XP 951 Diffusive Lithium Injection

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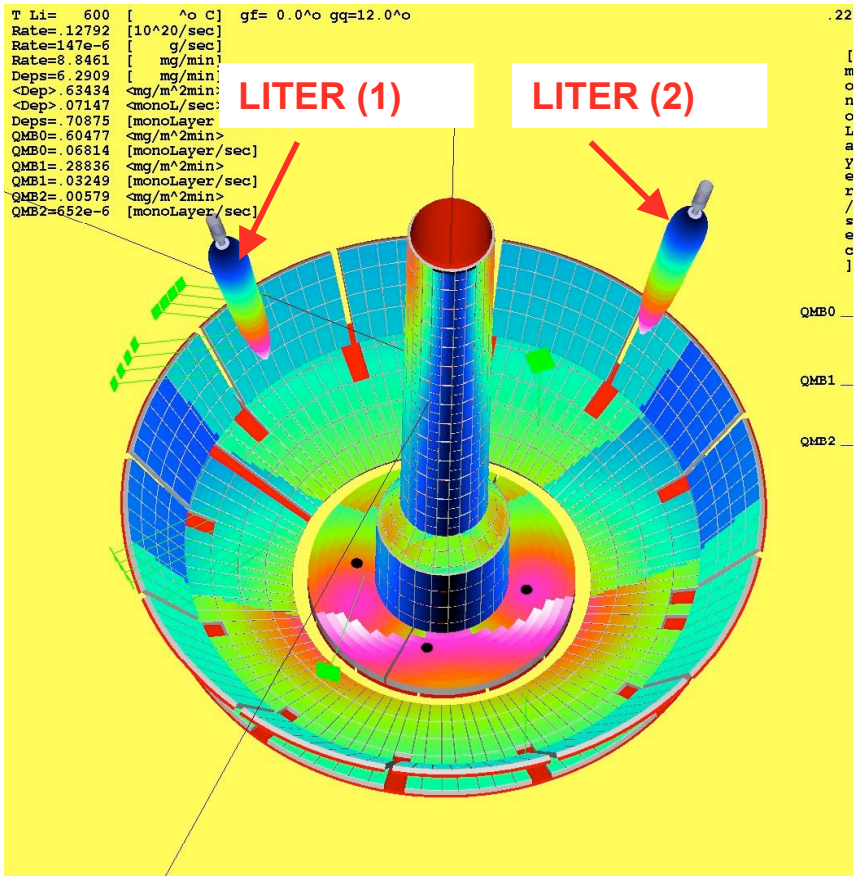
PPPL

Motivation:

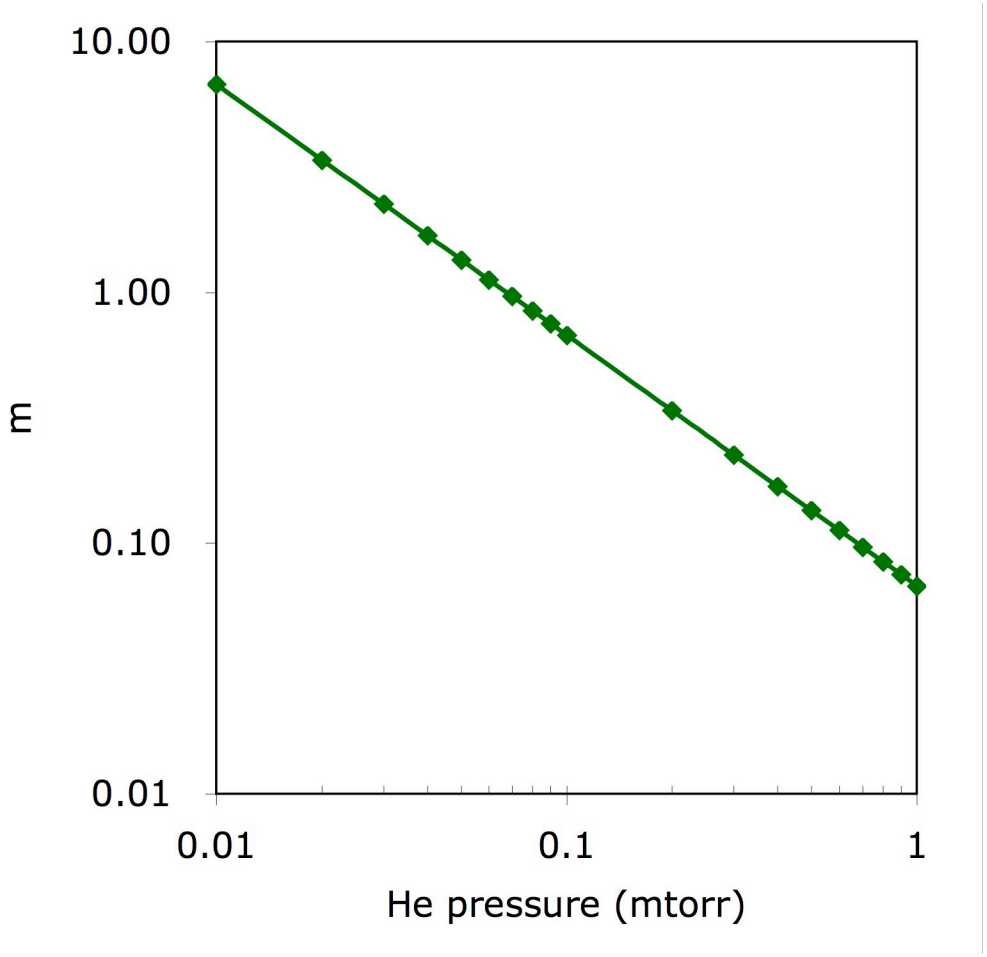
- Density and impurity control is goal of multi-year Li program on NSTX.
- But so far elimination of ELMs by Li appears to increase impurity accumulation late in discharge.
- Core carbon levels actually increase with Li. (R. Bell).
- Asdex experience showed that carbon impurities were not reduced without complete W coating of C.
- Complete vessel coverage with a Li coating thicker than the sputtering depth should, *by definition*, eliminate non-Li influx.

