Nuclear reactions induced by "Smart" materials

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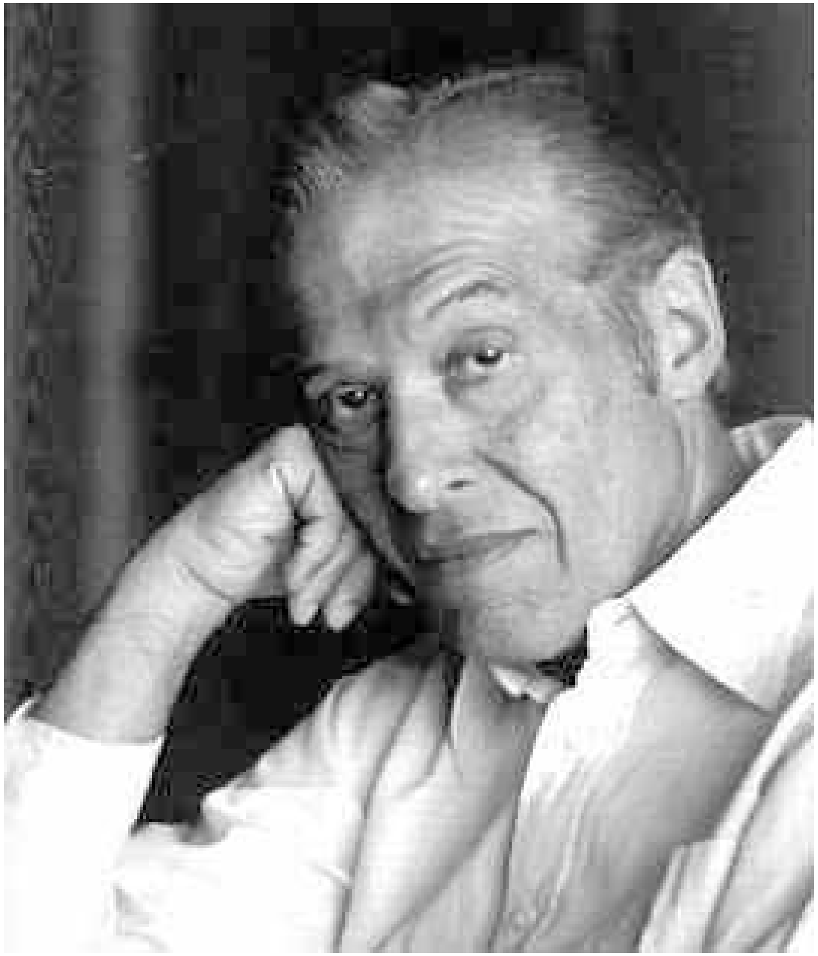
Presented by YS
@
Politecnico di Torino, Torino, Italia

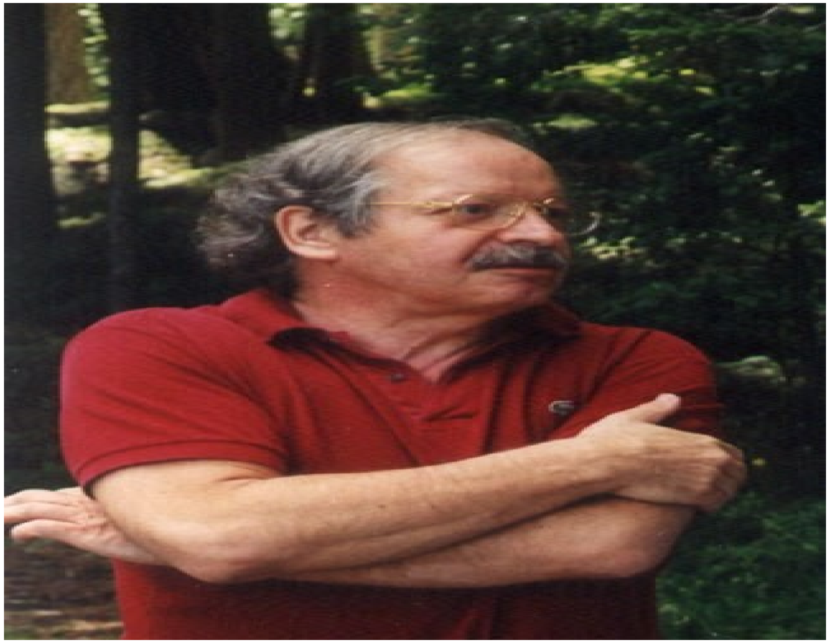
Plan of the talk

- 1. Brief review of a Low Energy Nuclear Theory [LENT]
- 2. Application to Piezo-electric rocks [a “smart” material]
- 3. Other methods of inducing low energy nuclear transmutations
- 4. The Preparata Project: An experimental program at Perugia

