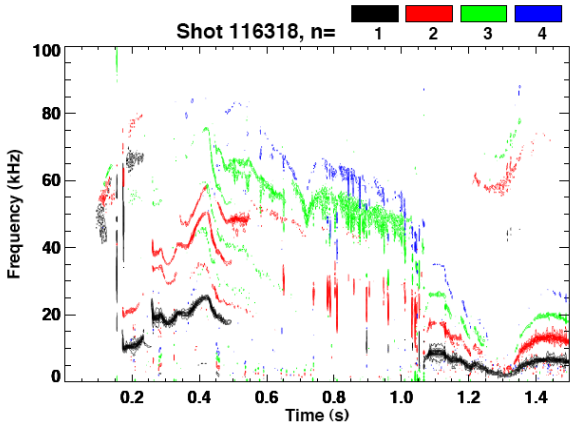
Effect of Impurities and Wall Conditioning on NTMs (XP 918)

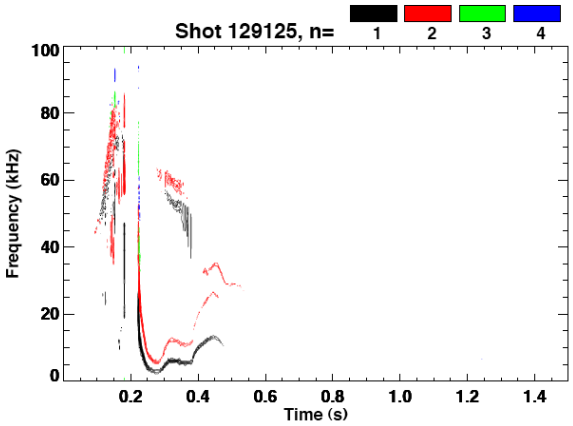
F. Volpe, S. Gerhardt & S. Sabbagh

Lithium wall conditioning, n=1 RWM control and n=3 EFC eliminated n=1 tearing modes at NSTX…

Without



With Li, n=1 f/back and n=3 correction



Full suppression not in all shots

Courtesy: S. Sabbagh

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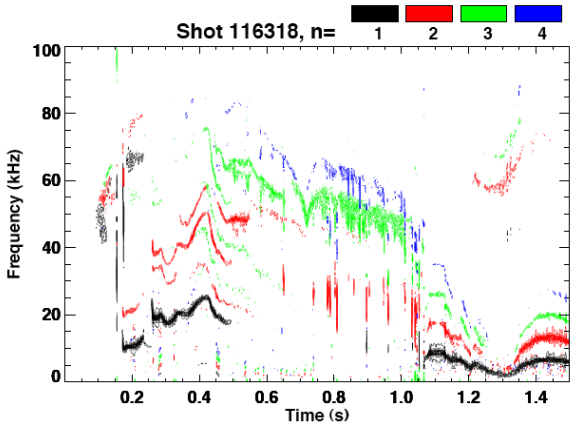

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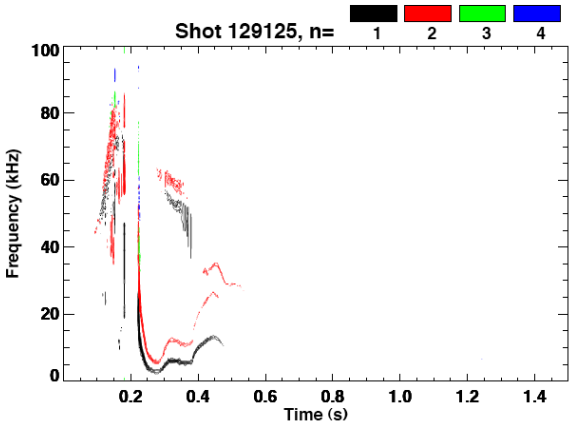
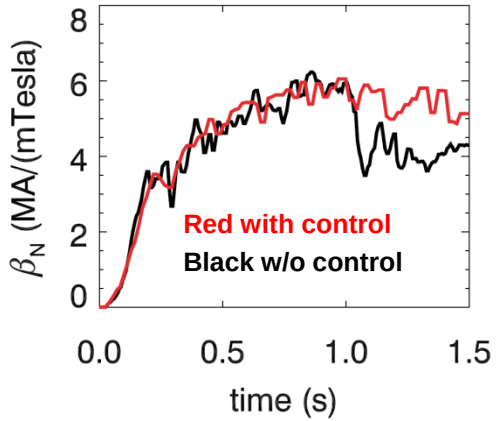
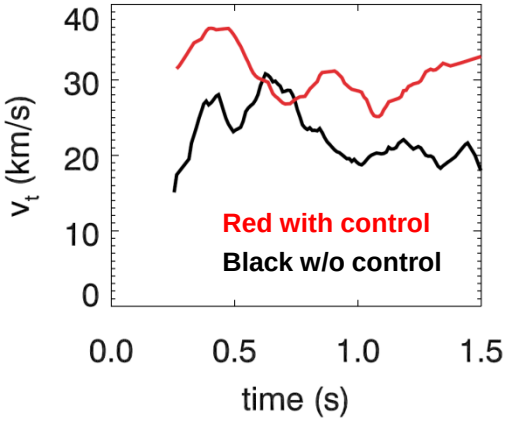


