NSTX

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XP-902: The Ongoing Search For the n=3 EF Source in NSTX

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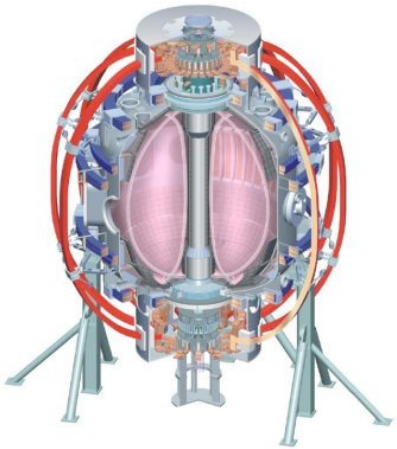
NSTX Team Review

1: Background, Previous Analysis, Present Conclusions
2: Shot Plans



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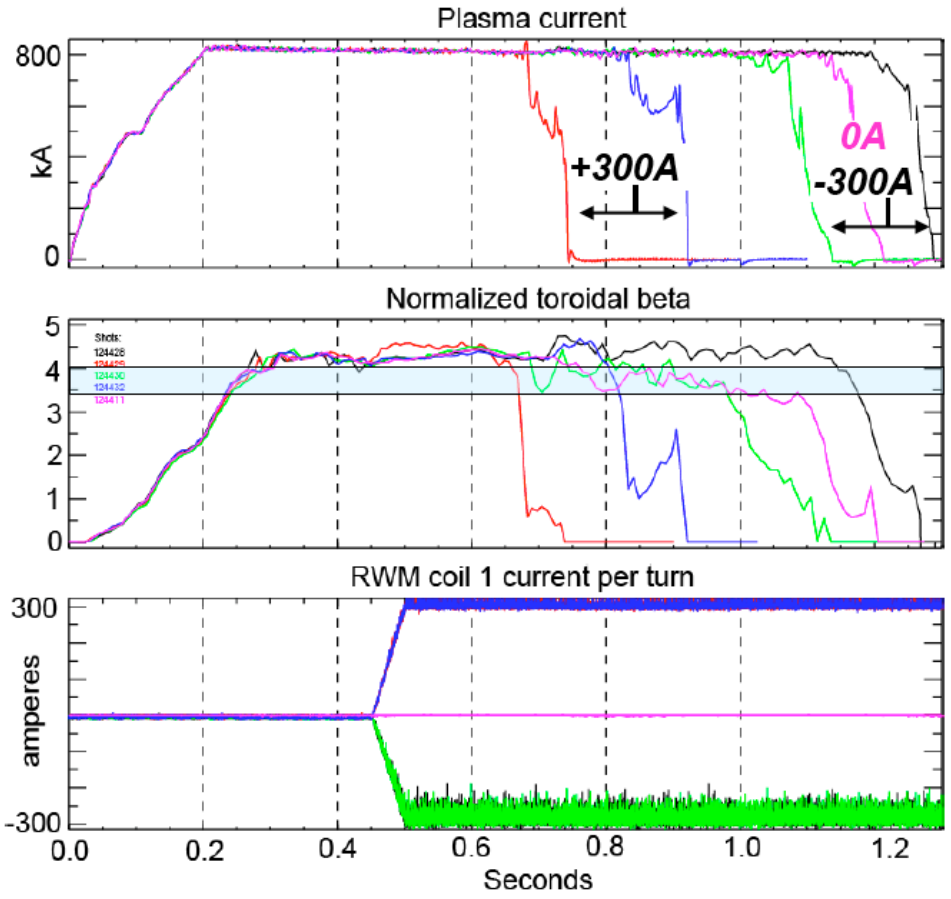
We All Remember That n=3 Correction Helps Performance



XP-902 Goals

1: Resolve whether the TF or PF coils are the EF source.

2: If PF coils, resolve whether it is the PF3 or PF 5 coil.

3: Develop an appropriate dynamic correction model.

XP-902 Methods

1: Select appropriate combinations [I_p, B_T, κ] in order to separate the contributions from various coil sets.

