Dark Matter Search with XENON

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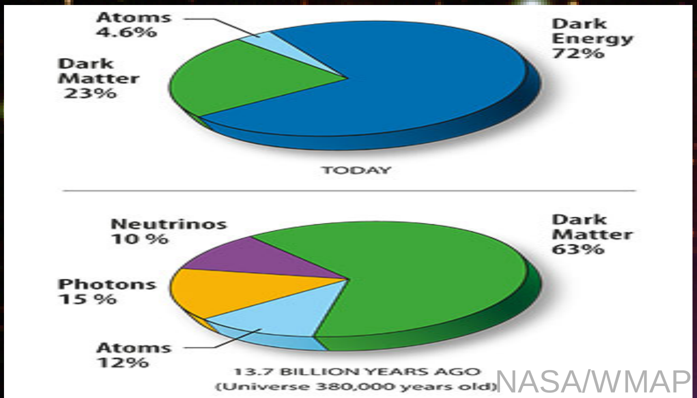
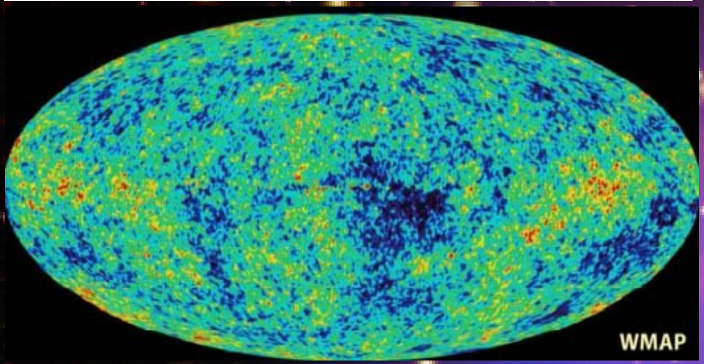
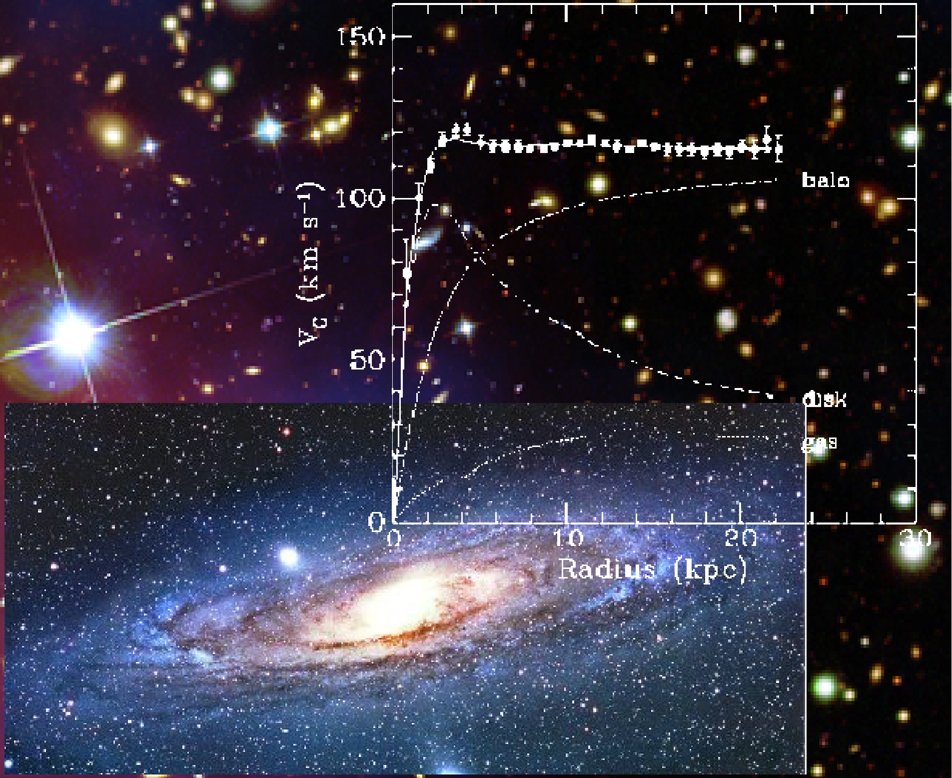
SPS Meeting 2012, ETH Zürich, 21.06.2012

www.physik.uzh.ch/groups/groupbaudis/xenon/

Dark Matter: Evidence & Detection

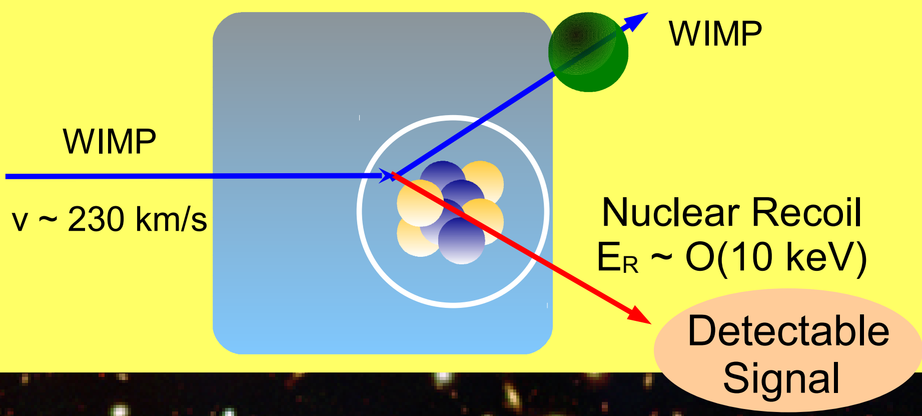






Direct Detection:

Elastic Scattering of WIMPs off target nuclei
→ nuclear recoil

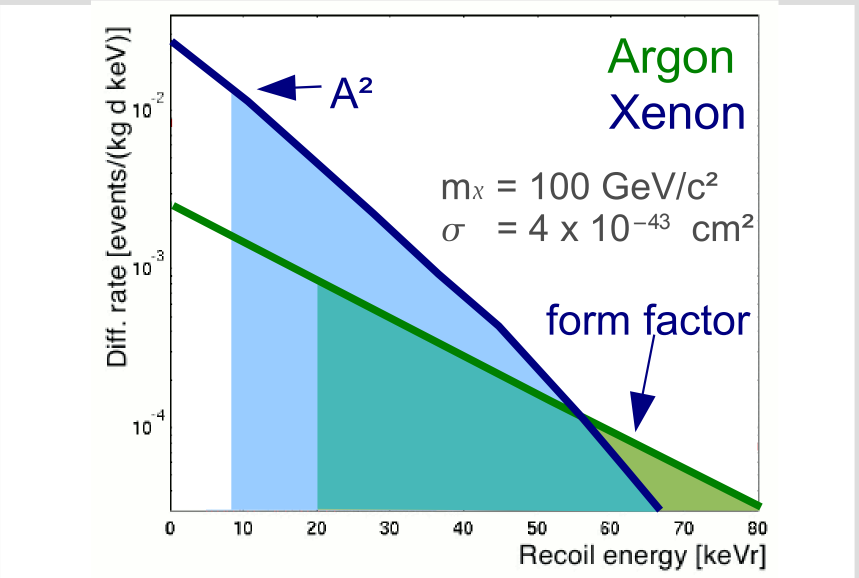


Direct WIMP Search

Expect tiny rates:

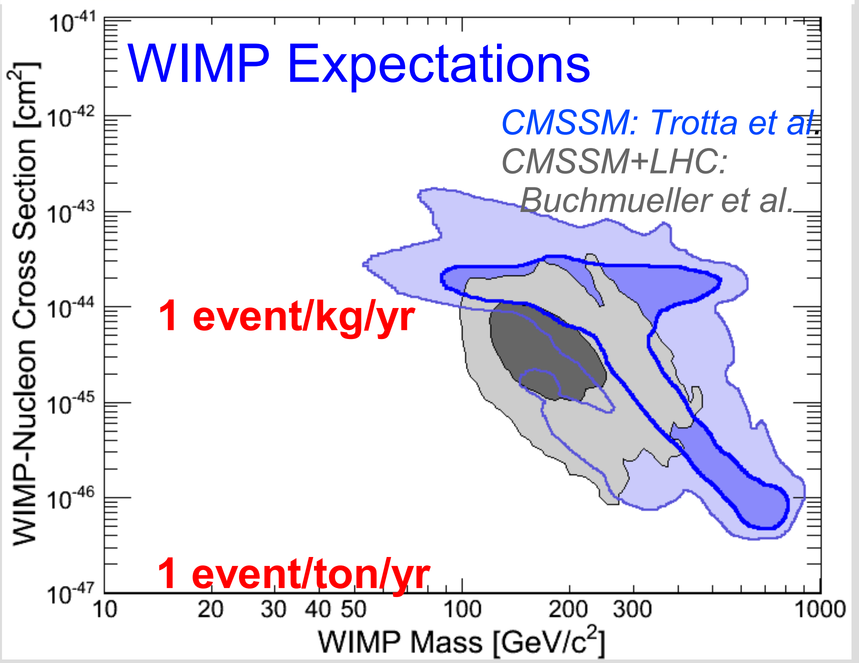
$R < 0.01$ evt/kg/day

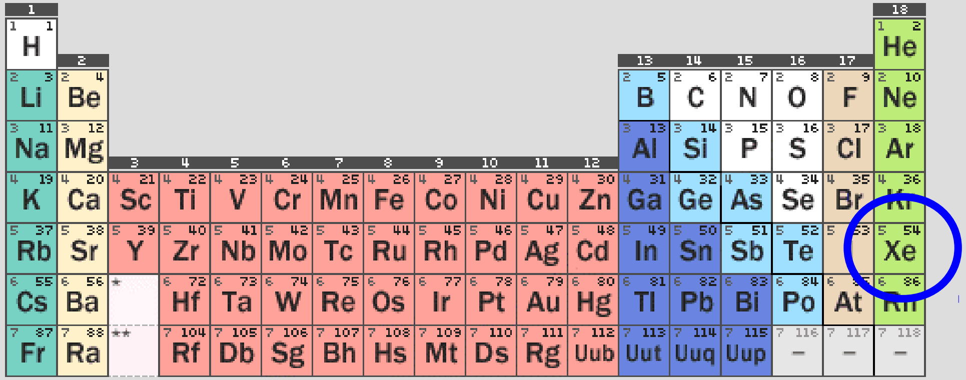
$E_R < 100$ keV



How to build a WIMP detector?

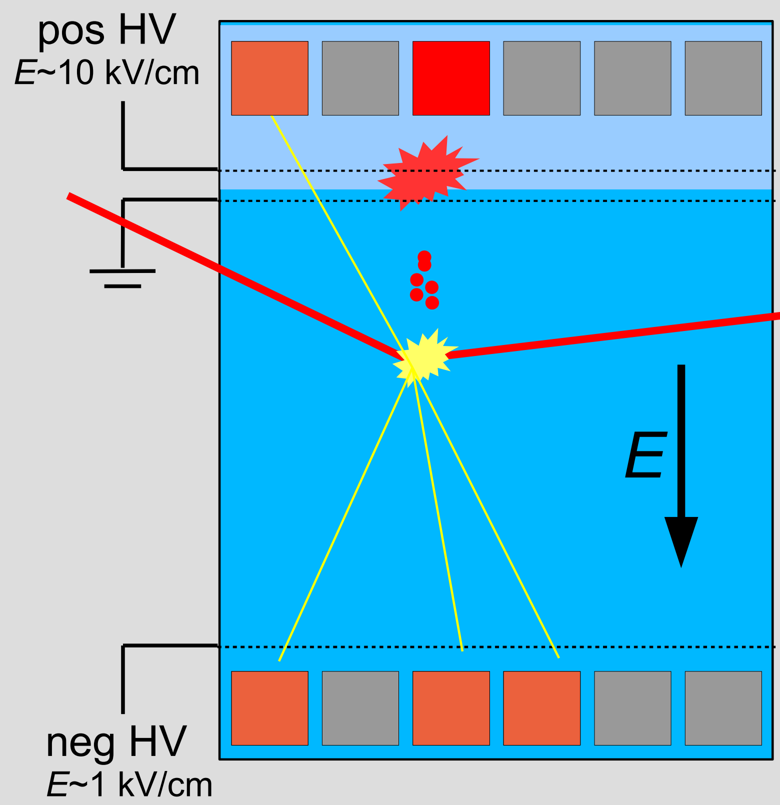
- large total mass, high *A* ✔ for Xe
- low energy threshold ✔ for Xe
- ultra low background ✔ for Xe
- good background discrimination ✔ for Xe

