SSC-N-92

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# "SSC Parameters 1" - a TK!Solver model for the Macintosh

## THE APPLICATION PROGRAM "TK!Solver"

TK!Solver is the registered trade mark of an application program which is available on microcomputers, like the Macintosh, and the IBM PC[1]. It allows the user to define a physical model by specifying a set of variables, and a set of equations connecting the variables. Some of the variables are labeled as input, and others as output. Upon command, TK!Solver solves the equations to find the values of the output variables corresponding to a given set of input variables. If the model equations are under- or over-constrained, only a partial list of solutions will be produced.

It is not necessary to write equations as the assignment statements familiar from most programming languages, so that expressions like a*b = c+d and a*x^2 + b*x + c = 0 are valid. It is a trivial task to relabel input variables as output, and vice versa, a common practical need. Units are attached to variables where necessary, and linear conversions between units may be specified. Variables may also be labeled as "lists", so that output lists can be solved as a function of an input list. Any of these lists can then be plotted, or tabulated.

Further detailed information about TK!Solver is found in the User Manual, which can be obtained from one of us (JMP or SGP). In addition there are sample models, and further documentation, on the disk "SSC! Solver", which we are making available for use on the CDG Macintoshes.

## THE MODEL FILE "SSC Parameters 1"

"SSC Parameters 1" is a TK! Solver model file which describes the SSC, as defined by a set of 84 parameters (variables) and 56 equations, in different 'sheets' of the file. No attempt will be made

except to include listings of the sheets at the end of this note. Each sheet is broken down into the same set of logically associated groupings of equations or variables, such as INTERSECTION REGIONS, or SYNCHROTRON RADIATION, et cetera. However, it is emphasised that some of the equations are approximations, and the user must bear the primary responsibility for understanding the physics behind the equations, in order to make his or her own estimate of the accuracy of the results. We are, of course, very willing to discuss, and if necessary revise, the contents of the model.

The disk "SSC! Solver" containing the model file can be obtained from one of us, or may be found in the CDG library. Later versions of the same model are under development, and will be placed on the same disk, as "SSC Parameters 2", et cetera. For example, it is hoped to include a description of longitudinal phase space behaviour as soon as possible. In the meantime, every attempt has been made to make the initial parameters in the file consistent with SSC parameters as they are currently defined[2].

## HINTS

"SSC! Solver" is not a 'start-up' disk, and so must be used with a second disk containing a system folder.

If a recent system is being used, the "Imagewriter" option in "Choose Printer" must be chosen before invoking TK!Solver, if printing is to be successful.

Try "Use Reduced Font", in the "Settings" menu.

Help is available through "About TK!Solver", in the  menu.

## REFERENCES


1 Software Arts, Inc., 27 Mica Lane, MA 02181

2 see, for example, J.M.Peterson, Parameter Meeting Notes, 11/21/85, SSC-N-79

# THE VARIABLE SHEET OF "SSC Parameters 1"

| St | Input | Name | Output | Unit | Comment |
|---|---|---|---|---|---|
| | | | | | FUNDAMENTAL MACHINE PARAMETERS |
| | 1.65 | b | | cm | vacuum chamber inner radius |
| | | Brho | 66712.792 | T*m | magnetic rigidity at storage energy |
| L | | chinat | -328 | | total natural chromaticity, with IRs |
| | | chinoIR | -80.68928 | | natural chromaticity omitting IRs |
| | | Ccell | 73.457846 | km | total length of full cells for closure |
| | 84.3 | Circ | | km | accelerator circumference |
| | 1 | Ei | | TeV | injection energy |
| | 20 | Es | | TeV | storage energy |
| | | frev | 3.5562584 | kHz | revolution frequency |
| | | gi | 1065.7799 | | injection gamma |
| | | gs | 21315.599 | | storage gamma |
| | 6 | NIR | | | number of identical intersection regions |
| | 2 | NUT | | | number of utility sections |
| | | R | 13.416762 | km | average radius of curvature |
| | | Trev | .28119442 | ms | revolution period |
| | | | | | HIGH ENERGY PHYSICS |
| | 1E33 | L | | 1/(s*cm^2 | peak luminosity per IR |
| | | n | 3.3356396 | | interactions per collision per IR |
| | | Rt | 200 | MHz | reaction rate per IR |
| | 2E-25 | stot | | cm^2 | total cross section |
| | | | | | INTERSECTION REGIONS |
| | .000071 | astar | | | total crossing angle |
| | | a0 | .00006458 | | characteristic beam profile angle |
| L | .5 | bstar | | m | beta star, same in both planes |
| | -20.60923 | chibs | | | nat. chromaticity per IR times beta star |
| | | Pt | 1.28168 | kW | radiated power per IR |
| | | sstar | 4.8432427 | mm | beam size at the collision point |
| | | | | | SINGLE BUNCHES |
| | 1E-6 | em | | m | normalised emittance |
| L | | Nb | 8.54784E9 | | number of protons per bunch |
| | .15 | slong | | m | rms bunch length |
| L | 5 | Sb | | m | bunch spacing |
| L | | Tb | 16.678198 | ns | bunch spacing in time |
| | | | | | MANY BUNCHES |
| | | Bu | .07519885 | | bunching factor |
| L | | Iav | .08211018 | A | average current per beam |
| | | Ip | 1.0919074 | A | peak current |
| | | M | 16860 | | number of bunches per beam |
| | | Nt | 1.4412E14 | | total number of protons per ring |
| L | | Ws | 461.77849 | MJ | stored energy per ring |

