ISSN 0915-633X

NATIONAL INSTITUTE FOR FUSION SCIENCE

H^- Ion Source Using a Localized Virtual Magnetic Filter in the Plasma Electrode: Type I LV Magnetic Filter

Y. Oka, O. Kaneko, K. Tsumori, Y. Takeiri, M. Osakabe,
T. Kawamoto, E. Asano, and R. Akiyama

(Received - Oct. 15, 1999)

NIFS-622 Dec. 1999

RESEARCH REPORT
NIFS Series

NAGOYA, JAPAN

H^- ion source using a localized virtual magnetic filter in the plasma electrode: Type I LV magnetic filter.

Oka, Y., Kaneko, O., Tsumori, K., Takeiri, Y., Osakabe, M.,
Kawamoto,T., Asano, E., Akiyama, R.

National Institute for Fusion Science, Toki-city, Gifu-prefecture, 509-5292, Japan

(Presented on 10 September 1999)

Abstract

A new multicusp H^- ion source using a Localized Virtual magnetic filter of type I [Ref.6] in the plasma electrode is investigated. A multipole (MP) arrangement with a spacing of 10 mm of the magnet bars holds an extraction hole, optimizing the efficient production of high H^- current, and at the same time only a small electron component was co-extracted with the H^- ions. The local filter arrangement separates the beam electrons at a low energy. It is shown that the co-extracted total electron current is determined principally by the integrated magnetic field flux (Gcm) of the local filter with an extraction system at a constant extraction voltage. When the value of the Gcm is increased, the total electron component is reduced, while the H^- electrical efficiency had a broad maximum around the optimized value of the Gcm. A thicker plasma electrode should be necessary for sufficient reduction of electron current. In pure hydrogen operation, the achieved current density of H^- is 10 mA/cm^2. When Cs was seeded in a filter optimized for pure volume mode H^- production, the maximum H^- current density obtained is 51 mA/cm^2 and the ratio I_{ele} / H^- is ~0.4 without applying a bias potential.

Keywords: hydrogen negative ion, ion source, magnetic filter, cesium deposition, NBI

I. Introduction

A small ion source with a single hole has been used to do basic study of H^- ion source with various arrangements of a new magnetic filter. The magnetic filter originated by K.Leung et al [1] produced two regions of a source plasma (i.e., a driver region and a target region) with different electron temperature. We have made two observations from our experiments on the magnetic filter in a pure hydrogen plasma source. Firstly, the H^- yield for the same filling pressure after the optimization of the magnetic filter tended not to show a preference for the different three types(type I, II,III) of magnet geometries [2] with a H^- current density up to several mA/cm^2. The electrical efficiency for H^- ion production, however, differed for each magnet configuration. Secondly, the electrons co-extracted from the plasma decreased with an increase of the filter magnetic field strength [3]. Furthermore, from the view of Hiske's modeling for the volume plasma source [4], an optimized magnetic filter aiming for the highest extraction current density of H^- ions should make a shallow dense plasma close to the plasma electrode with the extraction hole in the target region of the plasma.

It might be deduced that a criterion of the optimum arrangement of the magnetic filter for H^- ion source is to aim for high current density of the extracted H^- ions, and at the same time a small electron beam component extracted from the plasma. In most cases, if the latter is gotten, the former would be automatically gotten [5]. A virtual magnetic filter is proposed in the plasma electrode localized in the vicinity of each extraction hole. This local filter uses pairs of small permanent magnets, adjacent to each aperture as will be shown in Fig.2. We call this Localized Virtual Magnetic Filter of type I in the plasma electrode, i.e., a localized virtual magnetic filter H^- ion source. A similar magnet arrangement has been used for electron suppression, instead of filter action, in the literature.

In this paper we will investigate/optimize the ion source characteristics of H^- yield and the electron beam component with the local filter of type I, especially for the magnet arrangement of the multipole magnetic field. The characteristics of the Cesium seeded H^- source will also be tested. Detailed data for the comparison of different magnetic filter arrangements of type I will be submitted for publication. The first results of experiments for the local filter had been reported in ref.[6], and those for multiholes in ref.[7] (with a vacuum-immersed H^- source).

II. Ion source and the local filter arrangement

The ion source consists of a multipole plasma container which has a square cross section of 26(W) x 26(L) cm^2, and a small accelerator with a single extraction hole of diameter 4 mm (Fig.1). A movable back plate is fixed at 12 cm deep, creating a shallow chamber, to raise the discharge power density. Behind the backplate, a cryobottle is filled with liquid nitrogen to trap condensible impurity gases during all the phases of the study including the experiments of Cesium introduction. All six surfaces of the plasma source are covered by multipole magnets of SmCo5. They work as a discharge anode. The plasma electrode over 5x12 cm^2 around the beam hole has a local magnetic filter, and is isolated from the anode electrically and thermally. Unless otherwise stated, the plasma electrode is connected electrically to the anode without biasing. Eight 1.5 mm-diam M shaped tungsten filaments are extended into the field-free space. The hydrogen gas pressure in the plasma source was measured in the absence of the discharge. The discharge voltage ranged from 40 ~ 80 V and the discharge current ranged up to 800 A. The pulse duration for the beam ranged from 0.1 s to 1 s.

