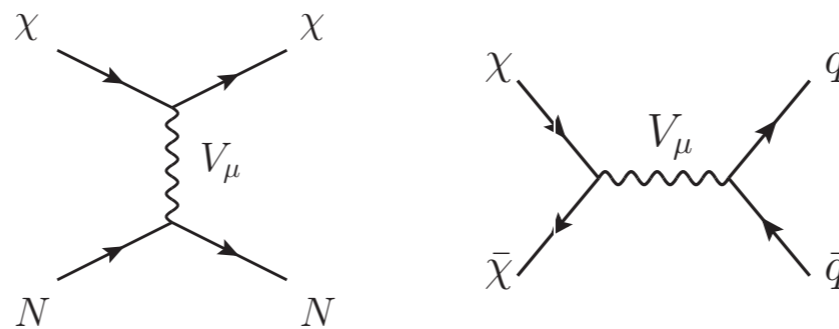
# An Example

- For a light mediator, a complete calculation is needed.

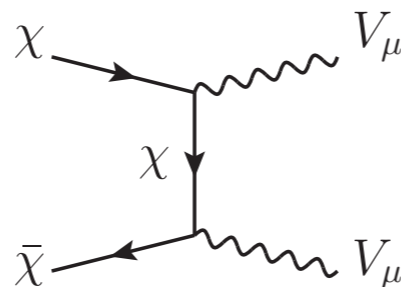
$$g_\chi \bar{\chi} \gamma^\mu \chi V_\mu$$

$$g_q \bar{q} \gamma^\mu q V_\mu$$

- Light DM annihilates to quarks only through the s-channel process.



- A resonance peak will appear when  $m_\chi \rightarrow M_V/2$
- If DM is heavier than the mediator, mediator pair production channel will open.

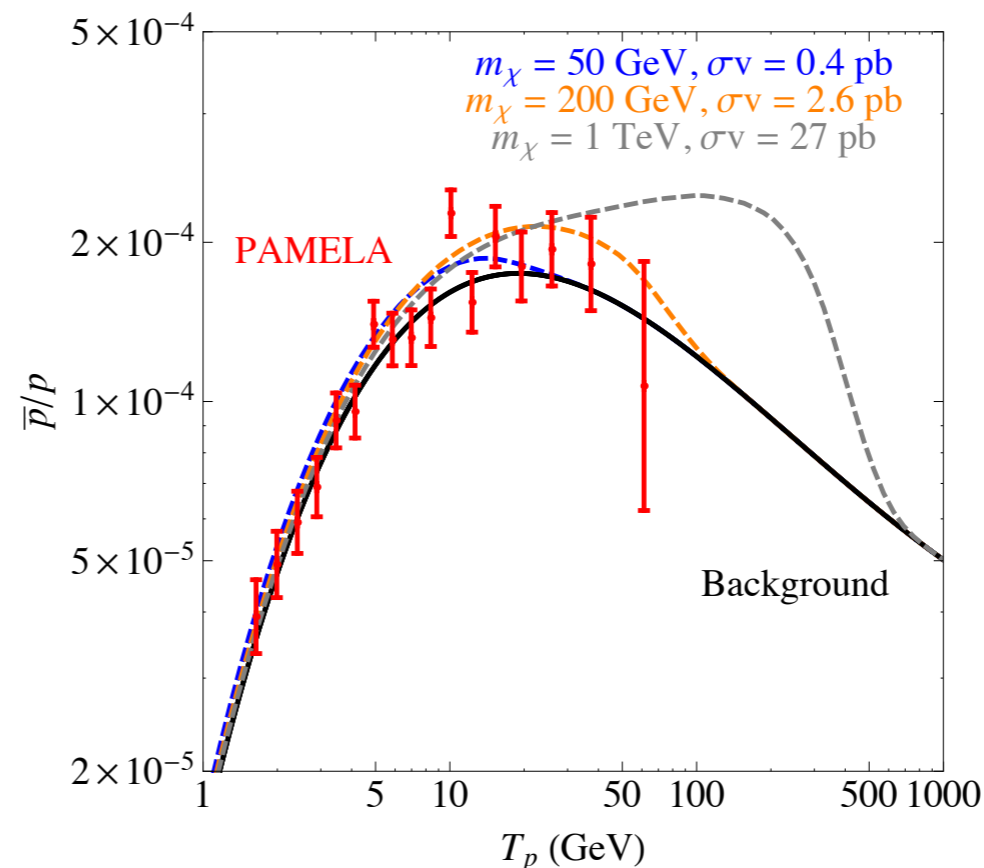


# An Example

- The dark matter contribution to the antiproton flux is determined by:

