

WIN 2013

WG4 - Astroparticle Physics

Summary

Rogerio Rosenfeld, Heidi Sandaker, Marco Cirelli

UHECR/Cosmo/BBN/BAU Summary

Rogerio Rosenfeld
IFT-UNESP and ICTP-SAIFR



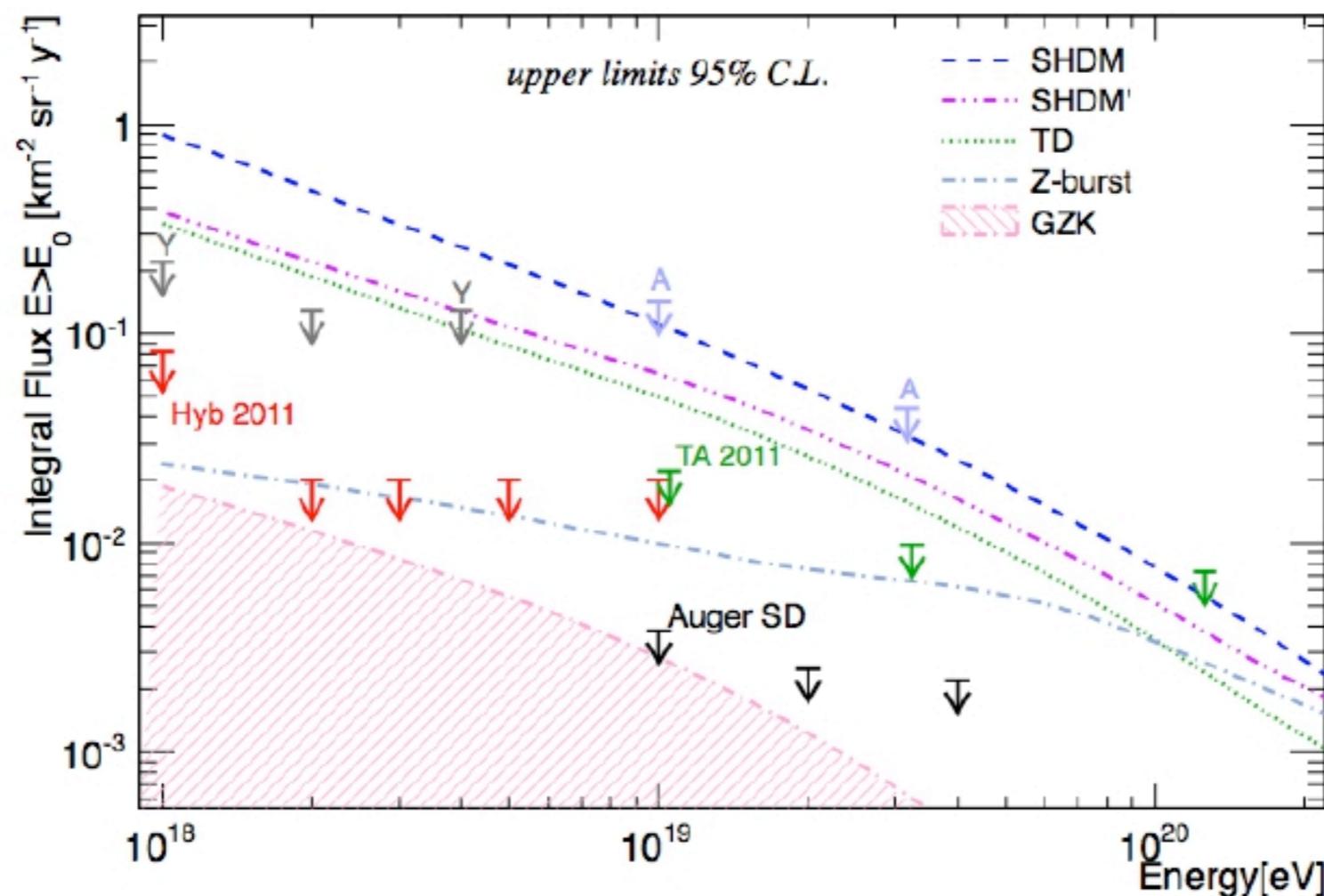
XXIV Workshop on Weak Interactions and Neutrinos - WIN'13

UHECR

I. Composition

a) Photons: no candidates over expected backgrounds –
“top-down”models disfavoured!

Hernan's talk



b) Neutrinos: good sensitivity for GZK neutrinos but no candidates found.

PeV neutrinos from 0.1 EeV protons colliding 1 eV photons?

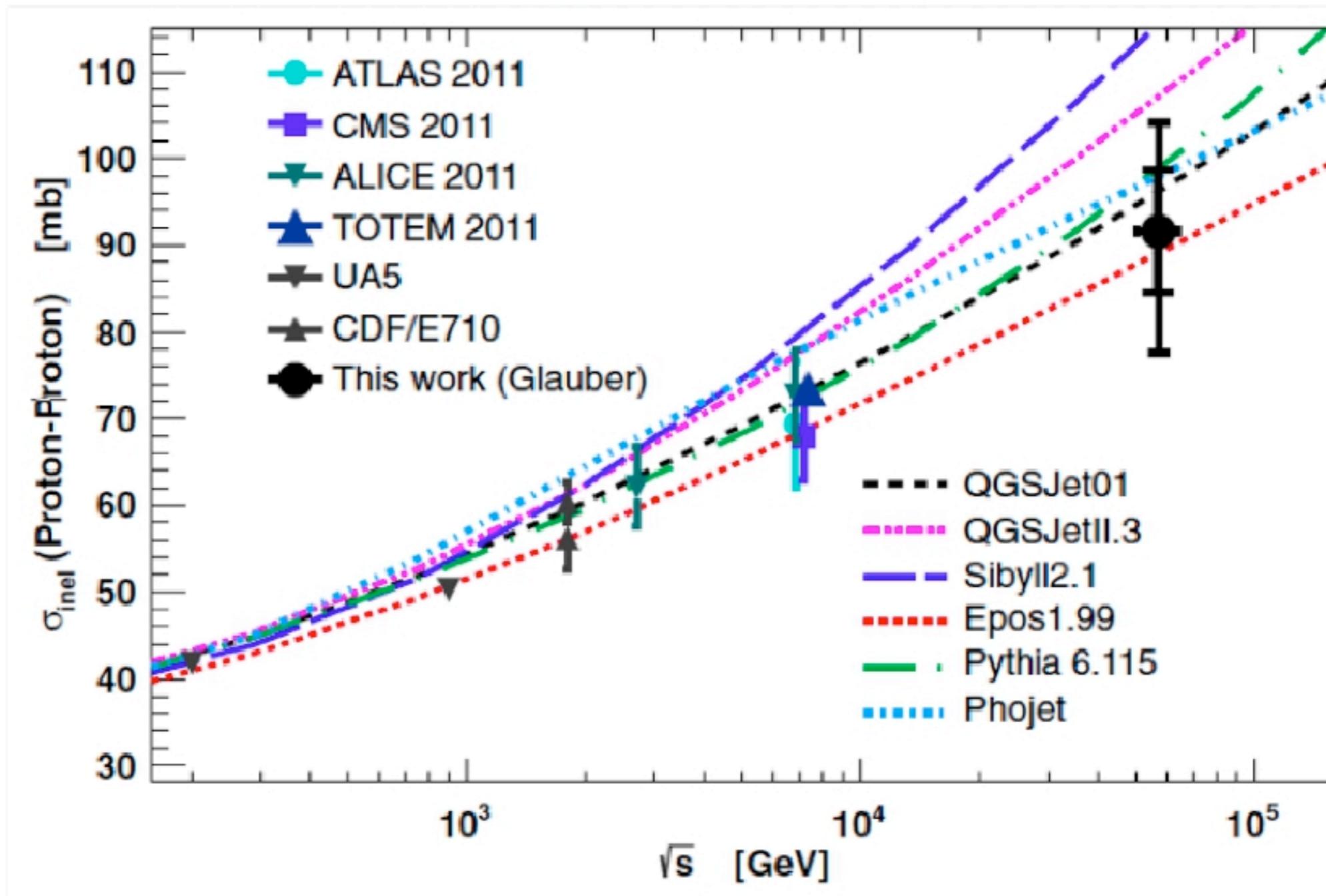
c) Neutrons: search with clustered events – null results

d) Hadronic primaries: tendency for heavier primaries (iron?) at high energies from Auger but tension with HiRes and TA.

LHC data helped to reduce uncertainties in the models!

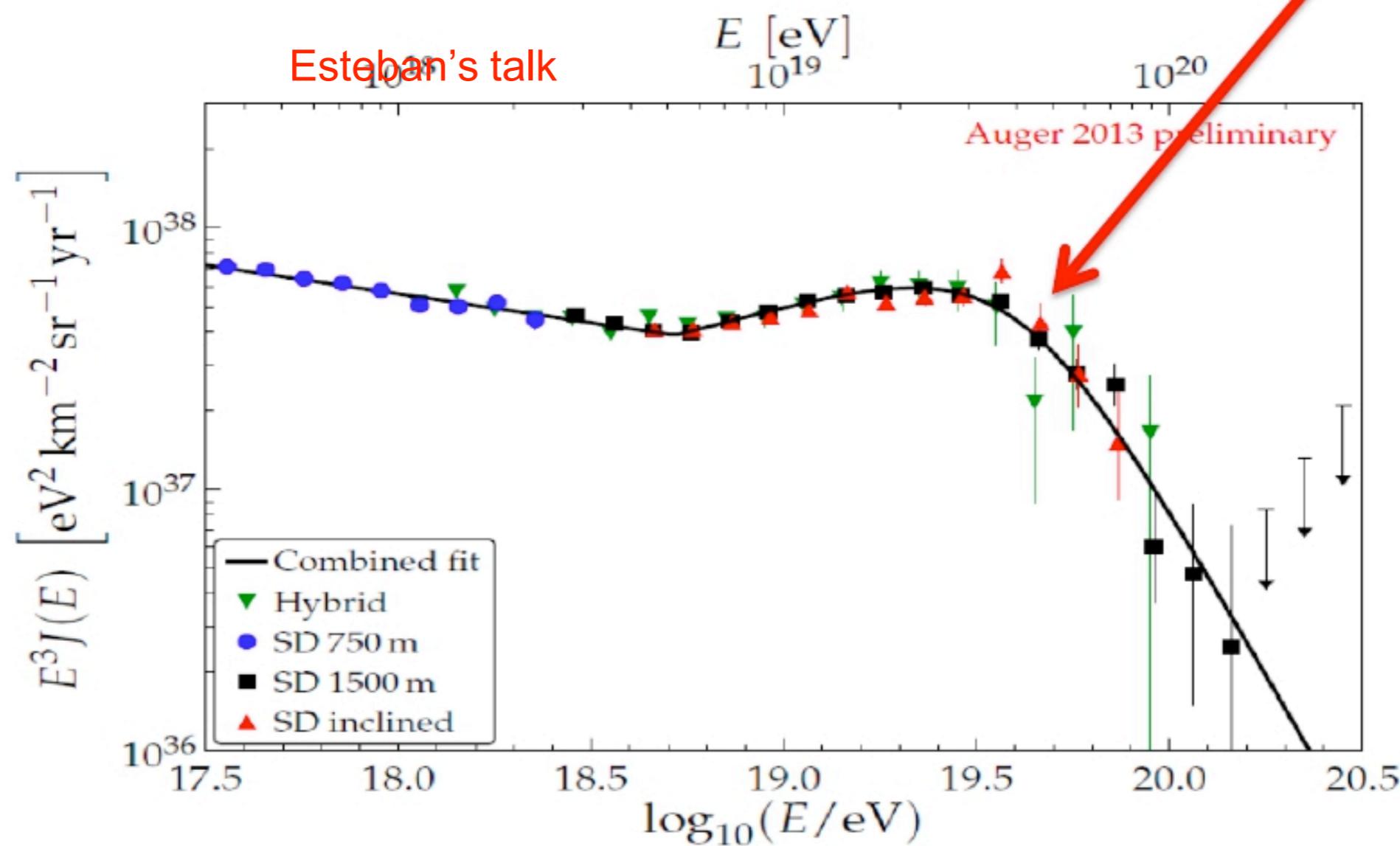
II. Proton-proton cross section at $E_{\text{CM}}=57 \text{ TeV}!$

Edivaldo's talk



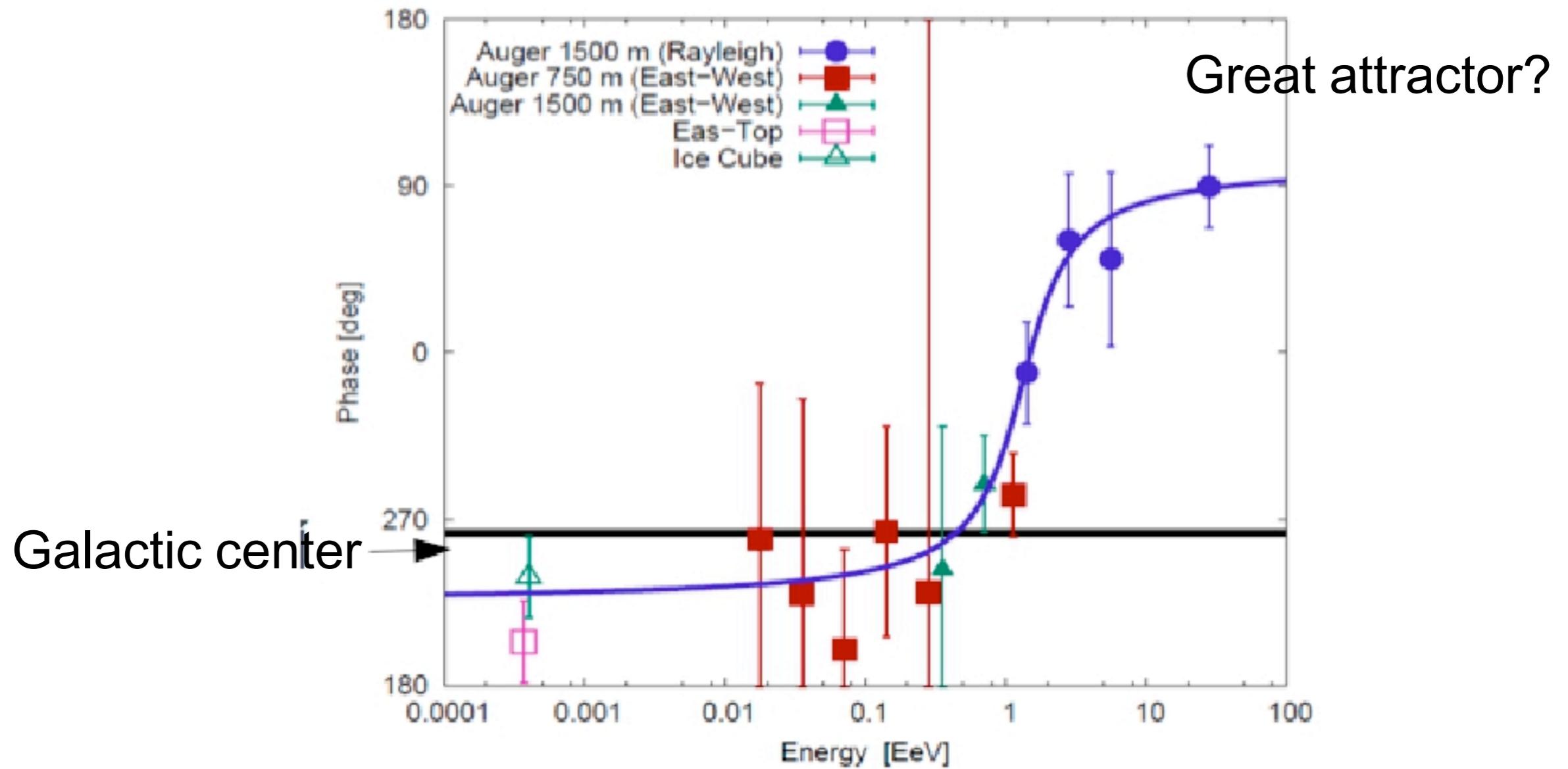
III. Spectrum

GZK cutoff
(or proton/iron exhaustion?)



IV. Large scale anisotropy (dipole)

Esteban's talk



Cosmology

Galli's talk

Planck released results in 29 papers!

Λ CDM is a very good overall fit (but low l's are low, tension at 2.5σ on H_0 with direct measurements). Weak lensing at high l's detected.

Assumptions:

- Adiabatic initial conditions
- $N_{eff}=3.046$
- 1 massive neutrino 0.06eV.
- Sudden reionization ($\Delta z=0.5$)

Beyond Λ CDM: opening the Pandora box with many new parameters, such as Σm_ν , N_{eff} .

Sensitivity to Σm_ν :

$\Sigma m_\nu < 0.93 \text{ eV}$

(95%; Planck+WP)

$\Sigma m_\nu < 0.66 \text{ eV} (< 0.23 \text{ eV})$

(95%; Planck+WP+highL)(+BAO)

$\Sigma m_\nu < 0.85 \text{ eV}$

(95%; Planck+WP+highL+lensing)

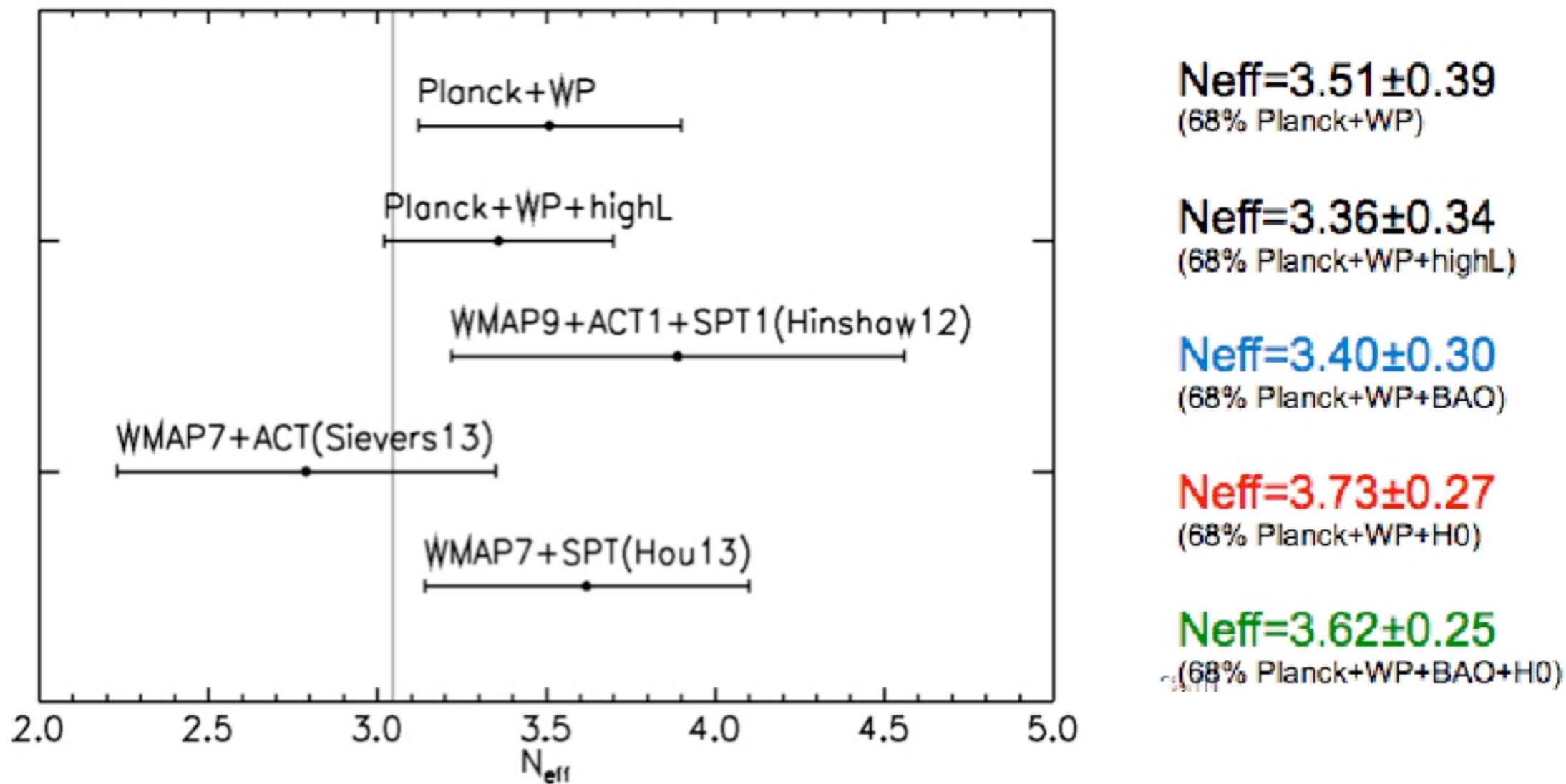
$\Sigma m_\nu < 1.08 \text{ eV}$

(95%; Planck+WP+highL)+Alens

Beware of correlations, eg, with σ_8

Sensitivity to N_{eff}

Galli's talk



No significant evidence for new relativistic species from Planck data alone.

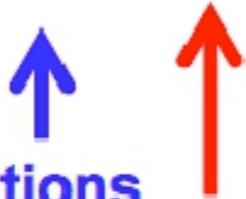
BBN

Good agreement between Cosmo and BBN on baryon density.
Main uncertainty in BBN results is in some low energy nuclear
cross sections.

Gustavino's talk

$$100\Omega_{b,0}h^2(\text{CMB})=2.20\pm0.03 \text{ (PLANCK2013)}$$

$$100\Omega_{b,0}h^2(\text{D/H})=2.20\pm0.02\pm0.04 \text{ (Cooke2013)}$$

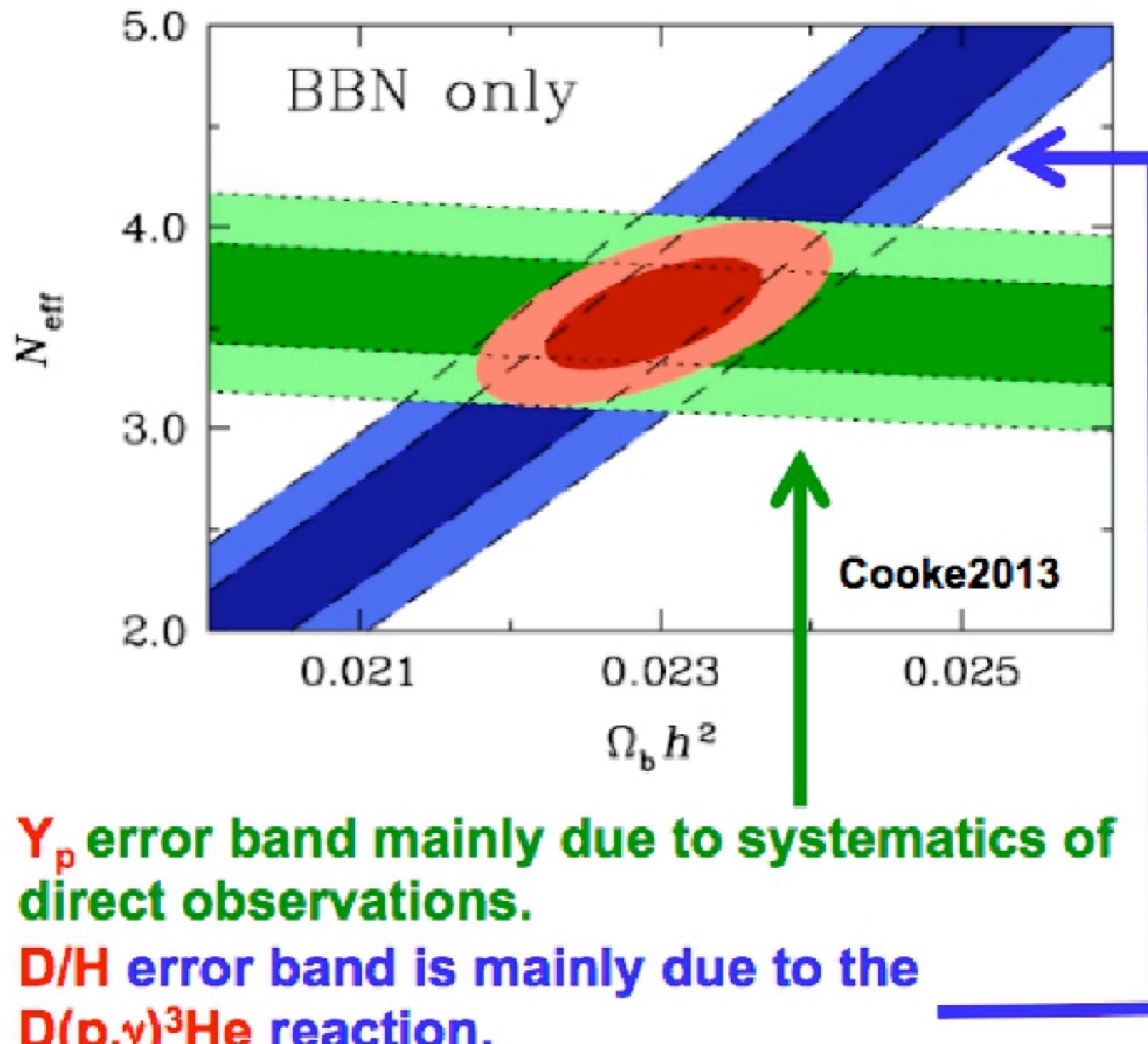


D/H observations
Nuclear Astrophysics (D+p reaction uncertainty)

LUNA at LNGS will perform a new measurement of the relevant cross sections (also for the lithium production).

N_{eff} from BBN

Gustavino's talk



Baryon asymmetry

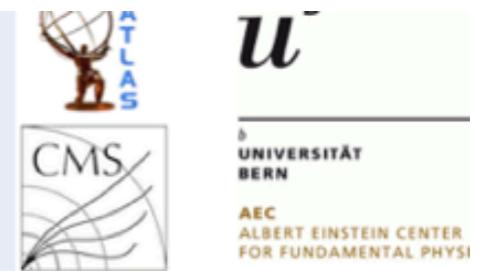
BAU still an open problem. Possibility to have baryogenesis from thermal leptogenesis in the inert doublet model.

