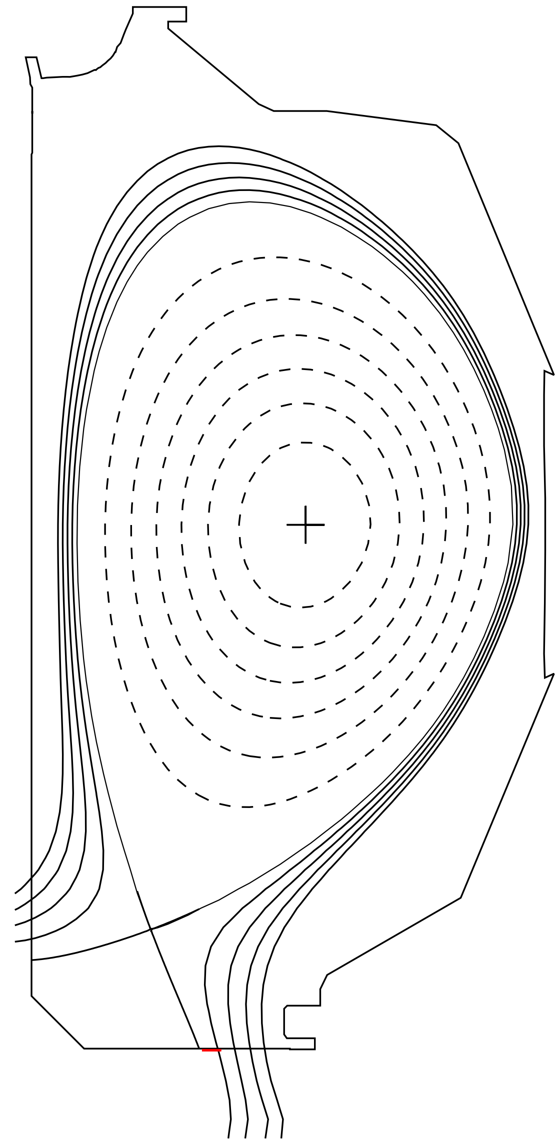
Basic Exposure Parameters for Lithium

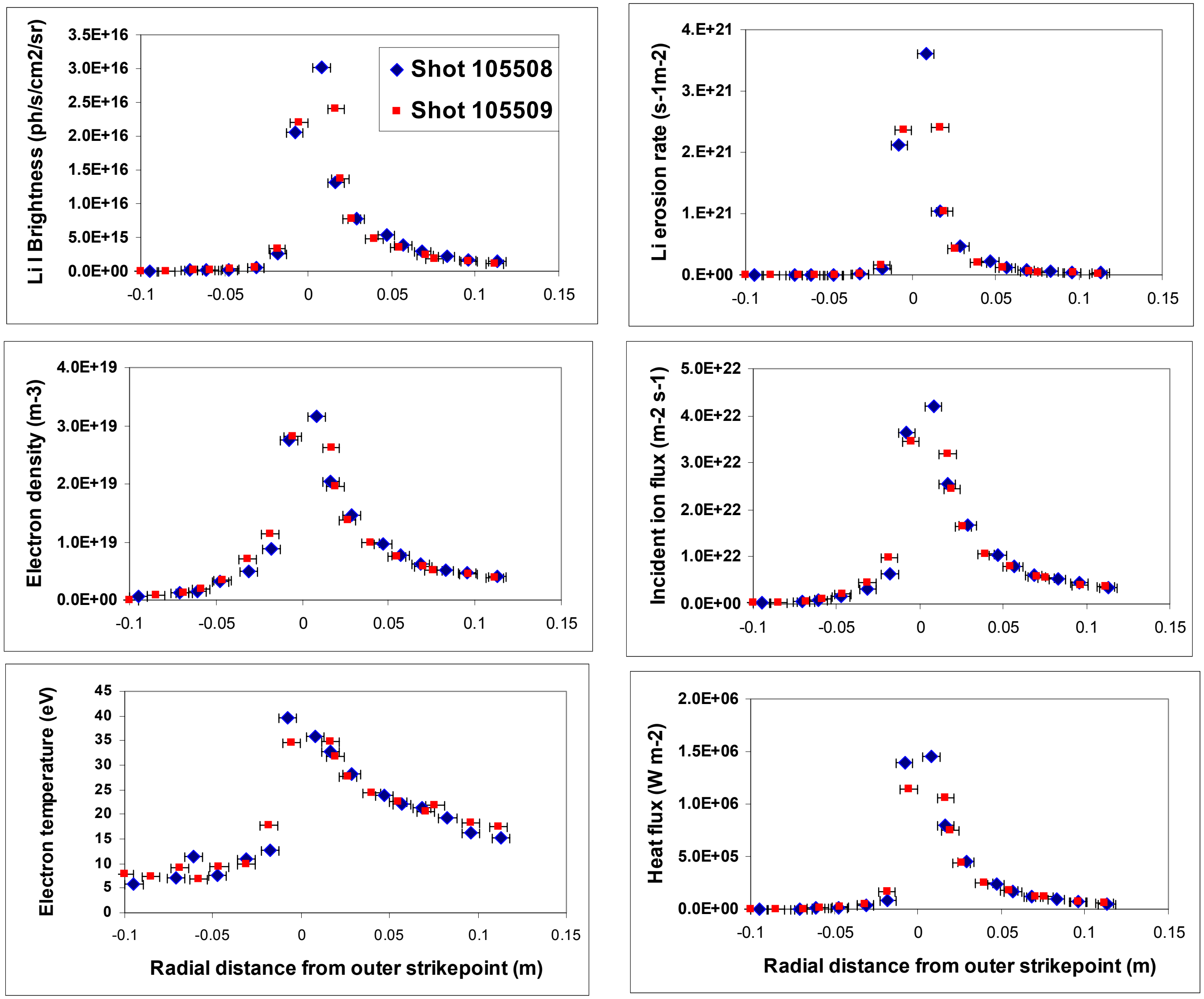
- Lower single-null plasma:
  - $I_p = 1.1$ MA, $n_e = 2.5 \times 10^{19}$ m^{-3}, B_T=2 T.
- L-mode confinement (i.e. no ELMs) maintained with very low heating power (~ ¼ of an effective source)

