First results on wave form and frequency dependence of AHE stimulations of coaxially-coiled constantan wires, under H_2 gas, by High Power-Voltage pulses at High Temperatures.

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Introduction

In the LENR-AHE (Low Energy Nuclear Reactions-Anomalous Heat Effect) project the importance of "*stimulation*" the AHE effects by electrons, particularly their simple and practical use, are appreciated.

- **Since 2011 we have focused on a specific (old, since 1890) Cu-Ni alloy, called Constantan ($Cu_{55}Ni_{44}Mn_1$), that has the peculiarity of "providing" quite large energy (up to 3 eV) for the dissociation of Hydrogen (and/or Deuterium) from molecular to atomic state (the starting point for any kind of reactions in the LENR field).**
- **In comparison Palladium (Pd), the most largely material used, can provide energy of only 0.424 eV.**

- **In addition, the cost of Constantan is several thousand times cheaper than Pd (recently 70 €/g): important attributes for any commercial application of the AHE.**

- **At the current time, the AHE are quite difficult to be induced and/or reproduced by a third part; moreover, the long-term stability remains an unsolved problem.**

Experimental set-up

- **Since 2019 we assembled the Constantan, in the shape of long (up to 2 m) and thin (diameters 100-350 μm) wires, as a coil that around an inner a Fe tube, used as counter-electrode.**

- **Geometry overall similar to (niche) both electrolytic systems and/or (old) vacuum tube diodes: *coaxial* type.**

- **The Constantan wire surfaces are coated, multiple depositions, by mixture of Low Work Function (LWF, i.e. SrO, K) and magnetic Fe_xO_y materials, deposited at sub-micrometric thickness (simple chemical-physical procedures).**

- **The Constant coaxial coil and some details of construction are shown in Fig. 1A, 1B.**

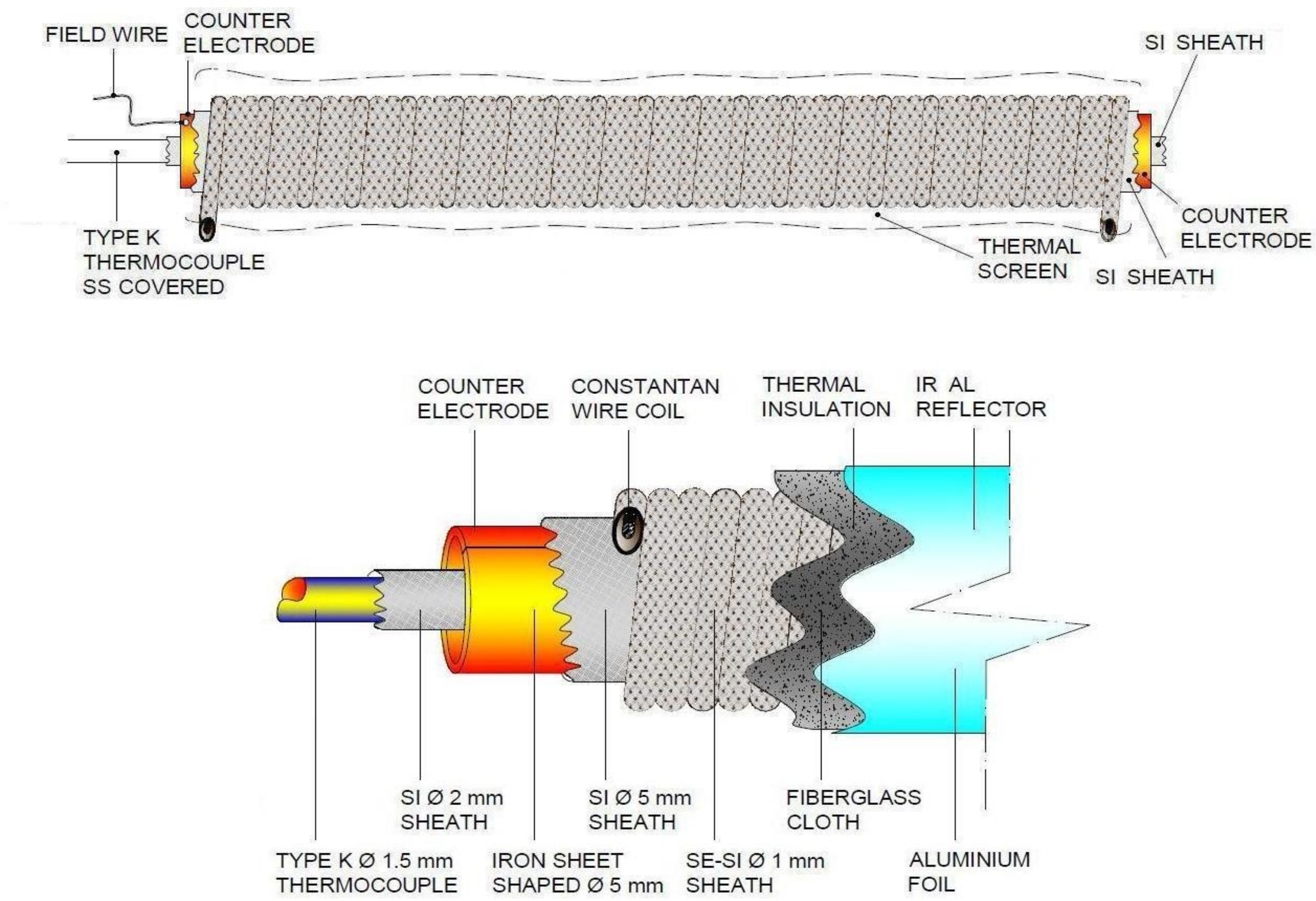

Fig. 1A. Scheme of the coaxial coil with its inner Fe counter-electrode. A coil, length of 158 cm, had usually 75 turns; recently reduced to about 50 because HV insulation problematics.

