AMS analyses of concentrations of hydrogen isotopes and other elements in tiles dismounted from the Toroidal Pump Limiter at Tore Supra Tokamak from FRANCE

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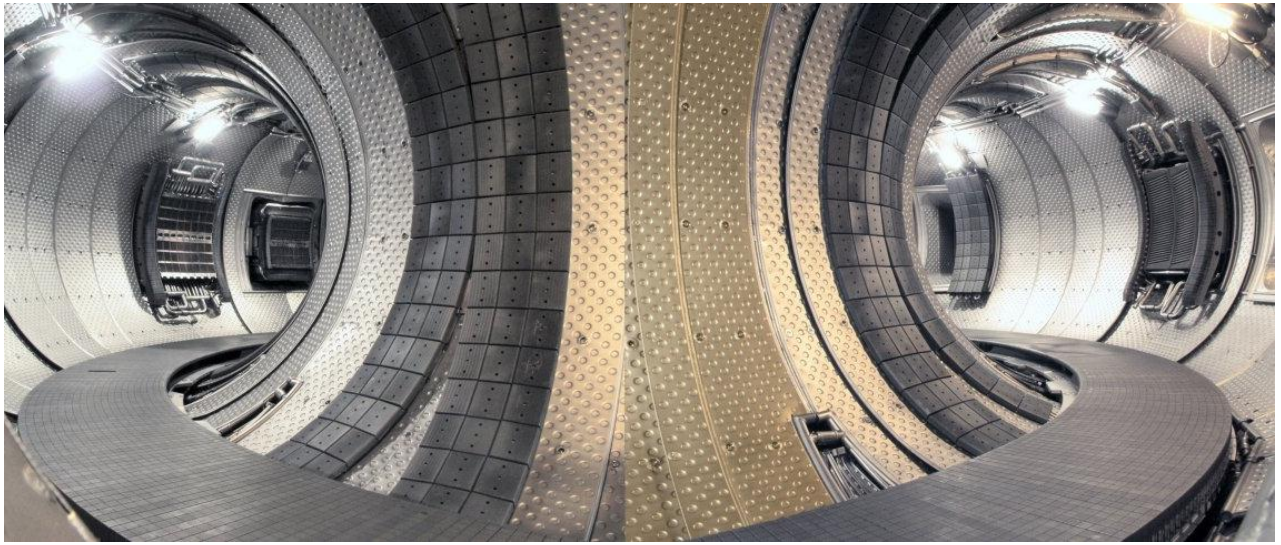


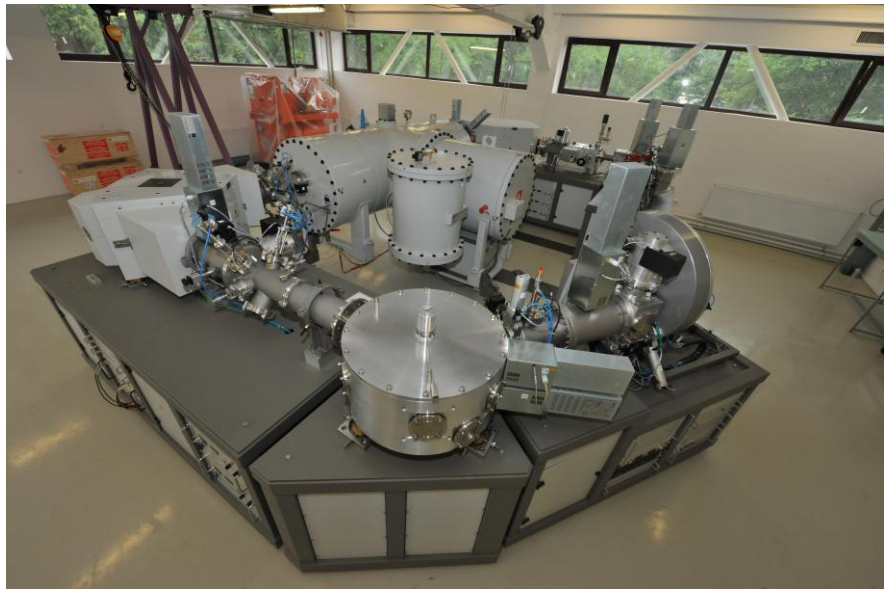
The Tore Supra Tokamak from FRANCE

What is AMS ?