  $P_{NBI} \sim 0.5$ MW + $P_{ohmic} \sim 0.7$ MW =

  $P_{in} \sim 1.2$ MW.
- Divertor plate plasma profiles as shown in next slide.
- DiMES viewed by one spectrometer, two visible cameras and IR camera.
- Solid lithium sample: O.D. ~ 2.5 cm, thickness ~ 1 mm, all-graphite backing.

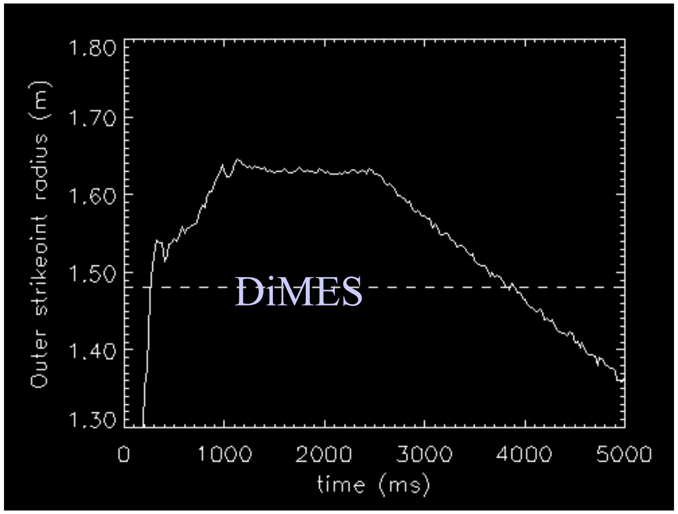


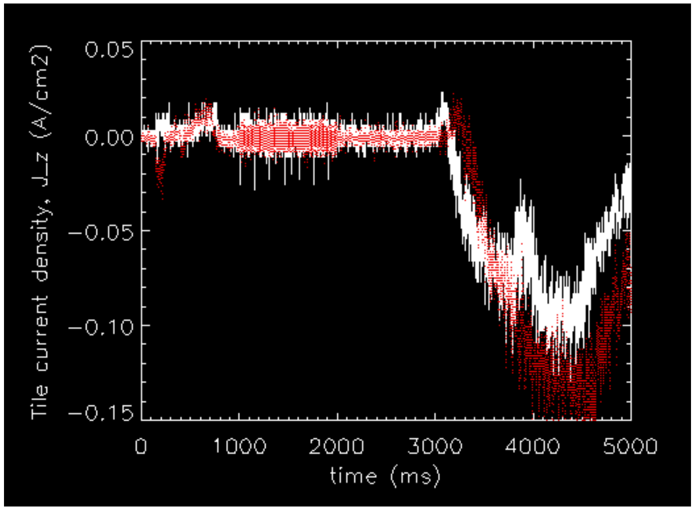
Divertor plasma profiles for Li exposure



