Reazioni nucleari con materiali
[Nuclear reactions induced by “Smart” materials]

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Presented by YS
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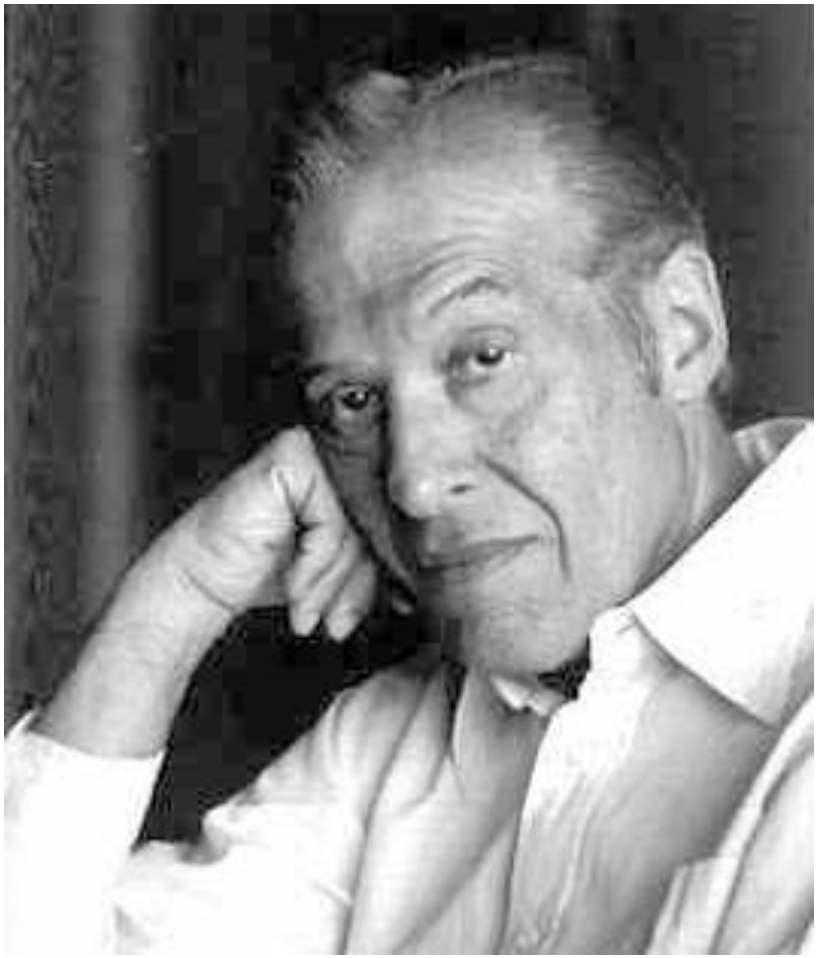
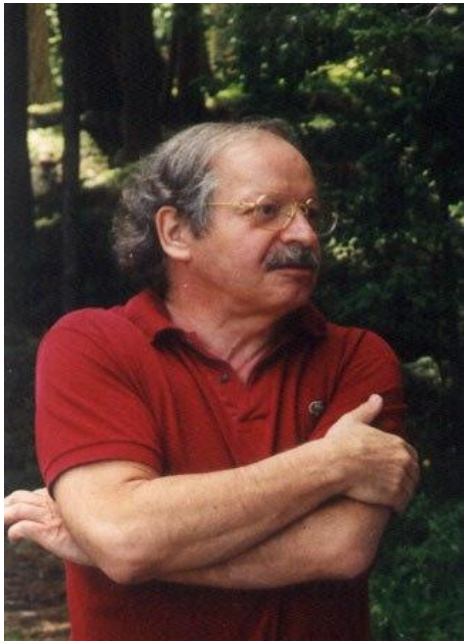
The Early Theoretical Explorers [I primi esploratori teorici]



Julian Schwinger



Giuliano Preparata

The Missing Links [L'Anello Mancante]:

What was missing in the analyses of Schwinger and Preparata?

Two important elements that would be discovered only through experiments after their demise:

- **A: The Japanese CF results showed that all the action is from a few atomic layers near the surface. They are not volume effects.**
- **[Superficie non volume]**
- **B: Neither included the weak**

interactions. Widom would introduce that. [Interazione debole di Fermi]

