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Hard X-ray synchrotron radiation measurements at the APS with vibrating wire monitors*

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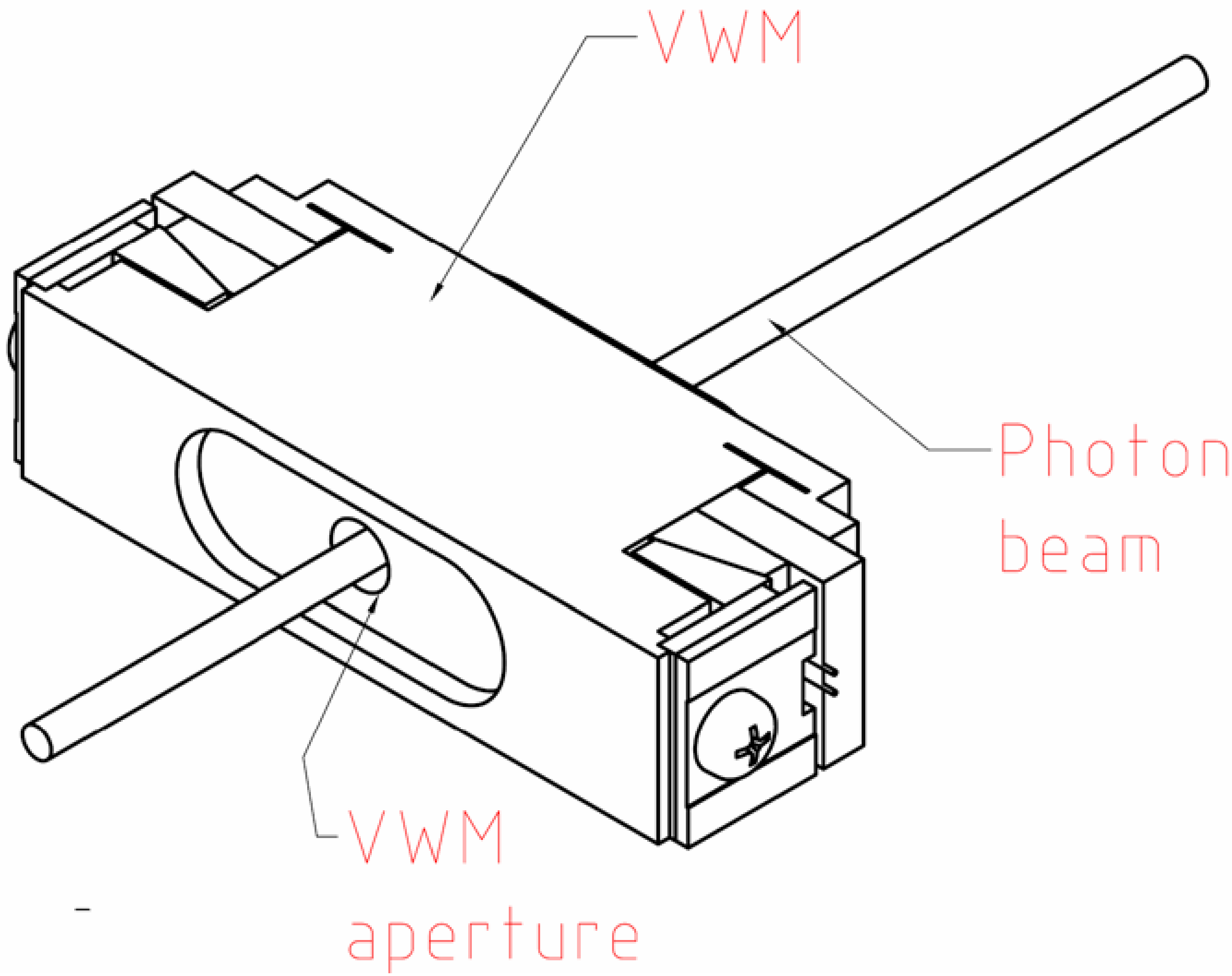
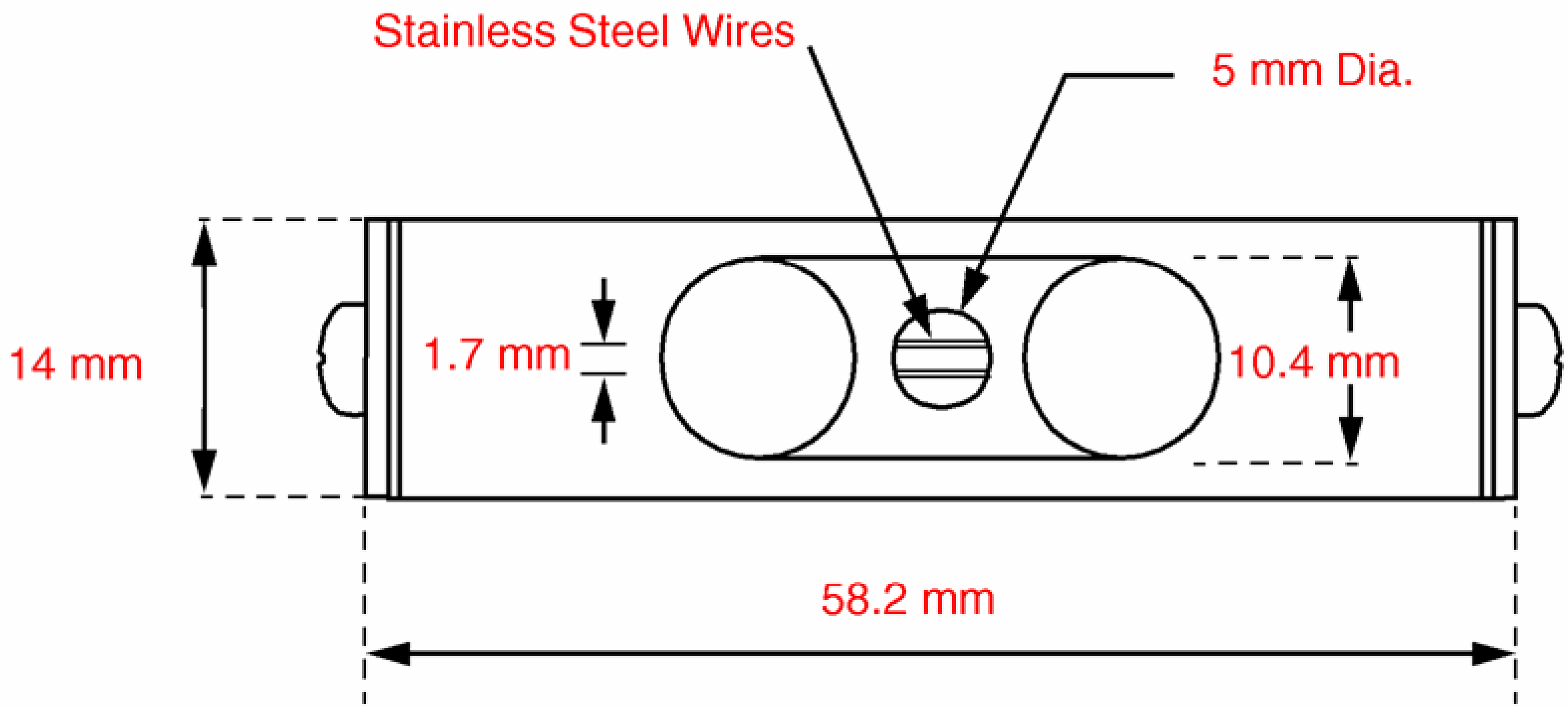
Outline

- Background
- Undulator beam measurements
- Comparison with Theory
- First 5-wire bending magnet radiation measurements

