Computer Code Development at the ESRF
RADIA & SRW

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ESRF Computer Codes

- 3D Magnetostatics
  - RADIA
- Synchrotron Radiation
  - B2E
  - SRW
- All codes operates on Windows 95,98,NT and PowerMac. They are FREE and available from ESRF at :
  "http://www.esrf.fr/machine/support/ids/Public/Codes/software.html"
- They make use of a commercially available front-end :
  - Igor Pro (B2E & SRW)
  - Mathematica (Radia)

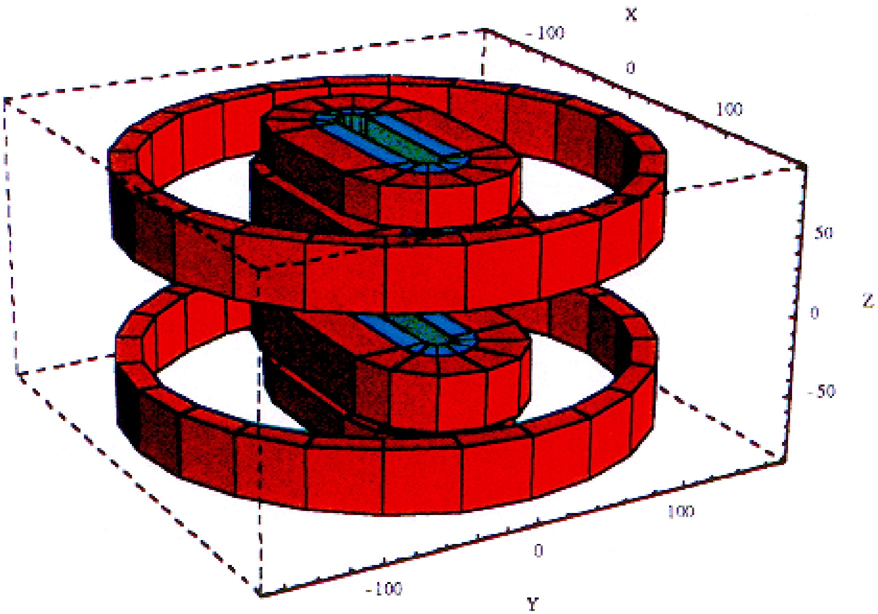
Radia

- Boundary integral approach
- Written in ANSI C++ for Efficiency and Flexibility
- Modeling capability for :
  - Non linear iron (polyhedron shape)
  - Anisotropic permanent magnet material (polyhedron shape)
  - Straight and curved current carrying elements (rectangular cross-section)
- Computes
  - Magnetic field
  - Field integrals
  - Force and Torque
- Interfaced to Mathematica (Wolfram research) for graphics , pre & post processing
- Multiplatform : PowerMac $ Windows 95/NT
- Available from "`http://www.esrf.fr/machine/support/ids/Public/index.html`"

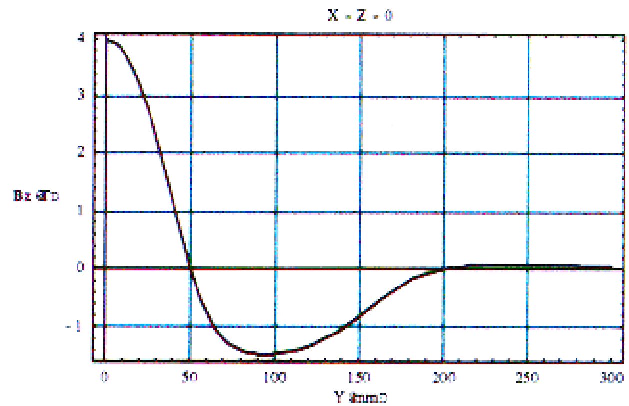
How Radia Works ?

- Analytical expression for the field produced by a set of uniformly magnetized **Parallelepiped**
  - Generalize it to the polyhedron.
  - Generalize it to field integrals over an arbitrary axis.
  - Implement Boundary conditions by mirroring.
  - Build a large full matrix and invert it by a proper relaxation algorithm.
  - Pre/post processing using Mathematica Language (Plot, 3D Graphics, functions,..).
  - Written in ISO C++ with heavy use of the STL library

