Summary: Astroparticle Physics Experiment

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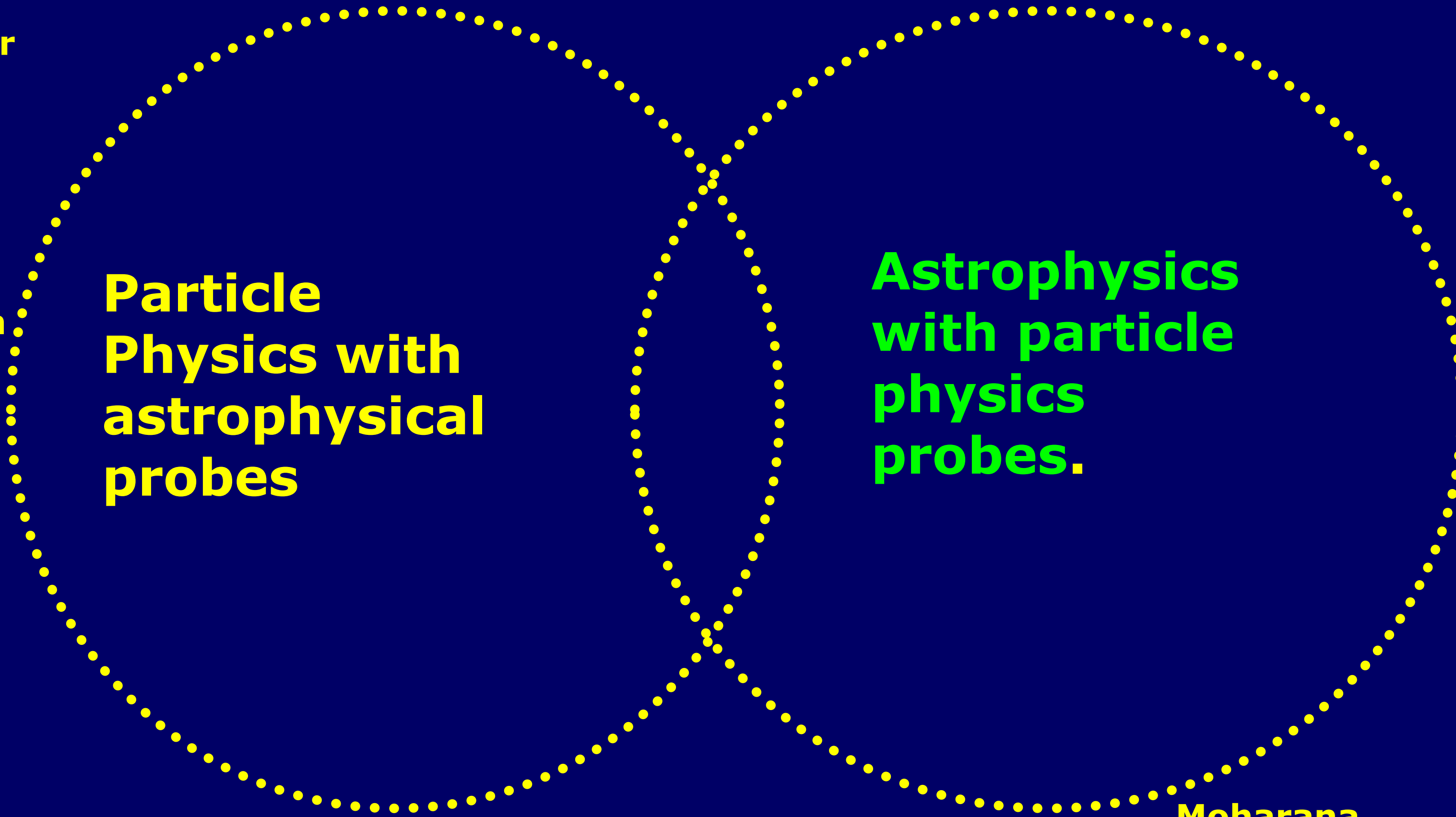
WIN 2015, Heidelberg

Astroparticle Physics

Weinheimer
Maricic
Horn
Wolf
Palladino
Diaz
Gorla
Heuermann
Dobi
Pollmann
Simgen
Pantic
Anderson
Fornasa
Sanchez
Hasegawa



Moharana

Gebauer
Sanguinetti

Strategy: one slide summary of each talk and then some synthesis from my side …

The big questions for astroparticle physics

- Nature of dark matter

  Dark matter dominate the astroparticle sessions

- Bayro/leptogenesis

- Neutrino mass, hierarchy, CP phase

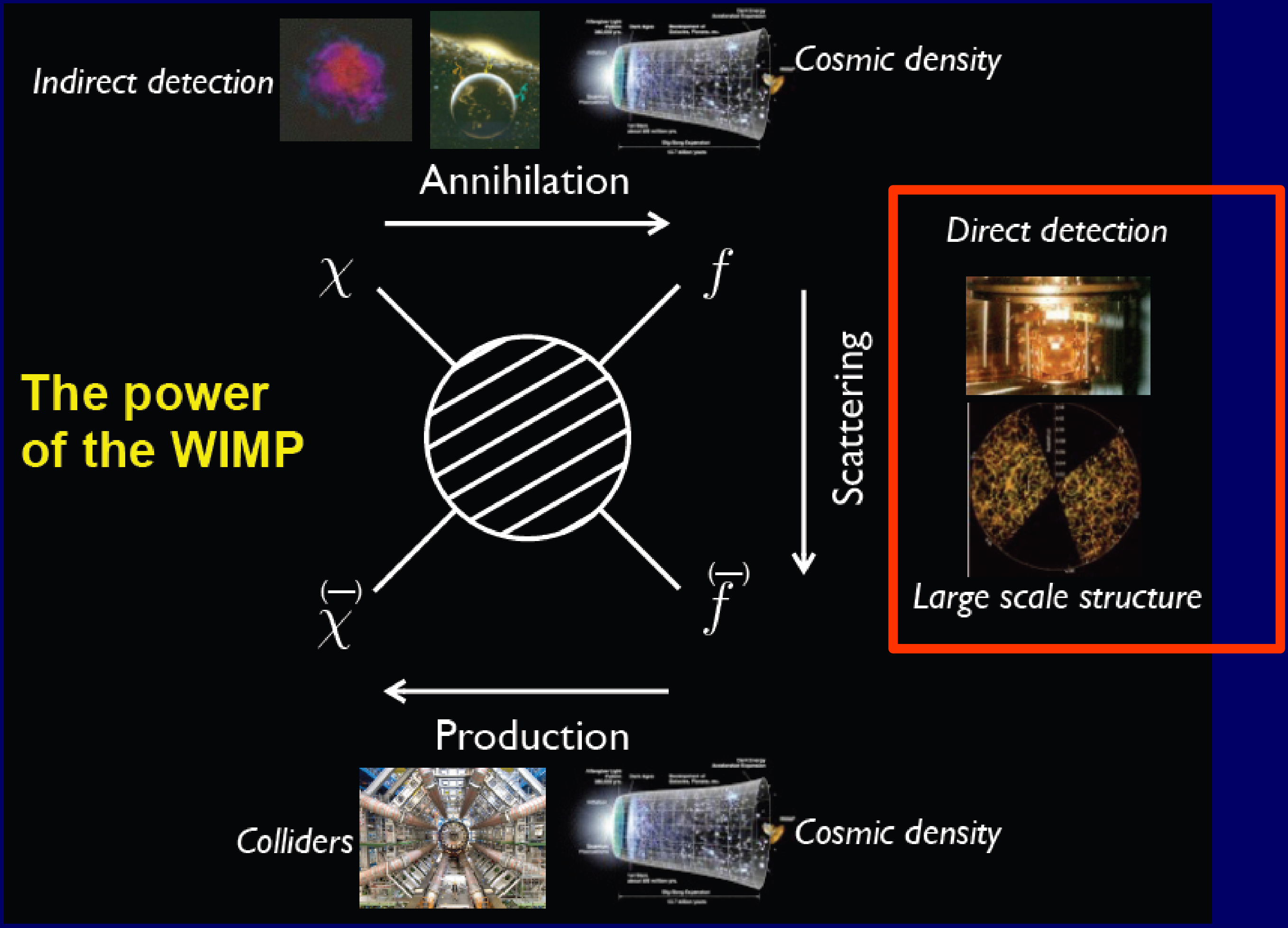
Many talks in Other sessions:
Eg:

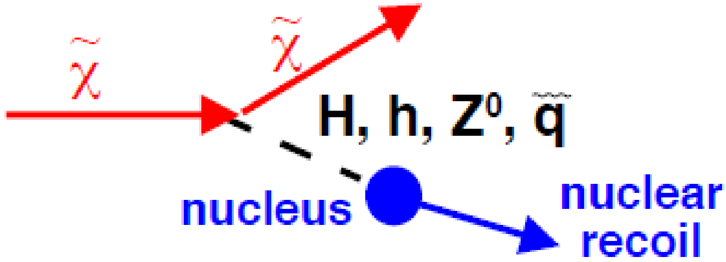
Hayato
Weatherly
Hernanod
Cherdack
Murphy
Arlen
Razzaque

- Cosmic-rays and neutrino astronomy, extreme objects

Astroparticle physics experiment

DIRECT DETECTION OF DARK MATTER





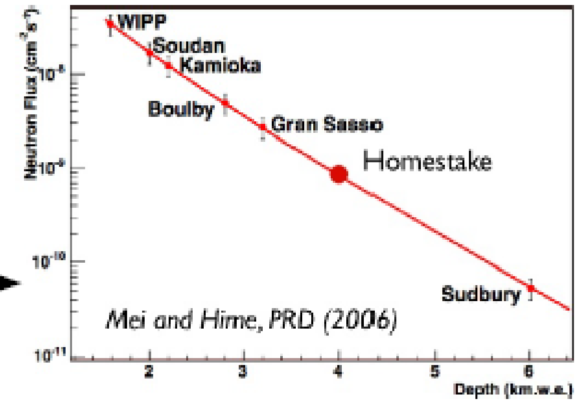
⇒ exponential recoil energy spectrum:

$$\frac{dR}{dE_r} = \frac{\rho_0 \cdot \sigma_0 \cdot F^2(q^2)}{2 \cdot m_{\tilde\chi} \cdot \mu_r^2} \cdot \langle \frac{1}{v} \rangle = \frac{\rho_0 \cdot \sigma_0 \cdot F^2(q^2)}{\sqrt{\pi} \cdot m_{\tilde\chi} \cdot \mu_r^2 \cdot v_0} \cdot e^{-\frac{E_r \cdot m_A}{2 \cdot \mu_r^2 \cdot v_0^2}}$$

but very low rate & very low recoil energy

⇒ **go underground to reduce μ`s and μ-induced n`s**

& shielding, very clean materials, .. →



⇒ **special techniques to suppress γ, e, α background**

a) large detector mass to see annual modulation (DAMA/LIBRA)

b) double read-out to distinguish nuclear recoil from others

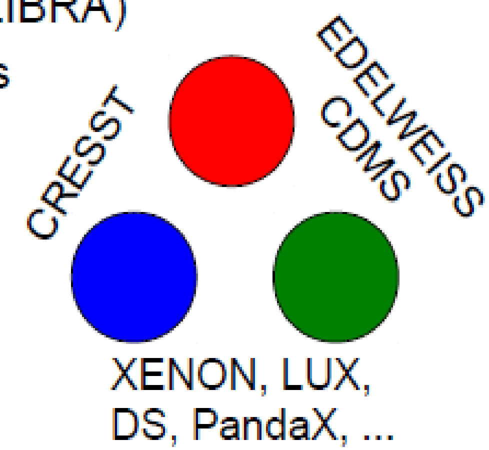
- cryobolometers:

  heat + ionsiation or heat + light

- liquid noble gas detectors:

  light + ionisation

c) directional (but not enough target mass)

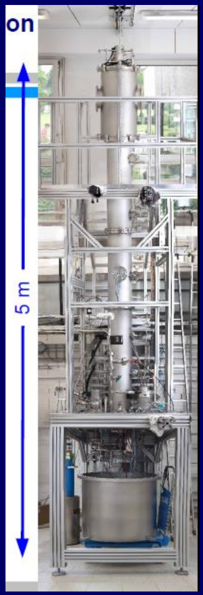


From
Weinheimer talk

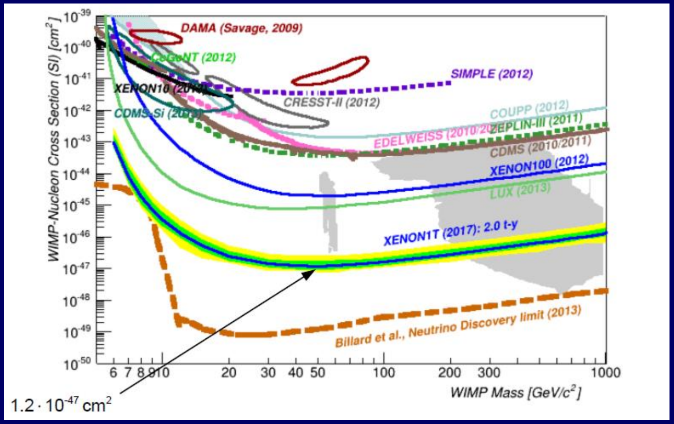
Xenon100/1T (Weinheimer)

- Dual phase LXe TPC
- XENON100
  - 225 34 kg fiducial
  - some are pending (150 d of data in t pipeline)
- XENON1T
  - Construction good progress, data taking foreseen by the end of the year.
  - Kr-in-Xe reduction improved by a actor 100!

