CERN DC Spark System Capabilities

Anders Korsbäck, BE-RF-LRF
University of Helsinki

Why DC Spark Systems?

$$E = \frac{V}{d} = \frac{kV}{\mu m} = GV/m$$

- By putting a voltage on the order of kV over an electrode gap of order µm, electrodes get subjected to electric fields on the same order as RF accelerating structures are
- We can do breakdown experiments without fancy, expensive, complicated RF testing facilities!
- Or, at least we hope that DC breakdown dynamics are similar enough to RF that results we obtain this way are of relevance for CLIC…
  - And if not, at least they advance theoretical understanding of breakdown…

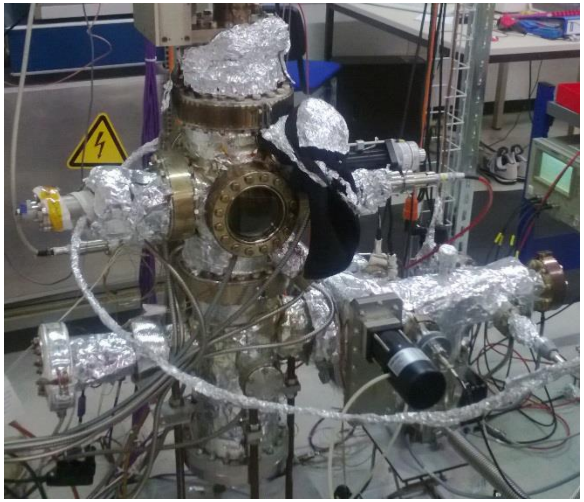
Overview

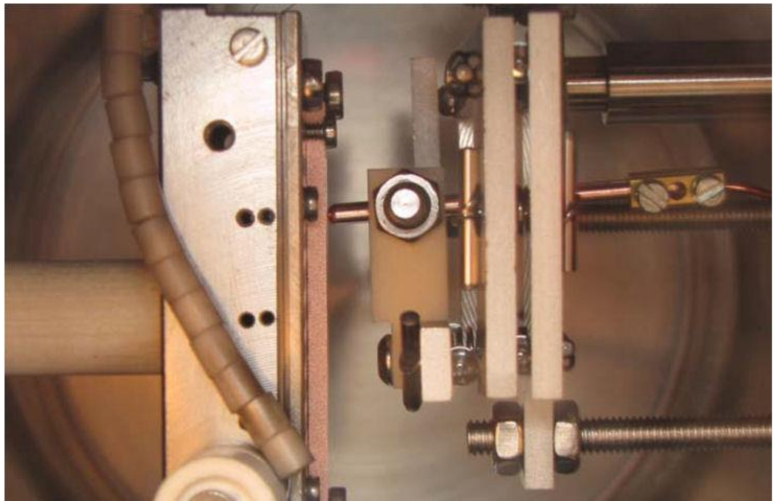
- In our lab, we have three high-voltage vacuum breakdown systems:
  - DC Spark Systems I and II, which both have a pin-anode, plate-cathode electrode setup
  - The Large Electrode System, which has a symmetric setup of two parallel disc electrodes

- We have two experiment control systems that apply voltage over the electrodes and collect measurement data:
  - The High Repetition Rate system, which applies square voltage pulses up to amplitude 8 kV, length 8 us, repetition rate 1 kHz
  - The DC voltage system, which applies DC voltage levels and is capable of field emission measurements

- We also have access to the SEM imaging capabilities of the EN group, and they have done post-mortem studies of electrodes