Racker's talk

LHC / CTA / HESS / Radio & γ -rays

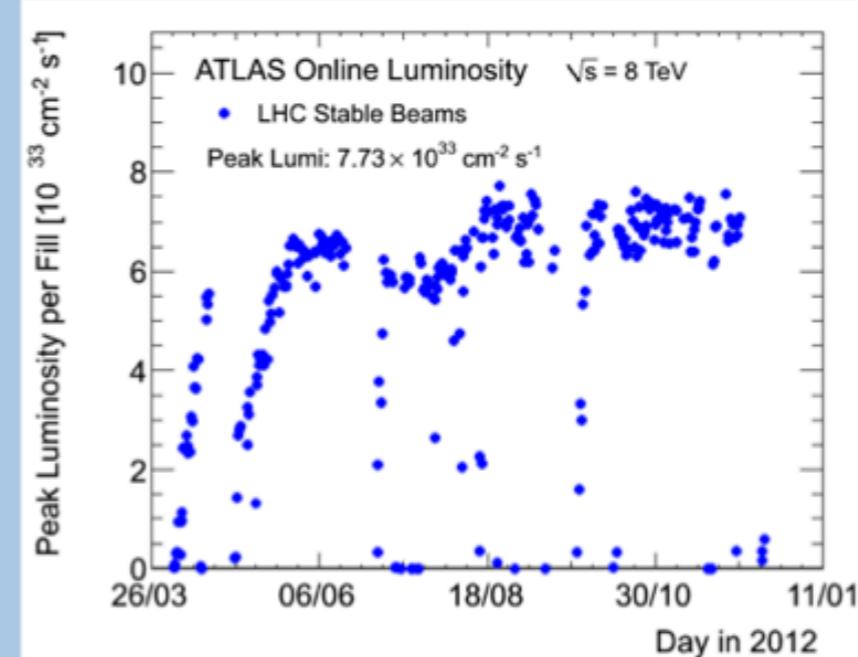
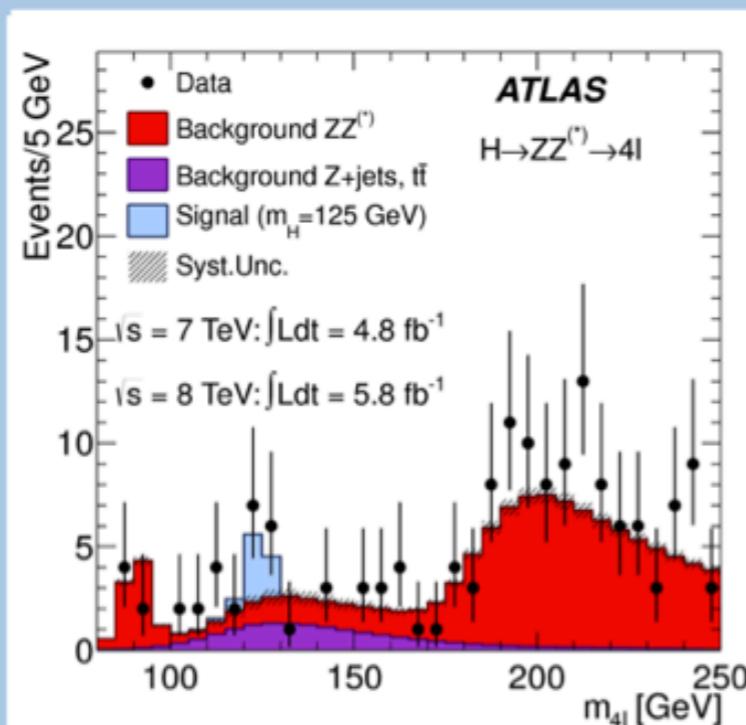
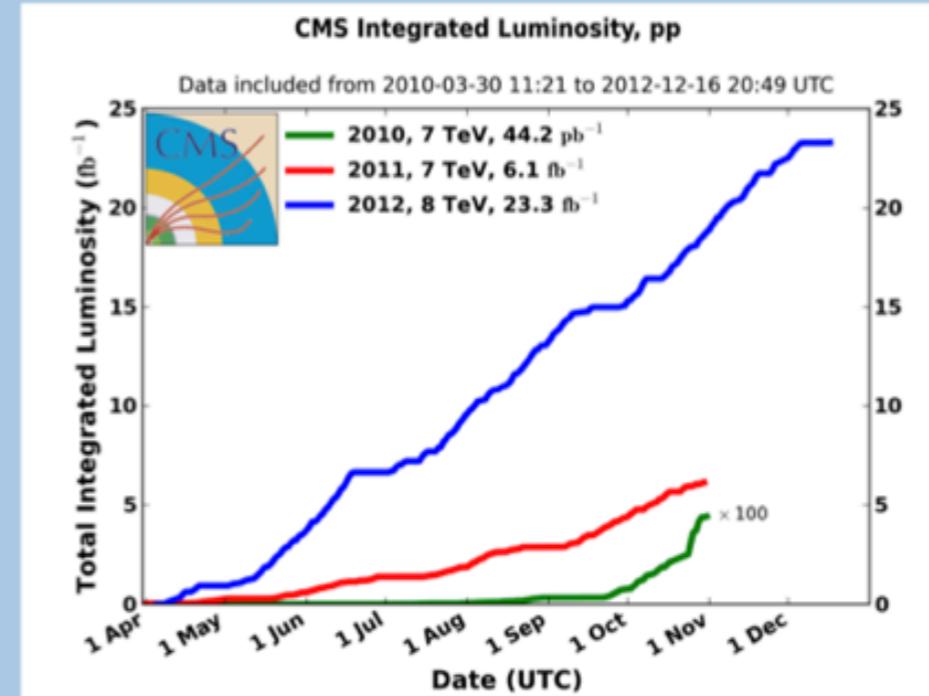
Win2013

A fantastic Run I taking data through 2012



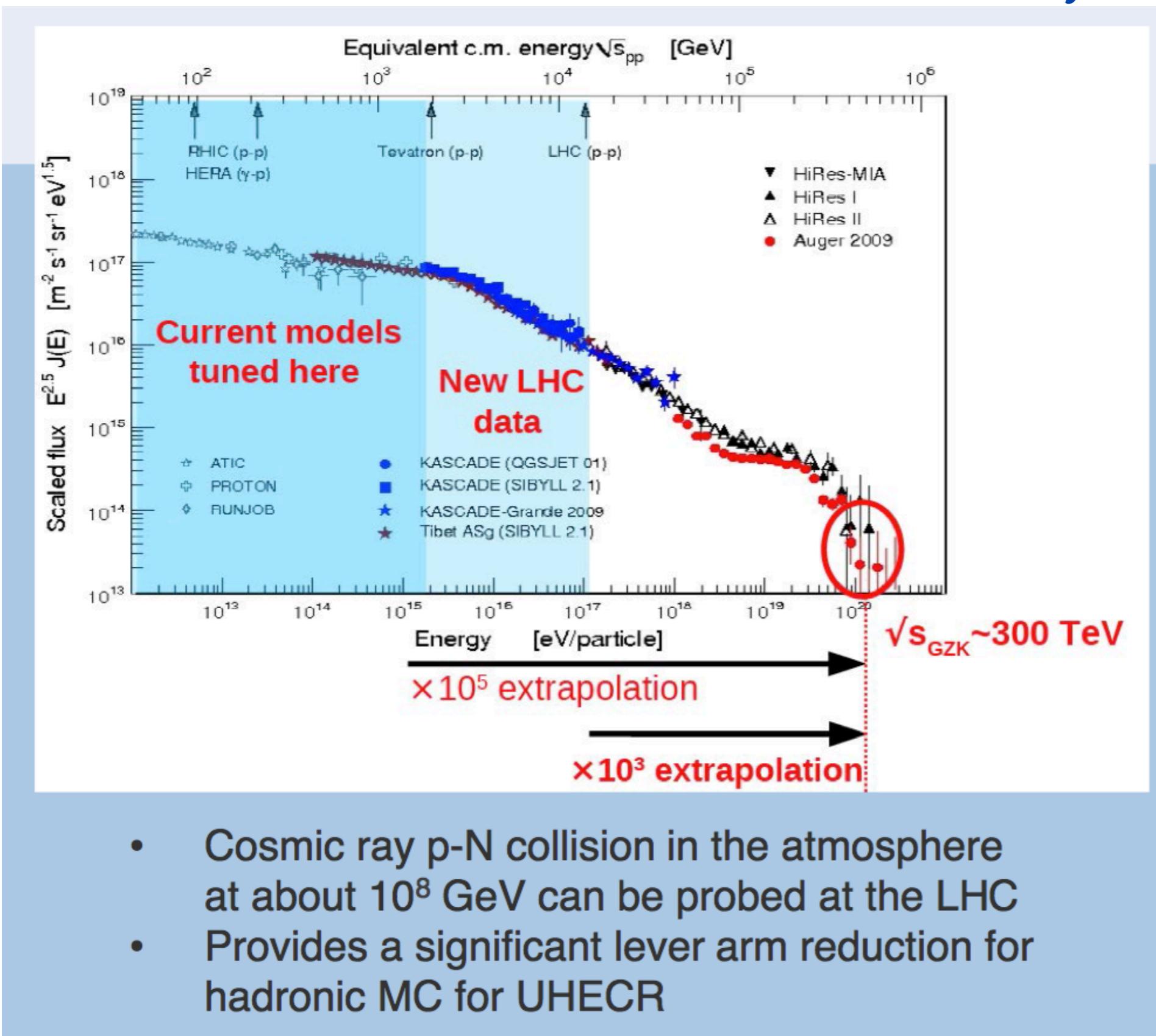
Luminosity (similar in ATLAS and CMS)

- ~5 fb⁻¹ at 7 TeV
- ~20 fb⁻¹ at 8 TeV
- Design proton bunch intensity
- Peak luminosity at $7.7 \times 10^{33} \text{ s}^{-1} \text{cm}^{-2}$
- >93% data taking efficiency



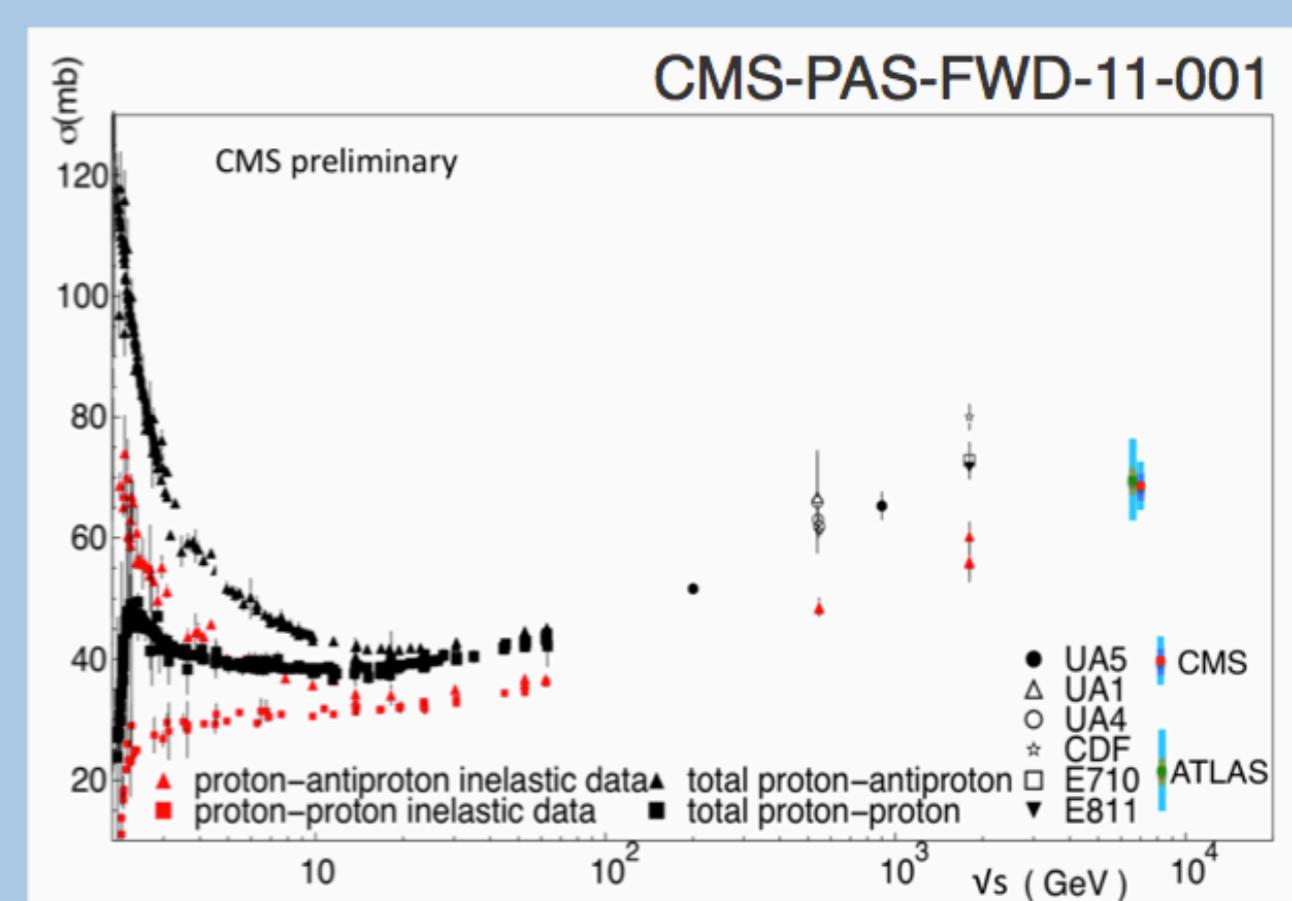
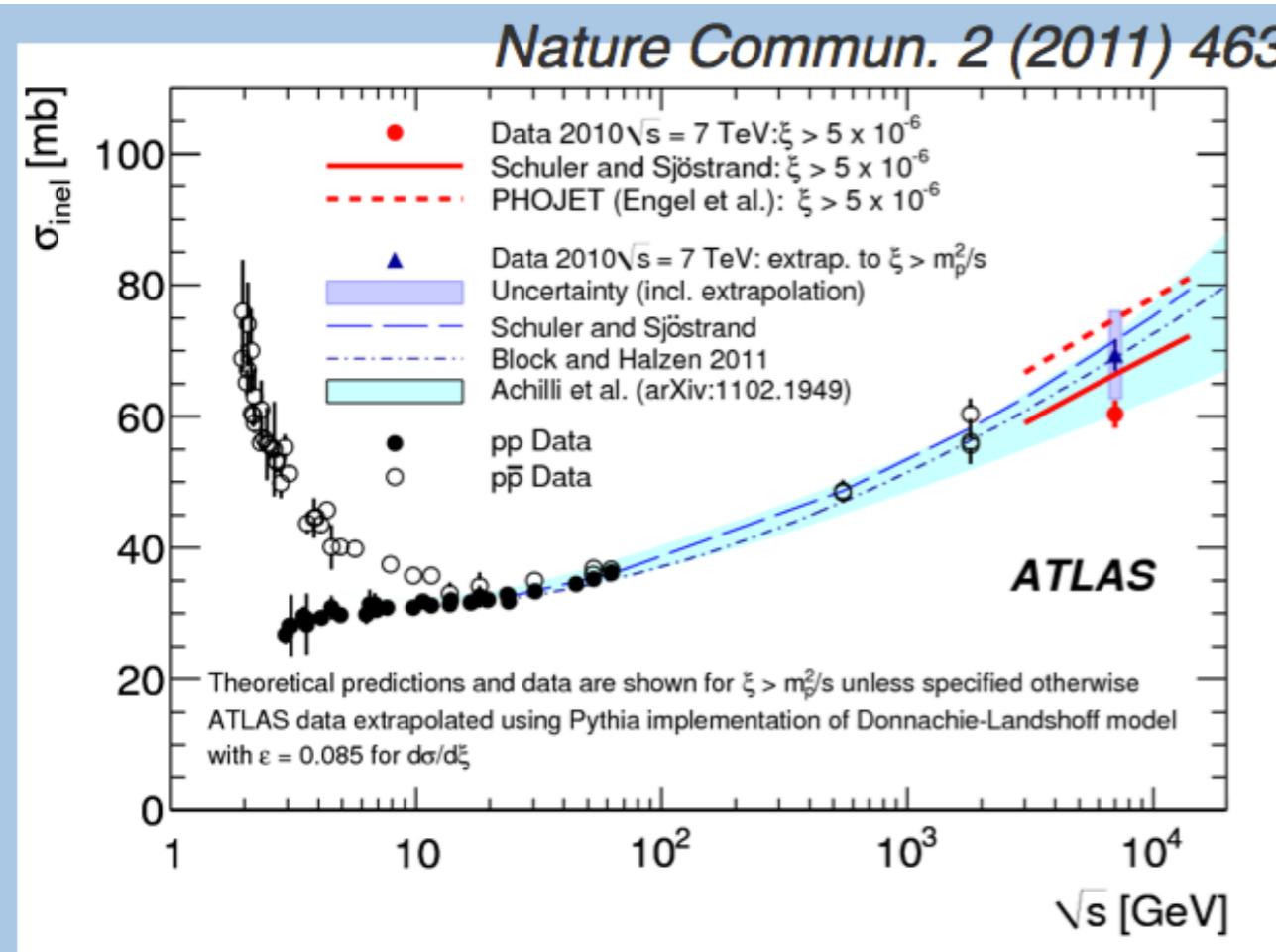
LHC results - Cosmic Rays

Michele Weber



LHC results - Cosmic Rays

Michele Weber



- Further measurements are made difficult by high instantaneous luminosity
- In principle also p-N p-O (p-Air) collisions are possible, but require significant beam studies and setup time

+ BLACK HOLES & EXTRA DIMENSIONS - no observed excess

How Do we Search SUSY @ LHC ?

Strong production: gluino pair, gluino-squark and squark pair (include **3rd generation**) production

1) Generic signatures :

Multi-jets + n_lepton/n_photon(n=0,1,
 ≥ 2) + large E_T^{miss}

2) large xs, but heavy SUSY mass scales

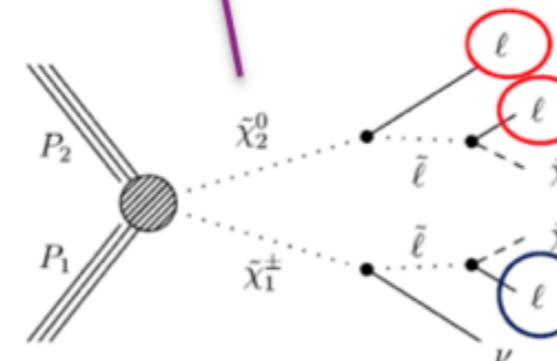
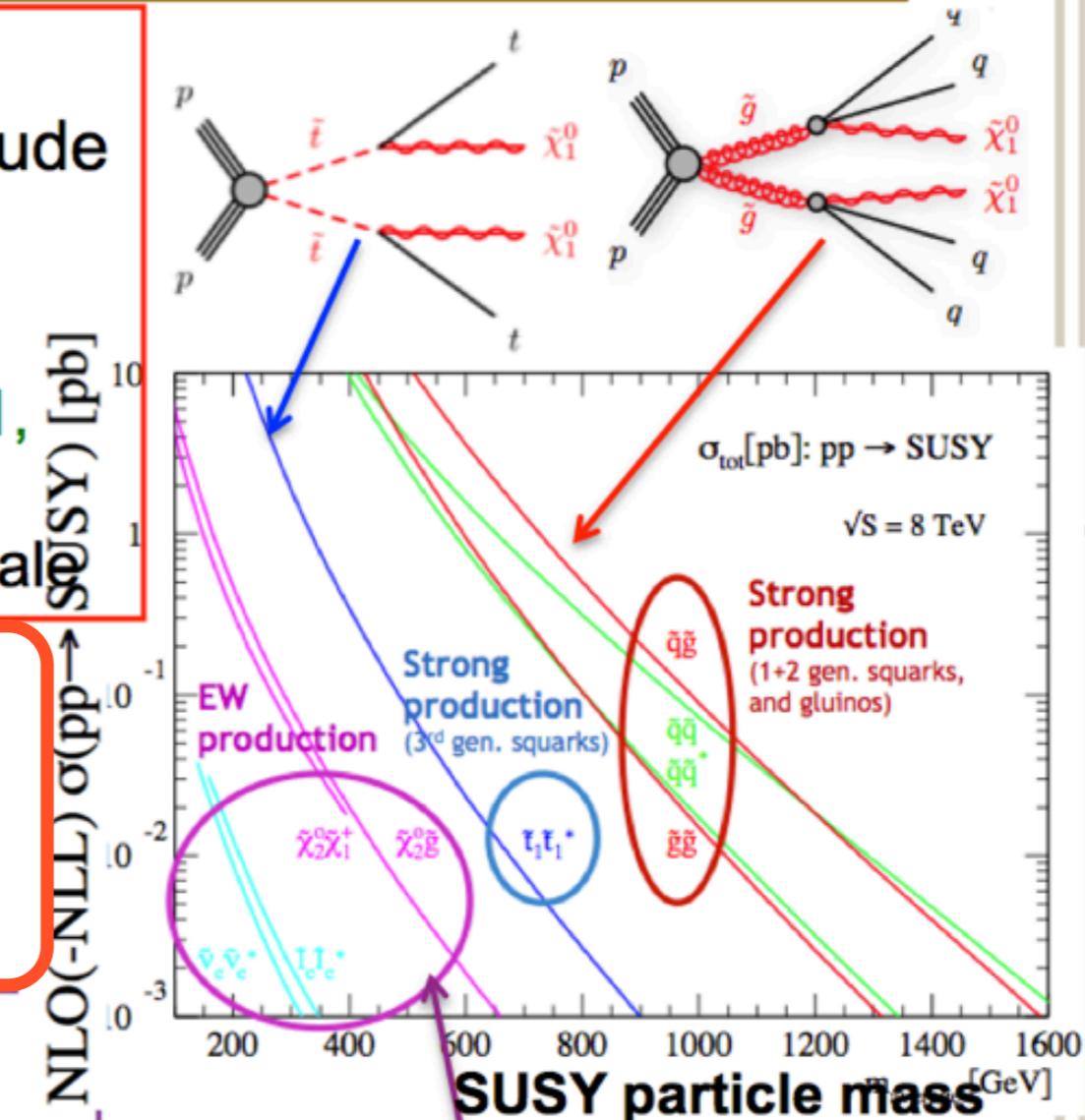
Final states:
 n_jets + n_leptons/n_photons
 + large E_T^{miss} (n ≥ 0)

Weak production: direct gaugino/slepton production

1) Generic signatures:

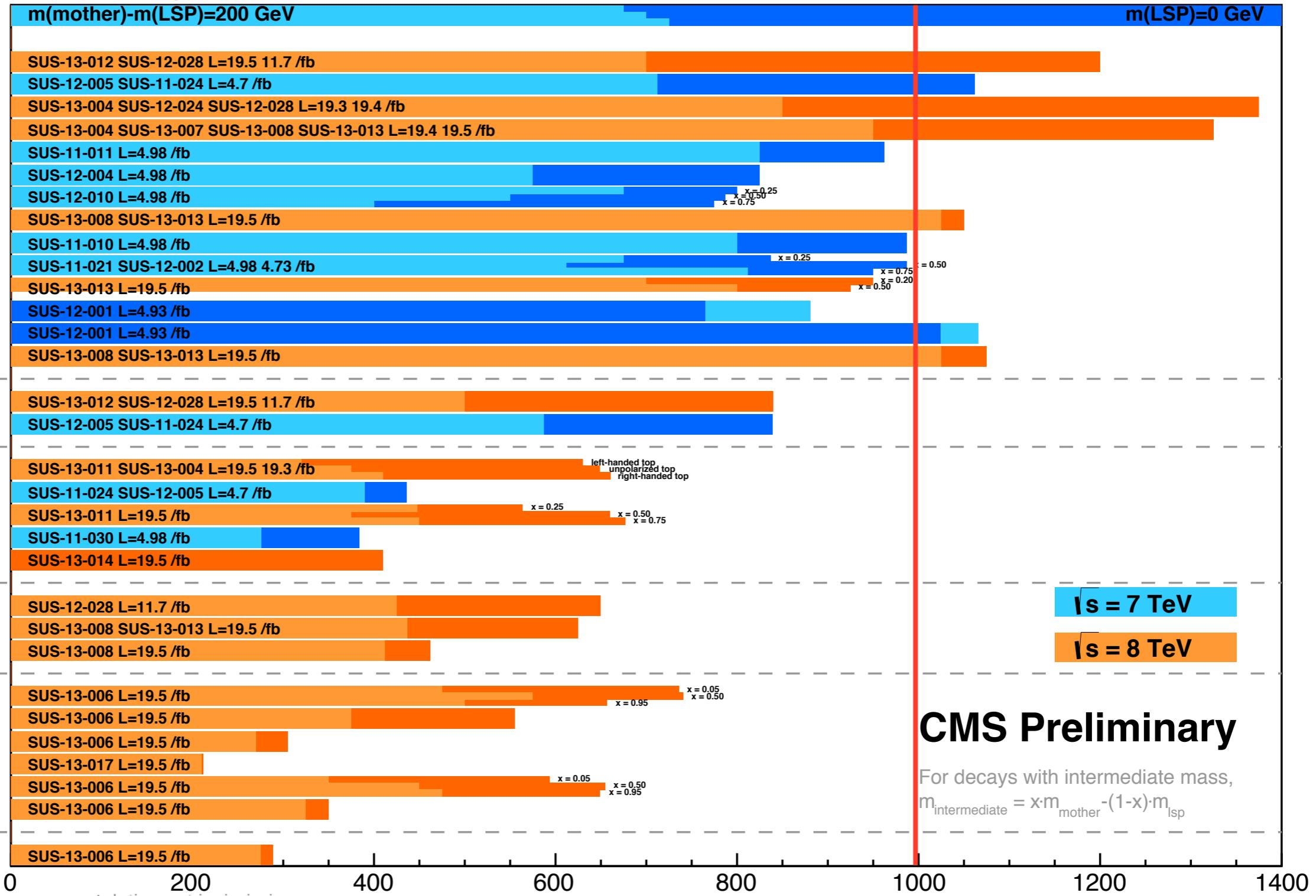
low-jet multiplicity + ≥ 2 leptons + large E_T^{miss}

2) low xs, but small SUSY mass scale



Summary of CMS SUSY Results* in SMS framework

SUSY 2013



*Observed limits, theory uncertain

Only a selection of available masses
 Probe *up to* the quoted mass limit

<https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResults>

LHC results - SUSY ATLAS results

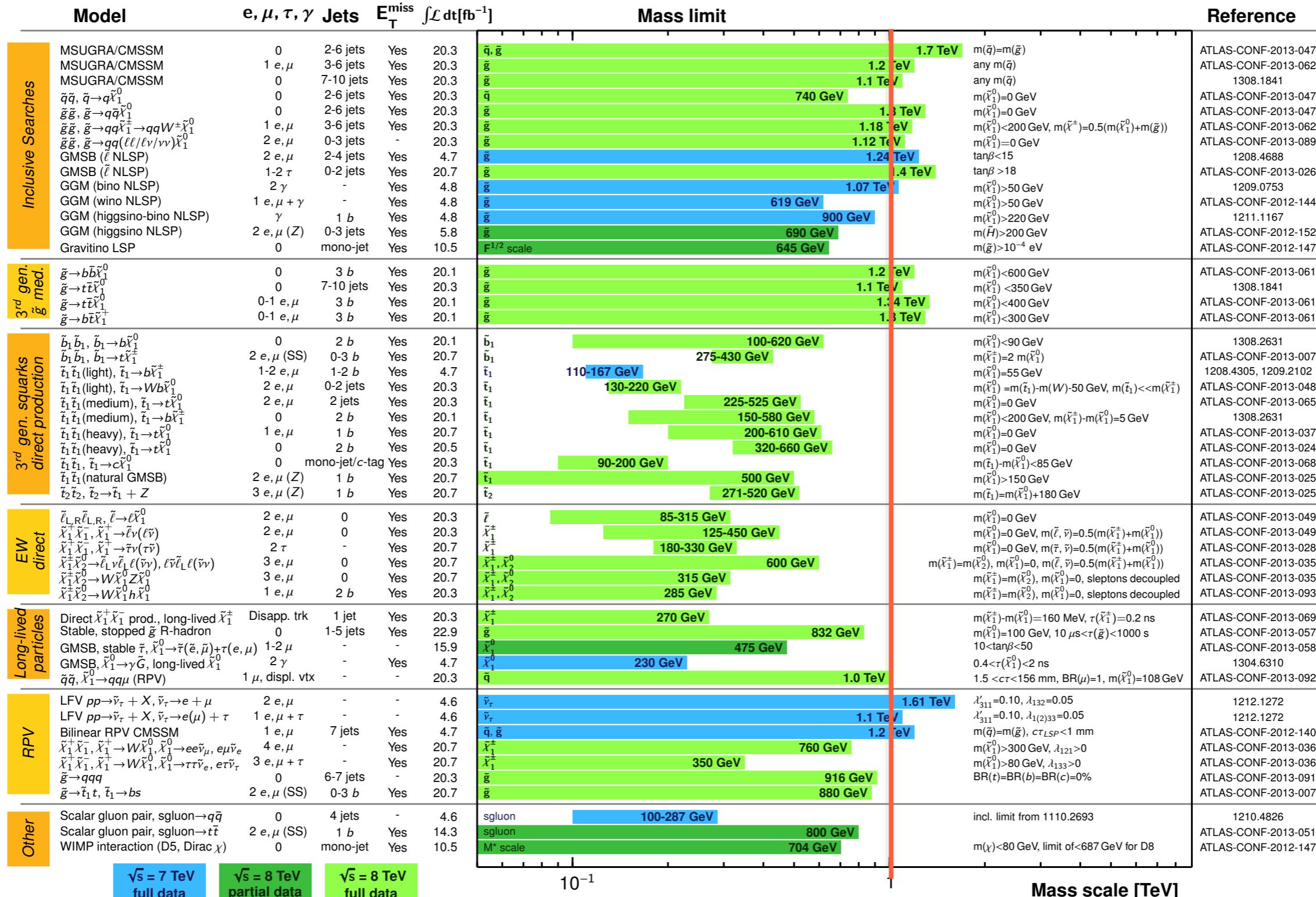
Xuai Zhuang

ATLAS SUSY Searches* - 95% CL Lower Limits

Status: SUSY 2013

ATLAS Preliminary

$\int \mathcal{L} dt = (4.6 - 22.9) \text{ fb}^{-1}$ $\sqrt{s} = 7, 8 \text{ TeV}$



$\sqrt{s} = 7 \text{ TeV}$
full data

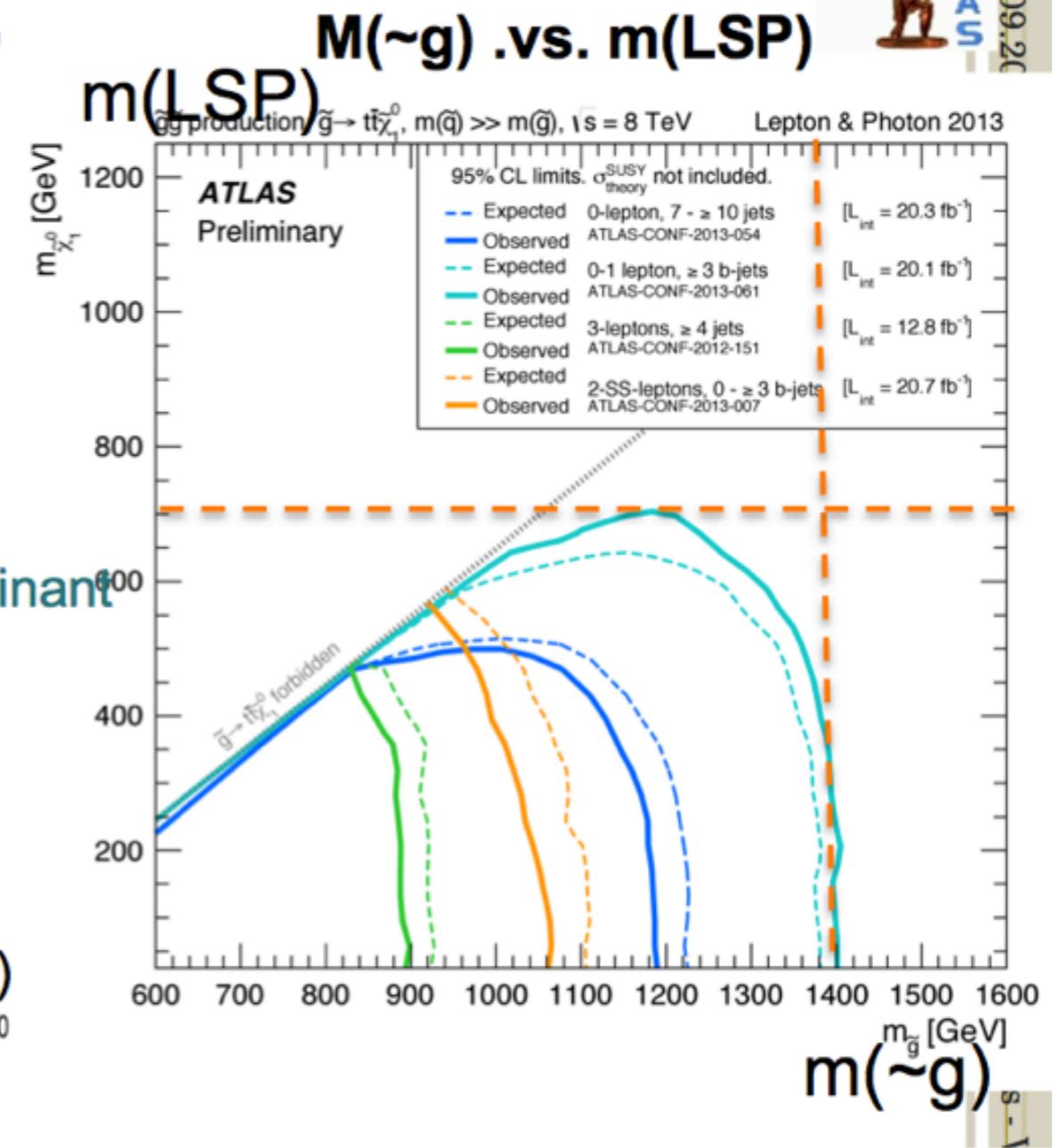
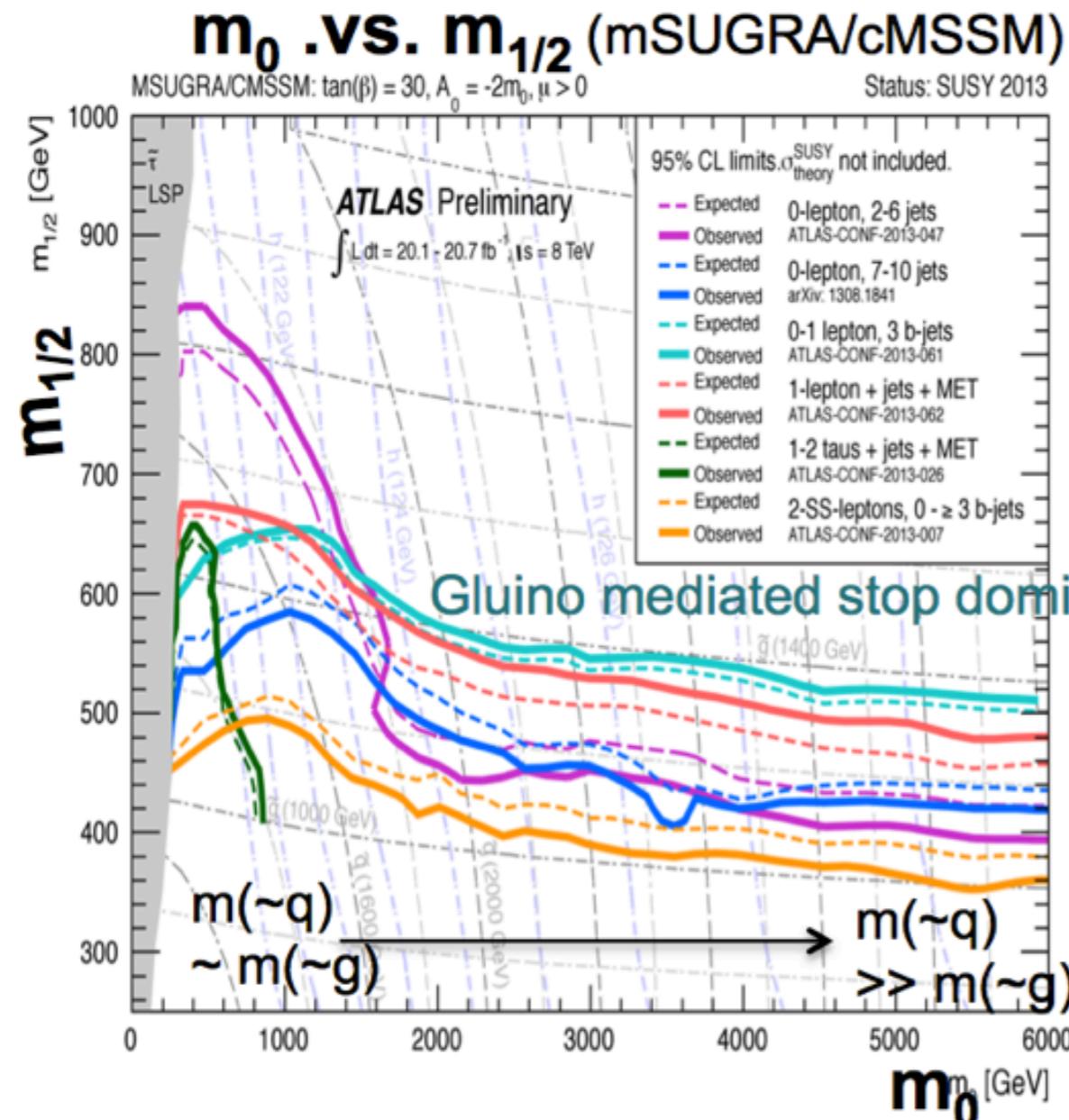
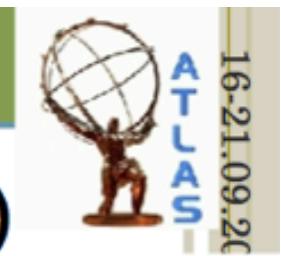
$\sqrt{s} = 8 \text{ TeV}$
partial data

