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Direct Search for Dark Matter with the XENON Experiment

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Exploring the Dark Sector

KIAS

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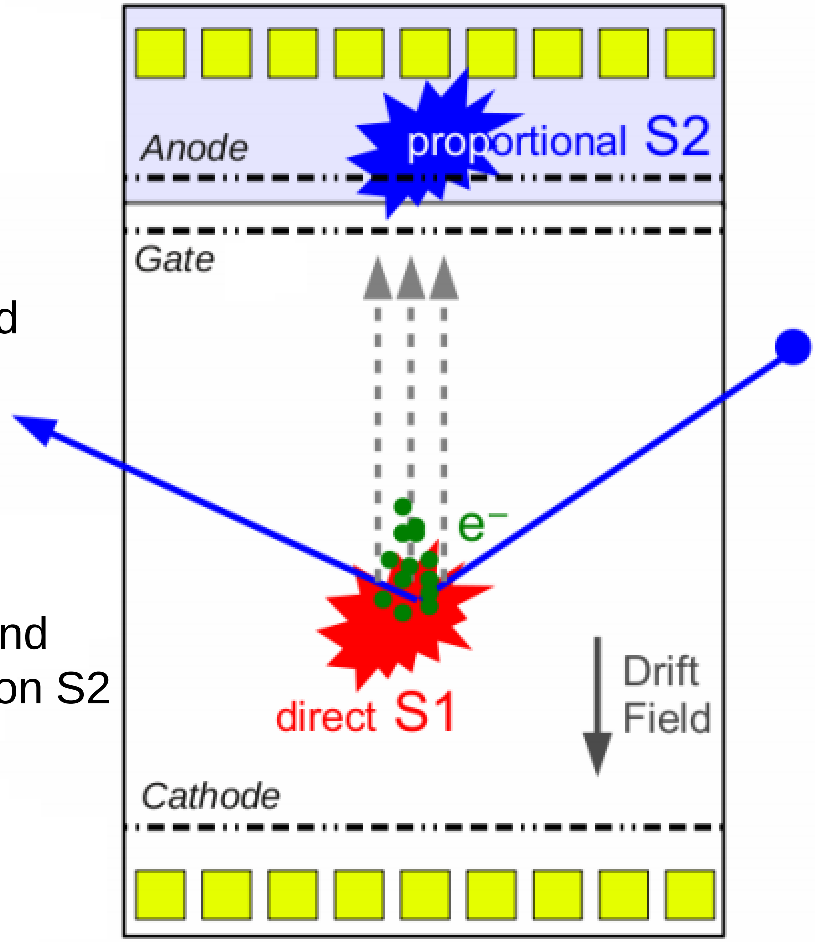
Liquid Xenon Time Projection Chambers

Particle detection with a xenon TPC

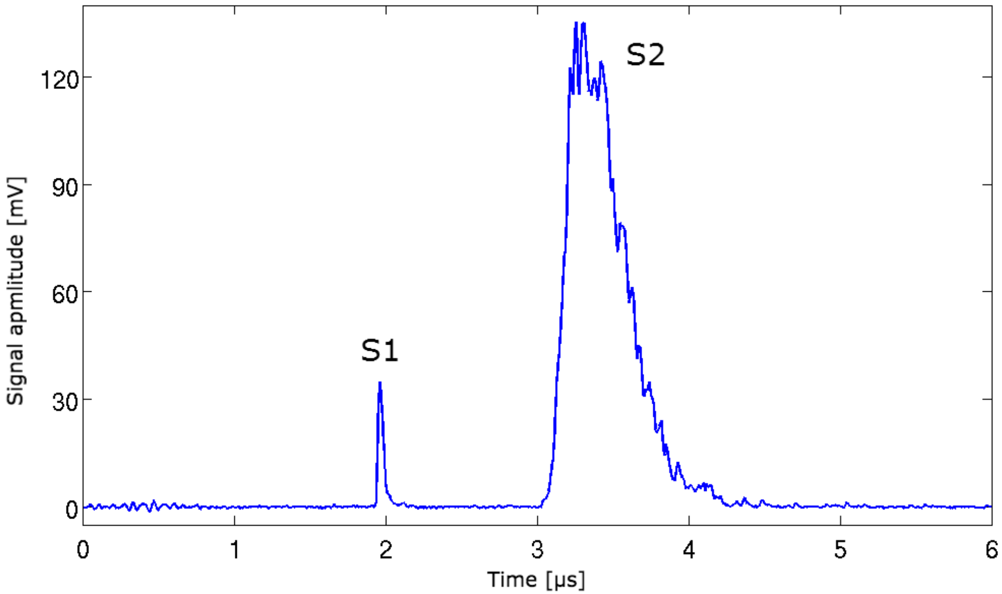
- LXe target
- Particles hitting a Xe atom generate direct scintillation light S1 and free electrons
- Cathode and gate generate a drift field and drive the electrons upwards
- Gate and anode generate the extraction field
- Electrons reaching the liquid surface get extracted into the gas phase, accelerate and generate secondary proportional scintillation S2
- PMT arrays detect the generated signals



