WP PWIE: SP E reporting 2022/ SP E planning for 2023

SPL E: Jari Likonen

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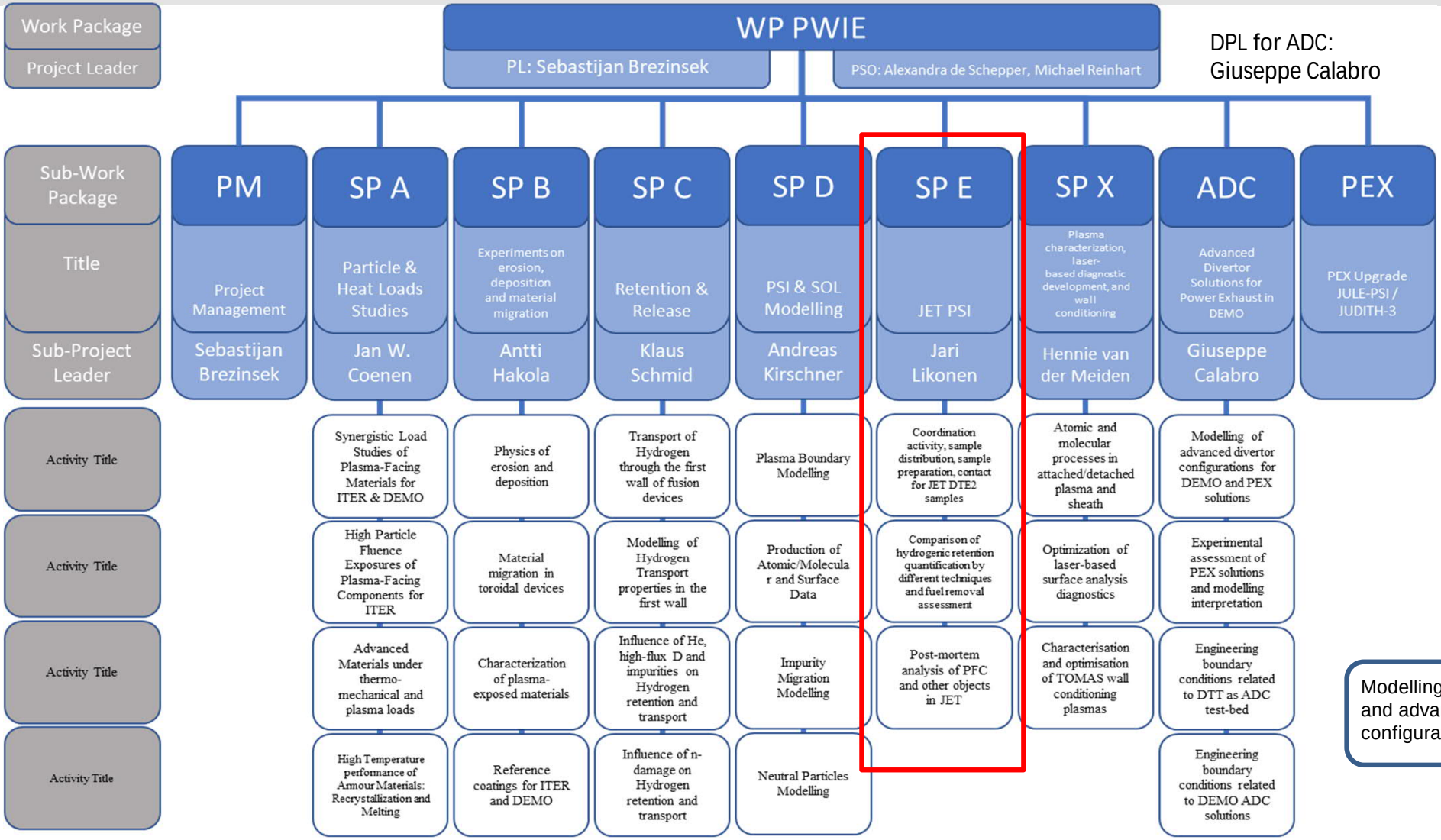
PWIE 2021/2022: SP E



DPL for ADC:
Giuseppe Calabro

Modelling of standard and advanced divertor configurations for DTT

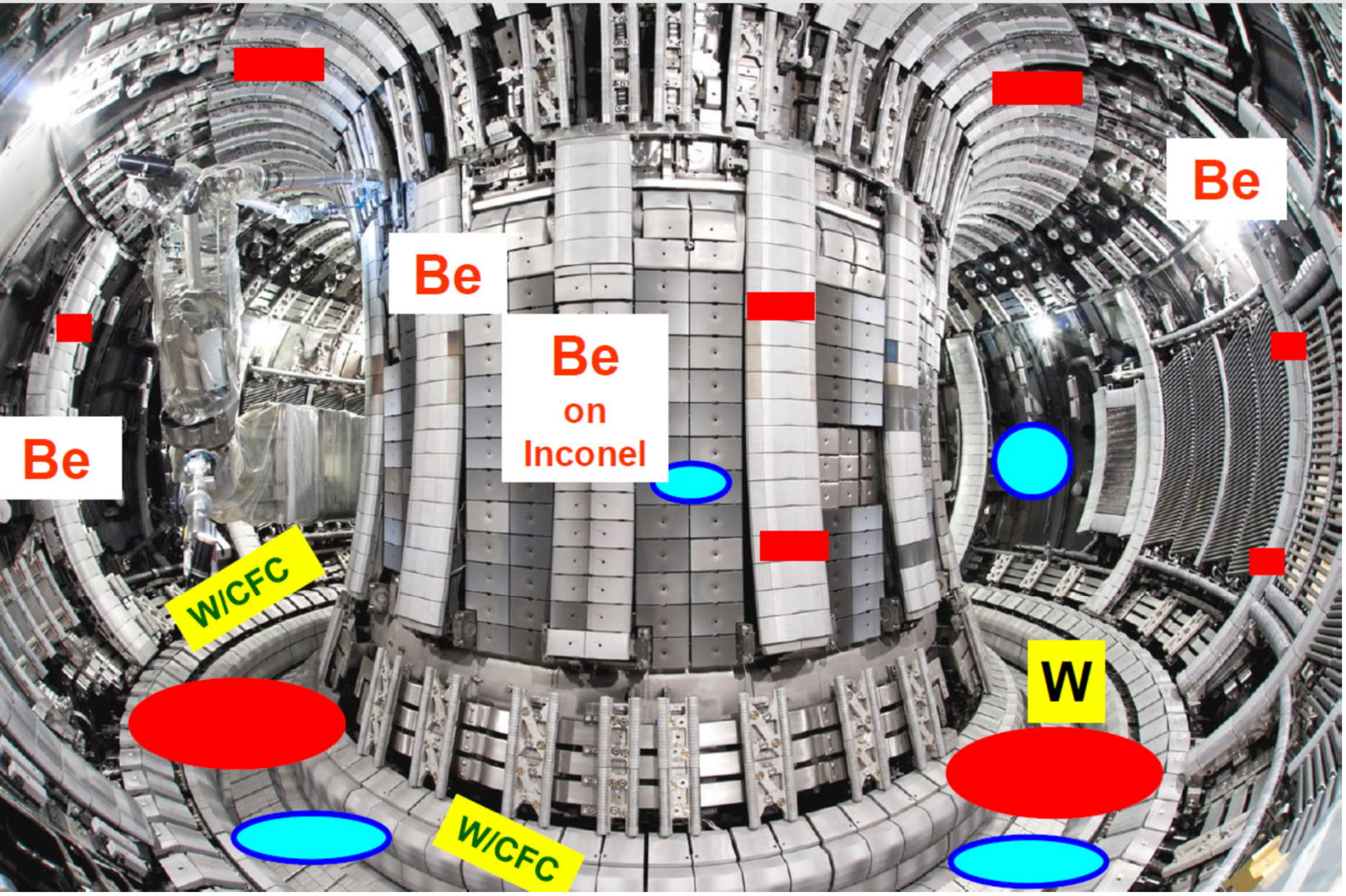
SP E Milestones 2022

WM43	SP E	JET Be and W sample preparation for post-mortem analysis in 2021 and 2022 performed (ITER)	31.12.2022
WM44	SP E	Comparison of hydrogenic retention quantification by different post-mortem analysis techniques completed (ITER + DEMO)	31.12.2022
WM45	SP E	Post-mortem analysis of Be limiters molten due to runaway electron beams impact completed (ITER)	31.12.2022
WM49**	SP D, SP E	Experiment, interpretation and initial modelling of WP PWI experiments in JET-ILW He plasmas carried out. First wall Be erosion by He impact and W nanostructure formation by He impact assessed.	WM49 only with WPTE possible

SP E Deliverables 2022

Activity	Deliverable ID(s)	Task Title
SP E.1	D001	Sectioning and preparation of samples from CFC divertor tiles. Distribution of samples to other laboratories (VTT)
SP E.1	D002	Sectioning and preparation of samples from metallic and diagnostics components. Distribution of samples to other laboratories. (IAP)
SP E.1	D003	Sectioning and preparation of samples from metallic components (FZJ)
SP E.2	D001, D002	Characterization of JET divertor tiles 0 and 1 with LIBS, LID-QMS, TDS and metallography (FZJ, CU)
SP E.2	D003	Analysis of samples from JET divertor tiles 0 and 1 with TDS and GDOES (IAP)
SP E.2	D004	Analysis of samples from JET divertor tiles 0 and 1 with TDS, FC and dissolution method (ISSP-UL)
SP E.2	D005, D006, D007, D008	Characterization of JET divertor tiles 0 and 1 using ion beam analysis RBS, NRA, HIERDA, µbeam NRA (IST, MPG, NCSRD, VR)
SP E.2	D009	Sectioning and preparation of samples from JET divertor tiles 0 and 1. Characterization of samples from JET divertor tiles 0 and 1 using SIMS, optical microscopy and TDS jointly with CCFE (VTT)
SP E.3	D001, D002	Characterization of JET plasma facing components with LIBS, LID-QMS, TDS and metallography (FZJ, CU)
SP E.3	D003	Sectioning and preparation of samples from metallic JET components. Analysis of JET plasma facing components with TDS and GDOES (IAP)
SP E.3	D004	Electron microscopy (SEM, TEM, FIB) of JET plasma facing components (IPPLM)
SP E.3	D005	Analysis of JET plasma facing components with TDS, FC and dissolution method (ISSP-UL)
SP E.3	D006, D007, D008, D009	Characterization of JET plasma facing and diagnostics components using ion beam analysis RBS, NRA, HIERDA, µbeam NRA (IST, MPG, VR, NCSRD)
SP E.3	D010	Characterization of JET plasma facing components using SIMS, optical microscopy and TDS jointly with CCFE (VTT)