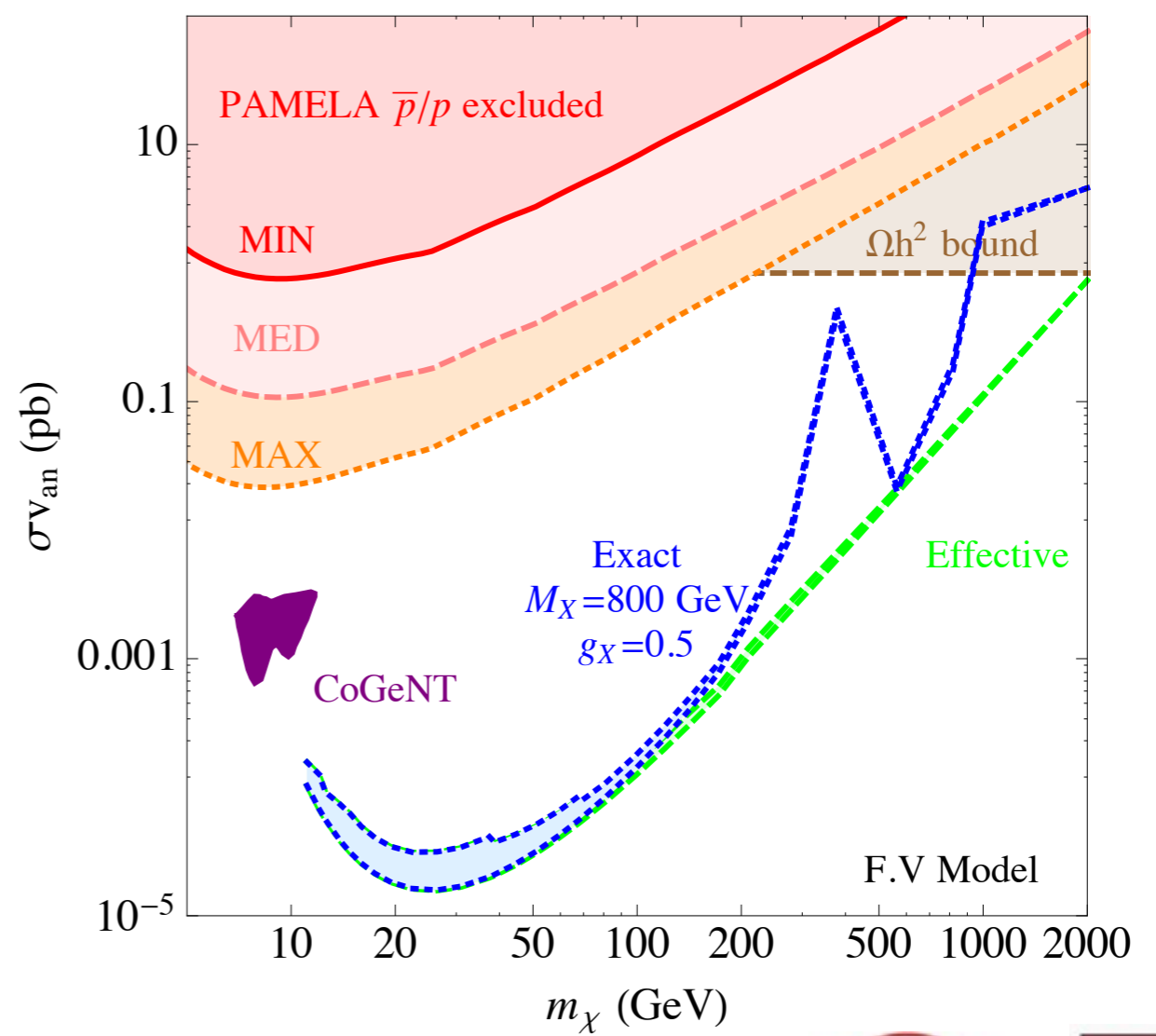
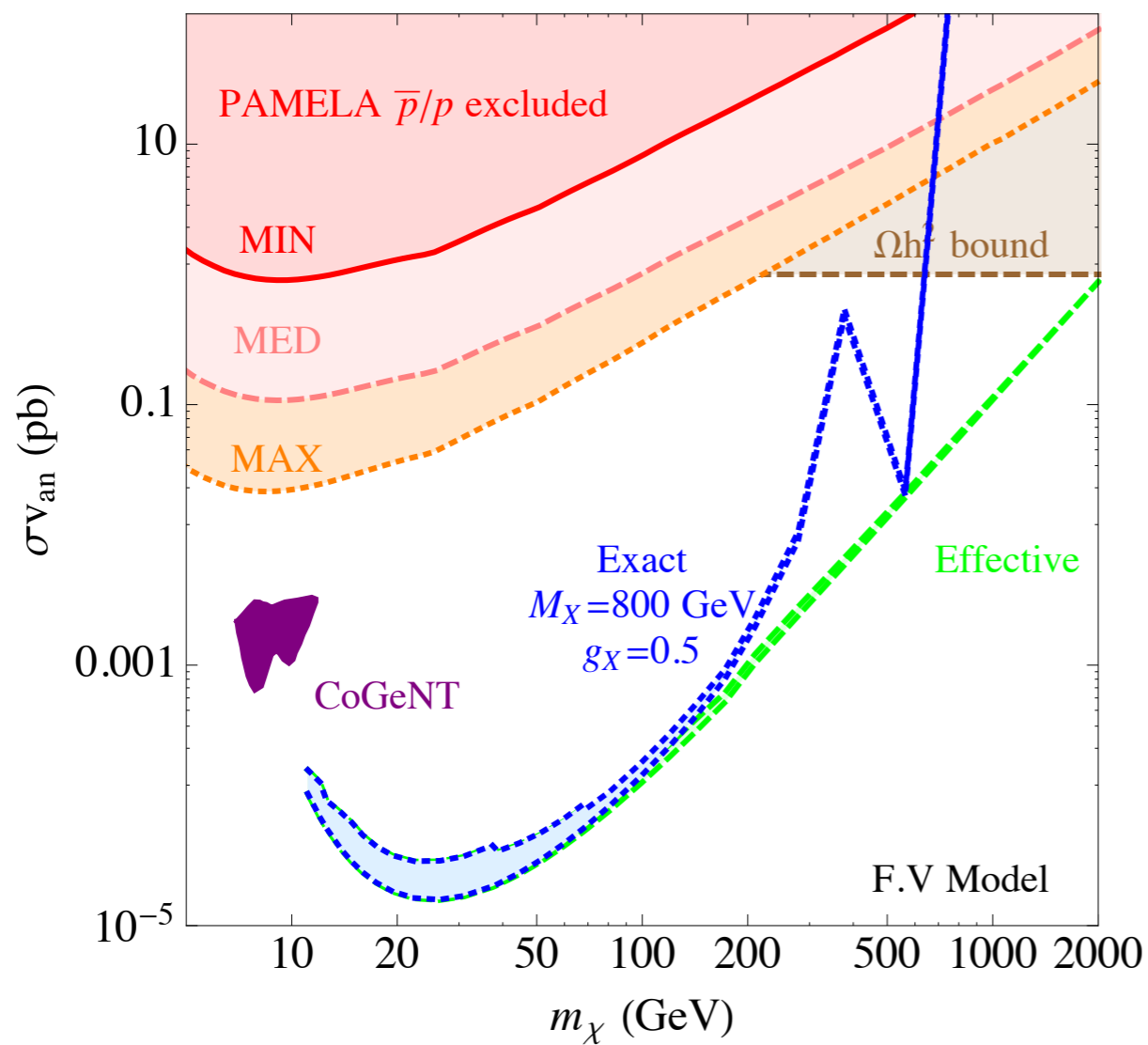
$$\begin{array}{l} \text{Source} \\ \text{Propagation (uncertainty)} \end{array} \left\{ \begin{array}{l} \langle \sigma v \rangle_{hadron} \times S \\ \text{Dark matter distribution (uncertainty)} \end{array} \right.$$

