
GLAST and the future of High
Energy Gamma-ray astrophysics
Aldo Morselli
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on behalf of the
GLAST Collaboration
Europhysics
Conference
on High
Energy
Physics
HEP 2007
HEP 2007
19th July, Manchester

Why study γ's?

- γ rays offer a direct view into Nature's largest accelerators.
- the Universe is mainly transparent to γ rays with < 20 GeV that can probe cosmological volumes. Any opacity is energy-dependent for higher energy.
- Most particle relics of the early universe produce γ rays when they annihilate or decay.

<u>Two GLAST instruments</u>:

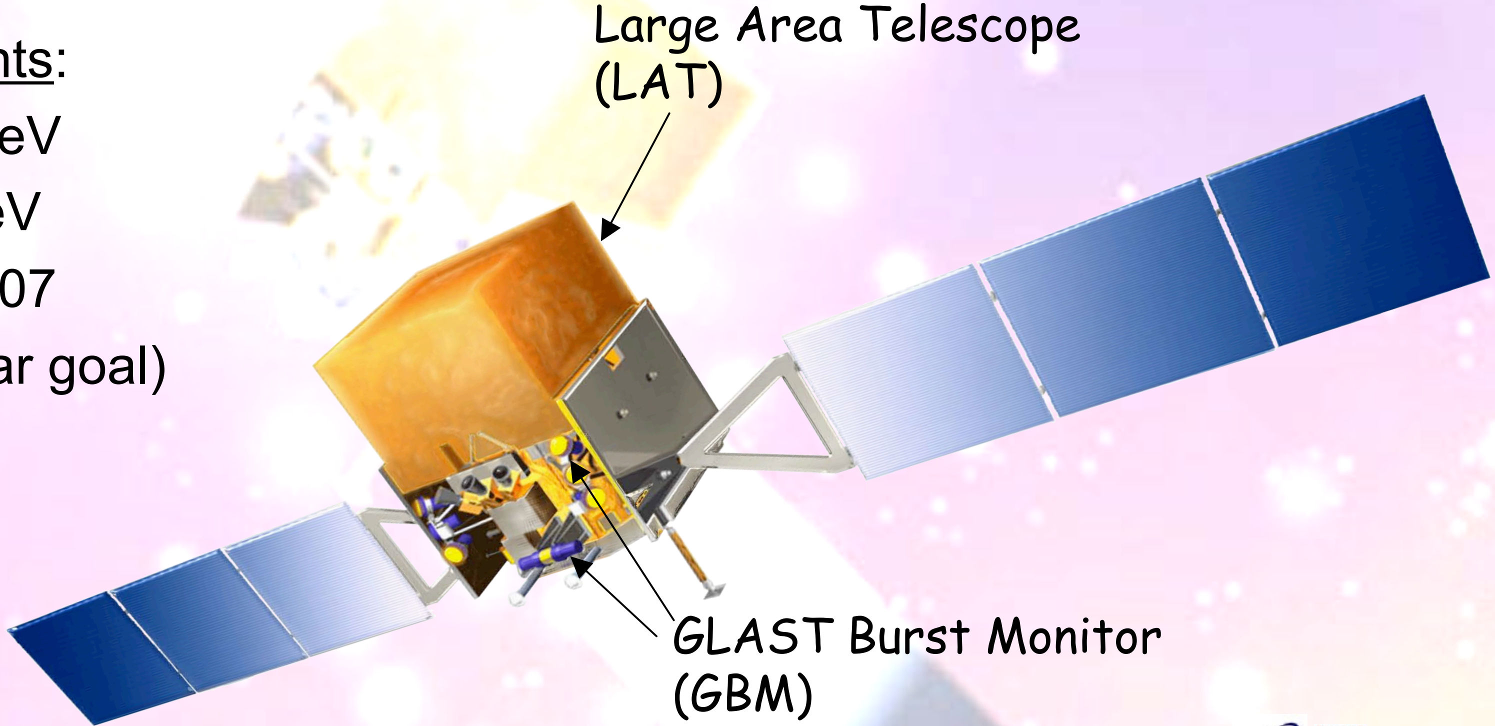
LAT: 20 MeV →300 GeV

GBM: 10 keV →30 MeV

Launch: December 2007

5-year mission (10-year goal)

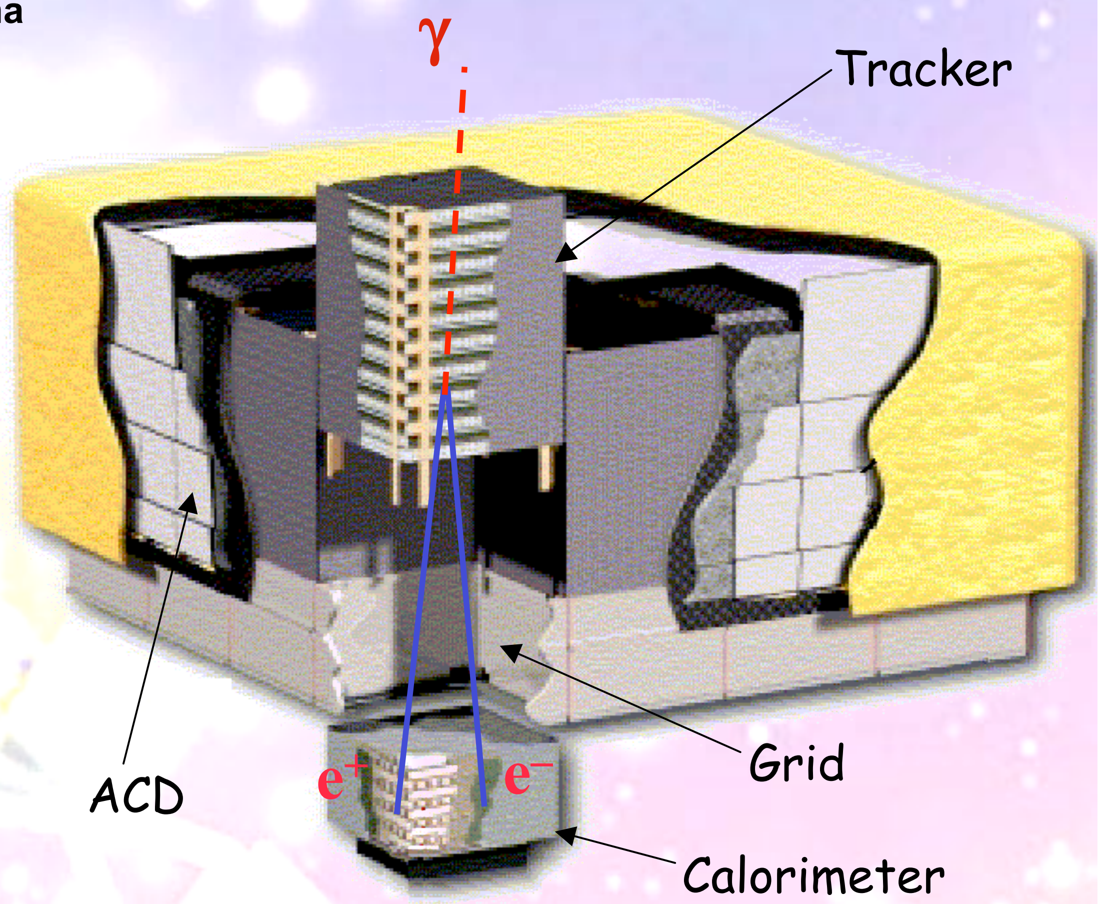
LEO @ 550km, ~26°



Overview of LAT

- Precision Si-strip Tracker (TKR) ~80 m^2 Si, 18 XY tracking planes. Single-sided silicon strip detectors (228 μm pitch) Measure the photon direction; gamma ID.
- Hodoscopic CsI Calorimeter(CAL) Array of 1536 CsI(Tl) crystals in 8 layers. Measure the photon energy; image the shower.
- Segmented Anticoincidence Detector (ACD) 89 plastic scintillator tiles and 8 ribbons. Reject background of charged cosmic rays; segmentation removes self-veto effects at high energy.
- Electronics System Includes flexible, robust hardware trigger and software filters in flight software.

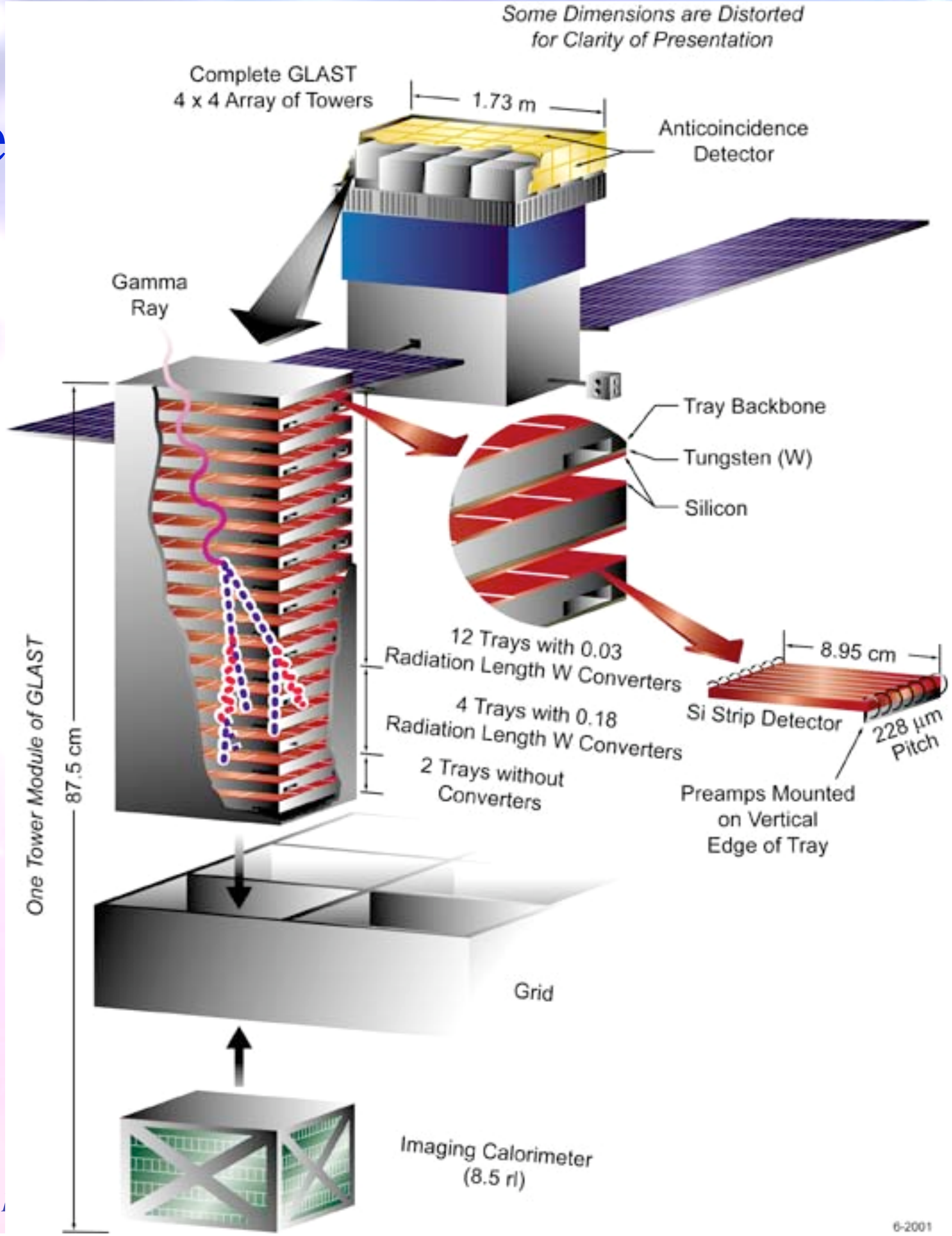
16 towers-TKR+CAL+DAQ



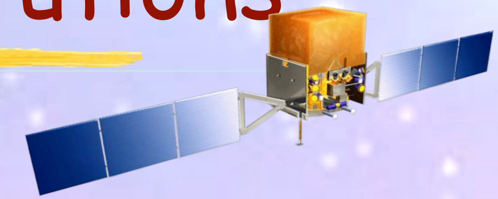
Systems work together to identify and measure the flux of cosmic gamma rays with energy 20 MeV - >300 GeV.

