TWELFTH INTERNATIONAL MAGNET MEASUREMENT WORKSHOP
ESRF, Grenoble, FRANCE, October 1-4, 2001

Insertion Device Magnetic Measurement at Sincrotrone Trieste

D.Zangrando

Specifications for Hall plate bench

- Main axis (Z) :

    Travel range 5.5 m, motorised.

    Pitch, roll and yaw : ± 20 µrad.

    Straightness and flatness : ± 50 µm, measured at a distance of 0.5 m. from the carriage surface in any direction.

    Encoder resolution 1 µm.

    Velocity 1-50 mm/sec.

    The supplier had to specify the positioning accuracy and the measuring accuracy

    (at distance of 0.5 m from carriage surface), over the full travel, and in addition per metre.

- Subsidiary axes : X (horizontal) and Y (vertical), mounted at 90 deg.

    Travel range 200 mm, motorised.

    Orthogonality of all three axes ± 50 µrad.

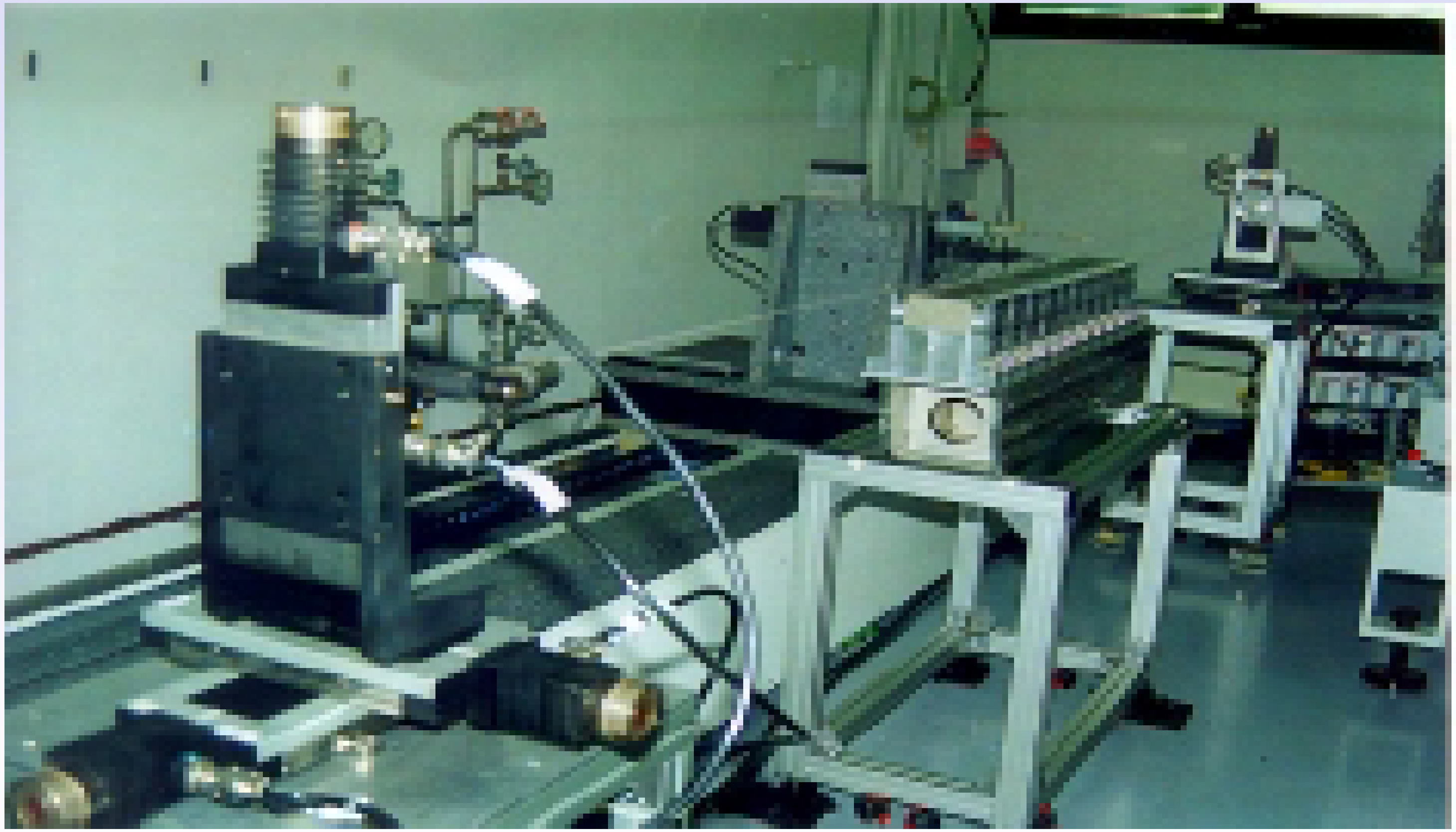
    Straightness and flatness specified by the supplier.

    Encoder resolution 1 µm.

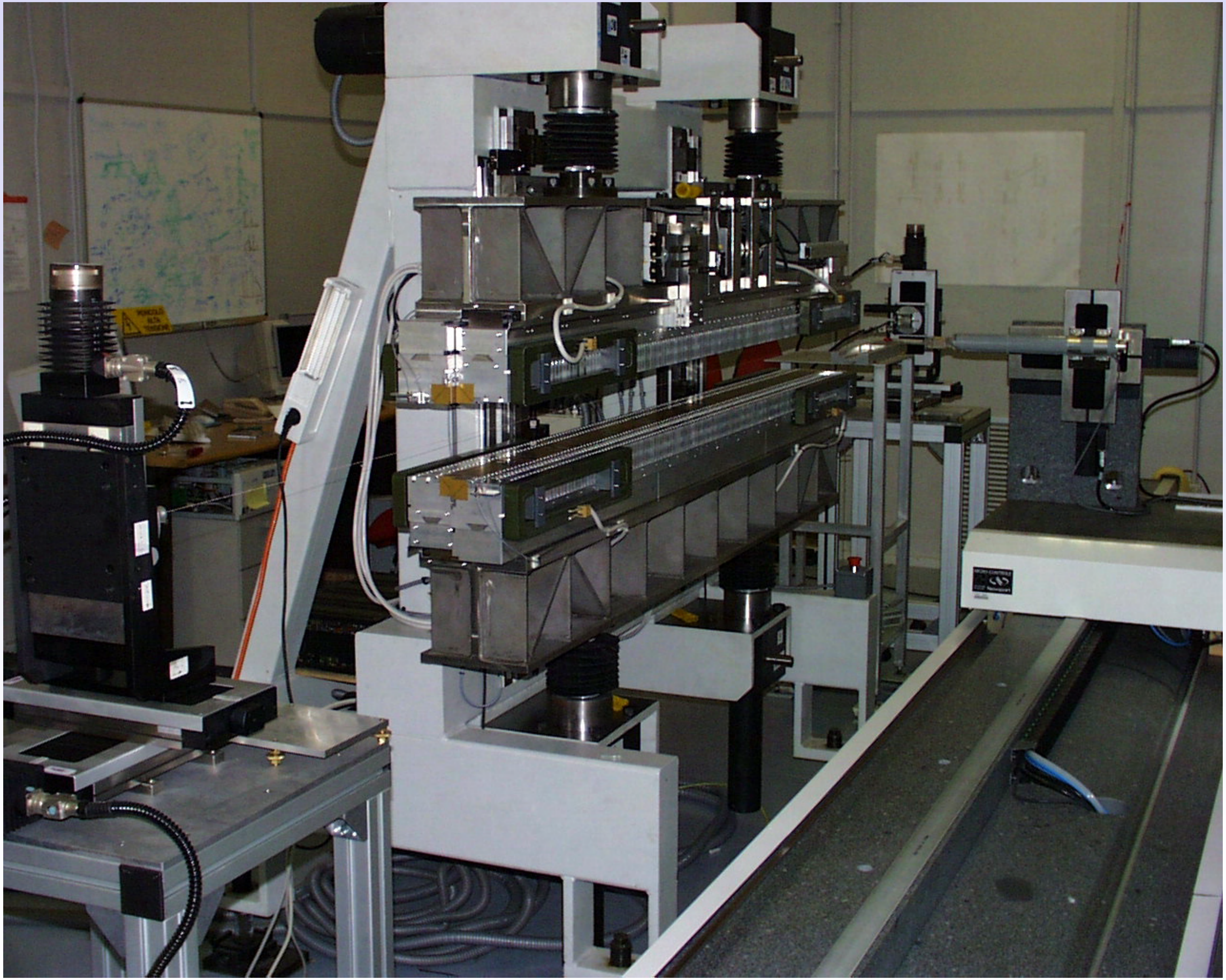
    The mid-point of the vertical translation stage (Y) must be positioned at 1.2 m above the floor.

