Summary of idm2010

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idm2010
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Introduction

Talks at idm2010

idm2010 delivered at ~30R

From Tripatlas.com:

Rate of speech: The Millirubbia (mR)

A millirubbia is a unit of speaking rate, usually applied during a technical talk, derived from **Carlo Rubbia**, Nobel laureate in physics 1984, who always spoke at 1 R. A normal person spewing forth data at break-neck speed may do perhaps 100 mR.

- ~130 talks, cannot cover all of them
- Especially, I did not find anyone willing to clone me to go to all parallell sessions
- Hence, I will present my personal biased view, apologies to those not mentioned and those I missed/forgot...
- Thanks to all the speakers
- ...and especially to those uploading their talks on the web...

Dark matter distributions

- Lot's of efforts both on simulation and observation side to pin down where the dark matter is and how it affects dark matter searches

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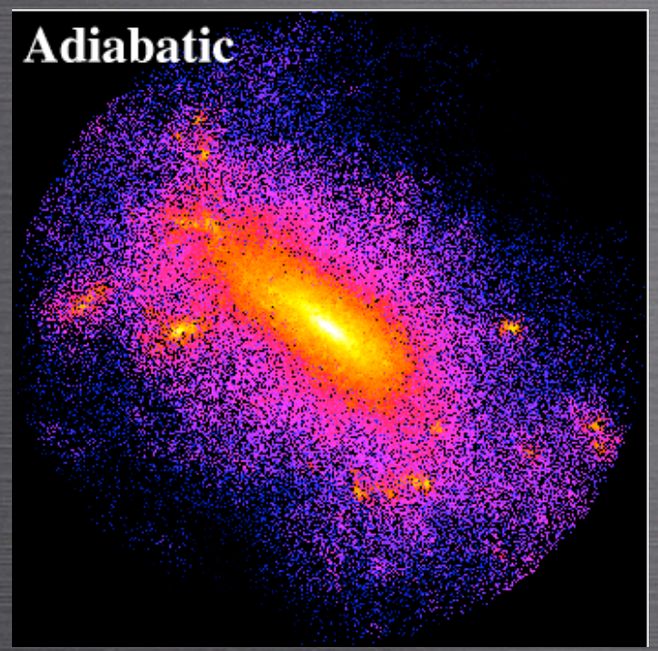
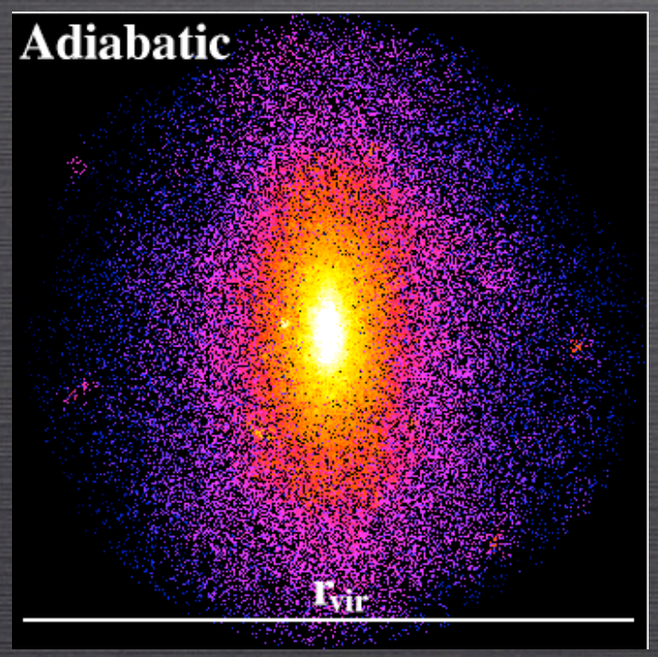
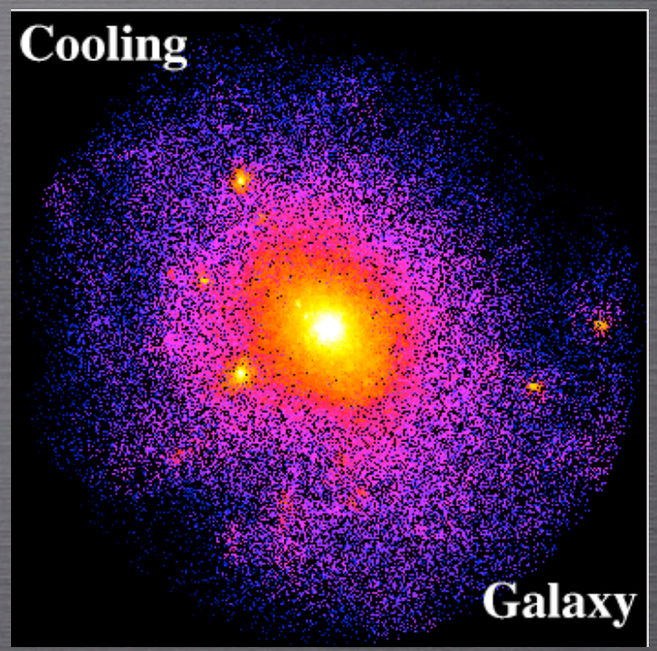
With Baryons

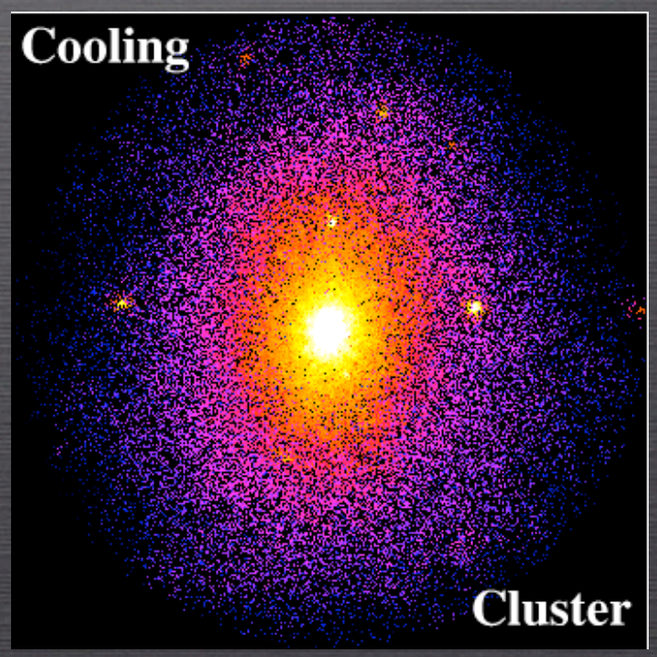
No Baryon cooling





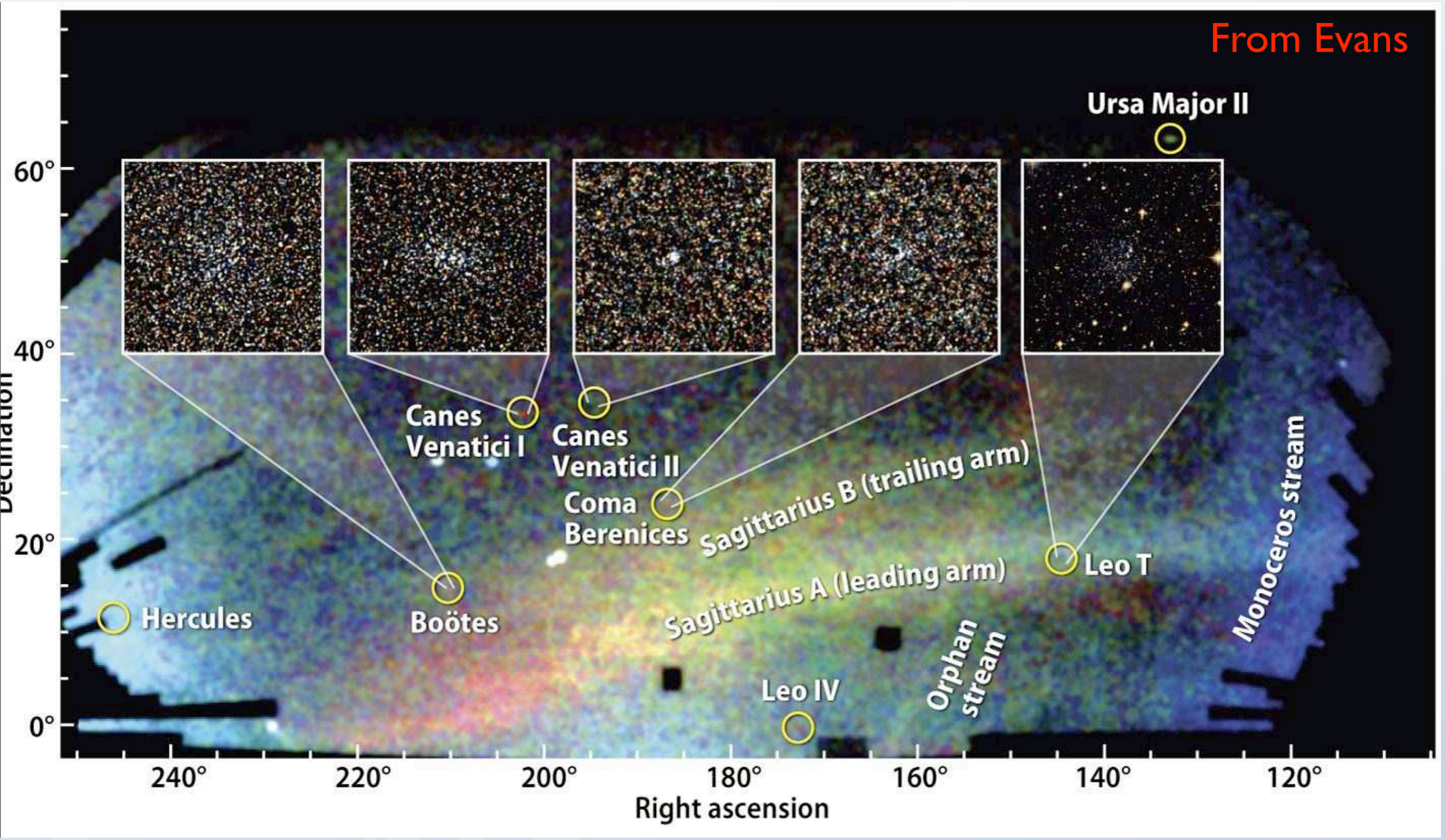
With Baryon cooling





From Zentner

1. Halos become significantly more spherical when baryons cool and form galaxies



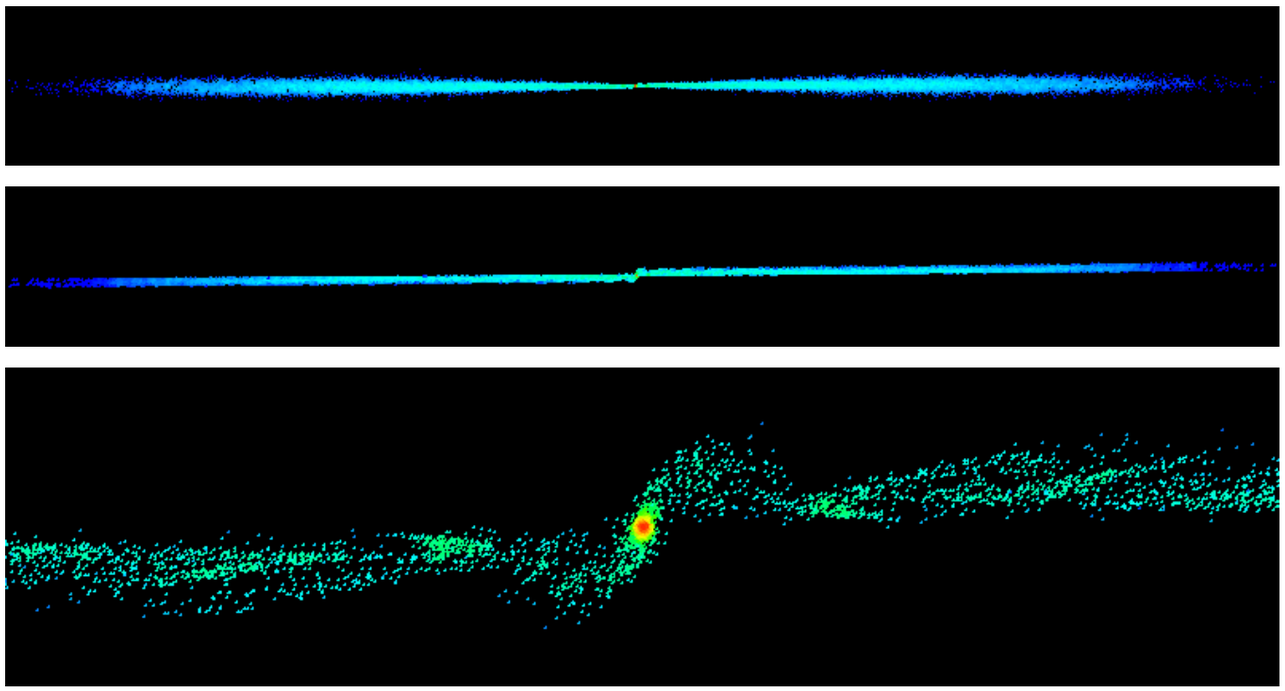
Many ultrafaint dwarf galaxies found,
in particular Segue 1 seems promising
(Strigari, Kaplinghat)

...or maybe it is a globular cluster (Evans)

Galactic microhalos and detection rates

From Schneider

- Tidal disruption in galactic potential (Milky Way like potential, circular orbit).



b ~1.5

- A significant amount of microhalos survive but they are very reduced in mass.
- Real space density: Smooth with rare peaks due to surviving cores.
- Velocity dispersion: Essentially Maxwellian distribution. Rare peaks possible.

Direct detection

- Many experimental results....

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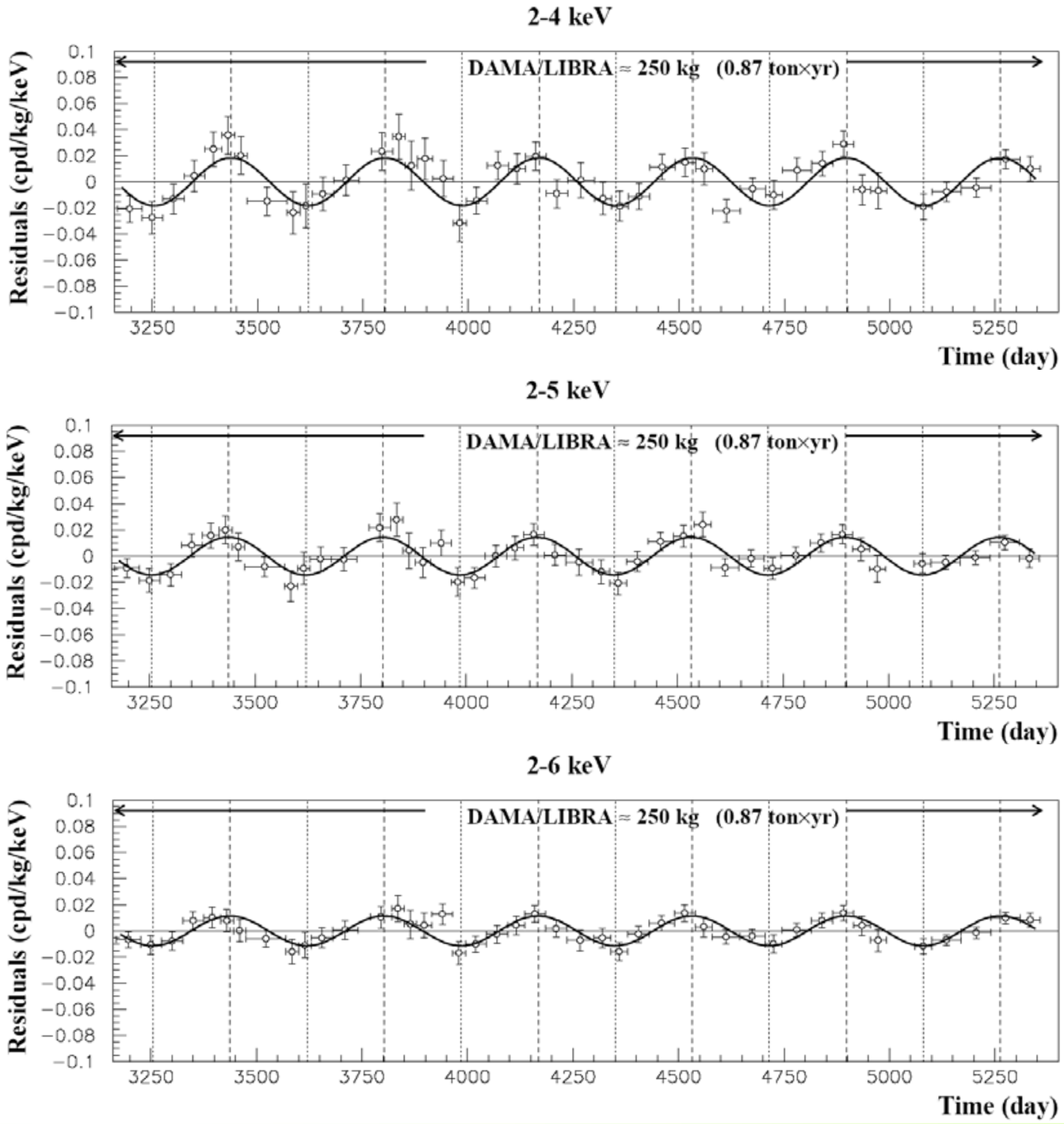
Model Independent Annual Modulation Result

experimental single-hit residuals rate vs time and energy

Acos[ω(t-t$_0$)] ; continuous lines: t$_0$ = 152.5 d, T = 1.00 y

DAMA/LIBRA 1-6 (0.87 ton × yr)



The fit has been done on the DAMA/NaI & DAMA/LIBRA data (1.17 ton × yr)

2-4 keV

A=(0.0183±0.0022) cpd/kg/keV

χ^2/dof = 75.7/79 **8.3 σ C.L.**

Absence of modulation? No

χ^2/dof=147/80 ⇒ P(A=0) = 7×10^{-6}

2-5 keV

A=(0.0144±0.0016) cpd/kg/keV

χ^2/dof = 56.6/79 **9.0 σ C.L.**

Absence of modulation? No

χ^2/dof=135/80 ⇒ P(A=0) = 1.1×10^{-4}

2-6 keV

A=(0.0114±0.0013) cpd/kg/keV

χ^2/dof = 64.7/79 **8.8 σ C.L.**

Absence of modulation? No

χ^2/dof=140/80 ⇒ P(A=0) = 4.3×10^{-5}

The data favor the presence of a modulated behavior with proper features at 8.8σ C.L.

