Latest results and Status of the XENON Program

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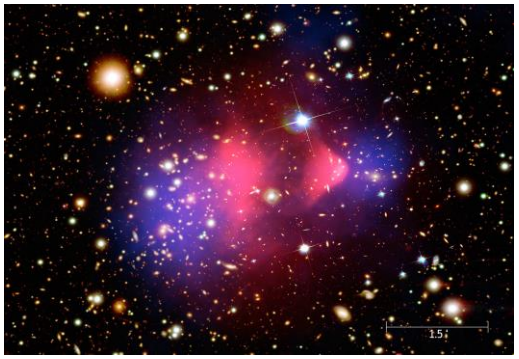
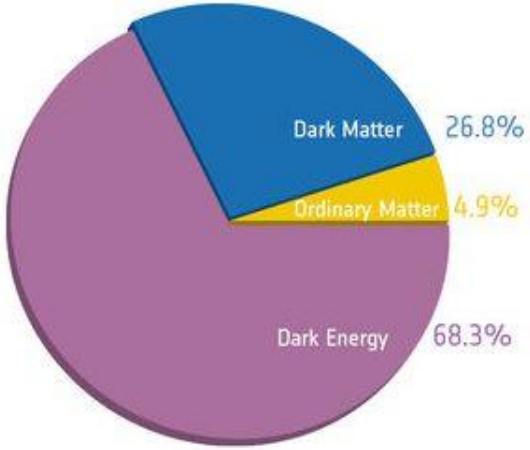
On behalf of the XENON Collaboration

28th Rencontres de Blois – May 31st 2016

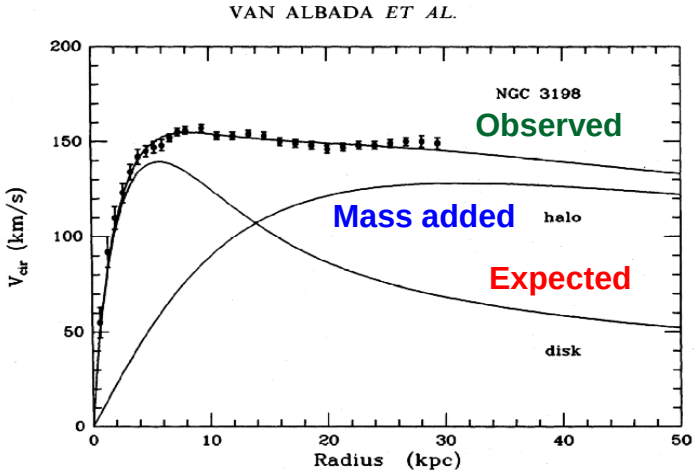
Dark Matter



Bullet cluster
X-ray observation inconsistent with the mass distribution from gravitational lensing



Energy density repartition in the universe
Dark matter has an energy density 5 times bigger than standard matter.



Galactic velocity rotation curves
Observed and expected velocity inconsistent. The difference can be explain by the presence of a non luminous mass

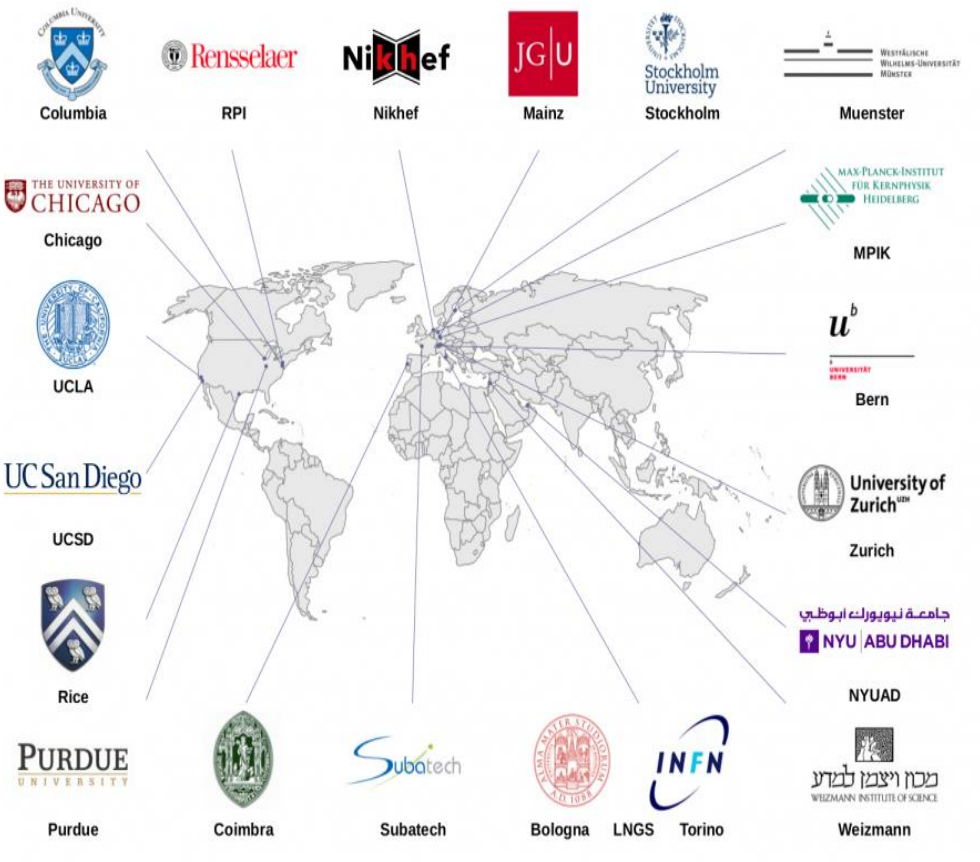
- **Dark Matter properties:**
  - Non baryonic
  - Neutral
  - Non relativistic
  - Weakly interacting
  - Not Standard Model particle

