WIMP Gamma Rays From the Galactic Center with GLAST and Accelerator Comparison

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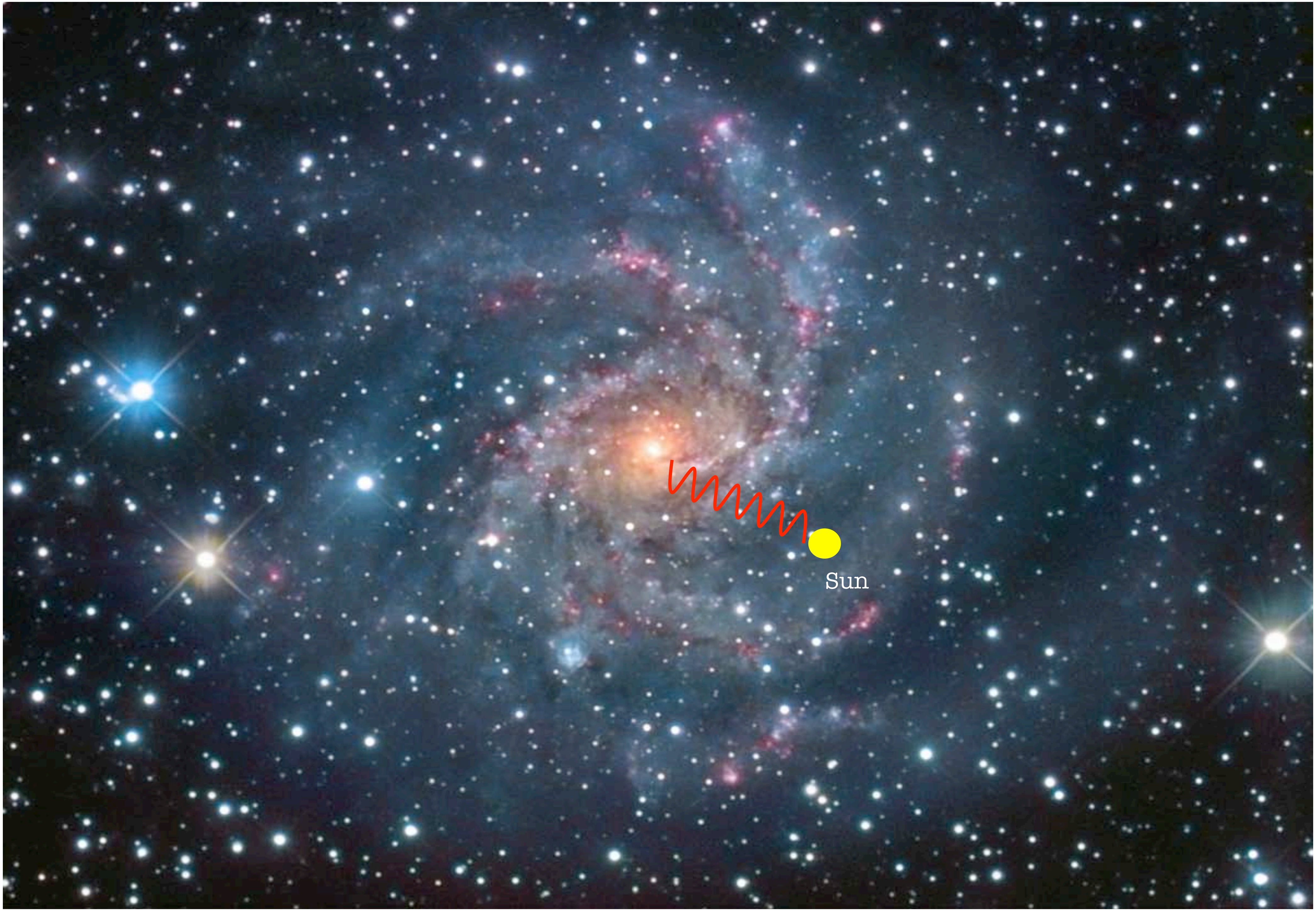
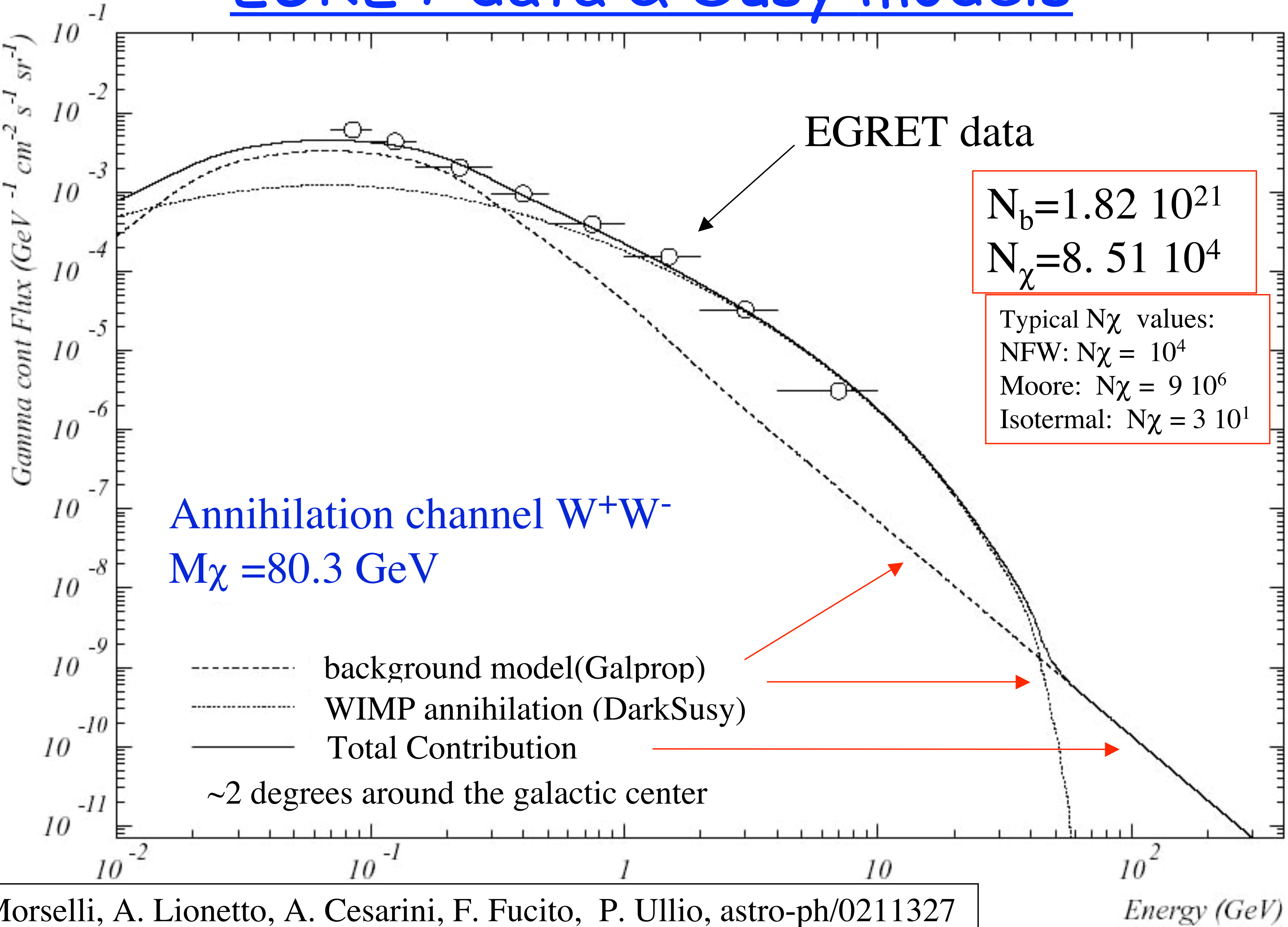
for the GLAST LAT Dark Matter and New Physics Working Group

First GLAST Symposium 5-8 February 2007

Stanford University


Sun

EGRET data & Susy models



A.Morselli, A. Lionetto, A. Cesarini, F. Fucito, P. Ullio, astro-ph/0211327

Signal rate from Supersymmetry

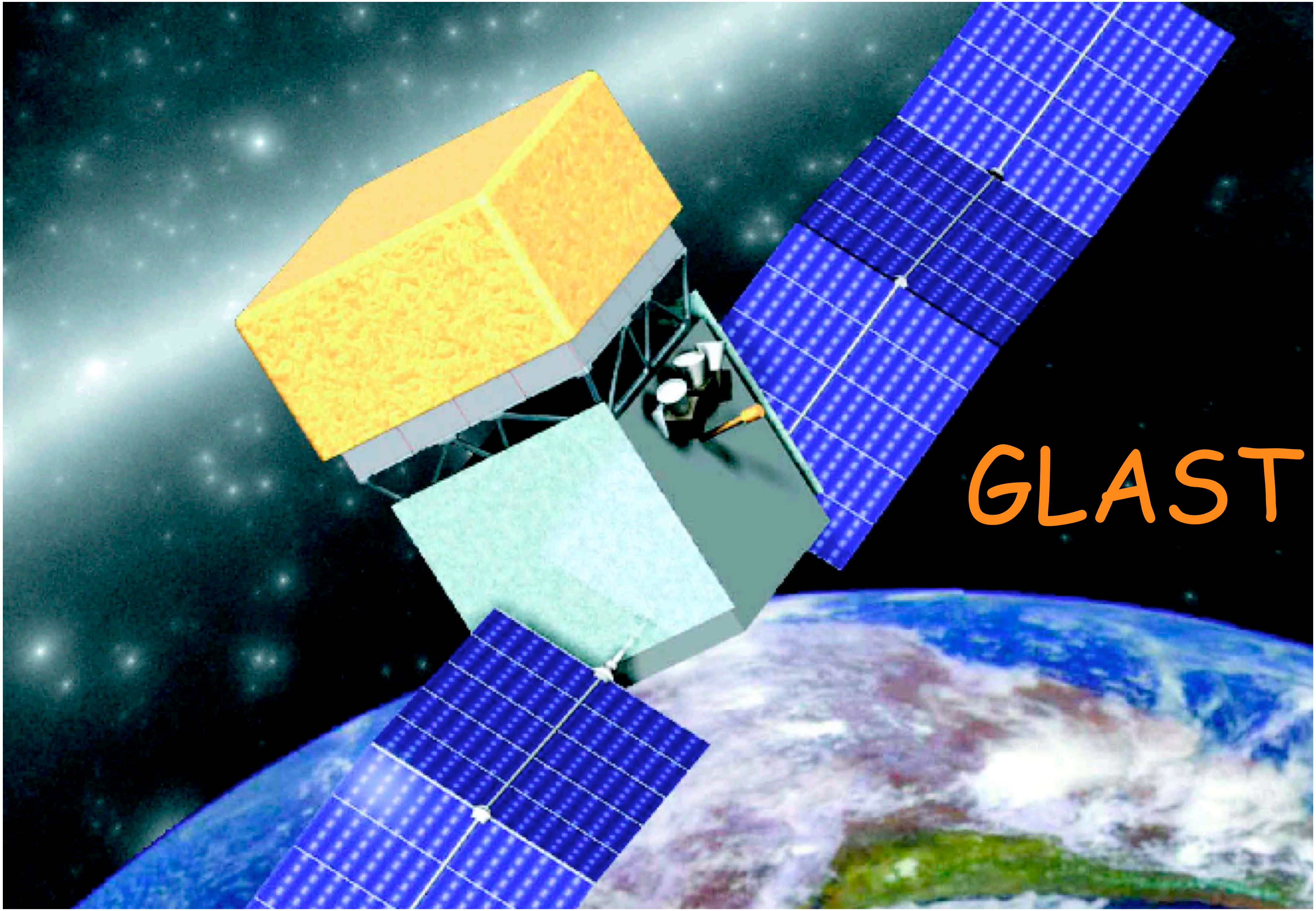
gamma-ray flux from
neutralino annihilation

$$\phi(E, \Delta\Omega) \propto \left(\frac{\sigma v}{m_\chi^2}\right) \int_{l.o.s} \int_{\Delta\Omega} \rho^2(l) \, dl \, d\Omega)$$

