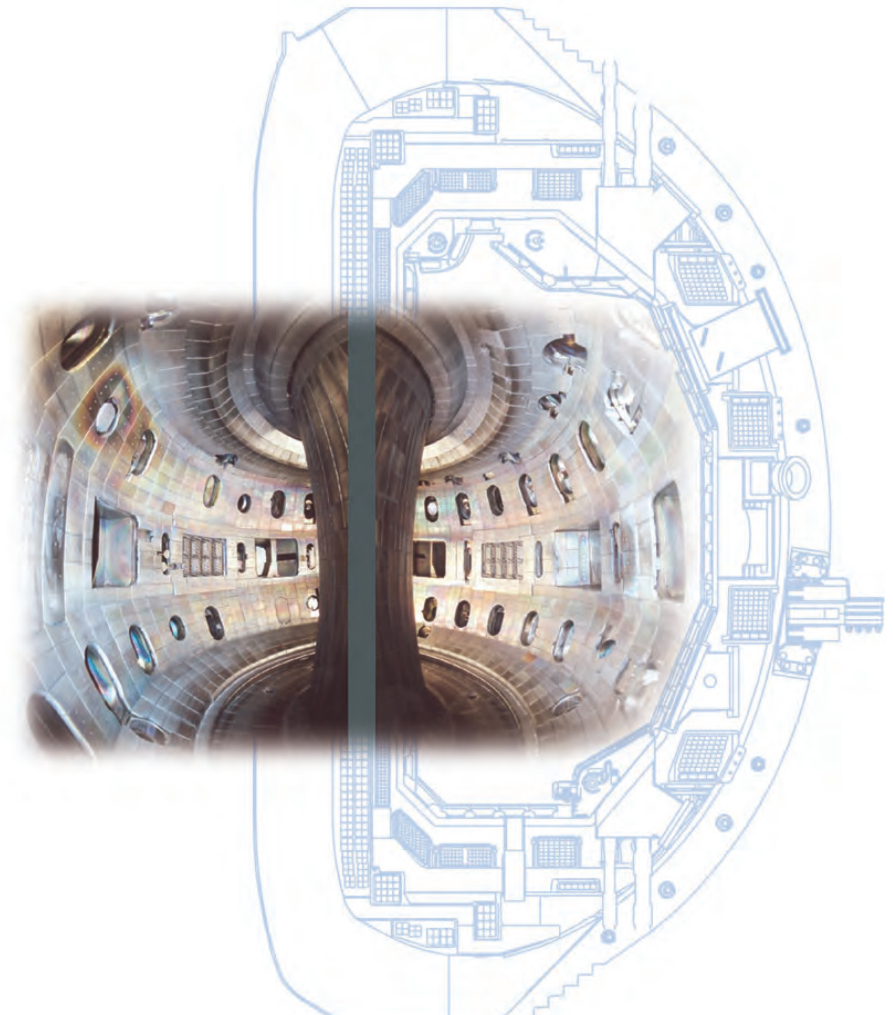
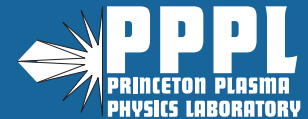


Assessing Dynamic Error Field Correction (DEFC)

M. OKABAYASHI, R. HATCHER, H.TAKAHASHI,
- PPPL,
A.M. GAROFALO, H. REIMERDES, M.J.LANCTOT,
- COLUMBIA U.,
G.L. JACKSON, R.J. LA HAYE, E.J. STRAIT,
- GA,
Y. IN, J. KIM,
- FAR TECH Inc.

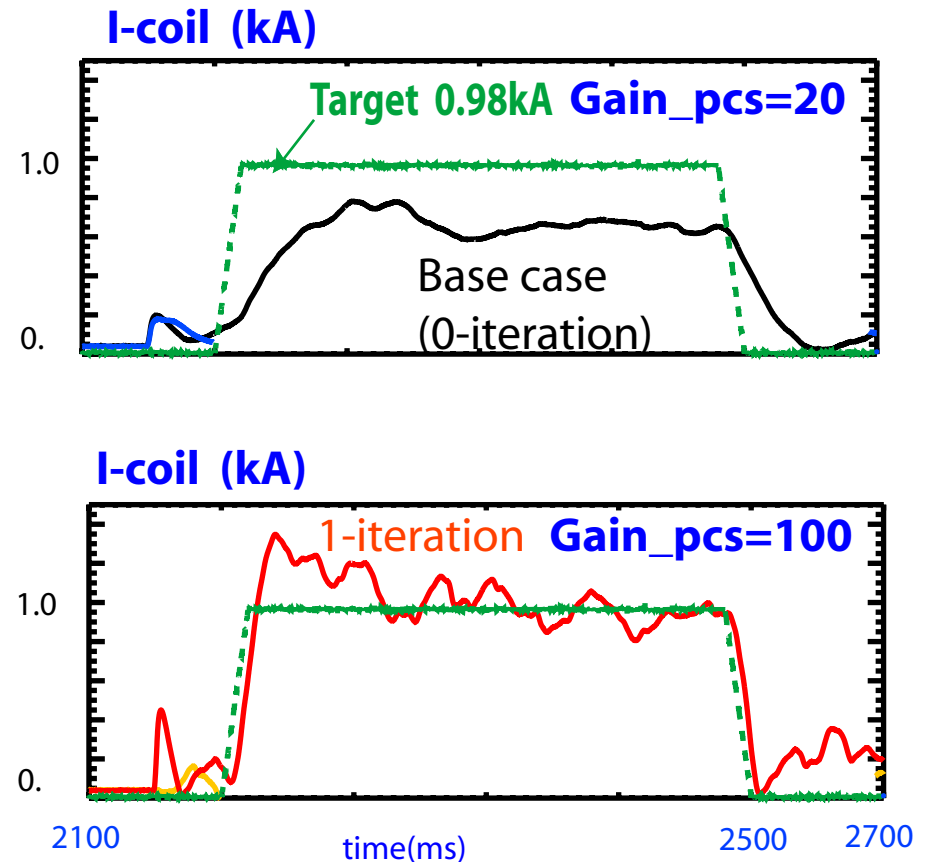
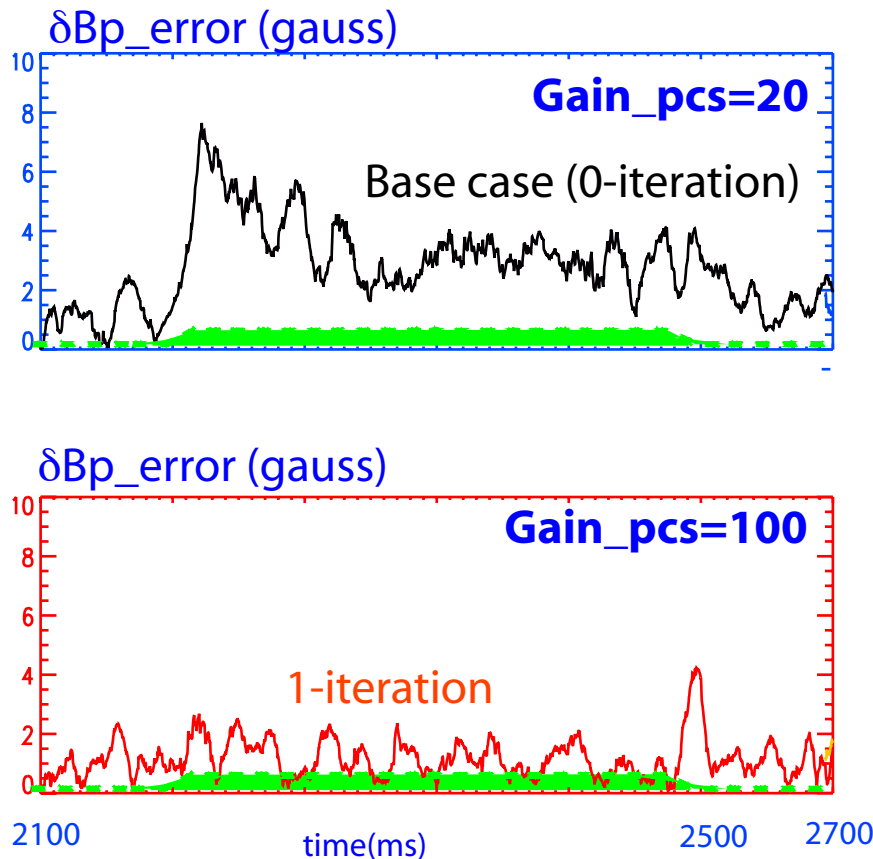


Post-APS 3rd Error/Non-Axisymmetric Magnetic Field Workshop
11/16/2007 1 PM – 6:00 PM



Dynamic Error Field Correction (DEFC) can Predict Error Field Correction Current within a Few Iterations.