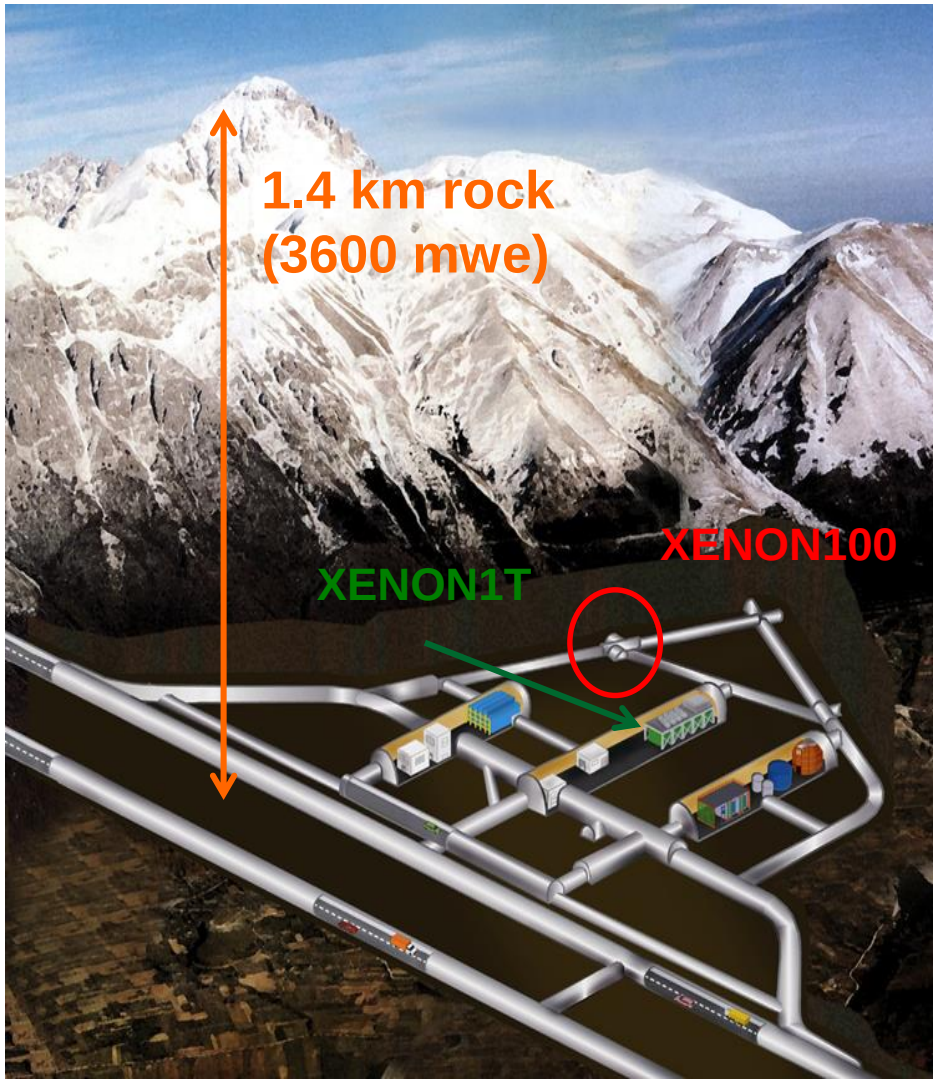
One of the most favored candidates as dark matter particle:

Weakly **I**nteracting **M**assive **P**article (**WIMP**)

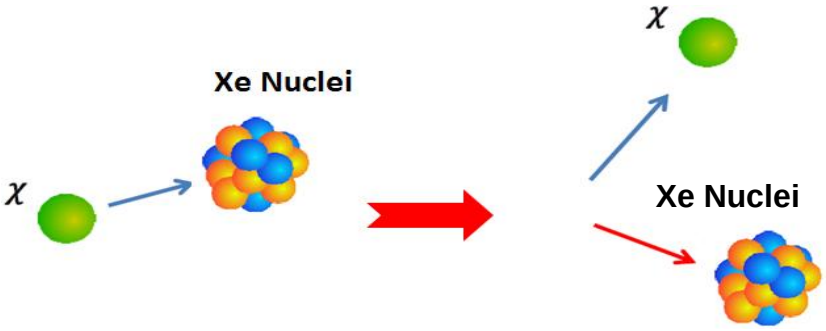
Location of the XENON experiment & Collaboration

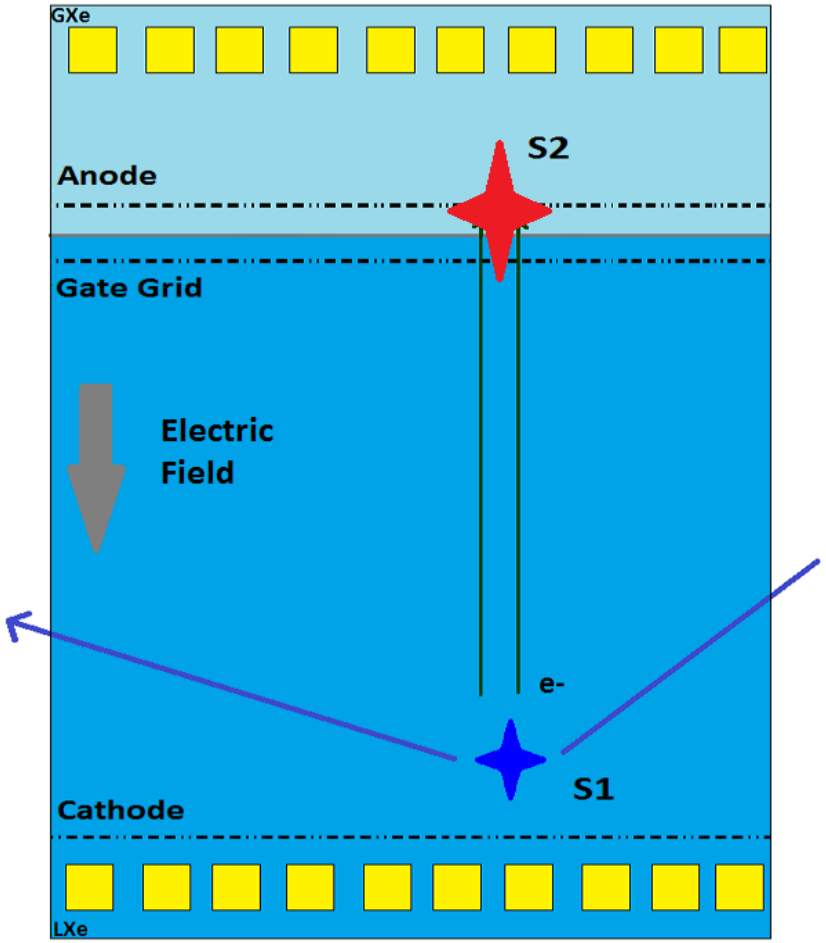
- **21 Institutes**
- **~ 150 Scientists**



