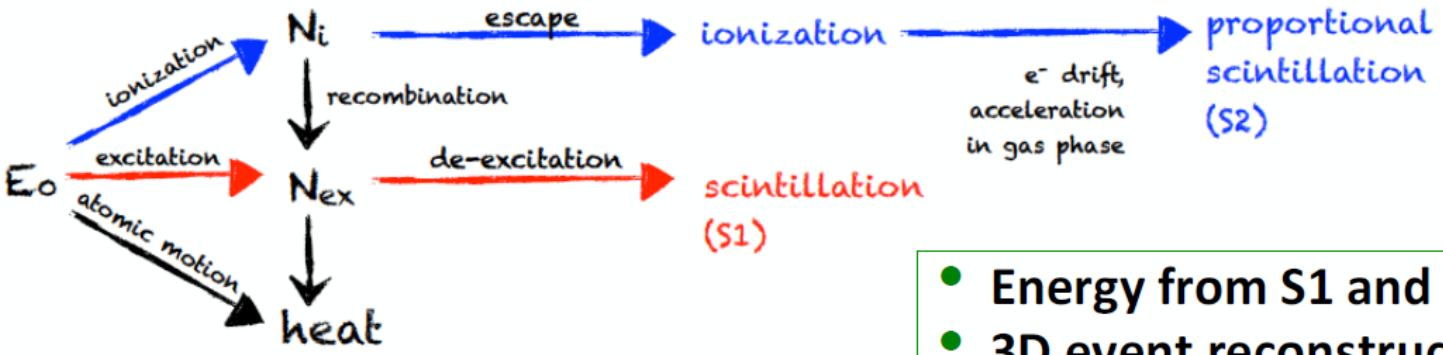
2018 Double Beta Research day in France

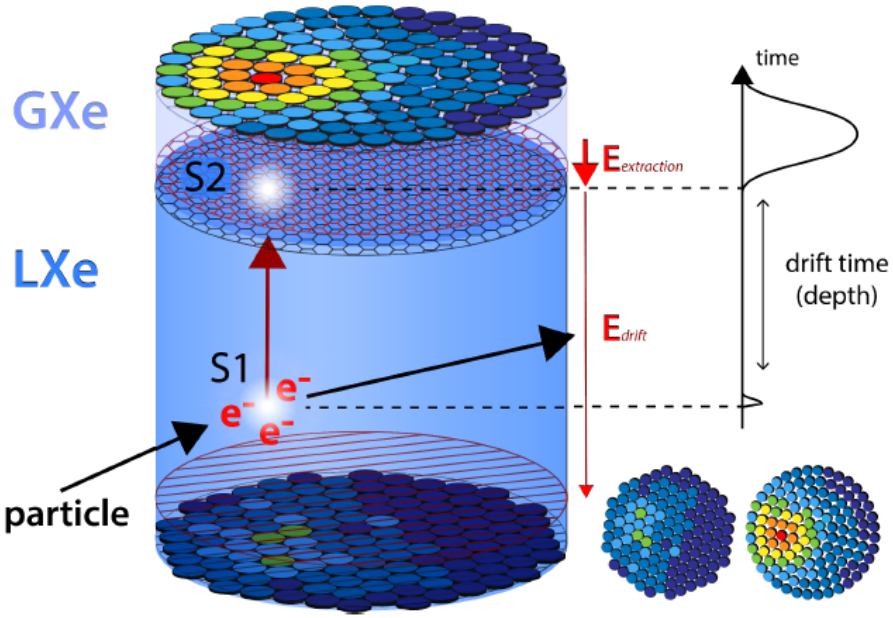
Large LXe dual phase TPC and DARWIN 2β experiments