$\sqrt{s} = 8 \text{ TeV}$
full data

*Only a selection of the available mass limits on new states or phenomena

<https://twiki.cern.ch/twiki/bin/view/AtlasPublic/>

Inclusive search for squark and gluino production



- $m(\sim q) \sim m(\sim g)$: $m(\sim g) > 1.7 \text{ TeV}$
- $M(\sim q) \gg m(\sim g)$: $m(\sim g) > 1.35 \text{ TeV}$
- **Conditional/indirect limit on LSP:**
 $m > 200-300 \text{ GeV}$

No exclusion for $M(\text{LSP}) \geq 700 \text{ GeV}$
Strongest limit: $m(\sim g) \geq 1400 \text{ GeV}$

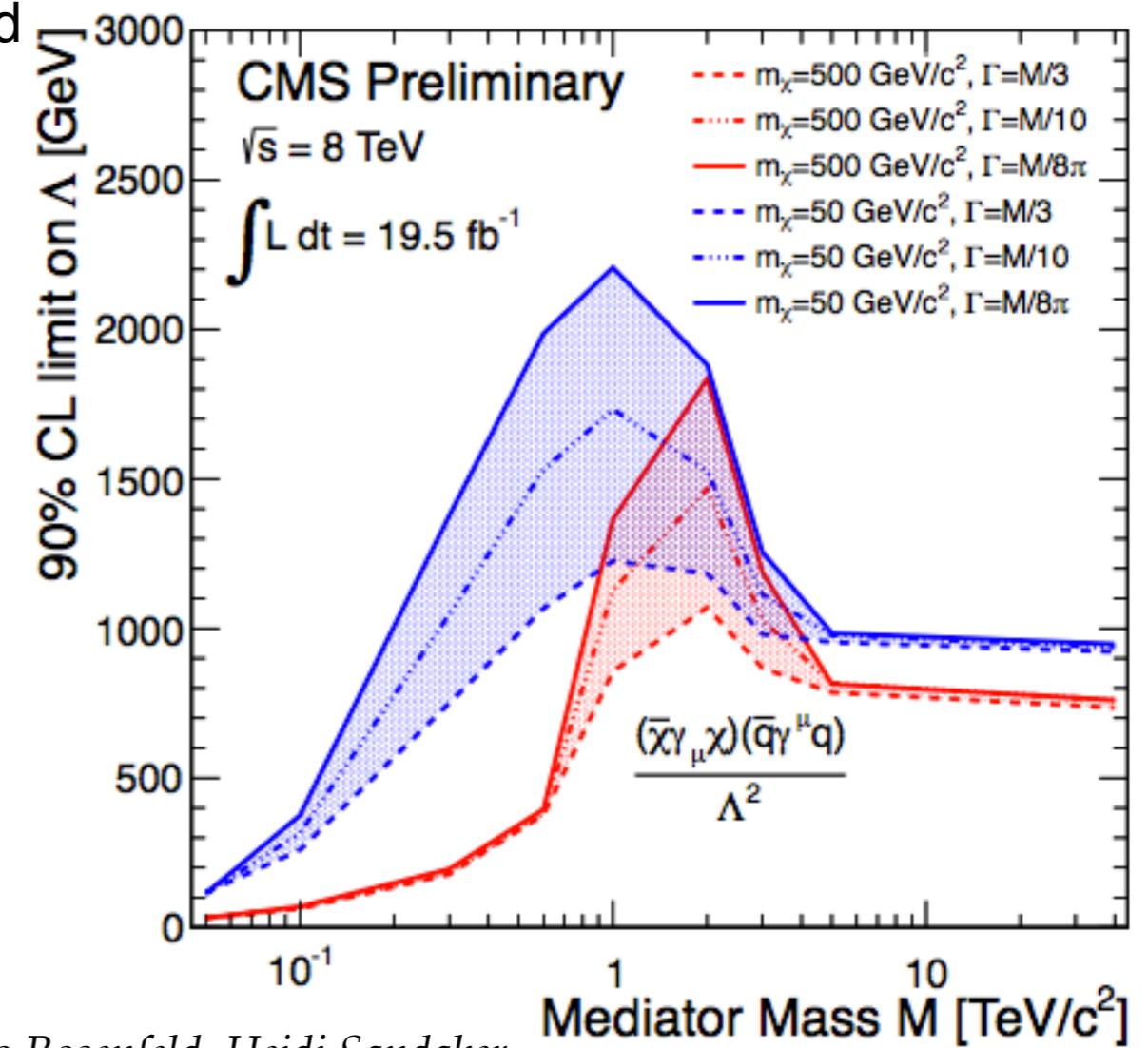
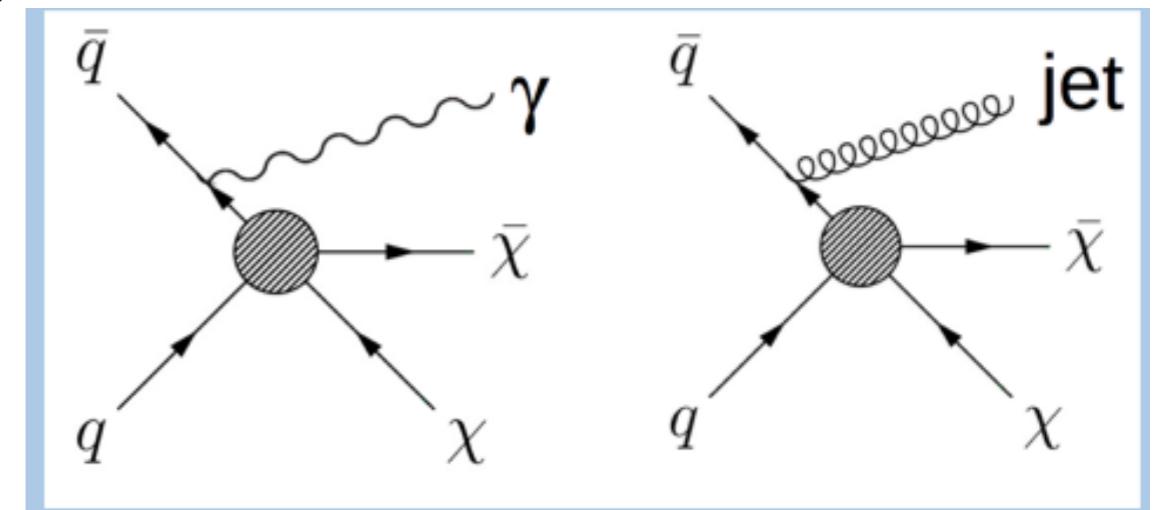
LHC results - Mono-X

James Pearce

- We look for large missing E_T and one **jet**, γ , W/Z or b
- Interpretation is done using EFT
 - We assume it is valid for LHC
 - We assume a heavy mediator, with very low rates
 - More discussion in the various Mono-papers !
- **No excess observed**
- LHC most sensitive to the low X mass range
- Mono- X searches at the LHC are competitive and complementary to direct and indirect detection experiments.

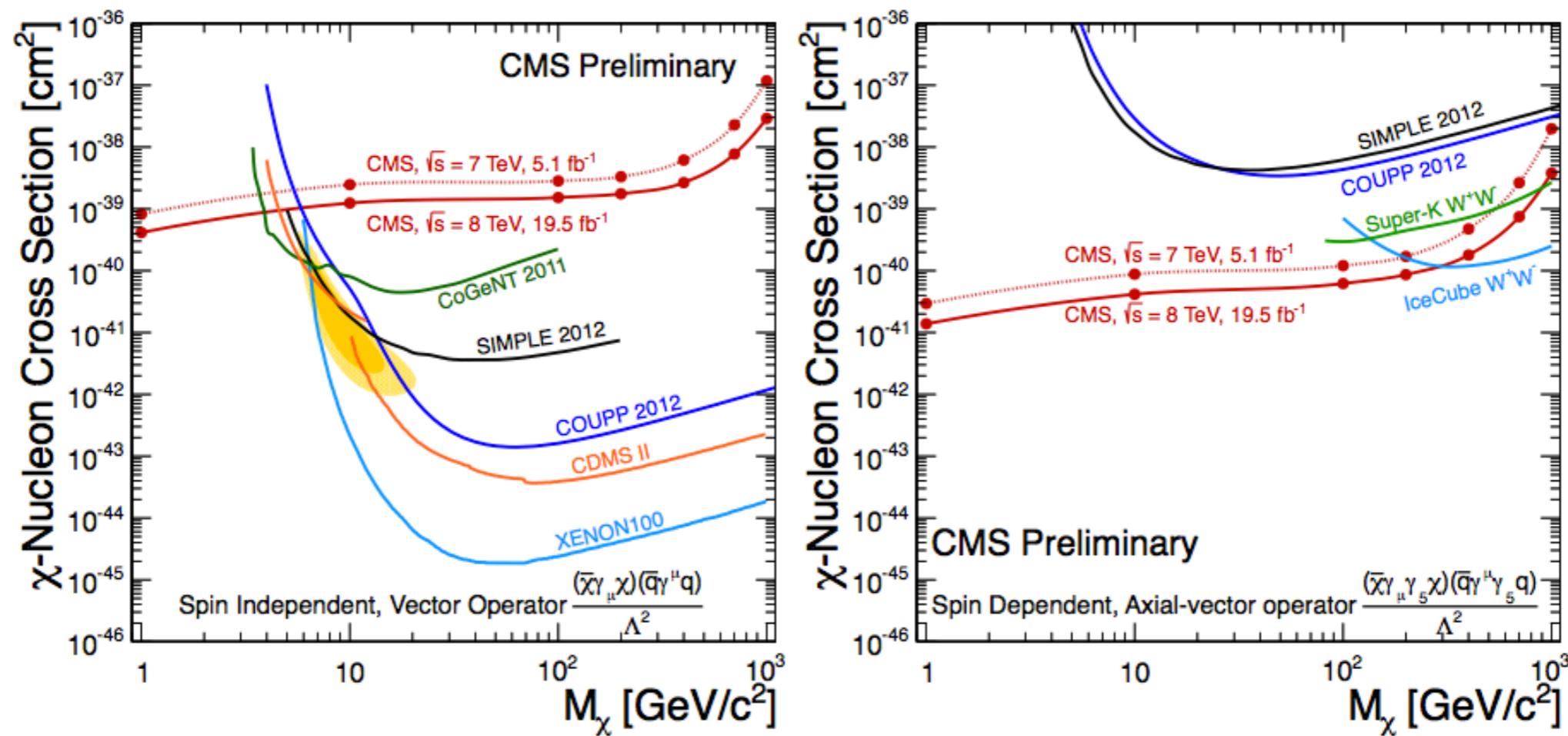
D1 (scalar), D5 (vector), D8 (axial-vector), D9 (tensor) and D11 (couples to gluons)

Name	Operator	Coefficient
D1	$\bar{\chi}\chi\bar{q}q$	m_q/M_*^3
D2	$\bar{\chi}\gamma^5\chi\bar{q}q$	im_q/M_*^3
D3	$\bar{\chi}\chi\bar{q}\gamma^5q$	im_q/M_*^3
D4	$\bar{\chi}\gamma^5\chi\bar{q}\gamma^5q$	m_q/M_*^3
D5	$\bar{\chi}\gamma^\mu\chi\bar{q}\gamma_\mu q$	$1/M_*^2$
D6	$\bar{\chi}\gamma^\mu\gamma^5\chi\bar{q}\gamma_\mu q$	$1/M_*^2$
D7	$\bar{\chi}\gamma^\mu\chi\bar{q}\gamma_\mu\gamma^5q$	$1/M_*^2$
D8	$\bar{\chi}\gamma^\mu\gamma^5\chi\bar{q}\gamma_\mu\gamma^5q$	$1/M_*^2$
D9	$\bar{\chi}\sigma^{\mu\nu}\chi\bar{q}\sigma_{\mu\nu}q$	$1/M_*^2$
D10	$\bar{\chi}\sigma_{\mu\nu}\gamma^5\chi\bar{q}\sigma_{\alpha\beta}q$	i/M_*^2
D11	$\bar{\chi}\chi G_{\mu\nu}G^{\mu\nu}$	$\alpha_s/4M_*^3$
D12	$\bar{\chi}\gamma^5\chi G_{\mu\nu}G^{\mu\nu}$	$i\alpha_s/4M_*^3$
D13	$\bar{\chi}\chi G_{\mu\nu}\tilde{G}^{\mu\nu}$	$i\alpha_s/4M_*^3$
D14	$\bar{\chi}\gamma^5\chi G_{\mu\nu}\tilde{G}^{\mu\nu}$	$\alpha_s/4M_*^3$



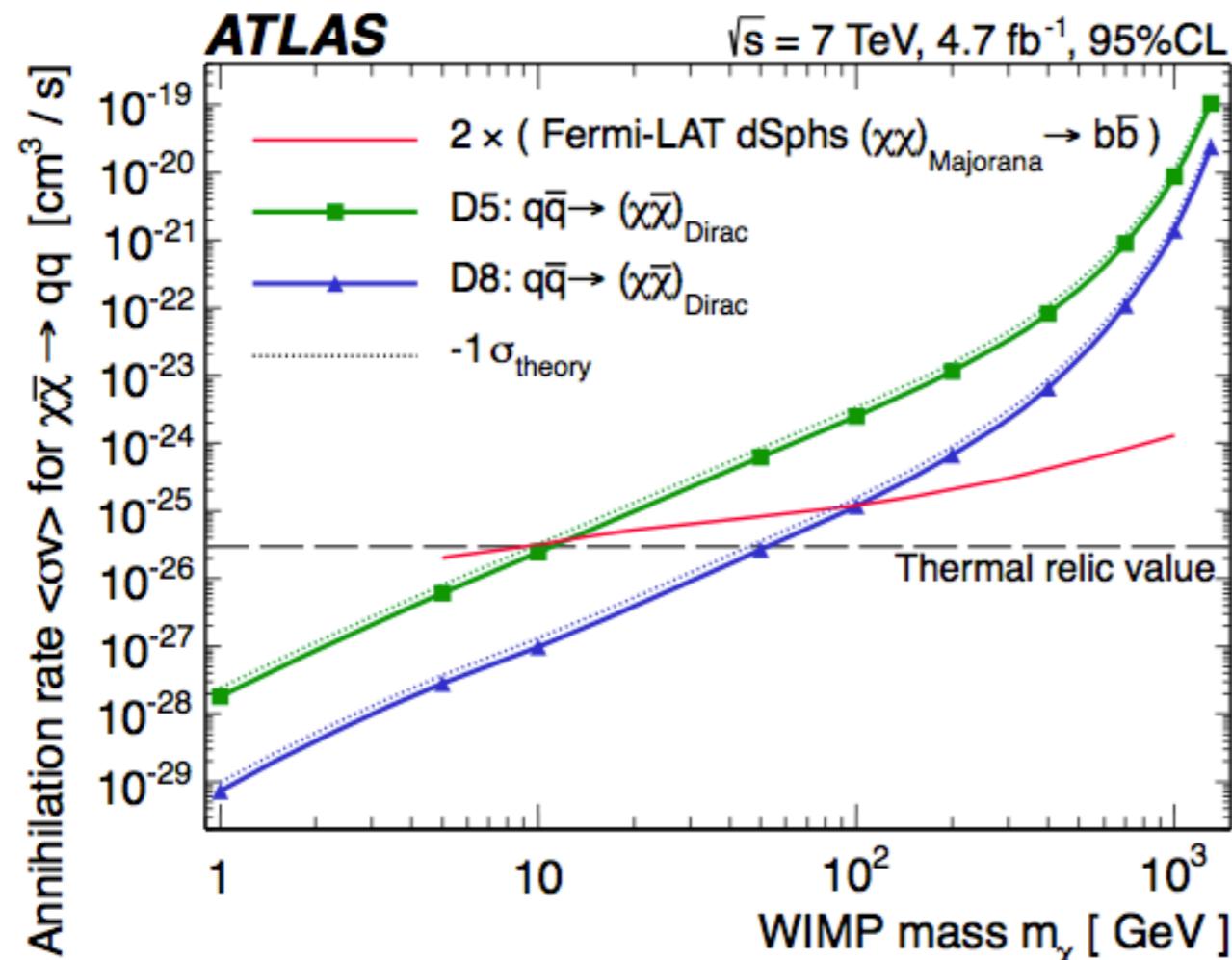
LHC results - Example Mono-Jet James Pearce

WIMP-NUCLEON SCATTERING LIMITS



- ▶ Cross sections above observed are excluded.
- ▶ Assumption is that DM interacts with SM particles solely by a given operator: SI = D5, SD = D8
- ▶ Yellow contours show candidate events from CDMS: [arXiv:1304.4279](https://arxiv.org/abs/1304.4279)

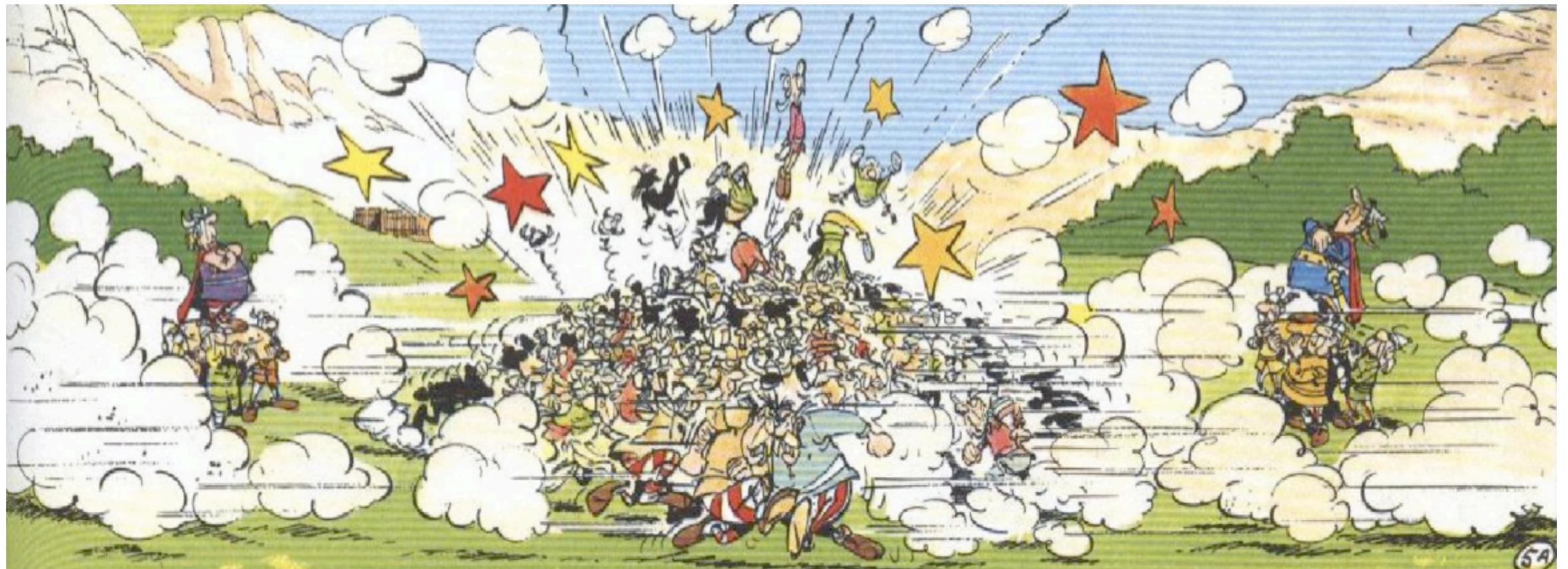
WIMP ANNIHILATION LIMITS



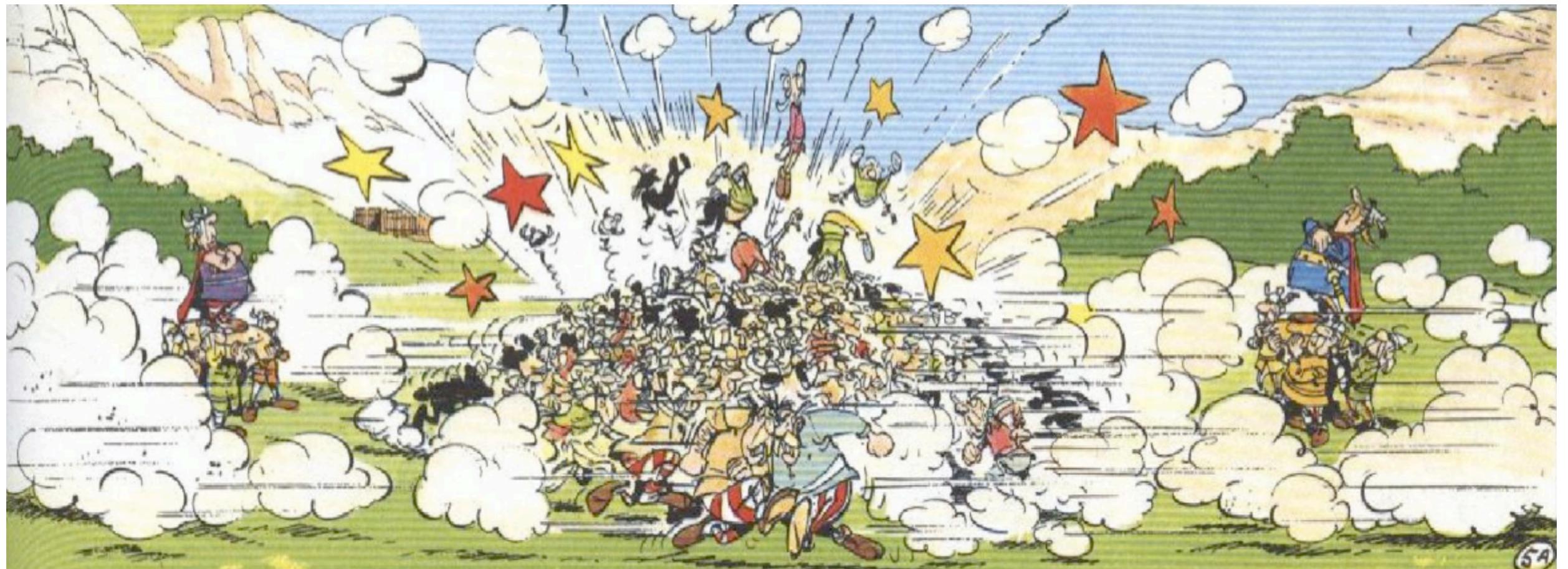
- Comparison with FERMI-LAT is possible through our EFT

- The results can also be interpreted in terms of limits on WIMPs annihilating to light quarks
- All limits shown here assume 100% branching fractions of WIMPs annihilating to quarks
- Below 10 GeV for D5 and 70 GeV for D8 the ATLAS limits are below the values needed for WIMPs to make up the DM relic abundance

LHC results - 7/8 TeV



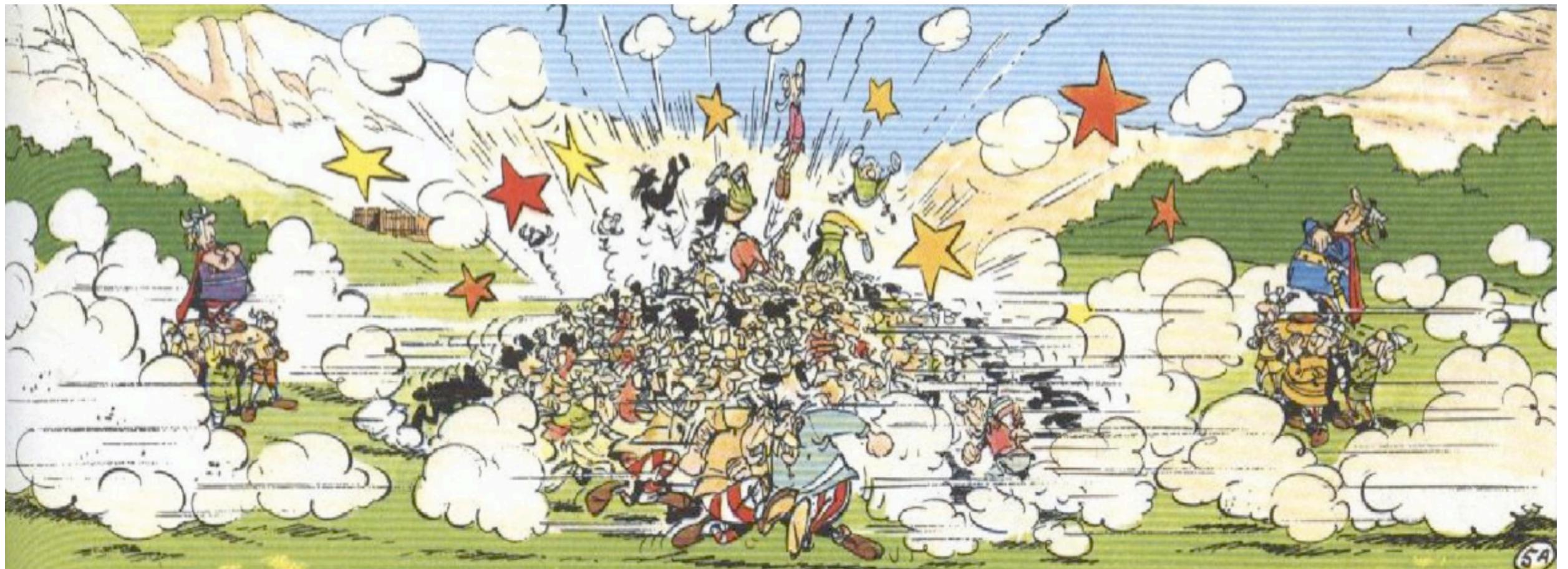
LHC results - 7/8 TeV



Discovery of the
Higgs particle !



LHC results - 7/8 TeV



Discovery of the
Higgs particle !



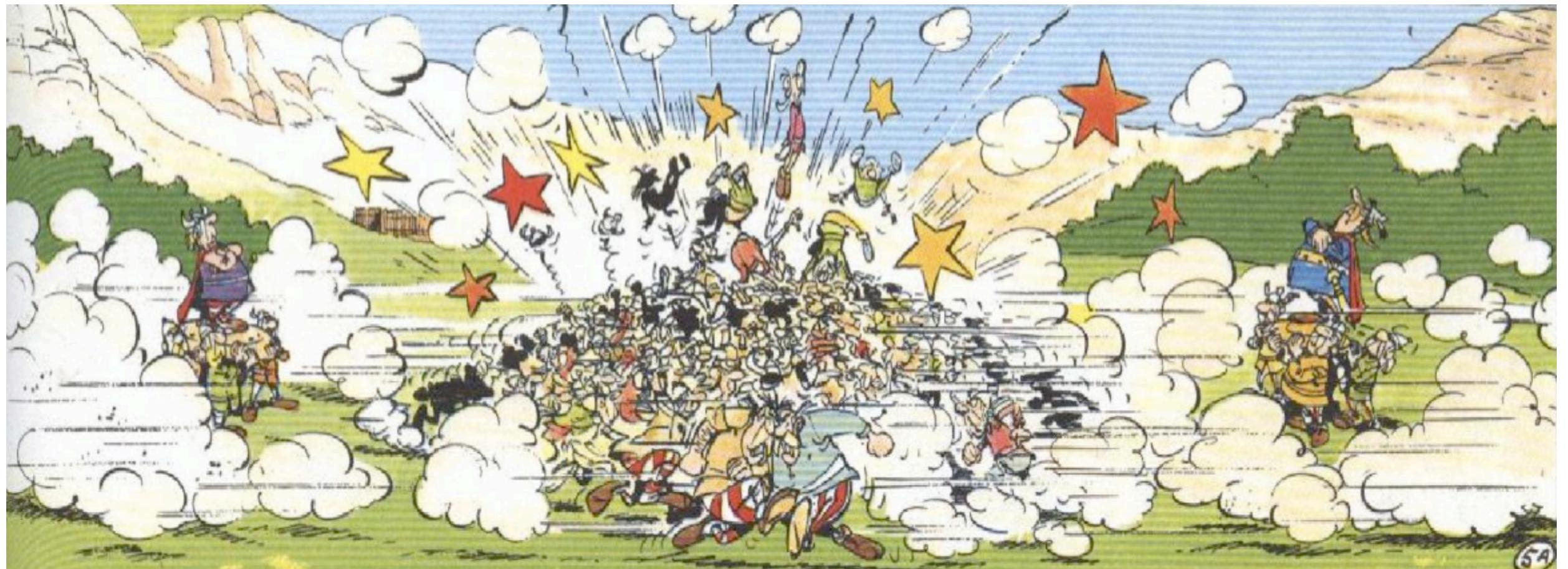
> CLICK



First sign of
headache?

