Overview of Recent DIII–D DiMES and MiMES Activities"Experiments in Support of ITER"

Presented by
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D.G. Whyte (U.Wis.), P. Stangeby, A. McLean,
J. Davis (U. of Toronto), W. Jacob,
K. Krieger (IPP, Garching), A. Litnovsky (IPP, Julich)

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New Jersey

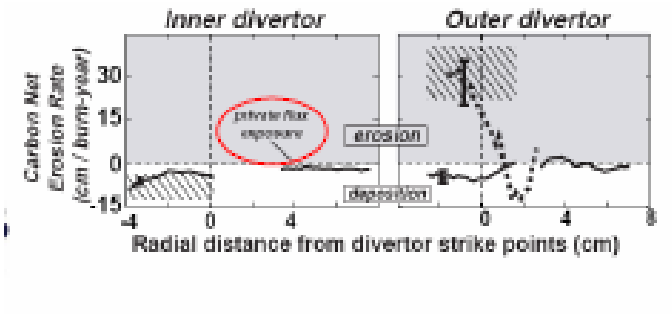
May 9–11, 2005

MiMES
@ mid-plane

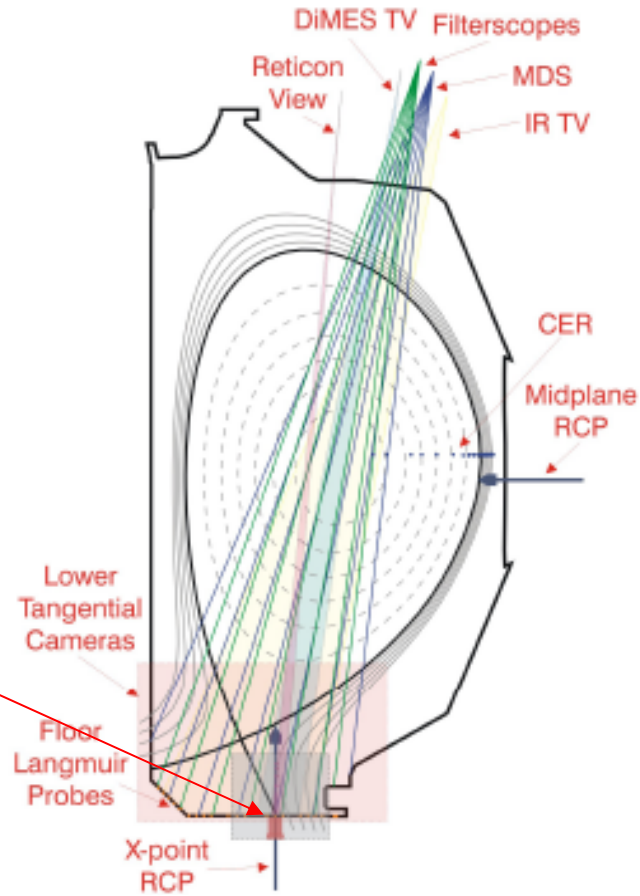
DiMES

- Gap experiment
- Mirror experiment
- Porous plug exposure
- Hydrogen sensor…Bastasz
- Tile current monitor
- Carbon dust…Rudakov
- DiMES vertical extension
- Fast probe and MiMES

Divertor Material Evaluation System (DiMES)
(Generated Significant Materials Erosion/Redeposition Data for ITER)