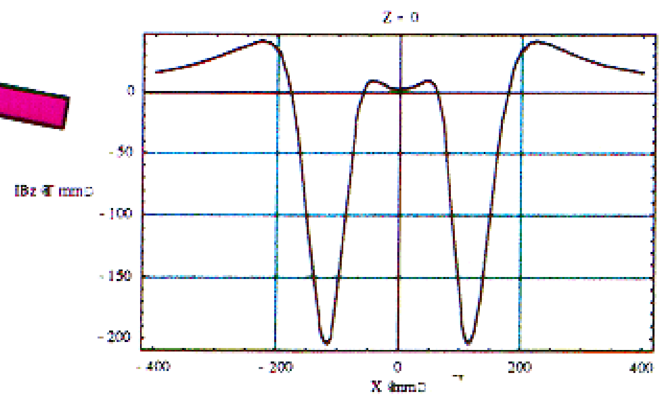
ESRF Superconducting Wiggler



Field

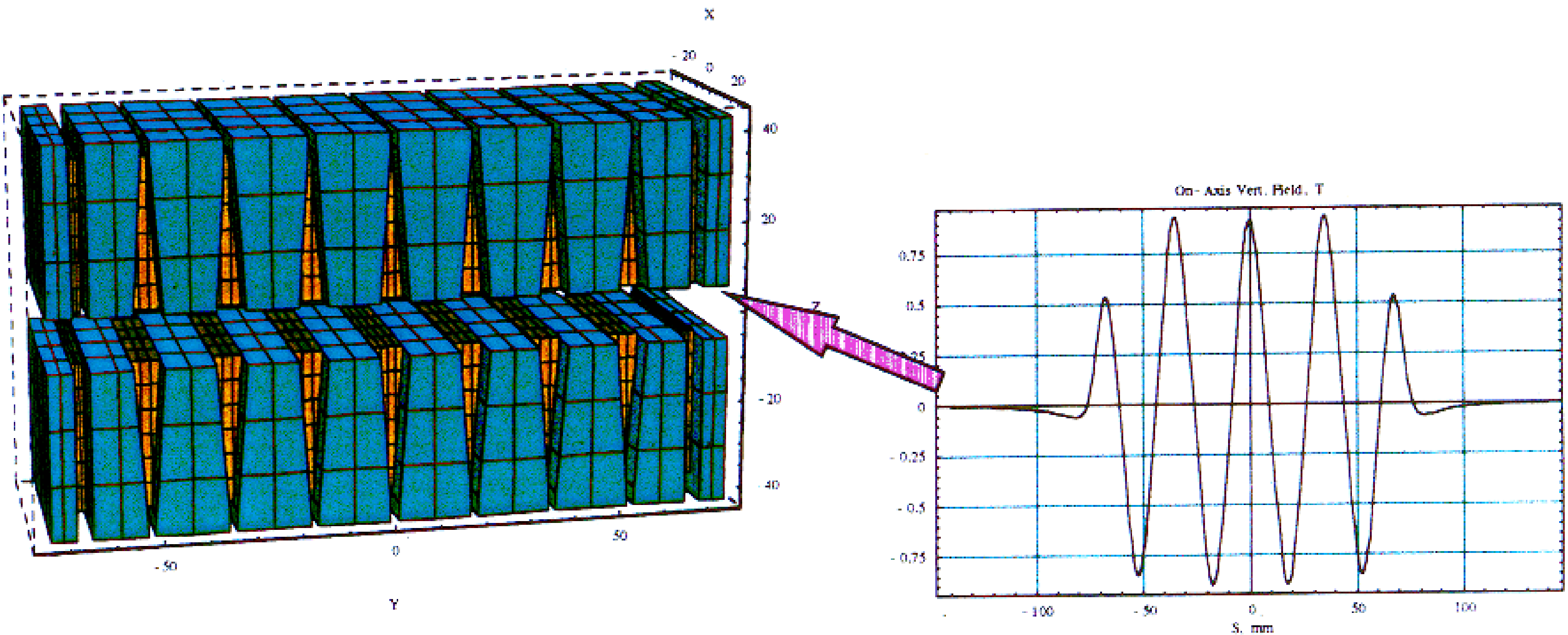


Field Integral

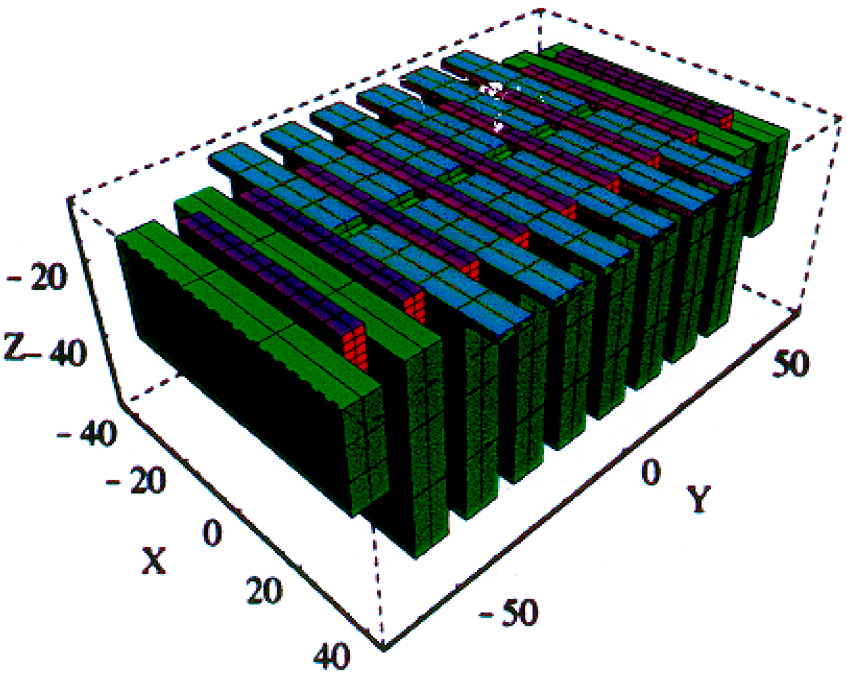


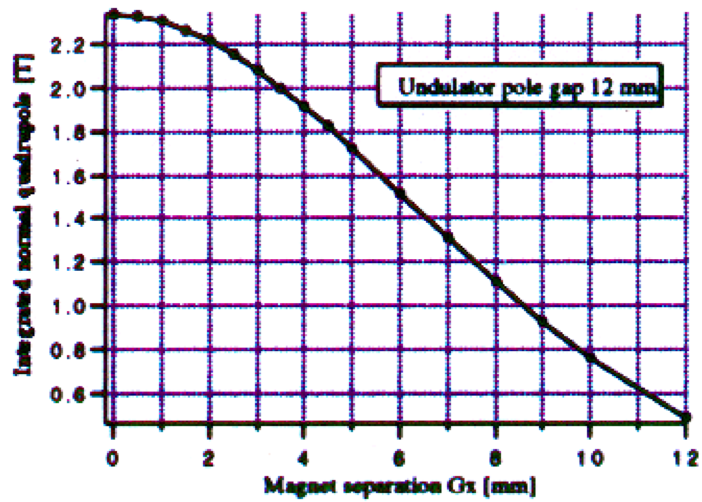
Wedge Pole Undulator

- CPU Time for Solving (PowerMac or Pentium 133, Period/Gap < 4)
  - ≈ 3 sec for the Central Field $B_z(0,0,0)$ with 1% absolute precision
  - ≈ 10 mn for the Field Integral $\int_{-\infty}^{\infty} B_z(0,y,0)\, dy$ with 20 Gcm absolute precision

