Task title:

Application of pulsed laser light for the removal of co-deposited deuterium/tritium from in-vessel components

Institution: Institute of Plasma Physics and Laser Microfusion, Association EURATOM/IPPLM, Warsaw, Poland

Chief Investigator: J. Wolowski, *speaker:* P. Gasior

Partners:

- Association EURATOM/FZJ - Forschungszentrum Jülich, Germany
- Association EURATOM/VR - Alfven Lab., KTH, Stockholm, Sweden
- Association EURATOM/IPPLM - Warsaw Univ. of Technol., Warsaw, Poland

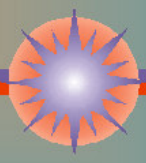
Outline

- Details of the task,
- The outline of the issues dealing with of tritium/deuterium retention and removal,
- The ablative removal of the codeposite – the equipment and the means of the experiment at the IPPLM,
- Results of first experiments:
  - ion diagnosis (IPPLM),
  - microscopy (FZJ),
  - profilometry (FZJ),
  - spectrometry (FZJ)
- Summary and conclusions.

Tasks

This project comprises the following tasks:

- investigation and optimization of laser ablation of co-deposited layer of graphite limiter tiles containing adsorbed deuterium,
- investigation of thermal desorption of deuterium from the limiter tiles using low fluence laser radiation or laser-generated x-rays,
- tests of thermal desorption of tritium by heating the co-deposit using x- rays generated by a high-fluency laser radiation interacting with high-Z targets.

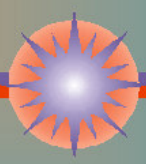


Tritium removal mechanisms:

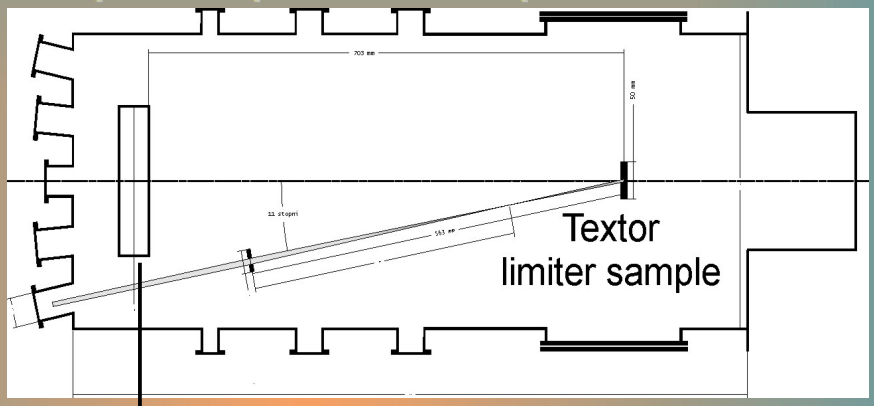
- mechanical methods,
- (laser) thermal desorption,
- discharges and chemical reactions,
- **laser ablation of the co-deposited layer**

Laser ablation method

- threshold for a pure graphite layer ablation - 0,7-1J/cm^2,
- threshold for a divertor/limiter co-deposited layer ablation: 0,3 - 0,5 J/cm^2,
- thickness of ablated co-deposite layer per pulse - 0,4 to 1,1 μm for laser fluencies from 1,0 - 7,6 J/cm^2,



Simplified experimental setup



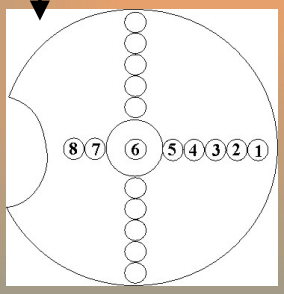
to IEA

Laser beam

Beam diameter: 3-10 mm

Laser pulse energy: up to 0.8 J

Repetition rate: up to 10 Hz



Set of ion collectors

1, 2, 3, 4, 5, 7 and 8 - ion collectors, 6 - hole for ions expanding to IEA

(front view)

Parameters to be measured and instrumentation to be applied

Parameters:

- energy, density and angular distribution of ions,
- amount of ions of particular elements,
- evolution of density of deuterium ions during increasing number of laser shots,
- evolution of density of carbon ions due to different structures of the co-deposite and pure graphite.