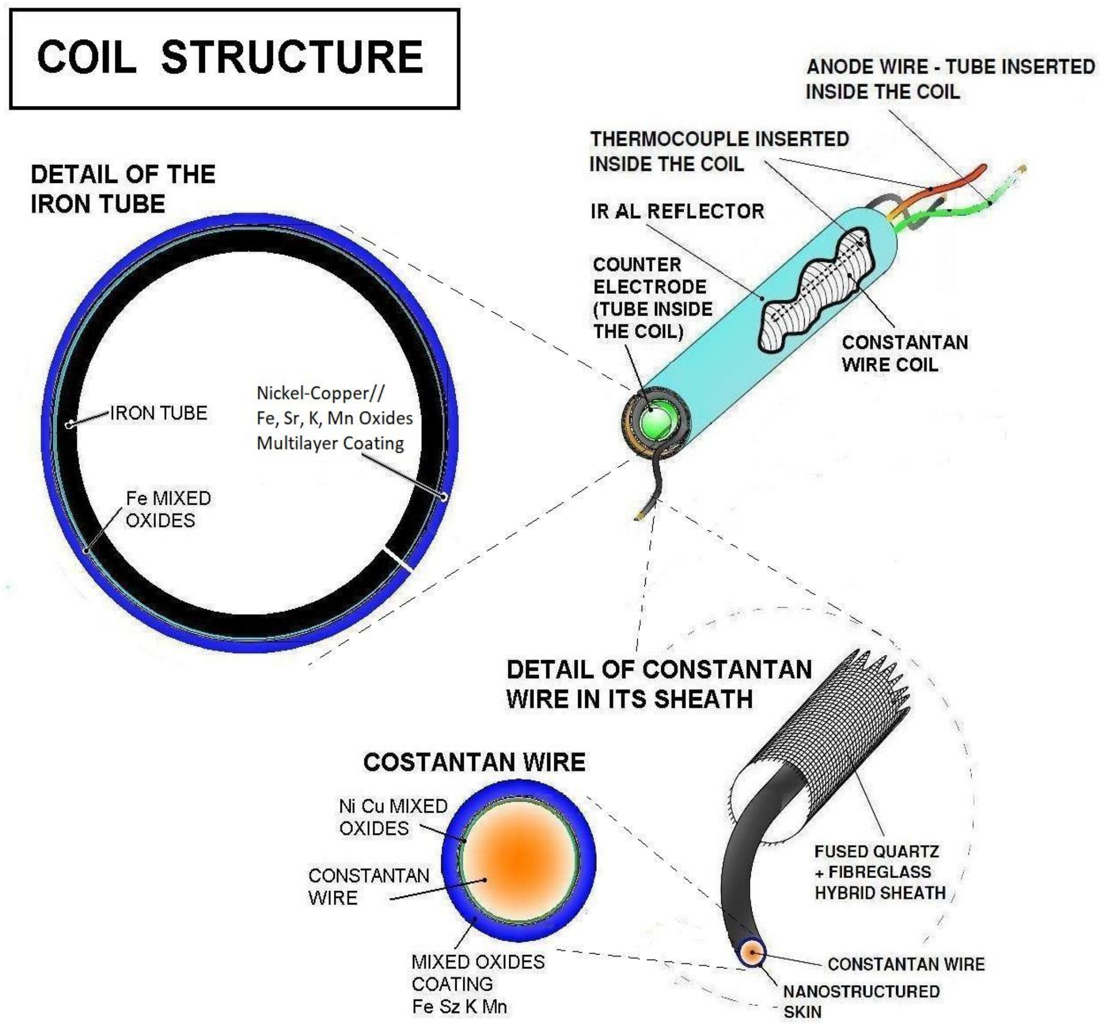

Fig.1B. Overview of the coil assembly: multilayer coating of LWF oxides; high temperature insulating hybrid glass-(AlO_2-SiO_2) porous sheaths; external IR reflector. In the recent experiments the IR reflector was removed because necessity to observe possible sparks.