- Simulated error field by C-coil with DEFC by I-coil



Q: Why is DEFC so efficient?

OUTLINE:

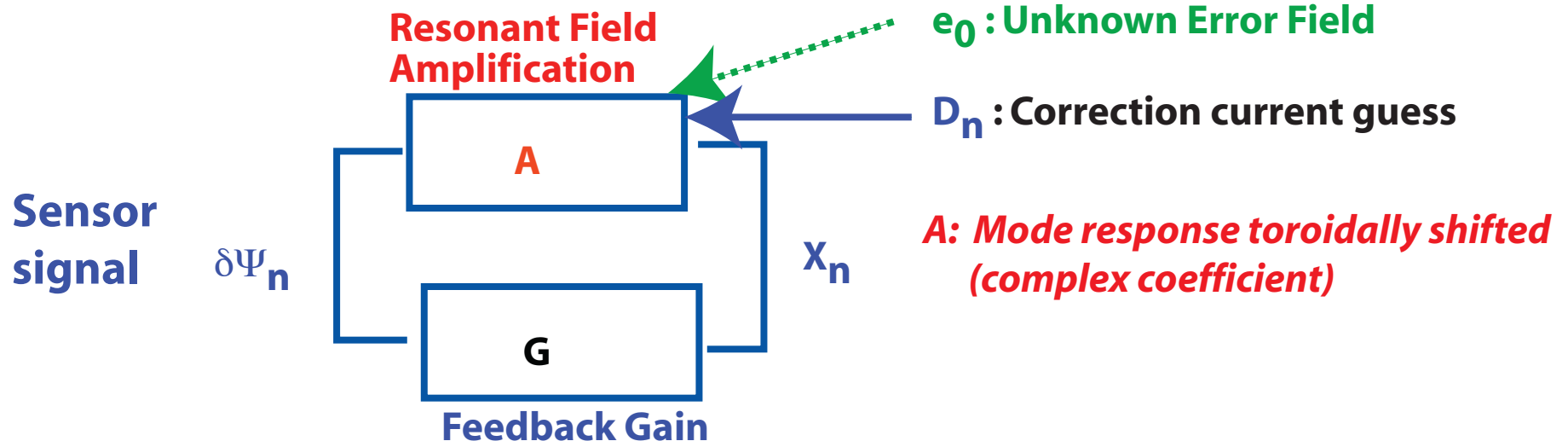
- **DEFC Concept**
- **A simple model**
- **Comparison of Model and Observation**
- **Possible DEFC of the ELM precursor?**
- **Summary**

Dynamic Error Field Correction (DEFC)

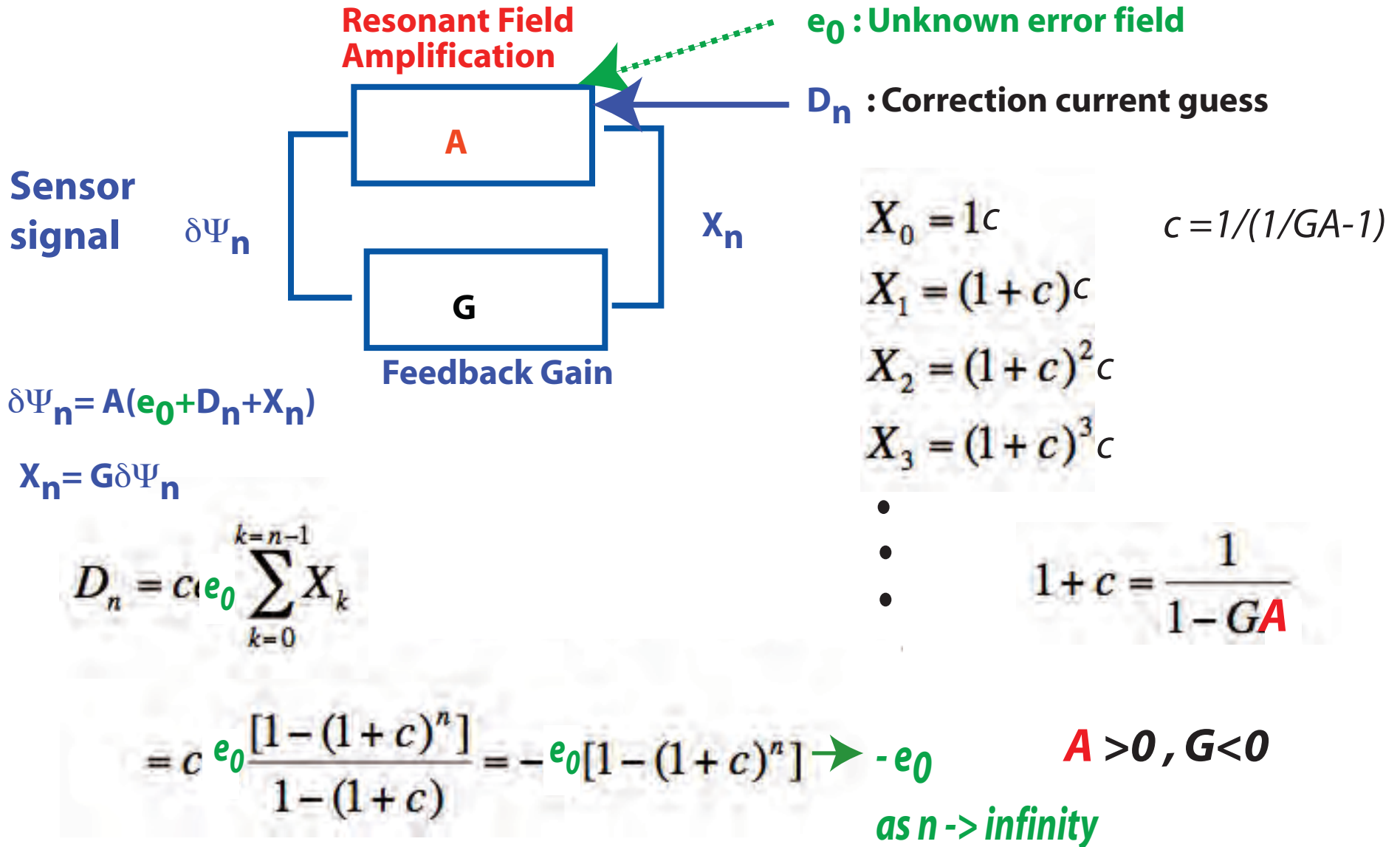
- **DEFC is one of most successful approaches for reducing the error field component against plasma deformations caused by external kinks**
- **Recently, reduction of the error field is recognized as a crucial element at low rotation to avoid magnetic island formation and mode locking**

Concept of DEFC

- Non-axisymmetric error field (e_0) produces the helical displacement due to resonant field amplification (A) to a marginally stable mode (**Resonant Field Amplification**)
- Feedback field minimizes the displacement by observing the deformation ($\delta\Psi_n$) and by trying to cancel out the component resonating to the marginally stable mode
- Required feedback current (X_n) \rightarrow Prepare the next step of the correction current (D_{n+1})
- with enough iterations, $D_n \rightarrow e_0$

