

# **ION BEAM ANALYSIS OF COMPONENTS WITH HIGH TRITIUM AND BERYLLIUM CONTENT**

**J. P. Coad, <sup>b</sup>D. E. Hole and <sup>c</sup>R-D. Penzhorn**

UKAEA Culham Science Centre, Abingdon, OX14 4DB, UK

<sup>b</sup>School of Engineering, University of Sussex, Brighton, BN1 9QH, U. K.

<sup>c</sup>Tritium Laboratory, Forschungszentrum Karlsruhe, D-76021 Karlsruhe, Germany

## **INTRODUCTION**

- **FUSION - TOKAMAKS, (JET, ITER-FEAT)**
- **USE OF BERYLLIUM**
- **DEUTERIUM/TRITIUM EXPERIMENTS**

## **RETENTION OF TRITIUM WITHIN THE VESSEL**

- **METHODS OF MEASURING D AND T**
- **ANALYSIS OF PLASMA-FACING SURFACES**
- **ANALYSIS OF DUST/FLAKES**

## **REMOVAL OF TRITIUM**

- **THERMAL TECHNIQUES**
- **OTHER METHODS OF REMOVAL/AVOIDANCE**
- **T REMAINING IN JET**

## **CONCLUSIONS**

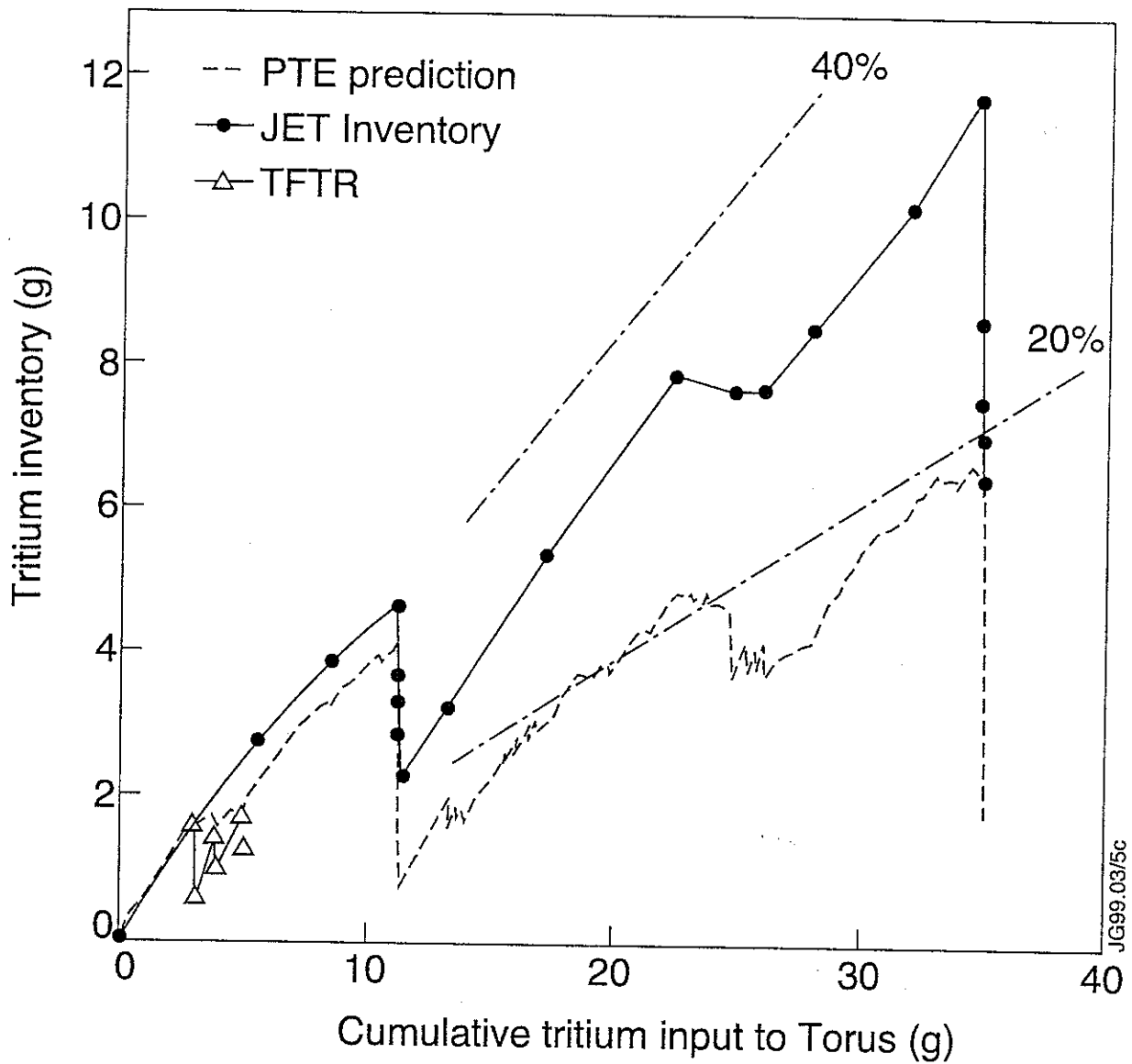
## **ITER-FEAT (PROPOSED)**

- **REDUCED-SIZE (COST) VERSION OF ITER**
