Capabilities for W source studies on WEST

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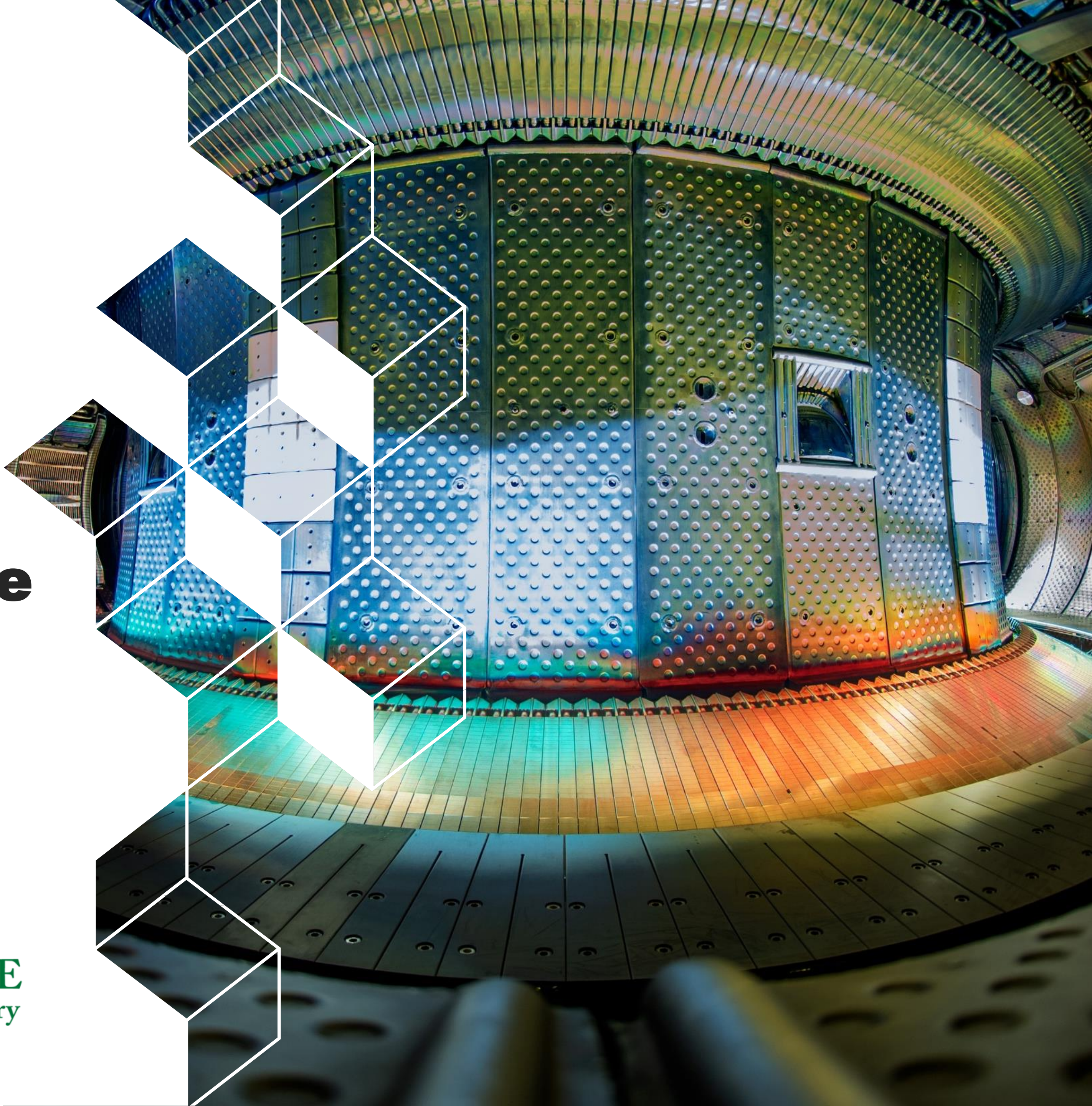


Outline

1. **Visible spectroscopy systems for W sources on WEST**

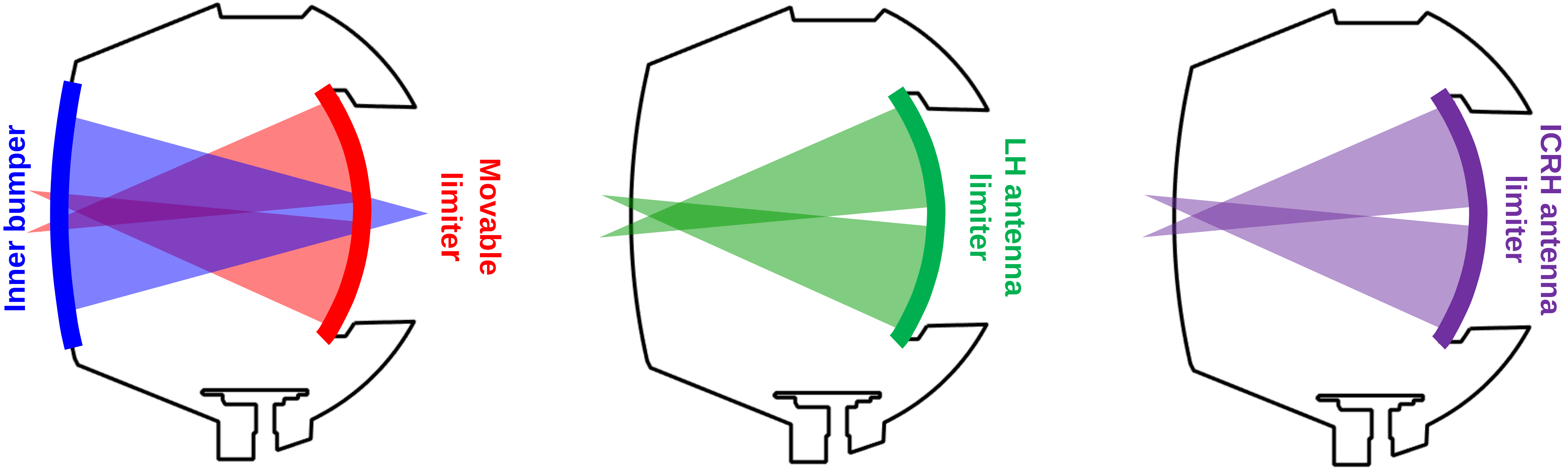
2. **Example of W sources monitoring on WEST limiters**