AMS = Accelerator Mass Spectrometry

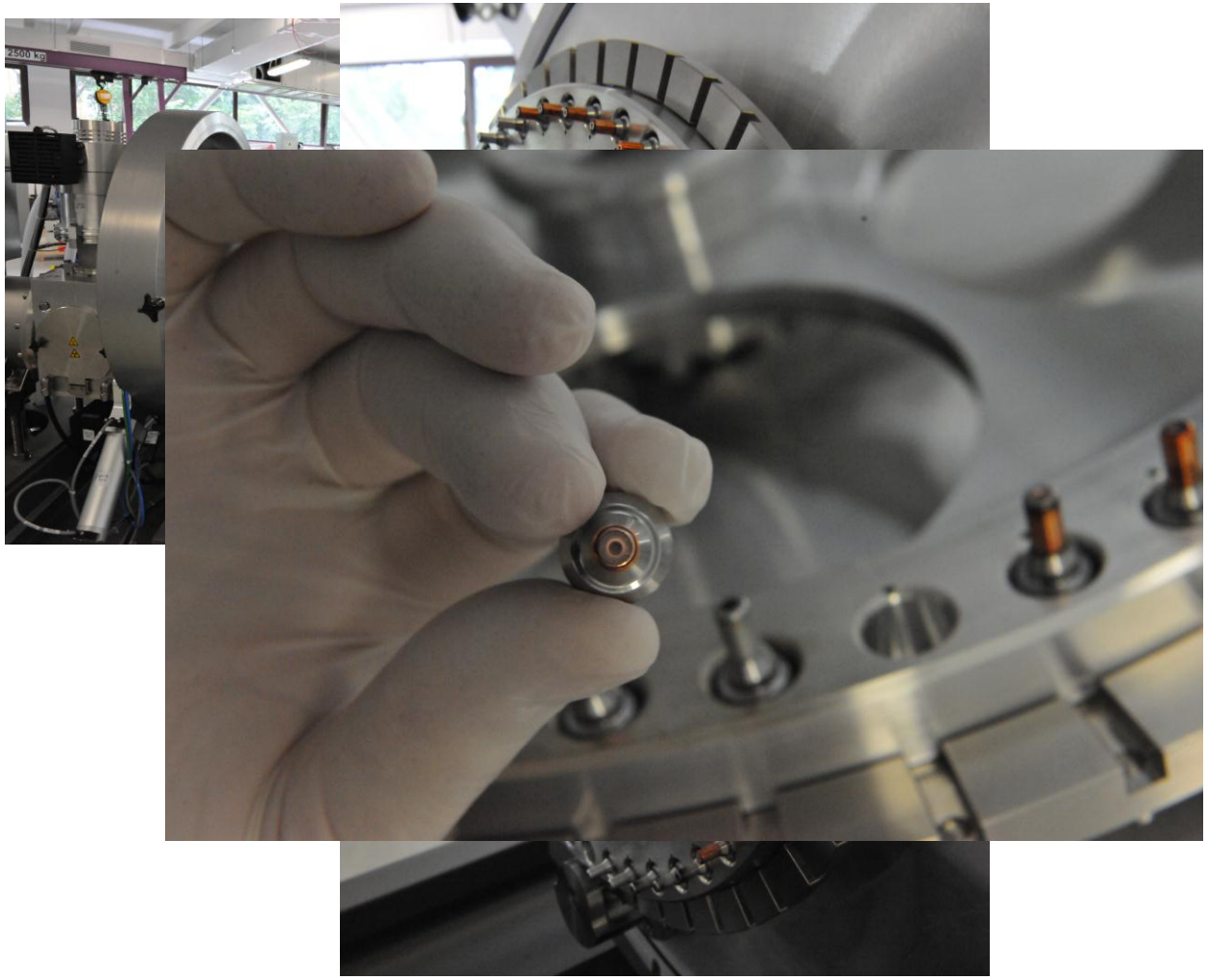
It is an analyzing method that selects and counts atoms one by one.

It is the most sensitive analyzing method known today and the only one capable of measuring the tritium and deuterium concentration depth profile continuously up to a depth of few hundred microns.



Its sensitivity is 10^{-16} for the ratio: isotope/element, equivalent with the possibility to select and register one single type of atom from a million of billions of other types of atoms.