Particle interactions in liquid xenon

Two interaction types in lXe:

- Electronic recoils (γ,e)
- Nuclear recoils (n,WIMP)

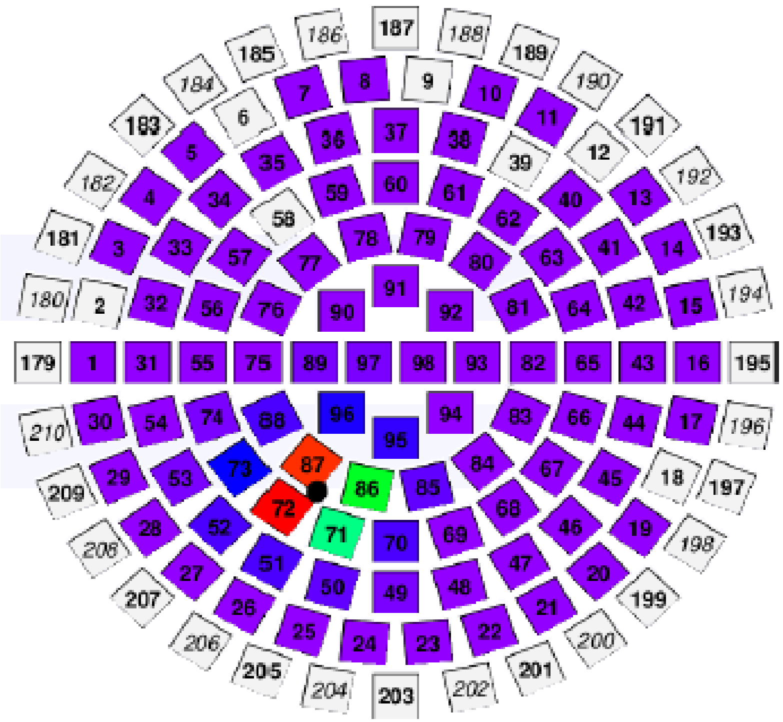


○ $\left(\frac{S2}{S1}\right)_e > \left(\frac{S2}{S1}\right)_n$

○ With a good understanding of those S2 to S1 ratios, a background reduction of >99% is possible

Position reconstruction in a xenon TPC

- Xenon TPC are able to achieve sub-millimeter resolution for event reconstruction
- Since the electron drift velocity at a given field is known, the vertical position can be calculated from the electron drift time
- The position in the horizontal plane is determined by comparing the signal strengths in different PMTs



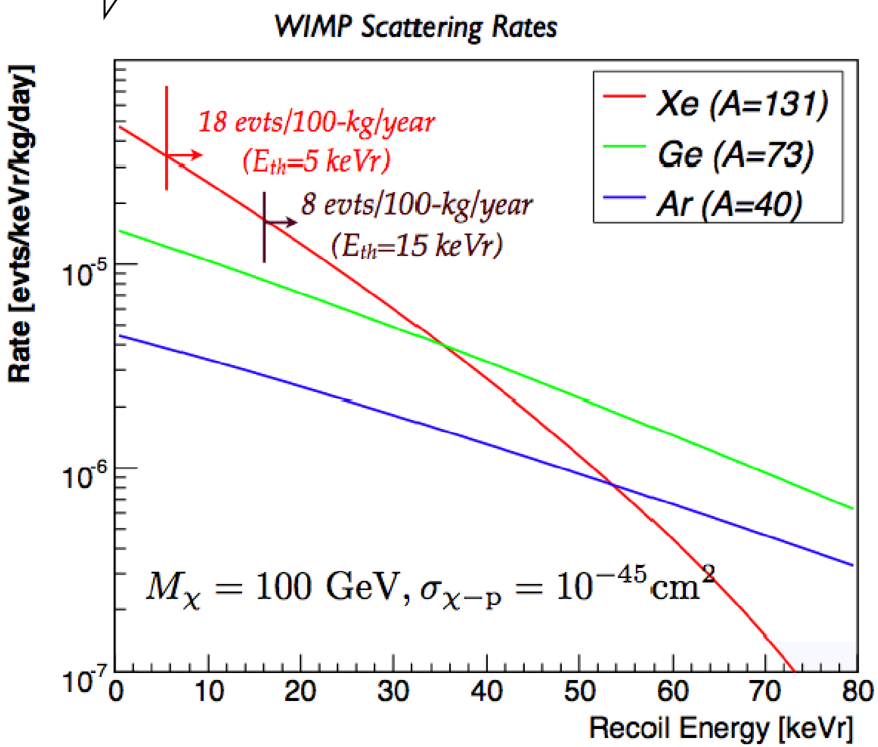
Advantages of a xenon TPC

- Good self-shielding
- Gamma discrimination through S2/S1
- Very low intrinsic radioactivity

