XP934: Improving $\langle\beta_N\rangle_{pulse}$ vs. rotation under RWM control and beta feedback

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v1.1

XP934: Improving $\langle\beta_N\rangle_{pulse}$ vs. rotation under RWM and beta feedback

- **Motivation**
  - Operation at high $\langle\beta_N\rangle_{pulse}$ with minimal fluctuation is highly desired
- **Goals**
  - Apply RWM and β_N feedback to improve reliability of control at various plasma rotation levels, ω_ϕ
  - Run at high levels of $\langle\beta_N\rangle_{pulse}$ with low β_N fluctuation
  - Determine limitations to steady $\langle\beta_N\rangle_{pulse}$; examine RWM triggering at different steady-state ω_ϕ
  - Characterize disruptivity vs. proximity to no-wall, with-wall limits and ω_ϕ
  - Re-optimize RWM control with reversed B_t
- **Addresses**
  - NSTX Milestone R(10-1): "Assess disruptivity/sustained high β"
  - ITPA joint experiment MDC-2

XP934: Improving $\langle\beta_N\rangle_{pulse}$ vs. rotation under RWM and beta feedback (II)

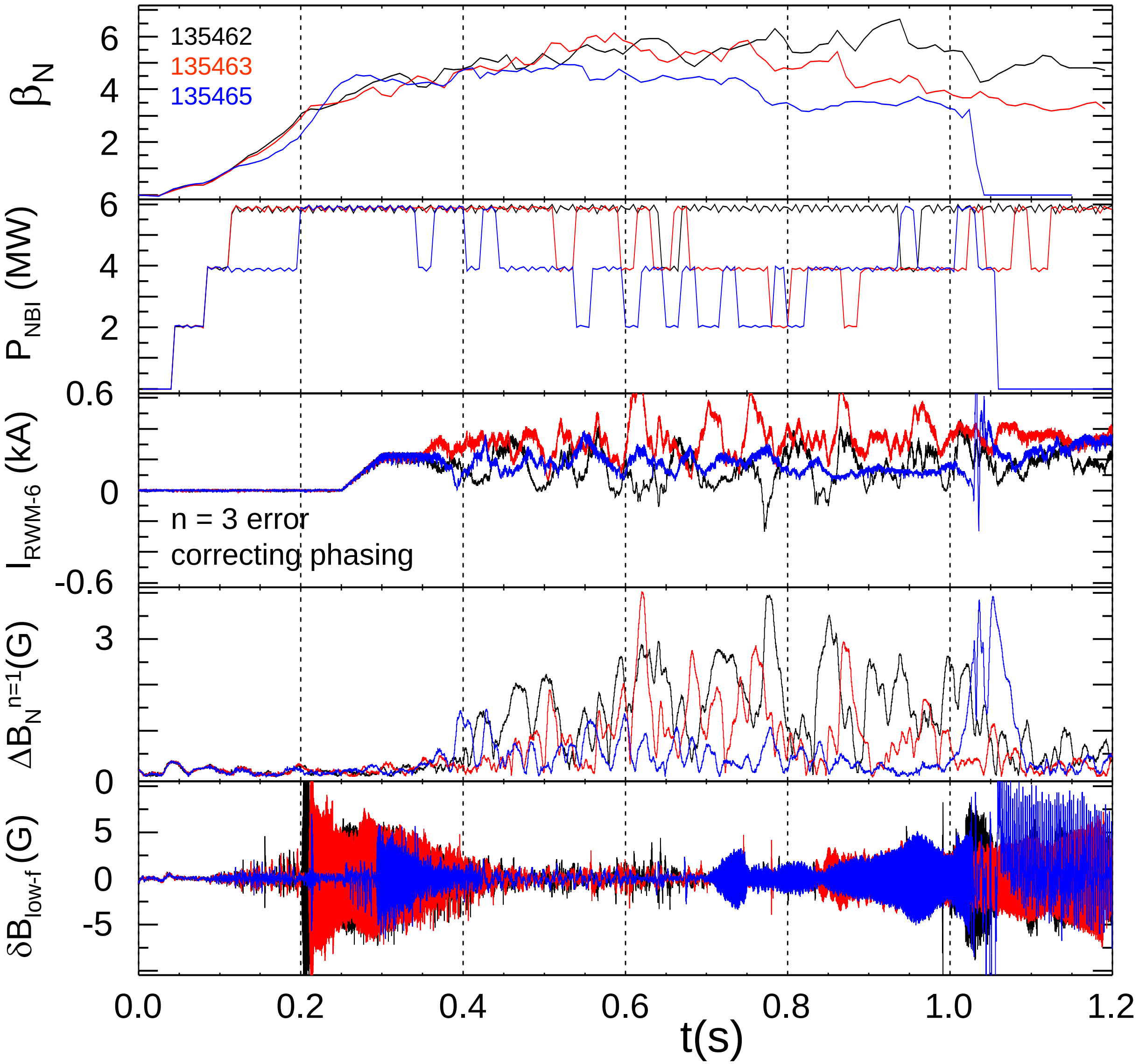
Approach

- Operate high β_N, long pulse plasmas (I_p =0.8 MA) as in XP935
- Vary steady-state ω_ϕ levels, as in XP933; now use n = 3 and n = 1 RWM control