Erosion-deposition diagnostics in JET-ILW



Marker tiles

- Divertor
- Main wall

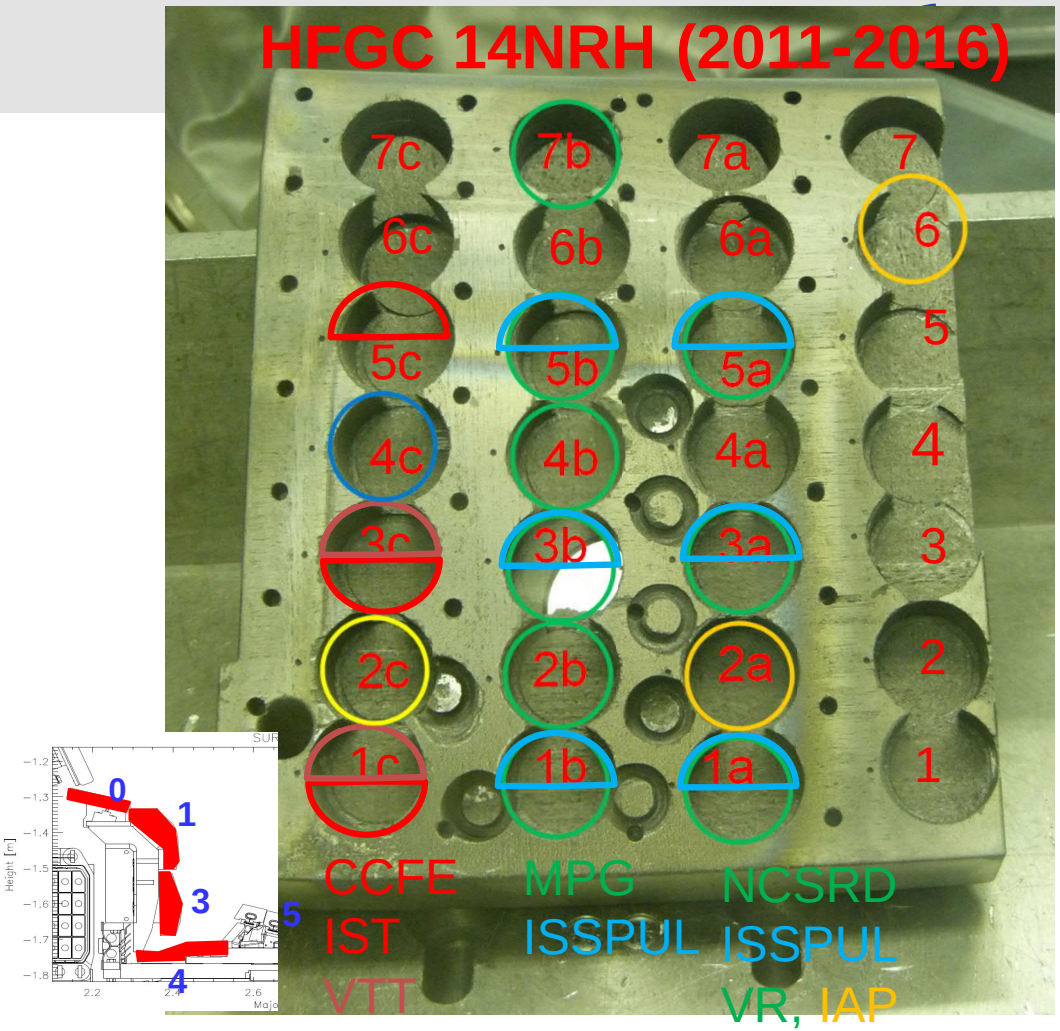
Probes

- Rotating collectors
- W sticking monitors
- Mirrors, cassettes
- W lamellae
- Langmuir probes
- QMB covers

SP E.1 Coordination activity, sample distribution, sample preparation, contact for JET DTE2 samples

SPE.1: Coordination activity (VTT)

- Task will concentrate on coordination, sample preparation and distribution of remaining JET ILW3 samples (no new ones available before end of JET operations)
- Sectioning and preparation of samples from CFC divertor tiles 0 and 1. Distribution of samples to other laboratories
- Coring of tiles 0 and 1 completed
- Four poloidal sets of samples prepared
- Samples distributed to various RUs.

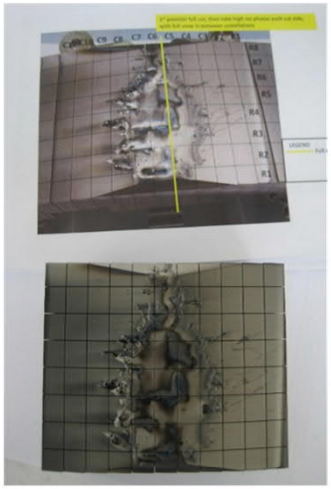


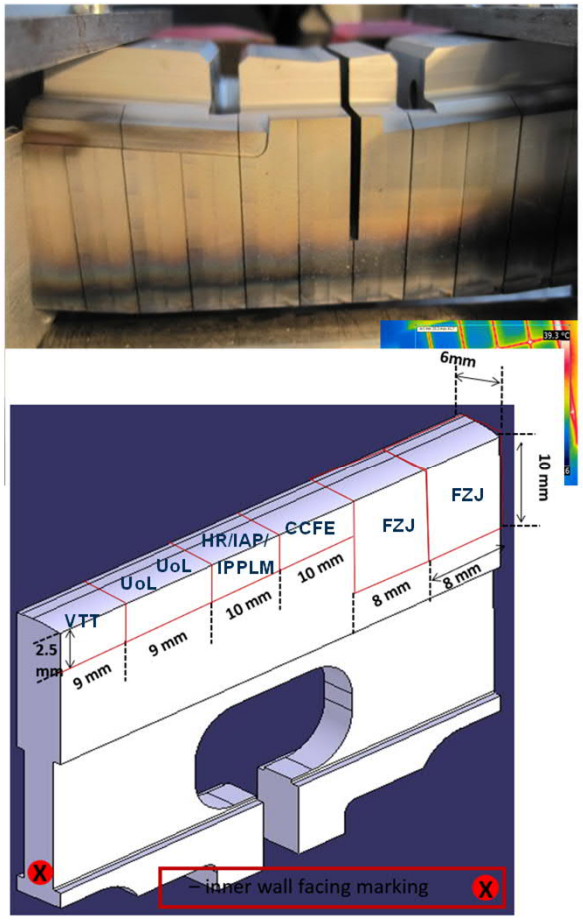
Deliverable: PWIE.SPE.1.T001.D001
Status: *Completed*
Facilities: *Hot cells at VTT*

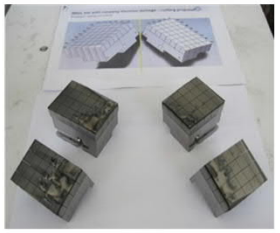
Human Resources: *2 PM*
Involved RU: *VTT and CCFE as a collaborator*
Linked WP or TSVV: *WPTE*

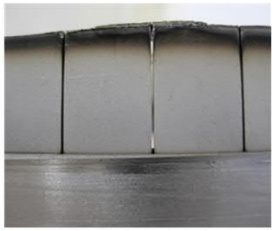
SPE.1: Coordination activity (IAP)

- Cutting of IWGL tile 1XR18 with runaway electron damage
- Preliminary images acquired
- Microscopy measurements from top and side surfaces have been made
- After microscopy, a decision will be made and cutting will proceed
- See I. Jepu's and C. Porosnicu's highlight talk
- Cutting of W lamellae: stack B to be completed in 2022, ILW1+3 and ILW3







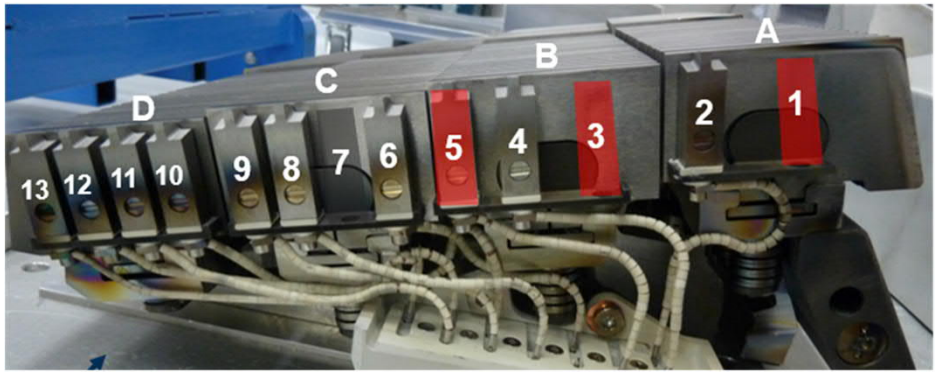


Deliverable: PWIE.SPE.1.T001.D002
Status: *In progress (to be completed by 31.12.2022)*
Facilities: *Hot cells at IAP*

Human Resources: *2 PM*
Involved RU: *IAP and CCFE as a collaborator*
Linked WP or TSVV: *WPTE*

SPE.1: Coordination activity (FZJ)

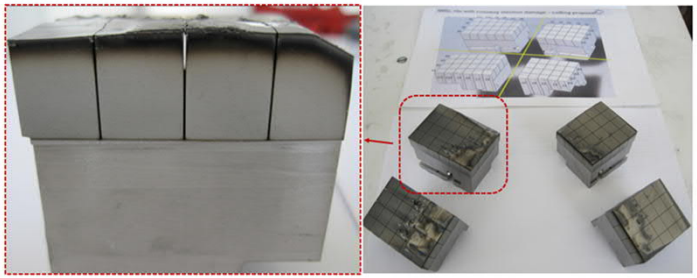
- Sent out samples (W lamellae B12 and B13) from FZJ storage to other labs for characterization before cutting
- Langmuir probes 15W: 1, 3, 5 to be cut



Deliverable: PWIE.SPE.1.T001. D003
Status: *In progress (to be completed by 31.12.2022)*
Facilities: *Hot cells at FZJ*

Human Resources: *1 PM*
Involved RU: *FZJ, IAP, VTT and CCFE as a collaborator*
Linked WP or TSVV: *WPTE*

SPE.1: Logistics & coordination (CCFE)



- Shipping & cutting of 1XR18 C3 IWGL at IAP – complete
- Decision on further sectioning needed – review with IO

- Shipping of some W lamellae (B stack) to IST for IBA, shipped and cut at IAP after IBA
- Shipping Langmuir probes to VR (and on to IPPLM), FZJ - complete
- Shipping divertor tiles to VTT for coring - complete

Deliverable:
Status: *Completed*
Facilities:

Human Resources:
Involved RU: *FZJ, IAP, VTT and CCFE as a collaborator*
Linked WP or TSVV: *WPTE*

SP E.2 Comparison of hydrogenic retention quantification by different techniques and fuel removal assessment

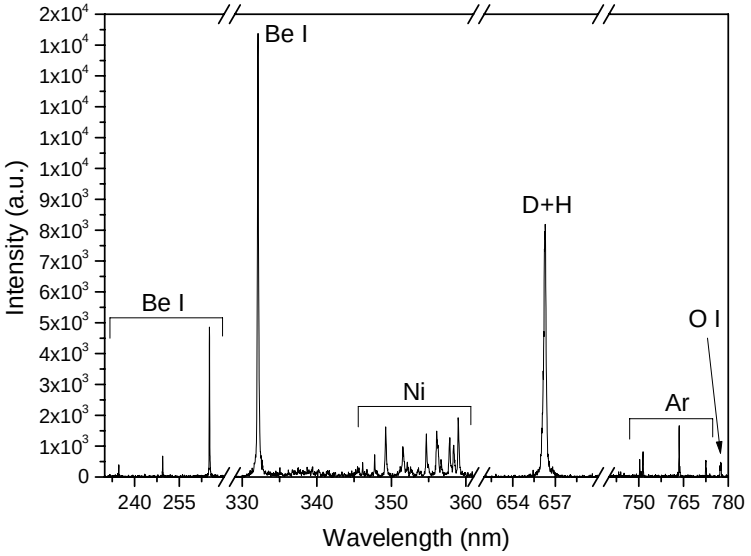
Goals:

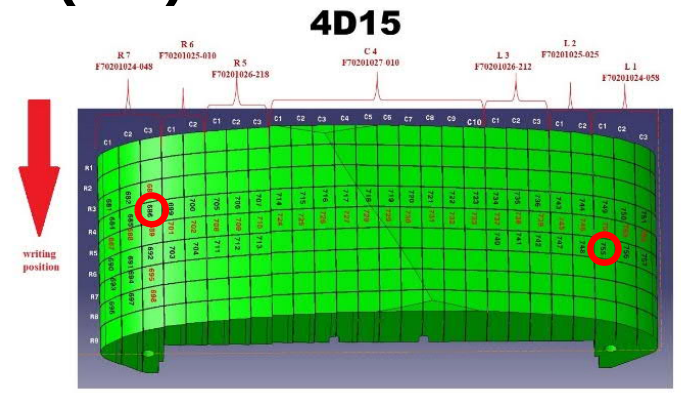
- Fuel retention after exposure to multiple campaigns on tiles 0 and 1
- Comparison with single campaign data
- Simulation of JET C39 baking experiment

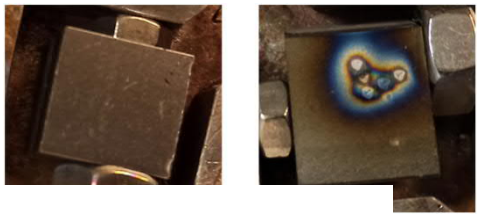
SPE.2: LIBS measurement of JET Be limiter samples (CU)

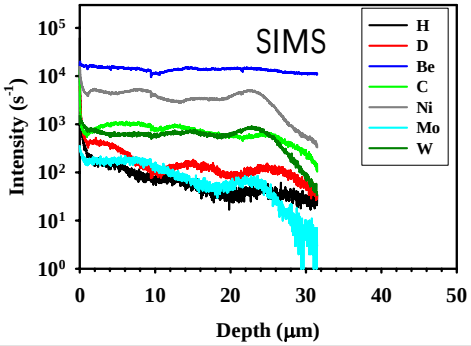
- Joint LIBS measurement campaign of Be limiter samples in May (VTT, CU, UT, IPPLM, ENEA)
- Samples analysed with LIBS: 4D15-686, 4D15-755, 2XR11-641
- Same samples analysed also with SIMS at VTT

- LIBS spectrum for sample 4D15-755
- D amount: ~6.4e17 cm^{-2} (SIMS)
- Further analysis in progress
- CF-LIBS
- Comparison with UT









Deliverable: PWIE.SPE.2.T001.D001, SPE.3.T001. D001
Status: *In progress (to be completed by 31.12.2022)*
Facilities:

Human Resources: *3 +1 PM*
Involved RU: *CU, UT, IPPLM, ENEA,VTT*
Linked WP or TSVV: *PWIE SPB*

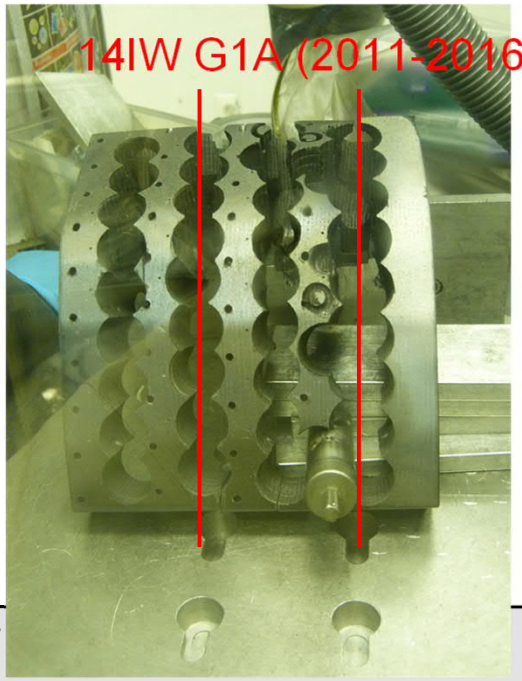
P. Veis et al. (CU)

SPE.2: Characterization of JET divertor tiles 0 and 1 with LIBS, LID-QMS, TDS and metallography (FZJ)

- The task has started but became stalled due to the unavailability of the FREDIS analysis chamber due to nuclear licensing issues (air tightness classification of the glove boxes).

- The misunderstanding on the requirements on the air tightness has been resolved but the overall process needs a renewed technical inspection IT is expected that this will be passed by end of October 2022.

- Shipping of tile pieces from tiles 0 and 1 to FZJ in 2022?

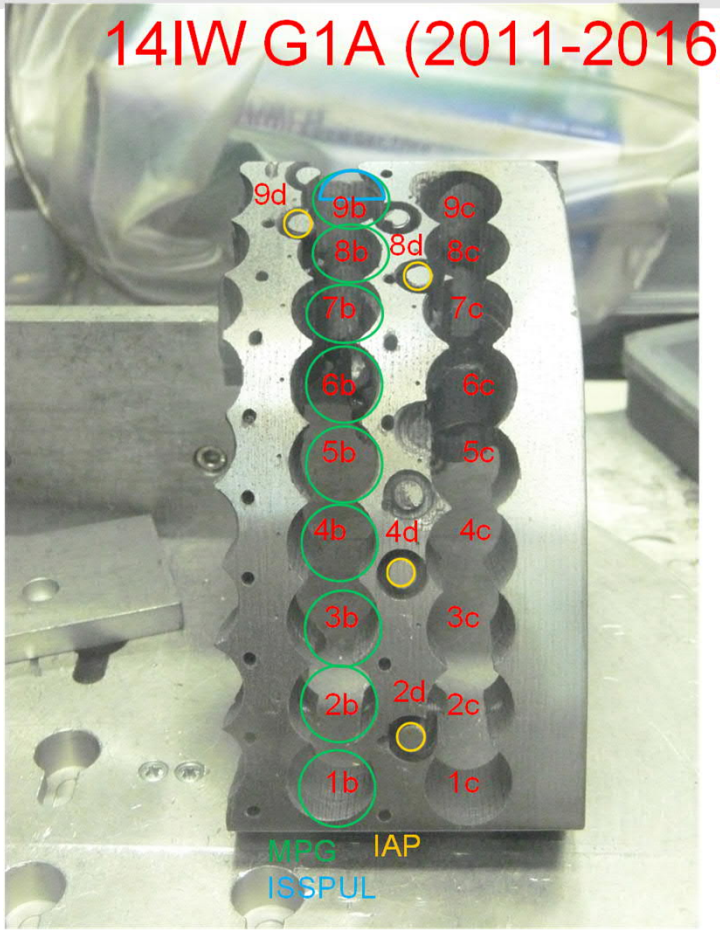


Deliverable: PWIE.SPE.2.T001.D002
Status: *Delayed*
Facilities:

Human Resources: 7
Involved RU: *FZJ*
Linked WP or TSVV: *PWIE SPB*

SPE.2: Analysis of samples from JET divertor tiles 0 and 1 with TDS and GDOES (IAP)

- Samples cored from JET tiles: 14IWG1A (2011-2016) and HFGC (2011-2016) received for GDOES and TDS measurements
- Sample preparation and required measurements are currently in progress and will be concluded by the end of 2022
- GDOES measurements and TDS analysis performed on selected samples will give information concerning the deposition/erosion pattern and fuel retention



Deliverable: PWIE.SPE.2.T001.D003
Status: *In progress (to be completed by 31.12.2022)*
Facilities:

Human Resources: 6 *PM*
Involved RU: *IAP*
Linked WP or TSVV: *PWIE SPB*

E. Grigore et al. (IAP)

SPE.2: Analysis of samples from JET divertor tiles 0 and 1 with TDS, FC and dissolution method (ISSP-UL)

- During reporting period all testing systems has been prepared
- Additional thermal desorption setup has been developed on-site and an existing setup upgraded for the use of different carrier gas (argon)
- Methodology for calibration of measuring equipment has been improved and calibration performed.
- Parameters of electrochemical dissolution method have been optimized and tested on the available samples
- Equipment for C39 baking experiments also prepared and tested.
- Analysis with TDS, FC and dissolution method will be completed in time.

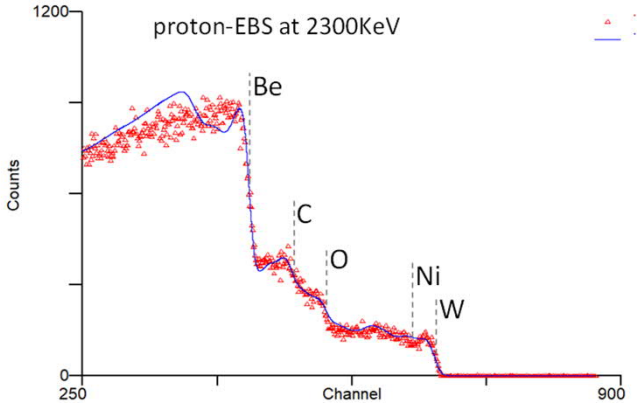
- **Waiting for samples to be returned from MPG and NCSRD to VTT for further cutting**

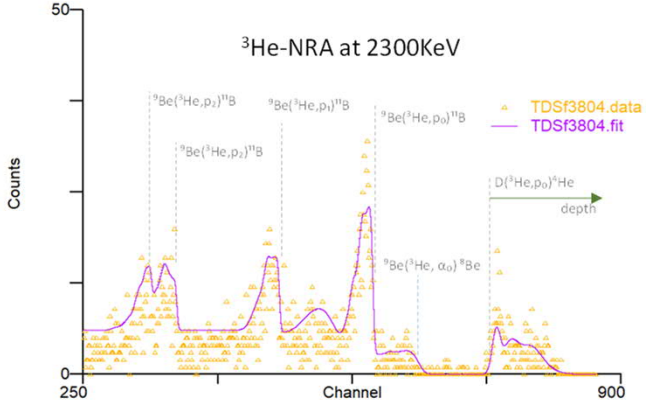
Deliverable: PWIE.SPE.2.T001.D004
Status: *In progress*
Facilities:

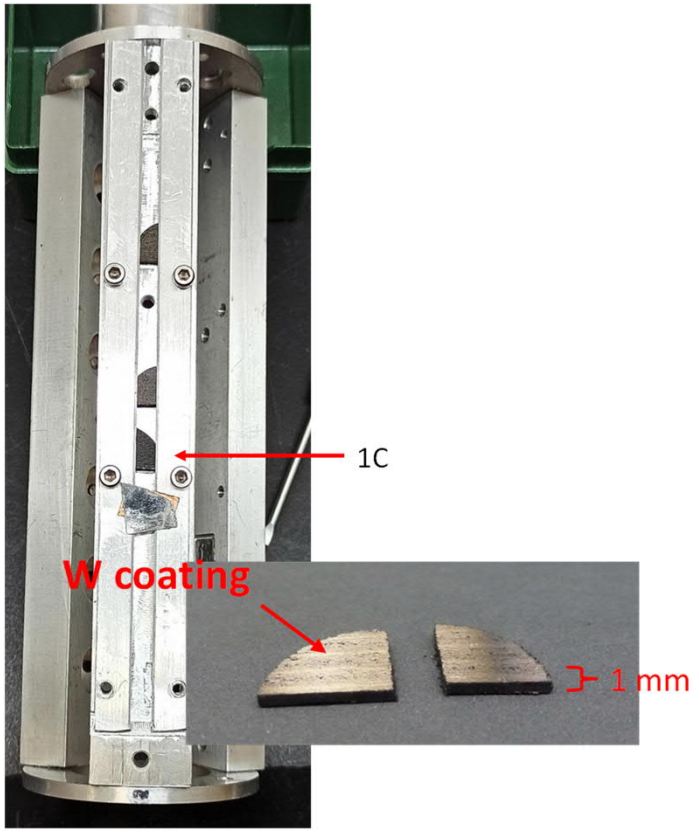
Human Resources: 6 *PM*
Involved RU: *ISSP-UL*
Linked WP or TSVV:

SPE.2: Ion beam analysis of divertor samples (IST)

- Aim is to perform ion beam analyses before and after TDS analyses, to compare TDS with IBA and check that TDS annealing empties sample
- Samples from tiles HFGC and 14IWG1A (exposed during ILW1-3) analysed at IST
- HFGC: D amounts ~1-3*10^{18}cm^{-2} (ILW3: ~1-10*10^{18}cm^{-2})
- Some indications that D amount does not increase as a function of exposure time
- See E. Alves' highlight talk







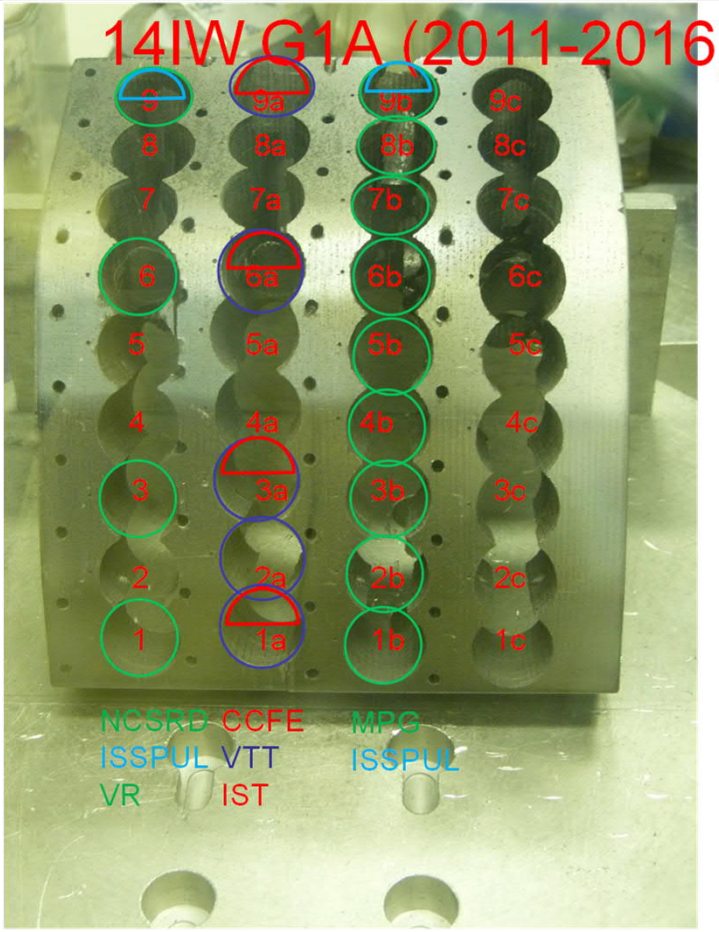
Deliverable: PWIE.SPE.2.T001.D005
Status: *Completed*
Facilities: accelerator (IST)

Human Resources: 6 *PM*
Involved RU: *IST*
Linked WP or TSVV:

SPE.2: Characterization of samples from JET divertor tiles 0 and 1 using RBS and NRA (MPG)

- Samples from tiles HFGC and 14IW G1A have been received in July 2022

- Analysis is foreseen until end of October

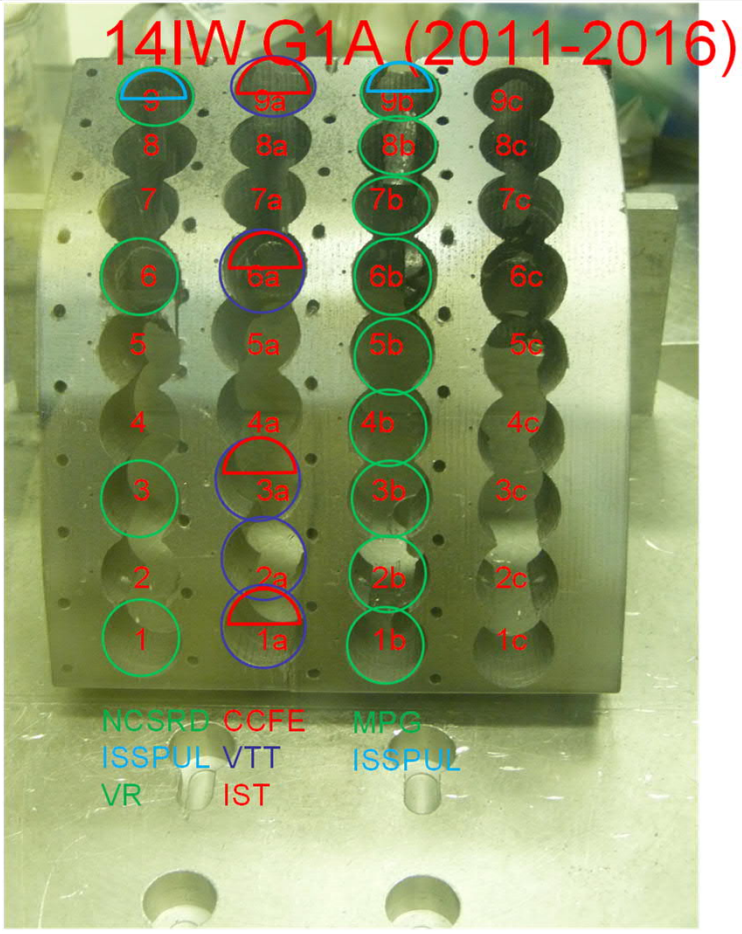


Deliverable: PWIE.SPE.2.T001.D006
Status: *In progress (to be completed by 31.12.2022)*
Facilities: accelerator (MPG)

Human Resources: 2 *PM*
Involved RU: *MPG*
Linked WP or TSVV:

SPE.2: Analysis of samples from JET divertor tiles 0 and 1 with μbeam NRA (NCSRD)

- Samples from tiles HFGC and 14IW G1A have been received in July 2022
- Task is delayed due to the delayed delivery of spare parts for TANDEM accelerator
- The experiments will start the 17th of October and are expected to finish by mid November



Deliverable: PWIE.SPE.2.T001.D007
Status: *In progress (to be completed by 31.12.2022)*
Facilities: accelerator (NCSRD)

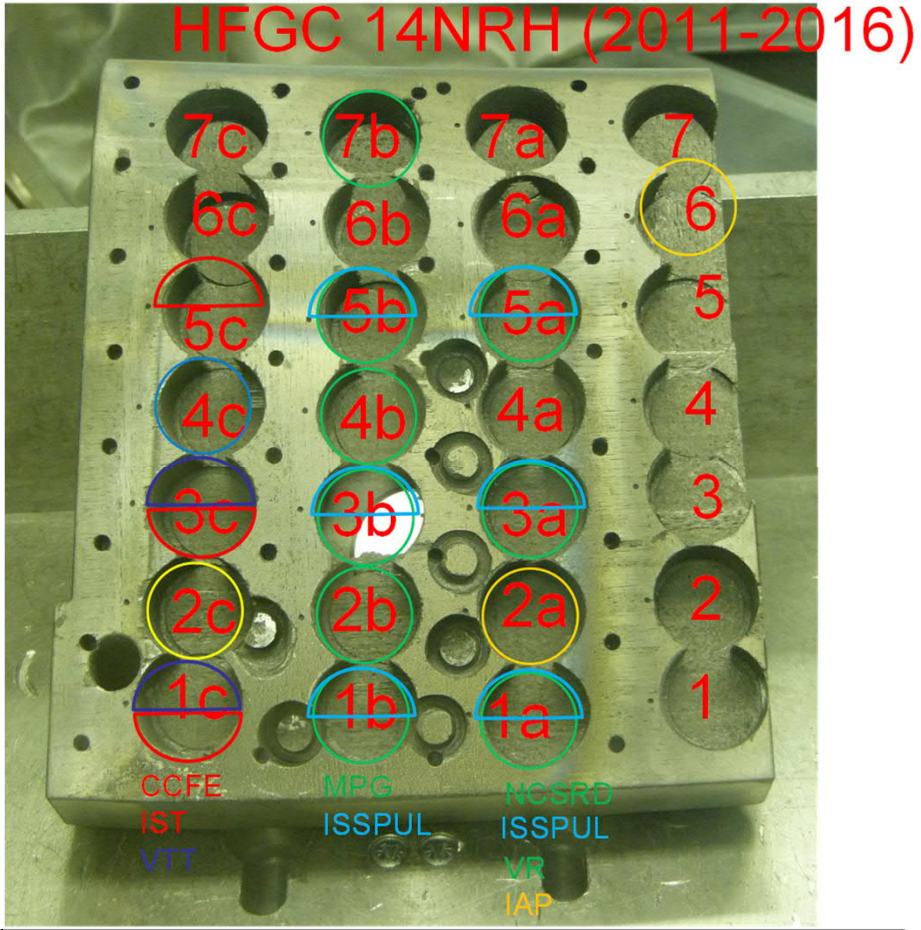
Human Resources: 2 *PM*
Involved RU: *NCSRD*
Linked WP or TSVV:

A. Lagoyannis et al. (NCSRD)

SPE.2: Characterization of samples from JET divertor tiles 0 and 1 using HIERDA (VR)

- Samples from tiles HFGC and 14IW G1A to be shipped once received from NCSRD

- Experiments are to be performed upon arrival of samples



Deliverable: PWIE.SPE.2.T001.D008
Status: *In progress (to be completed by 31.12.2022)*
Facilities: accelerator (VR)

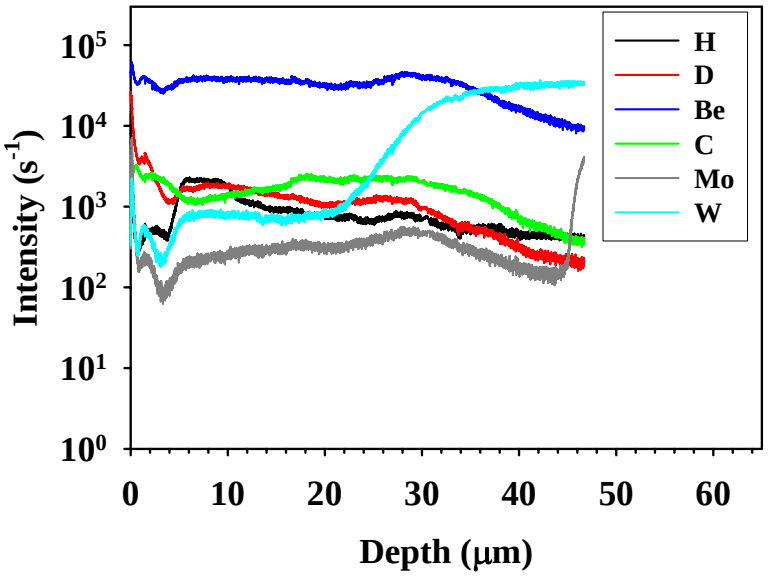
Human Resources: 3 *PM*
Involved RU: *VR*
Linked WP or TSVV:

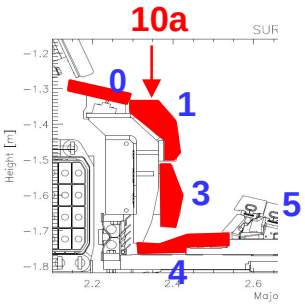
SPE.2: SIMS analysis of divertor samples (VTT)

- Fuel retention in tiles 0 and 1 exposed during ILW1-ILW3
- Comparison with single campaign results
- HFGC (2011-2016): co-deposited layer > 30µm
- 14IWG1A (2011-2016) apron: co-deposited layer, thickness ~30µm
- 14IWG1A (2011-2016) apron: D~ $4.8*10^{18}$ cm^{-2}
- Fuel retention not necessarily higher for multiple campaign tiles
- Further analyses (TDS, IBA) required

analysis	sample	D amount ($x1e^{18}cm^{-2}$)
SIMS	14ING1C-10a (ILW3)	5.4
TDS	14ING1C-10 (ILW3)	5.6

SIMS depth profiles, sample 14IWG1A-10a



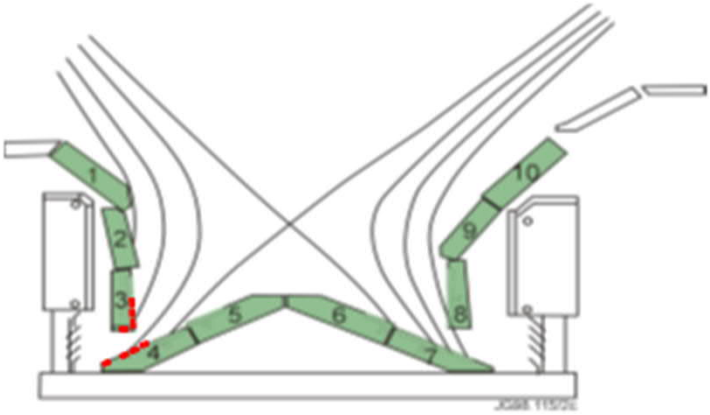


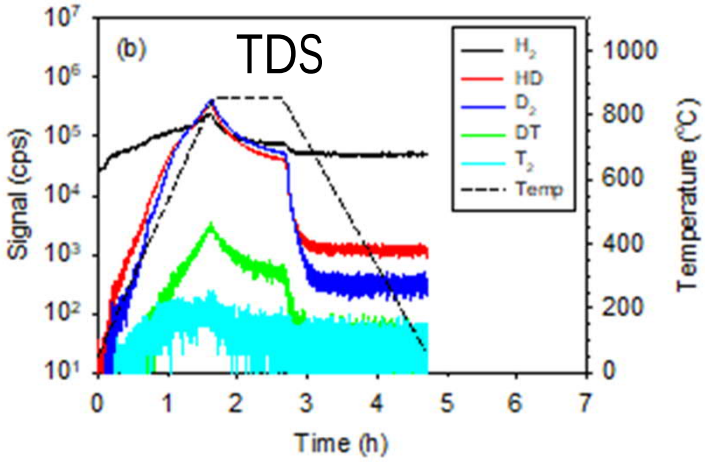
Deliverable: PWIE.SPE.2.T001.D009
Status: *Completed*
Facilities:

Human Resources: 7 *PM*
Involved RU: *VTT*
Linked WP or TSVV:

SPE.2: Fuel retention assessment (CCFE)

- Continuation of analysis of MkIIA divertor tiles (DTE1) using TDS and pyrolysis techniques
- Comparison made with previous results from 2001 (Penzhorn et al. JNM 2001)
- Highest T amounts were detected in the shadowed inner corner of the divertor
- A few samples were reannealed using same heating procedure and it turned out that a further ~40-50 % of T was then released
- TDS is not an accurate method for measurement of bulk T content of carbon unless the sample is repeatedly cycled to at least 1000 ^{o}C
- Total combustion and pyrolysis represent the best method for total T determination
- Knowledge of T inventories will be required for Health and Safety at ITER
- Off-gas measurement at JET is not accurate indicator of bulk T content because it requires carefully controlled conditions





Deliverable:
Status: *Completed*
Facilities:

Human Resources:
Involved RU: *VTT, CCFE*
Linked WP or TSVV:

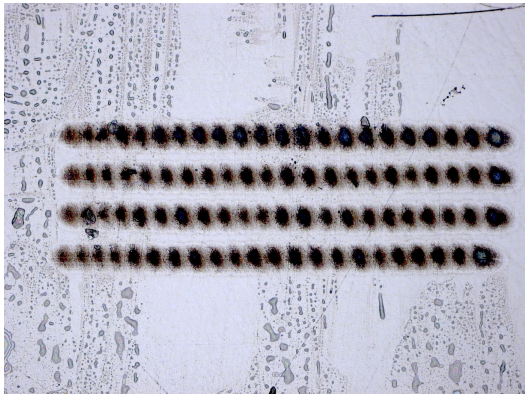
SP E.3 Post-mortem analysis of PFC and other objects in JET

Goals:

- investigate material migration, co-deposition and erosion
- study microstructure and recrystallisation of metallic components (Langmuir probes, W lamellae)
- analyse diagnostic components (sticking monitors, deposition monitors, mirror cassettes, louvre clips) → input data for modelling (SPD)

D2: Characterization of JET plasma facing components with LIBS, LID-QMS, TDS and metallography (other JET components)

- Same issue as for Task E.2
- Development of multi spot raster LIBS with improved sensitivity:
  - Increase the signal of LIBS due to increased ablation area
  - Increase of QMS signal measured during ablation (LIA-QMS method)
  - in spot overlap mode: crater spot edge effect negligible due to large ratio of scanning area to edge



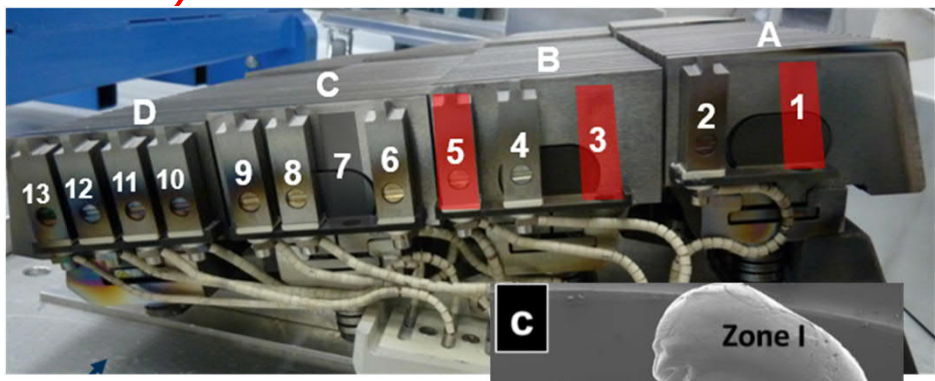
3 ps pulse length, 1030 nm wavelength,
25 µJ per Pulse, 100 kHz repetition rate

Deliverable: PWIE.SPE.3 D002
Status: *In progress / delayed*
Facilities: None

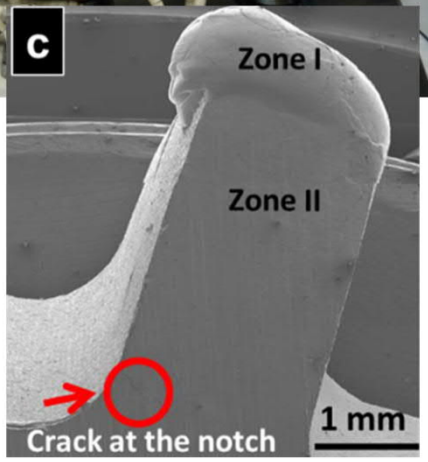
Human Resources: 10 PM
Involved RUs: FZJ
Linked WP or TSVV:

SP E.3 Electron microscopy (SEM, TEM, FIB) of JET plasma facing components (IPPLM)

- Langmuir probes 16W 1,3,5 (tile 5, exposed in ILW1+2) delivered to IPPLM from VR in September



- Metallography studies:
  - Recrystallization
  - Surface morphology (SEM)
  - Changes in mechanical properties (NIT)
  - Hardness (NIT)
  - XRD, microscopy
- Cracks run along the grain boundaries (which could indicate recrystallization)
- Re-melted and re-solidified material has been found on the tip



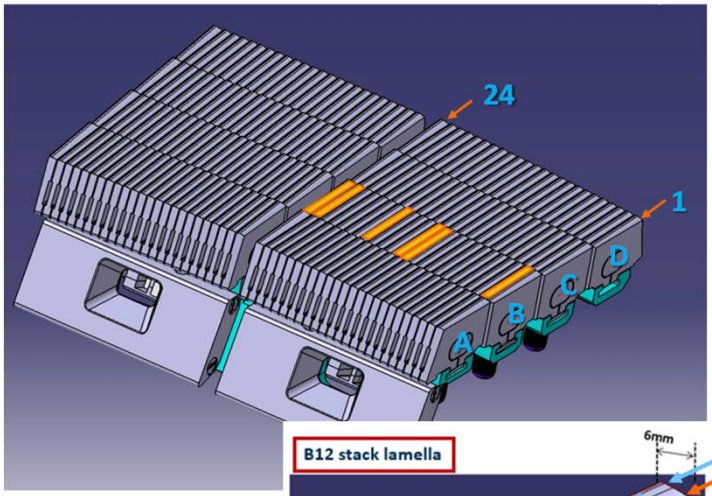
Deliverable: PWIE.SPE.3 D004
Status: *In progress/delayed*
Facilities: None

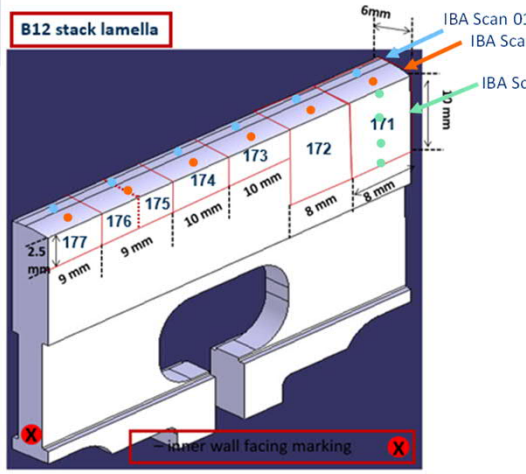
Human Resources: 6 PM
Involved RUs: IPPLM
Linked WP or TSVV:

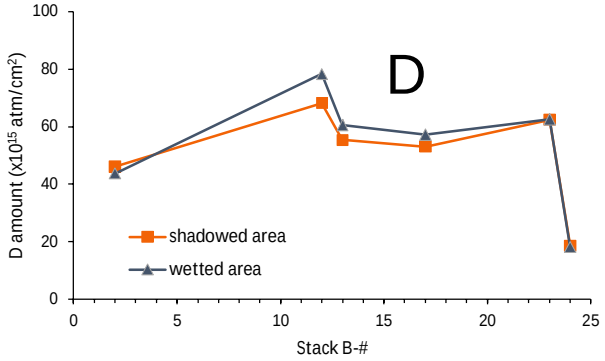
E. Fortuna-Zaleśna et al. (IPPLM)

