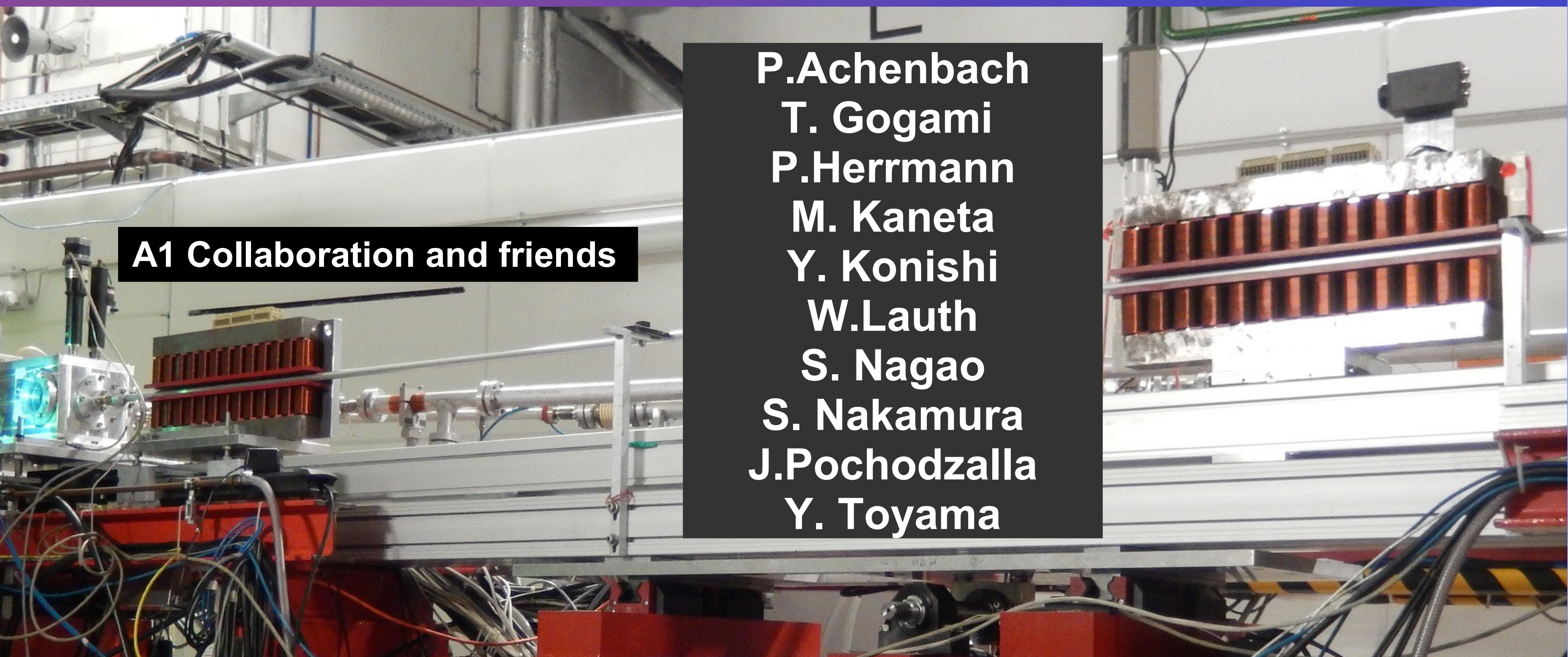
Systematic effects in the beam energy measurements by undulator radiation at MAMI



A1 Collaboration and friends

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A1

mami MAINZER MIKROTRON

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05.11.2020

JG|U

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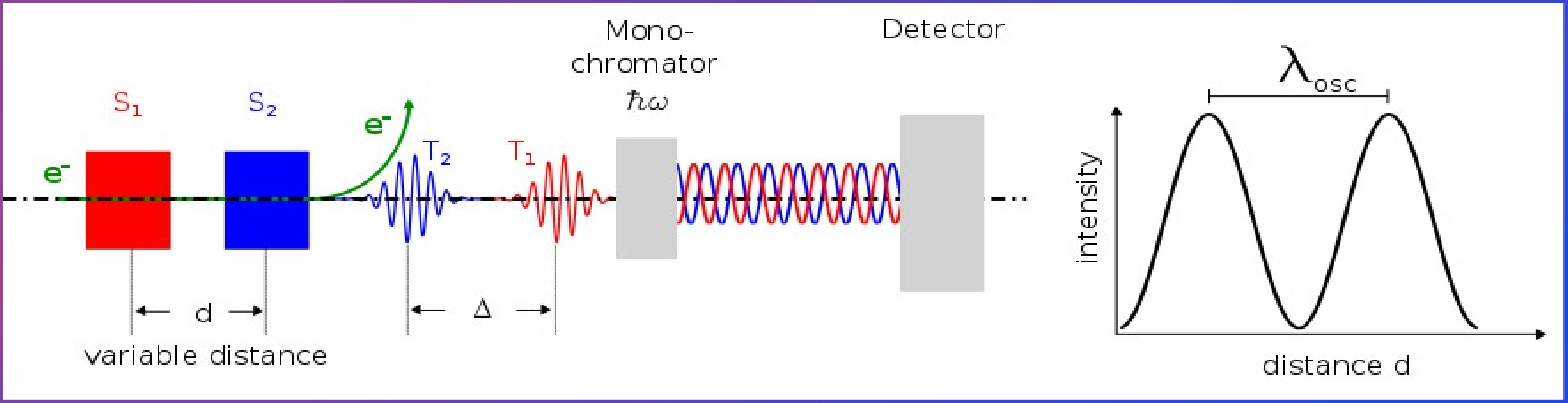
Method

Coherent sources	Wave packets	Monochromatic light	Light intensity of selected wavelength

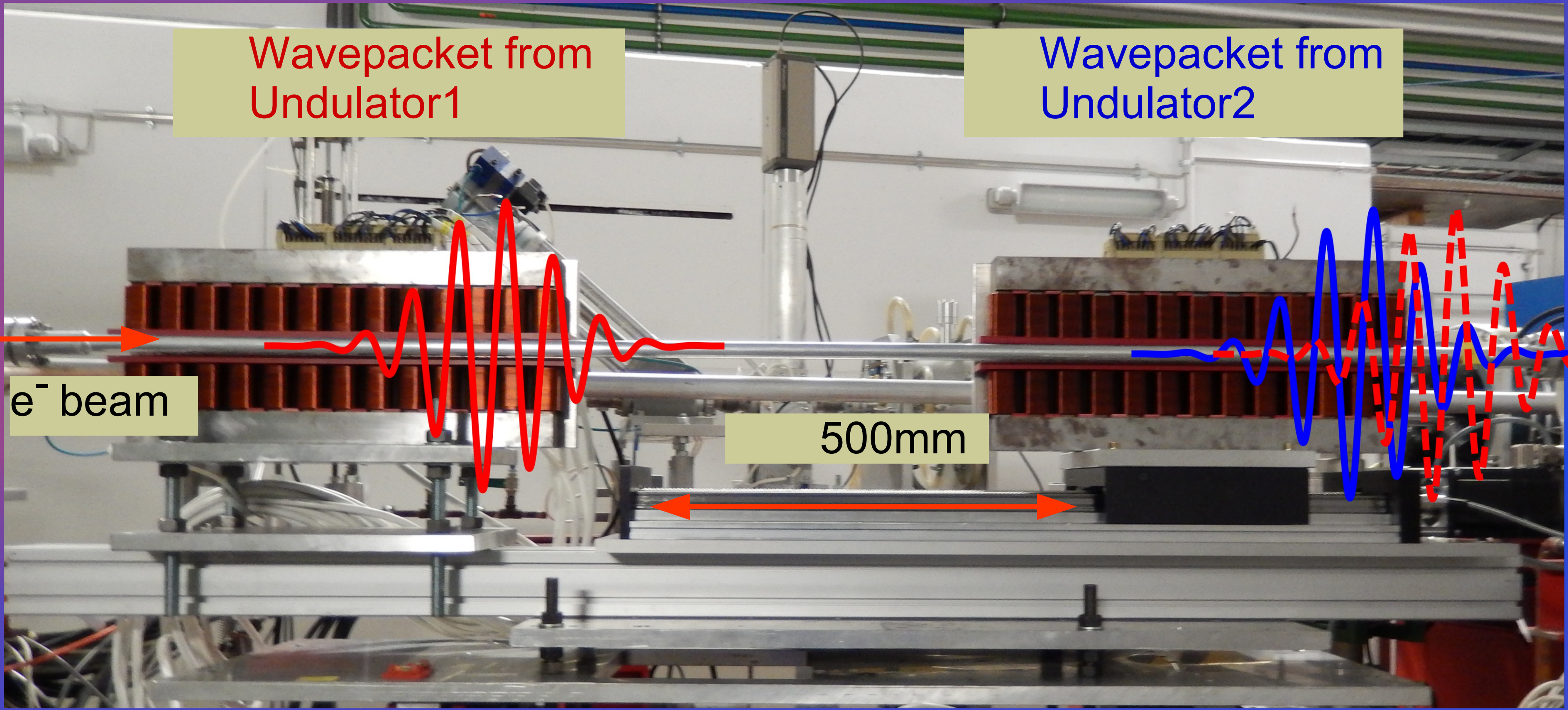


$$\lambda_{osc} = 2\gamma^2 \lambda_L$$

Example for wavelength and period

$$\left.\begin{array}{l}\lambda_L \approx 400\text{nm} \\ \gamma \approx 381\text{, E=195MeV}\end{array}\right\} \lambda_{osc} \approx 116\text{mm}$$