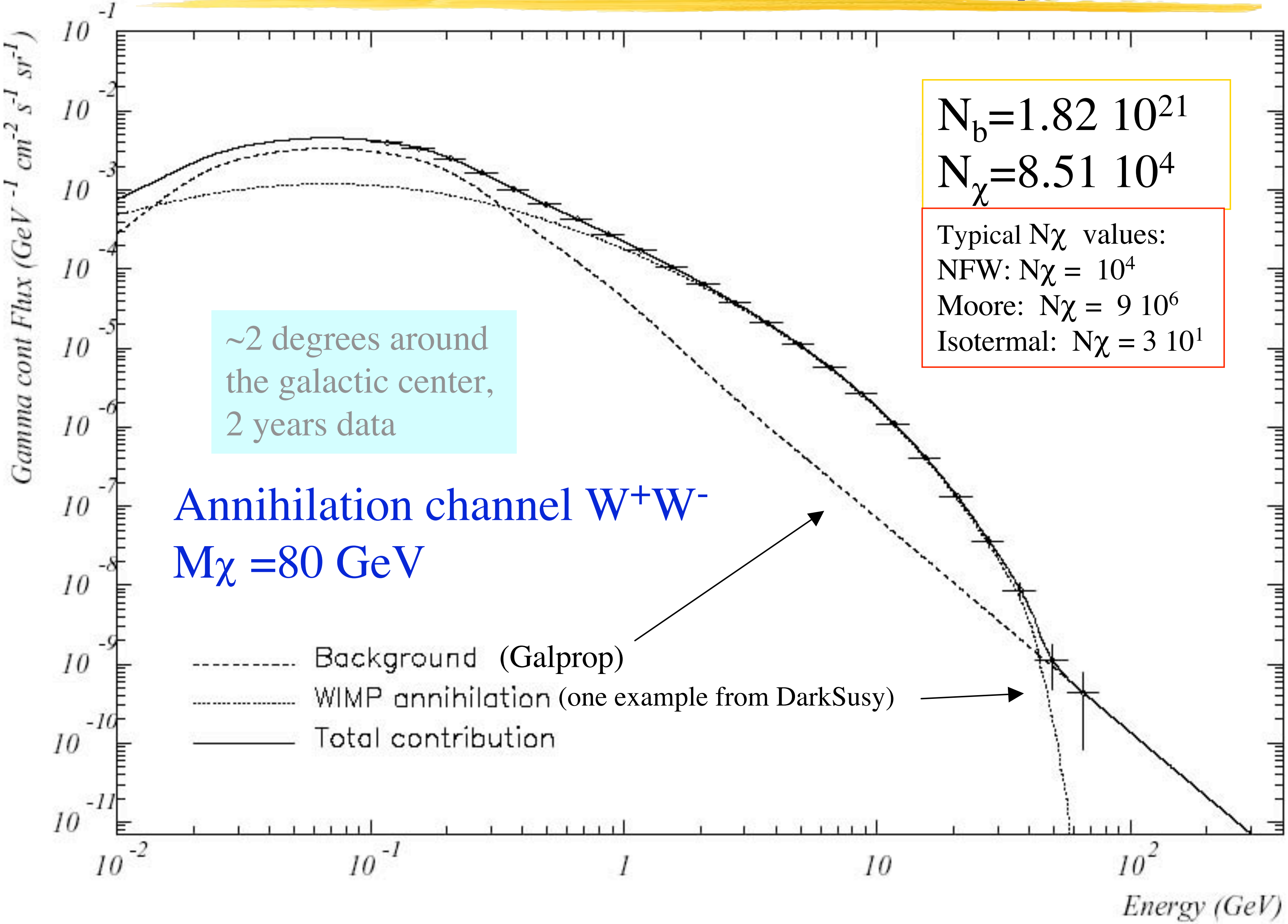
governed by
supersymmetric
parameters

J(φ):

governed by
halo distribution


GLAST

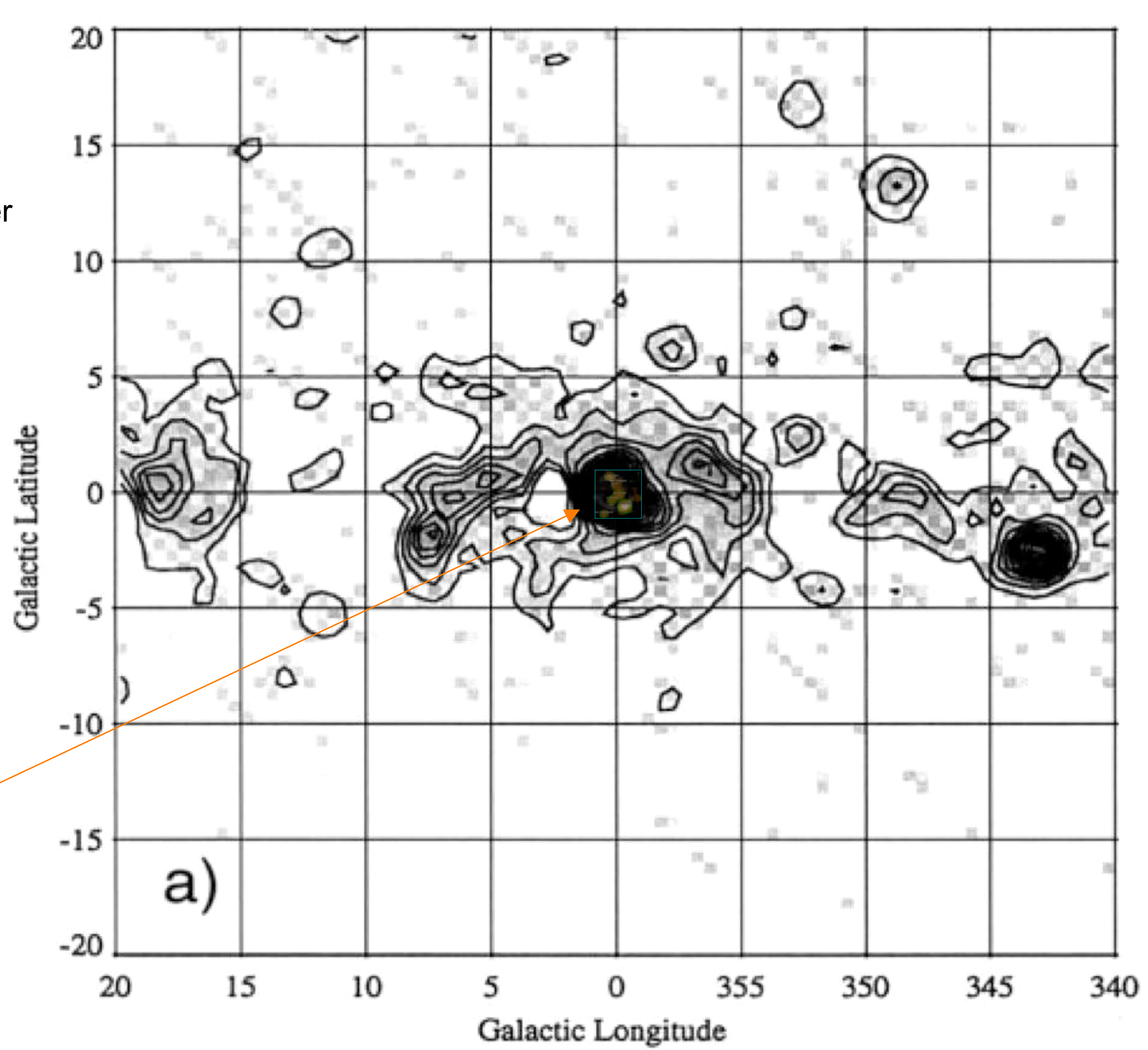
GLAST Expectation & Susy models



A.Cesarini, F.Fucito, A.Lionetto, A.Morselli, P.Ullio, Astroparticle Physics, 21, 267-285, June 2004 [astro-ph/0305075]