The small accelerator system uses an accelerator consisting of six electrodes, i.e., like an accel-decel system (which is called the advanced-accelerator of the LBL group). The gaps between the electrodes are 2 mm. The first electrode or plasma electrode, along with the entire ion source, is at a negative high potential for beam acceleration. No magnets are imbedded in the extraction or the second electrode. The primary reason for the choice of the six electrode accelerator in present source, instead of a usual two electrode system with magnets, is that the fringe magnetic field produced by magnets in the fourth electrode becomes very weak at the location inside the plasma source. Modification for the magnet were made to the first electrode of the local filter, i.e. the other electrodes were unchanged. The total negative-ion current I_{H-} was measured by a calorimeter plate at a distance of 11 or 25 cm from the accelerator. High voltage power supply drain currents, I_{HV} consist of the sum of the electron current Iele and

I_{H^-}. Acceleration/extraction energy was ~7 keV. Cesium was seeded by a Cs oven (not shown) through the side port. The material of the plasma electrode was changed from copper to molybdenum for Cs operation. Also thin molybdenum liners were added in front of the six inside-surfaces. One gram of Cs was used for four introductions.

A magnetic geometry of 3 x 3 SmCo5 (Fig.2) generates a Multi-Pole magnetic field (i.e., 3 x 3 MP). The magnet are oriented so that the magnetization is perpendicular to the plasma electrode. The magnets are buried midway in the grooves of the 4 mm thick plasma electrode, which has an extraction hole. Four plasma electrodes which have different spacing between the magnet bars, i.e. 10 (Fig.2), 15, 20, and 40 in mm over 5 x 12 cm^2, were fabricated. The target plasma in the plasma source occupies a plasma volume localized in a region with a high magnetic field very near the plasma electrode, while the driver region occupies the most of the remainder. The line integral of the magnetic field strength along the beam axis was taken from the center of the plasma electrode to a position of twice the length of the magnet gaps.

III. Experimental results

H^- yield; The H^- current increases with the discharge power but saturates at a high discharge power (in Fig.3). The maximum value of the negative-ion current increases, when the discharge power as well as the gas pressure are increased. The optimum spacing for 3x3MP became short, i.e.,10 mm, for a high discharge power plasma at a higher gas pressure, and long, i.e.,15~20 mm, for a low discharge power plasma. These characteristics are similar to ones for the rod filter, H^- source studied by K.Leung et al. A maximum H^- ion current density of 10 mA/cm^2 is achieved with 3Pa. The gas pressure during the discharge-on time was reduced compared with the initial gas pressure due to plasma pumping. There was a larger reduction of the pressure with the discharge power.

The extracted electron components vs the line-integrated magnetic field strength: The high voltage drain current I_{HV} (~the total electron current) increases linearly with the discharge power, and decreases with a decrease of the magnet gap at a given discharge power for the same gas pressure (in Fig.4). The ratio of Iele / I_{H^-} becomes smaller(better) as the gap is decreased (correspondingly strong magnetic field).

It is found from Fig.4 that the total electron component decreases with the increase of the line integrated magnetic field strength in the accelerator rather than the just the magnetic field strength. Even if the magnetic filter arrangement and/or the gap are changed, the accompanied electron behaviour tends to depend only on the value of Gcm. The necessary value of the line-integrated magnetic field is determined mainly by the electron energy, and the geometry of the extraction systems. The value of Gcm for efficient H^- production [2] should take priority in the local filter source over the value for suppressing electrons, although H^- production was optimized weakly with the magnetic field.

Characteristics of the Cesium seeded operation: Cs was introduced for the 3 x 3 MP with a gap of 10 mm, after a series of beam extraction experiment was executed. The amount of one Cs introduction was evaluated to be 0.1 ~ 0.25 gr. The Cs introduction was repeated, if required, until a saturation of efficiency of H^- production was observed.

When the number of Cs introductions (in Fig 5) is increased sufficiently, H^- production efficiency is increased by a factor of 3~5 compared to that for pure volume production. The H^- current increases in proportion to the discharge power, in contrast to the saturation in pure hydrogen plasma. When the discharge power (in Fig.5) and the pressure are low, the H^- production efficiency was low and saturates after small quantity of Cs introduction, i.e., one Cs introduction. For a high power discharge at high gas pressure, improvement of efficiency saturates after several depositions. The maximum achieved H^- ion current density is 51 mA/cm^2 [3] at a filling gas pressure of 3 Pa.

It is seen that I_{HV} is dramatically decreased with one~two Cs deposition (in Fig.6), while H- efficiency is still low. By adding more Cs, I_{HV} current starts again to increase due to increasing H^- current. The ratio of Iele / I_{H^-} of 0.3 to 0.5 at H^- ion current density of 51 mA/ cm^2 occurs without applying a bias potential.

Acknowledgement

One of authors (Y.OKA) would express his acknowledgements to Drs. J Whealton and A. England in NIFS, for technical discussions.