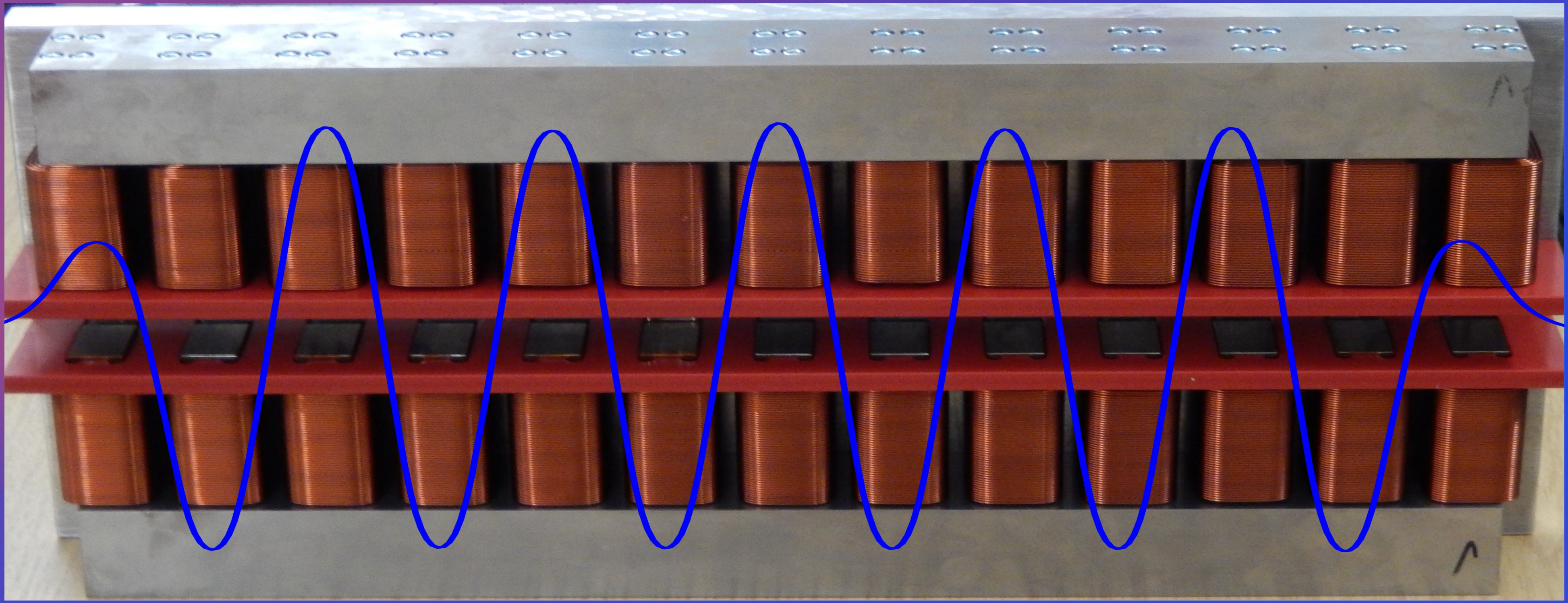
Undulators as sources for coherent radiation (former setup)



To Measure the oszillation period the second undulator ist moved by a motorized stage