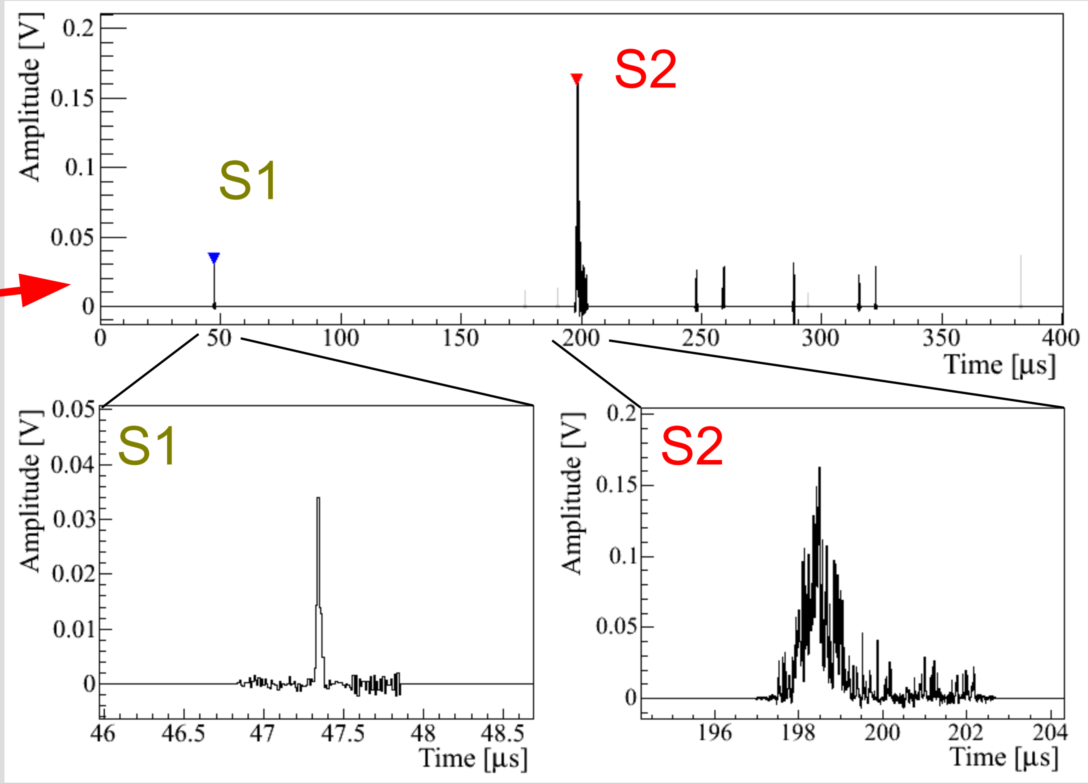




Dual Phase TPC

TPC = time projection chamber

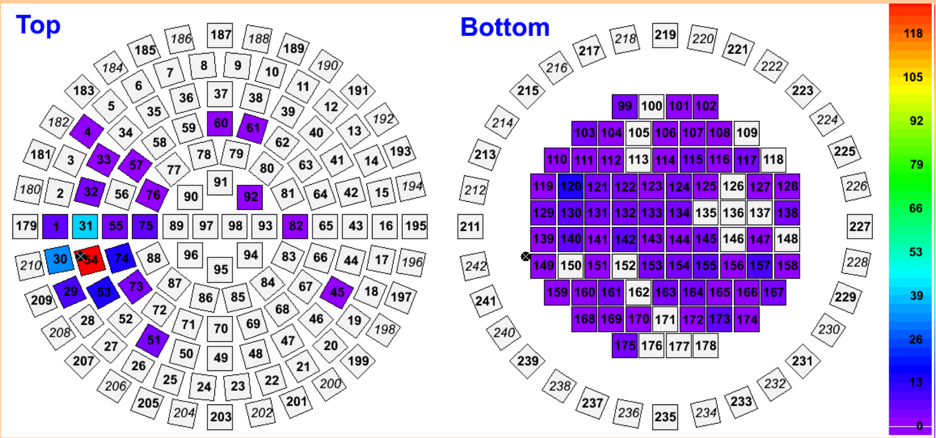


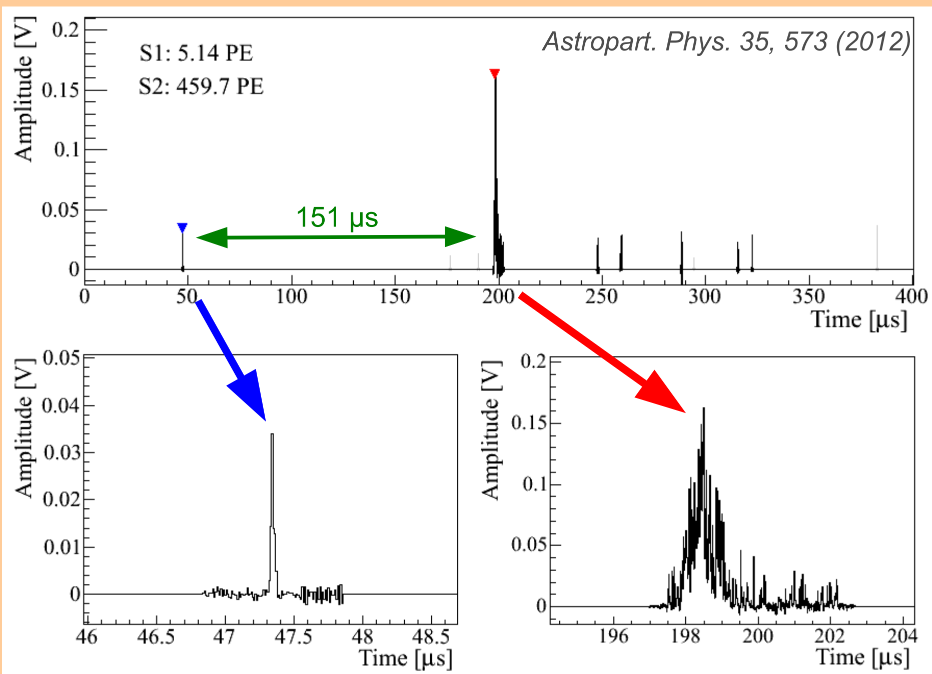


Dual Phase TPC

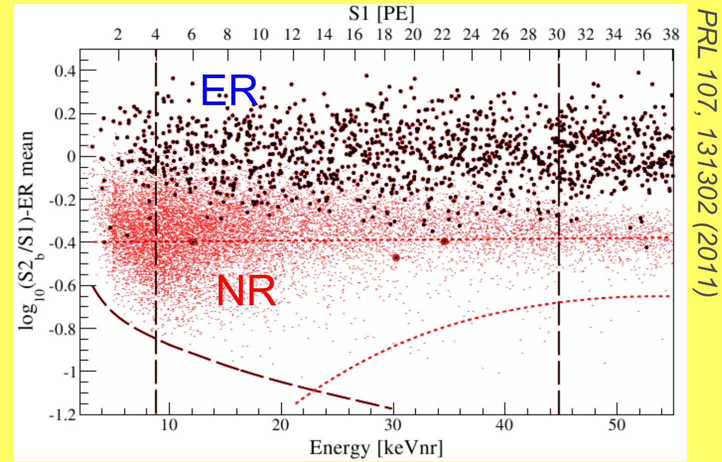
XENON Dark Matter Project

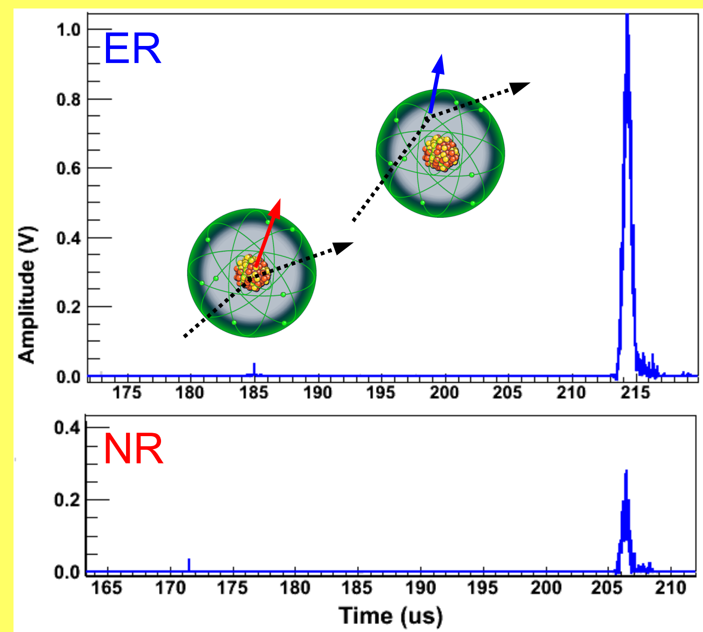
3d Vertex Reconstruction





Signal/Background Discrimination





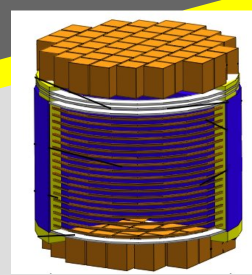
The XENON program

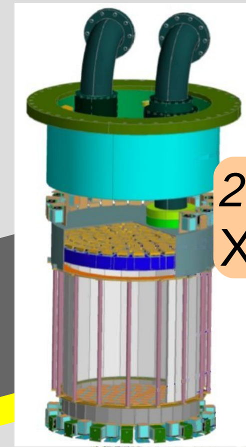
XENON Dark Matter Project

A phased WIMP search program

XENON R&D

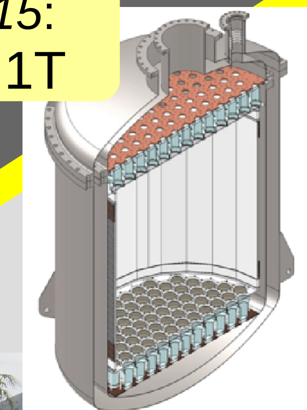
2005-2007: XENON10





2008-2012: XENON100

2010-2015: XENON1T

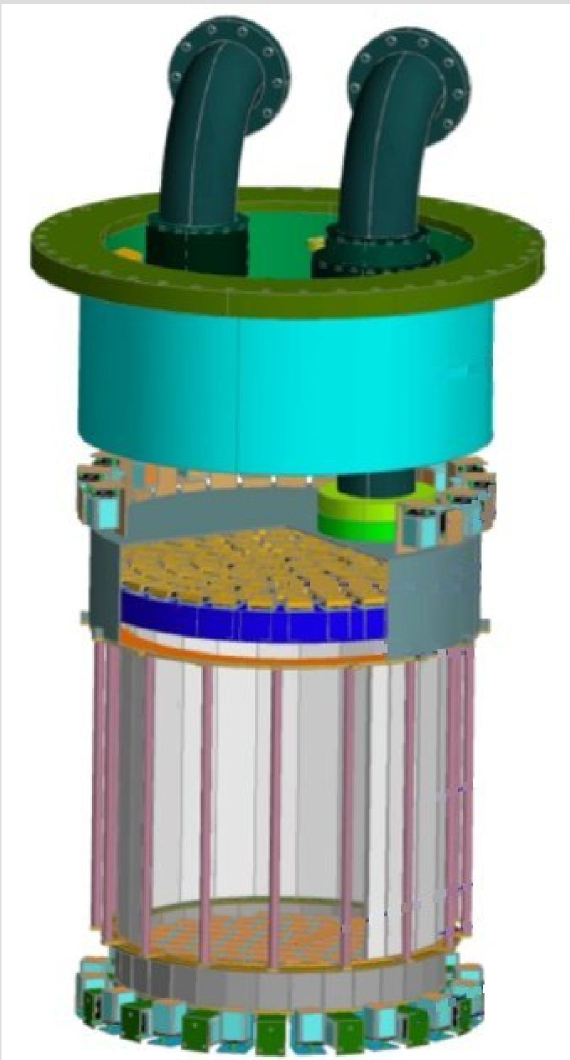


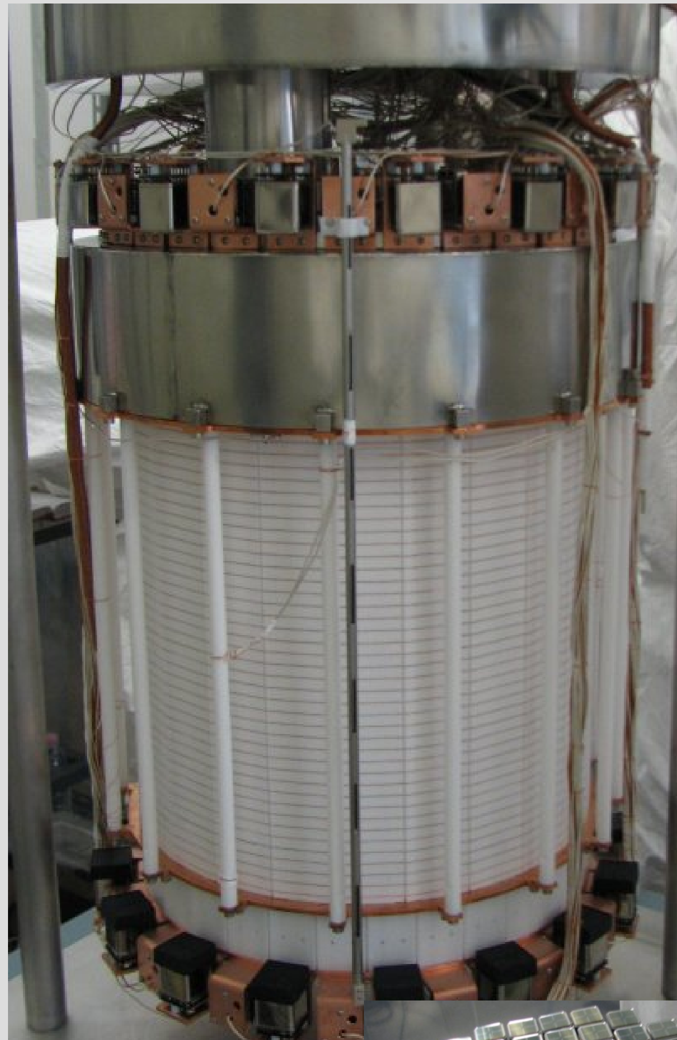
