Optical measurement of the electric field (stability)

Christian Velten

Objective

- Measure the electric field using the linear electro-optic (Pockels) effect
- Utilize existing technology/knowledge (i.e. from Cs-magnetometry [M. Sturm])
- Independent of (final) HV setup / assembly

Electric field effects

Absolute field strength

- EDM signal:

$$d_n = \frac{\hbar\,\Delta\omega}{4\left|\vec{E}\right|}$$

- Geometric phases:

$$\delta\omega \sim \frac{\partial B_z}{\partial z}\,\vec{v}\times\vec{E}$$

Field stability

- HV AC ripples (low-amplitude oscillations on the feedthrough and electrodes):

$$j(t) \sim \sin\left(\omega_{\mathrm{AC}}\,t\right)$$

➡ spin-flip possible if $\mathcal{O}\left(\omega_{\mathrm{AC}}\right) \sim 30\,\mathrm{Hz}$

- detection of alternating current:

$$\frac{\partial I}{\partial t} \neq 0 \Longrightarrow \frac{\partial E}{\partial t} \neq 0$$

(technically includes sparks and leakage currents)

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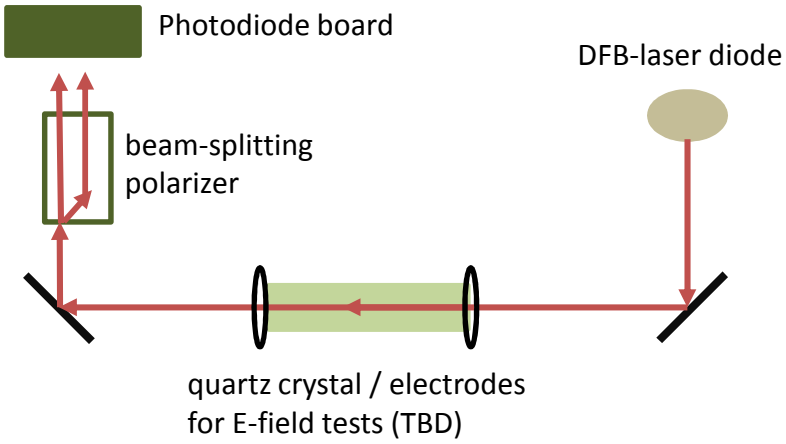
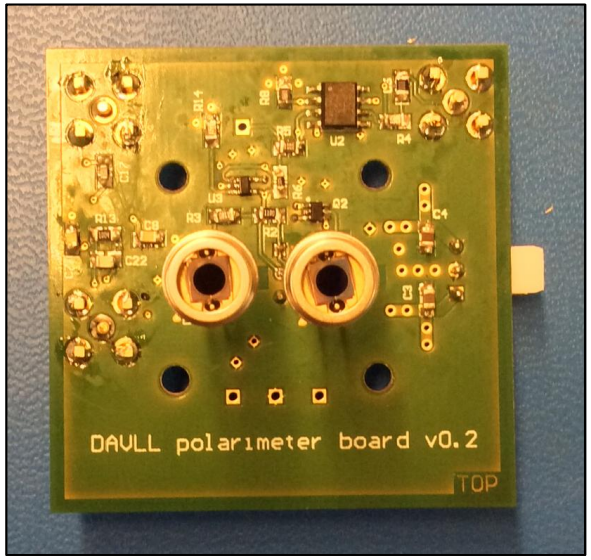
current technology

- 852nm DFB-laser diode
  - temperature controlled
  - 224.68 mA yielding 150 mW
- Table-top design
  (off-site at cluster building)



