# METIS documentation for input data structure

**Introduction:**

This document describes the content of input data structure (named "z0dinput") of METIS code. The first part describes the list of substructures and datas in data z0dinput structure. The second part describes the indput data model of METIS code, made of lists of time dependent scalar data with their description corresponding to waveform controling the plasma geometry, current, density, additional powers,...

Access to input data is not available in the standalone compiled version of METIS.

The syntax to access to structure field in Matlab is "z0dinput.<subtructure_name>.<field_name>. Example: "z0dinput.cons.ip".

Variable names missing in this documentation are unused in present version of METIS and are present in data structures to ensure backward compatibility.

**List of substructures and data of METIS input structure:**

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**1- cons:**

time dependant waveforms used to configure the scenario plasma current, electron density, additional powers, ....

**2- exp0d:**

this substructure contains the same fields than the substructure "post.zerod" but these fields are used to store data read in experimental data base at the initialisation of a METIS simulations.

**3- geo:**

time dependant waveforms used to configure the plasma geometry.

**4- info:**

tooltips for scalar parameters stored in substructure "option".

**6- machine:**

name of the device (Tore Supra, JET, ITER, ...).

**7- mode_exp:**

integer encoding for source of the data (see details in zerod_init.m).

**8- option:**

this substructure contains the scalar parameters allowing to tune internal physical models and numerical schemes of METIS. These parameters are descibed in detail in separate documents named "metis_documentation_for_parameters_expert_mode.pdf" for the expert mode and "metis_documentation_for_parameters_standard_mode.pdf" for standard mode.

**9- profinfo:**

tooltips for time dependant profile stored in substructure "zerod" of output data structure post.

**10- sepa_option:**

undocumented section.

**11- shot:**

shot number.

**12- zsinfo:**

tooltips for time dependant scalar stored in substructure "zerod" of output data structure post.

# 1. Substructure: cons

time dependant waveforms used to configure the scenario plasma current, electron density, additional powers, ....

## 1.1. flux

poloidal flux at LCFS waveform (Wb/2pi).

## 1.2. ftnbi

fraction of power from neutral beam injecting tritium (ftnbi) and deuterium (1-ftnbi) in DT plasma, or fraction of power from neutral beam injecting hydrogen (ftnbi) for other plasma compositon.

## 1.3. hmore

time confinement multiplication factor waveform (for any confiment mode Ohmic,L,H ...).

## 1.4. ip

plasma current waveform used as boundary condition of current diffusion equation (A).

## 1.5. iso

for D-T plasma: ratio between tritium and deuterium densities waveform ; for pB11, ratio between boron and hydrogen densities waveform and for D-He3, the real part is the ratio between helium 3 and deuterium densities waveform and the imaginary part is the ratio between tritium and deuterium densities waveform.

## 1.6. nbar

reference line averaged density waveform (m^-3); if imaginary part is non null, then imaginary part encode for gas puff waveform (e/s).

## 1.7. pecrh

power injected in the plasma by the electron cyclotron resonance heating system (W).

## 1.8. picrh

power injected in the plasma by the ion cyclotron resonance heating system (W).

## 1.9. plh

power injected in the plasma by the lower hybrid electron heating system (W).

## 1.10. pnbi

power injected in the plasma by the neutral beam injection system (W). the real part encode for first NBI and imaginary part encode for second NBI.

## 1.11. temps

vector of time slices of the waveform and of the simulation.

## 1.12. xece

position of the maximum power depostion for ECRH waveform.

## 1.13. zeff

line averaged effective charge waveform.

# 2. Substructure: geo

time dependant waveforms used to configure the plasma geometry.

## 2.1. K

elongation of the plasma waveform (ratio between the two axes of the ellipse).

## 2.2. R

major radius of the plasma waveform (m).

## 2.3. a

minor radius of the plasma waveform (m).

## 2.4. b0

vacuum magnetic toroidal field measured at geo.R (T).

## 2.5. d

mean value of the upper and the lower triangularity of the plasma waveform.

## 2.6. z0

vertical position of the plasma waveform (m).

# 3. Substructure: exp0d

this substructure contains the same fields than the substructure "post.zerod" but these fields are used to store data read in experimental data base at the initialisation of a METIS simulations.

## 3.1. RR

plasma resistor (ohm).