From Belli

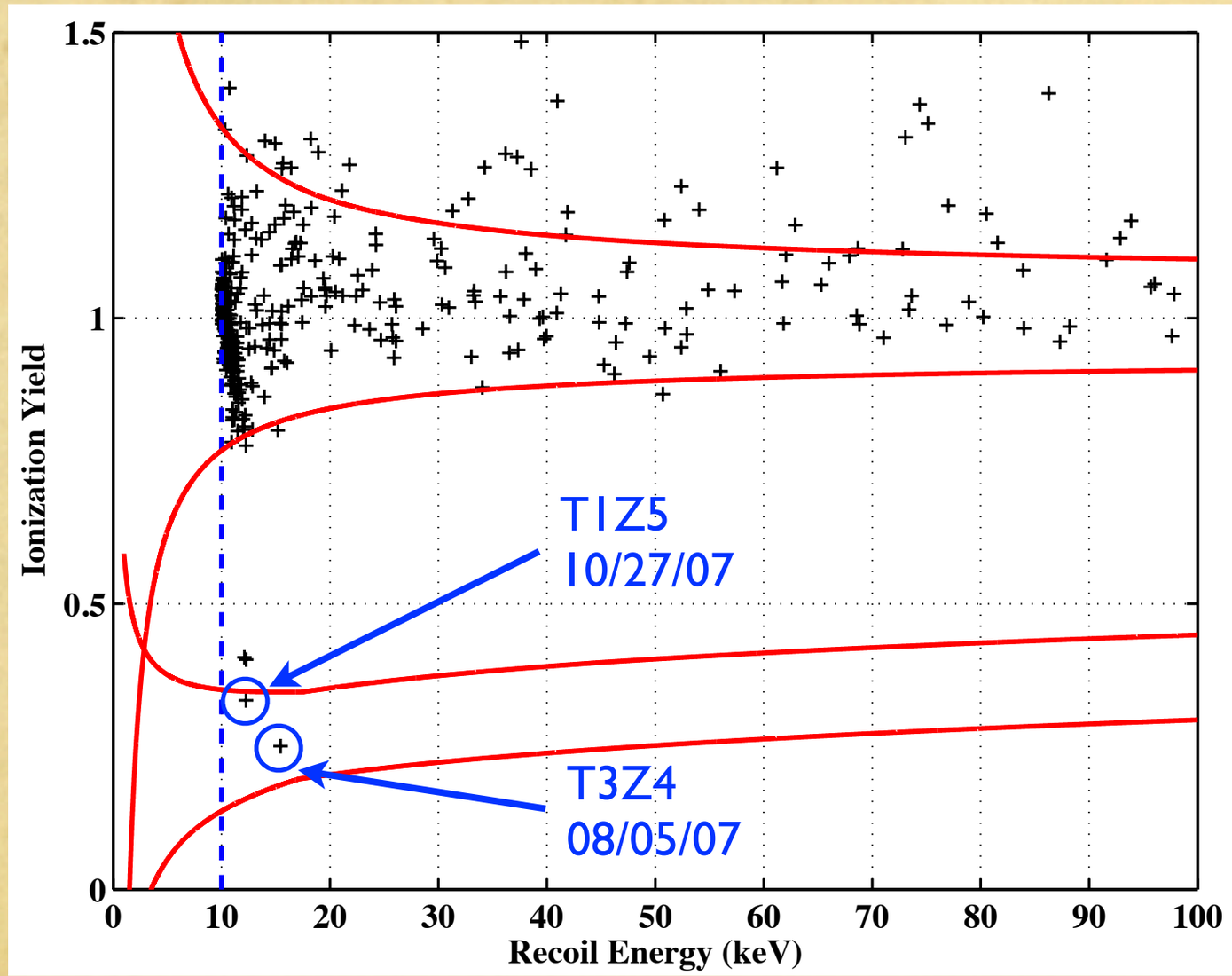
From Saab

The CDMS II Results

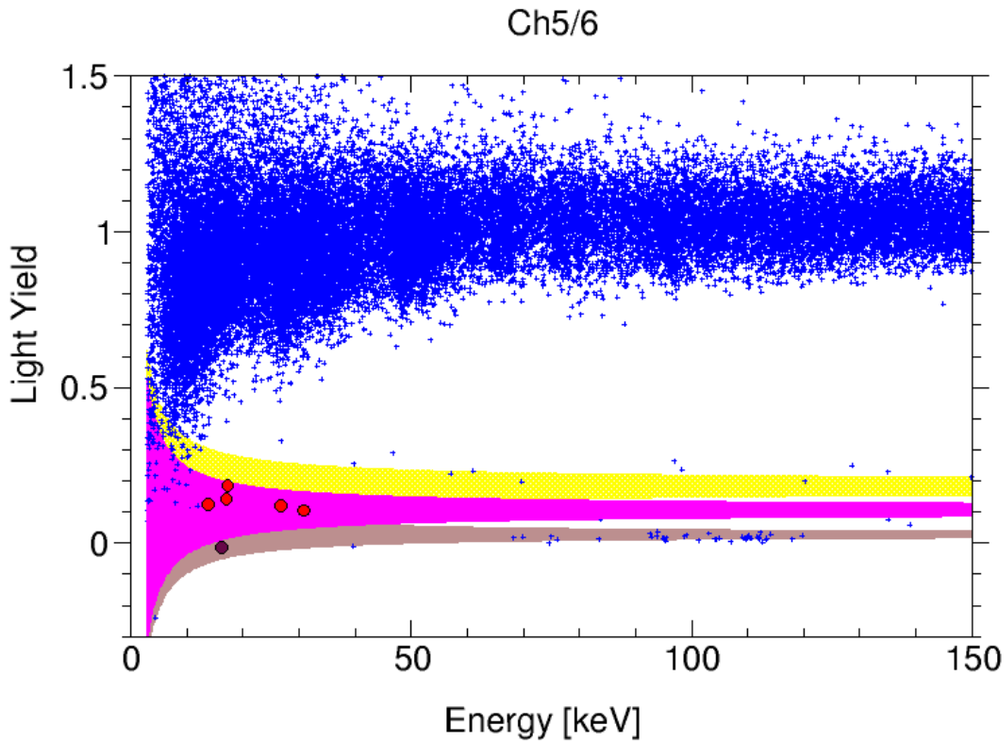
Data unblinded November 5 , 2009 for 14 Ge ZIP detectors

612 raw kg-days.
194.1 kg-d WIMP equiv.
@ 60 GeV/c^2
(10 -100 keV analysis energy range)

2 EVENTS OBSERVED !



What are these events in O-band ?



Detector	E0.1[keV]	events
5	12.35	5
20	11.85	2
29	11.65	4
33	15.55	2
43	15.55	4
45	19.15	2
47	17.35	4
51	9.65	6
55	22.25	3
total		32

Try to estimate background
Check for coincidences

Neutrons ?

a leakage ?

Low mass WIMPs ?

Sum of background estimates: 8.7

From Seidel

Direct detection data

- can be fit with e.g. light dark matter, spin-dependent, inelastic dark matter (See talk by Weiner, and others)
- But Xenon10, S2 only data kills light dark matter (or puts us at an aile seat...)

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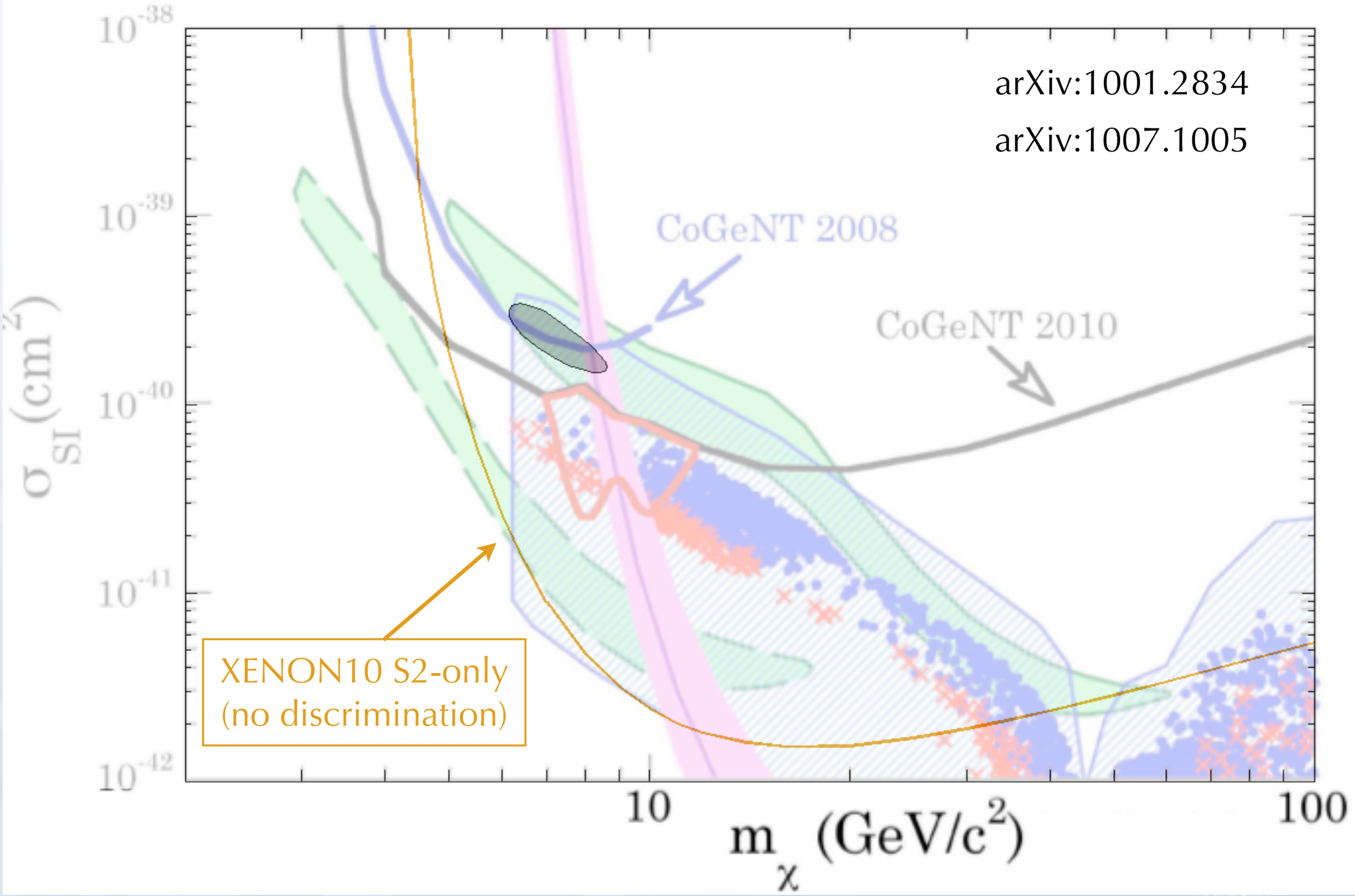

S2 only analysis

From Sorensen

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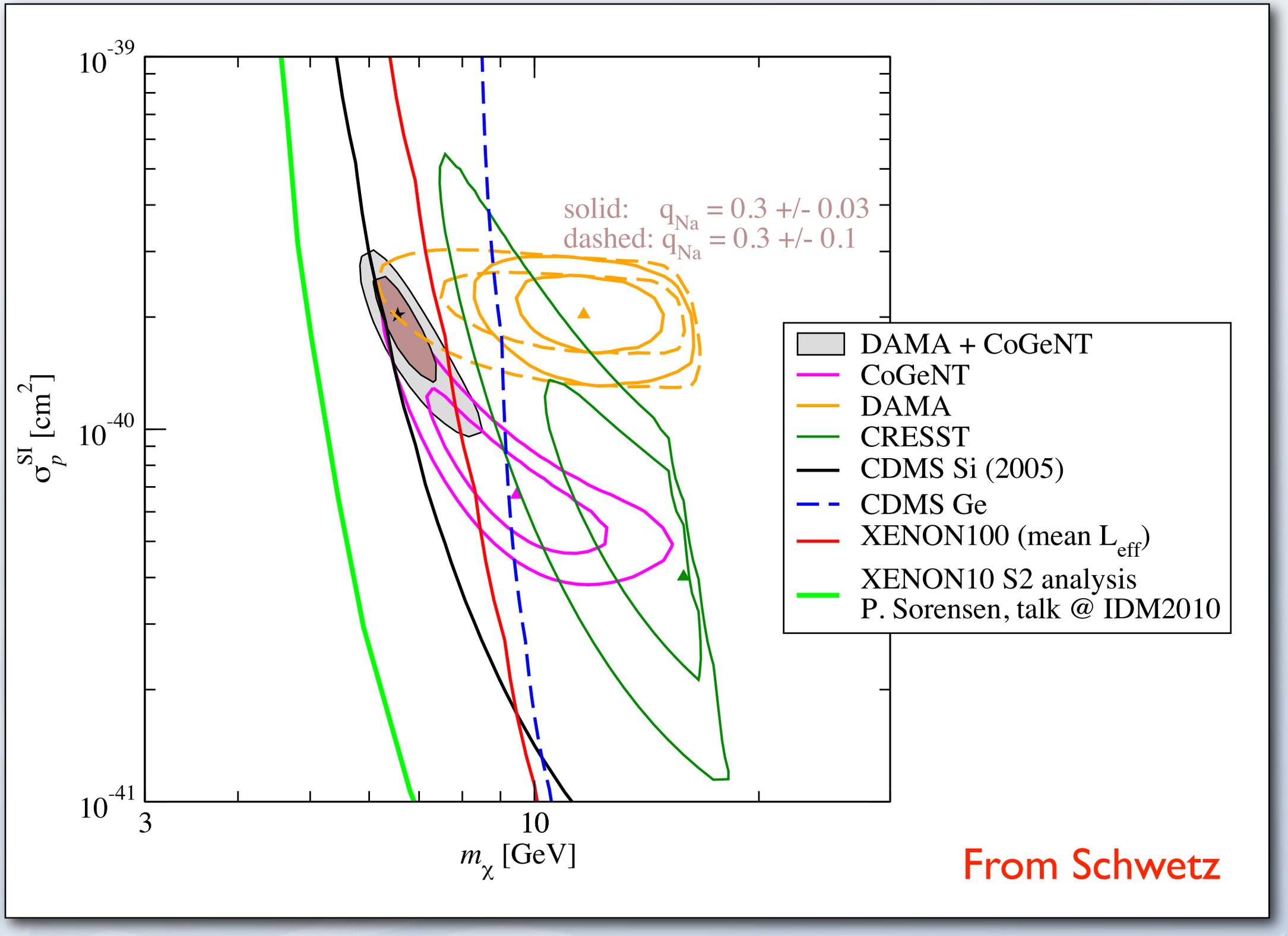

From Schwetz

Current status of low-mass spin-independent WIMPs

For more details, see talks by Schwetz, Weiner, Savage, ...

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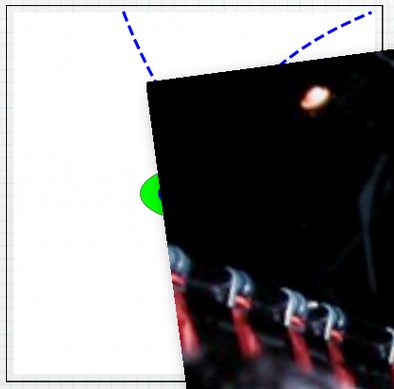
From Weiner

"Airtravel concept"

What's "ruled out"?

* Exclusion limits = Air travel

No limit



Relaxed, co

red, but you'd like to
g

What

l out"?

* Exclusion lim

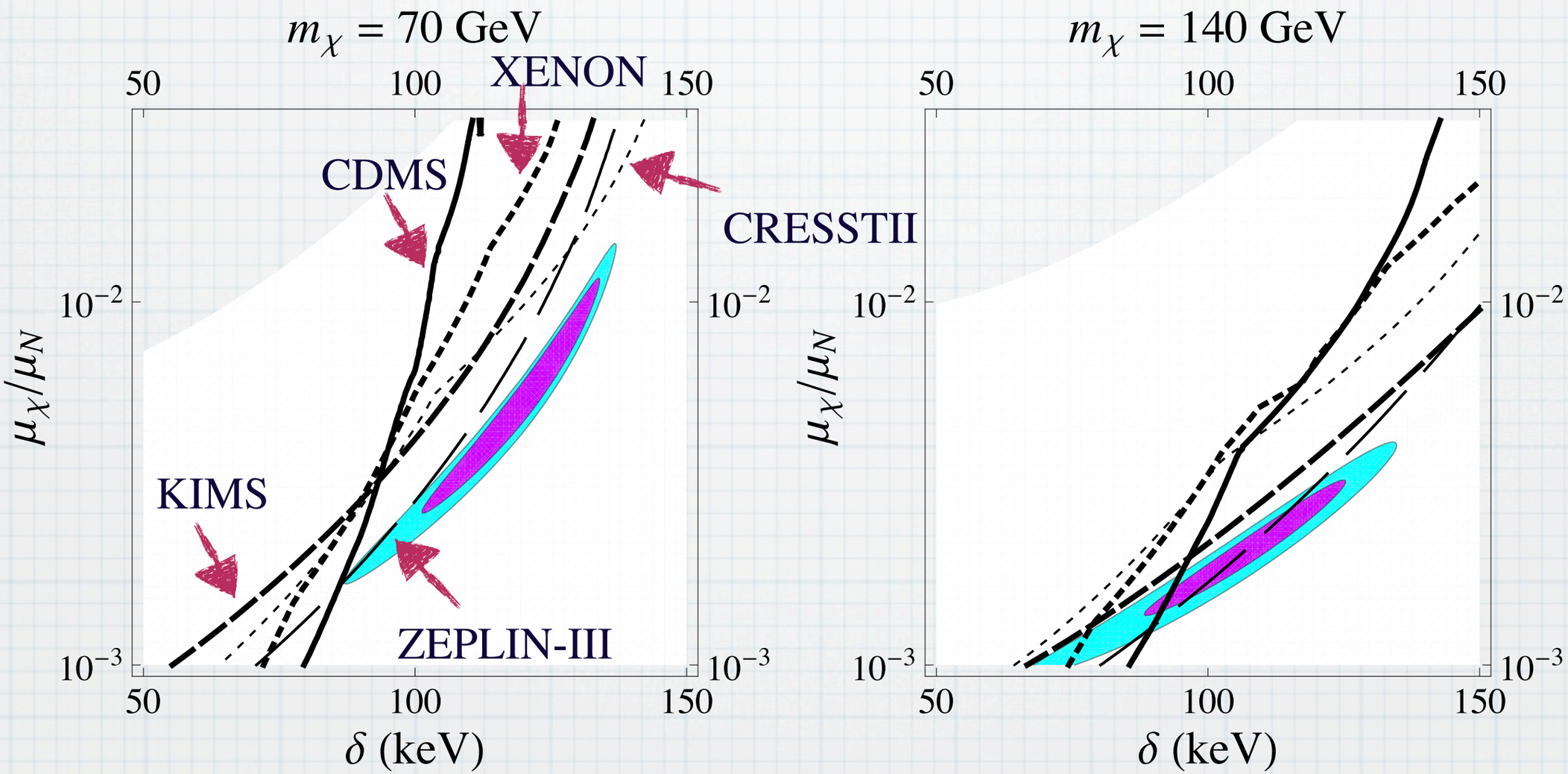
0(5-1 0)

Smiling, making the best of things, but you're pretty uncomfortable

Consideration of the model leads to major discomfort

From Weiner

Magnetic iDM Parameter Space

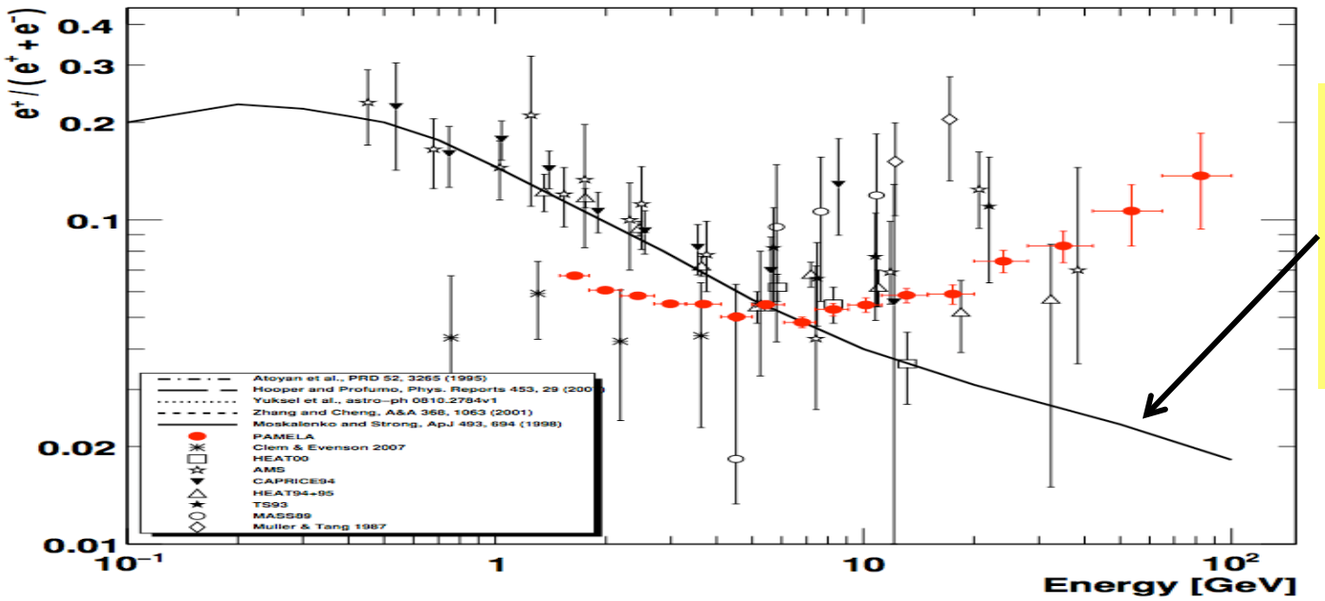


NB: CRESST II = Commissioning run

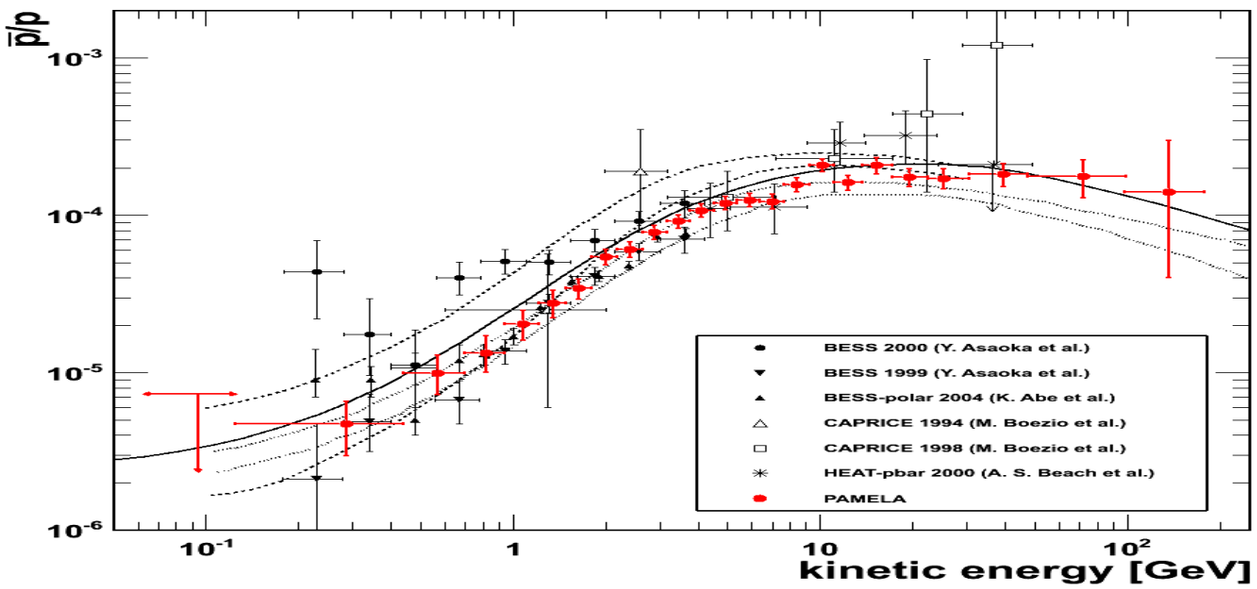
Maybe we should also include the theoretical discomfort with the models...

