COORDINATED RESEARCH PROJECT (CRP), IAEA

TITLE OF CRP: "INTEGRATED APPROACH TO DENSE MAGNETIZED PLASMA APPLICATIONS IN NUCLEAR FUSION TECHNOLOGY"

Background Situation Analysis (Rationale/Problem Definition)

The purpose of the present CRP is to plan and coordinate DMP activities that will address **relevant technology** and **materials issues** that need to be urgently investigated contributing to the knowledge pool of **mainstream fusion research**

The construction phase of large fusion facilities is in visible progress - **Iter** (France), the **Laser Mega Joule** (LMJ, France) and **National Ignition Facility** (NIF, United States of America)

These recent developments in fusion pave a clear *path for the forthcoming physics and technology* research activities, which are still required for the successful construction and operation of a **DEMO** fusion power plant

It is evident now, that to demonstrate feasibility of fusion energy the worldwide effort will be concentrated on **two basic fusion concepts**, namely, the **magnetic**, and the **inertial**, fusion confinement approaches

The scientific community is well aware of the level of complexity of the fusion energy problem that require intensive research efforts

Many of the basic problems to be investigated and solved urgently **are common or are similar for both fusion approaches**

Of critical importance is for instance the development of **new materials** capable to withstand the extreme radiation and heat loads expected in fusion reactors of both types

The applications of the **Dense Magnetized Plasma (DMP)** devices proposed for this CRP address problems that are of significant importance for the fusion research, in particular, **testing of materials** to be used in experimental reactors, **diagnostic methods of fusion products** necessary to monitor a reactor performance, etc.

On the other hand, **new needs imposed by mainstream fusion research** will stimulate **technological development of DMP devices** that will bring additional spin-offs in various other DMP application areas (medicine, biology, material science, etc.)

For the DMP community the new CRP, being a joint activity of many teams, will promote **technology transfer and expertise exchange** between developed and developing Member States

It will be an umbrella to attract the participation of young scientists, support the realization of common experiments carried out in modern laboratories, exchange of results as well as diagnostic equipment all in whole being important factors of capacity building especially beneficial for the participant teams from developing Member States

For the future, the *most promising applications of DMPs* that can contribute for solving scientific and engineering problems in support of fusion research are as follows:

Magnetic confinement

Nanosecond time resolved **testing and calibration of D-D and D-T neutron diagnostics**

Testing bench for charged fusion products diagnostics

Compact neutron sources for use in **characterization of neutron fields and cross-calibration of MCNP codes**

Tests of fusion candidate materials under transient heat loads

Test of **plasma facing and construction materials** under plasma and fusion products fluxes

Fuelling systems

Development of **plasma sources for fusion applications**

Inertial Confinement

Nanosecond time resolved **testing and calibration of D-D and D-T neutron diagnostics**

Testing bench for **charged fusion products diagnostics**

Compact neutron sources for use **in characterization of neutron fields and cross-calibration of MCNP codes**

Investigate the possibility to develop the PF technology to perform experiments **for lithium blanket concepts under representative pulsed neutron fluxes**

Test of **plasma facing and construction materials** under plasma and fusion products fluxes

Applications of DMP as **intense x-ray sources (backlighting, pellet ignition, etc.)**

DMP as source for **proton radiography for hohlraum characterization**

The particular features of DMPs that are advantageous for addressing the above listed research areas are:

- Very high efficiency of the **sources of fusion products and ionizing radiation** (neutrons, X-rays, streams of ions, electrons and various plasmas)
- **Scalability** to fit various demands
- Relatively **low cost, compactness and flexibility**
- PAs and PFs are the only small-scale devices that **can produce sufficiently powerful plasma streams** with many similar characteristics of the loads occurring in fusion reactors
- DMPs are intended to be used for **testing fusion plasma facing materials** under plasma streams and radiation loads (heat), investigate interactions of 14 MeV neutrons with several elements (lithium, boron, beryllium) and many others

Activities: The CRP will implement its program mainly through awarding of **contracts** or **agreements** of MS proposals. Several coordination meetings will take place to plan and coordinate individual and joint activities. The past experience will be transferred into this CRP in particular developing the **Individual Activity Matrix (IAM) and the Joint Activity Matrix (JAM)** during the first RCM

The development of a **database** to include characteristics of the testing devices, material types and results of tests **is crucial** for keeping track of the developments, to plan following-up experiments and to spread the results to the users. In addition to the direct research activities it is foreseen the realization of **joint experiments, workshops, expert meetings and schools**

