June 19, 2012

Documentation of the International Stellarator/Heliotron Confinement Database (ISHCDB)

Version ISHCDB_26

A. Kus, A. Dinklage
Max-Planck-Institut für Plasmaphysik, EURATOM Association, Wendelsteinstr. 1, 17491 Greifswald, Germany

Contents

I. INTERNATIONAL STELLARATOR/HELIOTRON CONFINEMENT DATABASE COLLABORATION

The collaboration is carried out under auspices of the
IEA implementing Agreement for
Cooperation in Development of the Stellarator Concept (2.10.1992).

The database is jointly hosted by
National Institute for Fusion Science (NIFS, Toki, Japan)
(`http://iscdb.nifs.ac.jp/`)
and Max-Planck-Institut für Plasmaphysik, EURATOM Association (IPP, Greifswald, Germany)
(`http://www.ipp.mpg.de/ISS/`).

The International Stellarator/Heliotron Confinement Database Collaboration is formed by:

E. Ascasibar	CIEMAT	Madrid, *Spain*
A. Dinklage	IPP	Greifswald, *Germany*
J. Harris	Australian National University	Canberra, *Australia*
A. Kus	IPP	Greifswald, *Germany*
S. Okamura	NIFS	Toki, *Japan*
R. Preuss	IPP	Garching, *Germany*
S. Sakakibara	NIFS	Toki, *Japan*
F. Sano	U-Kyoto	Kyoto, *Japan*
U. Stroth	U-Stuttgart	Stuttgart, *Germany*
J.N. Talmadge	U-Wisconsin	Madison, *USA*
A. Weller	IPP	Garching, *Germany*
H. Yamada	NIFS	Toki, *Japan*

Discussions and contributions are gratefully acknowledged from:

C.D. Beidler, R. Brakel, V. Dose, J. Geiger, P. Grigull, D. Hartmann,
M. Hirsch, K. Ida, Y. Igithkhanov, H. Maaßberg,
K. McCormick, D. Mikkelsen, S. Murakami, V. Tribaldos,
F. Wagner, and K. Yamazaki

and the Teams of

ATF, CHS, Heliotron-E, Heliotron-J, HSX, H-1, LHD, TJ-II, W7-A, W7-AS, W7-AS and W7-X.

II. CHANGES TO PREVIOUS VERSIONS

Release 26
Three groups (806 datapoints) of LHD high-beta *survey* data added (for gamma=1.20, gamma=1.22 , gamma=1.25). Together with the already existing two groups of *transport* data (for gamma=1.22 und gamma=1.25, introduced in the ISHCDB version 22) a total of 1200 LHD high-beta data are availiable. Their precise characteristics are described in the publication *International Stellarator/Heliotron Database progress on high-beta confinement and operational boundaries*, by A. Weller, et al., NF **49** (2009).
The database contains now 4940 observations.

Names of the columns PABSNBI and PABSNBI_V21 have been interchanged (correction).

Release 25
Four W7-AS high performance data with STDSET=0 added (H. Maassberg). The database contains now 4134 observations.

Release 24
71 predictive data for W7-X (Yu. Turkin) with STDSET=0 added.
The database contains now 4130 observations.

Release 23
Eight W7-AS CERC (H. Maassberg) and two TJ-II CERC (T. Estrada) datasets with STDSET=0 have been added.
The database contains now 4059 observations.

Some numeric fields contained ”-9999999” or ”-9.999e-09’ as missing data. All these fields are now marked with ”.” (like all others missing data). Corrections concern columns SEQ (LHD, W7-AS), BGASA (W7-AS), SEPLIM (LHD), MECH1 (W7-AS), MECH2 (W7-AS).

Release 22
Eight density scan shots of W7-AS (H. Dreier) and 394 LHD transport data added.
The database contains now 4049 observations.

Two data items from US_2003 series had STDSET= 1, but RowState=excluded:
39964, 0.679,
39966, 0.229.
In both cases STDSET=0 has been set.

In order to distinguish between several kinds of confinement for W7-AS HDH shots, the corresponding values in column COMM have been changed to ’HDH normal confinement’, ’HDH attached’, ’HDH detached’, accordingly.

Release 21
Thorough discussions on the uncertainties of W7-AS, LHD and CHS. For the other machines the worst estimations of the discussed uncertainties were taken. An high beta survey on the W7-AS data was performed leading to 313 datasets added to the database. A formula (with parameters fitted by Penningsfeld) for the global heat efficiency was employed to determine PABSNBI for W7-AS shots of US_2003, apart from 13 entries which were taken directly from FAFNER evaluations.

Release 20
The following shots were found to occur doubled in the database ISS DB07_17_release. These shots were erased from the DB17_19_release leading to a diminishing of the total number of datasets from 3226 to 3197 (incl. 4 predictive values for W7-X).