The Early Explorers



Julian Schwinger



Giuliano Preparata

The Missing Links:

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.**

- **B: Neither included the weak**

interactions. Widom would introduce

that.

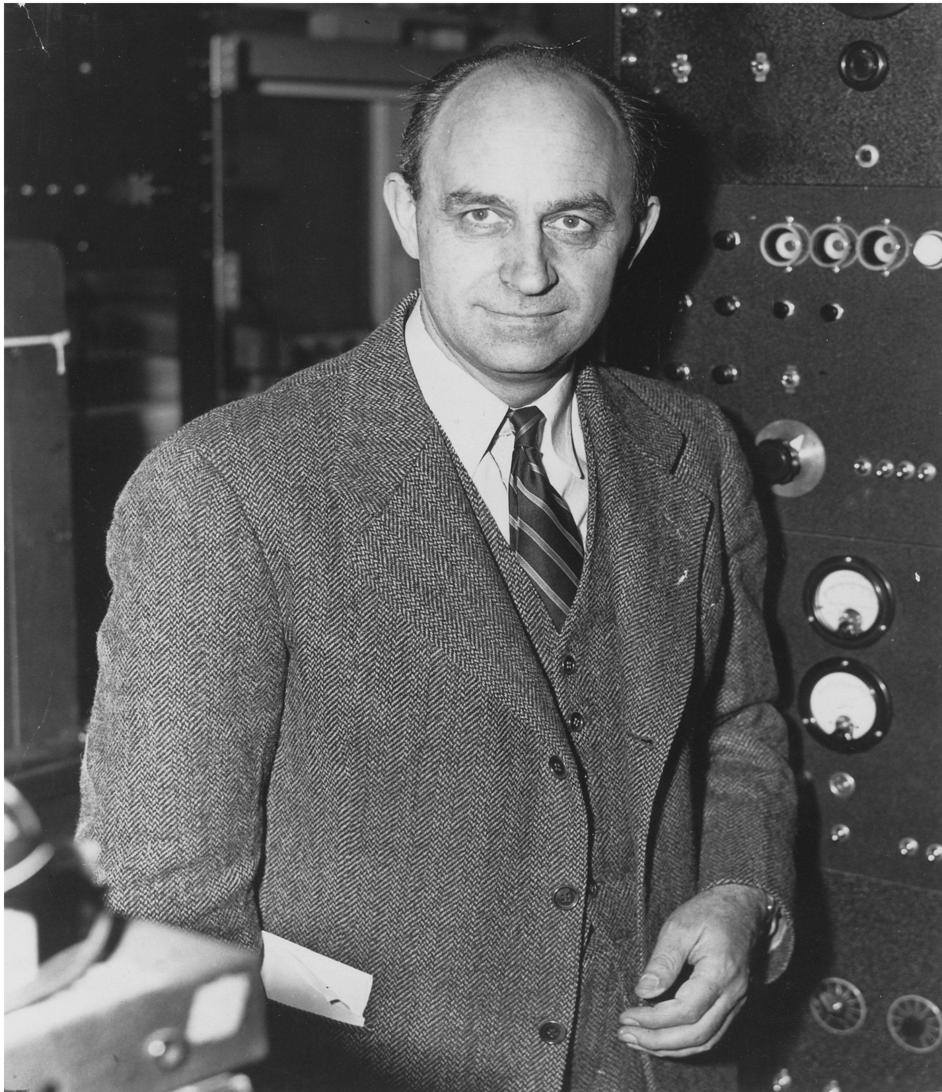
Electro-Weak Induced LENT: WLS Theory I

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

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

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] 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