These activities would help **to share** equipment, exchange expertise, plan new activities from the broader community

Regular publication of the results is expected and in addition **two special issues** are expected to be published in a peer reviewed scientific journal **after the third and fifth years** of the CRP

Action plan for CRP coordination

	Year 1	Year 2	Year 3	Year 4	Year 5
Assessment/Implementation of Dense Magnetized Plasma Applications					
Assessment of possibilities					
Requirements and planning					
R&D					
Update Status Report					
Dense Magnetized Plasma Technology Improvements					
Identify and Study Areas of Development					
Requirements and planning					
R&D					
Update Status Report					

Countries and International Organizations with DMP Activities

AAAPT*
Argentina
Chile
China
Czech Republic
Egypt
Estonia
Korea, Rep. of
France
Germany
Iran, Isl. Rep.
ICDMP**
ICTP***
India
Italy
Japan
Malaysia
MPS****
Mexico
Poland
Russia
Singapore
Thailand
United Kingdom
USA

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* Asian-African Association for Plasma Training (Singapore)

** International Center for Dense Magnetized Plasmas (Warsaw, Poland)

*** International Center for Theoretical Physics (Trieste, Italy)

**** Moscow Physical Society (Moscow, Russia)

The commitment of **the chief scientific investigators** will be essential for the successful achievement of the objectives; all of the scientific organizations involved will have to **ensure the progress and deliver tangible outputs** of their individual activities and engage in a networking approach with their partners and also in a broader context with external institutions

It is assumed that selection of contracts to award can be based fundamentally on the relevance of the proposals for the aims of the CRP while keeping at the possible extent a geographical and technical balance

It is assumed that the **tokamak and inertial fusion communities** will facilitate **collaborative links** with the DMP community to help to plan and design representative experiments. Five years will be required for the successful completion of the project

Support of mainstream fusion research

To design and provide representative tests for fusion candidate materials (first wall, divertor, others) - beryllium, tritium, others

To provide tests and calibration for fusion product diagnostics and MNCP codes

To develop powerful soft and hard pulsed X-Ray sources for fusion applications

To investigate basic processes in support of fusion technology (e.g. breading blanket, plasma fuelling, etc.)

To develop tools and methods of radiography utilizing neutron and proton beams

Development of DMP technology

Repetition rate and **discharge optimization**

To **develop diagnostics** for characterization of impinging radiation on material test samples

Components improvement for **costs reduction**

Improve the **measurements of transient phenomena** (ps to ns range)

Development of safe low-cost technology to perform **tritium-deuterium fusion discharges** for utilization as a source of 14-MeV neutrons

To improve characteristics of dense plasma sources used in high-energy **ion accelerators for applications in large fusion devices**

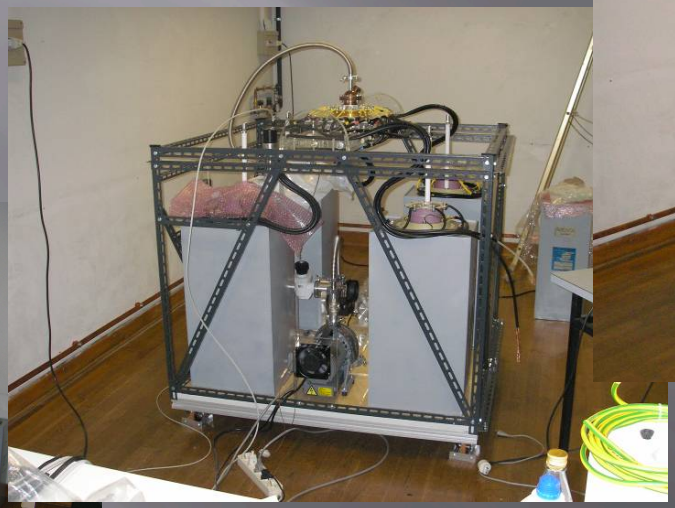
The previous IAEA CRP on this topic helped to build **a network of DMP laboratories** with improved technology and research capability that is **ready to be applied in many topics of mainstream fusion research**

The purpose of the present CRP is to plan and coordinate DMP activities that will address relevant **technology and materials** issues that need to be **urgently investigated contributing to the knowledge pool of mainstream fusion research**

