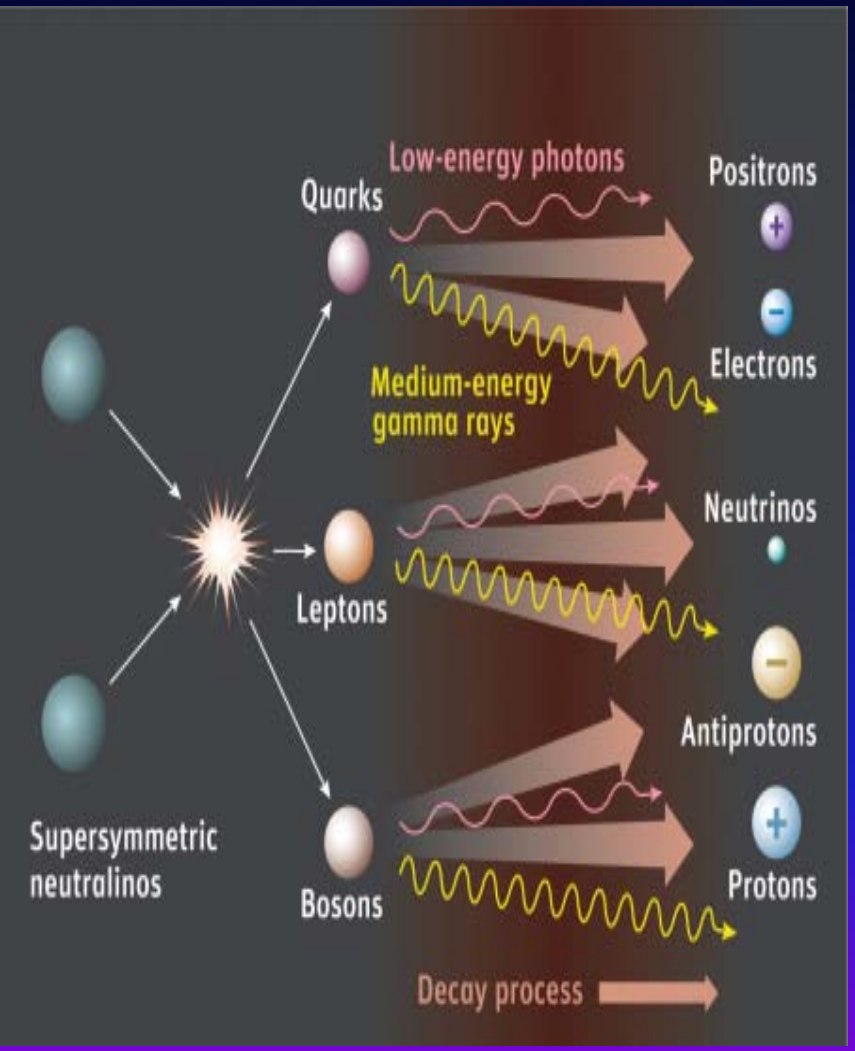
Indirect Dark Matter Searches in the Light of FERMI and PAMELA



Annihilation products from dark matter annihilation:

Gamma rays
(FERMI -> arXiv:1002.1576v1)

Positrons (PAMELA, arXiv:1001.3522)

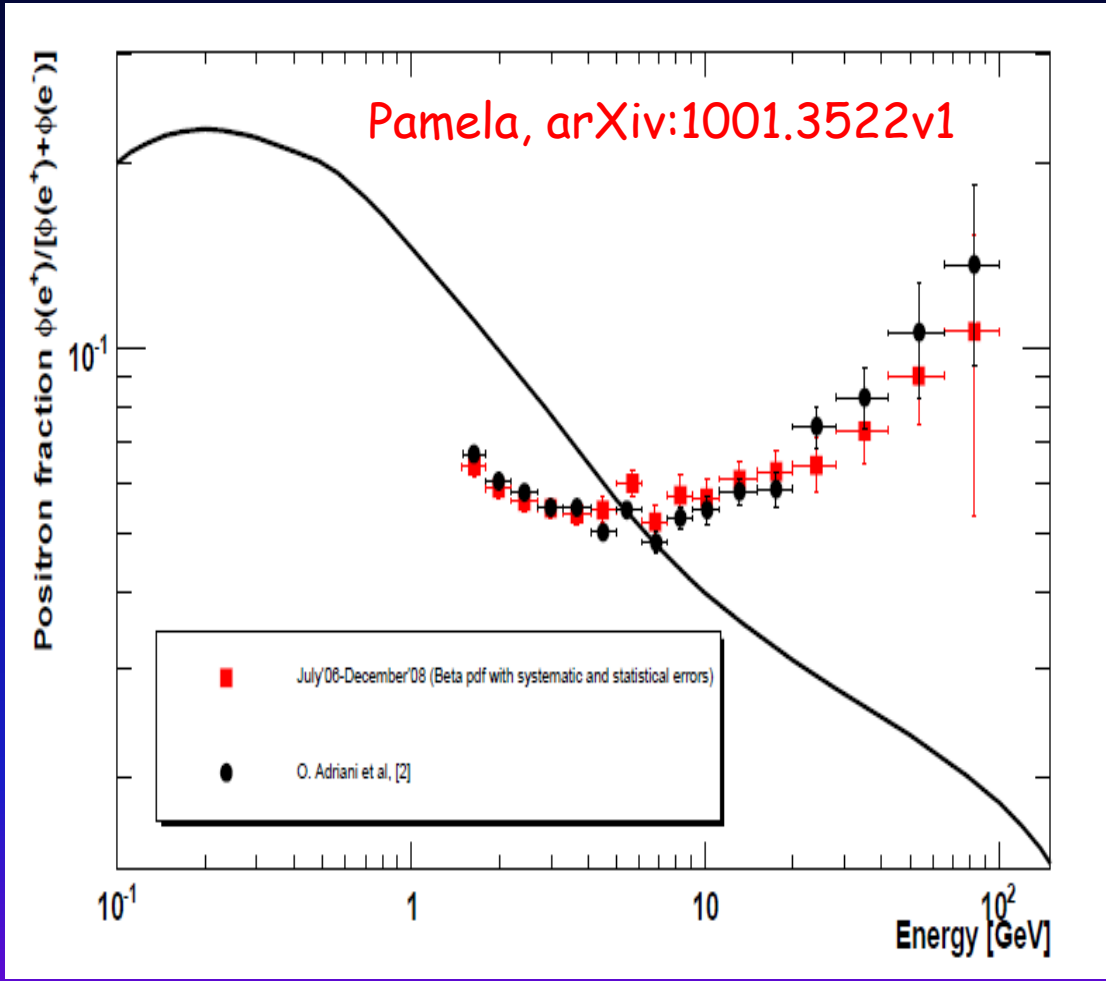
Antiprotons (PAMELA)

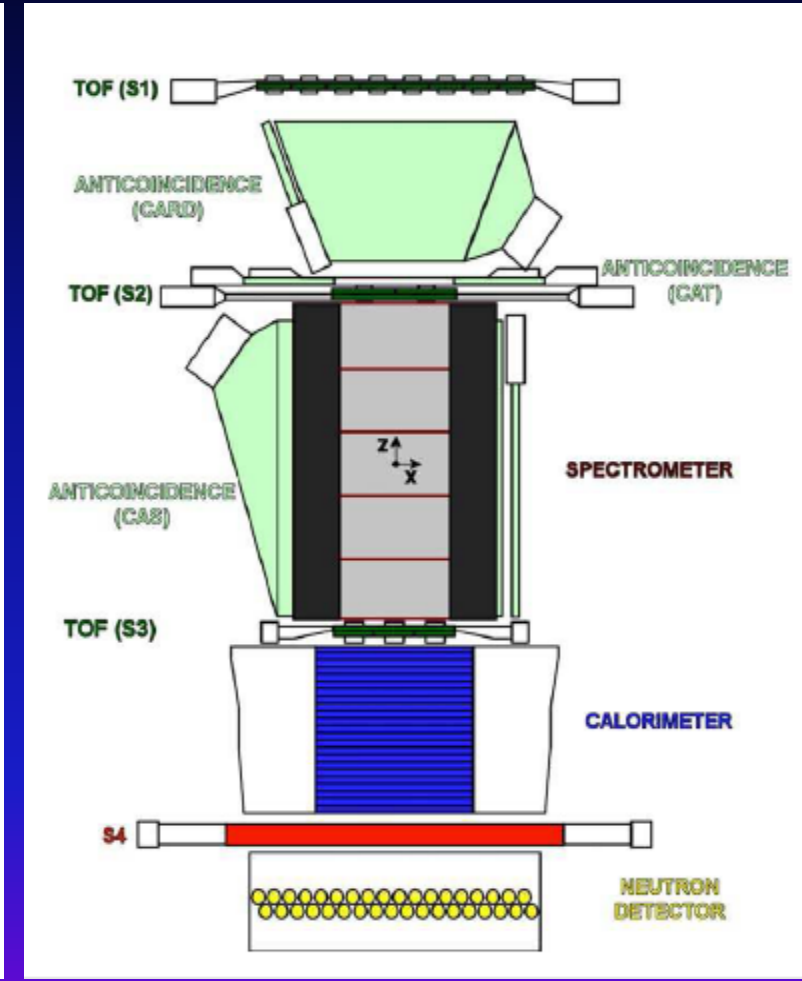
e+ + e- (ATIC, FERMI, HESS, PAMELA)

Neutrinos (Icecube, no results yet)

e-, p drown in cosmic rays?

