

**Effects of “super-Capuchin knot” geometry, and additional electric fields, on Hydrogen/Deuterium absorption: related AHE on long and thin Constantan wires with sub-micrometric surfaces at high temperatures.**

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## OUTLINE

- A) Short resume of key motivations to make knots with Constantan ( $\text{Cu}_{55}\text{Ni}_{44}\text{Mn}_1$ ) wires (long and thin), surface modified down to submicron dimensionality. Wires (initial diameter of 100 and 200  $\mu\text{m}$ ) powered by proper amounts of current, to increase locally the temperature (up to  $900^\circ\text{C}$ ), with related gradients of Hydrogen (or Deuterium) concentration. **Mainly discussed at ICCF21** (Colorado State University; June 3-8, 2018).
- B) Short resume of main results obtained by the application of “*Capuchin knot*” geometry on 200  $\mu\text{m}$  thick, PTFE covered, Constantan wires. Larger area of thermal gradient concentrations, in respect to single knot geometry, but several limitations on the total number of knots allowable and quite large difficulties on final assembling procedures. Results, about AHE, better with knots each having 8 turns in respect to 4. **Mainly discussed at IWAHLM13** (Greccio-Italy; October 5-9, 2018).

C) Description of the latest geometrical assembly, based on “endless” number of knot’s turns geometry, having most the advantages of Capuchin knot geometry and fewer limitations (*advanced coil*). Introduction of a **field wire** (HV), very close (1-2 mm distance) to the *advanced coil* internal location. Complex dependence of amount of AHE, and its stability over time, even on *field polarity*, frequency, local temperatures (up to 850°C, *in-situ* measured), wires diameter (200, 350  $\mu\text{m}$ ): first results. *Large improvements possible*.

D) Efforts toward compactness of the reactor coil (only 12 cm apparent length with a wire length of 180 cm) and large reduction of input power given at high temperatures (500-800°C) to start the reaction. *Preparation procedures, at this moment, over-simplified*.

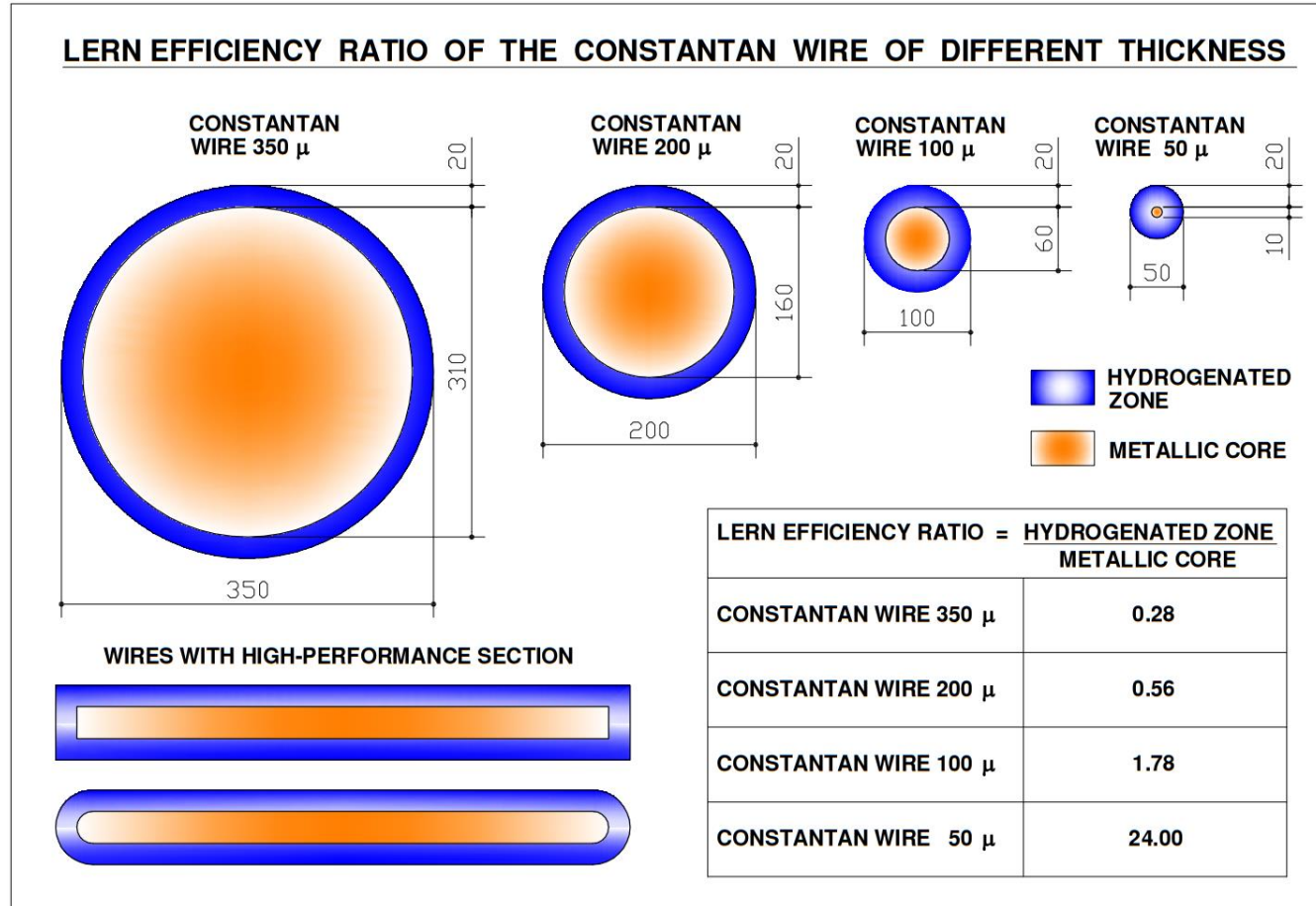
E) Very short notes, mostly theoretical, on a unconventional approach to evaluate/predict the LENR-AHE effects (mainly by Renato Burri, also at BK company).

## Introduction and Motivations

(extracted from ICCF21 and IWAHLM13, with several updating)

- Anomalous Heat Effects (AHE) have been observed by us in wires of  $\text{Cu}_{55}\text{Ni}_{44}\text{Mn}_1$  (Constantan) exposed to  $\text{H}_2$  and  $\text{D}_2$  in multiple experiments along the last 9 years.
- The Constantan, a quite low-cost and old alloy (developed around 1890), has the peculiarity to provide extremely large values of energy (1.56--3.16 eV) for the catalytic reactions toward Hydrogen (and /or Deuterium) *dissociation from molecular to atomic state* ( $\text{H}_2 \rightarrow 2\text{H}$ ). In comparison, the most known and very costly Pd (a precious metal) can provide only 0.424 eV of energy: computer simulation from S. Romanowsky et al., 1999. The energy given out during fast recombination process is quite high (about 4.5 eV): one of the largest among the chemical reactions. In deep space, at low Hydrogen pressures, the measured temperature is 36000 K: equilibrium among dissociation vs recombination.

- Some **H** (according to resistance reduction value up to 20-25 %; first measurements by German Scientists on 1989) is almost **stored inside the Constantan lattice**, after its absorption at high temperatures ( $> 180^{\circ}\text{C}$ ), few bar of pressure, several hours.
- The **amount of ratio among the active volume** (i.e. the thickness of sub-micrometric one) **and the bulk** (used mainly as support), **increases reducing the diameter of the wire**. A *qualitative sketch introduced by us (Fig. 1)*. We observed (by SEM) that, at least in our experimental conditions of wires preparation, the thickness of active section is of the order of 10-30  $\mu\text{m}$ . Main drawback is the easiness of the wire breaking at low dimensionality ( $\Phi < 100 \mu\text{m}$ ). Moreover such deleterious effect is worsened at the highest (and most useful!!) temperatures ( $> 700^{\circ}\text{C}$ ) operated in the test.



**Fig. 1. Qualitative sketch of the ratio among the “active region” (sub-micrometric sponge) for fast Hydrogen absorption/storage (blue color, tickness 20  $\mu\text{m}$ ), and the metallic bulk (brown color), changing the initial diameter of the wire.**

- Improvements in the magnitude and reproducibility of AHE were reported by the Authors of the present work in the past and related to wire preparation and reactor design.
- In facts, an oxidation of the wires by several hundred pulses of high intensity electrical current (up to 10-20 kA/cm<sup>2</sup>, even neglecting skin effects present because fast rise time, <1 μs, of the pulses) in air (and related quenching) creates a rough surface *(like sponge)*. It is featured a *sub-micrometric texture* that proved particularly effective at inducing thermal anomalies (once the H, D is absorbed/adsorbed) when *both temperatures* exceeds 300-400 °C *and* proper kinds of *non-equilibrium conditions* are promoted. *The effects increase as temperatures are increased, until adverse self-sintering effects (almost out of control, at the moment) damage the sponge structures and most of the AHE vanish.*
- The hunted effect appears also to be increased substantially by depositing segments of the wire with a series of elements: Fe, Sr (via thermal decomposition of their nitrates) properly mixed with a solution of KMnO<sub>4</sub> (all diluted in acidic heavy-water solution).

- The magnetic proprieties of constant wires change dramatically after the coating of Fe nitrate (further decomposed to FeOx) from “a-magnetic” to strong ferromagnetic. The special geometry of *Capuchin knot*, as speculation, could enhance such aspects. It is noteworthy that FeOx are recently reported to have magnetic properties enhanced up to 100-10000 times when at low dimensionality (10 micron down to 10 nm) as in our specific fabrication procedures (multilayer).
- Furthermore, an increase of AHE was observed after introducing the treated wires inside a sheath made of *borosilicate* glass (mainly Si-B-Ca; *BSC*), and even more after impregnating, the sheath with the same elements (Fe, Sr, K, Mn) used to coat the wires. Liquid nitrated compounds were first dried and later-on decomposed to oxides by high temperature (400-500 °C) treatments. The procedure was repeated several times.



- Finally, AHE was augmented after introducing equally spaced knots (the knots were locally coated with the mixture of Fe, Mn, Sr, K) to induce thermal gradients along the wire (knots become very hot spots when a current is passed along the wire).
- Interestingly, the coating appears to be nearly insulating and it is deemed being composed of mixed oxides of the corresponding elements (mostly  $\text{FeO}_x$ ,  $\text{SrO}$ ).
- Having observed a degradation of the *BSC* fibers at high temperature, an extra sheath made of quartz fibers was used to prevent the fall of degraded fibers from the first sheath, i.e. made a sort of *coaxial construction*. Main drawback was its large dimensionality.

