universität freiburg

Results from the Freiburg liquid xenon single phase TPC

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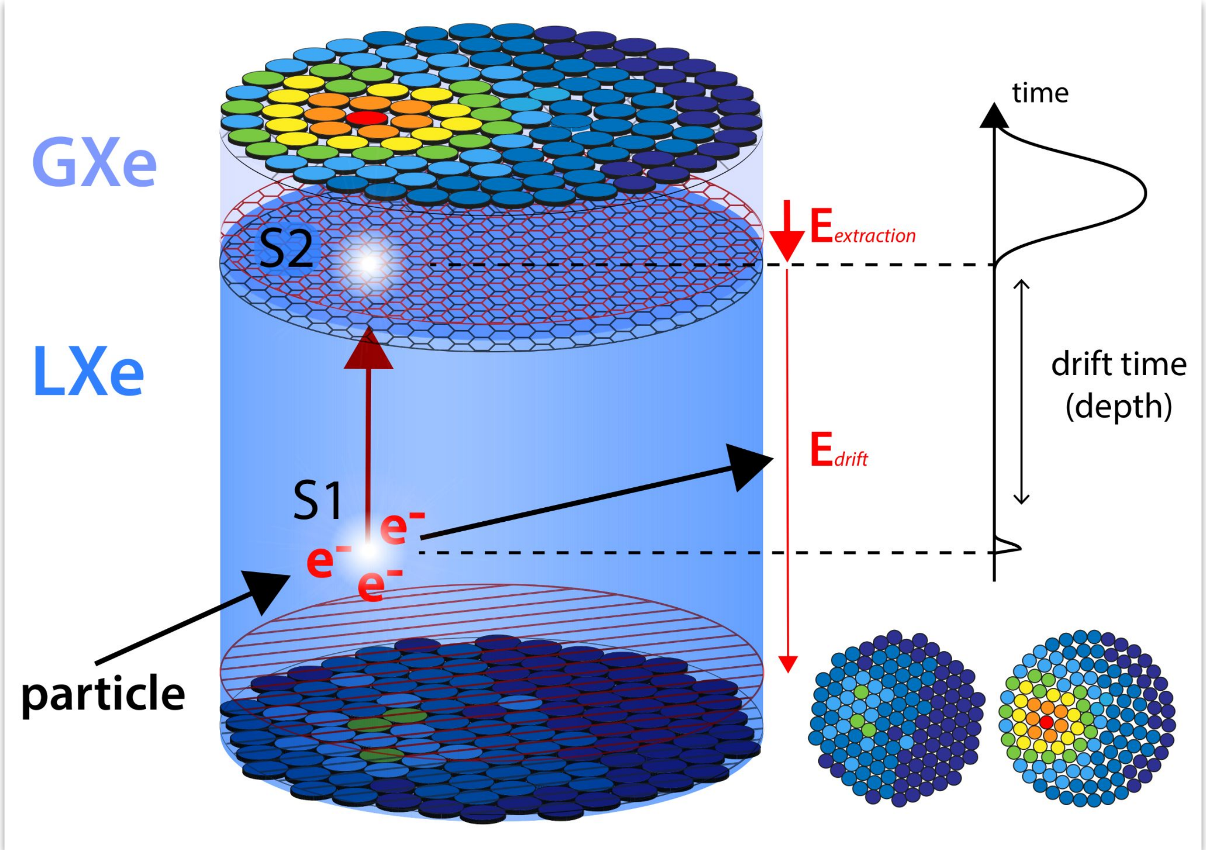
05. - 08. June 2023, Nantes

Refresher on dual phase xenon TPCs

Search for dark matter

Plenary- & Keynote talks:
E. Aprile, L. Baudis



Why a single phase liquid xenon TPC?

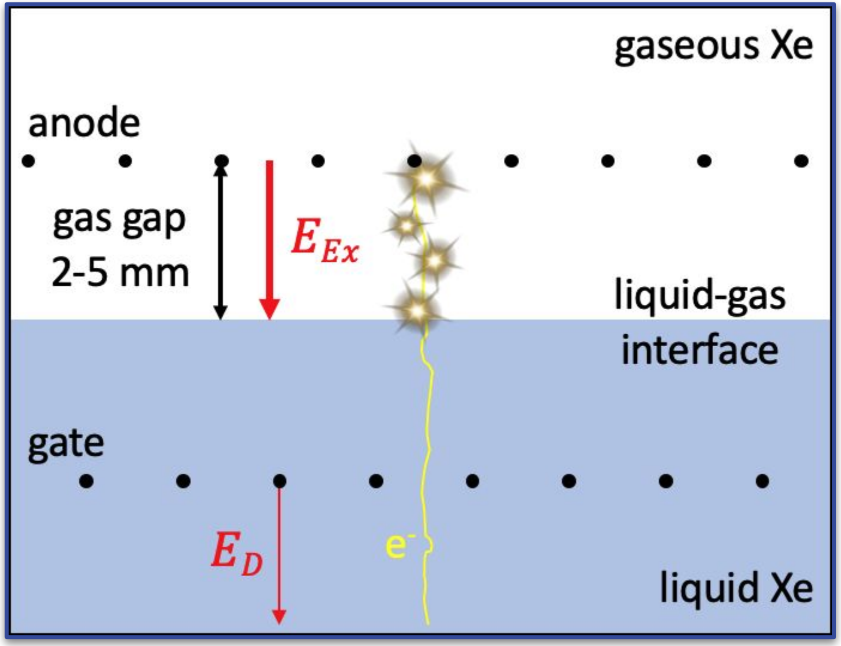
S2 creation only in gas gap below anode

- Liquid level control
- Anode wire sagging⇒ local corrections
- Waves

Delayed electron extraction

Total internal reflection (reduced LCE)

Why not remove the liquid-gas interface?

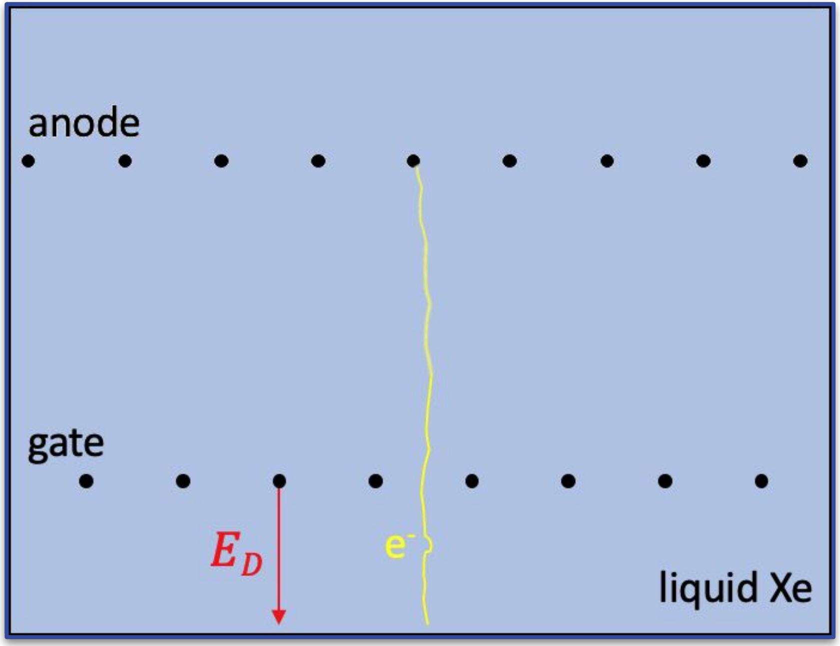


F. Kuger *et al* 2022 *JINST* 17 P03027

Just fill the TPC with xenon

Strong electric fields required:

> 400 kV/cm (E. Aprile *JINST 9 P11012 (2014)*)



F. Kuger *et al* 2022 *JINST* 17 P03027 (modified)

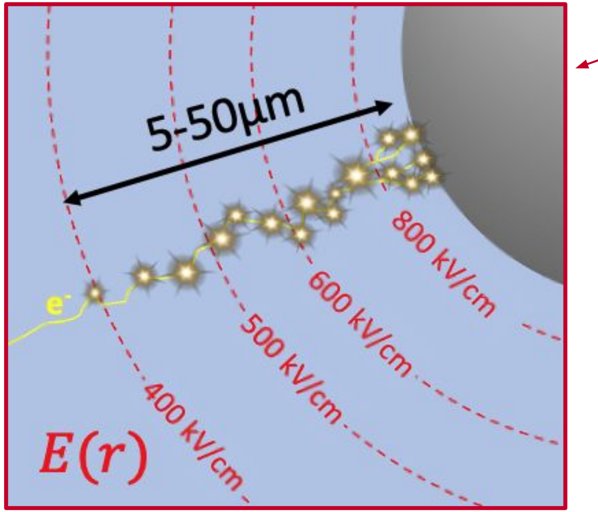
Just fill the TPC with xenon and use thinner wires

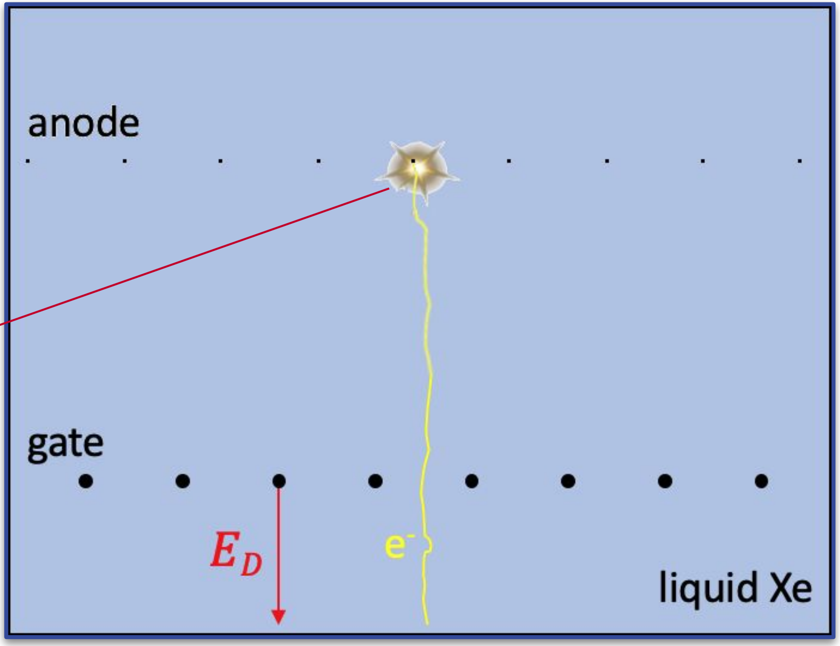
Strong electric fields required:

> 400 kV/cm (E. Aprile *JINST 9 P11012 (2014)*)

