17TH ADVANCED BEAM DYNAMICS WORKSHOP ON
FUTURE LIGHT SOURCES

Development of Variable Polarization Undulators for ELETTRA

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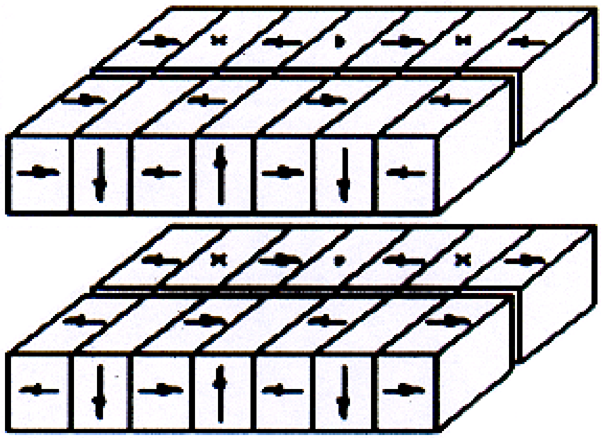
B. Diviacco – Sincrotrone Trieste

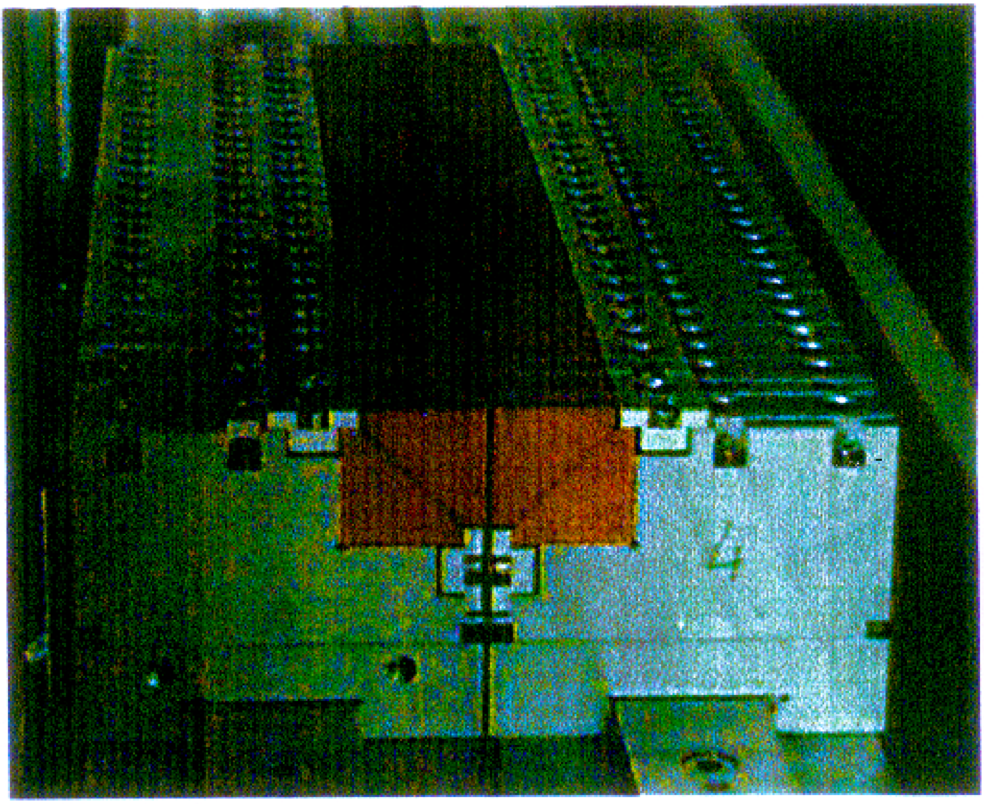
- An APPLE type structure has been chosen for the next 6 Elettra undulators



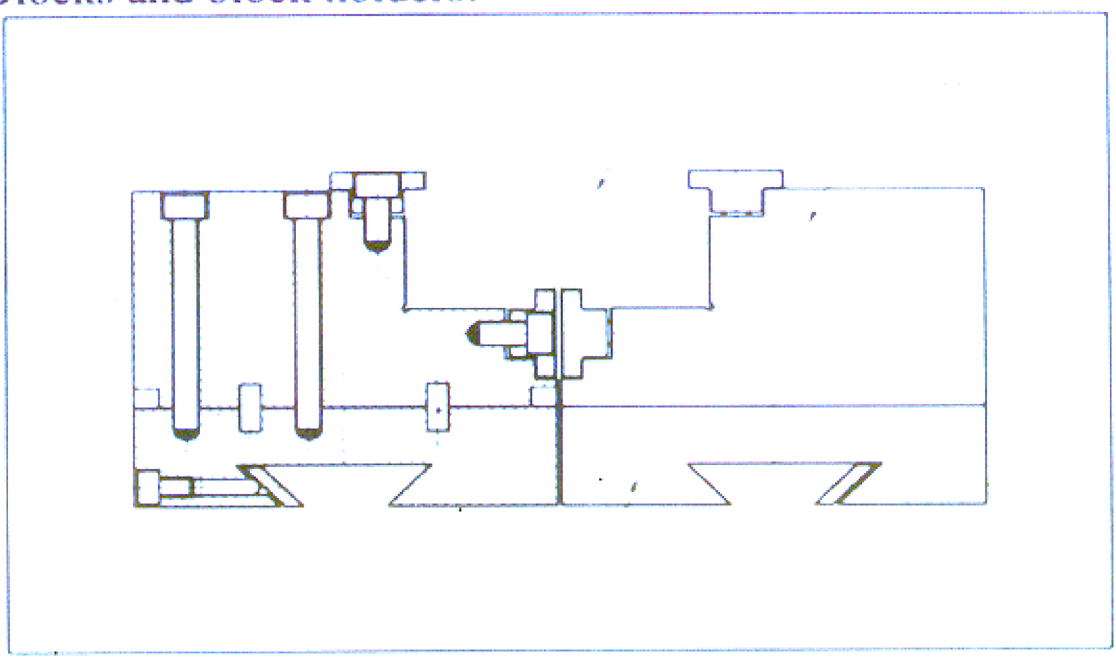
period (mm)	Np	Horizontal Polarization		Circular Polarization		Vertical Polarization	
		B_0 (T)	ε_1 (eV)	B_0 (T)	ε_1 (eV)	B_0 (T)	ε_1 (eV)
48	44	0.57	185	0.29	294	0.33	371
60	36	0.78	59	0.42	94	0.51	123
77	28	0.91	22	0.53	32	0.65	42
100	20	1.01	8	0.63	10	0.78	12
125*	17	0.78	8	0.47	10	0.60	12

* quasi-periodic

EU6.0



Blocks and block holders:



Magnetic material :	NdFeB (die-pressed)
Remanent field:	1.33 T
Dipole moment:	± 0.5%
Angle:	± 0.7 °
$\mu_{//}$:	1.05
$\mu_{\perp}$:	1.15

Is there an improvement in magnet block quality (homogeneity) observable over the last years ?

	typical N/S field difference	typical N/S field integral difference
isostatically pressed blocks (old)	several %	up to 20 %
die-pressed blocks (new)	0.5 %	0.5 %