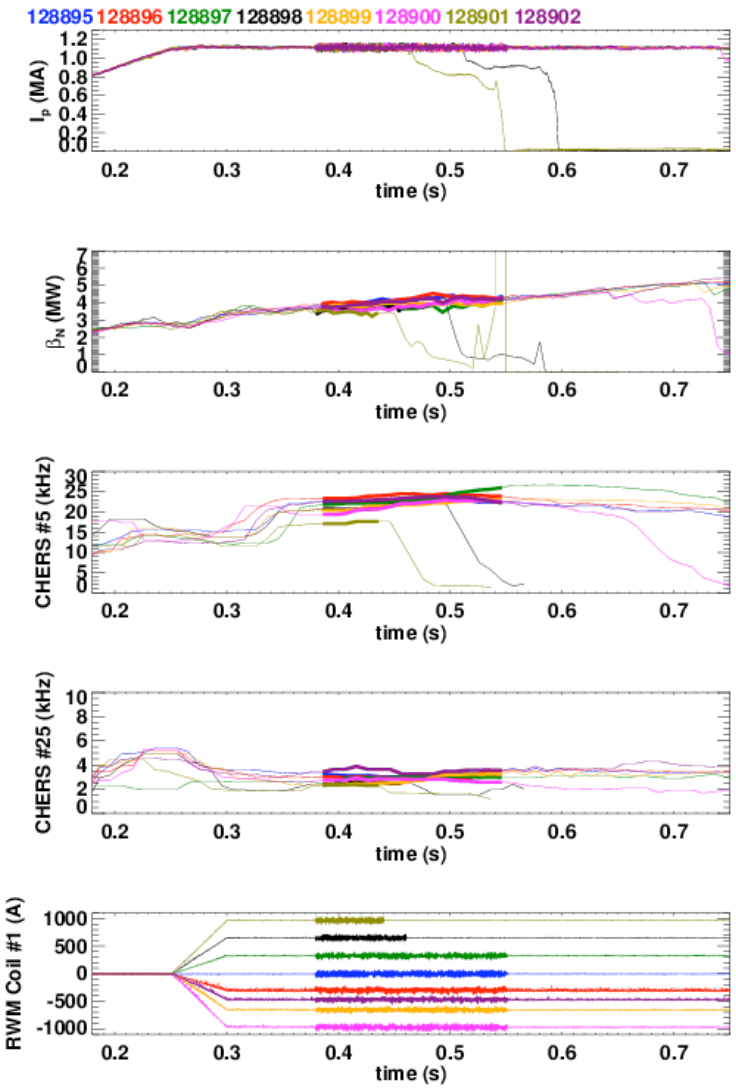
$B_T \rightarrow I_{TF}$

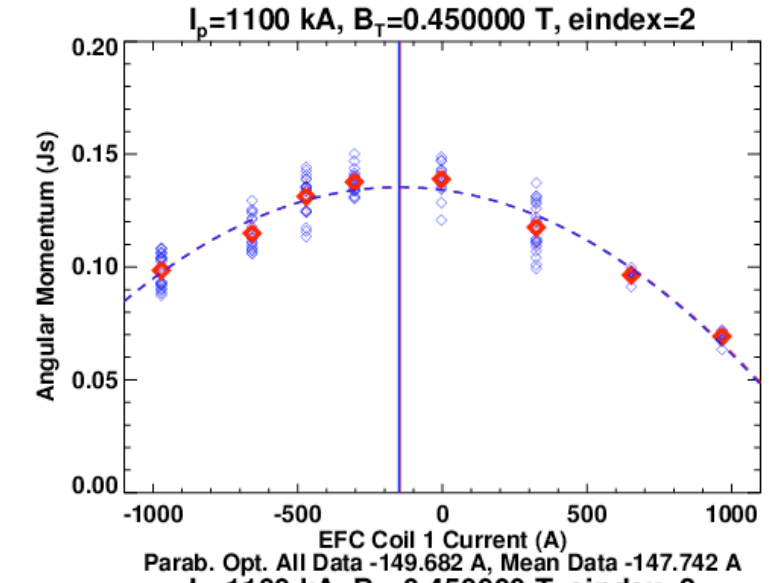
$I_P \rightarrow I_{PF5}$, I_{PF3}

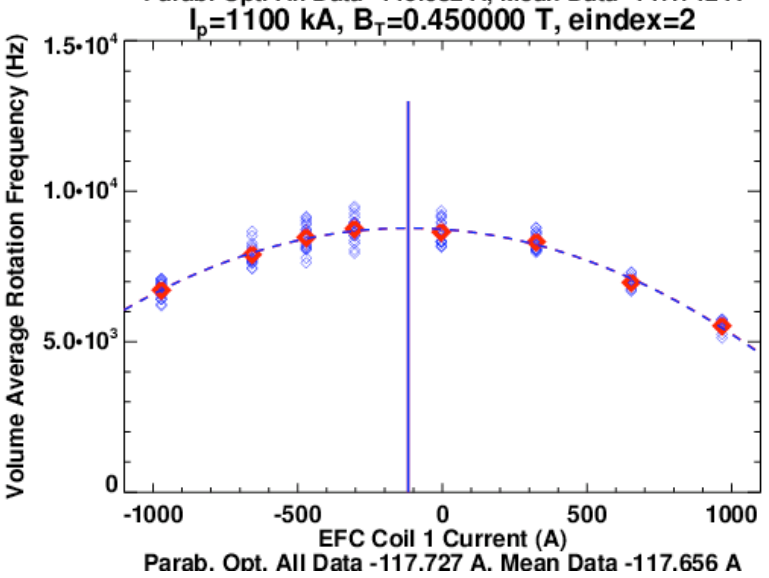
$\kappa \rightarrow I_{PF5}/I_{PF3}$

2: For each combination of these parameters, scan the applied n=3 field magnitude and phase, in order to determine the optimal correction.