- Recently the 2 sheaths assembly has been replaced with a **hybrid single sheath** developed, in an joint collaboration, among: a) **SIGI-Favier** (i.e. made of both borosilicate glass and  $\text{SiO}_2\text{-Al}_2\text{O}_3$  fibers), b) the **Metallurgical Company** located at the **NE of Italy** that makes (since 2012) also cross-check of our experiments (*further, their own improvements*), c) **Us**.
- The new hybrid single sheath is made by skein of 5  $\mu\text{m}$  filaments arranged to a tickness of 500  $\mu\text{m}$  and crossed each-other, like a net, alternating borosilicate glass (able to absorb atomic Hydrogen) and  $\text{SiO}_2\text{-Al}_2\text{O}_3$ . The portion of borosilicate is stable up to 750 °C while the  $\text{SiO}_2\text{-Al}_2\text{O}_3$  is stable up to 1200 °C of continuous operations. Such an unconventional geometry was optimized for our purposes, apart avoiding glass fibers uncontrolled degradation, to allow also *charged particles* to flow between Cathode and Anode (by HV).
- The key aspect of **Metallurgical Company** is their ability to find **practical solutions**, as simple as possible and at low cost, in the view of a near-future production of AHE reactors.

- The treated wire, comprising knots and sheaths, was then wound around a SS316 tube (Sulfur depurated) and inserted inside a thick wall glass reactor. The reactor operates via direct current heating of the treated wire, while exposing it to a 5-2000 mBar of D<sub>2</sub> or H<sub>2</sub> pure or their mixtures with a noble gas (*in these conditions also electromigration phenomena are supposed to occur*).
- In 2014, the Authors introduced a second independent wire, “floating” in the reactor chamber, and observed, just by chance, a weak electrical current (hundreds of μA, with several mV at the end of the wire), flowing in it while power was supplied to the first.
- At that time the sheaths were NOT impregnated by nitrate/oxide mixtures, so, possible leakage currents were unlucky to happen. The effect was also **confirmed/certified** (at Frascati Laboratory by their own instrumentations and specific SW for data acquisition) and (later-on) independently reproduced, by the **MFMP group (M. Valat, B. Greeiner)**.

- This current proved to be strongly related to the temperature of the first wire and clearly turned to be the consequence of his *Thermoionic Emission* (where the treated wire represents a *Cathode* and the second wire an *Anode*), according to the **Richardson law**.

- The key parameter of thermoionic emission is the Work Function ( $\Phi$ ), usually 1.5-5 eV, for electron emission, from the surface of the materials:

- $J = A_g T^2 \exp(-\Phi / K_B T)$

- with:
- $J$  = emission current density [ $A/m^2$ ];
- $A_g = \lambda_R A_0$ ;  $\lambda_R$  is a correction factor depending on the material (0.5—1);
- $A_0 = (4\pi q_e m_e k_B^2) / (h^3) = 1.2 \cdot 10^6 [A/m^2 K^2]$ , *Richardson constant*
- $q_e = 1.6 \cdot 10^{-19}$  C, electron charge;
- $m_e = 5.11 \cdot 10^{-5}$  eV, electron mass;
- $k_B = 8.617 \cdot 10^{-5}$  eV/K, Boltzmann constant.

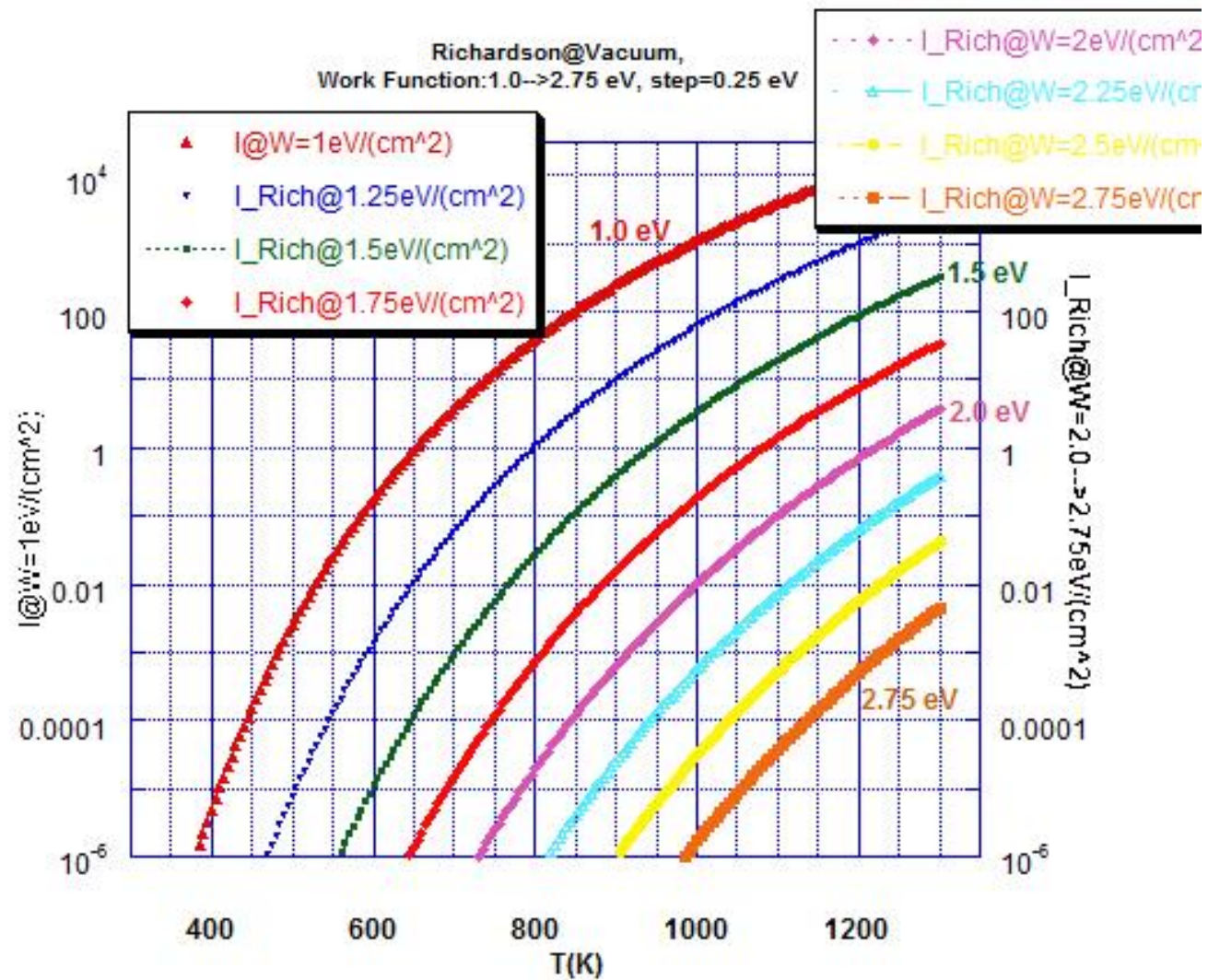


Fig.2. Dependence of electron emission on Temperature (300--1300K) and Work Function (1--2.75 eV)

- The presence of the thermoionic effect and a spontaneous tension between the two wires did strongly associate to AHE.
- The thermoionic effect is enhanced, in our specific procedures, by deposition of Low Working Function materials (LWFm), like SrO, at the surface of the constant wire, several thin layers.
- *In the Cold Fusion-LENR-AHE studies the Researcher that first (1996) introduced, intentionally, LWFm was Yasuhiro Iwamura at Mitsubishi Heavy Industries (Yokohama-Japan). Since that time he used CaO and later-on also  $Y_2O_3$ , both in electrolytic and gas diffusion experiments at mild (<80 °C) temperatures.*
- All these observations were reported at various Conferences, and tentative explanations were provided for the observed effects.

- The presence of thermal and chemical gradients has been stressed as being of relevance, especially when considering the noteworthy effect of knots on AHE.
- The ICCF21 Conference, held on June 2018, marked a turning point: the scientific community did show a notable interest on the effects of knots and wire treatments, further increasing the confidence on the described approach.
- From that moment, attempts to further increase AHE focused on the introduction of different types of knots, leading to the choice of the **“Capuchin”** type (see Fig. 3) and, very recently, to the **“advanced Capuchin knot”**.
- ***The knot design, specially Capuchin one, leads indeed to very hot spots along the wire and features three areas characterized by a temperature delta up to several hundred degrees.***



## FUNCTIONAL THEME OF THE CELANI COIL (FIRST TEST)

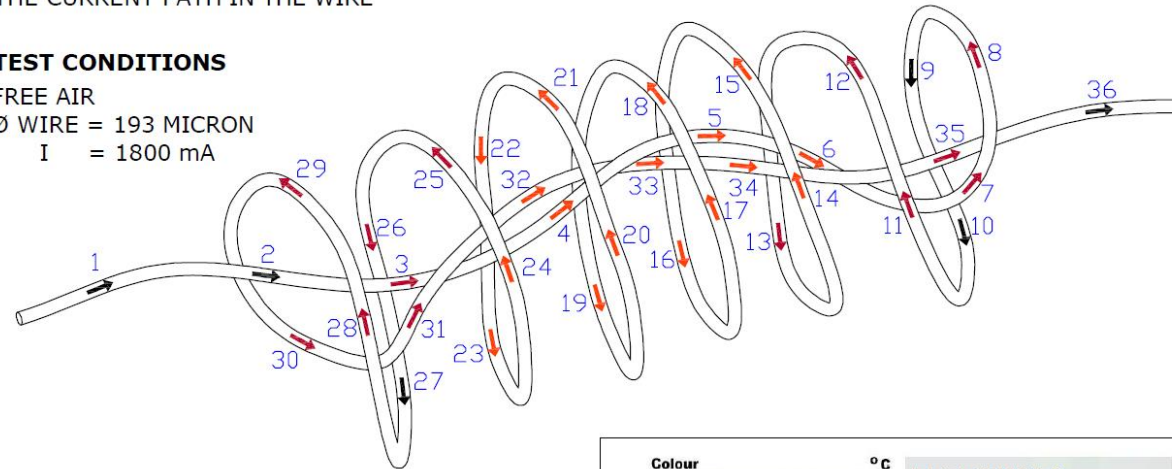
THE NUMERICAL SEQUENCE INDICATES  
THE CURRENT PATH IN THE WIRE




### TEST CONDITIONS

FREE AIR

Ø WIRE = 193 MICRON

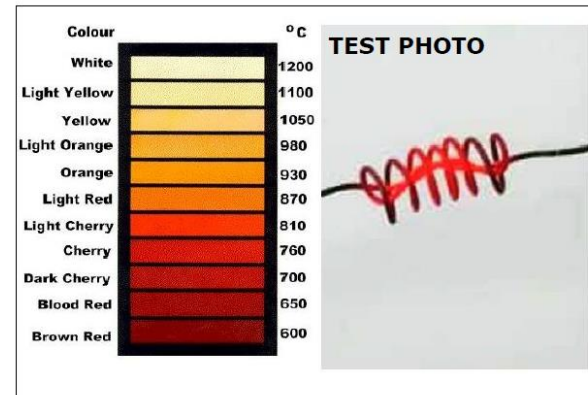
I = 1800 mA



-  HIGH TEMPERATURE
-  TRANSIENT TEMPERATURE
-  NORMAL TEMPERATURE

### NOTE

THE CONSTRUCTION OF THE COIL  
TAKES PLACE BY NOTING THE WIRE  
WITH THE "CAPPUCCINO" METHOD



**Fig. 3. Photo, in DC, I=1900 mA, of a piece of Constantan wire having a diameter of 193  $\mu$ m. Capuchin knots with 8 turns. Temperatures estimated by color. The dark area is at temperature  $<600^{\circ}\text{C}$ , the external helicoidal section is at about  $800^{\circ}\text{C}$ , the inmost section, linear, up to  $1000^{\circ}\text{C}$  in some areas.**

