Résumé des conférences d'été

matière noire / astro

Merci à Eric pour son aide!

Emmanuel Moulin

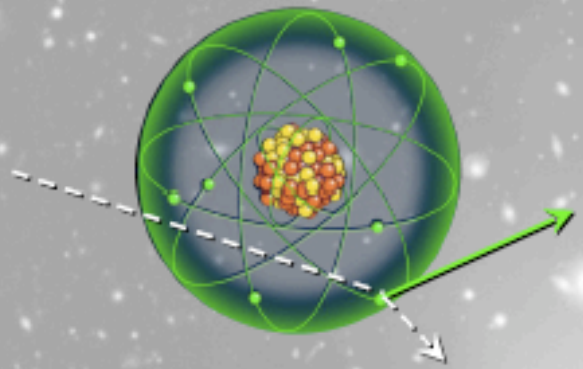
Séminaire SPP, 1er octobre 2012

Détection directe

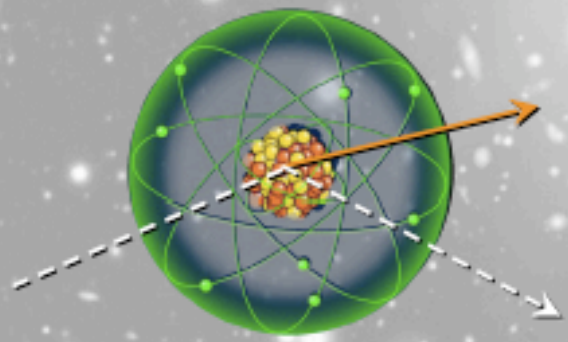
XENON, Edelweiss, CDMS

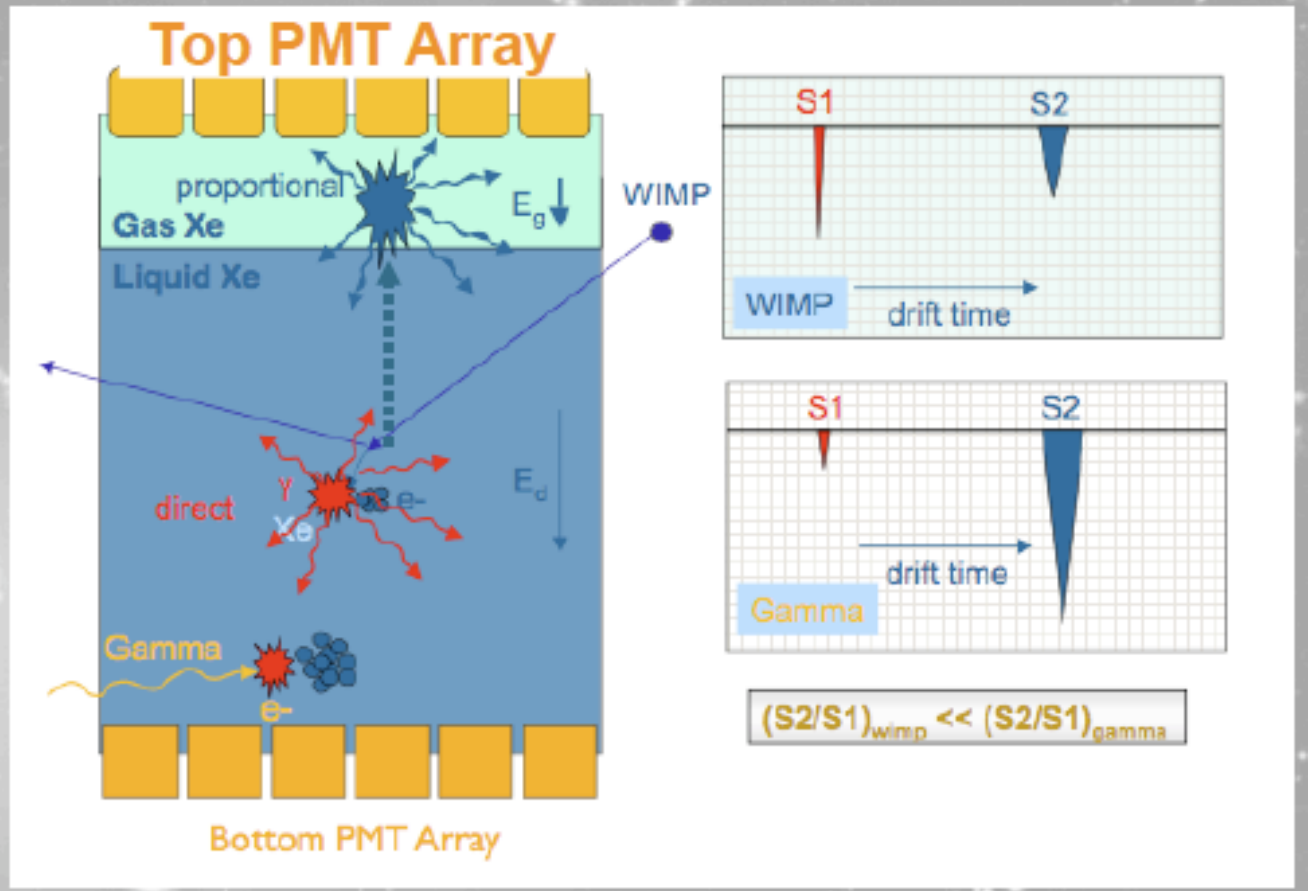
The XENON Two Phase TPC

e⁻/γ: electron recoil



n/WIMPs: nuclear recoil





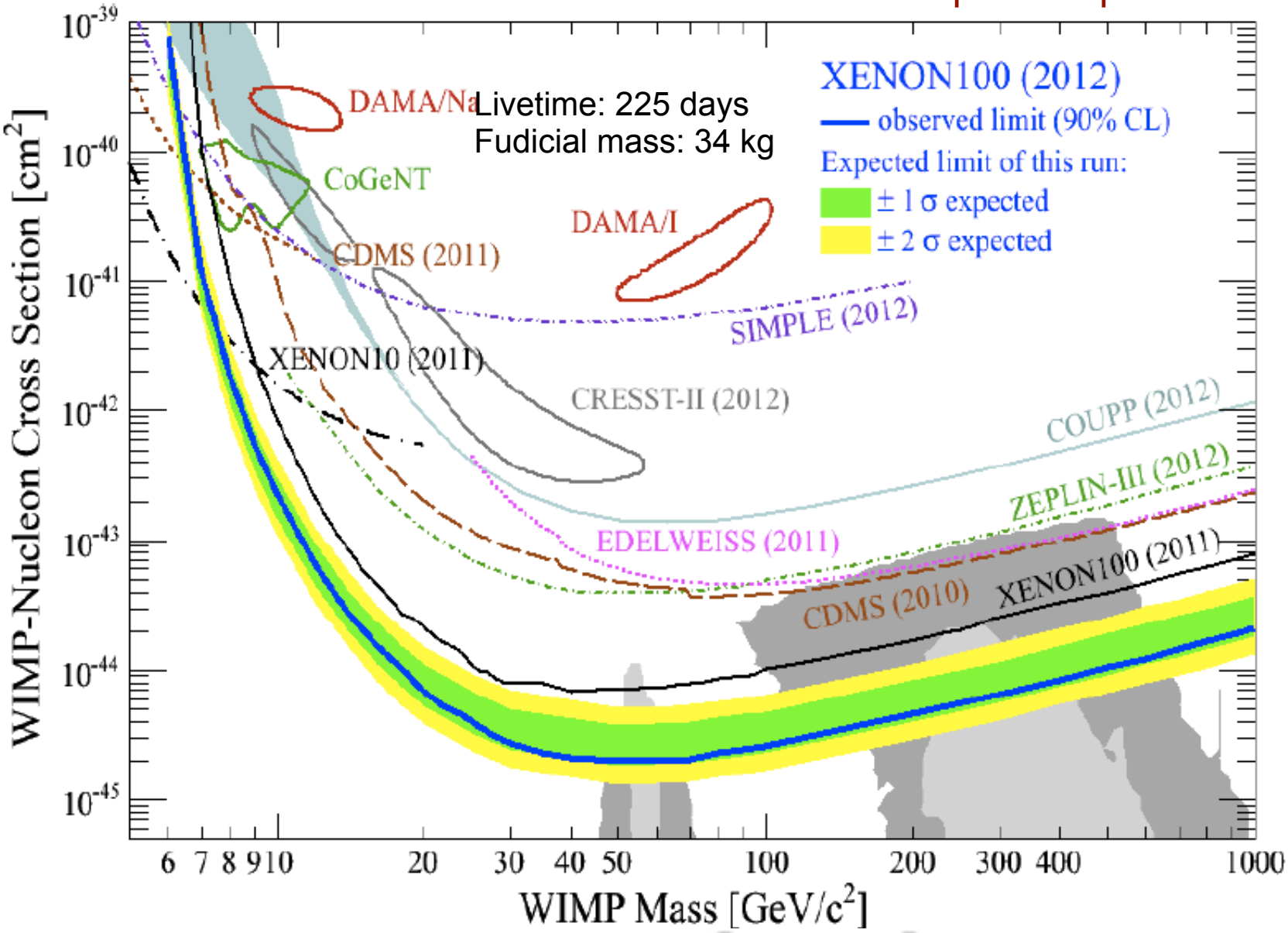
- **Single electron and single photon measurement sensitivity**
- **> 99.5% ER rejection via Ionization/Scintillation ratio (S2/S1)**
- **3D event-by-event imaging with millimeter spatial resolution**

Antonio J. Melgarejo (Columbia University)

