# SP B.1: Erosion and re-deposition of tungsten in Magnum-PSI

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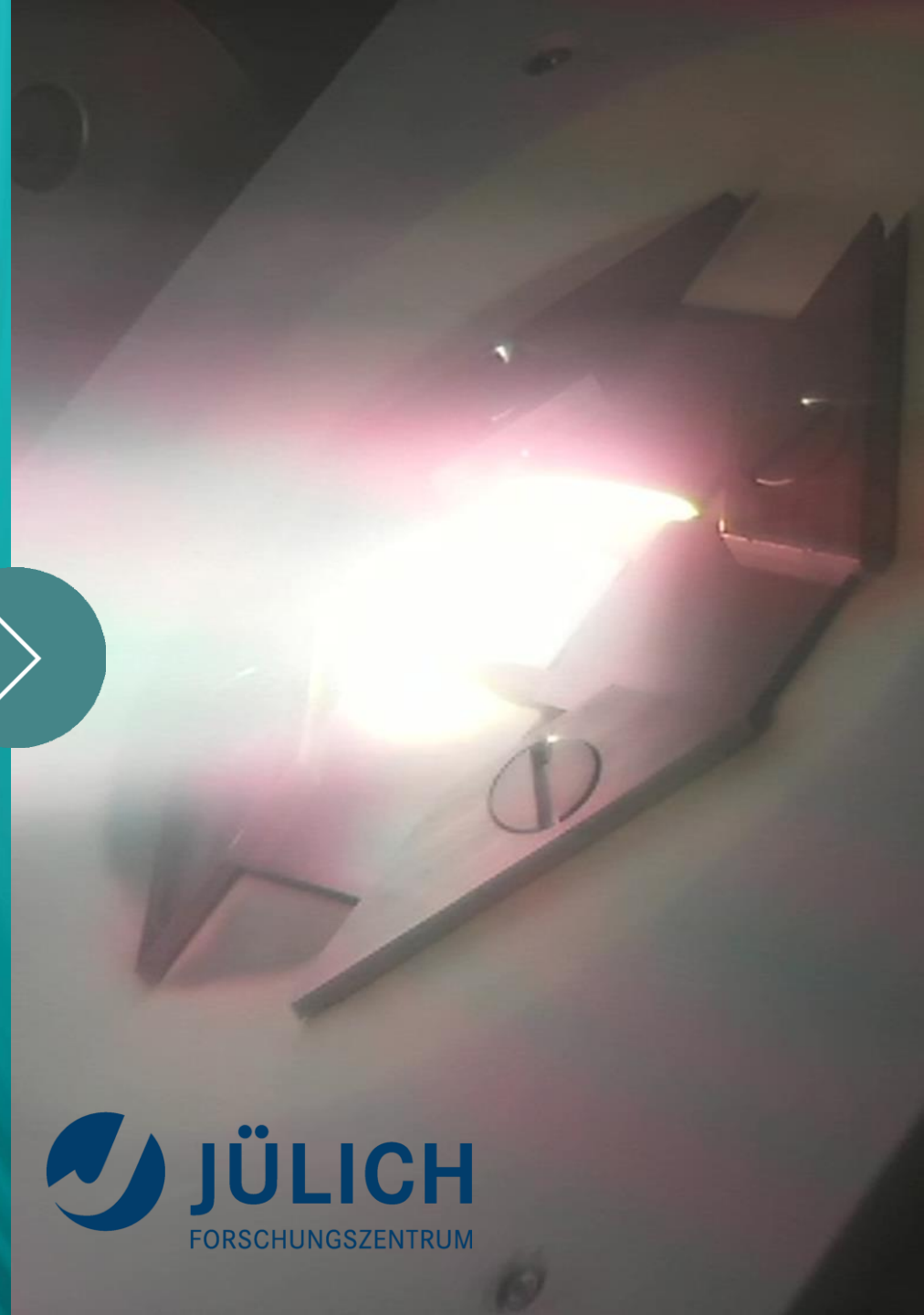


