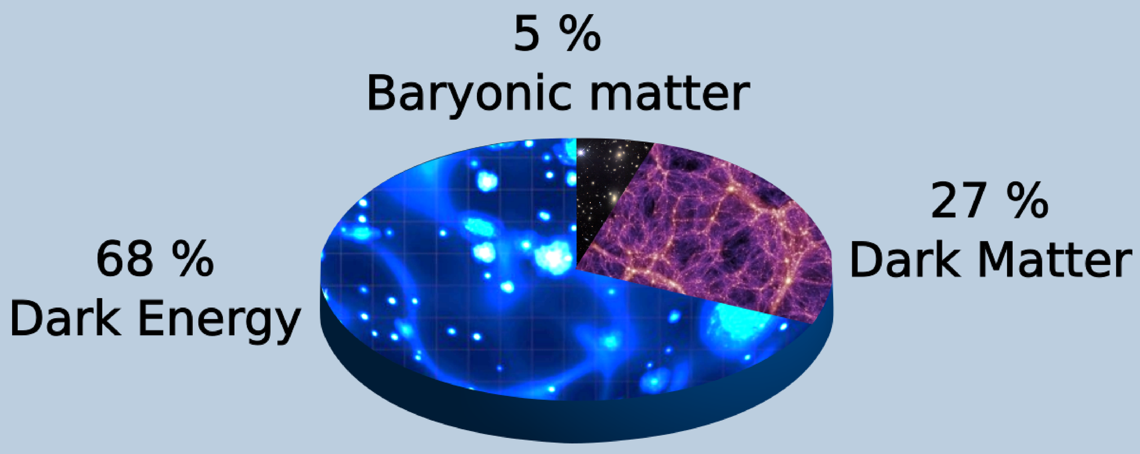
Low-background techniques for neutrino physics searches with DARWIN

G. Eurin, M. Lindner, T. Marrodán Undagoitia, H. Simgen
