Plans for polarized light at SLS

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Swiss Light Source

Paul-Scherrer-Institut
PSI

ICFA 17th Advanced Beam Dynamics Workshop on

FUTURE LIGHT SOURCES

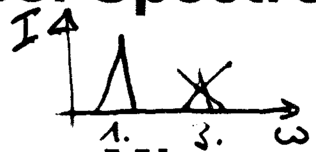
Argonne National Laboratory

April 6-9, 1999

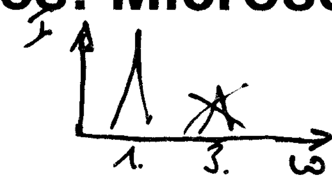
SLS Beamlines

10eV – 2keV

SIS: Surfaces / Interfaces: Spectroscopy
(L. Patthey)



SIM: Surfaces / Interfaces: Microscopy
(C. Quitmann)



5keV – 40keV

PX: Crystallography
(C. Schulze) High Brilliance

MS: Material Science
(B. Patterson) High Flux

Time available for ID construction:

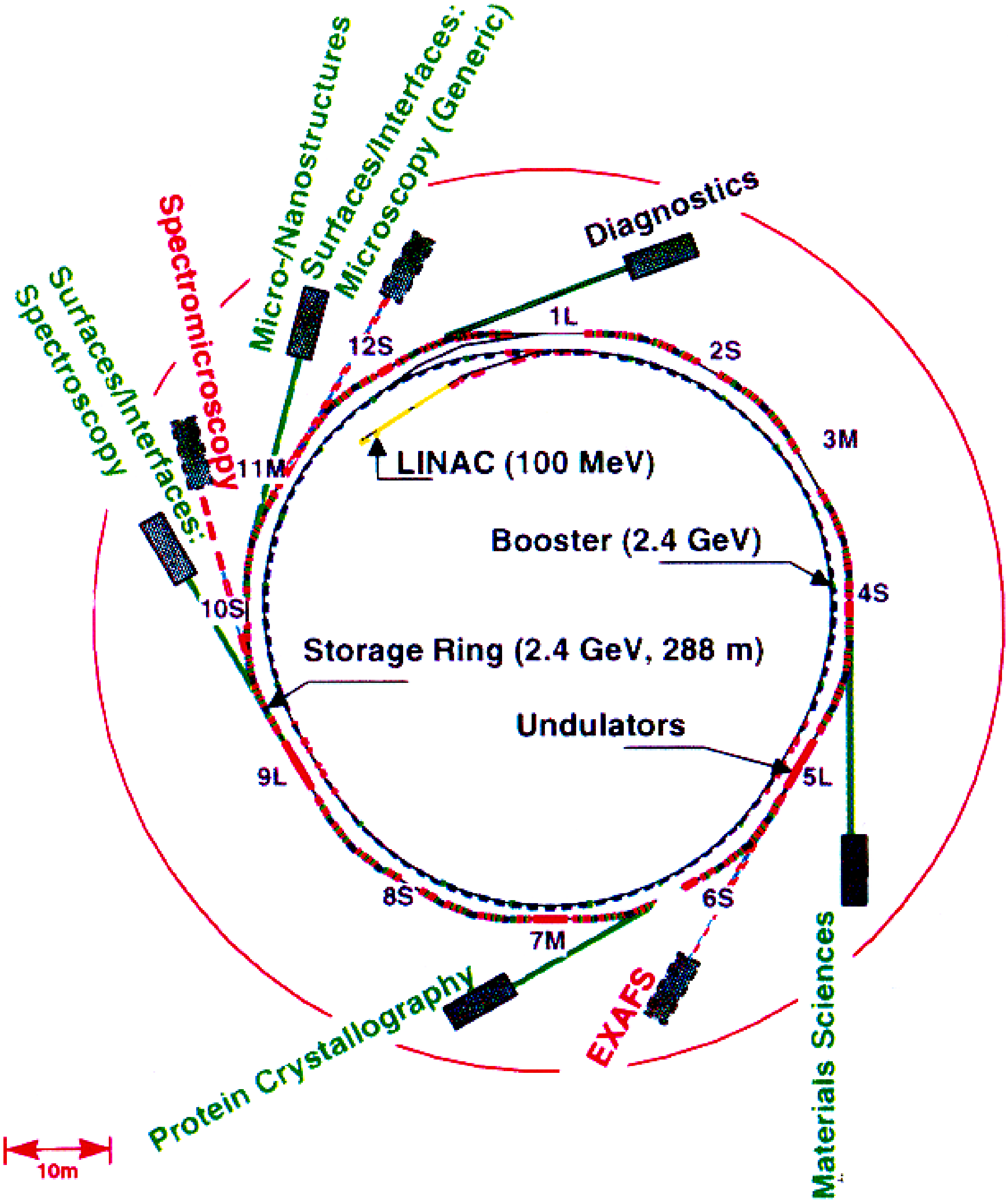
total 2.5 years

Start of 1st ID installation:

April 2001

PSI PAUL SCHERRER INSTITUT SLS

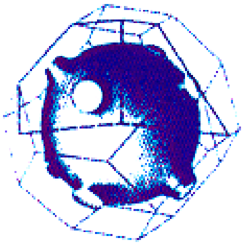
SLS Layout



The lines marked in green indicate the planned beamlines of the first generation from "insertion devices" like wigglers, wavelength shifters or undulators and from superconducting bending magnets. The lines marked in red indicate second phase beamlines.

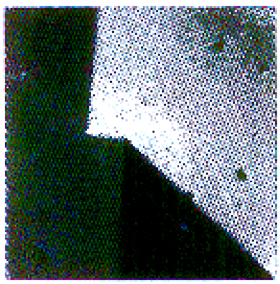
Insertion Devices dedicated to Experiments

Surface - Spectroscopy



10 eV
100 nm

Surface - Microscopy

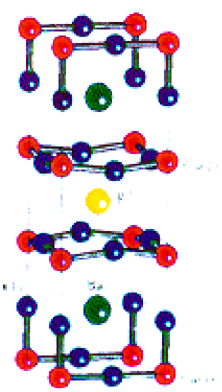


700 eV
2 nm

Protein - Crystallography

12 keV
1 Å

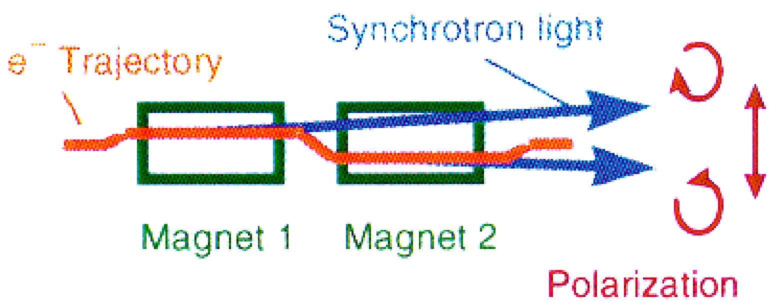
Materials Science



40 keV
0.3 Å

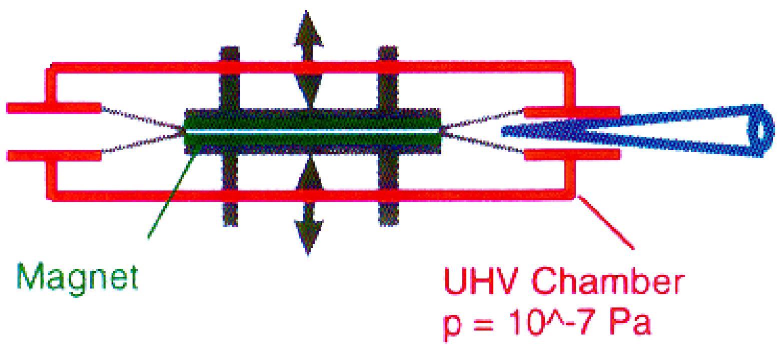
Linear and circular polarized light
Harmonic Suppression

Electromagnets

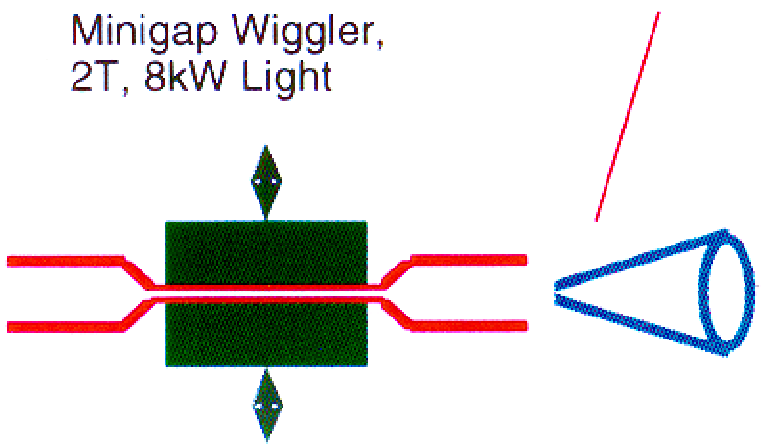


Permanent Magnets

In-Vacuum Undulator
2m long, 13th Harmonic



Minigap Wiggler,
2T, 8kW Light



Insertion Devices @ SLS

Name	UE212	UE56	U17	W60
Type	Electromagnet	Pure Permanent NdFeB	Hybrid SmCo	Hybrid NdFeB
Polarisation	eliptically	eliptically	linear	linear
Energy Range [eV]	10 - 600	95 - 2000	7k -7.5k	5k - 40k
Harmonics	1,3,5	1,3,5	3 - 13	wiggler
Period λ_u [mm]	212	56	17	60
Max. length L_u [m]	2 x 4.2	2 x 1.6	2	2
Number of periods	2 x 20	2 x 28	117	33
Min. gap g_{min} [mm]	18 (fixed)	15	4	7.5
B_{max} (verti./horiz.) [T]	0.4 / 0.1	0.83 / 0.4	1.0	1.9
K_{max} (verti./horiz.)	7.9 / 2.0	4.5 / 2.2	1.65	11
$\beta_{x,y}$ [m]	4.1 / 6.1	1.8 / 4.3	1.2 / 1.6	1.2 /1.6

Insertion Devices for Surface and Interface:

Spectroscopy

10 - 600 eV
Electromagnet

electronic structure,
core level and valence electrons
of surface and interace atoms

Physics:
Fermi - Mapping
Angle resolved Photoemission
XPD
X-ray Photoelectron Diffraction

high energy resolution
high angular resolution

Microscopy

90 - 1500 eV
Permanent

spatial structure,
core levels and shifts
to be element specific

PEEM, PEESM
Photoemission Electron (Spectro) Microscopy
MCD
Magnetic Circular Dichroismn