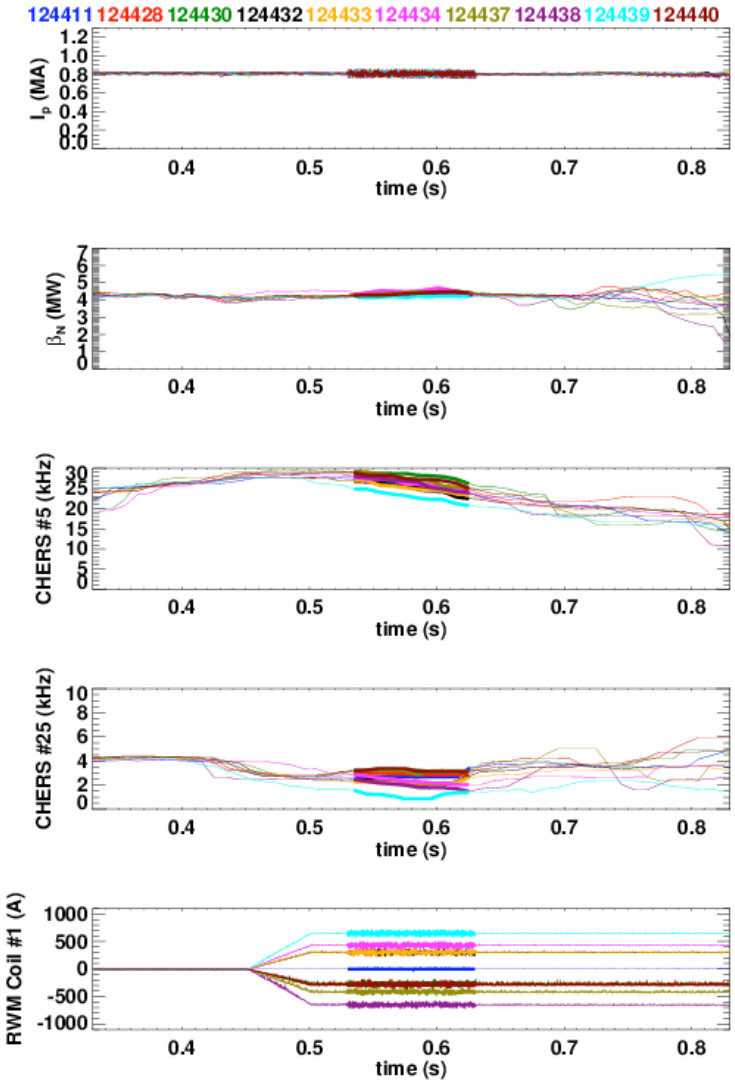
Case 1: XP 823, I_P=1100 kA, B_T=0.45 T (I)

