Design and First Measurements of a Superconducting Gravity-Impulse-Generator

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Podkletnov and Modanese[1] claimed that a high voltage discharge on a high-Tc superconductor produces a gravity force beam that can be measured using pendulums up to 150 m away from the apparatus. Obviously that would be of interest e.g. as a beamed propulsion concept.[2] More recently Poher[3] and Schroeder[4] showed similar results using a high current direct discharge through a high-Tc superconductor. Poher measured a strong mechanical impulse during the discharge as well as accelerometer signals inside a Faraday-shield in close proximity of the superconductor. We decided to build such a superconductor gravity impulse generator ourselves and to investigate the origin of the claimed accelerometer signals. Our custom-built cryostat allows to change the orientation of the superconductor as well as to directly discharge a high current through the superconductor or to generate a current using a coil around the superconductor. We designed a pulse generator capable of delivering up to 10 kA of current with voltages of up to 10 kV and pulse duration of up to 150 microseconds. In addition to a 3-axis high resolution accelerometer, we also investigated the magnetic environment as well as the acoustic noise from the discharges. To asses the effect of the high energy electromagnetic pulses generated by the discharges on the sensors, we applied an optical accelerometer. Our paper will present the results of our measurement campaign as well as an analysis of possible side-effects such as acoustic noise that can lead to false signals.

I. Introduction

A series of experiments started after the publication of the unexpected findings of E. Podkletnov and R. Nieminen[5] in 1992 while a ceramic high-temperature superconductor disc was rotated by using pseudo-rotating magnetic fields. The authors reported a weight loss of a proof mass placed above the disc dependent on its rotational speed. A follow-up paper[7] in 1997 described a modified set-up including a detailed description of the HTSC disc and its production process. The discs were described as having two regions with different critical temperatures along the rotational symmetry axis. One of which was a normal conductor at the temperature range (approx. 60 K) of the experiments. This was an important factor since it was reported that a homogeneous disc would not generate the same effect. The most important conclusion of the new measurements was that the effect was not only dependent on the rotation speed but also on the induced current's amplitude within the disc through the generated EM fields of the solenoids. A maximum weight loss of 2.1% was reported with a combined approach of rotation and induced current in the disc.

A reproduction of the experiment was performed by G. Hathaway et al. and published in detail in 2003.[6] The reproduction could show no evidence of a weight changing effect, although some aspects of the original set-up could not be met. Most importantly the magnetic levitation of the HTSC discs were unsuccessful and hence the rotation had to be done mechanically by using a motor, which delivered an average speed of 400 rpm, an order of magnitude less than specified by Podkletnov.[7] As a final conclusion Hathaway states that even though his measurement sensitivity was 50 times better than in the original reports, the results are inconclusive as to the existence of the claimed effect.

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Following the experiments with the rotating superconducting discs a new experiment has been designed and published by Podkletnov and Modanese[8] in 2001, in which most probably the object of investigation was the aspect of the induced currents from the previous trials. In this new set-up high energy DC discharges could be directed through HTSC material acting as one of the electrodes, hence eliminating the need for high frequency magnetic fields to induce the current. In the final design (Figure 1.), the reported discharges of up to 200 kV produced peak currents in the order of 10^4 A between a normal metal electrode and a HTSC disc, in which magnetic fields of up to 0.5 T were trapped. The electrodes were placed in a cylindrical evacuated enclosure while the distance between them could be varied from 0.15 to 0.40 m. With this assembly Podkletnov observed a radiation beam emitted along the discharge's axis that showed gravitation like properties. The discharges between the electrodes were focused with a solenoid wound around the chamber to optimize the reported effect, which was measured by using pendulums at close range (3-6 m) and at a distance of 150 m. It was claimed that the impulses measured with the pendulums were not attenuated by obstacles (e.g. brick walls) and were not divergent within the measurement's range. The amplitude of the pendulum's horizontal deflection was reported as being independent of the material and proportional to the mass of the sample. At the end of their paper, the authors state that preliminary observations of the interaction exists between a laser beam and the emitted flux. This effect was further investigated and the results were published[9] in 2012. It was claimed that the emitted beam attenuated the intensity of a laser beam (964 nm, 930 mW) by up to 7.5% when the incident angle was set to about 0.1°. The authors then describe a method of measuring the propagation speed of the emitted beam by using two synchronized atomic clocks. Two piezoelectric sensors placed at a distance of 1211 m were used to trigger the clocks. It was claimed that the time difference between the two triggers was 63±1 ns, which would imply a propagation speed of 64±1 c. No reproduction attempts have been made up to this date in order to confirm or dispute these reports. The replication of Podkletnov's latest impulse generator design was attempted by Junker and published in 2012.[10] The author describes in detail the carefully assembled setup including the sensors and data acquisition system, but no measurement results were included.

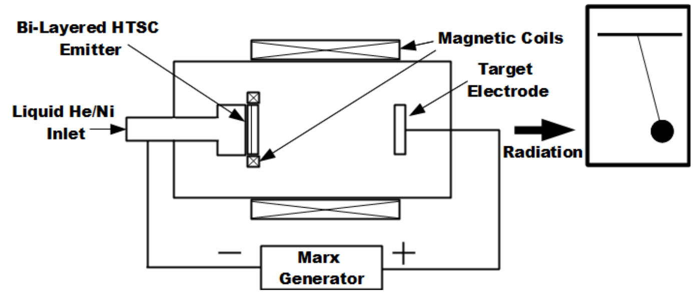


Figure 1. Schematic of Podkletnov's experimental setup[1]

More recently C. Poher et al. published a paper in early 2010[11] followed by a U.S. patent[12] later that year, in which -seemingly independent of Podkletnov- a method is described to generate a gravity like "flux" emanating from a HTSC having multiple layers with different critical temperatures similar to those of Podkletnov's designs. In his set-up the effect is caused by a high DC or AC current through the layered HTSC that is in direct contact with metallic electrodes (e.g. copper) at both ends. In addition to the emitted flux a strong recoil effect is also described, which was not observed in the experiments of Podkletnov. A major difference between the works of Podklenov and Poher is that the latter carried out thousands of measurements that were well documented and made recently publicly accessible[13] including short videos in which the claimed recoil effect is clearly visible. During the experiments numerous different HTSC

