DARWIN: towards a next-generation, multi-purpose LXe detector

Mariana Rajado Silva on behalf of the DARWIN collaboration

Universität Zürich[UZH]

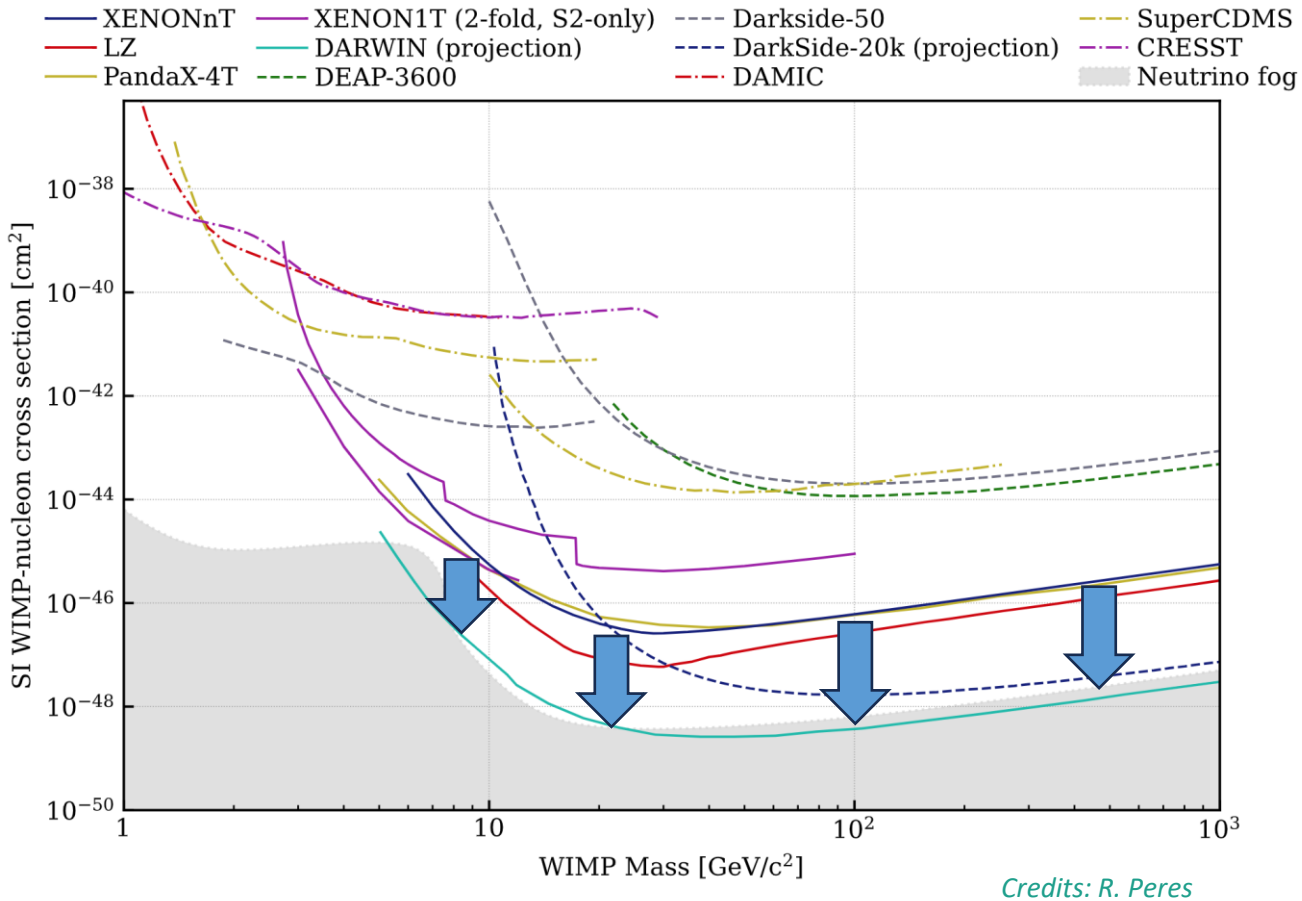
Joint Annual Meeting of SPS and ÖPG

Basel, 08.09.2023

erc European Research Council

