# FusionCanada

Bulletin of the National Fusion Program

Issue 21, August 1993

in this issue





ISSN 0835-488X

CANADA - ITER

## Canadian Participation in ITER EDA

The European Community has proposed to the four Parties of the International Thermonuclear Experimental Reactor (ITER) that Canada's National Fusion Program should become a contributor, via Europe, to the ITER Engineering Design Activities (EDA). ITER's supervisory bodies, including the governing ITER Council, have received Europe's proposal favourably. The four Parties in the ITER EDA are Europe, Japan, the USA and the Russian Federation.

The participation in the ITER EDA of other countries beside the four Parties is allowed under Article 19 of the EDA Agreement, which states in part that such other countries should possess relevant specific capabilities, and may only be involved in ITER through one of the four Parties.

Discussions between Europe and Canada are nearing completion for Canada to become involved in Europe's contributions to the ITER EDA. The arrangement will take the form of an Canada-Europe Implementing Agreement on ITER, under the general framework of a Canada-Europe Memorandum of Understanding (MoU) for cooperation in the field of controlled nuclear fusion. Canada participated in the earlier ITER Conceptual Design activities (1988 - 1990) through a similar arrangement with Europe.

Europe first tabled its proposal concerning Canada's ITER involvement at the December 1992 meeting of ITER's Management Advisory Committee (MAC) in Naka, Japan. The MAC gave its approval of Europe's proposal at its March 1993 meeting in Garching, Germany. In a report presented to ITER Council at its April 21-22 meeting in Garching, the MAC noted that Europe's proposal on Canada's involvement in ITER is appropriate in terms of Canada's fusion capabilities. The ITER Council is ITER's senior governing body. At the same April meeting, ITER Council endorsed Canada's prospective involvement in ITER. Europe will submit a formal proposal concerning Canada to ITER Council, following completion of the Canada-Europe Implementing Agreement on ITER and the overlying Europe-Canada MoU on fusion cooperation.

The ITER EDA work, to be completed in 1998, is intended to produce a buildable design for a working fusion reactor capable of 1,000 - 3,000 megawatts of fusion power. ITER might cost about US$5 - $6 billion to build; the actual construction cost will be updated during the EDA as the design advances. A country and site for building the ITER reactor should be chosen by late 1996.

*More information from Bill Holtslander, NFP Manager - International Program (See Contact Data).*

TRITIUM SUPPLY

## Tritium for JET

### Ontario Hydro to supply 90 grams of tritium to JET

Ontario Hydro has concluded an agreement with the Joint European Torus (JET) in Abingdon, England, under which Ontario Hydro has contracted to supply JET with up to 90 grams of tritium (about 900,000 Curies), between now and the end of 1996. The agreement, completed in March this year, includes a provision that Ontario Hydro will take back tritium from JET at the end of the project. Under local planning approval, the JET site is to be returned to 'green field' conditions, and no radioactive material may remain on the site beyond a specified time. Some of the tritium returned to Canada will be in the oxide form as tritiated light water. CFFTP will coordinate the take-back operations on behalf of Ontario Hydro.

Ontario Hydro also has an agreement with Kernforschungszentrum Karlsruhe GmbH (KfK) in Germany to supply up to 200 grams of tritium over 10 years for the new tritium laboratory at KfK (see FusionCanada 16, January 1992). Together, the tritium supply contracts for JET and KfK will earn export revenues well in excess of 5 million dollars. Ontario Hydro also supplies tritium for pharmaceutical research and to Canadian manufacturers of self-luminous lighting.

