Understanding longevity of lithium coatings in NSTX-U

NSTX-U FY15 Research Forum - M&P - TSG

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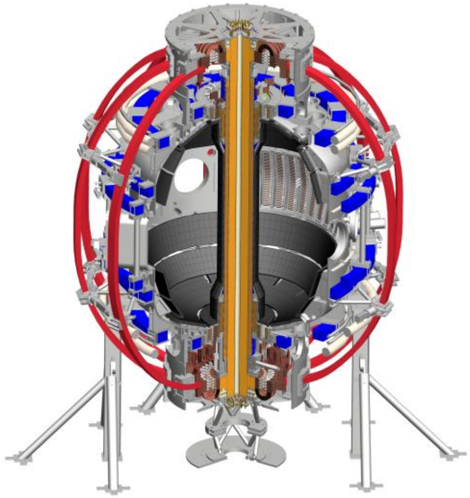
NSTX Upgrade



LLNL-PRES-XXXXXX

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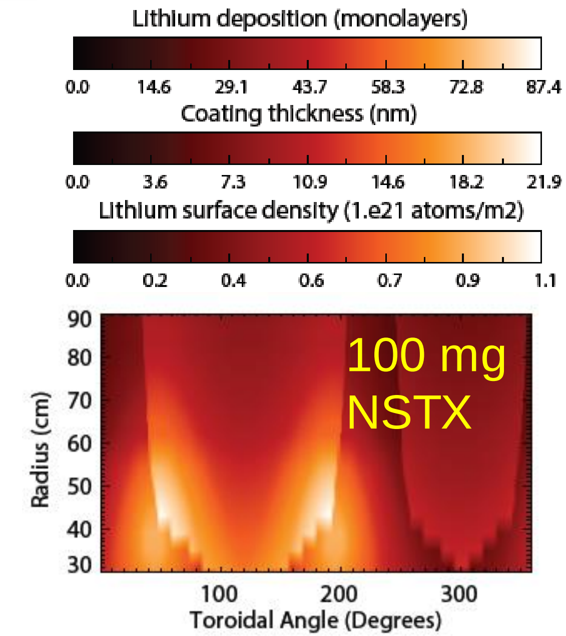
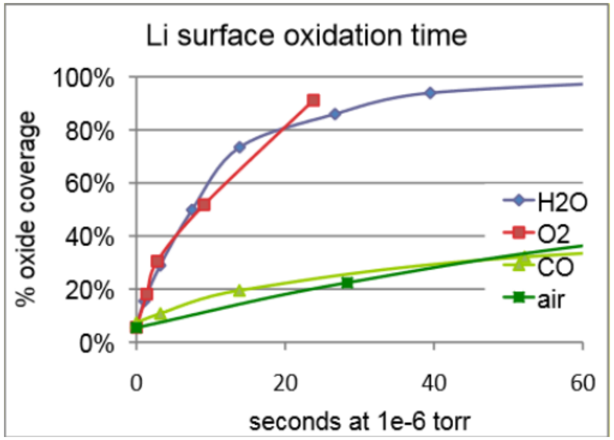
Goal: Understand and characterize lithium coatings longevity, conditioning effectiveness

- NSTX developed empirical recipe for Li conditioning (dose, frequency of pre-discharge evaporation)
  - Observed divertor recycling, lithium sputtering evolution lifetime inconsistent with gross erosion only
- Goals of this XP are:
  - Understand experimentally-observed lithium coatings lifetime
  - Develop a metric for lithium effectiveness based on PMI measurements to correlate with global parameters
- Support Thrust MP-1, MP-2 NSTX-U five year plan
- Cross-cutting with PC-TF
  - "Wall coating optimization for increased particle pumping"

Motivation: What determines lifetime of lithium effects on graphite in NSTX?

- What determines Li lifetime in NSTX?
  - D interaction with Li and not C:
    - Thickness vs implantation depth (~ nm)
    - Thickness vs graphite roughness (~ microns)
    - Areal density vs integrated fluence (erosion)
    - Intercalation in graphite
  - Passivation (activation?) of Li surface
    - Reaction with background gases (O, H_2O, ..)
    - Saturation with deuterium
  - Fraction of first wall with lithium coverage
    - Progressive coverage of PFCs without direct evaporation (to be addressed in PC-TF)





Skinner APS 2012

Tools: Enhanced spectroscopic tools + MAPP for most extensive measurements up-to-date