IDM, Chicago, July 23rd 2012

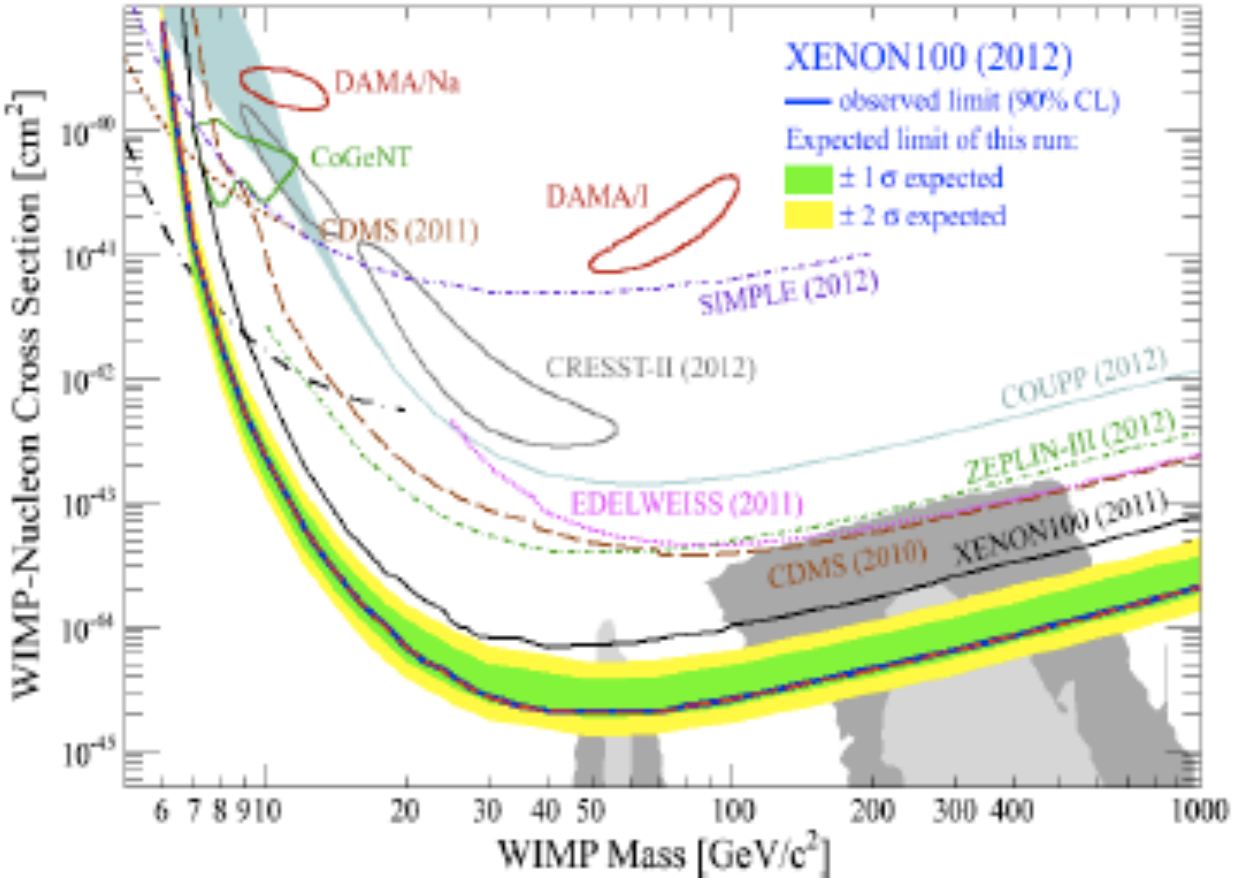
XENON100 results

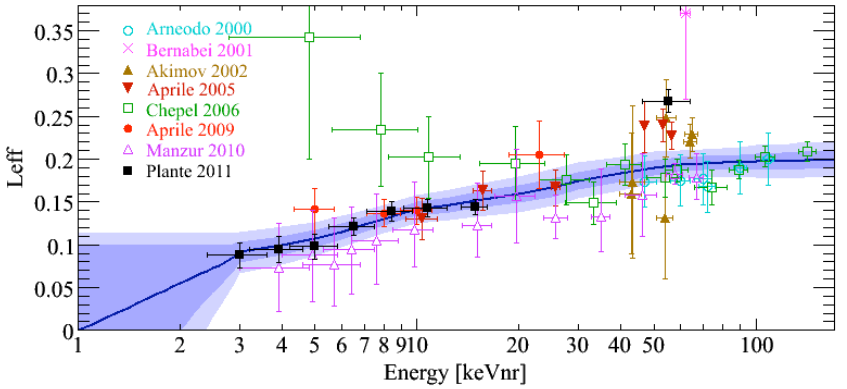
Spin-independent

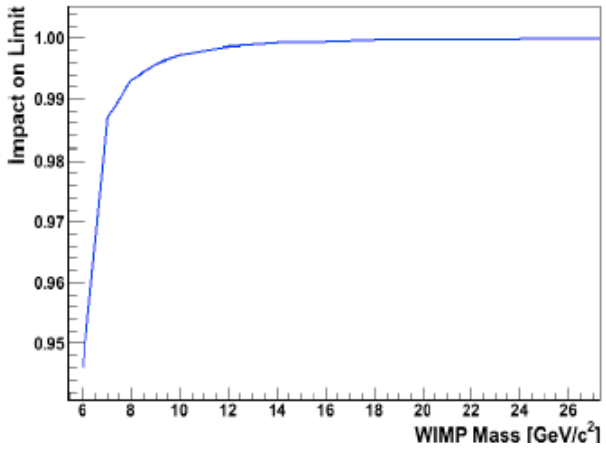


Upper Limit (90% C.L.) is 2 x 10^{-45} cm^2 for 55 GeV/c^2 WIMP

XENON100: energy scale







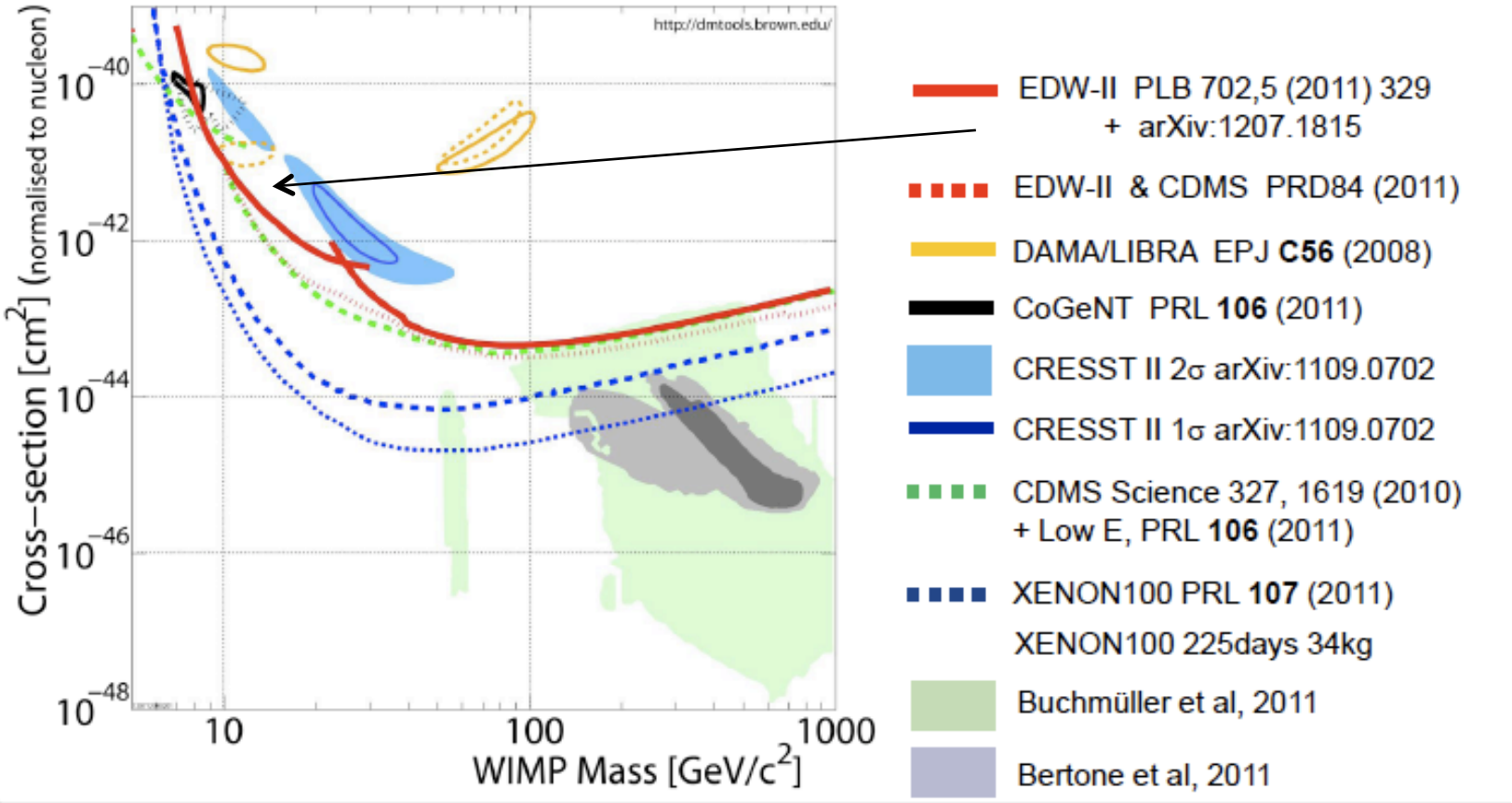
- Computation of the limit assuming that Leff is 0 below 3 keVnr (red line in the figure)
- The impact on the limit is below 5% for all the relevant mass range

EDELWEISS-II low mass results

- Analysis optimized for low-energy events

- Lower gamma rejection
- Decrease of the exposure

EDW (384kgd; [20-200keV], 5evts → $\sigma_{SI} < 4.4 \times 10^{-8}$ pb; $M_{WIMP} = 85$ GeV/c^2)
113 kgd; [5-20keV], 1-3 evts → $\sigma_{SI} < 1.0 \times 10^{-5}$ pb; $M_{WIMP} = 10$ GeV/c^2)



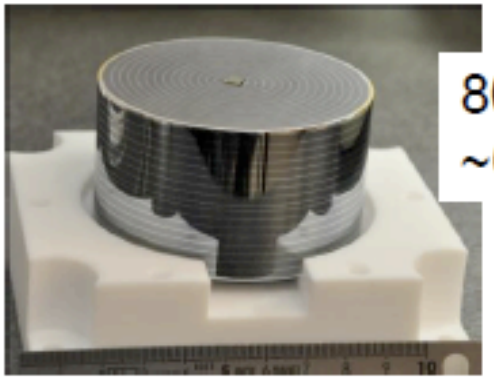
- Submitted to Phys. Rev. D 2012
- Competitive resutls wrt to CDMS-II low-mass results

EDELWEISS III: next generation of detectors

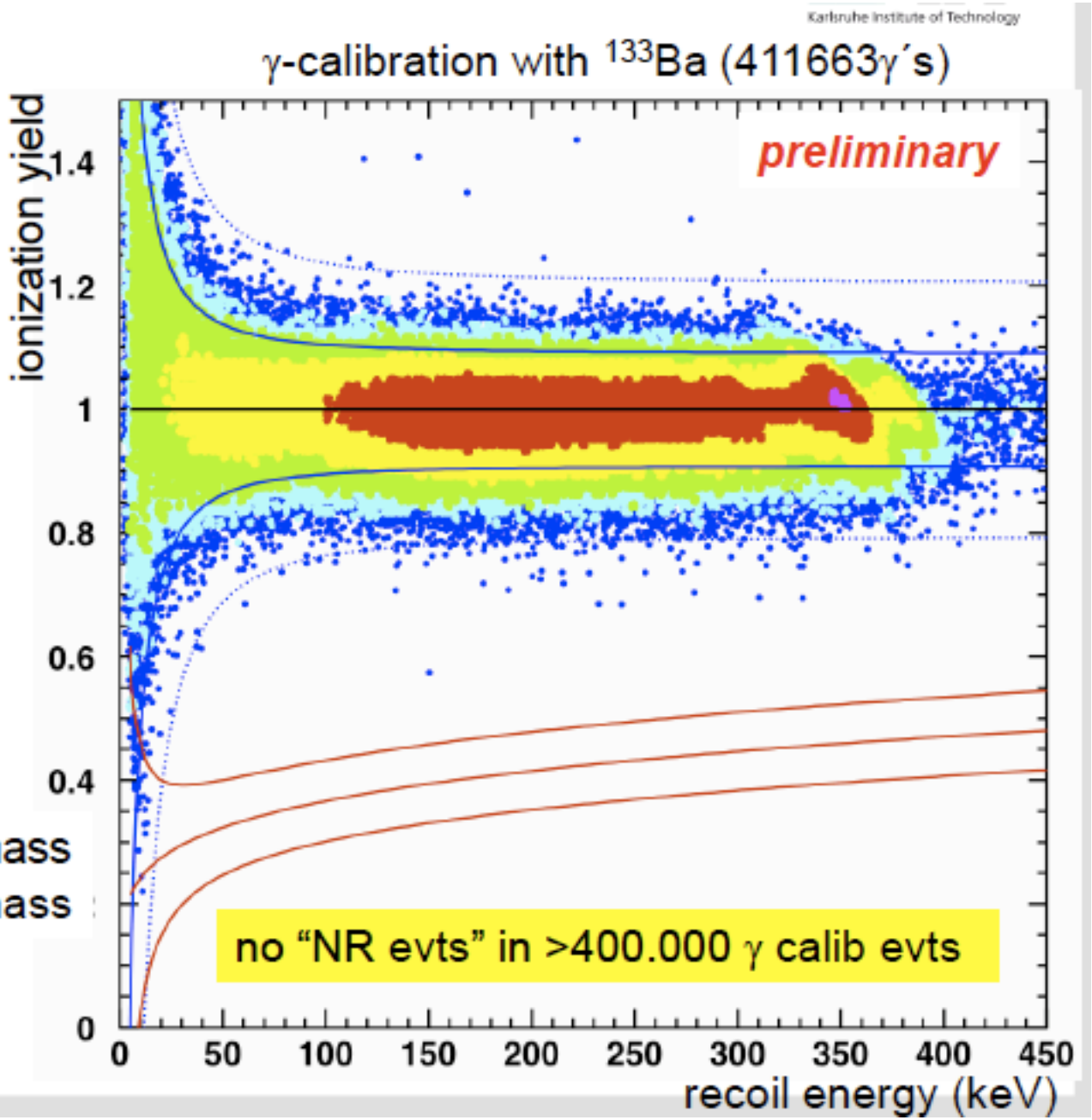
- 40 FID detectors of 800 g (m_{fid} = 600 g)
- Upgrade of internal cryostat and shielding
- Reduction of gamma bck
- 24 kg fudicial

No bck expected in 3000 $kgday_{fid}$

Detector technology ready for 1T scale cryogenic array

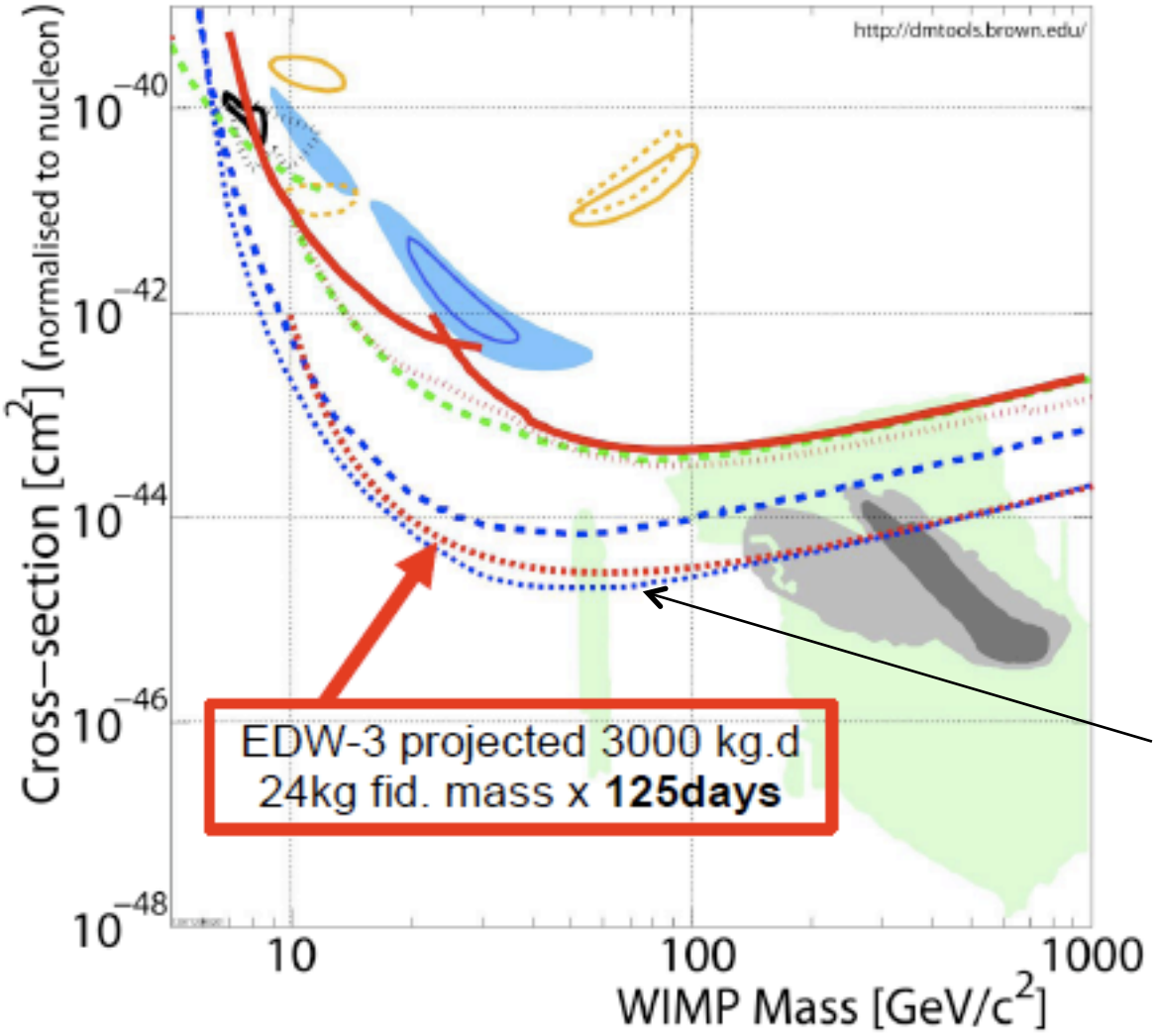


800g total mass
~600g fid. mass



EDELWEISS-III goal for 2013

<1 evt total background estimated for 3000kg.d eff. exposure



EDW-II PLB 702,5 (2011) 329
+ arXiv:1207.1815

EDW-III 24kg(fid) 6 months

DAMA/LIBRA EPJ **C56** (2008)

CoGeNT PRL **106** (2011)

CRESST II 2σ arXiv:1109.0702

CRESST II 1σ arXiv:1109.0702

CDMS Science 327, 1619 (2010)
+ Low E, PRL **106** (2011)

XENON100 PRL **107** (2011)