PAMELA Positron excess confirmed with new data and new analysis





Origin?

Depends on whom you ask!

My assumption:

$$|\text{Data}\rangle = a_{p->\pi 0}\,|\text{Background}\rangle + a_{DMA}\,|\text{DMA}\rangle + a_{sec}\,|\text{SNR}\rangle + a_{local}\,|\text{SNR(x)}\rangle + a_{pulsar}\,|\text{Pulsar}\rangle$$

Unitarity must be fulfilled. However, each component has enough uncertainty to saturate observations

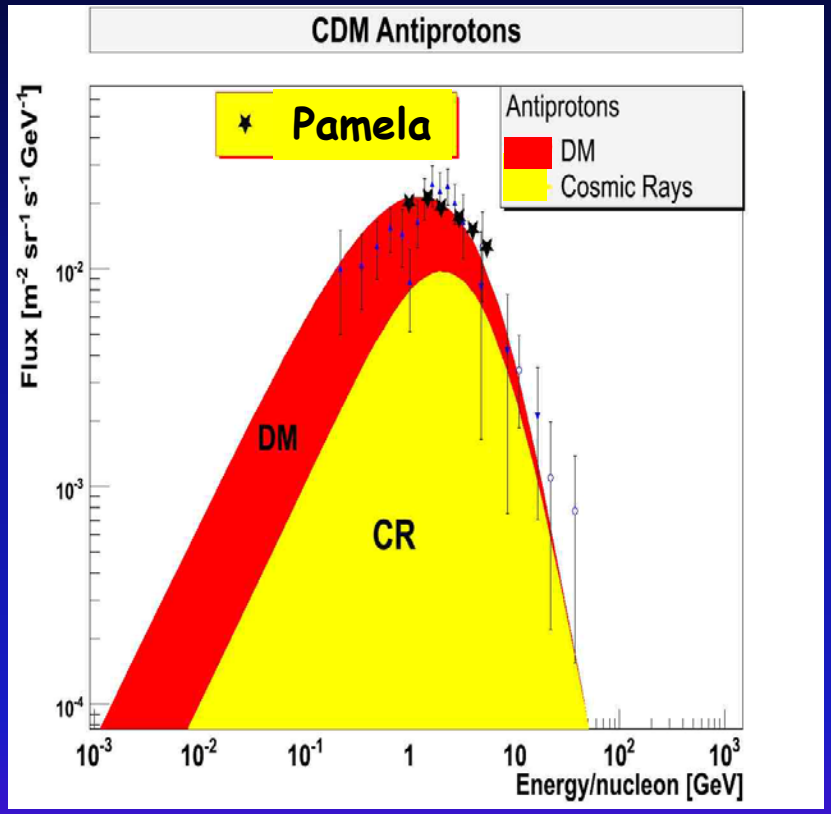
For details: WdB, AIP Conf.Proc.1200:165-175,2010. arXiv:0910.2601 [astro-ph.CO]

AMS-02 from CERN to Cape Canaveral on 26.08.2010

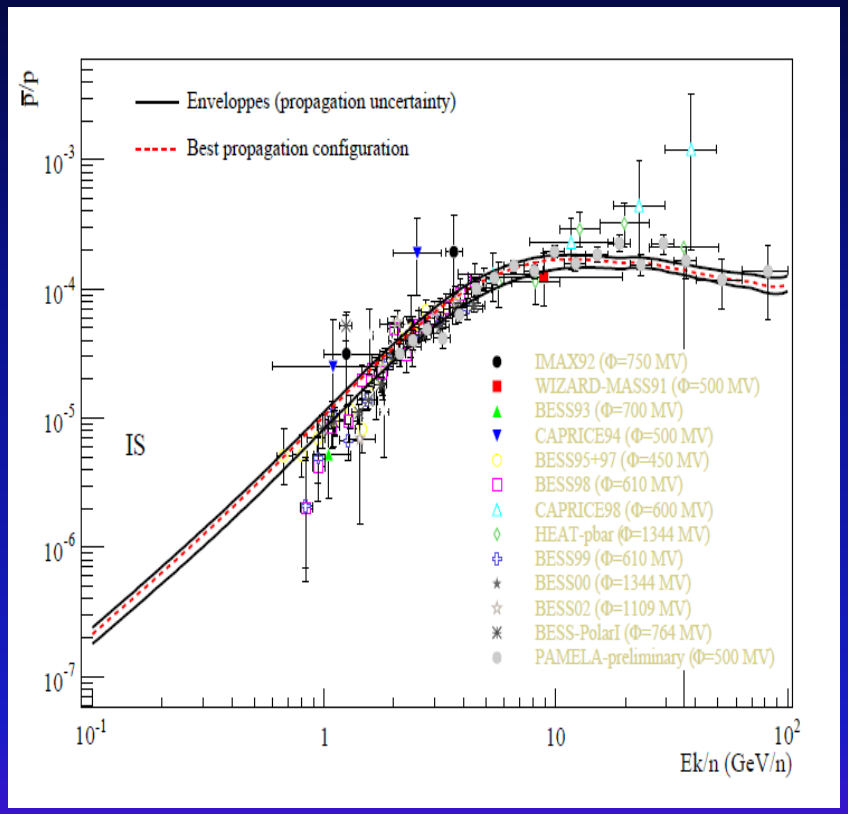
Antiprotons

GALPROP Antiprotons

Gebauer and WdB,arXiv:0910.2027



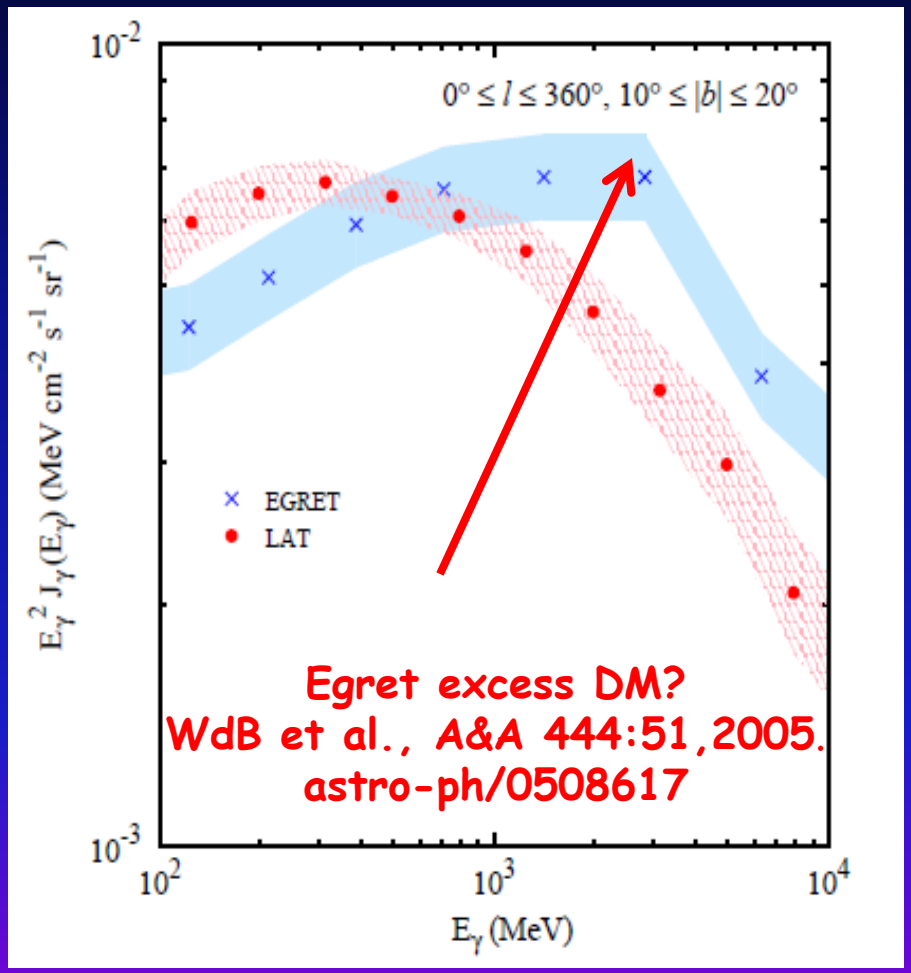
Donata et al. [0810.5292]