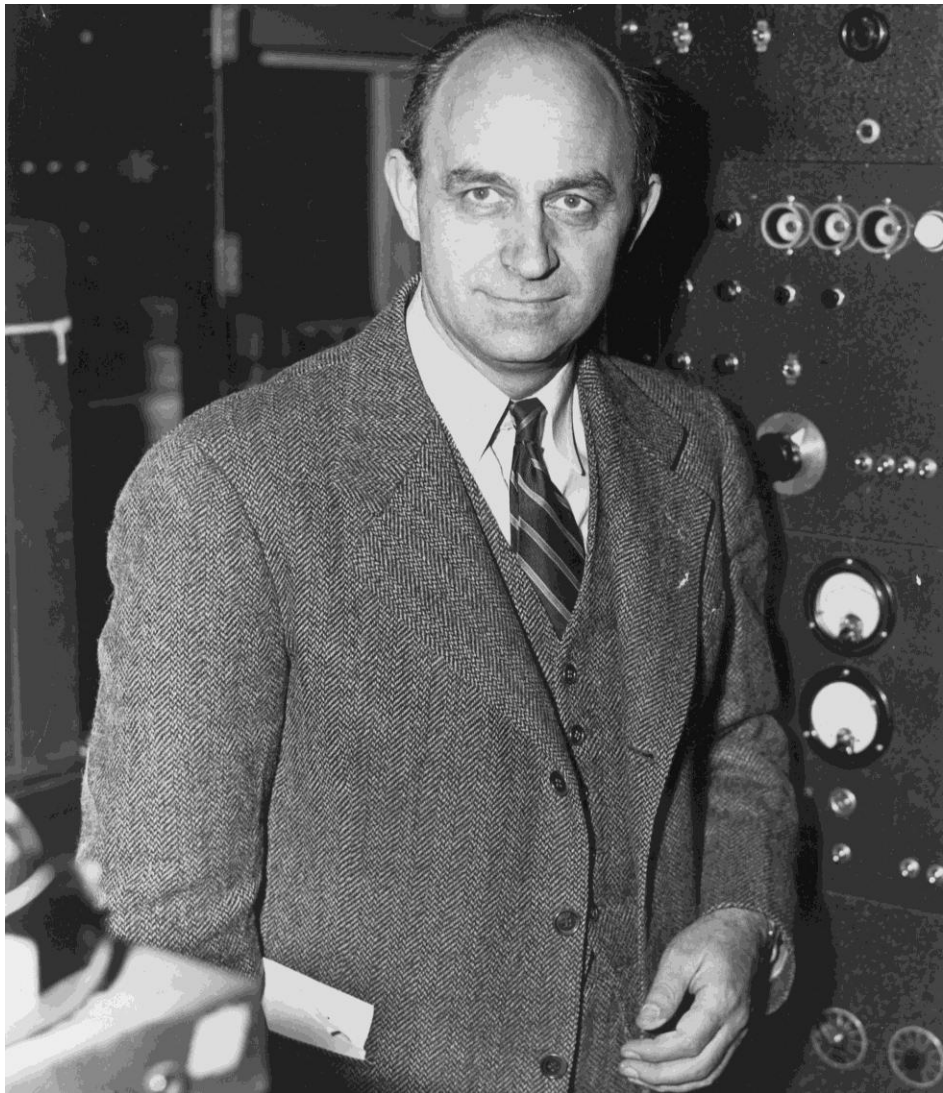
Electro-Weak Induced LENT: WLS Theory I

Widom added the Weak Force for LENT following the Fermi dictum:

Give me enough neutrons
And I shall give you the
Entire Periodic Table

$$n + {}^{A}X_Z \rightarrow {}^{A+1}X_Z + \gamma$$

$${}^{A}Y_Z \rightarrow {}^{A}Y_{Z+1} + e^- + \bar{\nu}_e$$



Electro-Weak Induced LENT: WLS Theory II

Electrons and protons in condensed matter have low kinetic energy and the inverse beta decay [electron capture by Wick]

$$e^- + p \rightarrow \; n + \nu_e$$

has a Q-value deficit of about 0.78 MeV. This means an energy W≥ 0.78 MeV needs to be put into the system for the reaction

$$W_{in} + e^- + p \rightarrow \; n + \nu_e$$

to proceed. W can be

(i) Electrical Energy: Widom-Larsen

(ii) Magnetic Energy: Widom-Larsen-Srivastava

(iii) Elastic[Piezoelectric & Piezo-magnetic] Energy: Widom-Swain-Srivastava

We have examples in Nature for all three

Threshold Energy Input for EW LENT

$$W = \gamma\, mc^2$$

$$W > W_{threshold} \sim 1.28\ MeV$$

$$\downarrow$$

$$\gamma_{threshold} \sim 2.5$$

Lack of this energy in usual condensed matter systems is why we have electromagnetic devices and not electroweak devices. Special methods are hence necessary to produce neutrons.

LENT in Human Body I

- **Potassium-40** (**^{40}K**) is a radioactive isotope of potassium which has a very long half-life of 1.248×10^{9} years, or about 3.938×10^{16} seconds.
- Potassium-40 is a rare example of an isotope that undergoes all three types of beta decay. About 89.28% of the time, it decays to calcium-40 (^{40}Ca) with emission of a beta particle (β^-, an electron) with a maximum energy of 1.33 MeV and an antineutrino. About 10.72% of the time it decays to argon-40 (^{40}Ar) by electron capture, with the emission of a 1.460 MeV gamma ray and a neutrino. Very rarely (0.001% of the time) it will decay to ^{40}Ar by emitting a positron (β^+) and a neutrino.[1]
- Potassium-40 is the largest source of natural radioactivity in animals and humans. An adult human body contains about 160 grams of potassium, hence about 0.000117 x 160 = 0.0187 grams of ^{40}K; whose decay produces about 4,400 disintegrations per second (becquerels) continuously throughout the life of the body.[2][3]

LENT in Human Body II

^{40}K occurs in natural potassium (and thus in some commercial salt substitutes) in sufficient quantity that large bags of those substitutes can be used as a radioactive source for classroom demonstrations.

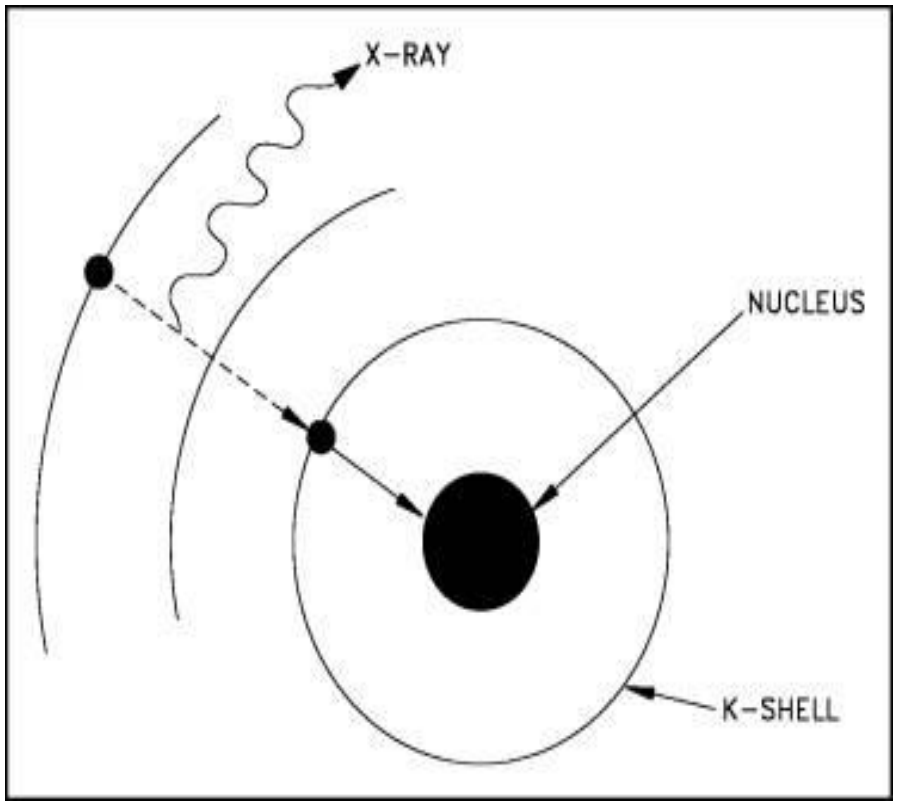
In healthy animals and people, ^{40}K represents the largest source of radioactivity, greater even than ^{14}C. In a human body of 70 kg mass, about 4,400 nuclei of ^{40}K decay per second.[1]

LENT in Human Body III

Electron capture occurs when an unstable nucleus grabs an electron from its inner shell to help stabilize the nucleus. The electrons combine with a proton to form a neutron that stays in the nucleus.

