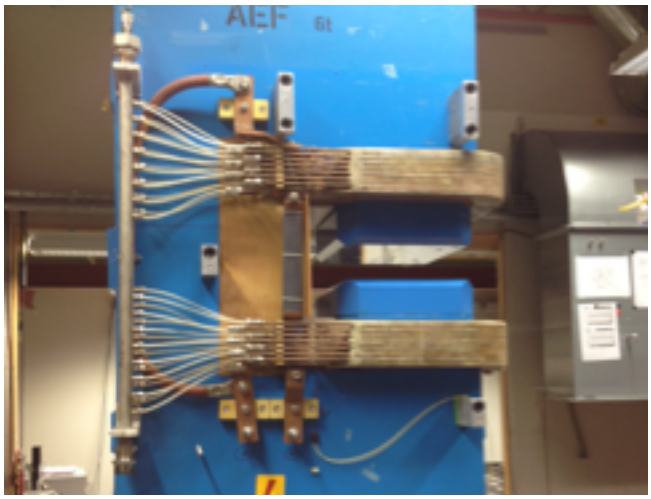
AMD2 Dipole (PROSCAN, PIF/Gantry 3)



AMD2 dipole (AEF from CERN)
measured from the beam exit end

gap = 100 mm

L465 x W1000 mm

conductor 7 x 7, D 4 mm
176 turns/coil, I_{MAX} = 220 A

MEASUREMENT DATE:
20–28. Oct. 2014

MEASUREMENT ARM:
brass cylinder interface Ø 40 mm
aluminum pipe Ø 28 mm, 1 m
carbon pipes Ø 10/8/6 mm, 1.5 m

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

INTEGRATION TIME:
20 msec

DVM-1 (1 V RANGE):
Hall probe sbv175 (150 mA)
powered in series with the other 2

DVM-2 (1, 10 V RANGE):
200 V / 500 A (MSG-1), 5 A/s

AIR CONDITIONING:
ON (T_{SET} = 24.5°)

OPERATORS:
Roland Deckardt
Vjeran Vranković (I20–I22)