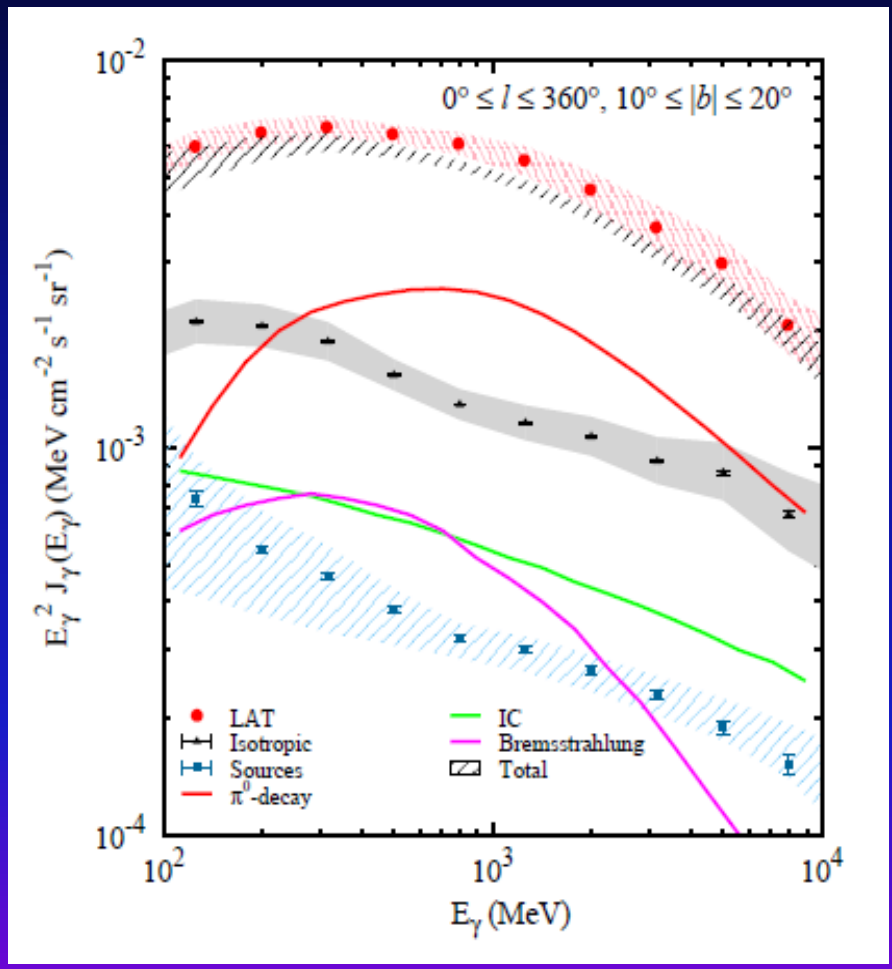


GALPROP (with and without) convection has deficit of antiprotons. Darksusy and others (which only look into charged particles, no gamma rays) can saturate data.

EGRET excess disappeared?

Only latitudes between 10 and 20 degrees considered

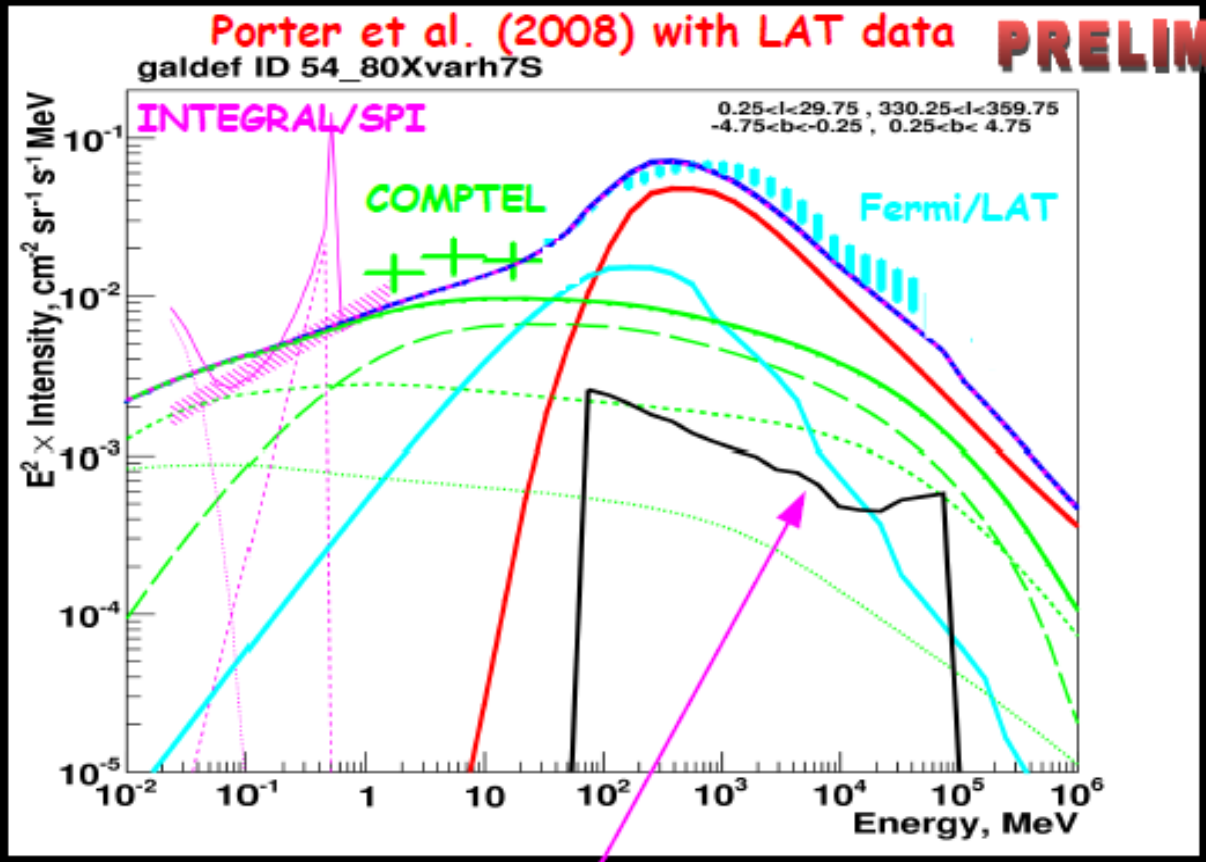




FERMI-LAT Coll., arXiv:1002.1576v1, 8 Feb 2010

Inner Galaxy: keV to ~ 100 GeV

IC:
Total
OPT
IR
CMB
Brem
π^0-decay
Model total



`isotropic' = instrumental + astrophysical backgrounds

- Initial model okay, but too low → increase CRs to compensate
- Electrons *= 1.75, protons *= 1.15