Dominique Thers, SUBATECH

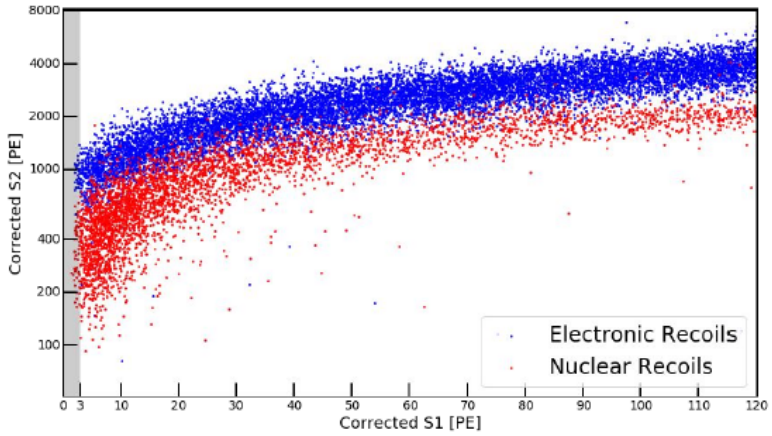
September 4th 2018, APC

Dual phase LXe TPC



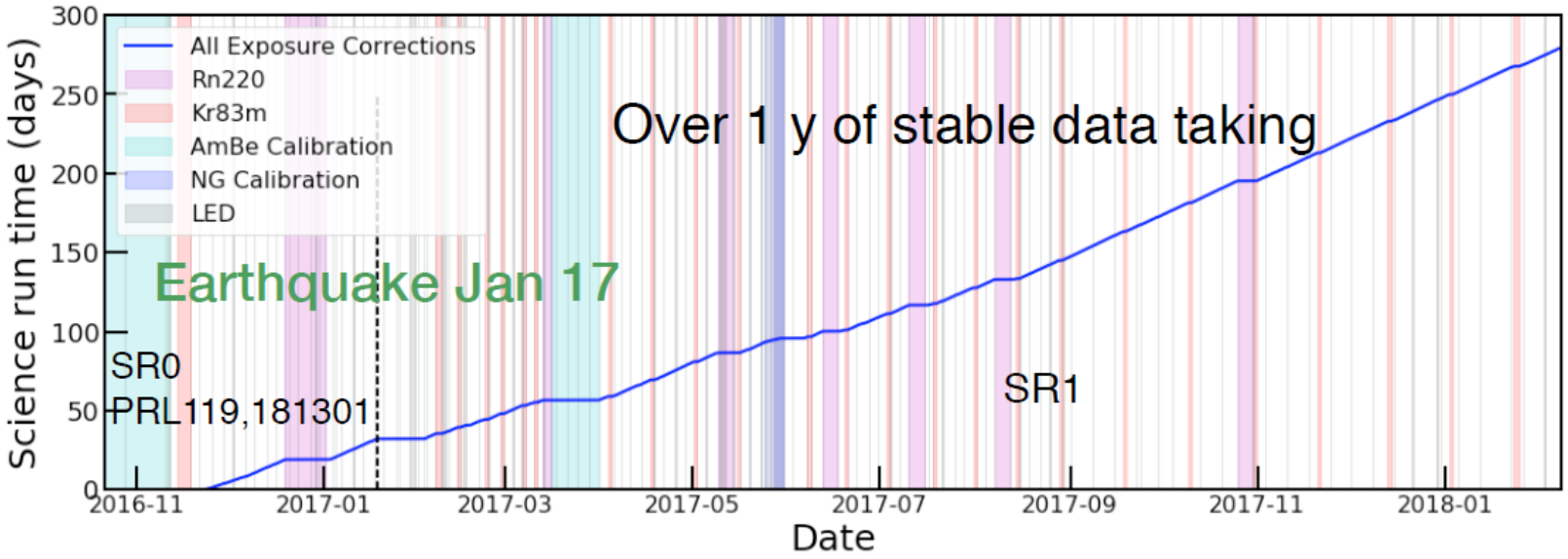


- **Energy from S1 and S2 area**
- **3D event reconstruction:**
  - X , Y from S2 hit pattern on top PMTs
  - Z from electrons drift time
- **ER - NR discrimination**
  $(S2/S1)_{WIMP,n} < (S2/S1)_{\gamma,\beta}$



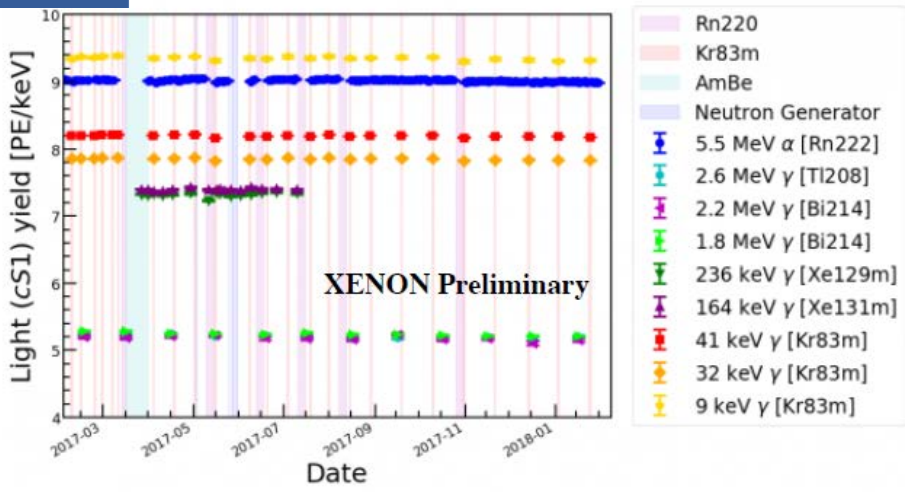
XENON1T SR0+SR1 exposure

- 278 days of exposure (~ 15 months)
- ~ 1 ton over 1 year, largest exposure
- Stability checked regularly during all the run
- Experiment still working now

