Charge detection via proportional scintillation in a single-phase liquid xenon TPC

Florian Tönnies, Fabian Kuger, Adam Brown
florian.toennies@physik.uni-freiburg.de

Albert-Ludwigs-Universität Freiburg

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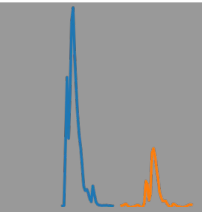

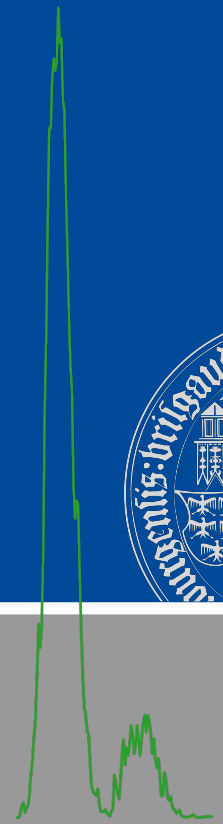

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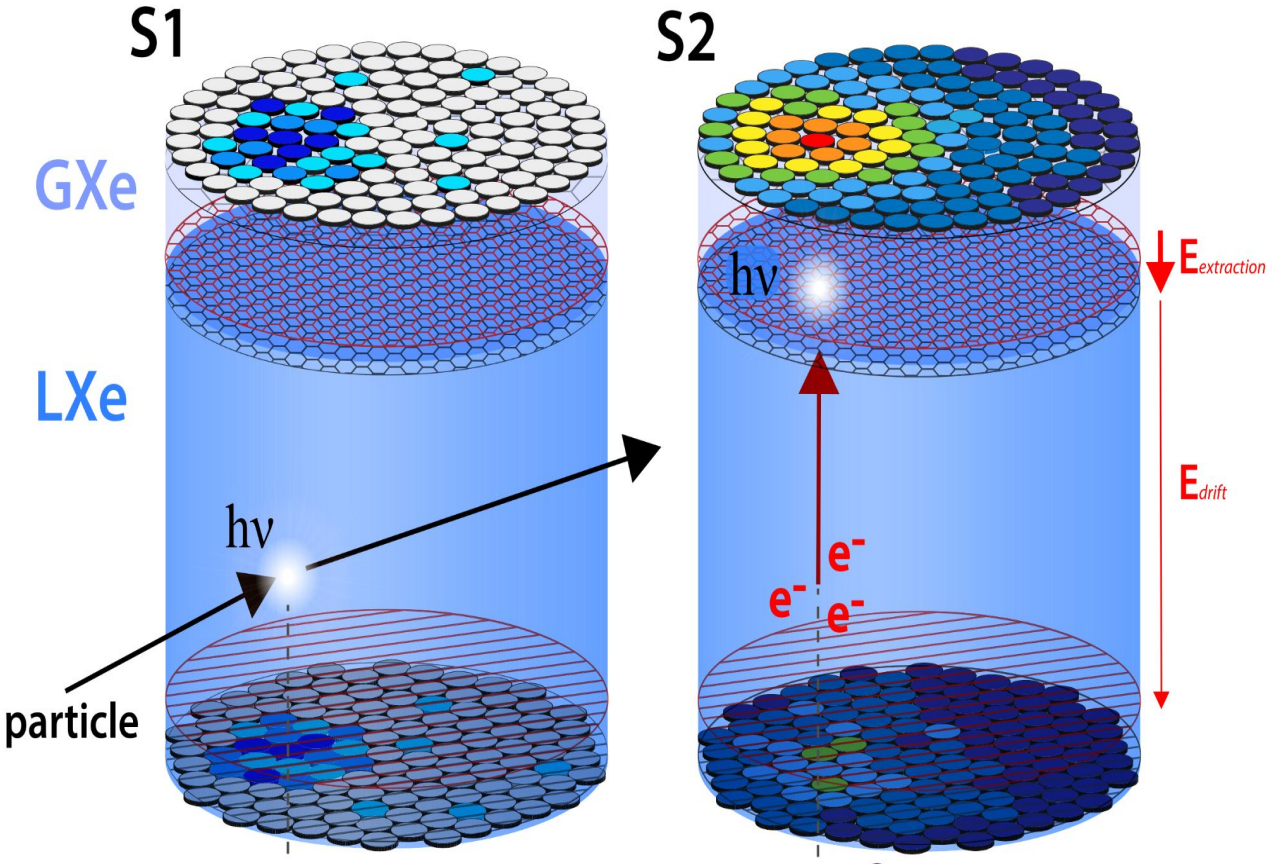
The dual phase TPC