Cosmic ray electrons and positrons

A Challenging Puzzle for CR Physics



Uncertainties on:
- **Secondary production (primary fluxes, cross section)**
- **Propagation models**
- **Electron spectrum**



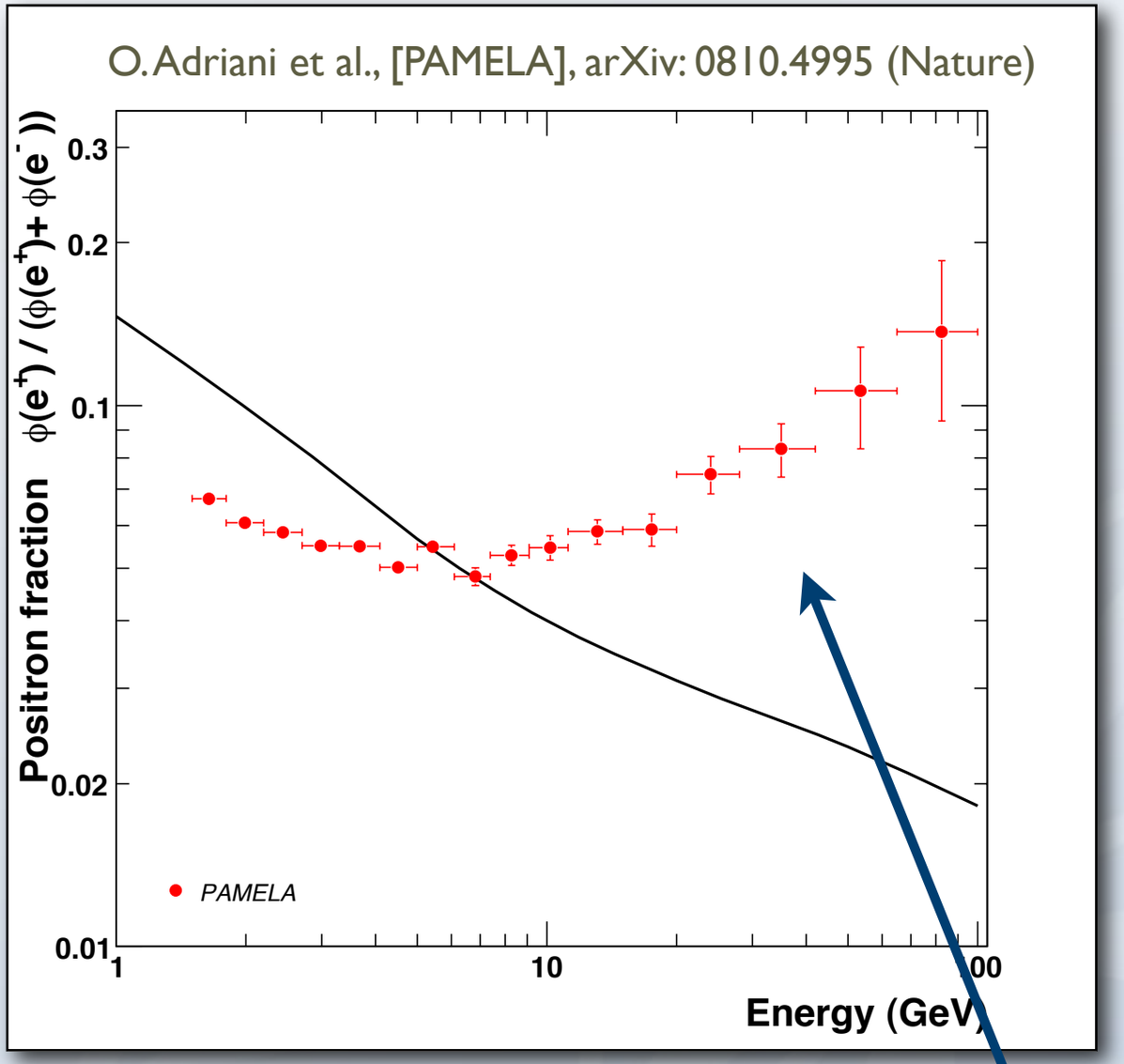
But antiprotons in CRs are in agreement with secondary production

From Picozza

Data and background expectations

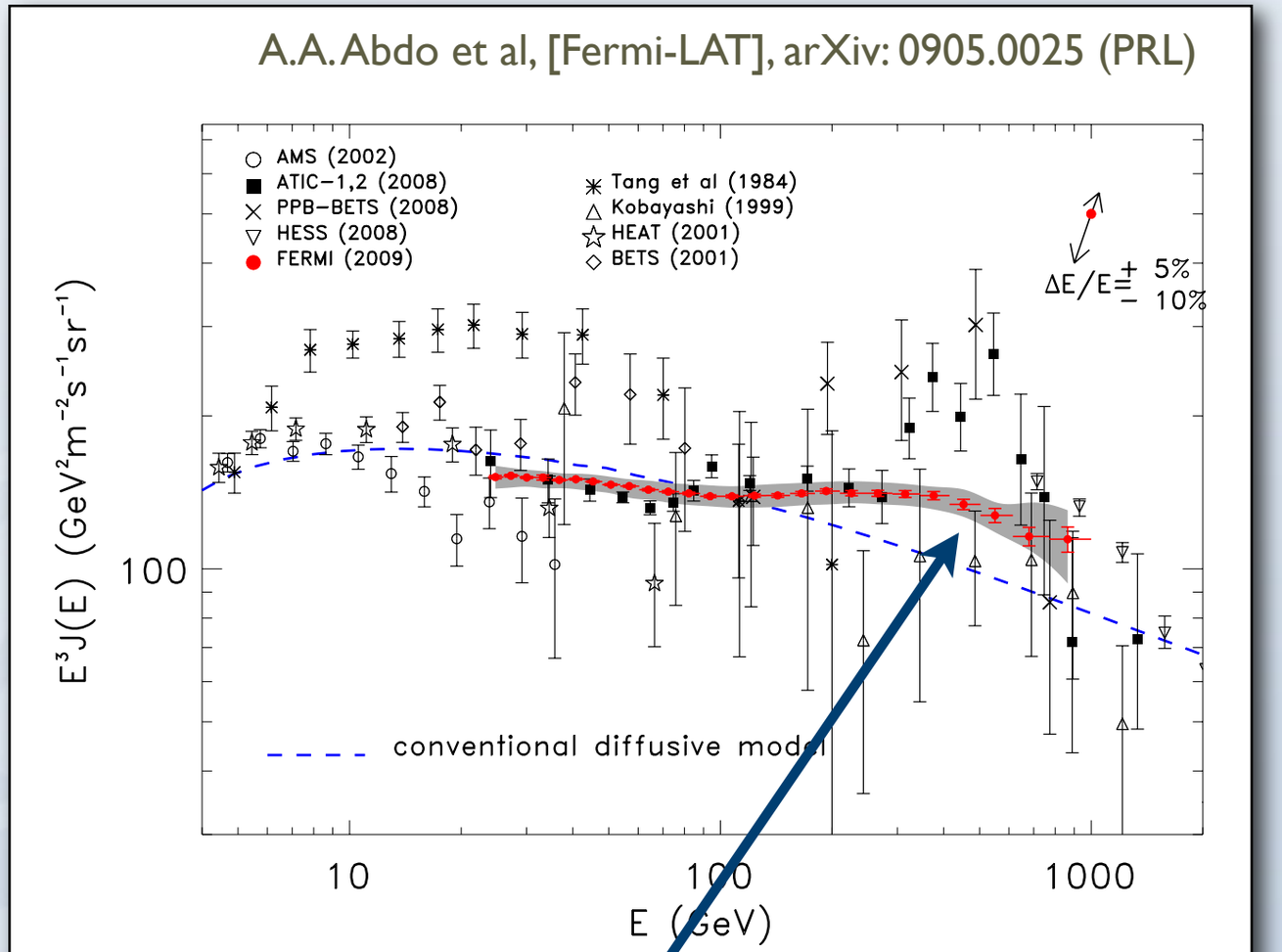
Positron fraction

O. Adriani et al., [PAMELA], arXiv: 0810.4995 (Nature)



$e^+ + e^-$ spectrum

A.A. Abdo et al, [Fermi-LAT], arXiv: 0905.0025 (PRL)



What are these excesses compared to the background?

more than 550 papers written on Pamela since Nov. 2008

...and more than 300 citing the Fermi-LAT paper from May 2009

...of which all but at most one are wrong...?

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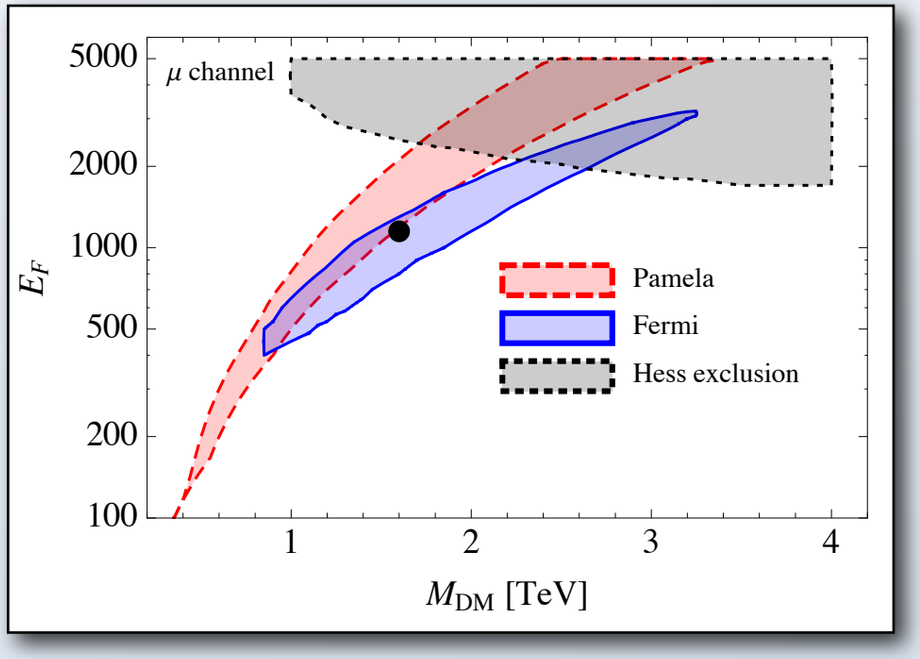
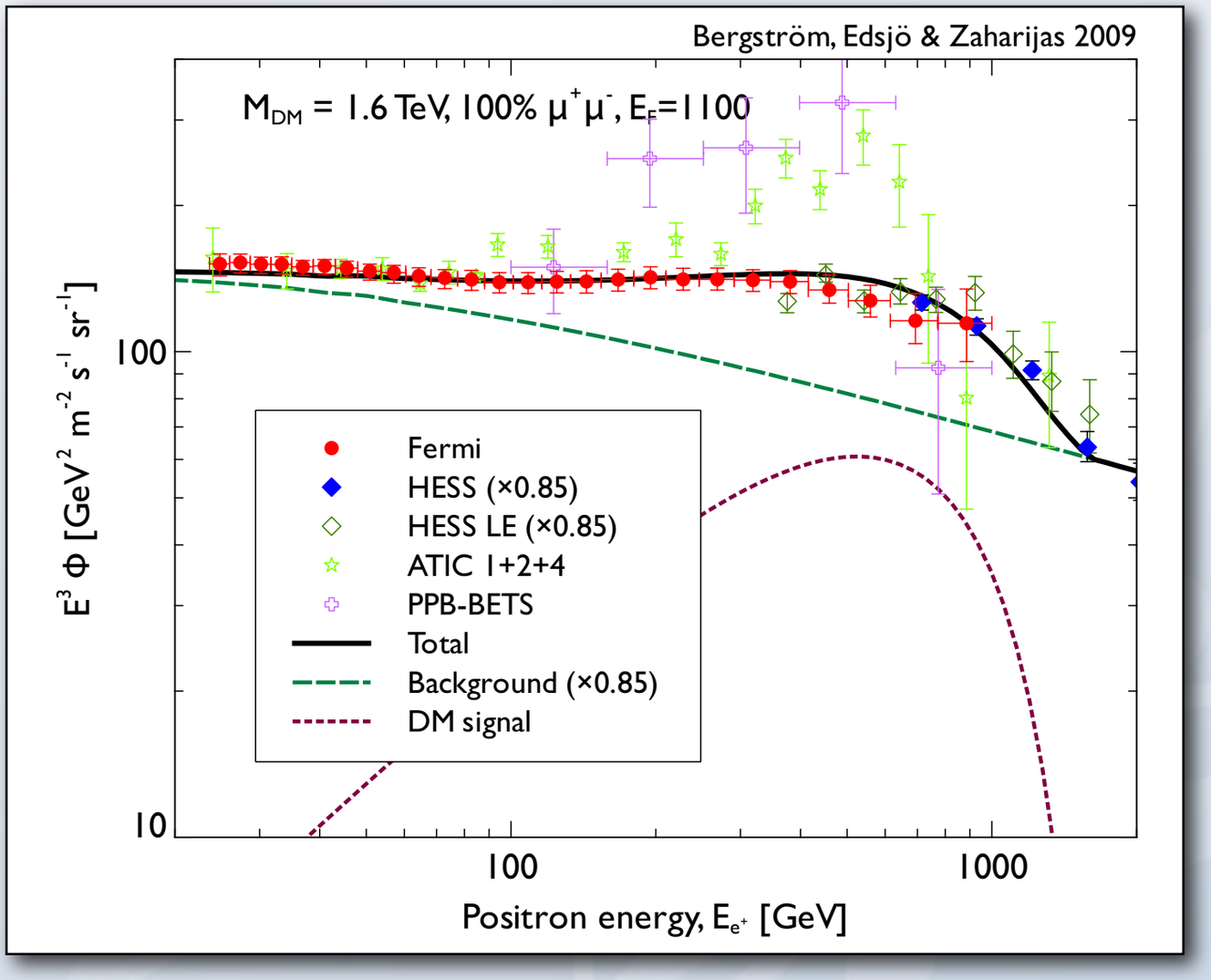
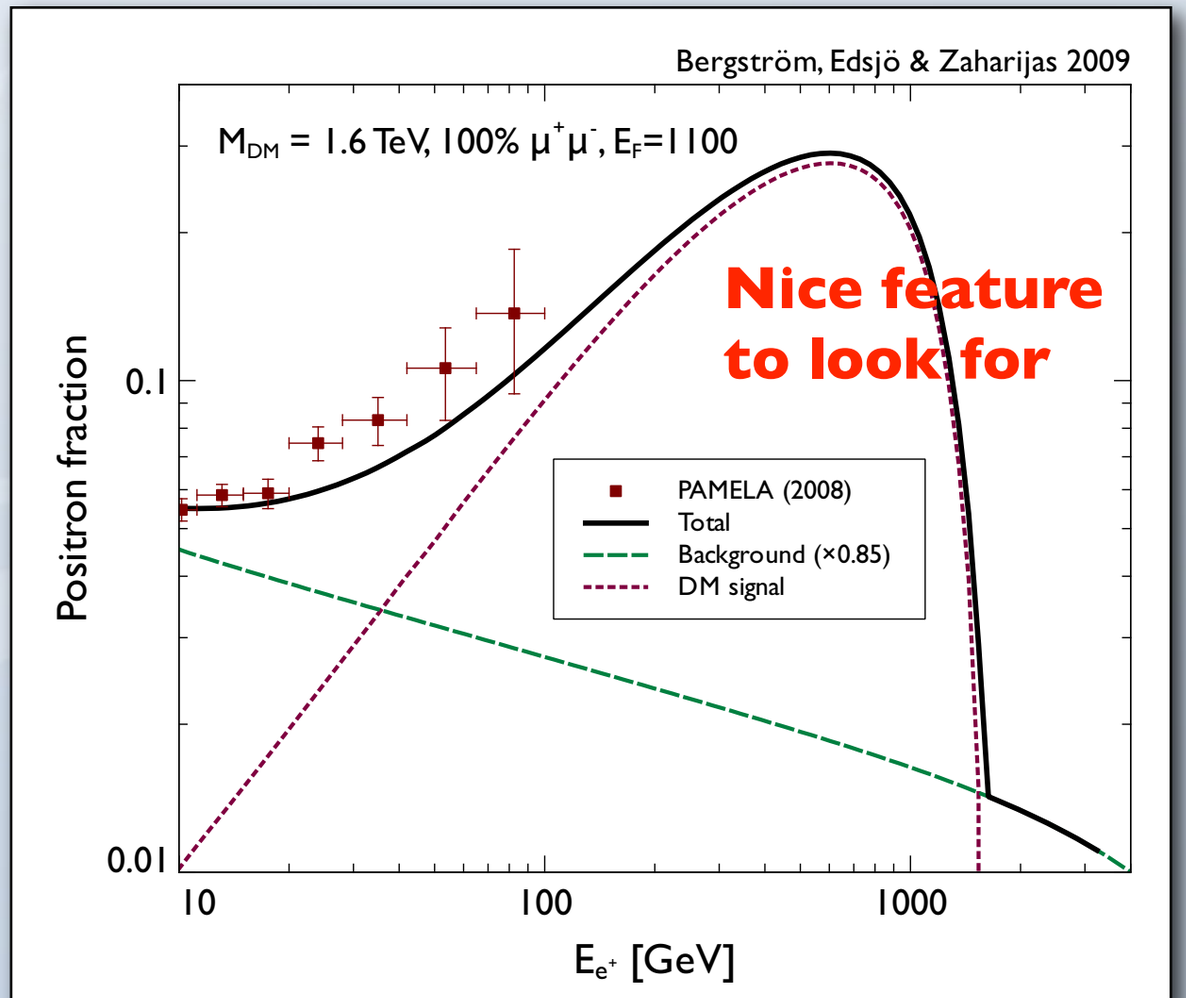
Dark matter – μ channel







Cored isothermal profile assumed here

We get good fits to Fermi, HESS and PAMELA data

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Lot's of constraints

- Synchrotron from GC
- Effects on CMB (Iocco, Slatyer, ...)
- Optical depth in early universe (talk by Iocco)
- ICS on CMB (Profumo, Jeltema & Belikov,Hooper)
- Galaxy clusters
- ...

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Propagation

Short recipe for secondaries

Proton and alpha fluxes

$\phi_p(E) \approx \phi_0 \, (E/1\,\mathrm{GeV})^{-2.75}$

ISM gas distribution

The source term

Inclusive nuclear cross section

$p+p \rightarrow e^+ + X$

$$\mathcal{Q}(E) \propto \int dE\, n_H\, \phi_p(E) \frac{d\sigma}{dE} \approx \mathcal{Q}_0 (E/1\,\mathrm{GeV})^{-2.75}$$

Propagation

from (x_s, E_s) to (x, E)

diff. + E-loss

Each box contains uncertainties !!!

