# **MDC-19 Error field control at low plasma rotation**

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| **TG priority:** High | **Start date:** 2014 | **Status:**  On-going | **Personnel exchange:**  TBD |
| **IO priority:**   | **End date:**  N/A | **Motivation:** Physics basis of error field control  |

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| **Device /****Association** | **Contact****Person** | **2016 TGRequest** | **Activity (from JEX/JA spreadsheet)** |
| **2014** | **2015** | **2016** | **2017** | **2018** |
| DIII-D  | M. LanctotC. Paz-Soldan | Desirable | Considering | Considering |   |   |   |
| AUG  | M. Maraschek | Desirable | Committed | Committed |   |   |   |
| RFX-Mod  | P. Piovesan | Desirable |   | Considering |   |   |   |
| MAST-U  | L. Piron | Desirable | Analysis |   |   |   |   |
| EAST  | Y. Sun | Desirable |   | Committed |   |   |   |
| KSTAR  | B. Park | Desirable | Committed |   |   |   |   |
| NSTX-U | J. K. Park | Desirable |   |   |   |   |   |
| theory | N. Logan/Park | Desirable |   |   |   |   |   |
| theory | Y. Q. Liu | Desirable |   |   |   |   |   |
| theory  | N. Ferraro | Desirable |   |   |   |   |   |

**This template is based on the 2014 report.**

**Purpose**:

* Quantify limitations of error field correction –  Quantify the role of rotation braking (e.g. NTV)
* Establish the importance of n>1 error fields – Develop low-rotation error field control strategies

**Results for 2014**

* Rotation braking from n=2 proxy error fields cannot be eliminated by minimizing the drive for the dominant n=2 plasma mode, suggesting that n>1 control requires additional degrees of freedom.
* Rotation braking measurements from n=2 fields in KSTAR show that poloidal harmonics with m>nq drive an edge-localized torque, while harmonics with m<nq reduce rotation across the entire profile.
* In RFX-mod tokamak discharges, greater shaping coil currents in diverted scenarios are correlated with enhanced error field signatures, including an increase in the low q95 threshold for disruptions to 2.5.
* In KSTAR, n=1 error field threshold measurements confirm the low intrinsic error field levels found in 2013. Analysis of very recent n=1 RMP ELM experiments is ongoing to verify these results.
* A new set of 2x8 RMP coils is commissioned in EAST. Optimizations in low q95 plasmas indicate a low n=1 intrinsic error field, confirmed by low density operation limited only by the runaway electron limit.
* DIII-D experiments demonstrate low-torque ITER baseline scenarios with the Test Blanket Module (TBM) mock-up coil are highly susceptible to rotation collapse and disruption, but stability and plasma performance can be recovered using only *n*=1 compensation fields generated by ex-vessel control coils.

**Plans for 2015**

* DIII-D: Analysis of recent TBM experiments will continue in order to validate single-mode paradigm for the multi-harmonic TBM error field. Experimental proposals are under development for 2015.
* RFX-mod: Experiments are planned in November to measure and correct EFs in single-null diverted discharges, and complete initial proxy error field experiments using n=1 fields.
* MAST: Empirically optimized n=2 correction currents will be compared to predictions of optimal currents using vacuum error field source model and MARS-Q.
* EAST: Proposals are foreseen for further n=1 EF studies at lower q95 to increase plasma sensitivity to intrinsic error field and to measure n>1 braking in ohmic and H-mode plasmas.
* KSTAR: Extensive data set of n=1 error field measurements will be analyzed to assess level of intrinsic error field in KSTAR. Proposals have been submitted for n=1 proxy error field experiments and will likely be pursued following upgrade to 3D coil power supplies in 2015.
* NSTX-U : Investigation of n=1-3 intrinsic error fields at the start of NSTX-U operation. The n=1 and n=3 errors are expected from the same PF5 non-circularity, but also possibly from new OH-TF centerstack.
* IPEC-PENT : Report of locking threshold database collected for 2004-2011 NSTX, DIII-D, CMOD, JET, KSTAR and using IPEC dominant mode analysis, with PENT analysis of non-resonant field effects where data allows. PENT is being extended for kinetic MHD effects in error field optimizations at high beta.
* Assessment of error field metrics with MARS-Q will continue using proxy n=1 error field measurements from DIII-D. Benchmarking against IPEC predictions will be completed.

**Background:** To date, development of error field control has generally considered only n=1 error fields, and correction with a coil set having a fixed poloidal spectrum. This approach is consistent with the “single-mode model” of error field control, i.e. that one needs to consider only the least stable plasma mode and the components of the error field and correction field that couple to that mode.

A new joint experiment is proposed to test the applicability of that model, including the possible roles of secondary stable modes and of rotation braking by non-resonant fields. The emphasis is on error field control at low rotation, where these secondary effects may become more important.

This joint experiment takes account of the facts that

* A growing number of tokamaks have non-axisymmetric coils for error field control, many with the capability to vary the poloidal and toroidal spectra
* ITER will have three rows of error field correction coils, plus the option of error field control using the ELM coils, affording great spectral flexibility

Working group WG-9 “Criteria for Error Field Correction for ITER” has addressed some of these issues for n=1, using existing data, and will be extended to n=2. The final report of WG-9 is expected in 2014. This new joint experiment is intended to coordinate joint experiments over a longer period of time.