1. ATF (11210, 0.372)
2. ATF (11217, 0.37)
3. ATF (11223, 0.37)
4. CHS (37025, 0.071)

5. W7-AS (25687, 0.44)
6. W7-AS (25843, 0.348)
7. W7-AS (25923, 0.3)
8. W7-AS (25927, 0.3)
9. W7-AS (25957, 0.497)
10. W7-AS (25993, 1.197)
11. W7-AS (25995, 1.197)
12. W7-AS (25998, 0.917)
13. W7-AS (26004, 0.309)
14. W7-AS (26005, 0.822)
15. W7-AS (26129, 0.3)
16. W7-AS (26191, 0.57)
17. W7-AS (26303, 0.597)
18. W7-AS (26305, 0.597)
19. W7-AS (26384, 0.558)
20. W7-AS (26422, 0.58)
21. W7-AS (26426, 0.5)
22. W7-AS (26437, 1.3)
23. W7-AS (26439, 1)
24. W7-AS (26439, 1.265)
25. W7-AS (26440, 0.7)
26. W7-AS (26440, 0.702)
27. W7-AS (26441, 0.25)
28. W7-AS (26919, 0.672)
29. W7-AS (26931, 0.56)

to read as *Device (shot, time)*.

As a preparation for a storage in a rational data-base system, the following column names have been renamed due to conflicts with reserved names.

- COMMENT → COMM
- UPDATE → UP_DATE
- DATE → SHOT_DATE
- TIME → SHOT_TIME
- WITH → WIONTH

III. DESCRIPTION OF COLUMNS

56 columns are compatible with the ISS95 database [8]. The designations and definitions are intended to be compatible with the ITER databases [4]. Present numbering refers to the database file `ISS_DB05_17.JMP`. Please note that some columns represent *Derived Quantities* which means that their value is calculated within the spread-sheet.

General parameters

1. DATASOURCE
   Sources of data:
   - ISS_DB05 (855 observations, 808 enter the standard set): ISS95 Database
   - W7AS_ECRH_AFTER_DIVERTOR_INSTALLATION (29 observations, 29 enter ISS04 scaling): W7AS data (ECRH heating only) (Dinklage, Kus)
   - US_2003 (167 observations, 165 enter the standard set): W7-AS data collected by Stroth after ISS95 (for 34609 and 40031 NEBAR is missing)
   - W7AS_HIGH_BETA (199 observations, 86 enter the standard set): W7-AS data collected by Weller. Some entries excluded from the standard set (see high beta survey below)
   - LHD_6th_EXP_CAMP_V2 (162 observations, 162 enter ISS04 scaling): data collected by Yamada
   - W7AS_NI (1 observation, 1 enters the standard set): W7-AS data containing NBI heating only data collected by Kus
   - HELJ data by Sano (111 observations, 54 enter the standard set)
   - HSX data by Talmadge (539 observations, 0 enter the standard set) (HSX power & density scans in different configurations)
   - predictive (W7-X by Dinklage) (4 'observations', 0 enter the standard set)
   - TJ-II_Jan04_2 data collected by Ascasibar (1130 observations, 316 enter the standard set):
   - BRAKEL data by Brakel (75 observations, 0 enter ISS04 scaling) (W7-AS ι- scan)
   - NF 41(1999)429 data entered by Dinklage (1 'observation', 0 enter ISS04) (ITER operation point)
   - HIRSCH data by Hirsch (2 observations, 0 enter ISS04) (L/H-mode in W7-AS)
   - GRIGULL/McCORMICK data by Grigull and Mc Cormick (60 observations, 0 enter ISS04) (HDH density scan in W7-AS (normal confinement, HDH attached, HDH detached in hydrogen discharges with hydrogen NBI heating)
   - PREUSS data by Preuss (preuss@ipp.mpg.de) (312 observations, 0 enter ISS04) (high beta survey of W7-AS data)
   - FUNABA LHD high-beta transport data
   - DREIER density scan data by Dreier
   - MAASSBERG W7-AS CERC data
   - ESTRADA TJ-II CERC data
   - TURKIN W7-X predictive data
   - MAASSBERG W7-AS high performance data
   - WELLER LHD high-beta survey data

2. COMM
   more detailed specifications, e.g. 'Power Scan,0.6x10E12,QHS,2003'

3. STELL
   Device that has supplied the data:
   ATF, CHS, HELE, HELJ, LHD, TJ-II, W7-A, W7-AS, HSX
   W7-X and ITER are predictive data

4. STDSET
   Standard data set:
   0, not included in analyses for ISS04; (applies for 1476 data)
   1, included in present analyses (applies for 1750 data)

5. SHEAR_INDICATOR
   Magnetic field shear indicator:
   0 for shearless stellarators (W7-A, W7-AS, W7-X);
   1, otherwise

6. UP_DATE
   Last update:
   [YYYYMMDD]

7. SHOT_DATE
   Date of shot:
   [YYYYMMDD]

8. SHOT
   Shot number or the first shot number of a sequence

9. SEQ
   Sequence number (designated for a series of similar shots)

10. SHOT_TIME
    Time during the shot at which the data are taken

11. PHASE
    Phase of the discharge:
    STAT, stationary phase

Plasma composition

12. PGASA
    Mass number of the plasma working gas:
    1, H; 2, D; 3, ^{3}He; 4, He

13. PCHARGE
    Charge number of the plasma working gas:
    1, H; 1, D; 2, He
    Derived quantity:

```
switch PGASA
    case 1, 2: PCHARGE = 1
    case 4: PCHARGE = 2
    otherwise PCHARGE = missing
end
```