EGRET, E > 1GeV

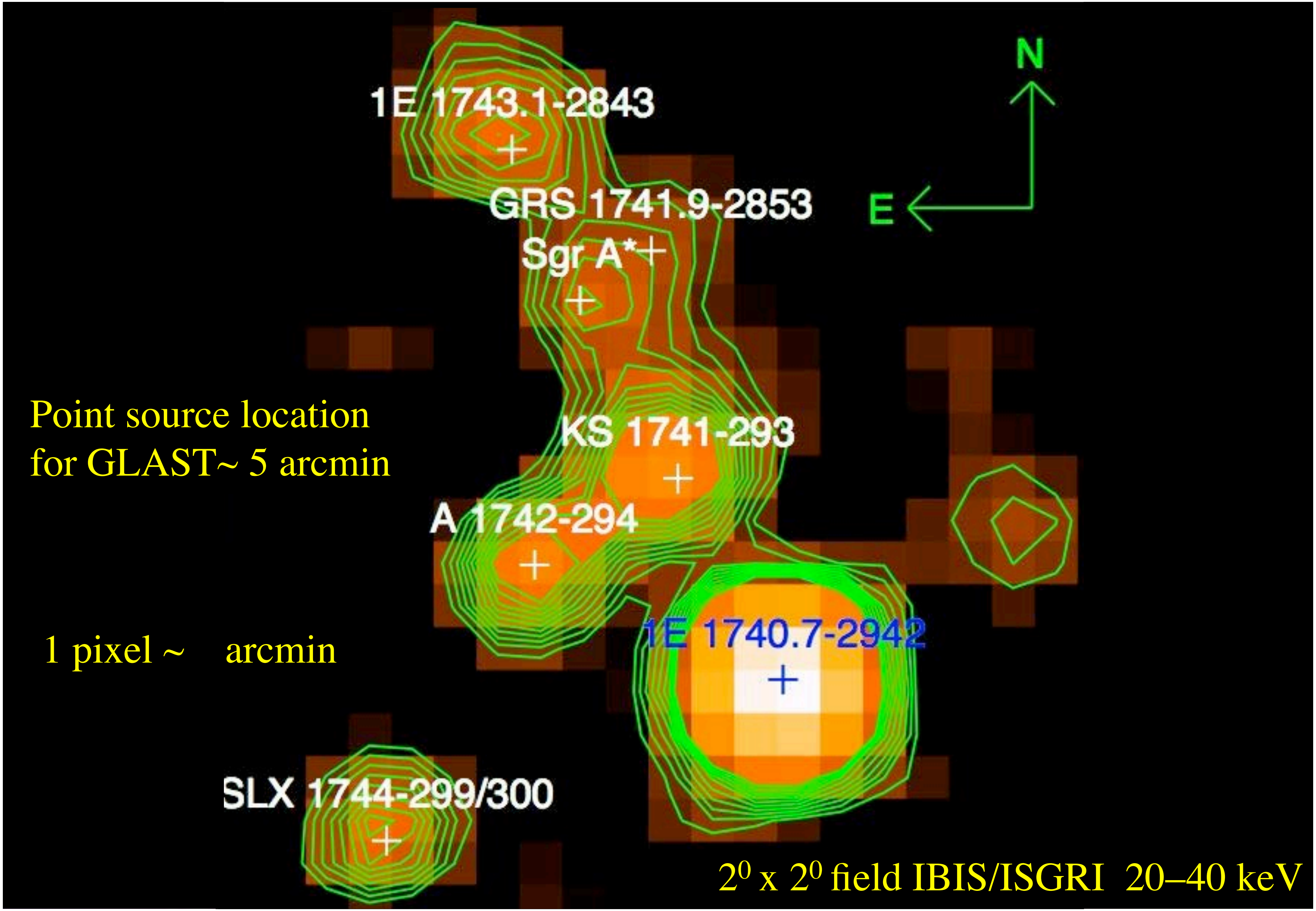
Mayer-Hasselwander et al, 1998

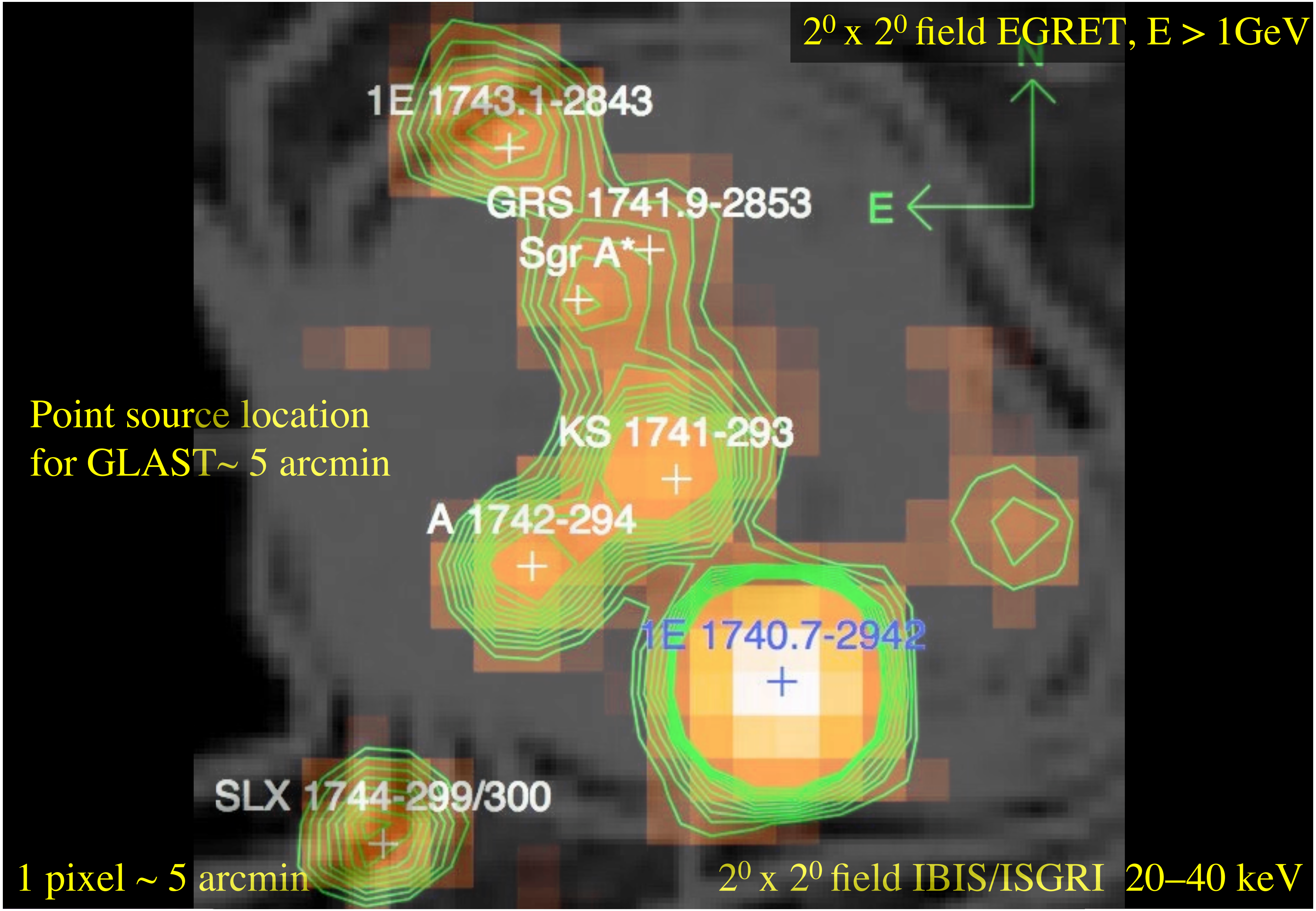


Integral data

$2^0 \times 2^0$ field IBIS/ISGRI

20–40 keV


1E 1743.1-2843
GRS 1741.9-2853
Sgr A*
KS 1741-293
A 1742-294
1E 1740.7-2942
SLX 1744-299/300
N
E
Point source location
for GLAST~ 5 arcmin
1 pixel ~ arcmin
2^0 x 2^0 field IBIS/ISGRI 20–40 keV


2⁰ x 2⁰ field EGRET, E > 1GeV
N
E
1E 1743.1-2843
GRS 1741.9-2853
Sgr A*
KS 1741-293
A 1742-294
1E 1740.7-2942
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Point source location
for GLAST~ 5 arcmin
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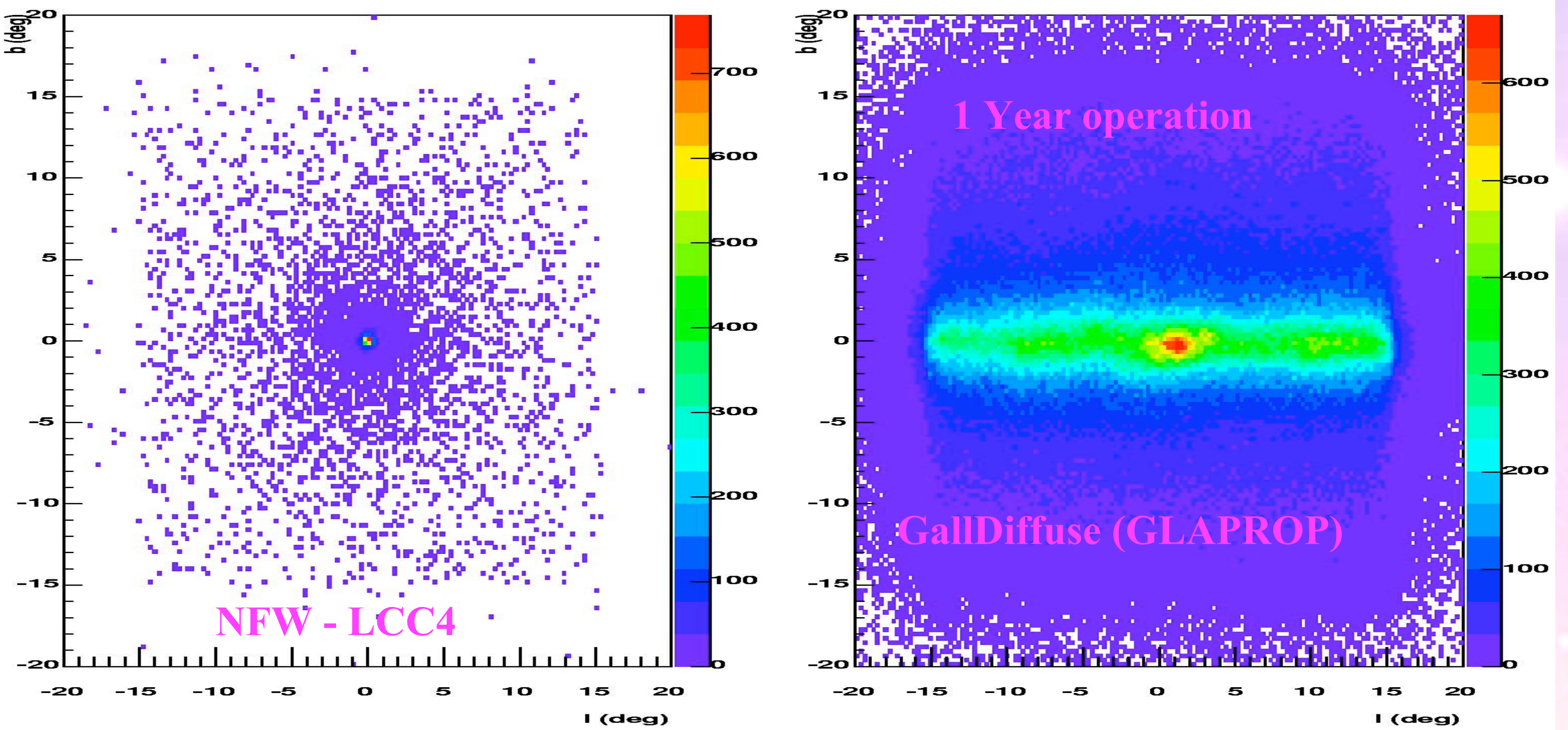
2⁰ x 2⁰ field IBIS/ISGRI 20–40 keV

Results of simulations for the mSUGRA point with parameters
$M_{1/2}$=420, M_0=380, tanβ=53 GeV

$m_\chi \sim$ 170 GeV , Ωh^2 = 0.114

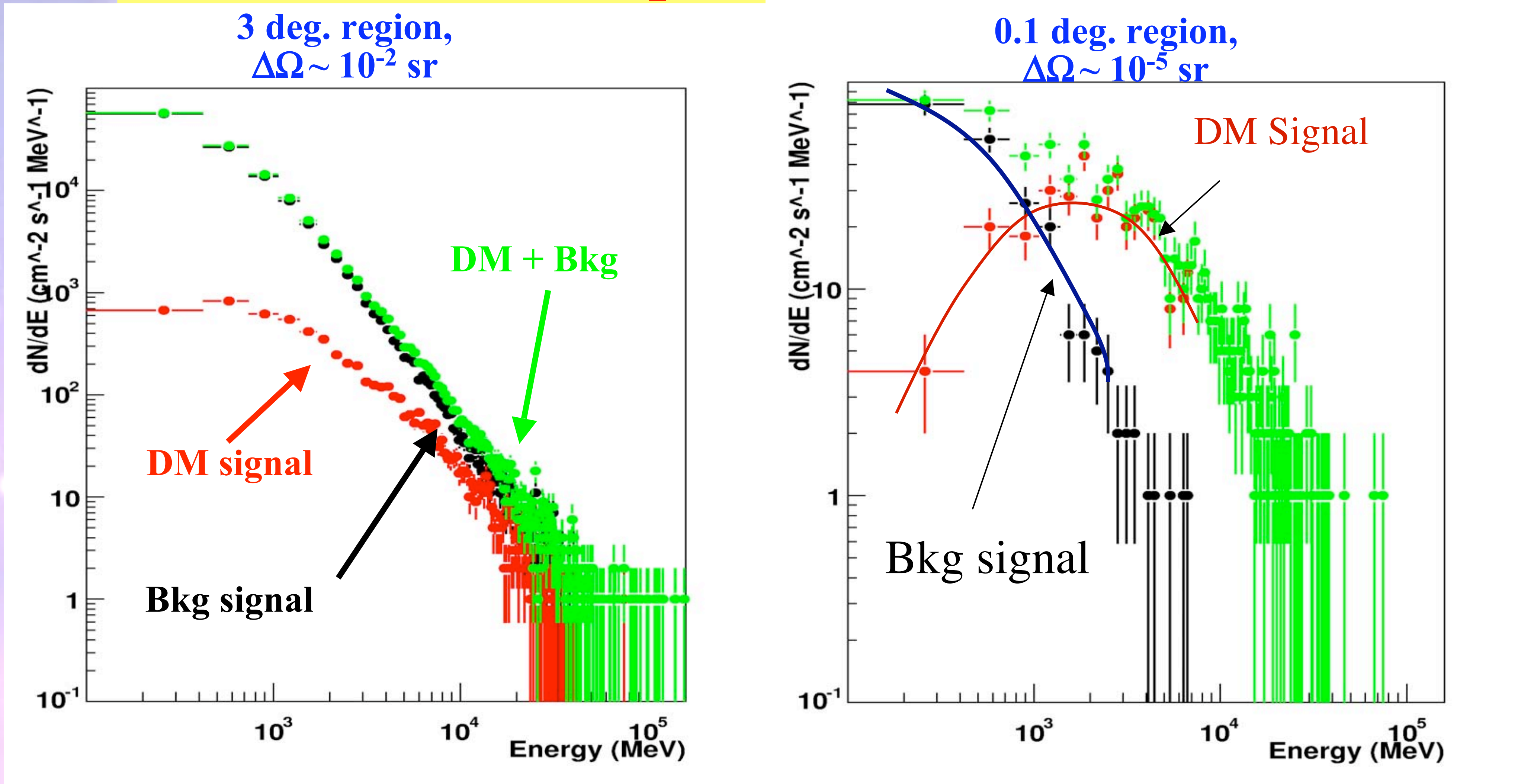
The dark matter halo used for the GLAST indirect search sensitivity estimate is a truncated Navarro Frank and White (NFW) halo profile.

$\Phi(E\gamma>100$ MeV) ~ 3 10^{-7} cm^{-2} s^{-1} in $30^0 \times 30^0$ Map (DarkSusy)



30 deg*30 deg count map obtained from GLAST simulations for a NFW profile with mSUGRA parameters after one year GLAST operation. This DM counts map has to be compared with the expected background as computed with the GALPROP code (on the left)

Differential spectra (GC centered)



Resulting differential spectra from LCC4 and Background simulations for two regions (3deg and 0.1deg radius) centered at the Galactic Centre.