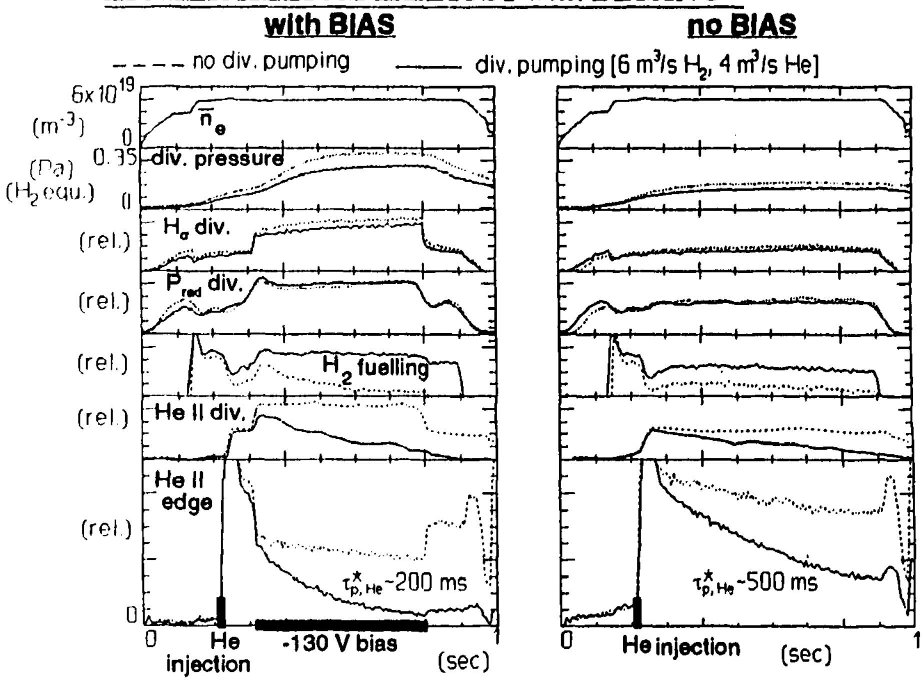
*continued inside*

## Plasma Helium Exhaust

## CCFM/TdeV

Significant pumping of helium from TdeV plasmas has been demonstrated recently via TdeV's divertors. These graphs, from recent TdeV experimental data, show how plasma biasing and cryogenic divertor pumping can increase the rate of helium exhaust from the TdeV plasma edge. This bleed rate for helium steadily reduces helium levels in the main plasma. The TdeV results indicate that helium control via divertors in fusion reactors may indeed be feasible with good divertor performance. This work is a continuation of TdeV's pioneering demonstrations in 1992 that divertors can be used to pump helium permanently from tokamak plasmas, and today TdeV remains the only divertor tokamak to have demonstrated helium pumping.

***HIGHER HELIUM EXHAUST with BIASING***




Helium was injected into TdeV in measured quantities to monitor its movement in these trials. With biasing and cryogenic divertor pumping, the evacuation time of helium ions from the main plasma to the active divertor was only about 20 times the energy confinement time of TdeV. By contrast, a fusion reactor would require a relative helium evacuation rate of about a factor of two better than this pumping performance (i.e. a helium evacuation time of about 10 times reactor energy confinement time) to avoid undesirable helium buildup in the reactor main plasma which could quench the fusion reaction by dilution.

The bottom graphs, left and right, during a plasma biasing pulse of 0.5 seconds at -130 V, show that a combination of biasing and divertor pumping reduced plasma edge helium concentrations on TdeV by a factor of about six or seven, compared with the case of no biasing and no divertor pumping. Solid-line graphs indicate results with divertor pumping; broken line graphs indicate absence of pumping. Graphs on the right side show results with no biasing. The **He II div.** graphs show helium pressure in the active divertor. Biasing increases helium divertor pressure (and hence retention) with no pumping. Divertor pumping draws down the divertor helium pressure with or without plasma biasing, indicating helium exhaust via the pumps.

*More information from Brian Gregory (514) 652-8729 or Réal Décoste (514) 652-8715, Fax (514) 652-8625.*

**CCFM - Centre canadien de fusion magnétique**

## TdeV Update

After the Spring maintenance shutdowns, TdeV began another 10 week experimental program at the beginning of July. Highlights of this program include:

- Extensive plasma edge investigations, including items such as correlations between edge parameters and divertor behaviour, and correlations between impurity flow and bulk ion flow.
- Lithium deposition experiments in TdeV, to assist TFTR at Princeton by measuring hydrogen isotope absorption in lithium deposited on the plasma chamber wall. This data will be useful in TFTR's forthcoming deuterium-tritium fuelled plasma shots, to help Princeton assess tritium quantities retained by lithium wall coatings.
- Further investigation of helium pumping from the plasma via the divertors.
- Study of plasma biasing from inside the plasma separatrix (the plasma's outermost closed magnetic flux surface) with a probe electrode.
- Divertor physics and operational trials, including divertor region radiation and plate heat flux measurements, and plasma impurity retention.

