The Current Astrophysical and Experimental Picture of Dark Matter

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The Case

The "best" matter density

WMAP (Bennett et al., 2003)

$$\Omega_m h^2 = 0.135^{+0.008}_{-0.009}$$

of which

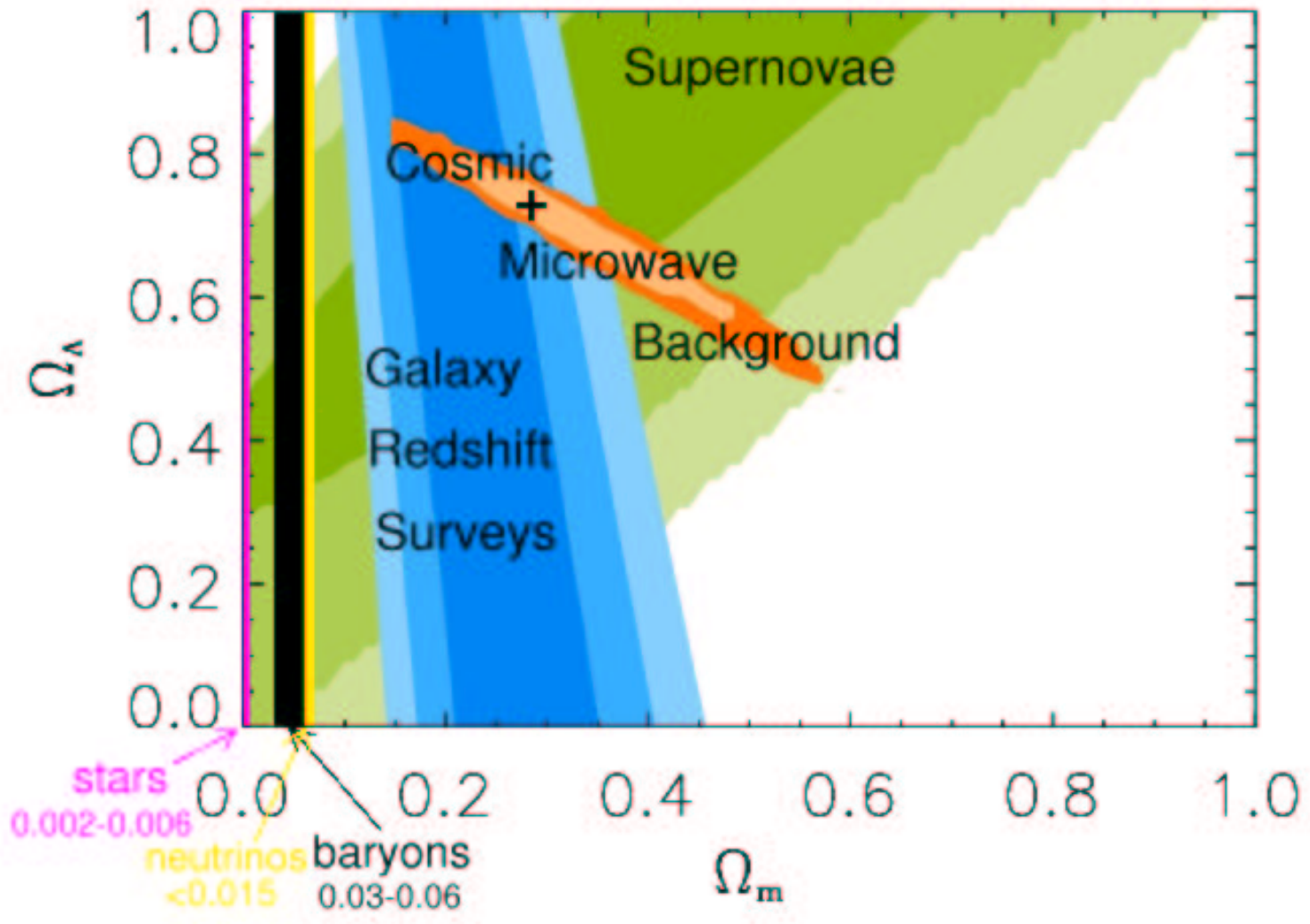
$$\Omega_\nu h^2 < 0.0076 \ (95\%\mathrm{CL})$$

$$\Omega_b h^2 = 0.0224 \pm 0.0009$$

$$\Omega_{\mathrm{CDM}} h^2 = 0.113^{+0.008}_{-0.009}$$

(Units are $1.879 \times 10^{-29}\ \mathrm{g/cm^3}$)