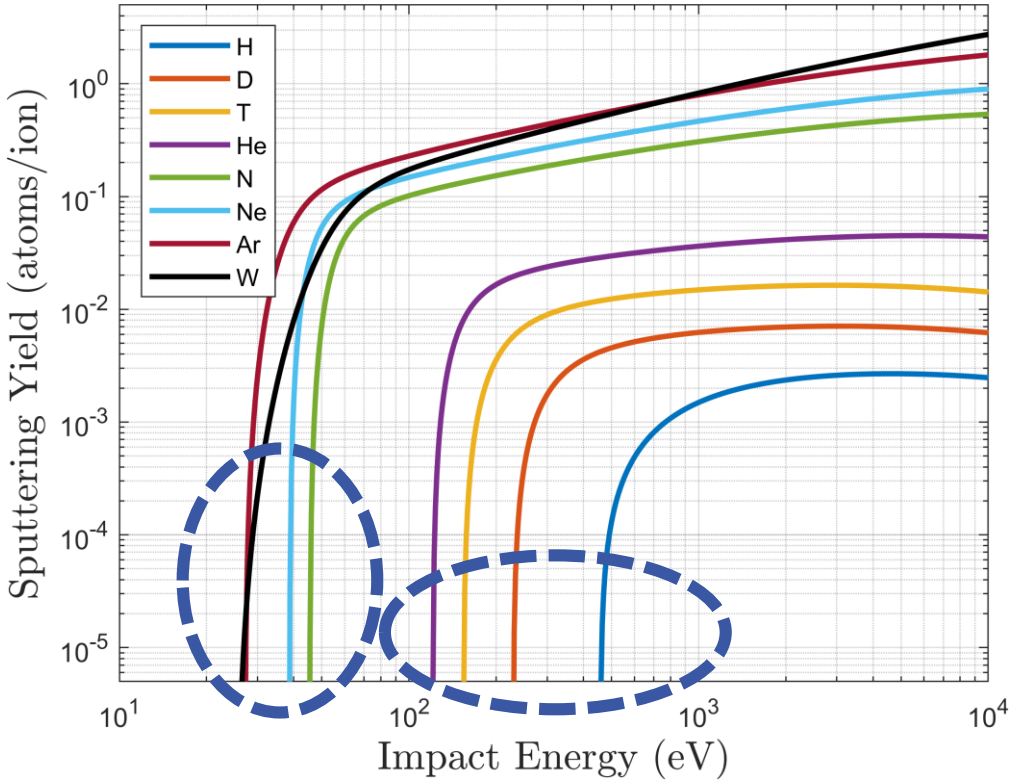
# Erosion is an important issue for the divertor

**ITER's divertor is planned to operate in the detached condition by impurity seeding.**

**Two types of impurities are present:**
**Intrinsic impurities: sputtering of the wall material.**
**Extrinsic impurities: seeded for detachment.**

**Due to the relatively low sputtering threshold energies of impurities, their effective erosion is an important issue for the divertor.**

