F. Méot, LPSC, Aug. 2007

Numerical experiments regarding acceleration in RACCAM spiral FFAG

I simulate the acceleration in FFAG ring shown in Fig. 1, parameters in the Table below, betatron functions in Fig. 2. Fig.3 shows the location of that particular optics in the stability domain.

Note : this experiment is not so realistic from the point of view of RF timing : RF frequency does not follow revolution time, synchronous RF phase drifts slowly from $\phi_s = 20$ deg to close to 90 degrees.

Parameters, including sample K/ξ values

Nb cells	10	
K	5.150E+00	
ξ	5.350E+01	(deg.)
pf	0.340	
gap	8.300E-02	(m)
$r_1/r_2/\Delta r$	2.84 / 3.46 / 0.62	(m)
E_1 / E_2, proton	17.0 / 180.	(MeV)
p_1 / p_2 / $ratio$	179. / 608. / 3.39	(MeV/c)
$B\rho_1$ / $B\rho_2$	0.598 / 2.03	(T.m)
B_1 / B_2	0.6115 / 1.700	(T)
$Trev_1$ / $Trev_2$	321.22 / 135.24	(ns)
$Frev_1$ / $Frev_2$	3.208513 / 7.620395	(MHz)
Dip. sector angle	12.2	(deg.)
Dip. bend angle	36.0	(deg.)
Drift L, inj.	1.18 -2×0.15	(m)
Drift L, xtr.	1.43 -2×015	(m)

Fig. 5 shows p_x versus turn number, for (a) 0 deg. tilt angle, (b) 40 deg. tilt angle. The particle considered islaunched on 17 MeV closed orbit with synchrotron RF phase $\phi_s = 20$ deg. Fig. 6 shows (r,r') motion of 100 particles evenly distributed on a 100π ellipse, in case of cavity orthogonal to 180 MeV closed orbit.

Fig. 6 shows transport of particles on a 100π ellipse during acceleration from 17 to 180 MeV, in case of cavity inclined by either 0 or 40 degrees.

Spiral ring

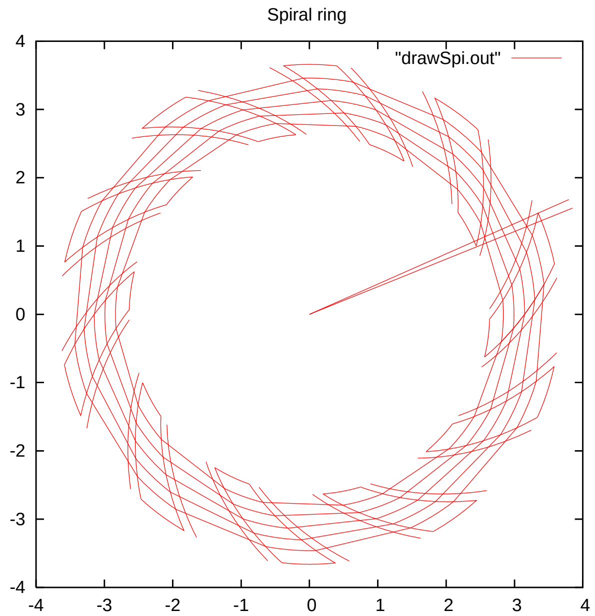

Figure 1: Spiral ring.

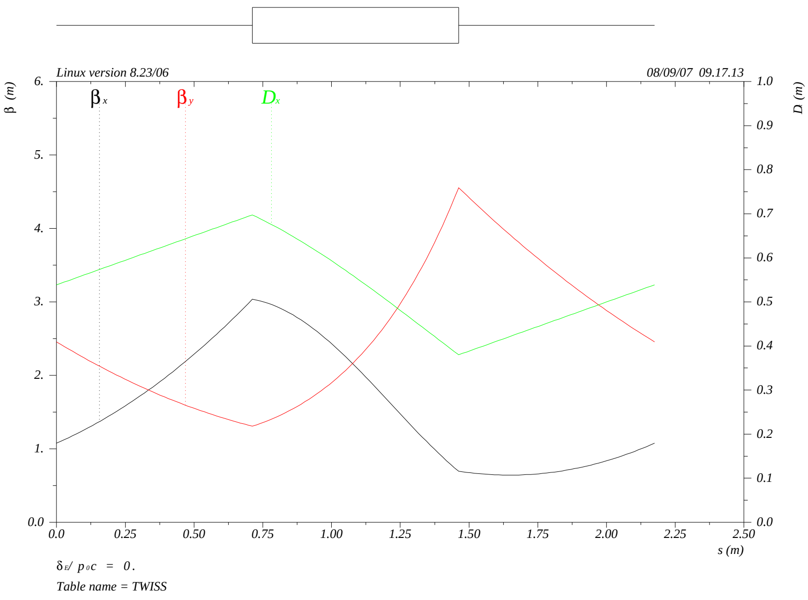

Figure 2: Optical functions, with K = 5.150 , ξ = 53.50 deg.
nb. cells, K, xi, Qx, Qy, Max. BetX, BetY, Dx : 10, 5.15, 53.5, 2.885360, 1.551076, 3.03684, 4.55498 0.69755