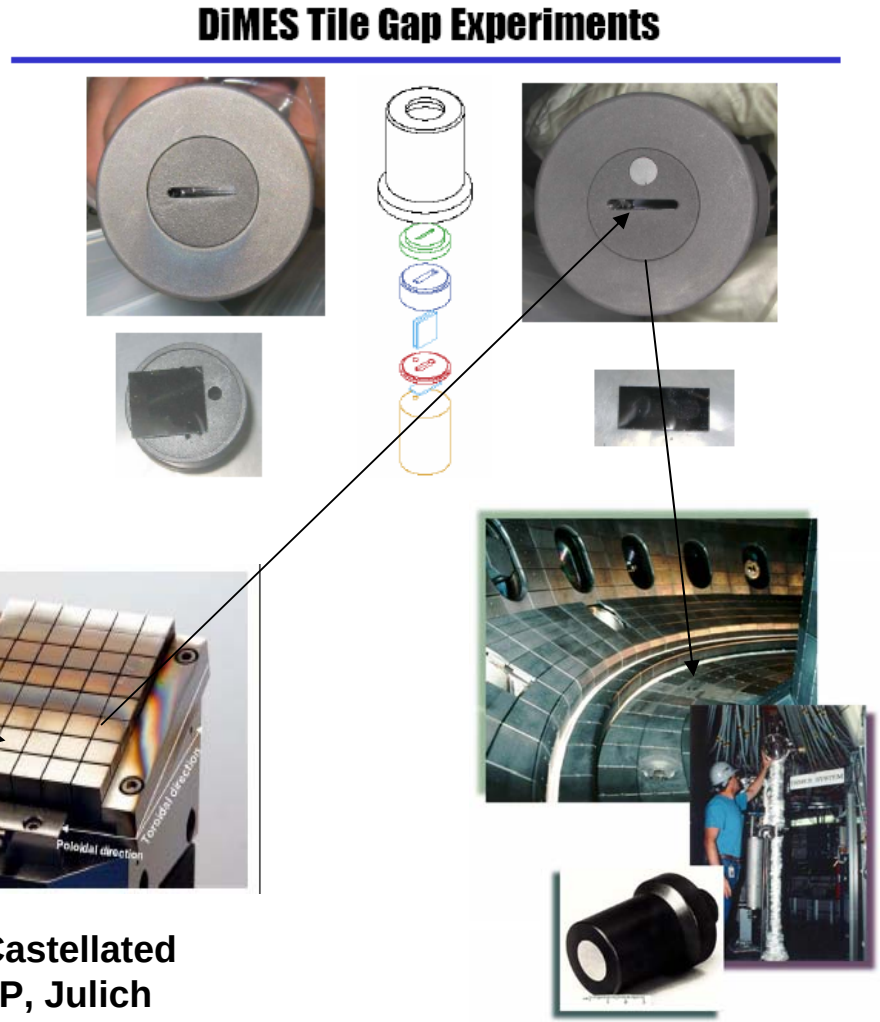
Large diagnostics coverage



DiMES Gap Experiments
(A joint IPP, Garching, SNL, DIII–D, ANL Project)

- Tritium deposition/retention in not accessible area is a critical issue for ITER

- DiMES gap experiments are to measure the deposited C at DIII–D divertor at different temperatures

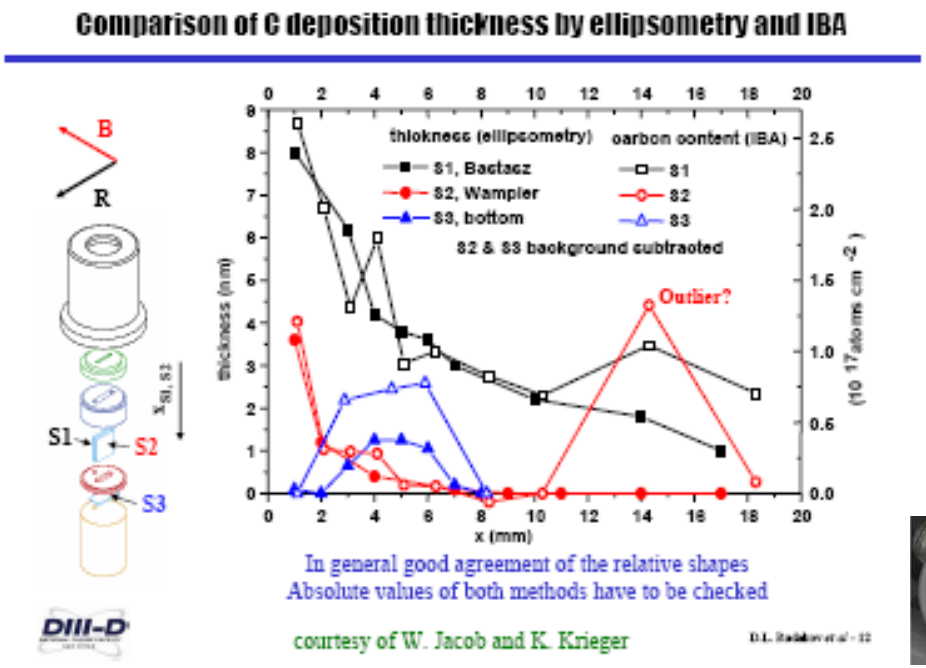


ITER Divertor

TEXTOR Castellated Limitor, IPP, Julich

Two Gap Experiments Completed (Plasma Conditions were Very Close)

1. **9 L–mode SAPP shots at machine temp on Aug. 2004**



Jeff Brooks of ANL using the DSLOT code has reproduced qualitative features of carbon deposition profile down the slot

- **Both ion beam analysis (IBA) and ellipsometry have been completed**
- **Results show coating: "soft " amorphous carbon type, with D/C atomic ratio of 0.2–0.6**

2. **9 L–mode SAPP shots again at 200°C on Oct. 2004**

Deposition being measured by IPP, Garching: preliminary results indicate minimum deposition? Measurements are continuing.

