Particle Astrophysics, Dark Matter and TeV gamma rays

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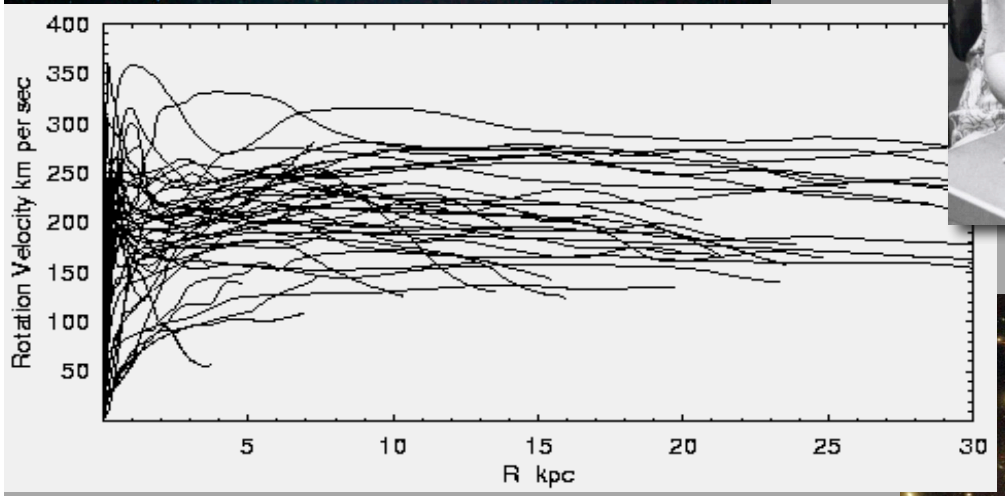
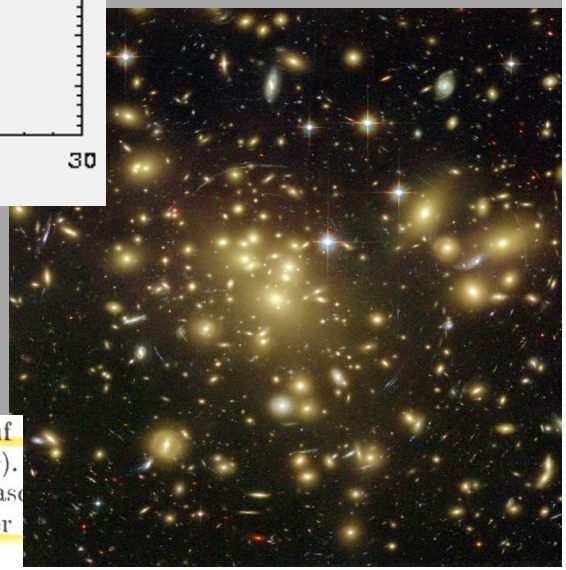
CTAs explore regimes where LHC or ILC cannot go

A Brief History of Dark Matter

Vera Rubin



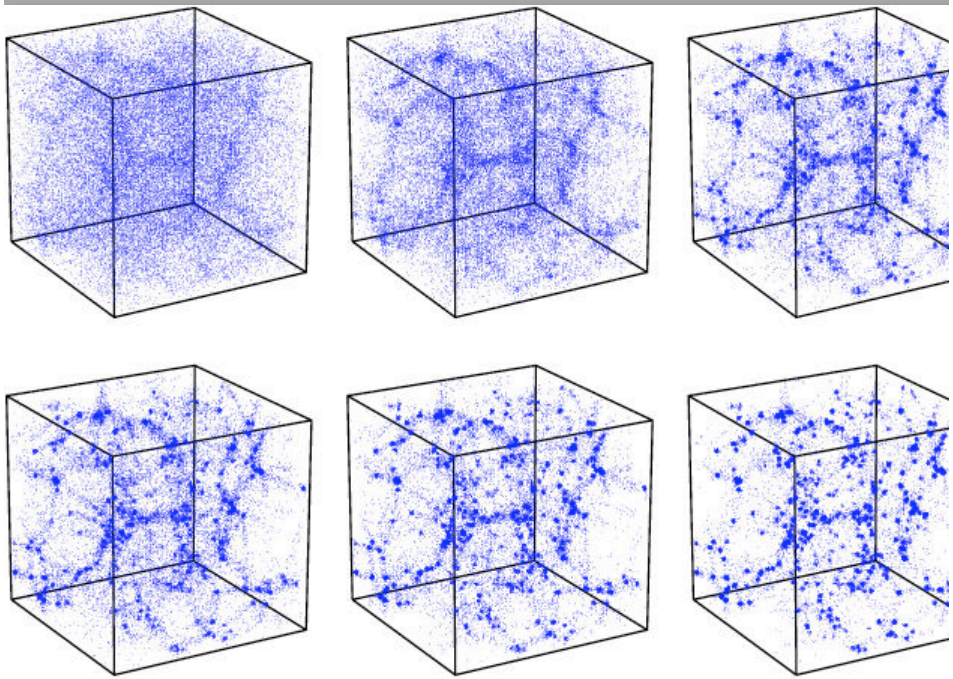


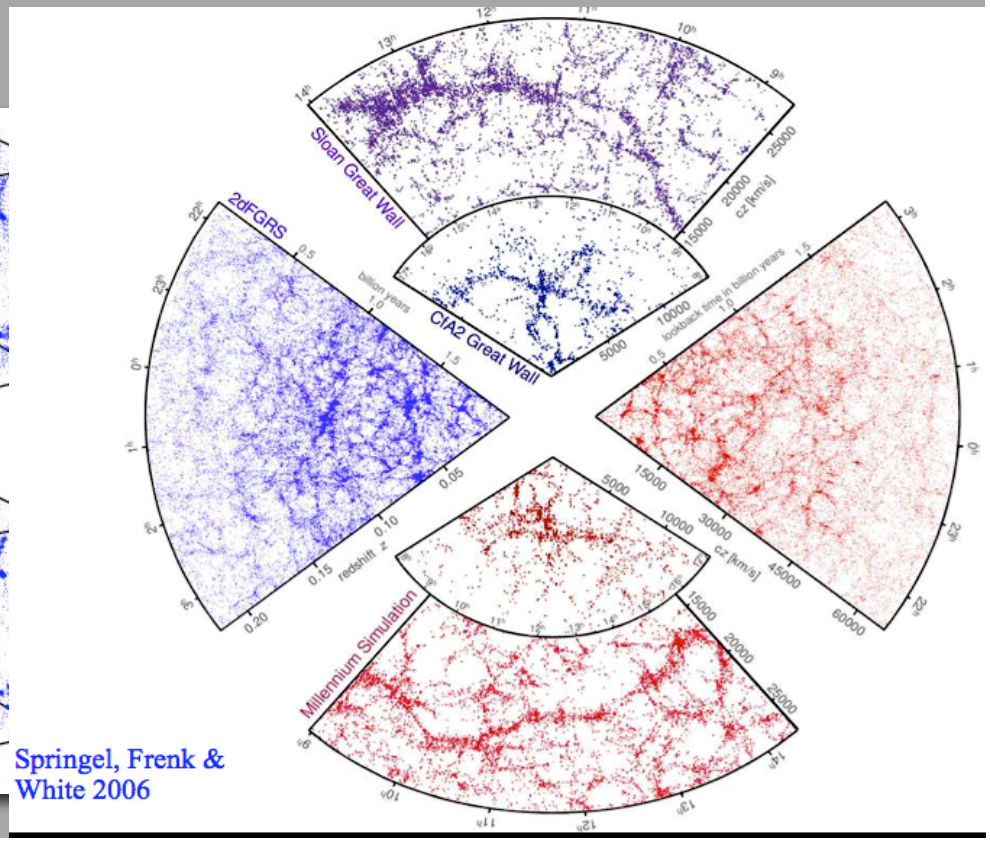
Fritz Zwicky

Comasystem mindestens 400 mal grösser sein als die auf
n Beobachtungen an leuchtender Materie abgeleitete[1]).
h dies bewahrheiten sollte, würde sich also das überras
esultat ergeben, dass dunkle Materie in sehr viel grösserer
rhanden ist als leuchtende Materie.