Goal: increase Li coverage of NSTX vessel wall by using LiTER to inject Li into low pressure helium. Adjust mean free path of Li in He by varying the helium pressure to produce a diffusive coating of the upper vessel, midplane and regions not in line-of-sight to LiTER.

Li diffusion in He



Calculation of lithium deposition in NSTX lower vessel. Note Li poor coverage of centerstack shadow and some areas on passive plates. [L. Zakharov].



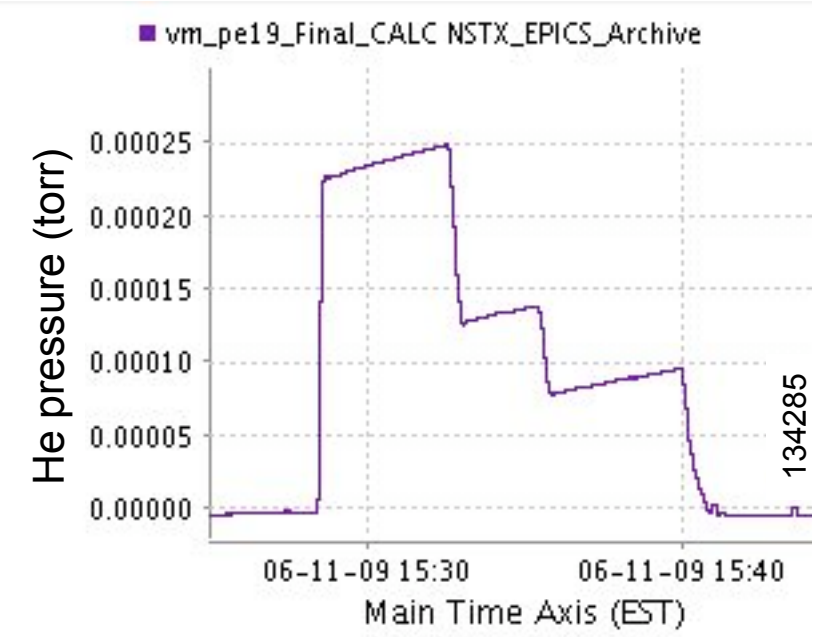
Mean free path of neutral lithium at 627 °C in helium gas at 27 °C (J. Nucl. Mater., 390-391 (2009) 1005).

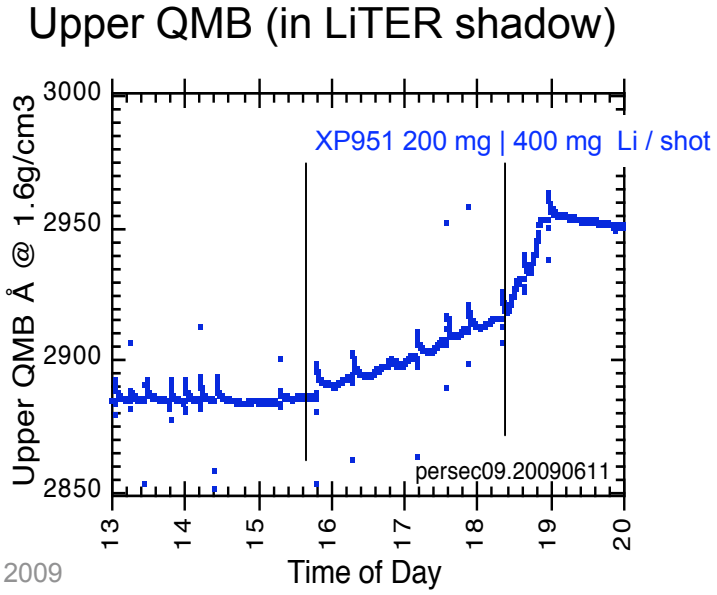
Ran XP on 2 days, Jun 11th results

- Started with baseline LSN H-mode fiducial with 200 mg Li evaporation into vacuum (no He).
- Varied He pressure in 3 steps during 10 min, 200 mg LiTER evaporation.
  - 1.2e-4 torr He ± factor two (mfp= 0.56 m)
  - 4e-4 torr He ± factor two (mfp= 0.17 m, *better*)
  - (No Monte Carlo calculations at this time.)
  - (some D2 outgassing too)

- Then double Li to 400 mg into
  - constant 25 e-4 torr He (mfp= 0.03 m)
  - constant 10 e-4 torr He (mfp= 0.07 m)
  - constant 4e-4 torr He (mfp= 0.17 m)

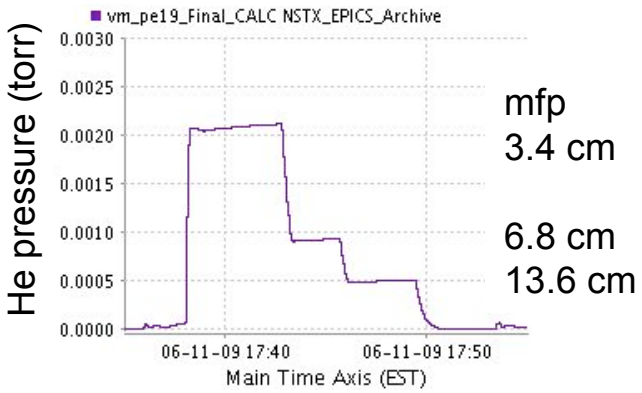
- See expected deposition on upper QMB.