3. **Example of divertor W source monitoring under high particle fluence**

4. **Capabilities for core UV and SOL visible spectroscopy W studies on WEST**

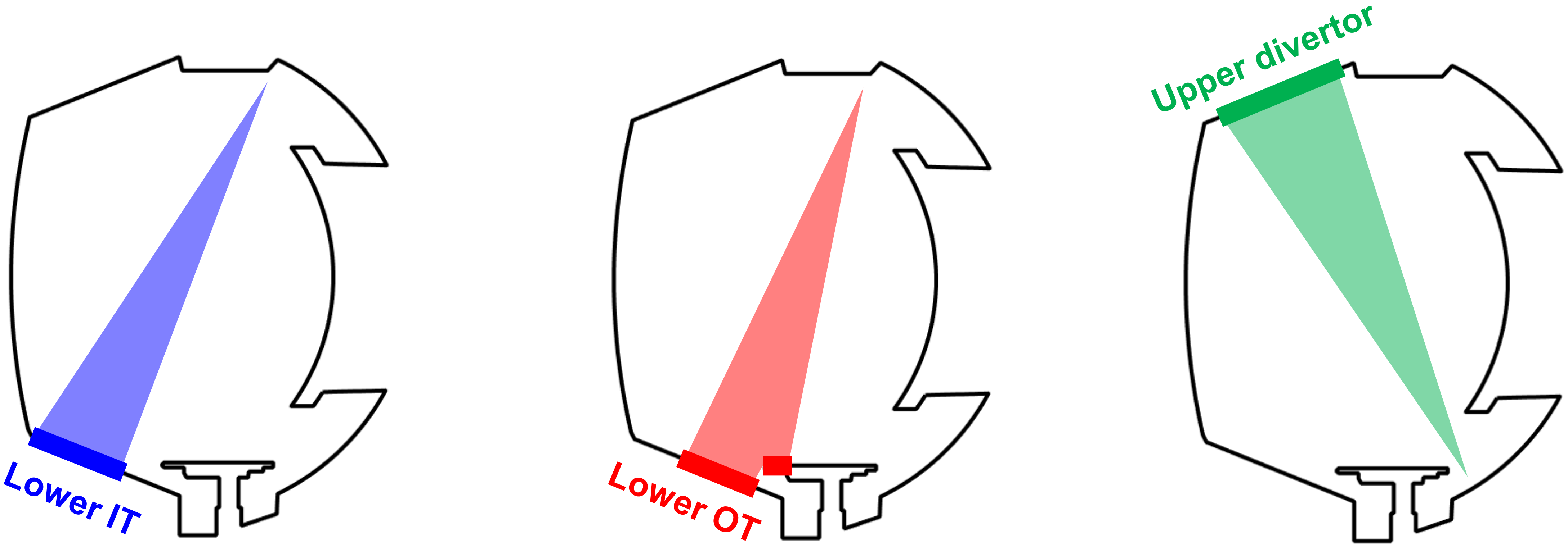
1. Visible spectroscopy systems for W sources on WEST

Good coverage of main chamber wall objects



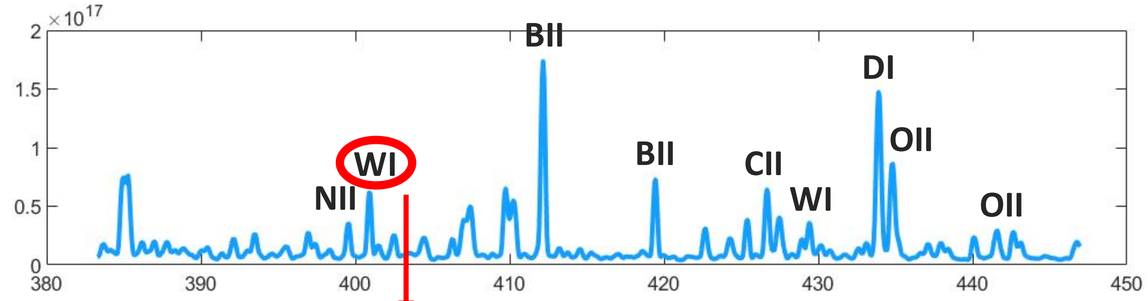
- **Limiters:** 8 LOS on one inner bumper and 12 LOS on the outer movable limiter
- **Antenna limiters:** 2 LH antennas covered, 1 ICRH antenna and a 2nd ICRH antenna soon (ORNL)

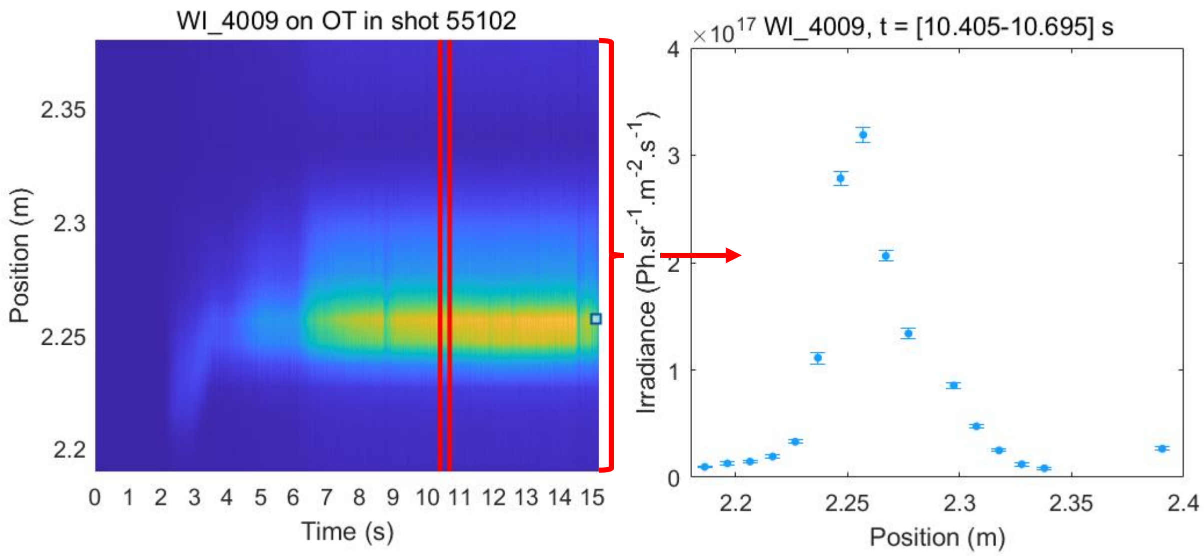
High resolution divertor visible spectroscopy LOS



- **Lower divertor:** IT and OT covered with 36 LOS for each with <1cm² resolution (smaller than a monoblock surface)
- **Upper divertor:** only the OT is covered with 36 LOS too