- **FUSION POWER >400MW (ITER WAS 1500MW)**
- **~10 PULSES PER DAY, EACH 300-500 SECS**
- **PEAK 14MV NEUTRON RATE (FLUX)  $5.3 \times 10^{20}$  n/s**  
**( $\sim 2 \times 10^{17}$  n/m<sup>2</sup>.s)**
- **LIFETIME NEUTRON YIELD  $\sim 0.3$  MW.yr/m<sup>2</sup>**
- **MAIN CHAMBER WALL - BERYLLIUM**
- **DIVERTOR: TARGET GRAPHITE, OTHER AREAS TUNGSTEN**
- **AUTHORISED IN-VESSEL TRITIUM: 450g**
- **PREDICTED T RETENTION: 2-10g/pulse (IF USE C TARGET)**

## **JET**

- **OPERATIONAL SINCE 1983, LARGEST TOKAMAK**
- **LINEAR DIMENSIONS ~ HALF THAT OF ITER-FEAT**
- **WALL: INCONEL WITH CFC PROTECTION,**
- **SOME BERYLLIUM COMPONENTS, PLUS Be EVAPORATION FOR CONDITIONING**
- **D-T CAMPAIGN IN 1997 PRODUCED 16MW (MAX)**
- **100g T PROCESSED, 35g FUELLED INTO TORUS, OF WHICH 11.5g RETAINED AT END OF CAMPAIGN**
- **REDUCED TO ~6g IN 4 MONTHS D-D OPERATION**
- **2g RELEASED BY EXPOSURE TO AIR (4 MONTHS)**