DATA DIRECTORY:
afs: group/magnet/meas/amd2

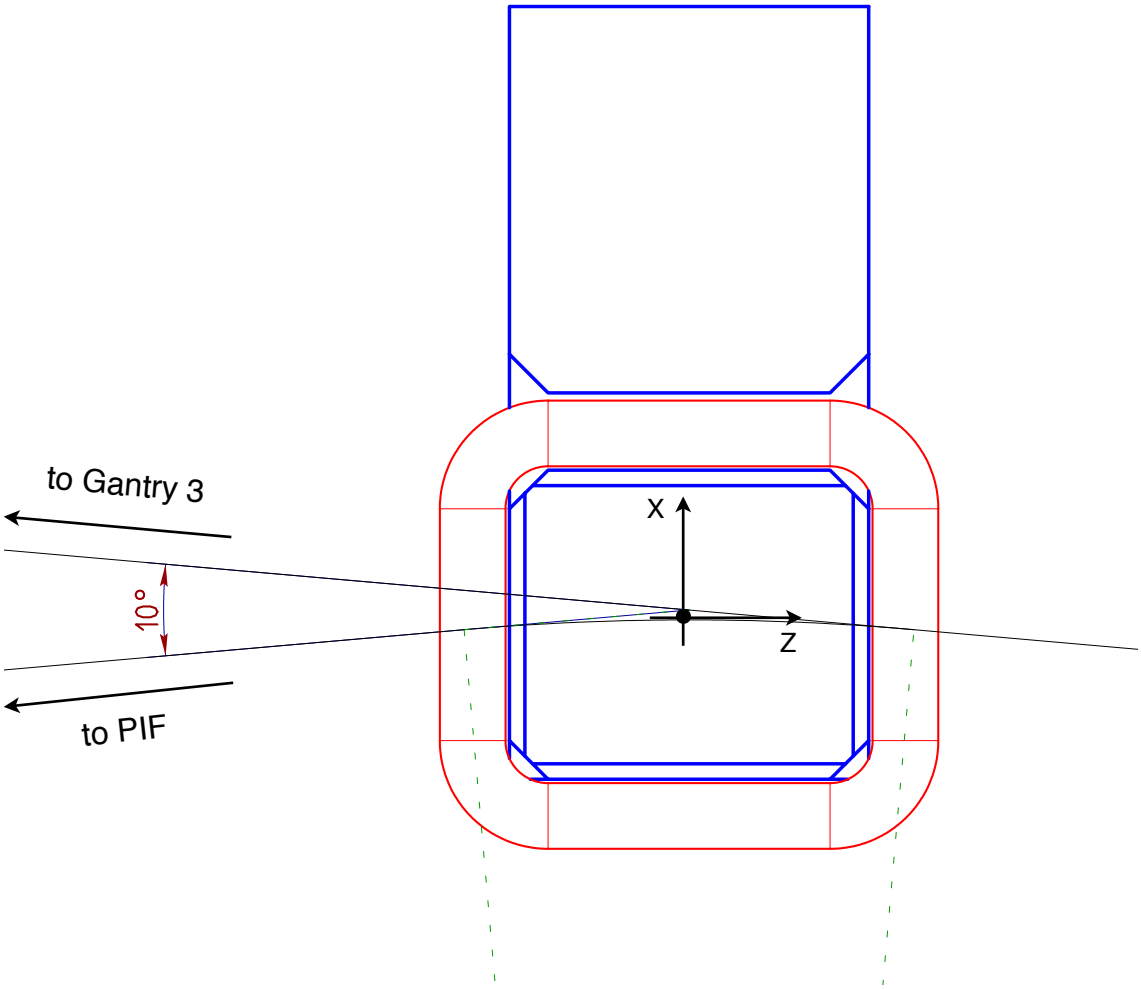
Magnet alignment and positioning

The AMD2 magnet was placed on the standard concrete blocks (H500mm). Since the magnet gap varies by almost 1 mm, the magnet's mid-plane and not the pole surface was used for levelling.

