Effect of Lithium Wall Conditioning on Impurities in LTX

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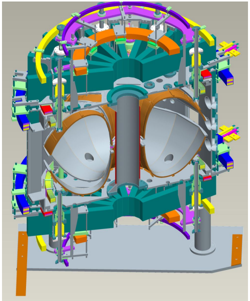
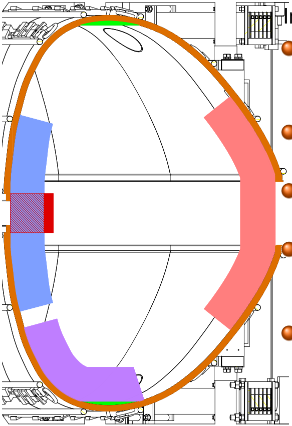
LTX and diagnostics



close-fitting shells

designed to be heated

and coated with lithium



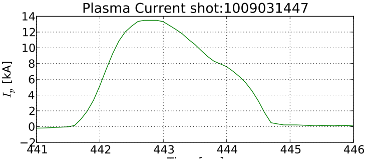
Impurity Diagnostics

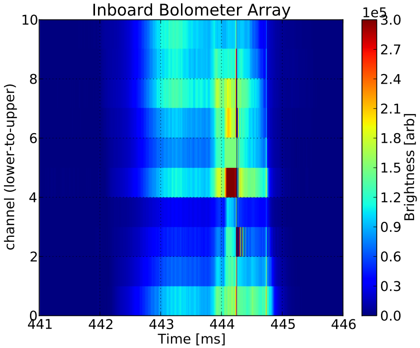
- inboard AXUV Lyman-α & Bolometer Array
- outboard AXUV Lyman-α Array
- limiter filterscopes: H_α, H_γ, C III, Li I
- center-stack filterscopes: H_α, O II, visible
- visible survey spectrometer: OceanOptics HR4000+

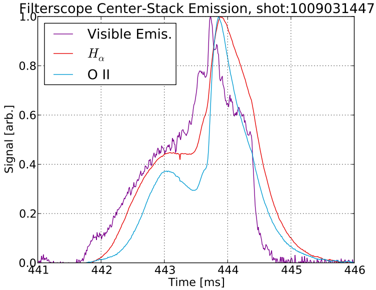
LTX Achieved Parameters

Major Radius	40 cm	Plasma Current	67 kA
Minor Radius	26 cm	Central Density	$\sim 8 \times 10^{18}\ \mathrm{m}^{-3}$
Toroidal Field	1.8 kG	Duration	20 ms

Evidence of radiative collapse in pre-Li discharges



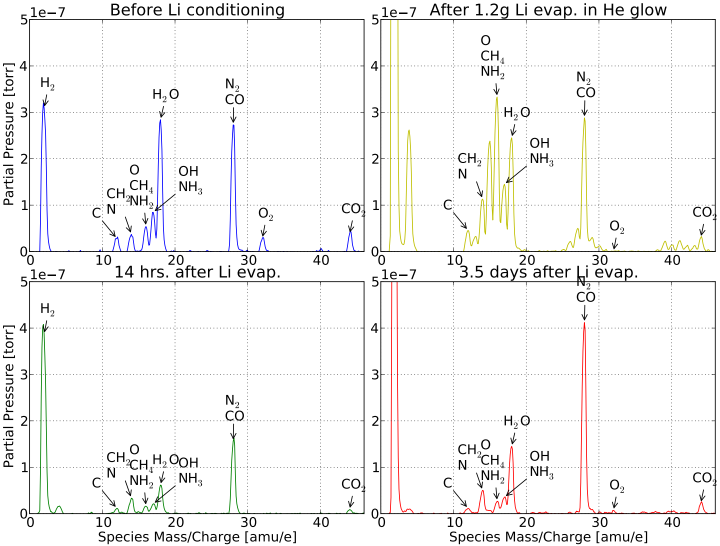




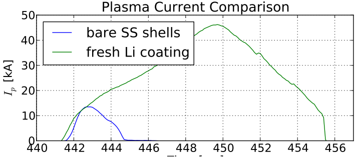
Suggest possible impurity collapse!

