HOMDYN USER GUIDE

RELEASE HTWA12

Massimo Ferrario (July 99)
FERRARIO@LNF.INFN.IT

.

THE HOMDYN CODE:

The code HOMDYN reads the input data from the file **INPUTDECK** (without extension) and saves the main output data on the file **HBUNCH.OUT**.

The user must provide also files containing on axis solenoids field distribution (z [m], Bz [T]) with the extension .**POI** and/or on axis rf field distribution (z [m], Ez [V/m]) with the extension .**SEK**. In both cases the step dz must be constant.

Additional output data are saved in the following files as explained later:

HOMDYN.SUM HSPACE.OUT HSLICE.DAT

HSCAN.OUT HQSCAN.OUT

An **INPUTDECK** file is reported in the next section followed by an explanation. I suggest the user to modify only the data indicated by upper cases and explained, while leaving unchanged all the other data.

TEND [sec] ==> the code stops the integration when t=TEND
H1 [sec] ==> integration step
HMIN [sec] ==> it has to be HMIN=H1
NLOOP N ==> the code saves output data in the file **HBUNCH.OUT** every dt=TEND/NLOOP
IPR2 N ==> the code saves output data in the file **HSPACE.OUT** every dt=TEND*IPR2/NLOOP
ZETA0 [m] ==> starting position of bunch center (must be ZETA0>DLB),
in RF GUN case it is the cathode position
ZSTOP [m] ==> the code stops the integration when the bunch center position exceeds ZSTOP even if t < TEND
EMEV [MeV] ==> bunch energy
SPREAD [+-MeV] ==> bunch energy spread, linearly correlated

MAXB N **==>** number of step in case of scanning **ISCAN>0**
CAR [C] ==> bunch charge
DLB [+m] ==> bunch length, when positive
[-sec] ==> laser pulse length when negative in case of RF GUN
IGA N ==> total number of slices, better an **odd** number
IMCAR 0 ==> image charge on the cathode disabled
1 ==> image charge on the cathode enabled

ISAVE 0 ==> none
1 ==> slices coordinates are saved when z=zstop in the file **SAVE.COR**
IREAD 0 ==> none
1 ==> slices coordinates are red from the file **READ.COR**
XEMIT [m rad] ==> rms normalized thermal emittance when ICATH=0
==> rms normalized thermal emittance per mm of bunch envelope size when ICATH=1
XRBUNC [m] ==> bunch envelope

YEMIT [m rad] ==> rms normalized thermal emittance when ICATH=0
==> rms normalized thermal emittance per mm of bunch envelope size when ICATH=1
YRBUNC [m] ==> bunch envelope

ICATH N ==> **0** user defined thermal emittance

==> **1** user defined thermal emittance per mm of bunch envelope size

==> **2** analitically defined thermal emittance for Cs_2Te photo cathode:

initial electrons kinetic energy is set to 0.75 eV and thermal emittance is computed according to Flottman formula:

$$\varepsilon_{n,rms}^{Th} = \frac{R_o}{2}\sqrt{\frac{2E_{kin}}{m_o c^2}}\frac{1}{\sqrt{3}}$$

==> **3** equivalent thermal emittance when BZCATH > 0, analitically

computed from Bush theorem: $\varepsilon_{n,rms}^{B_z} = \frac{eR_o^2 B_z}{8m_o c}$

==> **4** total emittance is computed from cases **2** + **3** added in quadrature

BZCATH [T] ==> residual solenoid field on cathode position

IPOI N ≤ 5 ==> number of files with extension .POI containing solenoid field profiles

ISOL N ≤ 20 ==> number of coil fields analytically computed

N=100 ==> constant Bz= **BMAX** along the beamline

$$B_z(z) = \frac{\hat{B}}{\left(1 + \left(\frac{z - z_s}{R_s}\right)^2\right)^{3/2}}$$