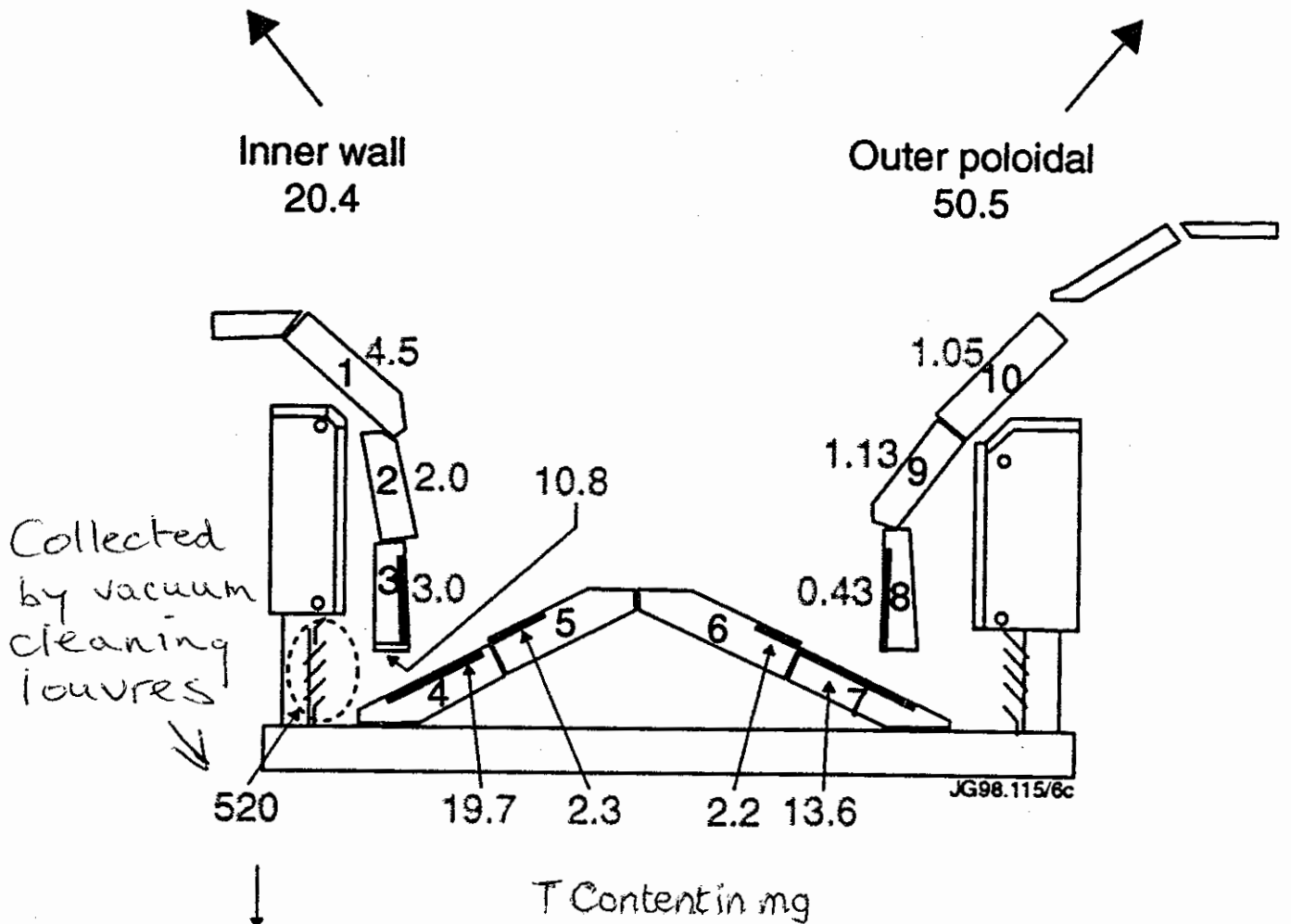
T retention in JET during DTE1 as a function of the T input to the torus



- (1) reduction by  $\sim 50\%$  mid-way through, and at end of campaign, by pulsing in D only.
- (2) this reduction is by isotope exchange of T by D in plasma-facing surfaces.
- (3) remaining T is in co-deposits in regions of little (or no) ion flux.
- (4)  $\sim$  one-half of this is released by exposure to air (i.e. venting torus).