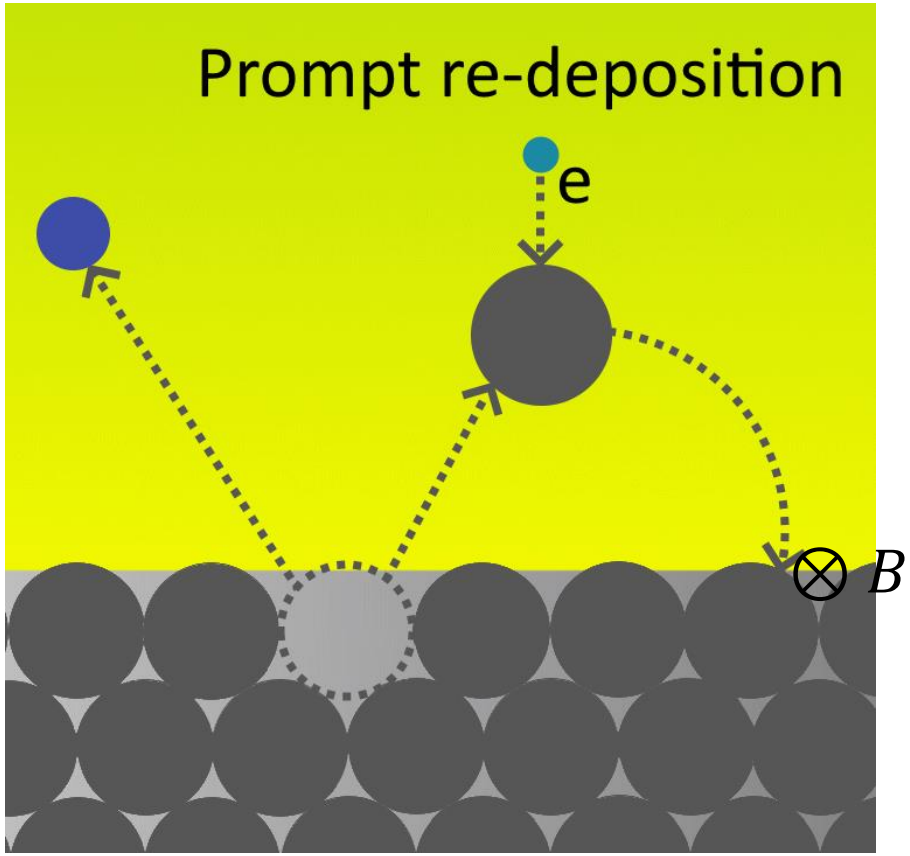
**Sputtering yields for tungsten**



# Re-deposition by entrainment or prompt re-deposition

**Two main mechanisms by which re-deposition occurs:**

**Prompt re-deposition:**
**After ionization, sputtered impurities may re-deposit because their gyro-motion intersects with the surface.**



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**Prompt re-deposition:**
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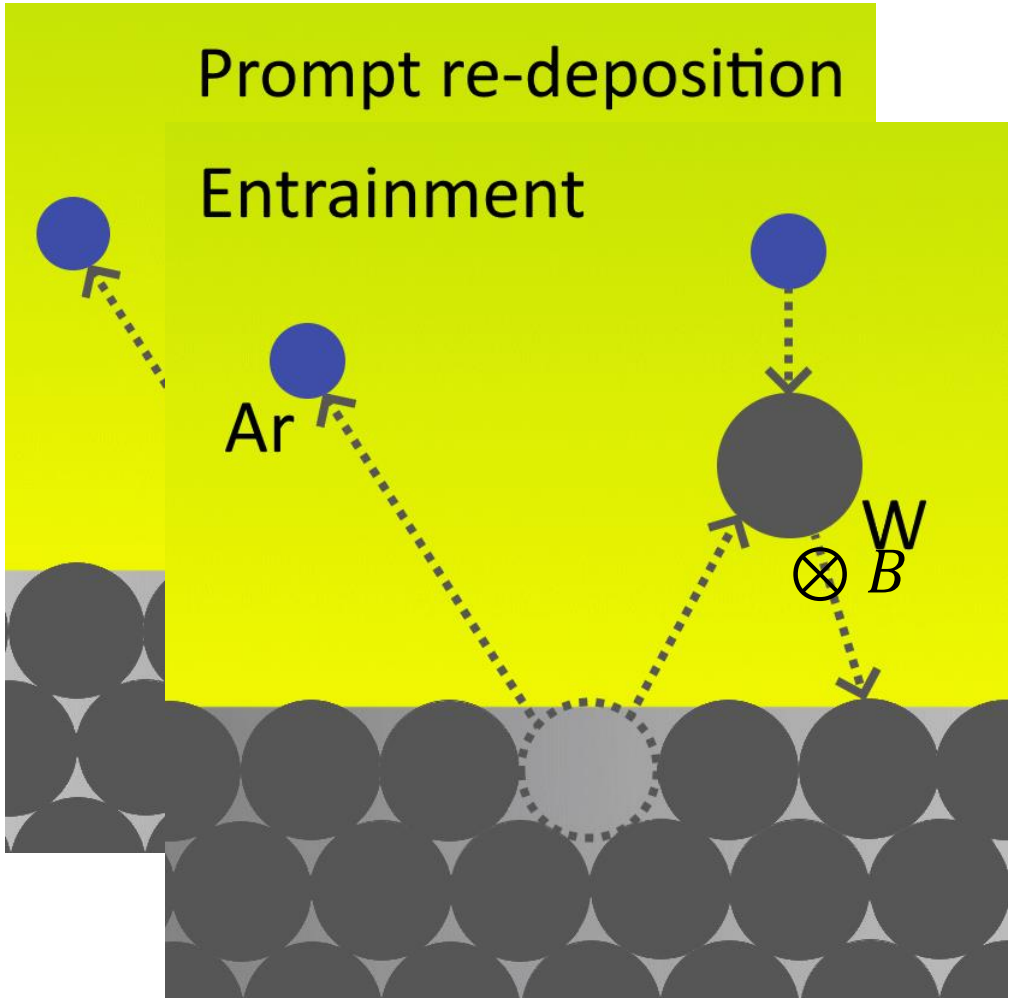
**Entrainment by ion-ion and ion-neutral friction:**
**The high collisionality induces a drag on the impurities that forces them to flow with the plasma.**