XENON100 225days 34kg

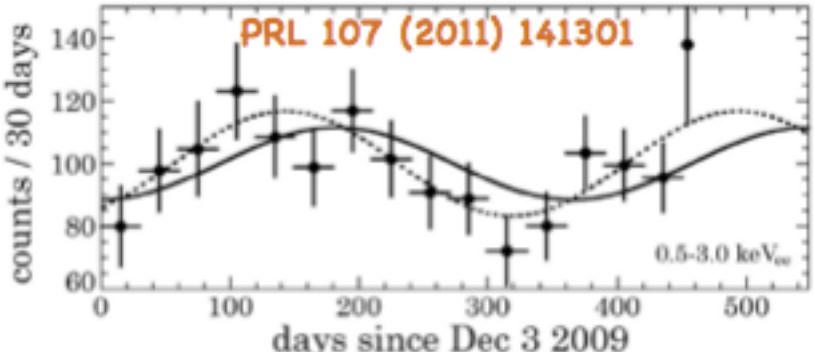
Buchmüller et al, 2011

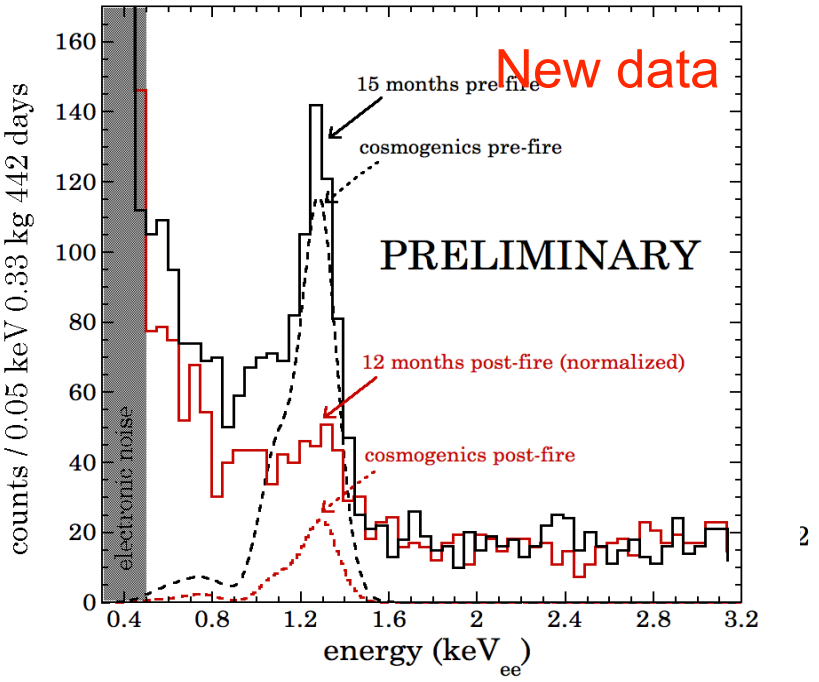
Bertone et al, 2011

CoGENT new data: PRELIMINARY

Recap

- Checking that all parameters employed in cuts have remained stable following the 3 mo. thermal cycle post-fire (we want to continue with no changes to those -cuts have been frozen from the beginning, a *de facto* blind analysis-)
- Low-energy excess still there.
- Rates look flatter on second year. Optimist: to be expected, the modulation was too large. Pessimist: to be expected, the modulation was a fluke.
- Cosmogenics nicely getting out of the way: the region 0.5-0.7 keV may have decayed an additional ~15% beyond what expected from these. Needs just a few more months to distinguish between a very long-lived decay there ($T_{1/2}$~6 years (!?)) or initial short decay from unrejected surface events. All this can affect modulation phase a tad.
- How to treat all this new info: we are performing a sophisticated 2D (energy-time) analysis in collaboration with Matt Bellis and Chris Kelso, able to test several halo model features.

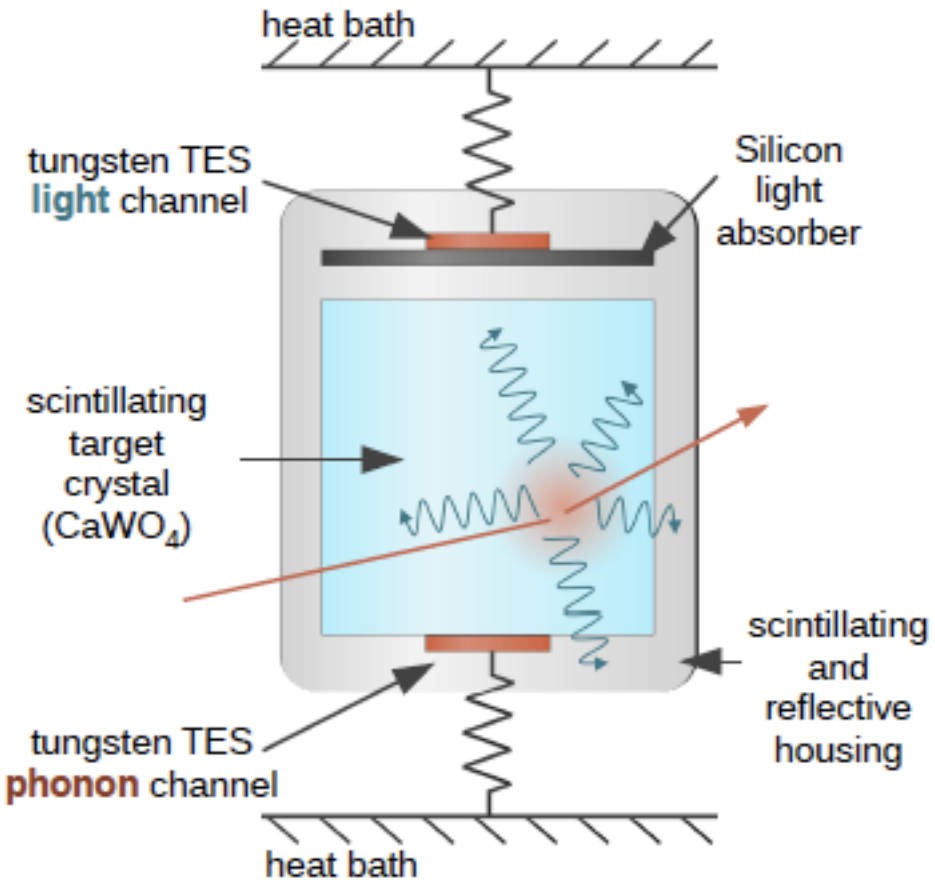


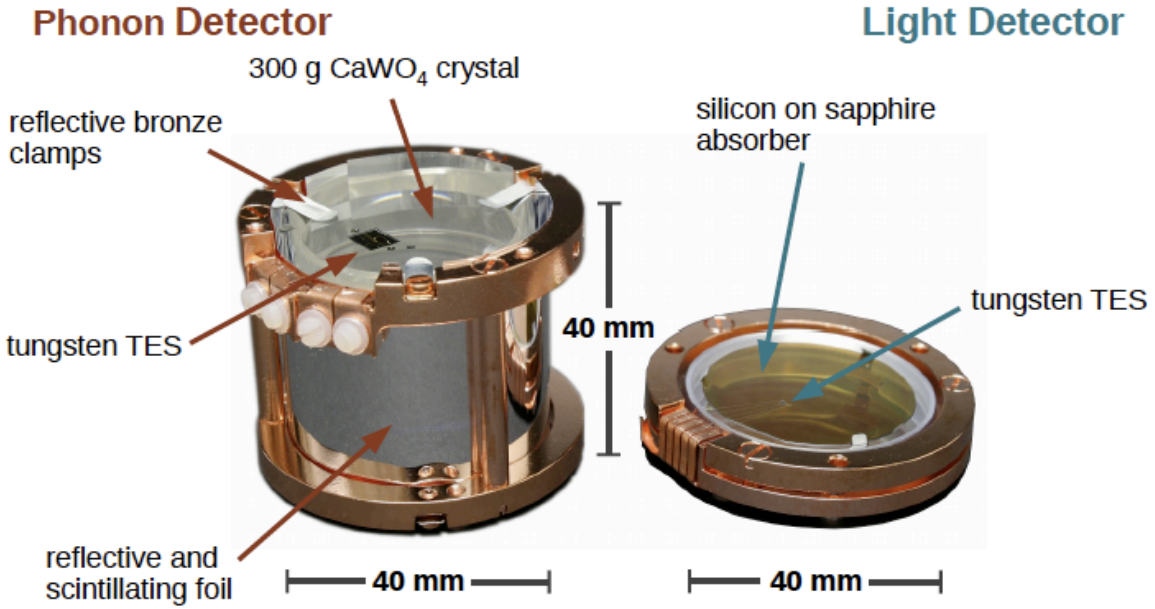


Clear need for C-4 x10 mass, reduced threshold and backgrounds, if we are ever to stop chasing our tails.

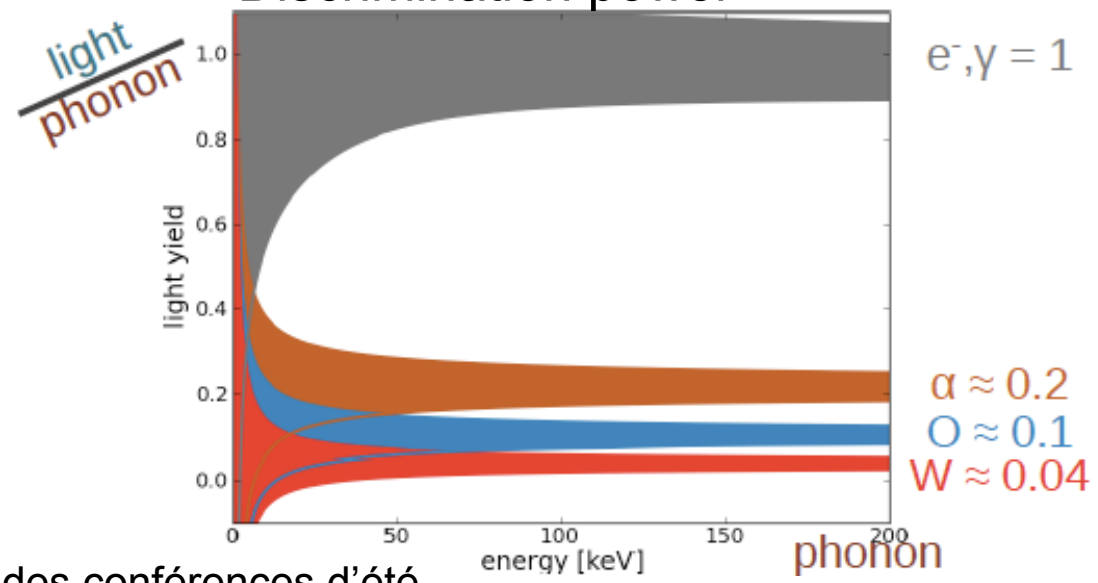
Paper coming soon…

CRESST II





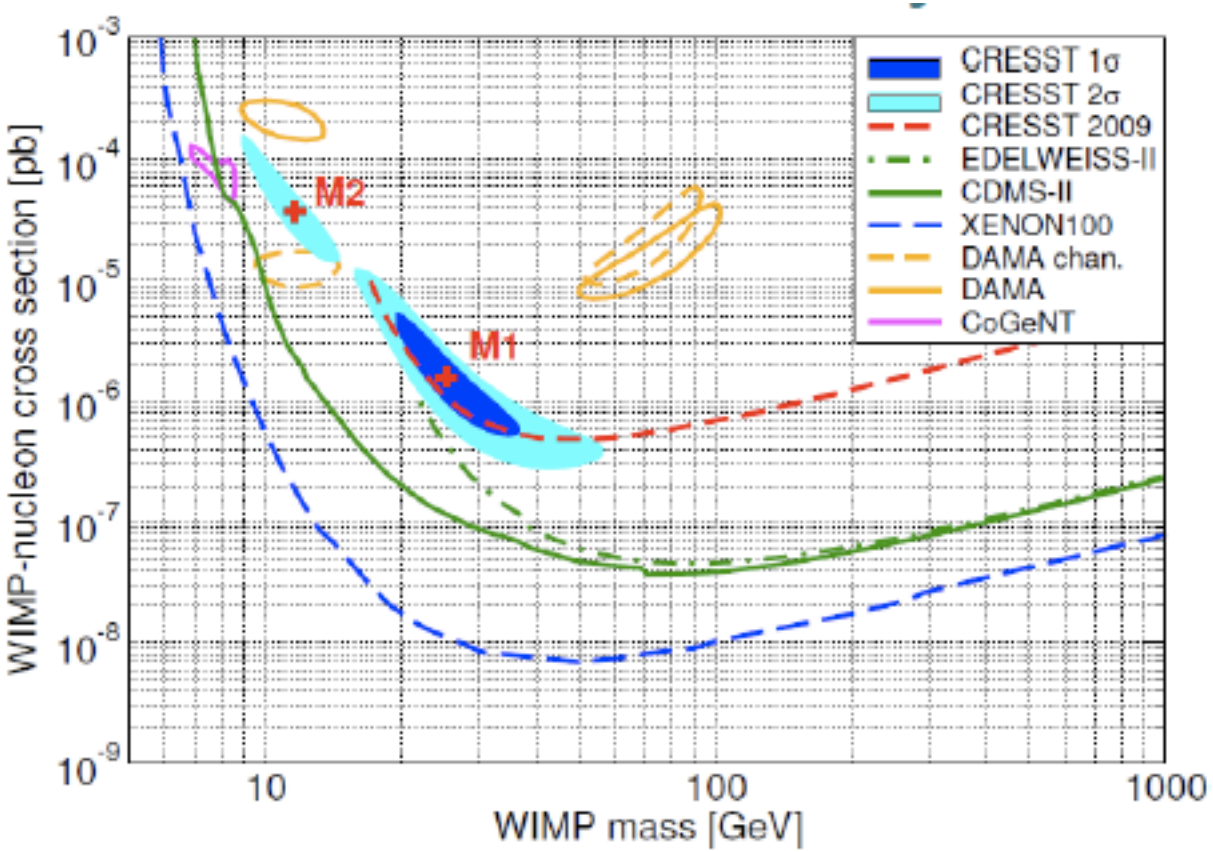
Discrimination power



Simultaneous measurements of
- eneygy deposited in the crytal
- scintallation light

CRESST-II results

- extensive, successful physics run of CRESST-II (July 2009 – March 2011)
- **8 $CaWO_4$ modules** (300g each) used in analysis
- net exposure of **~730 kg days**
- **67 events** observed in acceptance region