Installation and RF power testing of the 1 MW, 3.7 GHz lower hybrid current drive (LHCD) system is well advanced. The LHCD system is designed to drive TdeV's full 250 kA plasma current by itself. The multijunction LHCD microwave antenna will be installed on TdeV in the autumn. It is hoped to be injecting up to 1 MW of RF heating and current drive before the end of the year. A new and impor-

TRITIUM SUPPLY

# Tritium for JET

*continued*

JET will use the tritium from Canada in an extended series of deuterium-tritium (DT) fuelling operations in the JET tokamak fusion research machine. Significant amounts of fusion power are expected to be generated on a physics demonstration basis. These DT tokamak experiments are currently scheduled to take place throughout 1996. Deliveries of tritium may begin as early as Spring 1994 so that JET fuel cycle systems and tritium processing and storage facilities may be brought to needed tritium inventory levels and commissioned at operational flow rates.

JET has already been fuelled with DT for some tokamak shots in late 1991, when it produced a peak fusion power of about 2 MW for about 2 seconds. At present, JET is shut down for extensive modifications including installation of single-null divertor. JET tokamak experiments are scheduled to resume at the end of this year with deuterium fuel. The tritium will be supplied from Ontario Hydro's Darlington Tritium Removal Facility (DTRF). By June this year, tritium yield to date from this facility totalled 5.7 kg. Uninterrupted tritium yield rate for the DTRF is 2.5 kg per year.

AECL's Chalk River Laboratories support Ontario Hydro in tritium distribution. AECL recently licensed a shipping container to carry 50 grams of tritium on a titanium storage bed, so that large quantities of tritium can be shipped to Chalk River from the Darlington TRF. On behalf of Ontario Hydro, AECL repackages the bulk tritium for distribution in smaller quantities. AECL designed and built the 50 gram shipping container, which has been granted a type B(U) license. This container, with its U=Universal license designation, can be used for international shipments.

*More information from Bill Meeker or Gwen Keene at Ontario Hydro International, (416) 506-4949 or -4936 , Fax (416) 506-4684, or from Mike Ward, AECL Research Company (613) 584-3311 ext. 1663.*

ITER/Next Step

# Industry Qualification for EC ITER R&D

In anticipation of Canada's involvement with Europe's contributions to the ITER EDA, Canada was invited by Euratom earlier this year to submit names of Canadian companies capable of participating in the Technology R&D Tasks of the ITER EDA to be undertaken by Europe. Euratom has defined 15 key technologies for the Next Step in fusion reactor development. Here, Next Step refers to a burning plasma fusion machine such as ITER or NET. For each key technology, Euratom is establishing a list of suitably qualified industrial concerns to undertake R&D tasks. The lists would be used by the Euratom Home Team Leader when tendering for ITER EDA Technology R&D Tasks. Pending completion of Europe-Canada arrangements for Canada's involvement in Europe's ITER contributions, Euratom intends to include approved Canadian companies in these lists, subject to a qualification process. On behalf of Canada, CFFTP nominated the following companies, and coordinated submission to Euratom of their technical credentials:

**Vacuum Vessel, Shield and Blanket:**

*Vessel Shield Models:*
CANATOM, Inc.
Montréal, Québec
Contact: Tom Gellatly (514) 288-1990, Fax (514) 289-9300

CANATOM Subcontractor resources: Spectrum Engineering Corp., AECL CANDU, NUMET Engineering Ltd.

*Blanket Segment Models:*
Spectrum Engineering Corp.
Peterborough, Ontario
Contact: Jack Richman (705) 743-7520, Fax (705) 743-9878.

Spectrum Subcontractor resources: CANATOM, Inc., AECL CANDU, AECL Research, Numet.

**Remote Handling Equipment**

*Qualification of Standards and Tools; Transporters and End Effectors:*
SPAR Aerospace Ltd.
Brampton, Ontario
Contact: Brian Fuller (416) 790-4439, Fax (416) 790-4400.

SPAR Subcontractor resources: General Electric Canada Inc., AECL CANDU, Wardrop Engineering Inc., Spectrum, Numet, Vadeco Int'l Inc.