# Entrainment is a double-edged sword

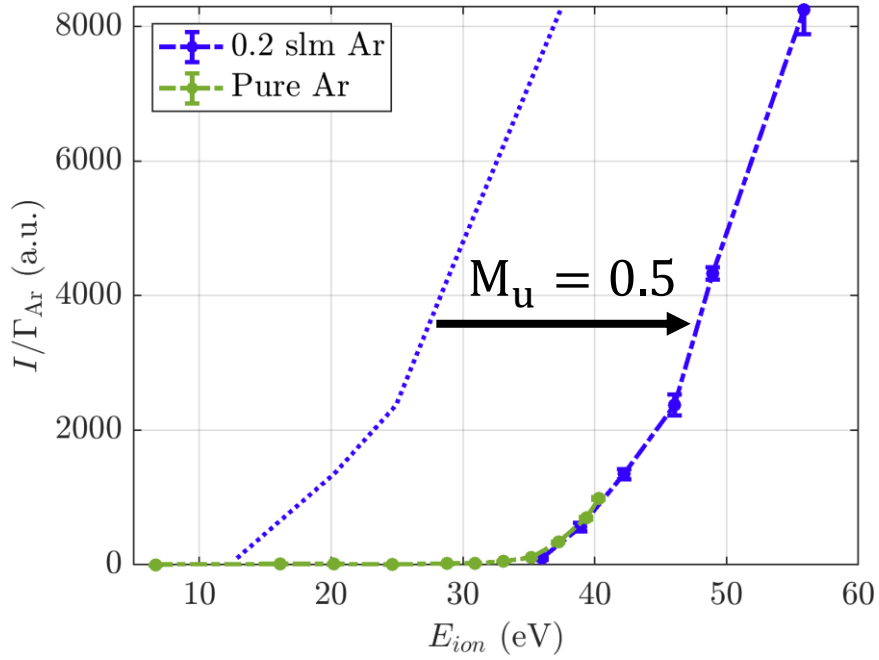
**Positive side:**

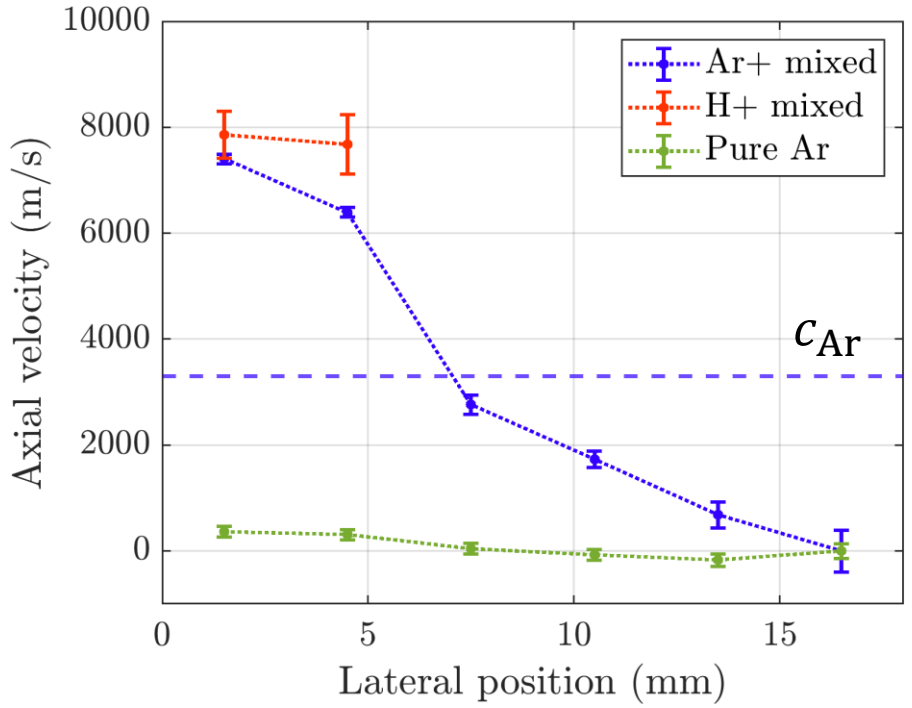
**Entrainment results in increased re-deposition rates.**