Thin anode wires

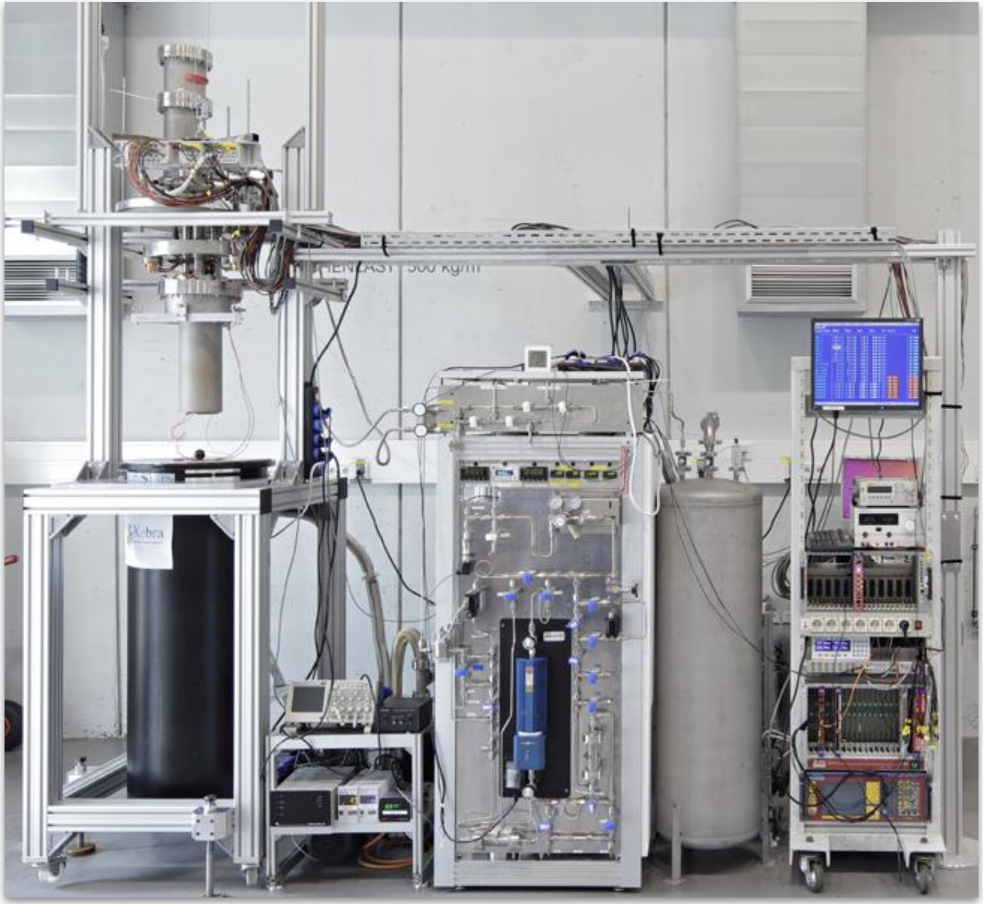
→ high fields at moderate Voltage



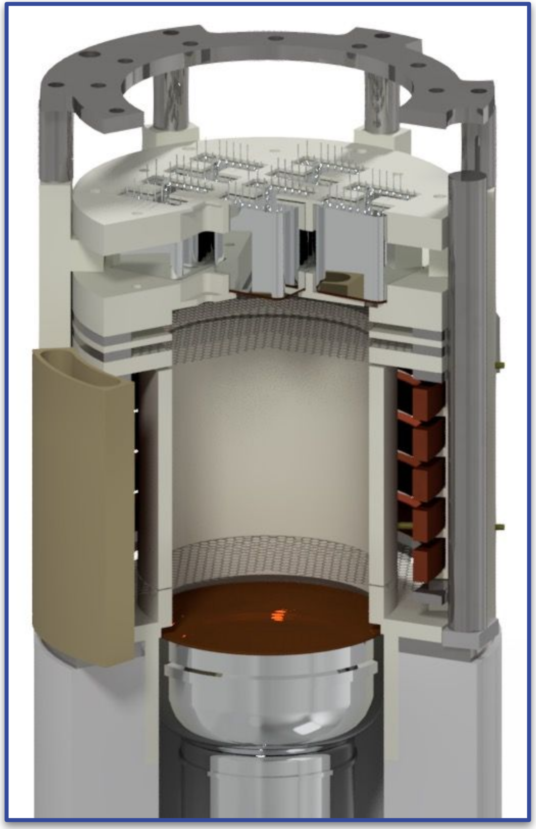


F. Kuger *et al* 2022 *JINST* 17 P03027 (modified)

Our Xebra setup



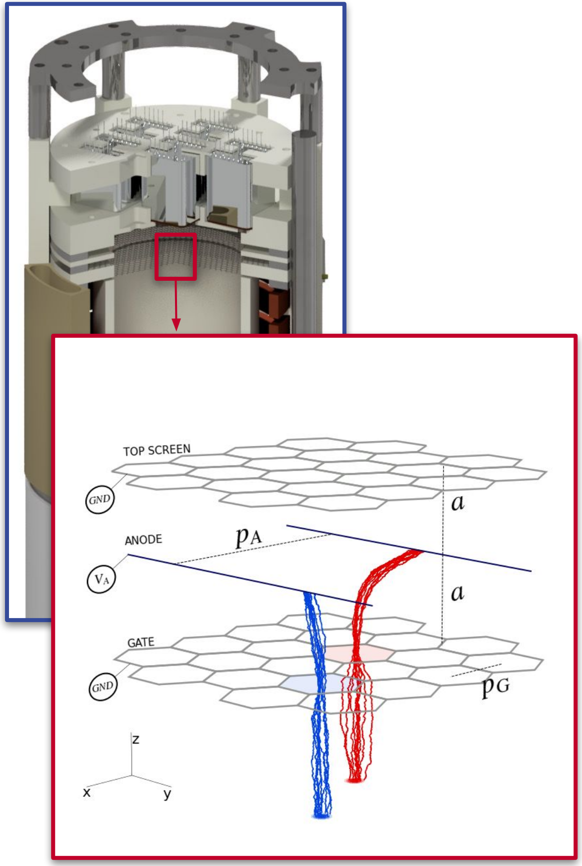
Our single-phase-TPC: following the dual phase design paradigm!



"Classic *dual phase*" layout:

- Size:
  - 7 cm height (cathode to gate)
  - 7 cm diameter
  - 1 kg LXe
- 7 top PMTs (1" x 1")
  1 bottom PMT (3")
- Standard electrode arrays
  - Cathode
  - Screen, **anode**, gate

Our single-phase-TPC: following the dual phase Paradigm!



Top electrodes

- Anode: Au-plated tungsten-wire
  (200 µm → 10 µm, pitch p_A: 10 mm)
- Screen/gate: etched SS hex mesh
  (thickness: 150 µm; p_G: 3 mm, a: 5 mm)

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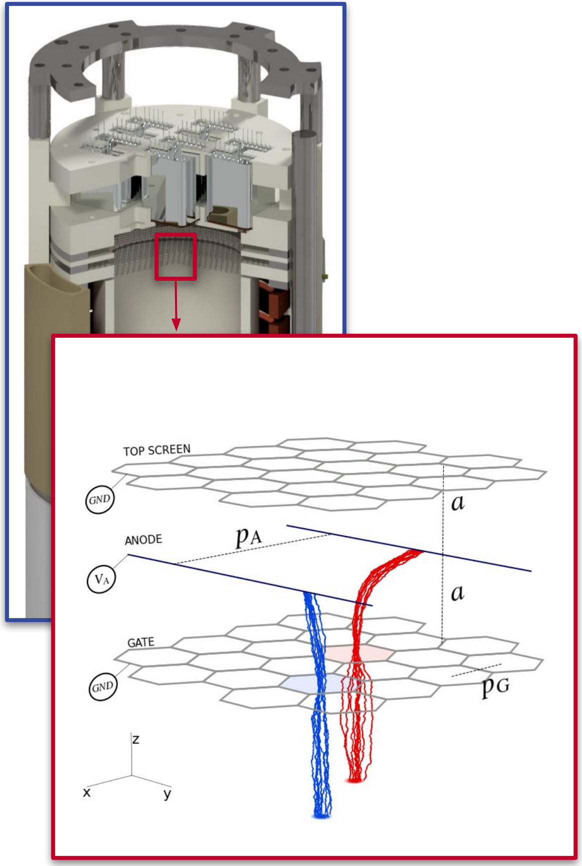

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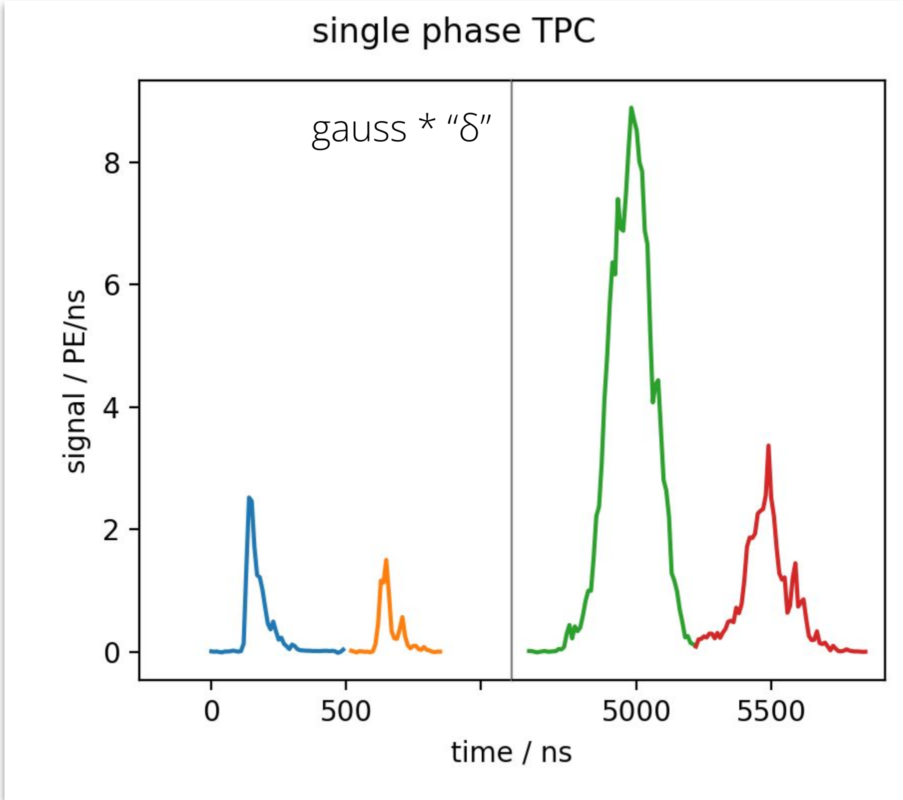
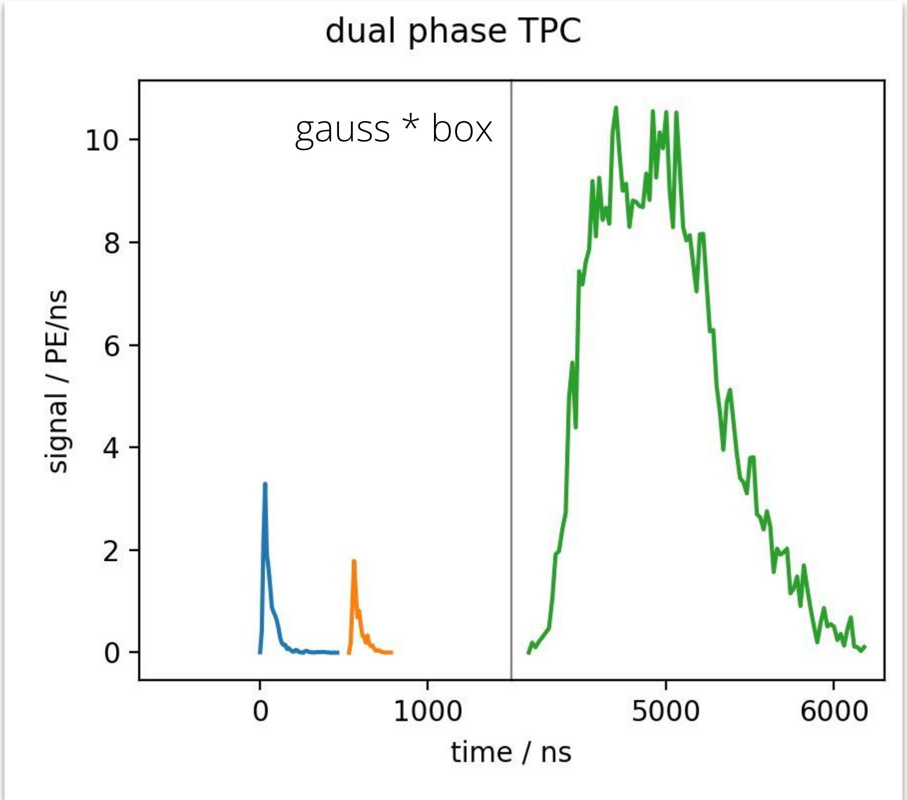
Additional advantages of our design