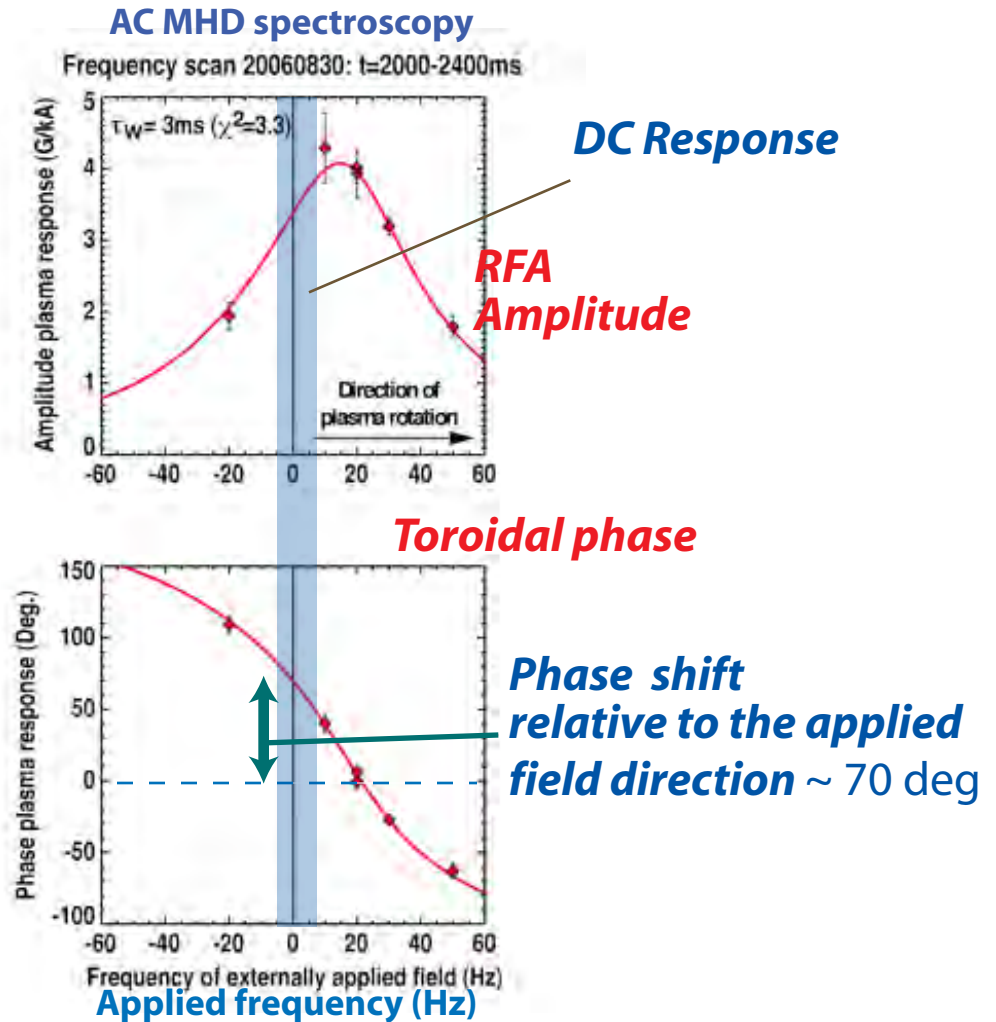
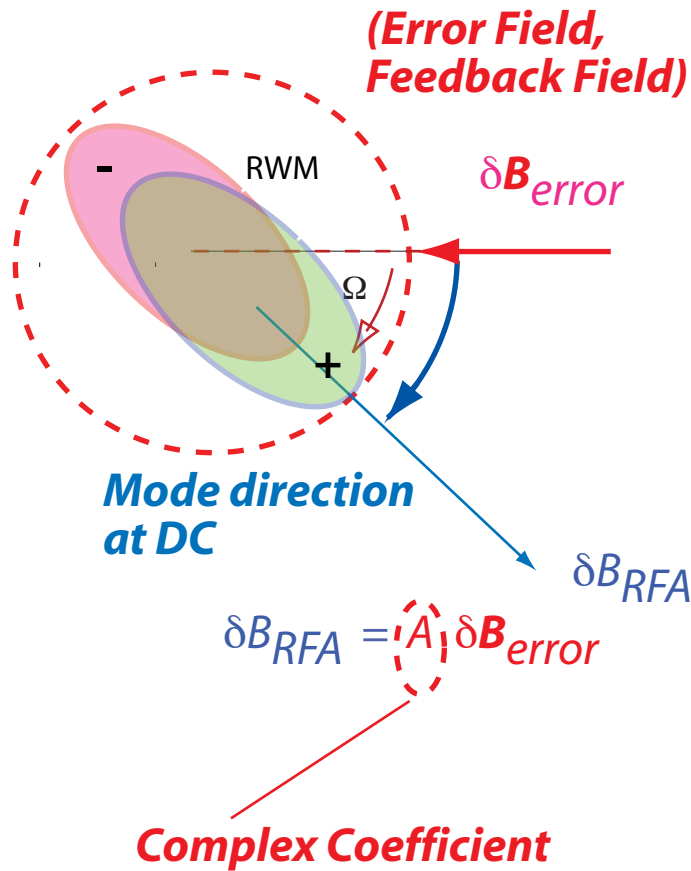


A Simple Model



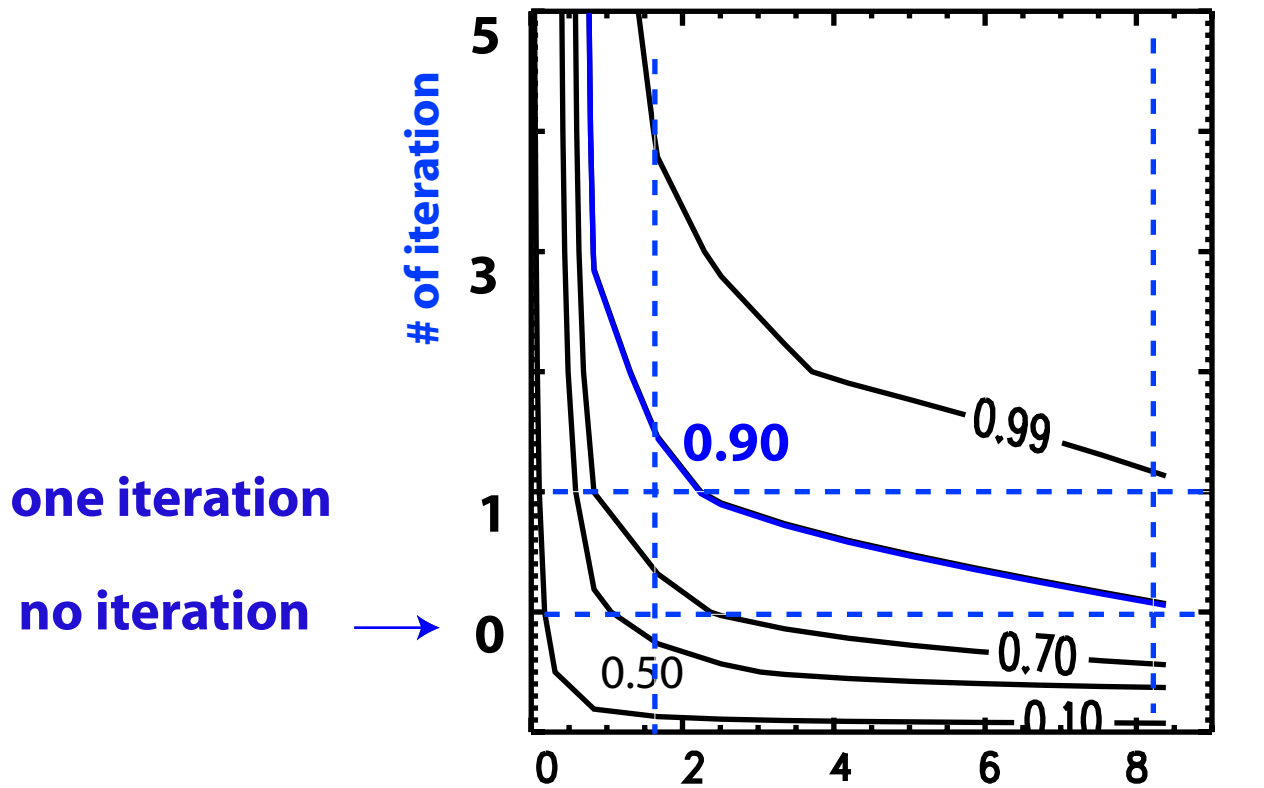
RWM Response to Non-axisymmetric Field is Shifted in the Toroidal Direction.