for the DARWIN collaboration, eurin@mpi-hd.mpg.de

DARWIN
Max-Planck-Institut für Kernphysik Heidelberg

Introduction



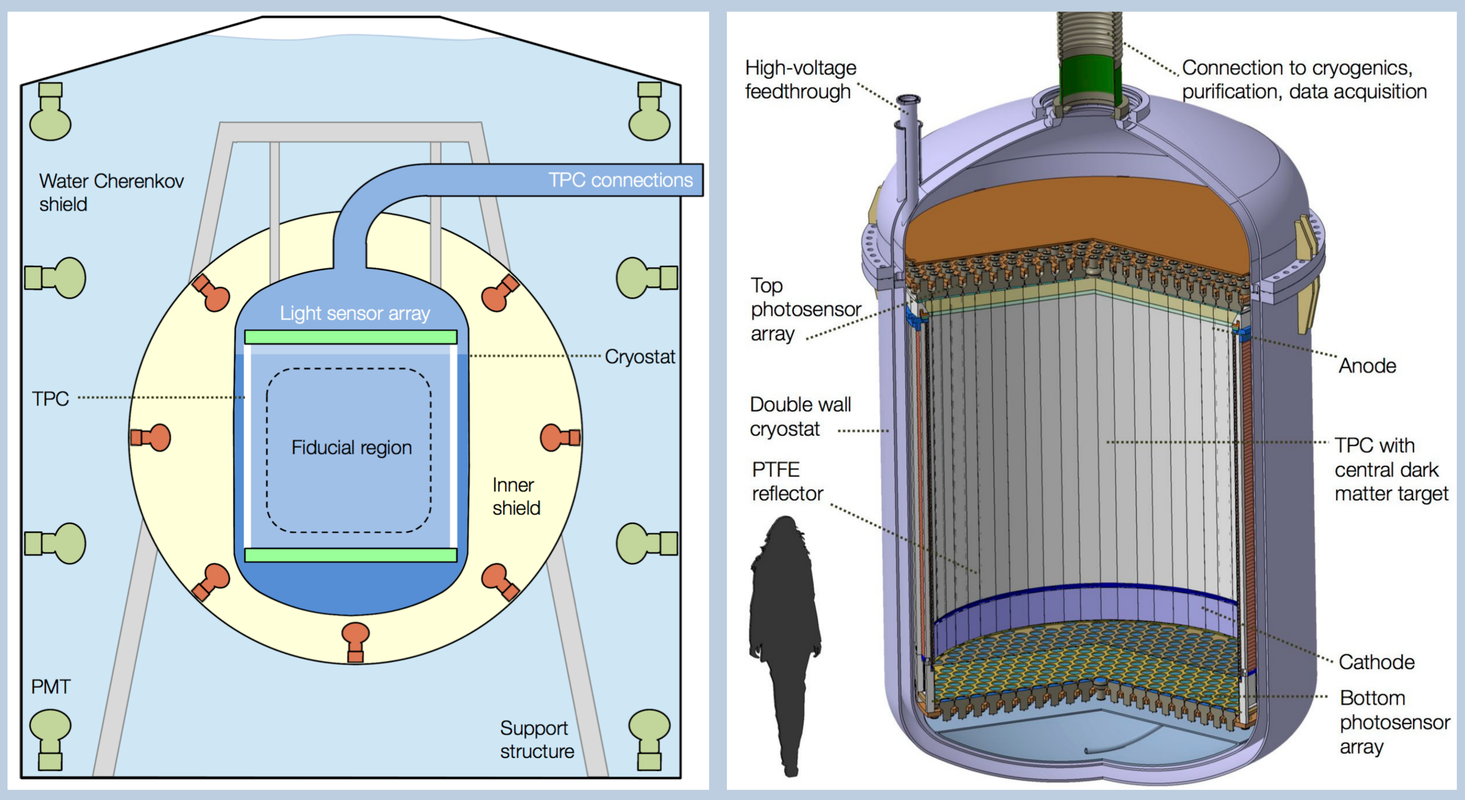
Composition of the Universe from Planck [1]