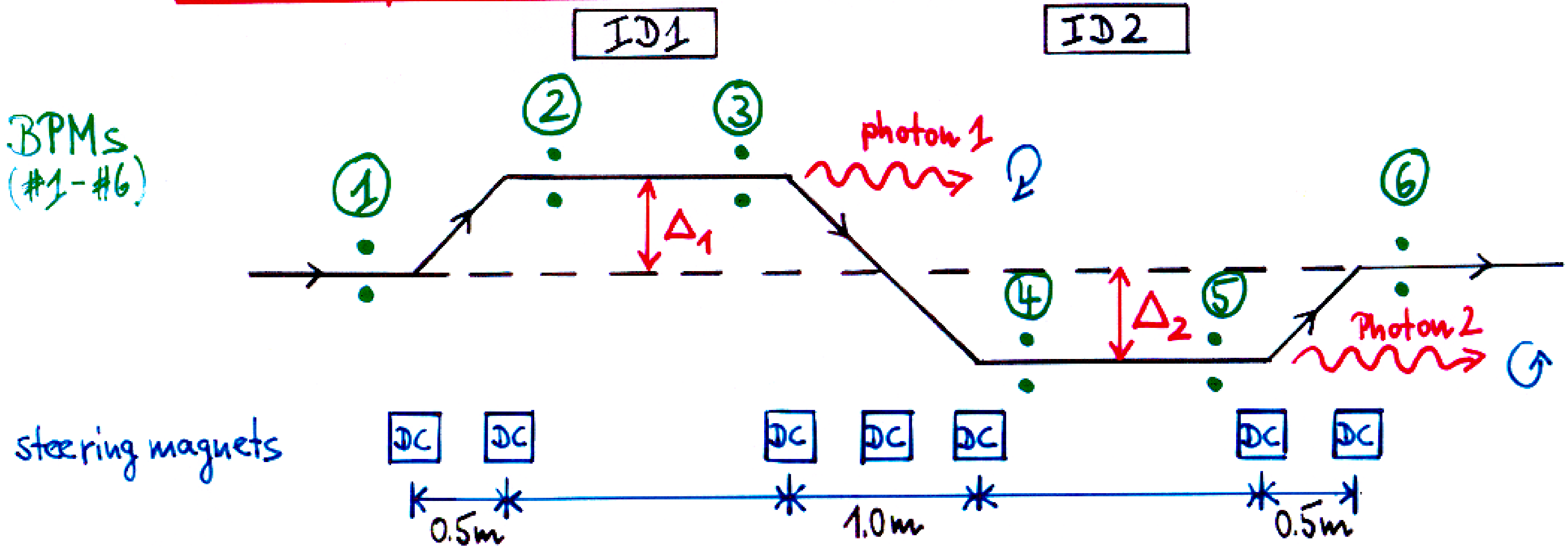
focused spot
spatial resolution comes from the detector

High Brilliance Undulators

Polarisation: Linear
Circular
switchable between left and right hand

Problem: Harmonics

Chicane for SIS and SIM beamlines at SLS



SIS-beamline		4.2 m				4.2 m	
SIM-beamline		1.6 m				1.6 m	

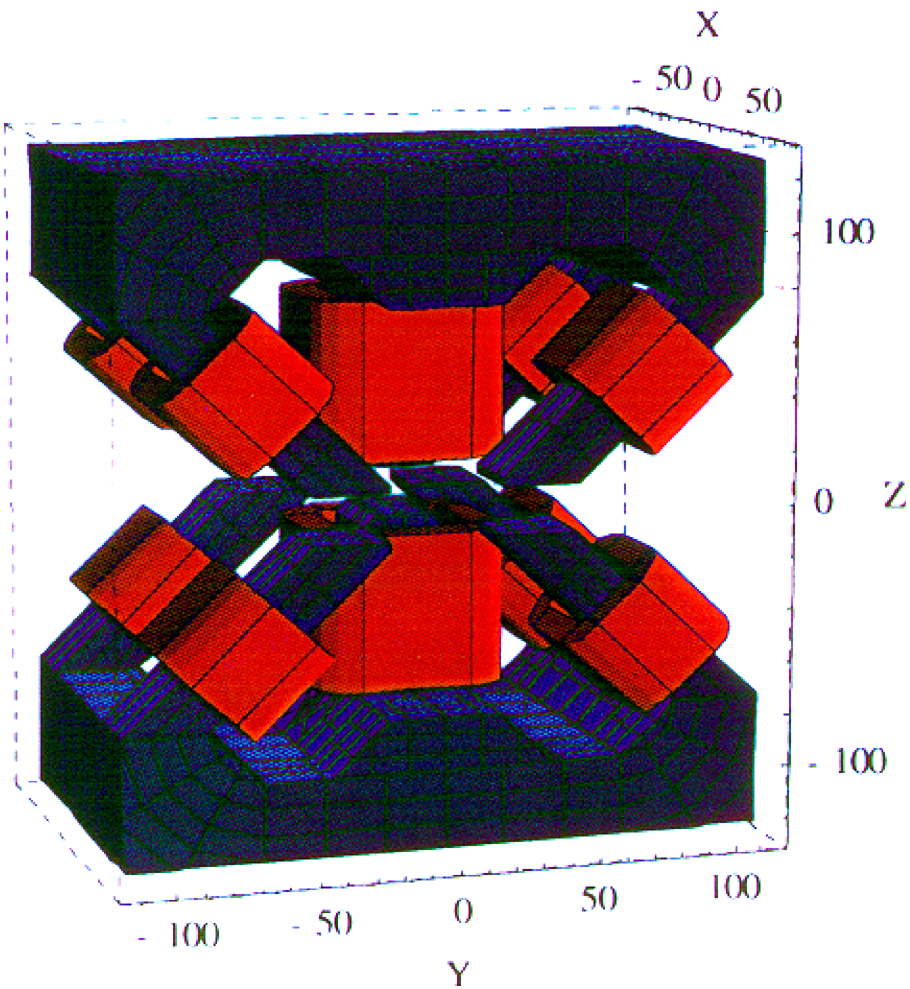
chicane mode	+1	-1	-1	0	+1	+1	-1
modulator mode (phase matching)	0	0	-1	+2	-1	0	0

beam displacement : $D = \Delta_1 + \Delta_2$, $\Delta_1 = \Delta_2 = 0.75\,mm$

1) BPMs : Analog System (for IDs ⊕ Interlock) ; position resolution ~ 1 μm
2) steering magnets : C - shape ; $\theta_{max} = 3\,mrad$ ($L = 0.15\,m$, $B = 0.16\,T$)

SIS - beamline

Electromagnetic Elliptical Undulator



period	212mm
gap	18mm
length	2 x 4.24m
number of periods	2 x 20
vertical field	0.4 T
hor. field	0.13 T
K - values	7.8 / 2.5
fundamental	10 eV / 20 eV
emitted power	2 kW
current vert.	125 A
current hor.	300 A

Design by ELETTRA

Presented at the
1997 Particle Accelerator Conference

DESIGN OF AN ELECTROMAGNETIC ELLIPTICAL WIGGLER FOR ELETTRA

R.P. Walker, D. Bulfone, B. Diviacco, W. Jark, P. Michelini, L. Tosi and R. Visintini, Sincrotrone Trieste, Italy
G. Ingold, F. Schäfers, M. Scheer and G. Wüstefeld, BESSY, Berlin
M. Eriksson and S. Werin, MAX-lab, Sweden

Abstract

The main aspects of the design of the electromagnetic elliptical wiggler under construction for ELETTRA are summarized.

1 INTRODUCTION

An electromagnetic elliptical wiggler (EEW) was first proposed for ELETTRA in 1991 as a source of circularly polarized VUV/Soft X-ray radiation with variable helicity [1,2], but due to funding limitations was not able to be constructed at that time. The present project commenced in February 1996 with partial European Commission funding as a collaboration between Sincrotrone Trieste, BESSY and MAX-lab. The project also includes the construction of a soft X-ray polarimeter which will be used to make a complete analysis of the polarization properties of the source in the 30-1000 eV range.

The detailed mechanical design and construction of the EEW is presently being carried out by Danfysik A/S, Denmark. The power supplies are under construction by OCEM SpA, Italy, while the control system and dynamic correction system are being developed at Sincrotrone Trieste. Following a period of magnetic testing at Trieste in September/October the device will be installed in ELETTRA and commissioning will start in November.

2 MAIN DESIGN PARAMETERS

Period	212 mm
No. vertical poles	32
No. horizontal poles	31
Length	3.332 m
Gap	18 mm
Max. vertical field	0.5 T
Max. horizontal field	0.1 T

The original parameters of the device were 12 periods of 230 mm with maximum vertical and horizontal field of 0.6 T (K_y=13) and 0.046 T (K_x=1) respectively. A review of these parameters was firstly carried out in order to optimize performance in the 5-1500 eV range, using both undulator and wiggler modes of operation, but within the constraints imposed by the existing beamline design [3] of not increasing significantly either the radiation power or the vertical source size. A better optimum proved to be with a reduced period length and an increased number of poles, with a reduced vertical field strength of 0.5 T. The maximum vertical deflection angle was also increased to $\pm 1.5/\gamma$ in order to provide more circularly polarized flux at low photon energies in the wiggler mode. The final parameters are listed in the table above.

The vertical field component will be powered with d.c., but three different operating modes are required for the horizontal field : d.c., trapezoidal from 0.1-1 Hz and sinusoidal from 10-100 Hz, to enable different types of data acquisition methods to be used in order to maximize the dichroism signal detection.

3 MAGNETIC DESIGN

The initial concept of the EEW was a combination of a vertical permanent magnet to generate a wiggler field and a horizontal electromagnet in order to provide the possibility of switching the helicity of the radiation. A new requirement however was the need to operate also in the undulator mode, requiring low vertical field strengths and therefore a large vertical gap. In order to avoid potential problems with field quality under these conditions, it was decided to investigate solutions involving two electromagnets. A scheme proposed by E. Gluskin of the APS was first studied which uses 3-poles to generate the horizontal field and therefore has the advantage that it is open on one side of the device [4]. It was found however that the asymmetric structure leads to small field gradients on the beam axis which might have unwanted beam dynamics effects in lower energy machines. From this we then developed the idea of a symmetric planar structure which is open on both sides of the median plane, as shown in fig. 1.

