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Error Field Threshold Study in High-β Plasmas with Reduced Input Torques (XP1018)

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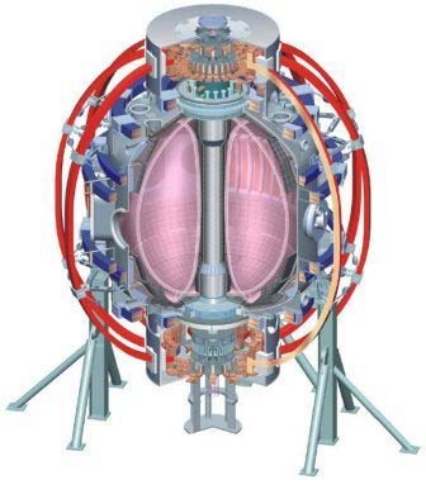
R. J. Buttery, S. A. Sabbagh,
and the NSTX Research Team

NSTX Result Review
B318, PPPL
December 1, 2010



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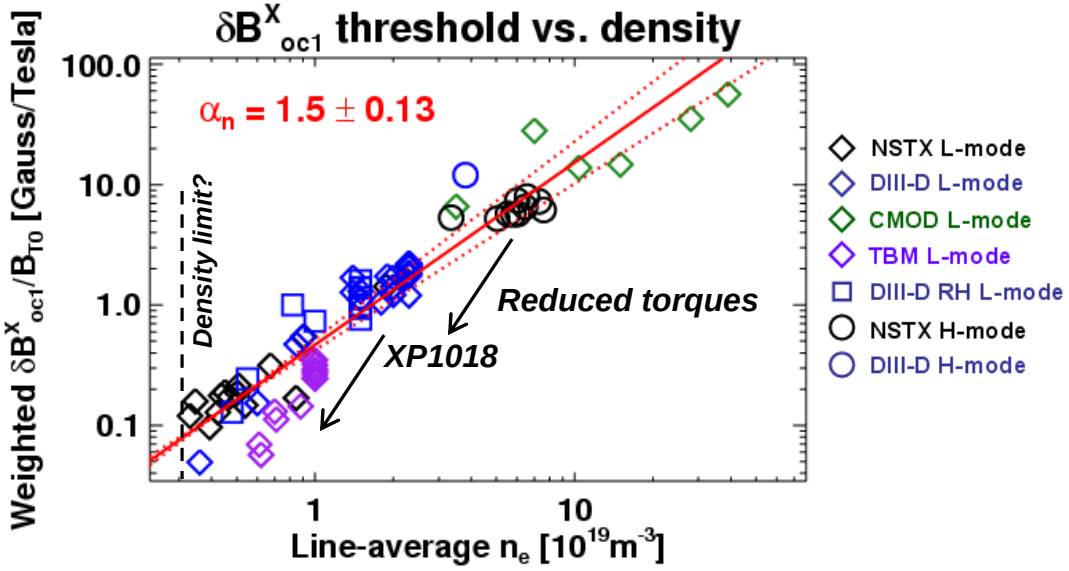
XP1018 will investigate the role of input torques (and rotations) on locking dynamics

- Input torques and rotations are the key to locking dynamics
- XP 915 (Buttery) used NBI + n=3 braking to reduce torques
- XP 1018 will use HHFW to reduce torques
  - More kinetic parameters (torque or rotation), or more field components (dominant field or NTV) are needed to improve threshold scaling?

$$\frac{\delta B^{x}_{oc1}}{B_{T0}} \le 0.4\times10^{-4}\left(n[10^{19}m^{-3}]\right)^{1.5}\left(B_{T0}[T]\right)^{-1.9}\left(R_0[m]\right)^{1.2}\beta_N^{-1.1}\left[\left(\omega/\omega_D\right)^{\alpha_\omega}\ ?\right]$$