Sample carousel of the AMS machine



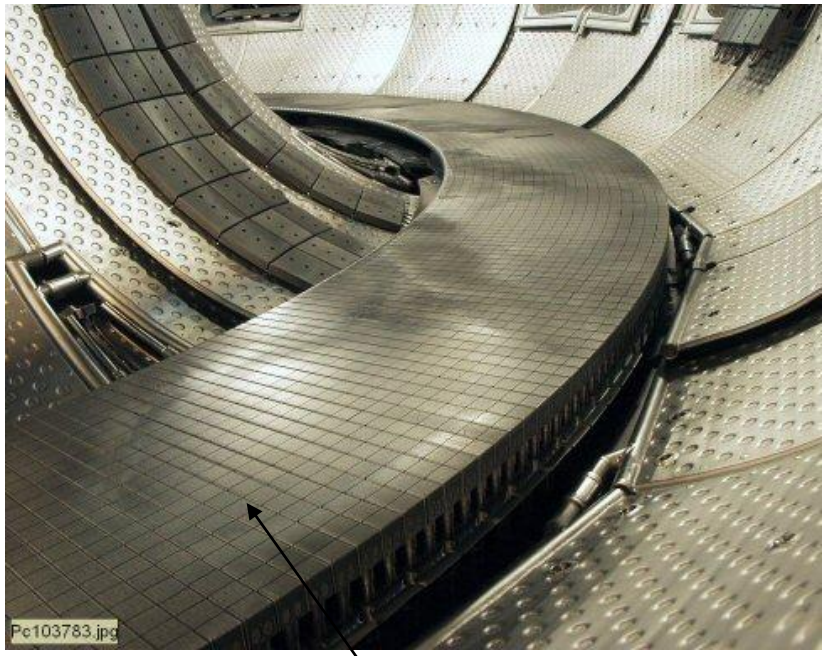
Objectives and tasks:

The main objective of this project is to study the fuel retention in the Toroidal Pump Limiter at Tore Supra Tokamak.

- Toroidal distribution of deuterium retention in protection tiles of the Tore Supra limiter measured by AMS;
- AMS measurements of radial distribution of hydrogen isotopes in the Toroidal Pump Limiter;
- The multi-elemental analyses of dust samples.

Task responsibilities for the first year :

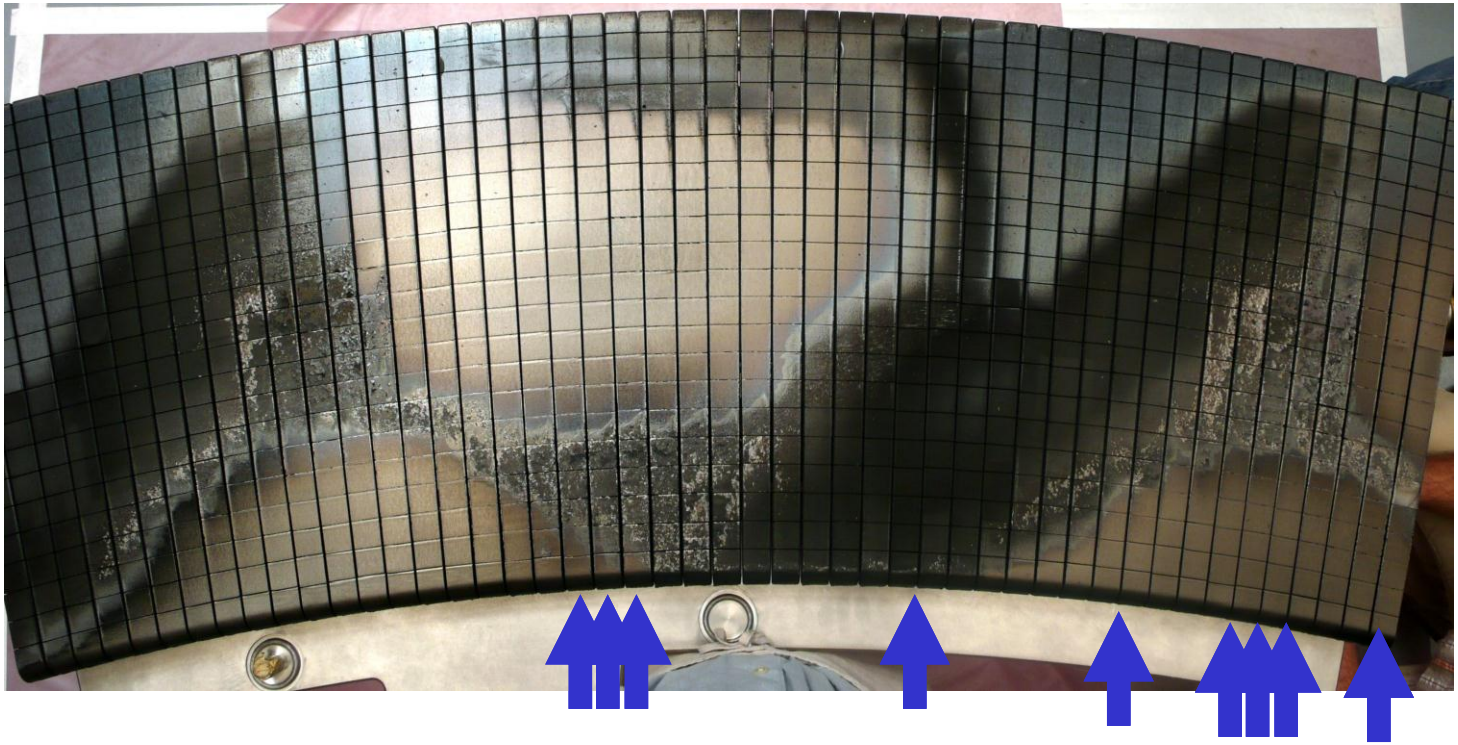
- Romanian team : AMS measurements
-French team: Cut and preparation of samples:
-Together: -General strategy
-Exploring of problems to be investigated
-Data processing and interpretation