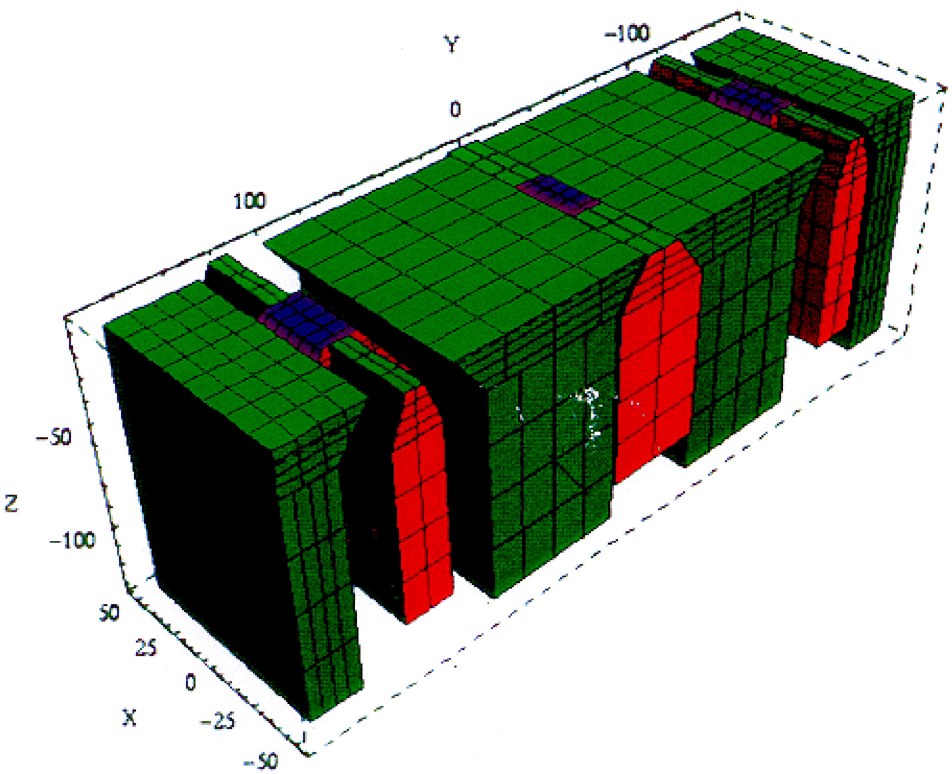


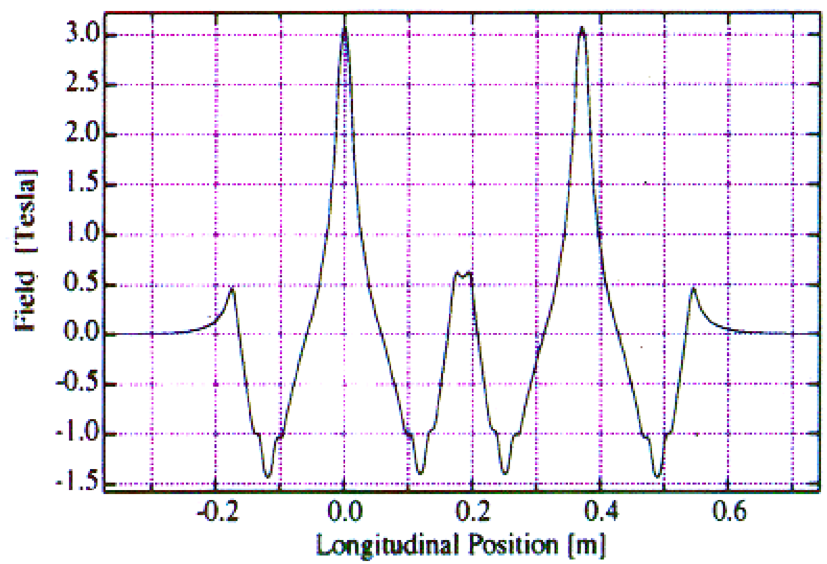
Undulator for the TTF FEL



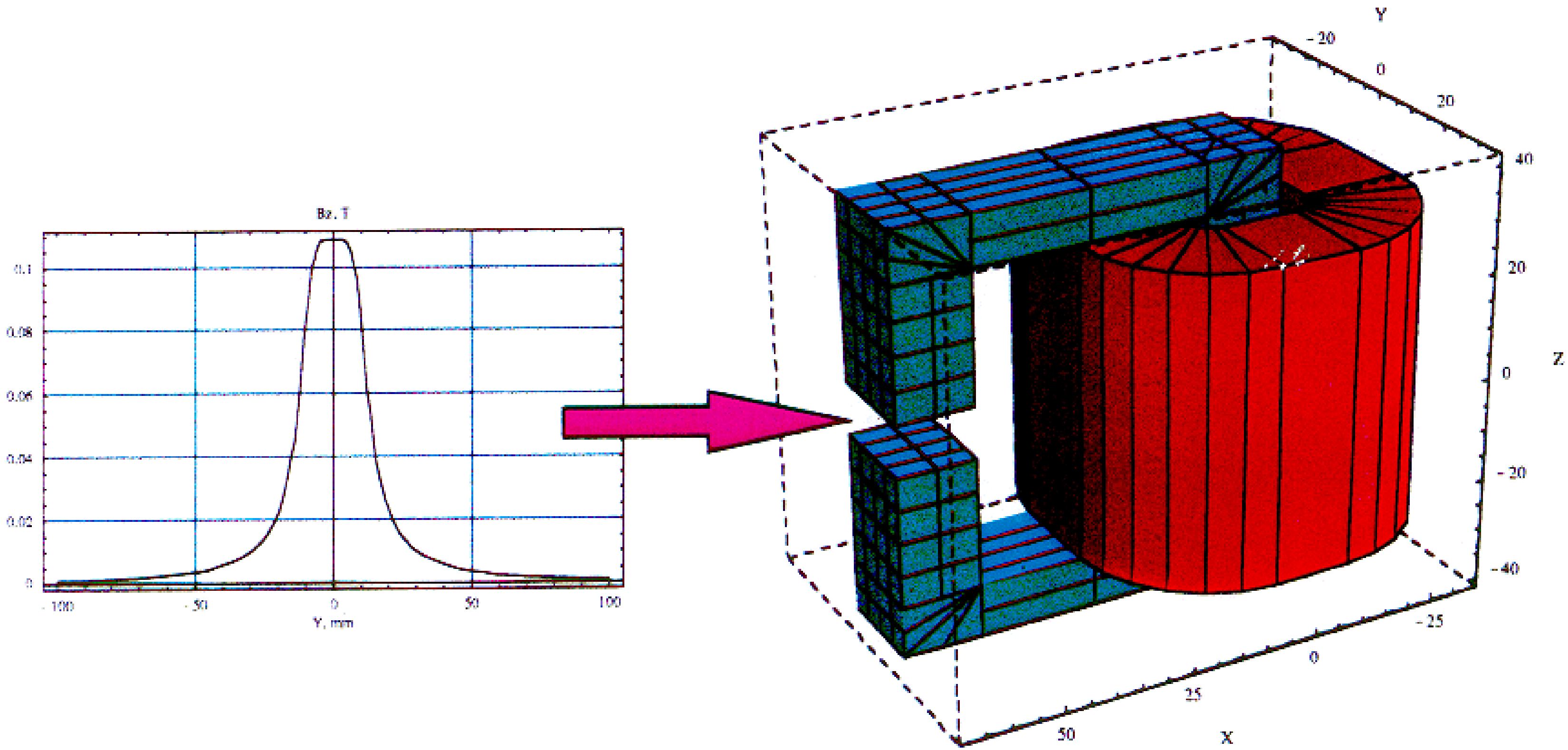


3 Tesla Wiggler

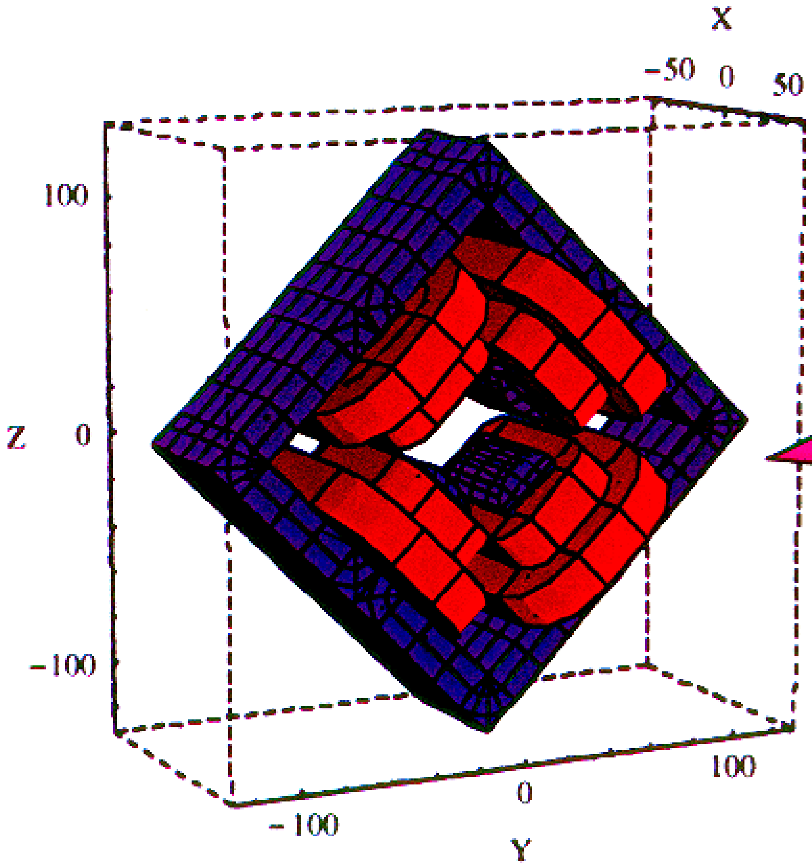


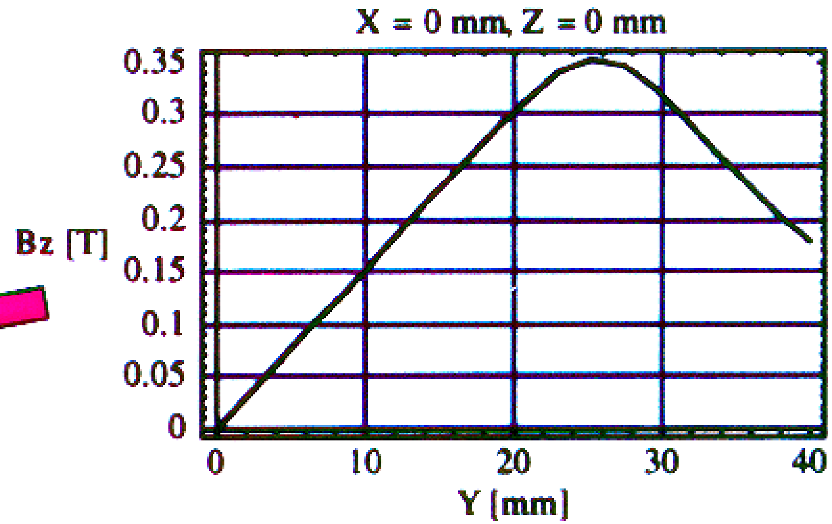


Dipole Steerer

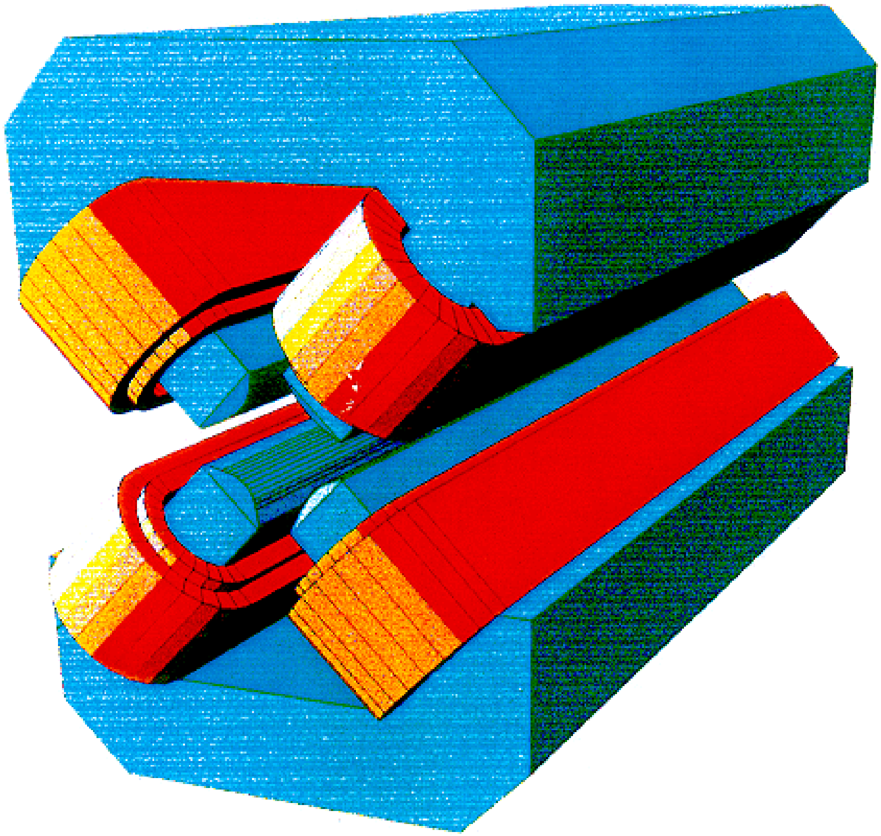


Quadrupole Magnet





CHAMFER OPTIMIZATION of an ESRF QUADRUPOLE

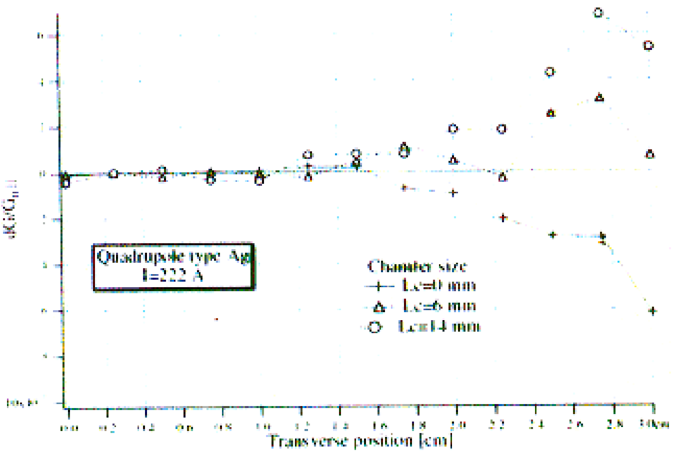