No visible signs of plasma contact was observed, yet exceptionally high erosion rate on the button (IBA measure-ment at SNL) at about 3 nm/s

DiMES Mirror Experiments
"First Tokamak Divertor Experiment"

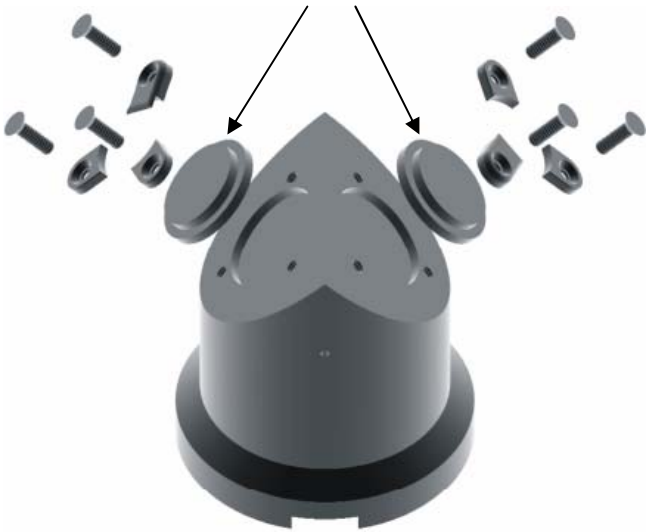
D. Rudakov (UCSD), A. Litnovsky (IPP, Julich),
A. McLean (UT, Canada) and DIII–D support

- Mirrors are foreseen for all optical diagnostics in ITER
- Mirrors surfaces can be modified by erosion, deposition…etc
- Limited access to in-vessel components call for testing in tokamak

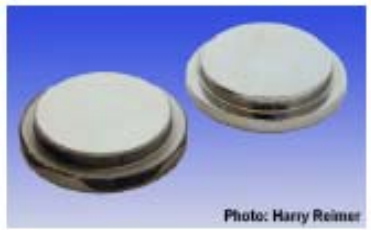
8th ITPA meeting, Culham, March 14–18, 2005