Present material specifications

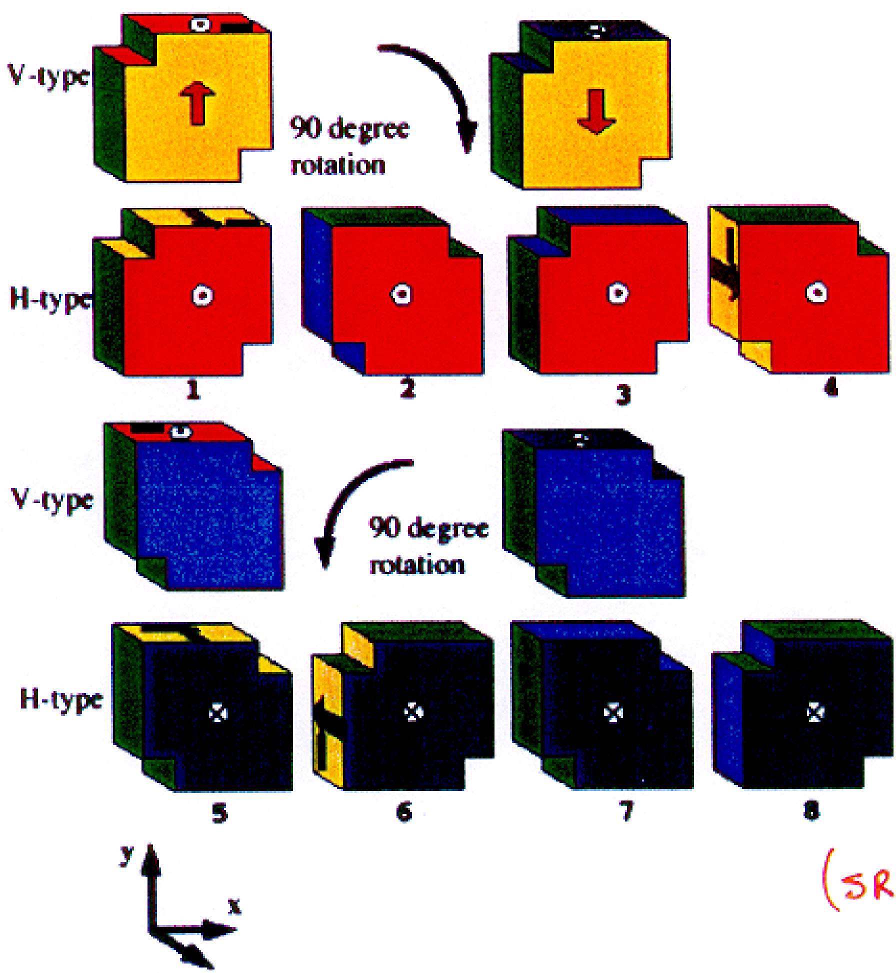
Remanent field	> 1.3 T
Dipole moment	± 0.5%
Angle	± 1 °
N/S rel. field diff.	0.5 %

Sorting and shimming techniques for circularly polarizing permanent magnet undulators

Sorting based on magnetization data (i.e. assuming homogeneous magnetization) has been used for the first time with good results

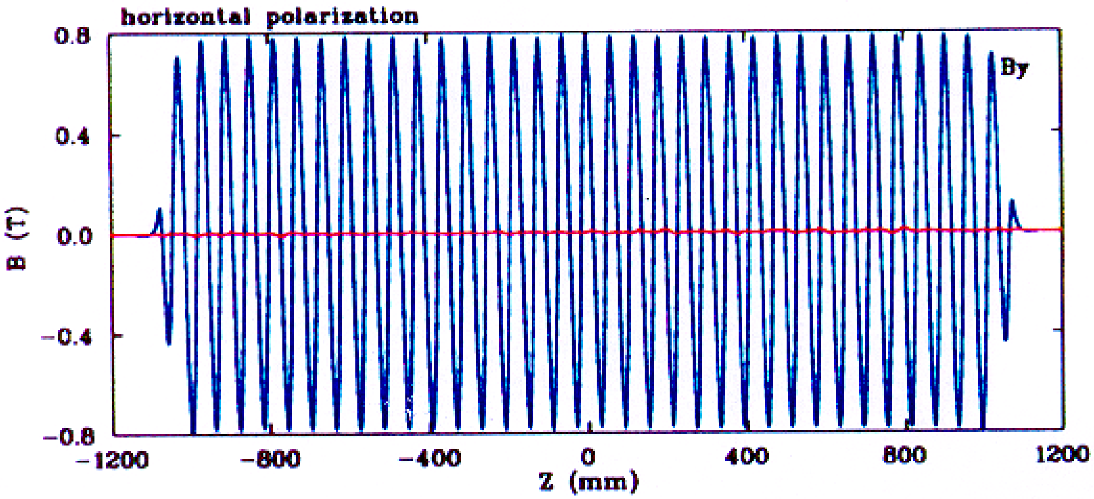
Simulated annealing algorithm optimizes for:

- rms optical phase error
- first and second field integral at x=0
- first and second field integral off-axis distribution



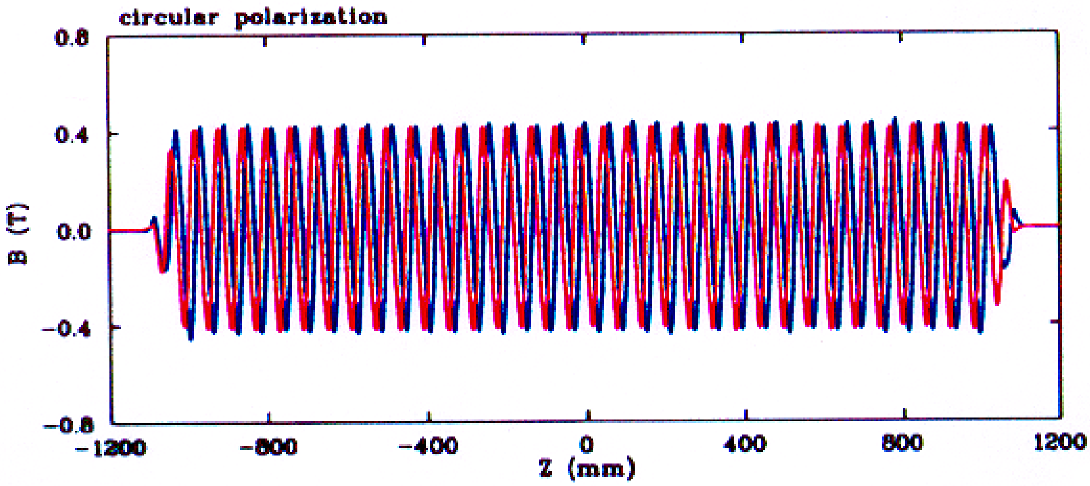
(SRRC PICTURE!)

Measured field at 19 mm gap in various polarization modes:



$\sigma_{By} = 0.3°$

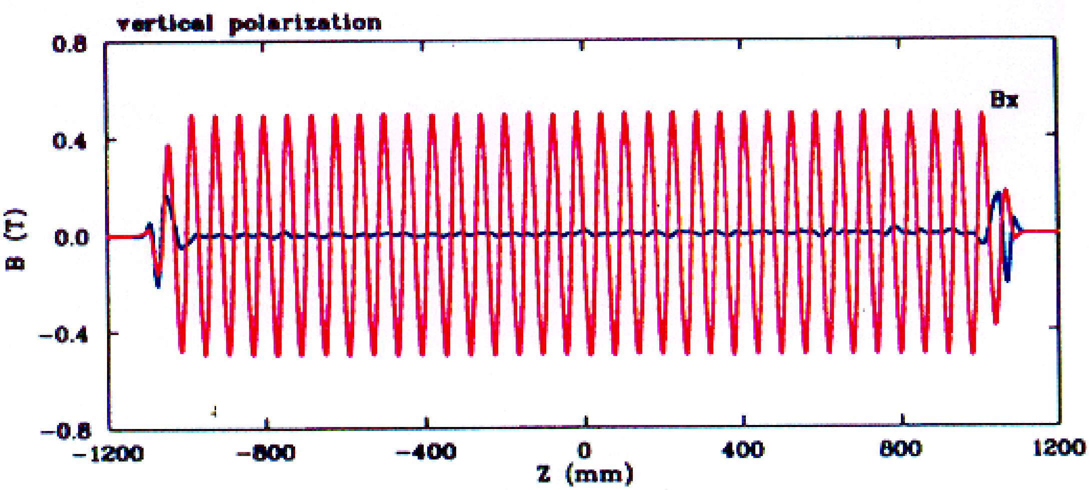
$\sigma_{\phi} = 5°$



$\sigma_{Bx} = 0.5°$

$\sigma_{By} = 1.1°$

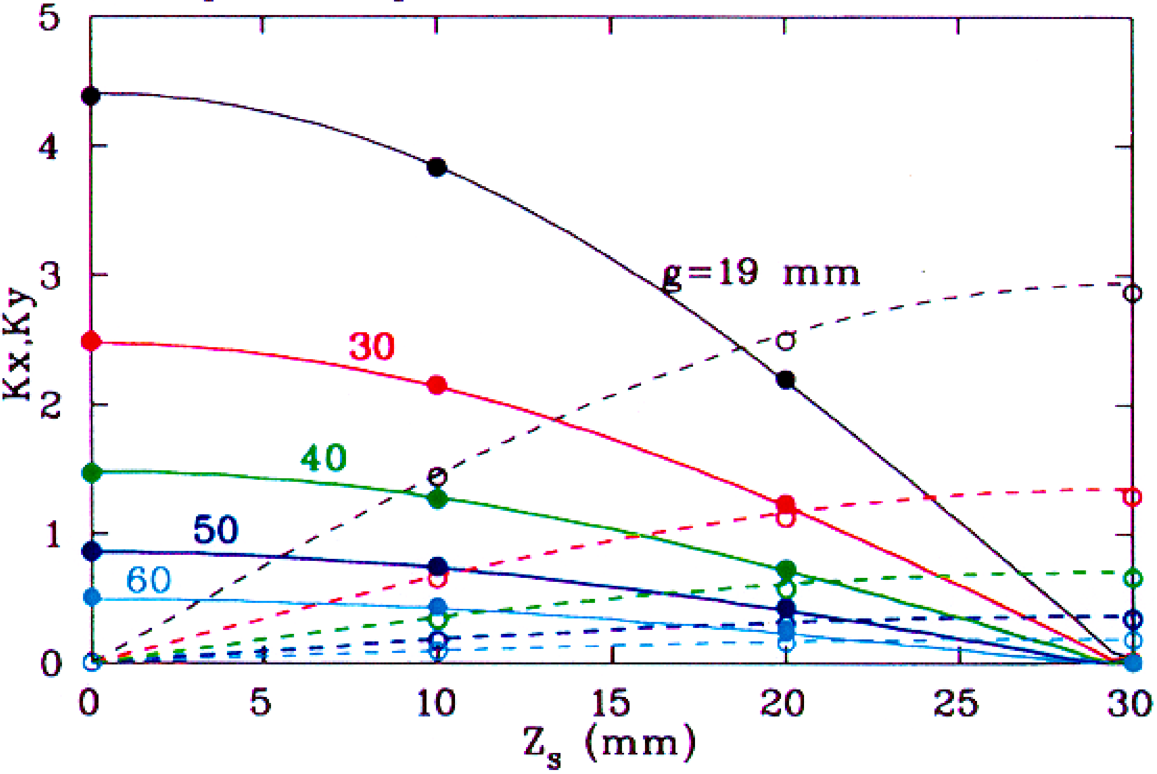
$\sigma_{\phi} = 10°$



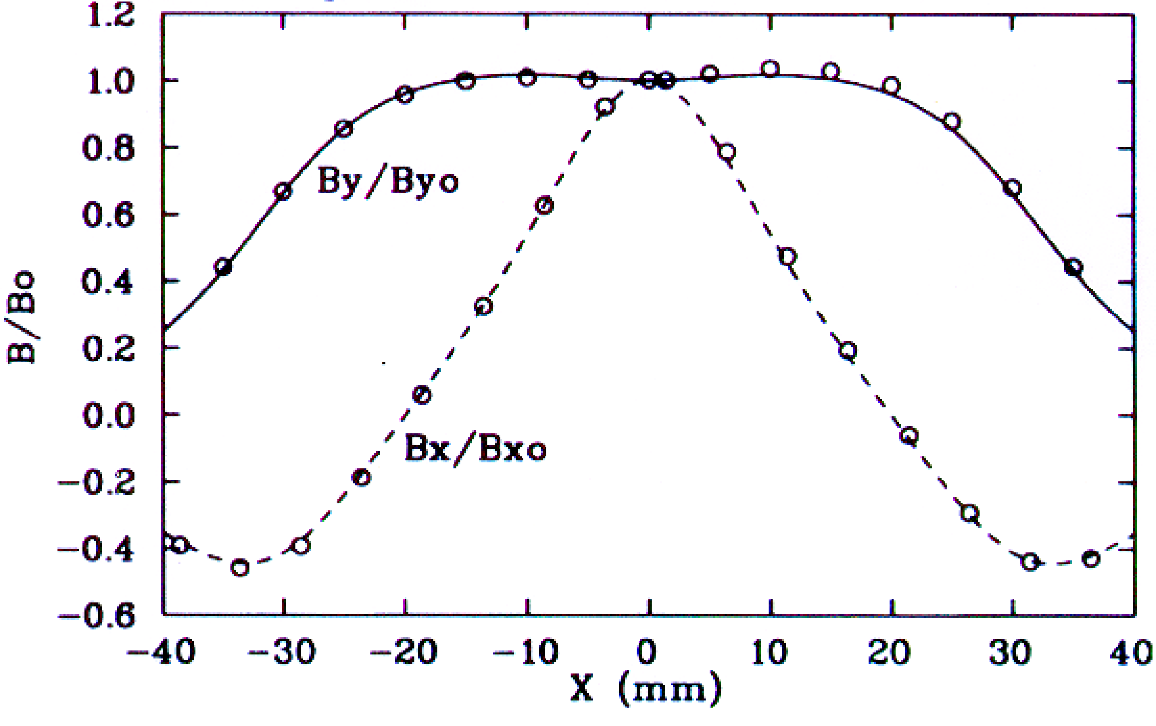
$\sigma_{Bx} = 0.4°$

$\sigma_{\phi} = 8°$

Measured/predicted peak field:



Transverse field profiles:



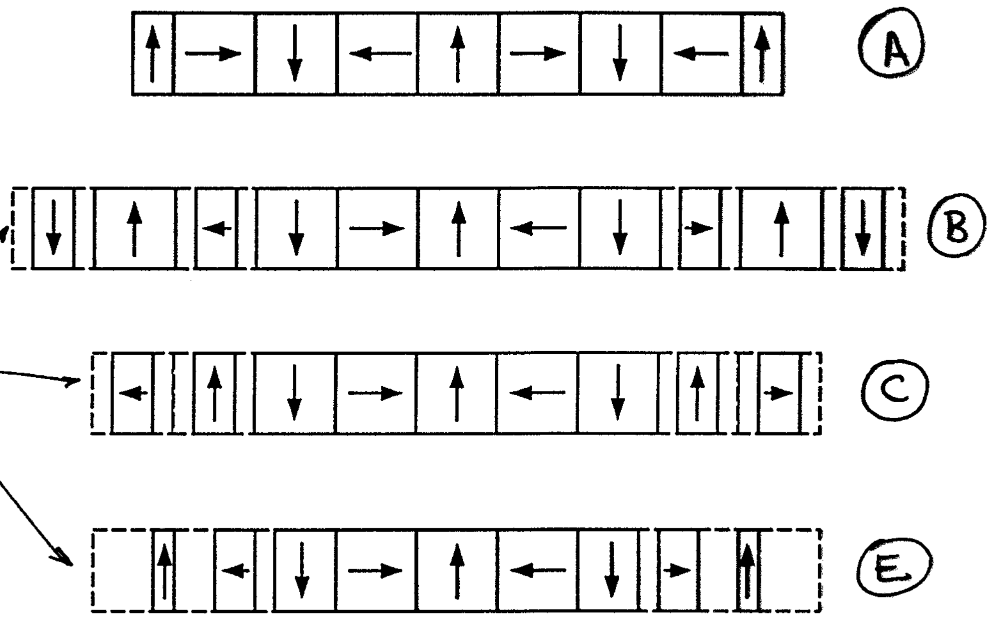
DESIGN OF TERMINATIONS FOR PPM UNDULATORS

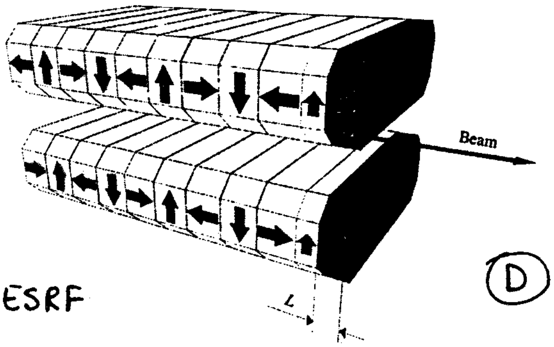
STANDARD

ELETTRA EPU6.0/12.5

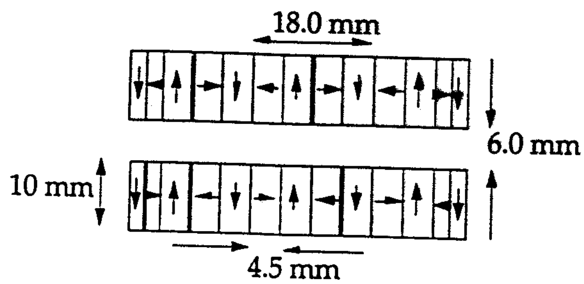
DISPLACEMENT FREE

SRRC EPU5.6 ?





