WIN'09: Dark Matter Theory Summary or what's hot in dark matter model building

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- Much like in collider searches of new physics, there is a lot of model building options and no chance to discriminate between them without a guidance from experiment
- Unlike in collider searches of new physics, there is a constant flow of experimental data that often put new twists

Evidence

- Rotation curves of galaxies and clusters of galaxies
- Spectrum of primordial density fluctuations from COBE and WMAP
- Numerical simulations of large scale structure
- Dwarf satellite galaxies

All evidence converging to collisionless matter component with $\Omega_{DM} \sim 0.3$, $\Omega_{DM}/\Omega_B \sim 5$

Bullet Cluster et al.

Constrains self-interaction cross section $\sigma/m \lesssim 1000/\,\mathrm{GeV}^3$

Alternative to CDM picture?

Talk of Zurab Berezhiani this conference: dark matter is made from mirror world particles who are exactly like the SM (just smaller temperature)
All in all, everything has to conspire to make it look as very weakly interacting collisionless component
Occam's razor: it IS a very weakly interacting collisionless component

What's next

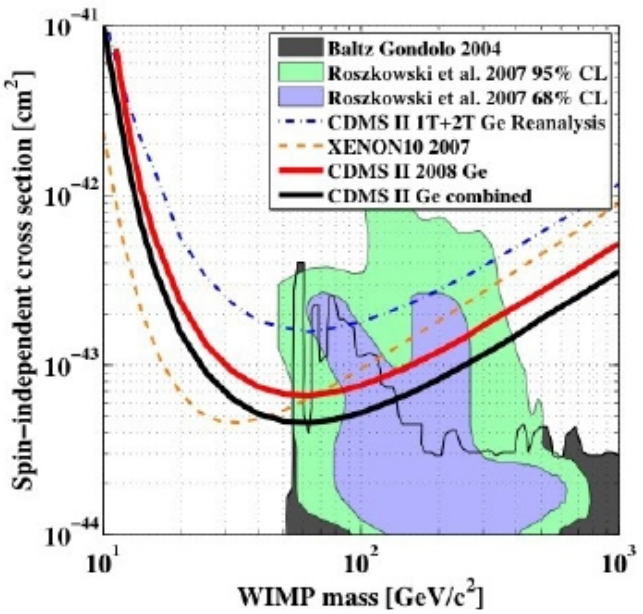
Pinpoint the microscopic properties of the particle (or several particles?) that makes dark matter

- Collider physics
  `Thourough investigation of particle properties, if we are lucky`
- Direct detection via recoil in detectors
  `Mass, Cross section on nucleons, Type of interactions`
- Indirect detection via cosmic rays
  `Mass, Annihilation cross section on nucleons, Type of interactions`

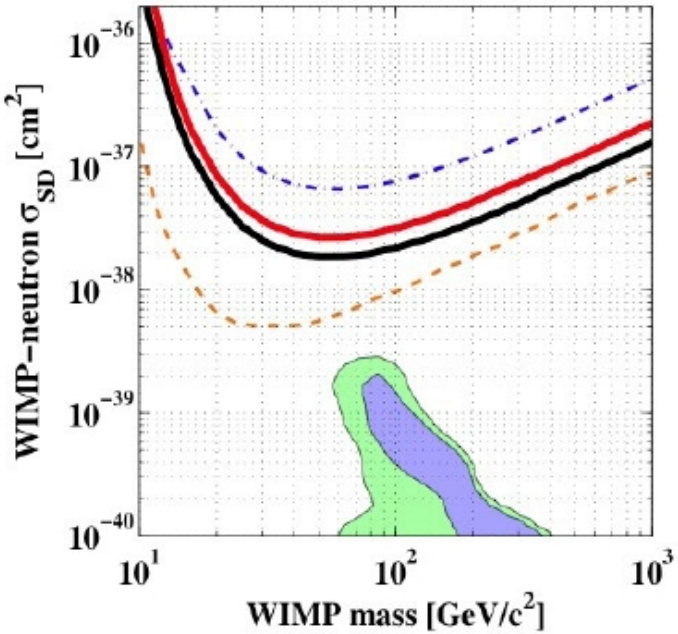
The last two have experienced astounding experimental progress in the last years; Further progress expected in very near future