Existence of Dark Matter:
Strong indication for BSM physics

Direct Dark Matter detection:
Current major experimental challenge

LXe dual-phase *Time Projection Chamber*:
One of the most promising techniques

The DARWIN experiment [2]

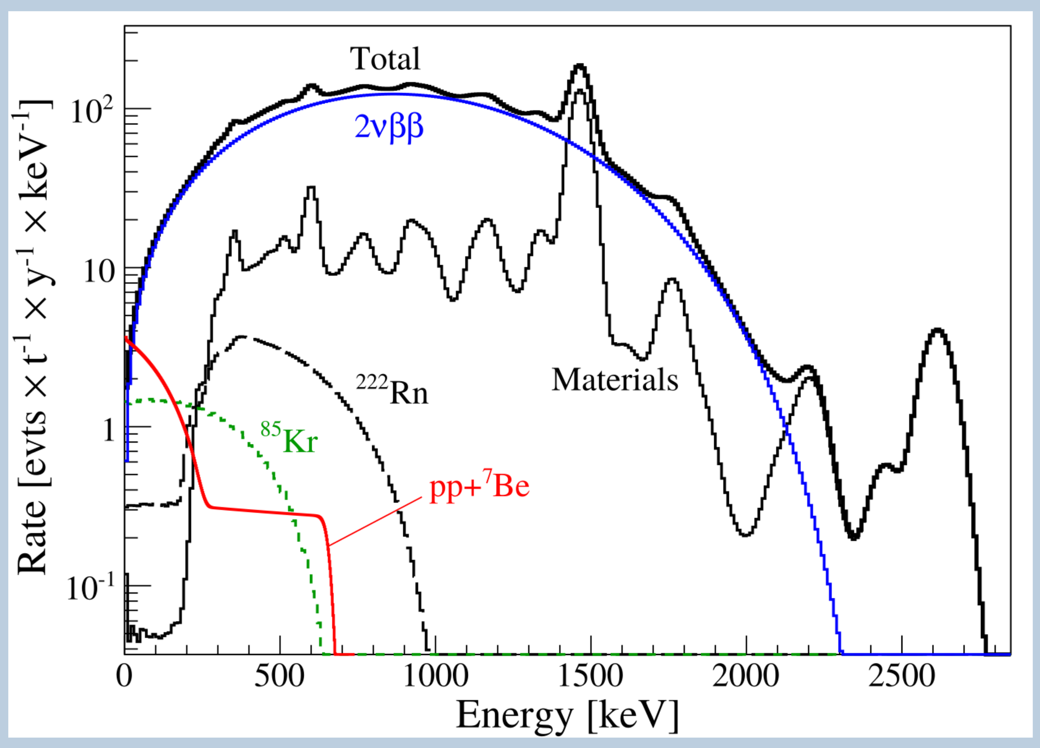


Scheme of the DARWIN detector

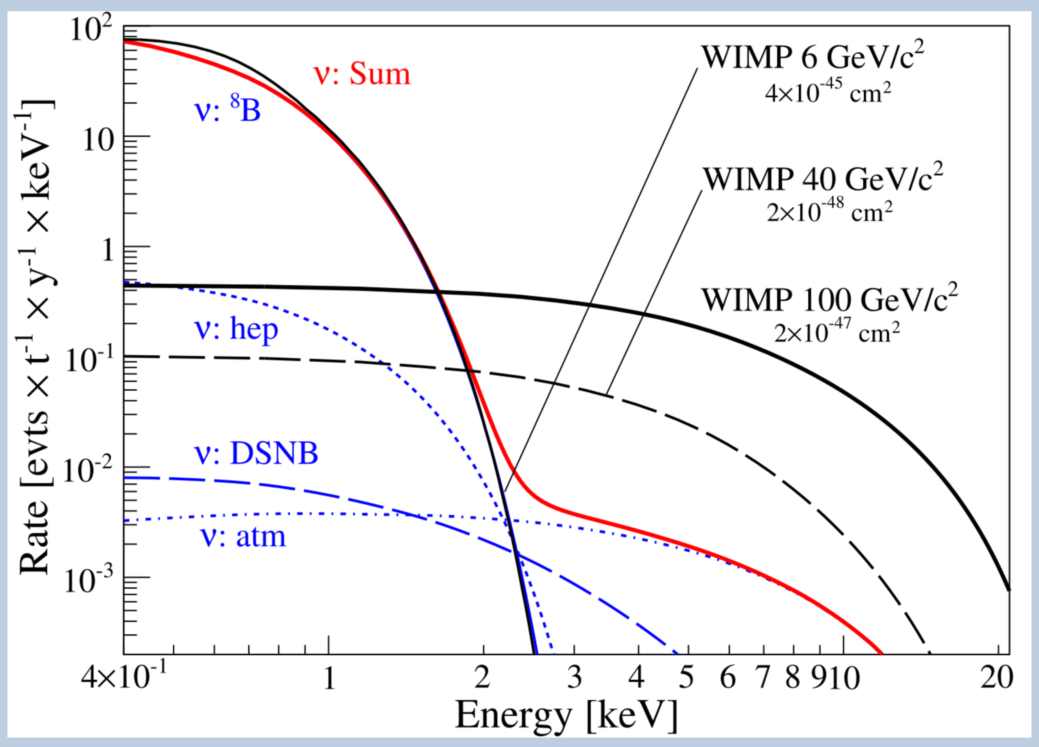
DARWIN collaboration: **27 institutes**

- TPC dimensions: **2.6m x 2.6m**
- **50t LXe** (total), **40t LXe** (TPC)
- Exposure target: **200 t×yr**
- Key components: **PMTs or SiPMs, low-background cryostat, PTFE reflector pannels, copper field-shaping rings**
- External background reduction: **Water Cherenkov shield**, liquid scintillator **neutron veto, underground installation** (possibly LNGS)