In the measurements coordinate system the magnet axis is the Z-axis, vertical axis is the Y-axis (see the sketch). The coordinate system origin is in the middle of the gap.

The positioning was done by eye.

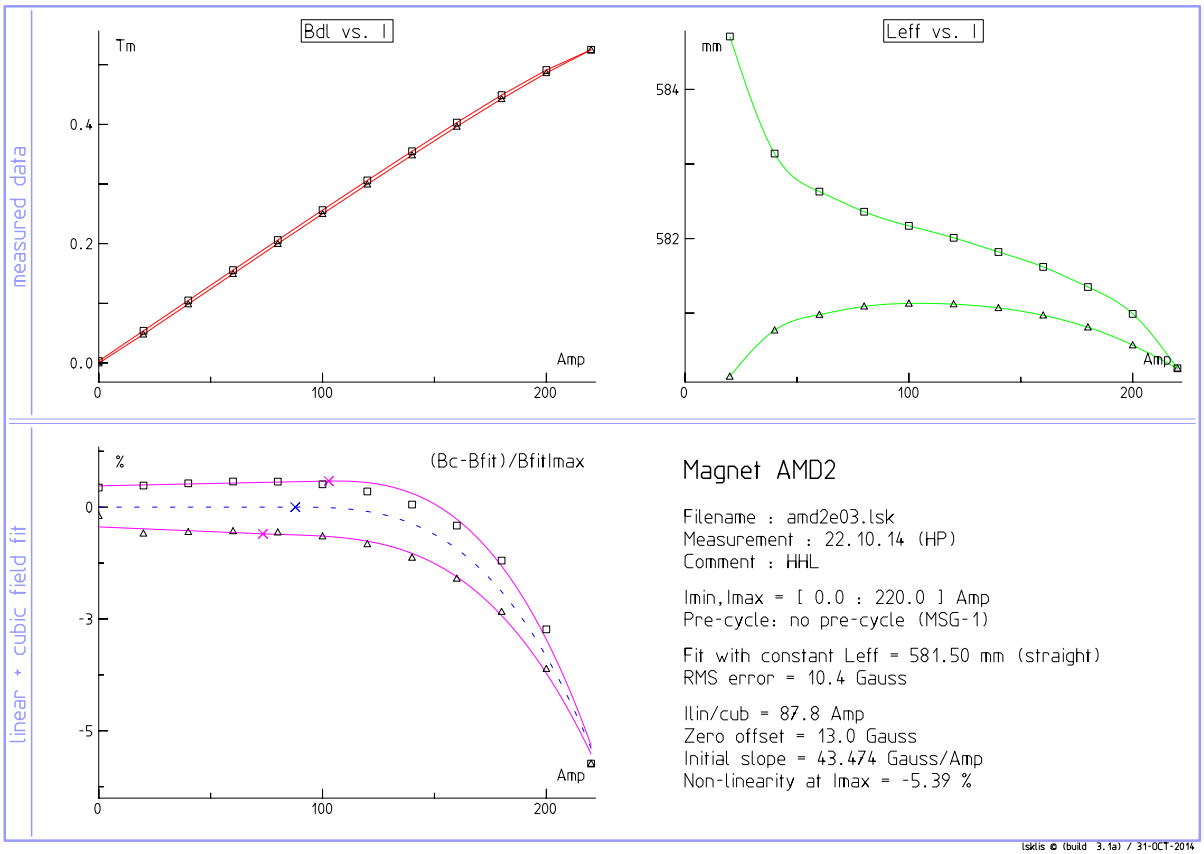
The probe was levelled with the help of a spirit level built into the measuring arm.