Direct detection - state of art

Spin-independent cross section limits

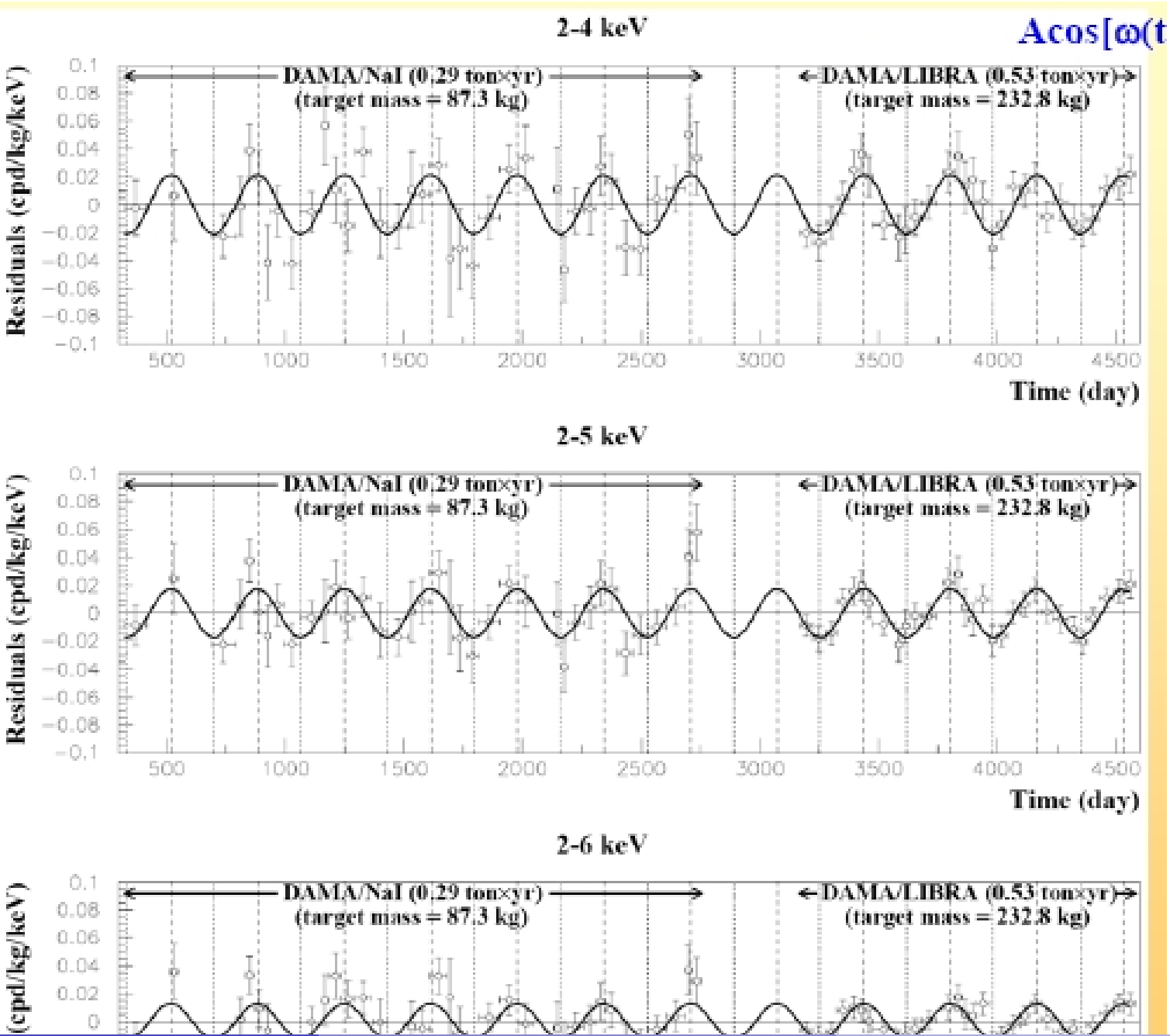


Spin-dependent cross section limits



Dark matter interacting with nucleons via Z boson exchange excluded, but lot's of other possibilities remain