| | | | | |
|---|---|---|---|---|
| | | | | BEAM DYNAMICS |
| | 1 | Dxco | mm | rms orbit error at injection |
| | | DQbb | .00626322 | Tot. head on beam-beam tune shift/spread |
| | | DQic | .00057548 | incoherent tune shift at injection |
| | | L0 | 1.4862E33 | 1/(s*cm^2 zero angle luminosity per IR |
| L | | Tlum | 33.36033 | hr init. current lifetime from lum. losses |
| L | | xse | .00104387 | head on beam-beam tune shift parameter |
| | | | | SYNCHROTRON RADIATION |
| | | Rph | 7.2298E20 | Hz total photon flux per ring |
| | | Psr | 10.114466 | kW synchrotron radiation power per ring |
| | | Ts | 12.682014 | hr nominal longitudinal damping time |
| | | Tt | 25.364028 | hr nominal transverse damping time |
| | | ucrit | .28358996 | keV critical photon energy |
| | | U0 | .12318164 | MeV energy loss per particle per turn |
| | | | | REGULAR CELLS - THIN QUADS (APPROXIMATE) |
| | | bave | 183.34649 | m beta average |
| | | bmax | 332.55376 | m beta maximum |
| | | bmin | 110.85125 | m beta minimum |
| | | cfih | .8660254 | cosine(fi/2) |
| | | sfih | .5 | sine(fi/2) |
| | | chicell | -.1837763 | natural chromaticity per cell |
| | | emax | 3.941433 | m dispersion maximum |
| | | emin | 2.3648598 | m dispersion minimum |
| | 60 | fi | | deg full cell phase advance |
| | 96 | Lh | | m half cell length |
| | | Ncell | 382.59295 | number of cells to close machine |
| | | | | DIPOLES |
| | 6.6 | Bfield | | T dipole field at storage energy |
| | 16.6 | Ld | | m magnetic length of a single dipole |
| | | Nd | 3825.9295 | number of dipoles to close machine |
| | 5 | Ndh | | number of dipoles per HALF cell |
| | | rho | 10.107999 | km radius of curvature in dipoles |
| | | theta | .00164226 | angular deflection in a single dipole |
| | | | | QUADRUPOLES (!!! APPROXIMATE !!!) |
| | | b1q | 224.16933 | T/m regular cell quad field gradient |
| | 250 | b1qmax | | T/m maximum allowed (IR) field gradient |
| | | kqmax | .00374741 | 1/m^2 maximum allowed (IR) quad strength |
| | 3.1 | Lquad | | m quadrupole magnetic length |
| | | q | .01041667 | 1/m regular cell quad focal strength |
| | | | | SEXTUPOLES (!!! APPROXIMATE !!!) |
| | | b2sd | -685.4091 | T/m^2 2nd differential of d sext B field |
| | | b2sf | 411.24546 | T/m^2 2nd differential of f sext B field |
| | 2 | Lsext | | m sextupole magnetic length |
| | | sd | -.010274 | 1/m^2 dx'/x^2, def. sext. strength, with IRs |
| | | sf | .00616442 | 1/m^2 dx'/x^2, foc. sext. strength, with IRs |
| | | sdo | -.0022024 | 1/m^2 dx'/x^2, def. sext. strength, cells only |
| | | sfo | .00132143 | 1/m^2 dx'/x^2, foc. sext. strength, cells only |
| | | | | UNIVERSAL CONSTANTS |
| | 299792580 | c | | m/s speed of light |
| | | Cg | 7.782E-18 | m/GeV^3 synchrotron radiation constant |
| | 8.854E-12 | e0 | | f/m permittivity of free space |
| | 6.582E-16 | hbar | | eV*s Plancks constant/(2*pi) |
| | .93828 | Mp | | GeV rest energy of the proton |
| | 1.602E-19 | qe | | Coul electronic charge |
| | | rp | 1.535E-18 | m classical radius of the proton |

