Material Analysis Particle Probe (MAPP)

Bryan Heim

Chase Taylor, Sean Gonderman, Miguel Gonzalez, J.P Allain

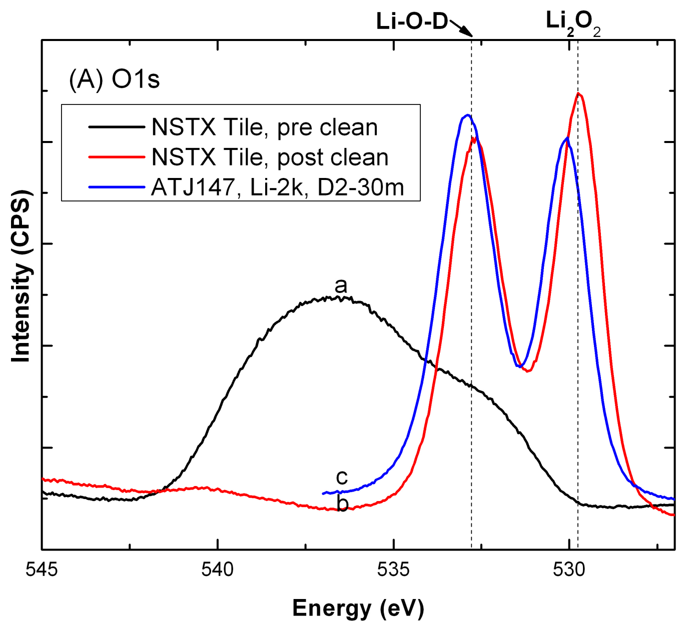
Nuclear Engineering, Purdue University

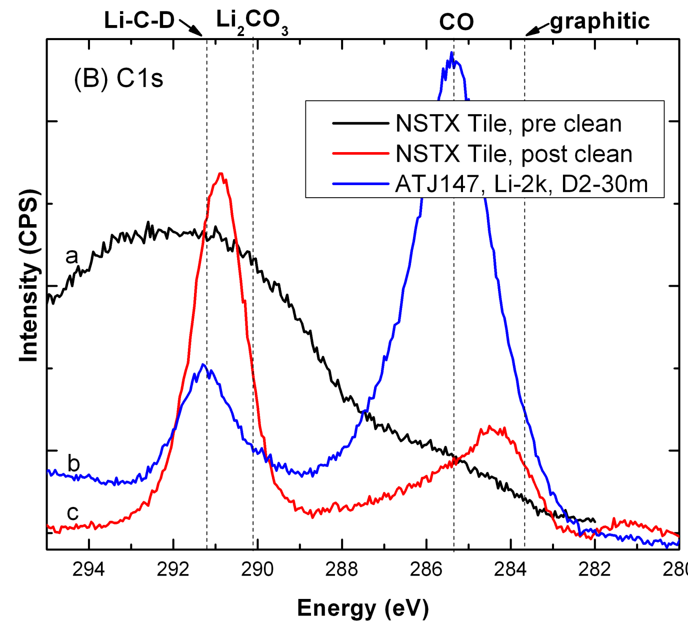
RSSEL

PURDUE ENGINEERING

Connect to reality

- Our offline, control experiments link directly to NSTX post-mortem tile analysis (following cleaning procedure).





- Post mortem tiles represent a campaign's worth of XPs.
  - Tile analysis yields excellent results.
- We want more than that! We want *direct* shot-to-shot analysis correlating core plasma physics to surface conditions!