- Efforts were also made to better understand the thermoionic effect of the wire, and the spontaneous tension that arises when a second wire is introduced close by (like an anode).
- Eventually a large AHE rise was noticed when introducing an extra tension between the active wire (cathode) and the second wire (anode) through an external power supply; a truly remarkable effect, despite his short duration due to the wire failure attributed to an AHE runaway able to melt it. The effect was measurable in 100  $\mu\text{m}$  wires where the Voltage drop along the wire (up to 100 V) itself is larger in respect to the usual 200  $\mu\text{m}$  wires voltage drop (about 30 V).
- Among others, we observed a general trend of larger values of AHE when the voltage drop along the wire is as large as possible: the NEMCA (revisited by C. Vayenas, about 1995), and/or G. Preparata-E. Del Giudice (voltage induced Coherences) effects are operative?

- Eventually the authors have observed a stunning similarity of the best performing reactor design and a thermionic diode where the active wire represents the cathode and the second wire the anode, whereas the electrodes are separated by fibrous layers impregnated with mixed oxides comprising Iron and alkaline metals.
- In short, some measurements, at low pressures, shown a current dependence like  $V^X$  with X among 1.15 and 1.5, similar to the *Child-Langmuir* law ( $I$  proportional to  $V^{1.5}$ ) for current emission inside a vacuum tube diode.
- *The whole of the observations allows to speculate on a thermoionic power converter able to generate electricity through the thermoionic emission of a cathode, heated by AHE, and collected by an anode (colder and/or featuring a different work function with respect to the cathode).*

## Advanced Capuchin coil construction

*The construction of new geometry was quite complex and several measures were provided to fulfill the specific requirements of the experiments, several times conflicting each-other.*

Some of the main problems/solution are resumed, as following:

A) The new system is (partially) based, about the main geometry of Constantan “turning”, on the well-known methodologies adopted (since about 1930) for the construction of the filaments of *incandescent light bulbs*.

In other words, the wires have a geometry of coils with both distance among spirals and diameter of the coil as short as possible.

B) To avoid short circuitry among adjacent spires, the **wires are put inside insulating sheaths** able to withstand high temperatures, i.e. the **hybrid** one before quoted (up to 1200 °C).

C) As final effect, part of the energy emitted from the (incandescent) wire is self-concentrated at the center of the coil where are located: a) the initial and final parts of the wire, b) a thermometer (type K thermocouple, SS covered and electric insulated, for local temperature measurement purposes), c) another wire (at large surface and inert in respect to H adsorption) used as the **anode** or generally **counter-electrode** of the system.

D) The effect of (partial) reflection of IR emitted is reinforced by a SS316 tube that reflects efficiently the temperature.

E) The construction is modular and the thick wall (3mm) glass reactor is the main container of 3 independent type of wires, each into an independent SS tube. One wire is used as general purposes test (made by Pt, identified as V1 because 100 µm wire diameter).

## F. CELANI REACTOR

V1 - COIL OF PLATINUM WIRE Ø 0.100 mm

V2 - COIL OF CONSTANTAN WIRE Ø 0.200 mm

V3 - COIL OF CONSTANTAN WIRE Ø 0.350 mm

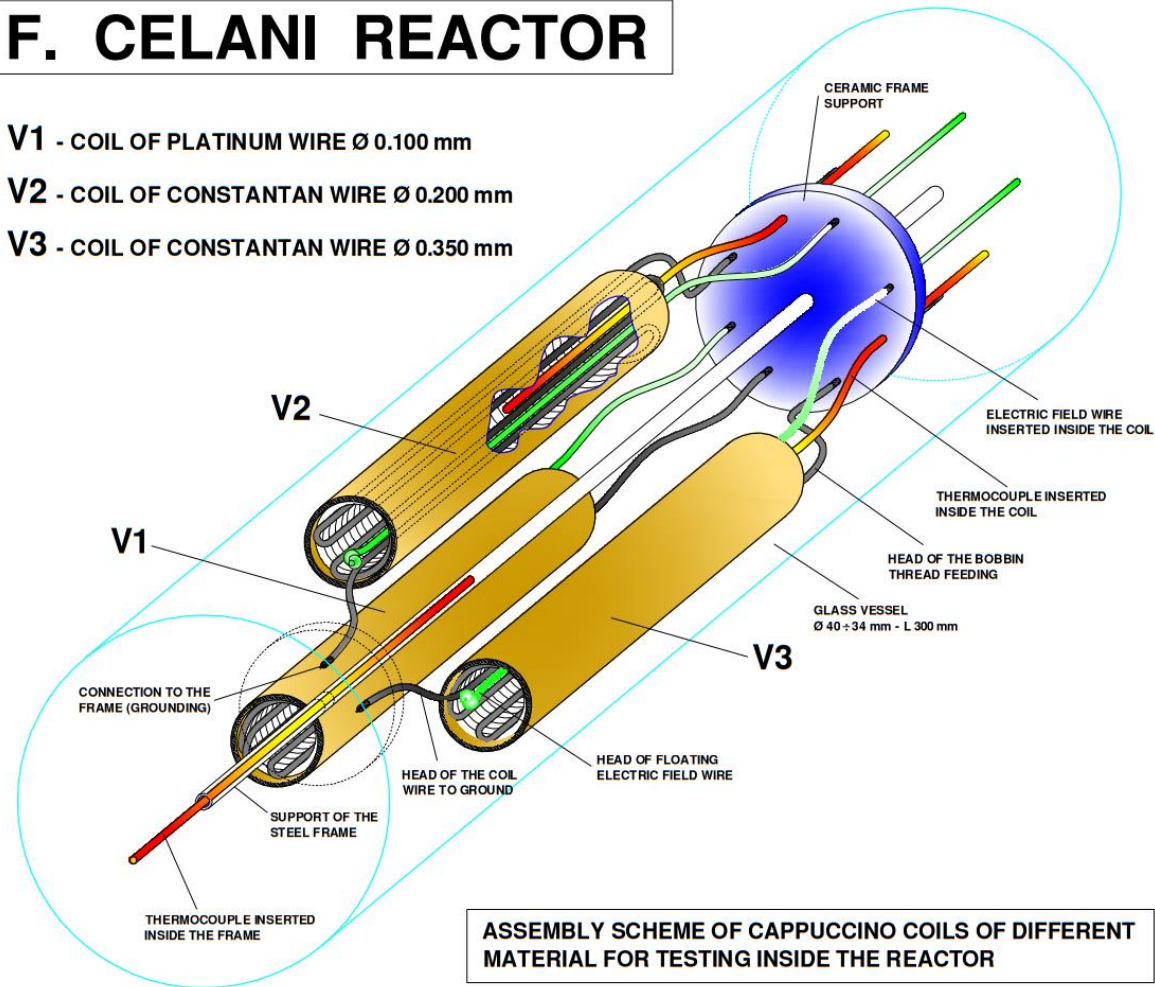


Fig.4. Overview of the assembling of the SS tube, each filled by coiled Constantan wire, except V1 (by Pt).

## CAPPUCCINO COIL (3+1)

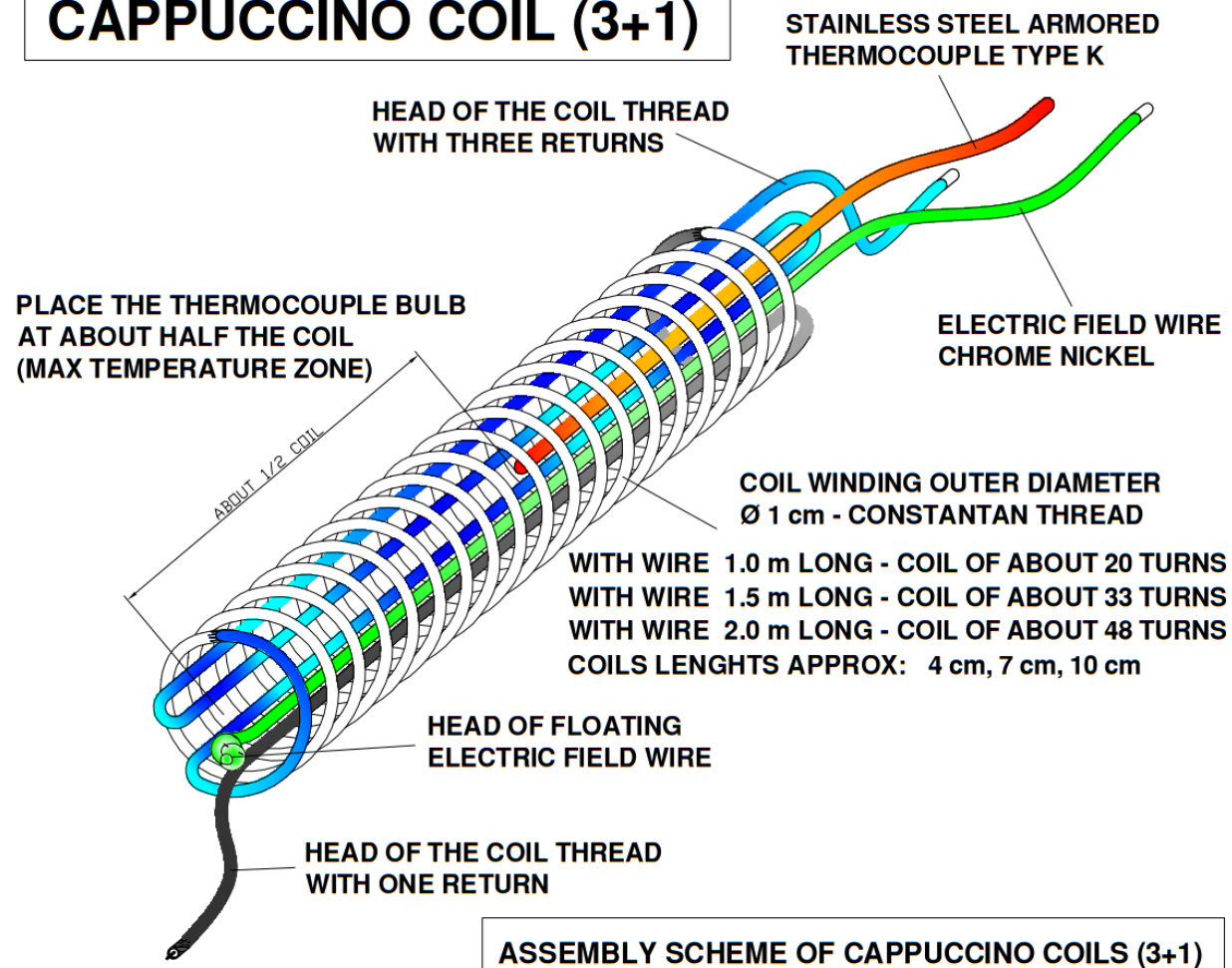


Fig. 5. Details of the assembling of typical “*Advanced Capuchin knot*”: thermocouple and Anode wire.