XENON100
2008 - 2015
30 cm drift TPC
161 kg xenon
$\sigma_{SI} < 2.0 \cdot 10^{-45}$ cm^2

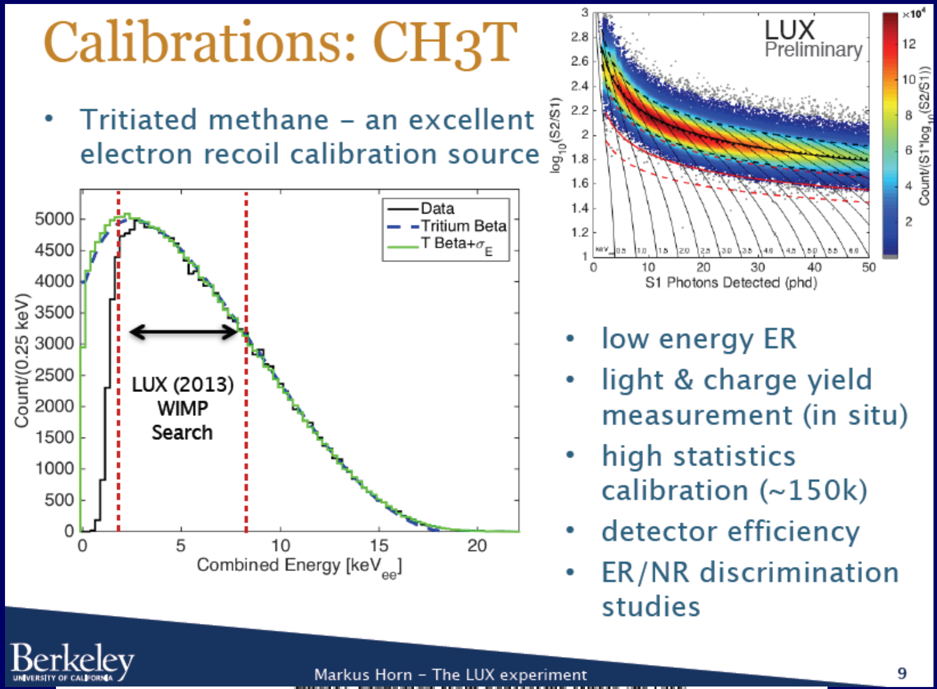


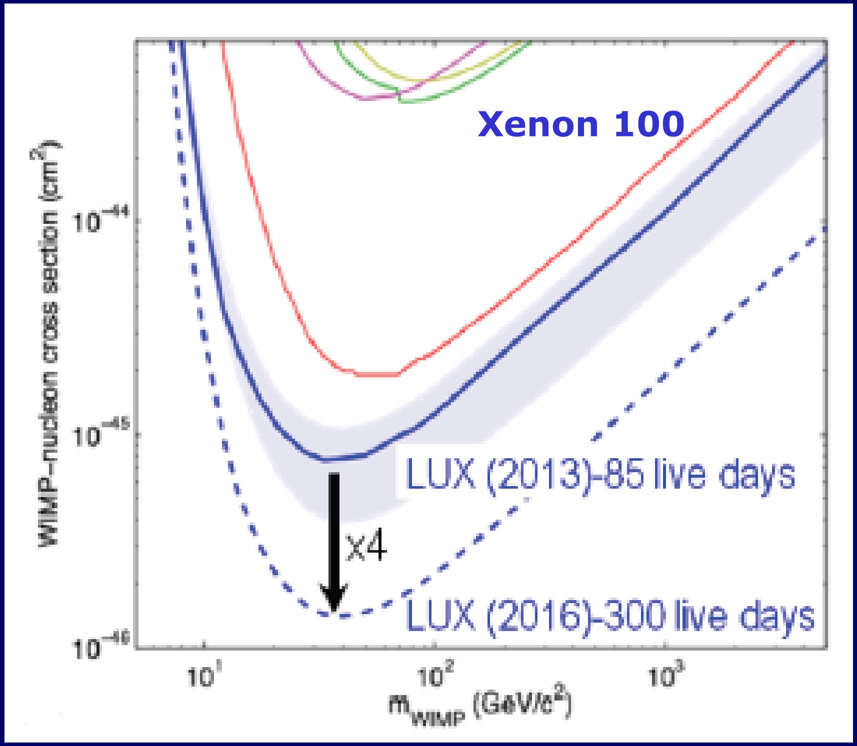
XENON1T (XENONnT)
2012 -
1000 cm drift TPC
3300 (7000) kg xenon
$\sigma_{SI} < 1.2 \cdot 10^{-47}$ cm^2 ($< 2 \cdot 10^{-48}$ cm^2)

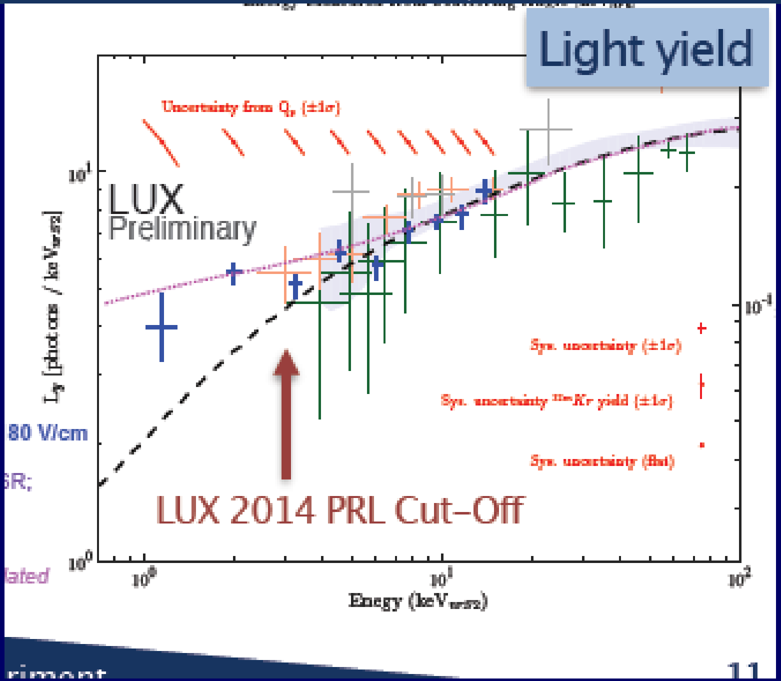


LUX (Horn)

- Dual Phase LXe TPCs , 118kg fiducial
- 3x data in the pipeline with new measurements of the light and charge yield (lower threshold).
- CH3T in-situ calibration

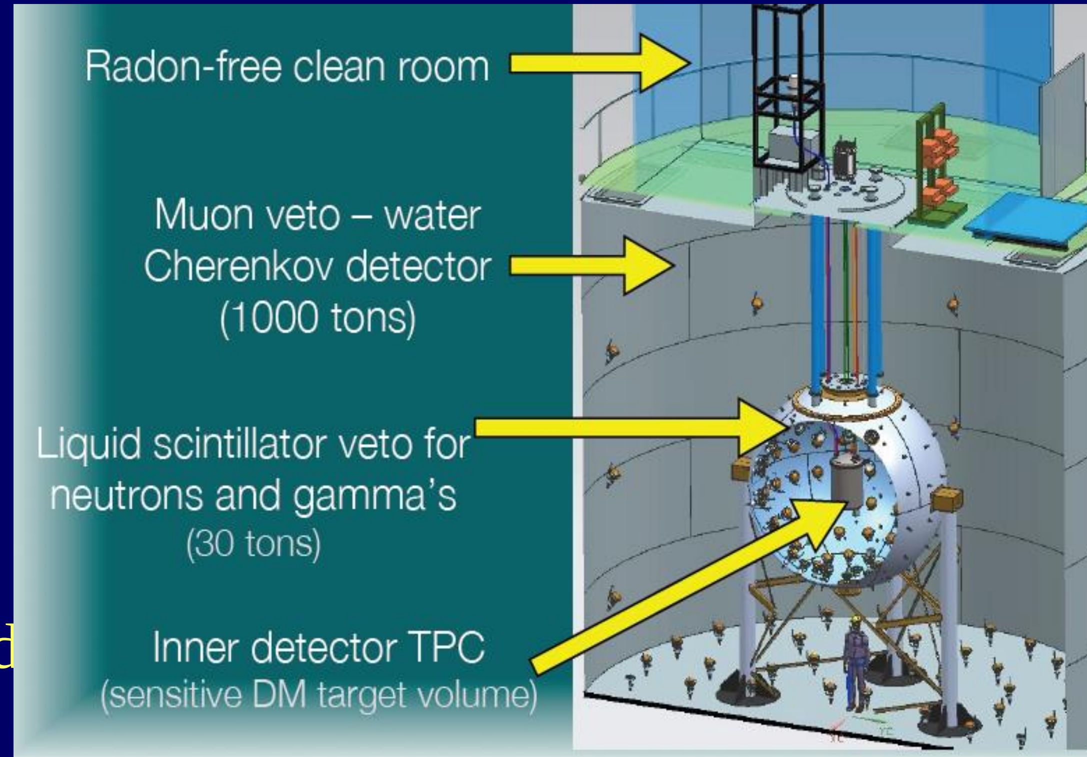


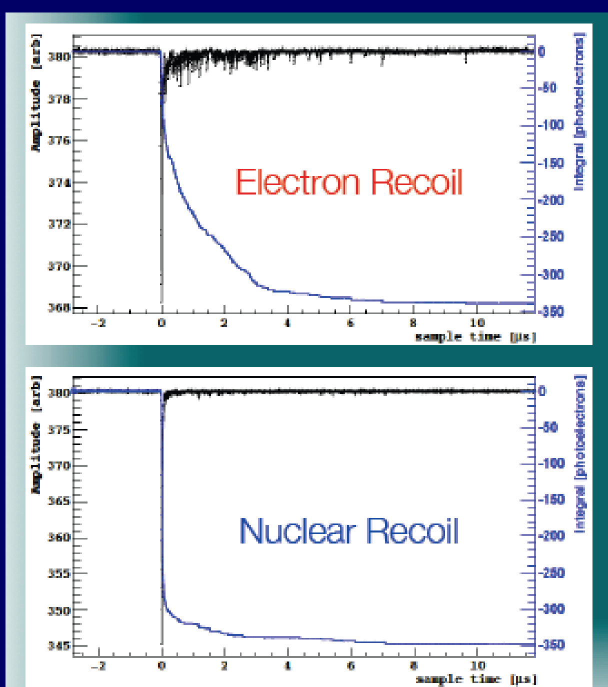


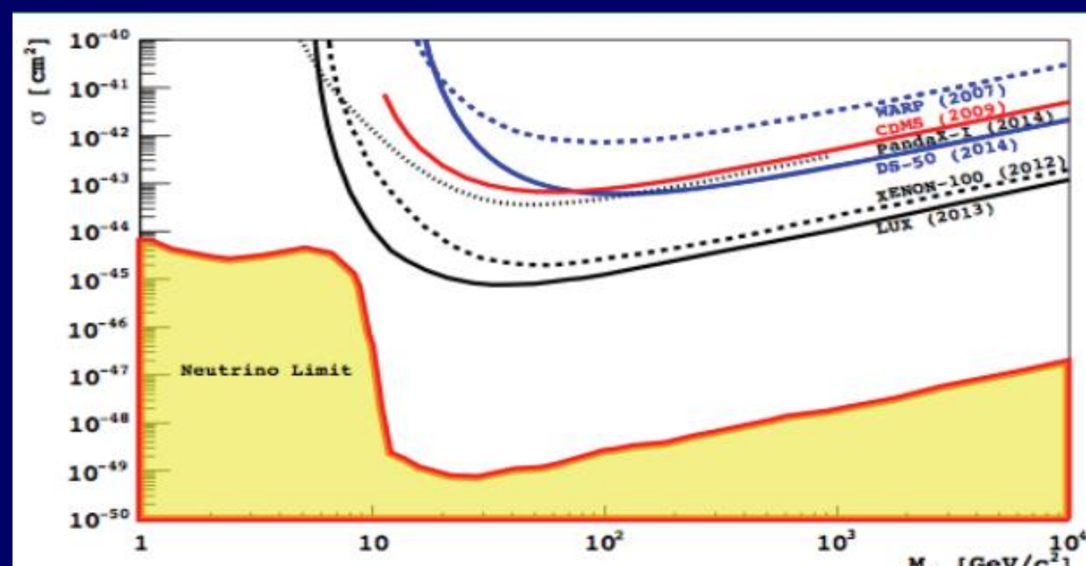


DarkSide (Maricic)