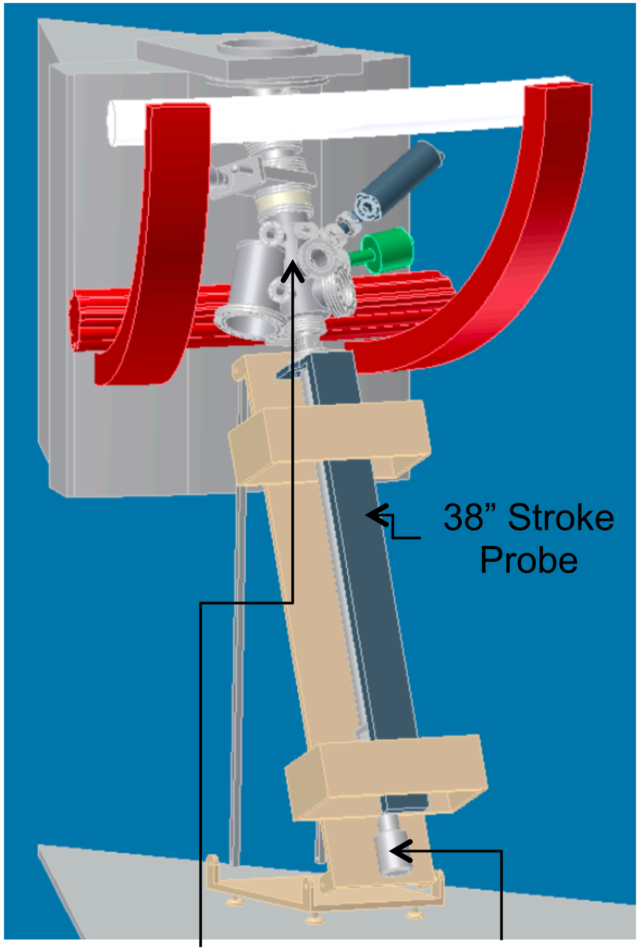
RSSEL

PURDUE ENGINEERING

MAPP Motivation:

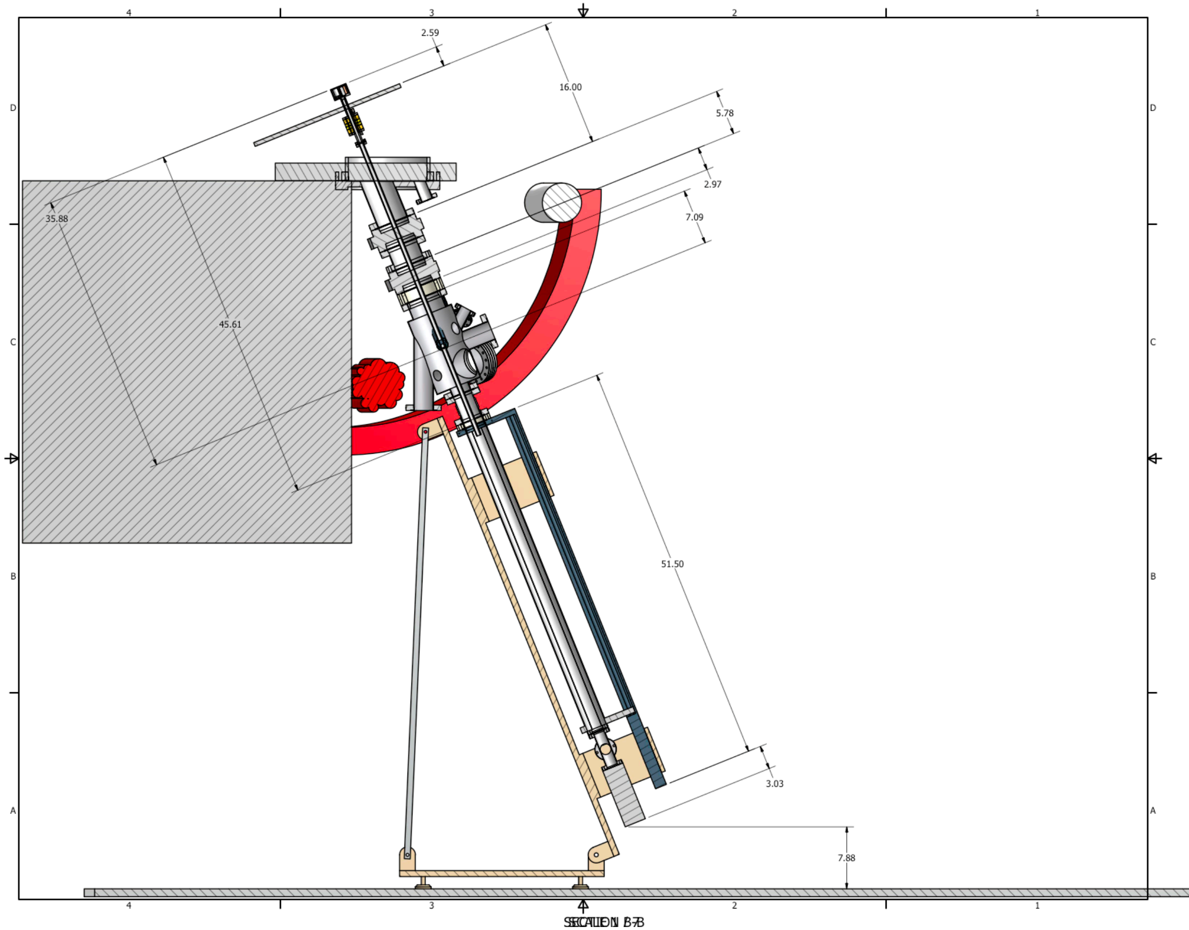
- Novel diagnostic
  - MAPP is the first in-vacuo surface analysis diagnostic directly attached to a tokamak, capable of shot-to-shot chemical surface analysis of plasma facing components. Provides a novel capability of directly linking plasma performance to surface conditions.
- Surface analysis
  - Relate transient particle pumping, increased energy confinement, and suppression of edge localized modes (ELMs) with plasma facing components (PFC) surface composition and deuterium retention measurements in exposed samples for various plasma conditions
- Deuterium retention
  - MAPP can study deuterium retention dependence on lithium deposition thickness of graphite and metallic sample substrates.
- Materials exposure
  - MAPP allows the exposure of a variety of materials (solid Li, liquid Li, W etc.) to a variety of NSTX plasma configurations.
- Full remote controlled operation