-> Amplification Coefficient is Complex Value



Large Overall System Gain Provides Sufficient Correction

DEFC Correction Current Efficiency



one iteration

no iteration

e.g.

Case 1: ~ 0.90

@ AG=2.2 with
1 iteration

Case 2: ~ 0.90

@ AG = 8.2 with
no iteration

AxG (overall system gain)

Plasma Amplification

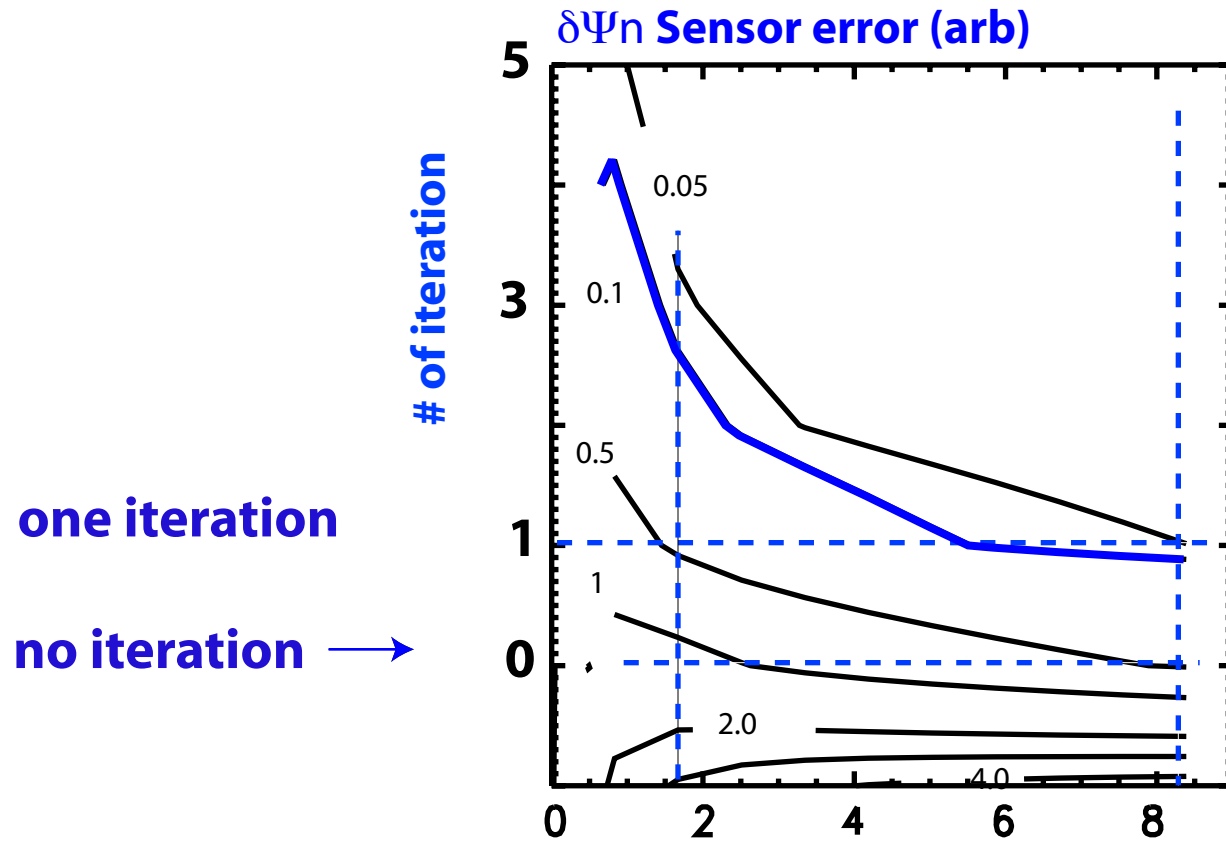
Feedback Gain

Experimental Issues

- what value of resonant field amplification?

- how high can a feedback gain be without negative consequence?

Deformation Can Be Minimized in a Few Iterations



one iteration

no iteration →

e.g.