Undulatorfield

500mm

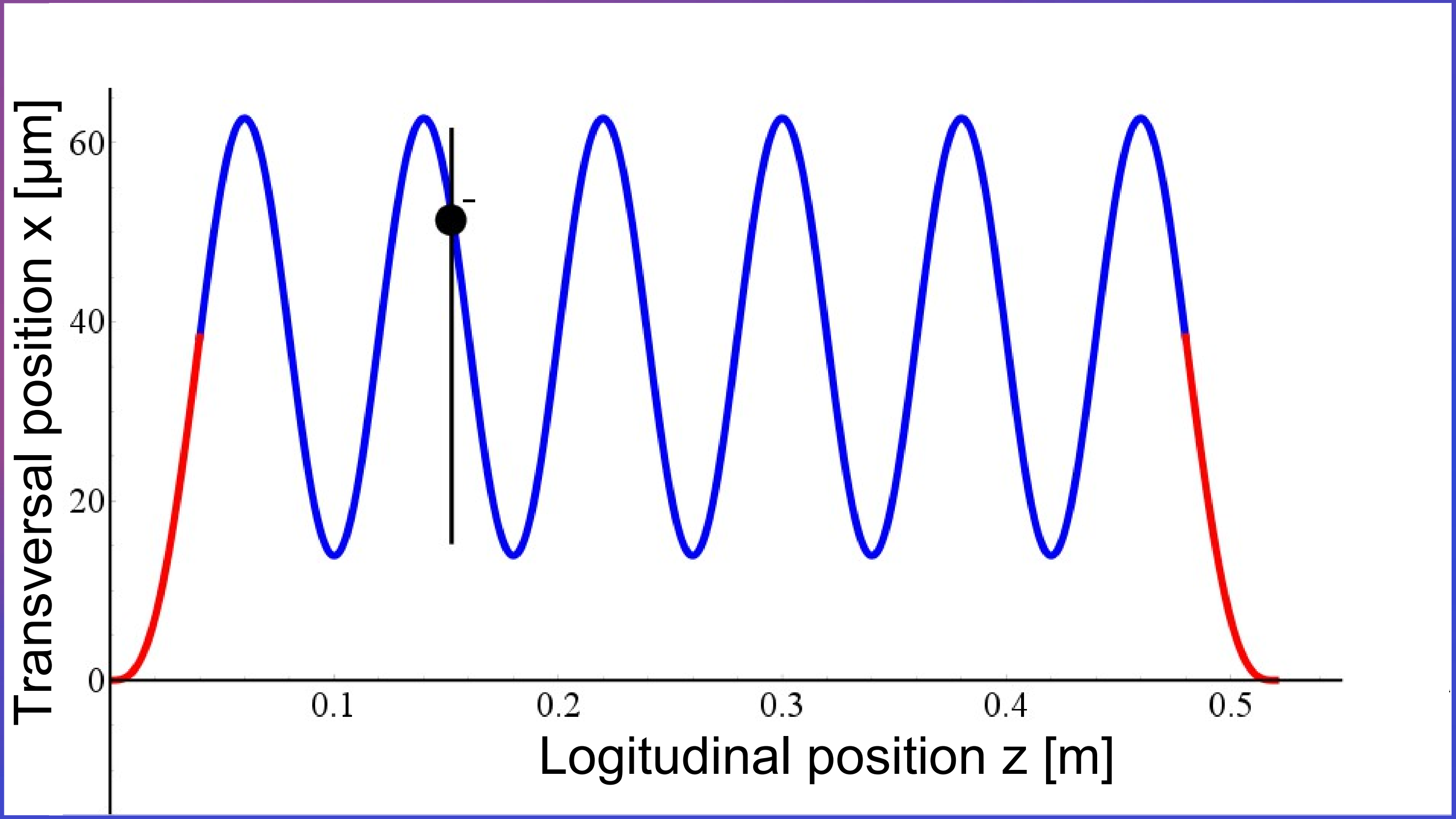


$B = \pm 100\, mT$

80mm

Undulator period λ_U

Emission of synchrotron radiation



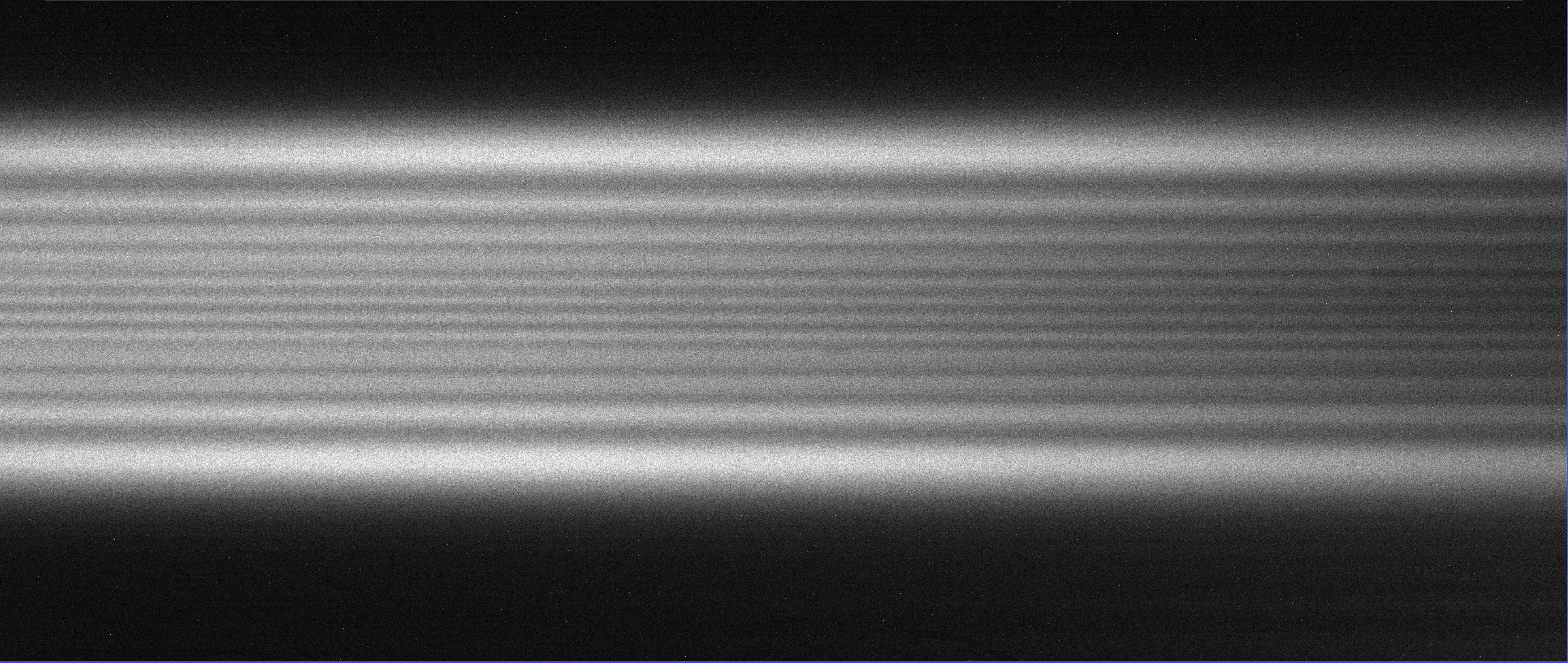
- Electrons oscillate perpendicular to the z-Axis
- The black bar suggests the idea of a high relativistic antenna moving towards the observer
- Emission takes place only in a finite length

Timeline of 2020

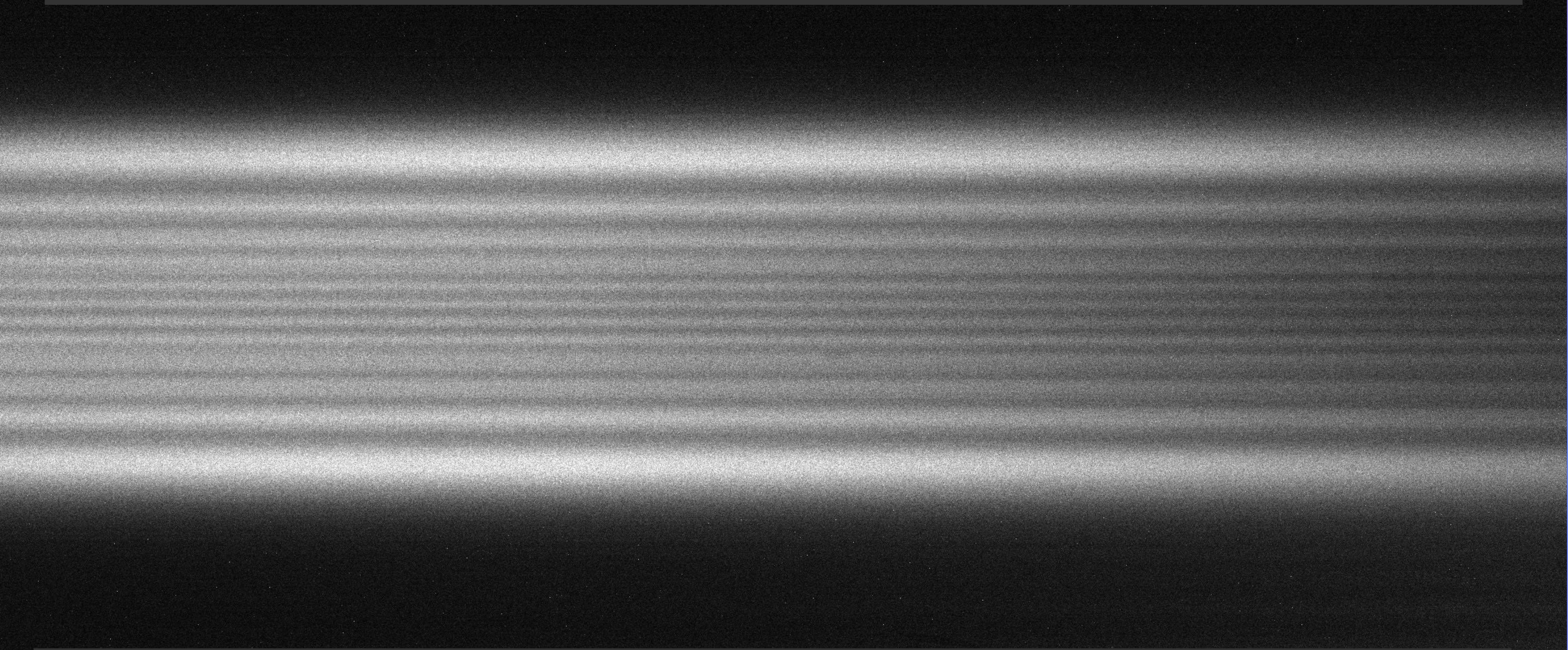
March 2020	195 MeV 180 MeV	No regulation	+Spectro meter	MAMI Energy at 195MeV
	180 MeV	With regulation		
June 2020	195 MeV	No regulation		MAMI Energy
	195 MeV	With regulation		MAMI Energy

