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Reproducibility of Excess of Power and Evidence of 4He in Palladium Foils Loaded with Deuterium

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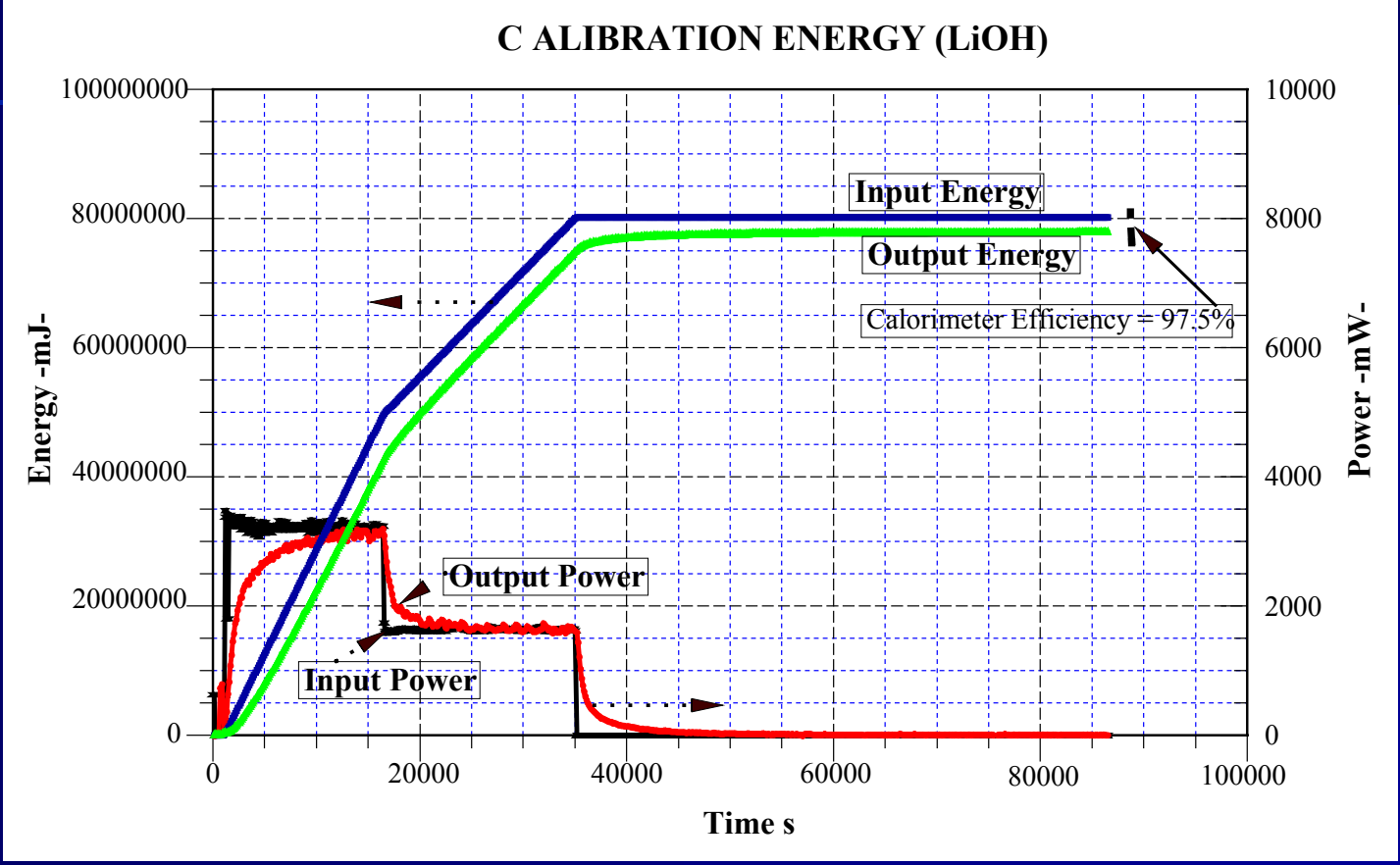
Topics

Material Science & Excess of Power Reproducibility

Surface Electronic Excitations with Lasers Trigger and Excess of Power Reproducibility

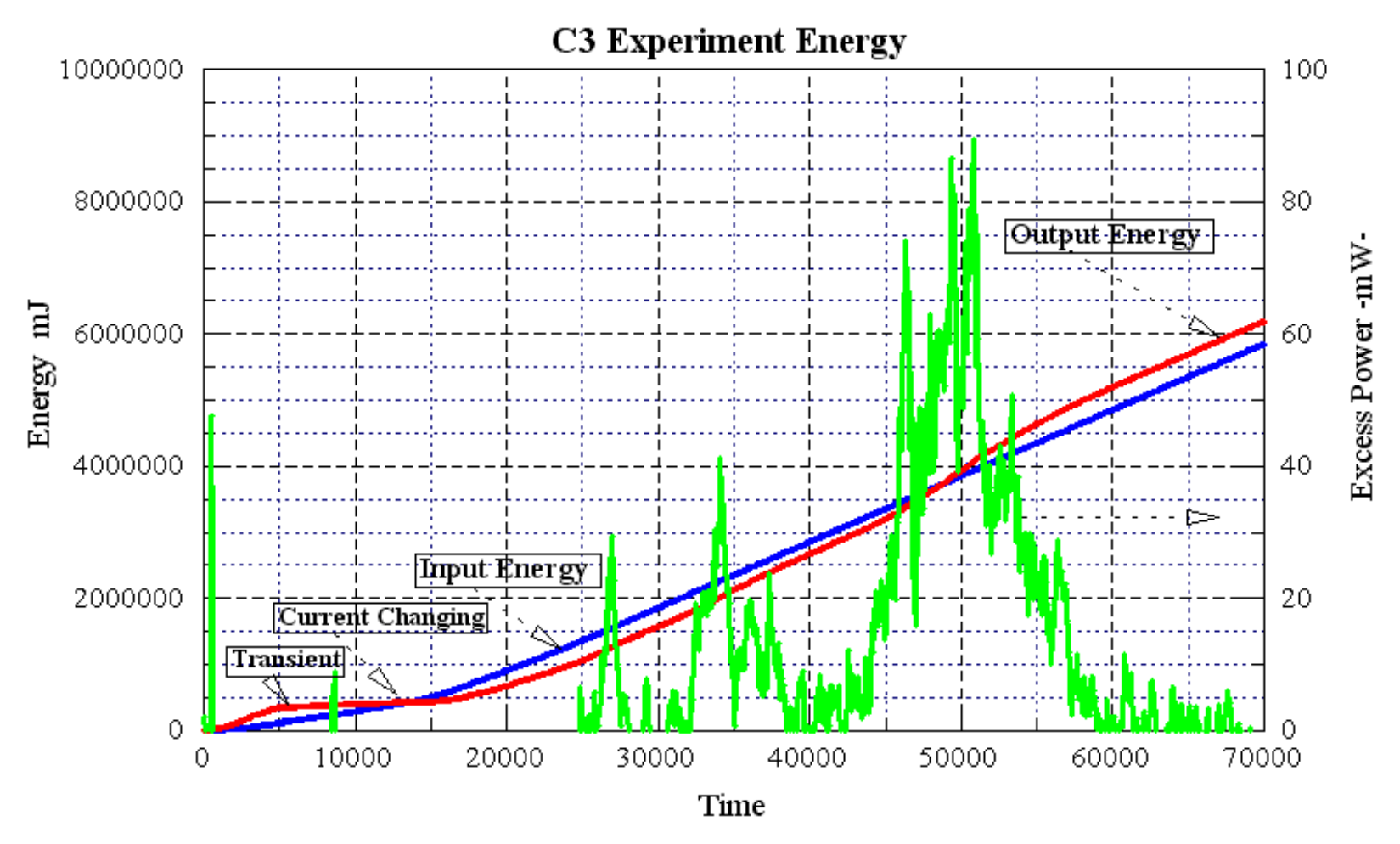
Experimental Results

Reference Experiments with LiOH: ENEA (Flow Calorimetry)