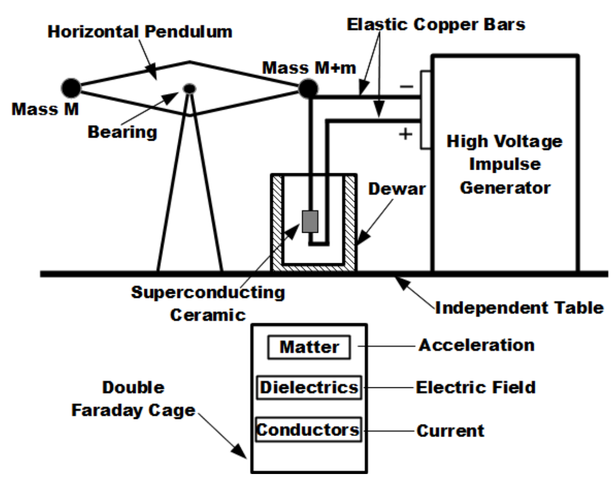


Figure 2. Schematic of Poher's Experimental setup and sensor arrangement[11]

discs (emitters) were tested in order to find the parameters that would allow an optimization of the composition, size and geometry. In their paper, Poher et al. describe a relatively simple setup for generating high voltage (up to 4 kV) DC discharges through the emitters. The current was generated by the discharge of a 47 μF capacitor connected in series with the emitter. The measurement of the recoil was done by a horizontal pendulum (Figure 2.) above the emitter while the gravity like flux was measured below in a double Faraday cage with a a non-ferromagnetic mass attached to a piezoelectric sensor at a distance of 26 cm from the emitter. Other sensors were also placed in the enclosure together with the accelerometer in order to measure the electromagnetic properties of the emitted flux and possible unwanted EM radiation. With these sensors both phenomena -recoil and flux- could be characterized. In the published results a maximum acceleration of the test mass of approx. 0.125 m/s^2 (0.0127 g) was measured[11] during a discharge of 2900 V and an estimated peak current (based on the derived total resistance of the circuit) of 6900 A through an unspecified type of emitter (designated EM42). A more detailed analysis and comparison between the experiments of Podkeltnov and Poher was already published by Modanese.[14]

Besides Poher's publications a much more extensive overview of his experiments and methods can be found online[13] in form of a journal, in which the various emitter types are described. Based the data found in the journal the conclusion can be drawn that in order to maximize -at least- the recoil effect, the emitters have to be as thin as possible and stacked on one another. He also states that the emitted flux is highly divergent and thus the sensor's projected area and distance from the emitter are crucial in the characterization process. The results of a measurement series in which the stacked piezoelectric sensor with an attached mass (of 0.687 x 10^{-3} kg) is shown in Table 1.

Five different types of sensing techniques were applied in order to try to distinguish between the claimed flux and other influencing factors like acoustic and EM noise:

1. piezoelectric sensor with a test mass (0.687 x 10^{-3} kg) attached on top
2. microphone
3. speaker/voice coil
4. light reflection on water surface
5. commercial accelerometer (11 kHz resonance) - A/120/VT/N from "DJB instruments"

Table 1. Poher's measurement results[13] of the claimed gravity like flux from a series of discharges through a stacked emitter, measured by the piezoelectric sensor with a sensitivity factor of 0.07 m/s^2/mV (0.0071 g/mV)

Discharge Voltage [V]	Discharge Energy [J]	Piezo Accelerometer [mV p-p]	Acceleration [mg]
1500	232	5.76	41.11
1900	373	7.60	54.25
2266	530	10.00	71.38
2575	685	7.92	56.53
2884	859	11.70	83.51

Since all of these methods had significantly lower resonance frequencies than the frequency of the claimed flux impulse, they were unable to deliver any conclusive data on its shape and magnitude. In fact the commercial accelerometer was put on top of a damping foam block, which actually results in a significant reduction of its resonance frequency. Industry standards dictate that the sensors are to be mounted on an as stiff as possible surface as tightly as possible in order for the sensors to meet their specifications. Hence the measurement methods applied could only be used as detectors of the anomaly's existence.

In some cases (e.g. speaker) the minimum time required for a measurable reaction of the sensor to an impulse was approx. the same as the time required for an acoustic signal to propagate into the measurement system. Even though the irrefutably existent recoil effect could be observed, it remains still an open question whether there is any presently unknown effect created in the experiment. It is still important to mention that up to this date no satisfactory explanation within known theoretical limits (e.g. electromagnetism, Joule heating) was presented for the recoil effect.

Another independent test series was conducted by Schroeder[4,15] in which a reproduction of Poher's experiments was attempted. In his setup, Schroeder connected a 1 inch diameter YBCO disc in series with a capacitor bank, which could deliver currents of up to 2 kA at 1 kV. He reported that a 1kV impulse produced an acceleration signal of approx. 0.00981 m/s^2 (0.01 g), which disappeared if the disc was above its critical temperature. To do further tests if indeed the induced current on the HTSC disc could be responsible for the reported anomalies, he connected a solenoid coil (Figure 3.) to the impulse generator and placed the HTSC disc into its middle. Also in this configuration an acceleration signal was measured only when the disc was in superconducting state, although no data is provided on the signal's amplitude.