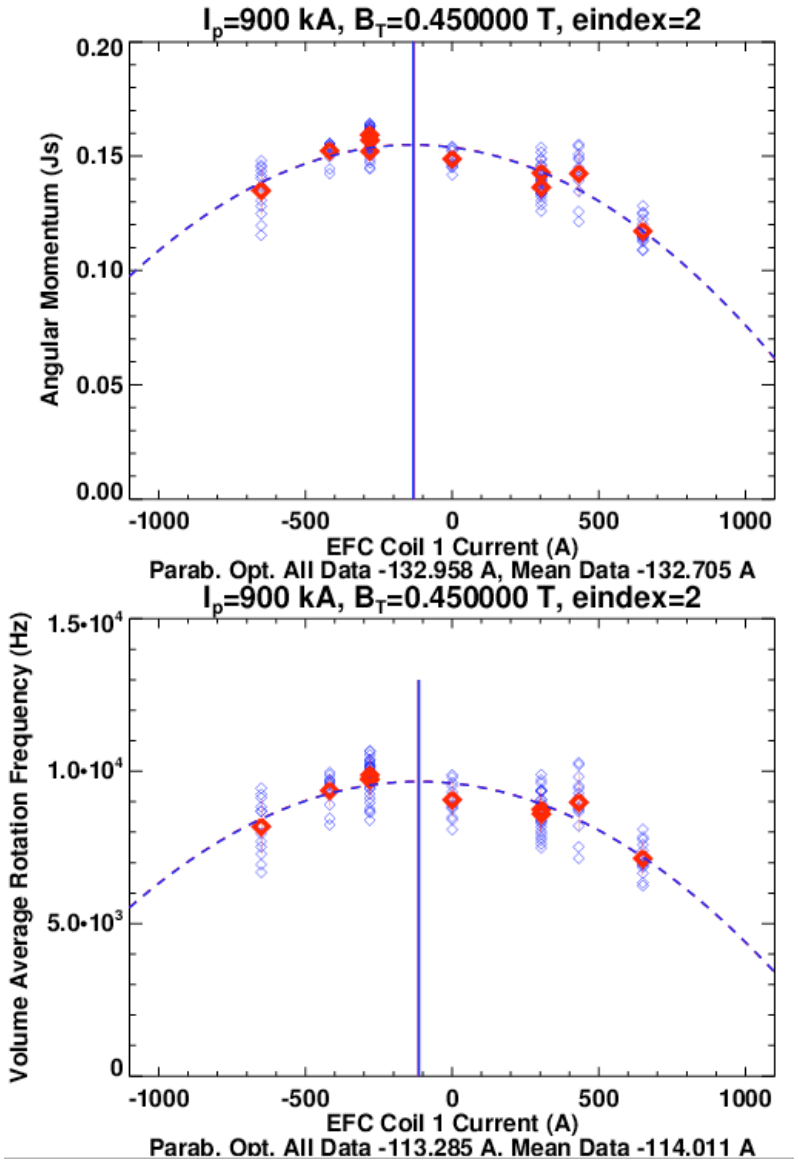




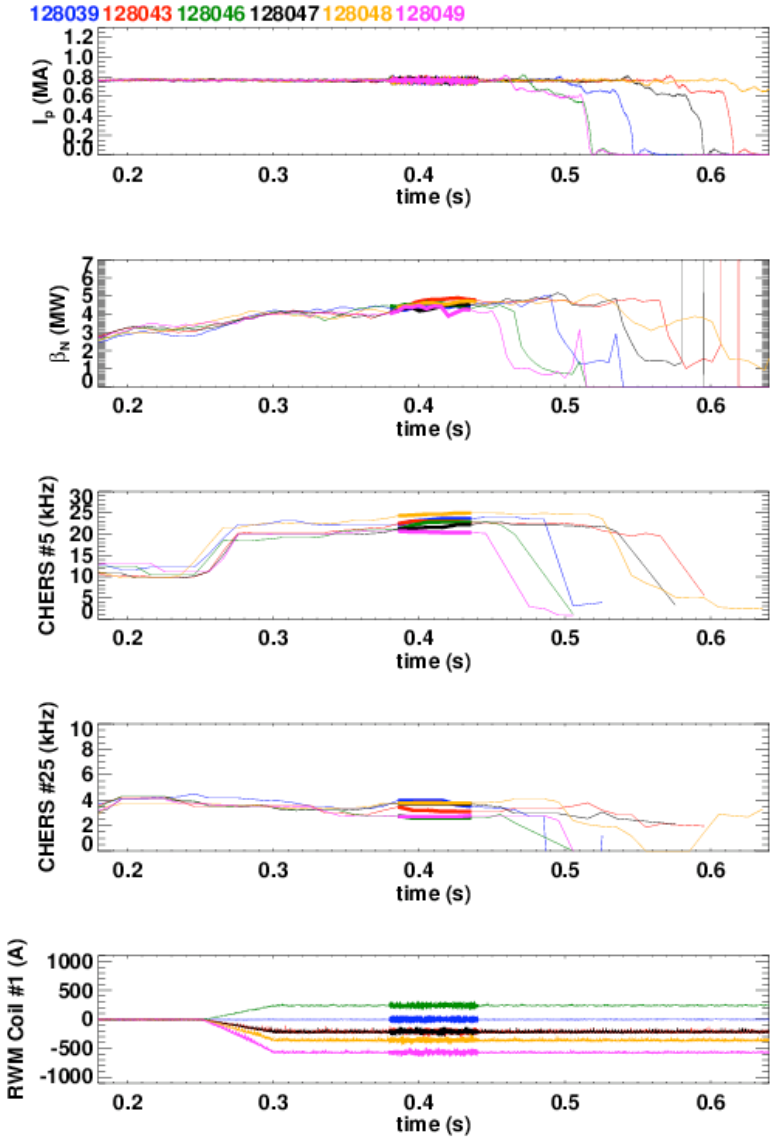


Case 2: XP 701, I_P=800 kA, B_T=0.44 T

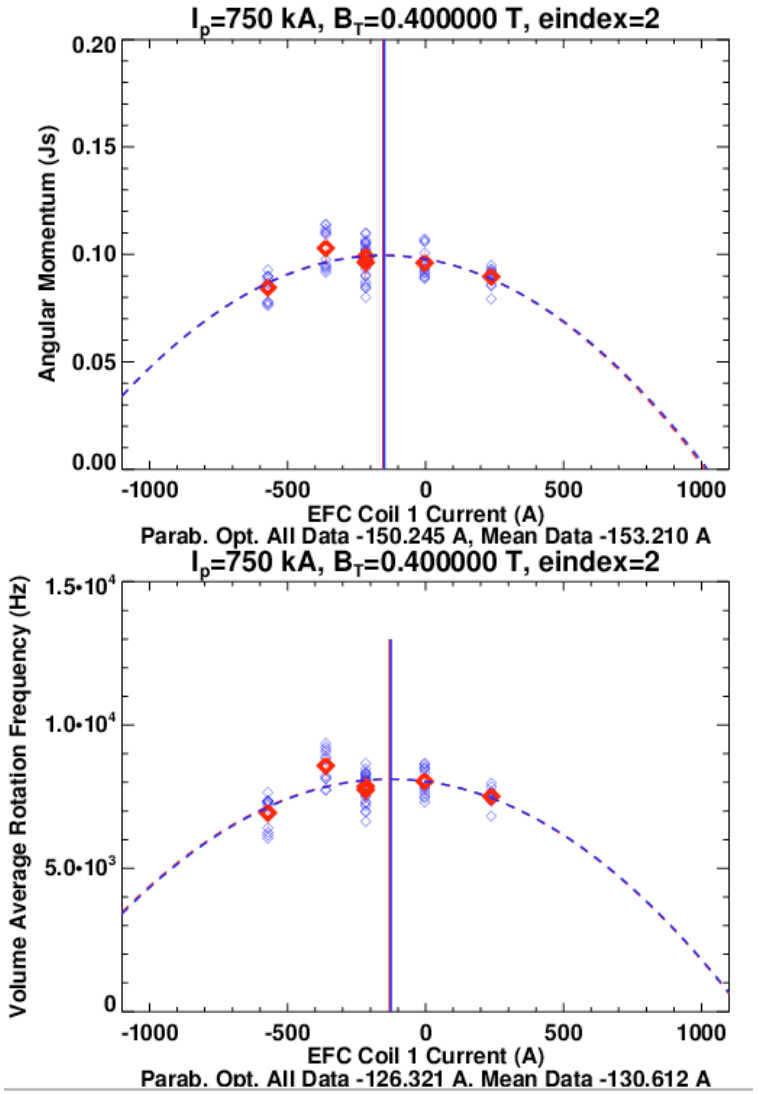