W coated carbon tiles forming the divertor mosaic

Work done by the French partner :

dismounting of 9 fingers from the toroidal Pump Limiter

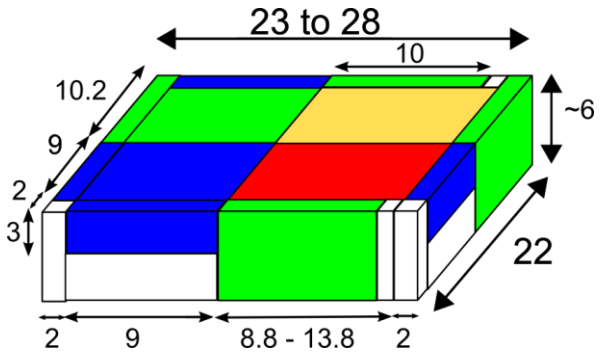


replaced fingers	28 27 26	17	10	6 5 4	1

WORK done by the French partner

each tile was cut according to the scheme below

Cutting scheme



compact view

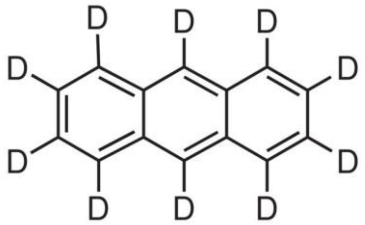
explosion view

Work done by the Romanian partner: AMS standard samples of Deuterium

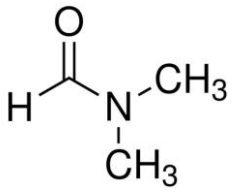
1) Estimative measurements were performed by SIMS for the concentration of hydrogen isotope in the collected samples for optimizing the standard samples concentration and experimental conditions for AMS.

2) Standard D/C samples were prepared

Primary:
-dissolving deutereted anthracite d10 in dimethyl-formamide (solvent) ,
Secondary:
-adding carbon powder in precise quantities for obtaining the desired final D/C concentration.
Final:
-after the evaporation of solvent the samples were mixed with a binder and were pressed to discs.



Anthracite d10

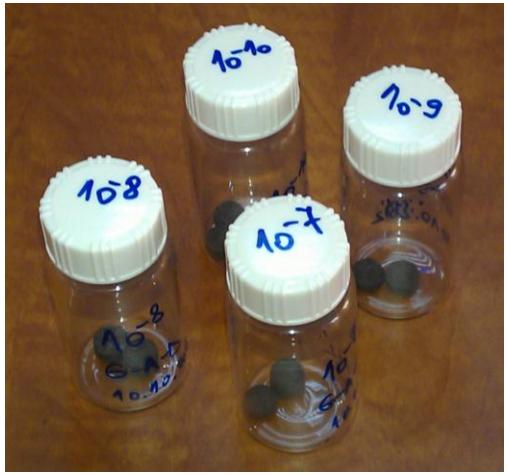


Dimethylformamide

Work done by the Romanian partner: AMS standard samples of Deuterium

Substances	$\alpha=n_d/n_g$			
	10^{-7}	10^{-8}	10^{-9}	10^{-10}
Graphite m_g (g)	1	1	1	1
Anthracene d10 m_a (g)	$1{,}58\times10^{-7}$	$1{,}58\times10^{-8}$	$1{,}58\times10^{-9}$	$1{,}58\times10^{-10}$