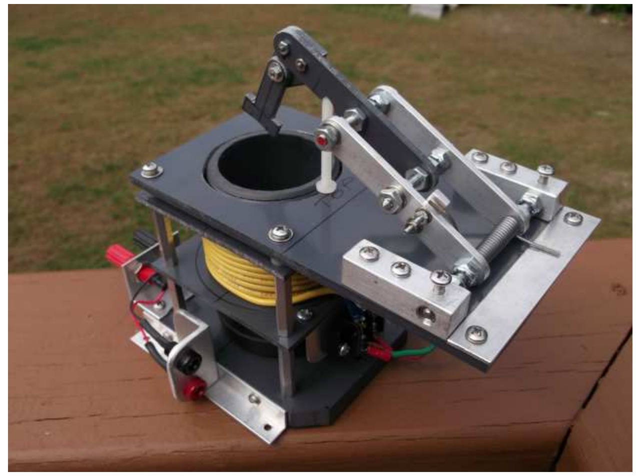


Figure 3. Schroeder's coil and HTSC disc support assembly[4]

One of us (MT) previously published[16,17] some anomalous signals recorded by accelerometers and laser gyroscopes close to mechanically rotating superconductors or matter at liquid helium temperatures. It was speculated that the acceleration of Cooper-pairs may produce a gravity-like field that was picked up by the sensors. Although strong signals were measured inside the cryostat, precise measurements outside the cryostat could not pick up signals and therefore the signals were believed not to be of gravitational origin. Of course the acceleration of the Cooper pairs by mechanical means was much less effective compared to speeds that can be obtained by a megawatt discharge through a superconductor. Therefore, the signals recorded by Podkletnov, Poher and Schroeder may also be a link to our earlier investigations.

We set out to design and construct an experimental setup in order to test the previously described claims, according to which a high voltage DC discharge or a high frequency magnetic field applied to various HTSC materials could generate a non-electromagnetic impulse beam that affects an accelerometer at a distance.

II. Experimental setup and results

Our primary objective was to create a high energy electrical current impulse delivery system that could be used in all of our measurements. This can be realized by charging up a capacitor bank to the required high voltage and by using a fast switch the bank can be then discharged (shorted) through any electrical load that is connected in series to it. It turned out that the most important part within such a system is the fast switch that could withstand the necessary currents of a few kA.

In order to gather experience we decided to approach the task in two steps:

1. A small scale version of the impulse generator that would deliver currents up to 900 A at a maximum voltage of 1 kV. These parameters were chosen in order to reproduce the experiments of Schroeder.
2. The final full scale system that would deliver current impulses in excess of 15 kA at a maximum voltage of 10 kV. This setup was foreseen to reproduce the experiments of Poher and possibly also those of Podkletnov at lower energy levels.

A. The small-scale experiments

1. Impulse generator design considerations

Four identical electrolytic capacitors were connected in series in order to increase the voltage limit of the system to 1200 V, resulting in a total capacitance of 205 μF. For the fast discharge switch we applied a medium power thyristor that would allow a current peak of up to 1 kA. During the first discharge tests into a normal conductor a high frequency, high amplitude EM radiation was emitted which induced significant error signals in the data acquisition system. At first it was suspected that the high current impulse path somehow interfered with the laboratory electrical ground. Thus a complete decoupling of the high current

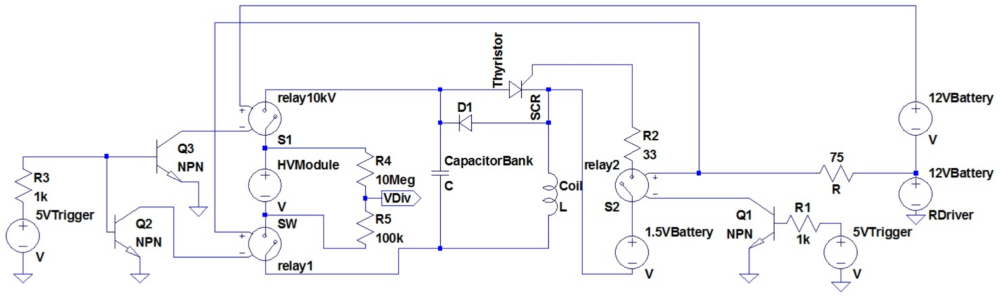


Figure 4. Schematic of the small-scale impulse generator's circuit

path from the ground was implemented through relays. A schematic of the circuit is shown in Figure 4. The triggering of the various elements was also done through the digital outputs of a PC based DAQ system. In order to prevent induced feedback errors a double decoupling solution with NPN transistors together with the relays was implemented. Even with these modifications the induced error in the DAQ system could not be removed. An oscilloscope was used in order to characterize the EMP signal (Figure 5.), because its frequency was significantly higher than the maximum sampling rate of our PC DAQ system.

The frequency of the signal turned out to be above 100 Mhz, which was the maximum sampling rate of the oscilloscope. After an analysis of the whole system it turned out that the induced EM radiation was generated at the instance when the current conducting cable connected to the load got switched to the high voltage pole of the capacitor bank. Because of the fast voltage rise that the thyristor allowed (500 V/μs) all the conductors between the load and capacitor bank were charged up to the high potential in a couple of microseconds, acting as a high power transmitting antenna. In order to eliminate this unwanted influence, considerable VHF/UHF shielding effort would have been needed either on the side of the generator/emitter assembly or the DAQ system. Since the two parts had to be connected through the output of the current sensor, acting as a bridge for the electromagnetic pulse (EMP) we decided to do the measurements with the oscilloscope. This way we were able to clearly distinguish the induced EMP, as its duration lasted only about 5% of the total discharge duration. Any kind of a signal that would depend on the current through the HTSC disc would be at least 20 times as long, reaching a maximum after 10 times the duration of the EMP. As it later turned out this was not the case with the PC DAQ system since the saturation caused by the EMP of the ADC, the accurate sampling rate (or settling frequency) fell by orders of magnitude.

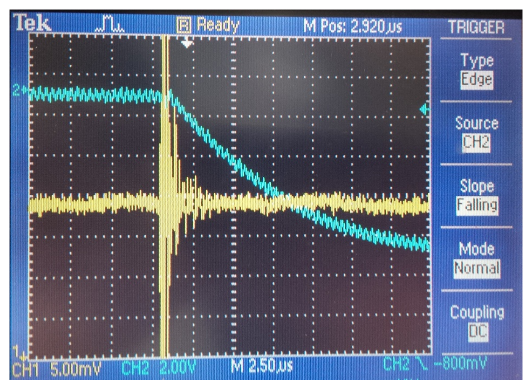


Figure 5. Induced EMP picked up by our oscilloscope. Channel 1 (5 mV/div) is measuring the output of an accelerometer, while Channel 2 (2 V/div) is measuring the output from the current sensor

2. *Sensor assembly*

A sensor assembly was designed and constructed that allowed the measurement of the acceleration (Colibrys - SF1500SN.A) and the magnetic field strength (Honewell SS495) in 3-D. The sensor pairs (each pair orthogonal to each other) were positioned in such a way that they would measure along the same axis, hence providing information of possible magnetic fields that would influence the accelerometers and thus giving false readings (Figure 6.). In order to determine the influence of a static magnetic field the sensors were read out simultaneously by the PC DAQ system while a strong magnet was moved around the closed sensor box. The applied magnetic field was above the hall sensor's minimum sensitivity by orders of magnitude but the accelerometers were unaffected. After this calibration step the magnetic field was measured during multiple discharges.