Excitation curve

Before measurements the magnet was cycled from 220 A to -220 A. The measurements were performed for the currents from 0 A to 220 A and then back to 0 A. Only half of the curve was measured because the power supply used (MSG-1) is unipolar.

The fields were measured at 23 currents on the line X = Y = 0, Z = ±1000 mm.



clsk.py -23

	$B \cdot dz(220A)$ [T·m]	L_{SEFF} [mm]	I_{LIN} [A]	$B_{OFFSET}(0A)$ [Gauss]	B_{SLOPE} [Gauss/A]	$NL(I_{MAX})$ [%]
amd2e03 22 Oct	0.52500	581.5	87.8	13.0	43.474	-5.39

Excitation curve

Magnet AMD2

File : amd2e03.lsk
Date : 22.10.14
Meas-type : HP
Comment : HHL

Pre-cycle : no pre-cycle (MSG-1)

#Curr: 23 (nPaths=2)
Z-dir: from -1000.00 mm, steps of 2.00 mm
X-dir: at 0.000 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
/	73.4	220.0	-29.4	9520.0	114.2	-556.0	7.5
\	102.8	220.0	58.4	9586.2	-166.1	-411.0	13.8
¯	87.8	220.0	13.0	9564.3	-40.7	-475.4	10.4

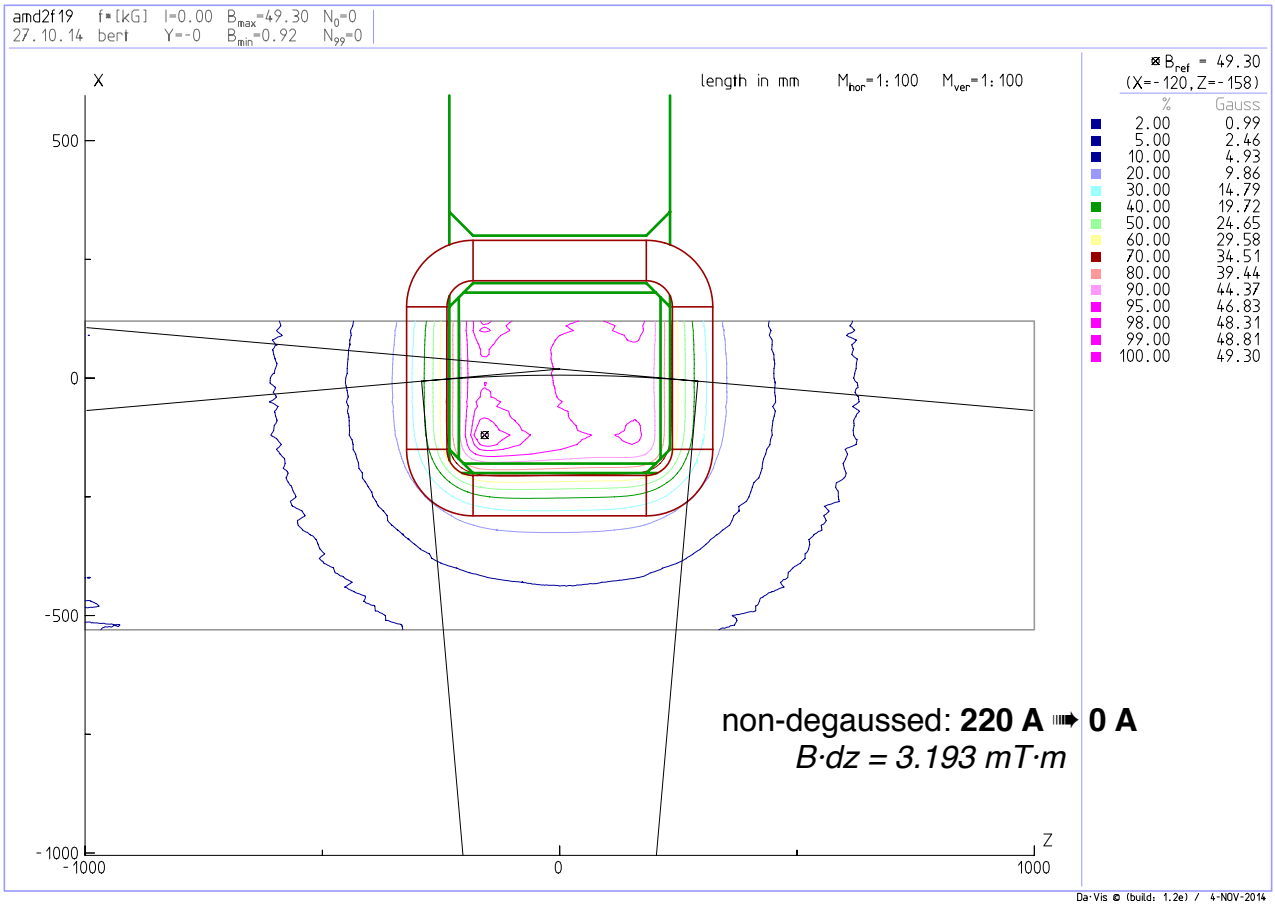
/ = increasing current branch
\ = decreasing current branch
¯ = average

constLeff (straight) = 581.50 mm
constLeff = 582.2 mm
constBendingRadius = 3336.0 mm
fullBendingAngle = 10.0 deg
Leff / Lz = 1.00127
particle E0 = 938.272 MeV