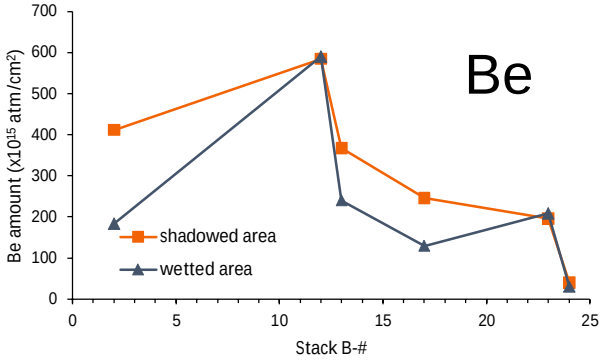
SP E.3 Characterization of JET plasma facing and diagnostics components using ion beam analysis (RBS, NRA) (IST)

- W lamellae from stack B (ILW1+3: B12, B17, B24; ILW3: B02, B13, B23)
- Be in the limit of detection → 20min/analysis spot
- For D detection limit one order of magnitude lower
- Lamellae B12 has the highest D and Be amounts









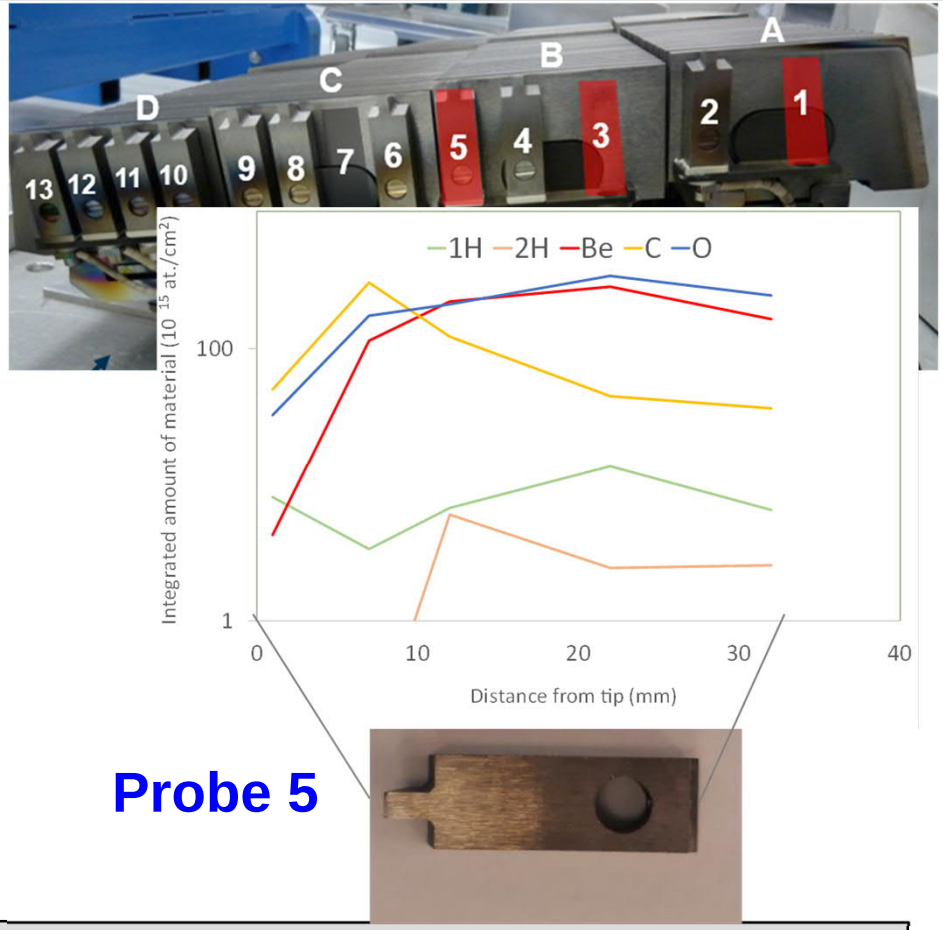
Deliverable: PWIE.SPE.3 D006
Status: *Completed*
Facilities: None

Human Resources: 5 PM
Involved RUs: IST
Linked WP or TSVV:

E. Alves et al. (IST)

SP E.3 TOF-ERDA beam analyses of Langmuir probes from 16W (VR)

- Langmuir probes 16W 1,3,5 (tile 5, exposed in ILW1+2)
- Be and O amounts are similar in most co-deposits
- Other elements found: H,D, He (only in a few points), N, ~Si, ~Ni (Inconel components).
- Not much D found on the samples (probes were taken out after ILW-2 campaign ended in hydrogen).



Probe 5

Deliverable: PWIE.SPE.3 D009
Status: *Completed*
Facilities: None

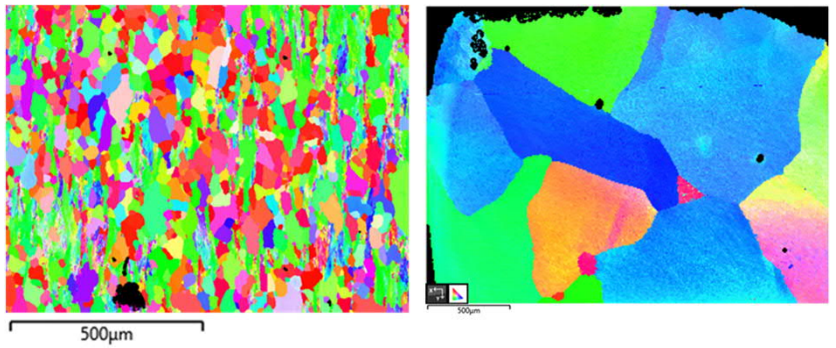
Human Resources: 7 PM
Involved RUs: VR
Linked WP or TSVV:

D. Primetzhofer et al. (VR)

SP E.3 Microstructure and material properties (CCFE)

- Langmuir probe from tile 6 exposed in JET divertor was studied to evaluate changes in mechanical and microstructural properties
- Langmuir probe showed signs of melting and the formation of bubbles up to 50 µm
- Average grain size had increased from 33 µm to 570 µm after irradiation and hardness had increased by 0.9 GPa
- IBA: no significant D retention
- See R. Kerr's highlight talk

EBSD images



Before: 33 ± 1 µm After: 570 ± 60 µm

Deliverable: Status: *in progress* Facilities: None	Human Resources: Involved RUs: CCFE Linked WP or TSVV:

Planning of SP E in 2023

Proposed SP E Milestones 2023

WMxx	SP E	JET Be and W sample preparation for post-mortem analysis in 2022 and 2023 performed (ITER)	31.12.2023
WM4xx	SP E	Comparison of hydrogenic retention quantification by different post-mortem analysis techniques completed (ITER + DEMO)	31.12.2023
WMxx	SP E	Post-mortem analysis of main wall tiles and diagnostic components completed (ITER)	31.12.2023

Proposed SP E Deliverables 2023

Activity	Deliverable ID(s)	Task Title
SP E.1	D001	Sectioning and preparation of samples from CFC divertor tiles. Distribution of samples to other laboratories (VTT)
SP E.1	D002	Sectioning and preparation of samples from metallic and diagnostics components. Distribution of samples to other laboratories. (IAP)
SP E.2	D001	LIBS, LID-QMS analysis of JET divertor tiles 0, 1, 4 and 6 jointly with FZJ and VTT (CU)
SP E.2	D002	Characterization of JET divertor tiles 0, 1, 4 and 6 with LIBS, LID-QMS, TDS and metallography (FZJ)
SP E.2	D003	Analysis of samples from JET divertor tiles 4, 6, 7 and 8 with TDS and GDOES (IAP)
SP E.2	D004	Analysis of samples from JET divertor tiles 0 and 1 with TDS, FC and dissolution method. Simulation of C39 JET baking experiment (ISSP-UL)
SP E.2	D005	Characterization of JET divertor tiles 0, 1, 4, 6, 7 and 8 using ion beam analysis (RBS, NRA) (IST)
SP E.2	D006, D007, D008	Characterization of samples from JET divertor tiles 4, 6, 7 and 8 using ion beam analysis (RBS, NRA, µbeam NRA, HIERDA) (MPG, NCSRD,VR)
SP E.2	D009	Sectioning and preparation of samples from JET divertor tiles 4, 6, 7 and 8. Characterization of samples from JET divertor tiles 4, 6, 7 and 8 using SIMS, optical microscopy and TDS jointly with CCFE (VTT)
SP E.3	D001	Characterization of JET plasma facing components with LIBS, LID-QMS, TDS and metallography (FZJ)
SP E.3	D002	Analysis of JET plasma facing components with TDS and GDOES (IAP)
SP E.3	D003	Electron microscopy (SEM, TEM, FIB) of JET plasma facing components (IPPLM)
SP E.3	D004	Analysis of JET plasma facing components with TDS, FC and dissolution method (ISSP-UL)
SP E.3	D005, D006, D007, D008	Characterization of JET plasma facing and diagnostics components using ion beam analysis (RBS, NRA, µbeam NRA, HIERDA) (IST, MPG, NCSRD, VR)
SP E.3	D009	Characterization of JET plasma facing components using SIMS, optical microscopy and TDS jointly with CCFE (VTT)

SPE Quick overview for 2022-2023

- No new tiles and components available before shutdown in 2023-2024
- Post-mortem analysis of JET tiles (divertor, limiters) typically a 2 year programme
- SP E work will be split between 2022 and 2023, 2022 work presented during this meeting

- Shipment of divertor tiles from CCFE to VTT in 3/2022
- Shipment of metallic components from CCFE in 4-5/2022
- Coring of divertor tiles completed in 6/2022
- First shipments of divertor samples to RUs in 7/2022
- Some delays in IBA analyses → further delays to other analyses

- Many of tasks in 2023 will be smooth continuation of 2022 activities

- **When shipping samples to another RU, INFORM ALWAYS CCFE AND VTT**

SPE: Tasks 2023

SP E1

Coordination activity, sample distribution, sample preparation, contact for JET DTE2 samples

- Continuation of activities
- Samples from divertor tiles 4, 6, 7 and 8 (exposed either in ILW1-3 or ILW2-3)
- Cutting of IWC tile 403
- Distribution of samples from DP tile 3A8
- Cutting of mirror cassettes

SP E2

Comparison of hydrogenic retention quantification by different techniques and fuel removal assessment

- Continuation of activities
- Post-mortem analysis of tiles 4, 6, 7 and 8 (IBA,SIMS,TDS,FC…)
- Lab experiments to simulate C39 baking experiment
- LIBS, LID-QMS analysis of JET PFCs

SP E3

Post-mortem analysis of PFC and other objects in JET

- Continuation of activities
- Characterisation of wall tiles IWC403, DP 3A8, 1XR18
- Characterisation of W lamellae and Langmuir probes
- CX fluxes to remote areas
- Analysis of mirror cassettes, louvre clips, sticking monitors, deposition monitors

SP E1

IAP

- Cutting of IWC tile 403, 1XR18
- Cutting of mirror cassettes, need to discuss with modellers (see J. Romazanov talk)

VTT

- Sampling of divertor tiles 4, 6, 7 and 8

CCFE

- Shipping of mirror cassettes, louvre clips, sticking monitors, deposition monitors, IWC tile 403 and DP tile 3A8 samples

SP E2

CU

- Continuation of work
- LIBS, LID-QMS analysis of JET divertor samples from tiles 0, 1, 4, 6 jointly with FZJ and VTT (preparations for JET LIBS experiment in 2024, see H. van der Meiden's and S. Almaviva's talk on Tuesday)
- Quantitative analysis by CF-LIBS

FZJ

- Continuation of work
- Characterization of JET divertor tiles 0, 1, 4, 6 with LIBS, LID-QMS, TDS and metallography of JET PFCs
- Quantitative analysis by CF-LIBS

IAP

- Continuation of work
- Analysis of samples from JET divertor tiles 4, 6, 7 and 8 with TDS and GDOES

SP E2

ISSP-UL

- Continuation of work
- Analysis of samples from JET divertor tiles 0 and 1 with TDS, FC and dissolution method.
- Simulation of C39 JET baking experiment.