A Brief History of Dark Matter

- ***WIMPs*** - Weakly Interacting, Massive Particles - are the leading class of dark matter candidates
- The large scale structure of our universe matches that predicted for ***cold***, ***collisionless*** dark matter
- WIMPs seed structure growth



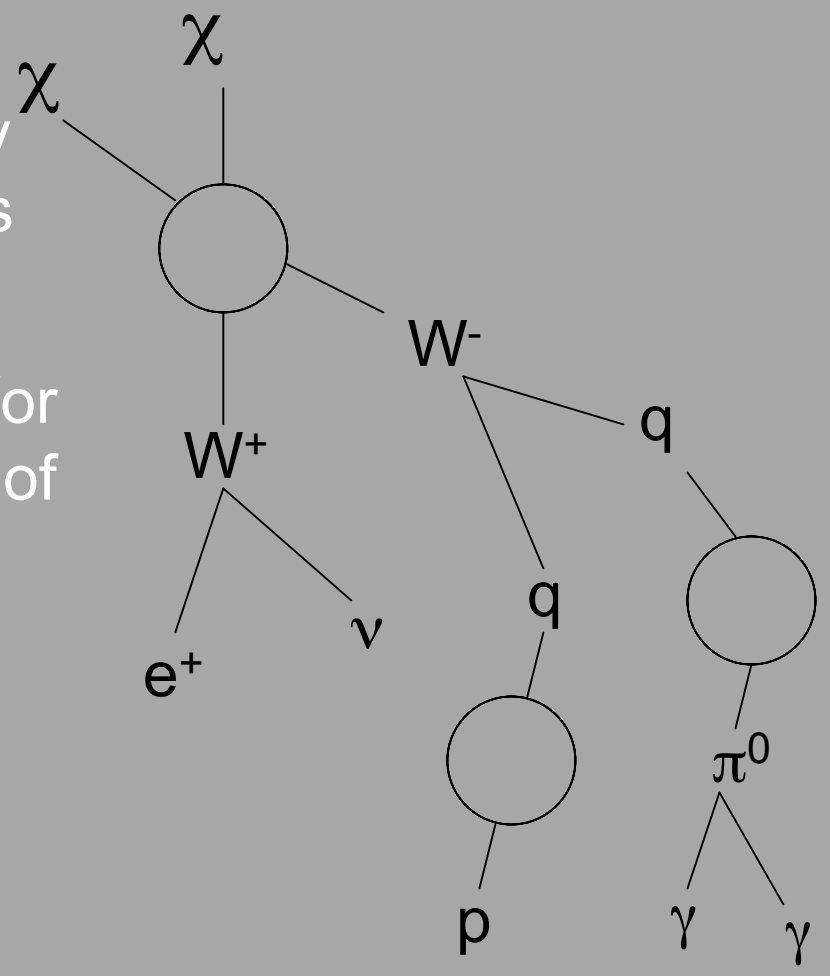


Springel, Frenk & White 2006

Indirect Detection of Dark Matter

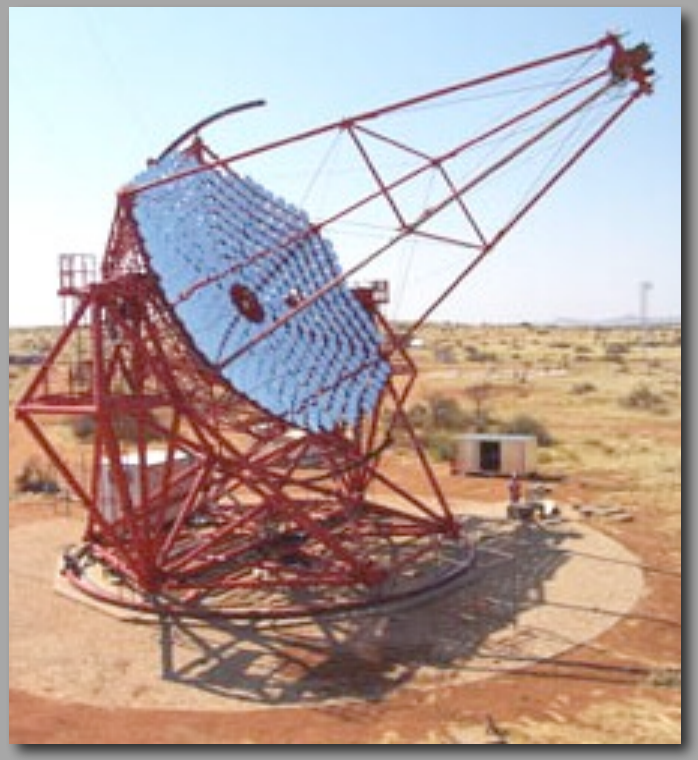
1) **WIMP Annihilation**
   Typical final states include heavy fermions, gauge or Higgs bosons

2) **Fragmentation/Decay**
   Annihilation products decay and/or fragment into some combination of high energy electrons, positrons, protons, antiprotons, deuterium, neutrinos and gamma rays



Gamma-Rays from the Galactic Center

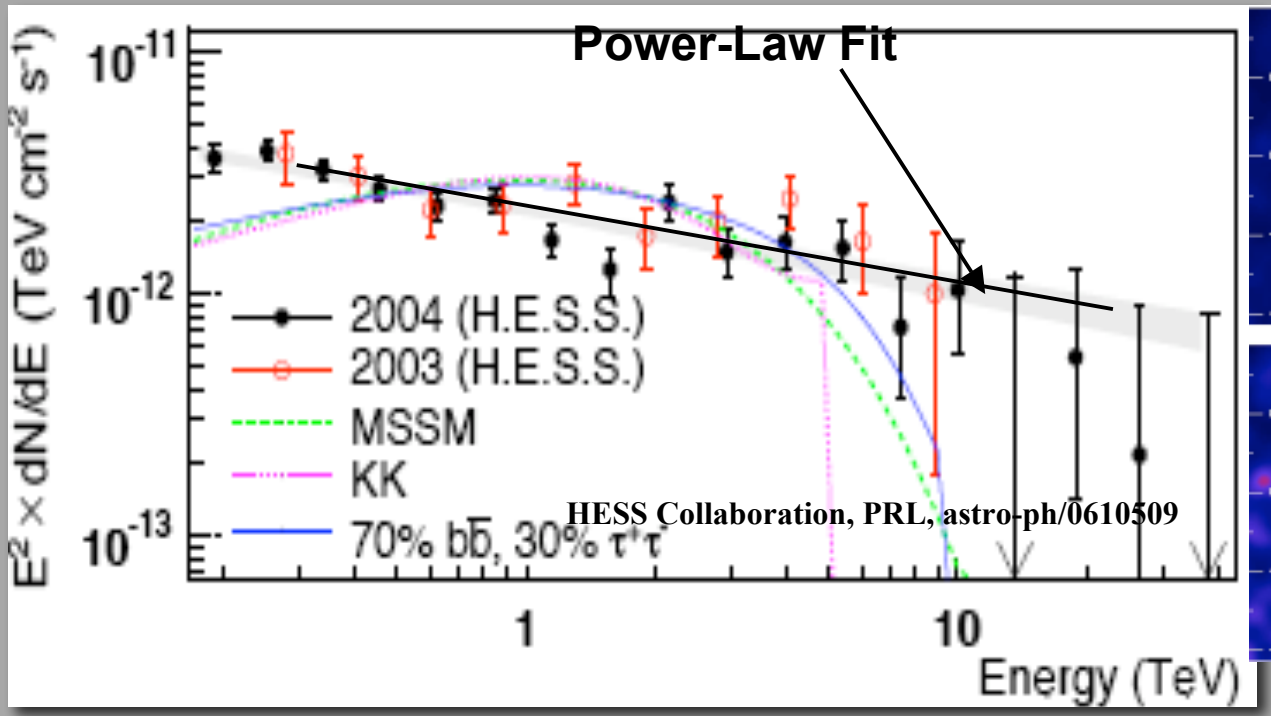
- Simulations predict that the GC contains very high densities of dark matter (and high annihilation rates)
- HESS, MAGIC, WHIPPLE and CANGAROO each claim positive detection of ~TeV gamma-rays
- Dark matter, or other astrophysics?