Full suppression not in all shots

TM suppression had beneficial effect on β_N and rotation:





Courtesy: S. Sabbagh

DIII-D experience also hints at effects of impurities and wall conditioning on NTMs

- DIII-D: more impurities → plasma more susceptible to 2/1 NTMs.
- In agreement with NSTX: Li conditioning → no n=1 TM
- However, at DIII-D:
  - Harder to get 2/1 and 3/2 NTMs in first shot post-disruption.
  - Sometimes 4/3, sometimes nothing.
  - A shot with less gas puffing helps re-obtaining NTMs in following discharge.
- Control room experience. Not a systematic study yet.

Motivation and open questions

- Correlation between
  1. impurity content, gas puffing and wall conditioning and
  2. NTM stability

  never experimentally, systematically characterized

- ITER relevance:

  wait for good wall conditioning before trying high β, if this poses a risk for NTMs → locking → disruptions.

- Power plant relevance:

  Liquid Lithium Divertor might prevent NTMs?

Open questions
(and tentative answers, to test experimentally)

- Direct/indirect: Li suppresses NTM or NTM trigger (e.g., ELM)?
- Synergy with n=1 DEFC and n=3 DEFC?

  Role of Li is prominent? ancillary? or synergistic?
- Mode is suppressed or just delayed (to after the end of the shot)?
- A continuous effect or a threshold effect?
- Reproducibility: suppression not observed in all shots

- Possible stabilization mechanisms, to test experimentally:
  - Impurities ↓ → Resistivity ↓ → Reconnection ↓ →(N)TM ↓
  - Impurities ↓ → Radiative losses ↓ → (N)TM ↓

    because rad. losses= driving mechanism in extended Rutherford Eq.

    "Radiative induced" TMs prior to disruptions in RFP [Salzedas, PRL 2002].
  - Current profile evolution slowed down
  - Modification of the pressure profile → BS drive and/or Δ' ↓
  - Rotation or magnetic shear ↑ → Δ' ↓

Tentative shot-plan, ½ day

1min D2-GDC +10min He-GDC +5min pump-out.

1. Repeat #133025 with 4MW NBI, n=3 EFC, n=1 DEFC, NO Lithium.
   n=1 NTM expected. If not, tweak parameters

   (1 good shot)

8min Lithiumization (2 LITER units, 15mg/min each)

2 Repeat.

NTM suppression or delay expected. If not, increase Li

(1 good shot)

1min D2-GDC +10min He-GDC +5min pump-out.

Lithiumization, with reduced/increased evaporation rate depending whether NTM was completely suppressed or only delayed

3 Repeat, scan Li evaporation rate shot-to-shot

Delay or mitigation should vary (if continuous) or suppression should not be obtained (if threshold). Identify "marginal" Li amount for full suppression or delay past end-of-shot.

(3-4 shots).

Tentative Shot Plan, cont'd

NO Lithization. He-GDC to avoid disrupting during Ip ramp?

4 Repeat best shot over and over, without re-Lithiumizing every time, until first NTM

Assess duration of benefits of a single Lithiumization

(2-4 shots).

5 Repeat "marginal shot" (i.e., NTM-stabilized shot that required smallest amount of Li) with reduced n=3 EFC and/or reduced n=1 DEFC gains, to isolate their effects on NTMs

(*4-5 shots*).

b) *Deliberately seed impurities. Scan of impurity content will be broader and yet partly decoupled from wall conditioning. Also, different species, interesting to compare.*

6 Repeat best Lithiumized shot with Argon puffed at the edge. Vary Ar puffing rate (*2-3 shots*).

7 Repeat in non-Lithiumized reference shot *(2-3 shots).*

Other requirements

Diagnostics:

- MSE, CHERS, TS and any other diagnostic of profiles relevant to MHD stability
- X-ray diagnostics and any other diagnostic of impurities in the core.
- Spectroscopic diagnostics and any other diagnostic of wall conditioning.

Analysis:

- TRANSP, UEDGE, DCON, PEST-III, NIMRAD (NIMROD+Bremsstrahlung)

Summary

Impurities and wall conditioning observed to affect NTMs in NSTX and DIII-D.

Goal of XP 918:

- First systematic characterization and interpretation
- Extrapolation to ITER

Experimental approach

Part 1: #129125, with less Li and/or less f/back and/or less EFC

Part 2: deliberate impurity seeding