# WP PWIE SP B – meeting on dust analyses needs

## Minutes 31 March 2025

### Physics questions to be addressed

* List below from the slides shown by Antti:
* *What kind of dust is produced in European fusion devices?*
  + *How are the dust properties dependent on the experimental campaigns?*
  + *Differences between tokamaks (AUG, WEST) and stellarators (W7-X)? Metallic vs. non-metallic devices?*
  + *General properties of dust – composition, size distribution, shapes of particulates, fuel content etc.?*
* *Can we reproduce the dust collected from fusion devices in laboratory conditions?*
  + *How similar or different laboratory-made dust is to that observed in fusion devices?*
  + *Are we sure that all the dust can be collected/sampled in fusion devices?*
  + *What are the lessons learnt from parametric studies? Which ”knobs” are the best to be tuned?*
  + *Can we properly understand re-mobilization tendency of ”real” dust?*
* *What is the most important mechanism for dust production in fusion devices?*
  + *Deposits peeling off? Arcing?*
  + *Nucleation in cooler parts of the edge plasma? Role of external impurities?*
  + *Other methods*
* *Link of dust to safety considerations of fusion reactors*
  + *Do we need to be worried about thick deposits forming during (long-pulse) operations?*
  + *Are there noticeable risks during off-normal events in fusion reactors (air and water leaks, disruptions etc.)?*
* Additional points raised in the discussions
  + **Collection efficiency** by each method is an important parameter to be considered 🡪 may lead to biased interpretation of results
  + **Dust transport** should also be addressed: how dust ends up in certain locations and are our dust samples representative ones?
  + **Dust production rates** to be clarified besides the production mechanisms
  + Adhesion problems may be the reason for dust production from peeling off of layers 🡪 **properties of deposits** to be investigated along with the dust samples
  + Not all the dust is produced by plasma 🡪 which part is due to breaking components during interventions and maintenance?
  + One should **concentrate on “typical dust”**, not necessarily on “interesting dust” 🡪 statistical approaches preferred
  + **Role of boronizations** in dust formation to be clarified
  + **Speed and trajectories** of dust particles need to be determined 🡪 at least possible on WEST
* Comparison between devices and plasma operations requires at least
  + Identifying difference between **attached and detached plasma operations** (different heat and particle loads and transport patterns)
  + Simulating **dust production by targeted experiments** (manipulator studies with well-prepared dust samples, laser blow-off experiments,…) and correlation with layers and IR measurements
  + Assessing the role of impurity gases in erosion: cooling down vs. enhanced sputtering
* Laboratory devices can provide much added value for the studies but on the other hand they require the database from “real devices” to be as extensive as possible 🡪 not yet the case 🡪 **focus on tokamak and stellarator dust analyses in 2025**
* Ideally one should analyze only recently generated dust 🡪 cleaning of dust samples *in situ* would be preferred but may be utterly difficult and may only clean “loose stuff” from the surface

### Analyses capabilities and boundary conditions

* **Microscopy will be the main workhorse** – other analyses (m-IBA, LIBS,…) for spots that have been deemed to require further considerations by microscopy
* m-beam analyses generally time consuming 🡪 only a few representative samples can be measured
* **Sticky probes easiest substrates for the analyses** (all devices) – other candidates are Si wafers (presently only on AUG, size ~20 × 80 mm2) and dust boxes (WEST) or filters (WEST)
* IBA can be used for compositional analyses and determining D content 🡪 requires also old results to be published

## Actions for next steps

* **Generally, we need to analyze more dust samples from all devices to obtain a more representative database** 
  + WEST: filters, dust boxes and especially sticky pads available already now
  + W7-X: sticky pads ready to be sent around
  + AUG: Si wafers could be redistributed to other labs
* **Proposal #1**: each device selects max 5 representative samples (from one campaign or corresponding samples from successive campaigns) to be sent to participating labs 🡪 action on Elodie, CP, and Martin
* **Proposal #2**: the labs would determine similarities/differences between the samples
  + Dust statistics, composition, and fuel content to be determined
  + When analyses completed, we will schedule another meeting to decide on next steps
* **Caveats:** (i) samples not that representative for the real situation, (ii) too many factors to be disentangled, (iii) analysis and collection efficiencies imperfect
* Action on participating labs to **contact machine representatives** (CP for W7-X, Martin for AUG, Elodie for WEST) for the samples
  + IPPLM: microscopy studies
  + FZJ: LIBS measurements
  + RBI: m-IBA for the fuel content
  + VR: m-IBA for the elemental fingerprint and boron patterns