Jun 11th results

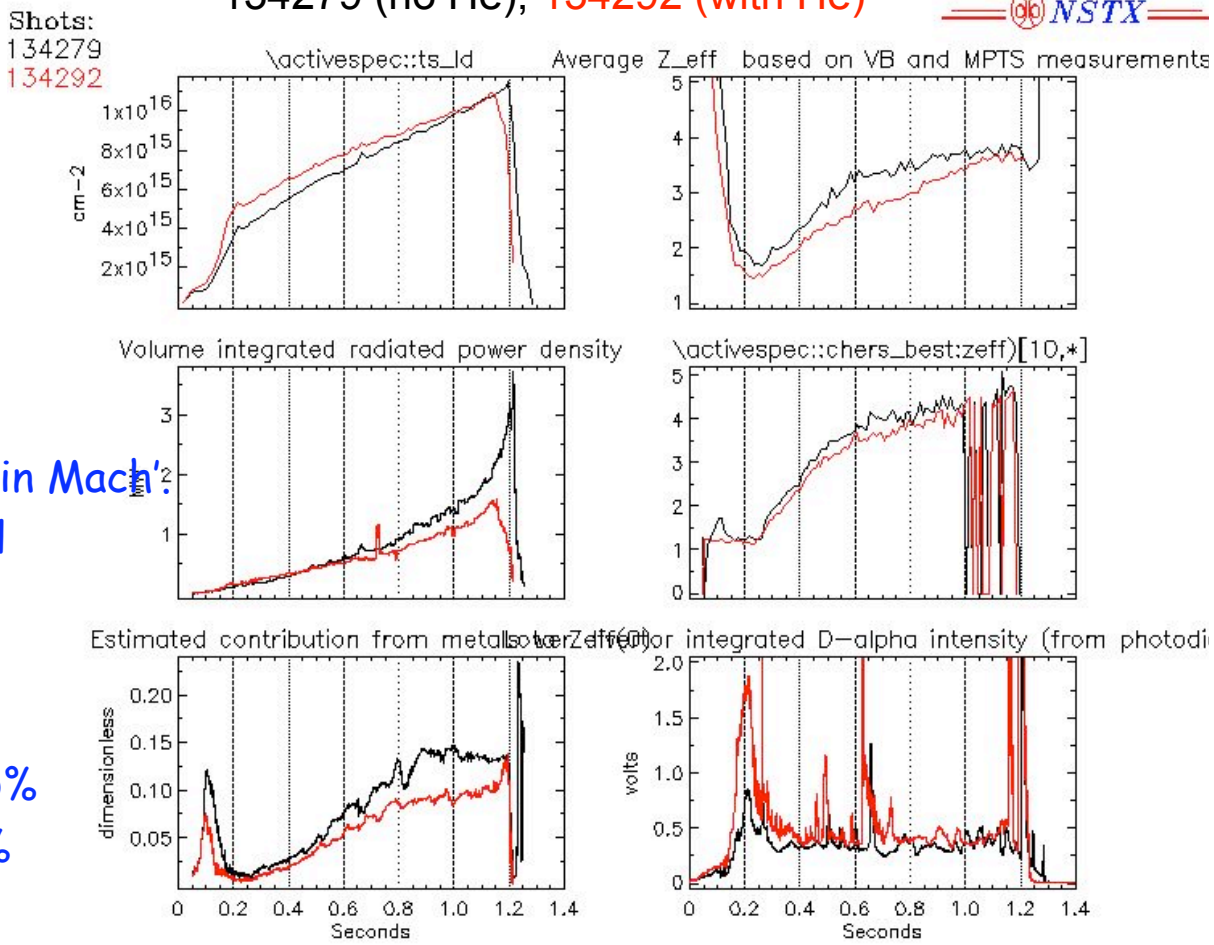
Li diffusion in He



mfp
3.4 cm

6.8 cm
13.6 cm

134279 (no He), 134292 (with He)



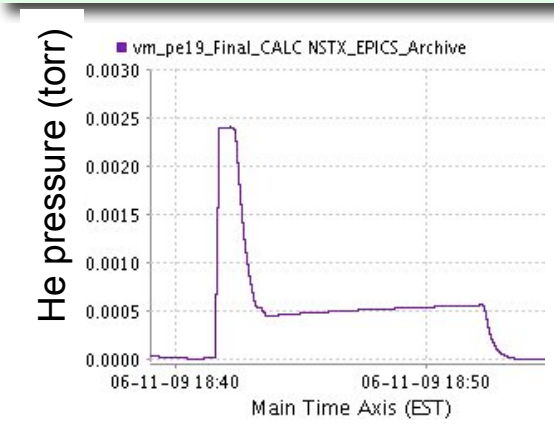
- 134279: 187 mg and
  134292: 183 mg Li evaporated 'in Mach'.
- Fueling (gas+NB) 76↗ 88 torr-l

At 1.0 s:

- Same line electron density.
- Visible bremstrahlung Zeff ↘ 5%
- Rad power ↘ 20%
- Carbon Zeff (chers) ↘ 6%
- Zeff (metals) ↘ 33%

Good start, but comparison complicated by difference in D-alpha (ELM) behavior.