- Dual phase LAr TPC
- Additional background rejection capability due to pulse shape discrimination
- First results based on atomspheric argon (Ar39), 1422 kg day
- March 2015: UAr run started

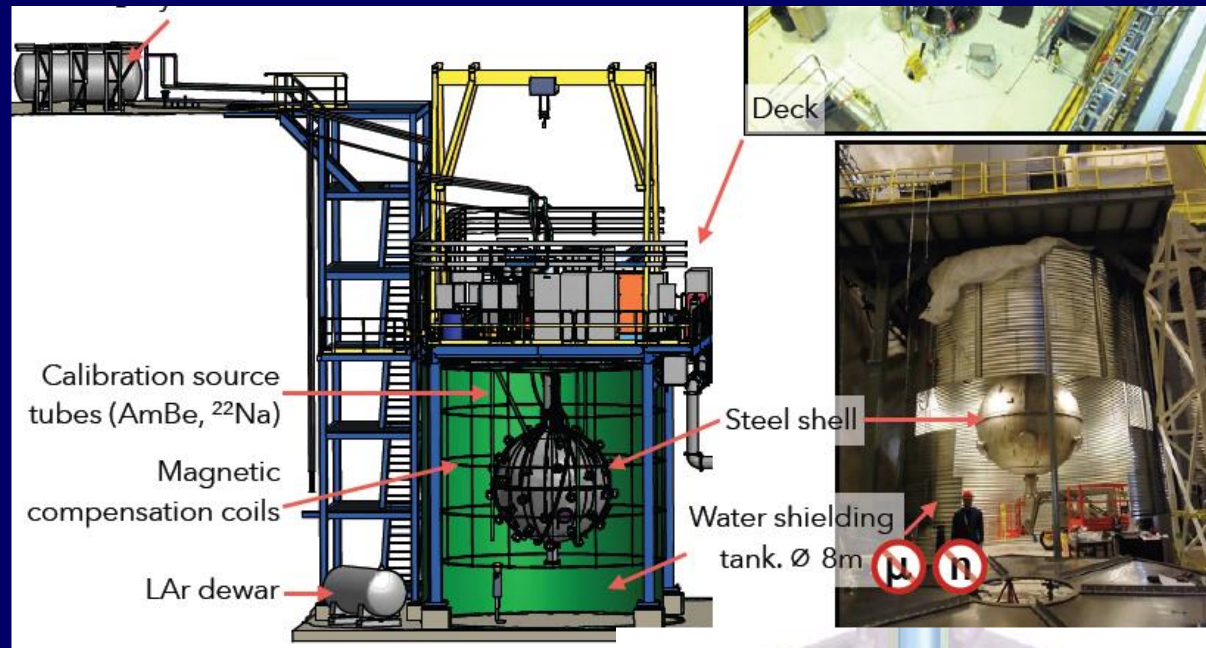


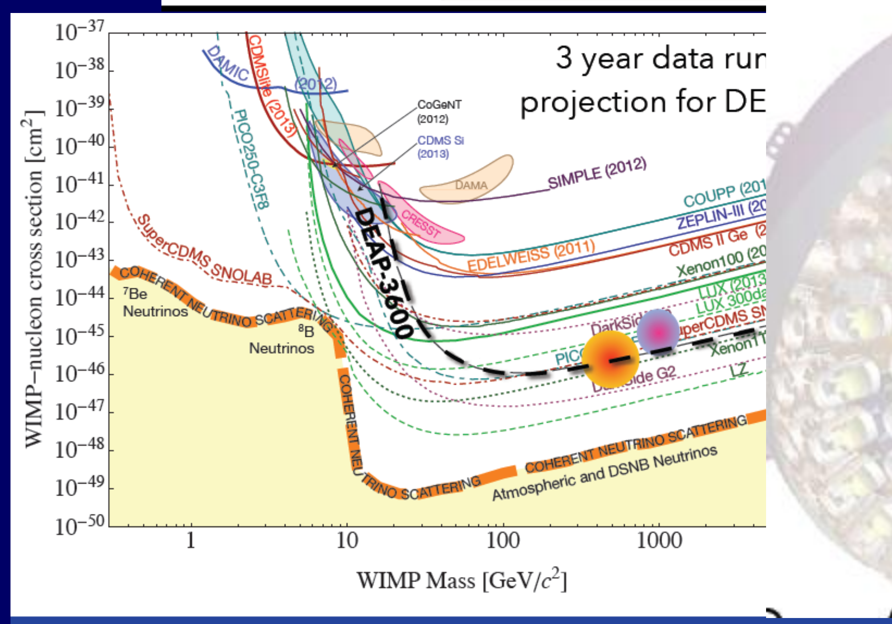


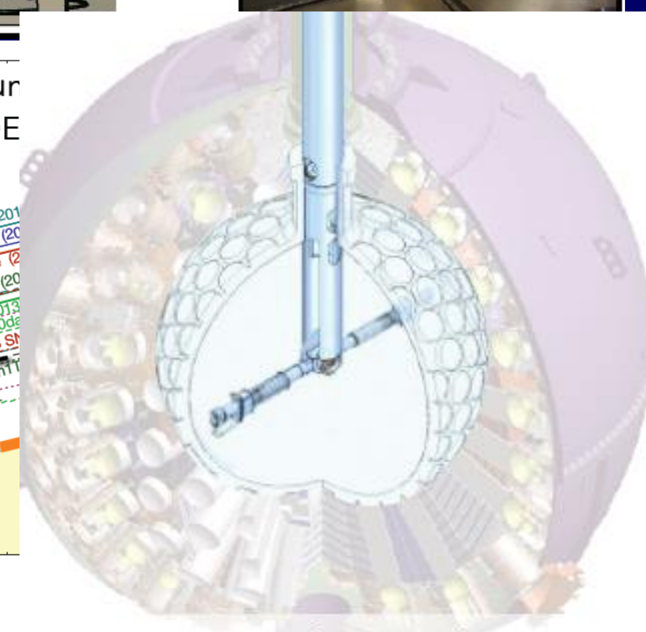


DEAP-3600 (Pollmann)

- Single phase LAr, 1 tonne fiducial
- Advantage: no field
- Pulse shape discrimination
- Comissioning under way
- 3 years results: ~2019,comparable to XENON1T

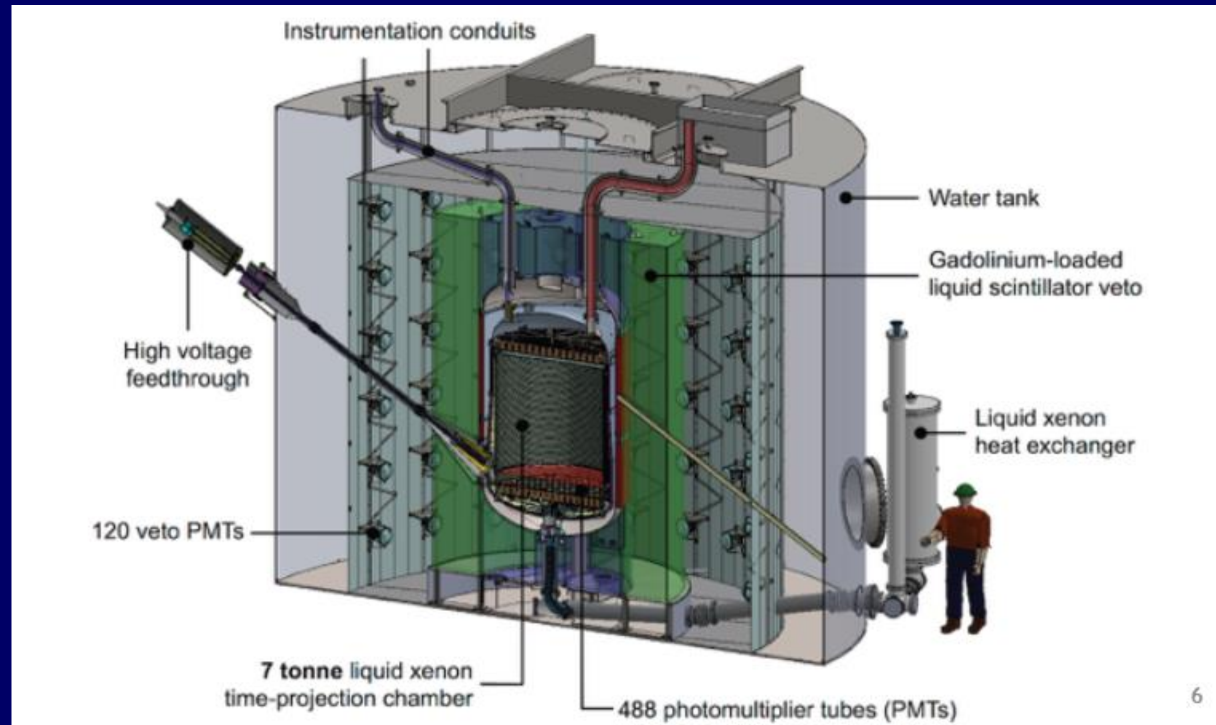


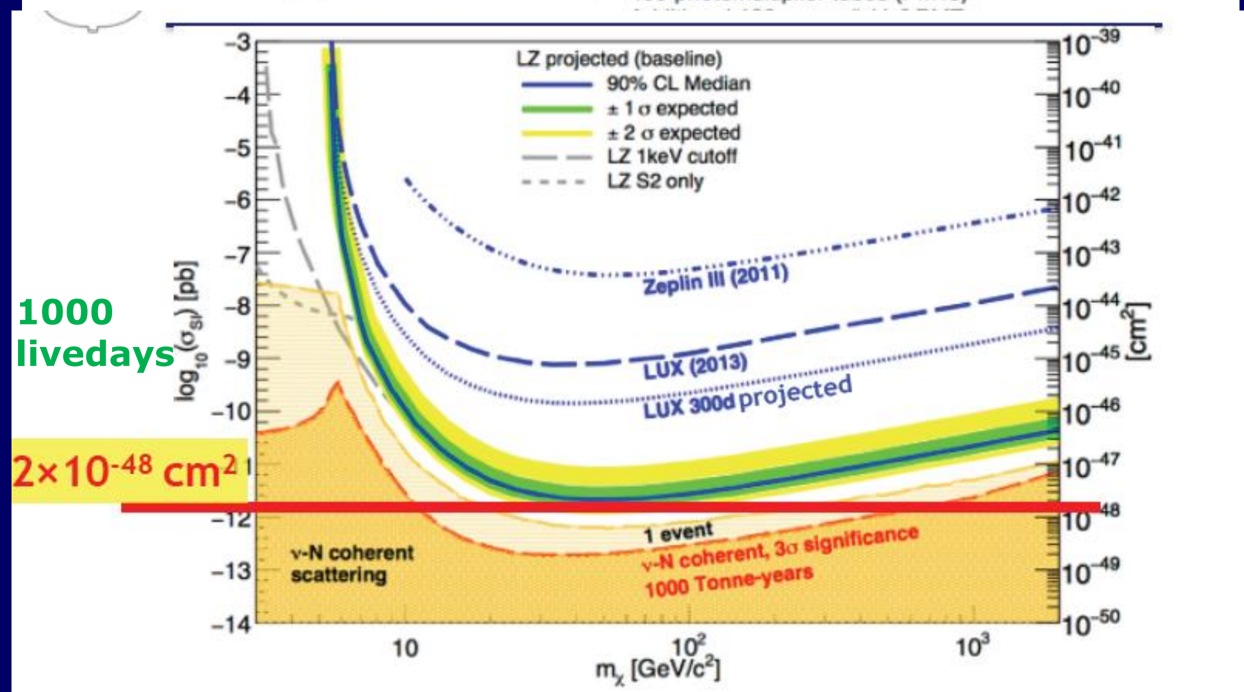




LZ (Dobi)