Gamma-Ray Large Area Space Telescope

GLAST Scheme



The GLAST Participating Institutions



American Institutions

SU-HEPL Stanford University, Hanson Experimental Physics Laboratory , ,
SU-SLAC Stanford Linear Accelerator Center, Particle Astrophysics group
GSFC-NASA-LHEA Goddard Space Flight Center, Laboratory for High Energy Astrophysics
NRL - U. S. Naval Research Laboratory, E. O. Hulburt Center for Space Research, X-ray and gamma-ray branches
UCSC- SCIPP University of California at Santa Cruz, Santa Cruz Institute of Particle Physics
SSU- California State University at Sonoma, Department of Physics & Astronomy , WUStL-Washington University, St. Louis
UW- University of Washington , TAMUK- Texas A&M University-Kingsville, Ohio State University

Italian Institutions

INFN - Istituto Nazionale di Fisica Nucleare and Univ. of Bari, Padova, Perugia, Pisa, Roma2, Trieste, Udine
ASI - Italian Space Agency
IASF- Milano, Roma

Japanese Institutions

University of Tokyo
ICRR - Institute for Cosmic-Ray Research
ISAS- Institute for Space and Astronautical Science
Hiroshima University

French Institutions

CEA/DAPNIA Commissariat à l'Energie Atomique, Département d'Astrophysique, de physique des Particules, de physique Nucliaire et de l'Instrumentation Associée, CEA, Saclay
IN2P3 Institut National de Physique Nucléaire et de Physique des Particules, IN2P3
IN2P3/LPNHE-X Laboratoire de Physique Nucléaire des Hautes Energies de l'École Polytechnique
IN2P3/PCC Laboratoire de Physique Corpusculaire et Cosmologie, Collège de France
IN2P3/CENBG Centre d'études nucléaires de Bordeaux Gradignan
IN2P3/LPTA Laboratoire de Physique Theorique et Astroparticules, Montpellier

Swedish Institutions

KTHRoyal Institute of Technology
Stockholms Universitet

Collaboration members:	**~225**
Members:	**77**
Affiliated Sci.	~80
Postdocs:	23
Graduate Students	32

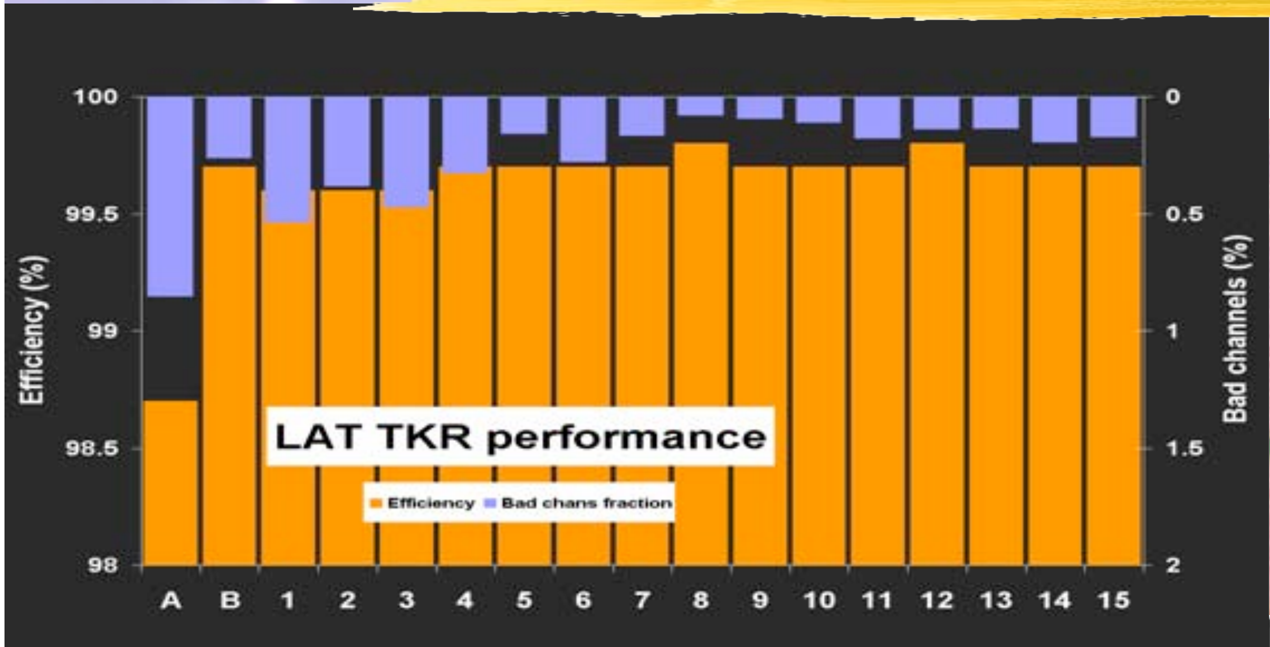
GLAST @ SLAC

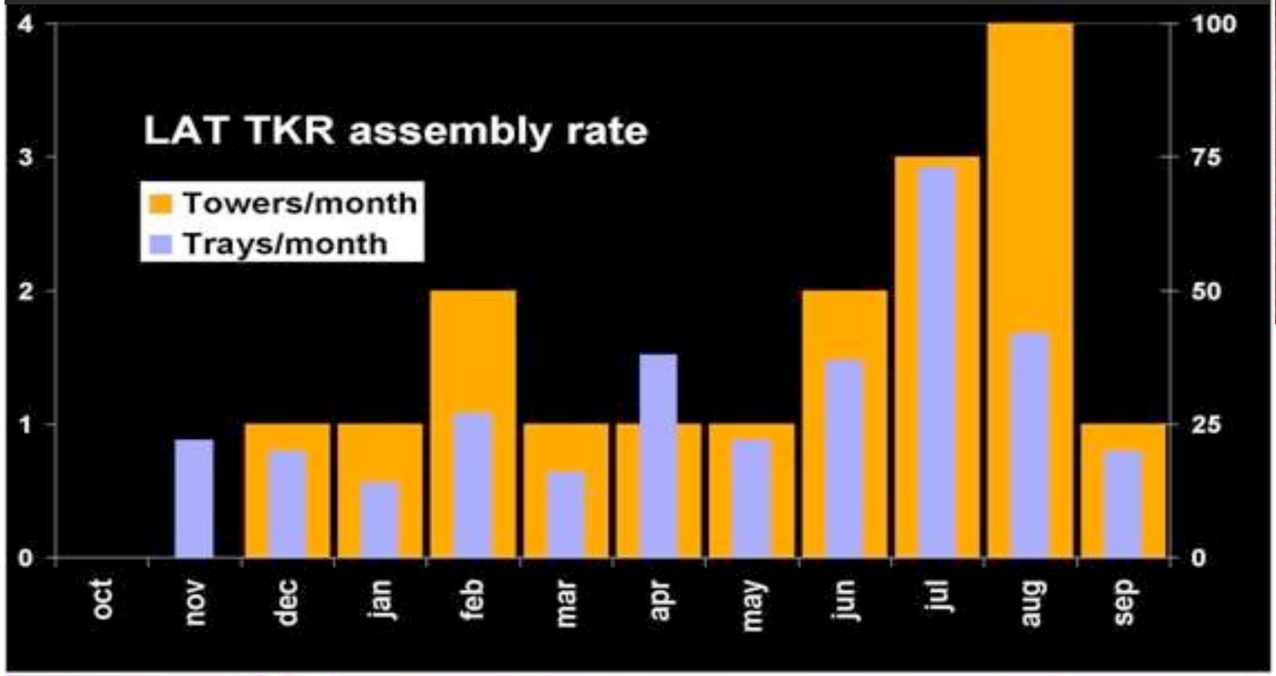
12/16 Towers in the GRID on 7/10/05

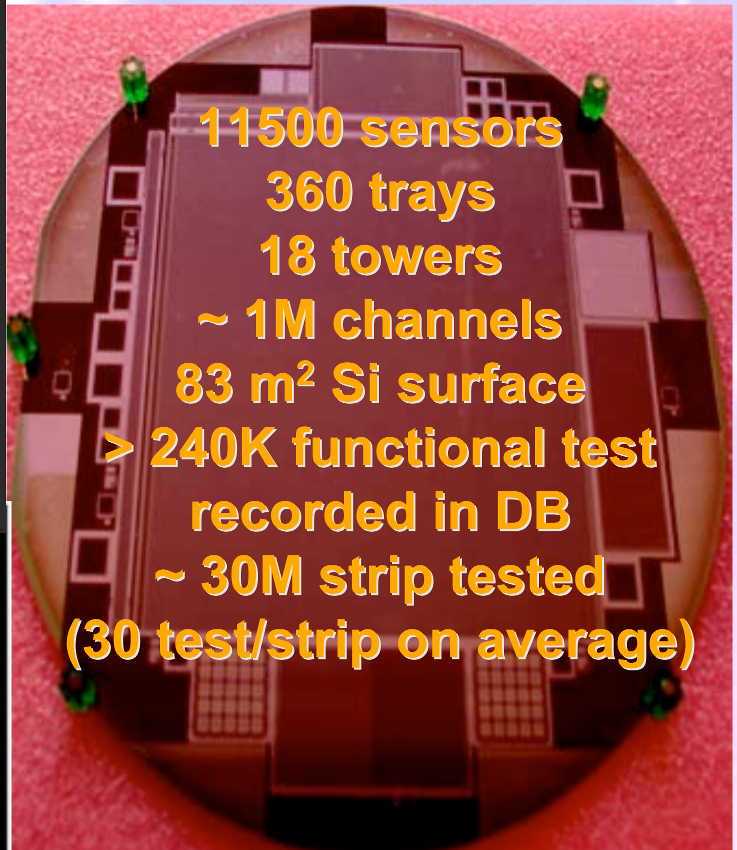
GLAST @ SLAC

16/16 Towers in the GRID on 20/10/05

The LAT Tracker numbers







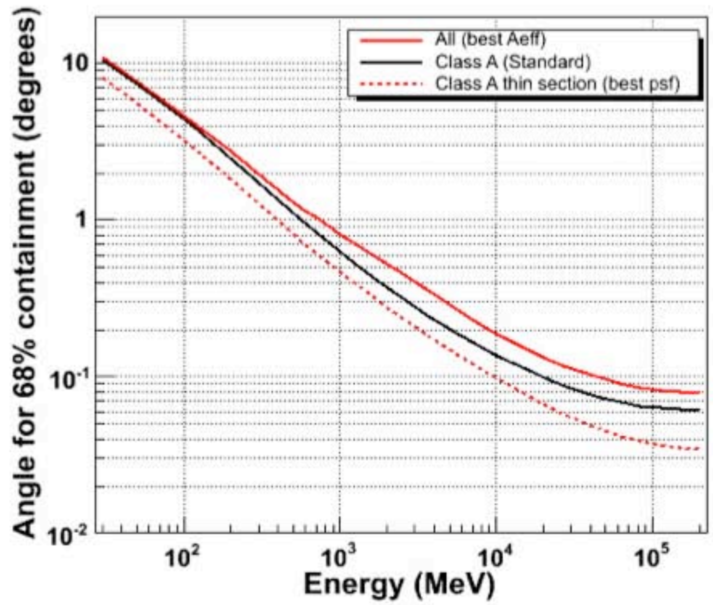
GLAST During Integration

Both the LAT and GBM are now integrated to the Spacecraft at General Dynamics in Phoenix, Arizona.

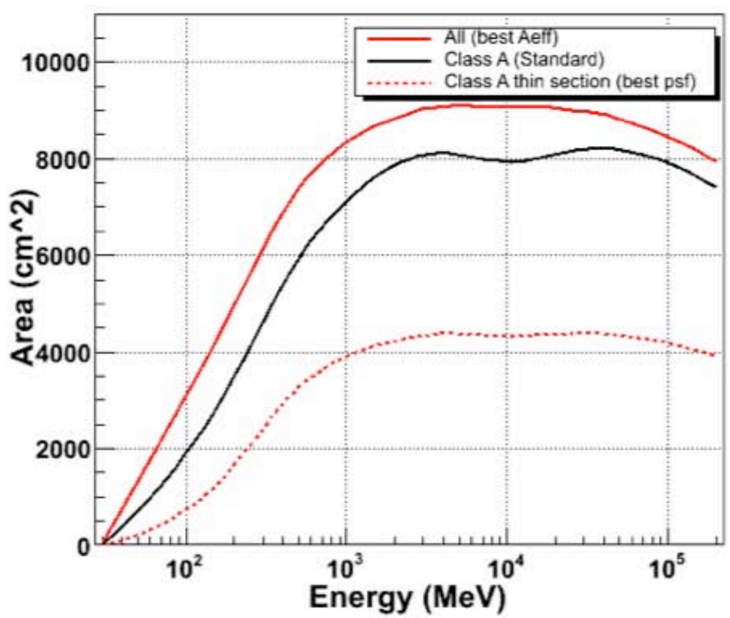
the LAT and the NaI GBM modules mounted onto the spacecraft.

