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Non-axisymmetric Control Coil Upgrade and related ideas

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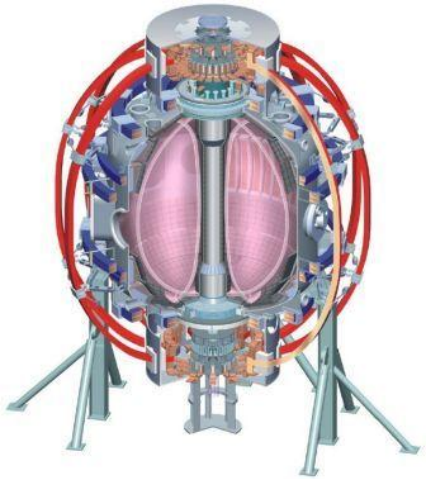
PPPL



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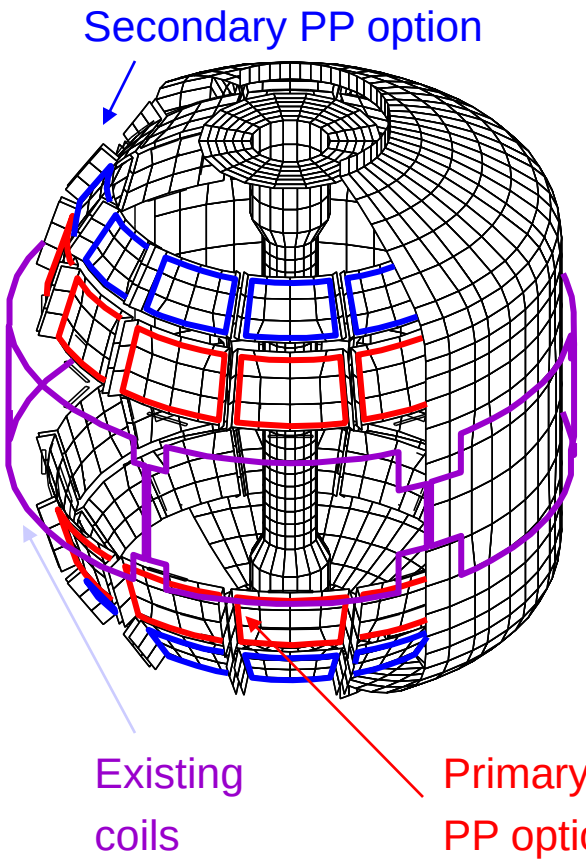
V1.0

Proposal and Motivation for Non-axisymmetric Control Coil (NCC) goes back many years – research still needed

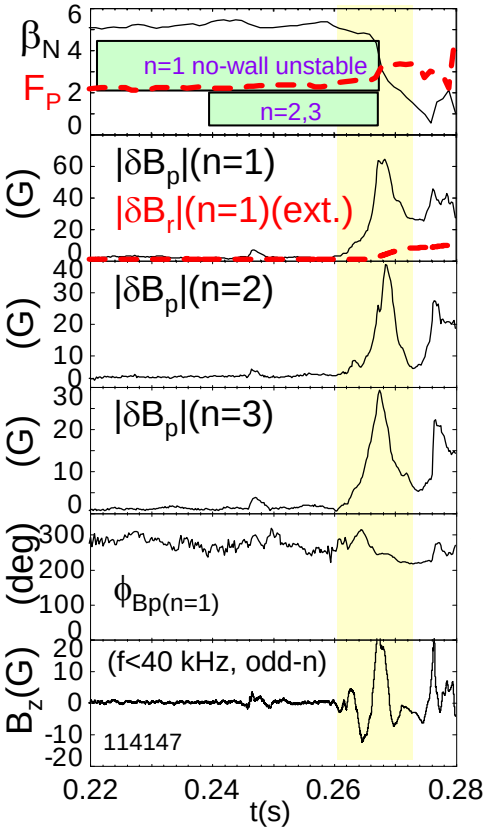
- Capabilities
  - 2nd NBI ✓
    - q profile variation
    - momentum source variation
  - Non-axisymmetric control coil (NCC) – at least four applications
    - RWM stabilization ($n > 1$, higher β_N)
    - DEFC with greater field correction capability
    - ELM mitigation ($n = 6$)
    - V_ϕ control increase; $n > 1$ propagation)
  - Non-magnetic RWM sensors; advanced RWM active feedback control algorithms (ITER, etc.)
  - Possible alteration of stabilizing plate materials / electrical connections

Proposed Internal Non-axisymmetric Control Coil (NCC)

(12 coils toroidally)



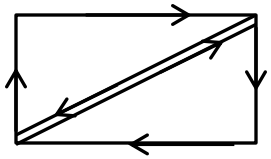
RWM with $n > 1$ RWM observed



(Sabbagh, et al., Nucl. Fusion 46, 635 (2006).)

