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Characterization of the LLD with a two-color infrared camera

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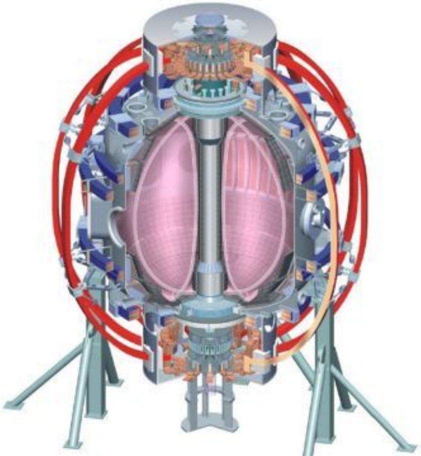
Adam McLean, ORNL
J.-W. Ahn, T. Grey, R. Maingi

Lithium TSG Session
NSTX Research Forum
Dec. 2, 2009



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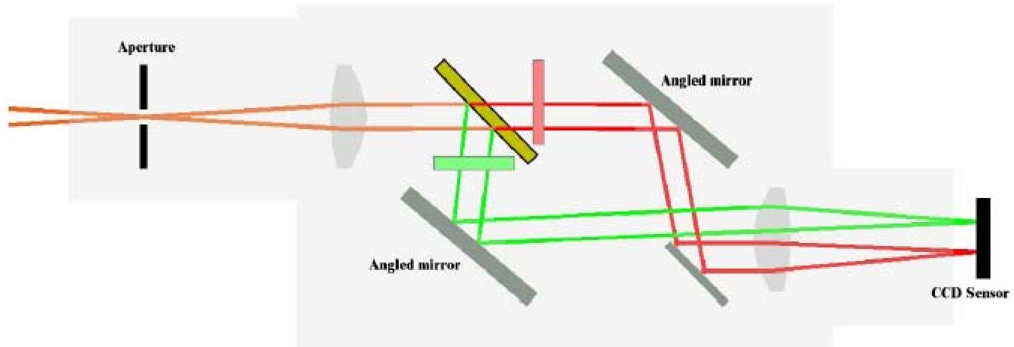
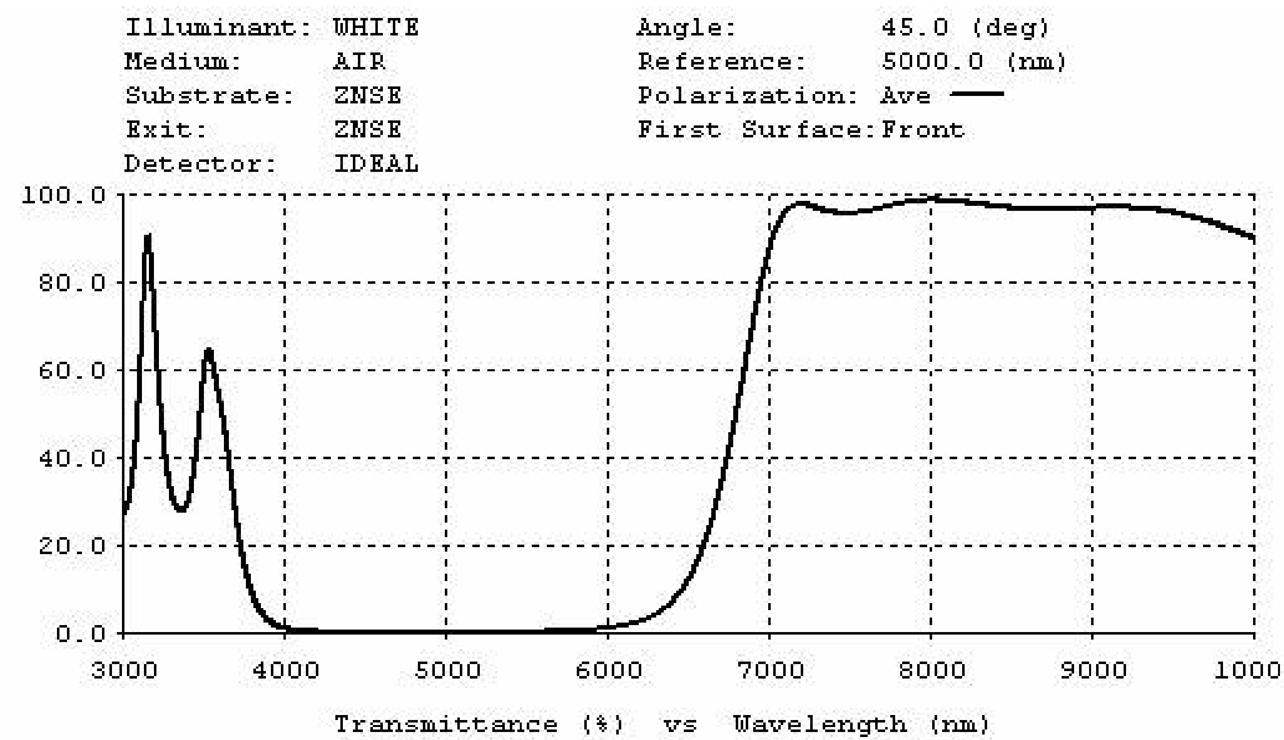
The two-color infrared camera is an innovative and essential diagnostic for operation of the LLD