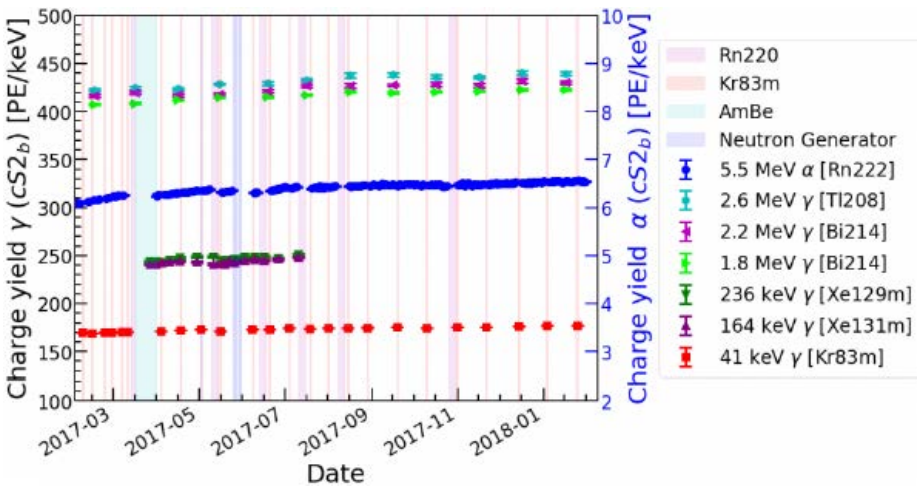


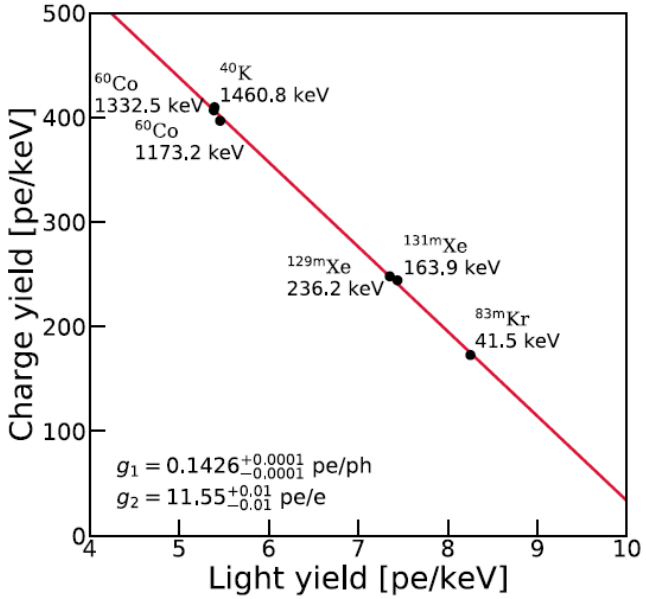
Energy measurement with XENON1T

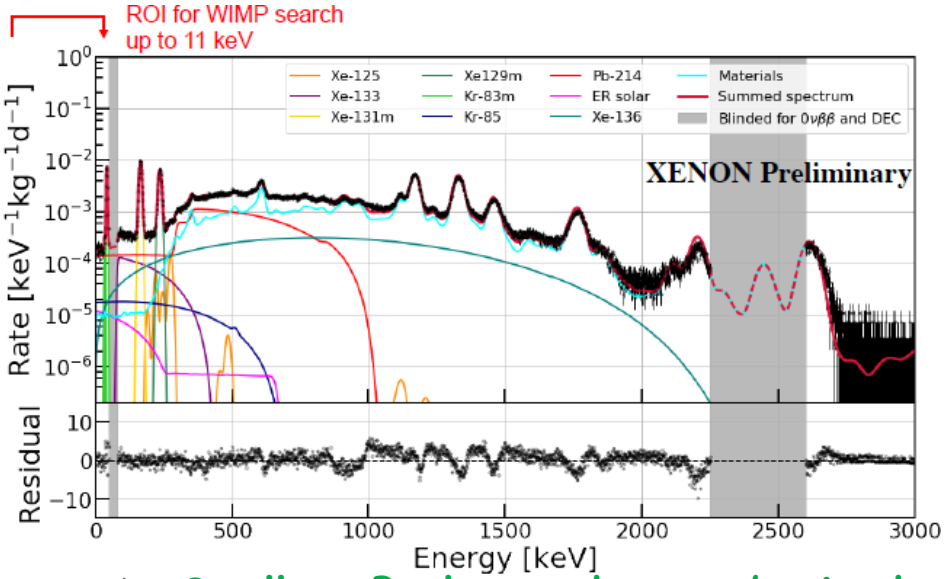
Scintillation Yield : S_1



Charge Yield : S_2

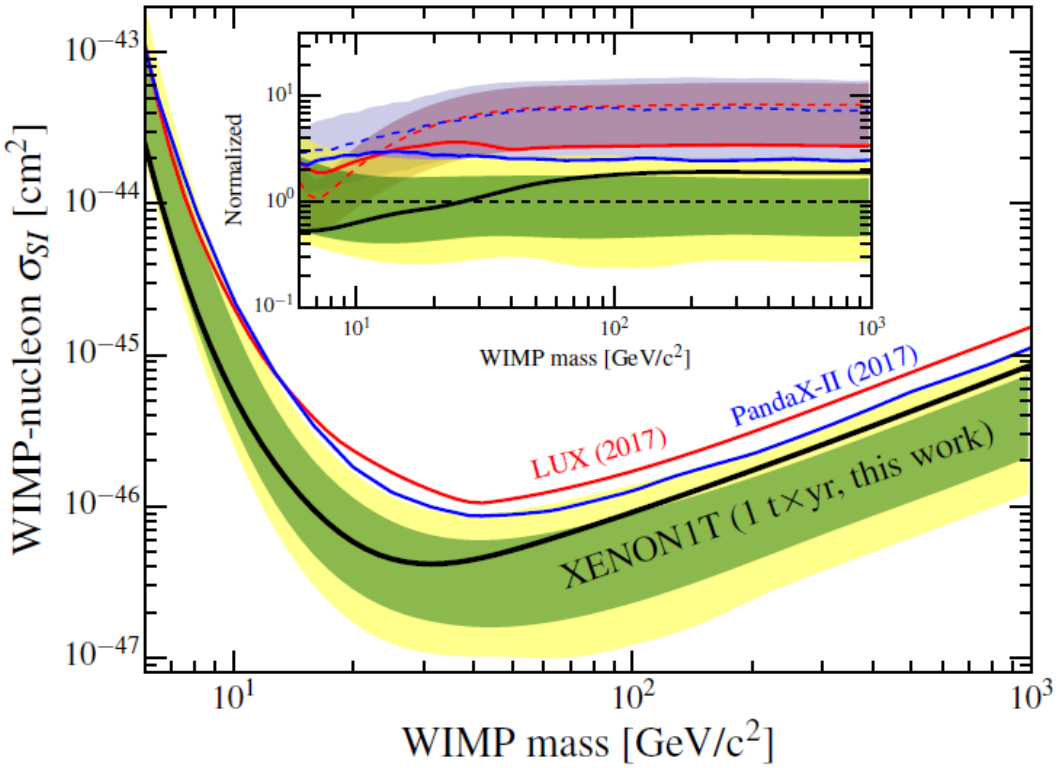






➢ **Smallest Background ever obtained with DDM experiments!**

XENON1T SR0+SR1 SI DDM results



- **Best world limit for mass > 6 GeV/c^2**
  Accepted by PRL, arXiv:1805.12562
- **DDM lead by dual phase LXe TPC experiments**

Double β decay search with xenon target

Xe-136 : Double β emitter

- **With neutrinos :**
  - **Q-value = 2.457 MeV**
  - **$T_{1/2}$=2.11±0.04(stat.)±0.21(sys.)×10^{21} yr**

  (EXO-200 arXiv:1108.4193v2)
- **Neutrinoless :**
  - **Limit : $T_{1/2}$>1.07×10^{26} yr**

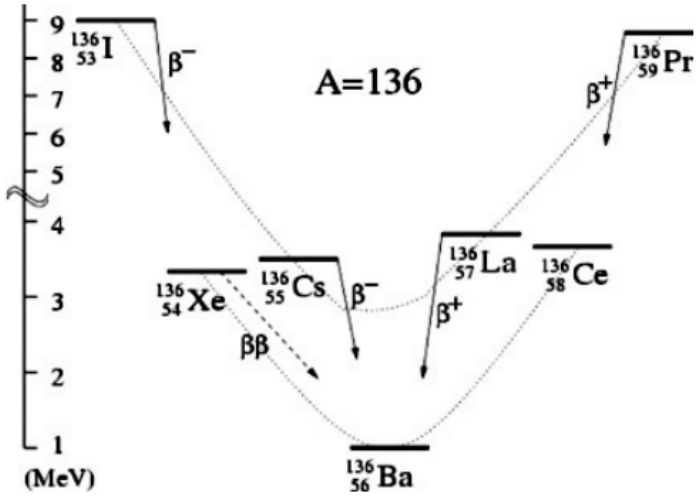
  (KamLAND-Zen arXiv:1605.02889)
- **Abundance 8.86% in natural xenon**

