High Voltage Monitoring and Characterization at KATRIN

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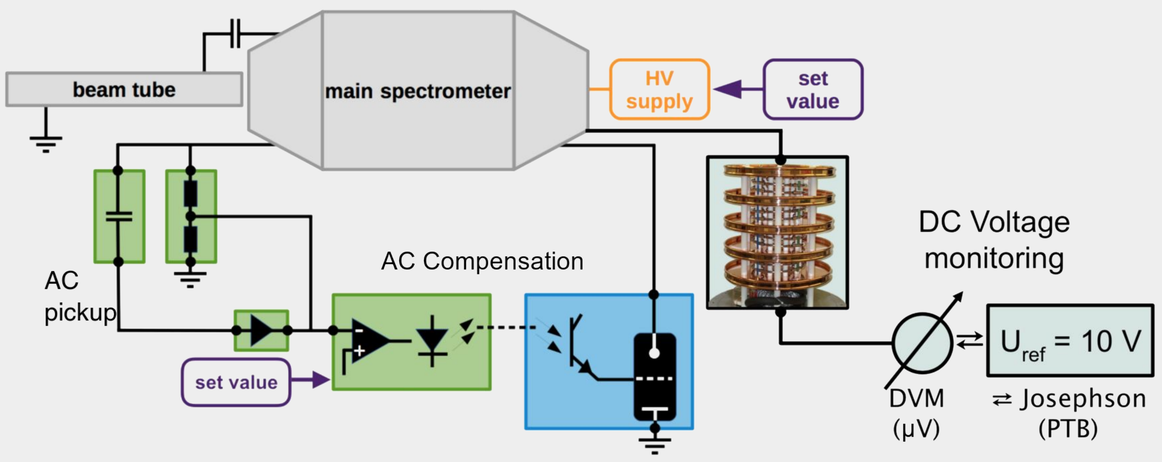
on behalf of the KATRIN collaboration

High Voltage Requirements

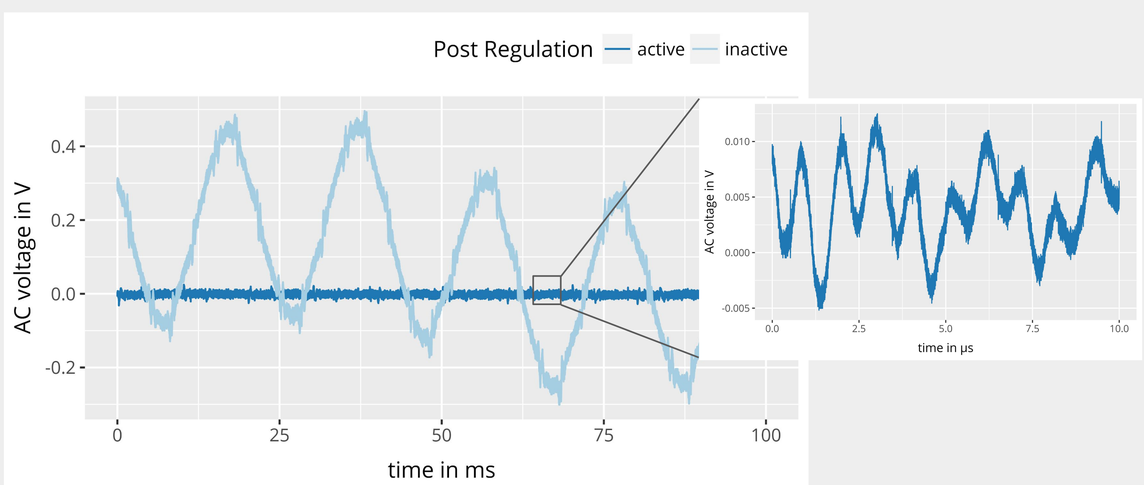
- Measure tritium decay spectrum by varying the retarding potential. The high voltage creating the potential needs to be precisely set and monitored.
- Relative high voltage uncertainty needs to be below 60 mV @18.6 kV (3 ppm). [Angrik, J. et al., FZKA (2005) 7090]

High Voltage Setup



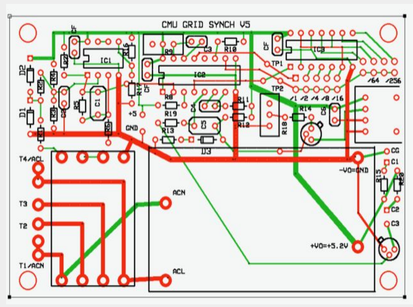
- Measure high voltage directly with a precision voltmeter via a purpose-built precision high voltage divider. [T. Thümmler et al., New J. Phys. 11 (2009) 103007]
- Calibration measurements using ^{83m}Kr electrons show stability of the divider on the ppm-level per year. [Arenz, M. et al., Eur. Phys. J. C (2018) 78:368]
- Post regulation system actively smoothes out voltage instabilities with frequencies up to 1 MHz.
- Smoothing capacitors suppress high frequency noise > 1 MHz.