LAT MC Derived Performance

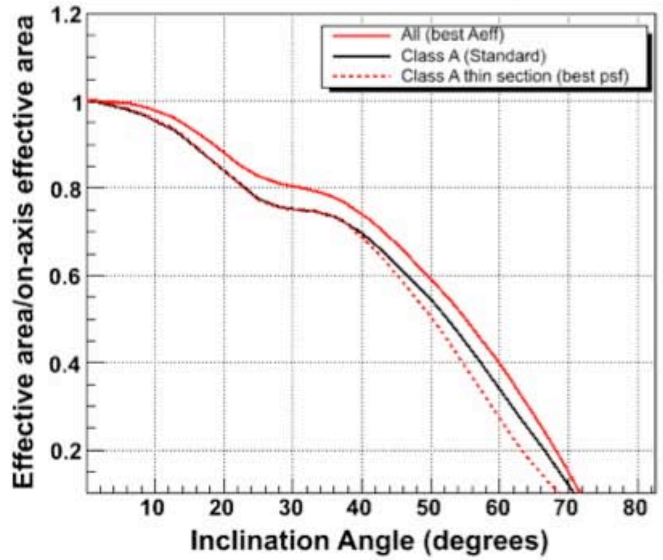
Angular Resolution vs. True Energy at Normal Incidence

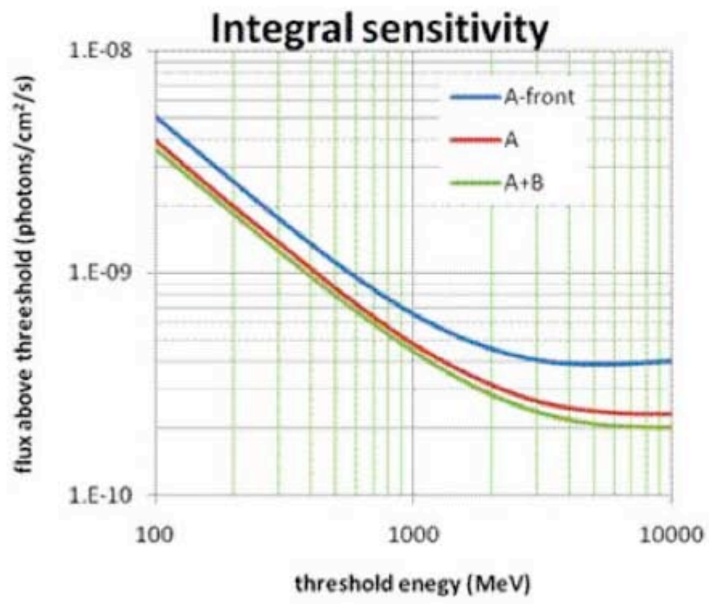


On-Axis Effective Area vs. True Energy

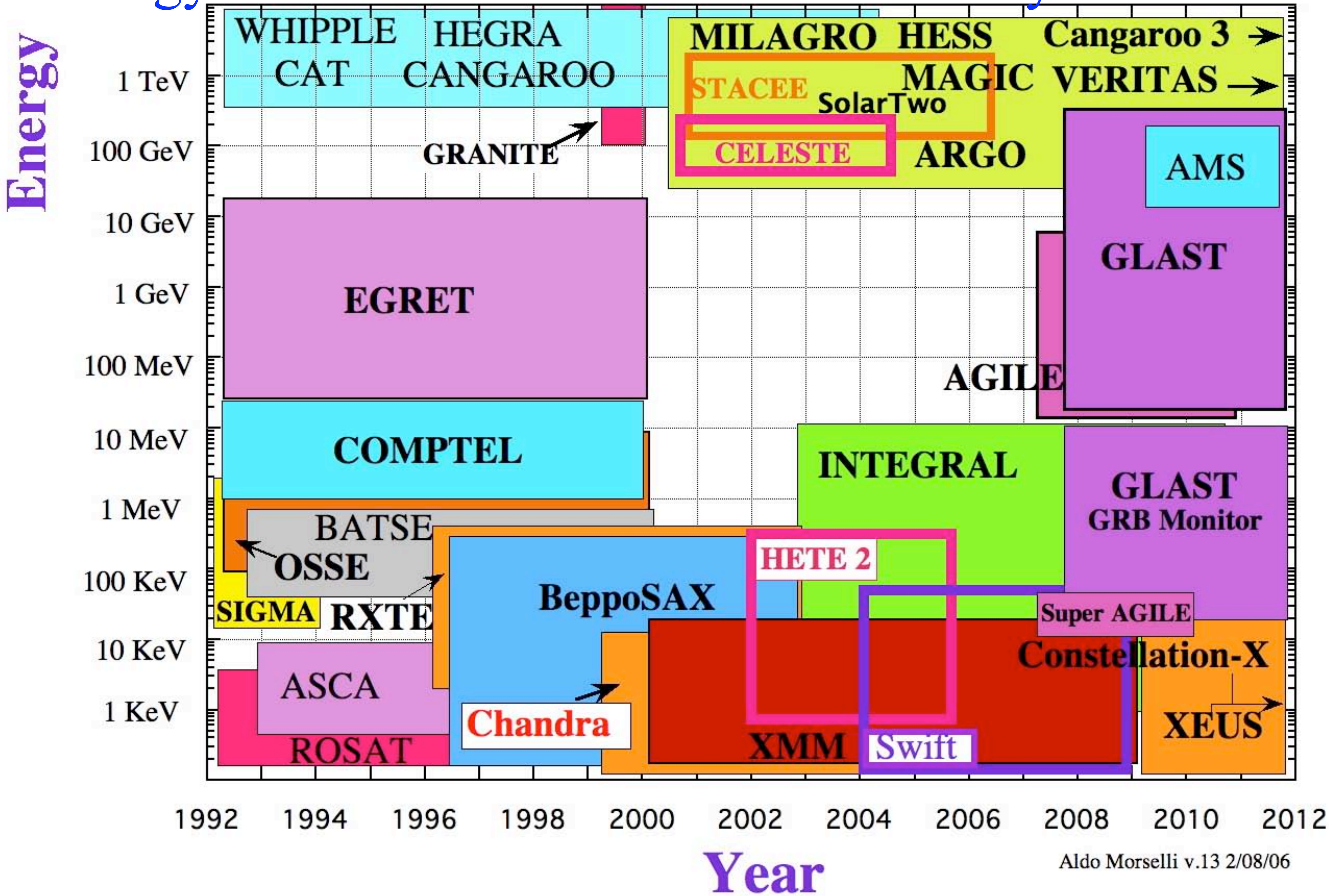


Relative Area vs. True Angle of Incidence at 10 GeV

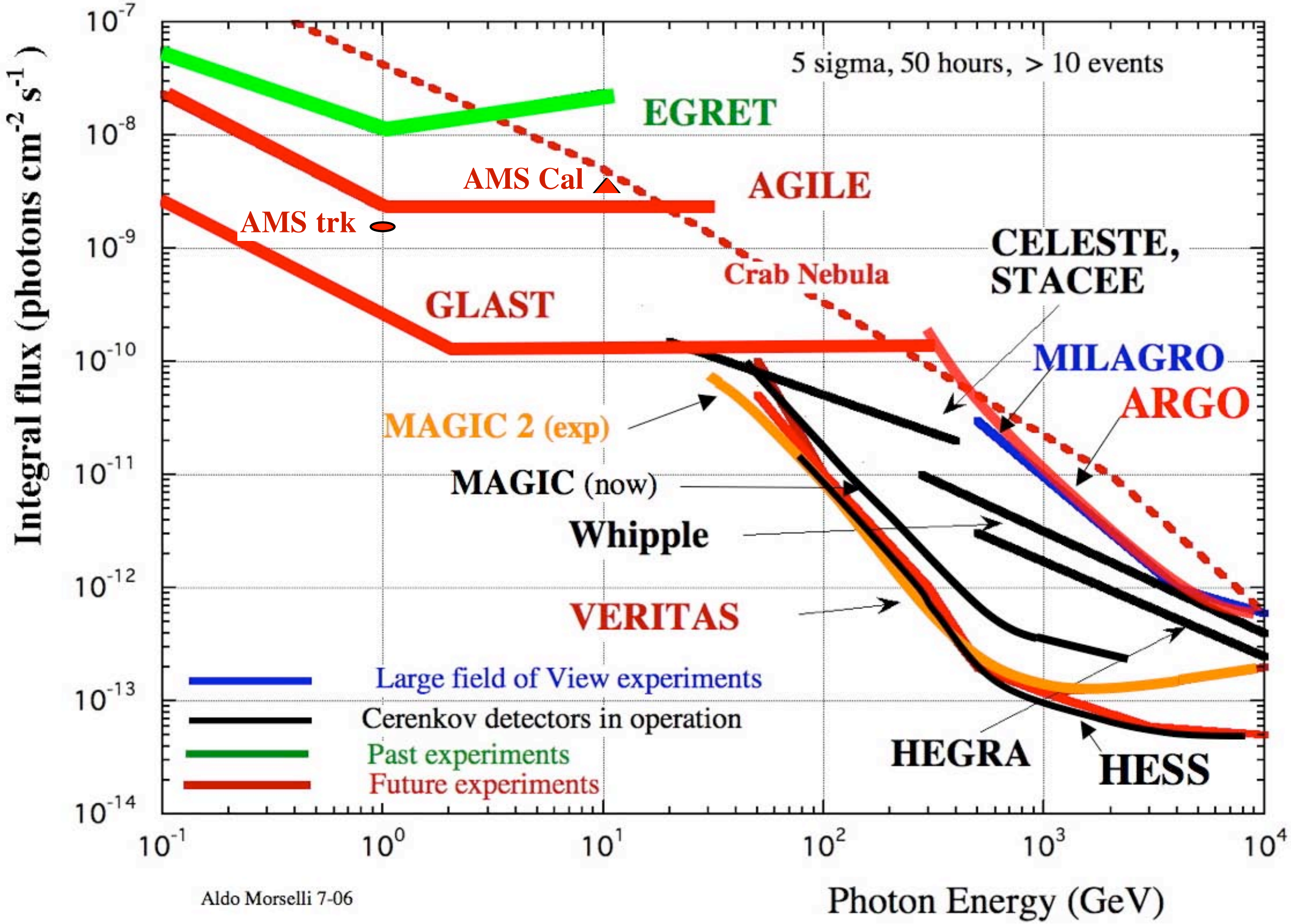




Energy versus time for X and Gamma ray detectors



Sensitivity of γ-ray detectors



High galactic latitudes(Φ_b=2 10^{-5} γ cm^{-2} s^{-1} sr^{-1} (100 MeV/E)$^{1.1}$). Cerenkov telescopes sensitivities (Veritas, MAGIC, Whipple, Hess, Celeste, Stacee, Hegra) are for 50 hours of observations.Large field of view detectors sensitivities (AGILE, GLAST, Milagro, ARGO, AMS) are for 1 year of observation.

GLAST LAT High Energy Capabilities

EGRET on CGRO firmly established the field of high-energy gamma-ray astrophysics and demonstrated the importance and potential of this energy band.

GLAST is the next great step beyond EGRET, providing a leap in capabilities:

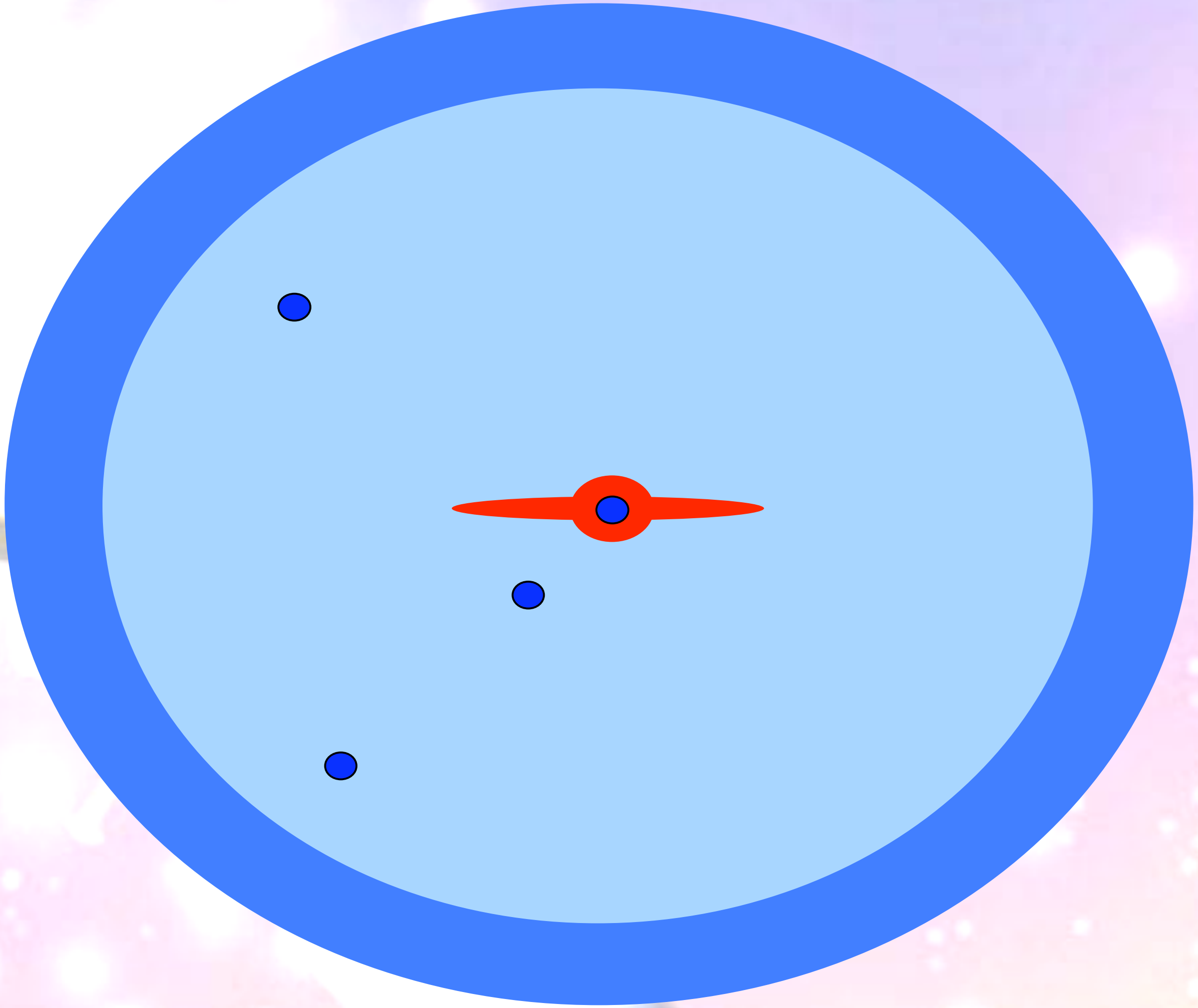
- Very large Field of View (FOV) (~20% of sky), factor 4 greater than EGRET
- Broadband (4 decades in energy, including the essentially unexplored region E > 10 GeV)
- Unprecedented Point Spread function (PSF) for gamma rays (factor > 3 better than EGRET for E>1 GeV). On axis >10 GeV, 68% containment < 0.12 degrees (7.2 arc-minutes)
- Large effective area (factor > 5 better than EGRET)
- Results in factor > 30 improvement in sensitivity below < 10 GeV, and >100 at higher energies.
- Much smaller deadtime per event (27 μsec, factor ~4,000 better than EGRET - 0.1 s)
- No expendables ➔ long mission without degradation (5 year requirement , 10 year goal).