ESRF



SLAC/BNL/LBL VISA UNDULATOR

NEARLY DISPLACEMENT FREE

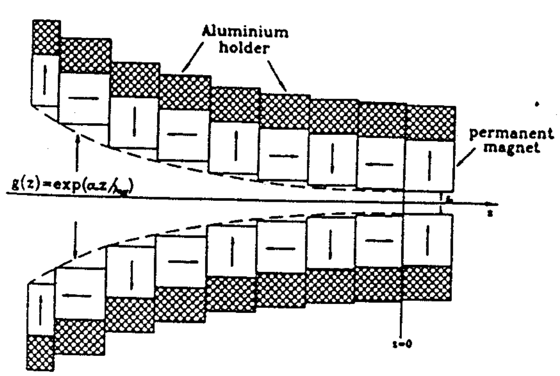
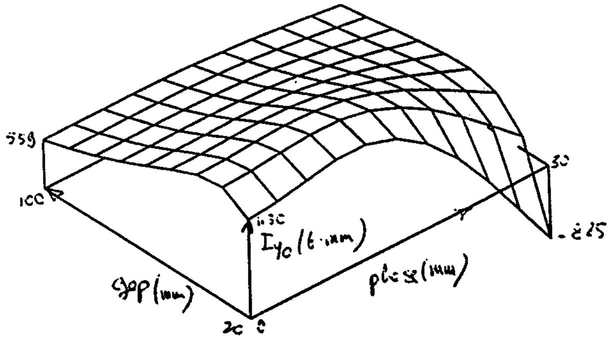


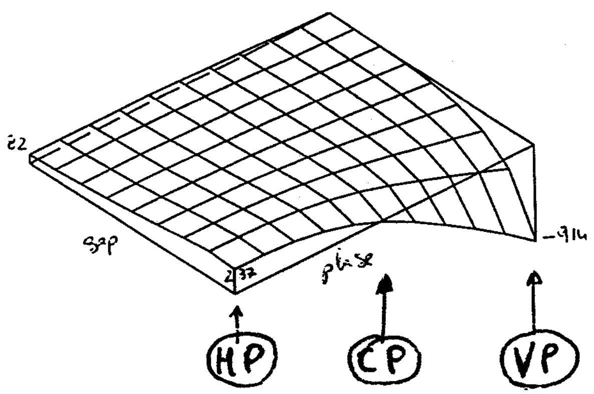
Fig. 2. Geometrical structure of an adiabatic end tapering.

LIVERPOOL UNIVERSITY FEM

$\mu \neq 1$ EFFECTS ($\mu_{\parallel} = 1.05$, $\mu_{\perp} = 1.15$) [EPU6.0]

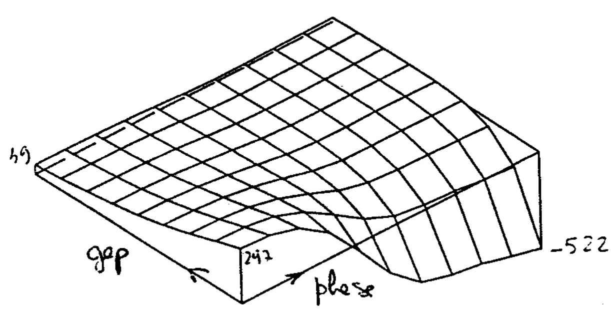


(A) STANDARD TERMINATION



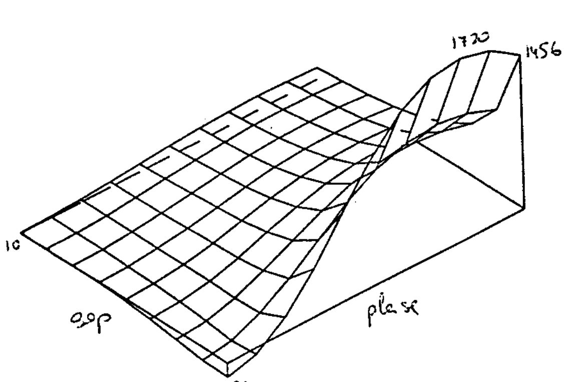
(B)

- Reduced ΔI_y (gap)
- Reduced ΔI_y (phase) (particularly between (HP) and (CP)



(C)

- Reduced ΔI_y (gap)
- "Fast" variation with phase

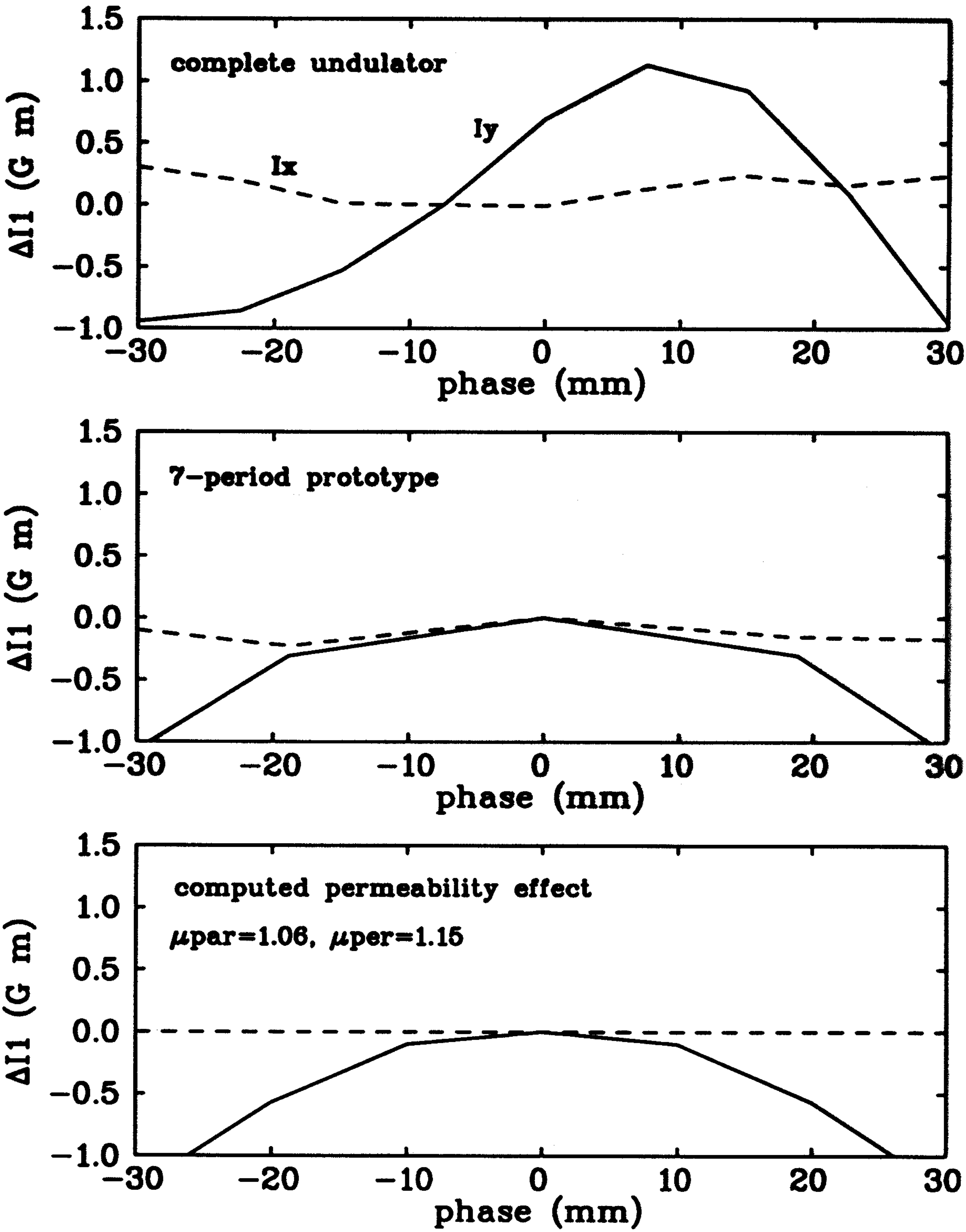


(D)