$^{40}K + e^- \rightarrow {}^{40}Ar$

The energy of the photon is 1.46 MeV.



LENT in Human Body IV

1. Approximately 4.4 x 10^3 nuclear reactions

are being produced per second by a human body just through the presence of about 1.87 milligrams of the radioactive isotope ^{40}K [total amount of potassium is about 160 grams in a person of weight about 70 Kg.].

2. It is interesting to note that ^{40}K is quite unusual in decaying mainly in three different ways:

(i) ^{40}K decays into ^{40}Ca via beta minus [electron emission],

(ii) ^{40}K decays into ^{40}Ar by electron capture [atomic electron K or L-shell electron getting captured by a proton and converting it to a proton] generating a neutrino and a photon.

(iii) Very rarely, it decays also via positron emission.

3. Now let us consider the energies involved:

In (i) the maximum energy to be shared between the neutrino and the electron is 1.33 MeV.

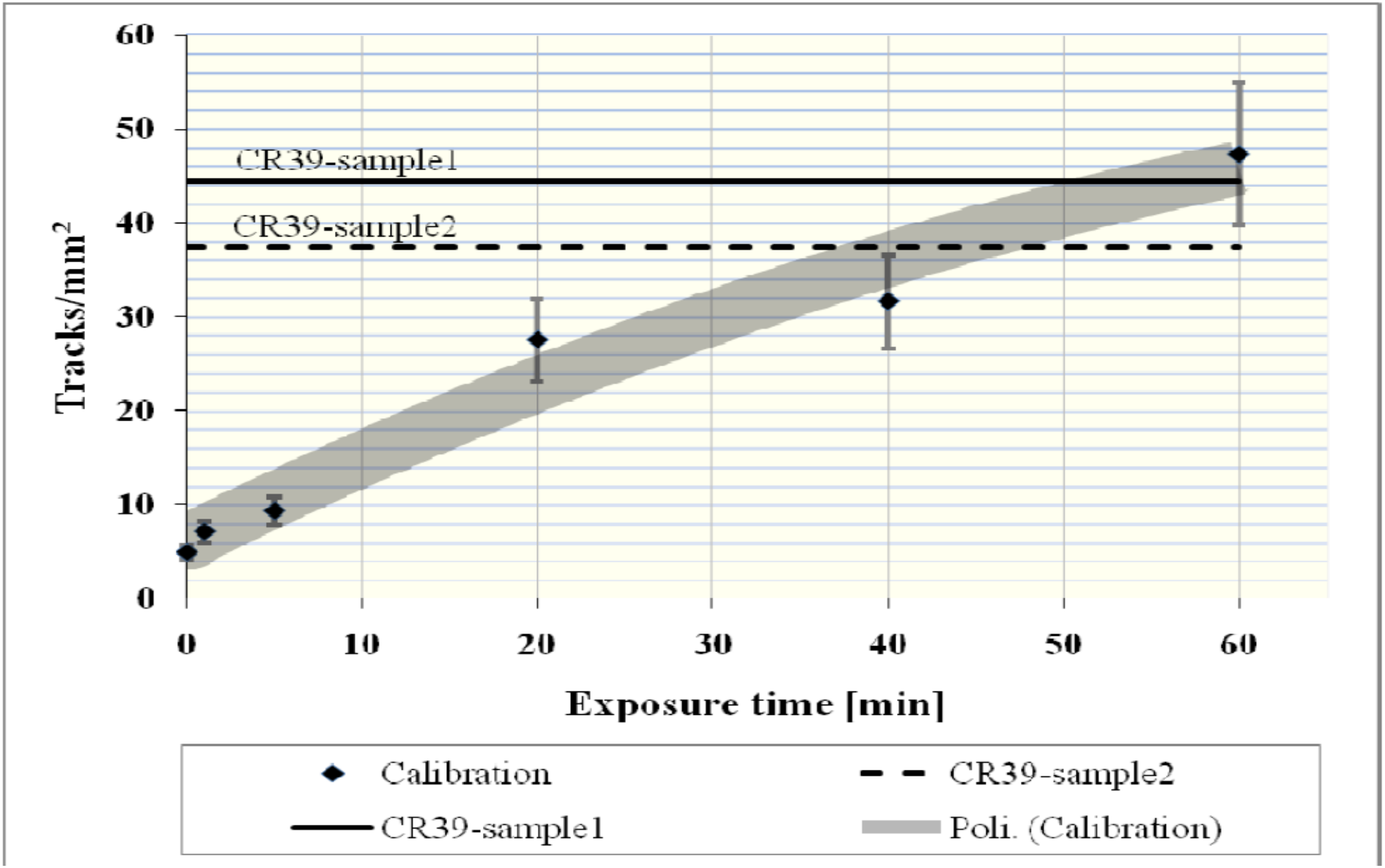
In (ii) the energy of the photon is 1.46 MeV.

Experimental Evidence of Neutron Production in a Plasma Discharge Electrolytic Cell

Domenico Cerillo, Roberto Germano,
V. Tontodonato, A. Widom, YS, E. Del Giudice,
G. Vitiello

Key Engineering Materials, 495 (2012) 104

Plasma Cell XV: Neutron Flux



The Promete Naples Experiment XIV: Evidence for Nuclear Transmutation

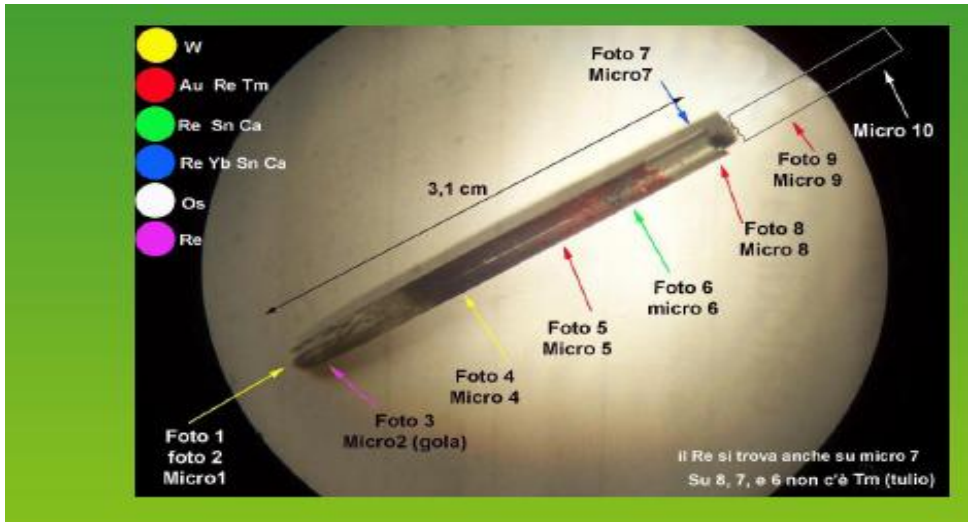
Cathode: Pure Tungsten in K_2CO_3

Substances found afterwards on the surface:

1. Rhenium [always]

With less abundance

2. Osmium
3. Tulium
4. Yttrium
5. Gold
6. Hafnium
7. Strontium
8. Calcium
9. Tin
10. Germanium
11. Zirconium
12. Platinum



4 Acid tests for LENT

For truly conclusive evidence that LENT has indeed occurred in a given experiment, we must have:

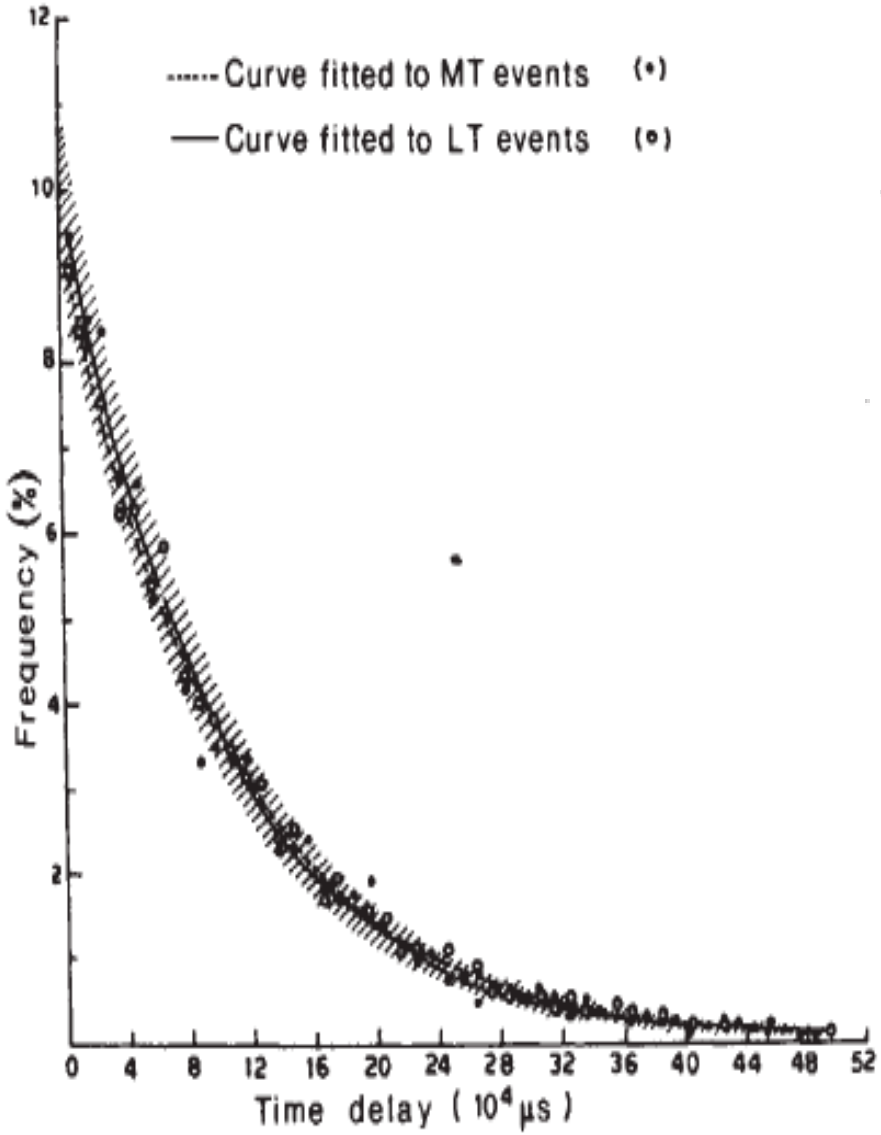
1. EM radiation [gamma's in the (100 KeV-MeV) range]

