Non-Axisymmetric Coils
and
Performance Improvement

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Perturbed Helical Equilibrium and Non-Axisymmetric Field coils

- RWM :
    - Does exist and can be sustained
        - in the Resonant Field Amplification Period
    - Controllable:
        - Plasma rotation and feedback (stable RWM)
    - Implication from NMA code (Ming Chu and Morrell)

- NAF-coils can impact on other crucial issues
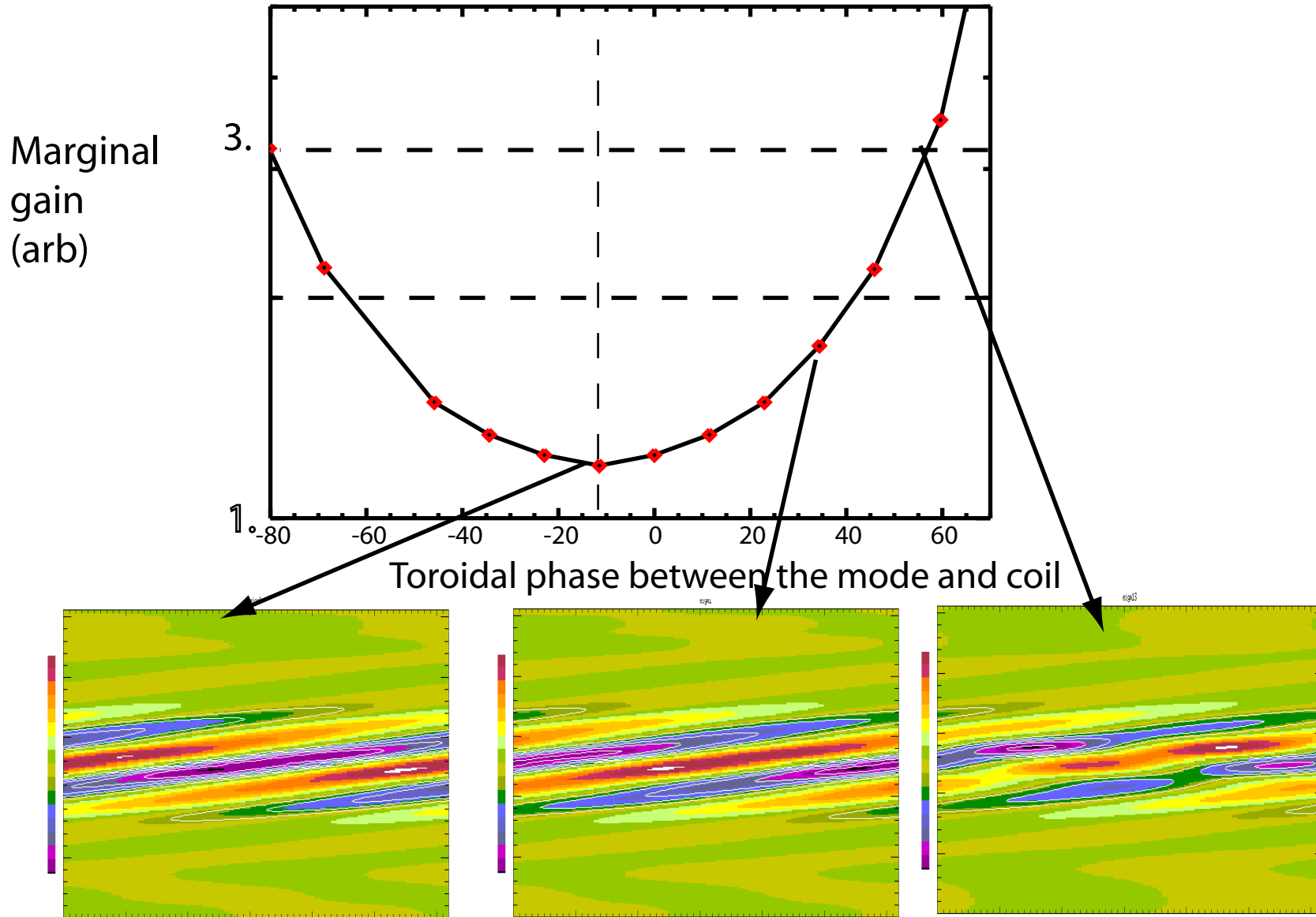   - Tearing modes
    - Edge and boundary physics

Recent results of NMA code

• During RWM feedback (to the unstable mode), the plasma surfaces deforms through the coupling of the non-aligned components of the feedback coil to the stable modes.

