Review of recent activity on CMNS at ENEA

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Topics

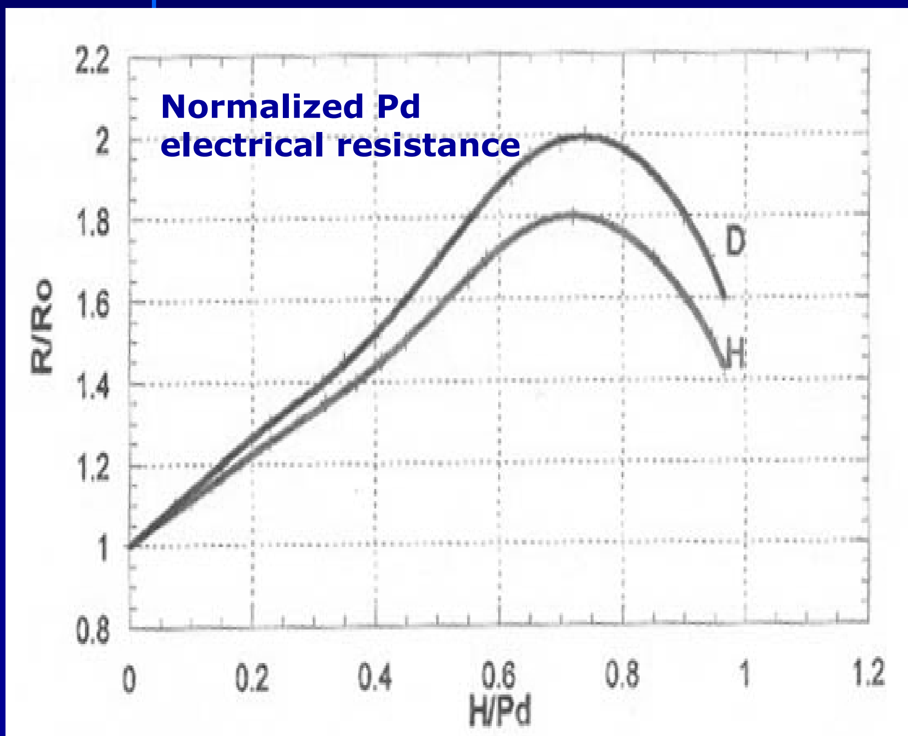
1)Materal Science & Reproducibility

2)Calorimetry

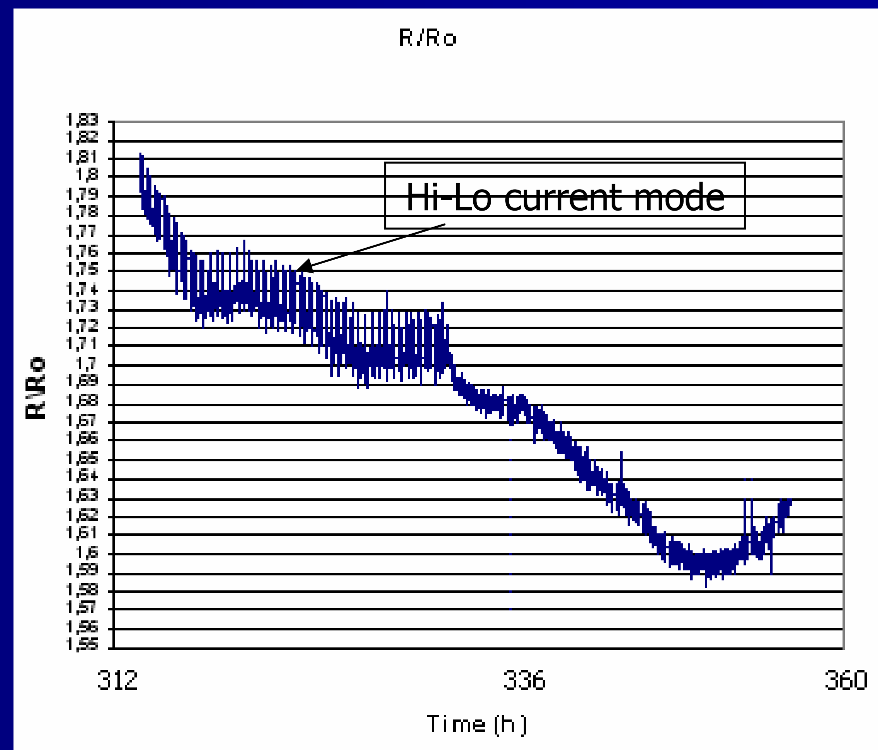
3) Laser Triggering of Excess of Power

4) Nuclear Ashes Measurements

MATERIAL SCIENCE: Reproduciblity of High Loading

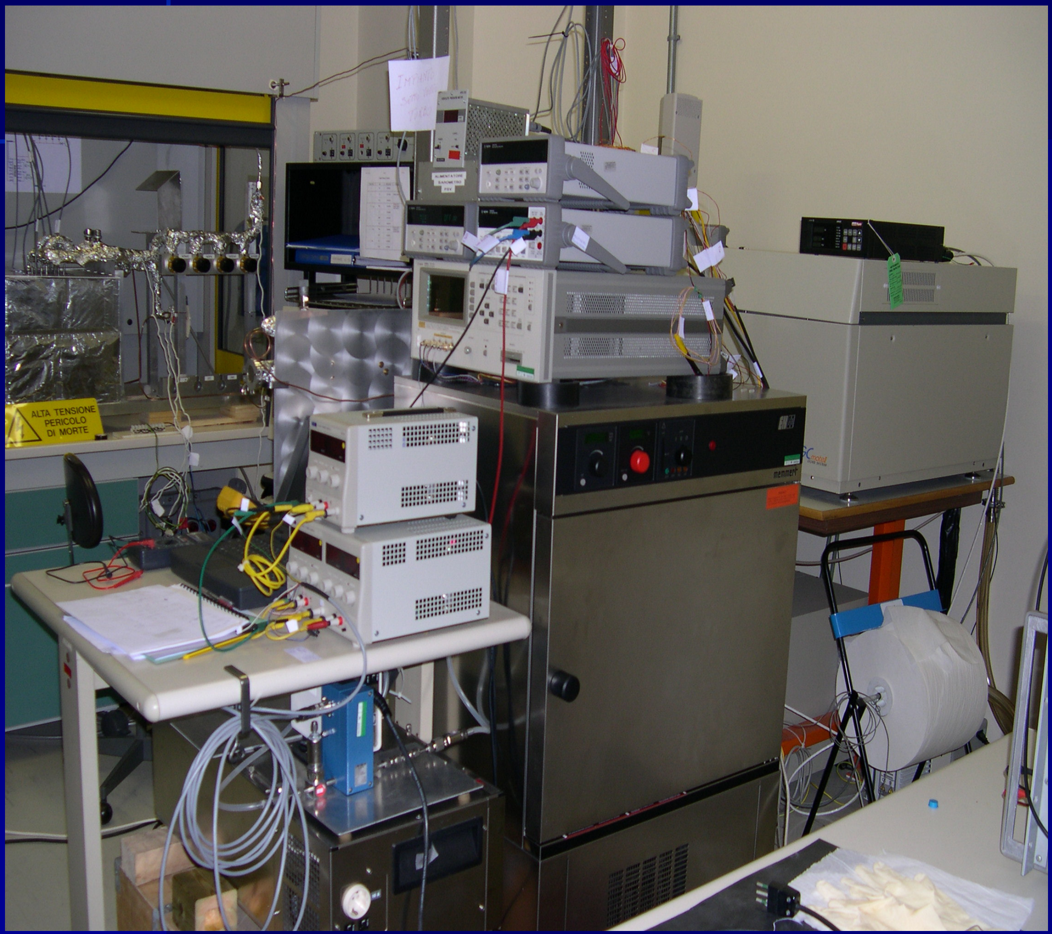


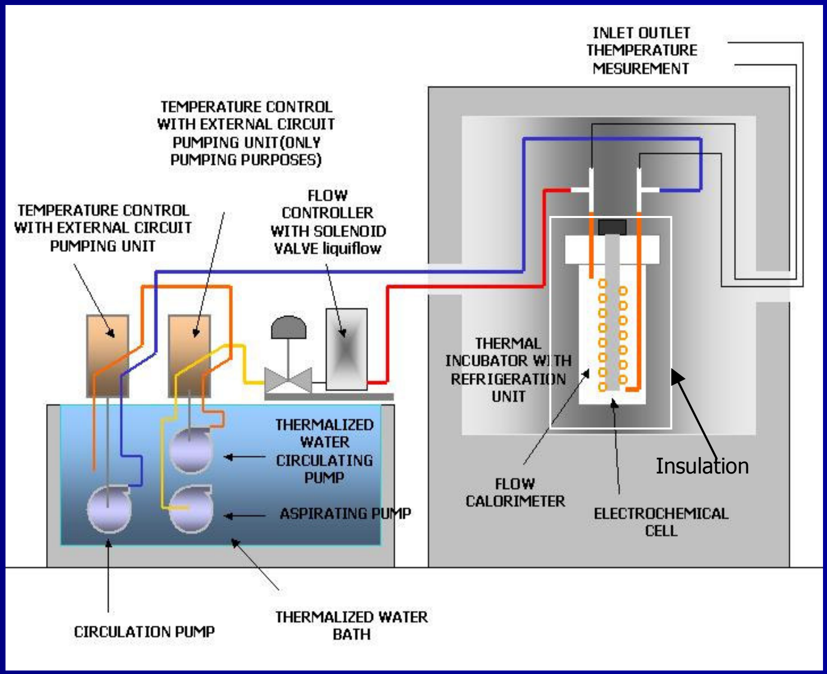
Baranowsky-McKubre curves.



Loading evolution into a treated Pd sample.

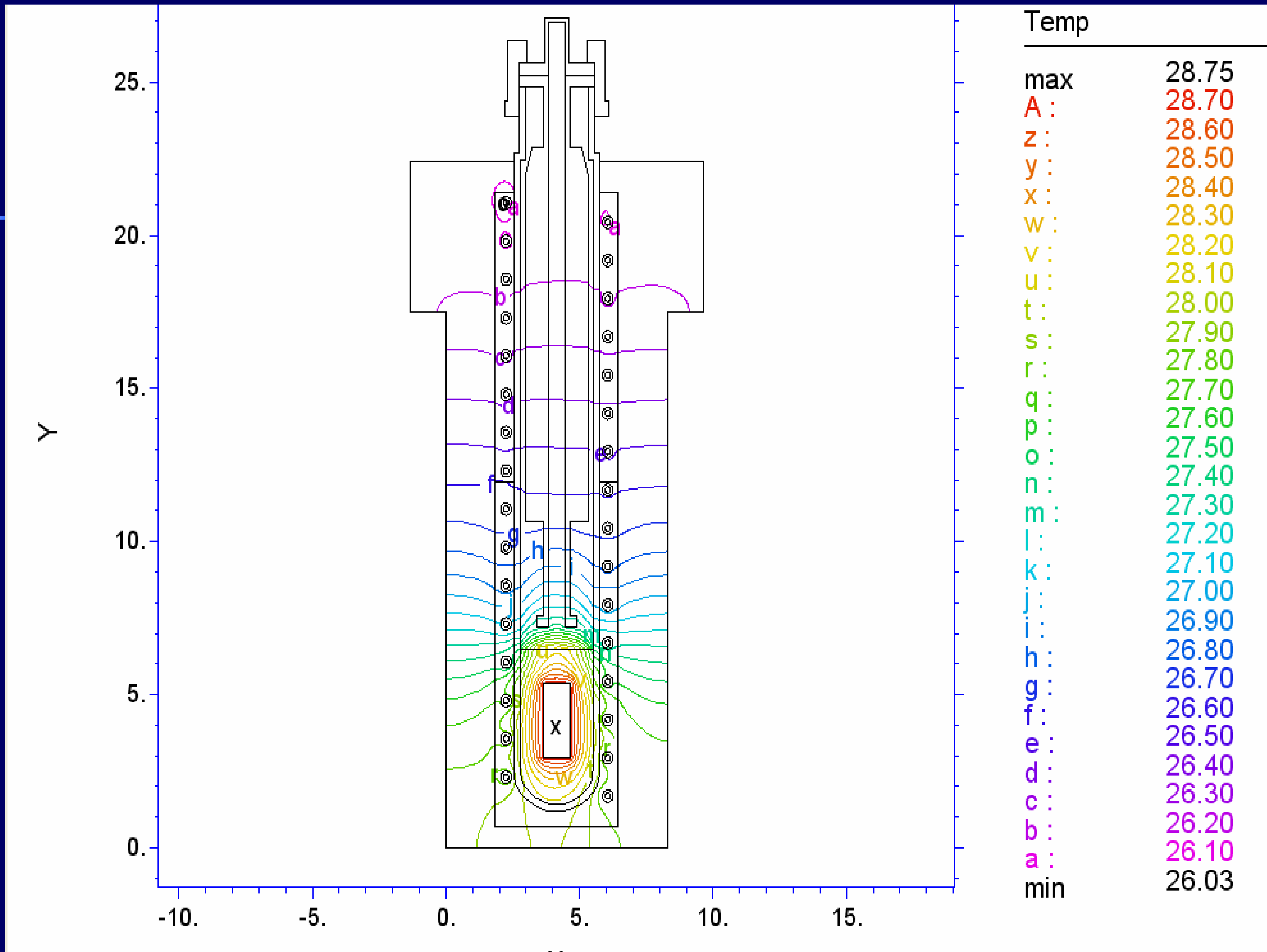
Flow Calorimetry on Closed Cells with Recombiner