- Xenon self shielding from top PMTs
- Existing design paradigm

Event comparison

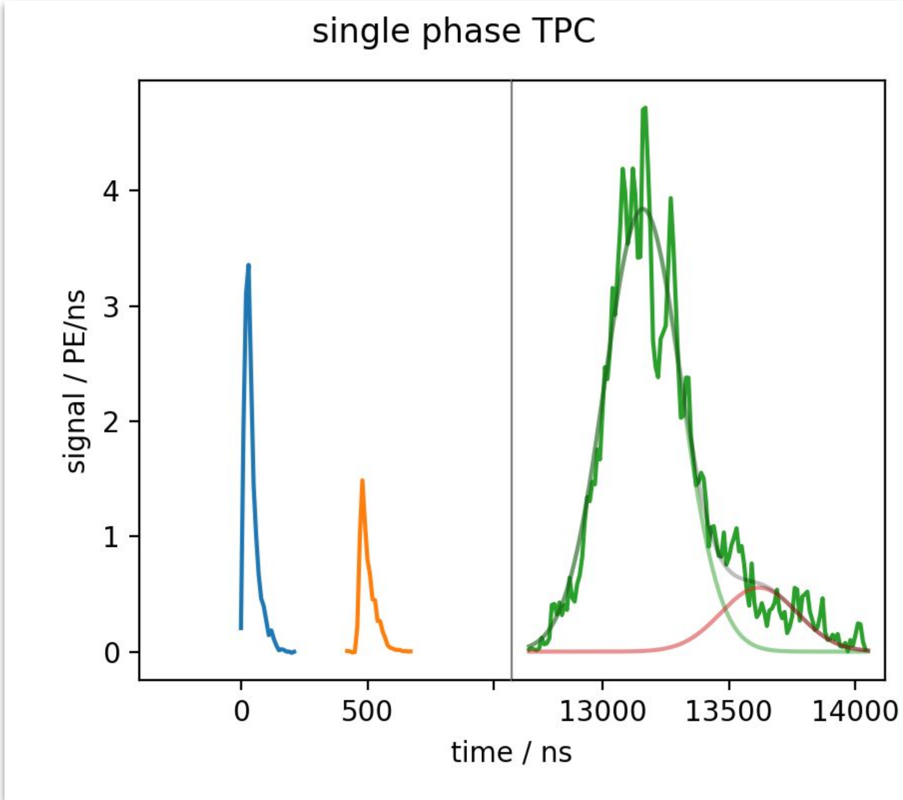
^{83}Kr

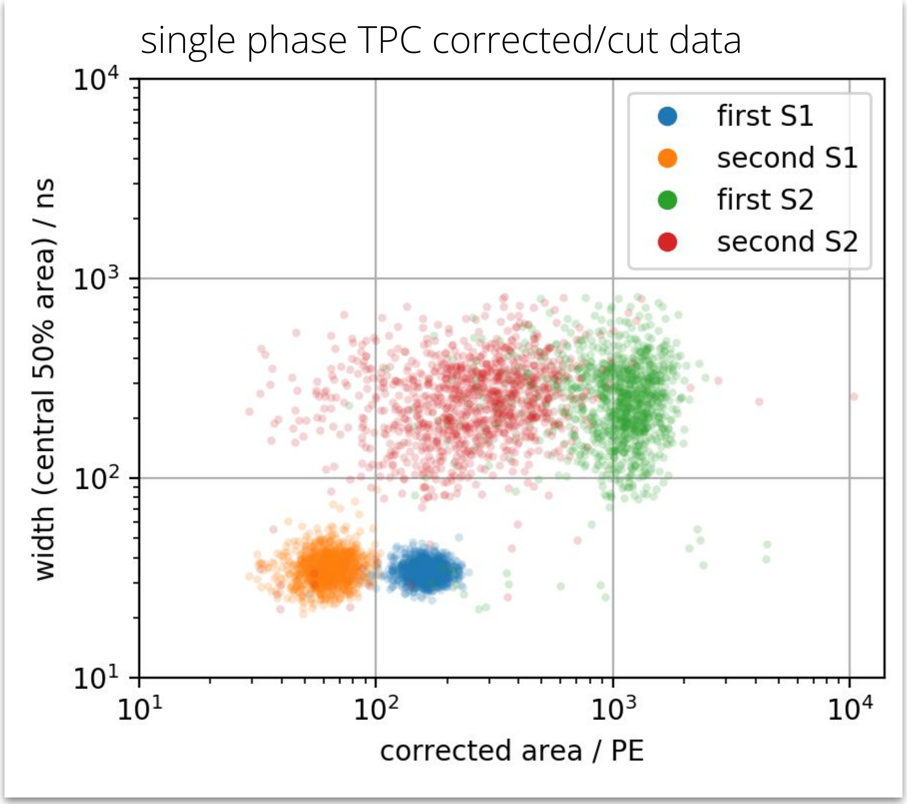




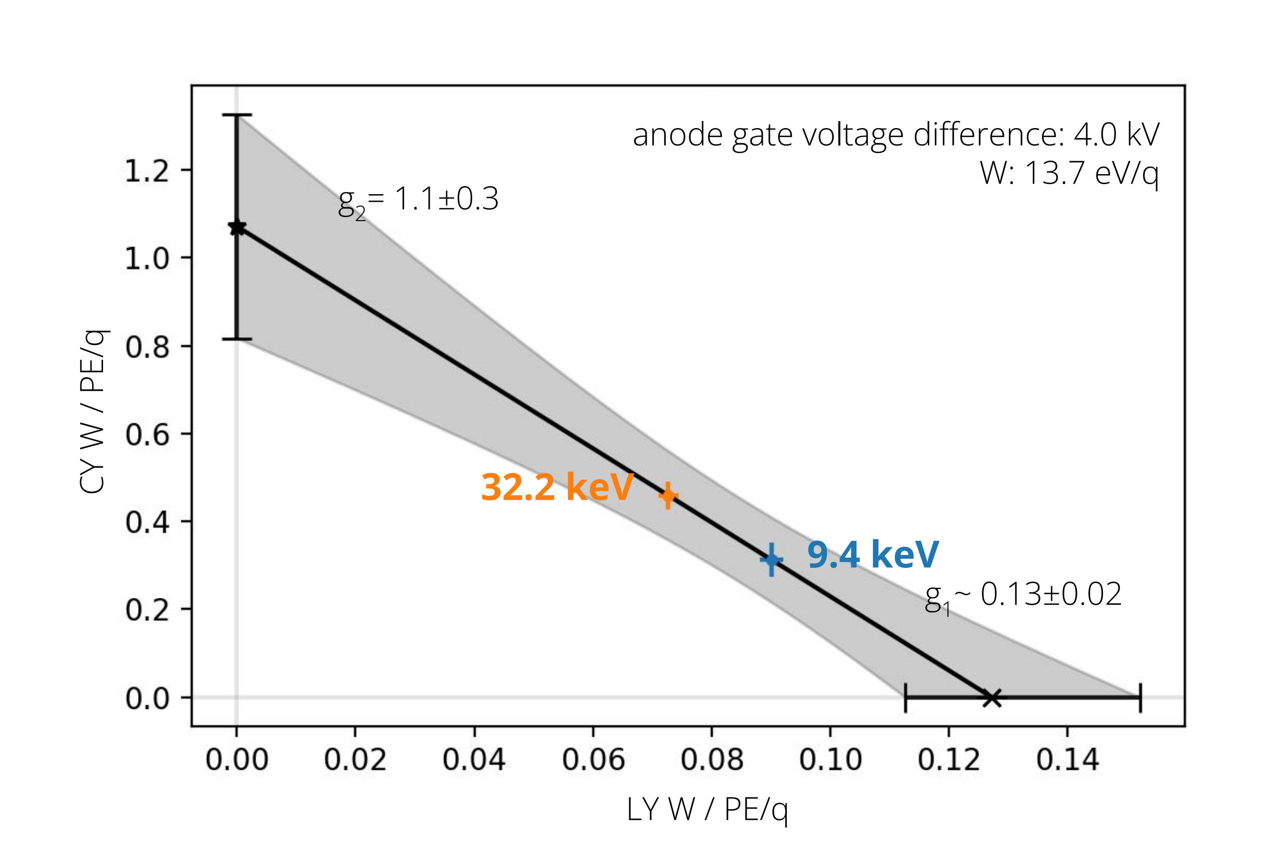
both events from 4.0 kV anode to gate voltage