2. Neutrons must be observed

3. Observance of materials not initially present [i.e., direct confirmation of nuclear transmutations]

4. More output energy than the input energy

LENT in Nature: Neutrons from Lightning



NATURE VOL. 313 28 FEBRUARY 1985 LETTERS TO NATURE 773

Neutron generation in lightning bolts

G. N. Shah, H. Razdan, C. L. Bhat* & Q. M. Ali

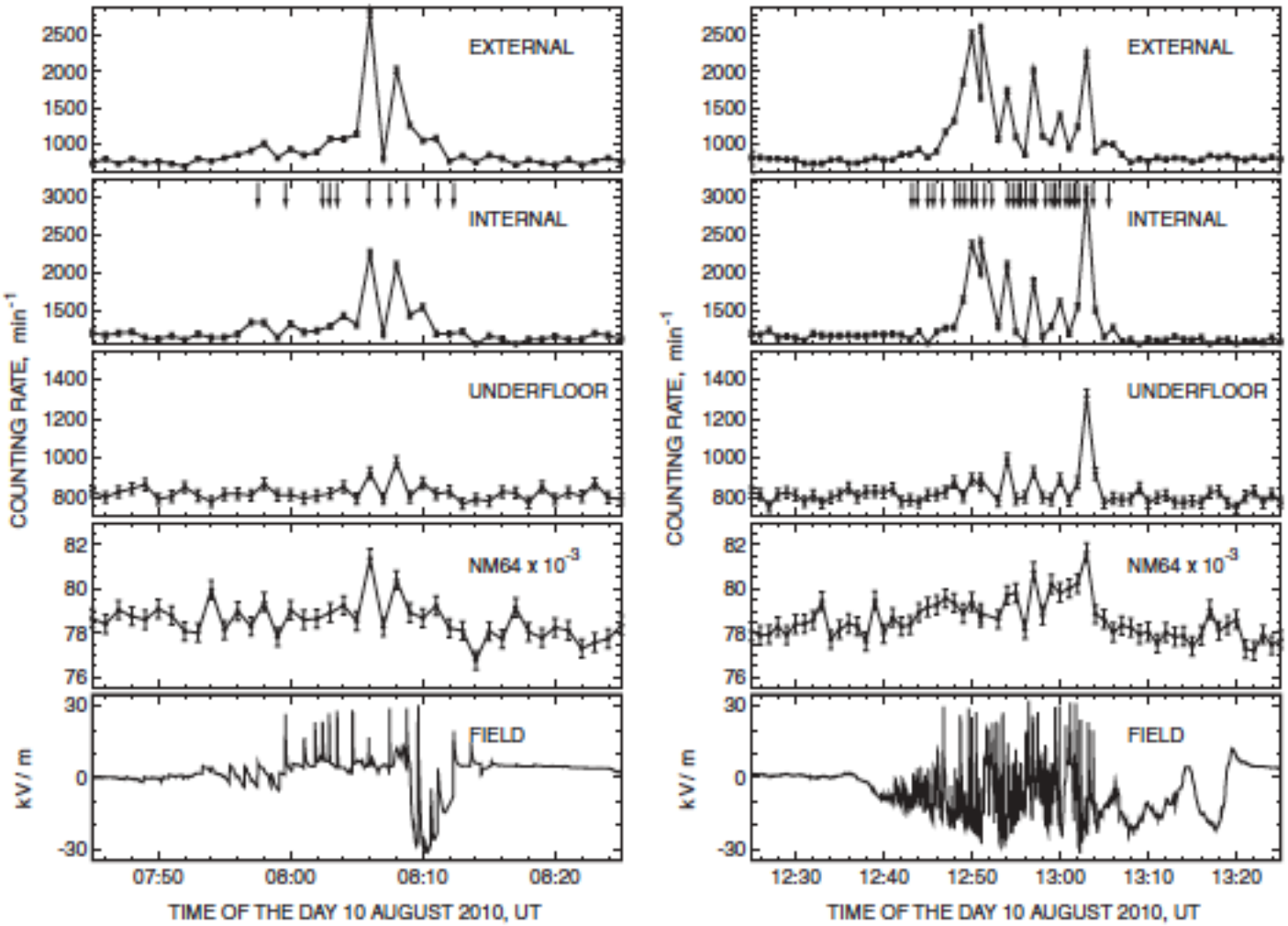
Bhabha Atomic Research Centre, Nuclear Research Laboratory, Zakura, Naseem Bagh, Srinagar-19006, Kashmir, India

Mean Current about 35 Kilo Amperes

$(I/I_o) \sim 2$

Strong Flux of Low Energy Neutrons Produced by Thunderstorms

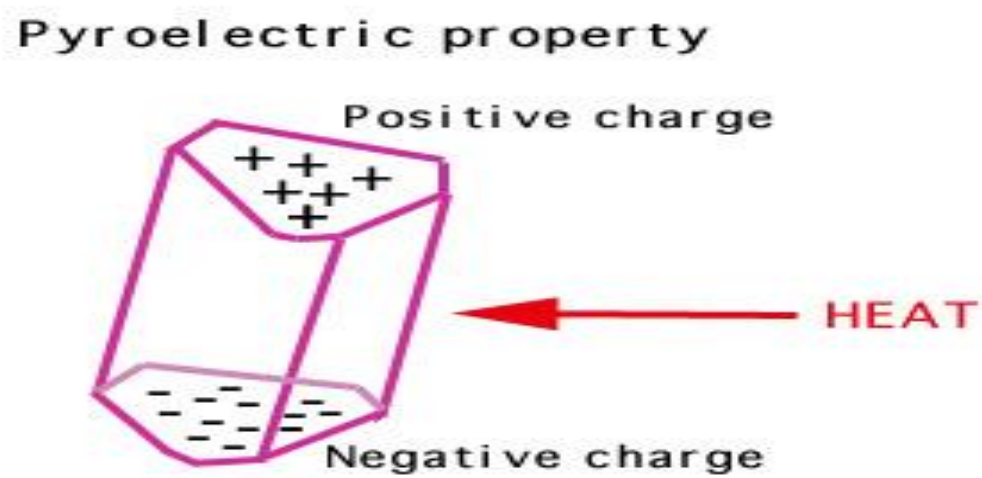
A. Gurevich *et al*: Phys. Rev. Lett. 108, 125001; 23 March(2012).



Two Smart Materials

1. Pyroelectric crystals:

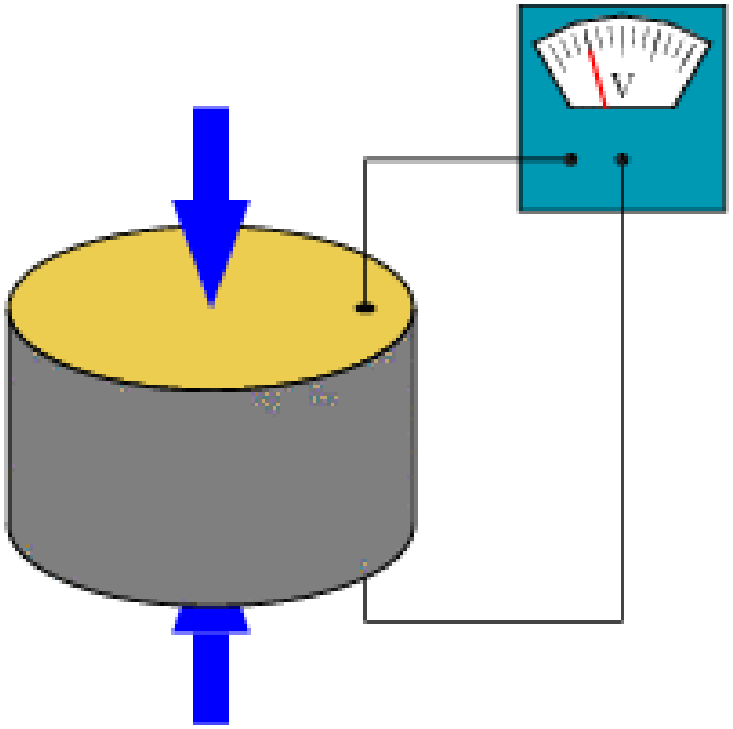
when heated or cooled produce electric fields



2. Piezoelectric crystals

when crushed produce electric fields

Piezoelectric Solids



Strains in a crystal produce voltages across the crystal and vice versa.