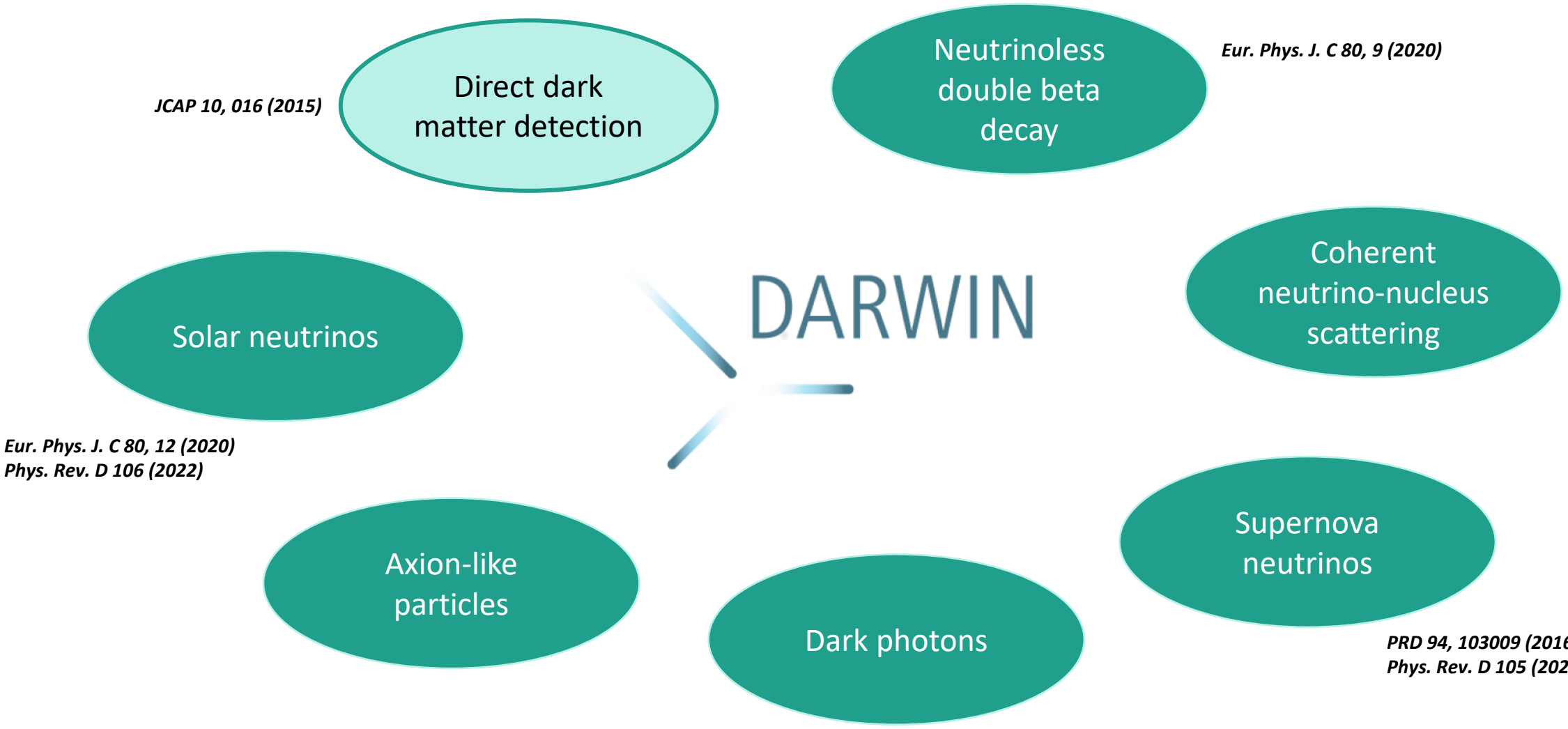
WIMP direct detection – current status

- Current experiments (XENONnT, LZ) about 1 order of magnitude away from irreducible neutrino fog
- DARWIN aims to close this gap - larger detector with lower background levels