All the measurement results were orders of magnitude weaker compared to the applied magnetic field in the calibration test. Hence the sensor was shown that it could be used to measure possible changes in acceleration during discharges in superconducting emitters. In all of our measurements the sensors were placed on a damped massive granite table (independent from the cryostat's table) in order to decouple them from environmental vibrations.

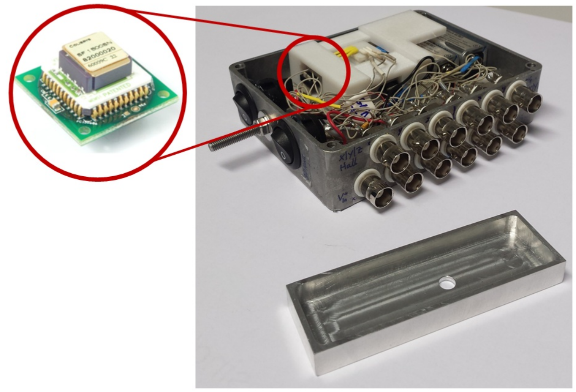


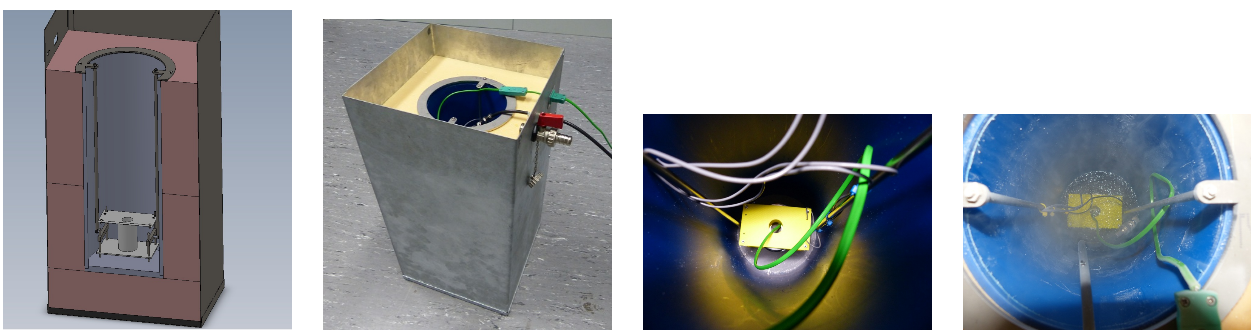
Figure 6. Accelerometer and Hall sensor assembly without the top cover

3. Emitter

For the emitter we used a commercially available YBCO disc produced through a melt-texture growth process with a diameter of 22 mm and a thickness of 3 mm purchased from CAN superconductors.

4. Cryostat and emitter support

A custom made cryostat was designed and built in order to provide a good mechanical support of the superconductor disc, the electrodes and a solenoid around the disc (Figure 7a). It was equipped with a connector for a type-K thermocouple, a BNC connector for the current impulse conducting leads and an outlet for the evaporated nitrogen gas. This design allowed a couple of hours of operation below Tc, after its cool-down period of about 30 minutes. For the outer layer an iron sheet with a high magnetic permeability was selected (Figure 7b) in order to keep any induced magnetic field inside the chamber and thus minimizing the possible influence on the sensors outside.



(a) Cyrostat CAD model cross section

(b) Finished cyrostat without its top cover

(c) Mounted HTSC disc at the center of the solenoid

(d) First cool-down of the assembly with LN

Figure 7. Cryostat design

5. Induced supercurrents in HTSC discs with a solenoid

First we set out to reproduce the measurements of Schroeder in which he directed the current impulses through a solenoid in the middle of which the HTSC disc was placed. In this configuration a rapidly changing magnetic field would induce a tangential supercurrent on the disc. Hence it would be expected that in case an anomalous effect would be produced, due to the induced current, it would propagate radially in the plane of the disc. Hence we put our sensor box first as near as possible to the cryostat wall at the disc's height. The dimensions of a coil, used (and specified) by Schroeder, was a 33 mm diameter, 13 mm high, 200 turn enameled magnetic wire coil. Since the magnitude of the induced current depends on the rate of voltage change, the optimum choice would be to create a solenoid which would make the impulse almost critically damped (on the under-damped side). As the circuit is a simple RLC oscillator, the value required

