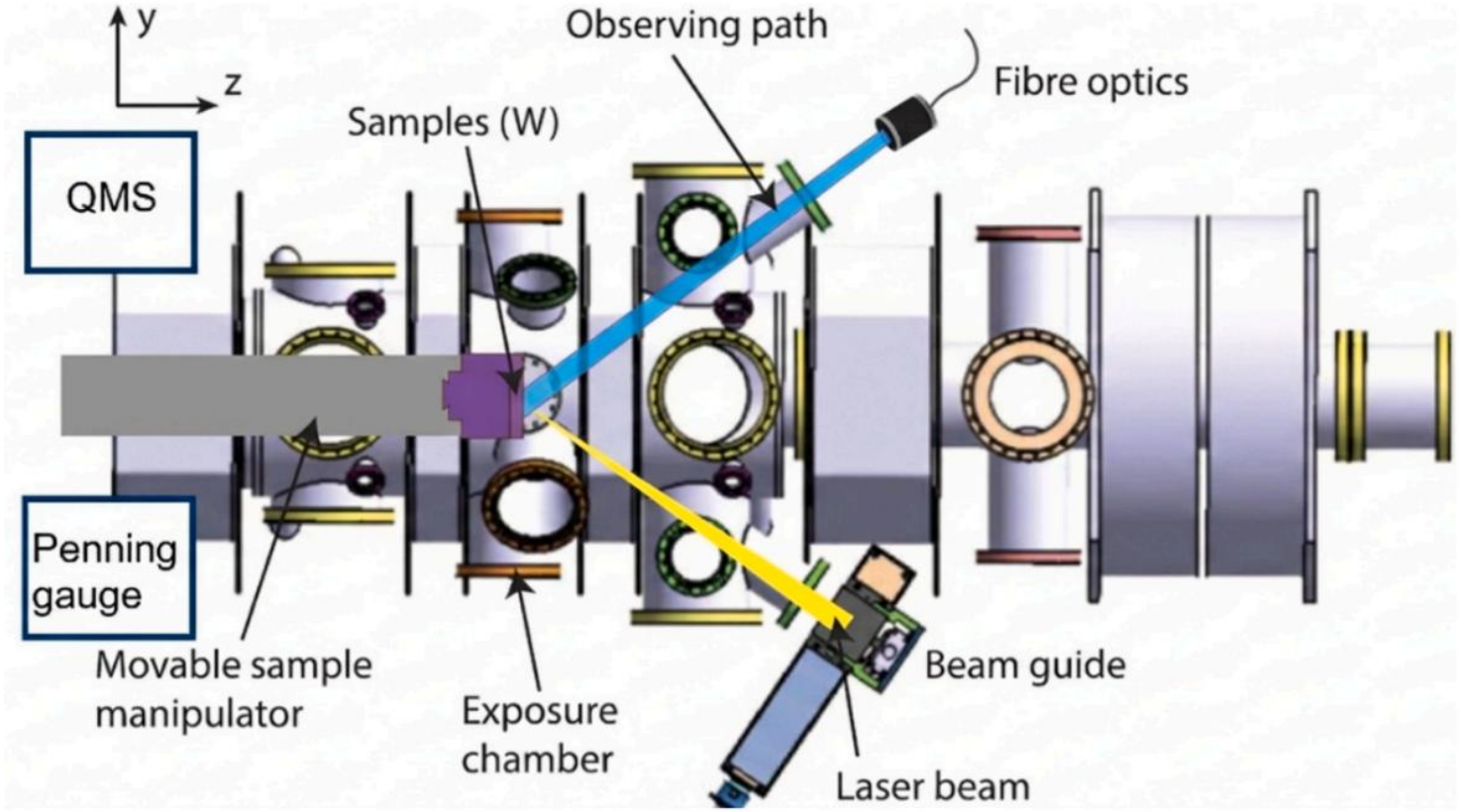


In-situ residual hydrogen isotope analysis by LIBS in PSI-2

OCT 28, 2026 I HUACE WU, RONGXING YI, MIROSLAW ZLOBINSKI, SEBASTIJAN BREZINSEK, FZJ

In-situ LIBS experimental setup in PSI-2



Objective: Evaluate the Feasibility of LIBS for In-Vessel Residual Gas Analysis and Its Impact on LIBS Hydrogen Isotope Measurements

