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## Wednesday 24 September

**Registration/Accommodation**

## Thursday 25 September

**9.15-11.30**

## Session I - Overview of tokamak experiments

Chaired by Guido Van Oost

| | | |
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| **9.15** | | **Opening of the TM** |
| **9.35** | **I-1** | **Results of Joint Experiments and other IAEA activities on Research using Small Tokamaks**<br>M Gryaznevich and the IAEA CRP RUST team |
| **10.15** | **OV-1** | **The International Joint Experiment @ ISTTOK**<br>I. Nedzelskiy |
| **10.40** | **OV-2** | **Overview of Recent Results on H Mode and Edge Plasma Turbulence in TCABR Tokamak**<br>Yu.K. Kuznetsov, I.C. Nascimento, I.L. Caldas, R.L Viana, F.A. Marcus, Z.O. Guimarães-Filho, J.H.F. Severo |
| **11.05** | **OV-3** | **Preliminary Design for a Small Spherical Tokamak for a Mexican Fusion Programme**<br>M. Nieto-Pérez, S. Barocio, F. Castillo-Mejía, E. Chávez, C. Gutiérrez, J. J. E. Herrera-Velazquez, J. J. Martinell, G. Ramos-López, R. Valencia |

**11.30-12.05** **Coffee break**

**12.05-13.45**

## Session II - Magnetic devices - Experiments/Modelling

Chaired by Yu.K. Kuznetsov

| | | |
|---|---|---|
| **12.05** | **MEX-1** | **Dynamics of RF discharge with H-mode transition in the Uragan-3M torsatron**<br>V. V. Chechkin, Grigor'eva L. I., Sorokovoy Ye. L., Sorokovoy E. L., Beletskii A. A., Slavnyj A. S., Lavrenovich Yu. S., Volkov E. D., Burchenko P. Ya., Tsybenko S. A. Lozin A. V., Kulaga A. Ye., Zamanov N. V., Kurilo D. V., Mironov Yu. K., Romanov V. S |
| **12.30** | **MEX-2** | **ALFVÉN RESONANCE HEATING IN URAGAN-2M TORSATRON**<br>V.E.Moiseenko, Ye.D.Volkov, V.I. Tereshin |
| **12.55** | **MEX-3** | **INTERMITTENT BURSTY TRANSPORT PHENOMENA IN TOKAMAK EDGE PLASMA**<br>I. Nanobashvili, P. Devynck, J.P. Gunn, S. Nanobashvili, J. Stöckel, G. Van Oost |
| **13.20** | **MEX-4** | **MHD BEHAVIOUR ANALYZES IN THE IR-T1 AND ISTTOK TOKAMAKS**<br>P. Khorshid, M. Ghoranneviss, H. Fernandes, P. Duarte, R. Coelho, D. Alves, C. Silva, S. Mohammadi, R. Arvin, A. Nikmohamadi |
| **14.00** | | **Lunch**<br>**Excursion** |

## Friday 26 September

**9:15-10:55** **Session III - Dense plasmas experiments**

Chaired by **Weissow B.**

**9:15 DPE-1** **RESEARCH OF D-D FUSION REACTIONS AT THE CTU IN PRAGUE**
P. Kubes, M. Bohata, D. Klir, J. Kravarik, K. Rezac

**9:40 DPE-4** **Studies of ions emission in a small plasma focus device of hundreds of joules**
José Moreno, Cristian Pavez, Ariel Tarifeño and Leopoldo Soto

**10:05 DPE-3** **Portable plasma focus for field applications. Nanofocus of tenth of joules and plasma focus of few joules**
Leopoldo Soto, Cristian Pavez, José Moreno, Ariel Tarifeño, José Pedreros, Luis Altamirano

**10:30 DPE-5** **Generation of Dense Magnetized Plasma Streams with Compact Magnetoplasma Compressor**
Yu.V. Petrov, I.E. Garkusha, V.V. Chebotarev, A. Hassanein, M.S. Ladygina, A.K. Marchenko, D.G. Solyakov, V.I. Tereshin

**10:55-13:20** **Session IV – Diagnostics**

Chaired by **Gryaznevich M.**

**10:55 D-1** **Development of the Beam Probe Diagnostics for Electric and Magnetic Fields Investigations in Fusion Plasmas**L.I.Krupnik

**11:20-11:45** **Coffee break**

**11:45 D-2** **Plasma density fluctuations measurements by heavy ion beam probe with a multiple cell array detector on the tokamak ISTTOK.**
I. S. Nedzelskiy, D. Alves, C. Silva, R. Coelho, H. Fernandes

**12:10 D-3** **Investigations of mirrors for ITER diagnostics in the modern fusion devices**
V. S. Voitsenya, A. Litnovsky for the SWG on First Mirrors of the ITPA Topical Group on Diagnostics

**12:35 D-4** **Ultra-fast scintillation probes for hard X-ray and neutron radiation recording**
Krzysztof Tomaszewski

**13:00 D-5** **Introduction to Plasma Diagnostics on HL-2A tokamak**
Y. Huang, Q.W. Yang, Y. Zhou, Z.Y. Cui, W.Li, L.W. Yan, Y. Liu, X.R. Duan, X.T. Ding

**14:00** **Lunch**

***Afternoon Interval***

**17:00-17:30** **Coffee break**

**17:00 - 18:30**

## Friday 26 September
## Session V – Posters

**P1** **Measurement of sheared electric fields at the plasma edge of the CASTOR tokamak**
J. Brotankova, J. Stockel, M. Hron, I. Duran

**P2** **Study of Sawtooth Oscillation in HL-2A Tokamak using Integrated Predictive Modeling Code**
N. Poolyarat, T. Onjun, and J. Promping

**P3** **Effect of Resonant Helical Magnetic Field on Plasma Displacement in IR-T1 Tokamak**
P. Khorshid, M. Razavi,M. Mollai and IR-T1 team

**P4** **Spectral and statistical analysis of density fluctuations in the SOL and diverted plasmas of the URAGAN-3M torsatron**
Beletskii A. A., Grigor'eva L. I., Sorokovoy E. L., Chechkin V. V., Sorokovoy Ye. L., Volkov Ye. D., Burchenko P. Ya., Kulaga A. Ye., Tsybenko S. A., Lozin A. V., Slavnyj A. S., Lavrenovich Yu. S., Zamanov N. V., Mironov Yu. K., Romanov V. S

**P5** **STUDY OF PLASMA PARAMETERS AT THE FIRST PHASE OF MODIFIED TORSATRON U-2M WORK**
A.V. Prokopenko, A.I. Skibenko, V.L. Berezhnyj, P.Ya. Burchenko, V.V. Krasnyj, A.E. Kulaga, G.G. Lesnyakov , A.V. Lozin, V.L. Ocheretenko, O.S. Pavlichenko, V.K. Pashnev, I.B. Pinos, A.N. Shapoval, O.M. Shvets, V.E. Moiseenko, I.K. Tarasov, M.I. Tarasov, S.A. Tsybenko, E.D. Volkov, N. V. Zamanov

**P-6** **Dynamics, Density Measurements and Neutron Emission Optimization in a Small Plasma Focus of Tens of Joules**
Ariel Tarifeño, Cristian Pavez, José Moreno and Leopoldo Soto

**P-7** **Spectral Distribution of Fast Deuterons in PF device**
E.Litseva, K. Rezac, M. Bohata, P. Kubes, D.Klir,

**P-8** **MEASUREMENTS OF X-RAY SPATIAL DISTRIBUTION ON A LOW-INDACTANCE VACUUM SPARK DISCHARGE**
O.A. Bashutin, A.S. Savjolov, E.D. Vovchenko

**P-9** **Methods improved characteristics of laser source of ions**
Khaydarov R.T., Akramov T.V., Tojinazarov F.M. Trent'ev V

**P-10** **Defect Structure Studies in Neutron Irradiated Be: Positron Lifetime Model Calculations**
T. Troev, E. Popov, N. Nankov L. Petrov and T. Yoshiie

**P-11** **Comparison between the Magnetic Field Reconstruction and the Tomographic Diagnostic in the ISTTOK Tokamak using the 3D-Maptor Code**
P.J. Carvalho, B.B. Carvalho, A. Neto, R. Coelho, E. Chávez, J.J.E. Herrera, H. Fernandez, J. Sousa and C. Varandas

**P-12** **Design and Fabrication a 2-D Array Magnetic Probe for Measurment of Magnetic Fields in IR-T1 Tokamak**
M.Ghasemloo, M.Ghoranneviss, R.Shariatzadeh

**P-13** **DAQViewer software tool for tokamak KTM data visualization and offline processing**
A.V. Sharnin, A.A. Mezentsev, A.V. Ovchinnikov, Pavlov V.M., Golobokov Y.N.