The system include the possibility to make in-flight measurements: during a Z-scan (without stopping) the electronic system is able to generate a TTL signal (trigger) to 2 voltmeters at predefined equispaced measuring positions. The starting/final points, trigger position, is programmable via computer (GPIB or RS-232).

Stretched wire and Hall plate bench



EU6 during magnetic measurements

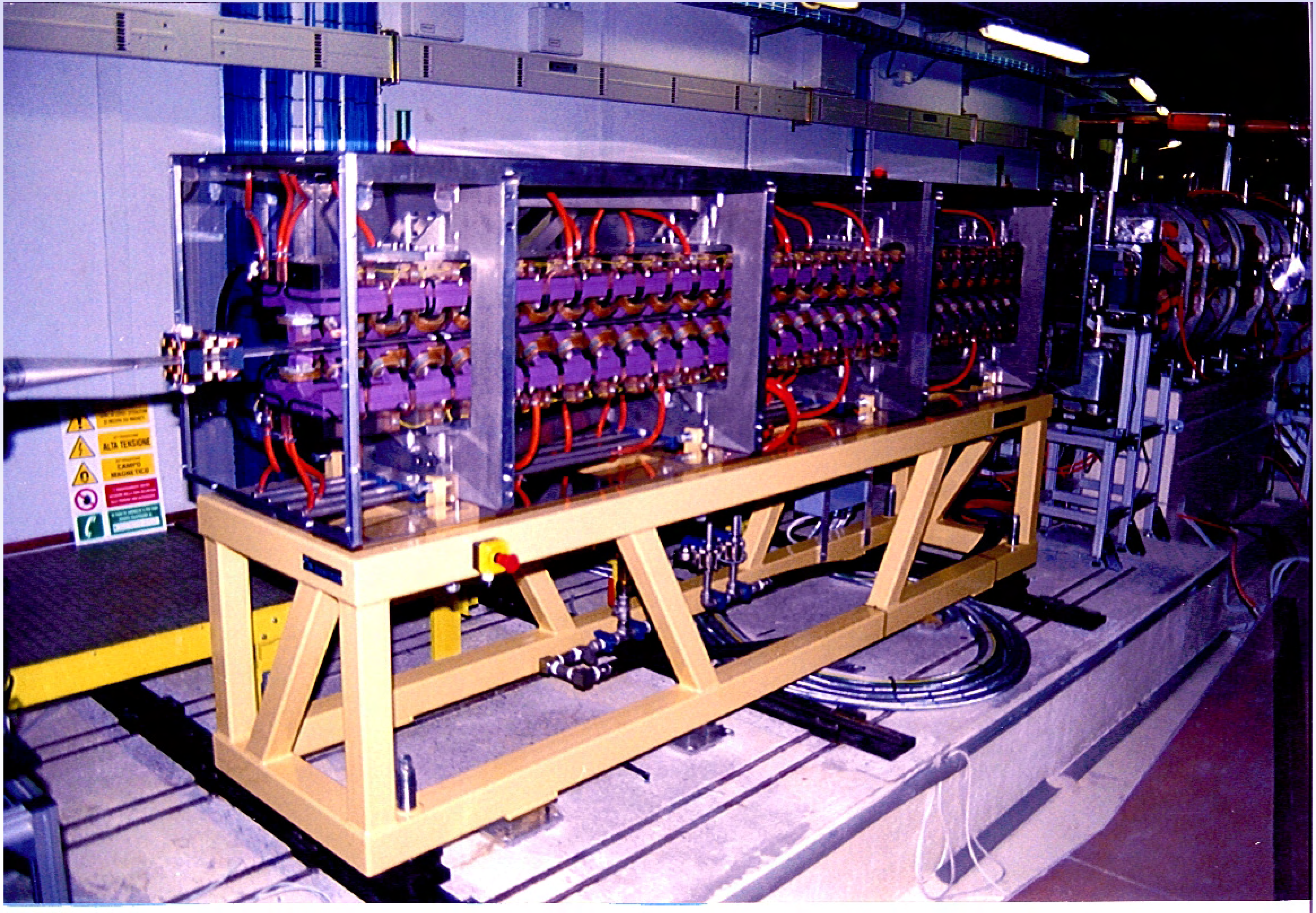


Elliptical IDs Installed :

Period (mm)	Np	Horizontal Polarization			Circular Polarization			Vertical Polarization		
		B_0 (T)	K	ε_1 (eV)	B_0 (T)	K	ε_1 (eV)	B_0 (T)	K	ε_1 (eV)
48(EU)	44	0.57	2.58	185	0.29	1.30	294	0.33	1.51	371
60 (EU)	36	0.78	4.41	59	0.42	2.39	94	0.51	2.87	123
77(EU)	28	0.91	6.56	22	0.53	3.85	32	0.65	4.69	42
100(EU) (1)	20	1.01	9.45	8	0.63	5.85	10	0.78	7.27	12
125(EU)	17	0.78	9.06	8	0.47	5.48	10	0.60	7.04	12
212 (EEW) (2)	32V, 31H	0.59	10					0.11	2	12

(*) Used for a combined SR beamline + S.R. FEL experiment (2 undulators)

(2) Elliptical Electromagnetic wiggler, with variable elicity (5eV, 1.3 KeV), max. 100 Hz


ALTA TENSIONE
CAMPO
MAGNETICO

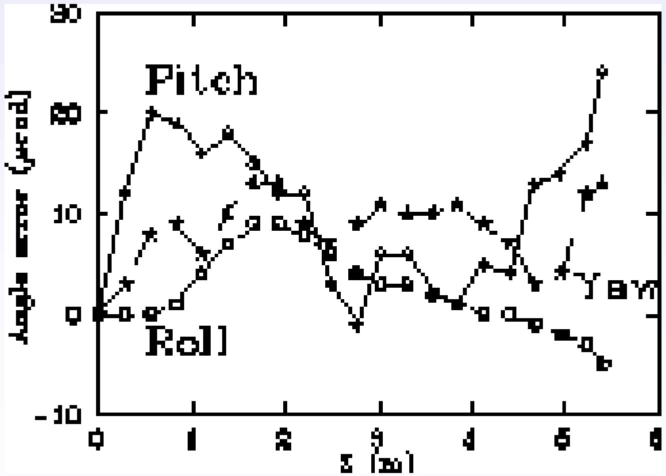
Hall plate bench: description

- The new Hall plate bench, supplied by Microcontrole-Newport (France), was installed in November 1997. It is based on long granite beams of 6.5 m. The bench lies on 12 leveling devices, regulated during the bench installation in order to meet the specified angle tolerances. A carriage moves (Z-axis) on air-bearing along the upper beam, driven by a belt system and a dc-motor (UE512CC). The length of travel of Z axis is 5.5 m. This carriage supports the X (horizontal) and Y (vertical) stages, each with 200 mm of travel, driven by stepping motors (MTL200P1). The total moving mass is about 225 Kg. and the max. Z speed is 60 mm/sec. The mass of the complete system is about 3.5 tons. The X and Y positions are measured by a rotary encoder, with a sensitivity of 1 μm, the Z position is read by a linear encoder (Heidenhain, model Lida 105 + Exe), having a sensitivity of 1 μm.
- All axes are driven by a standard MM4005 Newport integrated motion/controller connected to a PC via RS232 (or GPIB). This controller has the possibility to make in-flight measurements: during a Z-scan it is able to generate TTL signals (trigger) to 2 voltmeters (HP-3458) at predefined and equispaced measuring positions.
- Data taking is performed at 20 mm/sec; the data are stored in the voltmeter buffer and read at the end of the scan.

- First figure: measurements carried out using an electronic level (roll) and an autocollimator (pitch and yaw). It can be seen that the angle errors are within the tolerances specified, **apart from a pitch value (24 μrad)** but measured **at the limit** of the range (5.4 m.). For the old Hall plate bench we measured angle errors about twice larger, along the 2.5 m. Z axis.

- Second picture : the difference between the true displacement measured with a HP interferometer and the value given by the motion controller (Heidenhain encoder) as a function of the Z position. The positioning accuracy measured is about 2 times better than specifications (and 4 times the specification for the old bench).

- The squareness between the 3 axes has been measured by a reference granite cube and was better than 50 μrad.