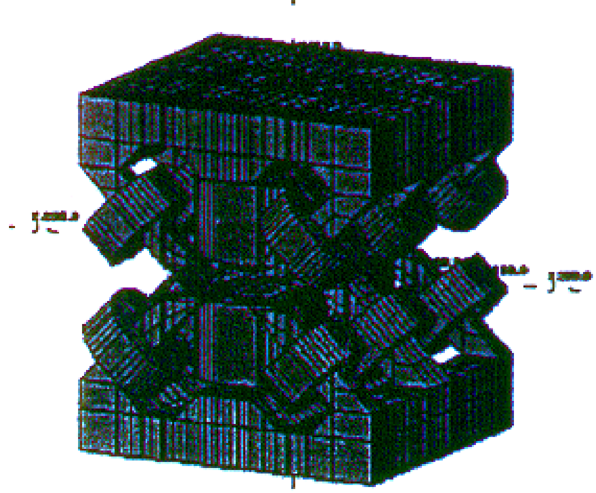
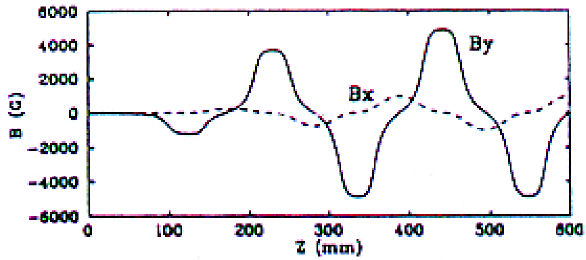


Figure 1. One-period model of the EEW for 3D field calculations.

Modelling the end-termination required extensive cpu-time. Both terminations with an outer vertical pole and outer horizontal pole were calculated. The latter has the advantage that the 3/4 vertical poles receive an equal deflection angle to that of the central poles, however it was found that the horizontal field integral was much larger in this case. The alternative arrangement was therefore selected, which results in only about 5 % less flux in the wiggler mode. Figure 3 shows the final computed field distribution and trajectory in the entrance region. It can be seen that the trajectory is well compensated with the oscillation axis coincident with the magnetic axis.



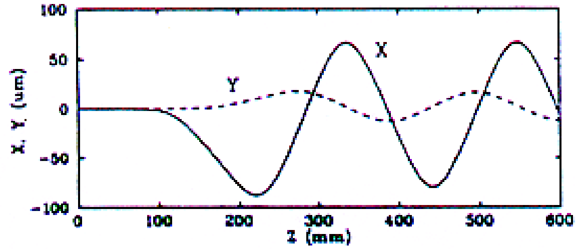


Figure 3. Field distributions (upper) and electron trajectory (lower) in the entrance region of the EEW.

Various pole profiles giving different transverse field distributions were studied and their effect on the beam dynamics properties investigated [6]. Despite earlier indications to the contrary, the pole profile was not found to have a significant influence on the dynamic aperture and so of the solutions investigated the ones giving the best magnetic performance, i.e. minimum field levels in the steel, were chosen.

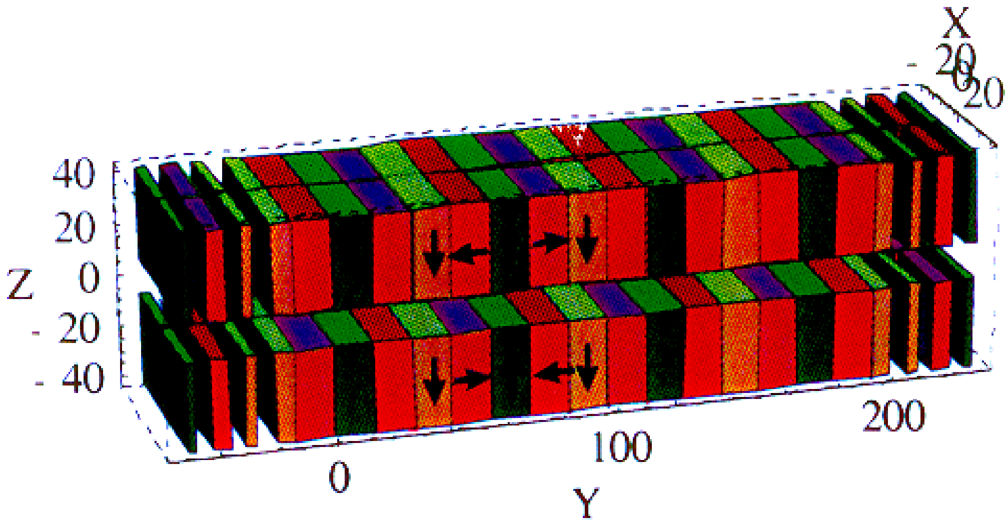
REFERENCES

[1] C. Poloni et al., Proc. 1991 Particle Accelerator Conference, IEEE Catalog No. 91CH3038-7, p. 2712
[2] R.P. Walker and B. Diviacco, Rev. Sci. Instr. 63 (1992) 332.
[3] A. Derossi et al., Rev. Sci. Instr. 66 (1995) 1718.
[4] E. Gluskin, Proc. 10th ICFA Beam Dynamics Panel Workshop, 4th Generation Light Sources, ESRF, Grenoble, Jan. 1996, p. WG1-56.
[5] Opera-3D, Vector Fields Ltd., Oxford, England.
[6] L. Tosi et al., these Proceedings.

SIM - Apple Undulator

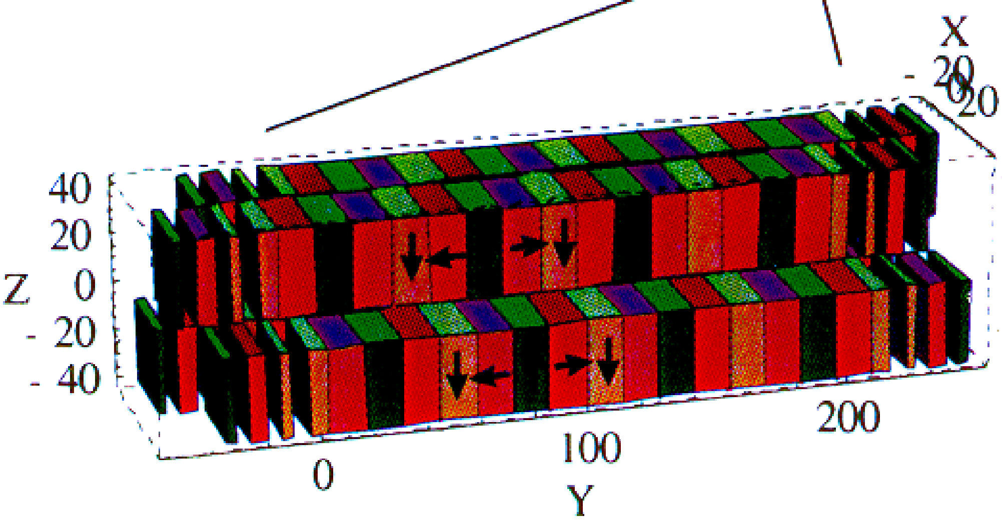
Lu = 56 mm, L = 2 x 1.6 m
Gap = 15 mm
B = 0.85 T (NdFeB, 1.22 T)