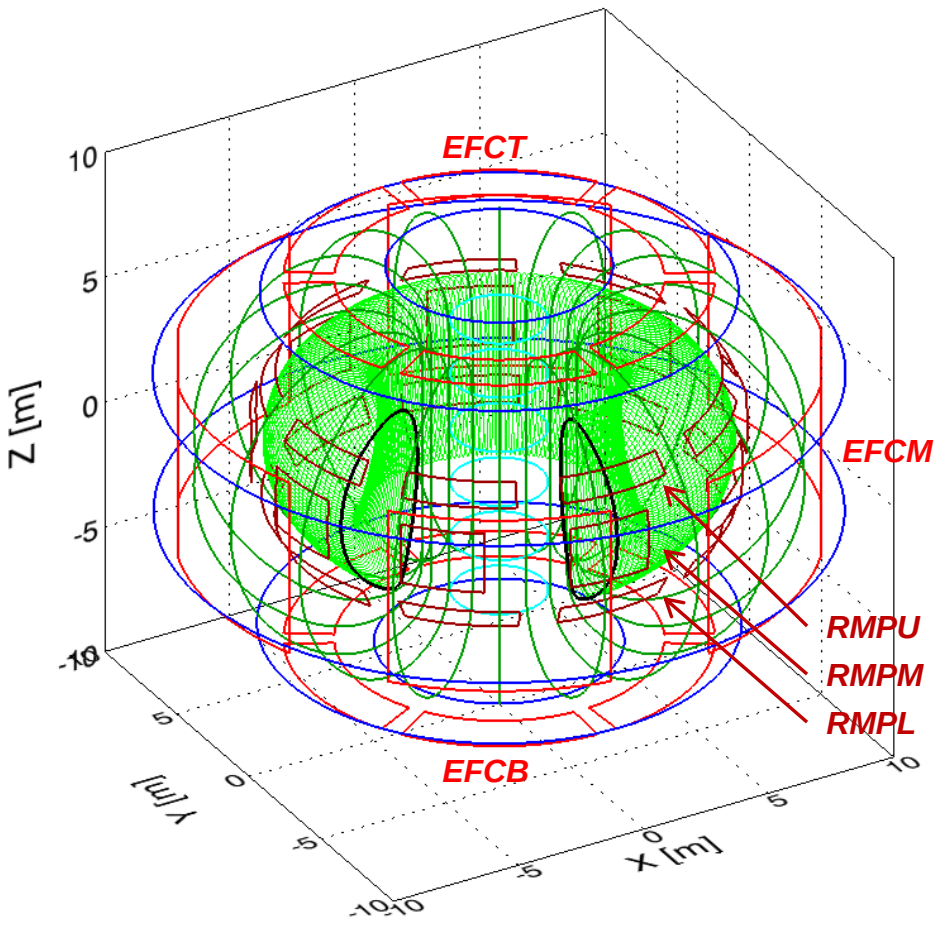
ITER error field study has been revisited based on (IPEC) dominant field and NTV

- ITER error field study made the report on final progress

- Strategy :
  - Produce n=1 field errors by shifting and tilting OH/PF/TF coils

    Using EFCC and RMPC,

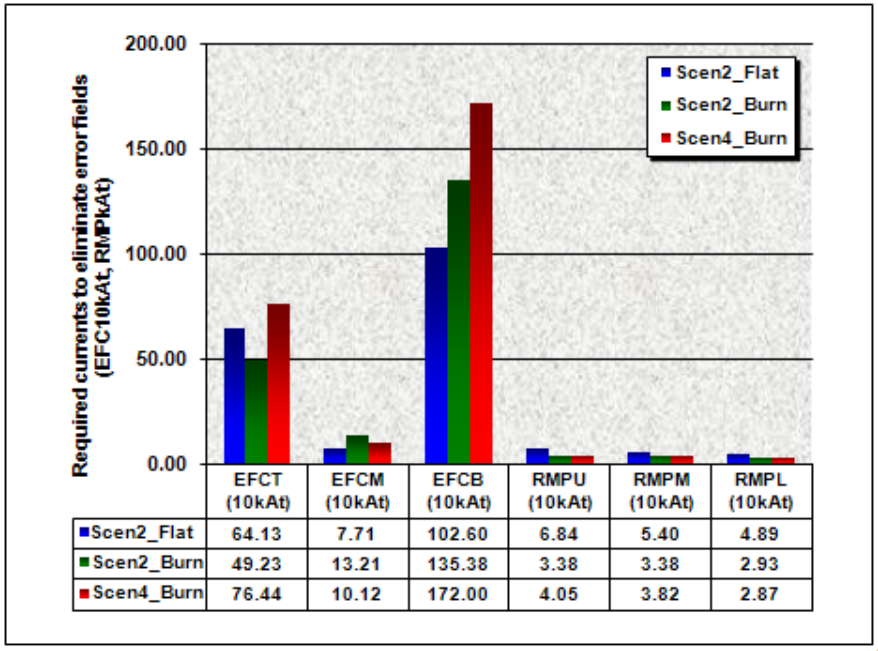
  - Remove the total resonant field (or dominant field), and
  - Minimize NTV simultaneously