ISHIELD N ≤ 20 ==> number of shielded coil fields analytically computed

IQUAD N ≤ 20 ==> number of hard edge quadrupoles

ICAV N [0,1] ==> number of SW rf structure

IFOUR N [1,4]==> **1:** TW structure: **Ep*sin(wt-kz+fi0)**

==> **2**: SW structure: **Ep*sin(wt+fi0)*sin(kz)**

==> **3**: SW structure: **Ep*cos(wt+fi0)*sin(kz)**

==> **4:** TW structure: **Ep*sin(wt-kz+fi0)** with input and output SW half end cells

ZSCREEN [m] ==> the rms normalized emittance is computed at constant Z every dz=zscreen, and saved in the file **HEMY.OUT**

ISCAN ==> **11** B field scanning if IPOI=1, only the main solenoid
==> **12** B field scanning if IPOI=1, both the main and the bucking coil
==> **13** B field map z position scanning if IPOI=1
==> **21** B field scanning if ISOL=1
==> **22** B field scanning if ISOL=1, both the main and the bucking coil
==> **23** B field coil z position scanning if ISOL=1
==> **41** all quads B' scanning
==> **42** last quad B' scanning
==> **43** triplet scan with $B'_2=2\,B'_1\,L_1/L_2$
==> **51** E peak scanning if ICAV=1
==> **52** Phase scanning if ICAV=1
==> **61** E peak scanning if IFOUR>0
==> **62** Phase scanning if IFOUR>0
==> **63** shifting z0fr if IFOUR>0
==> **101** Q scaling $\sigma_{x,y,z,} \div Q^{1/}$
⇨ **102** R scanning
⇨ **103** L scanning

STEP ==> step related to **ISCAN**

The following lines are optional and specify the beam line. They have to be added in the following order when the corresponding element is activated.

<u>If **IPOI=1** one has to add the following line:</u>

SOLMAP 'name5' ==> name of the file (5 letters exactly) with the extension .POI
ex: NAME5.POI
ZSOLEN [m] ==> entrance of the element : data in NAME5.POI are traslated
by dz=ZSOLEN
BMAX [T] ==> peak solenoid field

<u>If **ISOL>0** one has to add n=ISOL lines as follow:</u>

ZSOLEN [m] ==> peak coil field position
BMAX [T] ==> peak coil field

ZBHALF [m] ==> coil radius

<u>If **ISHIELD>0** one has to add n=ISHIELD lines as follow:</u>

ZSOLEN [m] ==> peak shielded coil field position
BMAX [T] ==> peak shielded coil field
RGAP [m] ==> shield radius
SGAP [m] ==> gap length

<u>If **IQUAD>0** one has to add n=IQUAD lines as follow:</u>

ZQUAD [m] ==> hard edge quadrupole entrance
QGRAD [T/m] ==> quadrupole gradient (+ focusing in X)
QLENGTH [m] ==> quadrupole length

<u>If **ICAV=1** one has to add the following lines:</u>

Z0CAV[m] ==> entrance of the element : data in NAME5.SEK are traslated by dz=Z0CAV
FI0 [deg] ==> rf field phase (90 deg is the crest)
EPEAK [V/m] ==> expected peak field at the position z = ZK

ZK [m] ==> point like generator position

MODO 'name5' ==> name of the file (5 letters exactly) with the extension .SEK
ex: NAME5.SEK
WN [Hz] ==> rf frequency
VSFH ==> normalization factor, it is the field value at z=ZK in the file NAME5.SEK , the data are then divided by VSFH and multiplied by EPEAK

<u>If **IFOUR>0** one has to add the following line:</u>

Z0FR [m] ==> entrance of the element

DNCEL	N	==>	number of cells per rf structure
Dlcel	[m]	==>	cell length

If **IFOUR=4** the input and output SW half end cells are authomatically set to be $\lambda/4$ long, the complementary TW half cells $\lambda/6$ long and the other full TW cells $\lambda/3$ long.