CEA visible spectrometers for W & other impurities

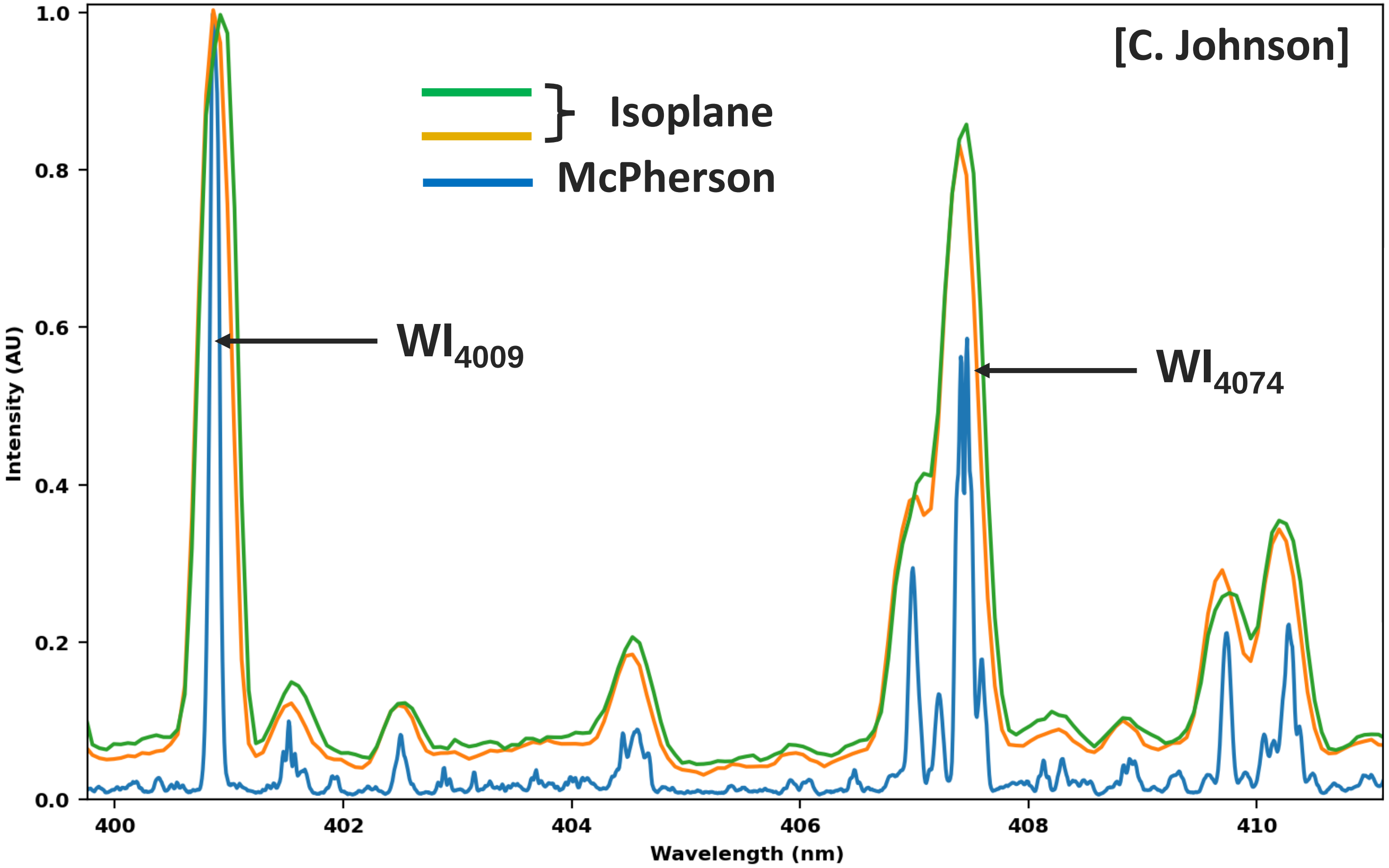




- **2 Princeton Instruments Isoplanes:** 27 channels (ROI) each looking at the 385 – 445 nm domain with 1024x1024 cameras → allows profiles on divertor targets and limiters
- 1 high resolution home made spectrometer dedicated to D_α – H_α measurements (512x512 camera looking at the 653.5 - 658.5 nm domain) for isotopic ratio calculation

ORNL visible spectrometers for W impurities

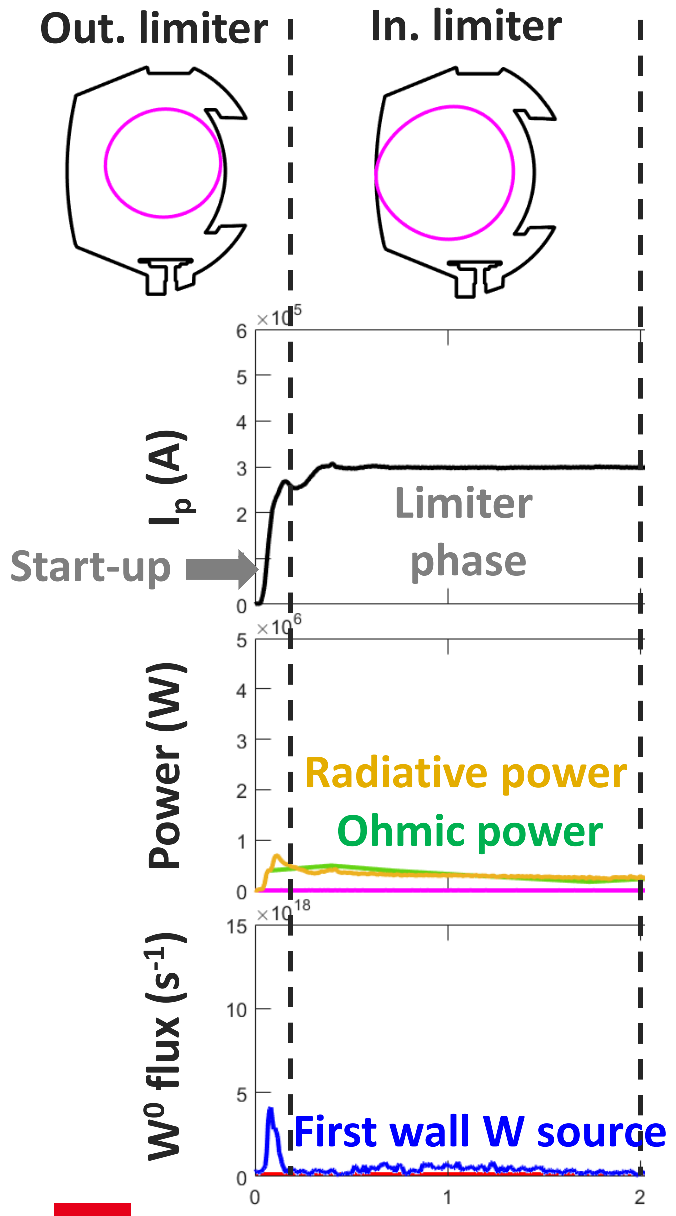
Oak Ridge National Laboratory



- **High resolution McPherson spectrometer:** 11 channels (ROI) each looking at a 12 nm range in visible and near UV (~350 to ~500 nm) with a 1600x1600 camera (absolutely calibrated for next campaign)
- **Filterscope:** 9 channels dedicated to WI at 4009 nm and D_α (in maintenance for the next campaign)

2. Example of W sources monitoring on WEST limiters

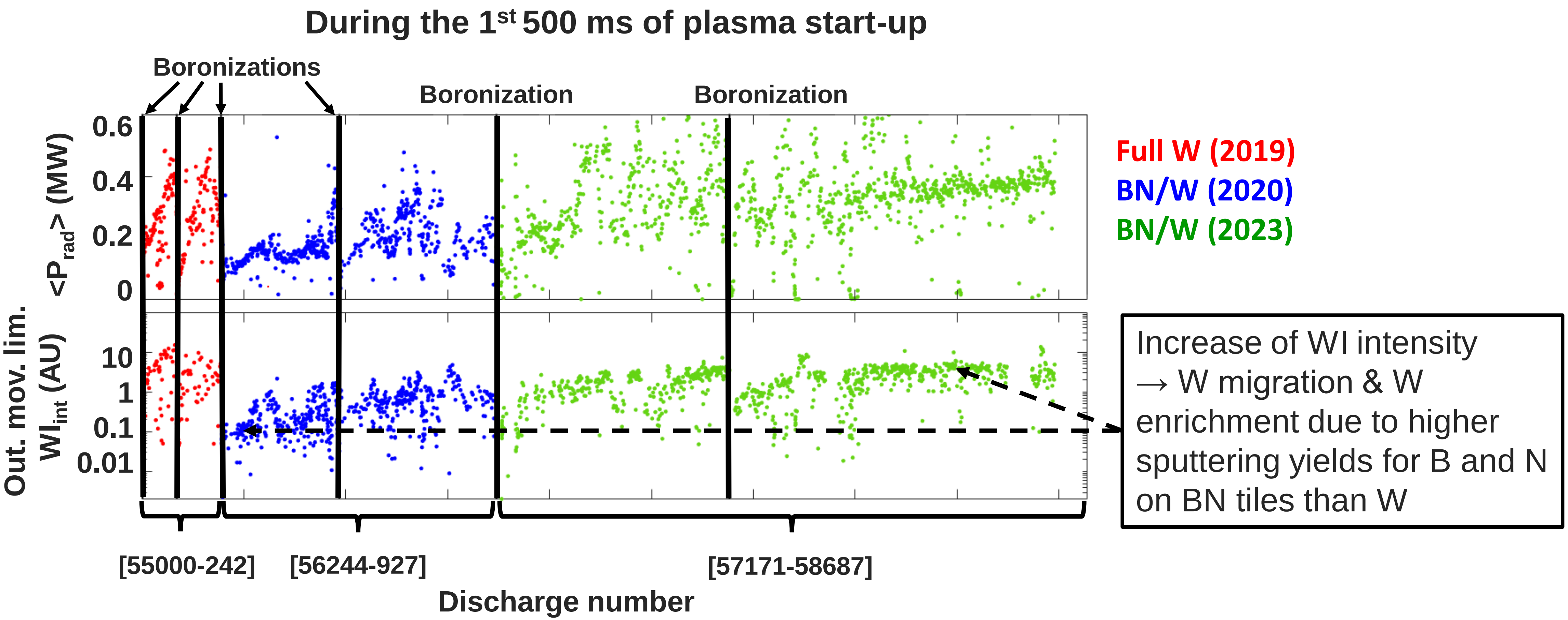
Significant limiter W sources during start-up