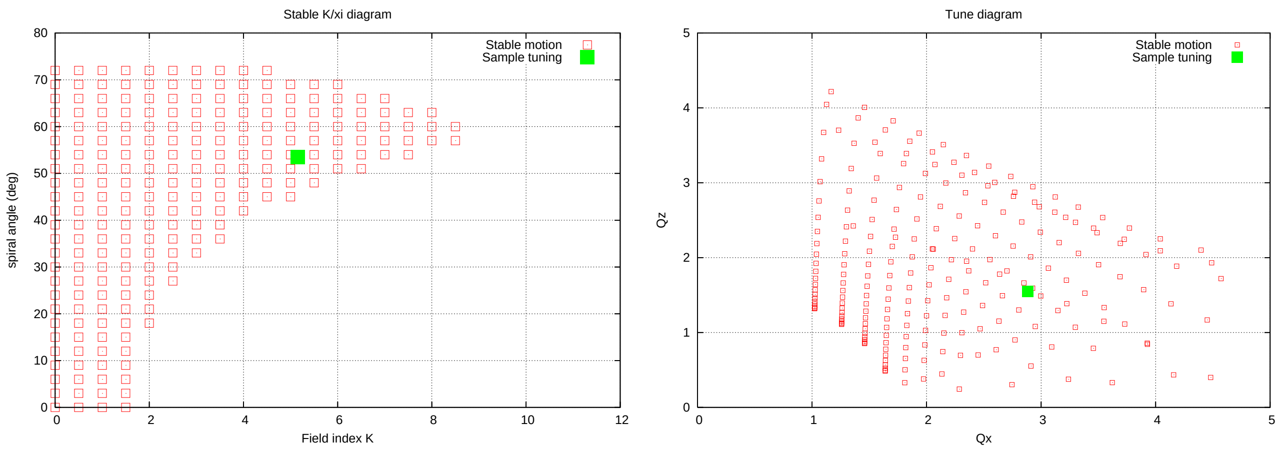

Figure 3: Stability domain, including sample working point. Left : K, ξ, right : ν_x, ν_z

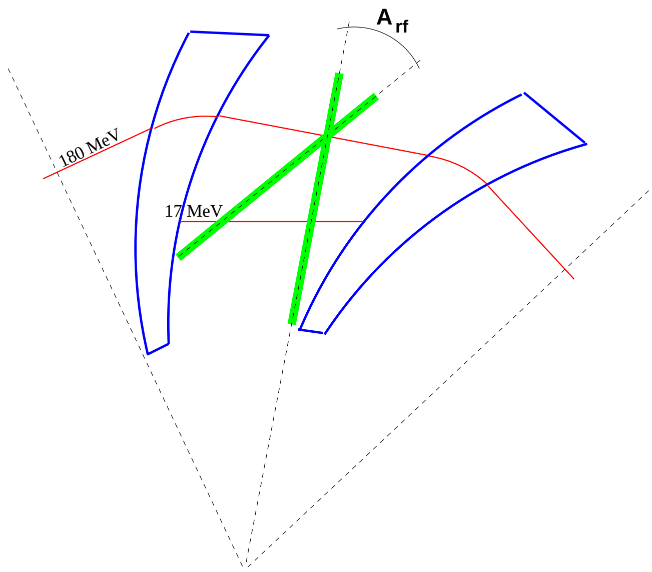

Figure 4: Positionning of the accelerating cavity in Zgoubi simulations. Tilting the cavity (A_{rf} angle) is performed using “CHANGREF”.

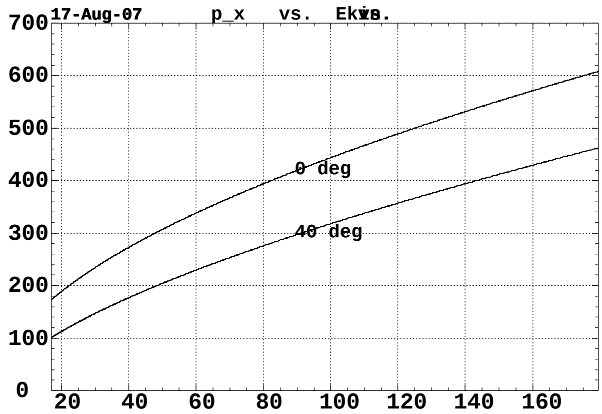

Figure 5: Evolution of the p_x component for cavity tilt of 0 and 40 degrees.
p_x is the momentum component normal to the cavity gap, the tilt angle is with respect to the ring radius.
In the 0 deg case, $|\vec{p}|$ and p_x practically superimpose.