Case 3: XP 823, I_P=750 kA, B_T=0.4 T

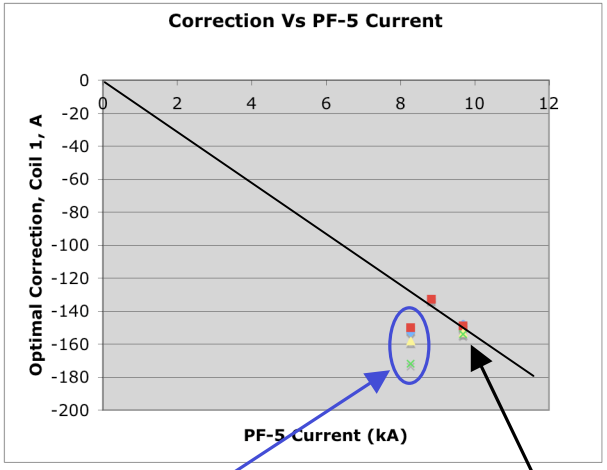


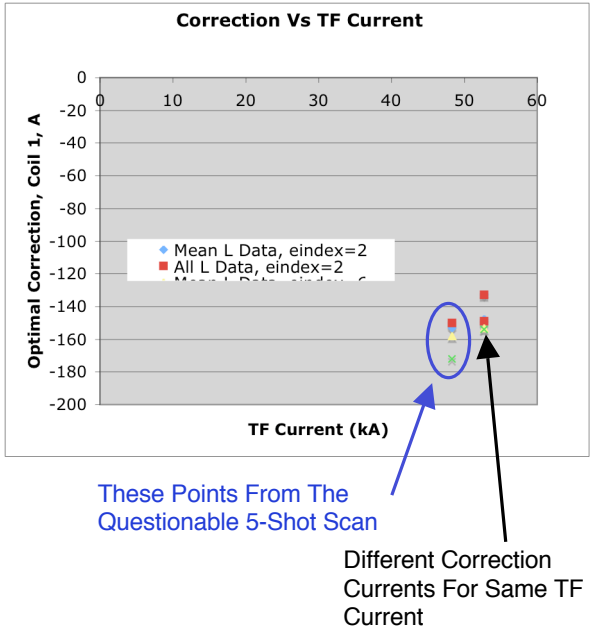
This Data Is Insufficient For Accurately Locating the Maxima