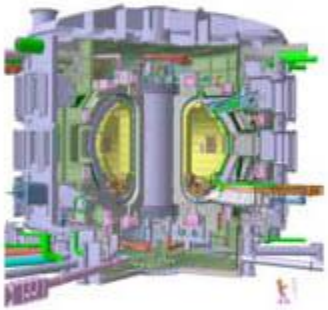
Table 1. Quantities of Substances used for producing the standards having the desired concentrations of D/C.

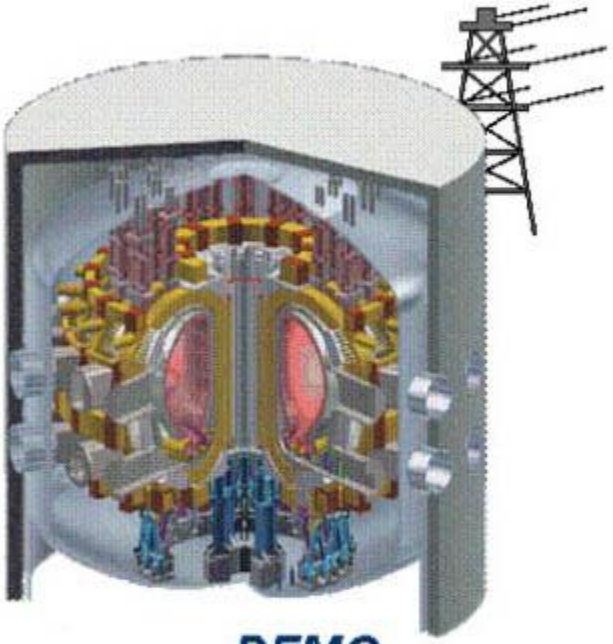


Used substances:

- Dimethyl-formamide (C_3H_7NO), MW=73,09 g/mol, manufacturer Veb Laborchemie Apolda, Germany (solubility of anthracene in DMF: 0,098 M);
- Anthracene-d10 ($C_{14}D_{10}$), 98,8 at % D, MW=188,29 g/mol, manufacturer CDN Isotopes, Canada;
- Carbon graphite powder, 99,9% MW=12 g/mol; manufacturer Johnson Matthey GmbH;
- Ethyl alcohol, (C_2H_5OH), purity 96 %, MW=46,07 g/mol, manufacturer SC Coman Product, Bucharest SRL.

ITER is the Next Step
Toward a Solution based on Tokamaks





Tore Supra	JET	ITER	DEMO
25 m^3	80 m^3	800 m^3	~ 1000 - 3500 m^3
~ 0 MW_{th}	~16 MW_{th}	~ 500 MW_{th}	~ 2000 - 4000 MW_{th}