Memmert Calorimetric box (±0.05°C) + Haake thermostatic bath +Bronkhorst high precision mass flow meter + HP-4263 LCR Meter. Measure limit: 50 ± 15 mW

Flow Calorimeter FEM Analysis



Finite element modelling has applied to design the calorimetric system

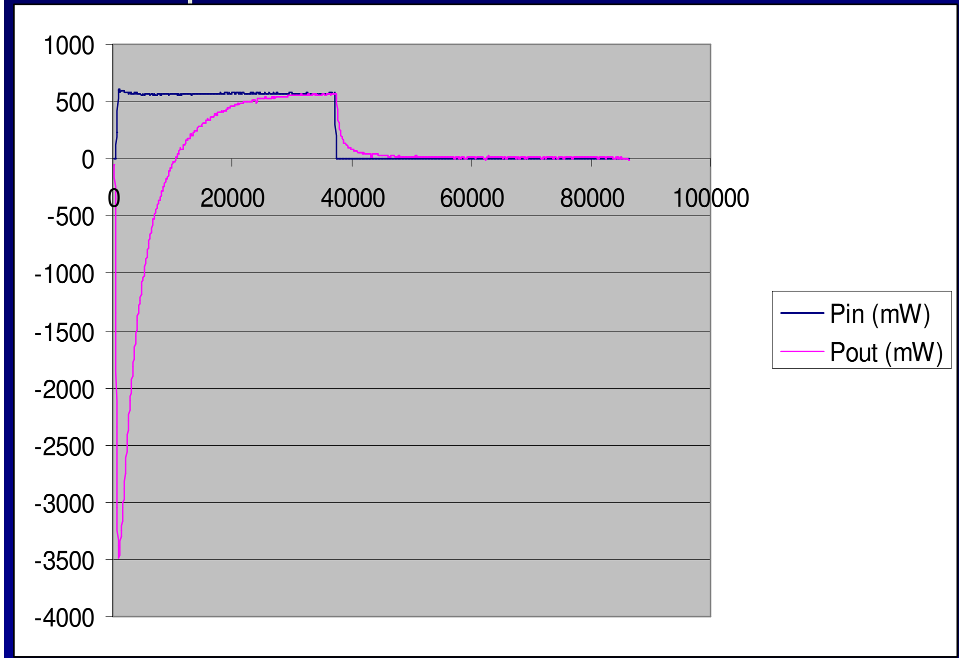
Charcteristics of the cell

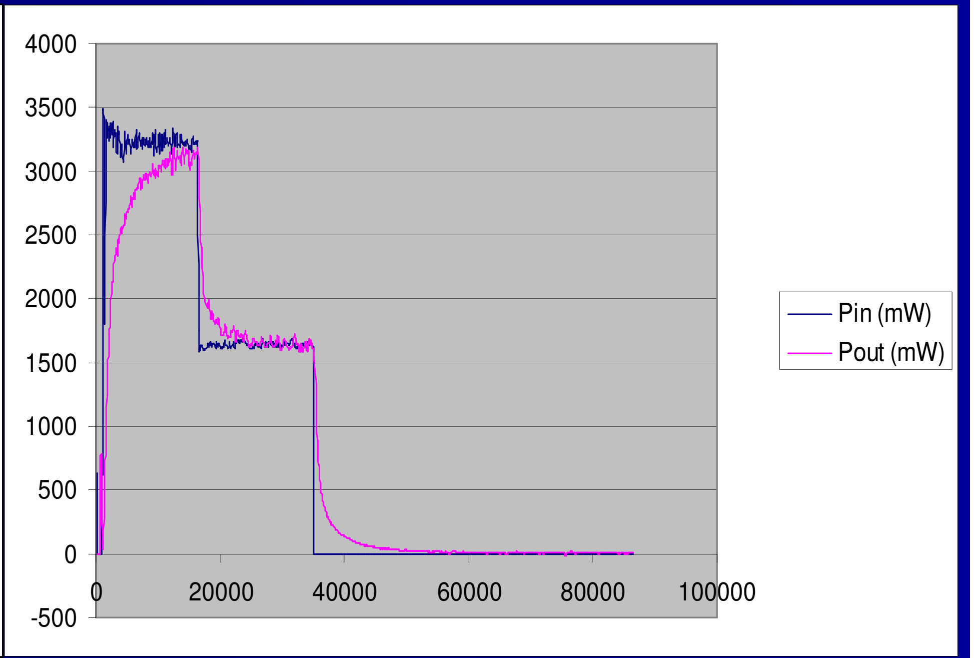
He leakage test ≤ 1x10-10 mbar l/s

Current = 5 - 300 mA
Voltage = 2 – 12 V

Symmetric electrochemical cell :Pt-foil/Pd-foil/Pt-foil
(20x10mmx50μm Pd)

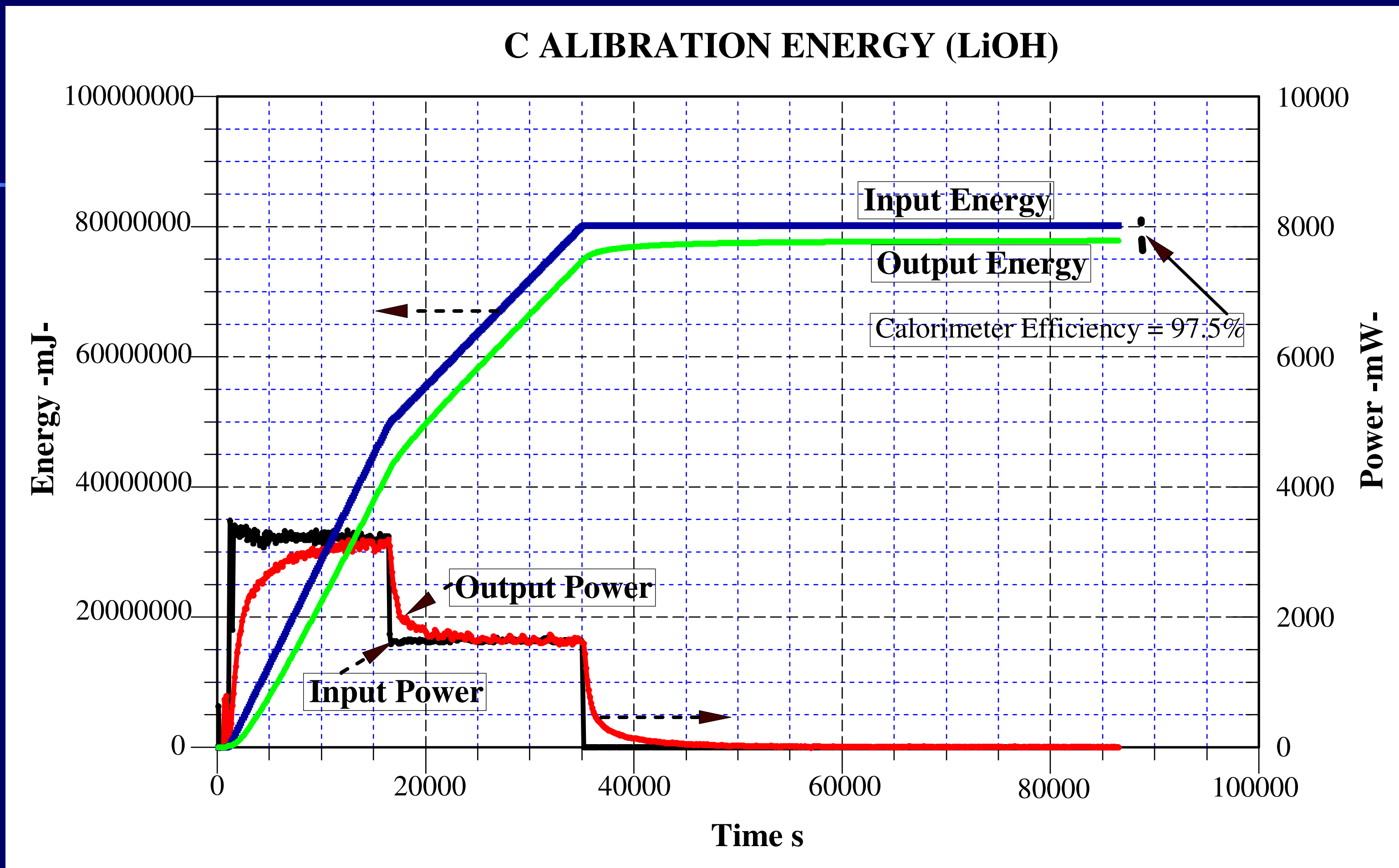
Reference Experiments with LiOH





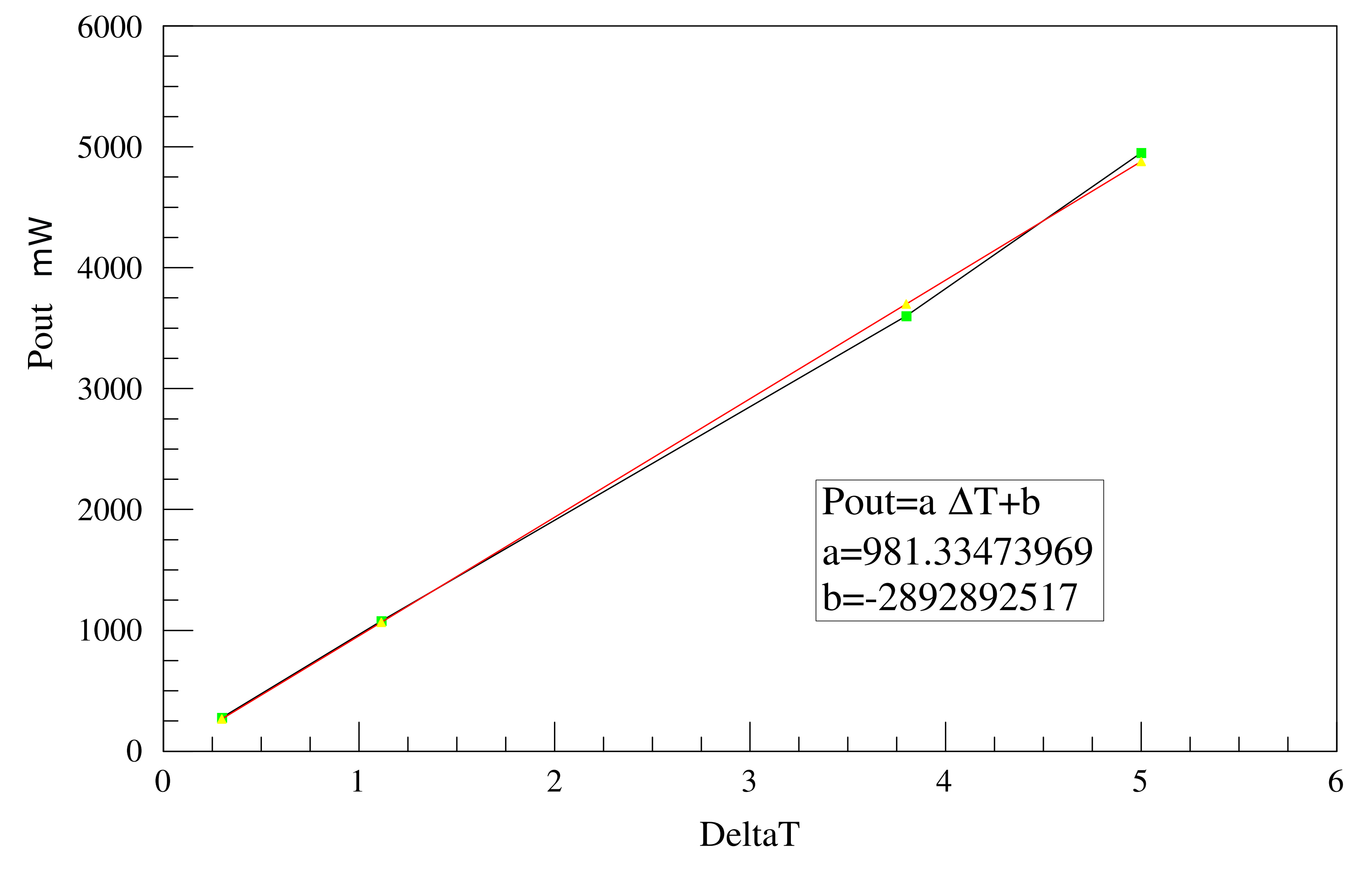
Input and output of power during electrochemical loading of hydrogen into Pd foils. Calorimeter efficiency = 97.5%.