The first four exposures swept the OSP past the Li sample

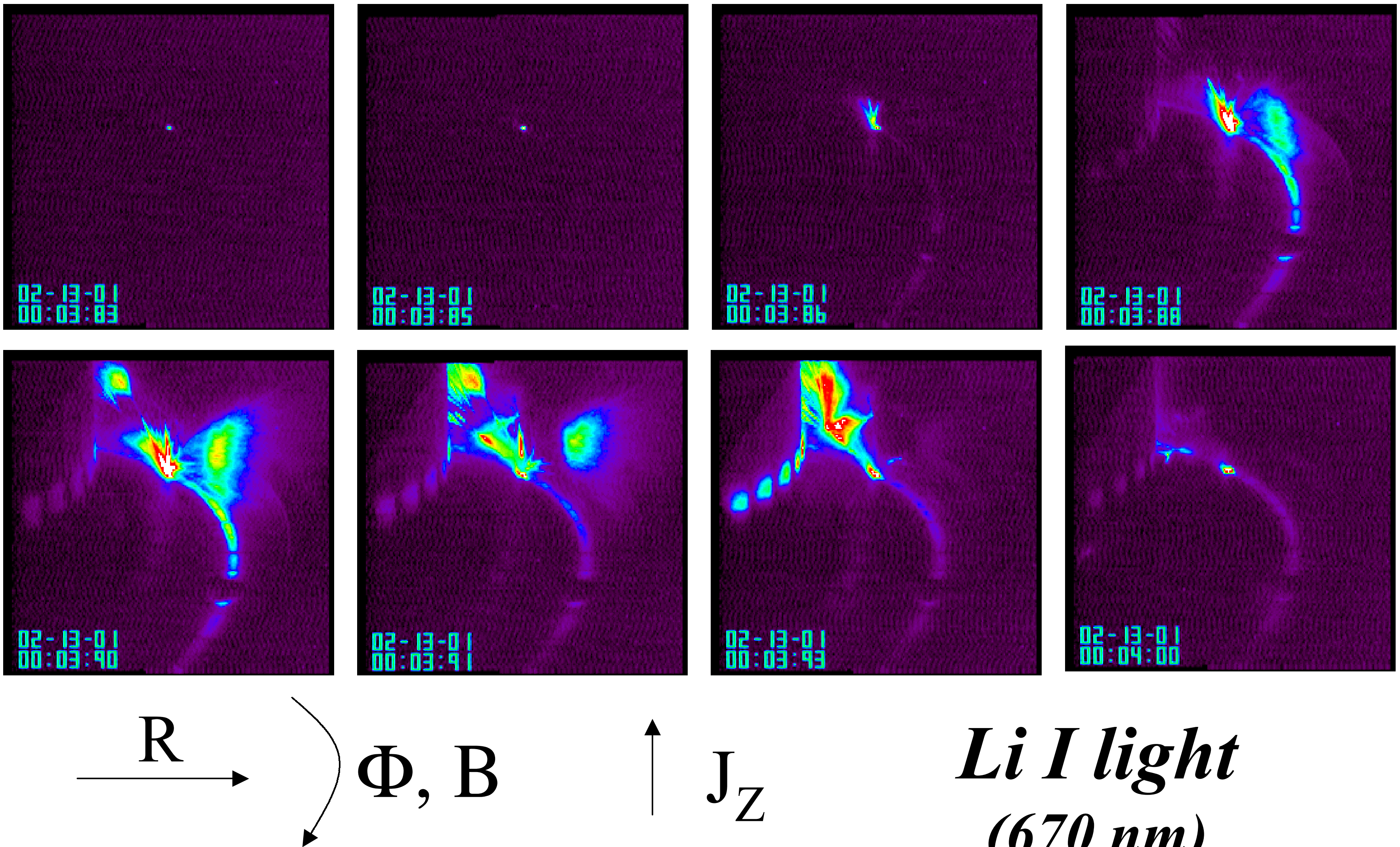
- First exposure discharge (105506):
  - Side-viewing camera showed significant "bursts" of lithium removal when the OSP was moved near (see proceeding slide).
  - Subsequent exposure was more quiescent.
  - The lithium bursts had little or no effect on the core plasma.
  - Visual inspection of the sample showed a highly reflective surface, indicating the lithium had melted.
  - Vertical thermo-electric currents ~ .1 A/cm^2 measured near OSP, going out of plate.
- Next three exposures (105507-09)
  - No large influx of lithium.
  - Reproducible shot-to-shot for lithium removal
  - Effective yield near separatrix ~ 10%.





White: ϕ=135, Red: ϕ=310
ϕ_{DiMES}=150

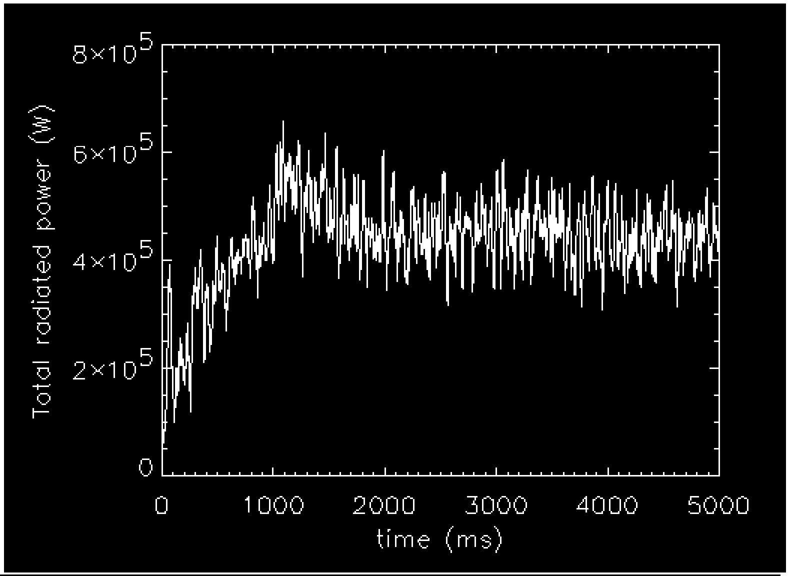
The very first OSP exposure of the lithium resulted in some "bursty" removal of the lithium