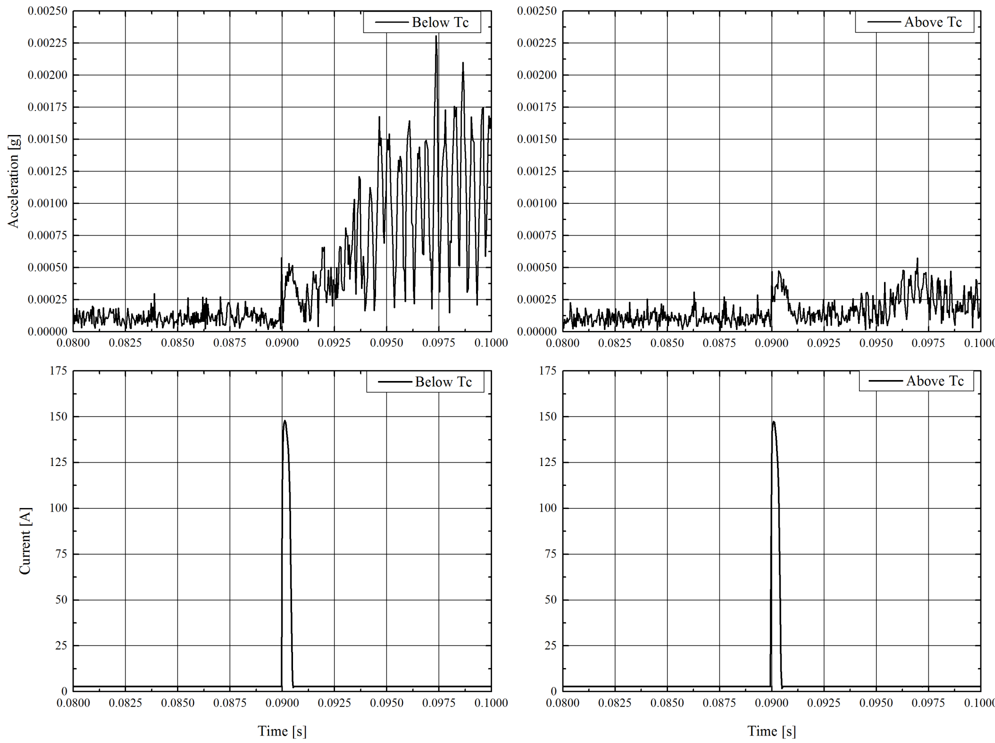


Figure 8. Magnitude of the 3-D acceleration field change measured during 20 impulses and averaged in non-superconducting (right) and superconducting state (left) of the YBCO disc

for the inductance is given by:

$$L = \frac{R_t^2}{4} \frac{C}{D_f^2}, \tag{1}$$

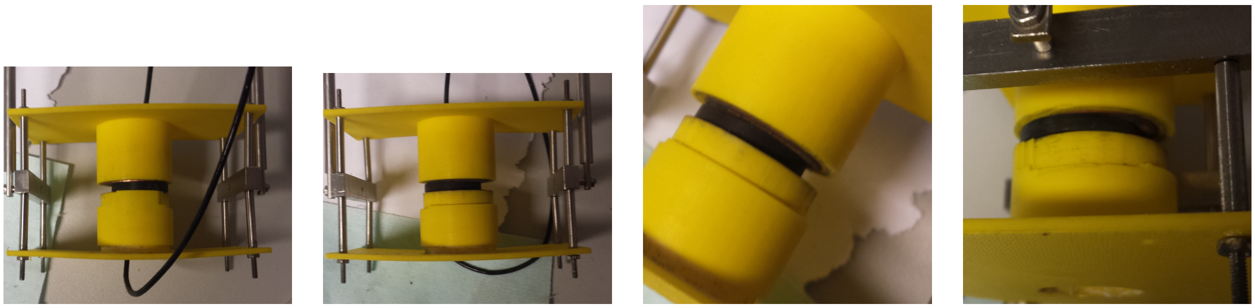
where L is the inductance, R_t is the total resistance of the circuit, C is the capacitance and D_f is the damping factor which is equal to 1 in the case of a critically damped impulse. The control measurements were carried out with a "dummy" aluminum disc and the HTSC disc at room temperature, after which the disc was cooled down to LN temperatures. The sensor was also moved along the vertical axis +/- 10 mm measured from the center of the disc. A typical discharge of approx. 1000 V produced a peak current impulse (near critical damping) through the coil of up to 200 A with a duration of up to 0.7 ms depending on the applied inductance. With these parameters and based on the reports of Schroeder we expected a peak acceleration signal in the order of 0.01 m/s^2 (0.001 g). A typical measurement is shown in Figure 8., where 20 discharges were averaged at a voltage of 800 V.

In all of our measurements a clear temporal distinction could be made between the start of the acoustic noise and the end of the current impulse, while the magnitude of the 3-D sensor noise was around 250 μg. With this setup we could not observe any anomaly within our measurement precision during the period of the discharge, although the apparent acoustic signal increased significantly in the superconducting state. It is important to note that in these measurements we used the PC DAQ system, which as already mentioned was influenced by the high EMP at the starting instant of the impulse. The peak during the discharge was caused most probably by this interference, since it can be seen in both the control and below Tc measurements. Further we have to mention here that we did not measure any trapped fields within the HTSC disc after the impulses. Schroeder was suspecting that this in fact could decrease the anomaly's amplitude, since the same magnetic field would not accelerate the same number of charge carriers if a magnetic field was trapped by the disc after the first impulse. Schroeder tried to overcome this uncertainty by moving a strong permanent magnet close to the HTSC disc and thus hoping to have disrupted the trapped fields.

6. Direct current discharges

In the next phase the HTSC disc was pressed between two copper plates having the same diameter as the disc, which in turn were connected to the current carrying cables. The contact resistance was measured through the current impulse profile and was determined that is was below 0.05 Ω. This value turned out to be important in case if we want to calculate the Joule heating across the contact resistances.

We decided to read out the sensor with an oscilloscope since in this configuration we expected the anomalous signal along the rotational symmetry axis of the YBCO disc and we wanted to clearly separate the EMP interference from real signals. A typical output of a single accelerometer during a control measurement (above Tc) can be seen in Figure 5.



(a) Front (b) Back (c) Back close-up (d) Right side close-up

Figure 9. Broken HTSC disc support

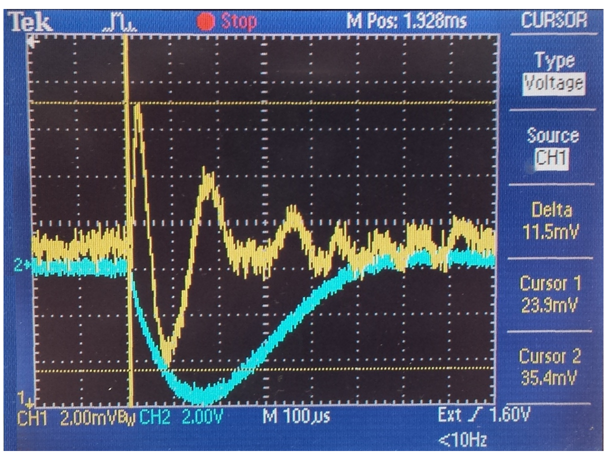


Figure 10. Anomalous accelerometer readout during a 500 V DC discharge through an YBCO disc below its critical temperature. CH1 is the accelerometer output (1.2 V/g) and CH2 is the current output (1 V/1 kA)

After the control measurements the disc was cooled down below Tc and discharges starting at 500 V have been carried out. Immediately we observed a significant change in the acoustic noise emitted from the cryostat. We could perform 14 discharges after which the electric contact was severed. After inspection it turned out that the support structure, made with a 3D printer was broken. A definite cause for the destruction of the support was not found. However as it can be seen in Figure 9. the force that broke the cylinder was oriented radially towards the outside, hinting that rapid pressure build-up could have been the cause. Although the contact resistance as measured could not have generated enough heat to evaporate the necessary volume of liquid nitrogen. During these 14 test discharges we observed three anomalous readings of the accelerometer with the oscilloscope. Since they were not repeatable, e.g. appearing in all of the discharges, we can not conclude anything specific from them at this point but for the sake of completeness we show one of the readings in Figure 10.