Instrumentation:

- set of ion collectors (ICs),
- electrostatic ion energy analizer (IEA).

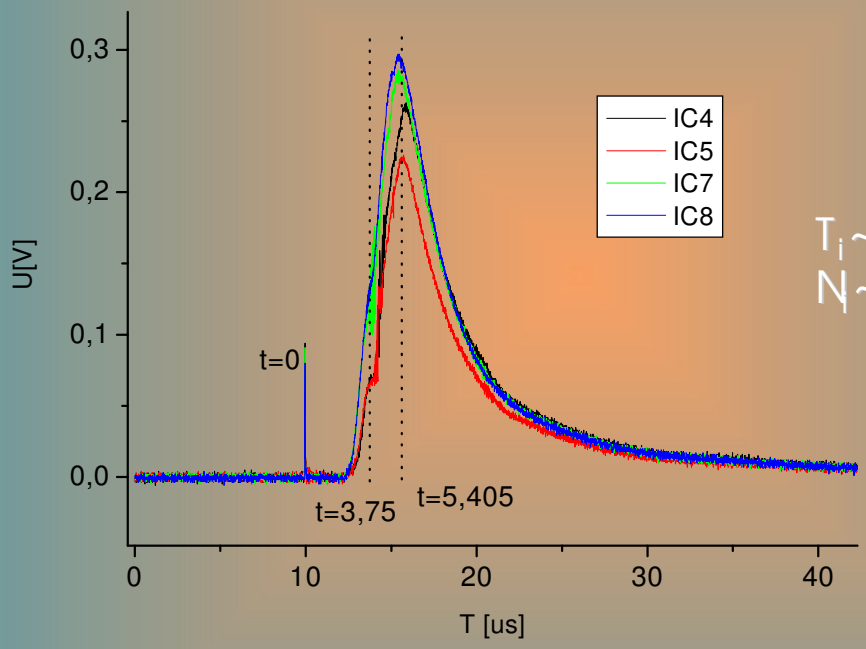
The results - preliminary investigation programme

- shots with the sharp focusing - single shots to analyze the ions and series of shots to ablate a layer of codeposite

- shots with medium focusing - single shots and series of shots to obtain ion characteristics, observation of the increasing depth of the craters and the changes of the surface with the increasing number of shots

- shots with weak focusing/no focusing - ions are unmeasurable - observation of changes in the treated surfaces and the uniformity of scanning

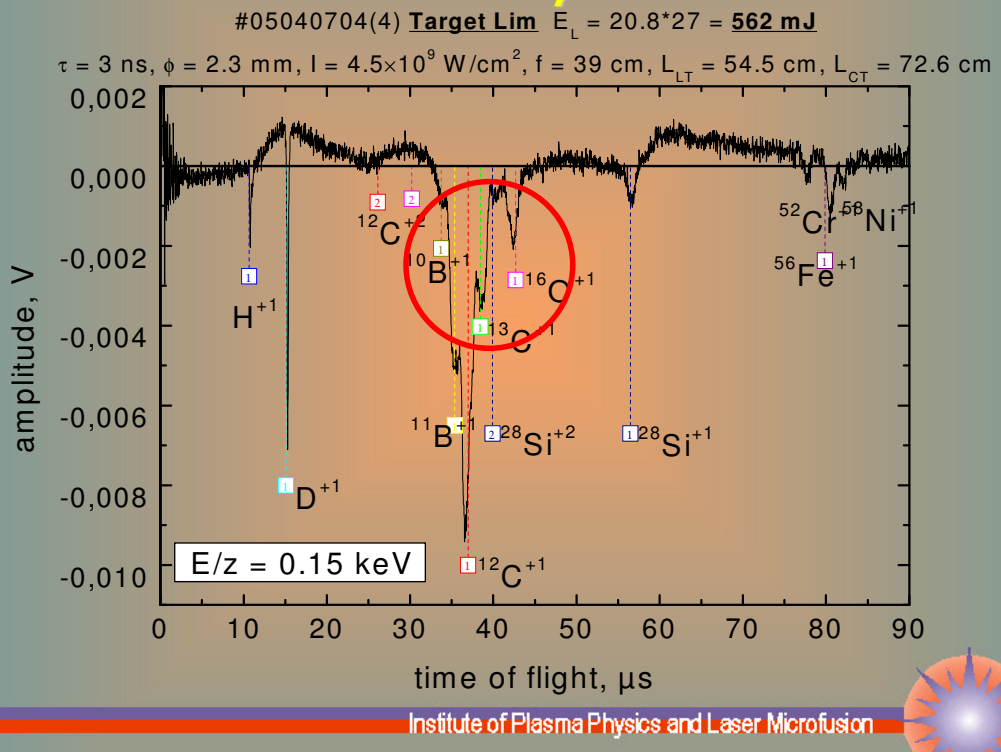
The results - the TEXTOR limiter - shots with the sharp focusing Ion collectors