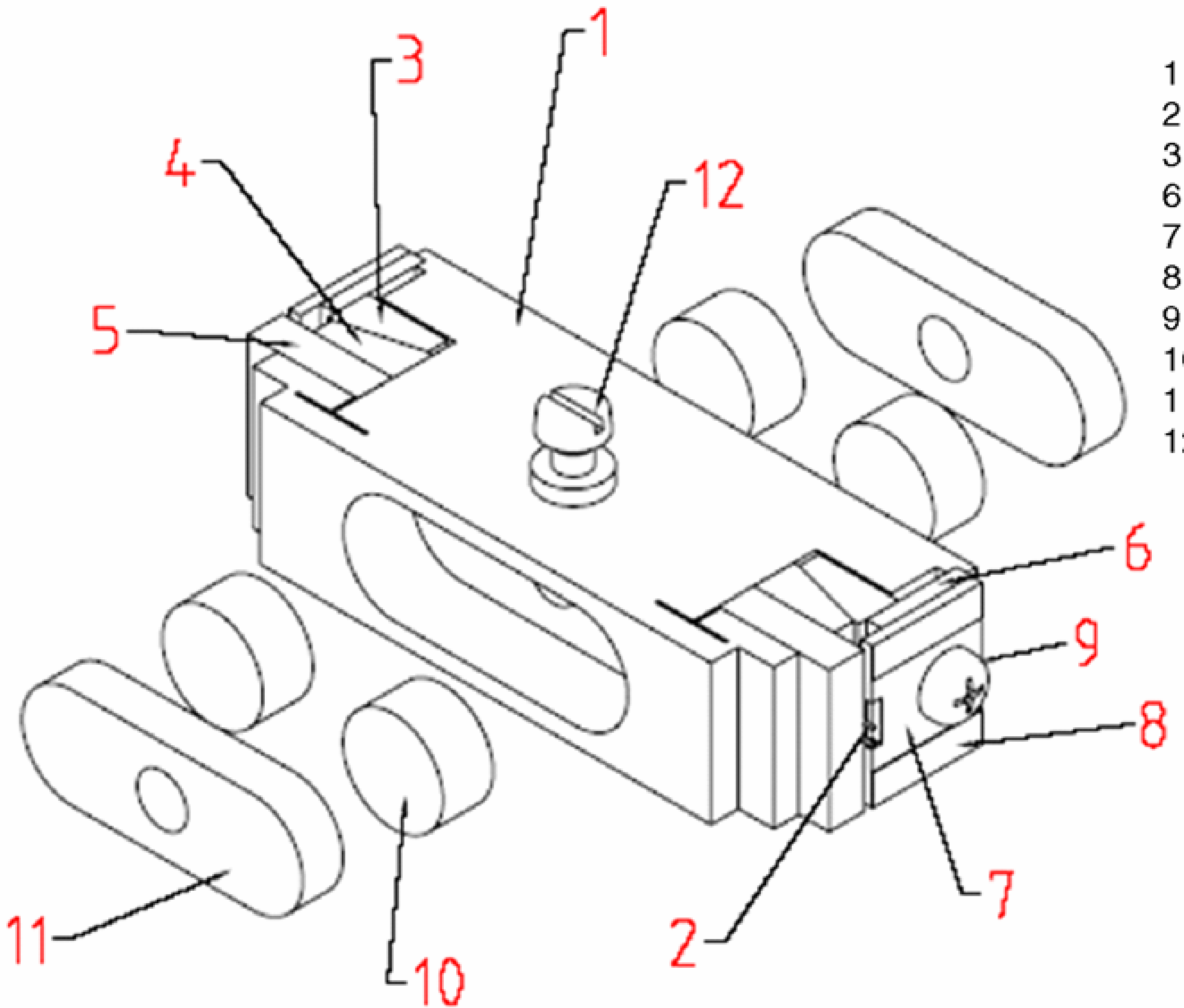
Two-wire Vibrating Wire Monitor used for Undulator Radiation Tests



View along x-ray beam direction

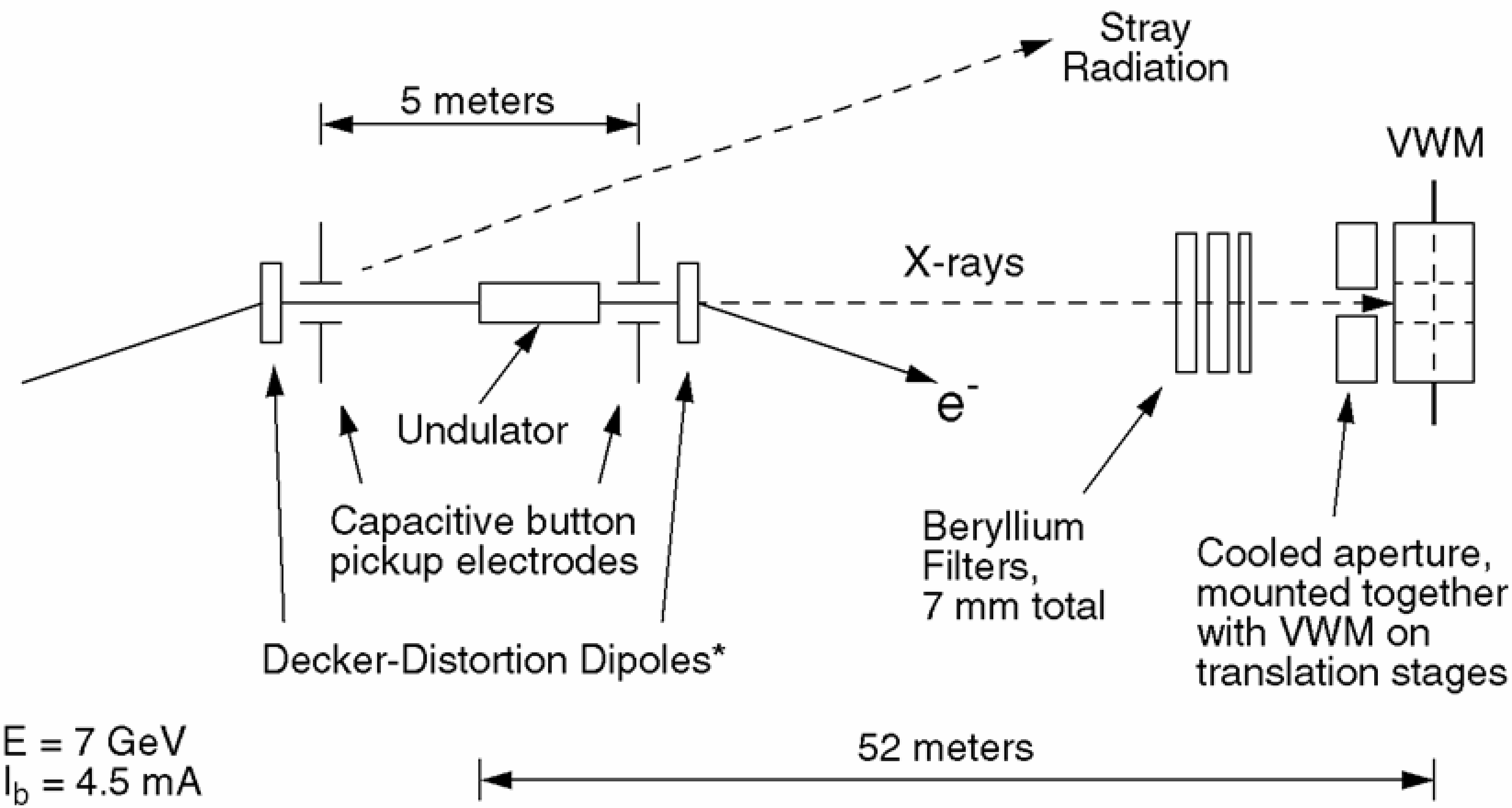


VWM Exploded View



1. VWM Base
2. Vibrating wires
3, 4, 5. Fastening Parts
6. Fastening Plate
7. Contact Plate
8 . Soldering Surfaces
9. Screw
10. Permanent magnet
11. Magnet poles
12. VWM mounting screw

