RESEARCH PROJECTS

Contact person	Project title	SHORT DESCRIPTION
gianluigi.seriannni@igi.cnr.it	Beam physics via tomographic diagnostics and numerical simulations	The proposed work regards the study of negative ion beam physics by PIC simulations supported by experimental measurements. The numerical code already employed in NIO1 will be developed and extended for application to SPIDER. As for diagnostics activities in NIO1, Langmuir probes, beam emission spectroscopy and beam tomography data can be used; in SPIDER the beam tomographic system will be commissioned and tested and the inversion algorithms will be finalised; together with beam emission spectroscopy and the Langmuir probes embedded in STRIKE the experimental characterisation of the beam will be performed.
diego.marcuzzi@igi.cnr.it	Thermo-structural verifications of the in-vessel mechanical components of the ITER-relevant neutral beam injectors for off-normal conditions.	The Neutral Beam Test Facility is being established at Consorzio RFX in order to test the Neutral Beam injectors for the ITER nuclear fusion experiment. Two devices are foreseen: SPIDER is devoted to the testing of the ion source and the experimental campaign has recently started, while the one-to-one prototype of the ITER heating neutral beam, MITICA, is mostly under procurement. The design for all mechanical components was completed and thoroughly verified for the reference conditions at full target performances. After the start of experiments, for both devices performances are expected to grow over quite a long time towards the goal, passing through intermediate scenarios and off-normal conditions featuring non ideal distribution of accelerated particles, hence heat loads and deformation/stress distribution inside the main components, in particular the beam source in both systems and the corresponding beam line components downstream. The work to be undertaken shall include proper verifications able to predict significant/probable cases and to check the behavior experimentally measured. Major attention shall be focused on the verification of the thermo-mechanical behavior and in particular the beam optics versus the components thermal deformation/alignment. Possible benchmark with other existing experiments can be exploited.
elena.gaio@igi.cnr.it	Studies for improving the RFX-mod2 power supply system	This PhD proposal deals with studies and experimental activities for improving the performance of the RFX-mod power supply system in line with the machine upgrade presently under detailed design phase and also in view of possible future enhancements of the RFX-mod2 performance. One of the main aims of the machine modifications in progress is addressed at improving the MHD active control capabilities in RFP and Tokamak configuration. The Power Supply (PS) system should be also revised accordingly, to take the maximum advantage from the new machine configuration. In particular, part of the PhD work will be devoted to analyze and realize possible improvements of the toroidal PS to contribute to a better control of m=0 modes and to achieve a more efficient Pulsed Poloidal Current Drive. Another activity line will be directed to improve the efficiency of the cleaning treatments of the first wall, in absence of the vacuum vessel, by using the Pulse Discharge Cleaning system. This plant, originally implemented for the first RFX to produce plasma pulses with current of 50 kA, some ms long

		and with a repetition rate of 0.2-0.5Hz, and only partially restored in 2002, needs to be completely revamped, starting with the analysis of its operation with the new machine assembly, the design revision, in particular as far as the control system is concerned, up to the assembly of the whole system and testing phases. With reference to possible future enhancements of the RFX-mod2 performance, a deep review of the operational concept of the poloidal circuit is proposed with the aim to fully exploit the double swing of the magnetic flux produced by the magnetizing winding, to increase the maximum plasma current and flat-top duration. The studies will be addressed to verify the feasibility of a circuital reconfiguration also trying to maximize the exploitation of the existing components and minimizing the need of additional ones.
lorella.carraro@igi.cnr.it	Bended crystal spectrometer for RFX-mod2 ion temperature and toroidal rotation measurements	A crystal spectrometer in the few Angstrom spectral range is planned to measure core ion temperature and toroidal velocity (Doppler broadening and shift) in the Padova RFP device RFX-mod2. The expected Ti of the order of 500eV-1Kev suggests measurements of Ar XVII emission lines [R.Bartiromo et al Nucl.Instrum. and Methods in Physics Research 225 (1984) 378-384, R.Bartiromo Nucl.Instrum. and Methods in Physics Research A255 (1987) 242-252, M. Bitter et al.,Review of Scientific Instruments 66, 530 (1995);Y.Shi et al Plasma Phys. Control. Fusion 52 (2010) 085014].
alessandro.fassina@igi.cnr.it	Fast electron analysis in RFP plasmas	The proposed theme deals with the characterization of fast electron (FE hereafter) populations in RFP discharges, with high priority on FE fraction quantification as a function of plasma conditions. In a second stage, the activity should move to modelling of FE generation, interaction with thermal particles and contribution to dynamo mechanism. In this framework, both data analysis and diagnostic R&D are foreseen; in particular, Thomson Scattering and Soft X-ray data (acquired before RFX-mod shutdown) will be analyzed. Diagnostic development will involve the construction of a SXR Pulse height analyzer, likely based on organic scintillators coupled to solid state photomultipliers.
susanna.cappello@igi.cnr.it	Alfvén waves excitation in toroidal fusion plasmas (recent detection in the Reversed-Field Pinch and comparison with Tokamak and Stellarator configurations)	Alfvén waves (so named after H. Alfvén “Existence of electromagnetic-hydrodynamic waves” Nature 150, 405, 1942) play fundamental roles in the physics of astrophysical and fusion plasmas. For instance, they are thought to be essential for the phenomenon of solar coronal heating and, in fusion plasmas, they are found to be excited by fast particles and to affect heating and transport properties. Alfvén waves have been observed in the RFX-mod device exploiting the Reversed-Field Pinch (RFP) magnetic configuration and, recently, their basic theoretical interpretation has been provided based on nonlinear MHD modelling with the SpeCyl numerical code. The proposed work consists in the MHD modelling of Alfvén waves in the RFP, and the comparison with experimental observations. The Tokamak and Stellarator magnetic configurations will be also possibly considered. A suite of numerical tools will be used, ranging from fluid (MHD) codes with increasing level of physical description (SpeCyl and PIXIE3D [D. Bonfiglio, L. Chacón and S. Cappello, Phys. Plasmas 17, 082501, 2010]), up to the coupling with kinetic modules that will make possible to study the interaction with energetic