Call for urgent need from well diagnosed divertor experiment

Mirrors

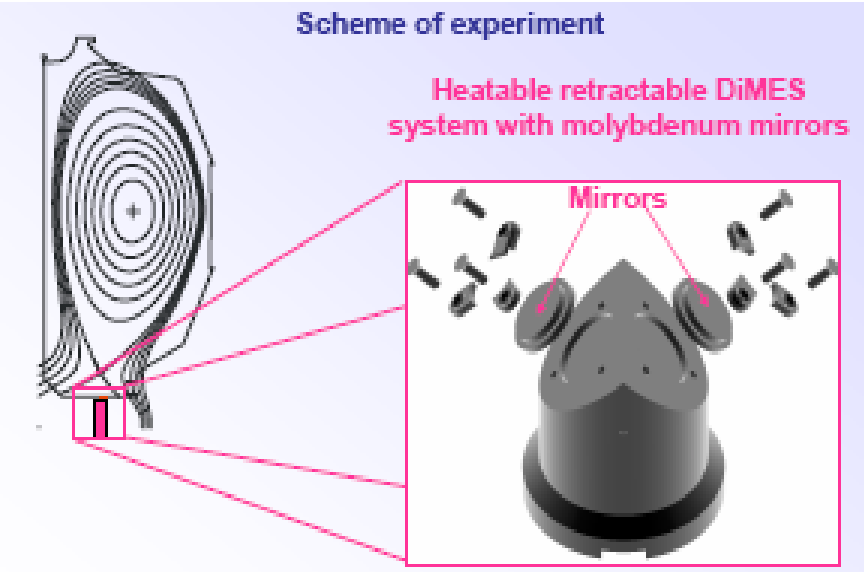


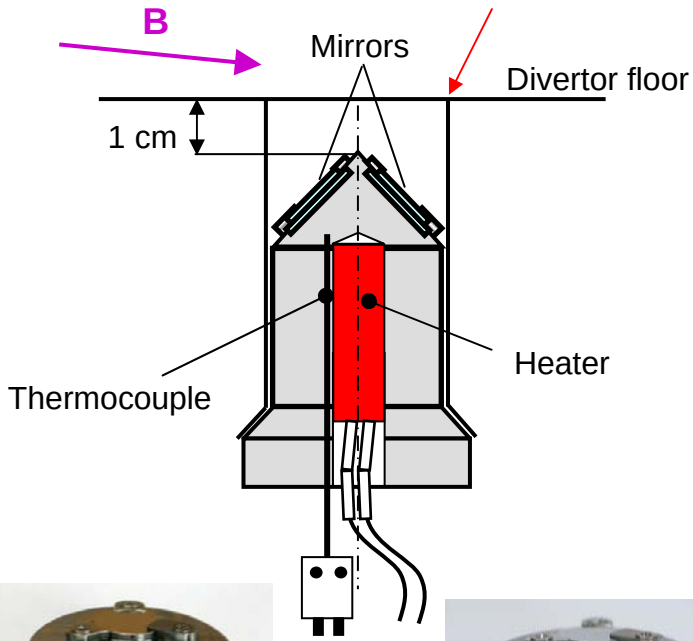
Fastest DiMES experiment: conception, designed, reviewed, fabricated, organized, tested and three sets of sample were exposed



Mo mirrors from KFA

THREE SETS OF MIRRORS WERE EXPOSED





- **The first set of mirrors was exposed in a piggyback mode over 2 days to 72 discharges with varying parameters for a total of 435 seconds**
- **DiMES was in the outer SOL in some shots and in private flux zone (PFZ) in others**
- **Significant semi-transparent deposits appeared on the mirror closest to the leading edge of the floor tile**

Before exposure

After exposure

Surprisingly Strong Effect at Relatively Low Temperature

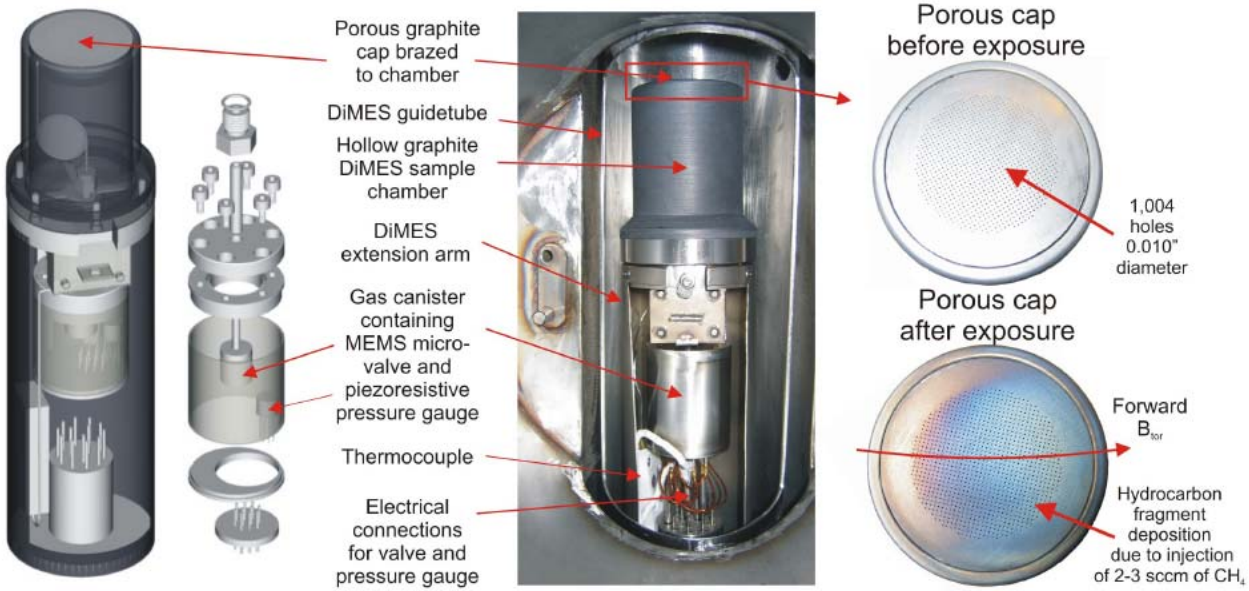
- Two more sets of mirrors were exposed as a part of C13 injection experiment to well-controlled reproducible partially-detached (PDD) ELMing H–mode discharges
- The second set of mirrors was exposed at ambient temperature (~30° C) to six identical discharges on the C13 setup day
- Visible deposits were found on both mirrors and holder elements upon removal
- The third mirror set was exposed on the C13 injection day to 17 discharges similar to those of the second exposure
- The mirrors were at elevated temperature changing from 140° C to 80° C in the course of the experiment
- Upon removal, virtually no deposits were visible on the mirrors
- Some of the deposits formed on the mirror holder elements in the previous exposures were gone
  - These are very preliminary observations
  - Could this be from chemical erosion by atomic hydrogen?
  - Mirror surface characterization is forthcoming at IPP, Julich