- Also depends on the knowledge of the cosmic ray background!



# An Example

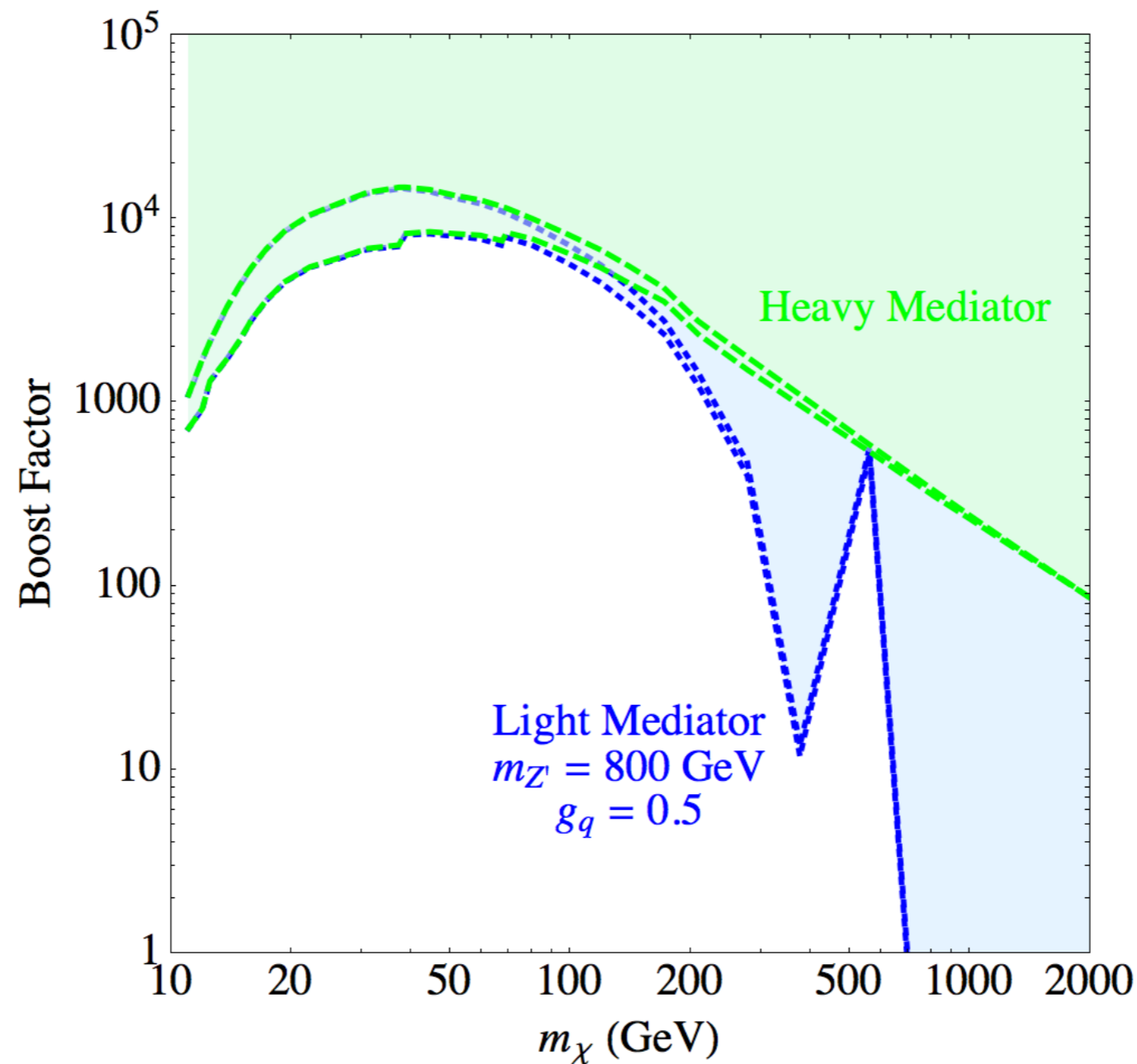
- Compare the result with the PAMELA data