Event comparison





g1 & g2 via krypton data only



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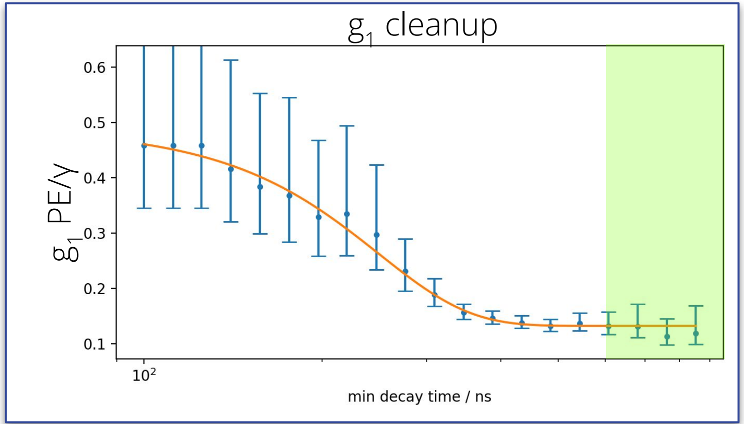
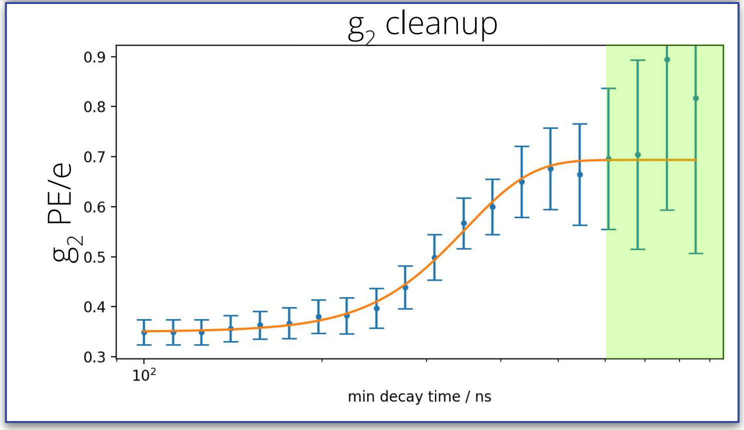
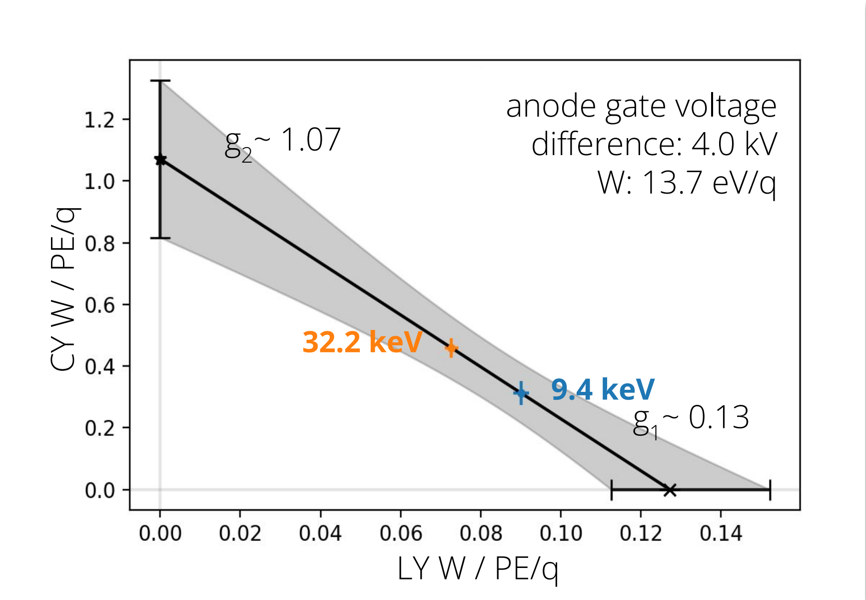
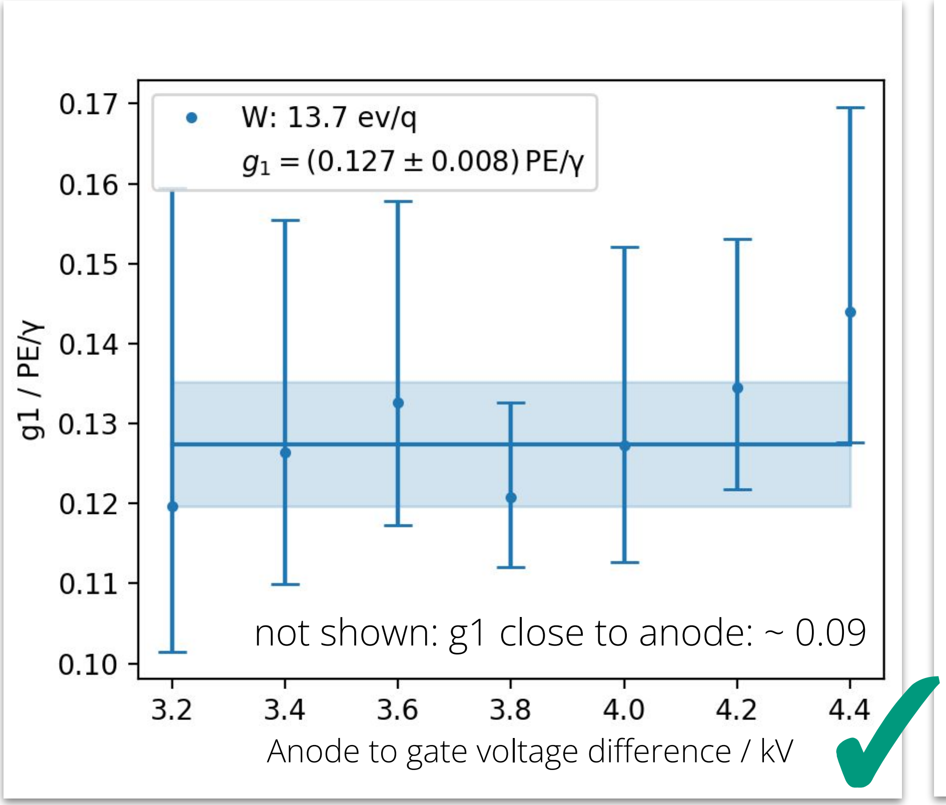