- No SUSY ?
- Nothing else ?

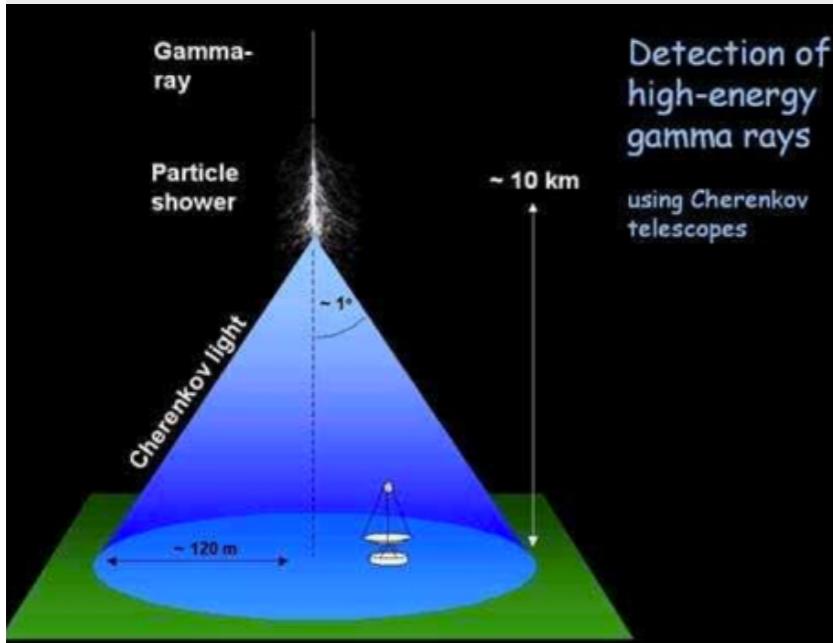
LHC results - 14 TeV ?



Ah, but we are not yet at design energy = 14 TeV !

- SUSY ?
- A surprise ?

The most advanced : H.E.S.S. 2



IACT experiments have entered into a new era

- Already >140 sources detected @ VHE
- HESS-II inaugurated a year ago - new results soon



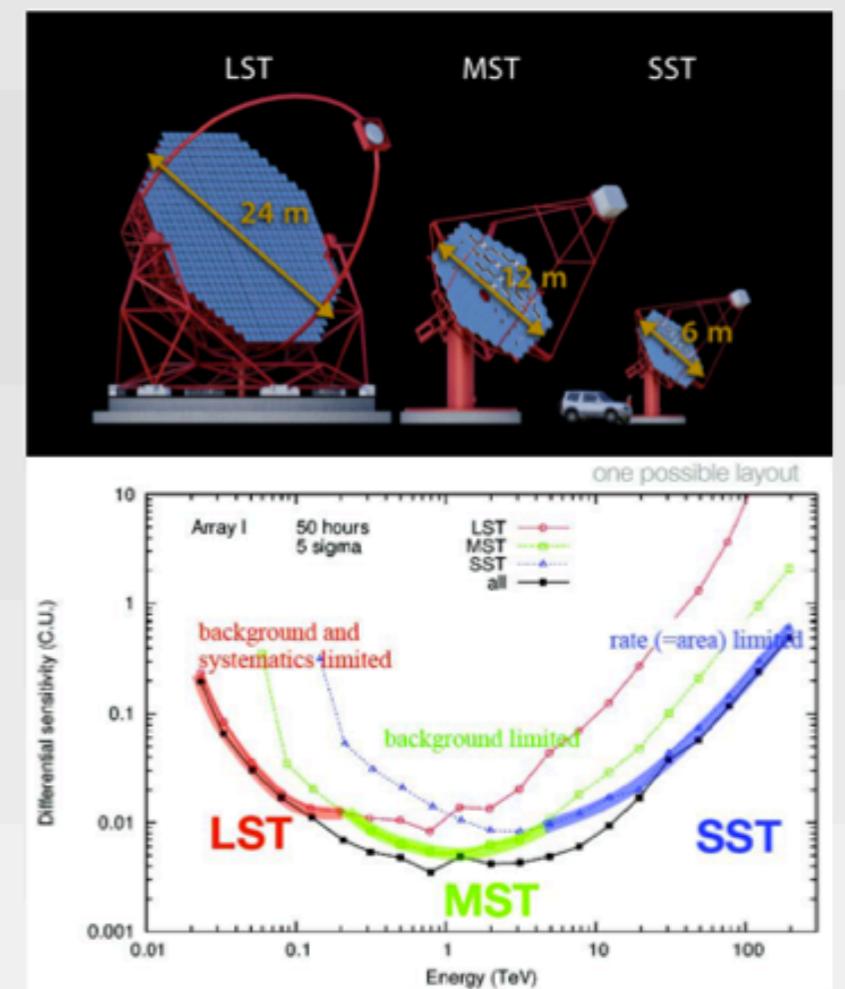
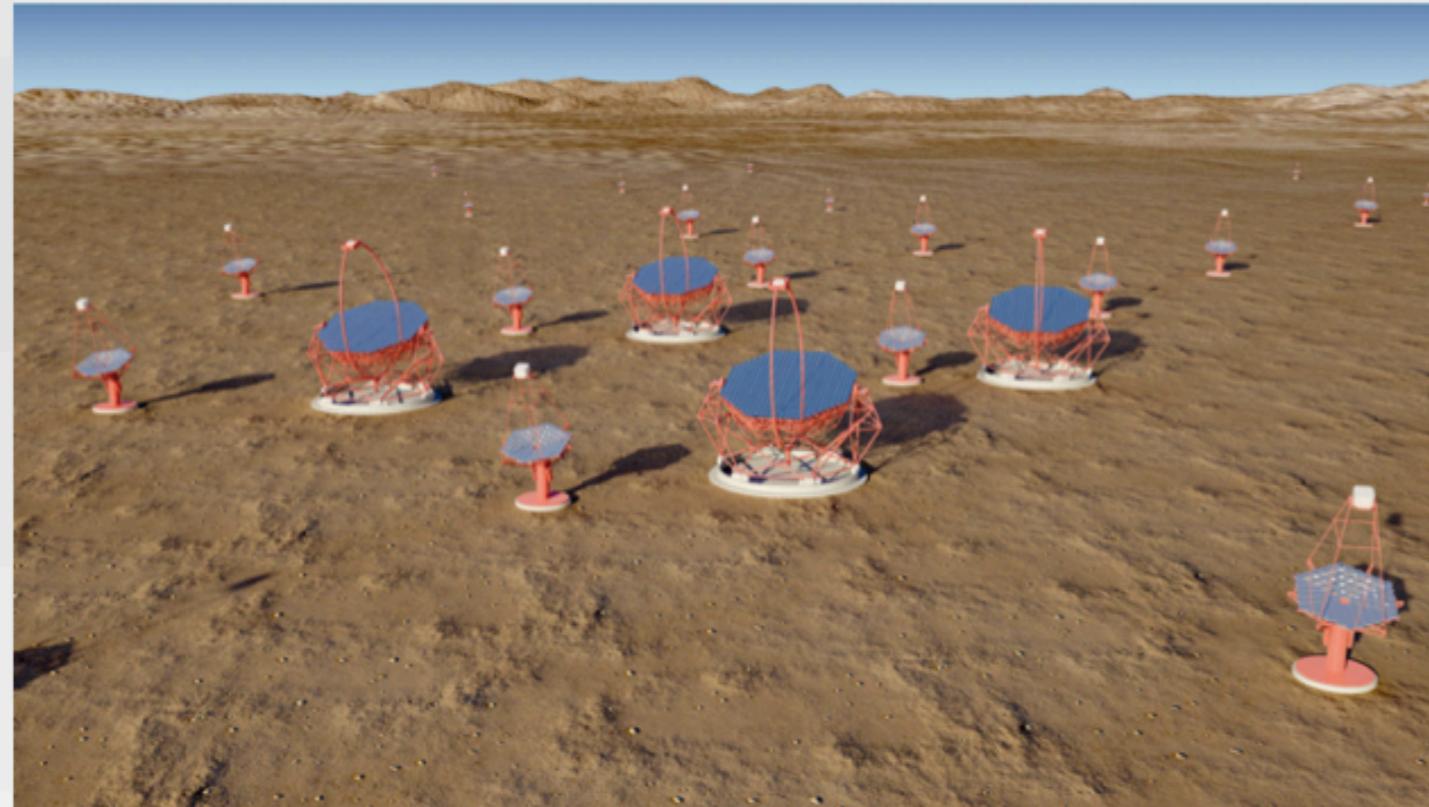
$\varnothing: 13m$

**Phase 1 : 4x Camera :1 ton, 960 PMTs
Begining of operation : 2004**

$\varnothing: 28m$

**Phase 2 : + 1 Camera :2 ton, >2000 PMTs
Begining of operation : 09/2012**

CTA - Cherenkov Telescope Array

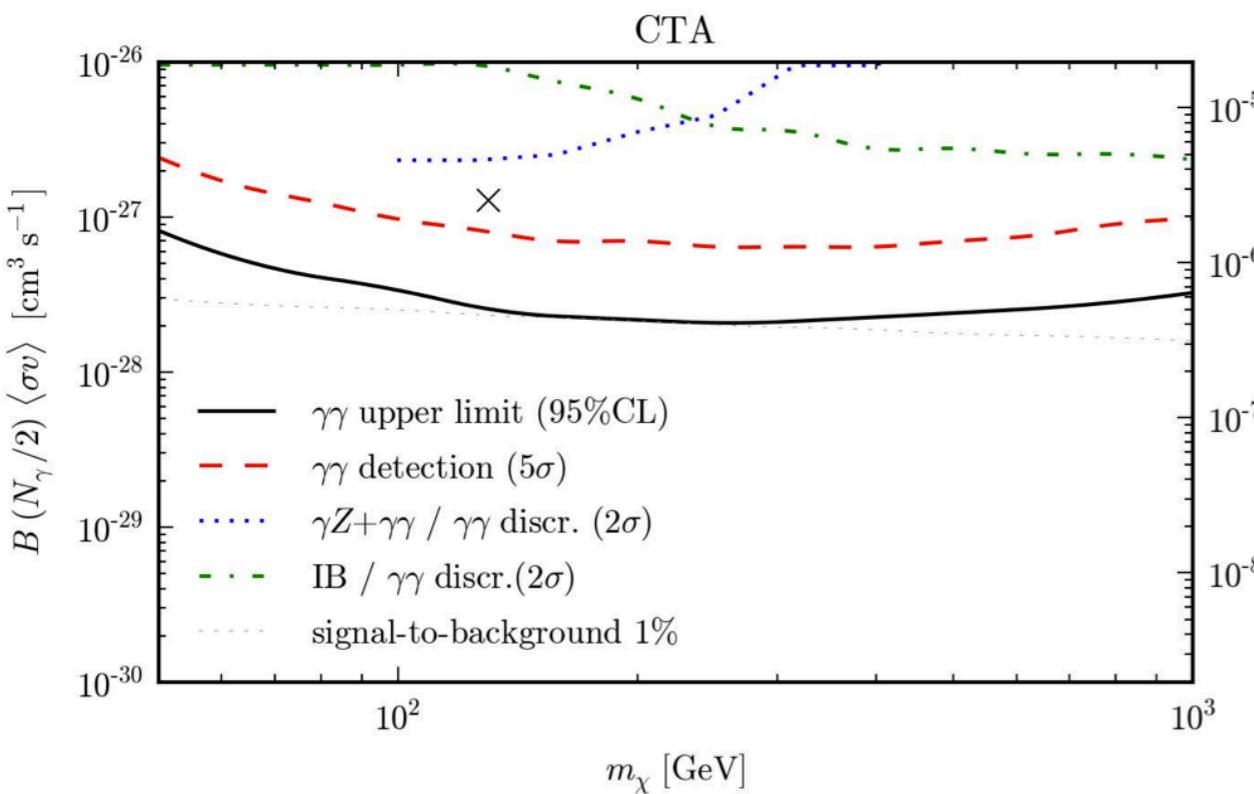
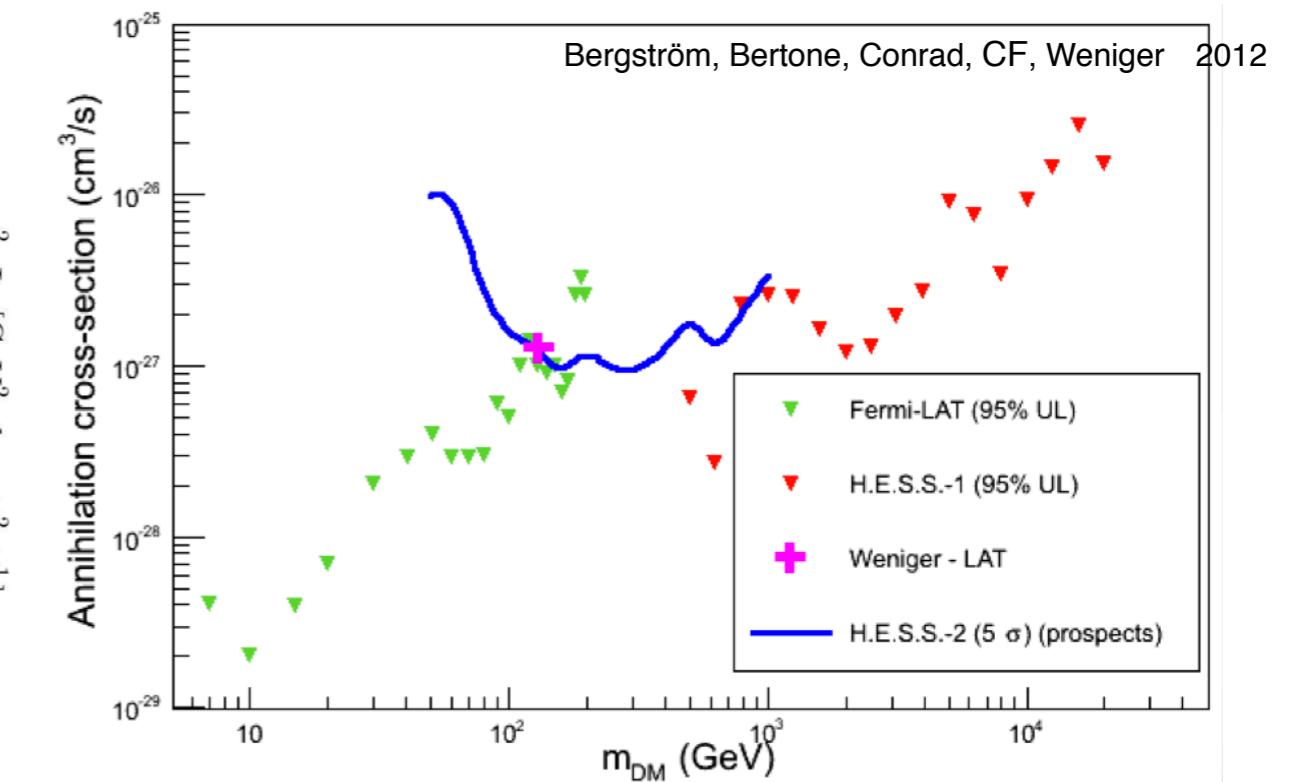
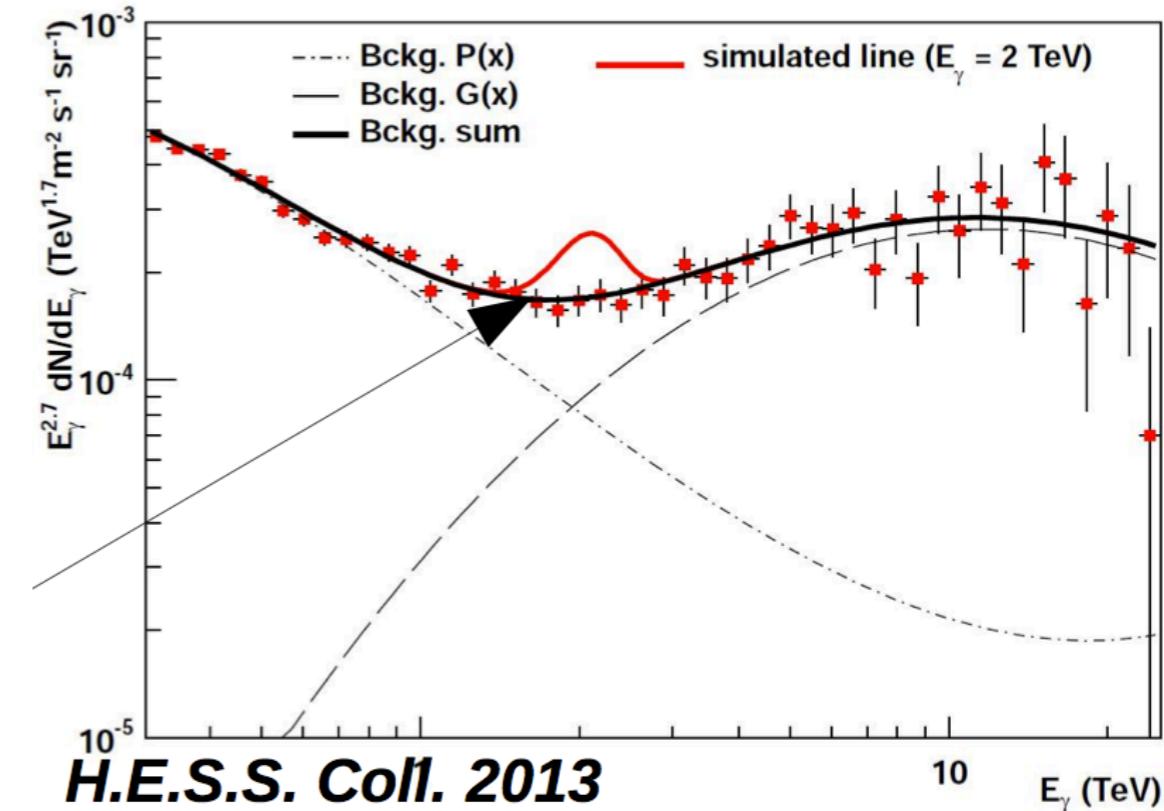


- The CTA observatory, will enlarge this window recently opened and allow to discovered ~10 times more sources
 - 27 countries
 - > 1000 scientists
 - 2 arrays
 - 3 types of telescopes
- Currently in the preparatory phase
- Construction phase will start in 2014
- >1000 sources expected
- ~ 1000h obs/y

Example analysis: Line searches

Christian Farnier

- Integration region similar to halo analysis
 - Data set :
 - 4-tel. events ($\Delta E/E$), 2004-2007 [112h] (E_{th})
 - No OFF subtraction
 - Bckg (« g-like » CRs) spectrum fitted
 - Profile likelihood search of a line-like signal on top of background
 - H.E.S.S. II prospects
- CTA expectations : Confirmation of Weniger (2012) line $>5\sigma$ in 5h [syst. uncertainties] & 1 vs 2 lines distinction reachable with additional time and refined analysis



Dark Matter searches with Radio and Gamma rays

Synchrotron emission and radio observations

Bounds on DM from present radio surveys

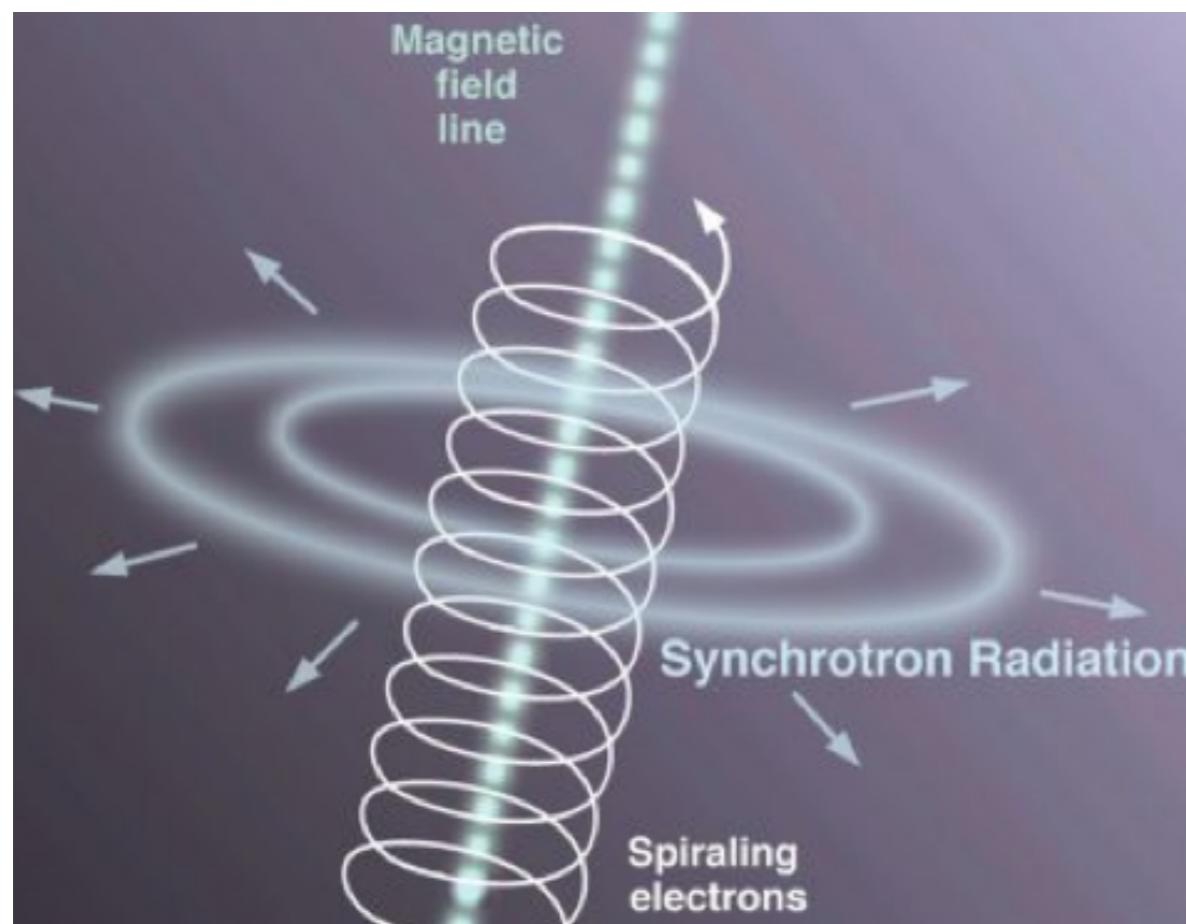
Extragalactic radio background and searches of extra-galactic DM radio sources

Based on Fornengo, Lineros, Regis, MT 2011, 2012, 2013 (in progress)

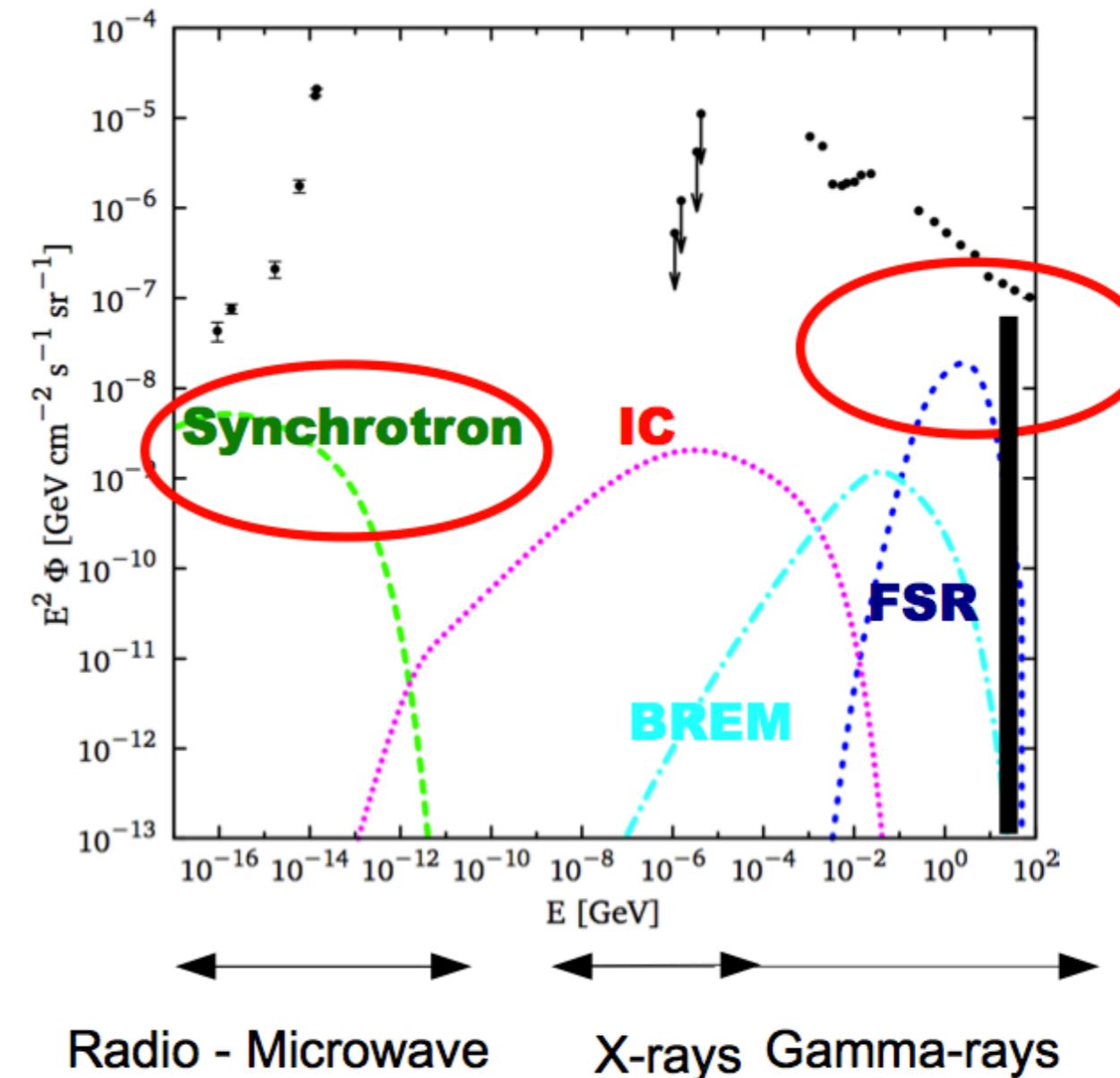
DM searches with gamma-ray lines

Status of the 130(5) GeV line Gamma-ray lines in DM models

Based on Jackson, Servant, Shaughnessy, Tait, MT 2010, 2013



Marco Taoso



Dark Matter searches with Radio and Gamma rays

Marco Taoso

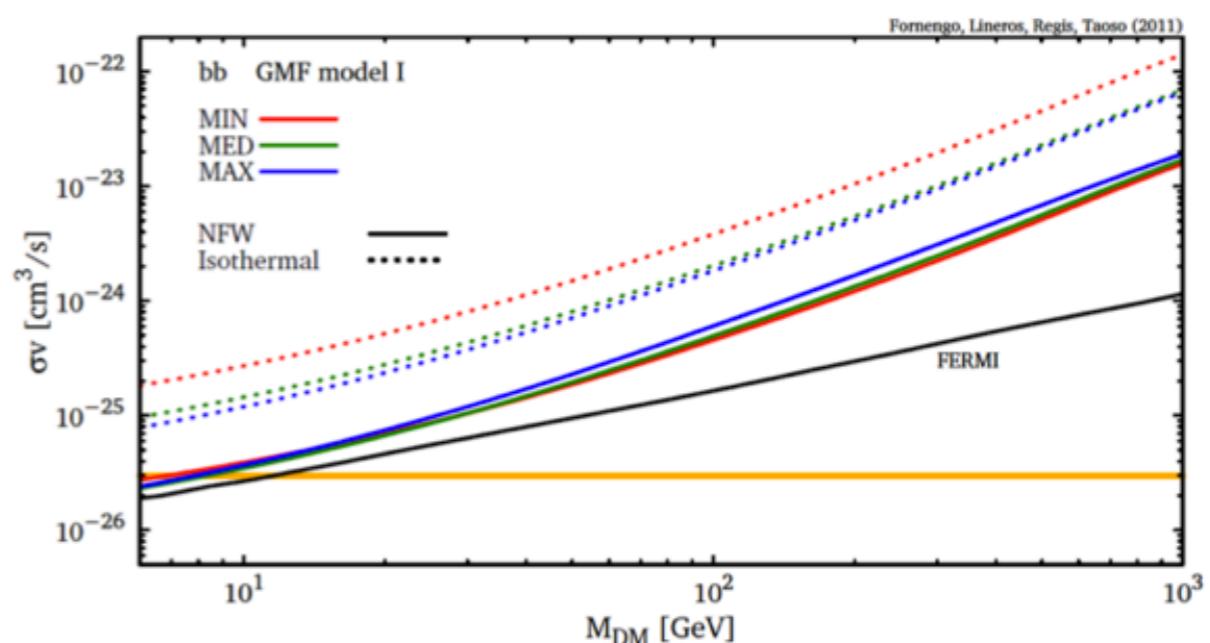
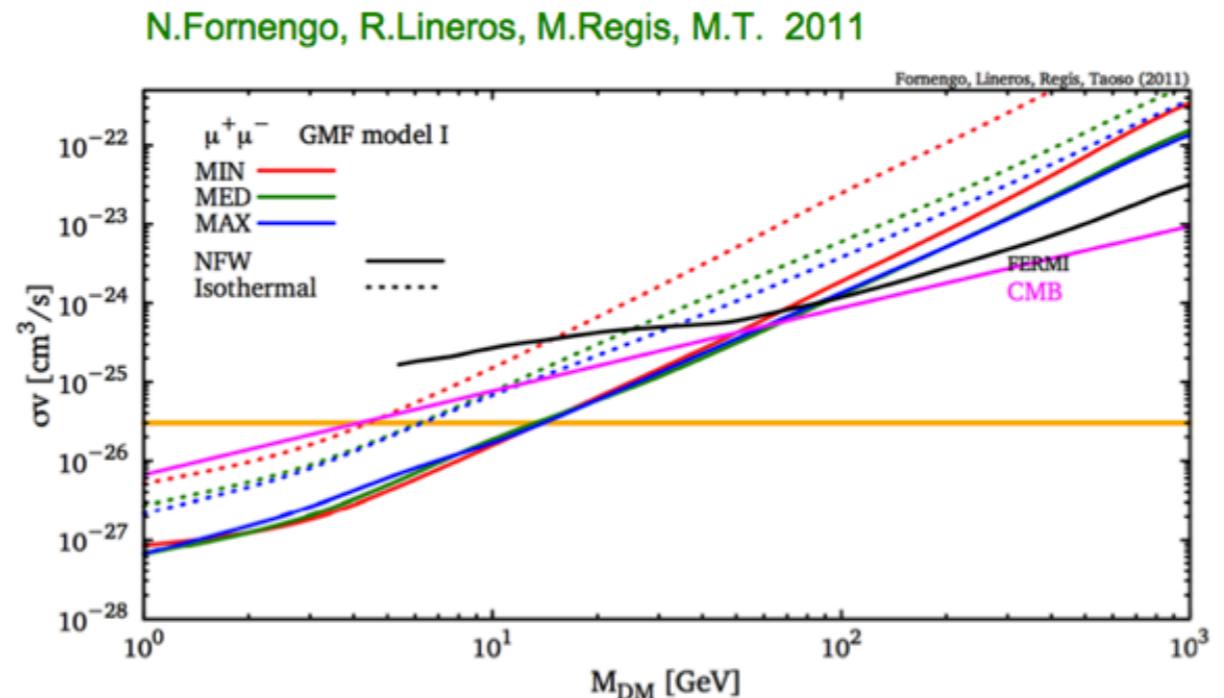
Example:

Constraints on DM

Bounds are better/worse than those from Fermi & CMB for leptonic/hadronic channels

Uncertainties:

- DM profile
- propagation parameters
- magnetic fields

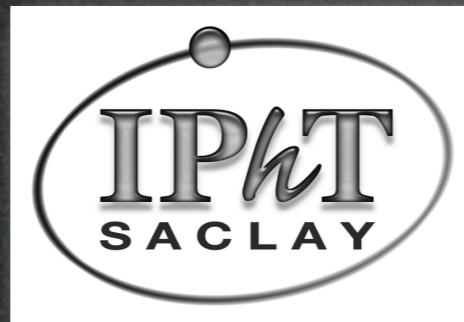


Thank you !

