



UNIVERSITÀ DEGLI STUDI DI NAPOLI
FEDERICO II

itee^{PhD}
information technology
electrical engineering



Federico Fiorenza

Magnetic control and reconstruction in fusion devices

Tutor: prof. Gianmaria De Tommasi

Cycle: 38

Year: 2023/2024

Candidate's information

- MSc degree: Automation and Robotics Engineering
- DIETI Research group/laboratory: Plasma control group/CREATE
- PhD start date – end date: 01/01/2023 – 31/12/2025
- PNRR-NEFERTARI
- Participation to JT-60SA IC, Naka, Japan (28/10/2023-3/12/2023)
- Fusion For Energy, Barcellona, Spain (3/11/2024-14/12/2024)

Summary of study activities

- Attended course “Innovation and Entrepreneurship”
- Japan International Fusion School 2024
- Symposium on Fusion Technology 2024
- Control and Decision Conference 2024
- JT-60SA IC Analysis and Modeling workshop

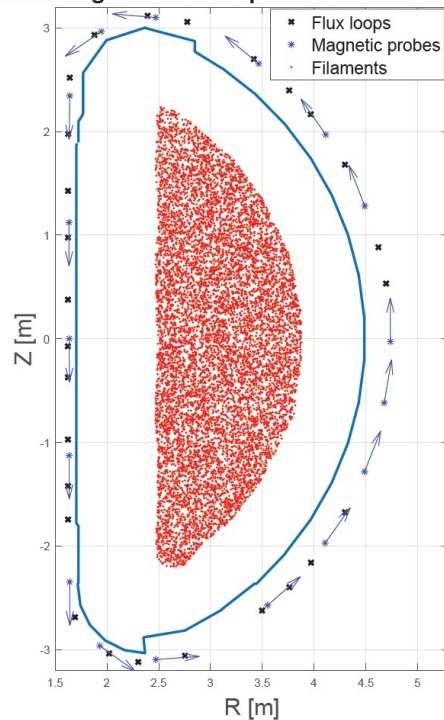
Research area(s)

- High-performance actuator sharing techniques for magnetic control in fusion devices
- Real-time algorithms for plasma shape, position and current reconstruction
- RFX-mod2 electromagnetic modeling
- Current State Opacity assessment in Petri Nets
- Finite Time Stability in non-linear systems
- Demodulation techniques in plasma diagnostics applications

Magnetic reconstruction algorithms

- Thanks to successful JT-60SA Integrated Commissioning and first Operation, ITER magnetic reconstruction algorithms can be tested and refined using real experimental data
- They are based on the solution of a QP optimization problems

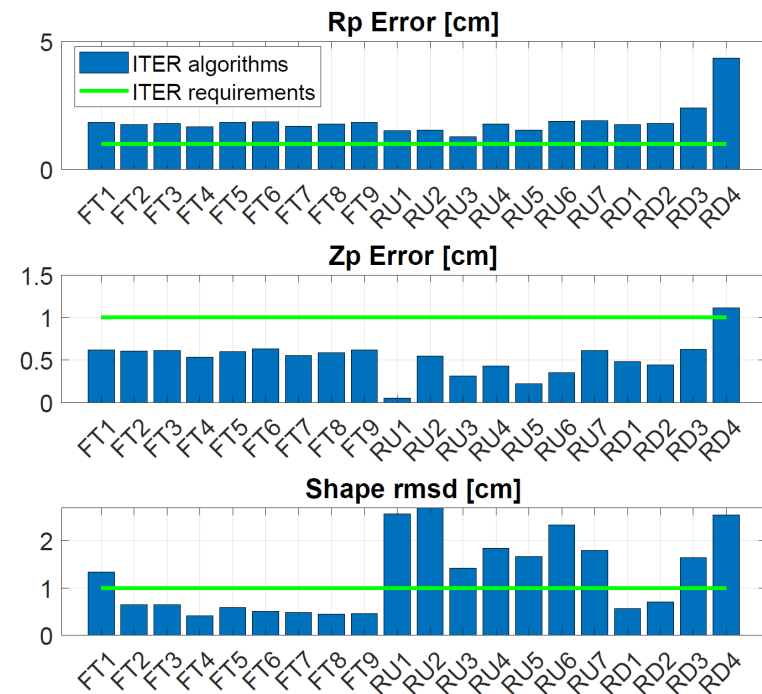
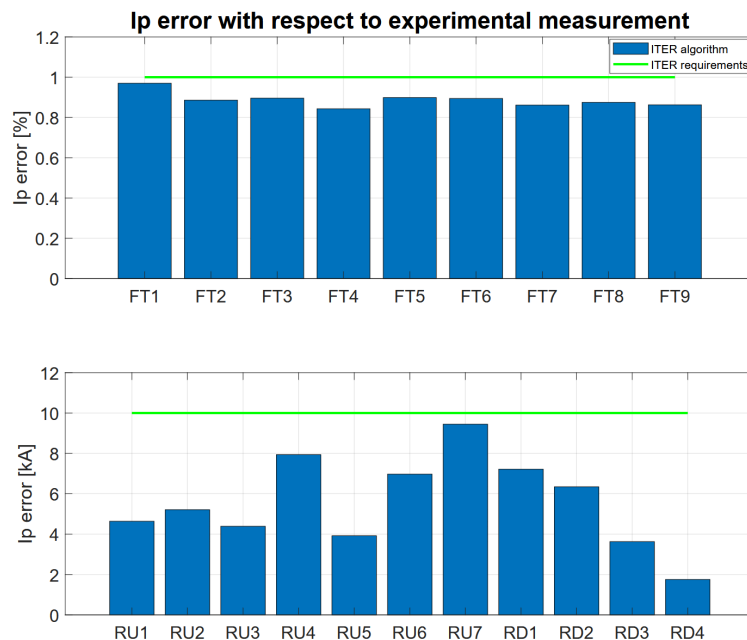
Magnetic diagnostics set-up and filaments distribution