First Time in history of MAMI

Typical Undulator spectrum

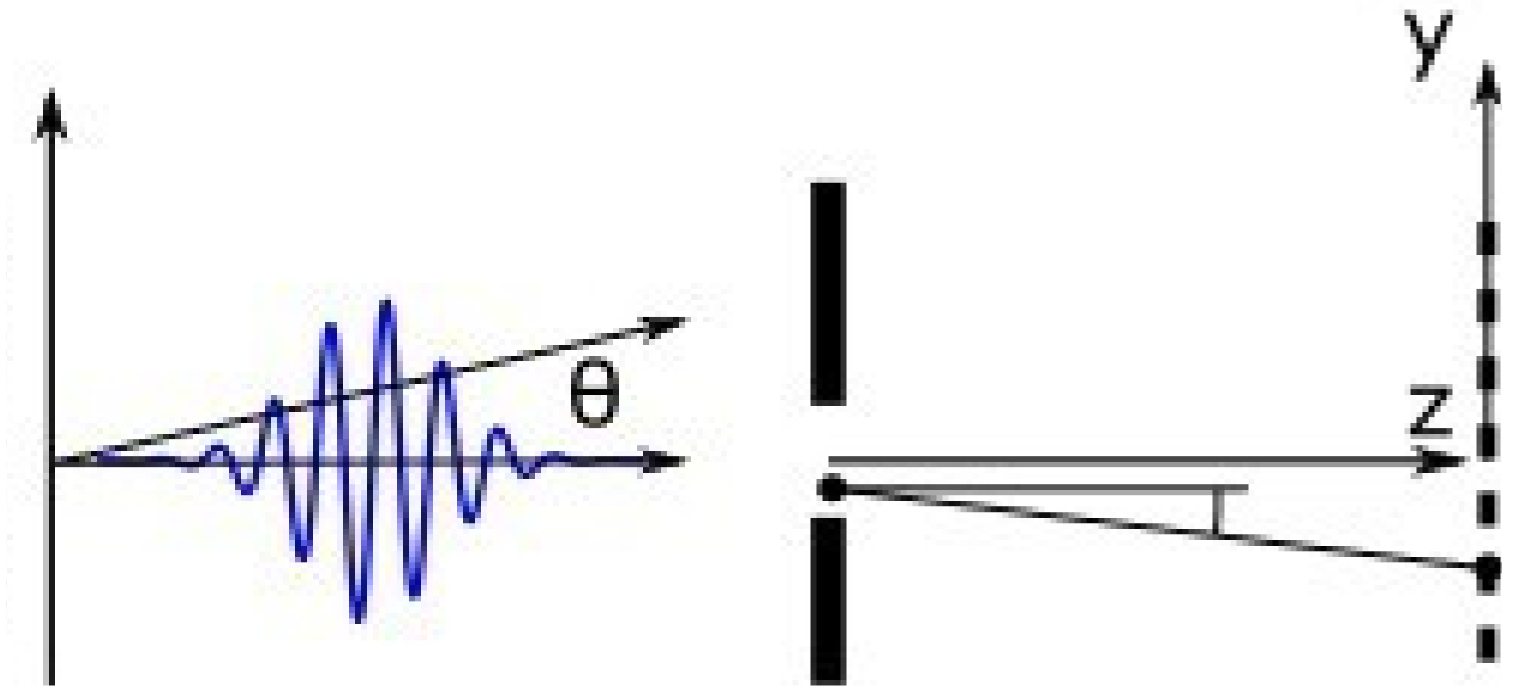


Typical Undulator spectrum

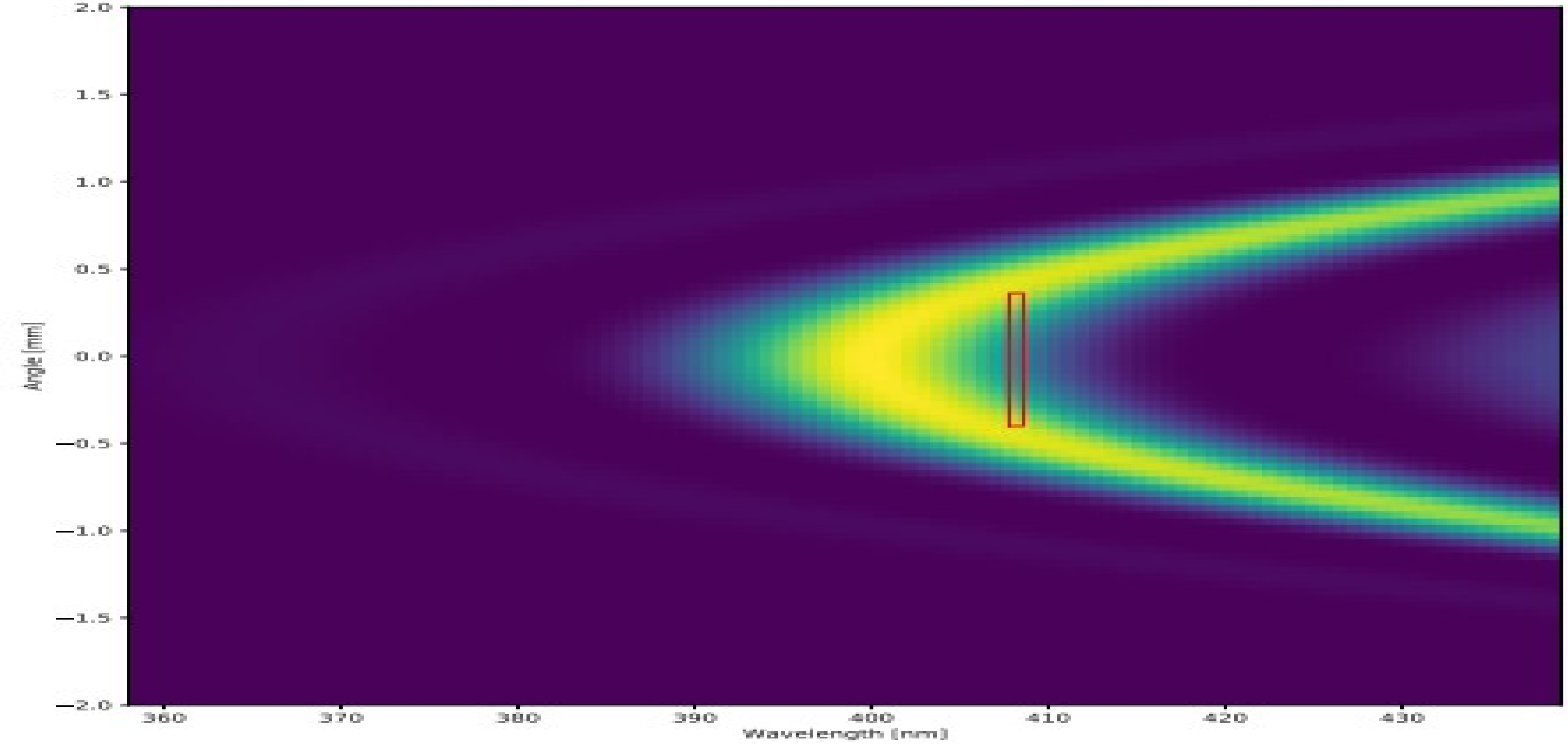


The stripes arise from Fresnel diffraction

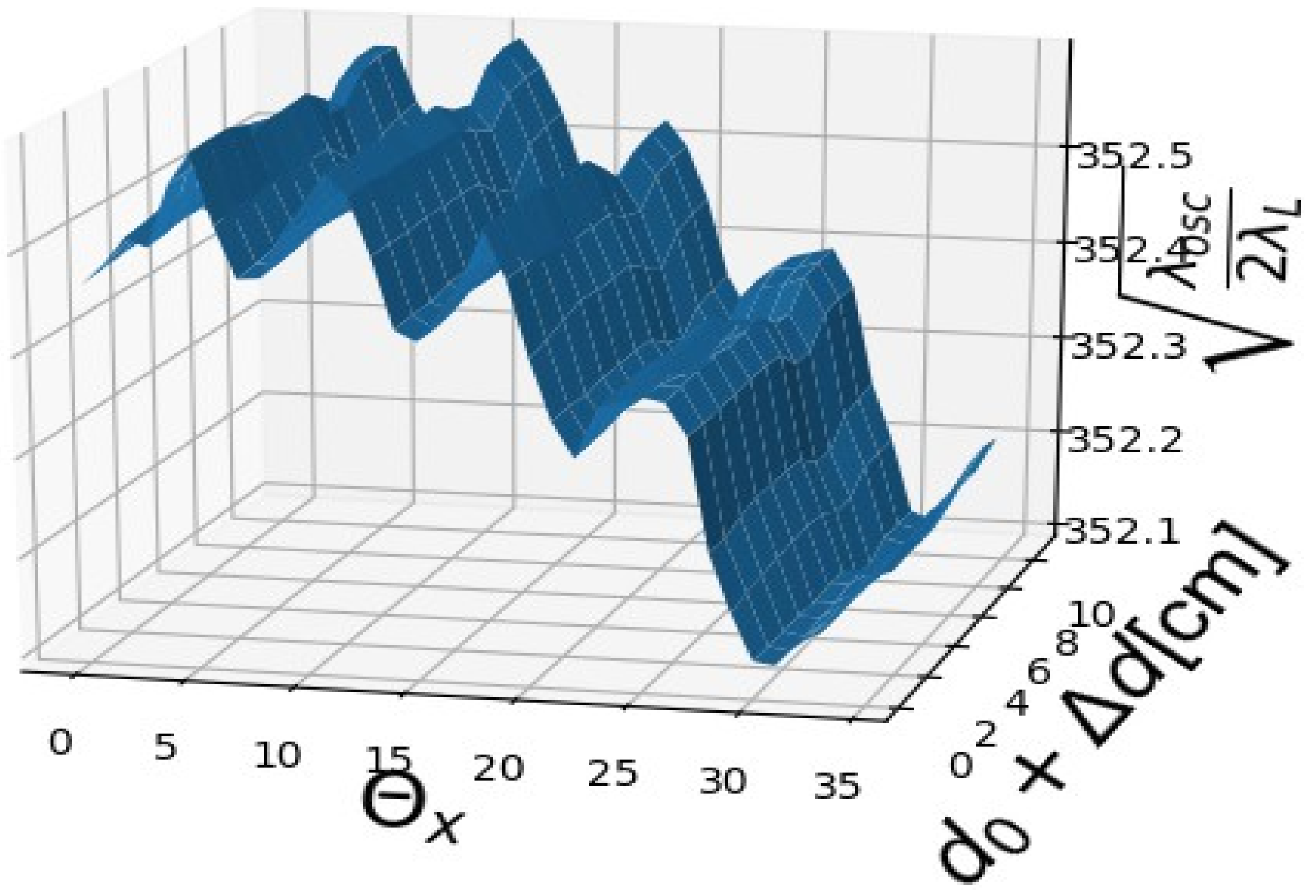
Where diffraction occures