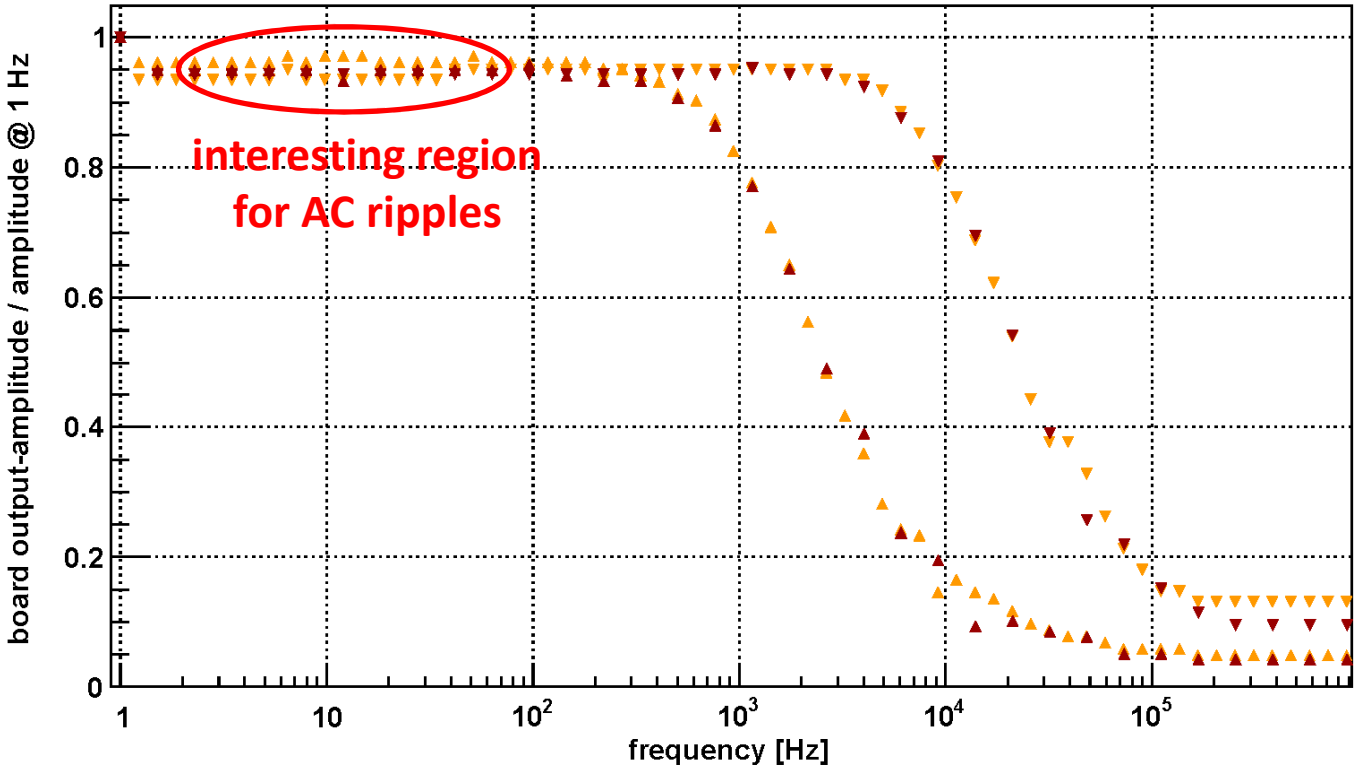
- low-noise photodiode board
- battery-powered (2x9V) for each +/- 9V and relative ground
  - few mV/min discharge



board characterization

Excellence Cluster 'Universe'

Transmission (board #1)