Flux at the Earth

$\gamma_\odot \approx \gamma_p + \frac{1}{2}(\delta + 1) \approx 3.5$

From Lavalle

Julien Lavalle, IDM-2010

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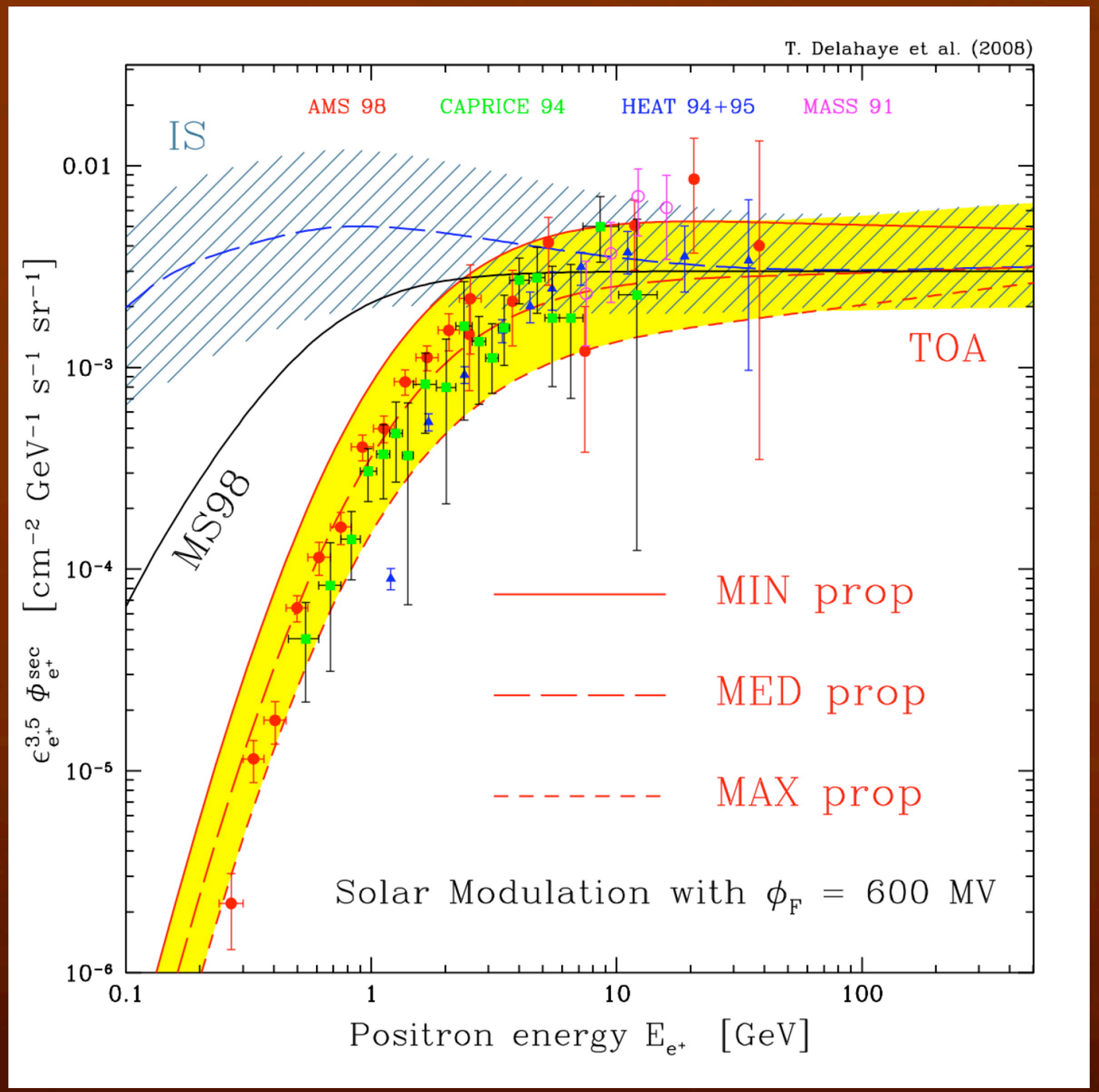
Example of results for secondary positrons



From Taillet

or maybe no standard diffusion at all...

Positron anomaly?

Claims of a primary source:

- The electrons are assumed to have the same production spectrum as the protons, and to suffer the same energy losses as the positrons $f_{s,e^-} = f_{s,e^+}$.

?

Unknown.[2]

- The e^+ flux, including the energy loss suppression, is calculated within a specific propagation model.

?

Unknown.[n]

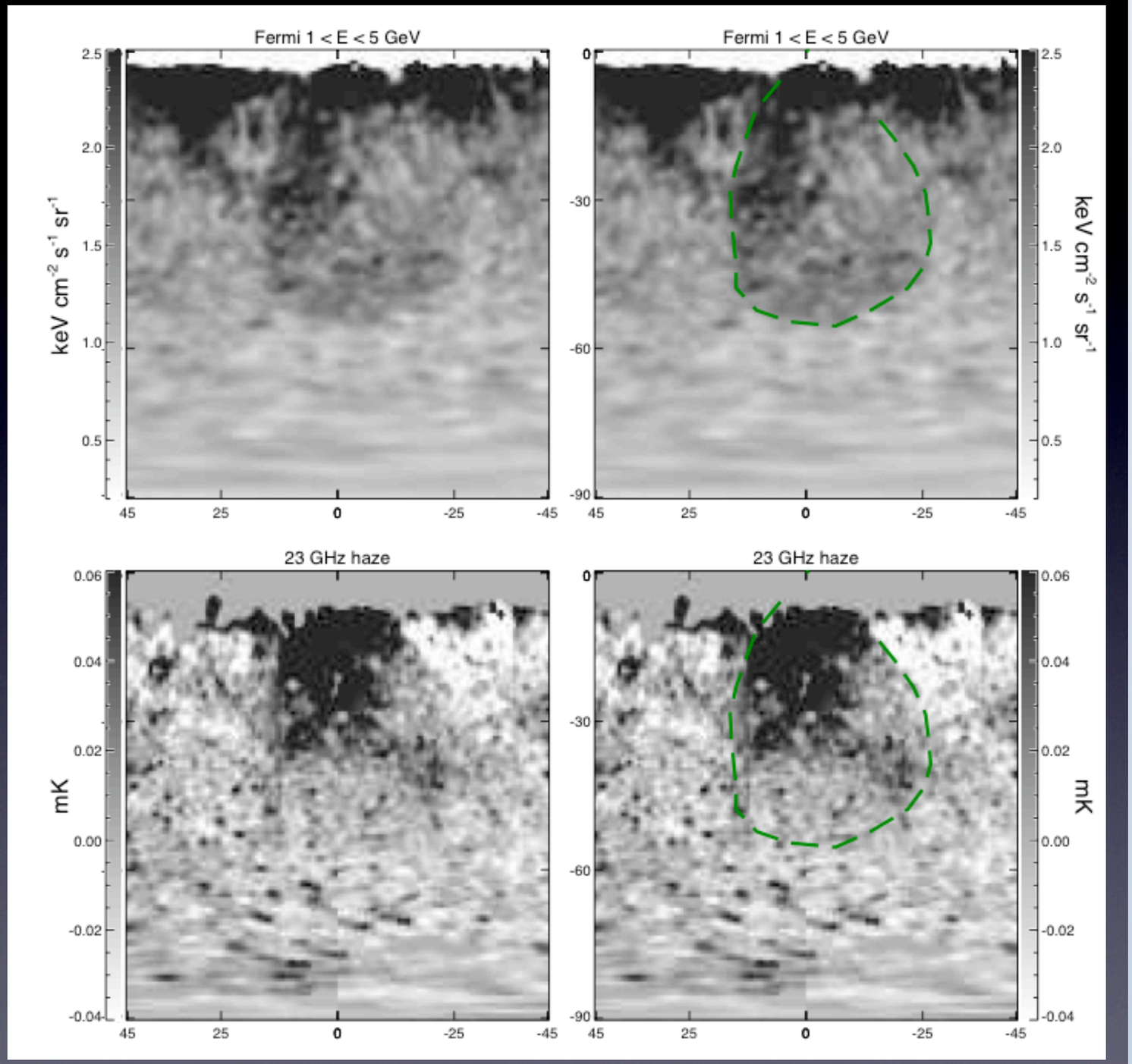
From Blum

Propagation

- By the fall of 2010, we "should" have 3–4 code releases:
  - Galprop (numerical), new version, Moskalenko et al
  - USINE (semi-analytical), first release, Maurin et al
  - Dragon (numerical), first release, Grasso et al
  - DMMW (analytical), first release, Gebauer et al, assumes spherical symmetry
- All of which should have interfaces to DarkSUSY and other signal codes like micrOmegas

See talks by Lavalle, Taillet and Gebauer

WMAP and Fermi haze



Su et al. (2010)

- Haze (WMAP and Fermi) evidence gets stronger, but support for dark matter interpretations weakens...

- Exist models (or ideas) by Biermann and Becker with quite different diffusion at the GC region

From Finkbeiner

Gamma ray searches

- Many ongoing gamma ray searches both with Fermi and ground-based telescopes

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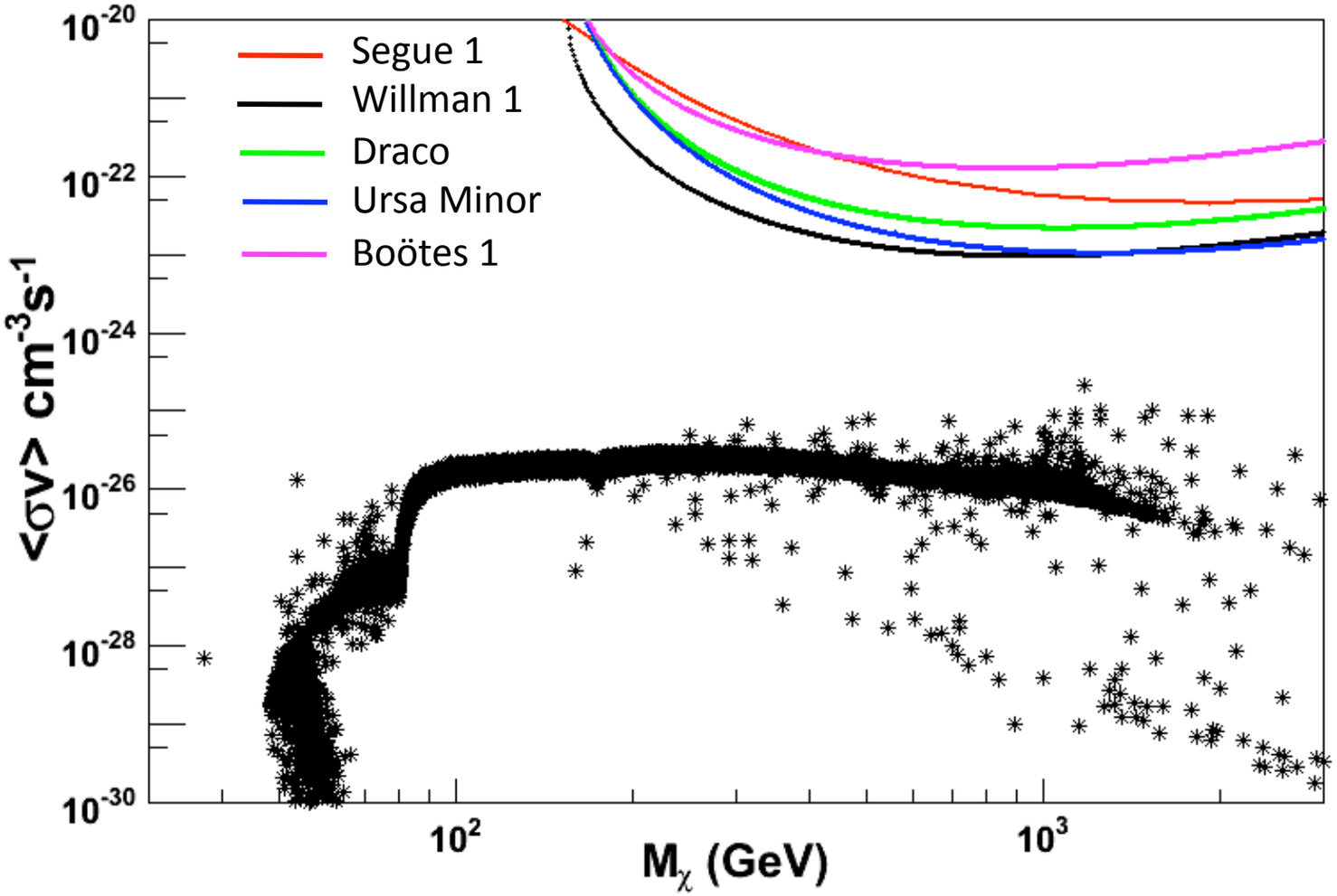
Veritas



- MSSM models from DarkSUSY within ±3 standard deviations of WMAP measured relic density
- 95% CL upper limits from Reflected Region Background Model analysis and Rolke zero-bounded profile likelihood
- Boost factor from substructure, internal bremsstrahlung could give ×10-100 smaller $<\sigma v>$

SEGUE 1 Results PRELIMINARY!

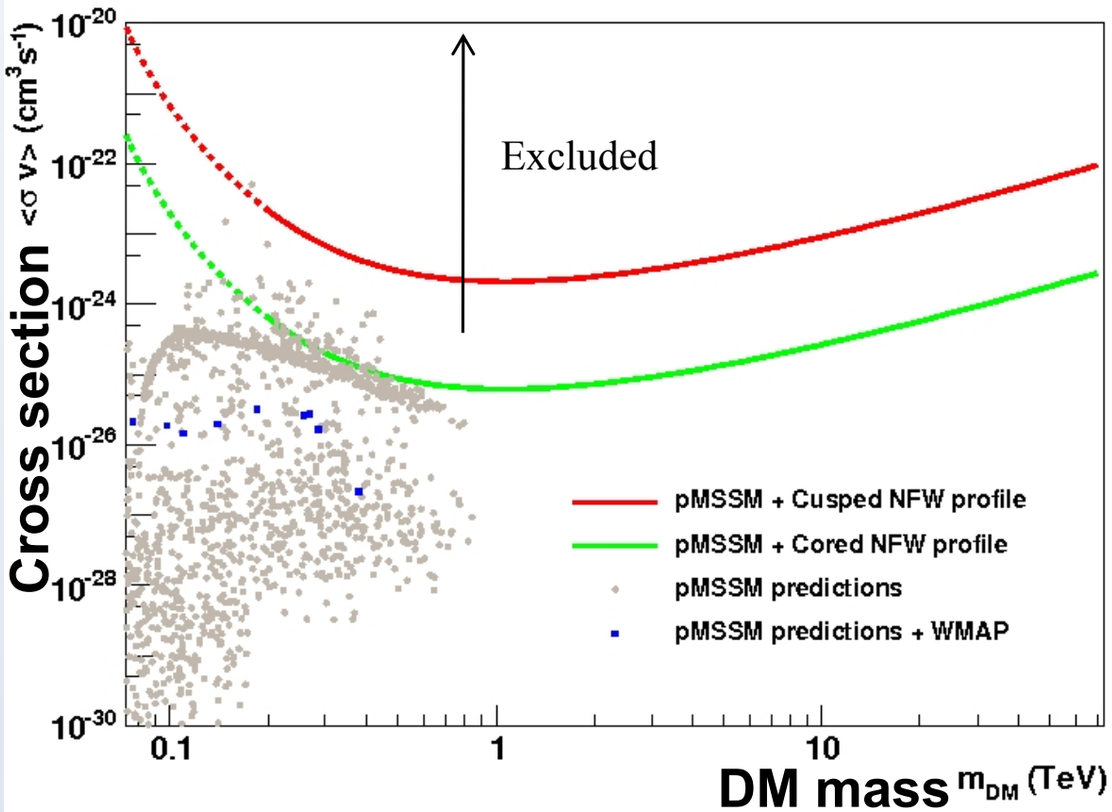
From Wagner

Sensitivity curves for Sagittarius dSph and Canis Major overdensity

Constraints on dark matter sensitivity curve at 95% C.L.:

(HESS Collaboration (F. Aharonian et al.) Astropart.Phys 2007)

(See also C. Farnier for HESS colab., IDM2008)



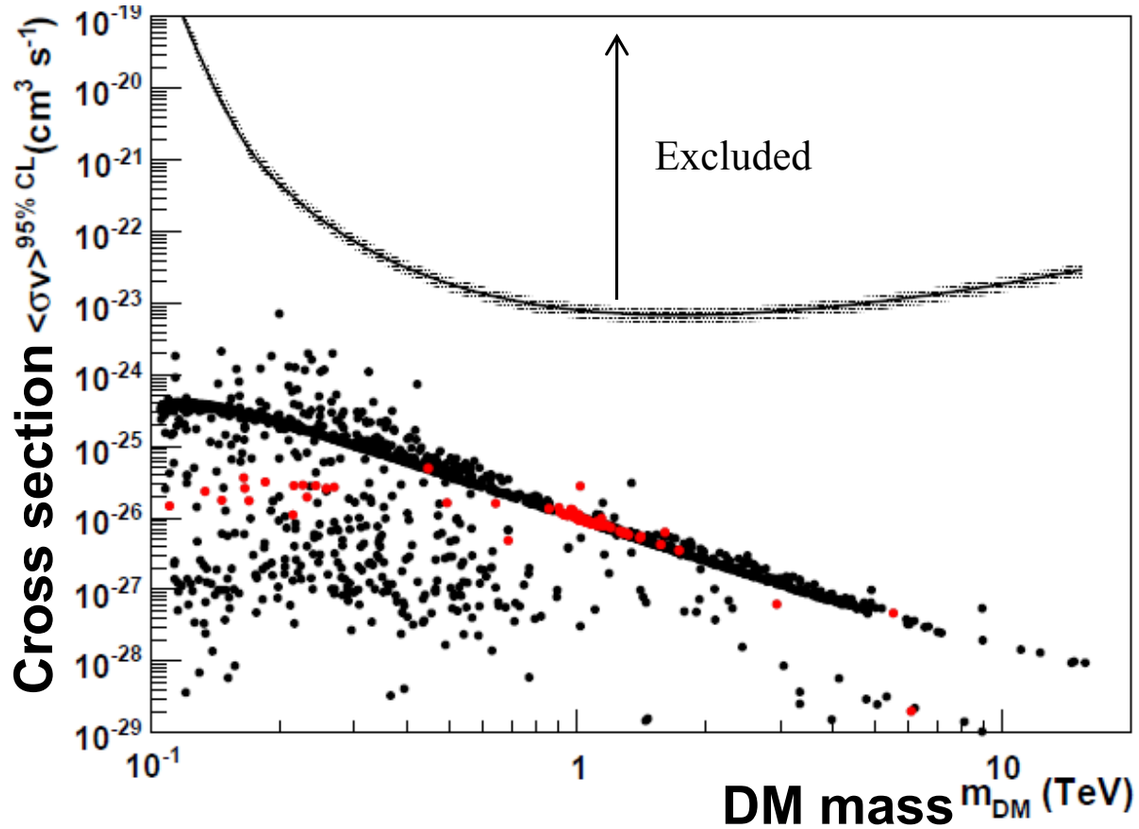
Sagitarius dSph

$$\bar{J} = 0.07 - 2.6\bar{J}^{GC}_{NFW}$$

Large uncertainty

- **Some pMSSM models with higgsino-like neutralino excluded**
- **BUT halo modeling of Sgr dSph too hard due to tidal stripping**

(HESS Collaboration (: F. Aharonian et al.). ApJ 2008)



Canis Major

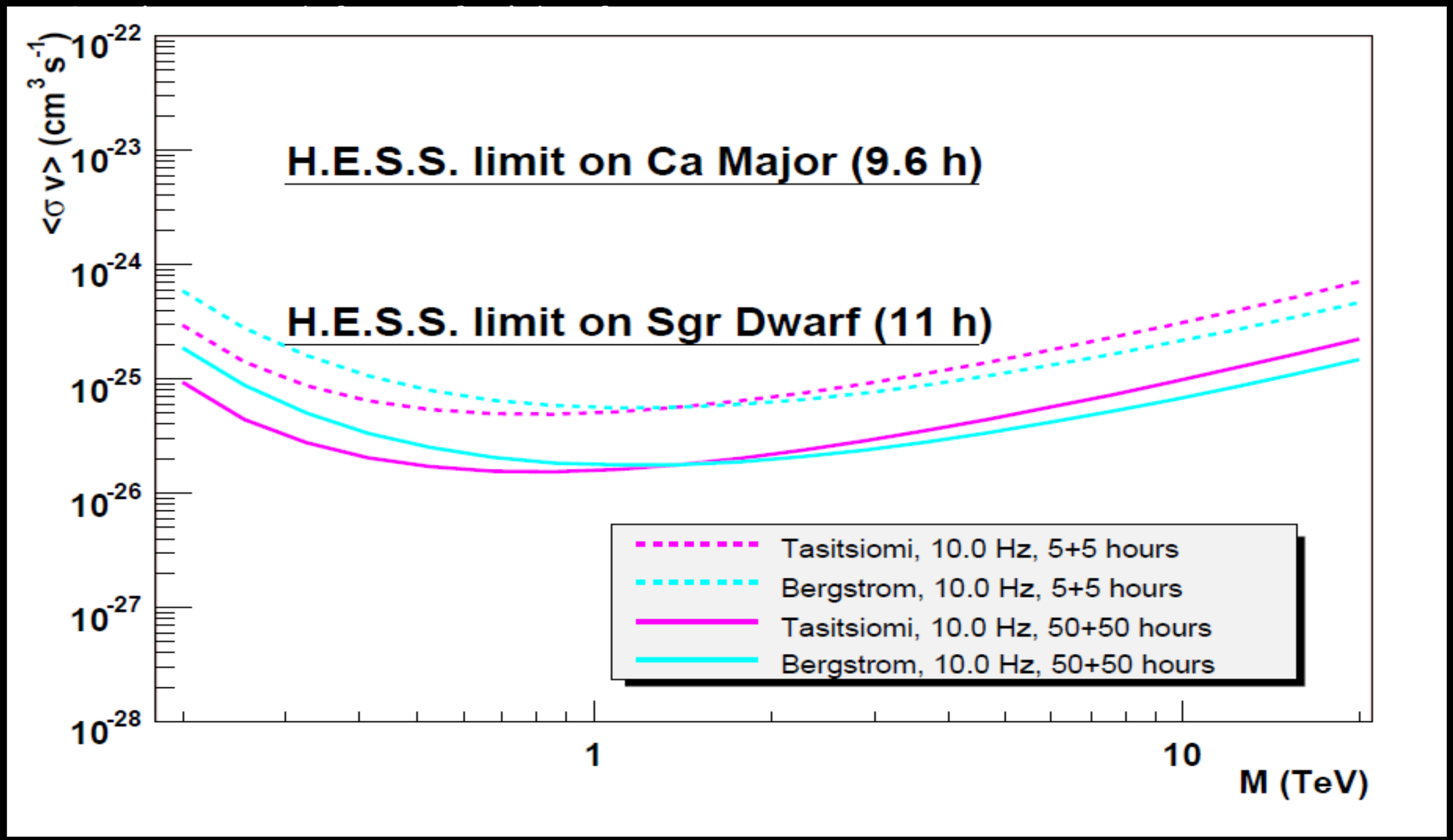
$$\bar{J} = 0.2\bar{J}^{GC}_{NFW}$$

- **Disrupted dwarf galaxy or simply a part of the warped Galactic disk?**
- **On the assumption of a dSph it has a very delicated halo modeling**