A possible explanation for these readings could be that the signature of the EMP changed after each discharge, since the mechanical vibration of the support structure of the disc (deduced from the increased acoustic noise) could have caused the disc in fact to chance position between the electrodes.

B. The full-scale experiments

Since the previous setup was destroyed we started the next phase in which we planned to build an impulse generator that would deliver currents up to 15 kA and maximum voltage of 10 kV. Further we decided to increase the dimensions of our emitters and make the support structure more robust.

1. *Impulse generator design*

We decided against using a high power thyristor since they are usually very sensitive to reverse voltages, which can easily destroy them. In our situation where constant changes are being done to the circuit it would take up a lot of time to tune the circuit every time. Hence we chose the solution of a spark gap that would be implemented through two brass spheres. The breakdown voltage of the spark gap would be in turn set through a stepper motor that would move one sphere while the second one would be fixed. In addition the control of the whole system would be made through a microcontroller powered by batteries in order to allow a complete electrical isolation of the impulse generator from the rest of the lab.

Two oil capacitors were acquired each having a capacitance of 100 μF and a voltage rating of 5 kV. This solution would allow us to either connect the two in series allowing a maximum voltage of 10 kV with 50 μF or in parallel resulting in a capacitance of 200 μF and maximum voltage of 5 kV. With these options the voltage increase/decrease rate, the duration and total energy of the impulse can be varied, allowing further flexibility in analyzing any possible artifacts or anomalies that we would encounter.

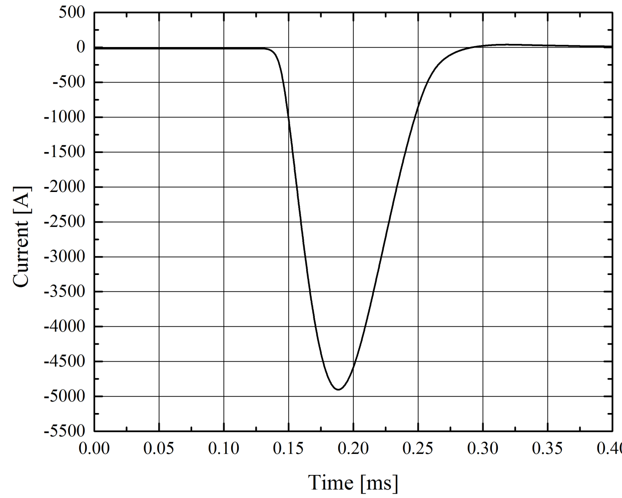


Figure 11. Current impulse profile of a 1.7 kV discharge into a 22 diameter, 3 mm thick aluminum disc at room temperature

The setup was tested first at voltages only up to 1700 V. A typical current profile at this voltage into the dummy emitter used in the previous trials can be seen in Figure 11.

2. *Piezoelectric accelerometer*

A new accelerometer (PCB-352C33) was also acquired that had a resonance frequency of about 60 kHz (supplied with a calibration sheet). The high frequency was necessary in order to have a high enough response time of the proof mass within the sensor so that any anomaly that would follow the current's profile (in the order of 10k Hz) could be measured accurately. Up to this date every measurement that tried to characterize the claimed anomalies connected to high frequency impulses was done with sensors well above their resonance frequency, hence the actual amplitude of these measurements is still an uncertain factor.

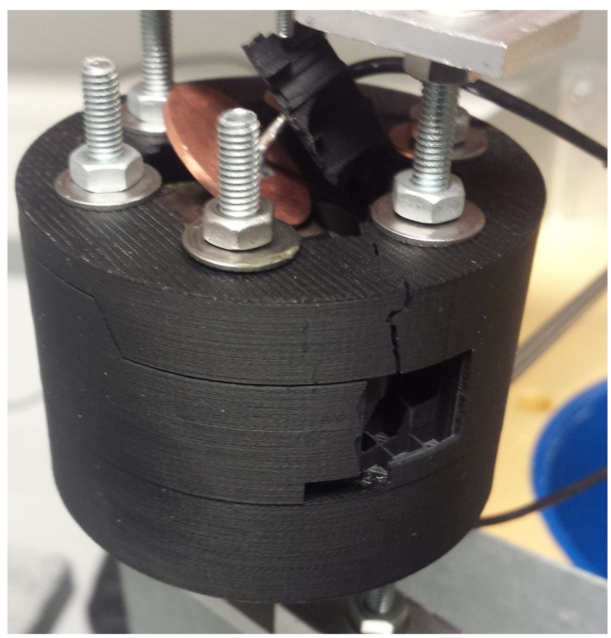


Figure 12. The destroyed second support after a few discharges at 1.3 kV into the YBCO disc

3. *Second HTSC disc support*

For the new support structure of the 22 mm YBCO disc a larger two part assembly was constructed, again with a industrial 3D printer which was held together by six bolts to assure an increased radial stiffness. The support was tested with the aluminum dummy at room- and at liquid nitrogen temperatures. After which the superconductor was placed inside it and measurements up to 1.2 kV were performed again at room- and liquid nitrogen temperatures.

The results of the first trials were rather unexpected, since after 18 discharges while the disc was below its Tc, the support broke apart again. In this case it seemed that one of the electrodes got pushed out of the assembly and essentially broke the plastic (Figure 12). No damage to the YBCO disc was observed.