- Set desired level(s) of β_N feedback, use to guard against confinement transients
- Vary B_p sensor feedback settings if RWM onsets at a given ω_ϕ
- At high $\langle\beta_N\rangle_{pulse}$, retake a shot several times to assess reliability
- Reverse B_t operation: establish optimal n = 1 feedback parameters

Status

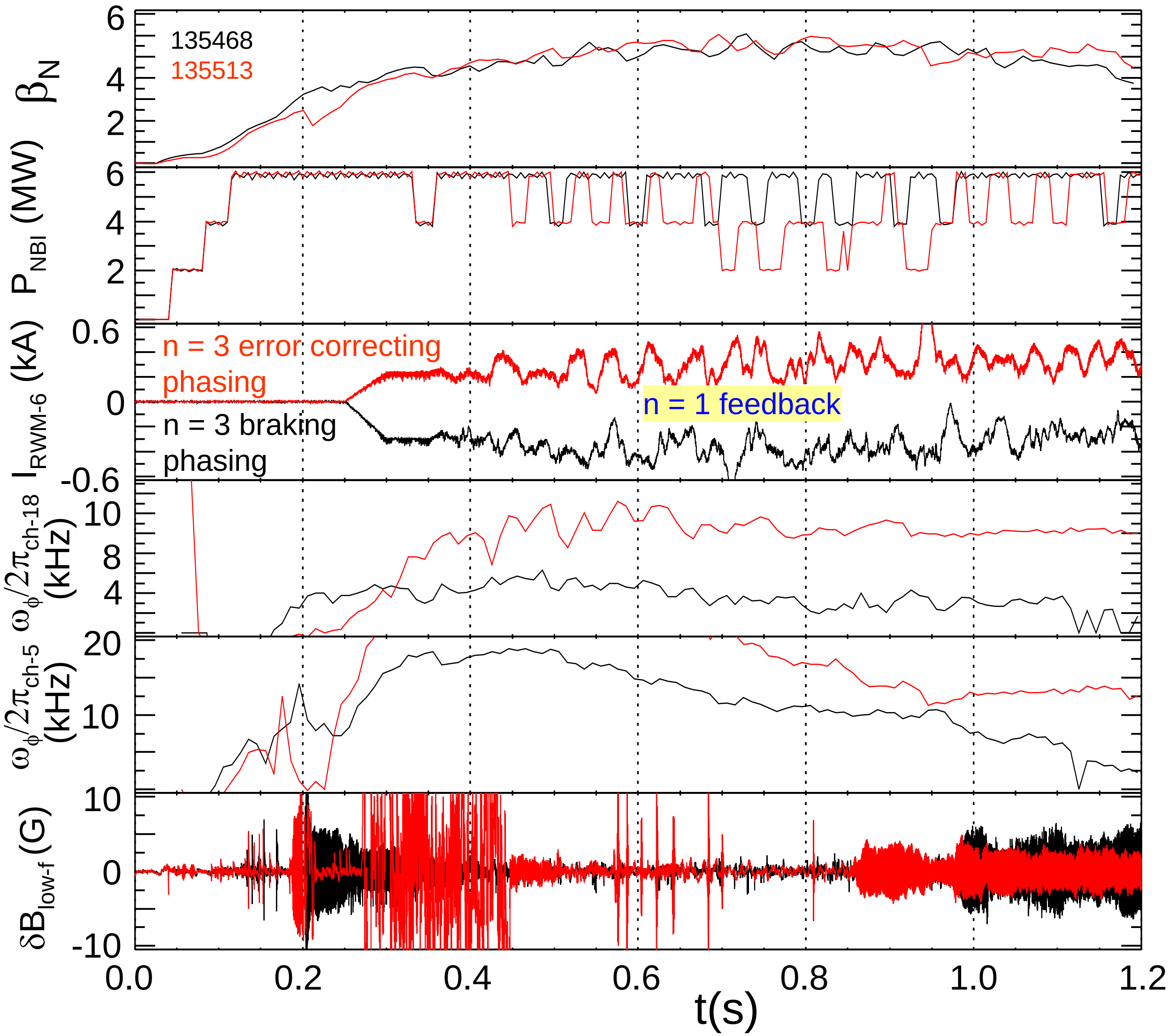
- Brief run – only 13 good shots (but good data)
- Successfully limited NBI power via β_N feedback
- Successful β_N and n = 1 RWM feedback at varied plasma rotation
- New ‘optimal’ n = 1 FB phase established in rev. B_t ; real-time determination of β_N improved with EFIT01 basis function model