HESS results, From Viana

Simulations for HESS sensitivity close to GC

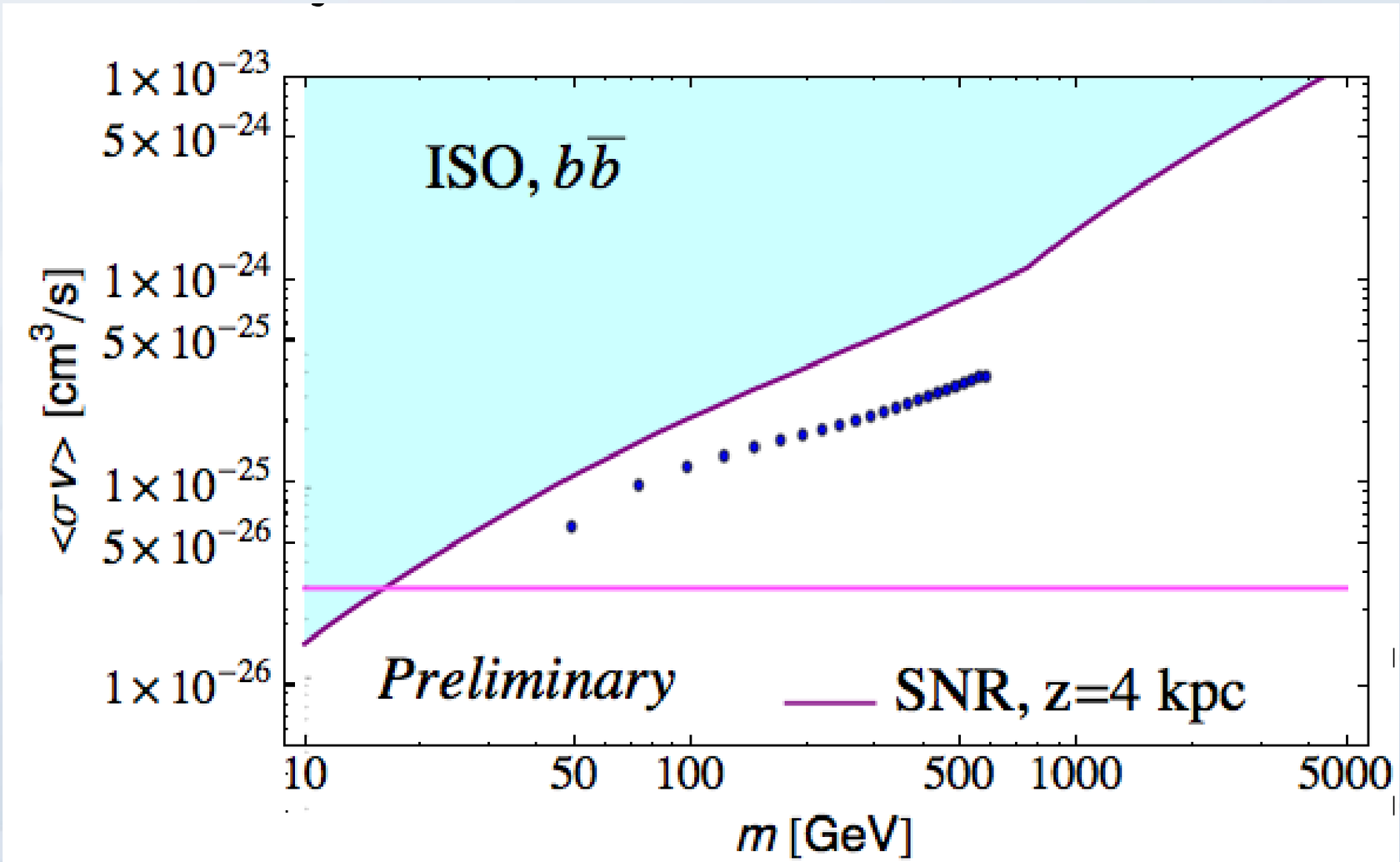
Current activities Background issues



From Viana

Diffuse galactic halo with Fermi

From Brandon Anderson:



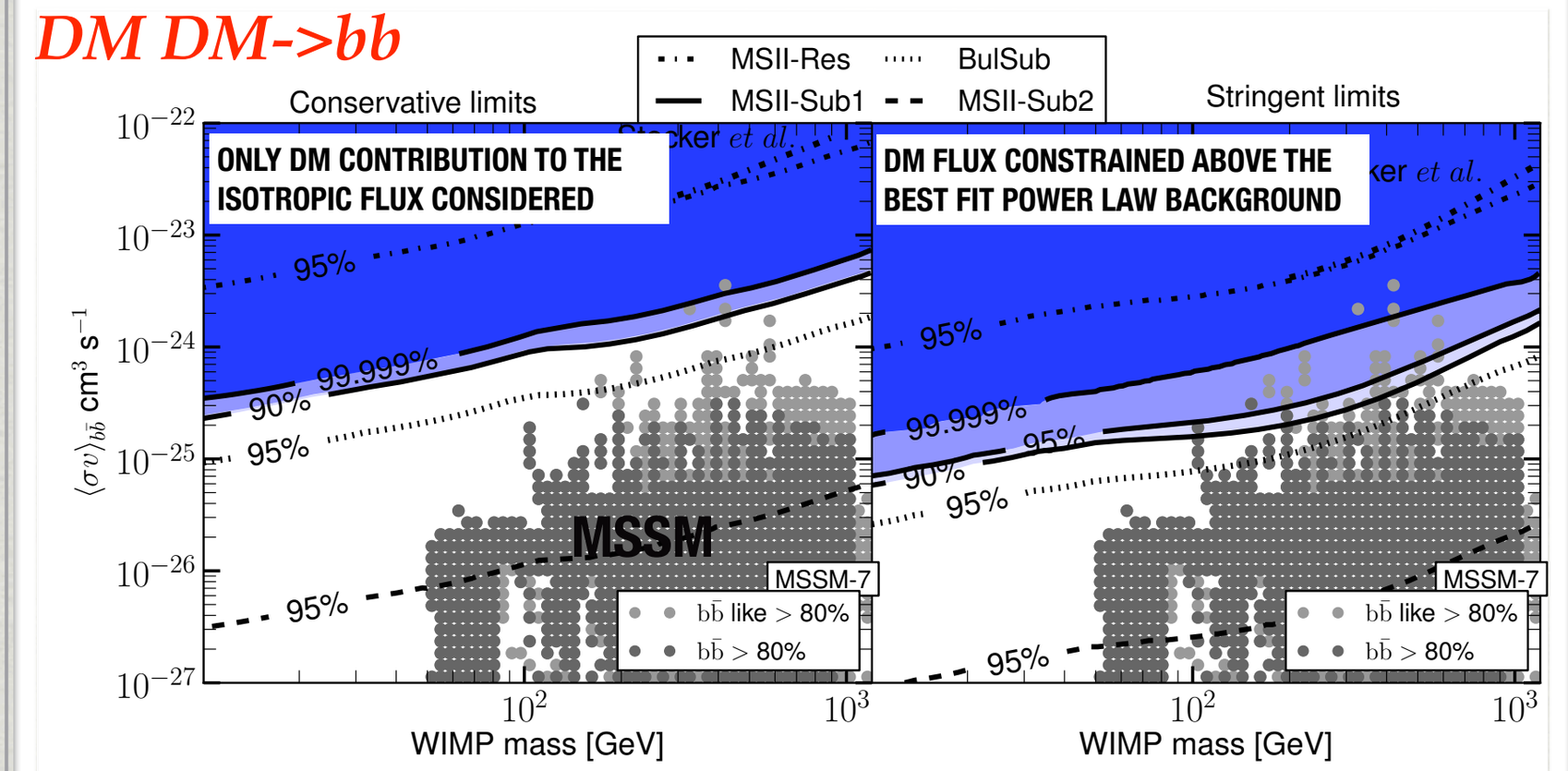
Note: Dots → 95% CL (this analysis, w/ DM subst.)
Line → 3σ

Diffuse cosmological gammas with Fermi

From Zaharijas

Isotropic diffuse signal - DM constraints

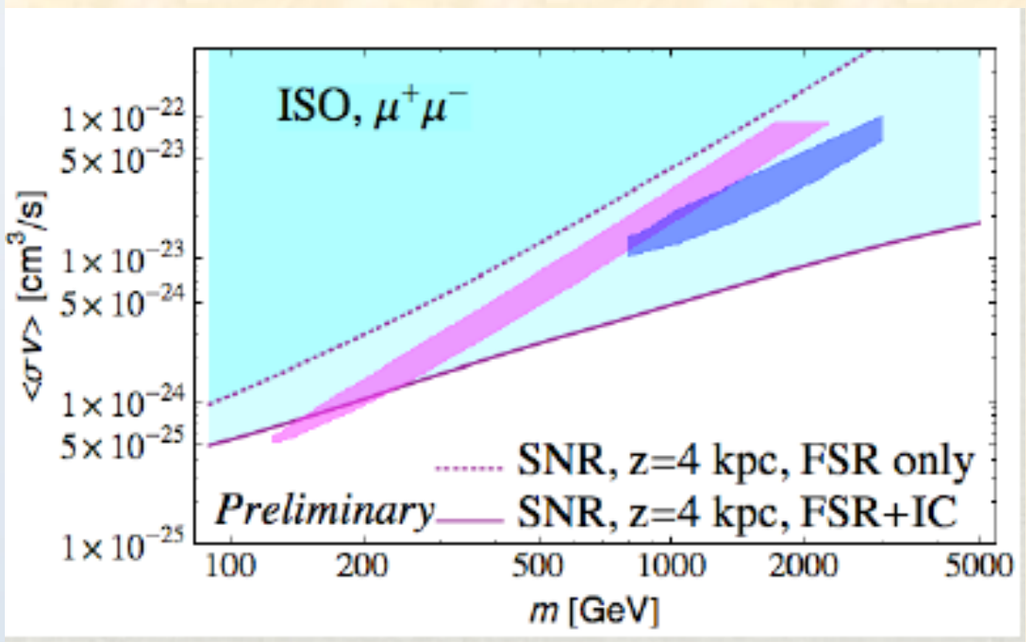
Fermi-LAT collaboration, JCAP 1004:014,2010.

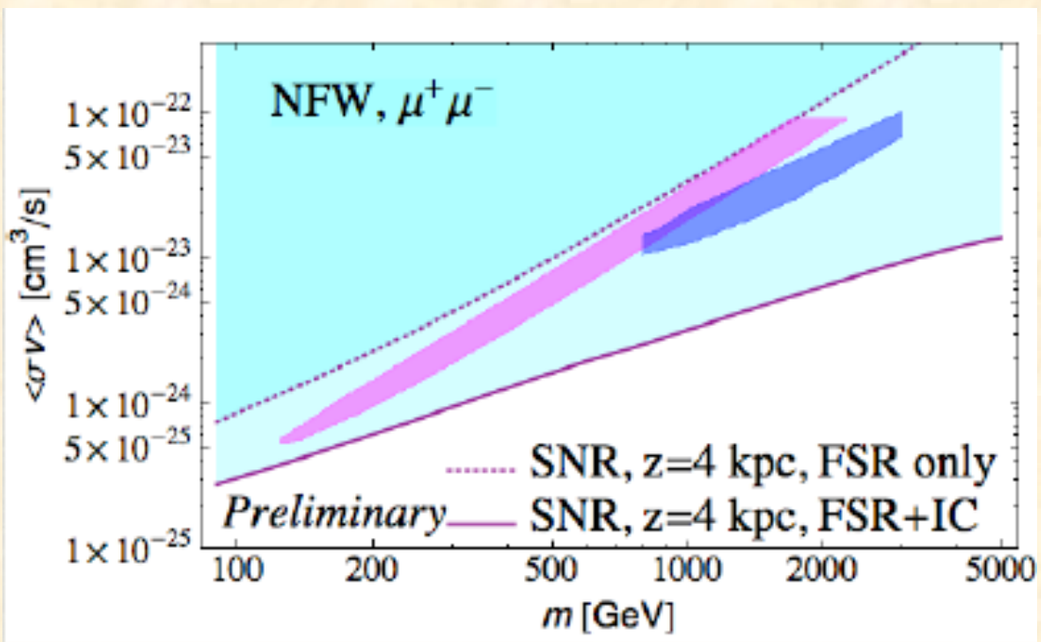


Cosmological DM signal has significant constraining potential. Though total flux uncertain, spectral information could potentially be used to disentangle DM galactic/extragalactic signatures.

FSR and ICS galactic gammas with Fermi

From Cuoco





- **FSR limits only comes from data up to 100 GeV and are quite weak.**

- **With FSR+ICS the Pamela/Fermi region is excluded independently of the DM profile.**

- Still uncertainties in the galactic diffuse model. Modeling improvements and thus better DM constraints are expected in the near future…

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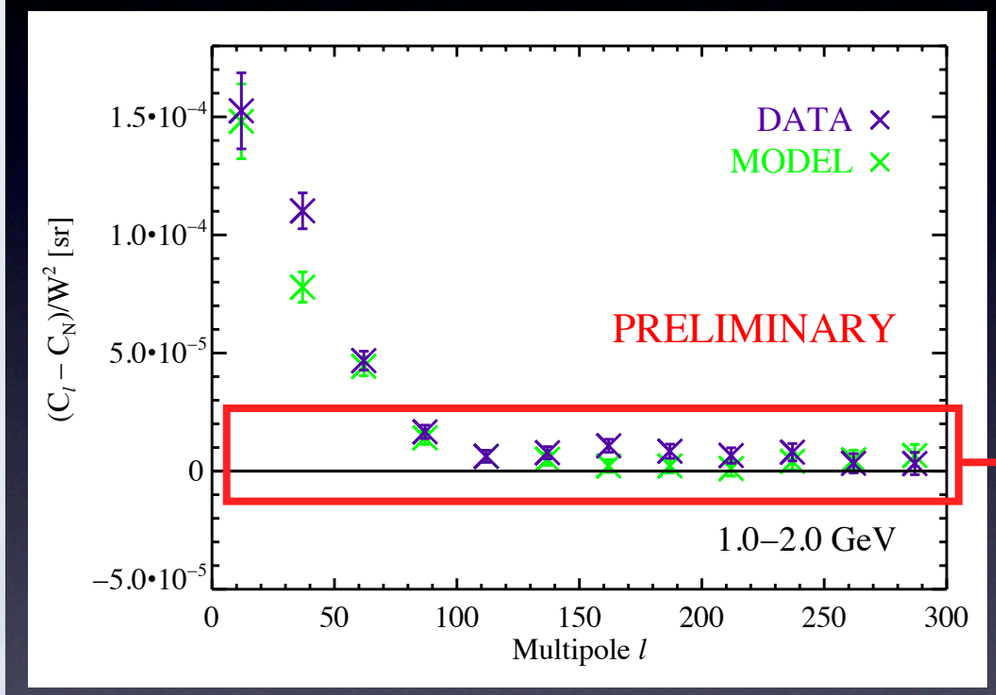
Anisotropies in Fermi data

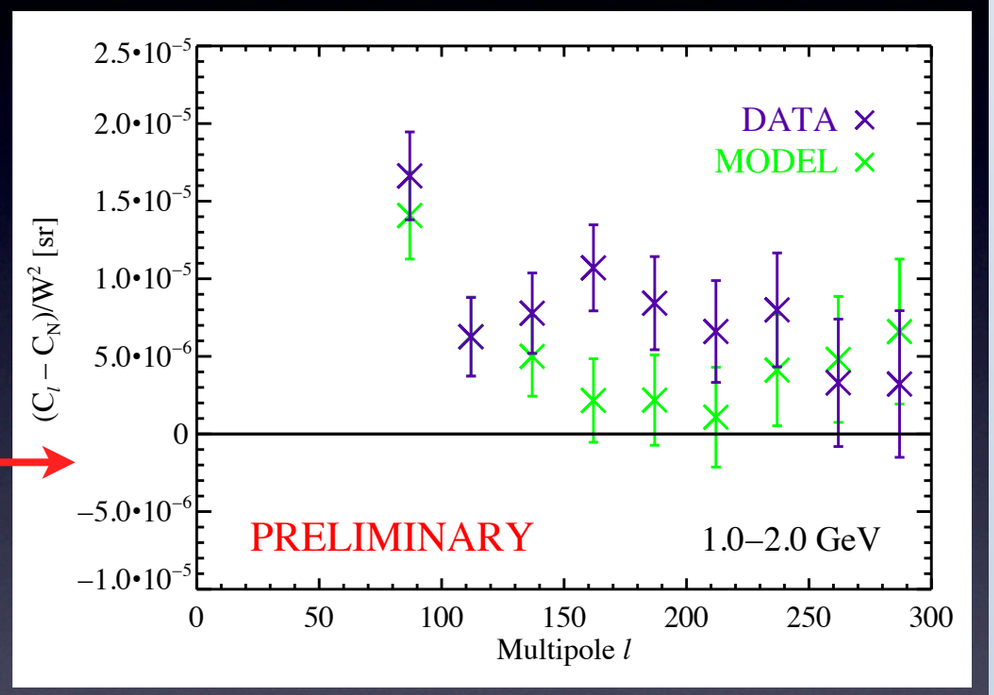
From Siegal-Gaskins

Data and Model Comparison

fluctuation angular power spectra

1 - 2 GeV





- at multipoles greater than ~ 100
  - angular power above the photon noise level is measured in the data at energies from 1 to 5 GeV; excess power is found at lower significance up to energies of 10 GeV
  - no significant angular power is seen in the model
  - the excess power in the data at these multipoles suggests a contribution from a point source population not present in the model

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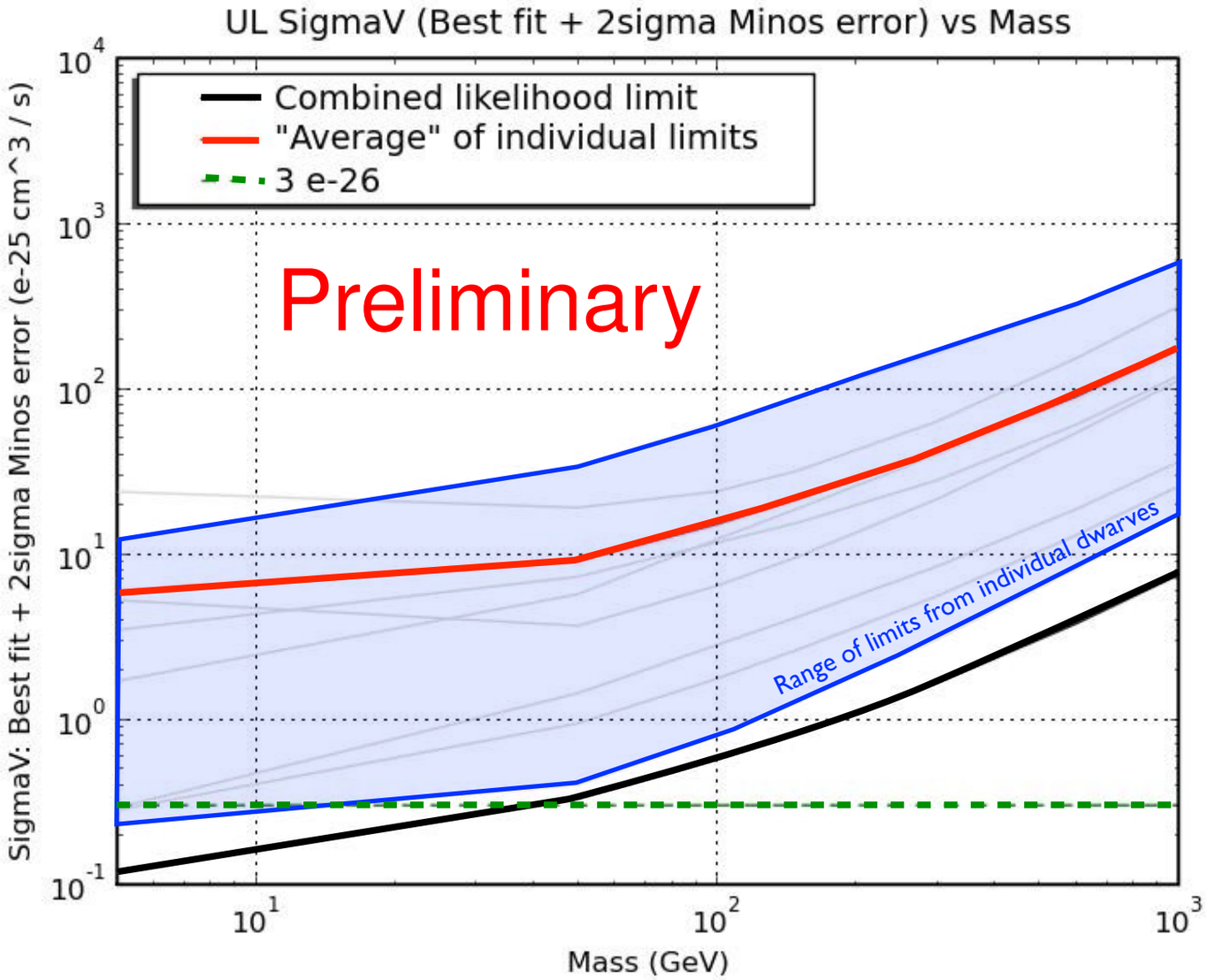
Stacked dwarf analysis from Fermi

From Maja Llena Garde



- Combined upper limit gives up to a factor 3 (45) better constraints compared to the best (average) dSph.
- The “average” limit of the individual cases is plotted here just to guide the eye. The grey lines are the individual limits and the dashed green line is the thermal WIMP cross-section.