PSI	[deg]	==>	phase advance per cell (ex: 120 corresponds to $2\pi/3$)
WN	[Hz]	==>	rf frequency
FI0	[deg]	==>	rf field phase (0 deg is the crest)
EP	[V/m]	==>	peak field

FIELD PROFILE DATA:

NAME5.POI ==> Solenoid field map on axis

Z [m]	Bz [T]
0.000000	.000000
3.200000E-03	15.7220
6.400000E-03	31.5290
9.600000E-03	47.5020
1.280000E-02	63.7310
1.600000E-02	80.3070
1.920000E-02	97.3290

NAME5.SEK ==> RF field map on axis

Z [m]	Ez [MV/m]
0.00000	0.999892
0.00015	0.999954
0.0003	0.999980
0.00045	0.999984
0.0006	0.999980
0.00075	0.999954
0.0009	0.999892
0.00105	0.9998
0.12	0.999682

In case of rf gun simulations, the spline routine in homdyn require to have at lest 3 points behind the cathode position, and to begin at z=0.0 with constant step.
The original SUPERFISH output, see below, has been traslated in order to have at least 3 points behind the cathode position:

Z [m]	Ez [MV/m]
0.00000	0.999984
0.00015	0.999980
0.0003	0.999954
0.00045	0.999892
0.0006	0.9998
0.00075	0.999682
0.0009	0.999538

```
0.00105   0.999375
```

ON LINE DIALOG WINDOW

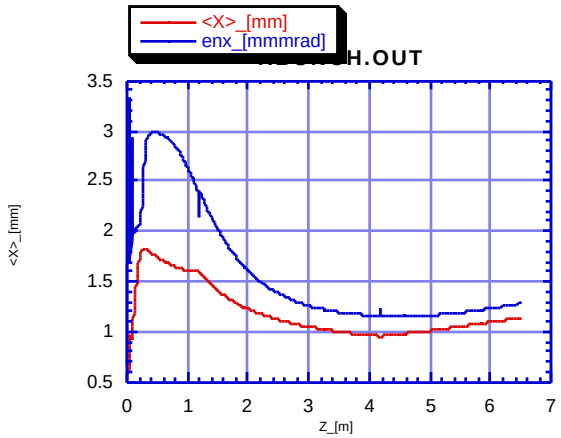
```
*************************************
*************************************
HOMDYN RELEASE HTWA
*************************************
*************************************

**************************************************
MULTI-BUNCH SESSION maxbunch=   2
**************************************************
.000000000000000  2.04800000000000  2.04800000000000
new45 solenoid field data: OK
**********************************************
SCANNING SOLENOID BMAX , BSTEP=  -1.000000000000000E-002
**********************************************
**********************************************
BEAM LOADING OFF, NMOD=   1
**********************************************
STEP AT CATHODE   1.851851851851851E-013
**********************************************
.000000000000000  .150000000000000  .150000000000000
new45 mode field data: OK
*************************************
SW-TW STRUCTURE: CELL LENGTH=   3.498978267973860E-002
*************************************
*************************************
bunch No.   1  is now running
*************************************
**********************************************
RMS NORM EMITTANCE   2.62884980395251  at zscreen
1.00000000000000
**********************************************
EMITTANCE MINIMUM   1.19252637821803  AT  4.40942508777596
ENVELOPE   1.37215772848426  MATCHING VOLTAGE 5.99528791525192
*************************************
bunch No.   2  is now running
solenoid scan B =   .270000000000000
*************************************
EMITTANCE MINIMUM   1.48500031731155  AT   6.50462683325886
ENVELOPE   2.70431206867663  MATCHING VOLTAGE   3.03328201233263
*************************************

END OF RUN

TYPE RETURN TO EXIT
```