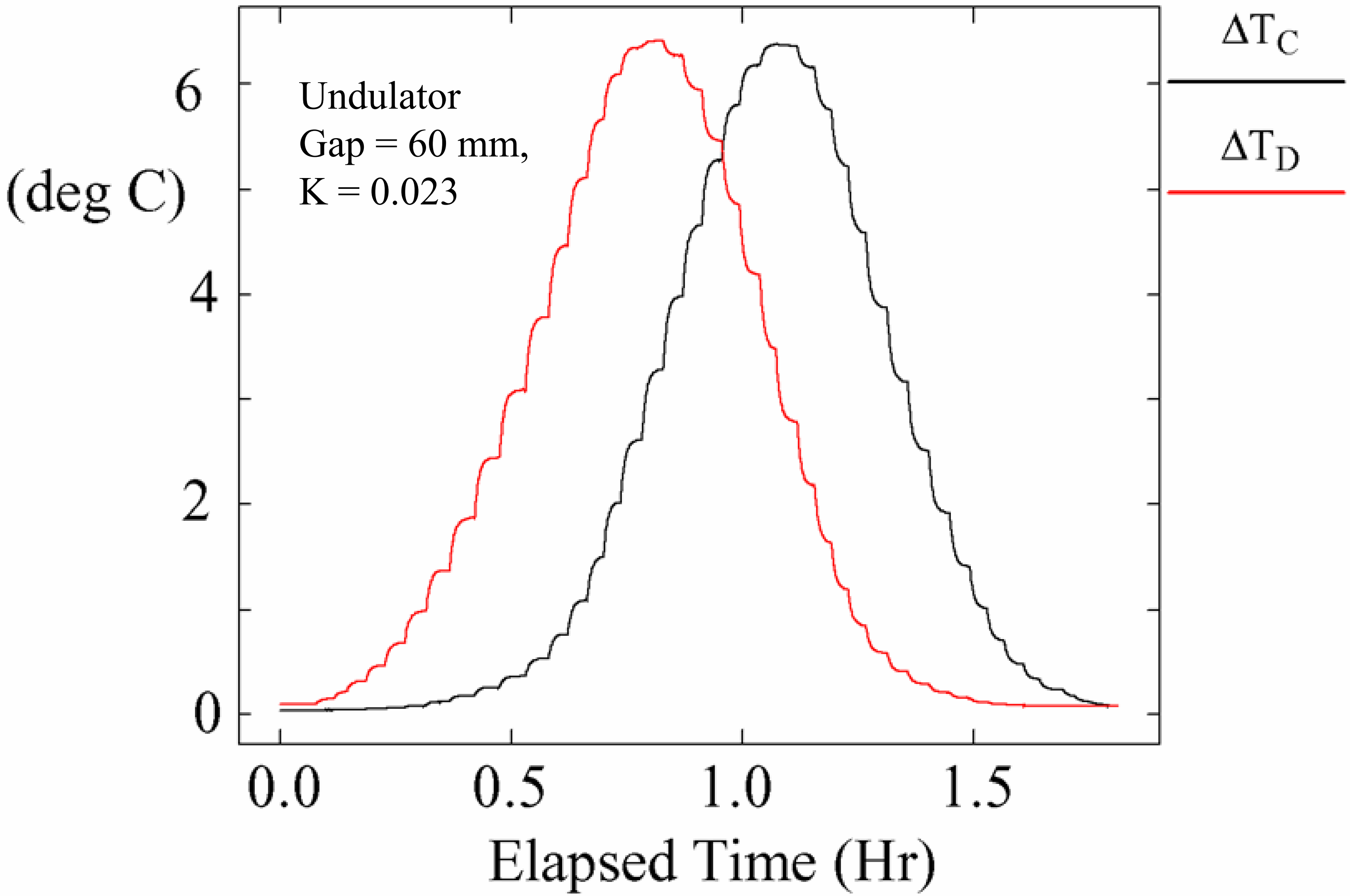
Plan View of VWM@APS Experimental Arrangement



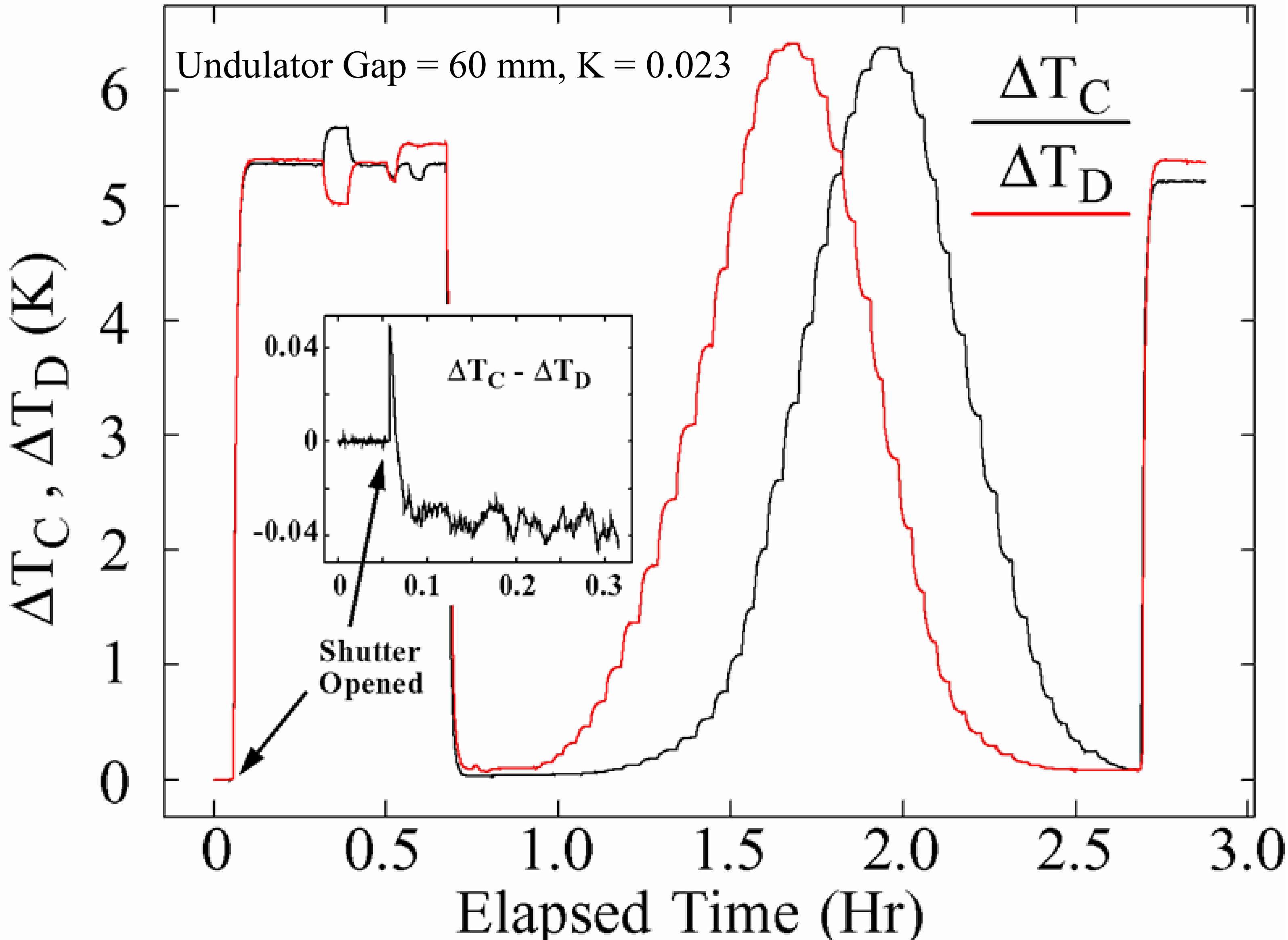
$E = 7$ GeV
$I_b = 4.5$ mA
APS Undulator type A,
Gap = 45 - 80 mm
(normal range 11 - 30 mm)

* G. Decker, O. Singh, *Phys. Rev. ST Accel. Beams* **2**, 11208 (1999).

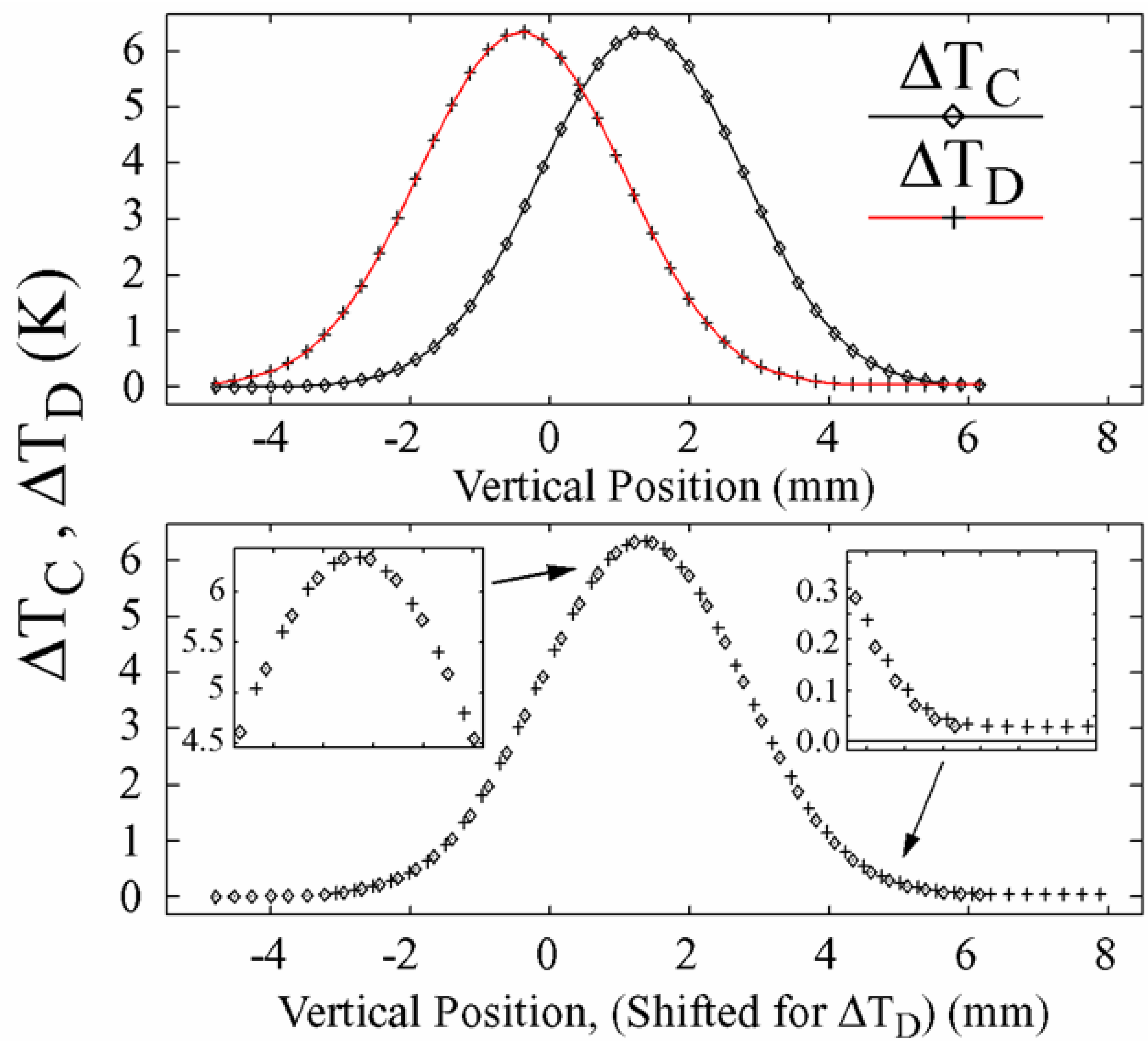
Vertical Undulator Local Bump Angle Scan Data, 5 μrad Steps