**P-14** **Data Acquisition and Control System Of Magnetic Field Coils Power Supply Units at KTM tokamak.**
Y.N. Golobokov, V.M. Pavlov, A.V. Obkhodskiy, S.V. Merkulov, A.V. Sharnin

**P-15** **Measurement of Plasma Displacements by Sine-Coil and Mirnov Coils in the IR-T1 Tokamak**
P. Khorshid, M. Mollai, M. Razavi and IR-T1 team

**P-16** **Comparing plasma parameters with and without feedback control system in IR-T1 Tokamak**
S. Mohammadi, M. Ghorannevis, M.K. Salem, R.Arvin, M.Gheydii

**19:00** **Conference Dinner**

**9:15-12:00**

## Saturday 27 September
## Session VI - Summary

Chaired by **Malaquias A.**

**9:15** **Overviews**
Guido Van Oost

**9:40** **Magnetic confinement experiments and modeling - other devices**
Kuznetzov Y.K.

**10:05** **Dense plasmas experiments**
Soto L.

**10:30** **Diagnostics**
Gryaznevich M.

**11:00- 11:20** **Coffee break**

**11:20** **I-2 H&CD and Diagnostics developments in the European Fusion Program**
Weyssow B.

**12:00** **Round Table** ***Closing***

## Session I - Overview of tokamak experiments

**I-1**

# RESULTS OF JOINT EXPERIMENTS AND OTHER IAEA ACTIVITIES ON RESEARCH USING SMALL TOKAMAKS

M Gryaznevich and the IAEA CRP RUST team
*EURATOM/UKAEA Fusion Association, Culham SC, Abingdon, UK*

Small tokamaks continue to play an important role in fusion research. Because of compactness, flexibility, low operation costs and high skill of their personnel, small tokamaks continue to contribute to many areas of Fusion research. New concept of interactive co-ordinated joint research using small tokamaks in the scope of IAEA Co-ordinated Research Project (CRP), started in 2004, is a significant step towards the improvement of the co-ordination of the collaboration and of the links between small and large tokamaks. Experimental work on small tokamaks is very appropriate for education of students, scientific activities of post-graduate students and for training of personnel for large tokamaks. Small tokamaks are suitable and important for broad international cooperation, providing necessary environment and manpower to conduct dedicated joint research programmes and develop communication tools. This is achieved through the promotion of mobility, exchange of equipment, joint experiments (JE), training courses, schools etc.

Joint Experiments in the framework of the IAEA CRP have been carried out on the tokamaks CASTOR at IPP Prague in 2005, T-10 tokamak at RRC “Kurchatov Institute”, Moscow, in 2006.and ISTTOK at IST, Lisbon, in 2007. They involved about 70 scientists from 16 countries. Experimental programmes were aimed to diagnose and characterize the core and the edge plasma turbulence and other parameters in a tokamak in order to investigate correlations between the occurrence of transport barriers, improved confinement, electric fields and electrostatic turbulence using advanced diagnostics with high spatial and temporal resolution. First JEs have clearly demonstrated that small tokamaks are suitable for broad international cooperation to conduct dedicated joint research programmes. The contribution of small tokamaks to the mainstream fusion research can be enhanced through coordinated planning. These activities under the IAEA CRP are already paying visible dividends and resulted in a substantial number of joint presentations and publications. The following JE is scheduled for March 2009 on the TCABR tokamak at the University of São Paulo, Brazil. Scientific results from JEs and other activities within the CRP will be overviewed.

*Acknowledgements. This work was partly funded by the IAEA technical contract under the CRP on the Joint Research Using Small Tokamaks.*

**OV-1**

# THE INTERNATIONAL JOINT EXPERIMENT @ ISTTOK

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*1) Associação Euratom/IST, Istituto Plasmas e Fusão Nuclear, Lisbon, Portugal*
*2) Ghent University, Belgium;*
*3) Euratom/UKAEA, Fusion Association, Culham ScienceCentre, Abingdon, United Kingdom;*
*4) International Atomic Energy Agency, Vienna, Austria*
e-mail: hf@cfn.ist.utl.pt

The 3rd International Joint Experiment (JE) has been carried out on ISTTOK following the last RUSFD conference, held at Lisbon, in the scope of the IAEA Coordinated Research Project (CRP). This program has allowed a great knowledge interchange among the "small" fusion devices community and, in particular in the development of common work-programs.

This communication gives an overview of the impact of such activities, with the main emphasis on the following four main working areas:

. •**Control and data acquisition:** The data acquisition system and the real-time plasma position control have been upgraded to allow long AC operation. ISTTOK is operating with state of the art data acquisition technology with emphasis on remote data access and collaborative tools to facilitate the exchange of information and the collaboration between scientists.

. •**Edge plasma physics:** The physics programme has been based mainly in the characterization of the edge transport using different types of probes and on the turbulent transport control using electrode biasing.

. •**Study of AC discharges:** An important achievement of ISTTOK has been the prolongation of the plasma discharge up to 250 ms by using only inductive operation. The characterisation and optimization of these discharges have been studied.

. •**Gallium:** The gallium liquid metal loop has been operated in AC plasma discharges with the aim of measuring its surface temperature increase and to study the power exhaustion capability of liquid metal jets.

The JE have proved to be a very useful applied forum to share knowledge and to initiate young scientists in some fields of tokamak operation and diagnostics. Many of the ISTTOK 2008 relevant results were obtained under this scope.

**OV-2**

# OVERVIEW OF RECENT RESULTS ON H MODE AND EDGE PLASMA TURBULENCE IN TCABR TOKAMAK

Yu.K. Kuznetsov[1], I.C. Nascimento[1], I.L. Caldas[1], R.L Viana[2], Z.O. Guimarães-Filho[1], F.A. Marcus[1], J.H.F. Severo[1]
[1] *Institute of Physics, University of São Paulo, 05508-090, São Paulo, Brazil*
[2] *Federal University of Paraná, 81531-990, Curitiba, Paraná , Brazil*[l]

The ETB formation by edge biasing has been studied on TCABR. The bifurcation is less evident and gradual improvement of plasma confinement with increasing electrode voltage/current is more pronounced as compared with CCT and TEXTOR. We investigated reduction of chaotic particle transport in sheared poloidal E×B flows. A theoretical analysis of the Hamiltonian two-wave model shows good agreement with experimental data on the effect of bias voltage. The MHD activity is dangerous for the ETB at the condition when magnetic island 3/1 is overlapping the barrier region. Wavelet cross-spectral analysis is used to characterize phase and frequency synchronization between Mirnov oscillations and electrostatic fluctuations in the plasma edge. The conclusion is that magnetic and electrostatic fluctuations are correlated and can exhibit phase and frequency synchronization. More detailed analysis of the turbulence structure is presented. The turbulence intermittence has been investigated from the analysis of the PDF. The skewness $S$ and kurtosis $K$ are usually positive and far from a normal distribution values S = $K$= 0. Without biasing, intermittency is somewhat higher at the edge. Electrode biasing changes this dependence to the opposite one, i.e. both $S$ and $K$ decreases at the edge and increases at the SOL. The poloidal phase velocity of ~ 10 km/s at the edge agrees qualitatively with the expected $E\times B$ plasma rotation, but there is large disagreement between phase velocity and $E\times B$ drift velocity especially at low values of the radial electric field and high values of the phase velocity. The recurrence quantification analysis was used to provide diagnostics of the deterministic content of plasma (floating potential) fluctuations. The conclusion is that the deterministic content of the turbulent signals is most pronounced in the SOL near the plasma boundary. The chaoticity follows the same trend. We conclude that the electrostatic plasma turbulence at the tokamak can be partially expanded by means of a deterministic nonlinear system. Intermittency was also considered in geometrical framework invoking fractal formalism. The non-linear behavior of the turbulent fluctuations scaling shows that plasma fluctuations posses multifractal statistics.