# Cross-section of JET MAIIA divertor used during DTEI campaign

Location of tritium in JET vessel during the post-DTEI shutdown



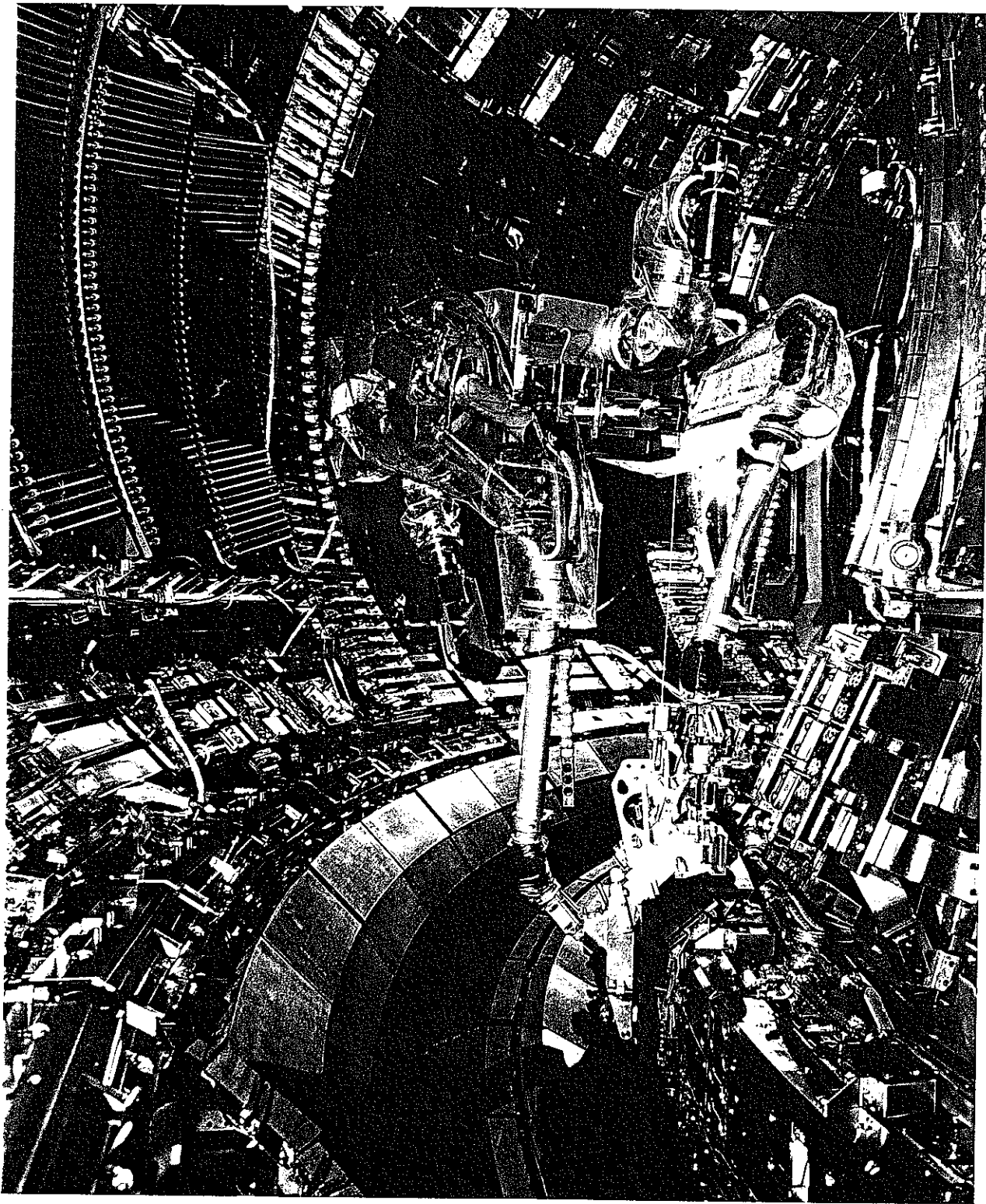
~3200?

(~2000 remaining by end 1999)

rest released by venting and baking to 300°C since 1998.