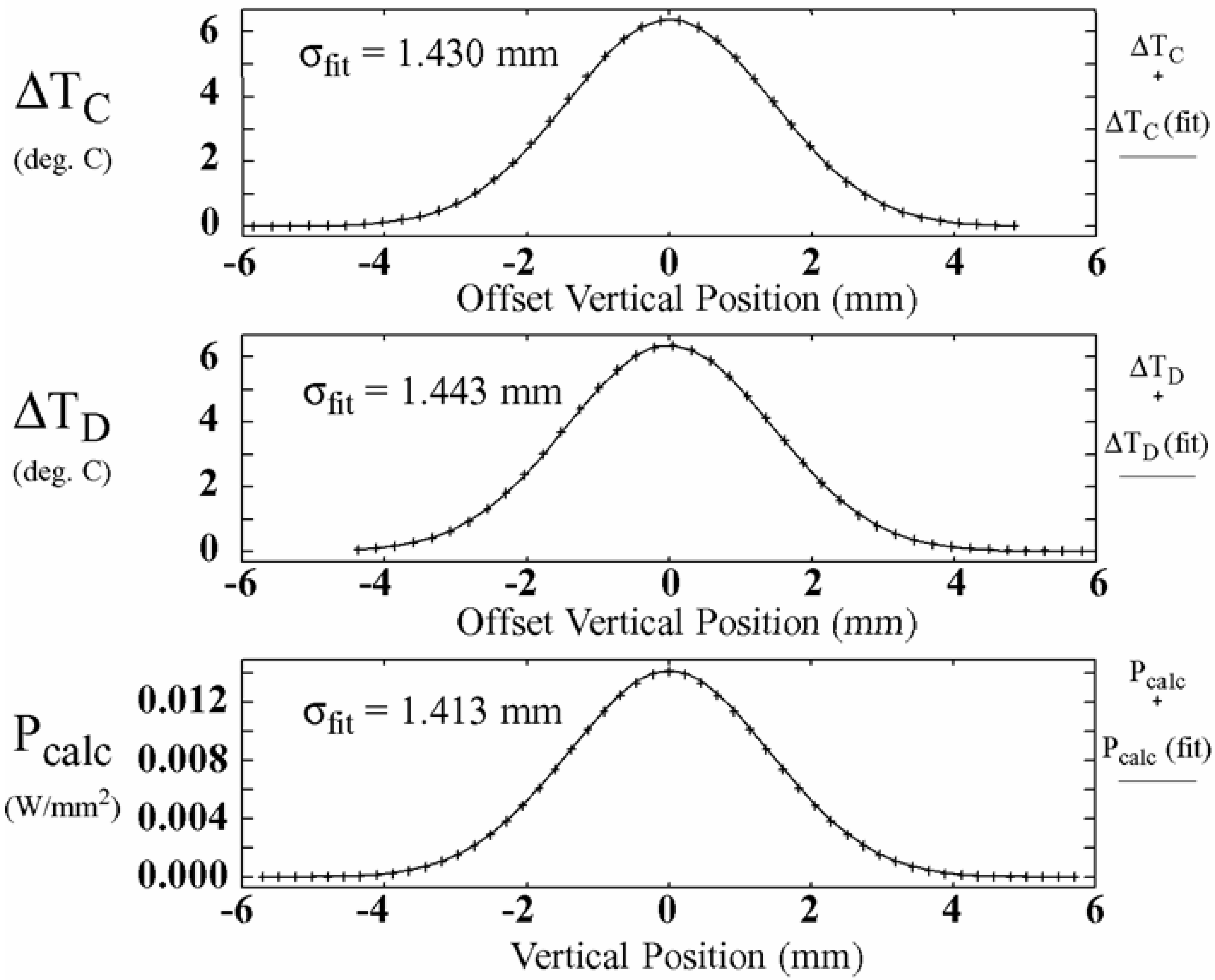
Vertical Undulator Local Bump Angle Scan Data, 5 μrad Steps



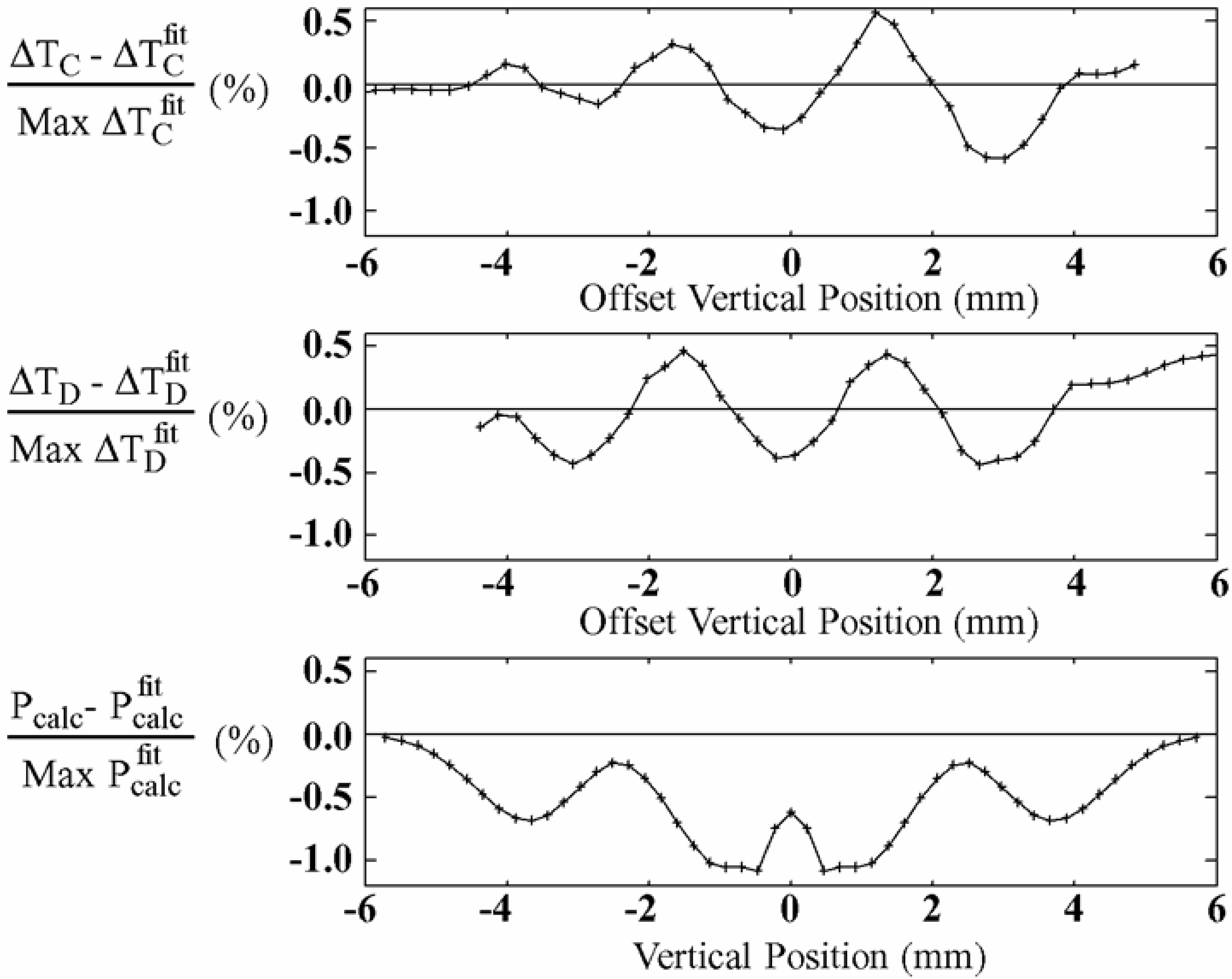
Undulator Beam Profiles after Segment Curve Fitting, Thermal Drift Subtraction, and Beam Current Normalization



