



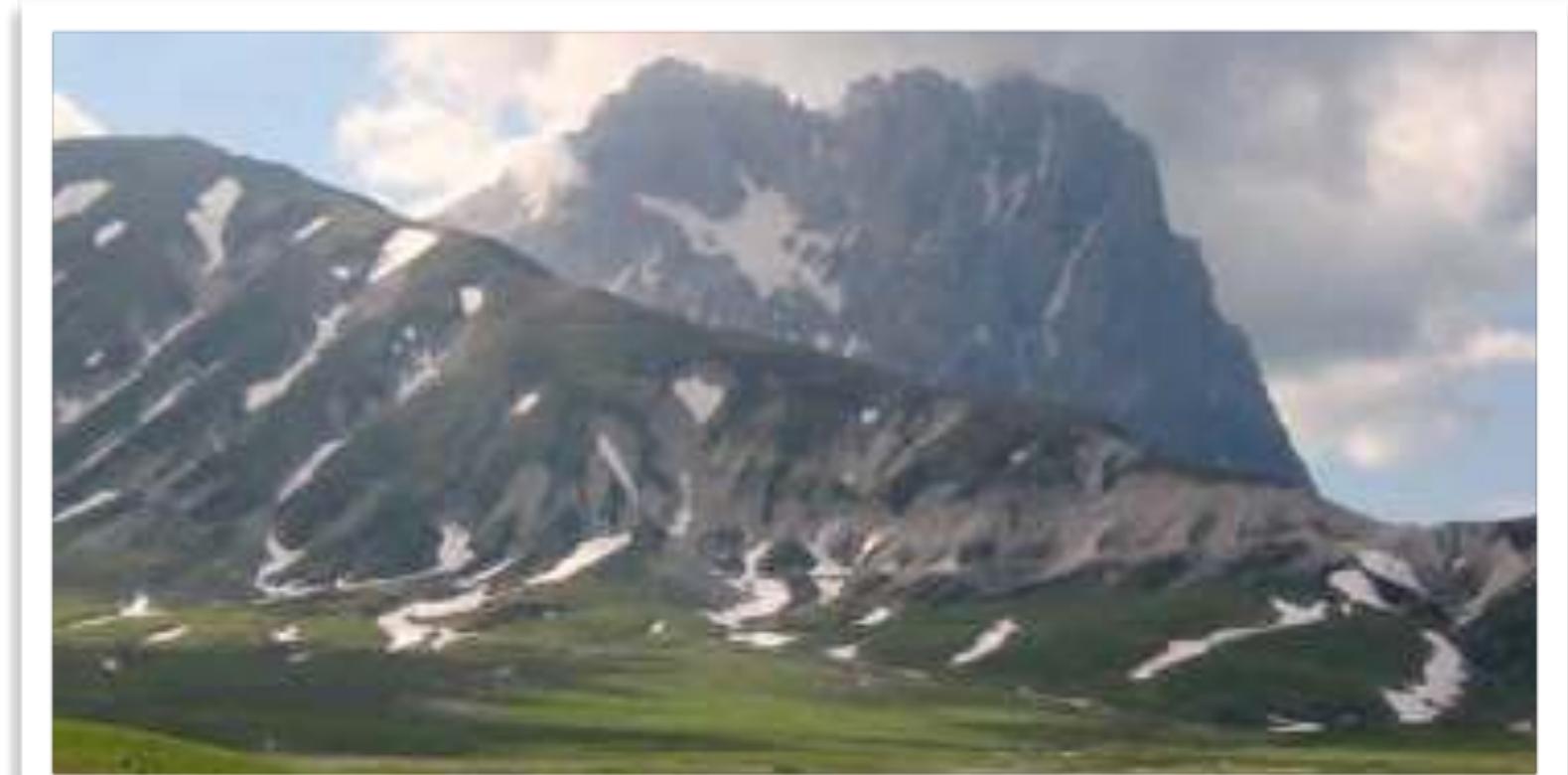
Universität  
Zürich<sup>UZH</sup>

# Highlights from the XENON dark matter search

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Laura Baudis  
University of Zurich

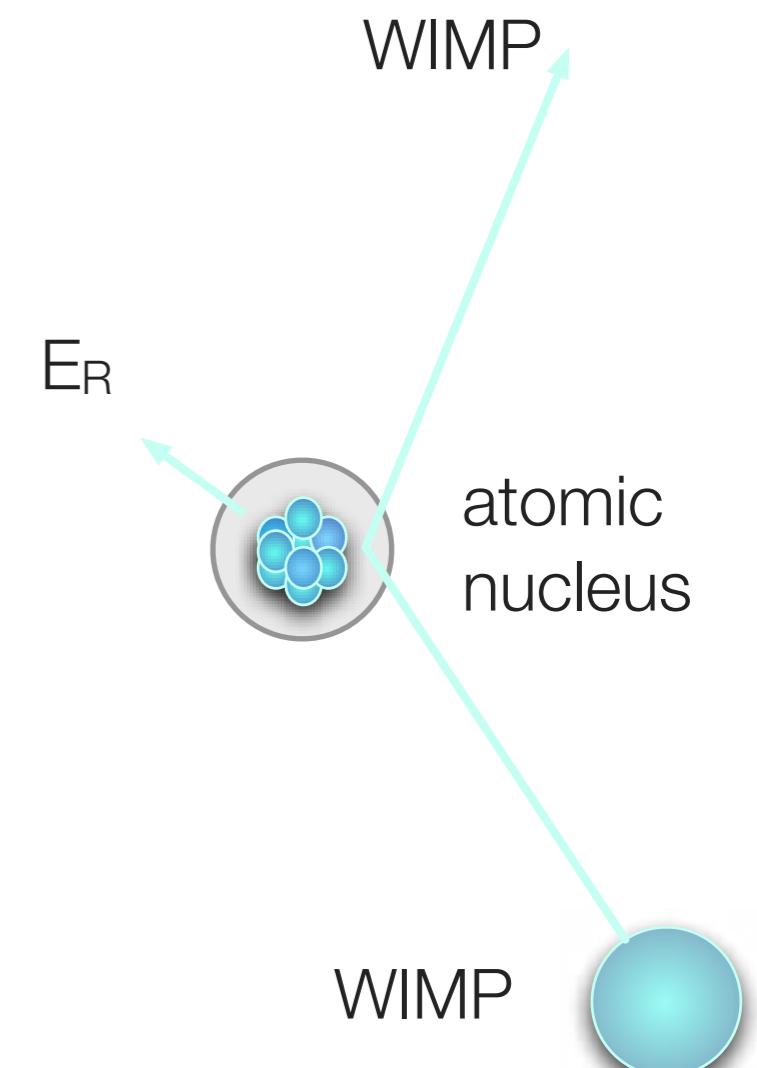
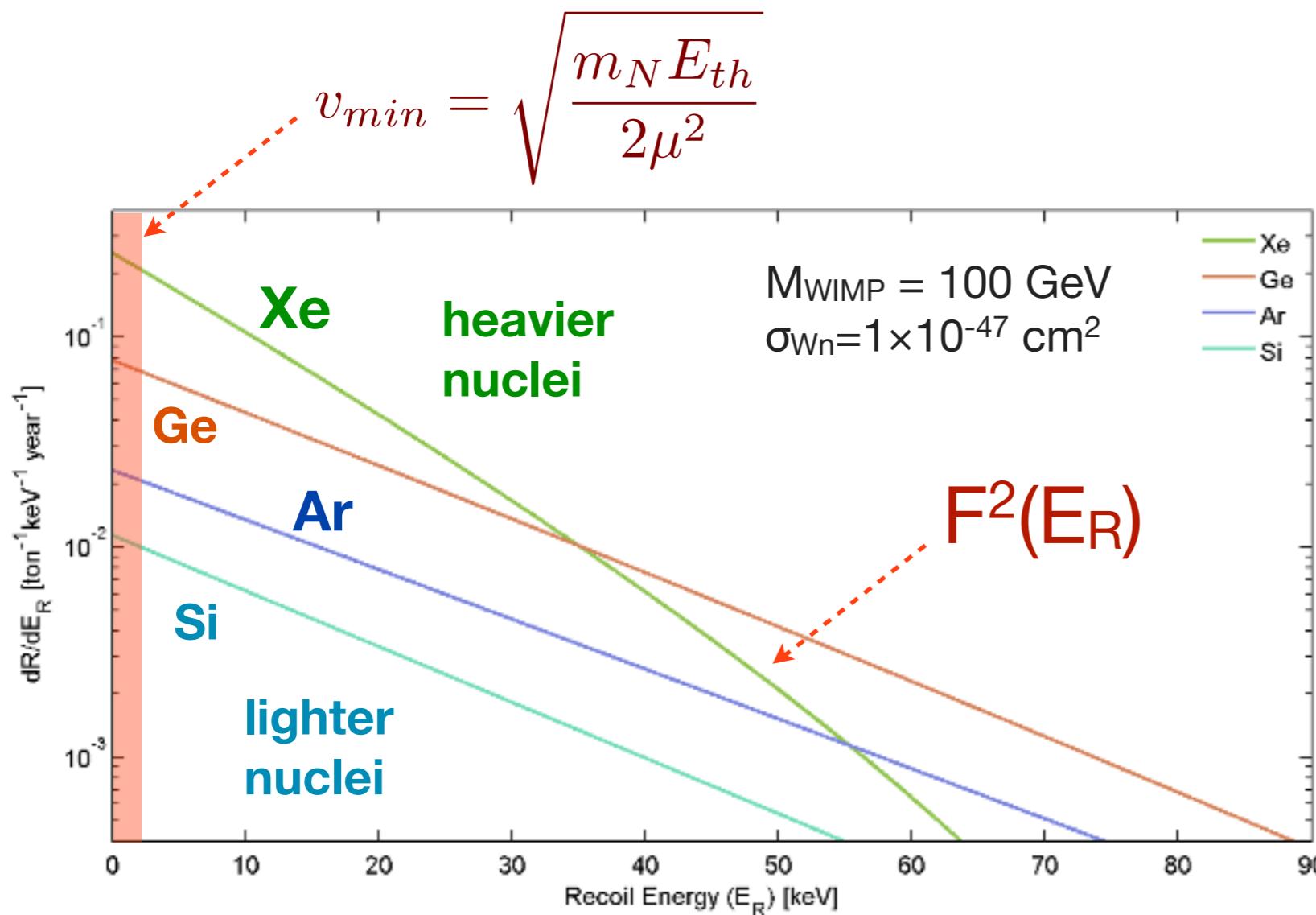
The spacetime odyssey continues  
Stockholm, June 3, 2015



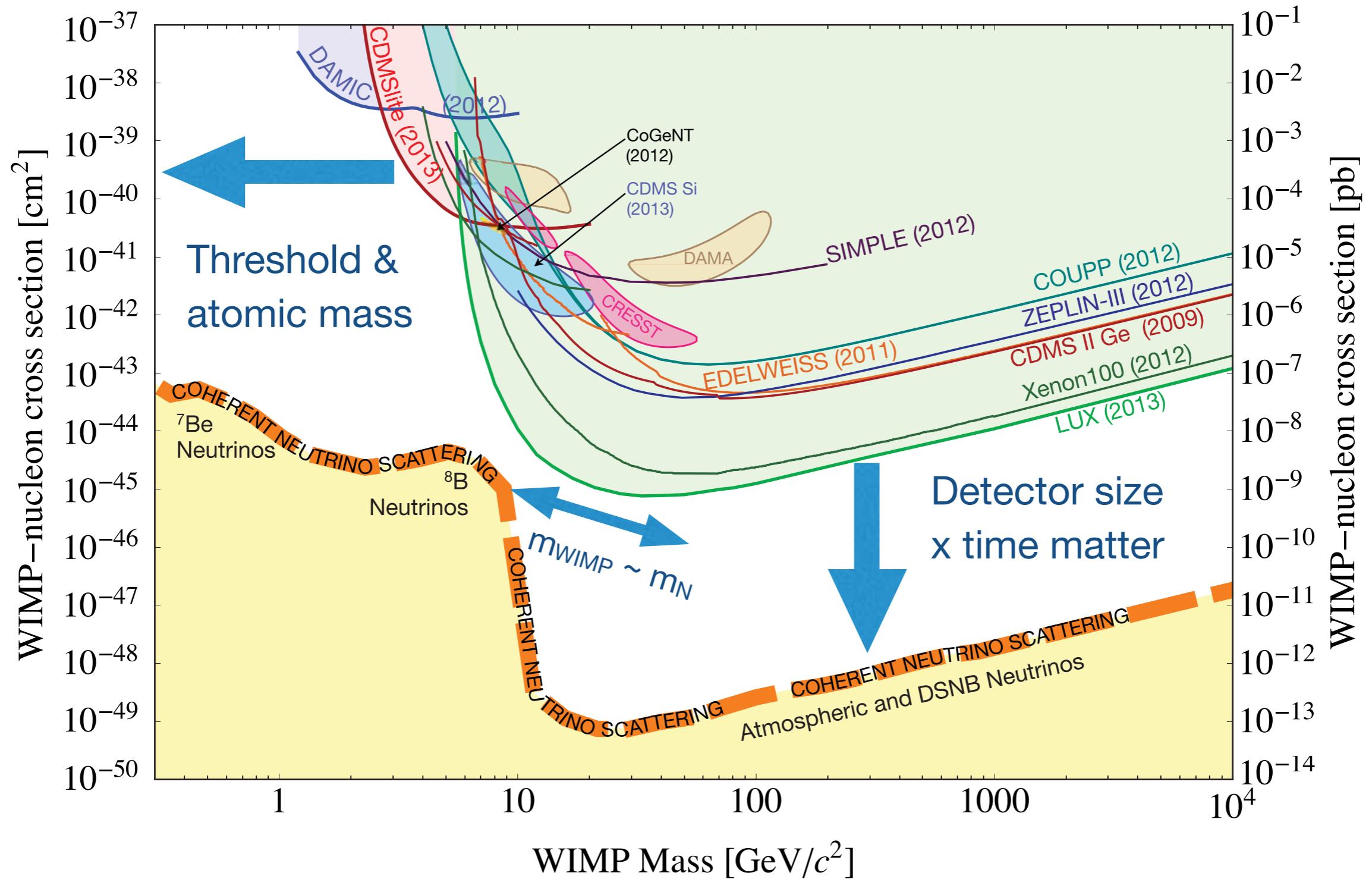
# Physics goal of the XENON programme

- Detect WIMP-xenon collisions

$$R \sim 0.13 \frac{\text{events}}{\text{kg year}} \left[ \frac{A}{100} \times \frac{\sigma_{WN}}{10^{-38} \text{ cm}^2} \times \frac{\langle v \rangle}{220 \text{ km s}^{-1}} \times \frac{\rho_0}{0.3 \text{ GeV cm}^{-3}} \right]$$



# The WIMP landscape in 2015



# Noble gases in Mendeleev's Periodic Table

Ueber die Beziehungen der Eigenschaften zu den Atomgewichten der Elemente. Von D. Mendeleeff. — Ordnet man Elemente nach zunehmenden Atomgewichten in verticale Reihen so, dass die Horizontalreihen analoge Elemente enthalten, wieder nach zunehmendem Atomgewicht geordnet, so erhält man folgende Zusammenstellung, aus der sich einige allgemeinere Folgerungen ableiten lassen.

	Ti = 50	Zr = 90	? = 180
	V = 51	Nb = 94	Ta = 182
	Cr = 52	Mo = 96	W = 186
	Mn = 55	Rh = 104,4	Pt = 197,4
	Fe = 56	Ru = 104,4	Ir = 198
H = 1	Ni = Co = 59	Pd = 106,6	Os = 199
	Cu = 63,4	Ag = 108	Hg = 200
Be = 9,4	Zn = 65,2	Cd = 112	
B = 11	Al = 27,4	? = 68	Ur = 116
C = 12	Si = 28	? = 70	Sn = 118
N = 14	P = 31	As = 75	Sb = 122
O = 16	S = 32	Se = 79,4	Te = 128?
F = 19	Cl = 35,5	Br = 80	J = 127
Li = 7 Na = 23	K = 39	Rb = 85,4	Cs = 133
	Ca = 40	Sr = 87,6	Tl = 204
	? = 45	Ce = 92	Pb = 207
	?Er = 56	La = 94	
	?Yt = 60	Di = 95	
	?In = 75,6	Th = 118?	

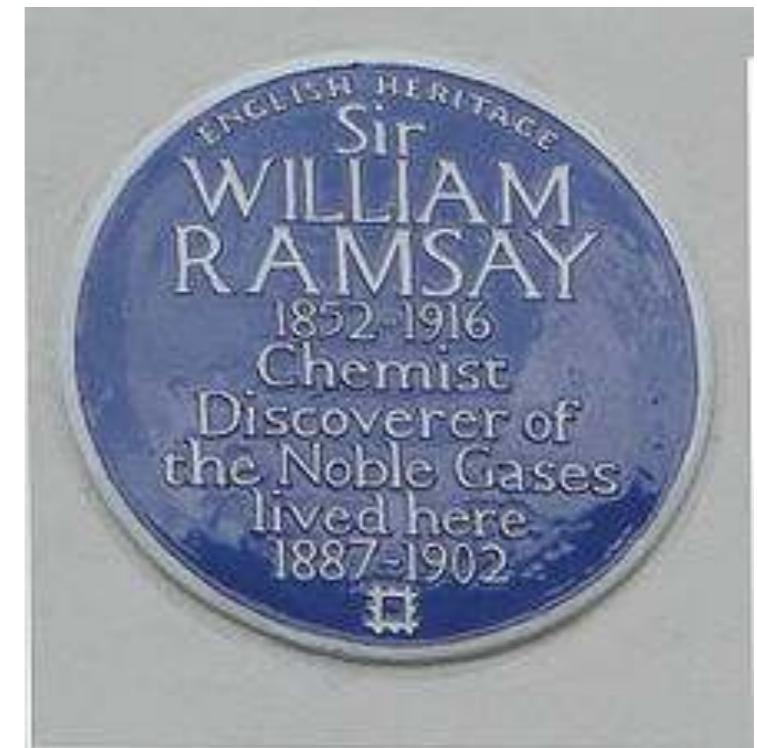
1. Die nach der Grösse des Atomgewichts geordneten Elemente zeigen eine stufenweise Abänderung in den Eigenschaften.

2. Chemisch-analoge Elemente haben entweder übereinstimmende Atomgewichte (Pt, Ir, Os), oder letztere nehmen gleichviel zu (K, Rb, Cs).

3. Das Anordnen nach den Atomgewichten entspricht der *Werthigkeit* der Elemente und bis zu einem gewissen Grade der Verschiedenheit im chemischen Verhalten, z. B. Li, Be, B, C, N, O, F.

4. Die in der Natur verbreitetsten Elemente haben *kleine* Atomgewichte

Discovered later by William Ramsay, student of Bunsen and professor at UC London  
1904 Nobel Prize in Chemistry



*"in recognition of his services in the discovery of the inert gaseous elements in air, and his determination of their place in the periodic system".*

Argon: "the inactive one", neon: "the new one", krypton: "the hidden one", **xenon: "the strange one"**

# Why xenon for direct dark matter detection?

- Dense, homogeneous target with self-shielding; fiducialization
- Large detector masses feasible at moderate costs
- High light (40 photons/keV) and charge ( $W_{\text{LAr}} = 24 \text{ eV}$ ,  $W_{\text{LXe}} = 15 \text{ eV}$ ) yields



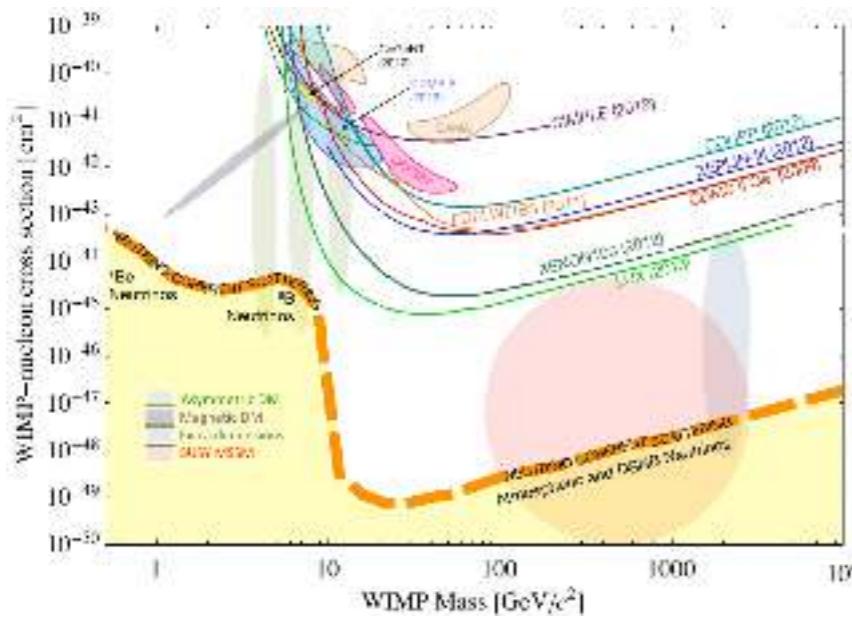
Properties [unit]	Xe	Ar	Ne
Atomic number:	54	18	10
Mean relative atomic mass:	131.3	40.0	20.2
Boiling point $T_b$ at 1 atm [K]	165.0	87.3	27.1
Melting point $T_m$ at 1 atm [K]	161.4	83.8	24.6
Gas density at 1 atm & 298 K [ $\text{g l}^{-1}$ ]	5.40	1.63	0.82
Gas density at 1 atm & $T_b$ [ $\text{g l}^{-1}$ ]	9.99	5.77	9.56
Liquid density at $T_b$ [ $\text{g cm}^{-3}$ ]	2.94	1.40	1.21
Dielectric constant of liquid	1.95	1.51	1.53
Volume fraction in Earth's atmosphere [ppm]	0.09	9340	18.2

W. Ramsay: “These gases occur in the air but sparingly as a rule, for while argon forms nearly 1 hundredth of the volume of the air, neon occurs only as 1 to 2 hundred-thousandth, helium as 1 to 2 millionth, krypton as 1 millionth and xenon only as about 1 twenty-millionth part per volume. *This more than anything else will enable us to form an idea of the vast difficulties which attend these investigations.*”

