LIMITING BD POWER IN A PULSED DC SYSTEM

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RESISTORS LIMITING THE POWER AVAILABLE FOR A BD

In order to limit the power available for a breakdown in between parallel Cu electrodes in a pulsed DC system, resistors were added in series between the Marx generator and the electrodes. Either one or two 2.7 kΩ high power resistors were used.

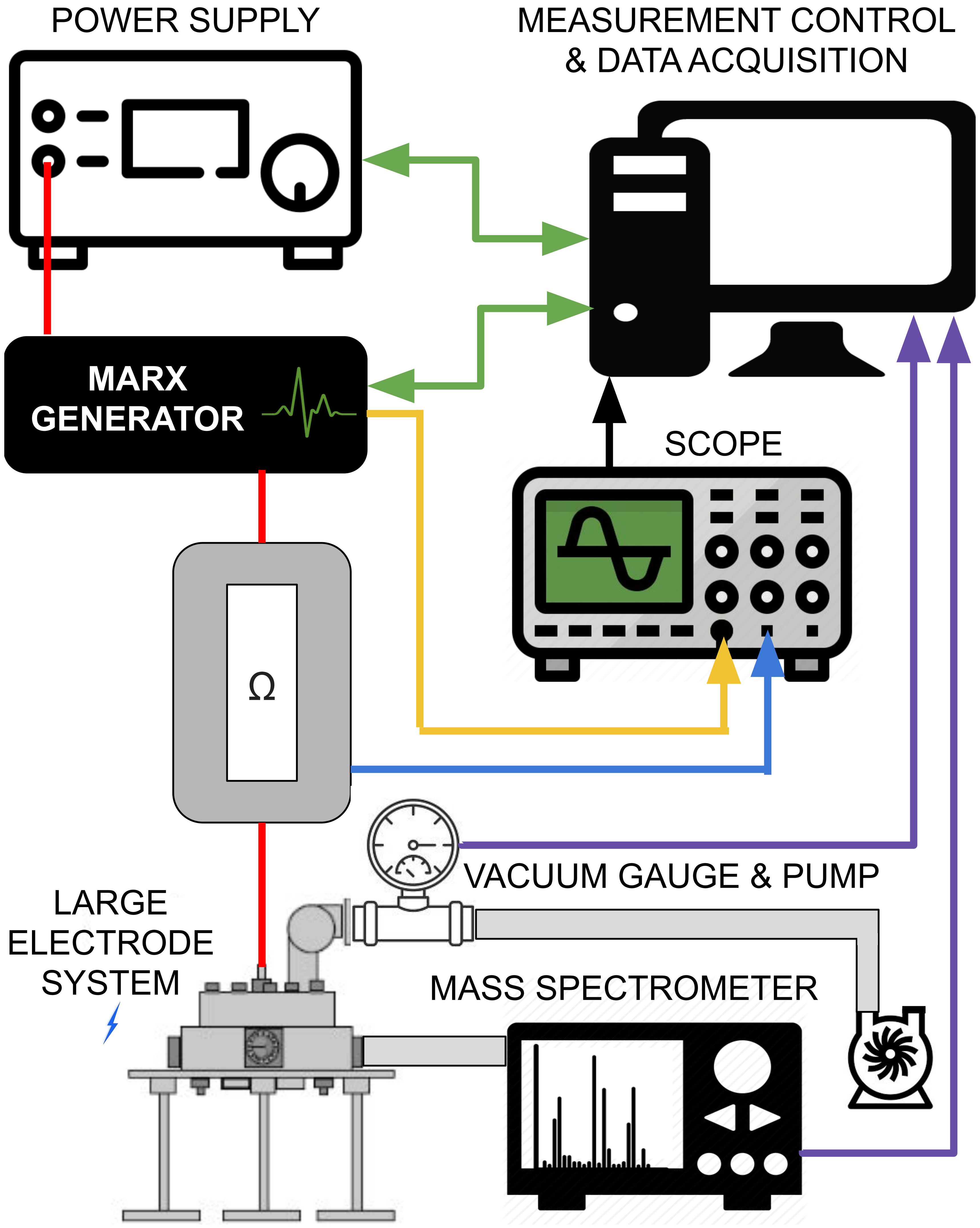

Figure 1: Schematic of the measurement setup including the resisotr box, which was not used in earlier measurements.

Effects in pulse length and BD detection

The additional resistors and cables increase both the resistance and capacitance of the system. This also measn that the time constant $\tau = RC$ increases significantly, thus making all the electronic fluctuations in the system slower. This greatly affects the rise and fall times of the DC pulses and has to be taken into account while comparing the pulse lengths of runs with and without the resistors. This was addressed by matching the durations while the pulses are more than 99 % of the amplitude. I.e. an 8 μs pulse without resistors has about approximately the same hight-time as a 14 μs pulse with a 2.7 kΩ resistor or a 20 μs pulse with 5.4 kΩ resistors.