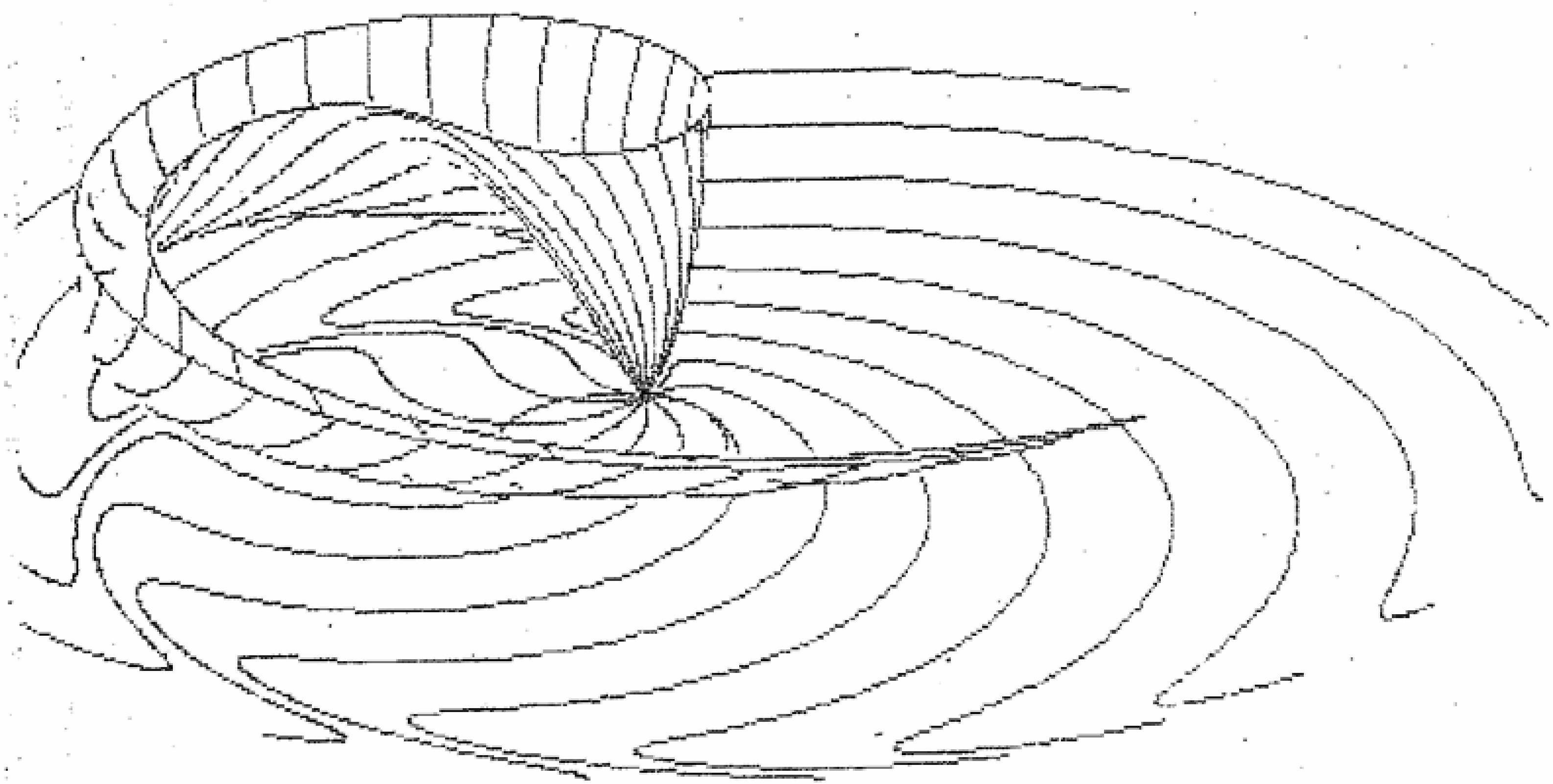
Measured and Calculated Power Density Profiles with Gaussian Fits



