IPhT CEA-Saclay

Marco Taoso

The Galactic Center GeV excess and its constraints

Rencontre de Physique des Particules

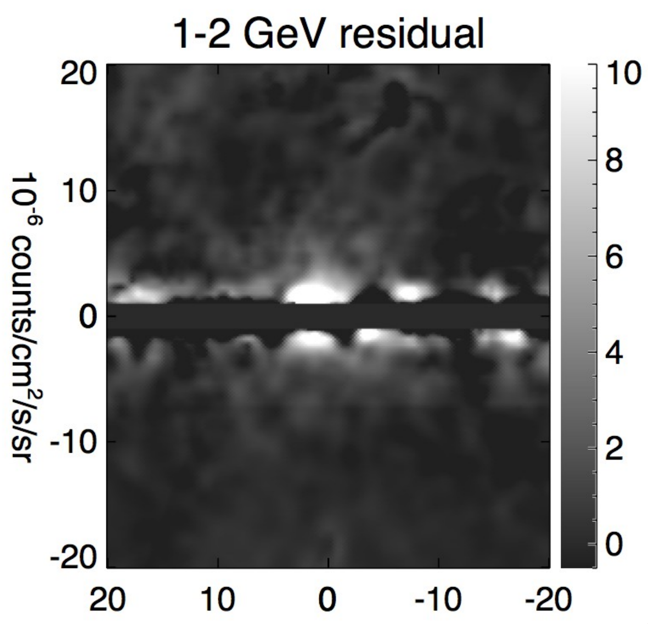
Paris 15-16/01 2015

Galactic center excess

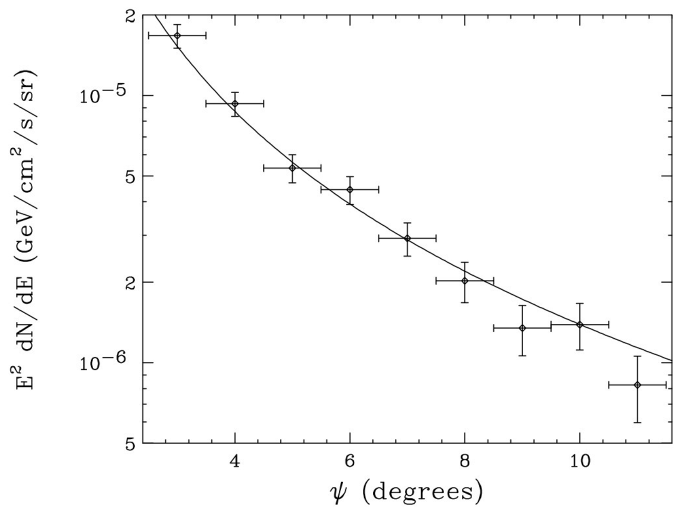
Gamma-ray excess at energies around few GeVs detected around the Galactic Center

Properties: extended (at least 10 degrees), spherically symmetric, centered at GC
Spectrum of residuals peaked in the GeV range

Data-Model



Extended. Not a point source



Daylan et al. 1402.6703

Incomplete list of analysis: Goodenough et al., Hooper et al., Abazajian et al., Macias et al., Macias et al., Zhou et al., Huang et al., Calore et al.,

GC excess: interpretation

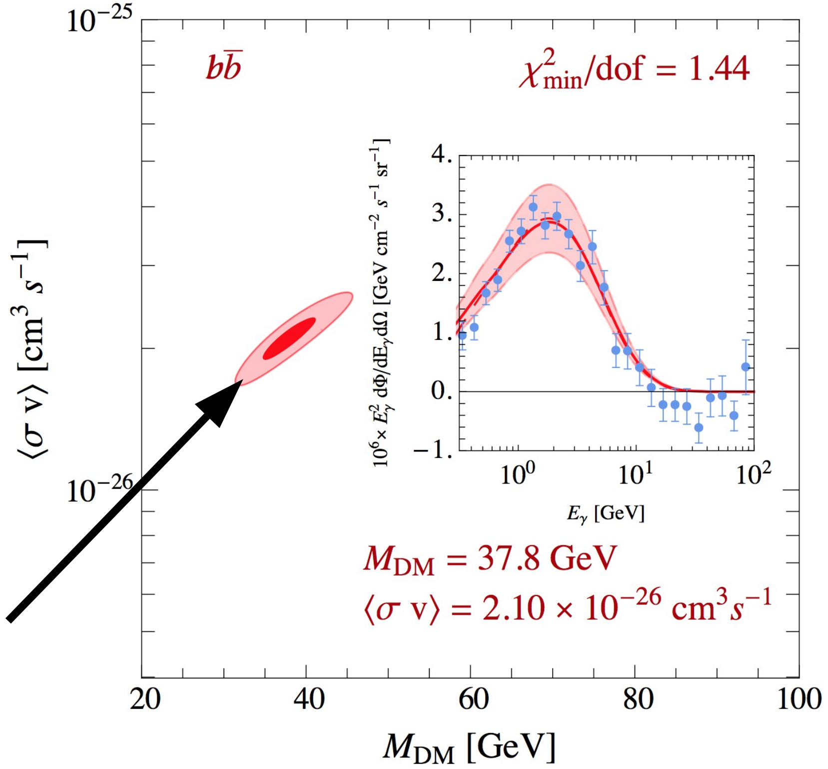
Emission can be explained by **DM annihilations** with density distribution NFW-like