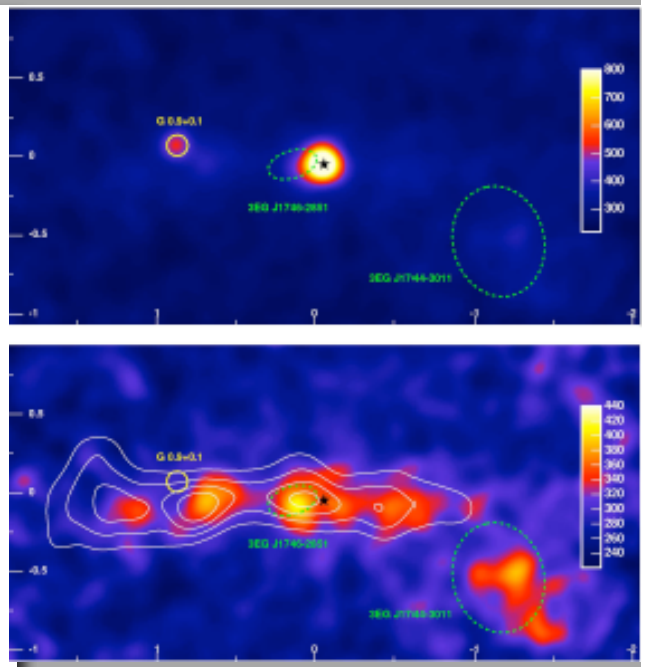
Gamma-Rays From The Galactic Center

Spectrum measured by HESS extends to at least ~10TeV

If annihilations: too heavy for neutralino? spectral shape?



HESS Collaboration, PRL, astro-ph/0610509



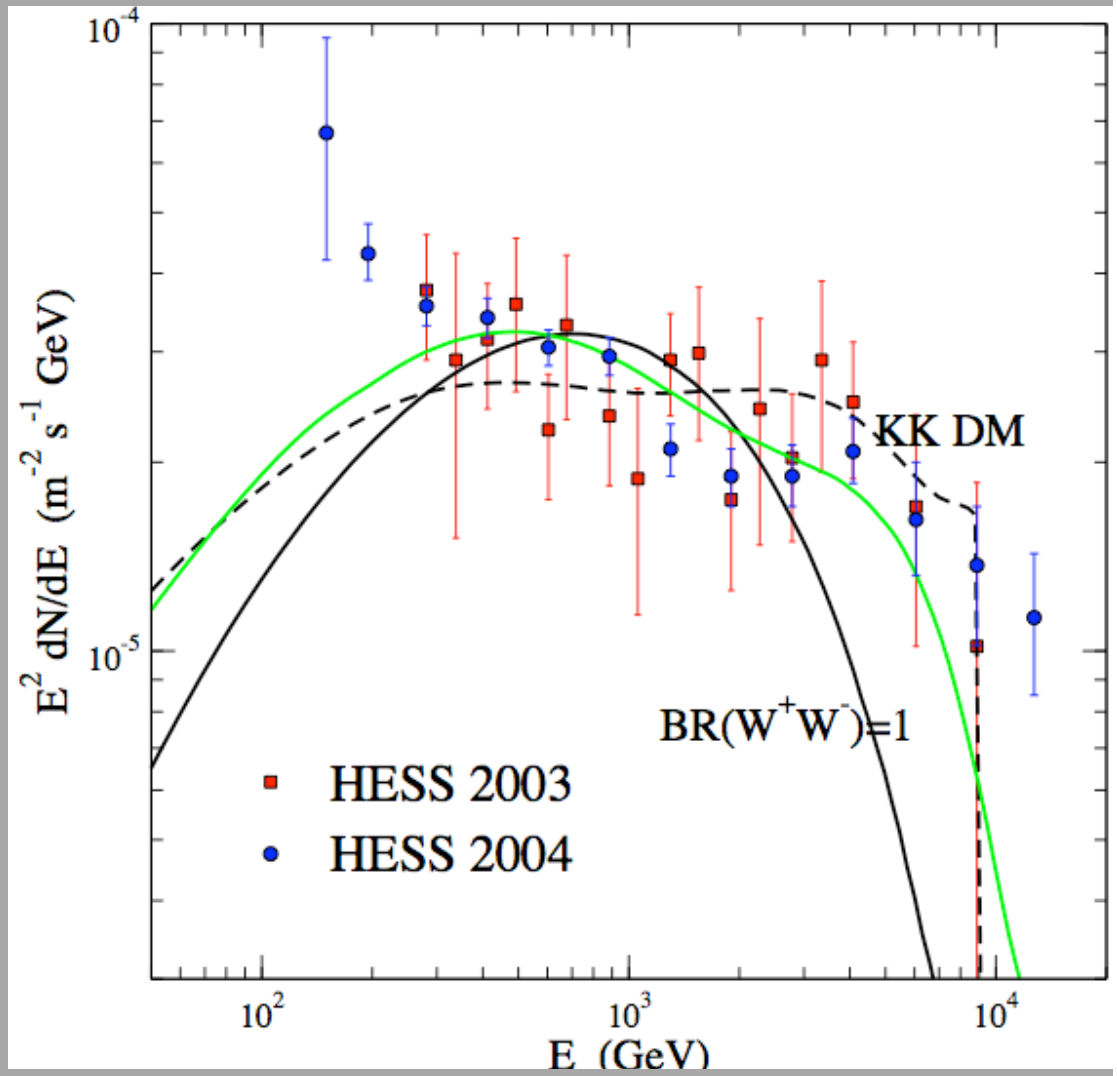
Or particle acceleration near supermassive black hole?

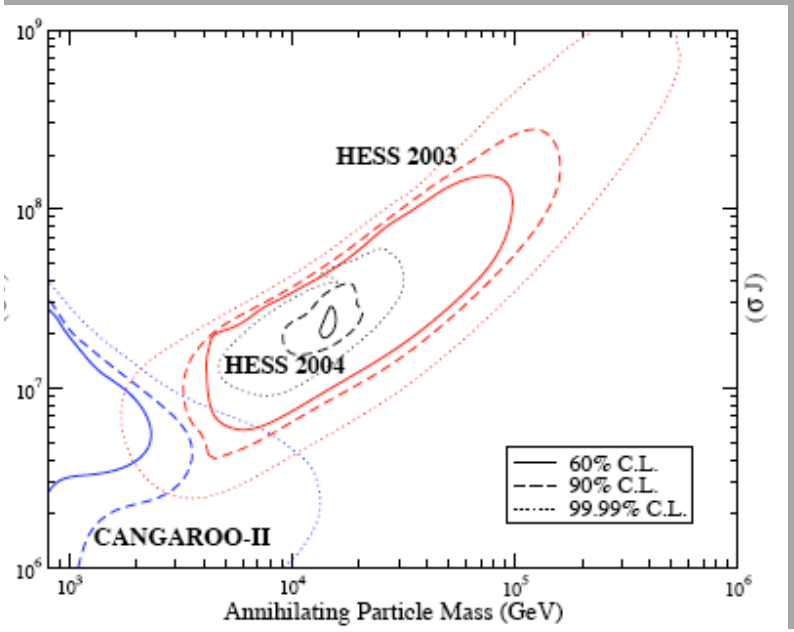
Aharonian and Neronov (astro-ph/0408303)

