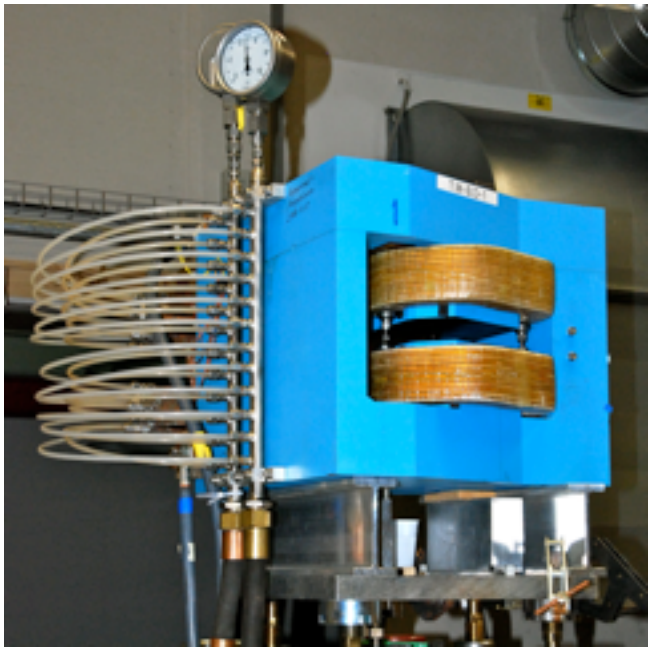
A45 Dipole (SwissFEL 250 MeV Injector)



A45 beam-dump dipole

gap = 30 mm
L = 310–486 mm
edge angle = ±22.5°

2 coils
12x6 turns/coil
I_{MAX} = 80 A (limited)

MEASUREMENT DATE:
5–11.May.2010

MEASUREMENT ARM:
brass cylinder interface Ø 40 mm
aluminum pipe Ø 28 mm, 1 m
carbon pipe Ø 12.1 mm, 1.5 m

MEASURING SPEED:
4.5 mm/sec (X-axis)
25 mm/sec (Z-axis)

INTEGRATION TIME:
20 msec

DVM-1 (1 V RANGE):
Hall probe sbv397 (150 mA)

DVM-2 (10 V RANGE):
50 V / 200 A (MSG-2.1), 2 A/s

AIR CONDITIONING:
ON (T_{SET} = 24°)

OPERATORS:
Roland Deckardt
Ivan Meier
Vjeran Vranković (report)

DATA DIRECTORY:
afs: sys/alpha_dux51/swdir/
magnet/meas/a45

Alignment and positioning

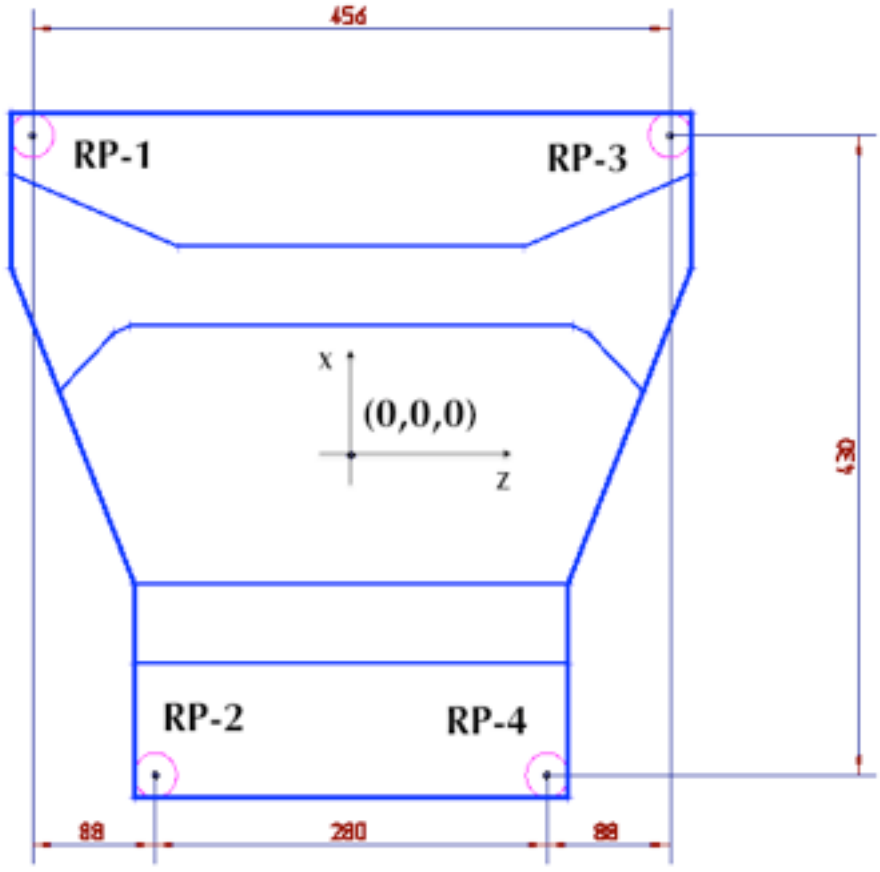
The magnet was placed on adjustable base plate. The base plate can be leveled by adjusting its feet heights.

