U.S. DEPARTMENT OF ENERGY | Office of Science

NSTX-U

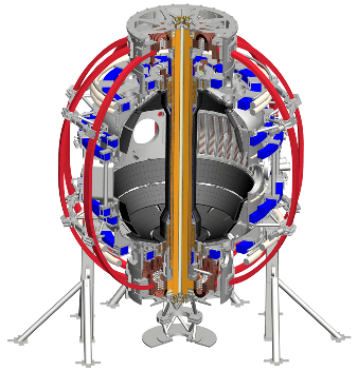
Characterization of boronized graphite in NSTX-U and its effect on plasma performance

F. Bedoya, **J.P. Allain**, R. Kaita, C.H. Skinner, F. Scotti and B.E. Koel

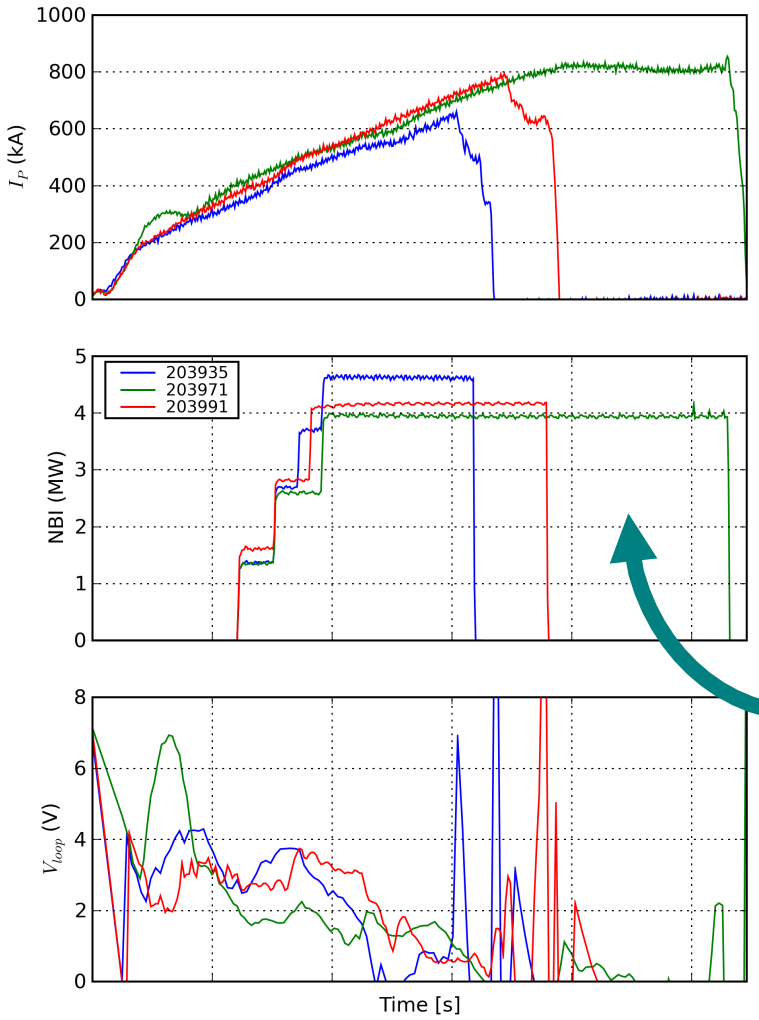
59th Annual APS DPP Meeting
Milwaukee, WI
Oct 23rd – Oct 27th 2017

