Excess in Diffuse Gamma Rays Interpreted as a Dark Matter Annihilation Signal

Is Dark Matter of Supersymmetric Origin?

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Monday Seminar - LAL Orsay, 14th May 007

Outline

Problems:

- Rotation curves of galaxies
- Matter content of the universe
- Excess in diffuse γ rays above 1 GeV

Solution:

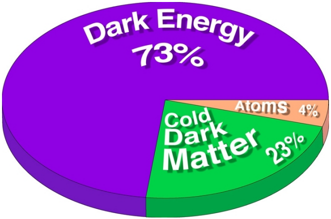
- Dark Matter halo around our Galaxy ...
- ... consisting of (supersymmetric) WIMPs ...
- ... which can annihilate into quarks and give rise to high energetic γ rays from π^0-decays

Dark Matter

Energy/Matter Content of the Universe

- Combination of CMB data with Hubble expansion data from SNIa
- $\sim$ 27% matter but only $\sim$ 4% baryonic matter
- $\sim$ 1% luminous matter

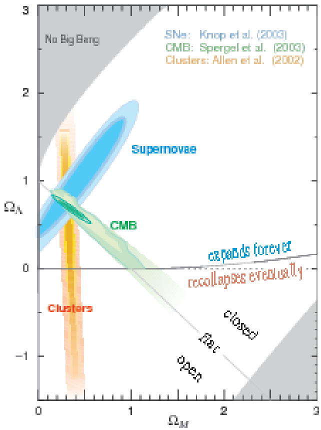
$\Rightarrow$ existence of baryonic and non baryonic DM



The Concordance Model of Cosmology

Cosmological Parameters

- Total density $\Omega_{tot} = 1.02 \pm 0.02$
- Dark energy density $\Omega_\Lambda = 0.73 \pm 0.04$
- Baryonic density $\Omega_b = 0.044 \pm 0.004$
- Matter density $\Omega_m = 0.27 \pm 0.04$
- Neutrino density $\Omega_\nu h^2 < 0.015$
- CMB temperature $T_{cmb} = 2.725 \pm 0.002$ K
- Age of the universe $t_0 = 13.7 \pm 0.2$ Gyr
- Radiation matter decoupling $t_{dec} = 379 \pm 8$ kyr



Dark Matter Candidates

Hot Dark Matter Candidates (HDM)

- Neutrinos

$\Rightarrow$ not more than 10% to 15% of Ω_{DM}

Cold Dark Matter Candidates (CDM)

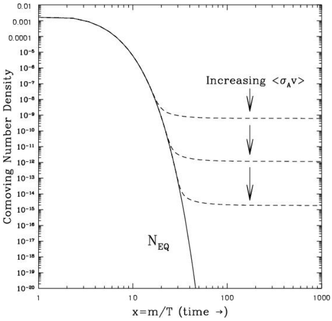
- Massive neutrinos
- Primordial black holes
- Axions
- Weakly Interacting Massive Particles (WIMPs)

WIMPs

One of the most promising candidates is the **W**eakly **I**nteracting **M**assive **P**article

Why?

- Assumption: DM in thermal equilibrium with early universe
- Approximative solution of the Boltzmann equation:
  $\Omega_\chi h^2 = \frac{m_\chi n_\chi}{\rho_c} \approx \left(\frac{3 \cdot 10^{-27}\ \mathrm{cm}^3\ \mathrm{s}^{-1}}{\langle \sigma v \rangle}\right)$
  $\Rightarrow$ cross sections of weak interaction



Dark Matter Annihilation

If WIMPs are Majorana particle

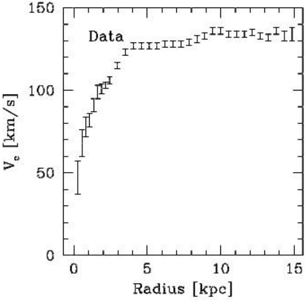
- At present WIMPs annihilate almost at rest into pairs of monoenergetic SM particles
- Fragmentation/decay of products
  $\Rightarrow e^+, e^-, p, \overline{p}, \nu, \overline{\nu}, \gamma$
  and maybe light (anti-)nuclei like Deuteron or Helium
- Ordinary matter particles will vanish in the sea of bg
- Antimatter and gammas maybe be detectable above bg

Rotation Curves of Galaxies

Observation vs. Expectation

- Expectation from Kepler's law: $v \propto 1/\sqrt{r}$ for $r \gg r_{disk}$
- Observation: $v \approx const$
- Possible explanation: existence of extended halo of DM

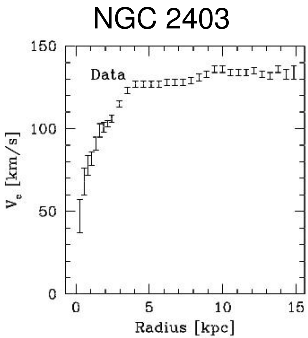
NGC 2403



Rotation Curves of Galaxies cont.

Determination of r Dependence

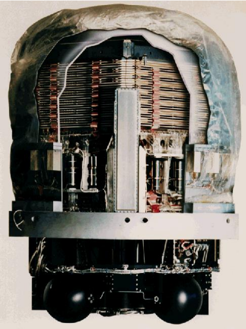
$$
\begin{aligned}
F_Z &= F_G \\
m \cdot v^2/r &= G \cdot m \cdot M(r)/r^2 \\
\Rightarrow v &= G \cdot \sqrt{M(r)/r} \\
v &\stackrel{!}{=} const \\
\Rightarrow M(r) &\propto r \\
\int \rho \, dV &\propto \int \rho(r) r^2 \, dr \\
\Rightarrow \rho(r) &\propto 1/r^2
\end{aligned}
$$



Diffuse Galactic Gamma Rays

EGRET Experiment

- Installed on CGRO satellite (together with BATSE, OSSE and COMPTEL)
- Measuring from 1991 to 2000
- Energy range from $\sim$ 30 MeV to $\sim$ 100 GeV
- Third EGRET catalog: 271 point sources
- Complete data - point sources = diffuse gamma rays



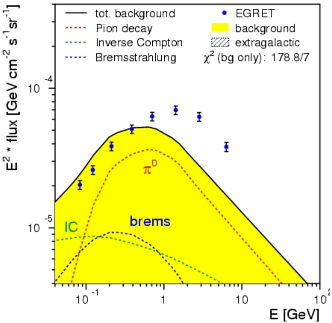
Diffuse Galactic Gamma Rays

EGRET Excess

- Comparison with Galactic models $\Rightarrow$ excess above 1 GeV
- Spectral shape of excess independent of sky direction
- Uncertainty of bg or a new contribution?