References;

1. K.N.Leung et al., Rev.Sci.Instrum.**54**,56(1983).

2. Y.Oka et al.,
J.Vac.Sci.Technol.**A12(6)**,3109(1994).

3. Y.Oka et al., Vacuum, in J.Vac.Society of Japan,**vol.35**,297(1992).

4. J.R.Hiskes et al., J.Appl.Phys,**56**,1927(1984).

5. J.H.Whealton, et al., Proceedings, this conference.

6. Y.Oka et al.,Proc. of the Domestic meeting in the Japan Society of Plasma Science and Nuclear Fusion Research, March 27, 1990, p.113.

7.Y.Oka et al.,Rev.Sci.Instrum.**67(3)**,1029(1996).

Figure captions,

Fig.1 H^- ion source with local (3 x3 MP) magnetic filter of type I.

Fig.2 Localized Virtual filters in the plasma (first) electrode in the upper figure. Distribution of the transverse component of the magnetic field along the beam Z-axis in the lower figure.

Fig.3 Dependence of the H^- ion current I_{H^-} on the discharge power.

Fig.4 Dependence of HV drain current I_{HV} (where interporation are made) on the line-integrated magnetic field strength. Different simbols correspond to I_{H^-} currents with different gas pressures of 1, 2, and 3 Pa for three discharge powers of 15, 30, and 45 kW.

Fig.5 H^- yield I_{H-} as a function of the discharge power with the integrated number (cycles) of Cs introduction as a parameter. Curve number (N) corresponds to the data after Nth introduction of Cs. 3Pa of H_2.

Fig.6 Dependence of the HV drain current I_{HV} on the discharge power with run as same as in Fig.5.