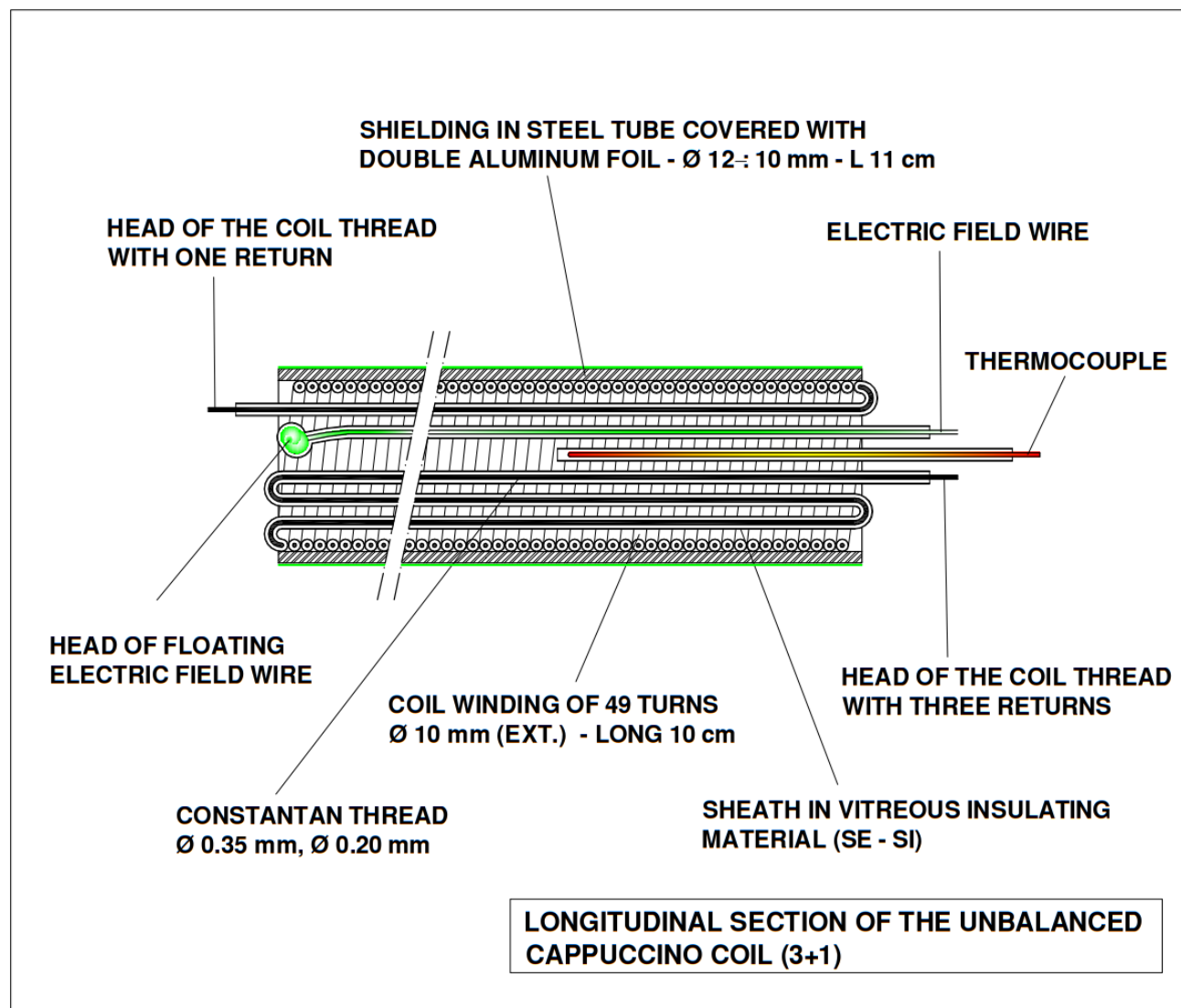
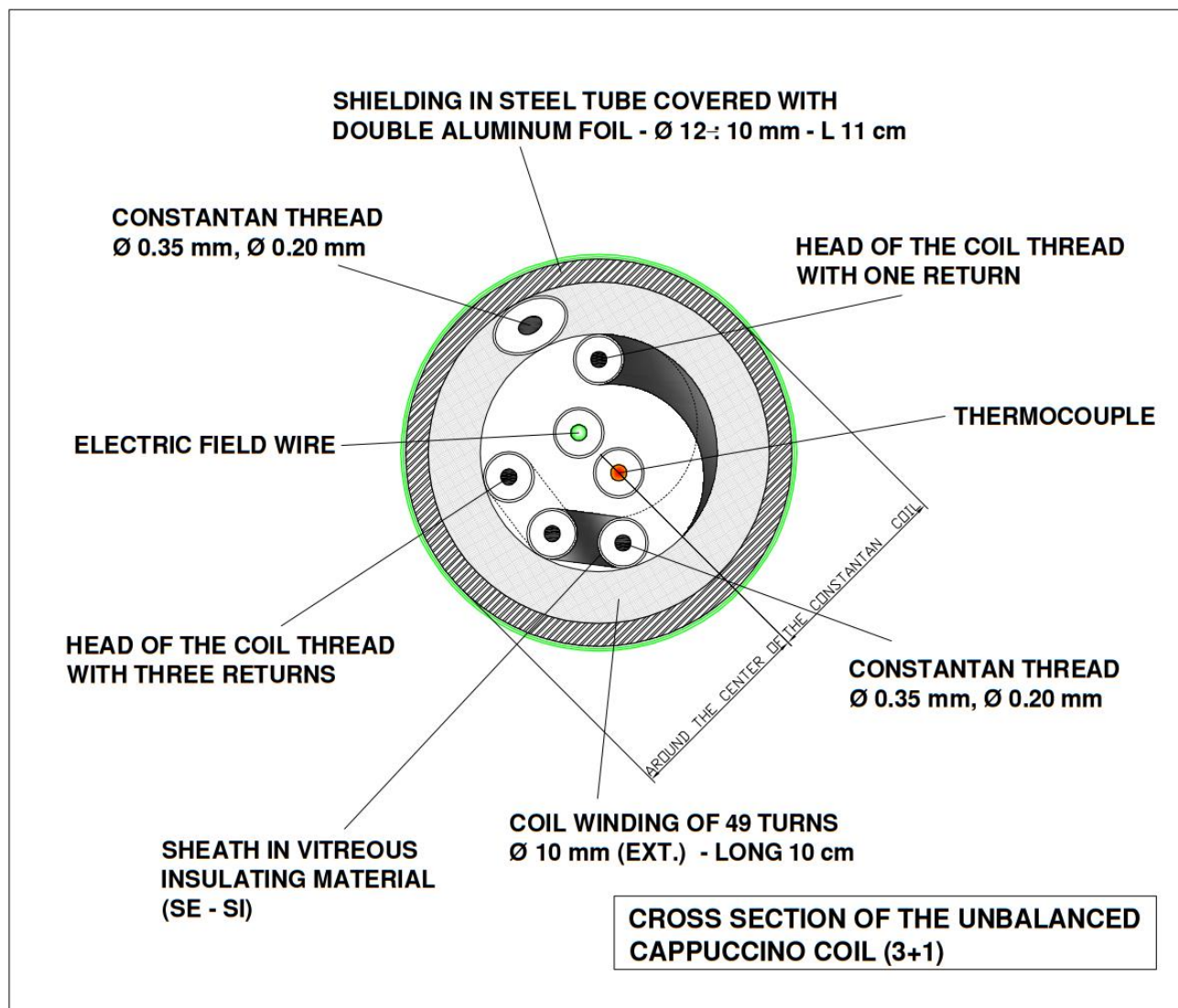


Fig. 6. Further details about *Advanced Coil* construction.