$T_i \sim 150 - 300$ eV

$N_i \sim 1{,}5 * 10^{10}$ cm^{-2}

The results - the TEXTOR limiter - shots with the sharp focusing ion analyzer



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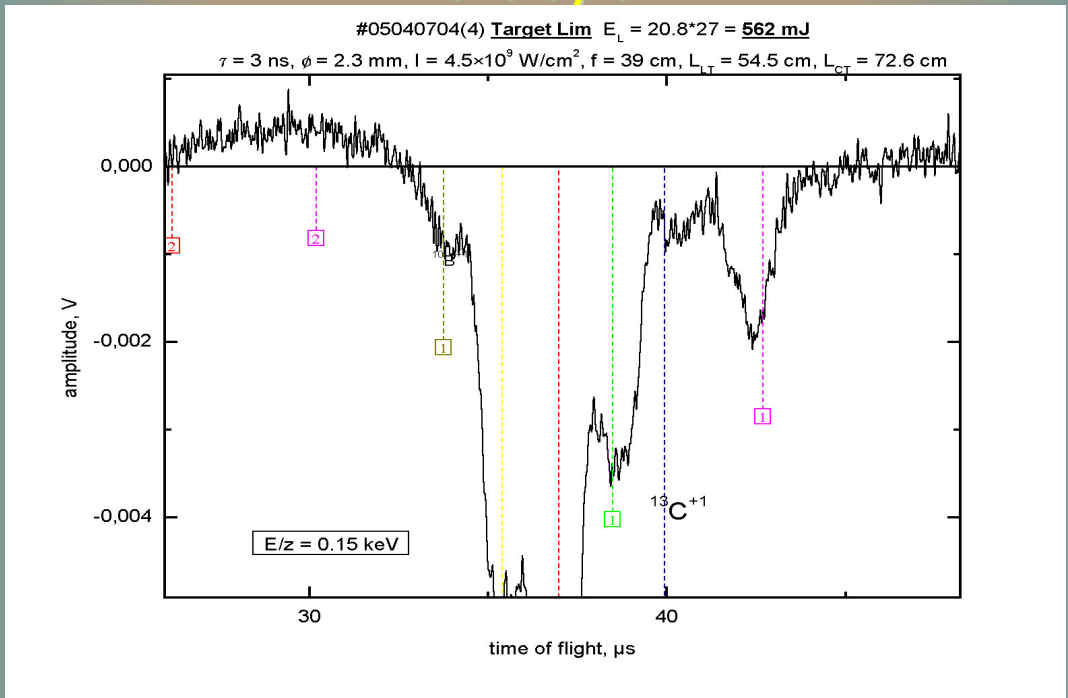
The results - the TEXTOR limiter - shots with the sharp focusing ion analyzer