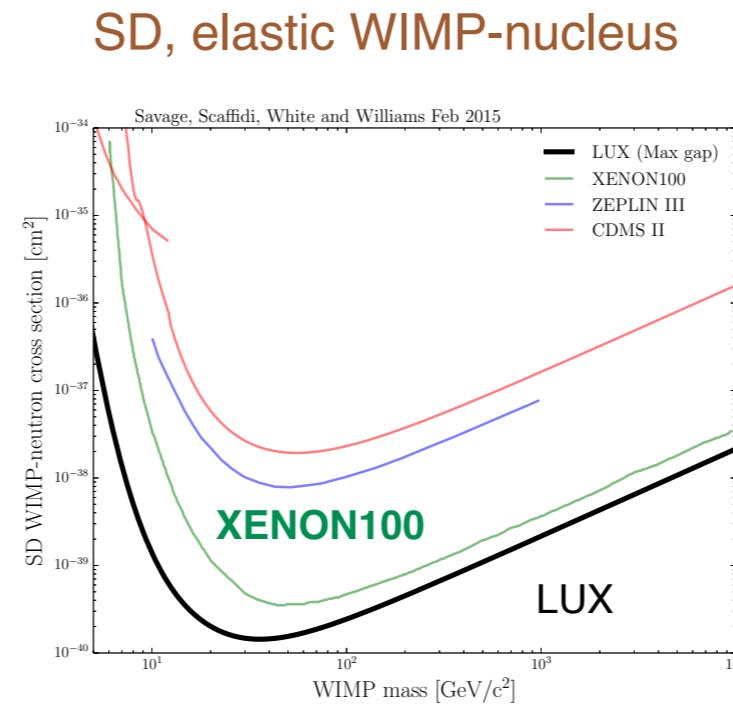
# WIMP physics with xenon

## Probe WIMP-Xenon interactions via various channels:

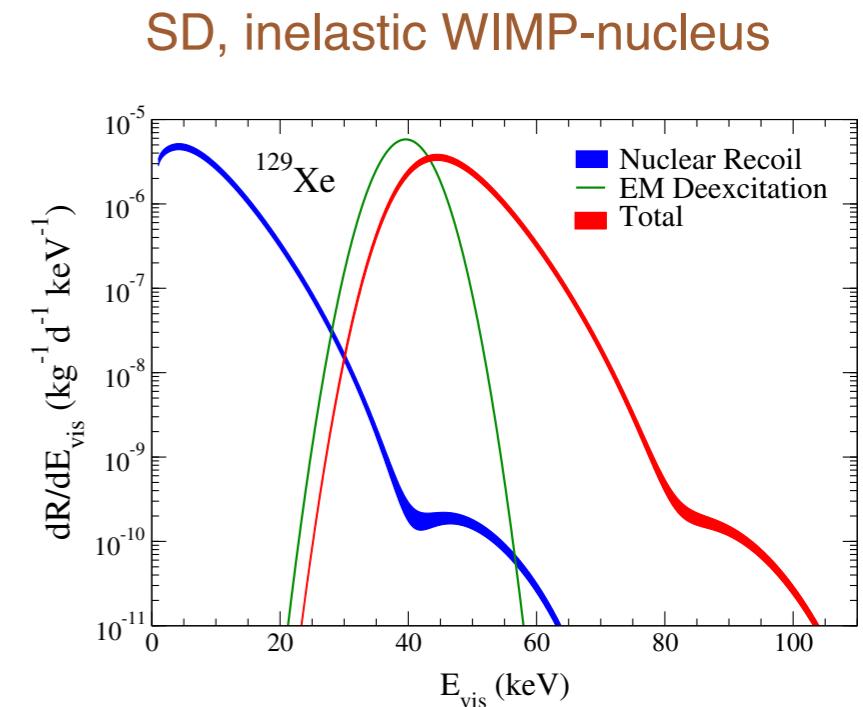
- spin-independent elastic scattering:  $^{124}\text{Xe}$ ,  $^{126}\text{Xe}$ ,  $^{128}\text{Xe}$ ,  $^{129}\text{Xe}$ ,  $^{130}\text{Xe}$ ,  $^{131}\text{Xe}$ ,  $^{132}\text{Xe}$  (26.9%),  $^{134}\text{Xe}$  (10.4%),  $^{136}\text{Xe}$  (8.9%)
  - spin-dependent elastic scattering:  $^{129}\text{Xe}$  (26.4%),  $^{131}\text{Xe}$  (21.2%)
  - inelastic WIMP- $^{129}\text{Xe}$  and WIMP- $^{131}\text{Xe}$  scatters     $\chi + ^{129,131} \text{Xe} \rightarrow \chi + ^{129,131} \text{Xe}^* \rightarrow \chi + ^{129,131} \text{Xe} + \gamma$   
1 ns 0.5 ns      40 keV 80 keV



arXiv:1310.8327

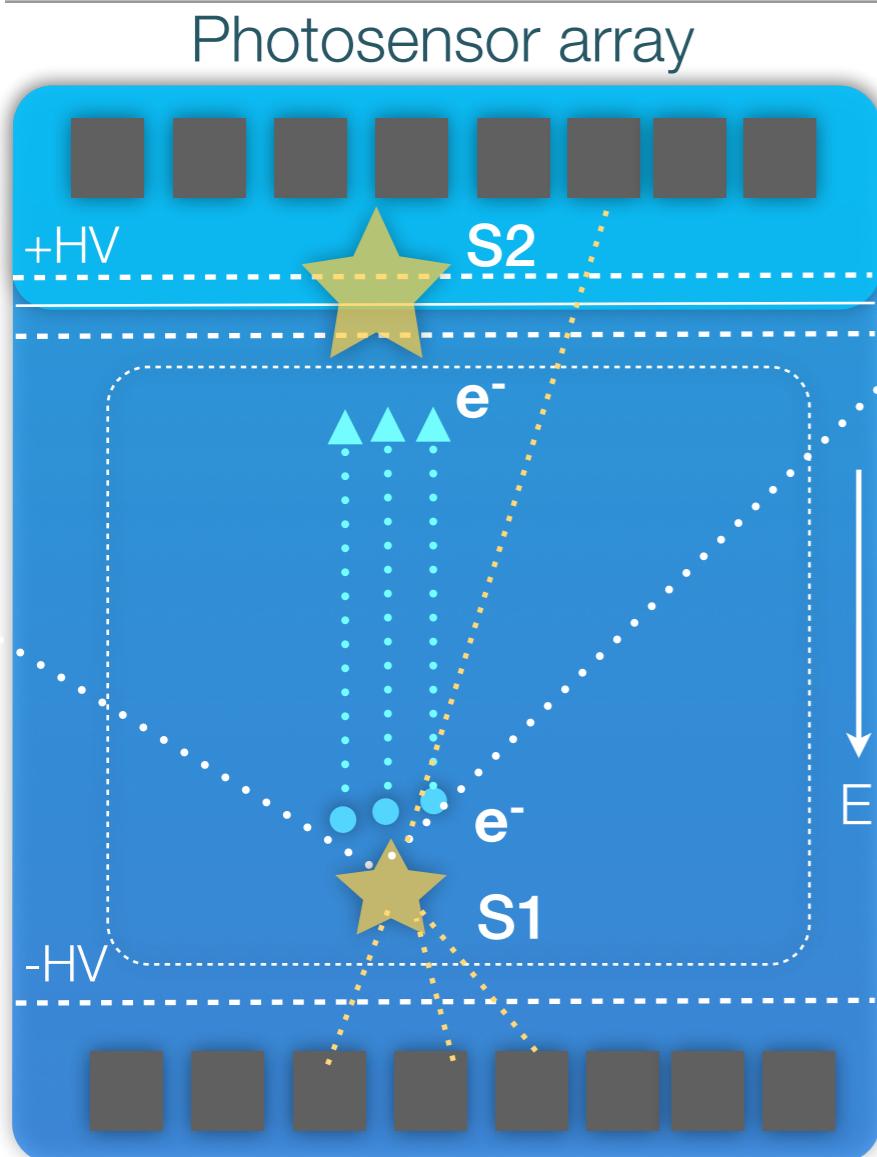


C. Savage et al, arXiv:1502.02667



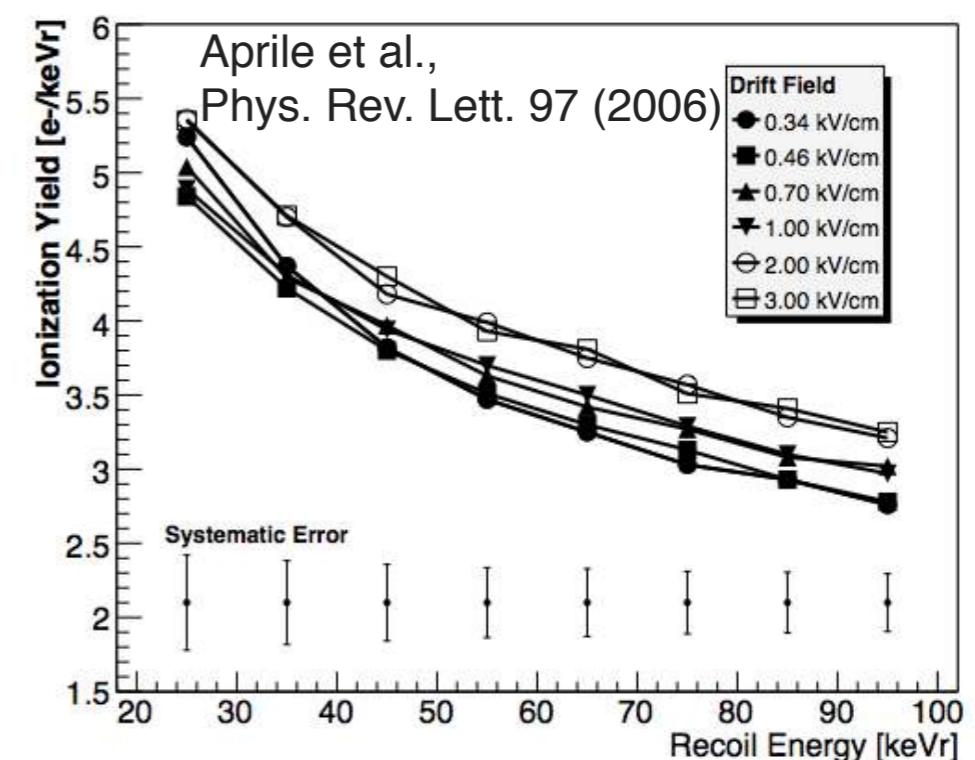
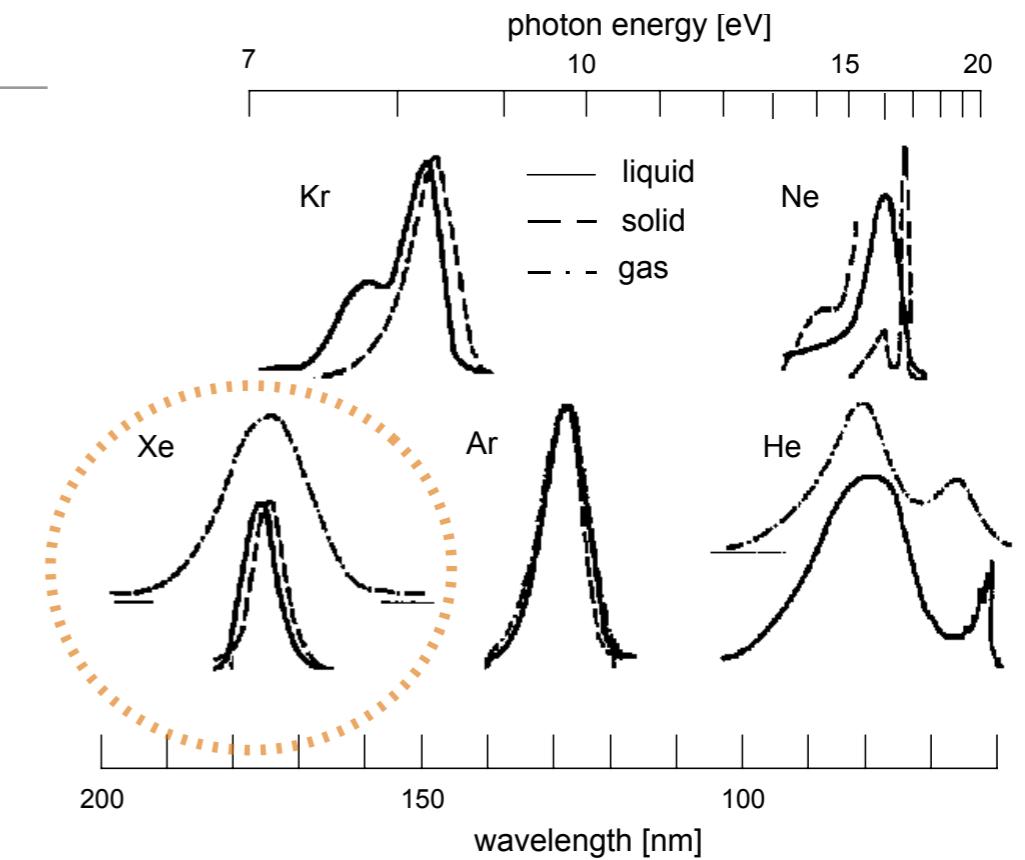
L. Baudis et al, Phys. Rev. D 88, 115014 (2013)

# The xenon time projection chamber

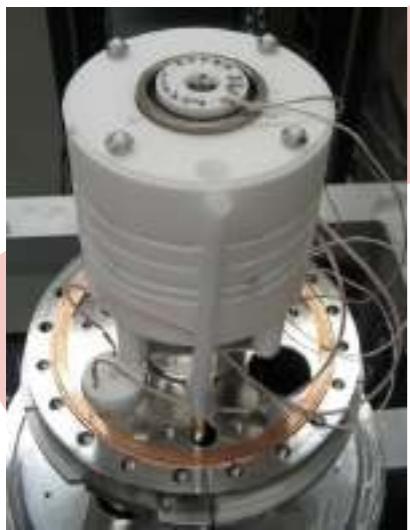


Light

Charge



# The XENON Programme



XENON R&D

XENON10



2005-2007

PRL100  
PRL101  
PRD 80  
NIM A 601

ongoing

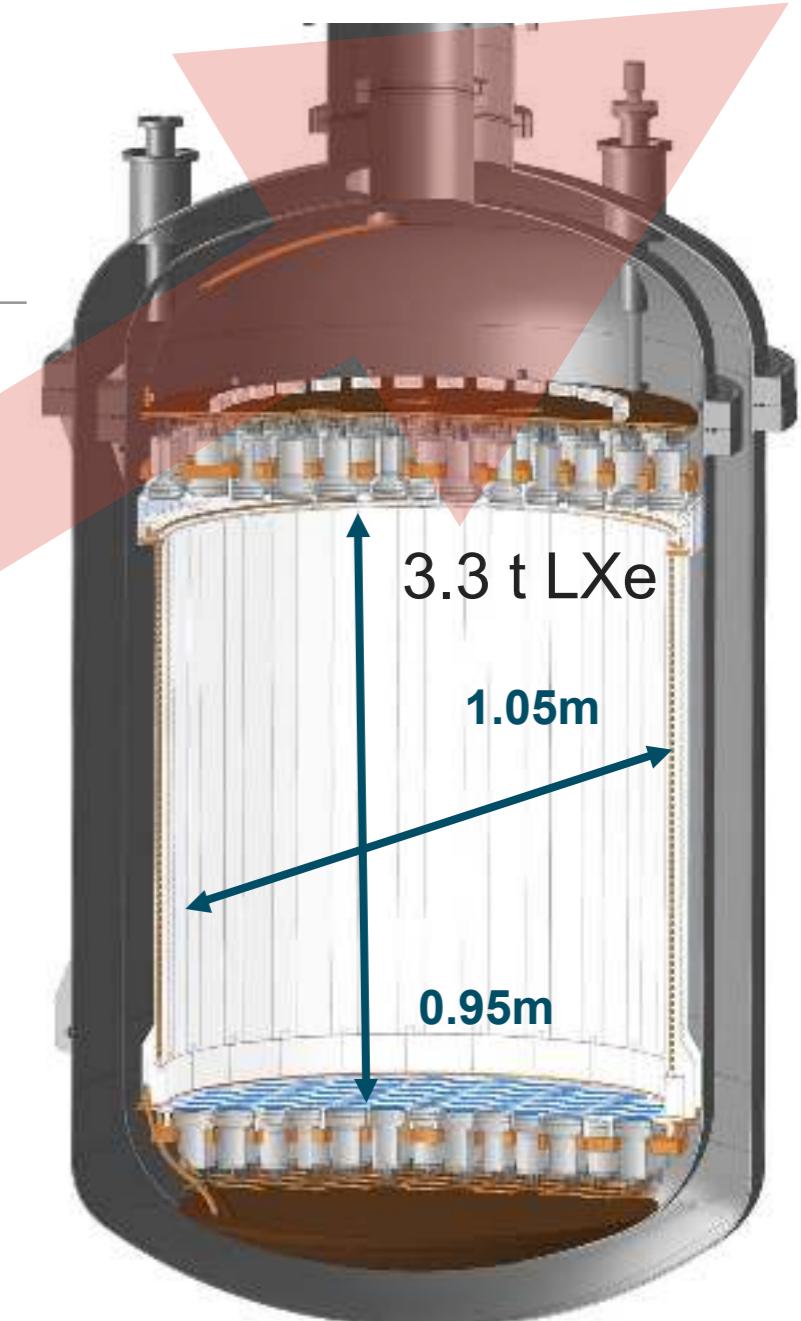
XENON100



2008-2015  
**taking calibration data**

PRL105  
PRL109  
PRL111  
...

XENON1T/nT



2013-2020

XENON1T(nT): under construction at LNGS

# The XENON Programme

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**XENON10**



**XENON100**



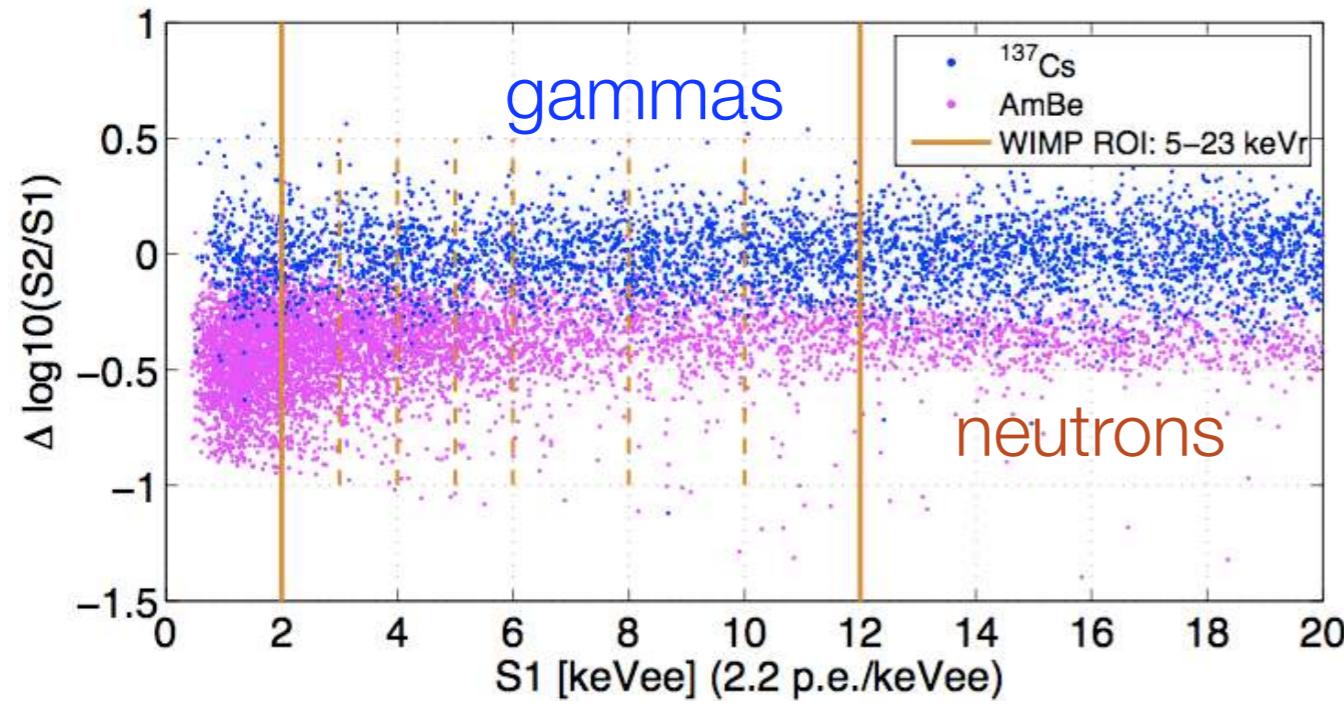
**XENON1T/nT**



**XENON10/XENON100: conventional shield, onion-like structure**

**XENON1T/nT: large water Cherenkov shield**

# The XENON10 experiment: 2005-2007



PRL 100, 021303 (2008)

