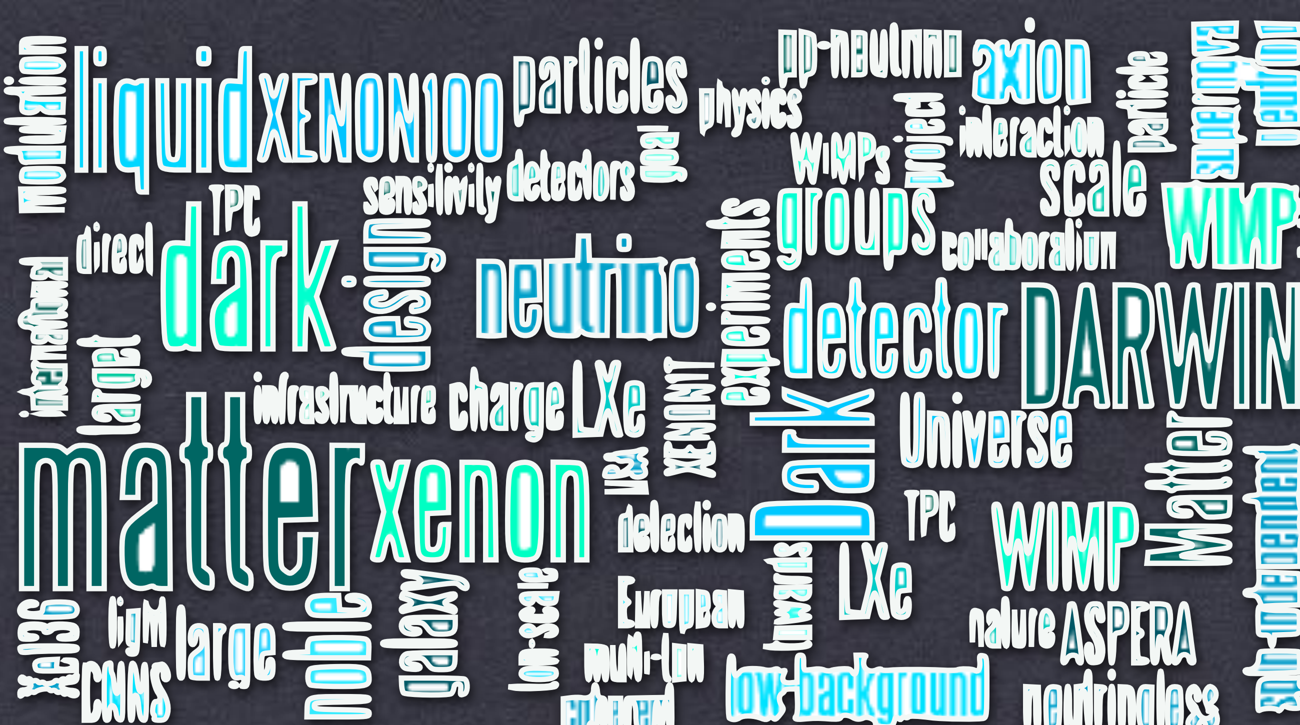
SIMULATIONS AND BACKGROUND ESTIMATIONS FOR DARWIN (DARK MATTER WIMP SEARCH WITH LIQUID XENON)

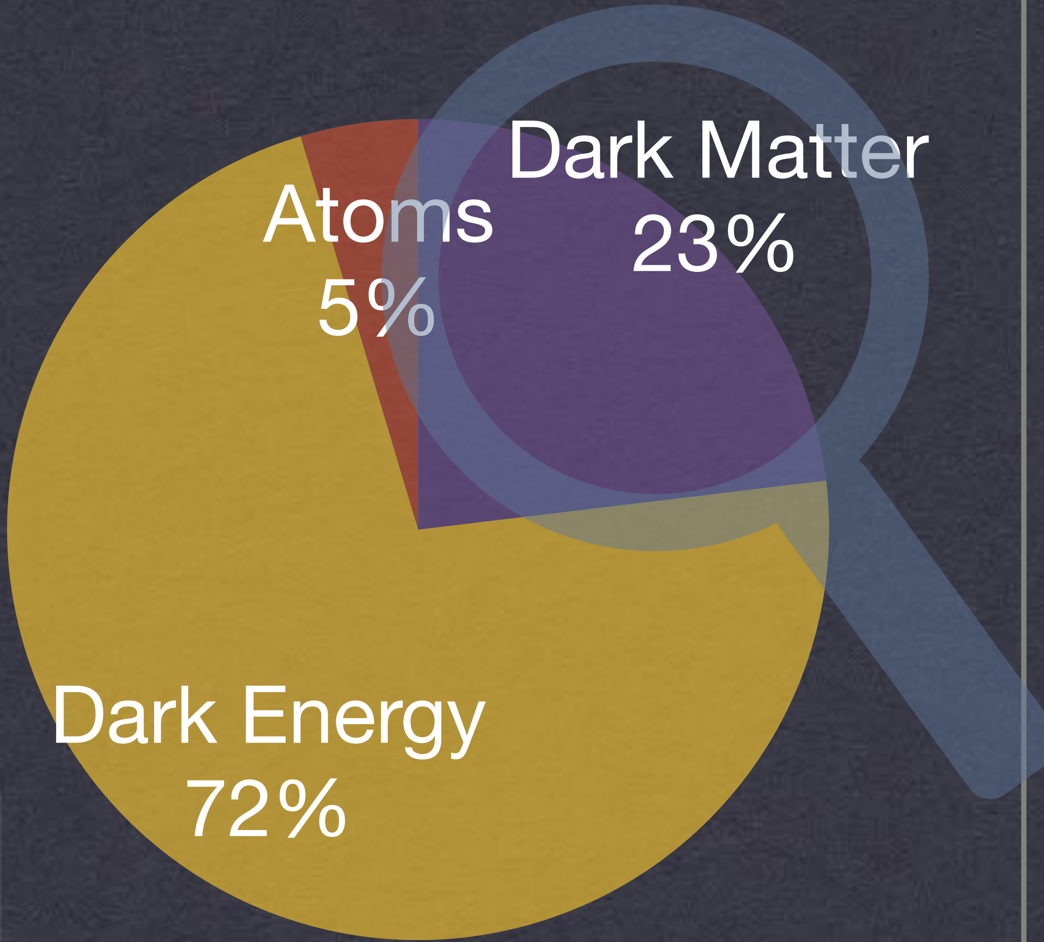
YANINA BIONDI, UNIVERSITY OF ZÜRICH
SPS MEETING, LAUSANNE 31 AUGUST 2018

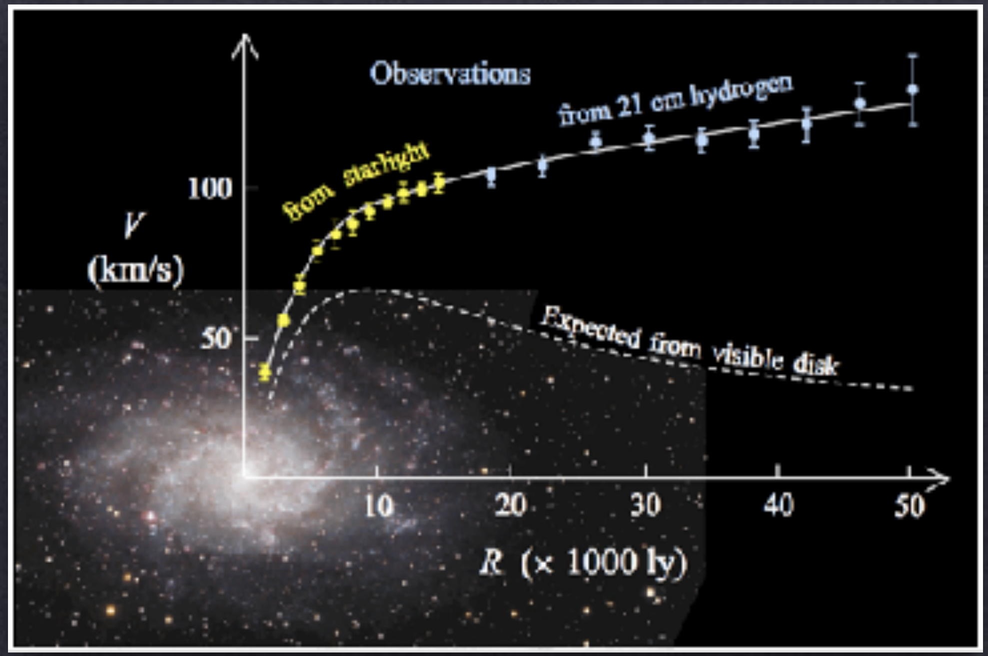


Contents

- Why we search for Dark Matter?
- How we search for Dark Matter
- The DARWIN experiment
- Background events in Dark Matter Searches
- Material screening with GATOR
- GEANT4 Simulations for gamma background