Atoyan and Dermer (astro-ph/0410243)

Gamma-Rays From The Galactic Center

Profumo 2005



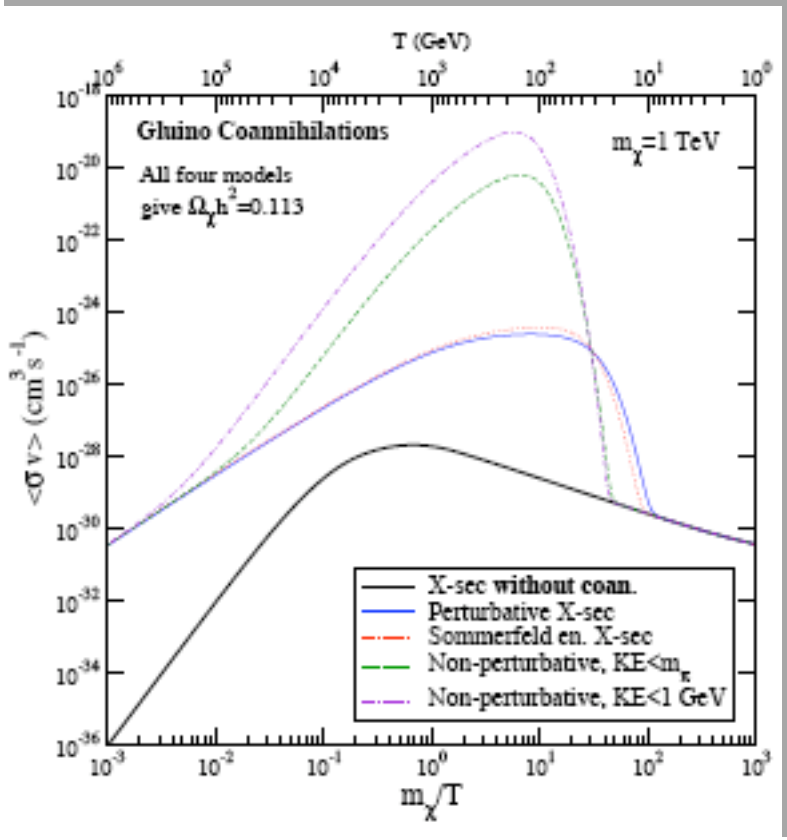


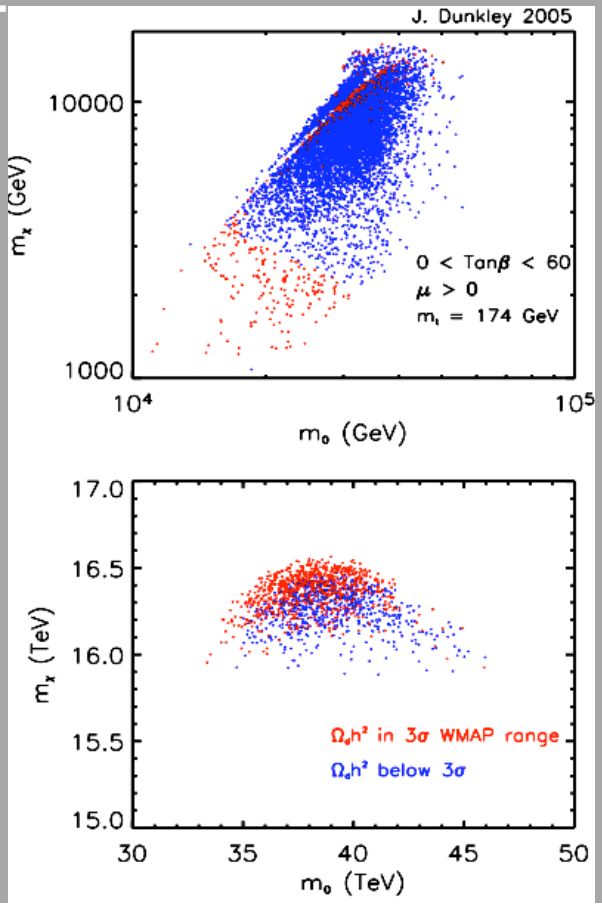
How high can you go in neutralino mass?

Coannihilations boost cross-section by 10-100 (Profumo 2005)
Stable SUSY LSP can go up to 20+ TeV

Or just lower neutralino component of dark matter

Or lets seek alternative to SUSY LSP……



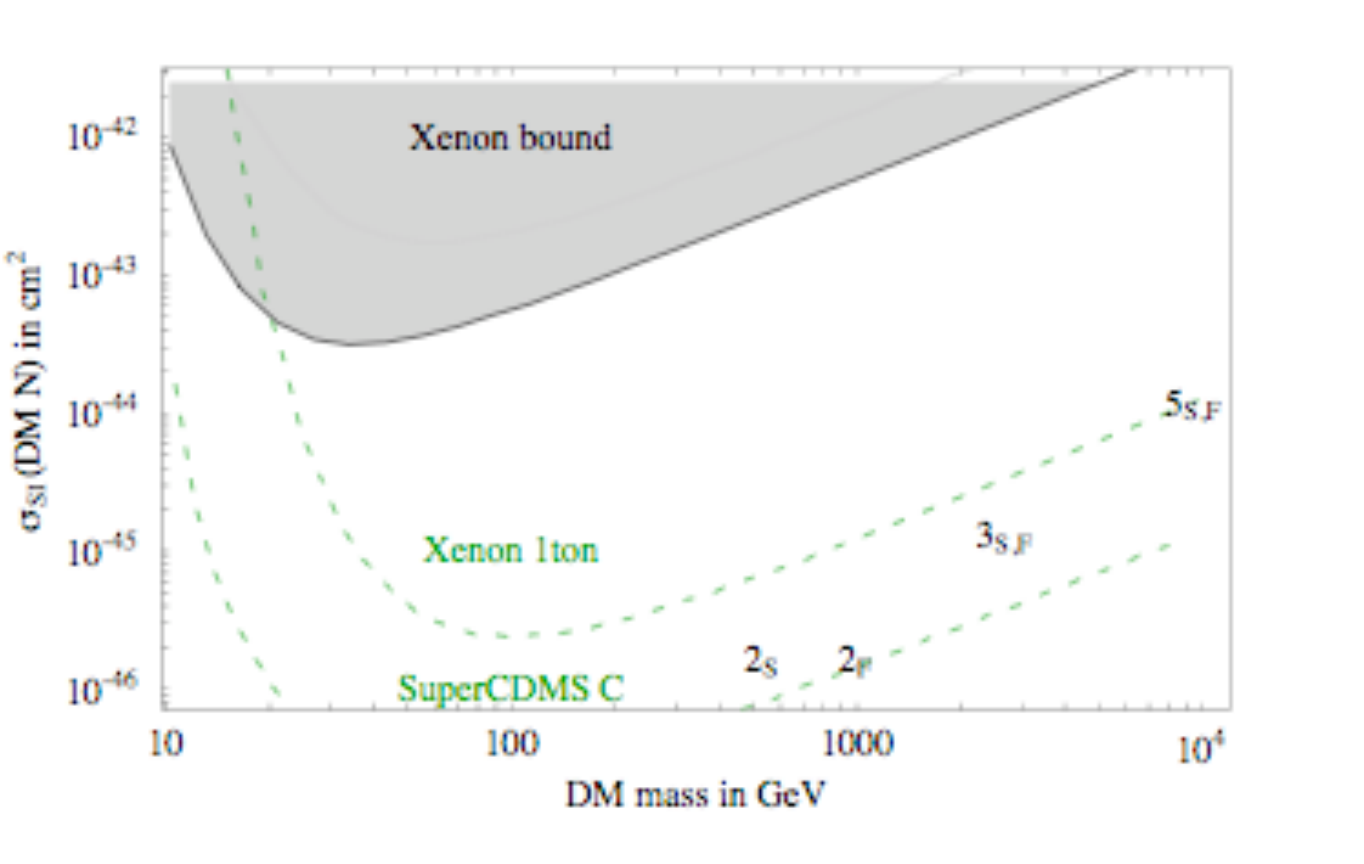


Direct detection

Minimal dark matter: (Cirelli et al. 2007)