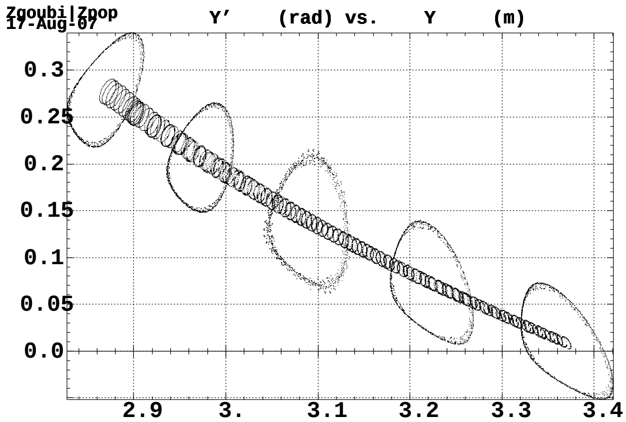

Figure 6: Acceleration of a 100π ellipse from 17 to 180 MeV. For comparions, maximum stable amplitude portraits at 17, ..., 180 MeV are shown.
zgoubi data file in App. A.

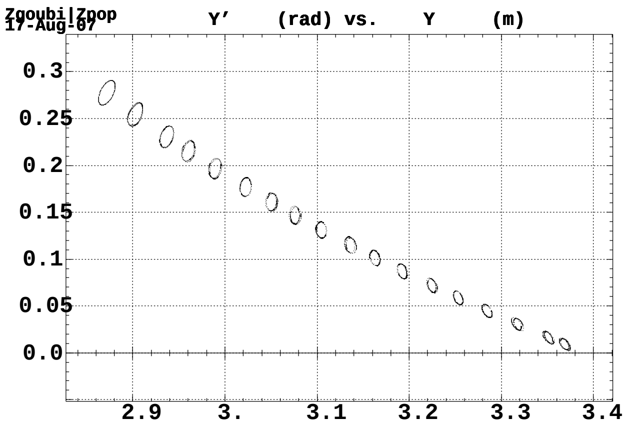

Figure 7: Acceleration of a 100π ellipse from 17 to 180 MeV. 40 deg and 0 deg cavity angle cases are plotted, every 1000 other turn, they superimpose thoroughly.

Appendix

A zgoubi data file, acceleration

```
Data generated by searchCO
 'OBJET'
  598.493433774 ->17.00 MeV            2029.47926 ->180MeV
 8
100  1  1
  2.871800  2.772000E-1  0.  0.0E+00  0.0E+00  1 '5'
-0.637334  0.818805  100e-6
-1.993011  4.296249   0.
  0.       1.        0.
'FAISCEAU'
    'PARTICUL'
    938.27231  1.60217733D-19 0. 0. 0.
'SCALING'    #START                                                           4
   1   1
CAVITE
2    17MeV        180
     1.         2.35   3.391=la loi theoriq
     1          16500
  'PICKUPS'                                                                   3
  1
  #S
  'FAISTORE'                                                                  4
  b_zgoubi.fai   #S
  100
    'MARKER'  #S
  'CHAMBR'
     1
    1  999.0000   16.6000  314.8442  0.
    'FAISCEAU'
    'POLARMES'
    0 0
    1. 1. 1.
     Dipole SPIRAL
    1000 300
    FIELDMAP
    0  0. 0. 0.
    2
      0.415
    2
     0.  -0.180840735 0.  -0.119159265
  ...
    'POLARMES'
   data are repeated 9 times
  ...
    'FAISCEAU'
'CHANGREF'
0. 3.368900E+02  -40.
'CHANGREF'
0. -3.368900E+02  0.
 'CAVITE'                                                      85
   6.1
3208513.18654   17.      f0 (Hz),  starting synch Ekin W_s0 (MeV)
  28884.   0.349066      Vp (V),  phis (rad)
'CHANGREF'
0. 3.368900E+02  40.
'CHANGREF'
0. -3.368900E+02  0.
'FAISCEAU'   #END
 'REBELOTE'
 16500   0.2  99
 'END'
```