Columbia *Rice* *UCLA* *U Zürich* *Coimbra* *LNGS* *Mainz* *SJTU*

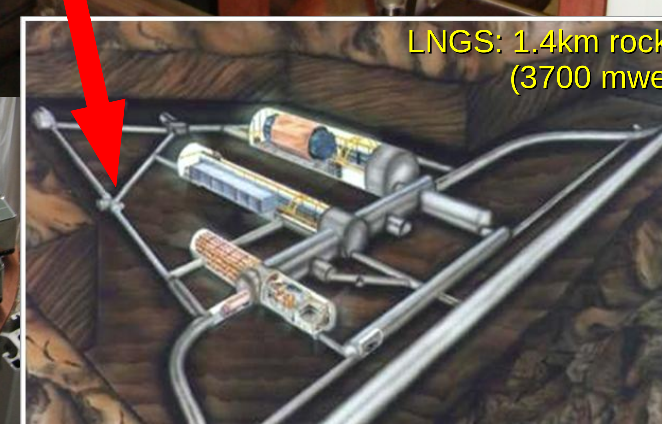
Bologna *MPIK* *NIKHEF* *Purdue* *Subatech* *Münster* *WIS*

XENON100

Astropart. Phys. 35, 573 (2012)





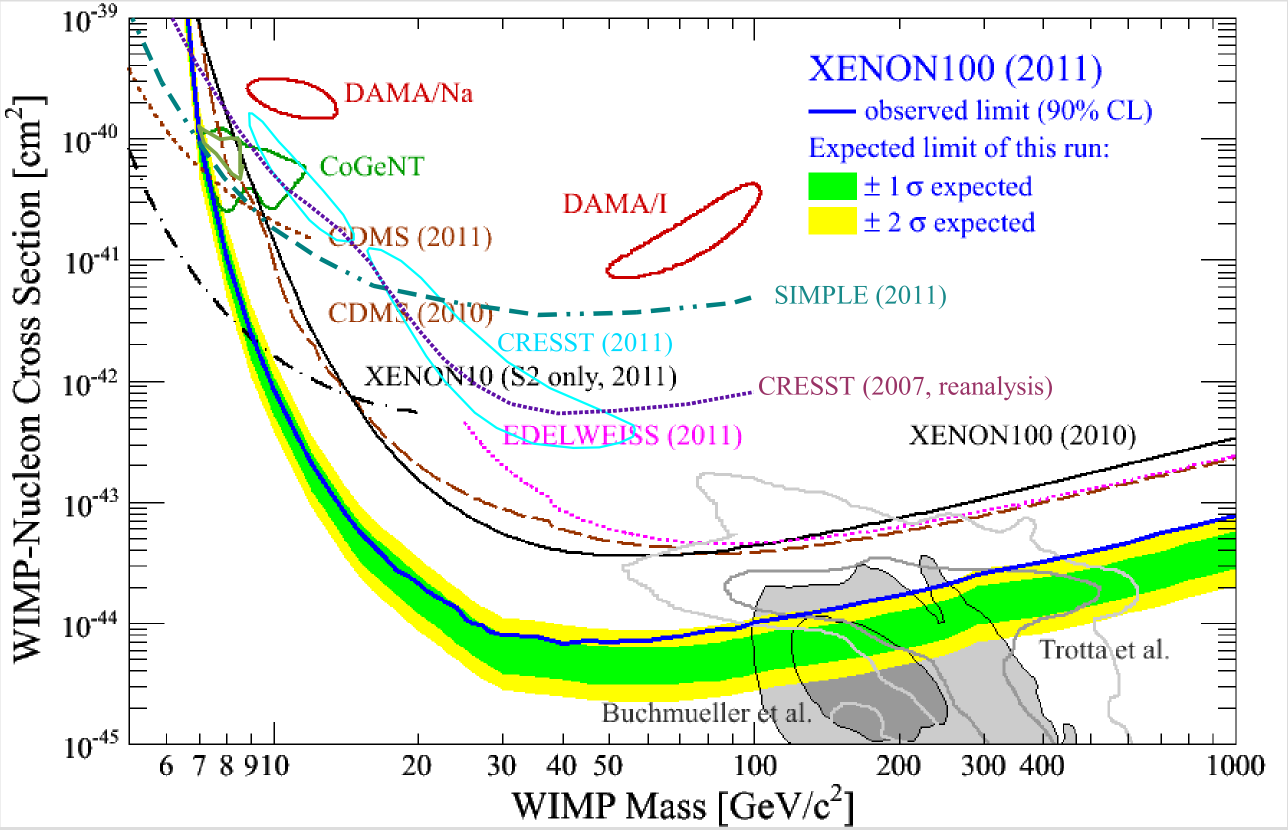


161 kg LXe, 62 kg in target
242 1" x1" PMTs

(spin-independent) WIMP Limit

XENON Dark Matter Project

The main result of 2011:



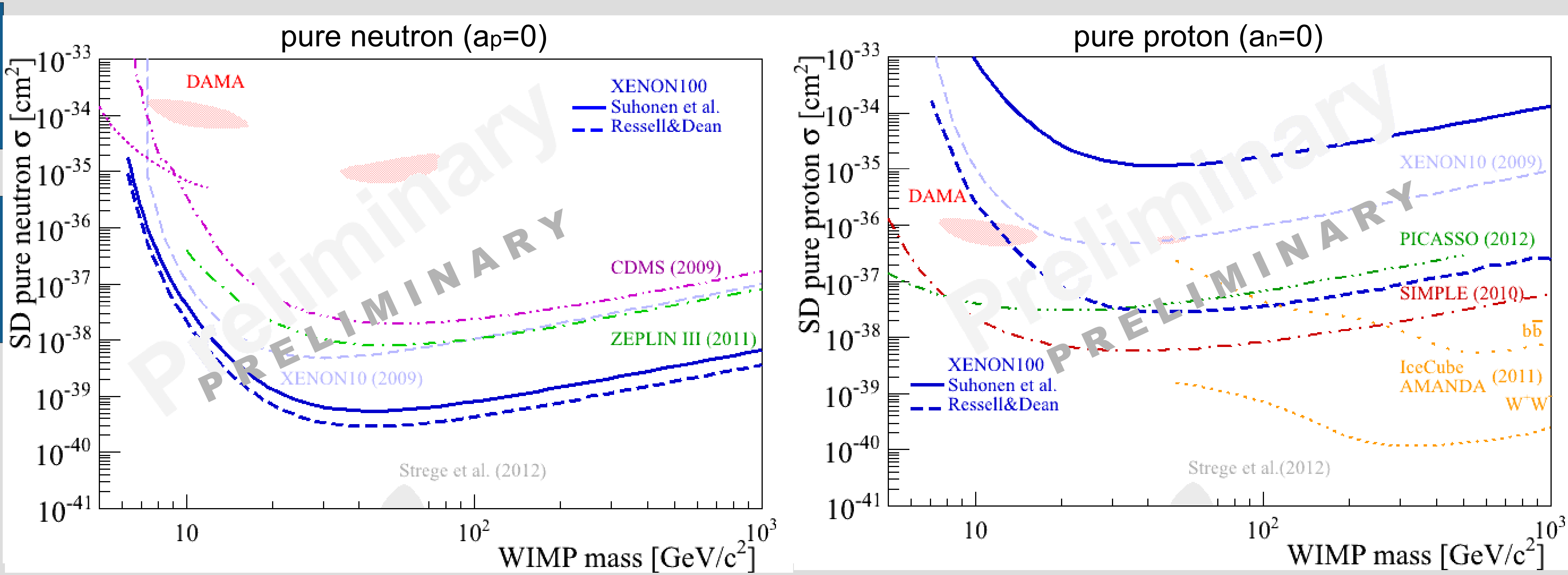
PRL 107, 131302 (2011)

already cited 325x

XENON100 sets the most sensitive limit over a large WIMP mass range

Challenges the CoGeNT, DAMA, CRESST-II signals as being due to light mass WIMPs

NEW: spin-dependent WIMP Limit



Spin-dependent interactions: WIMPs couple to total angular momentum J
Xe-129 and Xe-131 have unpaired spins → non-zero J