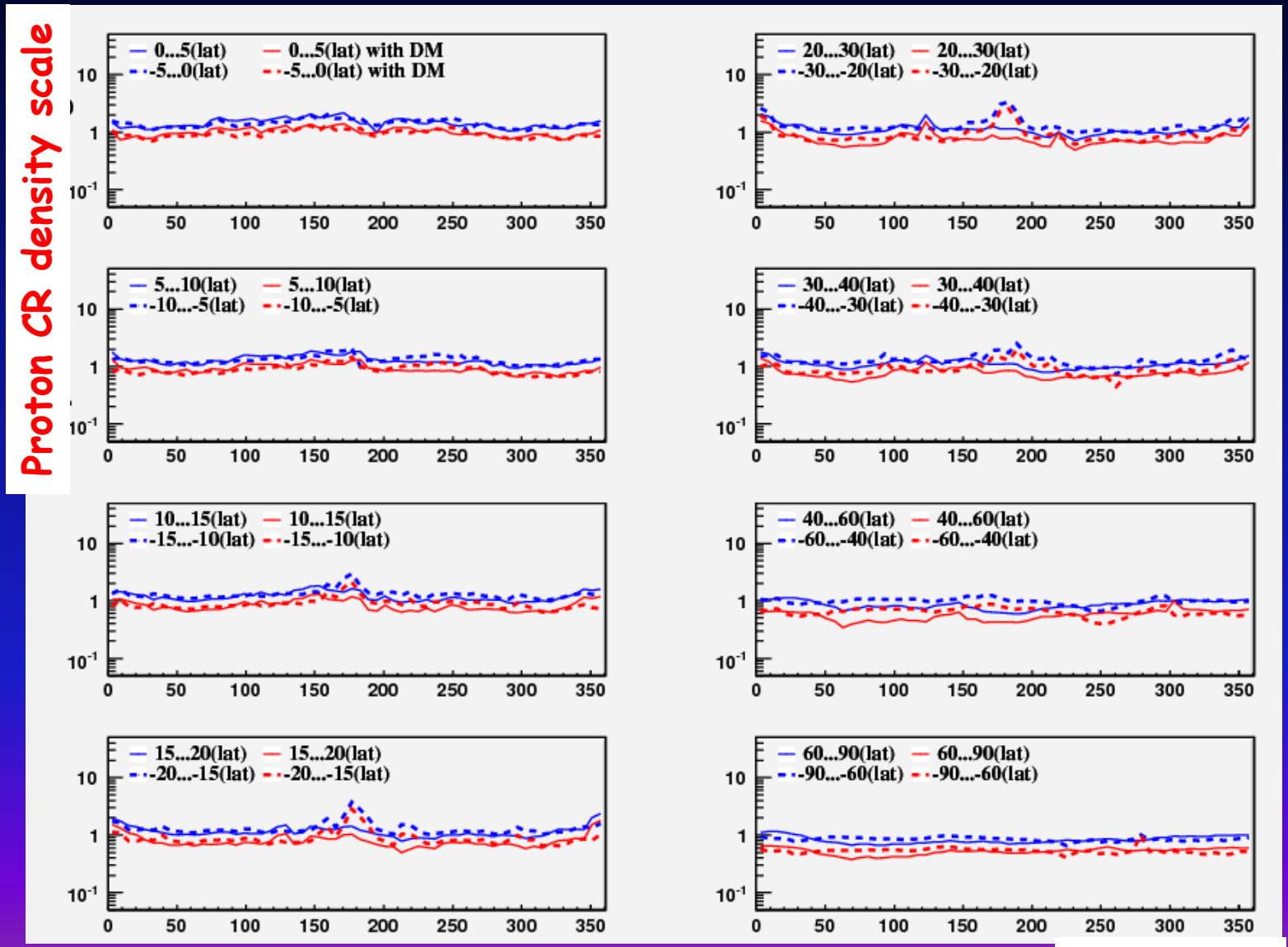
Data driven analysis of FERMI gamma ray data (publicly available from NASA archive)

Idea:
Fit known shapes of 3 main components:

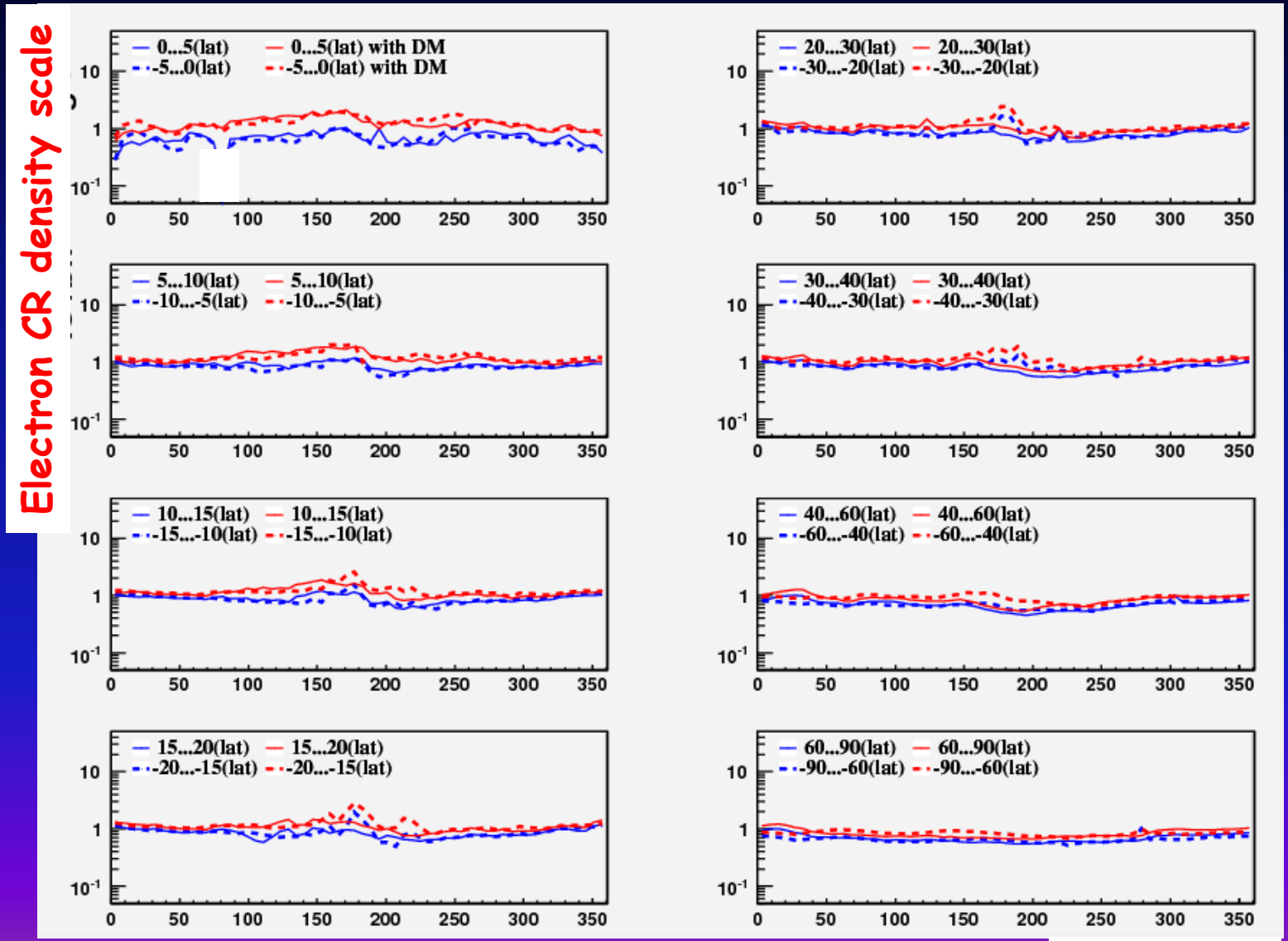
Inverse Compton:(IC) $\propto$ **CR electron density x ISRF**
Bremsstrahlung:(BR) $\propto$ **CR electron density x gas density**
$P_{CR}P_{Gas}$ scattering:(π^0) $\propto$ **CR proton density x gas density**

Main unknowns: CR electron density
CR proton density
(both measured locally, i.e. at a single point in Galaxy.)
For gamma rays need a diffusion model to calculate CR density anywhere. Best available model: GALPROP.
Gas density known from gas tracers,
ISRF from dust maps, CMB and visible light.