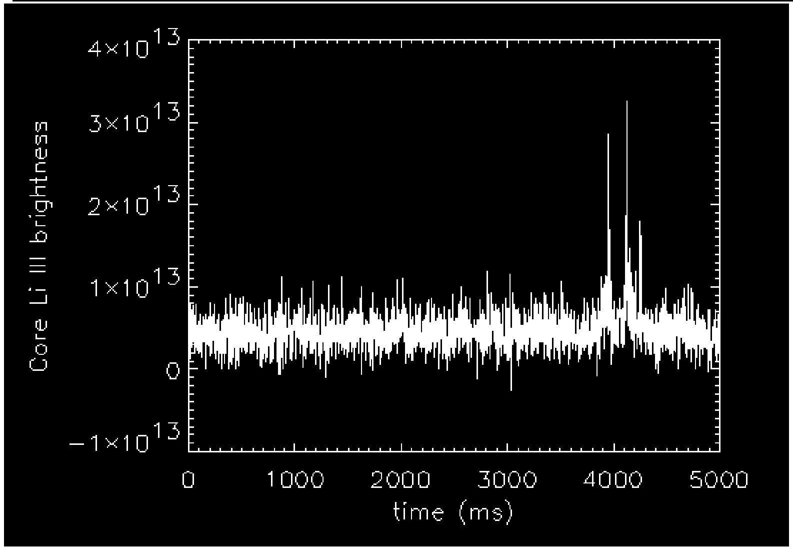
Li I light
(670 nm)

Li bursts in divertor during first exposure shot had little effect on the core plasma

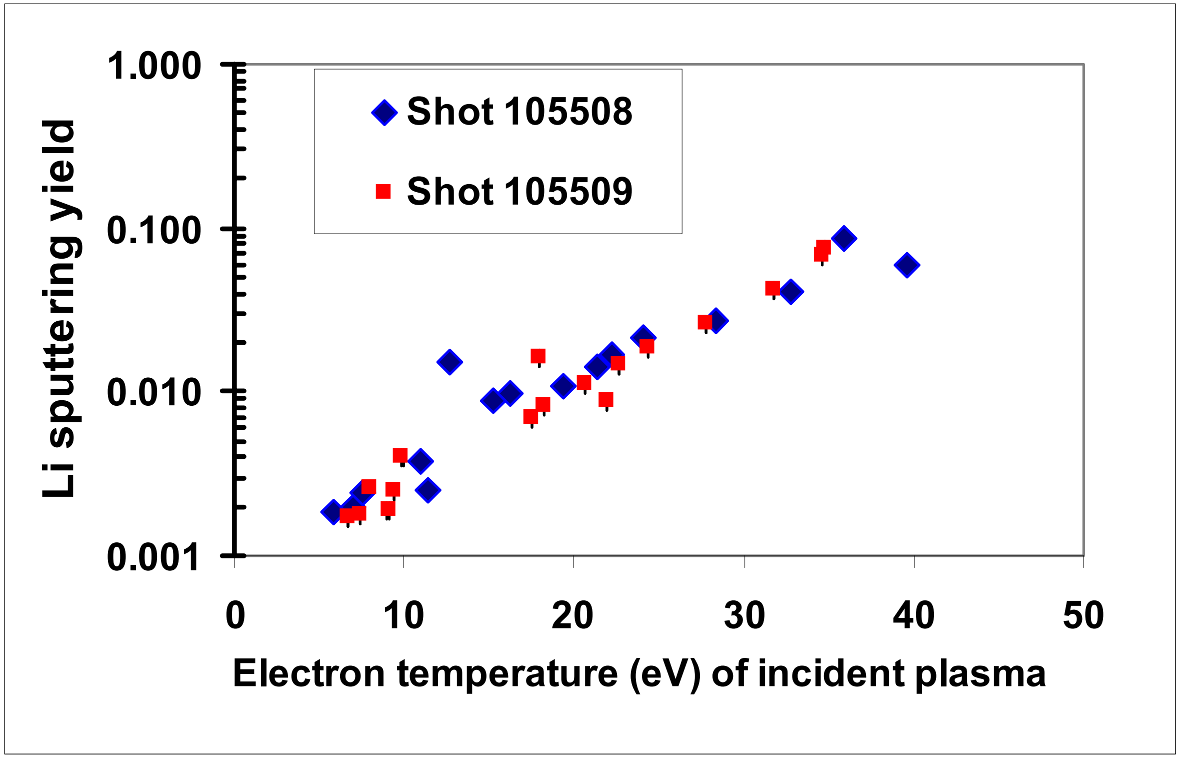
Total radiated power did not change



Very weak emissions of Li III in the core plasma



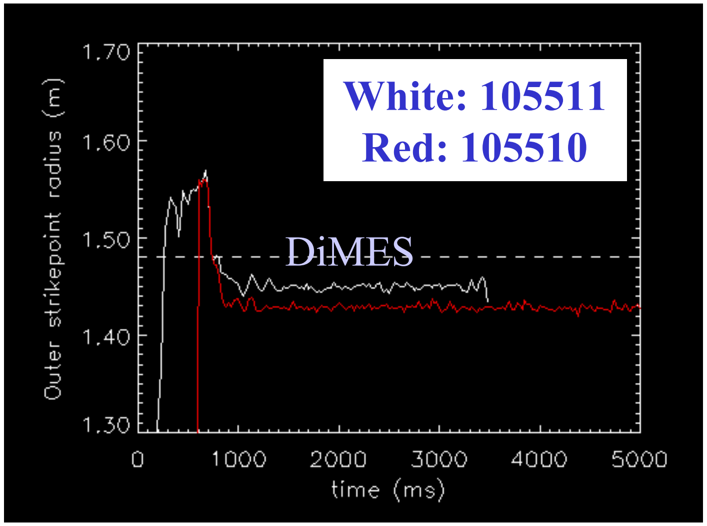
Effective yield of Lithium from reproducible, "well-behaved" swept discharges



- Yield measurement:
  - Incident flux from Langmuir probe
  - Li efflux from measured Li I brightness x S/XB(n_e,T_e) for transition

The next two discharges fixed the strikepoint position during the shot

- Shot 105510:
  - OSP ~ 5 cm inboard of DiMES for t >1000 ms.
  - T_e ~ 20 eV, q ~ 0.2 MW/m^2
  - Steady erosion throughout the shot, at a level consistent with the swept discharges.