RSSEL

PPPL

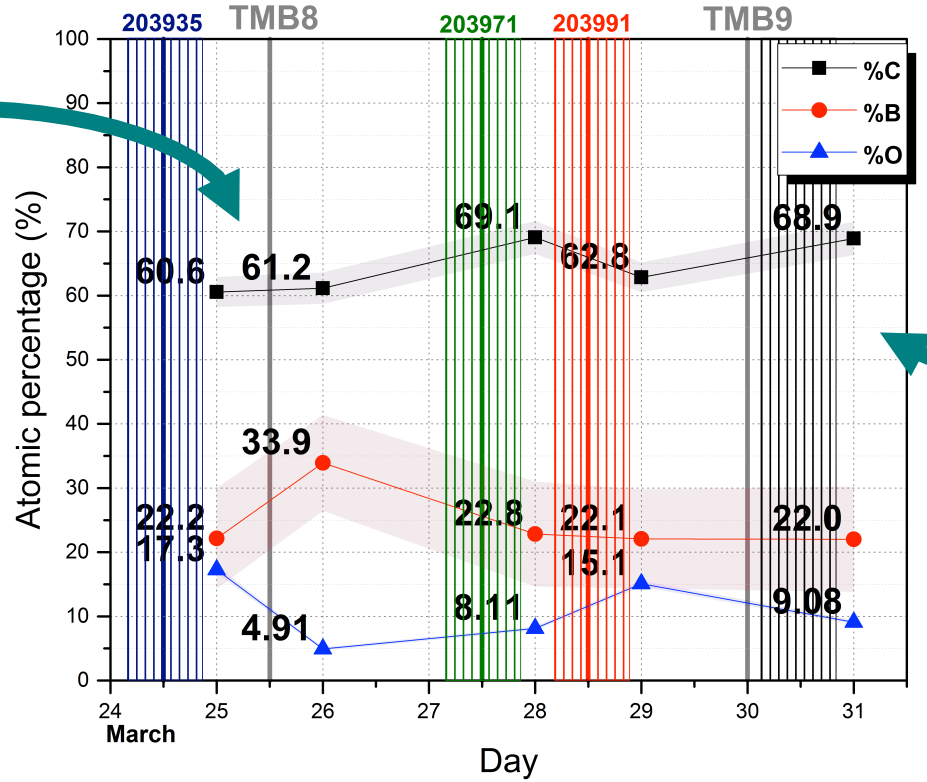


Motivation



Low oxygen concentration following boronization

Improved plasma performance on similar scenarios



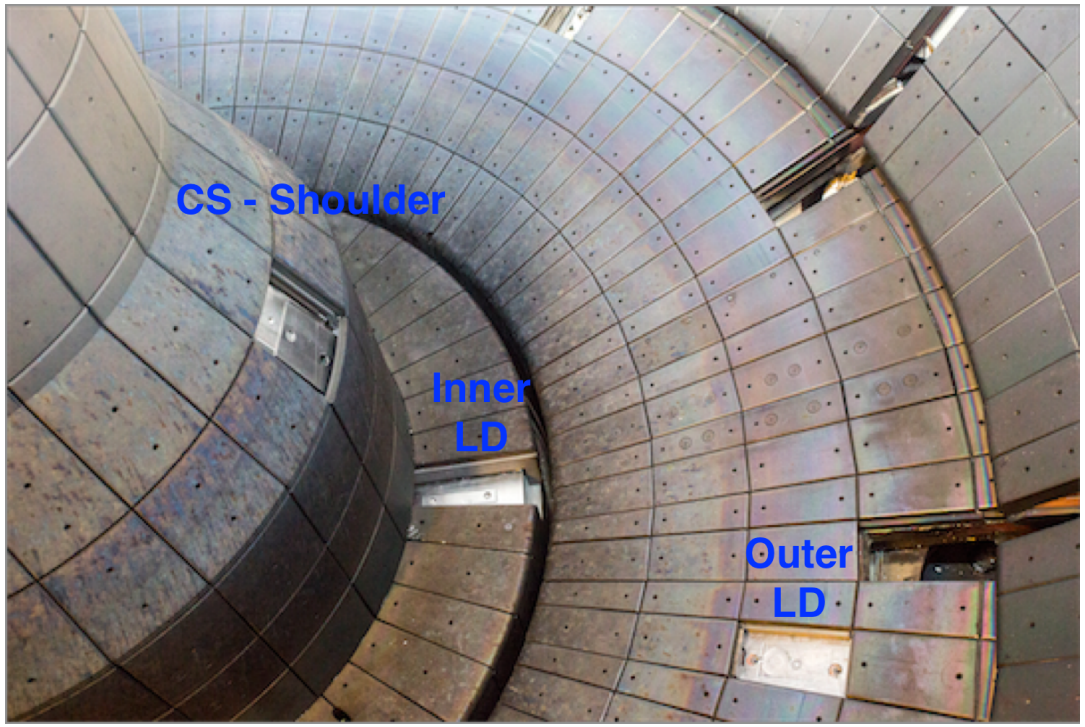
MAPP XPS data obtained at NSTX-U

Oxygen concentration reduction in PFCs with boronization seems to help improving performance.