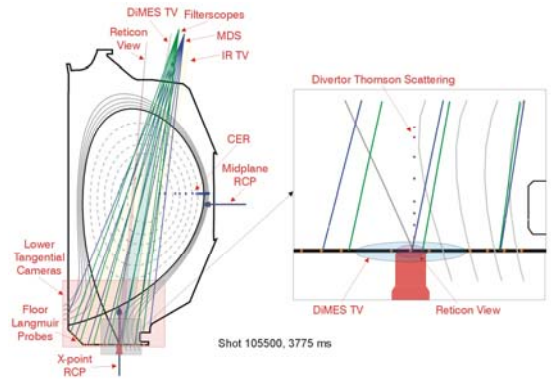
Porous Plug Experiment (Adam McLean, Dennis Whyte, Jim Davis, Peter Stangeby, Dmitry Rudakov)

Goal: **"Chemical erosion study", direct calibration of CD (molecule), CI (neutral) and CII (ion) spectroscopy for a known CH_4 injection**

Method: Inject methane through a porous graphite surface to simulate hydrocarbons release from a carbon surface by chemical erosion

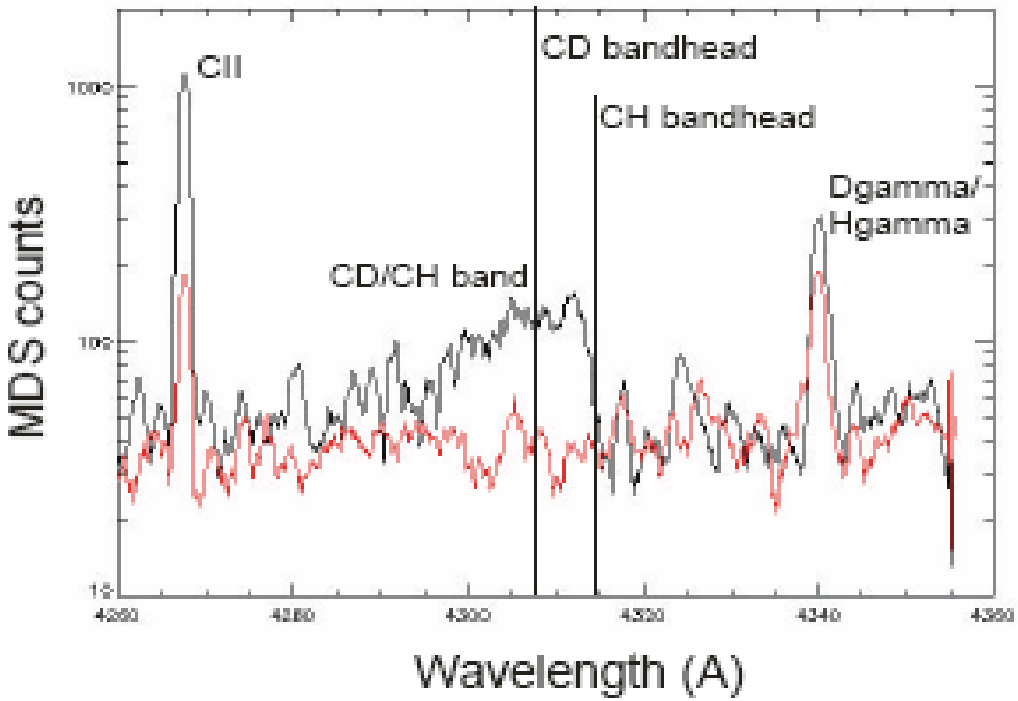
Diagnostics: Multi-chord Divertor Spectrometer (MDS), DiMES TV and lower tangential CID cameras





