New technologies for future direct detection LXe TPCs

Adam Brown, Robin Glade-Beucke, Jaron Grigat, Sebastian Lindemann, Tiffany Luce, Julia Müller, Marc Schumann, Florian Tönnies
Physikalisches Institut, Universität Freiburg, 79104 Freiburg, Germany

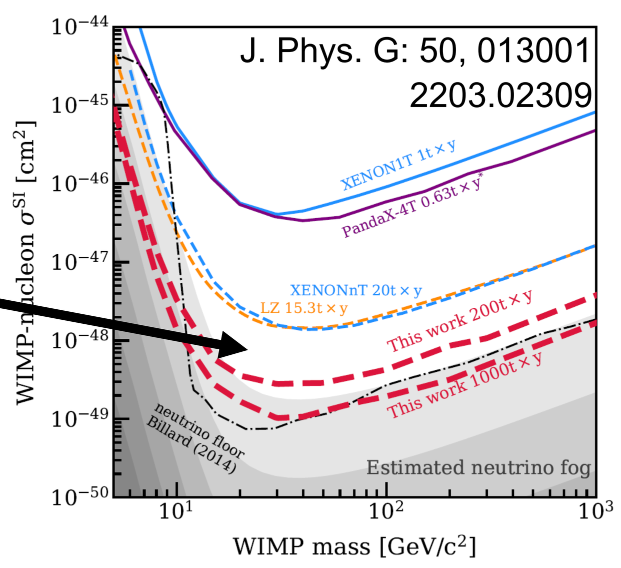
Introduction

Liquid xenon experiments set most stringent limits on WIMPs

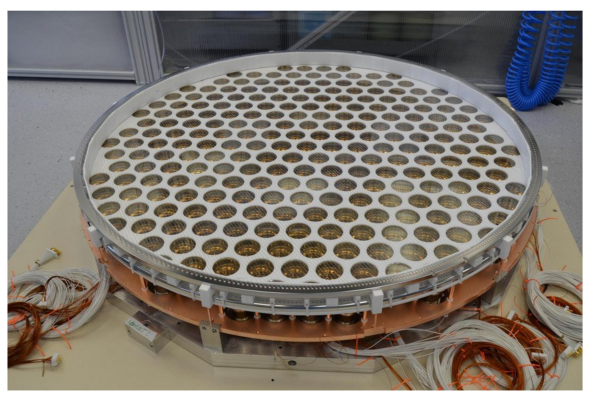
But plenty of room to explore before neutrino floor