$$\rho_{\mathrm{gNFW}}(r) = \rho_\odot \left(\frac{r}{r_\odot}\right)^{-\gamma} \left[\frac{1+(r/R_s)^\alpha}{1+(r_\odot/R_s)^\alpha}\right]^{-\frac{(\beta-\gamma)}{\alpha}}$$

with gamma = 1.2 - 1.3

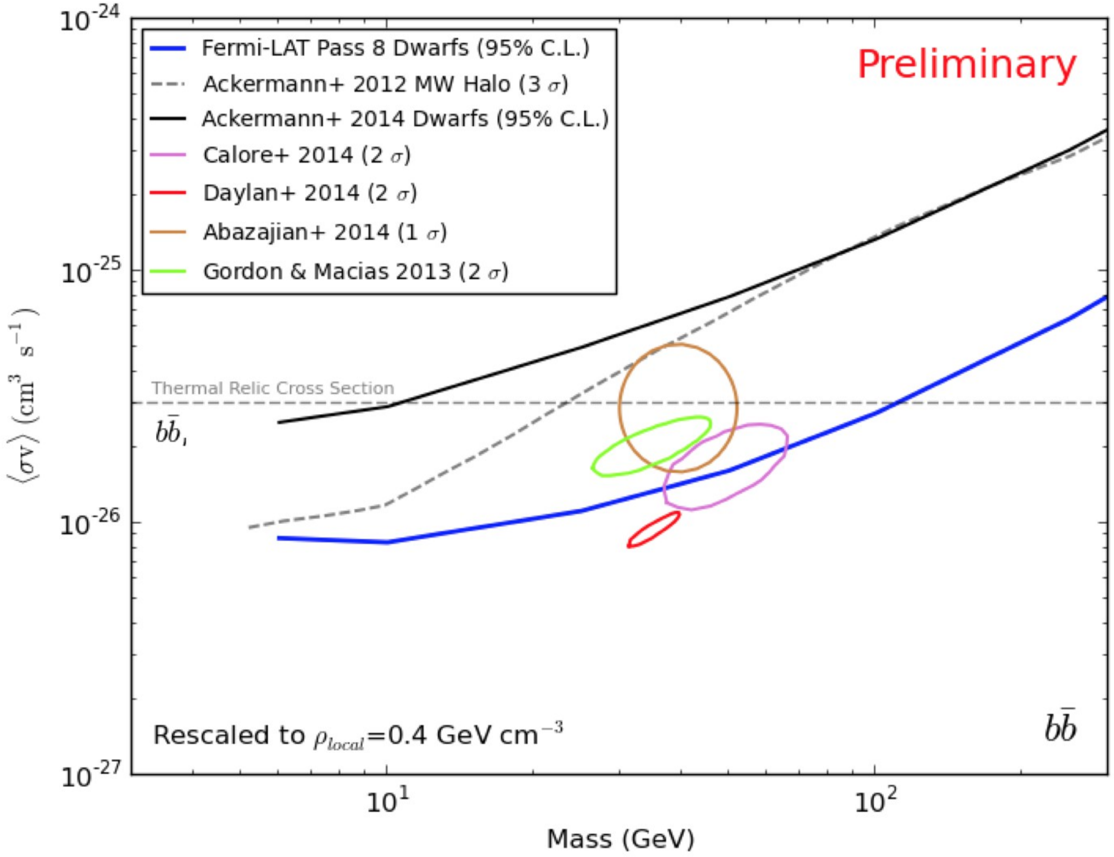
Energy spectrum well fitted by DM annihilations spectra

Cross-section close to thermal value!