Contributions

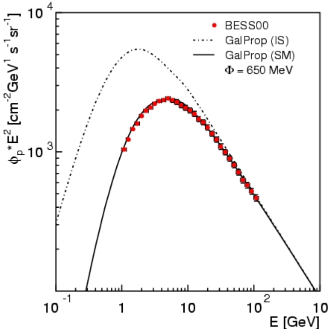
- Decay of π^0s produced in *pp* reactions of CR with IS gas
  $p + p \to \pi^0 + X \to \gamma\gamma + X$
- Bremsstrahlung
  $e + p \to e' + p' + \gamma$
- Inverse Compton
  $e + \gamma \to e' + \gamma'$



Galactic Background of Diffuse Gamma Rays

Dominant Contribution

- π^0 peak
- Shape determined by energy spectrum of CR protons
- CR proton spectrum measured locally by balloon experiments
- Locally measured spectrum is representative for rest of Galaxy $\rightarrow$ Conventional Model
- Uncertainty by solar modulation



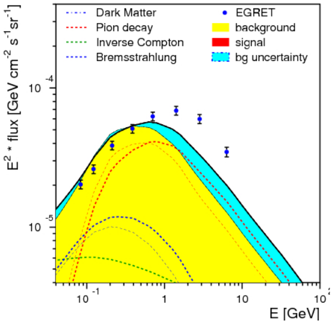
Calculation of bgs with `GalProp`

Moskalenko *et al.*, `astro-ph/9906228`

Galactic Background of Diffuse Gamma Rays

Uncertainty of Solar Modulation

- High energies: energy dependence γ_{high} is fixed (≈ 2.7)
- Low energies: uncertainty of γ_{low} can be compensated by solar modulation
- CM: $\gamma_{\text{low}} \approx 2.0 \Rightarrow \Phi_{\text{SM}} \approx 650$ MV
- $\gamma_{\text{low}} \approx 1.8 \Rightarrow \Phi_{\text{SM}} \approx 450$ MV
- $\gamma_{\text{low}} \approx 2.2 \Rightarrow \Phi_{\text{SM}} \approx 900$ MV



Dark Matter Annihilation

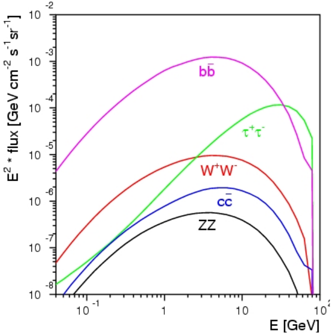
Spectral Shape of DMA Signal . . .

- WIMPs can annihilate at rest into a pair of monoenergetic SM particles
- Fragmentation/decay of products
  $\Rightarrow \pi^0$s
  $\Rightarrow \sim 30 \ldots 40$ γs per annihilation
- Different γ spectrum than bg (continuous CR spectrum)
  $\Rightarrow$ better fit to EGRET spectrum?
- Spectral shape similar for different annihilation processes

Calculation of signal with `DarkSusy`

Gondolo *et al.*, `astro-ph/0406204`

Gamma spectra for different processes ($m_{WIMP} \sim 100$ GeV)

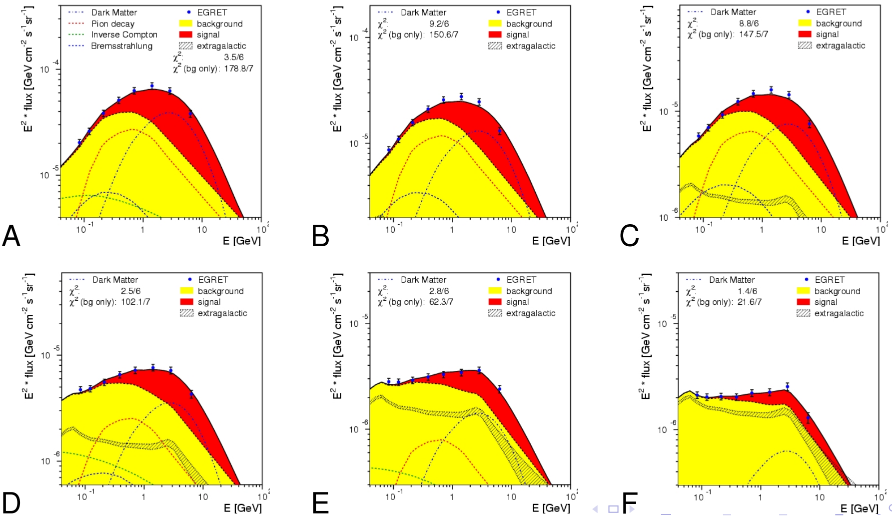


Fit to EGRET Spectrum with DMA signal

Fit Spectral Shape Only

- Uncertainties in interstellar gas density
  $\Rightarrow$ bg scaling
- Uncertainties in DM density
  $\Rightarrow$ signal scaling (boost factor)
- Free bg and signal scaling
  $\Rightarrow$ use point to point error $\sim$ 7% (full error $\sim$ 15%)