MAPP Renderings on NSTX



MAPP Analysis Chamber

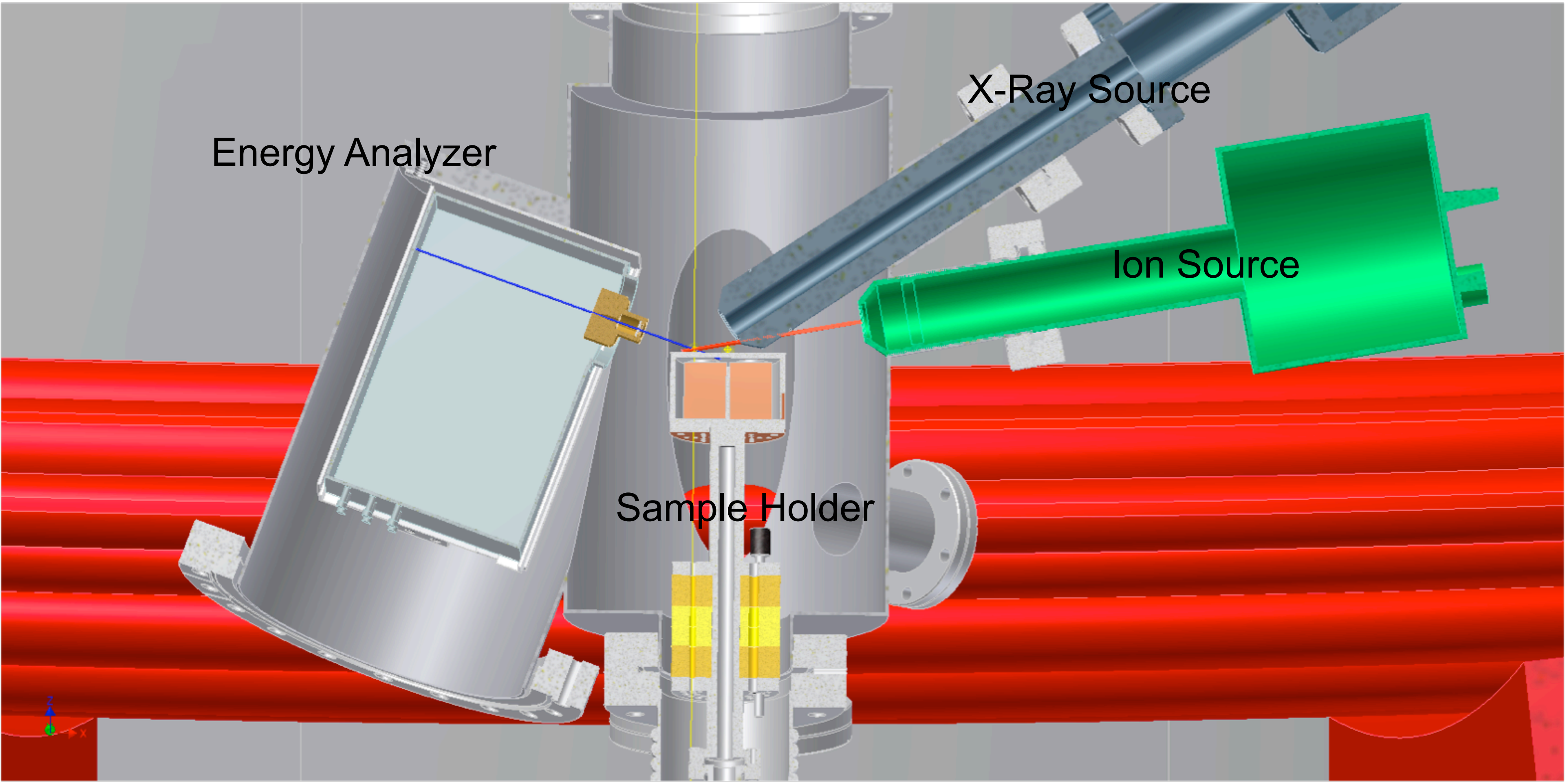
Rotary Feed-through



Probe can be inserted ~5" past divertor floor, and retracted for analysis.