Experimental results

- **In 2019 (ICCF22, flow calorimetry) we observed that applying a mild AC excitation (+-600 V, sinusoidal 50 Hz, low current) among the electrodes, covered by thin and partially porous glassy sheaths (holes <100 μm), under proper gas (pure H_2 and/or mixed with Ar, Xe) and low pressures (<100 mbar), it was possible to induce AHE and sustain the useful effects, once started.**

- **The effects were larger increasing temperatures (>600 °C) and lowering the pressures (down to few mbar). Such observations were consistent with both LWF materials (active at high temperatures, according to *Richardson's formula, i.e. electron emission*) and low pressure, where are possible also Paschen/DBD effects (at proper pressure-distance intervals) about gas discharge, with possible surfaces re-activation.**

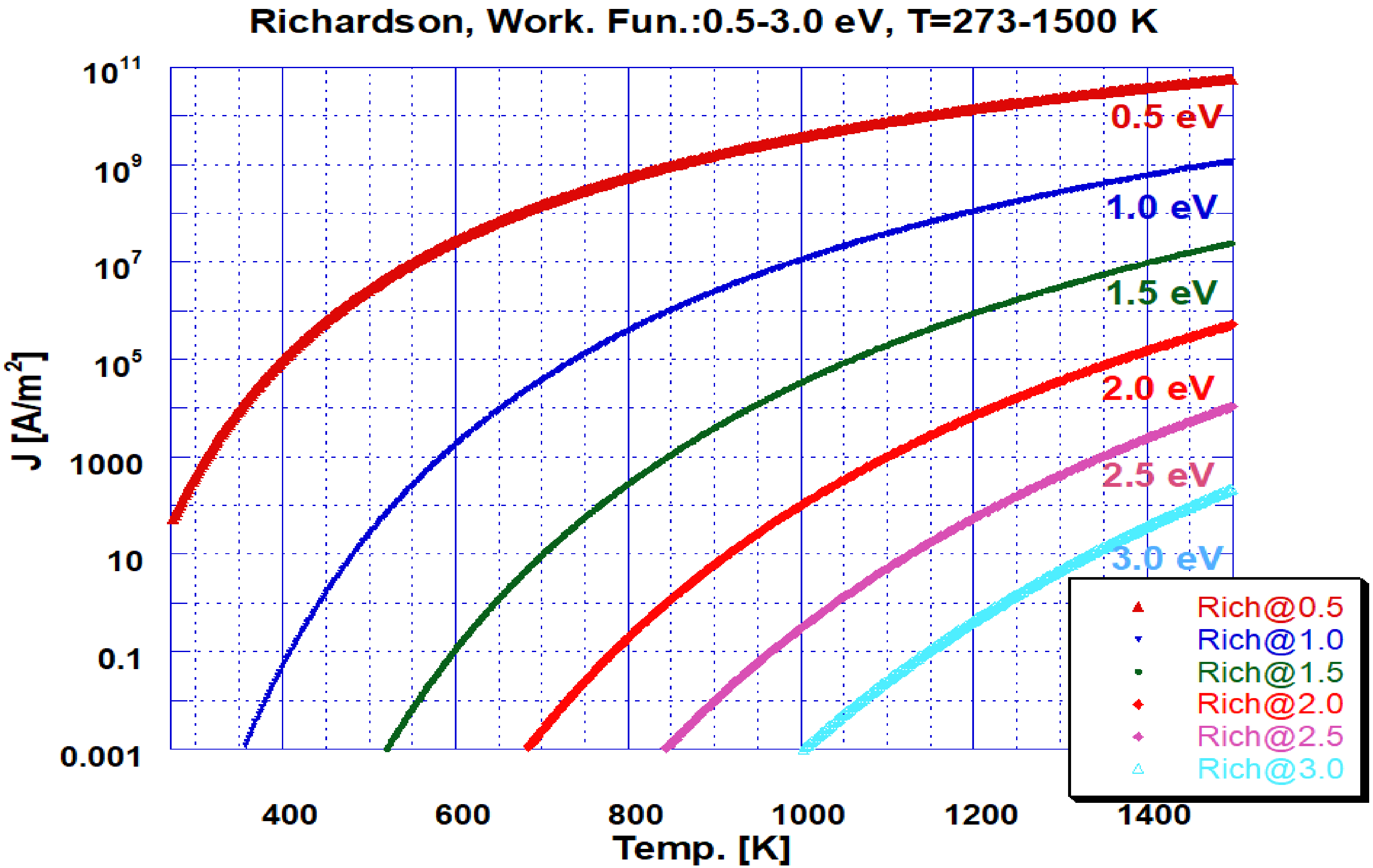

Fig.2. Calculated dependence of density of electron emission J (A/m^2) versus Temperature (273-1500 K) and Work Function (0.5—3.0 eV) as main parameter, according to the Richardson's law.