14. BGASA
    Mass number of the NBI gas:
    1, H; 2, D

Device geometry

15. RGEO
    Major radius of the last closed flux surface (m):
    ATF, (Rmax+Rmin)/2;
    Heliotron-E, 2.17 m + radial displacement;
    W7-AS, 2 m + radial displacement;
    For W7-AS high-beta data, the major radius is taken from VMEC calculations

16. RMAG
    Major radius of the magnetic axis in the vacuum geometry (m):
    Heliotron-E, 2.2 m + radial displacement; W7-AS, 2.05 m + radial displacement

17. AEFF
    Effective minor radius (m):
    ATF, the t = 1 radius, which is usually not in contact with the wall;
    CHS,radius limited by the inner wall;

Heliotron-E, radius of the last closed flux surface before the ergodic region;
W7-AS, last closed flux surface from simple formula interpolating between available configurations;
W7-AS high beta data, the minor radius is taken from VMEC calculations

18. VOLUME
    Plasma volume (m^{-3}):
    Derived quantity:
    $\mathrm{VOLUME} = 2 \times \pi^2 \times \mathrm{AEFF}^2 \times \mathrm{RGEO}$

19. ASEPARATRIX
    Separatrix area (m^{-2}):
    Derived quantity:
    $\mathrm{ASEPARATRIX} = 4 \times \pi^2 \times \mathrm{AEFF} \times \mathrm{RGEO}$

20. SEPLIM
    Minimum distance between the separatrix and the wall or the limiter(m)

21. CONFIG
    Device configuration:
    STD, standard configuration; LIM/STD, standard configuration with limiter

Machine conditions

22. WALMAT
    Material of the vacuum vessel wall:
    IN, Inconel; INCARB, Inconel with carbon; SS, stainless steel; SSCARB, stainless steel with carbon

23. LIMMAT Limiter material:
    C, carbon; BORC, boron carbide; SS, stainless steel; TIC, titanium-coated graphite

24. EVAP Evaporated material:
    C, carbonized; BOR, boronized; TI, titanium; CR, chromium; NONE, no evaporation

Magnetic configurations

25. BT
    Vacuum toroidal field at RGEO:
    ATF, calculated from coil current

26. IP
    Total plasma current (A):
    Positive values if it increases the vacuum iota (equivalent to the direction of the tokamak current)

27. VSURF
    Loop voltage at plasma boundary (V):
    positive values correspond to positive IP

28. IOTAA
    Rotational transform at the plasma edge (AEFF):
    W7-AS, from simple formula interpolating between available configurations

29. IOTA0
    Rotational transform at the plasma centre:
    W7-AS, from simple formula interpolating between available configurations

30. IOTA23
    Rotational transform at $r_{\mathrm{eff}} = 2/3\mathrm{AEFF}$:
    For the W7-AS high-beta data, the value is taken from VMEC calculations
    For the other devices see Ref. [8].

31. EPS_EFF23
    effective helical ripple for $1/\nu$ transport at $r_{eff} = 2/3AEFF$:
    (see, for example, Ref. [1], especially the equation on page 344).
    For W7-AS, data were provided by C.D. Beidler (DKES results)
    For LHD, data were provided by M.Yokoyama and S.Murakami (DCOM results). Finite beta effect is estimated from the interpolated expression of DCOM results.

32. PLATEAU23
    Plateau factor at $\mathrm{r_{eff}} = 2/3\mathrm{AEFF}$
    (see Eq. (25) in Ref. [3]).
    Data provided by M. Yokoyama.

33. KAPPA
    For LHD calculated by $(\kappa(\phi = 0) \times \kappa(\phi = \pi/20))^{1/2}$, i.e. averaging of local values at the vertically elongated position ($\phi = 0$) and the horizontally elongated position ($\phi = \pi/20$) where ϕ is the toroidal angle and $\kappa = (z_{max} - z_{min})/(R_{max} - R_{min})$ at the last closed flux surface.

Densities

34. NEBAR
    Line average electron density (m^{-3}):
    W7-AS, if available, from microwave interferometer, otherwise from a central HCN chord

35. DNEBAR
    Time derivative of NEBAR ($\mathrm{m}^{-3}\mathrm{s}^{-1}$):
    ATF, only steady state, set to 0;
    Heliotron-E, only steady state, set to 0;
    W7-AS, only steady state, set to 0
    Corresponds to DNELDT variable in the International Global H-mode Confinement Database [6].