In Figure 13. the measurements can be seen, which were gathered before the assembly broke. As it can be seen the EMP had a much more intense influence on the new accelerometer output than with the first one. It would seem that the EMP even excited the proof mass to vibrate, which can be seen after the current impulse. Measurements were taken on both sides of the disc while the electrode polarity across the disc was kept constant, the two sides of the disc were designated "front" and "back". The sensor was placed at 200 mm distance from the disc in alignment with its rotational symmetry axis on a separate damped granite table. With this setup a sensor base noise of $\pm 40\ \mu$g could be achieved.

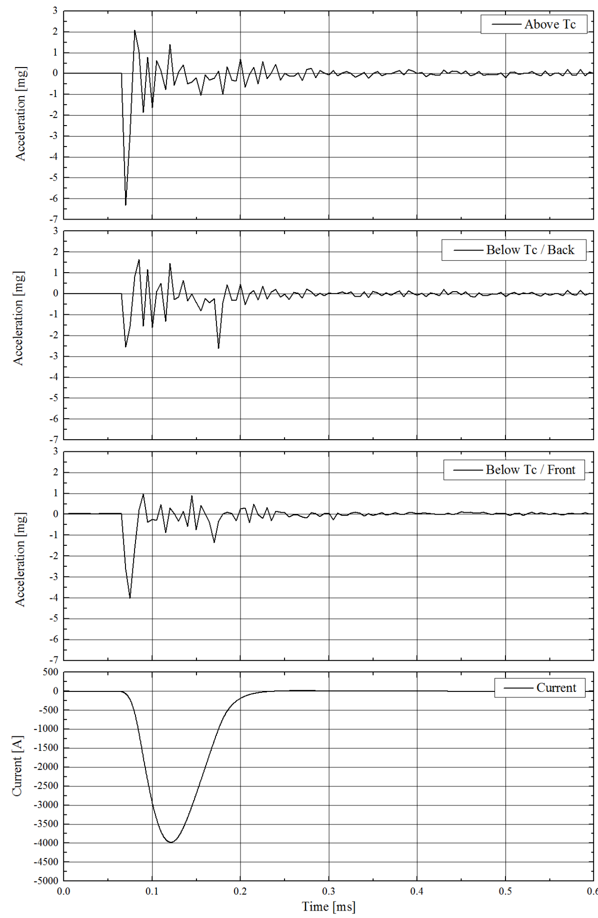


Figure 13. Measurement results with the piezoelectric sensor during discharges of 1.2 kV into the 22 mm YBCO disc

4. *Third support for the 61 mm YBCO disc*

The third support was produced simultaneously with the second one, but it was designed for a larger diameter disc, of 61 mm. After the experience with the second one we assumed that the destructive effect would in best case have the same strength or be stronger. Hence a quick solution was implemented to strengthen the assembly. To reinforce the structure against radial stresses we applied five thick cable binders around the circumference of the parts and for the axial reinforcement two copper plates were laser-cut to fit on both ends. The YBCO discs were cut out from a larger disc that was actually used in previous similar experiments.[6] This disc had a larger grain size and a weaker Meissner effect than the small commercial ones. Tests were carried out again at room temperature and below Tc in order to measure contact resistance between the disc and the new 61 mm diameter copper electrodes and to see if the support would hold. An immediate observation with this configuration was that the intense acoustic noise did not appear when the disc was below Tc suggesting that either the support was much stiffer and allowed no mechanical vibration inside or the new YBCO disc had different characteristics compared to the commercial one.

5. *Discharges into the 61 mm YBCO disc*

Since our piezoelectric accelerometer showed a significant influence from the discharge's EMP we decided to do a series of measurements with an optical accelerometer prototype. Since the sensor is still under development we cannot supply information about its details, although we are allowed to state that the resonance frequency of the sensor was close to 70 Hz and its sensitivity allowed the detection of a minimum acceleration impulse amplitude of 15 mg with a minimum pulse width of 600 μs.

The measurements were done again at room- and liquid nitrogen temperatures, at two distances of 10 mm and 400 mm from the cryostat and at three orientations of the superconductor. The sensor is shown in Figure 14. with the piezo-accelerometer on the right while facing the cryostat's wall. The area of the proof mass was orders of magnitude larger than that of the piezo-sensor.

We could safely increase the voltage of the discharges to 2.2 kV , of which two representative results are presented in Figure 15a, where the cryostat was placed at 10 mm away from the sensors and Figure 15b, where the distance was increased to 400 mm. A clearly identifiable signal in both cases is the accoustic noise that follows the current impulse. Further data analysis will be needed in order to determine the actual lower boundaries this measurement provided. For this the sensor has to be calibrated and characterized which will follow in the future. Another important aspect that we could show with our preliminary tests is that the optical sensor was not influenced by the EMP, which will be important for upcoming measurements where we will increase the discharge voltage up to 10 kV.

After the measurements were finished a new configuration was tried out, where the 61 mm and the 21 mm diameter discs were pressed together, aligned concentrically and inserted into the support. We wanted to investigate this station as well since the larger YBCO disc did not produce the high intensity acoustic noise. With this configuration control discharges were also done in order to asses the contact resistances between the electrodes and the two discs. After this the discs were cooled to LN temperatures and discharges at a voltage of 1.7 kV were performed. Indeed the acoustic noise reappeared with a much greater intensity. After a few discharges the assembly broke apart again with a much greater destructive force as before, as it can be seen in Figure 16. This time both superconductors broke into small pieces.