GLAST addresses a broad science menu of interest to both the High Energy Particle Physics and High Energy Astrophysics communities.

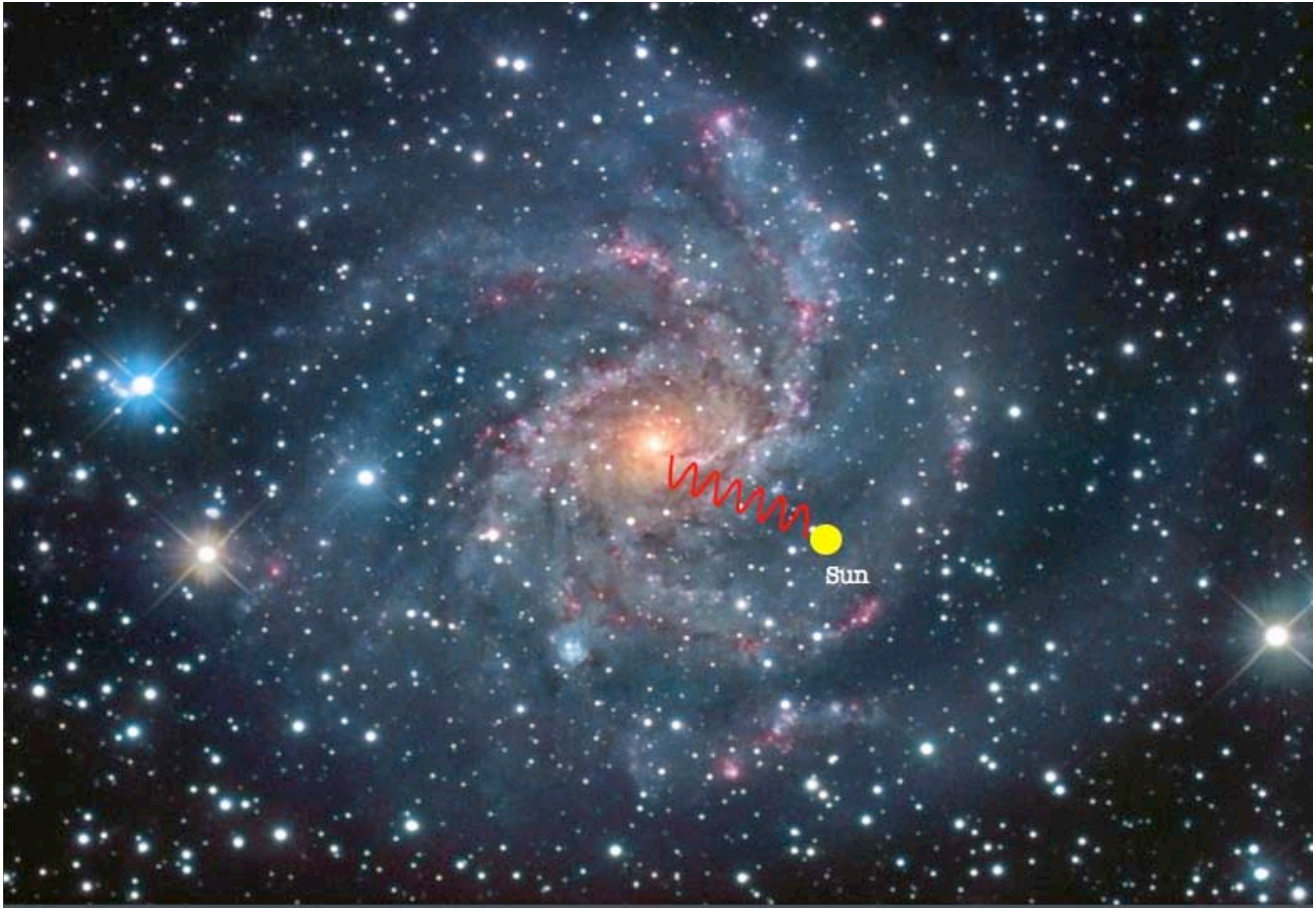
- Systems with (super-massive) black holes & relativistic jets
- Gamma-ray bursts (GRBs)
- Pulsars
- Origin of Cosmic Rays
- Probing the era of galaxy formation
- Discovery! Particle Dark Matter? Other relics from the Big Bang? Extra dimensions? New source classes?

Where should we look for WIMPs with GLAST?

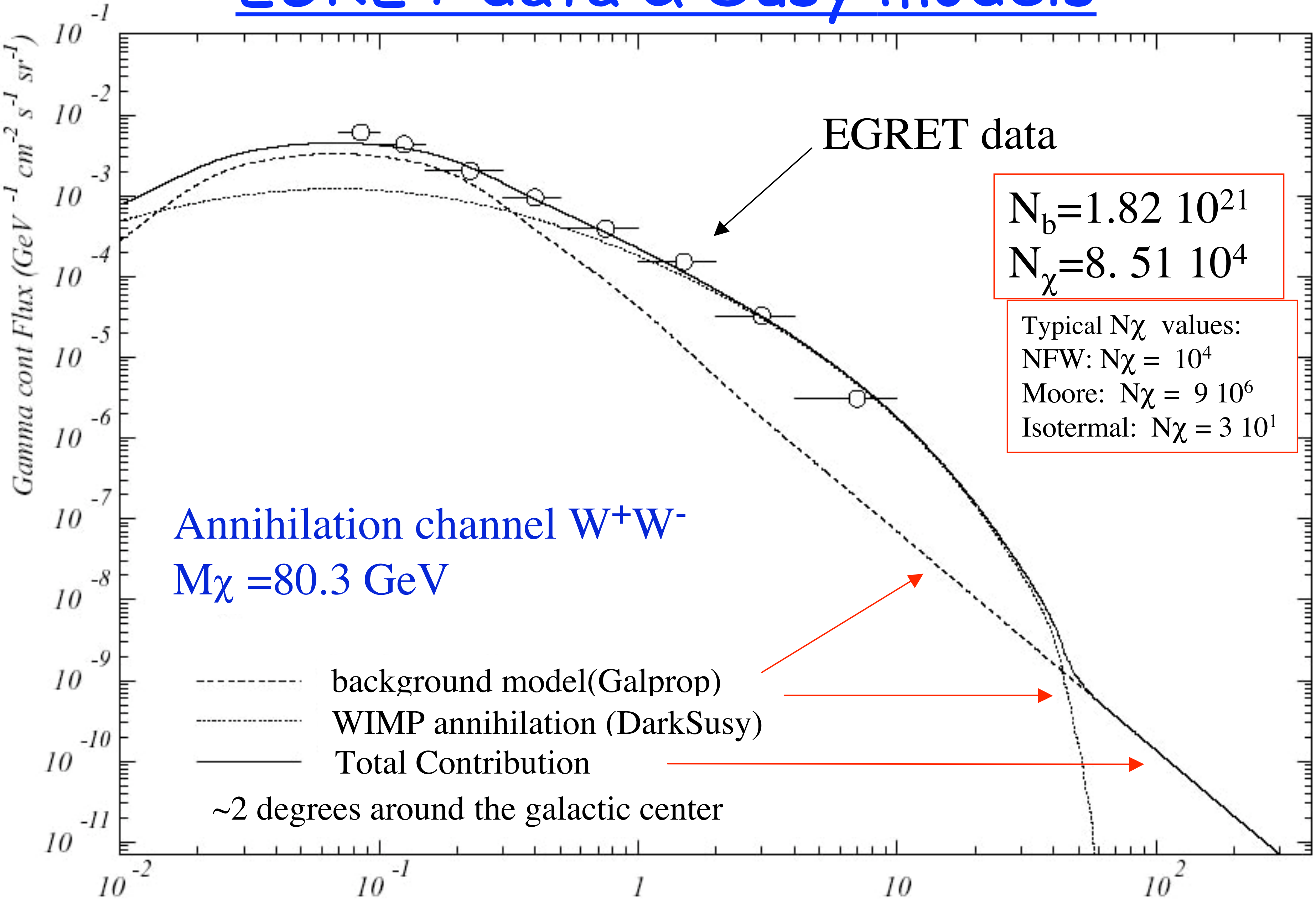
- Galactic center
- Galactic satellites
- Galactic halo
- Extra-galactic




viale
dell'Astronomia
via
della Fisica


Sun

EGRET data & Susy models



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

Signal rate from Supersymmetry

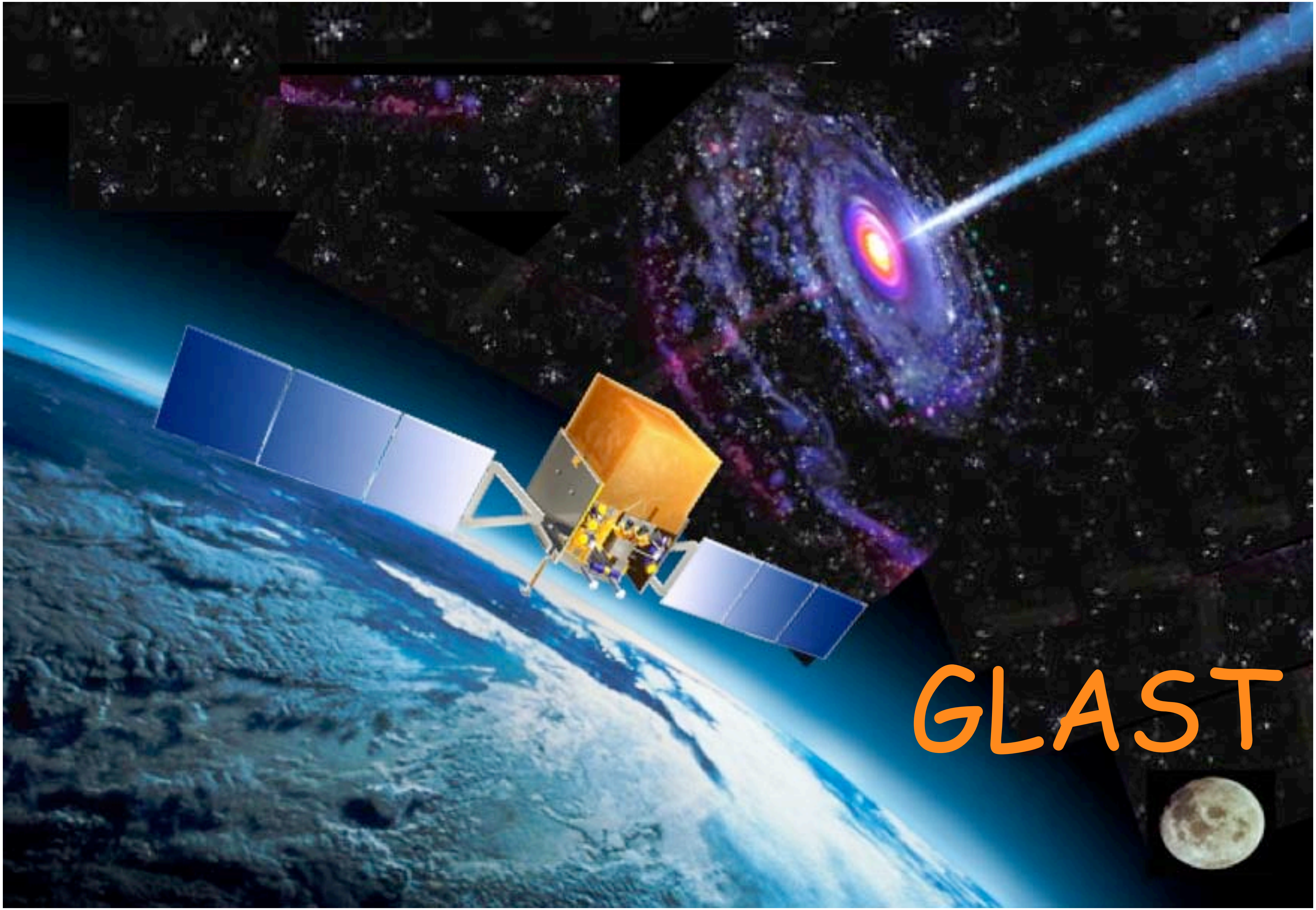
gamma-ray flux from
neutralino annihilation