Rate of Neutron Production

- Once the threshold is reached, the differential rate for weak neutron production is

$$\Gamma_2 \approx \left(\frac{3g_V^2 + g_A^2}{2\pi^2}\right)\left(\frac{G_F m^2}{\hbar c}\right)^2\left(\frac{mc^2}{\hbar}\right) n_2 (\gamma - \gamma_{threshold})^2$$

$$\Gamma_2 \approx \varpi \left(\gamma - \gamma_{threshold}\right)^2$$

$$10^{12}\frac{Hz}{cm^2} < \varpi < 10^{14}\frac{Hz}{cm^2}$$

A robust production rate for neutrons

Electric Field Acceleration

- Excitation of surface plasma modes at a mean frequency Ω, yields a fluctuating electric field *E*. These QED fluctuations renormalize the electron energy $$\tilde{e}^- + p \rightarrow \; n + \nu$$

$$W + M_p c^2 > \; M_n c^2$$

$$W = \gamma(mc^2) = mc^2 \sqrt{1 + (\frac{e^2 \bar{E}^2}{m^2 c^2 \Omega^2})}$$

Electric Field Mode II

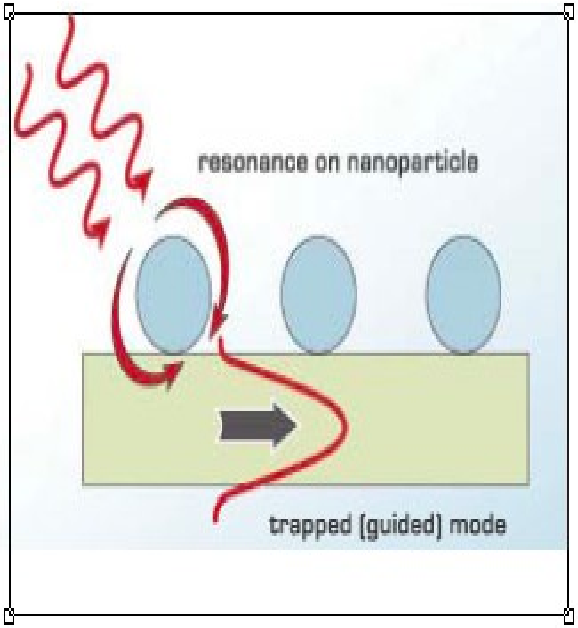
- Electric Mode [W-L]

Surface Plasmon Polariton [SPP] evanescent resonance modes can be set up on a metallic hydride surface generating strong local electric fields to accelerate the electrons