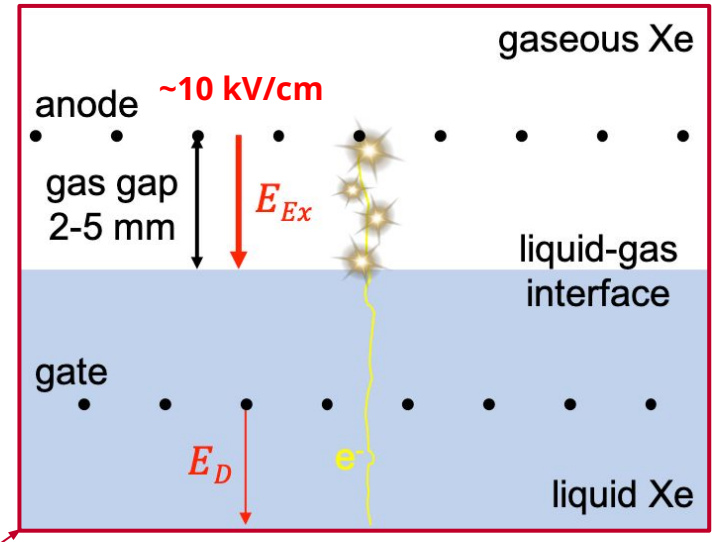
The Dual Phase TPC: issues

L/G interface

- Total reflection → lose S1-efficiency
- Delayed electron extraction
  → Lower S2 + delayed electron signals

Wire sagging (Hiu-Sze Wus talk)

- Worst case: wire touching L/G → no S2
- Stretch wires more + stronger Frame
  → More material
  → **More BG**



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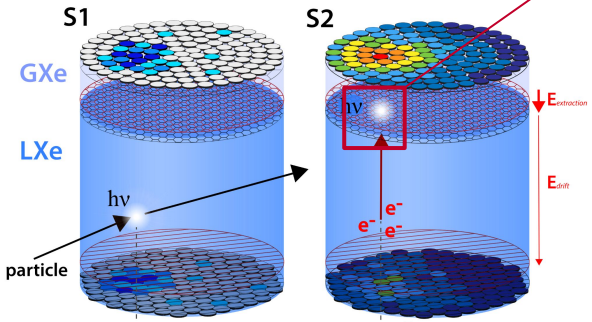


Single Phase TPC

Single Phase TPC: How

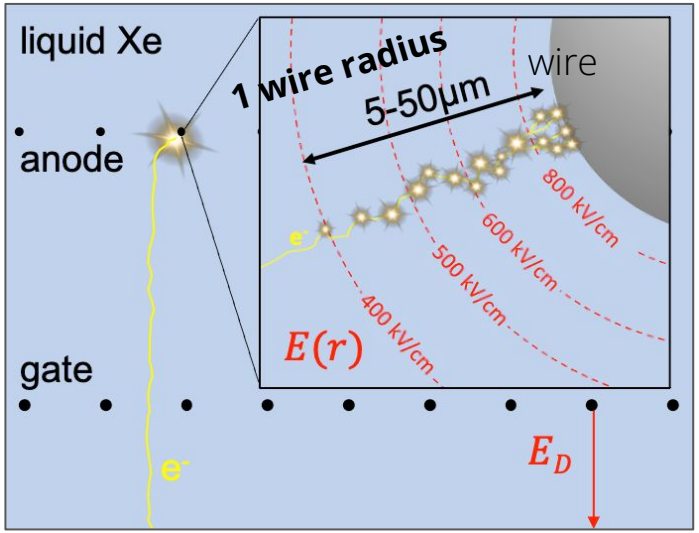
Fill TPC to top Photosensors with LXe

Strong E-fields required for prop. scint.

above 400 kV/cm
vs. 10 kV/cm

- Apply HV: challenging (sparks, …)
- **Thin wires:** 10-100 µm
  Balance diameter ↔ HV
- Scintillation only close to wires
  (→ narrower S2)

Proof of concept:
E Aprile *et al* 2014 *JINST* 9 P11012



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Single Phase TPC: advantages