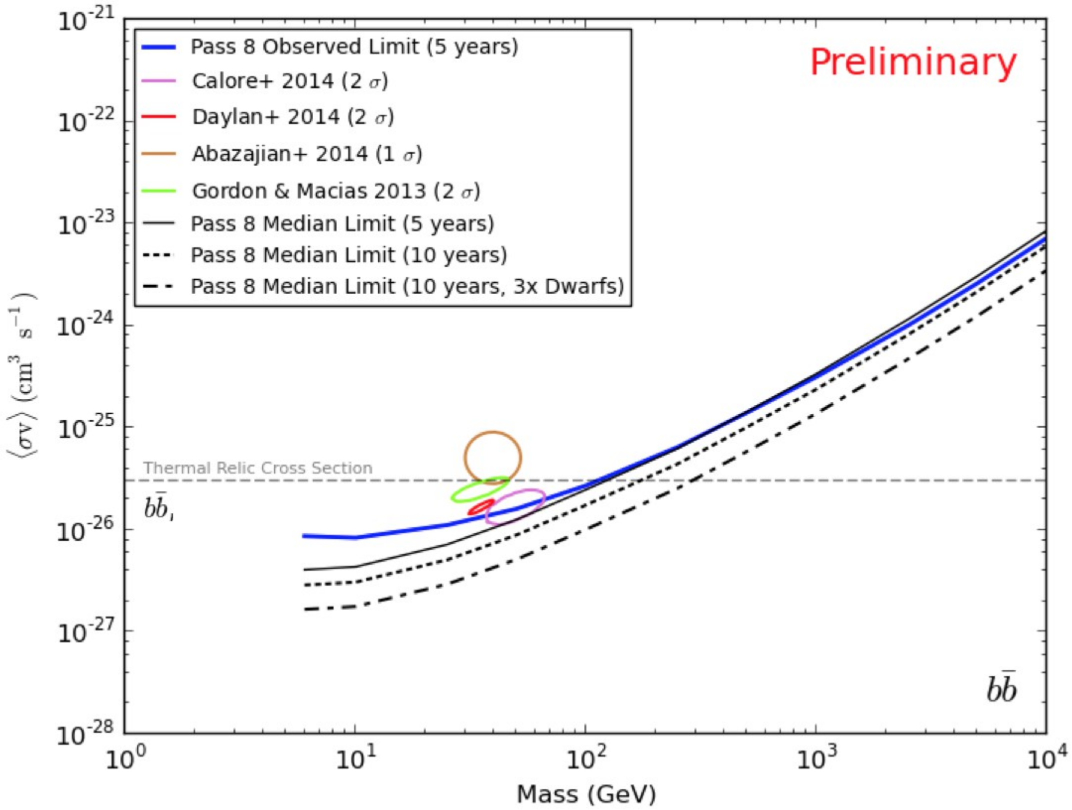
Other options: population of unresolved sources (milli-second pulsars?)
Burst events at GC, hadronic or leptonic

Dwarf bounds



From Anderson, Fermi Coll., Fermi Symposium 2014

Future dwarf bounds



From Anderson, Fermi Coll., Fermi Symposium 2014

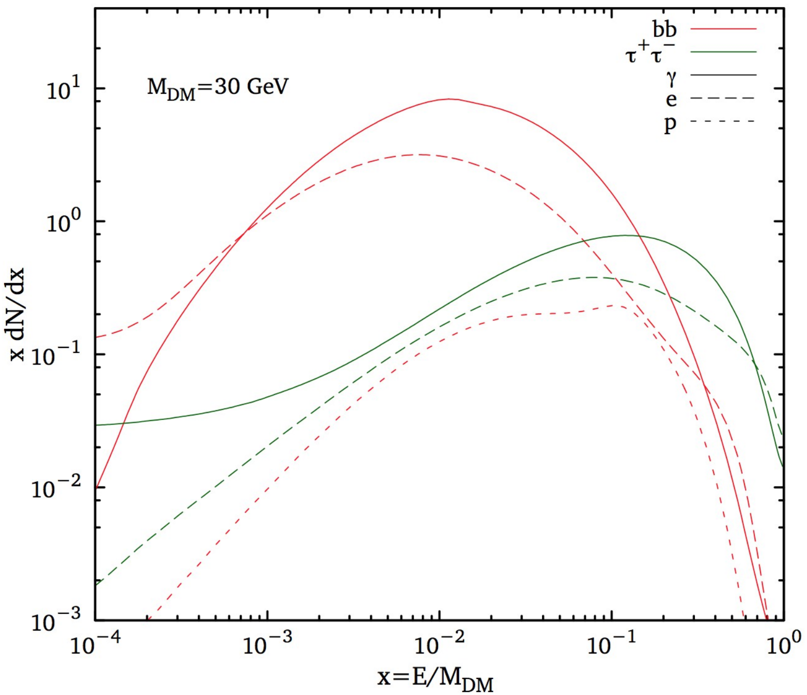
Role of secondary emissions

DM injects significant amount of energetic electrons and, depending on the annihilation channel, anti-protons