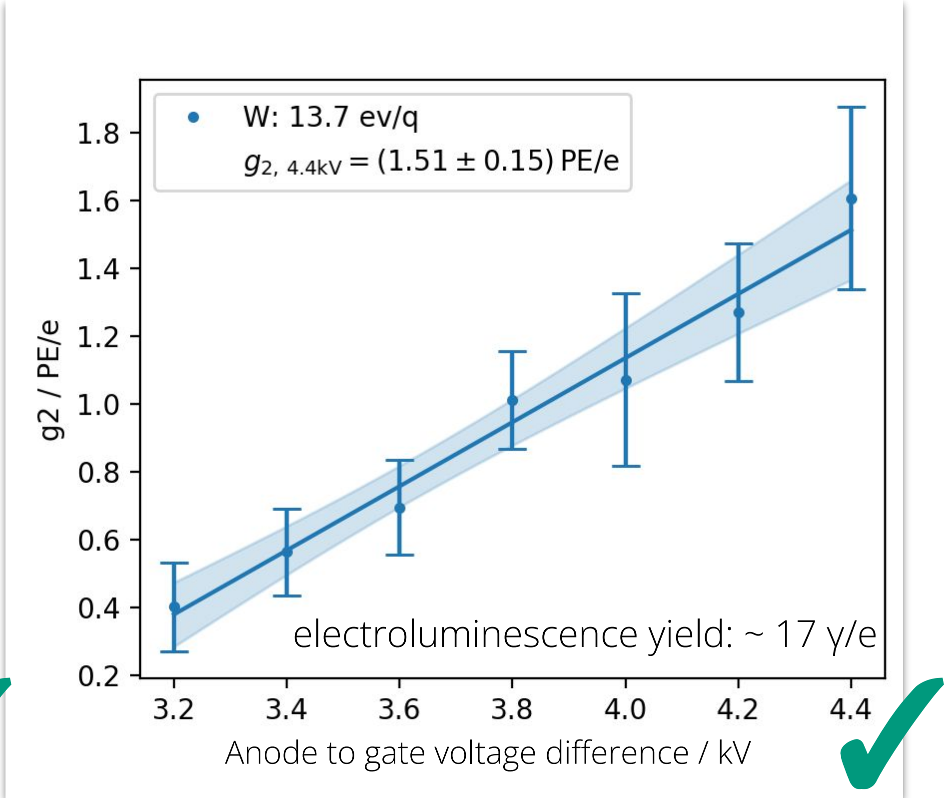




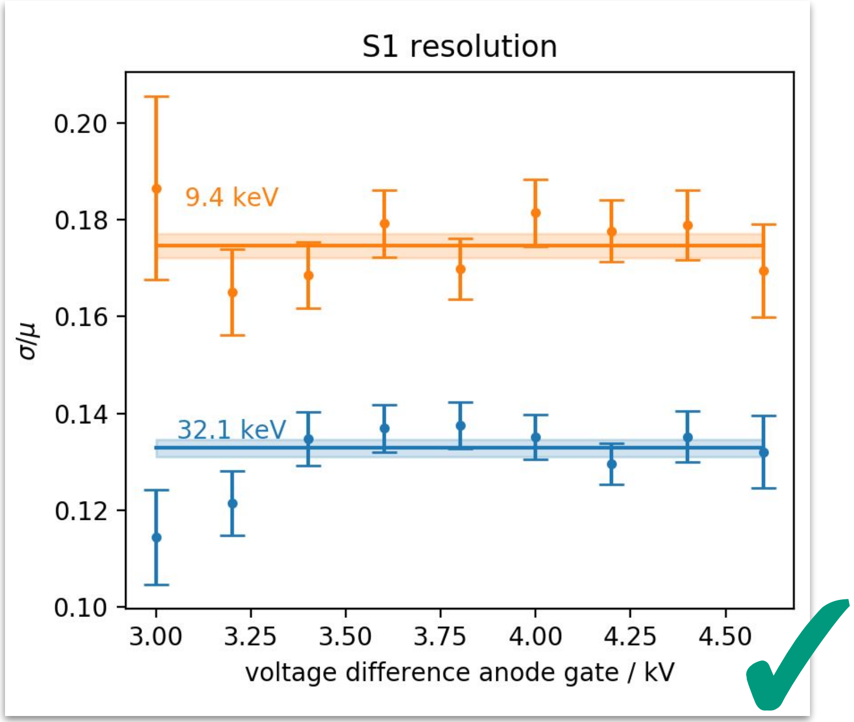
additional cut: decay time > 600 ns
reduce impact of first to second decay
(effect shown for S1 areas in Phys.Rev.D87:115015,2013)