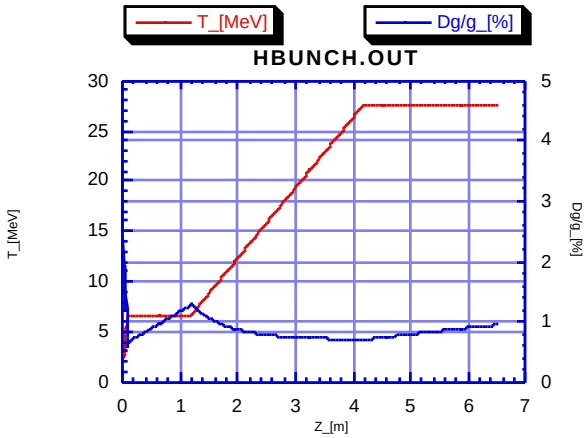
HOMDYN.SUM

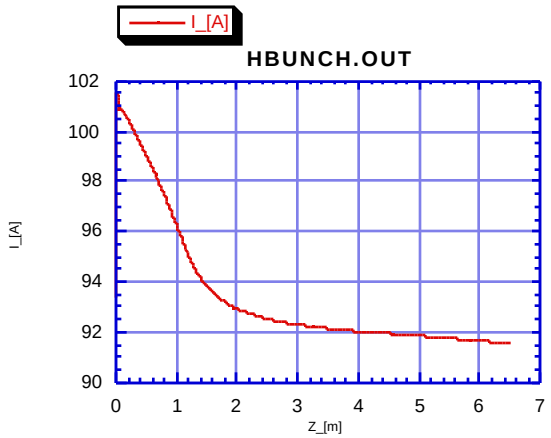
```
************  INPUT DATA  ************

 bunch charge =   1.000000000000000E-009  [C]
 average current =   .285600000000000  [A]
 bunch length =   5.930935055227571E-006  [m]
 bunch radius =   1.000000000000000E-003  [m]
 generator voltage =   140.000000000000  [MV]
 generator time constant  =   1.000000000000000E-015  [sec]
 RF period =   3.501400560224090E-010  [sec]
 bunch distance =   3.501400560224090E-009  [sec]
 filling time =   2.632157500501462E-006  [sec]
 injection time =   .000000000000000  [sec]
 beta =   1.978346985375990E-003
 injection energy =   1.000000000000000E-006  [MeV]
 injection phase =   36.0000000000000  [deg]
 injection energy spread =   .000000000000000  [MeV]
 number of slices =   55
 number of modes =   1
 number of bunches =   1
 aspect ratio =   168.607477689136
 stored energy =   77393596114.0417  [J]
 cavity length =   .150000000000000  [m]
 N electron per bunch =   6241460122.18782
 alfa KIM =   2.28921568627451


 ************** first bunch **************

 flight time =   2.173500000000040E-008  [sec]
 beta =   .999834120227568
 energy =   27.5476275653476  [MeV]
 dg/g =   .932735948392322  [%]
 bunch length =   3.666980230120600E-003  [m]
 bunch radius =   2.329906889805620E-003  [m]
 norm. rms emittance =   5.324938685348570E-006  [m rad]

 ************** last bunch **************

 flight time =   2.173500000000040E-008  [sec]
 beta =   .999834120227568
 energy =   27.5476275653476  [MeV]
 dg/g =   .932735948392322  [%]
 bunch length =   3.666980230120600E-003  [m]
 bunch radius =   2.329906889805620E-003  [m]
 norm. rms emittance =   5.324938685348570E-006  [m rad]
 aspect ratio =   .635374816222828
```