Clear Evidence Confirming that Chemical Sputtering is Very Weak in DIII–D

"Detailed analysis will be the focus of A. McLean's Ph.D thesis"

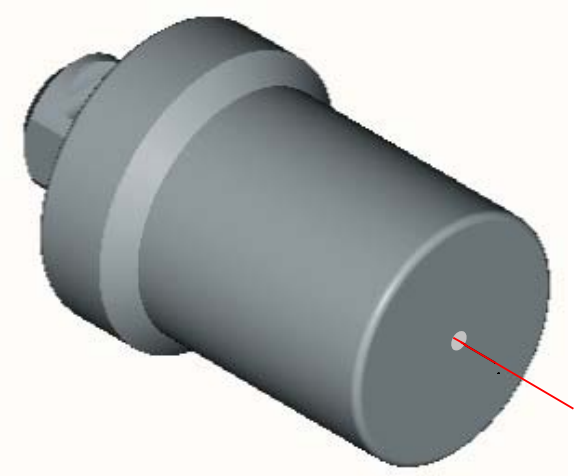


Shot 122196
Data summed from 2.3-5.0 seconds
Black: On DiMES
Red: Off DiMES

Note: CER Reticon spectrometer does detect CD band at off DiMES location but at low level

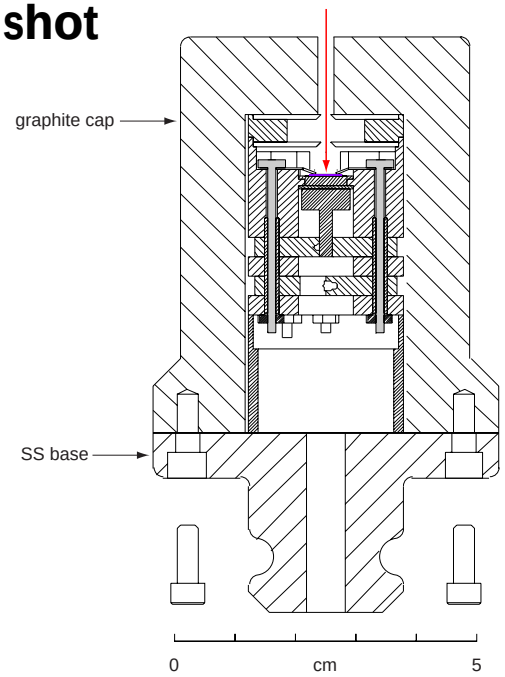
Hydrogen Sensor Diagnostic on DiMES

- **Purpose: provides shot-to-shot data on energetic particle flux to wall**



Description:

- **Unit fits inside a DiMES sample**
- **Sensor detects energetic H isotopes**
- **Integrates CX flux during a shot**
- **Reports on each shot**



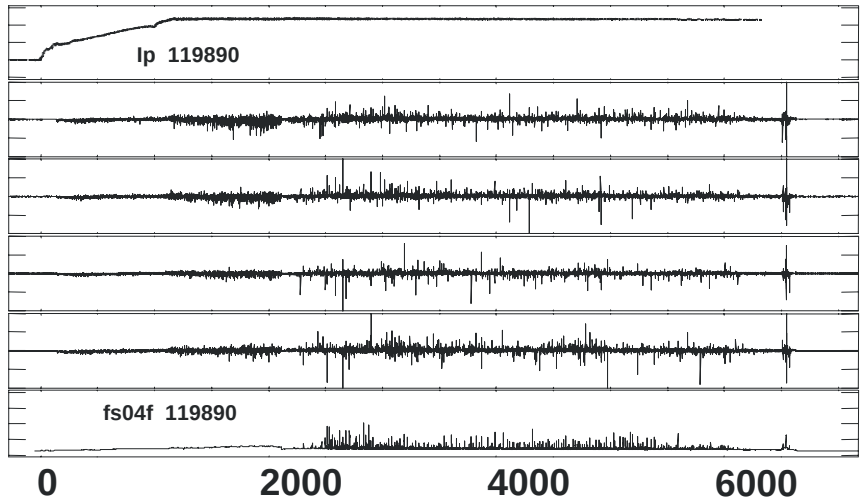
Implementation:

- **Diagnostic installed on DiMES in February 2005**
- **First tests in DIII–D conducted March 2005**
- **Sensors responded successfully and several days of DIII–D operations were monitored**
- **Its use as a routine PMI diagnostic being assessed**

Details reported by Robert Bastasz

High Density Probe Array (Li DiMES without Li slots)