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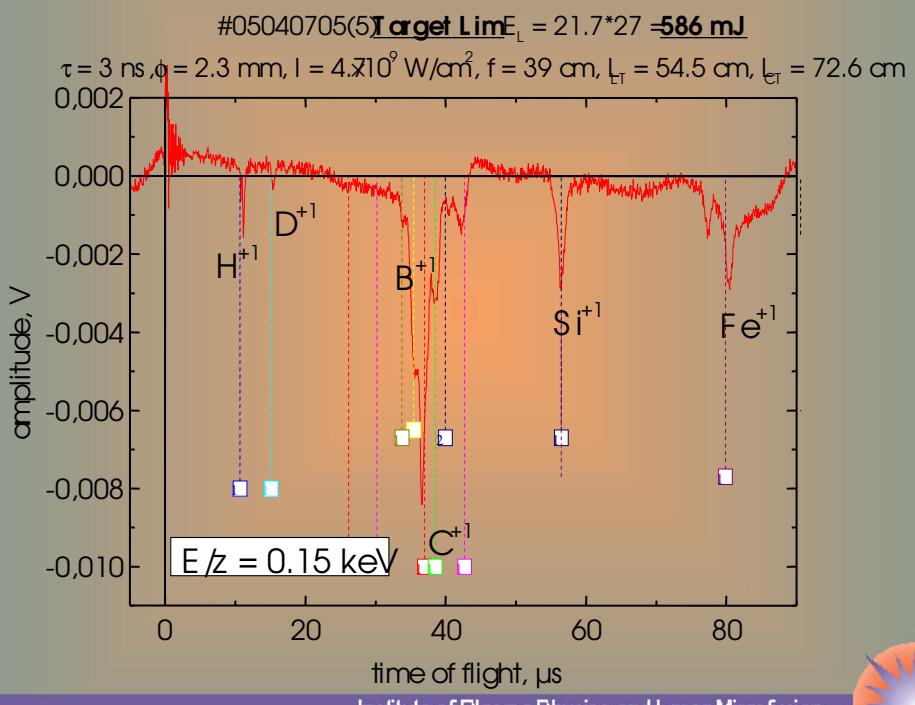
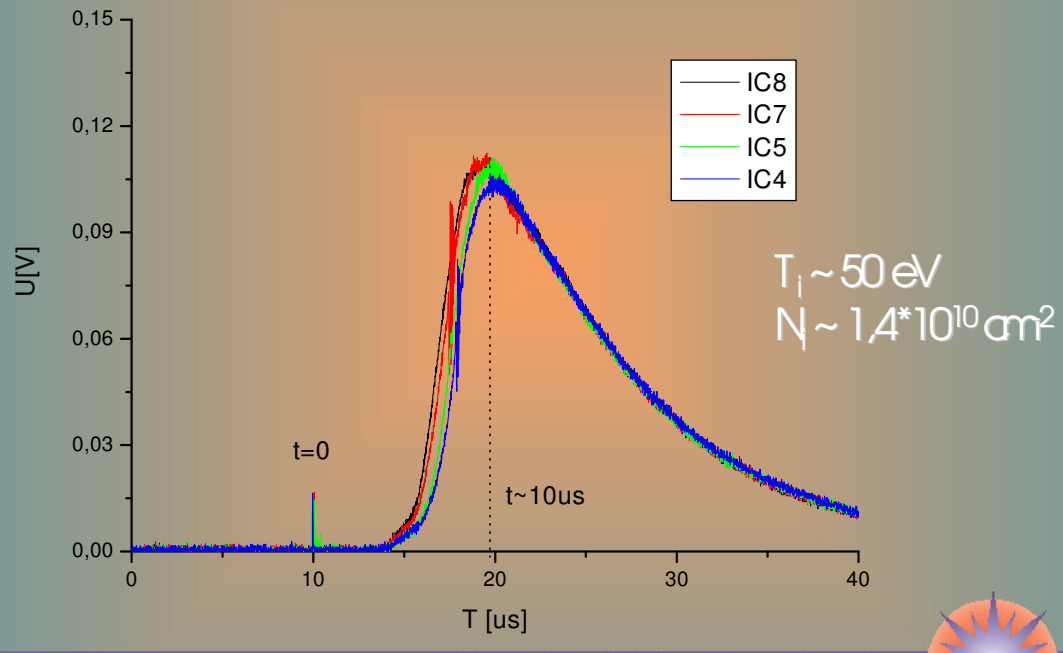
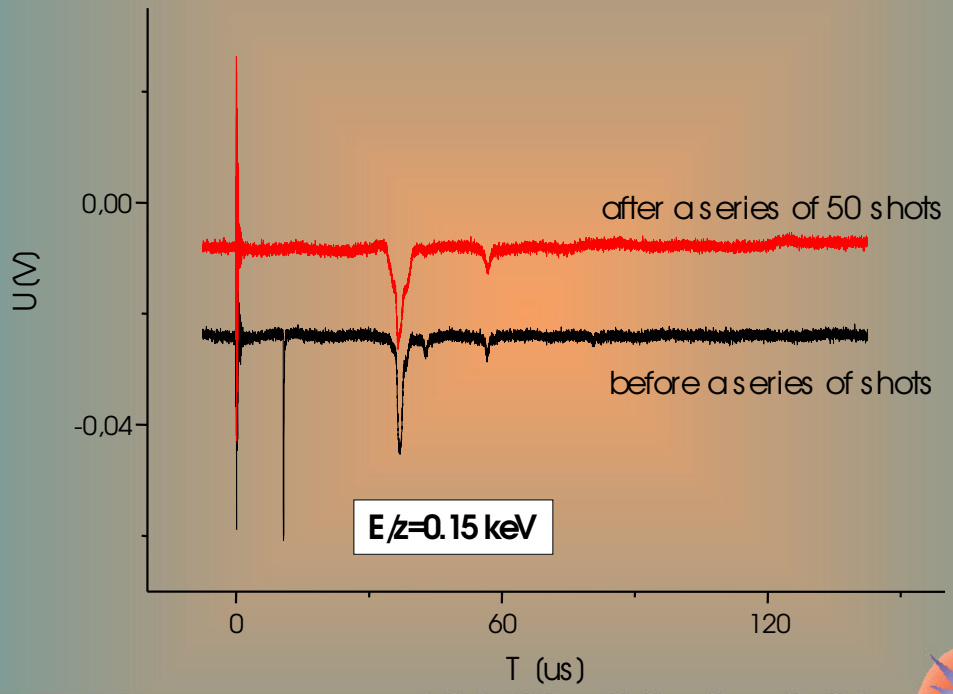
The results - the TEXTOR limiter - shots with the sharp focusing Ion analyzer - after a series of shots