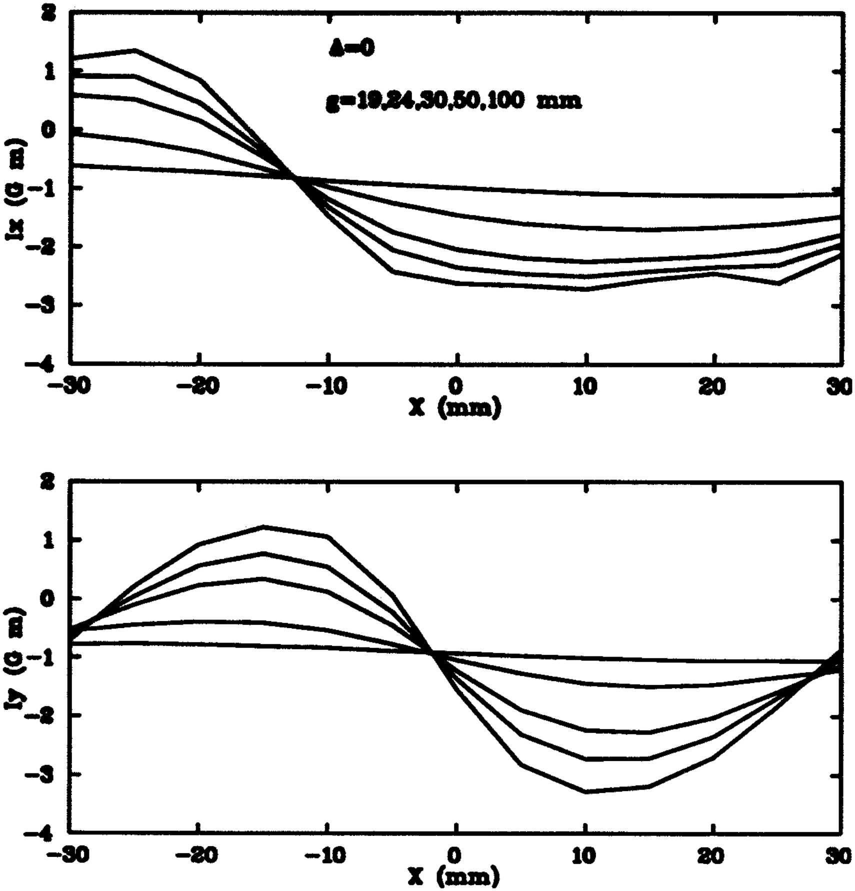
- Nearly zero ΔI_y (gap)
- Large and "fast" variation with the phase

ALSO TO CONSIDER :
- FRINGE FIELD AMPLITUDE
- RAMP-UP TO FULL FIELD

Variation of field integrals with the phase



Measured field integrals transverse distribution is dominated by a (~phase independent) quadrupole error (300 G):

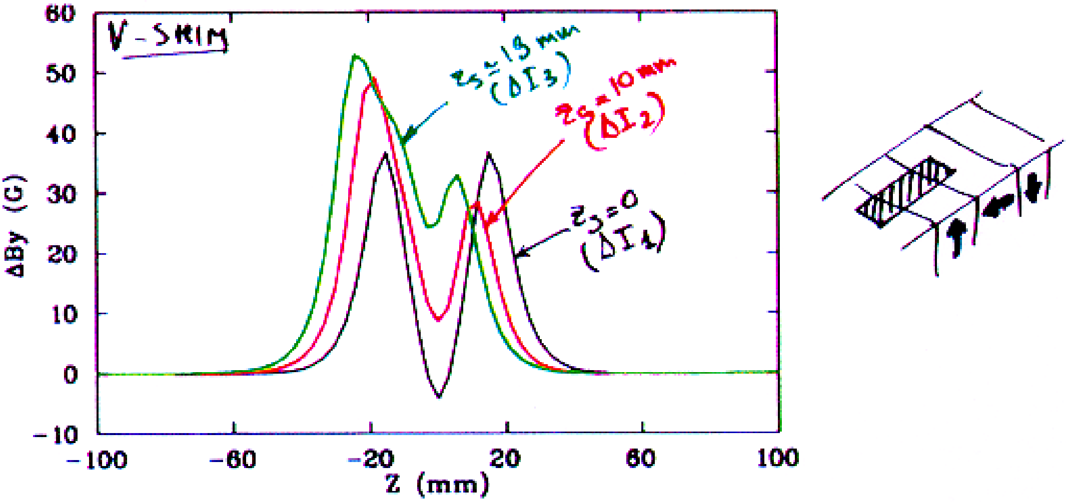


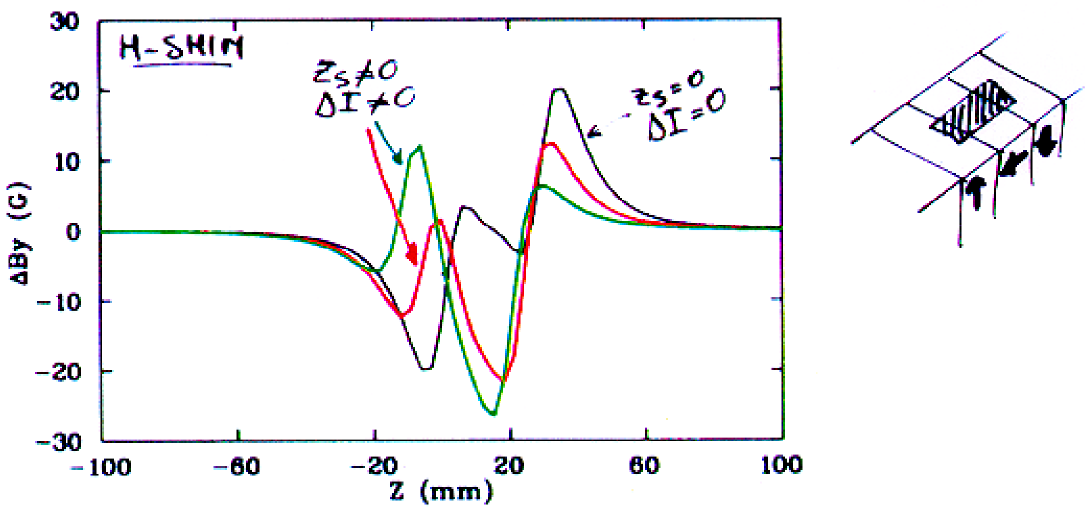
Shimming

Conventional shimming method is complicated by the strong dependence of the shimming effect on the phasing of the arrays.

Usual distinction between V-shim and H-shim is no more applicable in the variable polarization case.