We are reaching into the standard thermal WIMP region!!!

(Average J-value used here)

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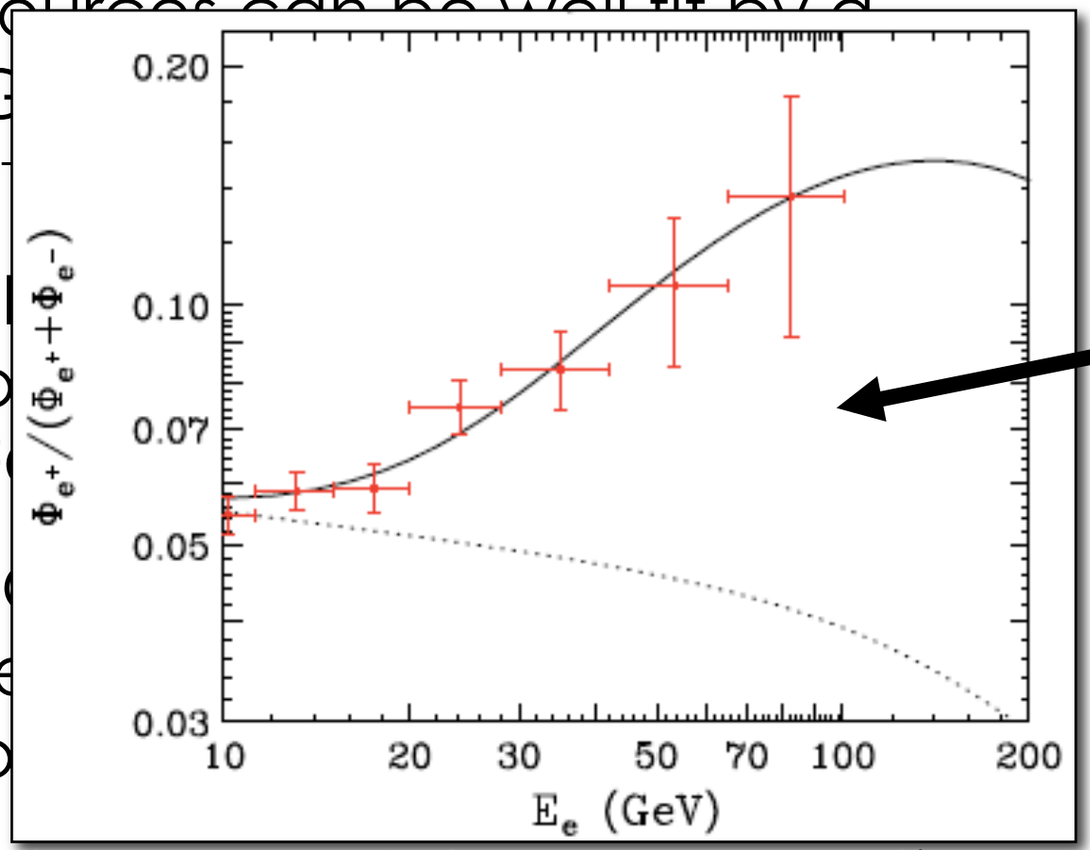
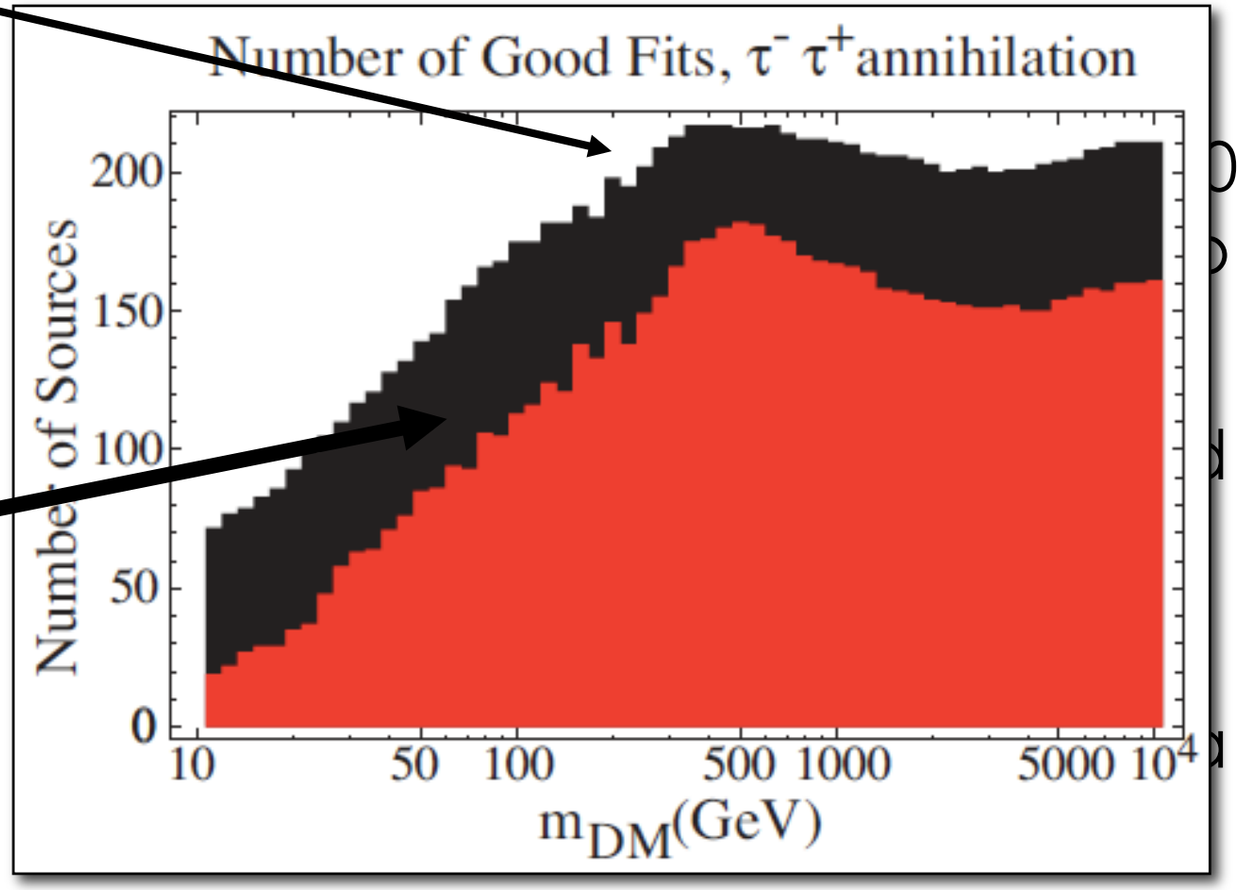
Nearby Dark Matter Subhalos

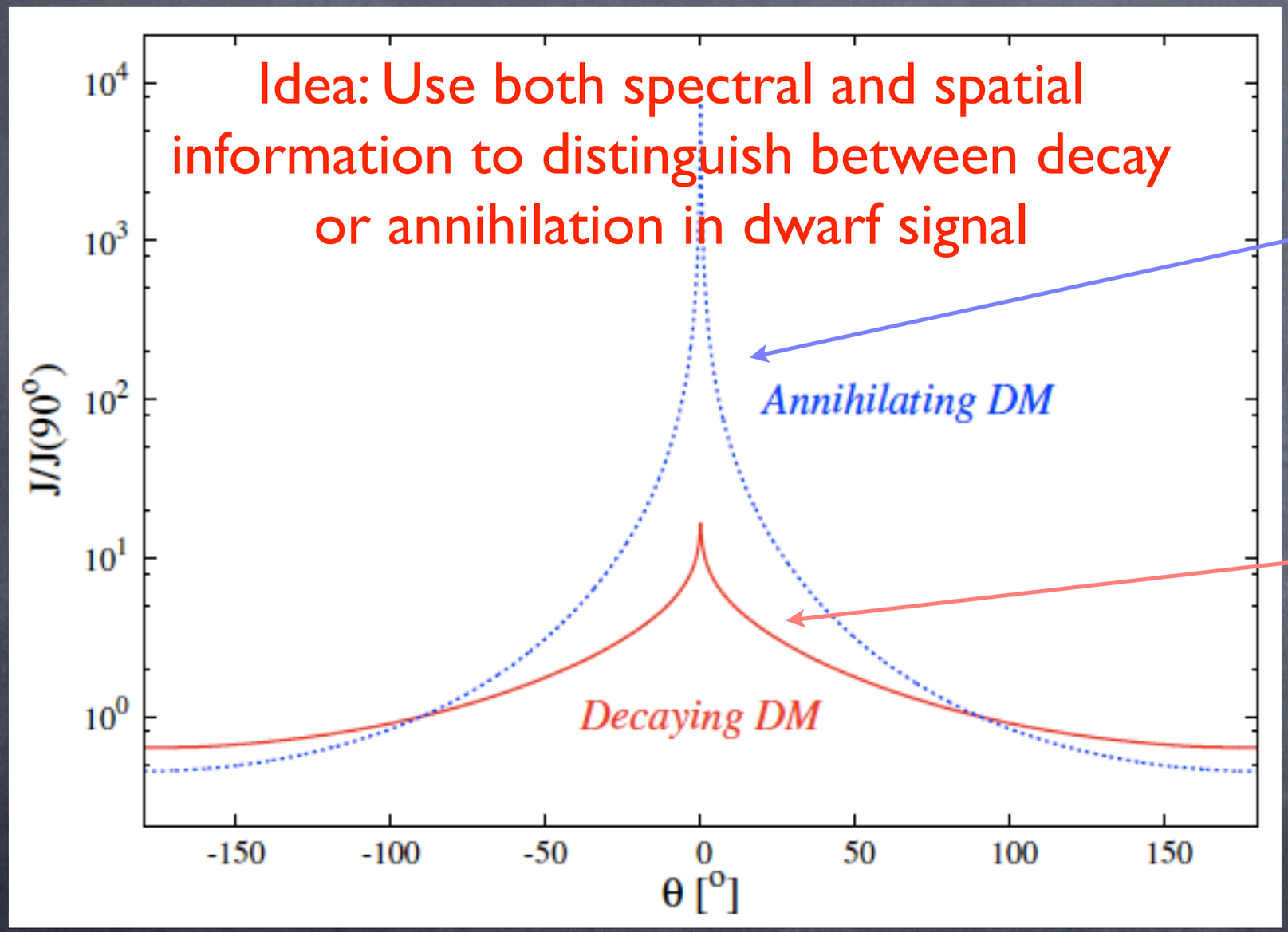
- But what would a subhalo population within the FGST look like?
- Perhaps something like this?
- A surprising number of FGST sources can be well fit by a
- Corresponds to a cross section of ~6×10^{-23} cm^3/s, not far from that required to explain PAMELA





M. Buckley and D. Hooper, arXiv:1004.1633

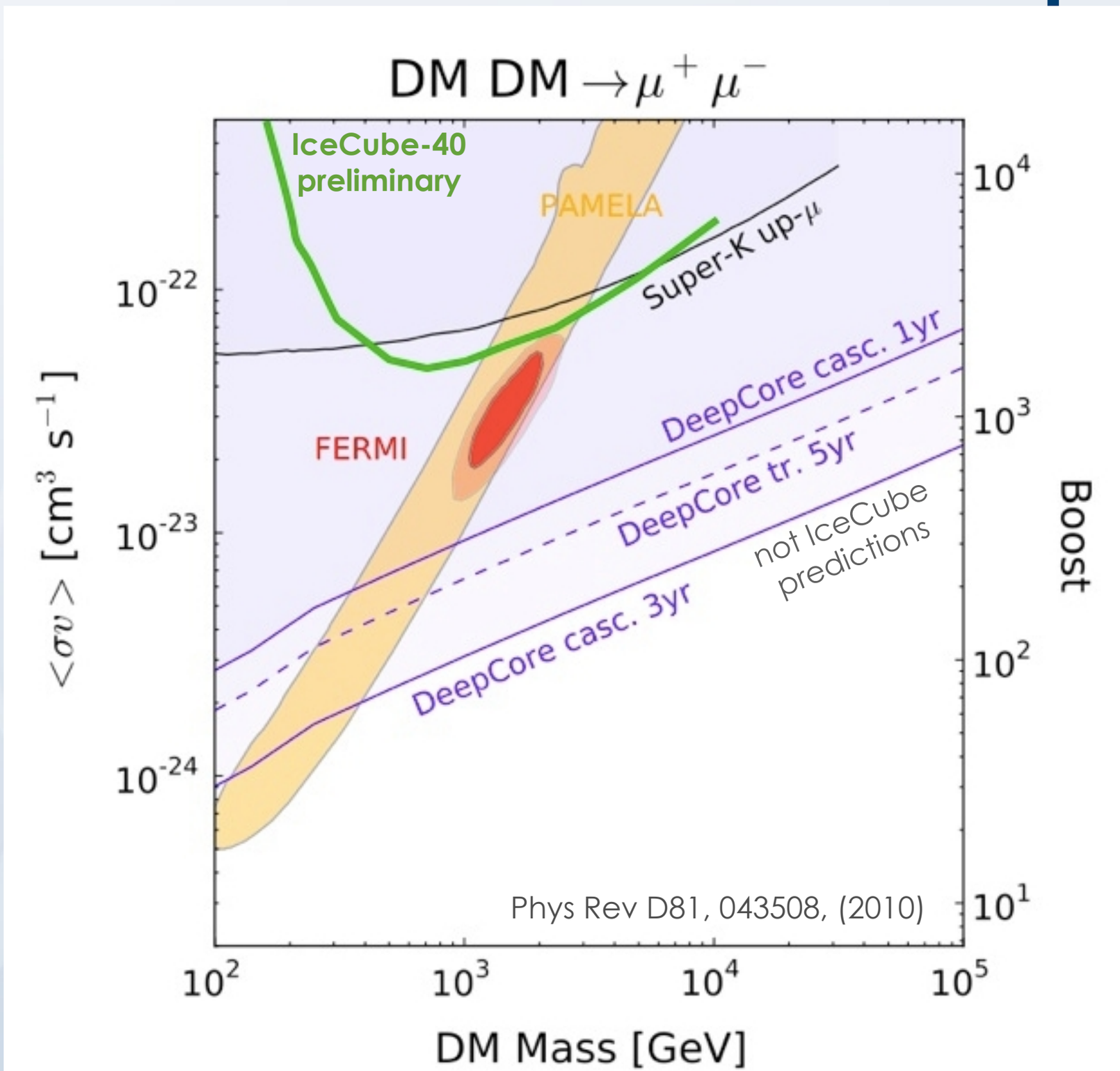
Annihilation or Decay or …?



G. Bertone, W. Buchmuller, L. Covi and A. Ibarra, *JCAP 0711:003, 2007*

From Palomares-Ruiz

IceCube / DeepCore



- DeepCore will be a significant improvement for dark matter searches, both for signals from the Sun, but also the GC as IceCube can be used as a veto

From Perez de los Heros

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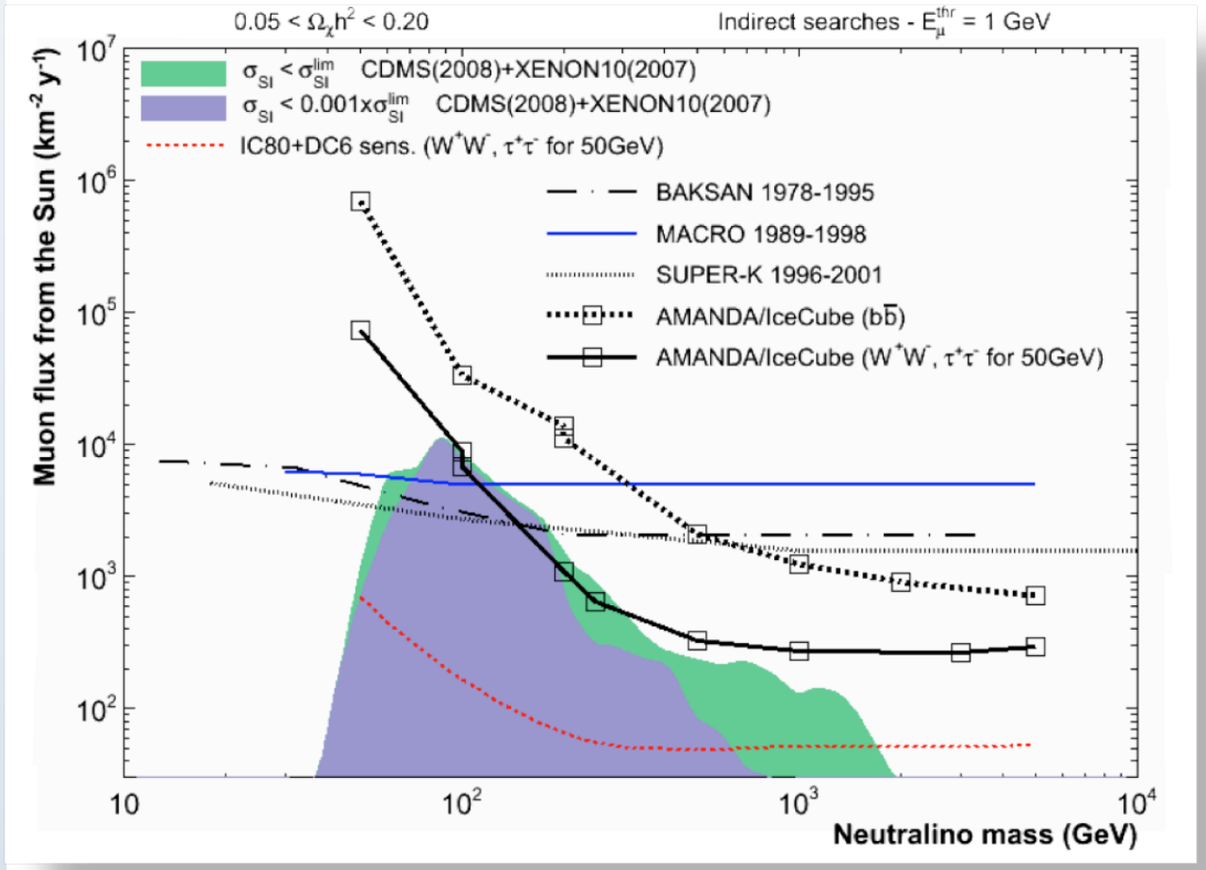
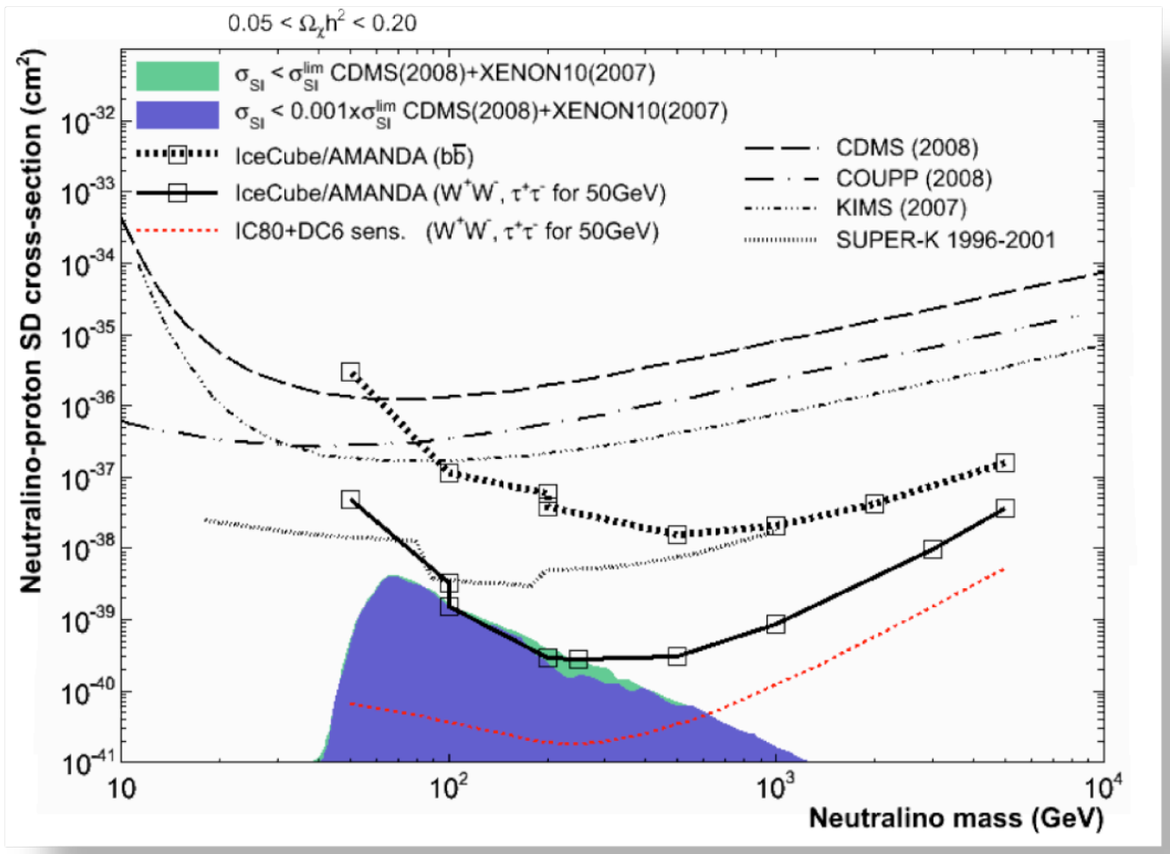
Complementarity IceCube / DD