The concordance cosmology



Adapted from L. Verde

The dark matter problems

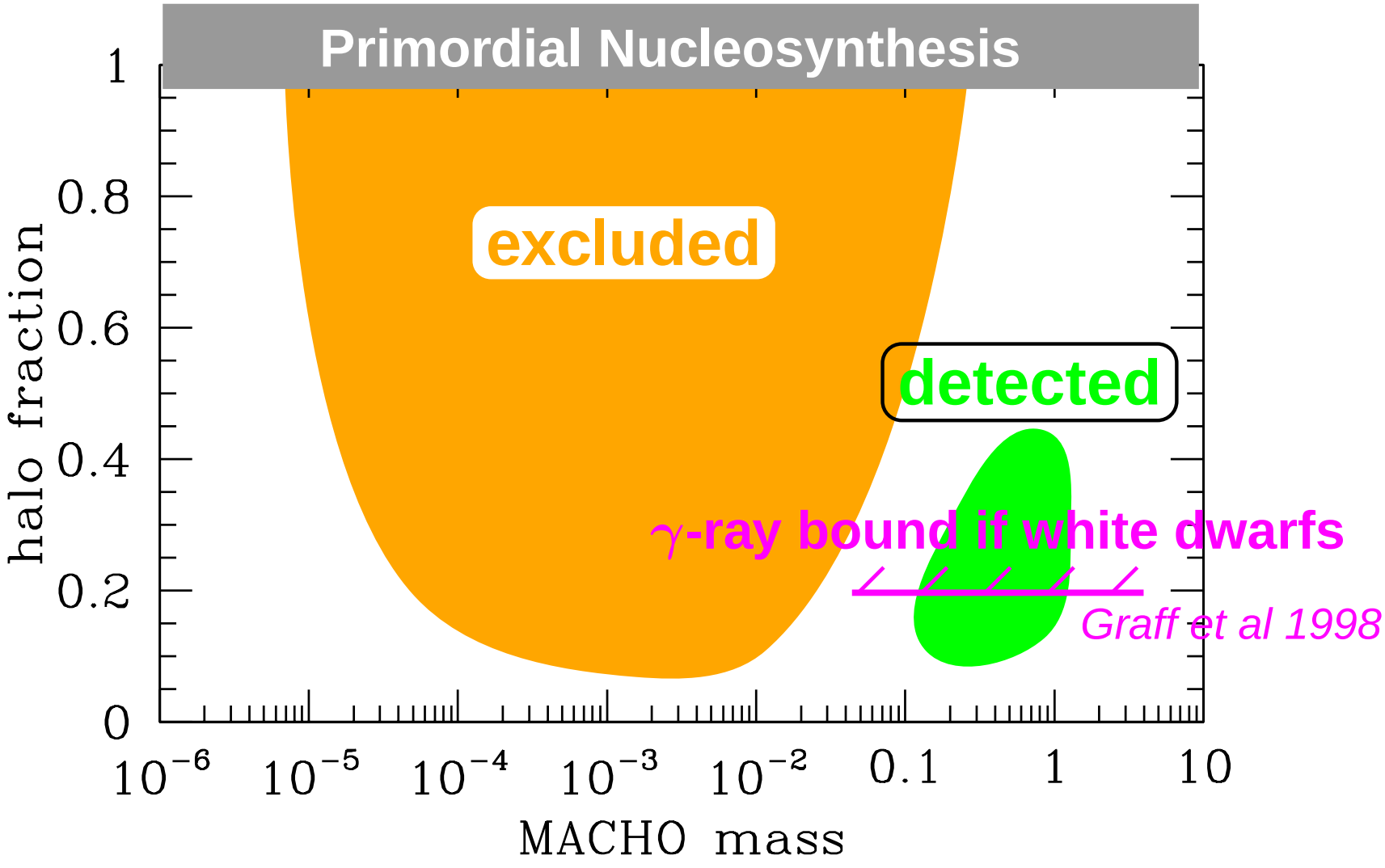
- **Missing baryons at low redshift**
- **Non-baryonic dark matter**

Suspects

Suspect #1: MACHOs

Massive Compact Halo Objects

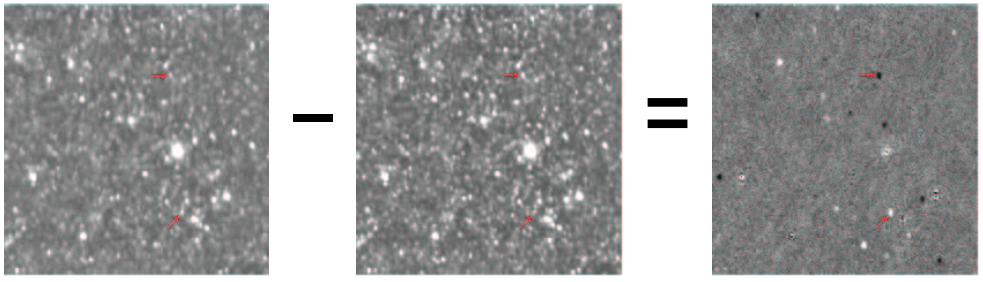
MACHOs!



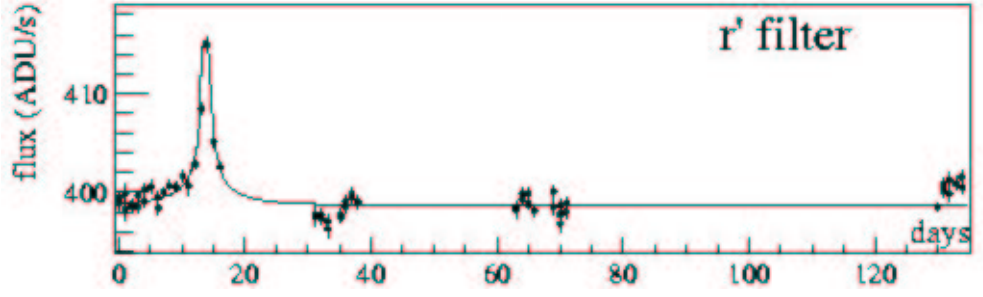
MACHO & EROS 1996-2000

“Pixel” microlensing

monitor unresolved stars in M31, M87, . . .