**Negative side:**

**Entrainment results in increased sputtering yields.**

$$E_{Ent} = M_u^2 \frac{m_{impurity}}{m_{main}} T_e$$




**The high impact energy of entrained impurities results in considerable sputtering.**

# Goal of the experiment

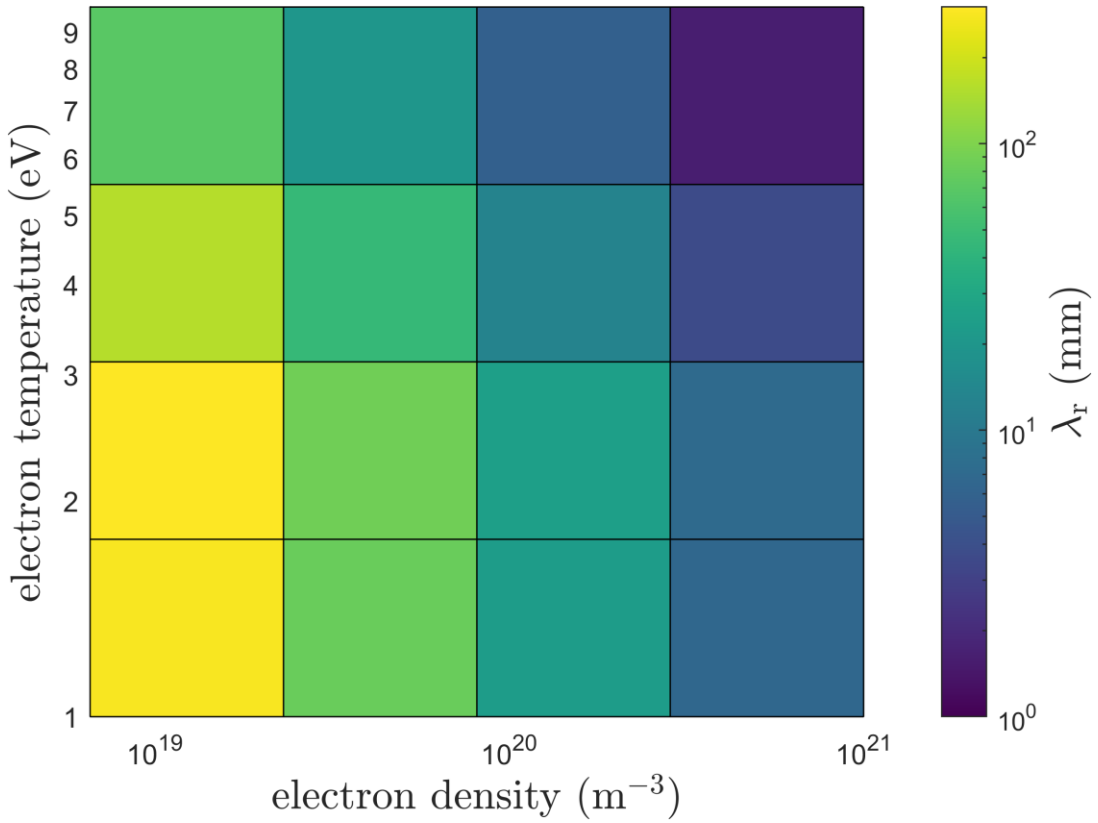
**Quantify the erosion and re-deposition of tungsten under ITER-relevant plasma conditions.**