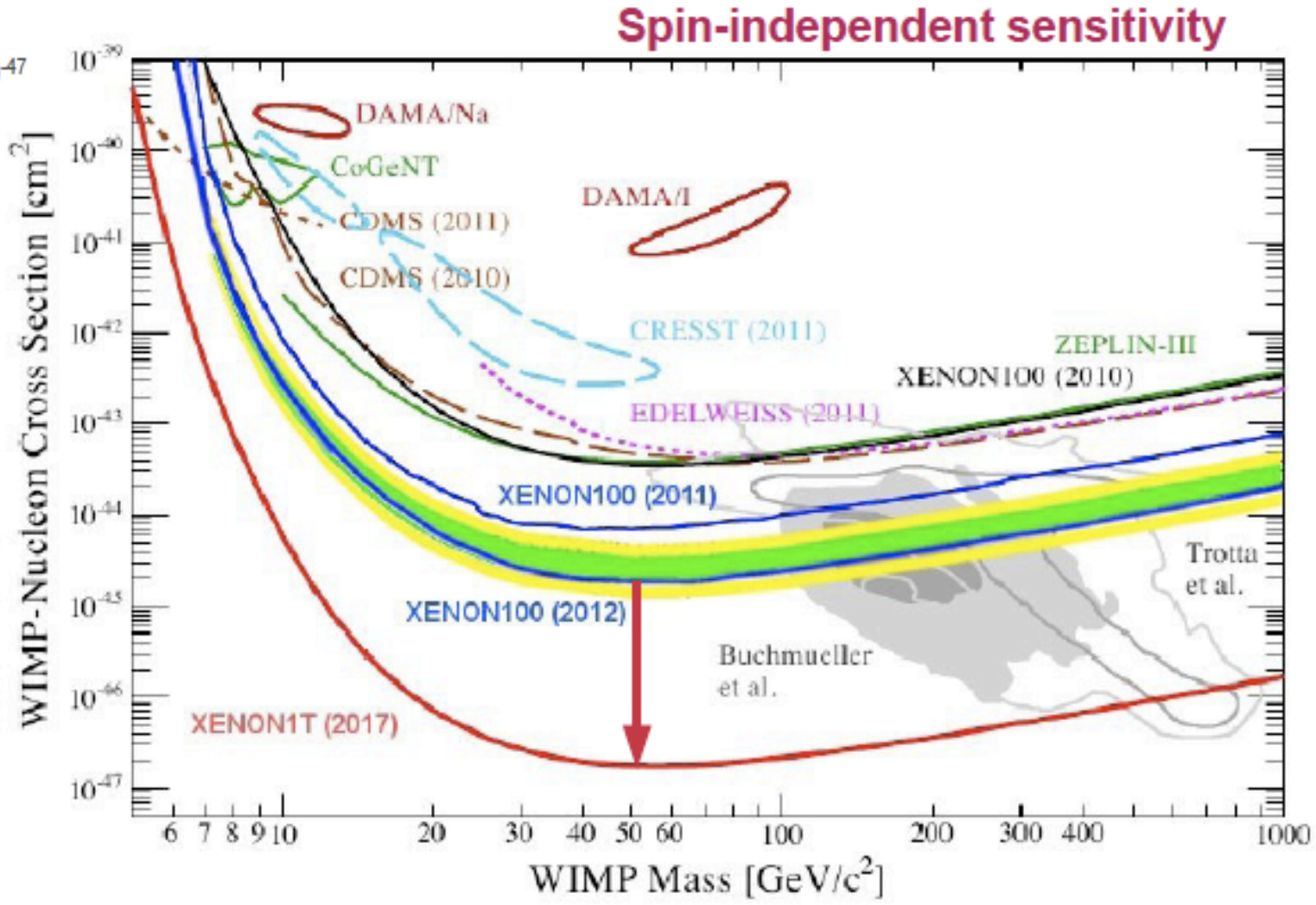
strong tension with other experiments and large background contributions

→ for clarification: **background reduction** needed

highest priority:
reduction of α and Pb recoil background

Future : XEN0N1T@LNGS

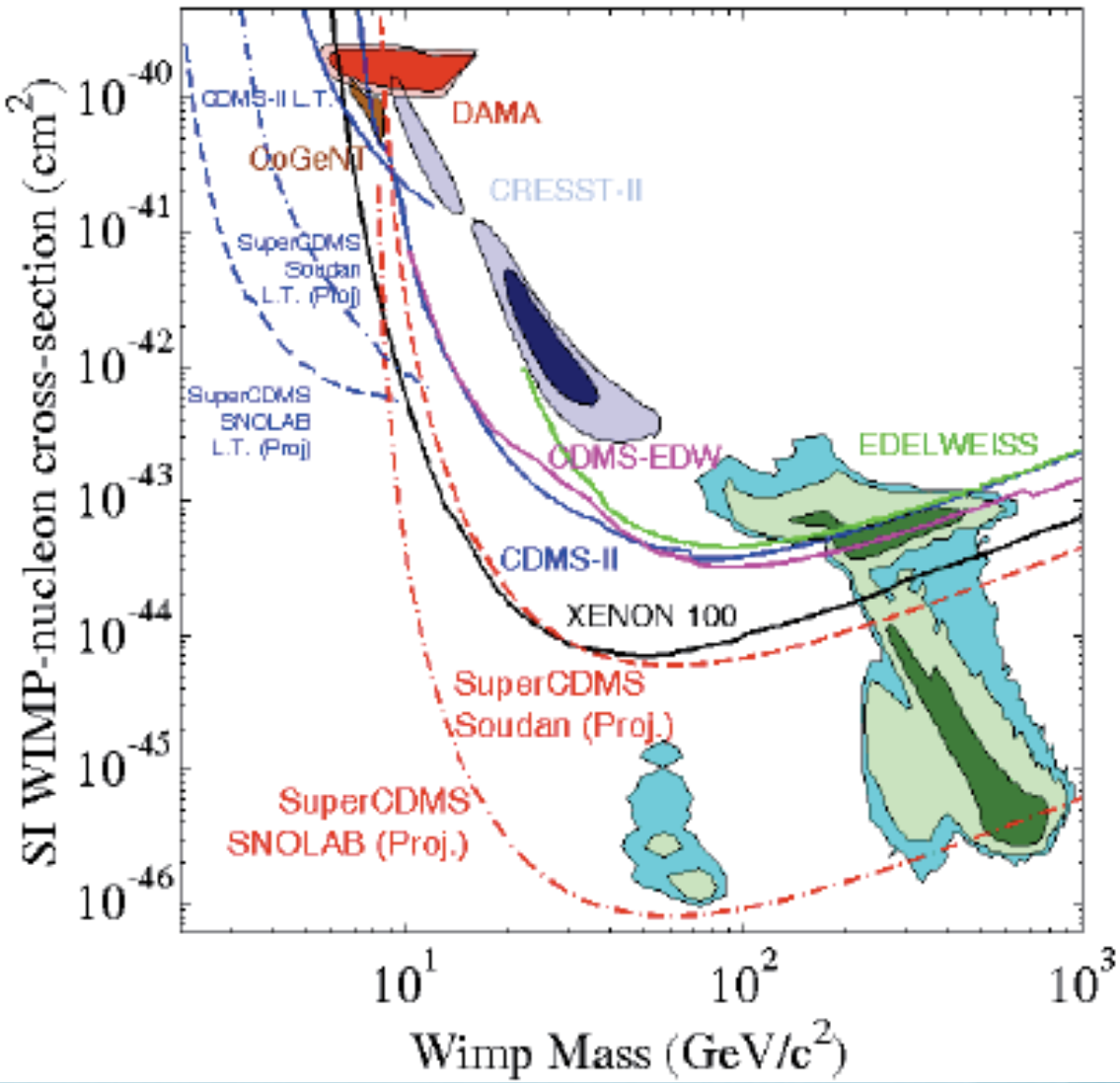
- Liquid xenon TPC to explore $\sigma \sim 2\times10^{-47}$ cm^2
- Detector size:
  ~ 1 m^3, ~ 3 t LXe, ~ 1 t fiducial mass
- Water Cherenkov Muon Veto
- Approved by INFN.
- Funded.
- Construction start: fall 2012.



- Sensitivity goal for SI cross section of 10^{-47} cm^2 expected by 2017

SuperCDMS@SNOLAB sensitivity

- Scintillator and optical test starting soon
- Final design by 2014
- SuperCDMS SNOLab construction 2014



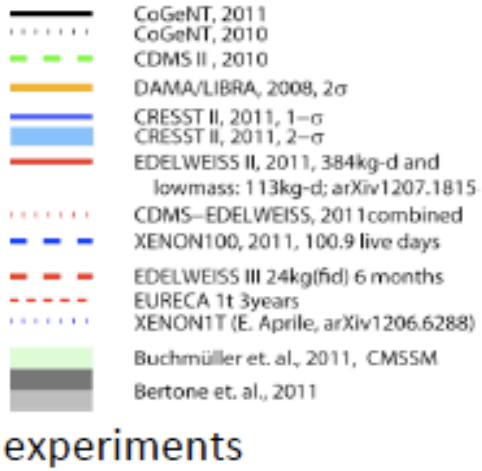
SNOLAB 200 kg (24 towers) run gets us to < 8 x 10^{-47} cm^2 @ 60 GeV/c^2 running at SNOLAB (deeper site, higher purity shielding)

EURECA : sensitivity reach

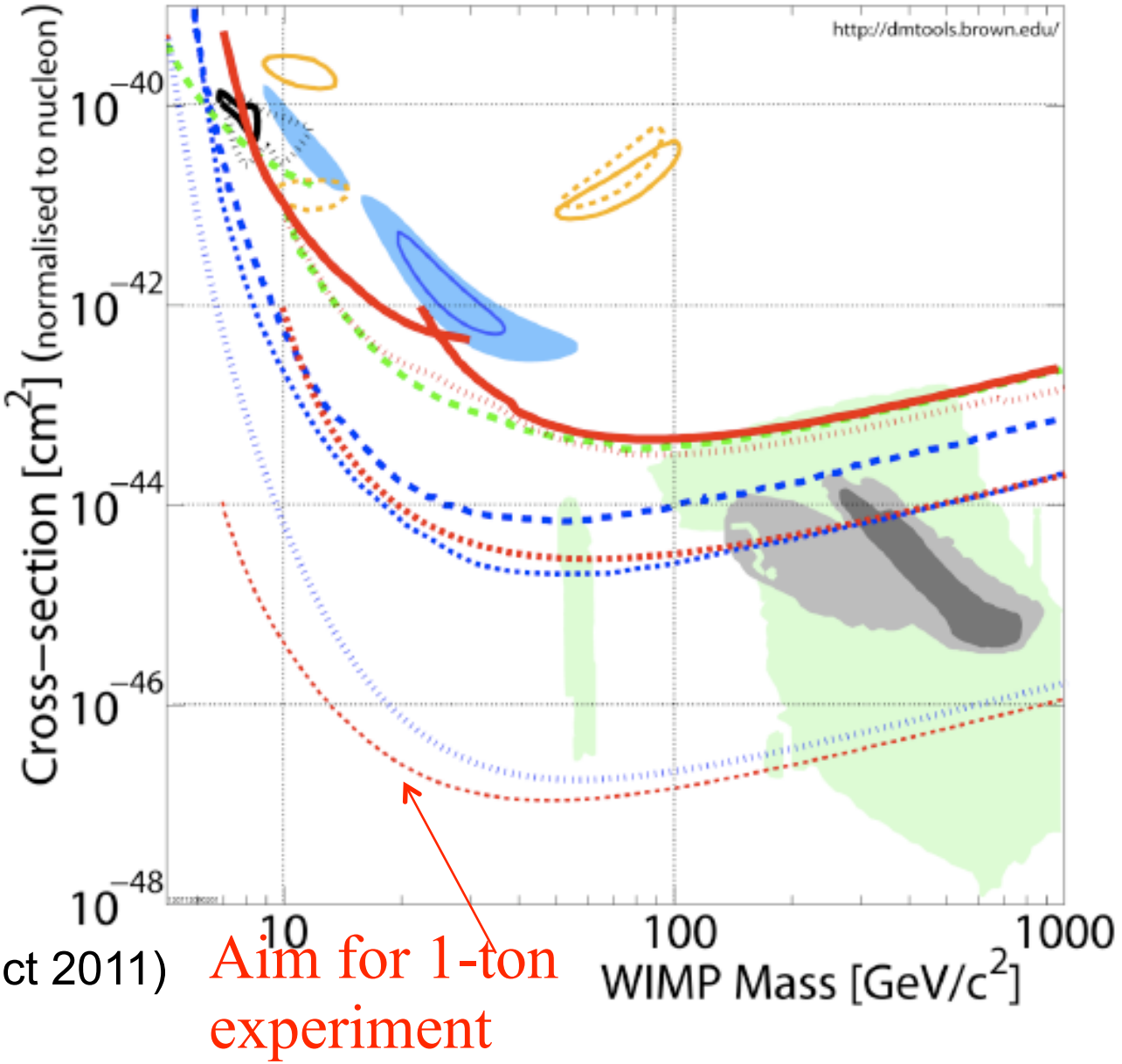
European Underground Rare Event Calorimeter Array

The future European 1-tonne cryogenic dark matter search

Aim:	$<10^{-10}$pb
Detectors:	Cryogenic Ge and scintillator calorimeters
Shielding:	Radiopure Cu, polyethelene, 3m water tank with PMTs
Infrastructure:	Cryostat to cool 1-tonne target
Collaboration:	EDELWEISS, CRESST, new members



experiments

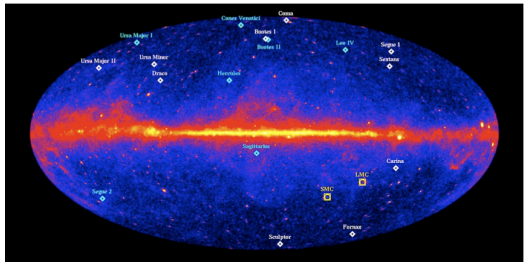


- Item in the ASPERA roadmap
- Coordinated cooperation with Super-CDMS (1st joint meeting: 7th Oct 2011)
- Conceptional Design Report 2012

Détection indirecte
Fermi, HESS, IceCube

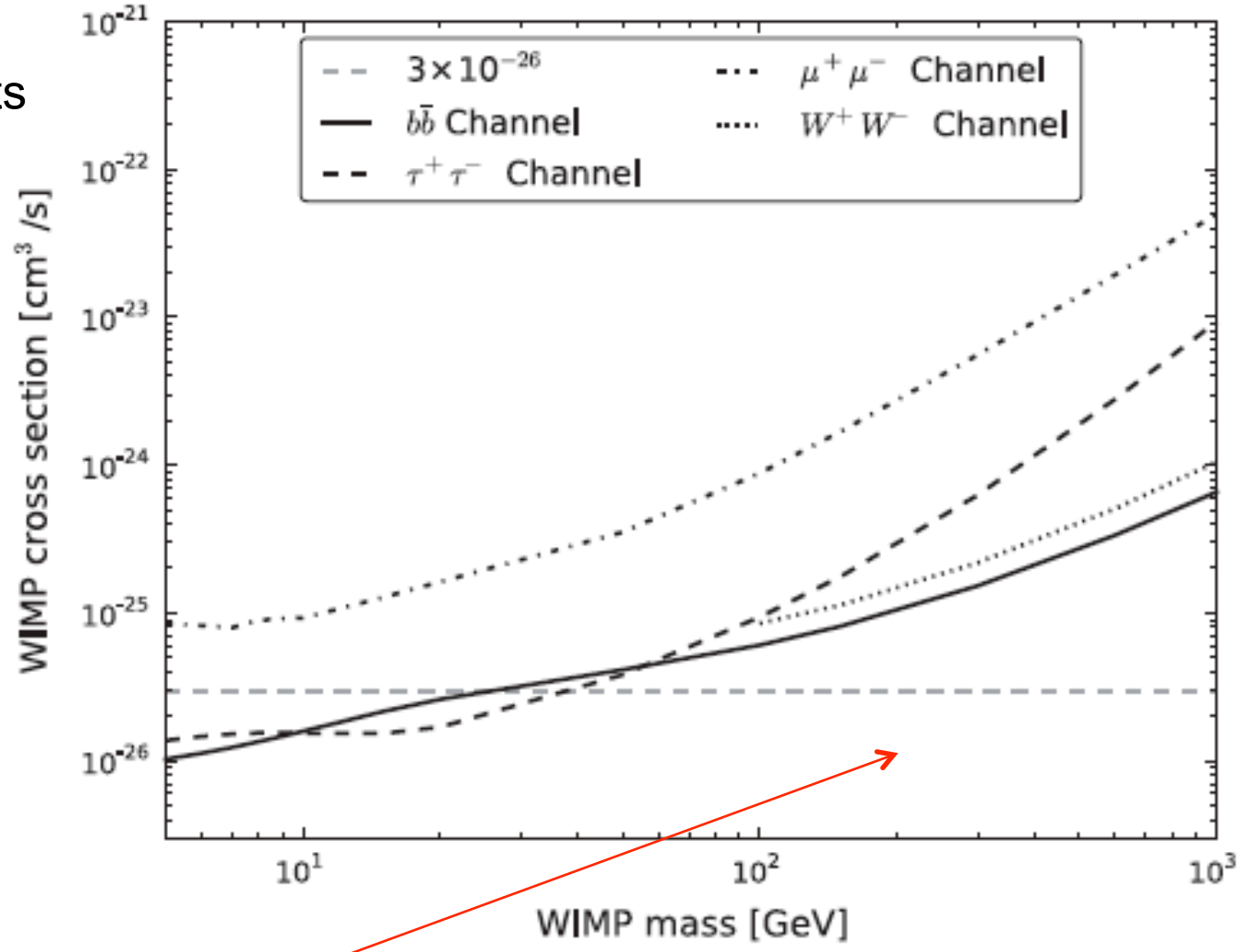
Fermi: dwarf galaxy stacking

- ✓ Most DM-dominated objects in the Universe
- ✓ Expected to be free from standard astrophysical bck