Linear Mode

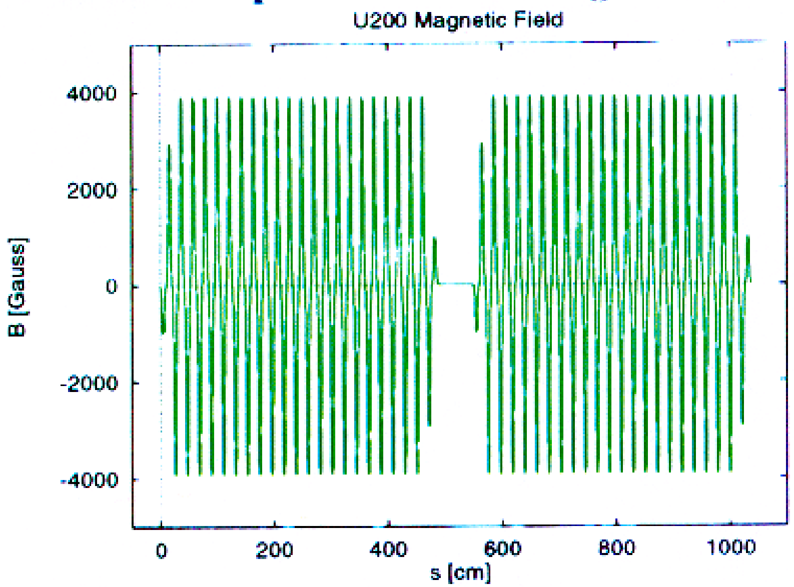


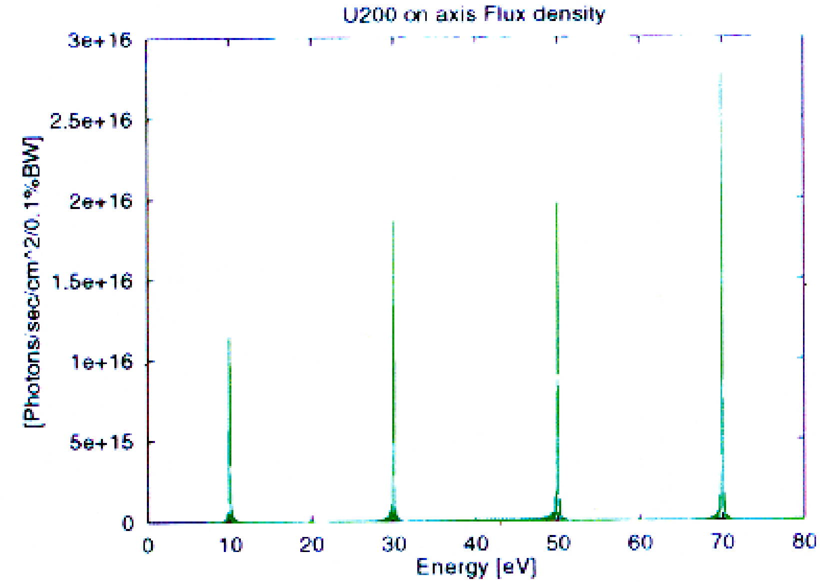
Displacement - free
entrance sections

Circular Mode

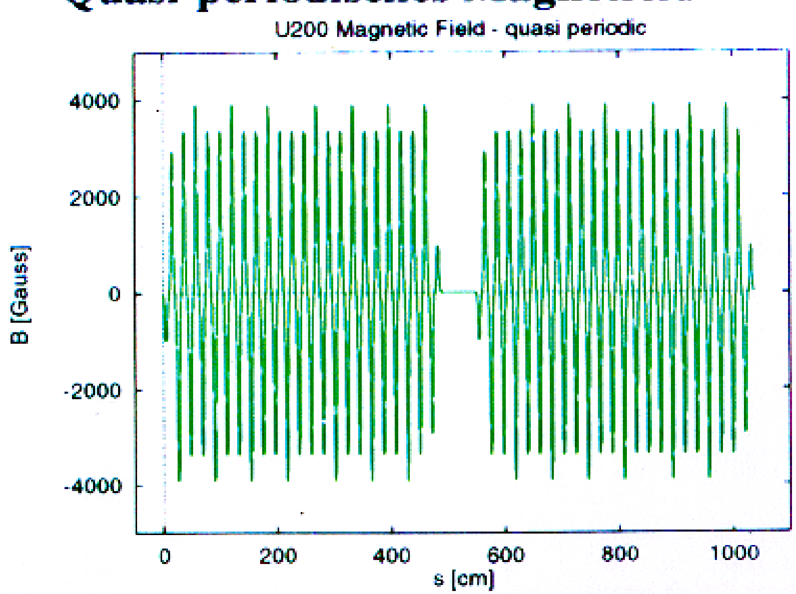


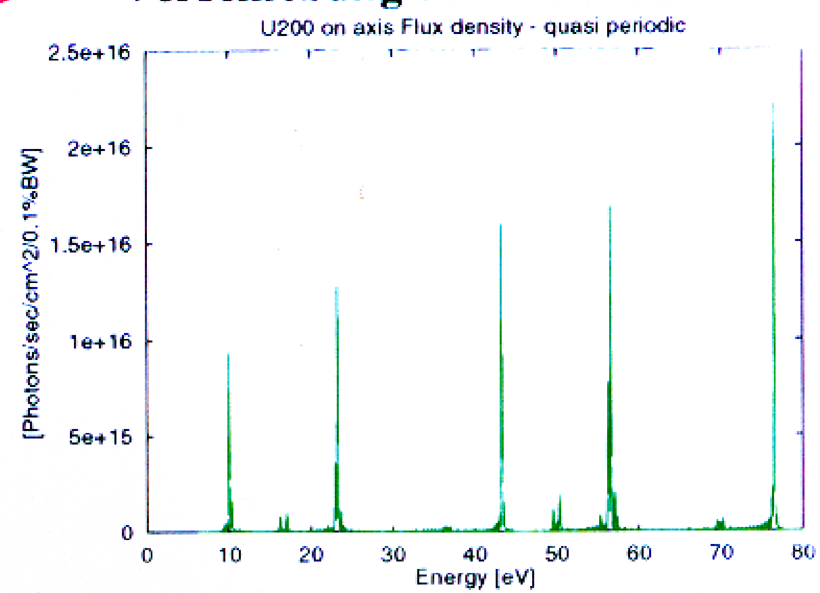
"Normales" periodisches Magnetfeld → rationale Harmonische



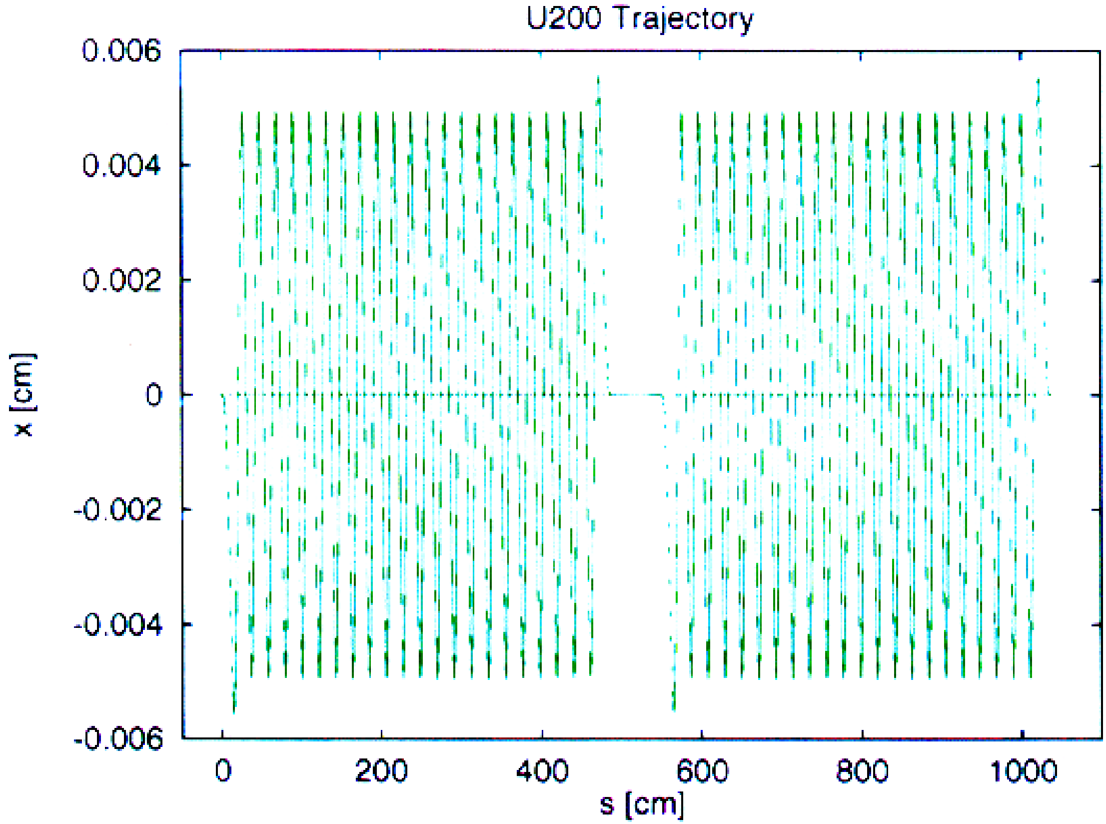


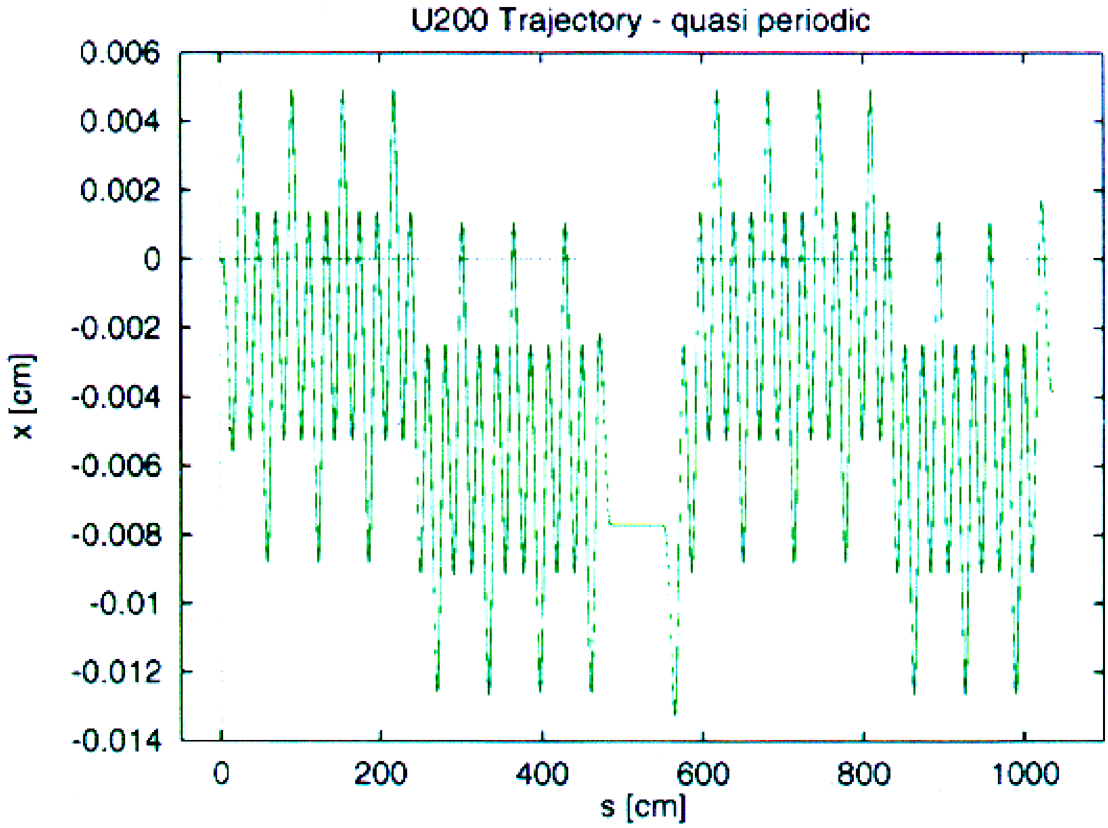
Quasi-periodisches Magnetfeld → Verschiebung der Harmonischen