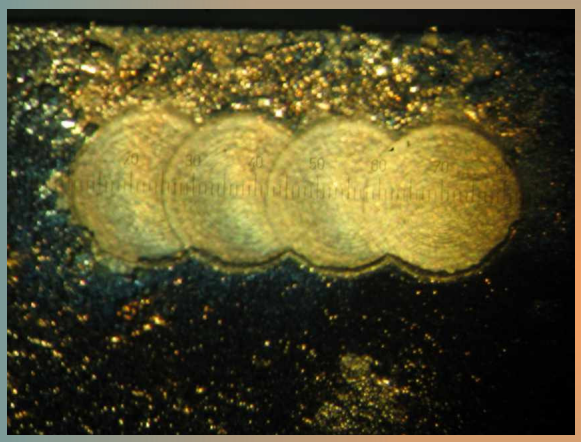
The results - the TEXTOR limiter - shots with the medium focusing Signals from the ion collectors

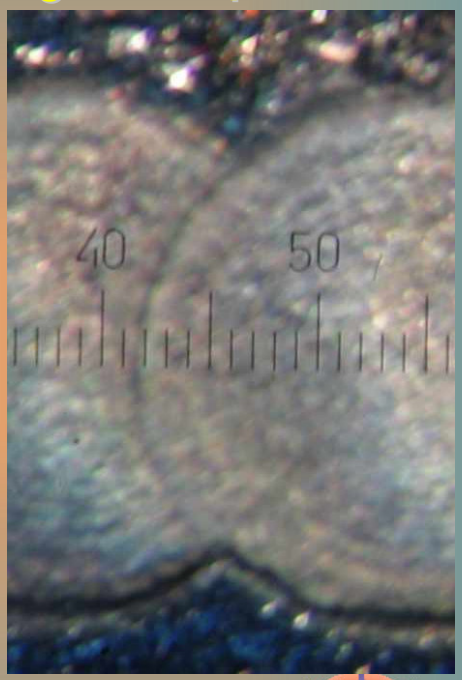


The results - the TEXTOR limiter - shots with the medium focusing ion analyzer - the effect of a burst of shots