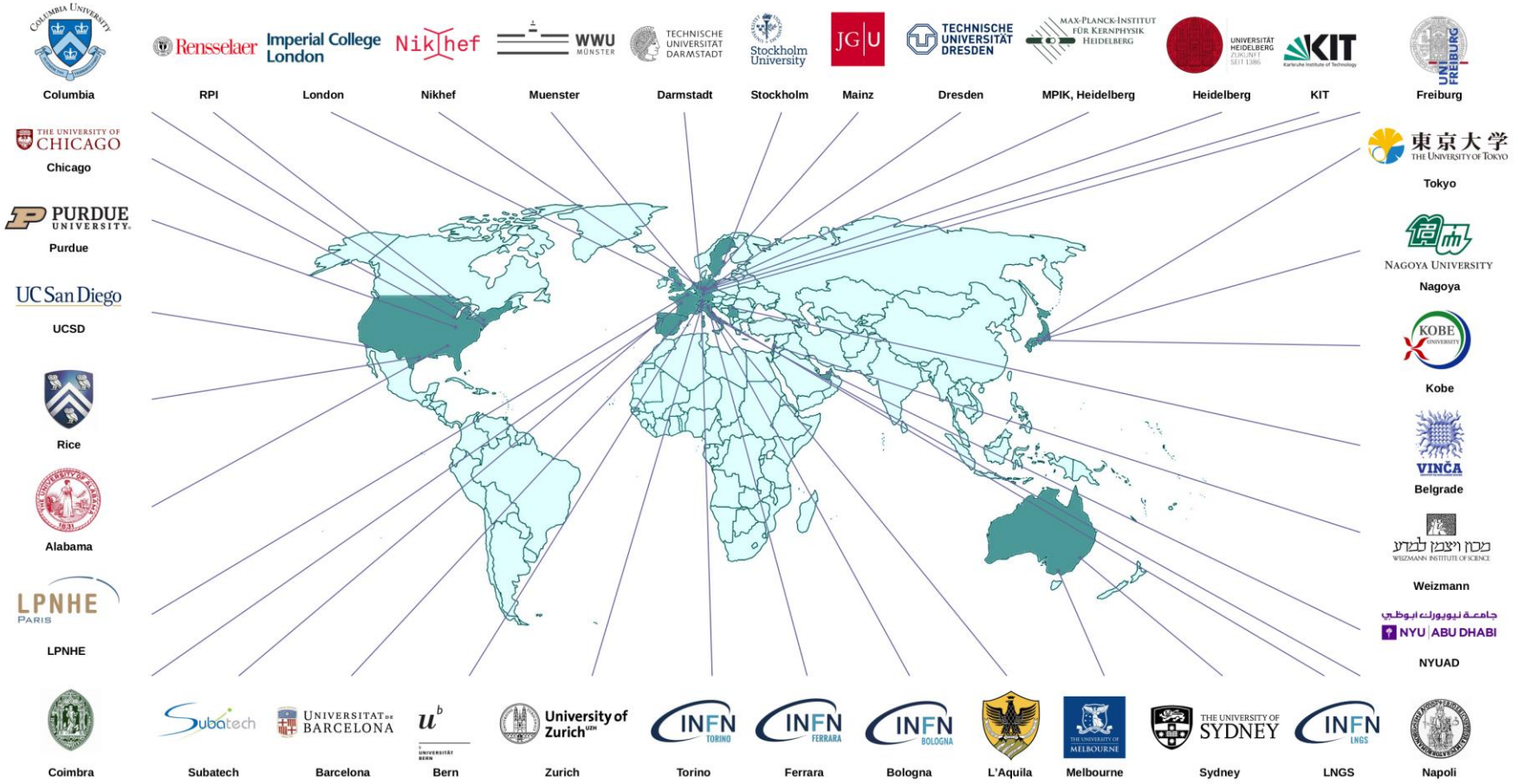
Credits: R. Peres

Science goals of DARWIN



The DARWIN collaboration

DARWIN Collaboration Meeting
Heidelberg, May 2023

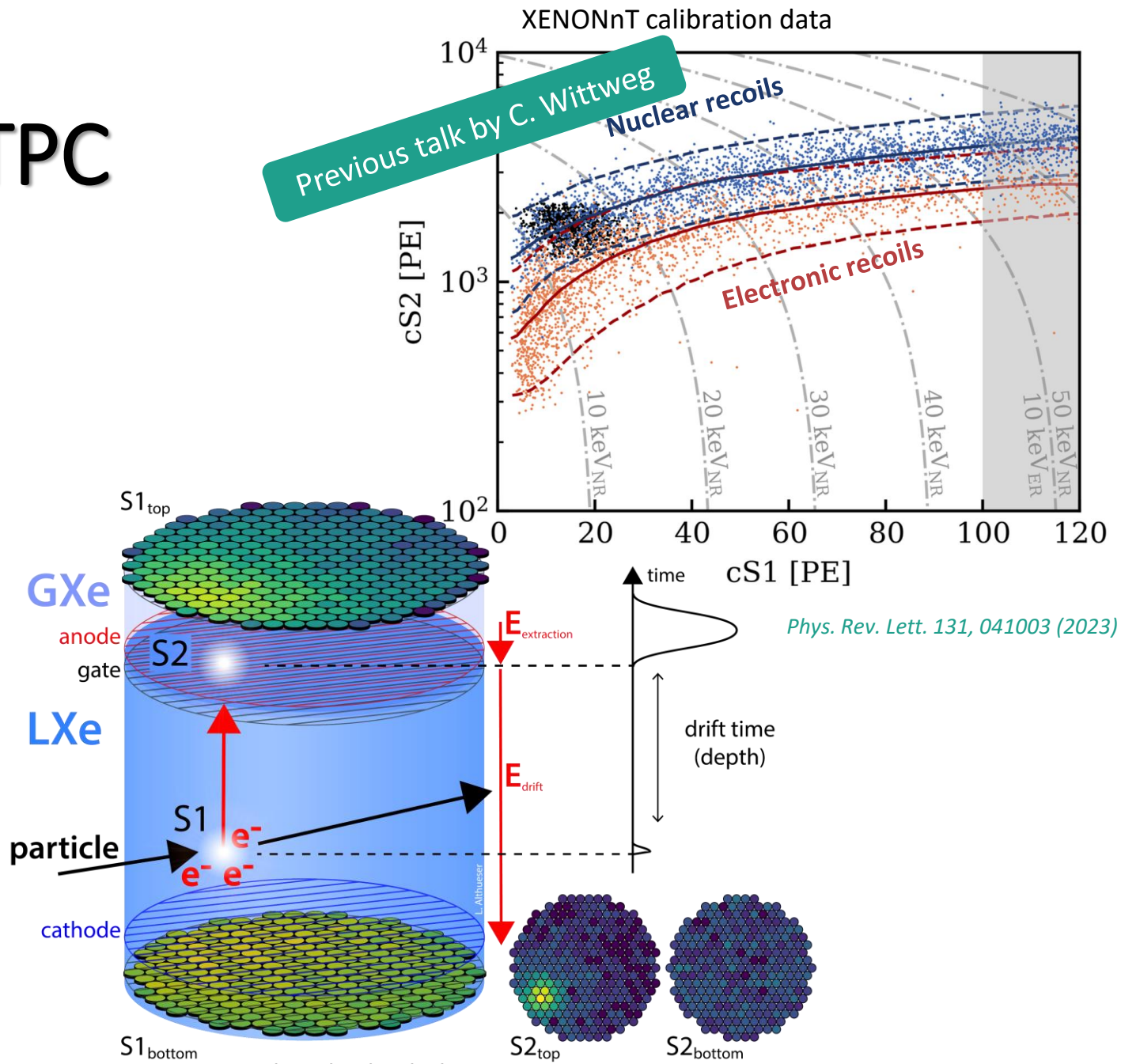