EFCT and EFCB coils are highly inefficient to reduce the dominant field

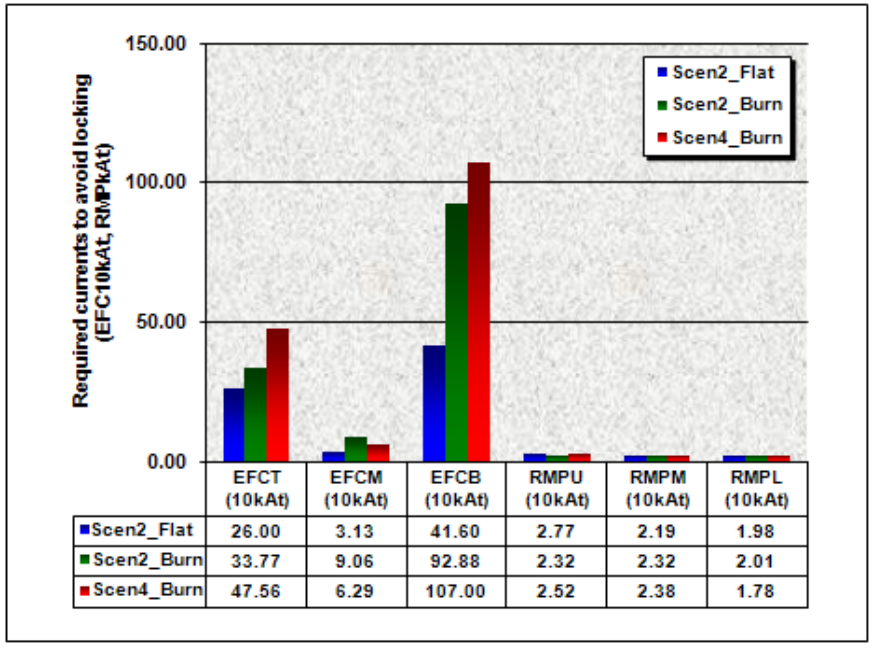
- Required currents to avoid locking are
  - EFCT, EFCB >> EFCM > RMPU, RMPM, RMPL
  - Then EFCT and EFCB can help other physics? Wouldn't RMP coils be better?

Required currents to eliminate overlap fields (Used only the dominant field)



	EFCT (10kAt)	EFCM (10kAt)	EFCB (10kAt)	RMPU (10kAt)	RMPM (10kAt)	RMPL (10kAt)
Scen2_Flat	64.13	7.71	102.60	6.84	5.40	4.89
Scen2_Burn	49.23	13.21	135.38	3.38	3.38	2.93
Scen4_Burn	76.44	10.12	172.00	4.05	3.82	2.87

Required currents to avoid locking (Used present scaling without torques)