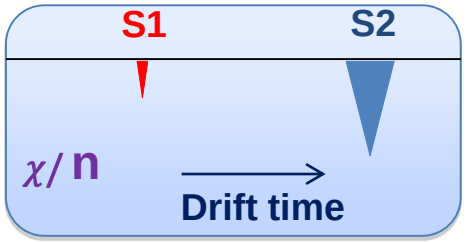


TPC Detector principle

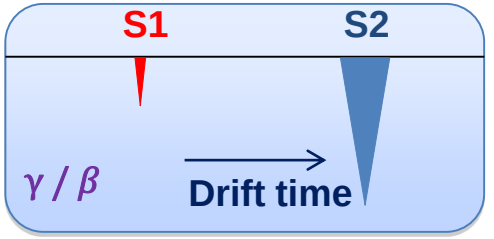


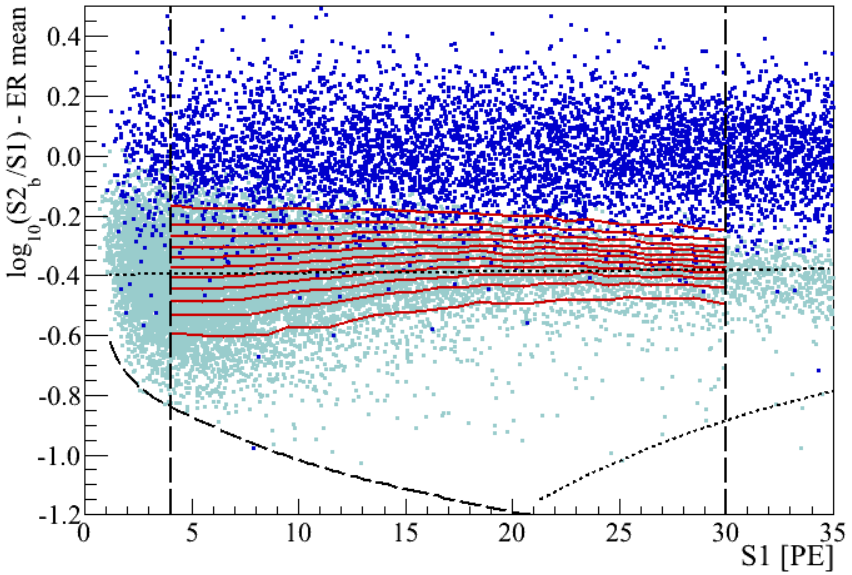


Nuclear **R**ecoil
WIMP, neutrons



Electronic **R**ecoil
Photons, electrons





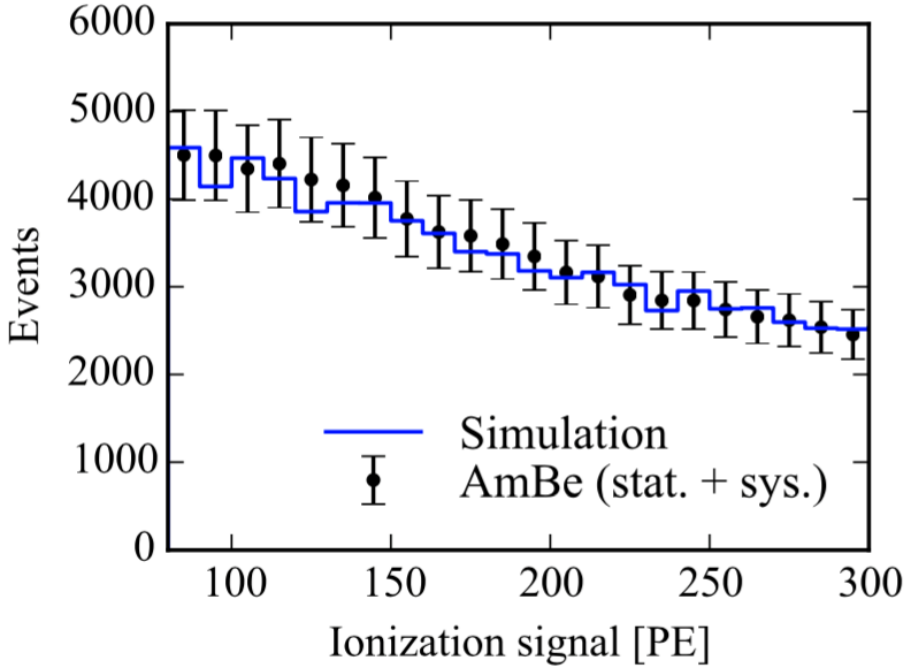
- Two signals : **scintillation** and **ionization** (S1,S2)
- **S1**: photons produced by de-excitation
- **S2:** scintillation signal produced by the electrons of ionization
- **3D position reconstruction**: allows fiducialization and multiple scatter rejection
- **S2/S1 ratio**: Discrimination between electronic and nuclear recoil

NEW

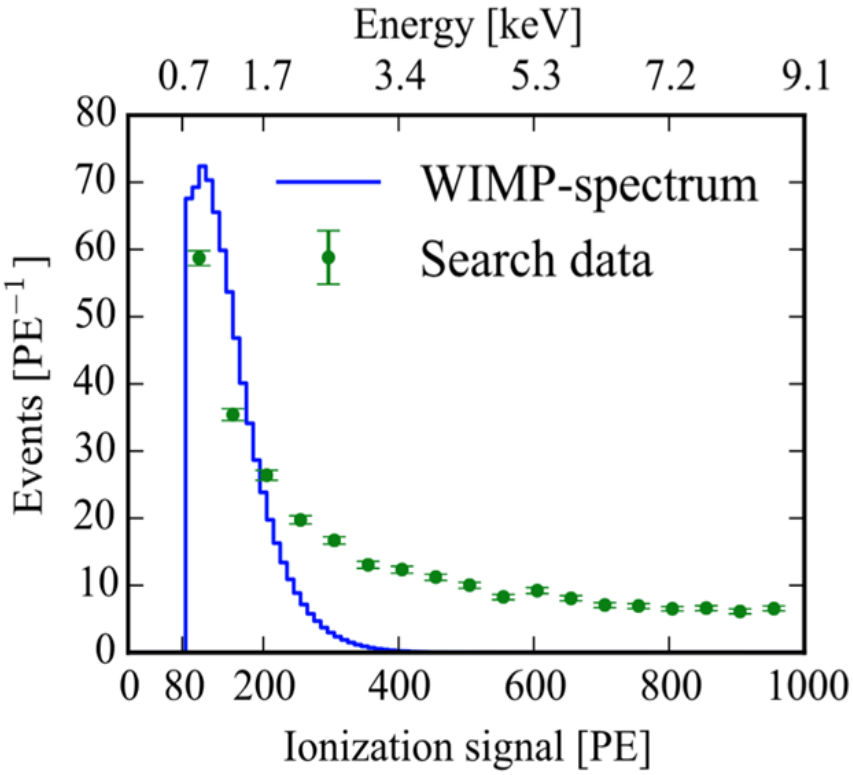
Low mass Dark Matter - Results

A low mass dark matter search using ionization signals in XENON100,
arXiv:1605.06262

- **Nuclear recoil analysis below S1 detection threshold**
  - No z position reconstruction
  - No S2/S1 ratio discrimination
- **0.7 keV nuclear recoil threshold**



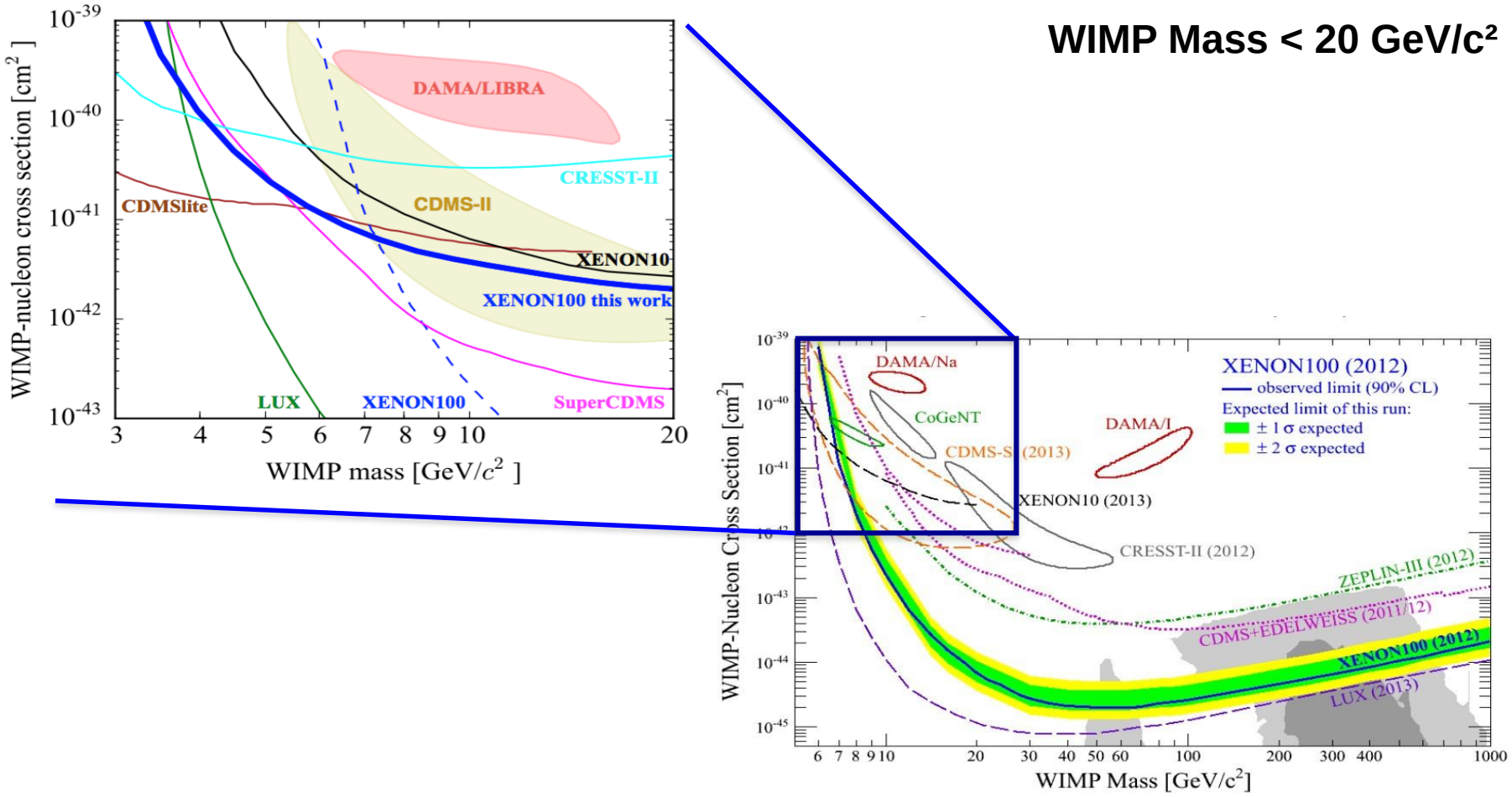
Understanding the S2-only energy scale: AmBe data compared to simulation