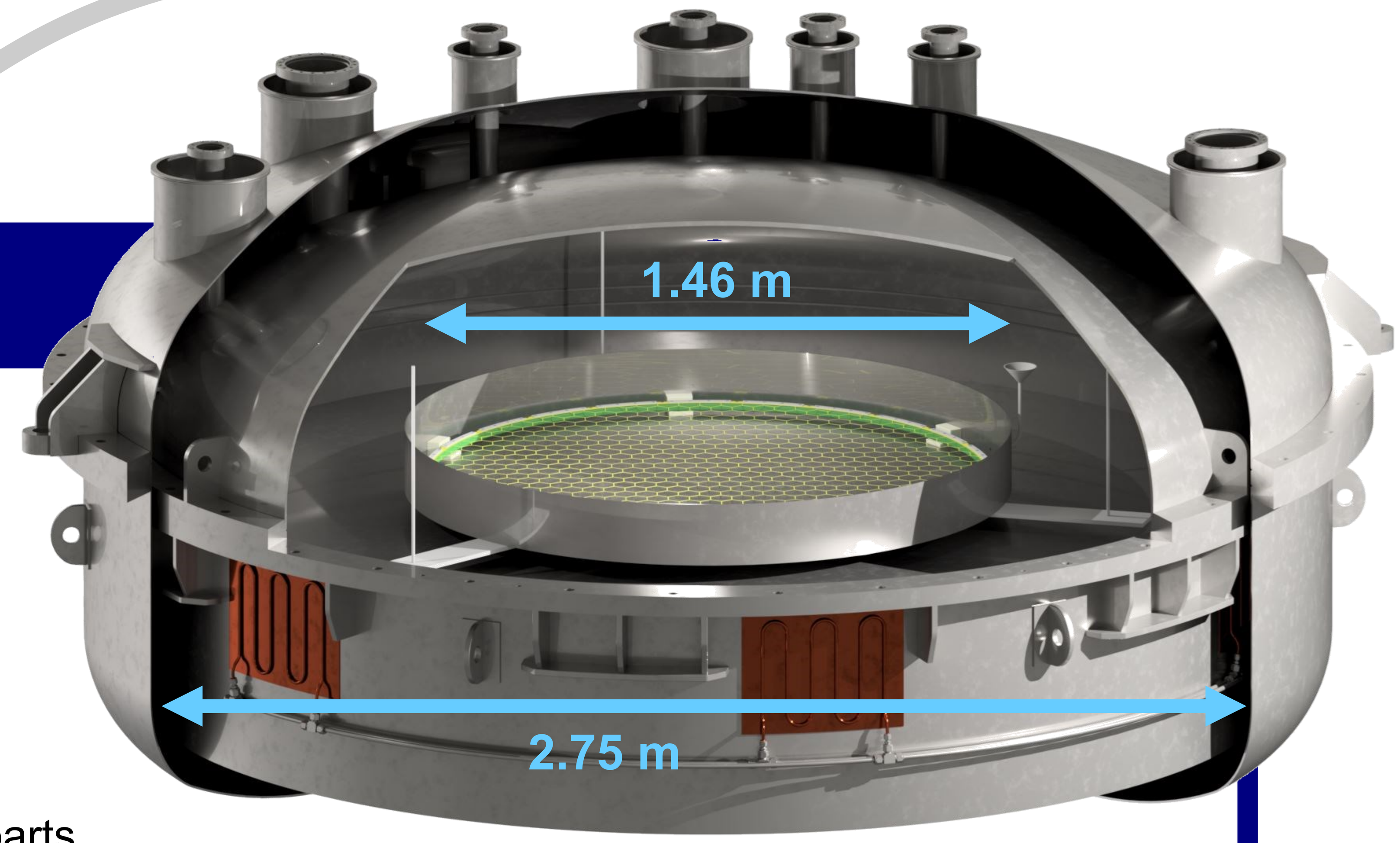
To get there need to:

- **Expand** to collect more exposure
- **Clean** to get reduce backgrounds



- Background requirements mean detector components must be lightweight and use clean materials
- Poses significant engineering challenge
- Parts need testing before use in TPC
- Examples are PMT arrays and electrodes

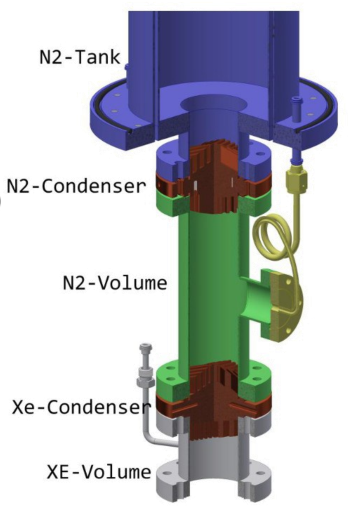




Expanding: Pancake large-diameter test platform

2.75 m vacuum-insulated cryostat for R&D on DARWIN-diameter components

- Cooled by liquid nitrogen
- Power to Xe cold finger adjustable (thermosyphon)
- Additional direct cooling using copper pads
  2 weeks to cool 3 t steel



Webcam image inside Pancake

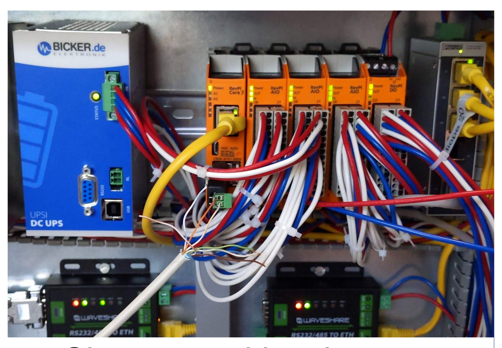
- **Webcams** allow visual inspection of parts being tested e.g. to look for sparks
- Standard USB webcams with heating pads
- Internal LED illumination

Bathtub concept:

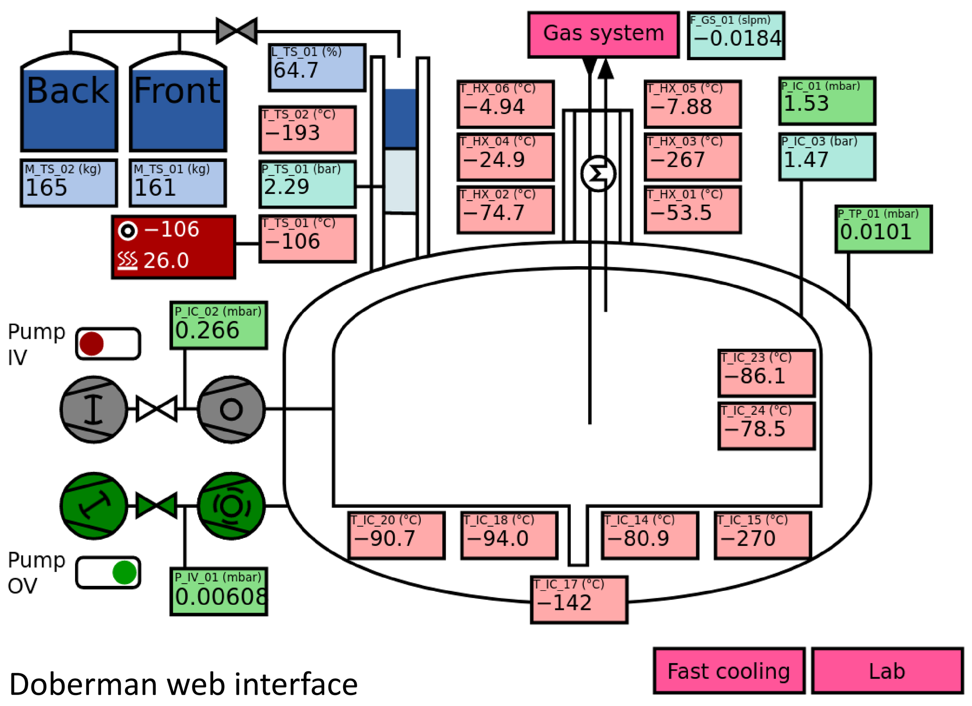
- 1.46 m open vessel with flat floor in inner cryostat
- Test "smaller" (still larger) components with less xenon or greater liquid depth

Slow control:

- Python-based
- Runs on industry-grade Revolution Pi
- Simple graphical interface on web