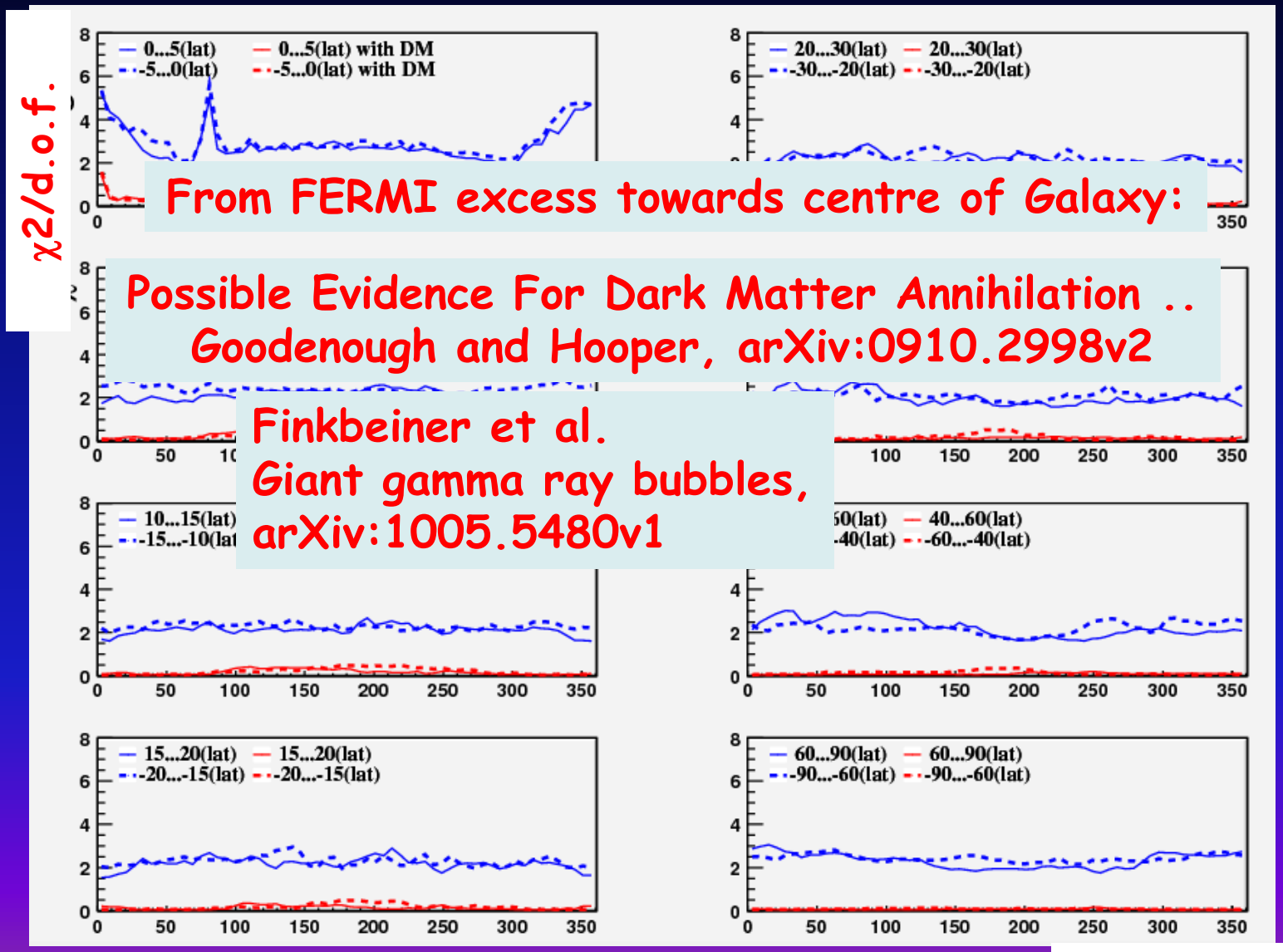
Fitted background in broad agreement with GALPROP



Fitted background in broad agreement with GALPROP



χ2 much improved by adding DM instead of rescaling CR densities



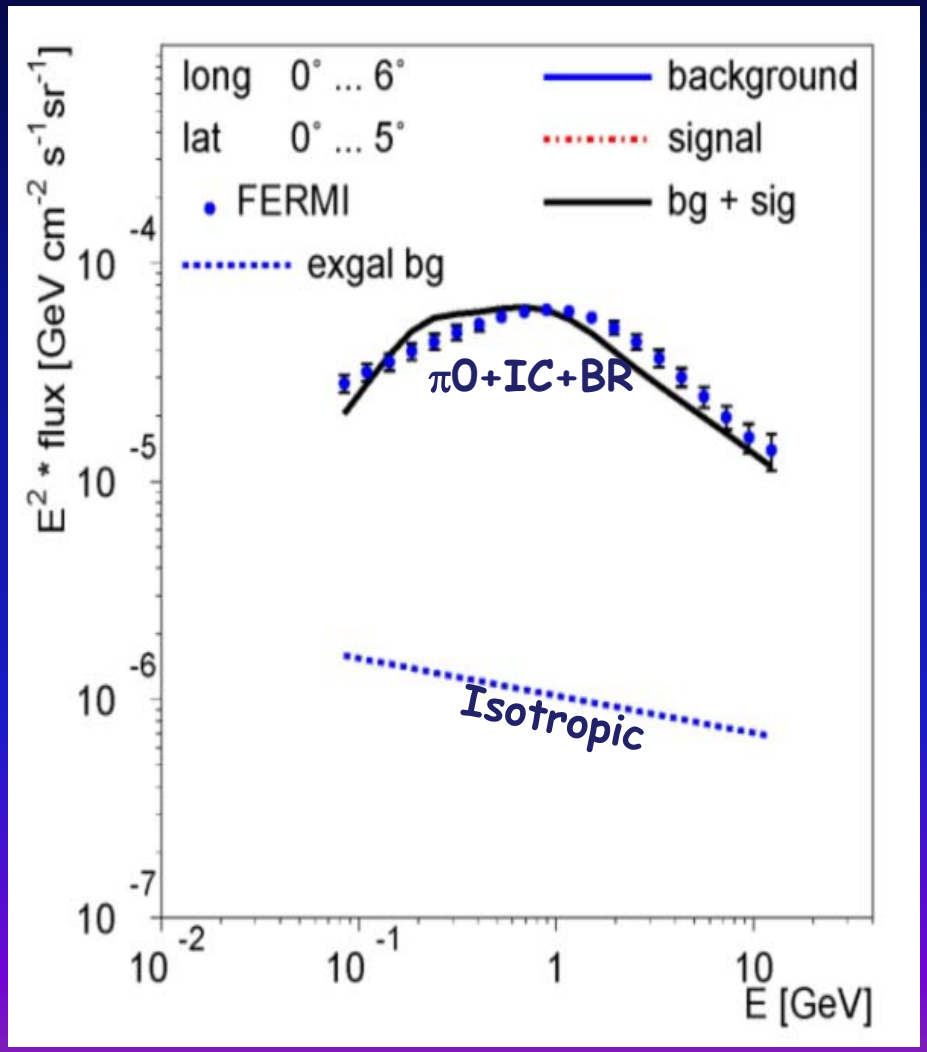
From FERMI excess towards centre of Galaxy:

Possible Evidence For Dark Matter Annihilation .. Goodenough and Hooper, arXiv:0910.2998v2

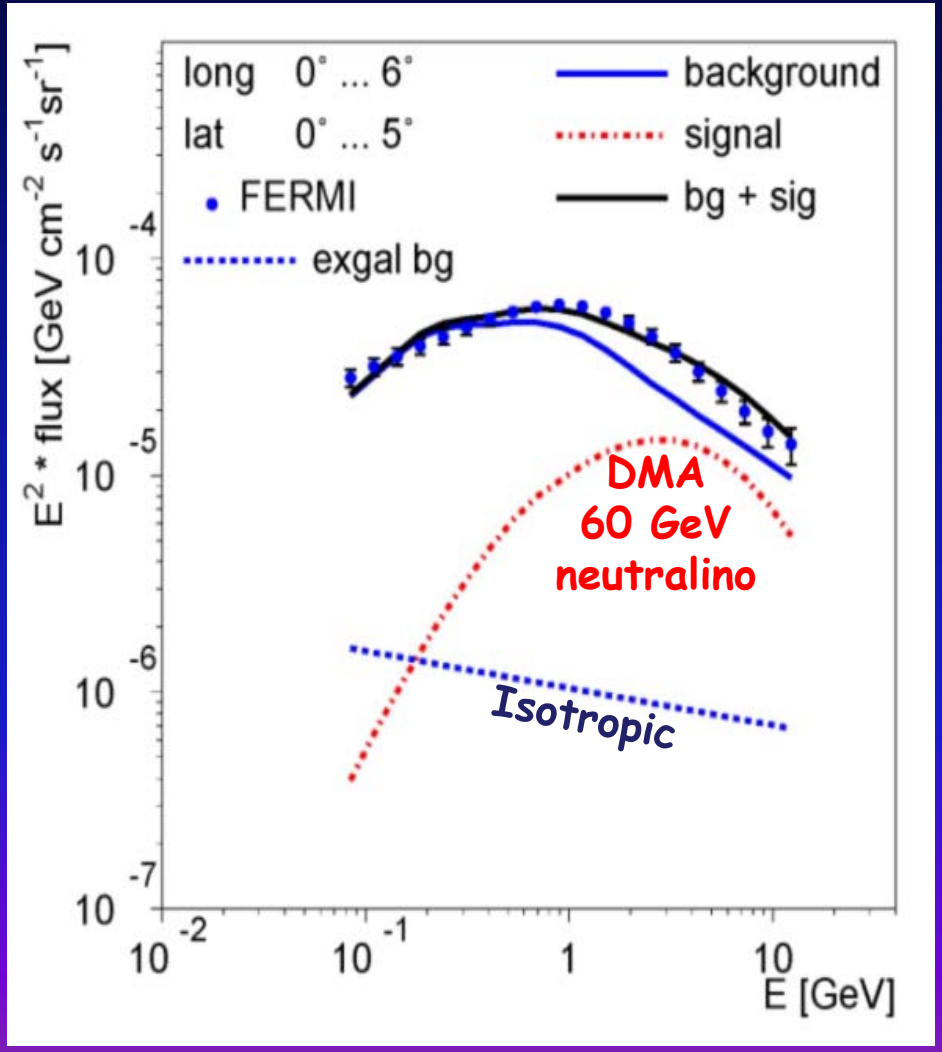
Finkbeiner et al. Giant gamma ray bubbles, arXiv:1005.5480v1

FERMI diffuse spectra from Galactic centre

without DMA



with DMA



What is DM haloprofile?