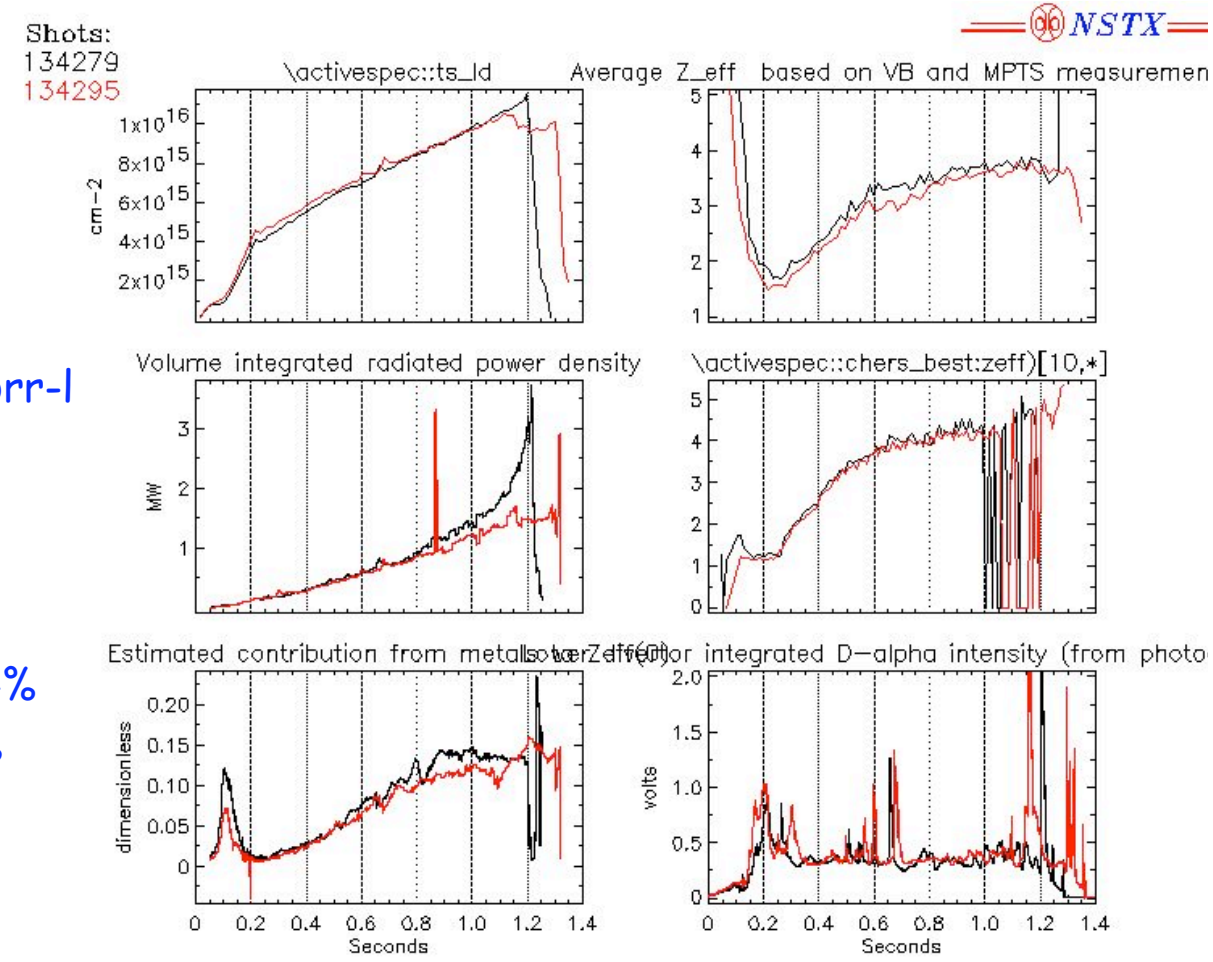
Jun 11th results with increased lithium



mfp
3.4 cm

6.8 cm
13.6 cm

134279 (no He), 134295 (with He)



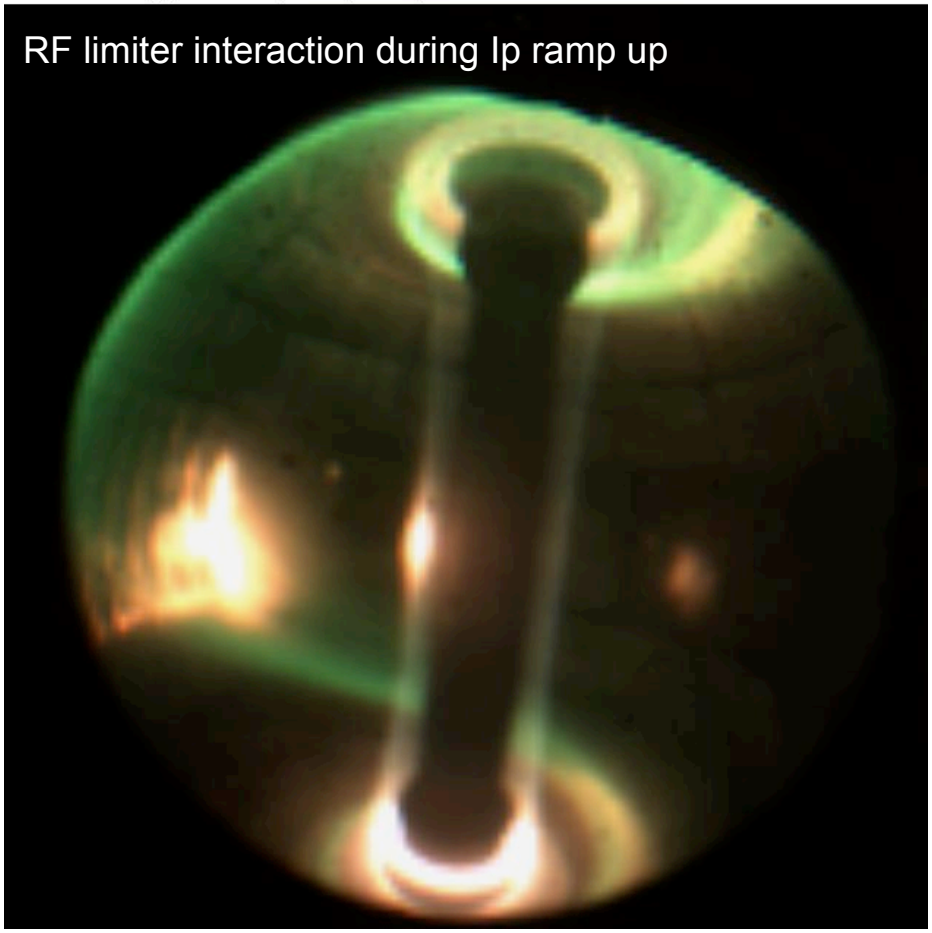
- 363 mg Li 'in Mach'.
- Fueling (gas+NB) ↗ 76 to 90 torr-l
- Ne line density close.