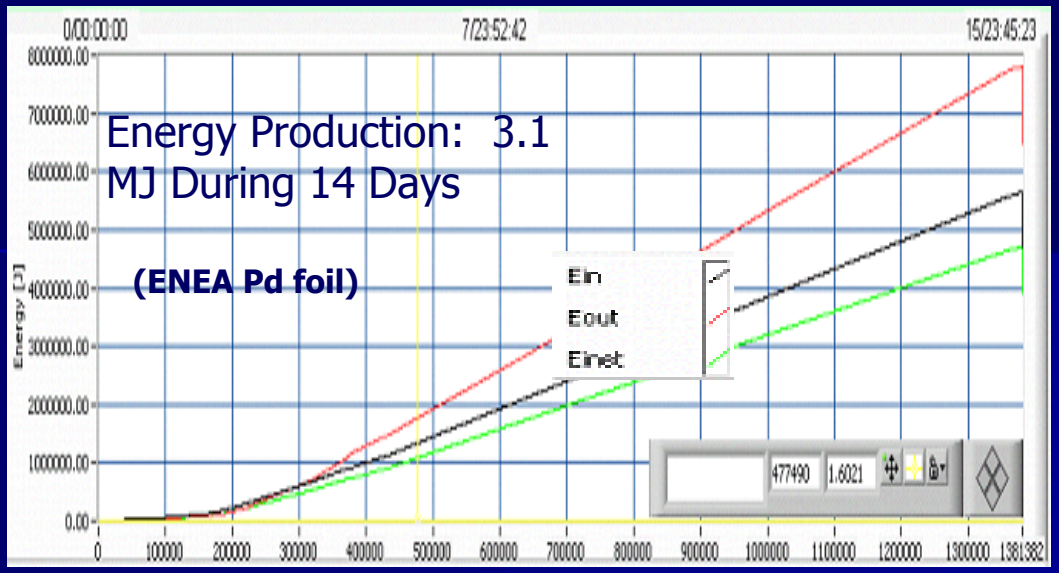
Input and output energy energy & input power plot for a calibtration experiment with H2O 0.1 M LiOH.

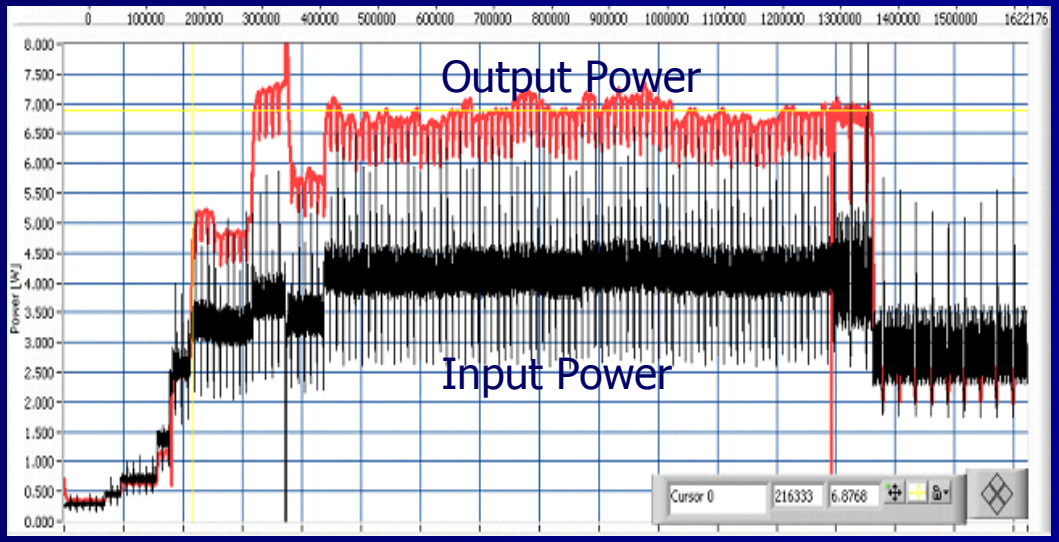
Excess of Power with LiOD: ENEA (Flow Calorimetry)



Heat effects are observed with D, but not with H, under similar (or more severe) conditions.

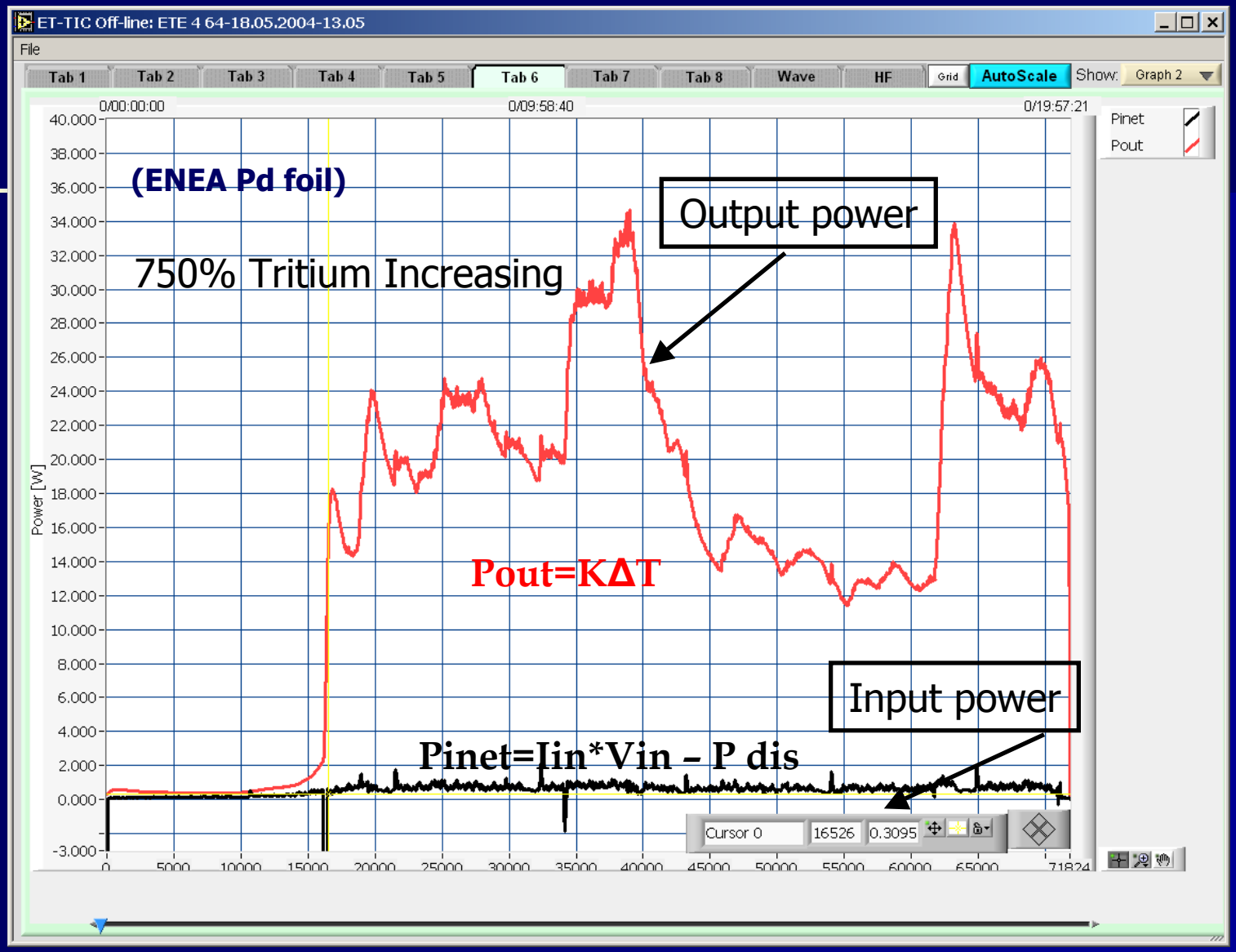
Excess of Power at Energetics Ltd received by using of SuperWave loading excitation





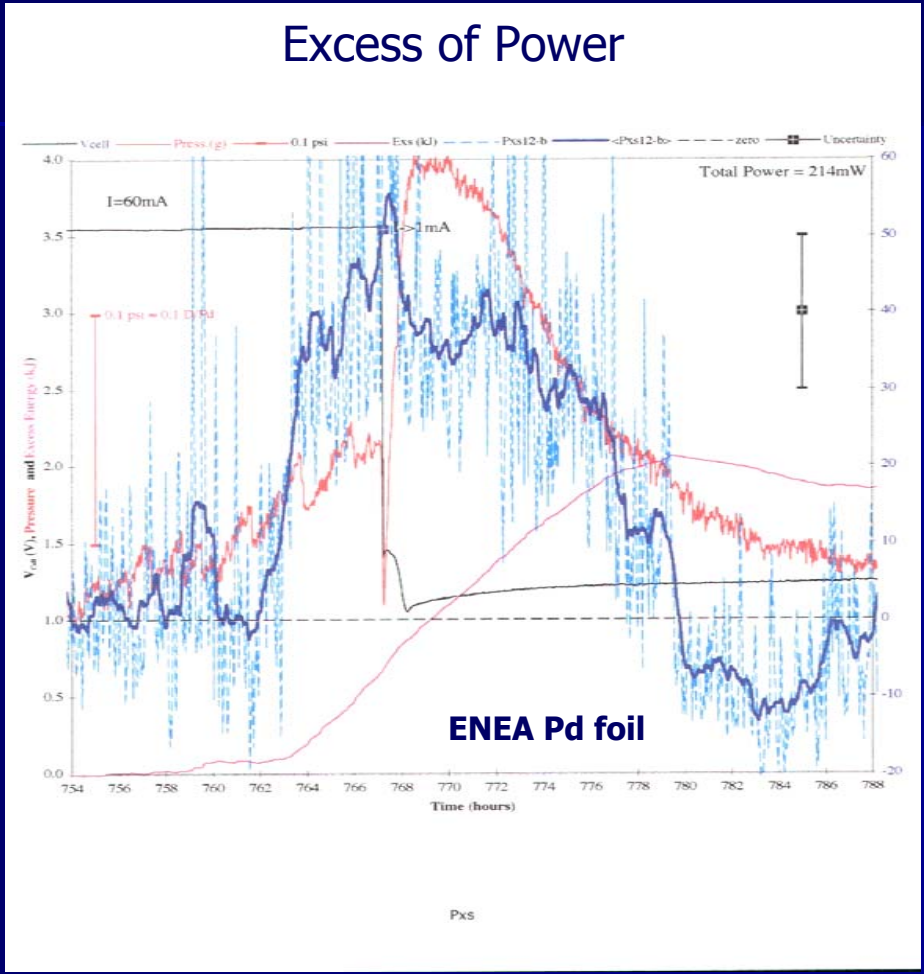
Excess Energy of 3.1 MJ (80% of input) corresponding to 1200 MJ/mol Pd