Suitable for low background experiments

○ High interaction rate at low energies due to the atomic mass

○ Easy to scale up the experiment



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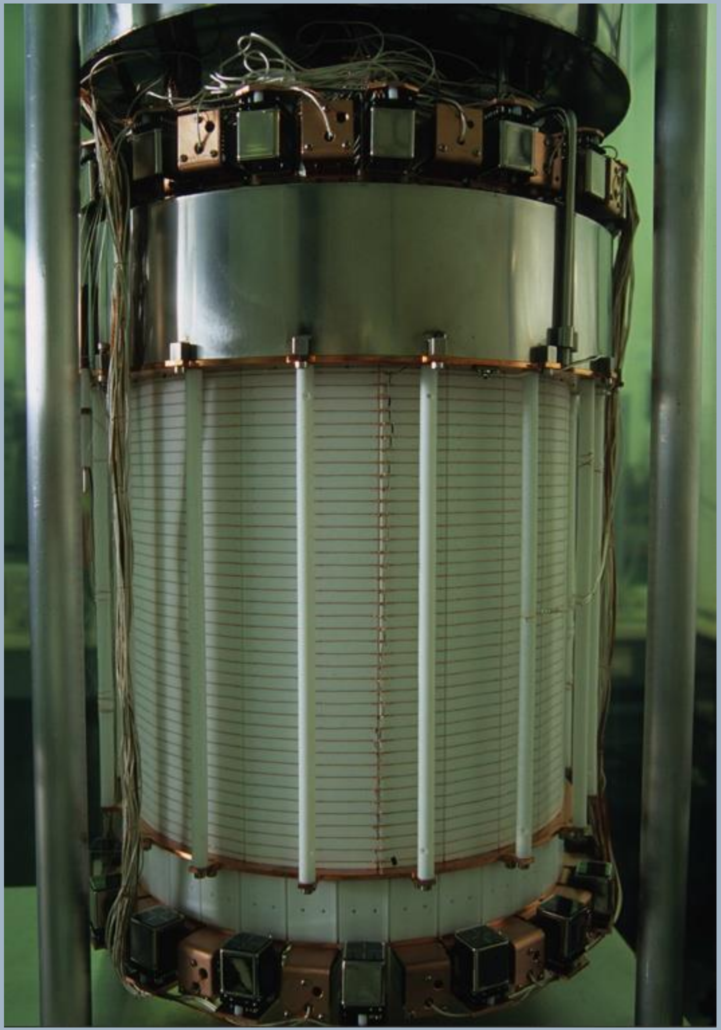
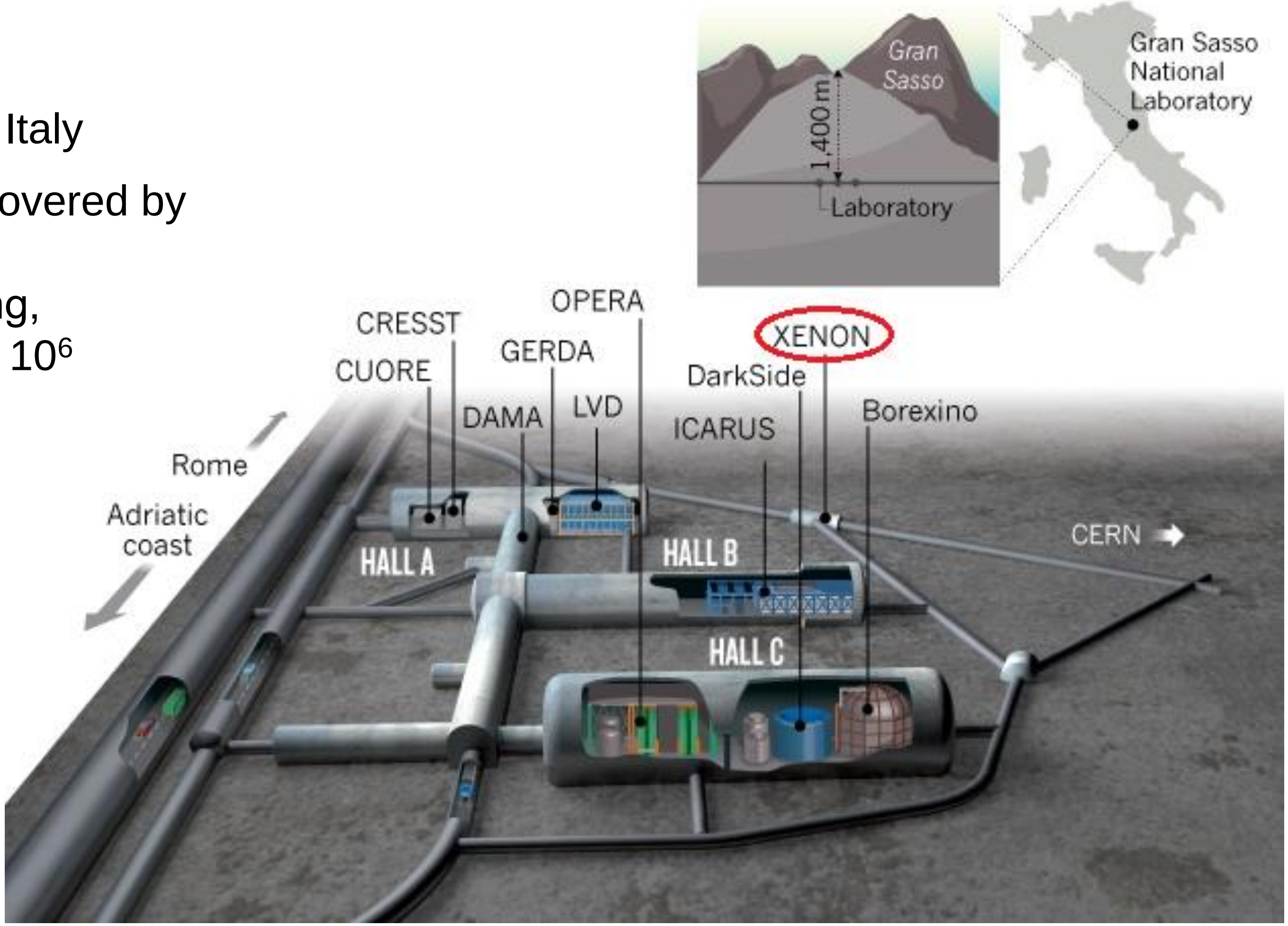
The XENON100 Experiment