- Never before utilized on a fusion device (primarily military applications to date)
- Installation of the LLD will make assumptions of high surface emissivity (applicable to graphite) inaccurate
  - Surface coating changes in real time during plasma shots, emissivity changes due to H-absorption in Li, reflections from Li surface, deposition of Li on C surfaces, erosion/transport of Li and C
  - Leads to significant error in surface temperature and heat flux as measured with traditional single color cameras
- Two-color camera measures temperature is based on the ratio of integrated IR emission in two IR bands, not single band intensity
- Image split into medium wavelength IR (4-6 μm) and long-wavelength IR (7-10 μm) using a dichroic beamsplitter, filtered with bandpass filters, projected side-by-side into the fast IR camera
- Optical adapter to existing fast IR camera (Ahn)

Enabling technology: IR dichroic beamsplitter

- Produced by Lambda Optics (US)
- Mounted at 45° in image splitter
- Passes >85% of long wavelength IR (7-10 micron)
- Reflects >99% of mid wavelength IR (4-6 micron)
- Also available in SWIR/MWIR (3-4 micron pass, 4.5-5.0 micron reflect) and LWIR/LWIR (8-9 micron pass, 10-12 micron reflect) for use with other IR cameras





Proposal: 1/2 day experiment for validation data collection, help characterize LLD performance

- Run repeat low triangularity discharges
  - Fixed OSP and stepped strike point sweeps in lower divertor
  - Compare results with strikes points away from LLD to 2009 results
  - Effect of thicker Li layer inboard of LLD?
- Repeat with OSP approaching cold LLD
  - Determine if results are reasonable, as predicted
- Repeat with LLD warm, hot
  - Check for changes, especially as Li vaporization becomes significant
- Calculate heat flux profile between shots
- Infer surface emissivity, elucidate roll of surface characteristics
  - What are the dominant causes for changes from assumption of graphite emissivity?

Disruptions during operation of the LLD

Adam McLean, ORNL
Stefan Gerhardt (Disruption Master)

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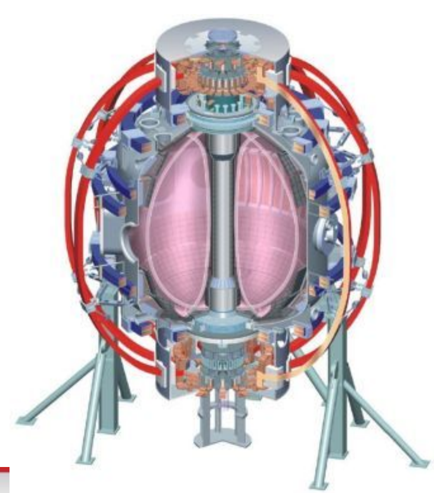
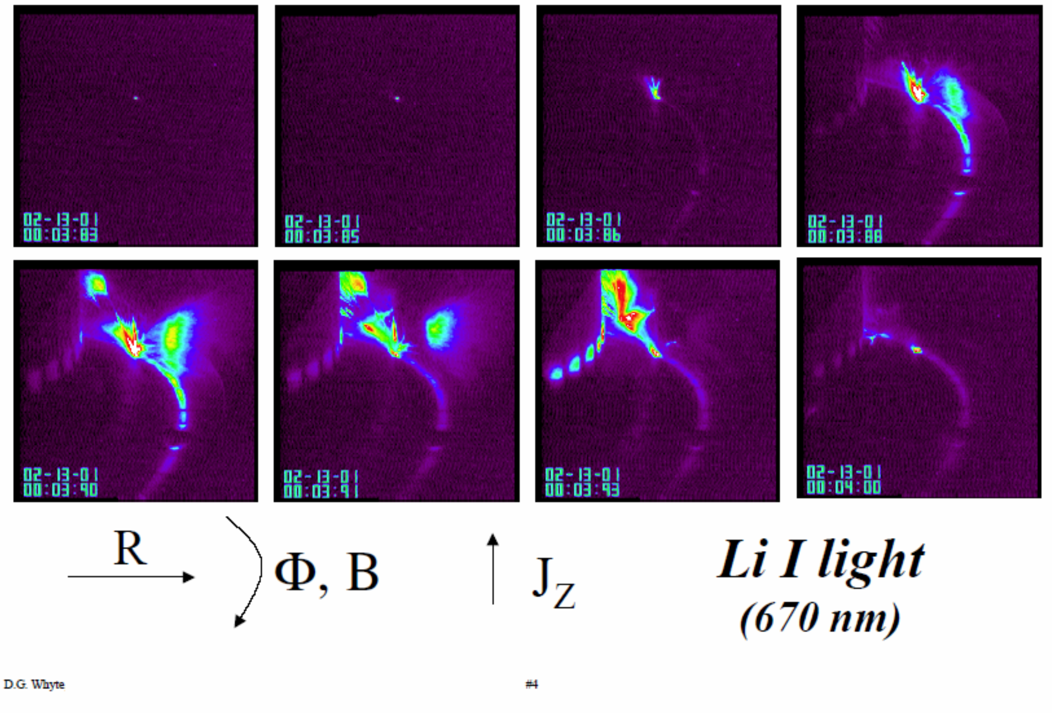