Successful NBI power limitation via β_N feedback



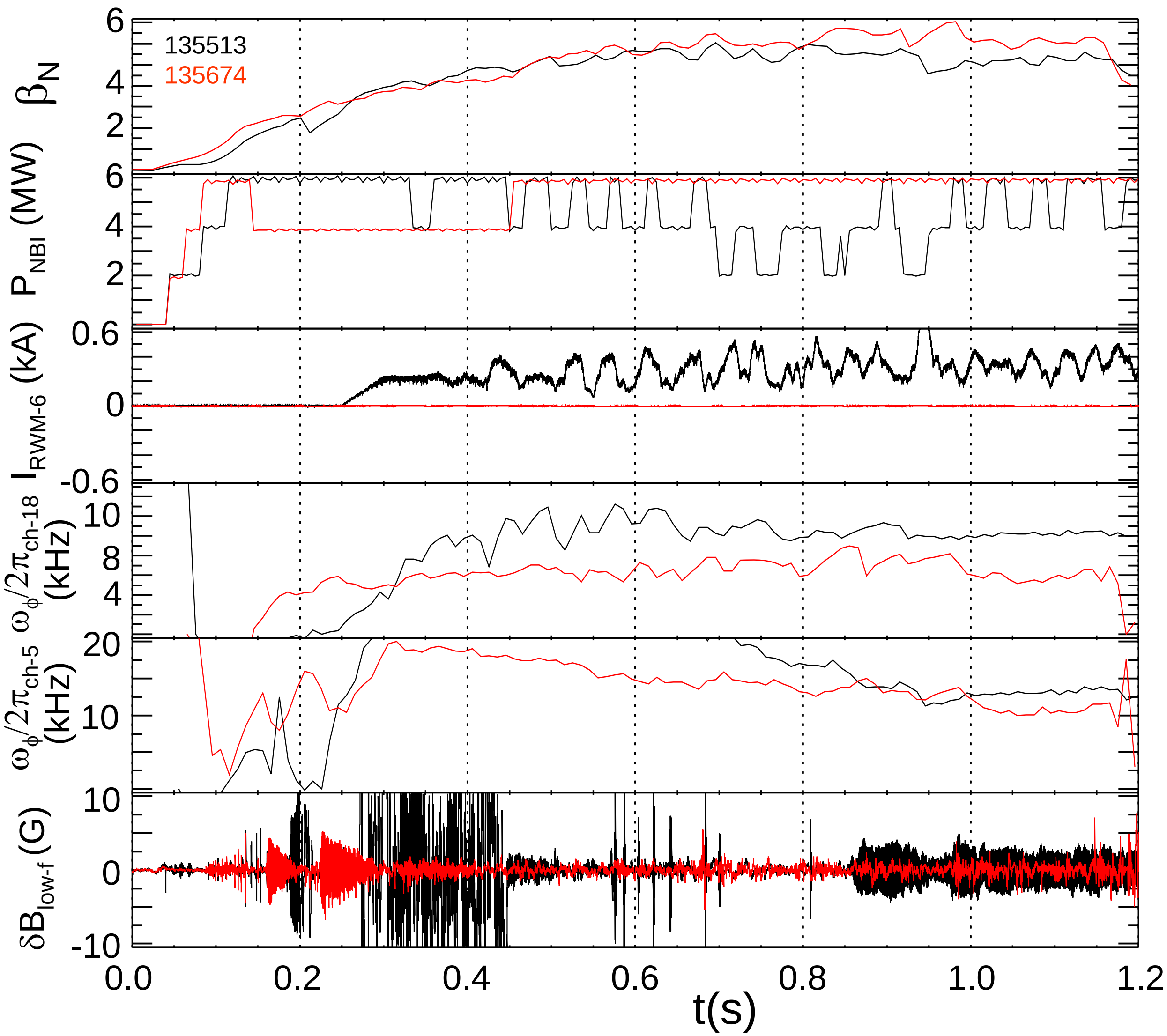
- Cases with n = 3 correcting field (highest ω_ϕ)
  - Nominal targets β_N = 4,5,6
  - NBI blocking shows FB
    - NBI power turned back on when n = 1 rotating mode appears
  - Higher activity in n = 1 LMD at highest betaN