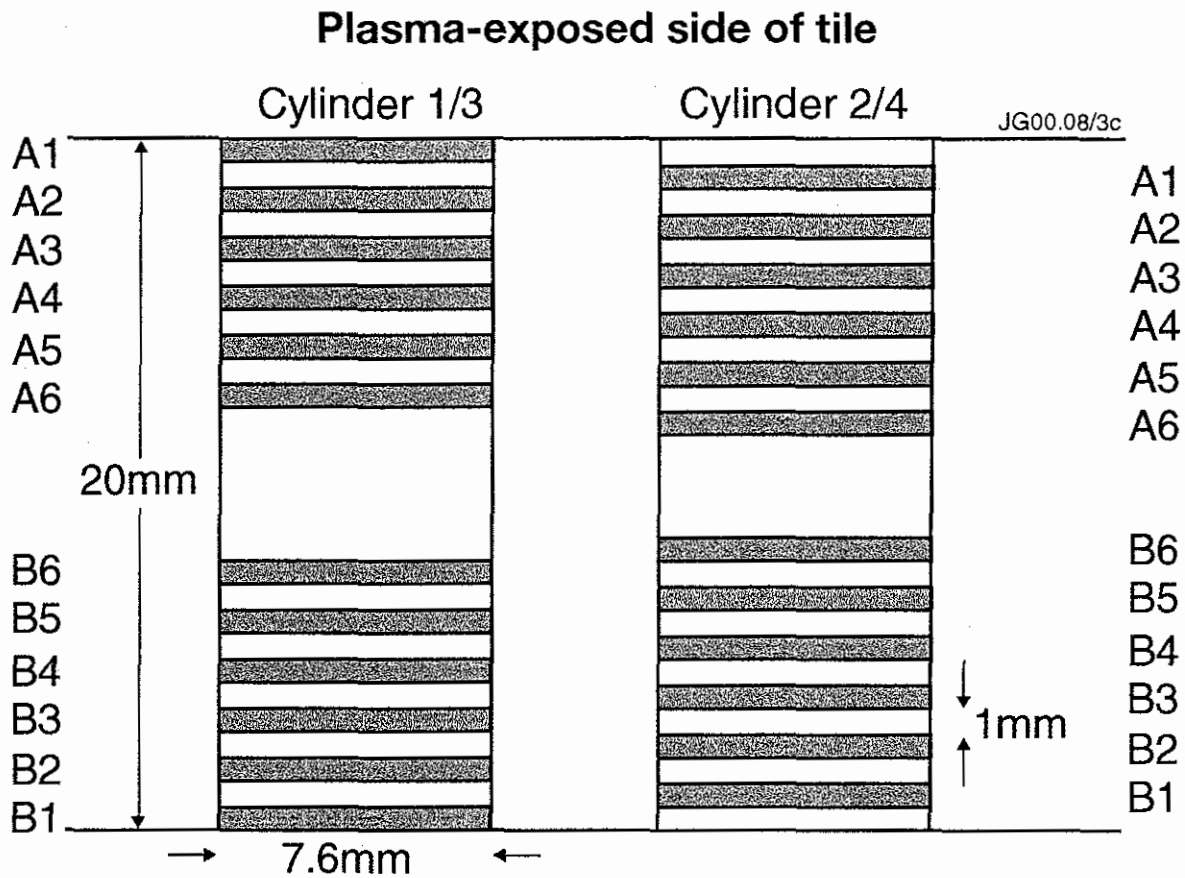
Many flakes have fallen beneath divertor structure onto vessel floor (seen by endoscope)

View of JET vessel, showing  
remote handling equipment used  
to replace divertor (and other components)



## Sampling of divertor tiles (CFC)

- (1) 7mm  $\phi$  core samples drilled through tile
- (2) Cut into 1mm slices
- (3) Top slice (including few  $\mu\text{m}$  surface film) contains typically 50 - 200 MBq  $\text{cm}^{-2}$  of T.