HP System performance - **REPRODUCIBILITY (rms)**

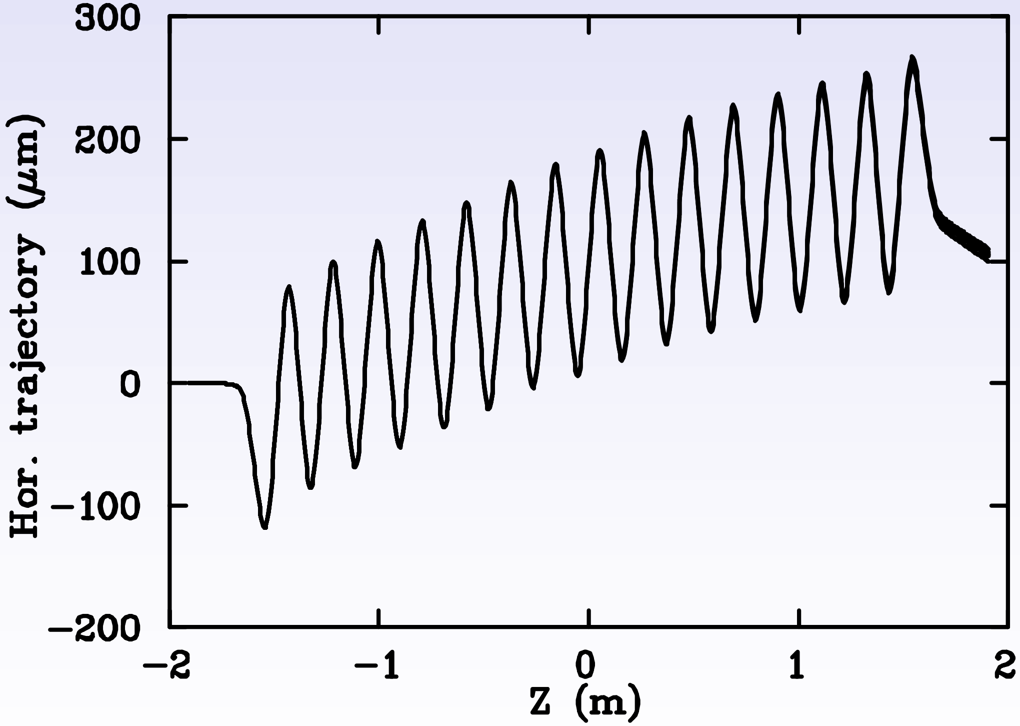
	I(Gm)		II (Gm^2)	
	H.	V.	H.	V.
• CLRC array (By peak 0.76 T, per.200mm) L=1 m, scan 1.4	**0.019** /	**0.034**	0.002 /	0.016
EEW (Bx,y peak =0.1, 0.6 T) L=3.2 m , scan 3.8 m	**0.041** /	**0.129**	0.010 /	0.037

With this bench, the overall reproducibility is improved: for Ix seems 10 times better (even though now the length of the scan is doubled)

(Old HP bench Ix,y, rms=0.17 , 0.15 Gm , scan 2.5 m)

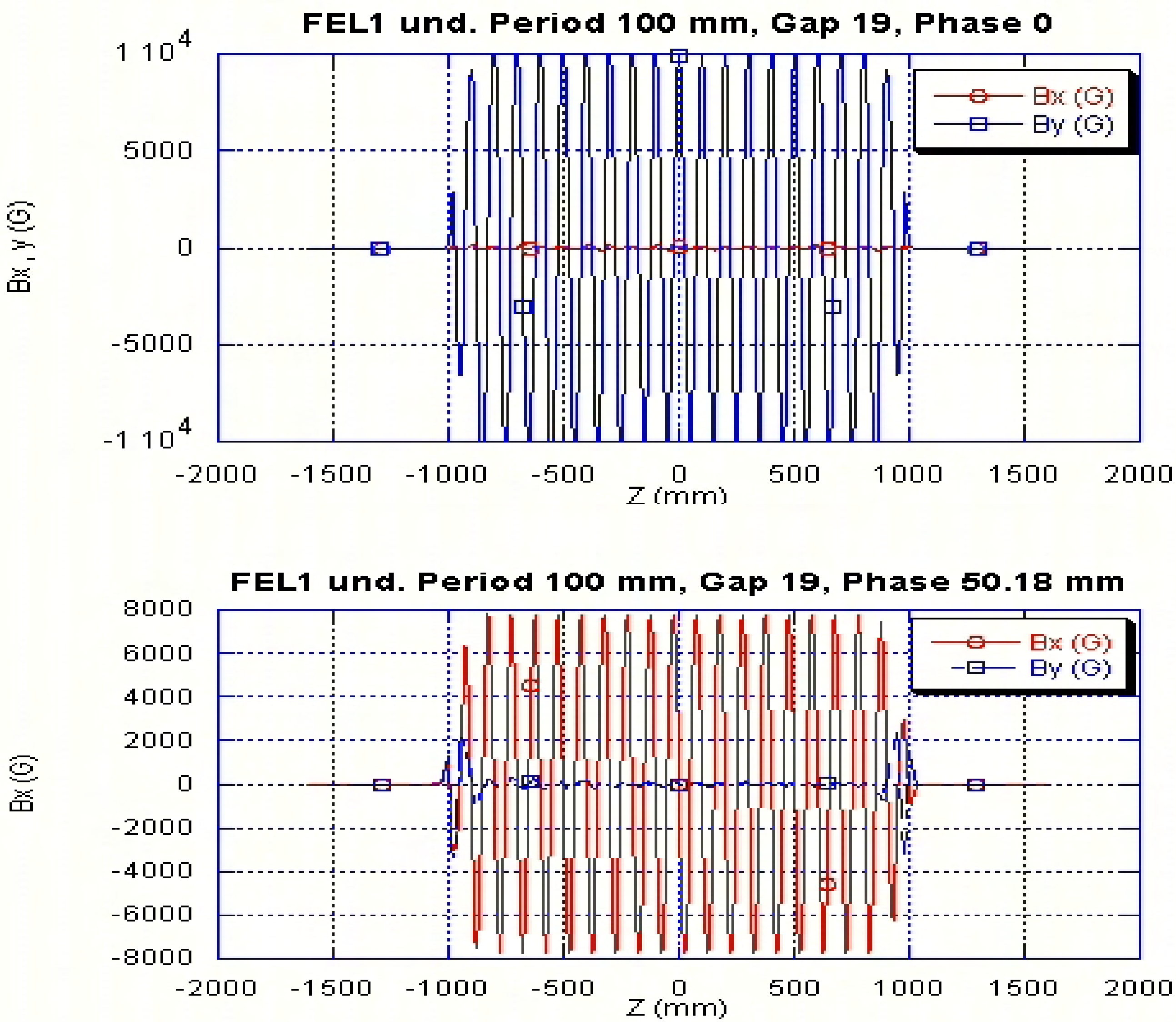
EEW : 8 trajectories, calculated from mag.meas.
(EEW at max. current) at e-beam 2 GeV

max. peak-peak posit.variation at wiggler exit : 10 μm, integration 3.8 m



Stretched wire bench
(for first and second field integral)

- It can be used for MULTIPOLE Field Integral Measurements
- Positioned in the front of the HP bench, … to be able to perform magn. meas. with both benches without having to move Ids
- 2 indipendent tables support the motorized stages with econdersof 1 μm
- Litz wire, 40 strands, wire length 4.2 m + Integrator
- Typical reproducibility (rms) ===> I= 0.02 Gm and II=0.01 Gm^2


FEL1 und. Period 100 mm, Gap 19, Phase 0
Bx (G)
By (G)
Bx , y (G)
Z (mm)
FEL1 und. Period 100 mm, Gap 19, Phase 50.18 mm
Bx (G)
By (G)
Bx (G)
Z (mm)

Correction for the Hall plate planar effect

- **EU6 at phase 0 (only By)**
- Extract planar coef. for Hor. HP (Bx)
- Fit : $Bx_{,meas}=a_0+By^{*}\,a_1+By^{2}{*}\,a_2$
- Gap 19 > $a_2=4.62\ 10^{-8}$ (G^{-1})
  4 runs, rms $0.03\ 10^{-8}$ (G^{-1})
- Gap 30 > $a_2=4.66\ 10^{-8}$ (G^{-1})
- Gap 40 > $a_2=4.1\ 10^{-8}$ (G^{-1})
- $a_1= < 0.1$ deg.