DARK MATTER IN OUR UNIVERSE

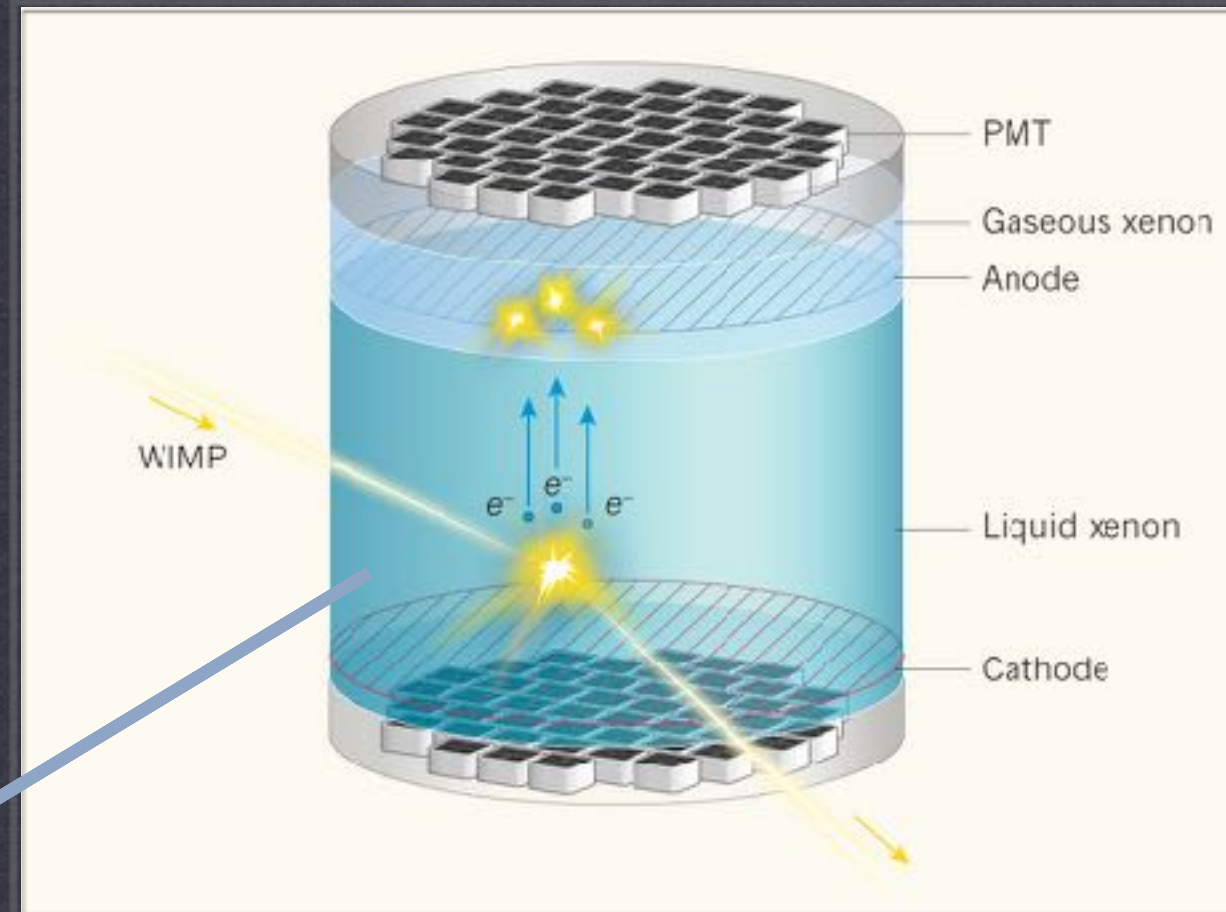


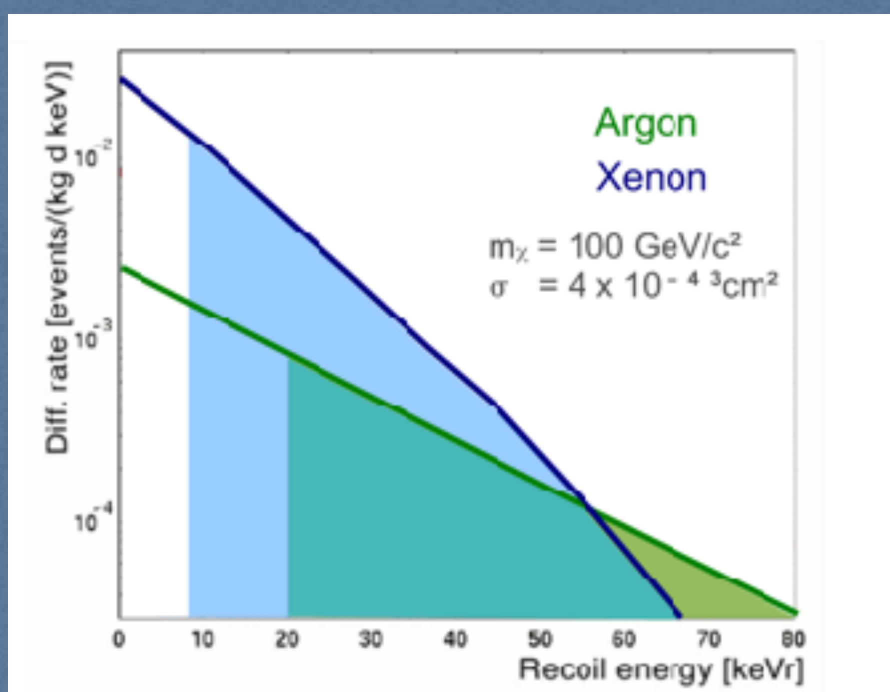


DIRECT DETECTION IN XENON EXPERIMENTS

$$E_{dep} = W_i(N_{ex} + N_i)$$

$$n_e = N_i(1 - r) = \frac{E_{dep}}{W_i}(1 - r)$$





$$n_\gamma = N_{ex} + rN_i = \frac{E_{dep}}{W_i}(r + N_{ex}/N_i)$$

$$\frac{1}{W} = \frac{S1/E}{g_1} + \frac{S2/E}{g_2}$$

XENON EVOLUTION

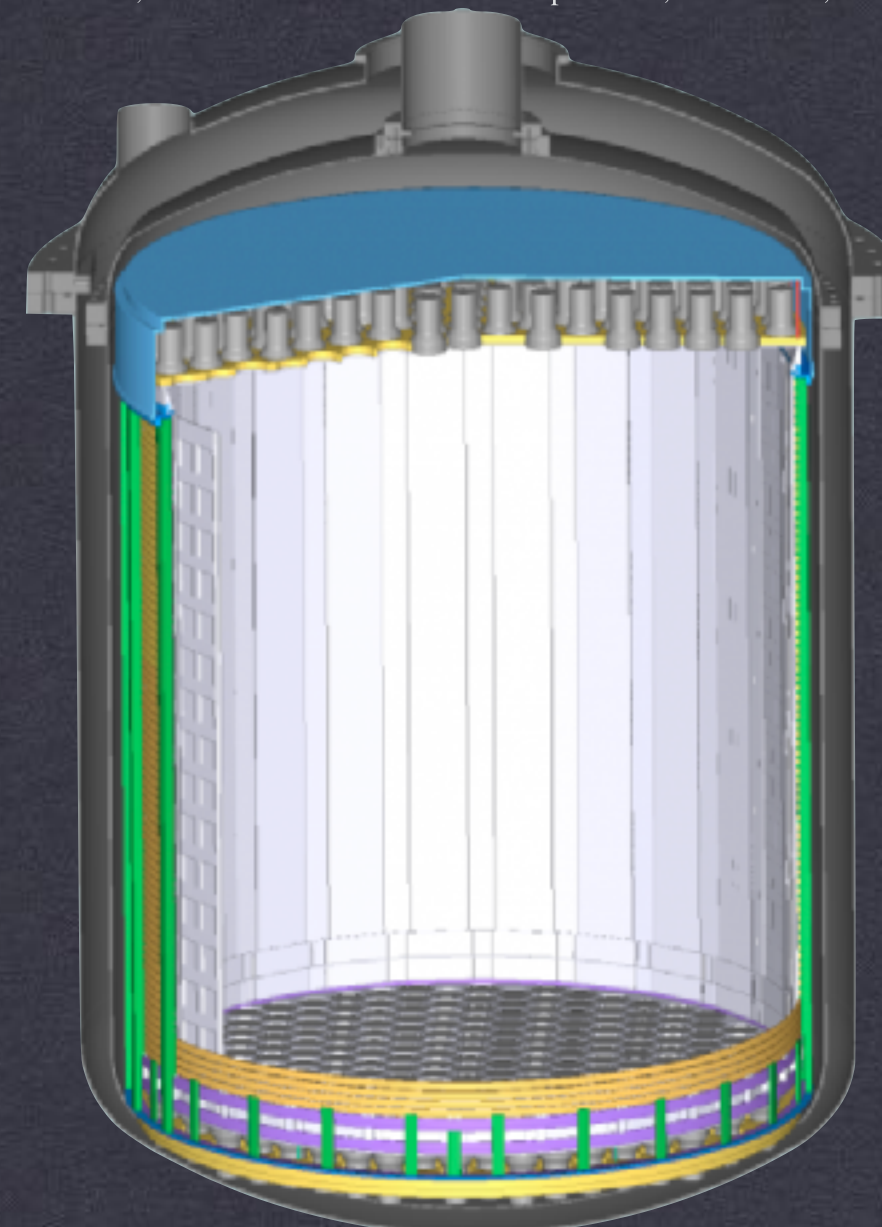
8 t