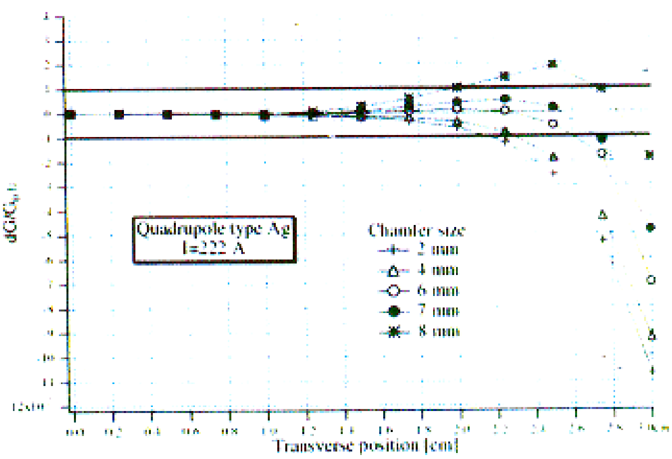
FLUX3D

200 000 2nd Order Tetrahedron
200 Mbyte Memory
3 Hours CPU

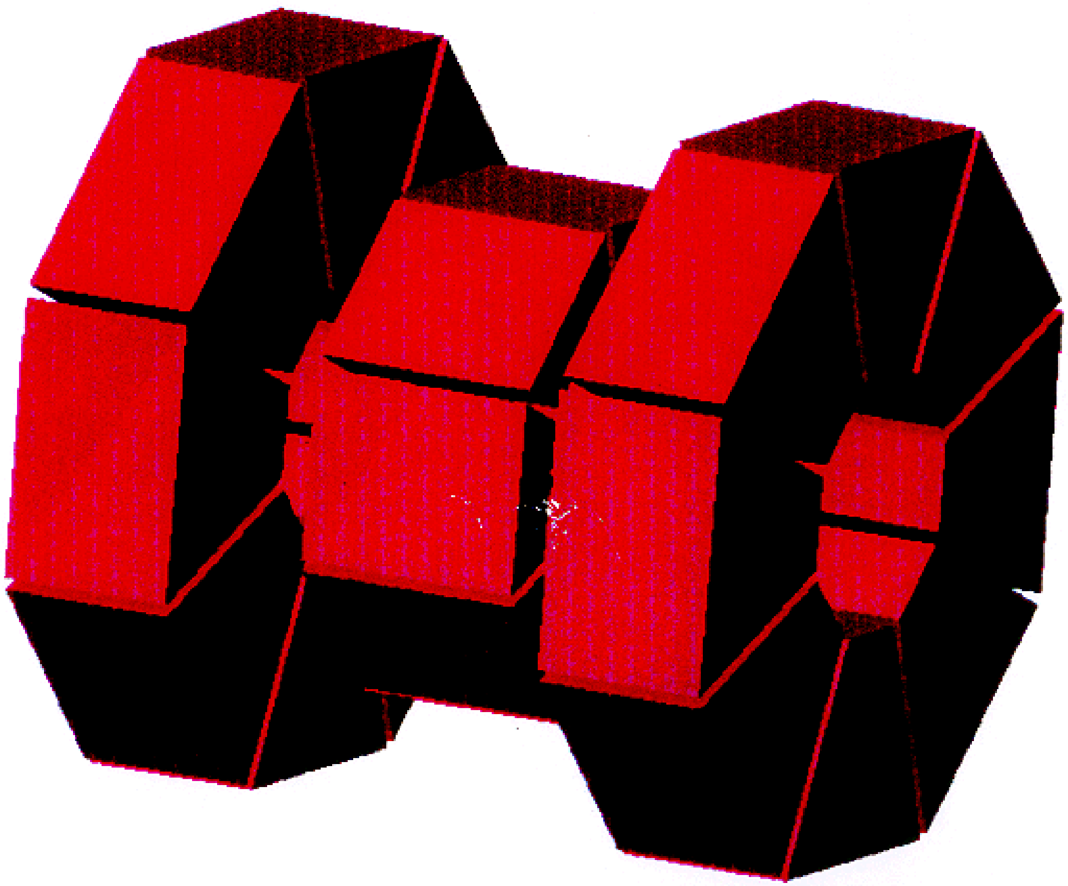
RADIA

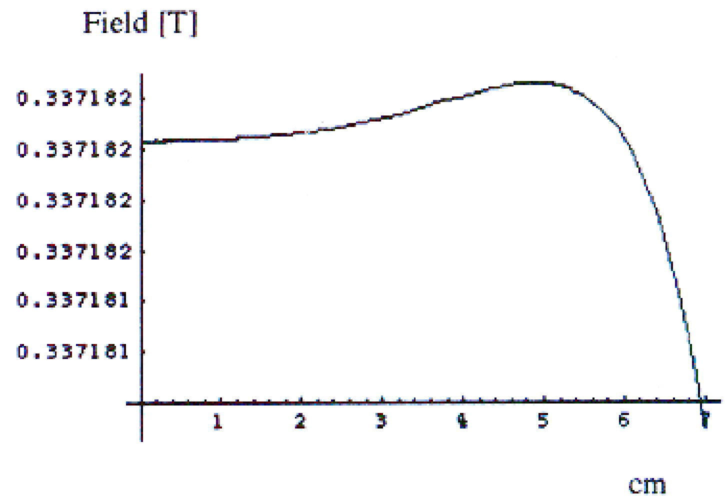
1500 Polyhedron
200 Mbyte Memory
1 Hours CPU





MRI Magnet with NdFeB





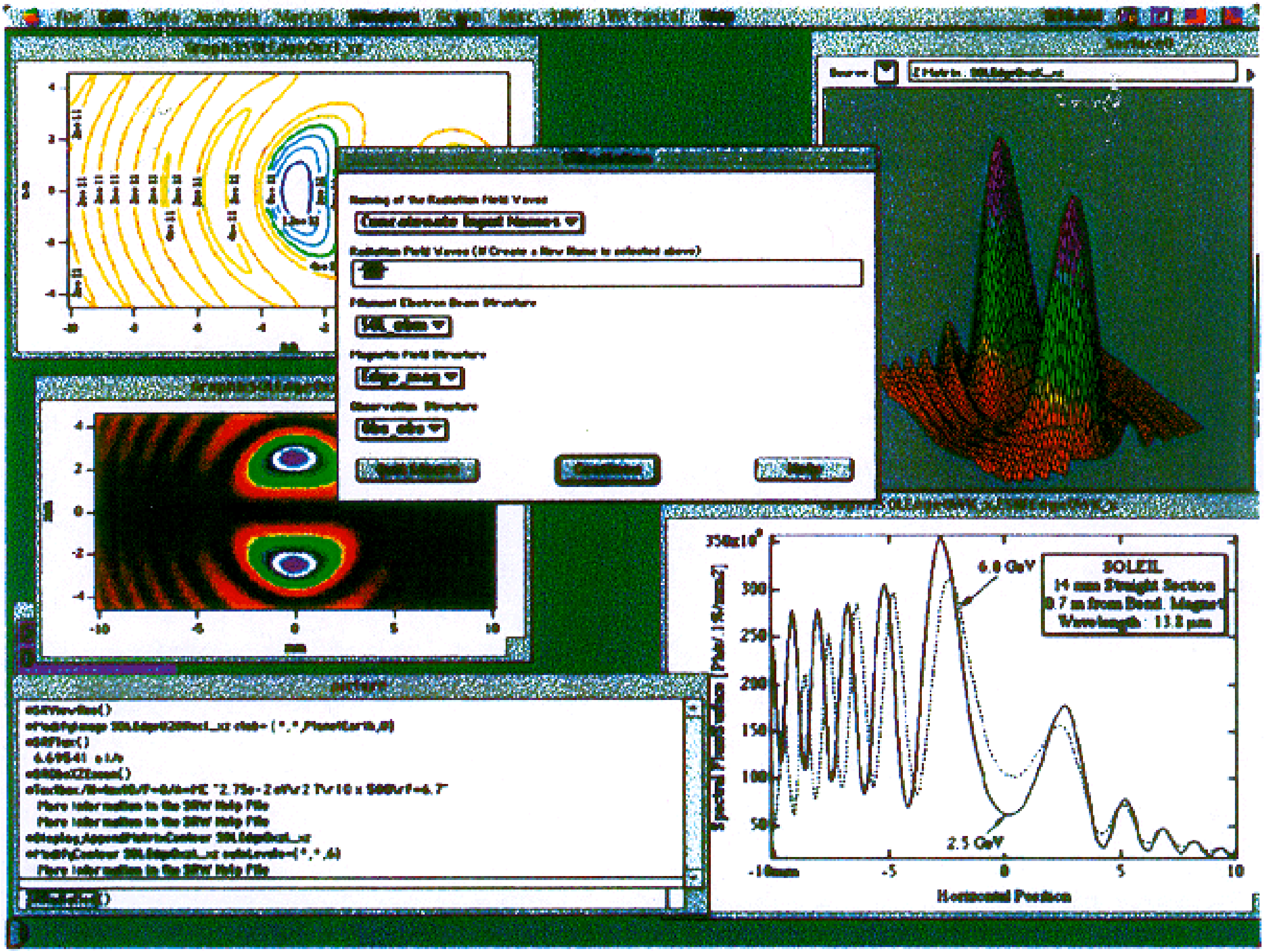
- Inner Radius = 18 cm
- 10^{-6} Field Uniformity over a Sphere of 6 cm radius
- Optimized with the Mathematica Functions