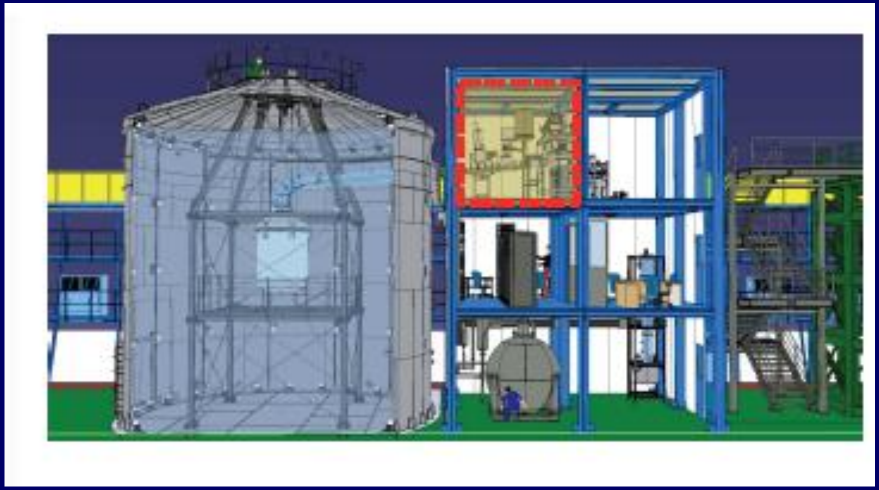
- G2 LXe dual phase, 5.6 tfiducial.
- DOE-CD partly passed
- Procurement started
- Builds on Lux (in-situ calibration. New: liquid scintillator veto.
- Comissioning by 2019

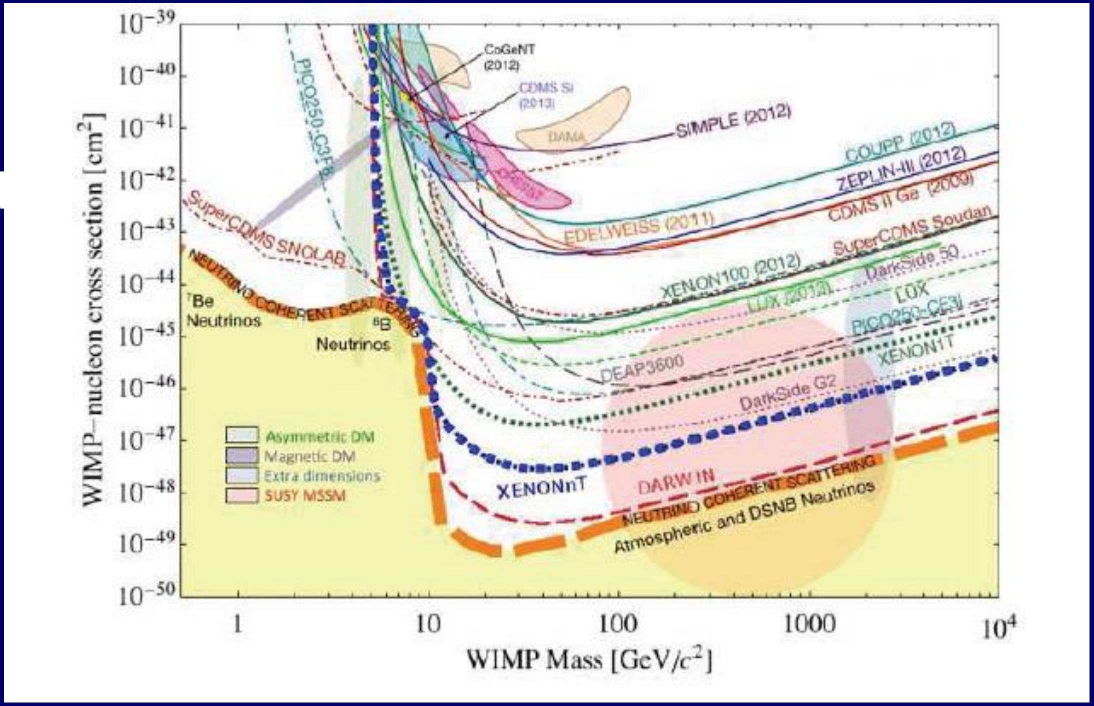




XenonNT and Beyond (Simgen)

- NT ~ 7 T active Xe
  - Most infrastructure (MV, Xe storage, purification, cryogenics,
  - ~ 4T Xe already procured
  - ~ 2017
  - NT ~ LZ (but LZ later)
- 2nd part challenges for G3 (20t LXe)
  - discrimination → light yield
  - mechanics, drift field
  - Kr removal (solved), Rd removal ….?)
  - Cosmogenic neutrons (LSz veto

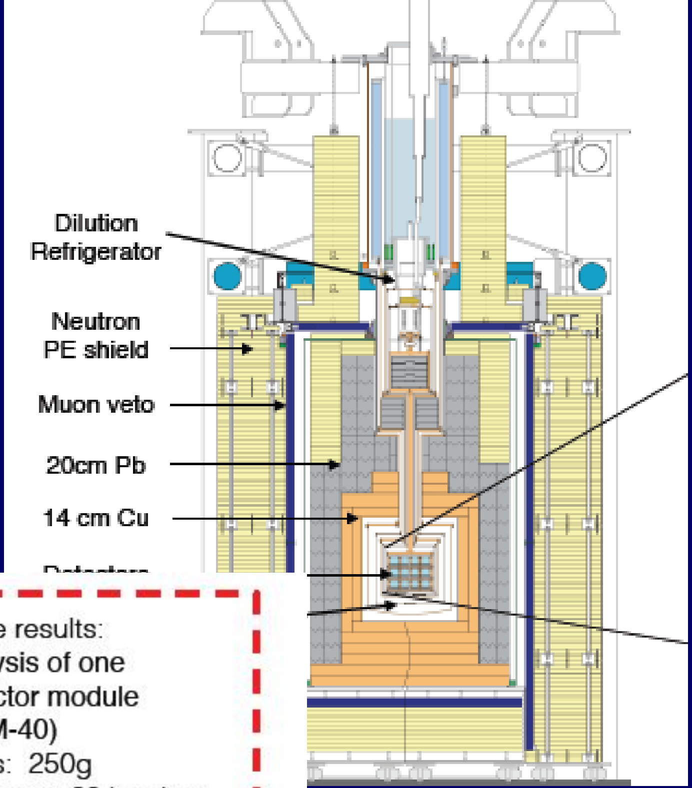




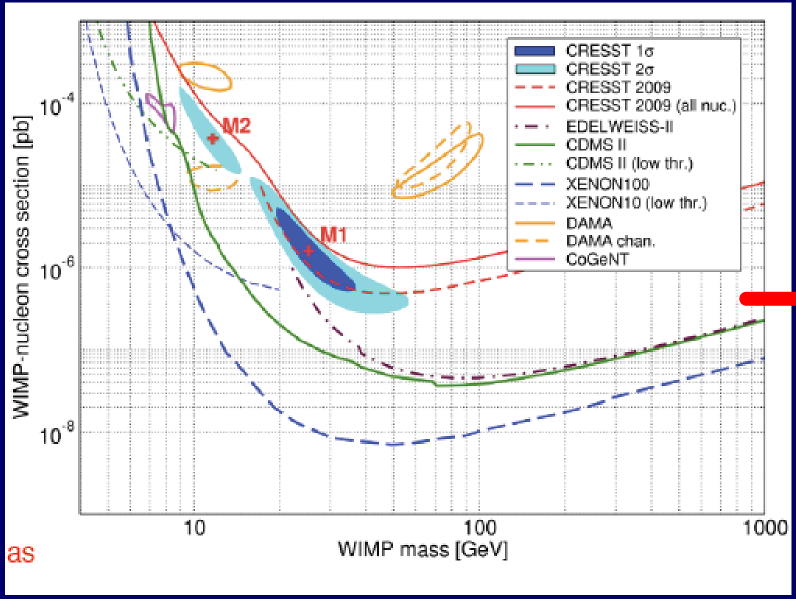
Let us turn to low masses …

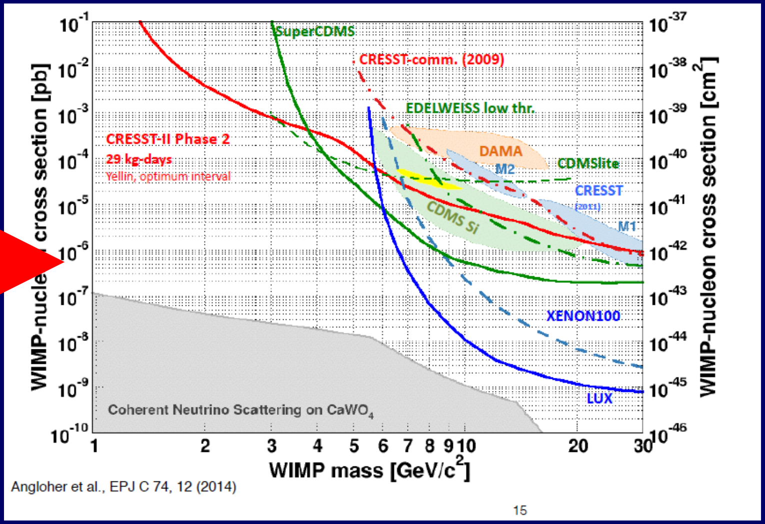
CRESST (Gorla)

- Cryo bolometer based on CaWO crystals (heat/light)
- Phase I had seen a 4σ excess
- Phase II: 29kg-days → gone
- 500kg-days about to be unblinded
- Upgrade optimized for low mass planned (CRESST-III→ threshold 600eV→100eV)



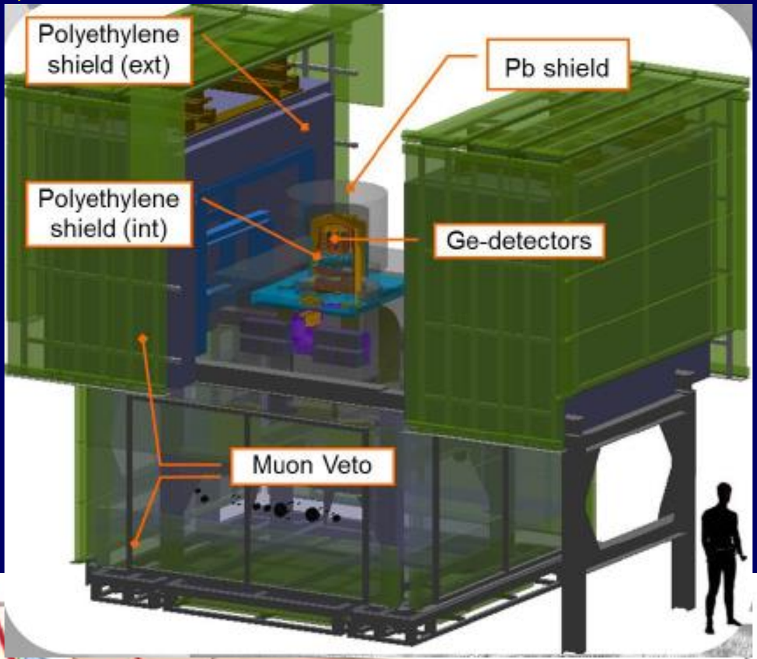
these results:
analysis of one detector module (TUM-40)
mass: 250g
exposure: 29 kg-days