Magnetite: piezomagnetic material

Magnetic counterpart of a piezo-electric material

Elastic energy is converted into Magnetic energy

Neutron production from fracturing “Smart” rocks [WSS]: I

- Theoretical explanation is provided for the experimental fact that fracturing piezoelectric rocks produce neutrons

- The mechanical energy is converted by the piezoelectric effect into electrical energy

In a piezoelectric material [quartz, bone, hair, etc.], forming a class called “smart materials”, conversion of

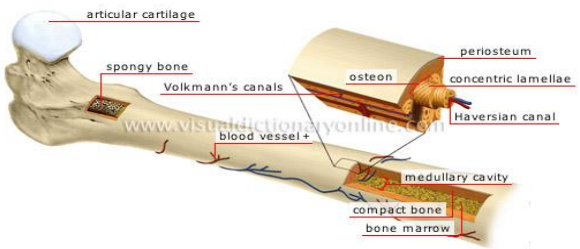
elastic energy $\longleftrightarrow$ electrical energy

can occur

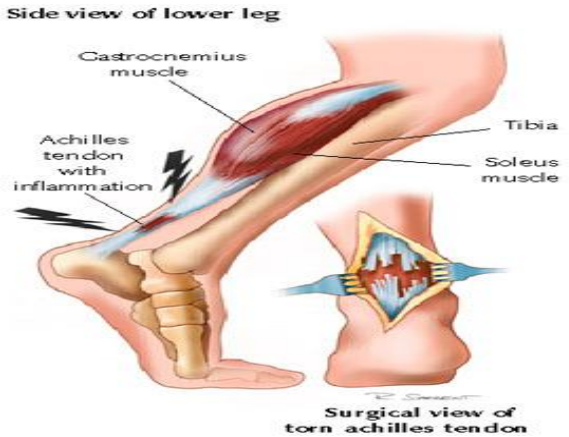
LENT in Smart Materials I: Pyroelectrics

A pyroelectric crystal develops an electric field due to (adiabatic) changes in its temperature and its opposite: an applied electric field causing an adiabatic heating or cooling of the system is called the electrocaloric effect.

Examples of natural pyroelectric crystal are: tourmaline, bone, tendon.



It was experimentally shown that pyroelectric crystals when heated or cooled produced nuclear dd fusion evidenced by the signal of 2.5 MeV neutrons. The system was used to ionize the gas and accelerate the ions up to 200 KeV sufficient to cause dd fusion. The measured yields agree with the calculated yields.



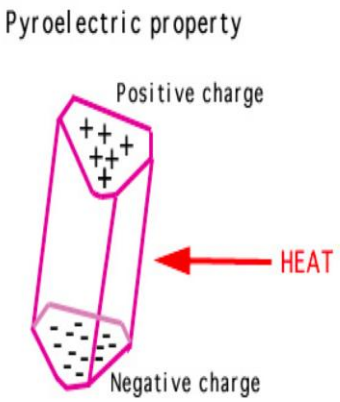
Pyroelectrics II

- In a single domain of a pyro-electric crystal, the mean electric induction is not zero:

$$< \mathbf{D} > \neq 0$$

- When such a crystal is heated or cooled, it gets spontaneously polarized: produces an electric field
- The effective electric field (E_{eff}) generated in the crystal is assumed proportional to the change in the temperature (ΔT): $E_{eff} = \phi \, \Delta T$
- Lithium Tantalate [$LiTaO_3$] has a large

$$\phi = 17 \text{ KV/cm K}$$



Pyroelectrics IV

$$d + d \rightarrow {}^{3}\mathrm{He} + n$$

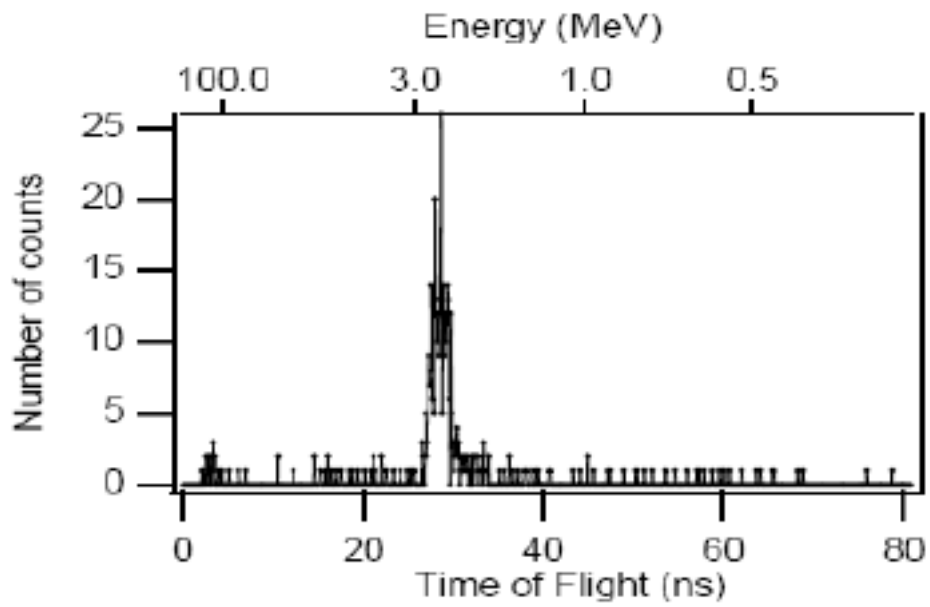


FIG. 1. Neutron time-of-flight spectrum. Neutrons were detected 62 cm from the target using a 7 mm thick plastic scintillator. The peak occurs at 2.45 ± 0.2 MeV, characteristic of DD fusion.

Electro-strong LENT I

Electro-strong Nuclear Disintegration in Matter

J. Swain, A. Widom and Y. Srivastava

arXiv: 1306.5165 [nuc-th] 19 June 2013

arXiv: 1306.6286 [phys-gen ph] 25 June 2013

Real photons and virtual photons [from electron scattering] have been used for over 50 years to disintegrate nuclei through giant dipole resonances.

In the past, accelerators have produced the needed [10-50] MeV photons for breaking up nuclei.

Our suggestion: accelerate electrons up to several tens of MeV through lasers and "smart" materials to cause electro-disintegration

Electro-strong LENT II

Processes usually studied are 1 & 2 neutron production

$$\gamma + A \rightarrow \ n + A^{*}; \gamma + A \rightarrow \ 2n + A^{**}$$

A^{*} & A^{**} are excited nuclei.