XENON1T PRELIMINARY, The XENONnT Dark Matter Experiment, Kaixuan Ni, 2017

3.2 t

161 kg

22 kg



XENON10

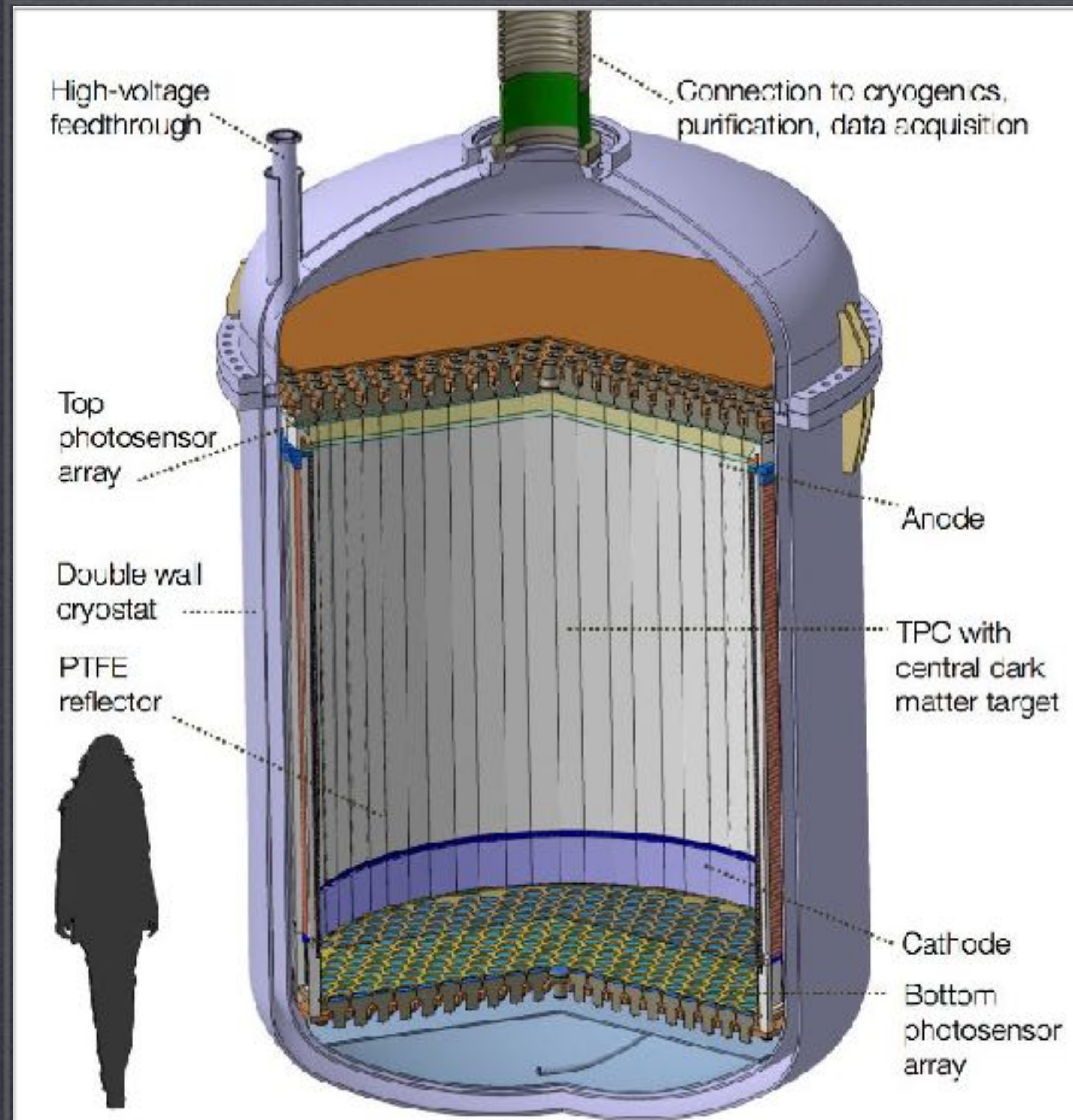
XENON100

XENON1T

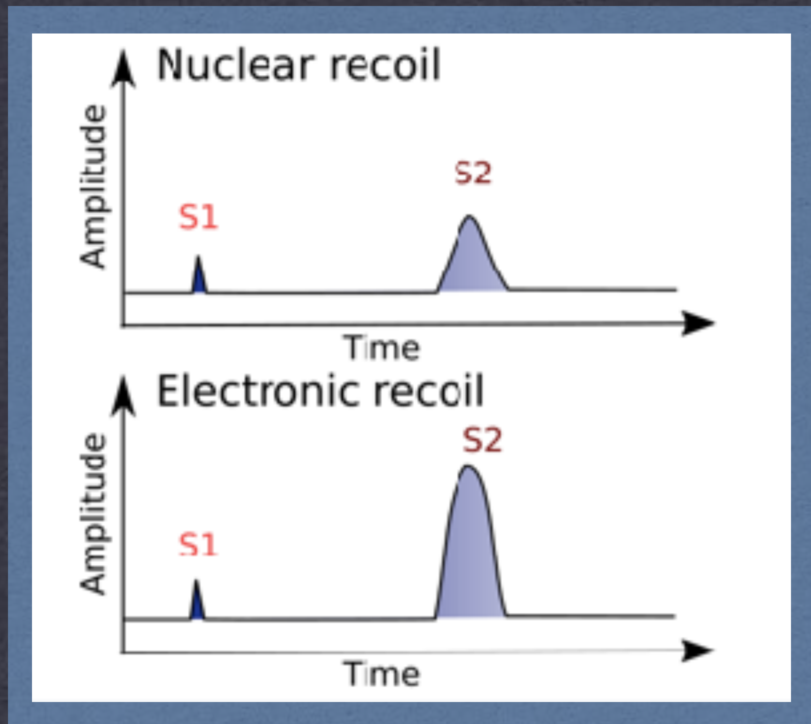
XENONnT

DARWIN EXPERIMENT

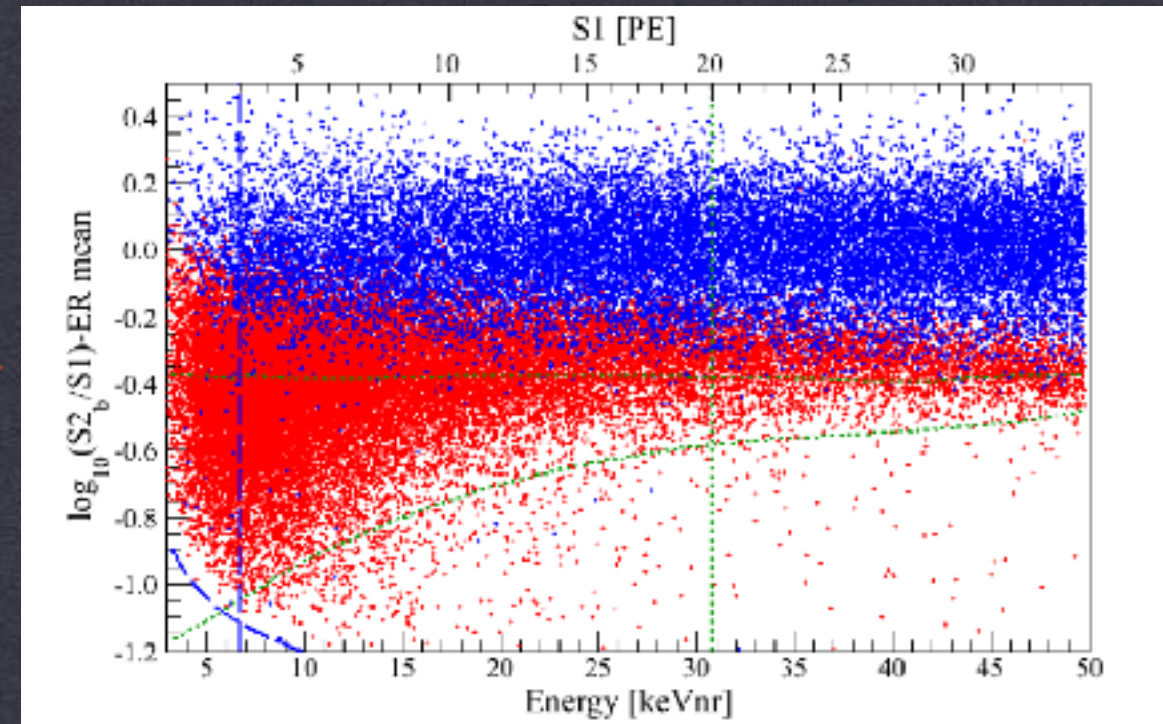
- Dual phase time projection chamber (TPC)
- 50 tons of LXe
- Low background double-wall cryostat
- Increase the amount of Sensors (PMTs of 3” diameter, SIPM, … and more candidates)