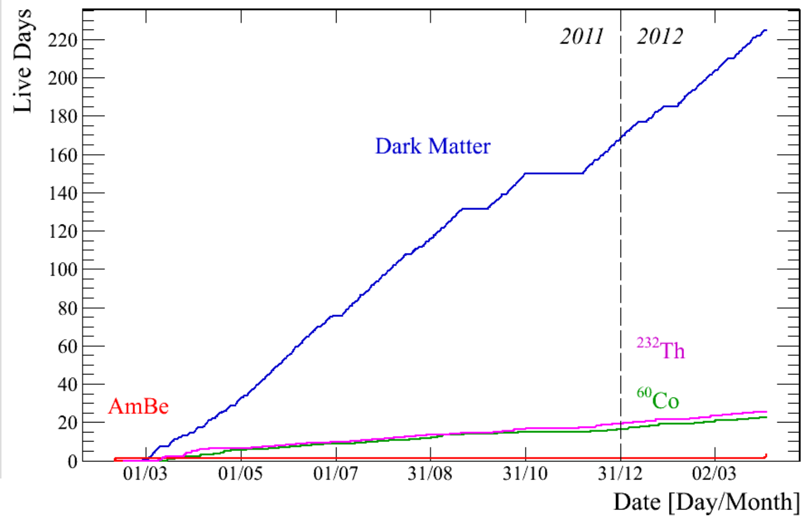
Rate: $$\frac{d\sigma}{dE_{nr}} = \frac{m_A \sigma^0_{SD}}{2\mu_A^2 v^2} F^2(q^2)$$ $$\sigma^0_{SD} = \frac{32}{\pi} G_F^2 \mu_A^2 [a_p \langle S_p \rangle + a_n \langle S_n \rangle]^2 \frac{J+1}{J}$$

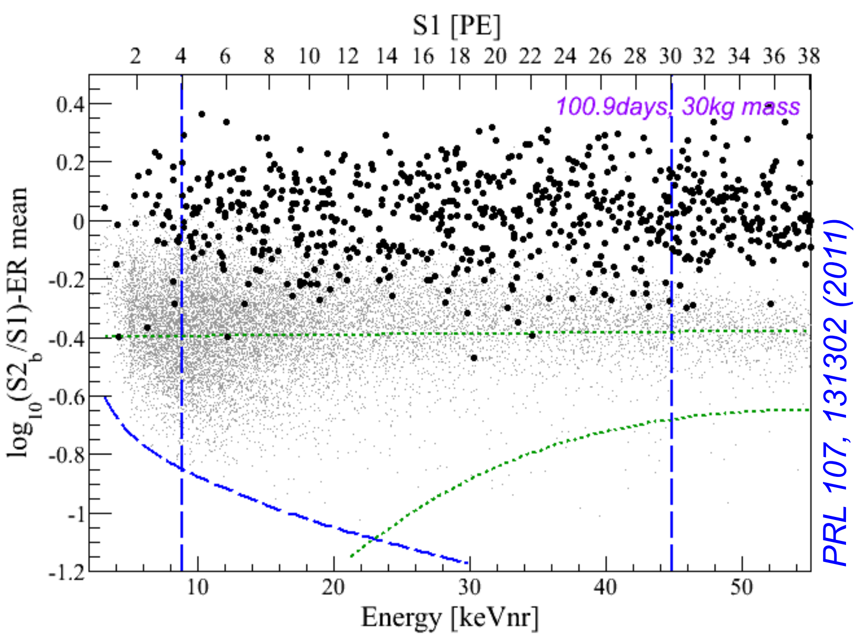
form factor F has to be calculated
using spin-structure functions
→ large theoretical uncertainties

The new Data (2011-2012)

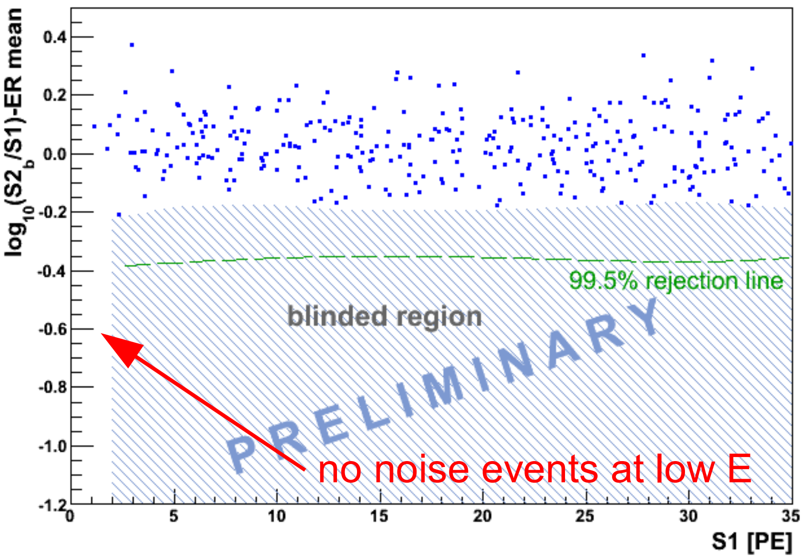
XENON
Dark Matter Project

We have collected >220 days of data
with lower background level
and lower trigger threshold