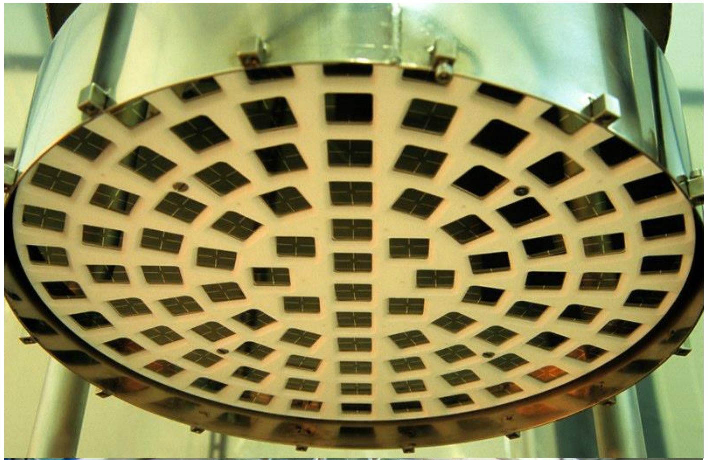


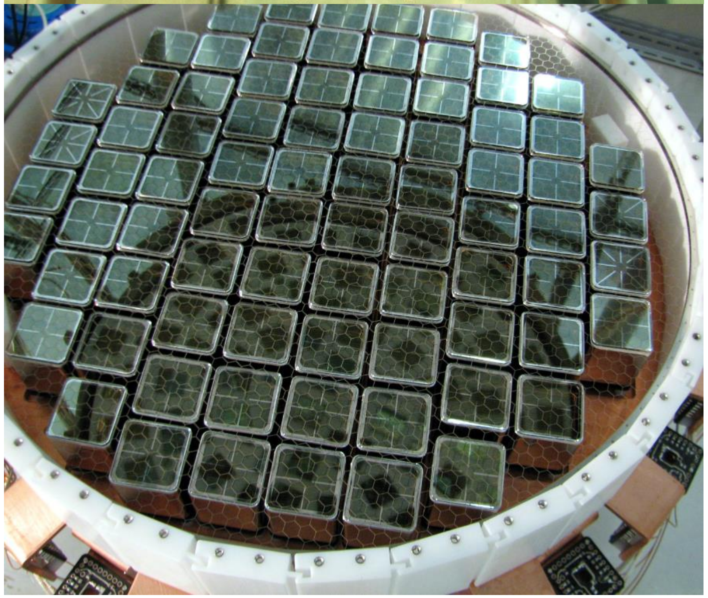
Location of the XENON experiment

- LNGS lab in middle Italy
- The experiment is covered by 1.4 km of rock
  → excellent shielding,
  mu flux reduction of 10^6



XENON100 specifications





- Diameter and height of target volume ~ 30cm
- Total xenon mass ~ 160 kg
- Target mass 62 kg
- 242 low radioactivity1'' PMTs
  are used for signal detection
- QE of the PMTs ~ 30%
- Spatial resolution ~ 3 mm in x-y
  ~ 0.3 mm in z