90% CL **muon flux limit** from the Sun υs neutralino mass
(compared to MSSM scans)



90% CL **neutralino-p Xsection** limit υs neutralino mass
(compared to MSSM scans)



$$\Phi_\mu \rightarrow \Gamma_A \rightarrow C_c \rightarrow \sigma_{Xp}$$

(particle physics and solar model)

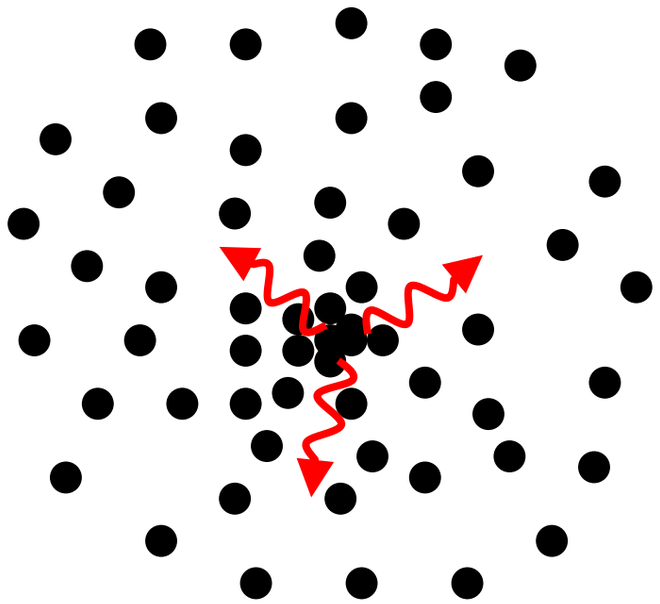
Phys.Rev.Lett.102,201302,2009

From Perez de los Heros

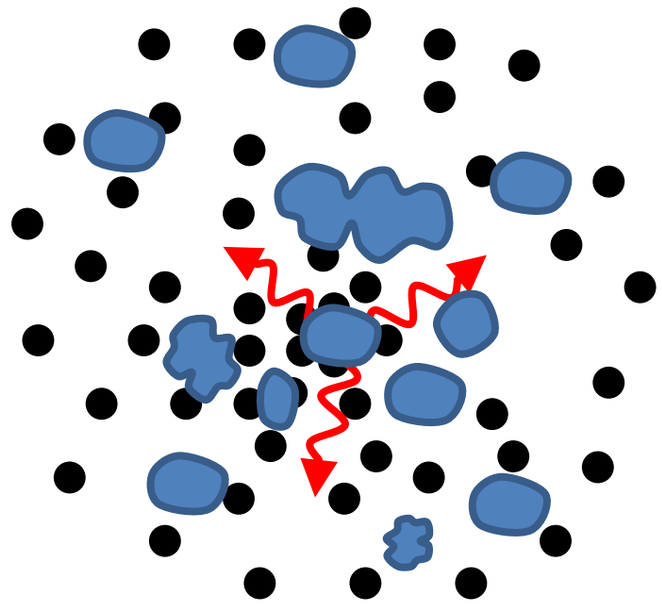
I encourage Super-K to extend analysis to lower masses!

Dark stars

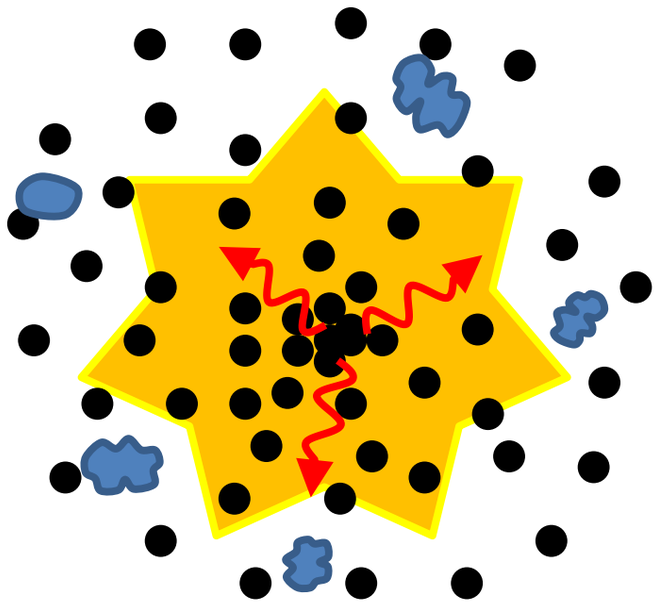
Dark stars – What? Where?



WIMP annihilation in centre of CDM halo



Gas cools and falls into the centre

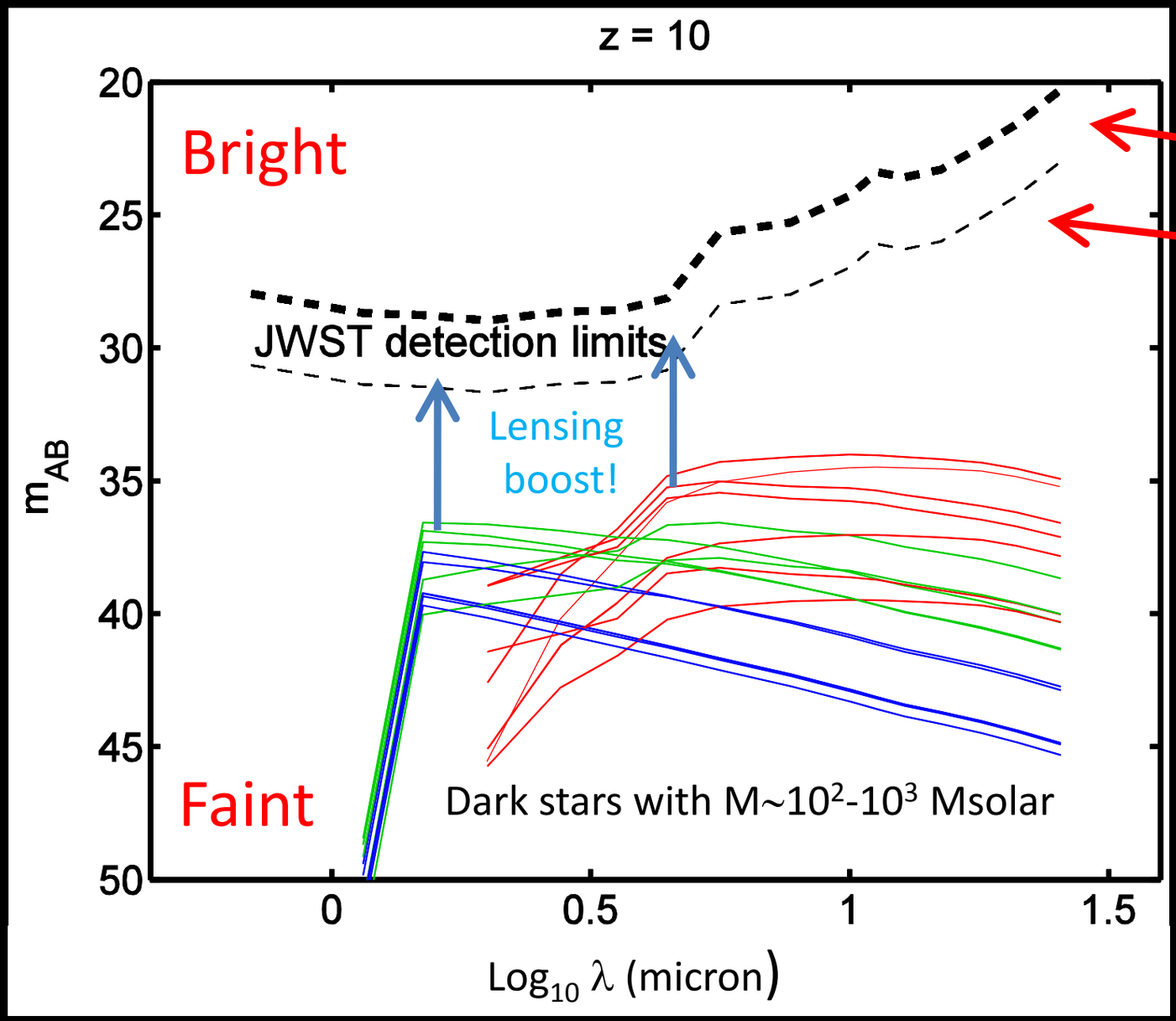


Star fueled by WIMP annihilation rather than hydrogen fusion

From Zackrisson

Can we see them?

Gravitational lensing



3 h @ 10σ

100 h @ 5σ

Good news:
Gravitational lensing will make *some* of these dark stars sufficiently bright! ☺

Zackrisson et al. 2010, ApJ 717, 257

From Zackrisson

Extragalactic background light?

Calculated EBL density vs. data

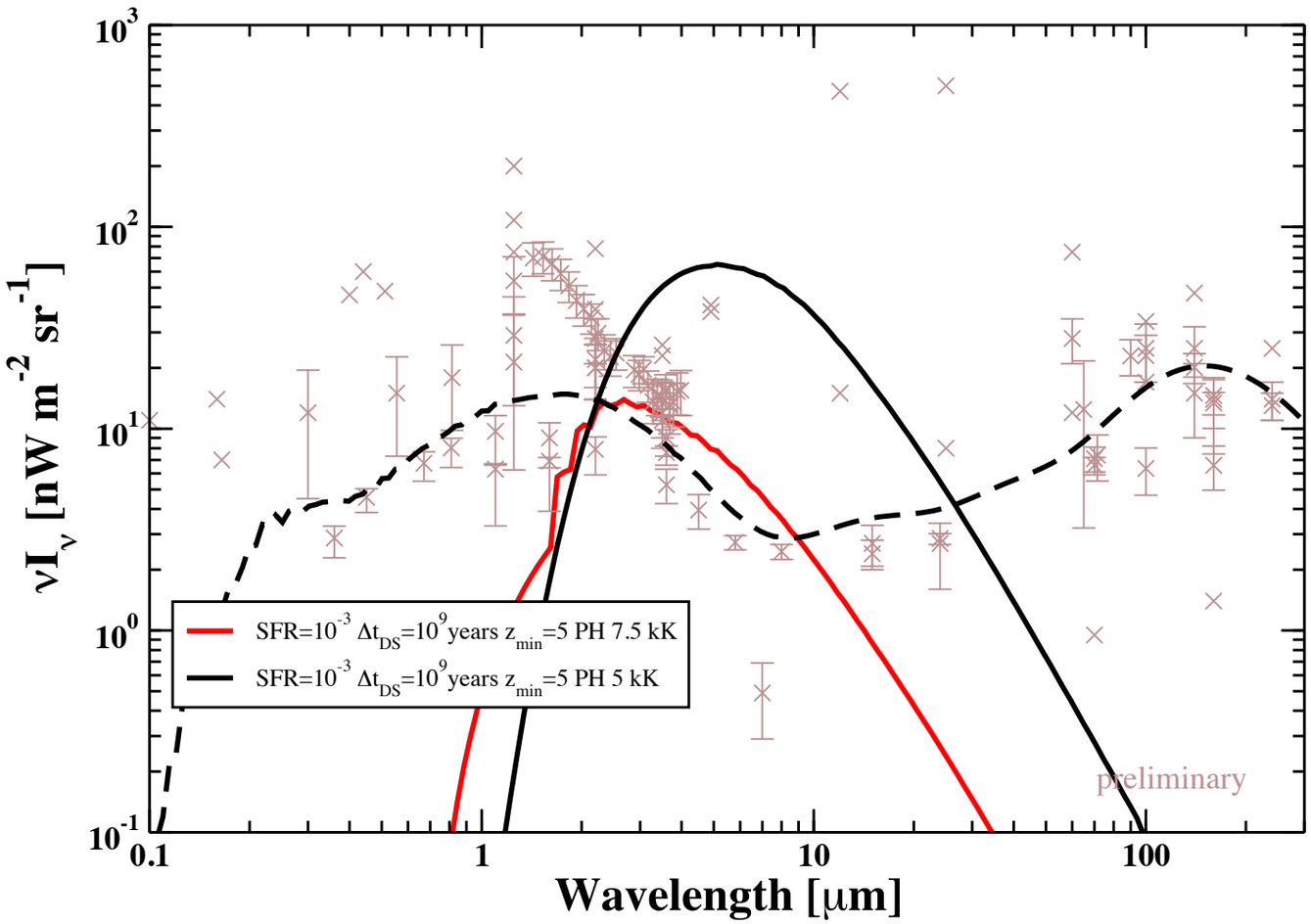


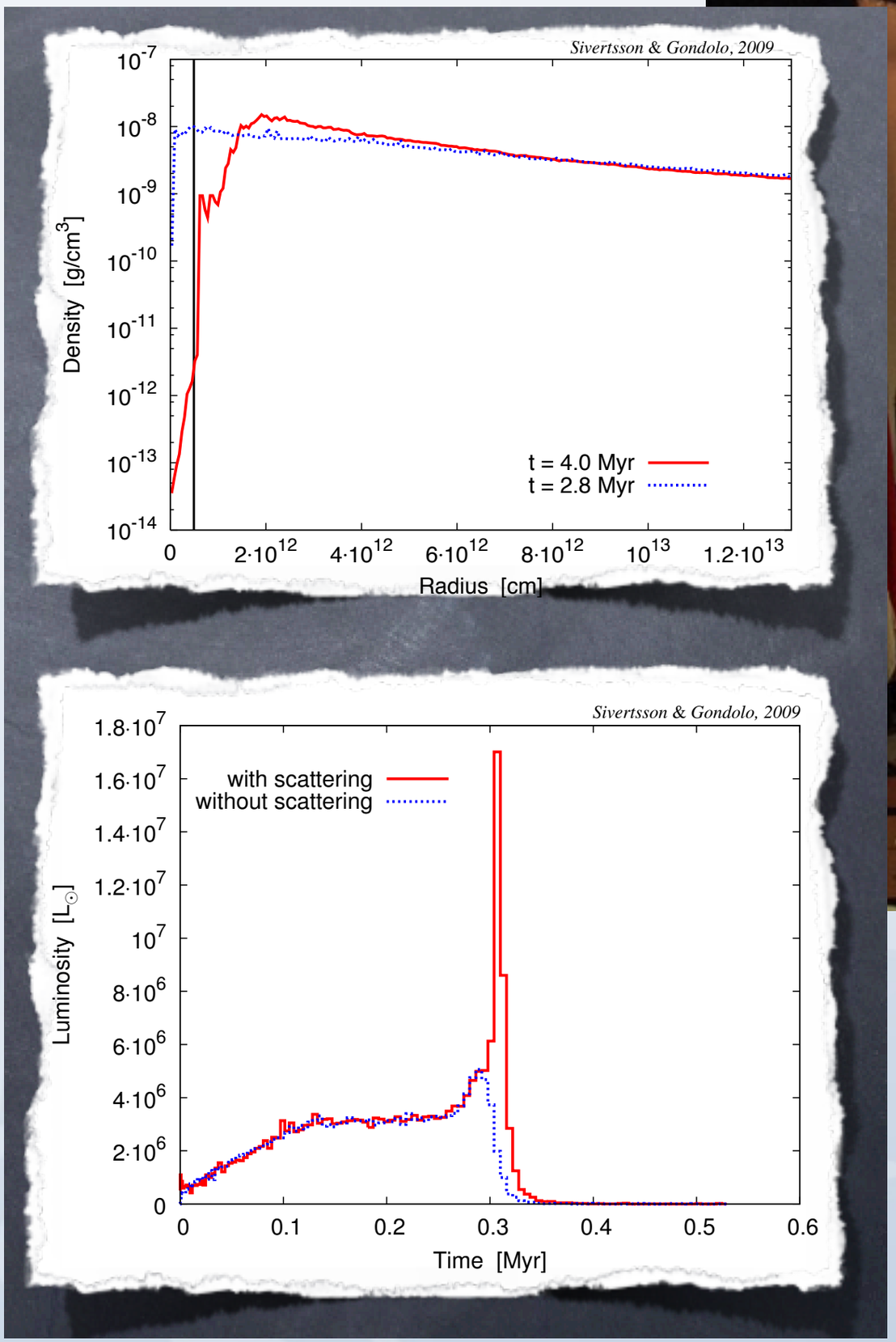
Figure: Maximum EBL contribution scenarios of DS parameters, EBL model by Kneiske *et al.* 2004 (black dashed line)

Basic Picture Continued

- Gas core forms
  - supported by DM annihilation
- More DM and gas accretes onto the core
  - Creating a massive Optically thick Ionized cloud
    - supported by DM annihilation.
- If Fusion
  - Star
- But DM Powered
  - Dark Star
- DM in the star comes from 2 different mechanisms
  - Adiabatic Contraction
  - DM capture.

From Spolyar

However, maybe the PoP III dark stars don't live long enough?



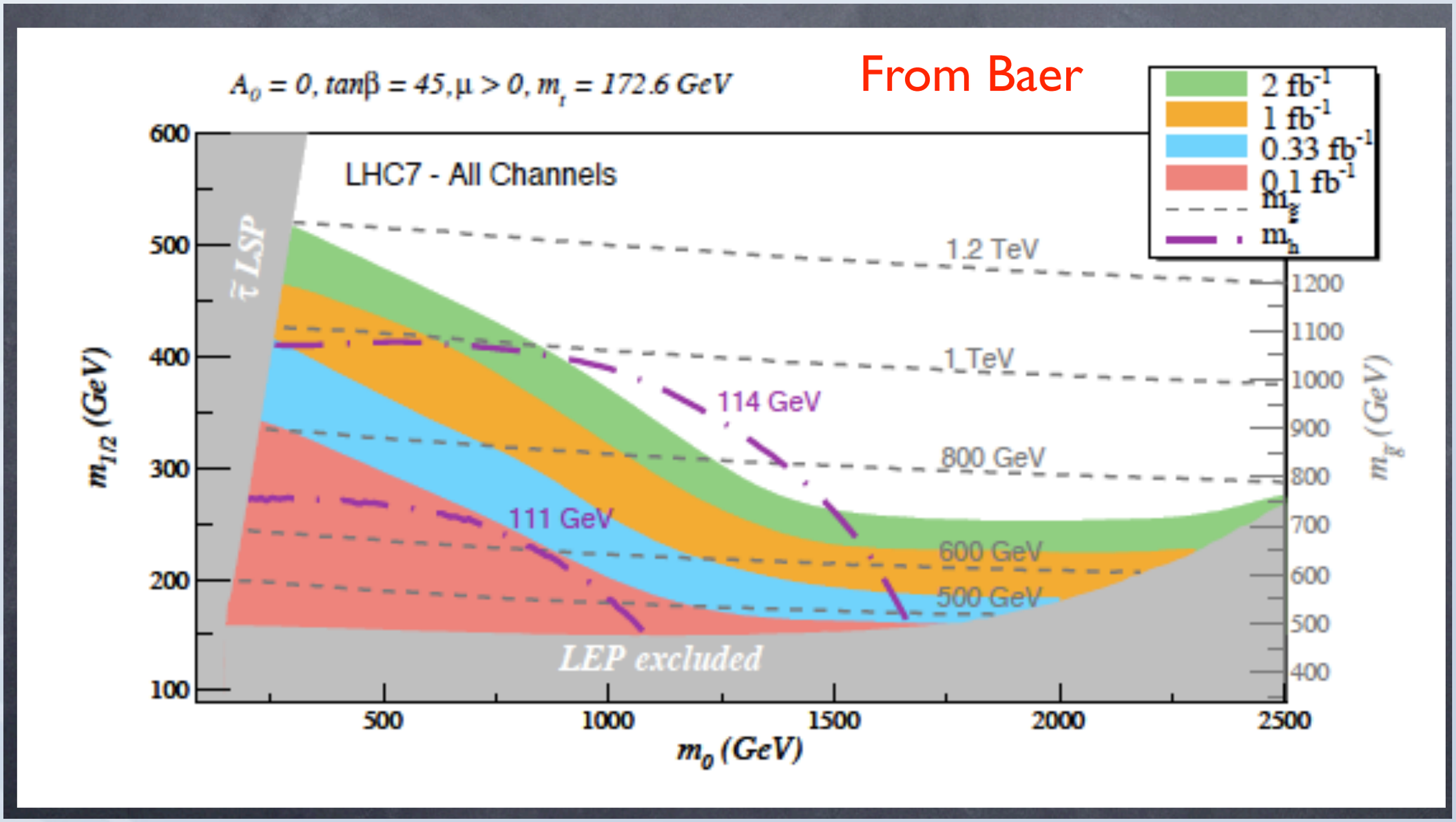
From Sivertsson

Stockholm University

LHC

- LHC up an running! We are eagerly awaiting results on new physics! (see previous talks)
- LHC should in several SUSY-scenarios reach up to several hundred GeVs already in first 7 TeV runs (see Baer's talk).