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

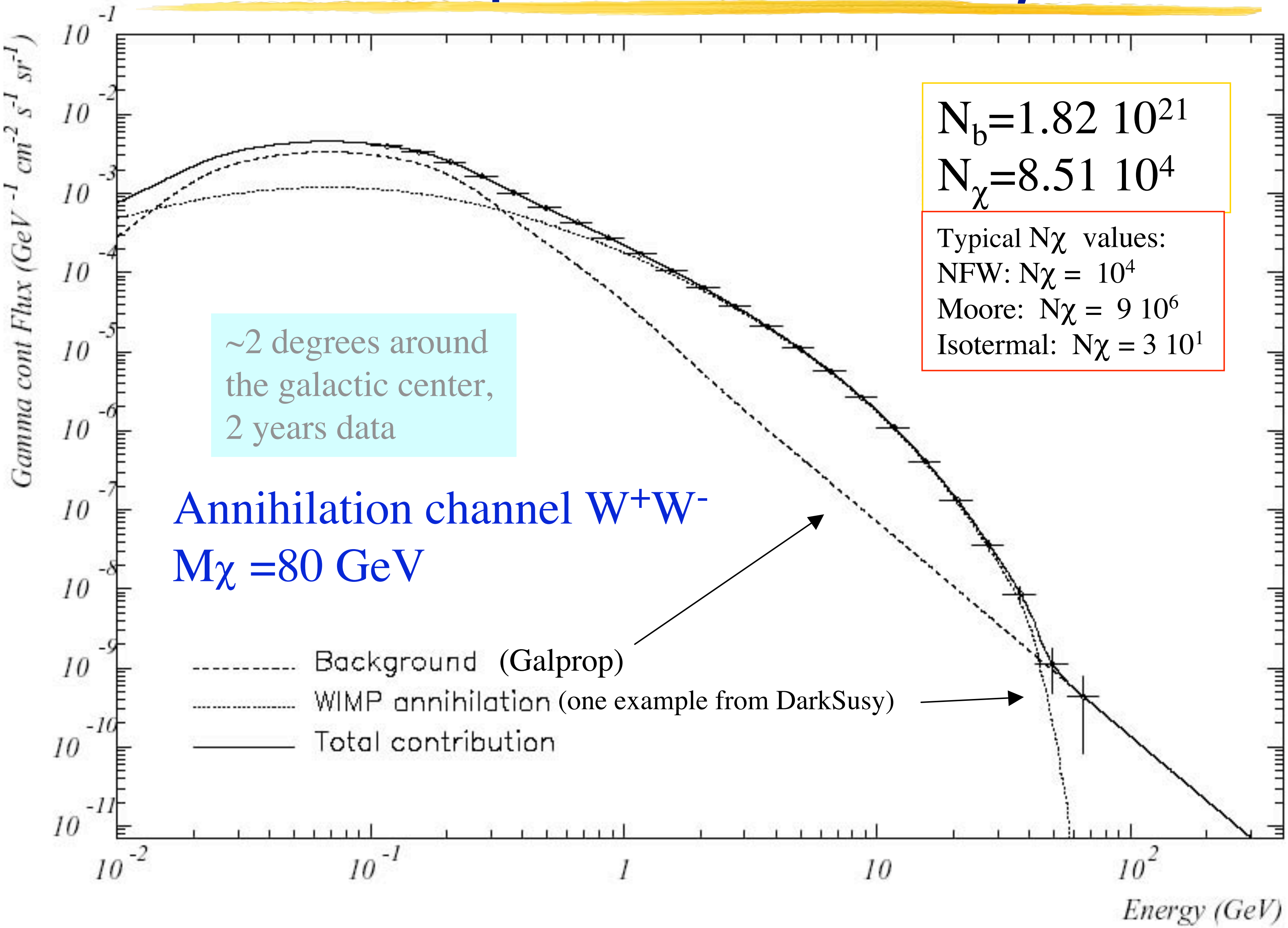
governed by
supersymmetric
parameters

$J(\varphi)$:

governed by
halo distribution


GLAST

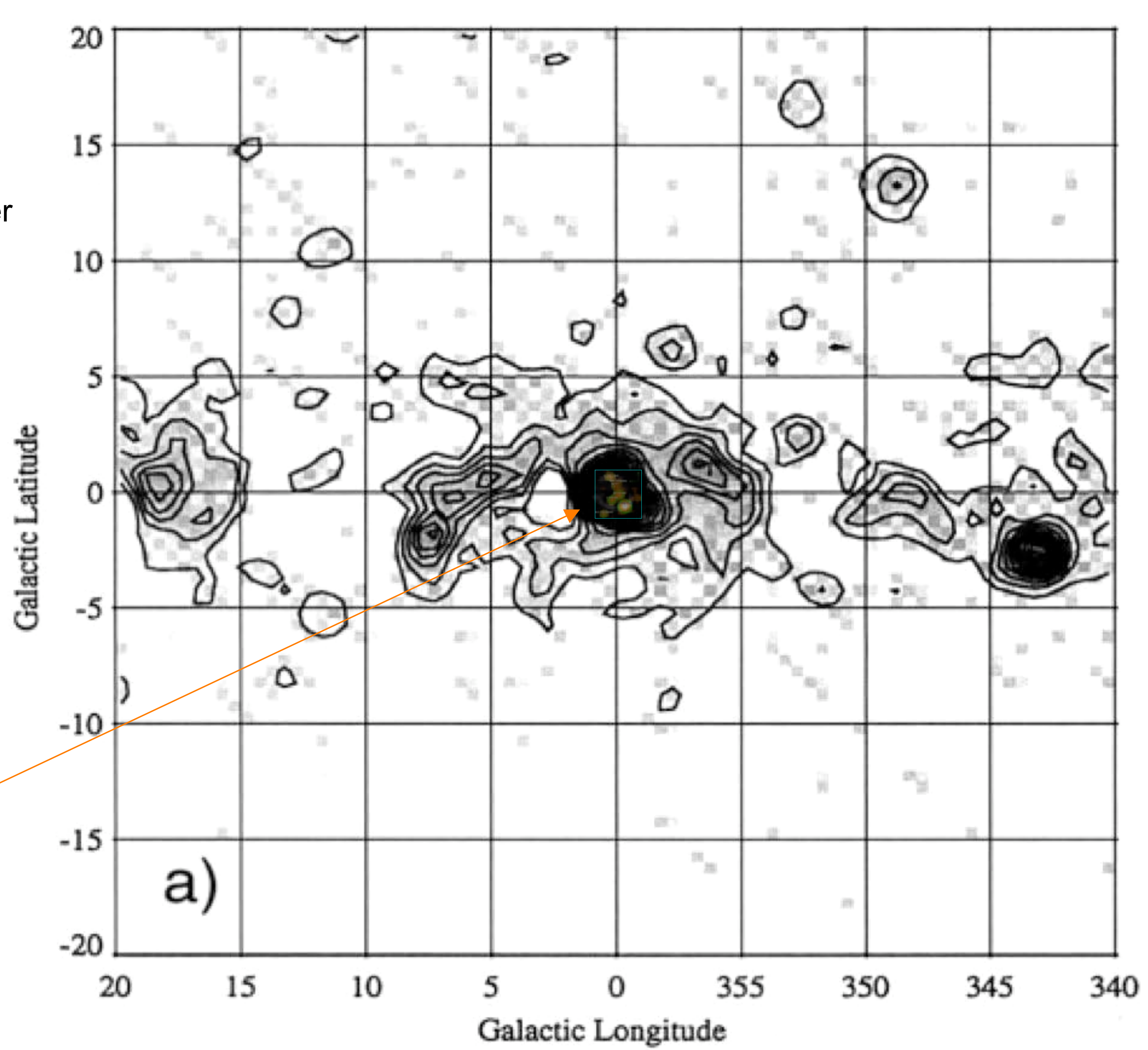
GLAST Expectation & Susy models



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

EGRET, E > 1GeV

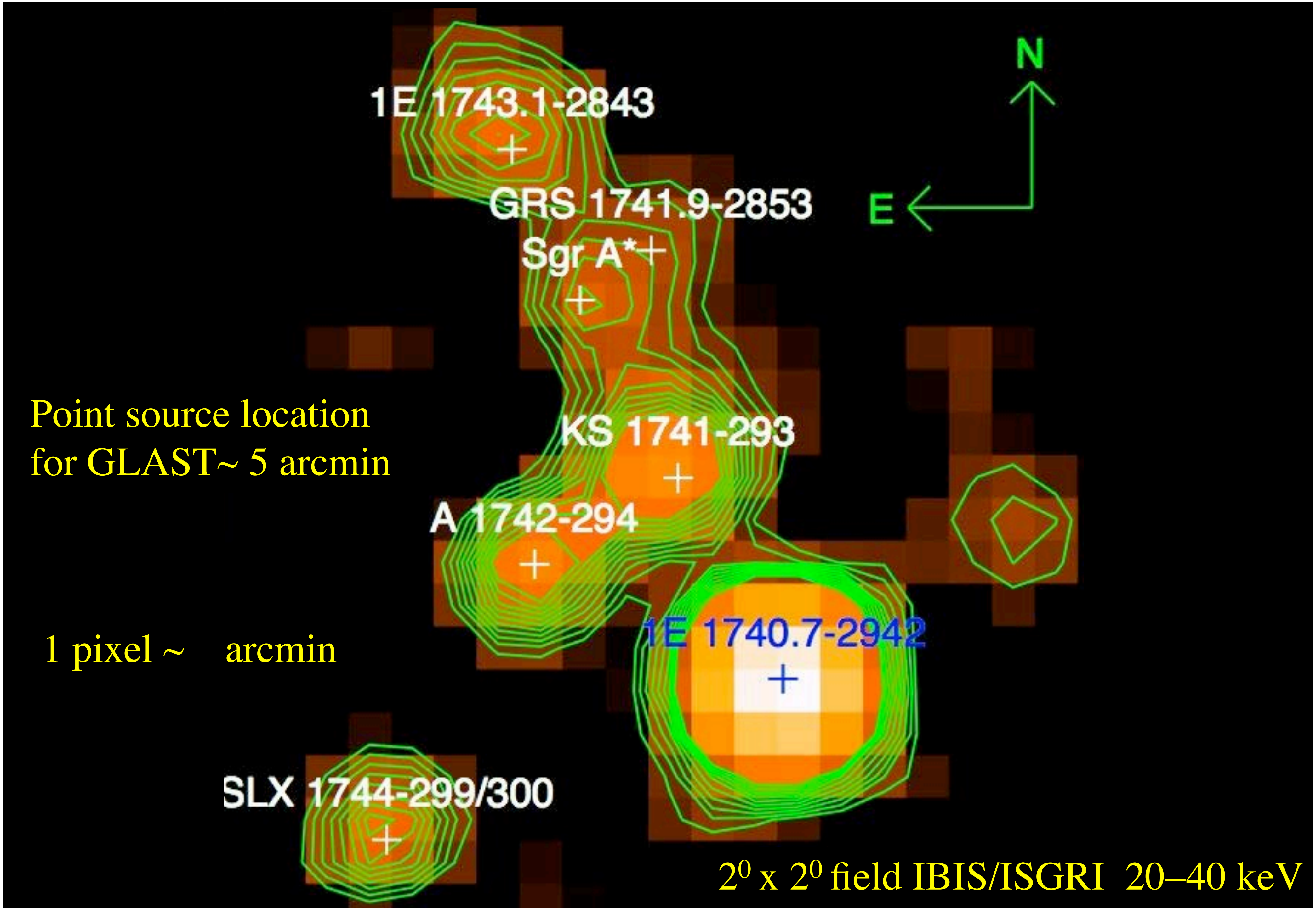
Mayer-Hasselwander et al, 1998

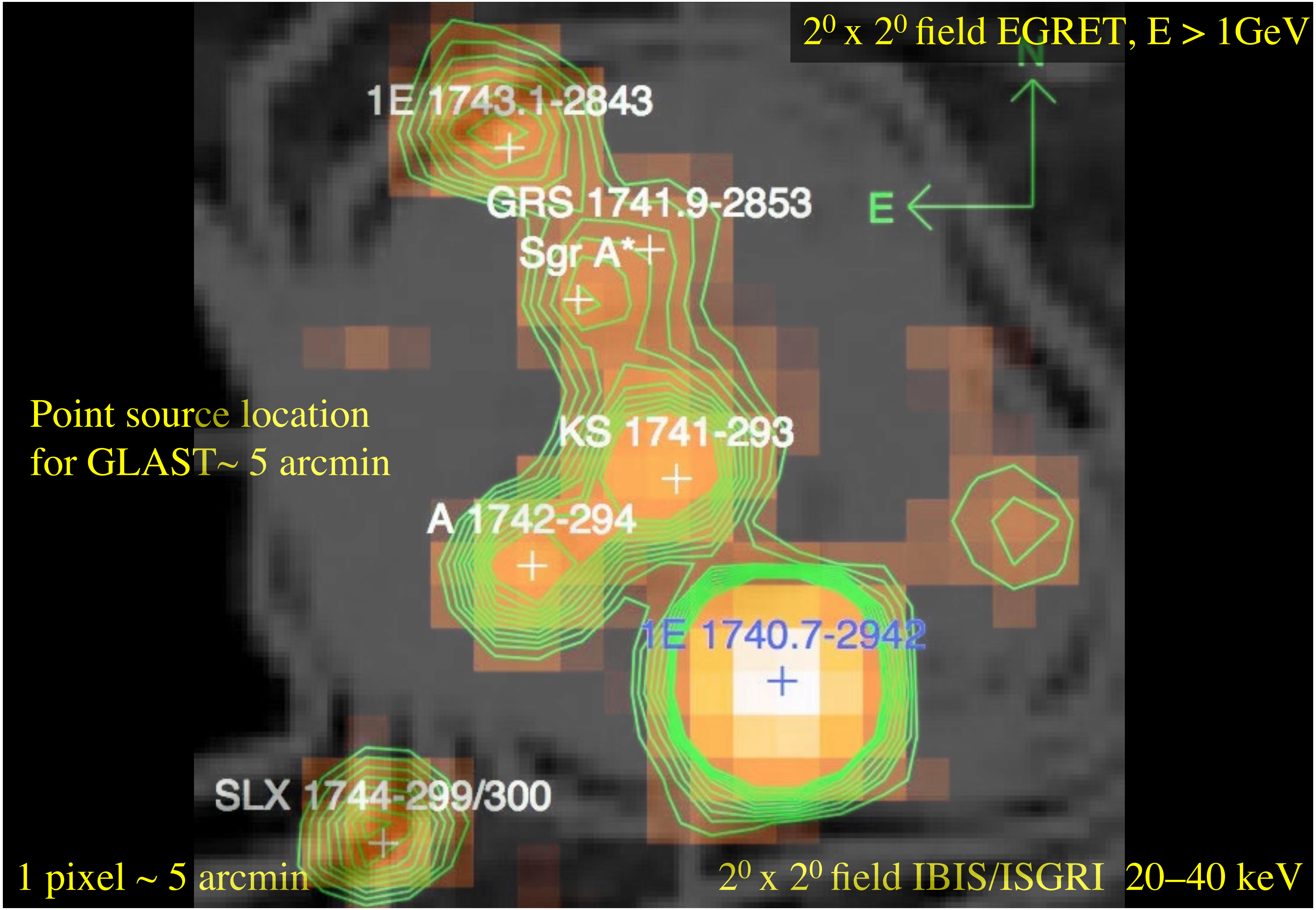


Integral data

2^0 x 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
2⁰ x 2⁰ field IBIS/ISGRI 20–40 keV