**OV-3**

# PRELIMINARY DESIGN FOR A SMALL SPHERICAL TOKAMAK FOR A MEXICAN FUSION PROGRAMME

M. Nieto-Pérez[1], S. Barocio[2], F. Castillo-Mejía[3], E. Chávez[2], C. Gutiérrez[2],
J. J. E. Herrera-Velazquez[3], J. J. Martinell[3], G. Ramos-López[1], R. Valencia[2]
[1]*CICATA-Querétaro, Cerro Blanco 141, Querétaro, QRO, 76090, México*
[2]*Instituto Nacional de Investigaciones Nucleares, Apdo. Postal 18-11801, México, D.F. México*
[3]*Instituto de Ciencias Nucleares, UNAM, Apdo. Postal 70-543, Ciudad Universitaria, 04510. México, D.F., México*

Small devices play an important role in fusion technology R & D: they allow the testing of new concepts and ideas that, if translated into better machine performance and/or understanding, may be implemented on larger reactors. This can be done in small machines without the risks involved in using the larger ones; they also offer the opportunity for scientific communities with limited resources to make important contributions to the advancement of fusion science and technology without the large resources pool demanded by a large experiment. Based on previous experiences in other countries, domestic fusion programs typically grow around an experimental facility that allows for contributions to the field, collaborations with well-established groups and the education/training of human resources. Researchers from Mexico involved in fusion have started an effort to design a small fusion machine with the following goals:

- To contribute in the development of fusion science and technology
- To agglomerate a dispersed network of specialists in plasmas and fusion around a centralized program
- To create awareness on funding agencies and political leadership about the importance of a program capable of forming fusion specialists

This work presents a preliminary design of a small (major radius ~ 0.3 m), single-null, low-aspect ratio ( < 1.5) and high beta (>20%) spherical tokamak. Vacuum vessel design, magnetic configuration design, current and voltage pulse generators, diagnostics to implement and initial heating schemes will be described in this work. The magnetic field configuration is studied by means of the 3D-MAPTOR code, which helps to establish the required currents needed for low ripple and proper safety factor values. Simulations of possible operating scenarios using the ASTRA code will also be presented.

## Session II - Magnetic devices - Experiments/Modelling

**MEX-1**

# DYNAMICS OF RF DISCHARGE WITH H-MODE TRANSITION IN THE URAGAN-3M TORSATRON

Chechkin V. V., Grigor'eva L. I., Sorokovoy Ye. L., Sorokovoy E. L., Beletskii A. A., Slavnyj A. S., Lavrenovich Yu. S., Volkov E. D., Burchenko P. Ya., Tsybenko S. A. Lozin A. V., Kulaga A. Ye., Zamanov N. V., Kurilo D. V., Mironov Yu. K., Romanov V. S.
*Institute of Plasma Physics, NSC "Kharkov Institute of Physics and Technology",*
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In the Uragan-3M (U-3M) torsatron with a natural helical divertor ((R = 1 m, $\bar{a} \approx 0.12$ m, $\iota(\bar{a})/2\pi \approx 0.3$, $B_\phi = 0.72$ T) plasma is produced and heated by RF fields in the $\omega \lesssim \omega_{ci}$ range of frequencies. In a chosen RF discharge regime the density $\bar{n}_e$ rises first after discharge ignition, passes over a maximum and then decays. In the general case, there are two not heating power-depending close values of $\bar{n}_e$ at the phases of density rise ($\bar{n}_{e1} \gtrsim 10^{12}$ cm$^{-3}$) and density decay ($\bar{n}_{e2} \approx \bar{n}_{e1}$) when the fast ion (FI, $\gtrsim$500 eV) content in the plasma passes over maxima. With both these maxima, burst-like FI ejections to the divertor are synchronized. At the density decay phase the FI ejection correlates with a hard edge $E_r$ bifurcation toward a more negative value with a stronger $E_r$ shear, thus resulting in suppression of edge turbulence and turbulence-induced anomalous transport, i.e., H-mode transition arises. Such a correlation might indicate that the transition is initiated by the ion orbit loss and by the radial drift of helically trapped ions.

Indications of a discharge state with H-mode are observed at the phase of density rise too.

At the initial phase of discharge at some $\bar{n}_{e3} > \bar{n}_{e1}$ (hysteresis) a reverse bifurcational transition to an L-like mode of confinement occurs. With this, a density decay starts ended by H-mode recover, provided $\bar{n}_{e2} \approx \bar{n}_{e1}$ is achieved in the process of decay. With the heating power high enough, the density $\bar{n}_{e3}$ can be in many-fold excess (up to ~ 3) of $\bar{n}_{e1}$ and as the power decreases becomes close to $\bar{n}_{e1}$ at some threshold power.

When elucidating the effect of H-transition on FI loss in U-3M, it has been observed that the FI outflow to the divertor increases after the transition in one of four examined field periods. Possible reasons for such a toroidal non-uniformity in FI loss is discussed.

**MEX-2**

# ALFVÉN RESONANCE HEATING IN URAGAN-2M TORSATRON

V.E.Moiseenko, Ye.D.Volkov, V.I. Tereshin
*Institute of Plasma Physics, National Science Center "Kharkov Institute of Physics and Technology"61108 Kharkiv, Ukraine*

Uragan-2M is a medium-size torsatron with reduced helical ripples. This machine has the major plasma radius R = 1.7 m, the average minor plasma radius $a \leq 0.24$ m and the toroidal magnetic field $B_0 \leq 2.4$ T. The Alfvén resonance heating in a high $k_{\|}$ regime [1] is advantageous for small size machines since it can be realized at smaller plasma densities than the minority and second harmonic heating. The Alfvén resonance heating is examined numerically in the approximation of radially non-uniform plasma cylinder with identical ends. The numerical model for wave excitation and propagation accounts for the longitudinal electron thermal motion and the finite ion gyroradius, which allow the model to treat correctly the propagation and damping of the kinetic Alfvén wave in hot plasma. A compact antenna consisting of four pi-phased loop elements is chosen to provide operation in a high $k_{\|}$ regime. The major drawback of the high $k_{\|}$ regime is the presence of plasma periphery heating owing to unavoidable excitation of low $k_{\|}$ Alfvén resonances. Calculations show that, with the proper choice of heating conditions, the periphery heating has an acceptable level. The radio-frequency power is delivered mainly to the electrons at the central part of the plasma column. If the ion temperature is high enough, the additional ion cyclotron heating is observed.

References

[1] Moiseenko V.E., in IAEA Technical Committee Meeting (Proc. 8th Int.Workshop on Stellarators, Kharkov 1991), IAEA, Vienna (1991) 207.

**MEX-3**

# INTERMITTENT BURSTY TRANSPORT PHENOMENA IN TOKAMAK EDGE PLASMA

I. Nanobashvili[1,2], P. Devynck[3], J.P. Gunn[3], S. Nanobashvili[1], J. Stöckel[4], G. Van Oost[5]
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Plasma turbulent transport at the edge of tokamaks is the object of one of the most intense studies in modern magnetic fusion research. Nowadays it is widely accepted that edge plasma transport has strong convective character. Large scale turbulent events – density bursts, which are formed intermittently on the diffusive background, play the important role in edge transport. These bursts cause rapid convective radial transport of plasma towards the wall with a speed which is a fraction of the ion sound speed. The most important result of this is that core plasma confinement degrades. At the same time in large scale tokamaks, especially in next generation devices like ITER, density bursts can cause the strong erosion of the first wall and unwanted re-tention of tritium. Therefore, it is very important to understand the physical nature of edge plasma turbulent transport – especially the origin and dynamics of density bursts – and develop the methods for their external modification and control.

Langmuir probes have been used to measure intermittent positive bursts of plasma density in the scrape-off layer (SOL) of the Tore Supra and CASTOR tokamaks. Temporal characteristics of these bursts have been investigated in detail. We observed monotonic radial decrease of average burst rate together with increase of average burst duration in the Tore Supra tokamak. In contrast, at the edge of the CASTOR tokamak the temporal characteristics stay nearly constant within quite wide radial region. The reason of this is that we have radially elongated turbulent events – streamers which govern turbulent radial transport at the edge of the CASTOR tokamak and which are responsible for the appearance of density bursts. Comparative analysis of burst temporal characteristics allows to conclude that radial transport at the edge of the Tore Supra tokamak should be governed by blob-like structures which have comparable radial and poloidal size.