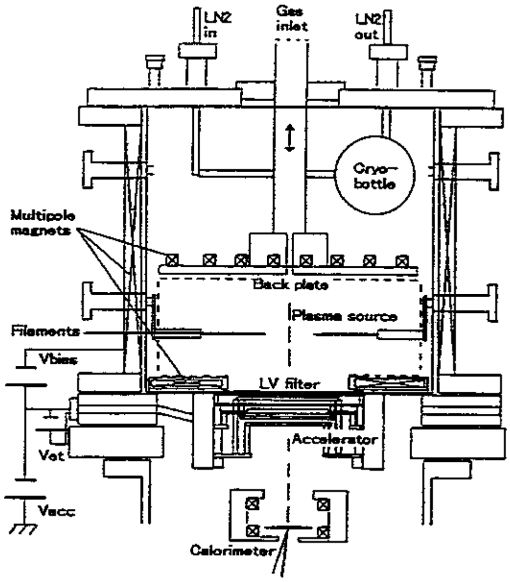

Fig . 1

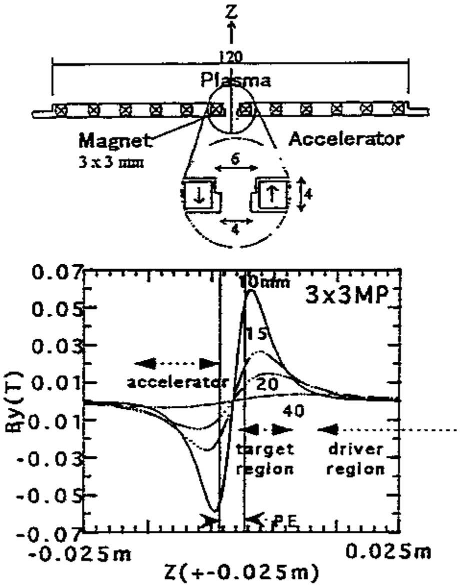

Fig . 2

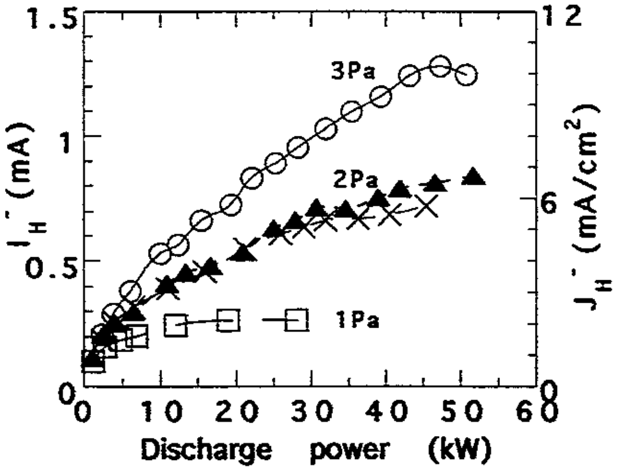

Fig . 3

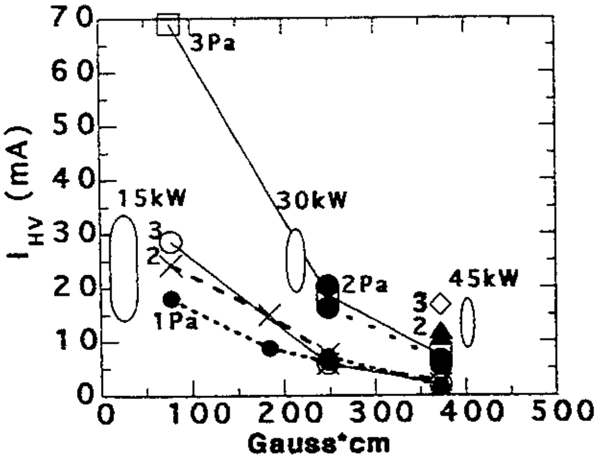

Fig . 4

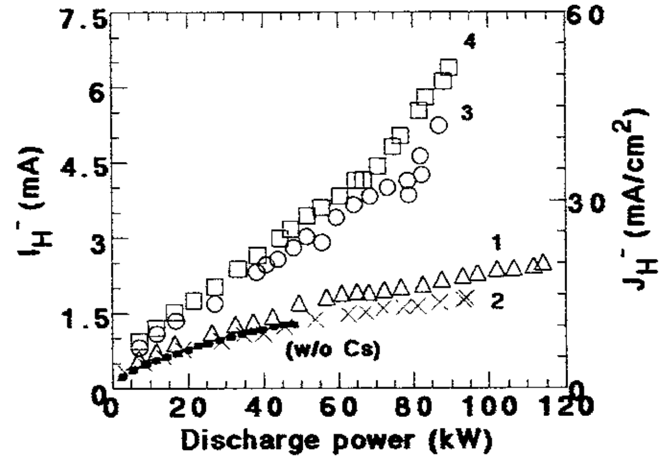

Fig . 5

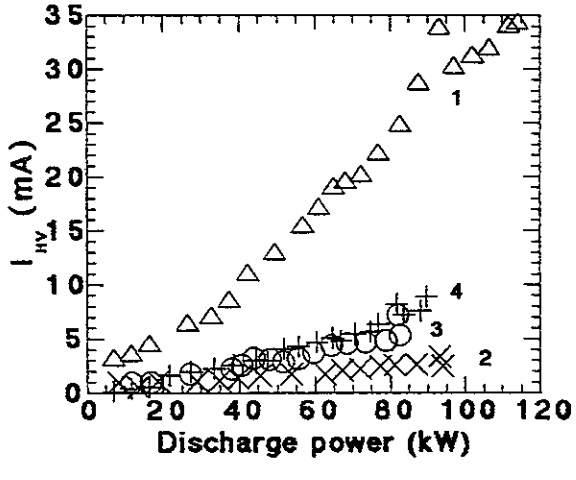

Fig . 6

Recent Issues of NIFS Series

NIFS-560 S Sudo, K. Kholopenkov, K Matsuoka, S Okamura C Takahashi, R Akiyama, A Fujisawa K Ida H Idei, H Iguchi, M Isobe S Kado, K Kondo, S Kubo, H Kuramoto, T Minami, S Morita, S Nishimura, M Osakabe M Sasao, B Peterson K Tanaka, K Toi and Y Yoshimura,
Particle Transport Study with Tracer-Encapsulated Solid Pellet Injection, Oct 1998
(IAEA-CN-69/EXP1/18)

NIFS-561 A Fujisawa, H Iguchi, S Lee, K Tanaka, T Minami, Y Yoshimura, M Osakabe K Matsuoka, S Okamura, H Idei, S Kubo, S Ohdachi, S Morita, R Akiyama, K Toi, H Sanuki, K Itoh, K. Ida, A Shimizu, S Takagi, C Takahashi, M Kojima, S Hidekuma, S Nishimura, M Isobe, A Ejiri, N. Inoue, R Sakamoto, Y Hamada and M Fujiwara,
Dynamic Behavior Associated with Electric Field Transitions in CHS Heliotron/Torsatron, Oct 1998
(IAEA-CN-69/EX5/1)

NIFS-562 S. Yoshikawa,
Next Generation Toroidal Devices; Oct 1998

NIFS-563 Y Todo and T Sato,
Kinetic-Magnetohydrodynamic Simulation Study of Fast Ions and Toroidal Alfvén Eigenmodes; Oct 1998
(IAEA-CN-69/THP2/22)

NIFS-564 T Watari, T Shimozuma, Y Takeiri, R. Kumazawa, T Mutoh, M Sato, O Kaneko, K. Ohkubo, S. Kubo, H Idei, Y Oka, M Osakabe, T Seki, K. Tsumori, Y Yoshimura, R Akiyama, T Kawamoto, S Kobayashi, F Shimpo, Y Takita, E Asano, S Itoh G Nomura, T. Ido, M Hamabe, M Fujiwara, A Iiyoshi, S Morimoto, T Bigelow and Y.P. Zhao,
Steady State Heating Technology Development for LHD, Oct 1998
(IAEA-CN-69/FTP/21)

NIFS-565 A Sagara, K.Y Watanabe, K Yamazaki, O Motojima, M Fujiwara, O Mitarai, S Imagawa, H Yamanishi, H Chikaraishi, A Kohyama, H. Matsui, T Muroga, T Noda, N. Ohyabu, T Satow, A A Shishkin, S Tanaka, T Terai and T Uda,
LHD-Type Compact Helical Reactors; Oct. 1998
(IAEA-CN-69/FTP/03(R)