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

Supersymmetry introduces free parameters:

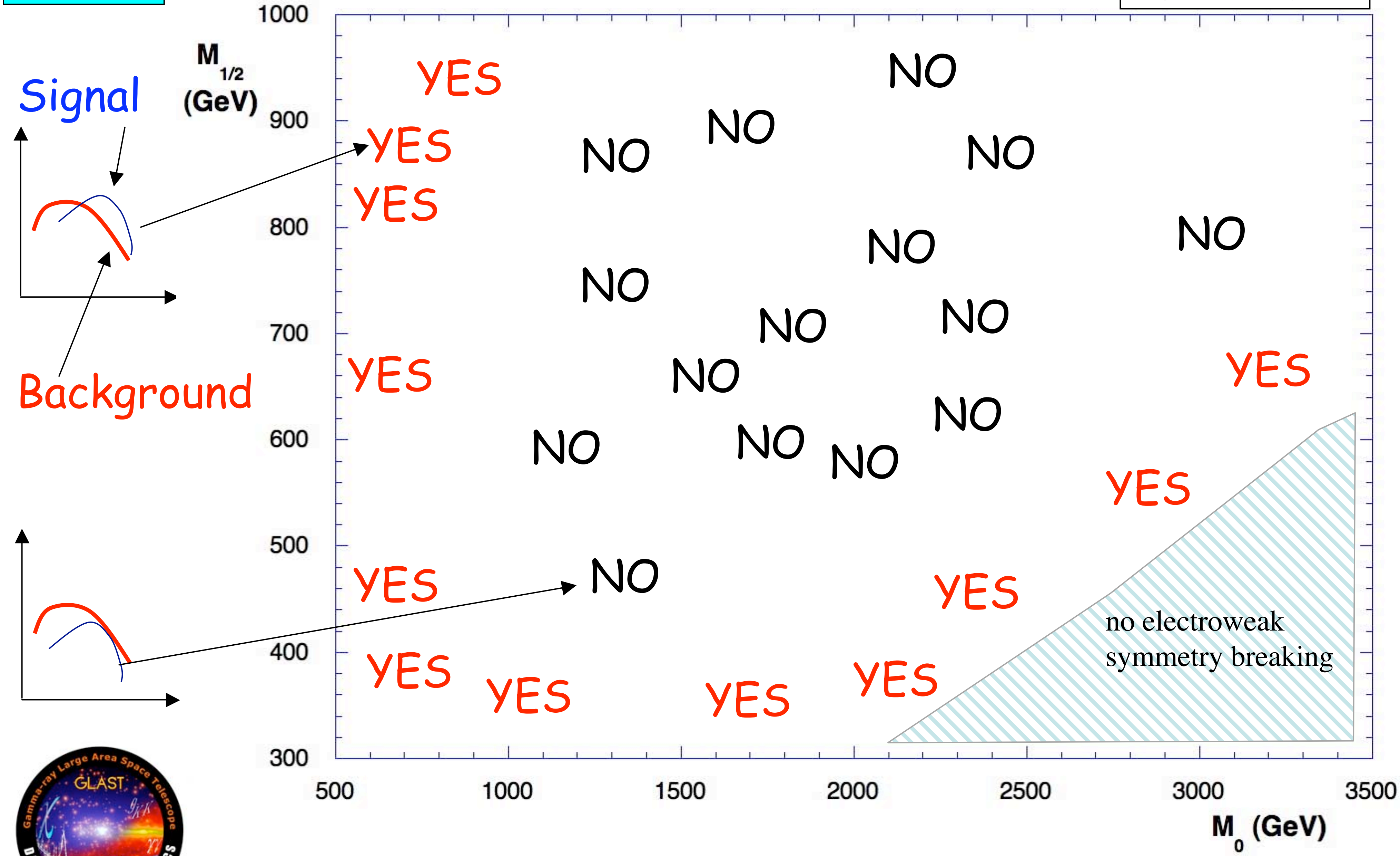
In the MSSM, with Grand Unification assumptions, the masses and couplings of the SUSY particles as well as their production cross sections, are entirely described once 5 parameters are fixed:

- $M_{1/2}$ 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 $\beta = v_2 / v_1 = \langle H_2 \rangle / \langle H_1 \rangle$ the ratio between the two vacuum expectation values of the Higgs fields

cMSSM

Signal and Background are separated ?

tg(β)=55, sign(μ)=+1



cMSSM

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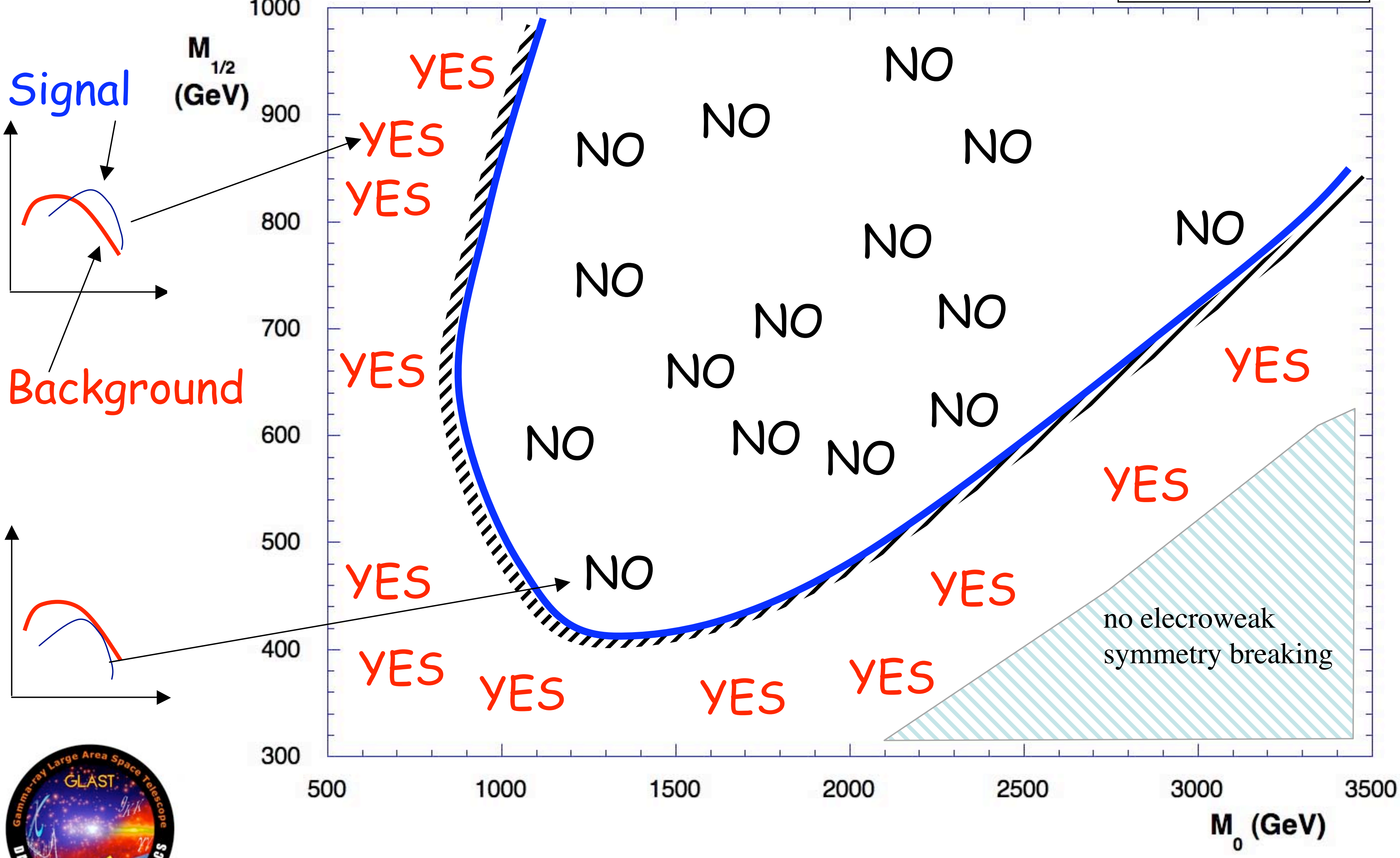
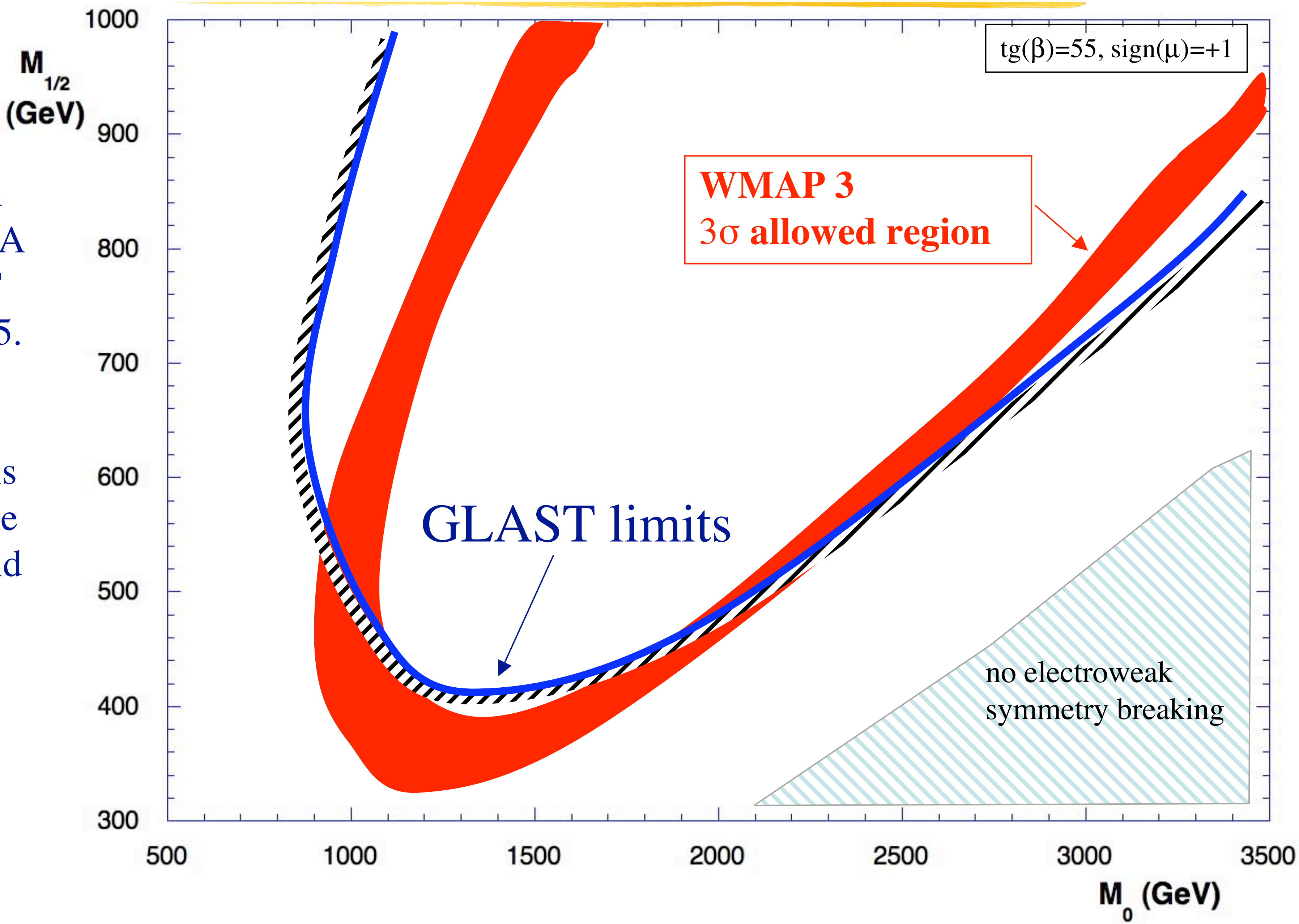