We have a synthesis of electromagnetic and strong forces in condensed matter via giant dipole resonances [GDR] to give an effective

"electro-strong interaction"

- a large coupling of electromagnetic and strong interactions in the tens of MeV range.

GDR Energy of light nuclei ~ (15-25)MeV;

GDR Energy of heavy nuclei ~ (10-20)MeV

Electro-strong LENT III

- GDR are well-studied and represent a strong coupling between all atomic nuclei and photons in the range of (10-25) MeV.
- GDR are well-known to be excited by electrons with a few tens of MeV with significant neutron yields (often 10^{-3} or more) per electron on thick targets, and both fast and slow neutrons can be produced.
- GDR are very well understood and used, both theoretically and practically in devices well outside the scope of nuclear physics proper [for example in medical physics].

Electro-strong LENT IV

- When electrons are accelerated to tens of MeV in condensed matter systems, then in addition to producing neutrons via electroweak processes, we expect, and at much higher rates, what we call "electrostrong processes", where nuclear reactions take place mediated by GDR.
- In this case one expects slow neutrons from evaporation of GDR's as well as some fast ones, and additional nuclear reactions when those neutrons are absorbed.

Electro-strong LENT V

Once electrons are accelerated to tens of MeV in condensed matter systems, then we expect both

endothermic and exothermic nuclear fission

&

appearance of new nuclei

due to further reactions of the decay products including subsequent decays and/or the absorption of produced neutrons.

Electro-strong LENT VI

- AN EXAMPLE: ALUMINUM AND SILICON FROM IRON

$$\gamma +^{56}_{26} Fe \rightarrow \; 2[^{28}_{14}Si + e^- + \bar{\nu}_e]$$

$$\gamma +^{56}_{26} Fe \rightarrow \; 2[^{27}_{13}Al + n]$$

If electrons are accelerated to several tens of MeV in condensed matter systems containing iron, then one may expect the appearance of aluminum and silicon.

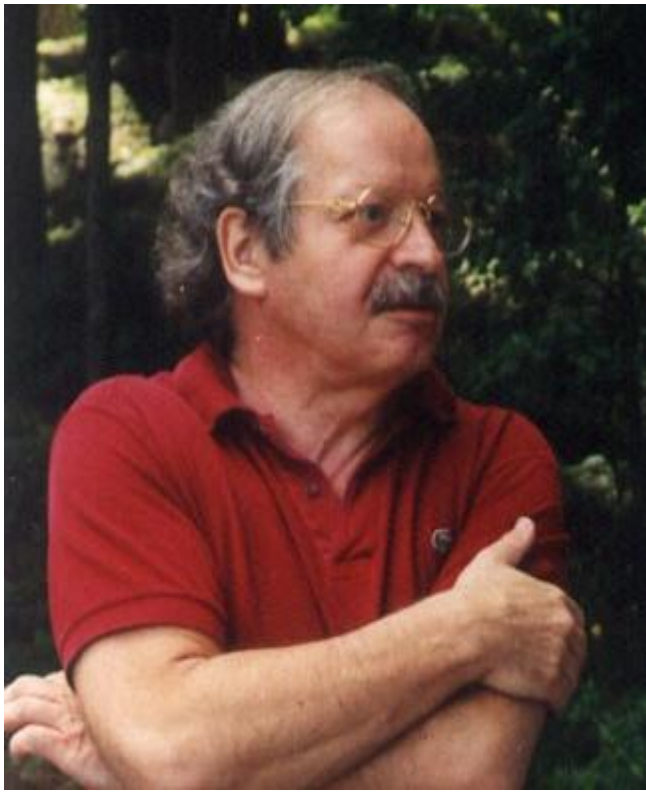
Experimental data: A. Carpinteri et al. [Politecnico Torino]

The Preparata Project at Perugia

At University of Perugia, we have assembled a group of experimentalists who have begun a set of Proof of Concept experiments to implement and check the theoretical results obtained by our group.

Presently we have a 3-year doctoral candidate [EM] and a Laurea Specialistica student and we are expecting to add a Post-doctoral researcher depending upon the availability of funds.

Technical and research support is being provided by CNP Lugano, Switzerland



Giuliano Preparata
(1942-2000)

The Preparata Project at Perugia II

As stated before, for the completion of the project our goal would be to make all 4 Acid tests for LENT

1. Evidence of some high energy [KeV-to-MeV] photons.

2. Evidence of some produced neutrons

3. Evidence of some nuclear transmutations [new elements found after which were absent before]

4. Some gain in energy

The Preparata Project at Perugia III

Brief Description of the Proof of Concept phase

A: Electron Excitation via Surface Plasmons:

AI: Selection and composition of materials

A2: Induction of Surface Plasmon Polaritons

A3: Detailed study of the resonance phenomena

B: Induction of nuclear reactions

B1: Study of rates vs. materials

B2: Spatial distribution of reaction regions [hot spots]