- The JT-60SA IC magnetic diagnostics set-up did not include normal field sensors, which are essential to estimate the current centroid position and shape...

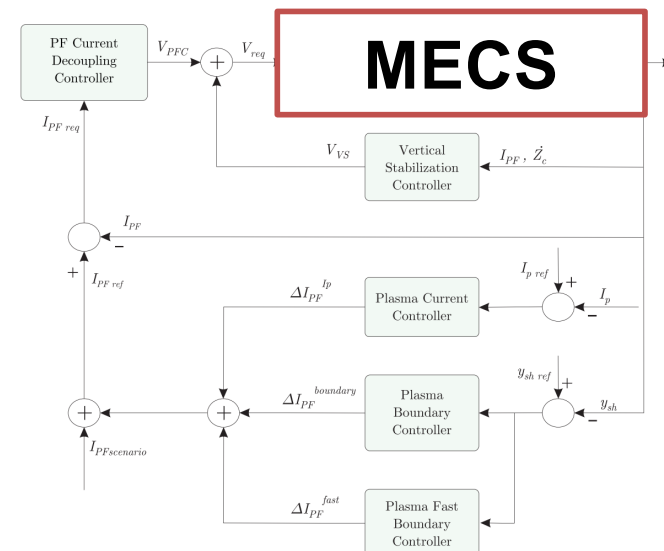
Magnetic reconstruction algorithms

- ... on the other hand for plasma current estimation they are not needed
- Current centroid position and shape reconstruction algorithms do not meet ITER requirements, while plasma current reconstruction does



Controller interface with plasma simulator

- A new magnetic control structure has been proposed in [P5] and applied to the test case of JT-60SA IC set-up.
- An activity aiming at interfacing the proposed controllers with the MECS simulator is currently ongoing
- This is needed to design an interface between MECS and other controllers since it will be the final testbench for any controller before being deployed on the real machine



Research products

[P1]	F. Fiorenza , G. De Tommasi, D. Frattolillo, C. Ingesson, S. Inoue, S. Kojima, M. Mattei, Y. Miyata, A. Neto, A. Mele, A. Pironti, O. Sauter, M. Takechi, H. Urano, “Preliminary validation of ITER magnetic diagnostic algorithms by using JT-60SA magnetic measurements,” <i>Fusion Engineering and Design</i> , submitted.
[P2]	S. Dubbioso, D. Ottaviano, F. Fiorenza , G. De Tommasi, N. Ferron, G. Manduchi, E. Acampora, R. Ambrosino, “Rapid prototyping of control modules for the DTT Plasma Control System,” <i>Fusion Engineering and Design</i> , submitted.
[P3]	F. Basile, G. De Tommasi, S. Dubbioso, F. Fiorenza , “On current-state opacity in bounded labeled Petri net systems,” <i>Transactions On Automatic Control</i> , submitted.
[P4]	T. Szepesi, A. Buzás, G. Cseh, G. Kocsis, Á. Kovácsik, D. Réfy, T. Szabolics, H. Homma, K. Kamiya, T. Nakano, M. Yoshida, W. Bin, G. De Tommasi, F. Fiorenza , D. Frattolillo, M. Iafrati, M. Mattei, A. Pironti, D. Ricci, C. Sozzi, J. Svoboda, J. Cavalier, “Analysis of the first plasmas of JT-60SA using the EDICAM visible video diagnostic”, <i>Nuclear Fusion</i> , submitted.
[P5]	G. De Tommasi, L. E. di Grazia, S. Dubbioso, F. Fiorenza , D. Frattolillo, S. Inoue, M. Mattei, A. Pironti and H. Urano, “Control of elongated plasmas in superconductive tokamaks in the absence of in-vessel coils,” <i>Nuclear Fusion</i> , vol. 64, no. 7, pp. 076005, July 2022, (Scopus/ISI Web of Science).