Thorn in the side



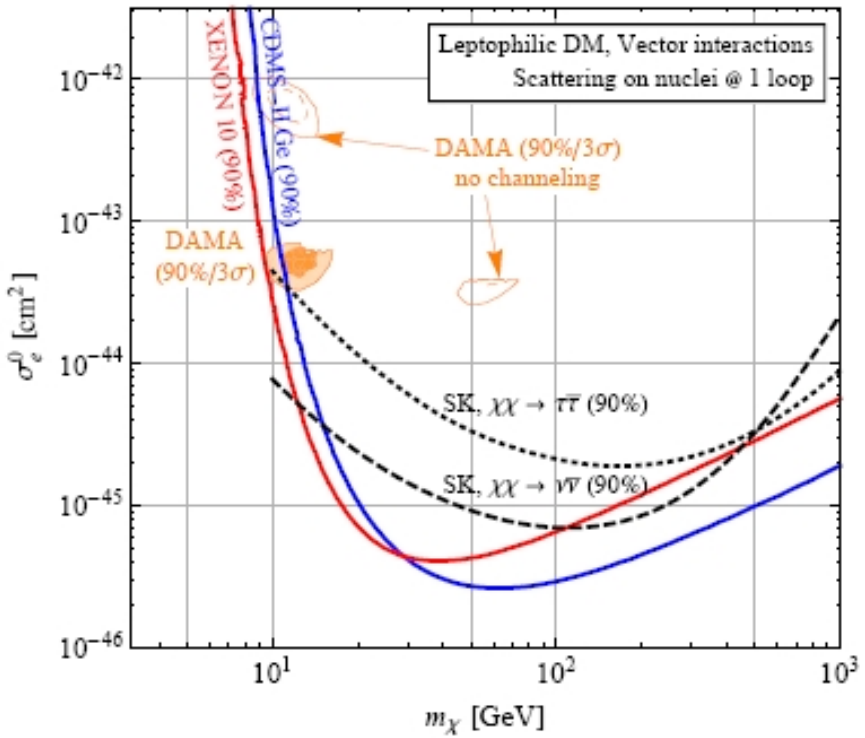
DAMA vs rest of the world

Can DAMA signal be reconciled with negative signals from other experiments?

- Inelastic dark matter (opening talk of Neal Weiner this conference)
- Form factor dark matter (Feldstein, Fitzpatrick, Katz)
- Anything else???

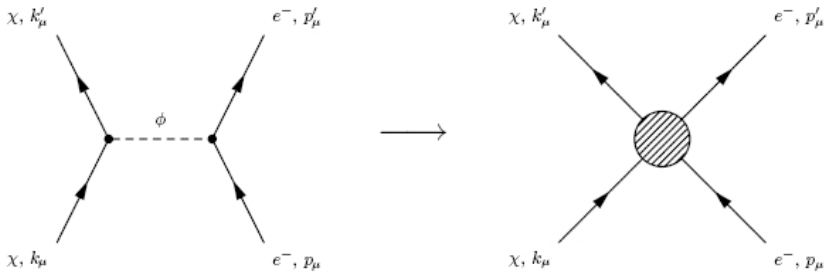
What is not compatible

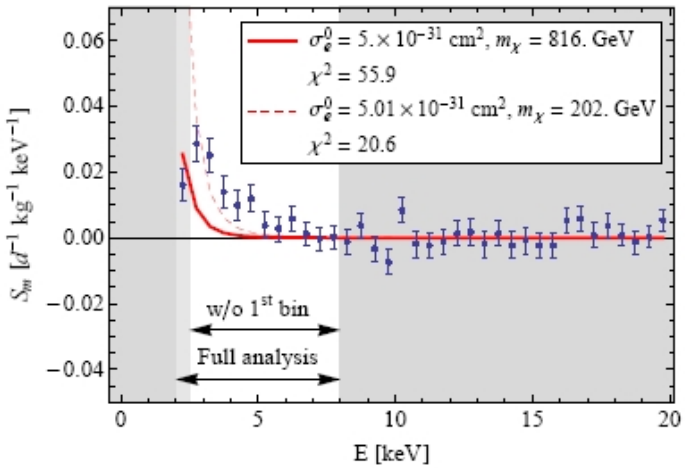
- Standard WIMP with spin dependent or spin independent cross section