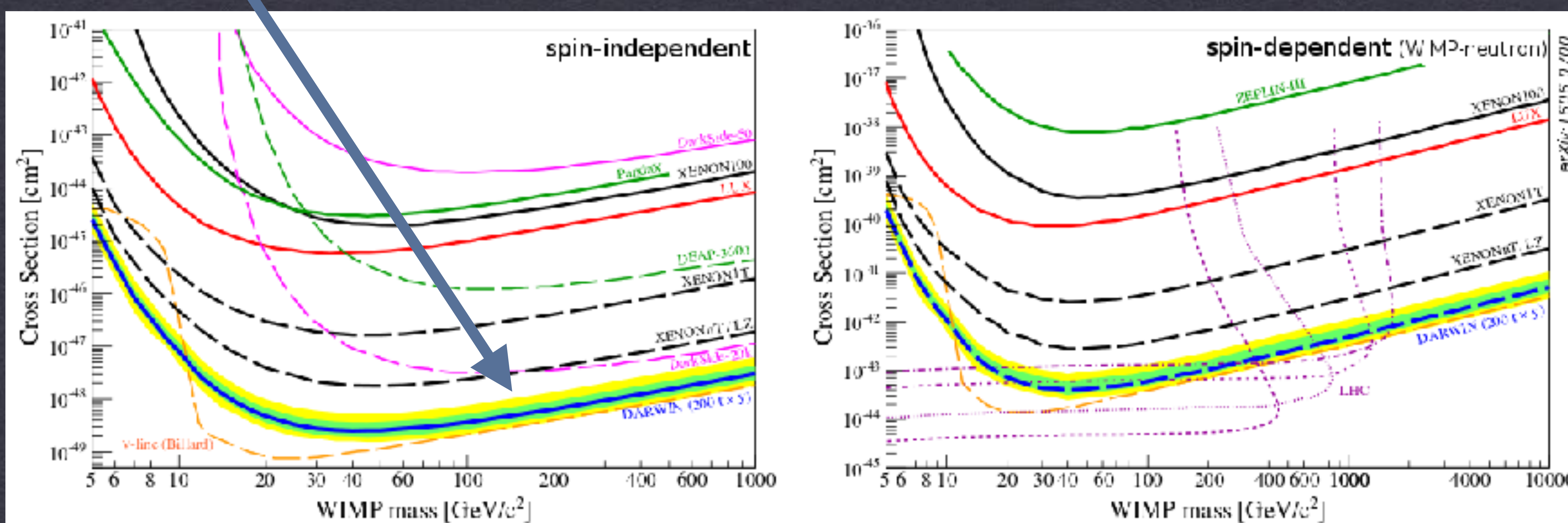
BACKGROUND DISCRIMINATION TECHNIQUES: ER AND NR



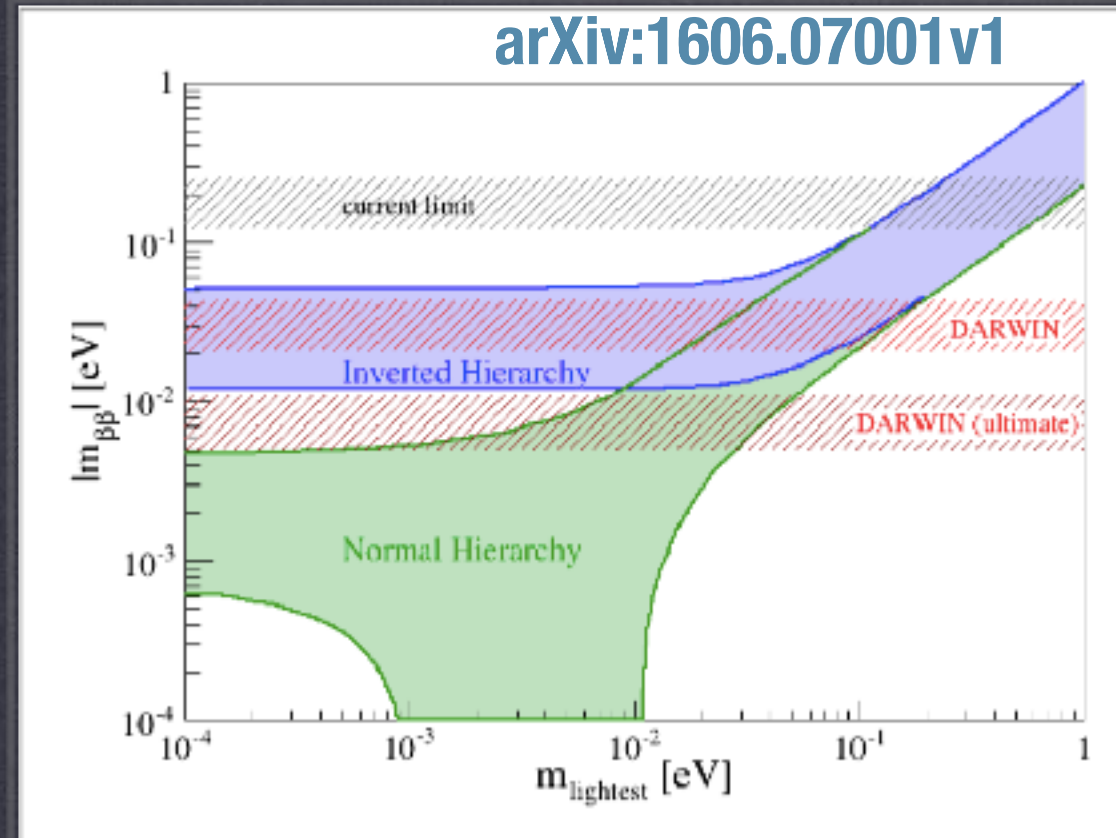
XENON1T: ER/NR Discrimination



EXPLORING THE ENTIRE ACCESSIBLE WIMP PARAMETER SPACE

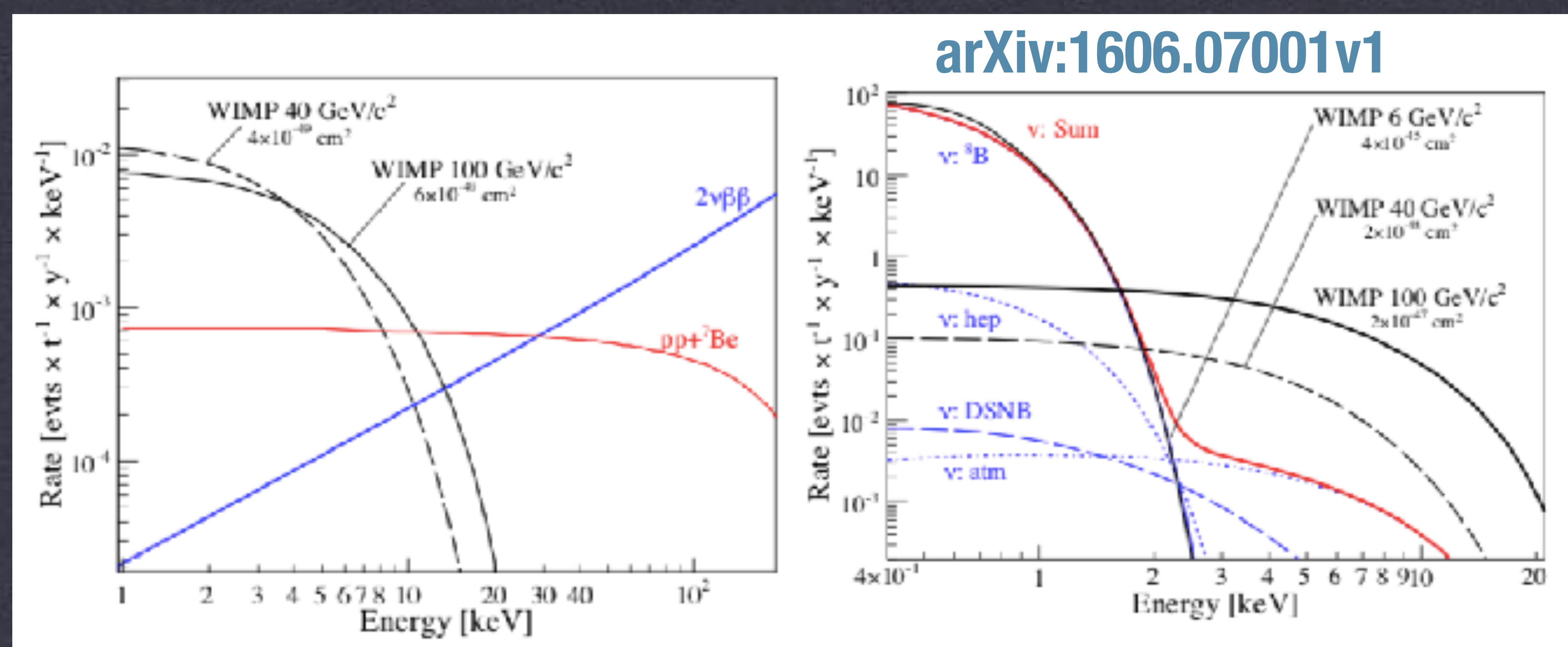


ROOM ALSO FOR NEUTRINO DETECTION



136Xe: 0νββ-decay candidate with a Q-value of 2.458MeV, well above the energy-range expected from a WIMP recoil signal.

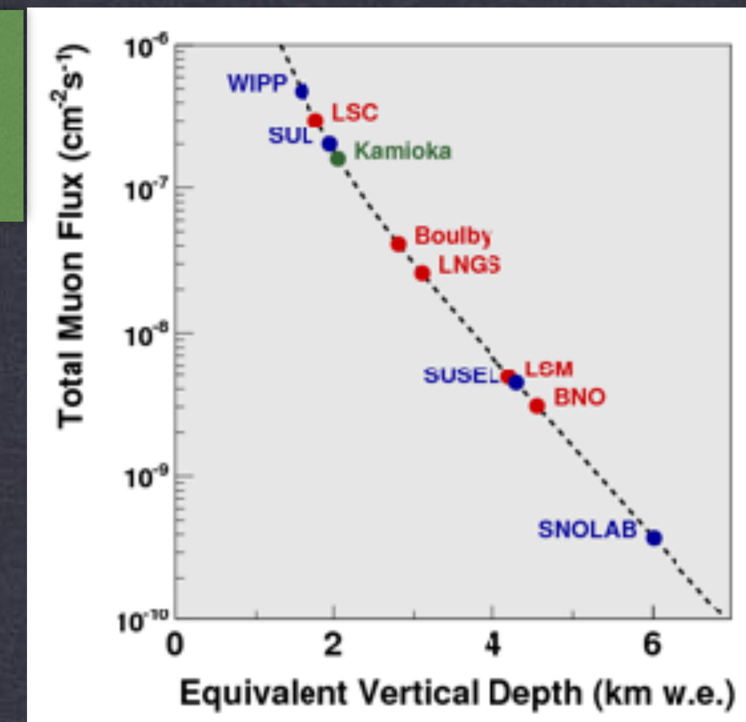
ER events from low energetic (pp + ^{7}Be) solar neutrinos:
Solar neutrinos are an interesting science channel



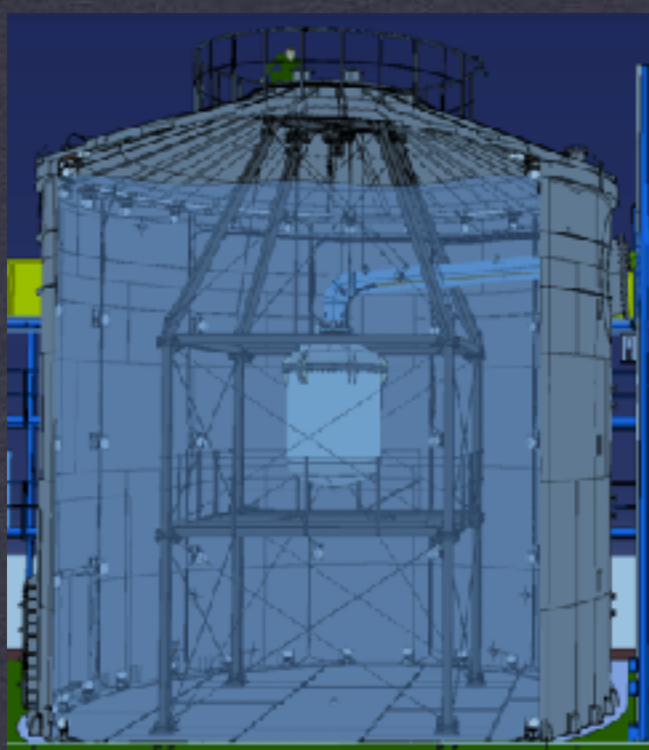
DEALING WITH BACKGROUND EVENTS

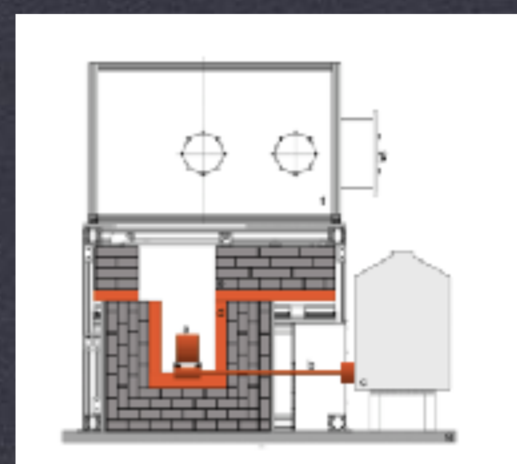
WHAT CAN WE DO?