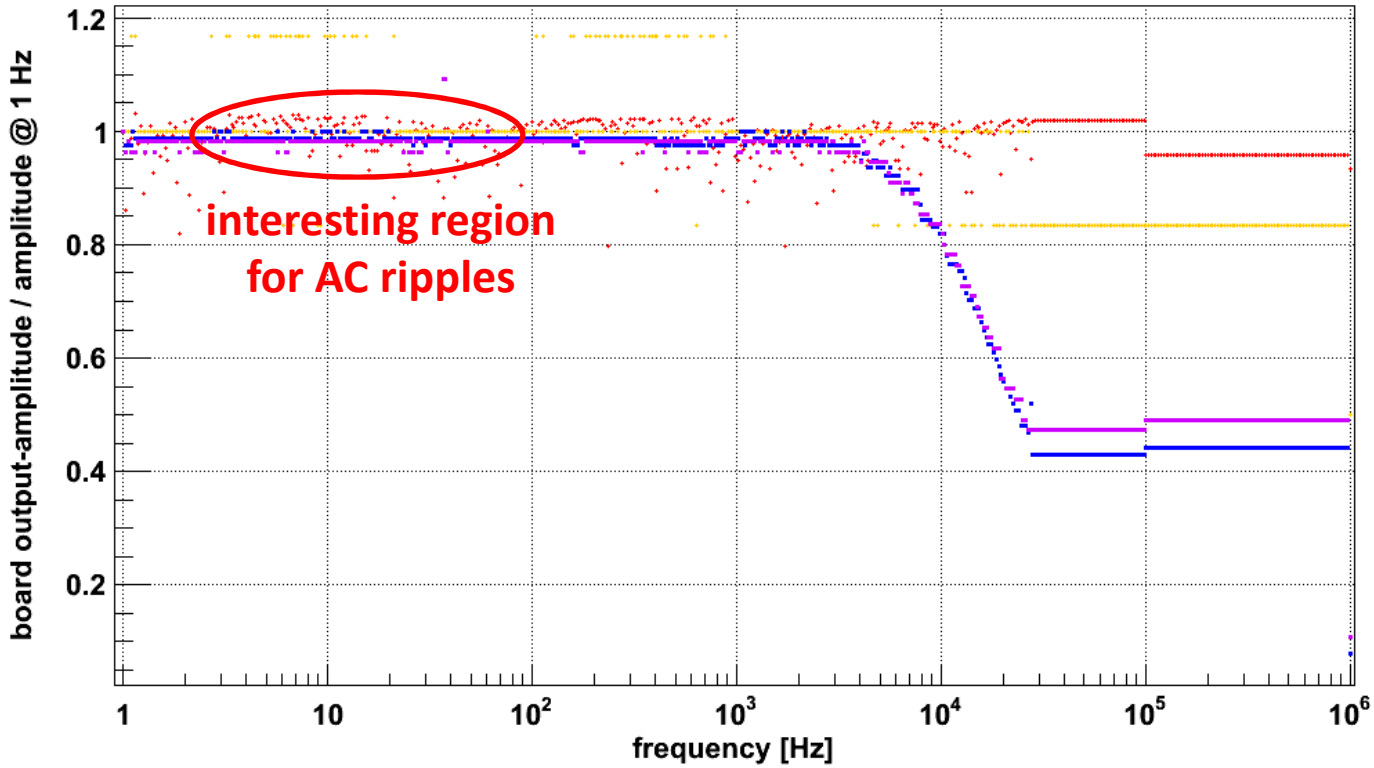
- Frequency sweep from 1Hz to 1MHz
- Oscilloscope amplitude readout

} completely automated (python), easily adaptable

board characterization

Excellence Cluster 'Universe'

Transmission (board #2)