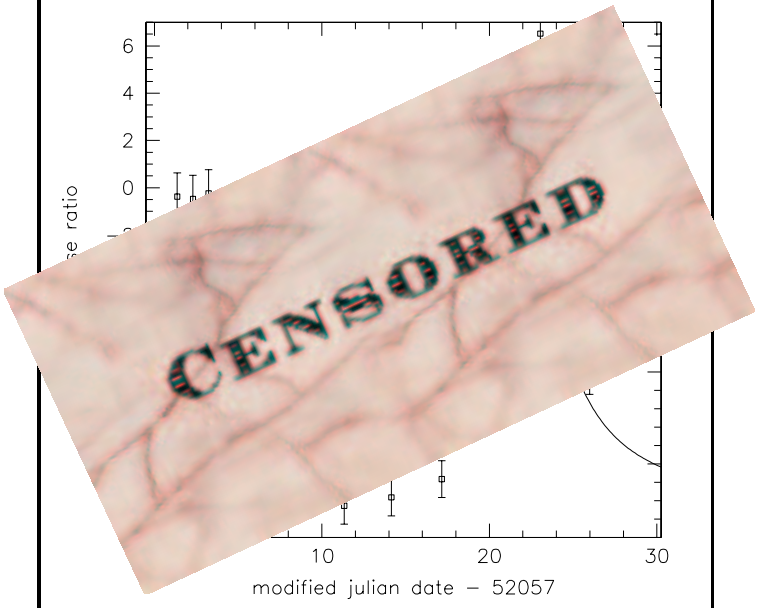


MEGA 2001



POINT-AGAPE 2001

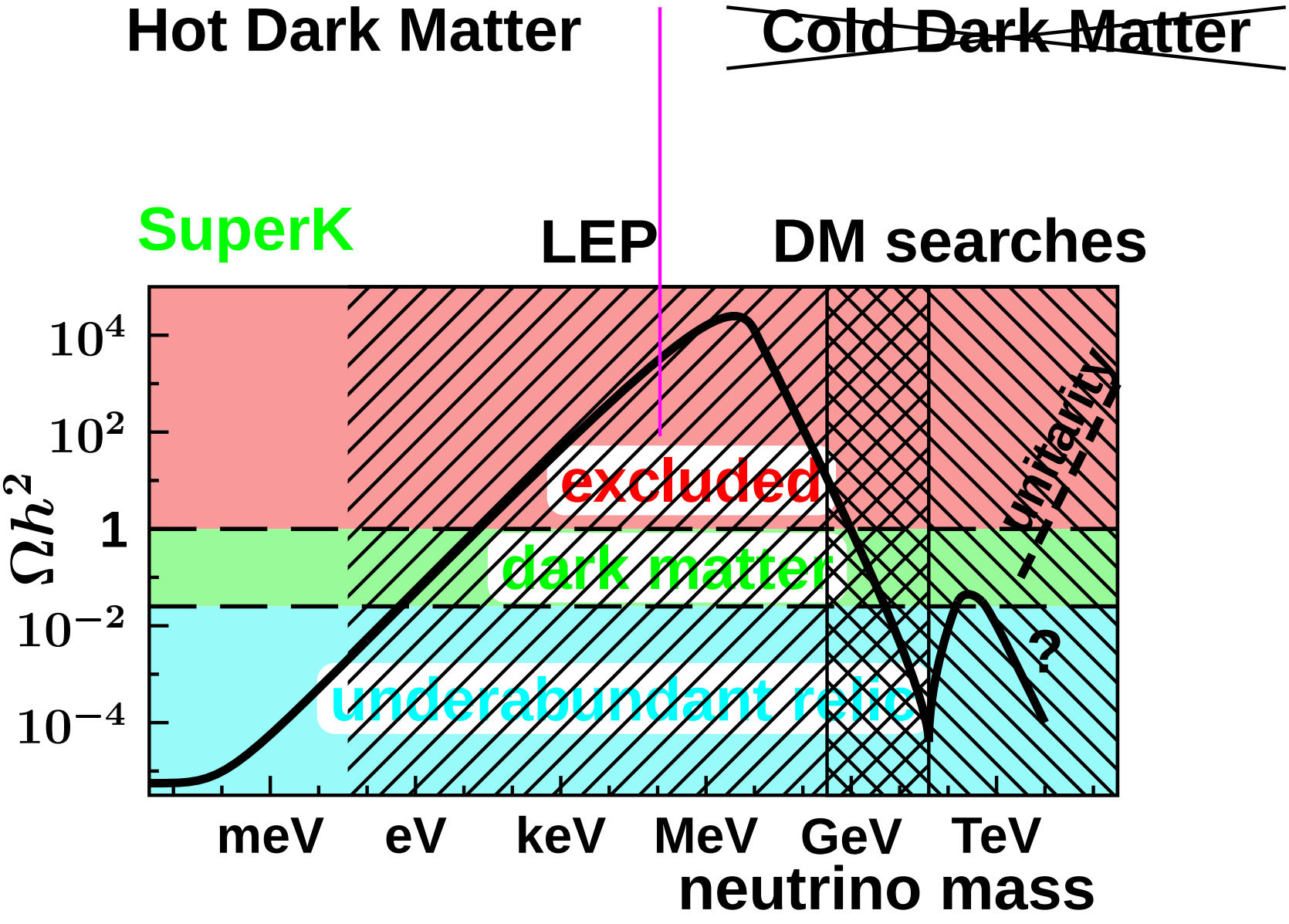
M87



Baltz,Gondolo,Lauer, Silk,et al, in prep

Suspect #2: neutrinos

Neutrinos as dark matter



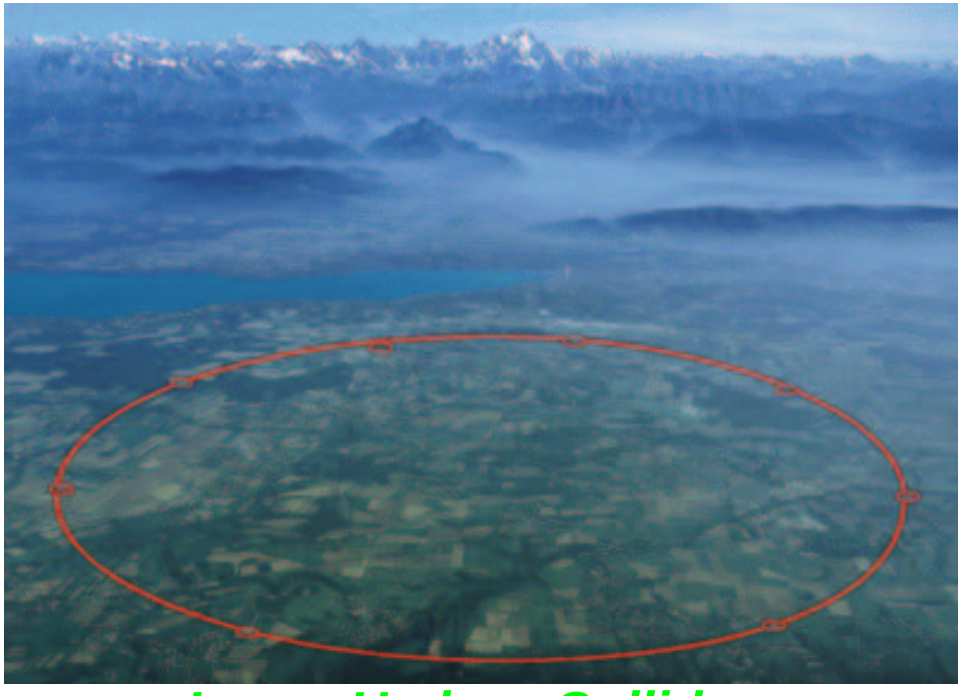
Suspect #3: WIMPs

Weakly Interacting Massive Particles

Supersymmetry

- **Unification of fundamental forces**
- **Stabilization of scalar masses**

slepton	$\leftrightarrow$	**lepton**
squark	$\leftrightarrow$	**quark**
gaugino	$\leftrightarrow$	**gauge boson**
higgsino	$\leftrightarrow$	**Higgs boson**