At 1.0 s:

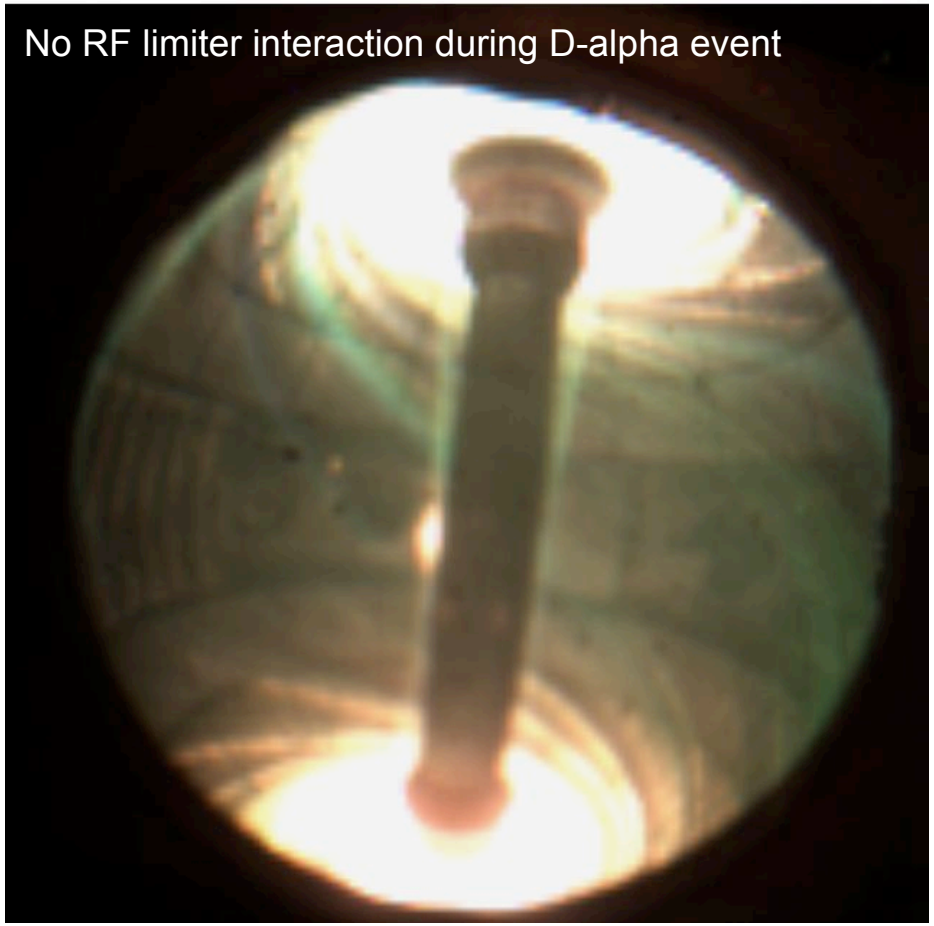
- Same line electron density.
- D-alpha similar.
- Visible bremstrahlung Zeff ↘ 4%
- Rad power ↘ 13%
- Carbon Zeff (chers) ↘ 3%
- Zeff (metals) ↘ 8%

Jun 11th plasma-wall interactions

/p/nstxcam/miro/2009/Miro_134295.cin at 195.001 ms



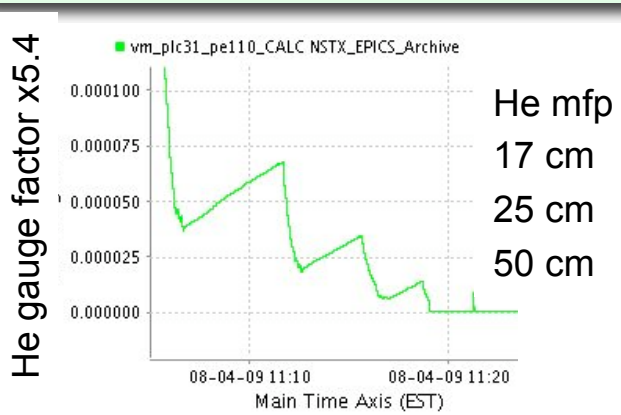
/p/nstxcam/miro/2009/Miro_134292.cin at 624.408 ms