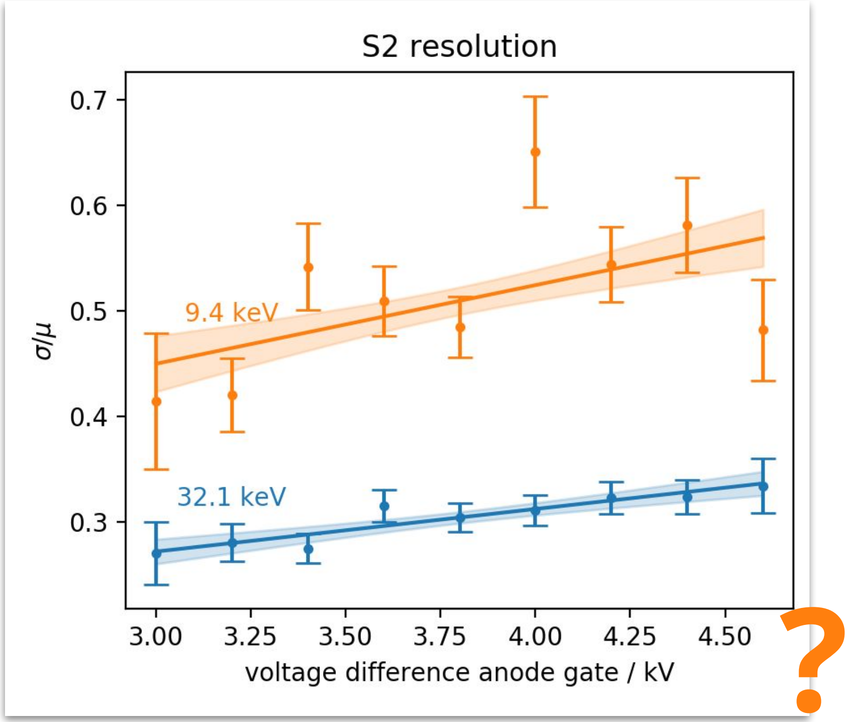
Anode-gate-voltage-difference dependent gain factors



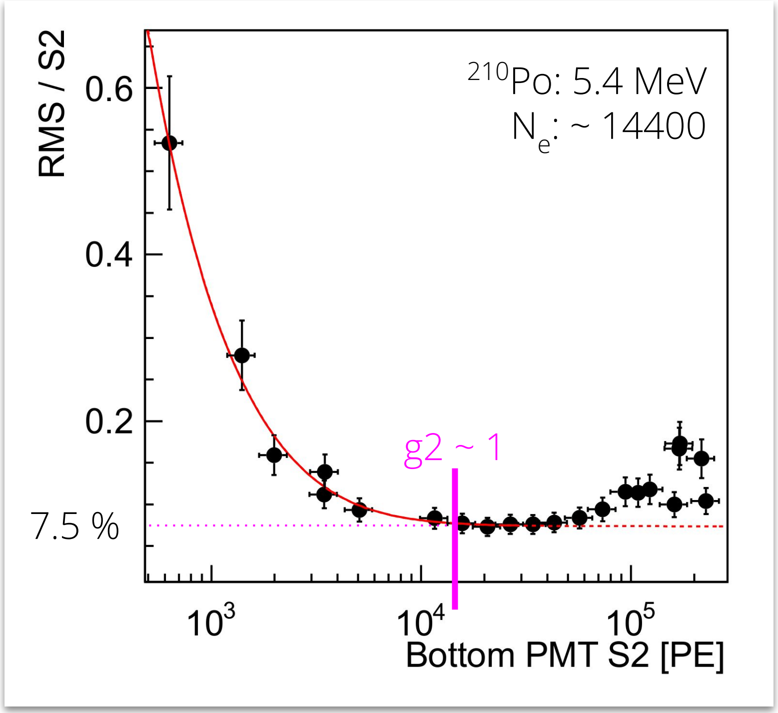


Energy resolution at 32 keV and 9.4 keV

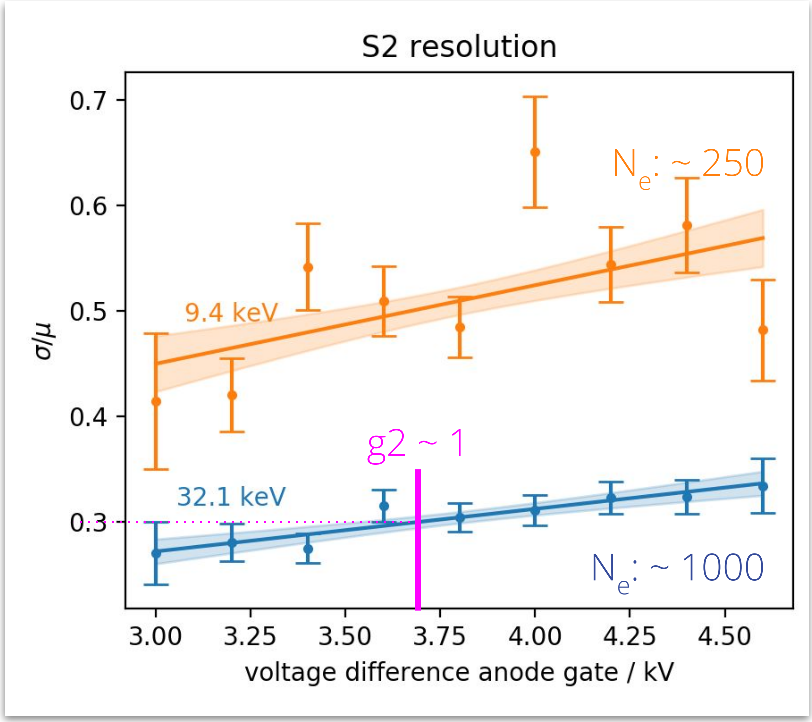




Energy resolution at 32 keV and 9.4 keV vs 5.4 MeV (very handwavy!)