Given DM contribution in 960 directions,
can one determine haloprofile?

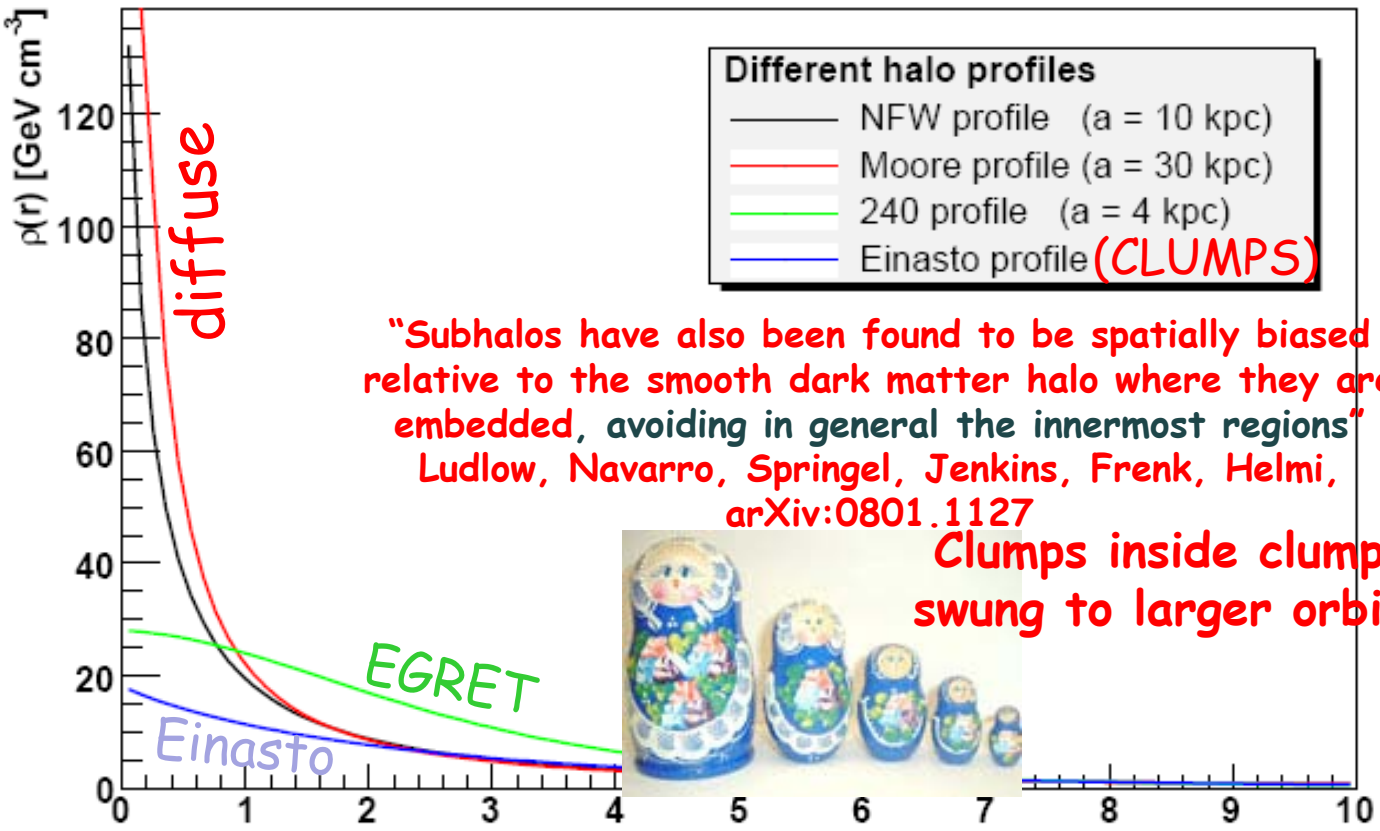
Procedure:

i)assume haloprofile ii)normalize to rotation curve
iii) calculate l.o.s. of gamma rays in 960 directions
iv) find optimum haloprofile parameters by minimum χ^2

Result:

1) NFW haloprofile for diffuse DM (>90% of mass) with boostfactor 1 and signal $\propto \rho^2$ +
2) clumpy halo profile with Einasto profile (~5% of mass and signal $\propto \rho$ +
3) two doughnut like ring structures with few % of mass

The new DM profile: NO Cusp for Clumps



"Subhalos have also been found to be spatially biased relative to the smooth dark matter halo where they are embedded, avoiding in general the innermost regions"
Ludlow, Navarro, Springel, Jenkins, Frenk, Helmi, arXiv:0801.1127

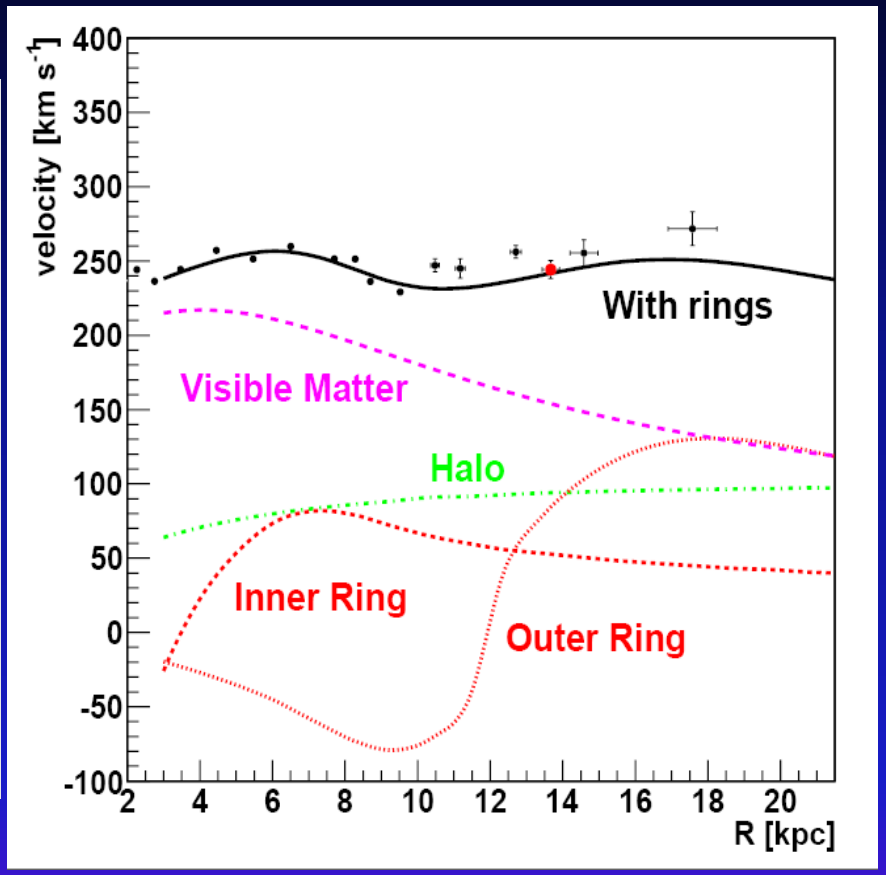
Clumps inside clumps swung to larger orbits