Electrons induce secondary gamma-ray emission through IC and brem

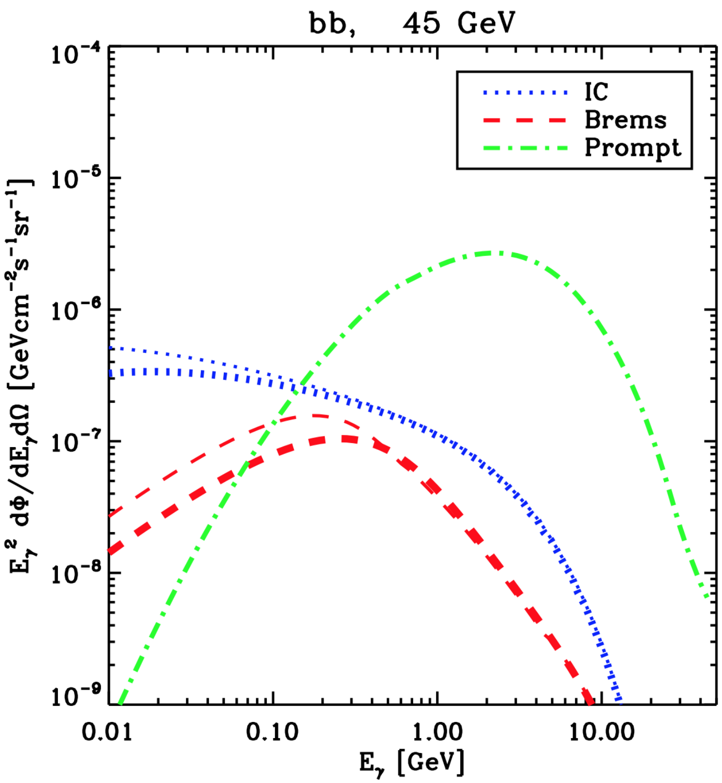
Electrons in magnetic fields → synchroton radiation → radio/micro-wave frequencies

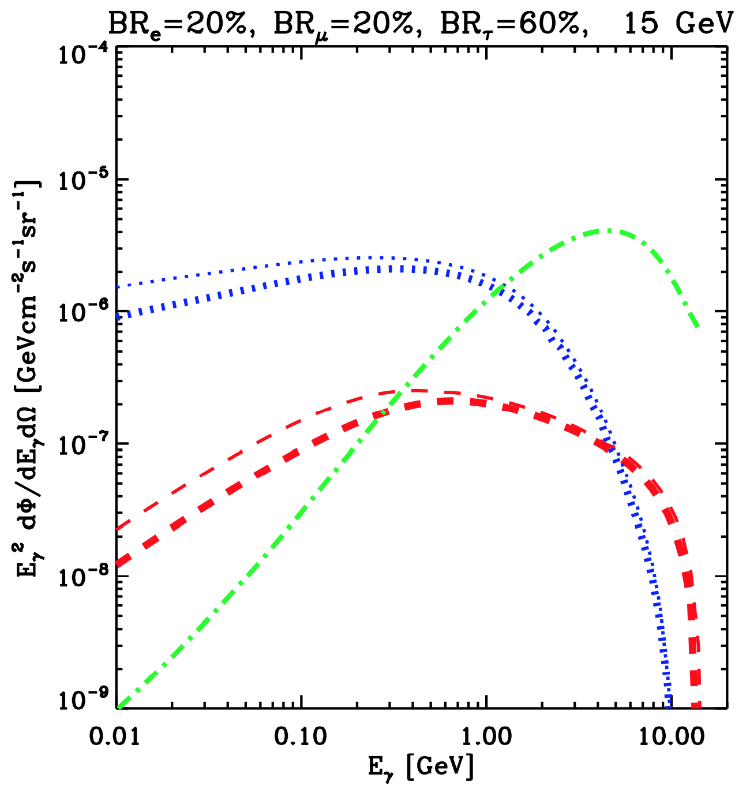
Anti-p fluxes bounded from local CR observations