• The deformation can be quite substantial using a 'non-helical' mid plane coil located outside the wall (like C-coil in DIIID).
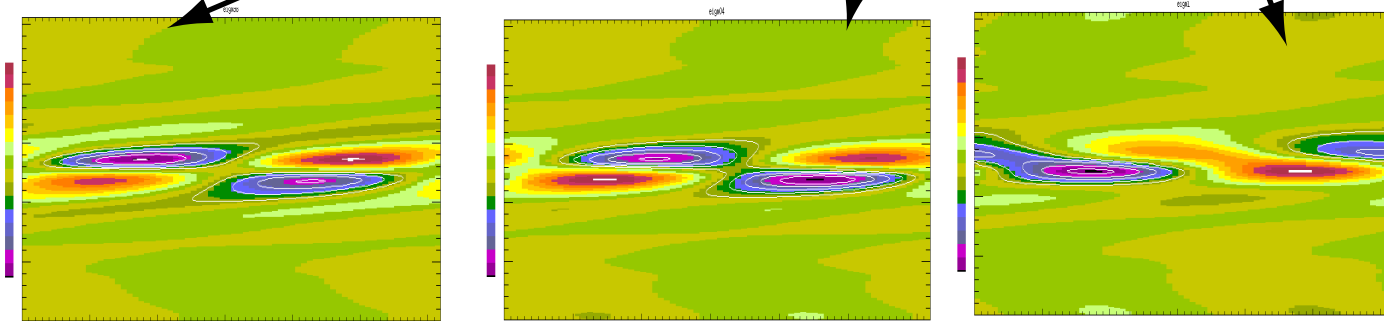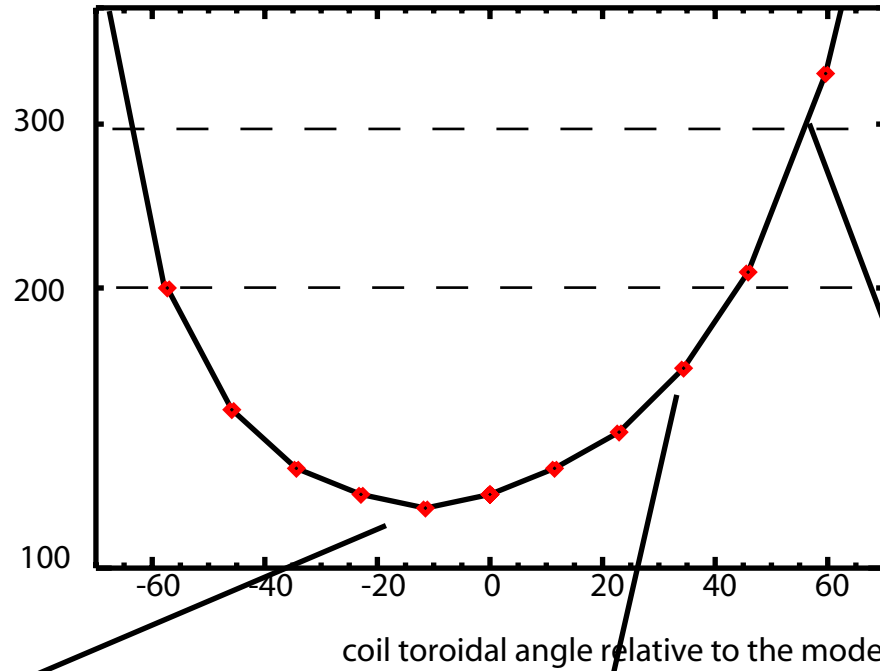
Mode distortion can be 'controlled' with the I-coil
- the toroidal phase needs to be aligned with the mode

Marginal gain (arb)

Toroidal phase between the mode and coil

sensr=1,

C-Coil: Stronger coupling with non RWM component, Significant mode distortion.