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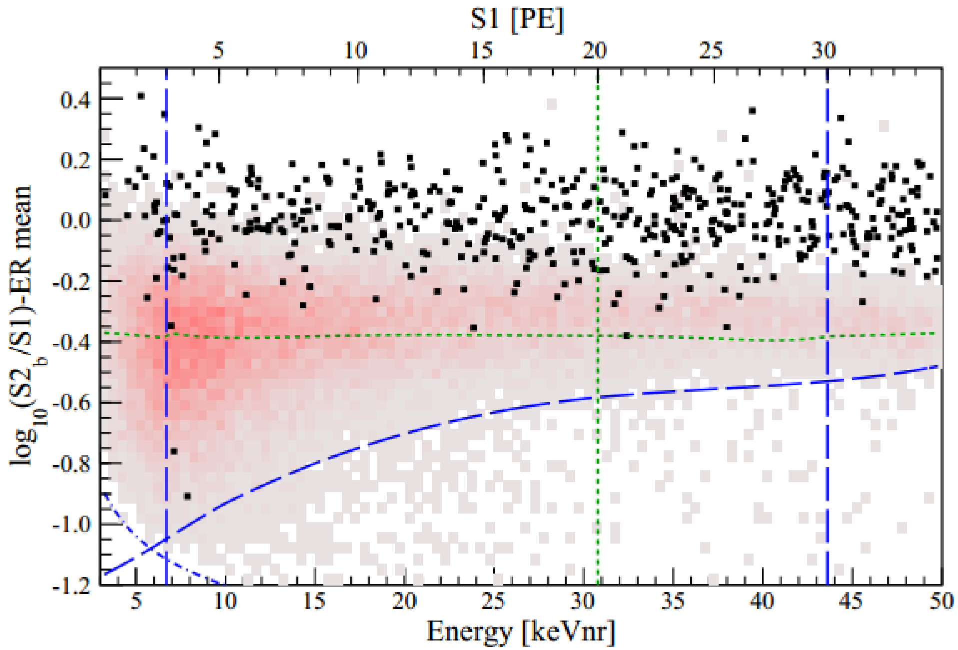
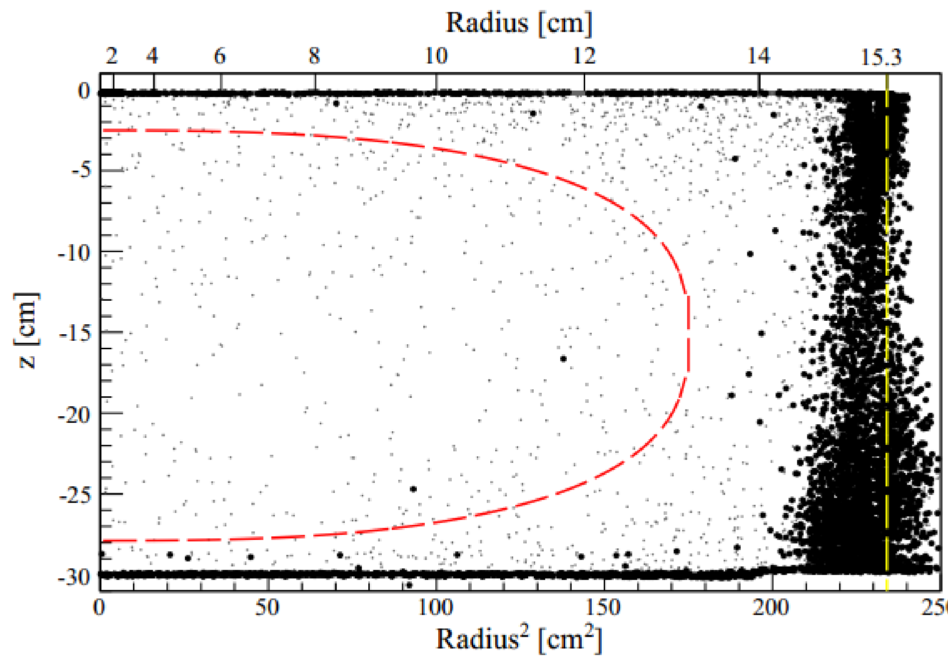
XENON100 results

- 225 life days of data is evaluated
- After S2/S1 and position cuts the expected background is ~ 1 event
- 2 events are observed
  26% probability for a background
  fluctuation to result in the excess
- Cross section limits for SI and SD can be derived





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Limits

- For a ~50 GeV WIMP the SI limit is $2*10^{-45}$ cm^{2}, for SD neutron interaction $3.5*10^{-40}$ cm^{2}