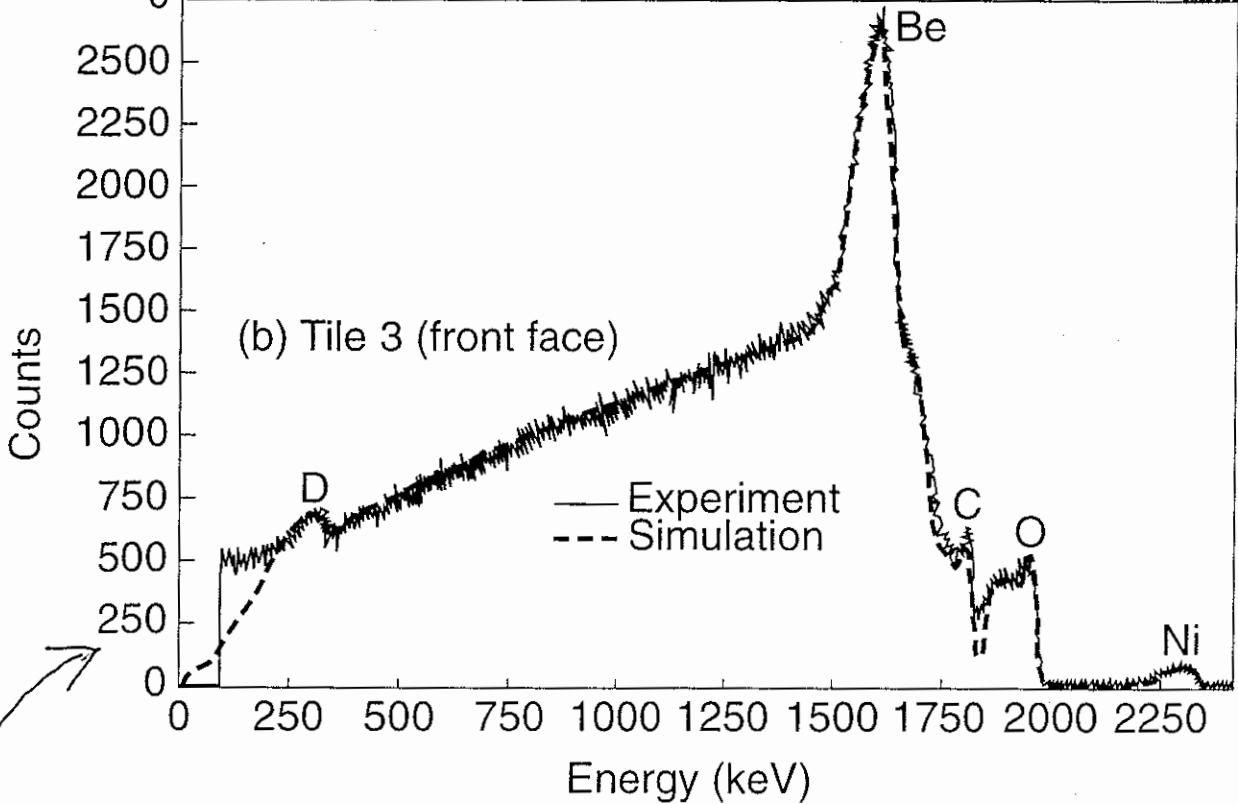
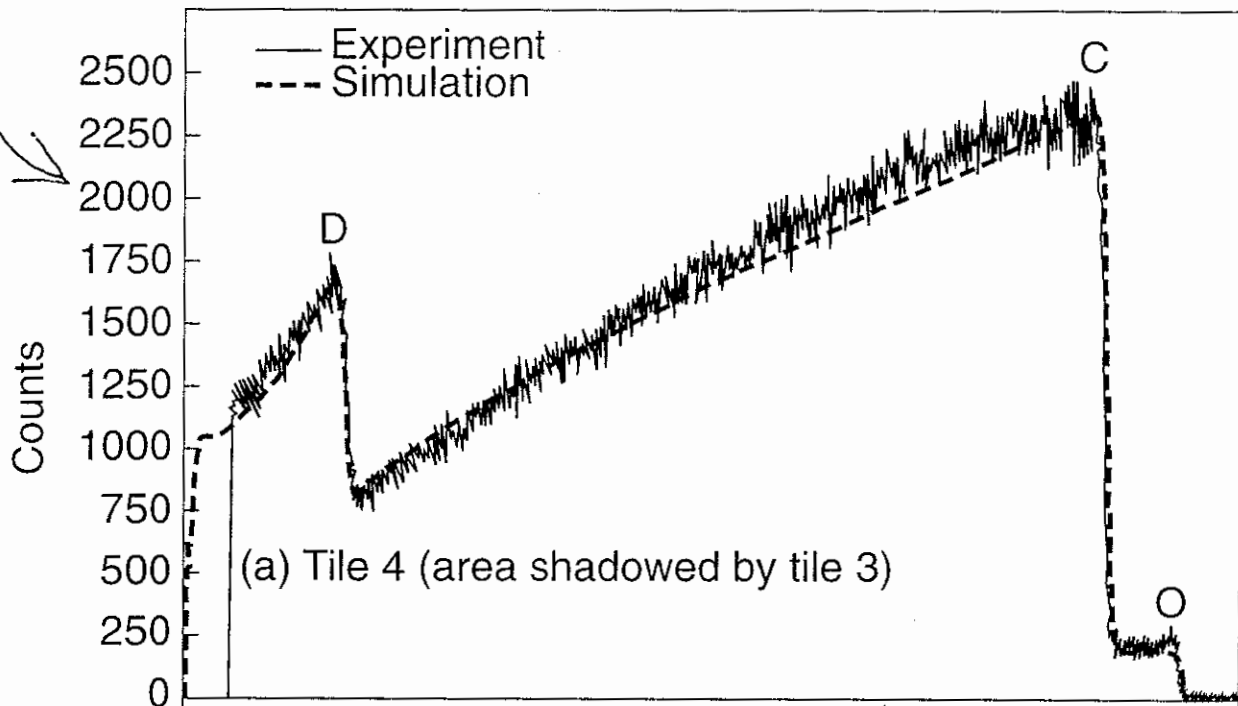