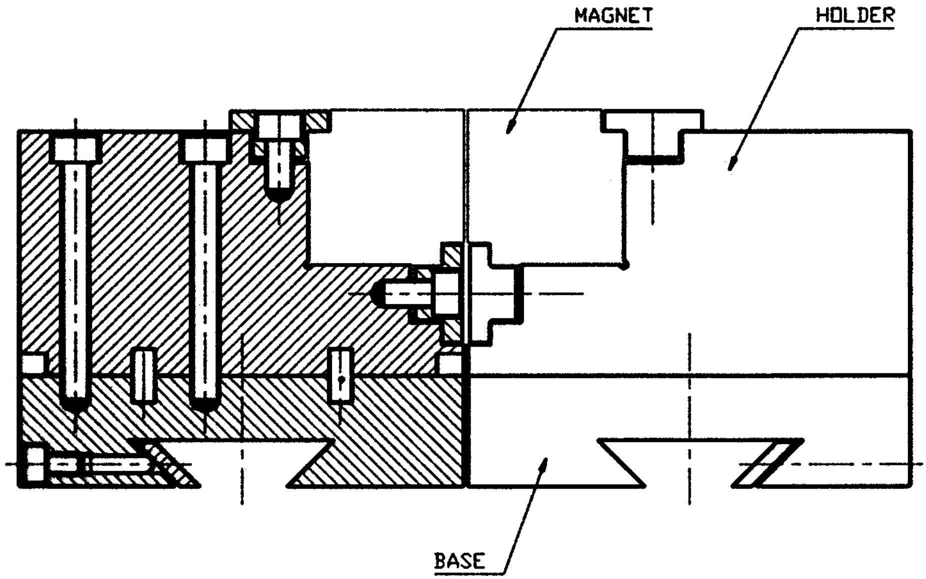
V-Shim and H-shim on-axis 'signatures' for linear, elliptical and circular polarization modes:

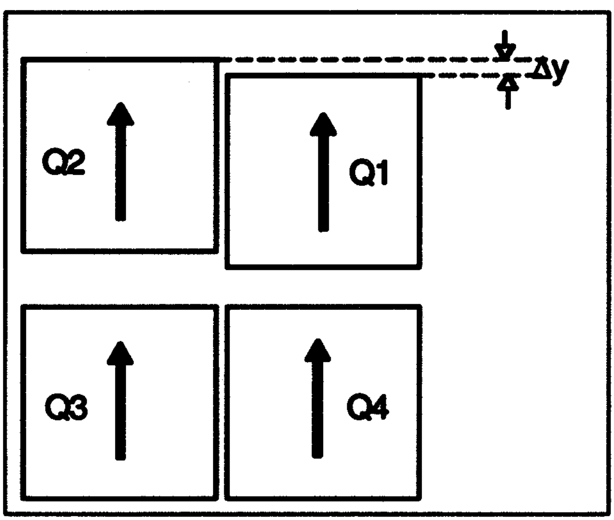




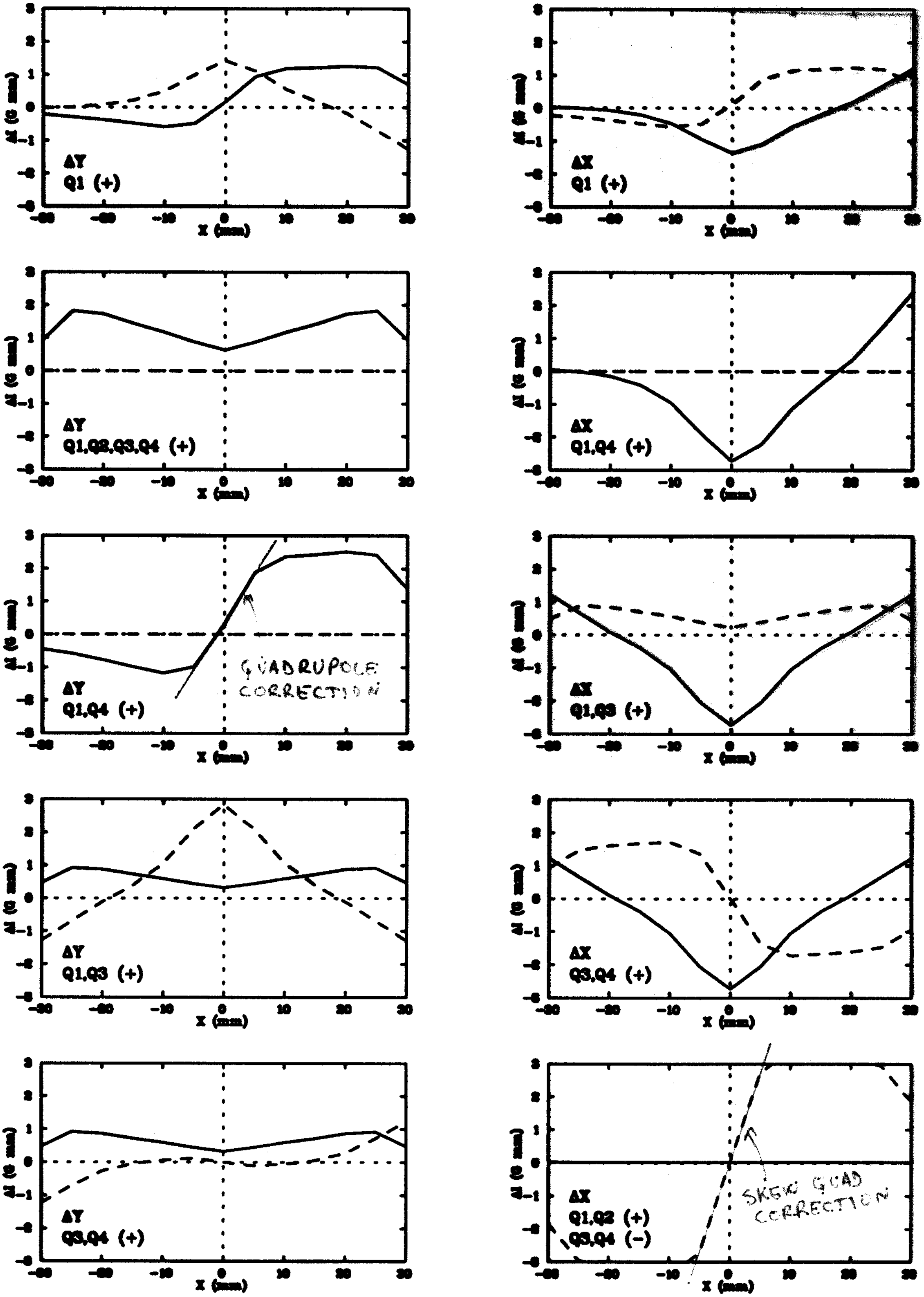
Multipole errrors correction by block displacement