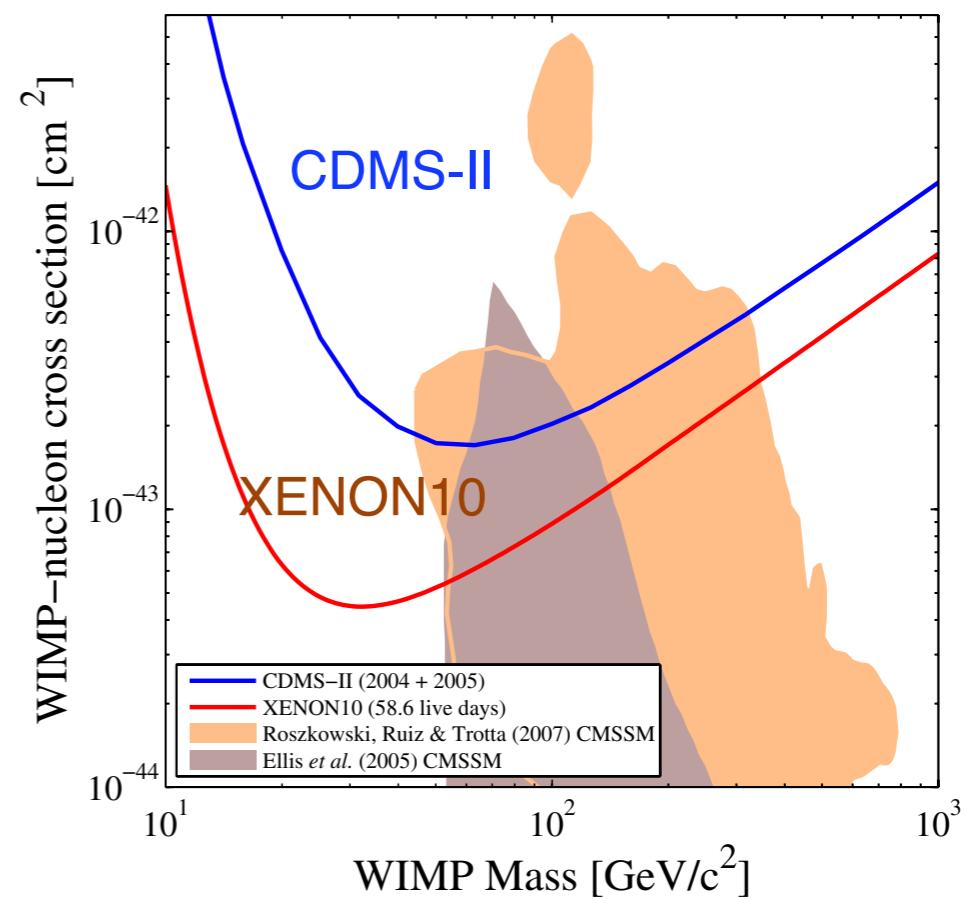
PHYSICAL REVIEW LETTERS

week ending  
18 JANUARY 2008

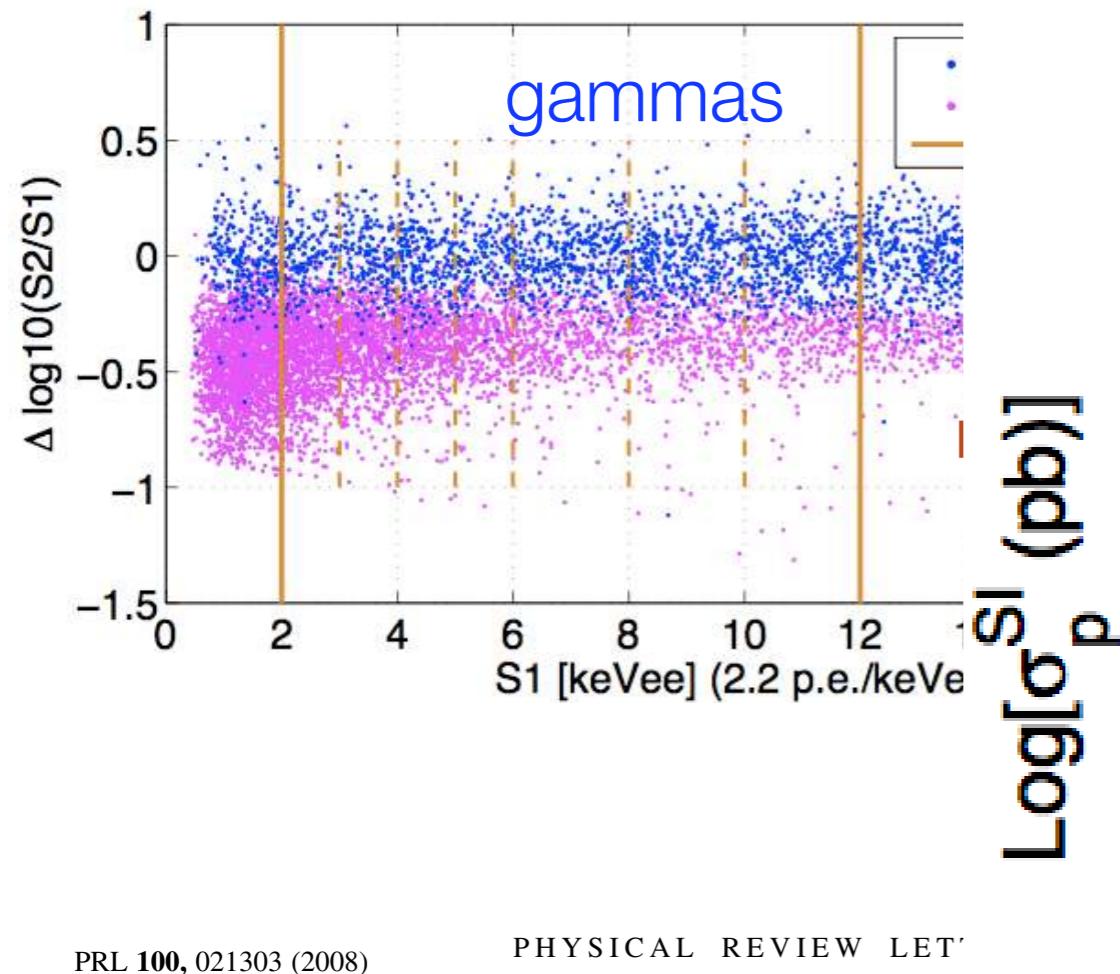
## First Results from the XENON10 Dark Matter Experiment at the Gran Sasso National Laboratory

J. Angle,<sup>1,2</sup> E. Aprile,<sup>3,\*</sup> F. Arneodo,<sup>4</sup> L. Baudis,<sup>2</sup> A. Bernstein,<sup>5</sup> A. Bolozdynya,<sup>6</sup> P. Brusov,<sup>6</sup> L. C. C. Coelho,<sup>7</sup> C. E. Dahl,<sup>6,8</sup> L. DeViveiros,<sup>9</sup> A. D. Ferella,<sup>2,4</sup> L. M. P. Fernandes,<sup>7</sup> S. Fiorucci,<sup>9</sup> R. J. Gaitskell,<sup>9</sup> K. L. Giboni,<sup>3</sup> R. Gomez,<sup>10</sup> R. Hasty,<sup>11</sup> L. Kastens,<sup>11</sup> J. Kwong,<sup>6,8</sup> J. A. M. Lopes,<sup>7</sup> N. Madden,<sup>5</sup> A. Manalaysay,<sup>1,2</sup> A. Manzur,<sup>11</sup> D. N. McKinsey,<sup>11</sup> M. E. Monzani,<sup>3</sup> K. Ni,<sup>11</sup> U. Oberlack,<sup>10</sup> J. Orboeck,<sup>2</sup> G. Plante,<sup>3</sup> R. Santorelli,<sup>3</sup> J. M. F. dos Santos,<sup>7</sup> P. Shagin,<sup>10</sup> T. Shutt,<sup>6</sup> P. Sorensen,<sup>9</sup> S. Schulte,<sup>2</sup> C. Winant,<sup>5</sup> and M. Yamashita<sup>3</sup>

- 22 kg LXe in total
- 20 cm diam, 15 cm drift
- 89 1-inch PMTs
- 0.73 kV/cm drift field

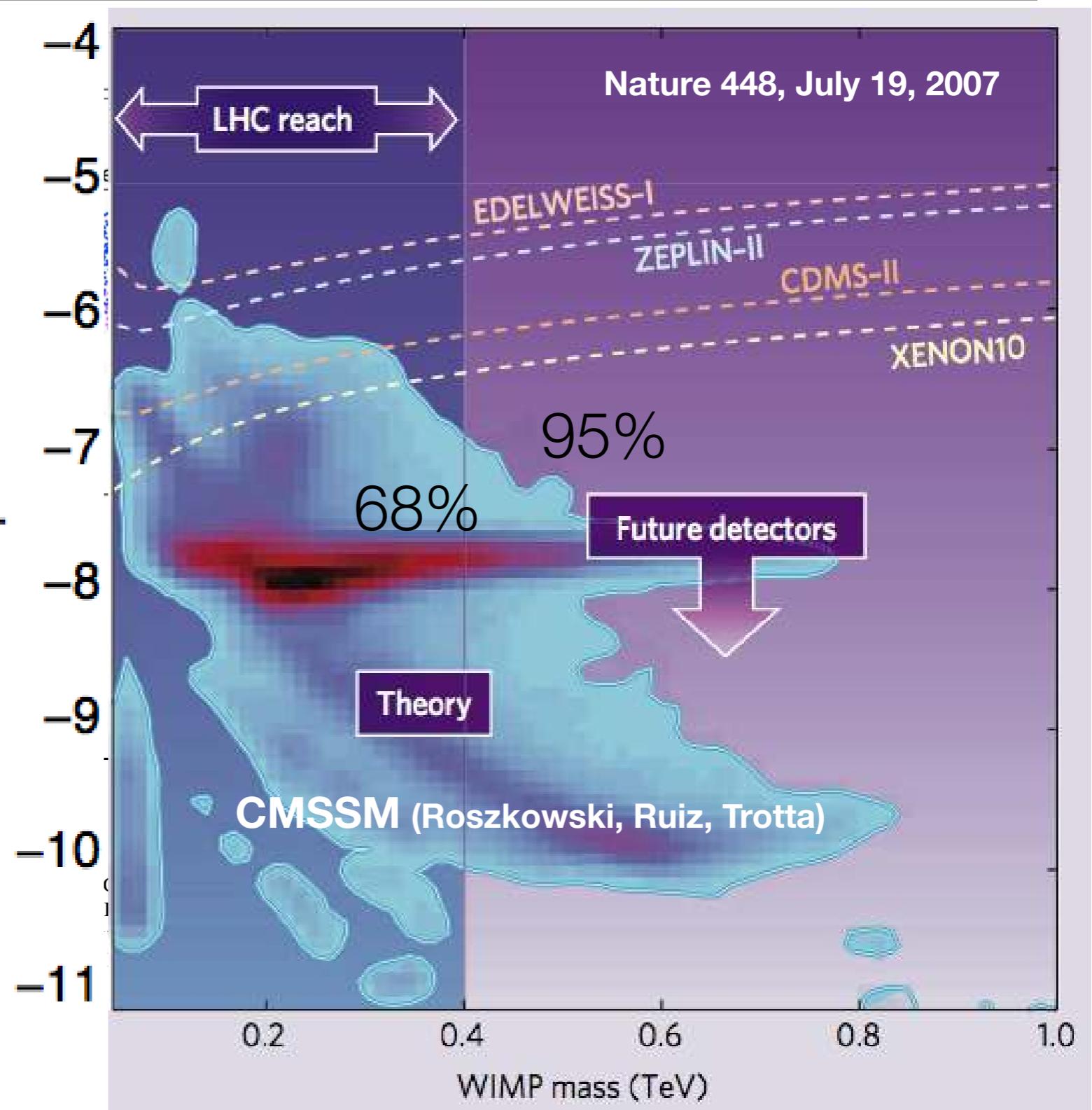


# The XENON10 experiment: 2005-2007



## First Results from the XENON10 Dark Matter Search at the Gran Sasso National Laboratory

J. Angle,<sup>1,2</sup> E. Aprile,<sup>3,\*</sup> F. Arneodo,<sup>4</sup> L. Baudis,<sup>2</sup> A. Bernstein,<sup>5</sup> A. Bozzo,<sup>6</sup> C. E. Dahl,<sup>6,8</sup> L. DeViveiros,<sup>9</sup> A. D. Ferella,<sup>2,4</sup> L. M. P. Fernandes,<sup>7</sup> S. F. R. Gomez,<sup>10</sup> R. Hasty,<sup>11</sup> L. Kastens,<sup>11</sup> J. Kwong,<sup>6,8</sup> J. A. M. Lopes,<sup>7</sup> N. M. D. N. McKinsey,<sup>11</sup> M. E. Monzani,<sup>3</sup> K. Ni,<sup>11</sup> U. Oberlack,<sup>10</sup> J. Orboeck,<sup>2</sup> G. P. Shagin,<sup>10</sup> T. Shutt,<sup>6</sup> P. Sorensen,<sup>9</sup> S. Schulte,<sup>2</sup> C. Winship,<sup>12</sup> and the XENON10 Collaboration



# The XENON10 Collaboration

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**LNGS, May 2006**



# The XENON100 experiment: 2008-2015

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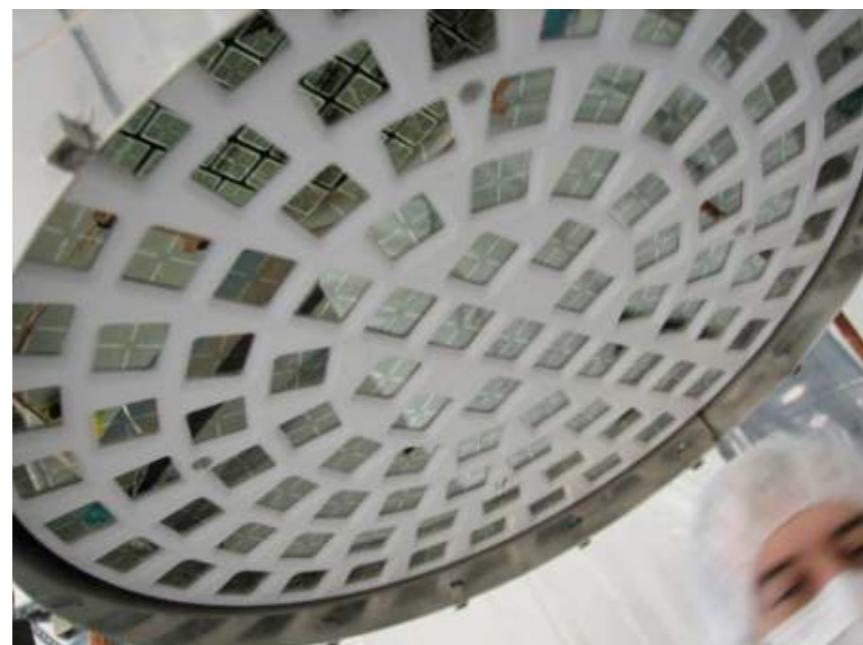


- Double phase time projection chamber with 161 kg (30-50 kg) of LXe total (fiducial), at LNGS
- 30 cm  $e^-$  drift length, 30 cm diameter
- 2 arrays of 1-inch, low-background PMTs + LXe veto
- Low radioactivity - screened/selected - materials

Instrument described in:  
Astroparticle Physics 35, 2012

Material screening results in:  
JINST 6, 2011

Detailed analysis paper:  
Astroparticle Physics 54, 2014

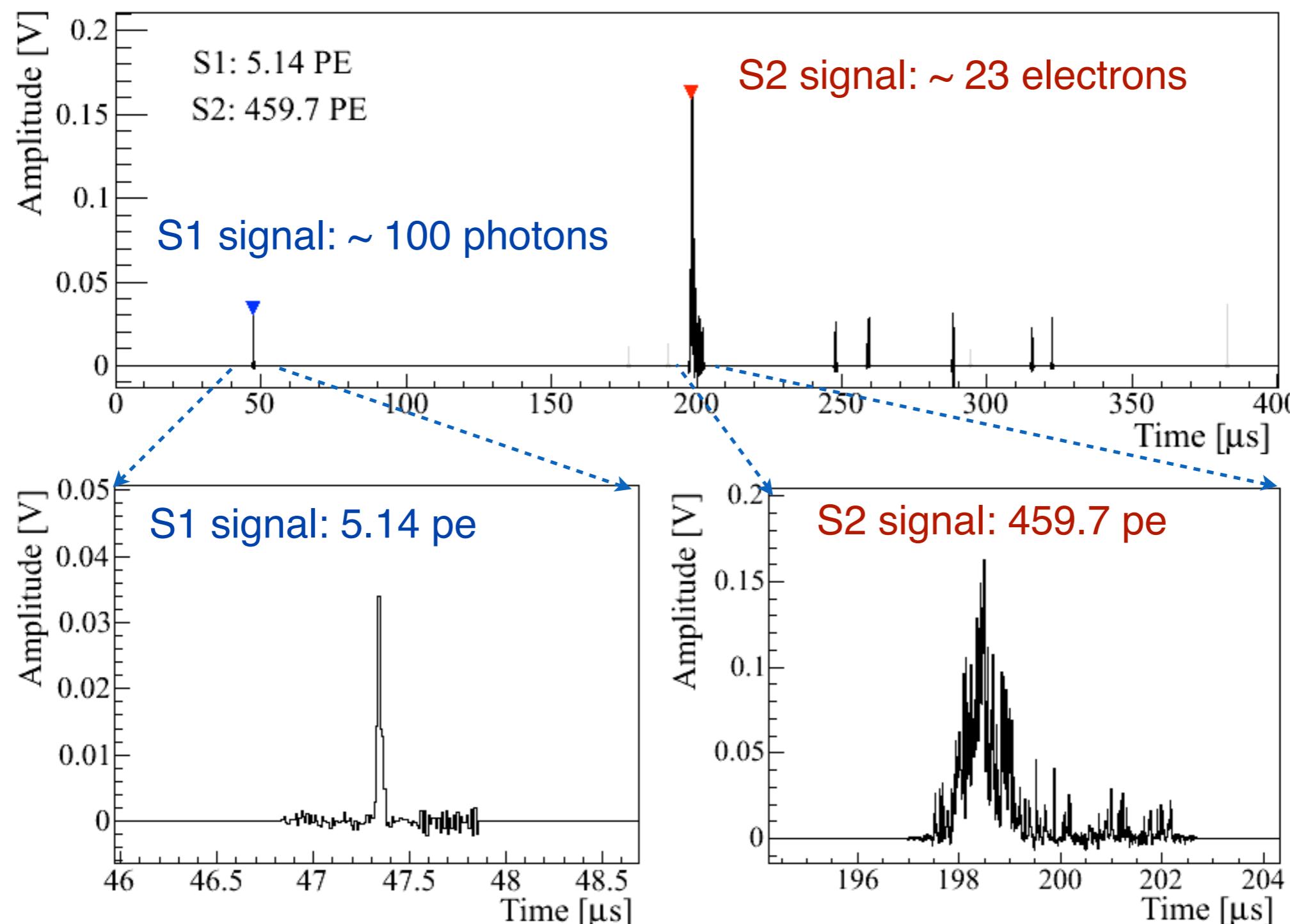


Top array: 98 PMTs



Bottom array: 80 PMTs

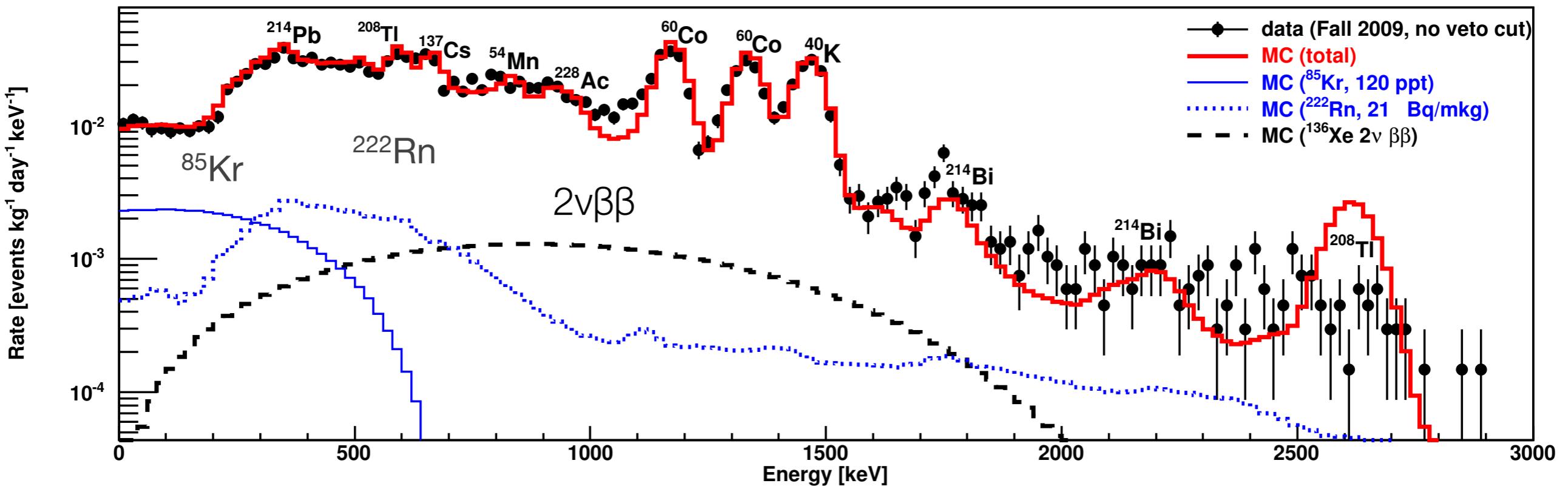
# Example of a low-energy event waveform



# The measured background in XENON100

- **Data and MC** (Run 07; no MC tuning; before the active LXe veto cut)
  - Region above  $\sim 1500$  keV: saturation in the PMTs
  - The background meets the design specifications:  $5.3 \times 10^{-3}$  events/(kg keV day)
- **100 times lower than in XENON10**

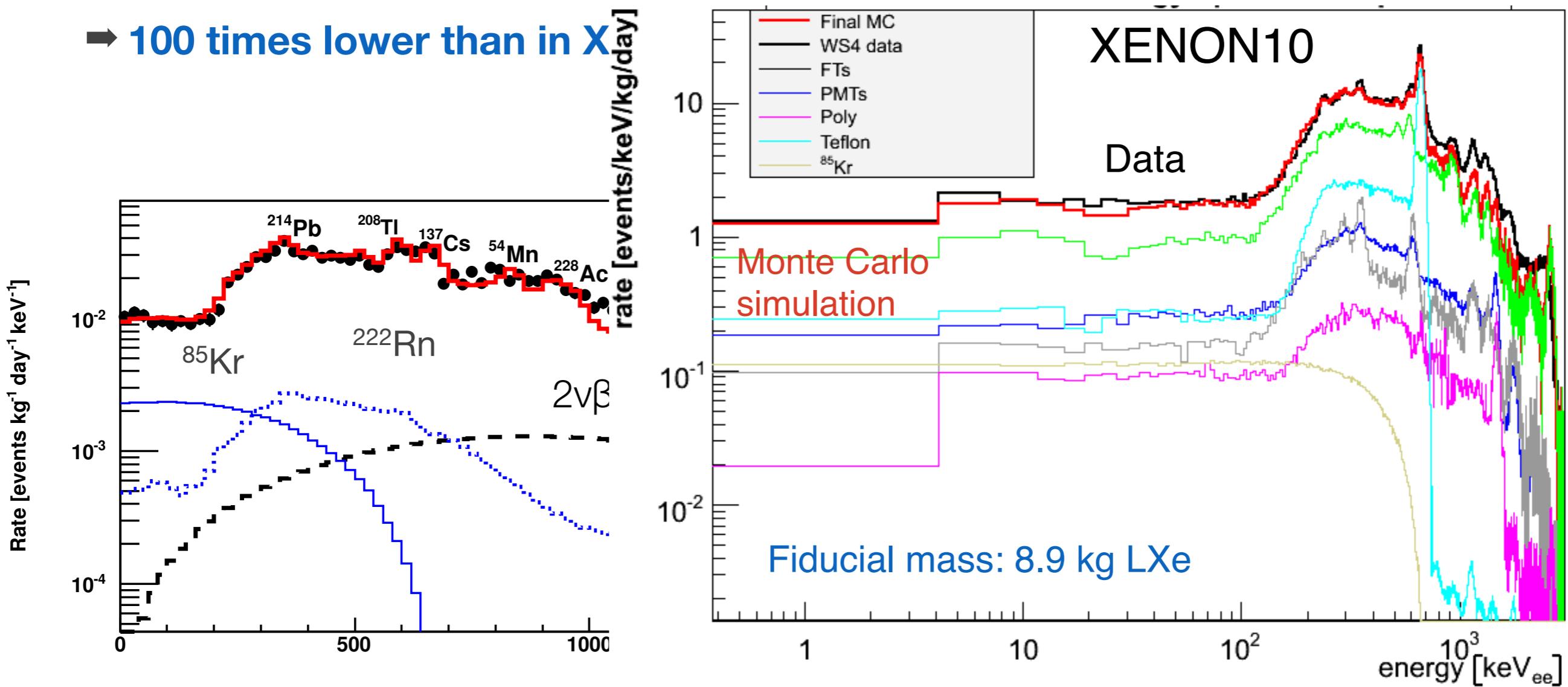
Aprile et al., XENON100 collaboration, PRD 83, 082001 (2011)