GOING DEEP UNDERGROUND



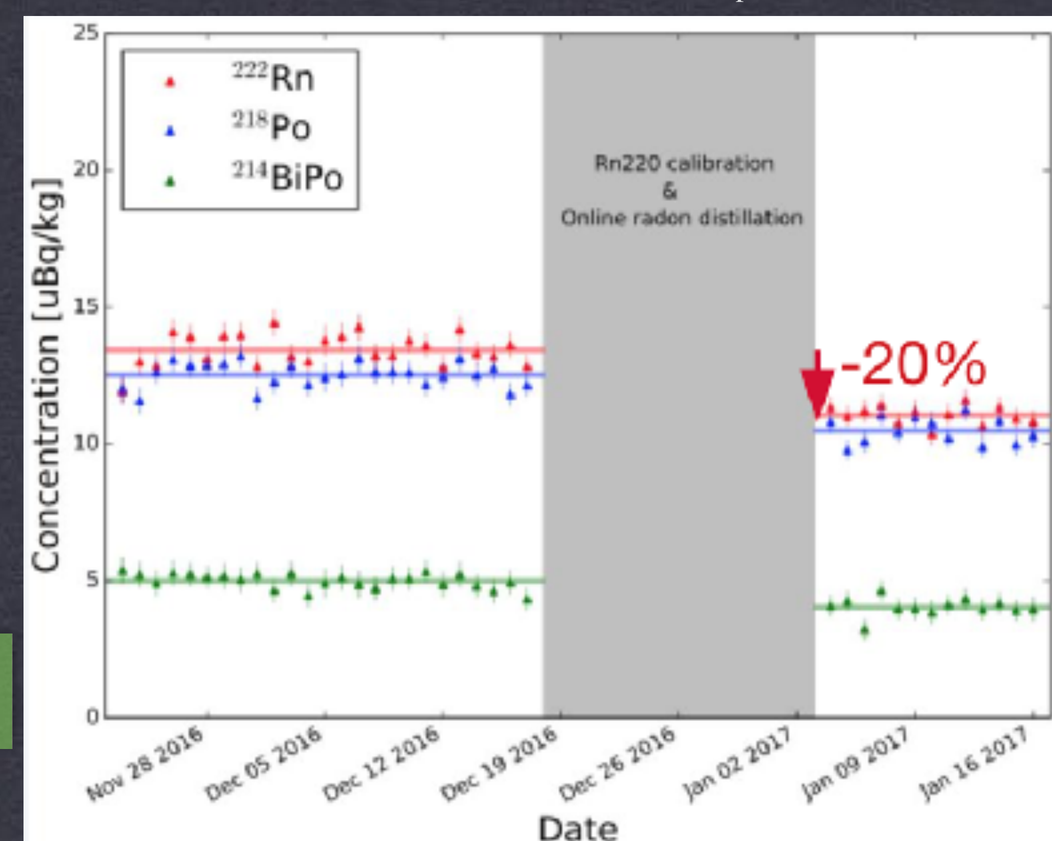
SHIELDING WITH WATER CHERENKOV DETECTORS





SCREENING OUR MATERIALS

XENON1T PRELIMINARY, The XENONnT Dark Matter Experiment, Kaixuan Ni, 2017

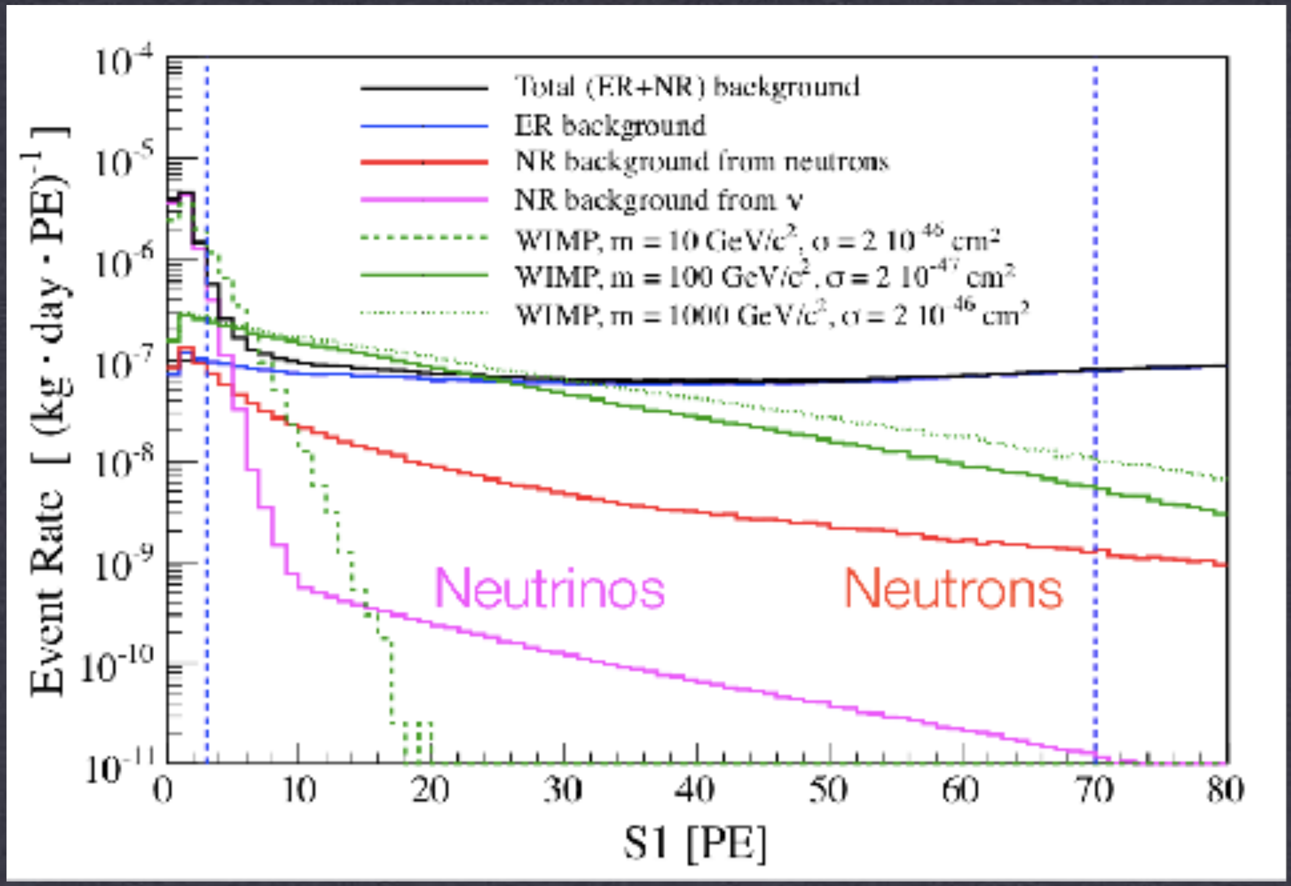


DISTILLATION FOR ^{85}Kr AND ^{222}Rn

MAIN BACKGROUNDS: WIMPS

XENON1T: arXiv:1705.01828v1

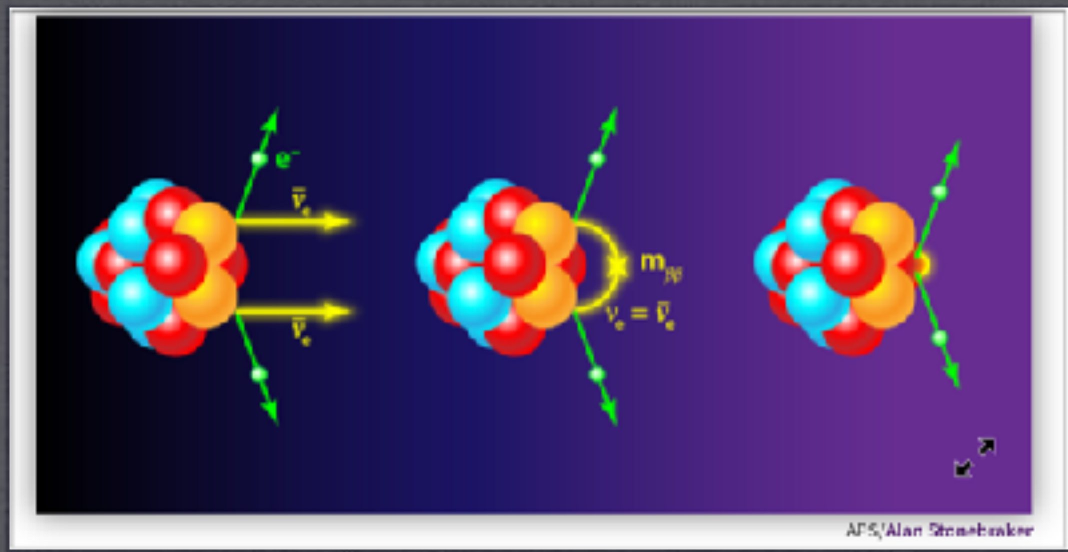
WIMPS ARE EXPECTED TO PRODUCE NUCLEAR RECOILS WITH THE XENON TARGET MASS



We get NR also from

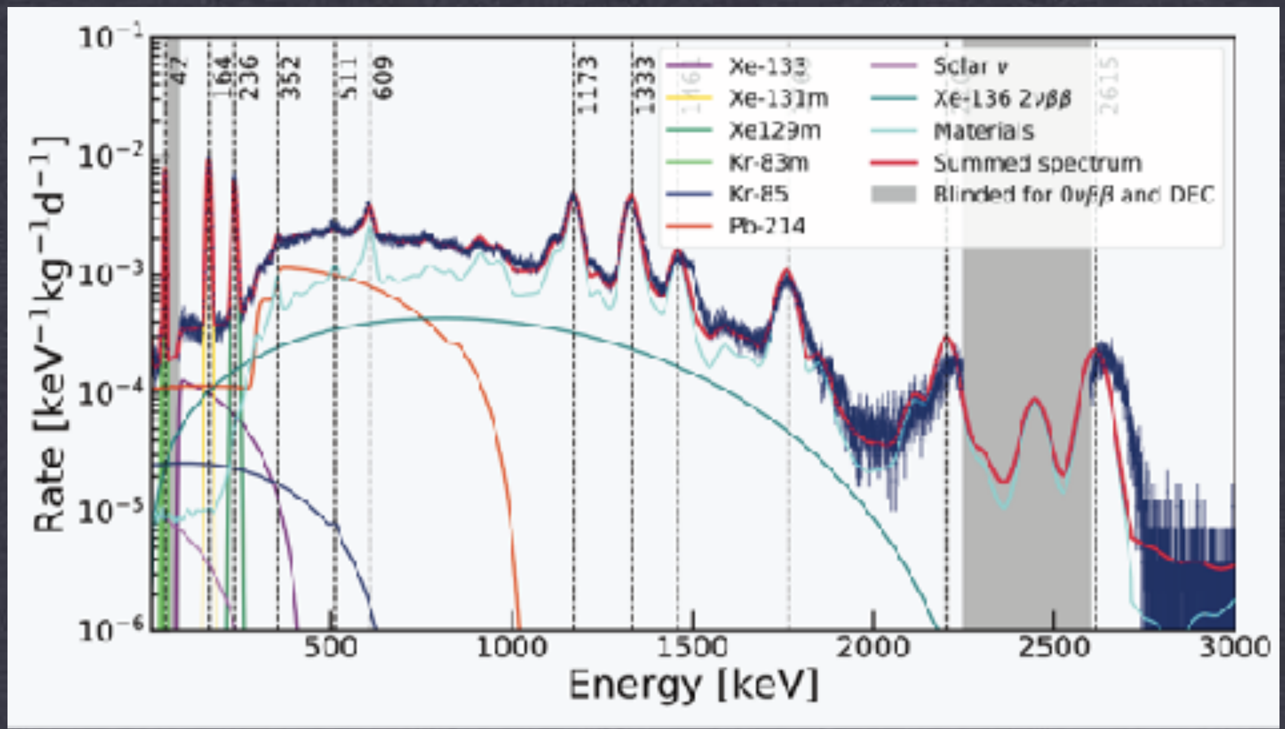