**Fig. 7. Cross section of the *Advanced Capuchin coil***



**Fig. 8. Photo of the reactor assembled, just before to be located into the air flow calorimeter.**



Fig. 9. Photo of the reactor, and calibrator (Ni-Cr wire) put inside the calorimeter (advanced version, 2 walls)



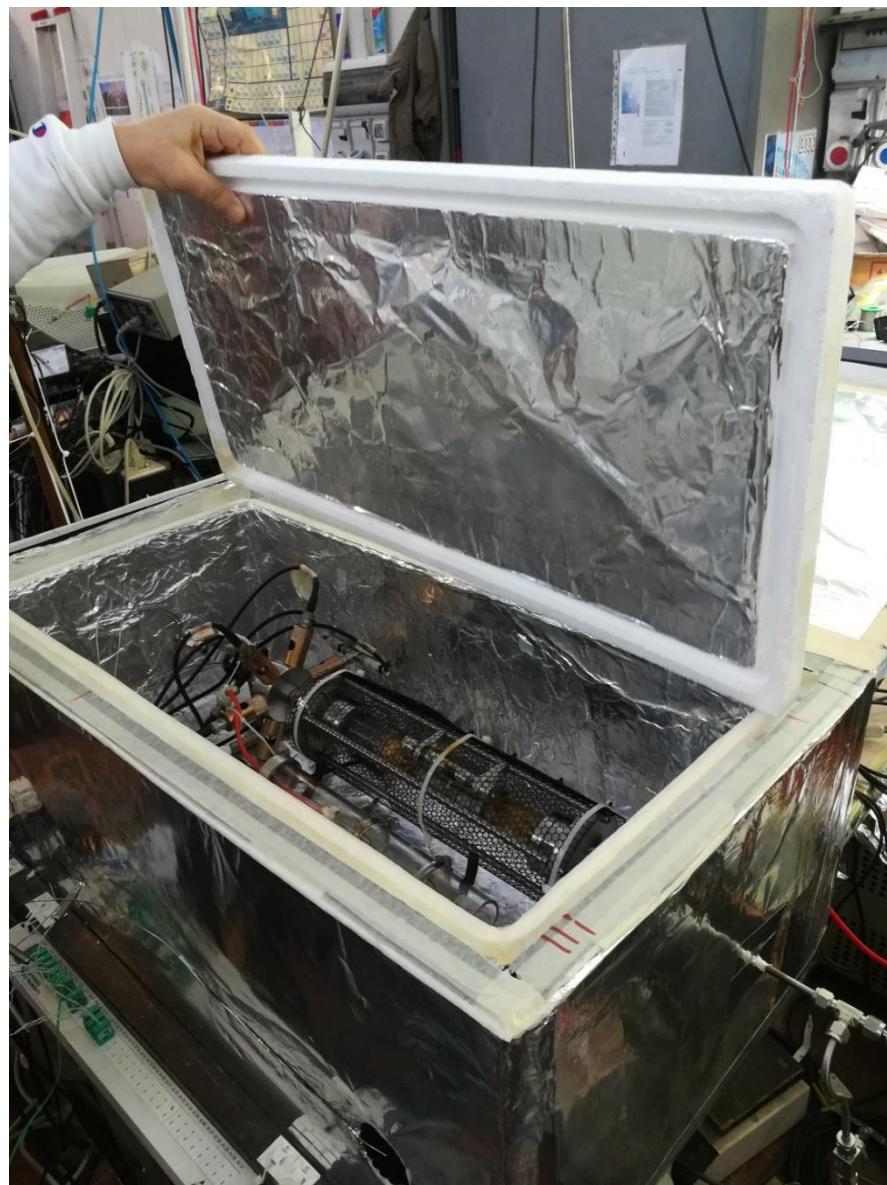


Fig.10. Photo of the Calorimeter, air flow, just before closing the cover. Glass reactor protected by SS net.

## Main Results

(work in progress)

The main results, obtained both with the new **“Advanced Capuchin knot” geometry** and electrical stimulation of the active wire by another wire that can be assimilated, because geometrical reasons, to an Anode or better to say **Counter-electrode**, are resumed as following:

- A) Because the combined effect of compact geometry and IR reflection ability of SS, the power needed to reach the “critical” temperature of 600°C, is about **2.5—3 times lower** in respect to previous “naked” geometry of the wire.
  
- B) An external field, connected to the *counter-electrode*, up to +-300V, is able to modify (i.e. increase or decrease), at macroscopic level, the amount of Deuterium absorbed by the Constantan wire, previously loaded, even at Room Temperature: **fully un-expected phenomena**. The effect, shown in Fig.11, is detected by the usual Resistance Ratio methods. Such **effect happens even in AC conditions**. Used the 50Hz allowable in Italy.

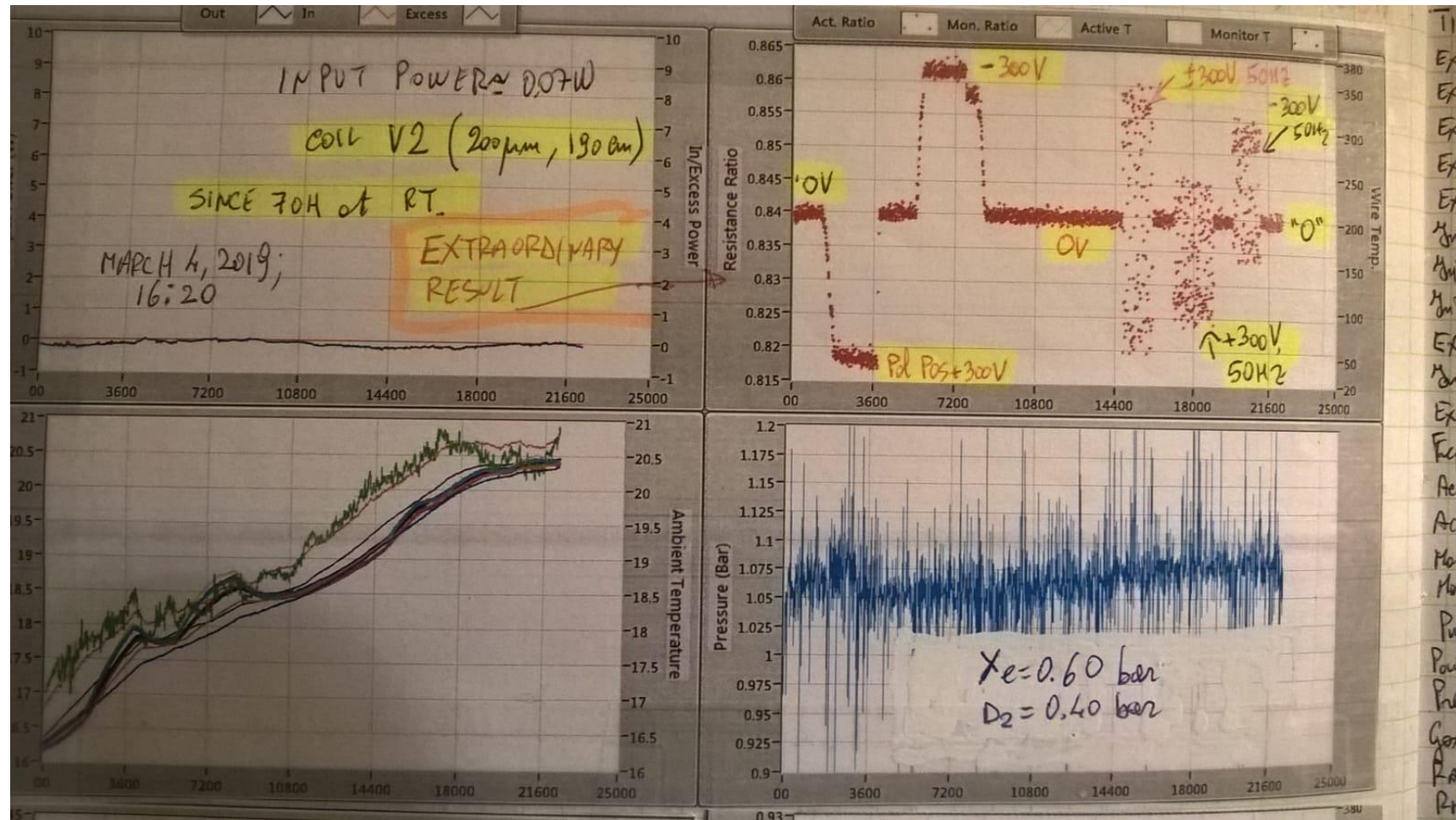


Fig. 11. Red color plot (UR). Effect of application of a Voltage (up to 300V, current <1mA), Positive, Negative, AC (50 Hz, symmetric), AC unipolar (Positive half-wave); AC unipolar (Negative, half-wave) on Constantan wire (previously loaded by D), 200  $\mu$ m diameter, at RT. The effect is reversible: return to initial (0.84) R/R<sub>0</sub> ratio at the end of the procedure. Decreasing of wire resistance means an increasing of D absorbed.

In usual experiments we observed, quite frequently, that at the “beginning” of a *variation step*, the AHE is usual larger then at the long time equilibrium. In the new setup we have the opportunity to put a thermometer at the inner core of the coil, where most probably the AHE effect is largest. Such type of measurement reconfirmed our general observations. Typical behavior is shown in **Fig. 12**: performance decreasing over time. Because confirmation of our guess, and thanks to the results about the role of large electric voltage, shown **Fig. 11**, we added such electric field (almost no current is absorbed) at the counter-electrode wire, as shown in **Fig. 13**: performances improved. In experiment shown in **Fig.14** we tested, in sequence: Positive voltage (+300 V)=> temperature increases; 0 V=> temperature stabilized=> no increasing; -300 V=> extremely fast/intense temperature increase and the wire was broken (melted?). Completely un-expected event. In **Fig. 15** are shown results with wire V3, using symmetric AC stimulation (+-230 V RMS, 50Hz) and AC coupling (100 nF) to the counter-electrode. Almost no effect to avoid temperature reduction over time. In **Fig. 16**, wire V3, are shown results using AC (50 Hz) excitation to counter-electrode by AC coupling (1  $\mu$ F) and DC reference to GND (by 100 kOhm) circuit. The temperature degradation was, up to leaving Italy to attend the MIT Colloquium, avoided. **At the moment, it is the more efficient solution found.** *Further work is mandatory to reconfirm the results and increase them, perhaps by the help of more sophisticated circuitry.*