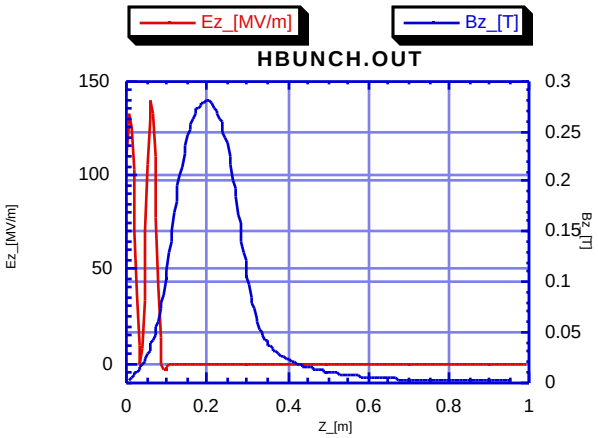
HBUNCH.OUT

Z_[m]	==>	central slice position
<R>_[mm]	==>	$\sigma_r = \frac{R}{\sqrt{2}}$
<L>_[mm]	==>	$\sigma_z = \sqrt{\left\langle \left(z - \langle z \rangle \right)^2 \right\rangle}$
I_[A]	==>	$\hat{I} = \frac{\beta c Q}{2\sqrt{3}\langle L \rangle}$
<X>_[mm]	==>	$\sigma_x = \frac{X}{2}$
enx_[mmmrad]	==>	$\varepsilon_{n,x} = \sqrt{\left(\varepsilon_{n,x}^{Th}\right)^2 + \left(\varepsilon_{n,x}^{C}\right)^2}$ $\quad \varepsilon_{n,x}^{C} = \sqrt{\langle \sigma_x \rangle^2 \langle \beta\gamma\sigma_x^{'} \rangle^2 - \langle \sigma_x \beta\gamma\sigma_x^{'} \rangle^2}$
<Y>_[mm]	==>	$\sigma_y = \frac{Y}{2}$
eny_[mmmrad]	==>	$\varepsilon_{n,y} = \sqrt{\left(\varepsilon_{n,y}^{Th}\right)^2 + \left(\varepsilon_{n,y}^{C}\right)^2}$ $\quad \varepsilon_{n,y}^{C} = \sqrt{\langle \sigma_y \rangle^2 \langle \beta\gamma\sigma_y^{'} \rangle^2 - \langle \sigma_y \beta\gamma\sigma_y^{'} \rangle^2}$
T_[MeV]	==>	average energy
Dg/g_[%]	==>	$\frac{\delta\gamma}{\langle \gamma \rangle} = \frac{\sqrt{\left\langle \left(\gamma - \langle \gamma \rangle \right)^2 \right\rangle}}{\langle \gamma \rangle}$
Ez_[MV/m]	==>	rf field as seen by the central slice
Bz_[T]	==>	solenoid field as seen by the central slice


<X>_[mm]
enx_[mmmrad]
H.OUT
<X>_[mm]
Z_[m]