DC Spark System I and II



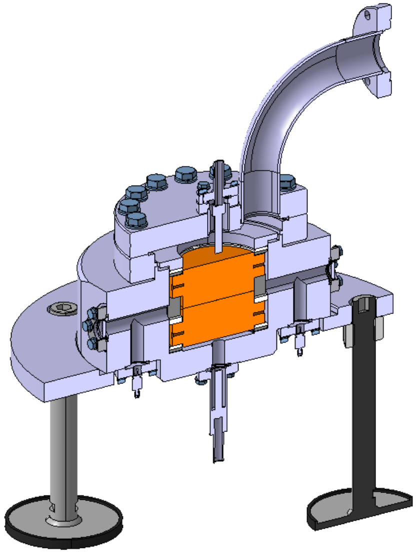


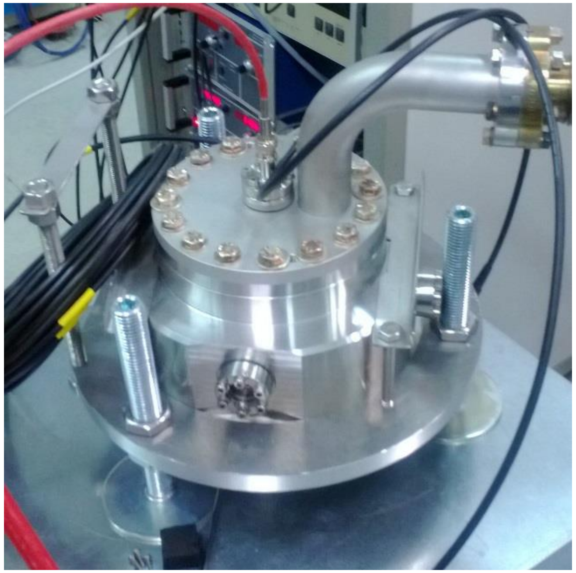
DC Spark System II, exterior (left) and electrodes (right)

These systems have an electrode setup of a pin-shaped anode and a planar cathode. Due to the tiny area where the gap is at its smallest, breakdowns are well-localized. The cathode is mounted on a stage that can be moved in all 3 dimensions, thus each cathode provides many fresh, unused spots for breakdown.

The anode is movable in one direction only, and pushed by a stepper-motor. Electrode gap distance is measured capacitively and can be controlled to less than 1 µm, if necessary without moving the electrodes into contact on the measurement spot. Also, feedback stabilization of the gap is possible.

The Large Electrode System

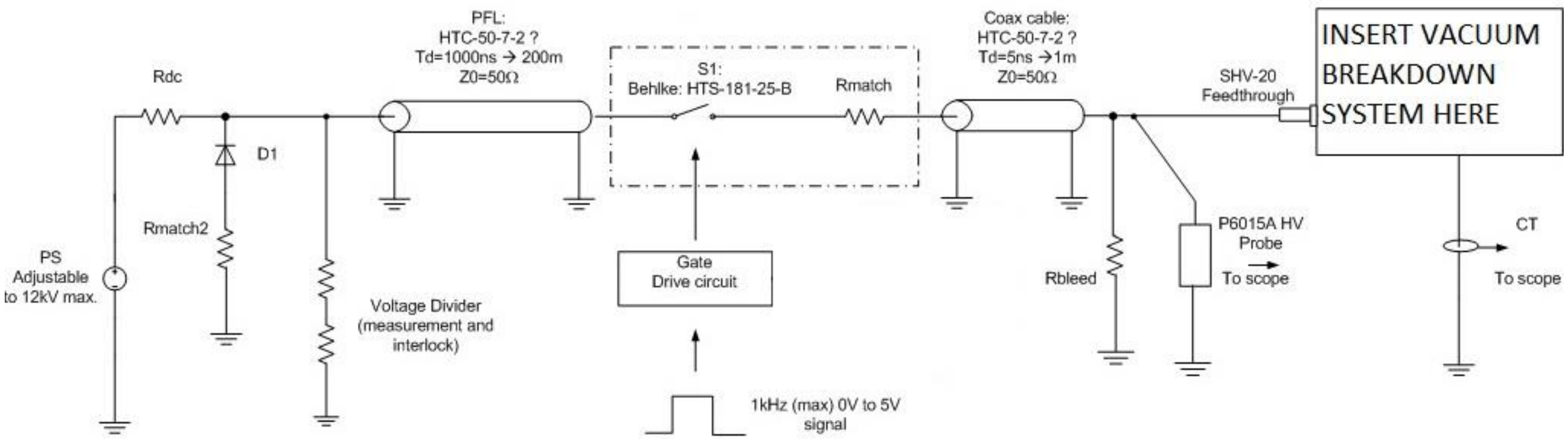




This system has a symmetric electrode setup of two parallel plates (diameter 62 mm). The gap is set through an interchangeable ceramic insert between them. All relevant parts are manufactured to sub-µm precision. Consequently, gap distance control is neither necessary nor possible (apart from changing the ceramic insert).