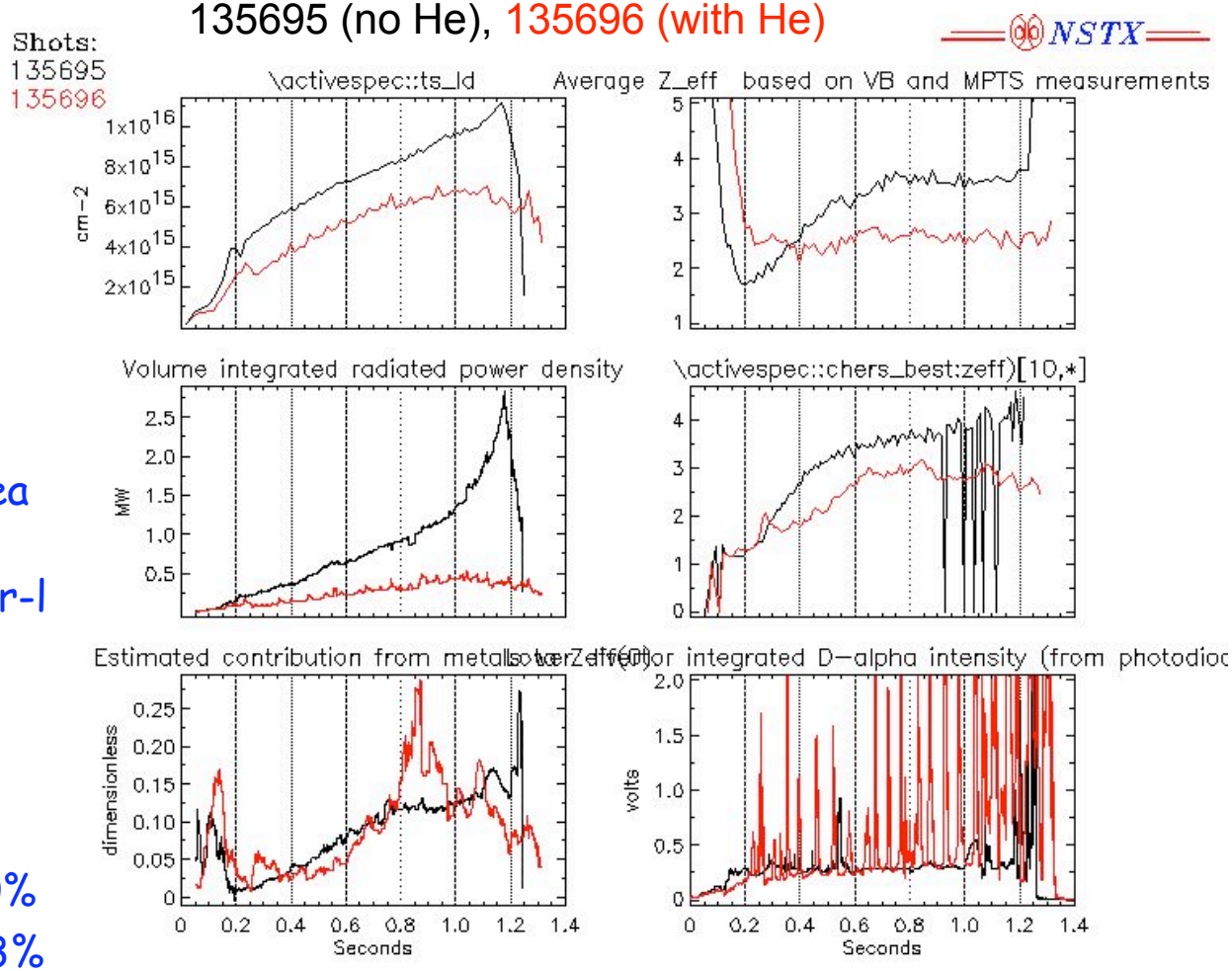
- Typically see RF limiter interaction with early 3 source NB (~130 ms) with- and without He but not during Ip flattop.
- E.G. event 134292 @ 624 ms not due to limiter interaction.
- No consistent 'greening' of Miro image from LiII 5485Å line.

Decide to do Monte Carlo calculations to optimize helium pressure (Stotler presentation)

Aug 4th results with MC guided He profile



135695 (no He), 135696 (with He)



Guided by MC calculations.

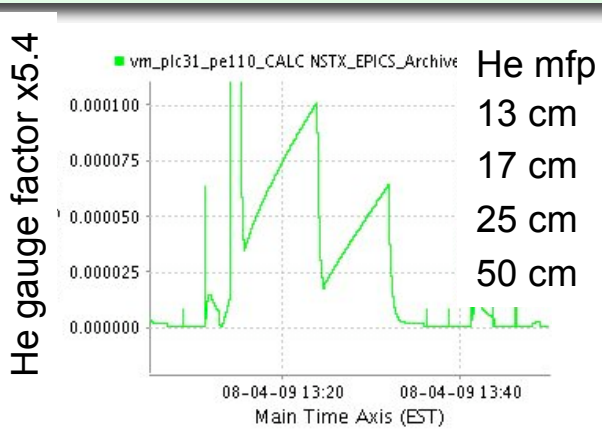
More Li to cover whole vessel area

- Li 'in Mach' 154 mg ↗ 622 mg
- Fueling (gas+NB) same 82 torr-l
- Ne line density lower.