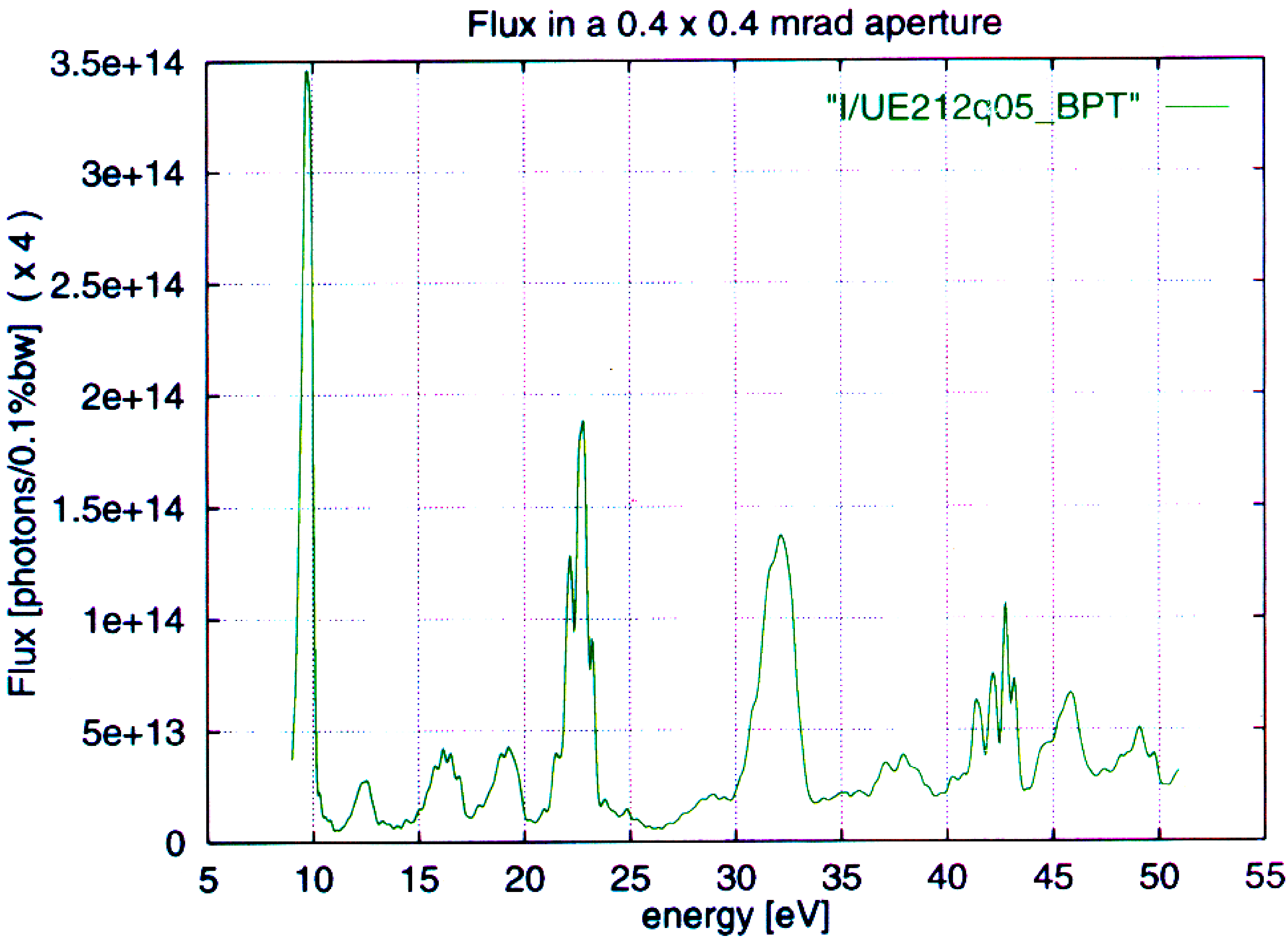




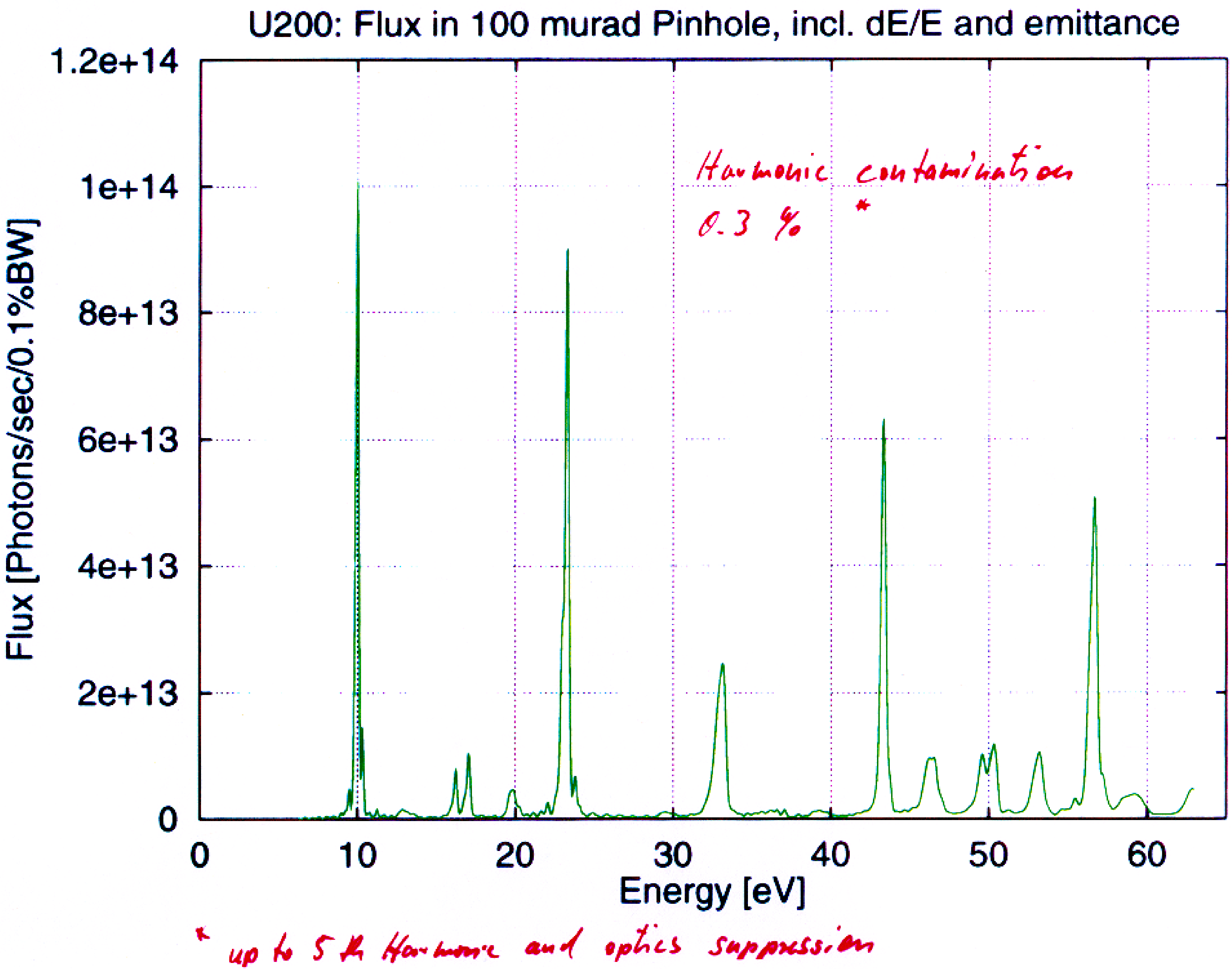
U200: Trajectory







Flux in a 0.4 x 0.4 mrad aperture
"I/UE212q05_BPT"
Flux [photons/0.1%bw] (x 4)
energy [eV]
3.5e+14
3e+14
2.5e+14
2e+14
1.5e+14
1e+14
5e+13
0
5
10
15
20
25
30
35
40
45
50
55



U200: Flux in 100 murad Pinhole, incl. dE/E and emittance
Harmonic contamination
0.3 % *
Flux [Photons/sec/0.1%BW]
1.2e+14
1e+14
8e+13
6e+13
4e+13
2e+13
0
0
10
20
30
40
50
60
Energy [eV]
* up to 5th Harmonic and optics suppression

spin ⊕ angle resolved photoemission experiments in ferromagnetic-to-paramagnetic phase transition ⟹ polarised light, helicity switching

Photoemission above the Fermi Level: The Top of the Minority *d* Band in Nickel

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(Received 2 July 1997)

clean ⊕ highly intensive photon source must provide low background intensities above the Fermi level E_F → Harmonic suppression, (quasiperd. undulator)

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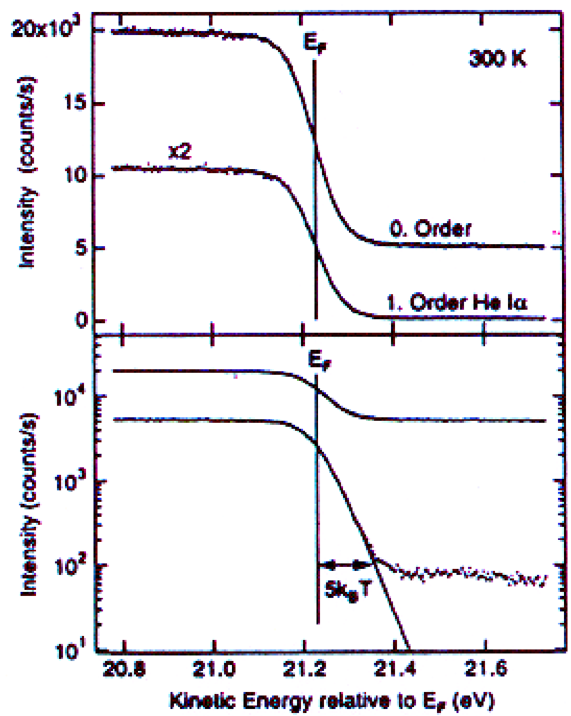


FIG. 1. Photoemission spectra taken near the Fermi level from polycrystalline Ag at 300 K. The analyzer energy resolution was 35 meV, and unmonochromatized (zero order) and monochromatized (1st order) He $I\alpha$ radiation was used for excitation. In the lower panel a logarithmic intensity scale has been chosen for the same data.

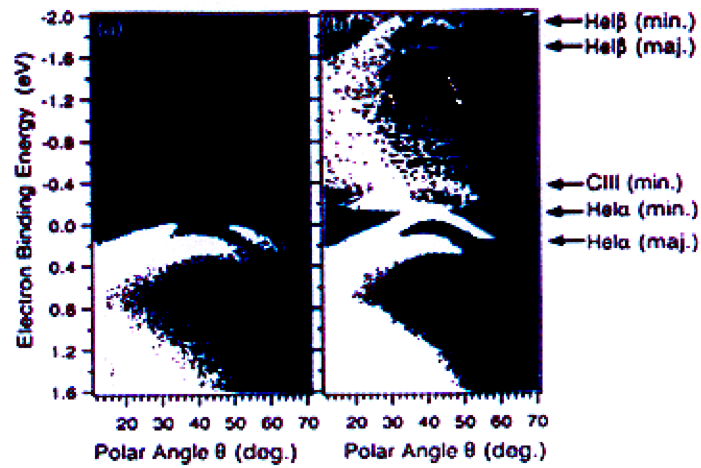


FIG. 2. Angle-scanned EDCs from Ni(111) measured with He $I\alpha$ radiation. In (a) the raw data are shown, while in (b) the data have been normalized for maximal angular contrast. The linear gray scale ranges from black at minimum intensity to white at maximum intensity.

SIS - beamline | SLS

polarisation

linear polarised mode : lm
circular " " : cm

energy

periodic mode : pm
quasiperiodic " : qm

	lm	cm
pm	(x)	x
qm	x	

@ 10 eV

1) qm ⊕ lm (horiz.)
2) pm ⊕ cm ($P_c \simeq 50\%$)

@ 50-250 eV

1) qm ⊕ lm (horiz.)
2) pm ⊕ cm ($P_c = 100\%$)
[3) qm ⊕ lm (vert.)] (in future)

@ 500 eV
(3. Harm.,
5. Harm.)