Further studies in the laboratory (*post-mortem and control*) to test this hypothesis

Experimental methods

Core samples



Tiles location

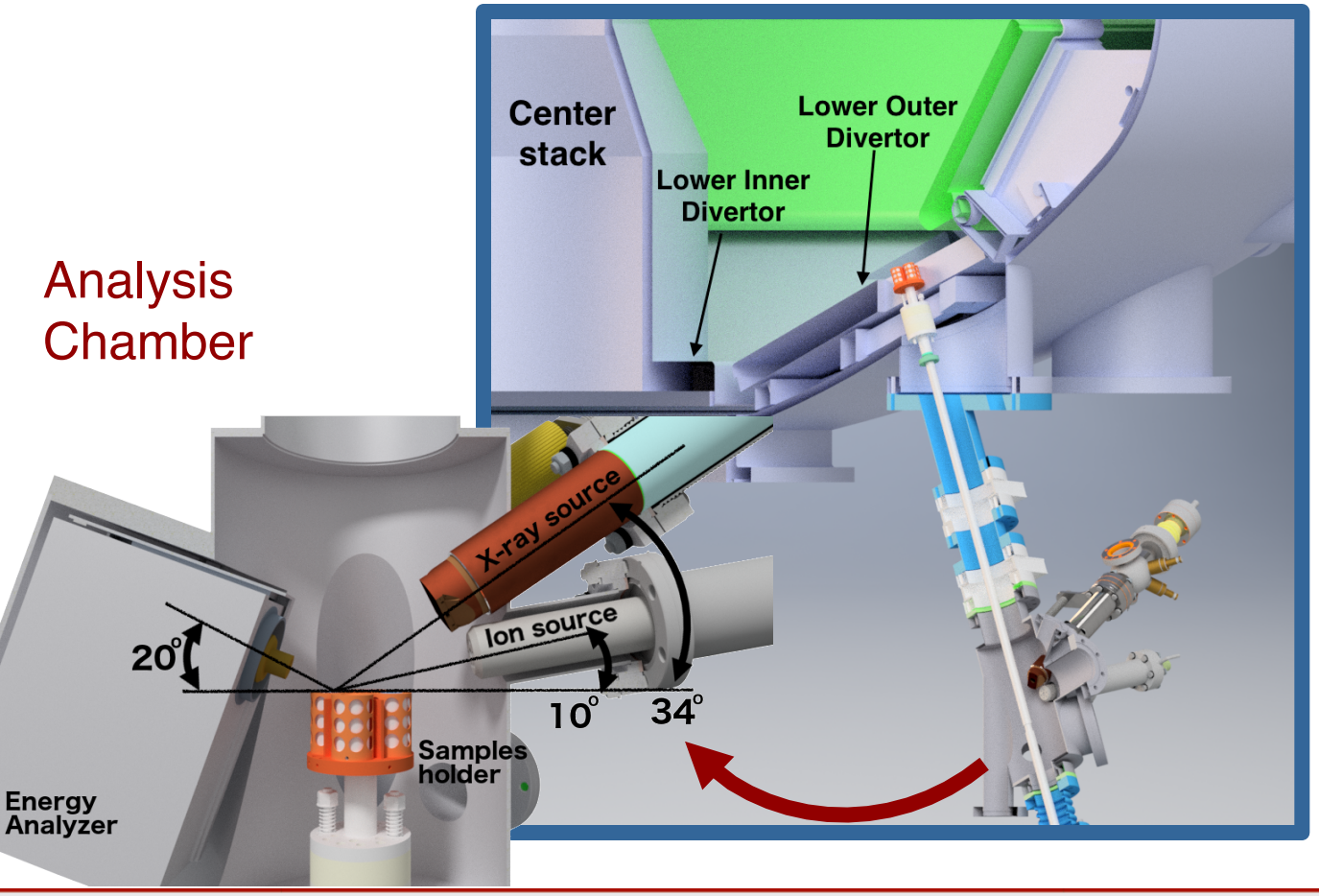
- A18, Center Stack (CS) Shoulder
- B17, Inner Lower Divertor (ILD)
- C18, Outer Lowe Divertor (OLD)