**Fuel Cycle**

*Components for Tritium Handling, Shipping and Atmosphere Detritiation:*
Ontario Hydro, Toronto, Ontario
Contact: Sav Sood (416) 592-5501, Fax (416) 592-4483

Ontario Hydro Subcontractor resources: AECL CANDU, AECL Research, Wardrop, Spectrum, Numet.

**Plasma Engineering:**

*High Frequency (radiofrequency) Transmission Lines:*
MPB Technologies Inc.
Dorval, Québec
Contact: Dr. Guy LeCLair (514) 652-8743, Fax (514) 683-1727.

*More information from Gary Vivian CFFTP (416) 855-4733, Fax (416) 823-8020, or from Bill Holtslander, NFP (See Contact Data).*

Yoshida thought could be suitable for atmospheric detritiation, hydrogen isotope separation, hydrogen-oxygen recombination and other duties in the ITER fuel cycle.

Dr. Valeri Chuyanov (left front), Deputy Director - ITER Joint Central Team, pauses for a photograph with Dr. Hiroshi Yoshida (centre front) during their visit to AECL Chalk River Laboratories in June. Drs. Chuyanov and Yoshida made a one week tour in June of Canadian fusion and nuclear sites. They are escorted here by Bill Holtslander (right), National Fusion Program Manager - International Programs, and by Peter Allsop (at back) of Chalk River's Tritium Technology Group.

**INTERNATIONAL**

# IEEE Award of Merit for Akira Hirose

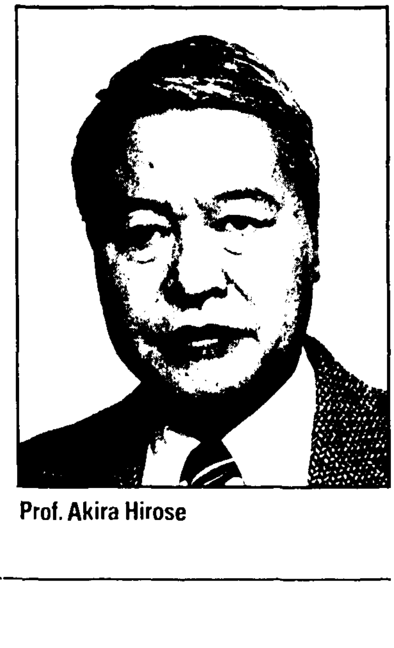
The Nuclear and Plasma Sciences Society of the IEEE (Institute of Electrical and Electronic Engineers) has presented Prof. Akira Hirose with its 1993 Merit Award for his contributions to plasma science. Prof. Hirose is leader of the Plasma Physics Group at University of Saskatchewan. The IEEE Merit Award - given rarely, only to those of exceptional merit - was presented to him in Vancouver on June 7, at the 20th IEEE International Conference on Plasma Sciences.

The Merit Award citation commends Prof. Hirose: "For pioneering contributions to the understanding of linear waves, instabilities, and turbulent heating in plasmas, and confinement studies of tokamaks."

Prof. Hirose was nominated for the Award by Karl Lonngren (Univ. of Iowa) and Brian Gregory (CCFM/INRS). His contributions to plasma science span many years, dating back to his Master's program on current driven ion acoustic instability. He is known as an excellent theoretician as well as a talented experimenter - an uncommon combination. As well as his many theoretical interests, Akira Hirose and his Saskatchewan group are experimentally investigating Ohmic H-modes, magnetic fluctuations in tokamak plasmas, anomalous thermal diffusivity and compact toroid fuelling, among other topics. He designed Saskatchewan's STOR-M tokamak and supervised its construction.

Among his numerous past and present advisory and committee posts in plasma science, Akira is a member of the Advisory Committee for Centre canadien de fusion magnétique. He is an editorial advisor for IEEE Transactions in Plasma Science, and for Canadian Journal of Physics.

*Prof. Akira Hirose can be contacted at University of Saskatchewan Physics Dept. (306) 966-6414, Fax (306) 966-6400.*



Prof. Akira Hirose

tant diagnostic is to be fitted on TdeV in October for measuring the electron velocity distribution of LHCD-driven plasma current. This instrument - an Electron Cyclotron Transmission device - was designed and built by University of Maryland in collaboration with CCFM.