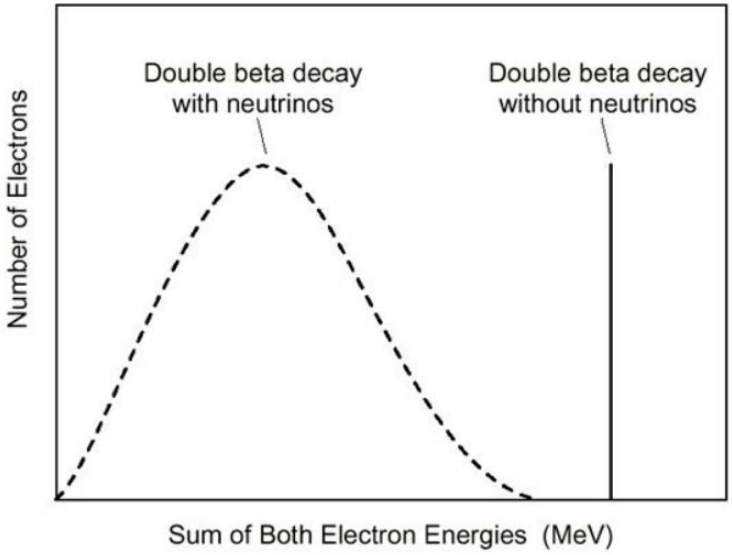
  (8.49 % measured in XENON1T) :
  - **XENON1T active volume ~ 2 tons**

    → ~ 169 kg Xe-136

➢ **~ 3 times more with XENONnT**

➢ **~ 20 times more with DARWIN !**

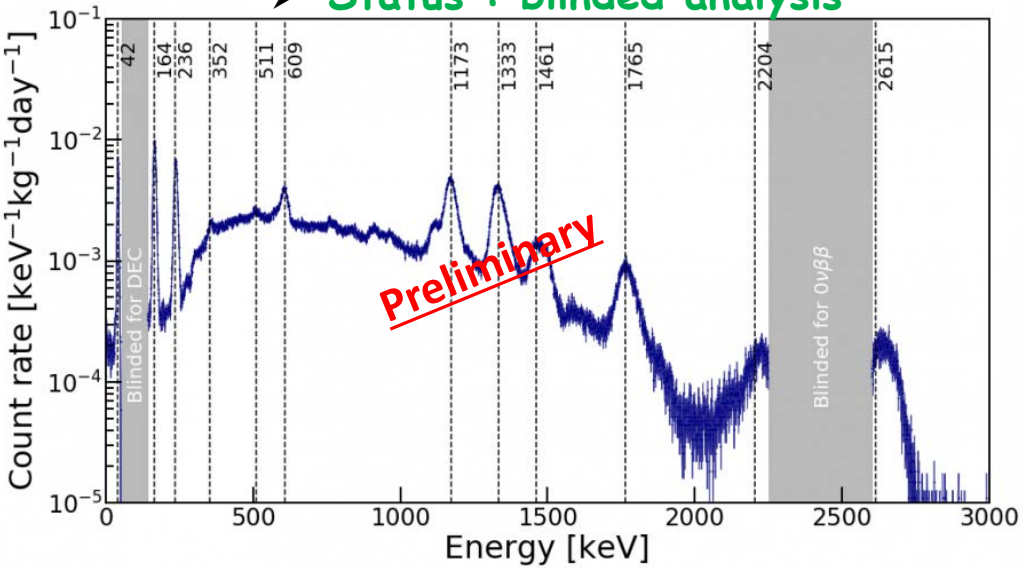




2.457 MeV

Double β decay in XENON1T

➢ **Status : blinded analysis**



Expected energy resolution ~ 1% at Q-value

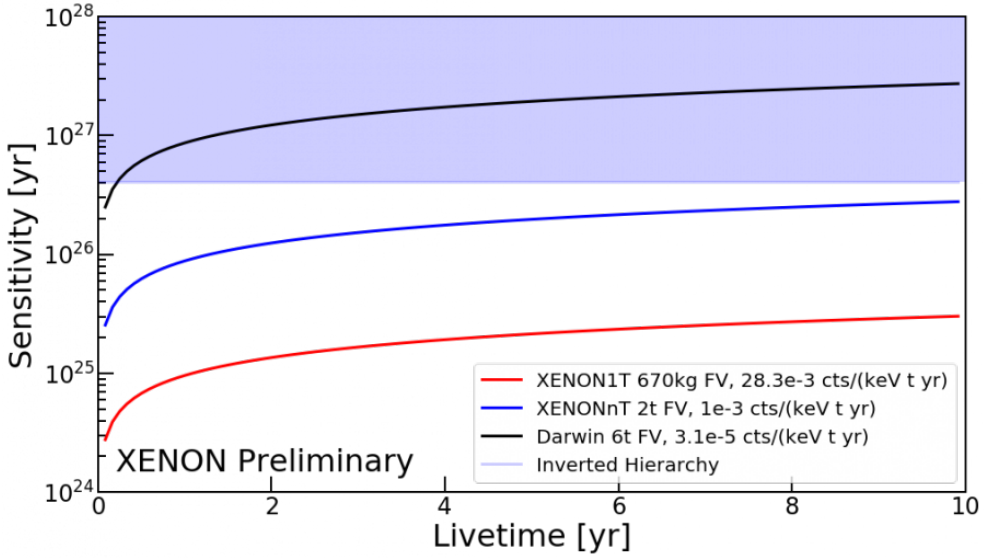
Active target under study

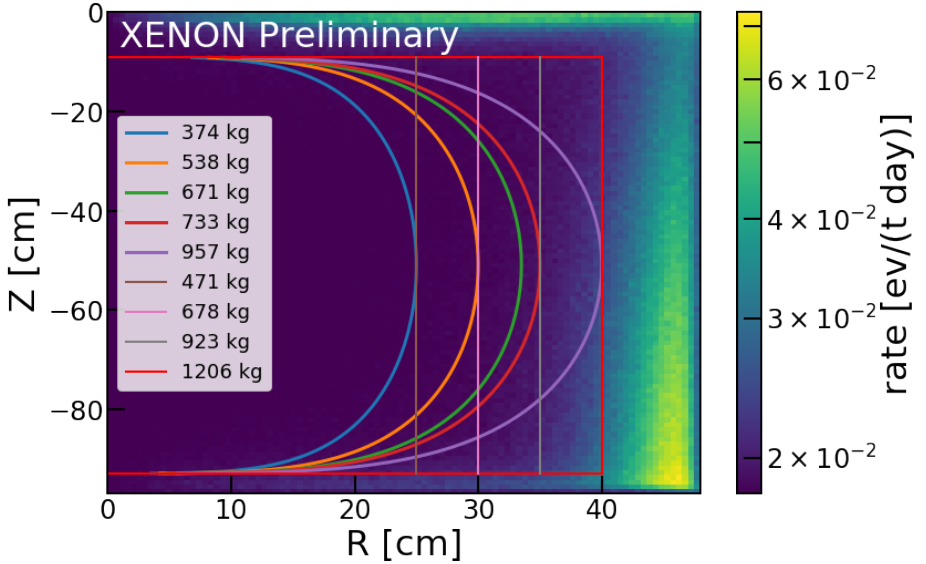
Expected efficiency > 90%

Work in progress :