Comparison of experimental results with two-dimensional fluid modeling based on flux driven interchange instability mechanism reveals the striking similarities between these two.

## MEX-4

# MHD BEHAVIOUR ANALYZES IN THE IR-T1 AND ISTTOK TOKAMAKS

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In the edge plasma of the IRAN-T1 and ISTTOK tokamaks the poloidal rotation velocity based on magnetohydrodynamic (MHD) behaviour has been studied. The bulk of plasma behaviour during plasma column rotation has been investigated. We found that mode number and rotation frequency of plasma column are different in angle position, so that the mode number detected from Mirnov coils array located in poloidal angle on the inner side of chamber is more than outer side which it can be because of toroidal magnetic field effects. The mode number of MHD activities in the ISTTOK due to low plasma current is more than IR-T1 and it shows a higher frequency oscillation in the magnetic perturbation signals with respect to IR-T1. Floating potential oscillations were also analyzed in two tokamaks and compared with MHD activities spectra. The results shown that the plasma current plays an important role in observation of a clear MHD behaviour.

## Session III - Dense plasmas experiments

**DPE-1**

# RESEARCH OF D-D FUSION REACTIONS AT THE CTU IN PRAGUE

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The device PFZ works as a combination of plasma focus and z-pinch principle with placed antianode in front of the anode. The current reaches maximum 200 kA in 2 μs. It is used mainly for the study of deuterons producing neutrons from fusion D-D reaction. As the diagnostics we use a silicon PIN detectors filtered with Al 0.8 μm foil, a soft X-ray microchannel-plate detector split into 4 quadrants, a time integrated XUV spectrometer, two scintillation probes to perform detailed time-resolved measurements of hard X-rays above hundred keV and neutron emission and the diagnostic laser beam for visualization of the pinched plasma. The detectors for neutron registration were cross-calibrated.

The results can be summarized as follows: Total neutron yield reaches a few times $10^6$ per 1 shot. Neutrons are emitted at the same time as hard X-rays with FWHM from 4 to 15 ns. Energy of neutrons registered side-on is in the range of 2,45 ± 0,25 MeV, the similar as downstream. The MCP frames show different evolution for the shots with the high and low neutron yield. At the pinches with the low neutron yield we observe evolution of instabilities. At the high neutron yield we observe a spherical structure in the time of X-ray emission.

On the PFZ device we test the methods and diagnostics used in the collaboration with the Institute of Plasma Physics and Laser Microfusion in Warsaw and with the Russian Research Center Kurchatov Institute in Moscow at the study of X-ray and neutron radiation. The research is realized in the frame of student bachelor, master and PhD works.

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**DPE-2**

# Z-PINCH EXPERIMENTS IN GENERATORS OF MEDIUM AND SMALL SIZE

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Experimental results of Z-pinch configurations are presented for two pulsed power generators in operation at the Chilean Nuclear Energy Commission. The first corresponds to the SPEED2 generator (4.1 μF equivalent Marx generator capacity, 180 kV, 2.5 MA in short circuit, 70kJ, 400 ns rise time, dI/dt~$10^{13}$ A/s) which was used in the mode linear Z-pinch by means of the formation of a hollow gas embedded Z-pinch using a conical electrode geometry. The other generator corresponds to a table top generator, constructed to operate in different configurations of load (1.2 μF, 30 kV, 180 kA in short circuit, 540J, 300 ns rise time, dI/dt ~ $6x10^{11}$ A/s). In order to study the details of the preionization schemes and the structure of the initial hollow discharge, the same conical electrode geometry is used with this generator. The characteristics and the evolution of the discharge are studied by means of optical refractive diagnostics.
On the other hand, preliminary results, using a table top device in an aluminum wire X-pinch of 25 μm wire diameter for the study of the x-ray emissions and possible applications, are presented.
X-ray time integrated pin-hole imaging with metallic filter and PIN diode with metallic filters were used in order to follow the temporal behavior of the discharge.

This work is supported by Bicentennial Program in Science and Technology, PBCT grant ACT26. C. Pavez thanks to grant PSD-01, PBCT.

**DPE-3**

# PORTABLE PLASMA FOCUS FOR FIELD APPLICATIONS. NANOFOCUS OF TENTH OF JOULES AND PLASMA FOCUS OF FEW JOULES

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The Thermonuclear Plasma Department of the Chilean Nuclear Energy Commission has designed and constructed plasma focus devices working with energies lower than 1kJ. These devices are: PF-400J working with hundred of joules (1, 2), PF-50J working with tens of joules (1, 3) and the ultraminiature device Nanofocus NF, that works with less than 1 joule (4). X-rays and neutron production have been characterized in the PF-400J and PF-50J. In particular, the neutron yield is of the order of $10^6$ and $10^4$ respectively. Evidence of X-rays and neutrons emission has been obtained in the ultraminiature device Nanofocus operating at 0.1J of stored energy and 20Hz of repetition rate. However, the reproducibility of this miniaturized device is low and several technological subjects have to be previously solved in order to produce neutrons for periods greater than minutes. Further studies in the Nanofocus will be carried out. In addition, a device with a stored energy between the boundaries of 50J and 0.1J is being explored. A compact, low weight (3kg), portable PF device (25cm x 5cm x 5 cm) for field applications has been designed. This device was designed to operate with few kilovolts (10kV or less) with a stored energy of 2J and a repetition rate of 10Hz without cooling. A neutron flux of the order of $10^4$-$10^5$ n/s is expected. Preliminary characterization of this device, PF-2J is presented.

Supported by Bicentennial Program in Science and Technology by grant ACT 26, Center for Research and Applications in Plasma Physics and Pulsed Power Technology, P$^4$. C. P is supported by PBCT grant PSD-01.

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## DPE-4

# STUDIES OF IONS EMISSION IN A SMALL PLASMA FOCUS DEVICE OF HUNDREDS OF JOULES

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Ion beam emission in plasma focus (PF) discharges was originally investigated to explain the strong forward anisotropy observed in the neutron emission. Several properties of deuteron beams have been measured, including their angular distributions and energy spectra in devices operating with energies from 1MJ to 1kJ. At present there is a increasing interest in the development of very small PF devices operating under 1kJ. As part of the characterization program of the very low energy PF devices (< 1kJ) developed at the Chilean Nuclear Energy Commission, the charges particle emission in discharges with $H_2$ and mixture of $H_2$ plus Ar are being studied. In order to obtain an estimation of the ions energy spectrum and ionization grade, by means time of flight method, a graphite collectors system operating in the bias ion collector mode was constructed and is being used [2, 3]. Preliminary results show the presence of hydrogen ions with an average energy of 30keV. Also, in some case, copper ions have been observed. The measurements, in different experimental conditions, are presented. The experiments have been performed in a plasma focus device of 400 joules [4] (PF-400J).

This work is supported by Bicentennial Program in Science and Technology, PBCT grant ACT26. C. Pavez thanks to grant PSD-01, PBCT.

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**DPE-5**

# GENERATION OF DENSE MAGNETIZED PLASMA STREAMS WITH COMPACT MAGNETOPLASMA COMPRESSOR

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Investigations of dense magnetized plasmas of different gases are in importance for various scientific and technological applications, e.g. hot plasma generators and efficient fuelling techniques (plasmoids), testing of fusion reactor materials with high energy loads, application of dense plasma as the source of ions and radiation in different wave length ranges etc. In particular, dense Xe plasma cloud can provide effective shielding of divertor plates and mitigation of disruptions due to high emissivity of Xe and resulting re-radiation of impacting energy.

This paper presents the investigations of pulsed plasma streams generated by magnetoplasma compressor (MPC) of compact geometry with conical-shaped electrodes and pulsed gas supply. The stored energy is 28 kJ for applied voltage of 25 kV. The device is able to operate with different working gases and mixtures. Operation mode can be varied from primary acceleration regime to compression one.

Plasma source efficiency was analyzed from electro-technical discharge characteristics, namely discharge current, total resistance and inductance. Measurements of total energy in plasma stream and radial distributions of plasma energy were performed with moveable calorimeters. Influence of different parameters of MPC operation on the total energy in plasma stream is discussed.

Spectroscopic measurements of plasma density and electron temperature in compression region of MPC have been performed on the basis of Stark broadening of spectral lines and intensities ratio in visible wave-range. Radial distributions of the plasma density were estimated using Abel inversion procedure. It was found that maximum value of plasma density in focus region achieved $10^{18}$ $cm^{-3}$.