Excess of Power at Energetics Ltd
received by using of SuperWave loading excitation



Excess Energy of 1.1 MJ (2500% of input) corresponding to 400 MJ/mol Pd

Excess of Power at SRI



Excess of Power at SRI (Excess Energy 1 MJ/Mol), 30% of input.

Plasmons-Polaritons Laser Triggering

Three excess of power over ten experiments giving high D loading (D/Pd > 0.9 in some cases also with less loading) have been observed at ENEA.

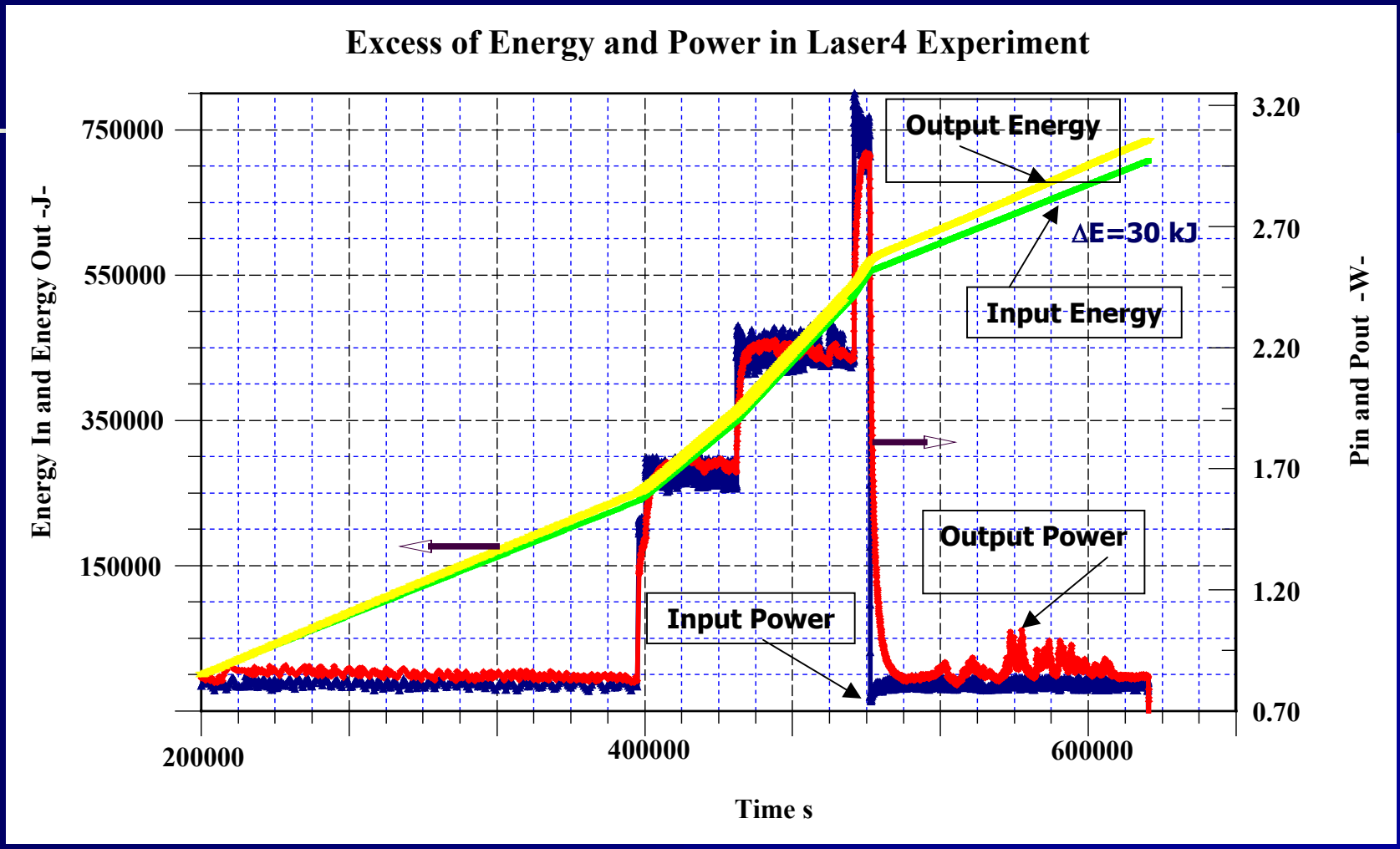
We can conclude that high D loading is a necessary condition for excess of power production during loading of Pd with D.

According to the idea that collective electron oscillations have a key role in LENR processes a proper trigger has been introduced to create surface plasmons (polaritons):