Energy & power (input and output) during calibration with H2O 0.1 M LiOH



Plot of energy & power (input and output) for calibration with H_2O 0.1 M LiOH.

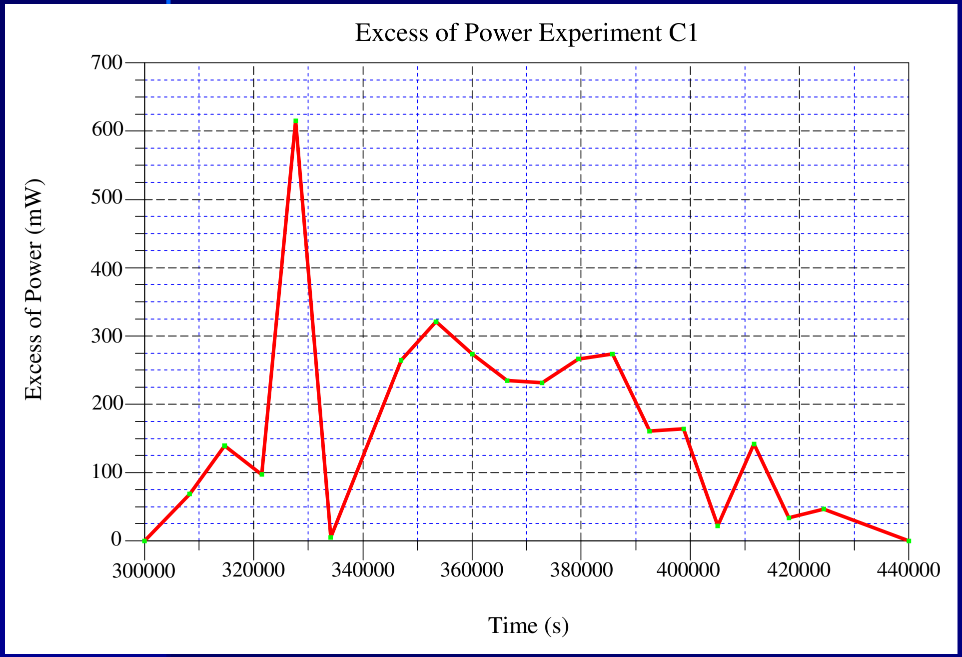
Flow Calorimeter Calibration Curve



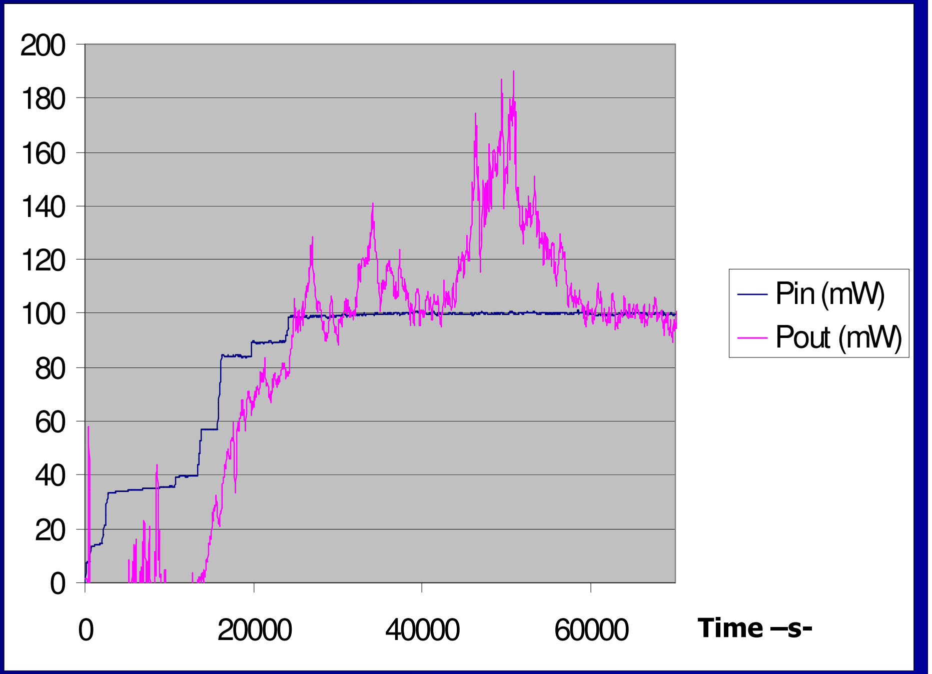
In principle flow calorimetry doesn't require calibration

Excess of Power with LiOD

C1 and C3 Experiments

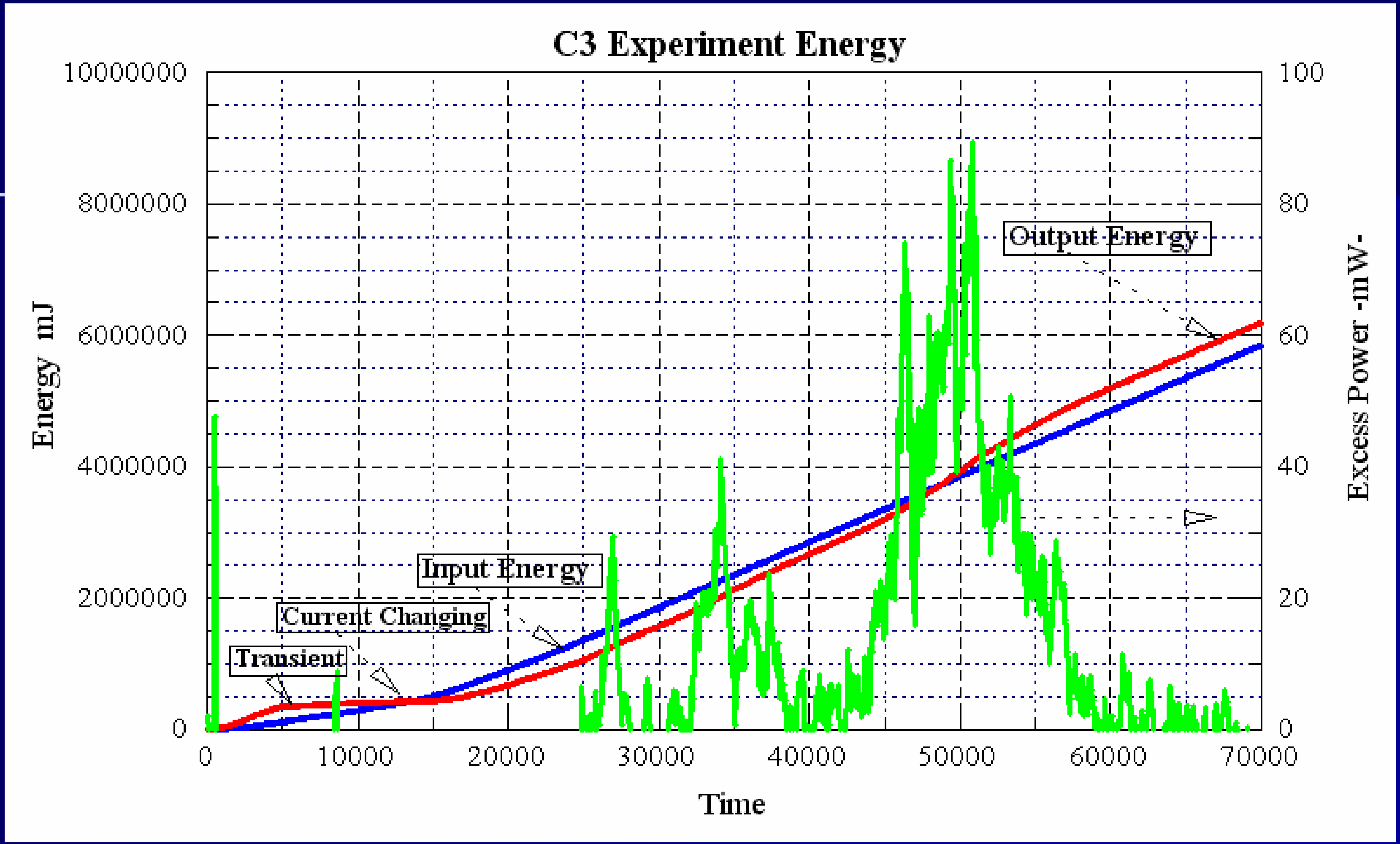


Experiment C1: excess of power vs time (45 KJ of produced energy = 35 MJ/mol Pd)



Experiment C3: excess of power vs time

Excess of Power and Excess of Energy in C3 Experiment



C3 experiment: plot of energy & power (input and output)

Remarks

Why a trigger ?

Two excesses of power have been observed over 9 experiments although the achieved D concentration in Pd (atomic fraction) has always been larger than 0.9.

The loading threshold D/Pd > 0.9 is clearly only a ***necessary condition***.

Plasmons-Polaritons Laser Triggering

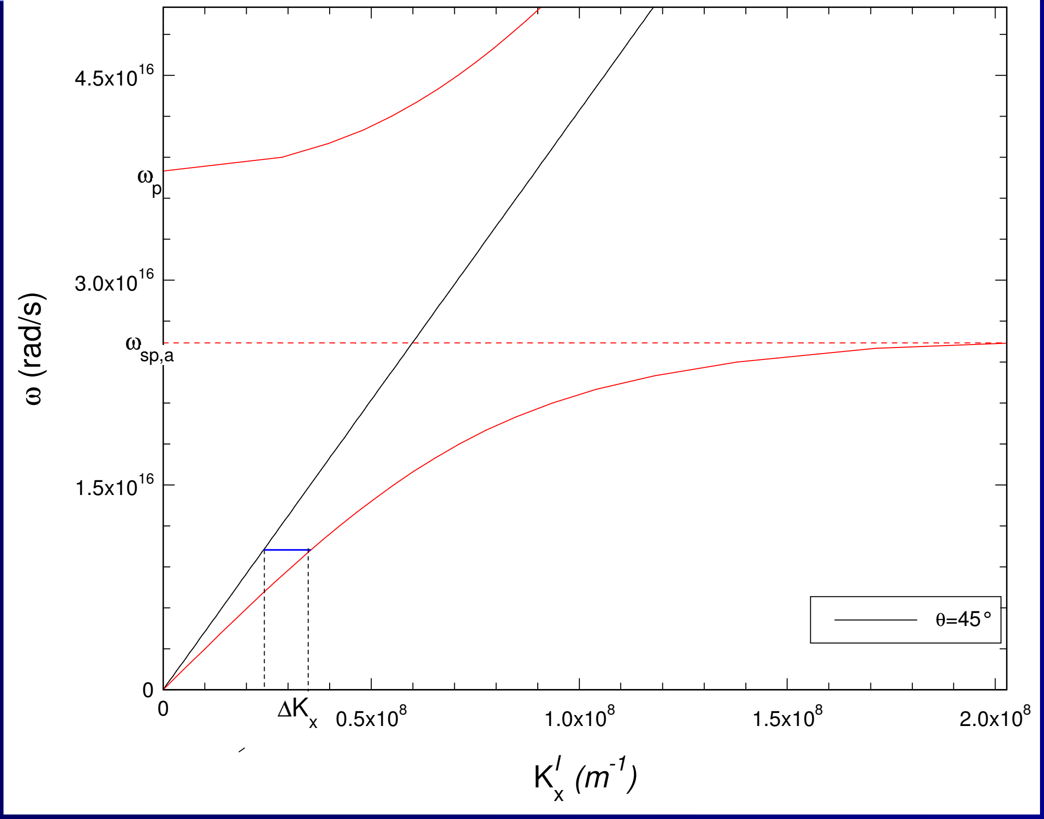
According to the idea that collective electron oscillations have a key role in LENR processes a proper trigger has been introduced to create surface plasmons (polaritons).