Experimental methods

Materials analysis in NSTX-U

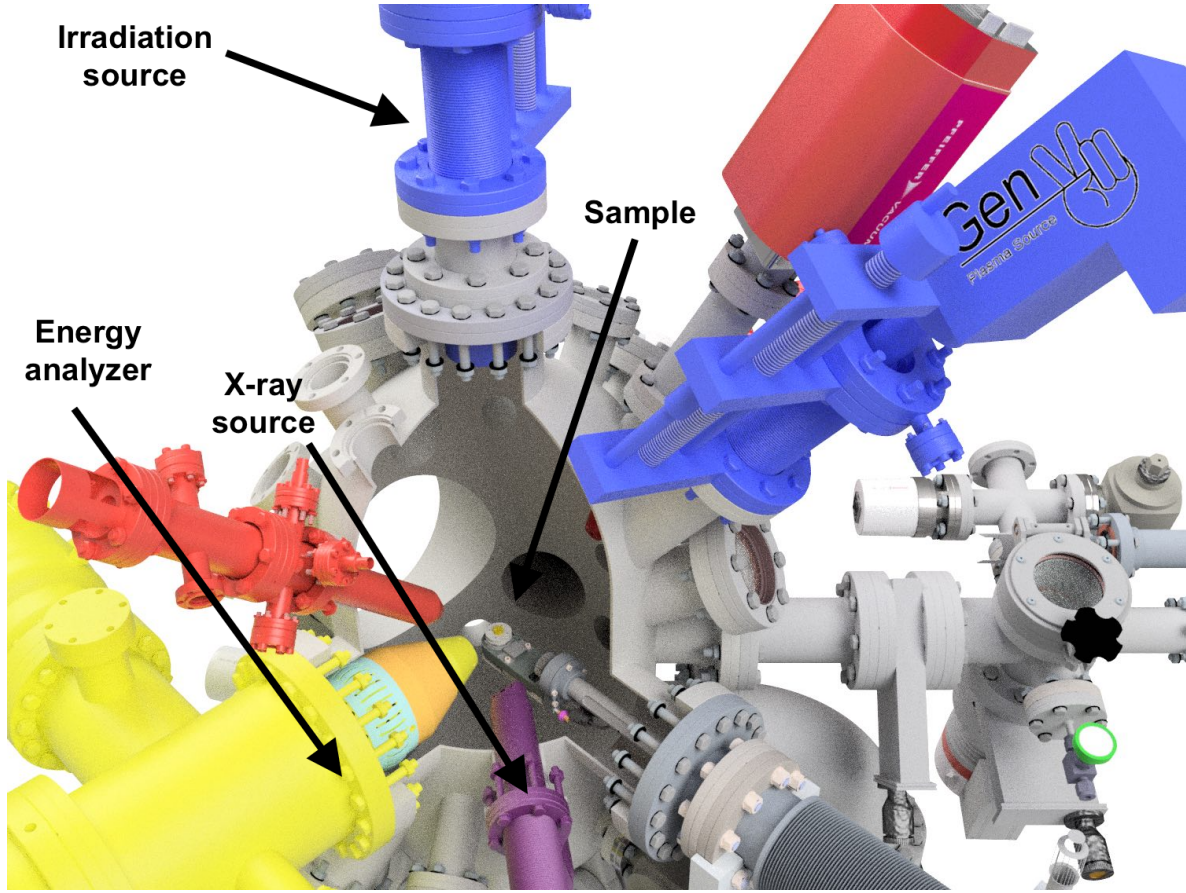
MAPP Facility

Analysis Chamber



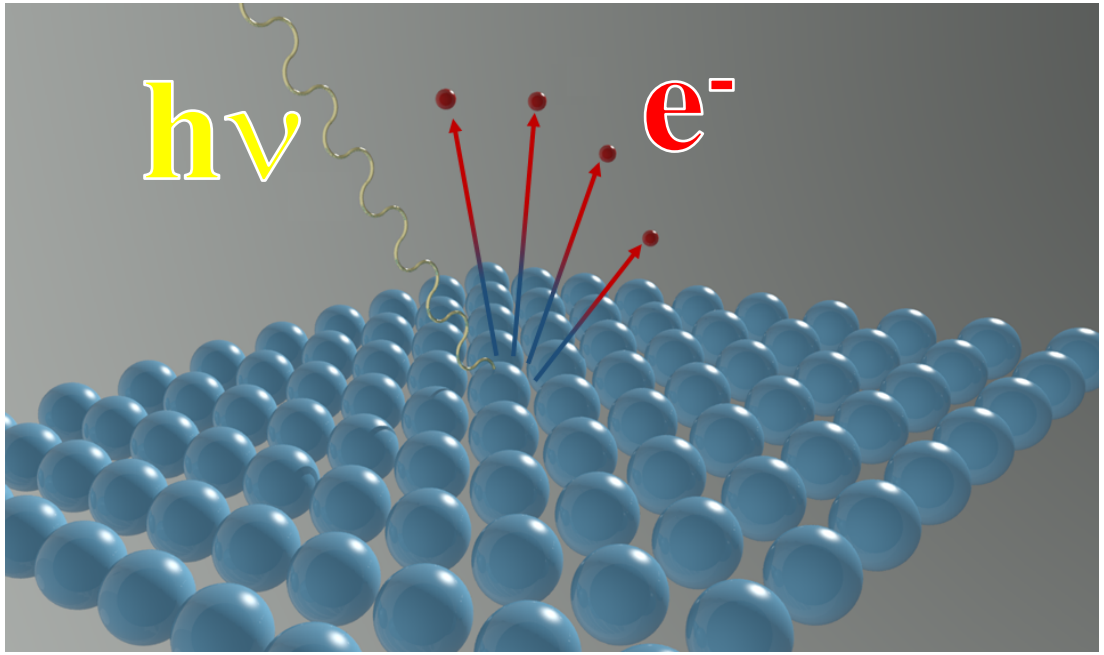
Post-mortem and Controlled experiments at University of Illinois