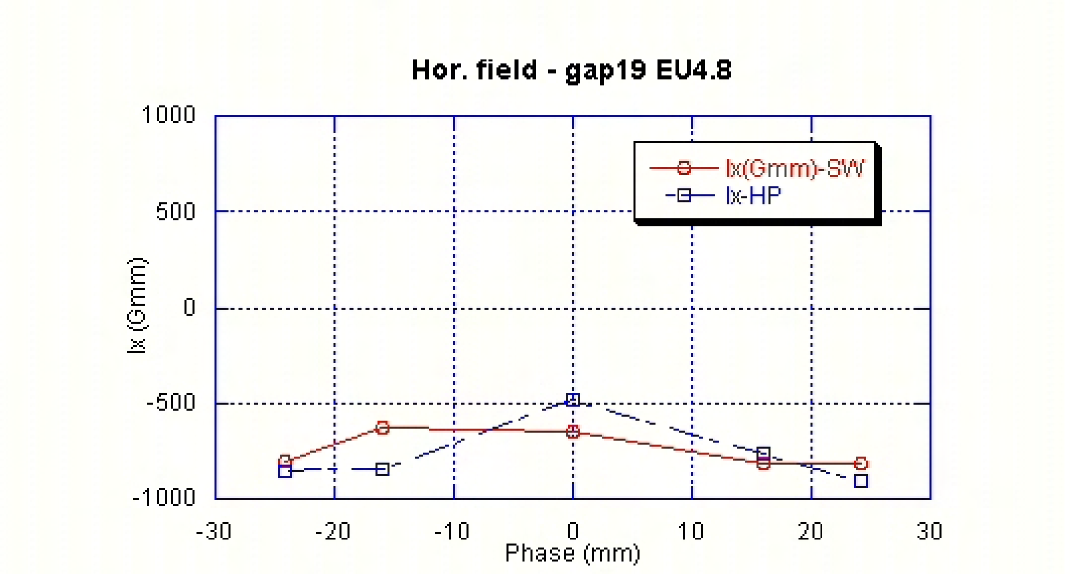
- **EU6 at phase ±30 mm (only Bx)**
- Extract planar coef. for Vert.. HP (By)
- Fit : $By_{,meas}=a_0+Bx^{*}\,a_1+Bx^{2}{*}\,a_2$
- Found out that the planar coef. was depending on the number of periods used in the fit:

  Gap 19 mm

500 pts	(**ph.pos**)	$a_2= -1.4\ 10^{-7}$ (G^{-1})
260 pts		$a_2= +2.0\ 10^{-8}$ (G^{-1})
500 pts	(**ph.neg**)	$a_2= -2.4\ 10^{-7}$ (G^{-1})
260 pts		$a_2= -1.4\ 10^{-7}$ (G^{-1})

- $a_1= 0.4$ deg.

EU4.8 : Hall plate - SW measurements GAP 19 mm

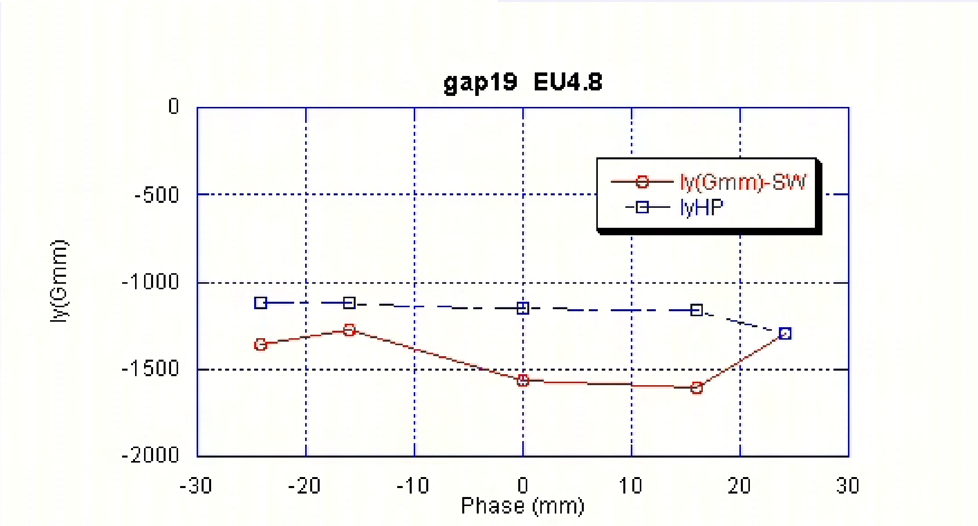


44 periods,

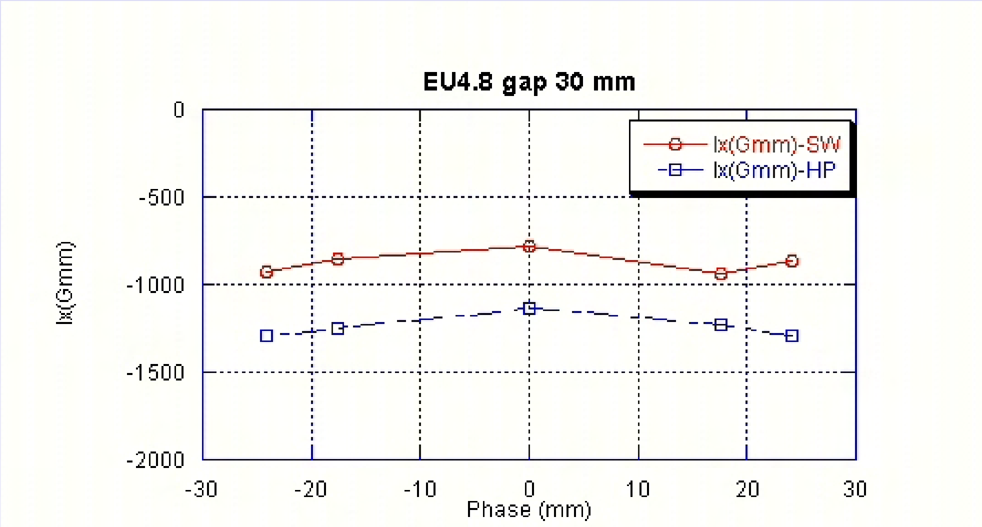
By=0.58 T, hor.pol. (phase=0)

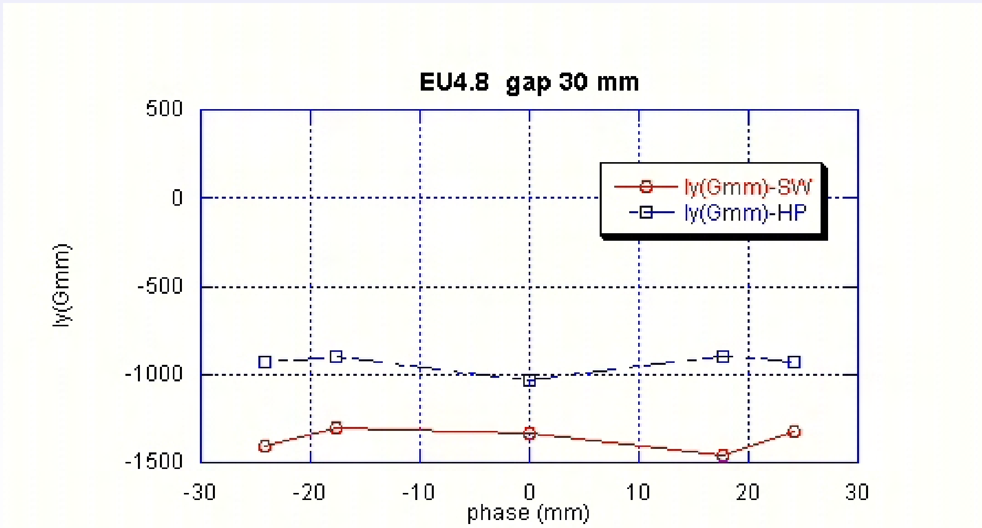
B=0.29 T, circ.pol.