About 200 members from 38 institutions around the world

Xenon dual-phase TPC

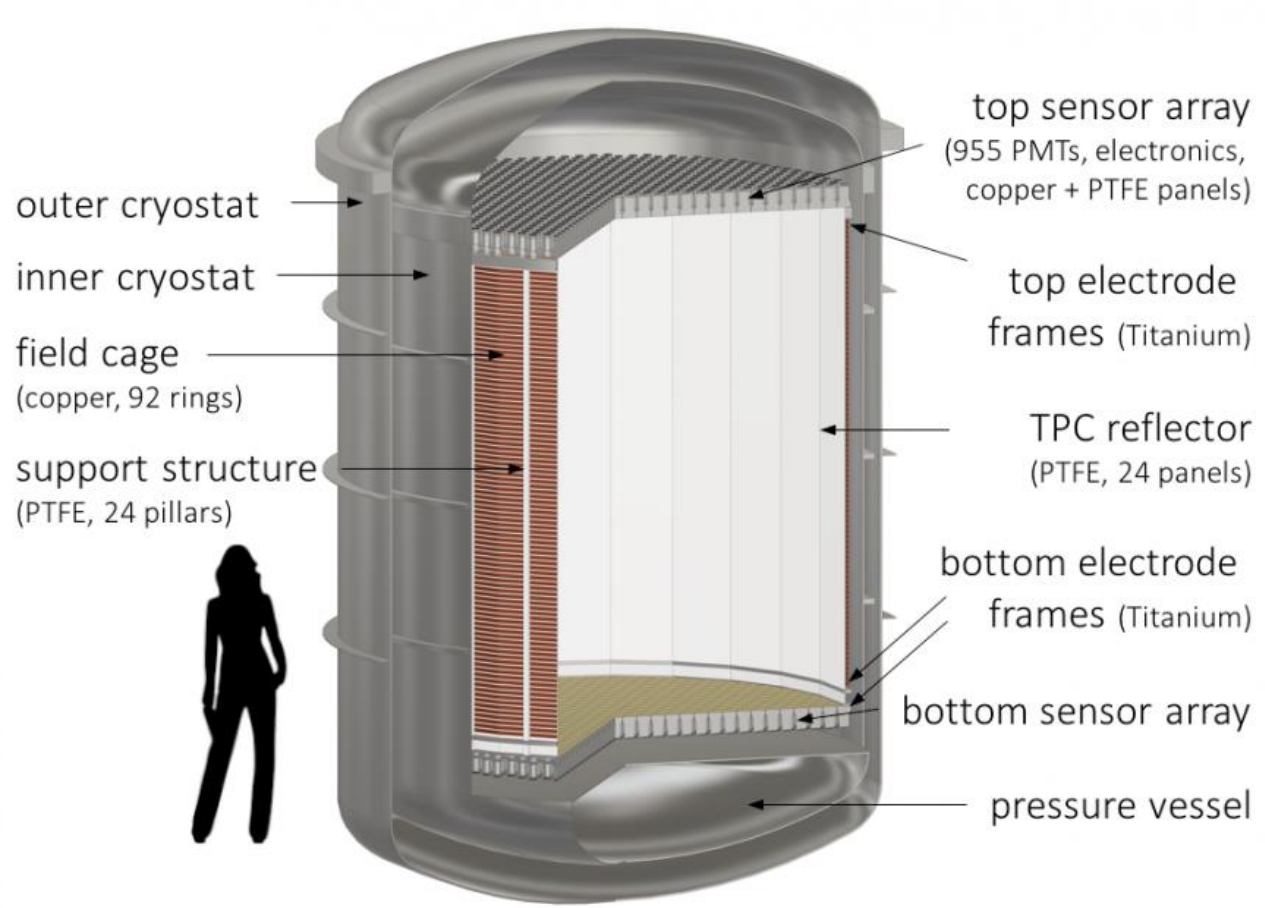
- Upon interaction in LXe:
  - Prompt light signal, **S1**
  - Delayed charge signal, **S2**