Supersymmetry introduces free parameters:

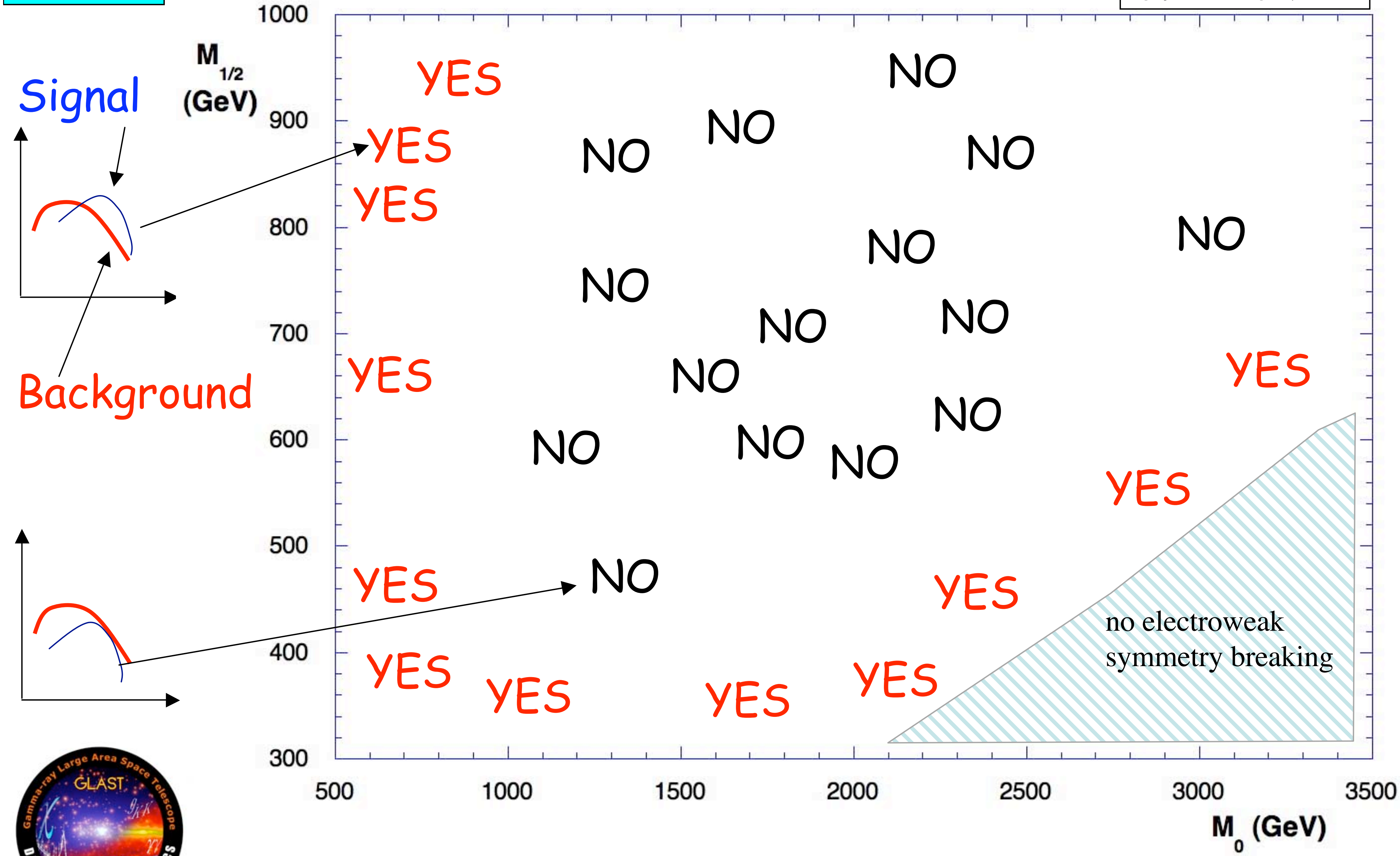
In the MSSM, with Grand Unification assumptions, the masses and couplings of the SUSY particles as well as their production cross sections, are entirely described once 5 parameters are fixed:

- $M_{1/2}$ the common mass of supersymmetric partners of gauge fields (gauginos)
- m_0 the common mass for scalar fermions at the GUT scale
- μ the higgs mixing parameters that appears in the neutralino and chargino mass matrices
- A is the proportionality factor between the supersymmetry breaking trilinear couplings and theYukawa couplings
- tang β = $v_2 / v_1 = \langle H_2 \rangle / \langle H_1 \rangle$ the ratio between the two vacuum expectation values of the Higgs fields

cMSSM

Signal and Background are separated ?

tg(β)=55, sign(μ)=+1



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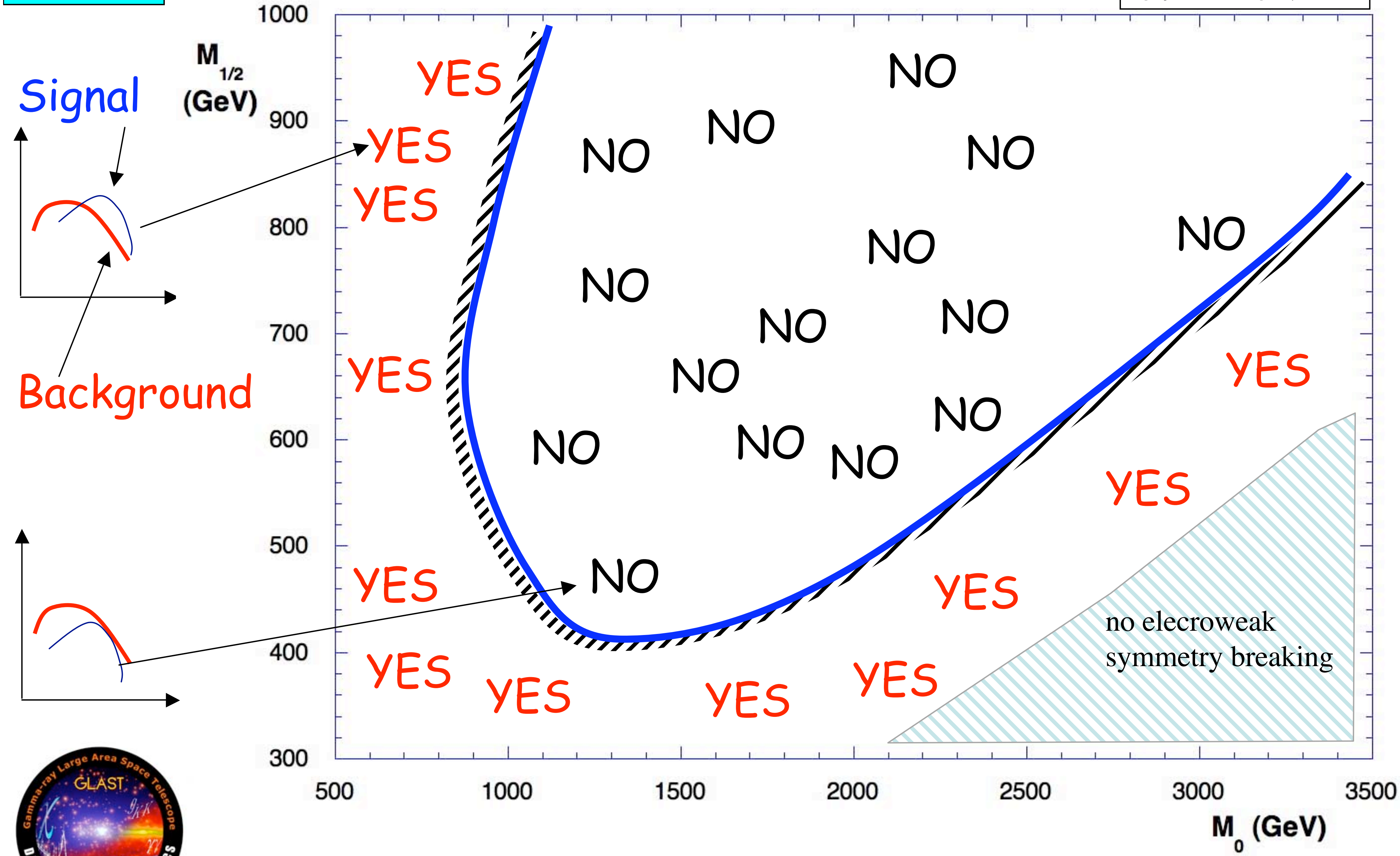
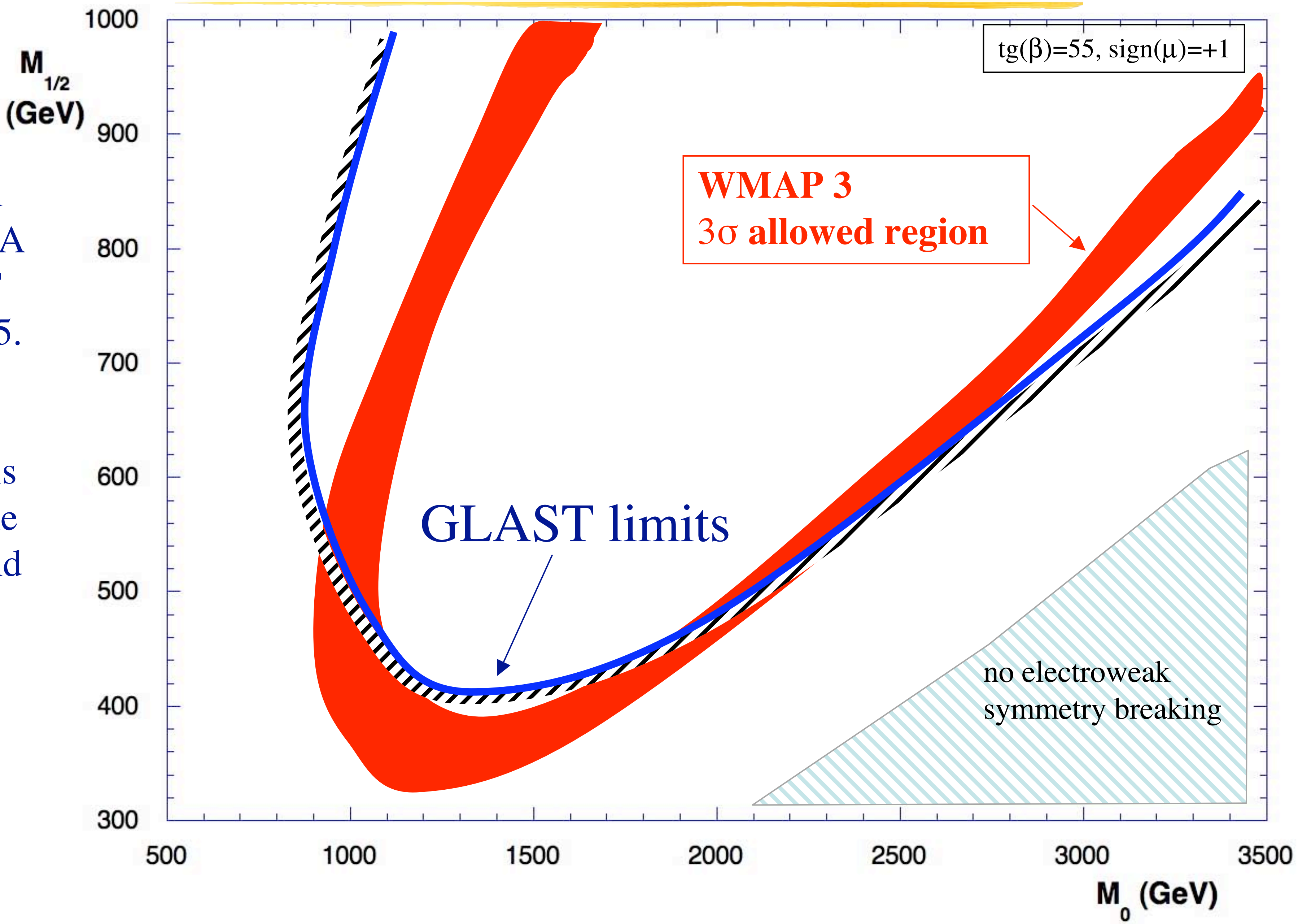


mSUGRA

3σ Sensitivity plot for for GLAST for a truncated (NFW) halo profile

Sensitivity plot for 5 years observation of mSUGRA for GLAST for tg(b)=55.