*Further information from Réal Décoste (514) 652-8715 or Brian Gregory (514) 652-8729, Fax (514) 652-8625.*

**INTERNATIONAL**

## NFP Director Selected as IFRC Chair

Dr. David Jackson, Director-National Fusion Program, was selected to chair the International Fusion Research Council (IFRC) of the International Atomic Energy Agency (IAEA), at the Council's July 8 meeting in Vienna.

The IFRC advises the IAEA Director General on the Agency's coordinated fusion research programs and matters such as fusion-related conferences, workshops and publications.

**CFFTP - Canadian Fusion Fuels Technology Project**

## ITER-related R&D Programs at CFFTP

The Canadian Fusion Fuels Technology Project (CFFTP) is Canada's coordinating centre for ITER-related technology R&D. CFFTP's own fusion technology development R&D programs are influenced by the technology needs of next step machines such as ITER. Included in CFFTP's 1993 R&D programs are projects addressing technology areas identified by Europe as being relevant to ITER and other next step machines. The scope of CFFTP's 1994 program content will be verified when the level of CFFTP's 1994 funding - which is at present being negotiated - has been determined. Elements of CFFTP's 1993 programs relevant to next step machines include:

**Fuel Cycle**

- Reactor torus exhaust processing
- Minimization of tritium inventory
- Isotope separation system design code development
- Detritiation processes
- Common fuel processes such as tritium monitoring and accounting, and tritium transportation.

**Remote Handling Equipment**

*Transporters and End Effectors*

- Radiation hardened multiplexer for robotics control systems
- Blanket handling devices
- Fibre optics

*Standards and Tools*

- Remote weld inspection technology
- Common Subsystems and tests

**Vacuum Vessel, Shield and Blanket**

- Design and testing of shield and driver blanket
- Cooling System design
- Water radiolysis

**Plasma Facing Components**

- Beryllium properties
- Doped graphites
- Hydrogen isotope retention in refractory metals
- Divertor heat transfer
- Divertor probe

**Safety and Environment**

- Operational safety assessment
- Reference accident consequences
- Probabilistic safety studies
- Integrated safety analyses

*More information from Gary Vivian, CFFTP, (416) 855-4733, Fax (416)823-8020.*

**ITER**

## ITER Deputy Director Chuyanov Tours Canadian Centres

Valeri Chuyanov, Deputy Director of the ITER Joint Central Team, visited Canadian fusion and nuclear power centres on a familiarization visit during June 1-5. He was also visiting Canada to attend the IAEA technical meeting on fusion safety held in Toronto June 7-11. He was accompanied on his Canadian tour by Hiroshi Yoshida, Tritium Plant Group leader, ITER Naka Co-centre. The tour was hosted by CFFTP.

Dr. Chuyanov visited the fusion and fission sites in order to familiarize himself with Canada's fusion and nuclear power programs, its nuclear science and technology infrastructure, and Canada's fusion-relevant technology capabilities. Since Canada intends to contribute to ITER in association with the European Community, Dr. Chuyanov took the opportunity to assess at first hand the scope of Canadian nuclear and fusion capabilities. The sites visited were CFFTP, the Bruce nuclear power plant site, AECL Chalk River Laboratories, the Darlington Tritium Removal Facility, SPAR Aerospace and Ontario Hydro Research Division.

After his one-week tour, Dr. Chuyanov remarked that he was surprised and impressed that Canada, with a relatively small population (30 million) had built a completely self-contained nuclear industry of excellent capability. He felt that Canada could indeed make valuable contributions to ITER. He said that he could see immediate possibilities for applications in ITER of some of the technologies he encountered in Canada. For example, he was interested in a hydrophobic catalyst, developed at AECL's Chalk River Laboratories, which both he and Dr.

# NEWS NOTES

**CFFTP Annual Report.** This report is now available at no charge by contacting Janine Loring at CFFTP (416) 855-4710, Fax (416) 823-8020. The report describes CFFTP R&D and applications projects for the period April 1992-March 1993.