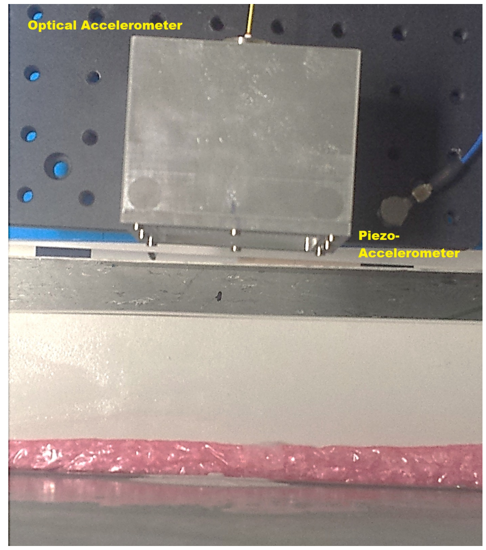
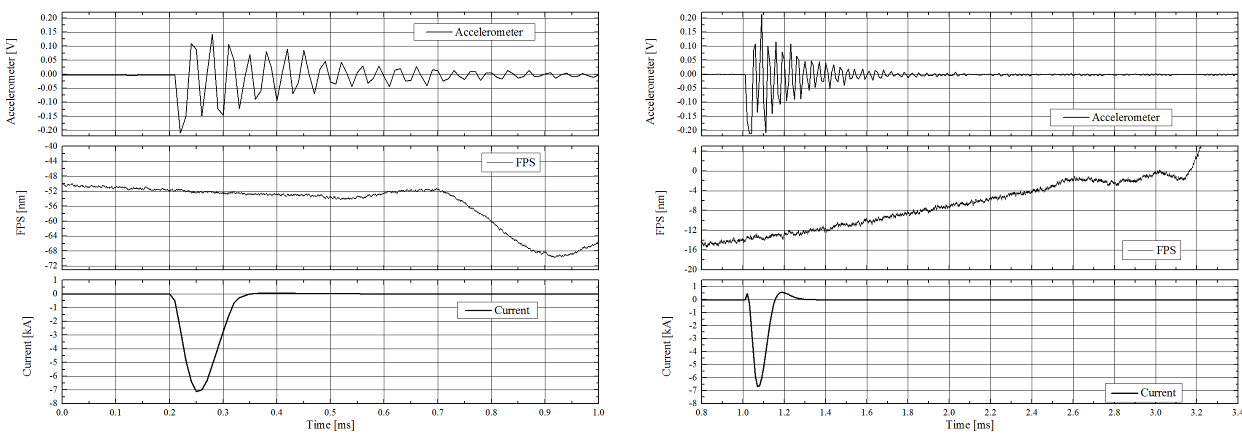


Figure 14. The optical accelerometer (top-center) facing the cryostat and the piezo-accelerometer (top-right) placed vertically for the reference measurements of the EMP influence



(a) 1 cm distance from the fron side of the emitter

(b) 40 cm distance from the fron side of the emitter

Figure 15. Representative measurements done with the optical accelerometer and piezo-accelerometer during discharges of 2.2 kV

III. Conclusion

During the last two decades multiple groups have reported claims that superconductors could emit gravity like beams when subjected to high intensity electrical current impulses. We set out to build an experimental facility in order to test these claims and finally end the dispute whether the reported effects are of currently unknown nature or just measurement artifacts.

We gathered experience by building a small scale impulse generator, with which we could deliver relatively small current impulses of up to 1 kA as direct current discharges through a 22 mm diameter YBCO disc and up to 200 A through a solenoid both serving the purpose of inducing a supercurrent. The measurement results during the discharges into the solenoid showed no anomaly. Further, the measurement results during the direct current discharges through the superconducting disc were inconclusive since the assembly broke before we could gather repeatable data. The cause for the destruction is still unknown, thus further investigation will be required to answer this open question.

Next we designed and built a high power impulse generator, that successfully delivered peak currents up to 9 kA at 2.9 kV. The maximum potential of the generator is still to be reached after additional safety and shielding will be installed in order to protect the lab equipment from the high intensity EMP. We performed discharges through the small, 22 mm YBCO disc of up to 1.3 kV and 4 kA, which quickly destroyed the reinforced support structure. The cause for the destruction is still unknown. We tested a new piezoelectric accelerometer with a guaranteed resonance frequency close to 60 kHz, which assures a fast enough rise time to accurately measure the amplitude of any gravity like anomaly with an impulse profile identical to the electrical current during the impulses. It was determined that the generated EMP at the instance of the discharge produced a mechanical vibration within the sensor, thus making any measurement unreliable. In the future a UHF/VHF shielded enclosure will be constructed within which all data acquisition will take place thus ensuring minimal unwanted influences.

Impulses were performed through a powder pressed 61 mm diameter YBCO superconductor. During these discharges of up to 2.2 kV and 8 kA, an optical accelerometer prototype was used to measure eventual anomalies. With these measurements we could put a maximum limit for any gravity like anomaly's magnitude emitted from this assembly to 15 mg. Further data processing and calibration will be carried out in order to determine the actual minimum threshold of the sensor in these conditions. We could determine that the optical sensor was not influenced by the EMP, which caused a lot of complications for us and the other teams as well. Finally we performed discharges through the small and large disc connected in series, which resulted in a much higher acoustic effect and quickly destroyed the new reinforced support. During the destruction of the support both superconductors broke into pieces, the cause of which is still yet to be determined.

For the future it is foreseen that we test multiple types of emitters as they were described within the works presented previously in this paper.

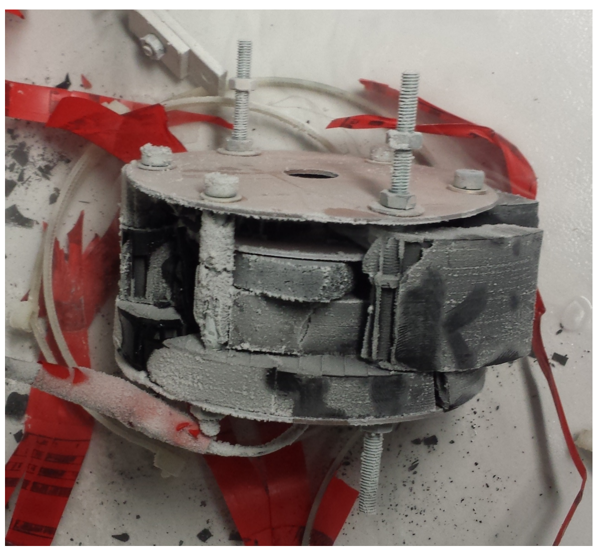


Figure 16. Destroyed support and superconductors by the double HTSC disc configuration during 1.7 kV discharges (photo taken right after the assembly was dismounted from the cryostat)

IV. Acknowledgment

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