- High density probe array is well suited to study fine spatial structure of tile currents near the strike point
- A dedicated DC power supply was built, allowing biasing the probes into ion saturation current collection
- DiMES probe array was used during 3 run days in support of experiments on ELM suppression by ergodic magnetic fields (I-coil) both in tile current monitor and Isat modes
- Results are yet to be analyzed

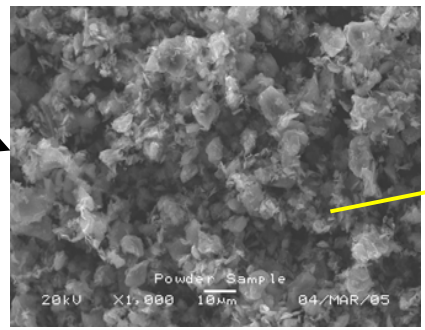


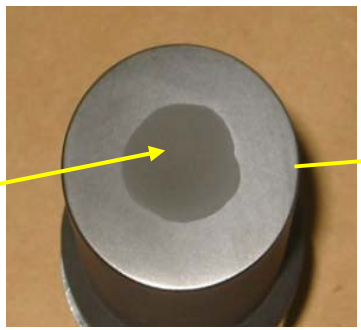
CARBON DUST MIGRATION, an ITPA issue

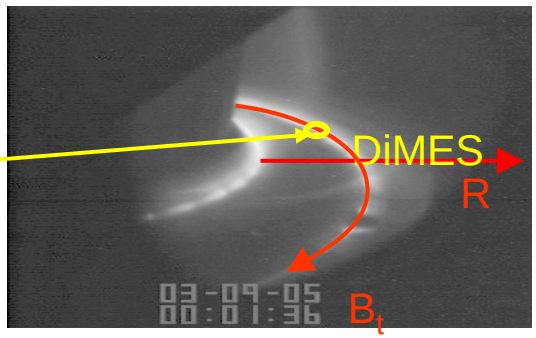
"Serious problem for ITER, tritium co-deposition, mix with Be and core contamination"
Skinner & Rudakov

DIII-D Tiles carbon source?

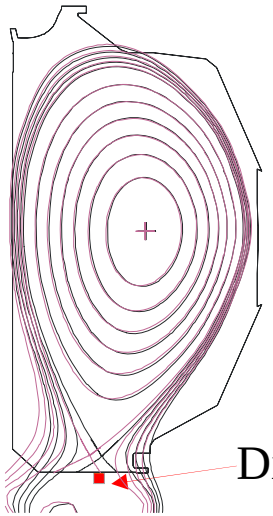
From Toyo Tanso, Japan

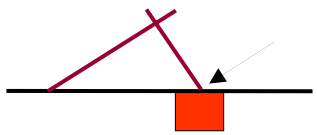






About 25 mg of 5 – 10 μm size carbon dust was introduced in DIII-D divertor





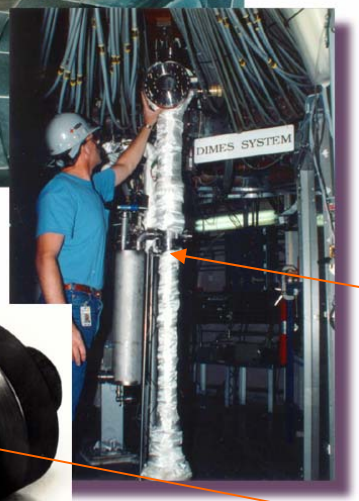
DiMES

When OSP was swept over DiMES, about 1-2% of the total carbon content of the dust penetrated into the core

Details reported by Dmitry Rudakov

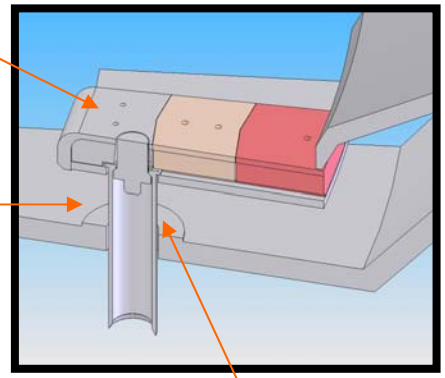
Dimes Vertical Extension (LTOA Modification)

"Raise sample by 11.27 cm, surface alignment to 0.1 mm"