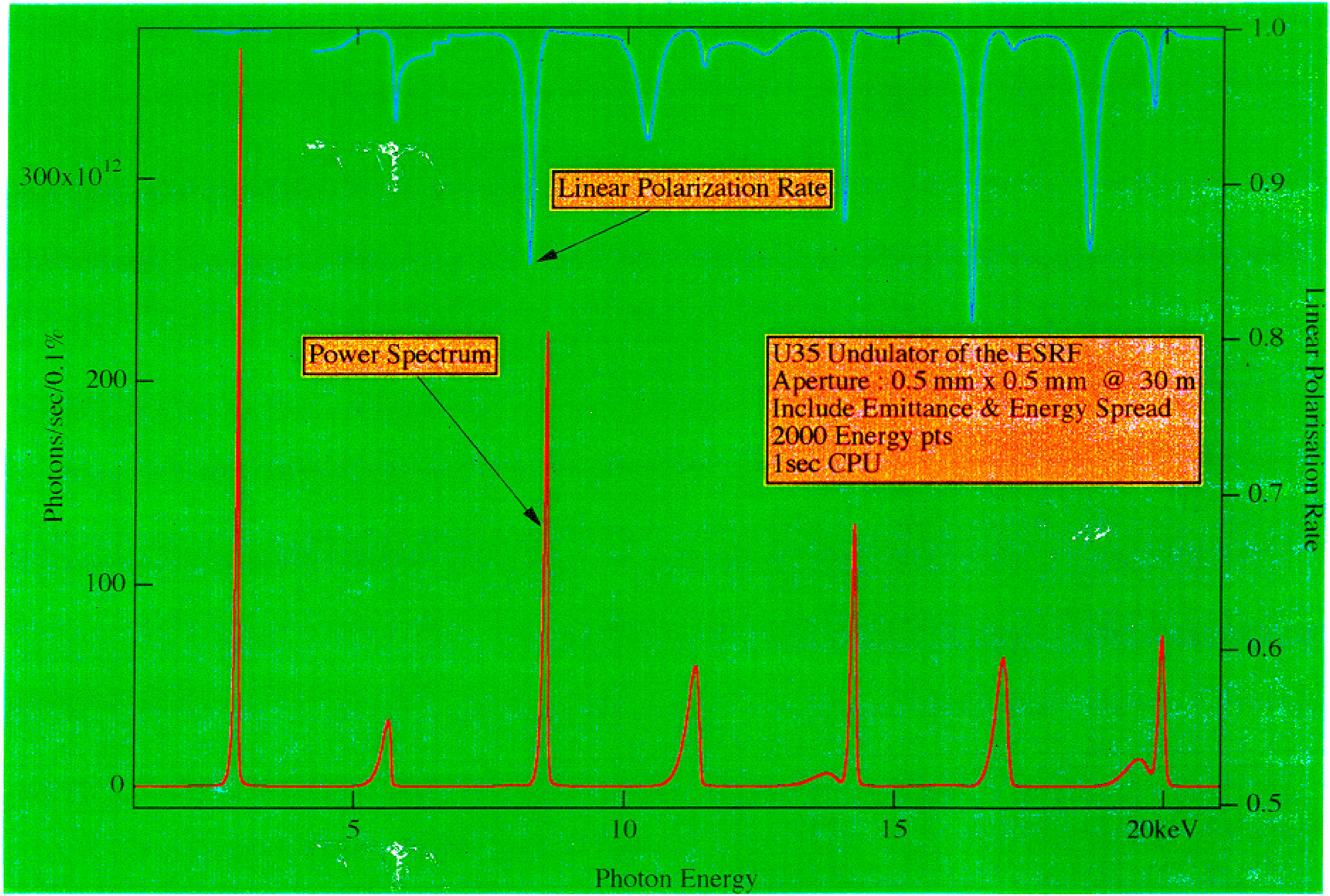
Conclusion

- A large number of tests made at ESRF, Lund,…show that the field computed with RADIA are confirmed by the experimental observations (to the precision of the definition of materials).
- The capability of a fast and accurate computation of field integrals is unique. This makes possible the design of passively corrected wiggler terminations,...
- 3D magnetostatic Field Computation is becoming MUCH CHEAPER with RADIA
  - Capital Cost (PC & Mathematica : 2000 $)
  - Running Cost (Fast solving Time)
  - Learning Cost

SRW Data Sheet

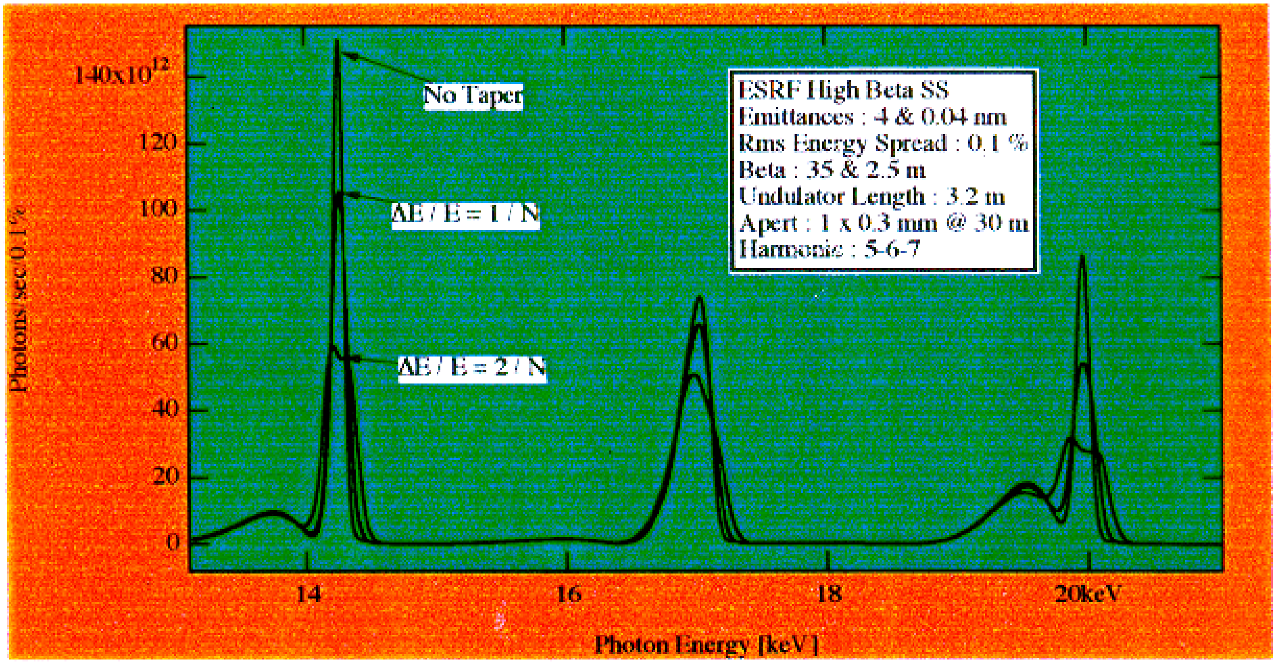
- Fast Computation of undulator spectra including emittance, energy spread, aperture, polarization assuming far field and no field errors
  - Conventional, Linear/helical, Tapered undulator , Optical Klystron, Figure-8,...
  - 2000 Energy pts, harmonic 1-7 in 1 sec.
- Heatload Computation including emittance Near Field for an arbitrary magnetic field.
- Wavefront produced by a filament beam in an arbitrary magnetic field + **Propagation** through Lenses, Aperture... Includes **Diffraction**
  - Imaging simulations.
  - Infrared beamline from edge radiation.
- Fast Computation of Bending Magnet & Wiggler Radiation (Under beta testing).
- Pre and Post Processing in Igor Pro (1D/2D Plot, Macros, Fitting..). Data input by Dialog box/Text Command.
- Multi-platform : PowerMac &Windows 9x/NT, Available for free from http://www.esrf.fr/machine/support/ids/Public/Codes/software.html


SOLEIL
14 mm Straight Section
0.7 m from Bend. Magnet
Wavelength : 13.8 μm
6.0 GeV
2.5 GeV
Horizontal Position