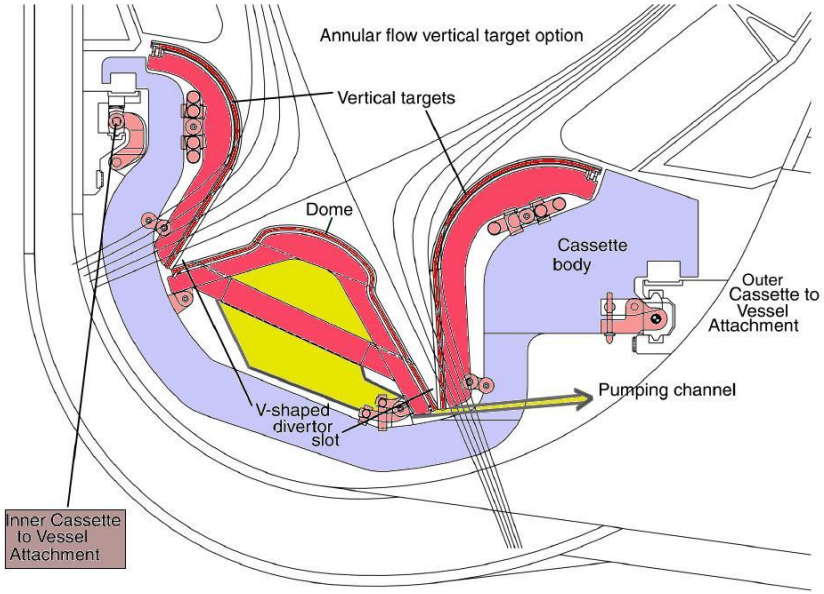
- Dominant self heating ---------->

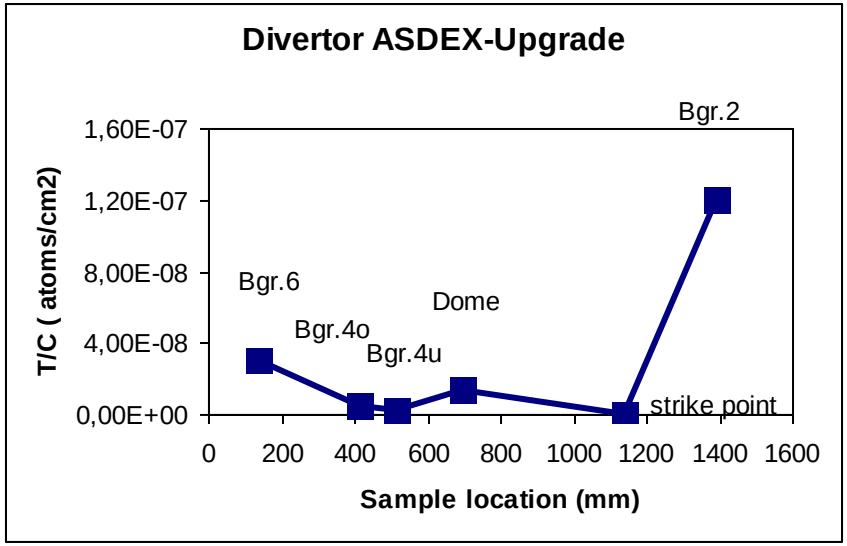
AMS is an efficient diagnose tool in fusion experiments

- *to characterize the plasma confinement ;*
- *to determine the quality of the neutral beam injectors used for energy input and also their perturbing interaction produced on the plasma confinement;*
- *to measure migration and retention of materials inside of the reaction vessel;*
- *to perform a rapid and sensitive comparison of the remnant T content after the application of laser detritiation techniques;*