- Signals provide information on:
  - Energy of event
  - 3D position of event (**z** from time difference)
  - **ER**/**NR** signal discrimination



DARWIN TPC - baseline configuration

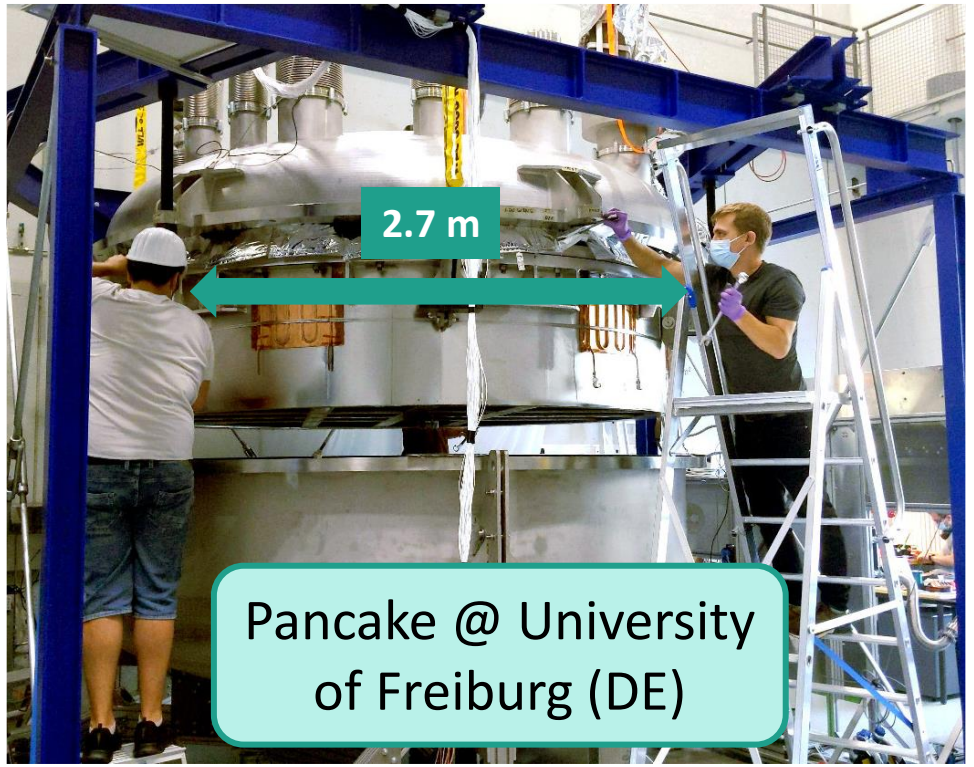
- **2.6 m** in diameter and **2.6 m** in height
- **50t** LXe target (40t active)
- **1,910** 3” PMTs organized in two arrays
- Muon and (Gd-doped) neutron vetoes
- Located at **Gran Sasso National Laboratory**, Italy
- Big detectors bring forth big challenges!



R&D – scalability

- Design and assembly of vertical and horizontal demonstrators

Electron drift



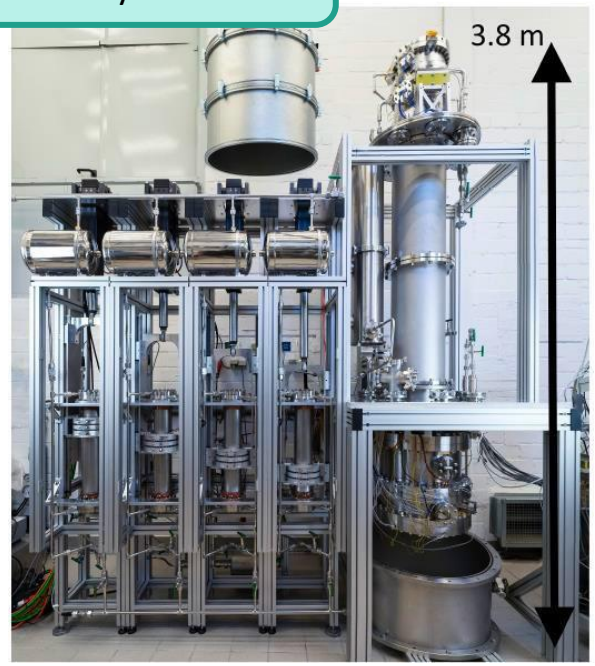
Electrode design and stability

JINST 16 P08052 (2021)