In the measurements coordinate system the magnet axis is the Z-axis, vertical axis is the Y-axis.

The probe was leveled with a spirit level built into the measuring arm.

The aligning and positioning of the magnet was done magnetically by measuring horizontal field maps of the double reference pin that was inserted in Ø30 mm brass adapter that was flush with surfaces of four corners on the magnet top plate (see the sketch below).

There is a discrepancy between the magnet drawing and the positions obtained from the reference pin. Distance between RP-1 and RP-3 is 454.3 instead of 456 mm from the drawing. Distance between RP-2 and RP-4 is 277.1 instead of 280 mm. Distance between the points in the other direction is 428.9 instead of 430 mm.



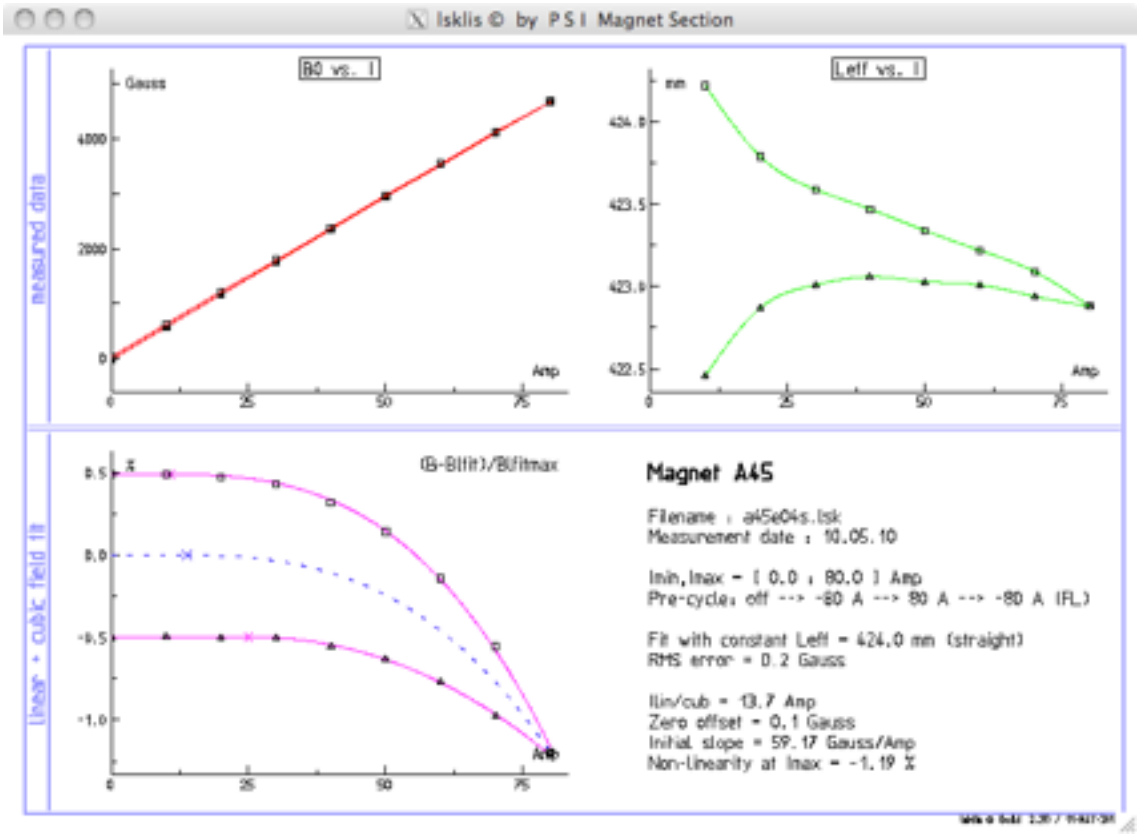
The coordinates of the points are shown in the table with the RP-1 being the first point measured, hence its' coordinates (Z=0, X=0).