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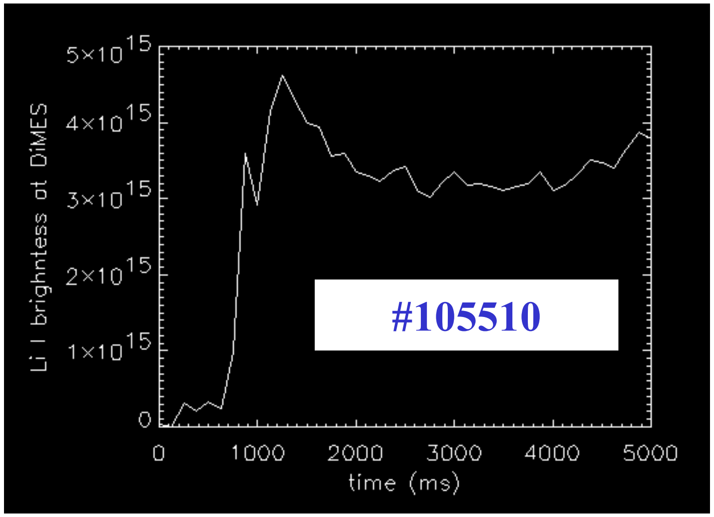
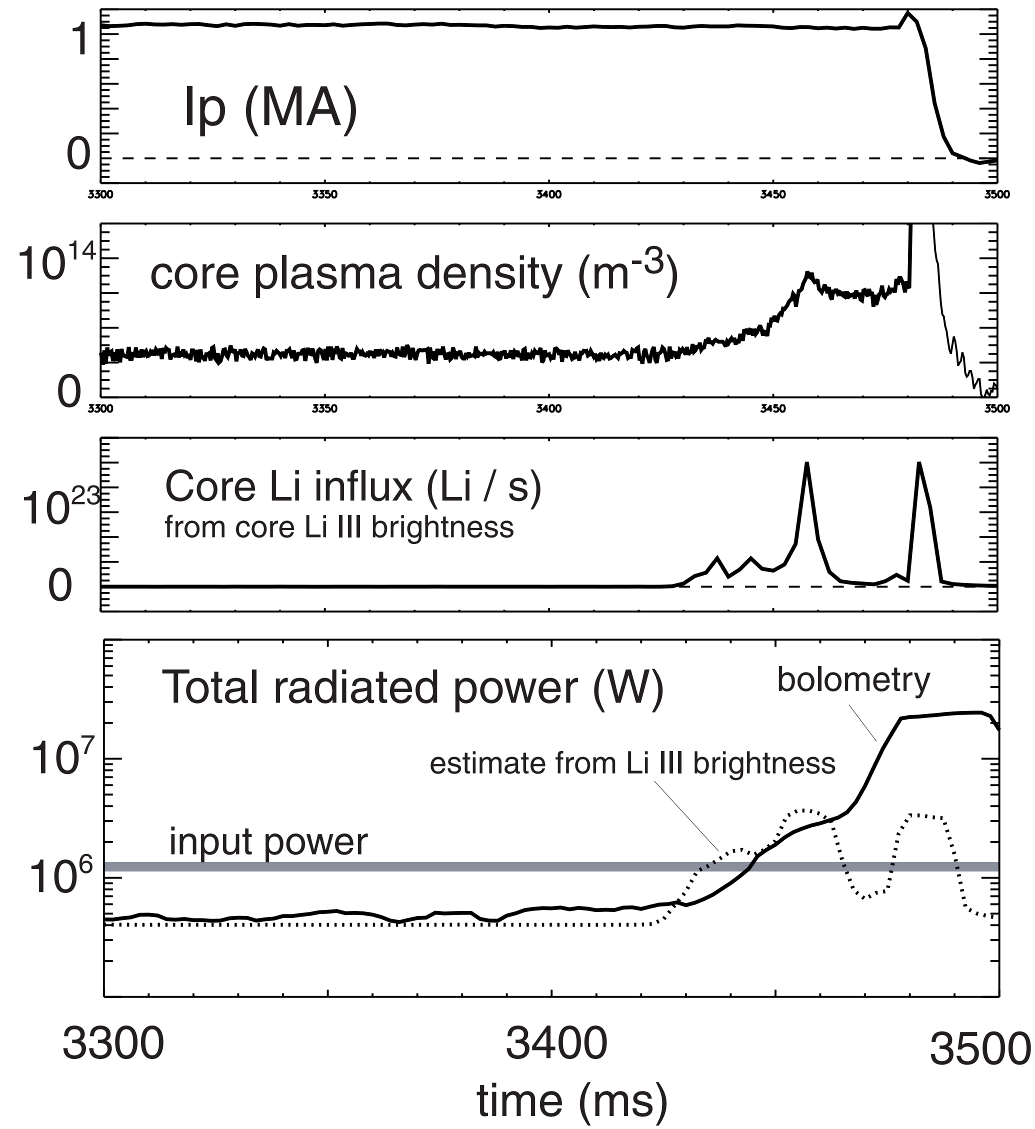
- Shot 105511
  - OSP ~ 3 cm inboard of DiMES
  - T_e ~ 30 eV, q ~ 0.45 MW/m^2
  - Increasing lithium removal rate t>3000 ms.
  - Radiative disruption occurs at 3478 ms.