mSUGRA

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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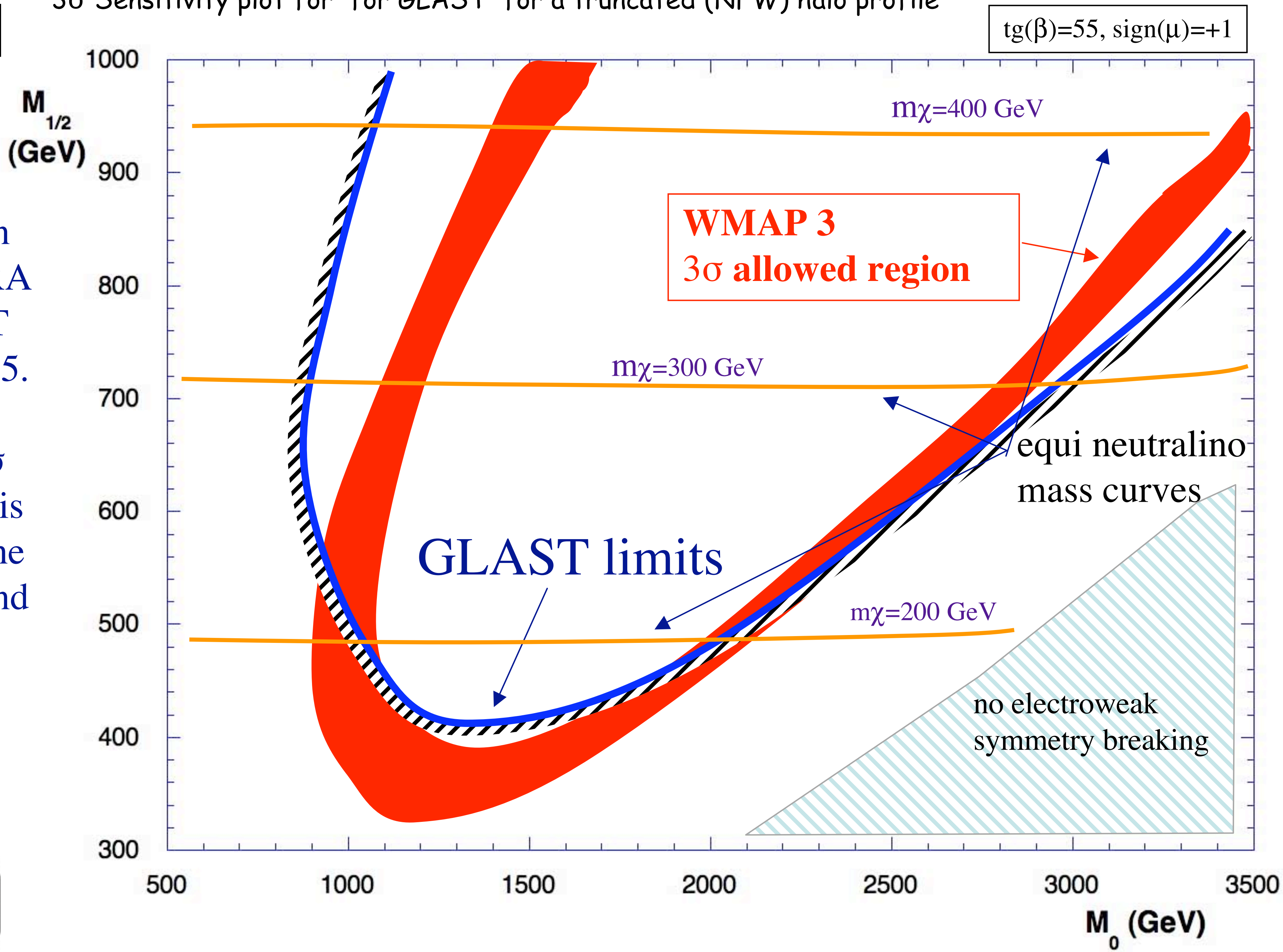
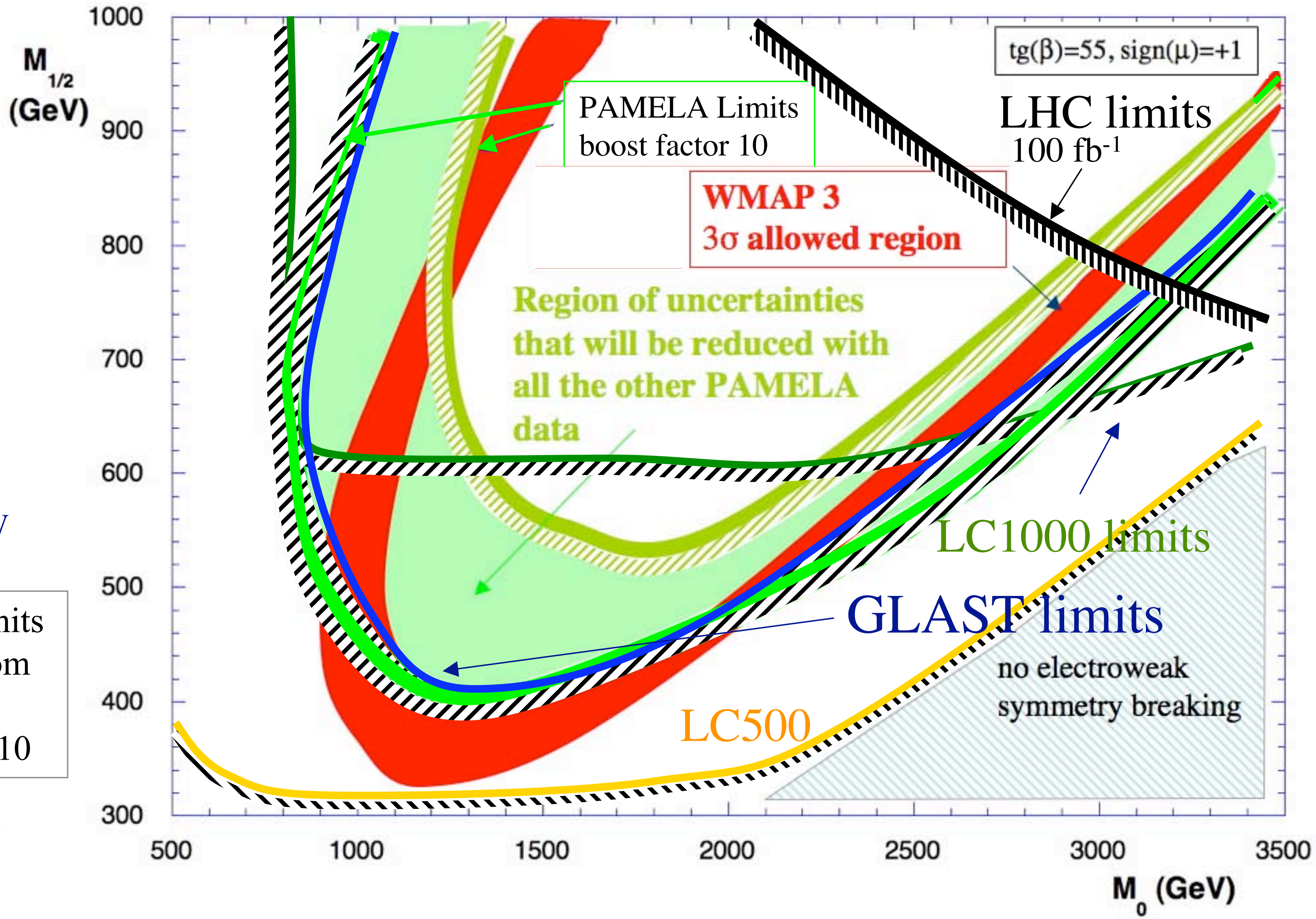


mSUGRA

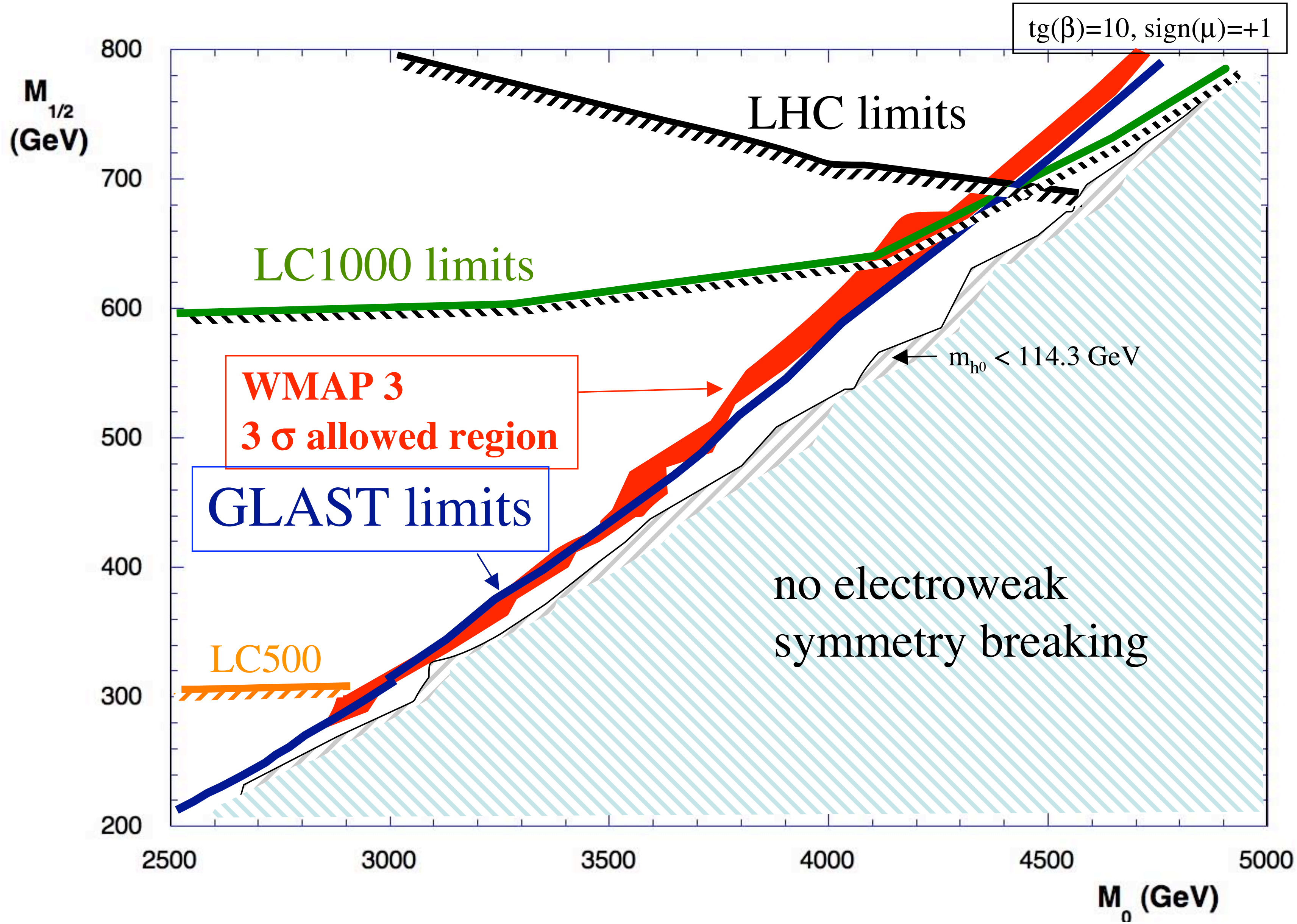
GLAST, PAMELA, LHC, LC Sensitivities to Dark Matter Search

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



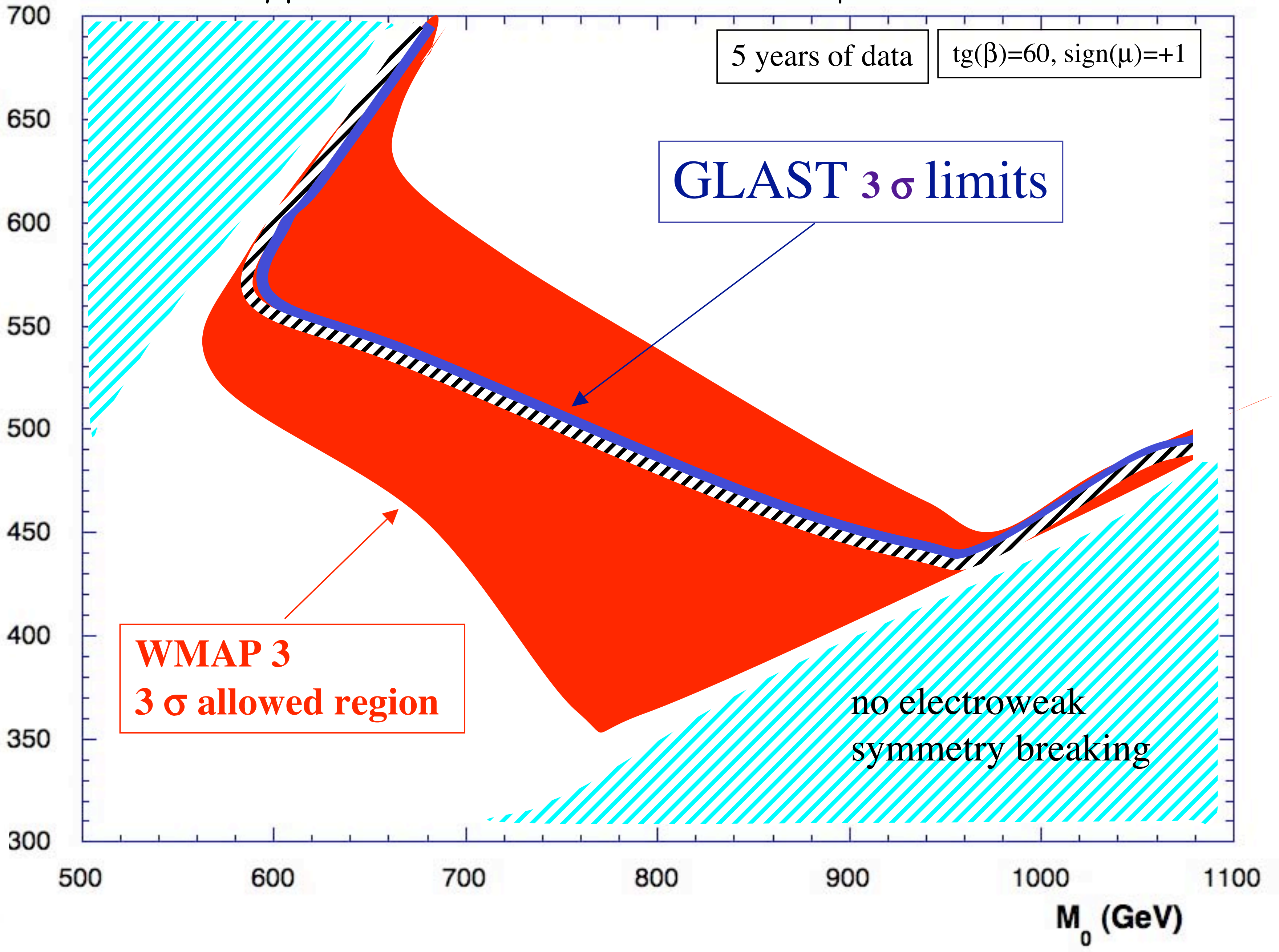
mSUGRA



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(β)=60. GLAST 3σ sensitivity is shown at the blue line and below for truncated NFW halo profile