Gain at marginal vs coil toroidal angle relative to the mode

coil toroidal angle relative to the mode

Non-Axisymmetric Field coils and Tearing modes

- Feedback field with toroidal phase feedforward can be synchronized with TM

- Feedback Freely can shift the frequency and direction of TM by changing the toroidal phase

- Synchronization to TM can take place with smooth transition

Feedback Freely Can Shift the Frequency and Direction of Tearing mode by Changing the Toroidal Phase Shift
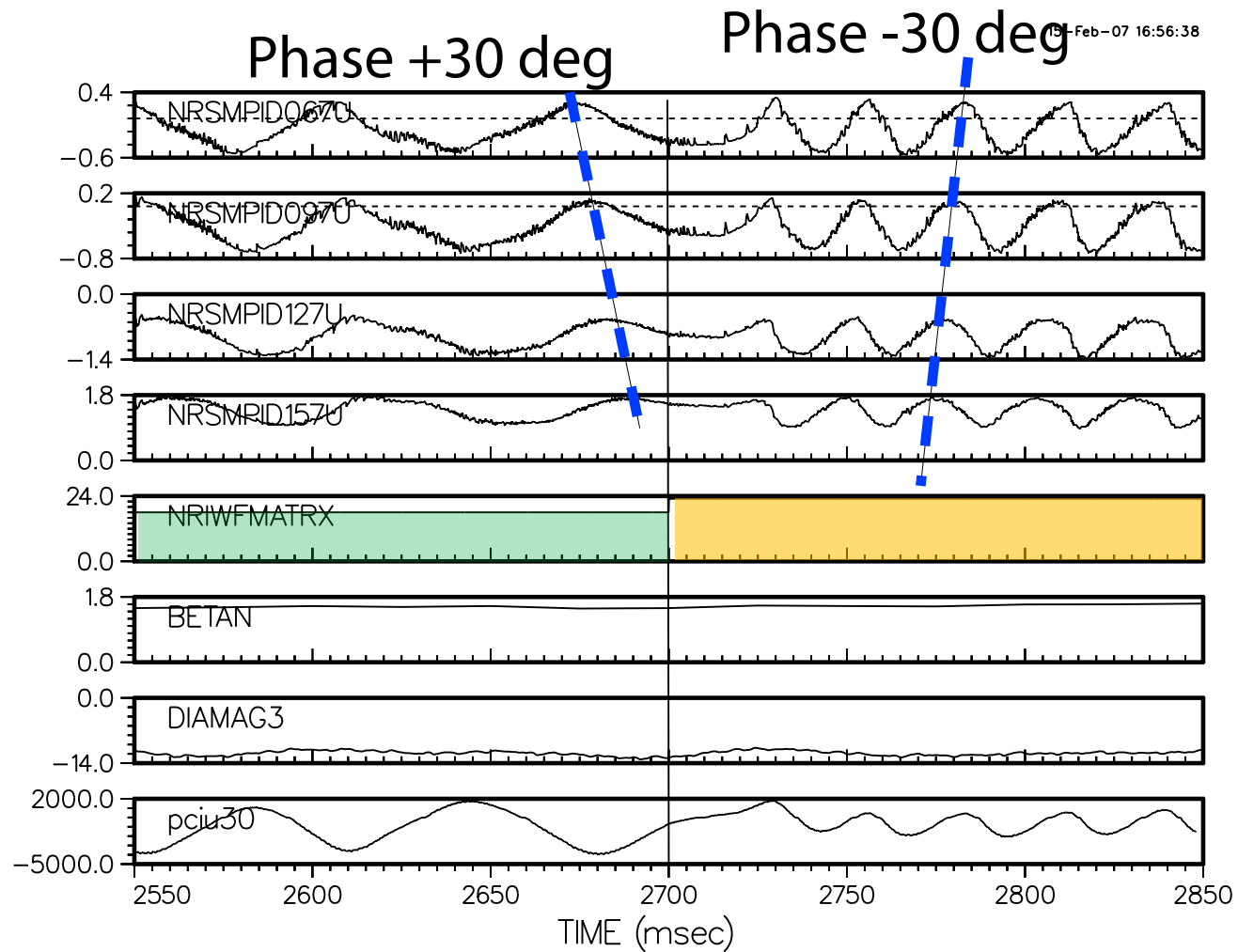
Fig. 1