- Frequency sweep from 1Hz to 1MHz
- Oscilloscope amplitude readout

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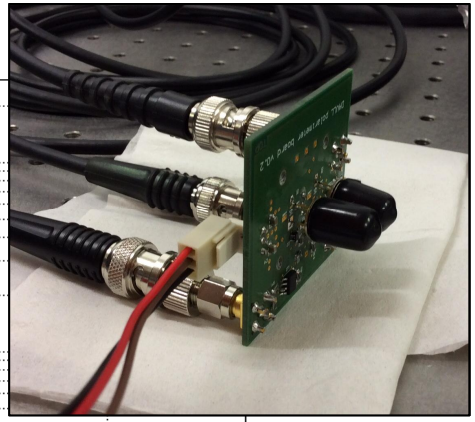
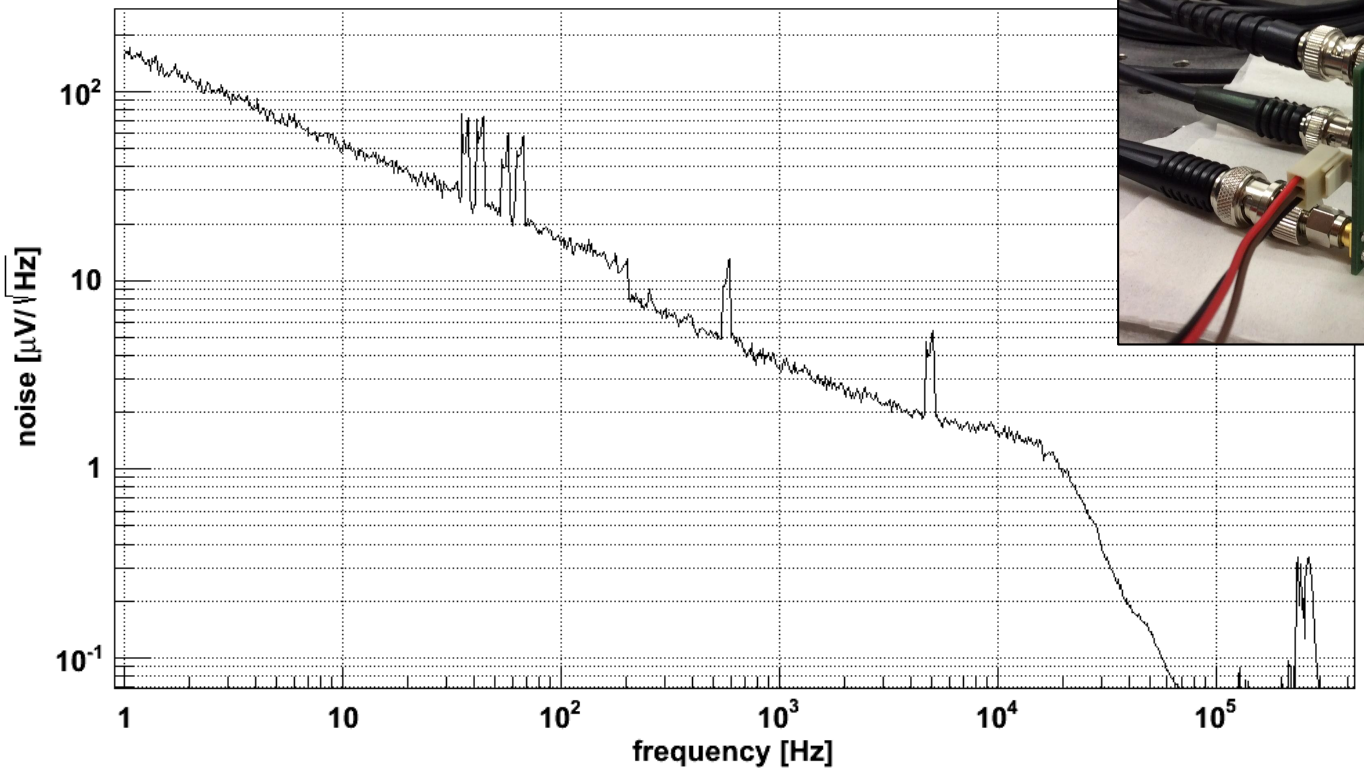
board characterization

Excellence Cluster 'Universe'

Dark noise





- Frequency sweep from 1Hz to 1MHz
- Readout via lock-in amplifier

} completely automated (python), easily adaptable

What‘s next?

- complete table-top setup
- characterize laser diode (e.g. stability) and quartz-rod
- apply high voltage (~10kV) with low-amplitude oscillations to mimic AC ripples