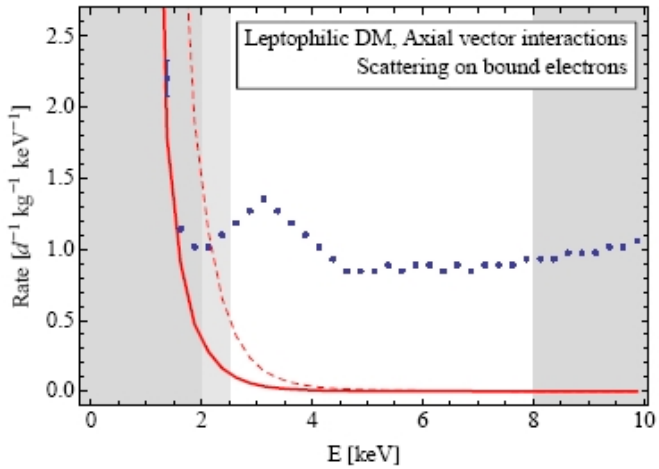


Leptophilic dark matter scattering on electrons

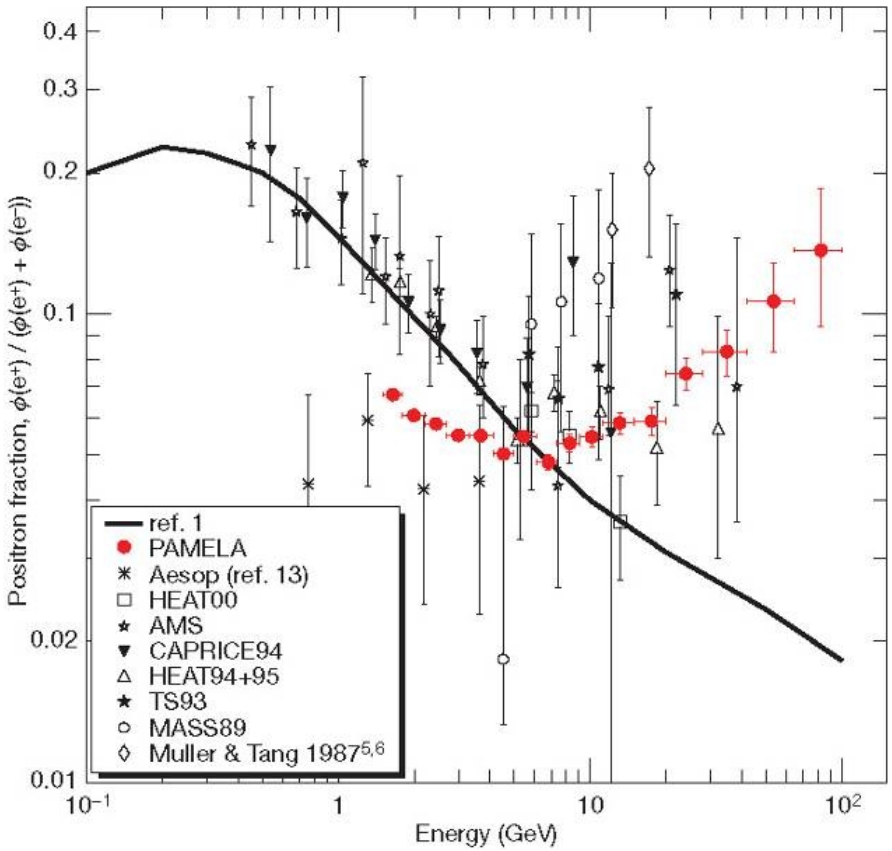
Talk of Jure Zupan this conference

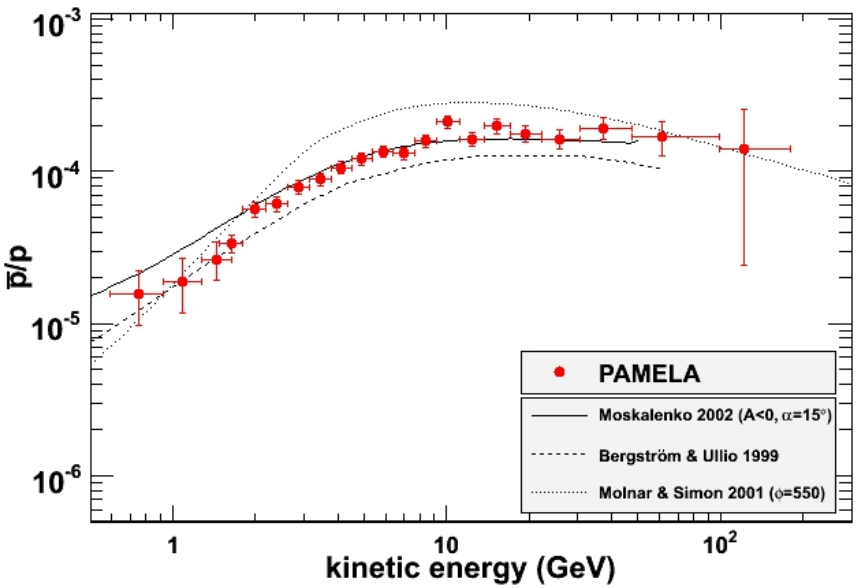






PAMELA positron and antiproton measurements