The results - the TEXTOR limiter - shots with the medium focusing - photos of the craters - scanning the co-deposite

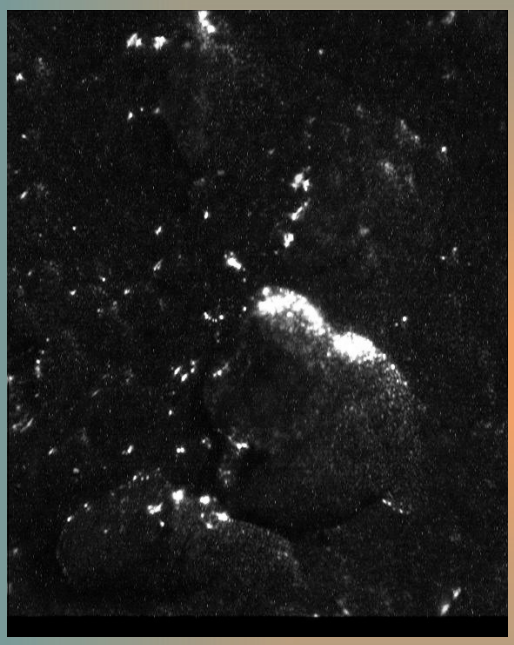




Four spots with 50 shots in one point

Focus on the overlapping region

Surface of the graphite from the co-deposited and eroded zone



The co-deposited zone

The eroded zone

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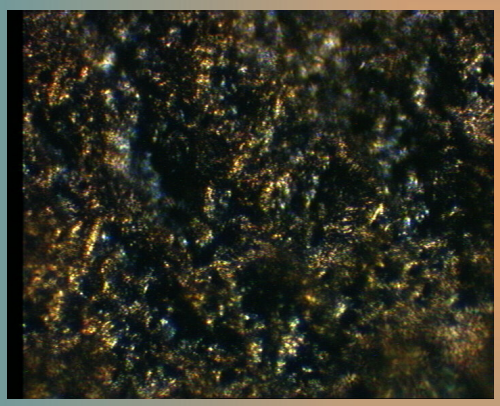
The surface of the tile