- Only vertical displacements are allowed with the present block holder design

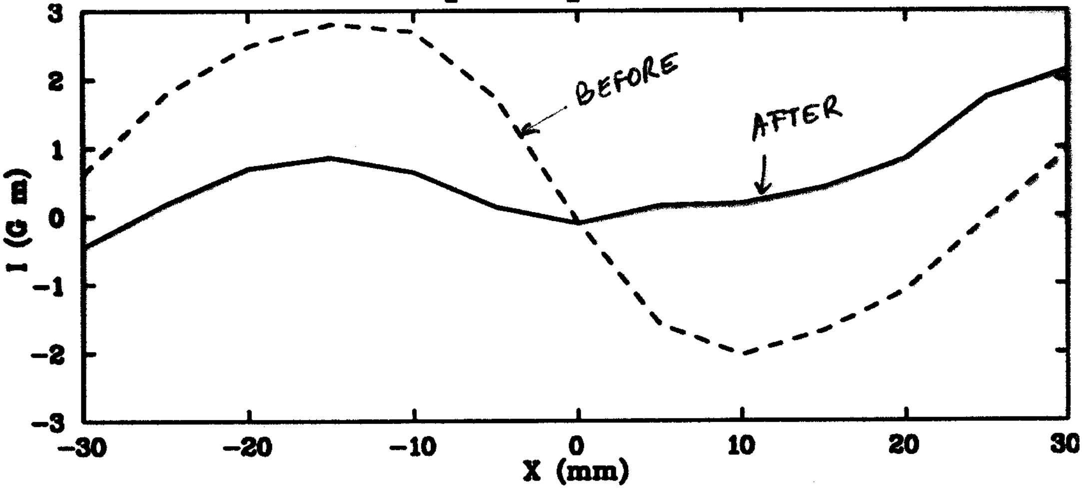




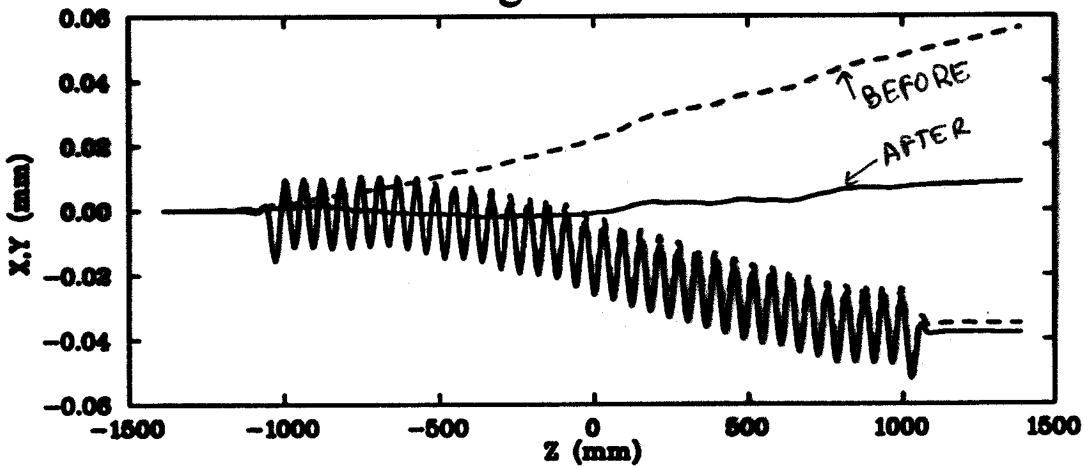
VERTICAL DISPLACEMENT (Δy) HORIZONTAL DISPLACEMENT (Δx)



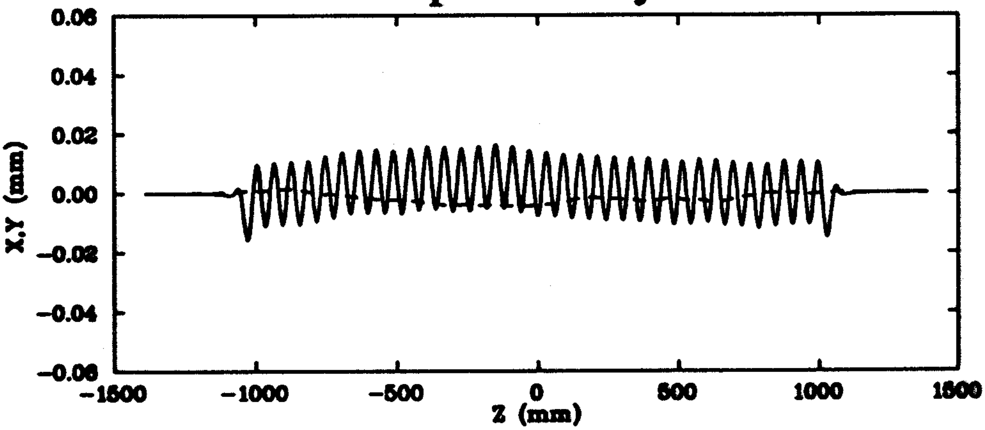
Correction of vertical quadrupole error...



...is achieved simultaneously with reduction of horizontal first and second field integrals



residual effect will be compensated by correction coils:

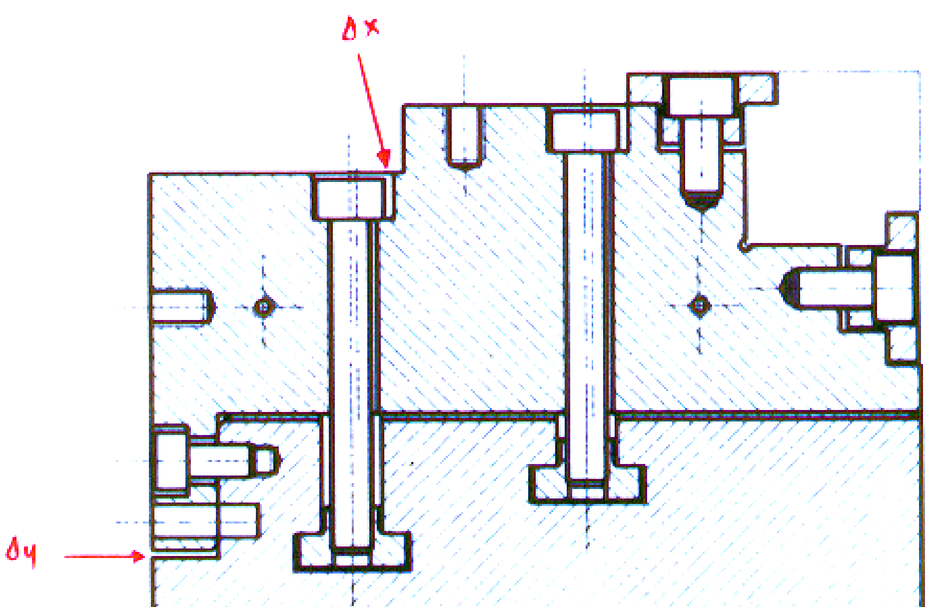


Measured skew and normal integrated quadrupole and sextupole errors after correction

gap (mm)	phase (mm)	Qx (G)	Sx (G/cm)	Qy (G)	Sy (G/cm)
19	-20	-129	-9	13	206
19	-10	-105	-40	-34	150
19	0	-61	-67	-15	90
19	10	-50	-71	43	57
19	20	-104	-47	76	139
30	0	-51	-14	-7	26
50	0	-33	13	1	-1

ERRORS BECOME SMALLER AT LARG GAPS. INHOMOGENEN

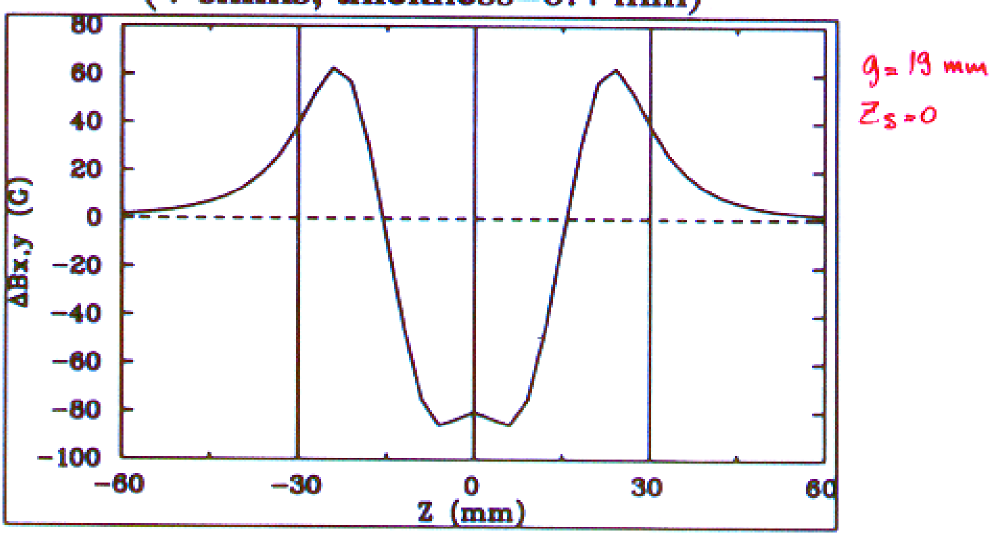
Improvements: new block holder allowing both horizontal and vertical displacement from the nominal position