- **In such conditions H_2 flux, in-out from the surface, seemed to be the most important macroscopic parameter to get AHE.**

- **In 2021 (ICCF23), we moved to very high power (up to 10 kV*A/g; minus polarity), short duration (10 μs), few kHz of repetition rate, fast rise and fall time (range between 100 ns and few μs), pulses.**

- **To give power to the wire we used ONLY the pulses, i.e. NO DC power was used, as in the previous experiments. The pulse duration was kept constant at 10 μs. The applied power was changed by variation of both the applied voltage to the pulser circuitry (from 50 V up to 400 V, steps of 50 V) and the repetition rate (1000, 1500, 2000, 2500 Hz). In such a way, we were able to have a power variation from 0.5 W up to 90 W.**

- **Typical high-power pulse, sent longitudinally to the 200 μm wire, is shown in Fig.3. The peak power density reached values as high as 10 kV*A/g (green line in Fig. 1): the weight of our coil is about 0.45 g.**

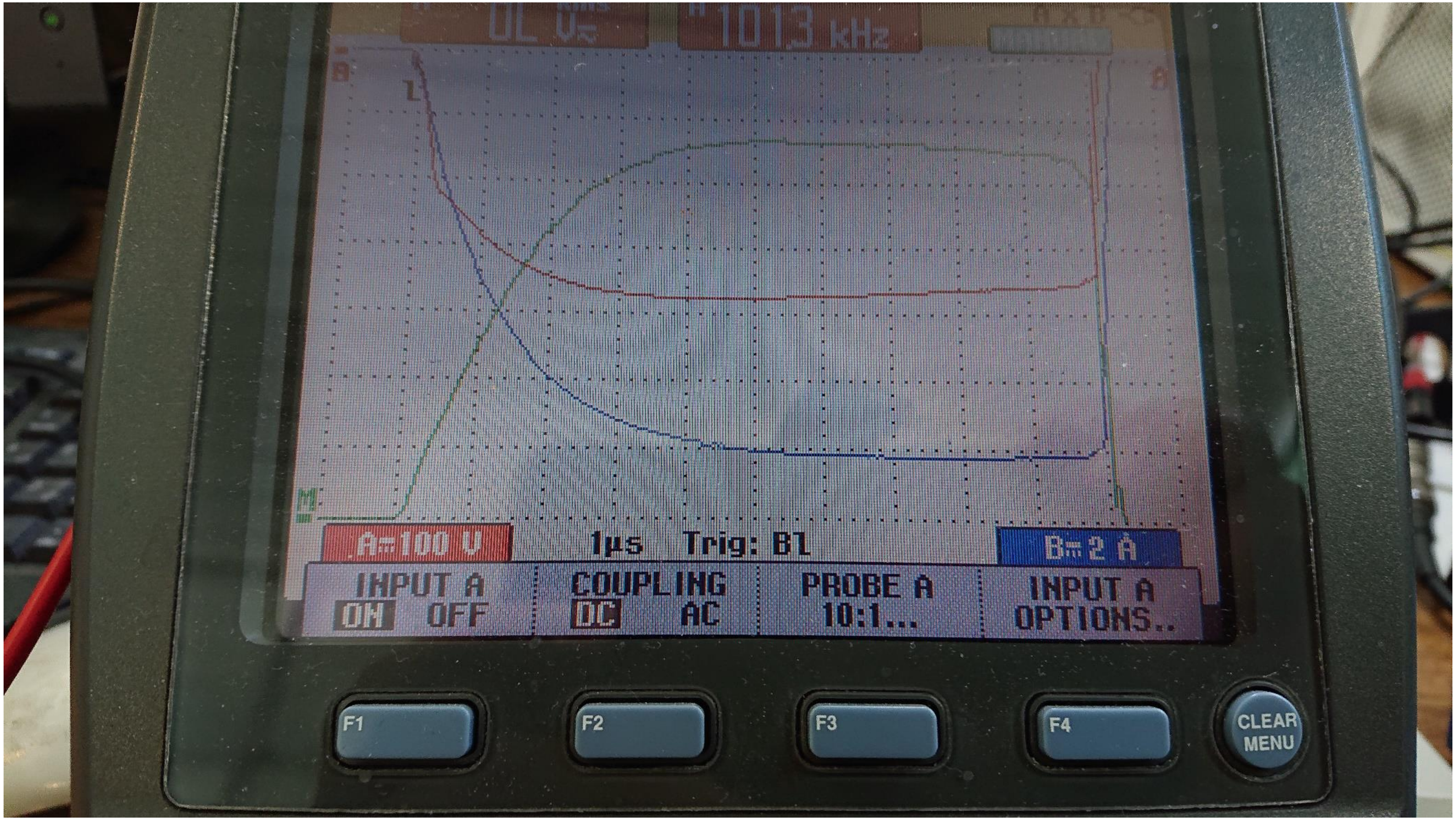

Fig. 3. Snapshot of typical pulse of high power, sent *longitudinally* to the 200 μm wire. Time: 1 μs /div. The Voltage is in red colour (peak value is -380 V), the Current is in bleu colour (peak value -12.4 A), the Power is green colour (peak value 4640 W, equivalent to 10 kV*A/g of Constantan).