Case 1: ~ 0.5

@ AG=1.8 with
1 iteration

Case 2: ~ 0.5

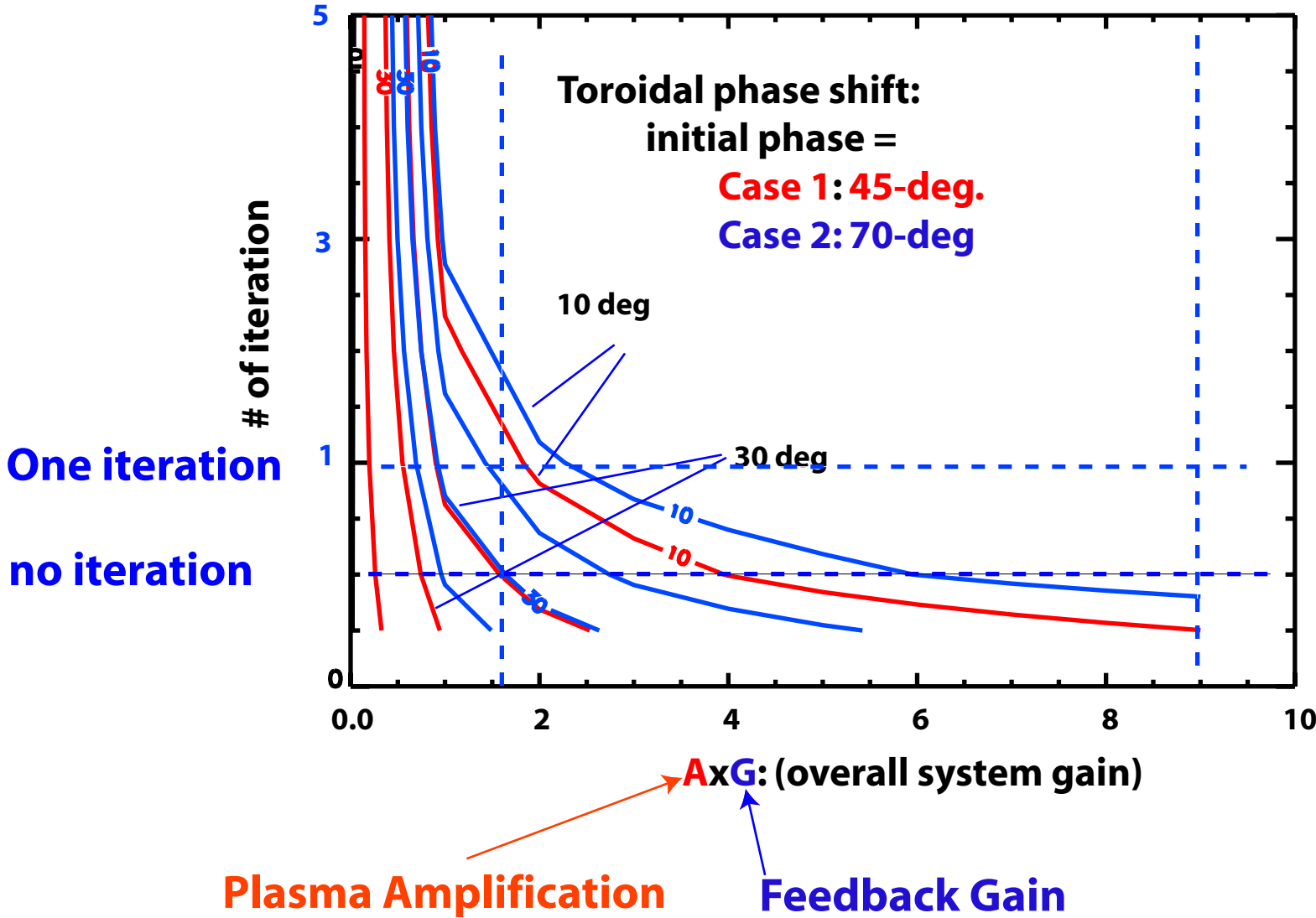
@ AG = 8.2 with
no iteration

Plasma Amplification

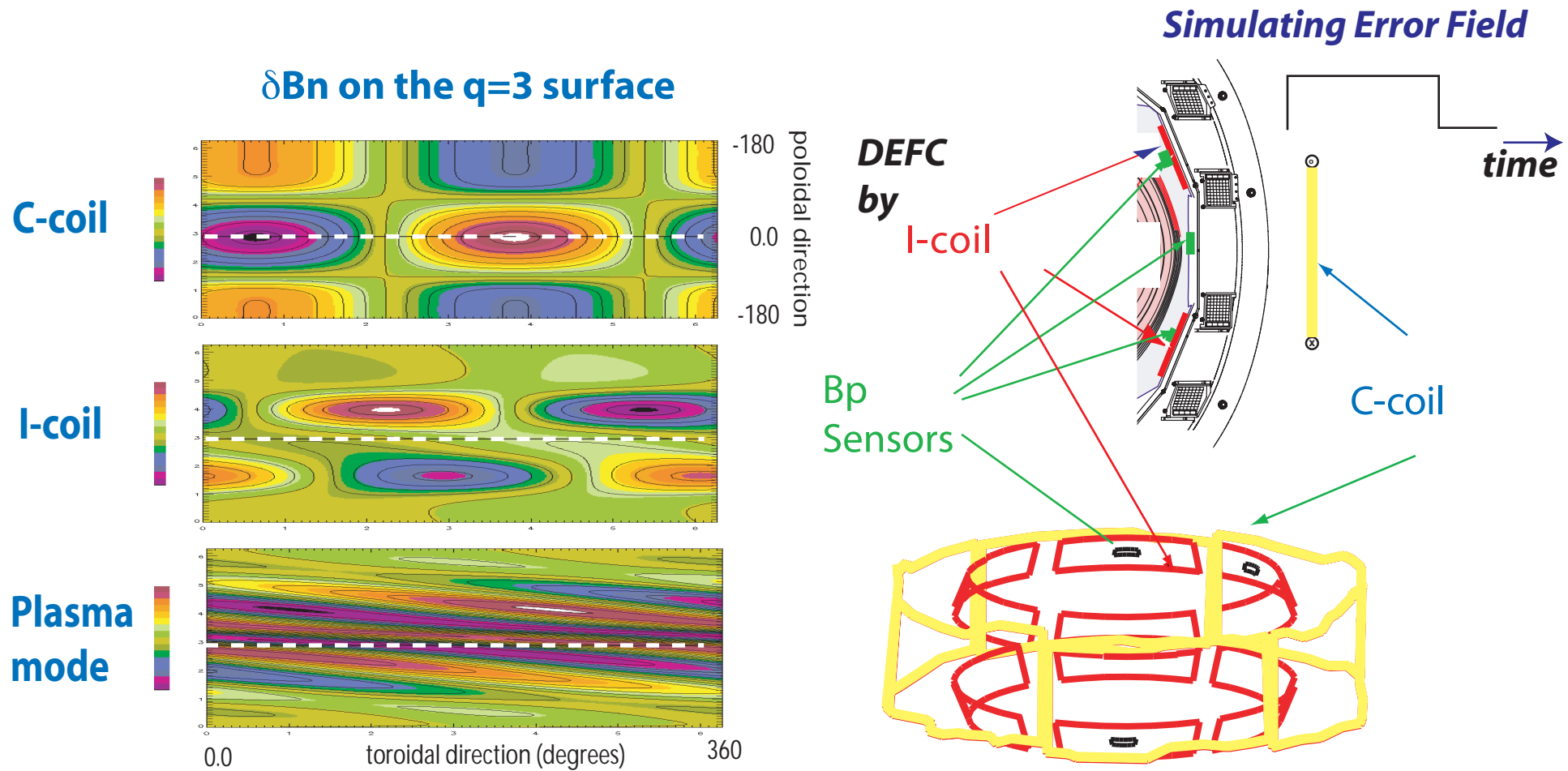
Feedback Gain

AxG (overall system gain)

Toroidal Phase shift Is Insensitive with A Few Iterations with Enough System Gain

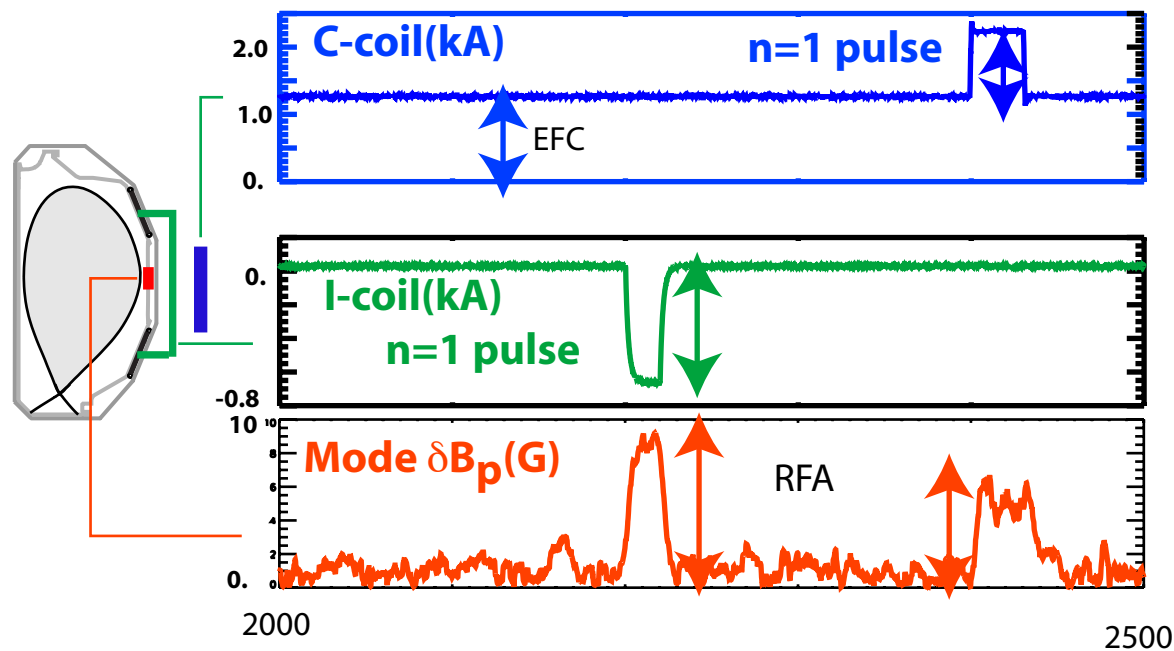


C-coil Provided Simulated Error Field and I-coil Reduces the RFA by Feedback with Slow Time constant