Laser Trigger

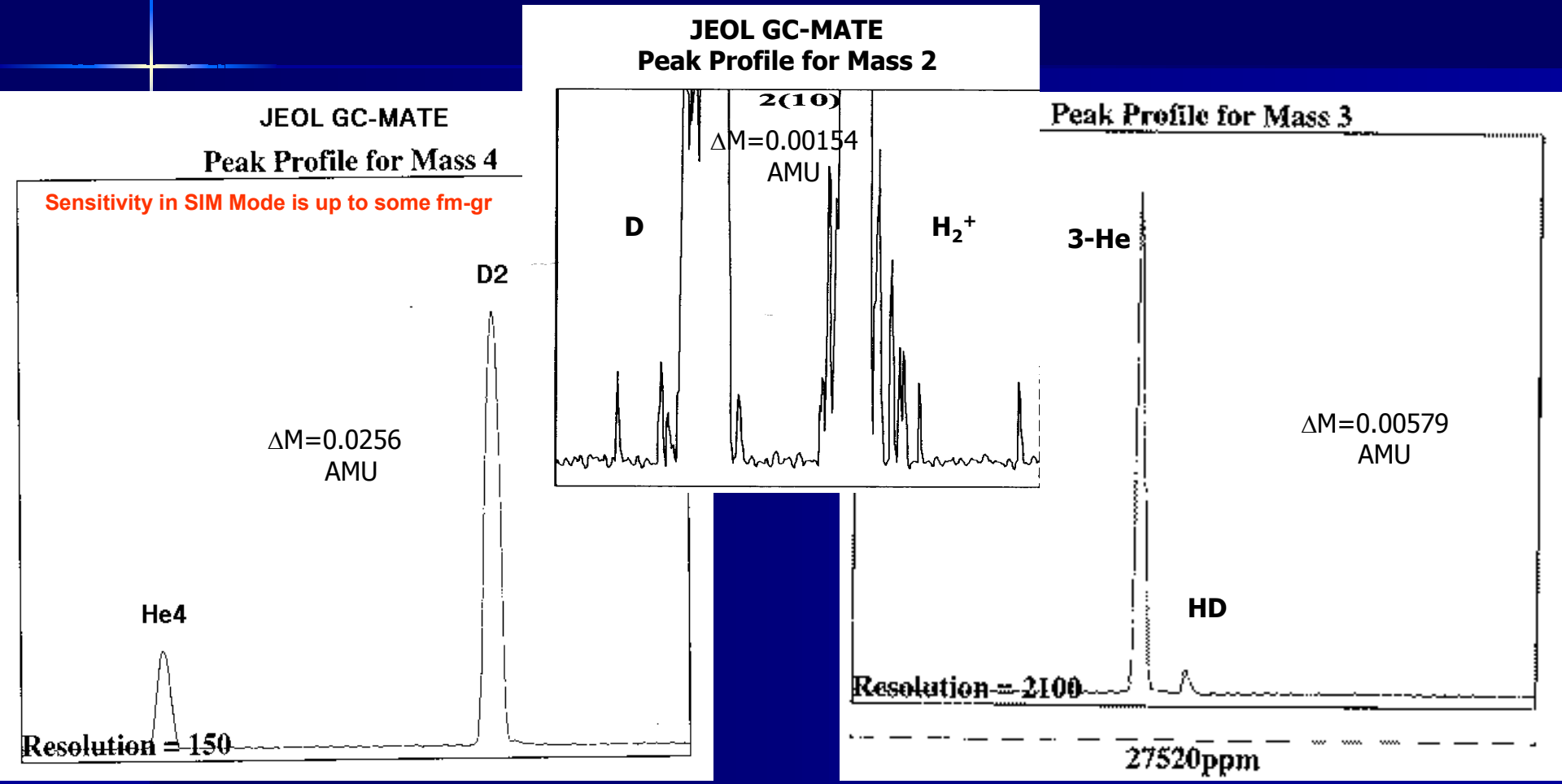
Laser4 Experiment: Calorimetric Results

30.3 kJ of produced energy: 19.4 MJ/ mol Pd



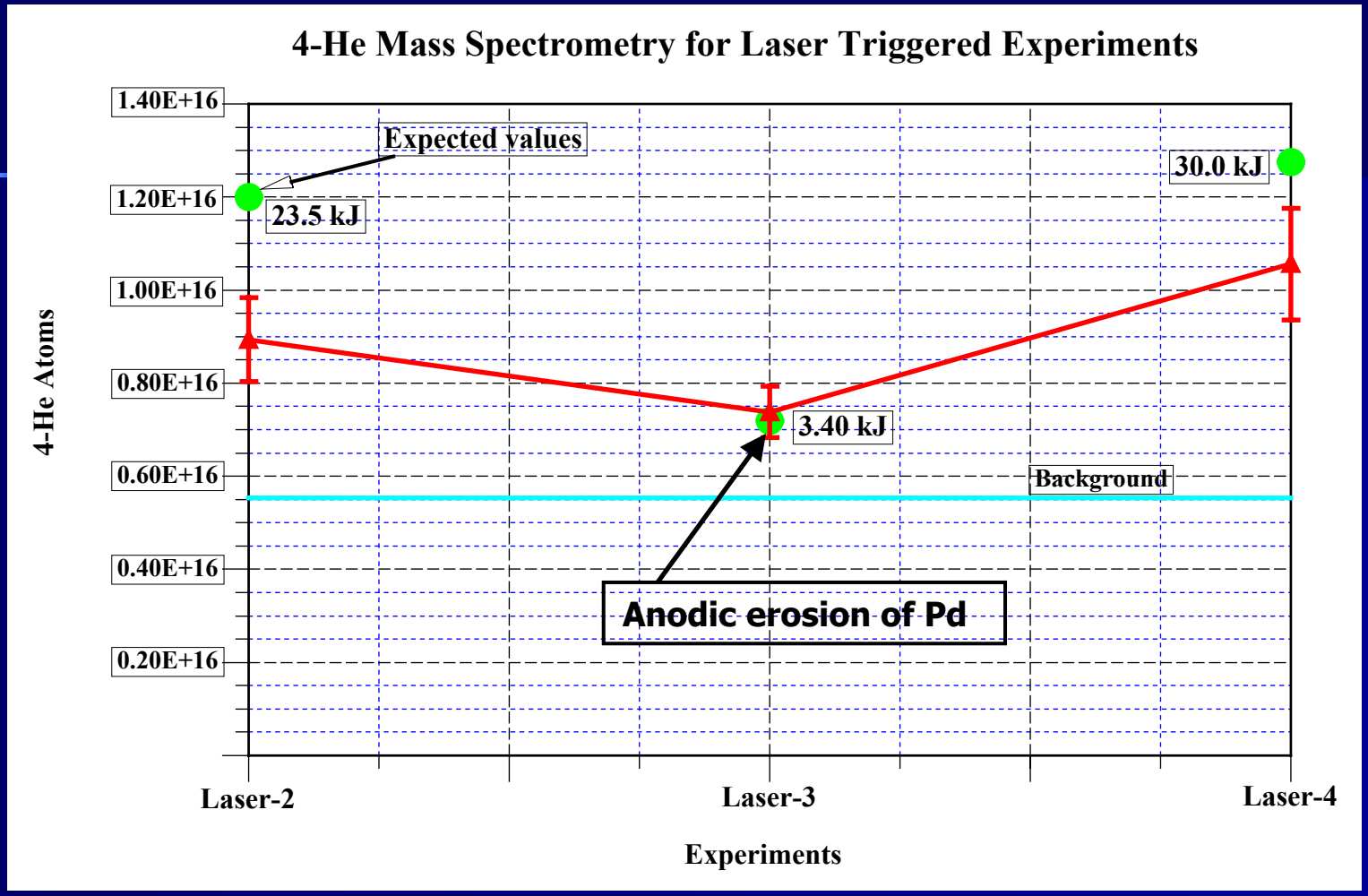
Excess of energy and excess of power in Laser4 experiment.

JEOL GC-Mate Mass Spectrometry



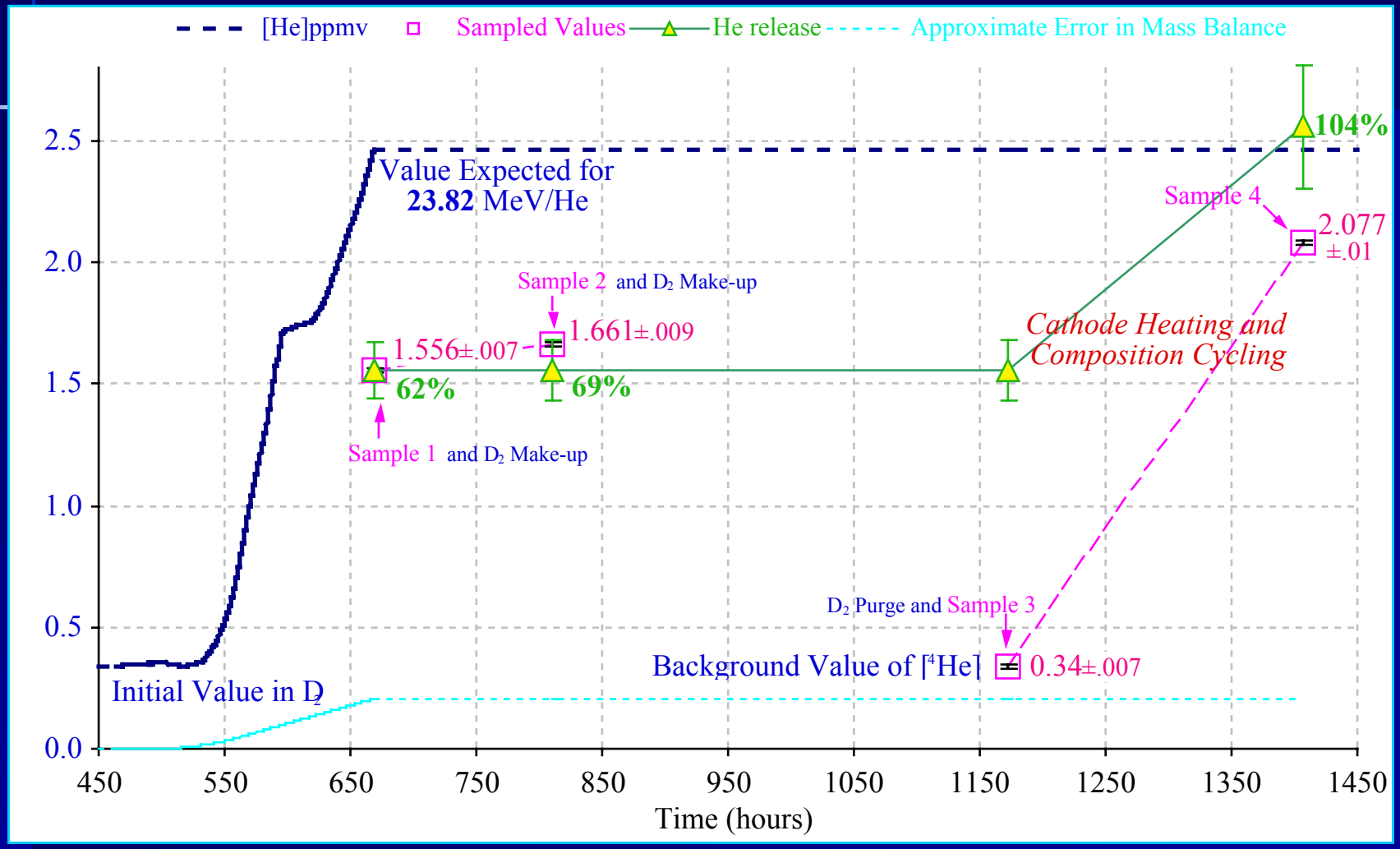
GC-Mate resolution up to 0.0001 AMU, sensitivity in SIM mode up to some Fg.