Time (s)

- Monitoring of the W source on main chamber objects has helped identifing a strong and harmful contribution from the outer movable limiter
- The maximum amplitude of the transient limiter W source during start-up is comparable to the divertor W source in ohmic

Monitoring of W migration on low Z limiter tiles

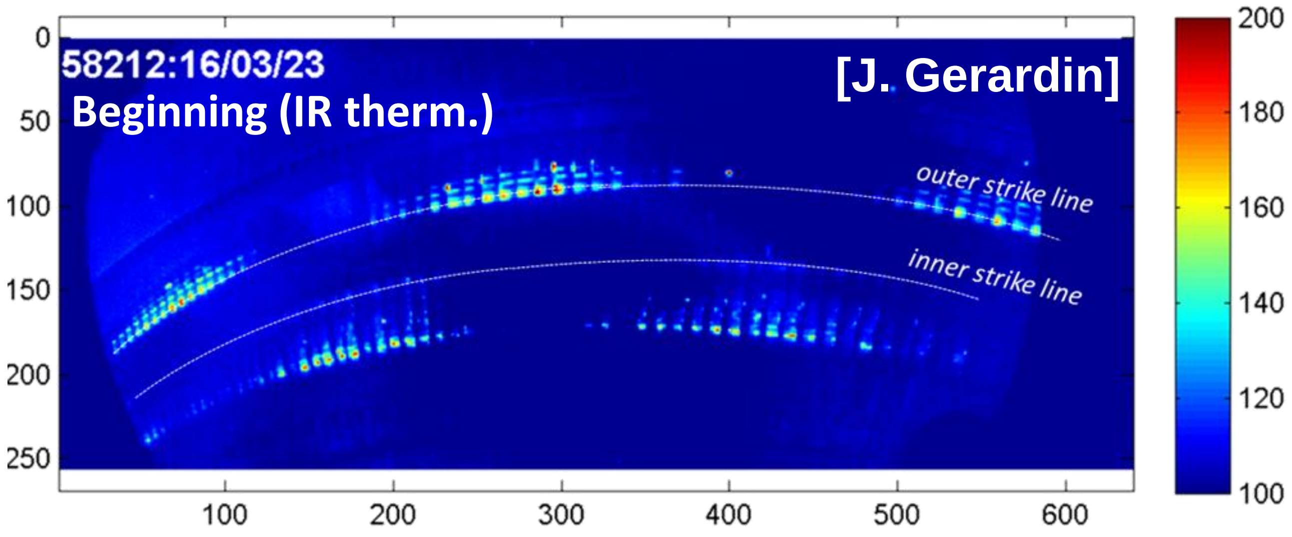


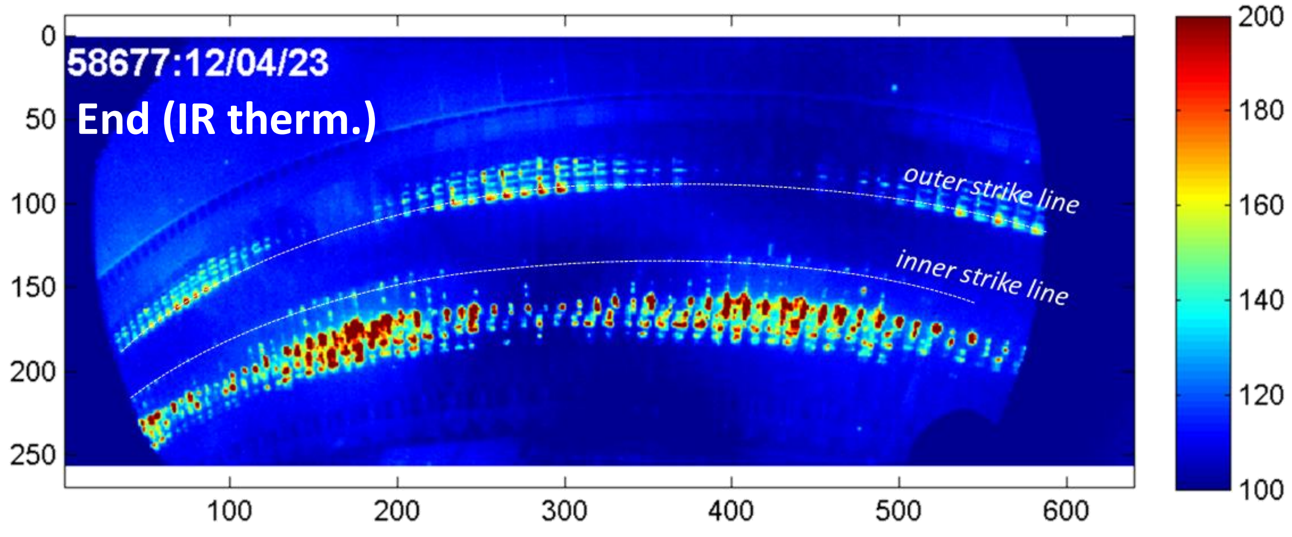
- Low Z (BN) tiles were tested on the 1st wall in WEST for 5 campaigns to characterize its effect vs a high Z 1st wall
- The visible spectroscopy system is sensitive enough to observe W migration & accumulation on the BN tiles.

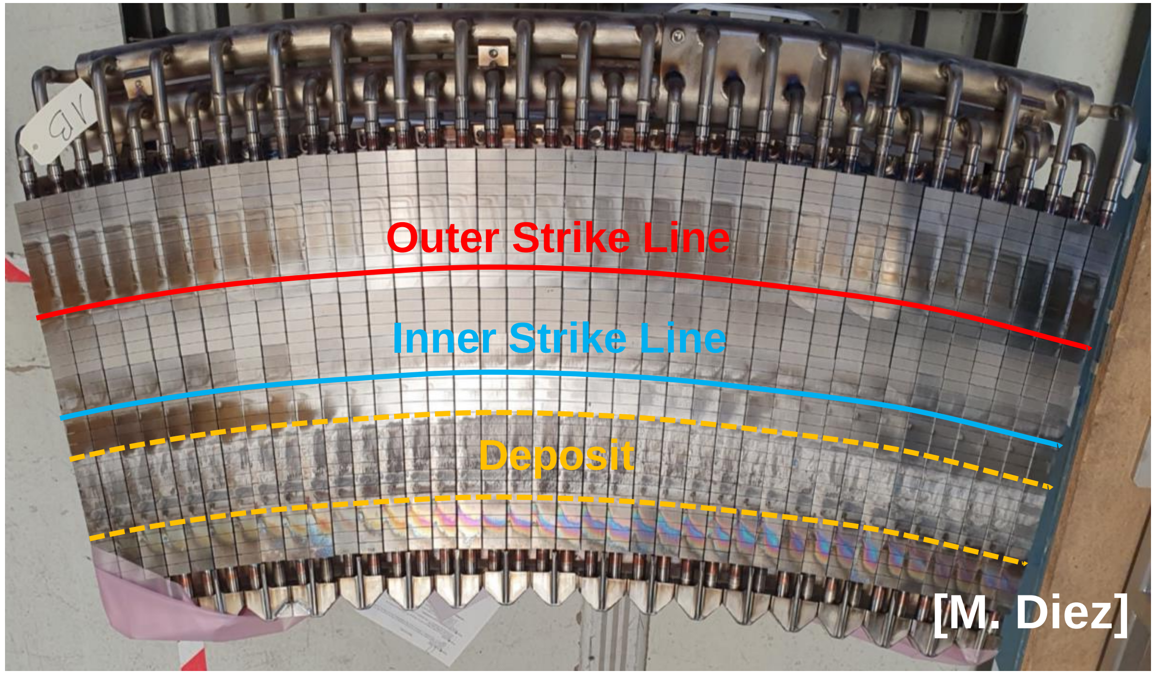
[C.Guillemaut et al., submitted to be published in NF]