21 September 2013
‘WIN 2013’, Natal, Brazil

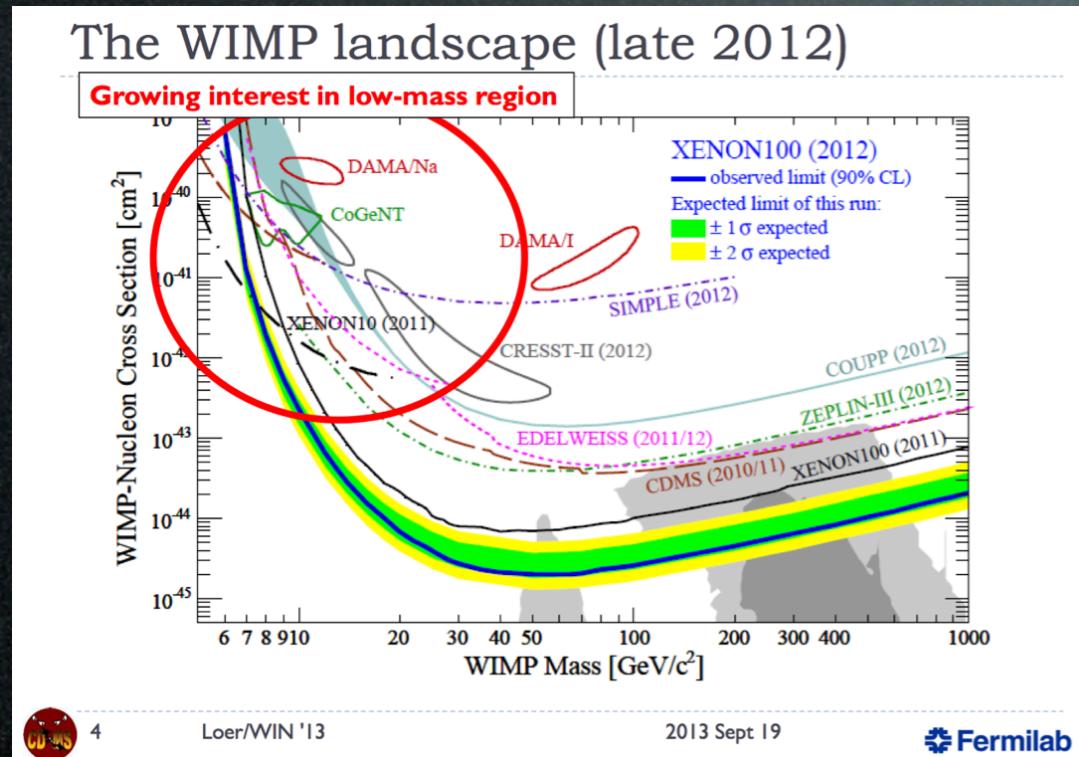
Dark Matter Summary: direct detection, neutrinos, charged cosmic rays, theory

Marco Cirelli
(CNRS IPhT Saclay)

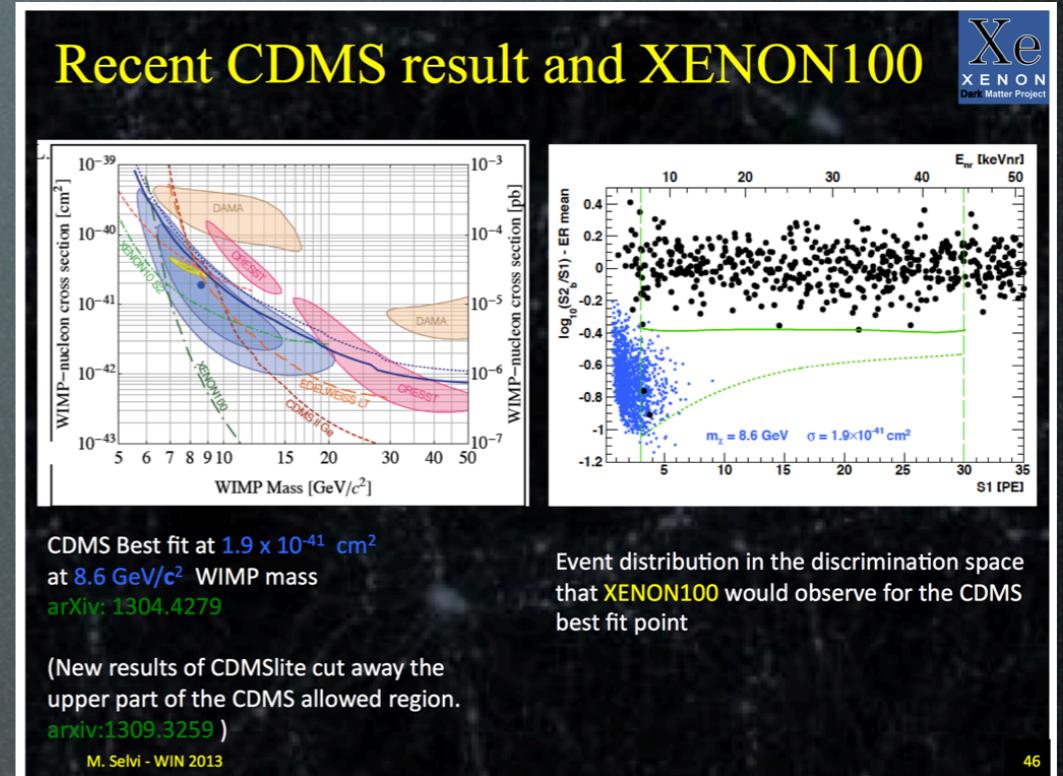


Direct Detection

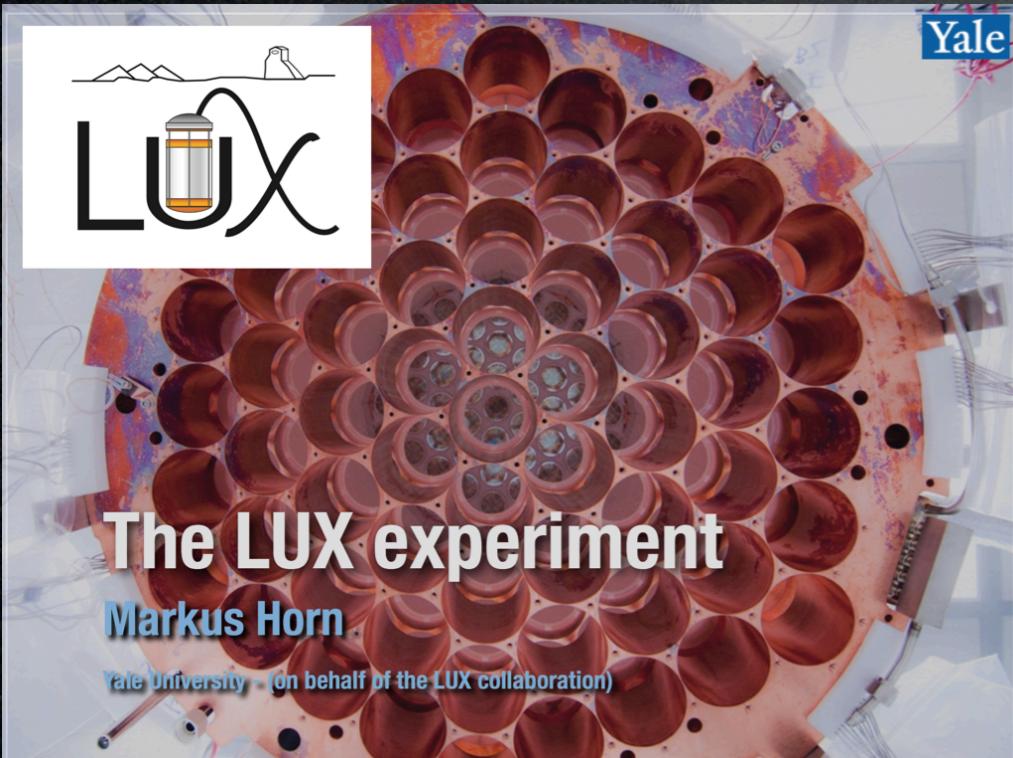
Ben Loer: ‘CDMS’



Marco Selvi: ‘Xenon’



Markus Horn: ‘LUX’

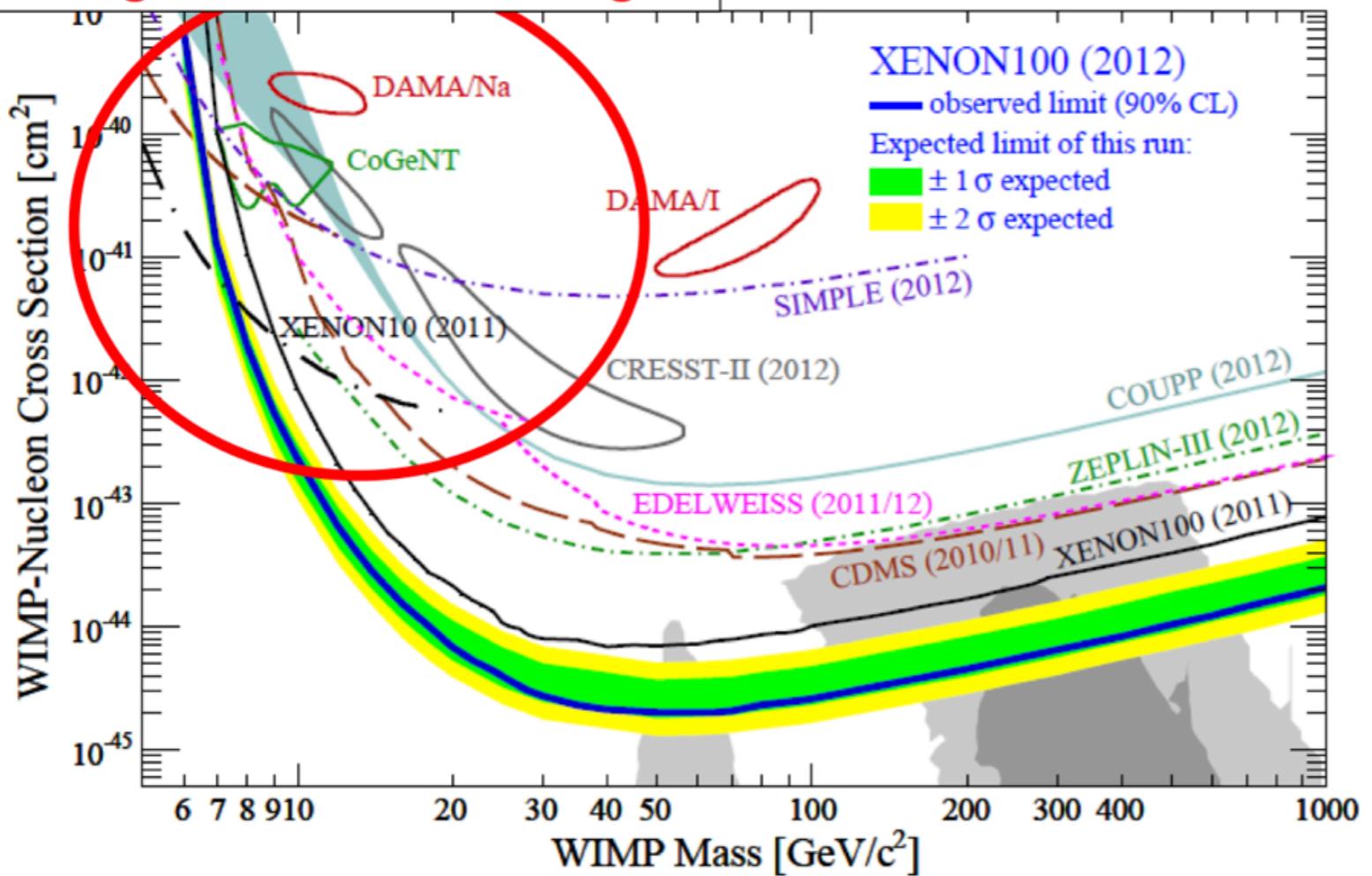


Direct Detection

Ben Loer: 'CDMS' + Marco Selvi: 'Xenon'

The WIMP landscape (late 2012)

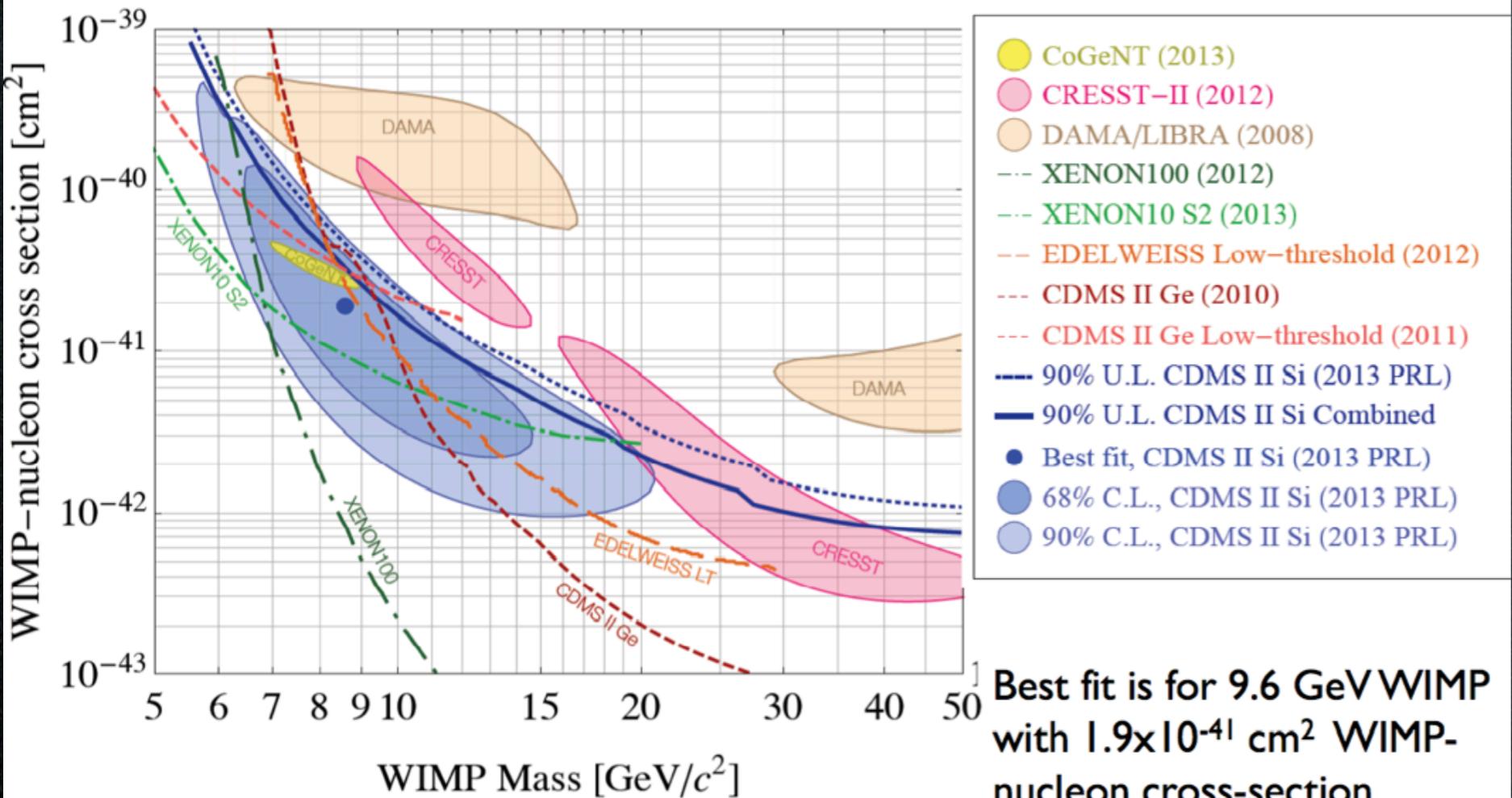
Growing interest in low-mass region



Direct Detection

Ben Loer: ‘CDMS’ + Marco Selvi: ‘Xenon’

CDMS-II Si Confidence intervals



14

Loer/WIN '13

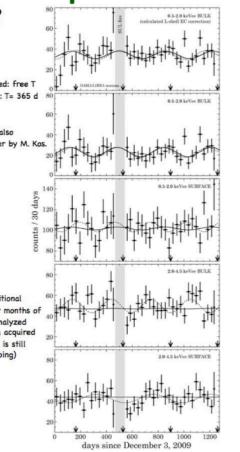
2013 Sept 19

Fermilab

Graciela Gelmini

CoGeNT new data at TAUP 2013 -Sept 9 not released yet
What is new?

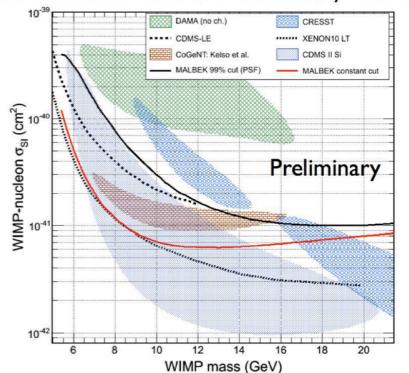
- Detector recovered from 3 mo post-fire outage w/o significant changes in performance. It has been continuously taking data ever since. All data are usable (compare to 10%-40% in CDMS low-energy analyses).
- Large exposure allows optimal separation of bulk and surface events down to 0.5 keVee threshold. Rise-time behavior as predicted by simulations and calibrations (PRD 88 (2013) 012002). Smooth variation of fit parameters with energy.
- Paper under review, preprint to appear soon. Data to be released in energy, time-stamp, and rise-time format. A straightforward analysis indicates a persistent annual modulation exclusively at low energy and for bulk events. Best-fit phase consistent with DAMA/LIBRA (small offset may be meaningful). Similar best-fit parameters to 15 mo dataset, but with much better bulk/surface separation (~90% SA for ~90% BR).
- Unoptimized frequentist analysis yields ~2.2σ preference over null hypothesis. This however does not take into account the possible relevance of the modulation amplitude found...
- Modulation amplitude is 4-7 times larger than that predicted by the SHM. Finding an absence of modulation would have severely constrained non-standard halo models as explanations for DAMA/LIBRA.



CoGeNT still sees modulation

MALBEK new data at TAUP 2013 -Sept 9
Demonstrator

90% exclusions from 221 day dataset



Malbek doesn't see anything at all

Direct Detection



14

N₃

Direct Detection



14 N³

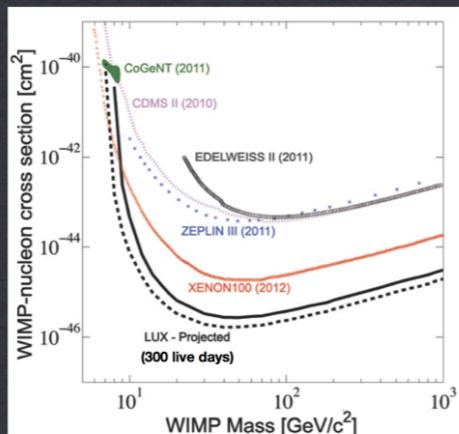
More (data)!

Direct Detection

Markus Horn: 'LUX'

Projections

- ▶ LUX has been operating underground since spring 2013
- ▶ stable detector operation achieved
- ▶ expect first WIMP search result in fall 2013



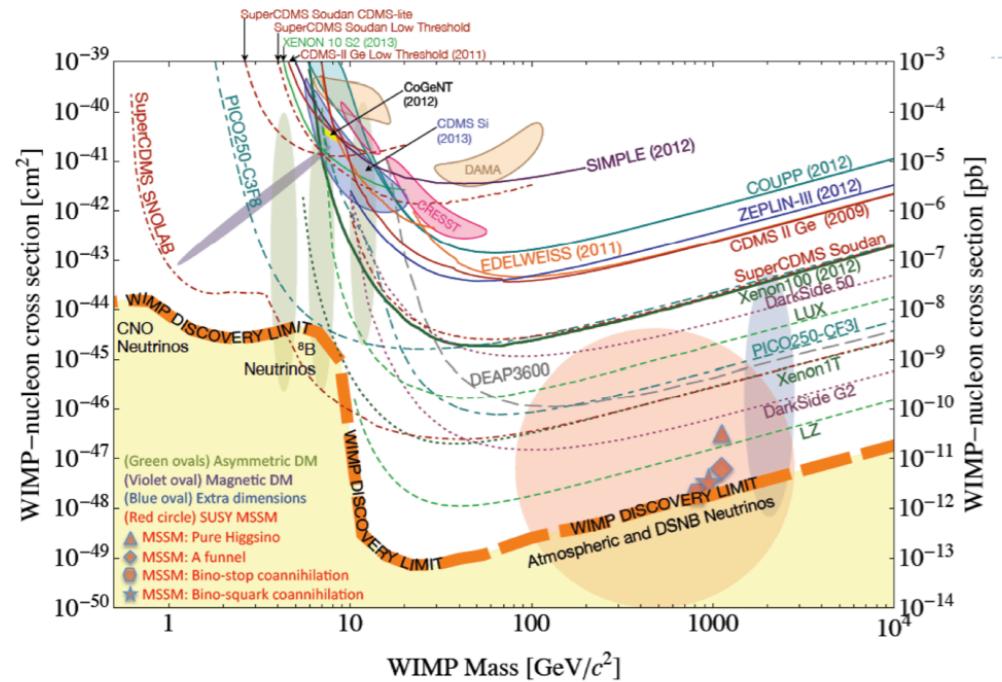
YALE UNIVERSITY

MARKUS HORN - THE LUX DETECTOR

Sep 19, 2013

Ben Loer: 'CDMS'

SNOMASS projection: next decade



CDMS

27

Loer/WIN '13

2013 Sept 19

Fermilab

Ben Loer: 'CDMS'

Coming up next: SuperCDMS SNOLAB

Move to North America's deepest underground lab for >100X reduction in cosmogenic neutron backgrounds; deploy 200 kg of advanced Ge iZIPs
Now seriously considering including silicon iZIPs



CDMS

24

Loer/WIN '13

2013 Sept 19

Fermilab

+ LZ, Edelweiss, PandaX, Xmass, DarkSide, Deap/Clean, MAX, Drift, Anais...

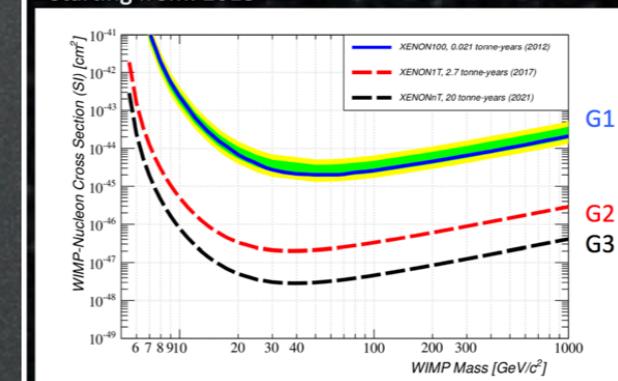
Marco Selvi: 'Xenon'

XENONnT

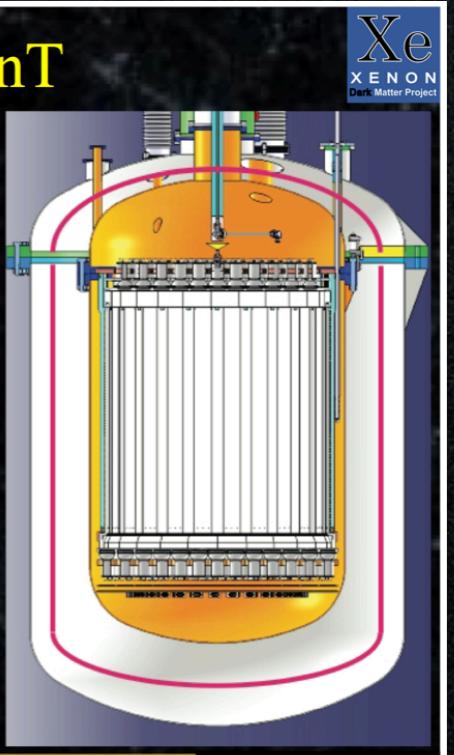
XENONnT is XENON1T setup but with a larger TPC and inner cryostat, all the other systems (from the outer cryostat to outside) remain the same.

Nb of PMTs: almost doubled

Aimed exposure: 20 ton-years
Starting from: 2018



M. Selvi - WIN 2013



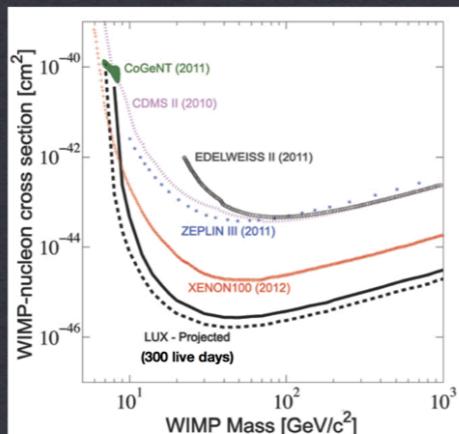
42

Direct Detection

Markus Horn: 'LUX'

Projections

- LUX has been operating underground since spring 2013
- stable detector performance achieved
- expect first WIMP search result in fall 2013



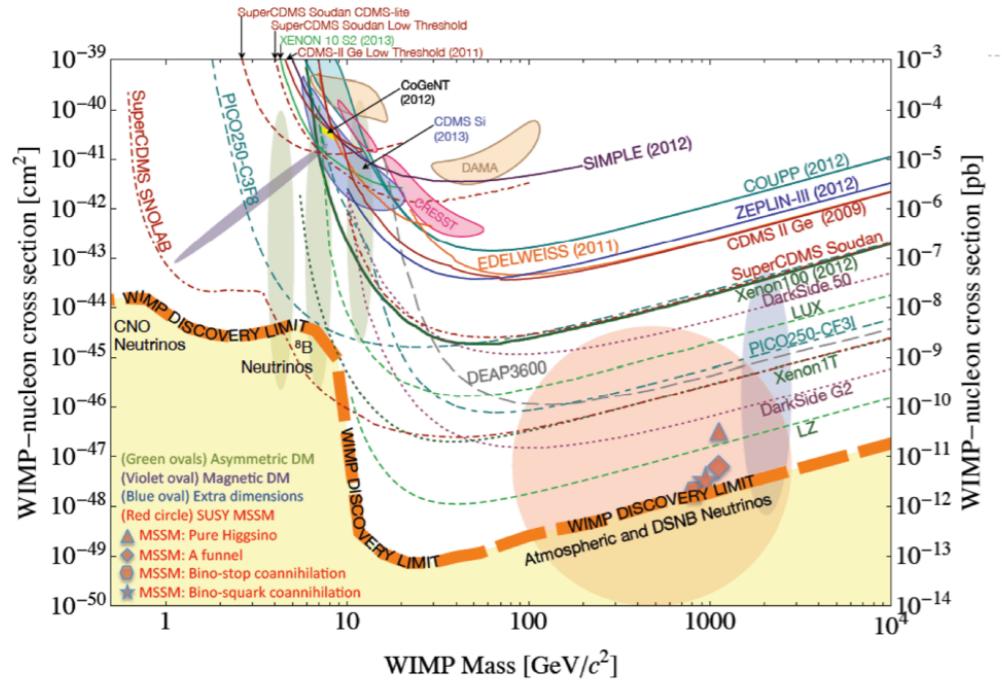
YALE UNIVERSITY

MARKUS HORN - THE LUX DETECTOR

Sep 19, 2013

Ben Loer: 'CDMS'

SNOMASS projection: next decade



CDMS

27

Loer/WIN '13

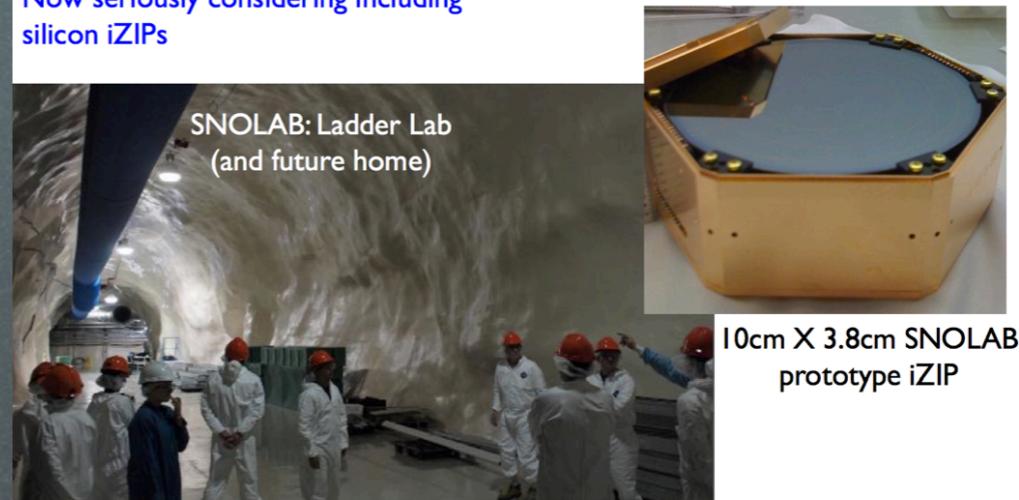
2013 Sept 19

Fermilab

Ben Loer: 'CDMS'

Coming up next: SuperCDMS SNOLAB

Move to North America's deepest underground lab for >100X reduction in cosmogenic neutron backgrounds; deploy 200 kg of advanced Ge iZIPs
Now seriously considering including silicon iZIPs



CDMS

24

Loer/WIN '13

2013 Sept 19

Fermilab

+ LZ, Edelweiss, PandaX, Xmass, DarkSide, Deap/Clean, MAX, Drift, Anais...