The disruption is caused by a radiative limit due to an enormous influx of Li to the core plasma

- Lithium completely dominates all other lines on core XUV spectrometer.
  - S/XB technique give 0.2-1x10^{23} lithium ionizations / s into core.
- Core plasma density doubles in ~ 30 ms coincident with core Li emission
  - Implies Li influx / ionization rate ~ 10^{22} s^{-1} in core plasma.
- Radiative power becomes much larger than input power leading to a radiative collapse
  - Estimate of Li caused radiated power matches well with bolometer.
- Disruption JxB forces removed all of the lithium from the DiMES cup.

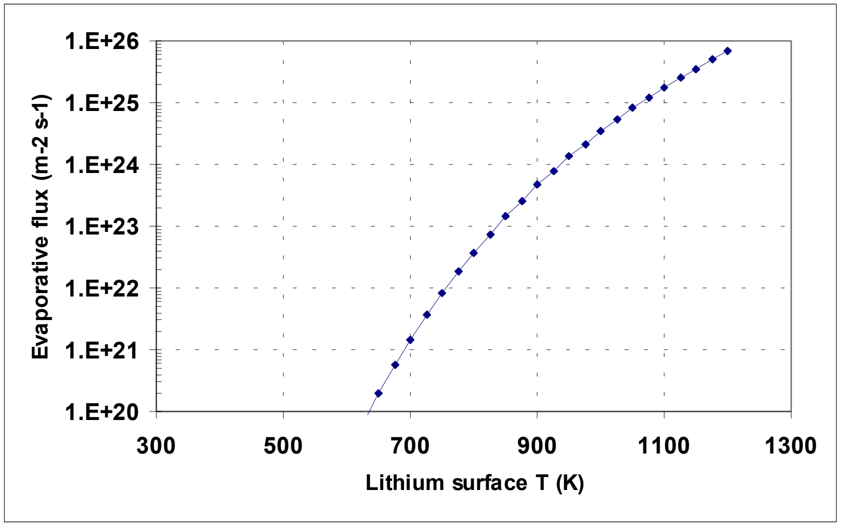


The core arrival rate sets the minimum for the lithium loss rate from DiMES

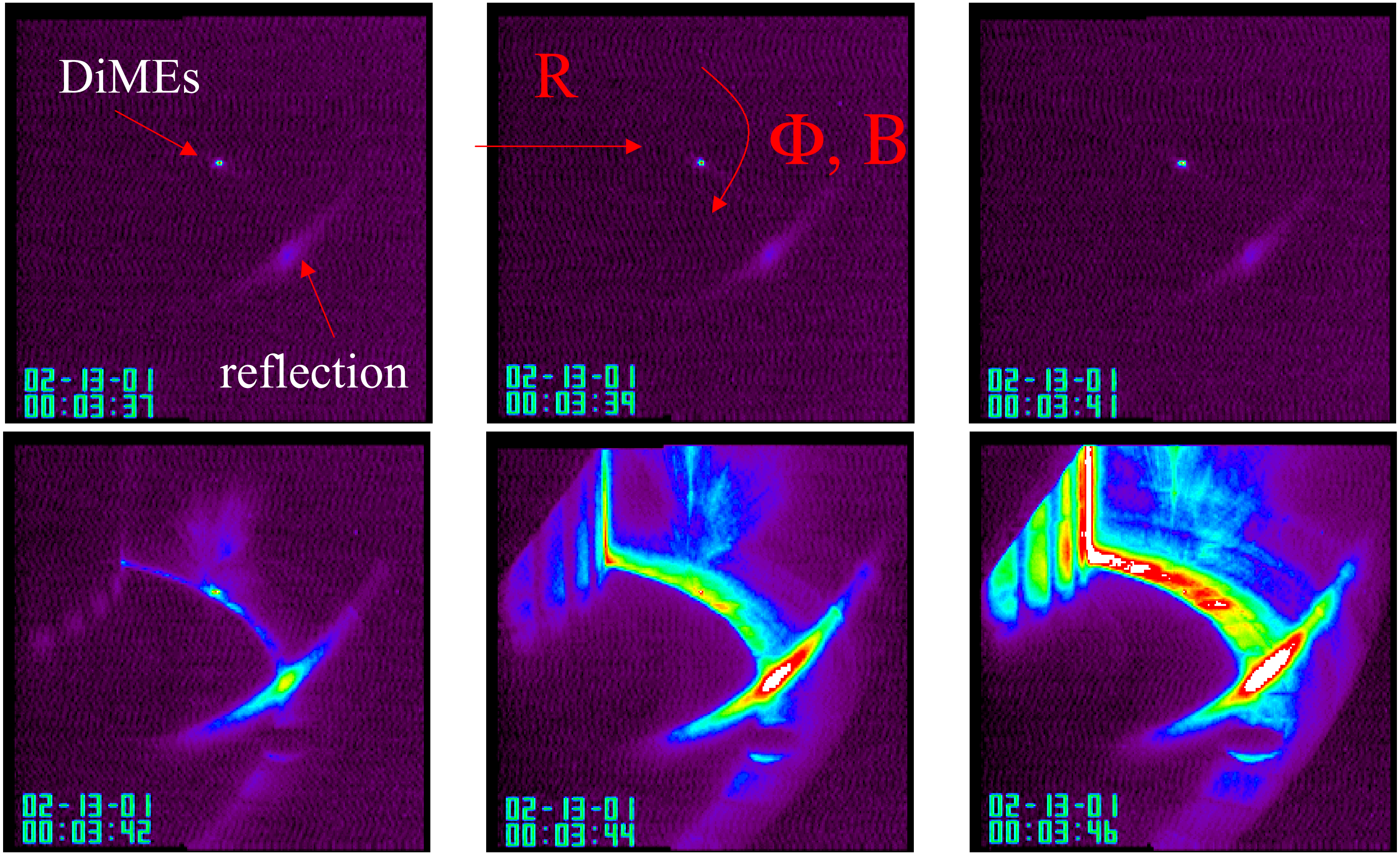
- Minimum removal rate of lithium from 5 cm^2 DiMES sample: $0.2 – 1 \times 10^{26}\ s^{-1}\ m^{-2}$.