L/G interface removed

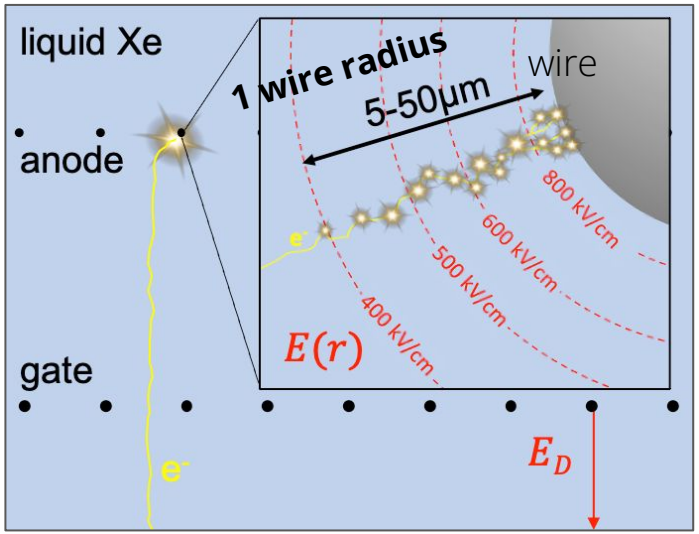
- No Total reflection → maximize S1-efficiency
- No electron extraction required
  → No delayed electrons (+ their signals)

Wire sagging

- impact on S2 generation much smaller

Bonus:

- No LXe-Level control required
  → Less material (no diving bell, weir,, ...)→ **Less BG**
- Tilting irrelevant
- Thinner wires → higher transparency



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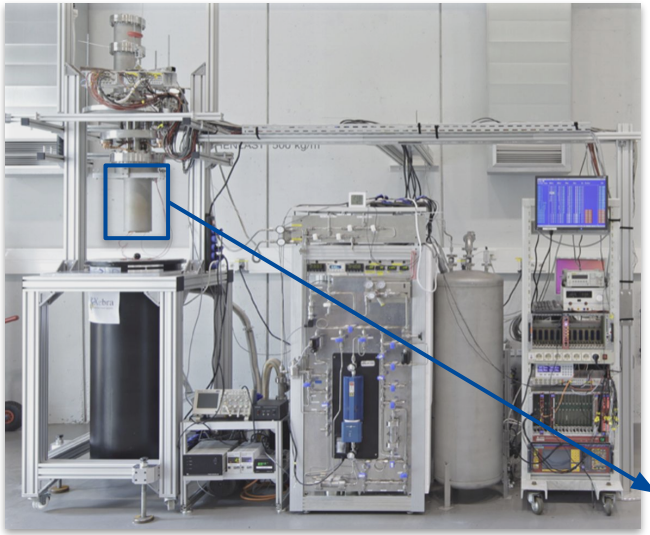
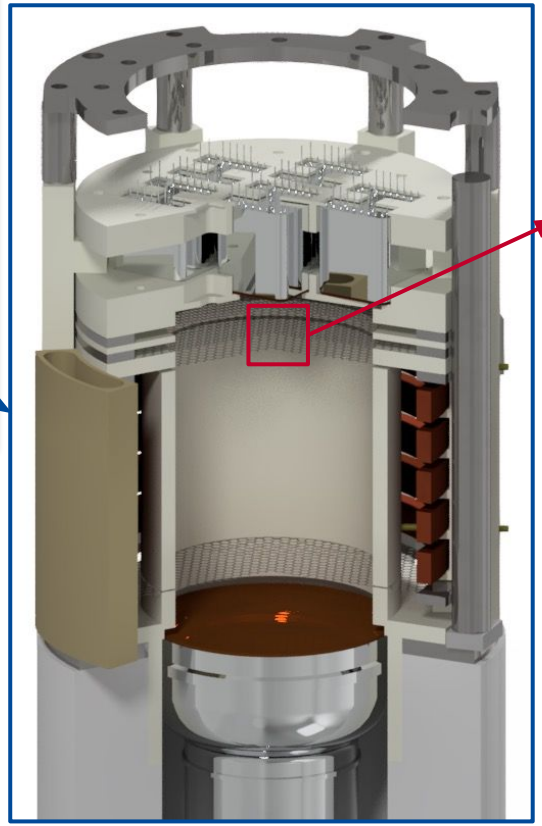
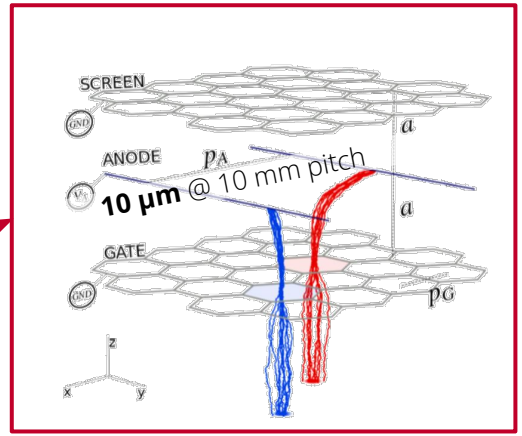
The XeBRA-Setup