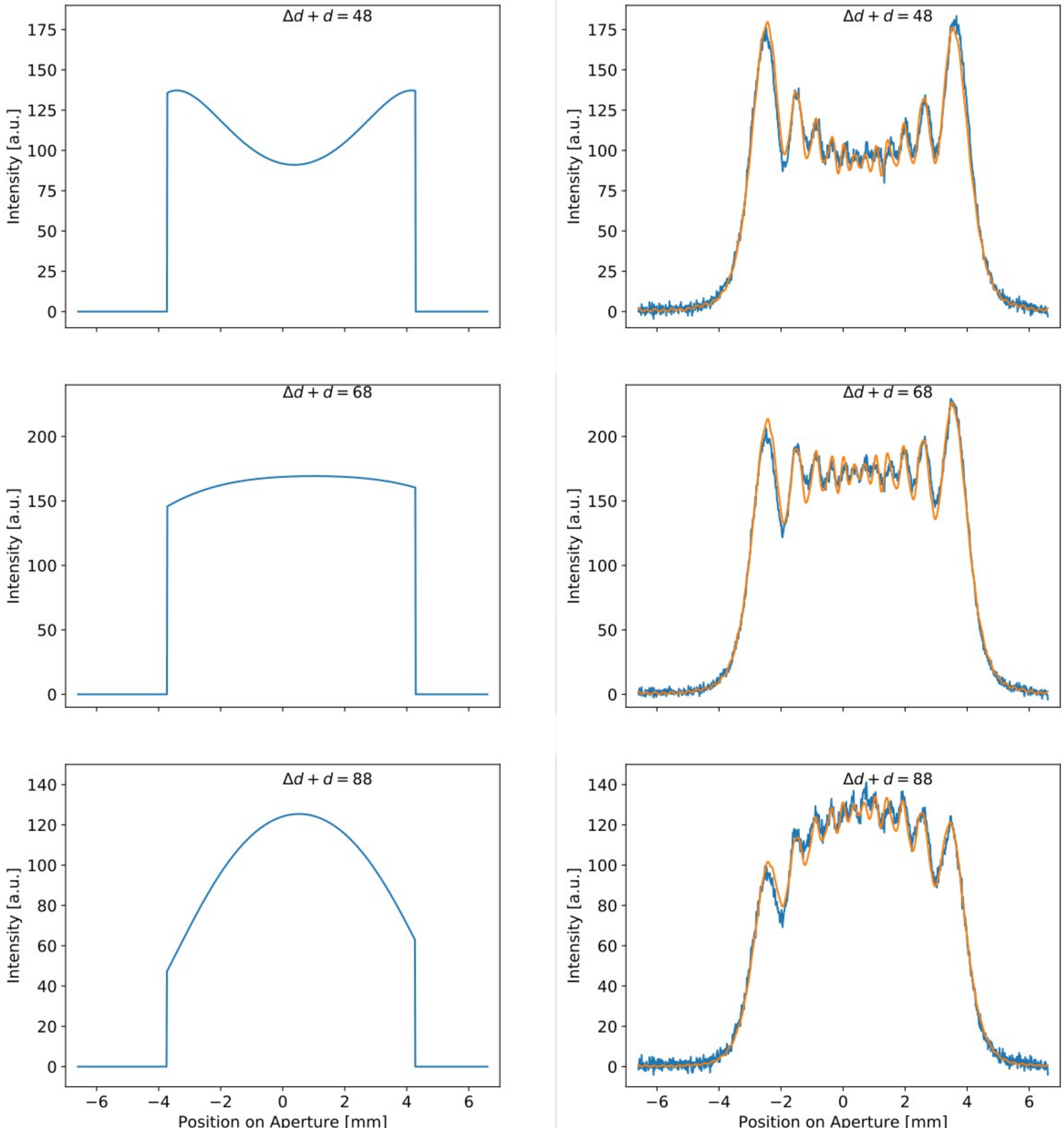


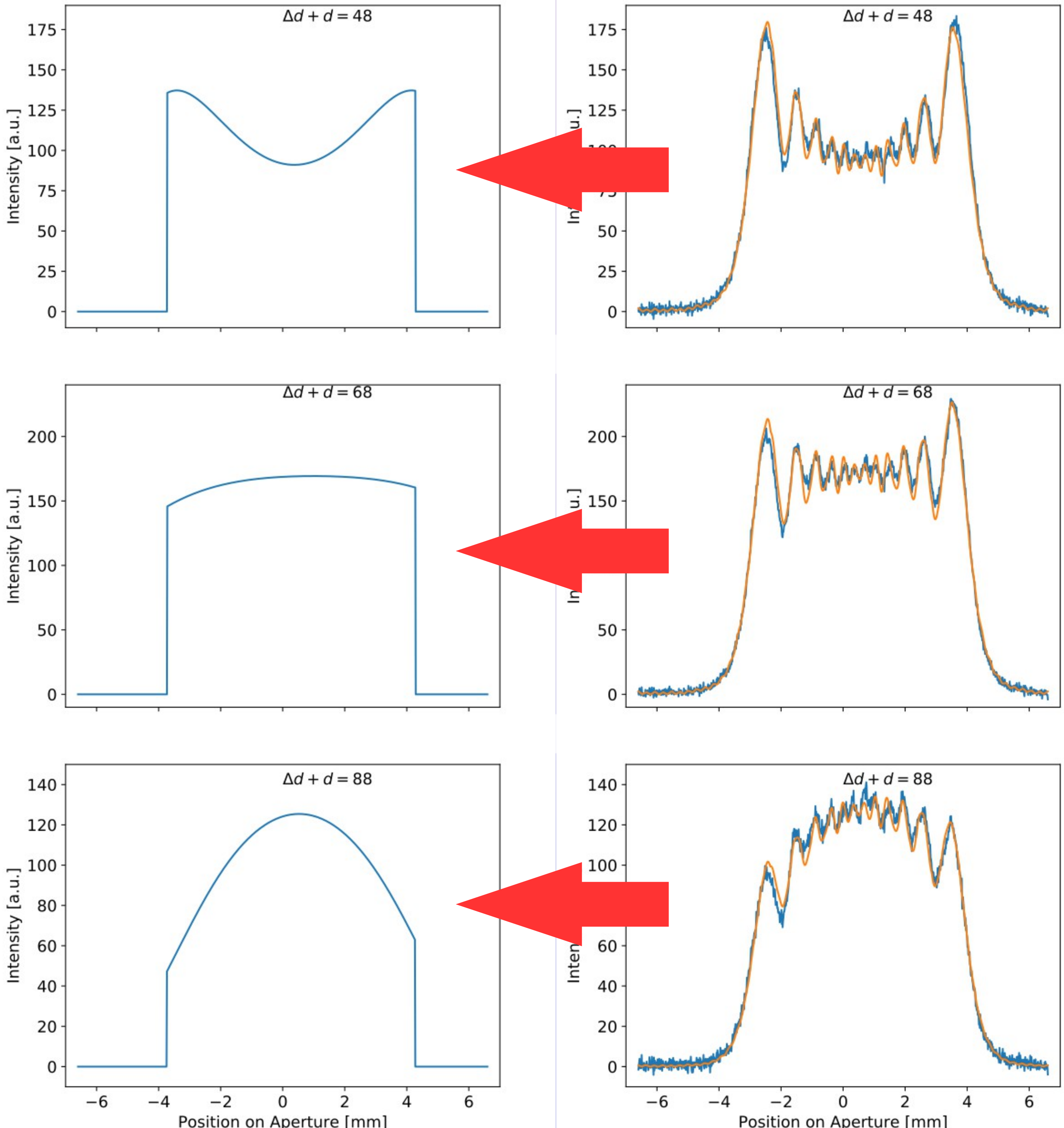
Undulator spectrum no Diffraction



Gamma is affected by the Pattern




Δd + d = 48
Δd + d = 48
Δd + d = 68
Δd + d = 68
Δd + d = 88
Δd + d = 88
Intensity [a.u.]
Position on Aperture [mm]