Surface plasmons are quantum of plasma oscillations created by the collective oscillation of electrons on a solid surface.

Surface plasmons may be generated by mechanisms able to produce charge separation between Fermi level electrons and a background of positive charges (i.e. lattice atoms):

1) Electrons beam.
2) Laser stimulation.
3) Lattice vibrations.
4) Charged particles interacting with a surface.

Coupling by Roughness



$$K_x = \frac{\omega}{c}\sin\theta \pm \Delta K_x = K_{sp}$$

Where:

$$\Delta K_x = \pm ng$$

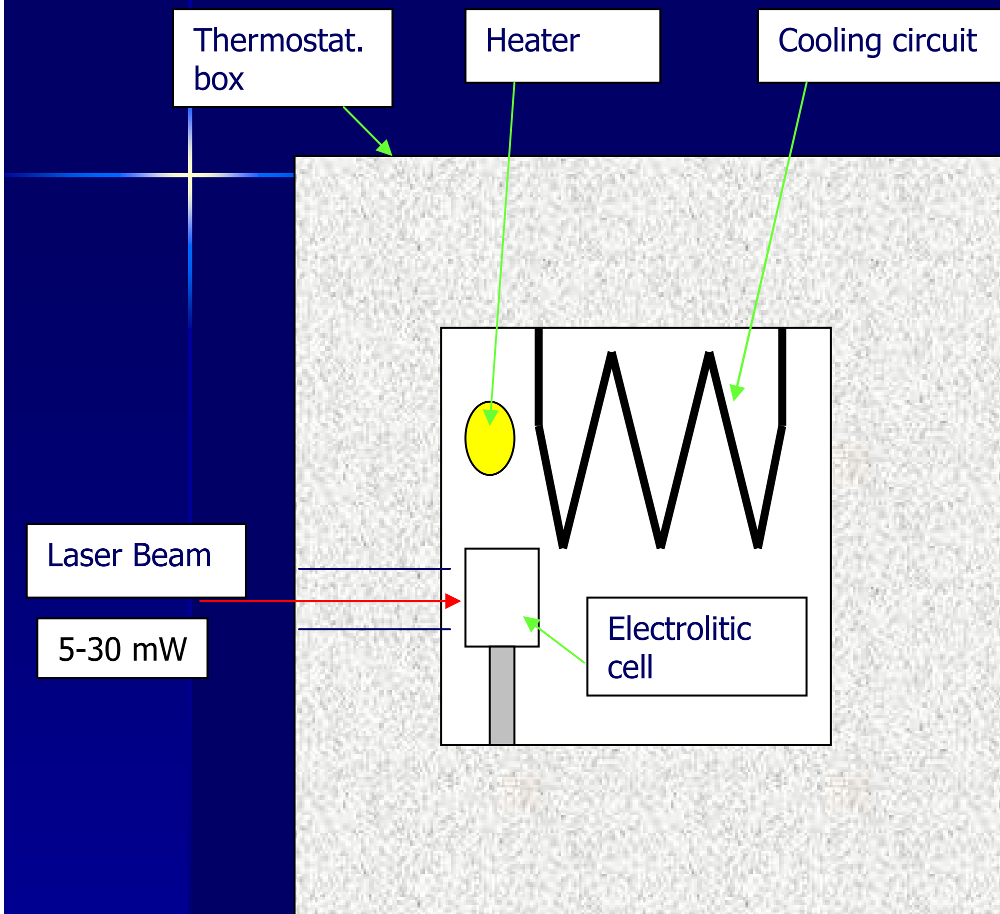
$$g = \frac{2\pi}{a}$$

n=1,2.....

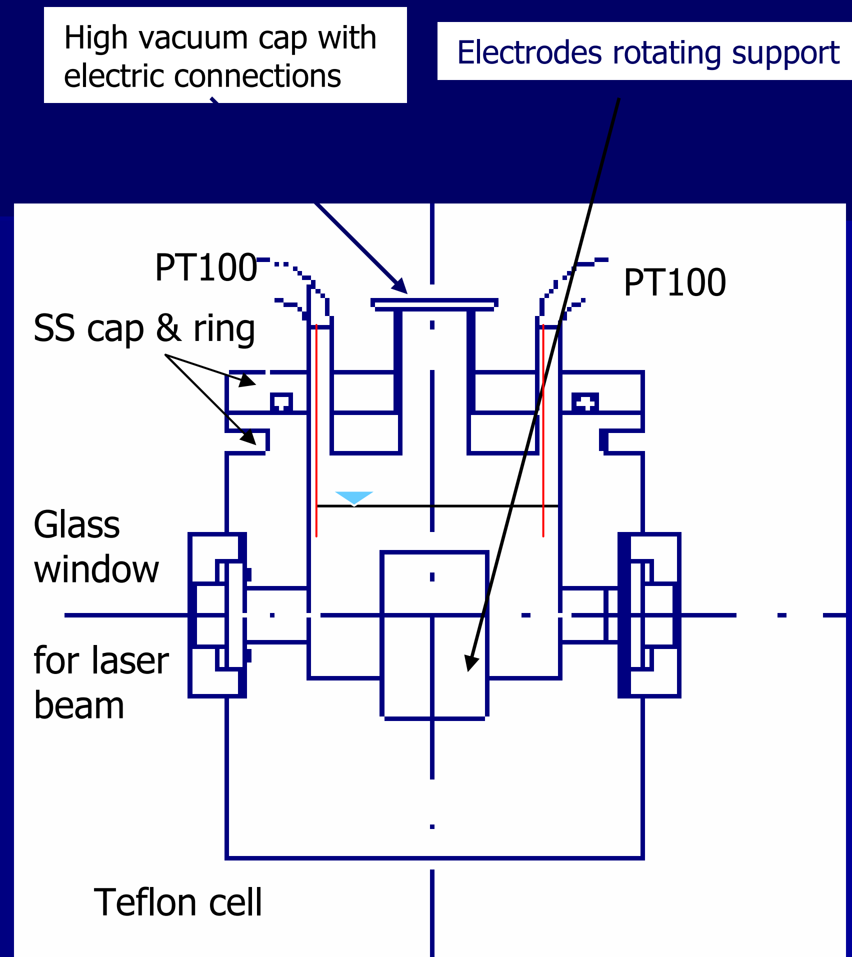
a is the surface corrugation lattice parameter.

Shift of the incident radiation wave vector produces plasmons excitation: a proper corrugation of the surface creates the required shift.

Isoperibolic Calorimetry under Laser Triggering



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



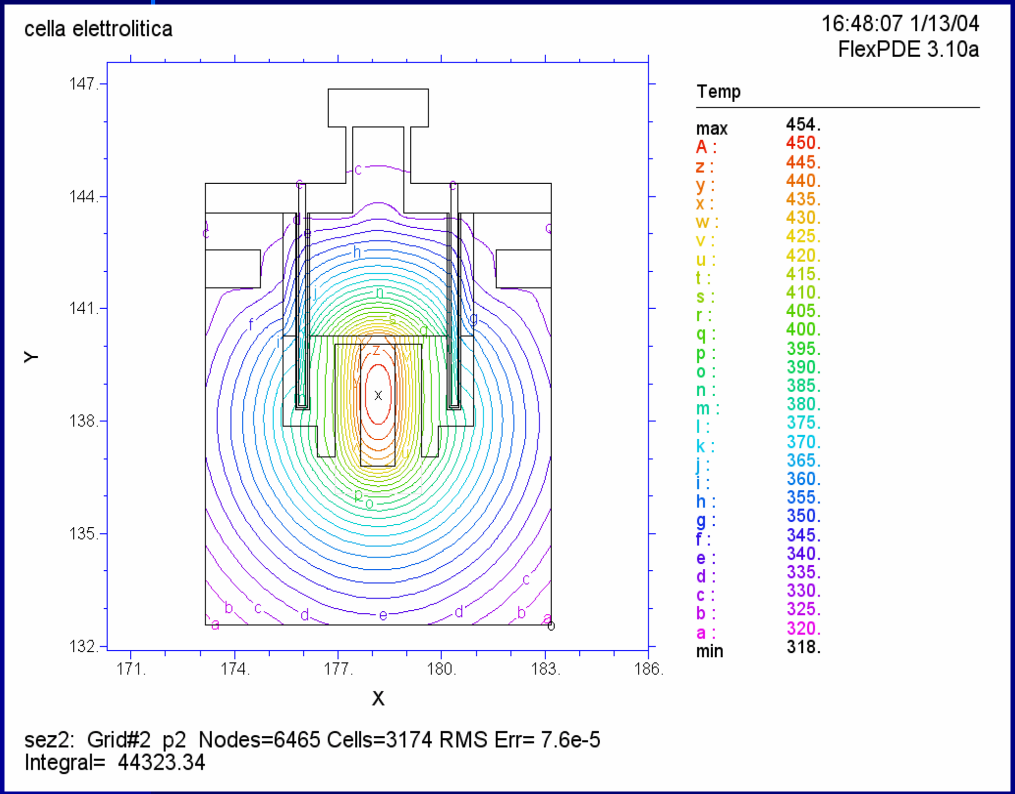
Electrochemical cell for laser triggering Experiments. He leakage ≤ 10^{-10} mbar l/s.

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

Current = 5 - 400 mA

Voltage = 2 – 15 V

Electrochemical Cell FEM Analysis to Design and Optimize the Isoperibolic Calorimetric System for Laser Triggered Experiments

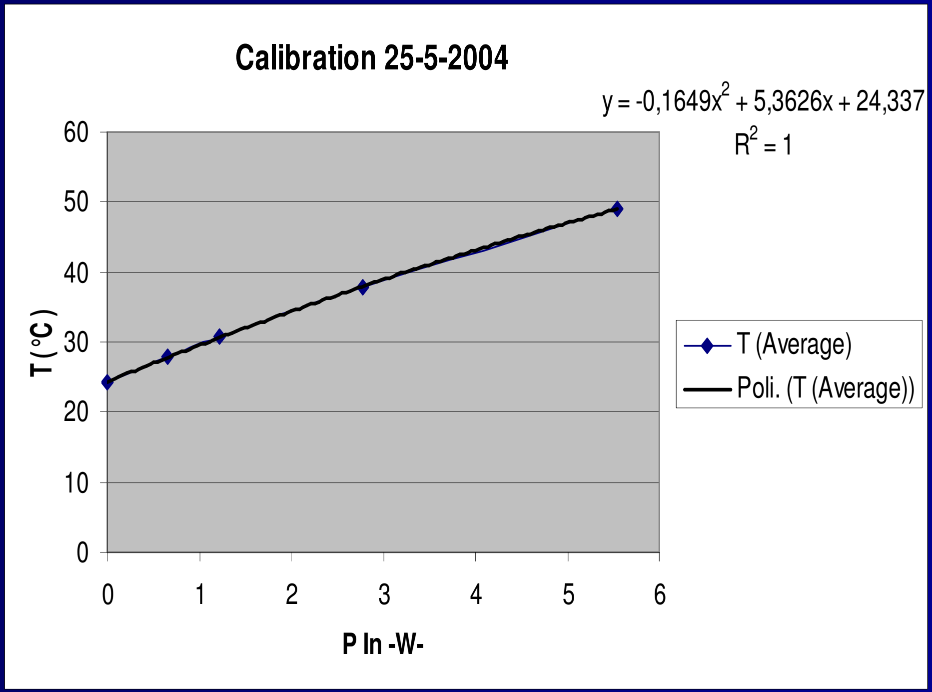


Simulated cell and experimental cell (closed cell with recombiner)

Isoperibolic Calorimetry for Laser Triggered Experiments.