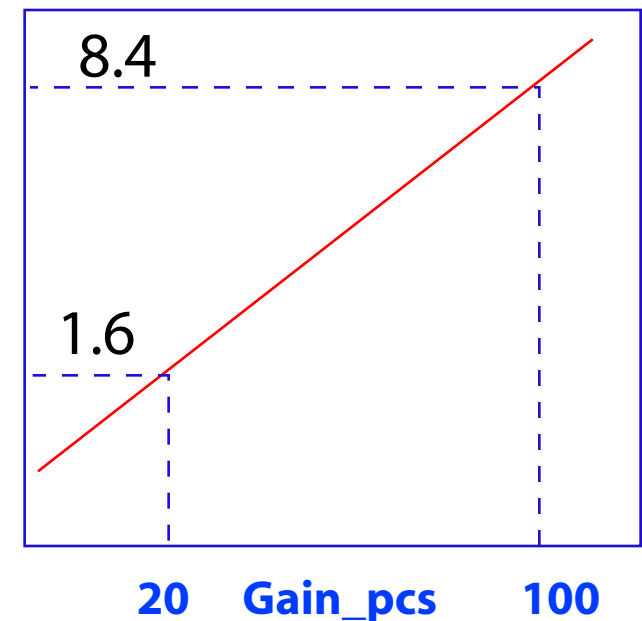


* 0 degrees is at the outer mid-plane

RFAs Excited by I-coil and C-coil Provides Relative DEFC Coupling Parameters

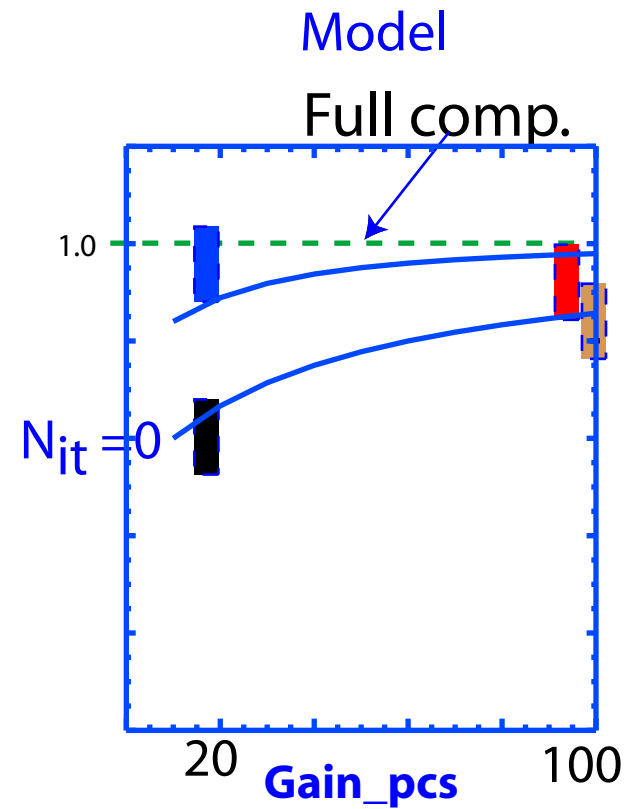
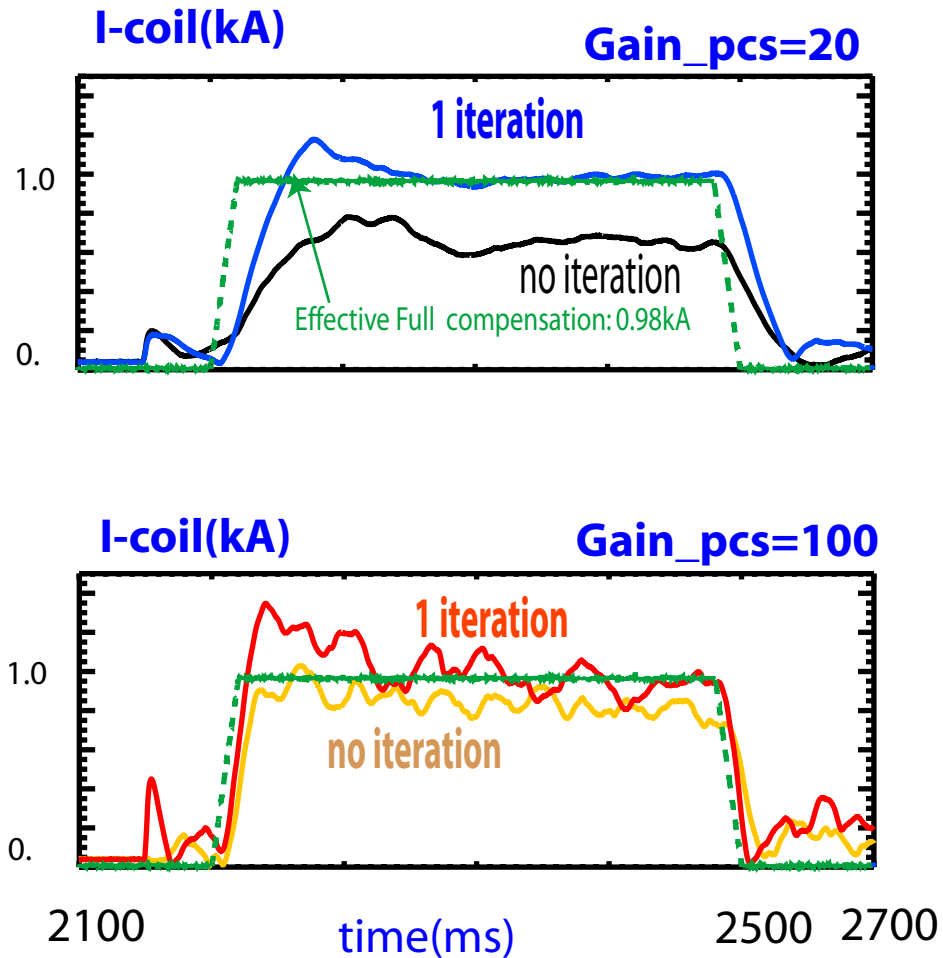


AG : system total gain

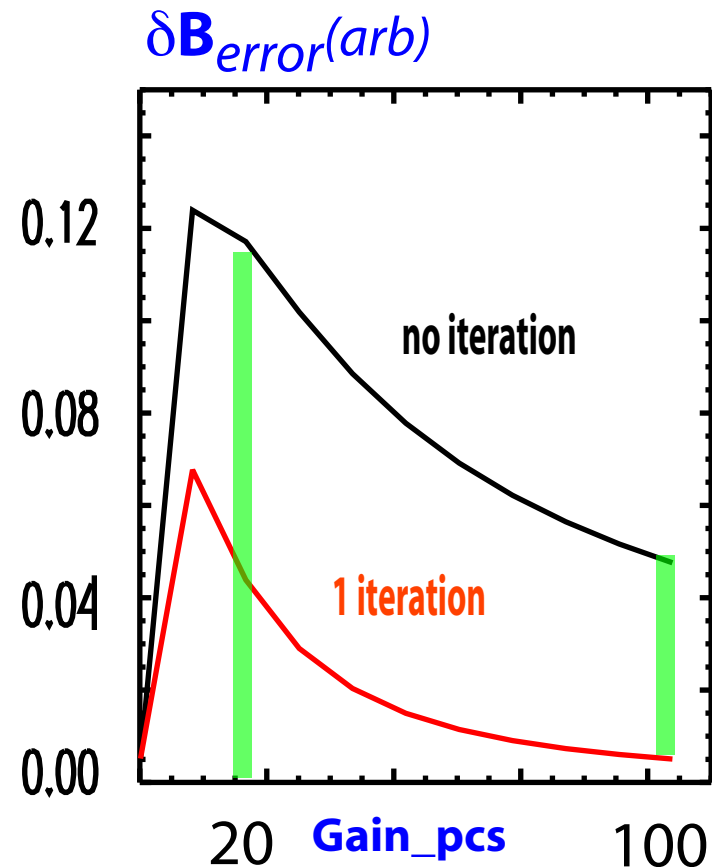
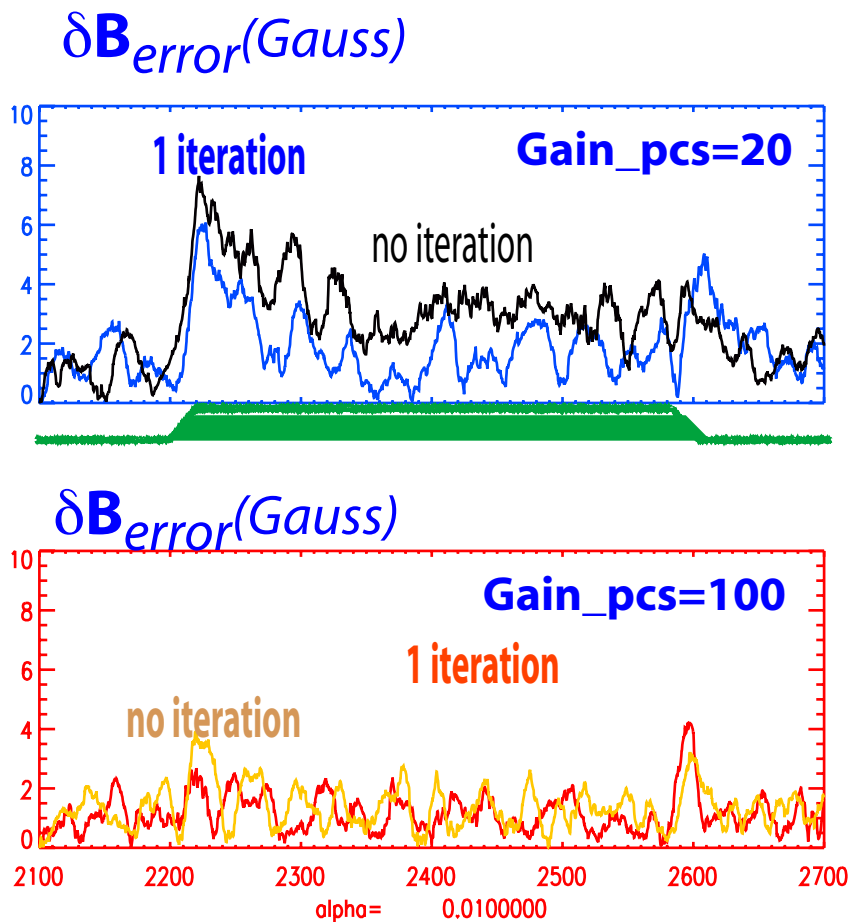