Laser Triggered Experiments: ^{4}He correlation With energy in Laser 2,3,4 experiments



The expected amount of increasing of ^{4}He is in accordance with the energy gain by assuming a D+D = 4He +24 MeV reaction. ^{4}He stripping from cathode increases the correlation with produced energy.

M4 SRI Experiment: Correlation of Heat with Helium During excess of Power Production with D Loading in Pd



[4]He concentration increasing into a cell giving excess of power. [4]He stripping from cathode makes the correlation with produced energy satisfactory.

Conclusions

- Heat effects are observed with D, but not with H, under similar (or more severe) conditions.

- Heat bursts exhibit an integrated energy at least 10 x greater than the sum of all possible chemical reactions within a closed cell.

- Experiments reproducibility was significantly improved as a result of material science study.

- Conditions are required to have a reproducible excess of power:

  1) Loading threshold D/Pd > 0.9 *necessary condition**
  2) Suitable material to have a reproducible loading above the threshold.
  3) Trigger
  4) Suitable status of the material to have coupling with trigger.

Three excess of power over three effective experiments have been achieved by respecting these conditions!

The same material allowed to reproduce the effect into three different Institutions.

The accordance between revealed ^4He and produced energy seems to be a clear signature of a nuclear process occurring in condensed matter.

*) The condition of D/Pd (average)>0.9 has not been fulfilled by ET experiments probably because of a not homogeneous loading

Back-Up Slides

Reproducibility of Loading and of Excess of Power as a Material Science Problem

Absorption of hydrogen inside a metal lattice is an equilibrium/disequilibrium problem because of the diffusive mass transfer process occurring during loading.

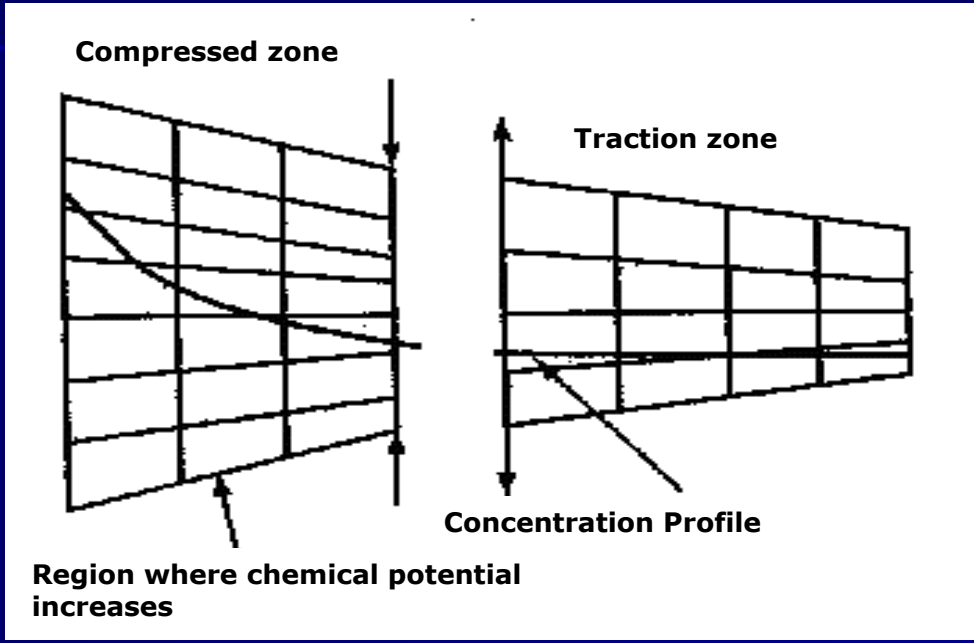
Equilibrium is achieved when hydrogen chemical potential inside the metal balances the chemical potential of hydrogen in the external phase.

The diffusive process is generated by a chemical potential gradient (disequilibrium).

Chemical potential of hydrogen in the metal lattice is strongly affected by the force fields that modify the free energy of the system.

Hydrogen entering the lattice produces a significant elongation of the lattice parameter.

A concentration gradient produces a stress field.



Effect of the hydrogen concentration profile on the stress field

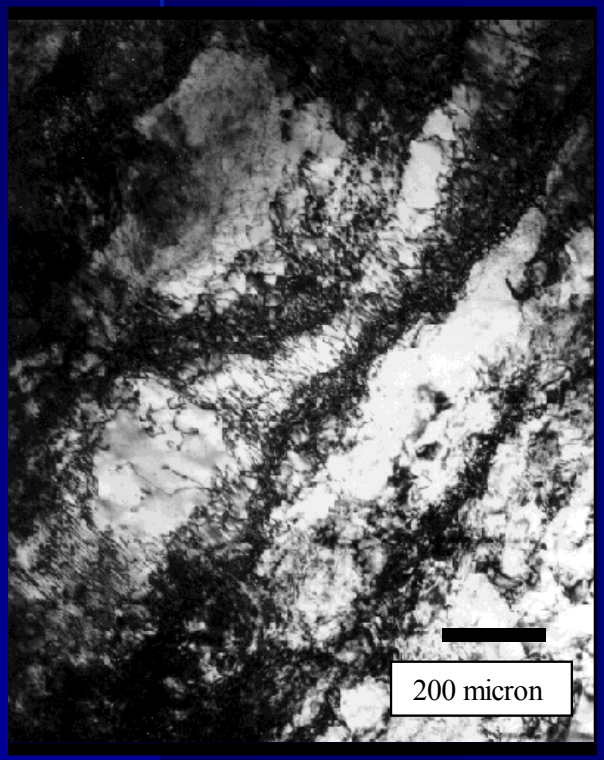
In presence of stress the chemical potential of an interstitial solute increases proportionally to the stress

$$\mu_H^* = \mu_H \pm V_s \sigma_h$$

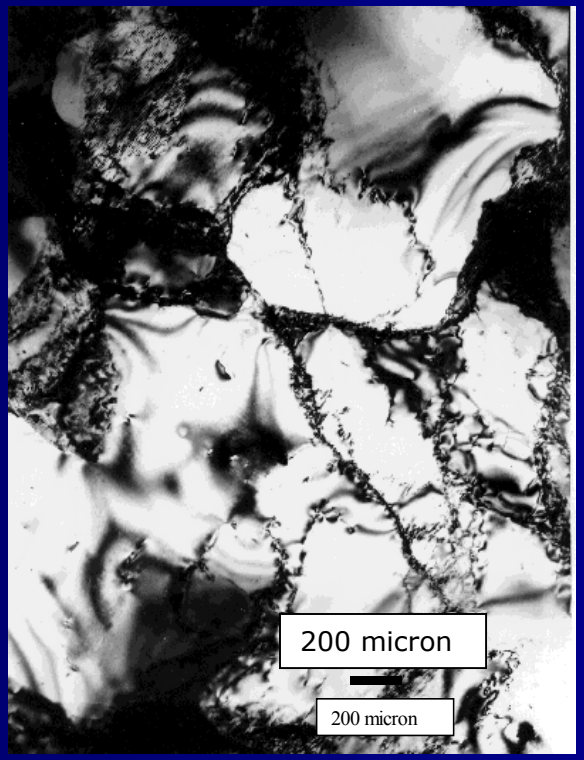
(V_s = solute molar volume)

Metallurgy

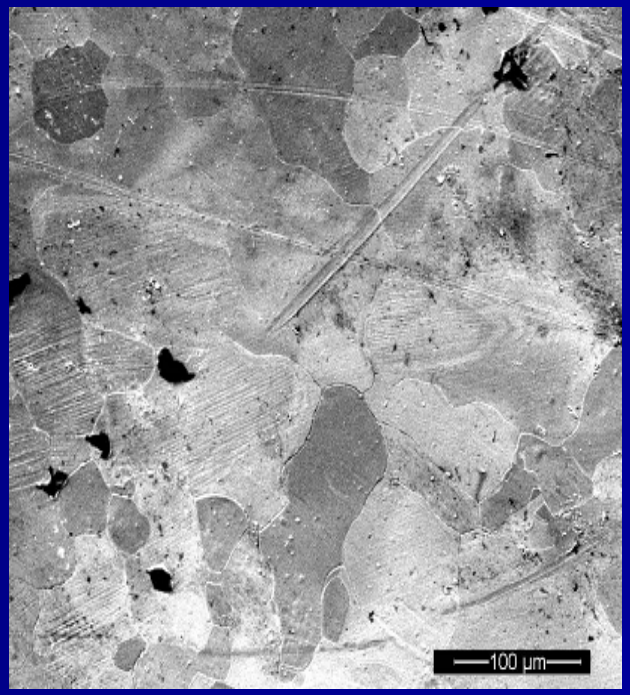
A proper metallurgy reduces the concentration gradients and then the stress field