# The measured background in XENON100

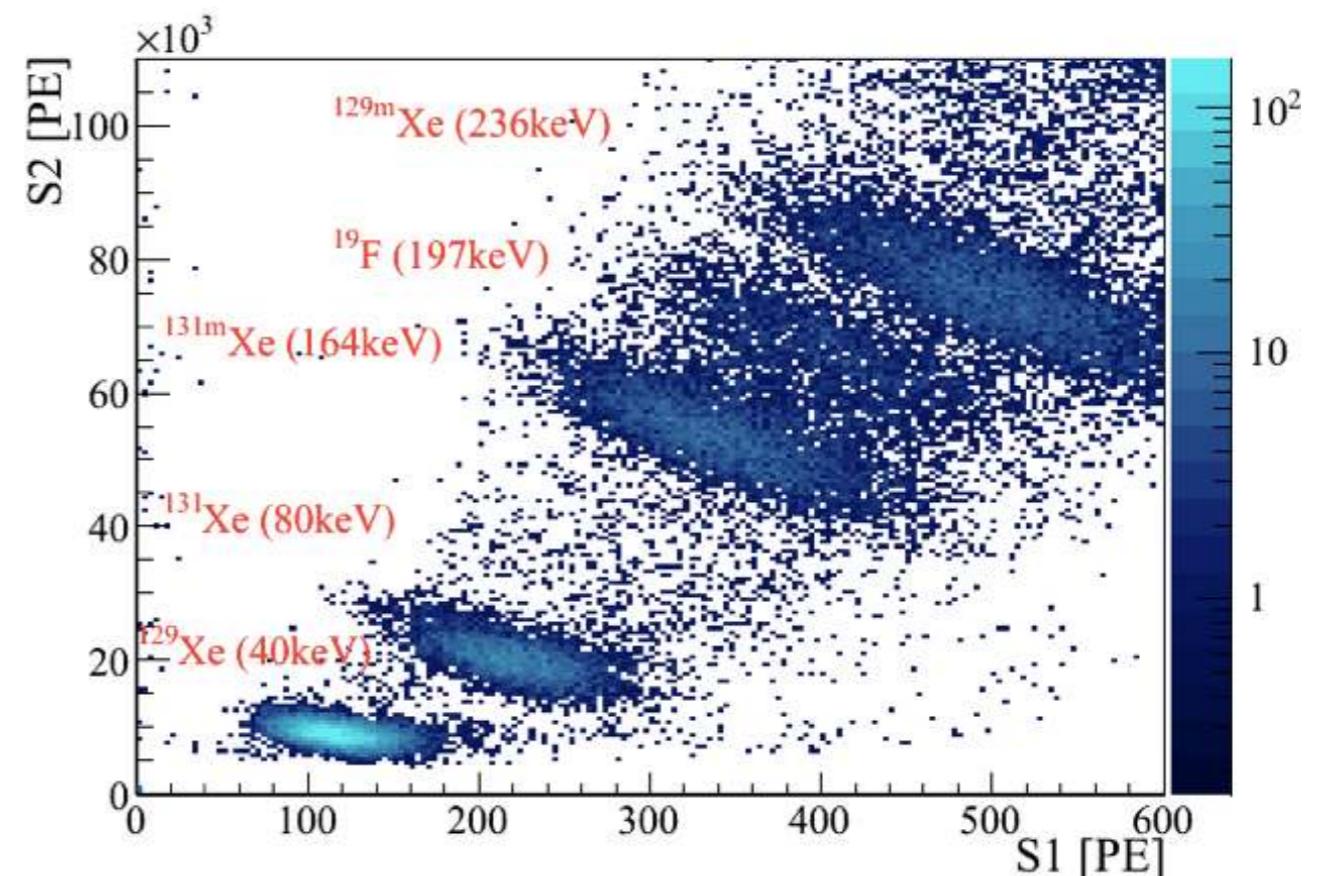
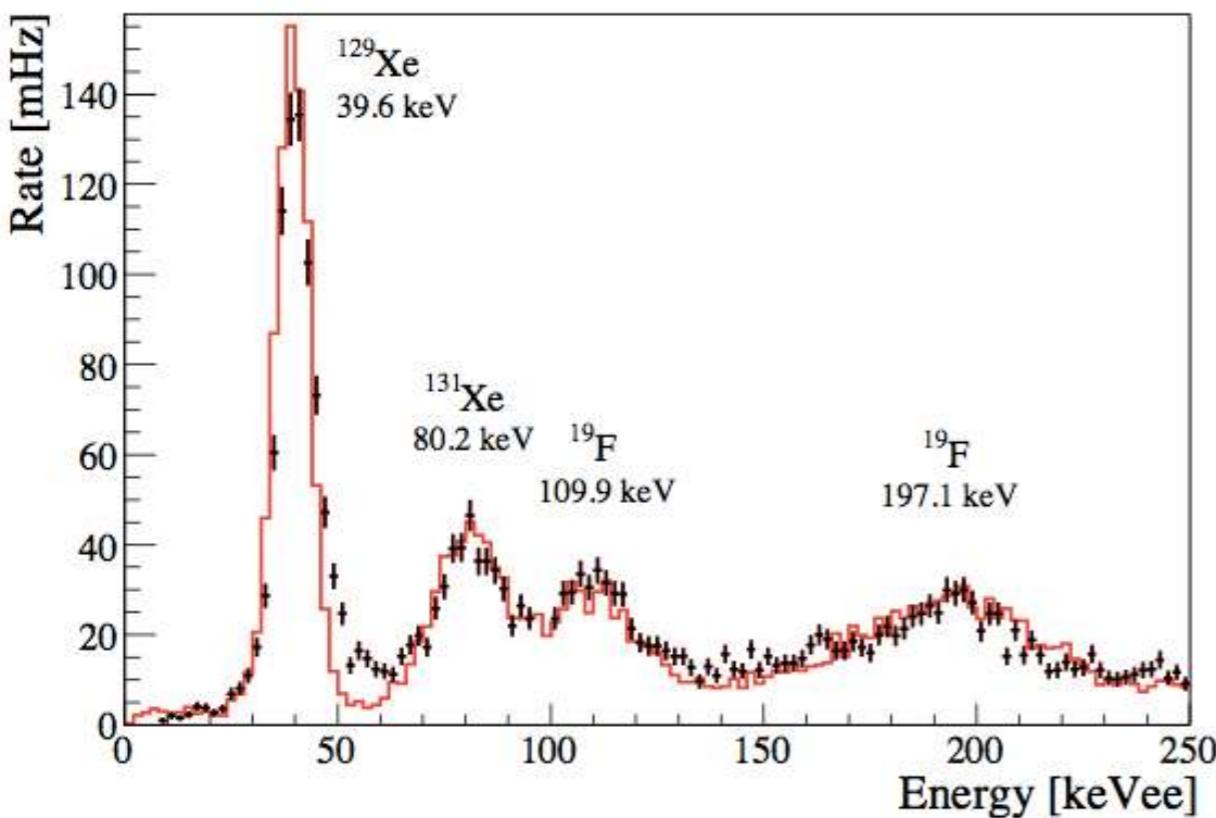
- **Data** and **MC** (Run 07; no MC tuning; before the active LXe veto cut)
- Region above  $\sim 1500$  keV: saturation in the PMTs
- The background meets the design specifications:  $5.3 \times 10^{-3}$  events/(kg keV day)

→ **100 times lower than in X**



# Gammas from neutron calibrations

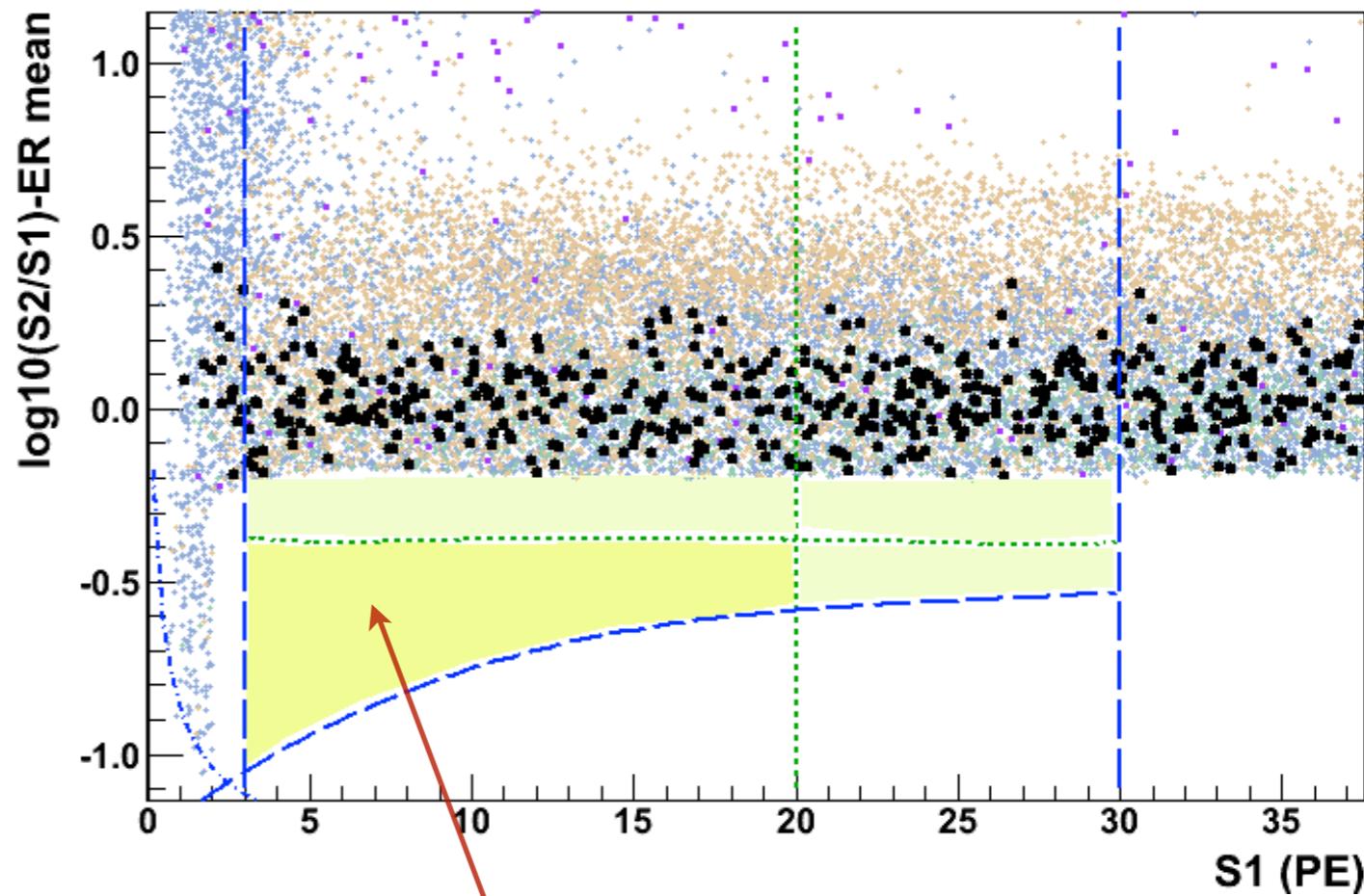
- AmBe ( $\sim$  MeV neutrons) data to map the nuclear recoil band, 220 n/s
- Inelastic n-scattering on Xe:  $^{129,131}\text{Xe} + \text{n} \rightarrow ^{129,131}\text{Xe} + \text{n} + \gamma$  (40 keV, 80 keV)
- Inelastic n-scattering on F (in PTFE):  $^{19}\text{F} + \text{n} \rightarrow ^{19}\text{F} + \text{n} + \gamma$  (110 keV, 197 keV)
- Also Xe n-activation lines:  $^{129m}\text{Xe}$  (236 keV) and  $^{131m}\text{Xe}$  (164 keV)



All gammas from the neutron irradiation of XENON100 are used to check/correct signal dependency with position and also to infer the LY at 122 keV

# Background prediction for Run10

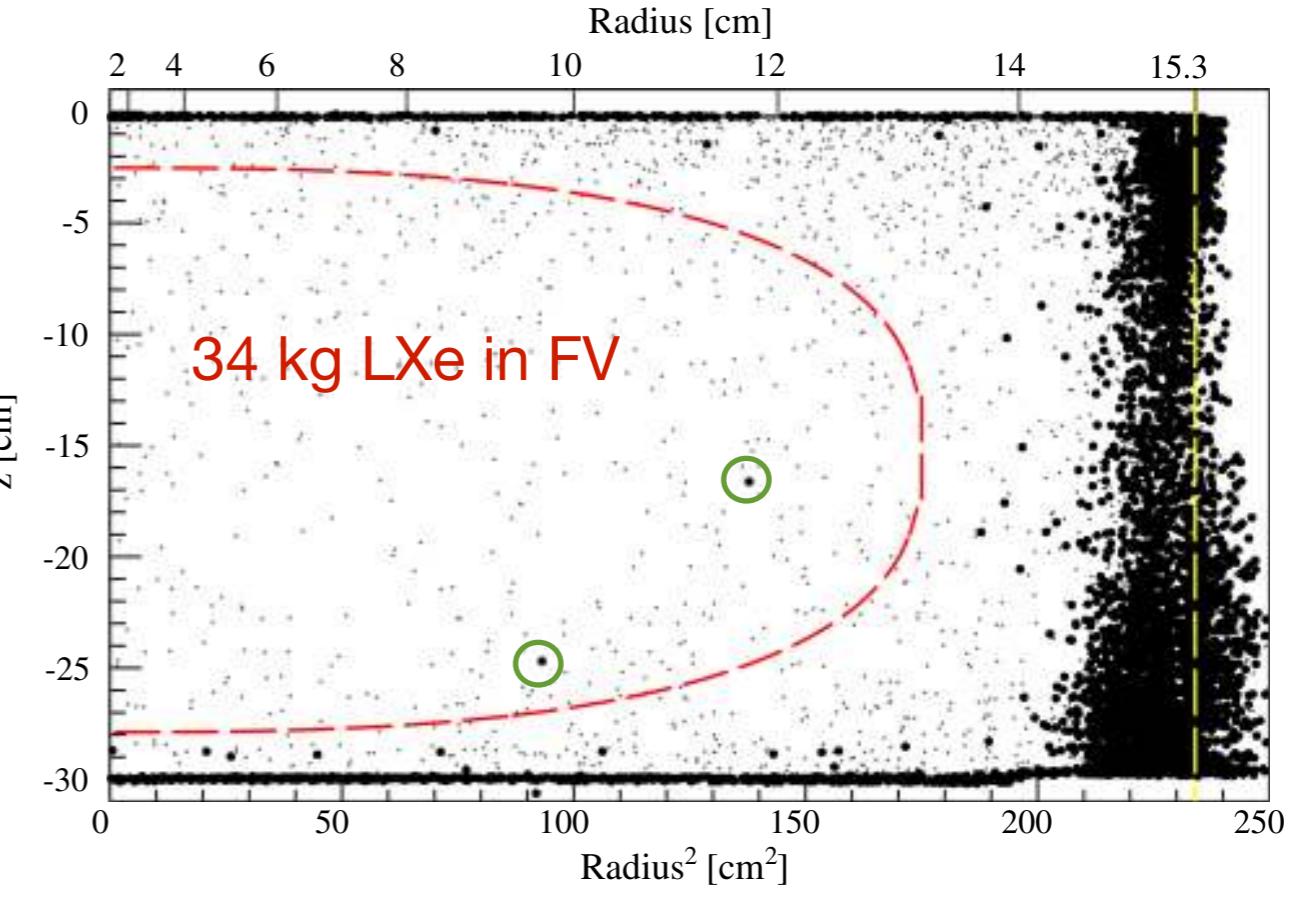
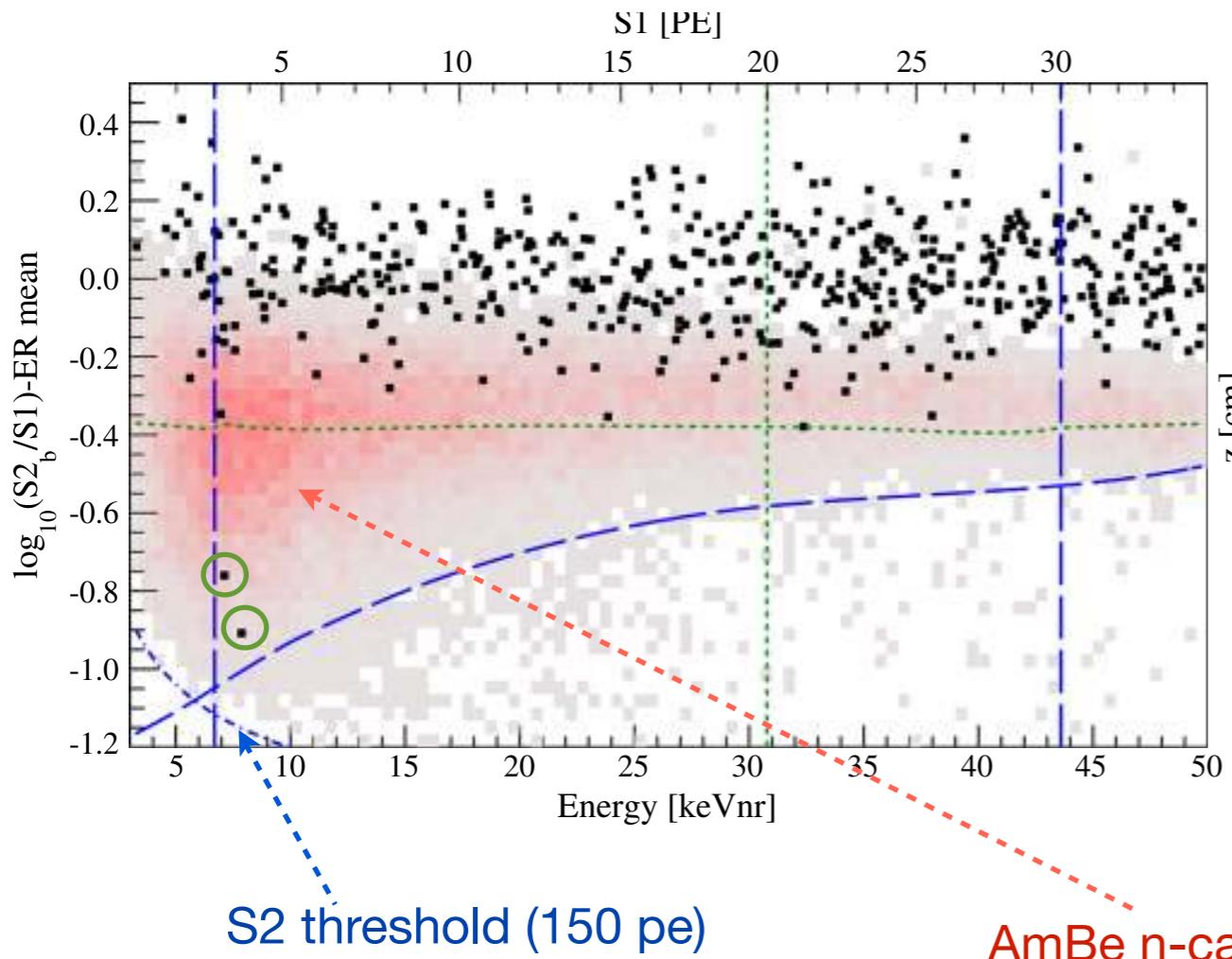
- Expected background in: 34 kg inner region, 224.6 live days, 99.75% rejection of electronic recoils
- Electronic recoil background:
  - $0.79 \pm 0.16$  events
  - from ER calibration data, scaled to non-blinded ER band background data
- Nuclear recoil background
  - $0.17 + 0.12 - 0.07$  events
  - from cosmogenic and radiogenic neutrons
- Total:  $1.0 \pm 0.2$  events



- *benchmark WIMP region (not used in PL analysis)*

# After unblinding the previous dark matter run

- Two events observed in signal region (there is a 26.4 % chance for upward fluctuation): at 7.1 keV<sub>nr</sub> (3.3 pe) and at 7.8 keV<sub>nr</sub> (3.8 pe) (note: zero events below 3 pe)
- Both events at *low S2/S1 with respect to NR calibration data*
- Visual inspection: waveforms of high quality