# THE RULE SHEET OF "SSC Parameters 1"

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S Rule

  "FUNDAMENTAL MACHINE PARAMETERS
  Brho = Es/c
  Ccell = 2*Ncell*Lh
  chinat = chinoIR + NIR*chibs/bstar
  chinoIR = Ncell*chicell*Circ/Ccell
  Ei = Mp*gi
  Es = Mp*gs
  Trev*c = Circ
  frev = 1/Trev
  2*PI()*R = Circ

  "HIGH ENERGY PHYSICS
  L = L0/sqrt(1+(astar/a0)^2)
  n = Rt*Tb
  Rt = L*stot

  "INTERSECTION REGIONS
  sstar = sqrt(em*bstar/gs)
  a0 = 2*sstar/slong
  Pt = 2*Rt*Es*qe

  "SINGLE BUNCHES
  Nt = M*Nb
  Sb*M = Circ
  c*Tb = Sb

  "MANY BUNCHES
  Bu = Iav/Ip
  Iav*Tb = Nb*qe
  Ip*slong*sqrt(2*PI()) = Iav*Sb
  Ws = Nt*Es*qe

  "BEAM DYNAMICS
  Tlum*NIR*Rt = Nt
  L0 = Nb^2/(Tb*4*PI()*sstar^2)
  xse = Nb*rp/(4*PI()*em)
  DQbb = NIR*xse
  DQic = ( (Nt*rp)/(2*PI()) ) * ( 1/(Bu*em*gi^2) + 2*bave*Dxco^2/(gi*b^4) )
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```
"SYNCHROTRON RADIATION
ucrit = 1.5*hbar*c*gs^3/rho
U0 = Cg*Es^4/rho
Ts = Trev*Es/U0
Tt = 2*Ts
Psr = Nt*frev*qe*U0
Rph*qe*ucrit = (15*sqrt(3)/8)*Psr

"REGULAR CELLS, ASSUMING THIN QUADS   !!! APPROXIMATIONS !!!
2*PI()*fi/360 = 2*Lh/bave
cfih = cos(PI()*fi/360)
sfih = sin(PI()*fi/360)
bmax = Lh*(1 + sfih)/(sfih*cfih)
bmin = Lh*(1 - sfih)/(sfih*cfih)
emax = 0.5*Lh*theta*Ndh*(2 + sfih)/sfih^2
emin = 0.5*Lh*theta*Ndh*(2 - sfih)/sfih^2
chicell = -sfih/(cfih*PI())
2*Ndh*Ncell = Nd

"DIPOLES
Bfield*rho = Brho
rho*theta = Ld
Nd*theta = 2*PI()

"QUADRUPOLES  !!! APPROXIMATIONS !!!
q = 2*sfih/Lh
b1q*Lquad = q*Brho

kqmax = b1qmax/Brho

"SEXTUPOLES  !!! APPROXIMATIONS !!!
sdo = -q/(2*emin)
sfo =  q/(2*emax)
sd = sdo*chinat/(Ncell*chicell)
sf = sfo*chinat/(Ncell*chicell)
b2sd*Lsext = 2*sd*Brho
b2sf*Lsext = 2*sf*Brho

"UNIVERSAL CONSTANTS
Cg = (4*PI()/3)*rp/Mp^3
rp = qe/(4*PI()*e0*Mp)
```