	Z	X	Y	By
RP-1	0	0	237.76	982.17
RP-2	89.11	-428.97	237.83	981.18
RP-3	454.29	-0.10	237.73	980.79
RP-4	366.20	-428.87	237.83	981.06

The magnet center was defined to be in the middle of these 4 points. Therefore:

	Z	X
RP-1	-227.40	214.45
RP-2	-138.30	-214.45

Excitation curve



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Magnet A45

File : a45e04s.lsk
Date : 10.05.10

Pre-cycle : off --> -80 A --> 80 A --> -80 A (FL)

#Curr: 17 (nPaths=2)
Z-dir: from -600.00 mm, steps of 2.00 mm
X-dir: at 0.00 mm

 linear_<1:Ilin> and cubic_<Ilin:Imax> approximation of Bc:
 Blin = b0 + b1 * Irel                    ;   Irel = I / Imax
 Bcub = Blin + b2 * Irel^2 + b3 * Irel^3  ;   Irel = (I - Ilin) / (Imax - Ilin)

       Ilin_A     Imax_A       b0_G       b1_G       b2_G       b3_G      RMS_G
       ======     ======       ====       ====       ====       ====      =====
 /       25.0       80.0      -23.3     4732.0      -29.2       -4.8        0.2
 \       10.6       80.0       23.5     4731.7      -13.2      -64.7        0.6
 ¯       13.7       80.0        0.1     4732.2      -16.1      -40.5        0.2

 / = increasing current branch
 \ = decreasing current branch
 ¯ = average

constLeff (straight) = 424.0 mm
bendingRadius = 3472.6 mm
fullBendingAngle = 7.0 deg
particle E0 = 0.511 MeV

   I_Amp        Bdz_Gmm    p_MeV/c      E_MeV      Bc_G     err_G
   =====        =======    =======      =====      ====     =====
    0.00*        -9947.8     -2.443      1.984     -23.5      -0.2
   10.00/      241071.4     59.192     58.683     568.6       0.1
   20.00/      491891.2    120.777    120.267    1160.1      -0.1
   29.99/      742445.1    182.297    181.787    1751.0       0.0
   39.99/      992384.6    243.666    243.156    2340.5      -0.2
   49.98/     1241458.2    304.823    304.312    2928.0       0.3
   59.98/     1489505.0    365.727    365.217    3513.0       0.1
   69.98/     1736310.6    426.327    425.816    4095.1      -0.4
   79.97*     1982422.1    486.756    486.246    4675.5      -0.5 (average of 2 fits)
   69.98\     1744732.1    428.395    427.884    4114.9       1.1
   59.98\     1502092.4    368.818    368.307    3542.7       0.3
   49.98\     1256919.0    308.619    308.108    2964.4      -0.2
   39.99\     1009803.9    247.943    247.433    2381.6      -0.7
   29.99\      761141.8    186.888    186.378    1795.1      -0.4
   20.00\      511363.1    125.558    125.048    1206.0      -0.4
   10.00\      260822.0     64.041     63.532     615.1       0.0
    0.00*        9947.8      2.443      1.984      23.5       0.0