Example of expected WIMP event with a mass of 6 GeV/c²

Low mass Dark Matter - Results

NEW



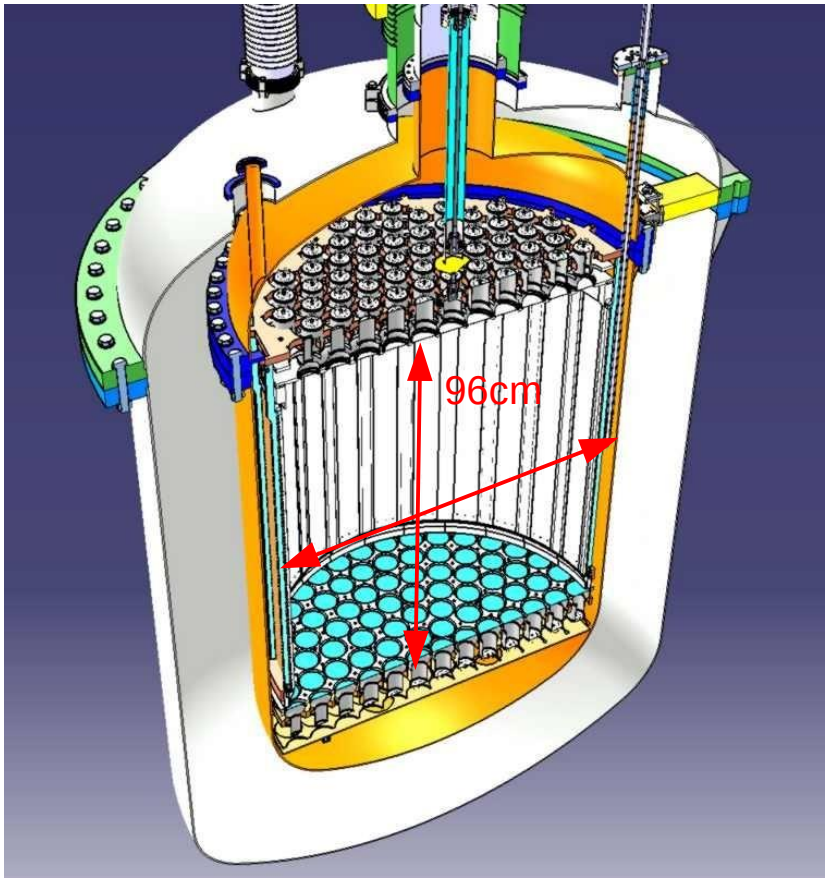
- Excluding limits on WIMP-nucleon cross section:

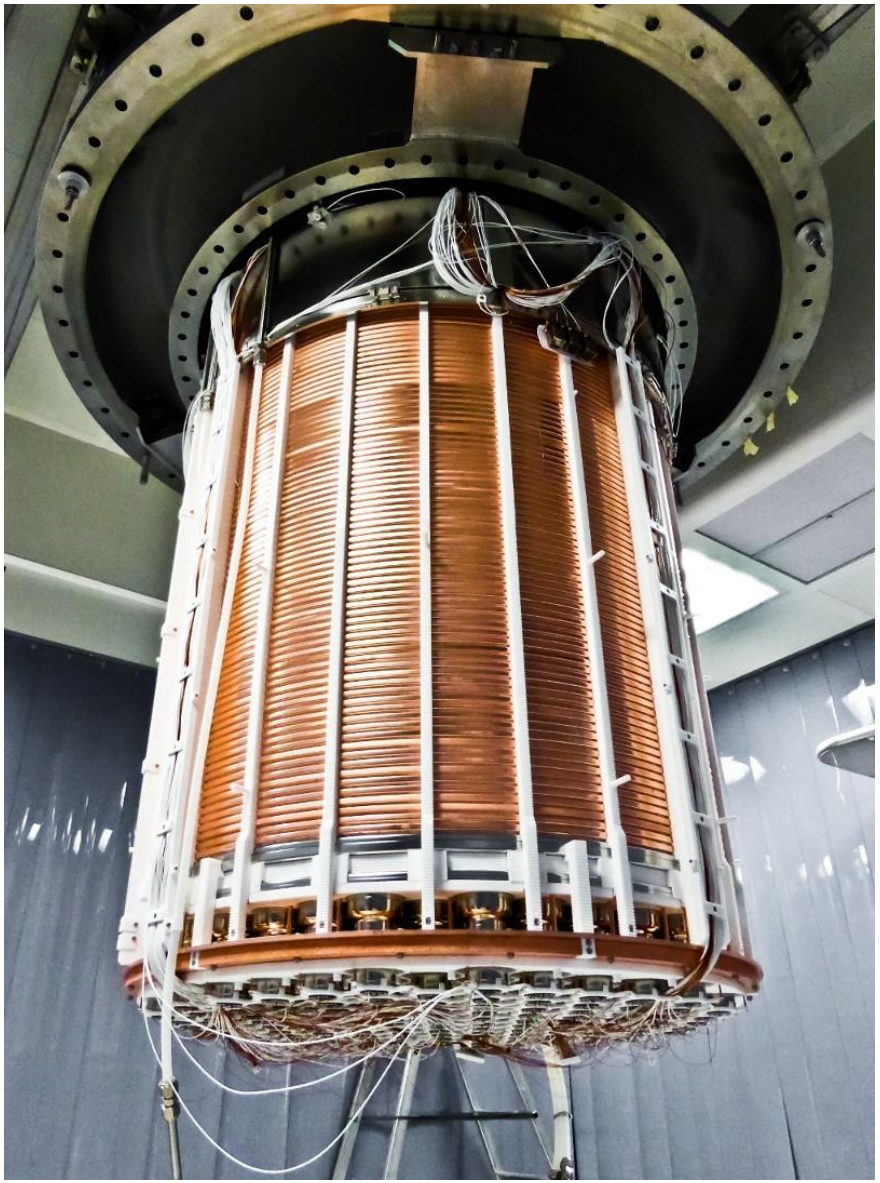
$$\sigma_\chi = 1.1 \times 10^{-41}\ \text{cm}^2 \text{ @ } m_\chi = 6\ \text{GeV/c}^2$$