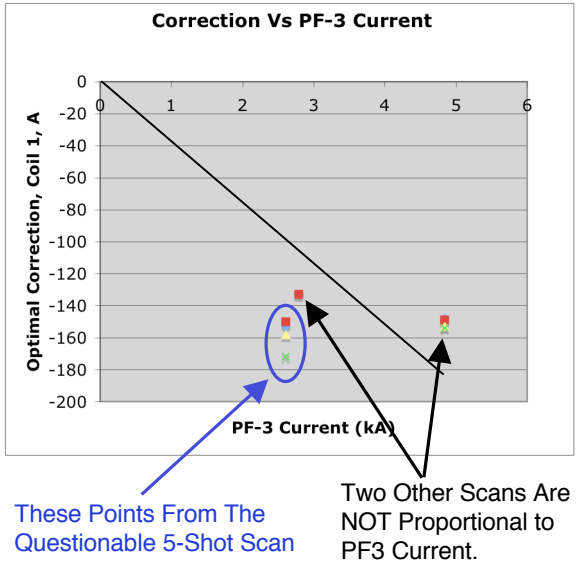


Conclusion: *PF5 is Mostly Likely Source,* But Evidence is Not Conclusive

- Use total angular momentum as the figure of merit in determining optimal correction current
- Two "Good" scans are well correlated with PF-5 Current
  - Lower current, 5 shot scan is hard to fit in the trend.
- This is inferring a lot from just 2 points, so take some more data.