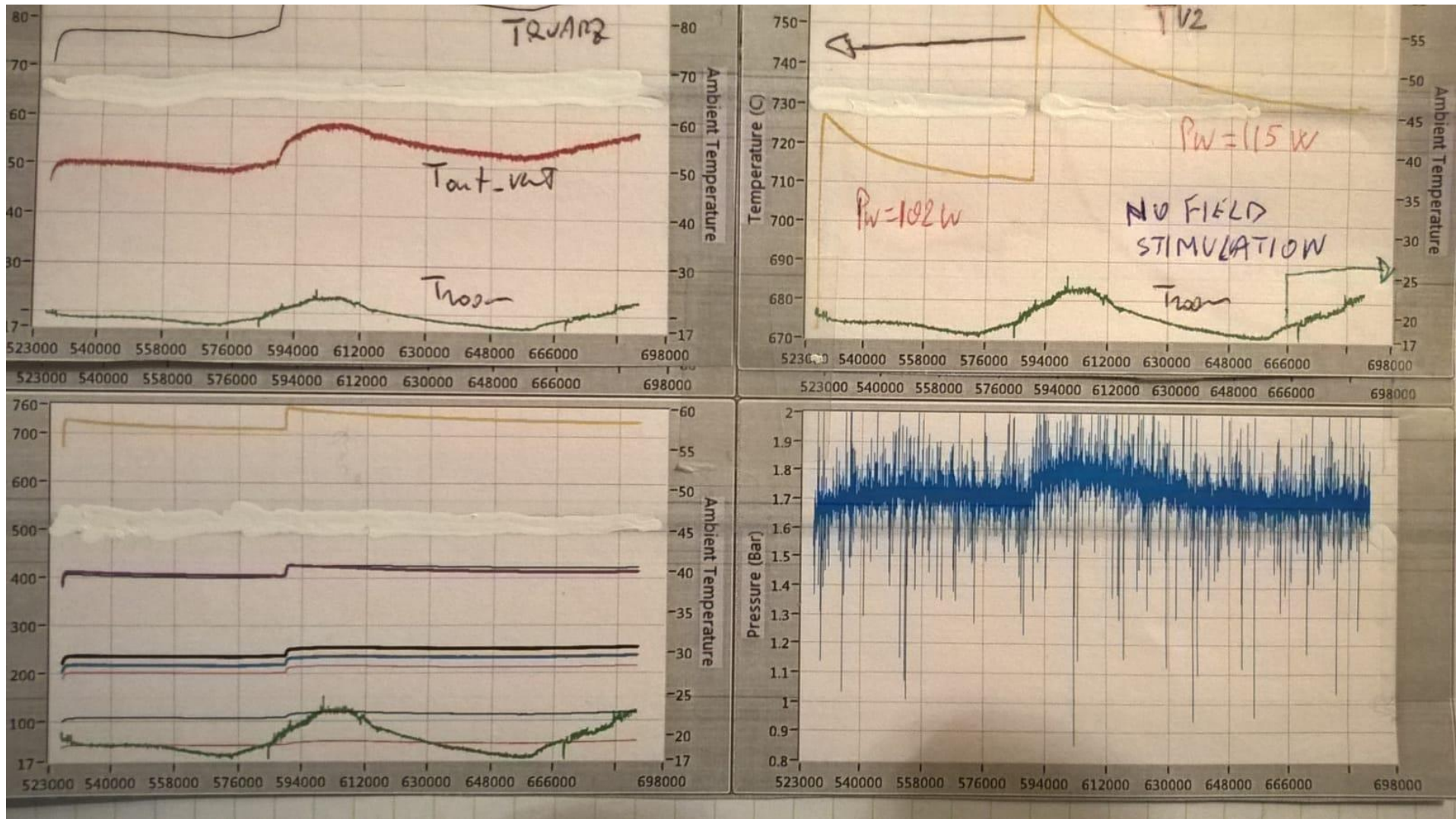


Fig. 12. Raw data. UR. Typical behaviour, no external field applied, of temperature at the centre of the coil. At the beginning large values, later slowly decreases.



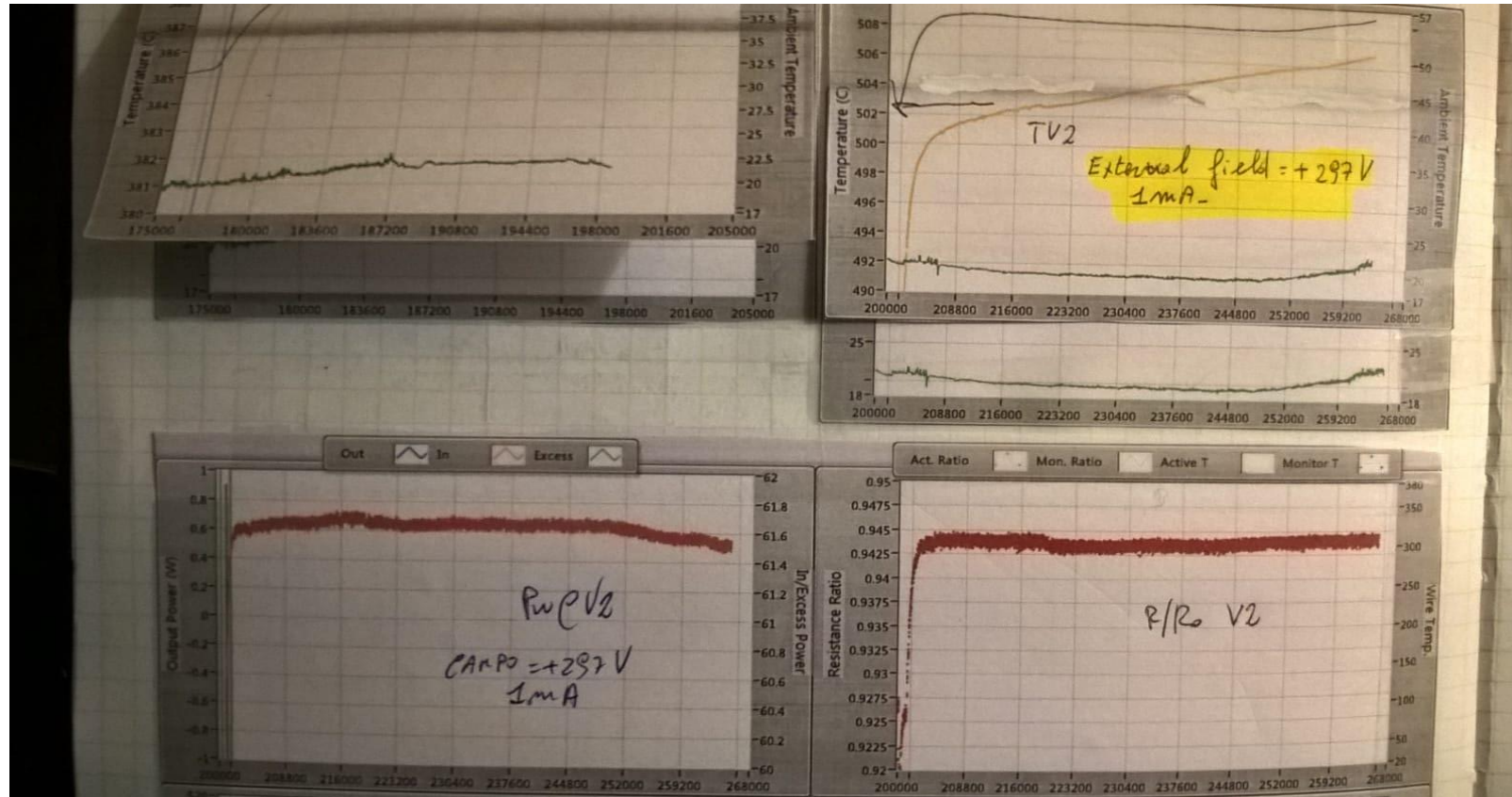


Fig.13. Advanced coil, raw data, with 200  $\mu\text{m}$  wire. Input Pw about 61 W. Applied a DC, external field of 300V ( $I < 1\text{mA}$ ). In Fig UR it is shown that the application of such field allows an INCREASING of internal temperature over time (from 502 to 507  $^{\circ}\text{C}$ ), continuously increasing. Moreover, observing DL, the input Pw is slowly decreasing. **In other words, the applied field has reversed the effect of spontaneous decreasing of temperature, i.e. AHE., observed in Fig. .12**

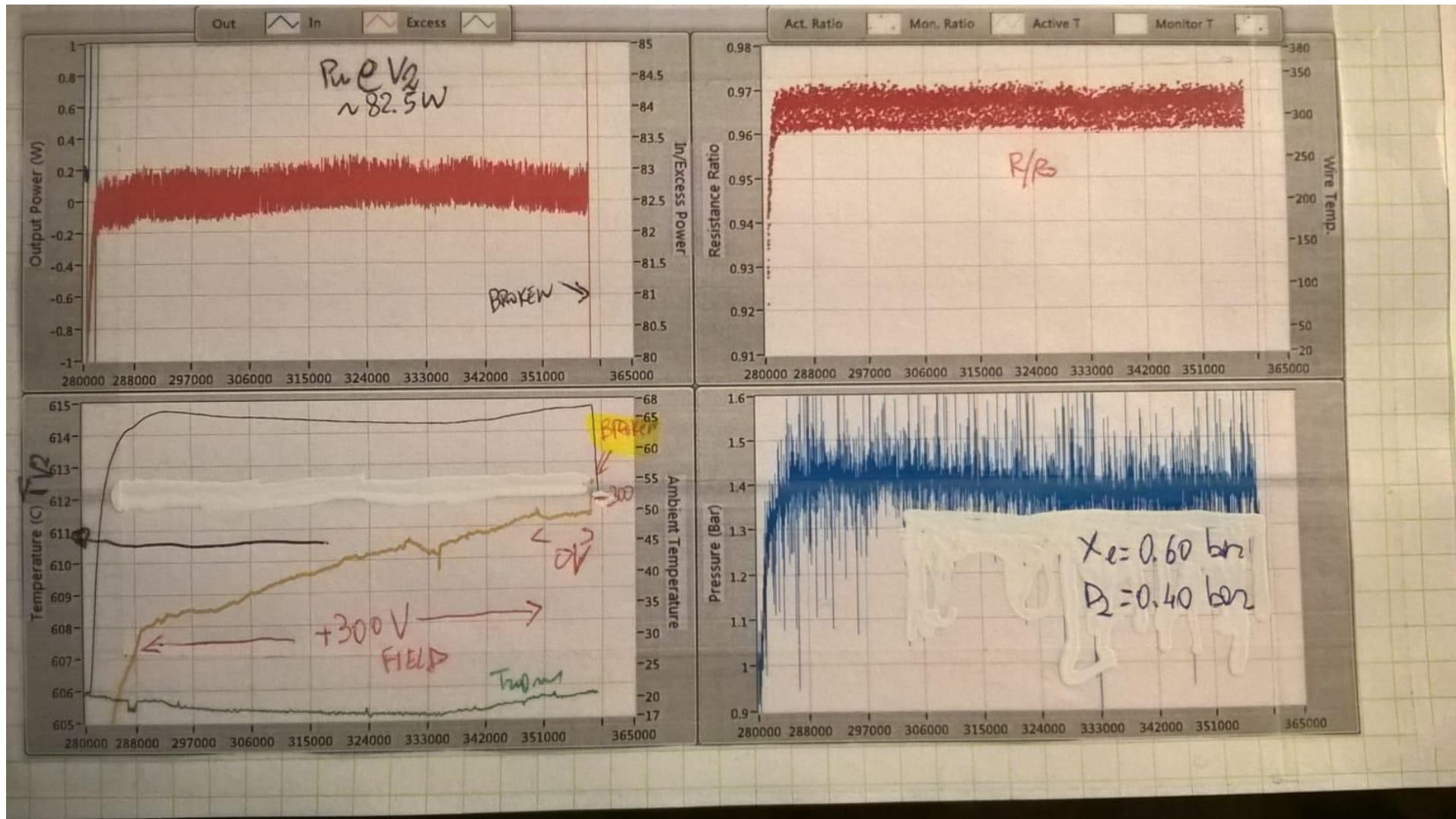


Fig. 14. Raw data, wire V2. Effect of electric field: A=+300V, temperature increases; B) 0 volts, temperature stabilizes; C) -300V, **extremely fast temperature increase but the wire was broken.** Clearly, 2 effects acting.