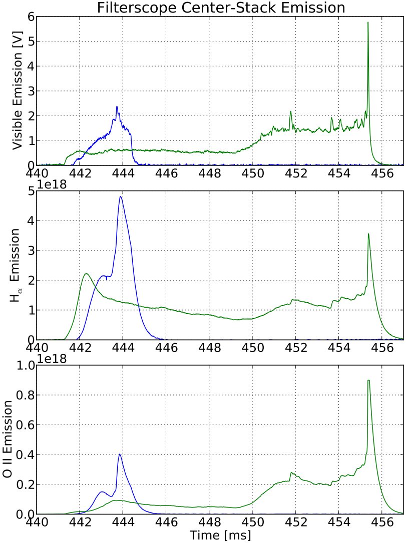
Necessary to reduce impurity influx!

Large reduction in RGA H_2O peak after Li evaporation



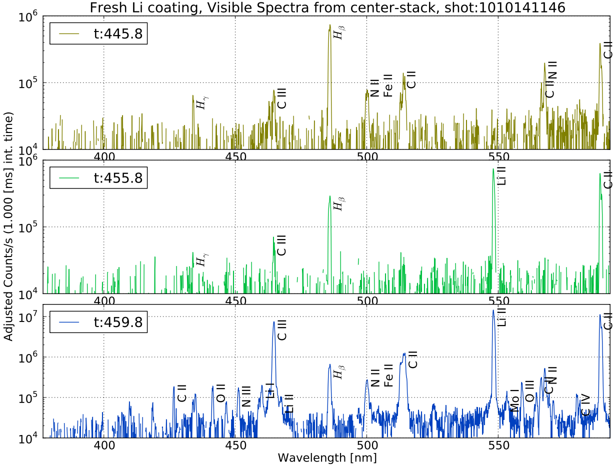
No radiative collapse with fresh, solid Li coatings





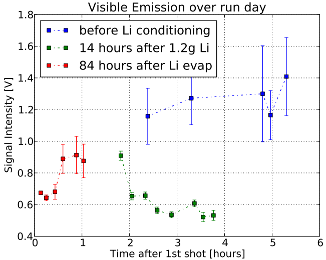
- significantly higher plasma currents and longer discharges
- plasma duration generally seems to be limited by V_{loop}
- lower overall impurity emission levels
- impurity emission rises during additional fueling

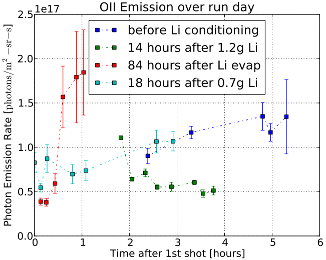
Relatively clean spectra in middle of discharge



- spectra taken at multiple time points during the same discharge
- Li and C appear to dominate fluxes from center-stack
- at end of discharge significant increase in impurity emission: Li, C, N, O, metal emission

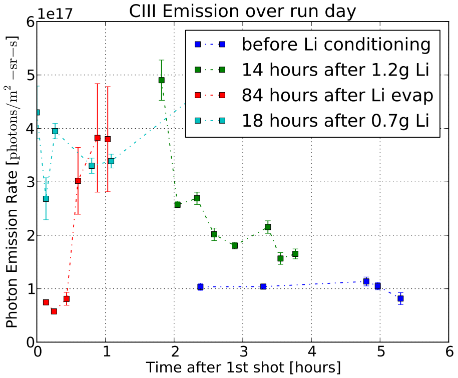
Fresh Li coating reduced total visible & O II emission





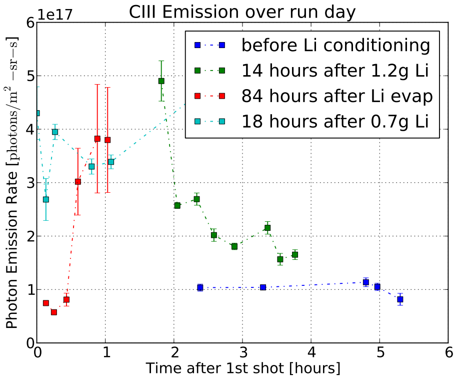
- fresh solid Li surface correlates with decreased visible and O II emission long-term trends
- occurs even though discharges with fresh Li surface had higher $\bar{n}_e$ due to increased fueling
- need better measurement of $T_{e,wall}$ to quantify oxygen flux into plasma

Li coating increases C III emission!?