E.Aprile et al. (XENON100 Collaboration) *A low mass dark matter search using ionization signals in XENON100, arXiv:1605.06262*

XENON1T

XENON1T – TPC

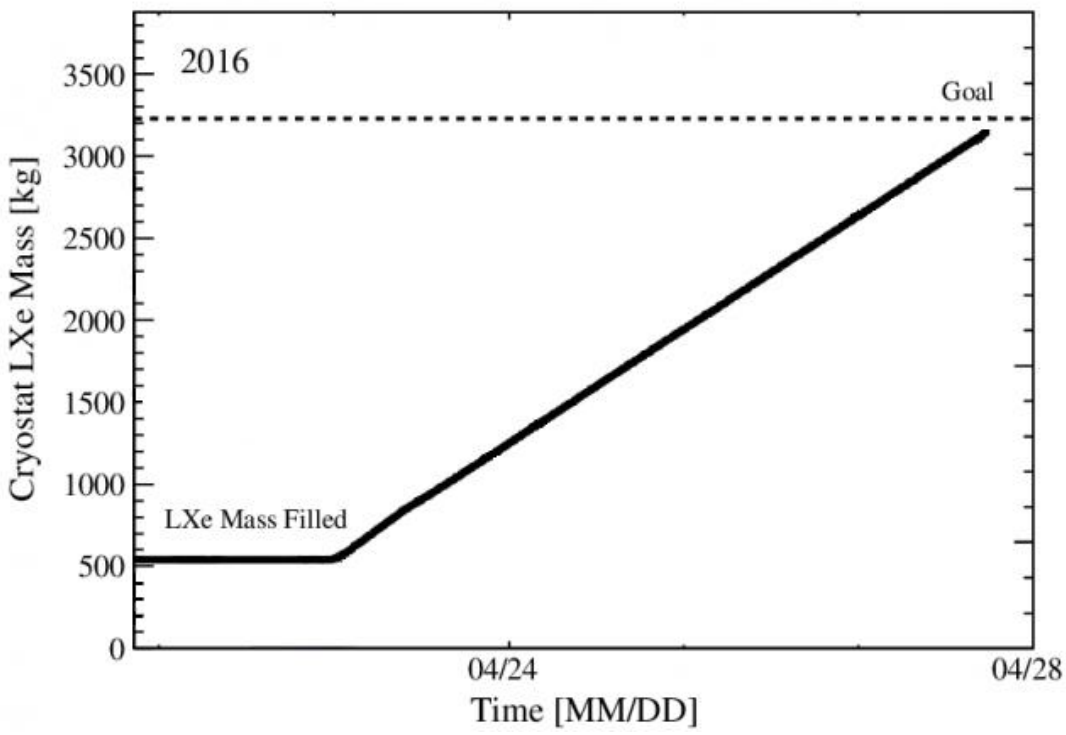




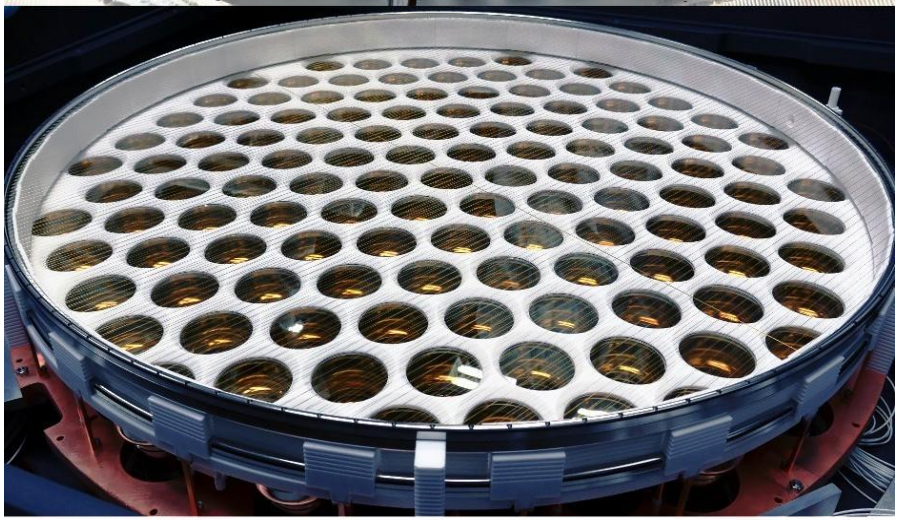
- 3.5 t liquid xenon in total
- 2.0 t active target
- ~1t fiducial target after 10cm cut from all sides
- 248 PMTs

XENON1T – ReStoX

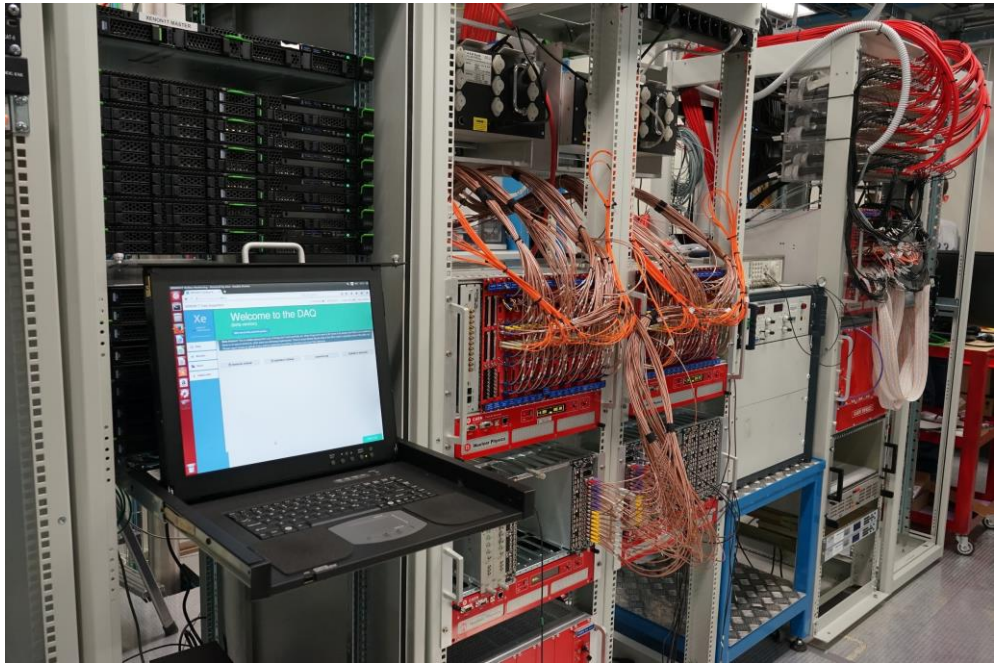
- Store up to 7600 kg of xenon in gaseous or liquid phase under high purity conditions
- Safely recovering of all xenon in few hours
- Commissioning phase completed
- ReStox has been filled by 3.5 tons of XENON which was successfully transferred to the cryostat.