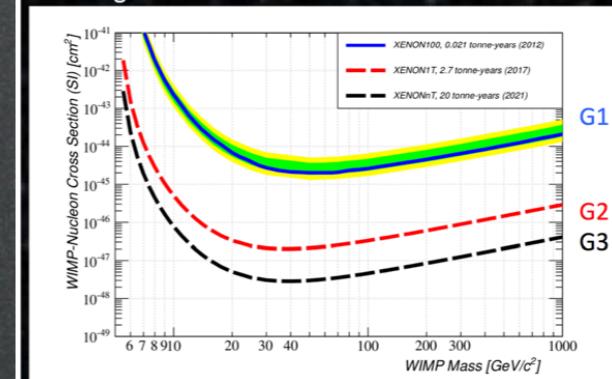
Marco Selvi: 'Xenon'

XENONnT

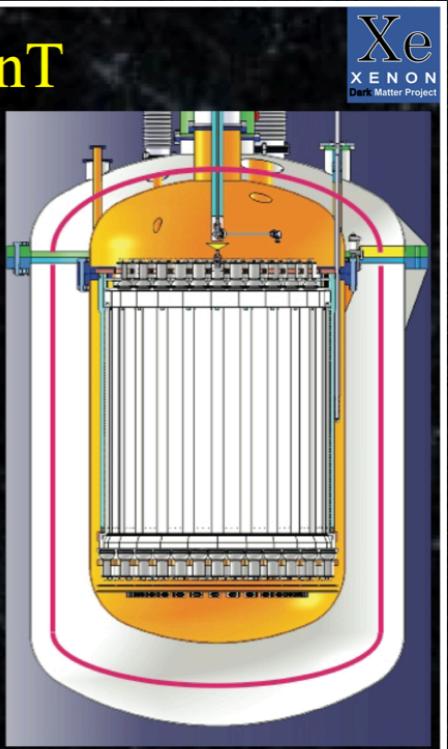
XENONnT is XENON1T setup but with a larger TPC and inner cryostat, all the other systems (from the outer cryostat to outside) remain the same.

Nb of PMTs: almost doubled

Aimed exposure: 20 ton-years
Starting from: 2018



M. Selvi - WIN 2013

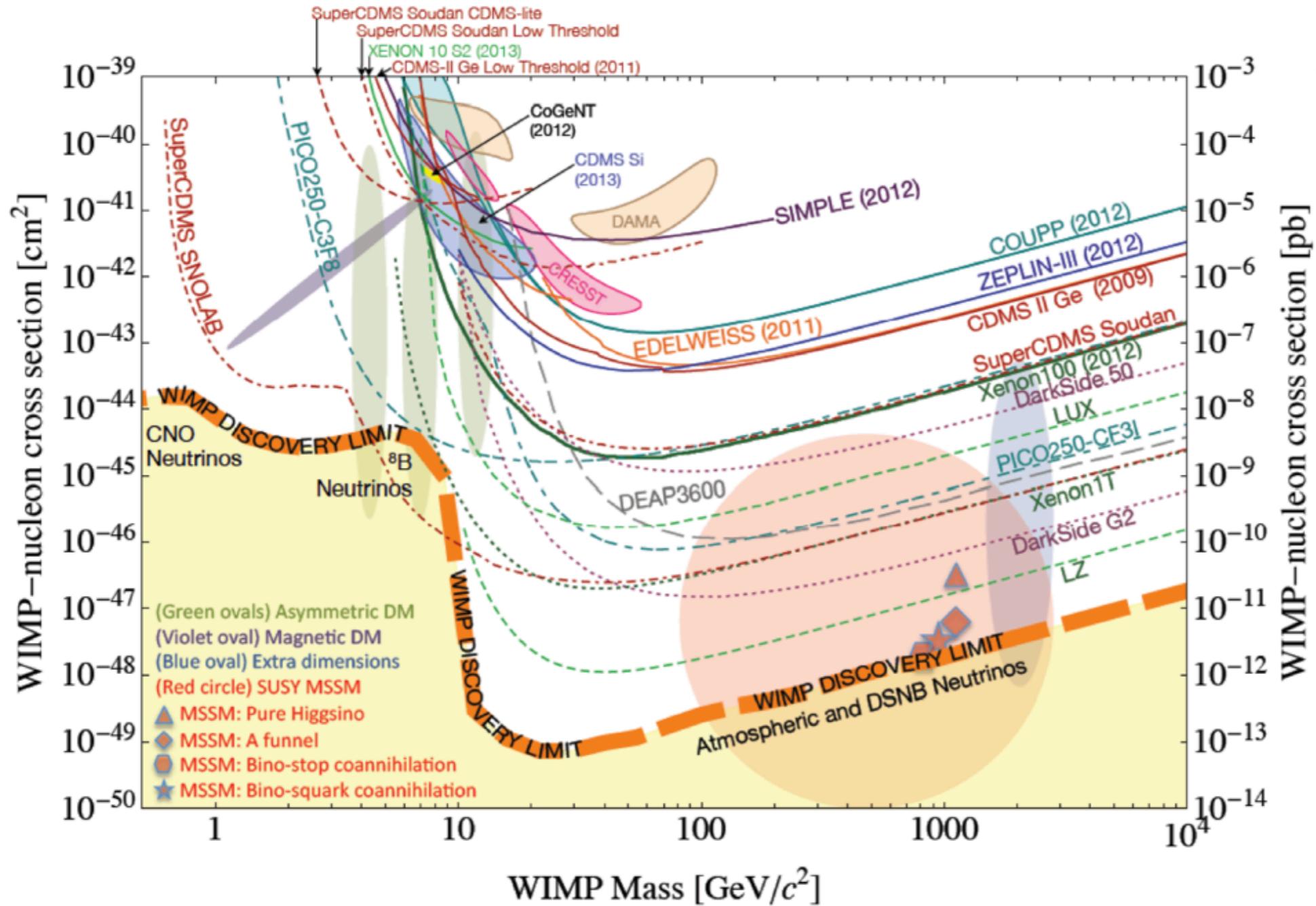


42

Direct Detection

Ben Loer: ‘CDMS’

SNOMASS projection: next decade



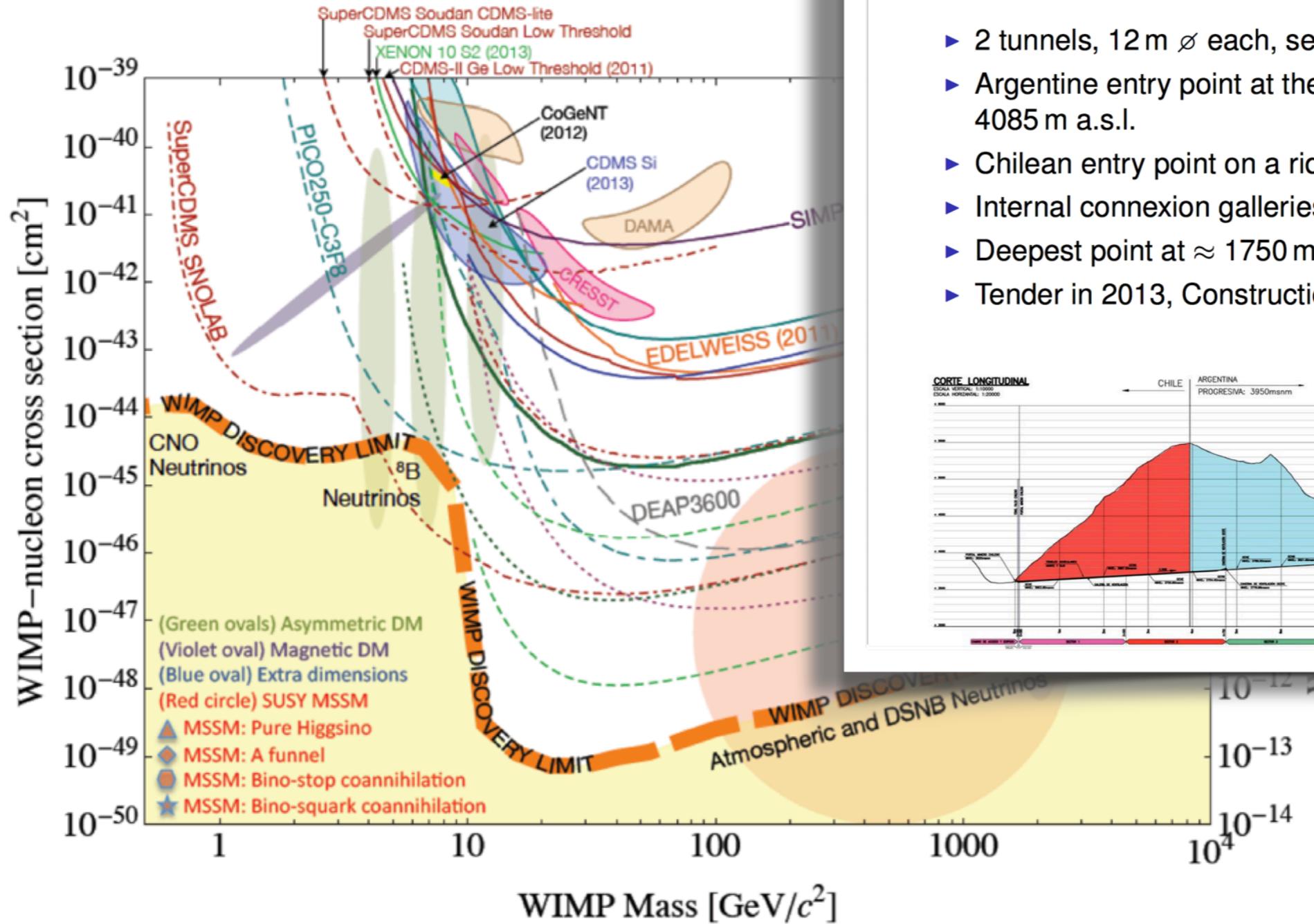
- huge effort
- there's a floor
- we'll swipe it all (almost)
- theorists know how to dig

Direct Detection

Ben Loer: 'CDMS'

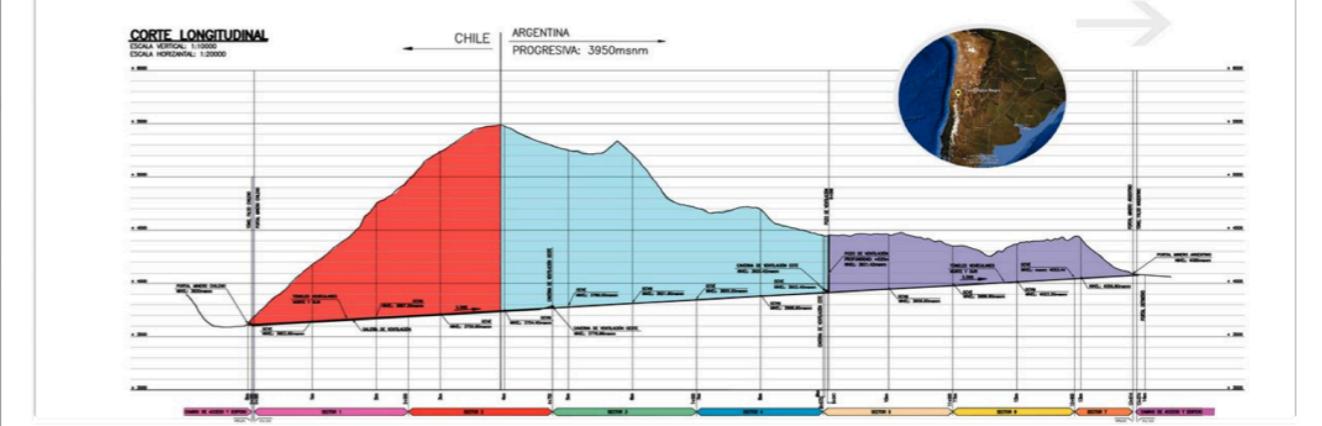
Osvaldo Civitarese + Hiroshi Nunokawa: 'ANDES'

SNOMASS projection: next generation



Tunnel proposed

- ▶ 2 tunnels, 12 m \varnothing each, separated by 60 m, \approx 14 km long
- ▶ Argentine entry point at the Quebrada San Lorenzo, 4085 m a.s.l.
- ▶ Chilean entry point on a ridge, at \approx 3600 m a.s.l.
- ▶ Internal connexion galleries every 500 m
- ▶ Deepest point at \approx 1750 m depth
- ▶ Tender in 2013, Construction 2014-2020



ANDES laboratory

- huge effort
- there's a floor
- we'll swipe it all (almost)
- theorists know how to dig



Indirect Detection

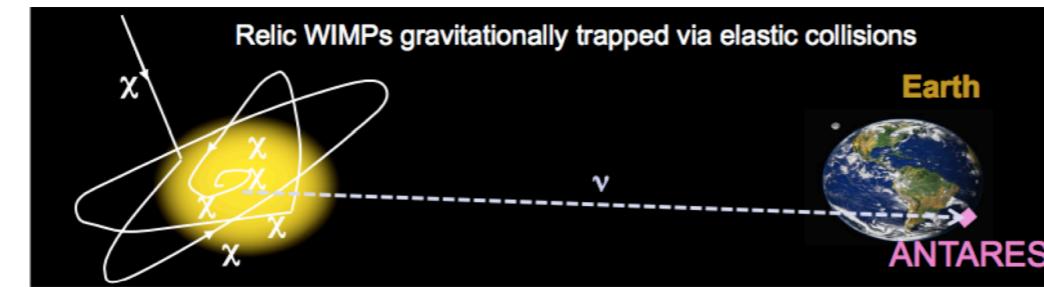
Neutrinos:

Alexis Dumas: ‘Antares’



Dark Matter

in the Sun



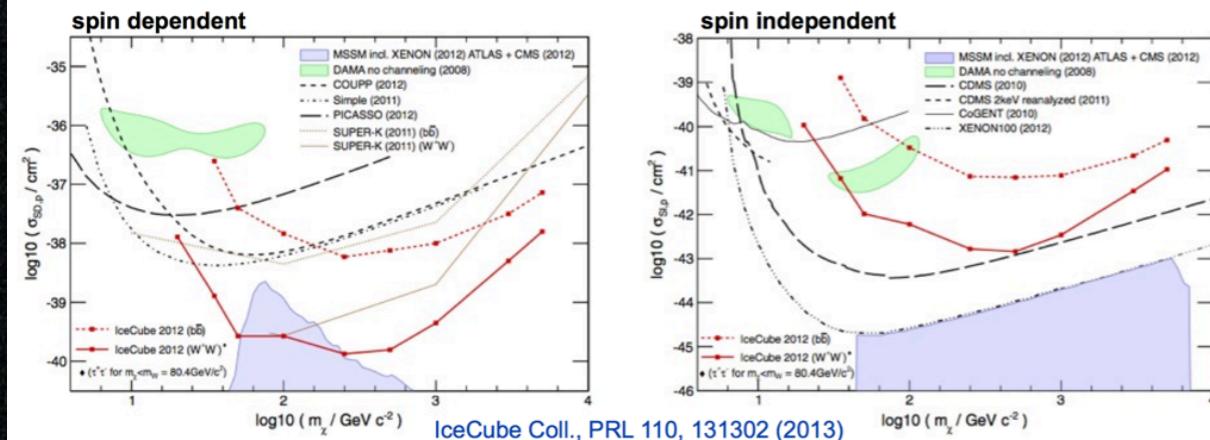
Clean signal

- no γ -rays contamination
- solar neutrinos < GeV
- astrophysical neutrinos > TeV

Alexander Knappes: ‘ICECUBE’

Search for Dark Matter accumulation in the Sun

- WIMPs (χ^0) captured by elastic scattering off nuclei in Sun
- Accumulation in center → annihilation to neutrinos
(R parity conservation assumed)
- After some time: equilibrium between capture and annihilation
→ annihilation rate depends on WIMP scattering cross section
- Sun mainly protons → IceCube mostly sensitive to spin-dependent cross section



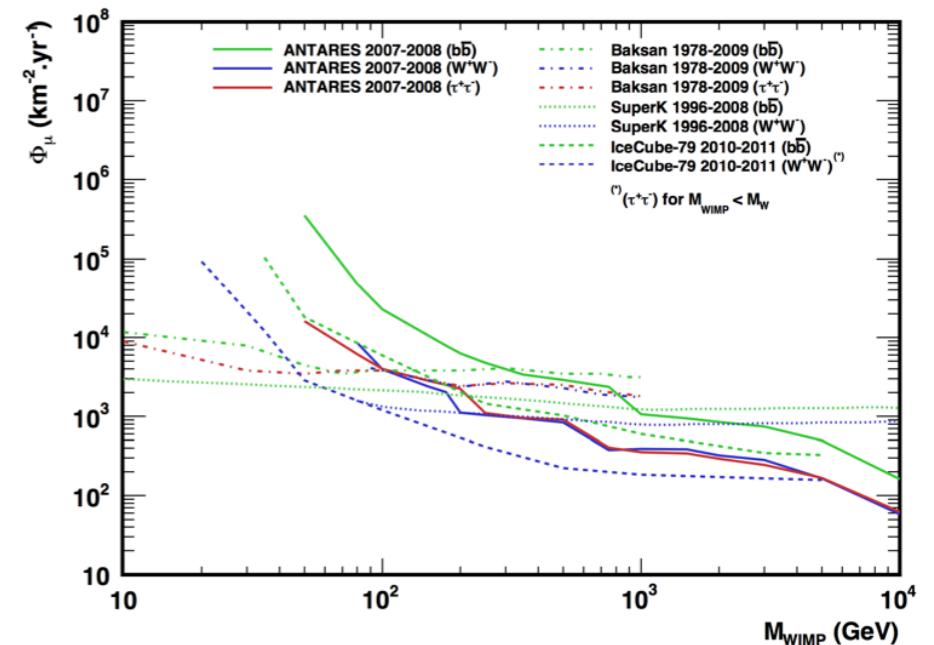
Alexis Dumas: ‘Antares’



Dark Matter

in the Sun

[arXiv:1302.6516]

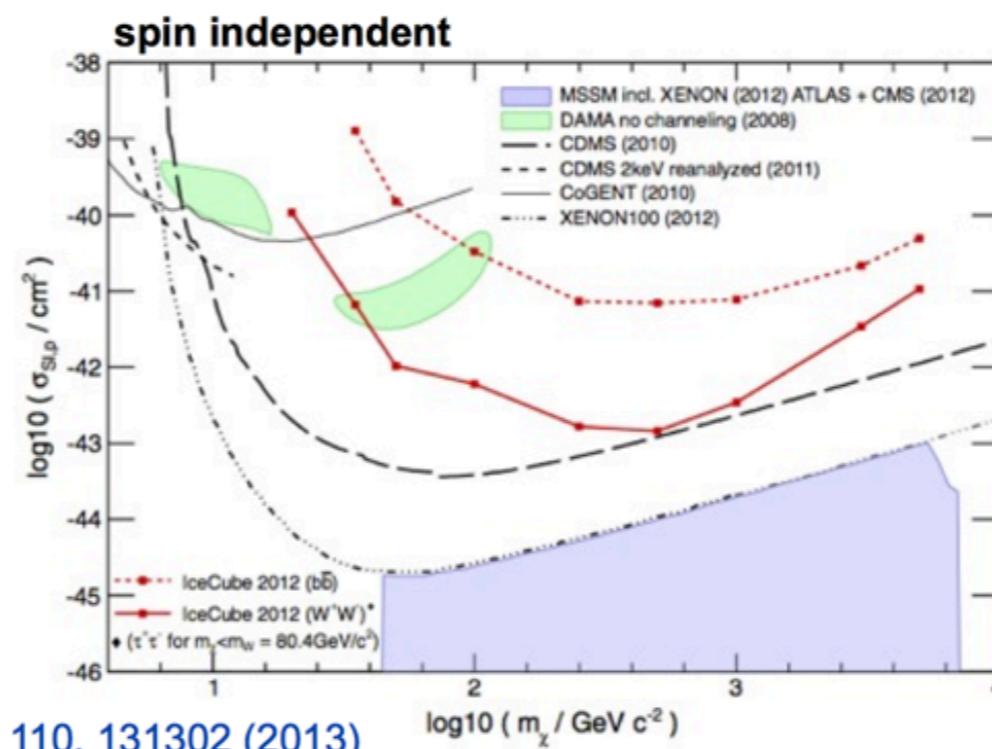
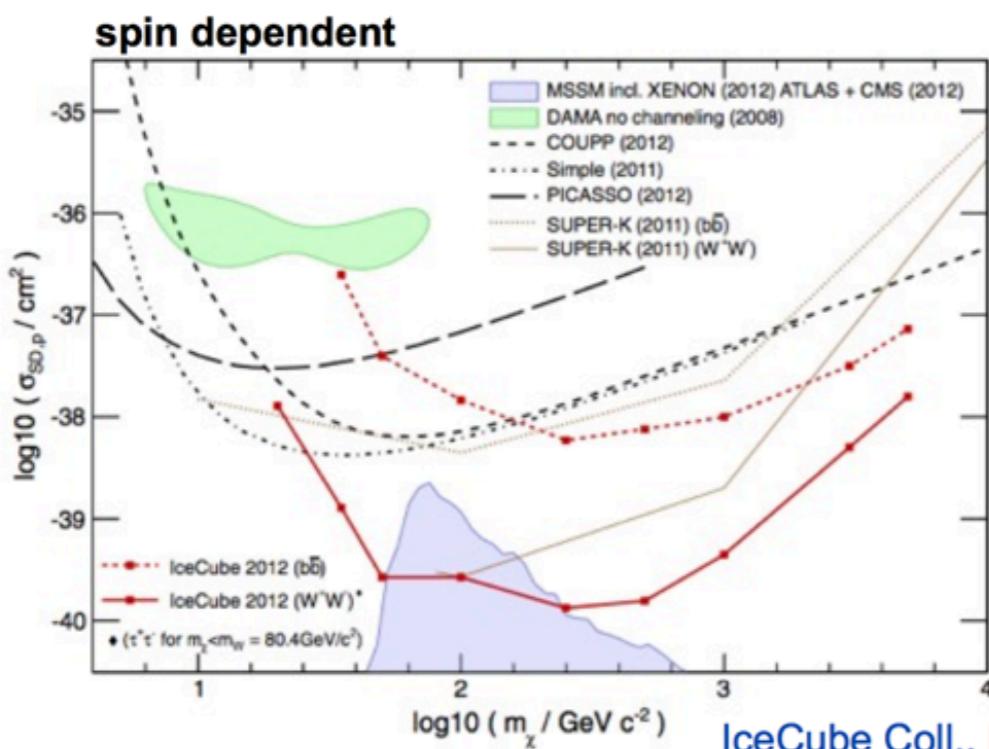


Indirect Detection

Alexander Knappes: 'ICECUBE'

Search for Dark Matter accumulation in the Sun

- WIMPs (χ^0) captured by elastic scattering off nuclei in Sun
- Accumulation in center → annihilation to neutrinos
(R parity conservation assumed)
- After some time: equilibrium between capture and annihilation
→ annihilation rate depends on WIMP scattering cross section
- Sun mainly protons → IceCube mostly sensitive to spin-dependent cross section



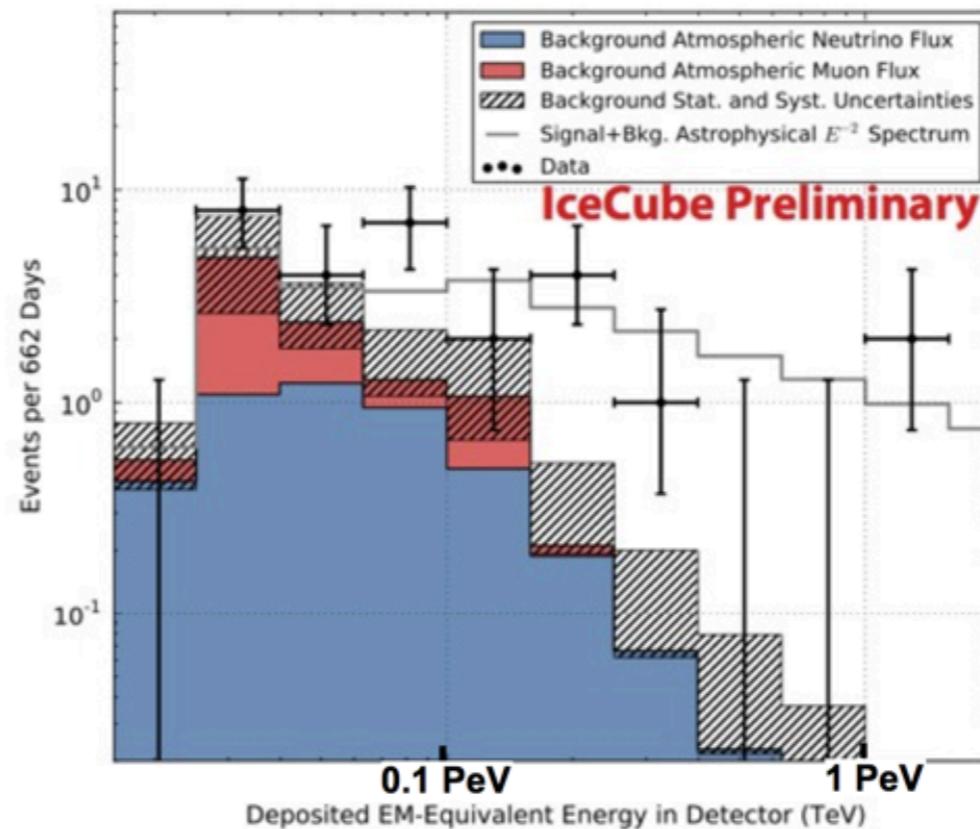
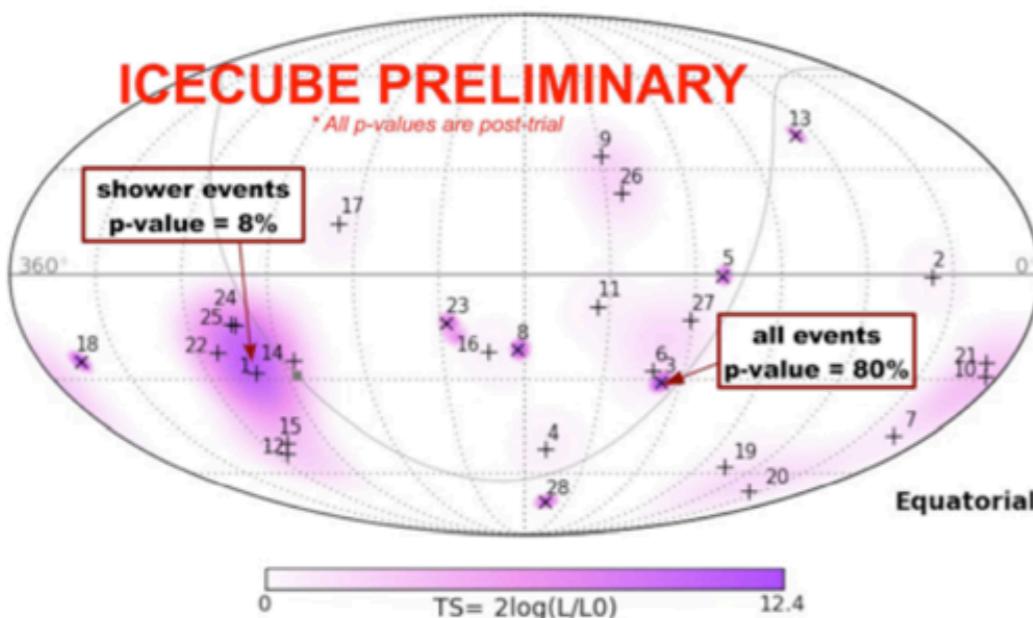
+ GC
+ halo
+ dwarfs

Indirect Detection

Alexander Knappes: 'ICECUBE'

Energy and zenith distribution of events

- ▶ Harder than expected from atmospheric background
- ▶ Excess compatible with isotropic flux (1 : 1 : 1)
(per flavor $E^2 \Phi_v = 1.2 \times 10^{-8} \text{ GeV cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1}$)
- ▶ Potential cutoff at $1.6^{+1.5}_{-0.4} \text{ PeV}$
(otherwise 3–6 more events at 2–10 PeV)
- ▶ No clustering of events or significant correlation with Galactic plane