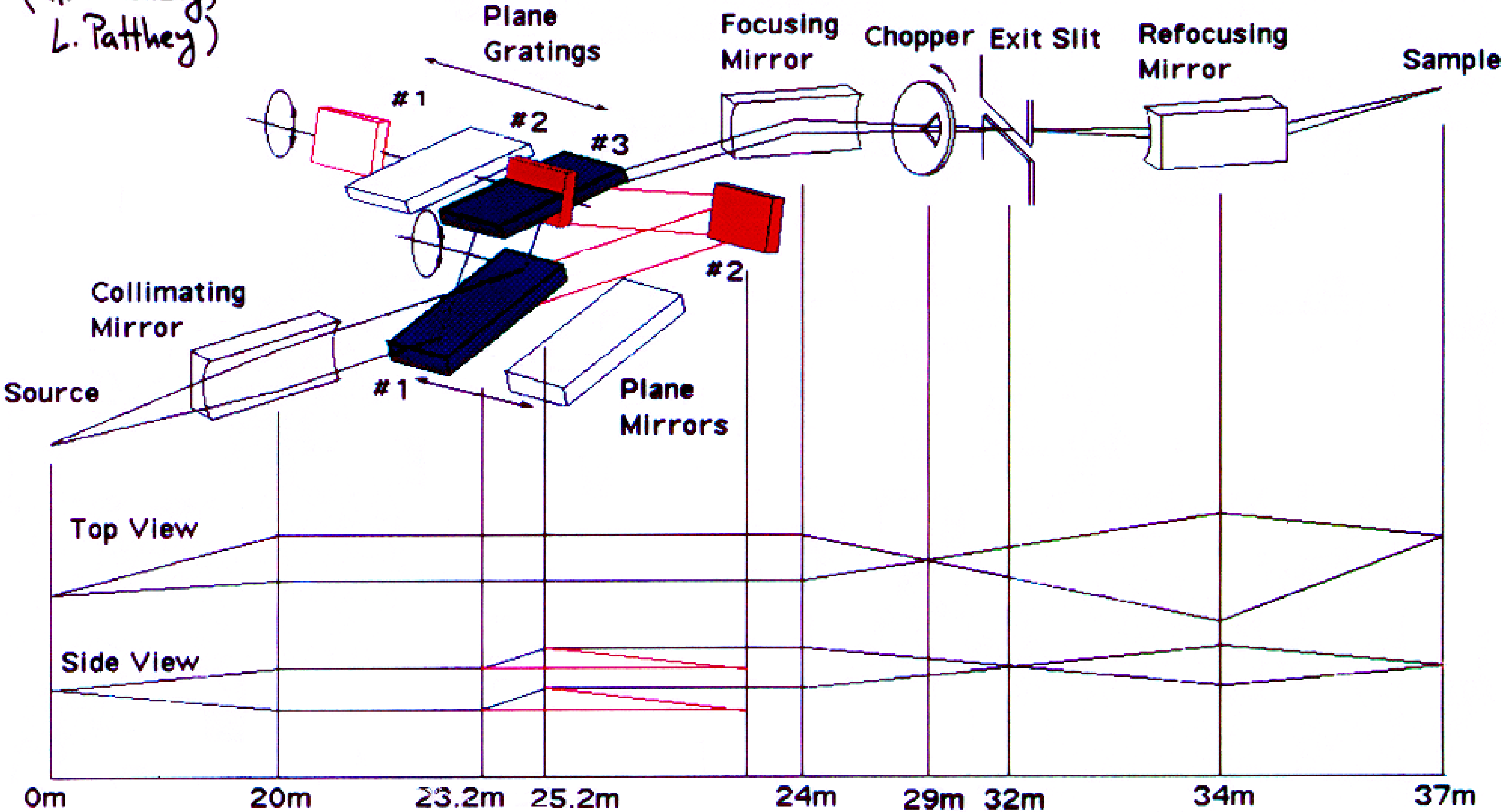
1) pm ⊕ lm (vert. ⊕ horiz.)
2) pm ⊕ cm ($P_c \simeq 70\%$)

Helicity switching rate:

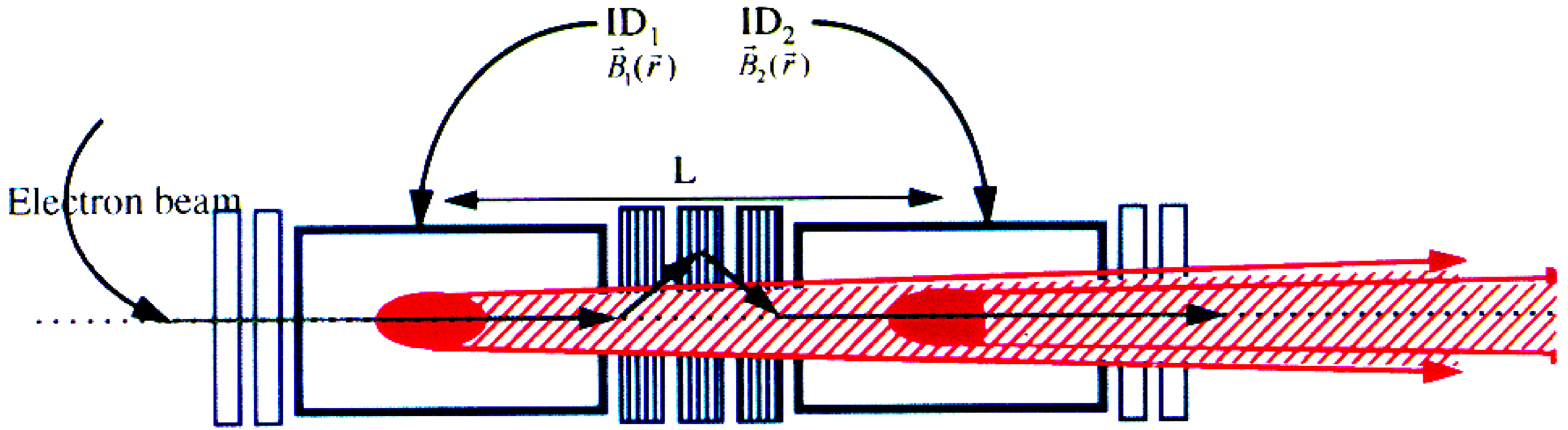
static → 100 Hz → 1 kHz (→ 10 kHz)
└ Lock-in techn.

PGM+NIM Optical Concept of the SIS Beamline

(under study)
(U. Flechsig,
L. Patthey)

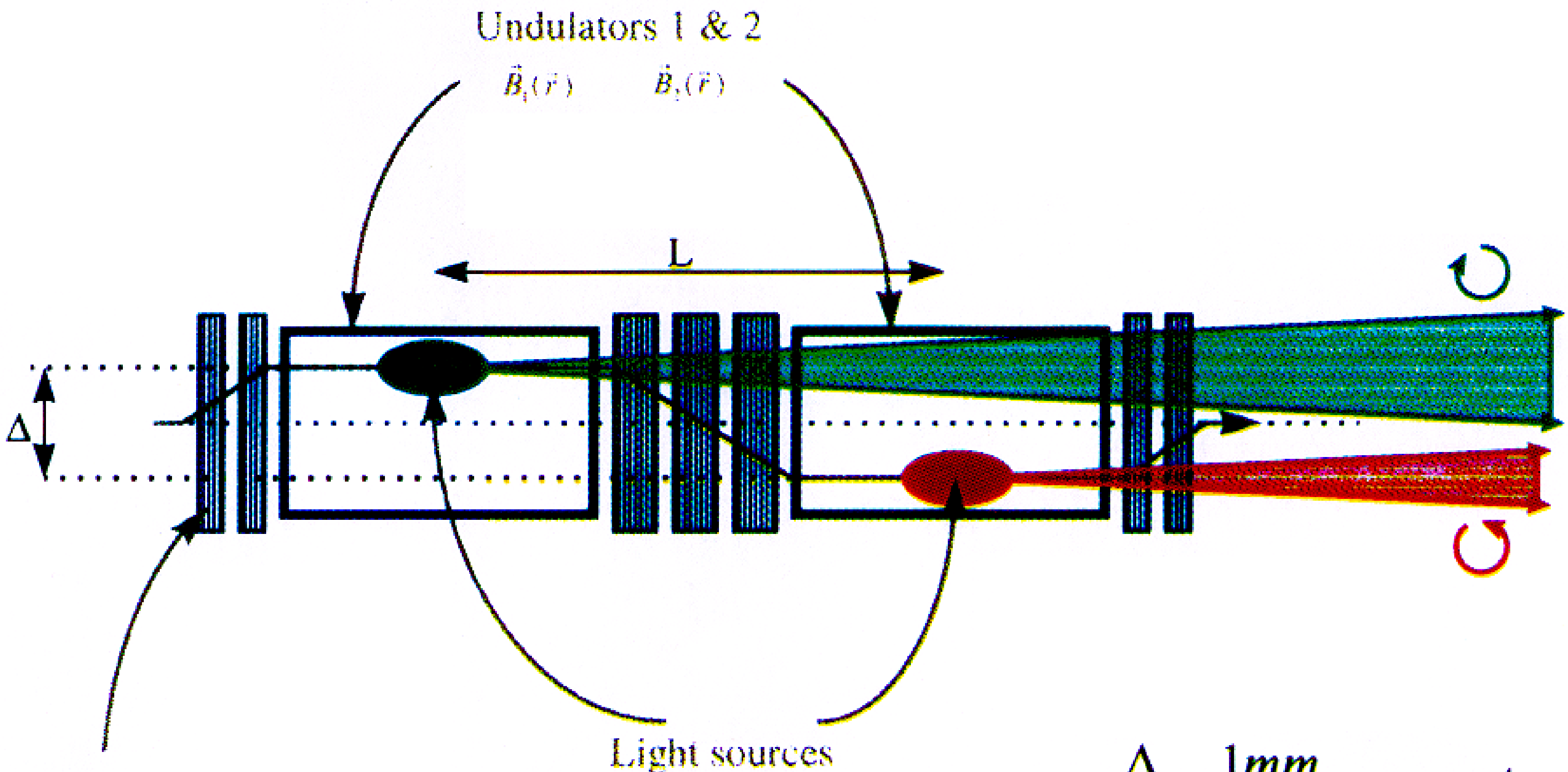


Coupling ID_1 and ID_2



- The two ID's can be coupled to a single device
- Phasematch e-beam & photon beam by chicane in center
- $L_{eff} = L_1 + L_2$
- Undulator : Brightness ~ L_{eff}^2 !