weak scale and couplings: $M/g \sim (T_0 M_{pl})^{1/2} \sim$ TeV

standard model + 1 new multiplet, weakly coupled (< 0.001) to Z



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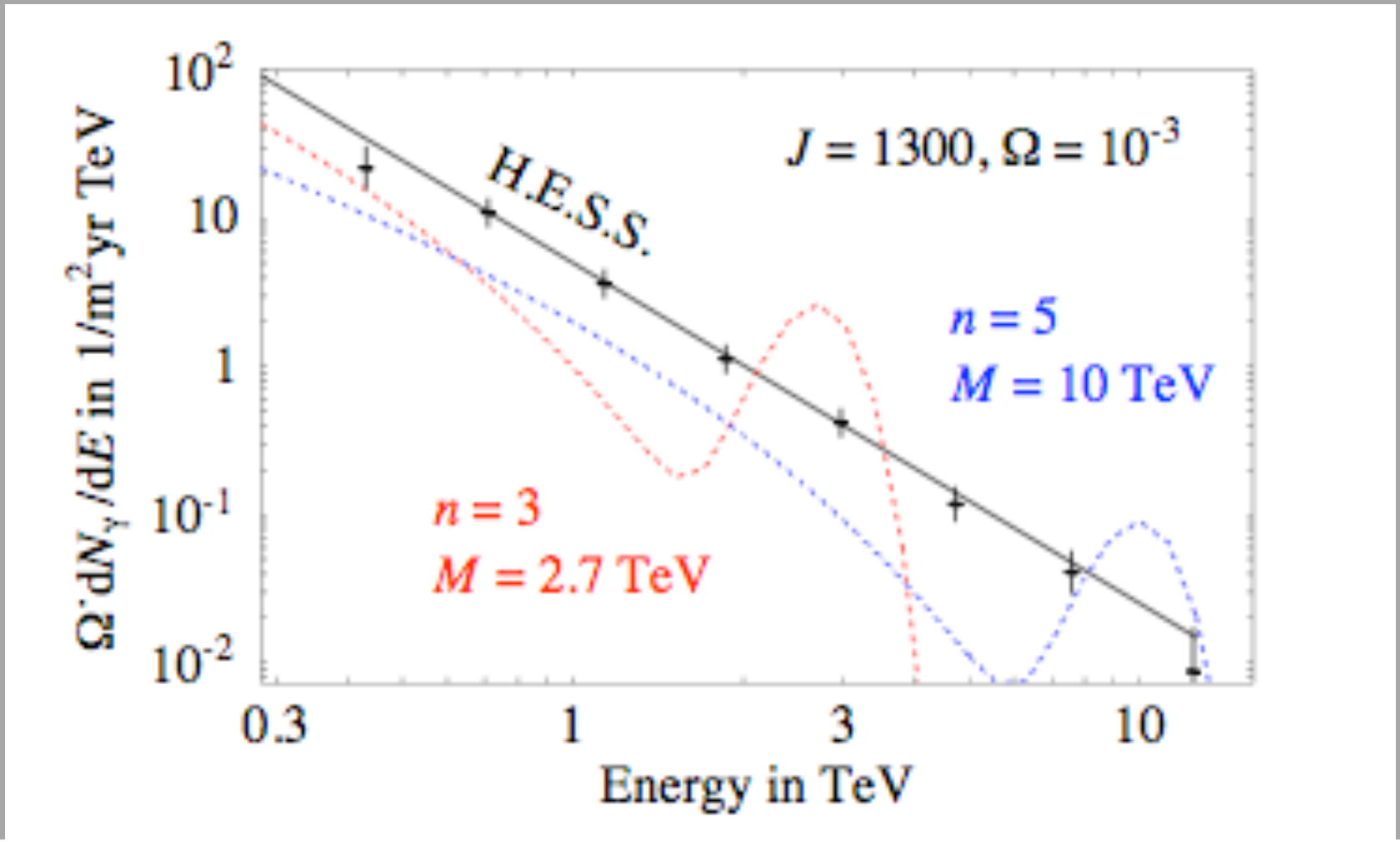
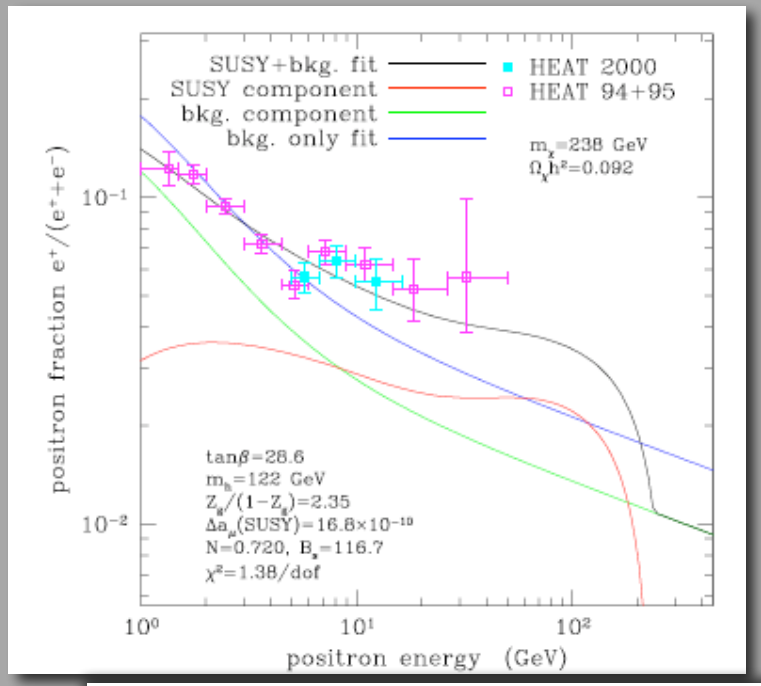
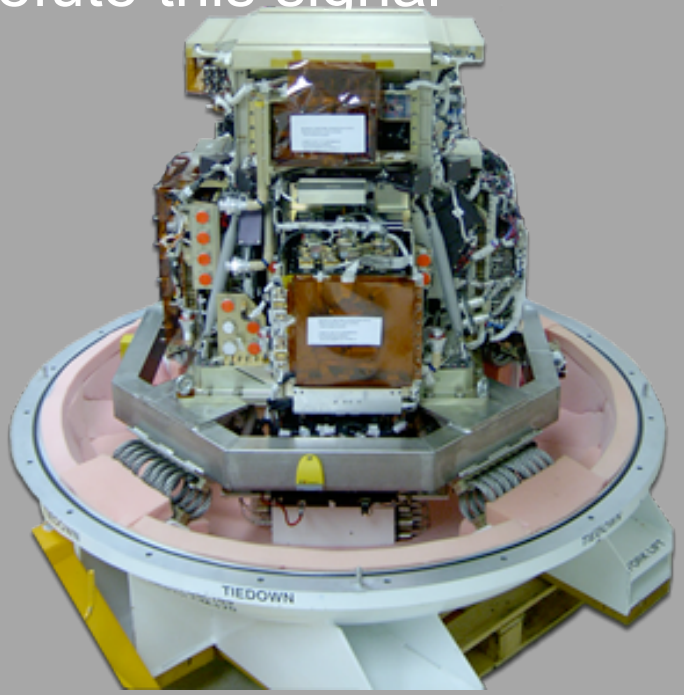