Gamma spectra from IC/brems

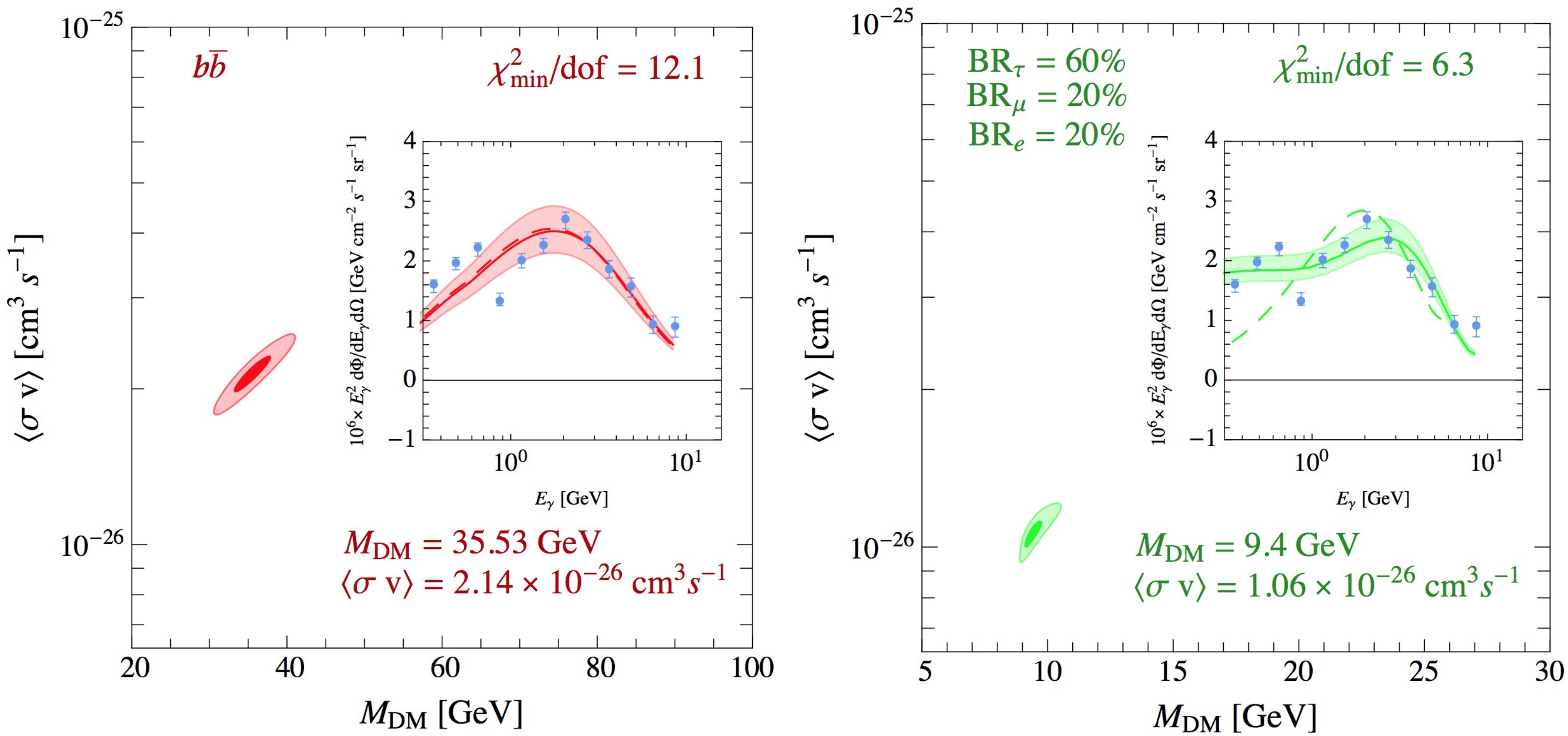
Compute Inverse-Compton and Brems produced by electrons using appropriate gas and Interstellar Radiation Field maps





Secondary emissions relevant for leptonic channels
Only marginal role for hadronic channels

Best-fit regions



Including secondary emissions, leptonic channels might be a viable options for GC excess

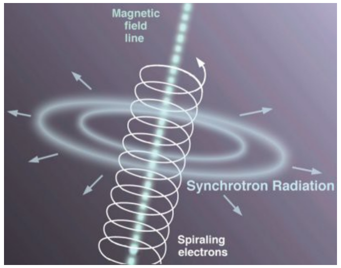
See also Lacroix, Boehm and Silk 1403.1987

Very recently a leptonic interpretation of GC emission proposed in

Abazajian, Canac, Horiuchi, Kaplinghat, Kwa, 1410.6168

Radio bounds

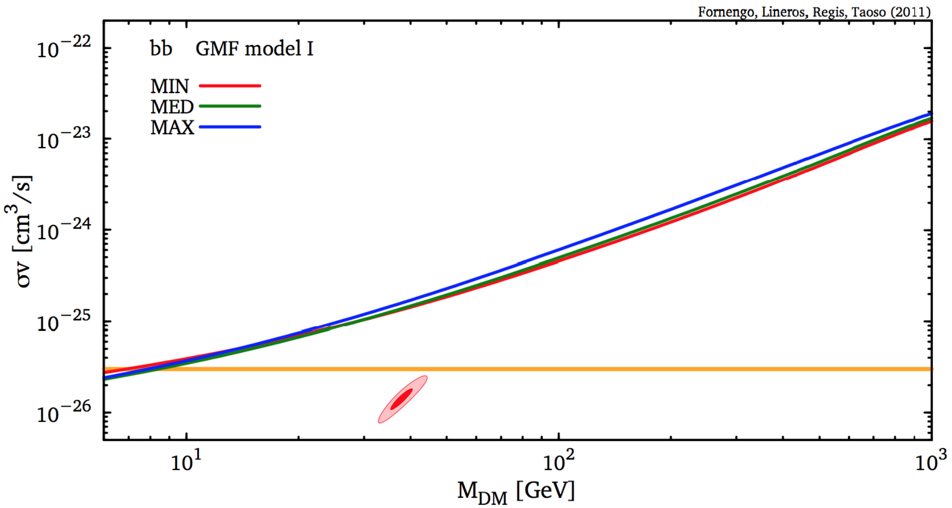
Synchrotron emission falls in radio band for typical values of the galactic magnetic field