Normally, the BD detection is done by triggering the Marx generator when the current is higher than the charging peak. However, with the resistors consuming the power, the BD current peak is negligible, thus making the BD detection much more difficult. Alternative ways, such as following the pressure or pulse width are possible, but much slower as they need to be triggered outside of Marx, therefore possibly enabling several BDs before the pulsing can be stopped. This can be evaded by triggering Marx by the current after the resistor, where there is almost no charging peak, but the BD peak is clearly visible.

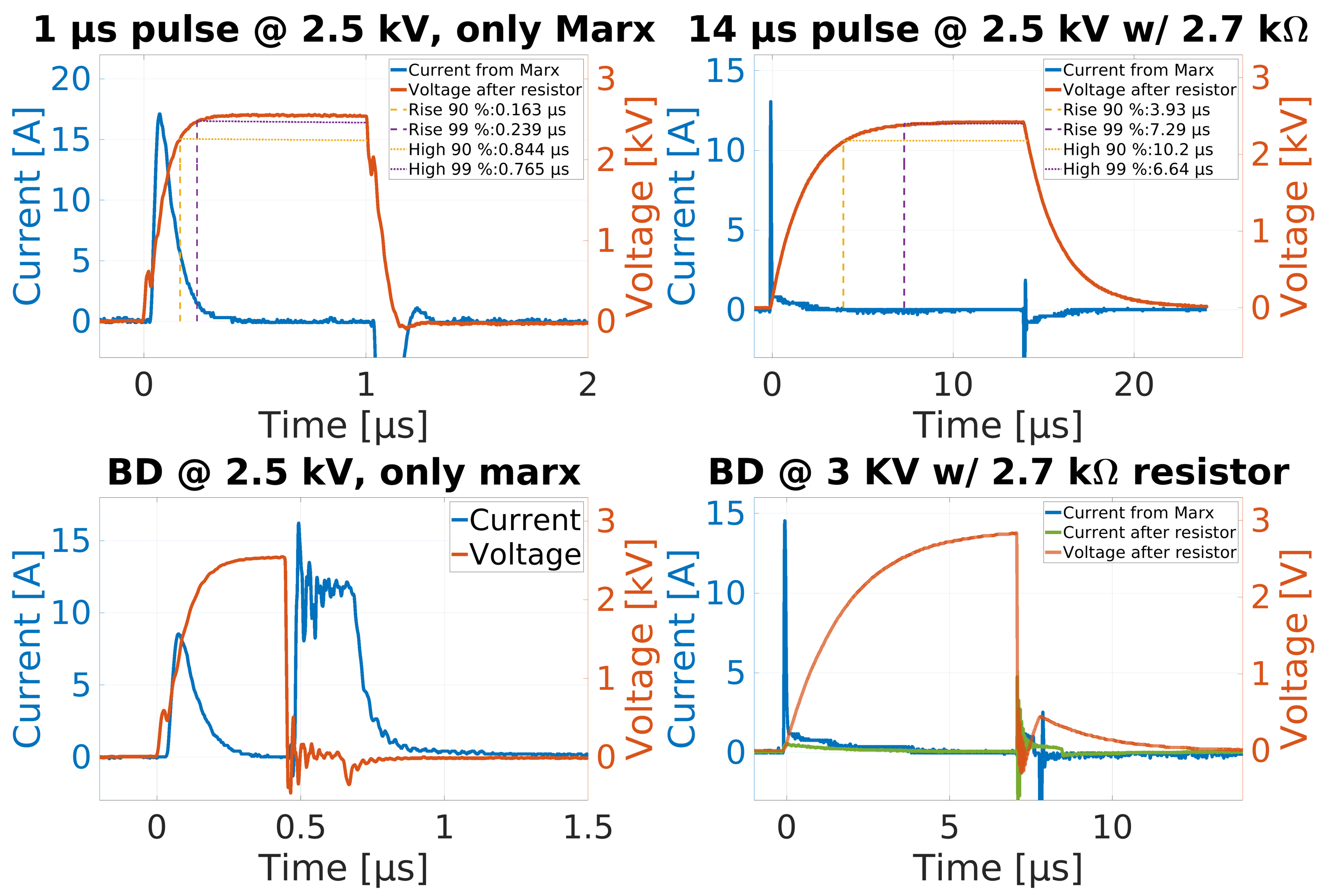

Figure 2: Waveforms for regular and breakdown pulses with and without resistors in the circuit.

PULSING WITH FREERAMP MODE

A so called freeramp mode was used for comparing the BD susceptibility with and without the resistors. In this mode, the pulsing for each run is started with a low voltage (typically 1000 V, i.e. 17 MV/m). The field is increased at a steady speed (e.g. 100 V/s) until a BD occurs and the BD field is stored. This way there are as little parameters as possible that could affect the breakdown rate and no need for distinct ramping after a BD. The conditioning effect can also be seen with this mode.