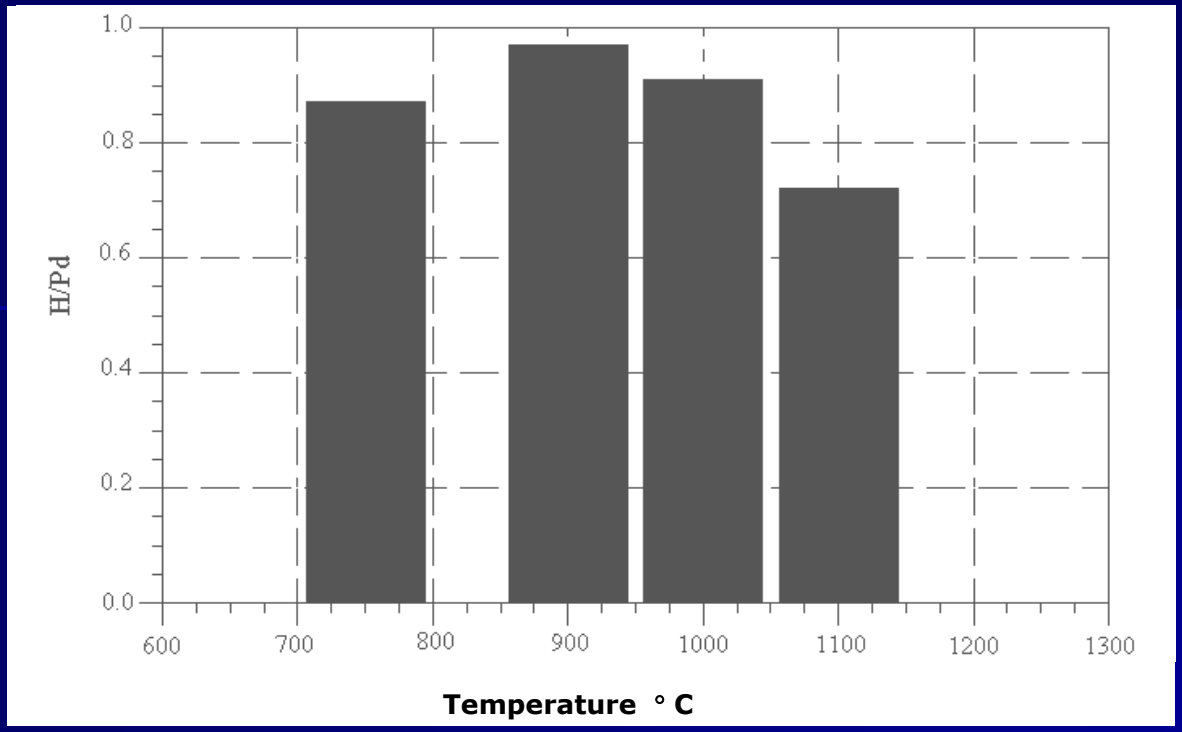
Cold worked Pd foil



Cold worked and annealed at 1100 °C for 5 hr Pd foil



Cold worked and annealed at 850 °C for 1 hr.



Annealing temperature effect on H loading in Pd

Self induced stress, created by very steep concentration gradients, makes impossible to achieve the concentration threshold D/Pd > 0.95 required to have excess of power production.

A Proper Microstructure of Pd due to metallurgical treatment allows high D loading

References

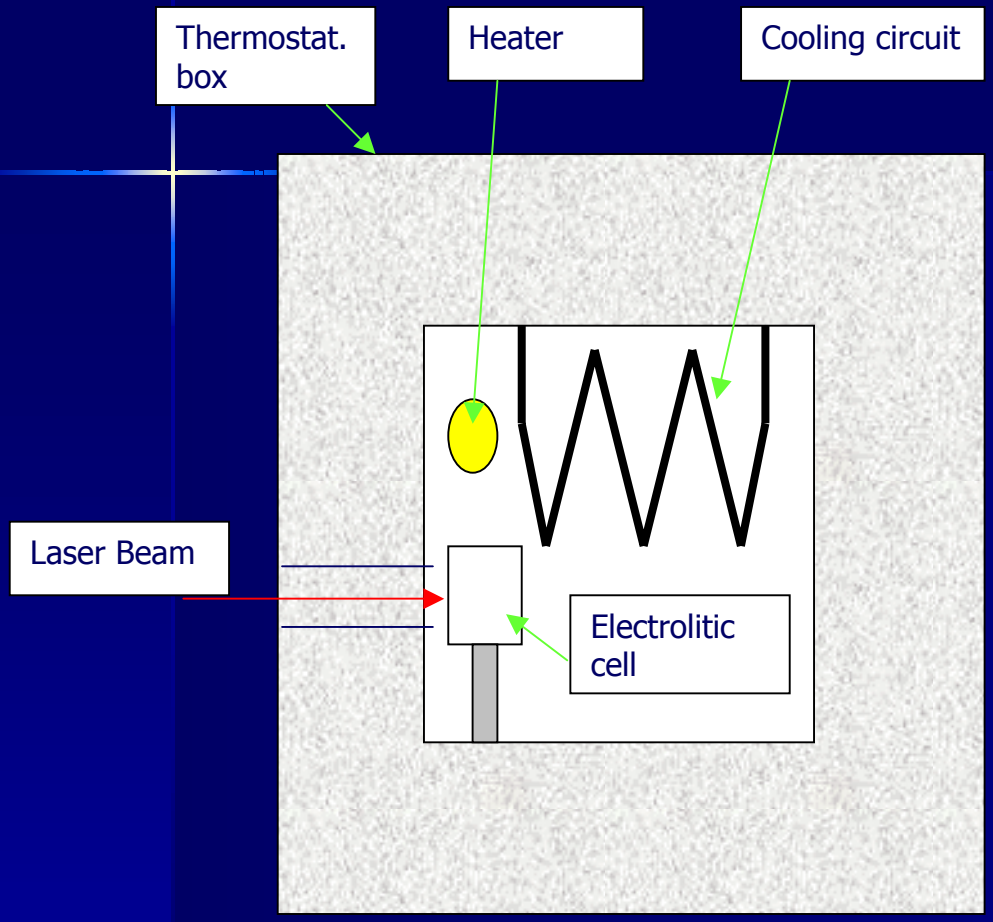
A.De Ninno, V. Violante et Al., Consequences of Lattice Expansive Strain Gradients on Hydrogen Loading in Palladium. Phys. Rev. B, Vol. 56, N. 5 (1997) 2417-2420.

A. Adrover, V. Violante et Al. Stress induced diffusion of hydrogen in metallic membranes, Cylindrical vs. planar formulations I, J. Of Alloys and Compounds I(2003).

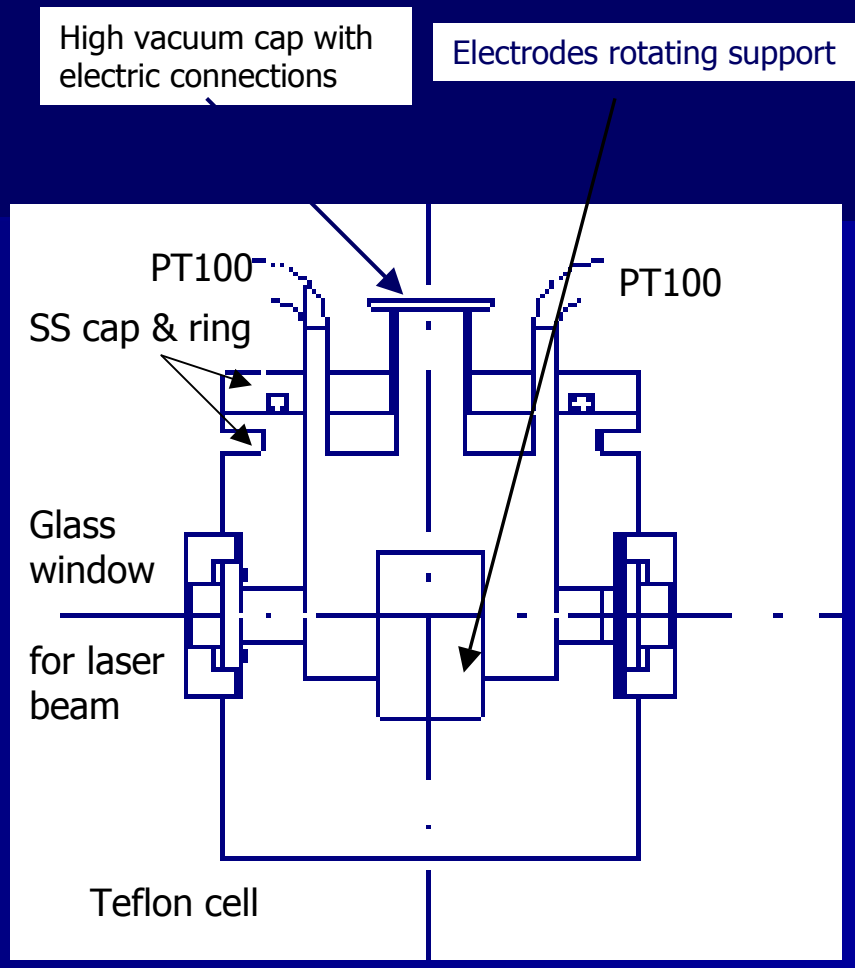
A. Adrover, V. Violante et Al. Stress induced diffusion of hydrogen in metallic membranes, Cylindrical vs. planar formulations II, J. Of Alloys and Compounds I(2003).