R&D – background reduction

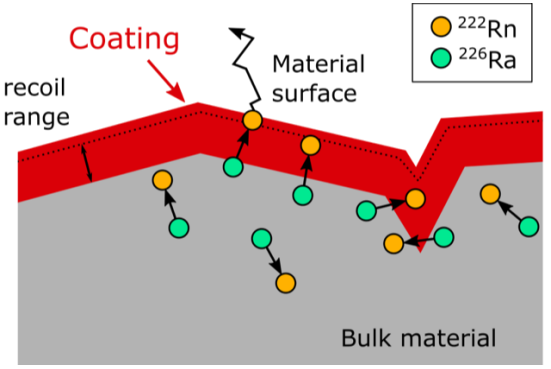
- Radon distillation column
  - Demonstrated in XENONnT
  - ^{222}Rn < 1 µBq/kg
  - ^{85}Kr < ppt
- Surface coating to avoid ^{222}Rn emanation
- Material screening and selection
- Hermetic TPC – separate LXe volumes to prevent impurity diffusion to inner one

Developed at University of Münster

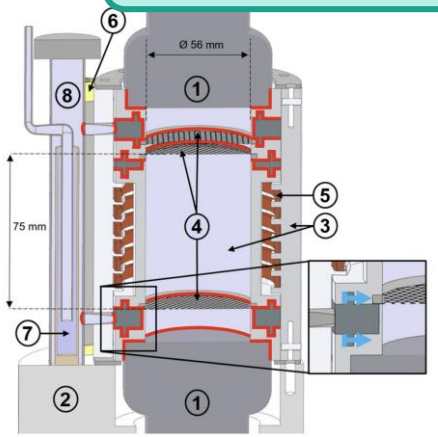


Eur. Phys. J. C 82, 1104 (2022)

Developed at MPIK Heidelberg



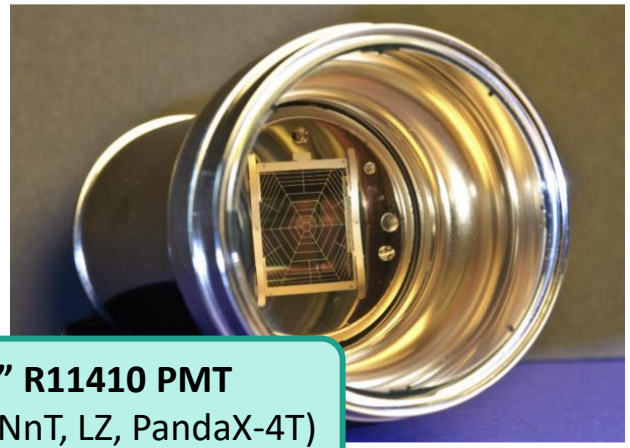
Developed at University of Freiburg (DE)



Phys. J. C 83, 9 (2023)

R&D – photosensors

JINST 16 P08033 (2021)



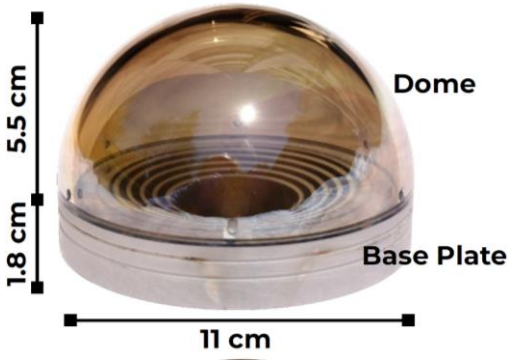
3” R11410 PMT
(XENONnT, LZ, PandaX-4T)

3” R13111 PMT
(XMASS)

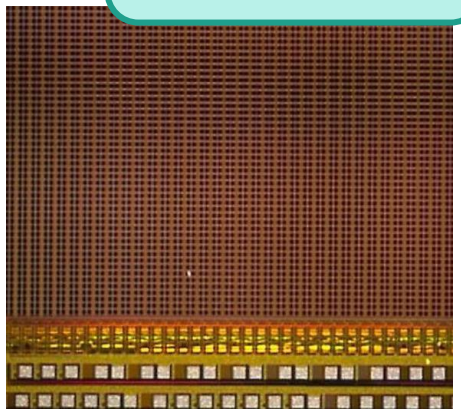
FBK VUV-HD Cryo SiPM
Characterization @
University of Zurich