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Laser & Detection

- Laser: Nd:YAG (1064 nm, 8.3 ns, 700 mJ)
- Spot size: 0.85 mm
- Spectrometer: Littrow (70 pm @ 656 nm)
- Gate delay / width: 300 ns / 1000 ns

Samples & Measurement Conditions

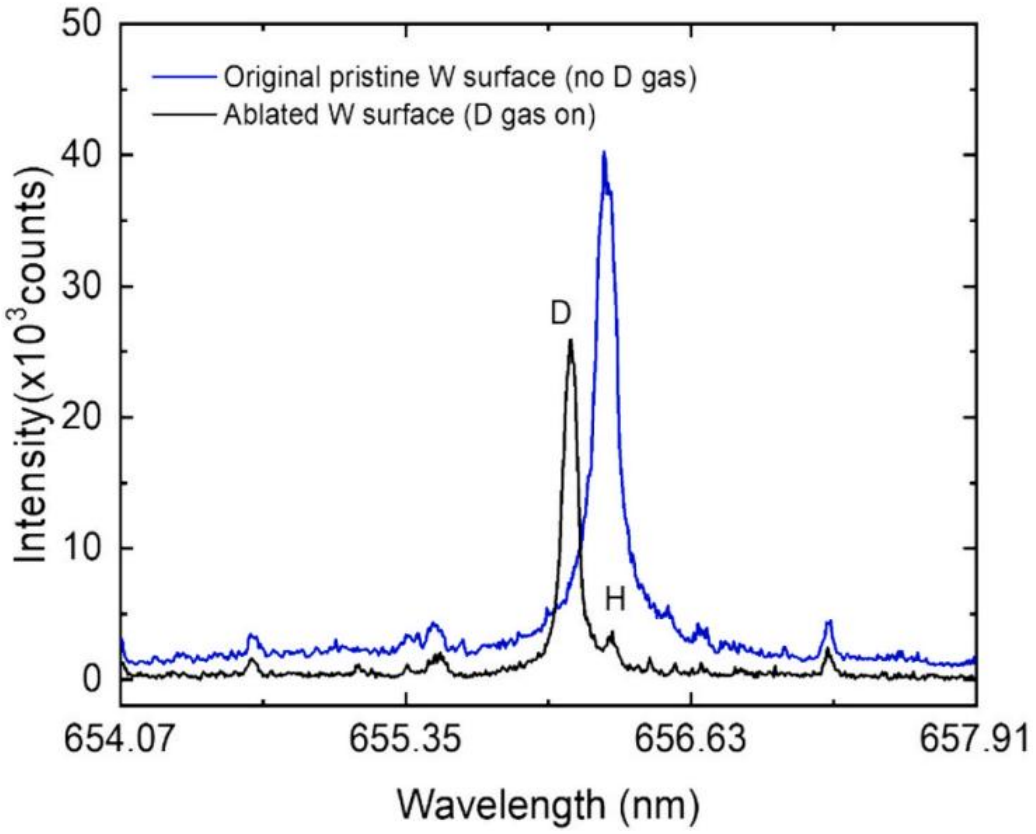
- Samples: ITER-grade W, stainless steel
- Sample preparation: Polished and annealed (1273 K, 1 h)
- Pre-ablation: 5 laser pulses
- D_2 purity: 99.8%