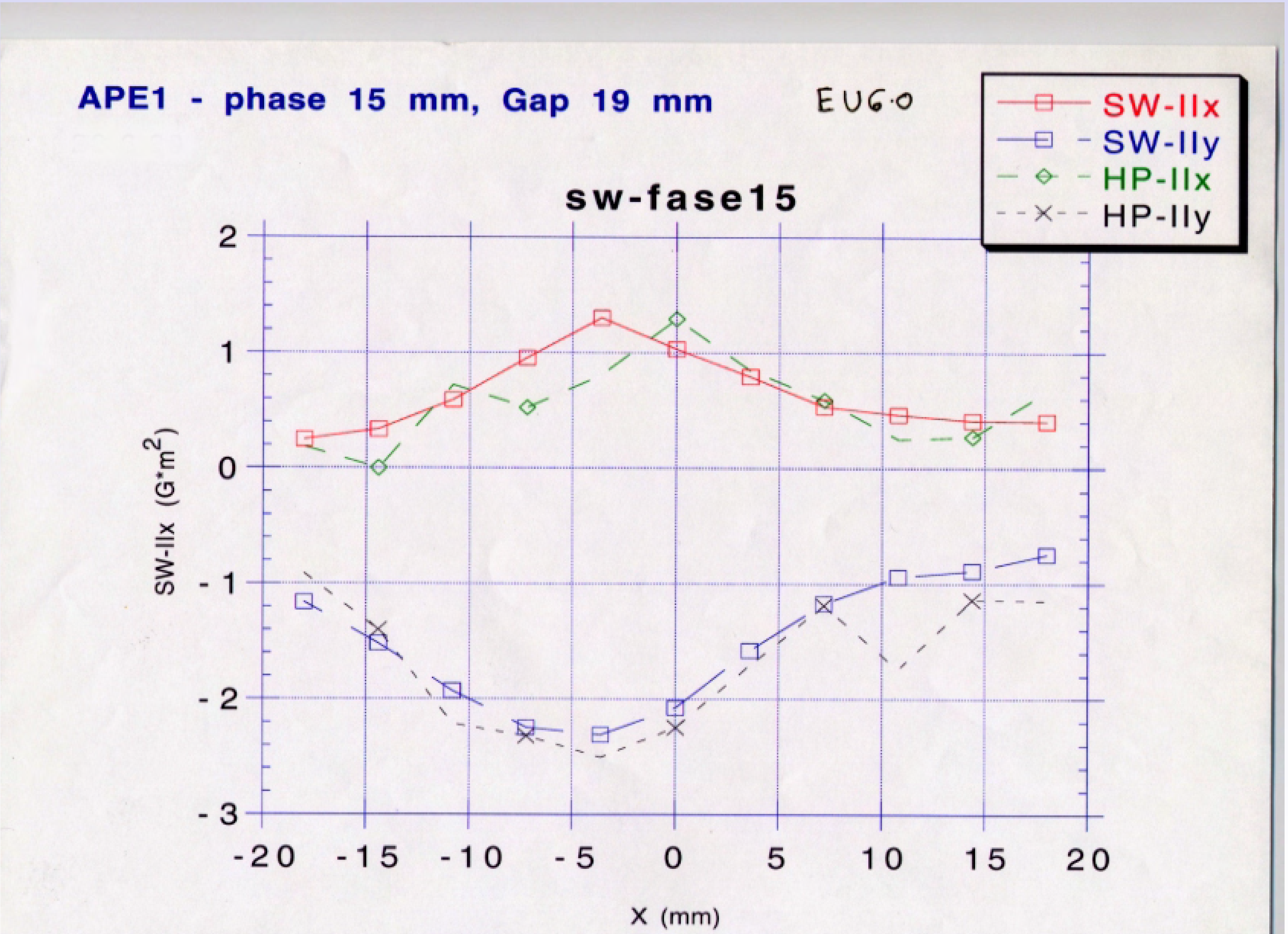
Bx=0.34 T vert.pol (phase=24mm)