Calibration is mandatory

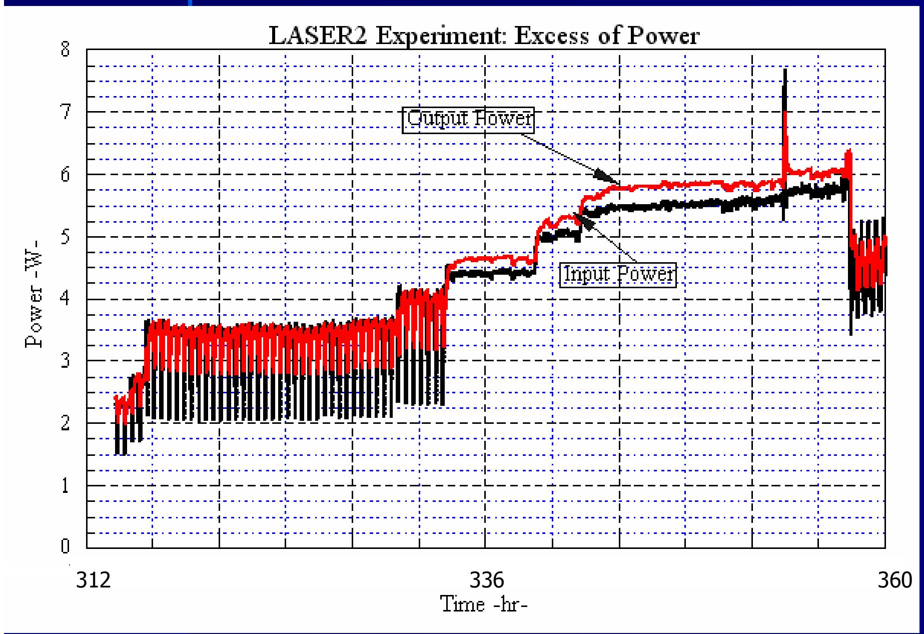
Calibration based on the average of the 2 PT-100 temperature values obtained by means of electrolysis in LiOD.

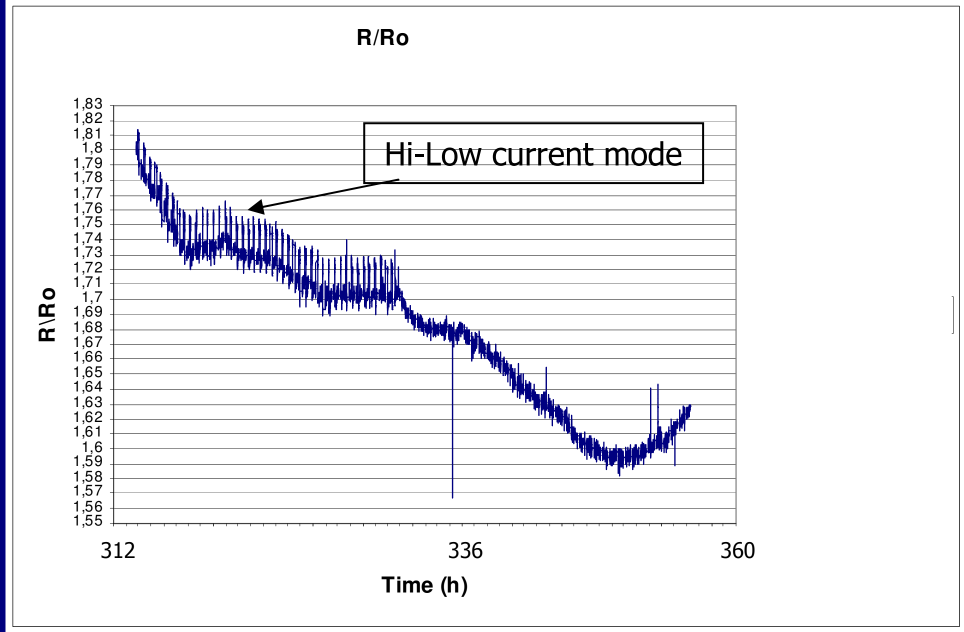


Calibration of the isoperibolic calorimeter

Laser2 Experiment

23.5 kJ of produced energy: 17.3 MJ/ mol Pd

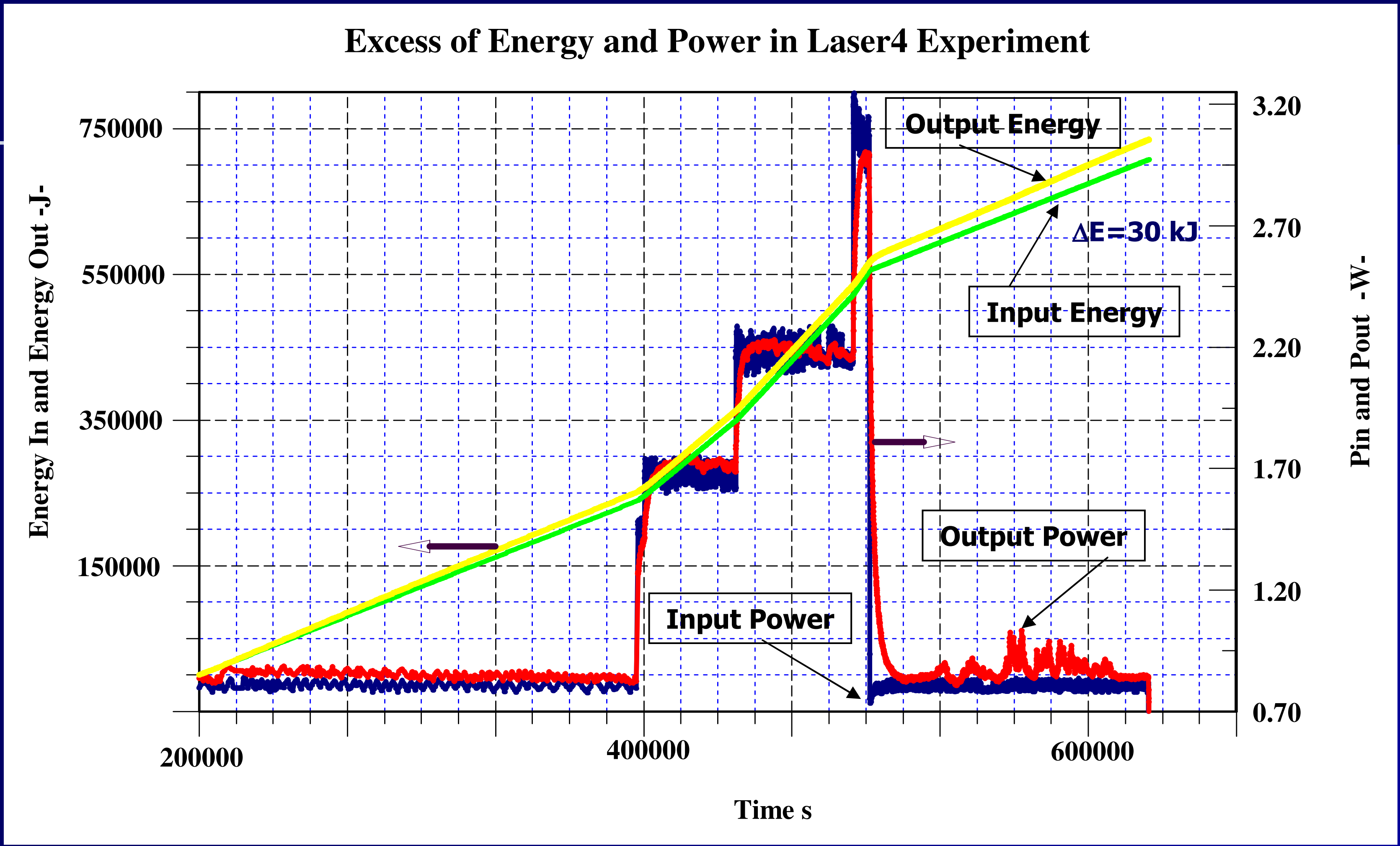




Evolution of the input and output power, last 300 hr under laser irradiation (P-polarization), 632 nm, 5 mW. ^4He production estimate 6.12E+15.

Evolution of loading (normalized resistance).

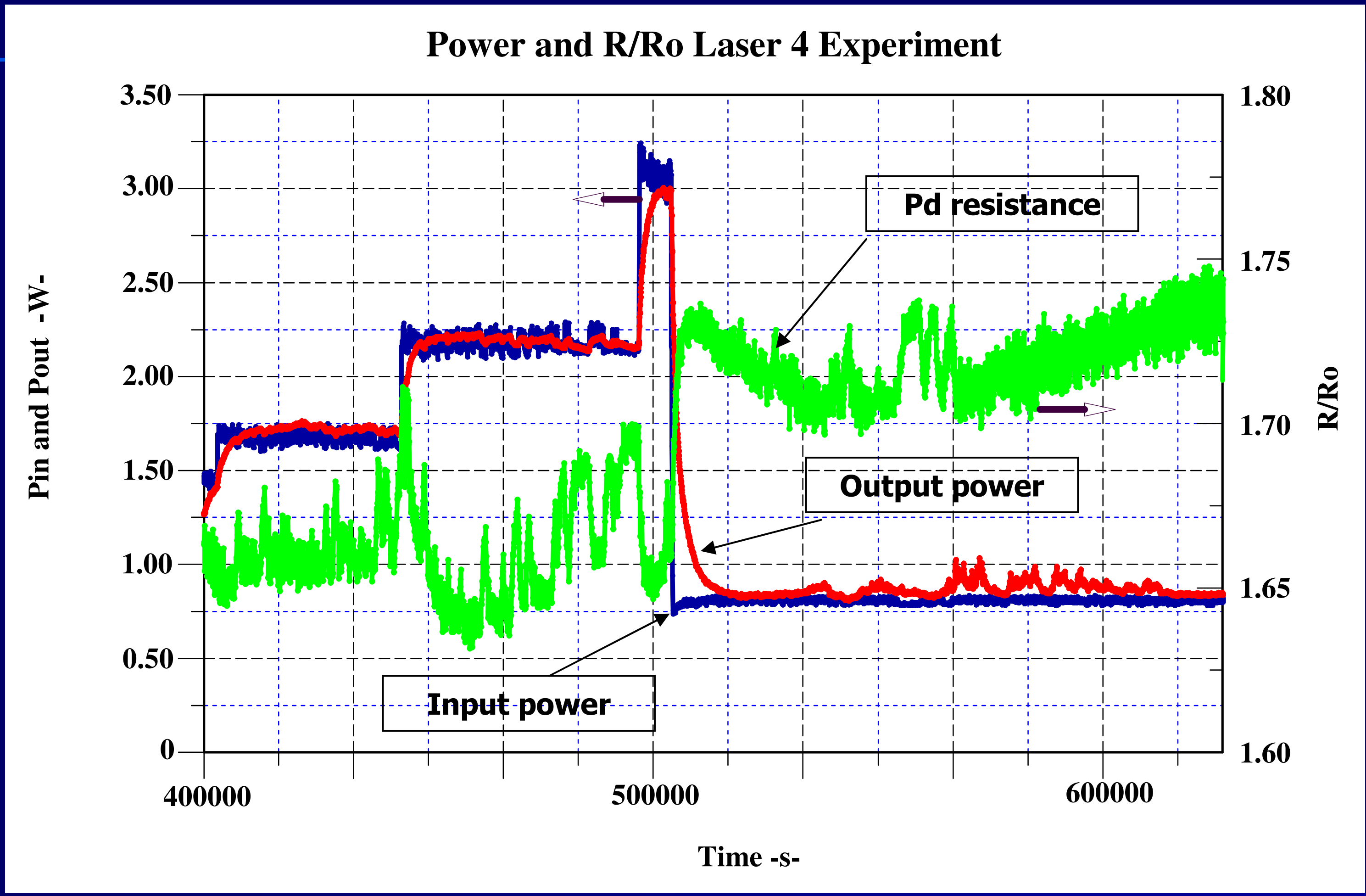
Laser4 Experiment: Calorimetric Results



Excess of energy and excess of power in Laser4 experiment.