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

$$\Omega$$

$$\frac{c\mathcal{E}}{\Omega} = \frac{me^2}{e} \approx 0.5 \times 10^6\ Volts$$



4 Acid tests for LENT

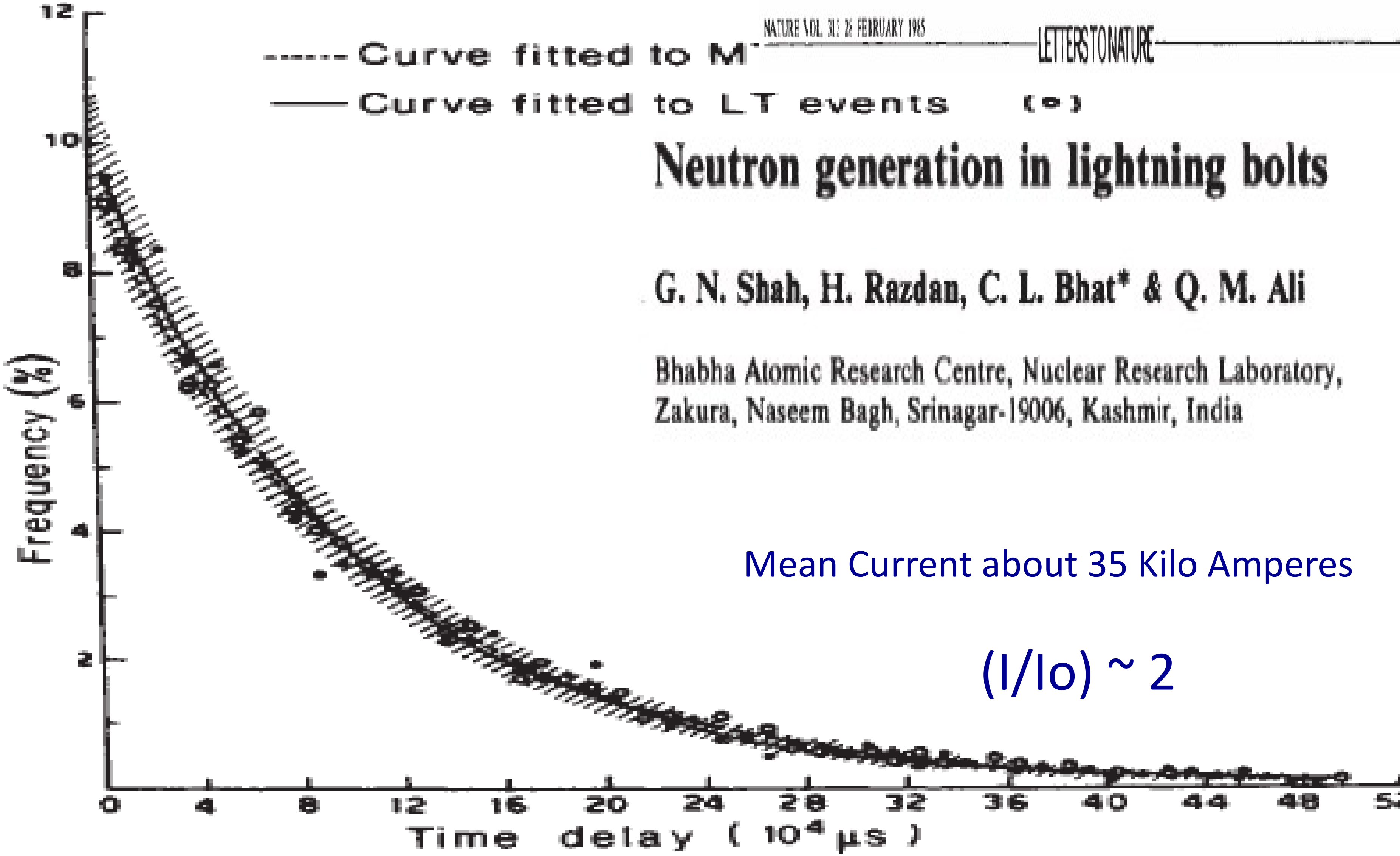
For truly conclusive evidence that LENT has indeed occurred in a given experiment, we must have:

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]