Impurities

36. ZEFF
    Average plasma effective charge

37. PRAD
    Total radiative power as measured with bolometry (W)

Input power

38. PECHl
    Port-through power for primary ECH (W):
    Heliotron-E, sum of 53 GHz powers;
    W7-AS, sum of 70 GHz powers

39. PECH2
    Port-through power for secondary ECH (W):
    W7-AS, sum of 140 GHz powers

40. MECHl
    Mode of primary ECH:
    1, fundamental;
    2, second harmonic

41. MECH2
    Mode of secondary ECH:
    1, fundamental;
    2, second harmonic

42. PABSECH
    Total absorbed ECH power (W):
    CHS, from radiation level at plasma collapse;
    Heliotron-E, from power switch-off experiments;
    W7-AS, 90 and 100% absorption in first and second harmonics, respectively

43. ENBIl
    Power-weighted neutral beam energy for the primary beams (V):
    W7-AS, sources 1+5; 1: 1/2 : 1/3 = 1:1:1

44. ENBI2
    Power-weighted neutral beam energy for the secondary beams (eV):
    W7-AS, sources 3+7; 1: 1/2 : 1/3 = 1:1:1

45. ENBI3 Power-weighted neutral beam energy for the secondary beams (eV)

46. RTANl
    Tangency radius for the primary beams

47. RTAN2
    Tangency radius for the secondary beams

48. RTAN3 Tangency radius for the secondary beams

49. PNBIl
    Port-through NBI power for the primary beams (W)

50. PNBI2
    Port-through NBI power for the secondary beams (W)

51. PNBI3
    Port-through NBI power for the tertiary beams (W)

52. GL_HEAT_EFF
    Parametric formula for the global heat efficiency for W7-AS derived by Penningsfeld. It is used to determine PABSNBI for the datasource US_2003 and in the calculation of the uncertainty of PTOT for all W7-AS shots

53. DGL_HEAT_EFF
    Derivative of GL_HEAT_EFF with respect to the minor radius AEFF

54. PABSNBI
    Original Fafner evaluations are available for the following W7-AS shot numbers and used for entry starting with the version 22: 31271, 31387, 31463, 31464, 31465, 31466, 31467, 34187, 34313, 34607, 34608, 34609, 37551.
    For other cases PABSNBI=PABSNBI_V21

55. PABSNBI_V21 Total absorbed NBI power corrected for shine-through, orbit and charge exchange losses (W):
    CHS, according to an expression deduced from HELIOS Monte Carlo calculations;
    Heliotron-E, according to the HELIOS Monte Carlo beam orbit following code;
    W7-AS, according to an parametric fit deduced from Fafner calculations.

56. PICH
    Port-through ICRF power (W)

57. FICH
    ICRF frequency (Hz)

58. PABSICH
    ICRF absorbed power (W)

59. POH
    Ohmic heating power (W)

60. PTOT
    Total absorbed power (W):
    Derived quantity:
    PTOT = PABSECH+PABSNBI+PABSICH +POH

61. PFLUX
    Power flux through separatrix (Wm^{-2}):
    Derived quantity:
    PFLUX = PTOT/ASPEPARATRIX

Profile information

62. NE0
    Central electron density at RMAG (m^{-3}):
    Heliotron-E, taken from FIR;
    W7-AS, taken from a fit to a Thomson scattering profile

63. TE0
    Central electron temperature at RMAG (eV):
    Heliotron-E, taken from a fit to a Thomson scattering profile;
    W7-AS, taken from a fit to a Thomson scattering profile

Energies

64. WDIA
    Total plasma energy as determined by diamagnetic measurements (J):
    Heliotron-E, from kinetic profiles and the beam contribution calculated by the PROCTR code

65. DWDIA
    Time derivative of WDIA (W):
    0, for PHASE=STAT and PHASE=c;
    missing, otherwise

66. WMHD
    Total plasma energy as determined from MHD equilibrium (J):
    ATF, saddle loop is not calibrated, use for reference only

67. WETH
    Total thermal electron plasma energy (J):
    W7-AS, from Thomson scattering profiles

68. WIONTH
    Total thermal ion plasma energy (J):
    W7-AS, from simulation with neoclassical transport coefficients

69. WTH
    Total thermal plasma energy from kinetic measurements (J)

70. DWTH
    Time derivative of WTH (W)
    0, for PHASE=STAT and PHASE=c;
    missing, otherwise

71. WFPER
    Calculated total perpendicular fast ion energy (J)

72. WFPAR
    Calculated total parallel fast ion energy (J)

Energy confinement times

73. TAUEDIA
    Global confinement time based on diamagnetic measurement (s):
    Derived quantity:
    $\mathrm{TAUEDIA} = \mathrm{WDIA}/(\mathrm{PTOT} - \mathrm{DWDIA})$

74. TAUETH
    Thermal energy confinement time (s):
    Derived quantity:
    $\mathrm{TAUETH} = \mathrm{WTH}/(\mathrm{PTOT} - \mathrm{DWTH})$

Not standard quantities

75. COFRANBI
    Ratio of co-injected beam port through power to total NBI power:
    Heliotron-E, perpendicular injection is set to 1;
    W7-AS sources(5 + 6 + 7 + 8)/all sources (BT $>$ 0)