GLAST 3σ sensitivity is shown at the blue line and below for truncated NFW halo profile



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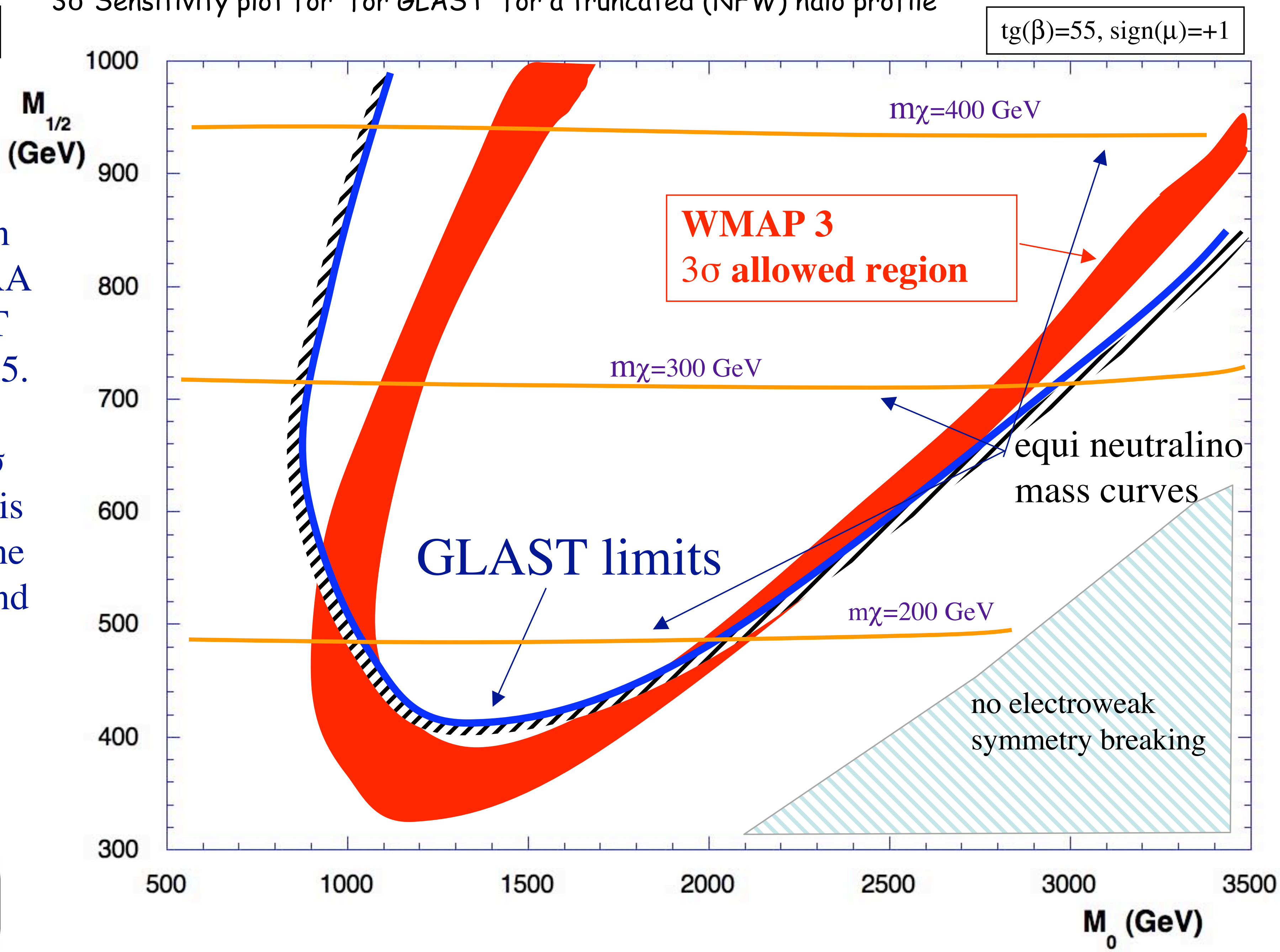
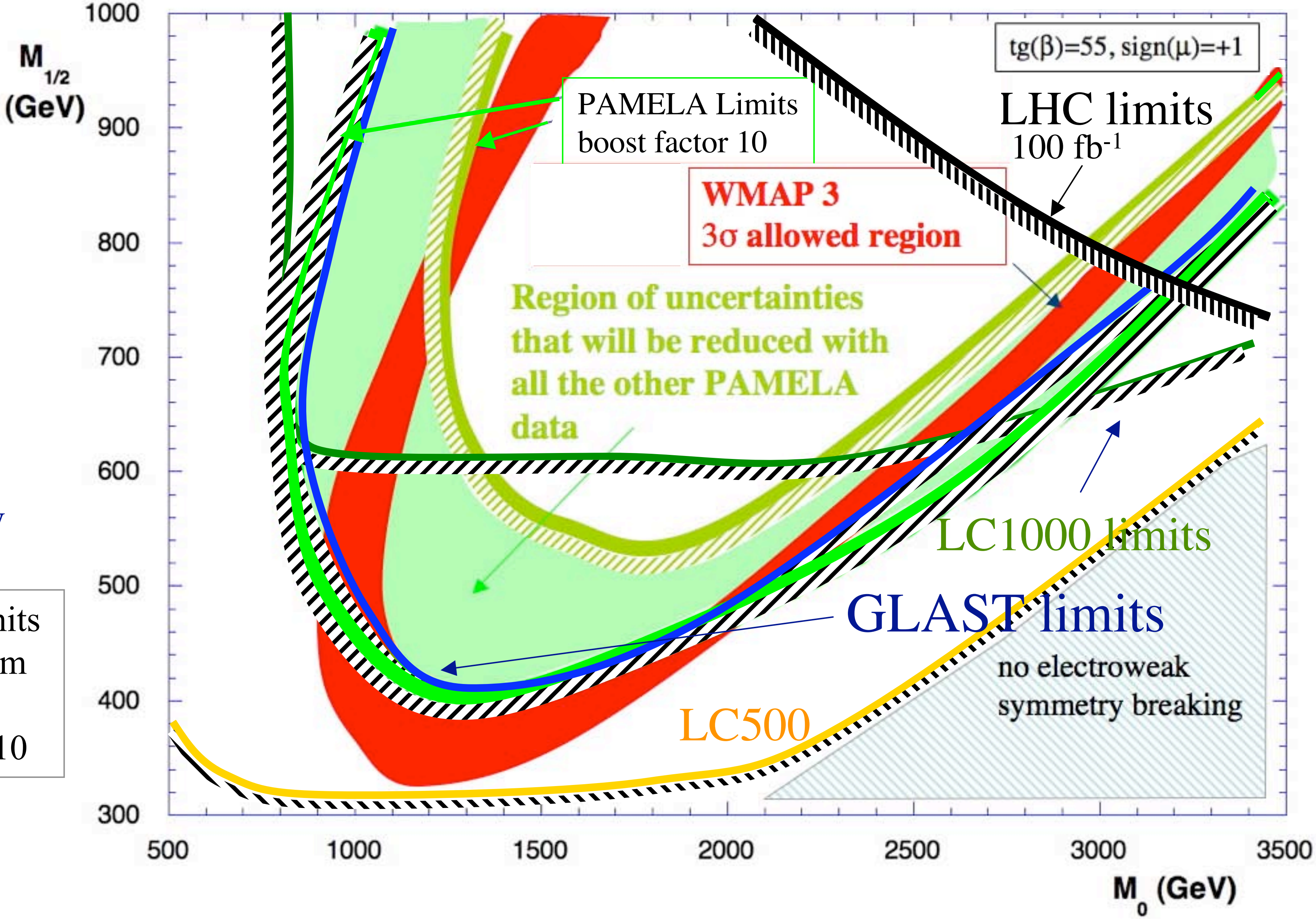


GLAST, PAMELA, LHC, LC Sensitivities to Dark Matter Search

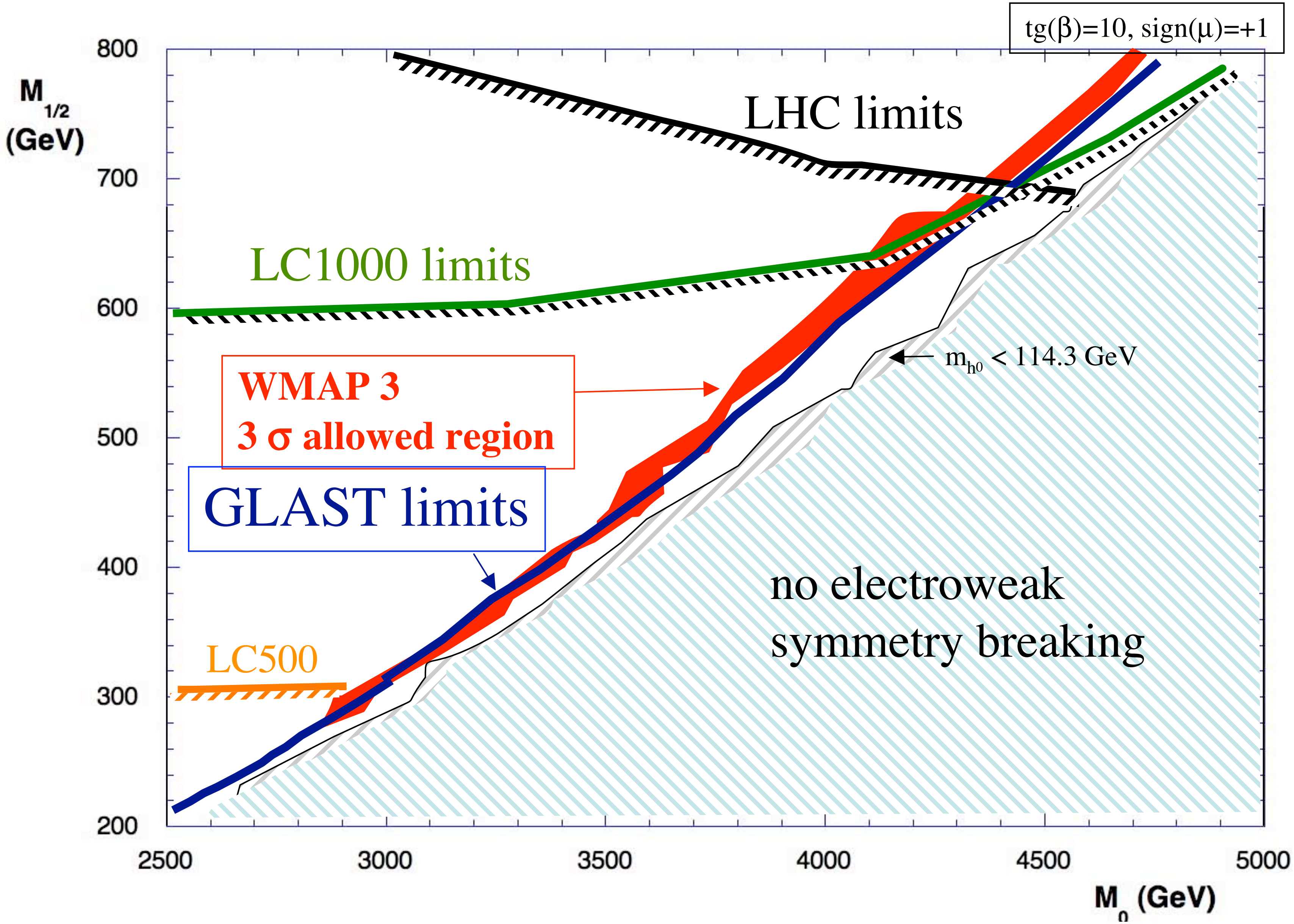
mSUGRA

Sensitivity plot for 5 years observation of mSUGRA for GLAST for tg(b)=55 and for other experiments. GLAST 3σ sensitivity is shown at the blue line and below for truncated NFW halo profile