New floor

Present floor

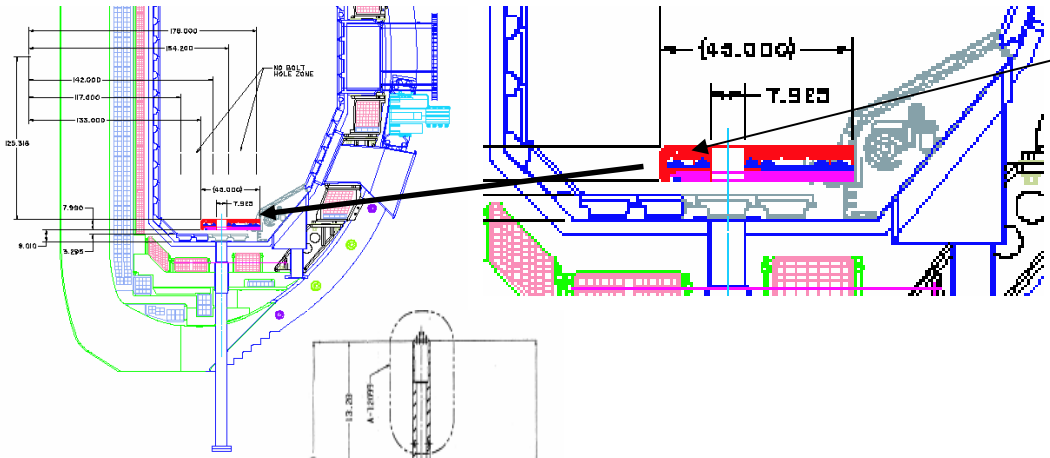


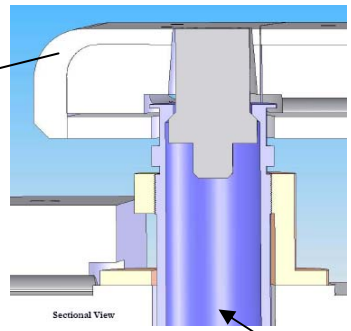
1. We will position the DiMES vertical location with a new alignment chimney

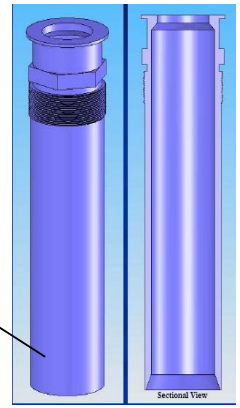
2. We will remove the double hydraulic cylinder from the mechanism for rework

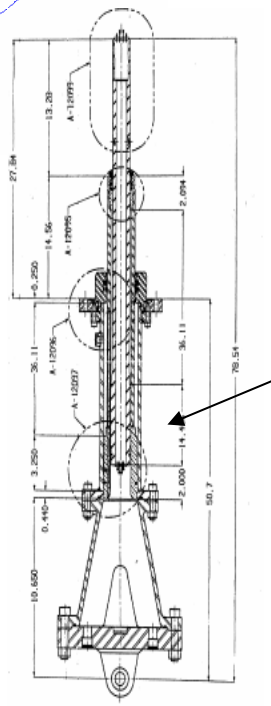
3. We will maintain the DiMES sample configuration/design

DiMES Vertical Extension and Alignment









DiMES hydraulic cylinder

- **Conceptual Design Review (CDR) completed on April 12, 2005**
- **Hydraulic cylinder vender quote received**
- **Modification plan in place**
- **DiMES scheduled to be disassembled on June 14, 2005**

Midplane Material Evaluation Sample (MiMES)

Physics Validation Review Completed
April 27, 2005

D. Rudakov, C. Wong, J. Boedo, N. Brooks, R. Moyer, J. Watkins, P. West

DiMES old window

Fast Probe and MiMES Physics Value Added Summary (Specific to MiMES)

- Airlock
  - Fast repair of the plunging probe head
  - Using changeable probe heads for specialized physics measurements: flows, Reynolds stress, magnetic fluctuations, ion temperature, etc.
  - Enable MiMES
  - No functionality of the present setup will be lost
- MiMES (Midplane Material Evaluation Sample), including conv. effects
  - Net erosion/deposition measurements (integrated over exposure time)
  - Tritium retention in the first wall elements (including tile gaps)
  - Complement to the existing DiMES system
- Optical view of probes/MiMES
  - Single chord filterscope view: real-time, in-situ erosion rates
  - 2D camera view: mass transport of the eroded material
  - Edge recycling and chemical sputtering of carbon