Regression variables and scalings

76. LOG_A
    Derived quantity:
    LOG10 AEFF

77. LOG_R
    Derived quantity:
    LOG10 RGEO

78. LOG_P
    Derived quantity:
    LOG10 PTOT

79. LOG_N
    Derived quantity:
    (LOG10 NEBAR) - 19

80. LOG_B
    Derived quantity:
    LOG10 BT

81. LOG_I
    Derived quantity:

```
switch STELL
    case ATF, W7-A, W7-AS (except high-beta): LOG10(IOTAA+(1-2/3)$^2$ (IOTA0-IOTAA))
    case CHS: LOG10(IOTAA+(1-2/3)$^3$ (IOTA0-IOTAA))
    case HELE, HELJ: LOG10(IOTAA+(1-2/3)$^4$ (IOTA0-IOTAA))
    case LHD, TJ-II, HSX, W7-X, W7-AS high-beta: LOG10(IOTA23)
end
```

    see also E. (1) in Ref. [8].

82. LOG_TAU
    Derived quantity:

```
switch STELL
    case HELE, TJ-II: LOG10(TAUETH)
    otherwise: LOG10(TAUEDIA)
end
```

83. LOG_TAUE_ISS95
    ISS95 scaling:
    Exponents used: $a_0 = -0.079$, $a_a = 2.21$, $a_R = 0.65$, $a_P = -0.59$[10], $a_n = 0.51$, $a_B = 0.83$, $a_i = 0.4$

84. LOG_TAUE_ISS04
    ISS04 scaling.

85. LOG_TAUE_W7
    ISS95W7 scaling.
    Exponents used: $a_0 = 0.115, a_a = 2.21, a_R = 0.74, a_P = -0.54, a_n = 0.50, a_B = 0.73, a_i = 0.43$

86. LOG_TAUE_LHD
    LHD scaling.
    Exponents used: $a_0 = 0.034, a_a = 2.00, a_R = 0.75, a_P = -0.58, a_n = 0.69, a_B = 0.84$, iota not used

87. LOG_TAUE_LG
    Lackner-Gottardi scaling.
    Exponents used: $a_0 = 0.68 * 0.0627, a_a = 2.00, a_R = 1.00, a_P = -0.60, a_n = 0.60, a_B = 0.80, a_i = 0.40$
    see also Ref. [8].

Dimensionless regression variables

88. TBAR
    Volume averaged temperature (eV):
    Derived quantity:
    $\mathrm{WDIA} \times \left(6 \times \pi^2 \times \mathrm{AEFF}^2 \times \mathrm{RGEO} \times \mathrm{NEBAR} \times 1.602 \times 10^{-19}\right)^{-1}$
    (for HELE and TJ-II WTH is used instead of WDIA)

89. LDEBYE
    Average Debye length:
    Derived quantity:
    $\left(\frac{8.8542\times10^{-12}\times\mathrm{TBAR}}{1.602\times10^{-19}\times\mathrm{NEBAR}}\right)^{1/2}$

90. LN_LAMBDA
    Average Coulomb logarithm:
    Derived quantity:
    $\ln\left(9 \times \frac{4}{3} \times \pi \times \mathrm{NEBAR} \times \mathrm{LDEBYE}^3\right)$

91. RHOSTAR
    Ion gyro radius normalized by minor radium:
    Derived quantity:
    $\left(\frac{\mathrm{TBAR}\times2\times1.602\times10^{-19}}{\mathrm{PGASA}\times1.66055\times10^{-27}}\right)^{1/2} \times \frac{\mathrm{PGASA}\times1.66055\times10^{-27}}{\mathrm{PCHARGE}\times1.602\times10^{-19}\times\mathrm{BT}\times\mathrm{AEFF}}$
    see also Eq. (14) in Ref. [6], note that the ion charge is included in the aforementioned definition.

92. BETA_ORIG
    Beta values from original datasets.

93. BETA_FORM
    Beta calculated using formula saved in the column-formula.

94. BETA
    Choice between BETA_ORIG and BETA_FORM.
    Except for high beta data, BETA=BETA_ORIG.

95. MFP_ION
    Ion mean free path
    Derived quantity:
    $16\times\pi\times(8.8542\times10^{-12})^2\times(1.602\times10^{-19}\times\mathrm{PCHARGE})^{-4}\times(1.602\times10^{-19}\times\mathrm{TBAR})^2\times\mathrm{NEBAR}^{-1}\times\mathrm{LN\_LAMBDA}^{-1}$

96. NUSTAR Normalized collisionality: connection length/trapped particle mean free path [6]:
    Derived quantity:
    $\mathrm{RGEO} \times 10^{-\mathrm{LOG\_I}} \times \left(\frac{\mathrm{RGEO}}{\mathrm{AEFF}}\right)^{3/2} \times \mathrm{MFP\_ION}^{-1}$