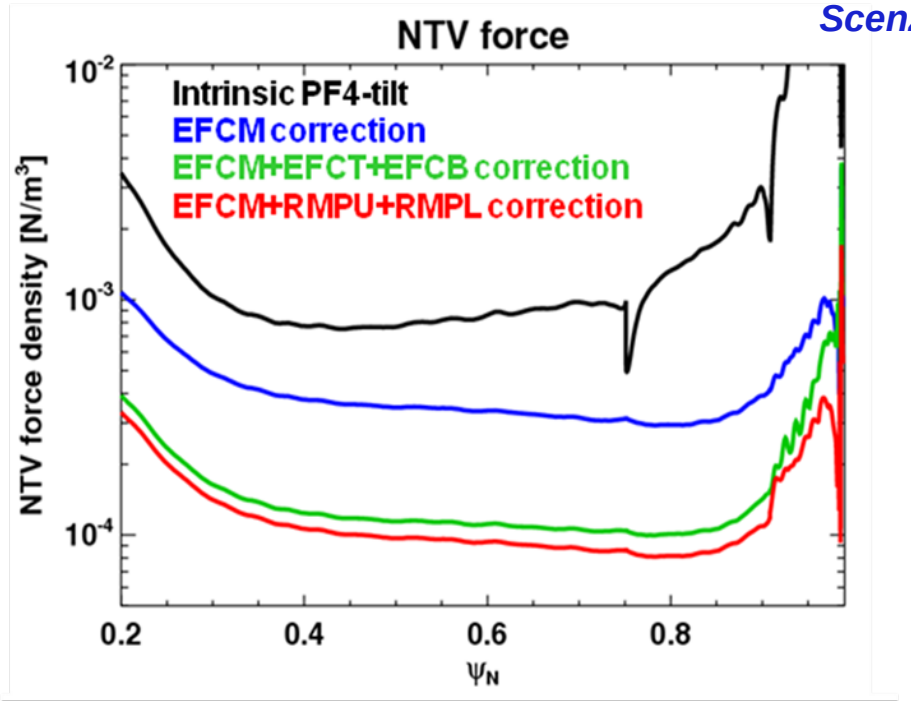


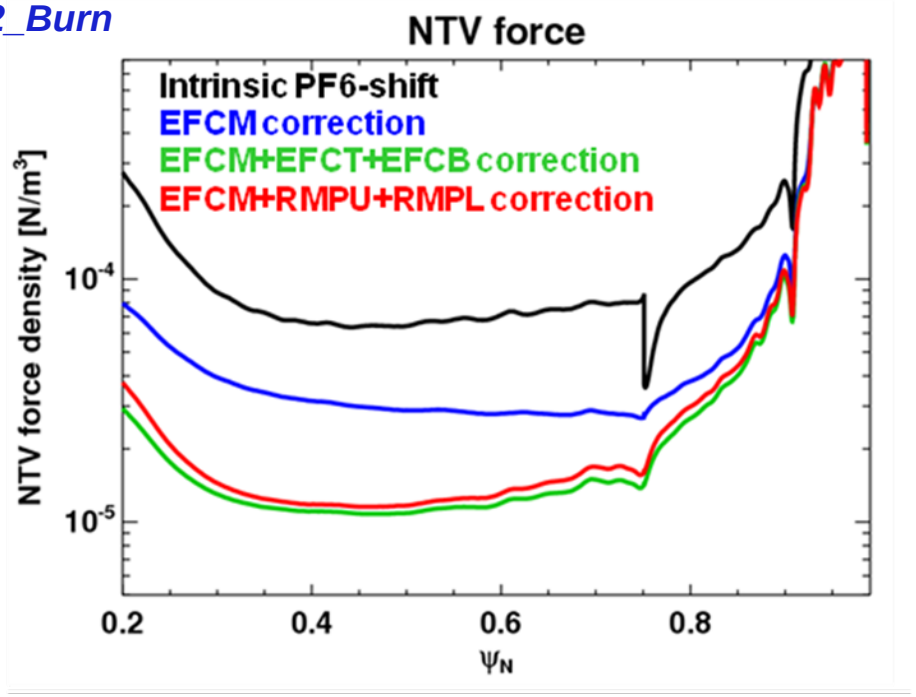
	EFCT (10kAt)	EFCM (10kAt)	EFCB (10kAt)	RMPU (10kAt)	RMPM (10kAt)	RMPL (10kAt)
Scen2_Flat	26.00	3.13	41.60	2.77	2.19	1.98
Scen2_Burn	33.77	9.06	92.88	2.32	2.32	2.01
Scen4_Burn	47.56	6.29	107.00	2.52	2.38	1.78

EFCM vs. EFCM+T+B vs. EFCM+RMPU+L

- EFCM gives NTV reduction by 1~2 orders of magnitude
- Further NTV reduction by a factor of 1~3 is possible by optimized configurations
  - **Mostly EFCM+RMPU+RMPL > EFCM+EFCT+EFCB > EFCM only**
  - **For some special cases, EFCM+EFCT+EFCB can be better**

Scen2_Burn





EFCM+RMPU,L >> EFCM,T,B > EFCM and ?

Key conclusion :

- EFCT and EFCB coils are inefficient to remove the total resonant fields
- EFCT and EFCB coils can help NTV reduction, but RMP coils can do much better with higher efficiency
  - **EFCM+RMPU+RMPL (71+23+23 kAt)**
  - **EFCM+EFCT+EFCB (95+164+257kAt)**
  - **EFCM only (132kAt)**

Future Work :

- Redo the analysis with RMP current limitation (<10kAt)
- Find other important unknowns in terms of
  - **Field component (Other than the dominant field)**
  - **Scaling parameters (Other than the density and the toroidal field)**