XENON1T – PMTs and DAQ



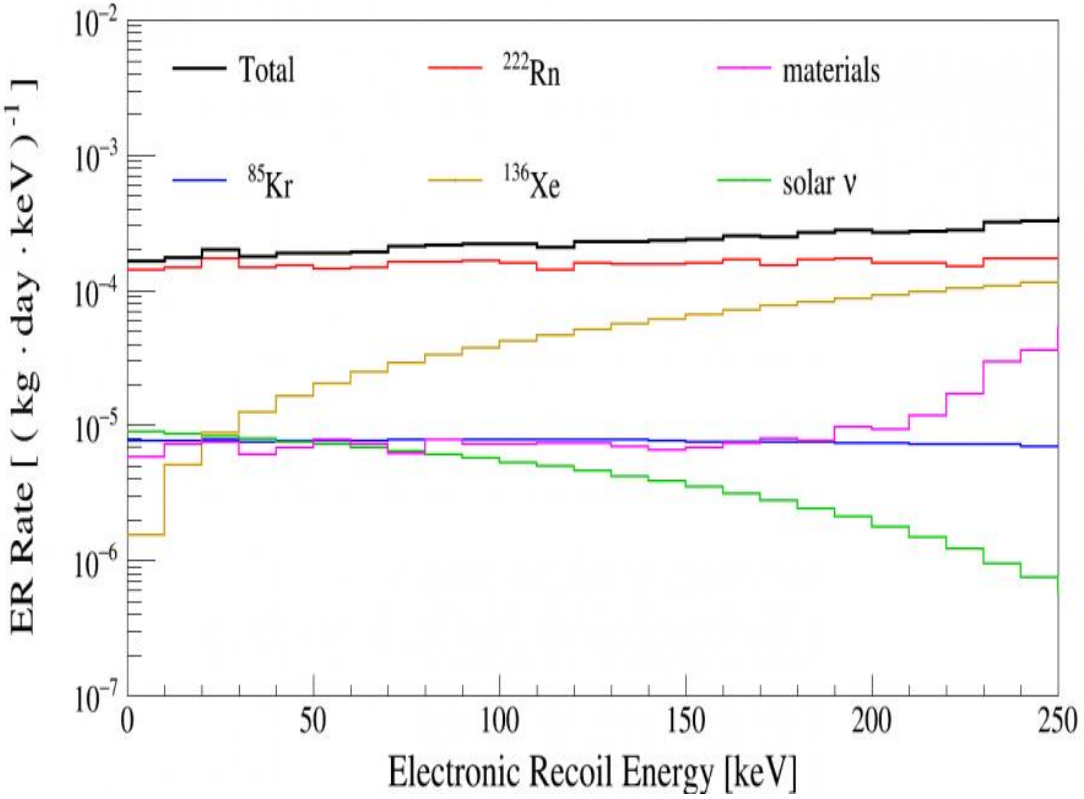
- 248 R11410 PMTs
- Triggerless readout
- Software trigger
- PMT/DAQ commissioning ongoing
- Continuously data taking
- Slow Control system for control and monitoring used for commissioning



Electronic recoil background

Physics reach of the XENON1T dark matter experiment, **JCAP no. 04 027 (2016)**

Before ER/NR discrimination

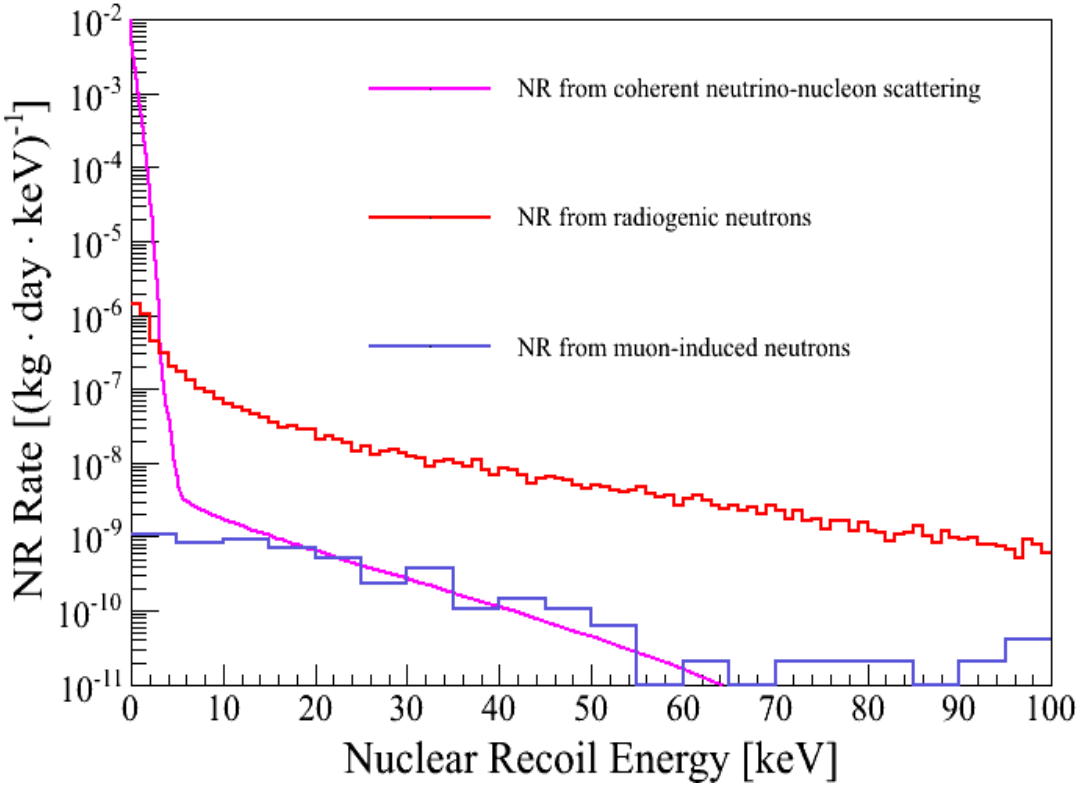


- **^{222}Rn**: main intrinsic source of background in LXe, part of the ^{238}U decay chain (components and gas system)
- **Solar neutrinos**: interaction with electrons of the medium
- **^{85}Kr**: from natural Kr of the atmosphere
- **^{136}Xe**: from natural Xe
- **Materials**: radioactivity of the main components of the TPC

- Main contribution from ^{222}Rn
- Total expected electronic recoil background:
  - 1t fiducial volume
  - Energy range: 1-12 keV
  - **720 ± 60 events.y^{-1}**