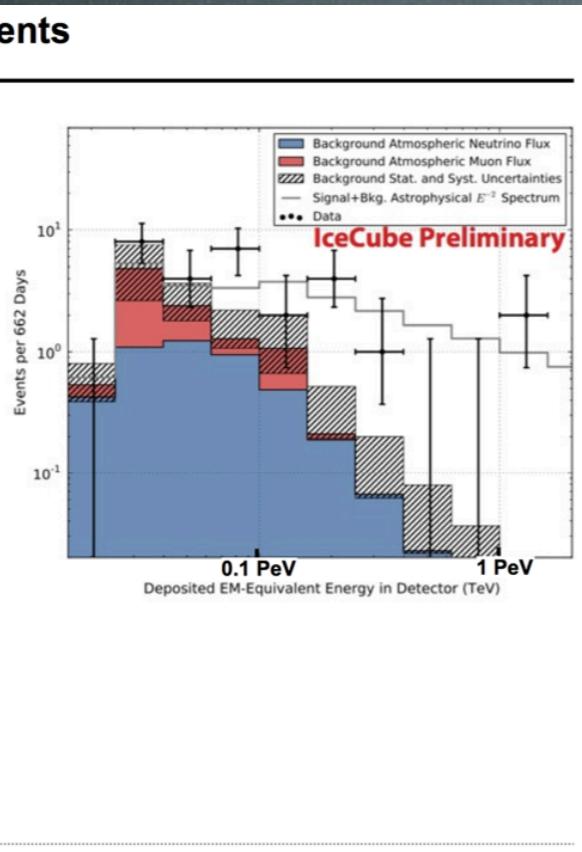
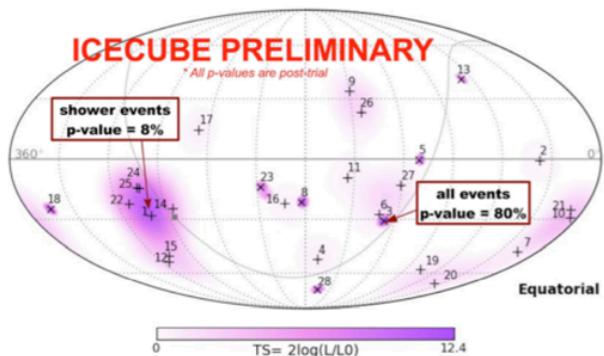


Indirect Detection

Alexander Knappes: ‘ICECUBE’

Energy and zenith distribution of events

- ▶ Harder than expected from atmospheric background
- ▶ Excess compatible with isotropic flux ($1 : 1 : 1$) (per flavor $E^2 \Phi_\nu = 1.2 \times 10^{-8} \text{ GeV cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1}$)
- ▶ Potential cutoff at $1.6^{+1.5}_{-0.4} \text{ PeV}$ (otherwise 3–6 more events at 2–10 PeV)
- ▶ No clustering of events or significant correlation with Galactic plane

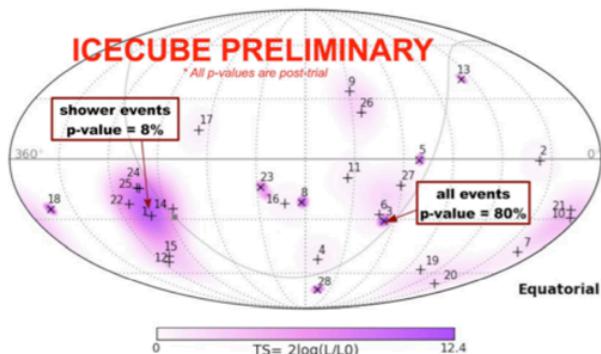


Indirect Detection

Alexander Knappes: ‘ICECUBE’

Energy and zenith distribution of events

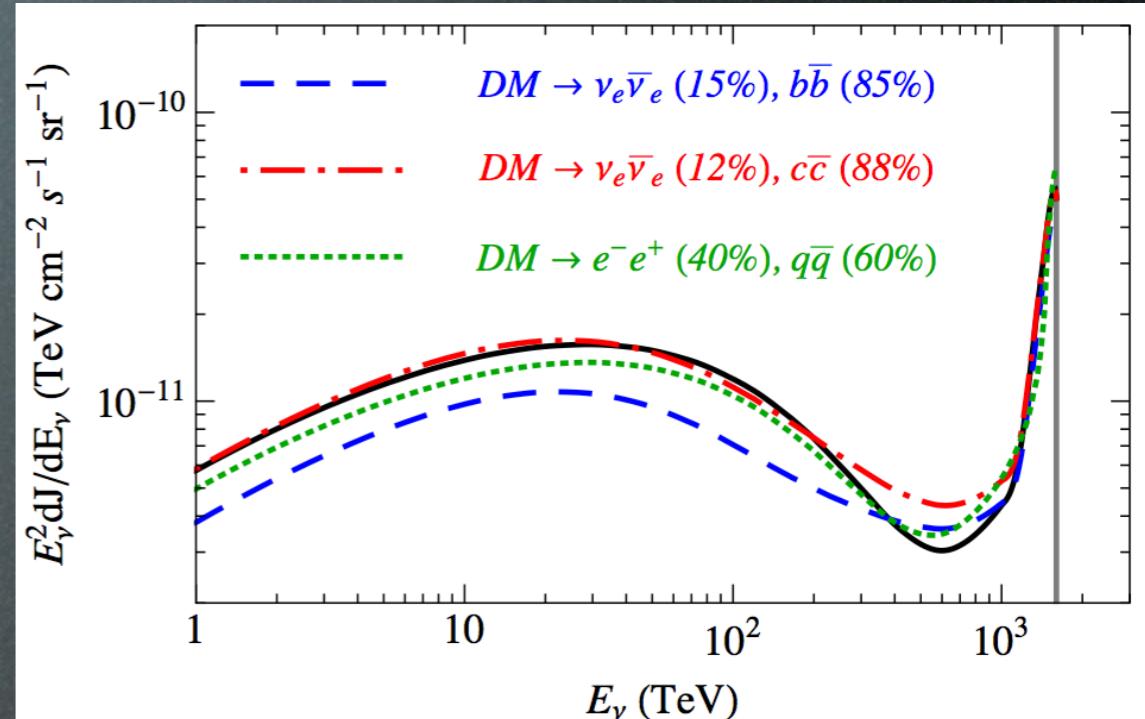
- ▶ Harder than expected from atmospheric background
- ▶ Excess compatible with isotropic flux ($1 : 1 : 1$) (per flavor $E^2 \Phi_\nu = 1.2 \times 10^{-8} \text{ GeV cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1}$)
- ▶ Potential cutoff at $1.6^{+1.5}_{-0.4} \text{ PeV}$ (otherwise 3–6 more events at 2–10 PeV)
- ▶ No clustering of events or significant correlation with Galactic plane



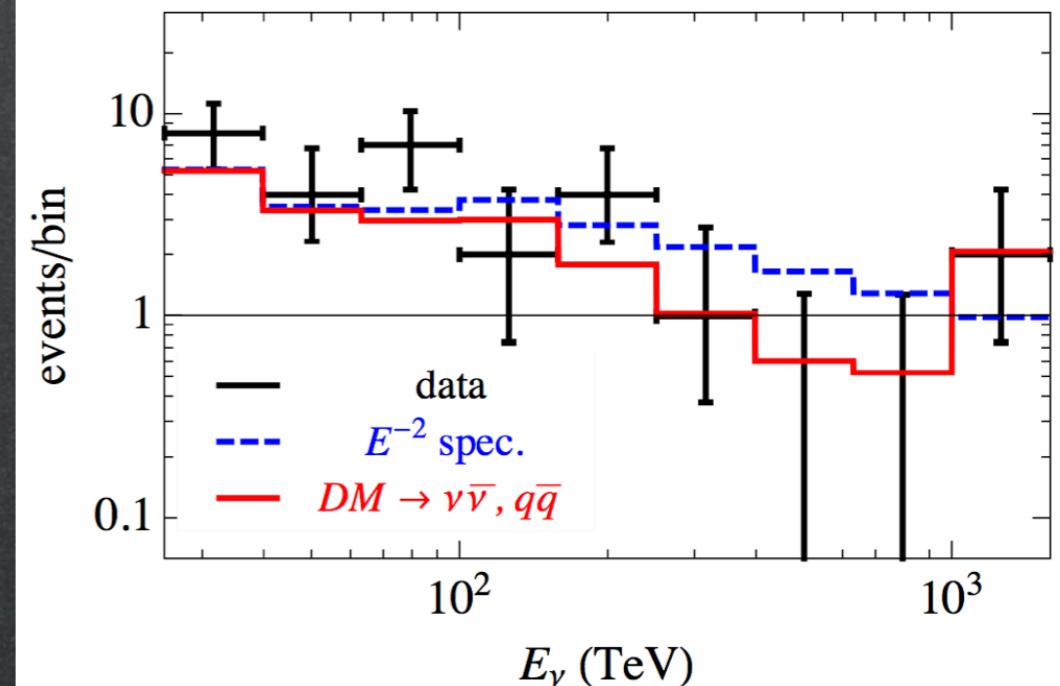
Alexander Kappes | WIN 2013, Natal | 17.09.2013 | 10



Arman Esmaili: ‘PeV decaying DM & ICECUBE’



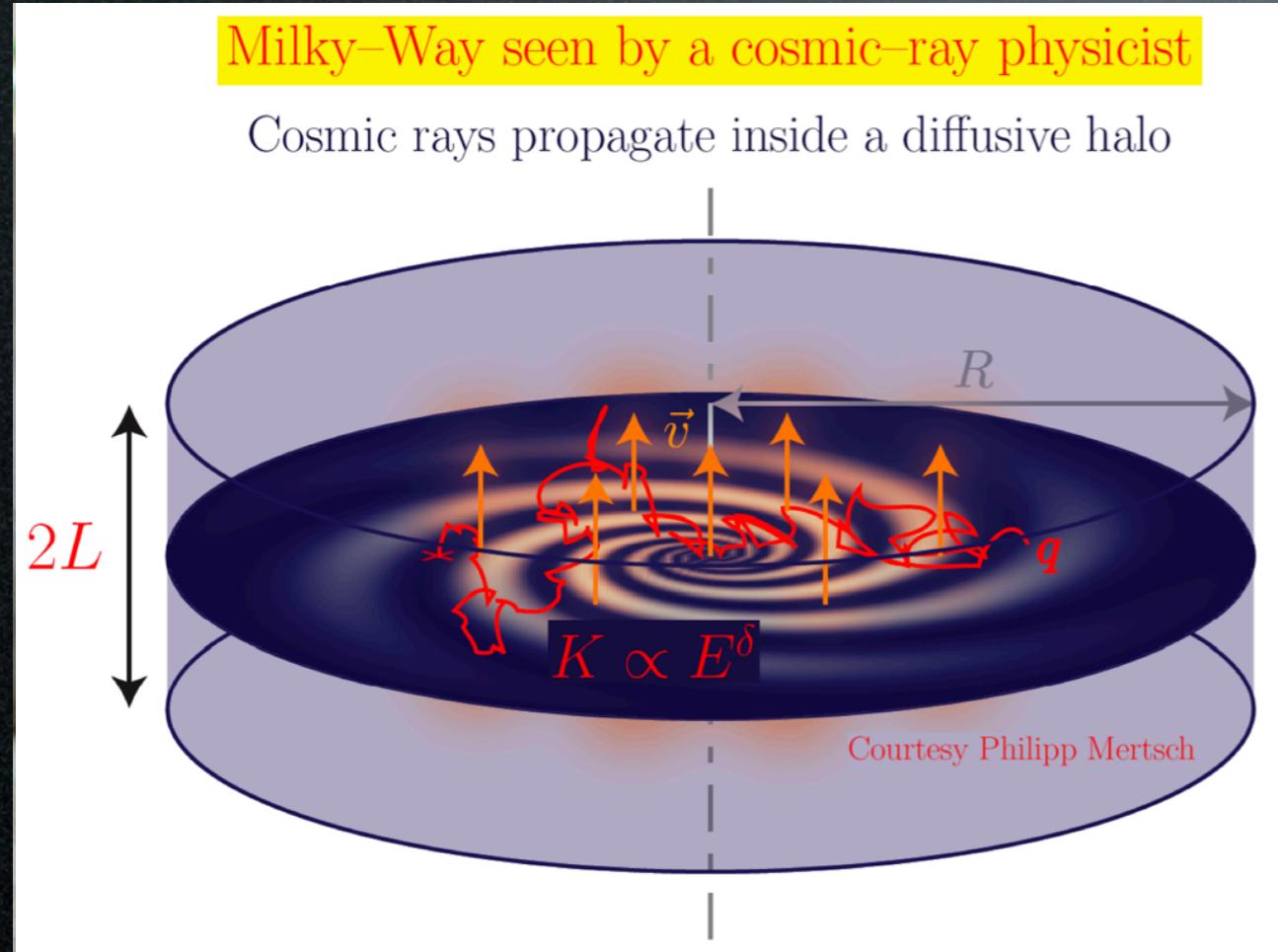
$$b_H = 0.12 \text{ and } \tau_{DM} = 2 \times 10^{27} \text{ s}$$



Indirect Detection

Charged particles:

Pierre Salati: 'Charged Cosmic Rays'



Gaëlle Giesen: 'Antiproton constraints'

Sylvie Rosier-Lees: 'AMS-02'

2) The importance of multi-messenger analyses

3) Magnetic turbulence & CR diffusion

we do **not** know where the sources are located and when they exploded.

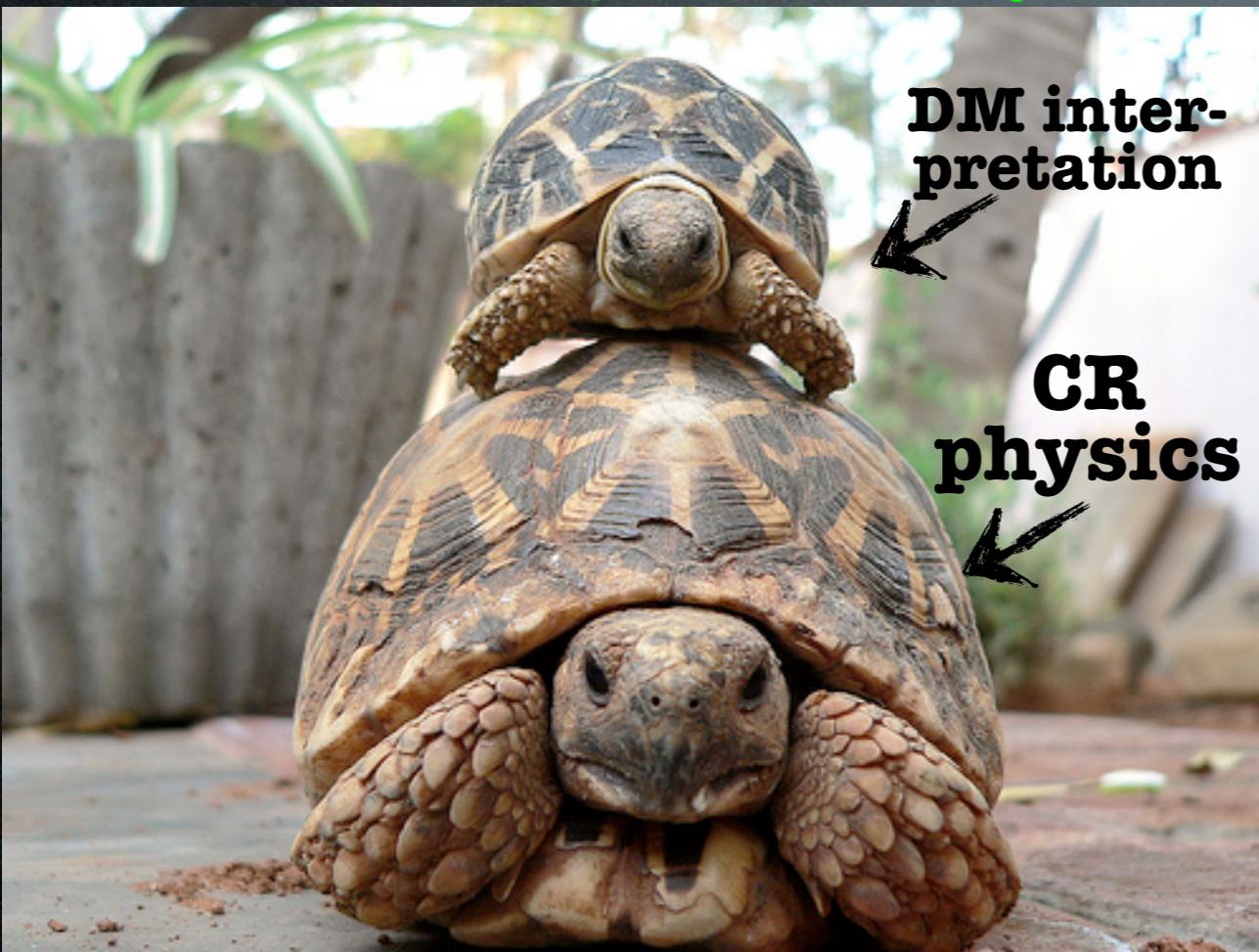
A statistical analysis is mandatory

Indirect Detection

Charged particles:

Pierre Salati: 'Charged Cosmic Rays'

Gaëlle Giesen: 'Antiproton constraints'



Sylvie Rosier-Lees: 'AMS-02'

2) The importance of multi-messenger analyses

3) Magnetic turbulence & CR diffusion

we do **not** know where the sources are located and when they exploded.

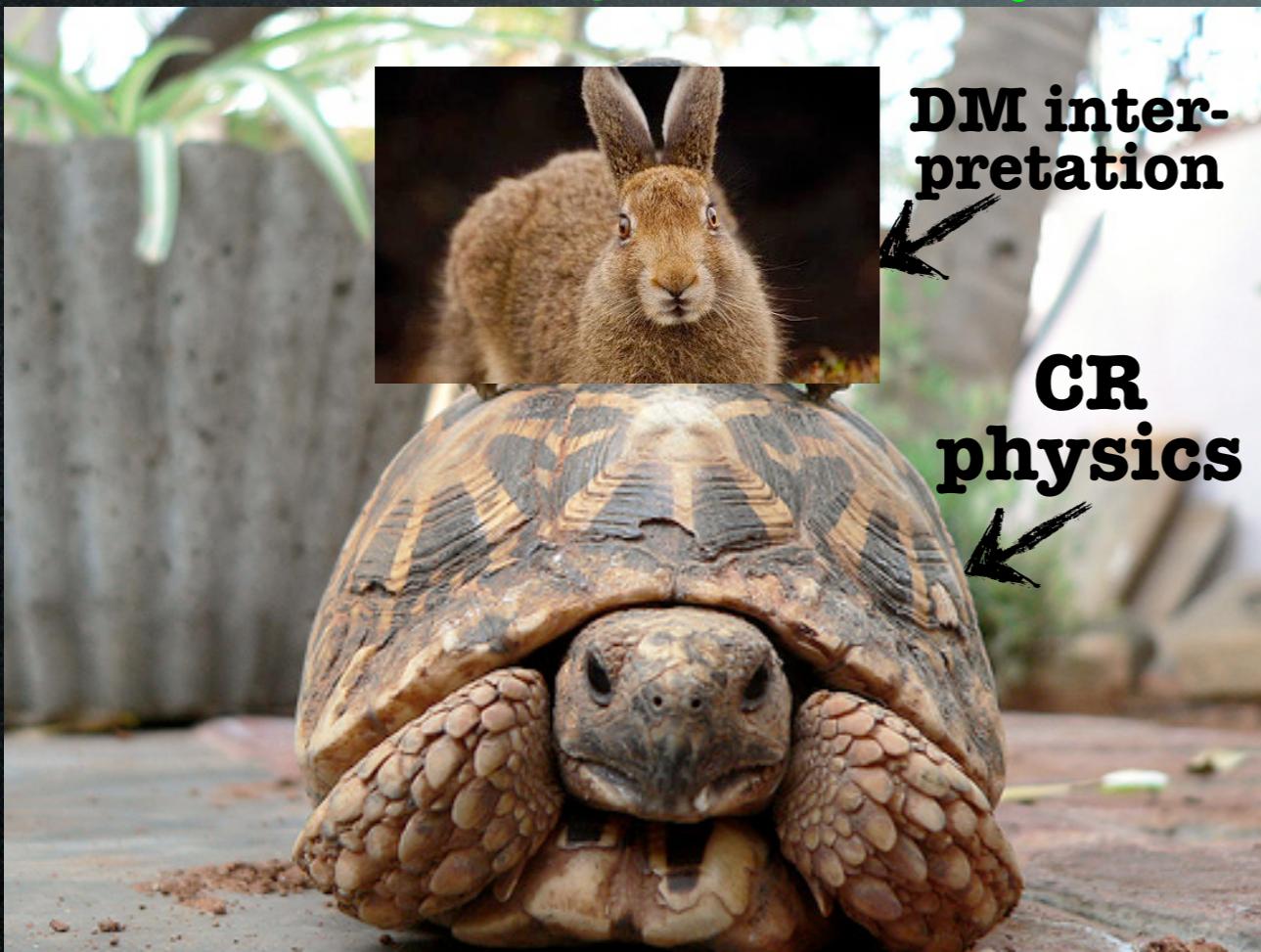
A statistical analysis is mandatory

Indirect Detection

Charged particles:

Pierre Salati: 'Charged Cosmic Rays'

Gaëlle Giesen: 'Antiproton constraints'



Sylvie Rosier-Lees: 'AMS-02'

2) The importance of multi-messenger analyses

3) Magnetic turbulence & CR diffusion

we do **not** know where the sources are located and when they exploded.

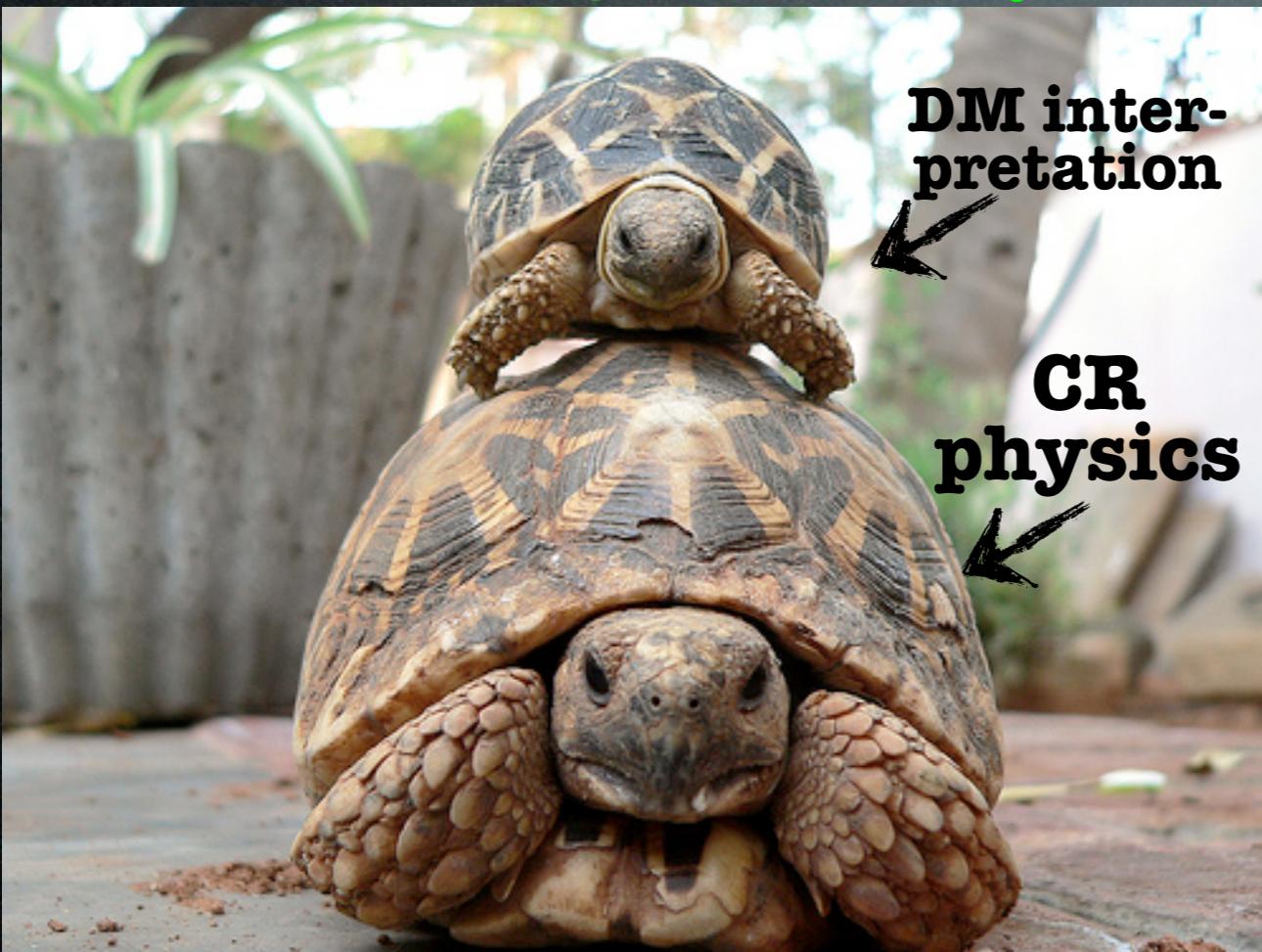
A statistical analysis is mandatory

Indirect Detection

Charged particles:

Pierre Salati: 'Charged Cosmic Rays'

Gaëlle Giesen: 'Antiproton constraints'



Sylvie Rosier-Lees: 'AMS-02'

2) The importance of multi-messenger analyses

3) Magnetic turbulence & CR diffusion

we do **not** know where the sources are located and when they exploded.

A statistical analysis is mandatory

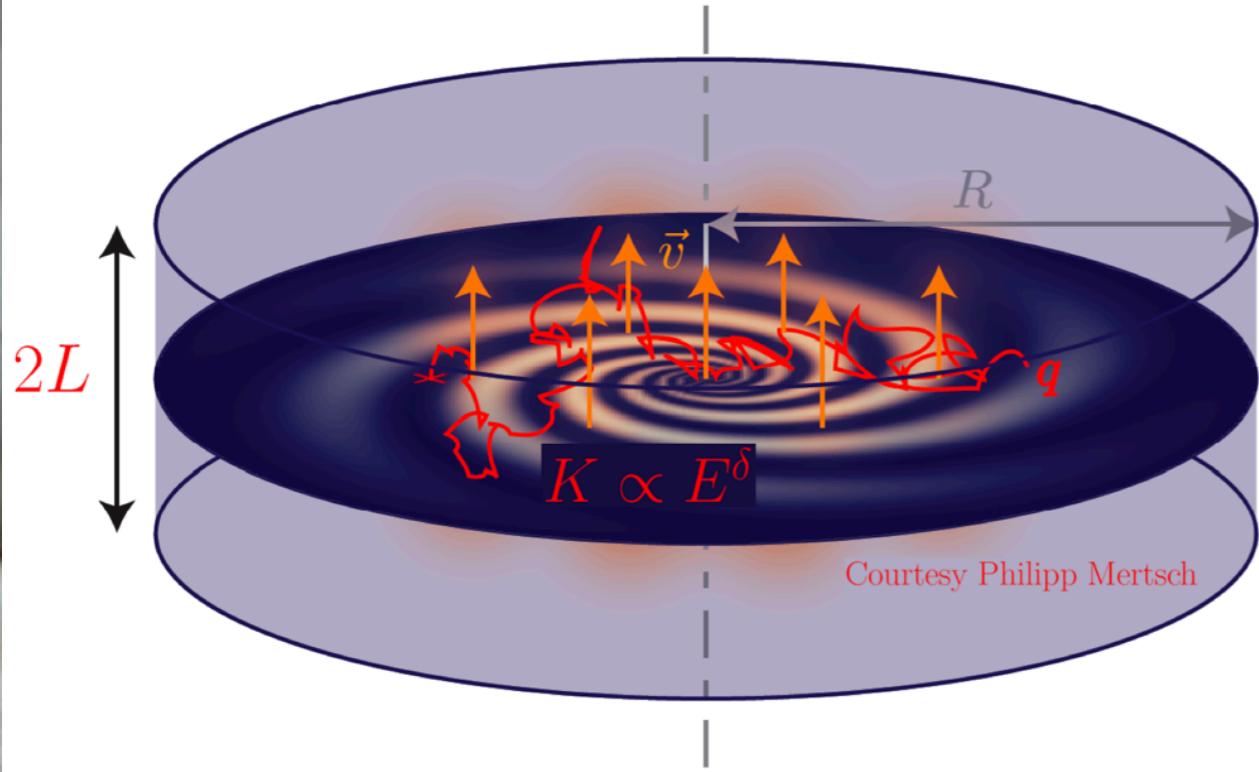
Indirect Detection

Charged particles:

Pierre Salati: ‘Charged Cosmic Rays’

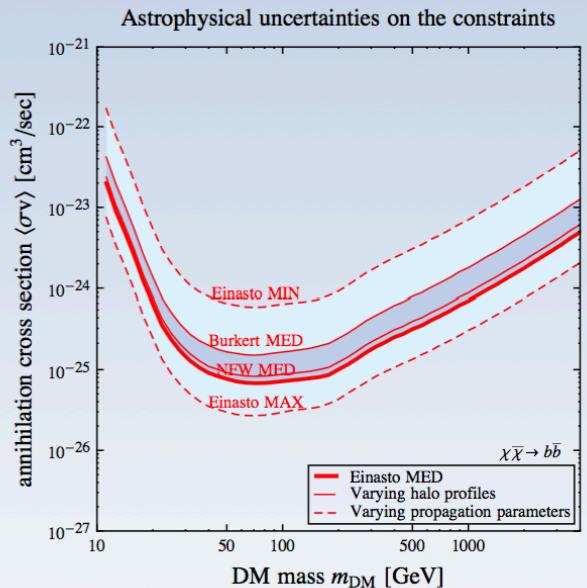
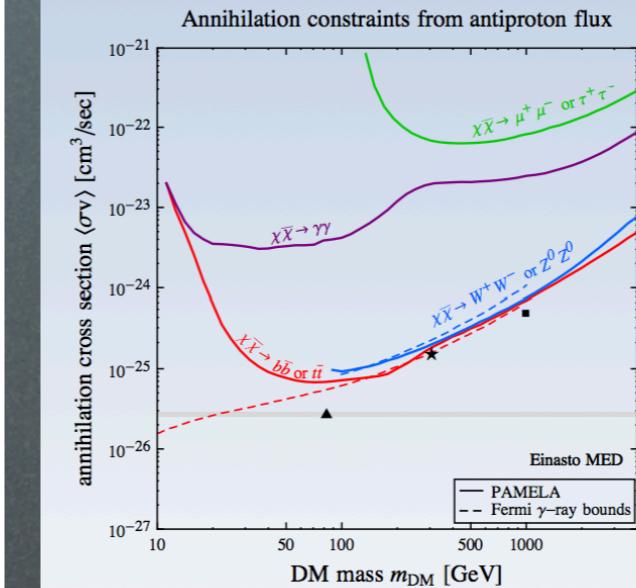
Milky-Way seen by a cosmic-ray physicist

Cosmic rays propagate inside a diffusive halo



Gaëlle Giesen: ‘Antiproton constraints’

Current Antiproton constraints from PAMELA for annihilating DM



Sylvie Rosier-Lees: ‘AMS-02’

2) The importance of multi-messenger analyses

3) Magnetic turbulence & CR diffusion

we do **not** know where the sources are located and when they exploded.