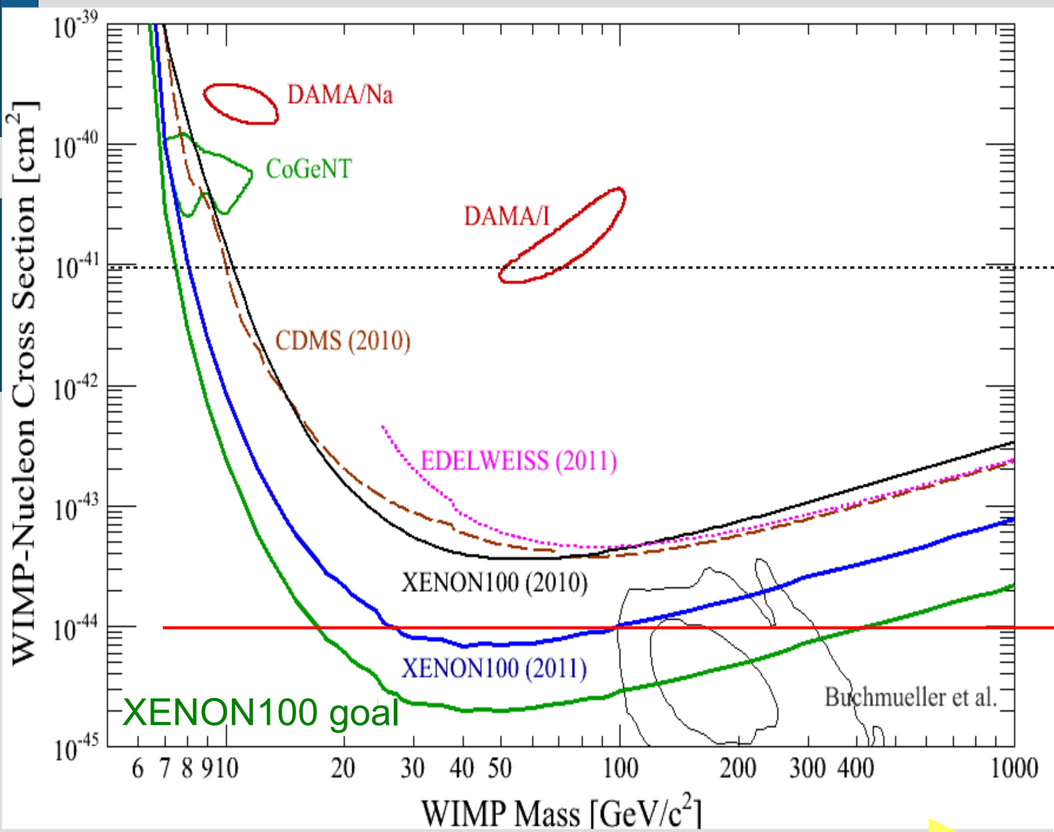


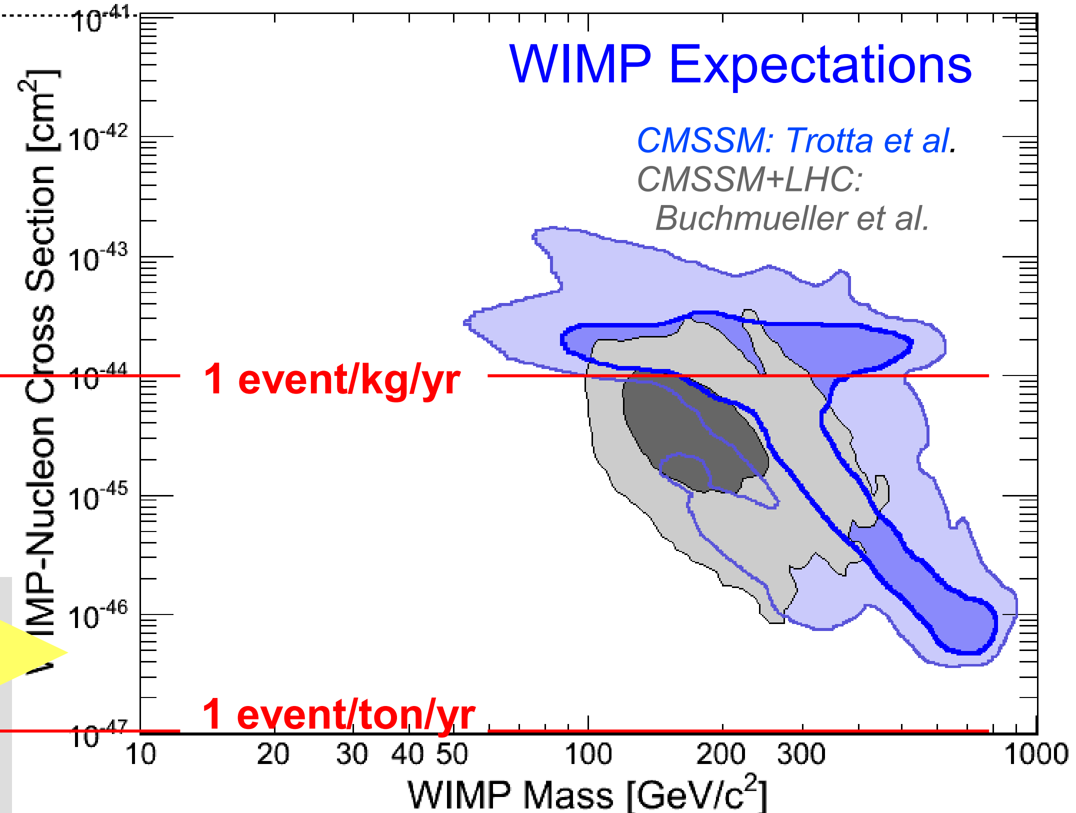
run_08: 100.9 days, 30 kg



run_10: 198 days, 30 kg

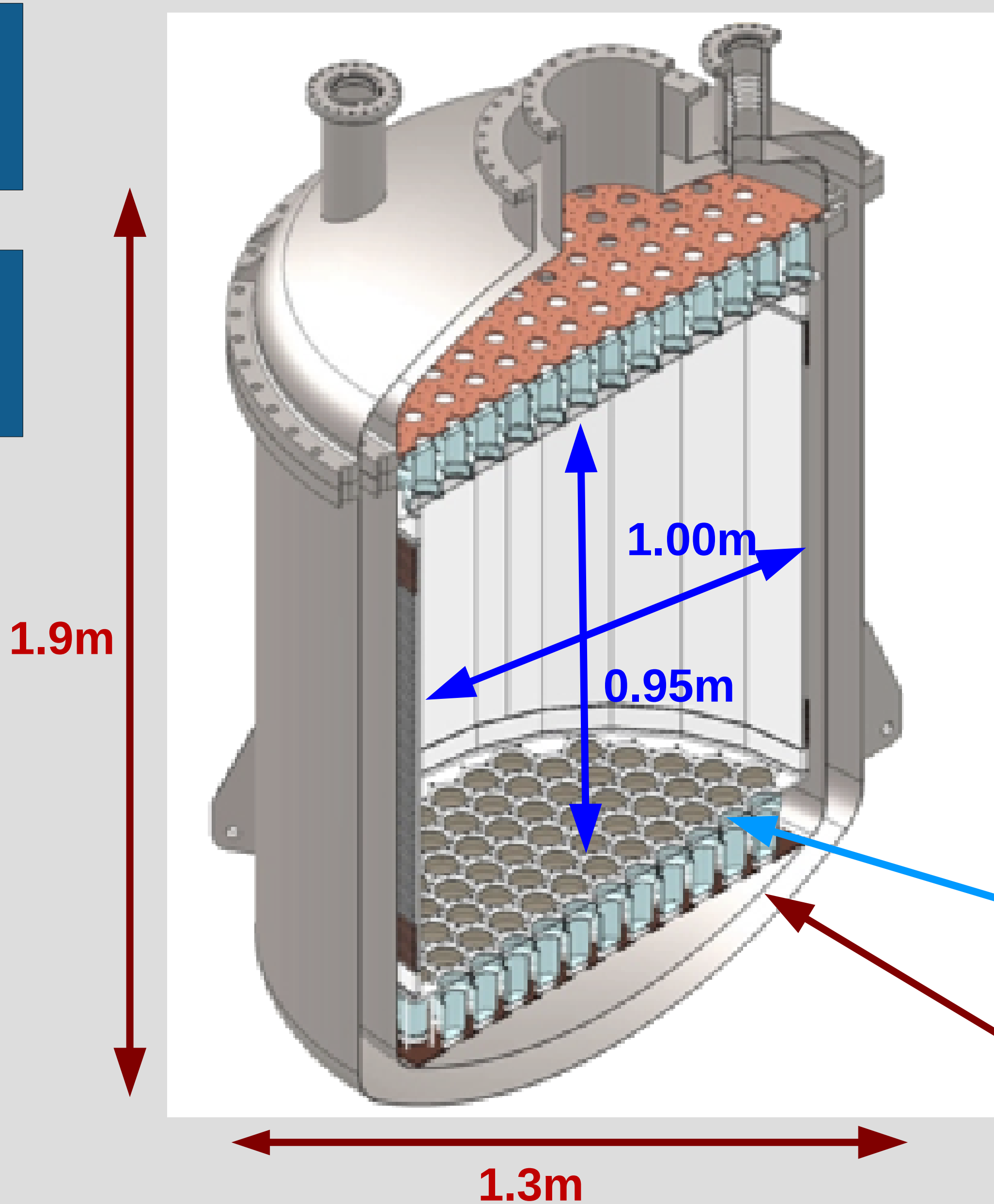
XENON100: Sensitivity





How do we get there?