- Background characterization
- Energy resolution increase

PhD Thesis : Chloé Therreau (Subatech)

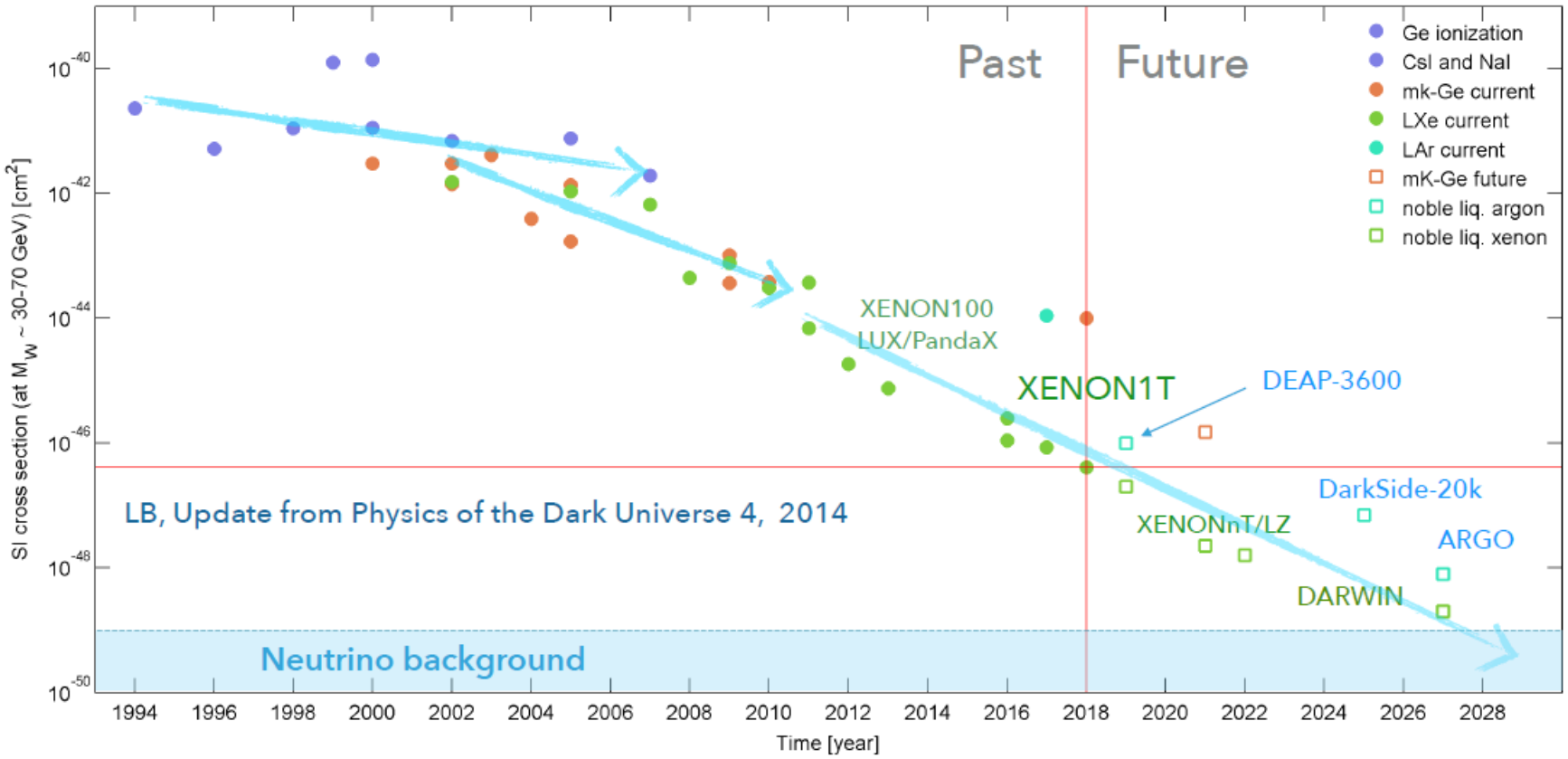




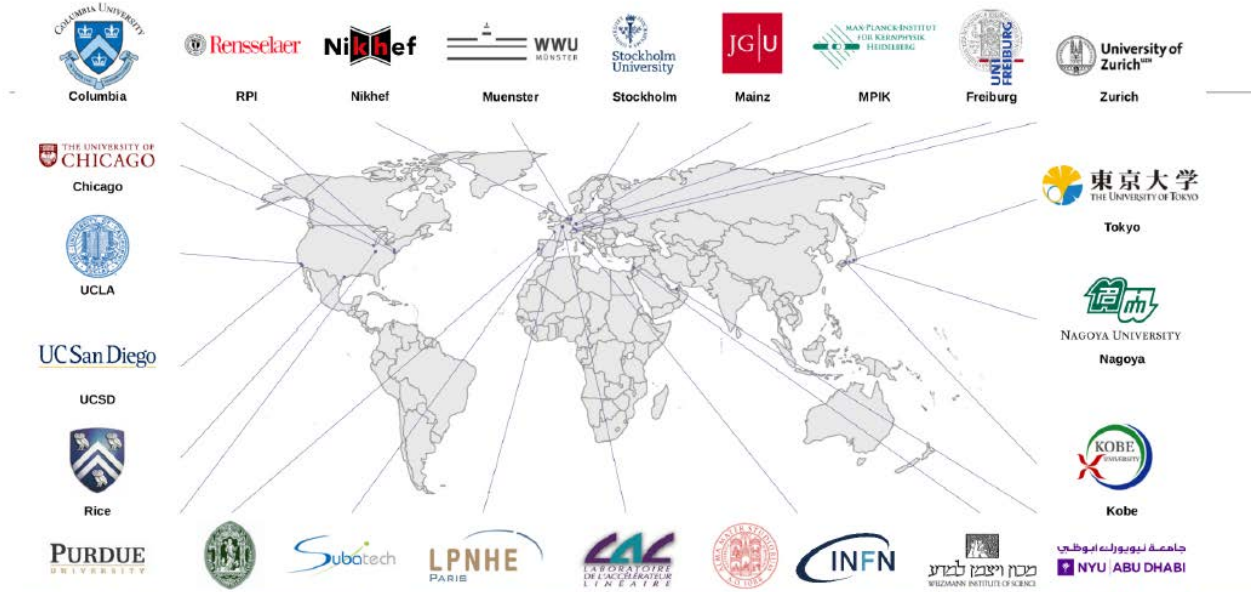
J2β2018, dominique.thers@subatech.in2p3.fr