Nuclear recoil background

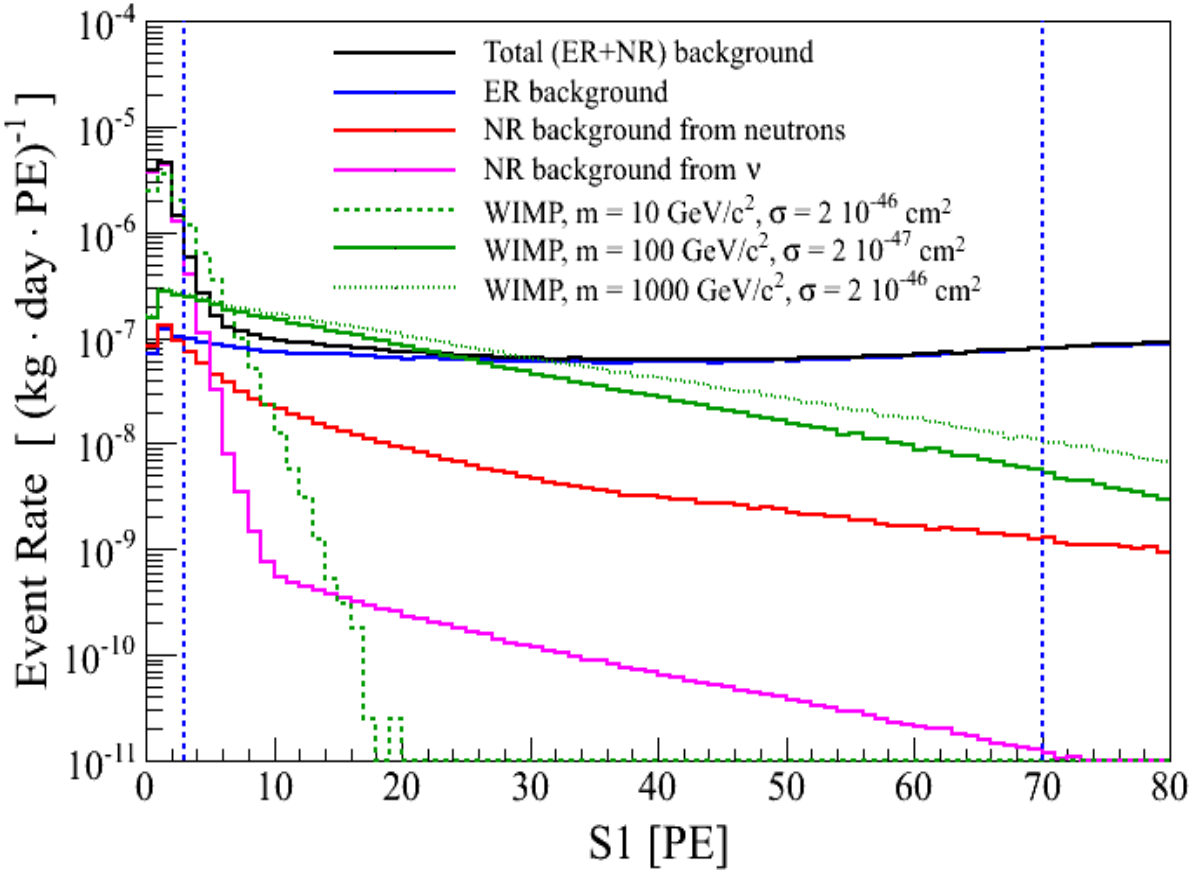
Before ER/NR discrimination



- Radiogenic neutrons: from detector components
- Muon-induced neutrons: neutrons produced by cosmic muon interaction on rock, concrete and detector materials
- Coherent neutrino-nucleus scattering: neutrinos scattering on xenon nucleus
- Main contribution from radiogenic neutrons
- Total expected nuclear recoil background:
  - Assuming 100% NR acceptance
  - 1t fiducial volume
  - Energy range: 4-50 keV
  - **0.62 ± 0.12 events.y^{-1}**

E.Aprile et al. (Collaboration) *Physics reach of the XENON1T dark matter experiment*, JCAP no. 04 027 (2016)

Total background prediction

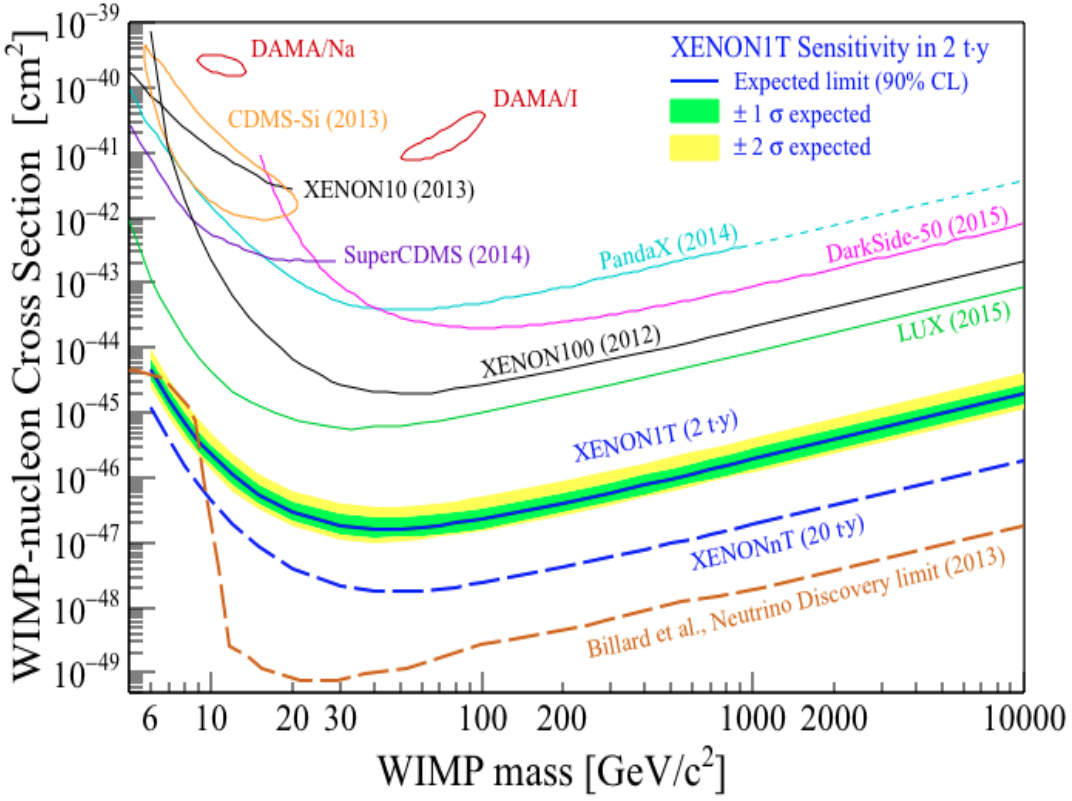


- **3-70 PE** S1 region
- **4-50 keV** NR energy region
- **2 t x y** exposure
- **99.75%** XENON100- like ER rejection
- **40%** NR acceptance