- **What is the re-deposition rate of tungsten?**
  **The re-deposition rate indicates the seriousness of the erosion.**

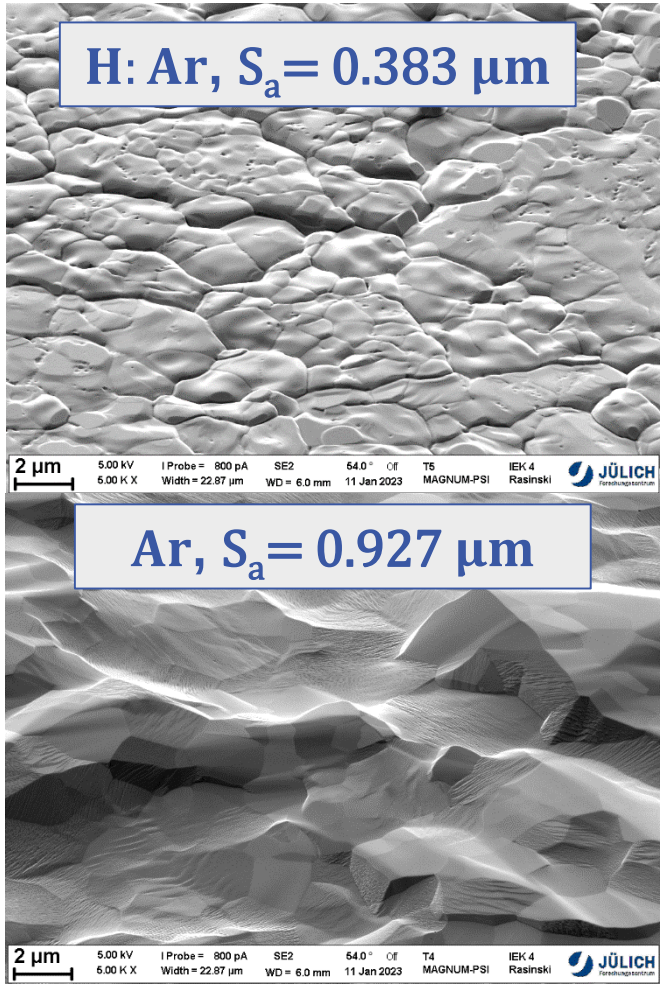
- **What is the dominant re-deposition mechanism?**
  **The re-deposition location can indicate the dominant re-deposition mechanism.**