$$\nu \sim 30 \text{ MHz} \frac{B}{6\mu G}\left(\frac{E_e}{1GeV}\right)^2$$

Constraints from radio surveys from 22 MHz – 1.4 GHz

Additional uncertainty wrt gamma: magnetic fields & propagation

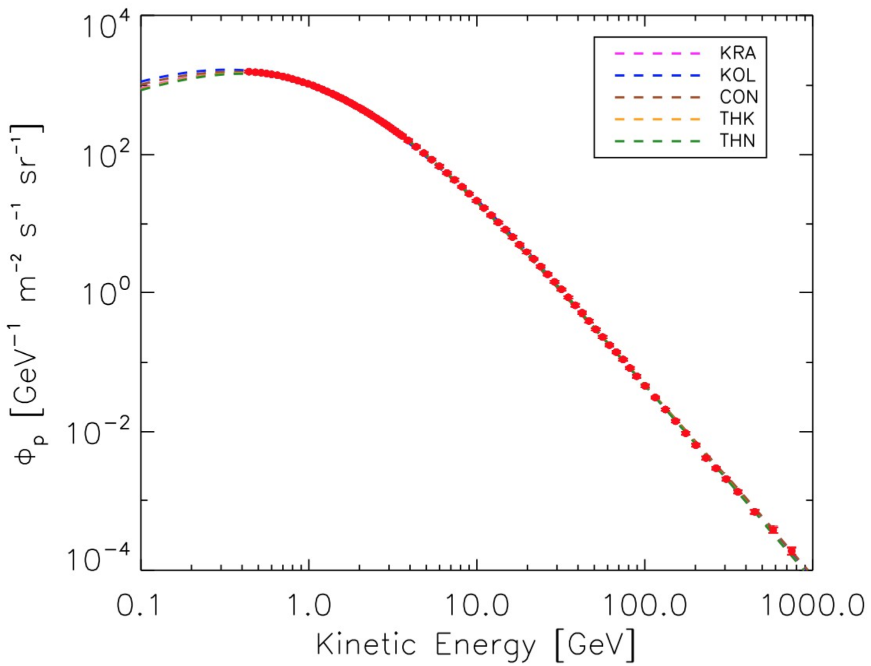


Fornengo, Lineros, MT, Regis 1110.4337

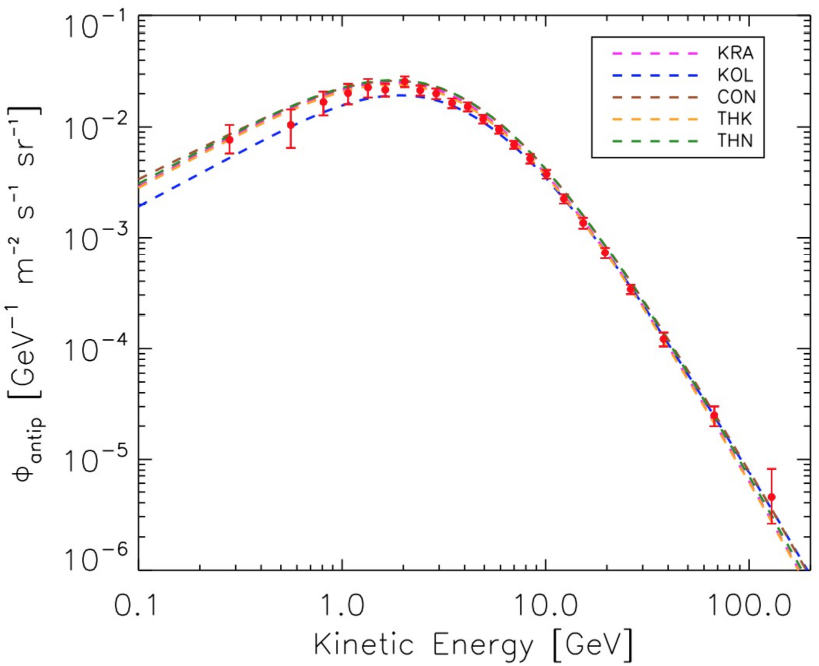
Antiprotons

PAMELA observations vs cosmic-rays propagation models

PROTONS



ANTI-PROTONS

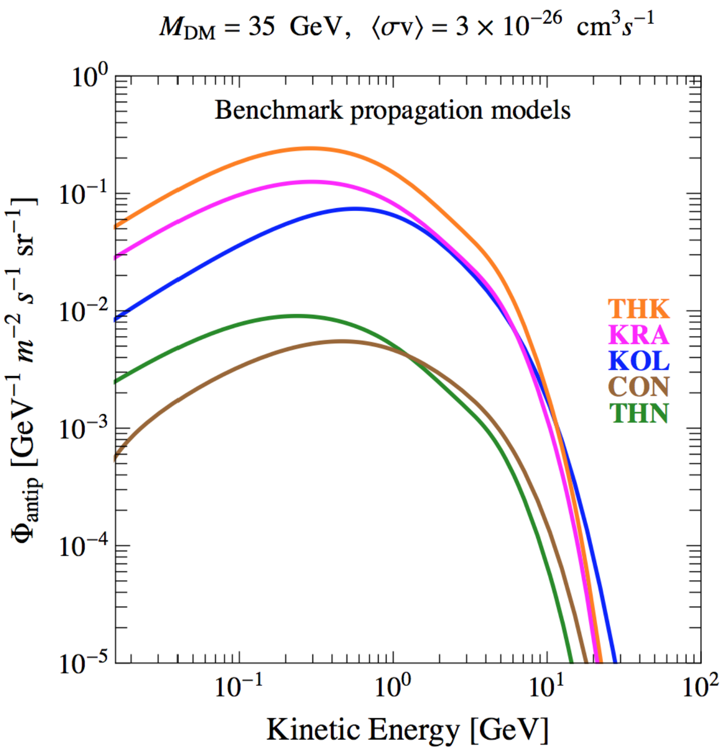