3. Example of divertor W sources monitoring under high particle fluence

Degradation of divertor surfaces with particle fluence



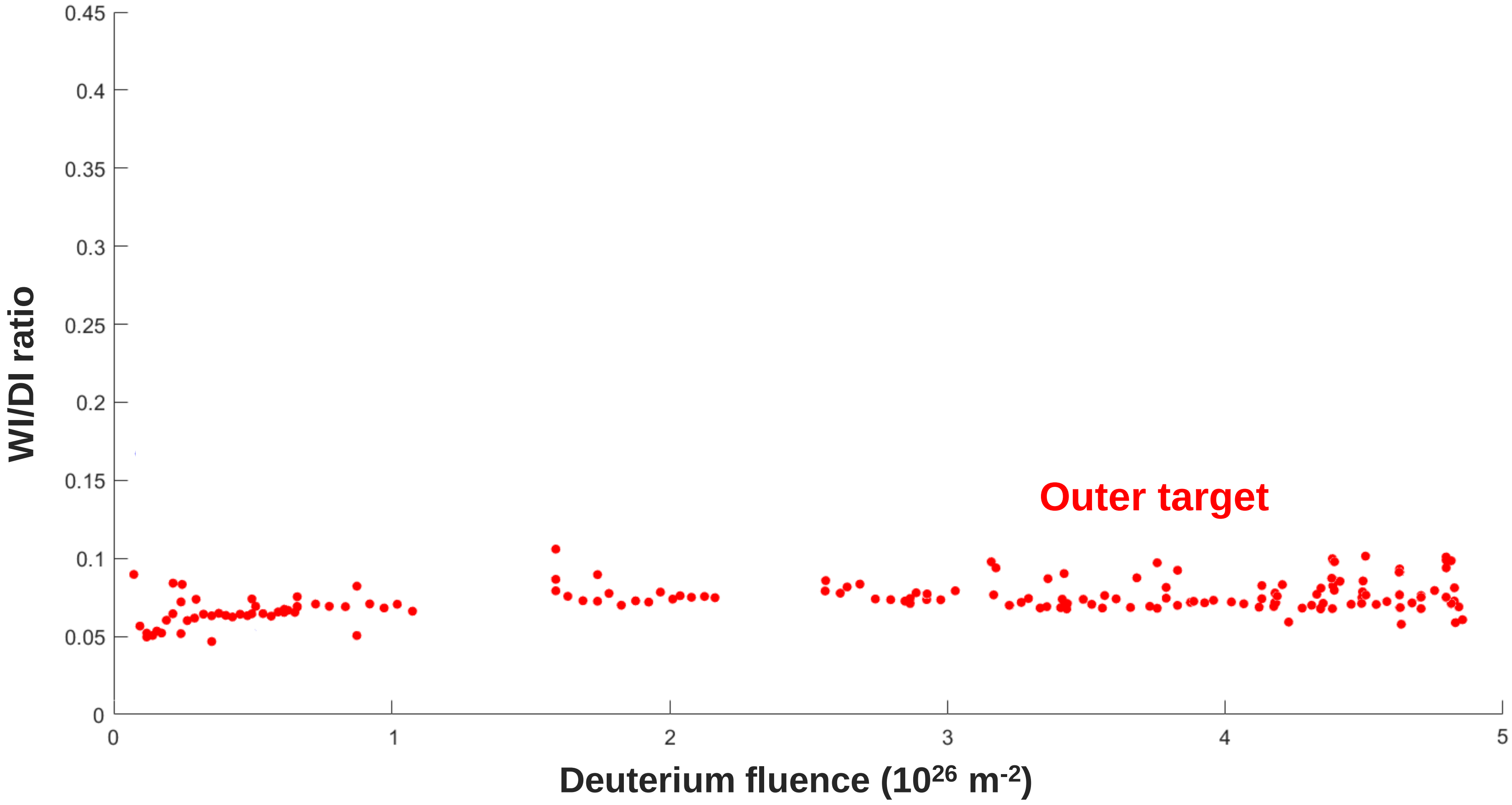




- Thanks to the unique capability of WEST to do long powered discharges, it as been possible to accumulate the particle fluence equivalent to two Pre-Fusion Plasma Operation ITER shots on a divertor made of ITER-grade W monoblocks
- The evolution of the divertor impurity sources were monitored all along by visible spectroscopy

[E.Tsitrone et al., submitted to be published in NME]

Evolution of the W divertor sources with fluence



- Small increase of the WI/DI ratio on the OT with D fluence
- The visible spectroscopy system observed a significant increase of the WI/DI ratio on the IT probably due to the accumulation of impurities in the deposit → enhanced W sputtering by impurities and self-sputtering

4. Capabilities for core UV & SOL visible spectroscopy W studies on WEST

Contribution of divertor vs antennas to core W content

Divertor LP array
[J.P.Gunn]

Use of S/XB with T_e and n_e given by LP to calculate the neutral W flux with visibe spectroscopy data

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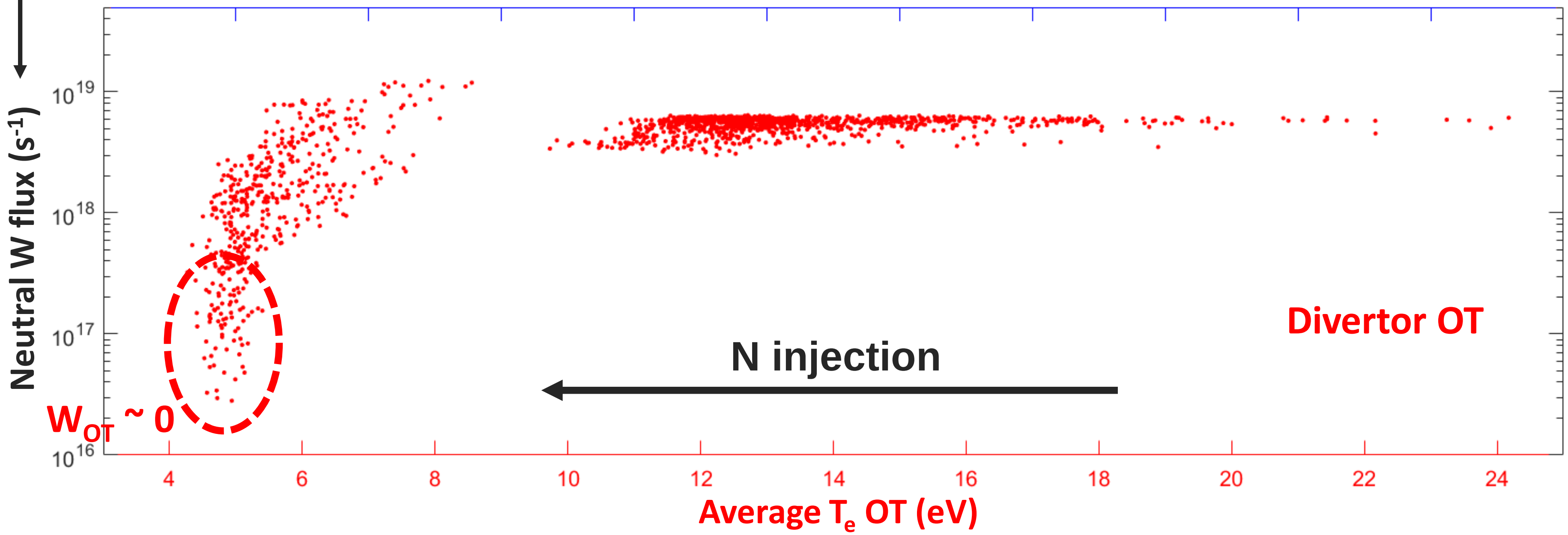