- CNNS
- Neutrons from the materials
- Cosmogenic neutrons

MAIN BACKGROUNDS - 0NBB DECAY



- ER RECOIL BACKGROUND IN THE MEV SCALE.
- THE 0NBB DECAY YIELDS TWO 1.23 MEV ELECTRONS WITH OPPOSITE THREE-MOMENTA (NEGLECTING THE NR OF THE ^{136}BA DAUGHTER NUCLEUS).

Chiara Capelli, Neutrino 2018 conference

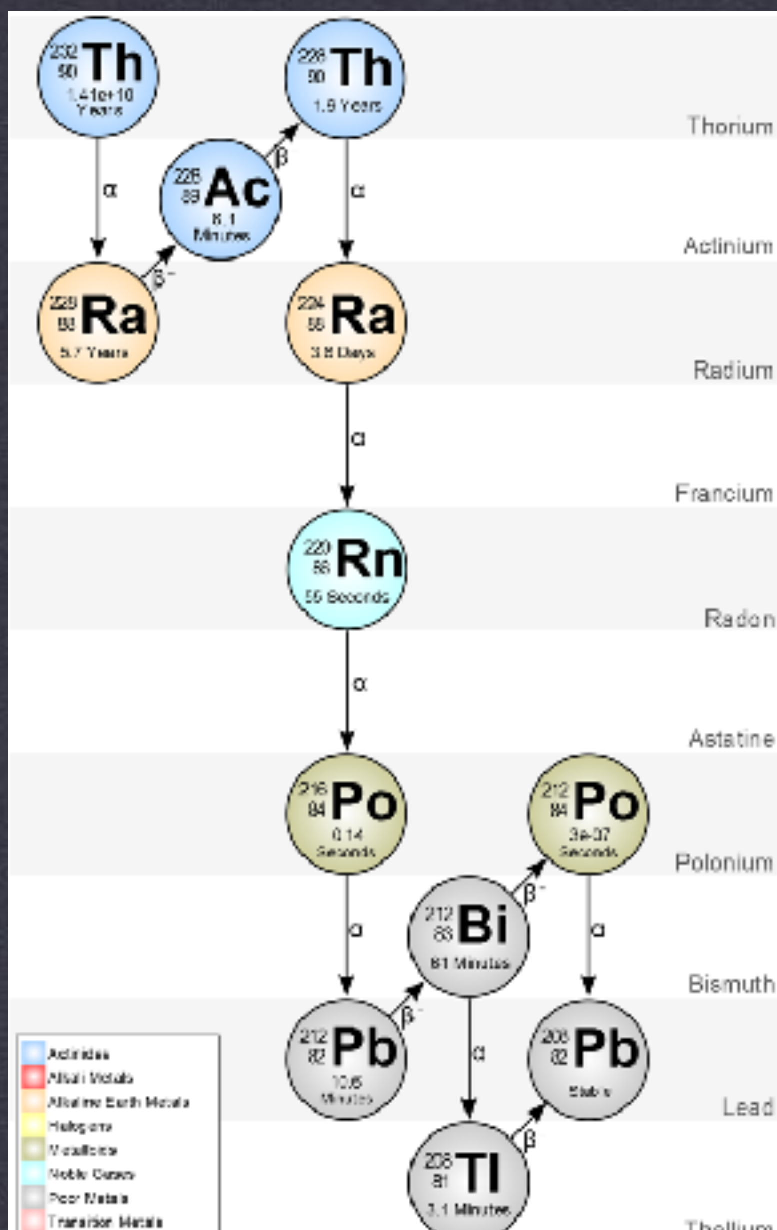


Background contribution in the region MeV from 2νββ ^{136}Xe and materials

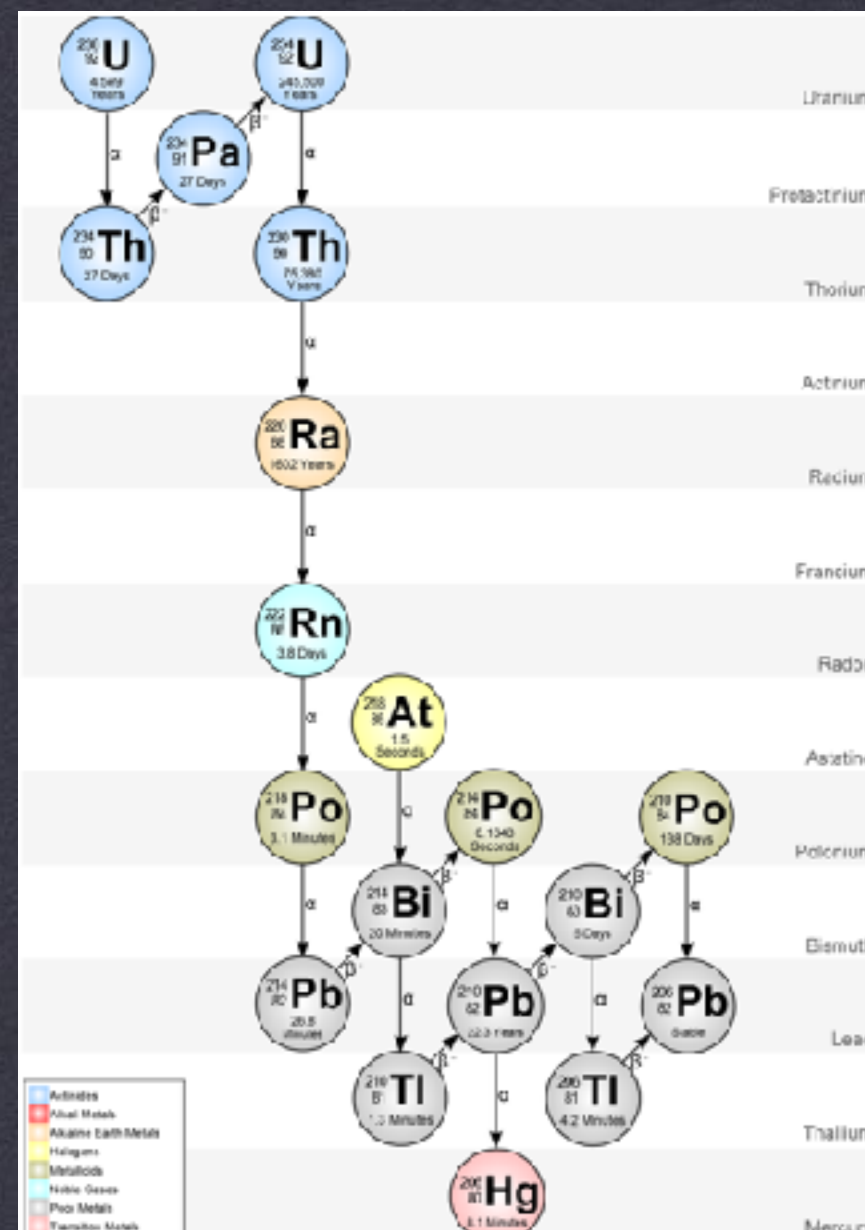
Intrinsic background from impurities ^{85}Kr and ^{222}Rn