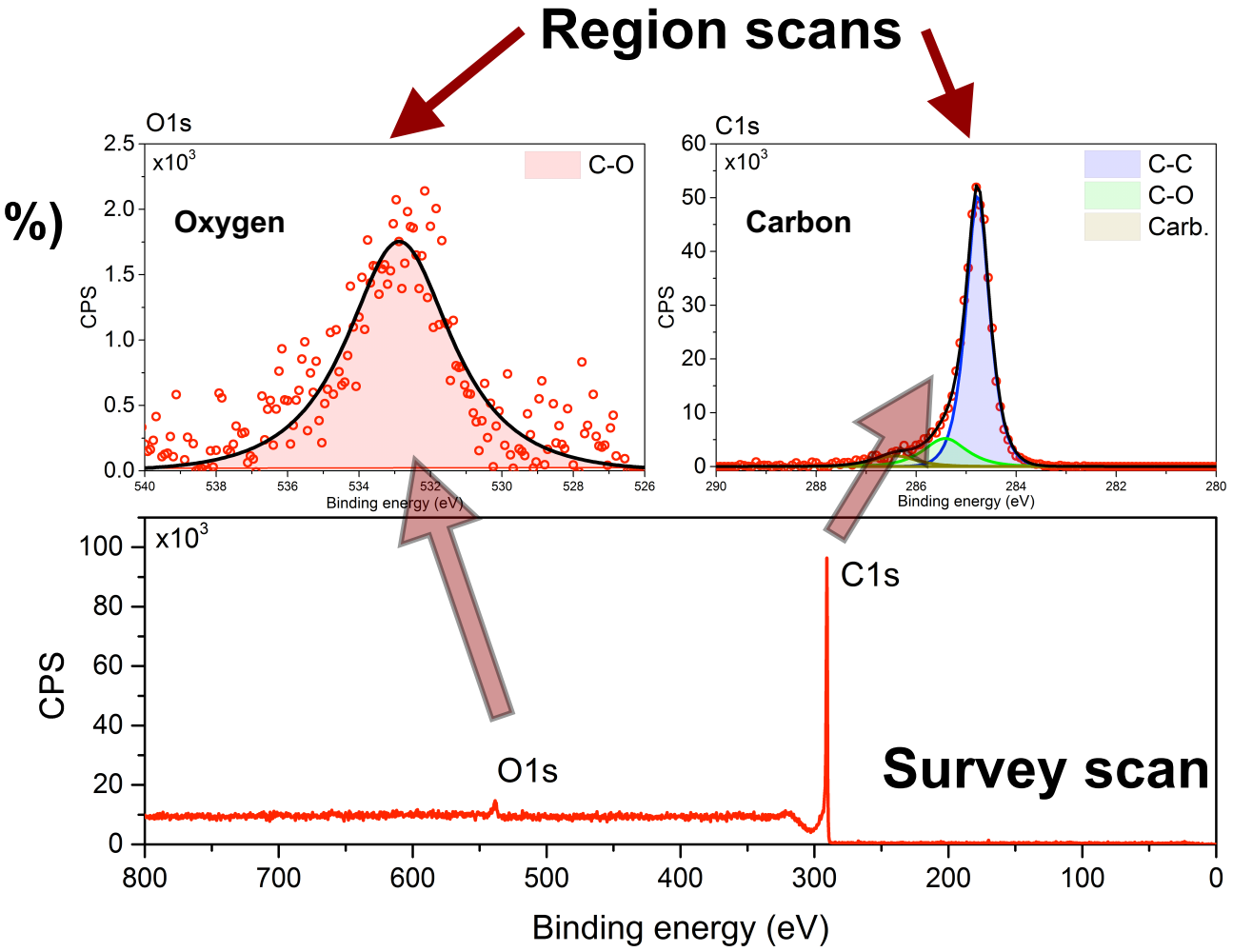
IGNIS Facility



Chemical identification of components via XPS

- Emission of photoelectrons under incident soft X-ray beam
- Probe top 10 – 20 nm of sample
- Elemental identification in survey scans
- Region scans allow quantitative analysis (at.%)