A. Adrover V. Violante et Al. Effects of self-stress on hydrogen diffusion in Pd membranes in the coexistence of α and β phases. J. of Alloys and Compounds II (2003).

Calorimetry under Laser Triggering



Calorimetric system for laser triggering experiments (T Box = set p. ± 0.15 °C)



Electrochemical cell for laser triggering Experiments. He leakage ≤ 10^{-10} mbar l/s.

Pd foil (20x10 mm x 50 μm) cathode, spiral Pt wire anode.

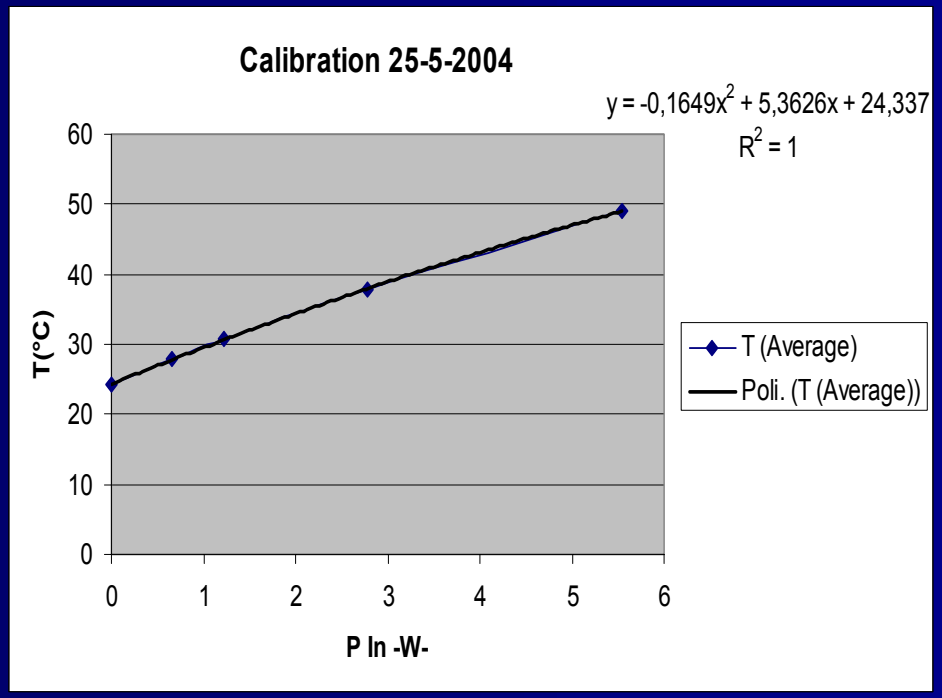
Current = 5 - 400 mA

Voltage = 2 – 15 V

Isoperibolic Calorimetry for Laser Triggered Experiments at ENEA.

Calibration is mandatory

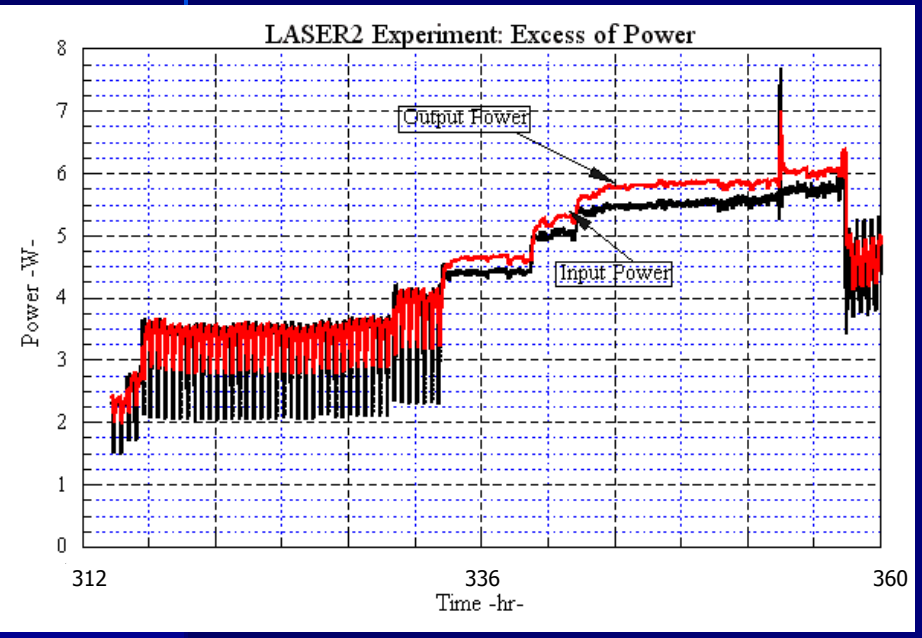
Calibration based on the average of the 2 PT-100 temperature values obtained by means of electrolysis in LiOD.