97. LOG_RHO
    Derived quantity:
    $\log_{10}(\mathrm{RHOSTAR})$

98. LOG_NU
    Derived quantity:
    $\log_{10}(\mathrm{NUSTAR})$

99. LOG_BETA
    Derived quantity:
    $\log_{10}(\mathrm{BETA})$

Uncertainties of the machine parameters

100. PHI_PARA
    LHD: Parallel flux (1/s). Needed for evaluation of uncertainty SIGMA_W.

101. PHI_HEL
    LHD: Helical flux (1/s). Needed for evaluation of uncertainty SIGMA_W.

102. PHI_TOR
    LHD: Toroidal flux (1/s). Needed for evaluation of uncertainty SIGMA_W.

103. SIGMA_AEFF
    Uncertainty of the effective minor radius (m):
    W7AS: Shot numbers less than 29000 were limiter shots. Magnetic islands are not considered in VMEC-calculations. Since they occur more frequently for IOTAA greater than 0.4: 1cm, otherwise 0.03 × AEFF. For BETA $>$ 0.01: 0.02 × AEFF. All other shots: 1cm
    ATF: 1cm
    CHS: 0.2 cm
    HELE: 1cm
    W7-A: 1cm
    LHD: 0.024 × AEFF
    HELJ: 1cm
    TJ-II: 1cm

104. SIGMA_PTOT
    Uncertainty of the total absorbed power (W):
    W7AS: For ECH 5%, for NBI: corrected for shine through, 10%
    ATF: ECH 20%, NBI 10%
    CHS: ECH 20%, NBI 10%
    HELE: ECH 20%, NBI 10%
    W7-A: ECH 0.3 × 1.25/BT
    LHD: NBI 8%
    HELJ: ECH 20%
    TJ-II: ECH 20%

105. SIGMA_NEBAR
    Uncertainty of the line average electron density (m^{-3}):
    The uncertainty stems mainly from the error in the effective minor radius and is therefore with help of error propagation law: SIGMA_AEFF × NEBAR/AEFF, eccept for CHS: 0.7% and LHS: 0.1% of NEBAR plus 6×10^{16}. W7-AS, if available, from microwave interferometer, otherwise from a central HCN chord

106. SIGMA_W
    Uncertainty of WDIA (J):
    W7AS: 200/2.553 × BT + const × WDIA with const=0.1 for shots before 1999 and const=0.01 afterwards. The time step is due to technical changes for the coil signal by Heike Laqua and improvements of the signal analysis by J. Geiger, both done within the year 1998.
    ATF: 40 × BT
    CHS: 40 × BT
    HELE: 0.1 × WDIA
    W7-A: 0.1 × WDIA
    LHD: $\sqrt{(0.02 \times \mathrm{WDIA})^2 (8 \times 10^7 \times \mathrm{BT}/3)^2 \times [(0.01 \times \mathrm{PHI\_TOR})^2 + (0.01 \times \mathrm{PHI\_PARA})^2 + (0.02 \times \mathrm{PHI\_HEL}/0.07)^2]}$
    HELJ: 0.1 × WDIA
    TJ-II: 0.1 × WTH

107. SIGMA_LOGA
    Uncertainty of LOGA:
    SIGMA_AEFF/(AEFF × LOG2(10))

108. SIGMA_LOGP
    Uncertainty of LOGP:
    SIGMA_PTOT/(PTOT × Log2(10))

109. SIGMA_LOGN
Uncertainty of LOGN:
SIGMA_NEBAR/(NEBAR × Log2(10))

110. SIGMA_LOGT
Uncertainty of LOGT. Since TAU is composed of WDIA/PTOT error propagation law gives $\sqrt{[SIGMA\_W/(10^{LOG\_TAU} \times PTOT)]^2 \, [SIGMA\_PTOT/PTOT]^2}/log_2(10)$

Grouping

111. ISS04_ALL
File Format (JMP) specific rows.
Indicate rowstates and device grouping.
All data are visible.

112. ISS04
File Format (JMP) specific rows.
Indicate rowstates and device grouping.
Only data entering ISS04 are visible.

113. ISS04_GROUPING
Description of ISS04 subgroups.

Data analysis

114. CHI Argument for least square fit:
$LOG\_TAU - \alpha_A \times LOG\_A\alpha_R \times LOG\_R\alpha_P \times LOG\_P\alpha_B \times LOG\_B\alpha_I \times LOG\_I\alpha_C$

115. CHI_SIGMA Argument for least square fit with uncertainties of the machine parameters:
$\frac{LOG\_TAU - \alpha_A \times LOG\_A\alpha_R \times LOG\_R\alpha_P \times LOG\_P\alpha_B \times LOG\_B\alpha_I \times LOG\_I\alpha_C}{SIGMA\_LOGT^2 + (\alpha_A \times SIGMA\_LOGA)^2 + (\alpha_P \times SIGMA\_LOGP)^2 + (\alpha_N \times SIGMA\_LOGN)^2}$

IV. SELECTION OF THE STANDARD SET

A. ISS95

The standard data set used in all the regressions of Ref. [8] can be obtained from the entire database under the following conditions:

1. Delete discharges in helium.
2. For ATF, delete discharge 6842. (3) For Heliotron-E, delete discharge 53 705.
3. For W7-AS delete all discharges with high power densities given by the condition $PTOT/NEBAR > 3 \times 10^{14}$Wm^{-3}.
4. For W7-AS, delete discharges 21089, 24734, 25966, 25969, 26000 and 26925.
5. Use the diamagnetic energy confinement time; only for Heliotron-E has the thermal confinement time be used. For observations included in the standard set, the parameter STDSET is set to 1. Otherwise this parameter is set to 0.