Successful β_N feedback at varied plasma rotation levels



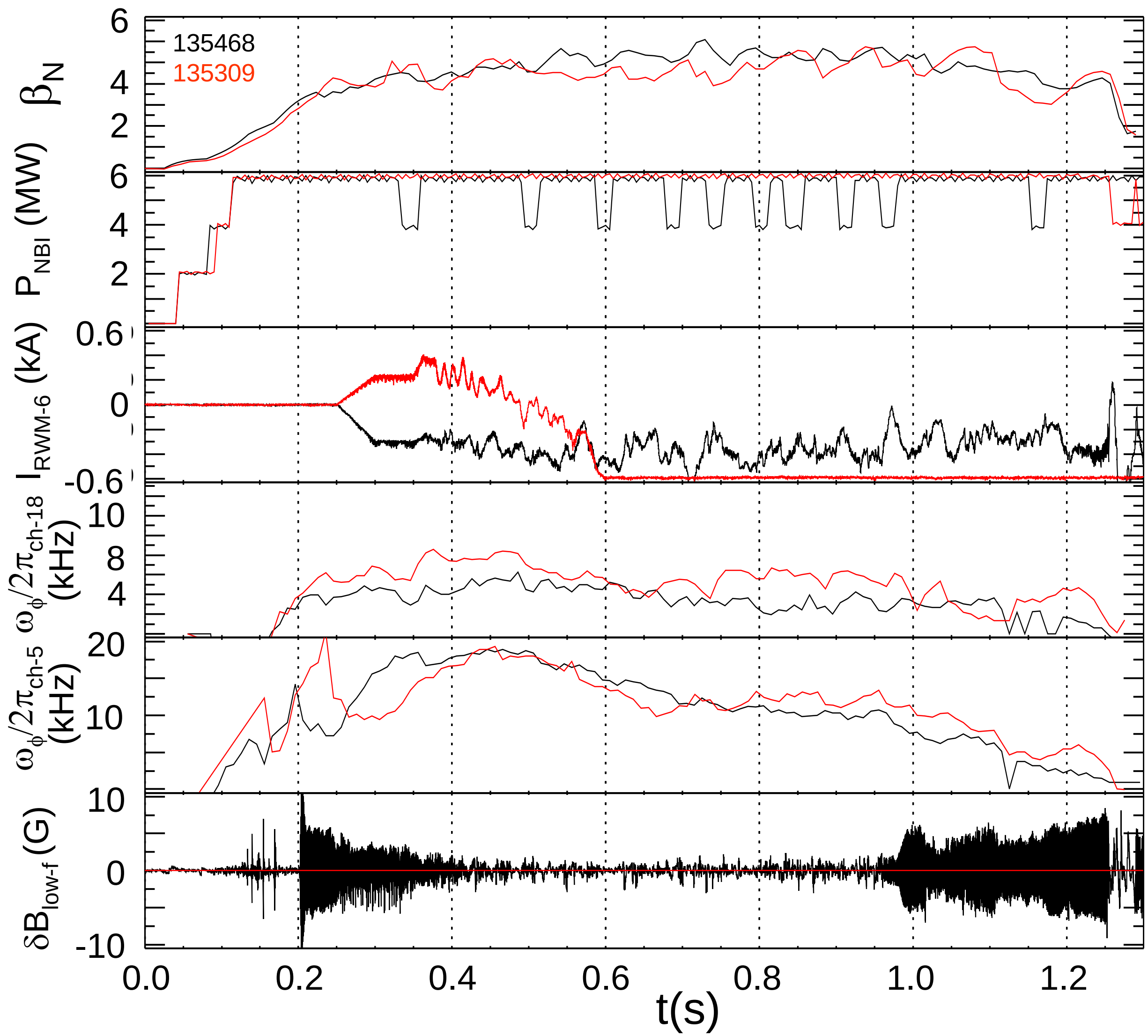
- Prelude to ω_ϕ control
  - Reduced ω_ϕ by n = 3 braking does not defeat β_N FB
  - Increased P_{NBI} needed at lower ω_ϕ
- Steady β_N established over long pulse
  - independent of ω_ϕ over a significant range

n = 1 and β_N feedback produces high β_N with low variation



- Comparison of shots with, w/o feedback
  - Steady β_N with FB
- Feedback helps protect against disruptions due to
  - confinement transients; RWM onset
- Need more shots to build reliability statistics