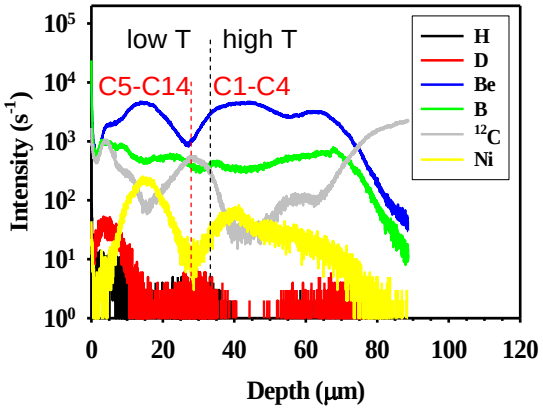
JET REACTOR VESSEL

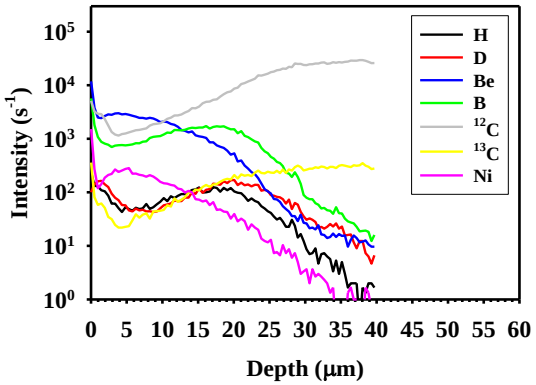
ASDEX-Upgrade tokamak Munich

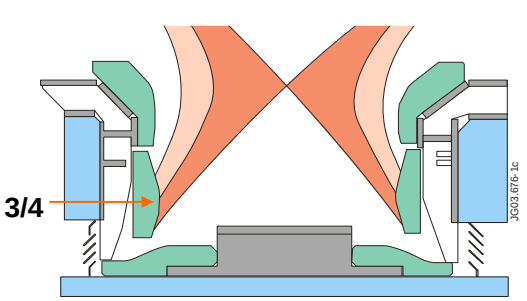


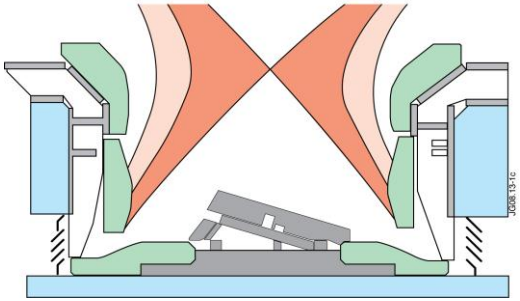


SIMS on Jet divertor tiles



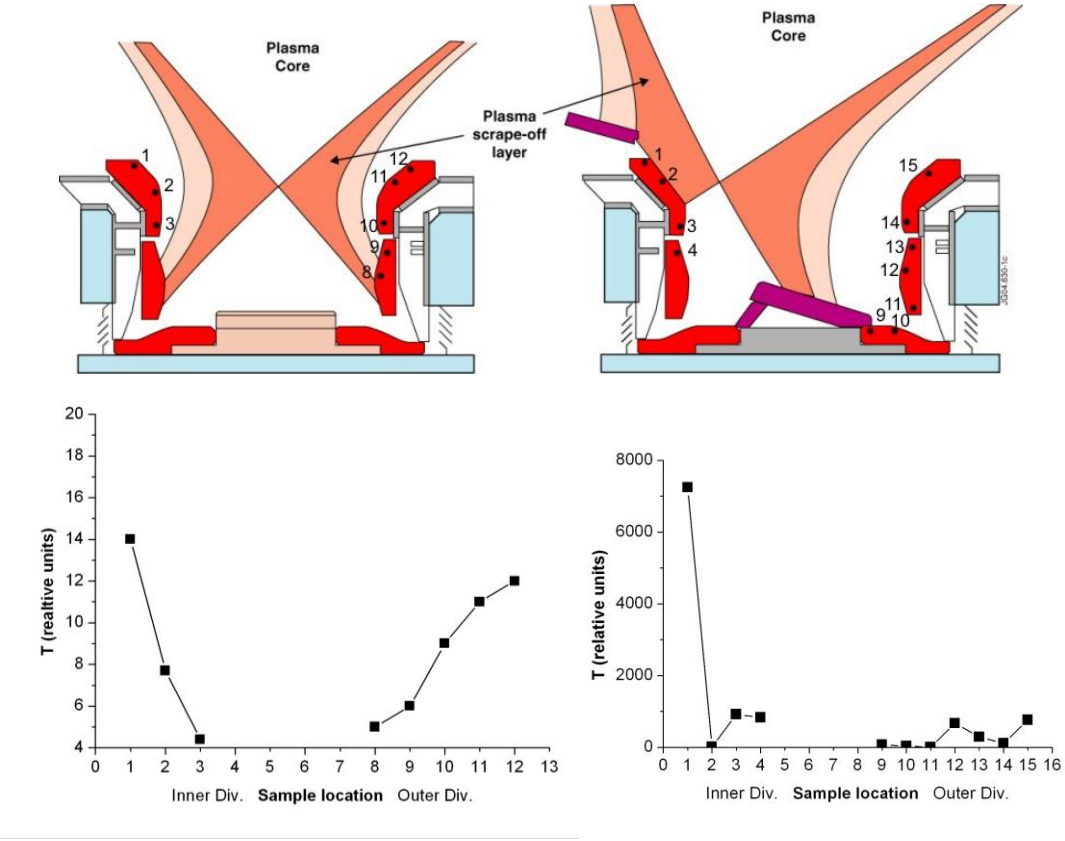






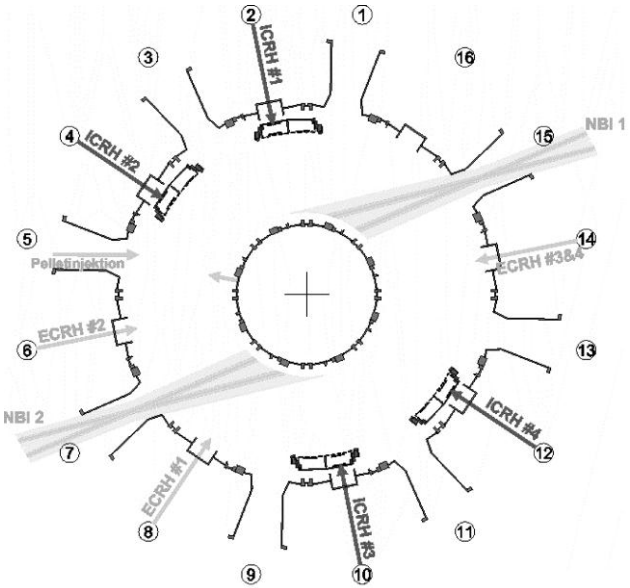
AMS on JET divertor

- JET Divertor geometries- AMS (change of thermal load)