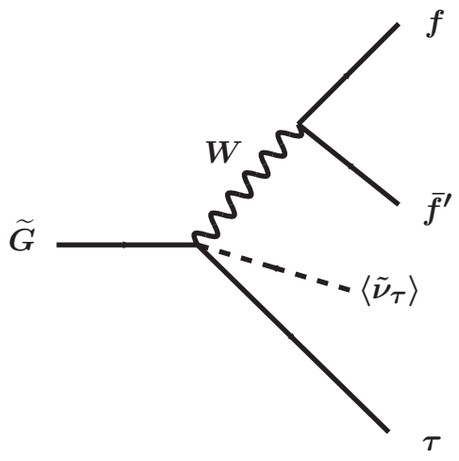
From Baer



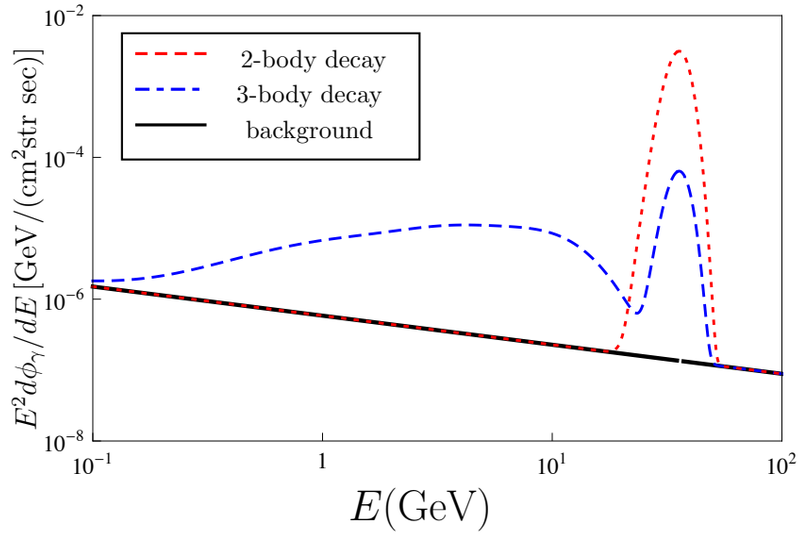
Dark matter models

- Many, many different models presented at the conference
- Apart from standard off-the shelf neutralino WIMPs some models are

New decay modes of gravitino dark matter



From Yaguna

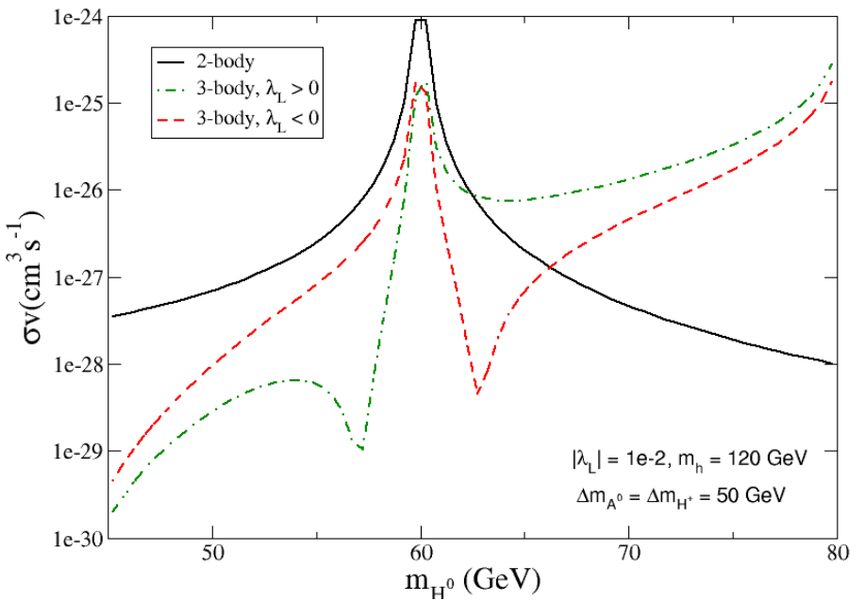


Inert Higgs model:

2-3 body annihilation cross section near m_W threshold

- σv_{2bdy} : higgs mediated,
  $\rightsquigarrow$ suppressed by Yukawa, m_h
- σv_{3bdy} : $\sigma v(WW^*)$ dominantly pure gauge + higgs mediated
  $\rightsquigarrow$ high multiplicity
  $\rightsquigarrow$ gauge unsuppressed

From Honorez



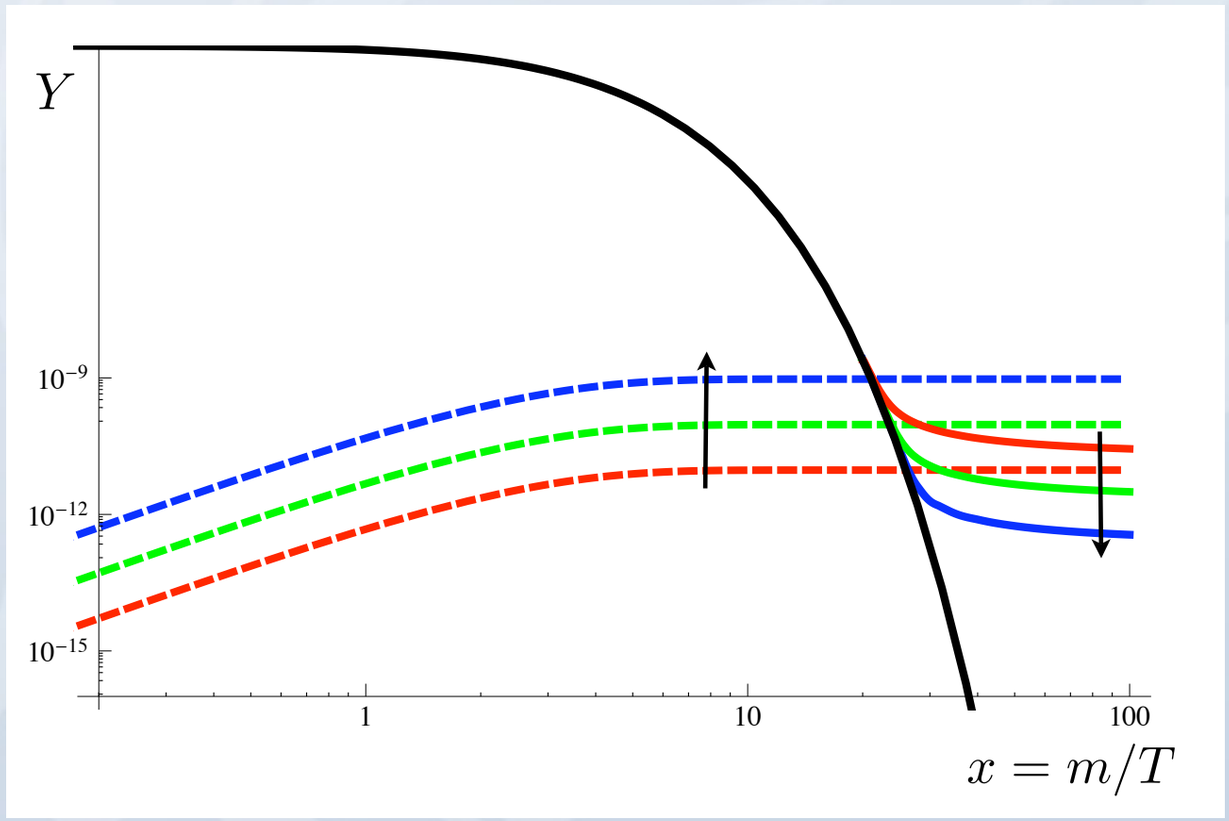
Kumar: WIMPless Miracle

Sikivie: The axion <u>is</u> the dark matter

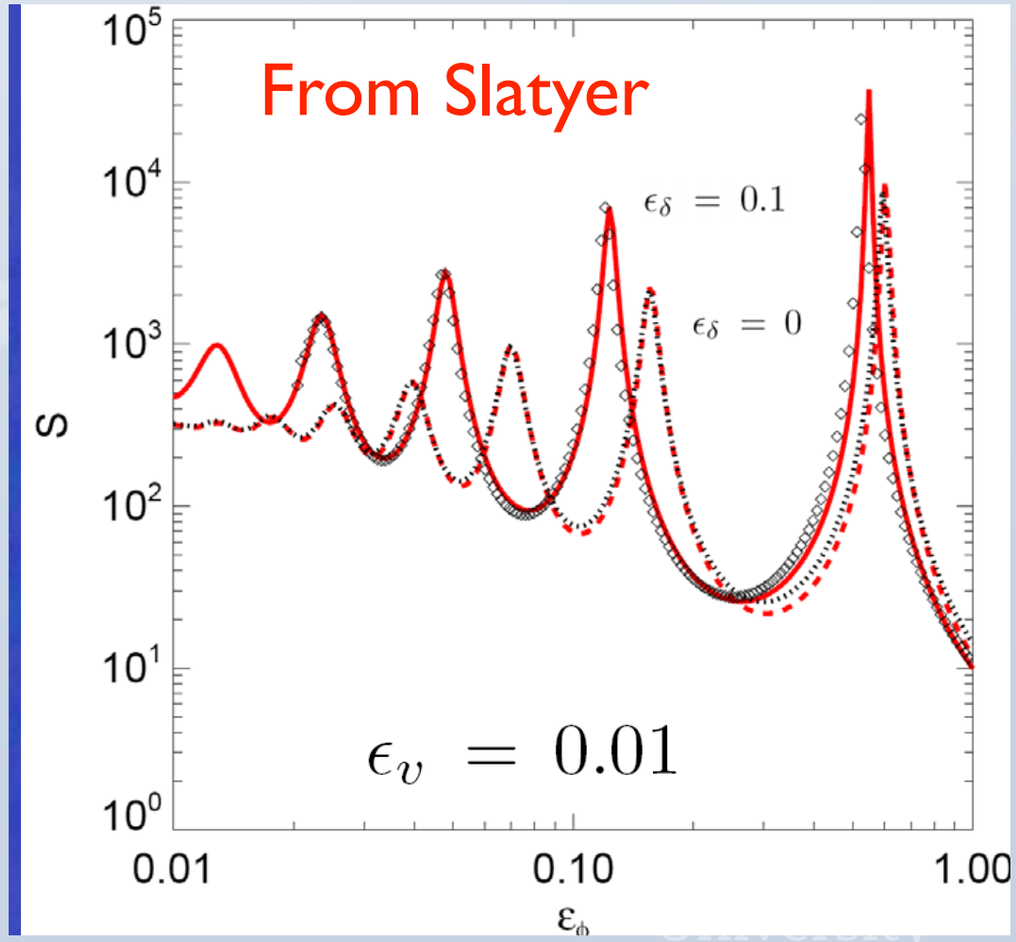
From March-Russell:

FIMP Dark Matter

FIMP = Frozen-In Massive Particle, or
Feebly-Interacting Massive Particle



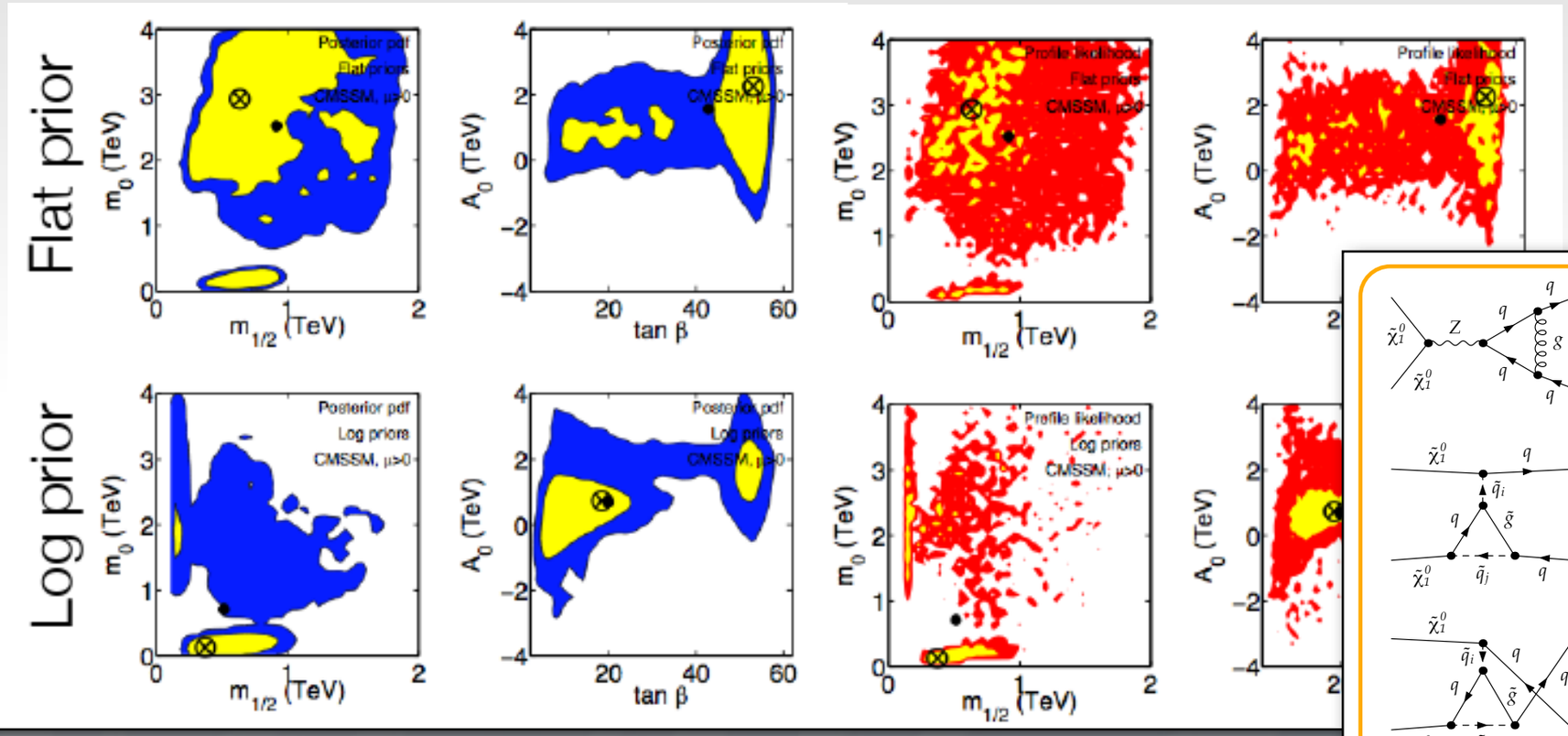
Sommerfeld enhancement
for inelastic dark matter



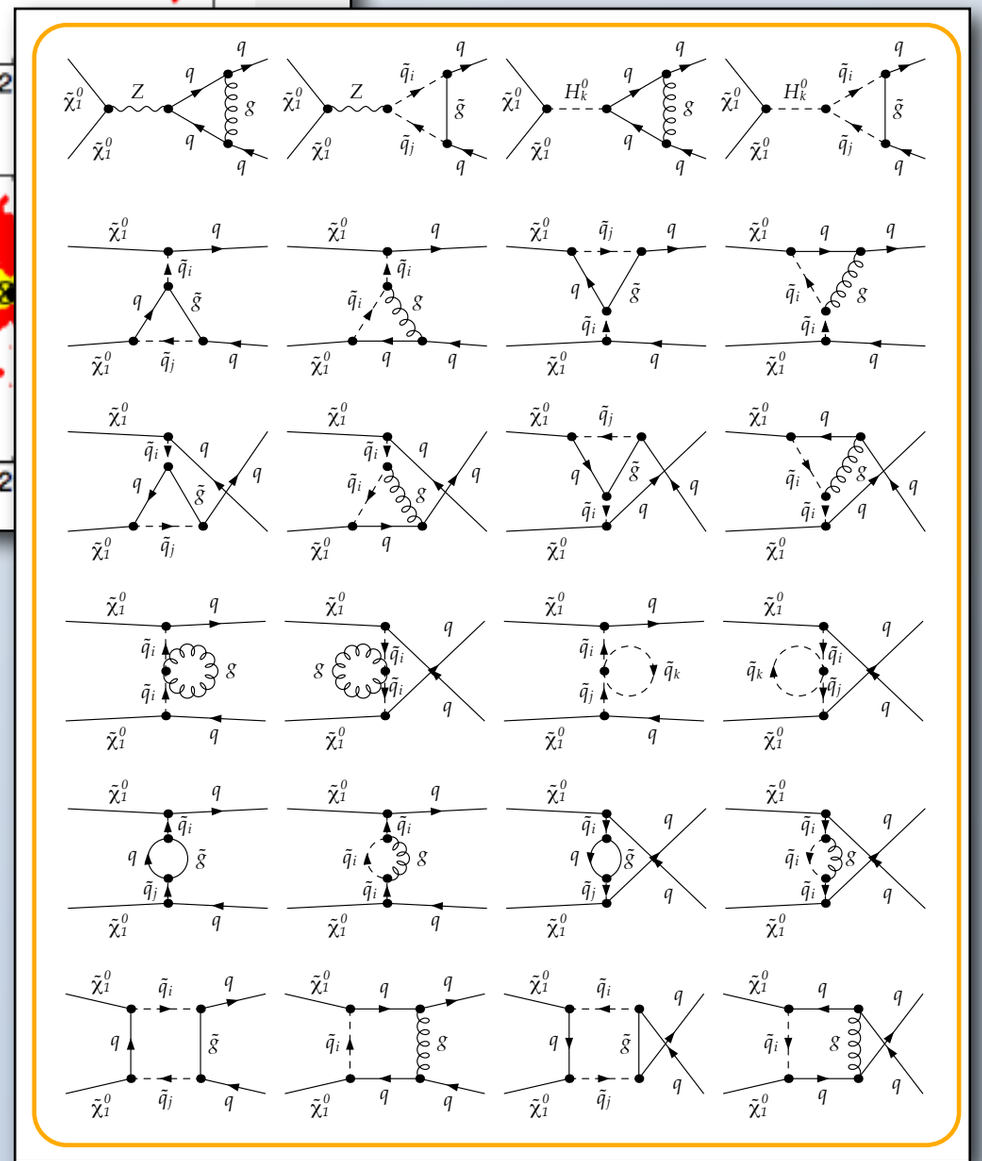
Lot's of efforts on precision also on the theory side...

2D posterior vs profile likelihood

Posterior | Profile likelihood



"Global fits"
From Ruiz de Austri



Higher-order corrections
From Herrmann

How does the dark matter *really* look like?

- Our Swedish astronaut Christer Fuglesang knows what to look for!

Identification of dark matter

- The title of this conference is quite ambitious and at its first incarnations many years ago it was a bit misplaced as we had no signals, which could help identifying the dark matter
- Now, however, we have
  - DAMA/Libra, CDMS II, CoGent, CRESST-II
  - WMAP and Fermi Haze
  - Pamela e+
  - Fermi and HESS $e^+ + e^-$
  - ....
- **Too many signals...?!**

Stockholm University

Future detectors / results

- Xenon100, Xenon 1 ton, Xenon 100 ton, XMASS, SuperCDMS, Lux, Eureca, ...
- HESS2, CTA, Hawc, DMA, ...
- IceCube/DeepCore, Antares, KM3Net, ...
- AMS, GAPS
- LHC
- ... (your favourite experiment/dream here...)

Stockholm University

What will happen at idm2012?

- Will we have a consensus model like in cosmology...?
- Will all "signals" have gone away...?
- Will we have a complete mess with signals in gamma rays, charged cosmic rays, neutrinos, direct detection, LHC, etc that does not fit together at all...?

Stockholm University

idm2012

- You are all welcome to idm2012 that will take place in...

Spain...

Lisbon..

Chicago...

Tokyo...

...or your place (let Neil Spooner know in that case)

in 2012

Before that, also put TeVPA 2011 in your agenda. It will be in Stockholm around first week of August, 2011 (± a few weeks...)

Stockholm University

- Special thanks to the local organizing committee:

  F. Amat, S. Becquet, M. Capdequi-Peyraneire, N. Clementin, J. Cohen-Tanugi, M. Compin, M. Delpont, K. Jedamzik, G. Moultaka, E. Nuss

- And all the secretaries!

Thanks!

Are you still friends with me?
I did show your slides in the beginning of the talk...