   p = Bdz / ( 2 sin(fullBendingAngle/2) ) * c * e-13
   E = sqrt(E0^2 + p^2) - E0
   Bc = Bdz / constLeff
   err = Bc - Bfit
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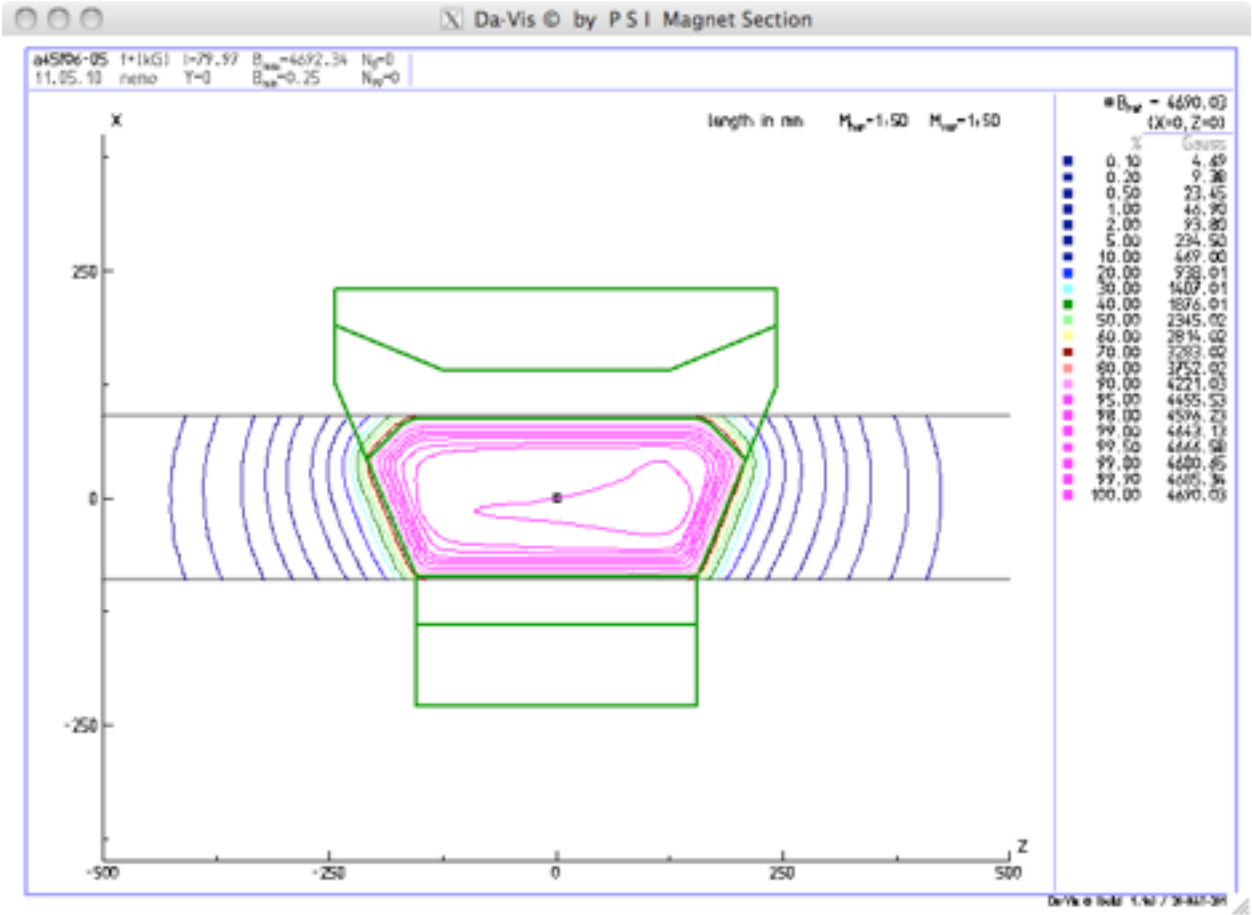
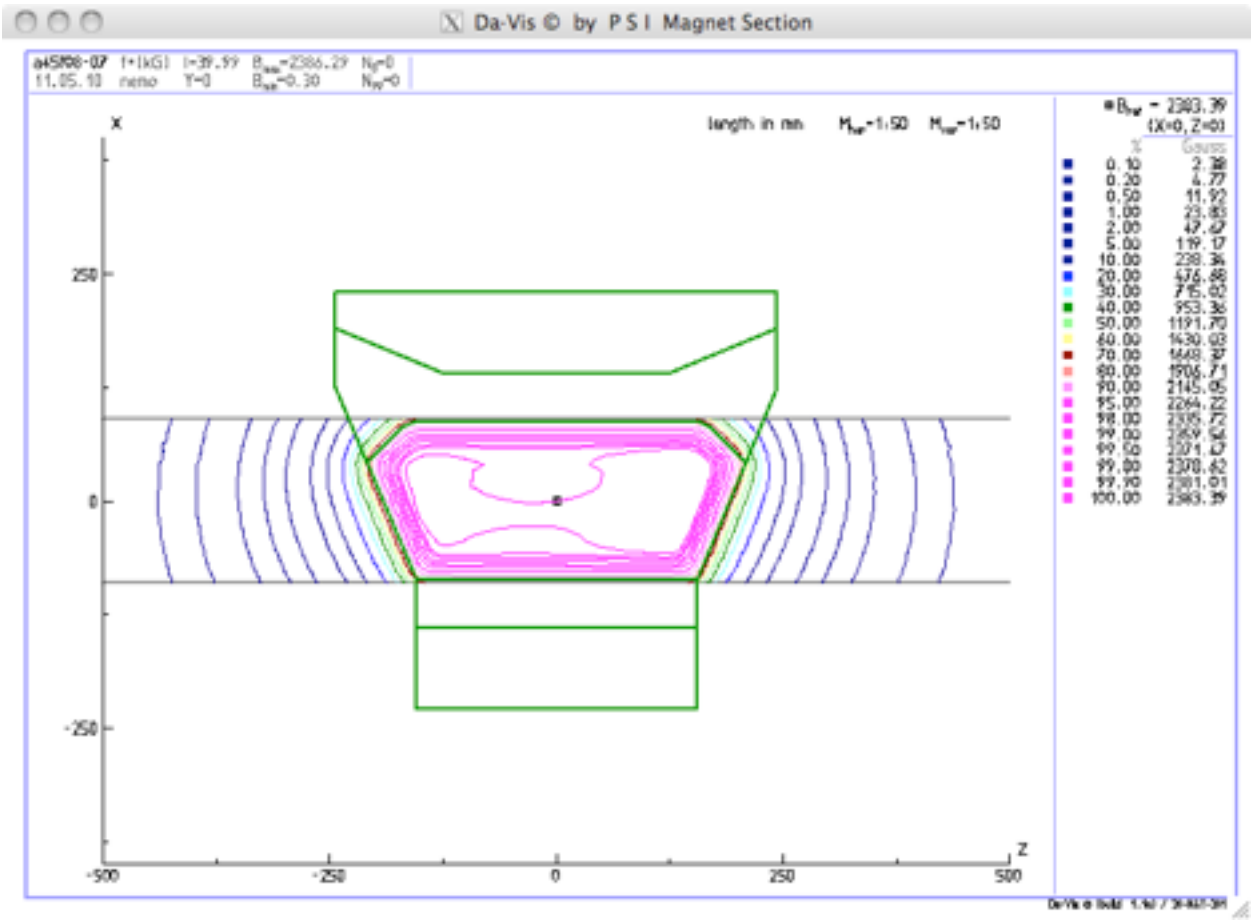
Field analysis