DDM drives upgrade strategy of LXe experiments

- **Sensitivity increase ~ factor 10 every 2 years**



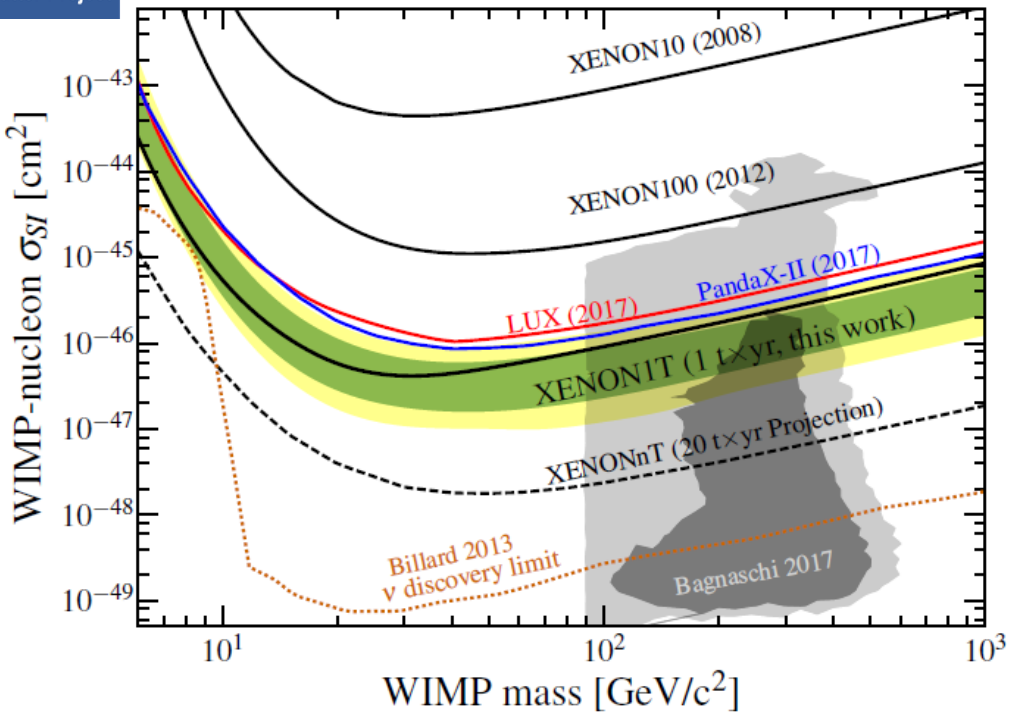
XENONnT



~ 170 researchers

3 Japanese teams joined XENONnT in 2018

XENONnT upgrade : construction started



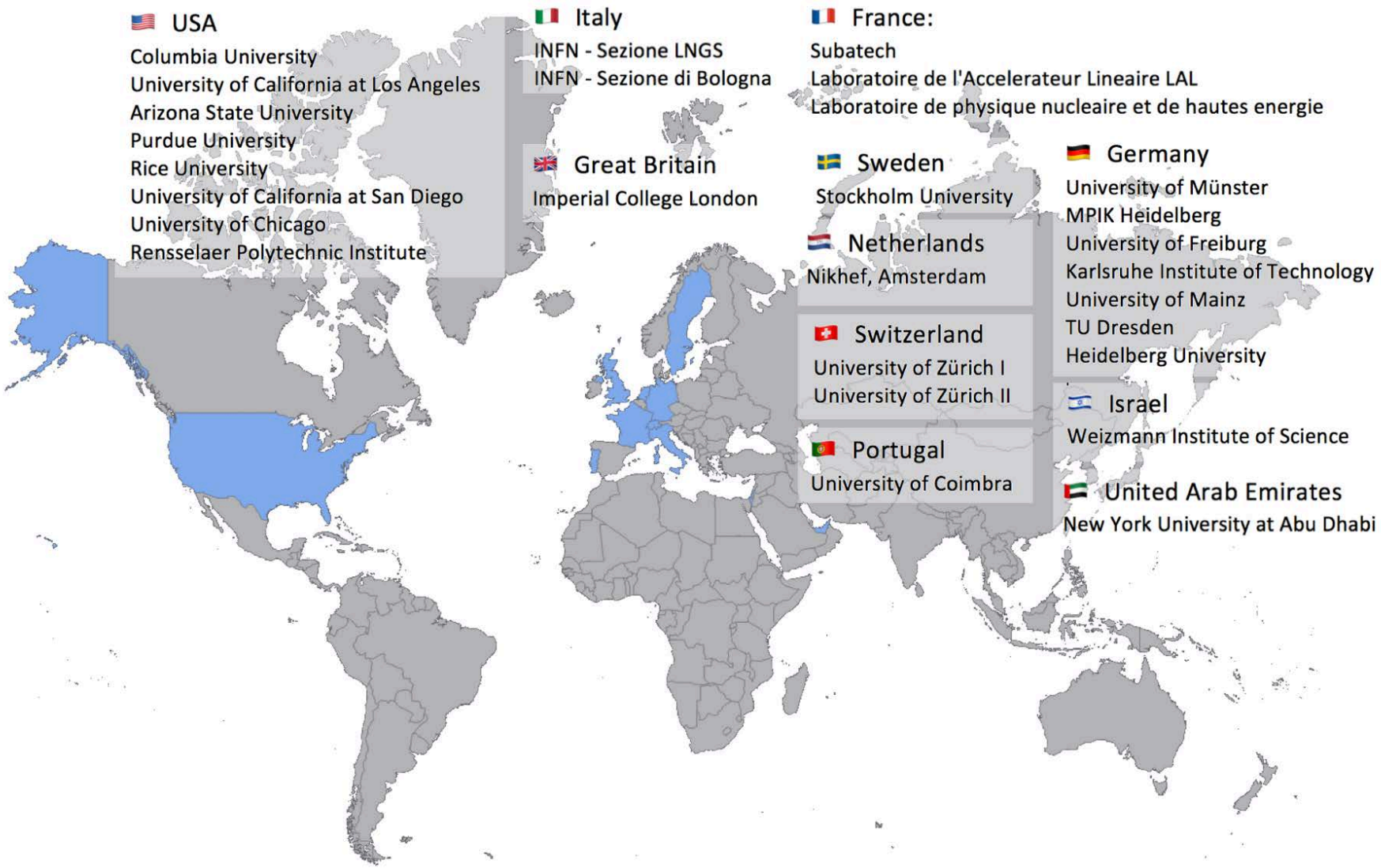
Active French contributions : 3 labs (LAL, LPNHE, Subatech)