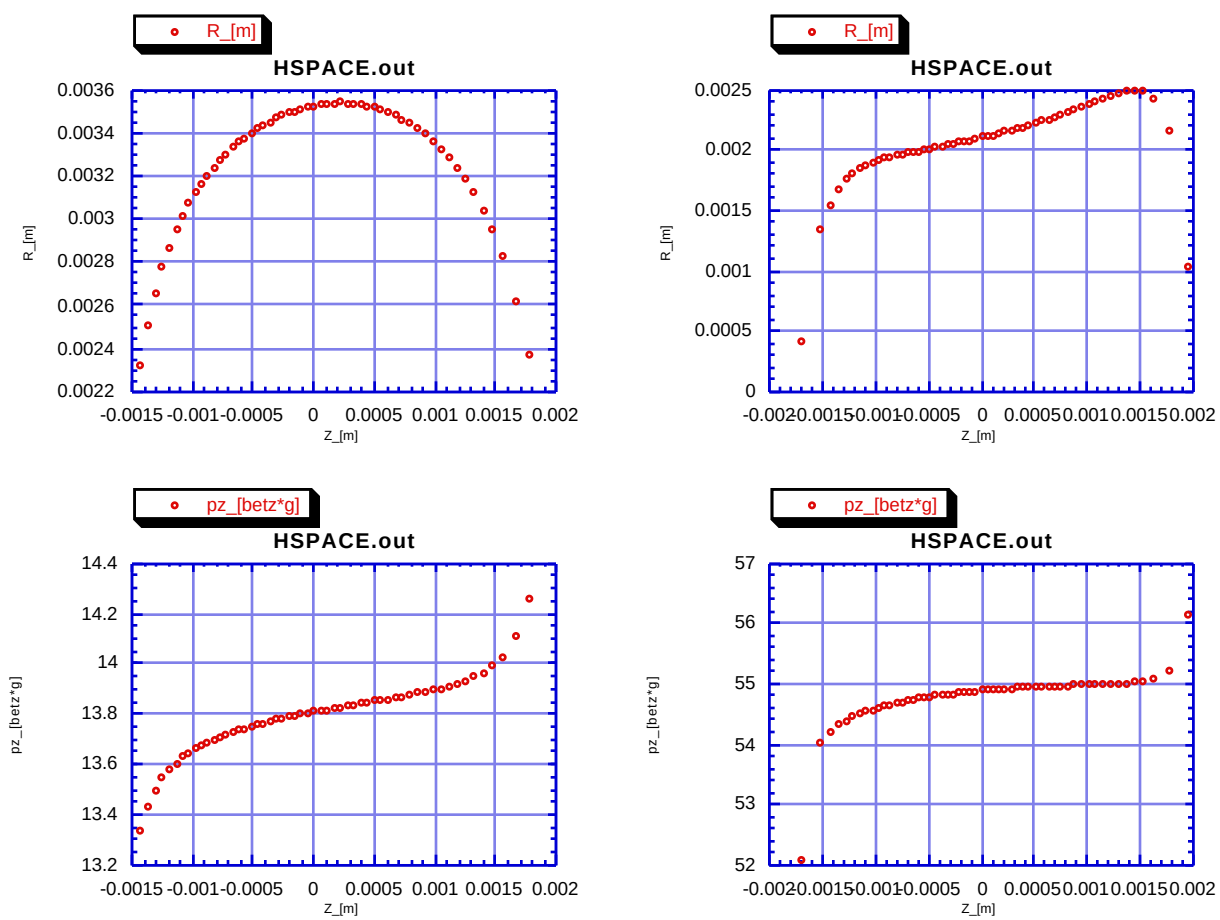

T_[MeV]
Dg/g_[%]
HBUNCH.OUT
T_[MeV]
Dg/g_[%]
Z_[m]

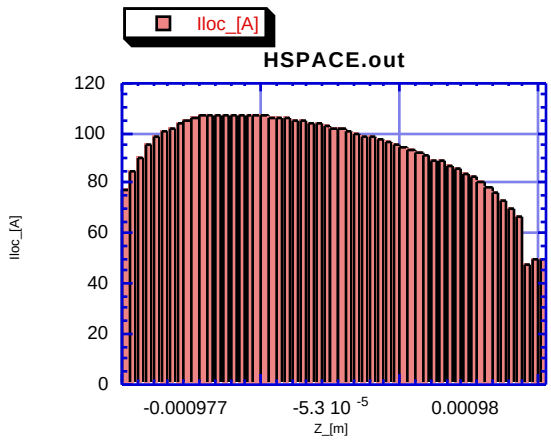

I_[A]
HBUNCH.OUT
I_[A]
Z_[m]

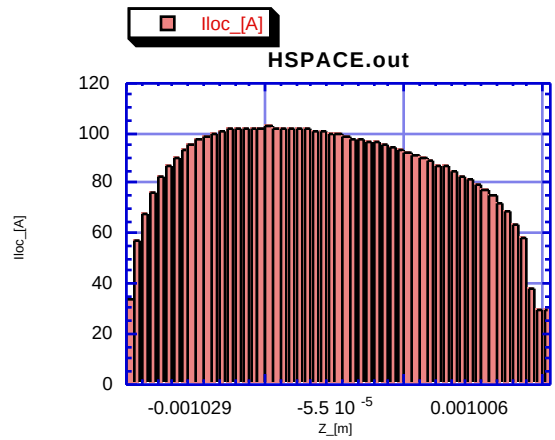

Ez_[MV/m]
Bz_[T]
HBUNCH.OUT
Ez_[MV/m]
Bz_[T]
Z_[m]