Δd + d = 48
Δd + d = 68
Δd + d = 88
Intensity [a.u.]
Position on Aperture [mm]

Fourier optics

Rayleigh Sommerfeldintegral:

$$E(x', y', z_0) = \iint i \cdot \frac{\cos\theta}{\lambda} \cdot \frac{E(x, y, 0)}{r} e^{ikr} \; dx\, dy$$

Spherical wave

Fourier optics

Undulator spectrum before aperture

$$E(x', y', z_0) = \iint i \cdot \frac{\cos\theta}{\lambda} \cdot \frac{E(x, y, 0)}{r} e^{ikr} \; dx\, dy$$

Undulator spectrum after aperture

Fourier optics in Fresnel approx.

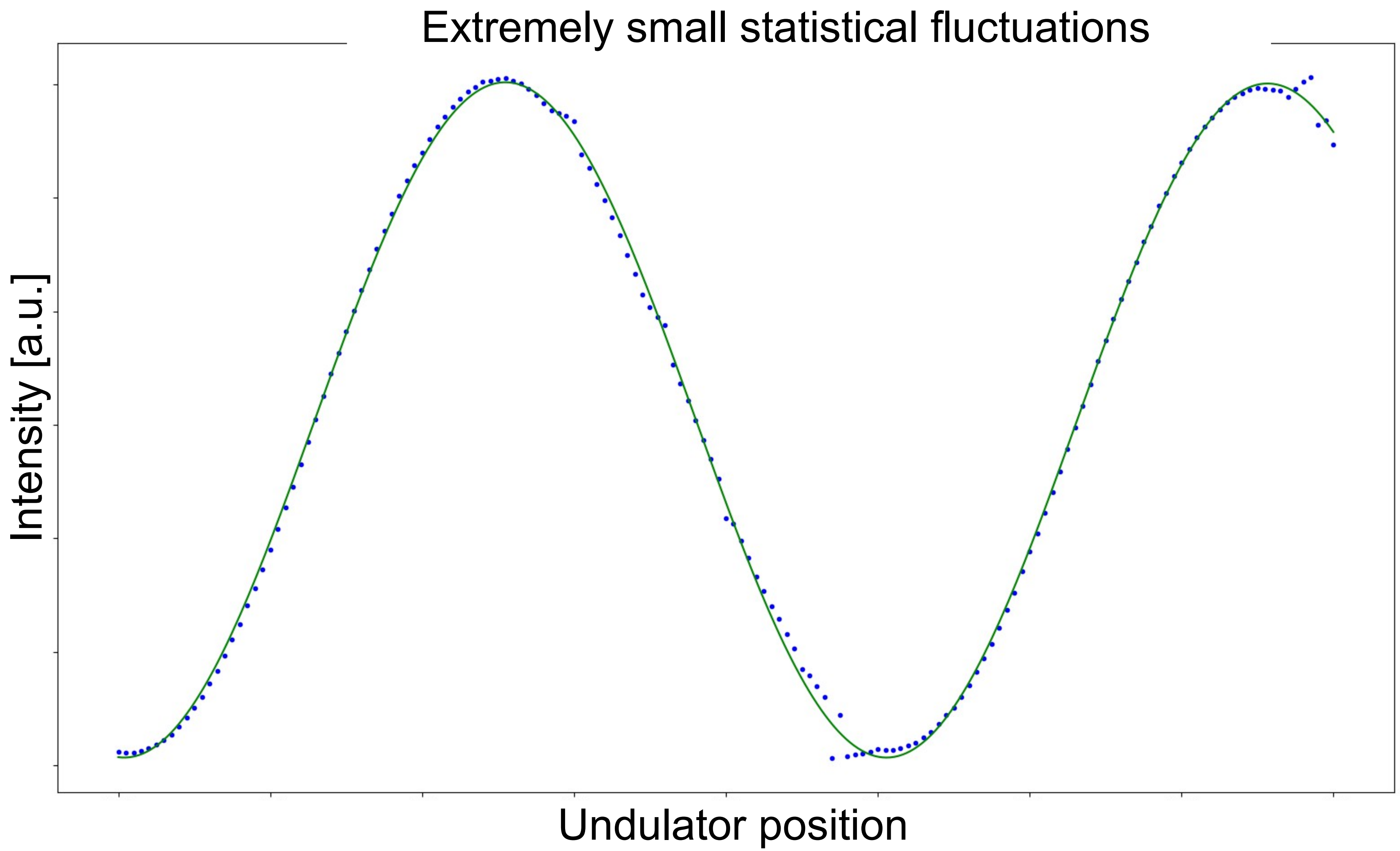
$$E(x', y', z_0) = \iint i \cdot \frac{\cos\theta}{\lambda} \cdot \frac{E(x, y, 0)}{r} e^{ikr} \; dx\, dy$$

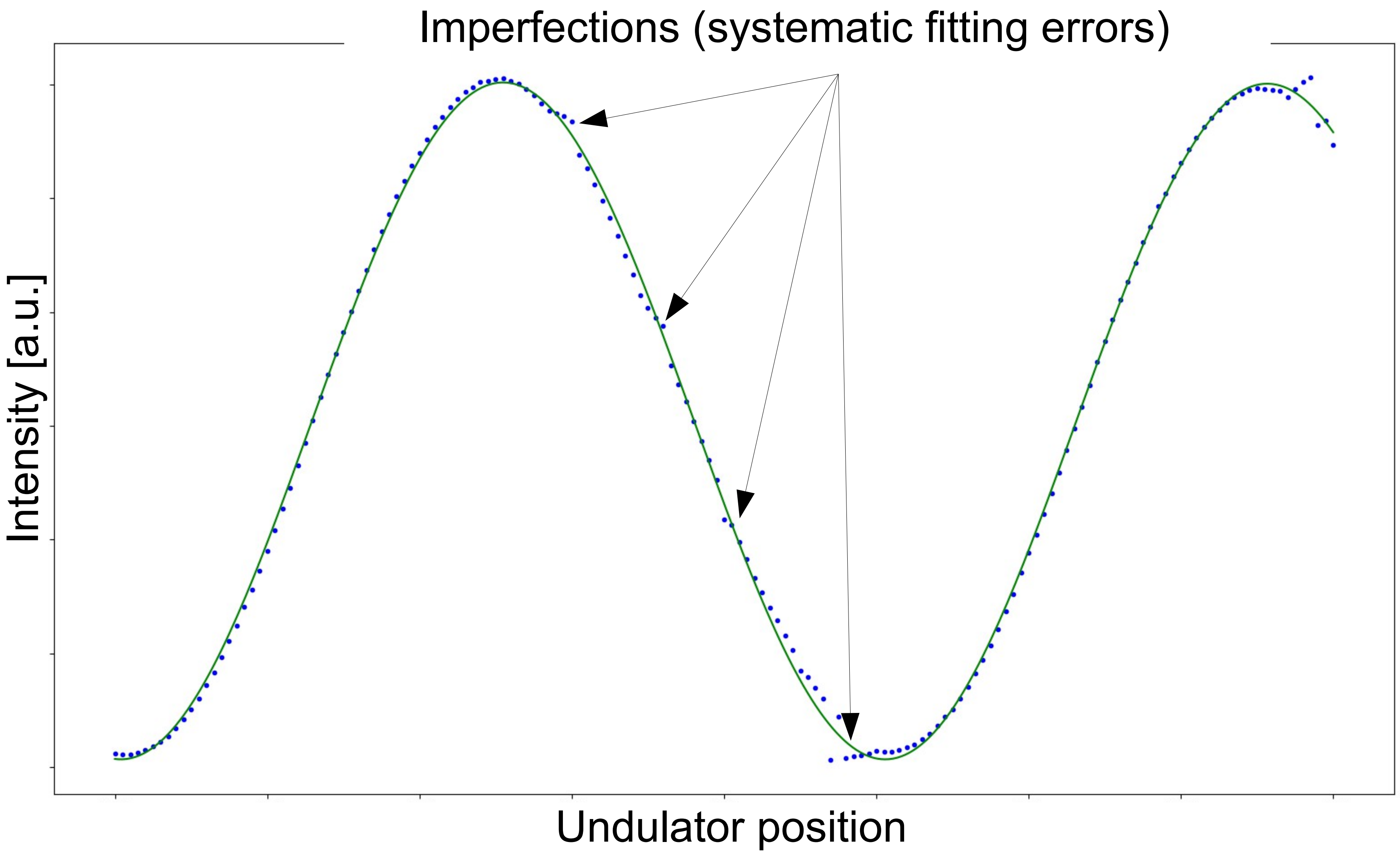
$$r = \sqrt{z_0^2 + (x - x')^2 + (y - y')^2} \approx z_0 \left(1 + \frac{(x - x')^2}{2z_0^2} + \frac{(y - y')^2}{2z_0^2}\right)$$