- 10 dwarfs
- NFW profiles only
- Ultra-faint dwarfs contribute most

Caveat: uncertainties remain on the DM halo modelling



Canonical WIMP annihilation cross section

M. Ackermann et al. [Fermi LAT Collaboration], PRL 107, 241302 (2011)

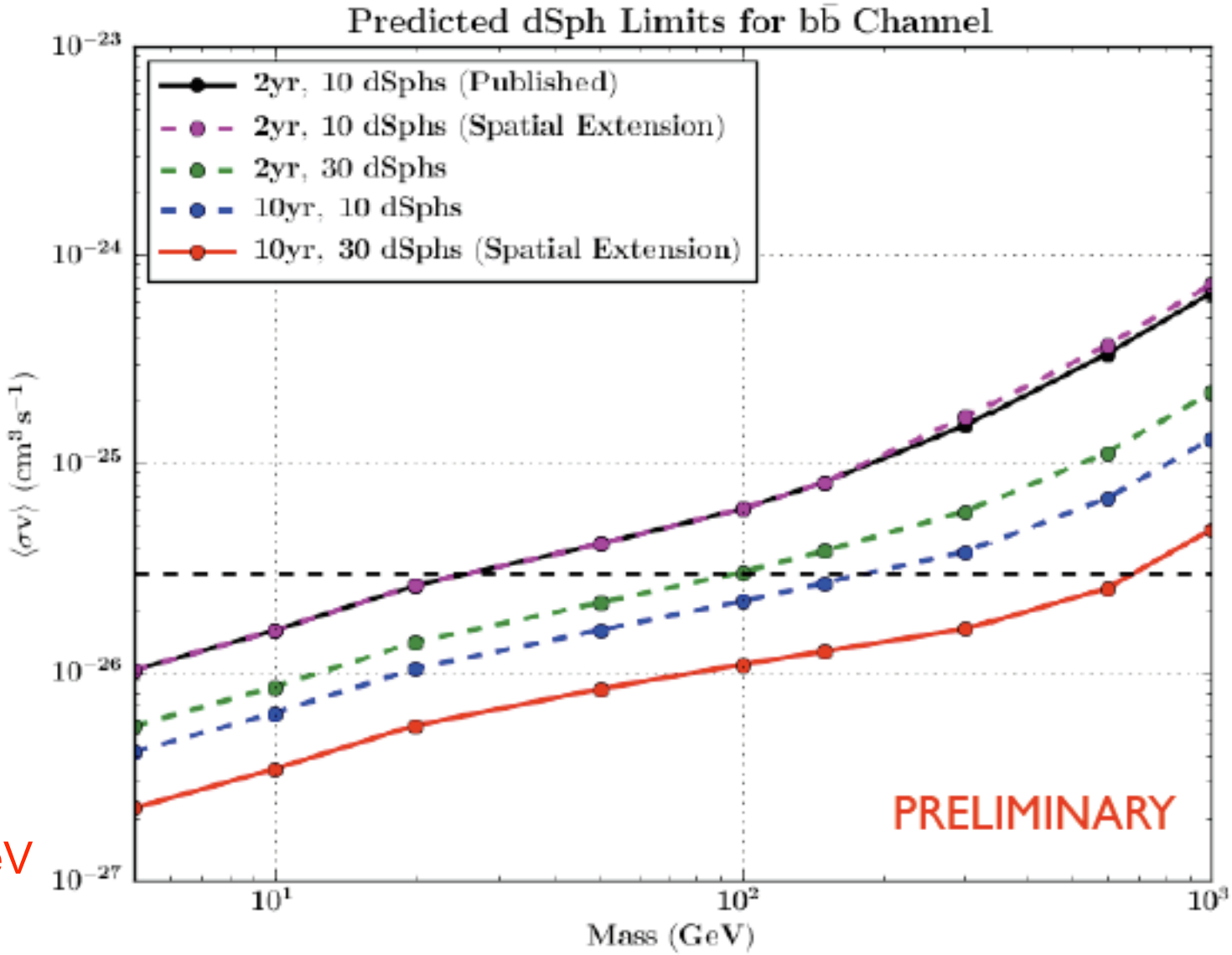
results exclude the canonical WIMP thermal relic cross-section for annihilation to $b\bar{b}$ or $\tau^+\tau^-$ for masses below ~ 30 GeV

Fermi: prospects

future DM limits from dSph projected to improve due to:

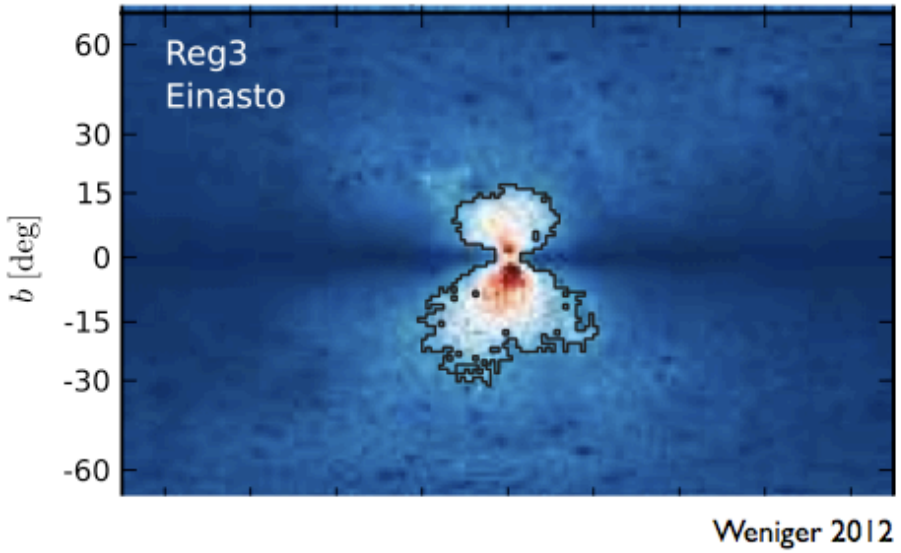
- increased observation time
- discovery of new dwarfs

10 yr, 10 dSph sensitivity to thermal WIMPs up to 100 GeV



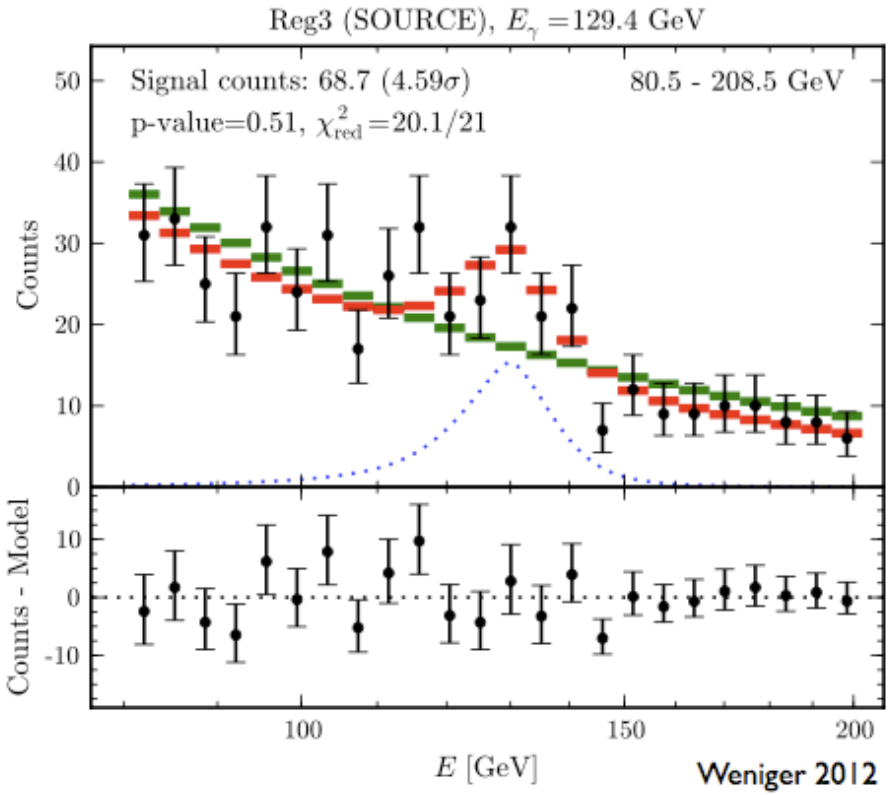
A 130 GeV line from dark matter in Fermi data ?

One region-of-interest for Weniger's line search



- Bringmann et al. find weak indication of a feature consistent with IB emission from DM annihilation
- Weniger claims a tentative gamma-ray line

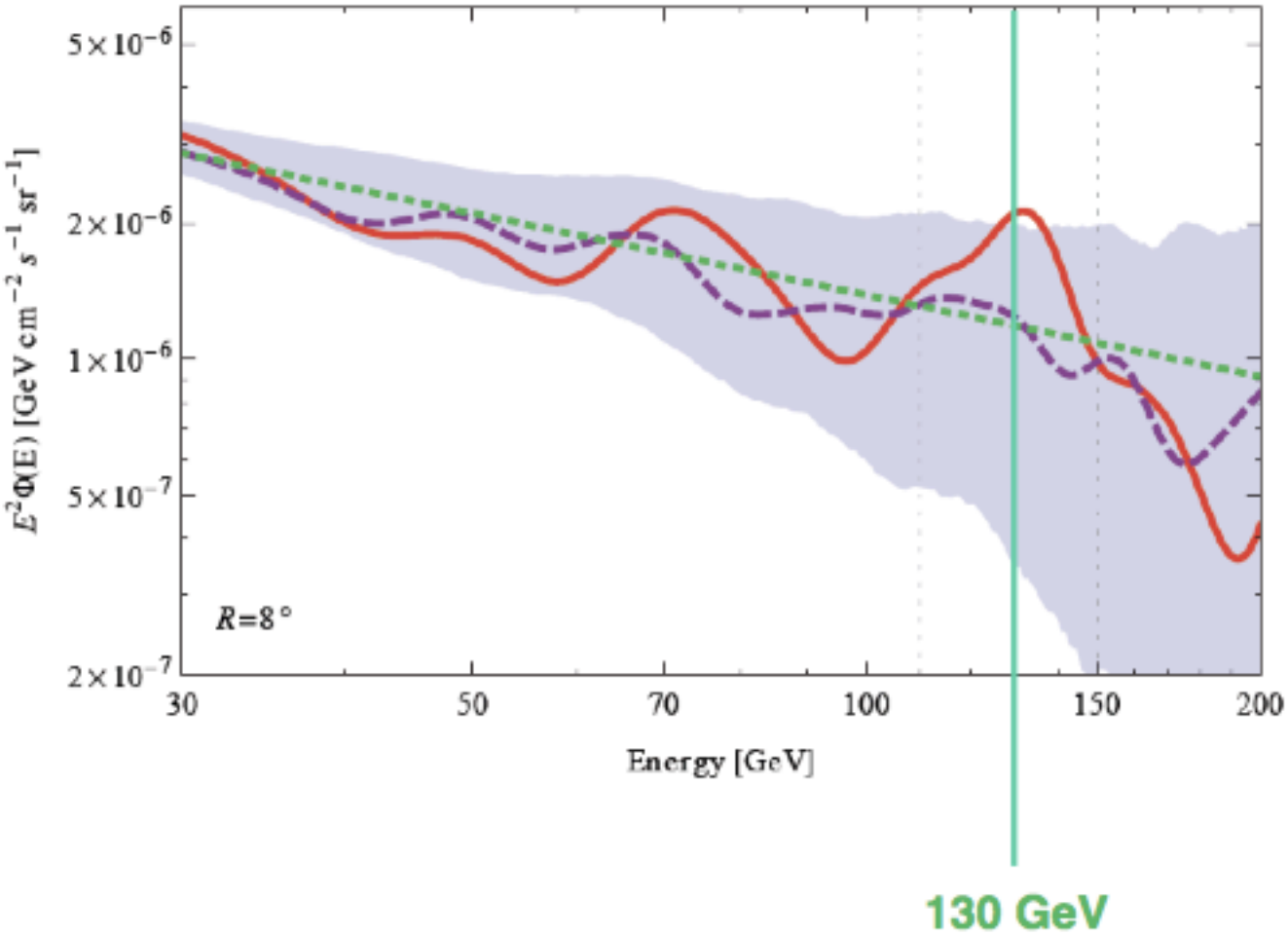
Spectrum of ROI with power-law and power-law+line fits



see also: Bringmann, Huang, Ibarra, Vogl, Weniger, arXiv: 1203.1312; Weniger, arXiv:1204.2797; Tempel, Hektor, Raidal, arXiv:1205.1045; Boyarsky, Malyshev, Ruchayskiy, arXiv:1205.4700; Geringer-Sameth & Koushiappas, arXiv: 1206.0796; Su & Finkbeiner, arXiv:1206.1616, Aharonian, Khangulyan, Malyshev, arXiv:1207.0458 ...

annihilation cross-section
$\langle \sigma v \rangle_{\chi\chi \rightarrow \gamma\gamma} \sim 1.3 \times 10^{-27}\ cm^3 s^{-1}$