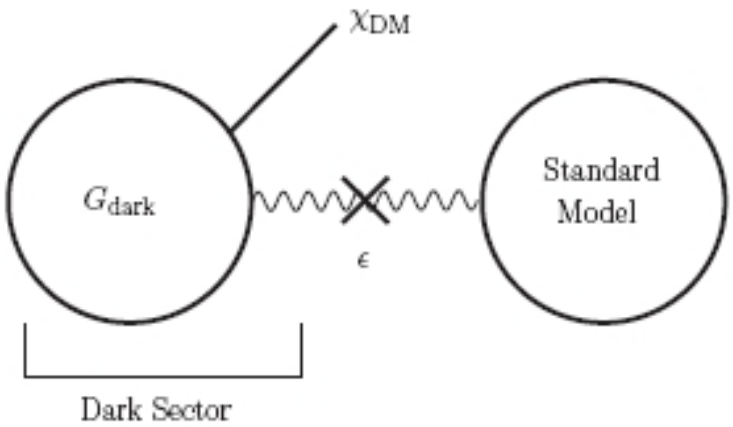
Waiting for AMS02 for confirmation

What is a GeV dark sector?

- Dark matter self-interaction, mediated by

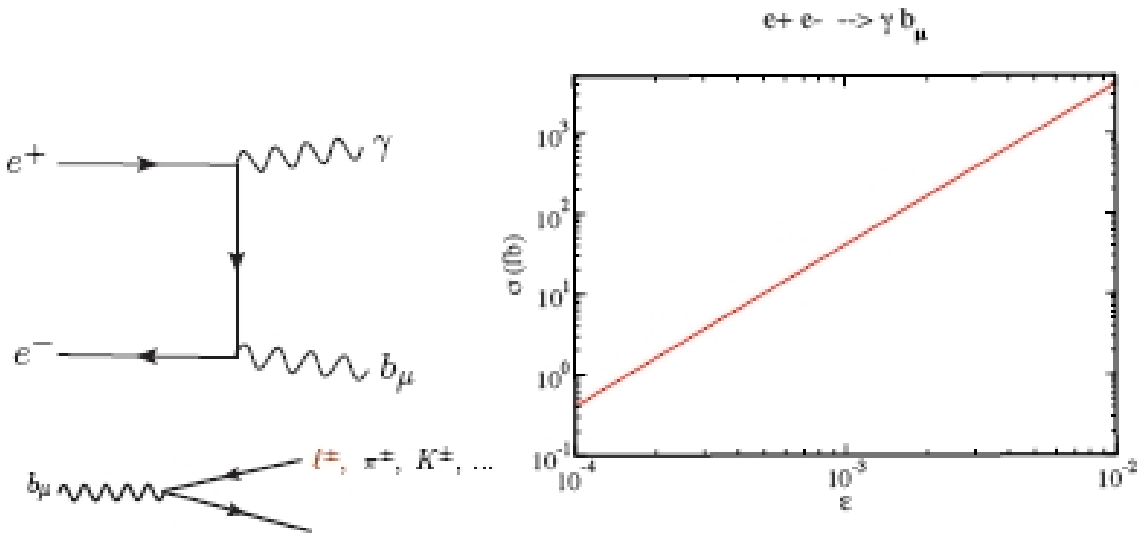
$$b_{\text{dark}} \subset \text{dark sector.}$$