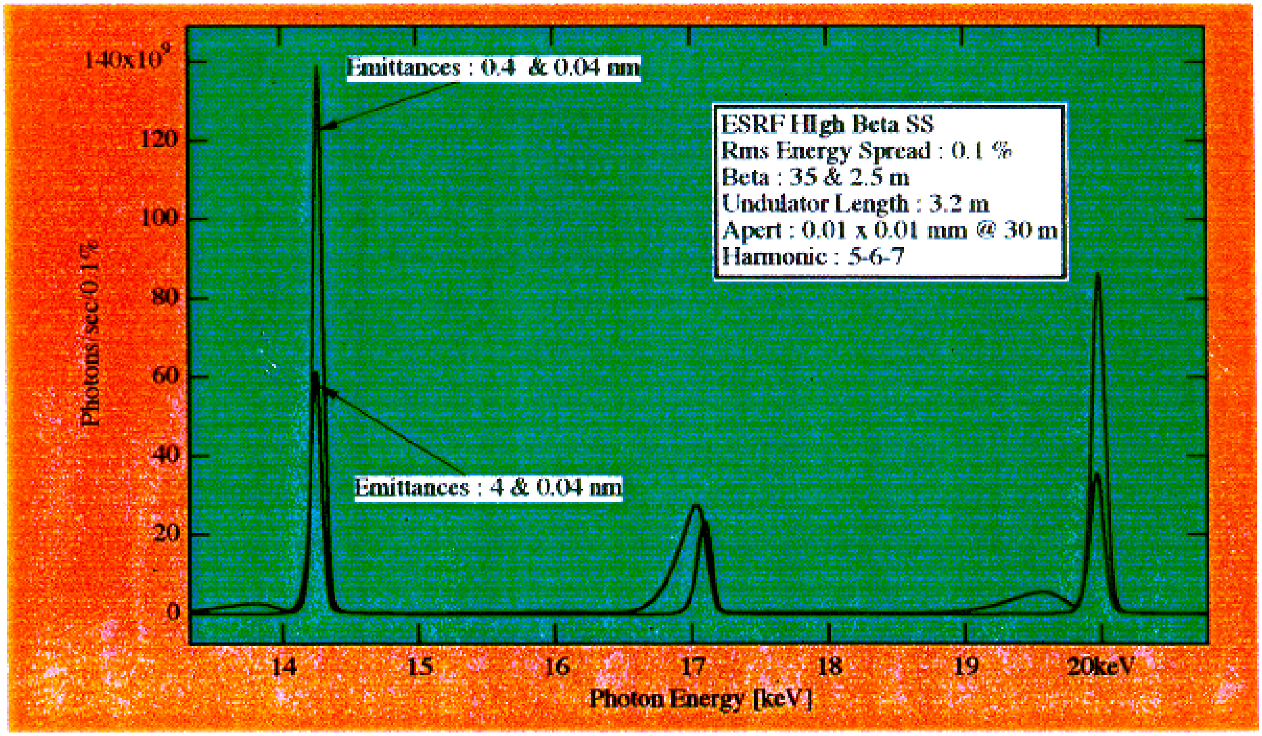


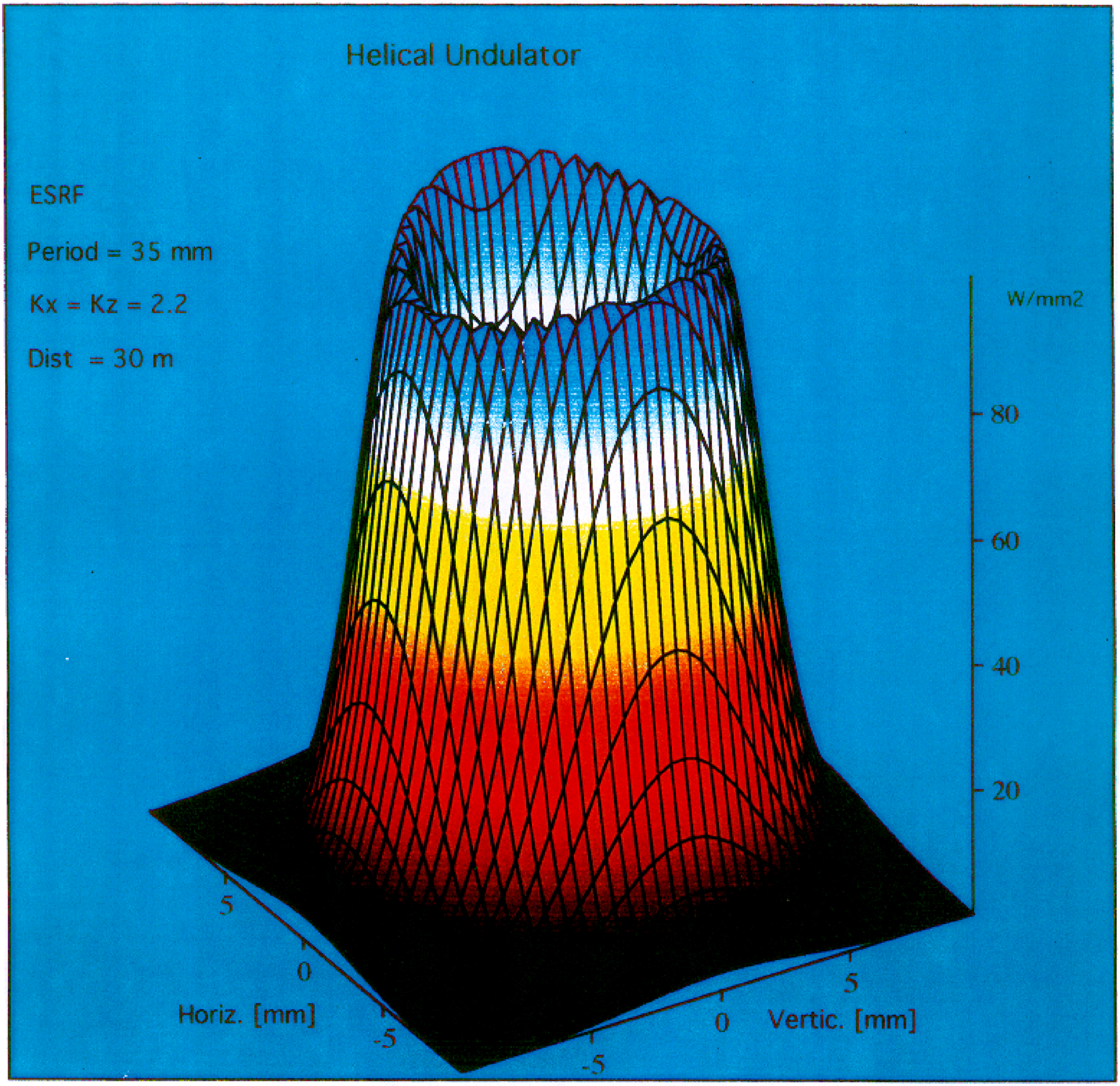
Linear Polarization Rate
Power Spectrum
U35 Undulator of the ESRF
Aperture : 0.5 mm x 0.5 mm @ 30 m
Include Emittance & Energy Spread
2000 Energy pts
1sec CPU
300x10¹²
200
100
0
Photons/sec/0.1%
5
10
15
20keV
Photon Energy
1.0
0.9
0.8
0.7
0.6
0.5
Linear Polarisation Rate

Effect of Taper

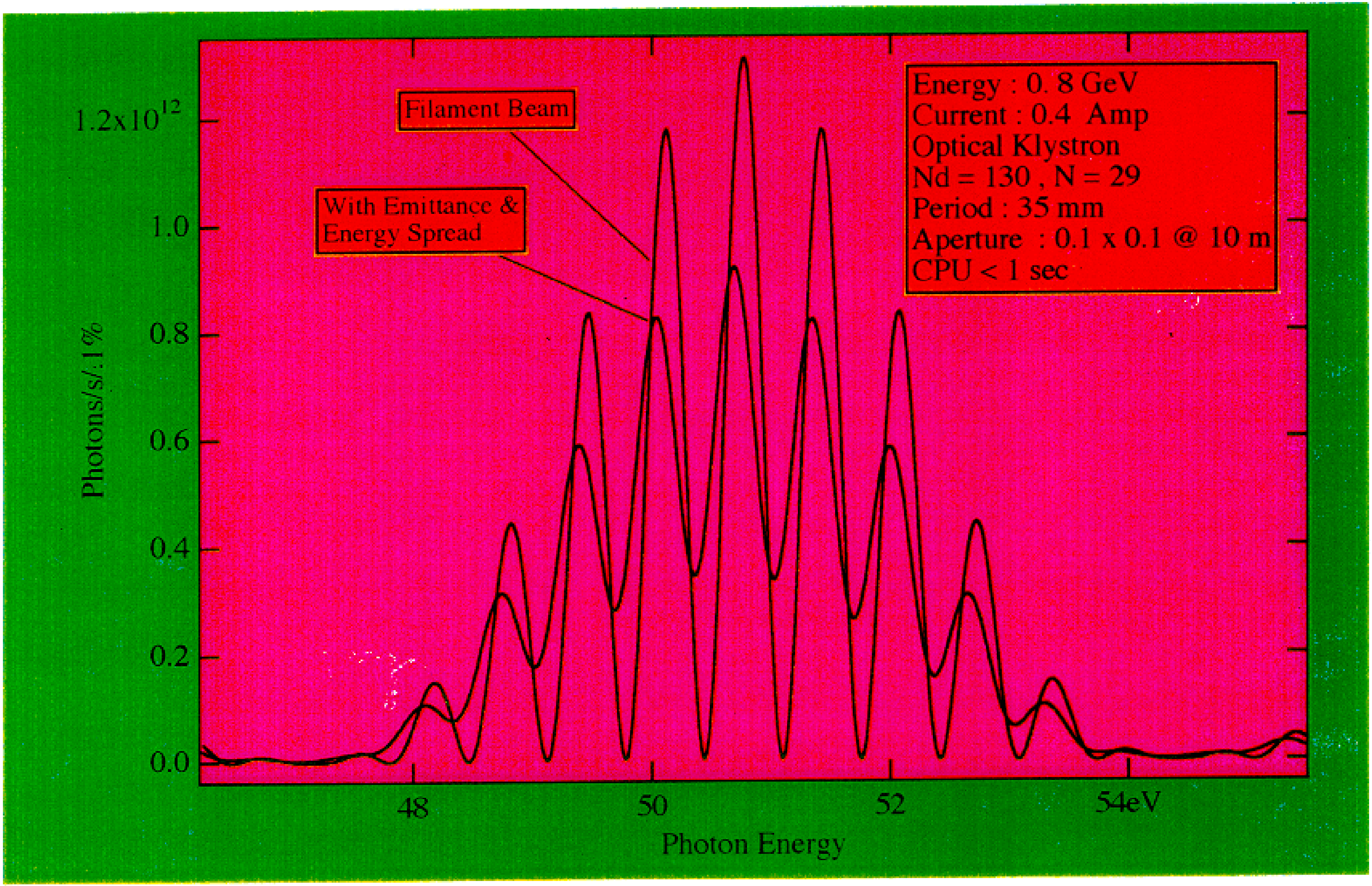


Effect of Emittance





Helical Undulator
ESRF
Period = 35 mm
Kx = Kz = 2.2
Dist = 30 m
W/mm2
80
60
40
20
5
0
-5
Horiz. [mm]
-5
0
5
Vertic. [mm]