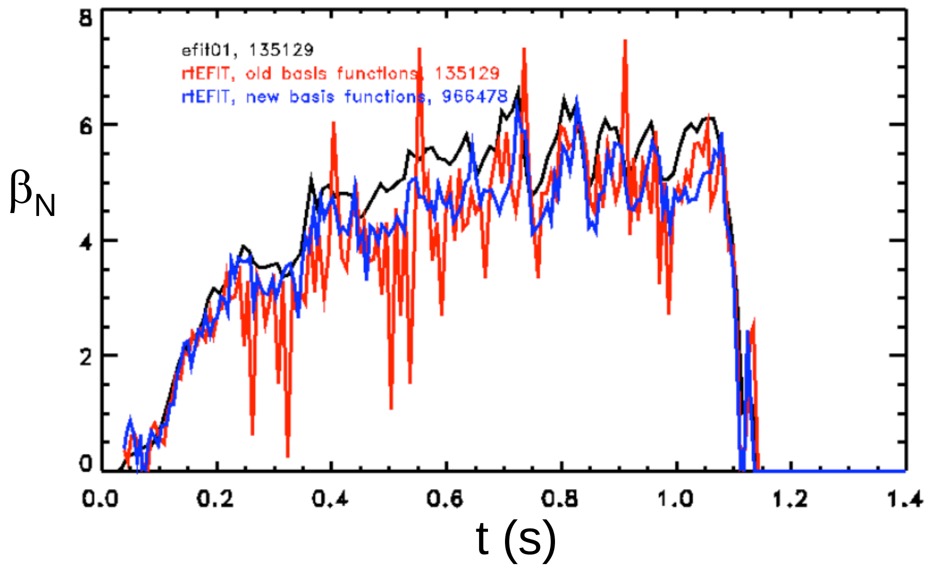
No issues with β_N feedback at reduced plasma rotation



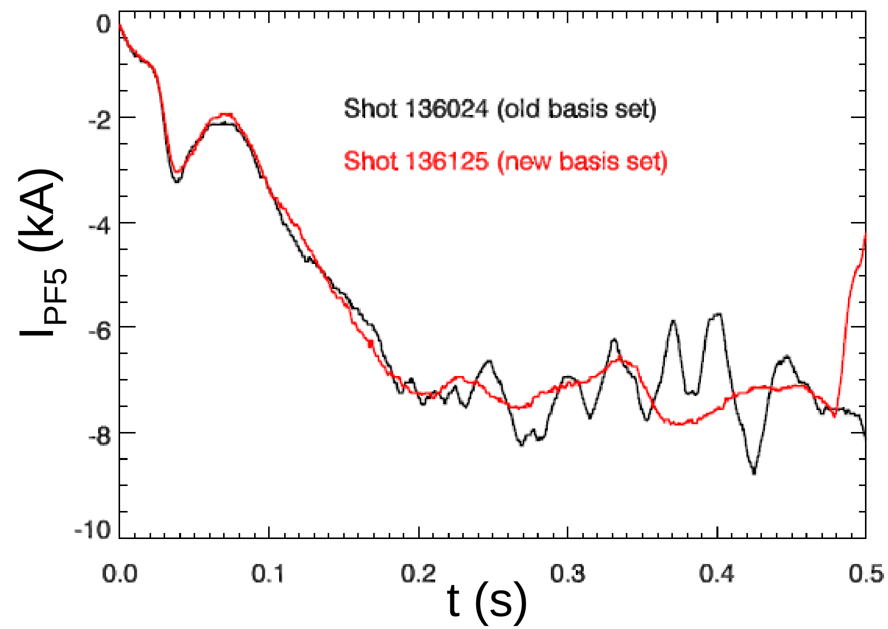
- Comparison of reduced ω_ϕ shots with, w/o feedback
- Greater β_N variation in case without feedback

rtEFIT basis function model upgraded to EFIT01 constraints

Real-time calculation of β_N less noisy



Oscillation of PF5 current reduced



- Model
  - Constraints tested on millions of converged, between-shots NSTX EFITs
  - Greater shaping possibilities for pressure ($p'(\psi) \sim \psi^2$, rather than ψ^1)
  - Finite edge current allowed through $f(\psi)$ function
- Improvements
  - Noise significantly reduced in R/T β_N calculation – will help β_N FB in 2010+
  - Issue of oscillating of PF5 current also reduced

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- Analyze $\langle\beta_N\rangle_{pulse}$ and β_N variations statistics for existing feedback shots
- Compare to shots w/o feedback
- Understand mode activity that leads to β_N variations to produce more constant β_N
- Dedicated shots in 2010 to build reliability statistics
  - an issue due to NBI source risk?
- Additional data with RWM onset during n = 1 and β_N FB yet to be analyzed