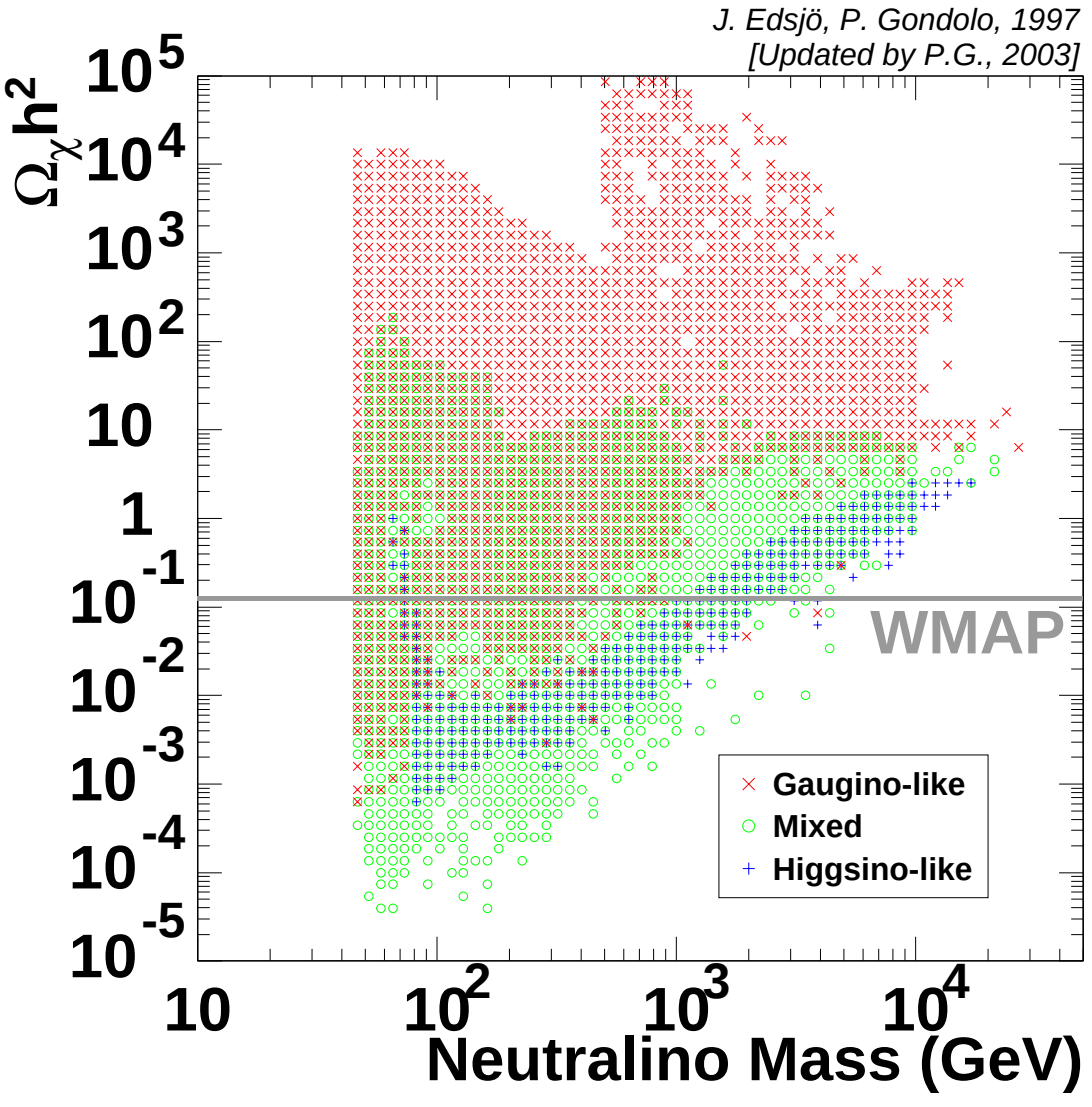


Large Hadron Collider

Next Linear Collider

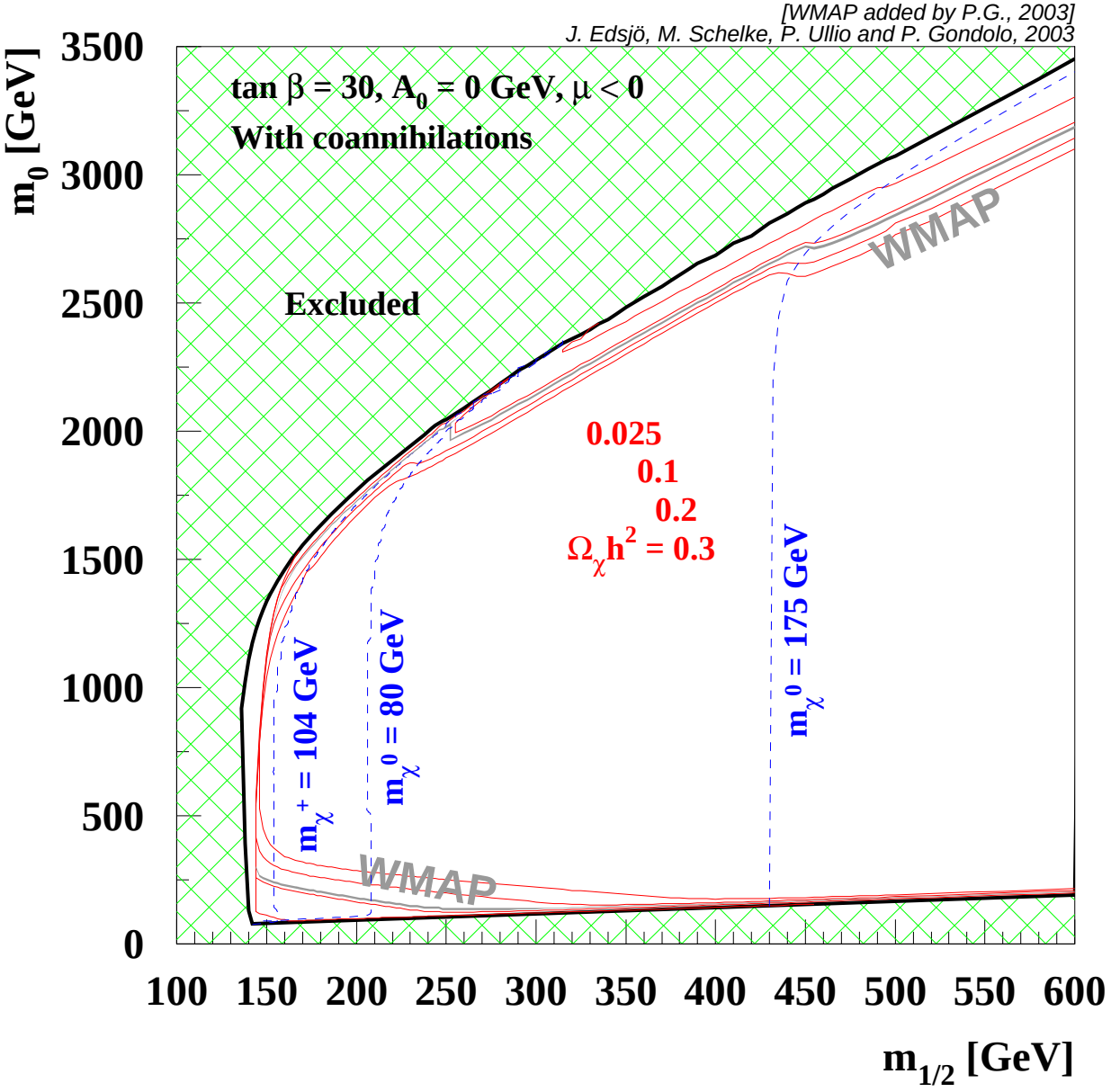
Supersymmetric dark matter

The lightest supersymmetric particle is a good dark matter candidate



Updated from Edsjö, Gondolo 1997

Some results in mSUGRA



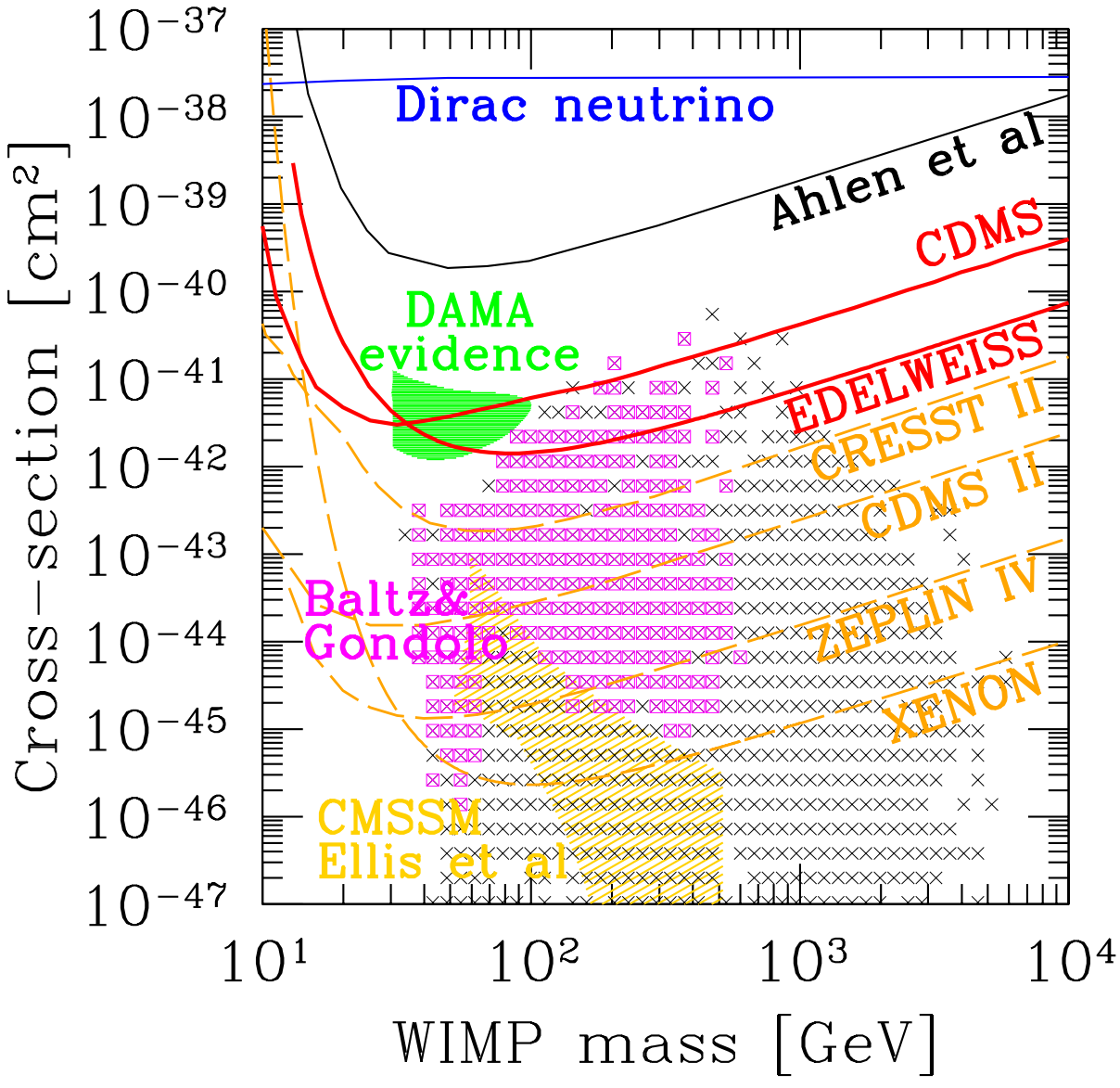
Cosmology and mSUGRA

- **Cosmological data on $\Omega_\chi h^2$:** **7%**
  WMAP first year data: $\Omega_{\rm CDM} h^2 = 0.113^{+0.008}_{-0.009}$
- **Neutralino annihilation chain:** **1%**
  Edsjö, Schelke, Ullio, Gondolo, 2003
- **Masses from GUT parameters:** **50%**
  See Allanach, Kraml, Porod, 2003