EXTRINSIC RADIOACTIVITY FROM MATERIALS

^{232}Th

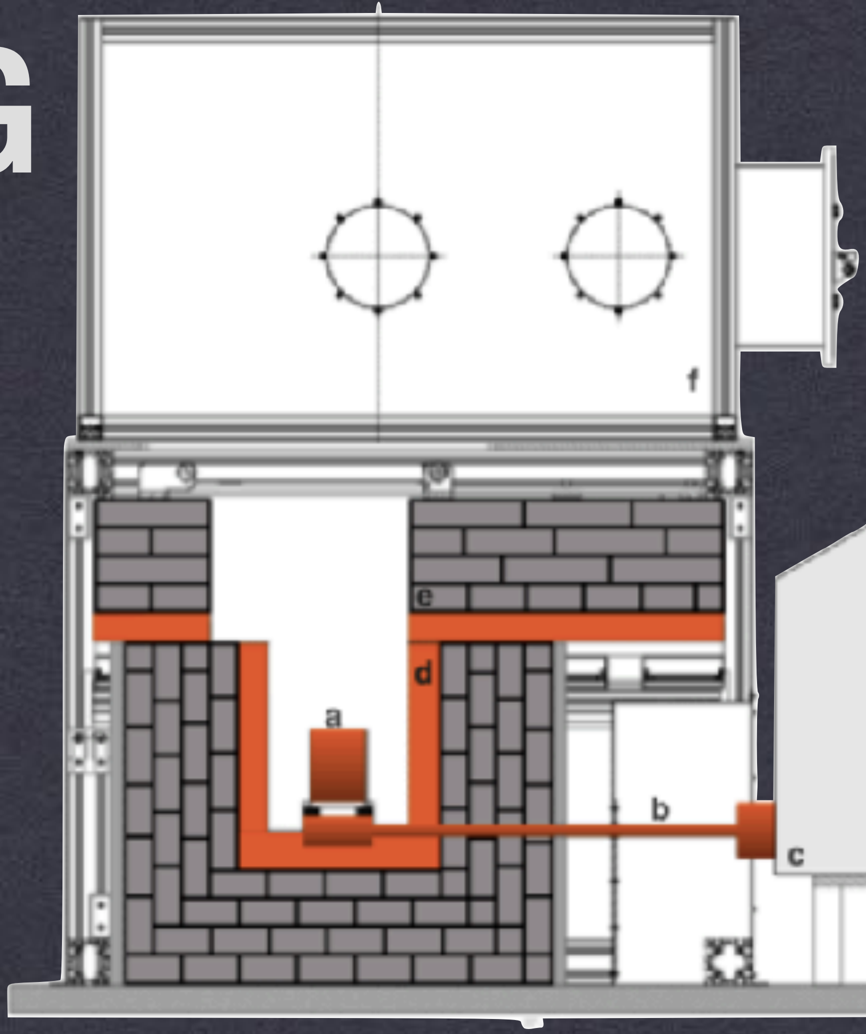


^{238}U



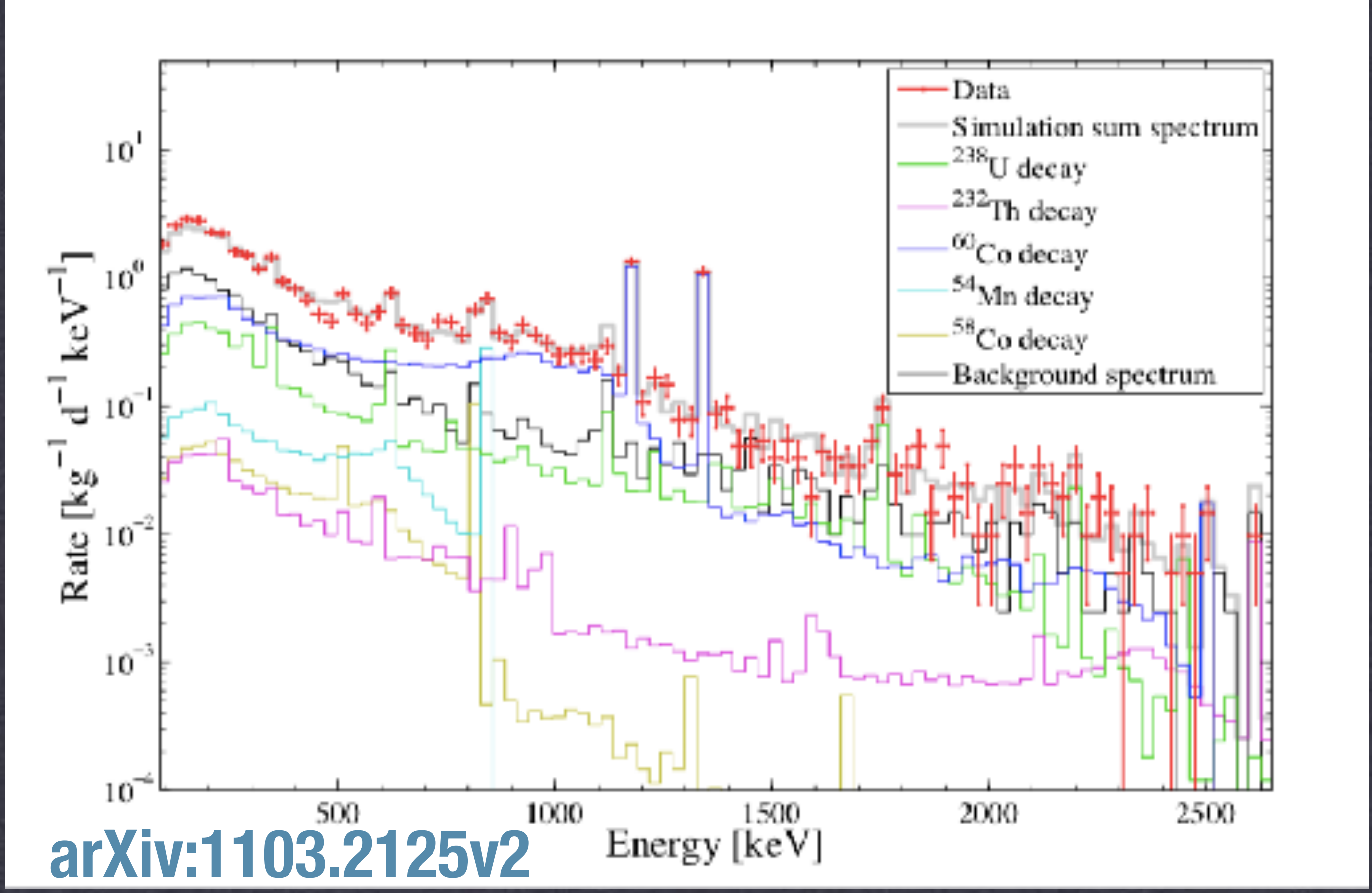
+ ^{60}Co ^{137}Cs ^{40}K

MATERIAL SCREENING WITH GATOR



Germanium detector placed in LNGS

Low background screening facility

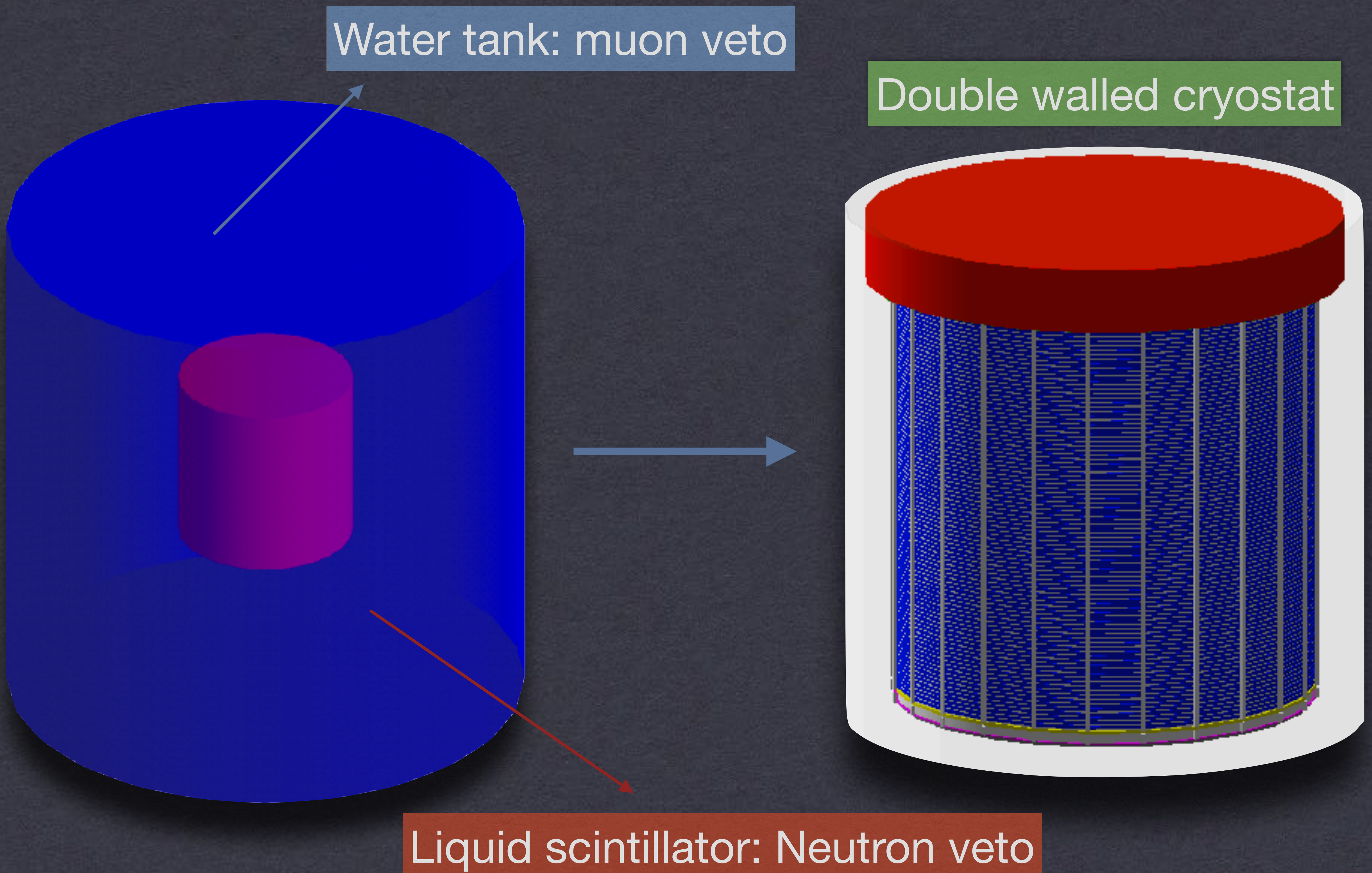


arXiv:1103.2125v2

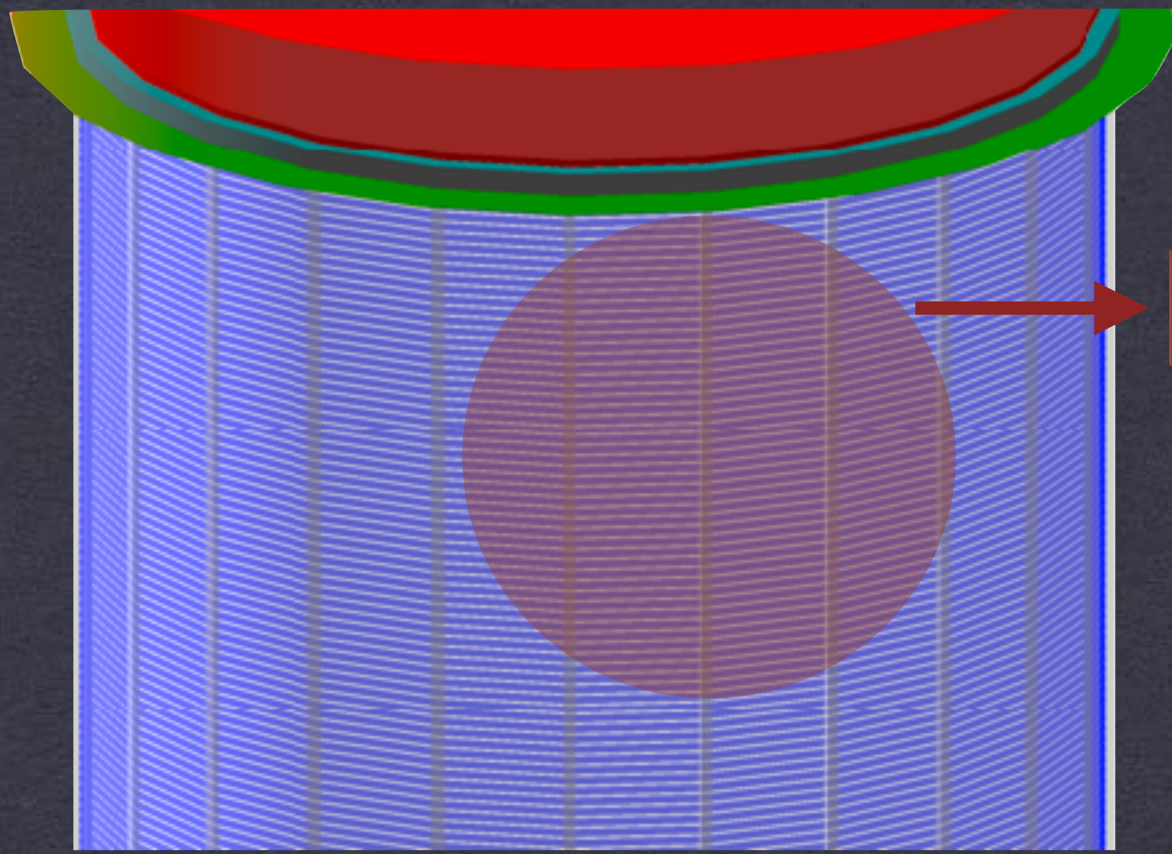
Sensitivity below ~mBq/kg, one of the best in the World

From a stainless steel sample

DARWIN GEANT4 GEOMETRY



DARWIN GEANT4 GEOMETRY



Copper rings for electric field shaping

PTFE pillars for structural support making use of its reflective properties

Two disk made from composite material that emulates the background introduced by the sensors

MATERIALS SUMMARY

~55 t of LXe

~180 kg of PTFE for the TPC

~230 kg of Stainless Steel for the Cryostat

232 Th 238 U

60 Co 137 Cs 40 K

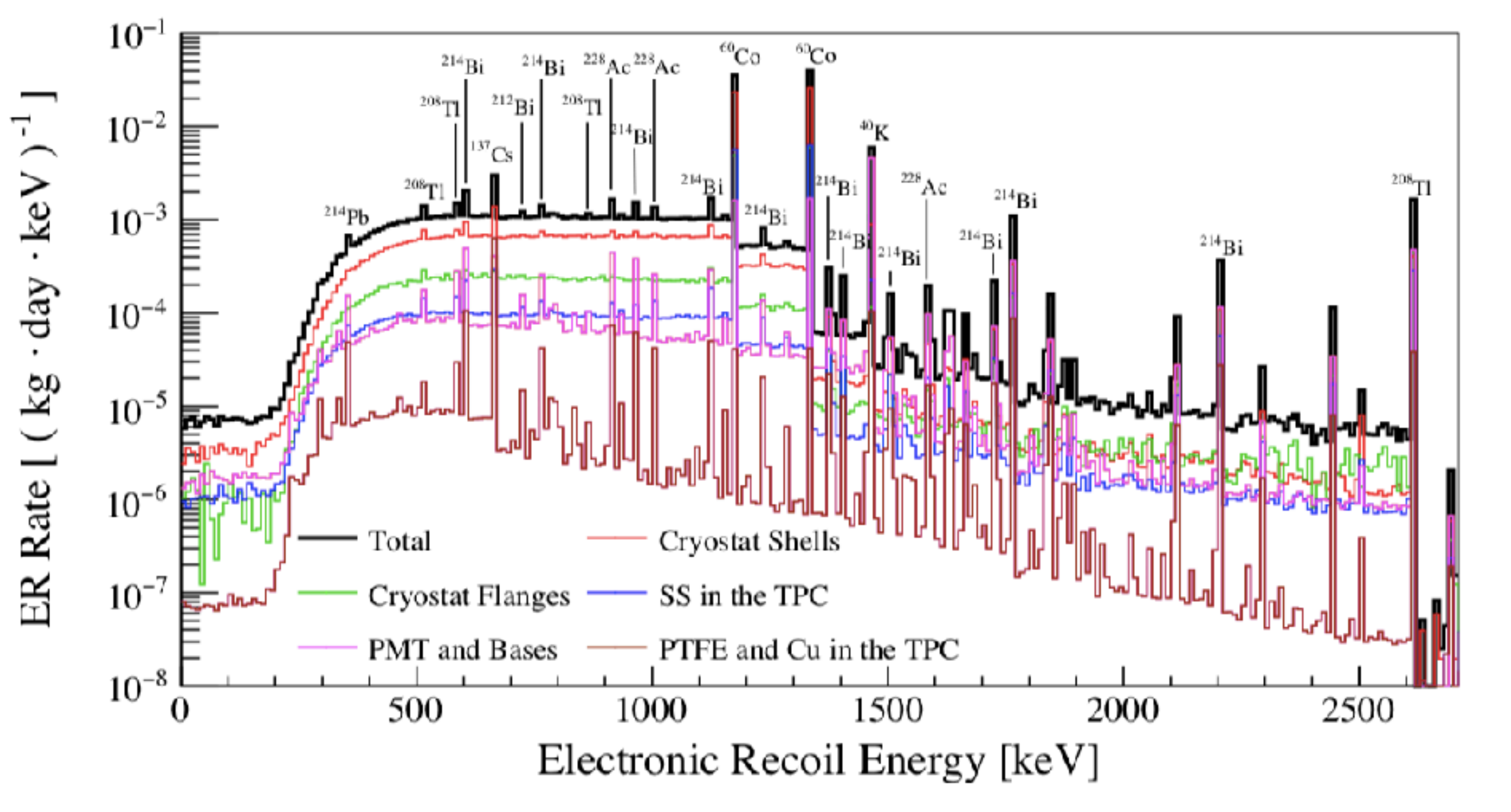
Currently performing simulations for these isotopes in PTFE material for Darwin's TPC

MATERIALS

LXe		55641.7	kg	19.5234	m³
GXe		15.8279	kg	2.68862	m³
LXe	filling	15.1315	kg	0.005309	m³
LXe	filling	3.77925	kg	0.001326	m³