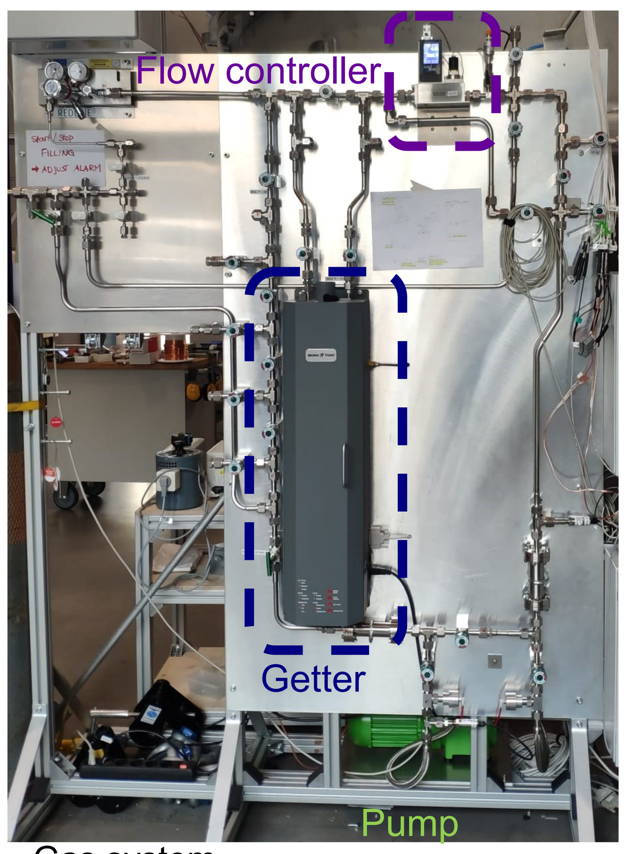
Slow control hardware



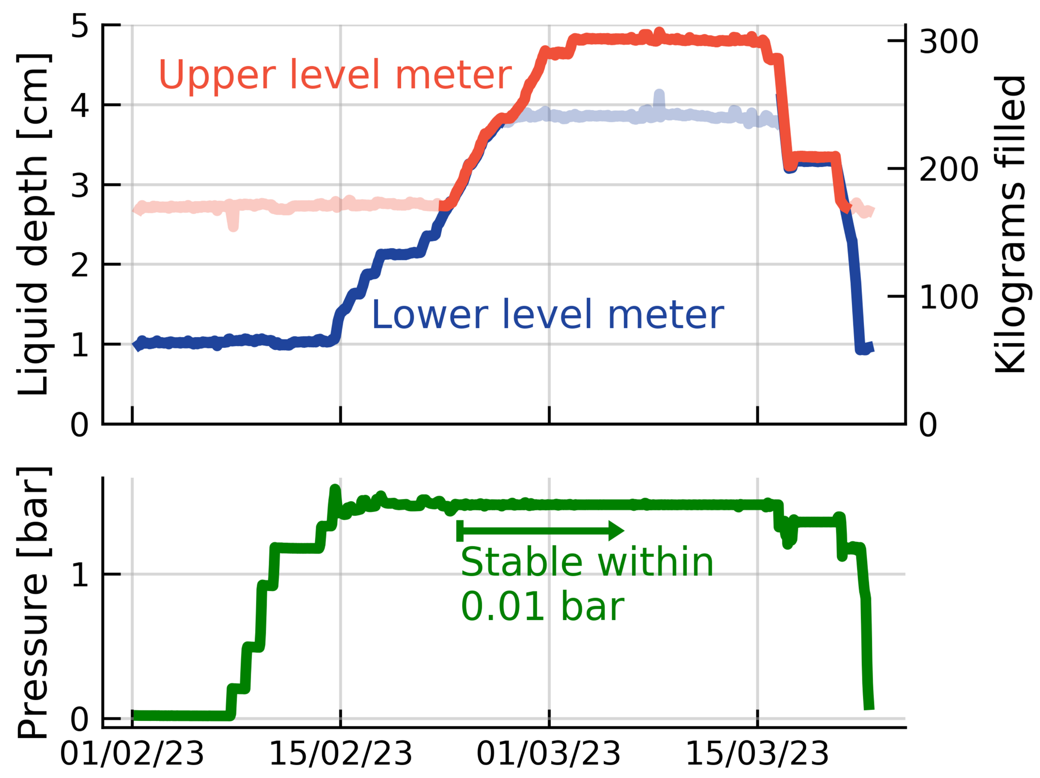
Doberman web interface

Gas system for filling, cleaning with high temperature gas purifier, and recuperation of xenon into bottles