Measured and Calculated Power Density Gaussian Fit Residuals

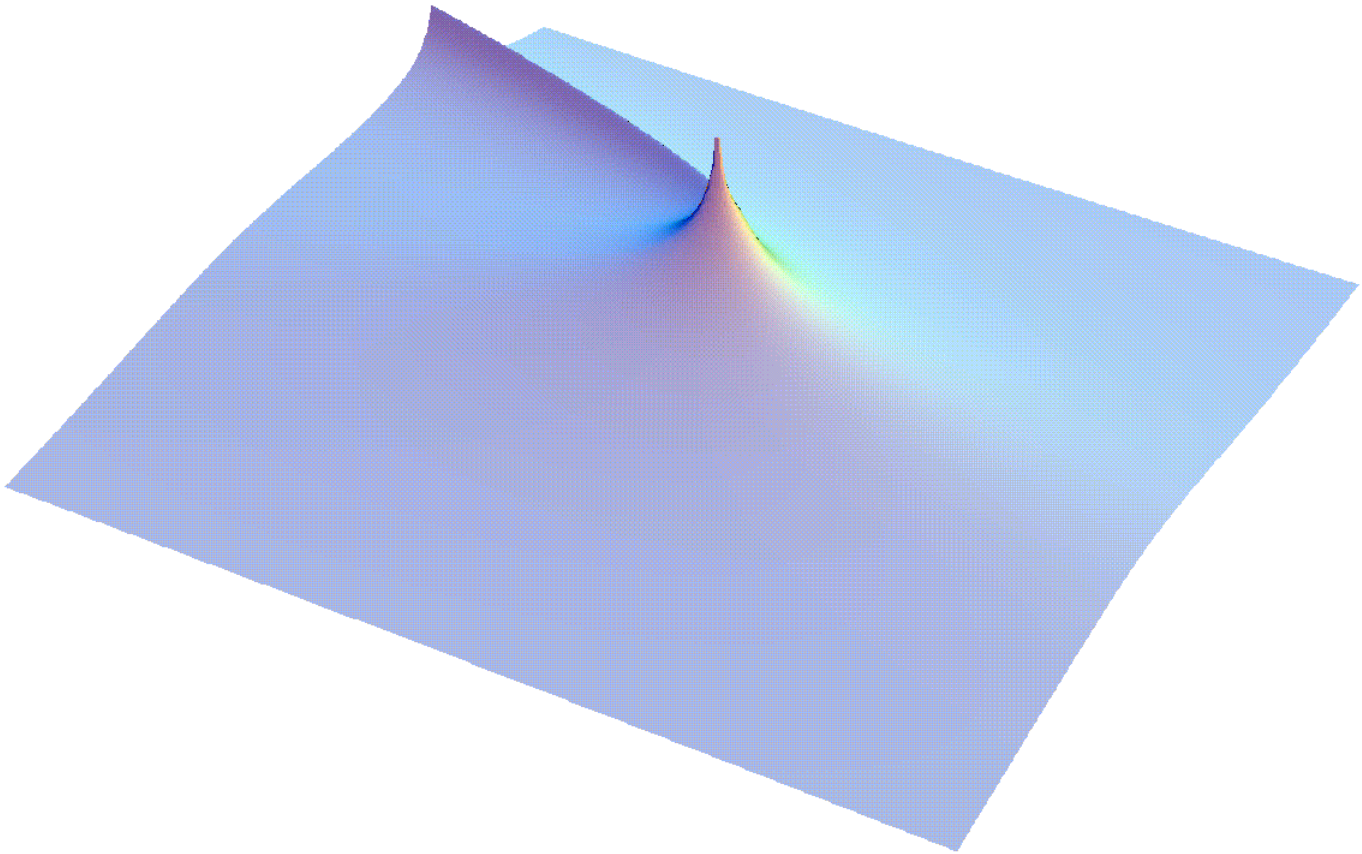


Synchrotron Radiation Electric Field Lines – Circular Motion*

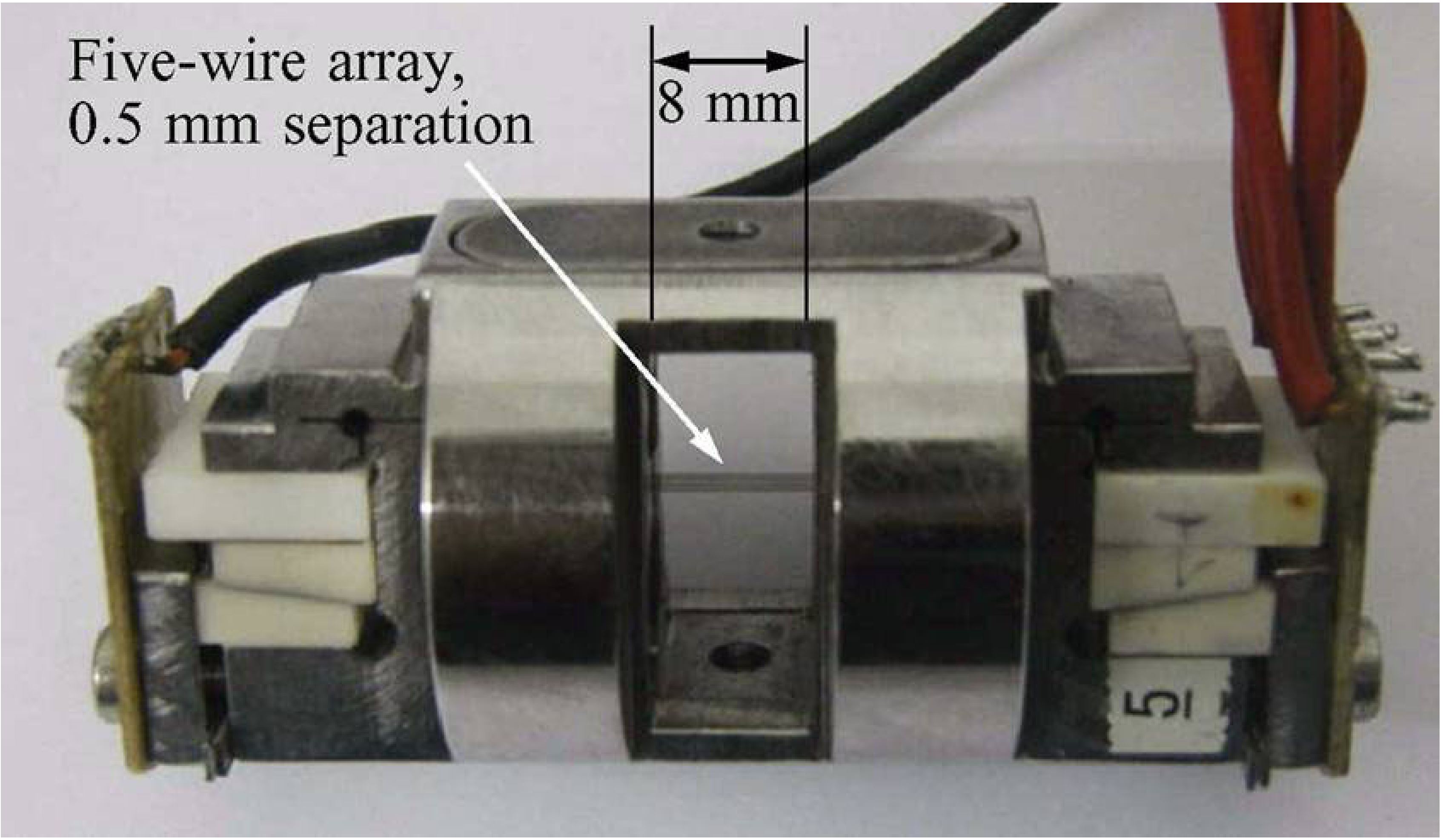


S.G. Arutunian, M.R. Mailian, “Twelve Illustrations of the Synchrotron Radiation Field,” YERPHI-1163-40-89, (1989)

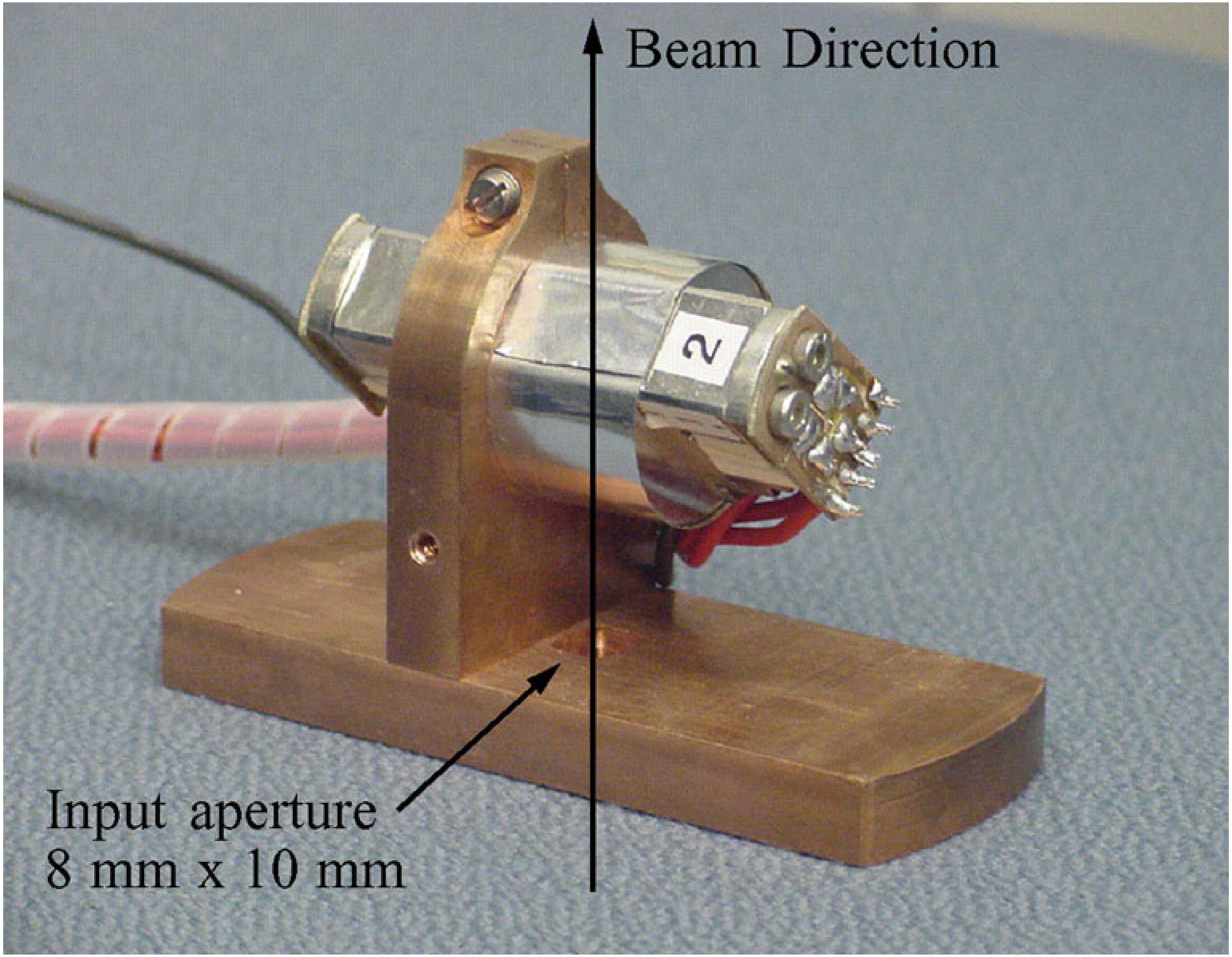
Synchrotron Radiation Wavefront Peeling away from an Electron (Scalar Potential)