- Deliverables to be compared with global parameters:
  - Local deuterium recycling (OSP, upper div, MAPP)
  - Li, C, O sputtering (OSP, upper div., MAPP)
  - Deuterium pump-out from SGI pulses
  - Wall loading rate from deuterium particle balance
  - MAPP elemental composition
- MAPP to complement spectroscopic measurement:
  - XPS between shots to provide elemental surface composition
  - Minimal XPS time ~10 minutes (0.1eV/s, 20 eV range, Li, C, O) to maintain same history on MAPP and PFCs
- Theory/modeling: UEDGE+ERO to compare MAPP surface composition with what inferred from spectroscopy

Experimental plan: test effect of erosion, intercalation, reaction with background gases

- Established highly shaped ELM-free Li-conditioned H-mode
- Test effect of thickness/areal density (~1 day):
  - Scan ~100x in areal density/incident ion fluence
  - 25mg (~5nm~D^+ range) to 500mg (~100nm<<surf. roughness)→0.25-5e21 at./m^2
  - For every lithium dose, scan integrated incident ion fluence:
    - Input power (1-6 MW), possibly upstream density or repeat shots
    - Further enhance particle flux via div. gas puff, SGI
- Test effect of intercalation (timescale tested by MAPP already):
  - Constant Li dose at different rates ending right before next shot (5, 10, 20 mg/min)
- Test effect of reaction with background gases
  - Constant dose but different rate, scan time before the next shot
- Evap. coatings vs. plasma deposition, real-time Li to refresh coatings?
  - Add LGI sub-ELM threshold (300 μm) to shots that show passivation

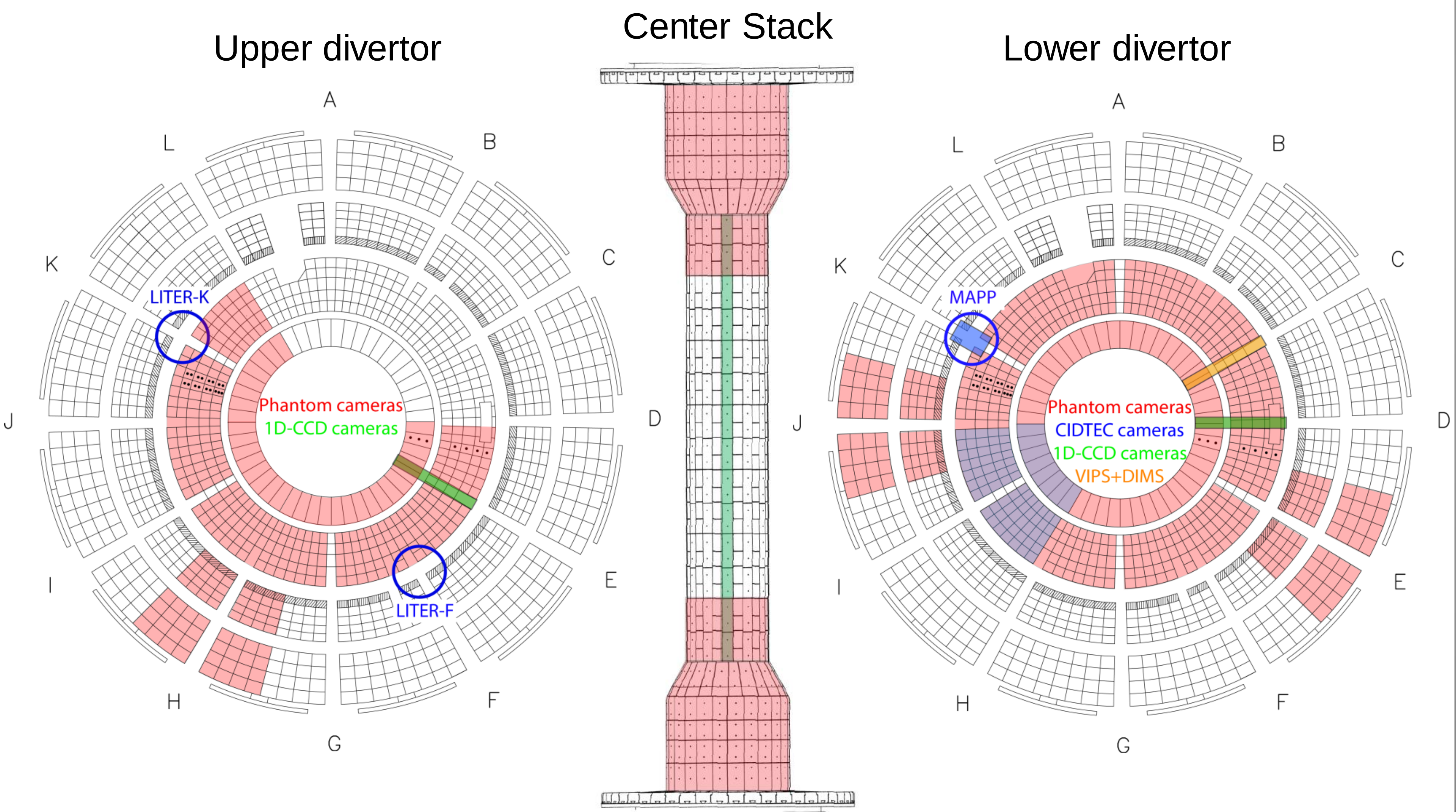
Additional requirements and collaboration/publication strategy