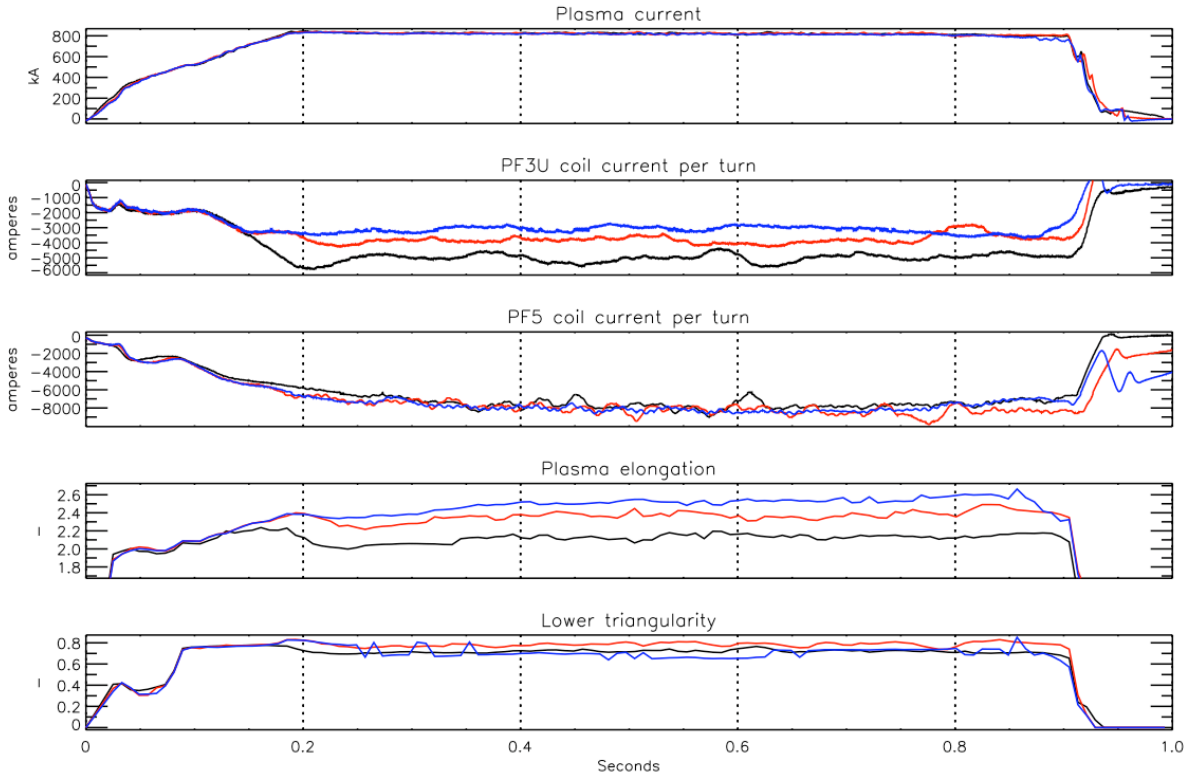


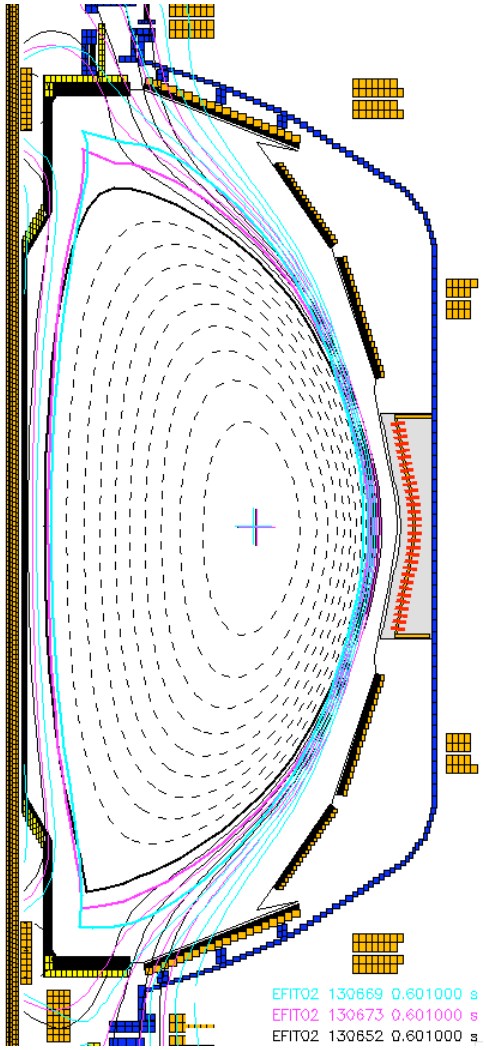


Resolve the PF5/PF3 Degeneracy Through Changing Kappa

- *DAG question at group review: "Can a PF-3 EF be isolated from a PF-5 EF"*
- *Example Case From κ-scan in XP-809*
- *PF-5 current unchanged, but large variation in PF-3*
  - *κ: 2.2→2.0 Yields I_{PF3}: 3kA→5kA*
- *However, changes the distance to PF-3, so do only once.*

Shots:
130652
130673
130669





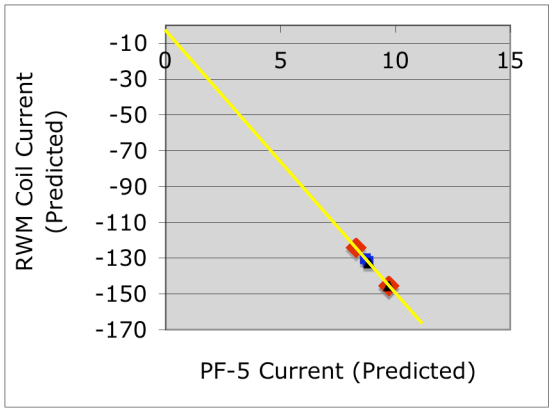
Part 1 Shot List: Continued Search For The EF Source

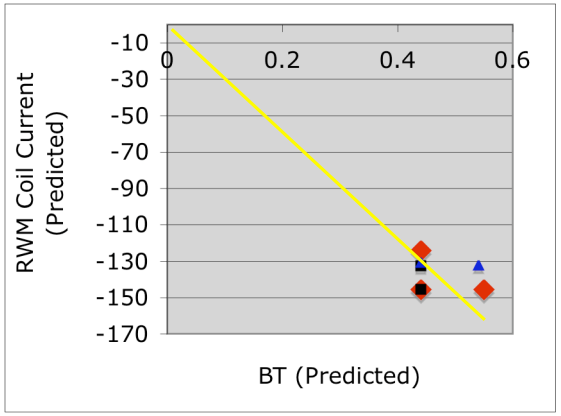
- Reference Shot:
  - high-κ, high-δ "2008-fiducial" shape. Hopefully "2008 fiducial shape"="2009 fiducial shape"
  - Should go into H-mode at t~110-115 ms, possibly with a "blip" of C.
    - Match early density evolution to 125329 (900kA), 128896 (1100kA), 128039 (750 kA).
- Method for Each [I_P, B_T, κ] Combination.
  - Take a reference shot with no SPA currents.
  - Begin scan over n=3 magnitude and polarity:
    - I_{SPA1}=-250,250,-500,500,-750, then other values based on data.
      - Wider range required for larger I_P.
  - Continue until the L vs. RWM curve is properly resolved (7-8 shots)
    - Run analysis code between shots to ensure sufficient data.
- Repeat the above "method" under the following I_P, B_T combinations.
  - Hope that first 3 conditions can fully implicate PF5, PF3 or TF, no need for more.