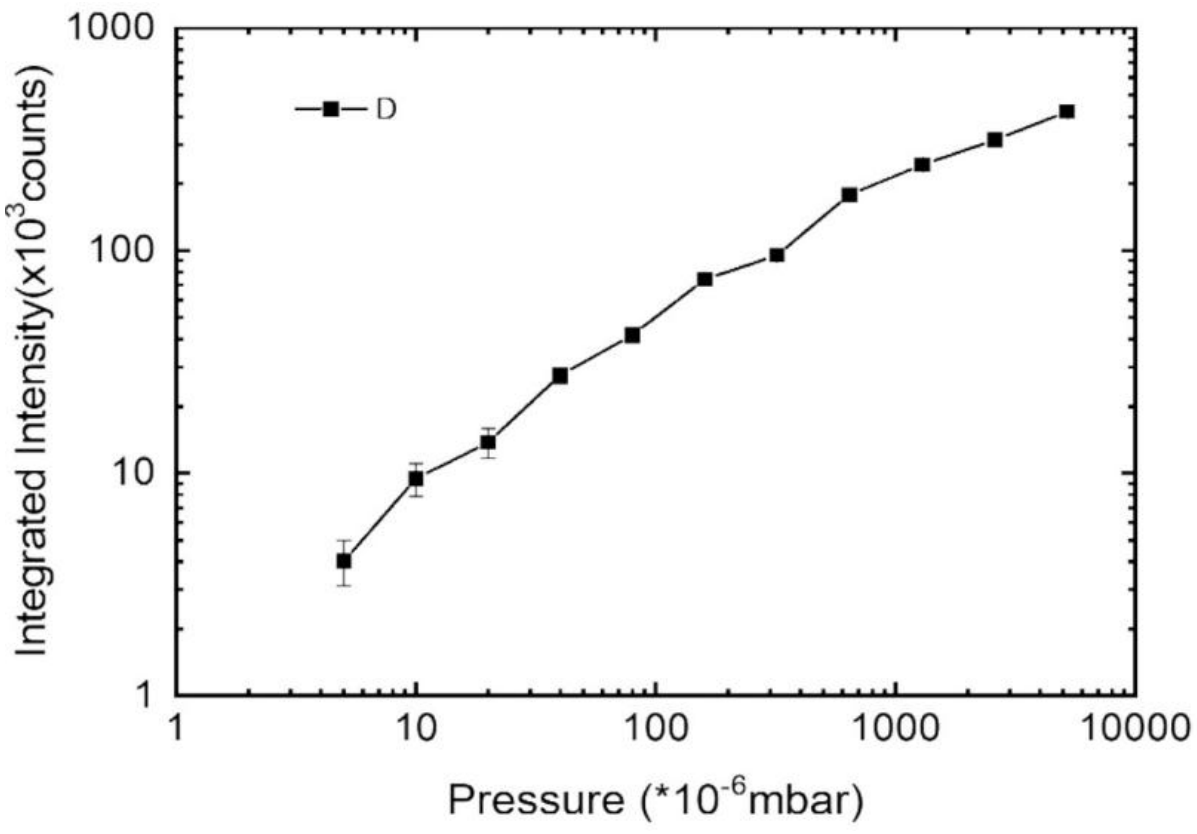
Measurement approach:

- **Metal target ablation under controlled hydrogen isotope gas pressures**
- **From 10^{-6} to 10^{-3} mbar in the vessel of the PSI-2**

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Influence of surface H and Source of the D spectral signal