NIFS-566 N. Nakajima, J. Chen, K Ichiguchi and M Okamoto,
Global Mode Analysis of Ideal MHD Modes in L=2 Heliotron/Torsatron Systems; Oct 1998
(IAEA-CN-69/THP1/08)

NIFS-567 K. Ida, M. Osakabe, K Tanaka, T Minami, S. Nishimura, S. Okamura, A Fujisawa, Y Yoshimura, S Kubo, R Akiyama, D.S Darrow, H. Idei, H. Iguchi, M Isobe, S. Kado, T Kondo, S. Lee, K Matsuoka, S. Morita, I Nomura, S. Ohdachi, M Sasao, A Shimizu, K. Tumori, S Takayama, M Takechi, S Takagi, C Takahashi, K Toi and T Watari,
Transition from L Mode to High Ion Temperature Mode in CHS Heliotron/Torsatron Plasmas, Oct 1998
(IAEA-CN-69/EX2/2)

NIFS-568 S. Okamura, K. Matsuoka, R Akiyama, D S. Darrow, A Ejiri, A. Fujisawa, M Fujiwara, M Goto, K. Ida H Idei, H Iguchi, N Inoue, M Isobe, K. Itoh, S Kado, K. Khlopenkov, T. Kondo, S Kubo, A Lazaros, S. Lee, G. Matsunaga, T Minami, S Morita, S Murakami, N. Nakajima, N Nikai, S Nishimura, I Nomura, S. Ohdachi, K Ohkuni, M Osakabe, R. Pavlichenko, B Peterson, R Sakamoto, H. Sanuki, M. Sasao, A Shimizu, Y Shirai, S Sudo, S. Takagi, C Takahashi, S Takayama, M. Takechi, K Tanaka, K Toi, K. Yamazaki, Y Yoshimura and T. Watari,
Confinement Physics Study in a Small Low-Aspect-Ratio Helical Device CHS, Oct 1998
(IAEA-CN-69/OV4/5)

NIFS-569 M.M Skoric, T Sato, A. Maluckov, M.S. Jovanovic,
Micro- and Macro-scale Self-organization in a Dissipative Plasma, Oct 1998

NIFS-570 T. Hayashi, N Mizuguchi, T-H Watanabe, T Sato and the Complexity Simulation Group,
Nonlinear Simulations of Internal Reconnection Event in Spherical Tokamak, Oct 1998
(IAEA-CN-69/TH3/3)

NIFS-571 A. Iiyoshi, A. Komori, A Ejiri, M Emoto, H. Funaba, M Goto, K. Ida, H Idei, S Inagaki, S. Kado, O. Kaneko, K Kawahata, S Kubo, R. Kumazawa, S. Masuzaki, T. Minami, J Miyazawa, T Morisaki, S. Morita, S Murakami, S Muto, T Muto, Y Nagayama, Y. Nakamura, H. Nakanishi, K Narihara, K Nishimura, N Noda, T Kobuchi, S. Ohdachi, N. Ohyabu, Y Oka, M Osakabe, T. Ozaki, B.J. Peterson, A Sagara, S. Sakakibara, R. Sakamoto, H. Sasao, M Sasao, K. Sato, M. Sato, T Seki, T Shimozuma M Shoji, H. Suzuki, Y Takeiri, K. Tanaka, K. Toi, T. Tokuzawa, K. Tsumori, I Yamada, H Yamada, S Yamaguchi, M Yokoyama K Y.Watanabe, T. Watari, R. Akiyama, H. Chikaraishi, K Haba, S. Hamaguchi, S Iima, S Imagawa, N Inoue, K. Iwamoto S Kitagawa, Y. Kubota, J Kodaira, R Maekawa, T Mito T. Nagasaka, A. Nishimura, Y Takita, C. Takahashi, K. Takahata, K Yamauchi, H Tamura, T Tsuzuki, S. Yamada, N Yanagi, H. Yonezu, Y Hamada, K. Matsuoka, K. Murai, K Ohkubo, I Ohtake, M. Okamoto, S Sato, T. Satow, S Sudo, S Tanahashi, K Yamazaki, M Fujiwara and O Motojima,
An Overview of the Large Helical Device Project; Oct 1998
(IAEA-CN-69/OV1/4)

NIFS-572 M Fujiwara, H. Yamada, A Ejiri, M. Emoto, H Funaba, M Goto, K Ida, H Idei, S Inagaki, S Kado, O Kaneko, K Kawahata A Komori, S. Kubo, R Kumazawa, S. Masuzaki, T Minami, J Miyazawa, T Morisaki, S. Morita, S Murakami, S. Muto, T Muto, Y Nagayama, Y Nakamura, H Nakanishi, K. Narihara, K Nishimura, N Noda, T. Kobuchi, S Ohdachi, N Ohyabu, Y. Oka,