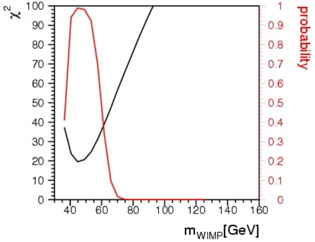
Fit to EGRET Spectrum with CM and DMA signal



Limits on WIMP Mass

region	l [°]	$\|b\|$ [°]	description
A	330-30	0-5	inner Galaxy
B	30-330	0-5	Galactic plane wo A
C	90-270	0-10	outer Galaxy
D	0-360	10-20	intermediate lat 1
E	0-360	20-60	intermediate lat 2
F	0-360	60-90	Galactic poles

$\chi^2/d.o.f.$ and probability:



Procedure

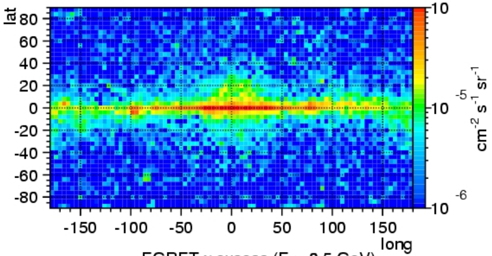
- $\Sigma\chi^2$ of 6 Regions of the sky
- Scan over WIMP mass

  $\Rightarrow m_{WIMP} \lesssim 70$ GeV (95% C.L.)

Determination of Halo Parameters

Directional Dependence of Excess

- Signal in sky region Ψ: $\Phi_{\mathrm{DM}} \propto \langle \sigma v \rangle \cdot \frac{1}{\Delta\Omega} \int d\Omega \int dl_\psi \left(\frac{\rho(l_\psi)}{m_\chi} \right)^2$
- Smooth $1/r^2$ profile yields not enough signal $\Rightarrow$ clumps
- Assume same enhancement by clumps in all directions



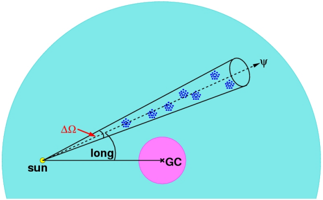
EGRET γ excess (E > 0.5 GeV)

Determination of Halo Parameters

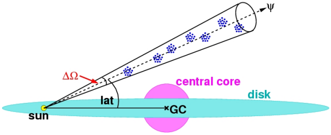
Method

- Divide skymap into 180 independent sky directions
  $\Rightarrow$ 45 intervals for gal. longitude (dlong = 8°)
  $\Rightarrow$ 4 intervals for gal. latitude ($|\text{lat}| < 5°$, $5° < |\text{lat}| < 10°$, $10° < |\text{lat}| < 20°$ and $20° < |\text{lat}|$)
- Divide gamma spectrum in low and high (<>0.5 GeV) energy region
- Use low energy region for bg normalization
- Use high energy region for determination of halo parameters

top view:



side view:



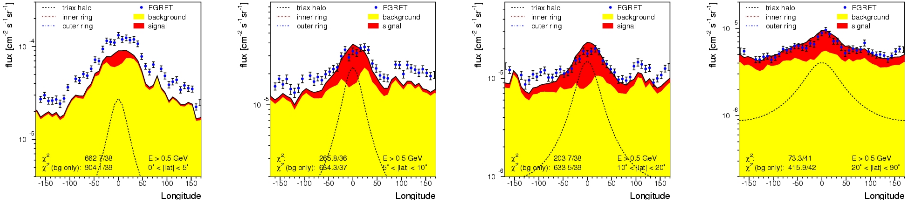
Determination of Halo Parameters

Isothermal Profile without Rings

Triaxial profile with $1/r^2$ dependence at large r and core at center

- Good agreement at large latitudes
- Too little flux in Galactic plane

$|\text{lat}| < 5°$ | $5° < |\text{lat}| < 10°$ | $10° < |\text{lat}| < 20°$ | $20° < |\text{lat}|$



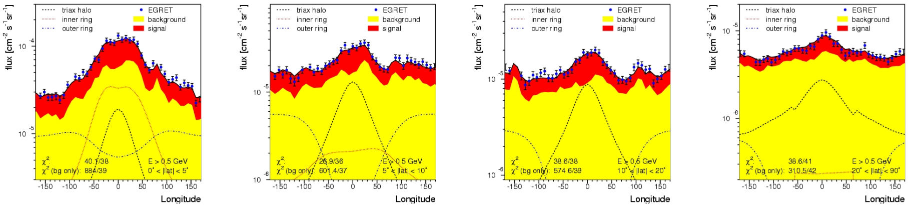
Determination of Halo Parameters

Isothermal Profile with Rings

Additional DM in galactic plane parametrized by two toroidal ringlike structures

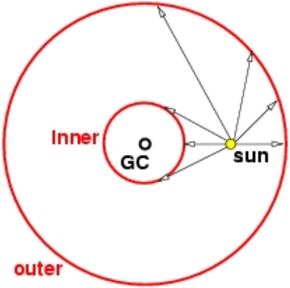
- Inner ring at $\sim$ 4 kpc; $\sim$ thickness of lum. disk (e.g. adiabatic compression)
- Outer ring at $\sim$ 14 kpc; much thicker than disk (e.g. infall of dwarf galaxy)

$|\text{lat}| < 5°$ | $5° < |\text{lat}| < 10°$ | $10° < |\text{lat}| < 20°$ | $20° < |\text{lat}|$

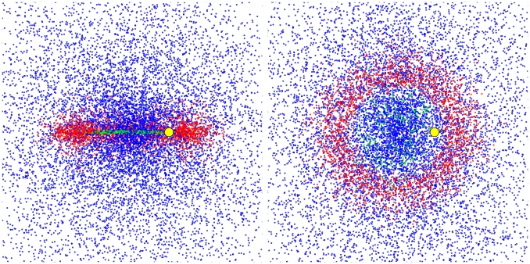


Visualization of Halo Profile

Sensitivity on ring parameters:



Dark Matter:



baryonic matter:

Example: Infall of Canis Major

Simulation by Nicolas Martin & Rodrigo Ibata

(http://astro.u-strasbg.fr/images_ ri/canm-e.html)

Tidal Stream of Canis Major

- Distance from Galactic center $\sim$ 13kpc
- Mass of gas $\sim 10^7 M_\odot$ from 21 cm line
- Mass of visible stars $10^8 \ldots 10^9 M_\odot$

Experimental Counterpart of Rings

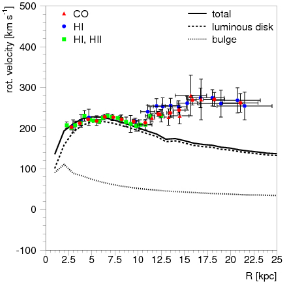
- Inner ring:
  $M_{\text{inner}} \sim 9 \cdot 10^9 M_\odot \approx 0.3\%$ of M_{tot}
  coincides with maximum of H_2 distribution
  Hunter *et al.*, Astrophys. J. **481** (1997) 205
- Outer ring:
  $M_{\text{outer}} \sim 8 \cdot 10^{10} M_\odot \approx 3\%$ of M_{tot}
  correlated with tidal stram of Canis Major at ~ 13 kpc ($10^8 \ldots 10^9$ $M_\odot$)
  Ibata *et al.*, `astro-ph/0301067`
- Massive substructures influence rotation curve of milky way

Rotation Curve of the Milky Way

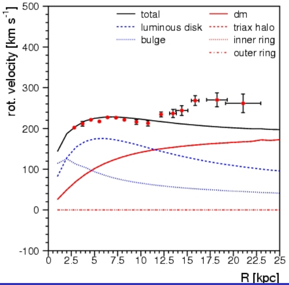
Comparison with Measured Rotation Curve

- Data are averaged from three surveys with different tracers
- Dark Matter improves agreement with data
- Triaxial halo cannot explain change of slope at $\sim$ 10 kpc

without DM:



with DM without rings:

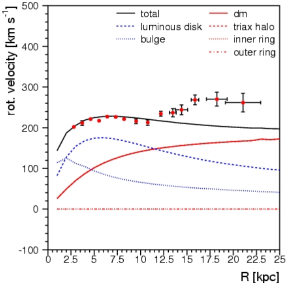


Rotation Curve of the Milky Way cont

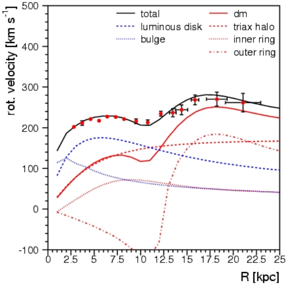
Including rings of DM

- Adding inner and outer ring from EGRET analysis
- Rings of DM can explain change of slope at $\sim$ 10 kpc

without rings:



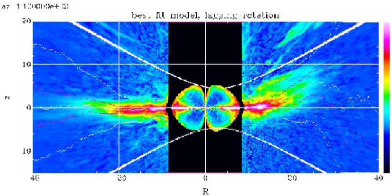
with rings:



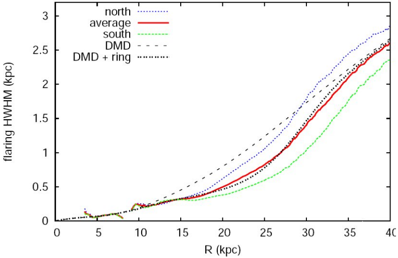
Flaring of Galactic Disk

- Massive ring improves prediction of gas flaring; mass needed $2.3 \cdot 10^{10} M_{\odot}$ (~ 4 times less than outer ring from EGRET analysis)

  Kalberla *et al.*, `astro-ph/07043925`
- Flaring is sensitive towards GC (no "velocity crowding"), while EGRET analysis is most sensitive towards anticenter (ring is dominant)
- **But:** ring density might not be constant



dark matter disk with ring - final model

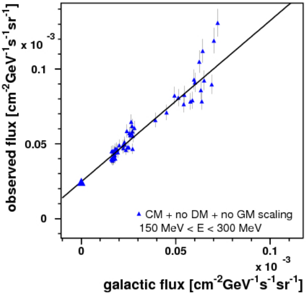


Extragalactic Background

Important bg at large Galactic latitudes (low Galactic bg)

Method of EGB Determination

- Choose one energy
- Divide skymap in regions of high and low flux
- Draw observed vs. expected flux
- y-axis intercept is EGB of chosen energy



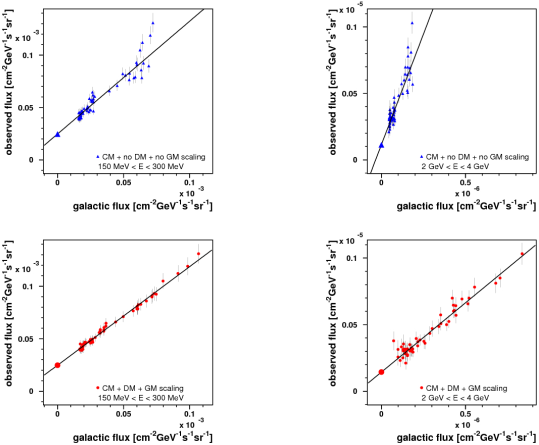
Sreekumar *et al.*, `astro-ph/9709257`

Allow scaling of DM and Galactic bg component → iterative algorithm has to be applied (scaling factors depend on EGB)

Extragalactic Background cont.