ADDING RESISTORS INCREASES THE MEAN BD ELECTRIC FIELD

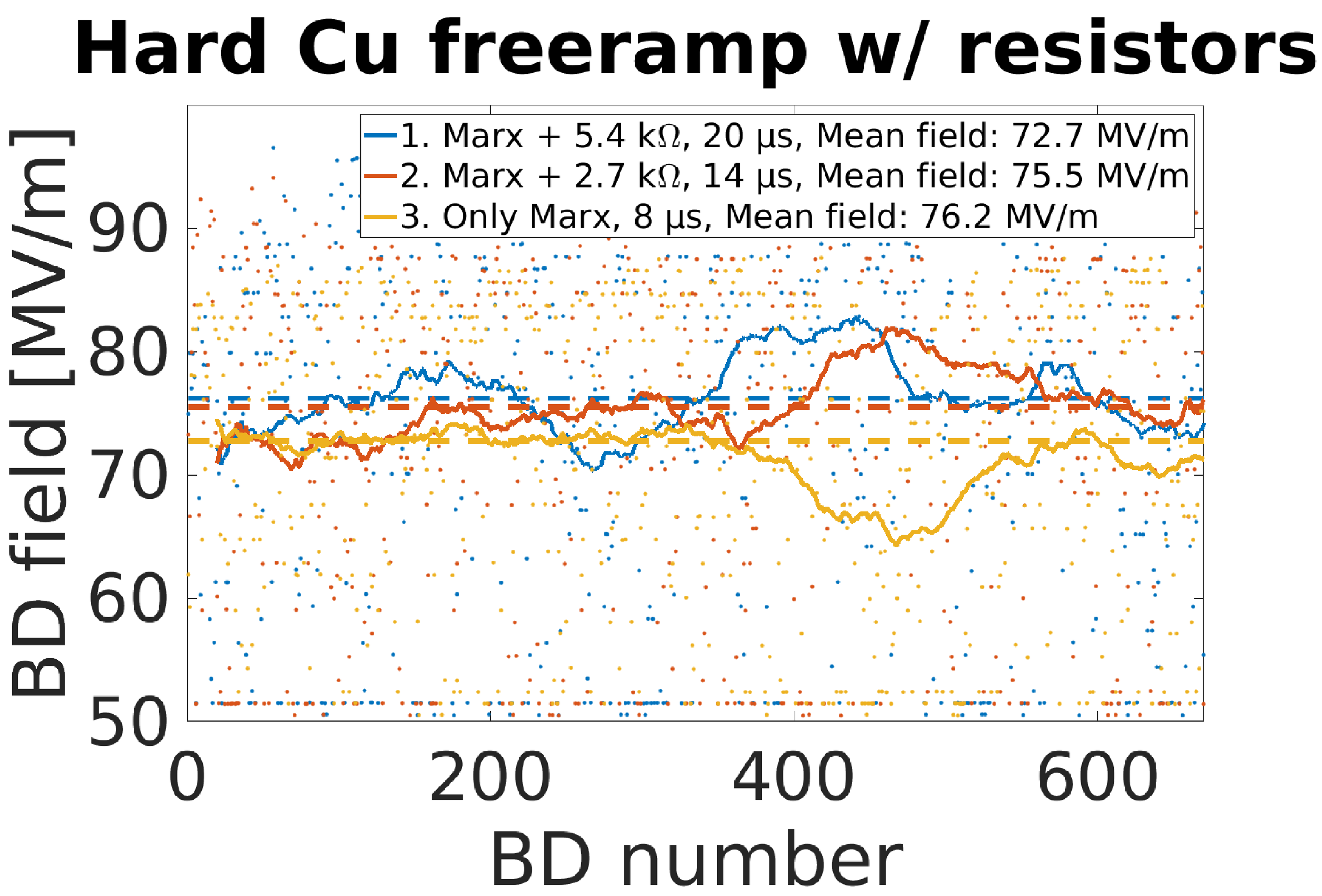

Figure 3: Results from the freeramp measurements with no resistors, 2.7 kΩ resistor and 5.4 kΩ resistors. The dots in the figure show the electric field for each BD, the solid lines — show continuous averages over 100 BDs and the dashed lines – – show the mean field over the whole run.

The results show a slight increase (5 %) in the mean BD field with the resistors. The measurements were conducted in the order shown in the legend, i.e. the possible conditioning during the pulsing plays *against* the the larger difference. Actually, longer measurements with 5.4 kΩ resistors show much larger differences of up to 19 %, but there the conditioning effect is clearly visible and this time acting *for* the larger difference.