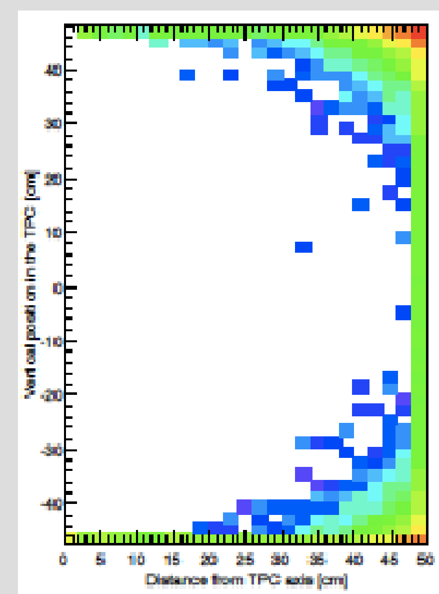
The next step: XENON1T



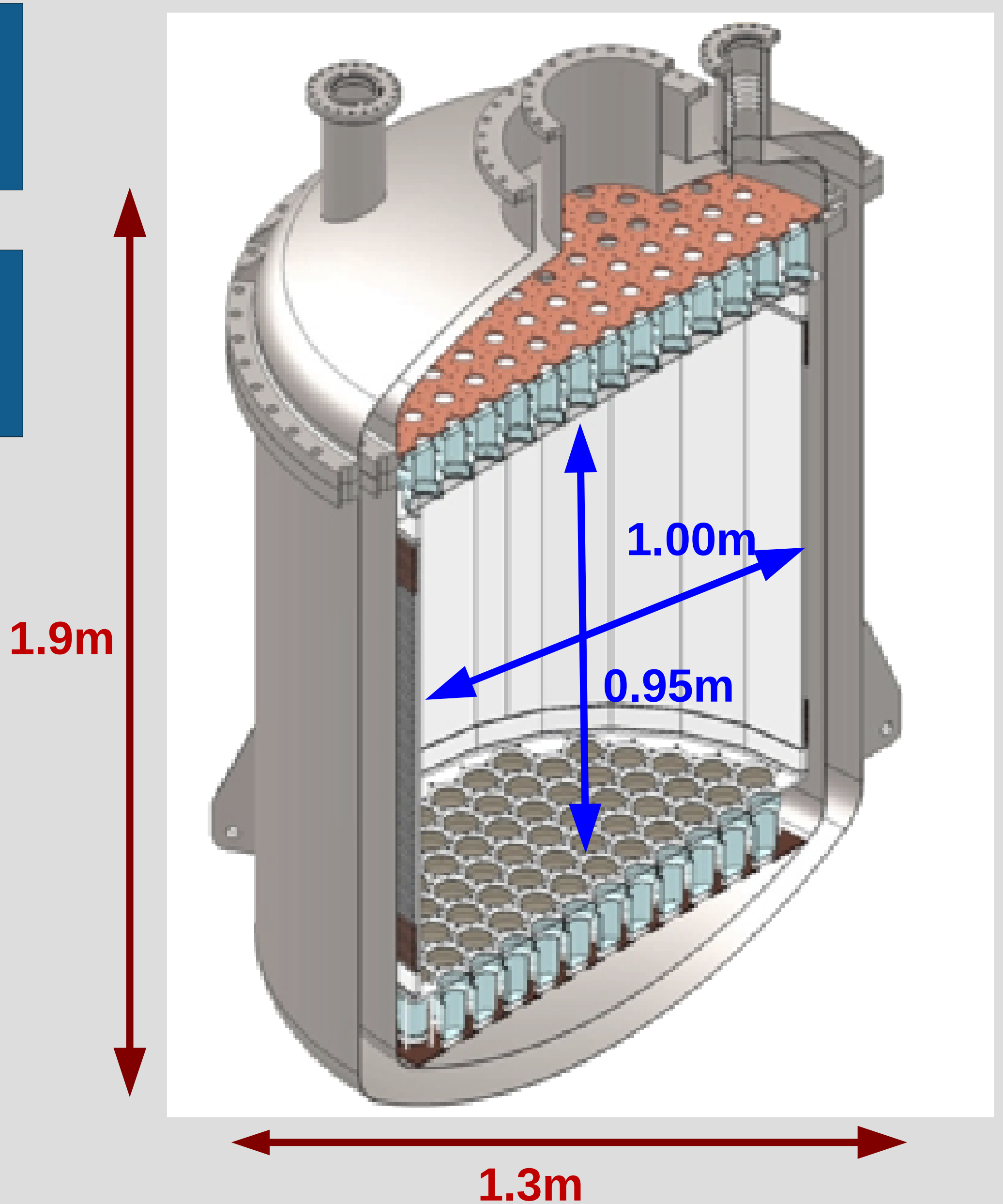
- 2.6t LXe ("1m³ detector")
  1t fiducial mass → 20x larger
- 100x lower background
  (~10 cm self shielding,
  low radioactivity components)
- background goal: <1 evt in 2 years

Low Radioactivity
Photon Detectors
(3", Total ~250)

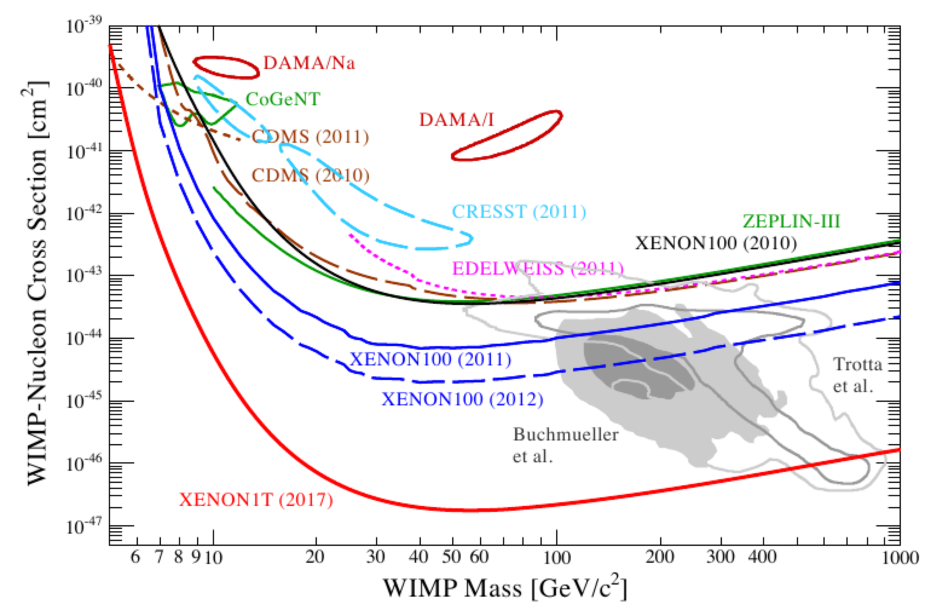
Ti Cryostat
(or low rad.
stainless steel)