**Expectation: small re-deposition lengths (2-10 mm) and high re-deposition rates (>95%).**

**Re-deposition length for tungsten**



# Sputtering and re-deposition of tungsten in Magnum-PSI 2022




**ITER's edge plasma will be much denser than for current tokamaks, allowing for impurity entrainment**

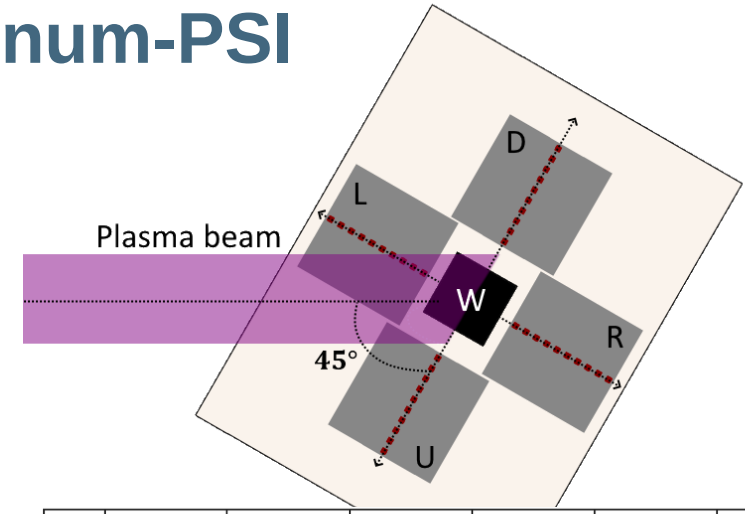
→ **H:Ar plasma exposure:**

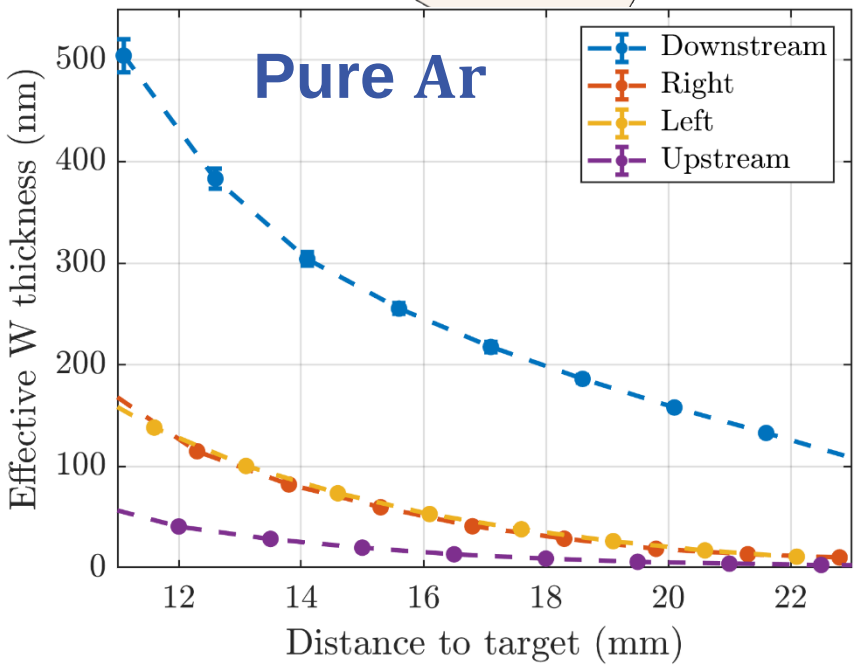
- High surface temperature (1280° C).
- Mo, Cu deposition from source.
- Small amounts of W erosion/deposition.

→ **Pure Ar plasma exposure:**

- Surface roughening due to sputtering.
- Considerable W re-deposition, more downstream than upstream.