JINST 17 C01038 (2022)

Abalone (HV dome with SiPM in base plate)
R&D @ Universities of Stockholm & L’Aquila

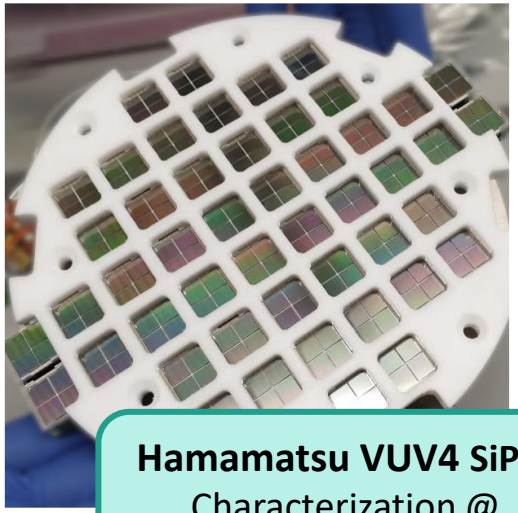


Digital SiPM
R&D @ University of Heidelberg



Talk by M. Adrover (Sep 6th)

2’’ R12699 PMT
Characterization @
University of Zurich

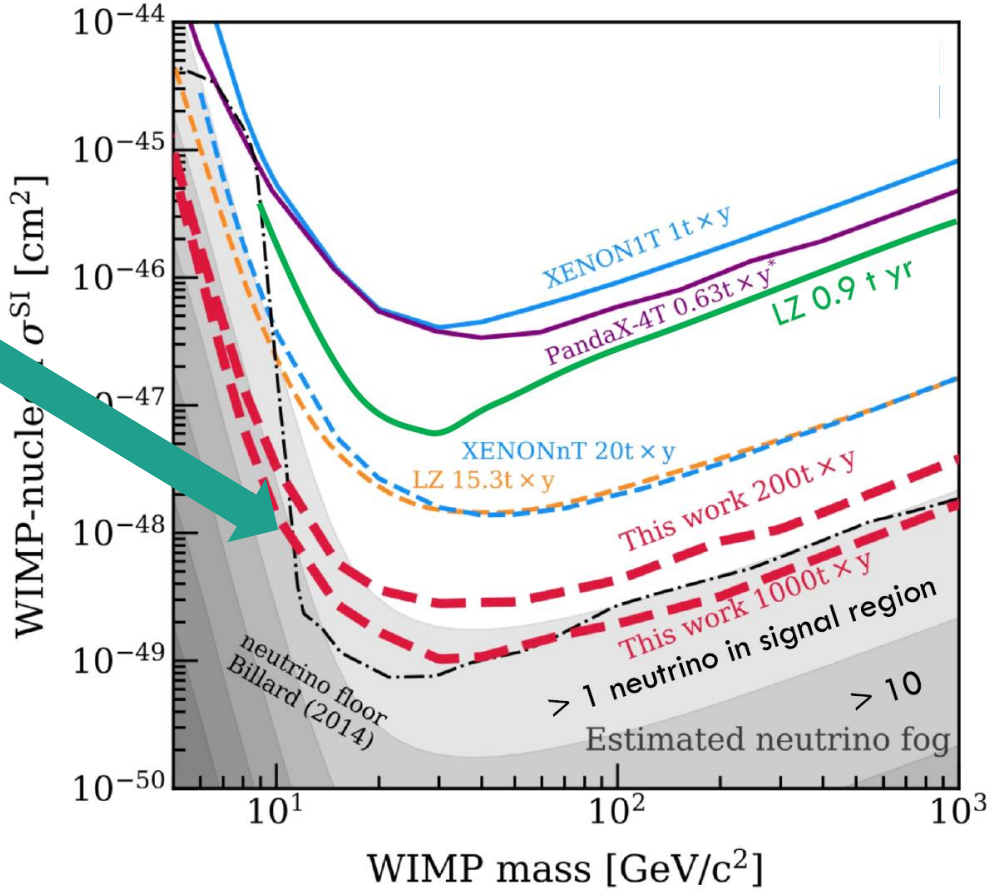


JINST 18 C03027 (2023)