## 3.2. Rsepa

matrix of experimental or prescribed R coordinate of LCFS given by points ([n_times x m_points], m >= 5, in m).

## 3.3. Zsepa

matrix of experimental or prescribed Z coordinate of LCFS given by points ([n_times x m_points], m >= 5, in m).

## 3.4. aitb

effect of itb on temperature peaking factor.

## 3.5. ane

exponent of electron density profile.

## 3.6. ane_actual

actual exponent of electron density profile obtained taking into account the reference and constraints from transport.

## 3.7. ape

exponent of electron pressure profile.

## 3.8. asser

if 1, feedback on vloop is on.

## 3.9. ate

exponent of electron temperature profile.

## 3.10. betan

normalized total beta of the plasma.

## 3.11. betap

poloidal normalized pressure of the plasma (thermal, ITER definition : betap_th(1)).

## 3.12. betaptot

poloidal normalized pressure of the plasma (total, ITER definition : betap(1)).

## 3.13. d0

Shafranov shift (m).

## 3.14. diboot

relative error on Iboot, at the end of convergence.

## 3.15. difcurconv

current diffusion solver state.

## 3.16. dini

relative error on Ini, at the end of convergence.

## 3.17. disrup

if = 1, ratiative disruption flag.

## 3.18. dlh

width of the power deposition of LH (su).

## 3.19. dpfus

relative error on pfus, at the end of convergence.

## 3.20. drmdt

d sqrt(PHI/pi/B0) / dt of LCMS(m/s) .

## 3.21. dsol

caracteristic SOL width (lambda_q, m).

## 3.22. dw

relative error on w, at the end of convergence.

## 3.23. dwbpdt

time derivative of plasma poloidal field energy (W).

## 3.24. dwdt

time derivative of total plasma energy (W).

## 3.25. dwmagtordt

time derivative of toroidal magnetic plasma energy (W).

## 3.26. dwthdt

time derivative of thermal plasma energy (W).

## 3.27. ecrit_he

alpha critical energy (eV): for He3 if option.gaz == 5, otherwise for He4.

## 3.28. ecrit_he3_DDn

critical energy (eV) of helium-3 fusion particules from D-D reactions.

## 3.29. ecrit_he4_DHe3

critical energy (eV) of helium-4 fusion particules from D-He3 reactions.

## 3.30. ecrit_he4_DT

critical energy (eV) of helium-4 fusion particules from D-T reactions.

## 3.31. ecrit_icrh

critical energy of ICRH accelerated fast ions (eV).

## 3.32. ecrit_nbi

critical energy of NBI beam (eV).

## 3.33. ecrit_p_DDp

critical energy (eV) of proton fusion particules from D-D reactions.

## 3.34. ecrit_p_DHe3

critical energy (eV) of proton fusion particules from D-He3 reactions.

## 3.35. ecrit_t_DDp

critical energy (eV) of tritium fusion particules from D-D reactions.

## 3.36. eddy_current

Eddy current in passive structure for breakdown description (A).

## 3.37. edgeflux

poloidal flux at the edge of plasma (V s).

## 3.38. efficiency

Fisch like LH current drive efficiency for LHCD(A/W/m^2).

## 3.39. einj_icrh

mean energy of fast ion produce by ICRH in minoritary scheme (eV).

## 3.40. einj_lh

mean LH electron energy, only define if rip = 1 (eV).

## 3.41. einj_nbi_icrh

beam energy including ICRH effects (eV; reserved for internal used only).

## 3.42. esup_fus

D-T fusion fast alpha suprathermal energy (J).

## 3.43. esup_icrh

ICRH fast ions suprathermal energy (J).

## 3.44. esup_lh

LH fast ions suprathermal energy (J).

## 3.45. esup_nbi

NBI fast ions suprathermal energy (J).

## 3.46. etalh

LH current drive efficiency (A W^-1 m^-2).

## 3.47. etalh0

LH current drive efficiency @ vloop = 0 (A W^-1 m^-2).

## 3.48. etalh1

LH current drive efficiency correction due to hot conductivity (A W^-1 m^-2).

## 3.49. firstorb_nbi

fraction of NBI power lost due to fast ion first orbit loss.

## 3.50. flux_edge_cor

Poloidal flux modification of reference cons.flux due to eddy current (Wb/ (2*pi)).