A statistical analysis is mandatory

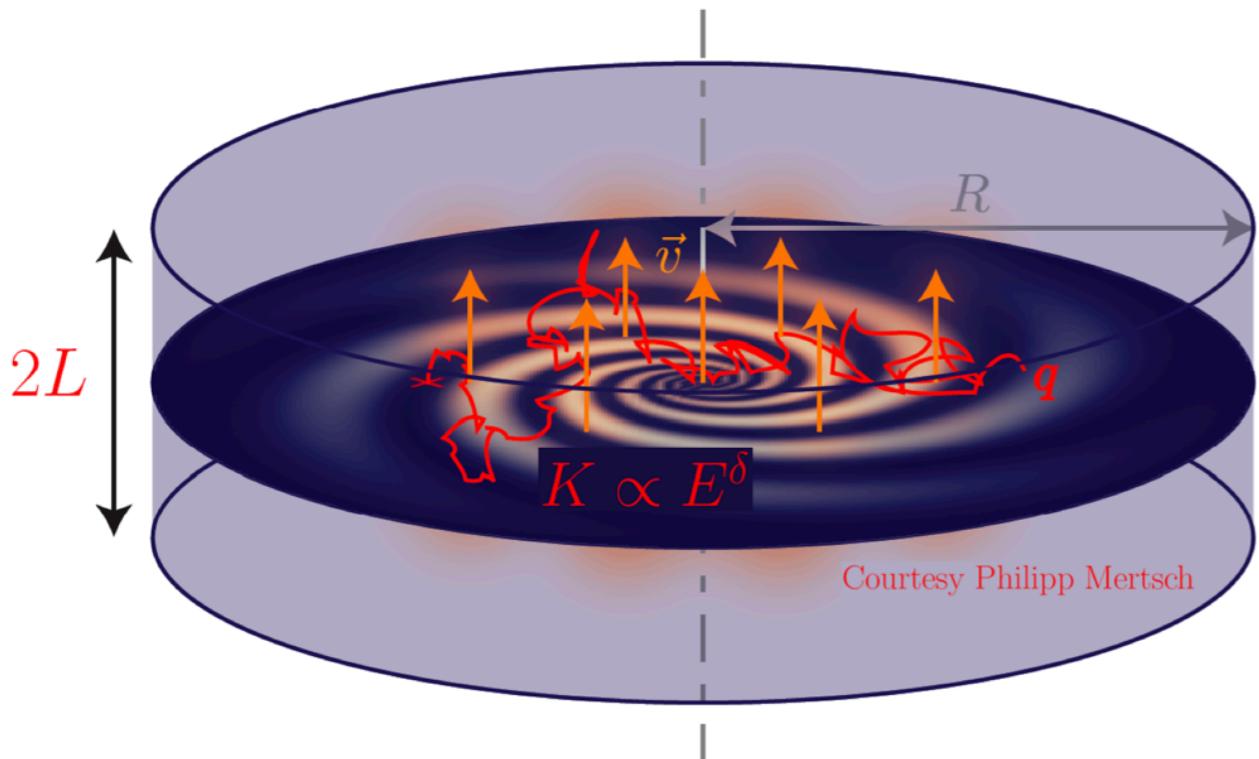
Indirect Detection

Charged particles:

Pierre Salati: ‘Charged Cosmic Rays’

Milky-Way seen by a cosmic-ray physicist

Cosmic rays propagate inside a diffusive halo



2) The importance of multi-messenger analyses

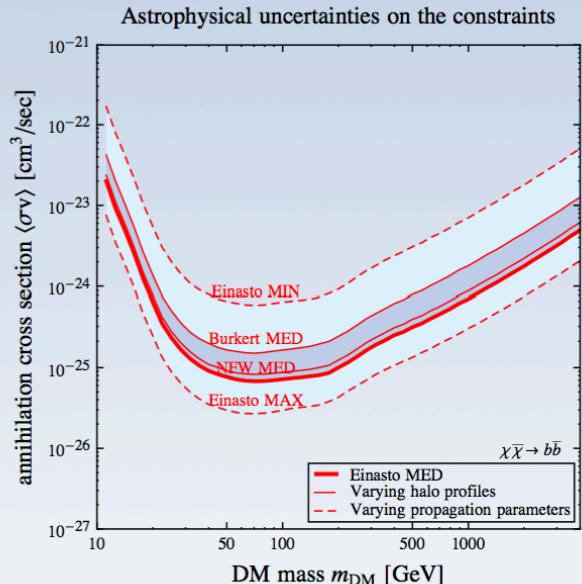
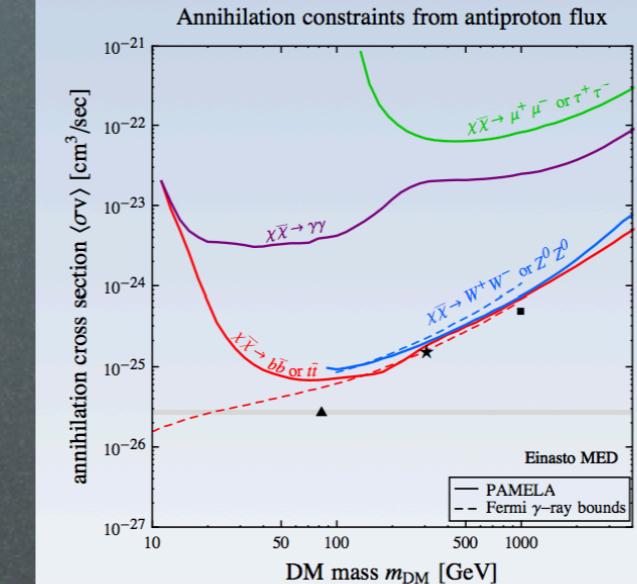
3) Magnetic turbulence & CR diffusion

we do not know where the sources are located and when they exploded.

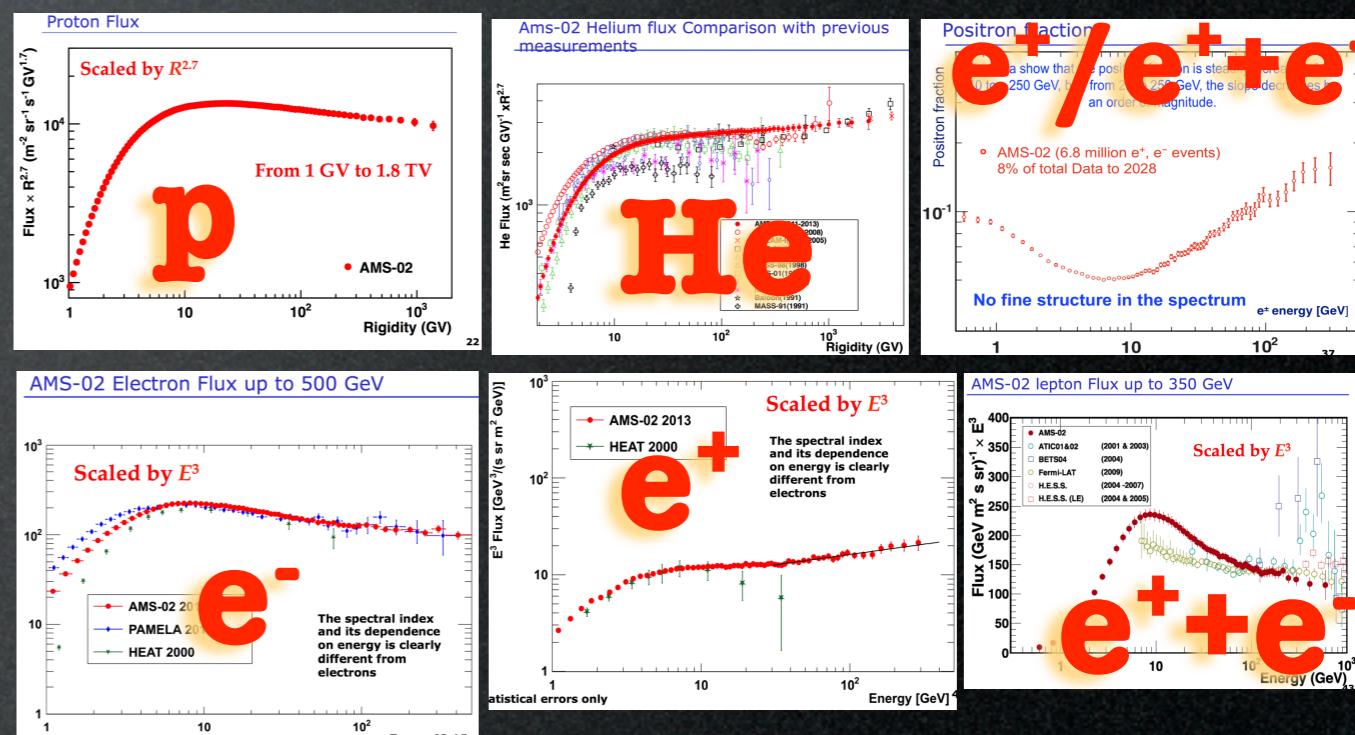
A statistical analysis is mandatory

Gaëlle Giesen: ‘Antiproton constraints’

Current Antiproton constraints from PAMELA for annihilating DM



Sylvie Rosier-Lees: ‘AMS-02’



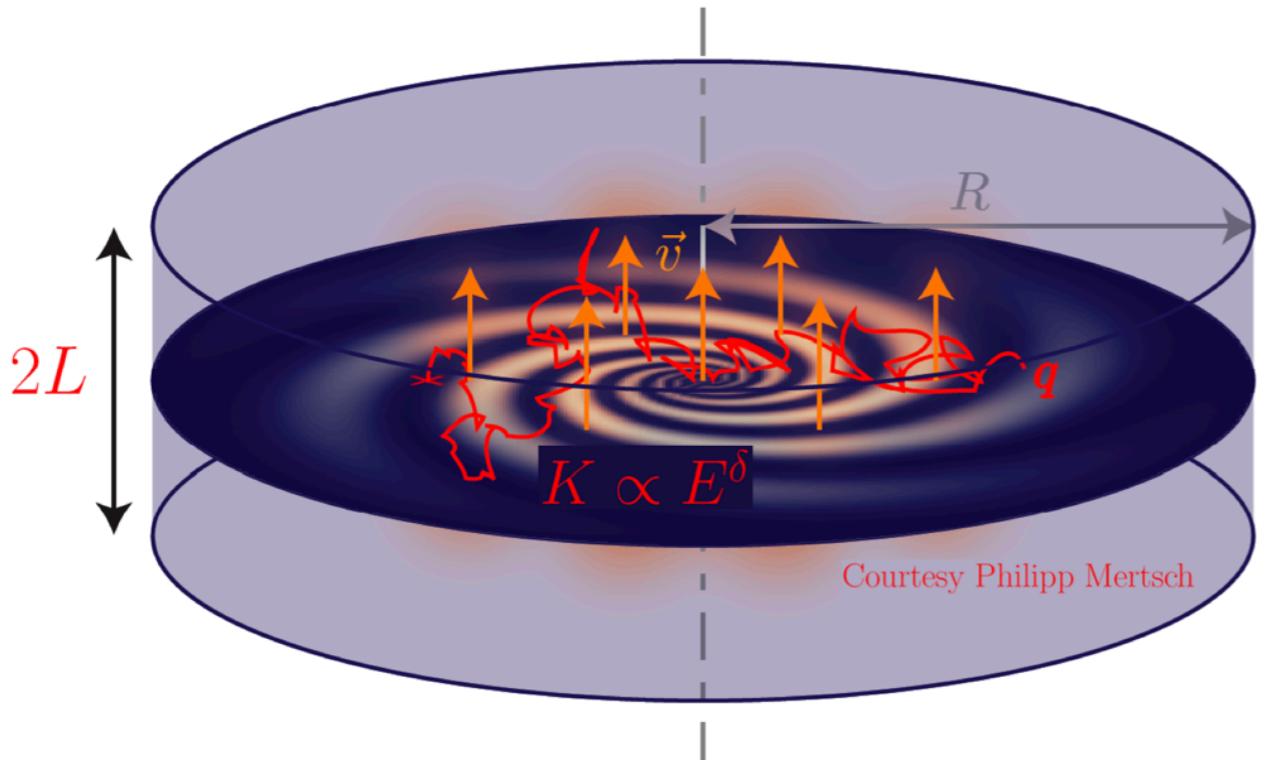
Indirect Detection

Charged particles:

Pierre Salati: ‘Charged Cosmic Rays’

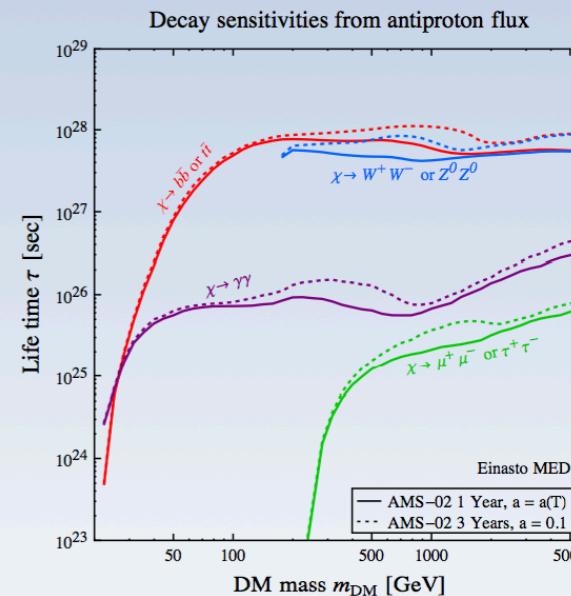
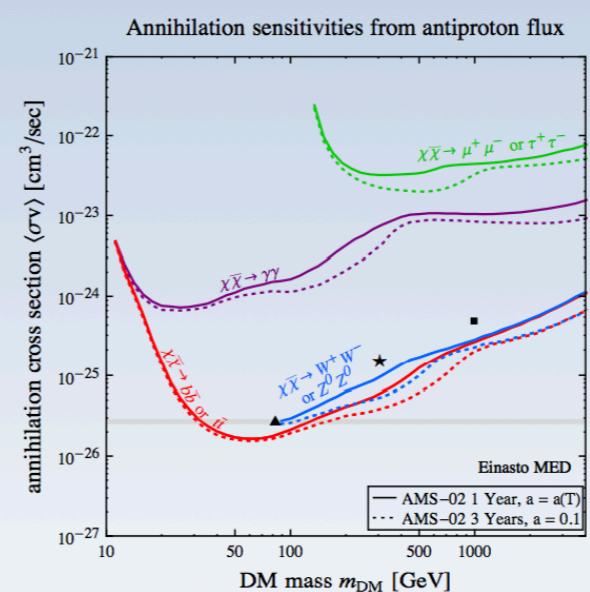
Milky-Way seen by a cosmic-ray physicist

Cosmic rays propagate inside a diffusive halo

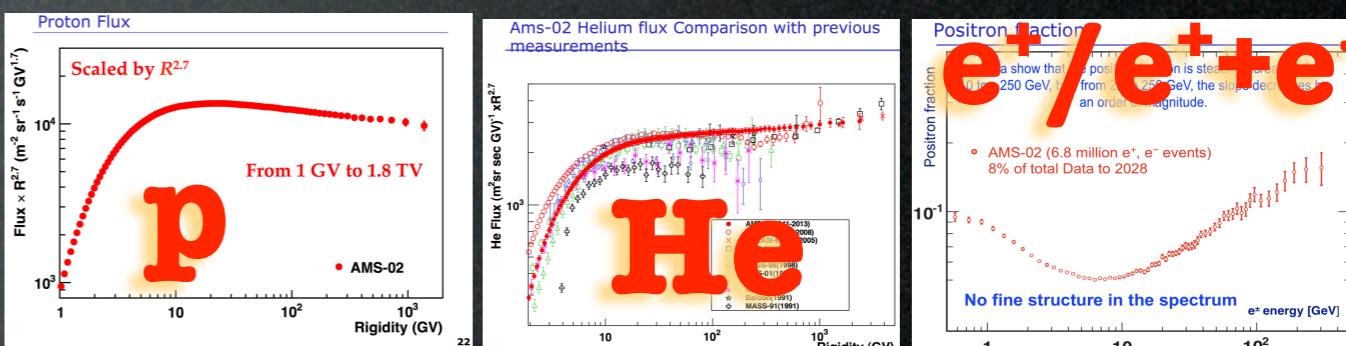


Gaëlle Giesen: ‘Antiproton constraints’

Future sensitivities of AMS-02



Sylvie Rosier-Lees: ‘AMS-02’

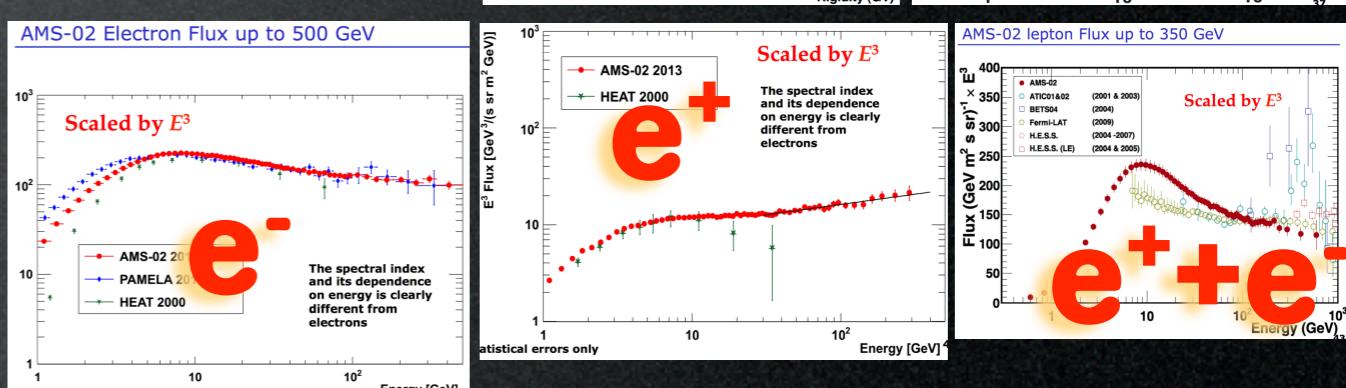


2) The importance of multi-messenger analyses

3) Magnetic turbulence & CR diffusion

we do not know where the sources are located and when they exploded.

A statistical analysis is mandatory



Theory

The word ‘neutralino’ has been mentioned 3 times!

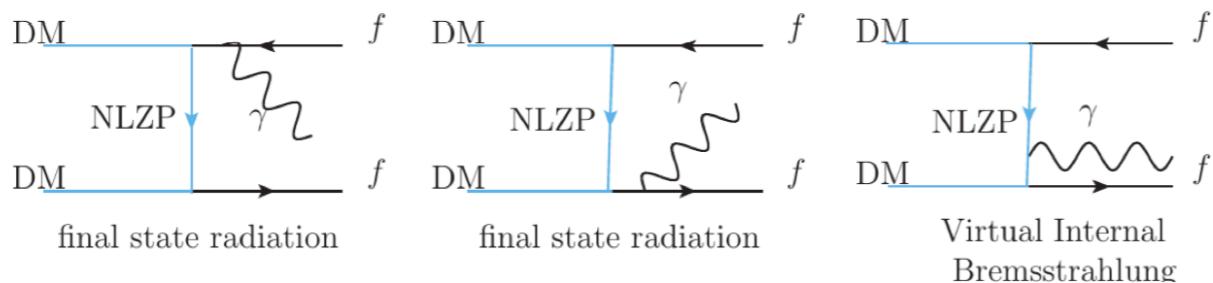
Theory

The word ‘neutralino’ has been mentioned 3 times!

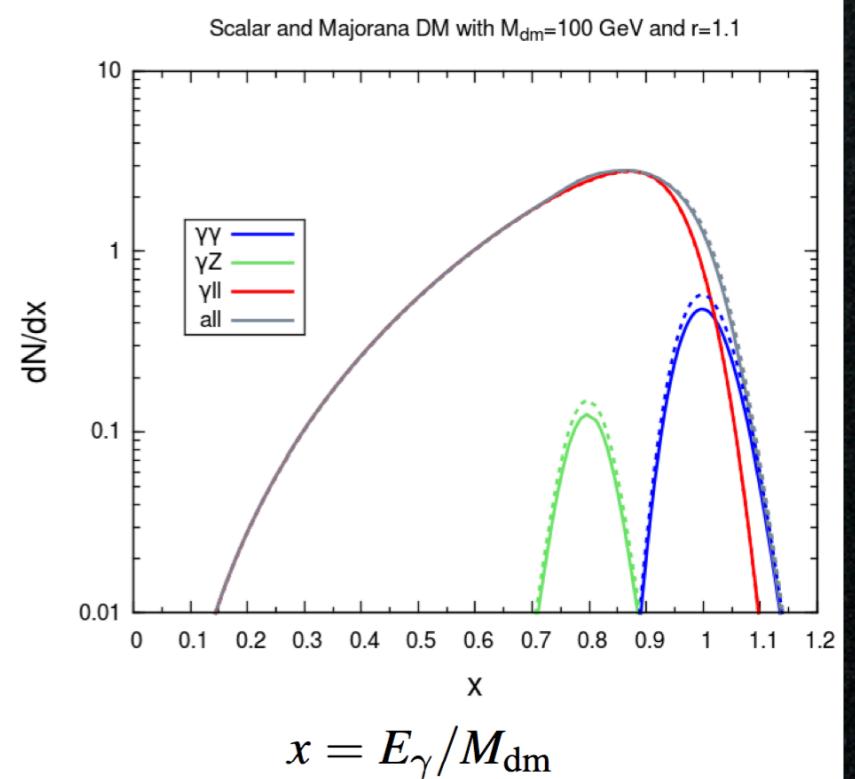
Laura Lopez-Honorez: ‘DM new ideas’

‘Toy’ models with degenerate spectrum,
featuring Internal Bremsstrahlung:
correct relic abund + features in γ -rays

Sharp spectral feature



Normalized γ spectrum



Theory

The word ‘neutralino’ has been mentioned 3 times!

Laura Lopez-Honorez: ‘DM new ideas’

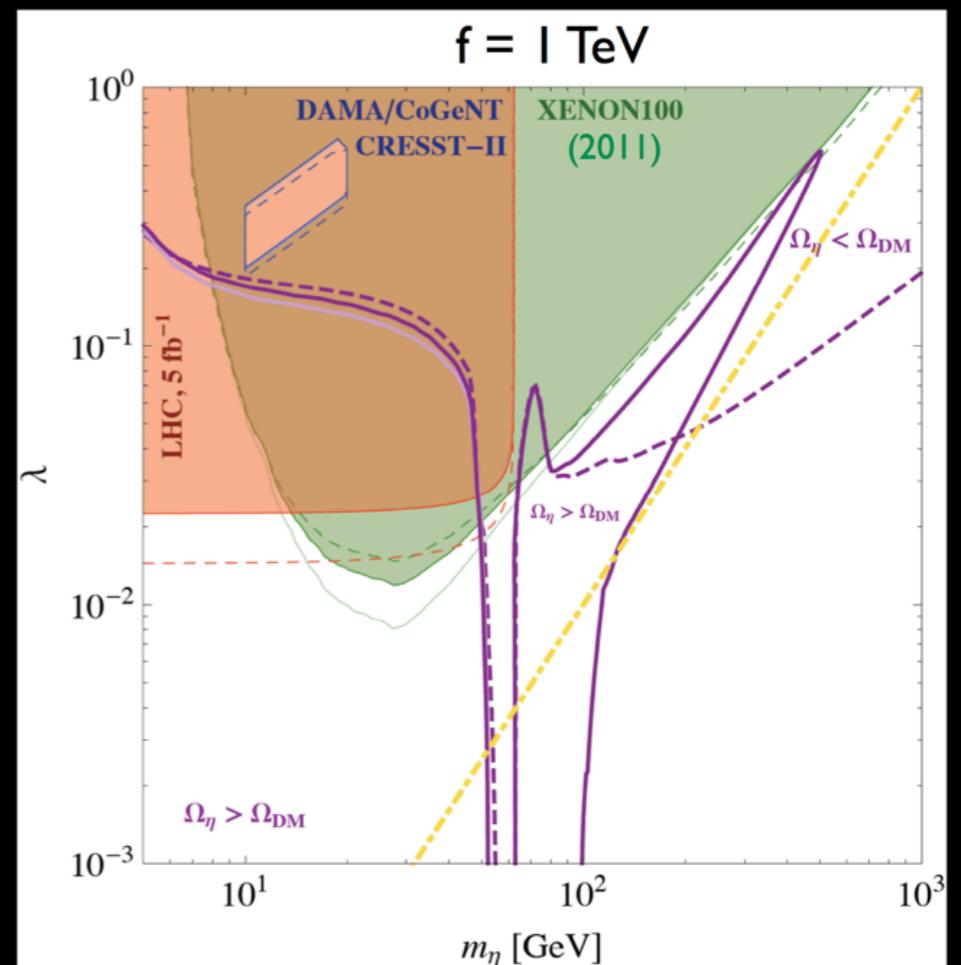
‘Toy’ models with degenerate spectrum, featuring Internal Bremsstrahlung: correct relic abund + features in γ -rays

Michele Frigerio: ‘pNGB as DM’

DM as a pNGB linked to the EW scale

Composite DM parameter space

dashed: elementary DM
solid: composite DM with $f = 1 \text{ TeV}$
Purple: relic density contours with $\Omega_\eta = \Omega_{\text{DM}}$
Red: disfavoured by LHC Higgs searches
Green: disfavoured by DM direct searches
below the yellow line: theoretically favoured ($\lambda \leq m_\eta^2 / f^2$)



Theory

The word ‘neutralino’ has been mentioned 3 times!

Laura Lopez-Honorez: ‘DM new ideas’

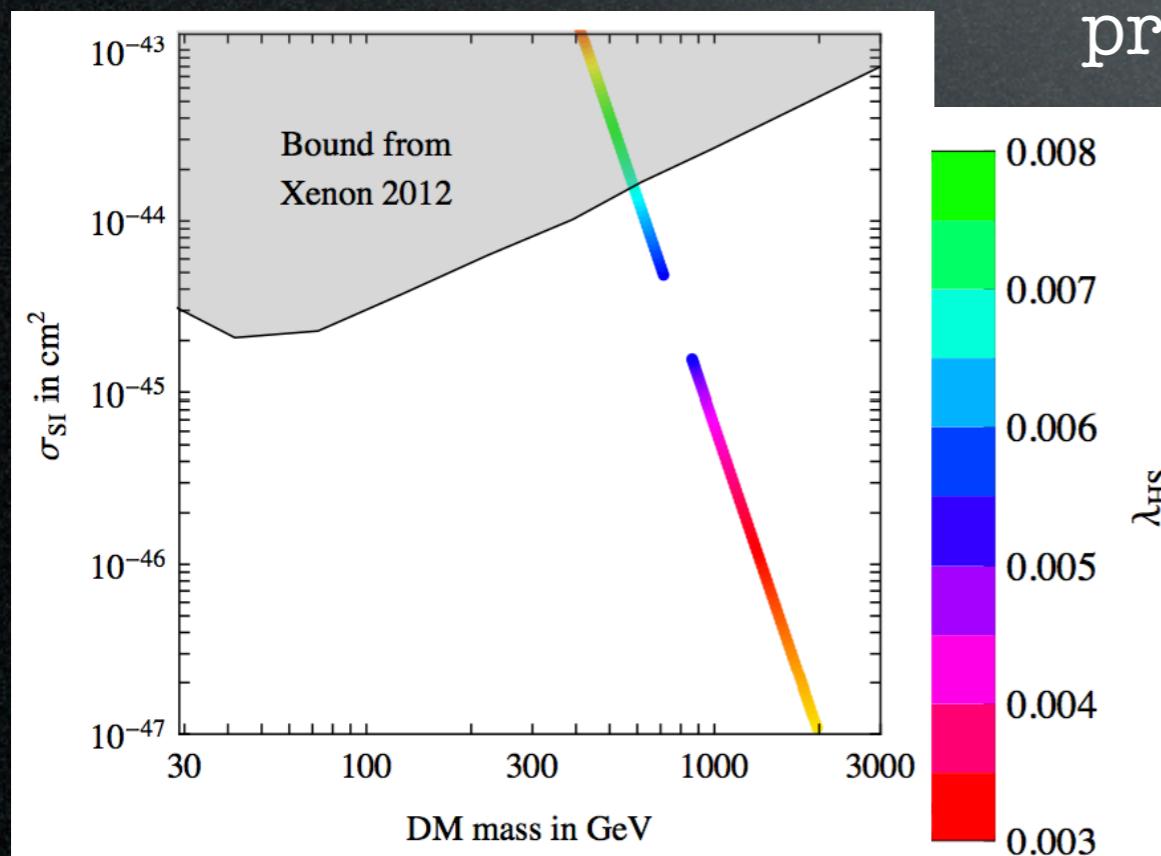
‘Toy’ models with degenerate spectrum,
featuring Internal Bremsstrahlung:
correct relic abund + features in γ -rays

Michele Frigerio: ‘PNGB as DM’

DM as a pNGB linked to the EW scale

Alessandro Strumia:
‘DM from modified naturalness’

DM as the automatically stable vector of
an extra $SU(2)_X$, mass ~ 1 TeV),
predictive in terms of 1 parameter λ_{HS}



Theory

The word ‘neutralino’ has been mentioned 3 times!

Laura Lopez-Honorez: ‘DM new ideas’

‘Toy’ models with degenerate spectrum,
featuring Internal Bremsstrahlung:
correct relic abund + features in γ -rays

Michele Frigerio: ‘PNGB as DM’

DM as a pNGB linked to the EW scale

Alessandro Strumia:
‘DM from modified naturalness’

DM as the automatically stable vector of
an extra $SU(2)_X$, mass ~ 1 TeV),
predictive in terms of 1 parameter λ_{HS}

The End