- RFA production (per kA) by C-coil is $\sim 43\%$ of I-coil
- Total system gain can be 1- 8.

Only A Few Iterations are Needed for DEFC to be Effective, Since the Overall System Gain is Large with Resonant Field Amplification

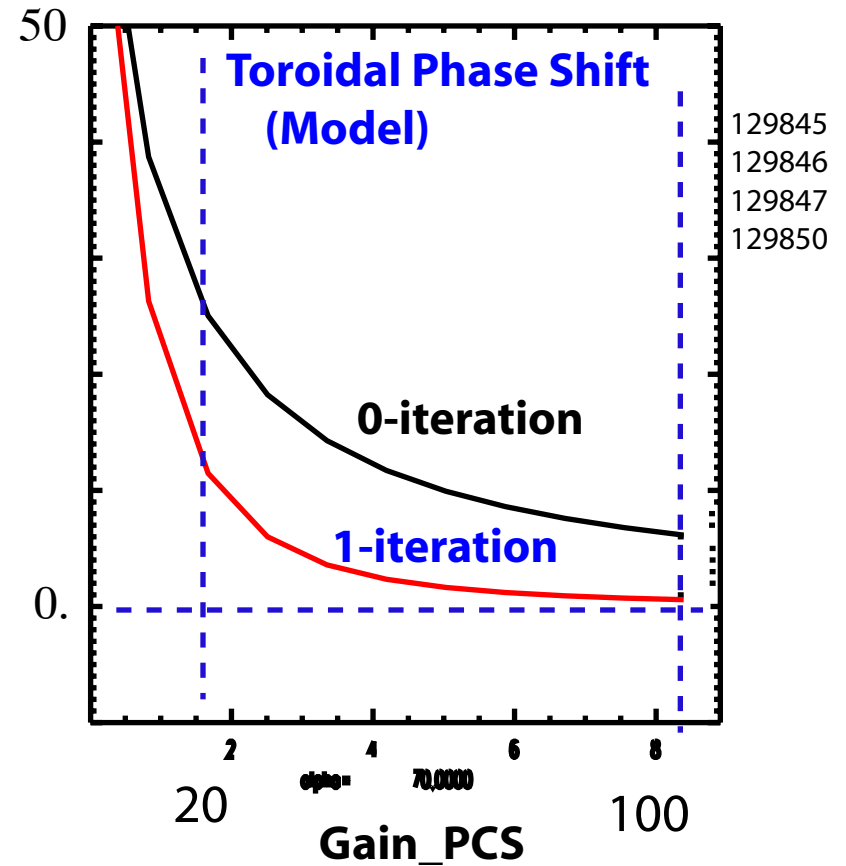
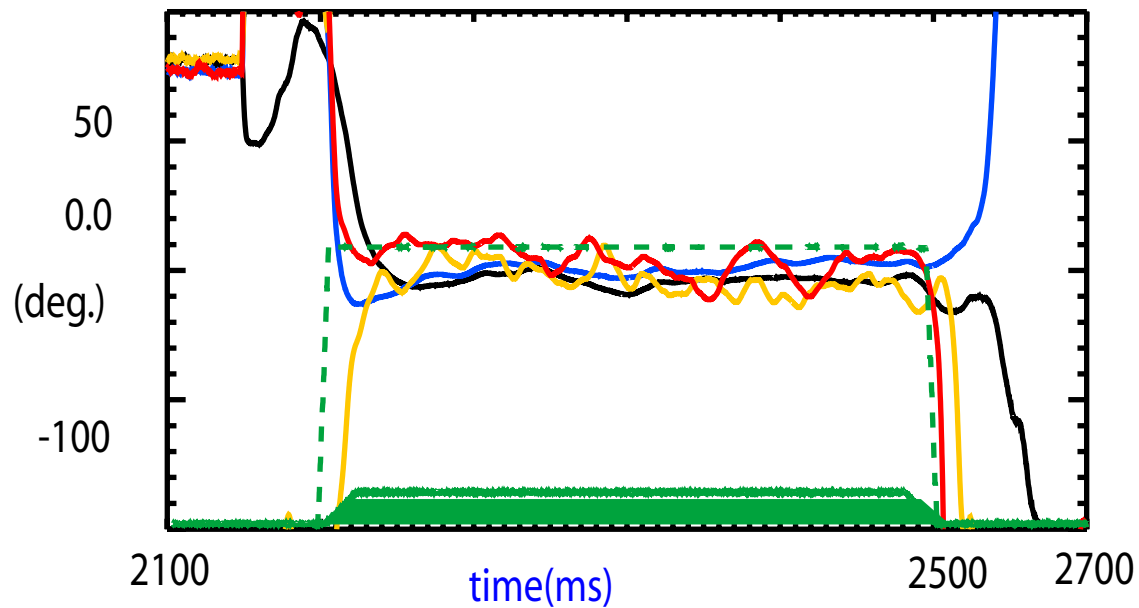


Only A Few Iterations are Needed for DEFC to be Effective, Since the Overall System Gain is Large with Resonant Field Amplification