The main advantage of this system over DC Spark Systems I and II is the larger electrode surface that gets subjected to the electric field, making it more analogous to RF structures.

The High Repetition Rate System

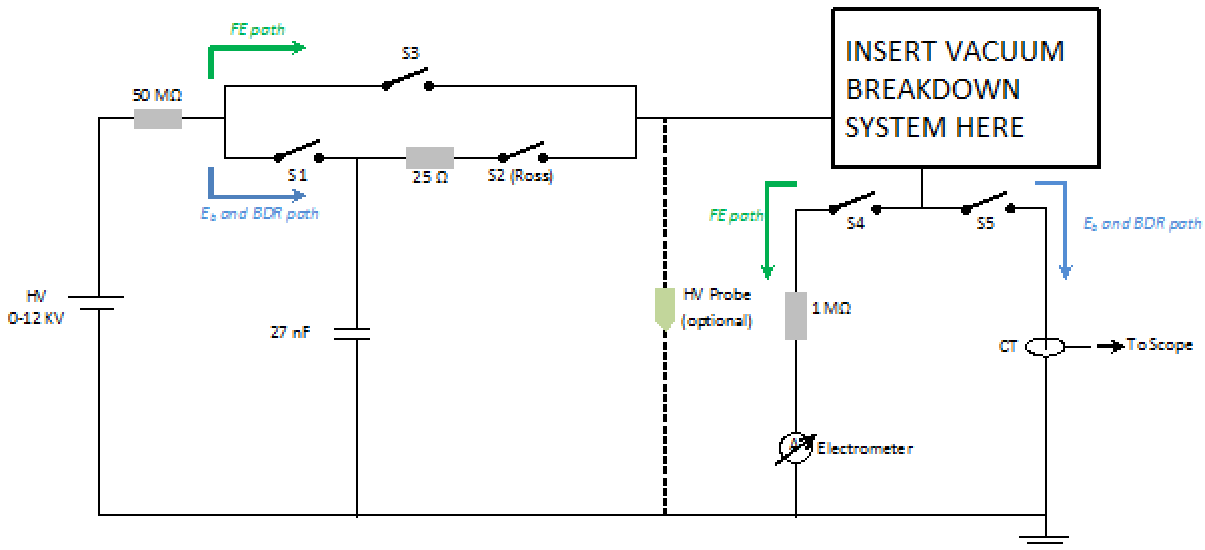


This control system is meant for collecting breakdown rate statistics. It applies voltage pulses of up to amplitude 12 kV, pulse length 8 µs and repetition rate 1 kHz, with control electronics that keep pulsing until a breakdown happens, at which point it stops pulsing and sends a signal to a computer, along with a value giving the number of pulses before breakdown.

The voltage is brought from the power supply to the system via a 100 m coaxial cable, acting as a capacitor that limits the energy available for discharge when a breakdown happens.

Fast high-voltage switching is achieved by a switch by Behlke GmbH, consisting of a stack of mosfets opened and closed in a precisely timed way. The occurrence of a breakdown is determined by the system via the current going into the vacuum breakdown system exceeding a threshold value, and is detected by a Bergoz current transformer.

The DC Voltage System



This control system applies constant DC voltage levels to the vacuum breakdown system. It can be used for measuring the breakdown susceptibility of an electrode not by breakdown rate, but by threshold breakdown field.

In addition to breakdown field measurements, it can be used for field emission studies, and is able to measure field emission currents in the pA range.

Thank you for your attention!