Parallel Displaced Beam



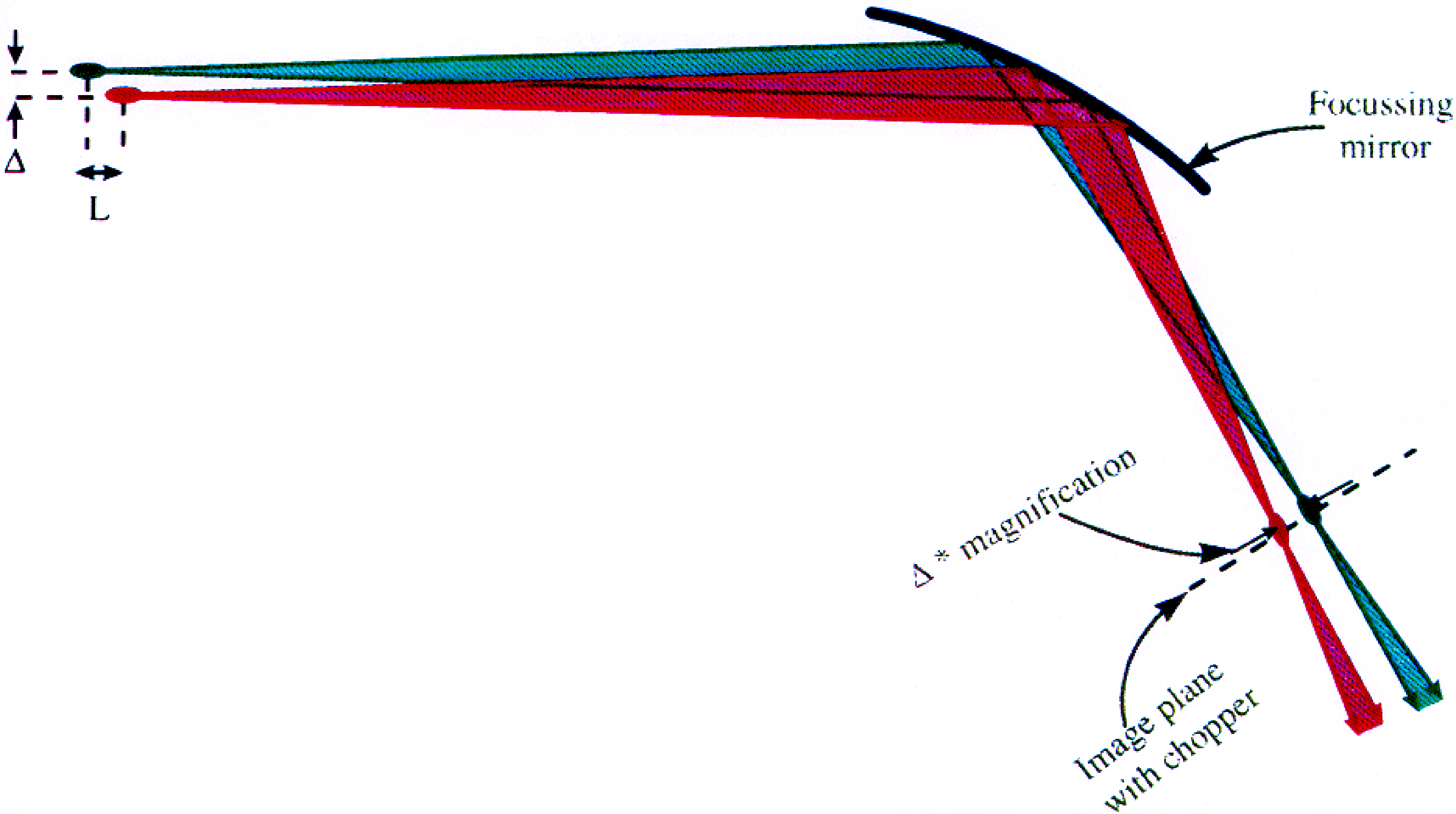
Kicker magnets

$\sim 3 * \sigma_{x,tot} \sim 0.5$ mm, 0.3°

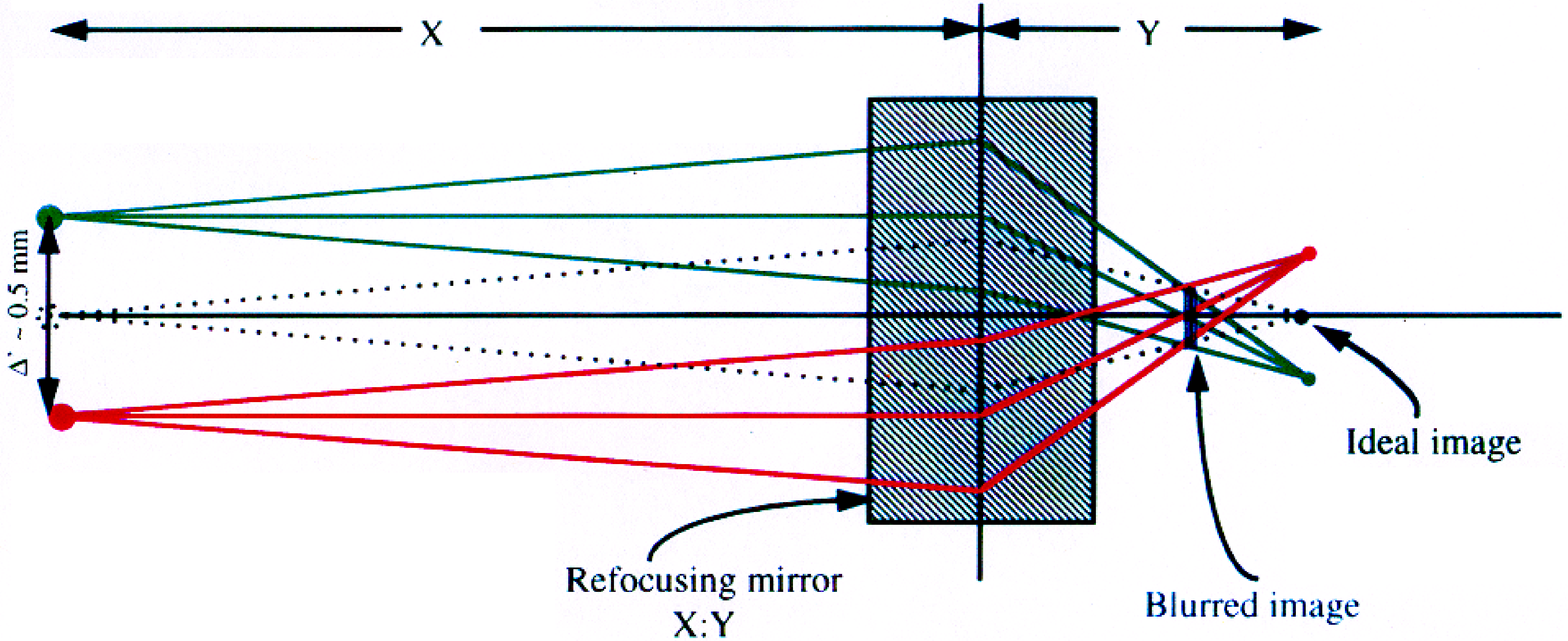
$$\frac{\Delta}{L} \cong \frac{1mm}{5m} \cong 2 \cdot 10^{-4}$$