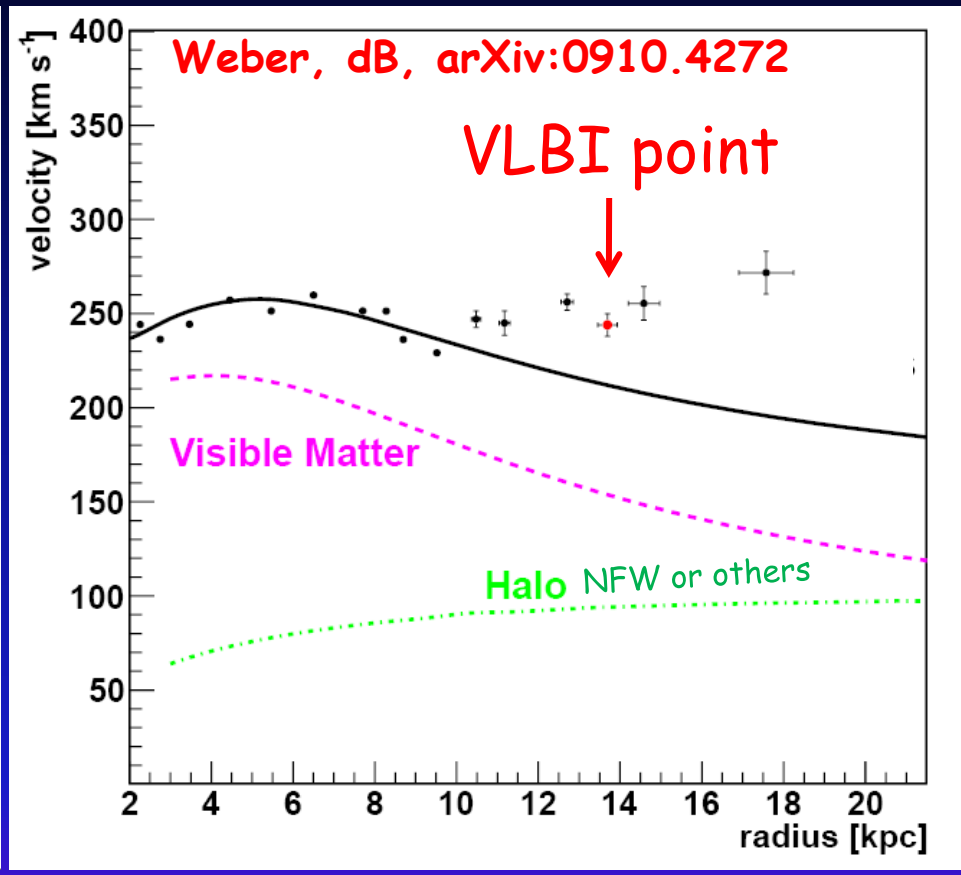
First by Diemand, Moore, Stadel,0402160v4

Consequence: Galactic Center not a point source for DMA anymore if clumps dominate

Rotation curve Milky Way

Weber, Thesis, 2010. KIT



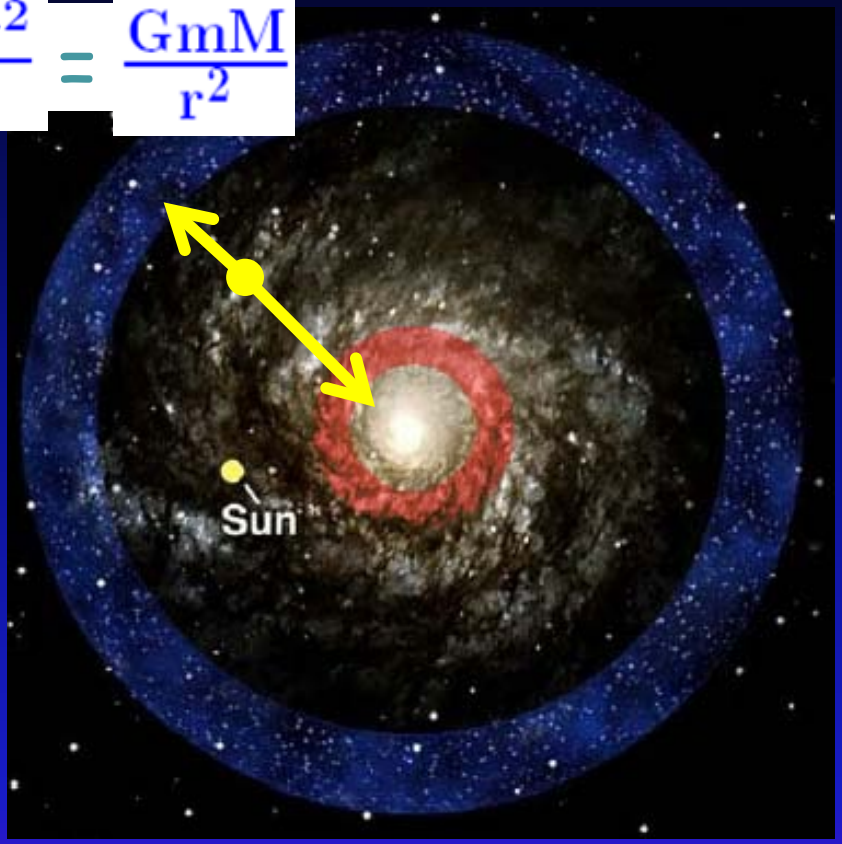


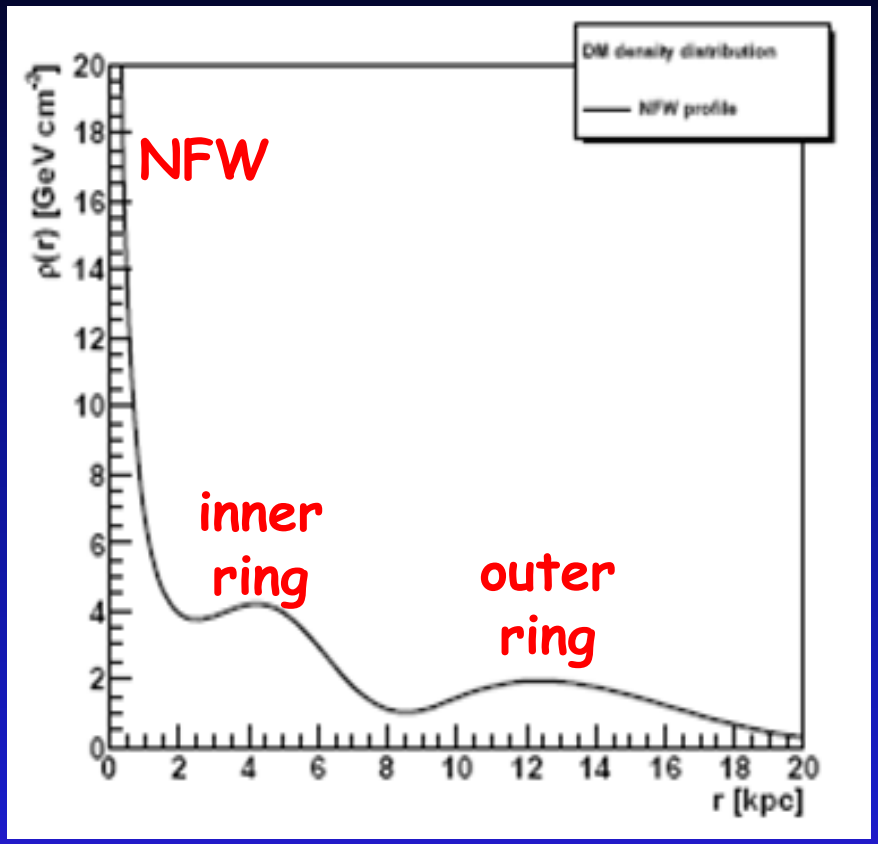
Oort limit on local density prevents larger DM contr.

$$\rho_{\odot,\mathrm{tot}} = \rho_{\odot,\mathrm{vis}} + \rho_{\odot,\mathrm{DM}} \approx 0.09 + 0.01\ \mathrm{M}_\odot\ \mathrm{pc}^{-3}$$
$$= 0.102 \pm 0.01\ \mathrm{M}_\odot\ \mathrm{pc}^{-3}$$ (Hipparcos dat