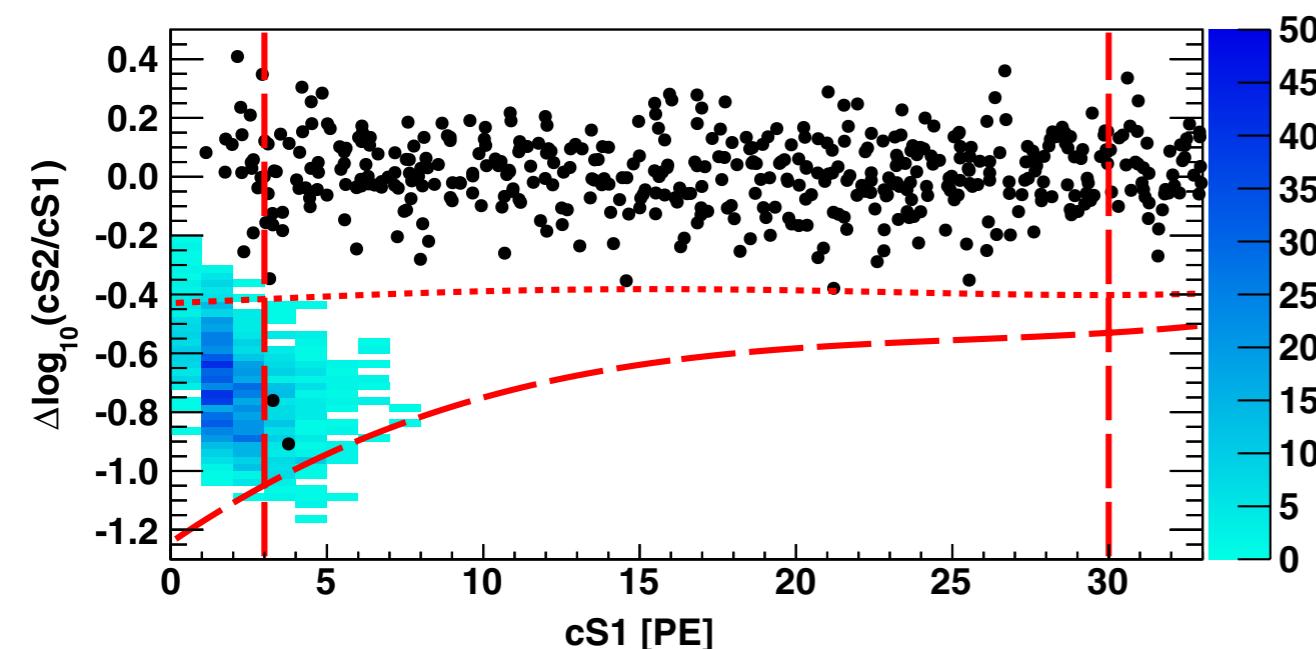


AmBe n-calibration data

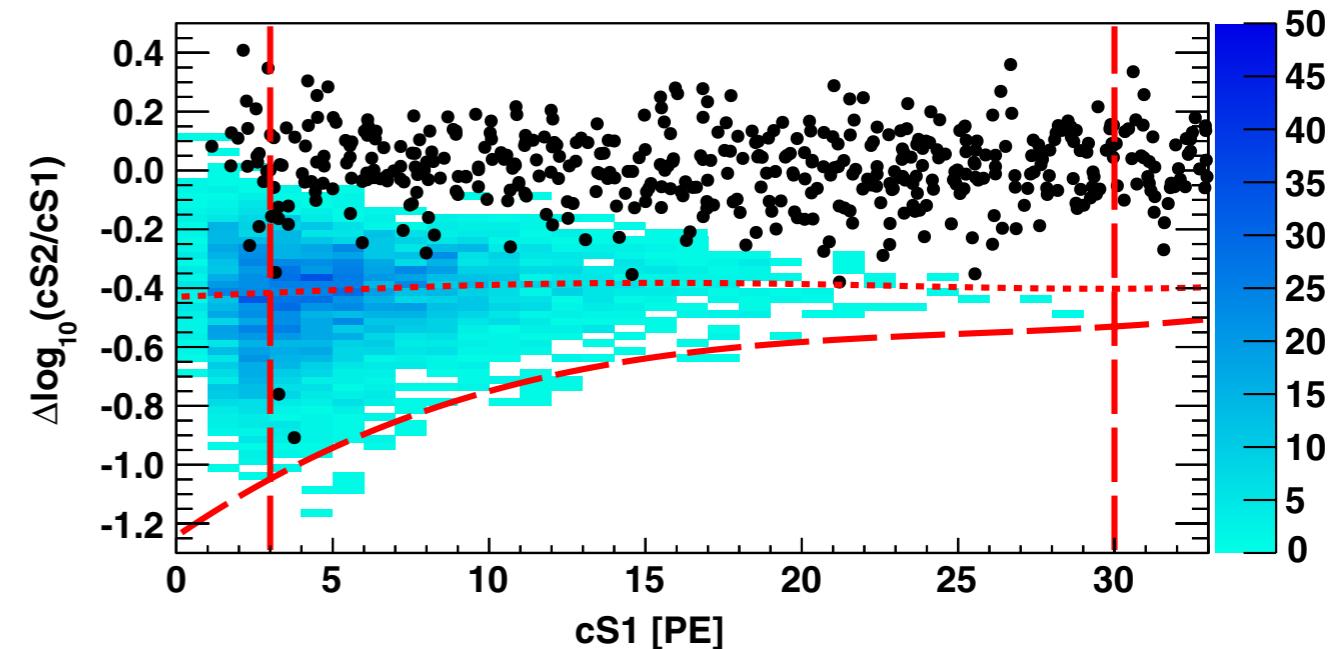
# XENON100 predictions for light WIMPs

- Past signal claims of other experiments in XENON100 data

WIMP with  $m_W = 8 \text{ GeV}$



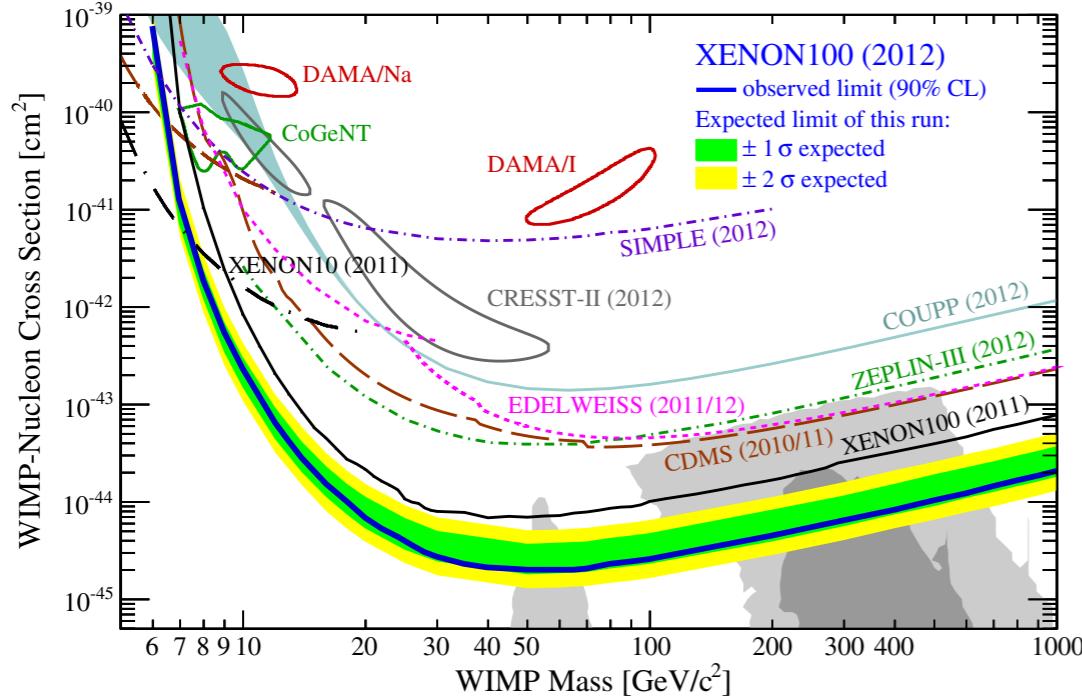
WIMP with  $m_W = 25 \text{ GeV}$



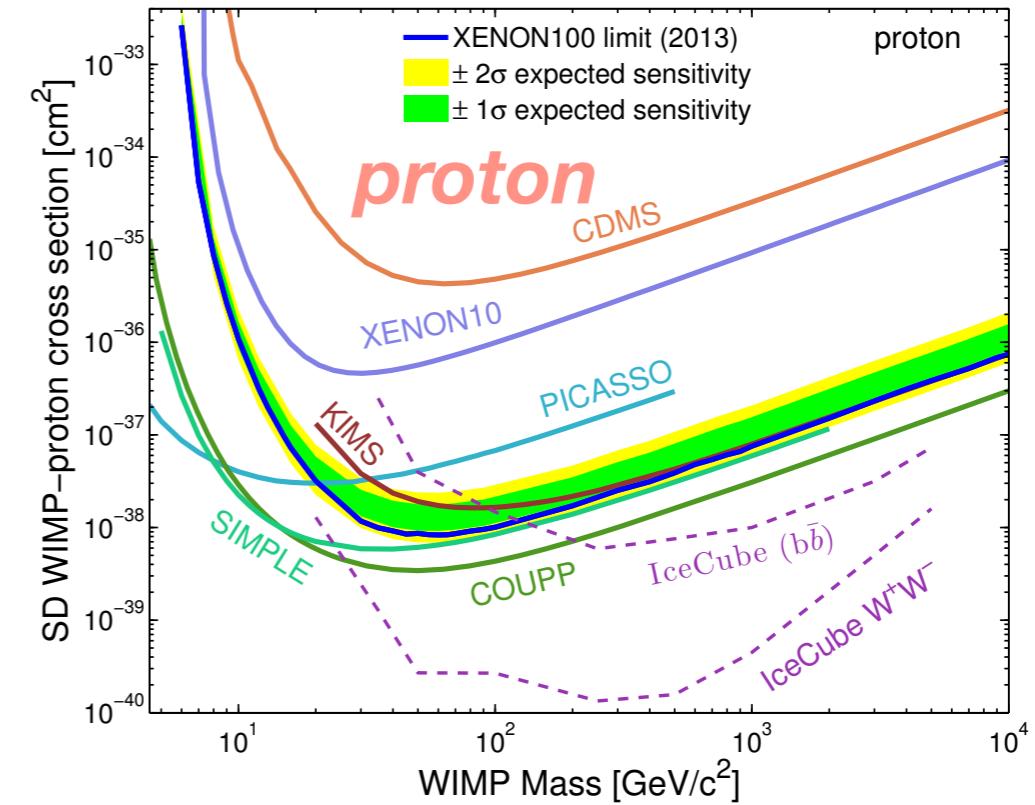
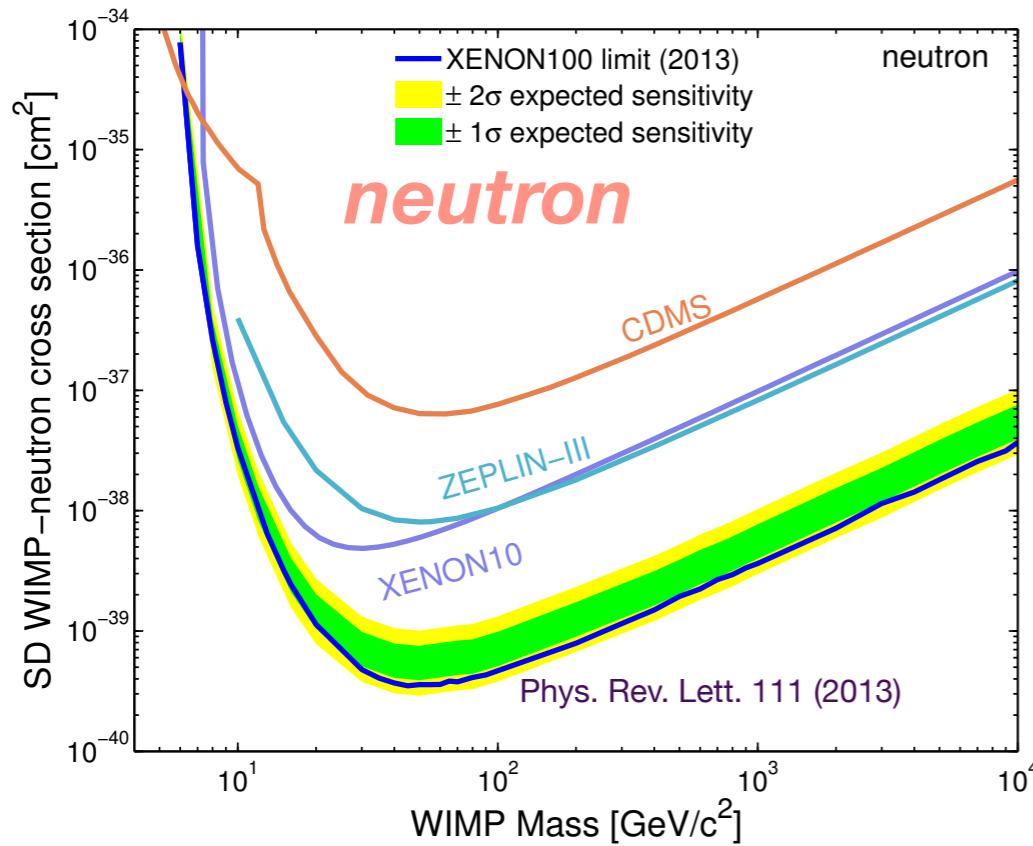
WIMP-nucleon cross section :  
 $3 \times 10^{-41} \text{ cm}^2$

WIMP-nucleon cross section :  
 $1.6 \times 10^{-42} \text{ cm}^2$

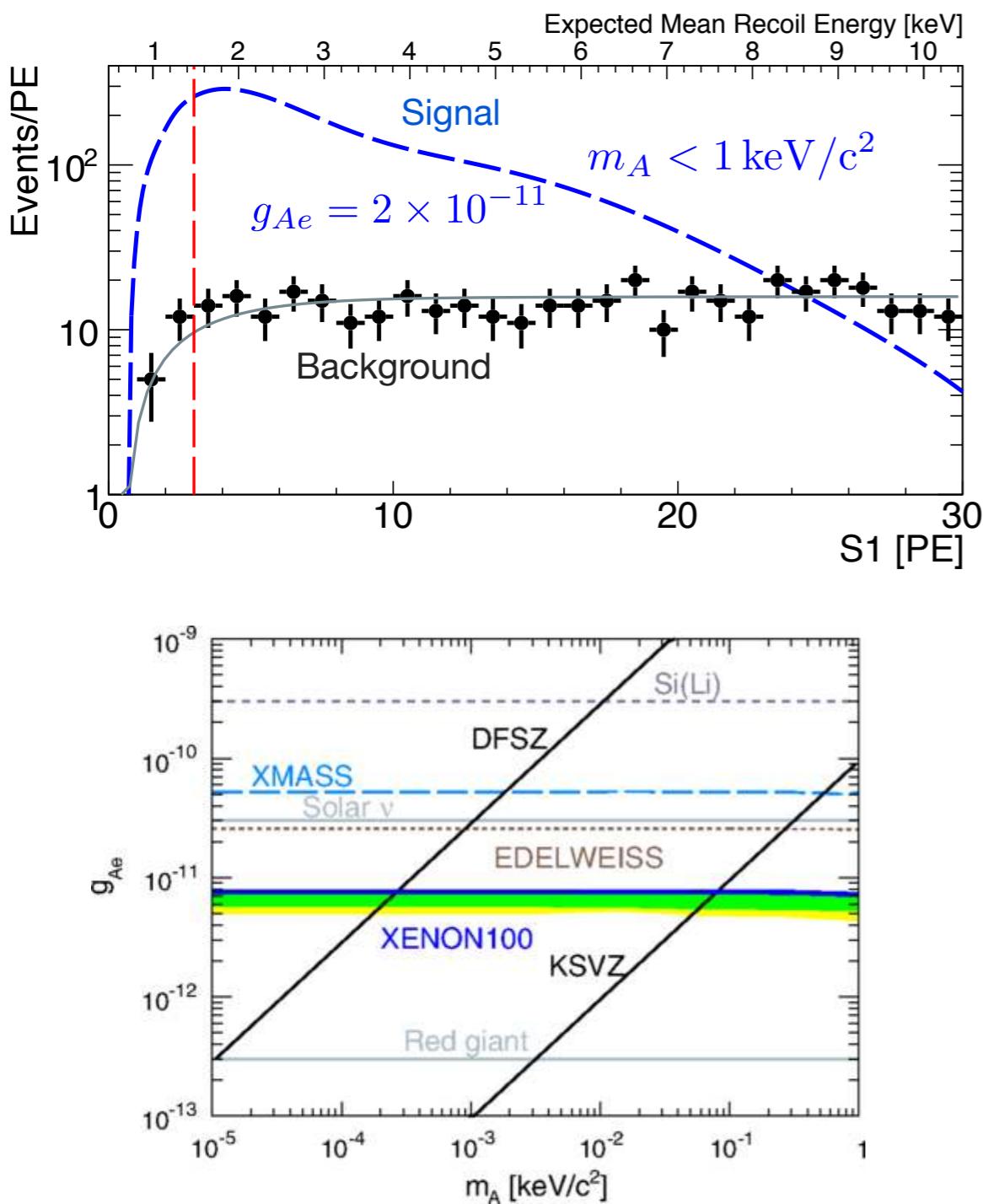
# WIMP results from XENON100



- Ultra-low background and design sensitivity achieved
- Background:  $\sim 5 \times 10^{-3}$  events/(kg d keV)
- No evidence for WIMP dark matter
- Upper limits on SI, SD WIMP-nucleon cross sections (PRL 109, PRL 111)



# Solar axions with XENON100



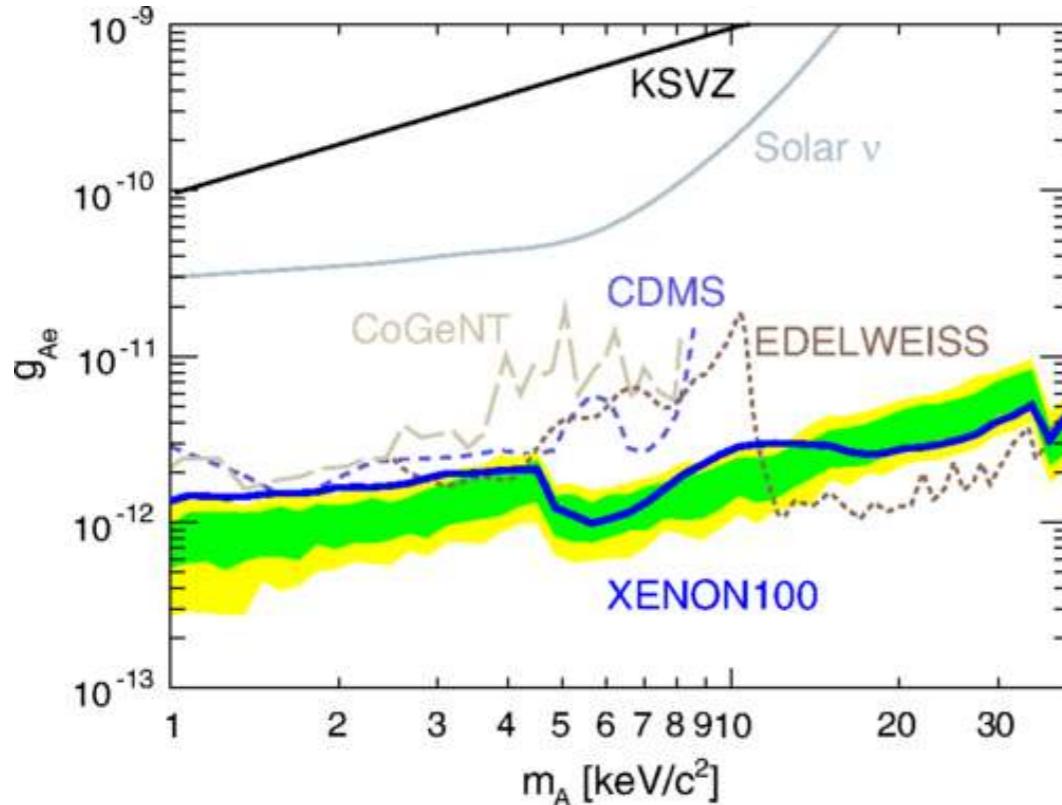
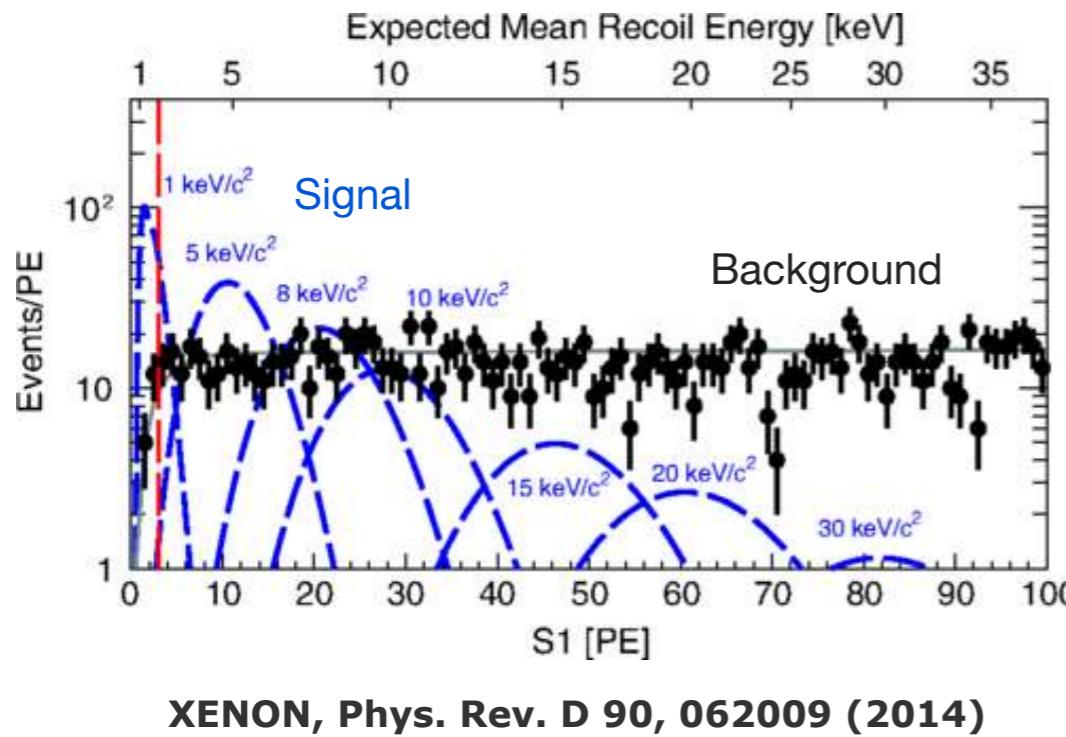
Look for solar axions via their couplings to electrons,  $g_{Ae}$ , through the axio-electric effect

$$\sigma_{Ae} = \sigma_{pe}(E_A) \frac{g_{Ae}^2}{\beta_A} \frac{3E_A^2}{16\pi\alpha_{em}m_e^2} \left(1 - \frac{\beta_A^{2/3}}{3}\right)$$

$$\phi_A \propto g_{Ae}^2 \implies R \propto g_{Ae}^4$$

- XEON100: based on 224.6 live days  $\times$  34 kg exposure; using the electronic-recoil spectrum, and measured light yield for low-energy ERs (LB et al., PRD 87, 2013; arXiv:1303.6891)

# Galactic axion-like particles with XENON100



Look for ALPs via their couplings to electrons,  $g_{Ae}$ , through the axio-electric effect