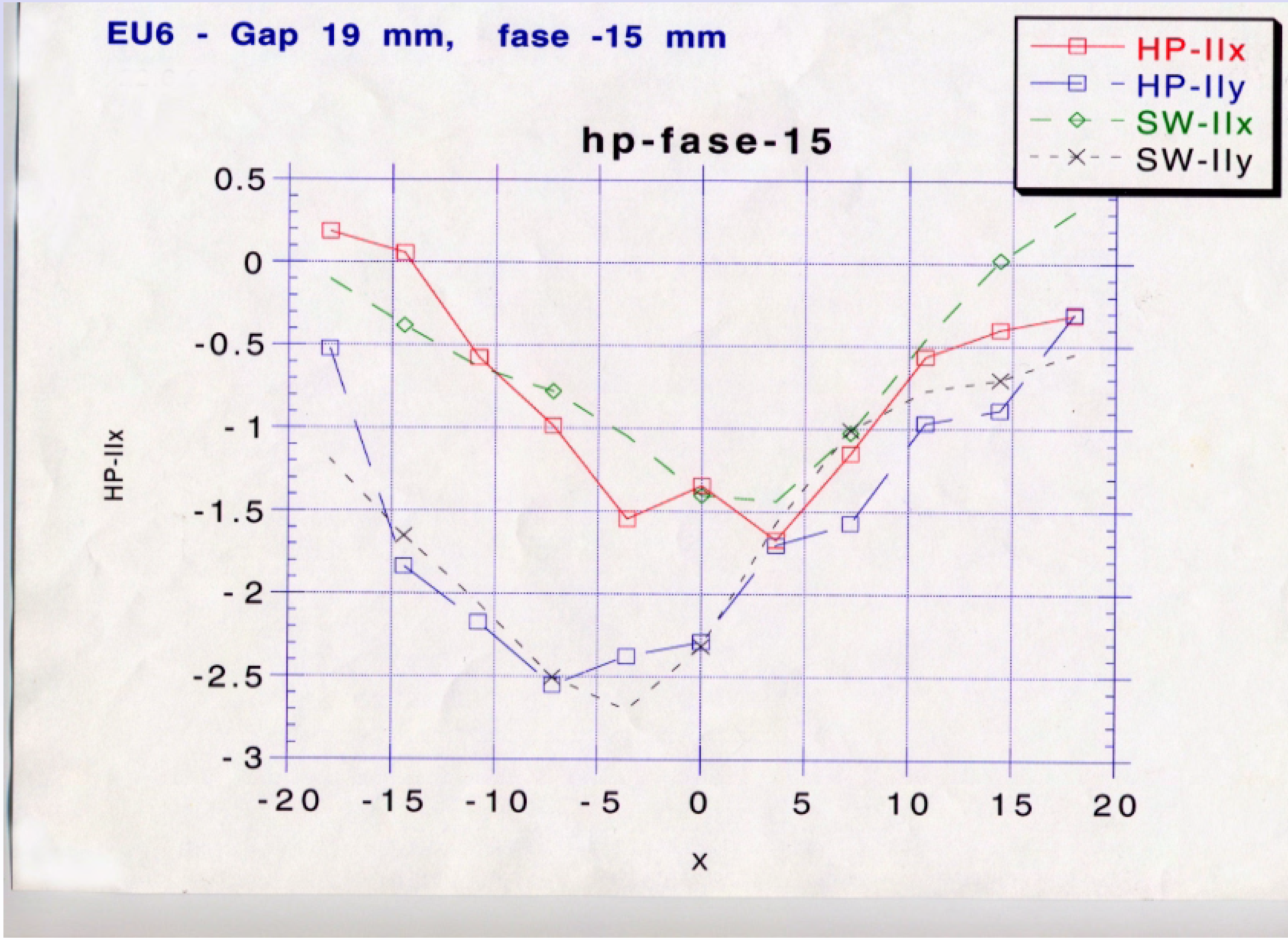
EU4.8 : HP - SW measurements GAP 30 mm

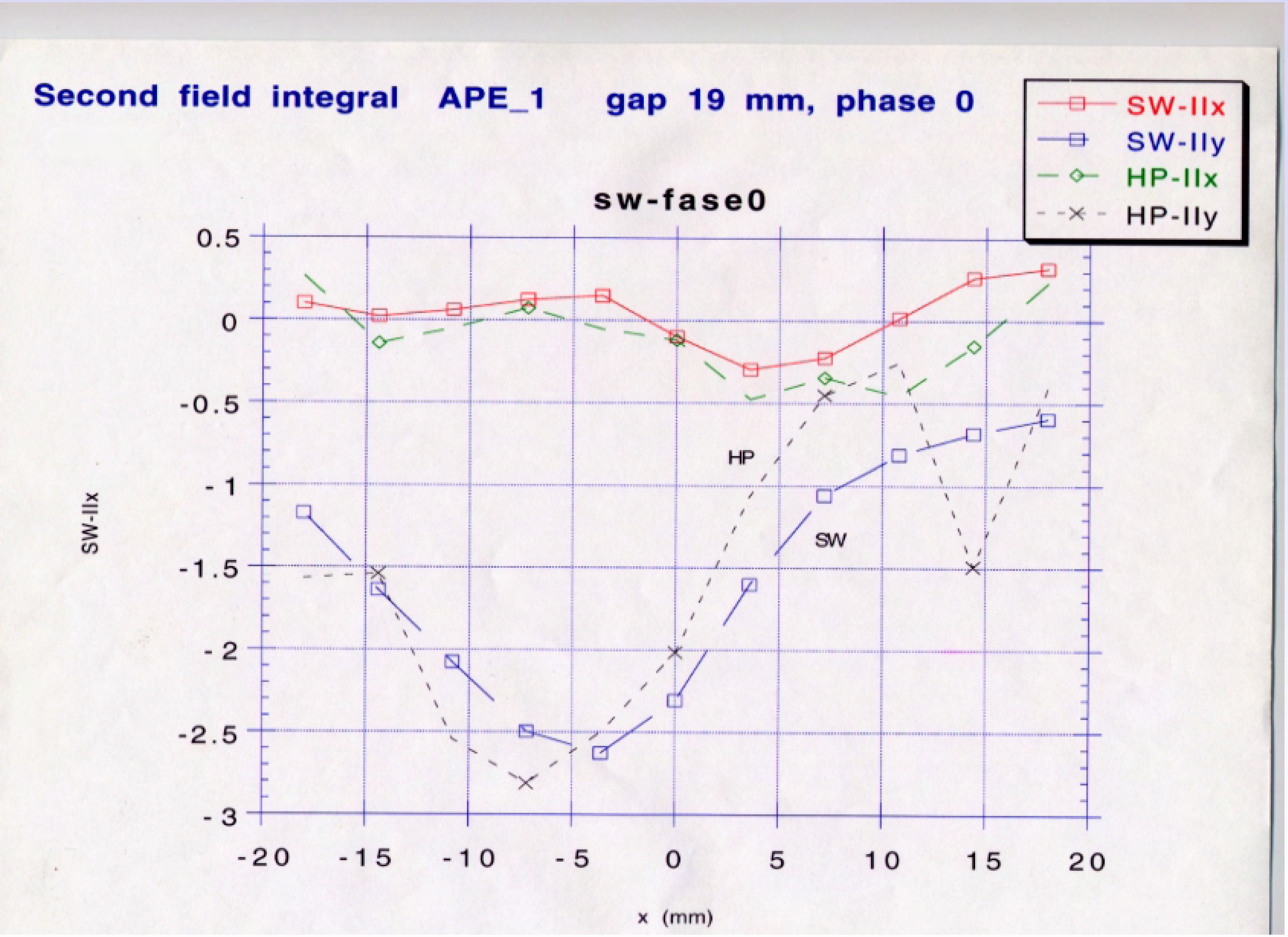




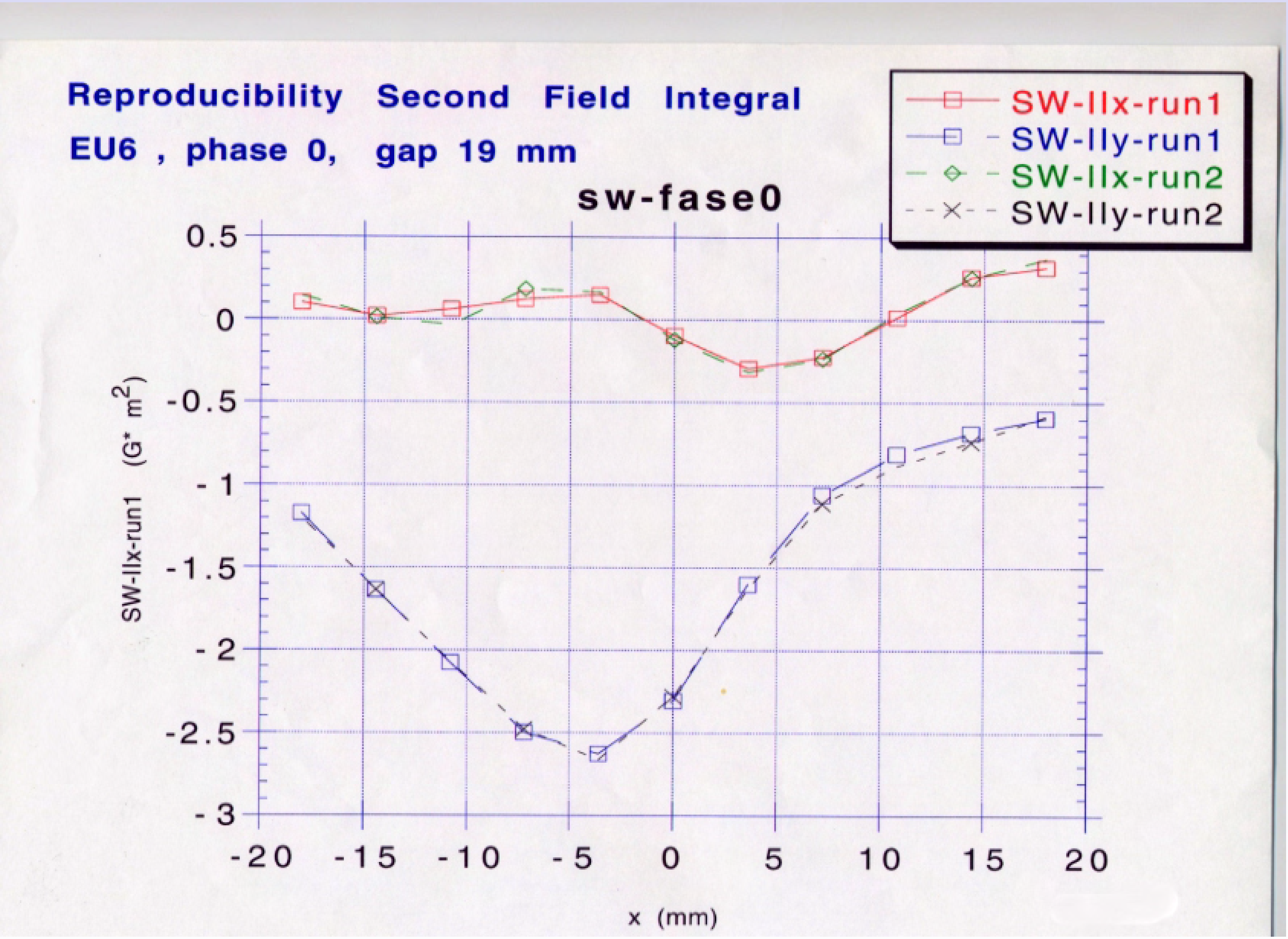


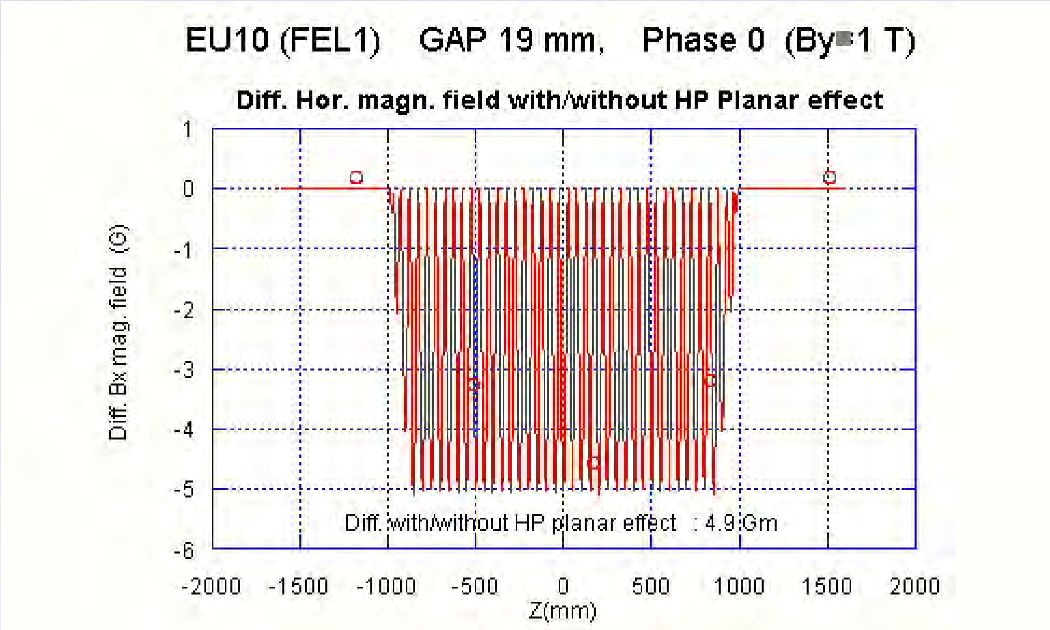
APE1 - phase 15 mm, Gap 19 mm
EU6.0
SW-IIx
SW-IIy
HP-IIx
HP-IIy
sw-fase15
2
1
0
-1
-2
-3
SW-IIx (G*m2)
-20
-15
-10
-5
0
5
10
15
20
X (mm)