accelerator limits @ 100 fb^{-1} from H.Baer et al., hep-ph/0405210



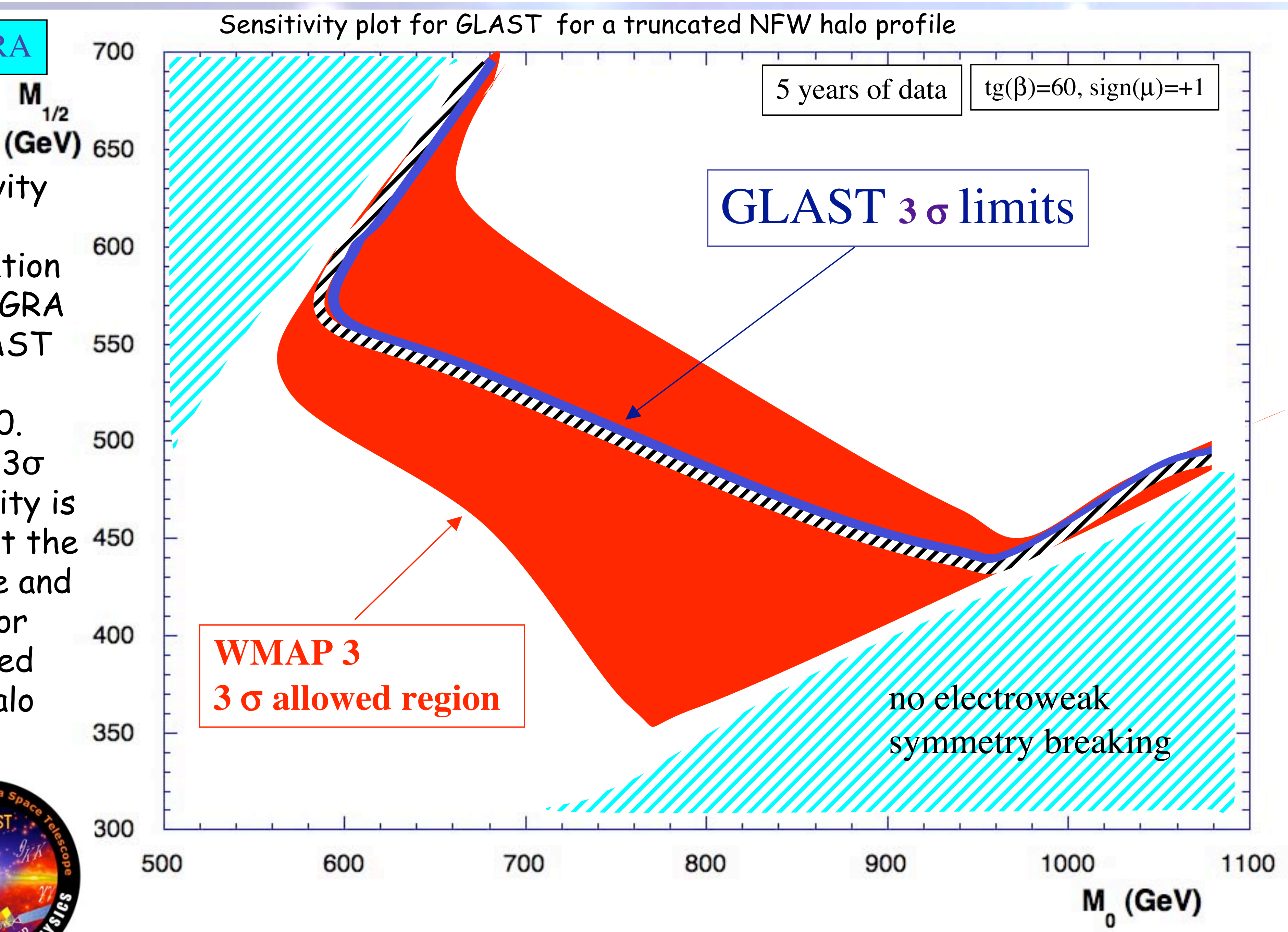
mSUGRA

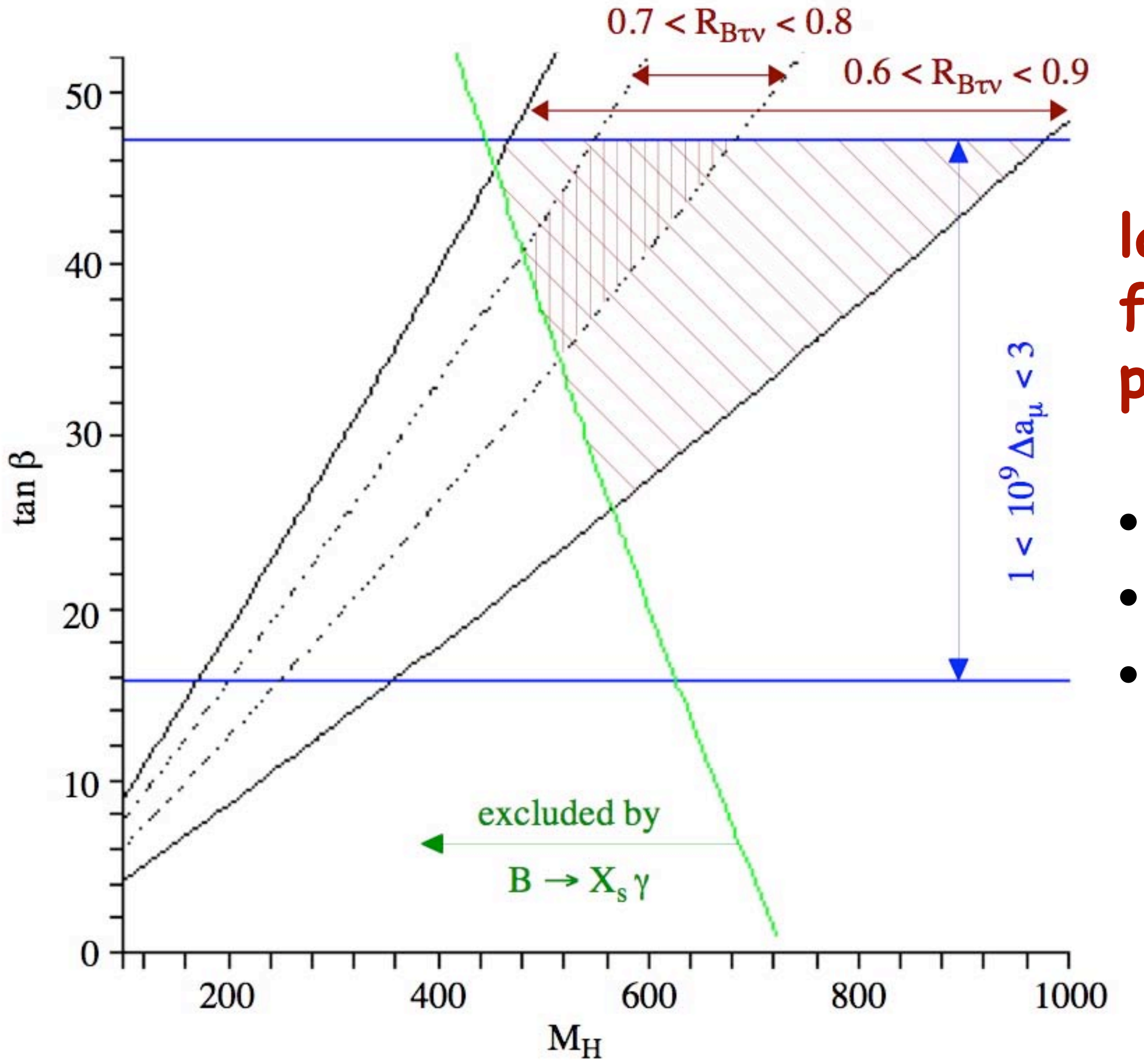


Sensitivity plot for observation of mSUGRA for a number of accelerator experiments and GLAST for tg(β)=10. GLAST 3σ sensitivity is shown at the blue line and below a for truncated Navarro Frank and White (NFW) halo profile

mSUGRA

Sensitivity plot for observation of mSUGRA for GLAST for $tg(\beta)=60$. GLAST 3σ sensitivity is shown at the blue line and below for truncated NFW halo profile





G.Isidori and P.Paradisi hep-ph/0605012

large tgβ regions favoured in flavour physics:

- suppression of B -> $\tau\nu$
- sizable enhancement of $(g\text{-}2)_\mu$
- small non-standard effects in ΔM_{Bs} and $B(B\rightarrow X_s\gamma)$

Model independent results for the GC

the background is (as in astro-ph/0305075)

$$\frac{dN(E_\gamma, l, b)}{dE_\gamma} = N_0(l,b)\left(\frac{E_\gamma}{1\,\mathrm{GeV}}\right)^\alpha 10^{-6}\ \mathrm{cm}^{-2}\,\mathrm{s}^{-1}\,\mathrm{GeV}^{-1}\,\mathrm{sr}^{-1}$$

$$\begin{aligned} N_0(l,b) &= \frac{85.5}{\sqrt{1+(l/35)^2}\sqrt{1+(b/(1.1+|l|\,0.022))^2}} + 0.5 \quad \text{if } |\mathrm{l}| \geq 30^\circ \\ &= \frac{85.5}{\sqrt{1+(l/35)^2}\sqrt{1+(b/1.8)^2}} + 0.5 \quad \text{if } |\mathrm{l}| \leq 30^\circ \end{aligned}$$

the gamma flux from WIMP annihilation is:

$$\phi_\chi(E,\psi) = 3.74\cdot 10^{-10}\left(\frac{\sigma v}{10^{-26}\ \mathrm{cm^3 s^{-1}}}\right)\left(\frac{50\ \mathrm{GeV}}{M_\chi}\right)^2 \sum_f \frac{dN_f}{dE}B_f$$

$$\cdot J(\psi)\ \mathrm{cm^{-2}s^{-1}GeV^{-1}sr^{-1}}$$

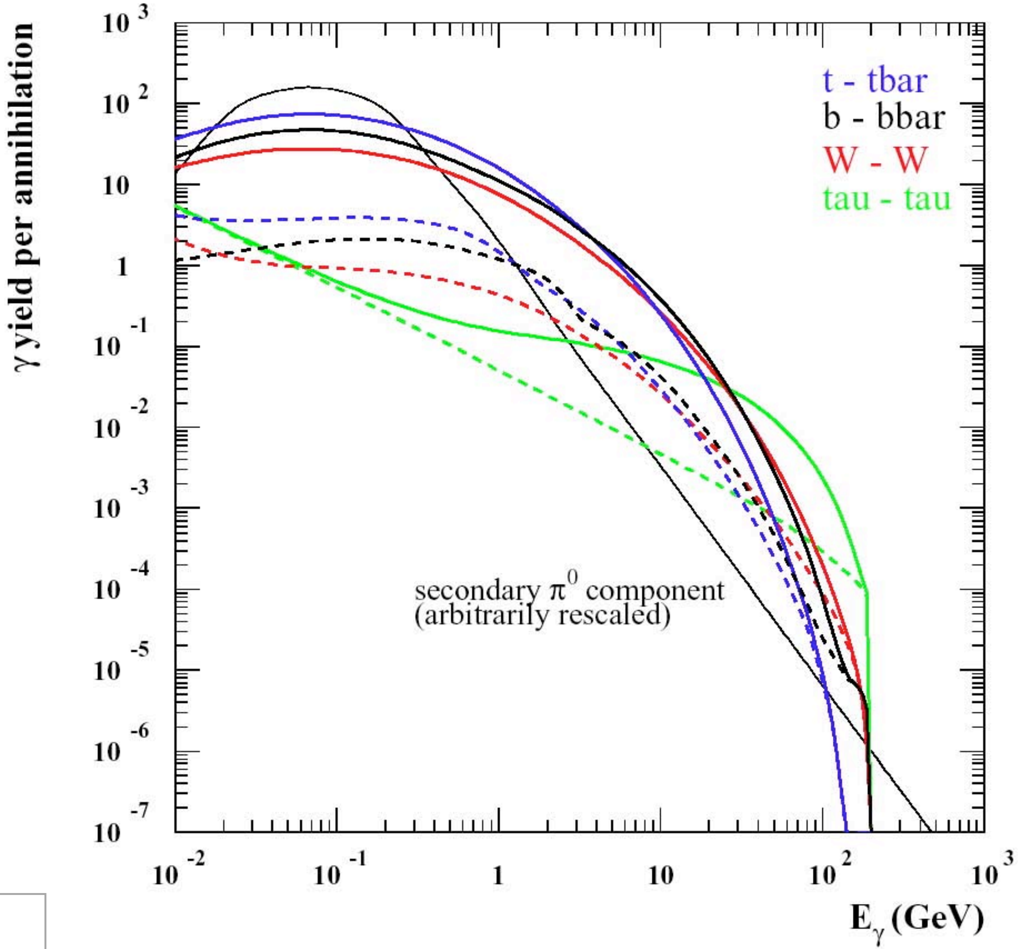
and it depends from σv and $M\chi$

Model independent results for the GC

- Assume a truncated NFW profile -
- Assume a dominant annihilationchannel

(good assumption except for $\tau^+ \tau^-$)

Differential yield for each annihilation channel



WIMP mass=200GeV

figure from: A.Cesarini, F.Fucito, A.Lionetto, A.Morselli, P.Ullio, Astroparticle Physics, 21, 267-285, June 2004 [astro-ph/0305075]