Laser4 Experiment: Calorimetric Results

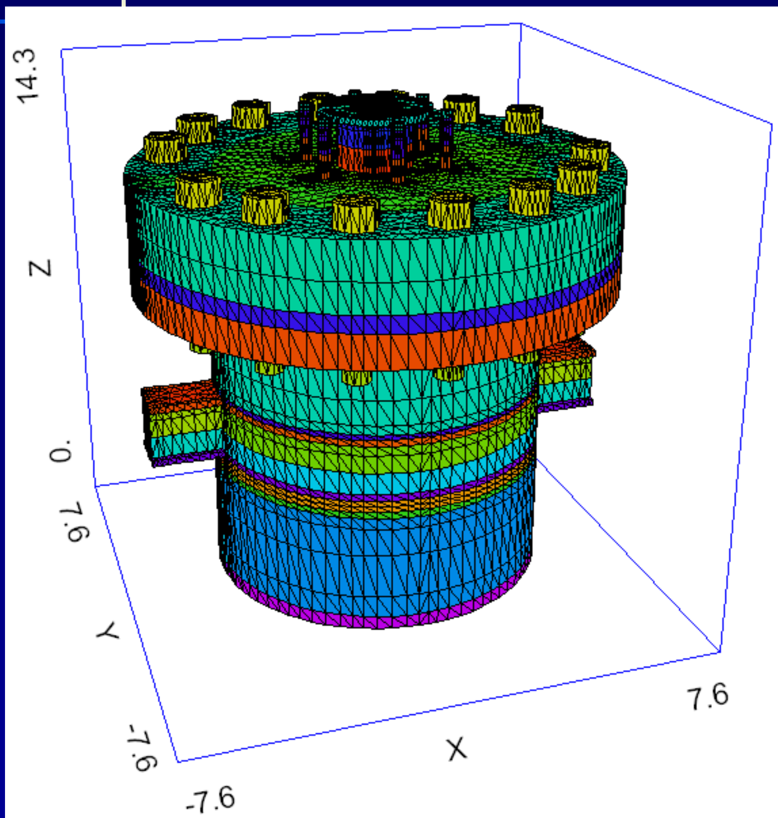
30.3 kJ of produced energy: 19.4 MJ/ mol Pd



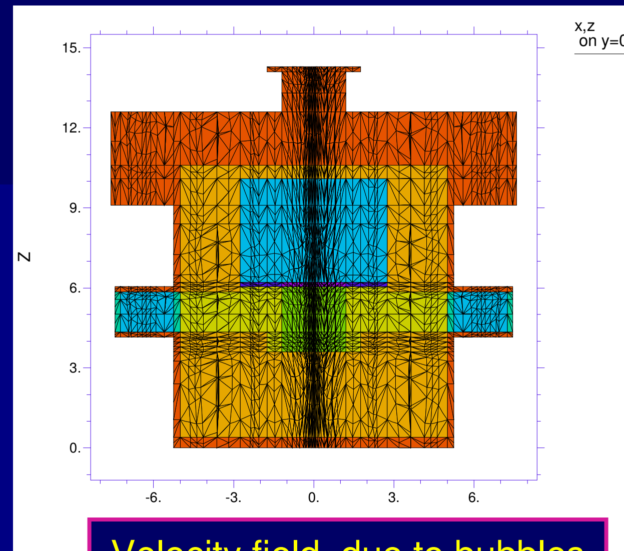
Excess of power and loading evolution.