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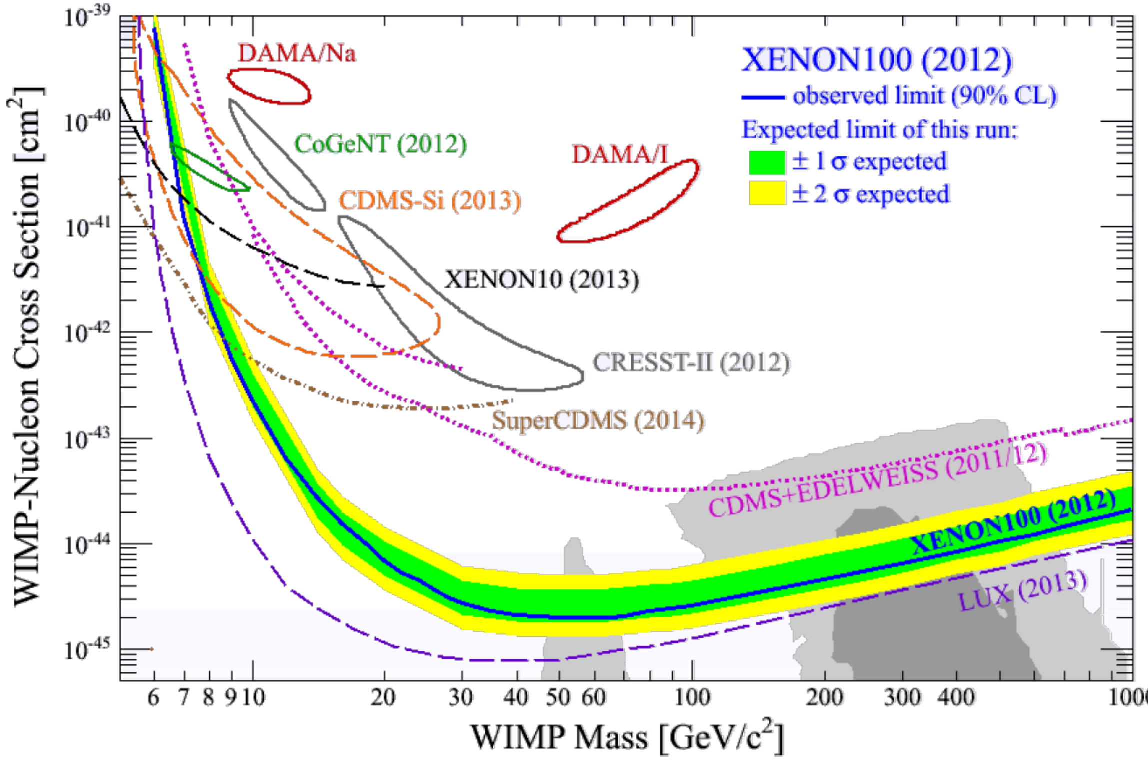