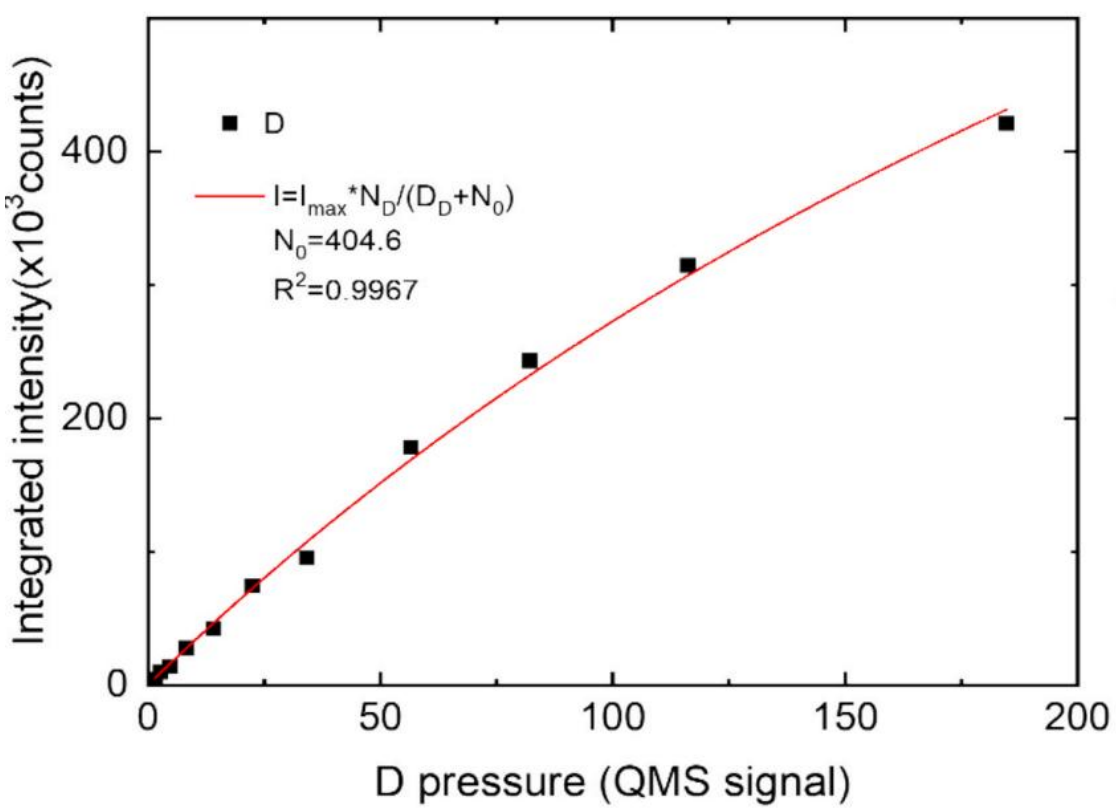


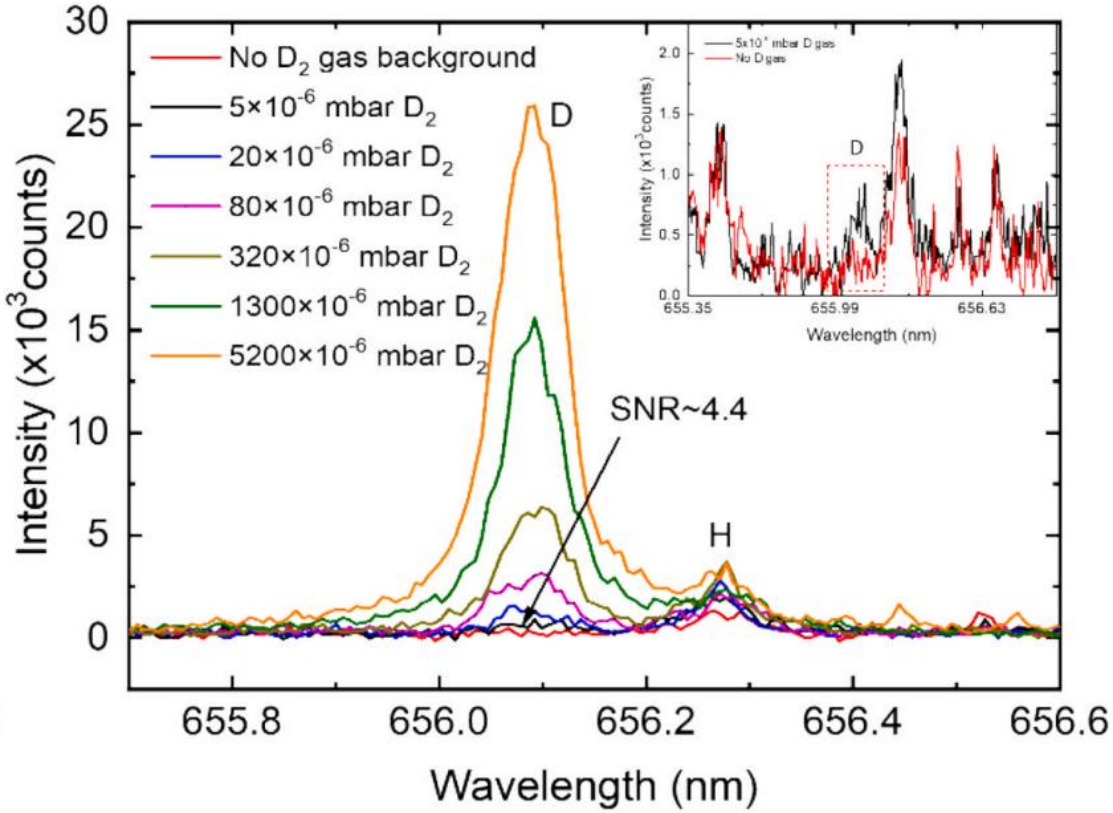
Adsorbed water, oxide layers, and residual hydrogen contaminants on the sample surface may still cause significant interference.