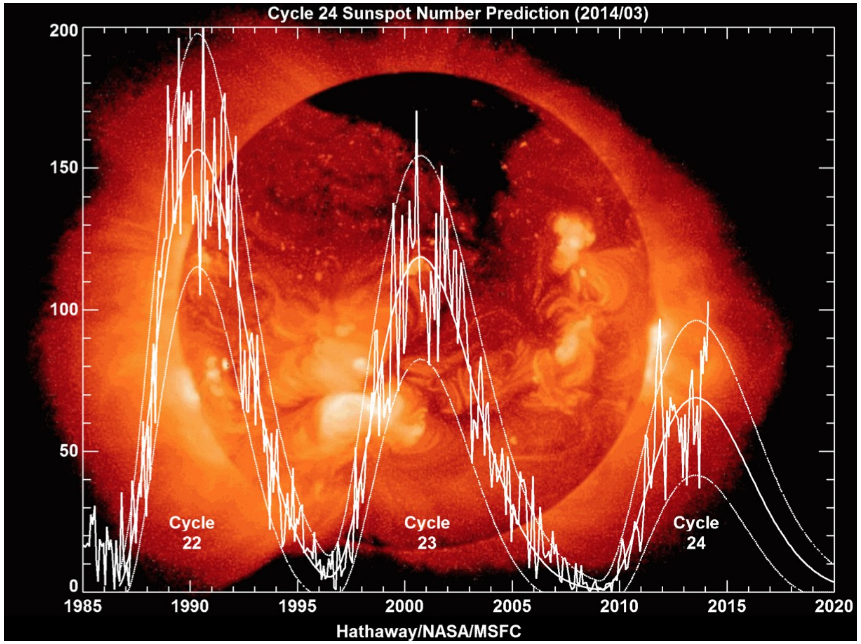
Models in good agreement with anti-p data

Use PAMELA DATA + anti-p cosmic-ray background to constrain anti-p from DM

Anti-p from DM: uncertainties

Two main uncertainties: propagation of anti-p inside the galaxy, solar modulation





Anti-p flux from DM strongly depends on the propagation model

Effect of solar wind very relevant for charged particles < 10 GeV

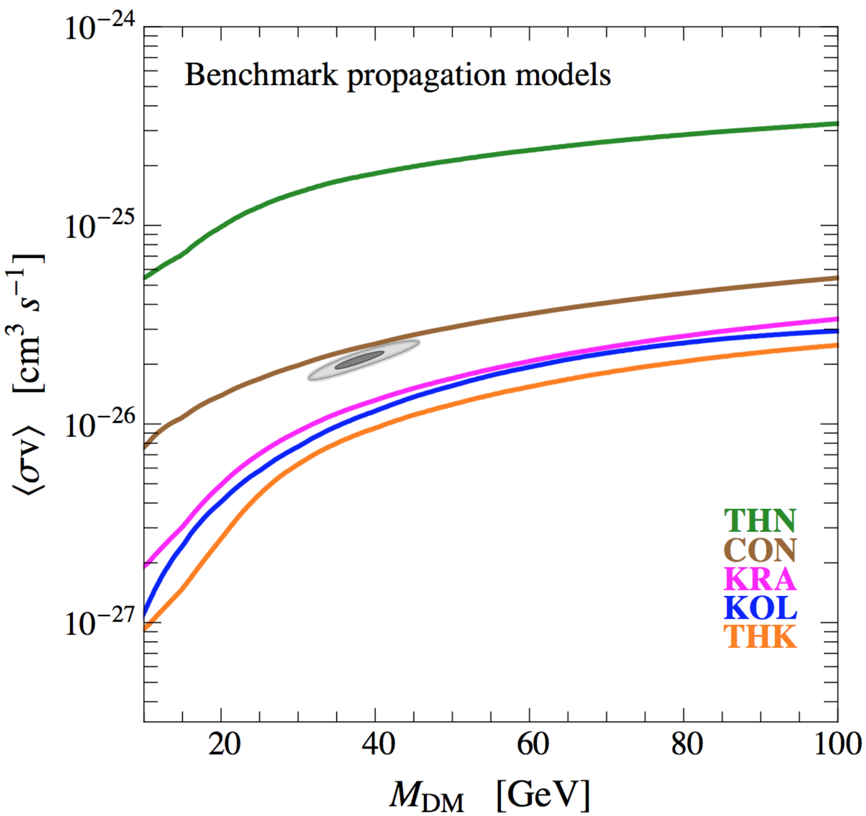
Cirelli, Gaggero, Giesen, MT, Urbano 1407.2173