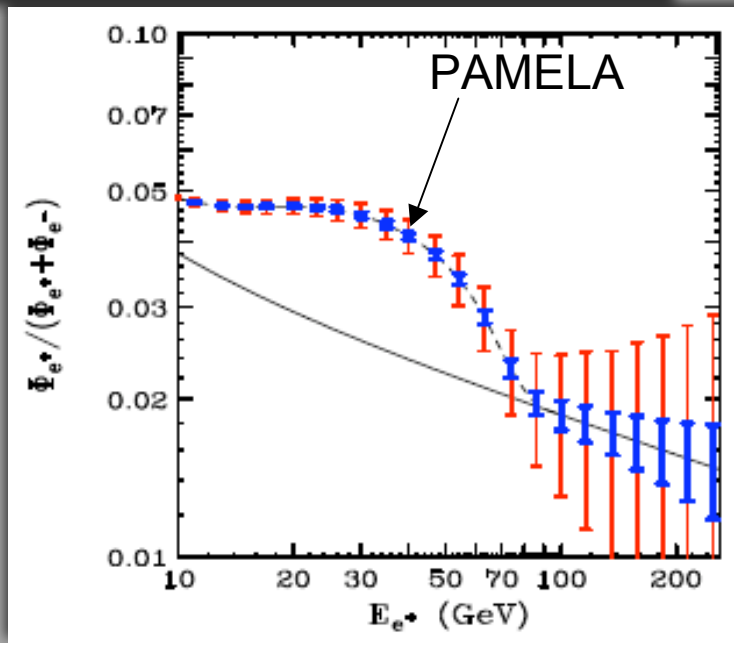
The HEAT Positron Excess

Fit to data can be easily improved if dark matter component is included

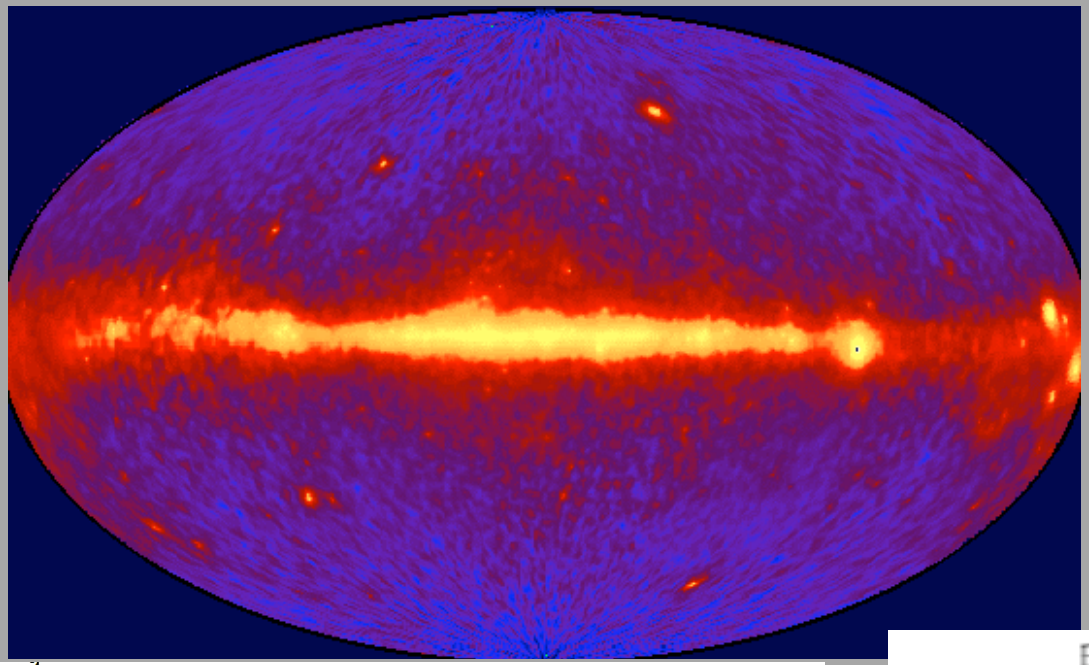
- Requires annihilation boost of ~50 or more (possible, but unlikely), or non-thermal dark matter production
- PAMELA data (soon) should confirm or refute this signal