M. Osakabe, T. Ozaki, B. J. Peterson, A. Sagara, S. Sakakibara, R. Sakamoto, H. Sasao, M. Sasao, K. Sato, M. Sato, T. Seki, T. Shimozuma, M. Shoji, H. Sazuki, Y. Takeiri, K. Tanaka, K. Toi, T. Tokuzawa, K. Tsumori, I. Yamada, S. Yamaguchi, M. Yokoyama, K.Y. Watanabe, T. Watari, R. Akiyama, H. Chikaraishi, K. Haba, S. Hamaguchi, M. Iima, S. Imagawa, N. Inoue, K. Iwamoto, S. Kitagawa, Y. Kubota, J. Kodaira, R. Maekawa, T. Mito, T. Nagasaka, A. Nishimura, Y. Takita, C. Takahashi, K. Takahata, K. Yamauchi, H. Tamura, T. Tsuzuki, S. Yamada, N. Yanagi, H. Yonezu, Y. Hamada, K. Matsuoka, K. Murai, K. Ohkubo, I. Ohtake, M. Okamoto, S. Sato, T. Satow, S. Sudo, S. Tanahashi, K. Yamazaki, O. Motojima and A. Iiyoshi,
Plasma Confinement Studies in LHD; Oct. 1998
(IAEA-CN-69/EX2/3)

NIFS-573 O. Motojima, K. Akaishi, H. Chikaraishi, H. Funaba, S. Hamaguchi, S. Imagawa, S. Inagaki, N. Inoue, A. Iwamoto, S. Kitagawa, A. Komori, Y. Kubota, R. Maekawa, S. Masuzaki, T. Mito, J. Miyazawa, T. Morisaki, T. Muroga, T. Nagasaka, Y. Nakmura, A. Nishimura, K. Nishimura, N. Noda, N. Ohyabu, S. Sagara, S. Sakakibara, R. Sakamoto, S. Satoh, T. Satow, M. Shoji, H. Suzuki, K. Takahata, H. Tamura, K. Watanabe, H. Yamada, S. Yamada, S. Yamaguchi, K. Yamazaki, N. Yanagi, T. Baba, H. Hayashi, M. Iima, T. Inoue, S. Kato, T. Kato, T. Kondo, S. Moriuchi, H. Ogawa, I. Ohtake, K. Ooba, H. Sekiguchi, N. Suzuki, S. Takami, Y. Taniguchi, T. Tsuzuki, N. Yamamoto, K. Yasui, H. Yonezu, M. Fujiwara and A. Iiyoshi,
Progress Summary of LHD Engineering Design and Construction; Oct. 1998
(IAEA-CN-69/FT2/1)

NIFS-574 K. Toi, M. Takechi, S. Takagi, G. Matsunaga, M. Isobe, T. Kondo, M. Sasao, D S. Darrow, K. Ohkuni, S. Ohdachi, R. Akiyama, A. Fujisawa, M. Gotoh, H. Idei, K. Ida, H. Iguchi, S. Kado, M. Kojima, S. Kubo, S. Lee, K. Matsuoka, T. Minami, S. Morita, N. Nikai, S. Nishimura, S. Okamura, M. Osakabe, A. Shimizu, Y. Shirai, C. Takahashi, K. Tanaka, T. Watari and Y. Yoshimura,
*Global MHD Modes Excited by Energetic Ions in Heliotron/Torsatron Plasmas;*Oct. 1998
(IAEA-CN-69/EXP1/19)

NIFS-575 Y. Hamada, A. Nishizawa, Y. Kawasumi, A. Fujisawa, M. Kojima, K. Narihara, K. Ida, A. Ejiri, S. Ohdachi, K. Kawahata, K. Toi, K. Sato, T. Seki, H. Iguchi, K. Adachi, S. Hidekuma, S.Hirokura, K. Iwasaki, T. Ido, R. Kumazawa, H. Kuramoto, T. Minami, I. Nomura, M. Sasao, K.N. Sato, T. Tsuzuki, I. Yamada and T. Watari,
*Potential Turbulence in Tokamak Plasmas;*Oct. 1998
(IAEA-CN-69/EXP2/14)

NIFS-576 S. Murakami, U. Gasparino, H. Idei, S. Kubo, H. Maassberg, N. Marushchenko, N. Nakajima, M. Romé and M. Okamoto,
*5D Simulation Study of Suprathermal Electron Transport in Non-Axisymmetric Plasmas;*Oct 1998
(IAEA-CN-69/THP1/01)

NIFS-577 S. Fujiwara and T. Sato,
Molecular Dynamics Simulation of Structure Formation of Short Chain Molecules; Nov. 1998

NIFS-578 T. Yamagishi,
Eigenfunctions for Vlasov Equation in Multi-species Plasmas Nov. 1998

NIFS-579 M. Tanaka, A. Yu Grosberg and T. Tanaka,
*Molecular Dynamics of Strongly-Coupled Multichain Coulomb Polymers in Pure and Salt Aqueous Solutions;*Nov. 1998

NIFS-580 J. Chen, N. Nakajima and M. Okamoto,
*Global Mode Analysis of Ideal MHD Modes in a Heliotron/Torsatron System: I. Mercier-unstable Equilibria;*Dec. 1998

NIFS-581 M. Tanaka, A. Yu Grosberg and T. Tanaka,
Comparison of Multichain Coulomb Polymers in Isolated and Periodic Systems: Molecular Dynamics Study; Jan. 1999