Fully built from 1/2" VCR components



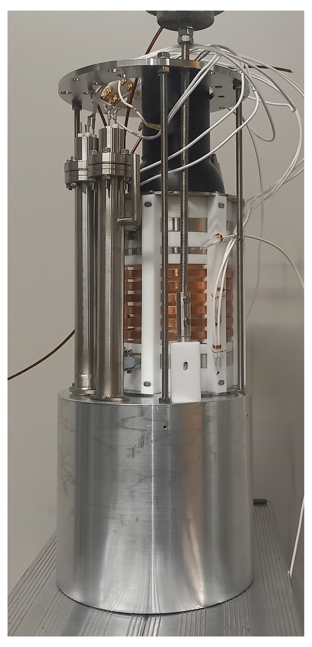
Gas system



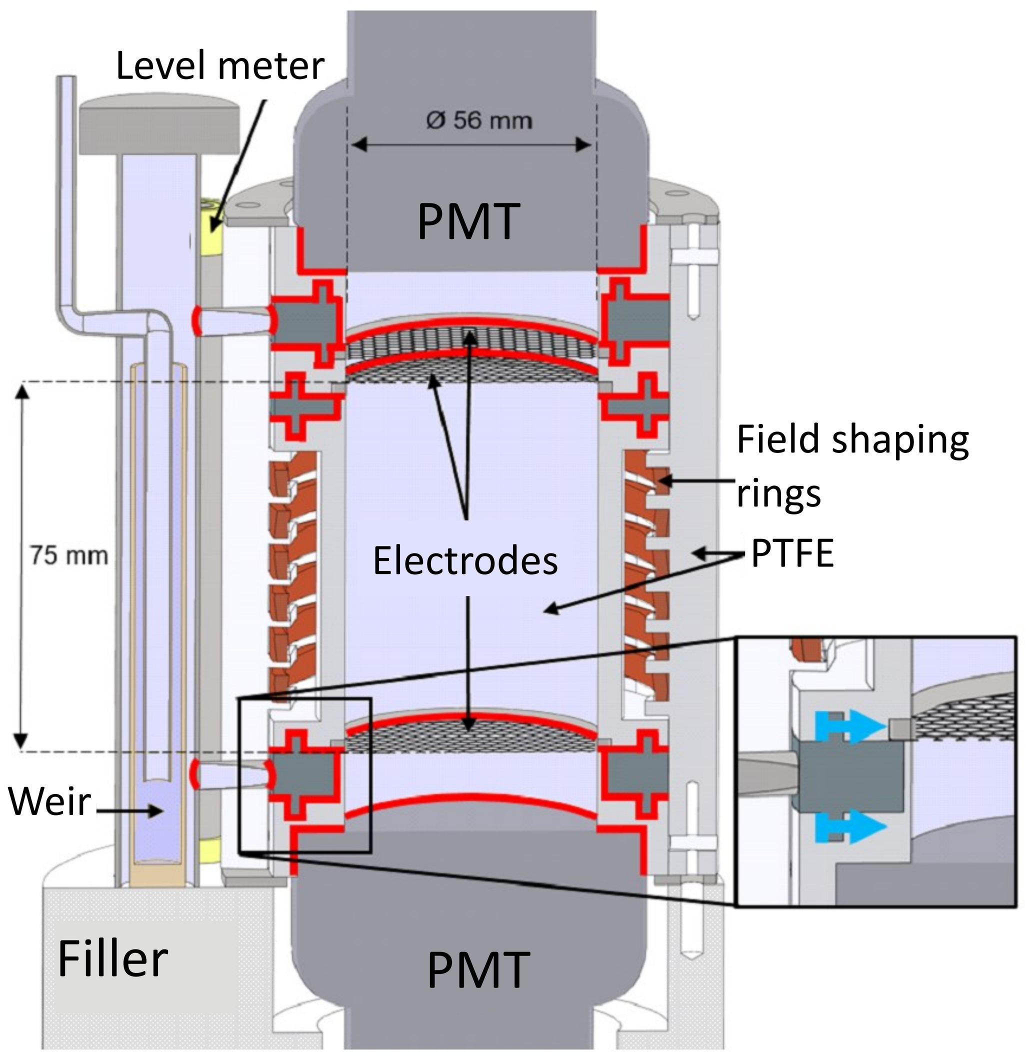
- Recent commissioning run with 300 kg Xe
- Demonstrated excellent stability

Cleaning: Hermetic TPC

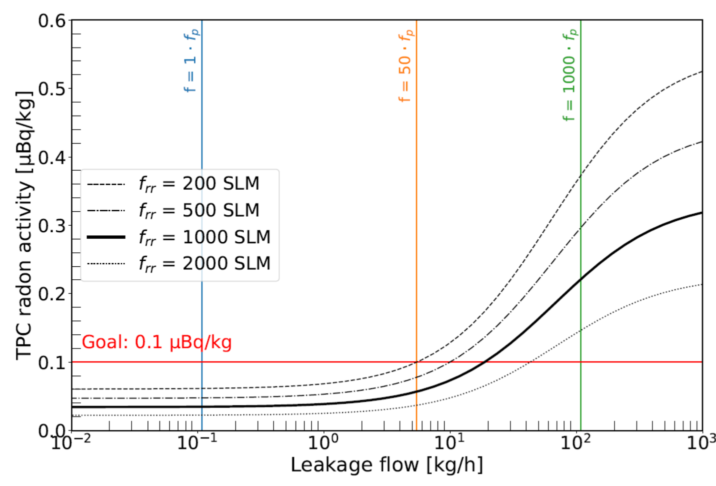
- The dominant background in existing xenon TPCs is ^{222}Rn
- Continuously emanated from all surfaces in detectors
- New technology needed to reduce from currently-achieved levels around 1 uBq/kg to the 0.1 uBq/kg DARWIN goal



- Since most surface area is outside TPC, one approach is sealing sensitive region → A "hermetic" TPC
- Prototype detector sealed by cryofitting
- At sealing points, PTFE parts seal around stainless steel when cold
- Independent gas systems in- and outside



- Leakage 0.11 ± 0.01 kg/h from decay time of injected ^{83m}Kr source
- Depending on assumptions about scaling (constant, with diameter, with area), significant reduction in activity



- **Promising concept** to reduce ^{222}Rn even if hermeticity is imperfect

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adam.brown@physik.uni-freiburg.de

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DFG Deutsche Forschungsgemeinschaft German Research Foundation