Classic TPC design with minor changes





- 7 x 7 cm cylindrical TPC
- 0.8 kg LXe
- 8 PMTs:
  7 top (1″ x 1″)
  1 bottom (3″)

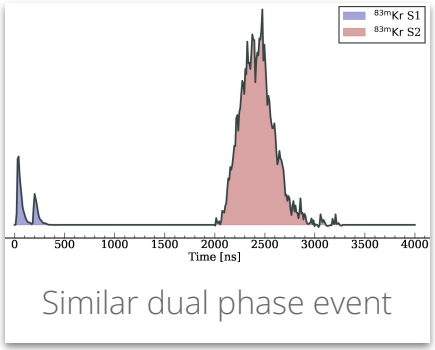
Operated

- With ^{83m}Kr as calibration source
- For 2 months total
- Successfully

Alternative Design:
Performance of a Radial Time Projection Chamber with Electroluminescence in Liquid Xenon
Y. Wei et al

Our TPC works!

- Distinguish all 4 Signals
  - S2s for short drift times
- **500 ns S2-width** vs > 1 µs



Similar dual phase event

^{83m}Kr (τ = 2.6 h)

32 keV

^{83m*}Kr (τ = 0.22 µs)

9.4 keV

^{83}Kr (stable)

Charge detection

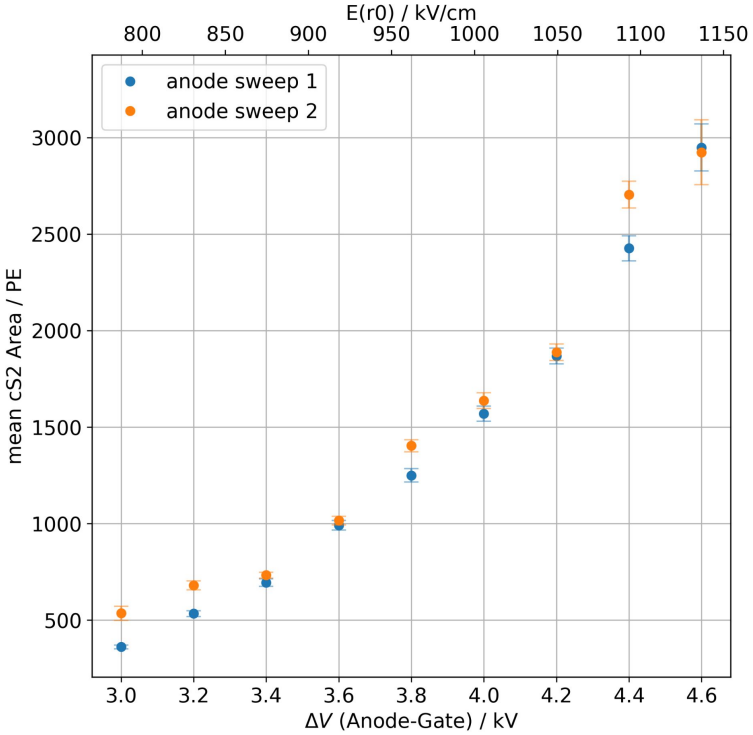
- Nest-Simulations: **1000 e^- total**
  900 (1.st S2) + 100 (2nd. S2) for ^{83m}Kr
- **3000 PE** @ 4.6 kV
  (corrected by e-lifetime)

⇒ g_2 = 3 PE/e^-
(dual phase: up to 30 PE/e^-)

Rises faster than linear with ΔV
(larger field, field above threshold longer distance)

ΔV > 4.6 kV → large increase in BG.
→ Analysis breaks down

g_1 ~ 10% (similar to dual phase)



Summary

- We successfully operate a single phase TPC (Design close to “classical” TPCs)
- S2s slimmer than in dual phase
- ^{83m}Kr S2-separation for short drift times
- g_1: 10% (comparable to dual phase)
- g_2: 3 PE/e^- (room for improvement)

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Self-Shadowing