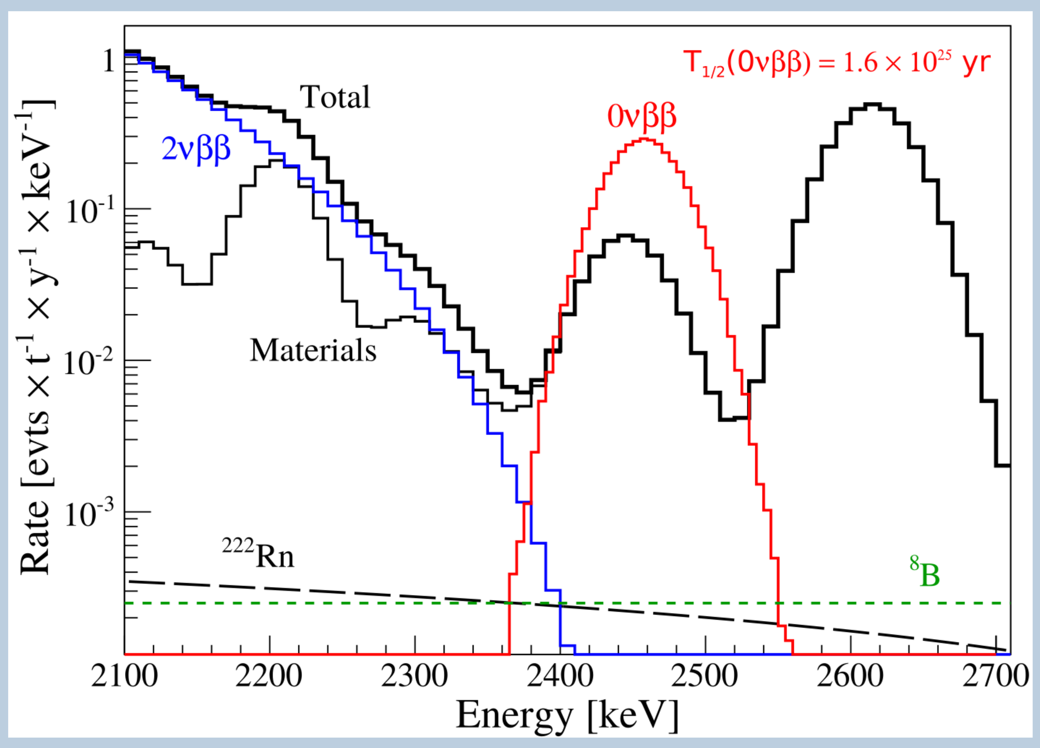
Possible background and neutrino signals in DARWIN [3]



Predicted background spectrum from detector materials and internal contamination.



Nuclear recoil spectrum for CNNS from $\nu_{\odot}$, diffuse supernova background and ν_{atm}.

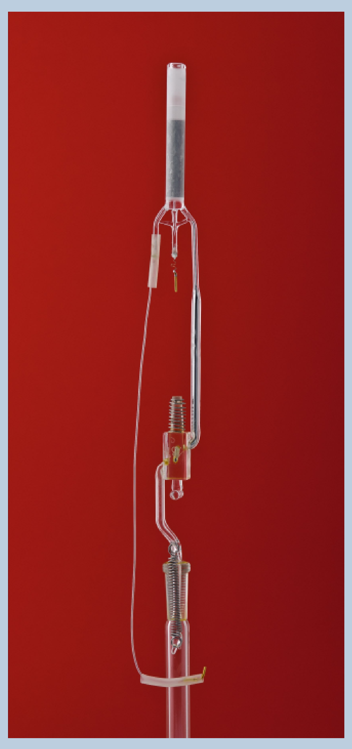


Predicted spectrum zoomed in the ROI for $0\nu\beta\beta$ of ^{136}Xe for 6t fiducial mass.

	^{222}Rn	Materials	$2\nu\beta\beta$	^{85}Kr
Background sources:				
Strategy:	Prior emanation measurement, cryogenics distillation & surface treatment	Prior material selection by screening, fiducialization at analysis level	Irreducible for $0\nu\beta\beta$ searches	Remote monitoring, cryogenics distillation