RSSEL

PURDUE ENGINEERING



Surface characterization techniques:
XPS, ISS, DRS, TDS

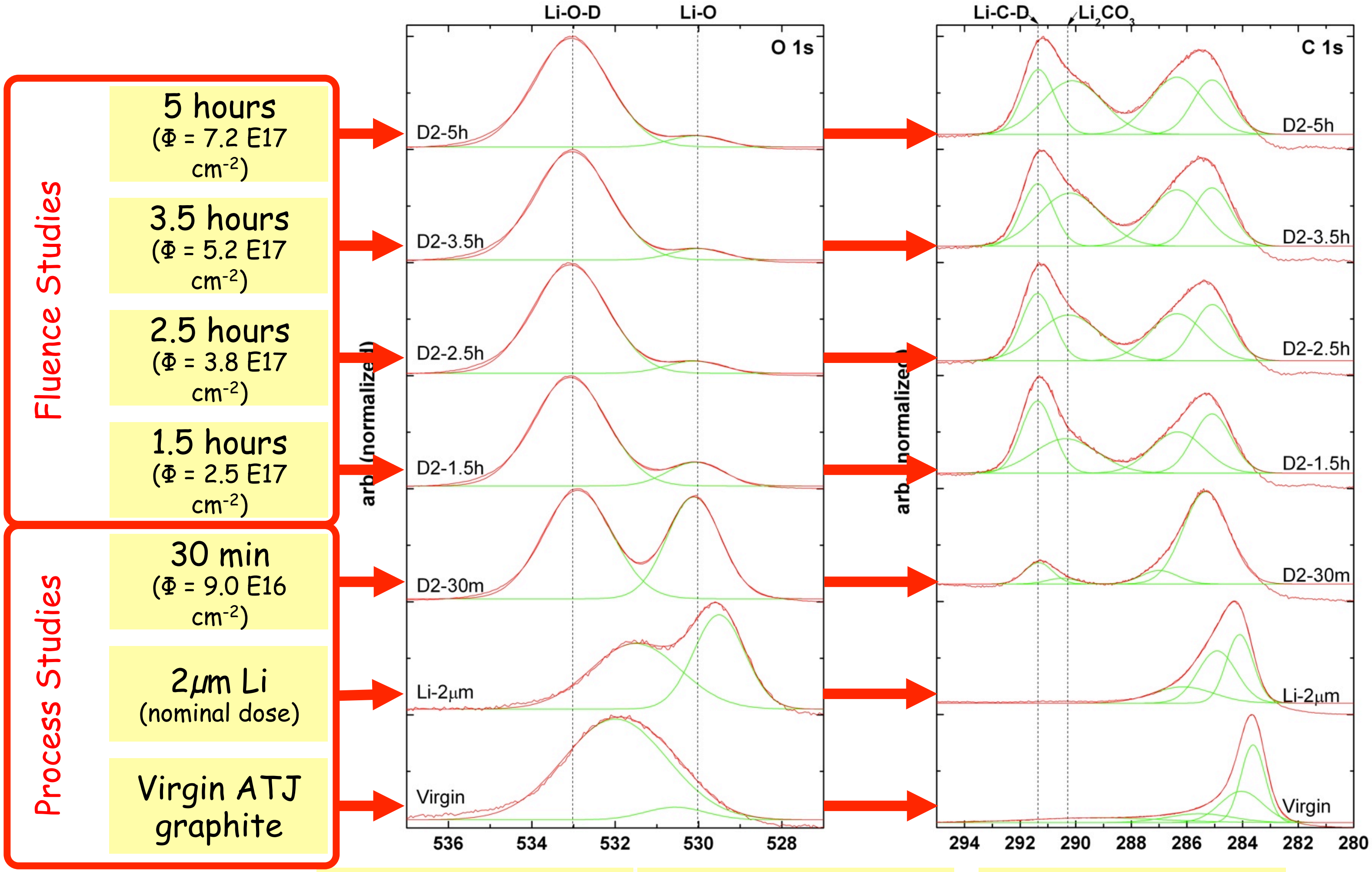
Characterization Techniques

<u>Prompt analysis of plasma facing surface:</u>

- Unique chemical interactions such as “Li-O-D” seen in ATJ graphite, and deuterium chemical interactions in surface will be identified by x-ray photoelectron spectroscopy (XPS).
- Elemental concentration (even hydrogen) on first few atomic monolayers will be measured by low energy ion scattering spectroscopy (LEISS) and direct recoil spectroscopy (DRS)