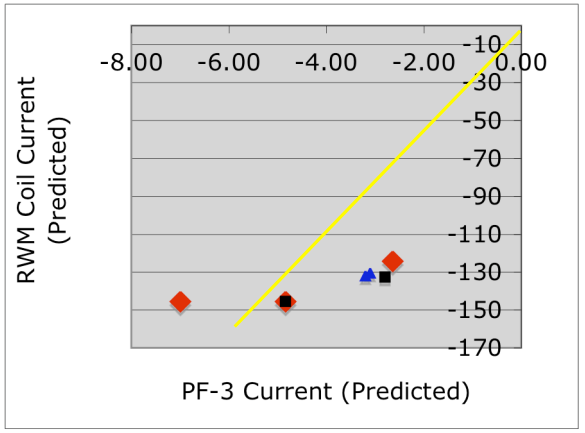
XP	Ip	BT	Ip/Bt	κ	Correction	Priority
823	750	0.4	1875	2.300	-153	Done, But Questionable
701	800	0.44	1818	2.240	-132.7	Done
823	1100	0.44	2500	2.360	-147.7	Done
902	1100	0.55	2000	2.360		1
902	750	0.44	1705	2.360		2
902	1100	0.44	2500	2.100		3
902	**900**	**0.54**	**1667**	**2.300**		**4**
902	**900**	**0.44**	**2045**	**2.300**		**5**

If Successful, Scans Should Resolve EF Source

- Assume that the PF5 coil is indeed the source of the error in determining the points below, and that the data is “perfect”.
  - Black: Existing Good Points
  - Red: Points For First Day
  - Blue: Contingency
- Chosen [I_P, B_T, κ] combinations should allow a determination of EF Source







Part 2: Improved Realtime Correction of n=3

- "Optimal" correction in 2008 used fixed ~300 A of n=3 correction, regardless of plasma current.
- Create new "tmf" algorithm:
  - imf="Initial Mode Feedback"
  - smf="Second Mode Feedback"
  - tmf="Third Mode Feedback"
- Simplest possible features for tmf:
  - Same pre-programmed waveform capability:

$$I_{SPAX,\mathrm{Pr}e\,\mathrm{Pr}og}$$

  - Coupling parameters from each PF/TF coil to each RMW coil:

$$\sum_{Ci=Coils} G_{Ci,SPAX} I_{Ci}$$

  - Same low-pass filtered n=1 FB requests, separate B_R & B_P:

$$I_{LPF,BP,SPAX} + I_{LPF,BR,SPAX}$$

  - Total request:

$$I_{tmf,SPAX} = I_{SPAX,\mathrm{Pr}e\,\mathrm{Pr}og} + \sum_{Ci=Coils} G_{Ci,SPAX} I_{Ci} + I_{LPF,BP,SPAX} + I_{LPF,BR,SPAX}$$

$$G_{PF5,SPA1} \approx -15\ (A/kA)$$
$$G_{PF5,SPA2} \approx -15\ (A/kA)$$
$$G_{PF5,SPA3} \approx +15\ (A/kA)$$

Part 2 Shot List: Testing of Optimized Correction

- Reference: Optimal I_P, B_T pair from previous scans.
  - Looks now like $[I_P, B_T]$=[1100kA, 0.45T] is a good configuration.
- Choose the PF5/SPA gain coefficients as:

$$G_{PF5,SPA1} \approx -15 \times f \quad (A/kA)$$
$$G_{PF5,SPA2} \approx -15 \times f \quad (A/kA)$$
$$G_{PF5,SPA3} \approx +15 \times f \quad (A/kA)$$

- 8 (or less) shot scan of the Gain Multiplier "f", verifying that realtime correction works.

SPA 1 Optimal Gain	SPA 2 Optimal Gain	SPA 3 Optimal Gain	Gain Multiplier	SPA 1 Gain	SPA 2 Gain	SPA 3 Gain	Shot Number
-15	-15	15	**-1**	15	15	-15	
-15	-15	15	**-0.5**	7.5	7.5	-7.5	
-15	-15	15	**0**	0	0	0	
-15	-15	15	**0.5**	-7.5	-7.5	7.5	
-15	-15	15	**1**	-15	-15	15	
-15	-15	15	**1.5**	-22.5	-22.5	22.5	
-15	-15	15	**2**	-30	-30	30	
-15	-15	15	**2.5**	-37.5	-37.5	37.5	