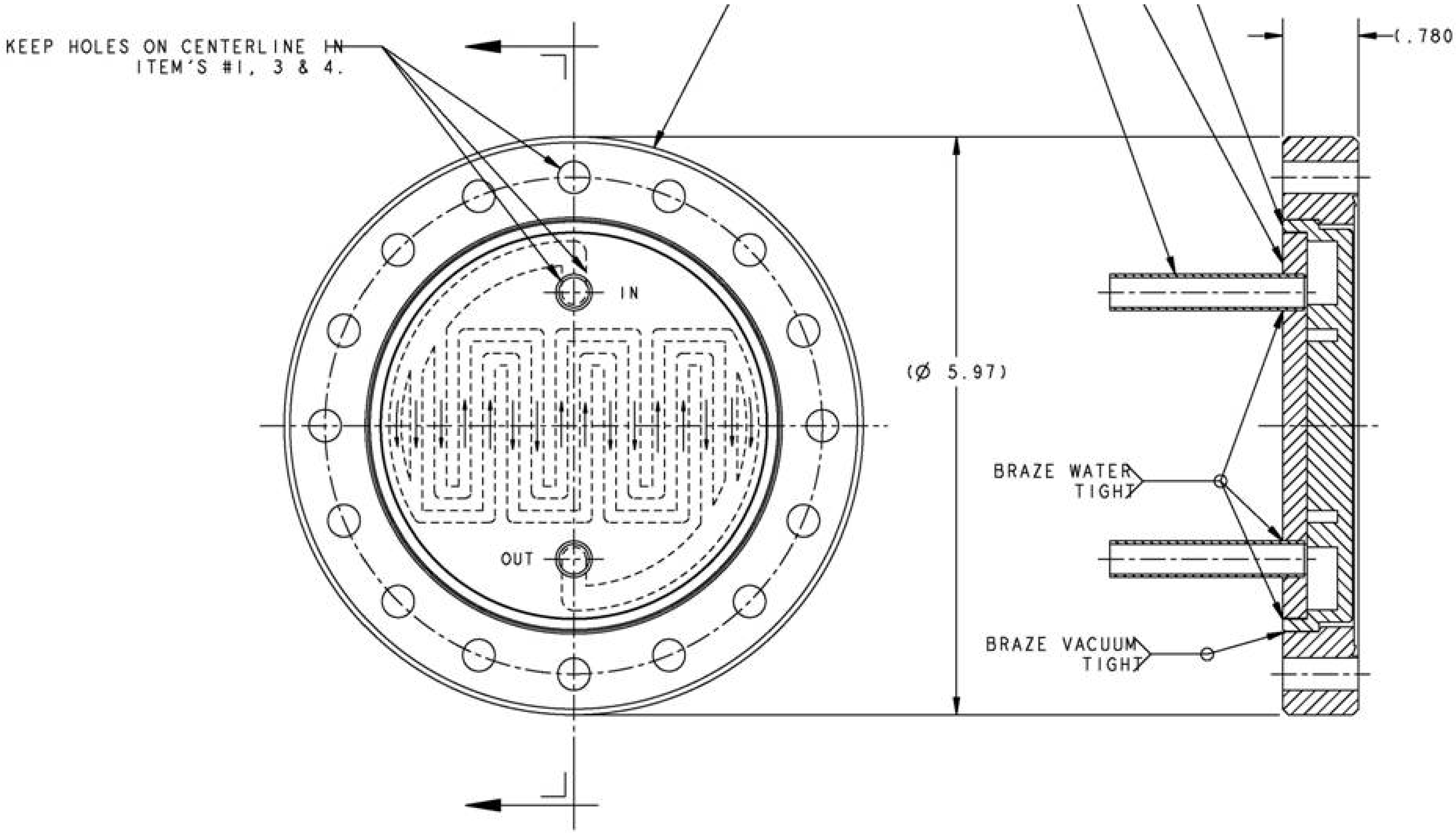
Five-wire In-Air VWM Device for Bending Magnet Radiation



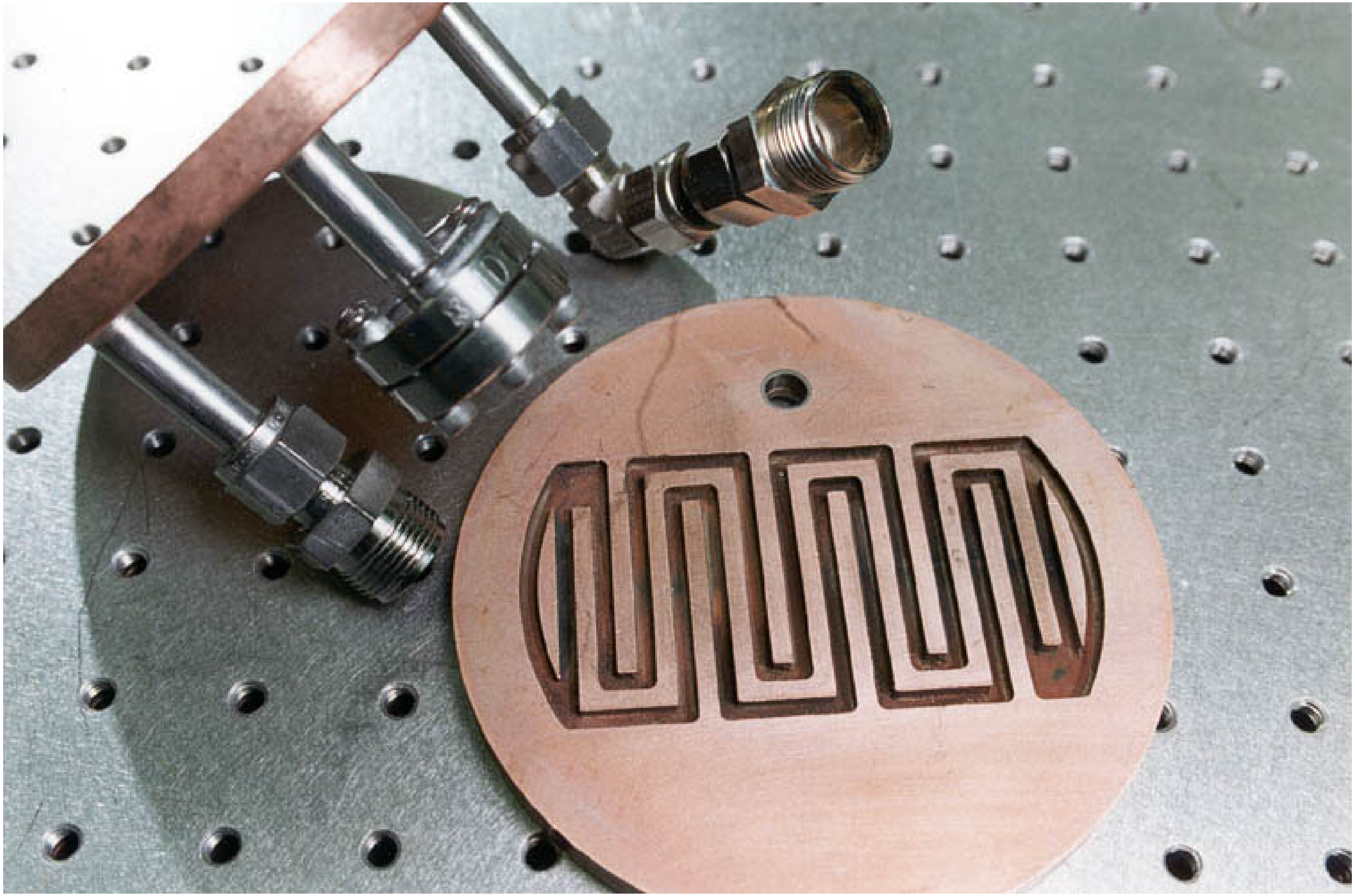
Five-Wire VWM Device for Bending Magnet Radiation with Mounting Mechanism



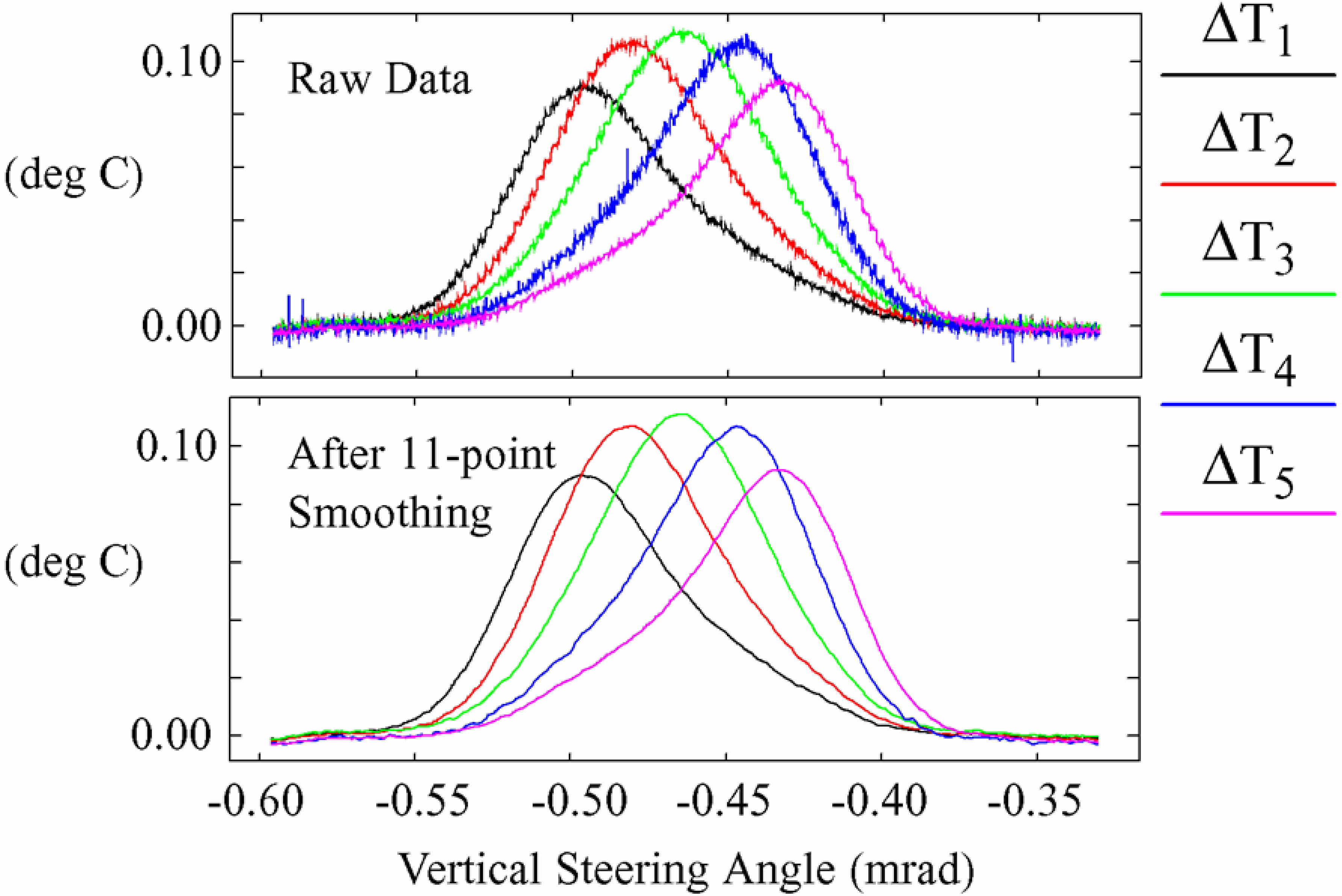
Bending Magnet Beamline Photon Beam Dump