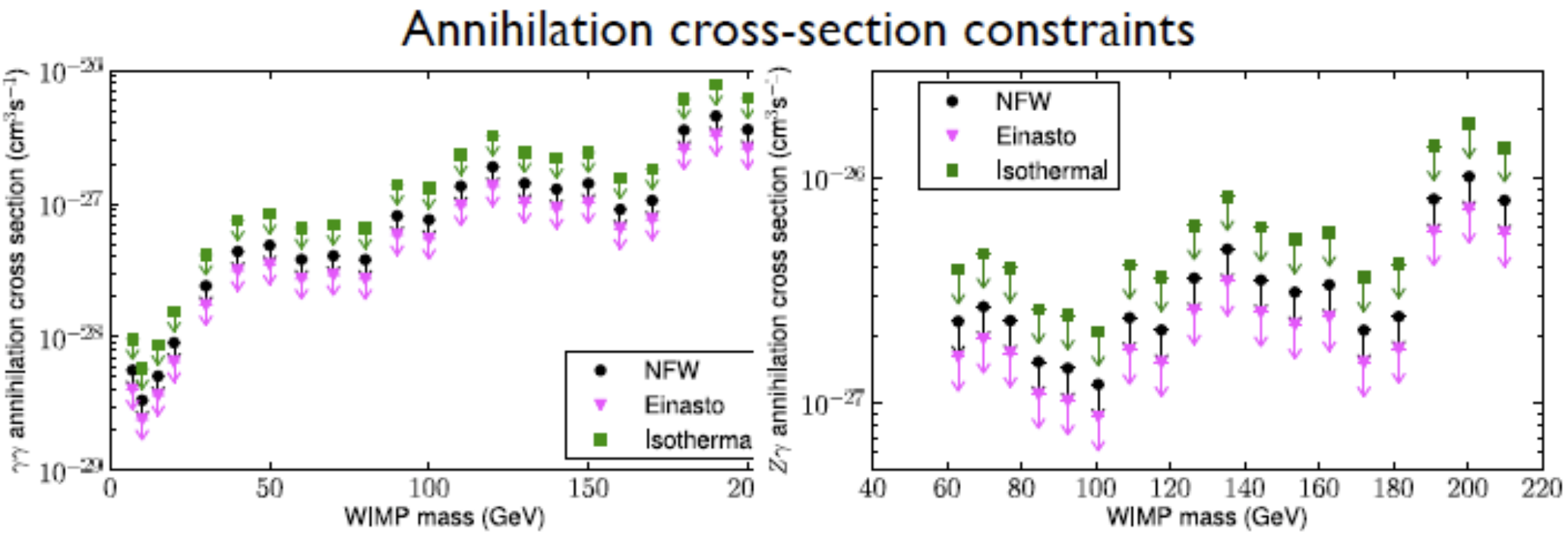
Confirming the evidence from stacking of 6 galaxy clusters?



Claimed 3.2σ effect (?) (A. Hektor, M. Raidal & E. Tempel, arXiv:1207.4466)

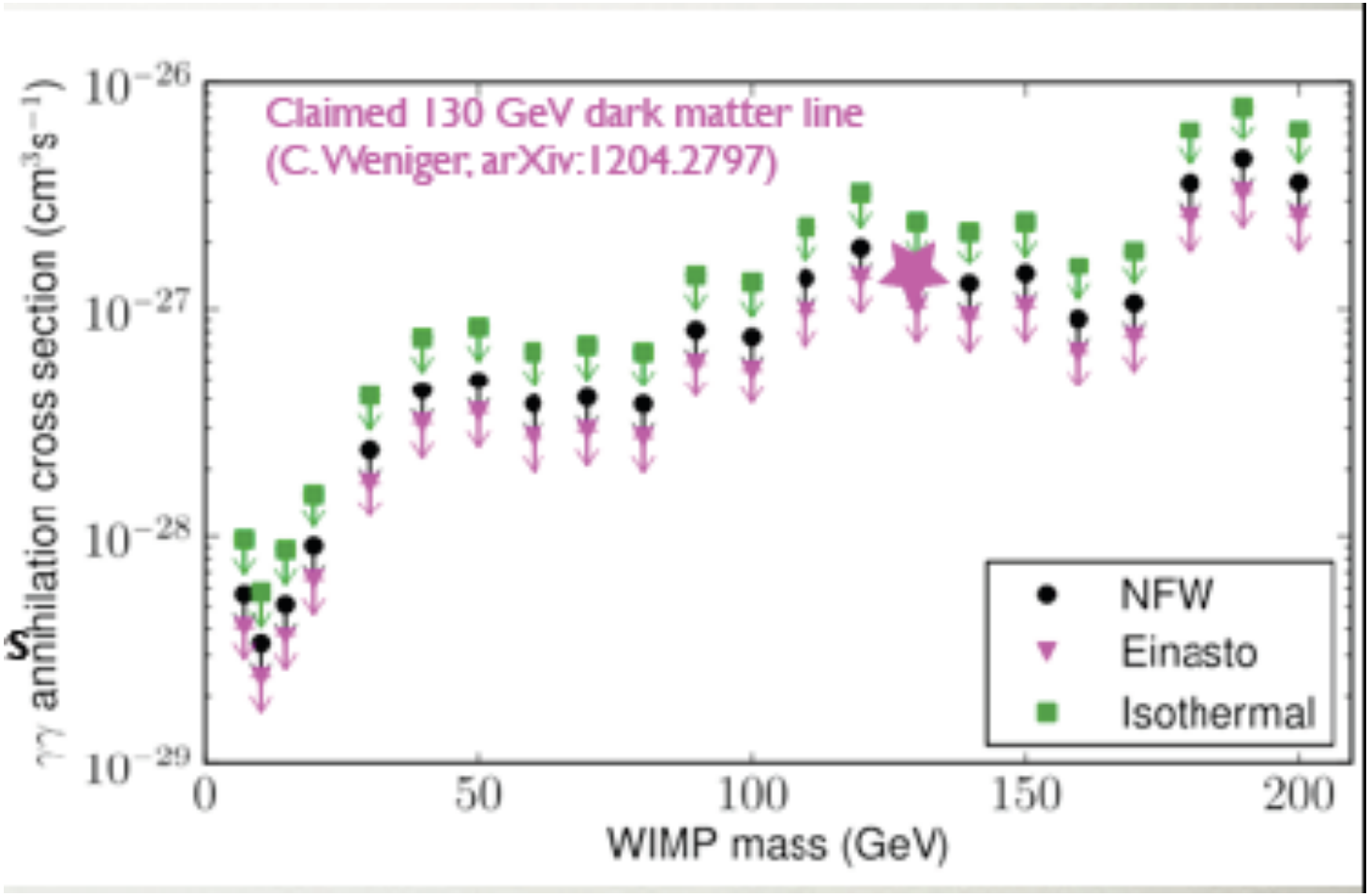
Fermi will collect at least twice the amount of data!

Upper limits on line signal from Fermi coll.



- Non-detection places limits on annihilation cross section to $\gamma\gamma$ and $Z\gamma$
- No statement from the Fermi coll. about the 130 GeV line

Upper limits on line signal from Fermi coll.



- Non-detection places limits on annihilation cross section to $\gamma\gamma$ and $Z\gamma$
- These limits are not in strong tension with signal claims

A 130 GeV from dark matter ?

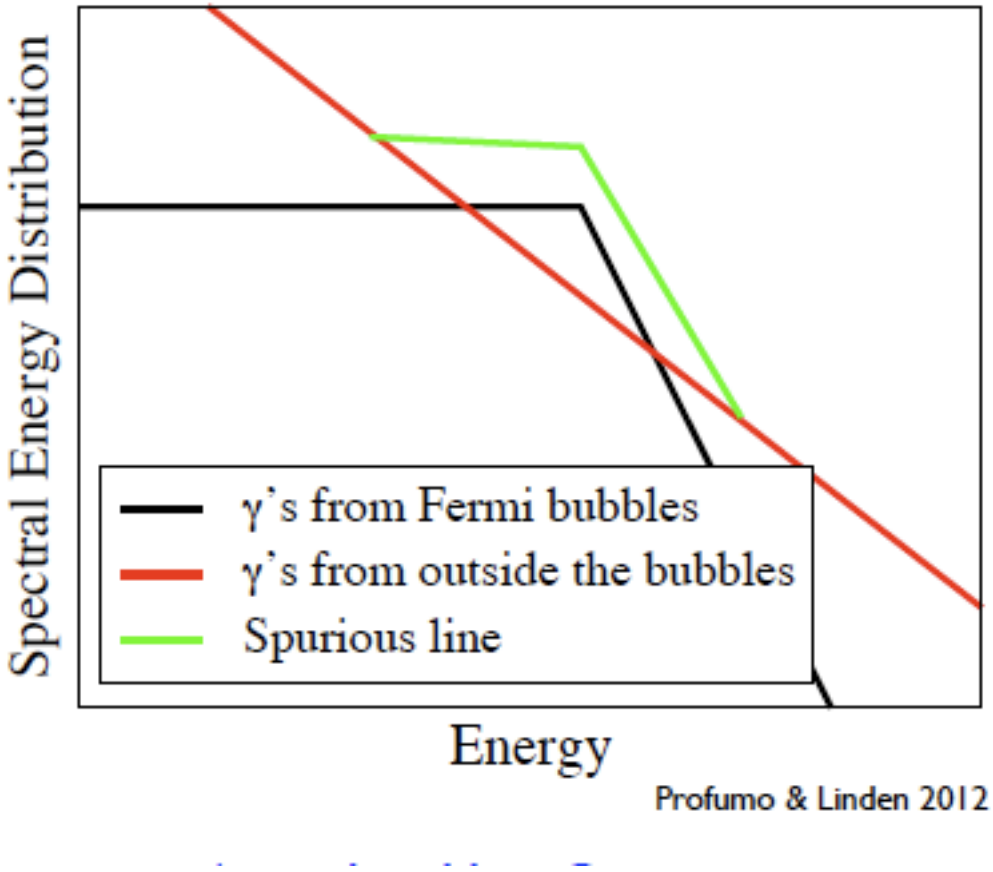
- Many studies find similar line-like features
- Su & Finkbeiner 2012 localize the feature to a region offset from the GC
- Could a break in the spectrum of the Fermi bubbles be mistaken for a line? (Profumo & Linden 2012)
- Non-DM astrophysical sources of lines? (Aharonian et al 2012)

- Many unresolved questions remain: stay tuned!

- Instrumental systematics, quality selection, … ?
- Any sign for continuum part of signal?!
- Statistical fluctuation: quite significant, but maybe the most likely explanation?

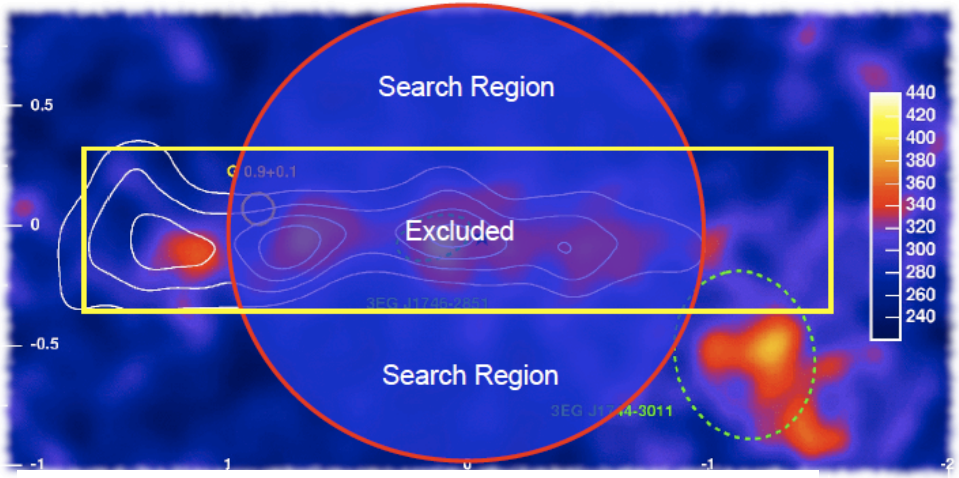
More data and analyses are needed

Schematic demonstration of how a broken power law could lead to a spurious detection of a line