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

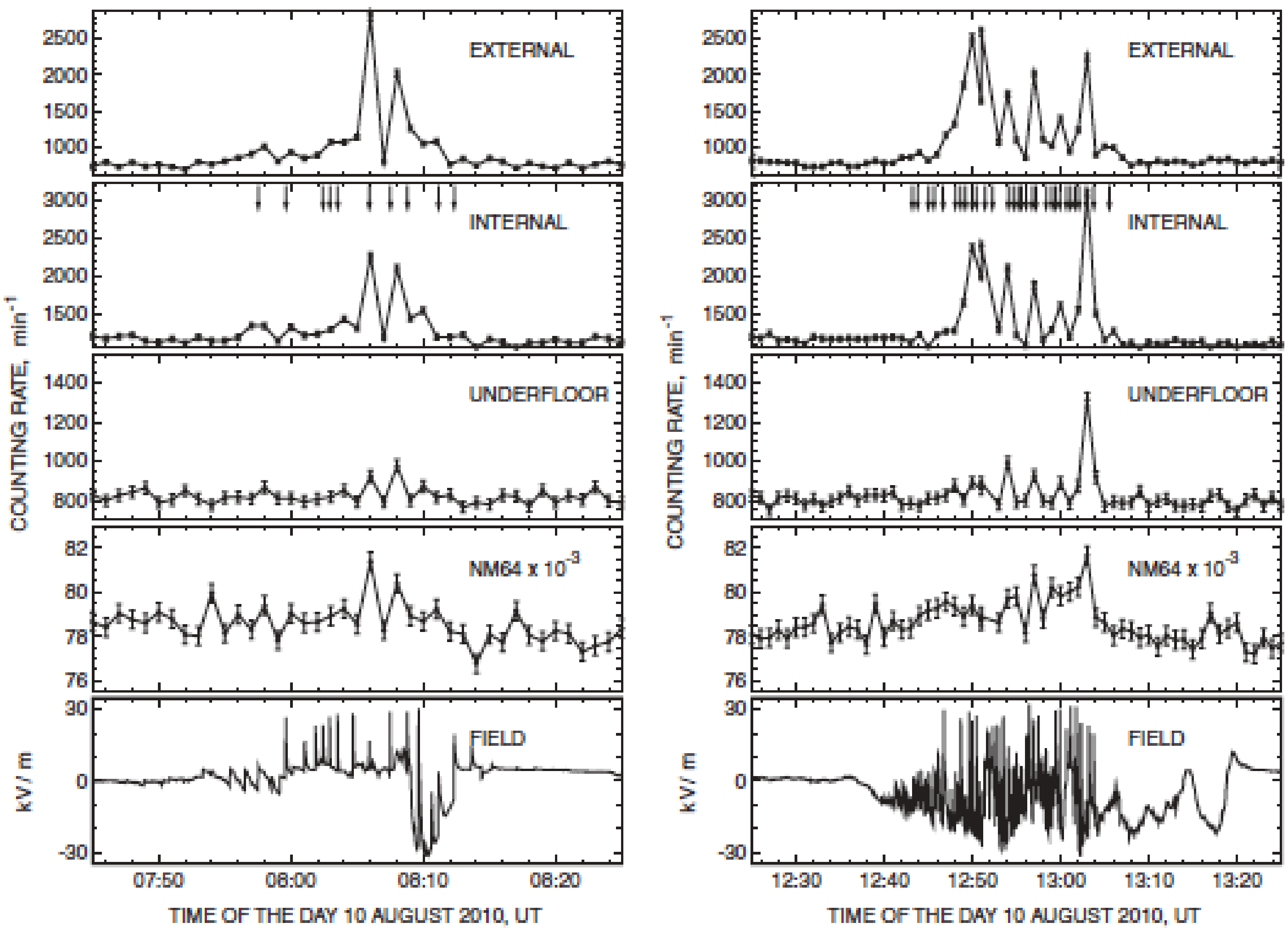
Bhabha Atomic Research Centre, Nuclear Research Laboratory, Zakura, Naseem Bagh, Srinagar-19006, Kashmir, India

Mean Current about 35 Kilo Amperes

(I/Io) ~ 2

Strong Flux of Low Energy Neutrons Produced by Thunderstorms

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



Strong flux of neutrons from thunderstorms II

Salient results and conclusions derived by the experimentalists:

- Most of the observed neutrons are of low energy in contrast to cosmic ray measurements where higher energy neutrons dominate.
- Measured rates of neutrons are anomalously high and to accommodate them an extra ordinarily large intensity of radiation in the energy range (10–30) MeV, of the order of (10–30) quanta/ cm2 /sec. is needed to obtain the observed neutron flux.
- The obtained γ- ray emission flux was about 0.04 quanta/ cm2 /sec., 3 orders of magnitude less than the needed value.
- In all these observations the radiation intensity was observed at moderate energies (50–200) KeV [3 orders of magnitude lower than that needed]

Strong flux of neutrons from thunderstorms III [Widom-Swain-YS]

We show that the source of a strong neutron flux at low energy is not theoretically anomalous.

The explanation, employing the standard electroweak model, as due to the neutron producing reaction

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

which is energetically allowed via the large high current electron energy renormalization inside the core of a lightning bolt.

Strong flux of neutrons from thunderstorms IV

- Consider an initially large number (N +1) of interacting electrons contributing to the electric current within the lightning bolt undergoing a weak process

$$(N+1)e^- + p^+ \rightarrow (N)e^- + n + \nu_e$$

- The importance of having a large number of "spectator" electrons is the induction of a coherent Darwin interaction between the electrons.

- Although only one electron disappears, many electrons are required to yield a high collective contribution to the reaction energy which thereby enhances the nuclear activity. We have shown that the