Relations to Previous CRPs: F13009: Dense Magnetized Plasmas, completed in 2007

Project Officer: Artur Malaquias

Dense Plasma Focus at ICTP

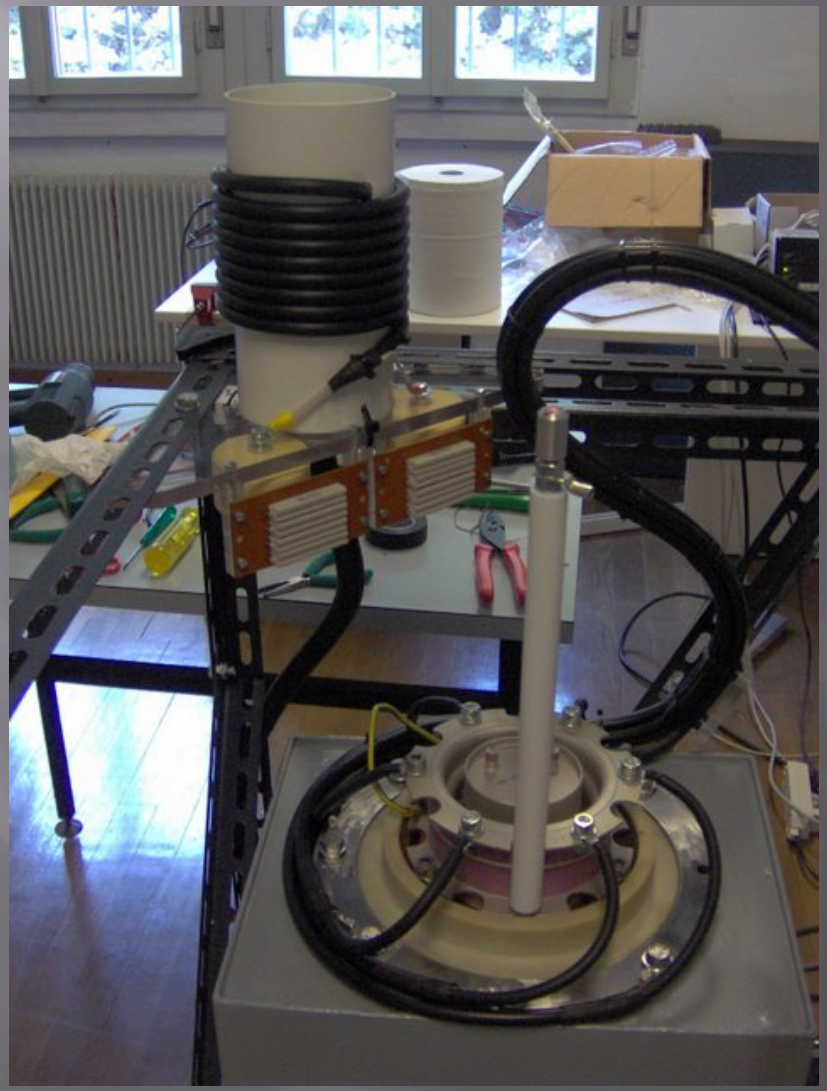


Transportable device at ICTP:

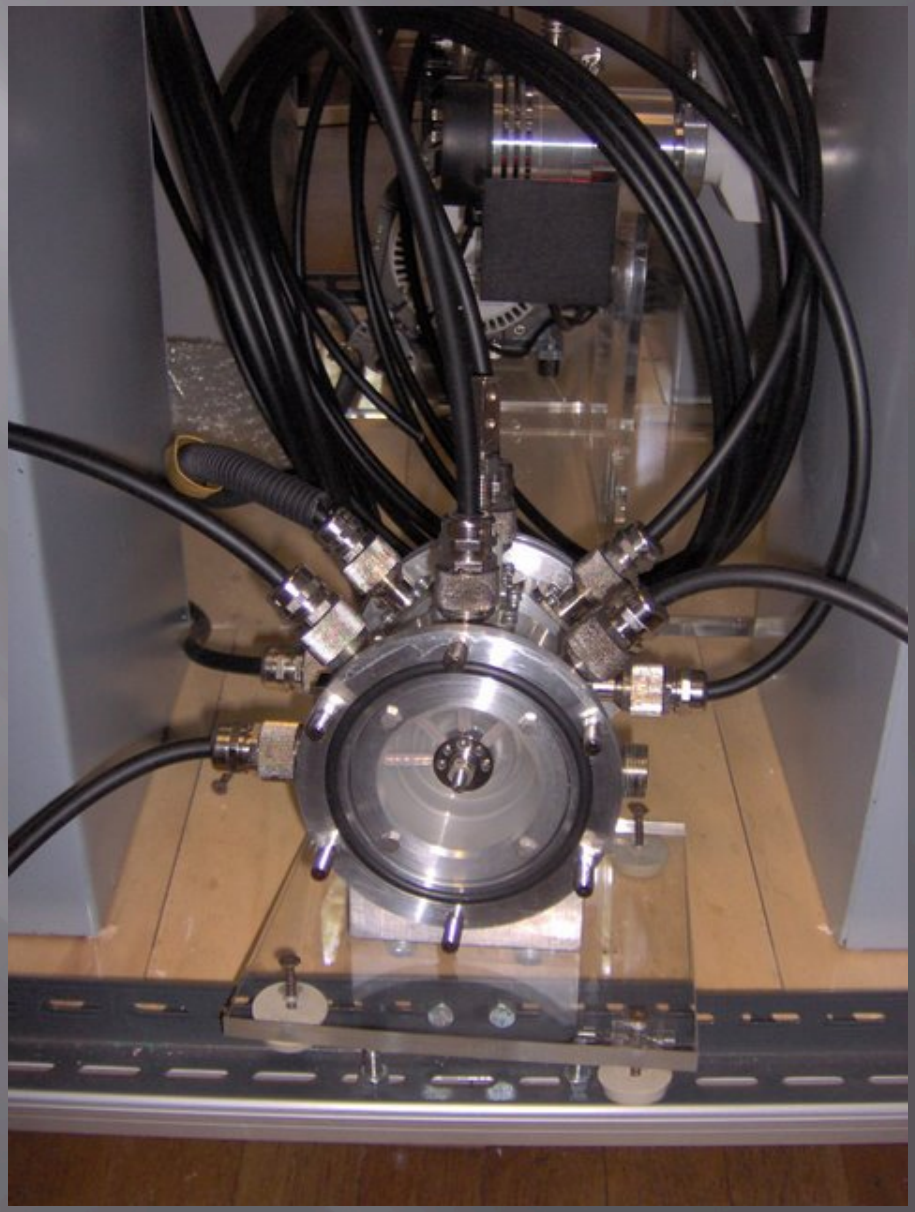
5 кДж, assembling stages

DPF chamber optimized for hard X-Ray radiation

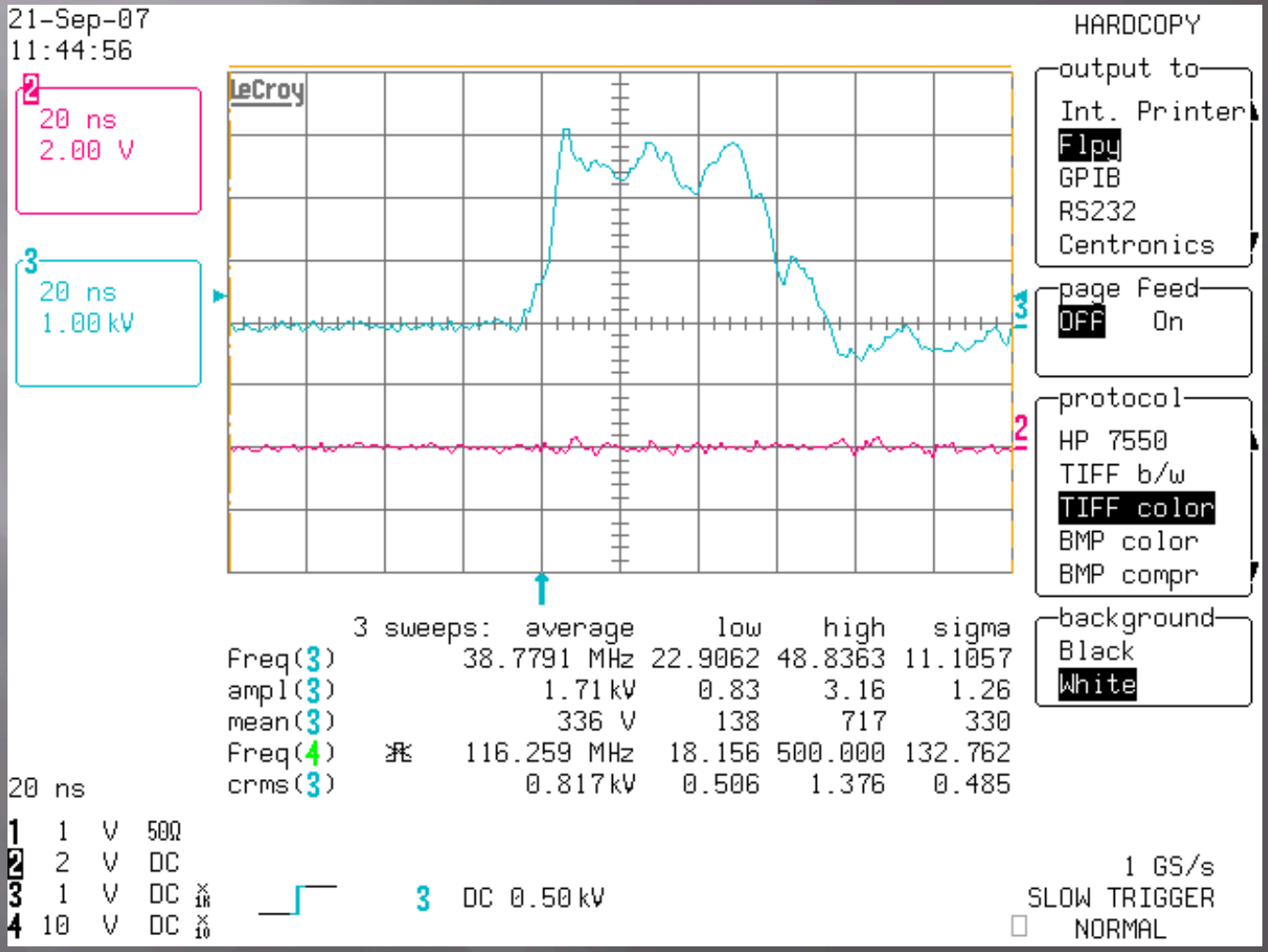
Capacitor, pseudospark and auxillaries