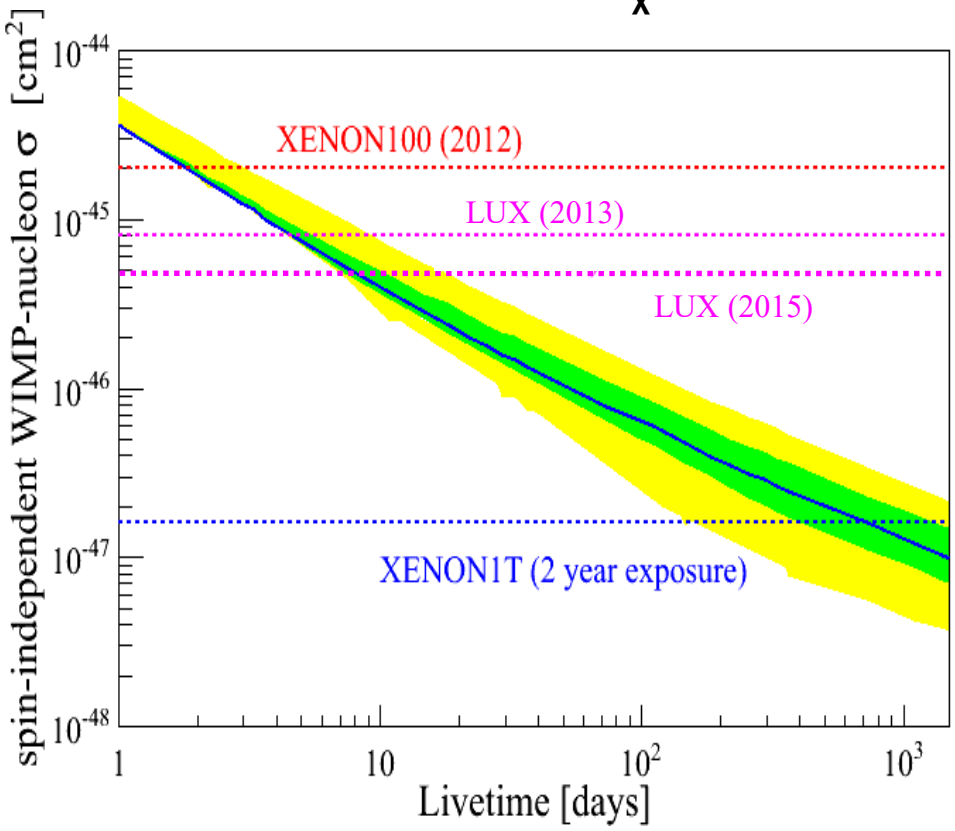
- Background estimation:
  - **Total Nuclear Background: 0.91 events**
  - **Total Electronic Background: 3.25 events**
  - **WIMP expectation at m=100 GeV/c² and σ=2.10^{-47} cm²: 2.85 events**

E.Aprile et al. (XENON Collaboration) *Physics reach of the XENON1T dark matter experiment*, JCAP no. 04 027 (2016)

XENON1T – Sensitivity



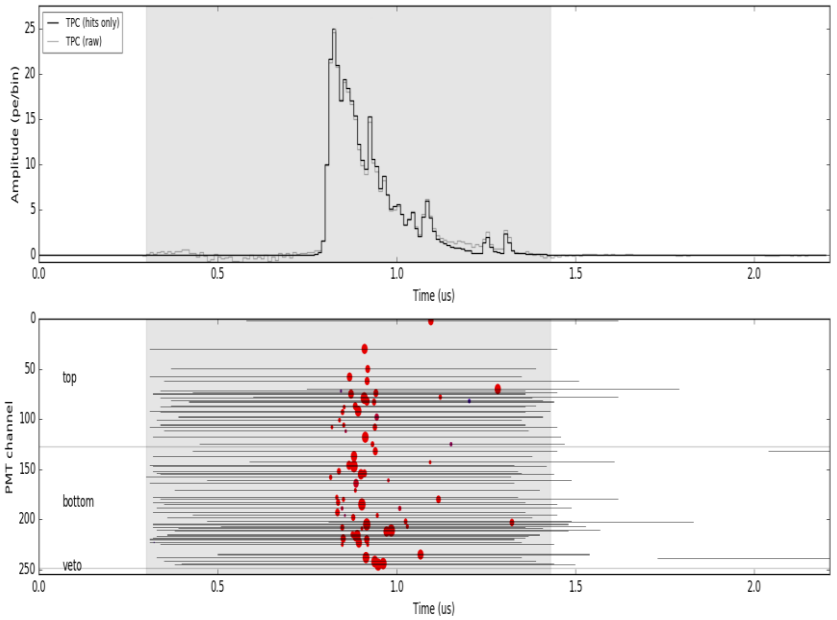
$m_\chi = 50\ \mathrm{GeV/c^2}$



- Expected sensitivity 100 times better than XENON100
- Sensitivity of currently running experiment reached in less than 10 days
- XENON1T first data coming soon

E.Aprile et al. (XENON Collaboration) *Physics reach of the XENON1T dark matter experiment*, JCAP no. 04 027 (2016)

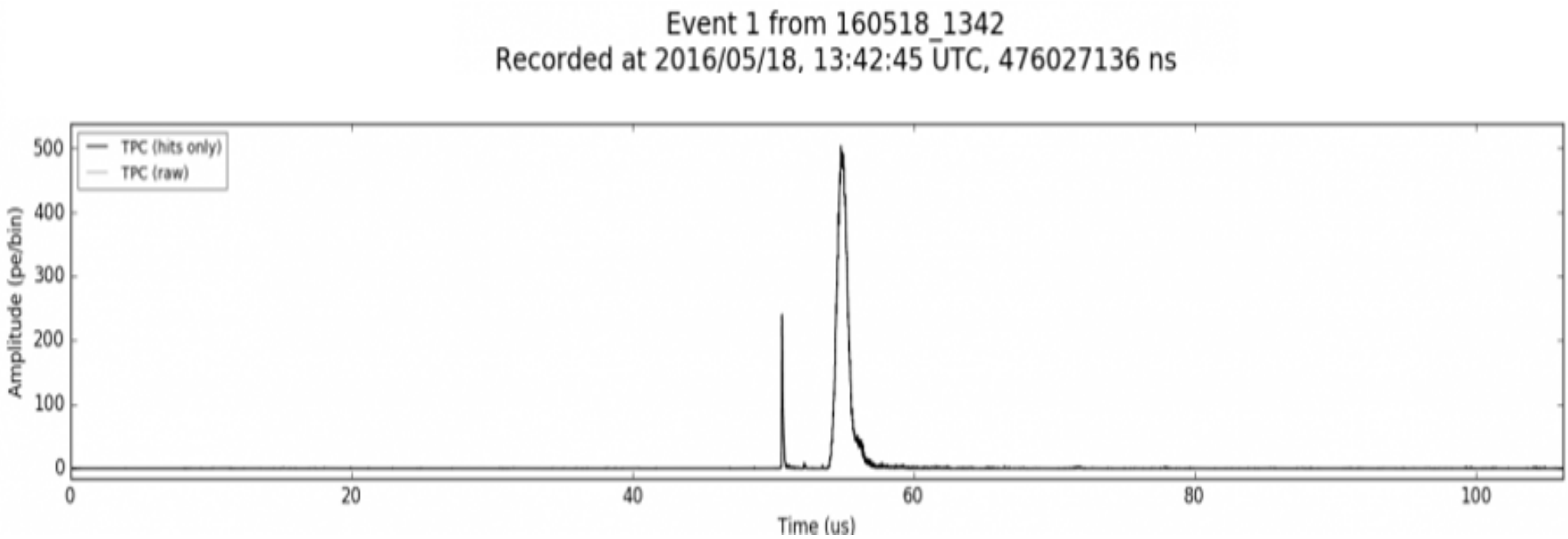
XENON1T - First light



- **17th March 2016**:
  first S1 signal seen in xenon gas

- **18th May 2016:**

first event with S1+S2 in two-phase operation



Thank you
for your attention