Focussing

2

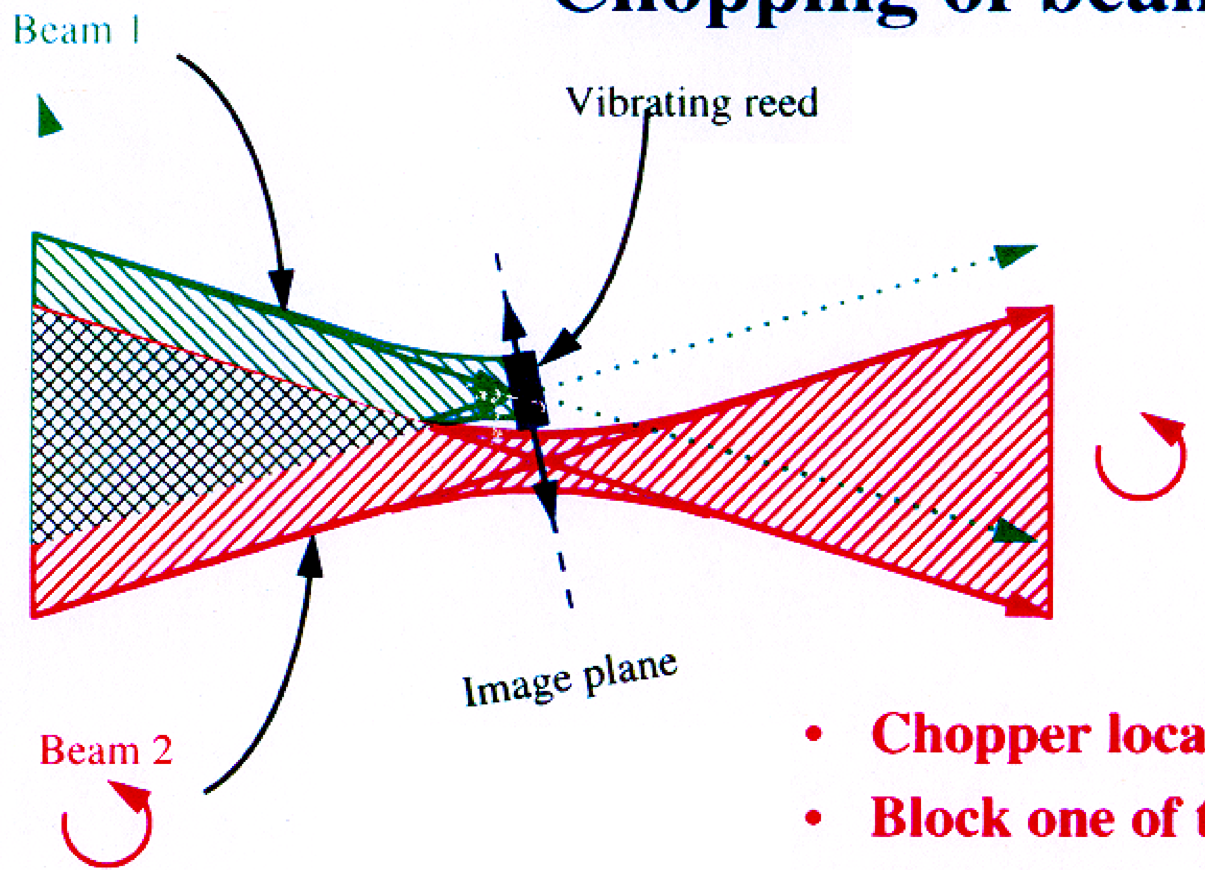

Δ
L
Focussing
mirror
Δ * magnification
Image plane
with chopper

Refocussing



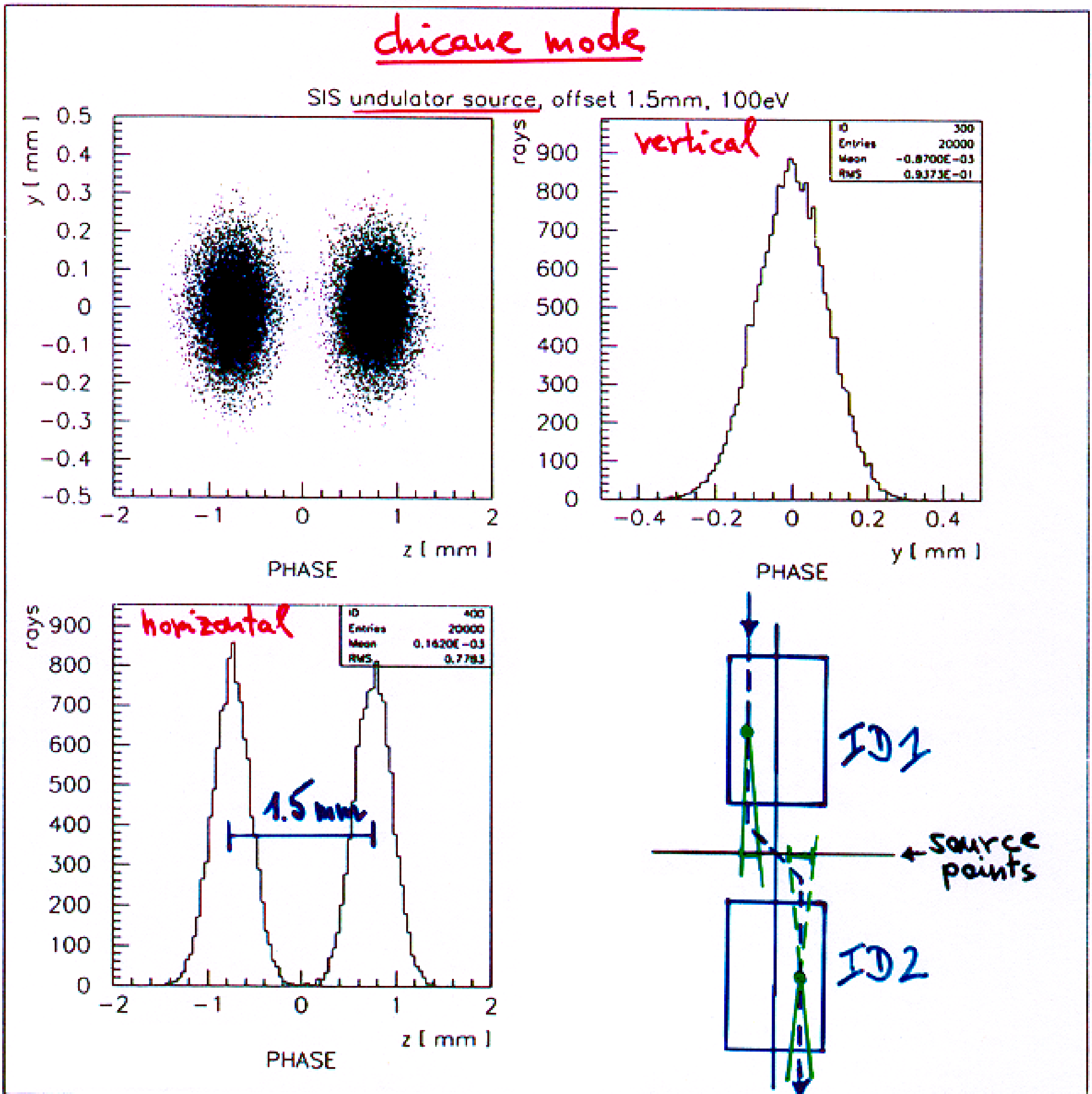
- Object size (Δ') << focal length
- Blurred image out of image plane gives increased spot diameter.

Chopping of beams



- Chopper located in image plane
- Block one of the two beams
- Separation: Δ’ = Δ * M ~ 0.5mm
- High chopping frequency due to small separation Δ’

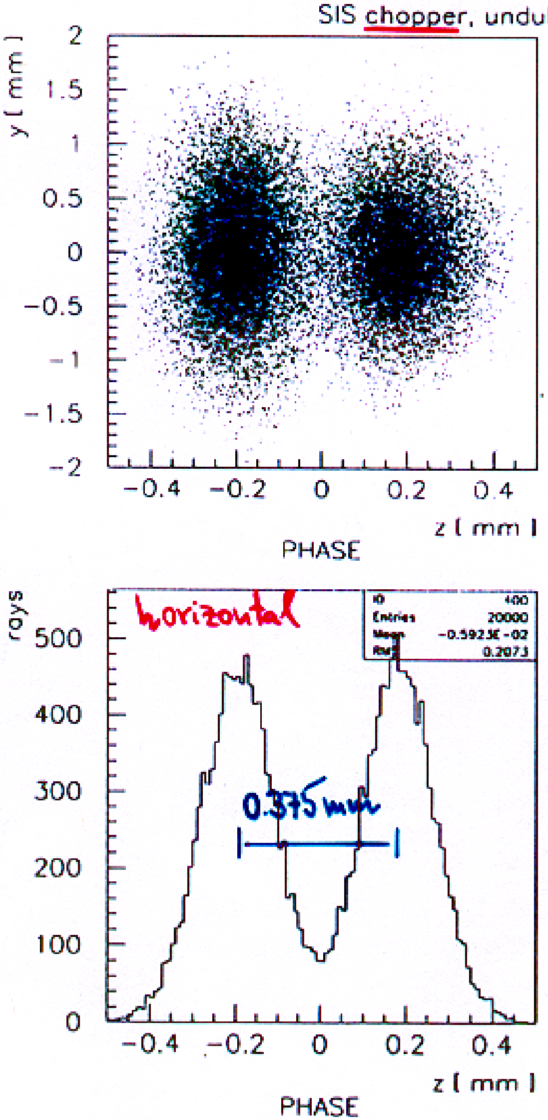
SLS / SIS-beamline



(M. Flechsig; calculation with PHASE)

SLS | SIS-beamline

chicane mode : ID1 ⊕ ID2



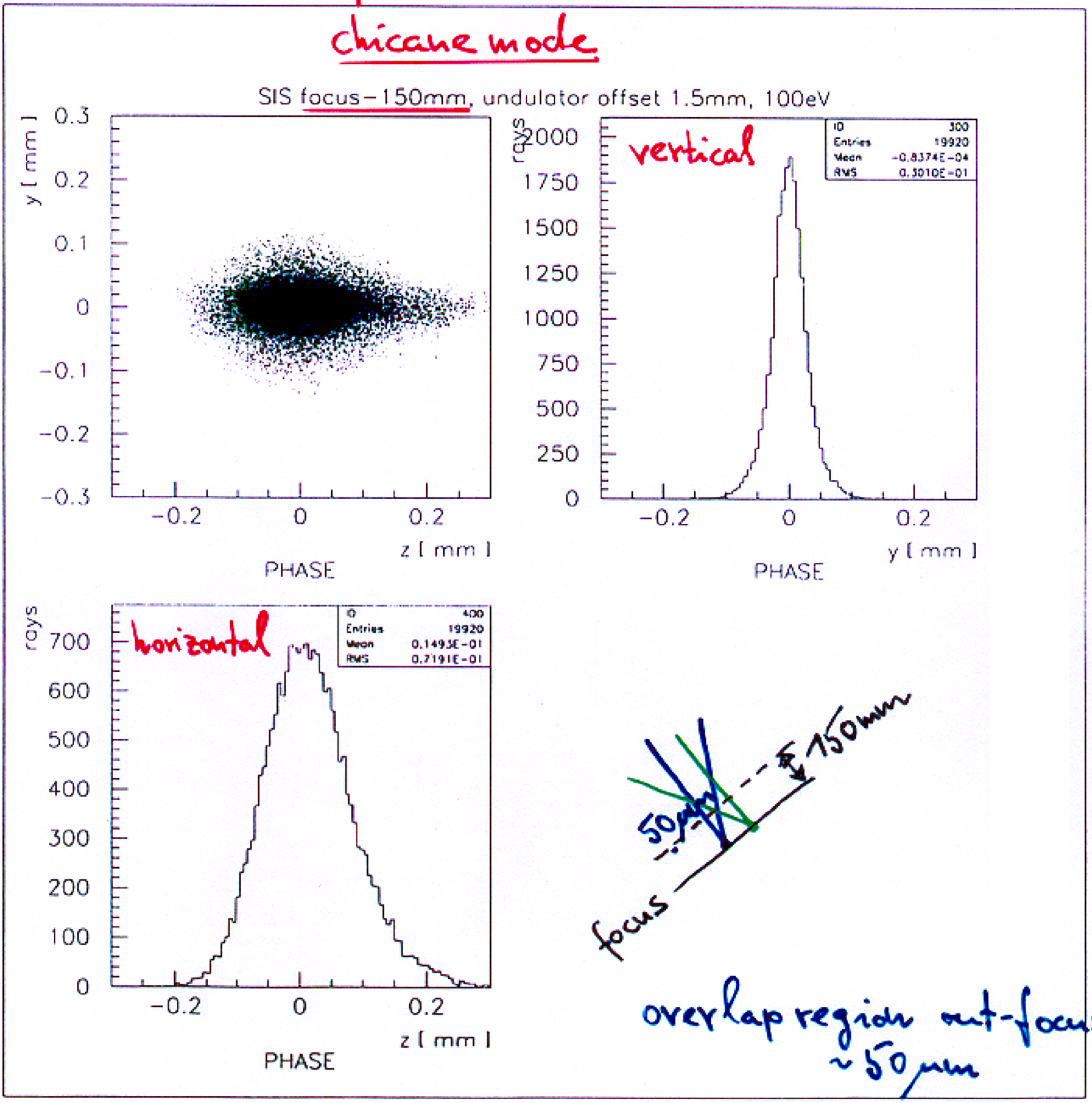
Separation of both beams at chopper location

demagnification 4:1

(U. Flechsig)

SLS | SIS - beamline

chicane mode



(U. Flechsig)