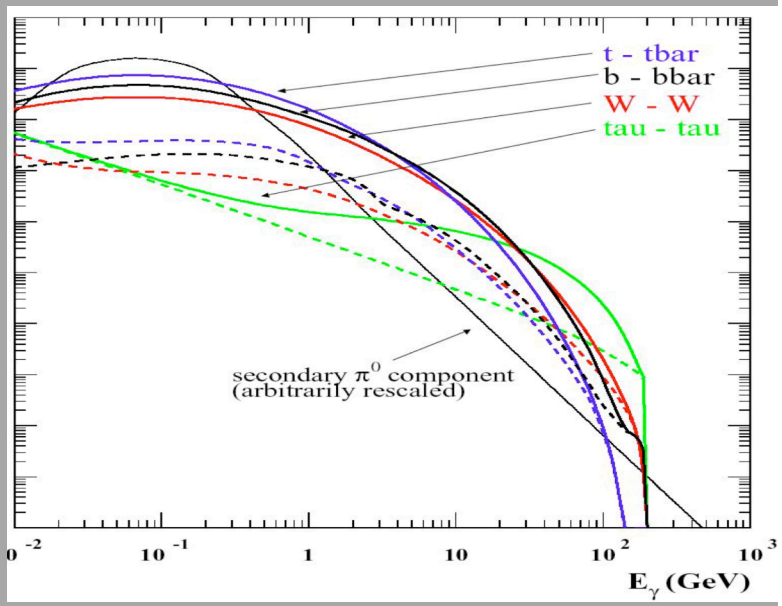


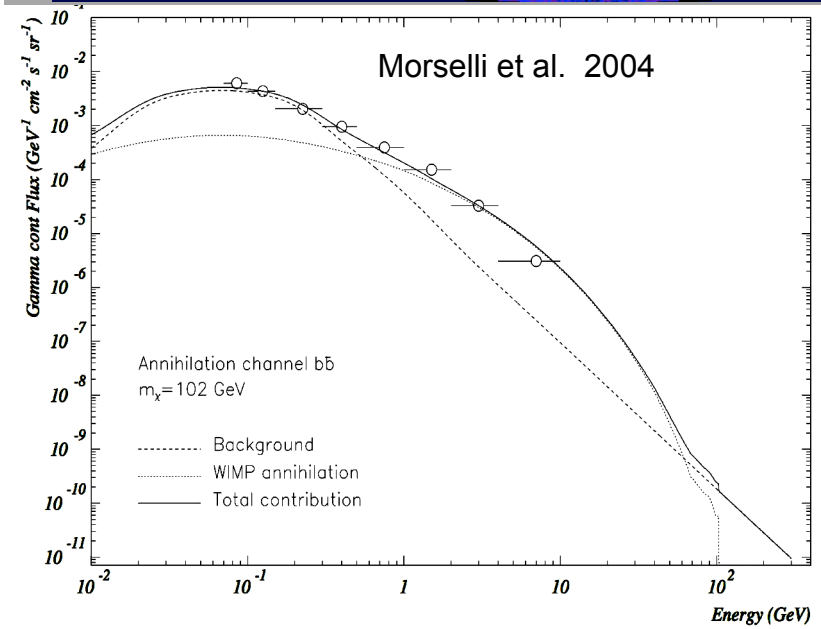


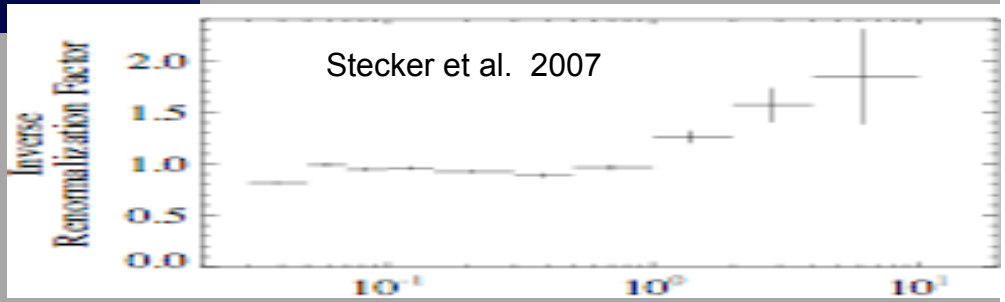


Gamma-Rays from the Galactic Center









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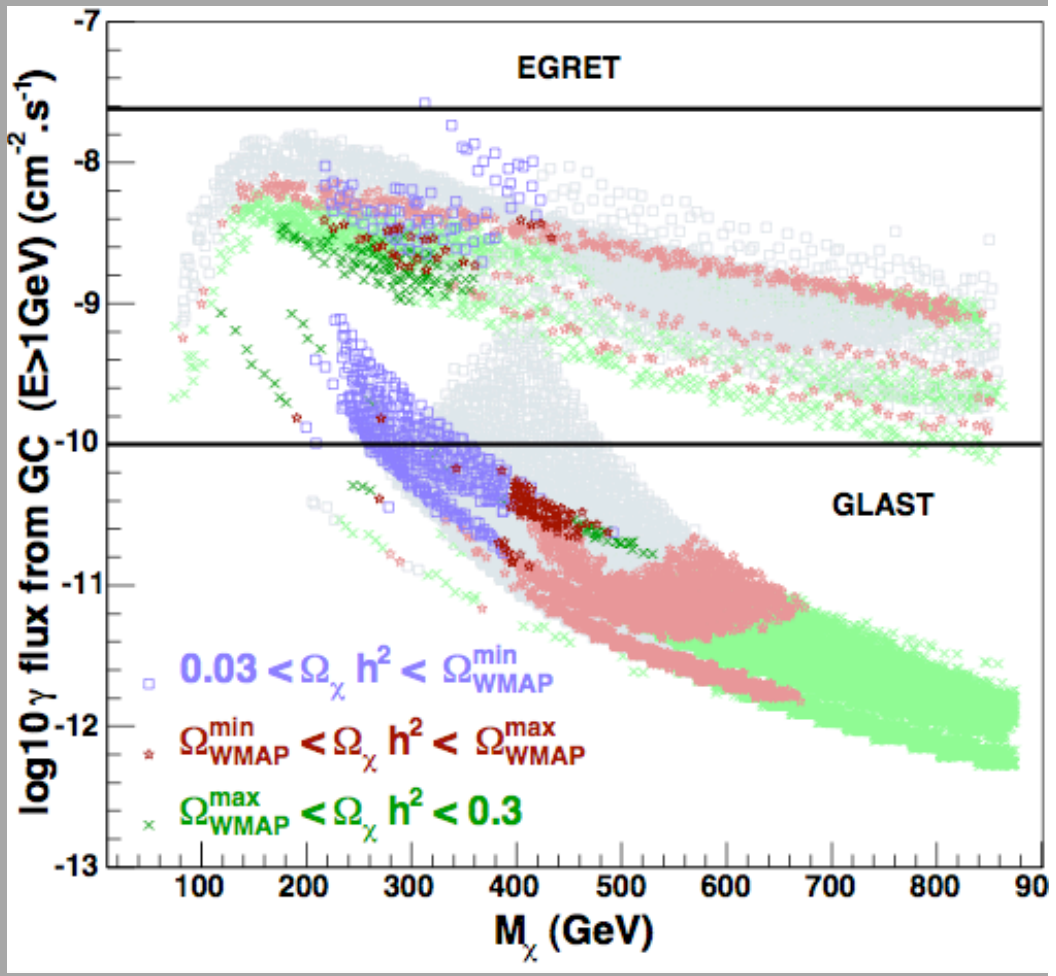
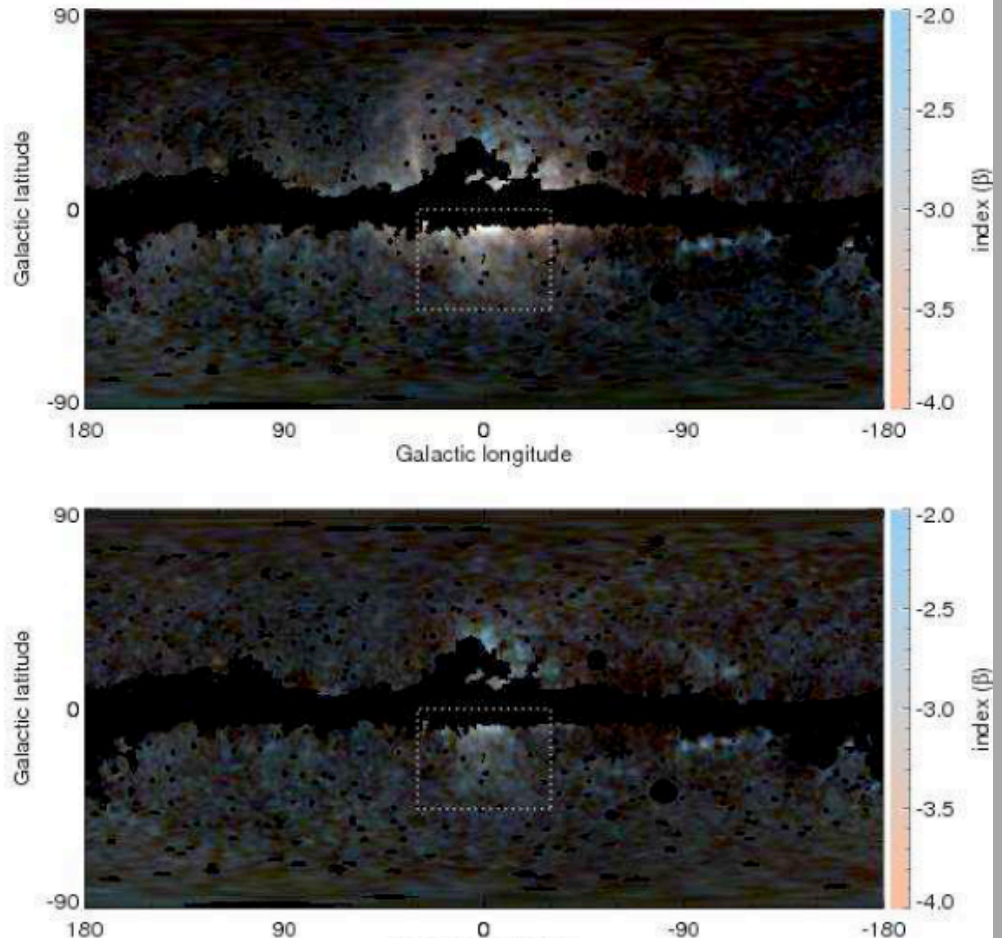