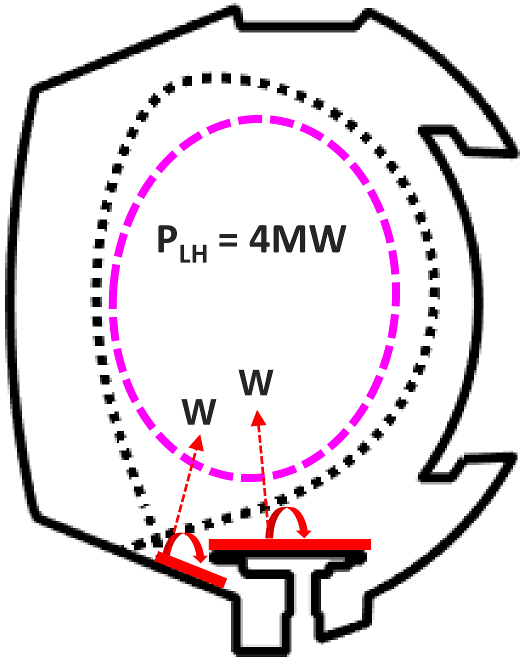

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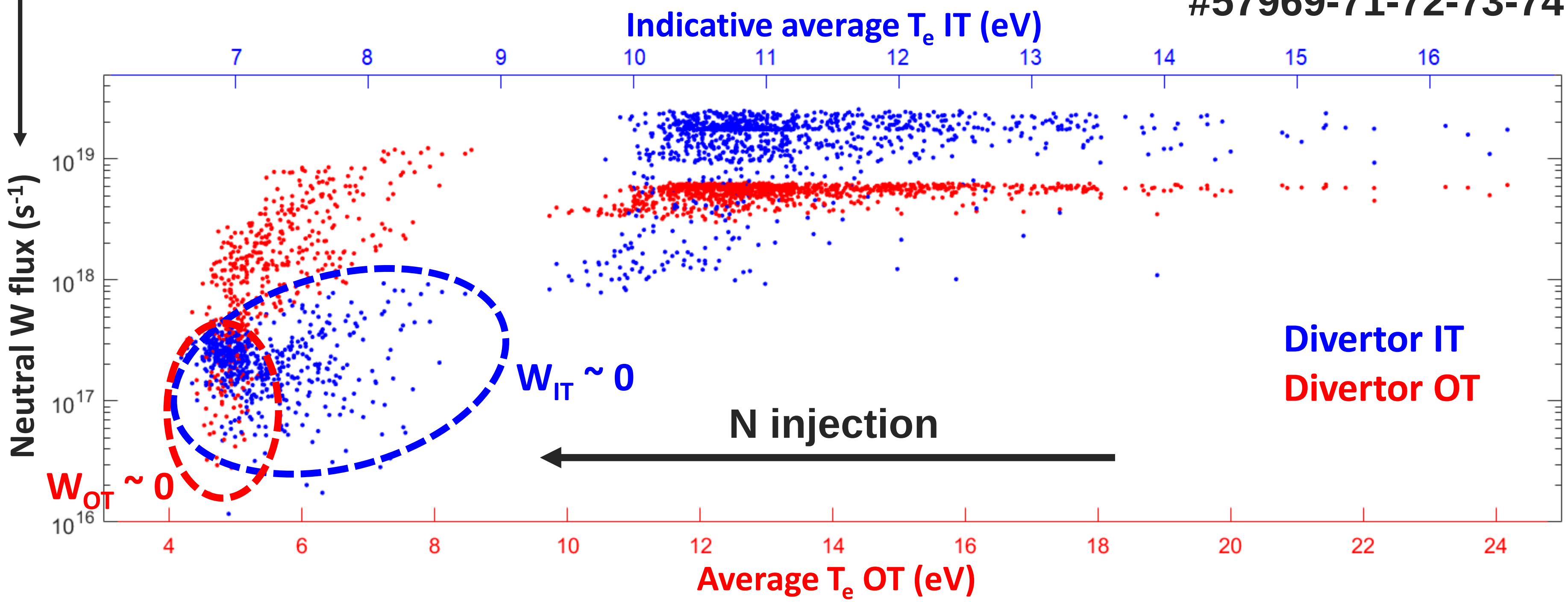
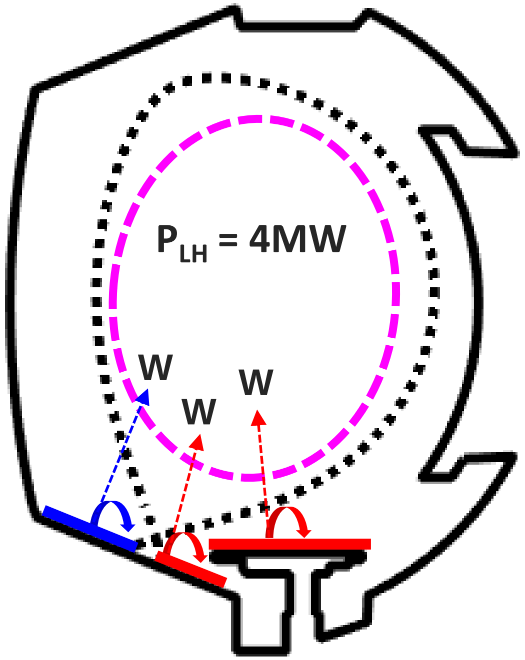
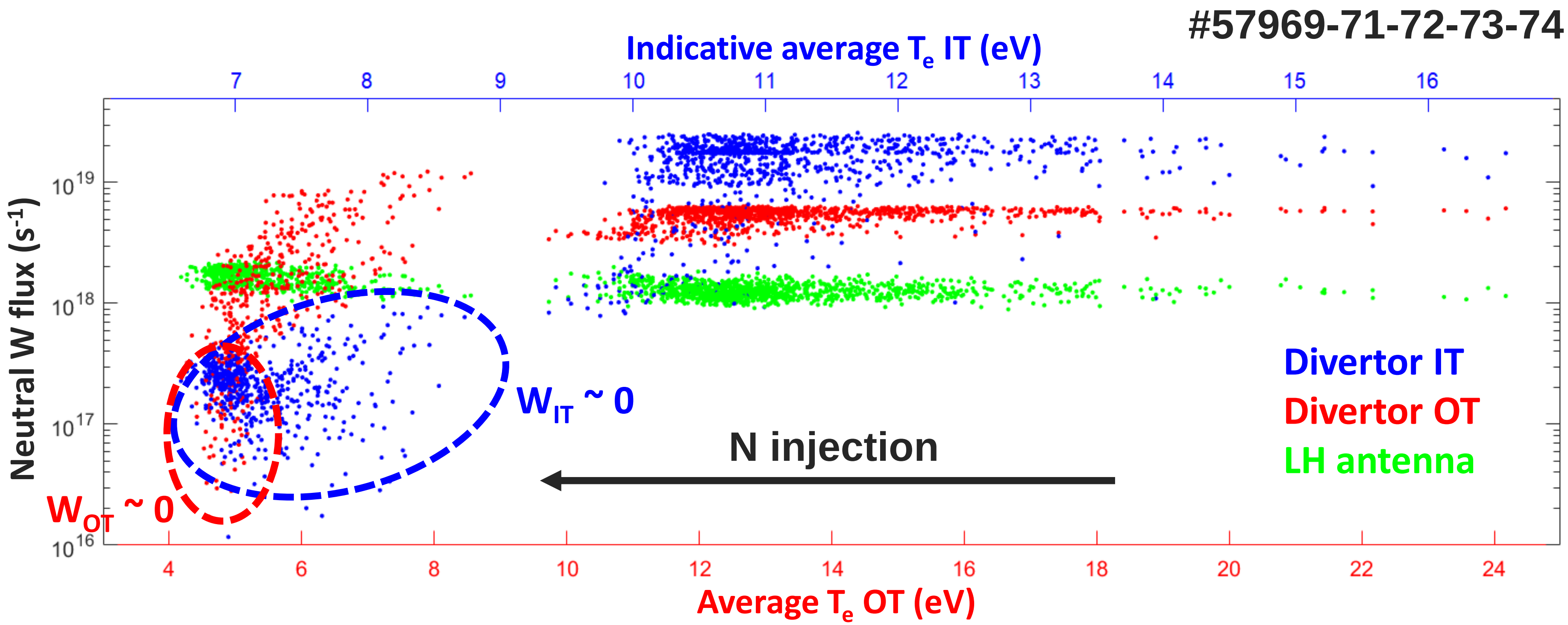
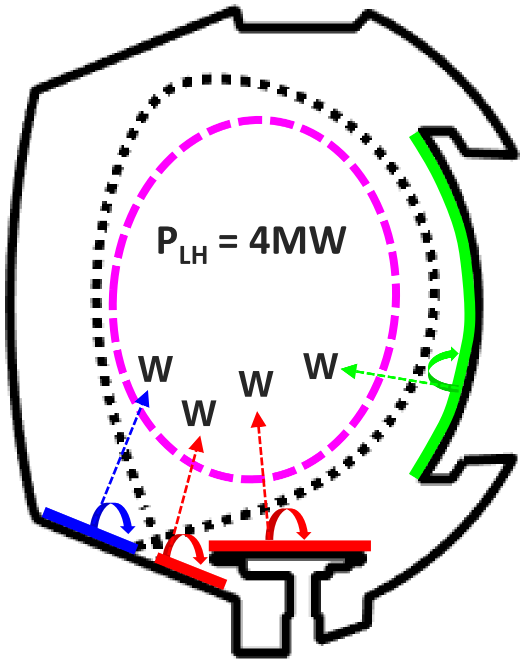