➢ **Re-deposition by entrainment**



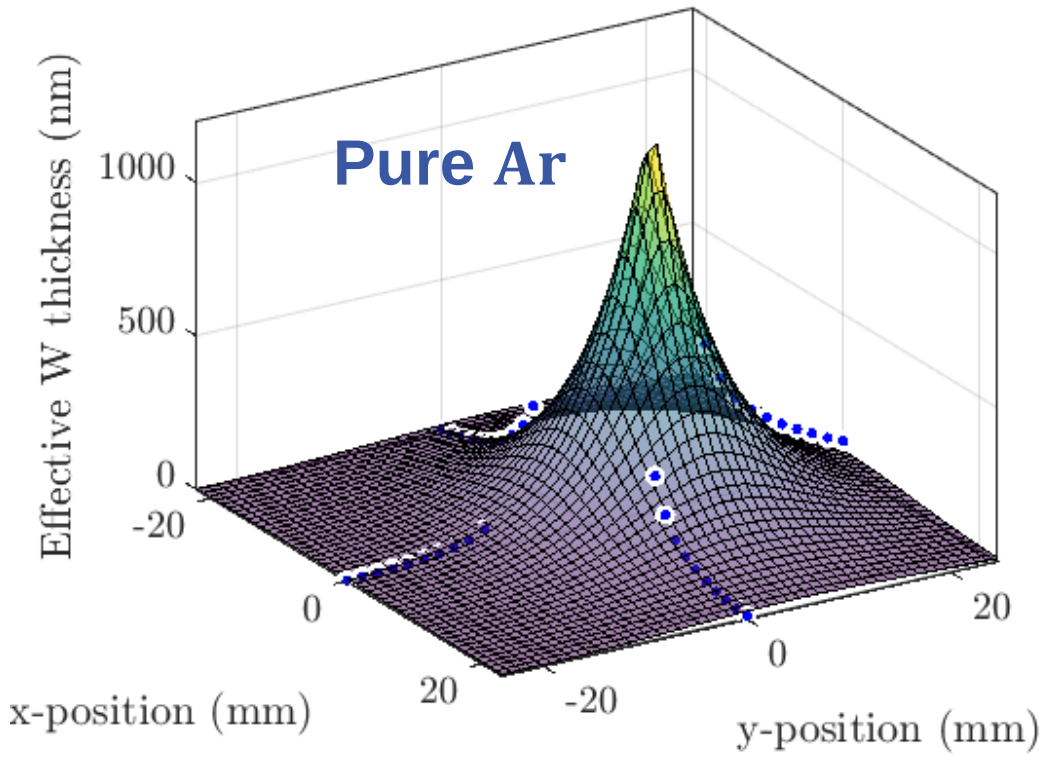



# Further studies: Acquire complete re-deposition profile

Re-deposition $R_T$ from theory & mass balance uncertain.

- **Complete re-deposition profile necessary to obtain certain re-deposition rates.**

| ID | $T_e$ (eV) | $n_e$ ($10^{20} m^{-3}$) | $\Delta l_g$ ($\mu m$) | $\Delta l_n$ ($\mu m$) | $R_T$ |
|---|---|---|---|---|---|
| Ar | 1.16 | 4.70 | 19.8 | 5.99 | 0.70 |



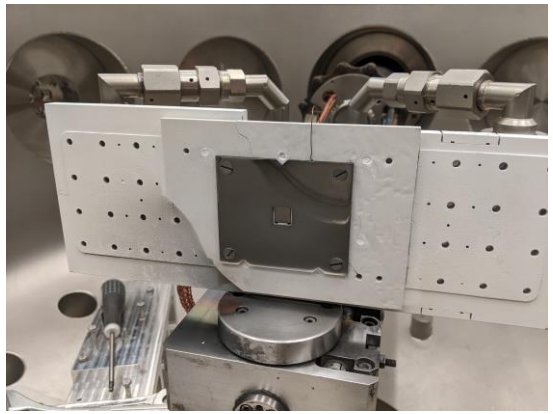
# Goals and approach 2023 activities

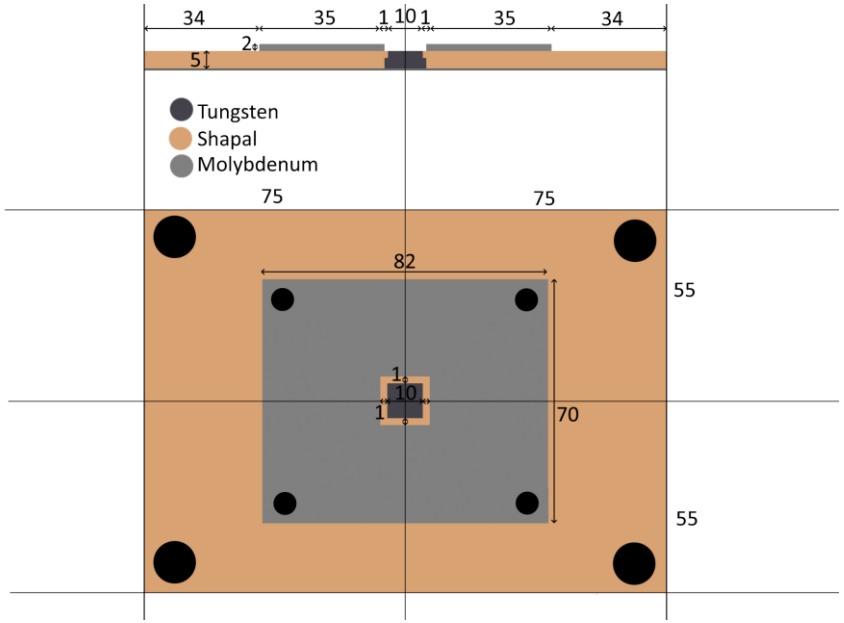
➢ **Goal 2023:**

- ❖ Obtain complete re-deposition profile for a denser plasma exposure (more entrainment) with a large witness plate.
- ❖ Analyse re-deposited W properties
- ❖ [Measure entrainment closer to plasma sheath edge (OES)]

**Planned post-exposure analysis:**

- ❖ RBS
- ❖ SEM
- ❖ NRA
- ❖ Profilometry





# Thanks for the attention

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