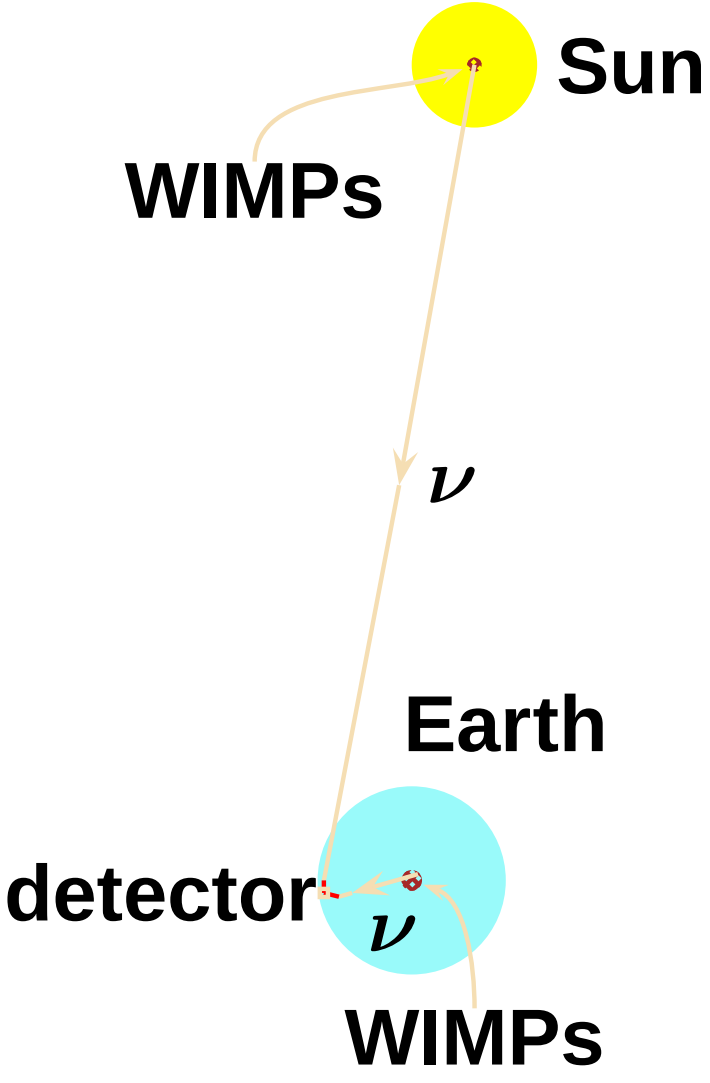
Searching for dark WIMPs

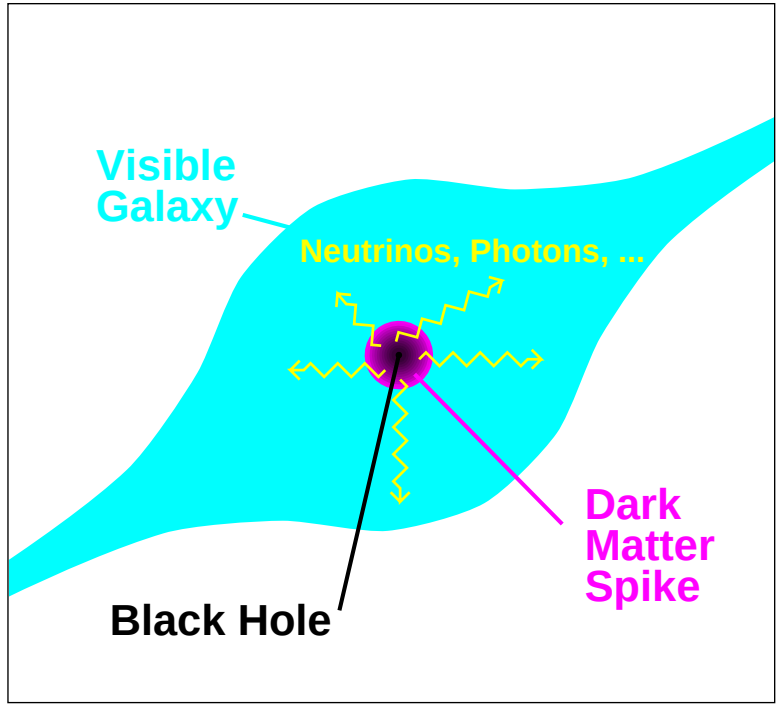
- direct detection
- neutrinos from Sun/Earth
- anomalous cosmic rays from galactic halo
- neutrinos, gamma-rays, radio waves from galactic center