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Annealing combined with laser pre-ablation reduces intrinsic H contamination, enabling background D detection. LIBS effectively responds to changes in background D pressure.

Spectral stability and Calibration curve



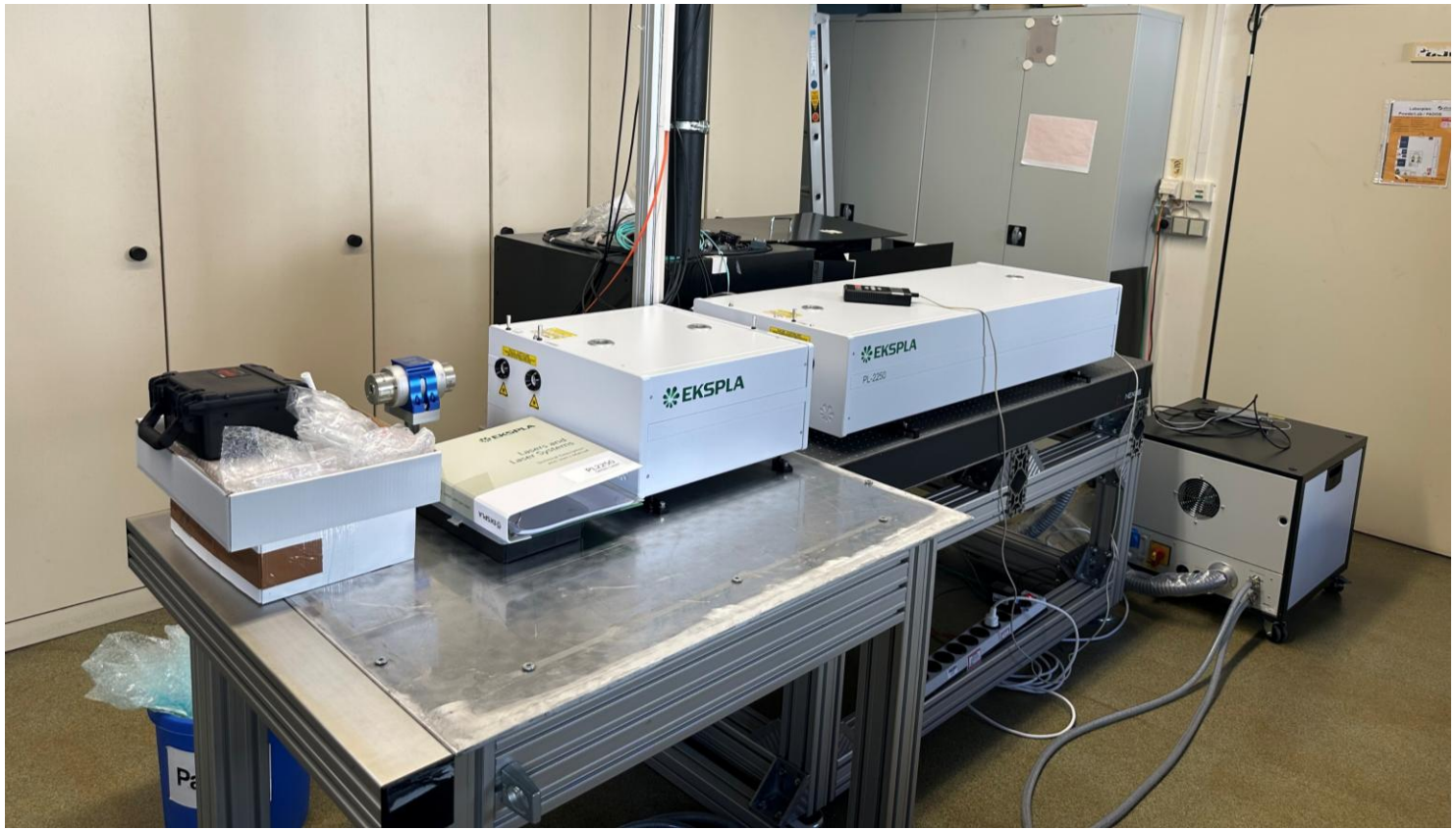


Minimum detected D_2 pressure: **5×10^{-6} mbar (SNR ~4.4).**
QMS-based calibration achieves **$R^2 = 0.9967$**.

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LIBS demonstrates strong potential for *in-situ* residual hydrogen isotope detection, while highlighting the need to **account for background gas contributions in boron-fuel retention measurements.**

ps-LIBS Set up (will be used for PSI-2 and TOMAS)



1. ps-laser has successfully passed the acceptance test and is ready for integration.

2. Its output energy and stability meet the requirements for LIBS measurements.

3. Beam-delivery layout and laser-safety system are being finalized.

EKSPLA | **INSTALLATION REPORT** | FL 38, 5th edition, valid from 2023-03-27

Model and serial number	PL2251C-10-P20, #FPL276 + HMFPL_SH-TH-FH, #HMFPL276

Customer:

Institution	Forschungszentrum Jülich GmbH, IFN-1 Institute , Jülich, Germany
Name, surname	Huace Wu
E-mail	hu.wu@fz-juelich.de
Date	2025 12 11
Signature	

Customer signature above certifies that the laser system is delivered and installed to customer's requirements (except as noted). Associated invoices are due and payable according to the contract terms.