Toroidal Phase Prediction Was Inconclusive Because of Poor Signal / Noise Ratio

Toroidal Phase Shift

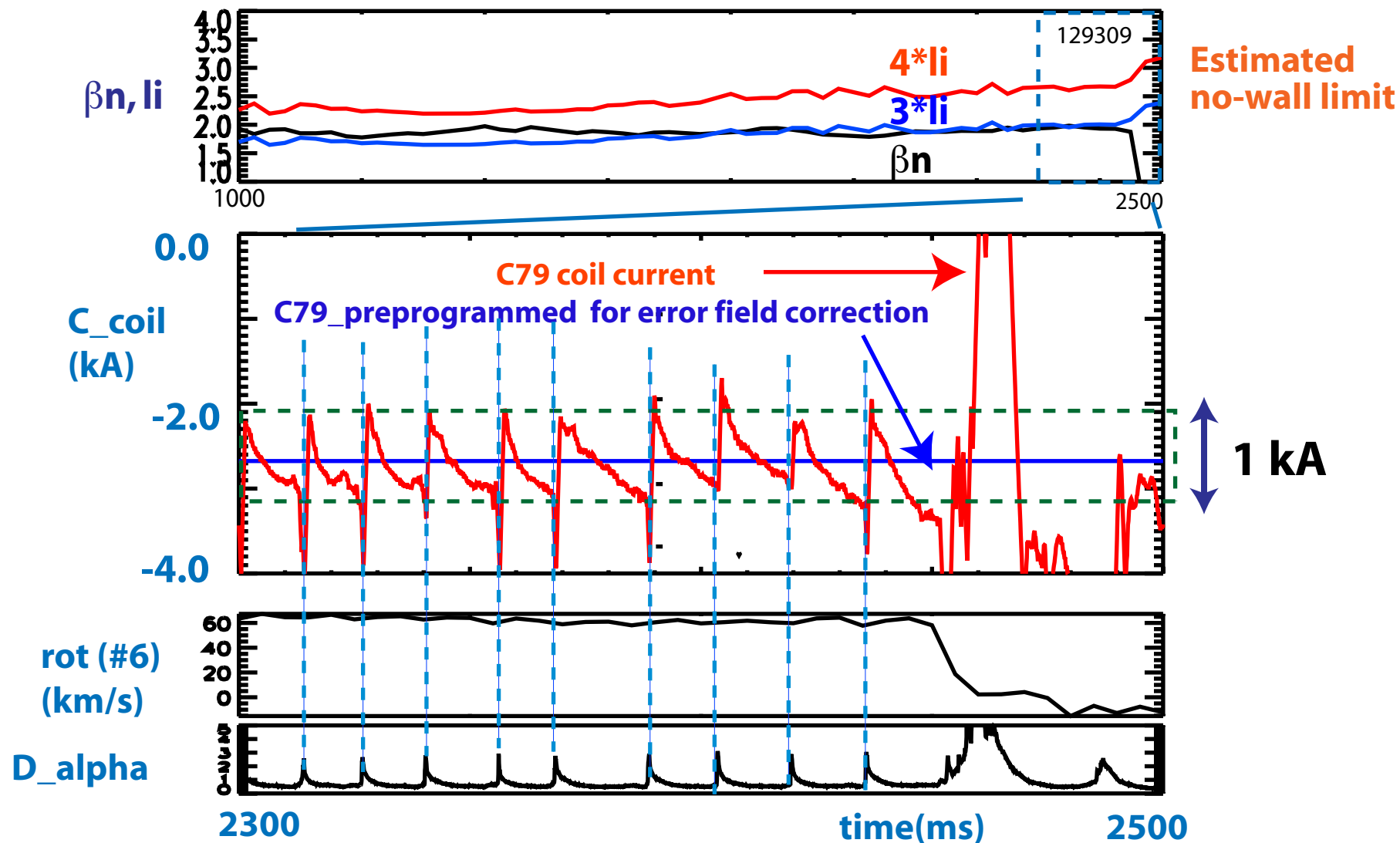


DEFC with ELM Precursor

ELM events were Initiated in a Fixed Toroidal Direction

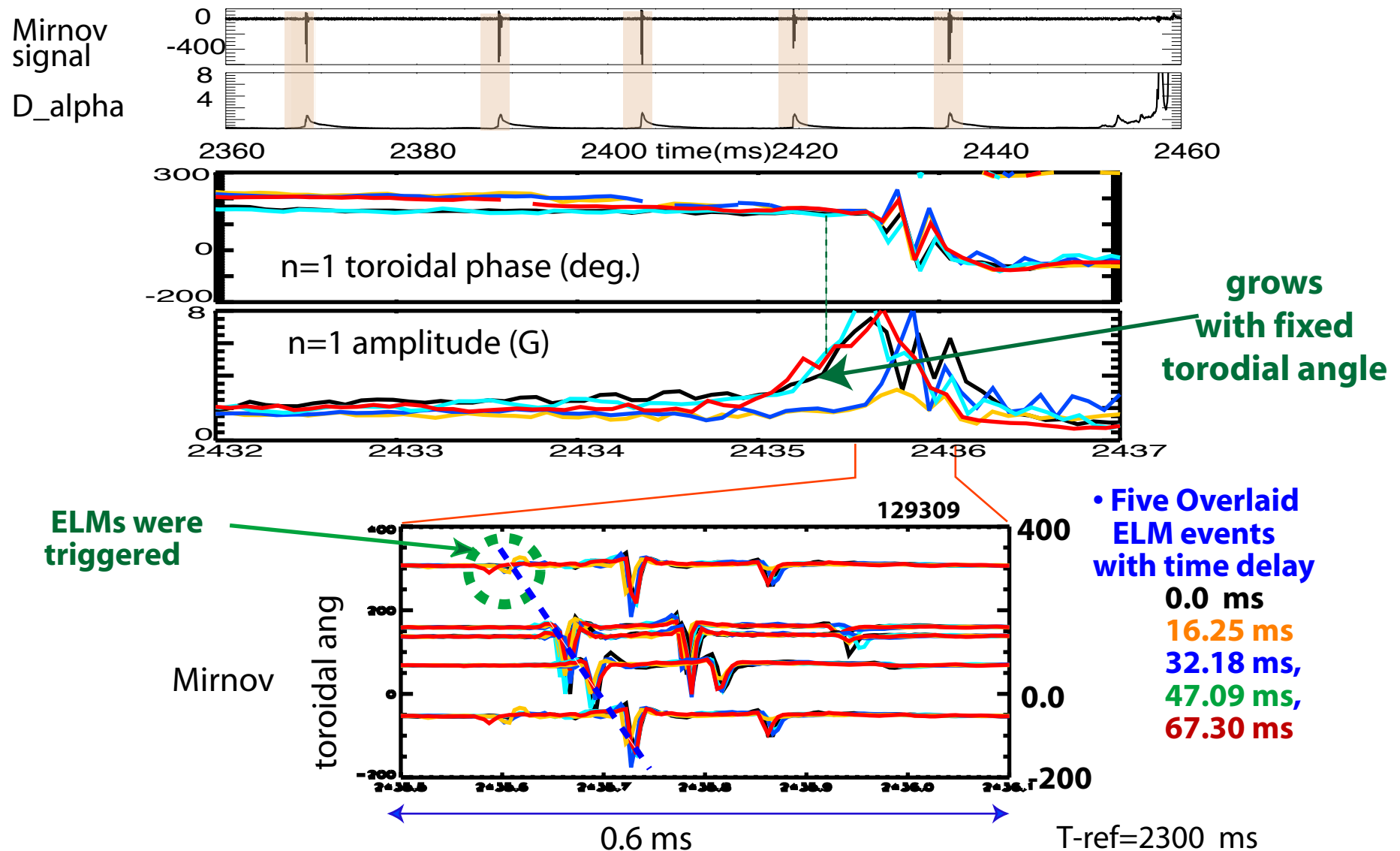
- AT plasmas
- Beta below no-wall limit
- With C-coils
 - DEFC to Fast Feedback (FB-time const. 200ms -> 0.2 ms)
- Seed: residual error field?

Below $\beta_{no-wall}$ limit, Feedback C-coil Produced Periodic ELM Events with modest Coil Current δI



- C-coil 1kA produces ~ 1.2 Gauss of $n=1$ component on the plasma surface

N=1 non-rotating component Precedes Reproducible ELM Collapse, Serving as a Precursor.



- Residual Error Field impacts the ELM events
 -> DEFC of the ELM precursor ?

Summary

- **DEFC is an excellent tool for determining error field correction**
- **High overall gain is provided by Resonant Field Amplification**
- **Challenges:**
 - **With less amplification below no-wall limit, can we improve the system by improving the sensing tools, changing the feedback logic, or optimizing the gain ?**
 - **Is the same approach valid, if the mode is sensitive to the non-axisymmetric magnetic field?**
 - **Usage of ELM-precursor DEFC for ELM control?**