- **construction and commissioning of ReStoX2**
- **mesh electrodes design and assembling**

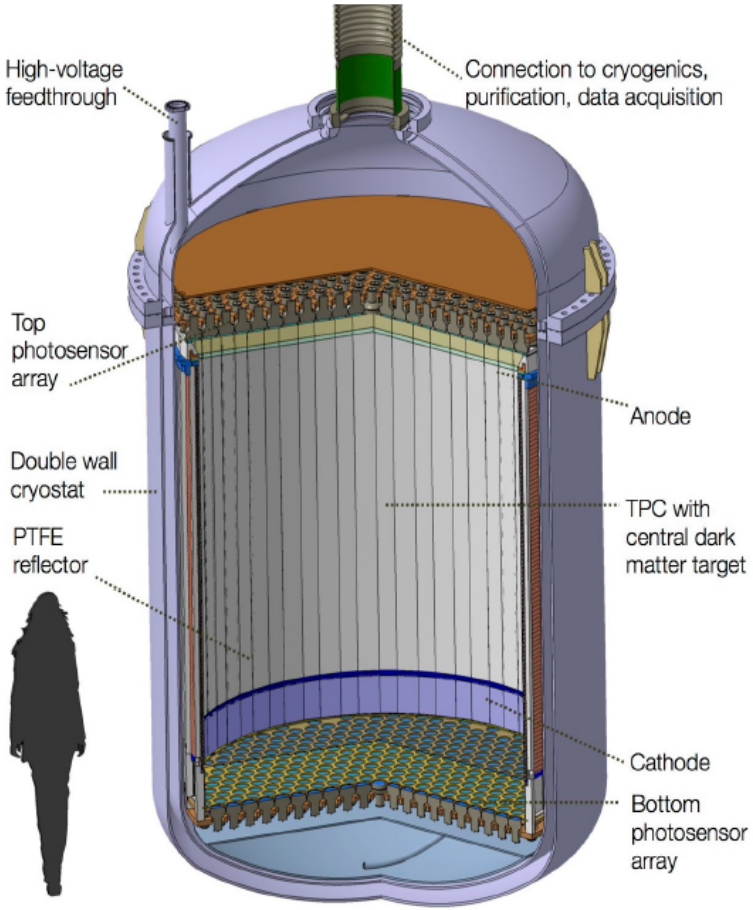
Science run expected
for end 2019/beginning 2020

ReStoX2 at LNGS (July 2018)

DARWIN, the next step in Europe

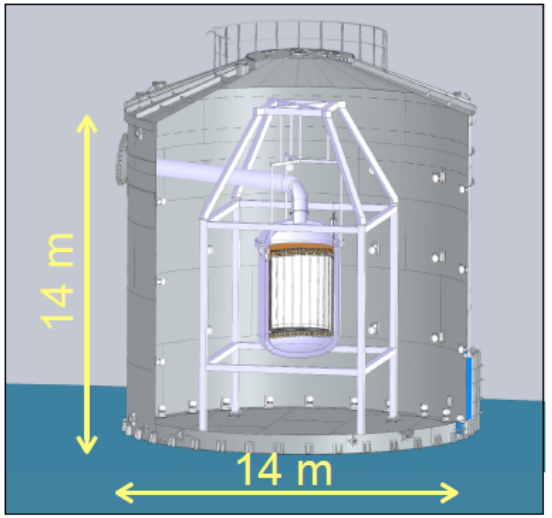


DARWIN, 40 tons of LXe to reach "neutrino floor"



the baseline design assumes PMTs but several alternative photosensors are under consideration

- Dual-phase Time Projection Chamber (TPC).
- 50 t total (**40 t active**) of liquid xenon (LXe).
- Dimensions: **2.6 m diameter and 2.6 m height.**
- Two arrays of photosensors (top and bottom).
- 1800 PMTs of 3" diameter (~1000 of 4").
- Drift field ~0.5 kV/cm.
- Low-background double-wall cryostat.
- PTFE reflector panels & copper shaping rings.
- Outer shield filled with water (14 m diameter).
- Inner liquid scintillator neutron veto.



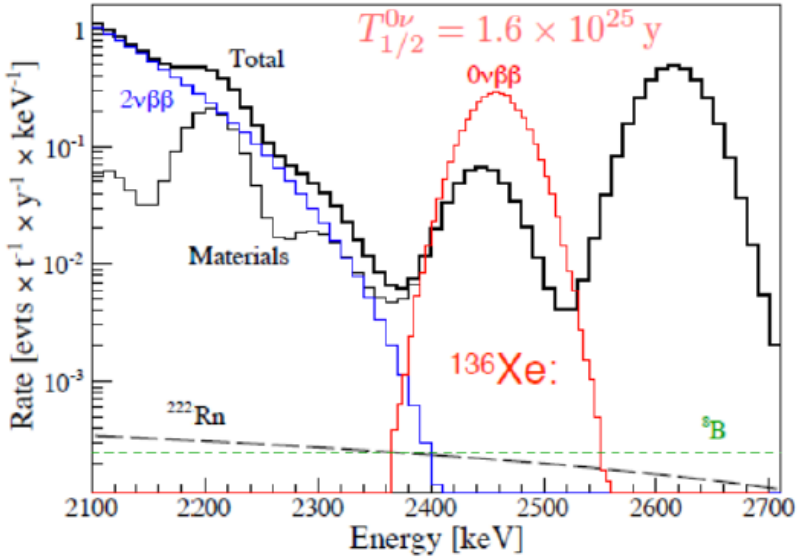
Possible realisation of DARWIN inside the water tank