Radial distributions of magnetic field in different cross-sections of plasma stream were measured by magnetic probes. From analysis of azimuthal magnetic field the output currents distributions in dense plasma stream were reconstructed.

Dynamics of the discharge and time behavior of plasma focus were analyzed for N, Xe and He-Xe plasma streams as well as for varied discharge voltage and time delays between the discharge and gas supply pulses. EUV measurements with AXUV photodiodes with different filters showed that the total radiated energy and peak power strongly depends on time delay between the gas supply start and the discharge ignition.

**D-1**

# DEVELOPMENT OF THE BEAM PROBE DIAGNOSTICS FOR ELECTRIC AND MAGNETIC FIELDS INVESTIGATIONS IN FUSION PLASMAS

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In the existing fusion devices with magnetic confinement the energy and particle transport is essentially anomalous defined by plasma turbulence, and don't submit to the "neoclassical theory". As a result, the large-scale devices such as LHD, W-7X, as well as ITER was designed on the base of empirical plasma confinement scalings.

So, understanding of the physical processes determining of the anomalous transport in fusion plasmas, including tokamaks and stellarators, is one of the main task of the modern plasma physics.

Discovery of the high confinement modes (H-mode) in the 80-th years and Internal Transport Barriers (ITB) in the 90-th years of the last century stimulated the interest in understanding the important role of the electric and magnetic fields in confinement of toroidal plasmas both of tokamaks and stellarators.

To investigate of the plasma electric and magnetic fields in devices with magnetic confinement it was given preference to Beam Probe Diagnostics. Today these diagnostics, particularly HIBP and BES take up a leading place in the fusion plasma investigations. With help of plasma probing by neutral and ionic beams it is possible to obtain information in the hot plasma of existing modern thermonuclear devices about space distribution of main plasma parameters, as well as their fluctuations. They are: electric potential, plasma density, electron temperature, density of impurity ions and poloidal magnetic field (plasma current).

The significant improvement in the HIBP diagnostic facilities and beam control and acquisition electronics on existing fusion devices: tokamaks T-10 ( Kurchatov Institute, Moscow), Tuman3-M (Ioffe Institute, St. Peterburg), and stellarators TJ-II (*Ciemat*, Madrid), WEGA (IPP, Greifswald) allow us to realize same actual physical programs.

Measurements of the electric potential and plasma density radial profiles in different regimes of plasma operation and ECR and NBI heating, behaviour of the electric field during ITB and L-H transition were performed. Separate attention have been devoted to biasing experiments. In the end a special measurements permit to observe same varieties of plasma fluctuations. Obtained results show the clear link between plasma potential, temperature, density and particle confinement.

One of the main problems of the BES method is increasing of the probing beam intensity for poloidal magnetic field measurements in existing large fusion devices. A new injector of the light alkali metal ions was developed for this problem resolving. The ion current of the thermoionic emitters run up to 10-15 mA for Li+, Na+ and K+ ions. We are proposed also to use in BES diagnostic more heavier atoms $Na^0$ or $K^0$ (instead of $Li^0$). This offer has a number of advantages for adaptation of this method to devices with large stray fields (stellarators) and large tokamaks.

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**D-2**

# PLASMA DENSITY FLUCTUATIONS MEASUREMENTS BY HEAVY ION BEAM PROBE WITH A MULTIPLE CELL ARRAY DETECTOR ON THE TOKAMAK ISTTOK

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It is recognized that the broad-band fluctuations observed in plasmas of thermonuclear devices are the cause of anomalously large energy and particle transport. Strong progress has been achieved on different plasma devices using a heavy ion beam probe (HIBP) diagnostic measuring the plasma potential and density fluctuations. Better understanding of turbulence properties can be obtained with a multiple cell array detector (MCAD) as plasma density fluctuations are measured simultaneously at a number of sample volumes. Together with design simplicity it presents a valuable additional tool for plasma turbulence investigations by HIBP. In this contribution, the capabilities of the MCAD for plasma density fluctuations measurements on the tokamak ISTTOK are estimated (including restrictions due to sample volume size and path effects) and compared with preliminary experimental data. The upgrade of MCAD for better diagnostic performance is also discussed.

**D-3**

# INVESTIGATIONS OF MIRRORS FOR ITER DIAGNOSTICS IN THE MODERN FUSION DEVICES

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Because of high level of neutron and gamma radiation, all methods of plasma diagnostics for providing optical and laser measurements of plasma parameters in ITER have to be based on the use of metallic mirrors. The plasma facing mirrors (first mirrors, FM) will operate in especially harsh working conditions, being subjected to impact of charge exchange atoms and ions. The re-deposition of contaminants (eroded materials) will be one of the main factors leading to degradation of optical properties of FMs. The effects of both these factors on mirror optical properties will depend strongly on mirror material and the mirror location inside the ITER vessel. The role of mirror material in retaining of mirror characteristics under long-term ion bombardment was investigated in laboratory experiments [1], confirmed by the direct comparative test in the tokamak [2], which allowed to narrow the list of candidate materials for mirrors. However for clearing up the effect of mirror location as well as the type and construction of mirror supporting infrastructure, the dedicated mirror experiments in fusion devices under operation have to be provided.

The first experiments with in-vessel mirror samples were carried out in JET (1997) with Al and Ni films deposited on polished graphite. In spite of very low initial reflectance of samples, the clear effect of their location on degradation of optical properties was found. The experiment with exposition of high quality SS (stainless steel) mirrors was provided on LHD during the third experimental campaign (1999), and the effect of mirror location was also observed. Gradually other fusion devices of different size are being involved in mirror experiments: Tore-Supra, T-10, TEXTOR, DIII-D, TCV, ASDEX Upgrade, HL-2A, HT-7, EAST, and Uragan-3M. Due to this, a quite large amount of information was obtained which is being analyzed with an aim to clear up the role of mirror location, mirror material and its structure, exposure temperature and deposit growth, developing techniques for deposition mitigation, *in situ* cleaning, and others. Such an analysis is planned to be provided in the presentation.

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**D-4**

# ULTRA-FAST SCINTILLATION PROBES FOR HARD X-RAY AND NEUTRON RADIATION RECORDING

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The design of the ultra-fast scintillation probe UFNSP-1 type (Fig. 1) will be presented. This probe is dedicated to record of ultra-short, hard X-ray and neutron radiation bursts. The probe itself consist of a microchannel plate photomultiplier tube (MCP-PMT) with photocathode diameter of 10 mm and a plastic scintillator with diameter of 45 mm. Both elements are characterized by ultra-short time response being in the range of 300 picoseconds. The appropriate Fresnel lens secures optical, non-imaging coupling between scintillator and MCP-PMT photocathode. Exemplary results taken during probe's performance tests will also be presented. They give unique opportunity to investigate the fine structure of hard X-ray and neutron emission (Fig. 2).