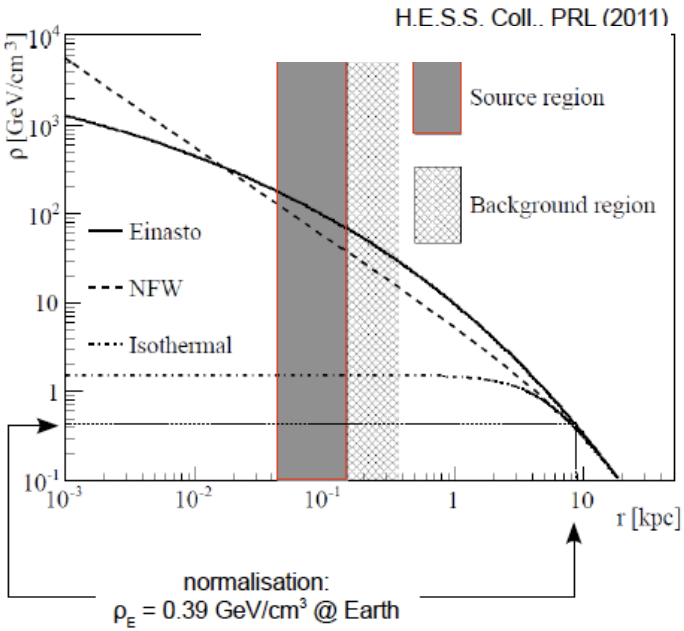


Profumo & Linden 2012

HESS-I limits on line signals

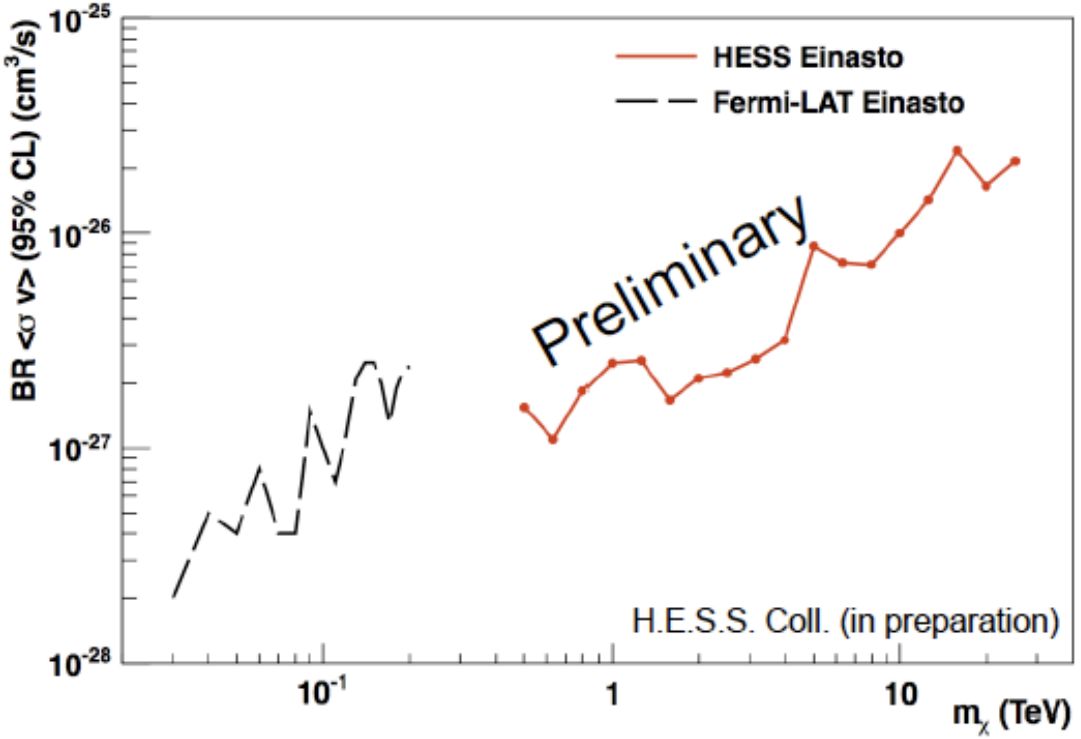


The role of the Dark Matter halo



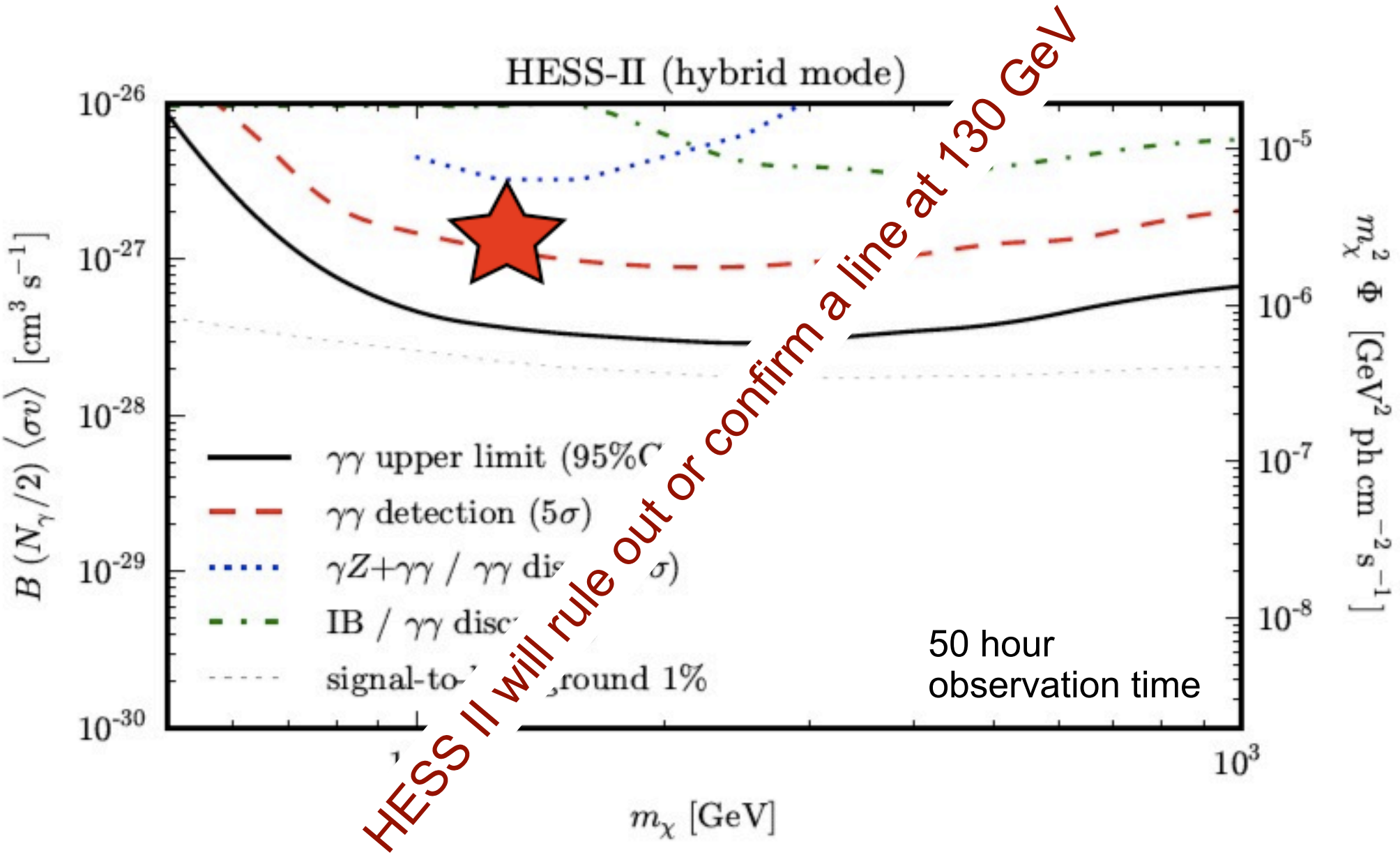
500 GeV – 25 TeV energy range

Central Galactic Halo: <σv> limits for χχ→γγ



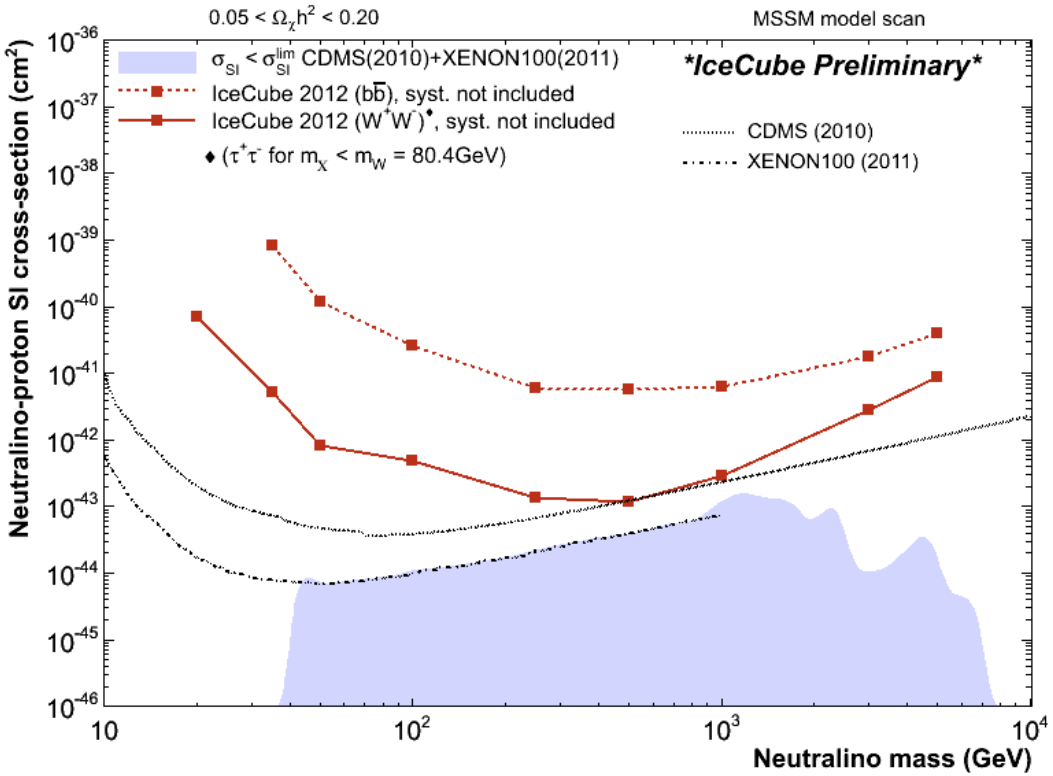
- Assume Einasto profile normalized to 0.39 GeV/cm^3 @ Earth
- Limits competitive to Fermi-LAT halo search