- **About AHE measurements, we used a simple "dissipation" calorimeter, i.e. *thermometry*, where we were able to make only relative measurements in respect to reference conditions that we imposed to produce zero AHE. This was necessary because short time scale needed for useful results (<0.5 h) compared to long (6 h) equilibrium time of our air-flow calorimeter.**

- **The results about AHE were evaluated considering ZERO AHE when the power given was in only in DC.**

- **Because such procedure the AHE values (if any), obtained by pulsing, are conservative.**

- **We observed, quite frequently, excess AHE of the order of several W. The values increased increasing the repetition rate.**

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- **Our aim was to induce also, *controlled and in-phase*, Paschen/DBD regimes by proper unipolar high voltages (over +1000 V) short time pulses with extremely fast rise time (100 ns range).**

- **In order to obtain such additional characteristics, the pulses were “self-generated”, internally to the coil, at the end of main power pulse (typical duration 10 μs, current I tens of A).**

- **We used the fact that the coil is intrinsically inductive with wire surface coated by several layers of magnetic materials (Fe_xO_y) and also the core is a magnetic material (Fe).**

- **The voltage generates is: V=L*dI/dt and “used” the fast rise-time (<100 ns) opening of the main switch (SiC technology).**
- **A typical high voltage pulse, due to the high current shown in Fig. 3, is shown in Fig. 5. Peak voltage value is as large as +1080 V.**

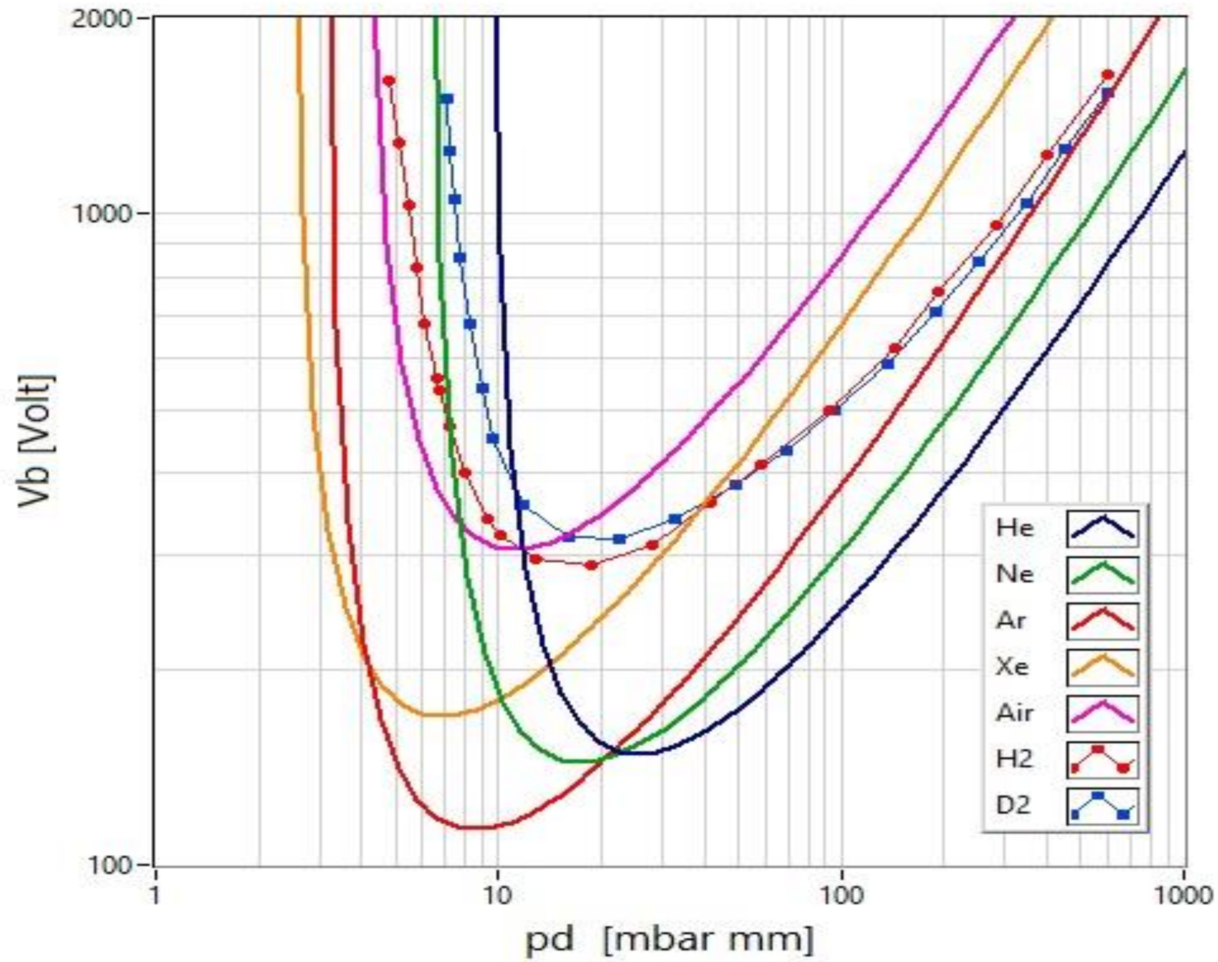

Figure 4. Paschen curve. Direct current breakdown tension (Vb) of several gases versus pressure and distance between electrodes (p*d). The addition of Ar to H_2 or D_2 clearly enables discharges at lower voltages. He could be useful at higher values of p*d. We made test with both noble gas (i.e. He, Ar), pure or mixed with mainly H_2. Mixtures with D_2 were also made but quite difficult to be fully understood.