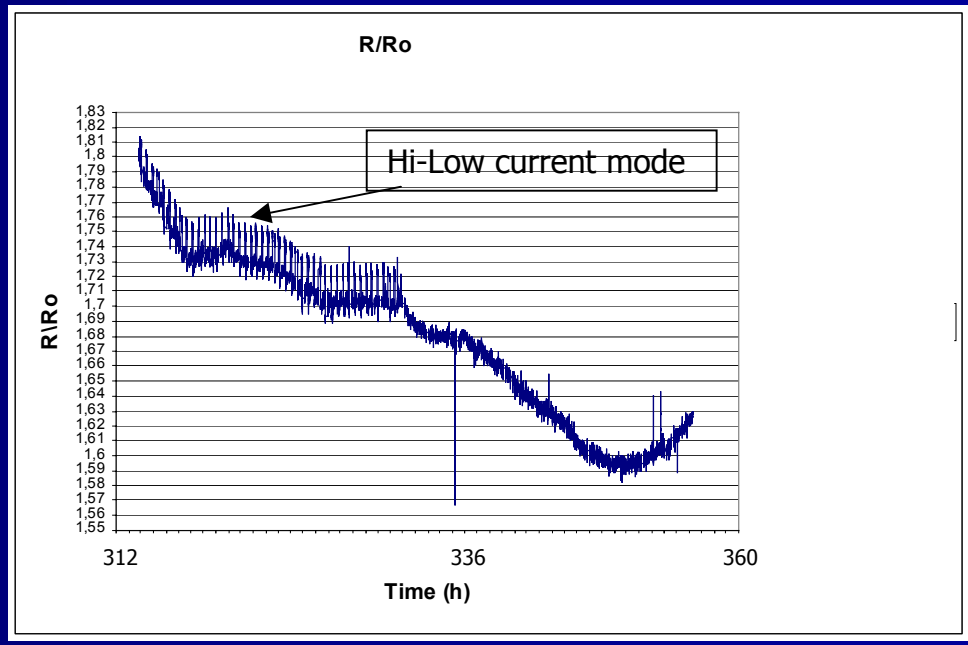


Calibration of the isoperibolic calorimeter

Laser2 Experiment

23.5 kJ of produced energy: 17.3 MJ/ mol Pd



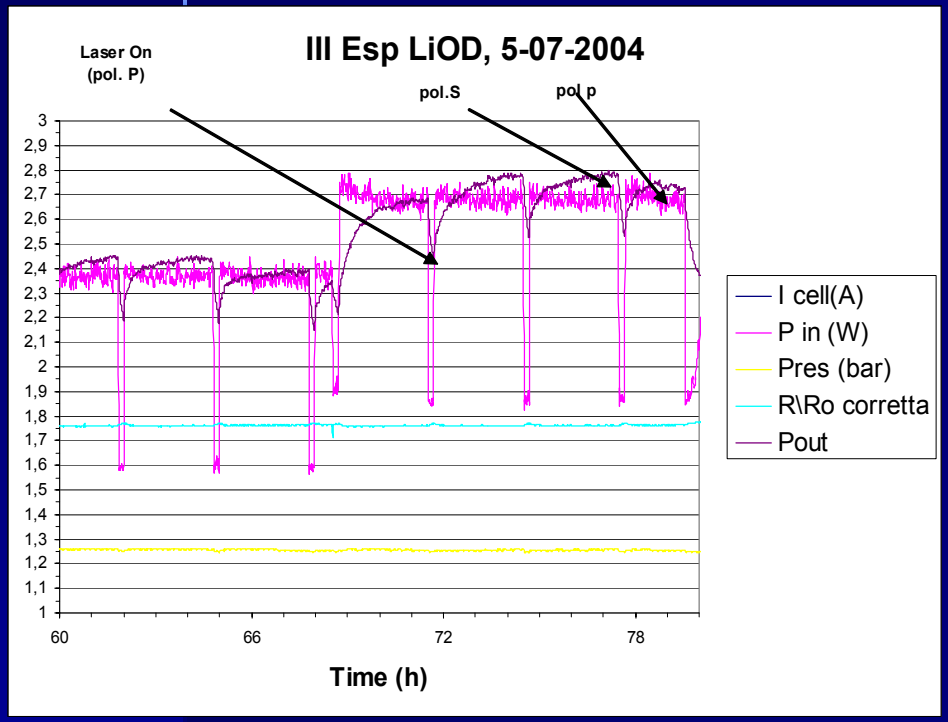


Evolution of the input and output power, last 300 hr under laser irradiation (P-polarization), 632 nm, 5 mW. ^{4}He production estimate 6.12E+15.

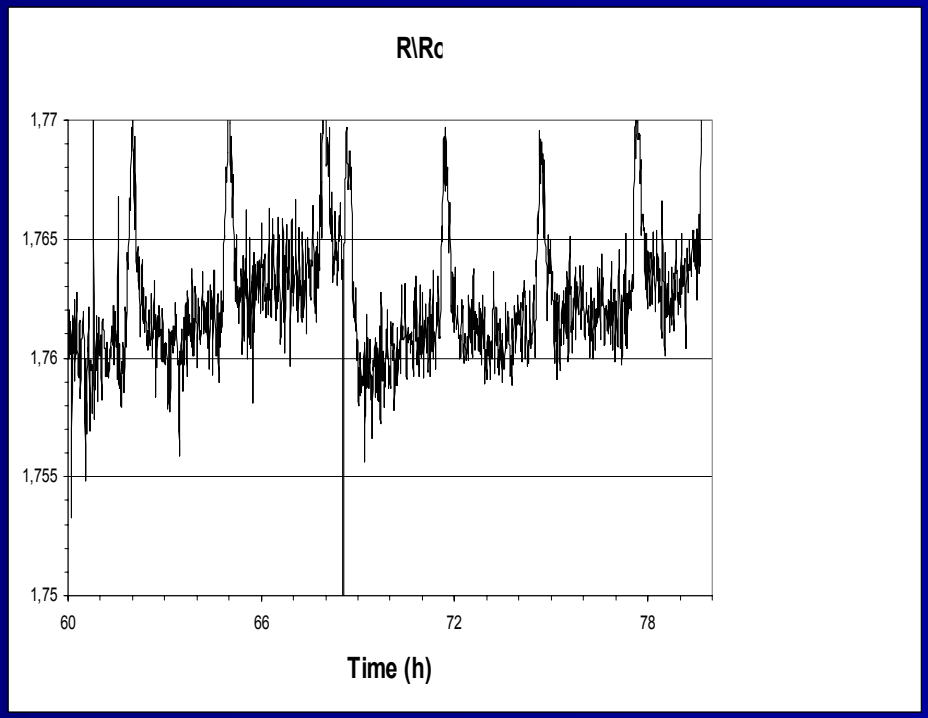
Evolution of loading (normalized resistance).

Laser3 Experiment: Calorimetric Results

3.4 kJ of produced energy: 2.5 MJ/ mol Pd



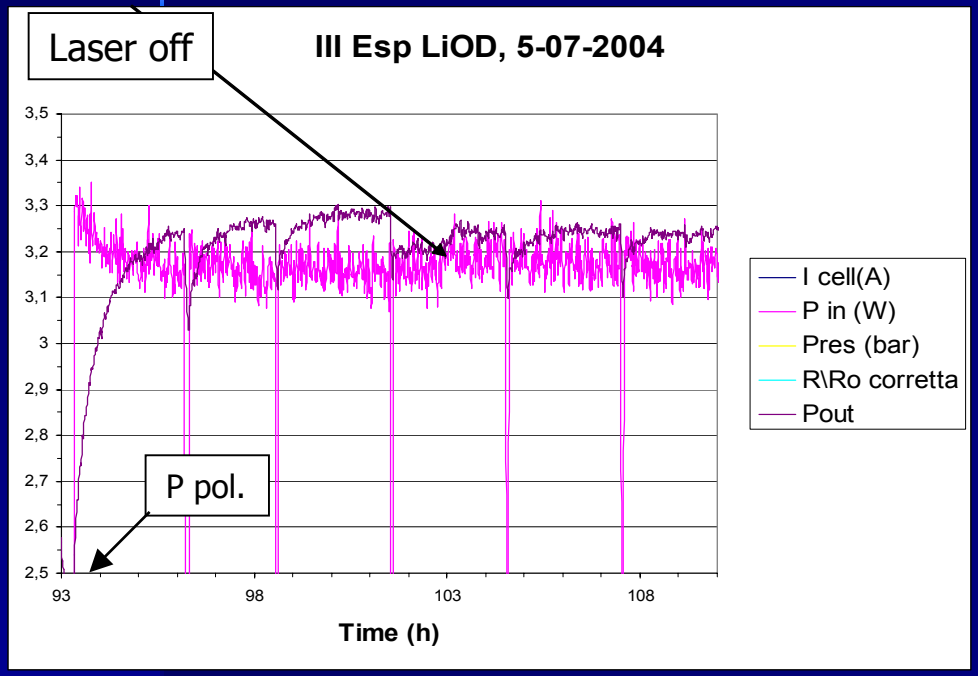
Excess of power under laser triggering (P and S polarization effect). 632 nm, 33 mW Hi-Lo current mode.

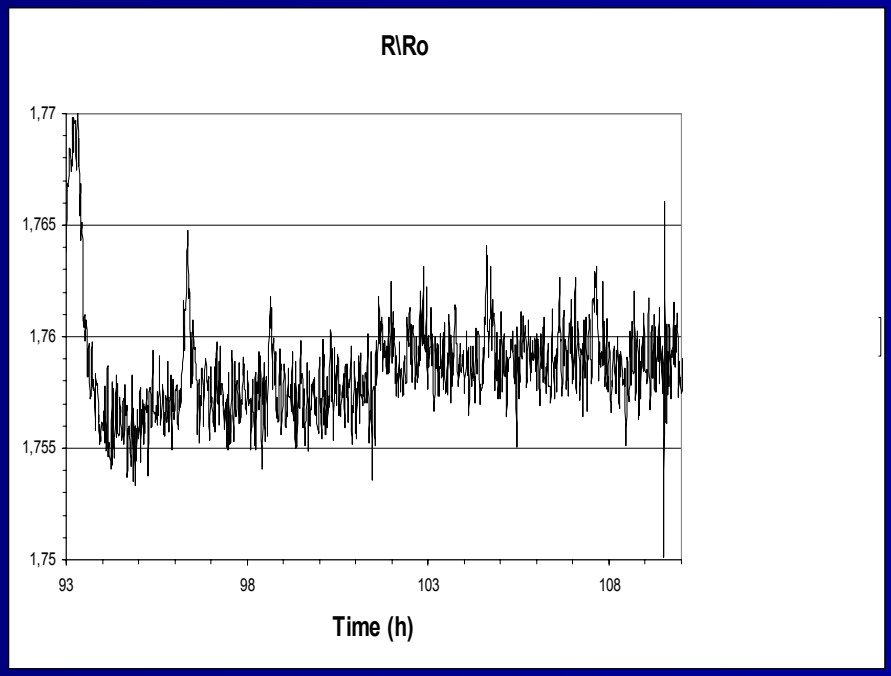


Loading evolution (normalized resistance)

Laser3 Experiment: Calorimetric Results

3.4 kJ of produced energy: 2.5 MJ/ mol Pd





Excess of power under laser triggering (laser off effect). Hi-Lo current mode.

Loading evolution (normalized resistance)