- Implies T>1100 K if removal is due to purely evaporative losses from liquid lithium.

- Equivalent depth of lost lithium from sample ~ 0.2-0.5 mm.

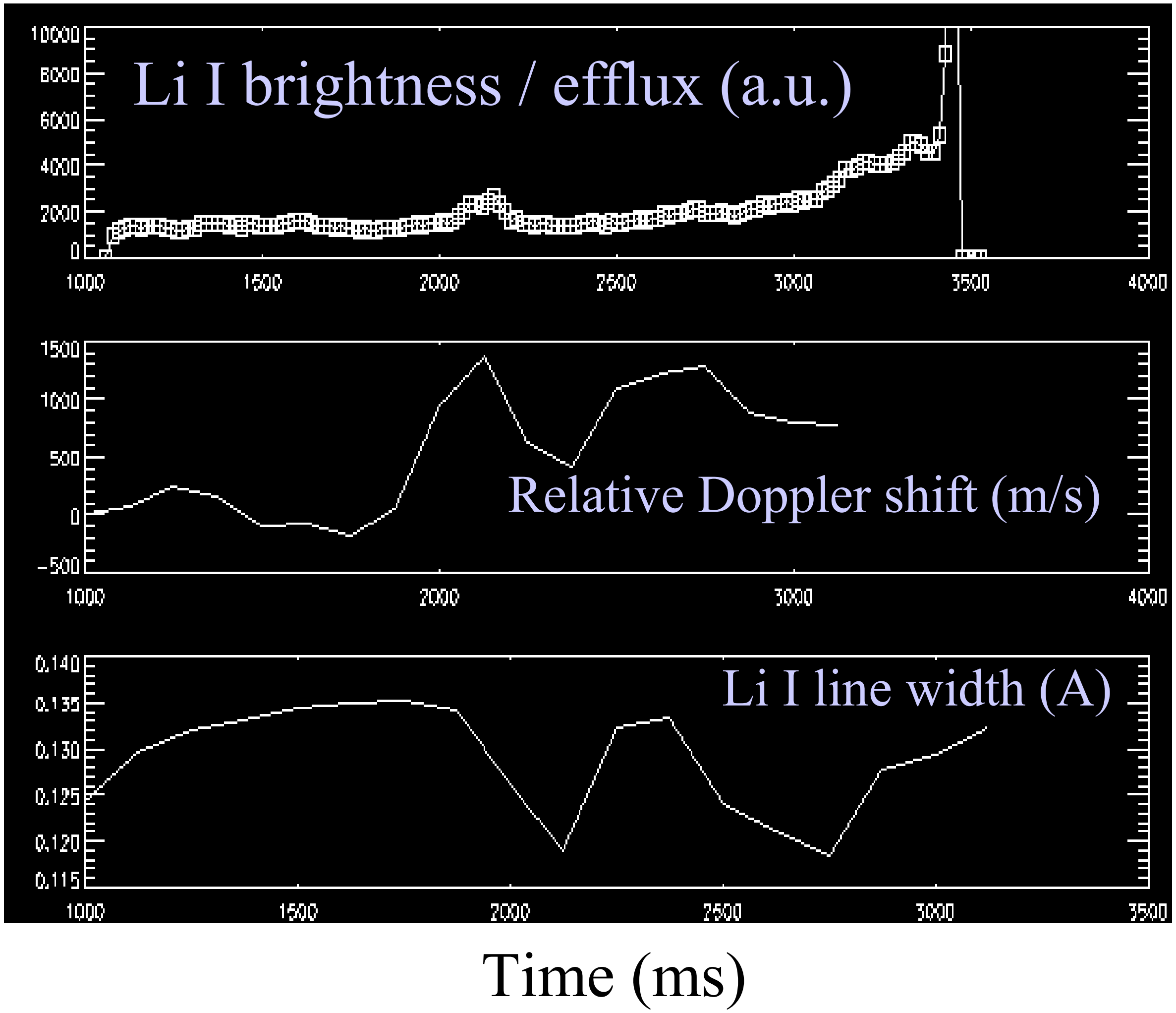


Video sequence of Li I light in divertor, following the large release of Li that causes the disruption