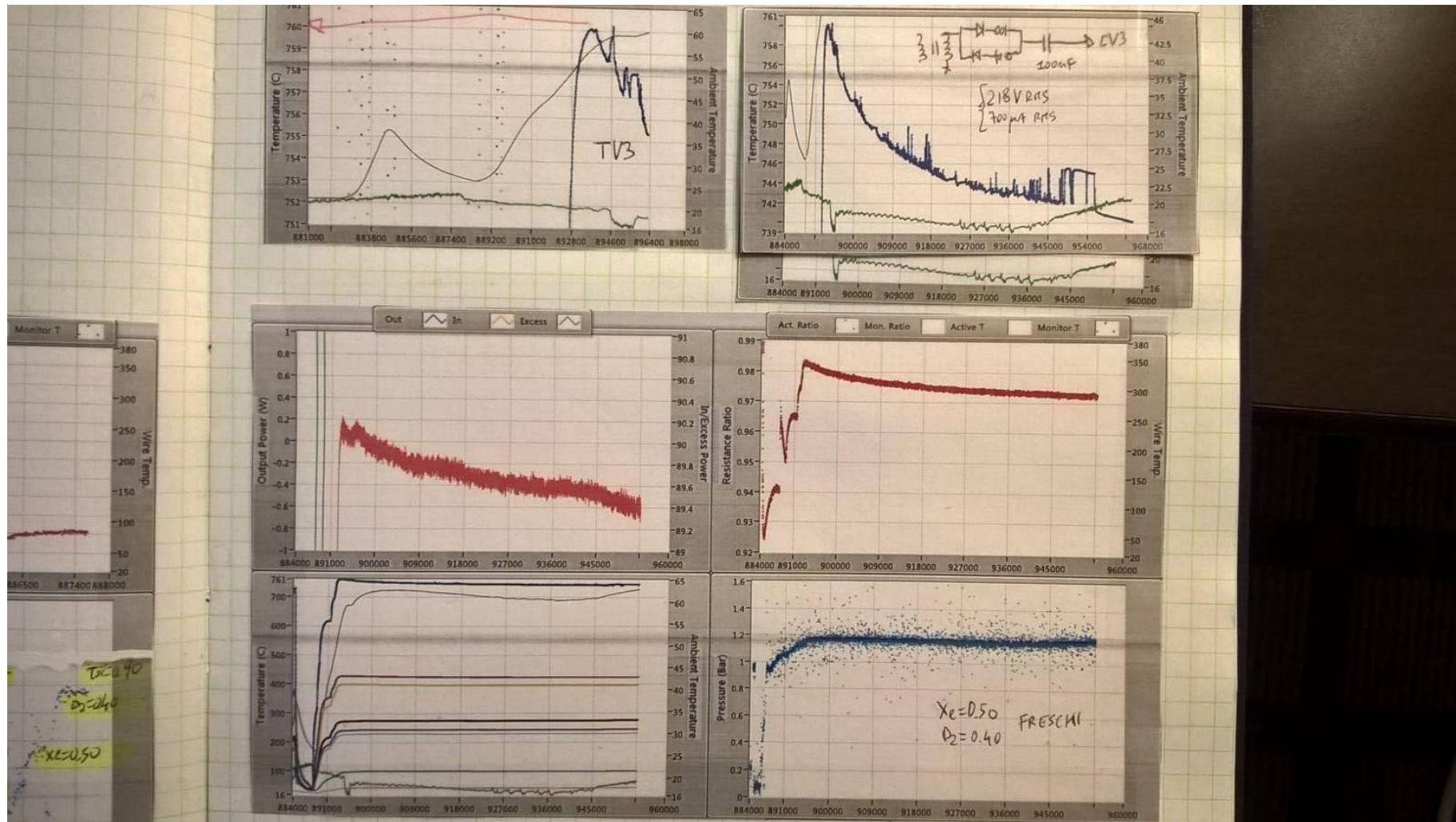


Fig.15. Raw Data. Wire V3. UR and UL. Behaviour of temperatures using symmetric AC stimulation (+230 VRMS, 50Hz) and AC coupling (100 nF) to the counter-electrode. Almost no effect to avoid temperature reduction over time.

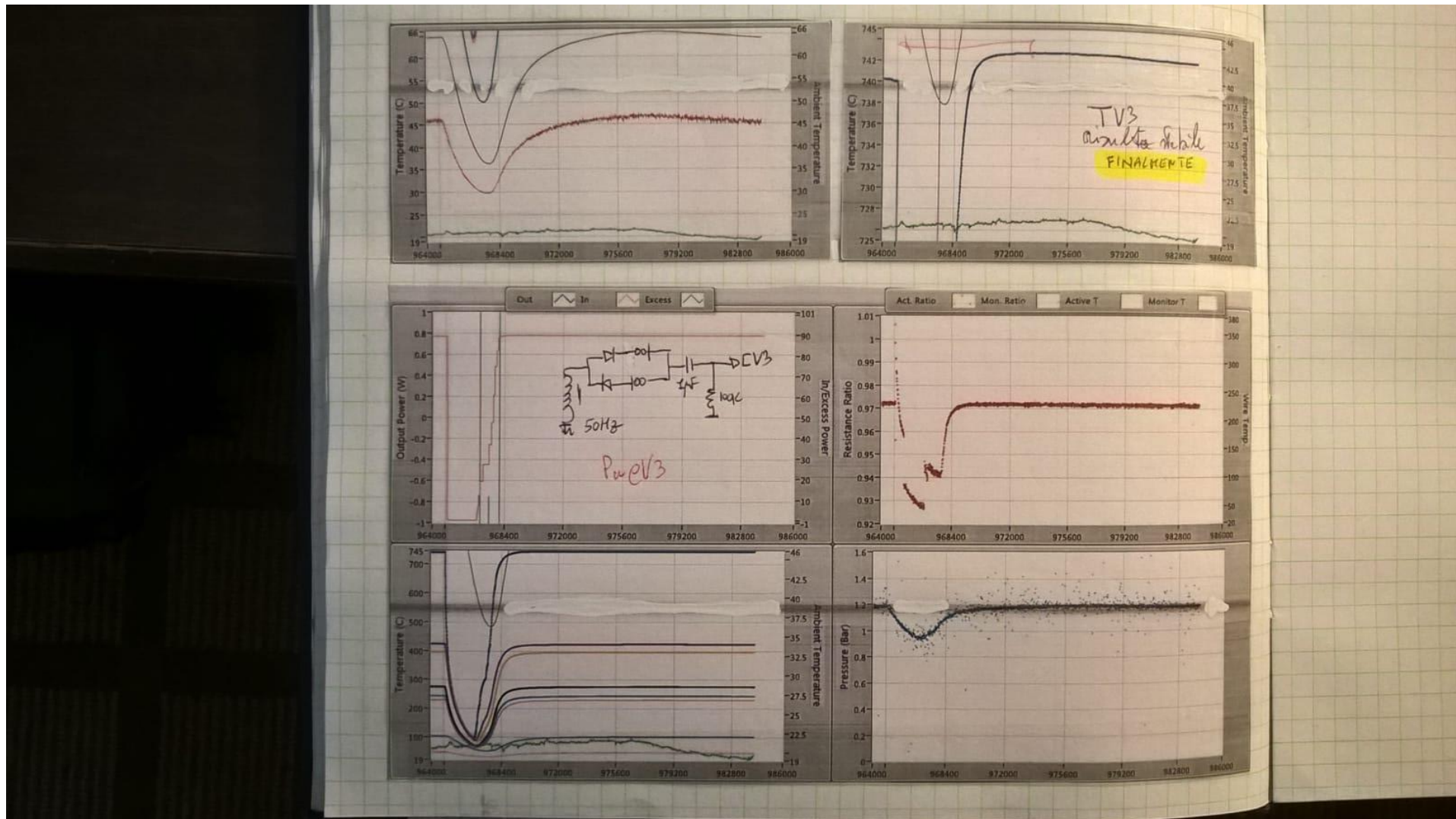
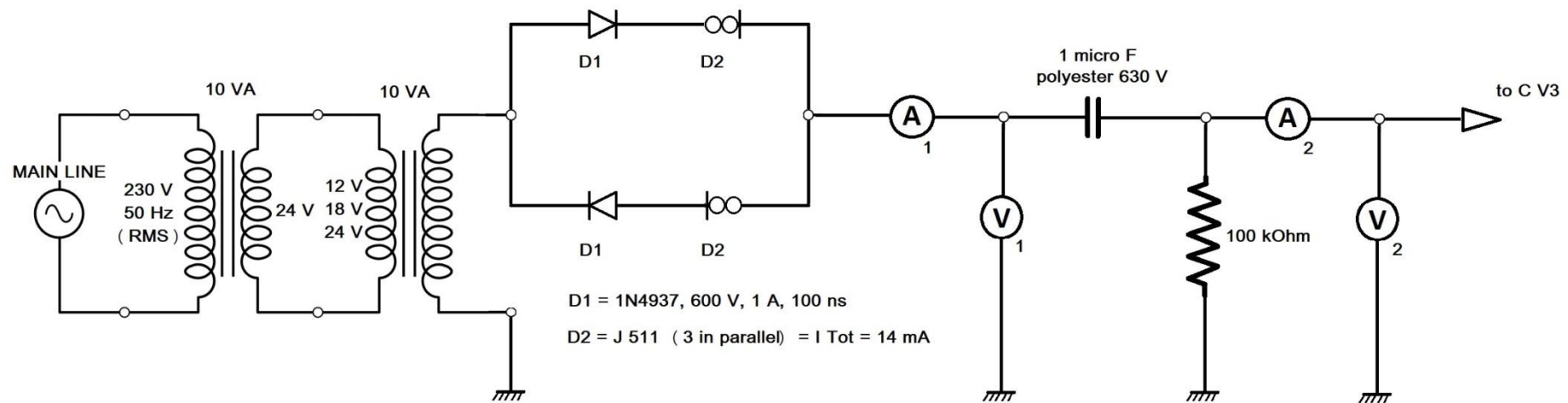


Fig. 16. Raw data. Wire V3. Results using AC (50 Hz) excitation with, AC coupled ( $1 \mu\text{F}$ ) and DC referenced to GND (by  $100 \text{ k}\Omega$ ). The temperature degradation was eliminated. **At the moment the more efficient solution.**

Details of, very simple, circuitry to excite the counter-electrode are shown in Fig.17.