EU6 - Gap 19 mm, fase -15 mm
hp-fase-15
HP-IIx
HP-IIy
SW-IIx
SW-IIy
HP-IIx
x
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-20
-15
-10
-5
0
5
10
15
20



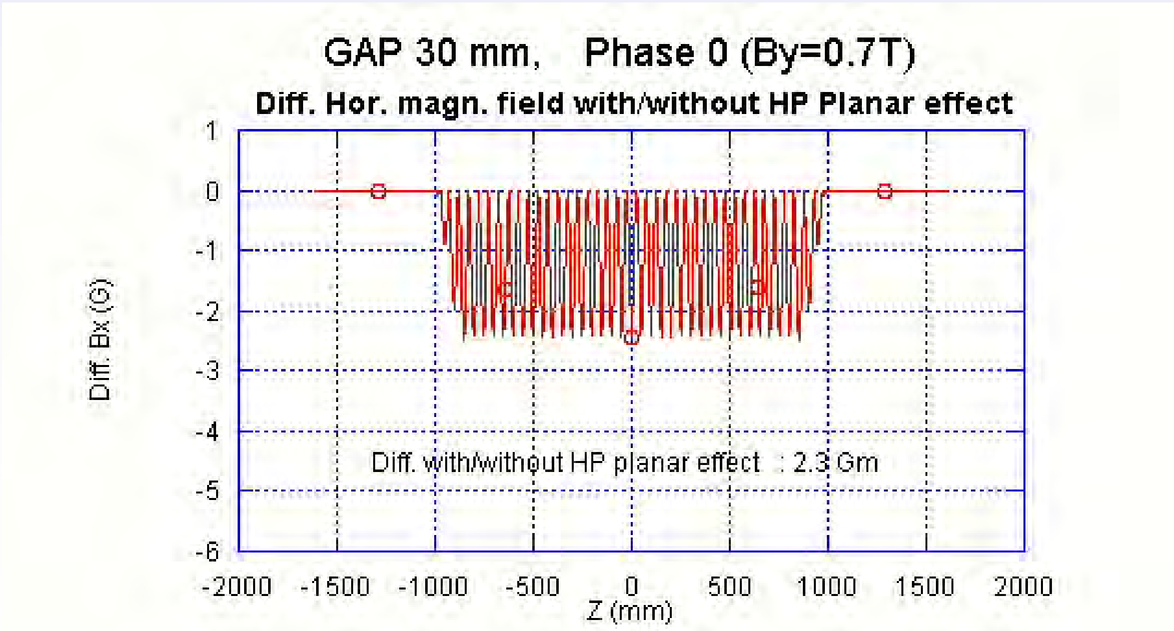
Second field integral APE_1 gap 19 mm, phase 0
SW-IIx
SW-IIy
HP-IIx
HP-IIy
sw-fase0
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-20
-15
-10
-5
0
5
10
15
20
HP
SW
SW-IIx
x (mm)


Reproducibility Second Field Integral
EU6 , phase 0, gap 19 mm
sw-fase0
SW-IIx-run1
SW-IIy-run1
SW-IIx-run2
SW-IIy-run2
SW-IIx-run1 (G* m2)
x (mm)
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-20
-15
-10
-5
0
5
10
15
20

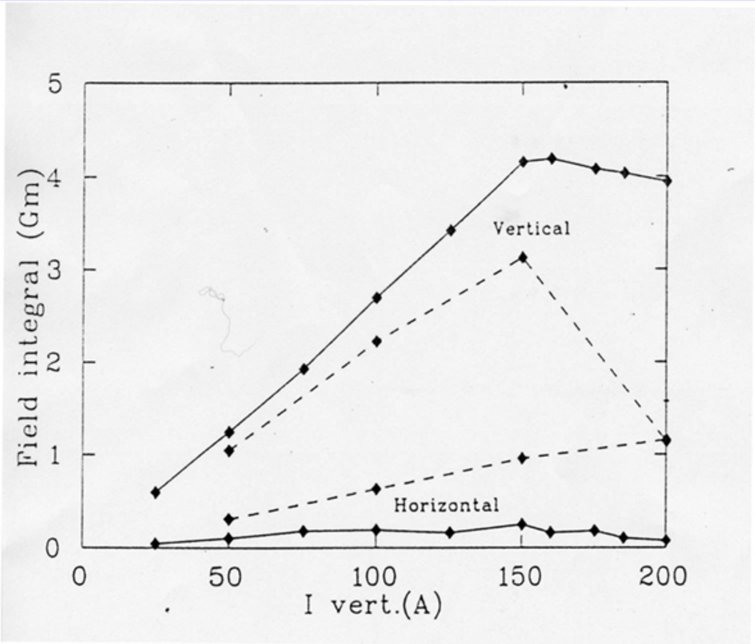


Effect of planar HP correction (Bx) due to By field

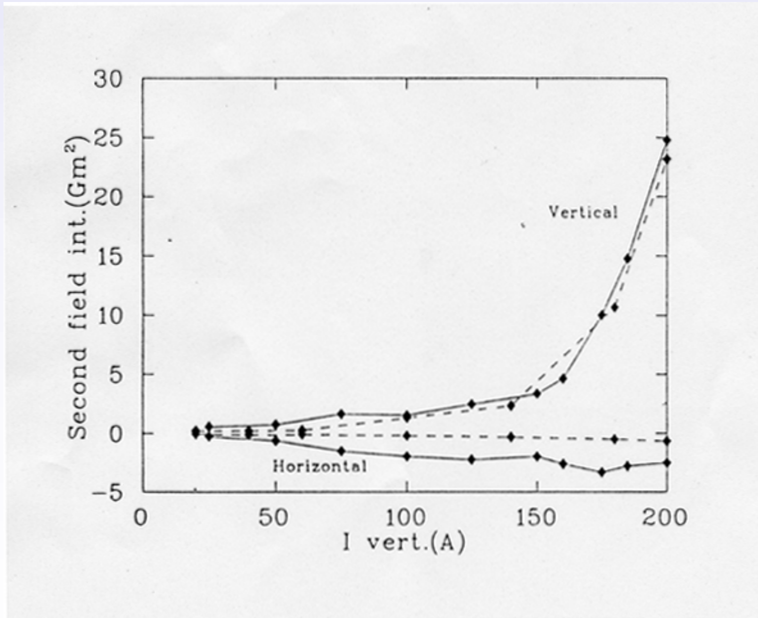
(planar coeff. 4.6e-8 G^{-1})