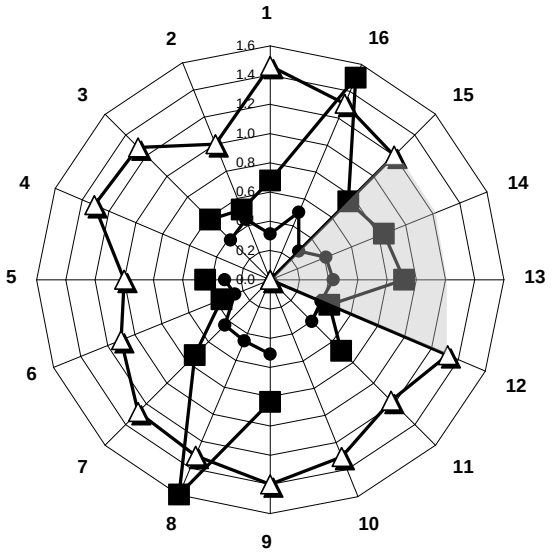


Neutral beam heating at ASDEX

- TOP View ASDEX

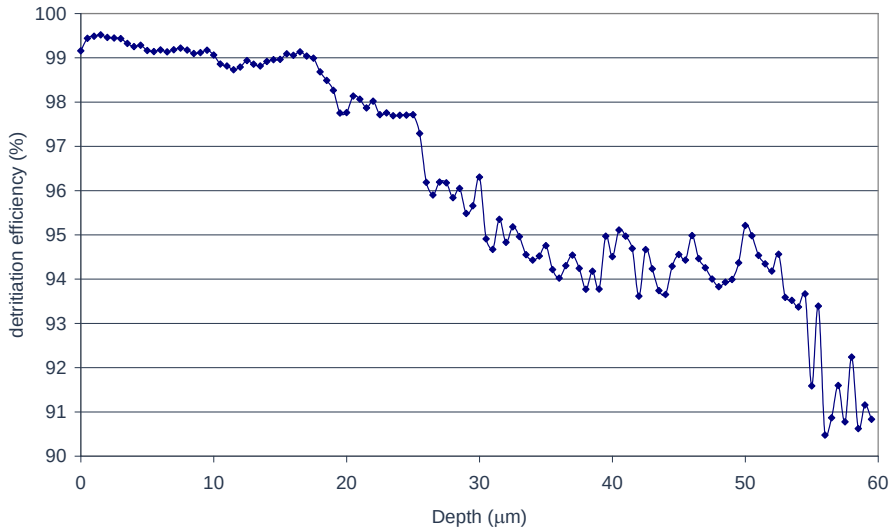


Tritium content – toroidal distribution



Detritiation measurement of divertor tiles from JET

- Using measurements of the T depth profiles from a detritiated and a not-detritiated tile.



Detritiation efficiency by Laser ablation measured with a 500 nm depth resolution by AMS

Divertor tile and the cuts performed for the tritium analyses. The right half part is the laser treated (detritiated) surface.

BENEFITS

CEA:

-A better knowledge of the fuel retention and total inventory in the tokamak Tore supra.

- An enhanced diagnose of the plasma discharges in the tokamak vessel.

- New perspectives for the upgrading of the tokamak

IFA:

-A new and interesting research project bringing a contribution to the future ITER project

-Contribution to the EURATOM and EFDA with benefit on long term.

PERSPECTIVES

This years:

AMS measurements of concentration depth profile of hydrogen isotopes in samples from the 9 relevant locations around the torus of the Toroidal Pump Limiter at Tore Supra.

Next year:

• AMS measurements of concentration depth profile of hydrogen isotopes in samples of radial geometry from the Toroidal Pump Limiter at Tore Supra
• Multi elemental analyses of depositions on the Toroidal Pump Limiter and internal wall at Tore Supra

In future:

The two partners have already been participating to a joint task under the EFDA JET Technology Programme. In the future it is most probably that the results of this project will open new perspectives for other joint researches. These could have even more important tasks to solve for the international project ITER. It is most probably that the cooperation between the two partners will be consolidated and continued under the EFDA UE project and it is probable to apply for a FP8 project.

THANK YOU FOR YOUR ATTENTION