## 3.51. frac_pellet

fraction of fuelling due to pellet.

## 3.52. fracmino

minority ions fraction accelerated by ICRH.

## 3.53. frloss_icrh

part of icrh power lost due to fast ions losses.

## 3.54. frnbi

fraction of NBI power absorbed in the plasma.

## 3.55. fwcorr

internal data to compute tem.

## 3.56. harm

ICRH minority scheme harmonic.

## 3.57. hitb

H factor of ITB.

## 3.58. hmhd

H factor limitation due to MHD (BetaN limit).

## 3.59. ialign

current drive alignment quality parameter (1 = good , 0 = bad).

## 3.60. iboot

bootstrap current (A).

## 3.61. icd

total current drive (A).

## 3.62. ieccd

ECCD current drive(A).

## 3.63. ifus

fast alpha (fusion) "bootstrap" current (A) .

## 3.64. ifwcd

FWCD current drive(A).

## 3.65. ilh

LH current drive(A).

## 3.66. inbicd

NBI current drive (A).

## 3.67. indice_inv

sawtooth invert radius indice.

## 3.68. ini

total non inductive current (A).

## 3.69. iohm

ohmic current (A).

## 3.70. ip

plasma current (A).

## 3.71. ipar

plasma current // B (A).

## 3.72. irun

runaway current (A).

## 3.73. j0fus

Jalpha at center (usage interne,su).

## 3.74. jxfus

Jalpha at xfus (su).

## 3.75. kidds_evol

facteur applique au coefficient de transport de Te pour la simulation de dents de scie en mode evolution.

## 3.76. li

internal self inductance (formule 3 of ITER FDR).

## 3.77. meff

effective mass (number of atomic mass, hydrogenoid ions).

## 3.78. modeh

confinement mode versu time:   0 = L et 1 = H.

## 3.79. mu0_nbi

initial value of pitch angle for NBI (V// / V').

## 3.80. n0a

number of cold neutral that input in plasma at the edge every second coming from recycling and gaz puff (s^-1).

## 3.81. n1m

volume averaged density of H + D + T ions (m^-3) or H+D if option.gaz = 11.

### 3.82. nDm

volume averaged density of deuterium ions (m^-3).

### 3.83. nTm

volume averaged density of tritium ions (m^-3); if option.gaz = 11, encode for volume averaged boron density; in this case the tritium density is null.

### 3.84. nb

number of convergence loops made.

### 3.85. nbar

line averaged electron density (m^-3).

### 3.86. nbar_nat

natural density (m^-3).

### 3.87. ndd

total DD neutrons per second (s^-1).

### 3.88. ndd_nbi_nbi

beam/beam DD neutrons per second (s^-1).

### 3.89. ndd_nbi_th

beam/plasma DD neutrons per second (s^-1).

### 3.90. ndd_th

plasma/plasma DD neutrons per second (s^-1).

### 3.91. ne0

estimation central electron density (m^-3).

### 3.92. nebord

estimation of plasma edge electron density (m^-3).

### 3.93. negr

Greenwald limit for electron density (m^-3).

## 3.94. nelim

plasma eletron density temparature estimation near the divertor plate (m^-3).

## 3.95. nem

volume averaged electron density (m^-3).

## 3.96. neped

top electron pedestal density (m^-3).

## 3.97. nhe4m

volume averaged density of helium-4 (m^-3) in case of option.gaz == 5, adding accumunication of He4 on option.frhe0 * zs.nem for initial volume averaged He4 density.

## 3.98. nhem

volume averaged density of helium (m^-3); if option.gaz == 5, encode for volume averaged He3 density and option.frhe0 * zs.nem encode for volume averaged He4 density.

## 3.99. ni0

estimation of central ionic density (m^-3).

## 3.100. nibord

edge ion density (m^-3).

## 3.101. nim

sum of volume averaged ions density (m^-3).

## 3.102. nimpm

volume averaged density of impurity (other than helium) (m^-3).

## 3.103. niped

top ion pedestal density (m^-3).

## 3.104. nmino

volume averaged ICRH minority density.

## 3.105. nsat

saturation electron density, use for the calculation of density (m^-3).

## 3.106. nwm

volume averaged tungsten density (m^-3);if option.Sn_fraction > 0, nwm become the sum of the density of W and Sn:<n_W> = (1 - option.Sn_fraction) * nwm & <n_Sn> = option.Sn_fraction * nwm..