Expect line feature at ALP mass

Assume  $\rho_0 = 0.3 \text{ GeV/cm}^3$

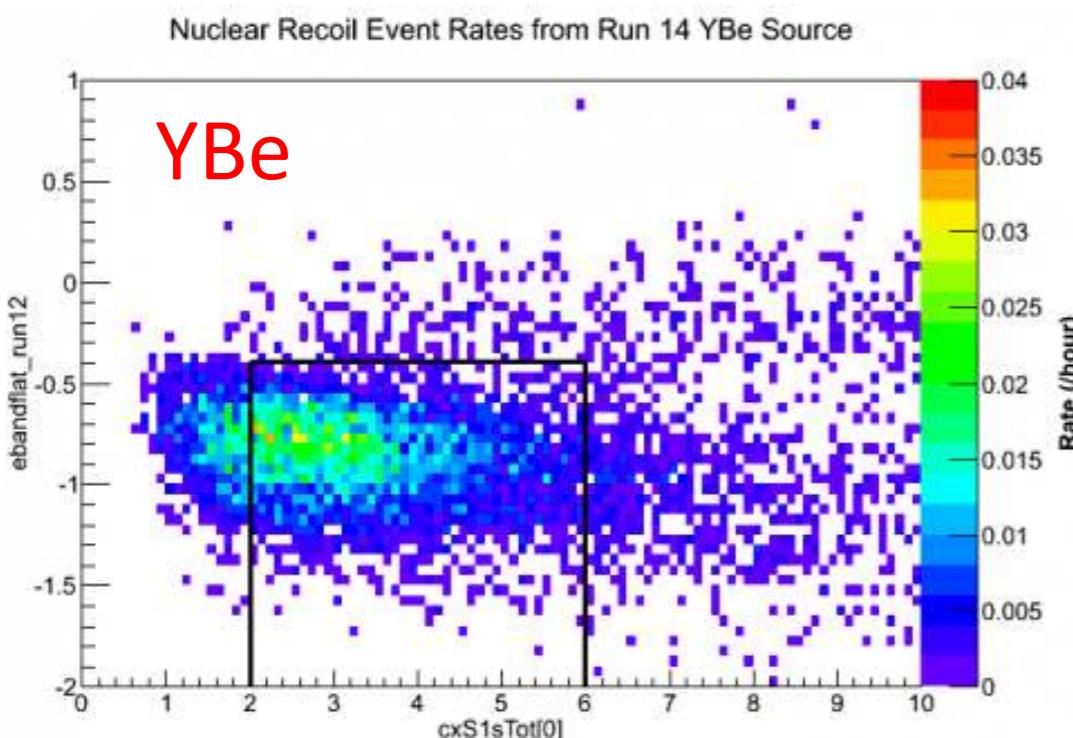
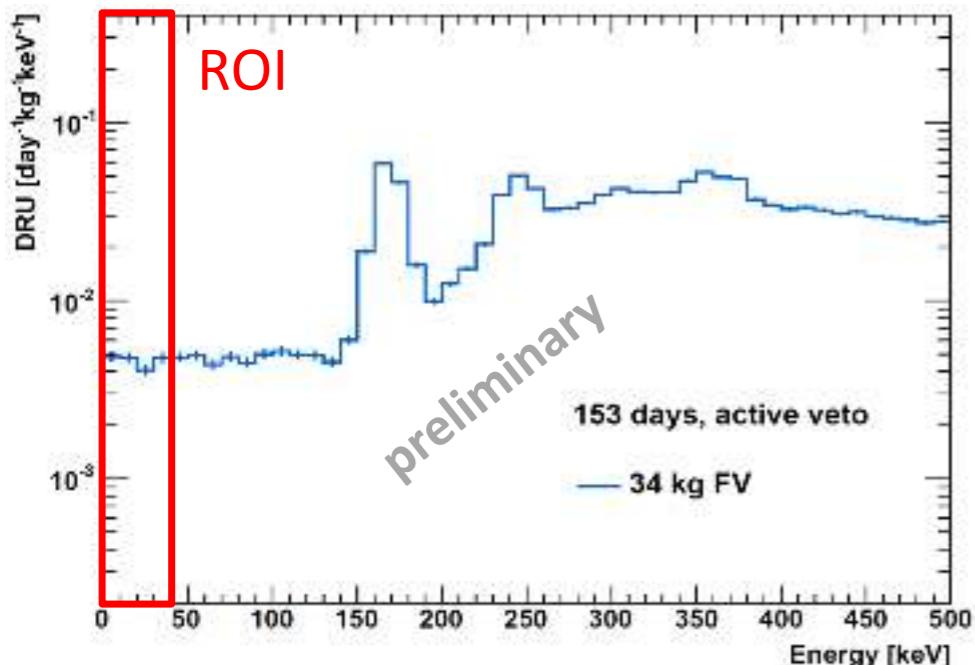
$$\phi_A = c\beta_A \times \frac{\rho_0}{m_A}$$

$$R \propto g_{Ae}^2$$

- XEON100: based on 224.6 live days x 34 kg exposure; using the electronic-recoil spectrum, and measured light yield for low-energy ERs (LB et al., PRD 87, 2013; arXiv:1303.6891)

XENON, Phys. Rev. D 90, 062009 (2014)

# Upcoming results from XENON100



- Search for annual modulation (2 papers submitted)
- Analysis of 153 live days of blinded dark matter search data close to unblinding; search for inelastic scattering on  $^{129}\text{Xe}$ , search for low-mass WIMPs
- Calibration measurements:
  - probe lowest nuclear recoil energies (max at 4.5 keVnr) with YBe source placed inside the shield; more than 80 live days collected and clear signal due to neutron scatters observed
  - currently  $^{83\text{m}}\text{Kr}$ ,  $^{220}\text{Rn}$  calibration run & analysis
- XENON100 is also used as a test facility for XENON1T/nT: novel online radon purification technique, by cryogenic distillation (Rn has 10 x lower vapour pressure than xenon) verified

# The XENON collaboration

LNGS, November 2014



Columbia



Rice



UCLA



Zürich



Coimbra



LNGS



INFN



SJTU



Purdue



Rensselaer



Chicago



Bologna



Subatech



Münster



Heidelberg Nikhef



Nikhef



Weizmann



Mainz



Bern

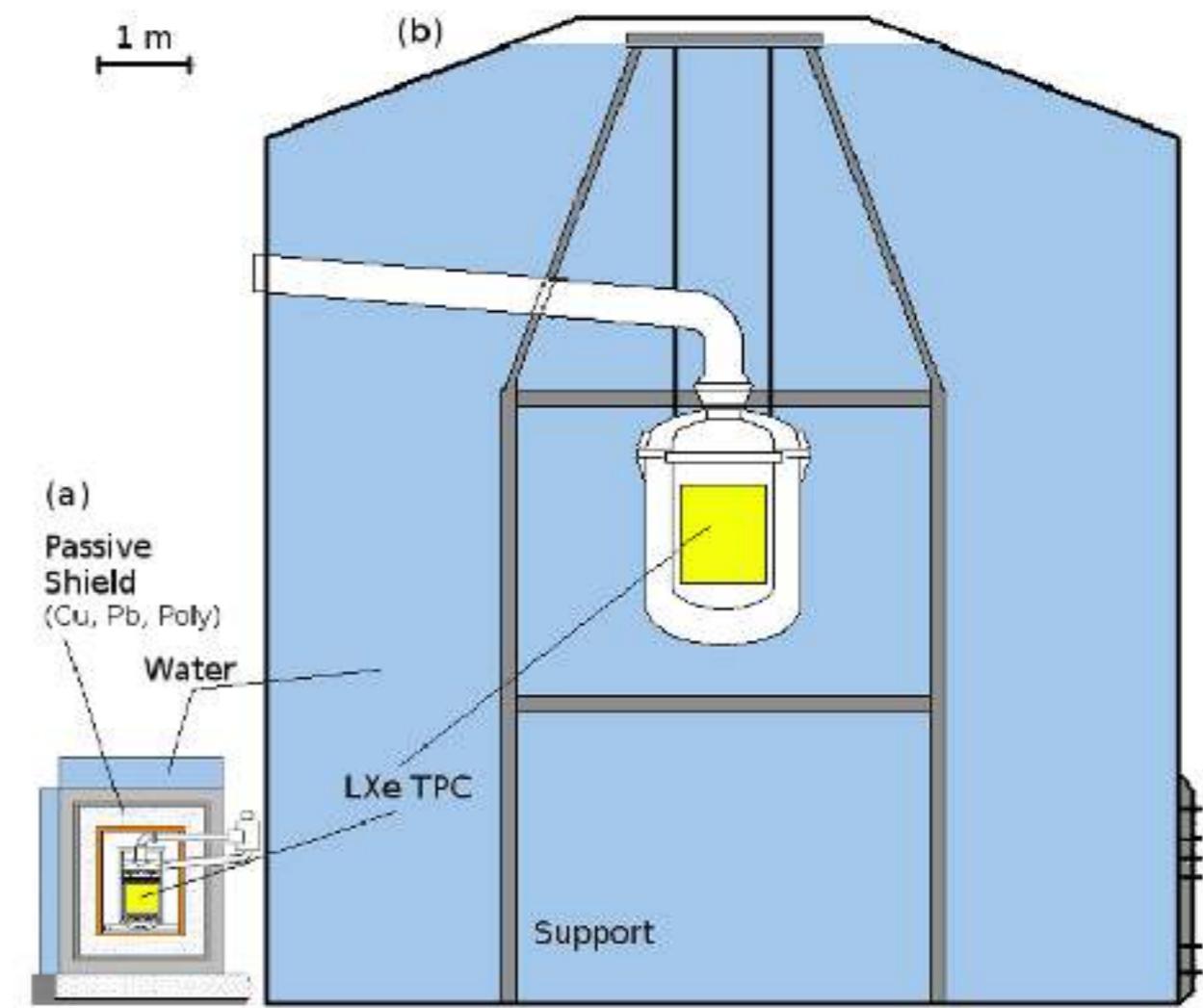


جامعة أبوظبي

NYU Abu Dhabi

# From XENON100 to XENON1T in numbers

	XENON100	XENON1T
Total LXe mass [kg]	161	3300
Background [dru]	$5 \times 10^{-3}$	$5 \times 10^{-5}$
$^{222}\text{Rn}$ [ $\mu\text{Bq/kg}$ ]	$\sim 65$	$\sim 1$
$^{\text{nat}}\text{Kr}$ [ppt]	$\sim 120$	$\sim 0.2$
e- drift [cm]	30	100
Cathode HV [kV]	-16	-100



# The XENON1T experiment

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- Under construction at LNGS since autumn 2013; commissioning planned for late 2015
- Total (active) LXe mass: 3.3 t (2 t), 1 m electron drift, 248 3-inch PMTs in two arrays
- Background goal: 100 x lower than XENON100  $\sim 5 \times 10^{-2}$  events/(t d keV)



# XENON1T: status of construction work

---

- Water Cherenkov shield built and instrumented
- Cryostat support, service building, electrical plant completed
- Several subsystems (cryostat, cryogenics, storage, purification, cables & fibres, pipes ) installed/ being tested underground



# XENON1T: status of construction work

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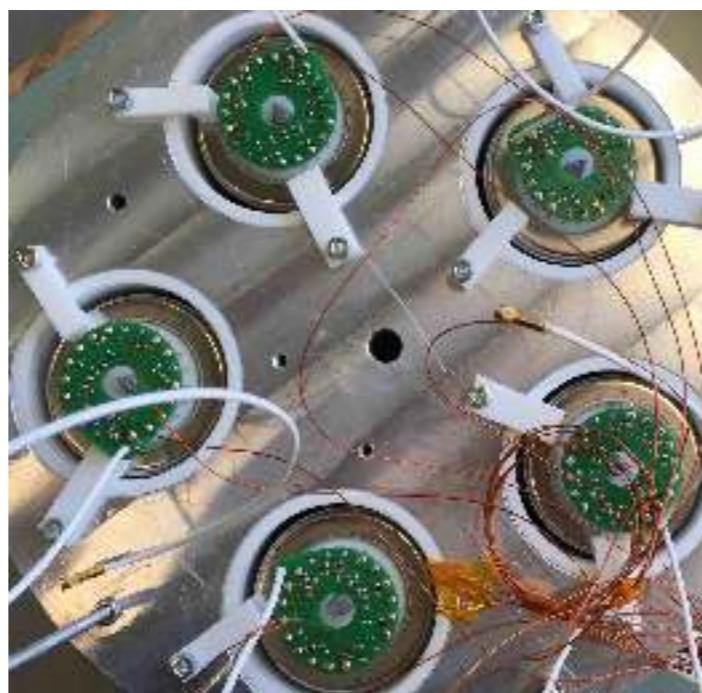
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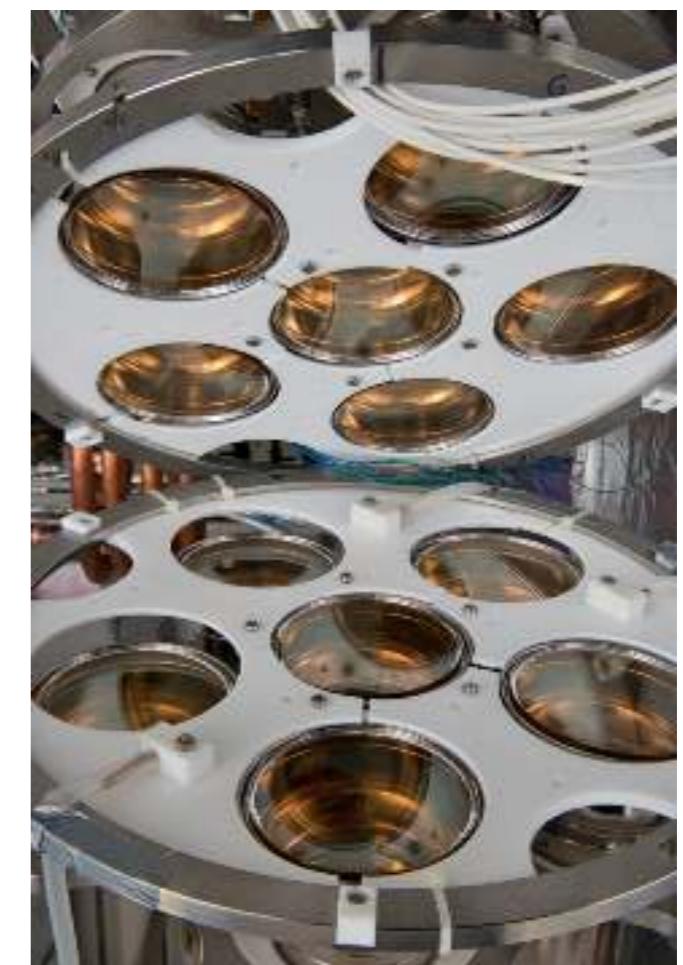
# The XENON1T inner detector

- PMTs are screened with HPGe, then tested in cold gas and - a subsample - in LXe
- TPC design is finalised, currently under prototyping, materials being screened

The TPC



PMT and final bases &  
cables tests in liquid xenon

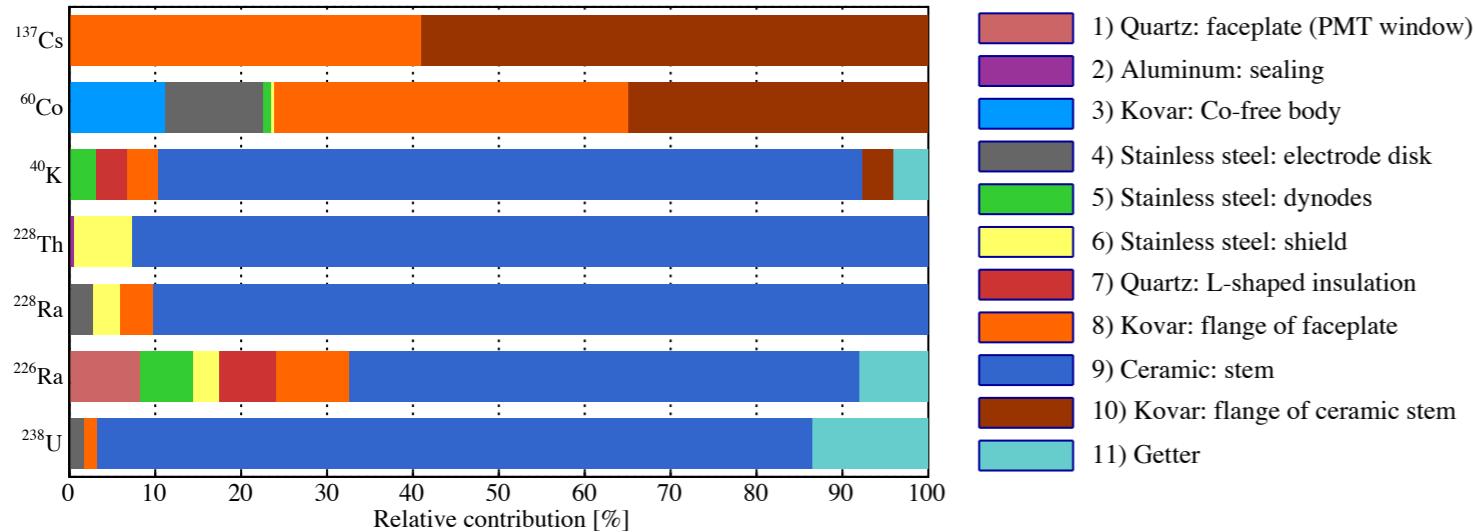


PMT tests at -100 C

# The XENON1T photosensors

R11410-21 3-inch PMTs; average QE at 175 nm: 36%, average gain:  $2 \times 10^6$  at 1500 V

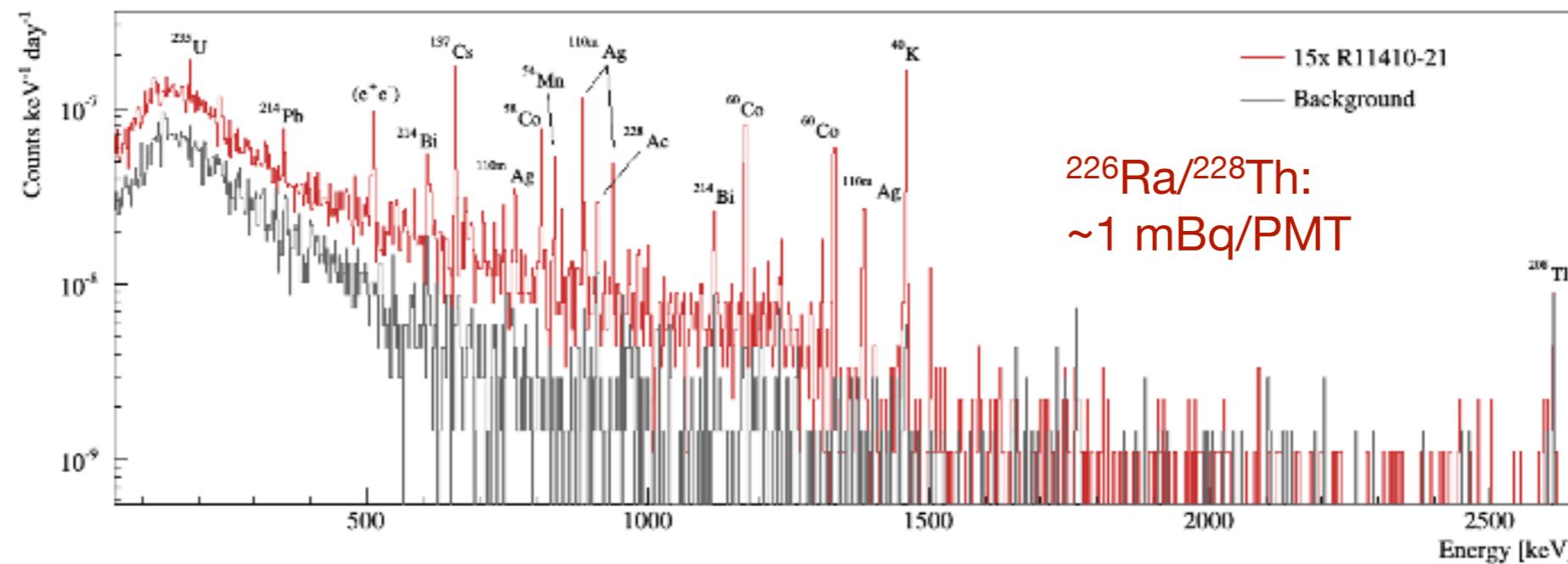
Material screening/selection for PMT production



Screening of final product

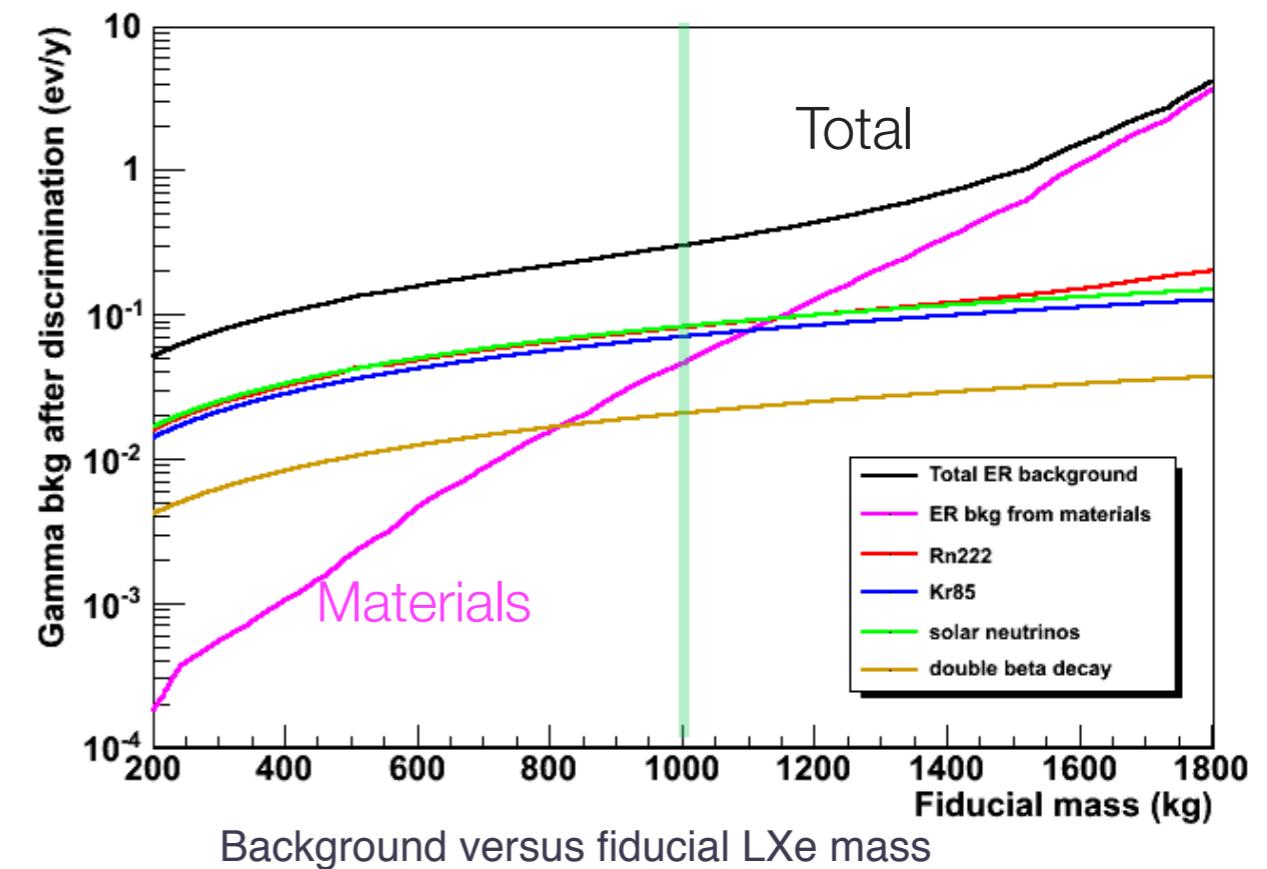
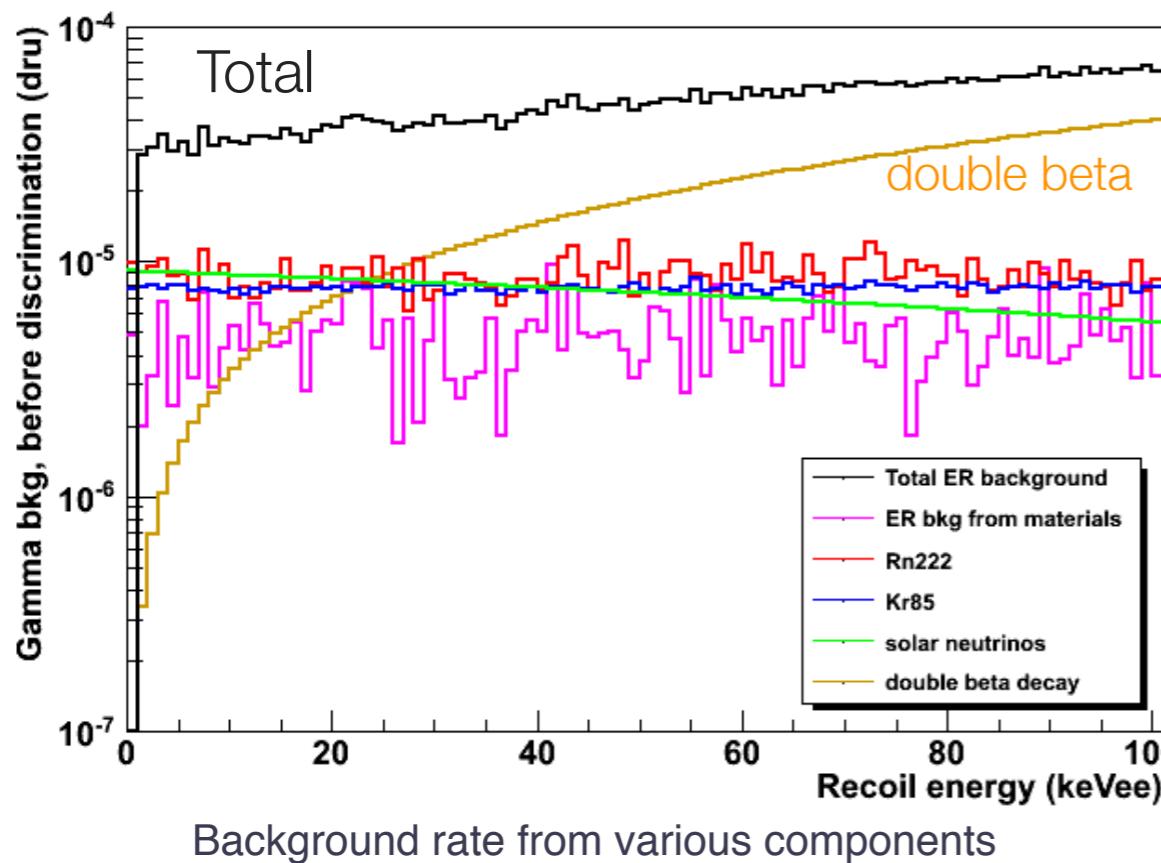