Model independent results for the GC

WIMP contribution higher than the maximum allowed by EGRET

uncertainties:
H column density

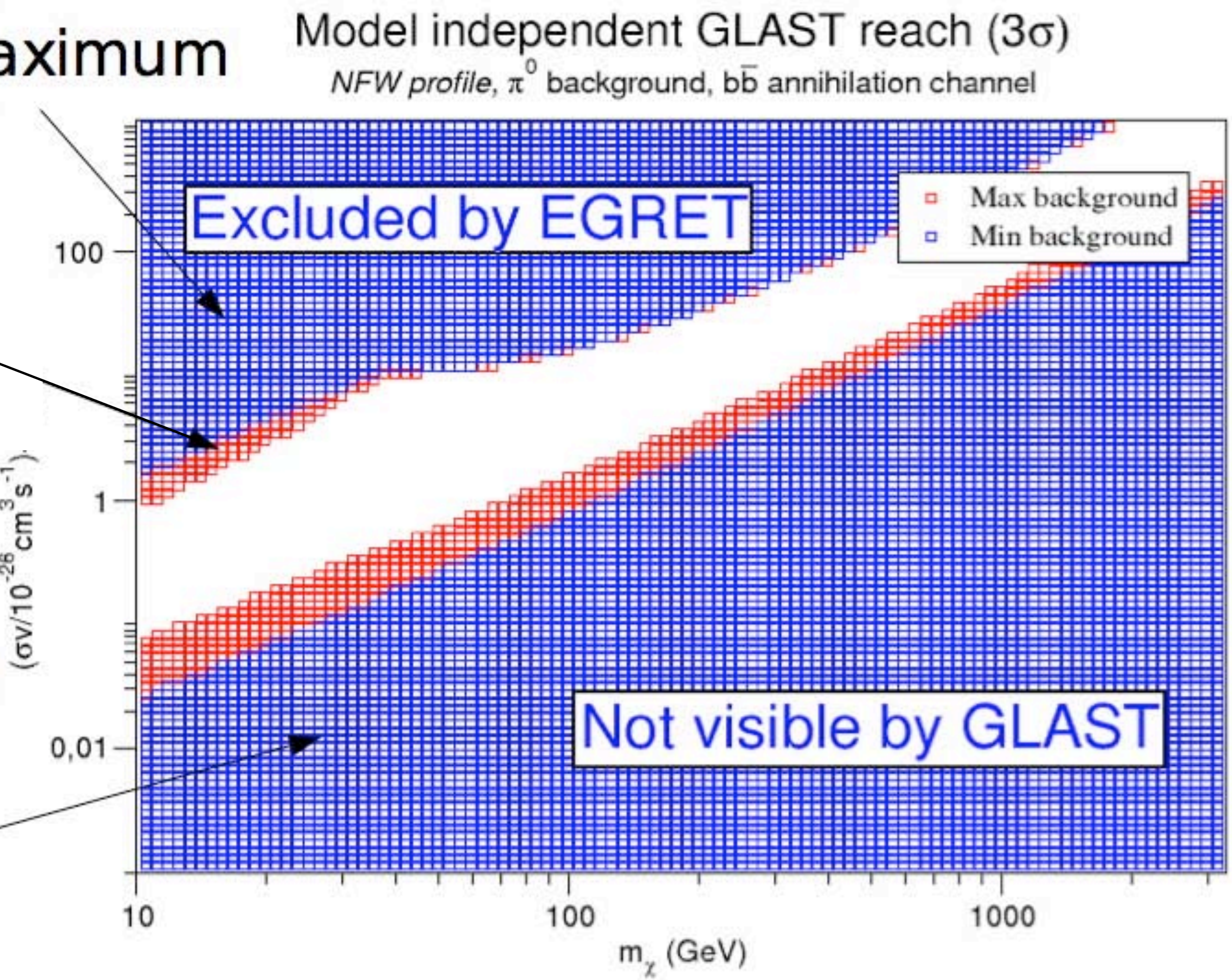
$<J(\psi)>=10^4$

$\Delta\Omega \sim 10^{-5}$ sr

Effective exposure (per year)
$3.7 * 10^{10}$ cm^{2}s^{-1}

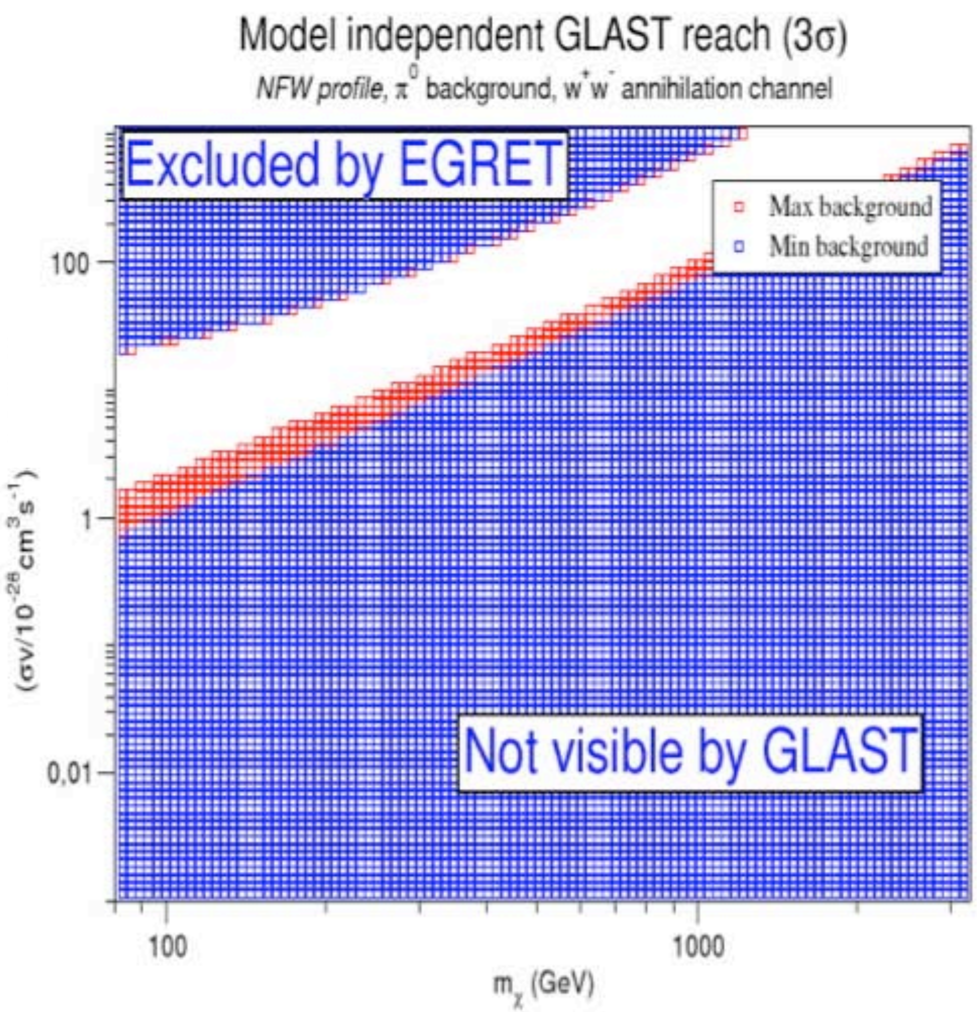
4 years exposure

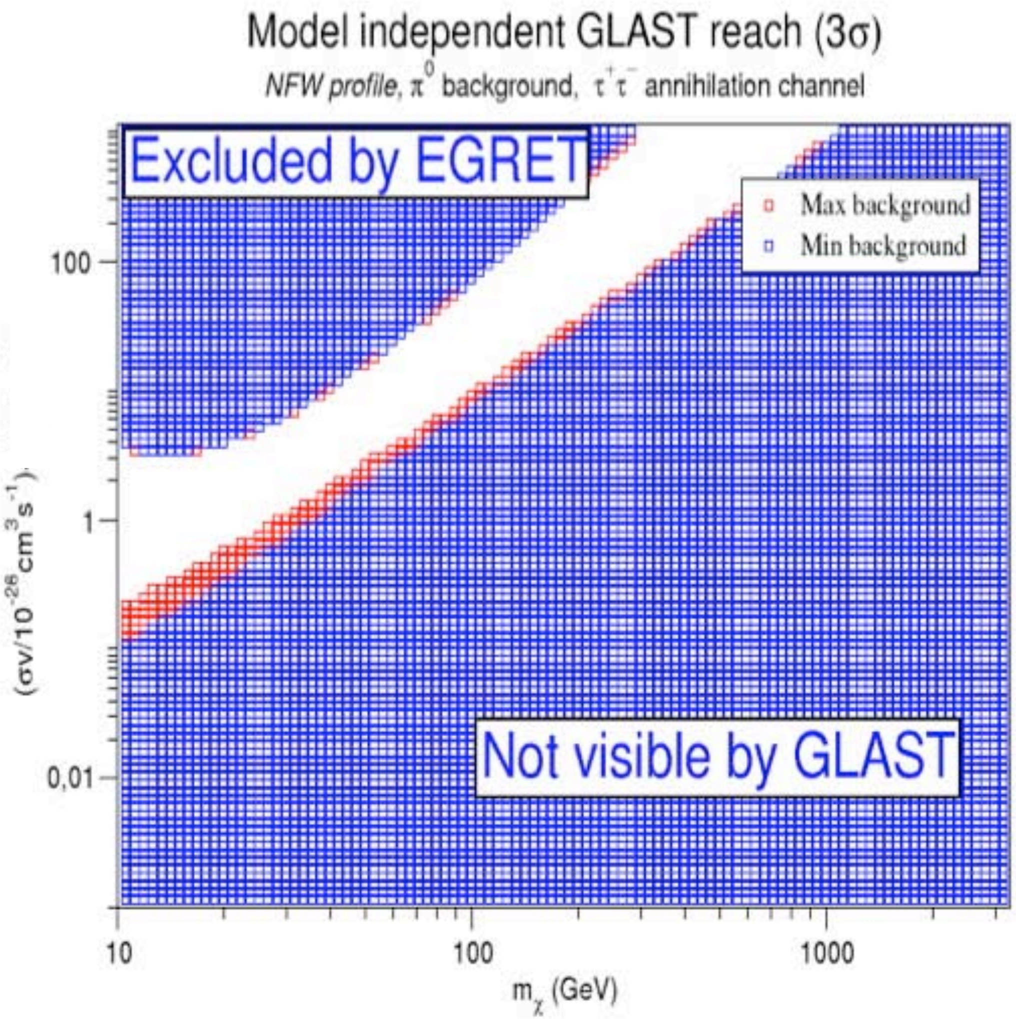
3 σ



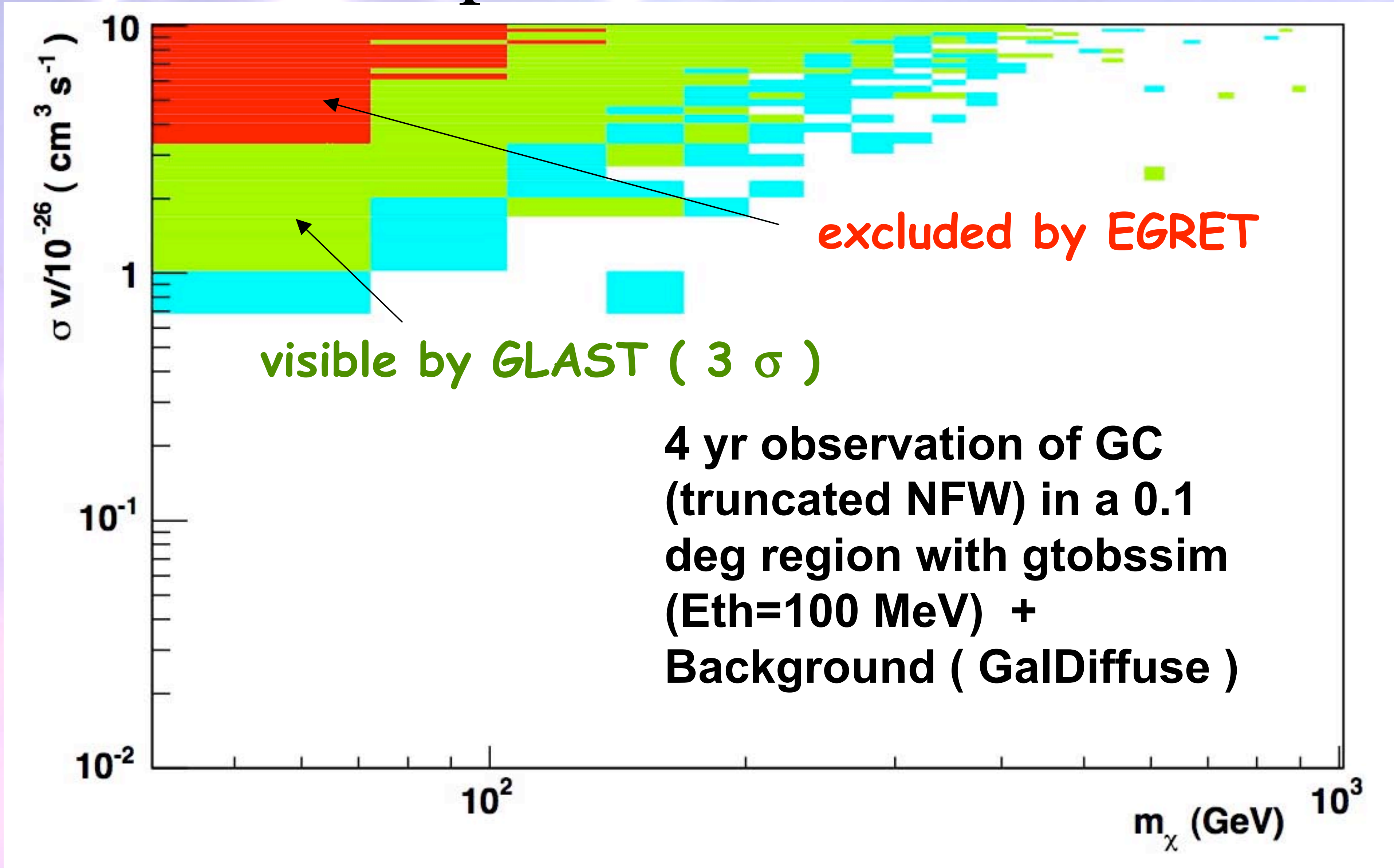
Model independent results for the GC

Results for different dominant annihilation channel





Model independent results for the GC



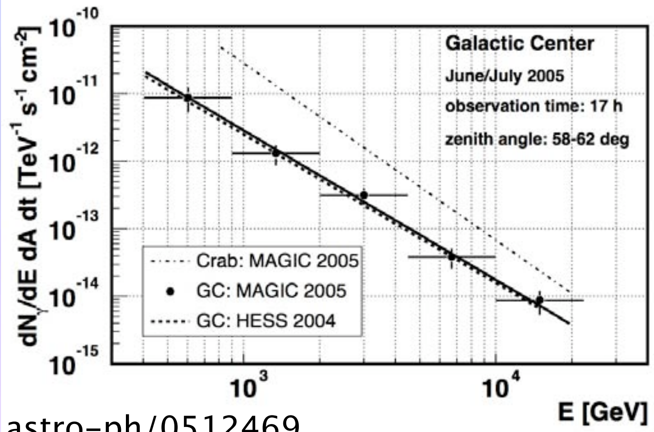
Galactic Center

HESS Spectrum

Unbroken power-law.

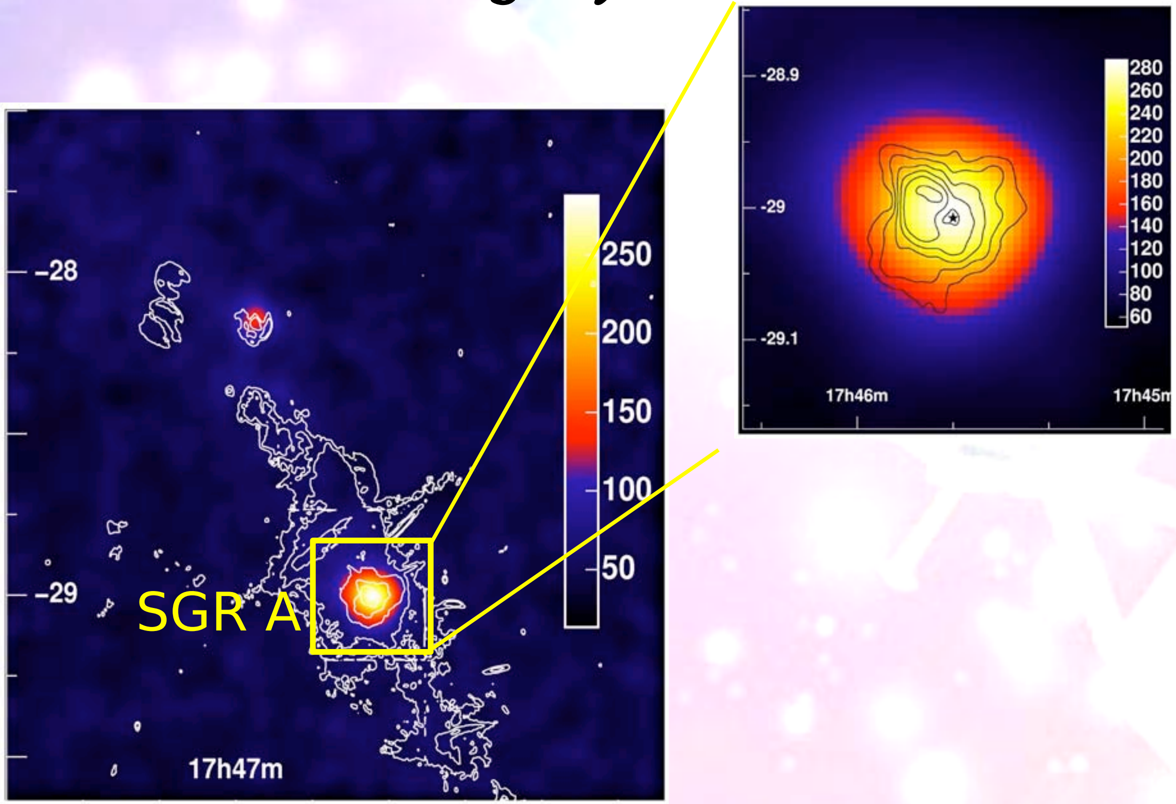
- ***Hard spectrum Γ = 2.2.***