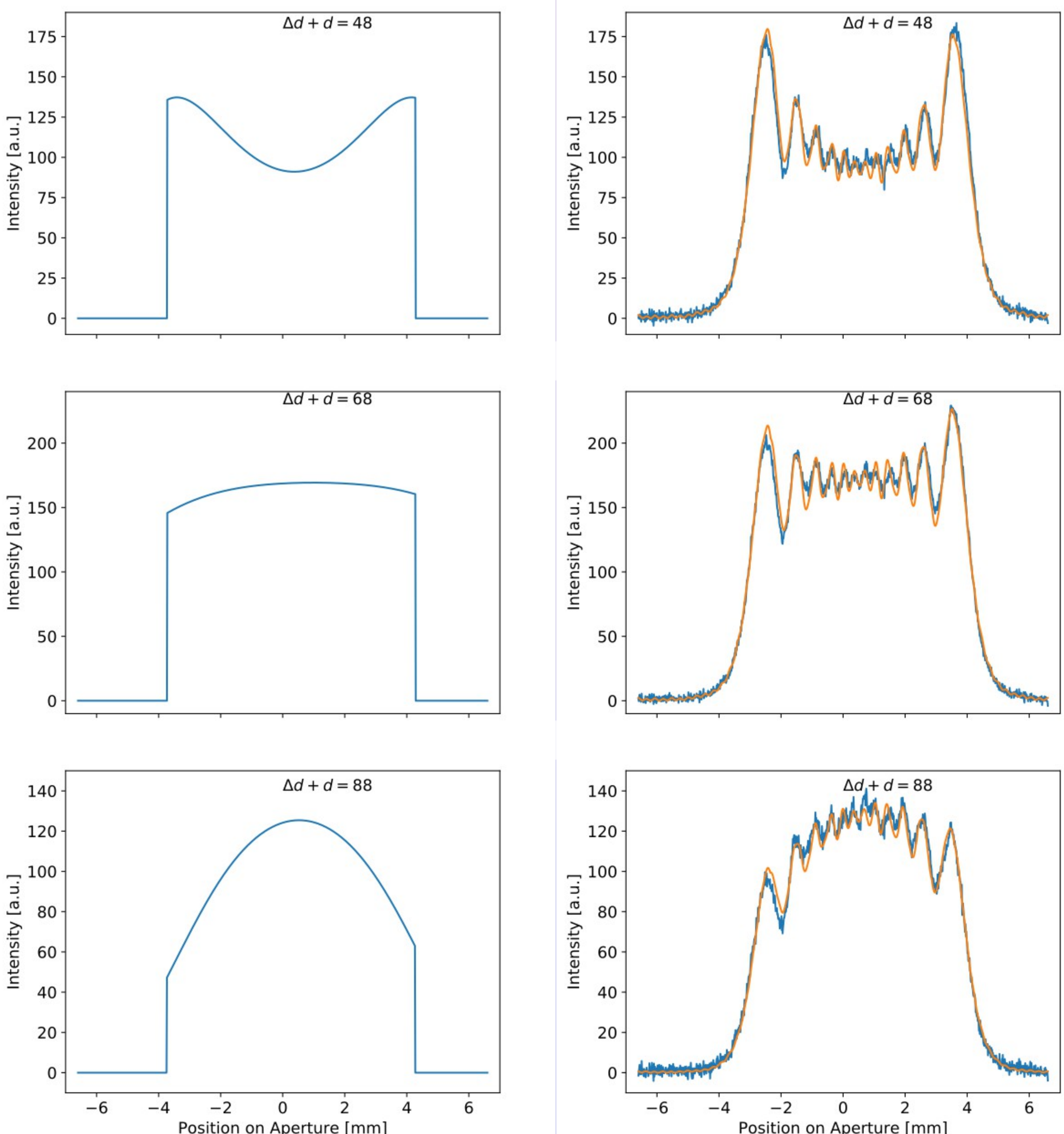
With Beam Stabilisation

Without Beam Stabilisation

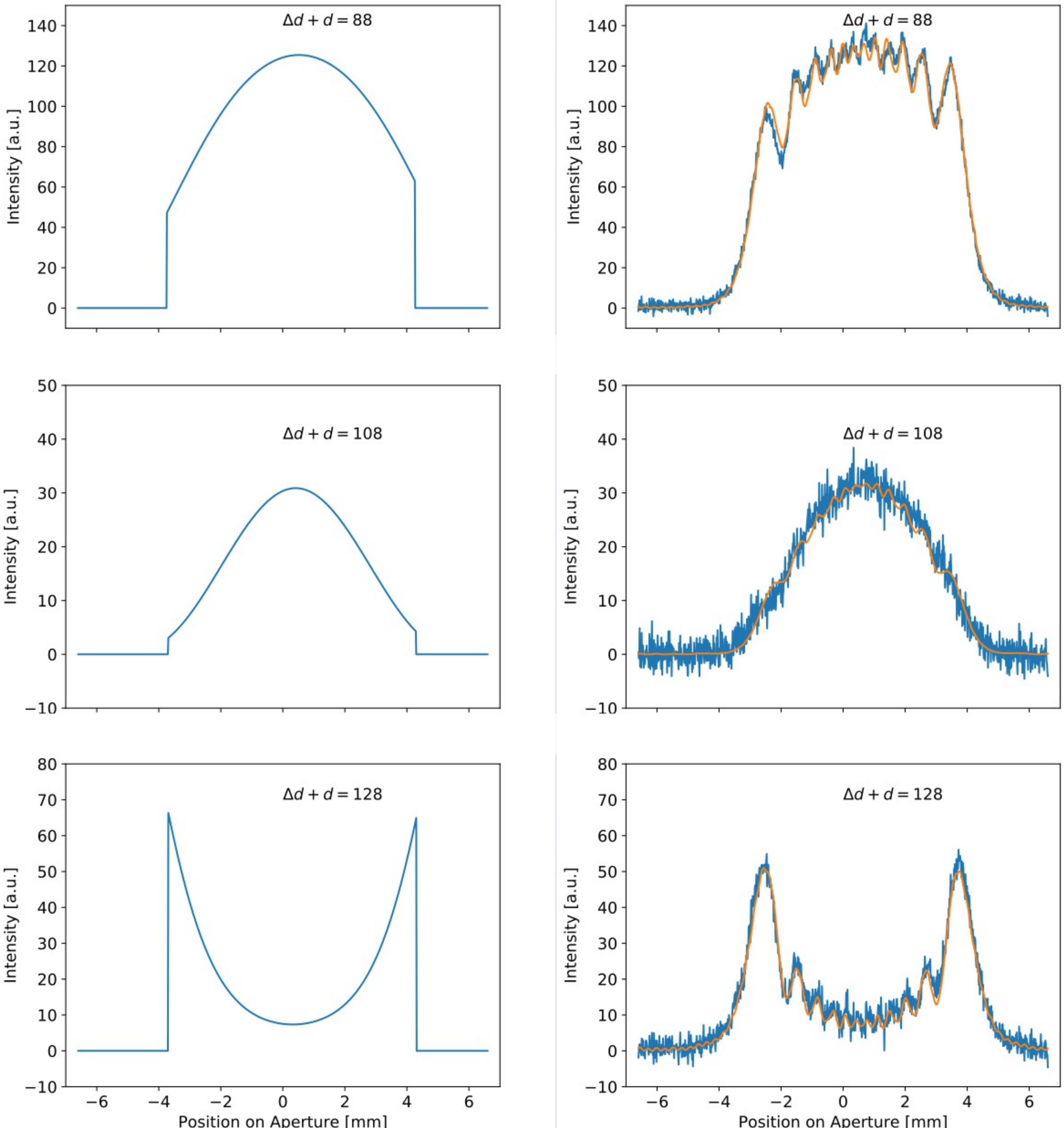
Thank you for your attention

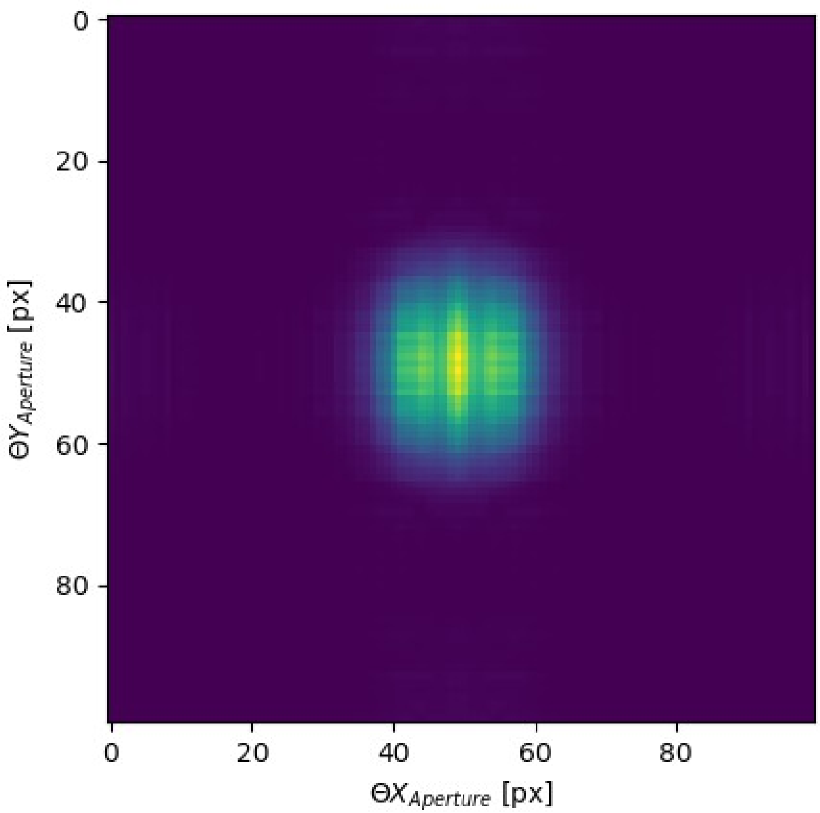

Extremely small statistical fluctuations
Intensity [a.u.]
Undulator position

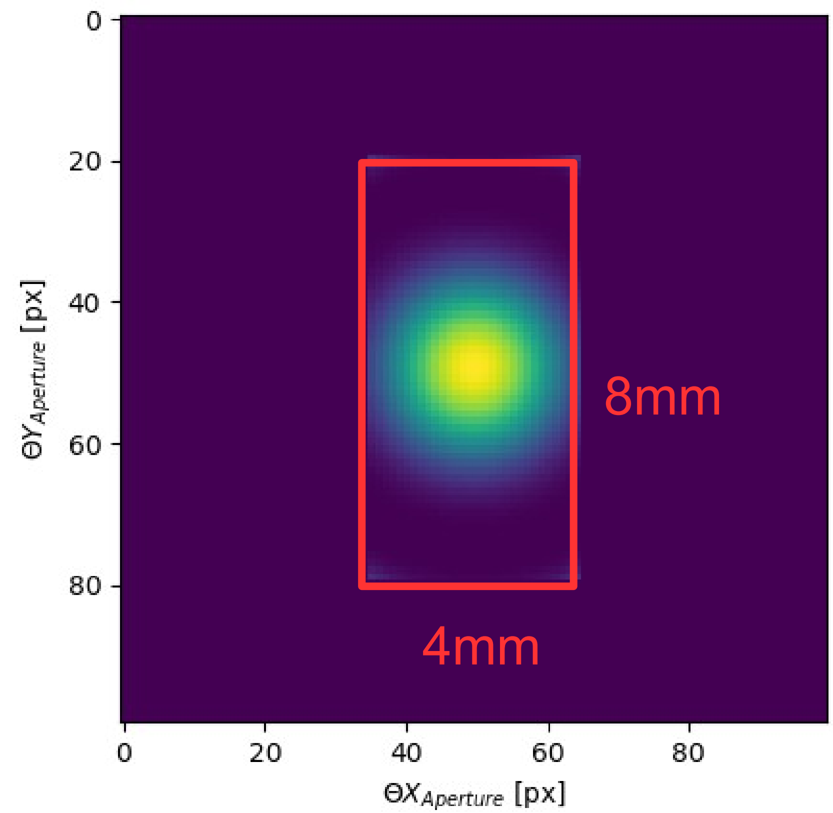