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 $\leftrightarrow$ electrical energy

can occur

Neutron production from fracturing rocks [WSS]: II

$\mathcal{E}$ Electric field

w Strain tensor

β Piezoelectric constant

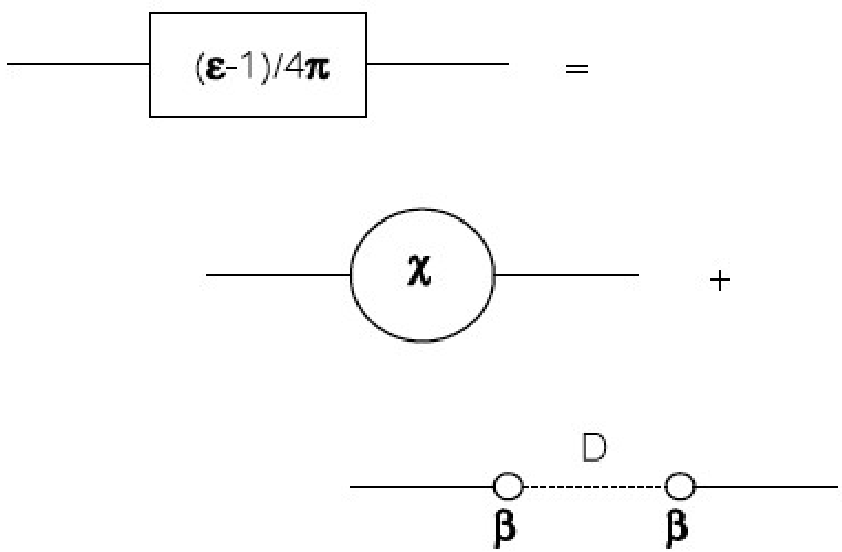
$$\mathcal{H}_{int} = -\int \beta_{ijk} E_i w_{jk} d^3\mathbf{r}$$

Neutron production from fracturing rocks [WSS]: III

$$\mathbf{D} = \mathbf{E} + 4\pi\mathbf{P},$$

$$\epsilon_{ij}(\zeta) = \delta_{ij} + 4\pi\tilde{\chi}_{ij}(\zeta),$$

$$\tilde{\chi}_{ij}(\zeta) = \chi_{ij}(\zeta) + \beta_{i,jk} D_{lknm}(\zeta)\beta_{j,nm}$$



- *Dijkl* is the phonon propagator
- εij is the dielectric response tensor; it appears in the polarization part of the photon propagator
- The Feynman diagram shows how the photon propagator is affected by βijk
- The above makes us understand why mechanical acoustic frequencies occur in the electrical response of piezoelectric materials

Neutron production from fracturing rocks [WSS]: IV

Numerical Estimates:

(i) vs velocity of sound vs. c is ~ 10-5 hence

(ωphonon /ωphoton) ~ 10-5 for similar sized cavities

(ii) The mean electric field E ~ 105 Gauss

(iii) The frequency of a sou[illegible] is

$$\Gamma(e^- + p^+ \to n + \nu_e) \sim 0.6 \text{ Hz} \qquad \varpi_2 \sim 10^{15} \frac{\text{Hz}}{\text{cm}^2} .$$

in the microwave range

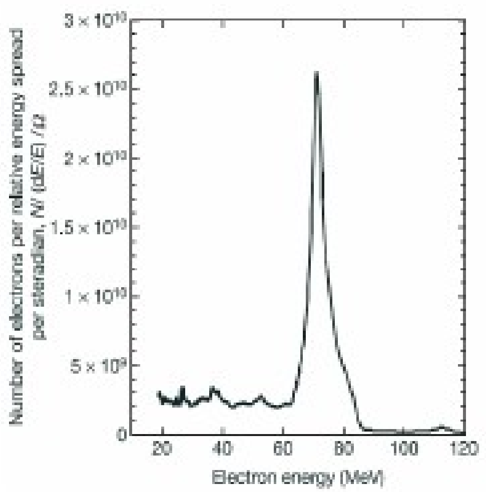
DREAM BEAMS by FAST LASERS I

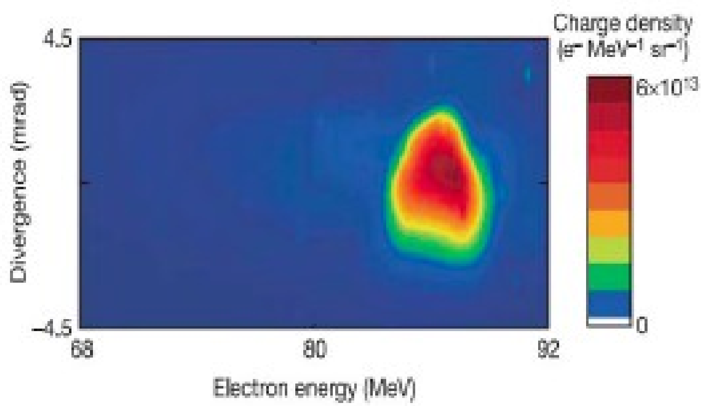
2nd Session – Experiments performed Multi-TW table top laser systems – Recent historical landmarks – First Mono-Energetic LWFA experiments