Fig. 5. Snapshot of the transversal pulse, time is 2 μs/div. As reference there is the current applied (in blue colour). The Voltage (200 V/div), positive, among the counter-electrode (i.e. the Fe tube) and the Constantan coil is in red colour. Maximum value, in this test, was +1060 V.

- **NOTIFICATION*. Anyway, at the moment we were not able to exploit all the possibilities of the system, i.e. Richardson and Paschen regimes, because uncontrolled excessive current during Paschen regime that catastrophically destroyed the thin Constantan wires.***

- ***We were forced to make test only in region of Voltage-Pressure out of the Paschen regime.***

Effects of pulse shape on AHE production.

- **Because we observed that the AHE increased increasing the frequency, we explored new regimes changing the values of pulse duration (decreased) and repetition rate (increased).**

We explored the combinations:

a) 5.0 μs at 5 kHz;

b) 2.5 μs at 10 kHz.

- **Typical snapshots from the oscilloscope are shown in**
  a) Fig 6 and 7, with 5 μs at 5 kHz;
  b) Fig. 8 and 9, with 2.5 μs, 10 kHz.

- **Similarly, to Fig. 3 and 5, are shown both the longitudinal current flowing along the wire (fig. 6, 8) and the transversal voltage (positive) among the Fe counter electrode (the most positive) and Constantan wire (Fig. 7 and 9).**

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Fig. 6. Snapshot of transversal pulse. Time duration 5 μs, repetition rate 5 kHz. Time division: 500ns.

Longitudinal voltage along the Constantan is in red colour (100V/div). Current is in blue (2 A/div), Power is in green (800 W/div). Because inductive effects, the power reached top values only for about 500 ns.

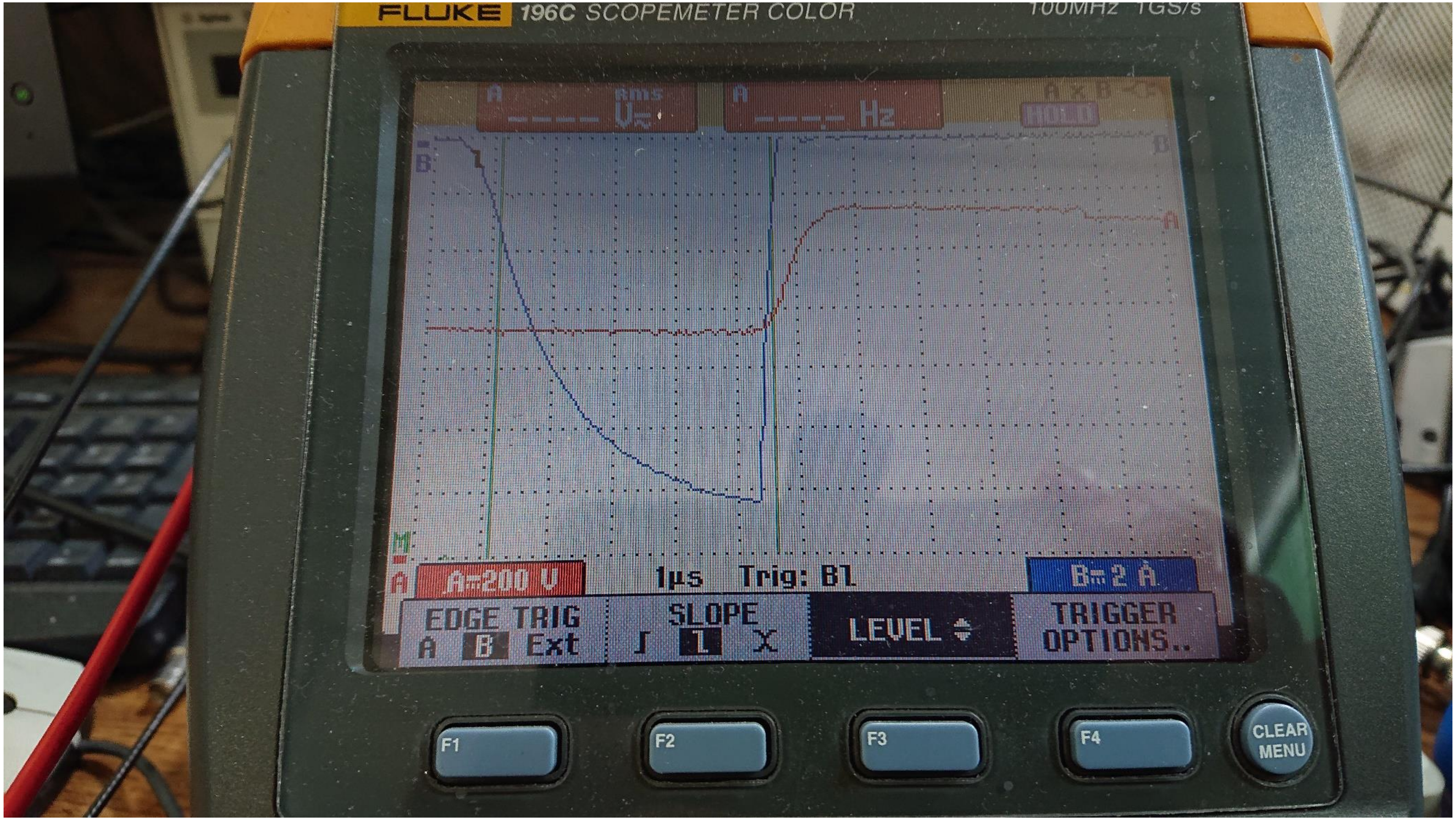

Fig. 7. Snapshot of transversal positive voltage (Fe <-> Constantan). Because the larger peak current (about 12. 5 A) at the moment of switching-off, in respect to 10 μs test, the peak Voltage (in red colour) reached values as large as +1160 V.