- ***No evidence for variability on a variety of time scales.***

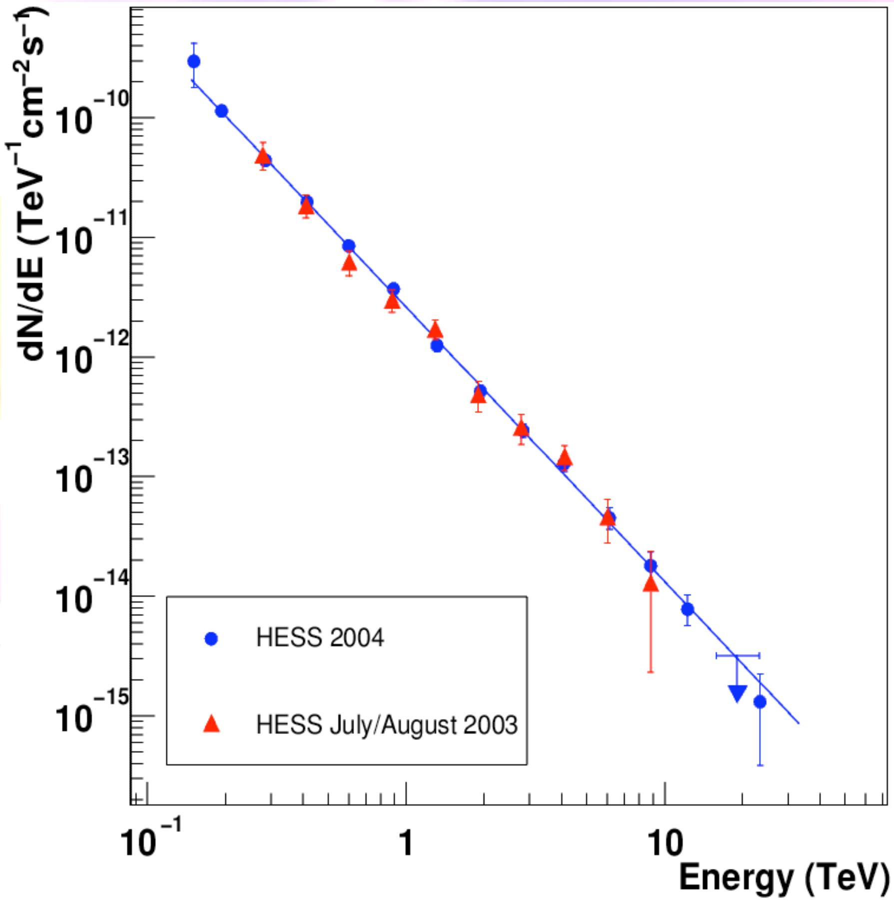
Good agreement between HESS and MAGIC (large zenith angle observation).



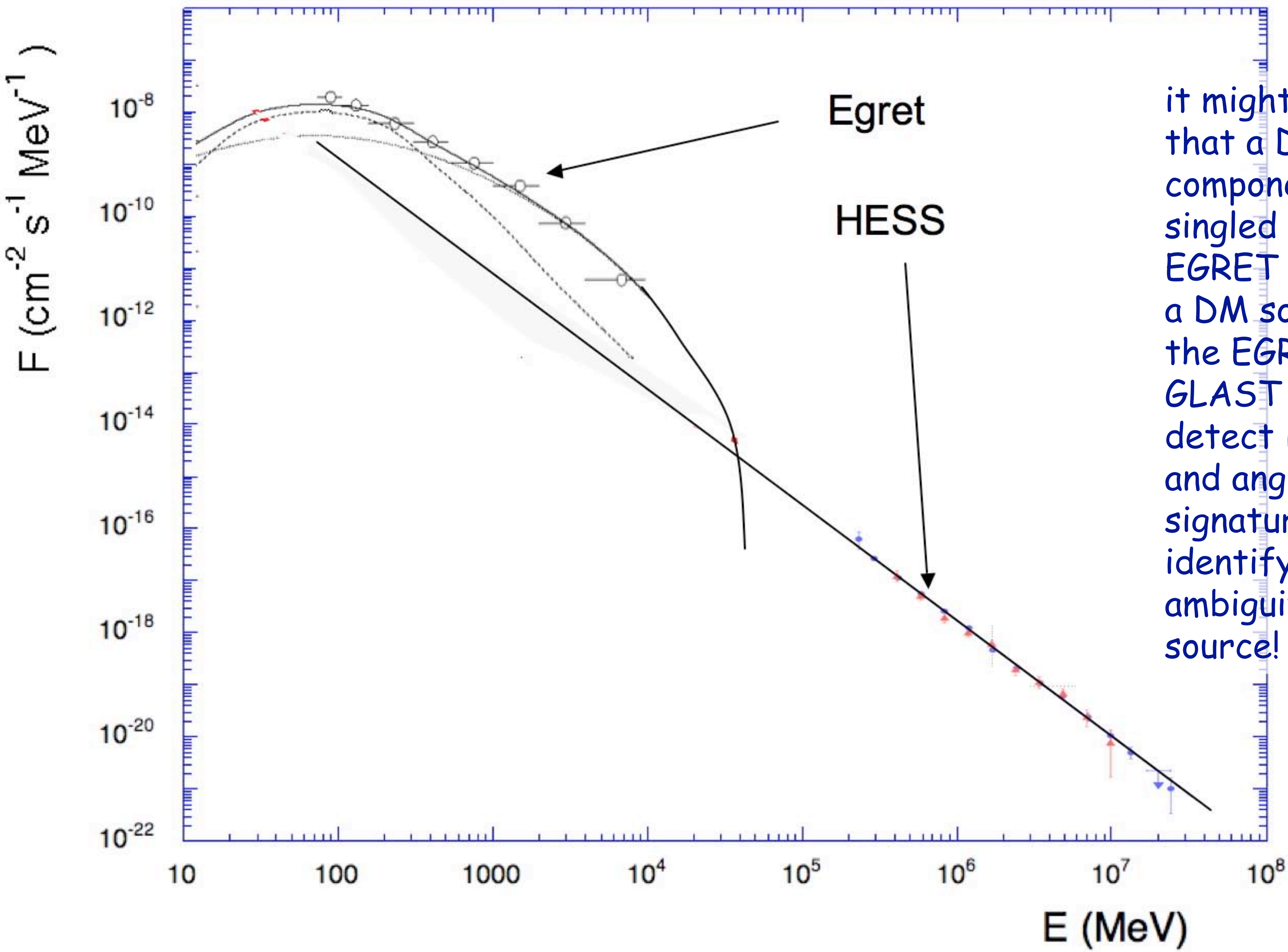
astro-ph/0512469

Consistent with SGR A* to 6″ and ***slightly extended.***





EGRET, GLAST, HESS



it might still be that a DM component could be singled out, e.g. the EGRET source (?): a DM source can fit the EGRET data; GLAST would detect its spectral and angular signatures and identify without ambiguity such DM source!

Conclusion

Discovery Potential for Supersymmetry

- GLAST will explore a good portion of the supersymmetric parameter space

- Search complementary to antimatter, LHC and Direct Search