HSPACE.OUT

Z_[m]	==>	slice position with respect to the central slice
R_[m]	==>	slice radius
pz_[betz*g]	==>	normalized longitudinal momentum $\beta_z\gamma$
pr_[rad]	==>	normalized transverse momentum $\beta_z\gamma R'$
zmed_[m]	==>	central slice position
Iloc_[A]	==>	slice peak current $\hat{I}_s = \dfrac{\beta c Q}{N_s L_s}$

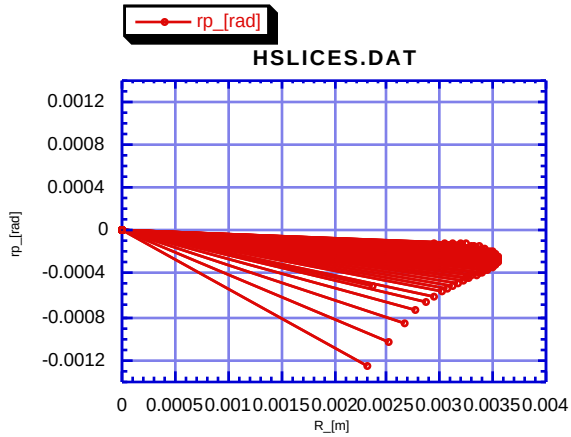


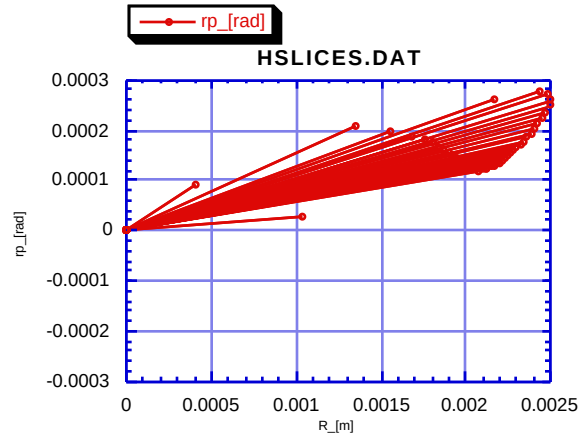




HSLICE.DAT

R_[m]	==>	slice radius
pr_[rad]	==>	normalized transverse momentum $\beta_z \gamma R'$
rp_[rad]	==>	$R' = \dfrac{dR}{dz}$
zmed_[m]]	==>	central slice position