NIFS-582 V.S. Chan and S. Murakami,
Self-Consistent Electric Field Effect on Electron Transport of ECH Plasmas; Feb 1999

NIFS-583 M. Yokoyama, N. Nakajima, M. Okamoto, Y. Nakamura and M. Wakatani,
*Roles of Bumpy Field on Collisionless Particle Confinement in Helical-Axis Heliotrons;*Feb. 1999

NIFS-584 T.-H. Watanabe, T. Hayashi, T. Sato, M. Yamada and H. Ji,
*Modeling of Magnetic Island Formation in Magnetic Reconnection Experiment;*Feb. 1999

NIFS-585 R. Kumazawa, T. Mutoh, T. Seki, F. Shinpo, G. Nomura, T. Ido, T. Watari, Jean-Marie Noterdaeme and Yangping Zhao,
*Liquid Stub Tuner for Ion Cyclotron Heating;*Mar. 1999

NIFS-586 A. Sagara, M. Iima, S. Inagaki, N. Inoue, H. Suzuki, K. Tsuzuki, S. Masuzaki, J. Miyazawa, S. Morita, Y. Nakamura, N. Noda, B. Peterson, S. Sakakibara, T. Shimozuma, H. Yamada, K. Akaishi, H. Chikaraishi, H. Funaba, O. Kaneko, K. Kawahata, A. Komori, N. Ohyabu, O. Motojima, LHD Exp. Group 1, LHD Exp. Group 2,
*Wall Conditioning at the Starting Phase of LHD;*Mar. 1999

NIFS-587 T Nakamura and T Yabe,
Cubic Interpolated Propagation Scheme for Solving the Hyper-Dimensional Vlasov-Poisson Equation in Phase Space, Mar 1999

NIFS-588 W X. Wnag, N Nakajima, S. Murakami and M Okamoto,
An Accurate δf Method for Neoclassical Transport Calculation, Mar 1999

NIFS-589 K. Kishida, K. Araki, S Kishiba and K Suzuki,
Local or Nonlocal? Orthonormal Divergence-free Wavelet Analysis of Nonlinear Interactions in Turbulence, Mar 1999

NIFS-590 K Araki, K Suzuki, K Kishida and S Kishiba,
Multiresolution Approximation of the Vector Fields on T^3, Mar. 1999

NIFS-591 K. Yamazaki, H. Yamada, K Y.Watanabe, K. Nishimura, S. Yamaguchi, H Nakanishi, A. Komori, H. Suzuki, T. Mito, H. Chikaraishi, K Murai, O. Motojima and the LHD Group,
Overview of the Large Helical Device (LHD) Control System and Its First Operation, Apr 1999

NIFS-592 T. Takahashi and Y Nakao,
Thermonuclear Reactivity of D-T Fusion Plasma with Spin-Polarized Fuel, Apr 1999

NIFS-593 H. Sugama,
Damping of Toroidal Ion Temperature Gradient Modes; Apr. 1999

NIFS-594 Xiaodong Li ,
Analysis of Crowbar Action of High Voltage DC Power Supply in the LHD ICRF System, Apr 1999

NIFS-595 K. Nishimura, R Honuchi and T. Sato,
Drift-kink Instability Induced by Beam Ions in Field-reversed Configurations; Apr. 1999

NIFS-596 Y. Suzuki, T-H Watanabe, T Sato and T Hayashi,
Three-dimensional Simulation Study of Compact Toroid Plasmoid Injection into Magnetized Plasmas; Apr. 1999

NIFS-597 H. Sanuki, K. Itoh, M. Yokoyama, A. Fujisawa, K. Ida, S. Toda, S.-I. Itoh, M Yagi and A. Fukuyama,
Possibility of Internal Transport Barrier Formation and Electric Field Bifurcation in LHD Plasma; May 1999

NIFS-598 S Nakazawa, N. Nakajima, M. Okamoto and N. Ohyabu,
One Dimensional Simulation on Stability of Detached Plasma in a Tokamak Divertor, June 1999

NIFS-599 S. Murakami, N. Nakajima, M Okamoto and J. Nhrenberg,
Effect of Energetic Ion Loss on ICRF Heating Efficiency and Energy Confinement Time in Heliotrons, June 1999

NIFS-600 R Honuchi and T. Sato,
Three-Dimensional Particle Simulation of Plasma Instabilties and Collisionless Reconnection in a Current Sheet,, June 1999

NIFS-601 W Wang, M Okamoto, N. Nakajima and S. Murakami,
Collisional Transport in a Plasma with Steep Gradients; June 1999