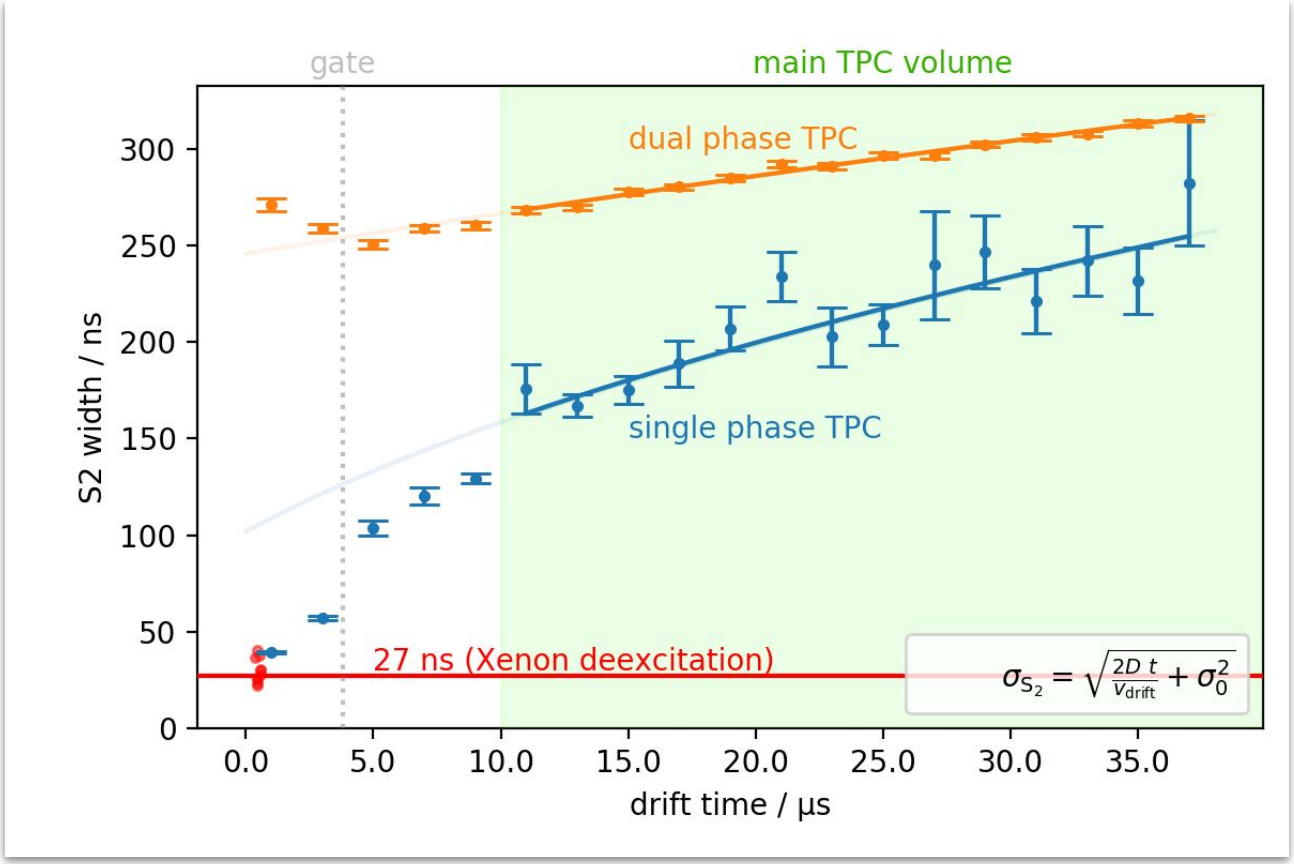


E. Aprile *JINST 9 P11012 (2014)*



32 keV: 7.5 % √(14400/1000) = 28% ✓
9.4 keV: another √4 ✓

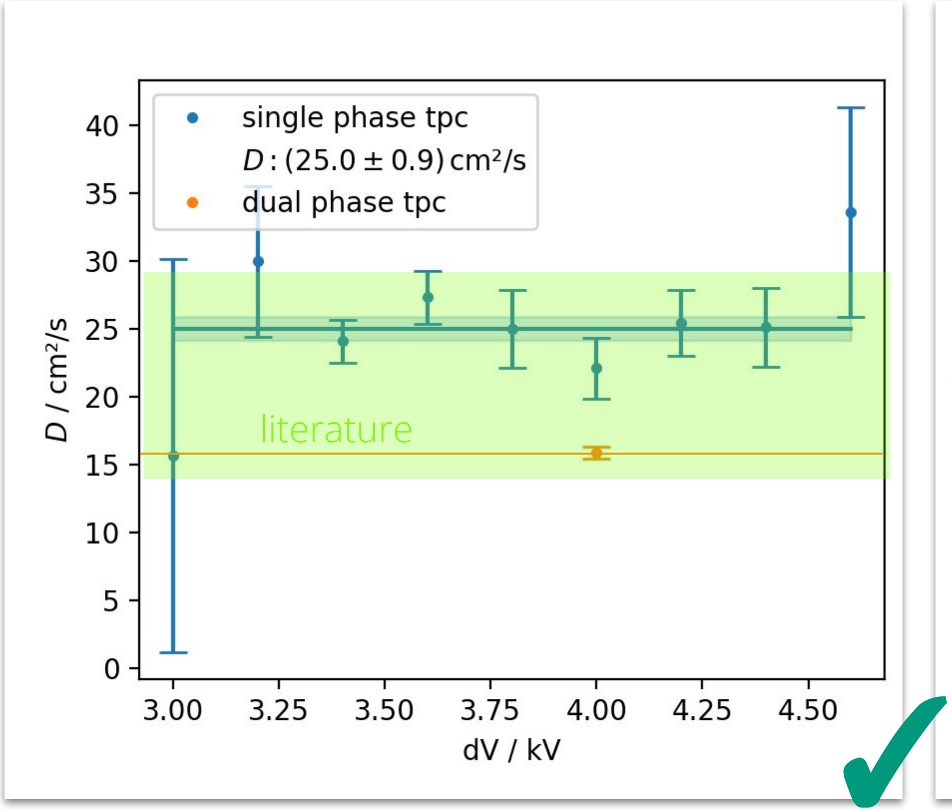
S2 width and diffusion

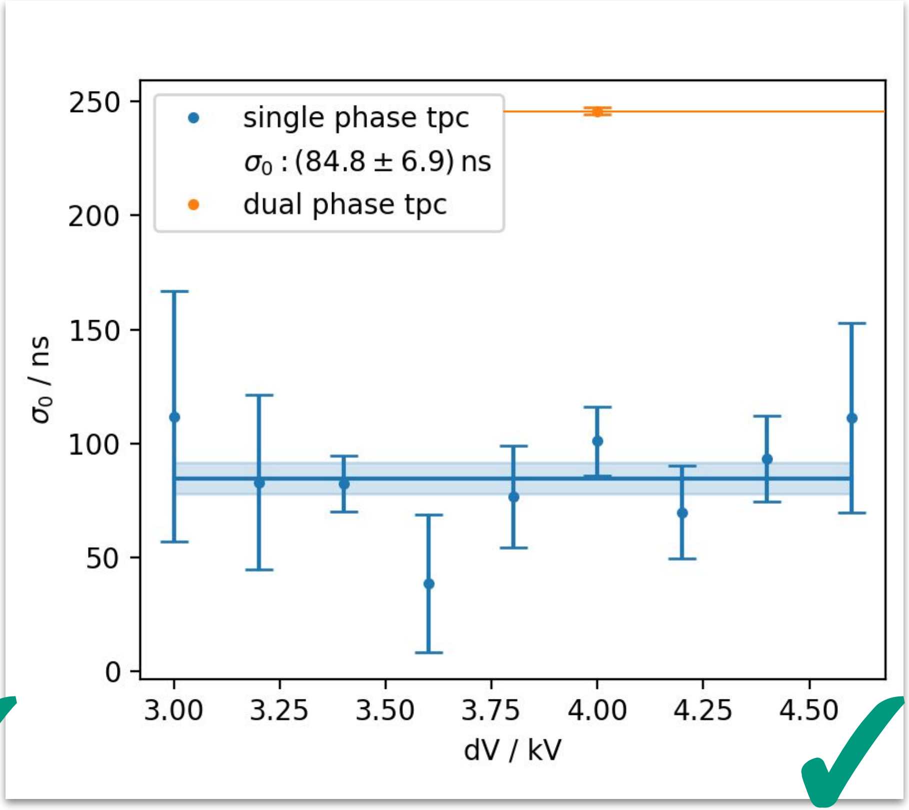


both datasets from 4.0 kV anode to gate voltage runs

S2 width and diffusion

$$\sigma_{S_2} = \sqrt{\frac{2D\,t}{v_{\mathrm{drift}}} + \sigma_0^2}$$





Summary

- We have a single phase TPC in Freiburg
- Results are promising but more research is required
- Our design tackles challenges for Darwin, details need optimization