Phase Shimming

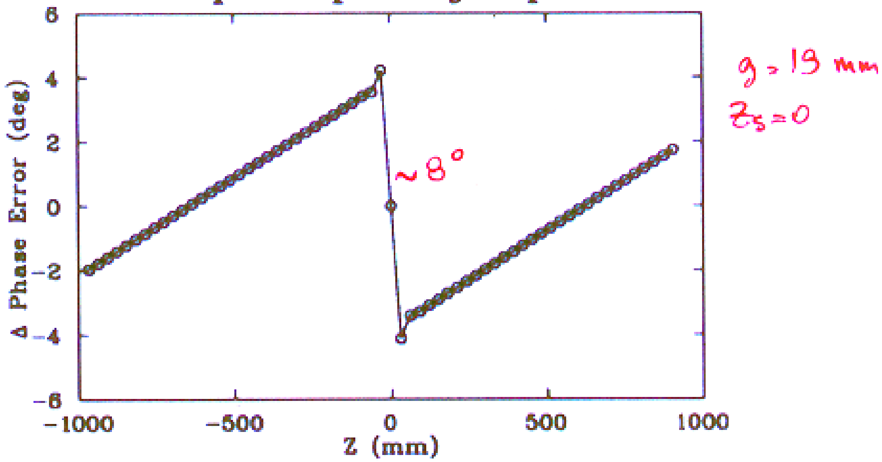
- Basic shimming unit consists of 2 or 4 shims placed on consecutive H-blocks

Computed field perturbation
(4-shims, thickness=0.4 mm)

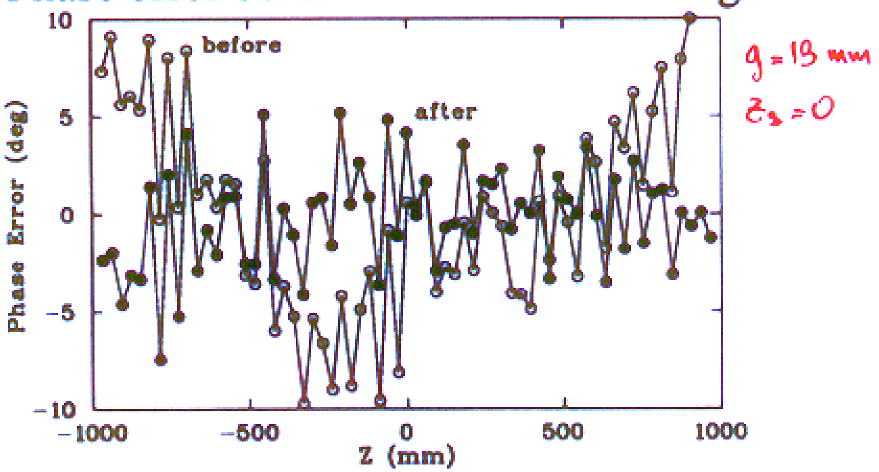


- The net effect on field integral is cancelled within the unit

Optical phase jump



Phase error before and after shimming



Rms phase error as a function of phase at 19 mm gap

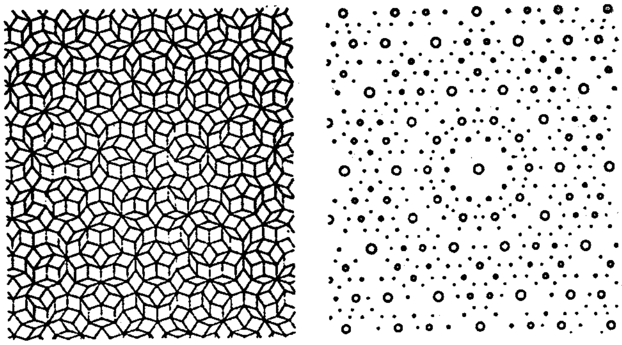
z_s (mm)	polarization mode	σ_Φ (°) before shimming	σ_Φ (°) after shimming
-20	circular	8.0	4.9
-10	elliptical	4.6	4.2
0	horizontal	4.5	2.3
10	elliptical	7.2	2.6
20	circular	10.0	4.8

Quasi periodic undulator

Diffraction from quasi-periodic cristals

⇓

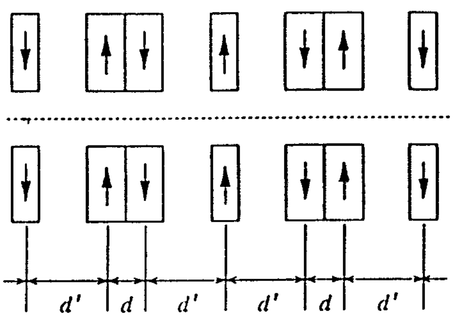
5/10-fold symmetry

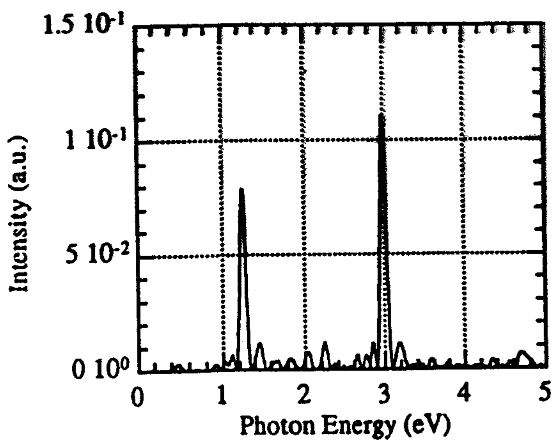


Quasi periodic sequence of pole separations

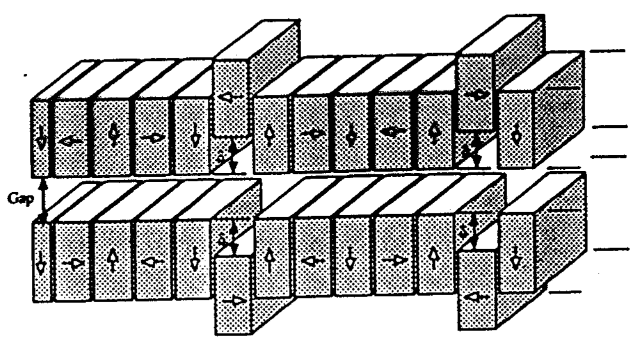
⇓

non-harmonic spectrum



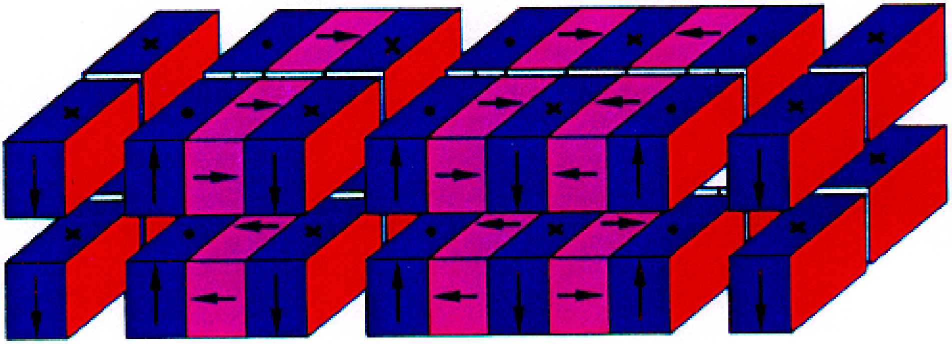


New concept: apply quasi-periodic sequence to field amplitude

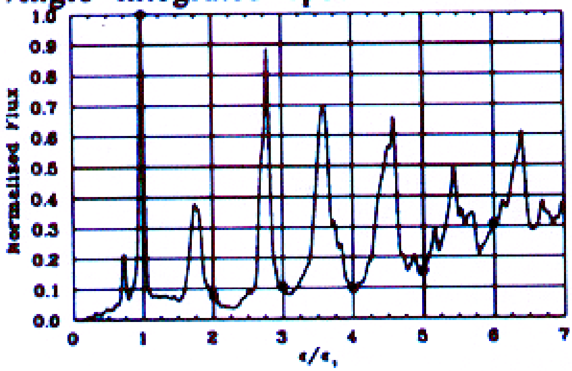


← INDEPENDENTLY PROPOSED AT ELETTRA AND ESRF

Quasi-periodic variable polarization undulator



Angle integrated spectrum in the linear ...



...and circular polarization mode