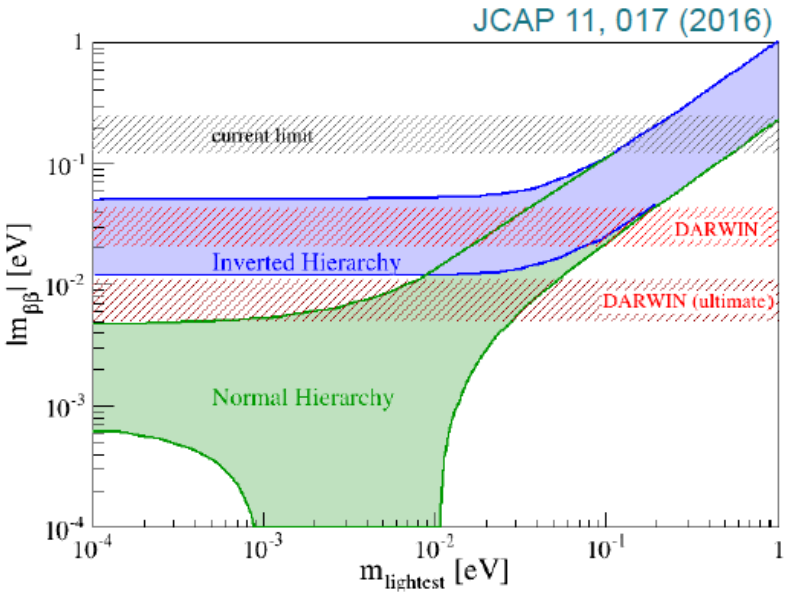
DARWIN, neutrinoless double Beta decay

Sensitivity @ 95% CL:

- 30 t*yr → $T_{1/2} > 5.6 \times 10^{26}$ yr
- 140 t*yr → $T_{1/2} > 8.5 \times 10^{27}$ yr

IMPORTANT: DARWIN might become a powerful, cost effective and time-wise competitive 0νββ experiment (no enrichment!)





Great opportunity in France with xenon production from fission

Isotopes	Période 1/2 vie	Composition Xe "air ambiant" (% massique)	Composition Xe "évents La Hague" (% massique)
Xe 124	**stable**	0,10%	
Xe 125	16,9 h		
Xe 126	**stable**	0,09%	
Xe 127	36,345 j		
Xe 128	**stable**	1,91%	0,06%
Xe 129	**stable**	26,40%	
Xe 130	**stable**	4,07%	0,17%
Xe 131	**stable**	21,23%	7,48%
Xe 131m	11,934 j		0,00%
Xe 132	**stable**	26,91%	20,99%
Xe 133	5,2475 j		0,00%
Xe 133m	2,19 j		0,00%
Xe 134	**stable**	10,44%	27,32%
Xe 135	9,14 h		0,00%
Xe 136	**$2{,}11.10^{21}$ a**	8,86%	43,98%

New project at La Hague led by French company Orano :

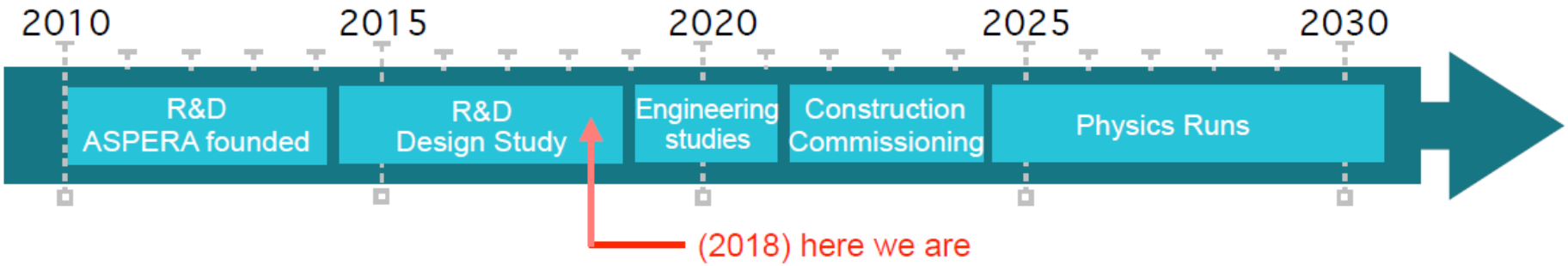
Extraction of the xenon from nuclear waste, Separation and production under prototyping

^{136}Xe abundance : ~ 44% ! (x5)
Several tons/year of expected production

Tricastin centrifuges could also be used for larger enrichment if needed

Could be in time for DARWIN

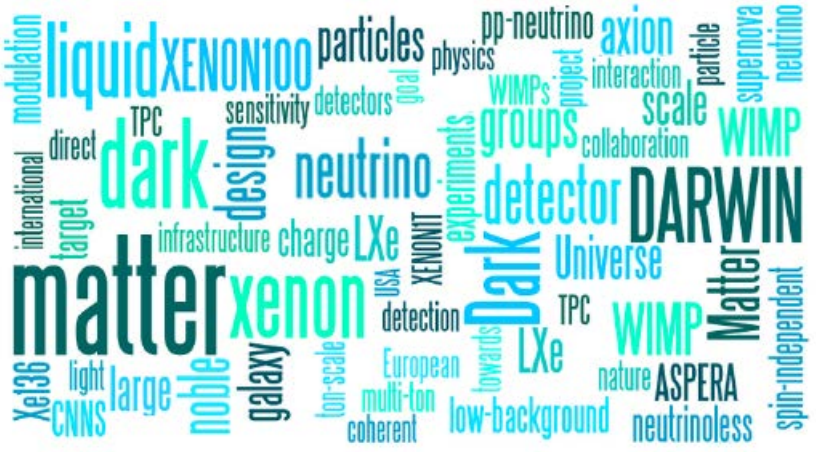
DARWIN-2β conclusions



28 groups from 11 countries
DARWIN is in the APPEC Roadmap
Working toward a CDR and a TDR

In France, R&D on:
- large LXe solution for recovering and storage
- mesh electrodes conception and design
- xenon from fission with Orano

DARWIN might be also considered for the official French Roadmap targeting 2β0ν search



www.darwin-observatory.org