After 500 shots without focusing →

After ~400 shots with sharp focusing ↓



After 80 shots with medium focusing →

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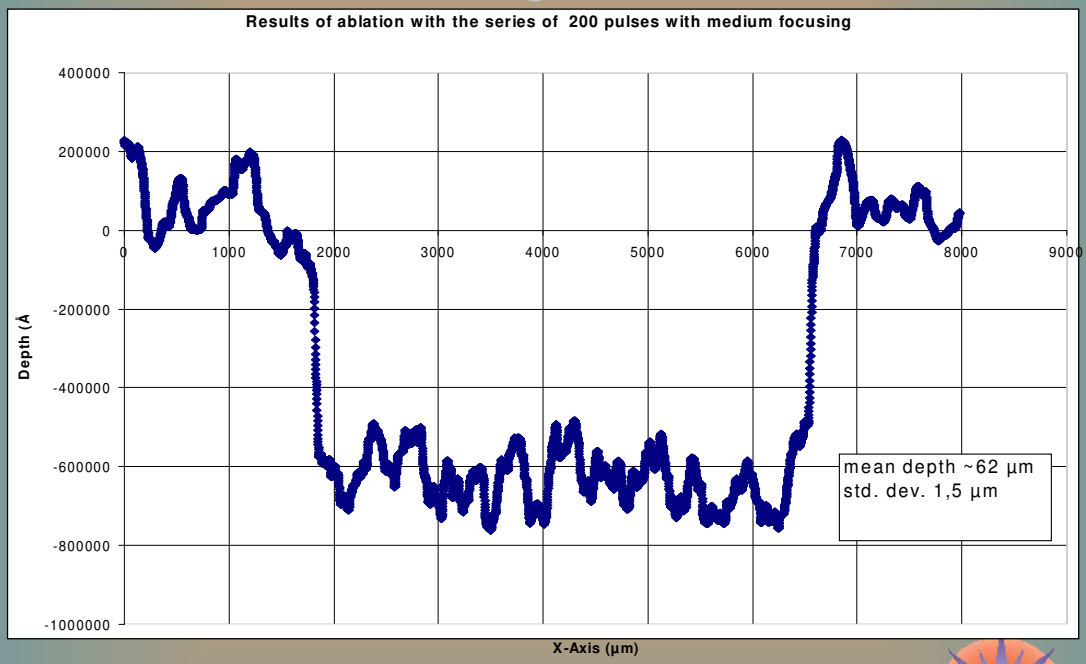
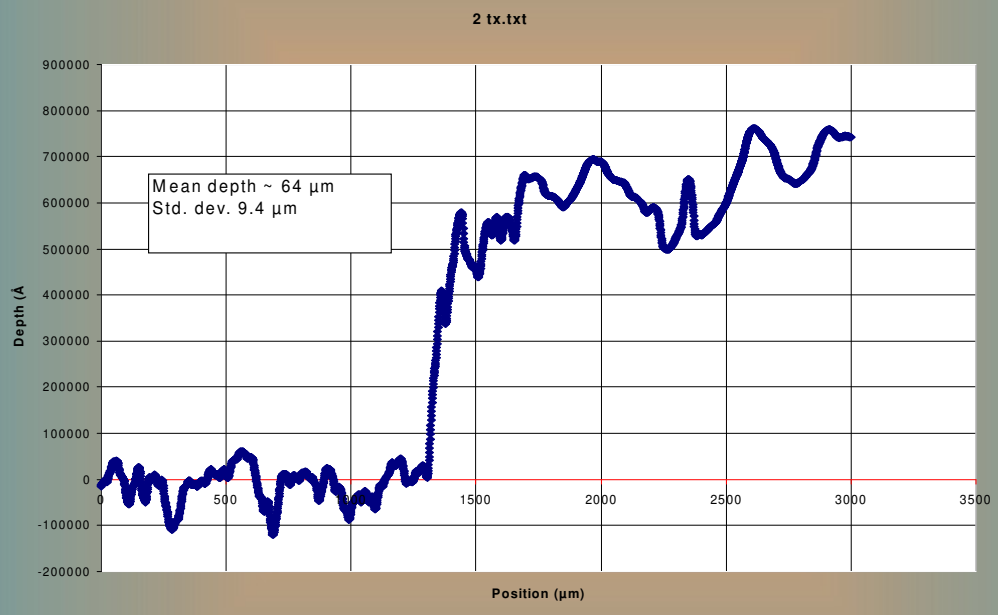
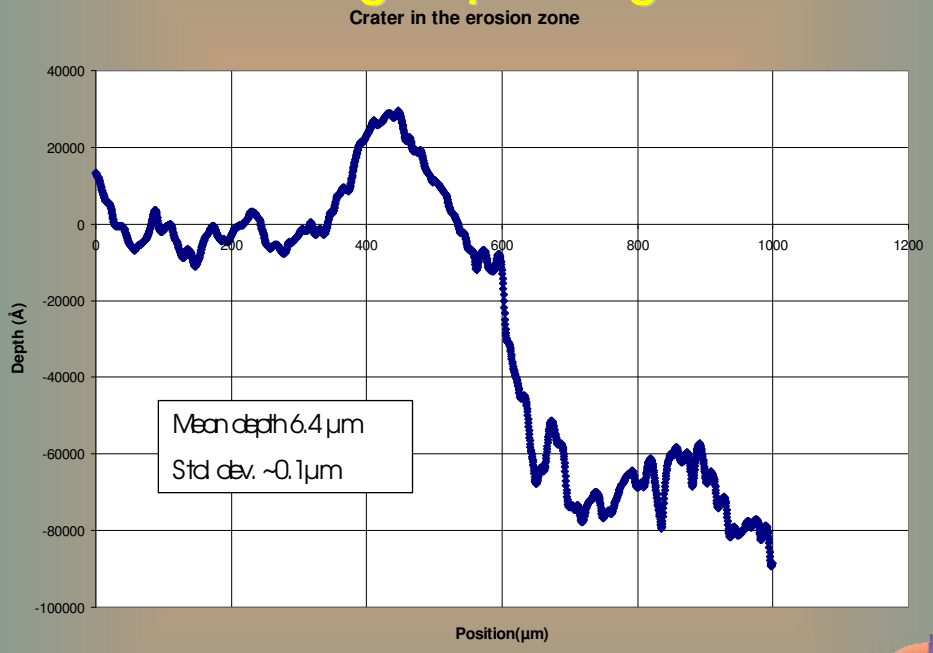
The results - the TEXTOR limiter - shots with the medium focusing - profile