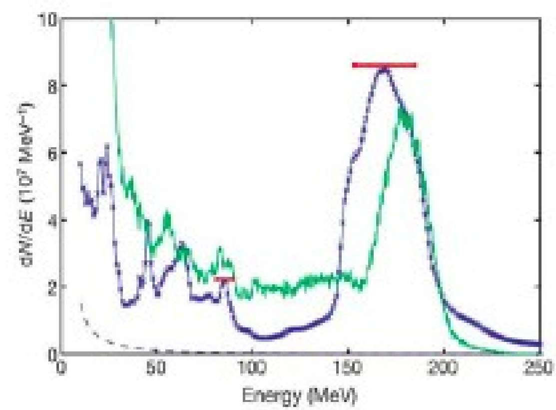
Mangles et al, Imperial College, UK: 70 MeV beam

Geddes et al, Lawrence Berkeley, USA: 85 MeV beam

Faure et al, LOA, France: 170 MeV beam







All images taken from Nature, 431

DREAM BEAM

DREAM BEAM II

2nd Session – Experiments performed Multi-TW table top laser systems – Recent historical landmarks – First Mono-Energetic GeV experiment

**Leemans et al,
Lawrence Berkeley, USA:
1000 MeV beam**

Long interaction length, i.e. 33 mm, via guiding through a Hydrogen filled, discharge capillary

Note : Maximum electron acceleration ~ 100 GeV in km long linear accelerators

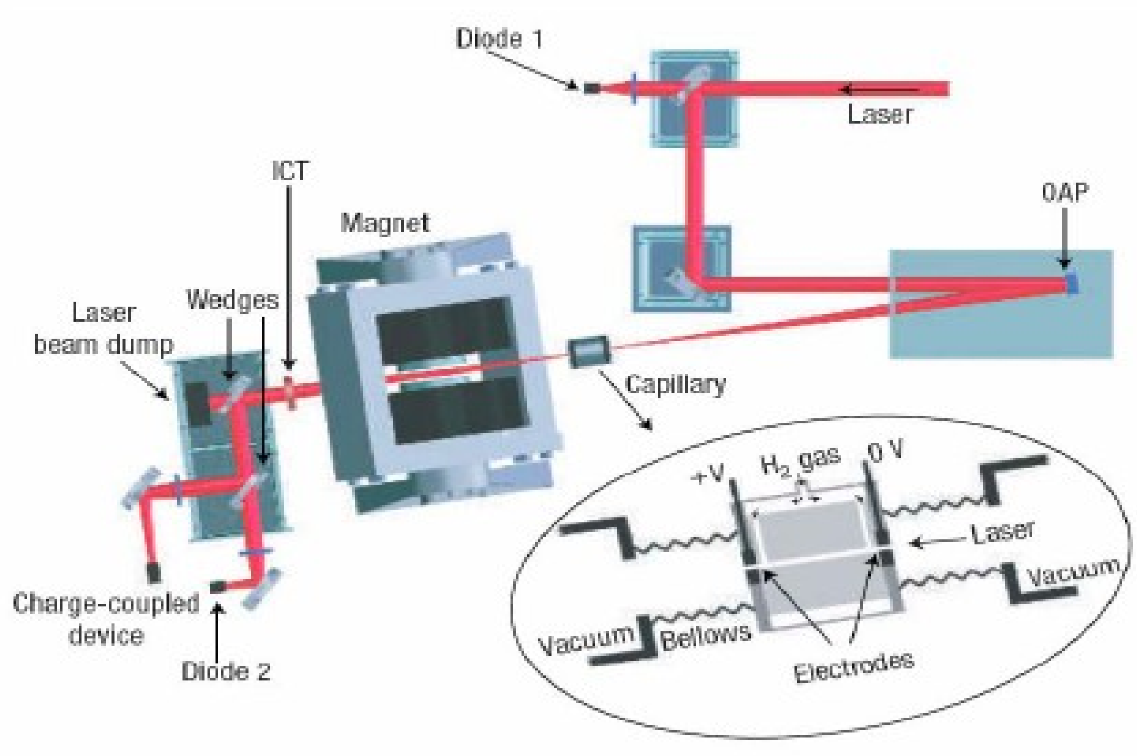
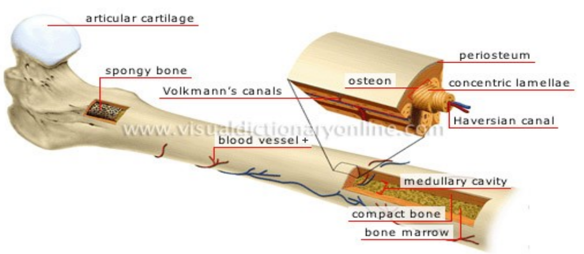