Study disruptions occurring on the LLD with the goal of avoidance, prevention (?)

- Disruptive events from Li-DiMES experiment still fresh in minds of many
  - First OSP exposure of Li-DiMES resulted in ‘bursty’ removal
  - Quiescent erosion followed by macroscopic release (~10^{22}/s) upon Li melting, radiative disruption
- Li influx >> evaporative loss rate
- Radial outward movement of Li consistent with measured J_zxB (which is always present near strike points)
- Conclusion: Surface non-uniformities most likely unacceptable (i.e., tiny bumps, ridges, etc.)



- Similar bloom not typical on FTU at up to 5 MW/m^2

Utilize new capabilities to determine causes and monitor response of LLD to disruption events

- New capabilities in NSTX for 2010:
  - Halo current diagnostics (Gerhardt)
  - Triple Langmuir probe array (Kallman)
  - Fast two-color IR viewing the LLD full time (McLean/Ahn)
    - Heat flux changes with LLD operating mode (cold, warm, hot)
    - Emissivity/surface condition variability
  - New spectroscopic capabilities (Soukhanovskii, Roquomere, McLean)
    - Phantom camera with LiI and LiII filters
    - Divertor spectrometer
    - Possible new full-time spectroscopic monitors on LLD

Proposal: ½ day experiment to study onset, results of disruptions on LLD

- Approach LLD with the OSP
  - Repeat in cold, warm, hot LLD operation
- Scan I_p, B_T, P_{INJ}, ELM regimes
  - Where in parameter space are disruptions most likely?
  - Can plasma parameters be varied more effectively with the OSP on graphite then moved to the LLD, or while the OSP is on the LLD?
- Is performance of subsequent discharges affected by a previous disruption on the LLD?
- Can we accurately determine the material (Li or Li compounds) eroded/removed/vaporized from the LLD in a disruption?

Study of Li condensation in NSTX

Adam McLean, ORNL

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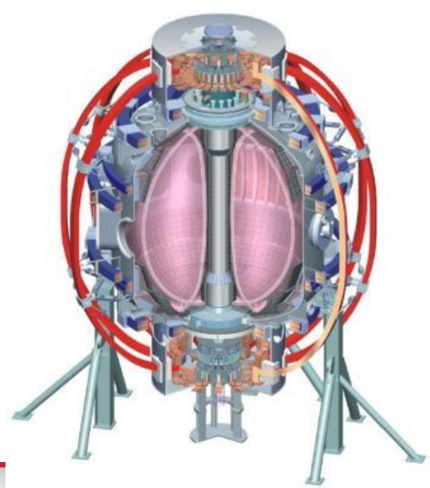

Li condensation on the vessel walls

- Eroded and evaporated Li will condense both back on the LLD and on graphite surfaces
- Self-regeneration of Li on LLD will reduce Li loss in the tray
- Amount of Li that will be lost to walls and its impact on the LLD fill time is unknown

- Take advantage of new spectroscopic capabilities (Soukhanovskii, Roquemore, McLean)
  - Phantom camera with LiI and LiII filters to measure Li removal rate, DI filter for recycling, CD and CI filters for signs of Li coating on graphite surfaces
  - Divertor spectrometer to monitor all atomic/ionic/molecular emissions
  - Possible new full-time spectroscopic monitors on LLD for start-to-end of campaign long-term trends in specific emissions

Proposal: Piggyback experiment to study Li condensation

- Scan I_p, B_T, P_{INJ}
- Compare data with varying heat flux, OSP duration on the LLD, LLD cold/warm/hot and Li coverage in the vessel
  - Do particular parameters enhance erosion and transport of Li?
- Search for signs of Li coverage
  - Changes in extent over time?
  - Can those changes be correlated to long-term plasma performance through 2010?
- Can molecular emission from Li_2, LiOD, LiC be detected spectroscopically in addition to LiD?
  - Significant for validation of Li atomic/molecular chemistry models in simulations