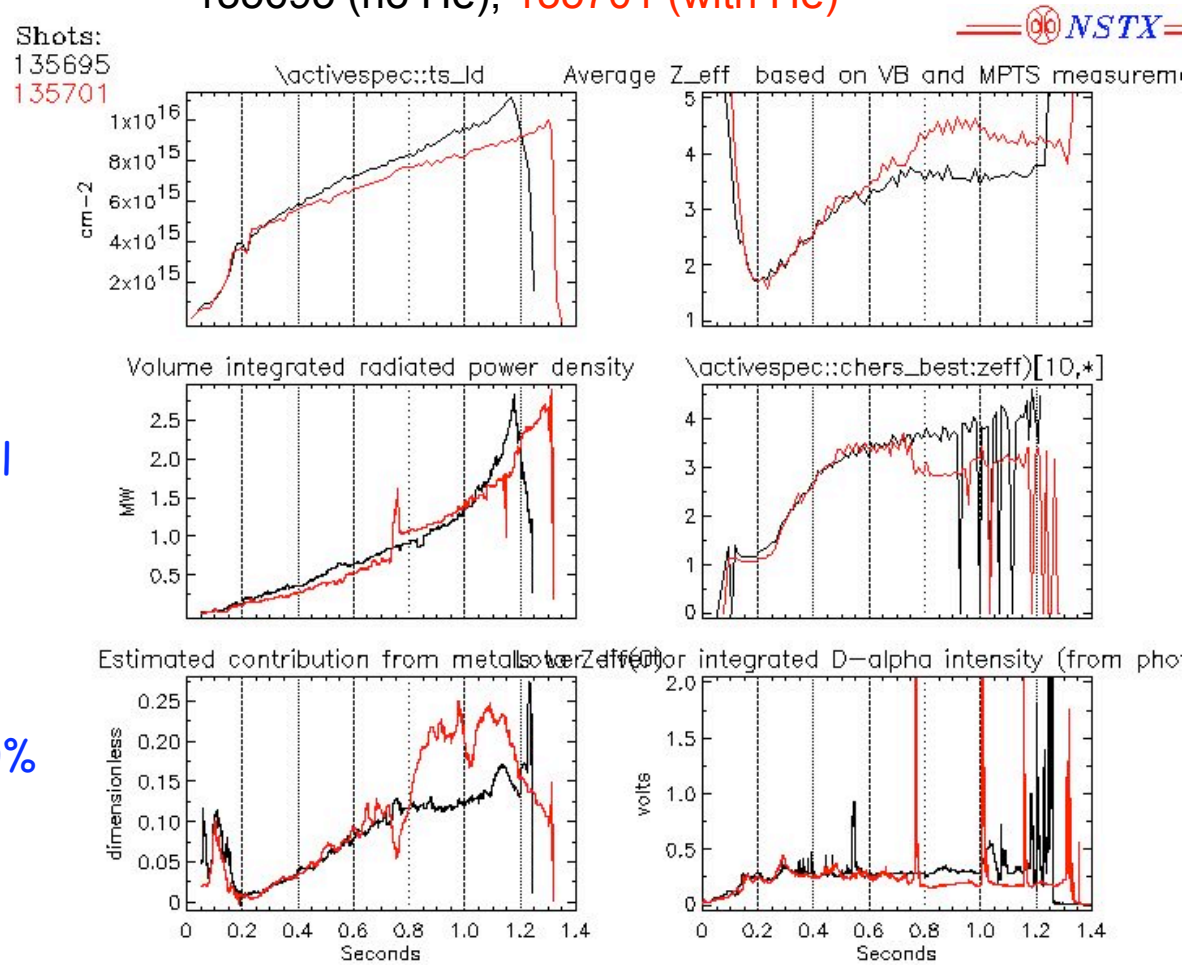
At 1.0 s:

- line electron density ↘ 31%
- D-alpha many ELMS.
- Vis. bremstrahlung Zeff ↘ 30%
- Rad power ↘ 63%
- Carbon Zeff (chers) ↘ 22%
- Zeff (metals) fluctuation, same @ 1 s

Aug 4th results with 1212 mg Li



135695 (no He), 135701 (with He)



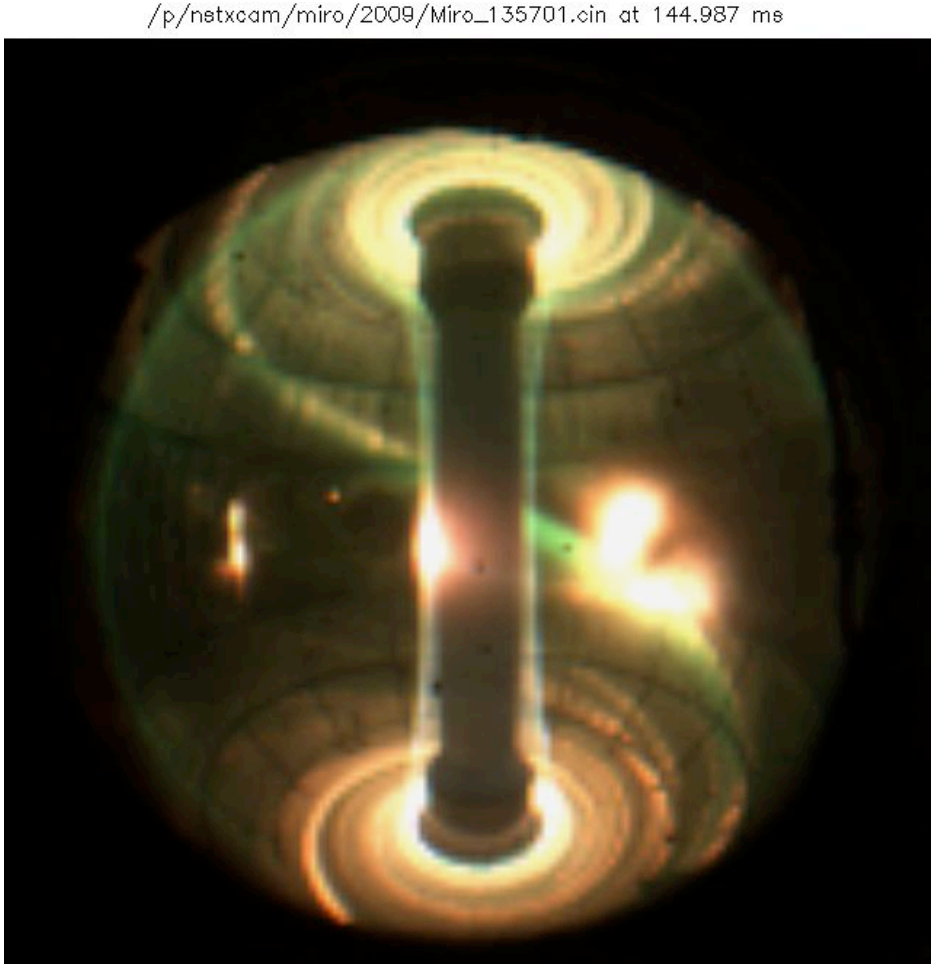
- Li 'in Mach' 154 mg ↗ 1,212 mg
- Fueling (gas+NB) 82 ↗ 134 torr-l
- Ne line density closer.