The earth and the background fields are removed from the measured fields:

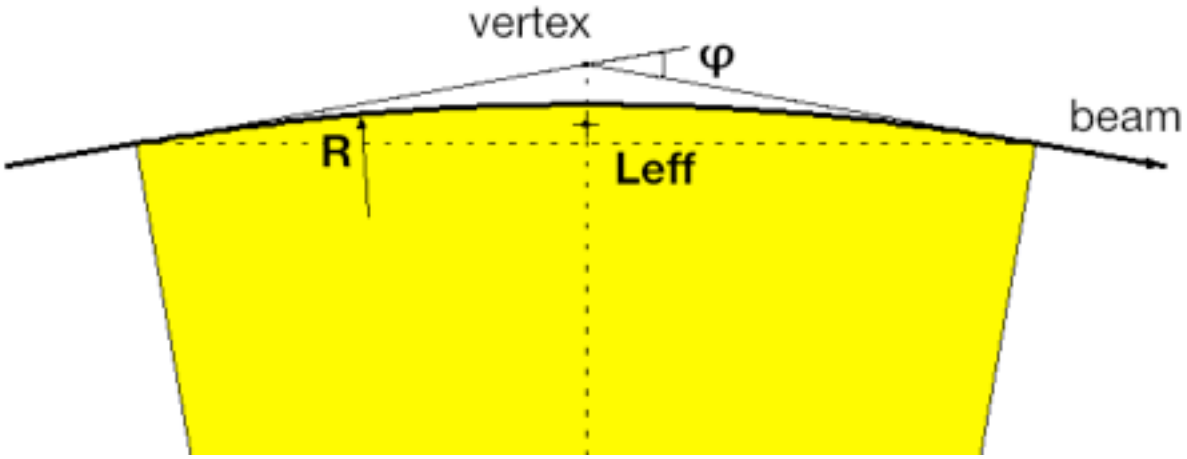
$$\frac{measurement(+current) - measurement(-current)}{2}$$

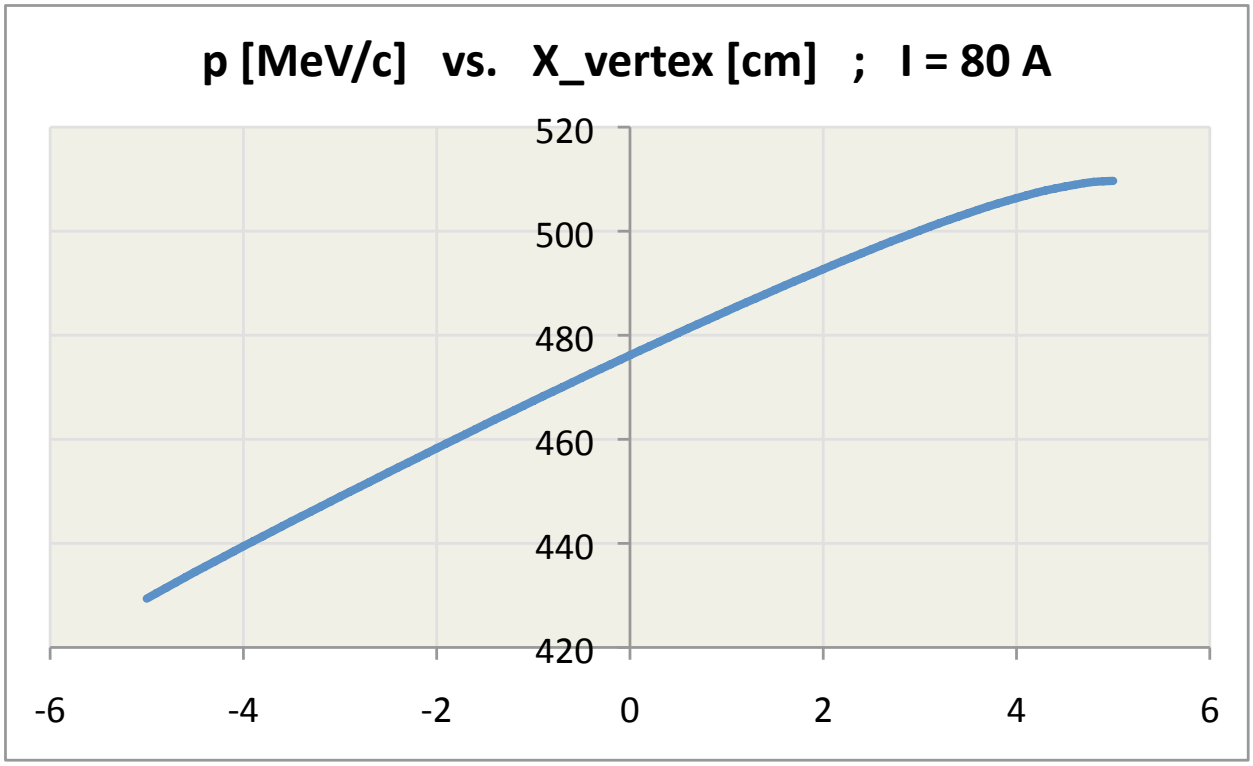
The field maps were measured at maximal current I = 80 A and at I = 40 A (80 A ↛ 40 A).