- Range of dark force $\simeq m_b^{-1} \sim \text{GeV}$
- Dark sector couples to SM with tiny couplings, parameterized by ϵ Typically: $\epsilon \leq 10^{-3}$



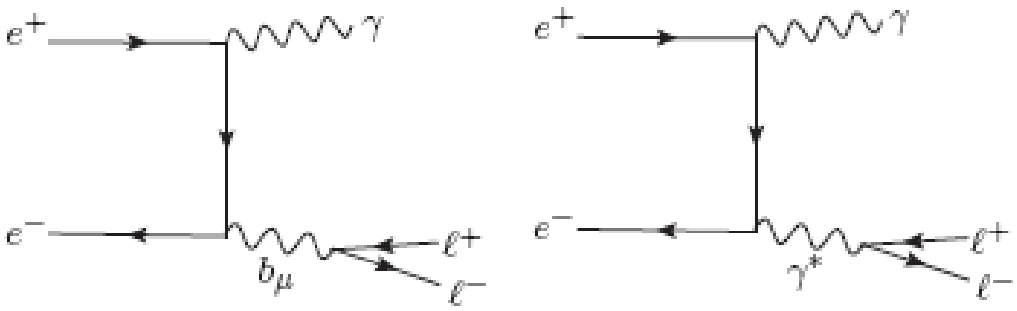
Talk of Matt Reece this conference: searches for GeV scale sectors at Tevatron, LHC, and low energy e+e- colliders

Production: associated with photon



Leptonic signal: $\gamma + \ell^+\ell-,\ m_{\ell\ell} = m_b$

Signal vs background estimates:



$$\frac{S}{\sqrt{B}} \sim \sqrt{\sigma_0 \mathcal{L}} \frac{\epsilon^2}{\sqrt{\alpha/\pi}} \sqrt{\frac{m_b}{\delta m}} \times \mathrm{BR}(U \to \ell^+\ell^-)$$