- LTX has no carbon PFCs
- C III emission has increased following Li evaporation
- but ... C III emission tends to decrease from shot-to-shot when operating with a fresh Li surface

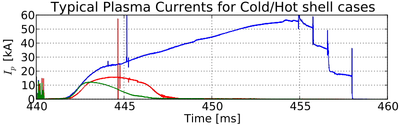
Li coating increases C III emission!?

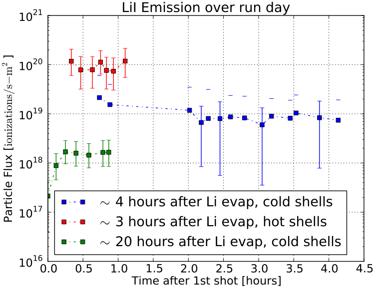


Reason for increased C III emission remains a mystery

- LTX has no carbon PFCs
- C III emission has increased following Li evaporation
- but ... C III emission tends to decrease from shot-to-shot when operating with a fresh Li surface

Hot shells increase Neutral Li Flux $\sim 10\times$





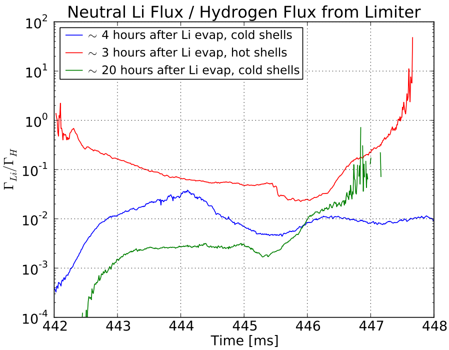
- 300 °C Li evaporation rate $\sim 4 \times 10^{18}$/m^2-s [Moir]

- physical sputtering and evaporation can source lithium into the plasma
  - about 2/3 of sputtered lithium is Li 1+
- insensitivity of Li (610 nm) S/XB coefficient to n_e, T_e allows determination of neutral Li flux:

$$\Gamma_{\mathrm{Li}^{0+}} = 4\pi\sigma^{S/XB}_{\mathrm{LiI}} I_{\mathrm{LiI}}$$

- 10X higher Li flux into plasma when operating with hot shells

Hot shells increase neutral Li flux more than H flux



- relative insensitivity of S/XB coefficients allow an idea of relative Li/Hydrogen fluxes:

$$\frac{\Gamma_{\mathrm{Li}^{0+}}}{\Gamma_{\mathrm{H}}} = \frac{\sigma_{\mathrm{LiI}}^{S/XB} I_{\mathrm{LiI}}}{\sigma_{\mathrm{H}_\alpha}^{S/XB} I_{\mathrm{H}_\alpha}}$$

- neutral Li influx increases more than hydrogen recycling rate for hot shells

Conclusions

- fresh Li plasma-facing surfaces may contribute to improved plasma performance by reducing impurity wall sources (oxygen, metals?) lowering overall plasma impurity content
- neutral Li flux into plasma is $\sim 10\times$ higher when operating with hot shells, and substantially higher than the estimate from the known Li evaporation rate
- the reason for increased carbon emission following Li conditioning remains unknown

Future Work

- install upgraded AXUV diode array to simultaneously measure Lyman-α and P_{rad}, and determine effect of Li conditioning on P_{rad}
- bring XUV spectrometer on-line to measure impurity emission from the core
- add filterscope channels:
  - measure multiple Li I lines to constrain T_e, n_e near wall
  - measure Li II emission to quantify ionized Li influx
  - measure C II emission to better quantify carbon fluxes by measuring emission that is more wall-localized
- determine hydrogen recycling and impurity yields by using edge modeling codes and Langmuir probe measurements

Acknowledgments

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Talk available at http://princeton.edu/~erikg/