WIMP direct searches



Neutrinos from dark matter

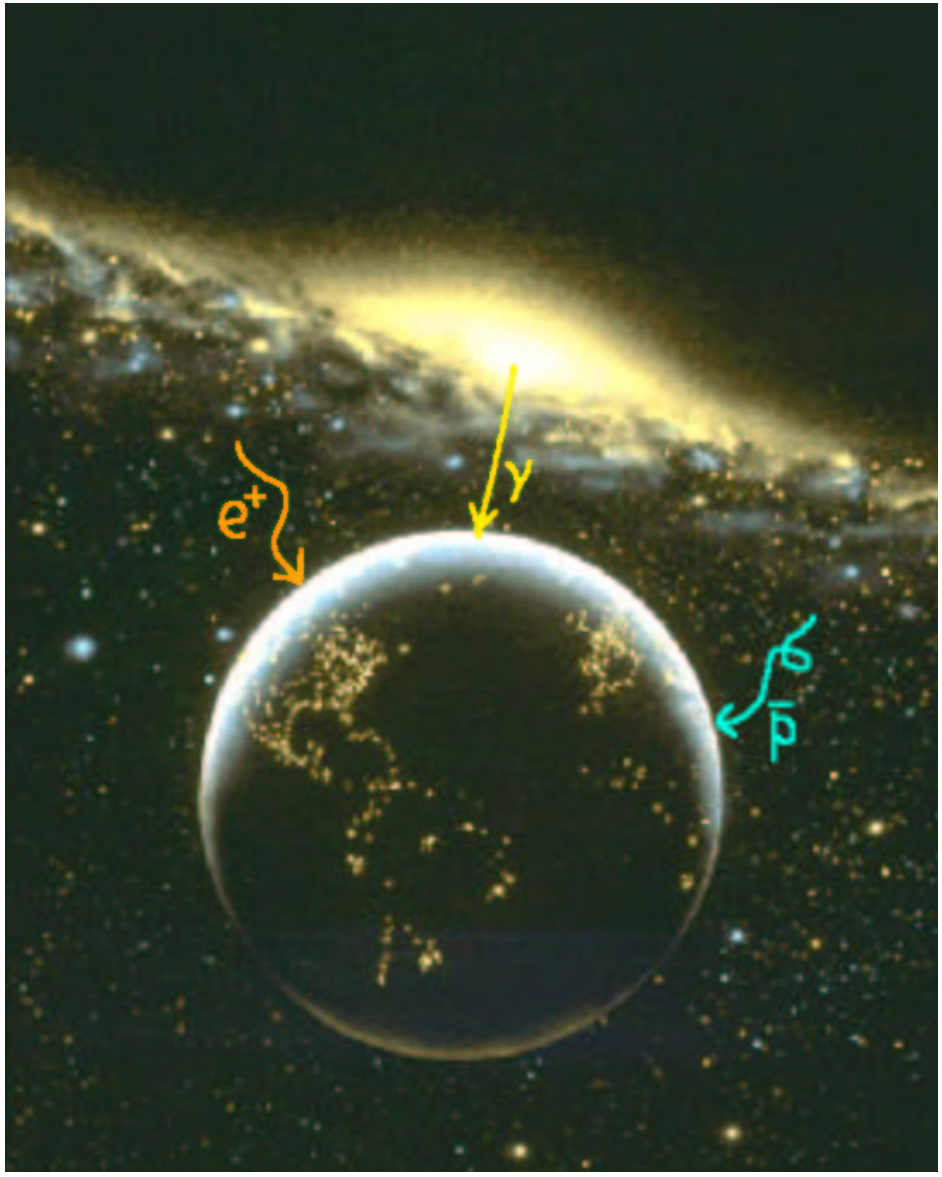




Gondolo,Silk 1999, Gondolo 2000

SuperK, AMANDA,
Antares, IceCube, . . .