$\mathcal{L}$: integrated luminosity; δm : resolution

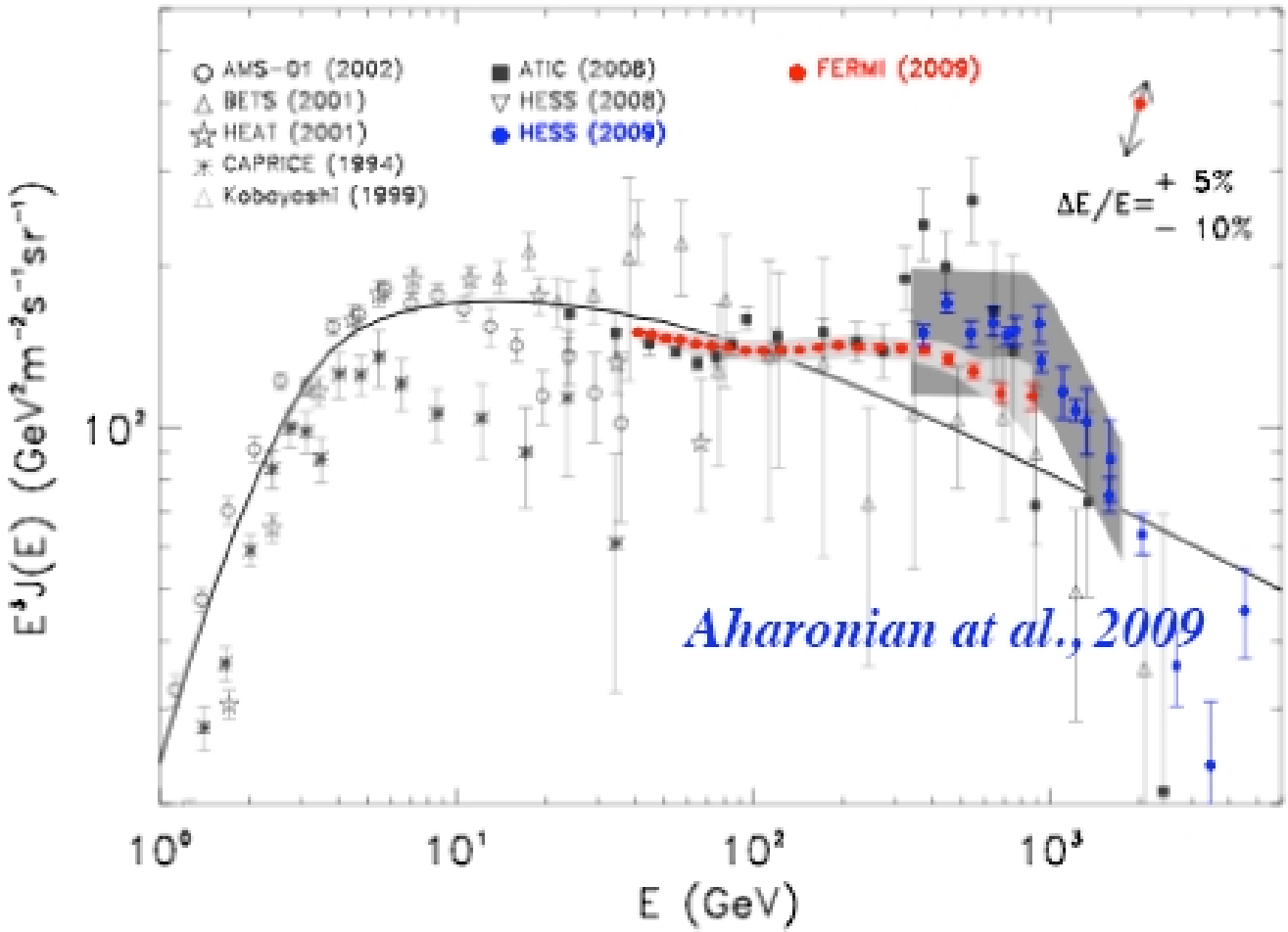
$\sigma_0 =$ rate$(e^+e^- \to \gamma\gamma) \sim 1 \times 10^4$ pb

$\mathcal{L} \sim 100\text{s fb}^{-1}, \delta m \sim 1 - 10$ MeV,

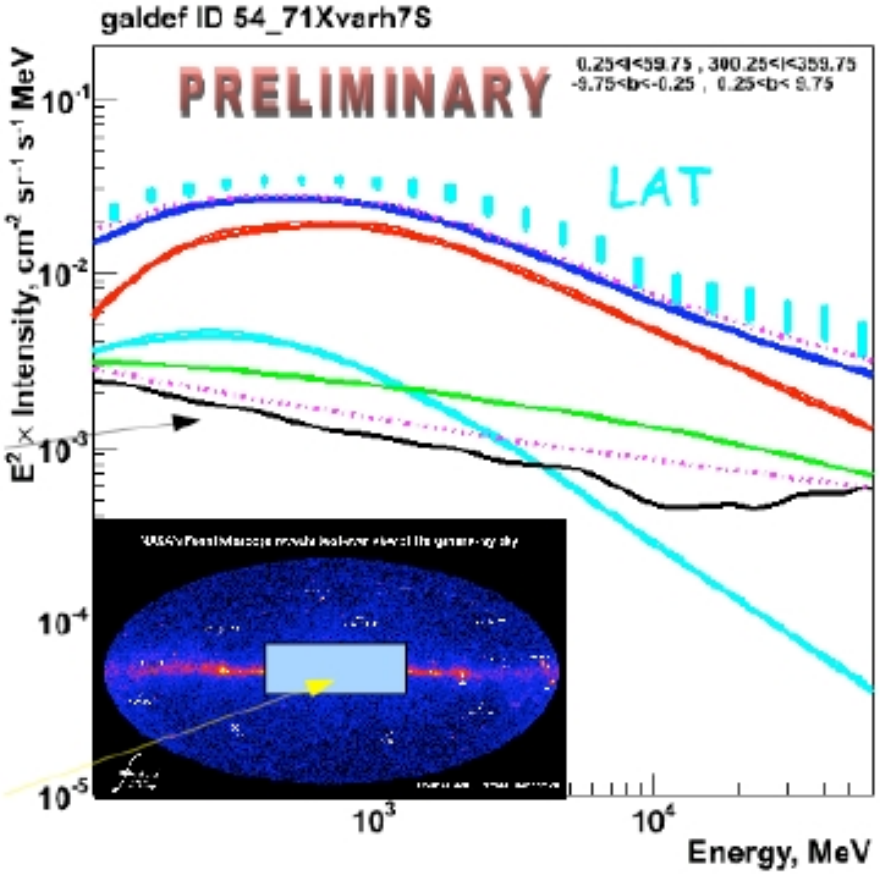
rough estimate of reach: $\epsilon \sim 10^{-3}$