XENON collaboration, arXiv:1503.07698v1



# XENON1T background predictions

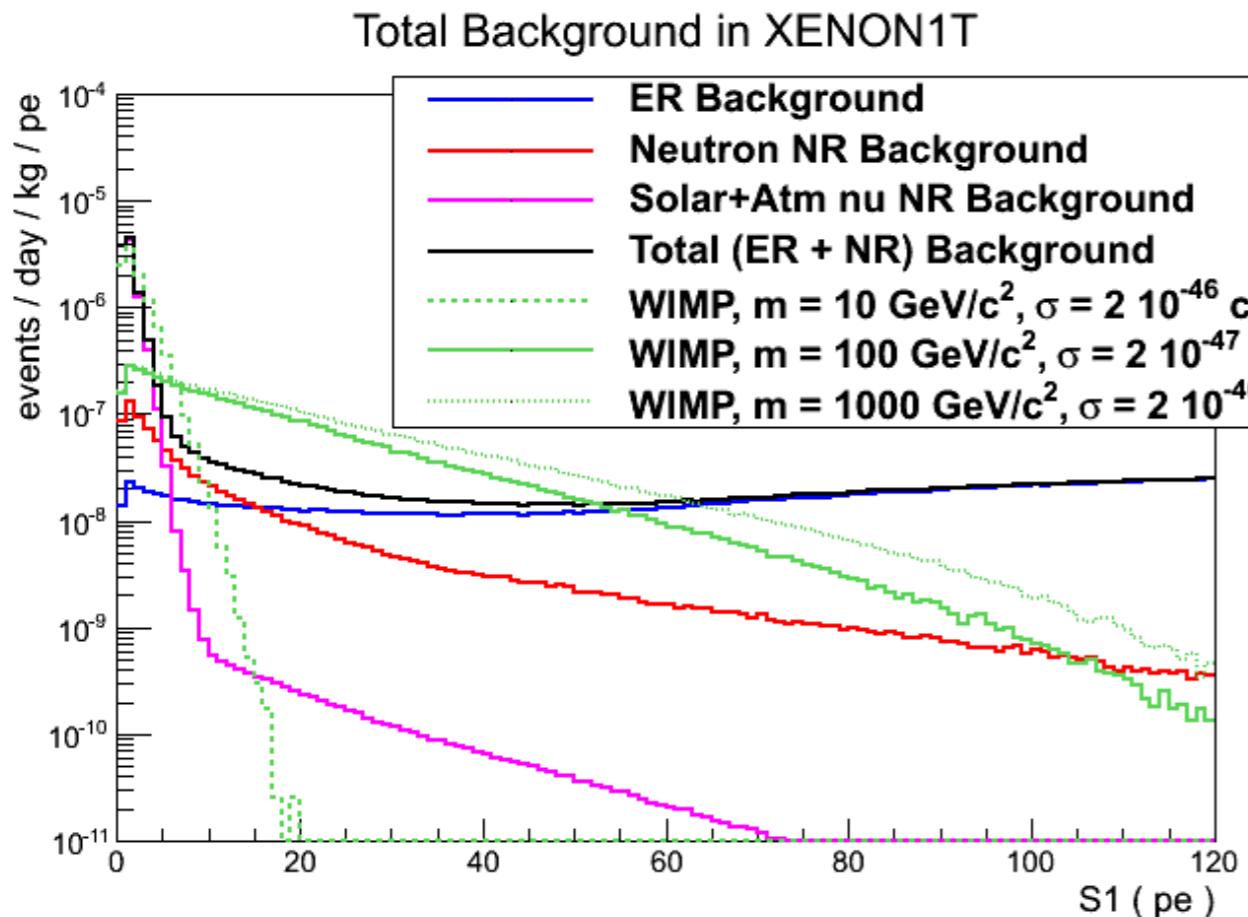
- Materials background: based on screening results for all detector components
- $^{85}\text{Kr}$ : 0.2 ppt of  $^{\text{nat}}\text{Kr}$  with  $2 \times 10^{-11} \text{ }^{85}\text{Kr}$ ;  $^{222}\text{Rn}$ : 1  $\mu\text{Bq/kg}$ ;  $^{136}\text{Xe}$  double beta:  $2.11 \times 10^{21} \text{ yr}^{-1}$
- ER vs NR discrimination level: 99.75%; 40% acceptance for NRs
  - Total ERs: 0.3 events/year in 1 ton fiducial volume, [2-12] keV<sub>ee</sub>
  - Total NRs: 0.2 events/year in 1 ton, [5-50] keV<sub>nr</sub> (**muon-induced n-BG < 0.01 ev/year**)



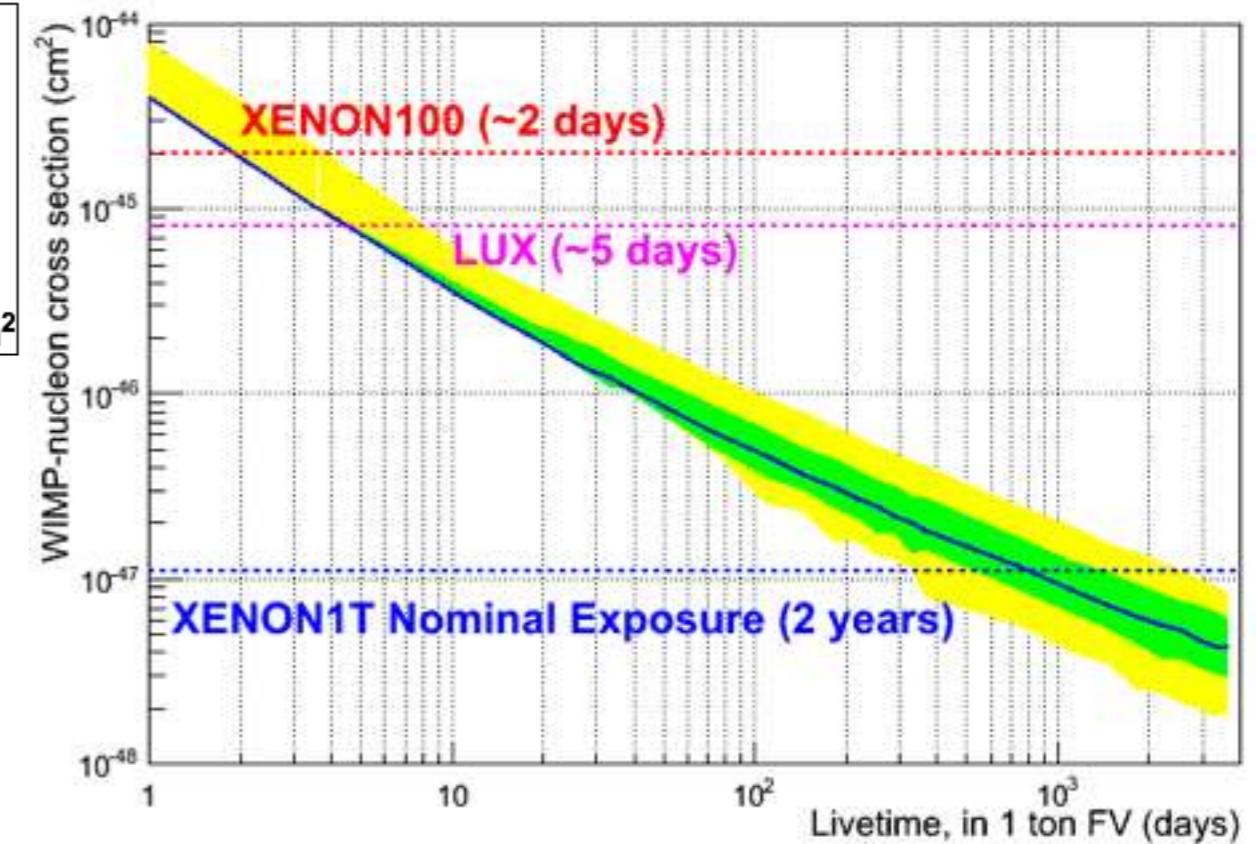
# XENON1T backgrounds and WIMP sensitivity

Single scatters in 1 ton fiducial  
99.75% S2/S1 discrimination  
NR acceptance 40%  
Light yield = 7.7 PE/keV at 0 field  
 $L_{\text{eff}} = 0$  below 1 keVnr

WIMP mass: 50 GeV  
Fiducial LXe mass: 1 t  
Sensitivity at 90% CL



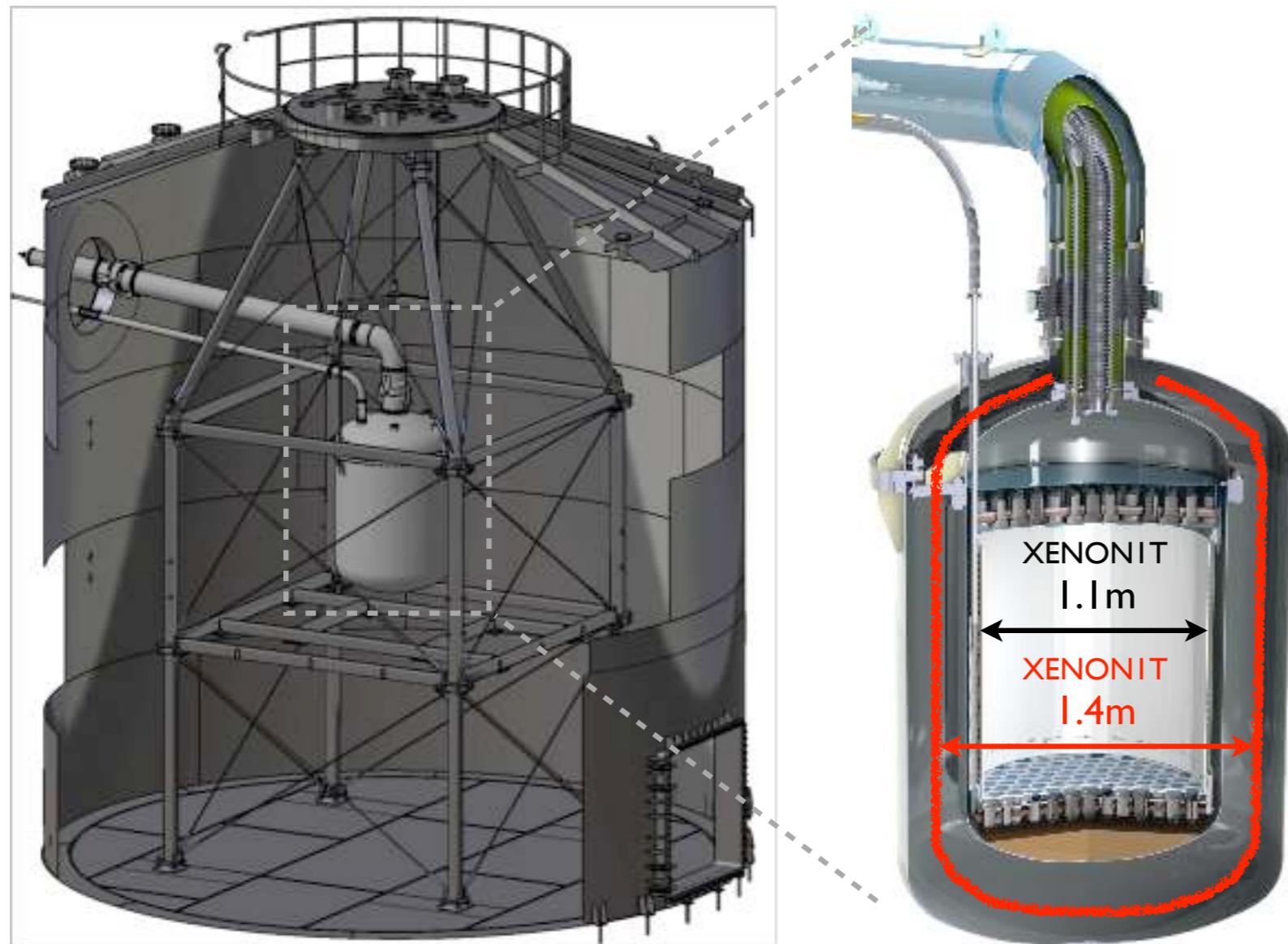
ER + NR backgrounds and WIMP spectra



Sensitivity versus exposure (in 1 ton fiducial mass)

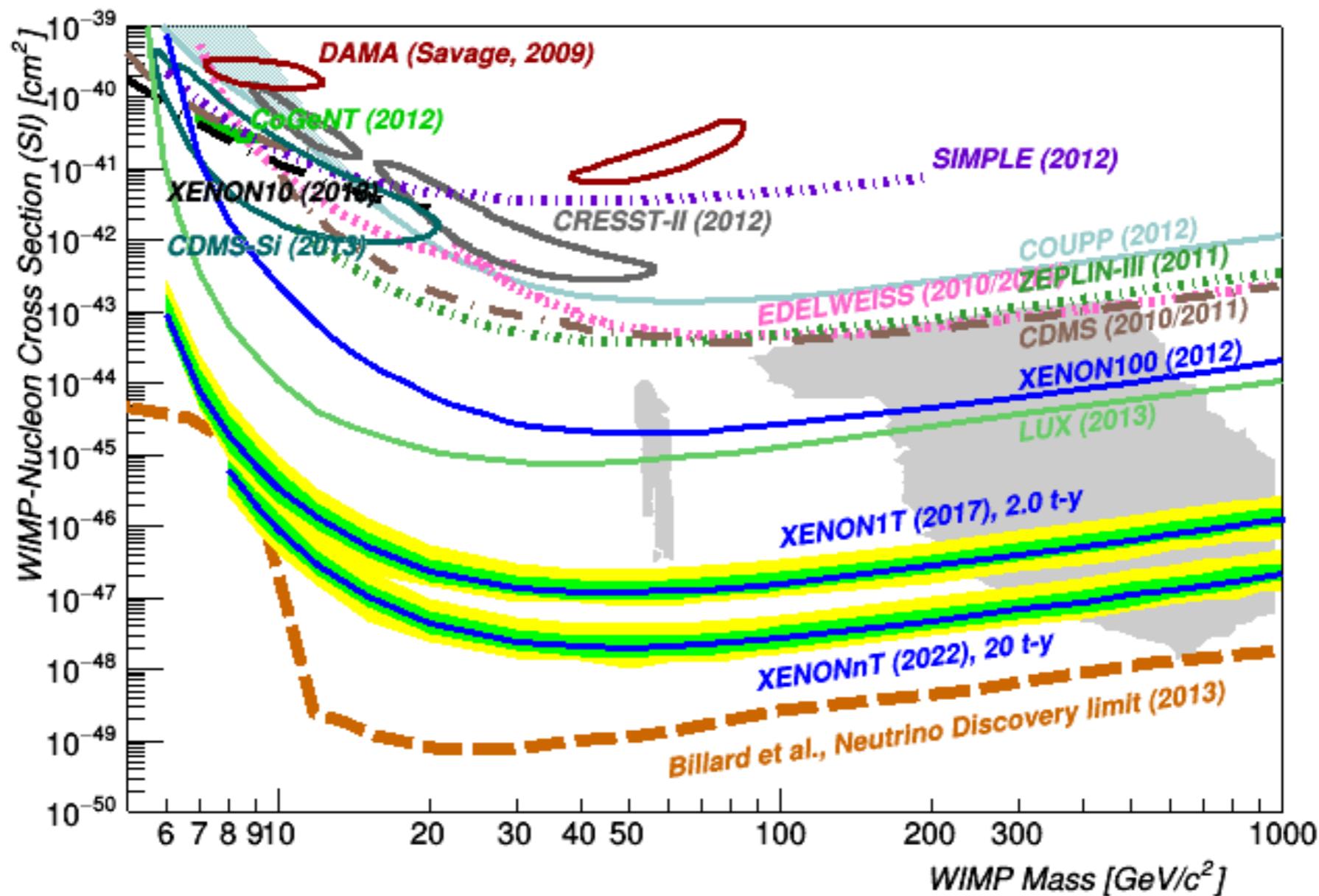
# XENONnT: 2018-2020

- Plan: double the amount of LXe (~7 tons), double the number of PMTs
- XENON1T is constructed such that many sub-systems will be reused for the upgrade:



- Water tank + muon veto
- Outer cryostat and support structure
- Cryogenics and purification system
- LXe storage system
- Cables installed for XENONnT as well
- More LXe, PMTs, electronics will be needed