low energies

high energies

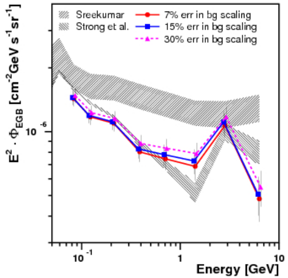


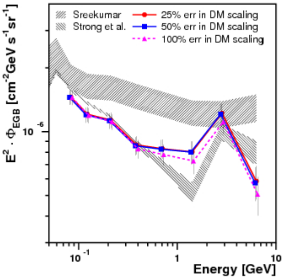
no DM + no GM scaling

with DM + with GM scaling

Spectral Shape of EGB

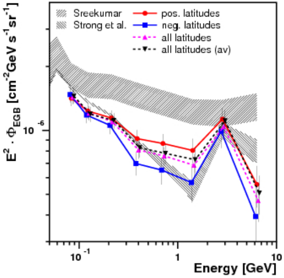
- Difference to prev. results at high energies → independent DM component contributing mainly at high energies
- New EGB shows a clear bump at a few GeV
- Systematic uncertainties (method) are relative small

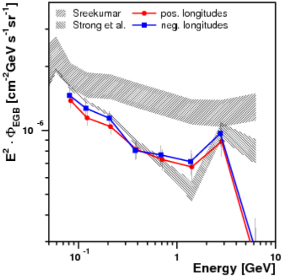




Anisotropy of EGB

- Strong effect for positive and negative latitudes ($\sim$ 30%)
- Weak effect for positive and negative longitudes

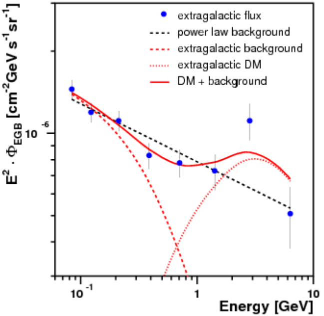




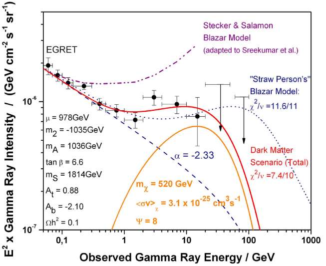
Extragalactic Background

Extragalactic DMA contribution

- Fit of new EGB with double power law and DMA signal ($\chi^2/d.o.f.$=5.7/4 ⇒ 22.4%)
- Fit with single power law ($\chi^2/d.o.f.$=11.7/6 ⇒ 6.9%)

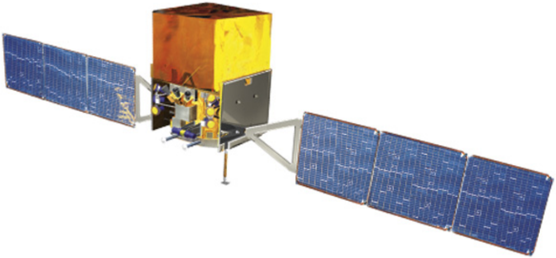


Elsaesser *et al.*, `astro-ph/0405235`



Next Generation Gamma Ray Telescope: GLAST

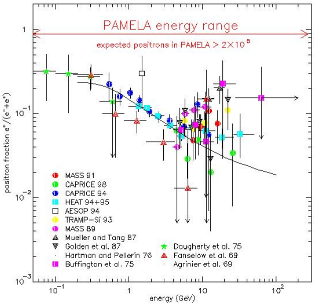
	EGRET	GLAST
E range	35 MeV - 30 GeV	10 MeV - 300 GeV
E res @10 GeV	12 %	6 %
eff. area @10 GeV	700 cm^2	8000 cm^2
Point Source Location	5'-10'	0.1'-1'
Single γ position @10 GeV	0.5°	0.1°

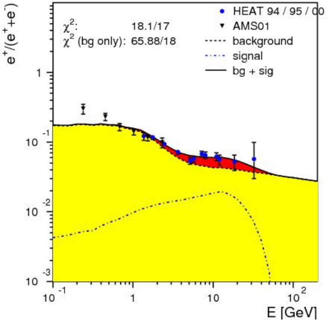


launch: late 2007

Positron Fraction

Conventional Model + DMA

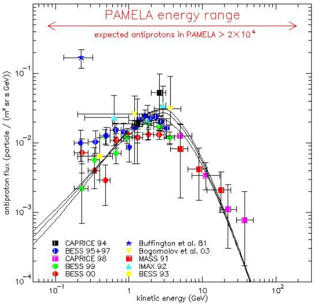




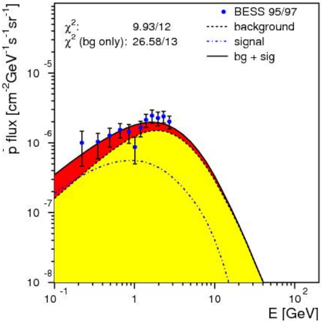
Previous balloon (e.g. HEAT) and satellite (AMS01) experiments show a hint of an excess at high energies

→ possible DMA contribution

Antiprotons



Conventional Model + DMA

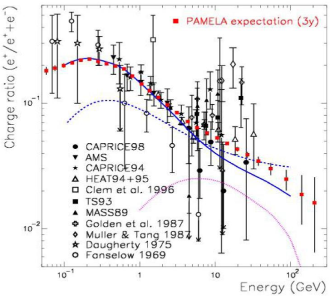


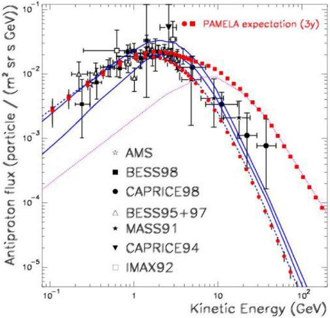
Difficult to compare different experiments because of solar modulation
→ still room for a DMA contribution in conventional Galactic models

Pamela, AMS . . .

Pamela (launched at 15th June 06) and **AMS02** (launched in ???) will measure charged particles (Pamela up to O, AMS02 up to Fe)

Main scientific goals: antimatter search, Galactic propagation models





Problem with Charged Particles

Incompatibility with Gamma Rays?