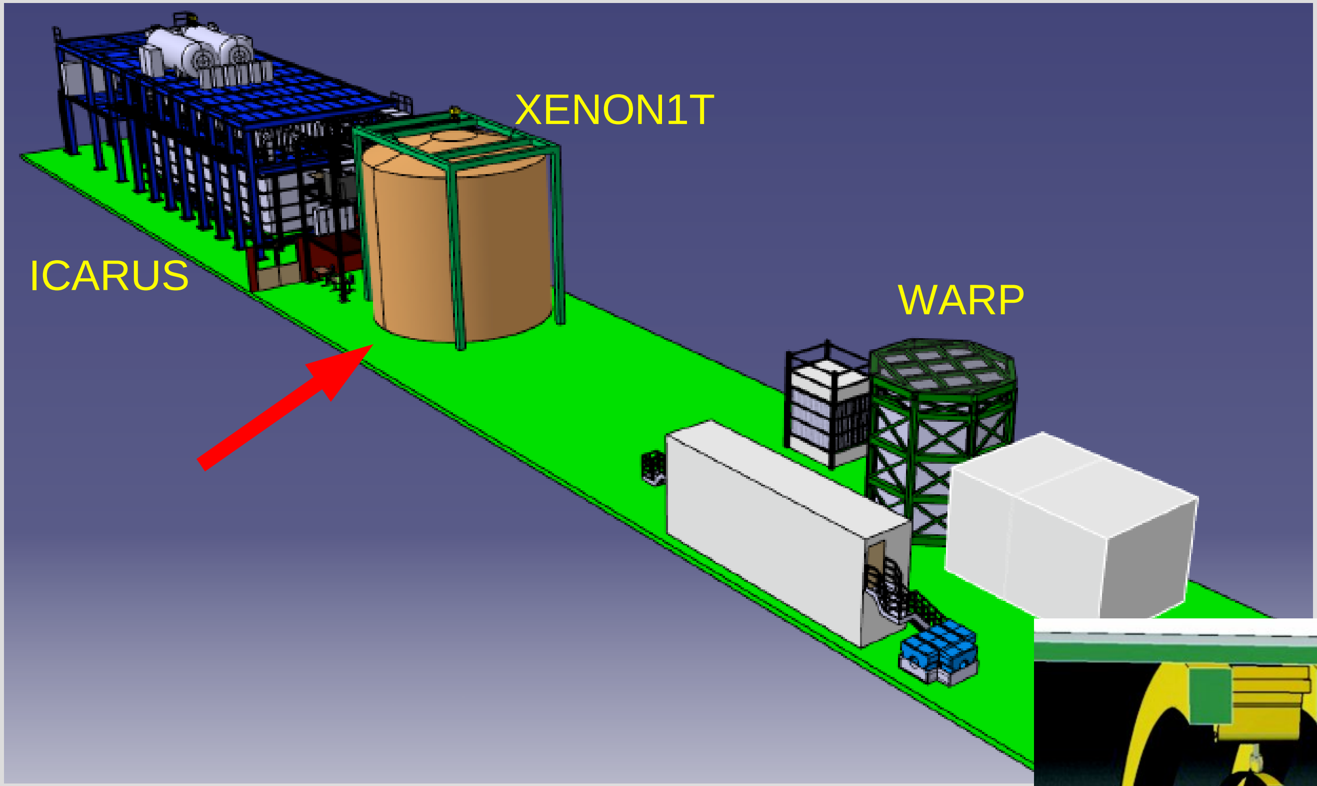
The next step: XENON1T



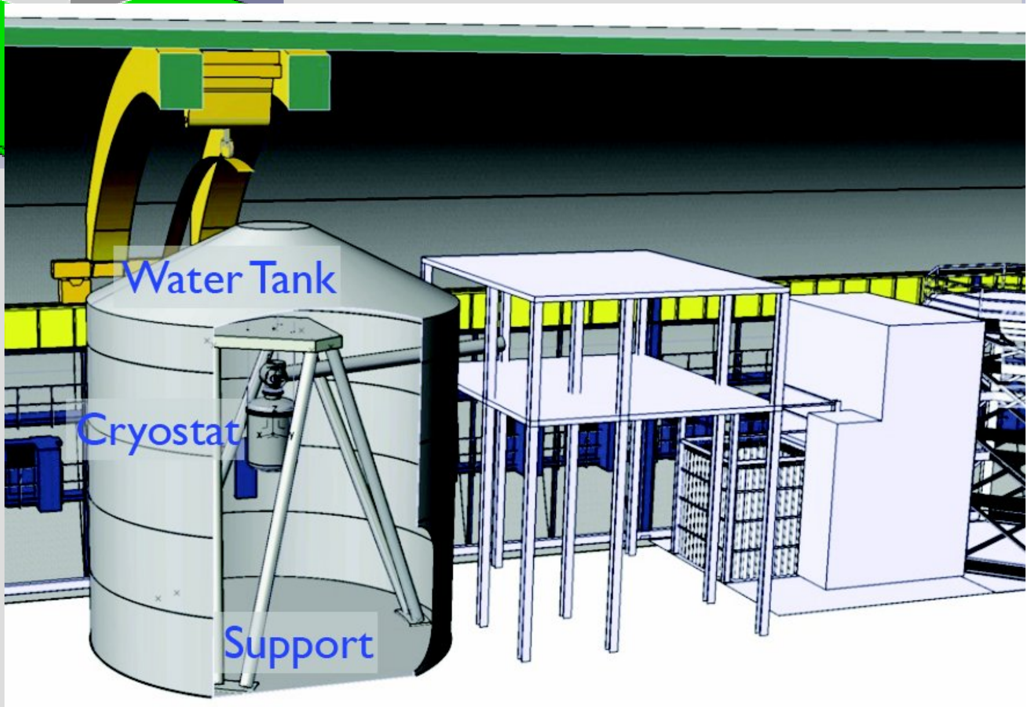
- 2.6t LXe ("1m³ detector")
  1t fiducial mass → 20x larger
- 100x lower background
  (~10 cm self shielding,
  low radioactivity components)
- background goal: <1 evt in 2 years
- Timeline: 2010 – 2017
- start construction in 2012



XENON1T @ LNGS

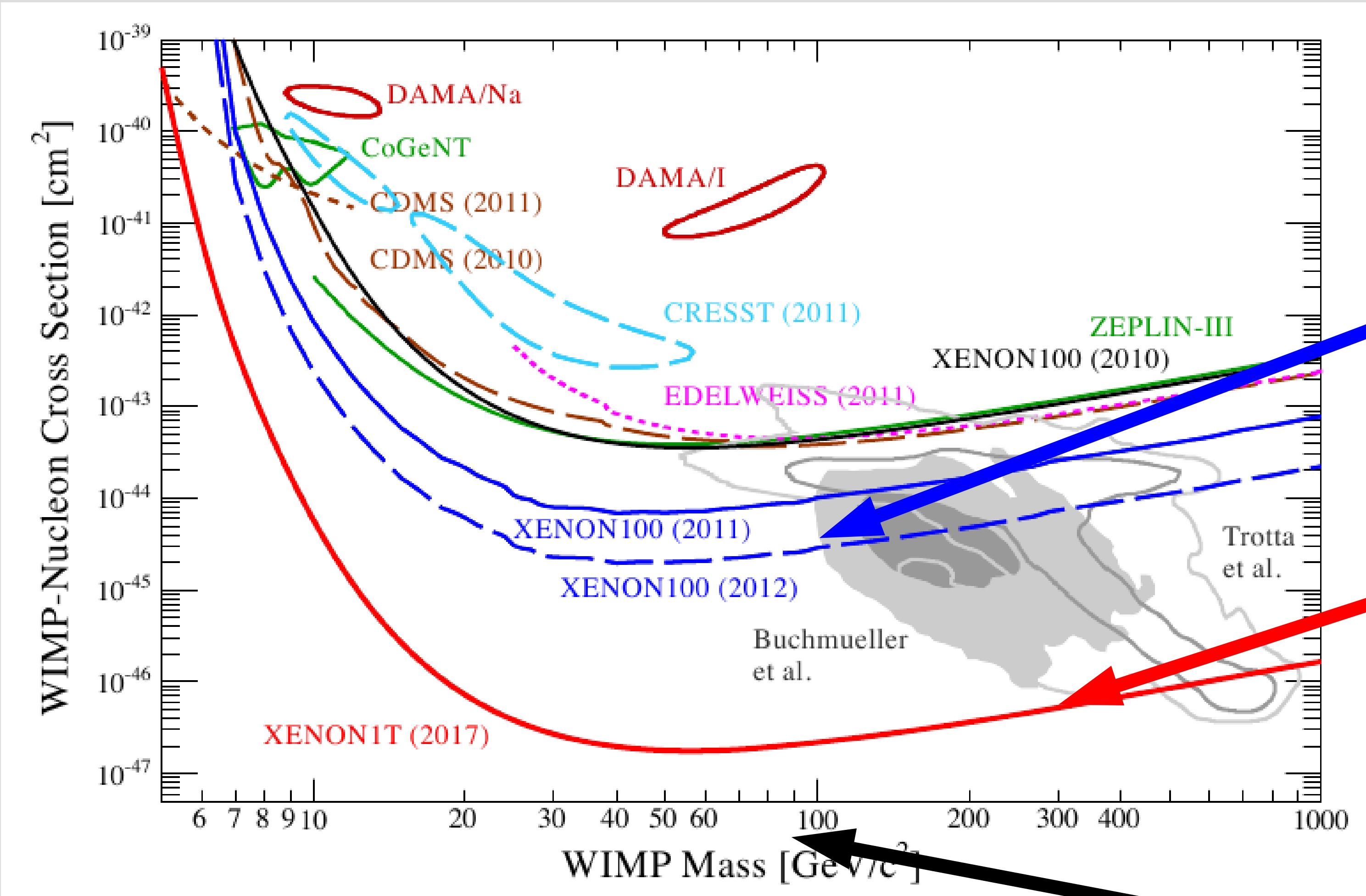


XENON1T
@ LNGS (Hall B)
➞ 4.8 m water shield
acting as active muon veto



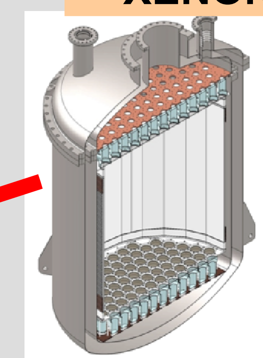
- Proposal and TDR submitted to LNGS
- Approved by INFN end of April 2011
- Approved by NSF (US) May 2012

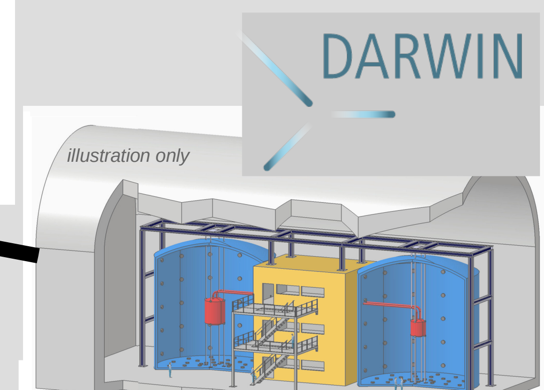
Summary



XENON100

XENON1T





http://darwin.physik.uzh.ch