Summary:	Yes/No
The goods are free from defects	Y
Product parameters match specifications	Y
Personnel training performed	Y
Final system settings saved (CSV, OPG, etc.)	Y

Measurements:

E_{1064}(@out) = 82,5 mJ (StD - 0,7%).
E_{1064}(after isolator) = 81,6 mJ (StD - 0,7%).
E_{532}(@ out) = 41,4 mJ (StD – 1,1%).
E_{355}(@ out) = 31,7 mJ (StD – 1,0%).
E_{266}(@ out) = 12,6 mJ (StD – 1,2%).

Comment:

The laser system is placed on two different tables, one is not optical table. The height of harmonics module was adjusted to match the laser. System needs to be place on proper optical table. After relocation the legs of harmonics unit need to be adusted.

EKSPLA representative:

Name, Signature	Valdemaras Rukavičius

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Conclusion & Outlook

- **LIBS demonstrates strong potential for *in-situ* residual hydrogen isotope detection, while highlighting the need to account for background gas contributions in wall fuel retention measurements.**

- **ps-LIBS enables *in-situ* measurements of boron and hydrogen isotopes. Optimal LIBS parameters were systematically established through prior studies.**

- **PSI-2 is nearing completion of repairs. The new ps-laser will be integrated into the LIBS setups of PSI-2 and TOMAS through optical-path design. In-situ LIBS studies of boron-containing films on tungsten substrates will be conducted at both facilities.**