**Basic Tritium Safe Handling Course.** The 1993 offering of this course will be held October 18-23 at AECL Chalk River Laboratories. The course is suitable for persons at fusion and tritium facilities, and may be of interest to those interested in environmental aspects of tritium, or those interested in nuclear and tritium facility decommissioning. The course involves some hands-on tritium laboratory work, and lectures on health effects and environmental behaviour of tritium. For registration information contact Maryann Zito, CFFTP, (416) 855-4701, Fax (416) 823-8020.

**TFTR Tritium Monitors.** This year, CFFTP together with a group of Canadian laboratories and companies has designed and supplied a set of tritium process monitors to Princeton for the TFTR tokamak. The monitors will measure tritium recovered from the TFTR torus exhaust and stored on molecular sieve beds. Tritium accounting will be an important function of the new tritium monitors. CFFTP performed the project integration for this work. The design and construction were done by Ontario Hydro Research Division, University of Toronto, Qualprotech, Inc. and Torrovap Industries. More information from Ron Matsugu, CFFTP, (416) 855-4727, Fax (416) 823-9644.

**Lithium Titanate Solid Breeder.** Pursuing their continued research into lithium titanate as a candidate solid breeder ceramic, CFFTP and AECL Research are preparing for in-reactor irradiation tests of lithium titanate ceramic. The tests should begin late this year in AECL's NRU reactor, as part of the CRITIC II breeder irradiation program. For fabricating the titanate ceramic, CFFTP is obtaining from Oak Ridge a quantity of lithium depleted in Li-6; the batch being purchased is 98.4% Li-7. For lithium ceramic irradiation tests in thermal fission neutron spectra, it is desirable to have a reduced Li-6 content so that tritium-producing neutron/Li-6 reactions take place throughout the lithium ceramic sample and are not concentrated near the sample surface.

## National Fusion Program

Director, *Dr. David P. Jackson*

The National Fusion Program (NFP) coordinates and supports fusion development in Canada. NFP was established to develop Canadian fusion capability, in industry and in research and development centres. NFP develops international collaboration agreements, and assists Canadian fusion centres to participate in foreign and international projects.

NFP is managed for Canada by Atomic Energy of Canada Limited. Federal funding is provided by the Department of Energy, Mines and Resources through the Panel on Energy Research and Development.

## 'FusionCanada' Bulletin

'FusionCanada' is available free to interested persons. It is published four times each year, in French and English editions. Write to NFP Office, 'Bulletin Subscriptions' (see Contact Data). Please specify French or English edition, (or both if desired), and number of copies if several are required.

Editors are invited to freely use or reprint items from 'FusionCanada'. Please credit 'FusionCanada' and National Fusion Program of Canada. Please also send to the NFP office a copy of the publication, or a proof or copy of the printed piece.

# Contact Data

**National Fusion Program**

National Fusion Program
AECL Research
Chalk River Laboratories, Keys Centre
Chalk River, Ontario
Canada K0J 1J0

Program Office: (613) 584-8036
Fax: (613) 584-4243

Dr. David Jackson
Director – National Fusion Program
(613) 584-8035

Dr. Charles Daughney
Manager – Magnetic Confinement
(613) 584-8037

Dr. Gilbert Phillips
Manager – Fusion Fuels
(613) 584-8038

Dr. William Holtslander
Manager – International Program
(613) 584-8039

**CCFM**
**Centre canadien de fusion magnétique**

CCFM
1804, montée Ste-Julie
Varennes, Québec
Canada J3X 1S1

Dr. Richard Bolton
CCFM Director-General
(514) 652-8701

Dr. Réal Décoste
CCFM Director-Operations
(514) 652-8715

Dr. Brian Gregory
CCFM Director-Research
(514) 652-8729

Secretariat: (514) 652-8702
Fax: (514) 652-8625

**CFFTP**
**Canadian Fusion Fuels Technology Project**

CFFTP
2700 Lakeshore Road West
Mississauga, Ontario
Canada L5J 1K3

CFFTP Program Manager
Dr. Donald Dautovich
(416) 855-4700

Enquiries: (416) 855-4701
Fax: (416) 823-8020

**FusionCanada Office**

Macphee Technical Corp.
80 Richmond Street West
Suite 1901
Toronto, Ontario
Canada M5H 2A4

Telephone: (416) 777-1869
Fax: (416) 777-9804

Ce Bulletin est aussi disponible en français

**Printed in Canada on recycled paper**