- Additional requirements:
  - Would be useful to have 1 s discharges with controlled R_{OSP}
  - Should run shortly after Li introduction to avoid large buildup
  - Repeat subsection of scans later in run to verify history effect
  - Benefit from one ATJ sample with same history as the PFCs
  - Benefit from remote MAPP operation between shots

- Collaboration + publication strategy:
  - Theory support from J.P. Allain
  - MAPP support from J.P. Allain, C. Skinner
  - UEDGE+ERO by LLNL postdoc

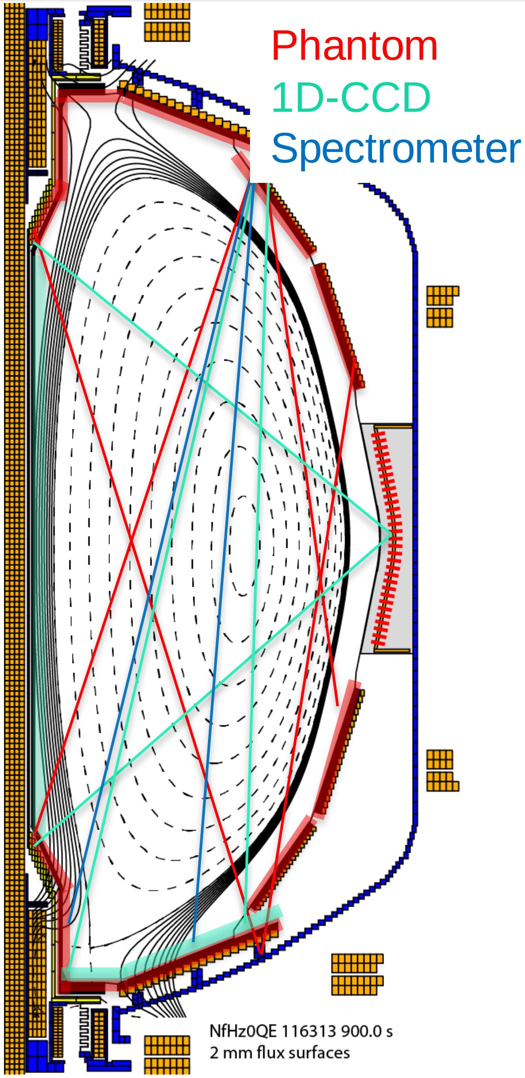
Backup

Tools: Upgraded diagnostics for full poloidal, toroidal coverage of impurity emission



Tools: Upgraded diagnostics for full poloidal, toroidal coverage of impurity emission

- Full poloidal coverage of impurity emission + full toroidal divertor coverage
  - Phantom (4), CIDTEC (1+ 1 two-color), 1D-CCD (9) cameras, 3 spectrometers
- High resolution views for MAPP and inboard divertor
- Views are centered at toroidal location of probes (Bay D, Bay J)
- Availability/reliability of probes limited extrapolation of influxes
  - Redundancy approach implemented for FY2015



Strategy: Simultaneous monitoring of different lines for divertor impurity influxes

- **Simultaneous** measurement of multiple lines of same charge state (carbon and lithium) to avoid uncertainty in plasma parameters (T_e, n_e) in lower divertor
  - C II lines with different dependencies on plasma parameters
    $\rightarrow$ C^{1+} influx determination (426, 514, 723 nm)
  - Li I lines with different dependencies on plasma parameters
    $\rightarrow$ Li^{0+} influx determination (460, 610, 670 nm)
  - Gerö band (CD) + C II line
    $\rightarrow$ chemical vs physical contribution
  - 909 nm region (DIMS)
    $\rightarrow$ C^{0+} influx, evaluation of f_{chem}/f_{phys}
- Upper divertor views to inform on evolution of upper PFCs