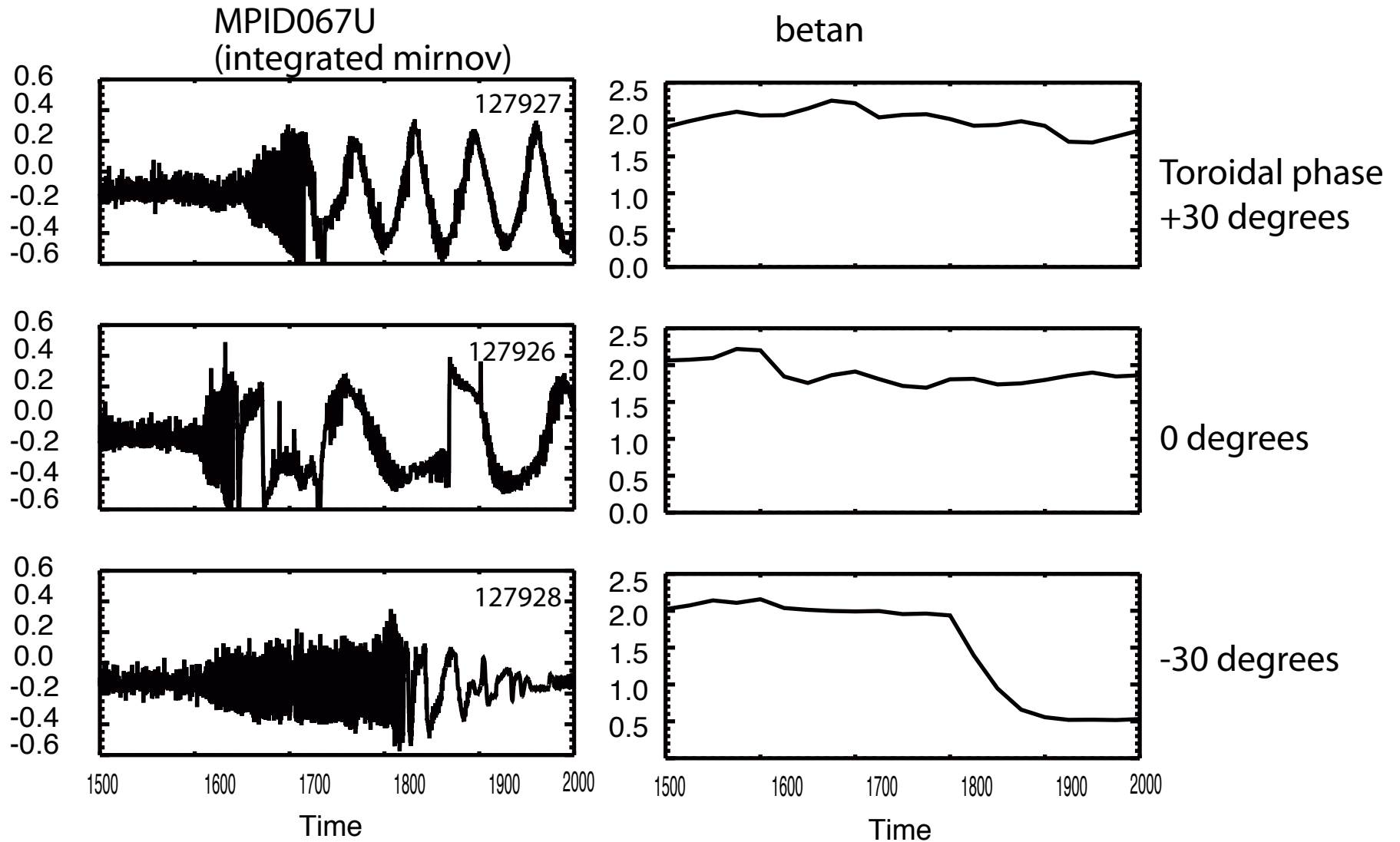# The synchronization to Tearing Mode can take place with smooth transition
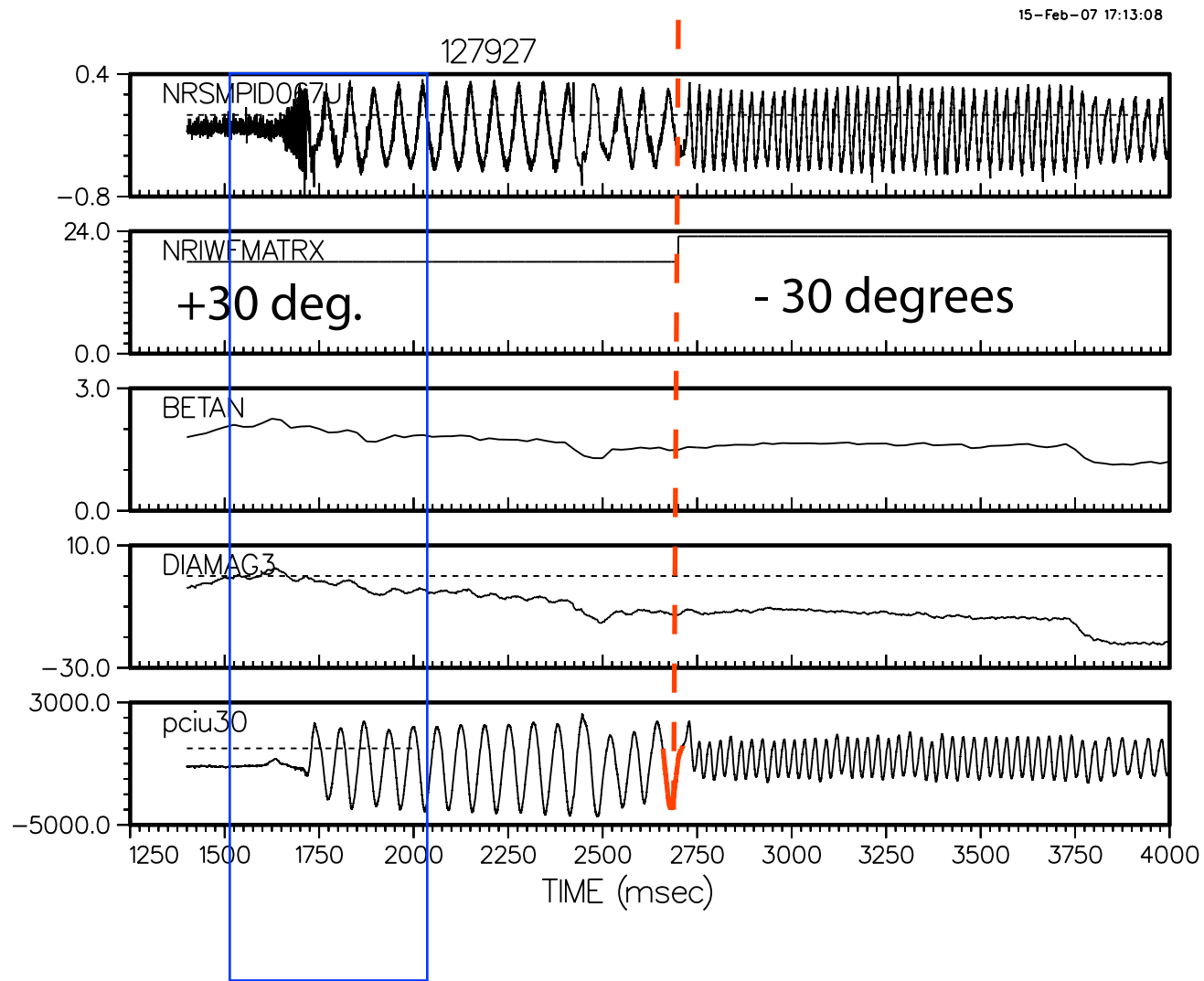
Fig. 2

Proper Adjustment of Toroidal Phase Is Required
For Smooth Synchronization converting to Slow Tearing Mode

Fig. (3)

Recommendation

- **Non-axisymmetric coil system is prerequisite for Improving Plasma Performance**

- **Internal coils with helicity (I-coils in DIIID)**

  - **N=1,2,3 RWM capability also for Locked mode**

  - **Error field correction Flexible to customize for various modes**

- **RWM, TM and ELM control**

- **Numerical and theoretical tools: Takes years to develop**