130 GeV line: HESS-II prospects

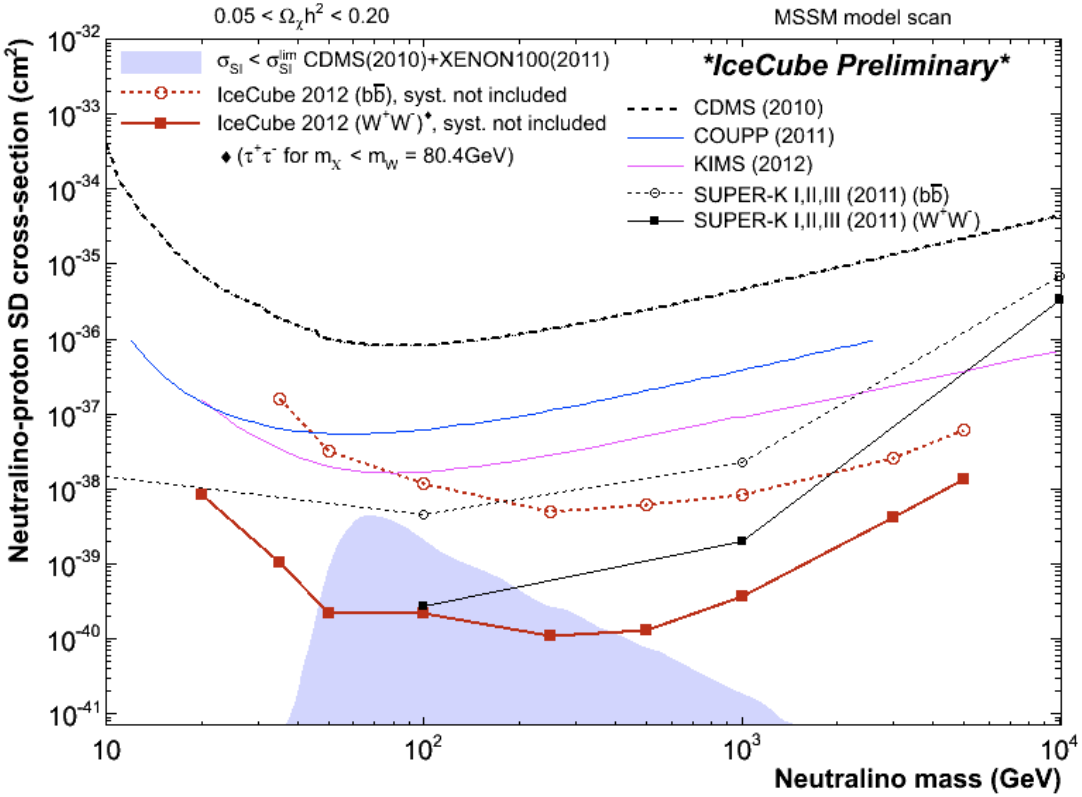


IceCube: limits on Solar WIMPs

Spin-independent limit



Spin-dependent limit

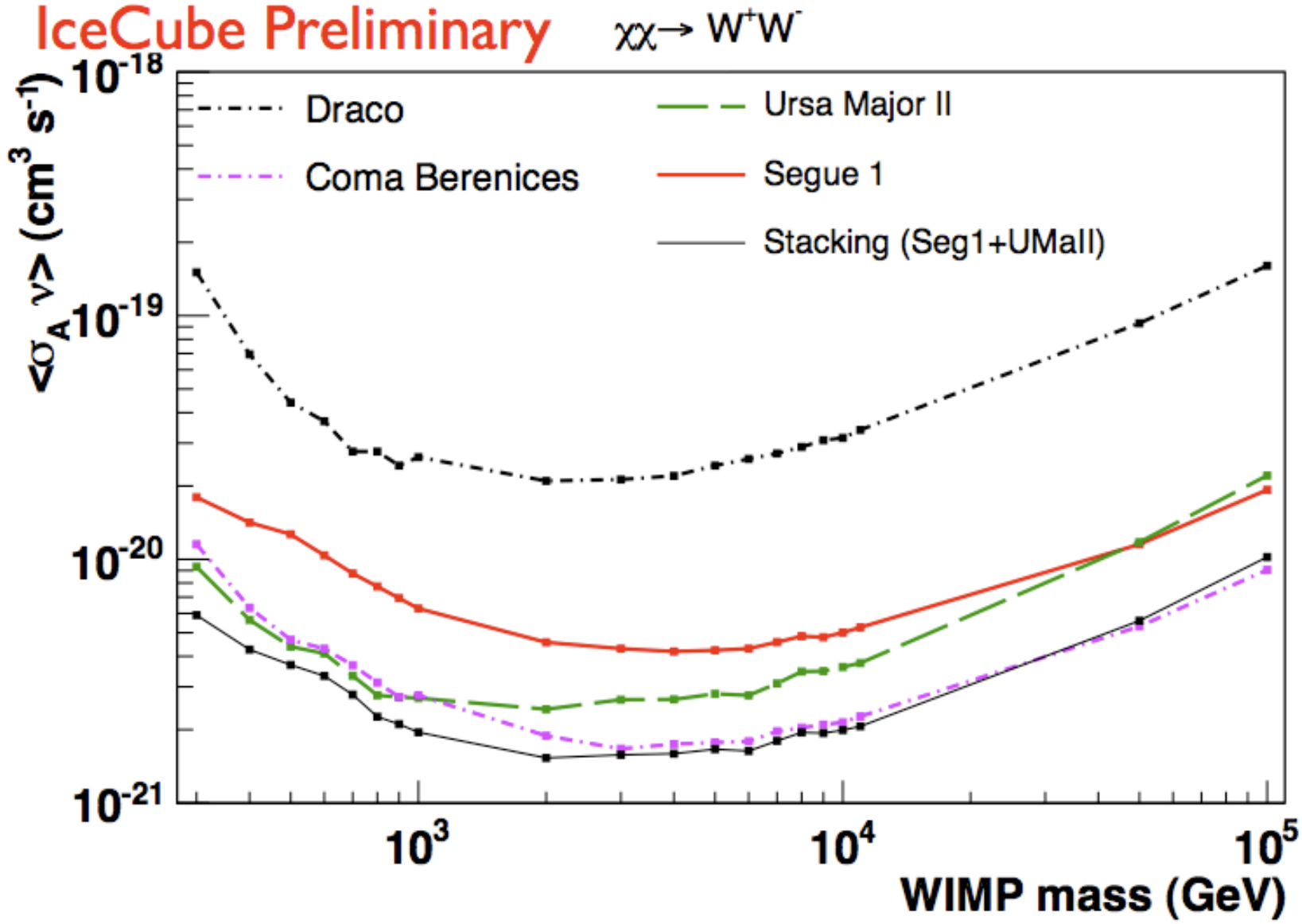


- With DeepCore, analysis reaches neutrino energies as low as *10-20GeV*

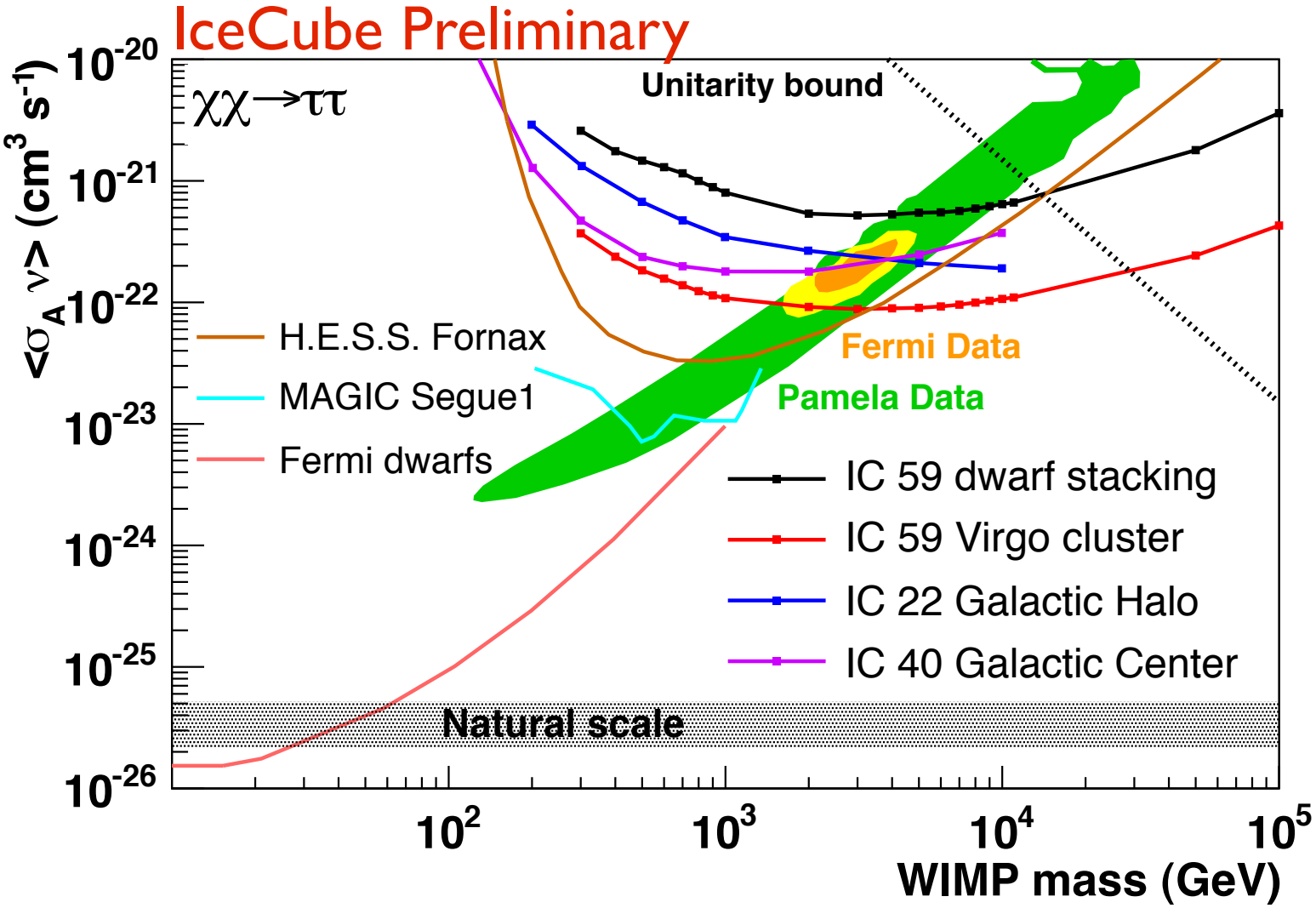
→ New very *competitive SD-cross-section limits*

IceCube: dwarf limits

Limits computed at **90% C.L.** as function of WIMP mass assuming branching fraction of 100% WW and NFW profile



Comparison of bounds



IceCube can test dark matter models motivated by PAMELA and Fermi electron data (e.g. Meade et al. 2008)

Results extremely competitive for high-mass WIMPs (see also Talk by B. Dasgupta Monday)

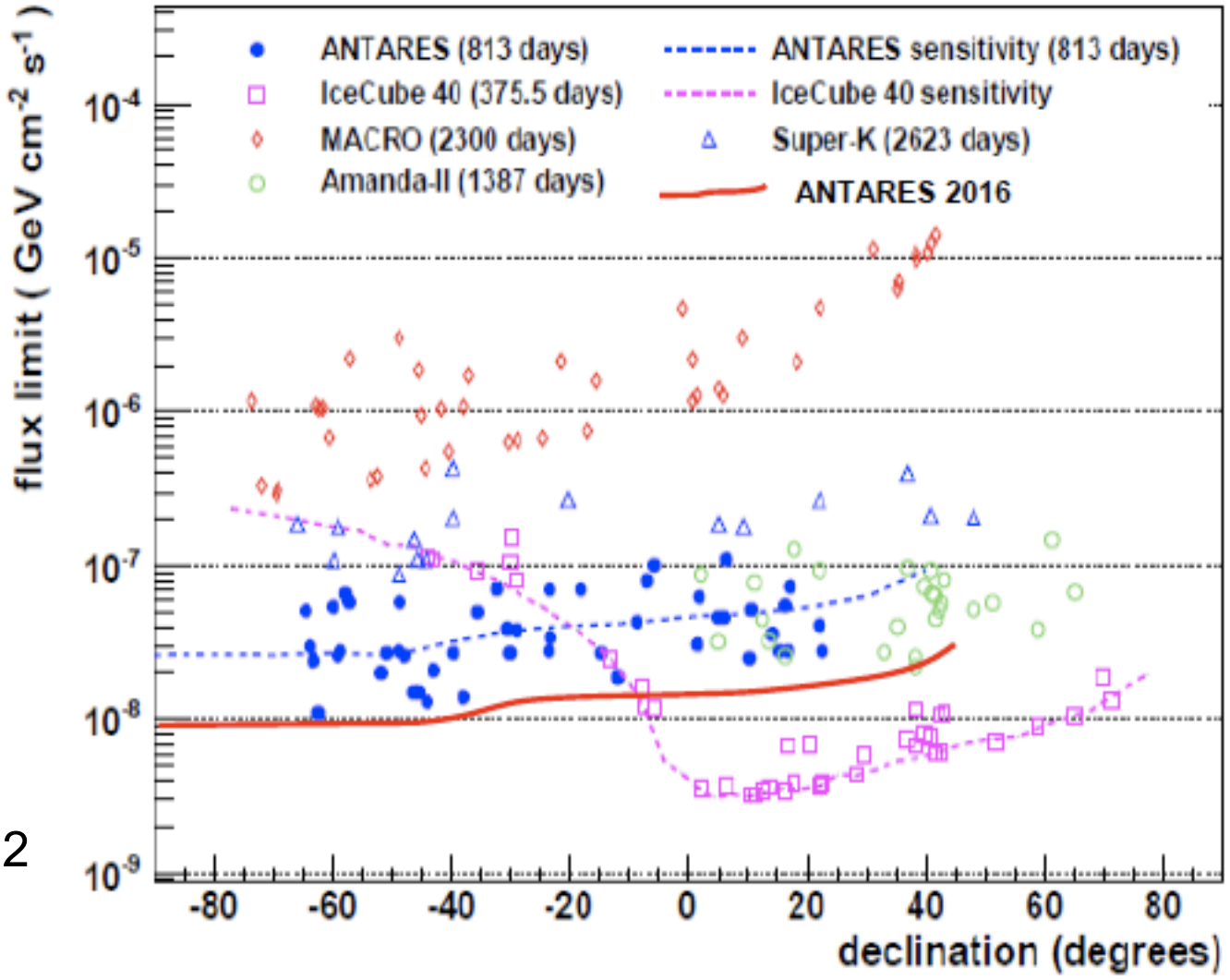
ANTARES: point source search

- Most significant cluster at $(\alpha,\delta)= (-46.5°, -65.0°)$
  → 9 (5) events within a cone of 3 (1) degrees
  → significance 2.2σ

Compatible with the background hypothesis

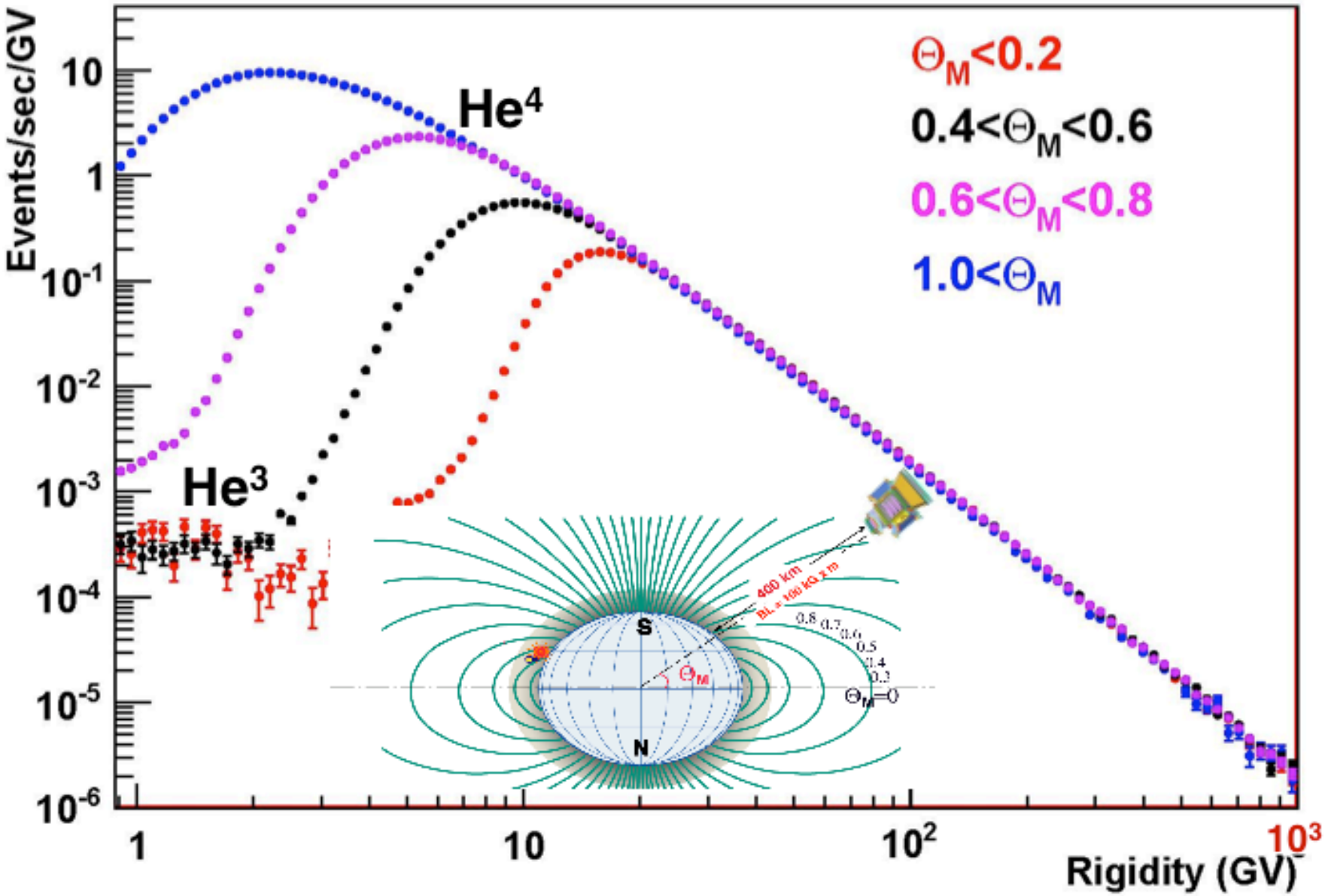
- By 2016: limits expected to be improved by a fator 2.5

- Submitted to Astrophys. J. 2012



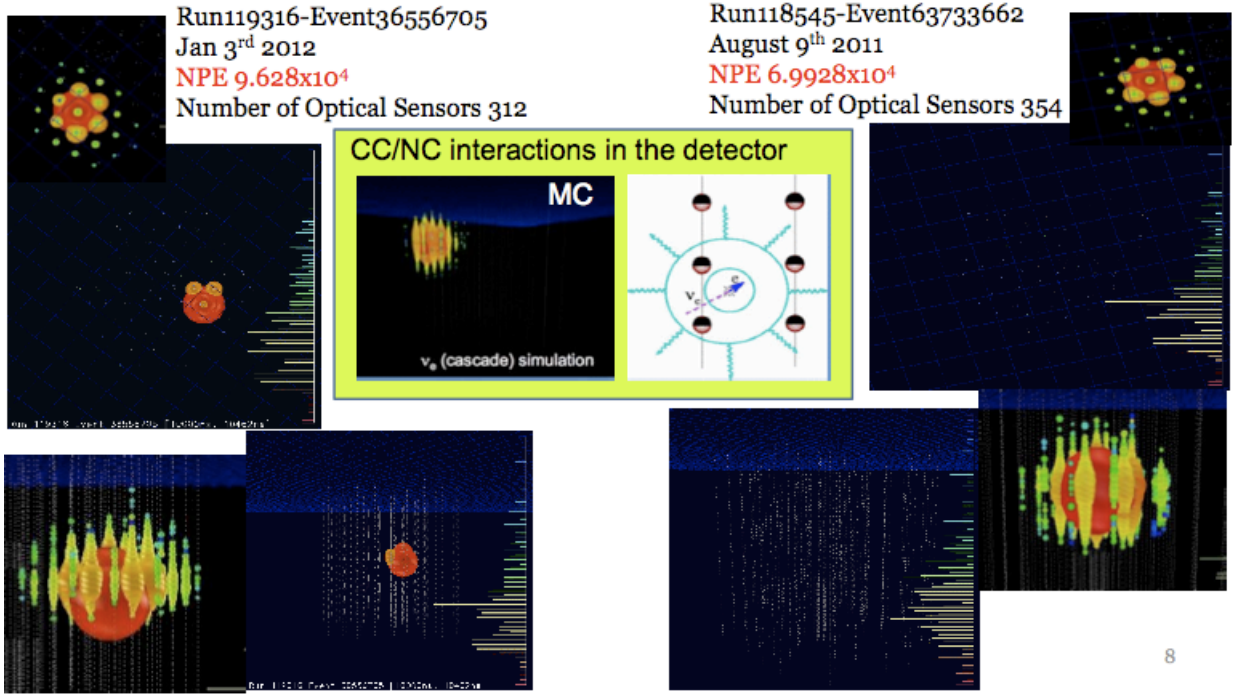
AMS

Data from AMS on ISS: He rate



Two PeV neutrinos detected by IceCube

- 2010 (79 strings) and 2011 (86 strings) data: livetime 673 days
- The highest energy neutrino events observed ever



- More cascade-event sensitive analysis needed
- Statistical confirmation foreseen with an independent sample

- Generally neutrinos identified as "through the Earth" up-going events
- Earth is opaque for UHE neutrinos
- UHE neutrino-induced events are coming from above and near horizontal direction

Possibility of the origin includes

- GZK ν
- on-site ν production from the cosmic-ray accelerators
- atmospheric prompt ν
- atmospheric conventional ν