B. W7-AS high-beta data

The data were collected by A. Weller. This data set refers to high beta campaigns in W7-AS. Only data with beta $>$ 1.5 % were considered (199 observations). High beta data always may be afflicted from configuration effects, such as islands or corrugated boundary structures. This has to be taken into consideration for iota values larger than 0.5. The iota value of the data set is iota at $r_{eff} = 2/3AEFF$.

The following shots are excluded from the standard data set:

- for not being in the criteria of the high beta survey: 43348, 51348, 51373, 54130, 54925, 56315, 56316, 56317, 56325, 56326, 56328, 56329, 56336, 56337, 56340, 56341, 56345, 56345, 56346, 56347, 56348, 56349, 56350, 56351, 56700, 56702, 56711, 56712

- high beta survey time point more stationary, higher beta (see below): 53007
- high beta survey time point with higher beta: 53008
- for entry at multiple times without change in scenario: 53052 at 0.249s, 53054 at 0.249s, 53055 at 0.249s, 54012 at 0.349s, 54019 at 0.229s, 54022 at 0.349s, 54023 at 0.349s, 54024 at 0.349s, 56403 at 0.597s and 0.598s, 56703 at 0.326s, 56723 at 0.399s
- for current Ip too high: 54147, 54152, 54153, 54156, 55852, 55876, 55904, 55905, 55907, 55908, 55909, 56286, 56293, 56298, 56299, 56302, 56306, 56307, 56308, 56309, 56310, 56311, 56312, 56952
- control coils not optimized: 53053
- for not being stationary: 54020, 54932 at 0.262s, 56936 at 0.279s, 56953 (last W7AS shot) → 0.28s and smaller times
- for ramp in vertical field Bz: 56736 at 0,444s, 56935, 56938 at 0,356s, 56939 at 0,291s, 56940 at 0,319s, 56945 at 0.279s and 0.339s and 0.533s, 56949, 56950
- 56952 not stationary at 0.229s and at larger times current Ip too high

Shot 51373 can be regarded to document the effect of control field coils; the control current of which is zero and has to be compared with shot 51385 in order to document the optimization of the plasma position due to the control coils.

C. LHD data

PHASE was set to ”STAT”.

D. W7-AS NI data

(shot #50886) PHASE set to ”STAT”, PNBI1, PNBI2 set to missing, PABSNBI calculated by Werner.

E. TJ-II data

There are 1130 discharges from TJ-II in the database, belonging to 43 different magnetic configurations. For the standard data set (used e.g. in the ISS04 scaling) we have selected the configuration named 100_44_64, which has the largest number of discharges and $\iota_{2/3} = 1.60$. For TJ-II, the thermal confinement time has been used.

F. Heliotron J data

The data were collected by F. Sano. This data set refers to electron cyclotron heating (ECH) campaigns in Heliotron J (shots 5287-5302 and 6049-6140 in 2001 and shots 7776-8084 in 2002) under the on-axis and off-axis heating conditions by using 70-GHz, 0.4-MW focused 2$^{\mathrm{nd}}$ harmonic ECH of X-mode. Only data with the standard (STD) magnetic configuration were considered, where the vacuum edge iota value is about 0.557 with low magnetic shear as well as with magnetic well depth of about 1.5% at the boundary. The internal plasma energy content was measured using the diamagnetic loop at the peak energy timing. The ECH absorption power was estimated using the TRECE code [9], where the calculated single-pass absorption efficiency for the flat density profile and the parabolic temperature profile is 0.429 for NEBAR $= 0.2 \times 10^{19}\,\mathrm{m}^{-3}$ and $T_e(0) = 1200$eV,0.495 for NEBAR $= 0.8 \times 10^{19}\,\mathrm{m}^{-3}$and $T_e(0) = 500$eV, and 0.598 for NEBAR $= 2 \times 10^{19}\,\mathrm{m}^{-3}$ and $T_e(0) = 250$eV. In the present data set, the effective absorption efficiency of ECH was assumed to be 66% taking into account the assumed 20-40% multi-reflection effects. The off-axis heating shots (BT $= 1.17$T and BT $= 1.30$T) and shots 8082 and 8084 are excluded from the standard data set of on-axis heating ($1.17 <$ BT < 1.30).

G. HSX data

The vast majority of the shots come with ECH power less than 100 kW. Since the densities are in the $10^{17}\,\mathrm{m}^{-3}$ range, the major fraction of the stored energy can be suspected to be nonthermal. HSX confinement time does not scale with density and power in the way that the other stellarators do. Data were excluded for ISS04 (STDSET = 0).