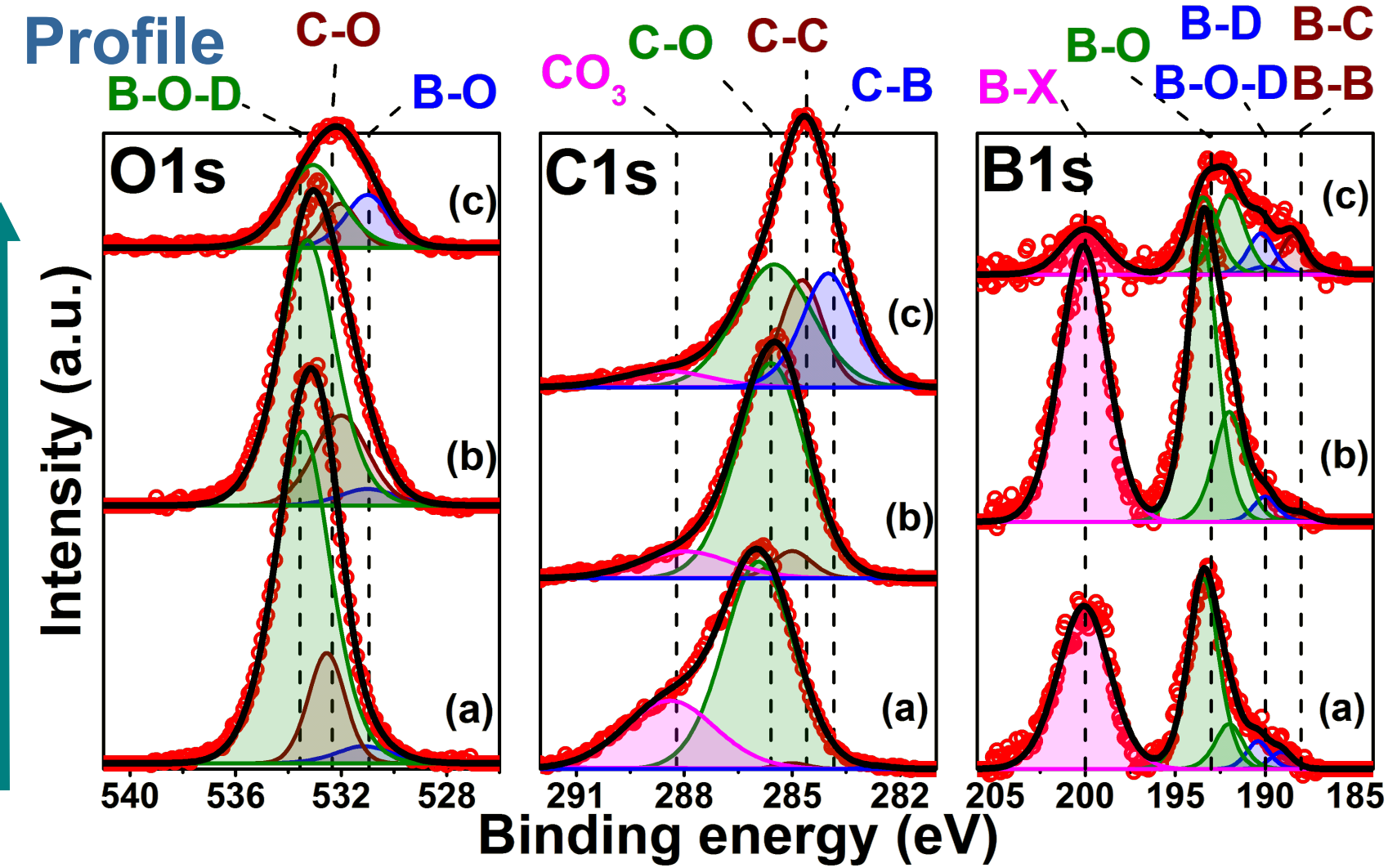




Results

Core B17 – XPS Depth Profile

- High presence of oxides throughout the whole experiment
- **Presence of a new XPS peaks, not previously observed, nor found in literature**
- Metallic states observable following Ar+ irradiation