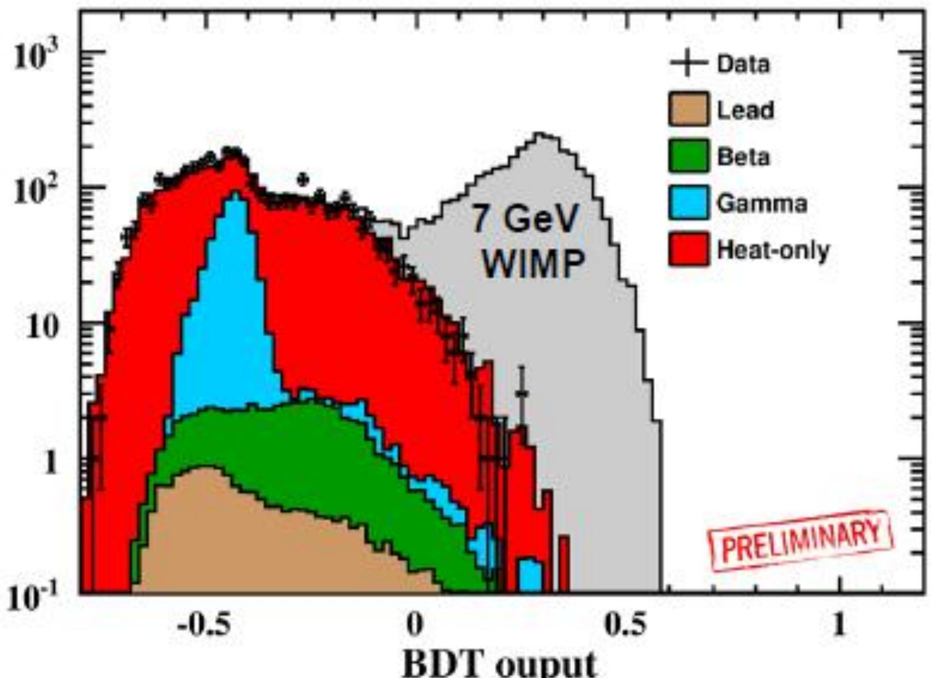


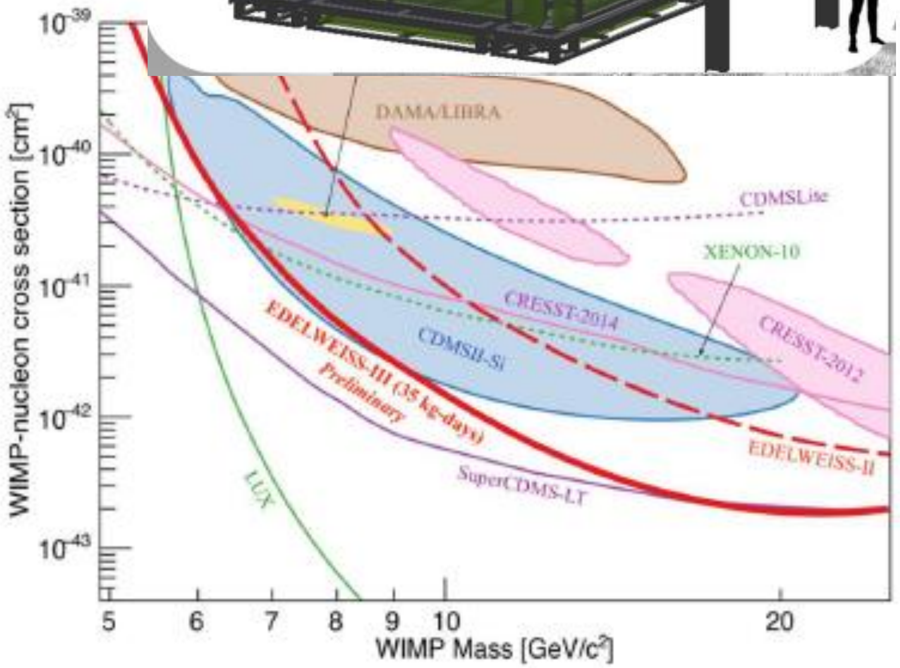


EDELWEISS-III (Heuermann)

- Cryogenic bolometer based on Ge, heat/ionisation
- Low mass WIMP analysis (<10GeV), presented based on 35 kg days
  (1 mod, Juli 2014-Apr 2015)
- 10 times more data in the pipeline

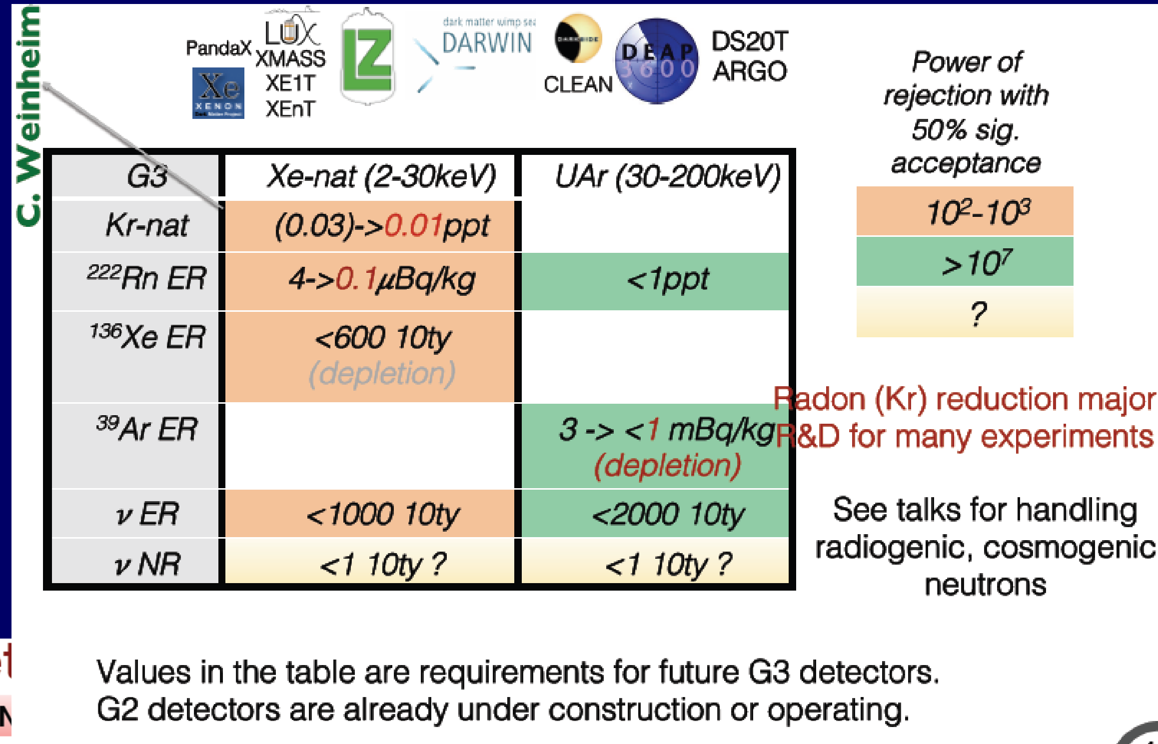






Future (Pantic)

- Thorough review of challenges for solid state and LXe/LAr G3 detectors.
- Directional detection



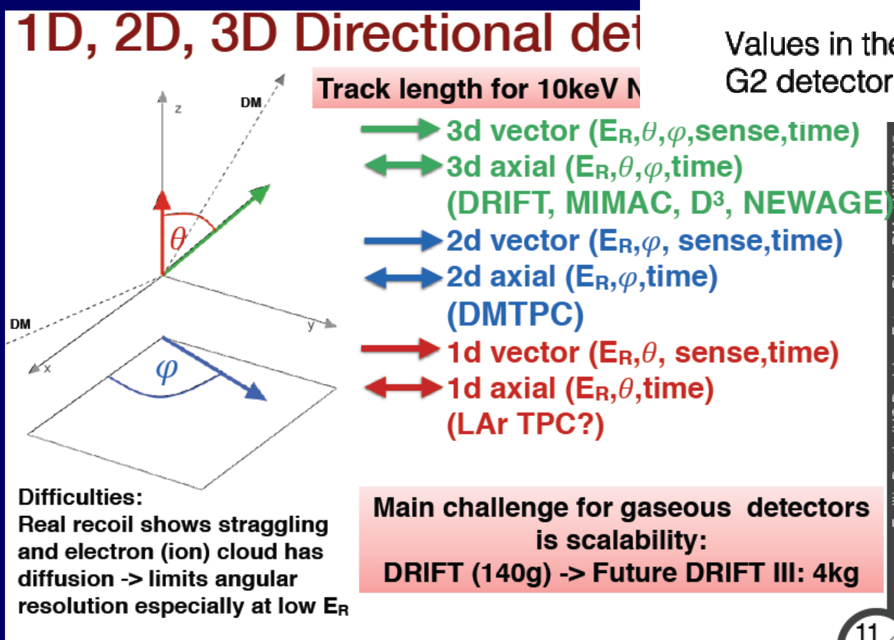
G3	Xe-nat (2-30keV)	UAr (30-200keV)
Kr-nat	(0.03)->0.01ppt	
^{222}Rn ER	4->0.1µBq/kg	<1ppt
^{136}Xe ER	<600 10ty (depletion)	
^{39}Ar ER		3 -> <1 mBq/kg (depletion)
ν ER	<1000 10ty	<2000 10ty
ν NR	<1 10ty ?	<1 10ty ?

Power of rejection with 50% sig. acceptance
10^2-10^3
$>10^7$
?

Radon (Kr) reduction major R&D for many experiments

See talks for handling radiogenic, cosmogenic neutrons

Values in the table are requirements for future G3 detectors.
G2 detectors are already under construction or operating.



One slide summary of the session.

For high mass (>10 GeV) dual phase liquid Xe TPCs continue to dominate. LUX/XENON100 have analyses in the pipeline that will push the limits by a factor of a few. Next break-through: XENON1T. Upgrade XENONNT and LZ (somewhat later will push the sensitivity to neutrino background. This scale will open new physics channels (CNNS, solar neutrinos …). The first LAr results which will be comparable to XENON1T will be single phase Lar (DEAP-360)

LAr dual phase have shown first results (DarkSide) and now pursue an aggressive

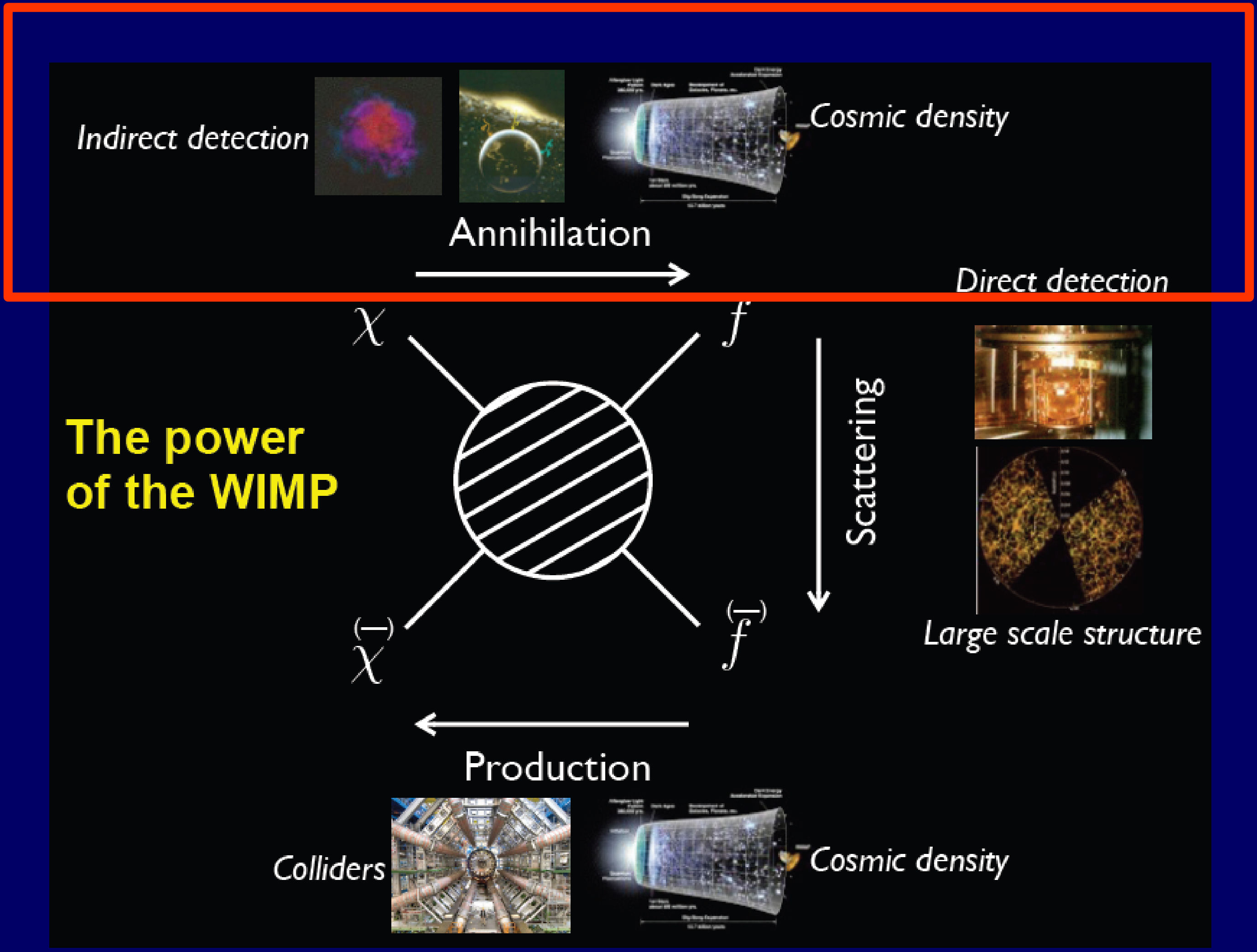
programme towards a 20t (G3) detector and 200t ((G4?) detector. For this scale detectors both LXe and LAr will face challenges (background rejectiacton (LXe), upscale by a factor 100 (LAr)

To my mind only NT scale detection will motivate N0-T detectors.

On the bolometer side, EDELWEISS/CRESST progress fast and pursue programs that focus on low mass (<10 GeV) WIMP range. G2: Eureca/SCDMS 2 x 50 kg bolometer is under formation.