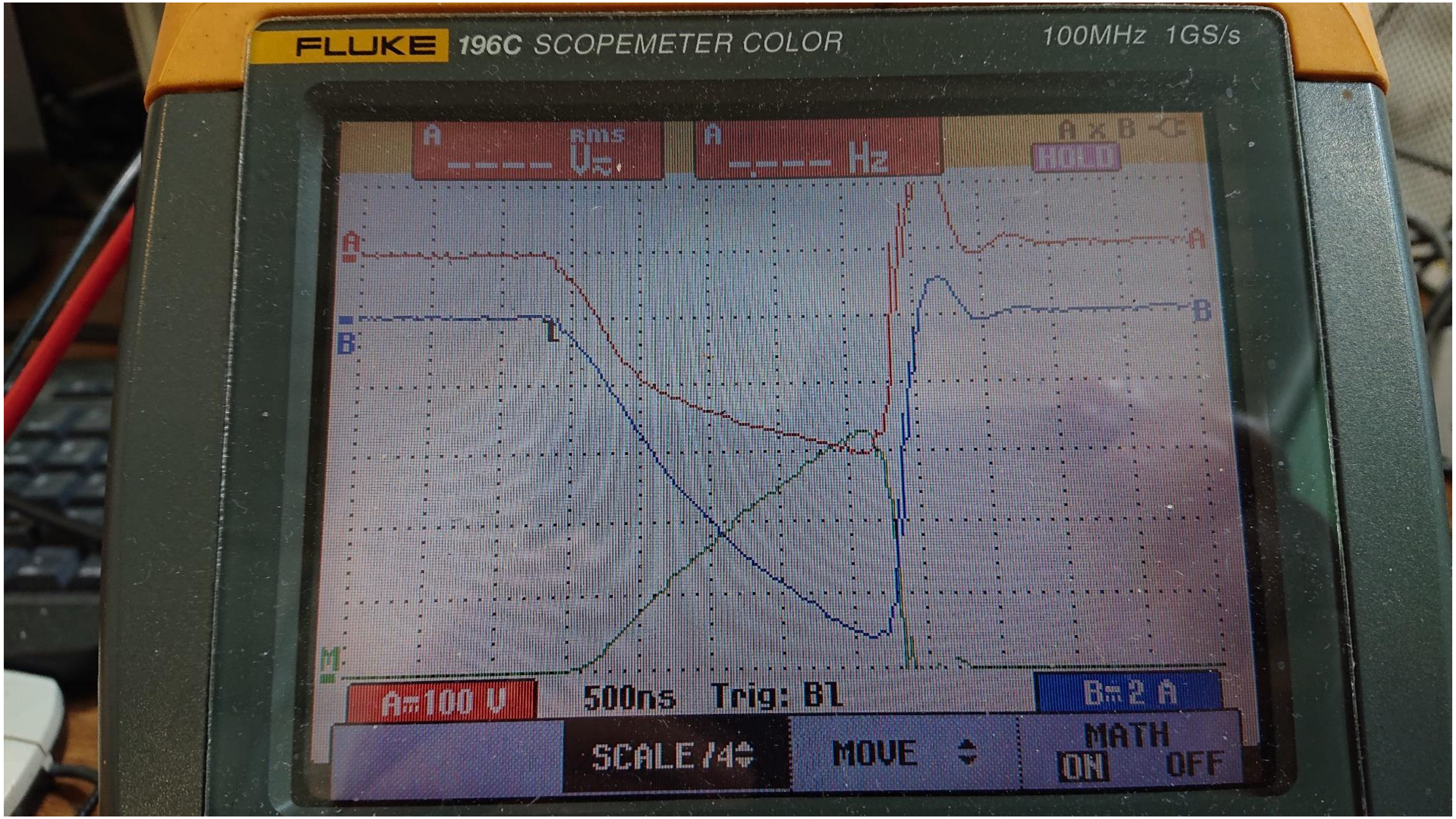

Fig. 8. Snapshot of transversal pulse. Time duration 2.5 μs, repetition rate 10 kHz. Time division: 500ns. Longitudinal voltage along the Constantan is in red colour (100V/div). Current is in blue (2 A/div), Power is in green (800 W/div). Because inductive effects, the power reached top values of only 2700 W, in respect to over 4600 W using 10 μs of pulse duration.