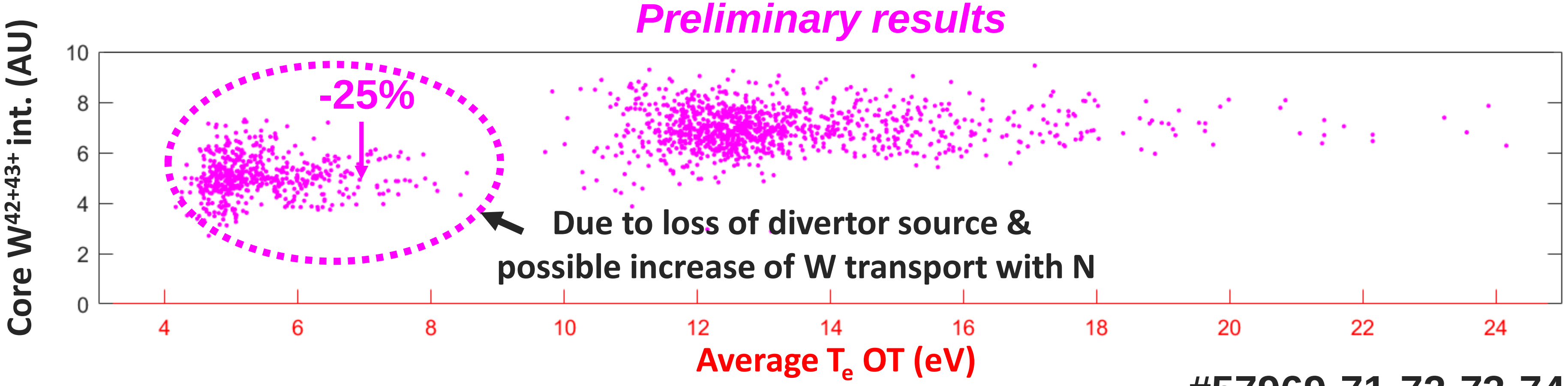
Contribution of divertor vs antennas to core W content