- Deuterium binding energy will be measured via thermal desorption spectroscopy (TDS)
- Analysis of four different samples can be conducted before and minutes after plasma exposure (in the time scale of surface reactions)

EXTRAS

XPS reveals peaks characteristic of deuterium retention



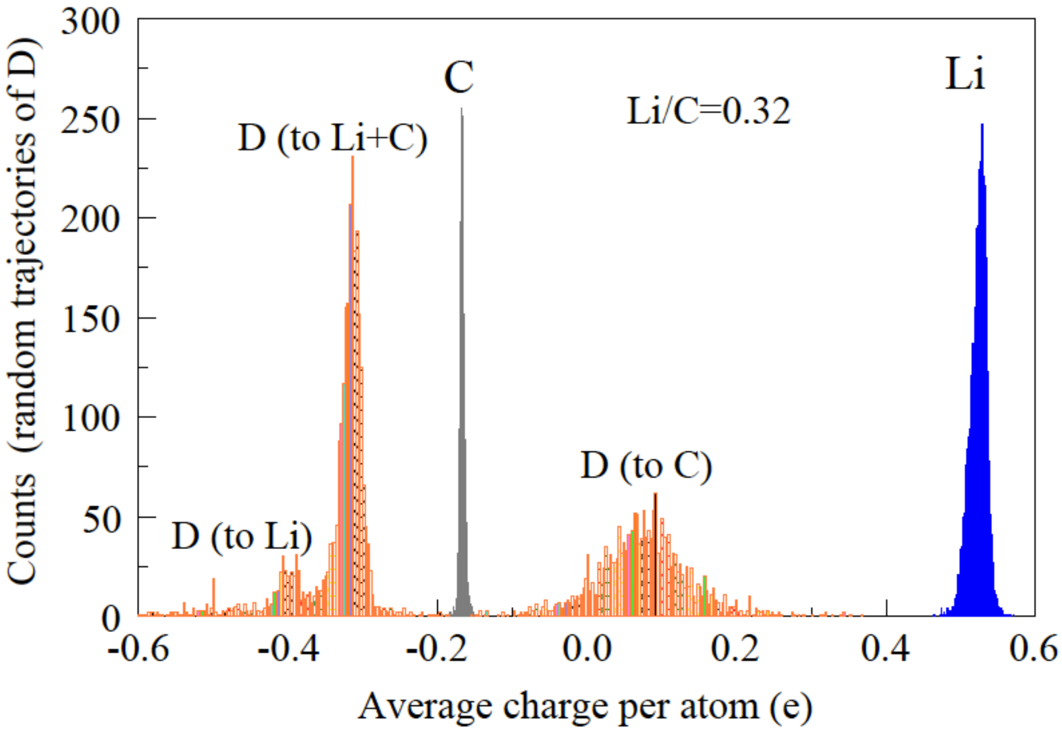
- Li-O-D peak (533.0 ± 0.6 eV) increases with D fluence
- Li-O peak (530.1 ± 0.6 eV) decreases with D fluence
- Li-C-D peak (291.4 ± 0.6 eV) increases