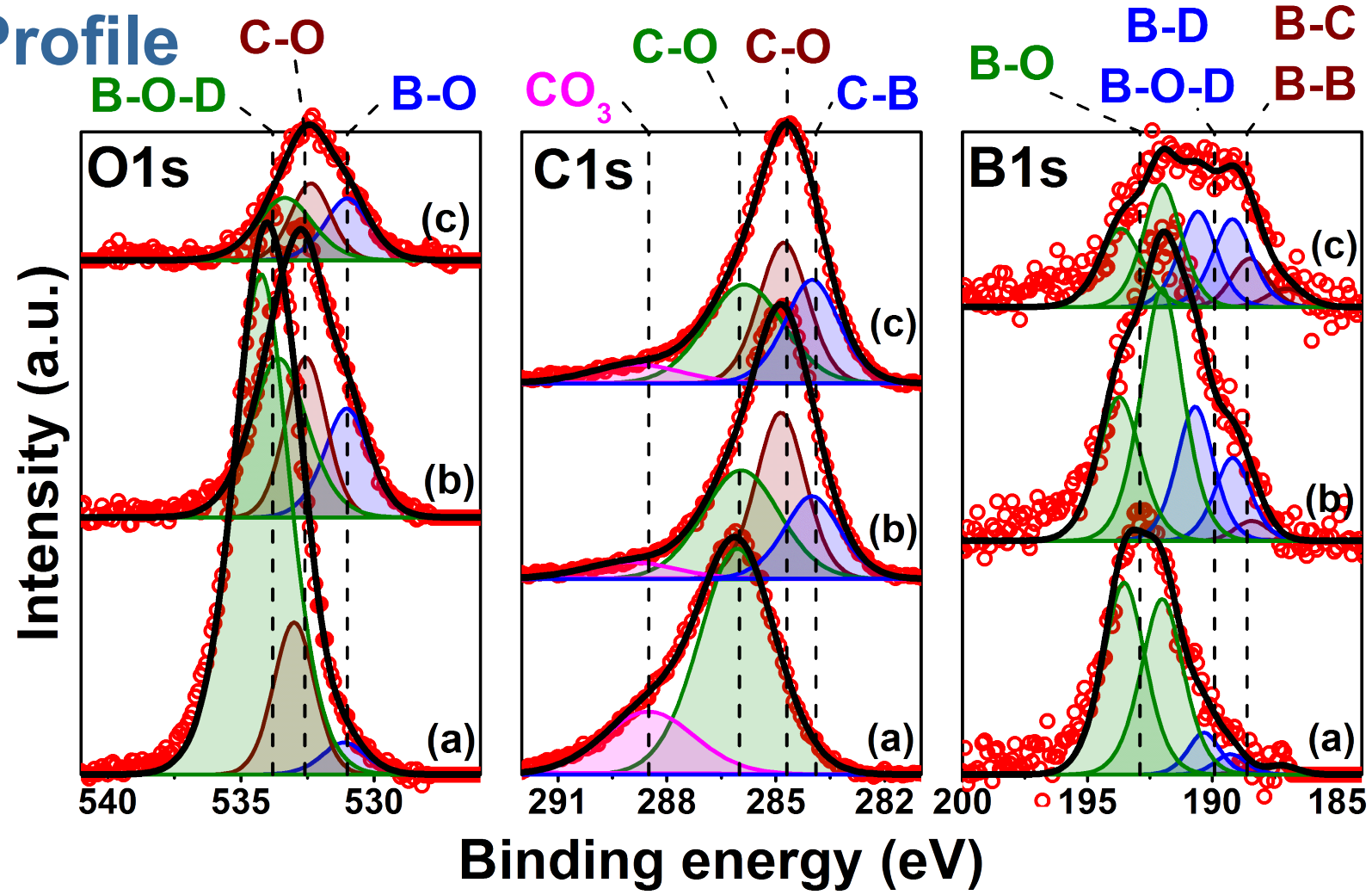


XPS peaks deconvolution of the depth profile data from core C18, (a) As is, (b) $1x10^{15}$ cgs Ar^+, (b) $3.5x10^{17}$ cgs Ar^+

Results

Core A17 – XPS Depth Profile

- Initial high presence of oxides (lower concentration than other cores)
- Metallic states visible after Ar+
- **Post-cleaning state has the closes resemblance to post-boronized state from MAPP**