### **Plasma-opposite side of tile**

- (4) T in slices  $> 1\text{mm}$  from surface may (in total) be 10 - 60% of A1 content.
- (5) Negligible T found inside graphite tiles - porosity around carbon fibres?

(3) C transported (as  $C_2H_x$  ??) to cool, shadowed region

(4) Films here thus pure C (no Be, metals) plus high concentration trapped  $\Delta$  (+T).

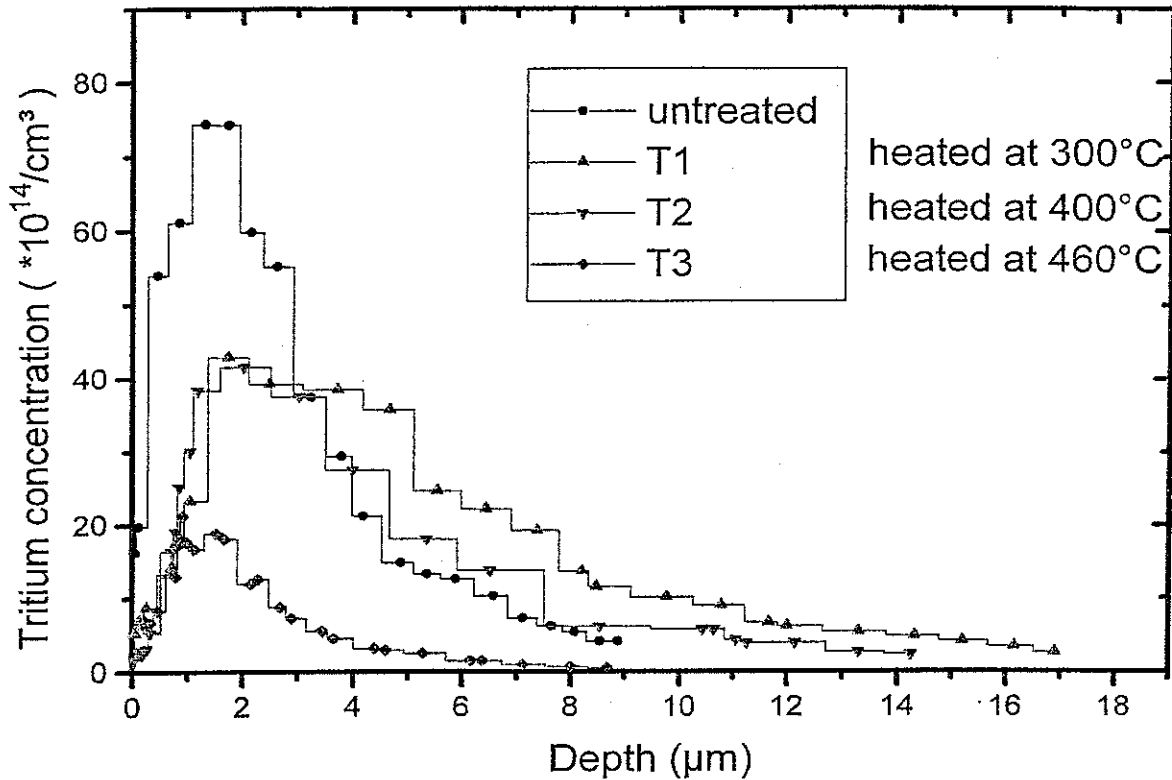


(1) C + 5-10% Beryllium sputtered from main chamber transported to divertor and deposited on tiles 1, 2, 3