**Fig. 17. Schematic of the circuitry developed to induce dynamic conditions to the Constantan wire, by a counter-electrode located 1-2 mm close.**

## Conclusions

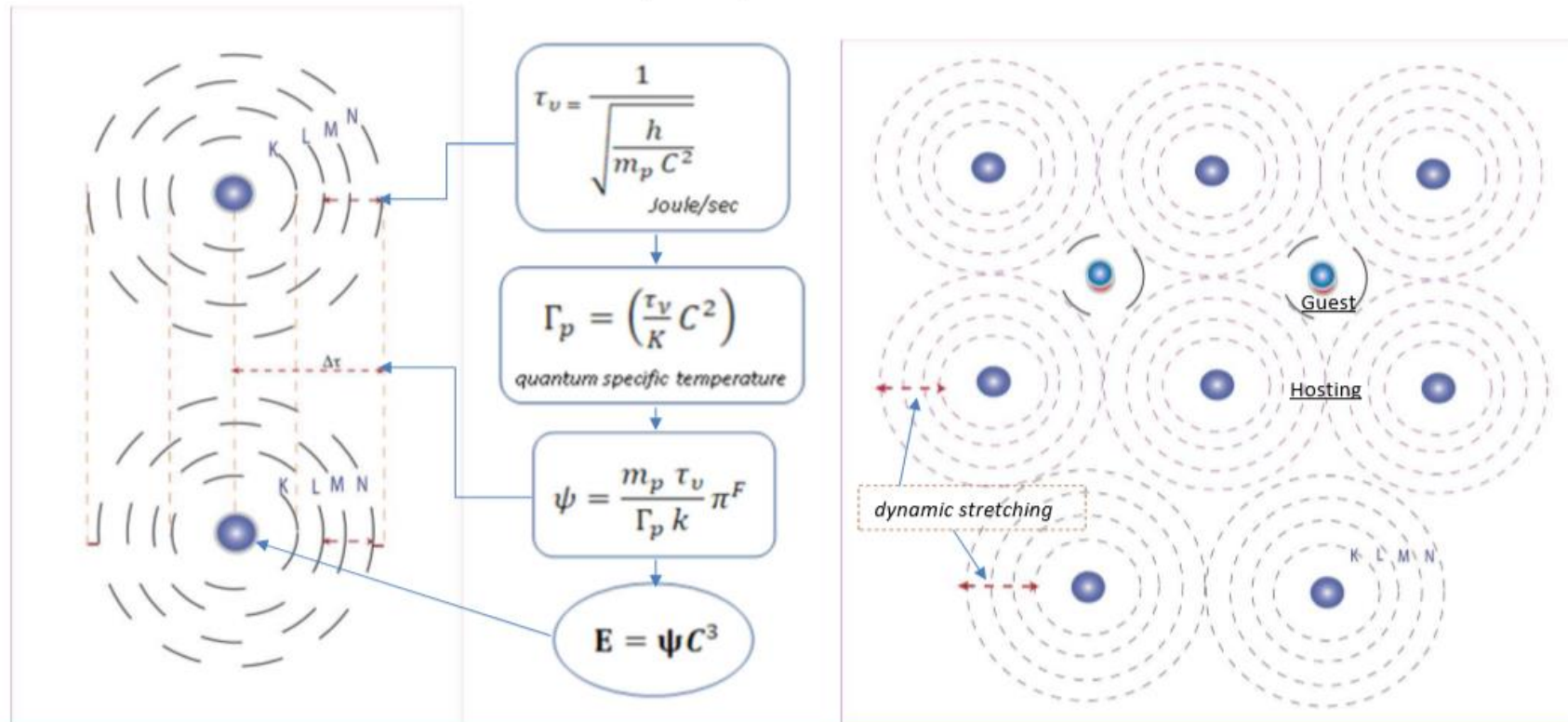
- A) The long work about exploiting the possible use of, low cost, Constantan in the LENR-AHE field seems to give quite promising results.
- B) One of the largest problems, i.e. **AHE reduction over time**, seems to be, at least partially, solved by using a weak, very low power, AC, HV excitation to an “inert” wire located, as close as possible (few mm) to the main active wire.
- C) Our system can be **LARGELY IMPROVED** up to reaching (hopefully) values of AHE of practical interest. At the moment we measured about 8-12 W, at 100 W input, for 200  $\mu\text{m}$  wire; the value dropped to only 3-5 W for 350  $\mu\text{m}$  wire and, **increased largely** (up to 12-15 W) using the AC stimulation. **The experiments shown are just the beginning for systematic studies.**
- D) Even our own peculiarity of “pulsed oxidation” was, at moment, omitted looking for construction procedures as simple as possible.
- E) It is **reconfirmed the role of large voltages** along the wires, possibly related also to a proper ratio between the active area (sub-micrometric) and the bulk; we observed new effects because **negative counter electrode of polarity the repels the electrons coming out from the wires.** **New interpretations are needed.**

**A new theoretical Model about AHE generation**

**by Renato Burri (also at BK company).**



## Principle of quantum AHE.



–  $h$  : Planck constant -  $m_p$  : atomic Planck mass -  $C^2$  : Speed of Light squared -  $K$  : Boltzmann constant -  $\pi^F$  : quantum compensation spacetime -  $(F)$  : Fibonacci coefficient

The study shows that the AHE is originated by a "dynamic stretching" of the distances of the external atomic orbitals (L, M, N). The study highlights that there is a close correlation between the mass of the nucleus and the distance of the orbital levels. The study is part of the Modern Physics and Complex spacetime, showed a new quantum variable indicated " **precursive time** " able to detect the time shifting between the nucleus and orbital levels.

Refer study: **Burri, Renè** (2019) - *Precursive time\_The hidden variable*; (2016) *Vacuum-Matter Interaction through Hyper-Dimensional Time-Space Shifting* . <http://dx.doi.org/10.4236/jhepgc.2016.23037>

The slide shows the main four equations that solve coherently the assumption under study.



## Acknowledgments

- A) We are indebted with the **Metallurgical Company**, located at the **NE** of **Italy**, that helped our experimental activities since 2011, providing us with materials, instrumentations, man-power and, overall, making several replications and improvements of our results in their own laboratories and with their internal Scientist. Very important cross-checking.
- B) We can't forget the help given by the **SIGI-Favier** Company (Italy-France) that developed, jointly with the NE Company and us, the new kind of hybrid glass fiber. They use was peculiar to allow the discovering of new effects in compact system at high temperatures.
- C) Travel expenses to allow my participation at “*2019 LANR/CF Colloquium at MIT, March 23-24, 2019 Cambridge MA 02139 (USA)*” partially supported by **BK S.p.A. Roma (Italy)**.

In the framework of Low Energy Nuclear Reactions (LENR) studies focused on Anomalous Heat Effect (AHE) generation by Hydrogen /Deuterium interaction with proper lattices, using Constantan (since 2012; CNM, alloy of  $\text{Cu}_{55}\text{-Ni}_{44}\text{-Mn}_1$ ) wires, with long (up to 130 cm) and thin shapes (surfaces made sub-micrometric by proper thermal treatments), since 2015 we developed a procedure to increase the local temperature of the wire (like hot spot) flowing specific amounts of current, by proper knots with low diameter holes. We observed that the amount of AHE increases: A) increasing the number of knots (up to 50/m); B) reducing the hole diameter (down to 200  $\mu\text{m}$ ); C) reducing the wire diameter (200, 100  $\mu\text{m}$ ); D) increasing the total length of the wire; E) increasing the local wire temperature and gradients along it. Moreover, the addition of oxides of specific elements (Fe, Sr, K, Mn; multilayer structure) at the surfaces of both wires and the specific glass sheaths (where CNM is inserted) had some effects both for the “lighting-on” and overall stability of the system, about AHE production (up to some days in the best experiments). Anyway, the reproducibility of the effects and the amount of AHE were, in the whole, not enough satisfactory, special toward a practical application (in prospective) of the effect. In addition, the amount of AHE, although not stable over time, was significantly reduced when we moved from isoperibolic thermal measurements (intrinsically with large thermal gradients along the wire length) to flow-calorimetry one (thermal gradients largely reduced).

In order to overcome such limitations we introduced, just after ICCF21 (Colorado State University-USA, 3-8 June 2018), a quite innovative geometry of the wire, based on the so called “*Capuchin knot*”. The first results were presented at IWAHLM13 (Greccio-Italy, 5-9 October 2018). By such geometry were reconfirmed both the beneficial effects of high temperatures and local (large) thermal gradients. Anyway, because excessive mechanical stresses during the preparation, the maximum number of turns was limited to 8 and minimal distance among the knots was about 12 cm. So, the total numbers of “coils” was limited to 4-5/m. Moreover, the construction of Capuchin knot and the overall installation inside the reactor (made by a tube of tick borosilicate glass) were quite difficult/time consuming.

Because such considerations we further developed the knot construction introducing an *hybrid geometry* that keeps the best of Capuchin geometry reducing, at the same time, the drawbacks of excessive mechanical stresses/difficulties. In addition, we had the opportunity to add both a “field” wire (insulated) and a thermometer inside the loop of the long coil. In conclusion, the number of turns is not anymore limited and the assembly is extremely compact: the apparent length, starting from a wire with 180 cm of length, is just 12 cm with an outer diameter of 1 cm. Such coil, with 50 turns, is inserted inside a 10-12 mm diameter SS316 tube that is used both for mechanical support and IR reflection emitted by the wire. In such a way the local temperature of most of the wire is largely increased (in respect to a nuke wire configuration, even covered by our usual hybrid glassy sheaths, i.e. borosilicate glass and  $\text{SiO}_2\text{-Al}_2\text{O}_3$  fibers) reducing (factor of 4-8) the external electric power needed to reach the operating temperatures (600-800 °C).

Although the new assembly is operative from only 1 month and the data are few, we observed: a) the AHE increases reducing the wire diameter (from 350 to 200  $\mu\text{m}$ ); B) the effects of AHE increases increasing the absolute temperatures of the wire (tested up to 850°C); C) the field wire, inserted inside a porous Quartz-Alumina sheath, quite close (1-2 mm) to the CNM coil, although absorbing a very limited amount of power (<1 mA at 300V) is able to both control the amount of Deuterium absorbed (by usual Resistance Ratio measurements) and the amount of AHE produced. Such (extremely interesting) result is obtained just by changing the values of *Voltage* applied and its *Polarity*. We started to study also the time response of the system: 5-10 ms of duration of, cyclic, excitation.