- The authors of `astro-ph/0602632` claim inconsistency in strength of DM signal for gamma rays and positrons/antiprotons
- Indeed boostfactors (from clumpy DM) are for charged particle smaller (factor ~ 0.1)
- **But:** propagation of charged particles is more complicated than Gamma Rays
- Is there a way to be consistent with DM interpretation of EGRET excess?

Galactic Bg of Gamma Rays & Charged Particles

Propagation Equation

$$\begin{aligned}\frac{\partial\psi}{\partial t} &= q(\vec{r},p) - \frac{1}{\tau_f}\psi - \frac{1}{\tau_r}\psi + \vec{\nabla}\cdot\left(D_{xx}\vec{\nabla}\psi - \vec{V}\psi\right) \\ &+ \frac{\partial}{\partial p}p^2 D_{pp}\frac{\partial}{\partial p}\frac{1}{p^2}\psi - \frac{\partial}{\partial p}\left[\dot{p}\psi - \frac{p}{3}\left(\vec{\nabla}\cdot\vec{V}\right)\psi\right]\end{aligned}$$

Ingredients of Propagation

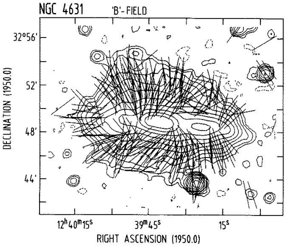
- Source spectrum
- Distribution of sources, gas and galactic fields
- Diffusion, Convection
- Energy losses, radioactive decay, interaction with IS gas ...

Solution of propagation equation with `GalProp`

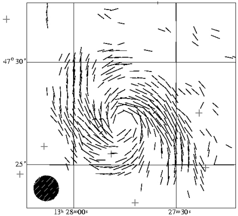
Moskalenko *et al.*, `astro-ph/9906228`

Magnetic Field of Galaxies

NGC 4631:



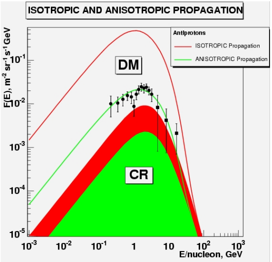
M51:



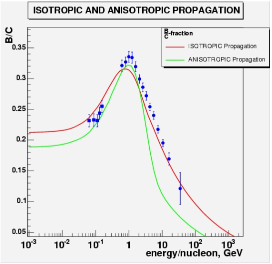
- A few μG perpendicular to galactic disk and along spiral arms
- Diffusion preferentially $\perp$ to disk? Slow radial diffusion?
- Isotropic $\rightarrow$ anisotropic diffusion
- Alternative: strong convection

Preliminary Results from GalPROP with Isotropic and Anisotropic Diffusion

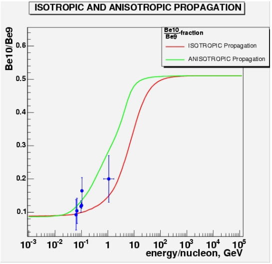
Antiprotons:



B/C:



Be^{10}/Be^{9}:

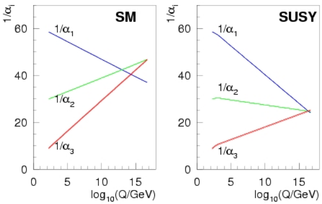


With anisotropic propagation flux of the charge particles can be tuned within a range of 2 orders of magnitudes, while the model is still ok with B/C an Be^{10}/Be^{9}!

Supersymmetry

Problems in the Standard Model (SM)

- No gauge coupling unification
- Hierarchy problem
- Fine tuning problem
- No DM candidat



Simultanous Soulution with Supersymmetry (SUSY)

- SUSY particles change running of couplings
- Hierarchy/fine tuning: SUSY-contributions have opposite sign → cancellation → logarithmic scale dependence
- DM: lightest neutralino is (often) perfect candidat (massive, stable, only weak interaction)

Supersymmetry

SUSY is broken, e.g. mSUGRA $\rightarrow$ 5 new Parameters

- m_0: unified mass of the fermion partners
- $m_{1/2}$: unified mass of the gauge boson partners
- $\tan\beta$: ratio of the VEVs of the 2 Higgs doublets
- unified trilinear coupling A_0, sign(μ)

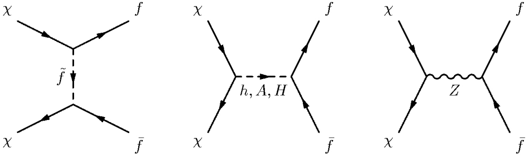
Contraints on the Parameter Space

- Higgs mass $m_h > 114.4$ GeV (SuSpect, hep-ph/0211331)
- $Br(b \rightarrow X_s\gamma) = (3.43 \pm 0.36) \times 10^{-4}$ (micrOMEGAs, hep-ph/0112278)
- $\Delta a_\mu = (27 \pm 10) \times 10^{-10}$ (micrOMEGAs)
- $\Omega_{DM} = 0.113 \pm 0.008$ (micrOMEGAs or DarkSusy, astro-ph/0406204)
- SUSY mass limit, EWSB, LSP neutral ... (SuSpect, hep-ph/0211331)
- Direct detection limits, ν flux from sun or earth (DarkSusy)

Neutralino Annihilation

- Neutralino is mixture:
  $|\chi_0\rangle = N_1|B_0\rangle + N_2|W_0^3\rangle + N_3|H_1\rangle + N_4|H_2\rangle$
- Annihilation cross section depends on SUSY **and** SM parameters

Feynman graphs:



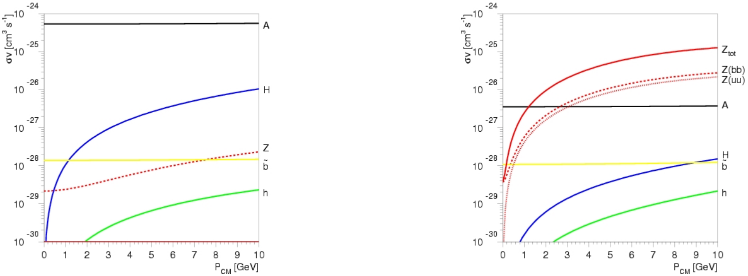
$\propto \frac{\mathbf{m_\chi \cdot m_f}}{\mathbf{m_{\tilde{f}}^2}}$ $\quad \propto \frac{\tan\beta \cdot \mathbf{m_{f_d}}}{\mathbf{m_W}} \mathbf{N_1 N_{3(4)}}$ $\quad \propto \frac{\mathbf{m_f \cdot m_\chi}}{\mathbf{m_Z^2}} \mathbf{N_{3(4)}^2}$

$\tan\beta \cdot \mathbf{m_{f_d}} \leftrightarrow \frac{\mathbf{m_{f_u}}}{\tan\beta}$

Energy Dependence of Annihilation

- *s*-wave (z.B. *s*-channel via *A*): $\langle \sigma v \rangle = \text{const}$
  with $\Omega_{DM} = 0.113 \pm 0.008$ yields $\langle \sigma v \rangle \approx 2 \times 10^{-26}$ cm^3/s
- *p*-wave (z.B. *s*-channel via *Z*): $\langle \sigma v \rangle \propto v$
  todays DMA cross section is very small $\longrightarrow$ large boostfactors

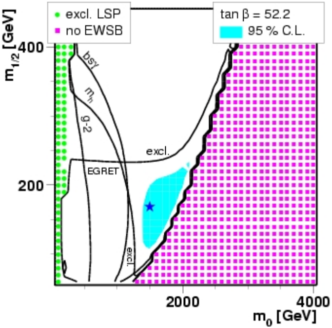
σ via A is dominant: **σ via Z is dominant:**



Cross sections calculated with `CalcHEP`, `hep-ph/0412191`

Allowed Parameter Space

- Scan over m_0-$m_{1/2}$-plane for fixed values of $\tan\beta = 52.2$ and $A_0 = 0$ GeV
- 2σ-contours for allowed region + consistency of the models (LSP neutral, EWSB ok)
- with EGRET-excess only a small region is left over:
  m_0: ∼1500 GeV . . . ∼2000 GeV
  $m_{1/2}$: ∼100 GeV . . . ∼250 GeV

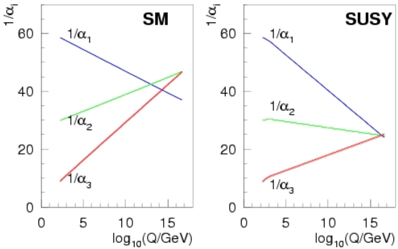


SUSY Mass Spectrum

Typical parameter set:

Parameter	value
m_0	1500 GeV
$m_{1/2}$	170 GeV
A_0	$0 \cdot m_0$
$\tan\beta$	52.2
$\alpha_s(M_Z)$	0.122
$m_t(pole)$	175 GeV
$m_b(m_b)$	4.214 GeV
Particle	**mass [GeV]**
$\tilde{\chi}^0_{1,2,3,4}$	64, 113, 194, 229
$\tilde{\chi}^{\pm}_{1,2}, \tilde{g}$	110, 230, 516
$\tilde{t}_{1,2}$	906, 1046
$\tilde{b}_{1,2}$	1039, 1152
$\tilde{\tau}_{1,2}$	1035, 1288
$\tilde{\nu}_e, \tilde{\nu}_\mu, \tilde{\nu}_\tau$	1495, 1495, 1286
$h, H, A, H^{\pm}$	115, 372, 372, 383

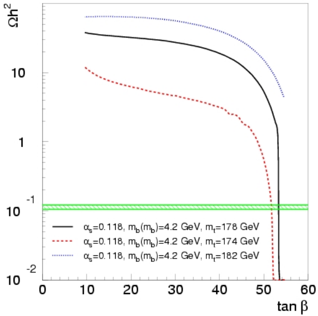
Unification of gauge couplings:



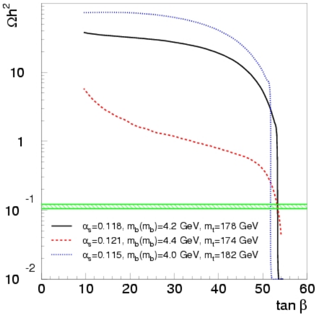
Observable	value
$Br(b \to X_s\gamma)$	$3.02 \cdot 10^{-4}$
Δa_μ	$1.07 \cdot 10^{-9}$
Ωh^2	0.117

RD Dependence on SM Parameters

Top mass m_t:



with m_b und α_s:

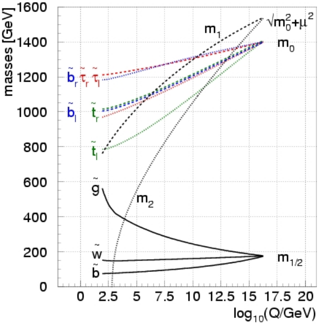


Large uncertainty, in particular for large tan β; **Reason:** RGE of breaking parameters and EWSB

Electroweak Symmetry Breaking

- Pseudoscalar Higgs mass:
  $m_A^2 = m_1^2 + m_2^2 = m_{H_1}^2 + m_{H_2}^2 + 2\mu^2$
- Condition: $\frac{M_Z^2}{2} = \frac{m_1^2 - m_2^2 \tan^2\beta}{\tan^2\beta - 1}$
- Dependence on SM parameters by RGE
- For large $\tan\beta \rightarrow$ running of m_1 and m_2 is steep
  $\rightarrow$ large uncertainty in m_A ...
  $\rightarrow$ ... in $\langle\sigma v\rangle$ ...
  $\rightarrow$ ... and in RD