Cosmic rays from dark matter

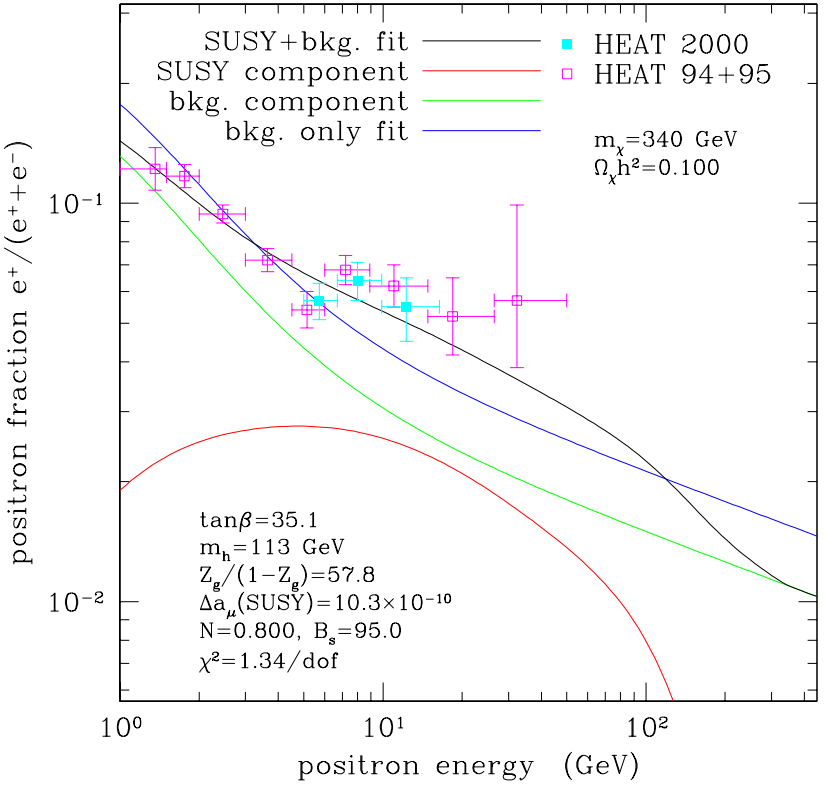


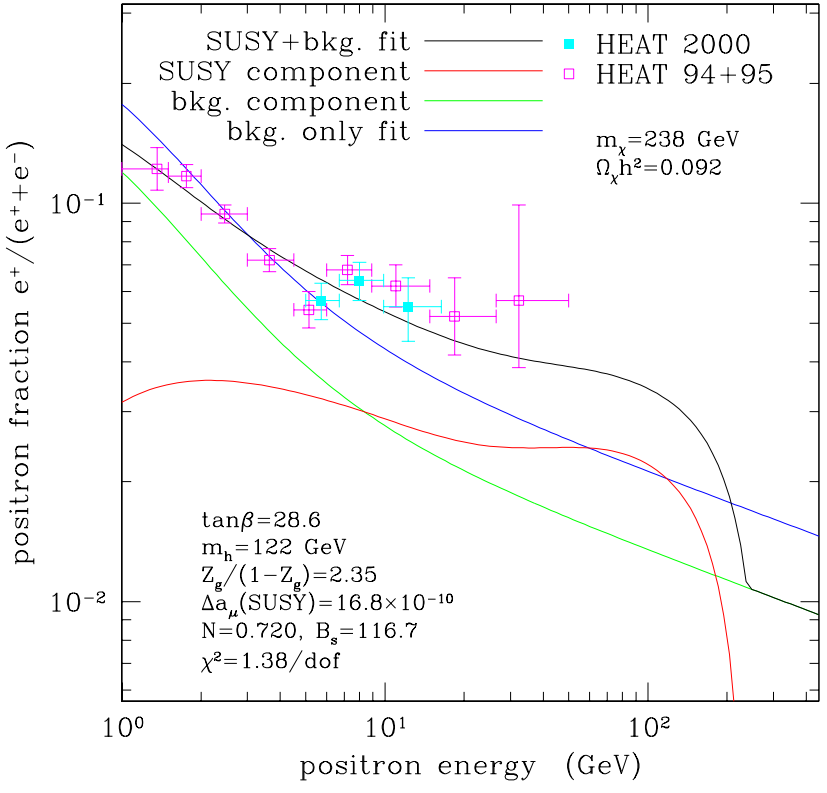
Background by J. Lomberg 1989

Positron excess

HEAT balloon finds anomaly in cosmic ray flux

Possible explanation: supersymmetry in the galaxy

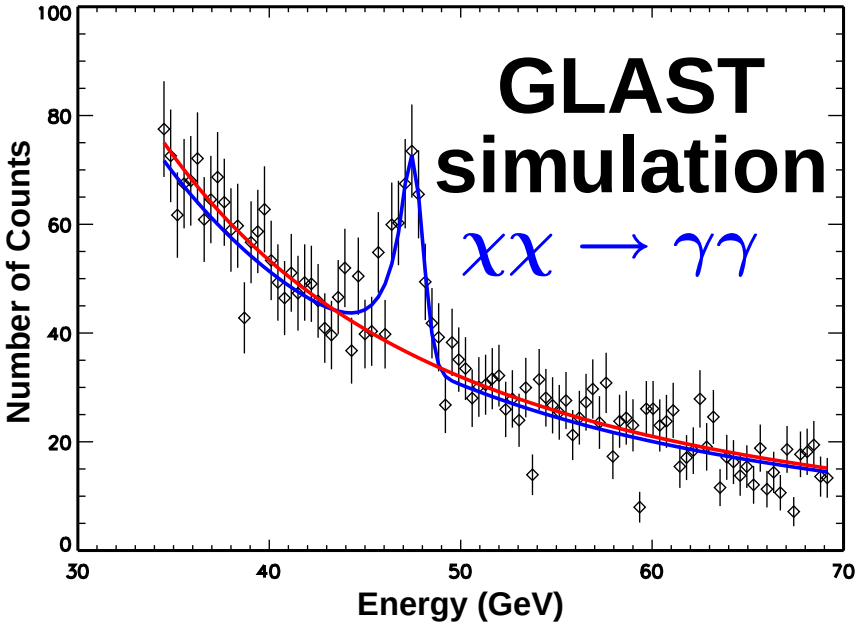


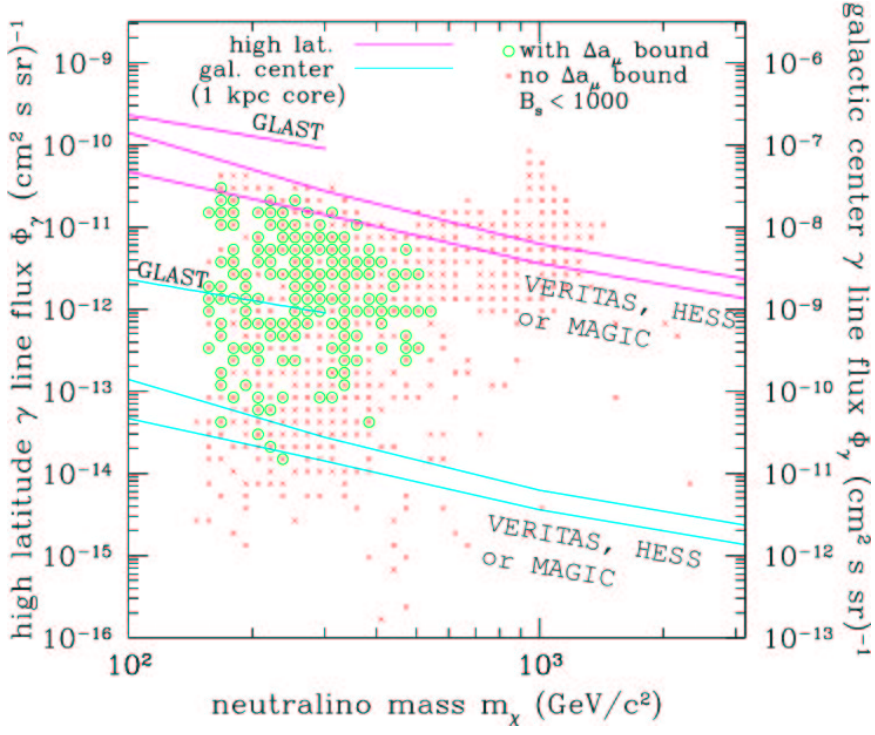


Baltz, Edsjö, Freese, Gondolo 2001

Positron excess

Future test of WIMP explanation: Gamma-rays from galactic halo





Baltz, Edsjö, Freese, Gondolo 2001

Other suspects:

Missing baryons:

- **black holes,**
- **cold-warm gas,**
- **…**

Non-baryonic:

- **axions,**
- **WIMPZILLAs,**
- **Kaluza-Klein particles,**
- **…**

Summary

Baryonic and non-baryonic dark matter

In search of the missing baryons

In search of non-baryonic dark matter

Dark Matter Mystery Solved