Gamma-Rays from the Galactic Center

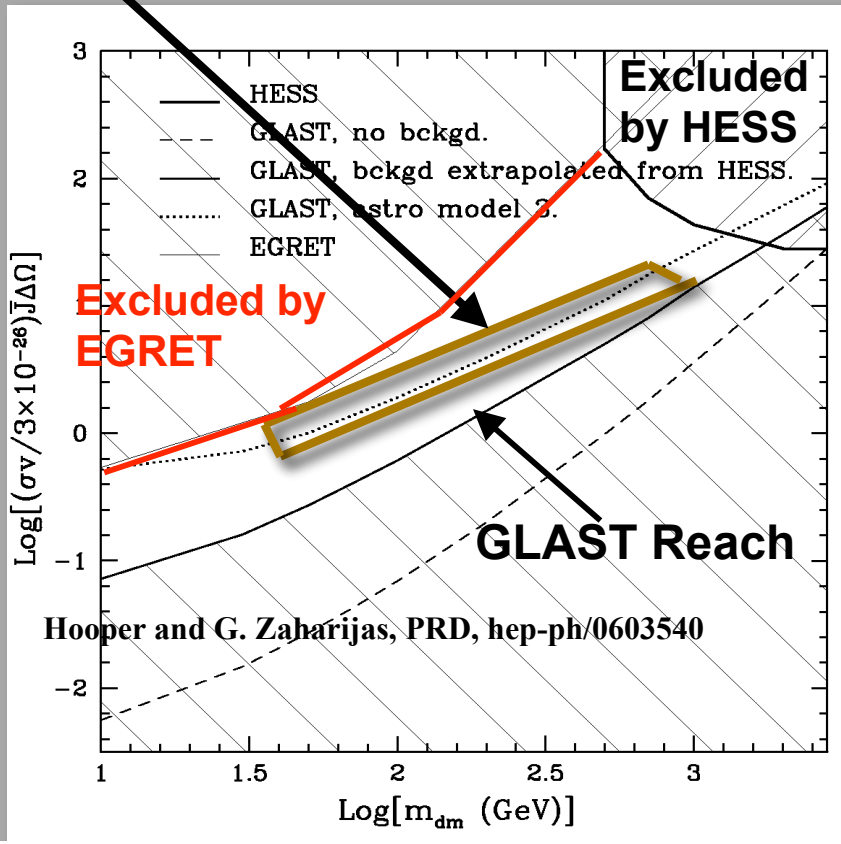
Annihilation cross-section of 3×10^{-26} cm^3/s predicts ~10^{39} GeV/sec in total annihilation power for ~100-1000 GeV WIMPs

synchrotron from e pairs observable with WMAP! (Finkbeiner 2004, 2007)

π^0 decay gamma rays observable by GLAST!



Range predicted by WMAP Haze



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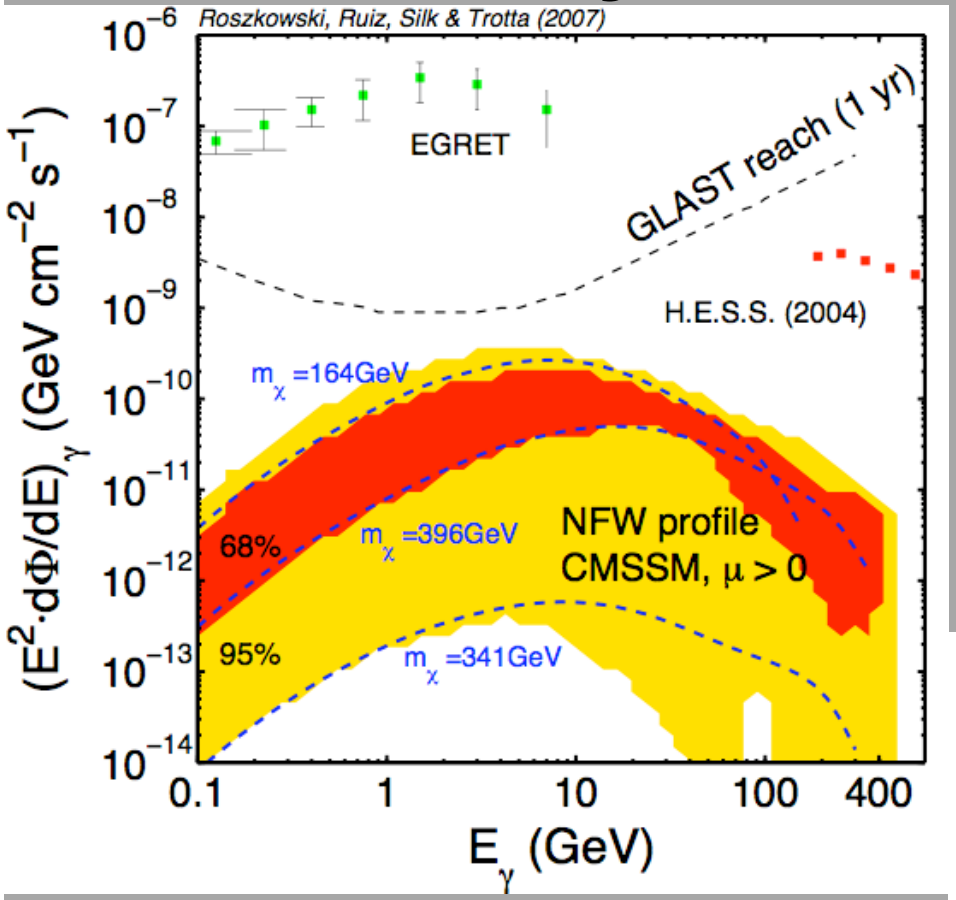
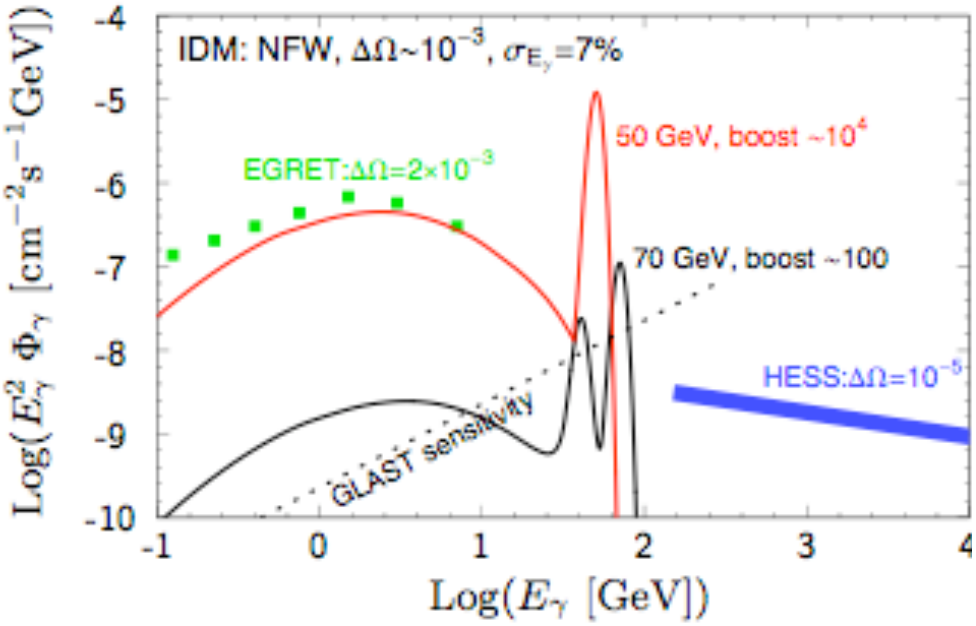


Gustafsson et al. 2007



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