Research products

[P6]	<i>F. Basile, G. De Tommasi, S. Dubbioso, F. Fiorenza, “An Optimization Approach to Current State Opacity Assessment,” in 63rd IEEE Conference on Decision and Control (CDC'24), Milano, Italy, December 2024 (Scopus/ISI Web of Science)</i>
[P7]	<i>F. Fiorenza, G. De Tommasi, D. Frattolillo, C. Ingesson, S. Inoue, M. Mattei, Y. Miyata, A. Neto, A. Pironti, M. Takechi, H. Urano, “Validation ITER magnetic diagnostic algorithms using JT60SA magnetic measurements,” in 33rd Symposium on Fusion Technology (SOFT'24), Dublin, Ireland, September 2024.</i>
[P8]	<i>S. Dubbioso, D. Ottaviano, F. Fiorenza, N. Ferron, G. Manduchi, R. Ambrosino, G. De Tommasi, “Rapid prototyping of control modules for the DTT Plasma Control System,” in 33rd Symposium on Fusion Technology (SOFT'24), Dublin, Ireland, September 2024.</i>
[P9]	<i>T. Szepesi, A. Buzás, G. Cseh, G. Kocsis, Á. Kovácsik, D. I. Réfy, T. Szabolics, S. Zoletnik, H. Homma, K. Kamiya, T. Nakano, M. Yoshida, T. Wakatsuki, C. Biedermann, D. Hathiramani, M. Jakubowski, M. Krause, M. Otte, W. Bin, G. De Tommasi, F. Fiorenza, D. Frattolillo, M. Iafrati, M. Mattei, A. Pironti, D. Ricci, C. Sozzi, J. Svoboda, “Visible video diagnostics for the support of Wendelstein 7-X and JT-60SA commissioning and operation,” in 33rd Symposium on Fusion Technology (SOFT'24), Dublin, Ireland, September 2024.</i>

Research products

[P10]	<i>T. Szepesi, A. Buzás, G. Cseh, G. Kocsis, Á. Kovácsik, T. Szabolics, D. I. Réfy, H. Homma, K. Kamiya, T. Nakano, M. Yoshida, W. Bin, G. De Tommasi, F. Fiorenza, D. Frattolillo, M. Iafrati, M. Mattei, A. Pironti, D. Ricci, C. Sozzi, J. Svoboda, "Analysis of the first plasmas of JT-60SA using EDICAM," in 50th EPS Conference on Plasma Physics, Salamanca, Spain, July 2024.</i>
[P11]	<i>C. Sozzi, G. De Tommasi, M. Iafrati, W. Bin, A. Buzás, L. Cordaro, L. E. DiGrazia, F. Fiorenza, D. Frattolillo, A. Gallo, L. Garzotti, G. Golluccio, G. Kocsis, Á. Kovácsik, L. Le Coz, P. J. Moreau, M. Mattei, L. Pigatto, A. Pironti, G. Pucella, D. I. Réfy, D. Ricci1, N. Richermoz, J. Svoboda, T. Szabolics, T. Szepesi, E. Tomasina, Y. Kazakov, L. Zani, G. Falchetto, F. Bonne, T. Bolzonella, J. Buermans, J. Cavalier, G. Cseh, S. Gerasimov, Q. Gorit, L. Figini, S. Nicollet, F. Villone, "The EUROfusion contribution to Operation 1 of JT-60SA," in 50th EPS Conference on Plasma Physics, Salamanca, Spain, July 2024.</i>

Next year

- Develop the interface between MECS and CREATE controllers
- Development and validation of RFX-mod2 magnetic control system
- Real-time implementation of advanced IQ demodulation techniques for the bolometer diagnostics