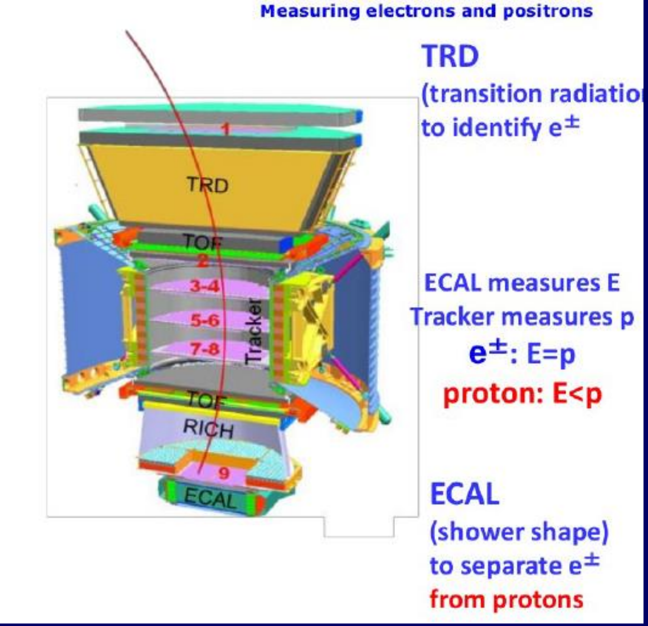
Astroaparticle physics experiment

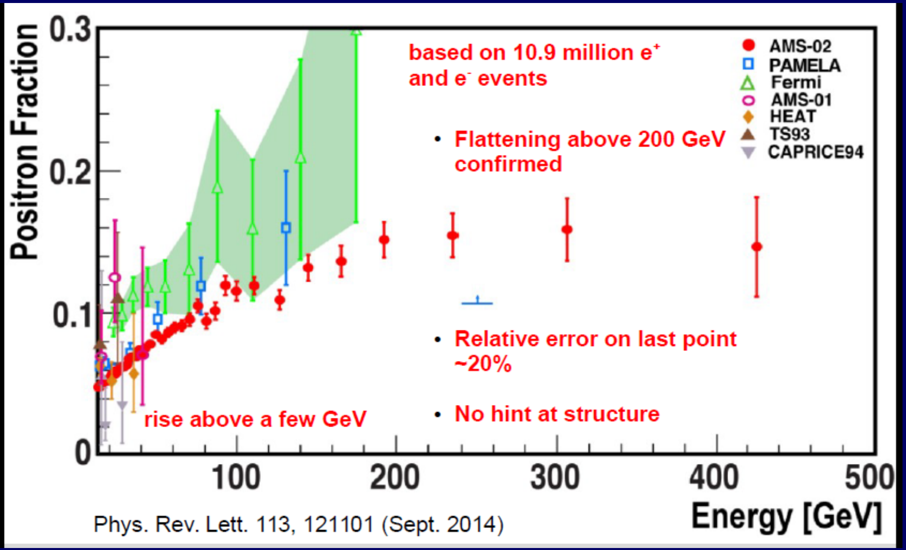
INDIRECT DETECTION OF DARK MATTER

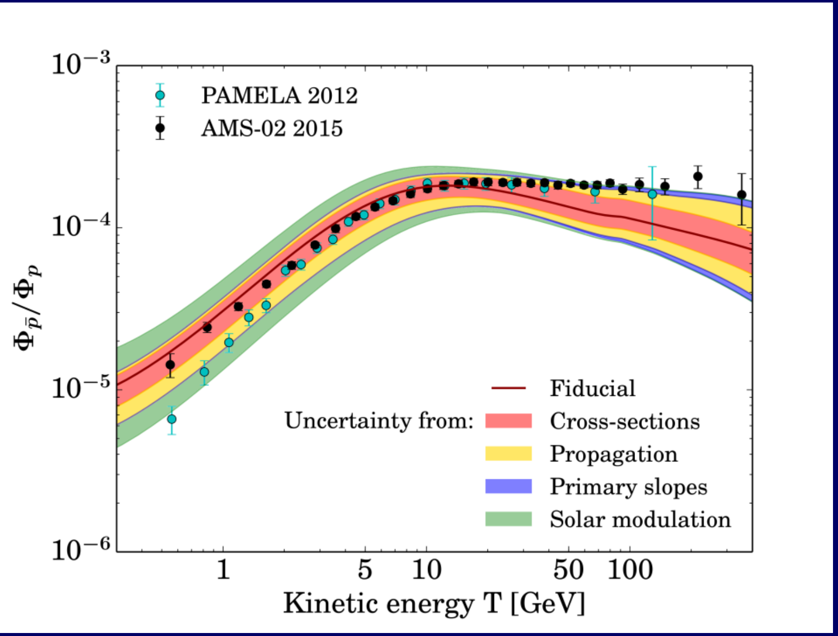


AMS (Gebauer)

- Spectrometer on ISS
- Positron fraction with flattening
- Antiproton-fraction excess
- p/Li/He hardening
- Dark Matter? No need it seems

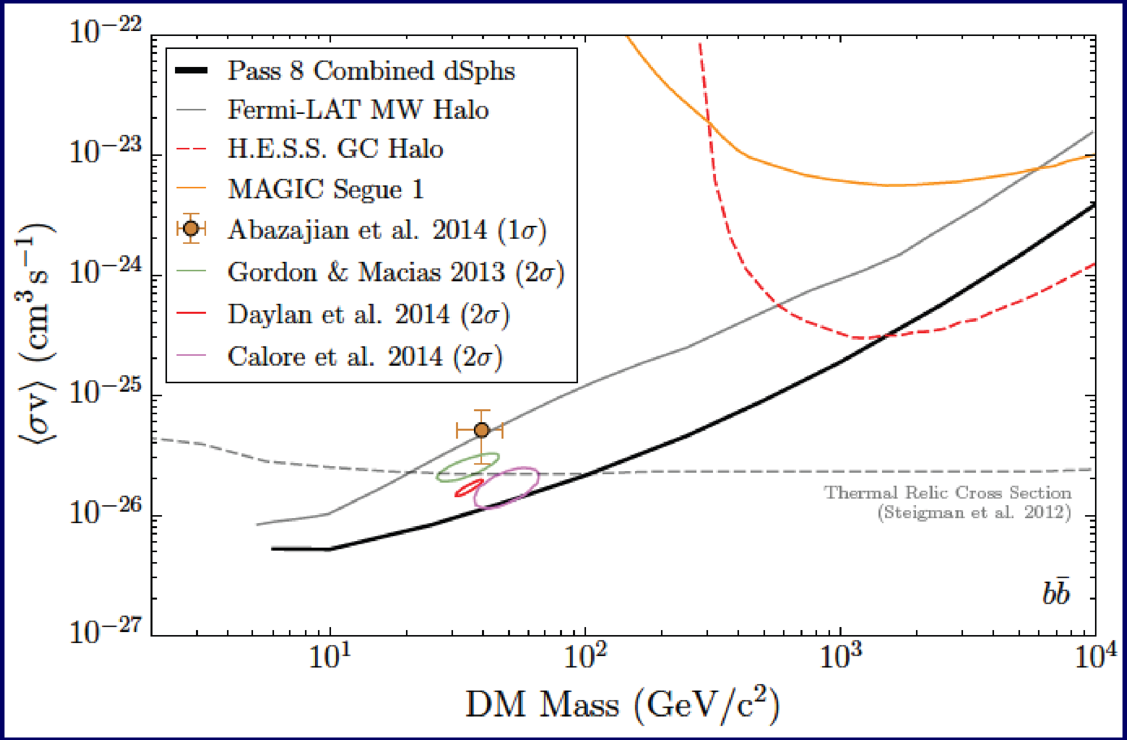






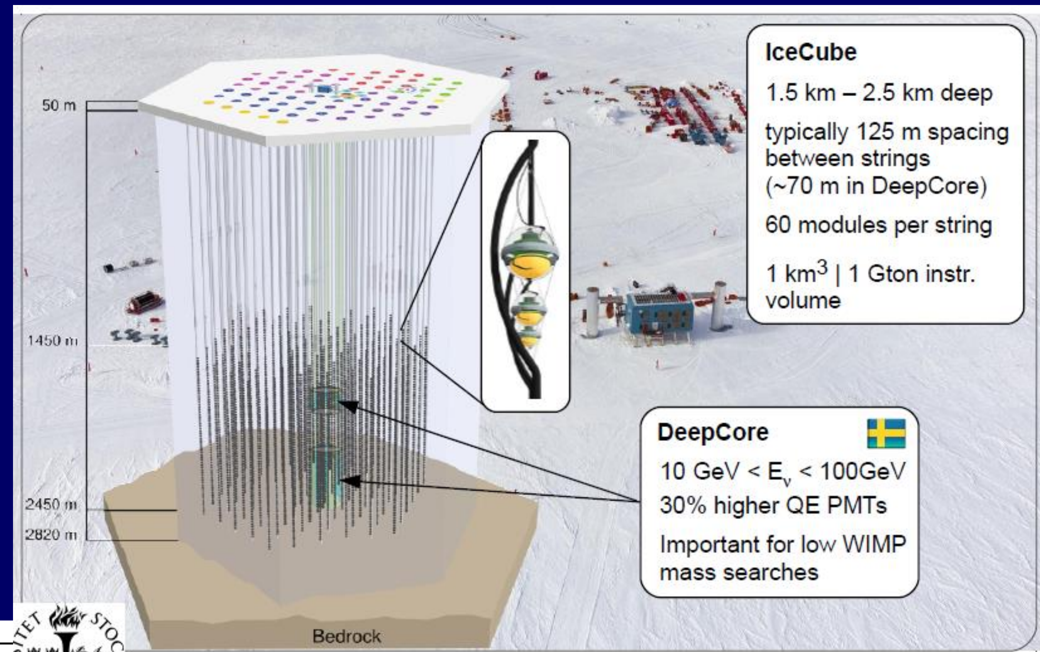
Fermi-LAT (Anderson)

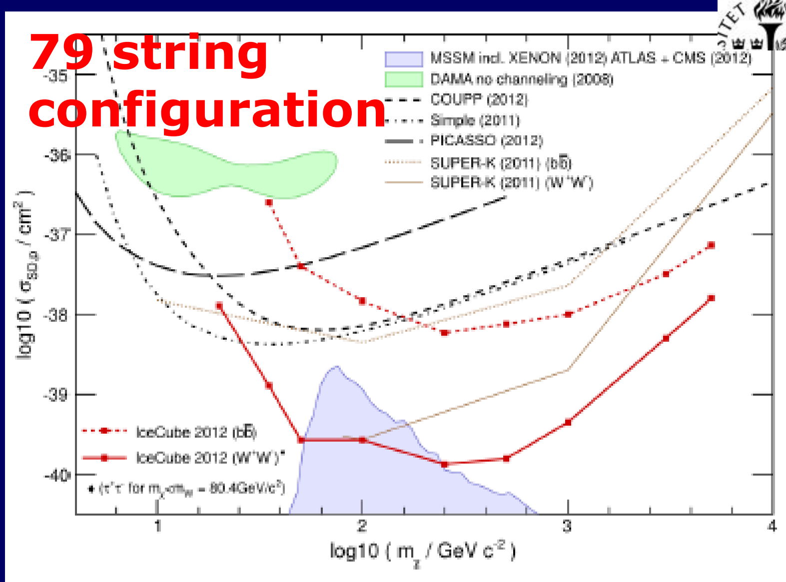
- 8th iteration of Fermi-LAT event selection
- Updated analysis of stacked dwarf analysis
- Exclusion of vanilla thermal WIMPs < 100 GeV (bbar)!
- State of the art in indirect detection

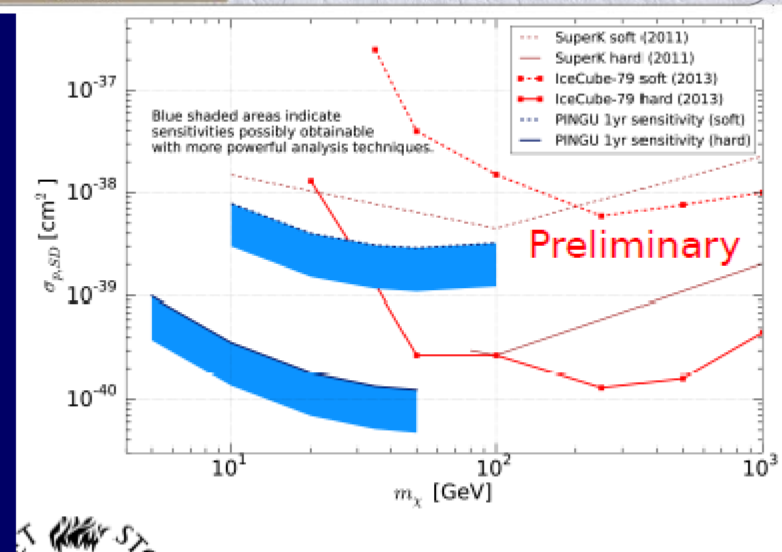


DM withICECUBE (Wolf)