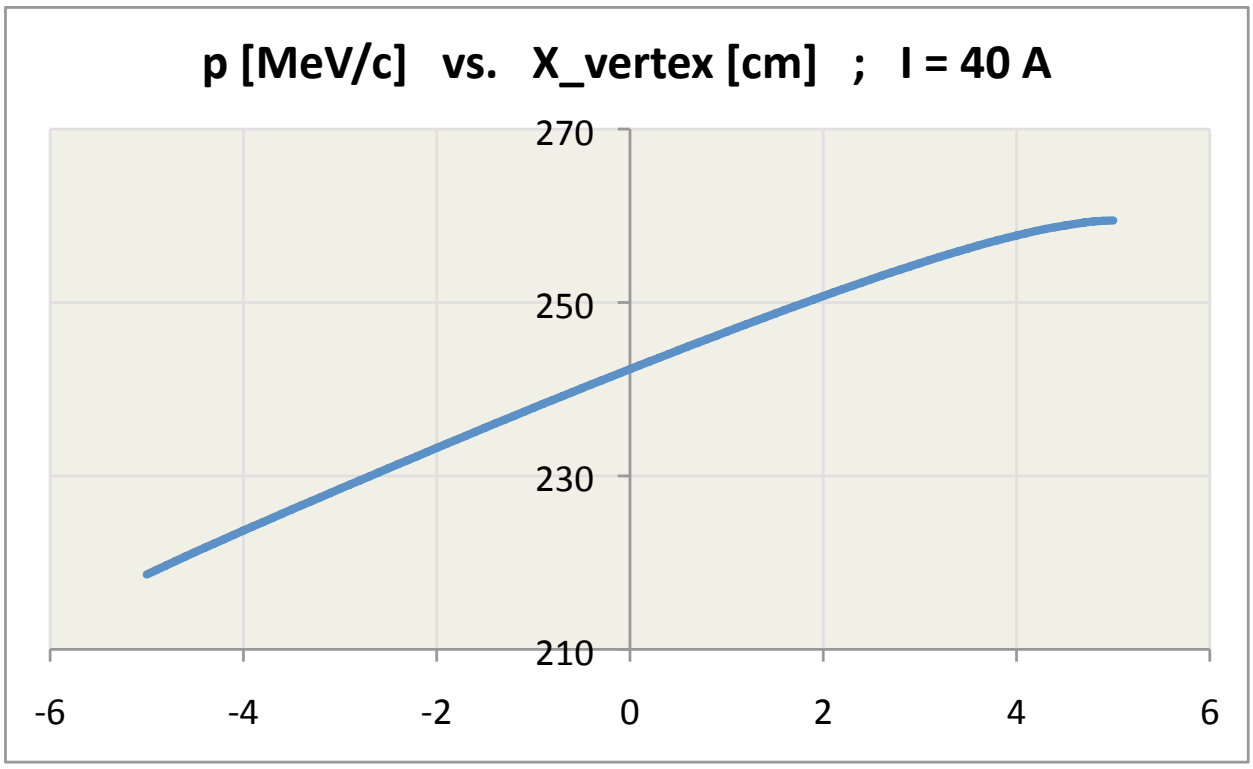




The position of the vertex point has a direct influence on the electron beam energy, Moving the vertex to the positive X coordinates will increase the electron energy for a given bending angle φ=7°.




p [MeV/c] vs. X_vertex [cm] ; I = 80 A
520
500
480
460
440
420
-6
-4
-2
0
2
4
6


p [MeV/c] vs. X_vertex [cm] ; I = 40 A
270
250
230
210
-6
-4
-2
0
2
4
6

X_vertex [cm]	**p** [MeV/c]	
	I = 40 [A]	**I = 80** [A]
2.0	250.74	492.70
1.5	248.71	488.72
1.0	246.63	484.62
0.5	244.49	480.43
0	242.32	476.16
-0.5	240.10	471.81
-1.0	237.85	467.37
-1.5	235.55	462.85
-2.0	233.23	458.27