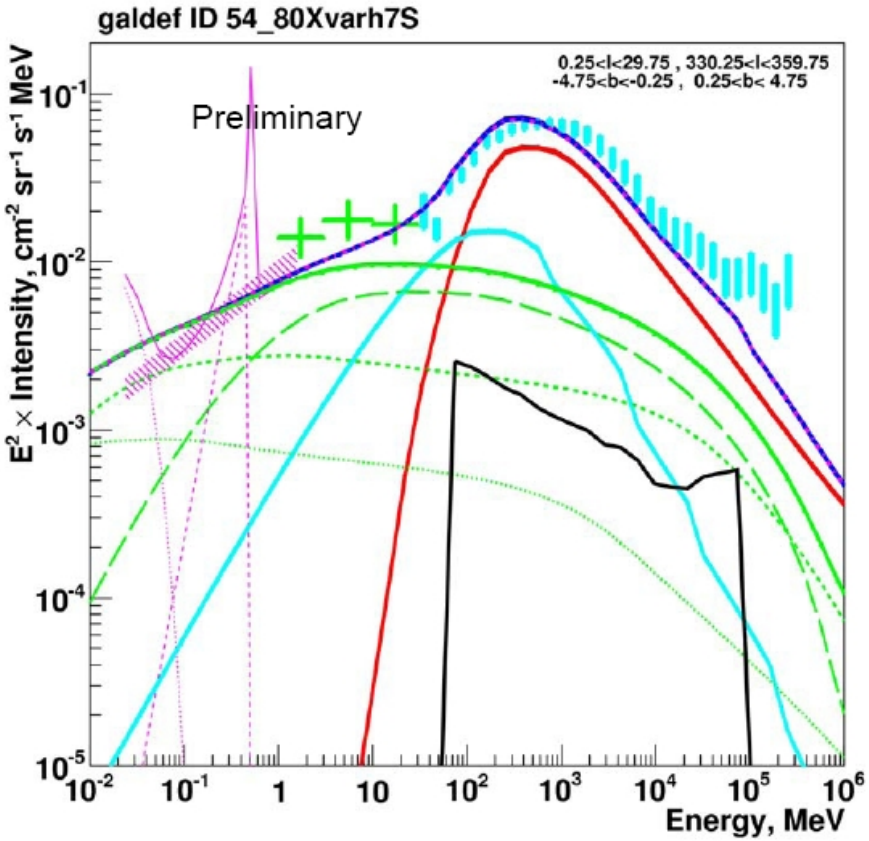
Luminosity crucial! Reach $\propto \mathcal{L}^{-1/4}$

FERMI electrons + positrons



FERMI diffuse gamma ray photons from GC





What are you waiting for?

Crucial measurements to unravel the PAMELA/FERMI puzzle

- Extending the positron and antiproton energy reach by PAMELA
- Clean measurement of the galactic center photons by FERMI
- Search for gamma ray emission from dwarf galaxies by FERMI
- Neutrinos from galactic center by ICECUBE

Arkani-Hamed et al [0810.0713] , as of today cited 213 times
Single model explaining:

- PAMELA positron anomaly
- Lack of PAMELA antiproton anomaly
- ATIC bump
- WMAP haze
- EGRET gamma ray anomaly
- DAMA modulation
- INTEGRAL anomaly

and also has susy in it...