Post Regulation Performance



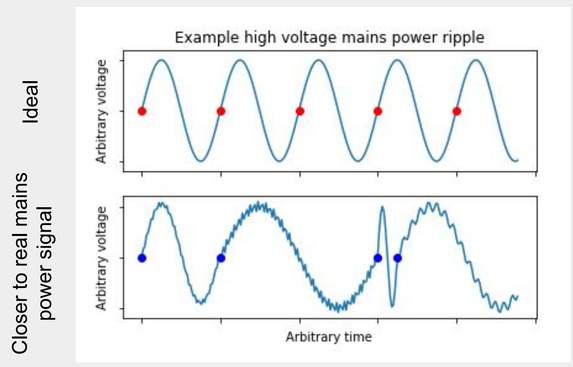
50 Hz Monitoring Hardware

- Designed, tested, and constructed a 50 Hz grid synchronization box.
- Outputs a synch pulse at the start of each mains power period, which provides a grid synch timing pulse, from November 2017 onwards.

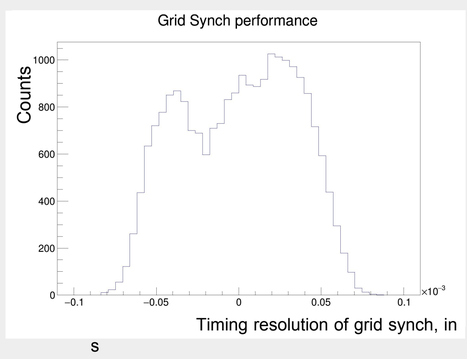


Grid synch box installed at the KATRIN detector system.

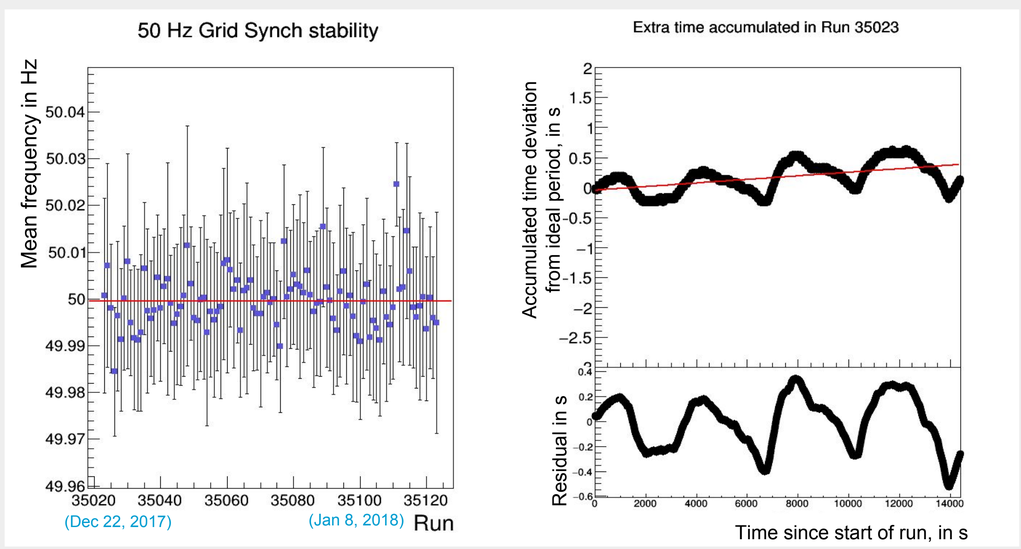
50 Hz Monitoring



- Grid synch signal provides information about mains frequency and timing (blue points), which is useful for characterization of systematics.



- Performance of the grid synch box: timing resolution of ~50μsec (~0.25% of average mains power cycle).



- Mean frequency of mains signal during run campaign: 49.9995 ± 0.0015 Hz
- Long-time mains frequency drift: deviations from ideal 50 Hz period show mains frequency varies (due to active control).

Conclusion

- Together with precision power supplies, achieved voltage stability with relative deviations of < 60 mV.
- Using the grid synchronization box, we are able to characterize the 50 Hz mains power signal.
- The active post regulation system suppresses any 50 Hz power-grid interference.
- Additional tests show no correlation between backgrounds and the 50Hz mains signal.

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