Image taken from Leemans et al., Nature Physics, 2 (2006)

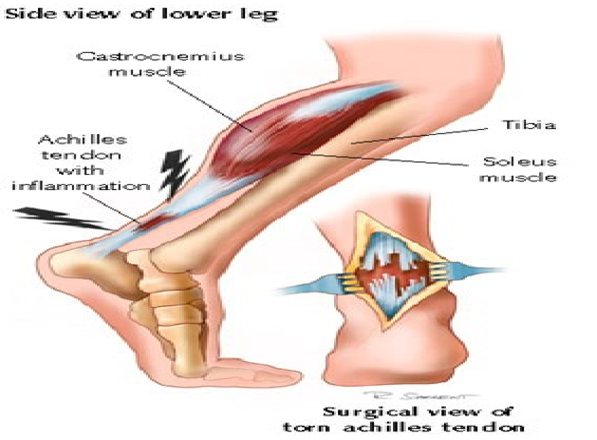
LENT in Smart Materials I: Pyroelectrics

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.

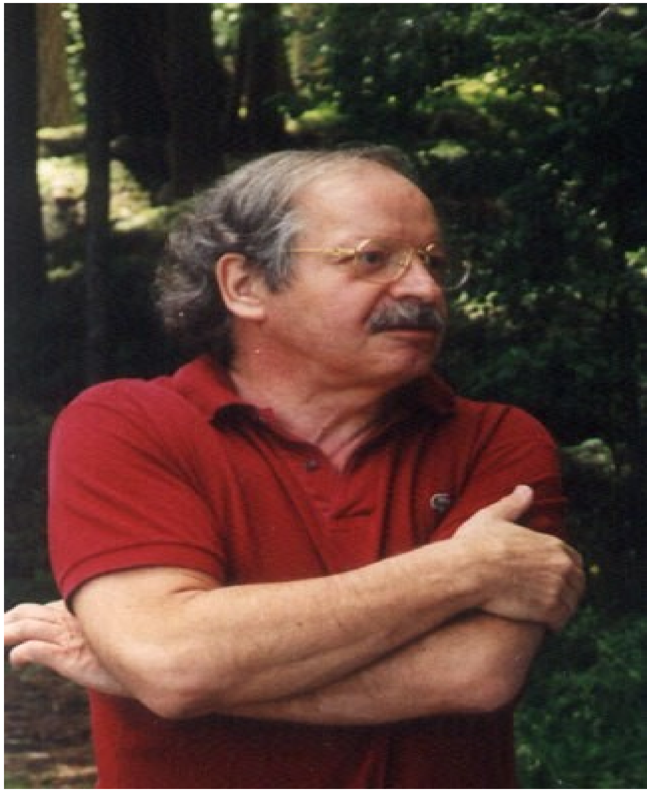


It was experimentally shown that pyroelectric crystals when heated or cooled produced nuclear dd fusion evidenced by the signal of 2.5 MeV neutrons. The system was used to ionize the gas and accelerate the ions up to 200 KeV sufficient to cause dd fusion. The measured yields agree with the calculated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



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 [Francesco Rocchi] and we are expecting to add a Post-doctoral researcher depending upon the availability of funds.

Technical and research support is being provided by ENEL, the largest Electric Power Company in Italy, who are our Collaborators.

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]

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

Summary and Future Prospects

Since, over a decade ago, when the pioneers in Italy GP, Emilio Del Giudice, De Ninno 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.

Which is more likely? Electro-Weak LENT or this?