NIFS-602 T. Mutoh, R. Kumazawa, T. Saki, K. Saito, F Simpo, G. Nomura, T. Watari, X Jikang, G. Cattanei, H. Okada, K Ohkubo, M. Sato S Kubo, T. Shimozuma, H. Idei, Y. Yoshimura, O. Kaneko, Y Takein, M. Osakabe, Y. Oka, K. Tsumori, A. Komori, H Yamada, K. Watanabe, S. Sakakibara, M. Shoji, R Sakamoto, S. Inagaki, J Miyazawa, S. Monta, K. Tanaka, B.J Peterson, S. Murakami, T Minami, S Ohdachi, S Kado, K. Nanhara, H. Sasao, H. Suzuki, K. Kawahata, N. Ohyabu, Y. Nakamura, H. Funaba, S Masuzaki, S. Muto, K. Sato, T. Monsaki, S Sudo, Y Nagayama, T Watanabe, M Sasao, K . Ida, N Noda, K. Yamazaki, K Akaishi, A Sagara, K. Nishimura, T Ozaki, K Toi, O. Motojima, M Fujiwara, A. Iiyoshi and LHD Exp Group 1 and 2,
First ICRF Heating Experiment in the Large Helical Device, July 1999

NIFS-603 P.C. de Vries, Y Nagayama, K. Kawahata, S Inagaki, H. Sasao and K. Nagasaki,
Polarization of Electron Cyclotron Emission Spectra in LHD, July 1999

NIFS-604 W. Wang, N. Nakajima, M. Okamoto and S Murakami,
δf Simulation of Ion Neoclassical Transport; July 1999

NIFS-605 T. Hayashi, N. Mizuguchi, T. Sato and the Complexity Simulation Group,
Numerical Simulation of Internal Reconnection Event in Spherical Tokamak; July 1999

NIFS-606 M. Okamoto, N. Nakajima and W. Wang,
On the Two Weighting Scheme for δf Collisional Transport Simulation; Aug. 1999

NIFS-607 O. Motojima, A.A. Shishkin, S. Inagaki, K. Y. Watanabe,
Possible Control Scenario of Radial Electric Field by Loss-Cone-Particle Injection into Helical Device, Aug 1999

NIFS-608 R. Tanaka, T. Nakamura and T. Yabe,
Constructing Exactly Conservative Scheme in Non-conservative Form; Aug. 1999

NIFS-609 H. Sugama,
Gyrokinetic Field Theory, Aug. 1999

NIFS-610 M. Takechi, G. Matsunaga, S. Takagi, K.Ohkuni, K. Toi, M. Osakabe, M. Isobe, S. Okamura, K Matsuoka, A. Fujisawa, H. Iguchi, S. Lee, T. Minami, K. Tanaka, Y. Yoshimura and CHS Group,
Core Localized Toroidal Alfven Eigenmodes Destabilized By Energetic Ions in the CHS Heliotron/Torsatron; Sep. 1999

NIFS-611 K. Ichiguchi,
MHD Equilibrium and Stability in Heliotron Plasmas; Sep. 1999

NIFS-612 Y Sato, M. Yokoyama, M. Wakatani and V. D. Pusovitov,
Complete Suppression of Pfirsch-Schluter Current in a Toroidal $l=3$ Stellarator; Oct. 1999

NIFS-613 S. Wang, H. Sanuki and H. Sugama,
Reduced Drift Kinetic Equation for Neoclassical Transport of Helical Plasmas in Ultra-low Collisionality Regime; Oct. 1999

NIFS-614 J. Miyazawa, H. Yamada, K. Yasui, S. Kato, N., Fukumoto, M. Nagata and T. Uyama,
Design of Spheromak Injector Using Conical Accelerator for Large Helical Device; Nov. 1999

NIFS-615 M. Uchida, A. Fukuyama, K. Itoh, S.-I Itoh and M. Yagi,
Analysis of Current Diffusive Ballooning Mode in Tokamaks; Dec. 1999

NIFS-616 M. Tanaka, A.Yu Grosberg and T. Tanaka,
Condensation and Swelling Behavior of Randomly Charged Multichain Polymers by Molecular Dynamics Simulations; Dec. 1999

NIFS-617 S. Goto and S. Kida,
Sparseness of Nonlinear Coupling; Dec. 1999

NIFS-618 M.M. Skoric, T. Sato, A. Maluckov and M.S. Jovanovic,
Complexity in Laser Plasma Instabilities Dec. 1999

NIFS-619 T.-H. Watanabe, H. Sugama and T. Sato,
Non-dissipative Kinetic Simulation and Analytical Solution of Three-mode Equations of Ion Temperature Gradient Instability; Dec. 1999

NIFS-620 Y. Oka, Y. Takeiri, Yu.I.Belchenko, M. Hamabe, O. Kaneko, K. Tsumori, M. Osakabe, E. Asano, T. Kawamoto, R. Akiyama,
Optimization of Cs Deposition in the 1/3 Scale Hydrogen Negative Ion Source for LHD-NBI System ,Dec 1999

NIFS-621 Yu.I. Belchenko, Y. Oka, O. Kaneko, Y. Takeiri, A. Krivenko, M. Osakabe, K. Tsumori, E. Asano, T. Kawamoto, R. Akiyama,
Recovery of Cesium in the Hydrogen Negative Ion Sources; Dec. 1999

NIFS-622 Y. Oka, O. Kaneko, K. Tsumori, Y. Takeiri, M. Osakabe, T. Kawamoto, E. Asano, and R. Akiyama,
H- Ion Source Using a Localized Virtual Magnetic Filter in the Plasma Electrode: Type I LV Magnetic Filter: Dec 1999