NCC upgrade can investigate several key physics issues, some new ideas based on new capabilities/understanding

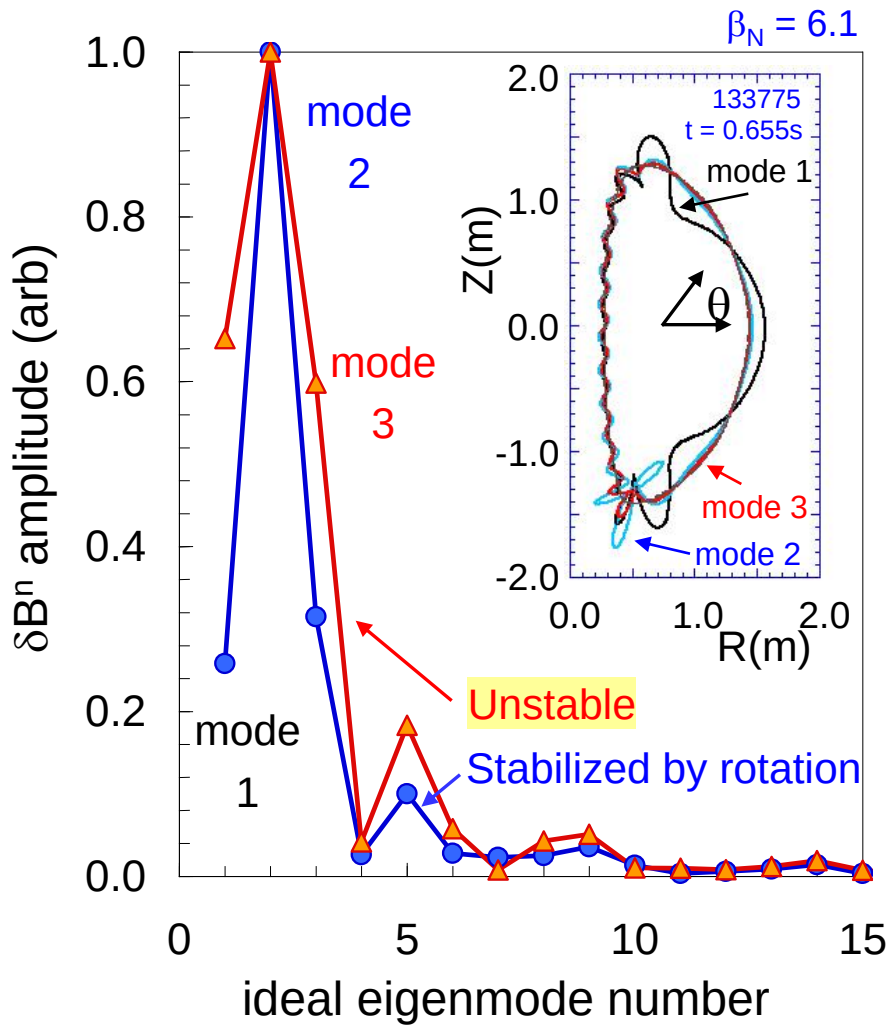
- NCC physics
  - Performance analysis performed for both RWM stability (Columbia) and ELM mitigation (GA - Evans) – now need to redo for NSTX-U (including recent physics understanding)
  - Several configurations considered:
    - Coils internal to vessel, coils external to vessel (i.e. "distant" coils)
    - Coils in front of primary/secondary passive plates, or among plates with altered plate material for some of the plates (e.g. SS)
  - Possible inclusion of diagonal elements for "stellarator" field



- NCC in light of present day ideas / capabilities
  - Internal "hairpin" coils (similar to KSTAR IVCC design) may ease implementation, give greater flexibility for physics studies
  - New RWM state-space controller allows far greater flexibility of global mode stabilization physics studies with these coils, with a relatively simple control software upgrade
  - New option of coils closer to divertor for control of "divertor" mode (multi-mode physics)
  - New consideration: field spectrum to produce favorable V_ϕ profile by NTV and NBI for kinetic global mode stability (MISK physics)
  - Examine best NCC field spectrum to potentially change edge fast ion profile for RWM and edge mode stability alteration (MISK physics)
  - Addition of "delta coils": strategically located dipole fields to enhance field spectrum for ELM mitigation, and possibly for time-dependent pulsed fields for ELM studies (T. Evans)

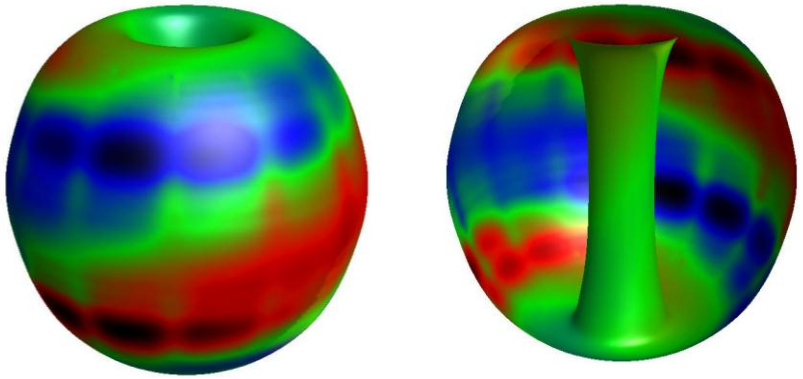
Multi-mode RWM computation shows 2nd eigenmode component has dominant amplitude at high β_N in NSTX stabilizing structure

δB^n RWM multi-mode composition



mmVALEN code

δB^n from wall, multi-mode response



- NSTX RWM not stabilized by ω_ϕ
  - Computed growth time consistent with experiment
  - 2nd eigenmode ("divertor") has larger amplitude than ballooning eigenmode
- NSTX RWM stabilized by ω_ϕ
  - Ballooning eigenmode amplitude decreases relative to "divertor" mode
  - Computed RWM rotation ~ 41 Hz, close to experimental value ~ 30 Hz
- ITER scenario IV multi-mode spectrum
  - Significant spectrum for n = 1 and 2

BP9.00059 J. Bialek, et al.; see poster for detail