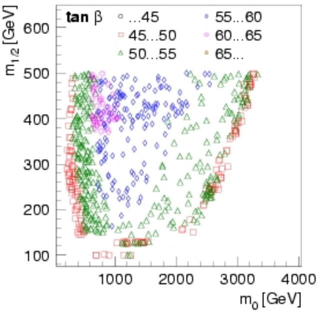
Running of breaking parameters:



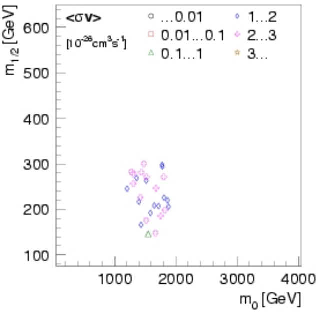
Allowed Parameter Space version 2

- Scatterplot of m_0, $m_{1/2}$ and $\tan\beta$; only parameter sets with correct RD are plotted
- Solutions at smallest $m_{1/2}$ yield at low T too small c.s. (p-wave) $\rightarrow$ large unphysical boost factors

wo. exp. constraints:



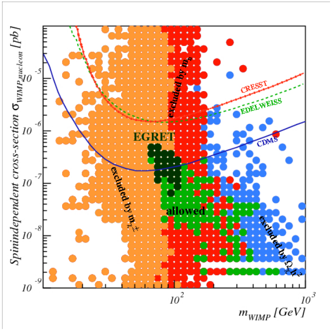
w. exp. constraints:



Spin-Independent Experiments

- Calculating SI cross section with `DarkSusy`
- Limits normalized to local $\rho = 0.3 \frac{GeV}{cm^3} \rightarrow$ halo dependent
- Our halo model has a higher $\rho = 1.2$ GeV cm^{-3}
- Even larger uncertainties, if most of DM is clumpy
- "EGRET Models" compatible with all present experiments possible

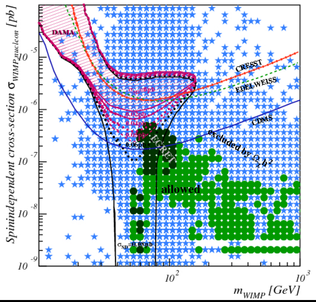
CDMS + EDELWEISS + CRESST:



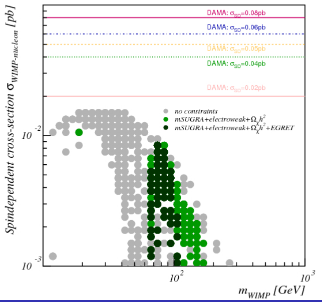
DAMA

- DAMA claims detection of an annual modulation of the rate
- Cross section ruled out by other experiments
- But DAMA maybe sensitive to SD cross section (nuclear spin)
- No mSUGRA model found, which provides enough SD c.s.

limits for different SD c.s.

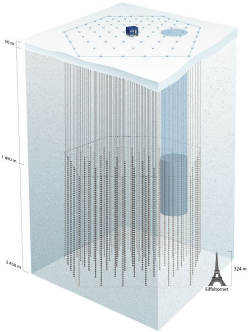


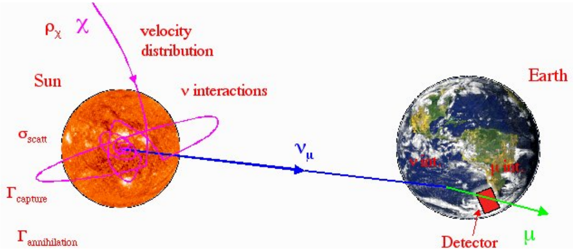
SD c.s. in mSUGRA



DM Capture in Planets or Stars

DM trapped in sun (or earth) $\rightarrow$ annihilation into pairs of SM particles
$\rightarrow$ decay/fragmentation to $X + \nu$
$\rightarrow$ observation by detectors like AMANDA, Baikal, Antares, ICECUBE

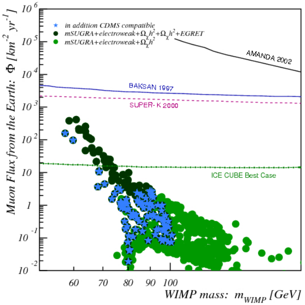




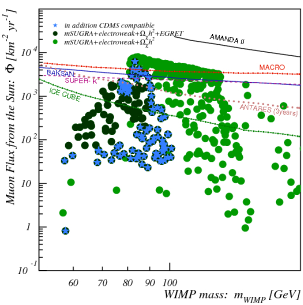
Fluxes from Earth and Sun

- Rates calculates with `DarkSusy`
- “EGRET models” are compatible with present limits
- km^3 detector will exclude parts of allowed parameter space

Flux from earth



Flux from sun



Summary

1. EGRET excess in the conventional Galactic model can be explained as Dark Matter annihilation of WIMPs in a mass range between 50 and 70 GeV
2. From the directional dependence of the excess a *possible* halo profile can be determined $\Rightarrow$ halo profile needs ringlike structures, which are correlated with observations
3. Determined halo profile is compatible with rotation curve of the Milky Way (de Boer *et al.*, Astronomy & Astrophysics 444 (2005) 51)
4. Consistently determined Extragalactic background also shows a bump at interesting energies (de Boer *et al.*, `astro-ph/07050094`, accepted by A&A)

Summary

5. EGRET data are compatible with DM consisting of supersymmetric neutralinos $\Rightarrow$ together with constraints from EWSB, Higgs mass, $Br(b \rightarrow X_s\gamma)$, a_μ only a small region of mSUGRA-SUSY parameter space is left over; particle masses are in the discovery range of the LHC (de Boer *et al.*, Phys. Lett. B 636 (2006) 13)
6. EGRET data are also compatible with present limits from direct and indirect detection experiments

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