Bending Magnet Beamline Photon Beam Dump



Result of Vertical Angle Scan, BM Source, 2 μrad Steps



Heat Convection Coupling Matrix

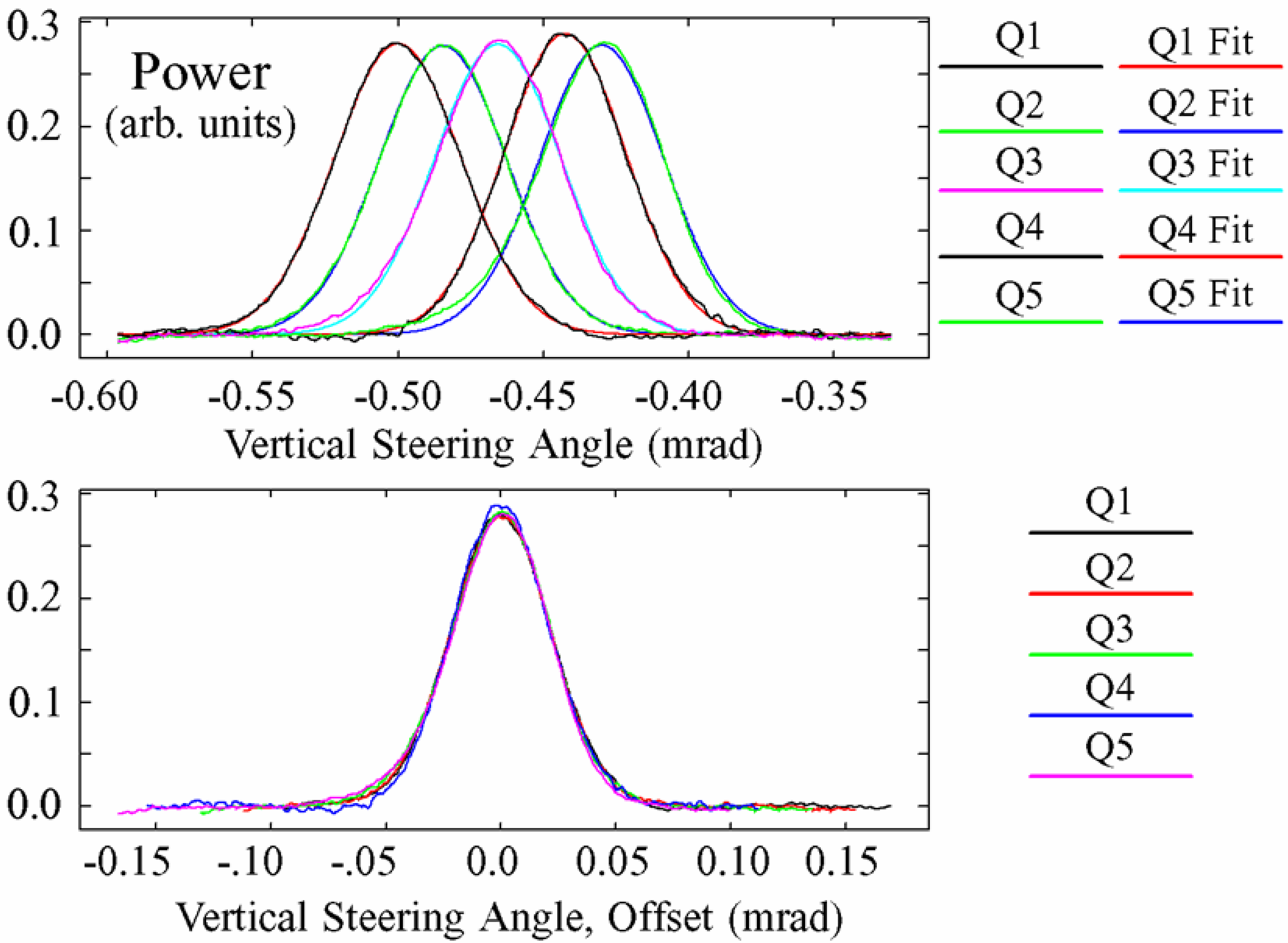
$$Q_1 = \alpha_{11} T_1 + \alpha_{12}(T_1 - T_2) + \alpha_{13}(T_1 - T_3) + \alpha_{14}(T_1 - T_4) + \alpha_{15}(T_1 - T_5)$$

$$Q_2 = \alpha_{12}(T_2 - T_1) + \alpha_{22} T_2 + \alpha_{23}(T_2 - T_3) + \alpha_{24}(T_2 - T_4) + \alpha_{25}(T_2 - T_5)$$

$$Q_3 = \alpha_{13}(T_3 - T_1) + \alpha_{23}(T_3 - T_2) + \alpha_{33} T_3 + \alpha_{34}(T_3 - T_4) + \alpha_{35}(T_3 - T_5)$$

$$Q_4 = \alpha_{14}(T_4 - T_1) + \alpha_{24}(T_4 - T_2) + \alpha_{34}(T_4 - T_3) + \alpha_{44} T_4 + \alpha_{45}(T_4 - T_5)$$

$$Q_5 = \alpha_{15}(T_5 - T_1) + \alpha_{25}(T_5 - T_2) + \alpha_{35}(T_5 - T_3) + \alpha_{45}(T_5 - T_4) + \alpha_{55} T_5$$


0.3
0.2
0.1
0.0
Power
(arb. units)
Q1
Q1 Fit
Q2
Q2 Fit
Q3
Q3 Fit
Q4
Q4 Fit
Q5
Q5 Fit
-0.60
-0.55
-0.50
-0.45
-0.40
-0.35
Vertical Steering Angle (mrad)
0.3
0.2
0.1
0.0
Q1
Q2
Q3
Q4
Q5
-0.15
-.10
-.05
0.0
0.05
0.10
0.15
Vertical Steering Angle, Offset (mrad)

Five-Wire VWM Gaussian Fit Results*

	gfit Centroid		gfit Sigma	
	mrad	mm	microrad	microns
ΔT_1	-0.5001	-3.201	21.96	140.5
ΔT_2	-0.4847	-3.102	21.95	140.5
ΔT_3	-0.4657	-2.981	21.87	140.0
ΔT_4	-0.4426	-2.833	21.01	134.5
ΔT_5	-0.4300	-2.752	21.51	137.7

* H / V machine coupling = 5.3%

Note centroid distance wire 1 to wire 5 is 0.45 mm vs. 2 mm actual

>>> Inclination angle = arcTan(0.45 / 2) = 12.7 degrees

Effect of Vertical Particle Beam Size on Measured Photon Beam Size*

gfit Sigma	Coupling = 5.3 %		Coupling = 2.6 %	
	microrad	microns	microrad	microns
ΔT_1	21.96	140.5	19.88	127.2
ΔT_2	21.95	140.5	19.96	127.7
ΔT_3	21.87	140.0	20.00	128.0
ΔT_4	21.01	134.5	19.29	123.4
ΔT_5	21.51	137.7	19.43	124.3

*Coupling change from 5.3 % to 2.6% corresponds to nominal change in vertical rms particle beam size from 58 to 40 microns

Conclusions

- Vibrating wire monitors provide quantitative measure of hard x-ray power density.
- Detectors are sensitive to sub-milliwatt levels of beam power.
- Temperature changes as low as milliKelvins resolved.
- Five-wire unit with inclination provides possibility of providing real-time beam size monitoring of beam size less than 100 microns with 100-micron diameter wires.