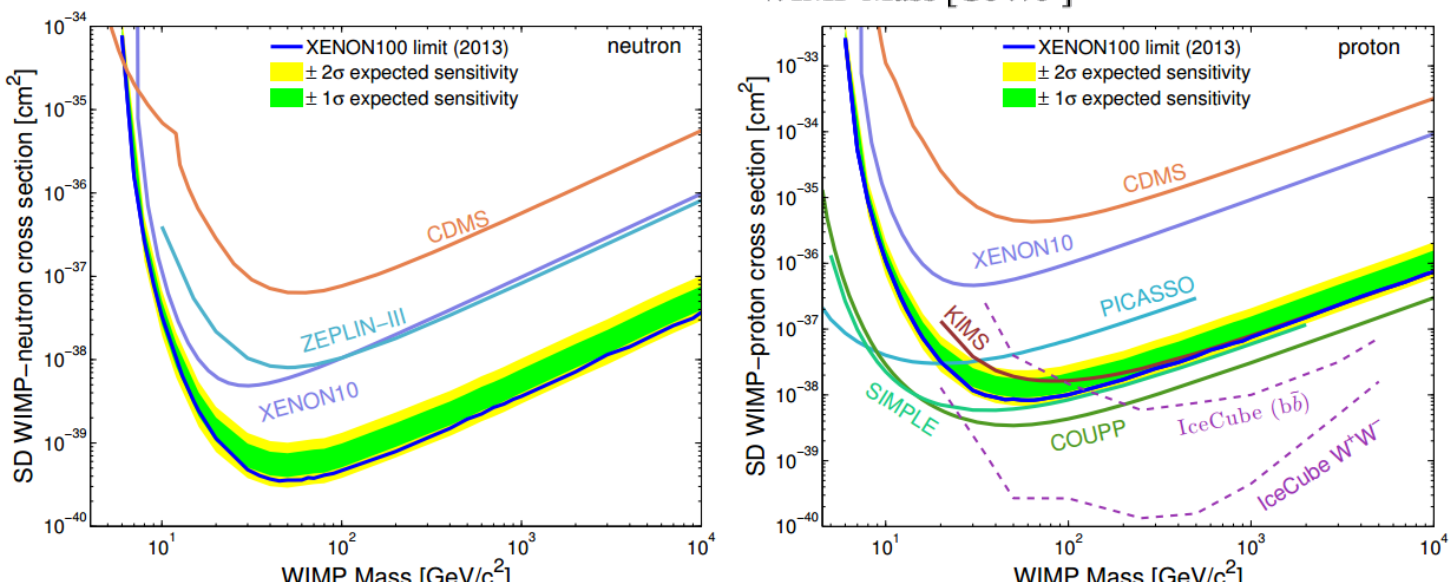

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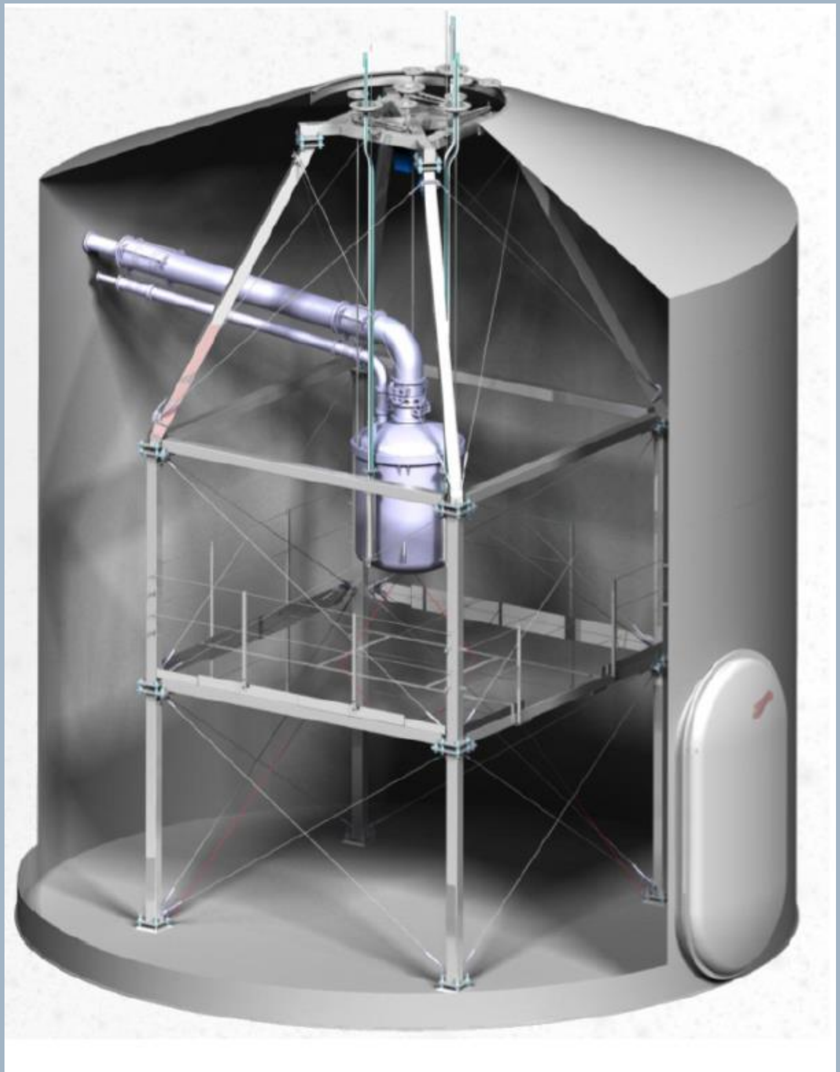
Outlook Into the Future



XENON1T

- Next generation XENON detector is under construction in LNGS
- Operation should start later this year
- Total xenon mass ~ 3t, target mass 1t
- Light is collected using 248 2’’ PMTs
- Shielded by 10 m of water and an active muon veto
- Expected sensitivity is 2 orders of magnitude better then XENON100

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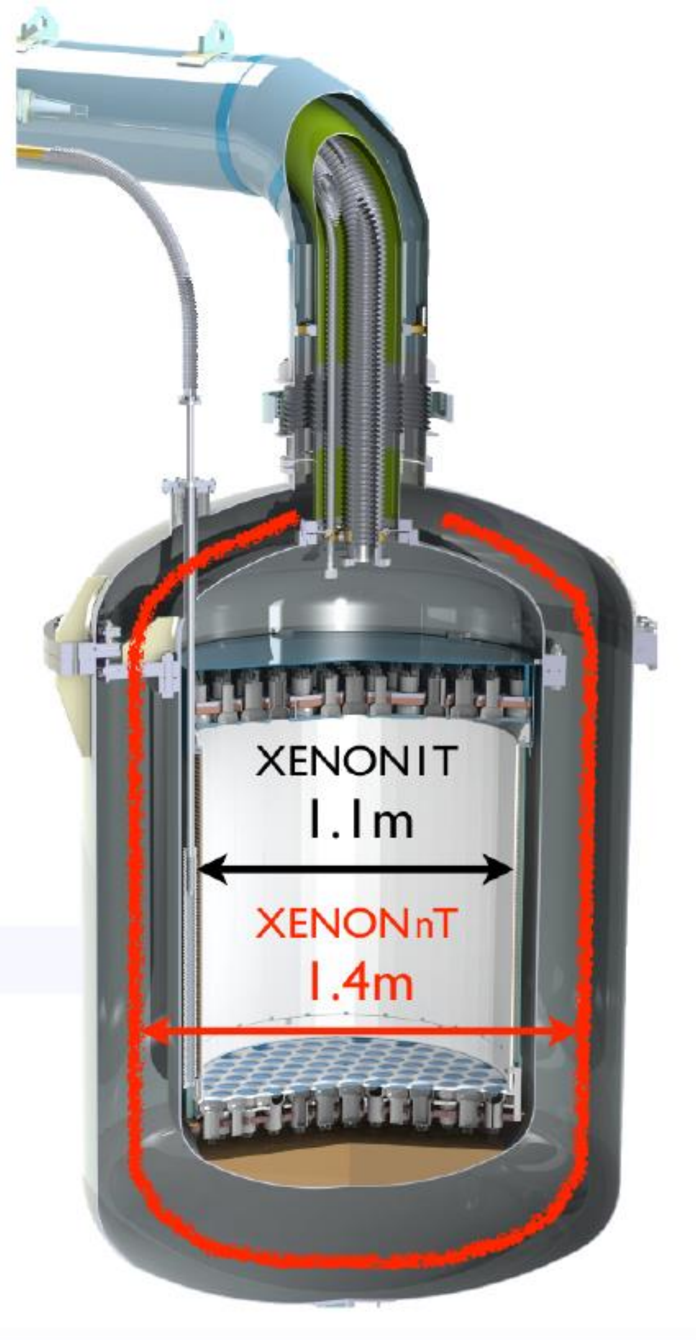
XENONnT