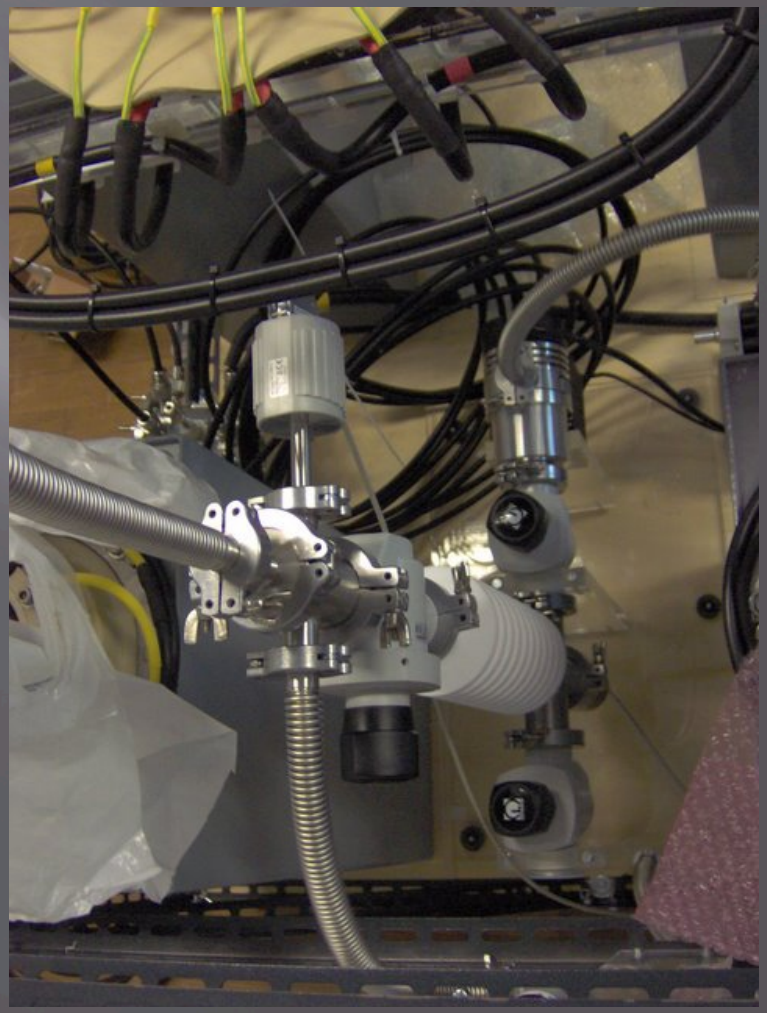
Master spark



Tests of the trigger pulse High-voltage probe (LeCroi, 1/1000, 100 MHz, up to 40 kV)



Pumping systems



THANK YOU