MPG

- Continuation of work
- Characterization of JET divertor tiles 4, 6, 7 and 8 with RBS and NRA

NCSRD

- Continuation of work
- Analysis of samples from JET divertor tiles 4, 6, 7 and 8 with µbeam NRA

SP E2

VR

- Continuation of work
- Characterization of samples from JET divertor tiles 4, 6, 7 and 8 using ion beam analysis (HIERDA)

VTT

- Continuation of work
- Sectioning and preparation of samples from JET divertor tiles 4, 6, 7 and 8
- Characterization of samples from JET divertor tiles 4, 6, 7 and 8 using SIMS, optical microscopy and TDS (jointly with CCFE)

SP E3

FZJ

- Continuation of work
- Characterization of JET plasma facing components with LIBS, LID-QMS, TDS and metallography

IAP

- Continuation of work
- Analysis of JET plasma facing components with TDS and GDOES

IPPLM

- Continuation of work
- Electron microscopy (SEM, TEM, FIB) of JET plasma facing components

ISSP-UL

- Continuation of work
- Analysis of JET plasma facing components with TDS, FC and dissolution method

SP E3

IST

- Continuation of work
- Characterization of JET plasma facing and diagnostics components using ion beam analysis (RBS, NRA)

MPG

- Continuation of work
- Characterization of JET plasma facing components using ion beam analysis (RBS, NRA)

NCSRD

- Continuation of work
- Analysis of JET plasma facing components with μbeam NRA

SP E3

VR

- Continuation of work
- Characterization of JET plasma facing and diagnostics components using ion beam analysis (HIERDA)

VTT

- Continuation of work
- Characterization of JET plasma facing components using SIMS, optical microscopy and TDS (jointly with CCFE)

EU-Japan collaboration

Topics (2022-2023)

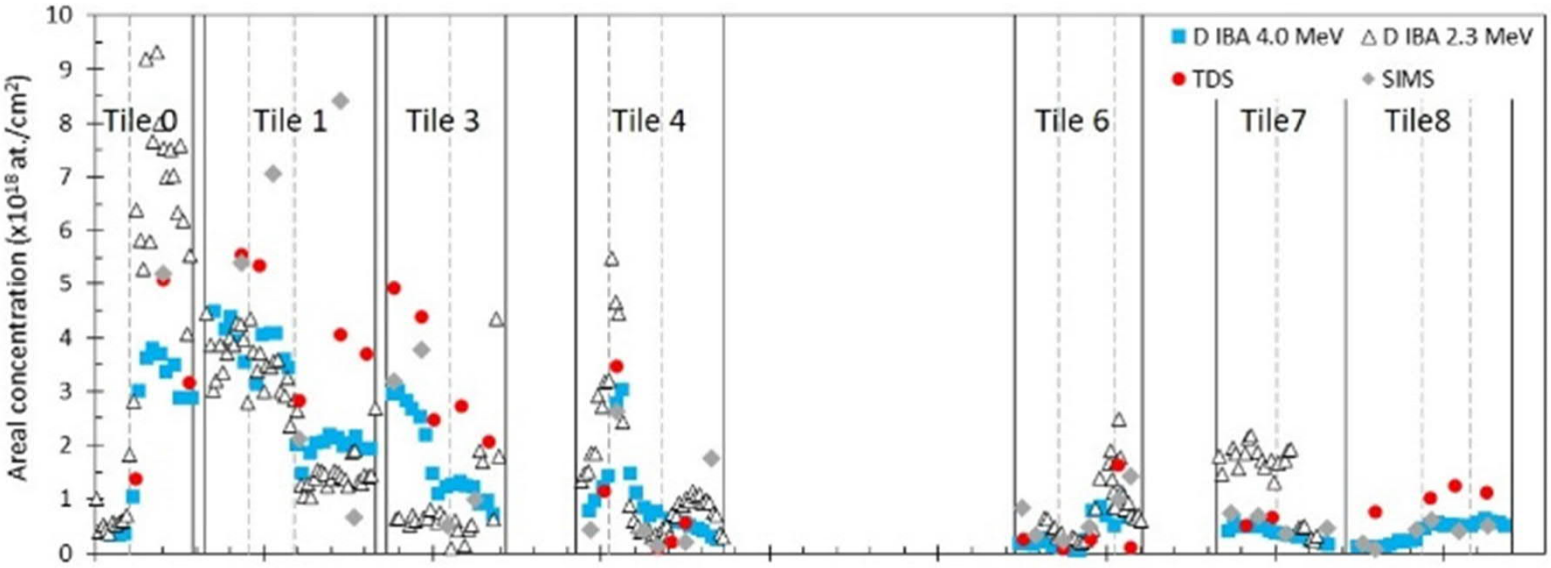
- IC09 SP E.2: EU-Japan (Rokasho/Broader Approach F4E), 2022 - 2023

- Analysis of divertor tiles (multiple campaigns)
  - Fuel accumulation in successive campaigns using BIXS technique
  - Tile gaps including W lamellae
  - IP imaging of divertor tiles
  - IP imaging of LID-QMS treated tile 0
  - Tritium depth profiling using IP imaging of laser ablated craters
- Analysis of Be wall tiles
  - Fuel accumulation in gaps
- Divertor samples from ILW1 and ILW3 analysed in the past → ILW2 samples to be shipped to Japan

Extra slides

SPE.2: Fuel retention in JET divertor

- Main deposition occurs at the top part of the inner divertor on tiles 0 and 1 with the highest fuel content.



- 61% percent of global fuel retention is in the divertor
- in inner divertor 47%

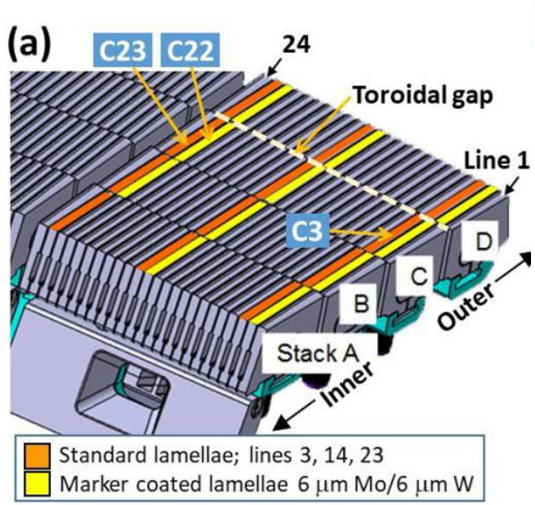
Deuterium areal concentrations on divertor tiles (ILW3) measured using IBA, TDS and SIMS
A. Widdowson et al. Phys. Scr. 2021

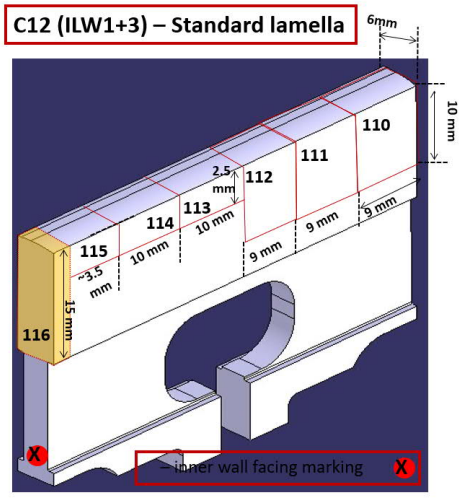
Deliverable: PWIE.SPE.2.T.001.D001-D009
Status: *N/A*
Facilities: *8 days accelerator (NCSRD, VR)*

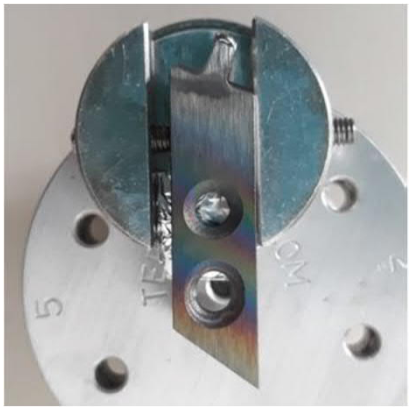
Human Resources: *total 21 PM +2PM for CU*
Involved RU: *CU, FZJ, IAP, ISSPUL, IST, MPG, NCSRD, VR,VTT and CCFE as a collaborator*
Linked WP or TSVV: *WP TE*

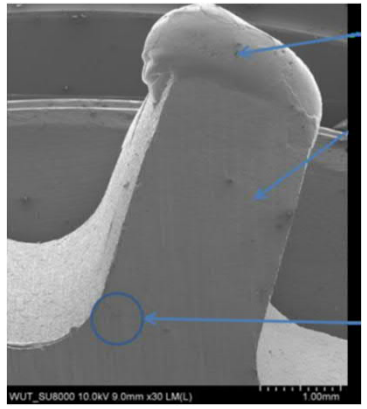
SPE.3: Post-mortem analysis of PFC in JET

- Task will concentrate on investigation of material migration from limiters and main wall towards divertor and on the characterisation of eroded PFC components.
- Post-mortem analyses will be made from existing samples as there is no sample removal foreseen by the end of 2024.
- Diagnostic components, such as rotating collectors, W sticking monitors, mirror cassettes, tungsten lamellae, Langmuir probes and QMB covers are available for post-mortem analyses.









Langmuir probe, ILW2

Deliverable: PWIE.SPE.3.T001.D001 - D010
Status: *N/A*
Facilities: *9 days accelerator (IST,VTT)*

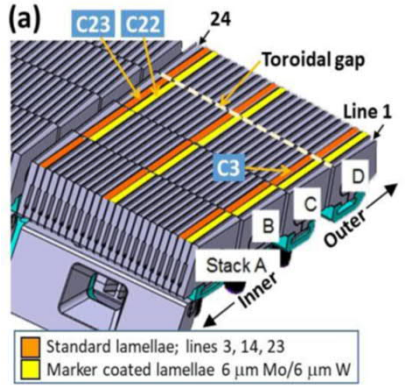
Human Resources: *total 61 PM*
Involved RU: *CU, FZJ, IAP, IPPLM, ISSPUL, IST, MPG, NCSRD, VR,VTT and CCFE as a collaborator*
Linked WP or TSVV: *WP TE*

Long exposure divertor tile analysis

Tile	Exposure in JET	Coating	To be done (if not yet available)	Action
HFGC Mod14N	2011-2016	Standard W coating	**- SEM on 4A**, 2b from ILW1 & ILW2 & ILW3 - IBA data exists on 2010-16 HFGC tile	Location of samples TBC
14IWG1A Full tile - uncored	2011-2016	Standard W coating	- 14ING1C(ILW1) core 10 – SEM available - 14ING1C(ILW2) core 10a&b - SEM available - 14ING1C(ILW3) core 10a – optical microscopy available, NO SEM found	- TOF sims - Sections of cores 8a and 10 a for ILW(1+2+3) tile
Tile 3			No three campaign tile available	
14BNG4D	2013-2016	Marker		Single campaign tile – sections to be checked
2BNG6C	2013-2016	Standard W coating	- ILW1 core 5b SEM available	
14BNG6D	2013-2016	There is no such tile	14BNG6D(ILW2) core 2b SEM available	
15BNG6C	2011-2016	Standard W coating?	(15BNG6C – “hot” tile) cores 5 to 9 available, cores 5,7,9 SEM-ed and EDX-ed	
2ONG7A	2013-2016	Standard W coating	IBA data available for outer divertor tiles for individual campaigns (M. Mayer)	
2ON G8B	2013-2016	Marker	Full tile available/	
Tile B Mod3N	2011-2016	Standard W coating	B2RH Cores 1-4 available	Option for future study for delamination studies
Tile C Mod3N	2011-2016	Std. W coating	Cores 1-4 available	Option for future study for delamination studies
W lamellae	2011-2012, 2015-2016	None	Crystallization, changes in microstructure studies *ILW3: Stack B: B02; B13; B14; B23; B24 available Stack C – cut samples	*some lamellae were exposed for two campaigns Check with Sebastijan

Microstructure and thermo-mechanical properties of W and Be

- ITER interest: *Power handling due to repeated/long term plasma exposure/damage/melting on W and Be*
- Comparison of non-exposed, exposed ILW1-ILW3, ILW3
- Microstructure of *W lamellae and Langmuir probes*:
  - Recrystallisation of W lamellae – Stack B,ILW2 and ILW3
  - Langmuir probes: hottest ones most interesting
    - 2 campaign probe 25(15BW), 26-melted and analysed(16BW) removed 2016
    - Probe 7&8
  - LPs (ILW2) analysed, ILW3?