Laser Cell Upgrade

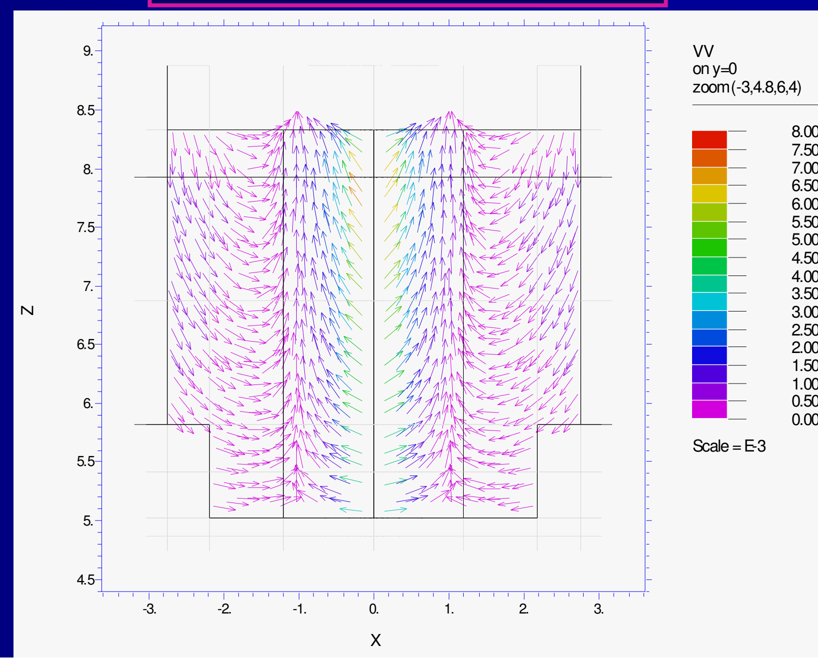
Mesh and Velocity Field



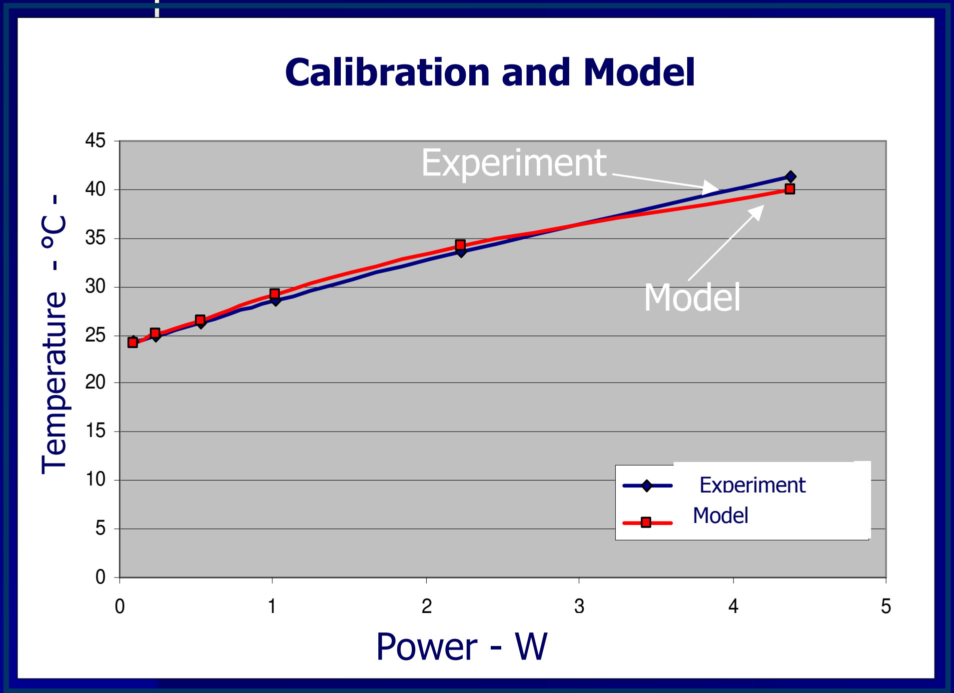
Mesh 3D



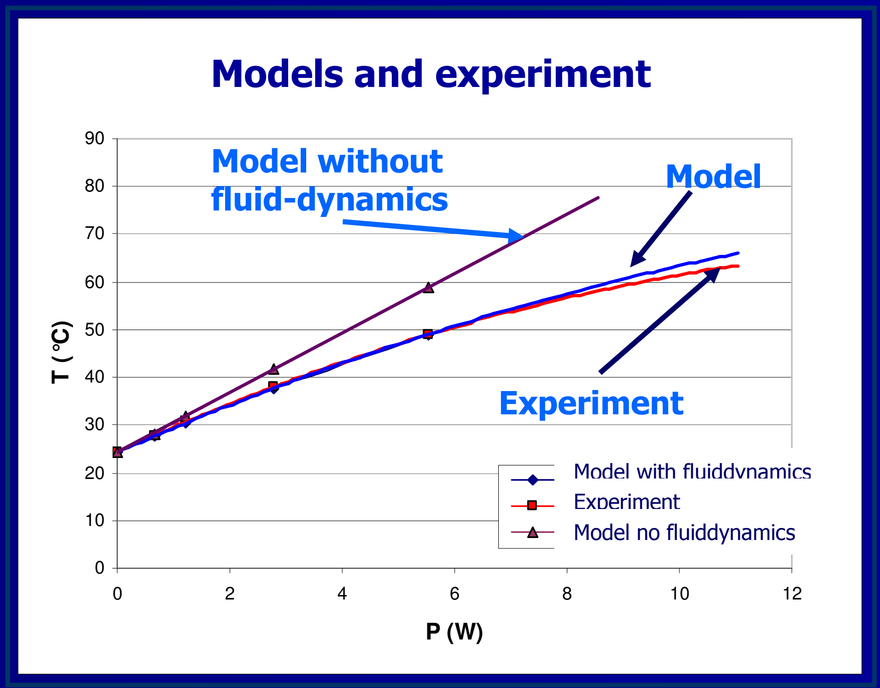
Velocity field due to bubbles



Comparison between Experimental Data and Model

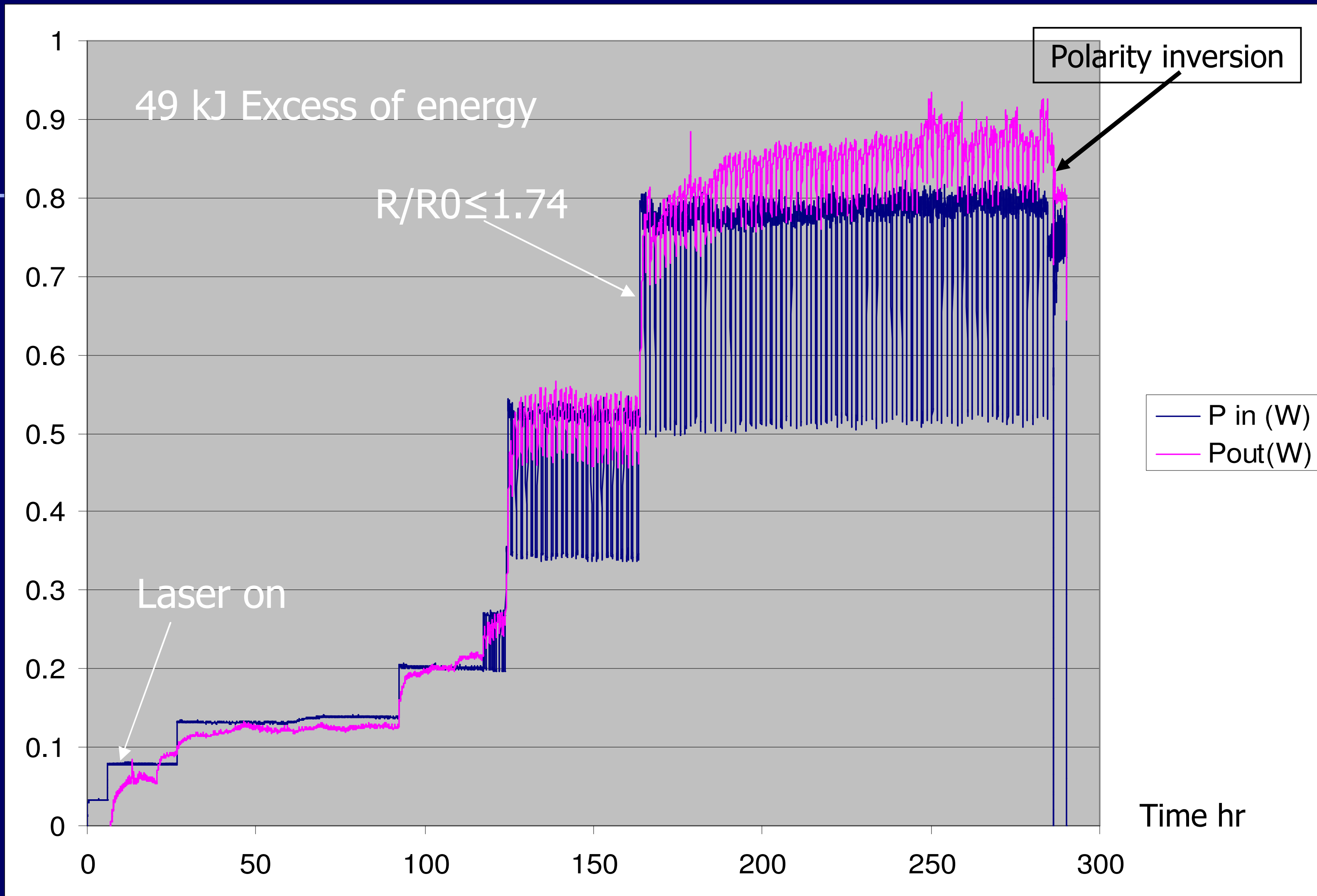


Comparison between calibration data and model



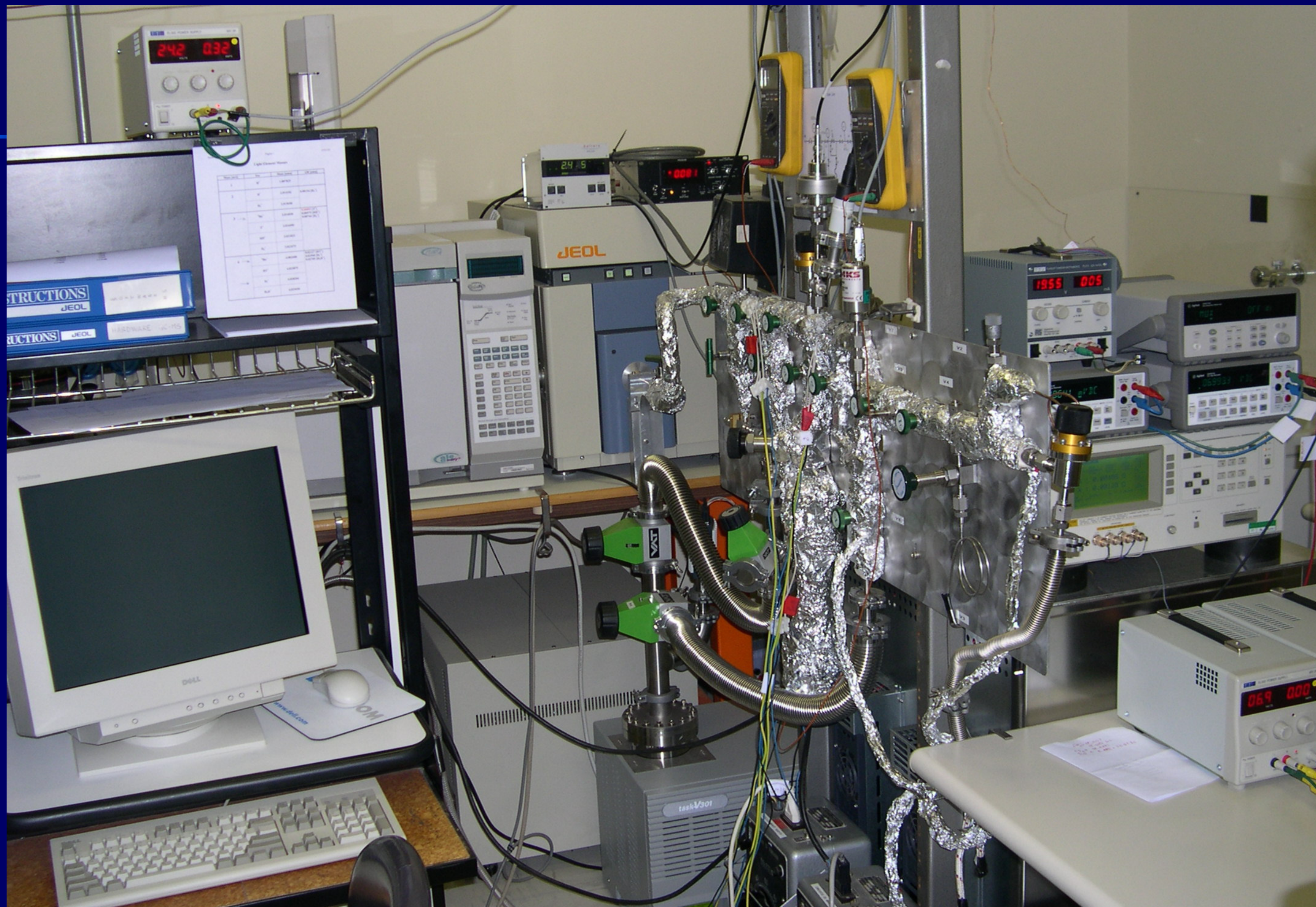
Comparison between experimental data and model, with and without fluid-dynamics

Laser 5 Experiment: Calorimetric Results



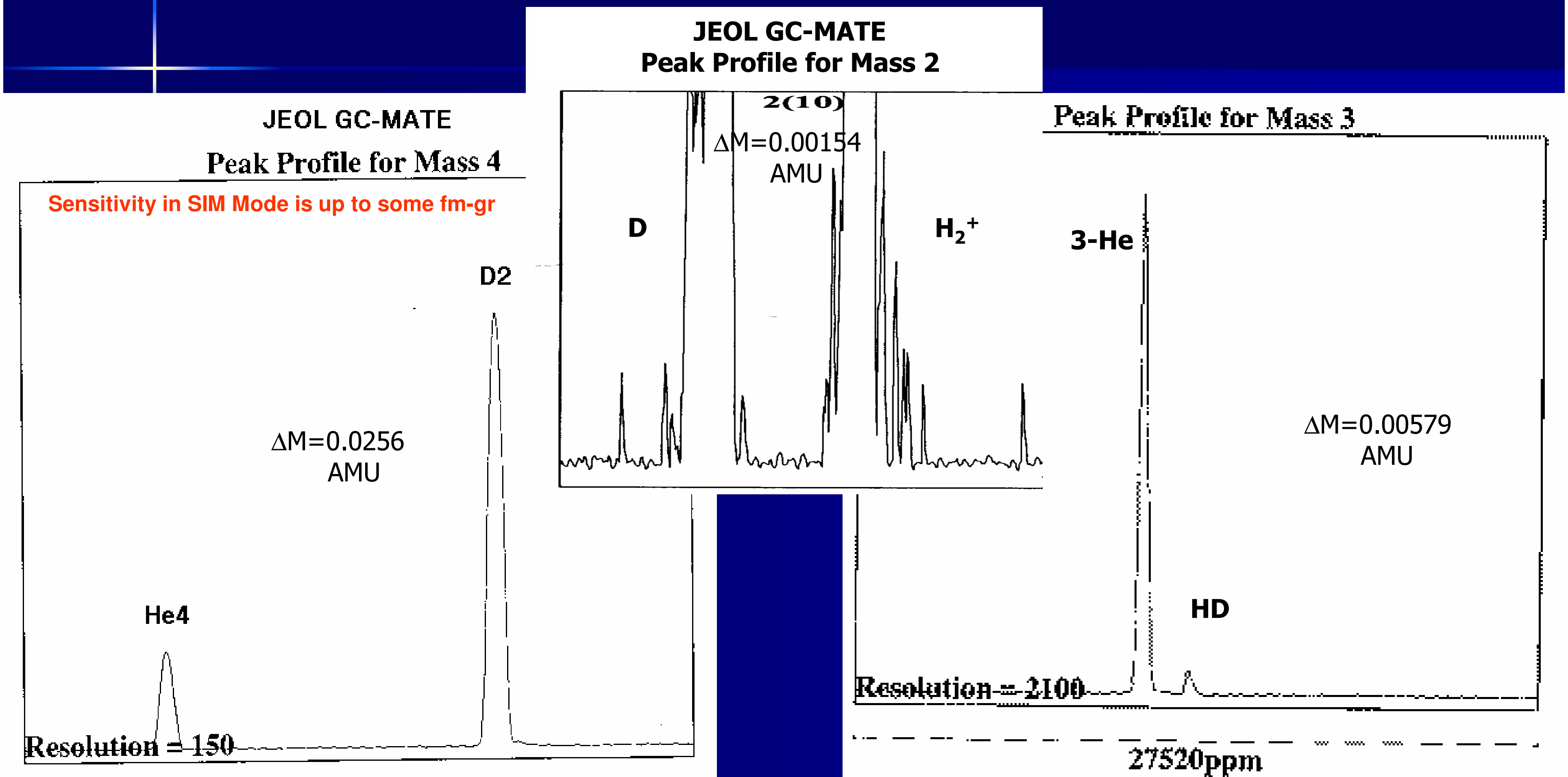
Excess of power during laser triggering (HeNe laser)

Mass Spectrometer: JEOL GC Mate

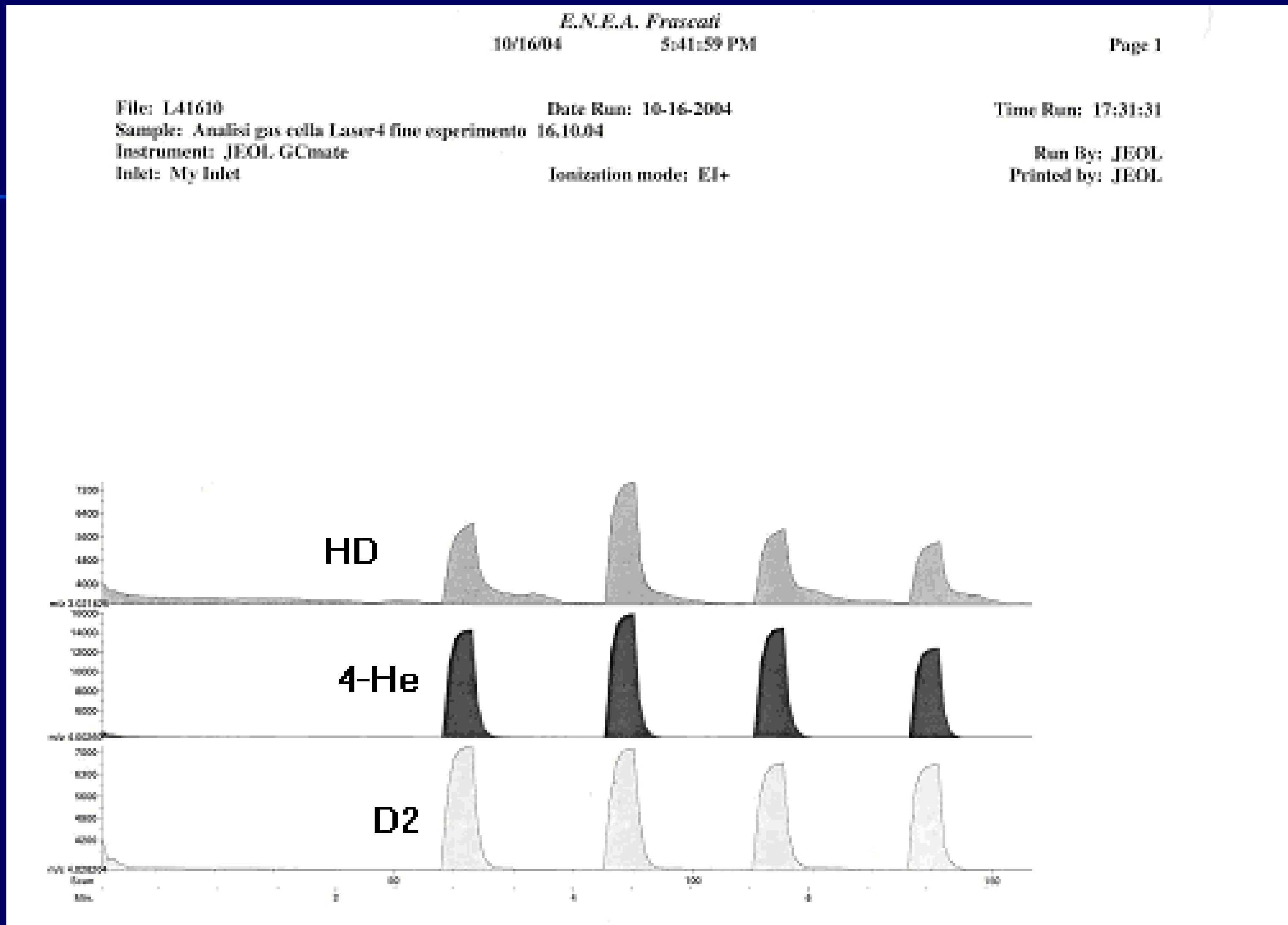


JEOL mass spectrometer and inlet system.