Figure 1. General view of the ultra-fast scintillation probe UFNSP-1 type

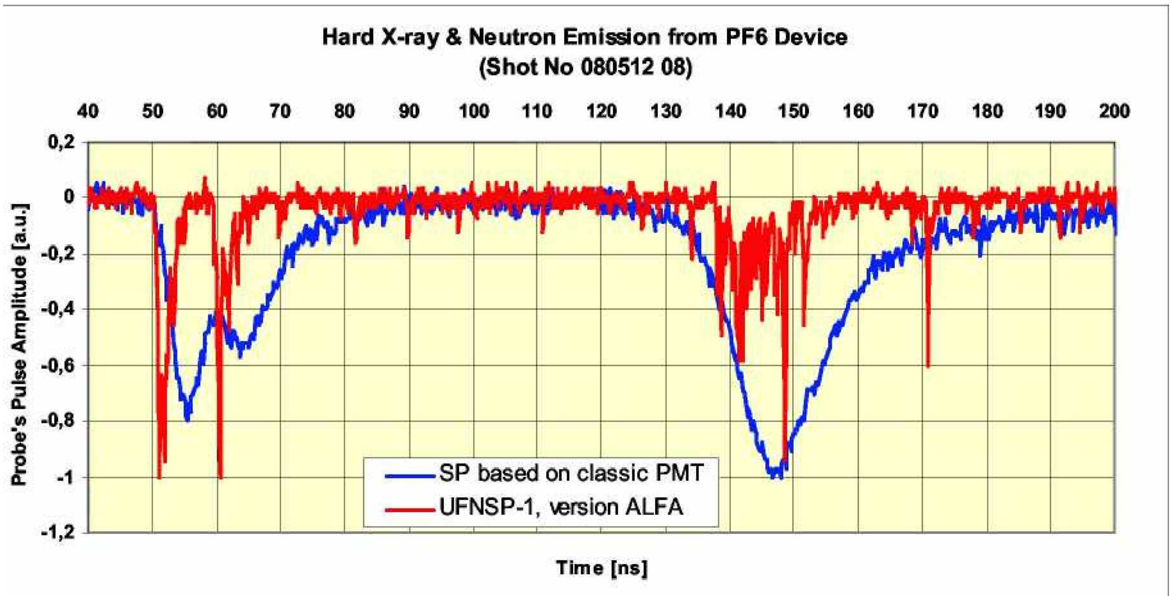


Figure 2. Time-of-flight measurement of hard X-ray and neutron radiation - pulses shape comparison recorded by means of scintillation probe equipped with classic PMT and ultra-fast scintillation probe. The left part of waveforms is associated with hard X-ray emission, whereas right part of waveforms is associated with neutron emission. Both probes have been located two meters away from ground zero. Estimated neutron yield - $3x10^8$ neutrons/shot. The experiment was carried out on small-scale *plasma-focus* PF6 device located at the Institute of Plasma Physics and Laser Microfusion, Warsaw, POLAND.

**D-5**

# INTRODUCTION TO PLASMA DIAGNOSTICS ON HL-2A TOKAMAK

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About 30 diagnostics have been equipped on HL-2A ($R$=1.65 m, $a$=0.40 m) tokamak for experimental studies of divertor and edge plasma physics, plasma profile control, plasma confinement and transport, etc. Among them are basic diagnostics for magnetics, visible optics, fast ionization gauges and divertor target Langmuir probes. Meanwhile, some diagnostics with good temporal and spatial resolutions are developed to provide required measurements of main plasma parameters, such as electron cyclotron emission (ECE) radiometer with 20 channels by sweeping frequency from 104 GHz to 181 GHz in 4 ms and 3 cm spatial resolution for electron temperature measurement. The electron temperature is also measured by Thomson scattering system with Nd:YAG laser of 4 J pulse energy at the repetition rate of 10 Hz and about 25 five-channel filter polychromators to observe the plasma region of -40 cm <z< 20 cm. The ion temperature is measured by one chord charge exchange neutral particle analyzer (CXNPA) with 8 energy channels in parallel electric field. The electron density measurements are performed, not only by eight-channel HCN laser interferometer wth about 300 mW laser power and 13mm-waist probing beams horizontally spaced from z = 24.5 cm to z = -24.5 cm and separated 7 cm to each other, but also by a sweeping frequency microwave reflectometry with 1 ms time resolution and 1 cm spatial resolution in the density range of (0.8–3) $\times 10^{19}\ m^{-3}$. The 100 channel soft x-ray system (5 pinhole cameras, 20 channels for each, response energy range 1 keV -10 keV ) can give local soft x-ray emissions reconstructed by a tomographic technique with spatial resolution 2.5 cm and temporal resolution 10 $\mu s$ respectively. The 64 channel bolometer ( 4 arrays, 16 channels for each, energy range 1eV-10 keV ) can analyze the evolution of total radiation losses with spatial resolution 2.5 cm and temporal resolution 50 $\mu s$ respectively. 4 movable three-step Langmuir probe(TSLP) arrays, which are mounted to the equatorial ports in different toroidal positions, are developed to measure edge plasma parameters, turbulence and zonal flows(ZFs).

**P-1**

# MEASUREMENT OF SHEARED ELECTRIC FIELDS AT THE PLASMA EDGE OF THE CASTOR TOKAMAK

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Understanding of plasma turbulence in magnetic confinement devices is believed to be one of the key elements leading to practical exploitation of fusion as an ultimate energy source for mankind. Turbulence is responsible for anomalously high losses of particles and energy from the edge plasma. In order to suppress the negative effects caused by turbulence, proper understanding of the phenomena occurring in the plasma edge is needed.

The shear of the radial electric field, causing a shear of poloidal velocity is one of the mechanisms reducing turbulence in the edge plasma. It occurs naturally in magnetic fusion devices, however, it needs to exceed certain value to suppress the radial transport.

Radial electric field and the poloidal plasma velocity were measured by a radial array of Langmuir probes and a full poloidal array of Langmuir and magnetic probes at the CASTOR tokamak. Position of the velocity shear layer was established with precision of 1 mm and the value of the velocity shear was estimated. A detailed study of the relation between the properties of radial electric field profile and the turbulence behaviour in the edge plasma of the CASTOR tokamak will be presented.

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**P-2**

## STUDY OF SAWTOOTH OSCILLATION IN HL-2A TOKAMAK USING INTEGRATED PREDICTIVE MODELING CODE

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In this work, we carried out the self-consistent simulations of plasmas in HL-2A tokamak using the 1.5D BALDUR integrated predictive modeling code [1]. The plasma core is determined using Multi-mode (MMM95) core transport model [2]. The plasma temperature and density profiles, as well as other plasma parameters, are obtained as the predictions in each simulation. It is found that both plasma temperature and density profiles in these simulation are peak near the plasma center. In addition, the sawtooth oscillation will be study, using the Porcilli model [3], in terms of the sensitivity of line-average number density, auxillarty heating power, and impurity content in the plasmas.

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**P-3**

## EFFECT OF RESONANT HELICAL MAGNETIC FIELD ON PLASMA DISPLACEMENT IN IR-T1 TOKAMAK

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The effect of a resonant perturbing helical magnetic field (RHF) with l=2, 3 and n=1 on plasma displacement in IR-T1 Tokamak is studied. The structure of magnetic field lines in tokamak with RHF is investigated by means of analytically calculation of the Biot–Savart law. The behavior of plasma displacement is different when the l mode is different. However, it is found that in both cases RHF influences on displacement measured by sine-coils. Also, we found that there are some locations where the effect of external magnetic fields on sine-coils is very low and it doesn't influence in the feedback control signals.

**P-4**

# SPECTRAL AND STATISTICAL ANALYSIS OF DENSITY FLUCTUATIONS IN THE SOL AND DIVERTED PLASMAS OF THE URAGAN-3M TORSATRON

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In the «Uragan-3M» torsatron with an open natural helical divertor (U-3M: $l$ = 3, $m$ = 9, $R_o$ = 1 м, $\bar{a} \approx 0.12$ м, $\iota(\bar{a})/2\pi \approx 0.3$) and a plasma produced and heated by RF fields ($\omega \lesssim \omega_{ci}$), joint studies of low frequency (5-100 kHz) density (ion saturation current) fluctuations in the scrape-off layer (SOL) and in the diverted plasma, have been carried out recently, using Langmuir probe arrays [1]. It has been shown, that in the SOL to more (less) distantly located points relative to the last closed magnetic surface (LCMS), higher- (lower-) frequency fluctuations are inherent. Such a spectral splitting in two subranges occurs in the diverted plasma flows (DPF) too. During *L-H*-like transition in U-3M, simultaneously with strong $E_r$ shear formation, a suppression of lower-frequency fluctuations and a decrease of local radial turbulent particle flux take place [2].

In this work, results are presented of investigation of plasma density fluctuations with the use of probability distribution function (PDF) analysis. It is shown, that during *L-H*-like transition, layers appear in the SOL plasma where the third order moment (skewness) of ion saturation current and local radial turbulent particle flux PDFs become smaller, that argues about particle outward transport decrease. These layers appear in the SOL plasma in each of two inspected helical magnetic field periods in similar poloidal cross-sections. Also, evaluations of the fourth order moment of PDFs (kurtosis) that characterize peakedness or flatness of the distribution have been made. The analysis of DPF ion saturation current fluctuations have been carried out in a similar way.

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**P-5**

# STUDY OF PLASMA PARAMETERS AT THE FIRST PHASE OF MODIFIED TORSATRON U-2M WORK

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Results of plasma parameters measurements at the first phase of studies of plasma production and heating in torsatron U-2M ($l$ = 2, $m$ = 4) after modifications of magnetic system, vacuum system and RF antennas are presented. RF system (antennas and oscillators) was used for vacuum chamber cleaning (at small magnetic field) and conditioning (at normal magnetic field).