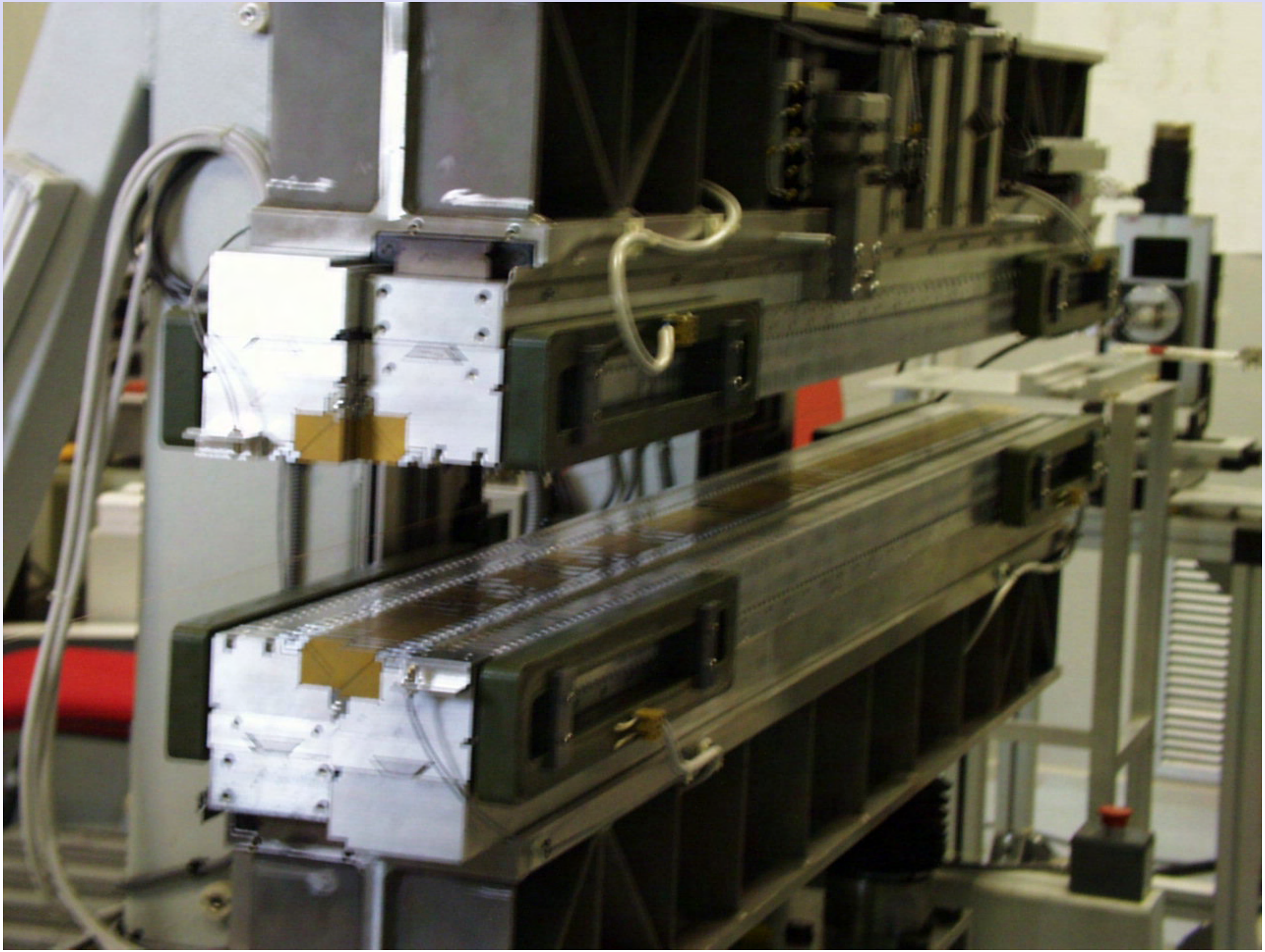


EEW : Horizontal and vertical first and second field integral, measured on the electron beam and in magn.meas. lab.

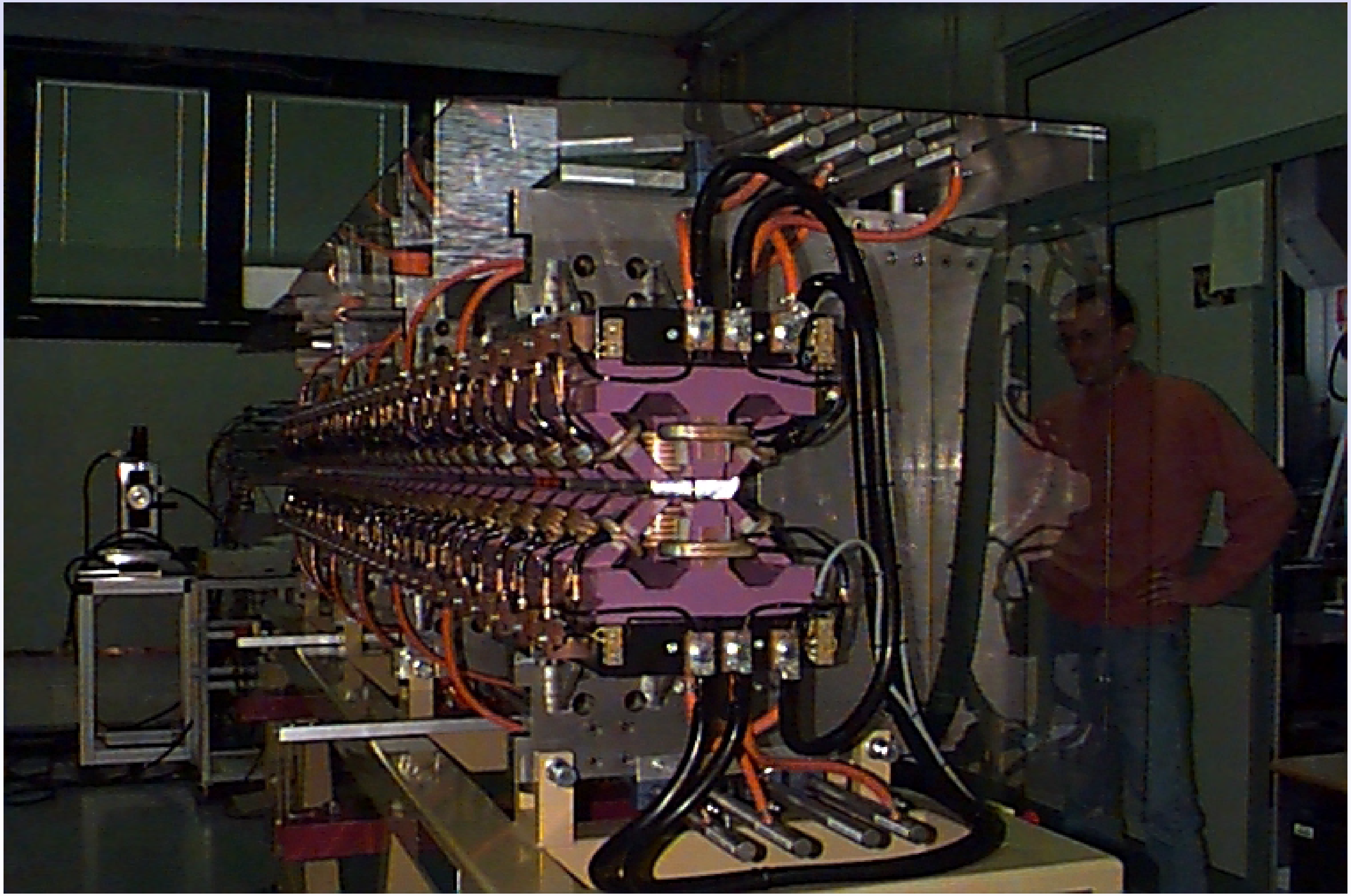


- Solid : electron beam
- Dotted : magn.meas.lab.





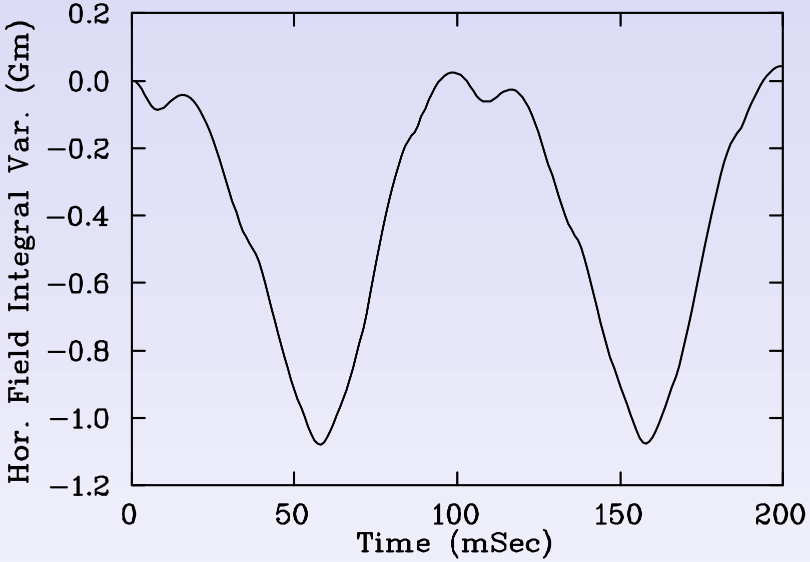
Electromagnetic Elliptical Wiggler EEW (period 212 mm, Bx,y=$\oplus$0.1,0.5 T)



EEW - AC measurements

- The flipping coil technique was chosen to perform dynamic measurements (up to 100 Hz) of field integral variation. i.e. we needed to measure the voltage induced in the static coil by magnetic flux variation, by varying the hor. current.

- Litz wire, 19 strands, stages distance: 4.2 m , connected to HP3458 Voltmeter



Peak to peak field integral variation and rms reproducibility as a function of the integrating time (aperture) of the voltmeter.

Freq. (Hz)	Apert. (mSec)	ΔIx (Gm)	Ix,rms (Gm)
10	0.4	1.153	0.070
10	0.8	1.160	0.029
10	1.5	1.186	0.006
100	0.4	1.104	0.098
100	0.8	1.013	0.037

ELETTRA Storage ring sensitivity (2 GeV)

- Horizontal plane sensitivity : 14 G mm/μm closed orbit (rms) (at IDs corr.coils position)
- Vertical plane: 16 G mm/ μm closed orbit (rms) (at IDs corr.coils position)
- ELETTRA BPMs / Storage ring stability ≈ 1 - 2μm rms (closed orbit)
- Accuracy requested for 2-3 μm closed orbit rms ➒ **0.01 -0.03 Gm**