Radon emanation principle

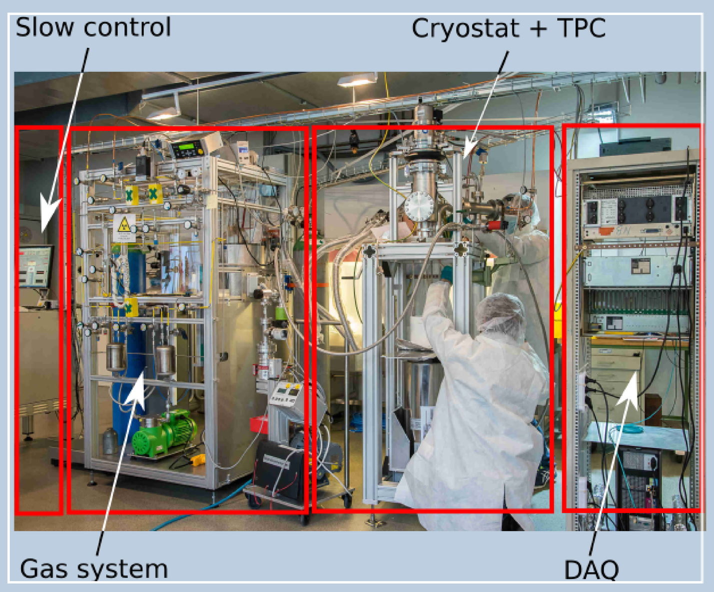
- Sample in vessel **until equilibrium**
- **AutoEma**: automatized and reproducible extraction from vessel ⇒ High throughput
- Filling in highly sensitive (20 μBq) α-decay detector: **proportional counter**
- Results stored in **GeRn database @ MPIK**

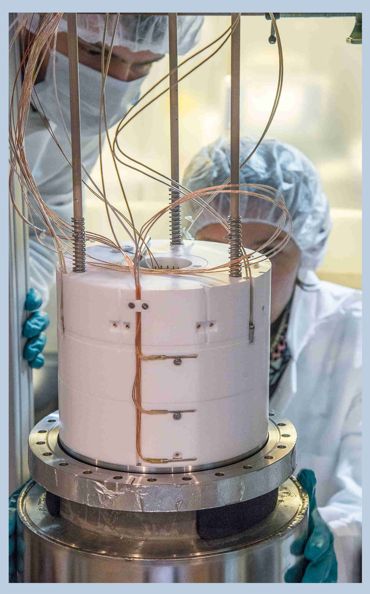



AutoEma and a proportional counter

Surface treatment R&D

- **Surface cleaning for material in LXe**
- Sources of impurities: **residues from construction, ^{222}Rn daughters, dust, etc.**
- Investigated strategies:
  - Metal coating of the surface
  - Strong acids chemical treatment
  - Subsequent surface protection
- Proof of treatment compatibility with LXe TPC operation:





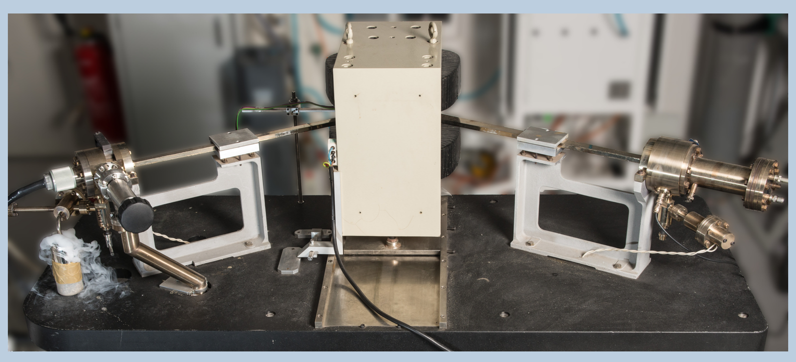
HeXe TPC @ MPIK

γ-spectrometry

- **High Purity Germanium** γ-spectrometers
- **Non-destructive method** for solid samples
- Material screened and selected according to their **radio-purity**
- Several HPGe's available in the collaboration: **GIOVE @MPIK [5], GeMPI&GATOR @LNGS, GeMSE @Uni. Freiburg**

The GIOVE HPGe detector

^{85}Kr measurements



Mass spectrometer of the RGMS

- Krypton: intrinsic background source
- Contamination in LXe monitored with a **Rare-Gas Mass Spectrometer** [4]
- Sensitivity of **8 ppq** and contamination at **sub-ppt levels** measured

References

[1] Planck collaboration, P. A. R. Ade et al. *Astron. Astrophys.*, 571, 2014.

[2] J. Aalbers et al. *JCAP*, 1611:017, 2016.

[3] L. Baudis et al. *JCAP*, 1401:0444, 2014.

[4] S. Lindemann and H. Simgen *EPJ C*, 74, 2014.

[5] G. Heusser et al. *EPJ C*, 75, 2015.