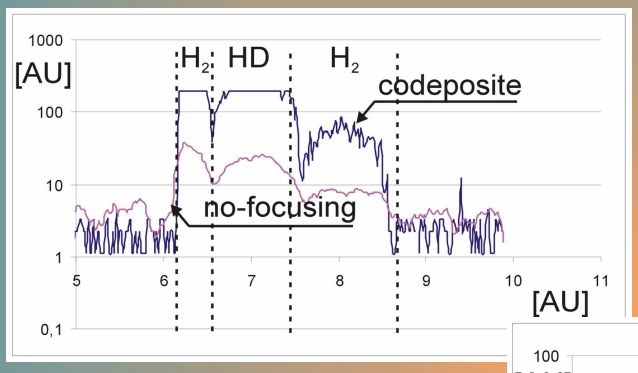
The results - the TEXTOR limiter - shots without the focusing - profile



The comparition – the crater oblated in the erosion zone using sharp focusing

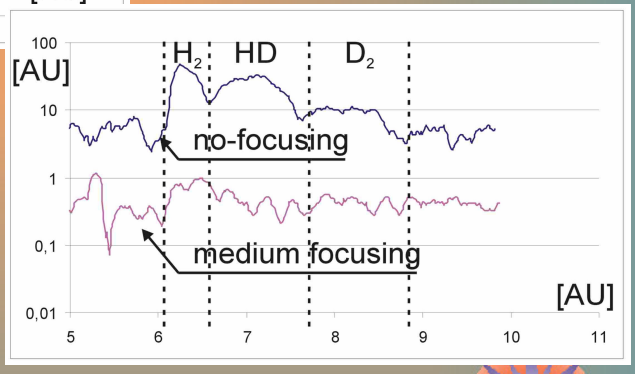


QMS spectrometry



Comparision of amounts of H isothopes in the co-deposite before and after a series of laser shots without focussing

Comparision of amounts of H isothopes in the co-deposite treated with laser beam with medium focussing and un-focussed



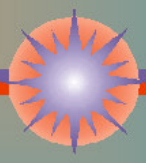
Summary

- First experiments proved a laser ablation to be sufficient mechanism for co-deposite removal from the divertor/limiter tiles,

- There are needed some more experiments to optimize and control the process of detritation,

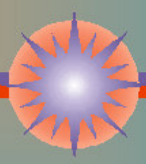
- The diagnostics equipment in IPPLM allows measuring a wide spectrum of parameters of laser plasma and distinguish elements present in such plasmas and targets used to generate'em.

- There are some further measurements needed in cooperation with FZJ Jülich and Alfven Lab.



Future investigation

- Choice of the optimal focusing parameters and number of shots in series,
- Investigations of different scanning schemes - line, stepped and at various tracks,
- Investigation of the material structure effects in cooperation with FZJ Jülich and Alfven Lab,
- Attempts of description of the observed processes in the means of physical phenomena,
- Development of some technical details to make the method reliable in the practical use.



Thanks for Your kind attention

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