RSSEL

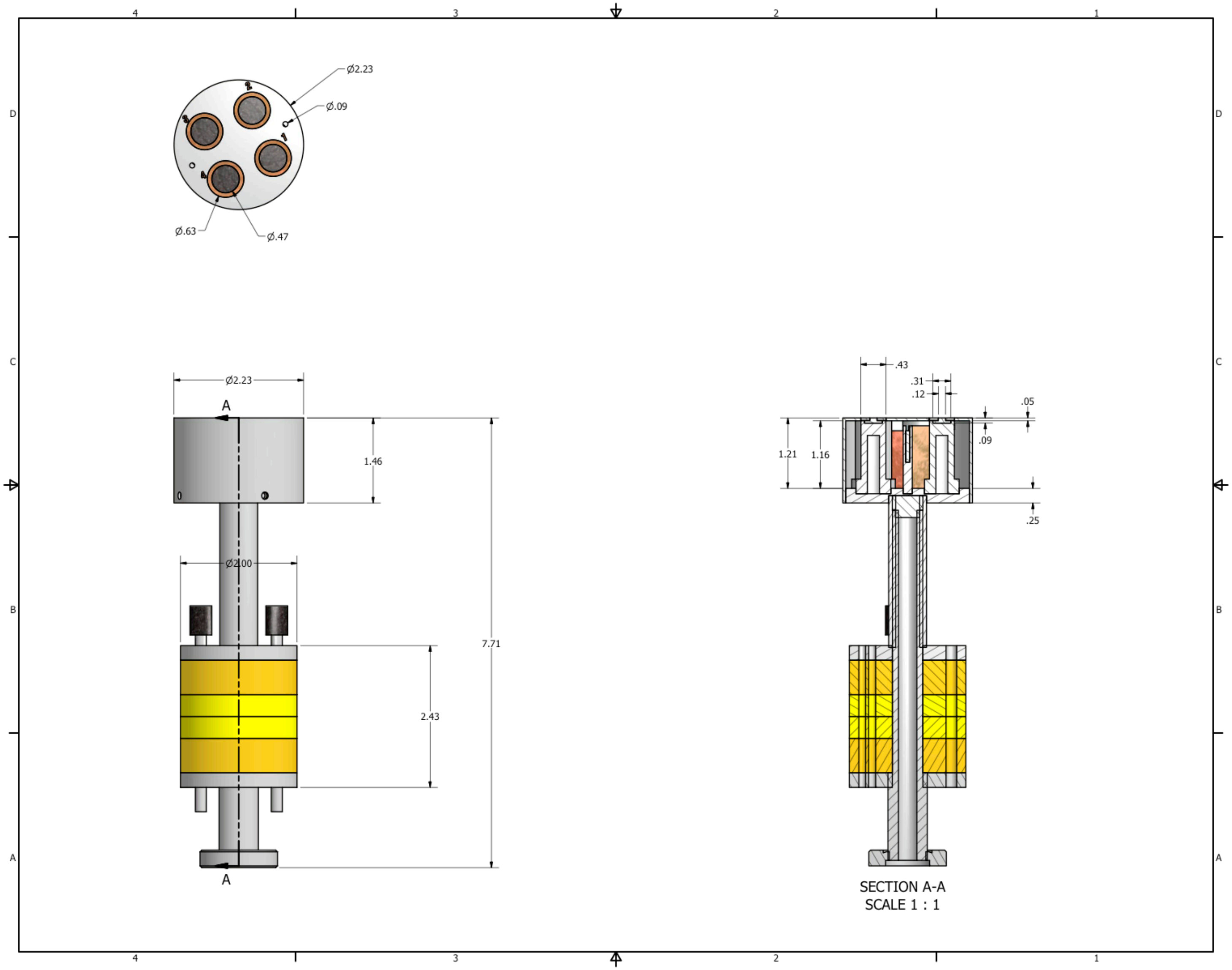
PURDUE ENGINEERING

Experiments vs. Modeling

- Experimentally, we cannot easily isolate carbon and oxygen. Models can!
  - P.S. Krstic's TBDFT results show that for 4800 trajectories D bound:
    - to Li-C is 896
    - to C only is 824
    - To Li only is 351
  - Probability to bond to Li-C (3/4) is 3 times larger than the one to C (1/4)



Extra Slides (Sample probe)



RSSEL

PURDUE ENGINEERING

MAPP- Fully inserted