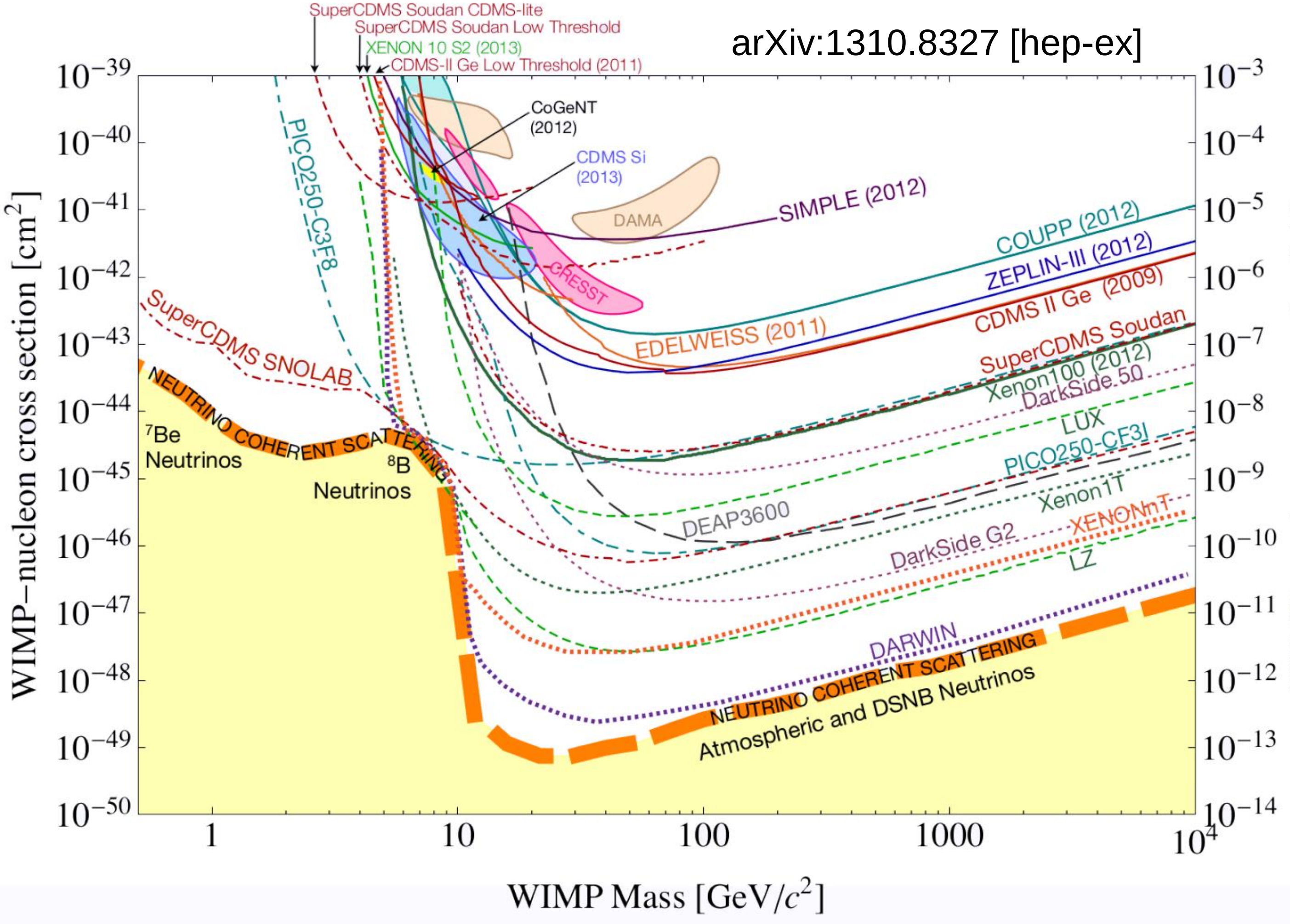
- Most XENON1T parts are designed in a way that allows for an easy upgrade
- The upgrade would increase total Xe mass to ~7t
- Sensitivity would improve another order of magnitude
- Planed for 2018



Predictions for future limits

- Experimentally accessible parameter space is limited by the neutrino background and is expected to be fully reachable within next 10-15 y

arXiv:1310.8327 [hep-ex]



Thank you for your attention

Any questions?