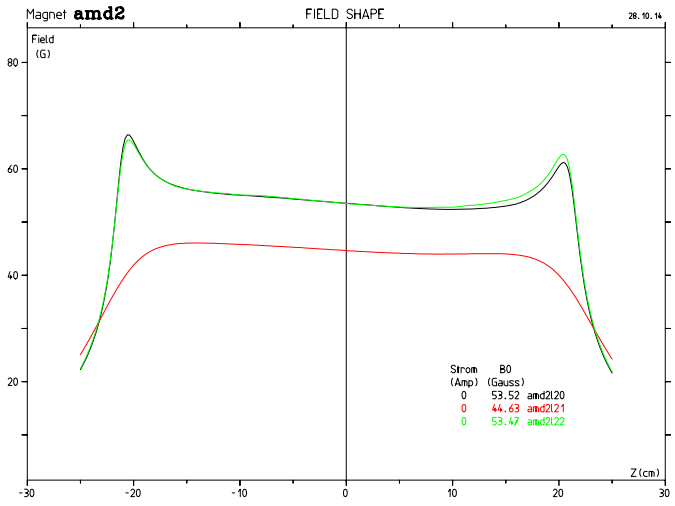
I_Amp	Bdz_Gmm	p_MeV/c	E_MeV	Bc_G	err_G	
0.00*	-3137.1	-0.540	0.000	-5.4	24.0	
19.97/	479684.7	82.499	3.620	824.9	-9.9	
39.98/	987472.1	169.832	15.246	1698.1	-2.5	
59.98/	1494041.0	256.955	34.549	2569.3	3.2	
79.99/	1998413.1	343.700	60.970	3436.7	4.5	
99.99/	2499130.3	429.817	93.763	4297.7	-0.1	
119.99/	2994962.8	515.094	132.090	5150.4	-6.2	
140.00/	3483991.3	599.200	175.009	5991.4	-8.8	
160.00/	3963594.3	681.685	221.490	6816.2	-3.3	
180.00/	4427736.0	761.512	270.138	7614.3	8.1	
200.00/	4862467.0	836.279	318.596	8361.9	9.7	
220.00*	5249977.5	902.926	363.891	9028.3	-29.8	(average of 2 fits)
200.00\	4911431.0	844.701	324.215	8446.1	21.6	
180.00\	4491386.0	772.458	277.066	7723.8	11.6	
160.00\	4029420.0	693.006	228.181	6929.4	-13.5	
140.00\	3549932.5	610.541	181.154	6104.8	-24.1	
120.00\	3060677.3	526.396	137.575	5263.4	-19.0	
99.99\	2563720.5	440.926	98.439	4408.8	-6.5	
79.99\	2061432.1	354.539	64.749	3545.0	1.2	
59.98\	1555681.9	267.557	37.403	2675.3	3.3	
39.98\	1047905.1	180.226	17.152	1802.1	1.6	
19.98\	539558.3	92.797	4.578	927.9	-1.1	
0.00*	31926.1	5.491	0.016	54.9	-3.5	

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

Degaussing



protons E_0 = 938.3 MeV
E = 250 MeV ☛ p = sqrt(E·(E+2·E_0)) = 729.1 MeV/c
B·dl = p/300 · phi ☛ **phi = 1.3 mrad** (for the non-degaussed magnet)



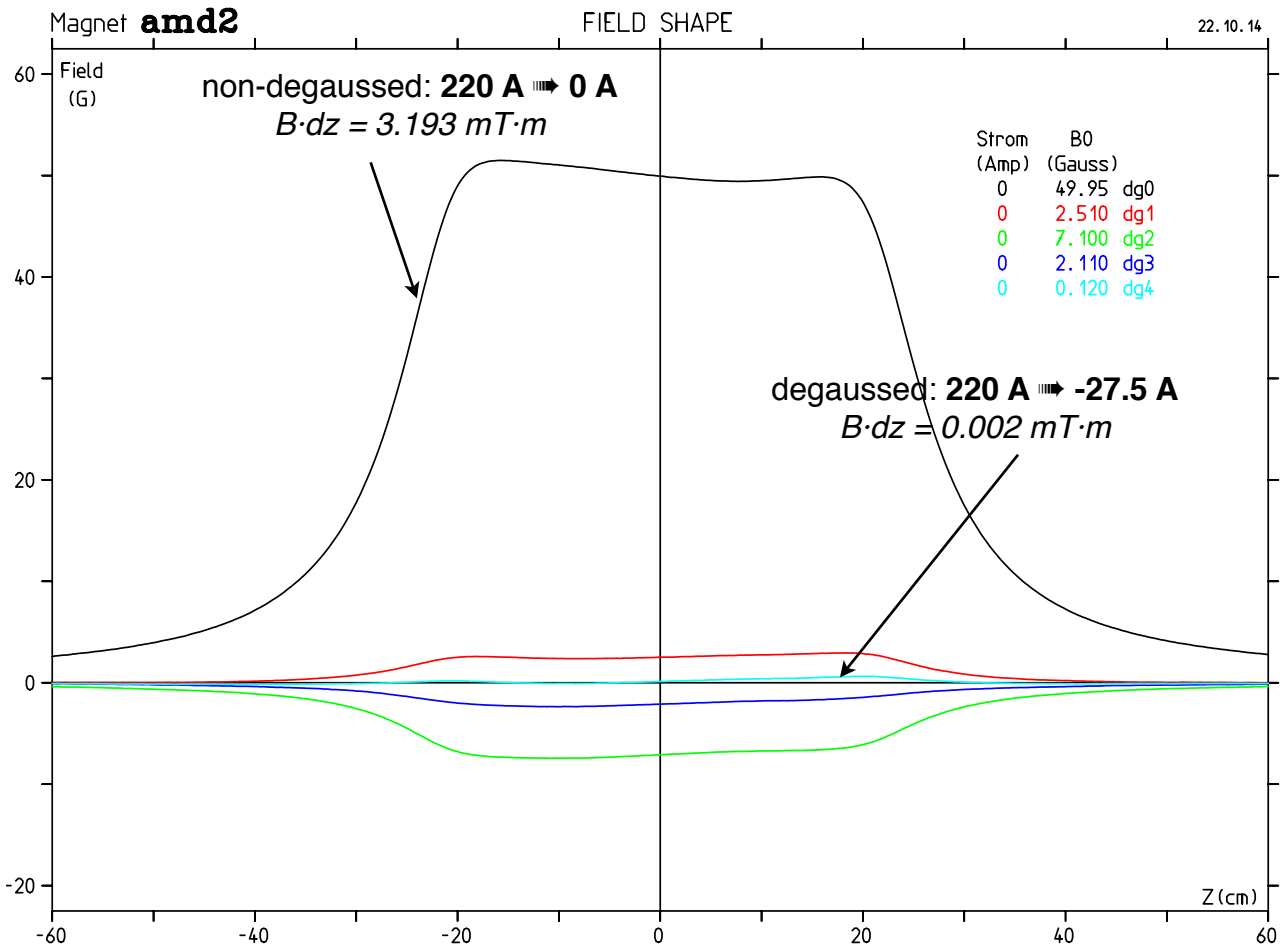
Remanent fields at X = 170 mm and at the different Y positions (-40, 0 and +40 mm) of the non-degaussed magnet.