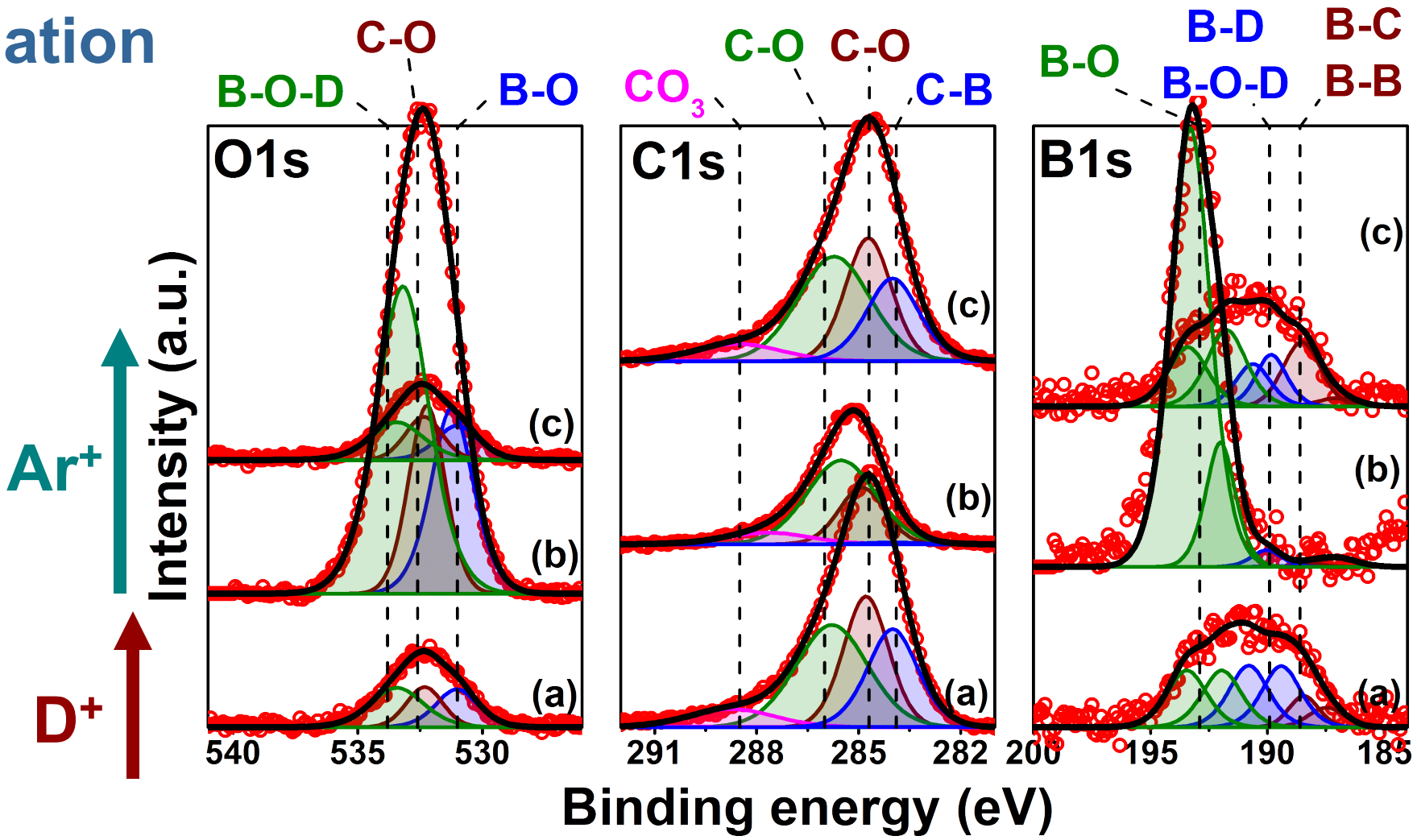
XPS peaks deconvolution of the depth profile data from core C18, (a) As is, (b) $1x10^{15}$ cgs Ar+, (b) $3.5x10^{17}$ cgs Ar+

Results

Core A17 – D⁺ Irradiation

Deuterium irradiation drives oxidation of the B coatings, the oxides can be *easily* removed with additional irradiation.

Similar to what we observed in NSTX-U with MAPP !!



XPS peak deconvolution, (a) 3.5×10^{17} cm^2 Ar$^+$, (b) 6.0×10^{16} cm^2 D$^+$ (c) 2.0×10^{17} cm^2 Ar$^+$

Conclusions

- Samples manufactured from tiles extracted from NSTX-U were characterized *post-mortem* using XPS and ion beam etching

- The boron concentrations on the three samples were different, implying possible non-uniform deposition during boronization

- The sample from the ILD, located at the PFR showed a second high energy XPS peak not previously observed. We hypothesize that this can be related to high D_2 presences or interactions with high *E* ions

- **D^+ irradiation of clean *post-mortem* sample showed similar behavior to that observed in MAPP:**
  - **Deuterium ions driven oxidation**
  - Plasma (Ar^+) induced sputtering and oxides removal