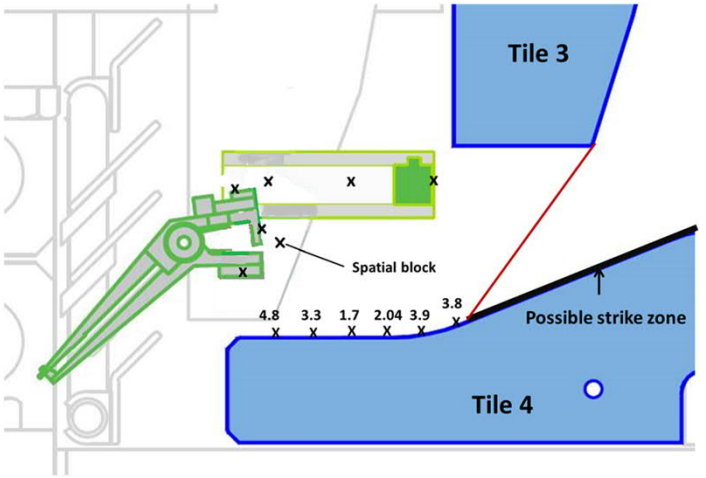
- Thermo-mechanical properties
  - Nano-indentation on W (CCFE, IPPLM)
  - Thermal conductivity – laser flash on W (CCFE)
- Microstructure of Be castellations? Need for additional analyses?
  - Data from Makepeace, Jepu, Pintsuk available

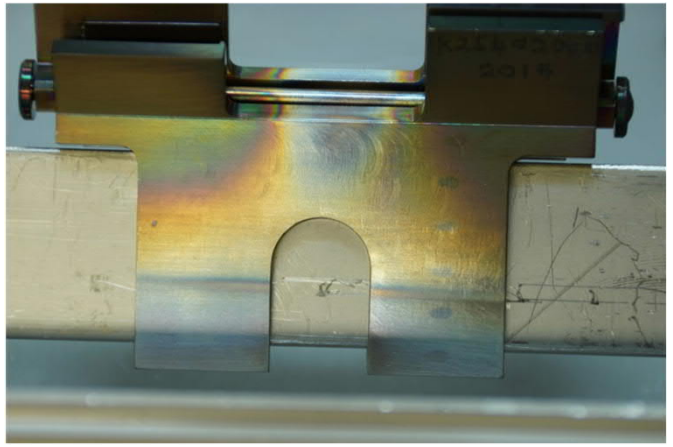
Long term exposure inner wall tiles

Tile	Exposure in JET	Marker coating	Cut?	Status
2XR11	ILW1-ILW3	No	Yes	Done
2XR6	ILW3	No	No	?
2XR15	ILW3	No	No	?
1XR18	ILW1-ILW3	No	Yes – damaged area	Is this for ITER RE damage studies?
2XR9	ILW2-ILW3	Yes	No	
2XR18	ILW2-ILW3	Yes	No	
7Z12R/L (recessed)	ILW3	W coated	No	Done, no need for further analyses
403 IWC		Be coating	To be kept (SPE)	Done?
412 IWC		Be coating	Cut one IWC	Done?
4D15	ILW1-ILW3	No	Yes	Done
3A8	ILW1-ILW3	No	Yes - damaged	Sections at FZJ

Analysis of louvre clips

- Aim:
  - Chemical structure of deposits
  - Modelling of Be, W migration
- IBA (TOF-ERDA) analyses completed
- Cutting of louvre clips required for TDS (Raman-MRF; XPS-IAP if cut?)
- ILW3 louvre clips to be used.
- ILW1&2 to be kept for possible future comparison if ILW3 results are interesting





Analysis of mirrors and mirror cassettes

- No resources allocated for mirror cleaning under SPE in 2022-2023
  - L. Marot has provided a list of mirrors for future experiments
- Analysis of mirror cassettes
- *Aim: validation of ERO modelling, metal migration inside cassette*
- Which cassettes are available?
- Cutting perhaps required depending on geometry in ERO modelling
- Bottom of channels easily accessible for IBA, side walls?
- Cutting plan after discussions with modellers
- Analysis of baffles?

- ITER mirror holder
  - Available
  - IBA?

Available (found in BeHF):

3E ILW1 mirror cassette(rack 2 box 4a)
2N wedge ILW1
2ON middle ILW2
4B ILW2 (rack 3 box 10)
2IN ILW2 (rack 3, box 10)
14N wedge ILW2 RH and LH
13N wedge ILW(1+2+3) rack 2 box 8a
13IW wedge ILW(1+2+3)
4B (with baffles) ILW3 came back from IPPLM shipment march 2021 – some results in Moon's paper
ILW3 cassettes are mostly available

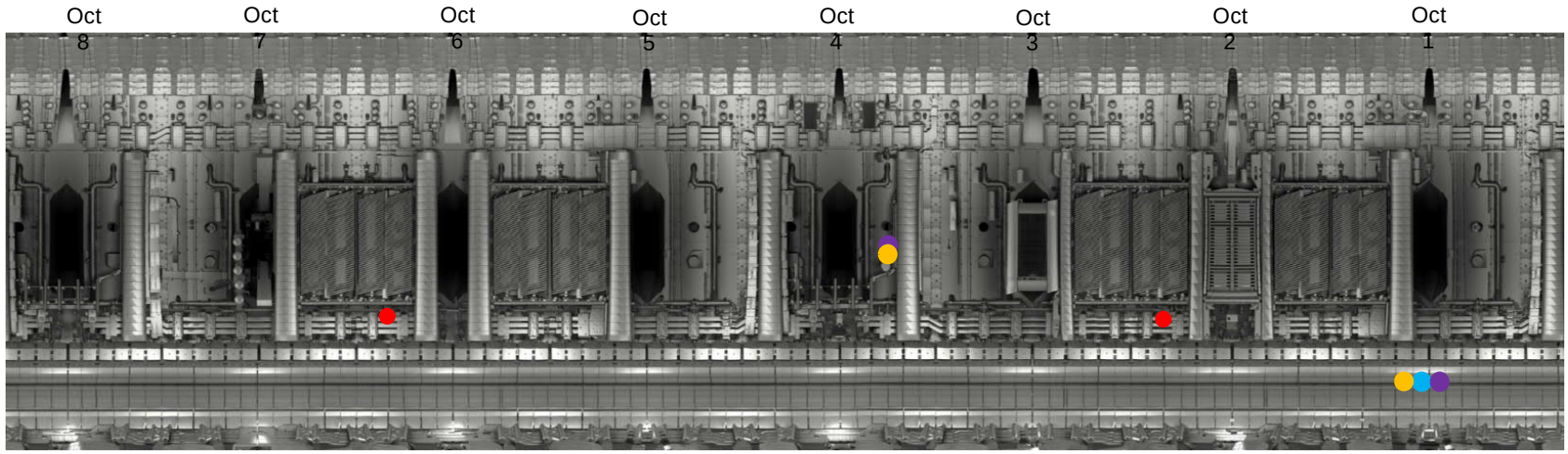
Standard cassette

Baffled cassette

Other passive diagnostics

- Sticking monitors (W foils) (2x inner wall and wedge) (ILW3)
- Deposition monitors IN and OU (Si

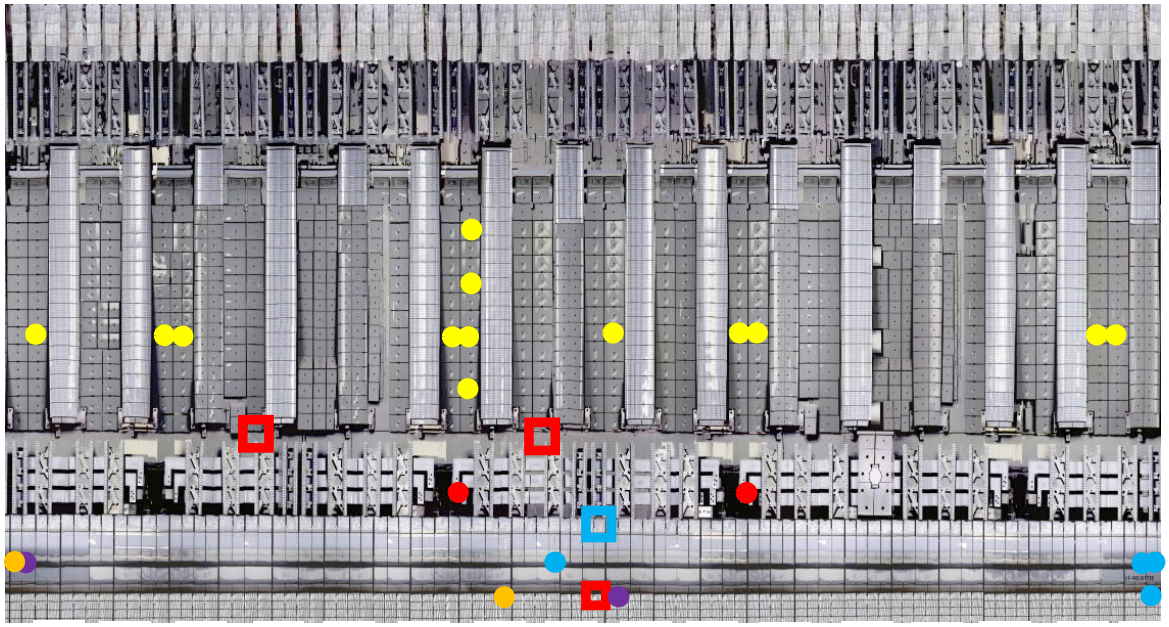
Erosion/deposition diagnostics: Outer wall & divertor



- Mirrors - (divertor deposition monitors, outer wall damaged/non-damaged)
- Rotating collectors
- QMB 5 (cover = deposition monitors)
- Dust collectors

Rendered image – NOT photograph

Erosion/deposition diagnostics: Inner wall & divertor



- Mirrors (deposition monitors)
- Rotating collector
- QMB 1, 2, 3, 4 (covers = deposition monitors)
- Inner wall cladding inserts 50:50 W:Be
- Tungsten sticking monitors
- Dust collectors
- HFGC tile – target for LID-QMS

Rendered image – NOT photograph