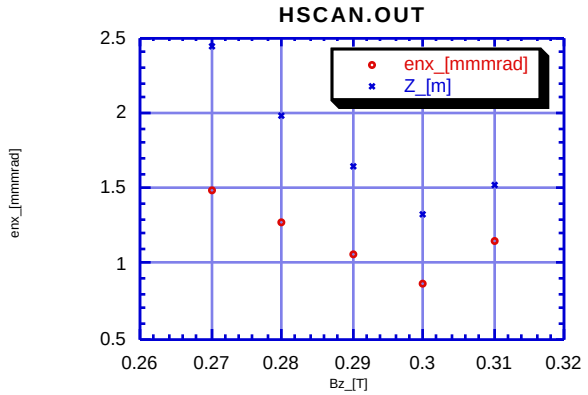


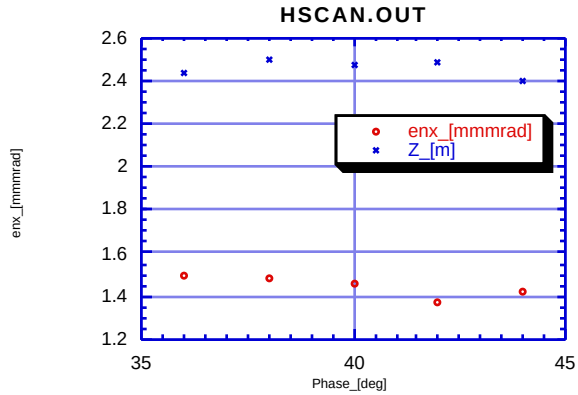


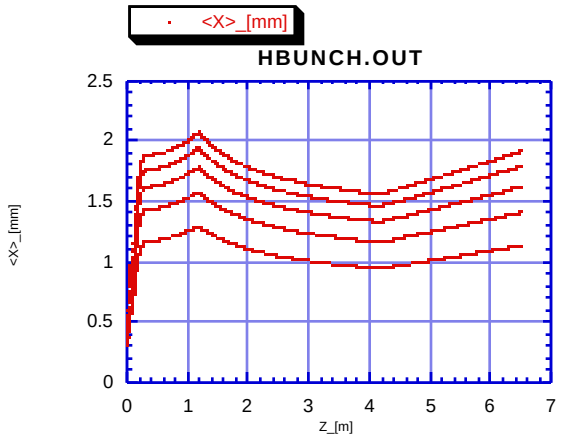
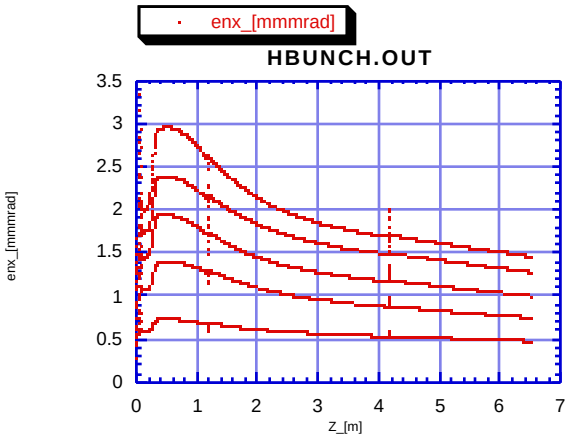
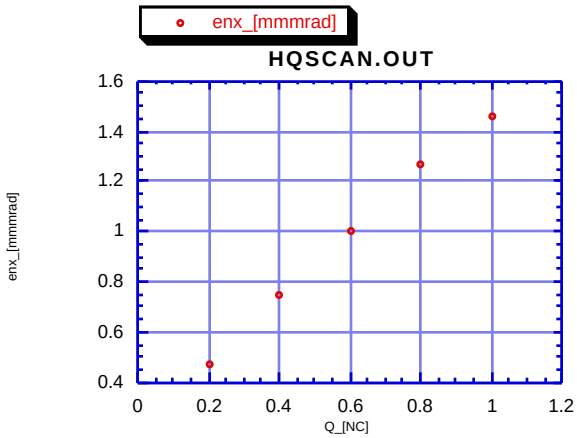
HSCAN.OUT

Data are saved at the emittance minimum position during parameters scanning

N	==>	iteration index
enx_[mmmrad]	==>	emittance minimum
Z_[m]	==>	position of emittance minimum
<R>_[mm]	==>	beam envelope at the emittance minimum position
I_[A]	==>	peak current at the emittance minimum position
Phase_[deg]	==>	phase value during scanning
Zsol_[m]	==>	solenoid position during scanning
Bz_[T]	==>	solenoid field during scanning
Qgrad_[T/m]	==>	quadrupole gradient during scanning





HQSCAN.OUT

N	==>	iteration index
Q_[nc]	==>	bunch charge
enx_[mmmrad]	==>	emittance minimum
Z_[m]	==>	position of emittance minimum
<R>_[mm]	==>	beam envelope at the emittance minimum position
R0_[mm]	==>	scaled bunch radius
L0_[ps]	==>	saled bunch length