Energy : 0. 8 GeV
Current : 0.4 Amp
Optical Klystron
Nd = 130 , N = 29
Period : 35 mm
Aperture : 0.1 x 0.1 @ 10 m
CPU < 1 sec
Filament Beam
With Emittance & Energy Spread
1.2x10^12
1.0
0.8
0.6
0.4
0.2
0.0
Photons/s/.1%
48
50
52
54eV
Photon Energy

U35 Undulator at the ESRF

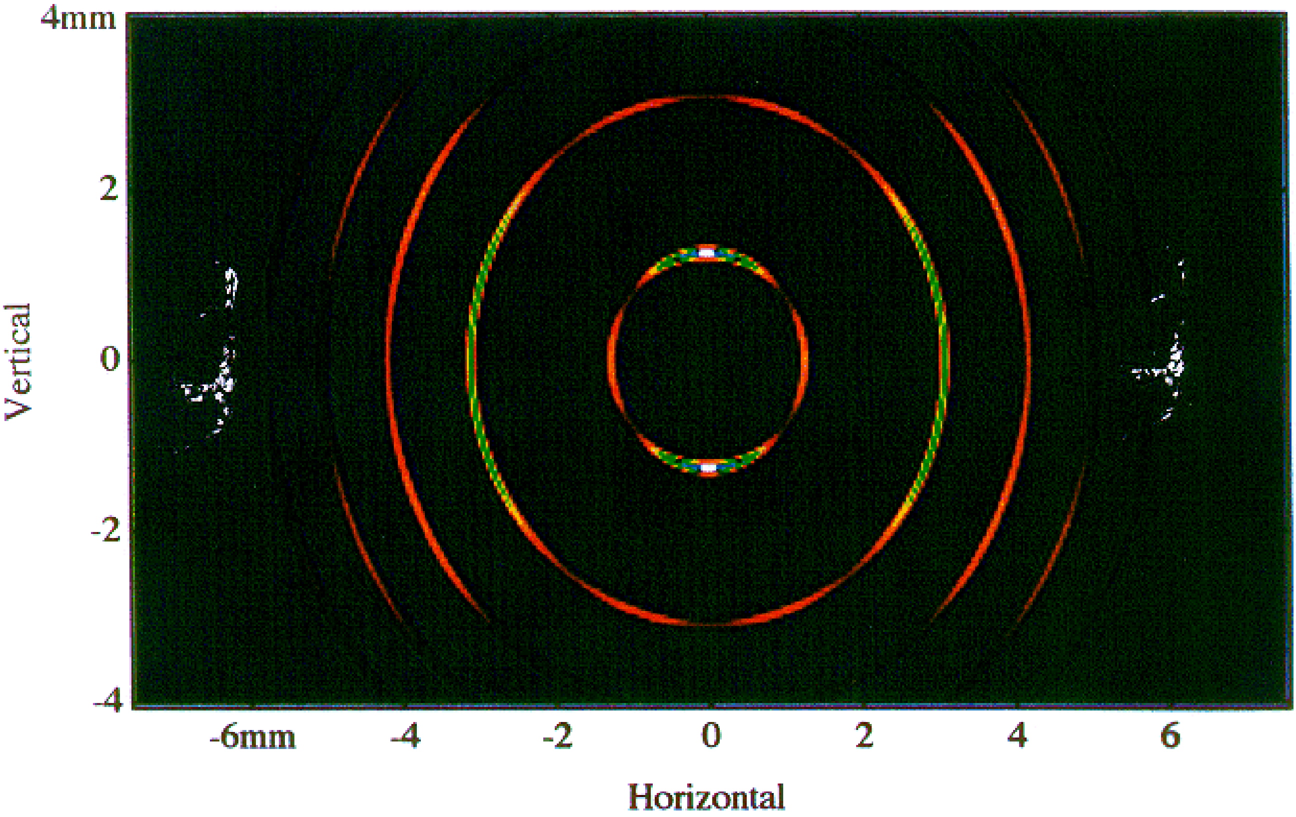
30 m from the Source

Energy = 8 keV

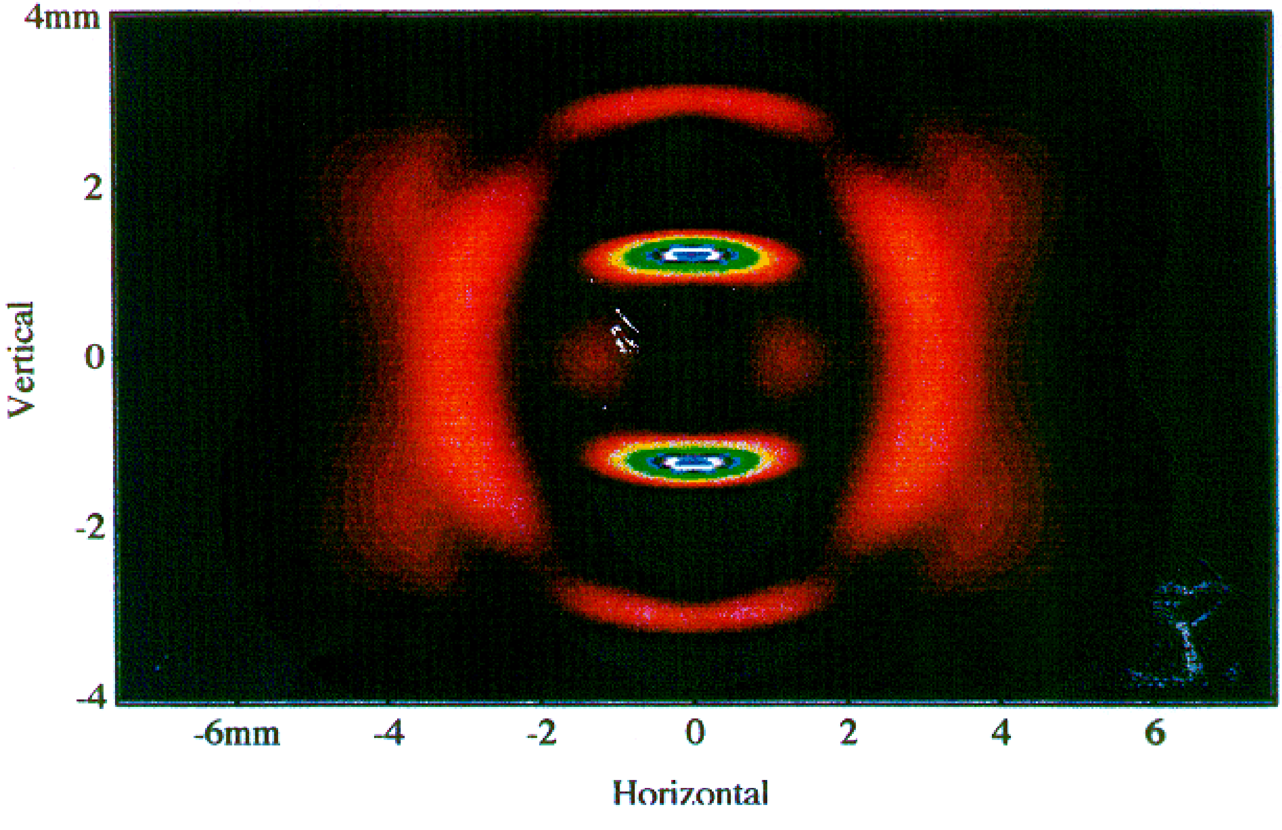
Harmonic 3,4,5,6 ...