JEOL GC-Mate Resolution and Sensitivity



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



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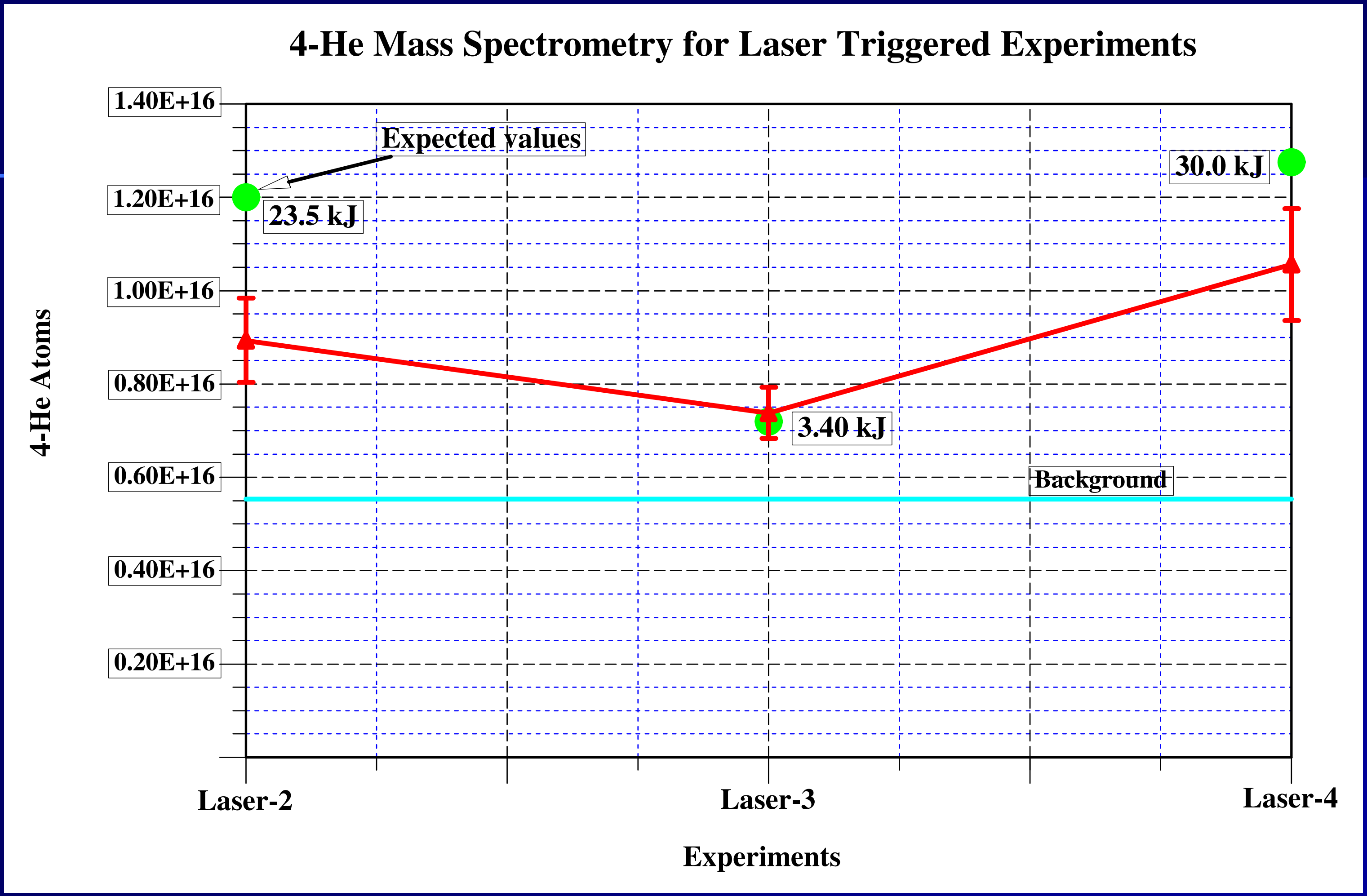
File: L41610 Date Run: 10-16-2004 Time Run: 17:31:31

Sample: Analisi gas cella Laser4 fine esperimento 16.10.04

Instrument: JEOL GCmate Run By: JEOL

Inlet: My Inlet Ionization mode: EI+ Printed by: JEOL

Laser Triggered Experiments: ^{4}He Results



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

Search for Isotopic Shift in Electrochemical Experiments

The research has been conceived to identify evidences of nuclear processes occurring, at low energy, in condensed matter.

The working conditions have been selected to reduce contamination effects, in particular to reduce the background of elements' impurities in the isotopic ratio measurements on a marker element.

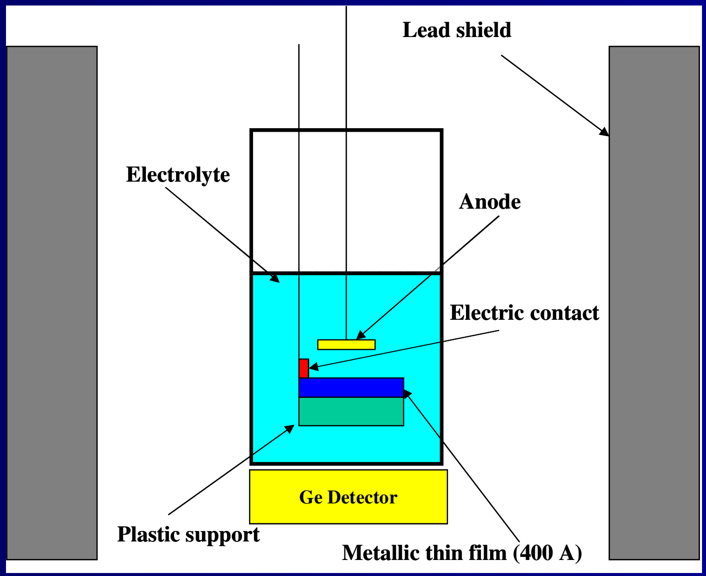
Neutron Activation Analysis was applied such a study

Thin Films Experiments for Isotopic Composition Analysis

Cells were realized by using only :

1) Pure polyethylene
2) Pure Pt (99.98)
3) 400 Å Ni film on a pure polyethylene support (ϕ=12mm, thickness=1 mm)

Experimental cell into the lead shield



Nuclear Measurements

Nuclear Activation Analysis (NAA) facility of the Nuclear Measurements Laboratory of the Casaccia ENEA Research Center has been used for the experiments.

The irradiation has been done by means of the TRIGA 1MW MarkII reactor (neutron flux=2.6E+12 cm^{-2} s^{-1}, thermal/fast = 2/1) with irradiation time of 24 hours over five days, and 10 minutes for long and short irradiation respectively.

Measurements have been done after a proper radioactive cooling time, by using a coaxial Ge(i) ORTEC detector and an ORTEC counting chain.

Rough data have been treated by ORTEC MAESTRO-II and OMNIGAM softwares. Pure standards and standard mixtures of Zn, Ag, Cr, Co and Fe have been allocated with samples over the 30 irradiation positions used.

Neutron flux and spectrum can be considered to be homogeneous since the irradiation facility was a rotating one.

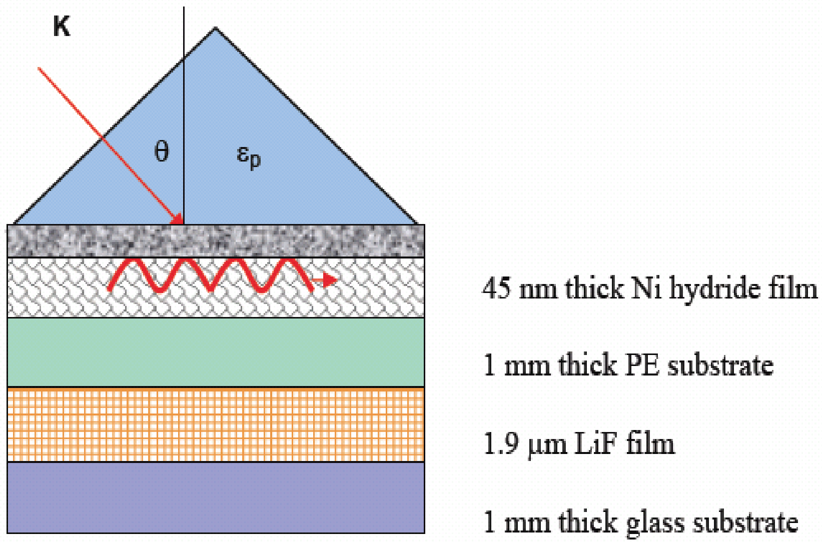
The high reproducibility of the specific activity of Zn and Ag pure standards allows us to consider that the irradiation has been properly optimised.

X-Ray measurements have been performed with a planar Ge ORTEC detector.

RUN (b): ISOTOPIC COMPOSITION ANALYSYS

	Ni1b	Ni2b	CuPd1b
Ag107	<0,019	<0,034	<0,026 BDL
Ag109	0,025	0,06	0,0075
Shift Ag%	29,37	47,39	NE

LiF X-RAY IMAGING IN HYDROGEN LOADED Ni FILMS UNDERGONE TO LASER IRRADIATION



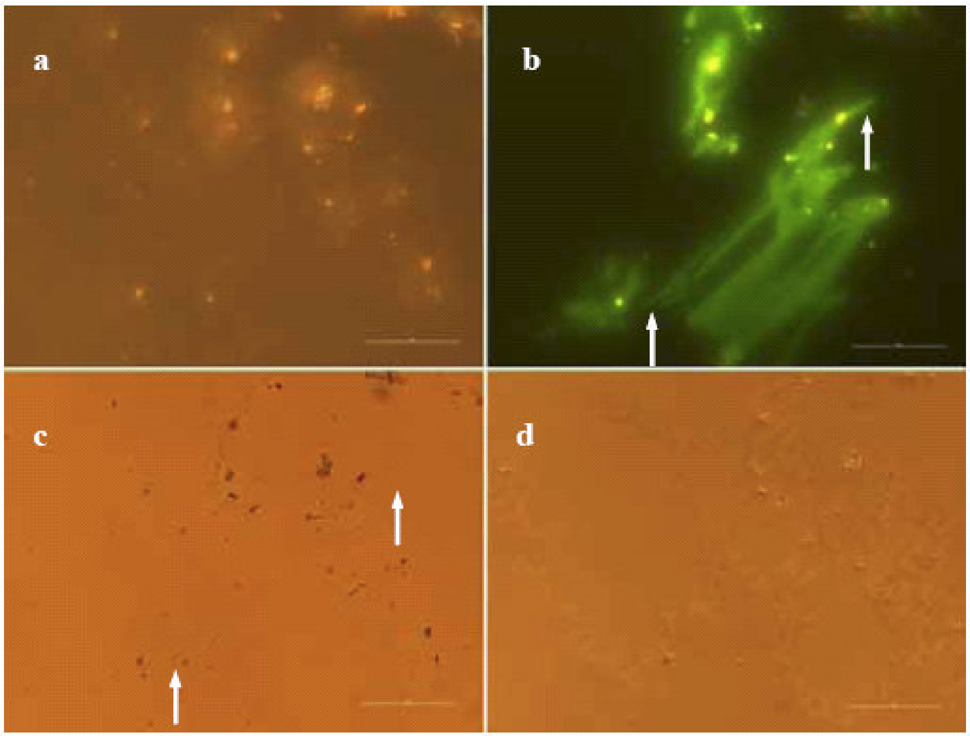


Figure 2. Optical images of the exposed LiF film surface obtained in different microscope operation mode. Transmission mode, dark field, a). Fluorescence mode, UV illumination, b). Transmission mode, white light, c). Transmission mode, phase contrast, d). Reference line = 50 µm.

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.

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

Evidences of isotopic shift and X Ray emission have been observed in the experiments.