- Very competetive limits on spin dependent WIMP nucleon cross-section
- PINGU good potential for masses below a few 10s of GeV

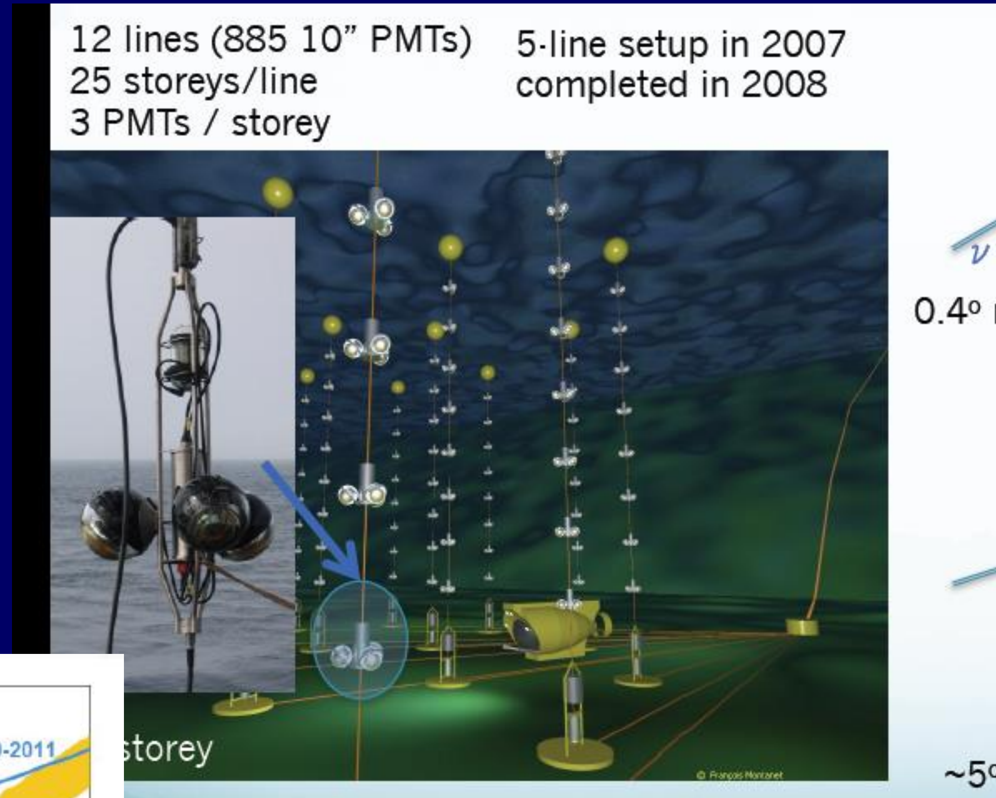


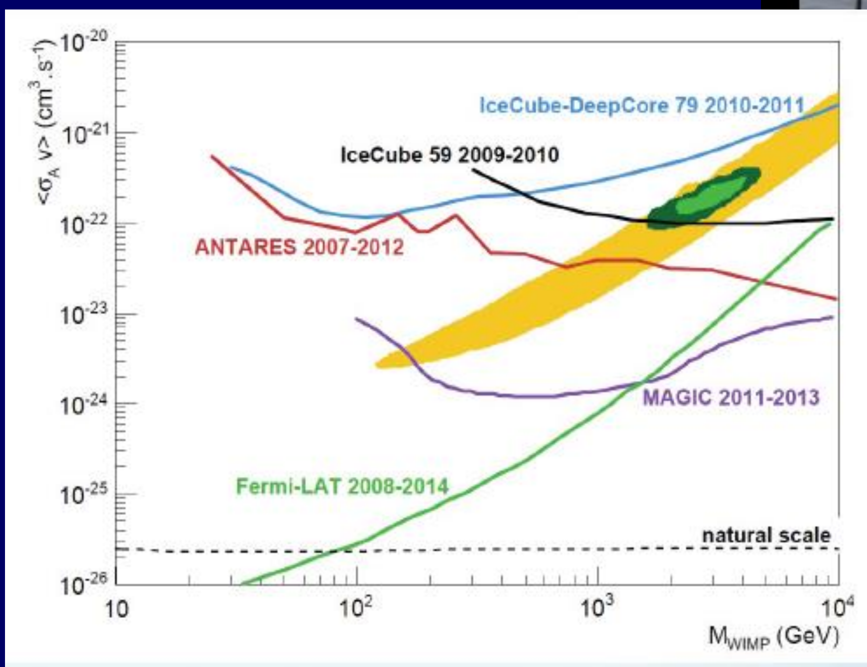


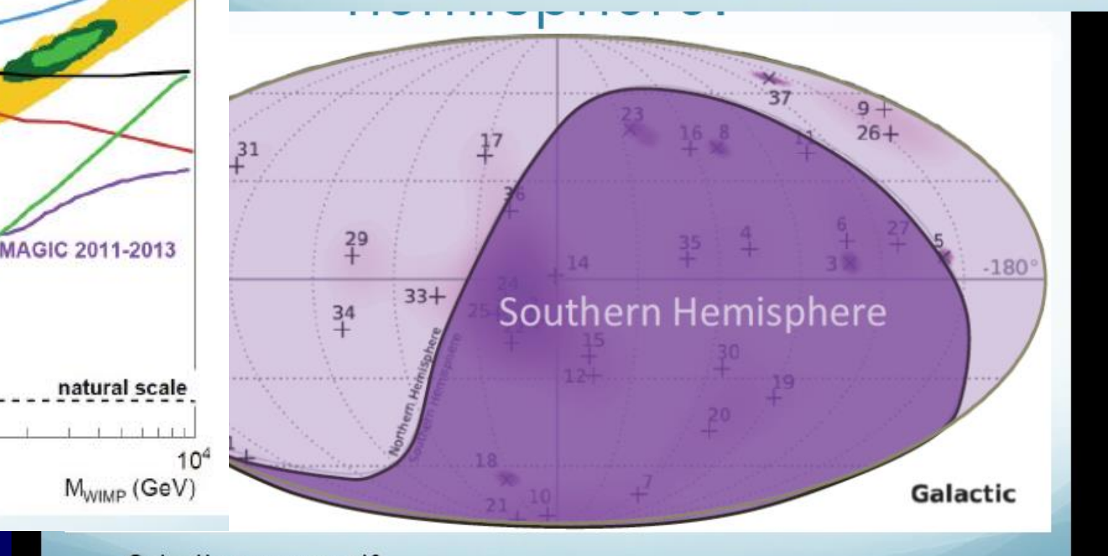


ANTARES

- Main advantages exposure of GC, e.g. Fermi-bubbles.
- end of data taking 2016

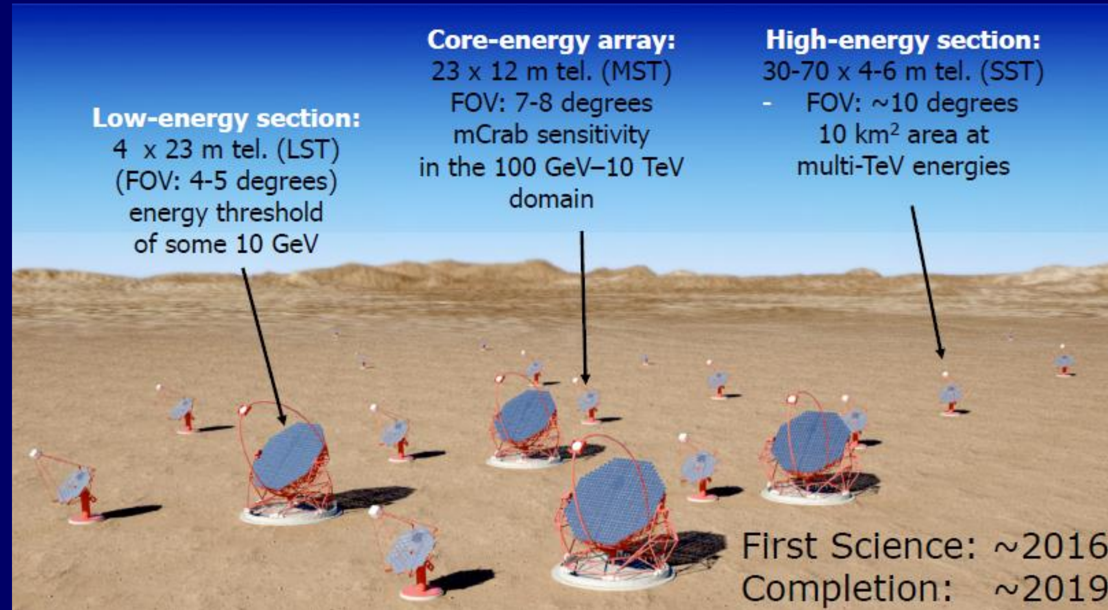


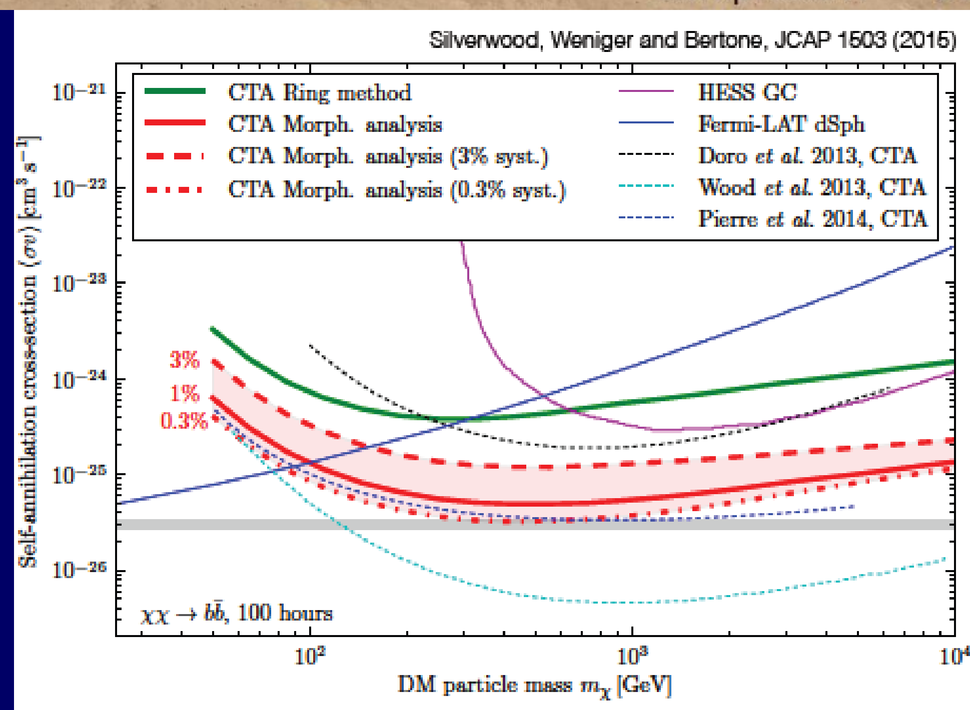




CTA (Fornasa)

- ~80 telescope Cherenkov telescope
- GC: Namibia/Chile
- Galactic Center Halo constraints vanilla WIMP thermal dark matter upto ~1 TeV
- Decision on site this year, start of construction next year. Prototyping in full swing.
- 2016 -- 2019