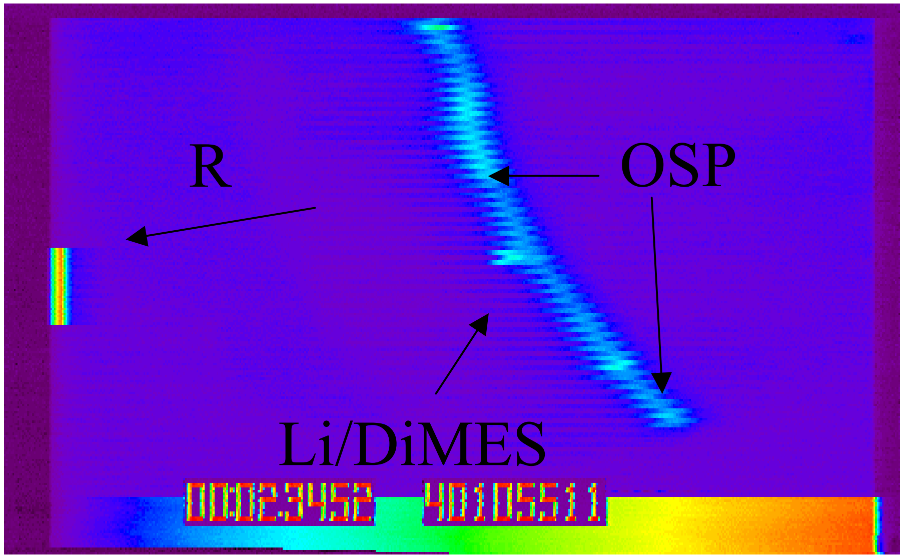


The lithium intensity and removal mechanism evolves during the exposure

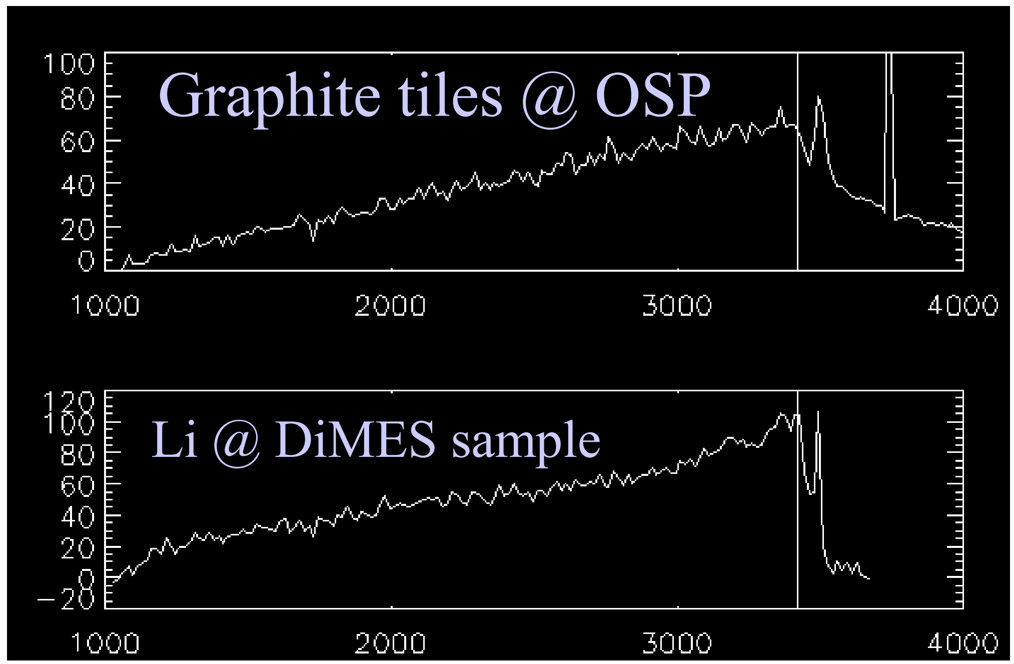
- The lithium removal rate has temporary increase at 2100 ms and then continually increases after ~2500 ms
- Low time-resolution spectral shapes reveal interesting correlation
  - As Li removal increases…
  - The Li comes off with a lower speed (directed away from plate)
  - And the Li I broadening / temperature decaease.
- **This correlation suggests that evaporative-like processes are becoming important in the removal of the lithium**
  - Result similar to PISCES.



IR imaging indicates constant heating, but Li appears to be hotter than surrounding graphite



Time history of IR brightness



Time (ms)

- Linear rise as expected for T dependence of this system with constant q.
- IR emission decreases at ~3420 ms (line shown) simultaneous with sudden decrease in J_z and V_f to ~ 0.
- Need some rough of Li emissivity to quantify this data.
- Li removal by disruption is obvious.

There is a rapid response in nearby divertor conditions that is simultaneous with the large influx of lithium

- The causality of these events is still being determined (this is very close to the time resolution limit we have with the camera systems).
- T_e from Langmuir probe ~ 15 degrees away from DiMES.
- J_z from tile current monitor 15 degrees from DiMES.
- Does Li removal rate passes through effective unity yield?