At 1.0 s:

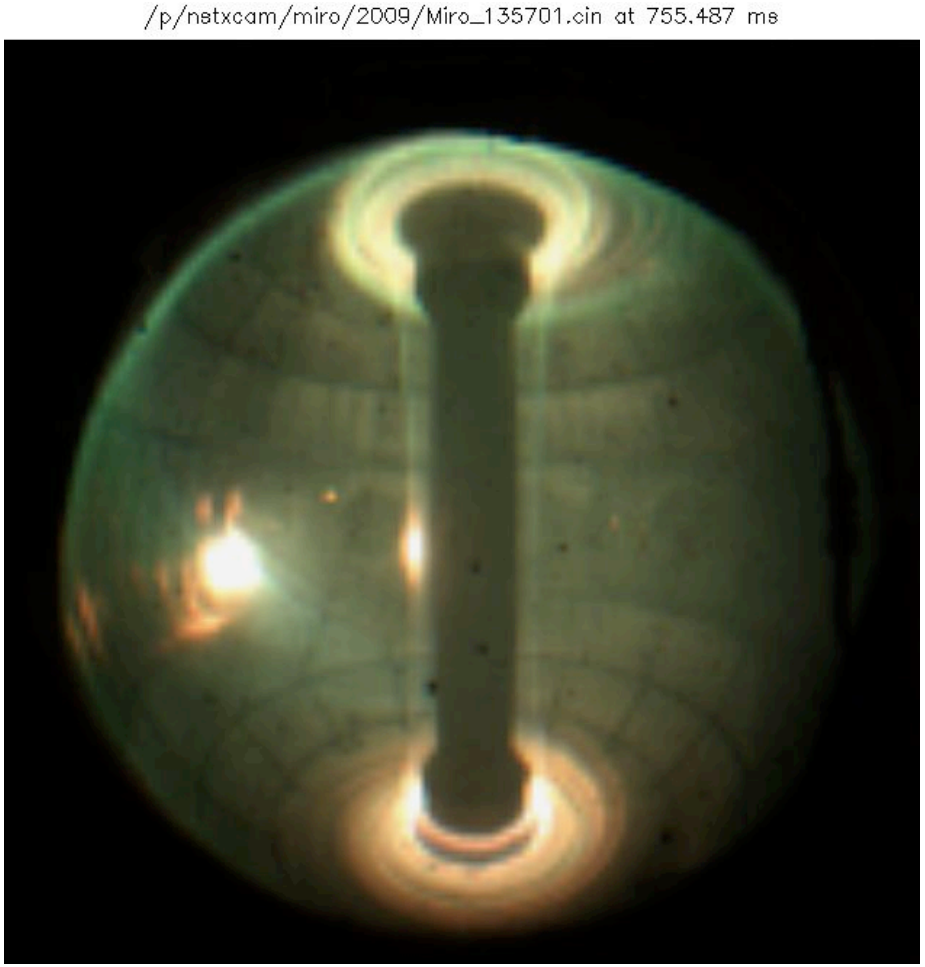
- line electron density ↘ 12%
- D-alpha + ELMS.
- Visible bremstrahlung Zeff ↗ 20%
- Rad power ↗ 5%
- Carbon Zeff (chers) ↘ 18%
  after event @ 0.76s
- Zeff (metals) ↗ 37%

Event @ 0.76 s increases Zeff metals, but decreased Zeff carbon.

Aug 4th results



Strong interaction at Bay I @ 144 ms



Strong interaction with RF limiter @ 755 ms
Strong LiII 5485Å emission.

Conclusions:

- Promising initial results on June 11th.
- Disappointing results on Aug 4 with more Li and Monte Carlo guided He profile.

To Do:

- Identify cause of PMI events - ELMS or MHD or …. ? (help appreciated)
- Check edge density profiles. Could Li lowered edge density lead to more intense PMI that defeated attempt to reduce impurities ?
- Possibly Beam ion loss increased with reduced edge electron density. Expect most loss at midplane. (Darrow).
- Does 3 NB source injection during Ip ramp up generate impurities from lost beam ions?
- Spectroscopy: identify impurities: Boron, Nitrogen…

General issues:

- How to fuel a low recycling plasma ?
- Reconfigure SOL hardware for increased clearance this outage ?
- 2010 campaign: plan on at least 2 weeks to learn how to control density and impurities with LLD ?