In this paper the results of electron density profile measurements via microwave interferometry and some data of ECE measurements and impurities emission observation are presented. To determine the plasma density profiles a two chord (central and shifted) inerferometry was used. Data from these interferometers allowed to get a maximal density $N_0$ magnitude and parameter p in formula describing the density profiles $N(r) = N_0\left[1-(r/a)^p\right]$.

The method of two chord interferometry was tested by numerical experiment and by comparison with density profile measured by electric probe on U-3M torsatron.

The maximum of plasma density in the discharge depends on introduced power, magnetic field and pressure. In the process of conditioning a series of consecutive discharges were performed. The maximum electron density in the discharge and the time of its existence were changing and reaching their maximal values at some optimal number of discharges. This optimal number was increasing when the vacuum chamber wall became cleaner.

Typical interferometer signals (i.e. the relative phase and transmitted amplitude) show a large level of low frequency phase fluctuations (3-5 kHz) on a slowly varying mean level. Nature of these fluctuations will be studied.

These data will be used for optimization of conditioning process in U-2M.

**P-6**

# DYNAMICS, DENSITY MEASUREMENTS AND NEUTRON EMISSION OPTIMIZATION IN A SMALL PLASMA FOCUS OF TENS OF JOULES

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Experimental results of dynamics, density and neutron emission in the PF-50J device are presented. The PF-50J is a plasma focus machine operated at tens of joules, whose main electrical characteristics of this small device are: 160 nF equivalent capacitance, ~ 40 nH total inductance in short circuit, 150 ns first quarter of period, 25 - 35 kV charge voltage, energy E ~ 50 - 100 J, 50 – 70 kA peak current in short circuit [1]. The PF-50J is the only Plasma Focus reported in the literature in the range of tens of Joules that emits neutrons [2, 3]. In the present work, interferometric sequences of the discharge evolution and density measurements using hydrogen and deuterium as filling gas are shown. Sequences include radial compression phase as well as observation of plasma jets at late times of the discharges. Together with interferometric diagnostics, measurements of the electrical signals (current and voltage), radiation emission (hard x-ray and neutrons) using plastics scintillators coupled to photomultipliers and neutron production using $^3$He detectors in current mode are obtained [4]. Finally, results of the device optimization for neutron emission under anode effective large, anode radius, insulator length, charge voltage, and pressure are presented.

This work is supported by Bicentennial Program in Science and Technology, PBCT grant ACT26. C. Pavez thanks to grant PSD-01, PBCT.

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**P-7**

# SPECTRAL DISTRIBUTION OF FAST DEUTERONS IN PF DEVICE

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The main characteristic of the plasma focus device PF 1000 in IPPLM Warsaw is the maximal current of 2 MA, which is suitable for the study of fusion D-D reaction with the neutron yield of $10^{10}$ – $10^{11}$ per one shot. For investigation of the plasma parameters the X-ray and neutron diagnostics are performed. 9 scintillation detectors in axial direction (upstream and downstream) and one in side-on direction were used for determination of energy distribution of neutrons. The nearest detector is situated in 7m from the plasma focus and the furthermost was situated in 83 m distance.

In this contribution 7 shots were processed. Energy distribution of neutrons in axial and side-on directions was compared for shots with different neutron yield. We estimated the distribution of the total energy of fast deuterons producing neutrons assuming an isotropic distribution of deuterons in the energy range from 10 to 50-100 keV and an anisotropic distribution of faster deuterons with energies above 50-100 keV with dominant downstream velocity component.

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**P-8**

# MEASUREMENTS OF X-RAY SPATIAL DISTRIBUTION ON A LOW-INDACTANCE VACUUM SPARK DISCHARGE

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This paper presents measurements of x-ray source spatial distribution on a low-inductance vacuum spark discharge on the basis of helium-like ion lines structure analysis.

The measurements was carried out on the micropinch setup Zona-2 with current up to 150 kA and discharge period 8,5 μs. Two focusing spectrographs, mounted in Johann geometry with spatial resolution in direction perpendicular to dispersion plane were used for x-ray spectrum registration. The dispersive element was a spherically bent mica crystal. Radius of curvature was 150 mm. The dispersion plane of one of the spectrographs was oriented perpendicular to discharge axis, and dispersion plane of the other was oriented parallel to discharge axis.

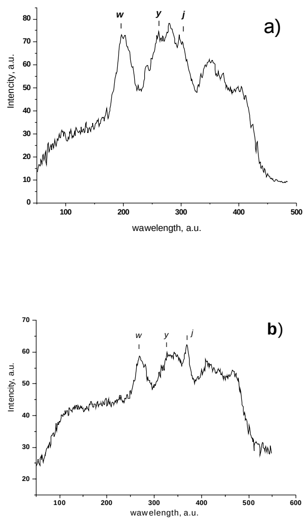


Fig.1 Spectra FeXXV in different orientation of crystal dispersion place

Substantial change of dielectronic satellite line ***j*** ($1s2p^2\ ^2D_{5/2}$ - $1s^22p\ ^2P_{3/2}$) intensity relative to resonance ***w*** ($1s2p^1P_1$ –$1s^2\ ^1S_0$) and intercombination ***y*** ($1s2p^3P_1$ –$1s^2\ ^1S_0$) lines was found for mutually perpendicular orientations of the crystal dispersion plane (fig.1) The conclusion about anisotropic electrons distribution on velocities in vacuum spark discharge was made. The intensities of spectral lines of FeXXV ions and dielectronic satellites as function of x-ray source location were researched. Main sources of x-ray are placed on discharge axis in local regions with radius less than 100 μm and high electron density and temperature. Quotion of intensities of resonance ***w*** and intercombination ***y*** lines was used to estimate the electron plasma density. Electron temperature was estimated by the relative intensity of resonance ***w*** and dielectronic satellite ***j*** lines. In our case, the maximum electron density $N_e \sim 10^{21}$ cm$^{-3}$ and temperature $T_e \sim 1$ keV were reached in a small plasma point (less than 100 μm ) located on distance about 1 mm from the anode. The obtained dependence of maximum plasma parameters during micropinch events from initial plasma line density in discharge corresponds to the radiative collapse model.

**P-9**

# METHODS IMPROVED CHARACTERISTICS OF LASER SOURCE OF IONS

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At present there are number of works devoted to the study of laser-produced plasma as a source of ions for the inertial confinement fusion [1] together with heavy ion accelerators and the systems on the base of powerful impulse of electrical charge, i.e. Z-pinches. Laser ion source (LIS) have been recently designed [2] to load the Heidelberg electron beam ion trap with a pulsed beam of lowly charged ions from solid elements. Due to many characteristics of laser-produced plasmas LIS takes advantages over e.g. a common metal vapor vacuum arc method [3] as a source of ions. Most of the studies of laser-matter interaction field have been carried out for the laser intensities ranging from $10^{12}$ to $10^{19}$ W/cm$^2$, where the interests were directed towards investigations of laser-fusion, x-ray lasers, shock-related phenomena etc. Not much attention was given to the low intensity part of the laser radiation ($10^{9}$-$10^{12}$ W/cm$^2$). However, this regime was shown to be very useful for the material scientists in the fields of material preparation e.g. of thin films of high-$T_c$ superconductors [4]. The laser pulsed-deposition technique shows considerable promise for the fabrication of such films. Many theoretical and experimental [5,6] works have been carried out in order to optimize the performance of the laser ion source and to determine important operating parameters such as the velocity, mass and charge-state distribution of the generated ion beam and plasma temperature.

In this work we discuss three methods to improve characteristics of laser source of ions, namely: i) the effect of the angle of interaction of laser radiation with targets on the plasma ions characteristics, ii) the use of targets of different concentration to improve the parameters of plasma ions, and iii) influence of laser frequency on the plasma parameters. Our study will be based on the analysis of mass-charge spectrum of laser-produced plasma ions in the range of laser intensity.

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**P-10**

# DEFECT STRUCTURE STUDIES IN NEUTRON IRRADIATED BE: POSITRON LIFETIME MODEL CALCULATIONS

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At present beryllium is a high priority material in the field of fusion technologies considered as one of major materials for first wall of the fusion prototype reactors ITER and DEMO [1-3]. .The neutron irradiation of beryllium leads to elastic and inelastic interaction of neutrons with the matrix atoms. In Be irradiated by high-energy neutrons the production rates of H and He by (n, p) and (n, α) reactions are much higher than those by low energy neutrons.