		particles (from neutral beams or fusion reactions) and the resulting excitation of Alfvén waves.
susanna.cappello@igi.cnr.it	3D nonlinear MHD modeling studies: plasma flow and resistive boundary impact on magnetic self-organization in fusion plasmas	The student will have to test and use a set of tools for the numerical modelling of fusion plasmas: the student will investigate the role of a macroscopic plasma rotation and of a resistive wall on the dynamics of hot plasmas, with a special attention to self-organized helical states in the Reversed-Field Pinch. The study will consist in a mix of numerical effort and the subsequent comparison with experimental measurements - with the beneficial outcome of helping understanding the plasma dynamics in the RFX-mod2 experiment. Reference papers: S Cappello et al, Varenna-Lausanne Theory of Fusion Plasmas, AIP Conf. Proc. 1069, 27 (2008) D Bonfiglio et al., Phys. Rev. Let. 111, 085002 (2013) M Veranda et al., Nucl. Fusion 57, 116029 (2017)
paolo.innocente@igi.cnr.it	Power exhaust and plasma divertor interaction study by means of a 2D edge numerical code	The study of power exhaust, plasma interaction with the wall and in particular in the divertor is of fundamental importance for the definition of the operating conditions of current experiments aimed at the development of fusion reactor, for the realization of future experiments and in perspective for the final design of reactors. For the study of the interaction very sophisticated 2D fluid-montecarlo type codes are used. The recently developed SOLEDGE2D-EIRENE is particularly suitable for these studies because it presents several advantages compared to older codes. In particular it is able to fully describe the interaction of the plasma with the wall for all the magnetic configurations currently experimented and proposed. The code can be used to analyse experiments already performed and in the execution phase in the main tokamaks in operation such as JET, ASDEX, TCV, MAST and EAST. Experimental comparison allows code validation and the estimation of transport parameters in the various operating conditions. The code can be also used to evaluate the convenience of the different divertor magnetic configurations proposed for the new tokamak experiment under construction in Italy and called DTT (Divertor Test Tokamak), whose main purpose is the study of plasma interaction in various magnetic configurations.
gabriele.manduchi@igi.cnr.it	New architectures for real-time plasma control	The new RFX-mod2 machine provides a larger number of Electromagnetic (EM) probes for the diagnostic of the plasma behavior. This introduces an opportunity of significant improvement of the plasma time control system that can rely on a more accurate knowledge of the plasma shape and instabilities. The foreseen improved dynamics in EM probe signals will also introduce new requirements for the digital real-time control system. For this reason, the original digital control architecture of RFX-mod will be improved both in hardware, with more sophisticated ADC channels and in software, by adopting a new version of the software framework for real-time control used at RFX-mod. The proposed activity consists in the development of the new control architecture and will include both the project of the control algorithms and their implementation in the new software architecture. The activity will be complemented by exploring the application of innovative approach taken from the emerging field of the controllability of complex networks