C: Detection of products of nuclear reactions

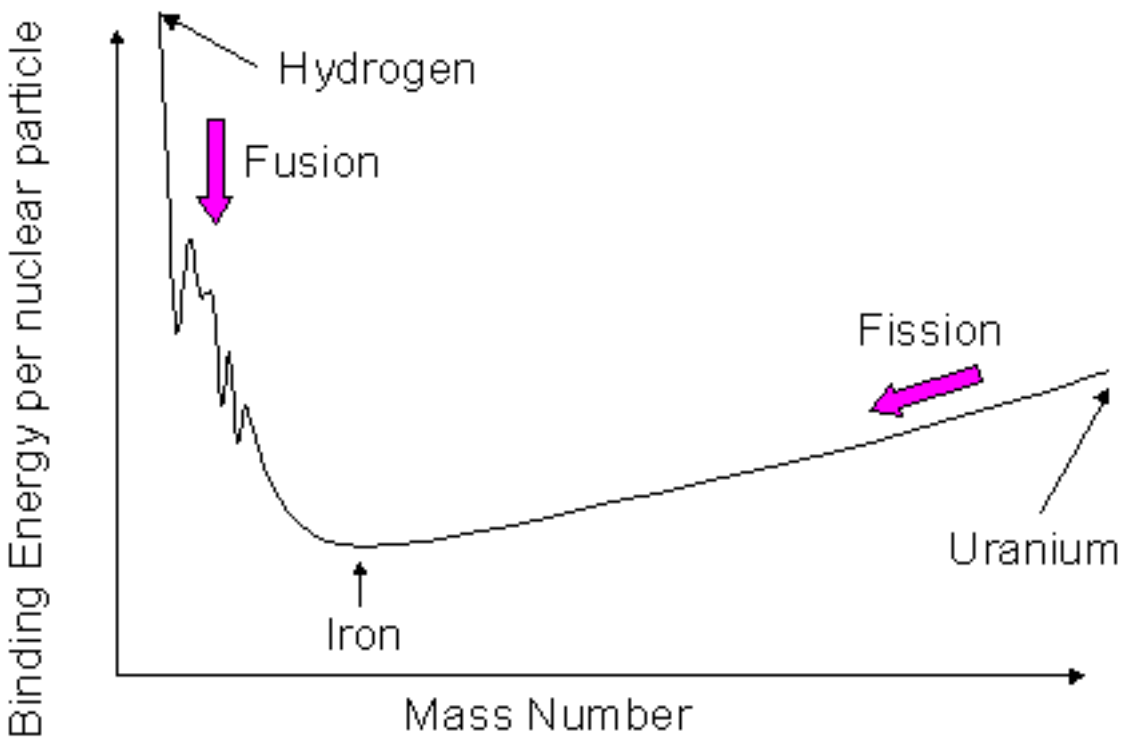
C1: Choice of detection techniques

C2: Study of final products

C3: Analysis of results

Synthesis of Electroweak & Electrostrong, fulfills the Fermi dictum to reproduce the entire periodic table given enough neutrons.

We dedicate it to the memory of the two J/Gulians:
Julian Schwinger and Giuliano Preparata who worked so hard and suffered so much



Errors by Governments regarding Energy Planning I

- The success with the hydrogen bomb in the fifties, led its father Edward Teller declare to the US in 1960 [when I reached there as an 18 year old student] that very soon the energy problem would be solved for ever.

- 50 years later & after an expenditure of over 200 billion dollars, the latest prognosis about available energy from hot fusion in the US is 2060 and in Europe it is 2050. This lie should be totally unacceptable to any policy maker in Europe or the US but Europe would dump another 2 billion Euros this year in HF.

Errors by Governments regarding Energy Planning II

Not one scientist working for a European government has spoken out against this waste of public fund and false promise. In 2012, in a seminar that I gave at CERN in Geneva, I did.

And please believe me, many influential Italian physicists were very angry with me and they have “made me pay” for this “sgarbo”.

The irony is that Obama has undersrtood part of the US mistake and has cancelled three major HF programs in the US

But Europe –which is typically two decades behind in correcting a US mistake- has not.

Errors by Governments regarding Energy Planning III

One percent of HF fund being currently squandered on HF would let Low energy nuclear reactions go forward and would most likely produce some astonishing results in a few years rather than beyond the intellectual life times of most European parlamentarians making the present wrong decisions.

Summary and Future Prospects of our Project

Since, over a decade ago, when the pioneers in Italy Giuliano Preparata, Emilio Del Giudice and their group were doing experiments, some theoretical and technical advances have occurred.

But more than that, the paradigm about low energy nuclear reactions has been shifting, albeit slowly.

Hence, our optimism. Time will tell.

Thank you

Spare Slides

A Sad Petition against Piezo nuclear processes

According to news reports, 1300 ricercatori Italiani have signed and sent a petition to the Italian Minister against nuclear reactions from piezoelectric materials and low energy nuclear reactions in general. There have been devastating articles in all major Italian newspapers: Corriere della Sera, La Stampa, La Repubblica, Il Manifesto,…

It saddens me that a majority of physicists who have signed, do not know much about piezo-electric effect even after signing.

They obviously do not know that Russian groups have reported [during the period 1953-1987] high energy particle production from fracturing certain crystals. They do not know that there is supporting Japanese work published in 1992 and that there is a serious discussion about this subject in a book published by the Cambridge University Press in 1993.

They do not know that fracture induced nuclear transmutations and neutron production have been reported by Russian groups in three papers [published in Nature, JETP and Physica], by an Indian group [published in Phys Lett A] and two papers by a Japanese group [published in Nuovo Cimento and Jap. J of App Phys]. We have ourselves published three papers in reputable journals on this subject.

As the Nobelist Julian Schwinger, might have said, have they forgotten that physics is an experimental science?

Let us turn to piezo electric theory.

How many of the *signers* know that there is a well studied Hamiltonian which describes how elastic energy is directly converted to electrical energy and vice versa?

How many have bothered to learn about Griffith's law about micro-cracks? It teaches us that stresses needed to create a micro crack can be about a thousand times smaller than the stress needed to break all chemical bonds?

How many know that Carrara marble is not piezoelectric but quartz is? Quartz marbles when crushed would produce large electromagnetic radiation thanks to a direct transformation of piezoelectric elastic energy into electromagnetic energy.

How many theorists amongst the *signers* have bothered to draw and compute a one-loop Feynman diagram and check that the photon propagator inherits the acoustic frequencies in the microwave range?

How many have bothered to estimate the size of the electric fields generated through a microcrack in a piezoelectric crystal? And thence estimate how large an acceleration is imparted to an electron.

How many have bothered to estimate the chemical potential [which an electron sees] in order to find that it can easily be in several tens of MeV's when a piezoelectric rock is crushed and hence more than capable of producing neutrons?

Alas, had they done so they would have shed their negative attitude and realized that a recent proposal to employ piezoelectric sensors for advanced warning against earthquakes has a lot of merit and certainly worthy of investigation by researchers for the general good of Italy.

Failure to do so would lead us to buy such devices in the near future from Japan most probably.

It is a reasonable fear that this petition would very soon lead to articles in Nature and Science [science equivalent of Moody's or Standard & Poor for the financial world] trashing Italian physics, once a jewel of Italian and international science.

"Elegant Soutions. Ten Beautiful Experiments in Chemistry"

by

Philip Ball

Rutherford had teamed up with British chemist Frederick Soddy to find that thorium produced argon:

They realized the implication with something akin to horror.

`The element was slowly and spontaneously transforming itself into argon gas!', Soddy later wrote.

At the time, he was shocked.

Soddy reportedly stammered to his colleague in the lab,

`this is transmutation: the thorium is disintegrating.

`For Mike's sake Soddy', Rutherford thundered back, `don't call it transmutation. They'll have our heads off as alchemists.'

But transmutation was truly what it was.