Solution for Rotation Curve: 2 doughnut-like structures

$$\frac{mv^2}{r} = \frac{GmM}{r^2}$$

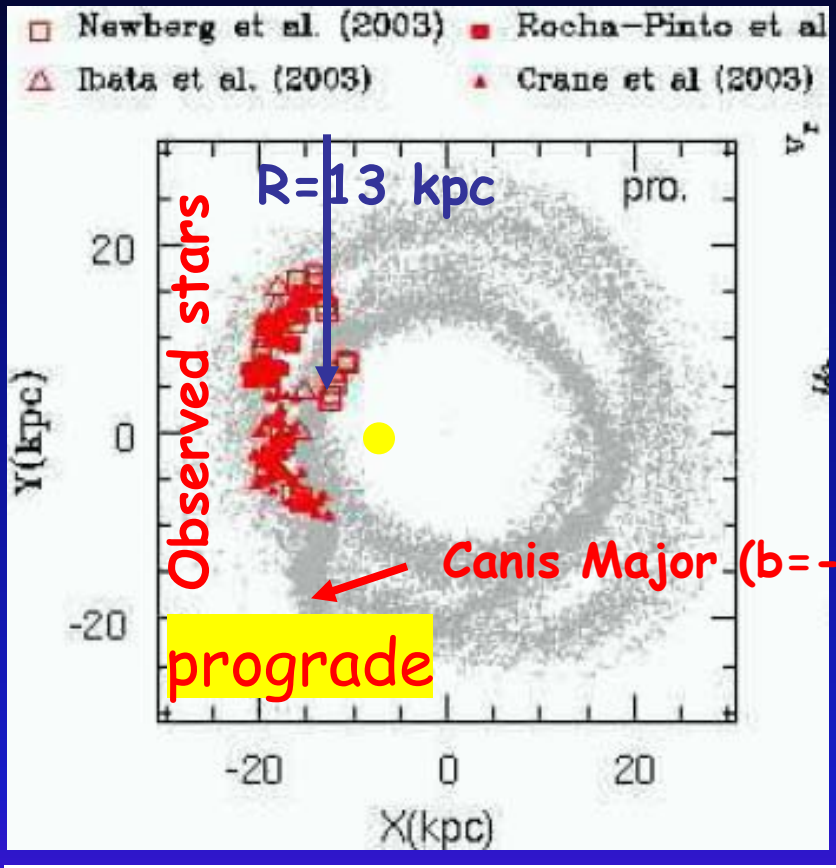


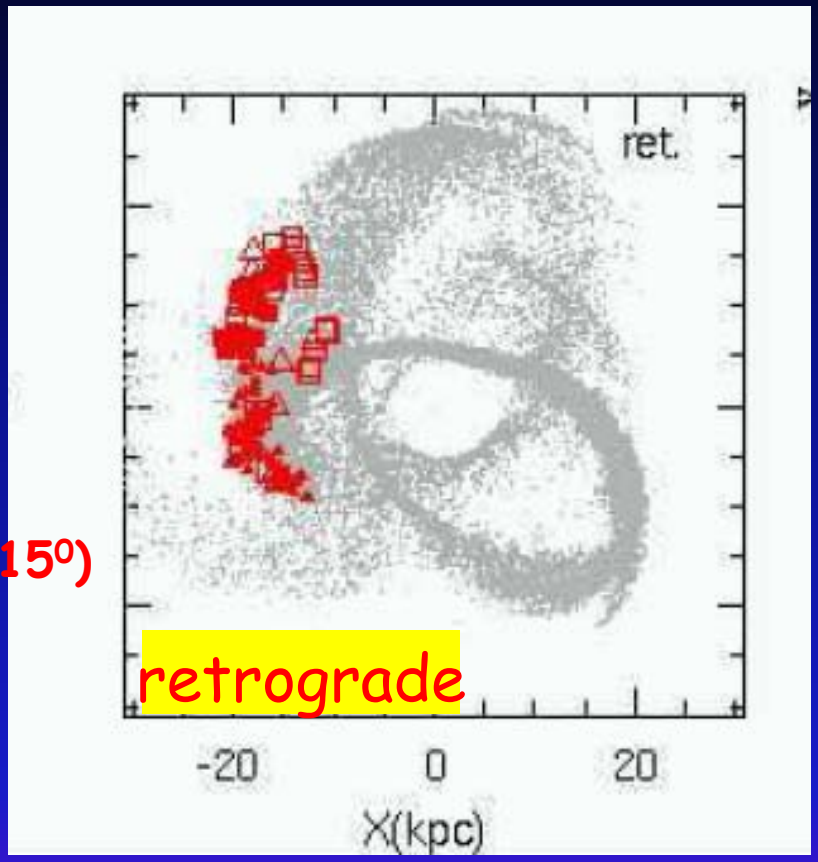


Motivation for "outer ring": Monocerus ring of stars (SDSS, 2002), discussed as tidal disruption of Canis Major dwarf AND gas flaring

Motivation for "inner ring": dust ring

N-body simulation from Canis-Major dwarf galaxy

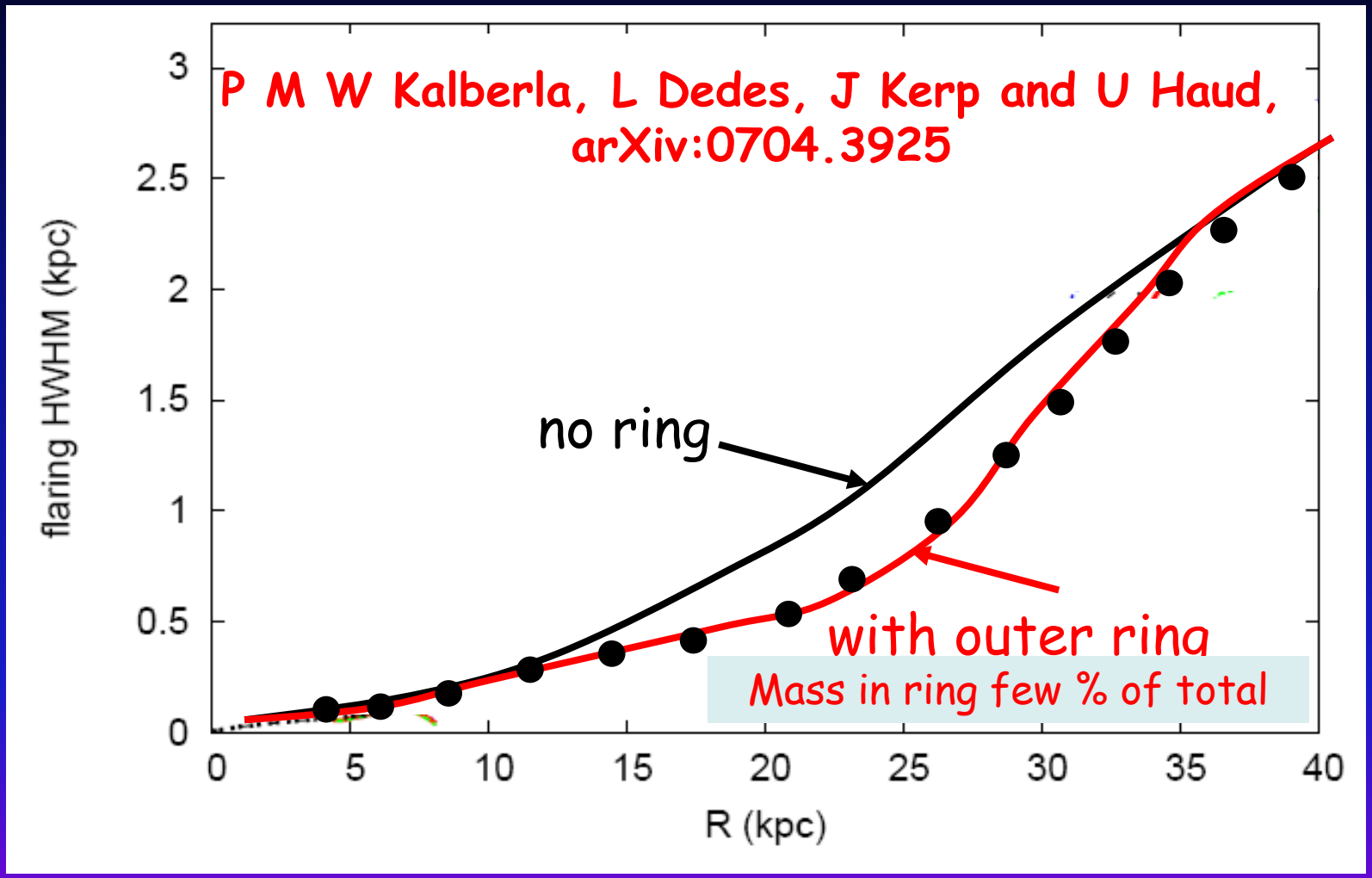




A comprehensive model for the Monoceros tidal stream

J. Peñarrubia[1], D. Martínez-Delgado[1], H.W. Rix[1], M.A Gómez-Flechoso[2], J. Munn[3], H. Newberg[4], E.F. Bell[1], B. Yanny[5], D. Zucker[1], E. K. Grebel[6]

Gas flaring in the Milky Way



Gas flaring needs also outer ring with mass of $2.10^{10} M_{\odot}$!

Summary

Fermi data show excess of diffuse Galactic gamma rays w.r.t GALPROP

Excess compatible with DMA (using data driven spectral shape fits instead of relying on GALPROP (but systematic errors in FERMI data?).

HOWEVER, FERMI DATA PREL. WAIT FOR NEXT REPROCESSING WITH BETTER BG REJECTION FOR ANY CONCLUSION

DMA interpretation compatible with rotation curve (RC) if doughnut-like DM structures used in disc, as required independently by new data on rotation curve and gas flaring.

Conclusion saying no excess in antiprotons is model dependent. GALPROP still allows up to 50% of antiprotons from DMA