# XENONnT WIMP sensitivity

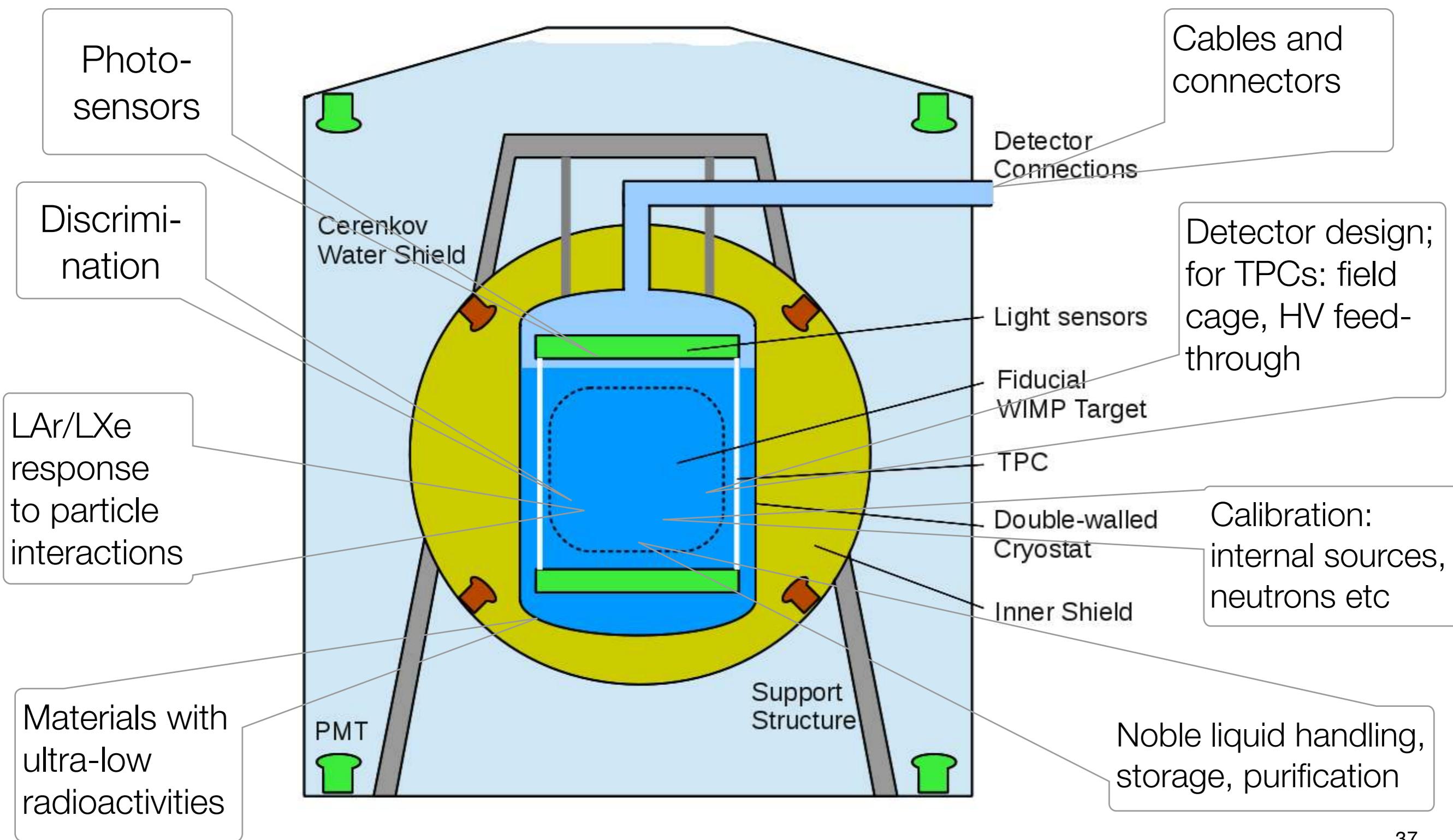


# DARWIN Dark matter WIMP search with noble liquids



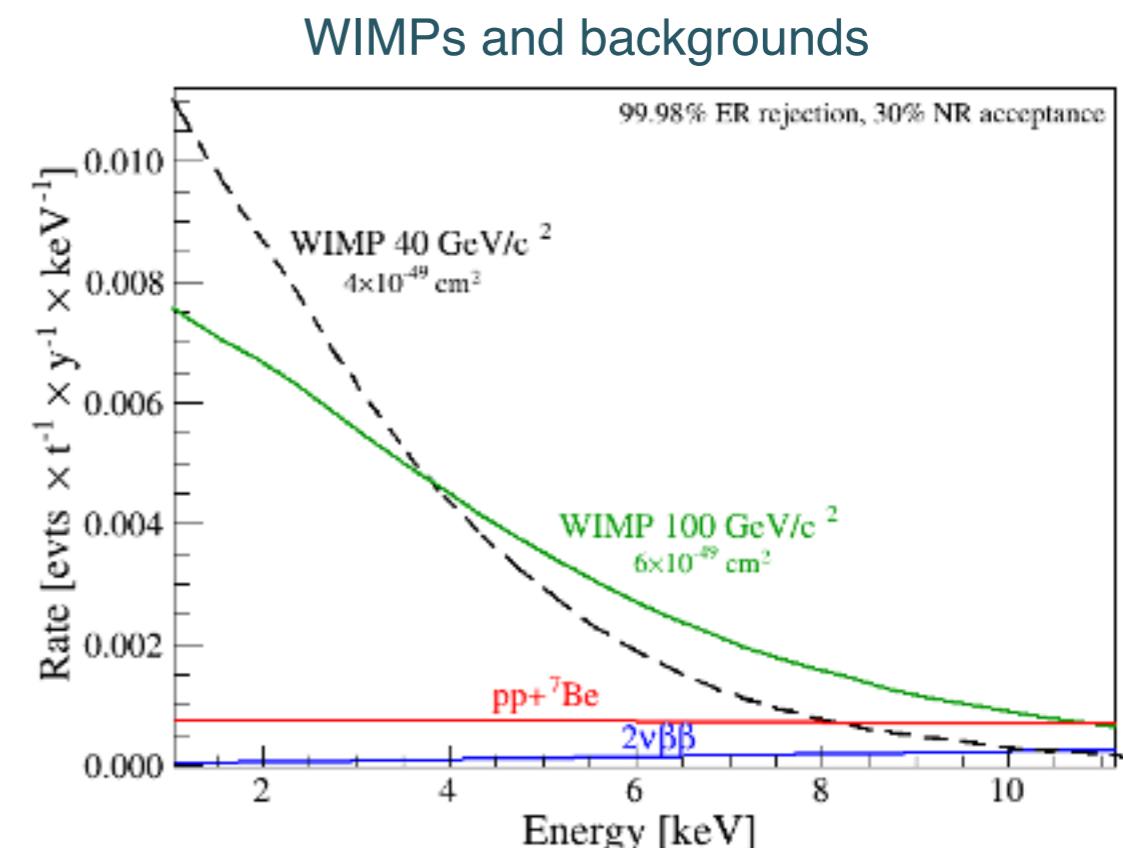
- R&D and design study for 30-50 tons LXe detector
- ~ few  $\times 10^3$  photosensors
- >2 m drift length
- >2 m diameter TPC
- PTFE walls with Cu field shaping rings (baseline scenario, 4- $\pi$  readout under study)
- Background goal: dominated by neutrinos
- Physics goal:
  - WIMP spectroscopy
  - many other channels (pp neutrinos, double beta decay, axions and ALPs, bosonic SuperWIMPs...)

# Strong R&D programme required



# Backgrounds: electronic recoils

- Materials (cryostat, photosensors, TPC)
- $^{222}\text{Rn}$  in LXe: **0.1  $\mu\text{Bq/kg}$**  (**1  $\mu\text{Bq/kg}$**  => same background level as solar neutrinos)
- $^{85}\text{Kr}$  in LXe: **0.1 ppt  $^{85}\text{Kr}$**  (**0.2 ppt  $^{85}\text{Kr}$**  => same background level as solar neutrinos)
- $^{136}\text{Xe}$  double beta decay
- Solar neutrinos (mostly pp,  $^7\text{Be}$ )



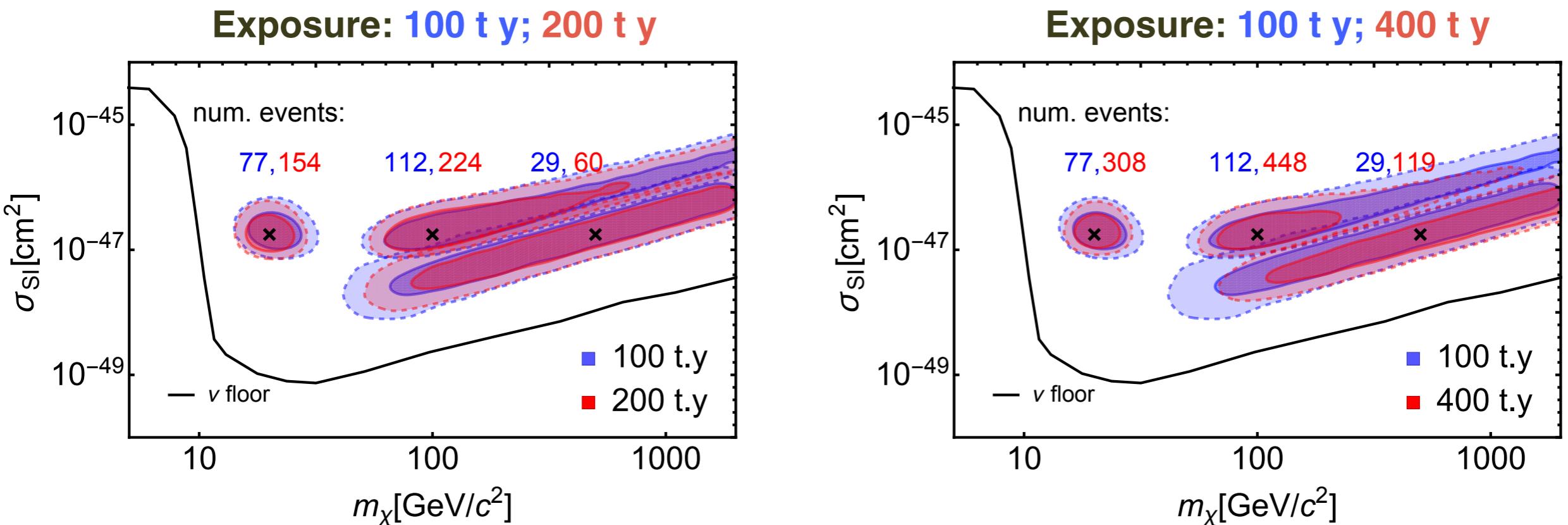
Channel	Before descr	After descr (99.98%)
pp + $^7\text{Be}$ neutrinos	95	0.488
Materials	1.4	0.007
$^{85}\text{Kr}$ in LXe (0.1 ppt $^{85}\text{Kr}$ )	40.4	0.192
$^{222}\text{Rn}$ in LXe (0.1 $\mu\text{Bq/kg}$ )	9.9	0.047
$^{136}\text{Xe}$	56.1	0.036

1 t x yr exposure,  
2-30 keVee

200 t x yr exposure  
4-50 keVnr, 30% acceptance

# WIMP physics: spectroscopy

- Capability to reconstruct the WIMP mass and cross section for various masses (**20, 100, 500 GeV/c<sup>2</sup>**) and a spin-independent cross section of  $2 \times 10^{-47} \text{ cm}^2$  (assuming different exposures)



1 and 2 sigma credible regions after marginalizing the posterior probability distribution over:

$$v_{esc} = 544 \pm 40 \text{ km/s}$$

$$v_0 = 220 \pm 20 \text{ km/s}$$

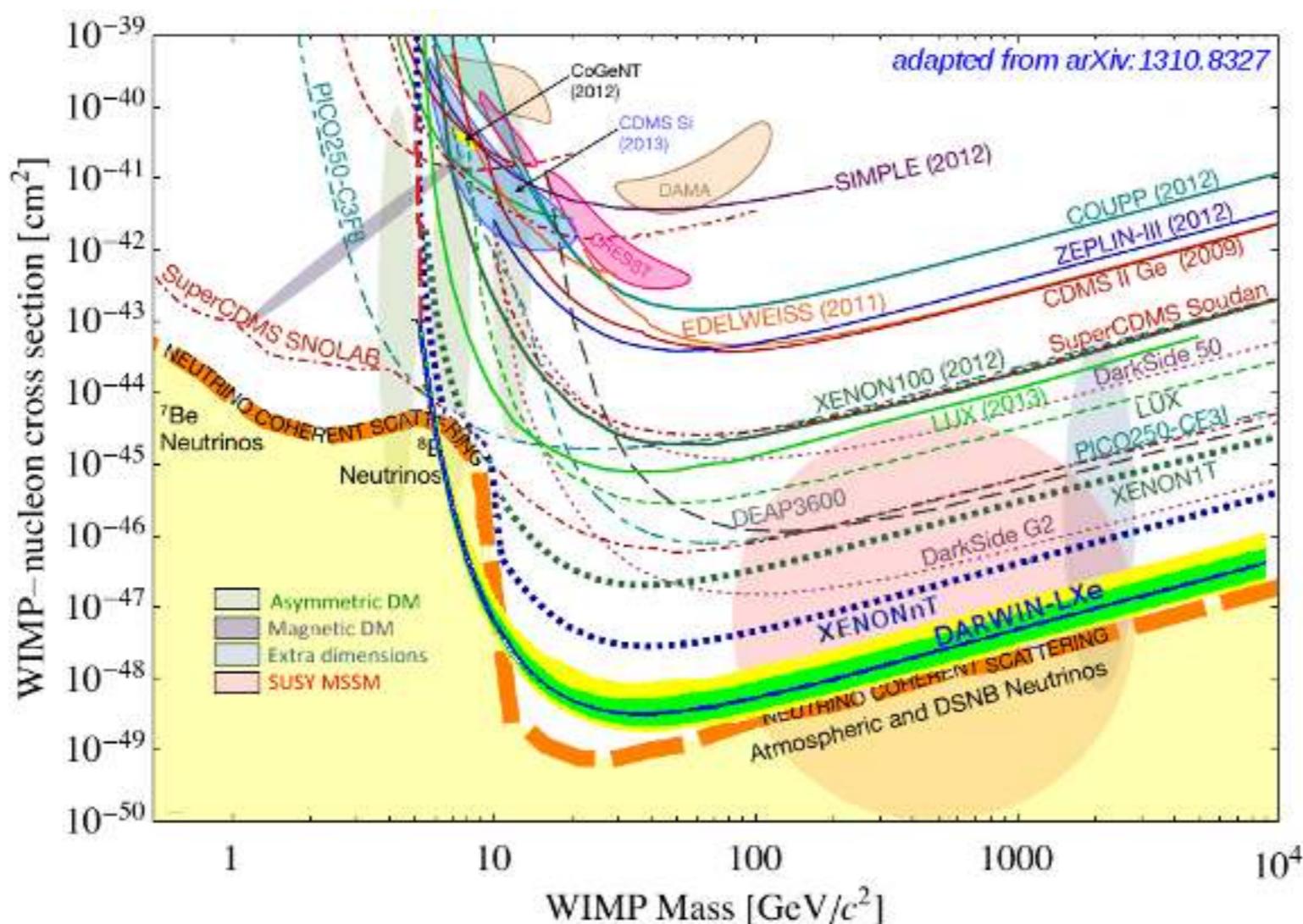
$$\rho_\chi = 0.3 \pm 0.1 \text{ GeV/cm}^3$$

Update: Newstead et al., PHYSICAL REVIEW D 88, 076011 (2013)

# Sensitivity for spin-independent cross sections

- $E = [3-70] \text{ pe} \sim [4-50] \text{ keV}_{\text{nr}}$

200 t y exposure, 99.98% discrimination, 30% NR acceptance, LY = 8 pe/keV at 122 keV



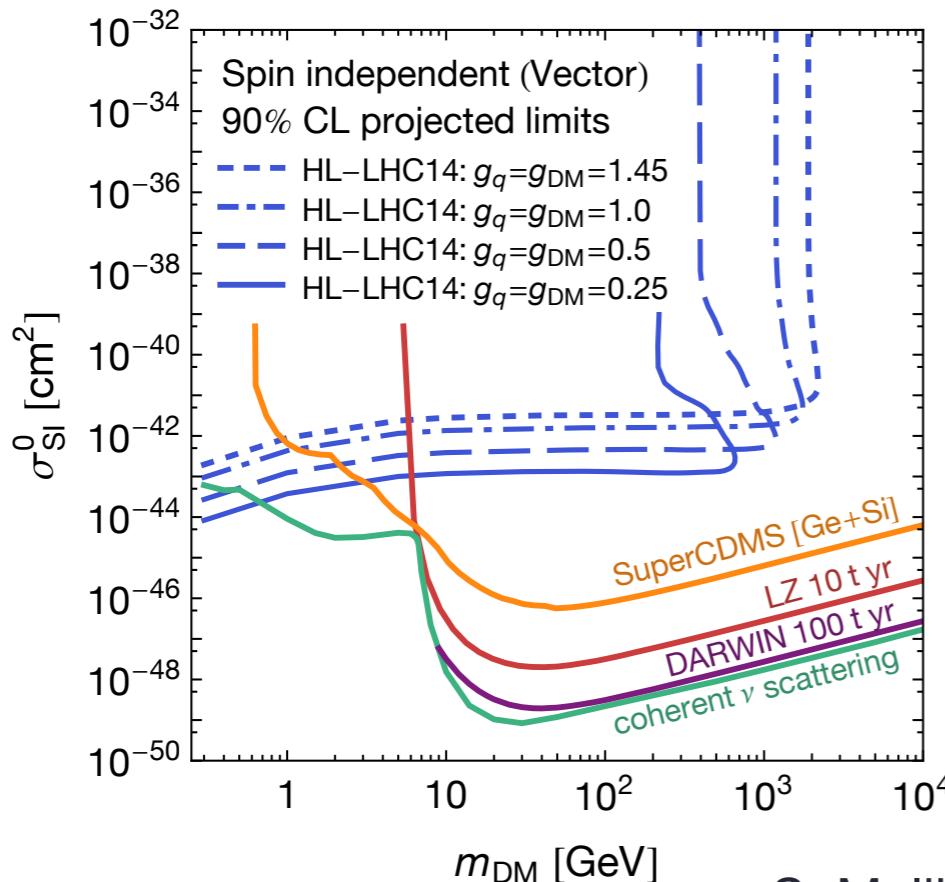
Note: “nu floor” = 3-sigma detection line at 500 CNNS events above 4 keV

# Complementarity with the LHC

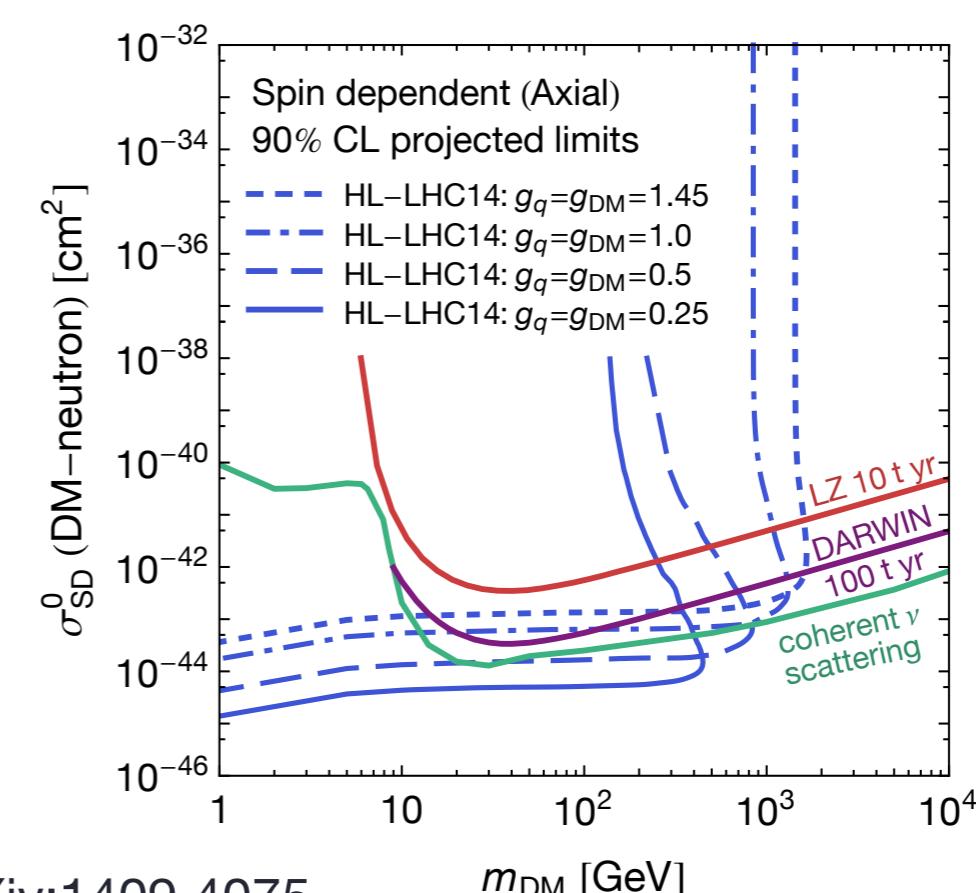
- Minimal simplified DM model with only 4 variables:  $m_{\text{DM}}$ ,  $M_{\text{med}}$ ,  $g_{\text{DM}}$ ,  $g_q$
- Here DM = Dirac fermion interacting with a vector or axial-vector mediator; equal-strength coupling to all active quark flavours

$$\sigma_{\text{DD}} \propto \frac{g_{\text{DM}}^2 g_q^2 \mu^2}{M_{\text{med}}^4}$$

## Spin independent

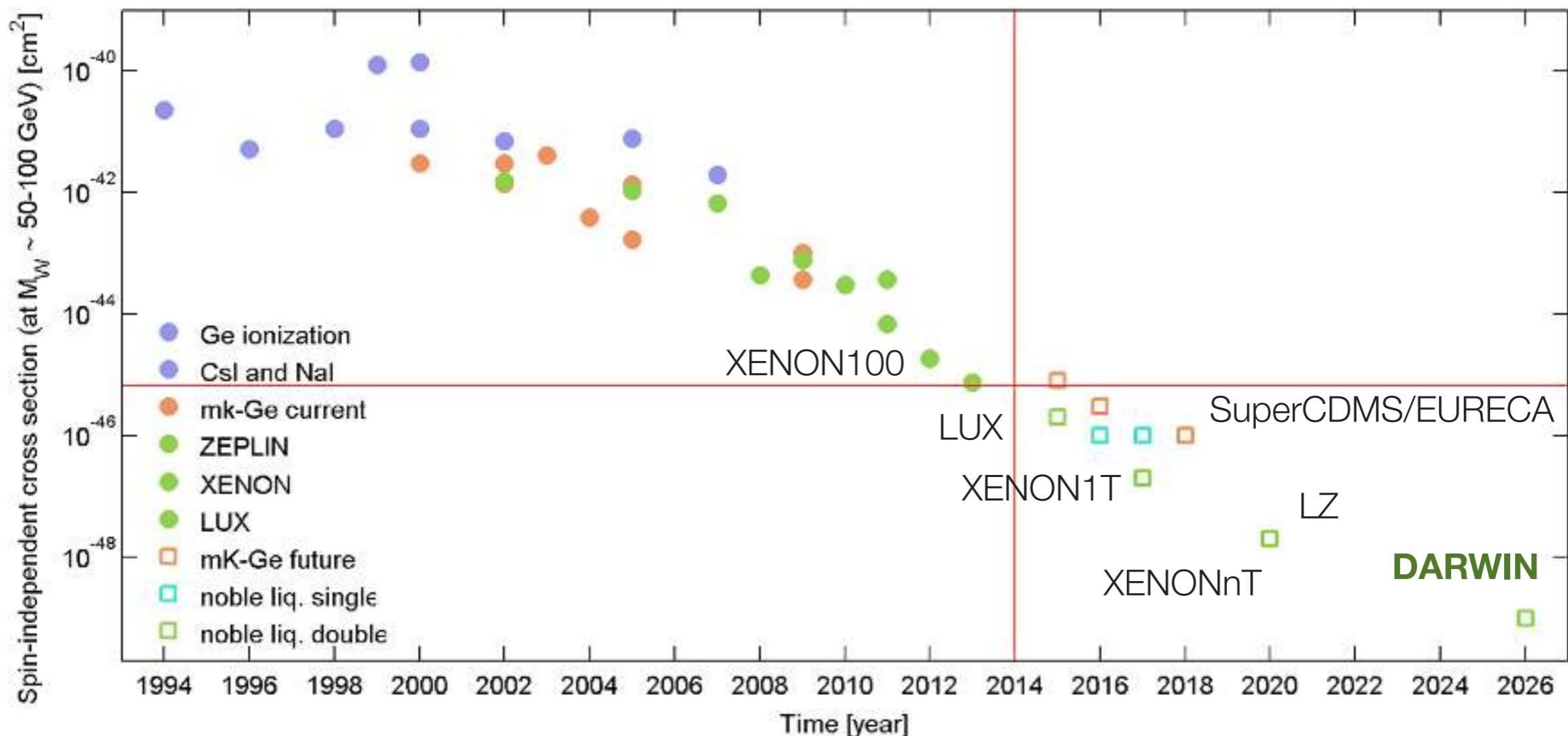


## Spin dependent



# Evolution of the experimentally probed WIMP-nucleon cross section

- Sensitivity at WIMP masses above  $\sim 6 \text{ GeV}/c^2$  is clearly dominated by *noble liquid (Xe) time projection chambers*



# Summary

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- New particles with masses and cross sections at the electroweak scale still viable candidates for galactic dark matter
- Liquid xenon based experiments offer great sensitivity over a wide range of masses
- XENON100 has reached its design sensitivity for medium-heavy WIMPs, and it can also probe other type of interactions (axions, ALPs, light WIMPs)
- XENON1T is well under construction at LNGS & various home institutions, integration of all sub-systems is planned for fall 2015, with commissioning ~ late 2015
- XENONnT is proposed as a fast upgrade to XENON1T, with a factor of 10 increase in sensitivity
- DARWIN - an R&D and design study for a third-generation, ‘ultimate’ WIMP dark matter detector - would operate a 30 - 50 t LXe detector, with the goal of probing the experimentally accessible parameter space for masses  $>\sim 10$  GeV & spectroscopy
- It could also detect pp-neutrinos in real time, with high stats, possibly coherent neutrinos scattering, axions, ALPs, bosonic SuperWIMPs, etc

The end

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