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

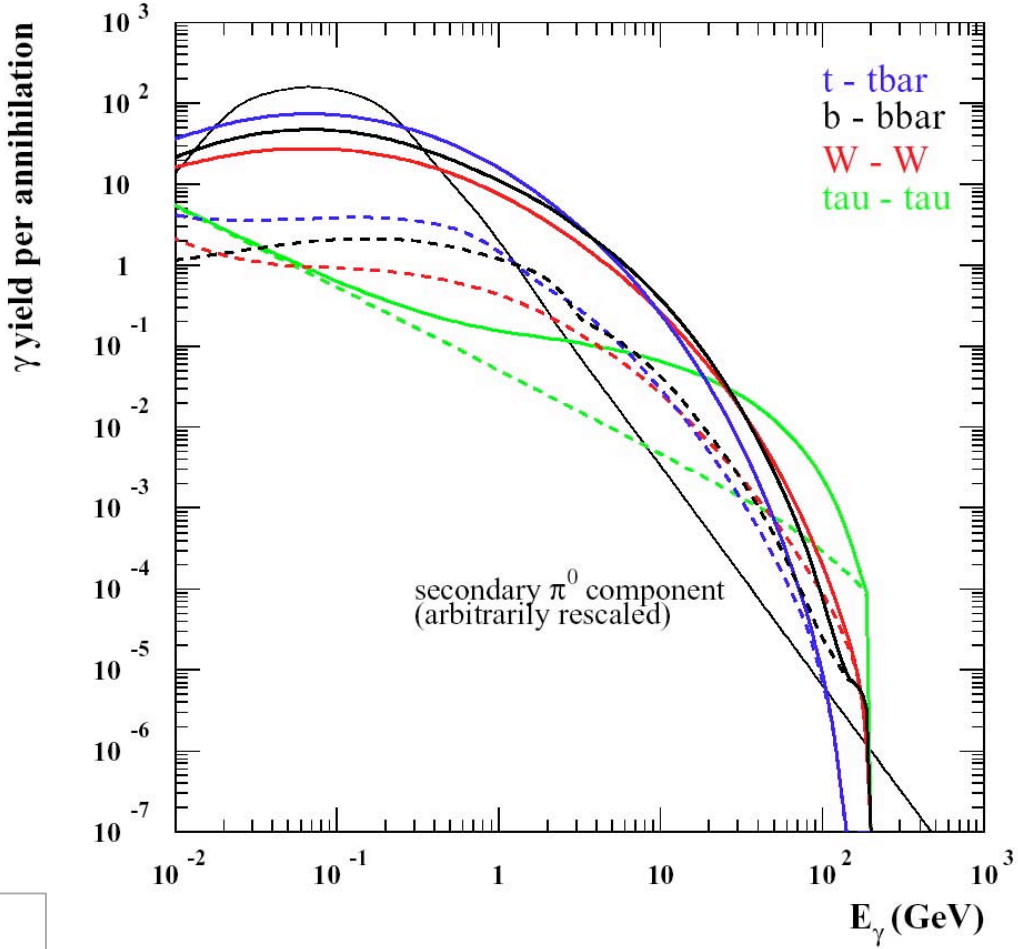
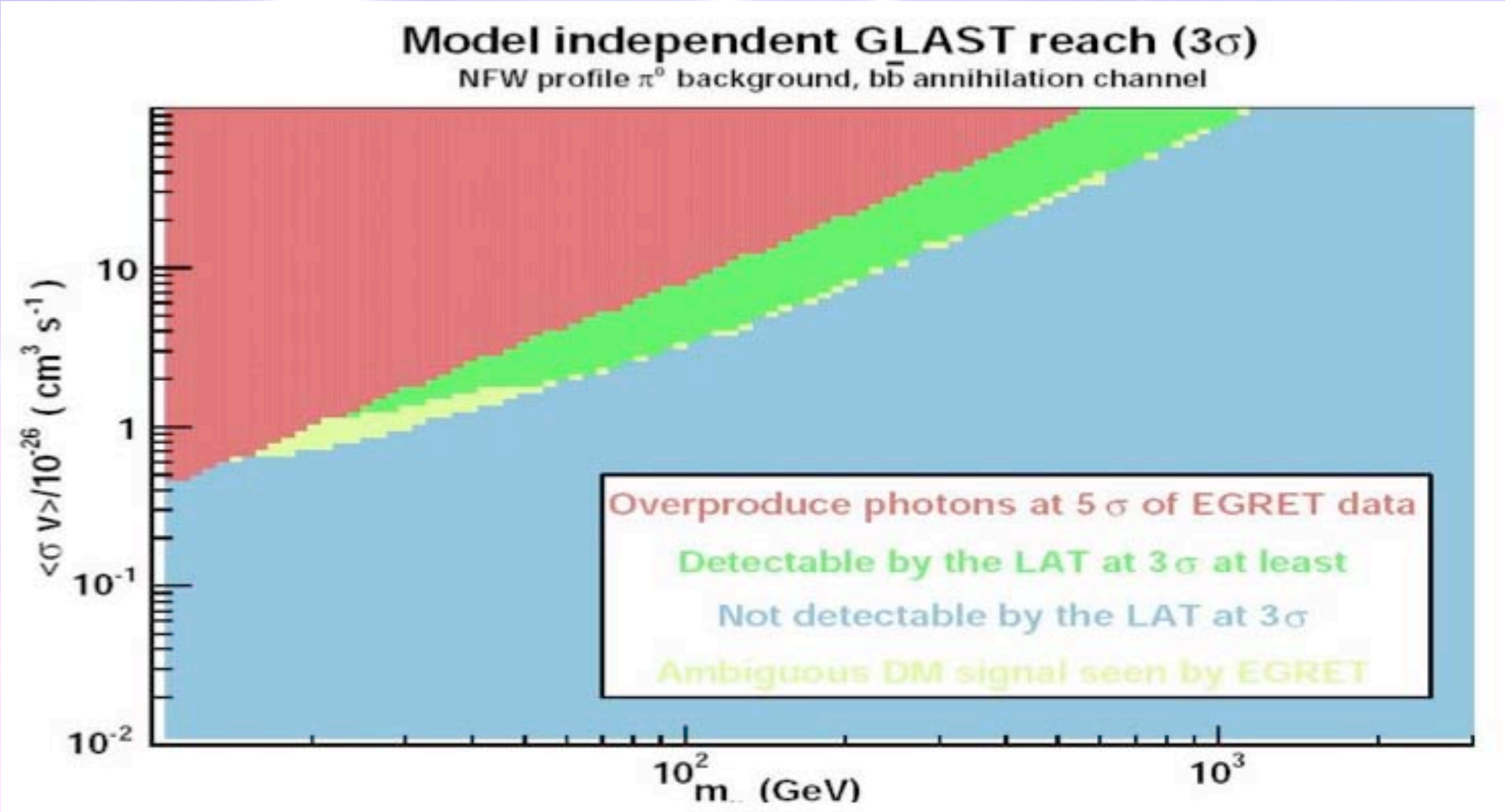


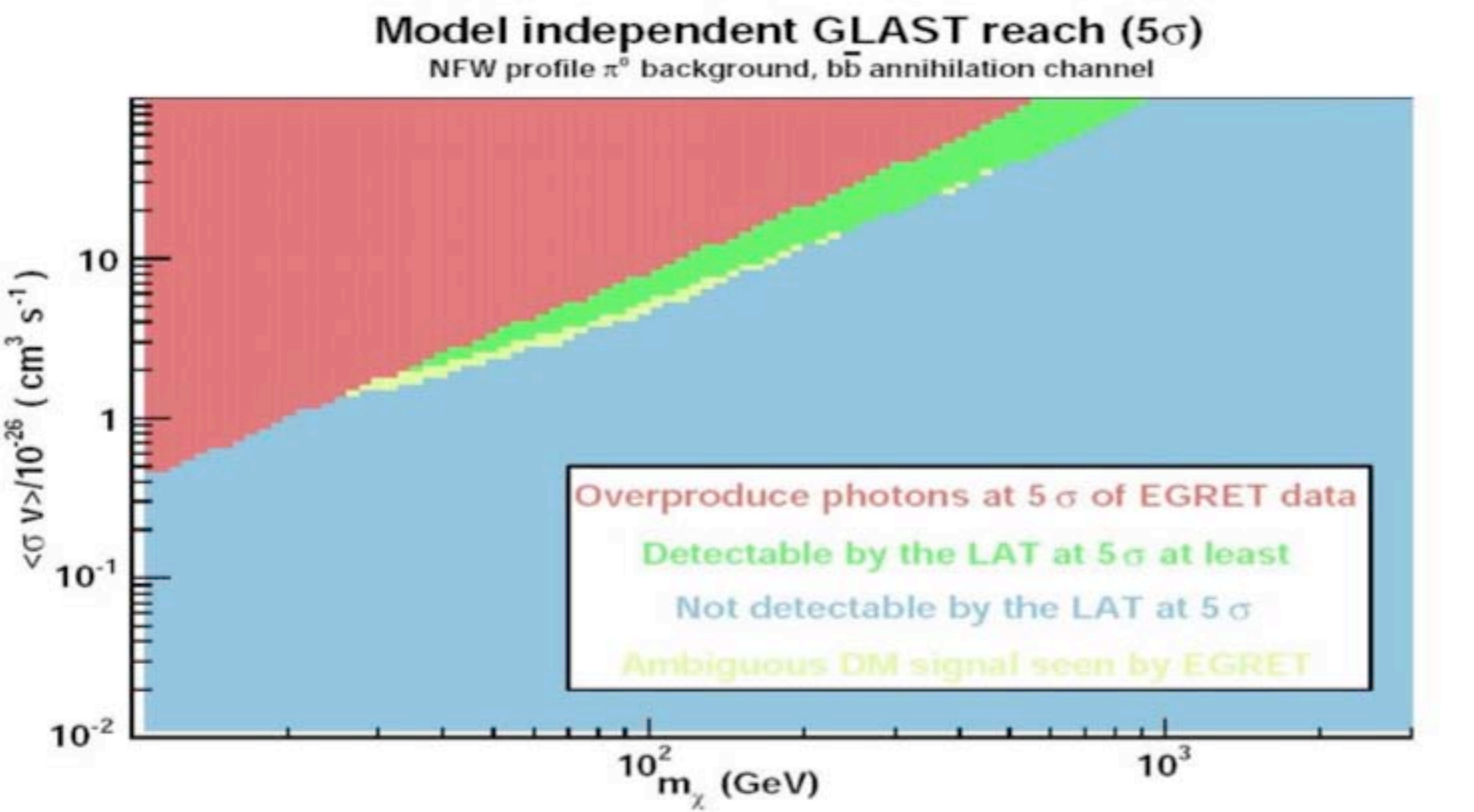
figure from: A.Cesarini, F.Fucito, A.Lionetto, A.Morselli, P.Ullio, Astroparticle Physics, 21, 267-285, June 2004 [astro-ph/0305075]

Model independent results for the GC



1 deg radius , 4 years of operations, truncated NFW (J(ψ)= 1200, E>1GeV)

Model independent results for the GC



GLAST Master Schedule

- **August 2004**

Assembling of first tower completed

- **Middle of October 2005**

Completion of the LAT – *Environmental testing*

- **February 2006**

Delivery to NRL–

- **31 Jan. 2008**

Kennedy Space Flight Center

LAUNCH

•June 2008

Science operation begins!

more info : http://people.roma2.infn.it/glast/

Conclusion

GLAST launch is currently scheduled for Jan. 31 2008.

- Guest Investigator Program Proposals due September 9

http://glast.gsfc.nasa.gov/ssc/proposals/GI_Program_Background.html

SWIFT instrument launches on the same type rocket planned for GLAST