Anti-p constraints on DM

Consider charge-dependent effects

Marginalize over interval of Fisk potential to set the constraints

Interval of ± 50% around Fisk of p from a dedicated analysis based on HELIOPROP



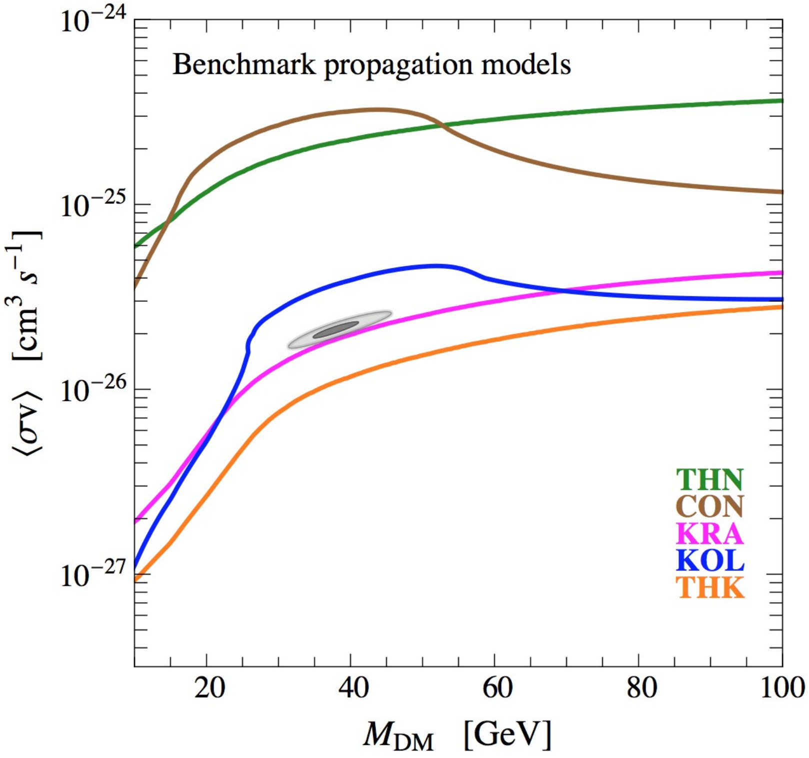
$$\phi_F^{\bar{p}} = \phi_F^{p} \pm 50\%$$

Anti-p constraints on DM

Very conservative range of variation of Fisk potential bracketing extreme observed

Variations of the Fisk potential

Cirelli, Gaggero, Giesen, MT, Urbano 1407.2173



$\phi_F^{\bar{p}} \in [0.1, 1.1]$ GV

Other recent analysis on anti-p bounds & GC excess: Bringmann, Vollmann, Weniger 1406.6027, Hooper, Linden, Mertsch 1410.1527

Conclusions

New extended source in the GC region on top of astro foregrounds!

Energy spectrum and morphological **properties fit well with expectations from DM** but alternative astrophysical explanations are also viable

DM interpretations **not yet constrained by Dwarf** constraints but future improvements should cover that region of the DM parameter space

Secondary emissions matter, both for spectral properties of the emission and constraints

Anti-p flux from PAMELA allows to set very stringent bounds on DM but beware of theoretical uncertainties on CRs production and propagation and of the solar modulations

For conservative choices, **anti-p bounds are compatible with the GeV GC excess**

THANKS

Benchmark models

	KRA	KOL	CON	THK	THN	THN2	THN3
z_t [kpc]	4	4	4	10	0.5	2	3
D_0 [10^{28} cm^2 s^{-1}]	2.64	4.46	0.97	4.75	0.31	1.35	1.98
δ	0.50	0.33	0.6	0.50	0.50	0.50	0.50
η	-0.39	1	1	-0.15	-0.27	-0.27	-0.27
v_A [km s^{-1}]	14.2	36	38.1	14.1	11.6	11.6	11.6
γ	2.35	1.78/2.45	1.62/2.35	2.35	2.35	2.35	2.35
dv_c/dz [km s^{-1} kpc^{-1}]	0	0	50	0	0	0	0
ϕ_F^p [GV]	0.650	0.335	0.282	0.687	0.704	0.626	0.623
$\chi^2_{\rm min}$/dof (p in [25])	0.462	0.761	1.602	0.516	0.639	0.343	0.339

Adopt a set of propagation model tuned against protons and B/C data

Span models with thick (10 kpc) – thin (1kpc) diffusion regions

Include models with large re-accelleration and convective winds