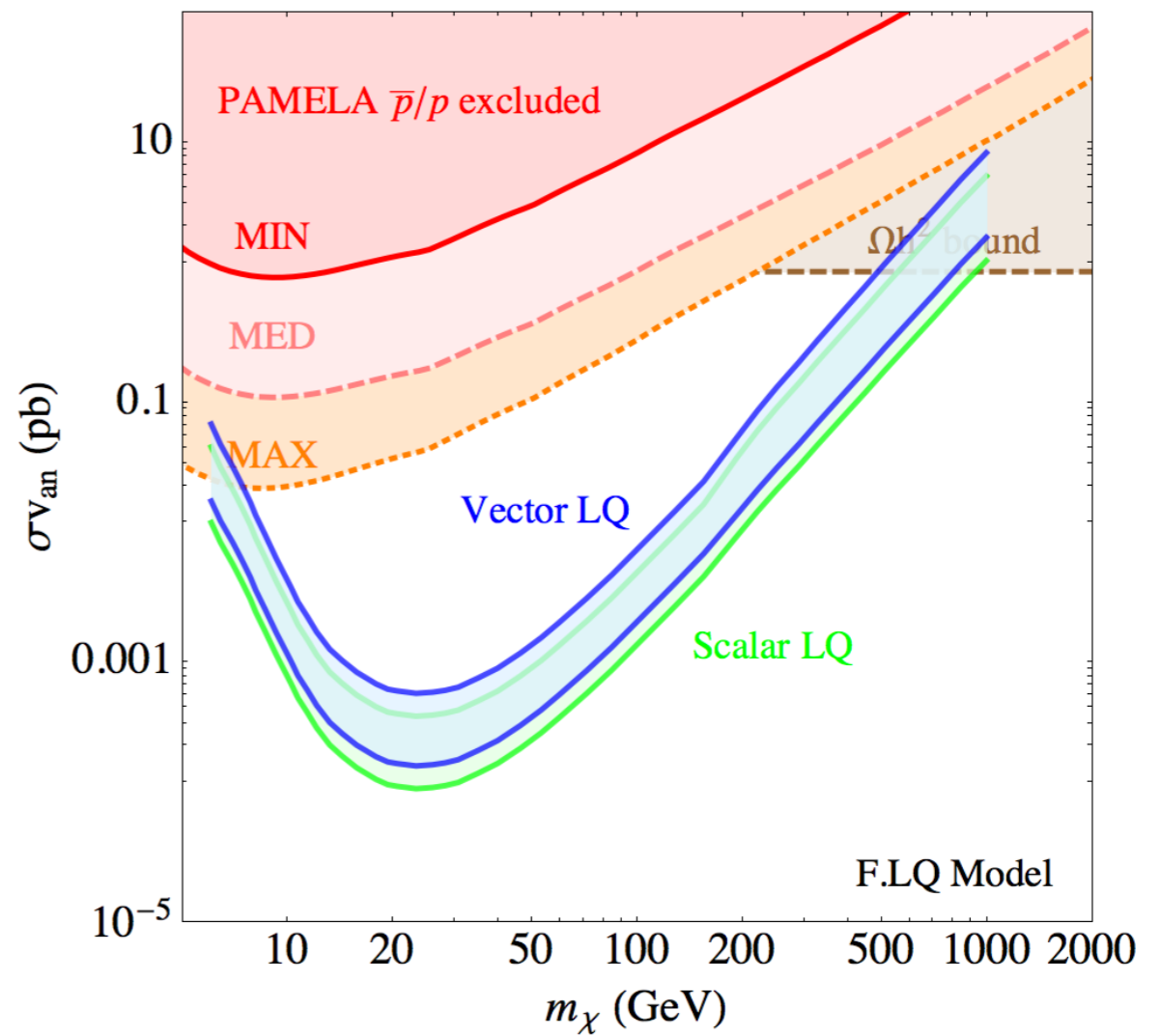
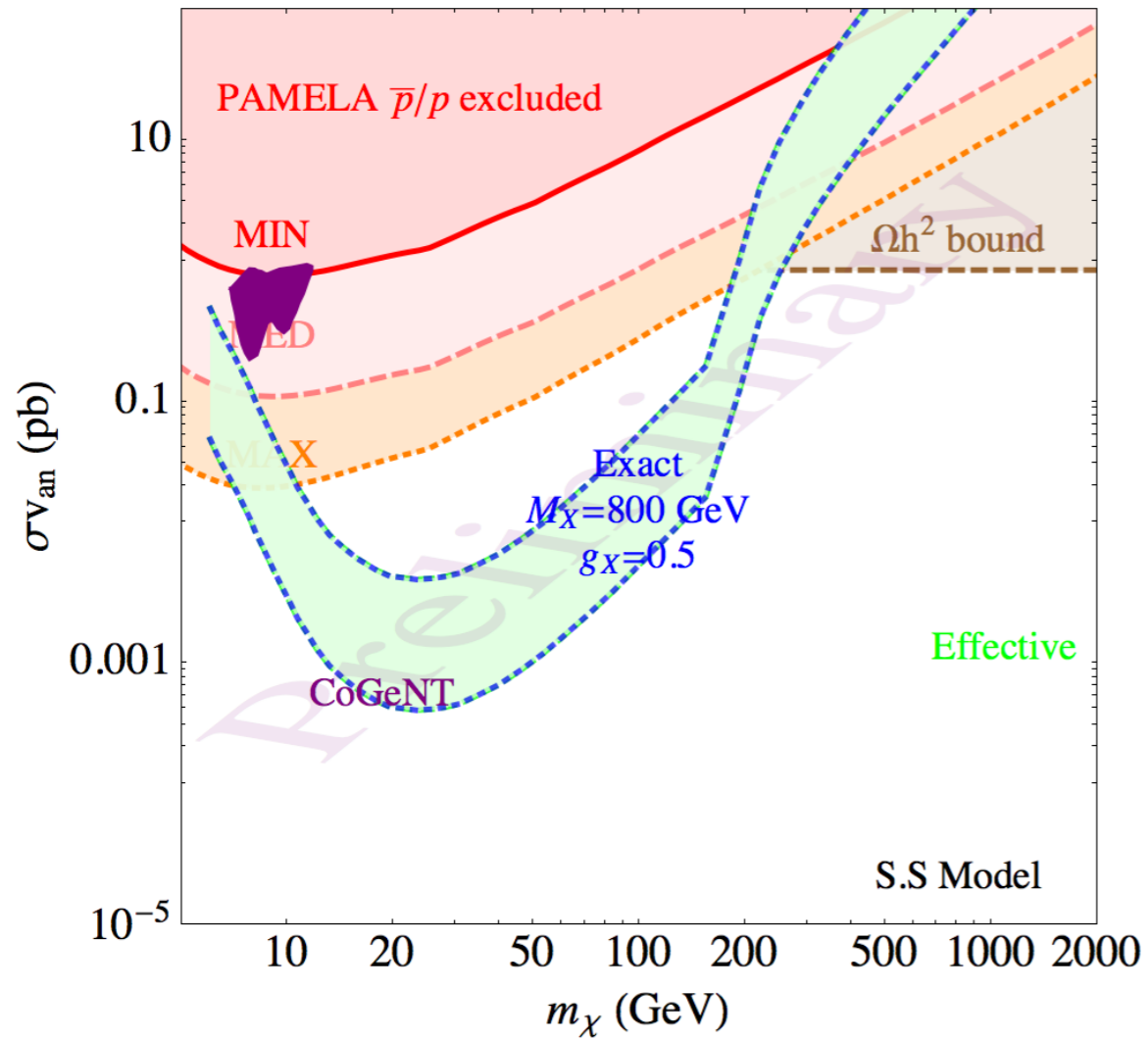
# An Example

- Compare the result with the PAMELA data



- We also calculate

DF.S    F.VLQ    F.SLQ    MF.S    S.S    S.F    S.V  
 V.S    V.F    V.V .....



# Summary

- More and more data will come from both the direct detection and the indirect detection experiments.
- We emphasize the connection between the cross section for the elastic scattering off the nuclei measured in DM direct detection experiments and that of the DM annihilation into hadrons measured by the indirect detection experiments is completely general.
- If future DM direct detection experiments confirm the two event signals observed by the CDMS, or the result shown by the CoGeNT etc, our analysis can be applied to give a suitable boost-factor constraint.



**THANK YOU!**