Degaussing

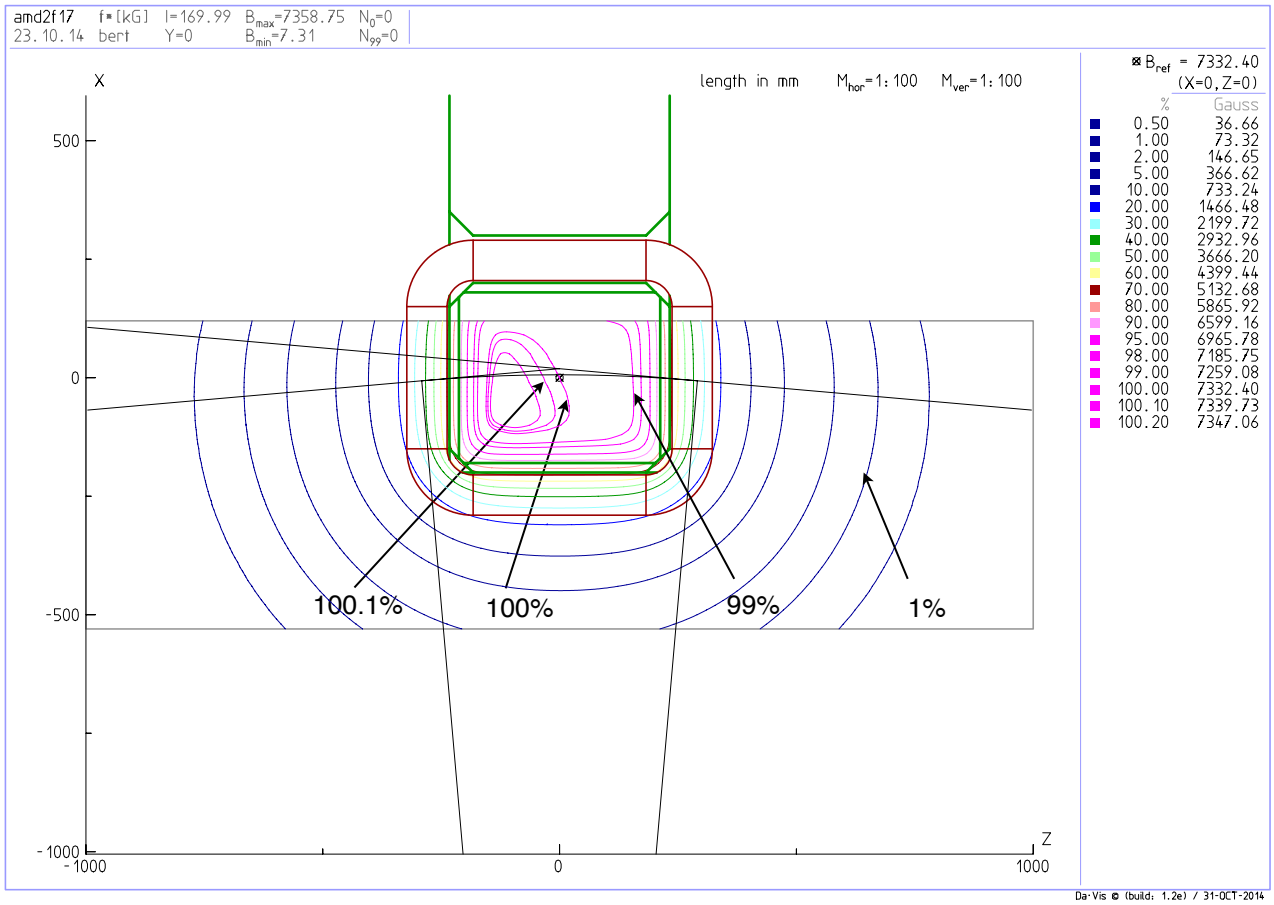
printf "/\n\n" | xmes orig_files/amd2l06
… (same for all the other fieldmaps)