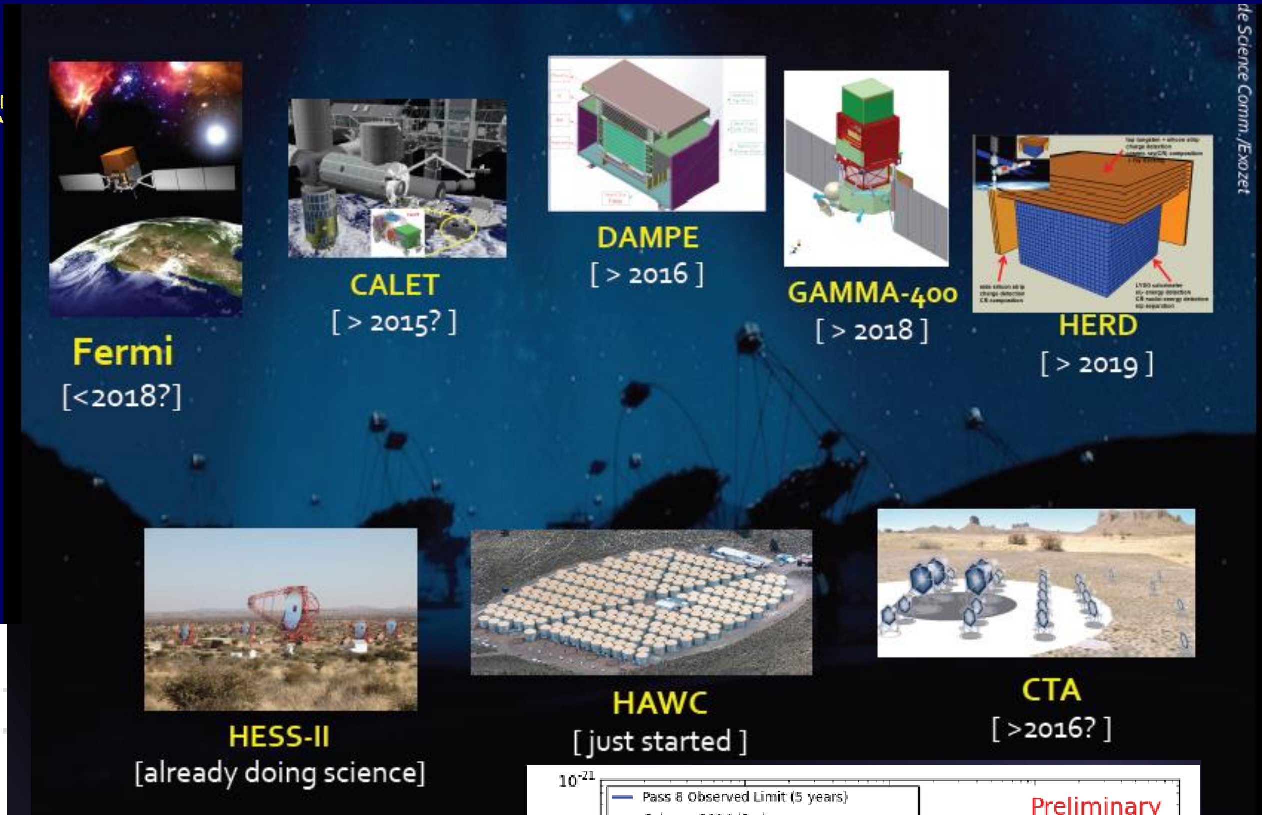


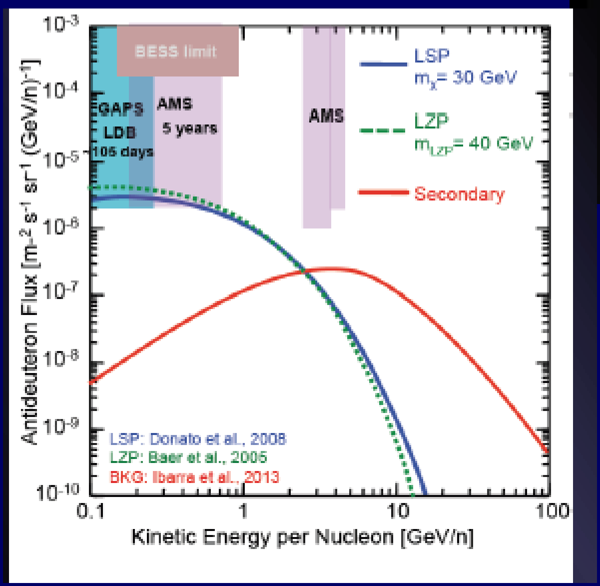


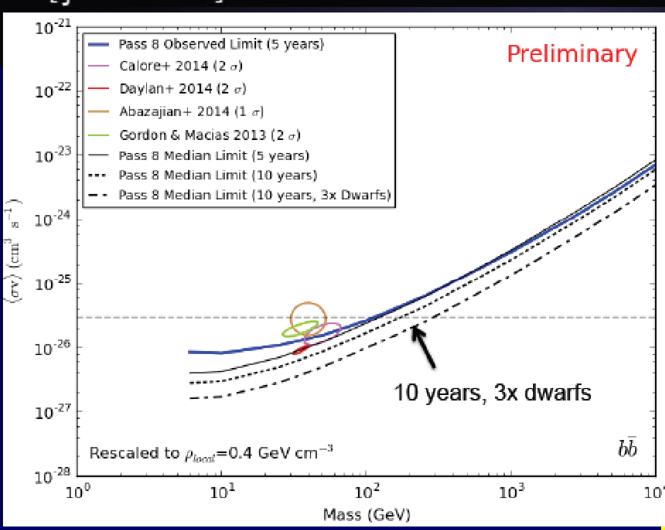
Other future (Sánchez-Conde)

- IACTs: HESSII, VERITAS: $\sigma v \sim 10^{-25}$
- Big calorimeters: CALET (2016), DAMPE (2016)
  HERD (2019)

Cosmic-rays: GAPS







1 slide summary of sessions

Charged cosmic provide an unexplained excess, which could be dark matter, however unlikely in the view of plenty of conventional explanations. It is not clear whether data will tell.

IceCube is pushing its sensitivity in annihilation but it is largely competitive only for WIMP signals from Sun, i.e. SD scattering cross-section. Future: PINGU pushing this constraints to lower limits, HE extensions → non-standard WIMP scenarios.

The spear head of indirect detection is the Fermi-LAT search in dwarf galxies, now excluding robustly thermal WIMPs below 100 GeV. At tension with the alleged Galactic Center excess.

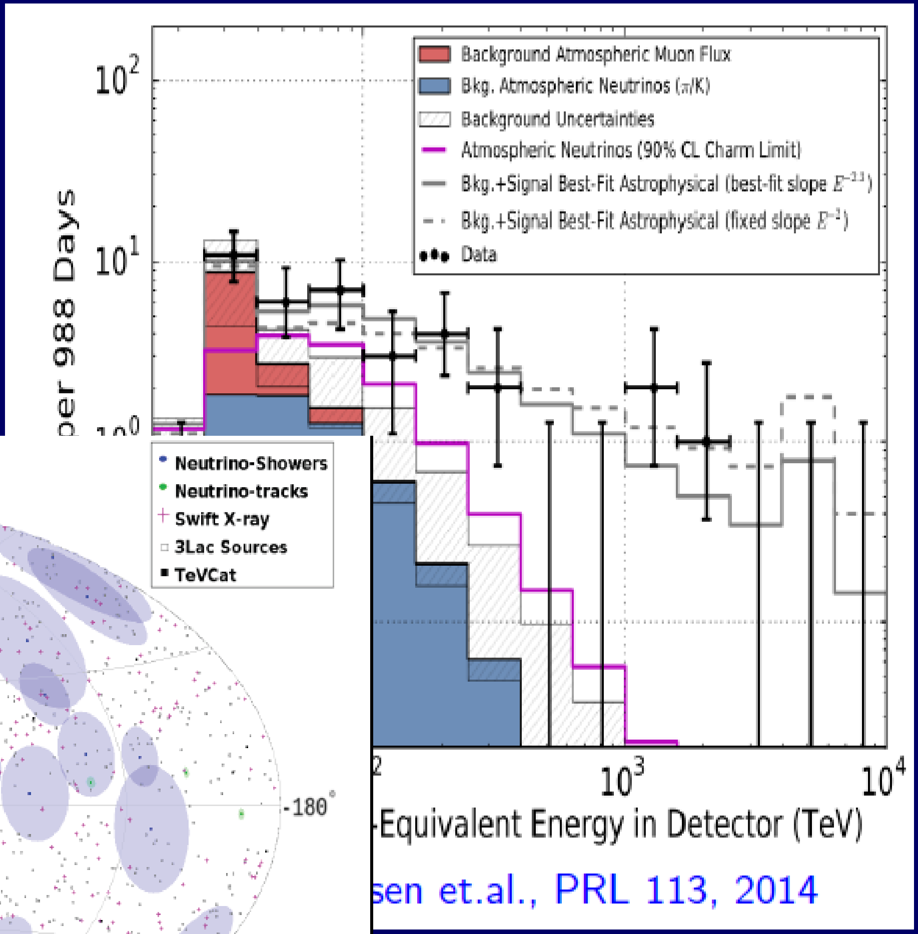
Future: CTA, especially interesting if LHC does not see anything (WIMP masses > 500 GeV), nearer (Fermi-like): DAMPE, HERD, GAMMA-400, LE: PANGU,AstroMeV

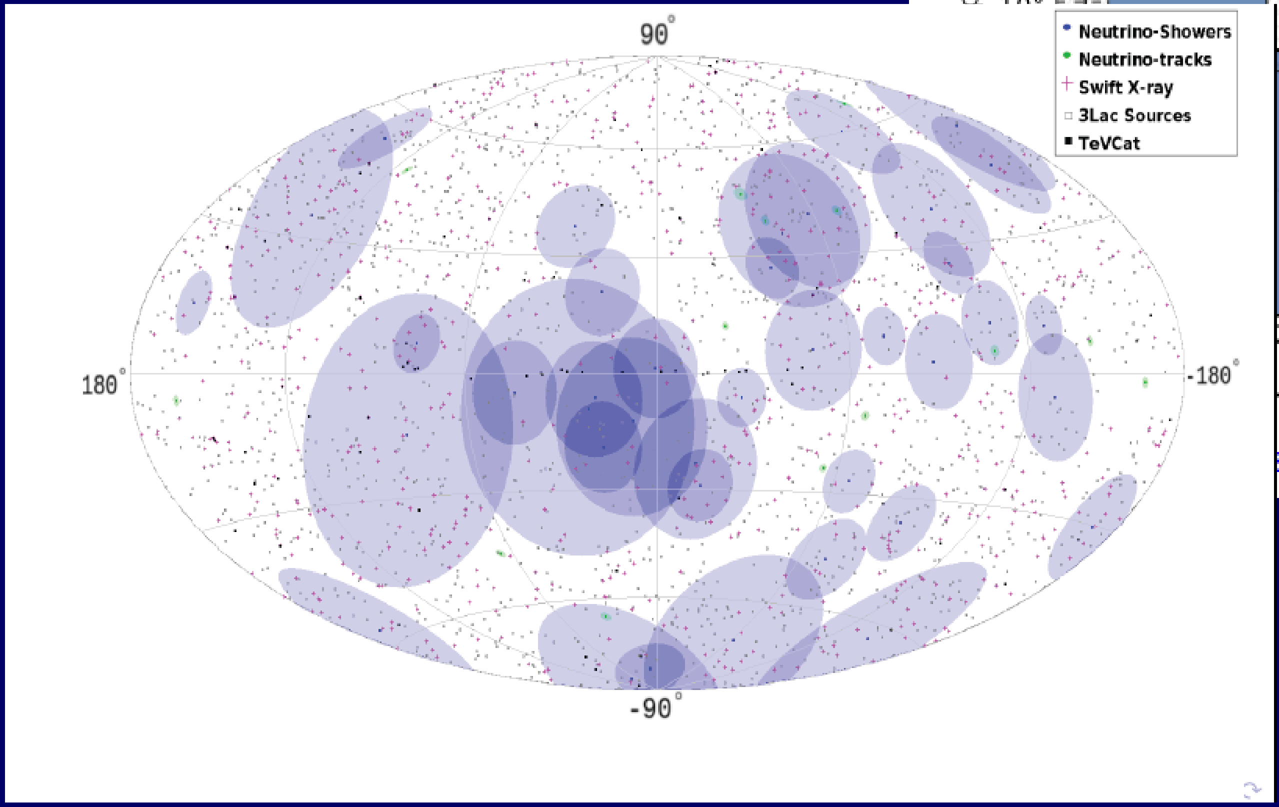
Astropartile physics - experiment

COSMIC NEUTRINOS

IceCube events (Moharana)

- 37 events, 5.7 sigma over background (about 15 expected), 3 years
- Correlatíon study with cosmic-rays, known extragalatcic sources.





Predictions for WIN 2017

- Indirect detection of WIMPs
  - vanilla WIMP exclusion upto 200 GeV or GC excess confirmation?
- Direct detection of WIMPs
  - Ultimate LUX results
  - First XENON1T results
  - XENONNT construction status reportmt
  - EdelweissIII/CRESSTIII results, SCDMS,EURECA R&D
- Cosmic neutrinos
  - First detection of cosmic neutrino point source
- LHC run2 will guide us
  - CTA explore ~ TeV range

(see Heinemeiers talk for an example of LHC results effect on DM in SUSY, Buchmüllers talk on simplified models)

1T

Source	Background (ev. / ton /y)
ER (materials + intrinsic + solar ν)	0.32
NR from radiogenic neutrons	0.22
NR from neutrino coherent scattering	0.21 (relevant just for low mass WIMPs)
Total	**0.55** (0.75 for low mass WIMPs)

NT

Source	Background (ev. / ton / y)
ER (intrinsic + solar ν)	0.27
NR from neutrino coherent scattering	0.21
Total	**0.48**