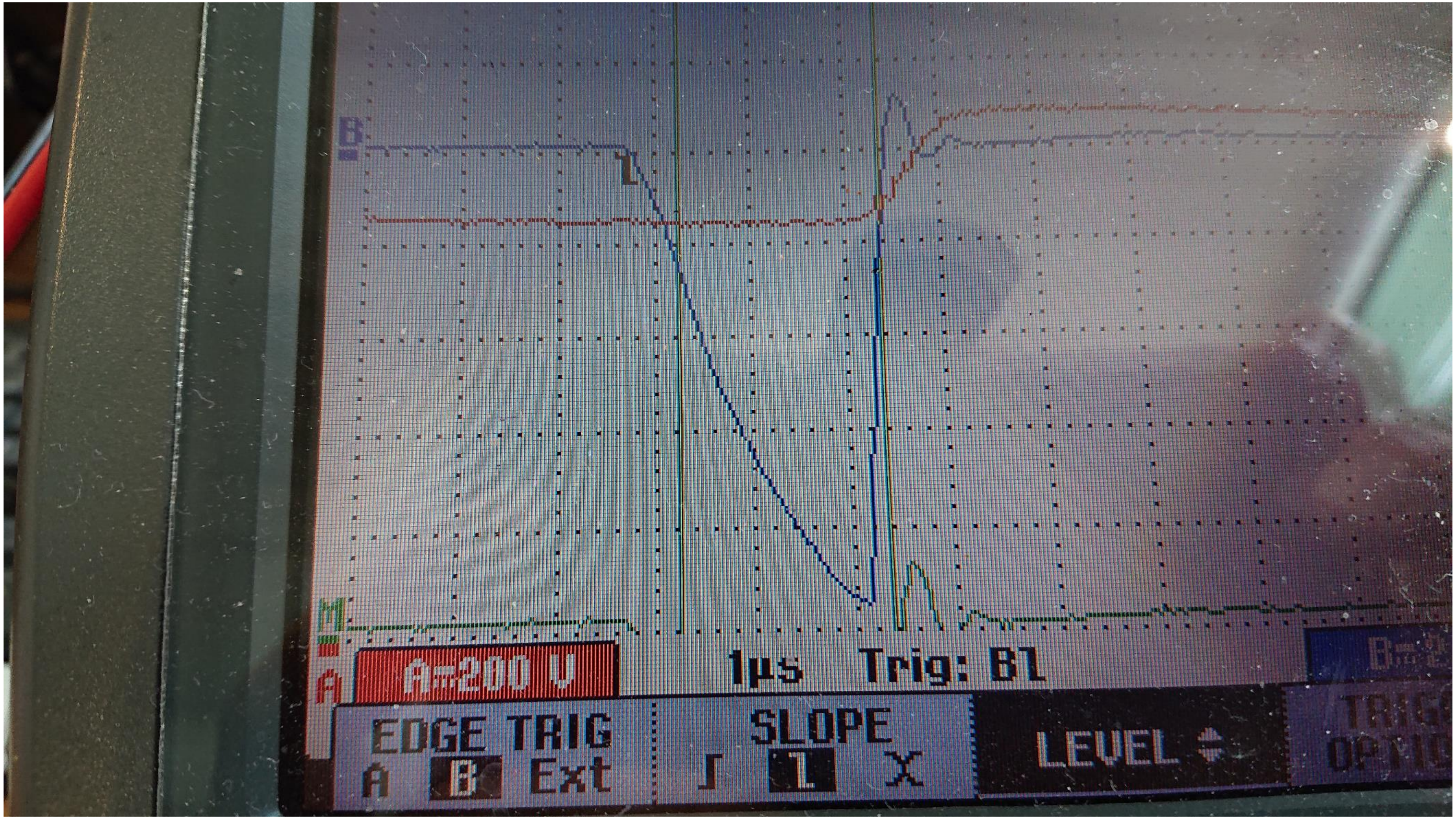

Fig. 9 Snapshot of transversal positive voltage (Fe <-> Constantan). Nerveless peak current at the at the moment of switching-off, is only 11.6 A, the peak Voltage (in red colour) reached values of +1080 V, perhaps because complex phenomena of iron saturation at longer time of the pulse.

Main result

- **We were able to make just one full test, by H_2 at 5 bar.**

- **Observed that *AHE increased increasing the frequency (1→10 kHz) and reducing the pulse width (10→2.5 μs).***

- **The effects were *larger* than expected considering just *skin effect* (dependence as square-root of frequency).**

  ➔Combined effects to get large skin effect because: very fast-rise time and short pulse duration; magnetic material at the surface=> $\delta=(\rho/(\pi*\nu*\mu_r*\mu_o))^{0.5}$.

- **Other tests were planned: change gas type (Ar-H_2 mixture) to increase internal temperatures; improve the performances of the system coil-pulser; explore new HF effects, if any.**

- **After some days of experiments the pulser was partially damaged and we didn't have, at the moment, the spare parts needed to replace them.**

- **Anyway, we think that we need even higher performances devices about rise and fall time characteristics, i.e. SiC technology of semiconductors: to replace our (old) previous version of devices.**

- **In conclusion, at the moment we don't have possibility to fully explore such extremely interesting effect that increased, in an unexpected way, the AHE*: we were forced to move, at the moment, to other type of experiments that didn't need pulser➔ see next our presentation.***