## 3.107. pbrem

Bremsstrahlung radition losses (W).

## 3.108. pcyclo

cyclotron radiation losses (W).

## 3.109. pddfus

fusion power from DD reactions (W).

## 3.110. peakdiv

divertor peak power surface density estimation   (W/m^2).

## 3.111. pecrh

ECRH power(W).

## 3.112. pei

equipartition power (W).

## 3.113. pel

total thermal power deposition on electron, use in the calculation of   Ti/Te (W).

## 3.114. pel_fus

Alpha power going on electron (W).

## 3.115. pel_icrh

ICRH power going on electron (W).

## 3.116. pel_nbi

NBI power going on electron (W).

## 3.117. pelec

reactor electric power provide to the network (W).

## 3.118. peri

length of the LCMS (m).

## 3.119. pfus

total fusion power of alpha for D-T plasma and p-B11 plasma heating the plasma or from charged products for D + He3 (W).

## 3.120. pfus_loss

fusion power loss due to first orbit losses of fast alpha (estimation, W).

## 3.121. pfus_nbi

NBI induce fusion power heating the plasma (W).

## 3.122. pfus_th

fusion thermal power depostion of alpha particles (W).

## 3.123. phiplasma

toroidal magnetic flux due to the plasam (Wb).

## 3.124. picrh

ICRH power, decrease of ripple losses in TS (W).

## 3.125. picrh_th

ICRH thermal power depostion (W).

## 3.126. pin

total heat power (W).

## 3.127. pion

total thermal power deposition on ions, use in the calculation of Ti/Te (W).

## 3.128. pion_fus

Alpha power going on ions (W).

## 3.129. pion_icrh

ICRH power going on ions (W).

## 3.130. pion_nbi

NBI power going on ions (W).

## 3.131. pioniz

power losses due to cold neutral ionization and charge exchange betweens ion and cold neutrals(W).

## 3.132. pioniz_i

power losses due to charge exchange betweens ion and cold neutrals (W).

## 3.133. piqj

peaking factor of current profile.

## 3.134. piqnbi

peaking factor of the NBI power deposition profile (su).

## 3.135. plh

LH power , decrease of ripple losses in TS (W).

## 3.136. plh_th

LH thermal power depostion (W).

## 3.137. plhrip

LH power loss in ripple for Tore Supra (W).

## 3.138. plhthr

additionnal power crossing the LCMS; must be compare to L->H threshold power (Ryter PPCF 2002).

## 3.139. plim

total power estimation on divertor plate (W).

## 3.140. ploss

plasma losses power, as defined in ITER basis (W).

## 3.141. plossl2h

threshold power for transition from L mode to H mode for the selected scaling law (W).

## 3.142. pnbi

NBI power (W).

## 3.143. pnbi_icrh

equivalent beam power increase needs for neutron rate enhancement due to ICRH synergy effects (W).

## 3.144. pnbi_th

NBI thermal power depostion (W).

## 3.145. pohm

ohmic power (W).

## 3.146. poynting

flux of Poynting vector through the LCMS (W).

## 3.147. pped

total pressure @ pedestal top (Pa).

## 3.148. ppedmax

maximal allowed total pressure @ pedestal top (Pa).

## 3.149. prad

impurity radition losses in core plasma, without Bremsstrahlung (W).

## 3.150. pradsol

radiation losses in the SOL (W).

## 3.151. priptherm

TS ripple losses, thermal part (W).

## 3.152. pth

thermal power input, define as tau_E * Pth = Wth (W).

## 3.153. pttfus

fusion power from TT reactions (W).

### 3.154. pw

effective power define as taue * pw = W (W).

### 3.155. q0

estimation of central value of safety factor.

### 3.156. q95

safety factor @ 95% of poloidal flux.

### 3.157. qa

edge safety factor.

### 3.158. qeff

effective safety factor at the edge (computed with ITER formula).

### 3.159. qmin

estimation of minimal value of safety factor.

### 3.160. rm

sqrt(PHI/pi/B0) of LCMS (m) .

### 3.161. rres

ICRF resonance layer radial position (m).

### 3.162. salpha

total number of alpha fusion particules from D-T reactions, from p-B11 reactions per second or from D-He3 reactions (s^-1).