Hamamatsu VUV4 SiPM
Characterization @
University of Zurich

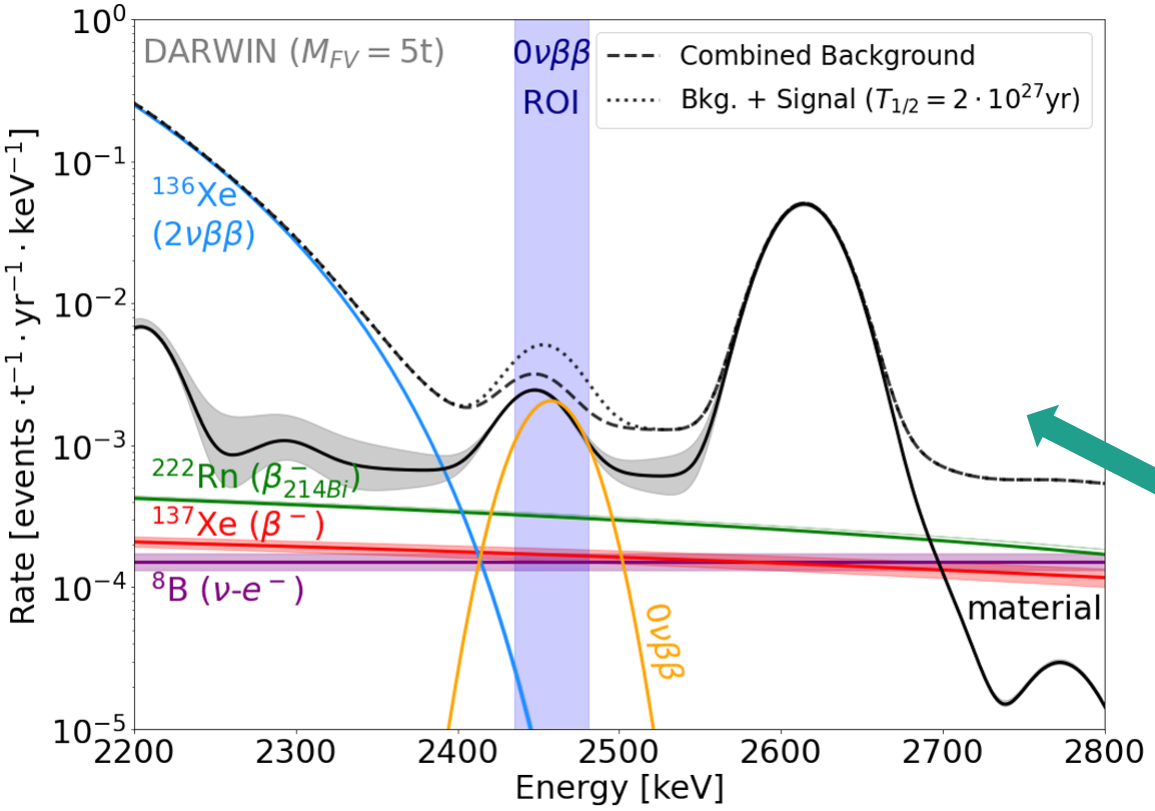
WIMP dark matter

- Probing WIMP cross-sections into the neutrino fog
- Projected limits dashed and current limits solid
- 200 tonne-year exposure probes cross--sections down to **$3x10^{-49}$ cm^2** and is sensitive to solar neutrinos



J. Phys. G: Nucl. Part. Phys. 50, 013001 (2023)

Neutrinoless double beta decay

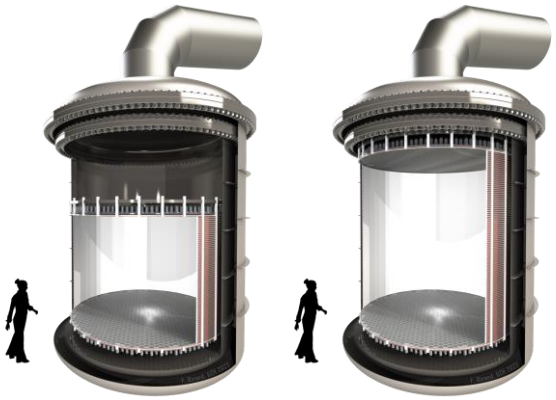


- Half-life sensitivity limit of **2.4×10^{27} years** for 10 years of exposure with 5t fiducial mass
- Predicted background spectrum around the 0νββ ROI for 5t

Eur. Phys. J. C 80, 808 (2020)

The XLZD consortium

- Collaborative effort from **XENON**, **LUX-ZEPLIN** and **DARWIN** to build the ultimate dark matter detector
- MoU signed July 6th, 2021
- 104 research groups from 16 countries
- Community whitepaper: *J. Phys. G: Nucl. Part. Phys.* 50 013001 (2023)



40 t or 60 t

XLZD Meeting
UCLA, April 2023

Summary and outlook

- The DARWIN collaboration aims at building a **multi-purpose, highly sensitive LXe detector**
- The detector would be limited by the irreducible neutrino fog (plus instrumental backgrounds)
- Larger scale brings many challenges, addressed by **R&D projects in multiple universities**
- The **XLZD consortium** wants to build the ultimate dark matter detector!

Thank you!

Questions?