(2) C re-eroded by chemical sputtering leaving Be-rich film ( $\leq 70\%$  Be) on tiles 1-3

# Profiles in samples from same tile by AMS

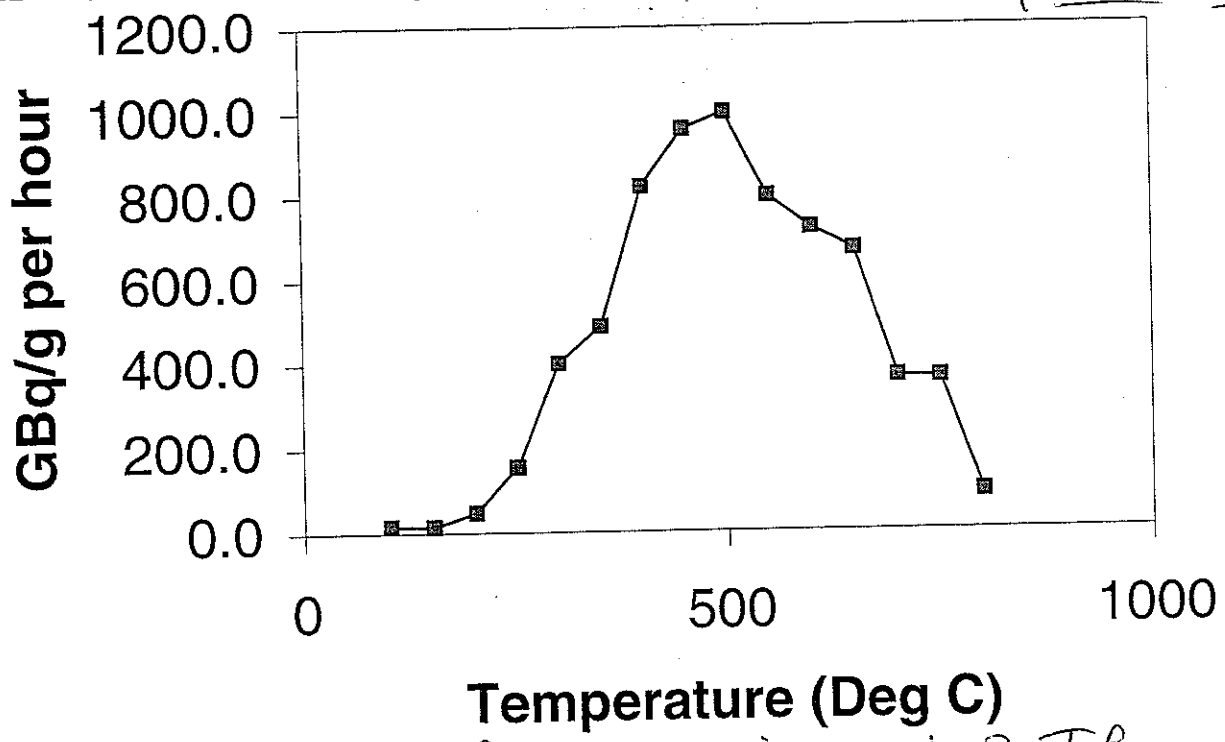
(Accelerator  
Mass  
Spectroscop



heated at 300°C  
heated at 400°C  
heated at 460°C

- (1) Significant reduction in T seen only after heating to  $>400^\circ\text{C}$
- (2) This is higher temperature than possible to bake ITER

## Outgassing of JET flakes (collected from louvers)



- (1) Activity of flakes is  $\sim 1-3 \text{ TBq g}^{-1}$ .
- (2) In DTE1 T was  $\sim 2\% \Delta$  (so activity of deposits in ITER  $\sim \times 25$ ).
- (3) Max outgassing at  $\sim 500^\circ\text{C}$ .