150 x 300 pts in 30 sec CPU

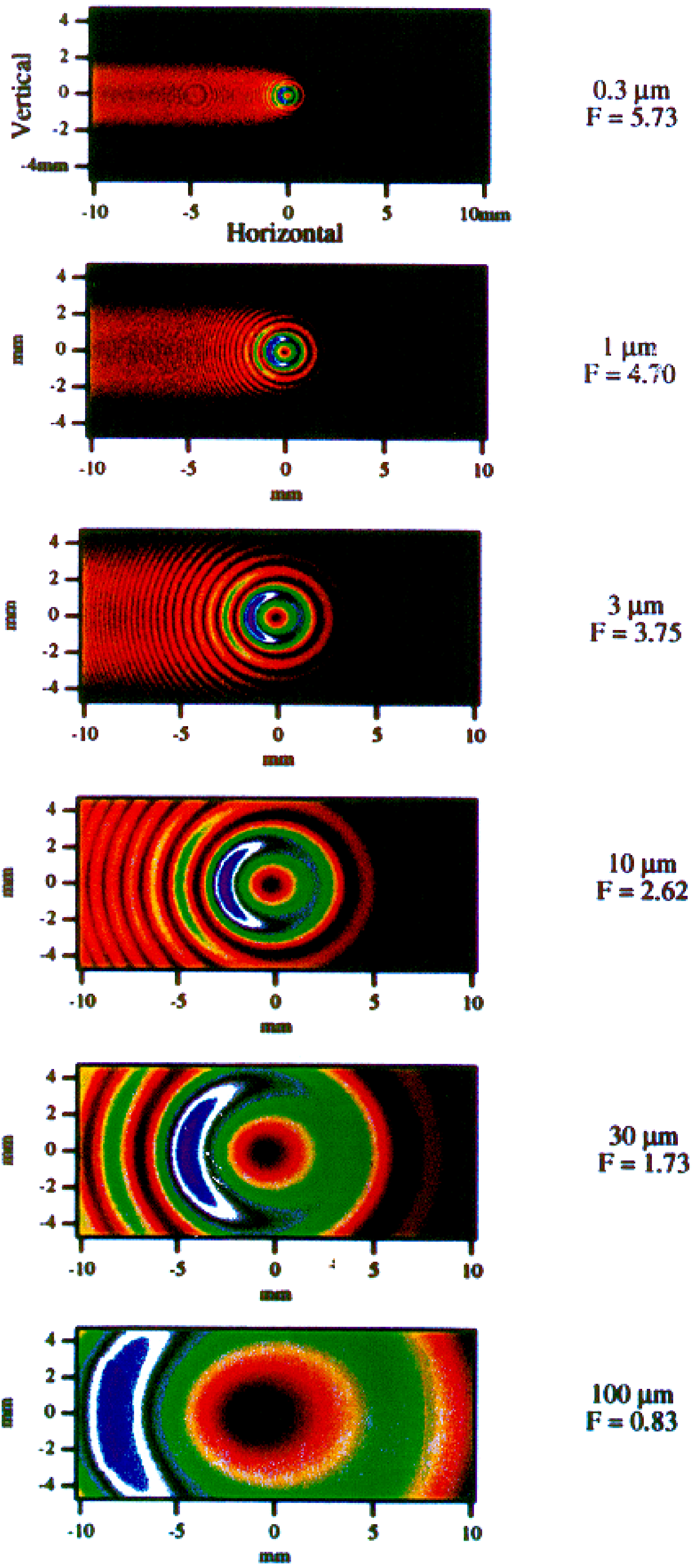
Filament Beam



Including Emittance



SOLEIL (2.5 GeV, 1.56 T)
5 m between Bend. Magnets
Observ. @ 0.7 m from last Bend. Magnet



Plane of the Lens "Filament" e-beam.

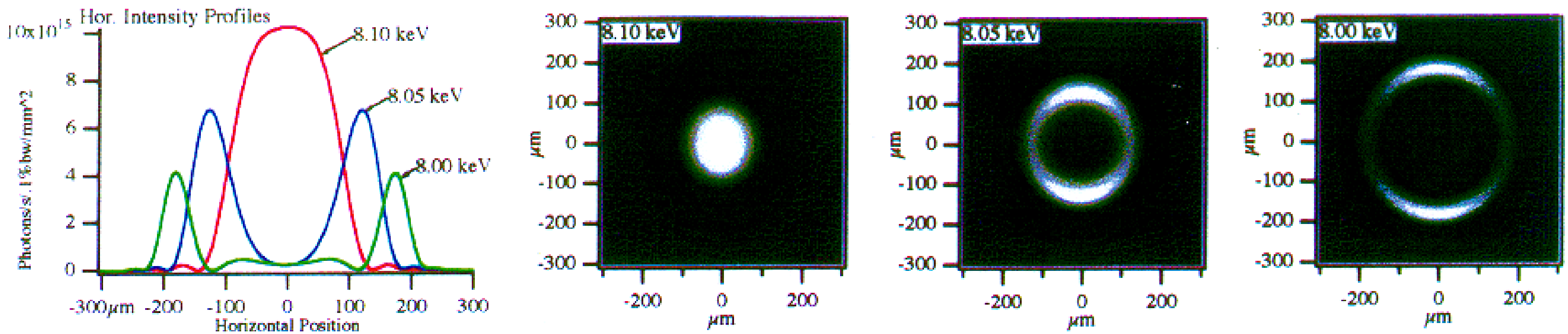


Image Plane. "Filament" e-beam (1: 1 Imaging)

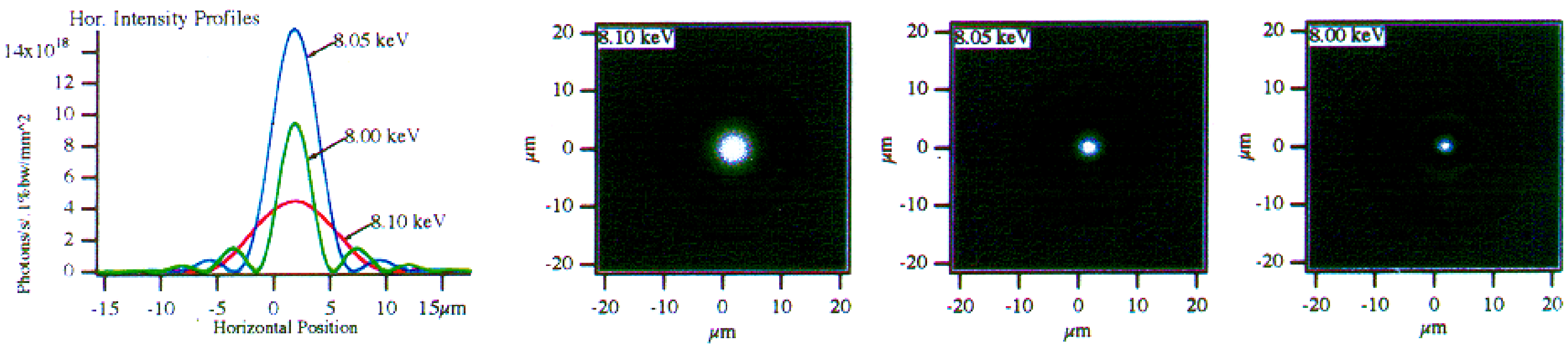
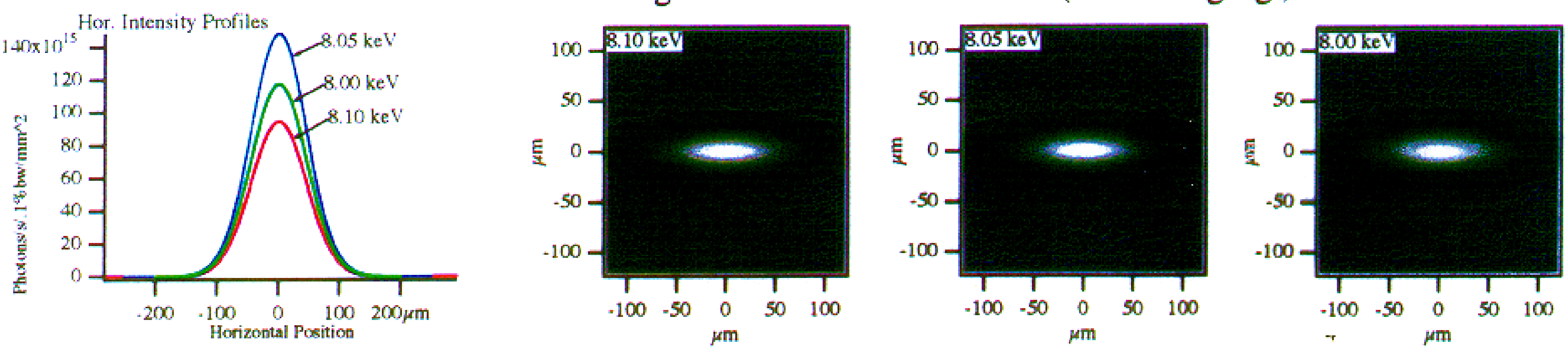


Image Plane. "Thick" e-beam (1: 1 Imaging)



Focusing of Bending Magnet Radiation by a Beryllium Lens

$\beta_z = 35$ m
Filament Electron Beam
Distance Lens-Src = 4.5 m
Hole Diameter = 0.8 mm
Magnification 1:2.6
Energy = 25 keV