Contribution of divertor vs antennas to core W content

Preliminary results



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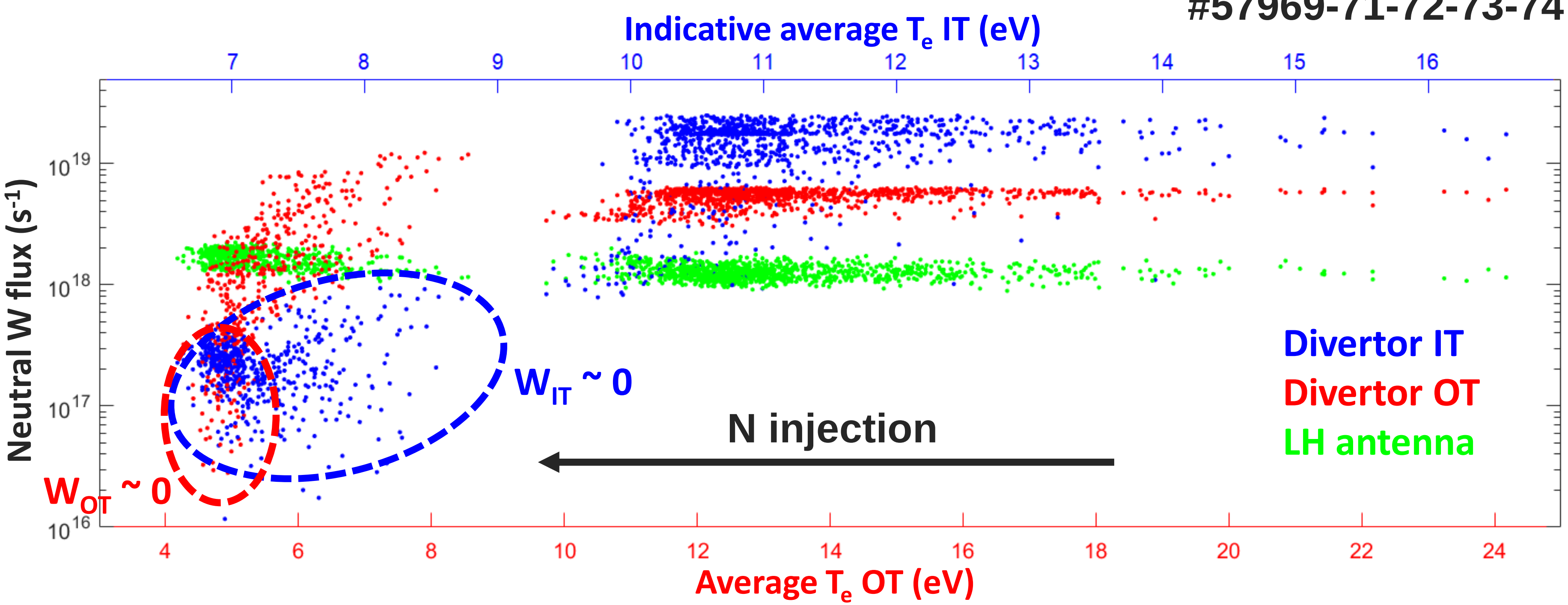
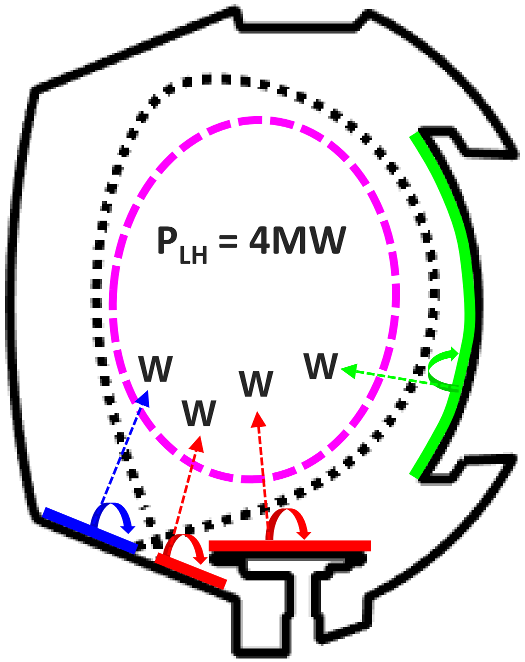
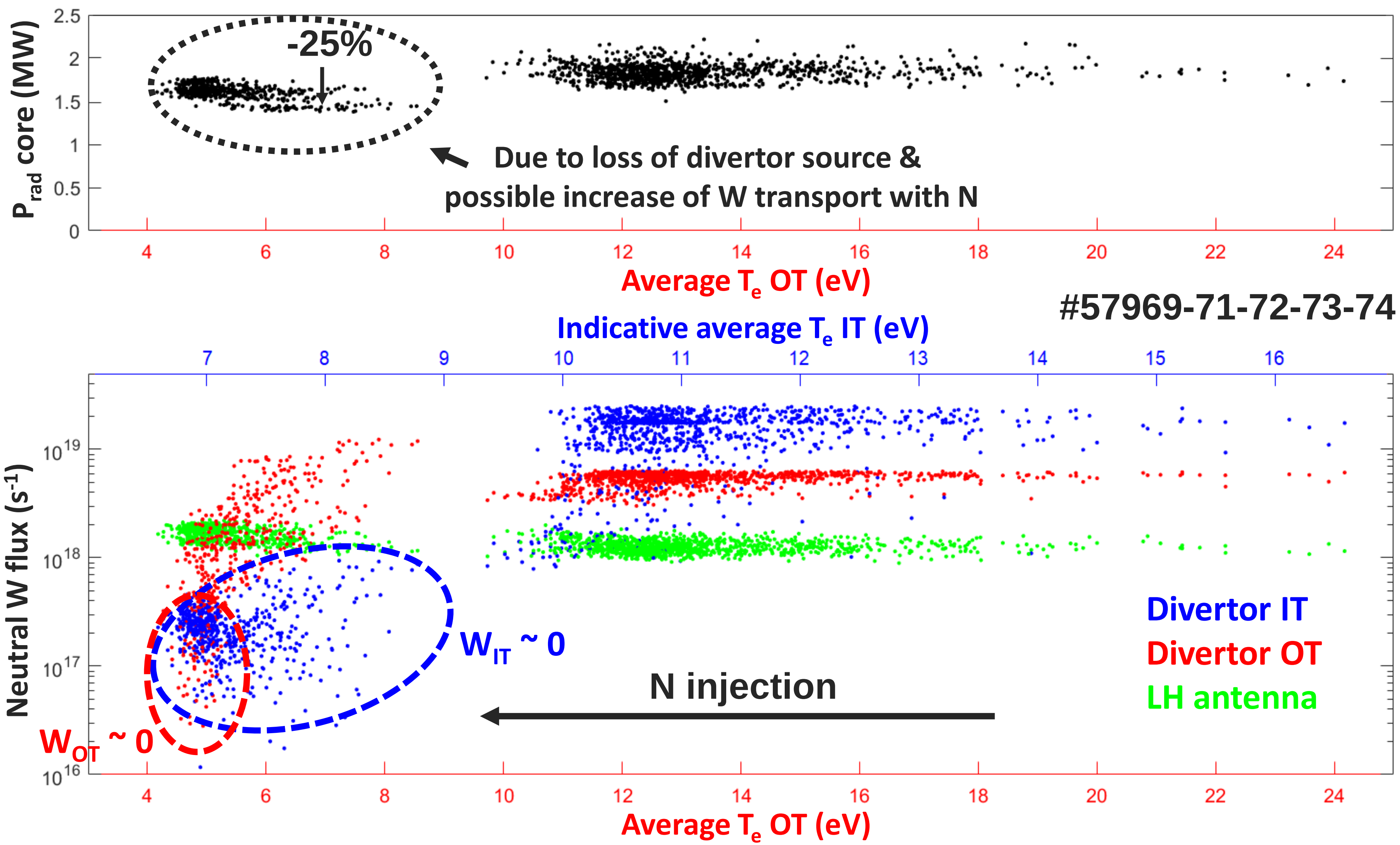


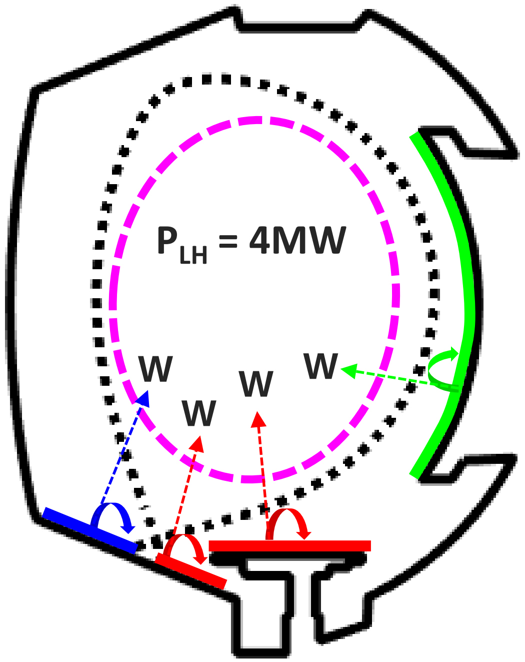


- Contribution from antennas to core W content seems dominant
- Smaller contribution from the divertor probably dominated by the IT

More information on WEST UV spectroscopy of core W impurities:
[R Guirlet et al., 2022, Plasma Phys. Control. Fusion 64 105024]

Contribution of divertor vs antennas to core W content





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Summary

- WEST visible spectroscopy system covers all plasma facing objects (upper & lower divertors, one inner limiter, the outer movable limiter, 2 LH antennas and 2 ICRH antennas) with a very high spatial resolution on the divertor monoblocks in particular ($<cm^2$).

- The system can follow transient impurity sources (down to a few ms time resolution for the grating spectrometers) as well as steady state contributions for the very long duration of WEST discharges (several min).

- The visible W spectroscopy measurements can also be coupled to UV spectoscopy analysis of W core impurities to study and better understand W transport in a full metal machine.

Merci!