Total	Xenon:	55676.4	kg	22.2187	m³
PTFE	Reflect	93.5154	kg	0.042507	m³
PTFE	Reflect	2.15805	kg	0.000980	m³
PTFE	Reflect	2.15805	kg	0.000980	m³
PTFE	Long Pi	82.368	kg	0.03744	m³
PTFE	Short P	1.9008	kg	0.000864	m³
Total	PTFE:	182.1	kg	0.082772	m³
SS30	4LSteel	200	kg	0.025013	m³
SS30	4LSteel	26.3391	kg	0.003292	m³
SS30	4LSteel	10.5356	kg	0.001316	m³
Total	SS304LSteel	236.982	Kg	0.0296227	m³

EXTRINSIC CONTAMINATION FROM MATERIALS

XENON1T: arXiv:1705.01828v1



Energy spectrum in 1 t FV of the total ER background from the detector materials (black), and the separate contributions from the various components (colors).

SIMULATIONS STATUS

- CURRENTLY RUNNING SIMULATIONS FOR GAMMA BACKGROUND FOR DIFFERENT MATERIALS IN THE TPC (PTFE, COPPER, STAINLESS STEEL)

- NEXT STEPS:
NEUTRONS FROM MATERIALS

CHALLENGES FOR THE FUTURE

- LIMIT THE CONTRIBUTION OF BACKGROUND EVENTS FOR THE LARGEST DARK MATTER DETECTOR IN THE WORLD
- OPTIMISE THE DETECTOR NOT ONLY FOR DARK MATTER SEARCHES, BUT ALSO SOLAR NEUTRINOS, 0NBB DECAYS… -> SEE PATRICIA SANCHEZ TALK

- OBTAIN GOOD SENSITIVITIES BOTH FOR WIMP NUCLEAR RECOIL AND NEUTRINO LESS DOUBLE BETA DECAY IN XENON

THANKS !