Modeling of irradiation effects in Be has been started with the mission to increased the understanding of radiation effects on the microstructure and the influence of neutron irradiation on its mechanical properties. The interactions of radiation defects with point and linear defects in metal lattice are of practical importance for the predicative models of mechanical behavior. The modern numerical methods of modeling are now able to explain many structural problems. The purpose of model calculation of positron lifetime in Be is to demonstrated that the properties of the material are compatible to ensure a reliable operation of the blanket.

Positron lifetime model calculations for pure Be samples and Be samples containing vacancies and vacancy-clusters (nano-voids), supported by the Local Density Approximation [LDA] and directed to better understanding of the mechanism of defect formation and their interaction with hydrogen and helium atoms. The work has coved also positron lifetime computer simulations for 14 MeV neutron irradiated Be samples, containing hydrogen and helium. The obtain results could be validated by positron lifetime and Doppler broadening of annihilation gamma-line measurements as well as an electron microscopy measurements.

**P-11**

# COMPARISON BETWEEN THE MAGNETIC FIELD RECONSTRUCTION AND THE TOMOGRAPHIC DIAGNOSTIC IN THE ISTTOK TOKAMAK USING THE 3D-MAPTOR CODE

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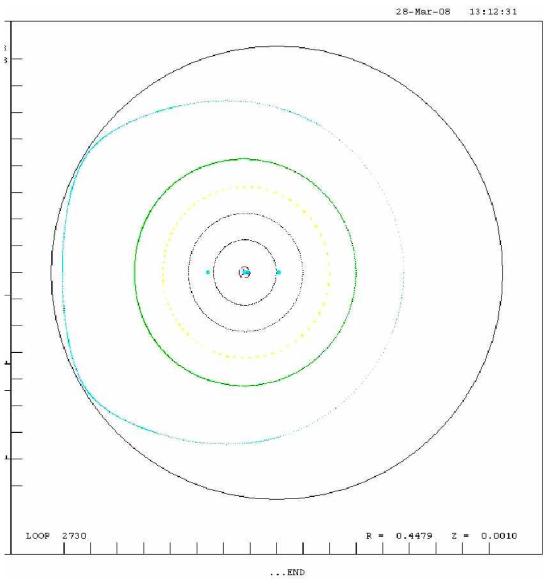
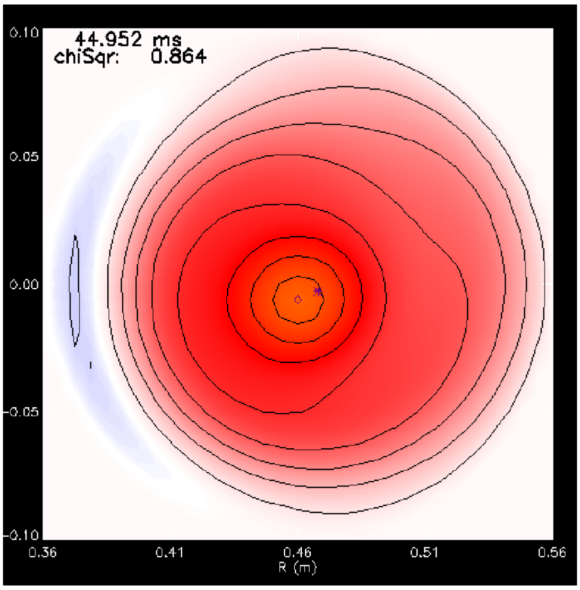
The 3D-MAPTOR code has been used in the past in order to reconstruct the magnetic field surfaces of the NOVILLO tokamak, in order to reconstruct the behaviour of the magnetic field surfaces in the ISTTOK tokamak. The currents of the toroidal magnetic field, the ohmic heating and vertical coils from shot No.16465 are taken into account, along with a suggested plasma current density profile. The results are compared with those of the visible tomographic diagnostic, which is currently used in order to control the plasma position during alternating current discharges. A qualitative agreement between both images can be appreciated.



**P-12**

# DESIGN AND FABRICATION A 2-D ARRAY MAGNETIC PROBE FOR MEASUREMENT OF MAGNETIC FIELDS IN IR-T1 TOKAMAK

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The effects of magnetic fields on the behavior of plasma have considerable importance, so knowledge of Tokamak cross-sectional magnetic fields are absolutely essential.

In this paper we have measured magnetic fields and their variation with a 2-D magnetic probe array in IR-T1 Tokamak in absence of plasma inside torus.

This array oriented in such a way that can measure magnetic fluxes due to the vertical, toroidal and ohmic magnetic coils in different positions. The detail of results will be discuss in full paper[1].

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**P-13**

# DAQVIEWER SOFTWARE TOOL FOR TOKAMAK KTM DATA VISUALIZATION AND OFFLINE PROCESSING

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DAQViewer software tool is devoted for fusion data visualization and analysis. Mainly developed for tokamak KTM control and data acquisition system [1] DAQViewer suitable for offline data visualization and analysis from wide range of fusion devices, using local data files in supported file formats or remote access software services. Currently, it can work with KTM fusion data in XFile format and fusion data in DASFile format [2] from T10, Globus, Castor and other devices. XFile format is designed for KTM CODAS as general format of transport files for data exchange between KTM digital control system, diagnostics, database and visualization software tools. DASFile format is supported for compatibility with DASPlus software tools such as DASSQL database [2].

DAQViewer provides carefully designed graphical user interface for fusion data visualization and analysis. Currently DAQViewer has been successfully tested and verified for operation with KTM CODAS and DASPlus software, including diagnostics data reading and preprocessing, diagnostics metadata analyzing, KTM CODAS data acquisition subsystems configuring, just as remote accessing to DASSQL database and local DASFile processing.

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**P-14**

# DATA ACQUISITION AND CONTROL SYSTEM OF MAGNETIC FIELD COILS POWER SUPPLY UNITS AT KTM TOKAMAK.

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Data acquisition and control system (DACS) of magnetic field coils power supply units is a part of KTM Control And Data Acquisition System (CODAS) [1]. DACS is used to control plasma parameters and to gather plasma parameters information for research purposes.

It consists of six control and data acquisition subsystems, one per a specific set of coils (PF1-2, PF3-6, PF4-5, TF, HFC, CS). Most of that subsystems participates in realtime plasma parameters control contour with control cycle times up to 3.3 ms. Every DACS subsystem runs a RTLinux realtime OS and a special software complex for data acquisition and control on a x86 architecture based single board computers.

DACS subsystems computers stores acquired data at XFile format, that was developed in Tomsk Polytechnic University as general file format for data exchange between KTM digital control system, diagnostics, database and visualization software tools. After the shot, the data files acquired are transmitted to the KTM CODAS data server to be further processed. Such a system design leads to a satisfactory response time with affordable system price and provides a good flexibility of data preprocessing and control algorithms modification.

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## P-15

# MEASUREMENT OF PLASMA DISPLACEMENTS BY SINE-COIL AND MIRNOV COILS IN THE IR-T1 TOKAMAK

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A method for the measurement of the plasma position in the IR-T1 tokamak in toroidal coordinates is developed. A sine-coil, which is a Rogowski coil with a variable wiring density is designed and fabricated for this purpose. An array of Mirnov coils employed for measurement of plasma position. An analytic solution of the Biot–Savart law, which is used to calculate magnetic fields created by toroidal plasma current, is presented. Results of calculations are compared with the experimental data obtained in no-plasma shots with a toroidal current-carrying coil positioned inside the vessel to simulate the plasma movements. In both techniques plasma position calculated and compared. The results are shown a good linear behaviour of plasma position measurements in both techniques. But results of sine coil had less errors with respect to Mirnov coils experiment.

## P-16

# COMPARING PLASMA PARAMETERS WITH AND WITHOUT FEEDBACK CONTROL SYSTEM IN IR-T1 TOKAMAK

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The negative feedback control system of horizontal displacement is designed to balance plasma and improve the quality of discharge and physics diagnoses. The situation with feedback control in compared to the situation without feedback, the negative feedback control shows some important merits:

- It helps to reduce the displacement of plasma from the set position and helps different diagnosis on Tokamak.
- It helps to improve the condition of plasma confinement time in Tokamak and also t increase the plasma duration and repetitive discharge.

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