### 3.163. salpha_he3

total number of helium-3 fusion particules per second from D-D reactions (s^-1).

### 3.164. salpha_he4

total number of helium-4 fusion particules per second from D-T and D-He3 reactions (s^-1).

### 3.165. salpha_n

total number of neutrons per second from D-D and D-T reactions (s^-1).

## 3.166. salpha_p

total number of proton fusion particules per second from D-He3 and D-D reactions (s^-1).

## 3.167. salpha_t

total number of tritium fusion particules per second from D-D reactions (s^-1).

## 3.168. sext

external plasma surface (m^ 2).

## 3.169. slh

rotation torque due to LHCD and ECCD (N m).

## 3.170. sn0fr

friction source on edge neutral that damps the toroidal rotation (N m).

## 3.171. snbi

rotation torque due to NBI (N m).

## 3.172. sp

poloidal plasma surface (m^ 2).

## 3.173. stf

number of wrong data in zs data structure containing NaN or Imag.

## 3.174. taue

energy confinement time (s).

## 3.175. taue_alt

energy confinement time, Helander & Sigmar definition (s).

## 3.176. tauee

scale of electron heat confinement time (s).

## 3.177. tauei

exchange electon/ion heat time (s).

### 3.178. tauh

confinement time of energy in H mode for the selected scaling law (s).

### 3.179. tauhe

confinement time of helium impurity/ashes (s).

### 3.180. tauhe_h

confinement time of helium impurity/ashes in H mode (s).

### 3.181. tauhe_l

confinement time of helium impurity/ashes in L mode (s).

### 3.182. tauii

scale of ion heat confinement time (s).

### 3.183. tauip

carateristic time of R-L equivalent plasma circuit (s).

### 3.184. tauj

diffusion time of current (s).

### 3.185. taup

confinement time of matter (s).

### 3.186. taus_he

caracteristic slowing down time for alpha particules (s).

### 3.187. taus_icrh

caracteristic slowing down time for ICRH fast ions (s).

### 3.188. taus_nbi

caracteristic slowing down time for NBI fast ions (s).

### 3.189. tauthl

confinement time of energy in L mode for the selected scaling law (s).

### 3.190. te0

estimation of central electron temperature (eV).

### 3.191. tebord

estimation of plasma edge electron temperature (eV).

### 3.192. telim

plasma eletron temparature estimation near the divertor plate (eV).

### 3.193. tem

volume averaged electron temperature (eV).

### 3.194. temps

time slices vector.

### 3.195. teped

top electron pedestal temperature (eV).

### 3.196. tibord

edge ion temperature (eV).

### 3.197. tiped

top ion pedestal temperature (eV).

### 3.198. tite

volume averaged ratio Ti / Te.

### 3.199. vloop

loop voltage, as vloop .* iohm = pohm (V).

### 3.200. vmes

loop voltage as measured on a fixed magnetic loop (V).

### 3.201. vp

plasma volume (m^3).

## 3.202. w

total plasma energy (J).

## 3.203. wbp

poloidal field energy of the plasma (J).

## 3.204. wdia

3/2 perpendicular plasma energy (J).

## 3.205. wmagtor

toroidal magnetic plasma energy (J).

## 3.206. wrad

estimation of bulk volume averaged toroidal rotation velocity (rad/s).

## 3.207. wrlw

plasma energy contents for electron computed with RLW sacling law (J).

## 3.208. wrot

toroidal plasma rotation stored energy (J).

## 3.209. wth

thermal plasma energy (J).

## 3.210. xeccd

position of the maximum power deposition of ECCD(su).

## 3.211. xfus

Jalpha maximum position (su).

## 3.212. xitb

radius of itb due to a revserse shear (estimation,su).

## 3.213. xlh

position of the maximum power deposition of LH deposition maximum position (su).

## 3.214. xnbi

position of the maximum power deposition of NBI(su).

## 3.215. xped

pedestal normalized position.

## 3.216. xpoint

flag for diverted plasma;for plasma in limiter mode = 0; for plamsa in divertor mode = 1.

## 3.217. xres

ICRF resonance layer normalized radius position.

## 3.218. zeff

plasma effective charge with alpha particles.

## 3.219. zeffsc

zeff scaling (private data, do not use).

## 3.220. zmszl

ratio between volume averaged zeff and line averaged zeff .