printf "l07\n-l06\n/2\n\ndg1\ny\n" | combi
… (same for all the other fieldmaps)

	I_{dg1} [A]	B·dz(0A) [mT·m]	I_{dg2} [A]	B·dz(0A) [mT·m]	I_{dg3} [A]	B·dz(0A) [mT·m]	I_{dg4} [A]	B·dz(0A) [mT·m]
amd2	**30** (l07-l06)	**0.149** -0.0, 2.9	**20** (l09-l08)	**-0.444** -7.5, -0.1	**25** (l13-l12)	**-0.127** -2.4, 0.0	**27.5** (l15-l14)	**0.002** -0.2, 0.6



Field integrals (straight)



printf “amd2f17\n<v51,57\n\n\n\n” I combi

	I [A]	B_0 [Gauss]	L_{SEFF} [mm]	B·dz [T·m]	B_{1fit} [G/mm]	B_{2fit} [G/mm²]
amd2f17 23 Oct	170	7332.4	581.5	0.42639	-0.193	-0.0069
amd2f18 23 Oct	90	4401.1	582.1	0.25621	-0.118	-0.0040

Hard edge model representation and raytracing

L_{SEFF} = 581.5 mm
R = 581.5 / (2·sin(5°)) = 3336.0 mm
sag = 3336.0 · (1 - cos(5°)) = 12.7 mm

$X_{vertex} - X_{beam}$ = 3336.0 · (1/cos(5°) - 1) = 12.7 mm
position magnet so that the beam is ±sag/2 relative to the magnet centre
X_{vertex} = 12.7 + 12.7/2 = 19 mm

INTEGRATE: X_vertex = 19 mm						
			beam entrance edge		**beam exit edge**	
	I [A]	**Z_0 [mm]**	**angle [°]**	**curvature [m]**	**angle [°]**	**curvature [m]**
amd2f17 23 Oct	170	-0.7	-5.056	-1.793	-4.997	-1.802
amd2f18 23 Oct	90	-0.7	-5.054	-1.868	-4.997	-1.972

TRACK: X_vertex = 19 mm, Z_0 = -110 mm, X_0 = -77.238 mm, $d_{err} = (X_{end} - X_0) \cdot \cos(5^a)$				
	I [A]	**E [MeV]**	**X_{end} [mm]**	**d_{err} [mm]**
amd2f17 23 Oct	170	252.6	-77.260	0.022
amd2f18 23 Oct	90	98.3	-77.260	0.022

Beam vertex point