H. W7-X data

The data refer to operational parameters given adopted from Grieger *et al.* [5]. The data do not incorporate any optimization considerations but are the scaling extrapolations. It is to be emphasized that these extrapolations are considerably smaller than the figures in the W7-X proposal. Data should not be used in any scaling (STDSET = 0).

I. BRAKEL

W7-AS data from the ι-scan shown in Fig. 2 of [2]. Data not used for ISS04 (STDSET = 0).

J. ITER

Reference for ITER operation from [7]. Data should not be used in any scaling (STDSET = 0).

K. HIRSCH

Comparative H- and L-mode data. Data not used for ISS04 (STDSET = 0). AEFF is an upper limit.

L. GRIGULL/McCORMICK

Density scan for divertor operation covering the transition from normal confinement (NC) to attached HDH to detached HDH operation. AEFF was determined from vacuum field calculations (Gourdon code). The absorbed power was estimated from extrapolations of the Penningsfeld formula. Data not used for ISS04 (STDSET = 0).

M. PREUSS

W7-AS high-beta survey: the data were collected by R. Preuss. The search criteria have been: toroidal magnetic field at 36 degrees in between -1.5T and 1.5T, ICOR1 smaller than -1kA, IP in between -0.5kA and 0.5kA and PNBI larger than 2MW. Only those shots were taken into account which obeyed a stationarity criteria, i.e. variation of less than 10% relative for ± 0,05s around shot time. Data added to the standard set after completion of ISS04 (STDSET = 0).

N. FUNABA LHD high-beta transport data

LHD high-beta data collected by H. Funaba (STDSET = 0).

O. DREIER

W7-AS density scan data collected by H. Dreier. Data added to the standard set after completion of ISS04 (STDSET = 0).

P. MAASSBERG CERC data

W7-AS CERC data (STDSET=0).

Q. ESTRADA

TJ-II CERC data (STDSET=0).

R. TURKIN

W7-X predictive data (STDSET=0).

S. MAASSBERG high performance data

W7-X high performance data (STDSET=0).

T. WELLER LHD high-beta survey data

LHD high-beta data collected by A. Weller during his stay at NIFS in autumn 2007, in cooperation with S. Sakakibara and H. Funaba. (STDSET = 0).

V. ISHCDB DATA IN 0-D UFILES

One 0-D Ufile corresponds to one row in the ISHCDB.

However, in the Ufiles (that are ASCII files) a single field length is limited to 10 characters. That means specifications contained in the columns DATASOURCE and COMM may be truncated.

Also some column names have to be changed:

ISHCDB column	Ufile field name
SHEAR_INDICATOR	SHEAR_IND
ASEPARATRIX	ASEPAR
GL_HEAT_EFF	GL_HEAT_E
DGL_HEAT_EFF	DGL_HEAT_E
LOG_TAUE_ISS95	L_TAUE_95
LOG_TAUE_ISS04	L_TAUE_04
LOG_TAUE_W7	L_TAUE_W7
LOG_TAUE_LHD	L_TAUE_W7
LOG_TAUE_LG	L_TAUE_LG
SIGMA_NEBAR	SIG_NEBAR
SIGMA_AEFF	SIG_AEFF
SIGMA_PTOT	SIG_PTOT
SIGMA_W	SIG_W
SIGMA_LOGA	SIG_LOGA
SIGMA_LOGP	SIG_LOGP
SIGMA_LOGN	SIG_LOGN
SIGMA_LOGT	SIG_LOGT

---

[1] Beidler, C. D., and W. N. G. Hitchon, 1994, Plasma Phys. Control. Fusion **35**, 317.
[2] Brakel, R., and W7-AS Team, 2002, Nuclear Fusion **42**(7), 903.
[3] E. Rodriguez-Solano Ribeiro, and K. C. Shaing, 1987, Phys. Fluids **30**(2), 462.
[4] EFDA, 2004, `http://efdasql.ipp.mpg.de/HmodePublic/DataDocumentation/Datainfo/DB3varlist.htm`, EFDA, Garching.
[5] Grieger, G., and the W7-X Team, 1998, J. Plasma Fusion Res. SERIES **1**, 53.
[6] ITER Physics Expert Groups on Confinement and Transport and Confinement Modelling and Database, ITER Physics Basis Editors, and ITER EDA, 1999, Nucl. Fusion **39**, 2175.
[7] Kardaun, O., 1999, Plasma Phys. Control. Fusion **41**, 429.
[8] Stroth, U., M. Murakami, R. A. Dory, H. Yamada, S. Okamura, F. Sano, and T. Obiki, 1996, Nucl. Fusion **36**, 1063.
[9] Tribaldos, V., and et al., 2002, J. Plasma Fusion Res. **78**, 996.
[10] Note: Since PTOT in the ISS95 scaling was used in MW, LOG_P is replaced by (LOG_P - 6) in LOG_TAUE_ISS95, LOG_TAUE_W7, LOG_TAU_LHD, LOG_TAU_LG