Imperfections (systematic fitting errors)
Intensity [a.u.]
Undulator position

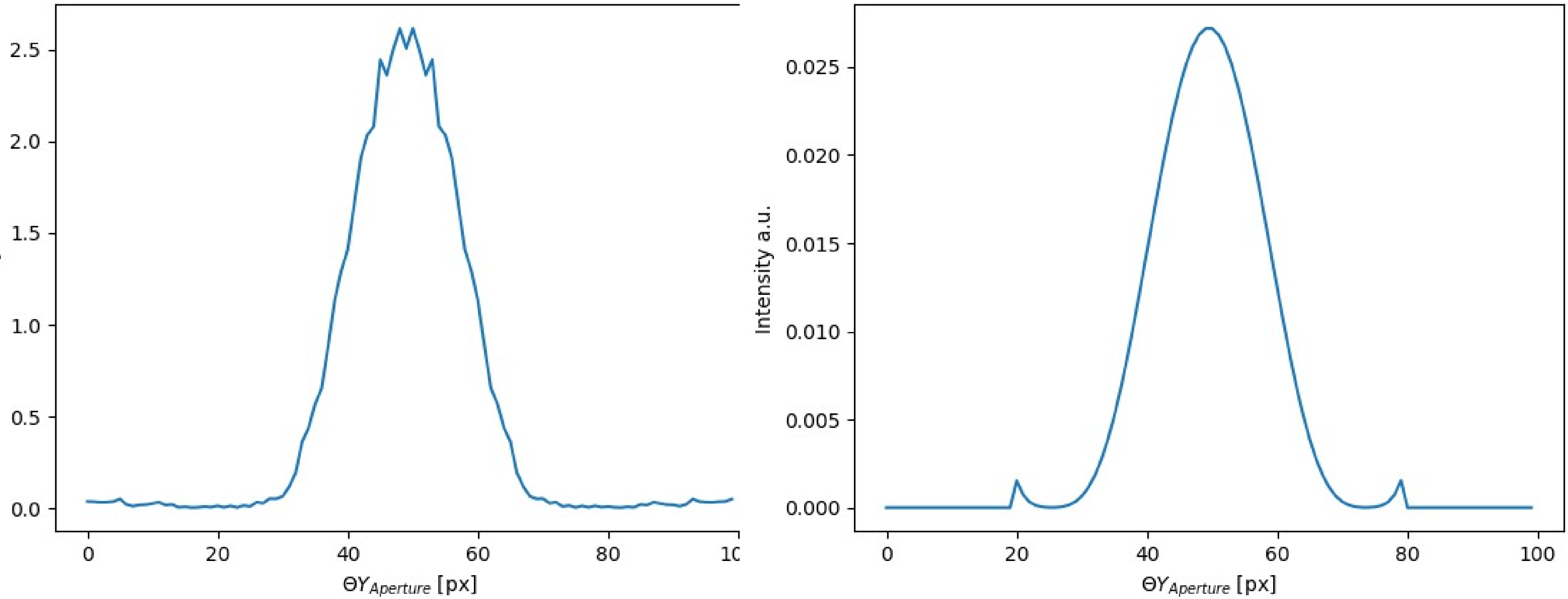


$\Delta d + d = 48$
$\Delta d + d = 48$
$\Delta d + d = 68$
$\Delta d + d = 68$
$\Delta d + d = 88$
$\Delta d + d = 88$
Intensity [a.u.]
Position on Aperture [mm]

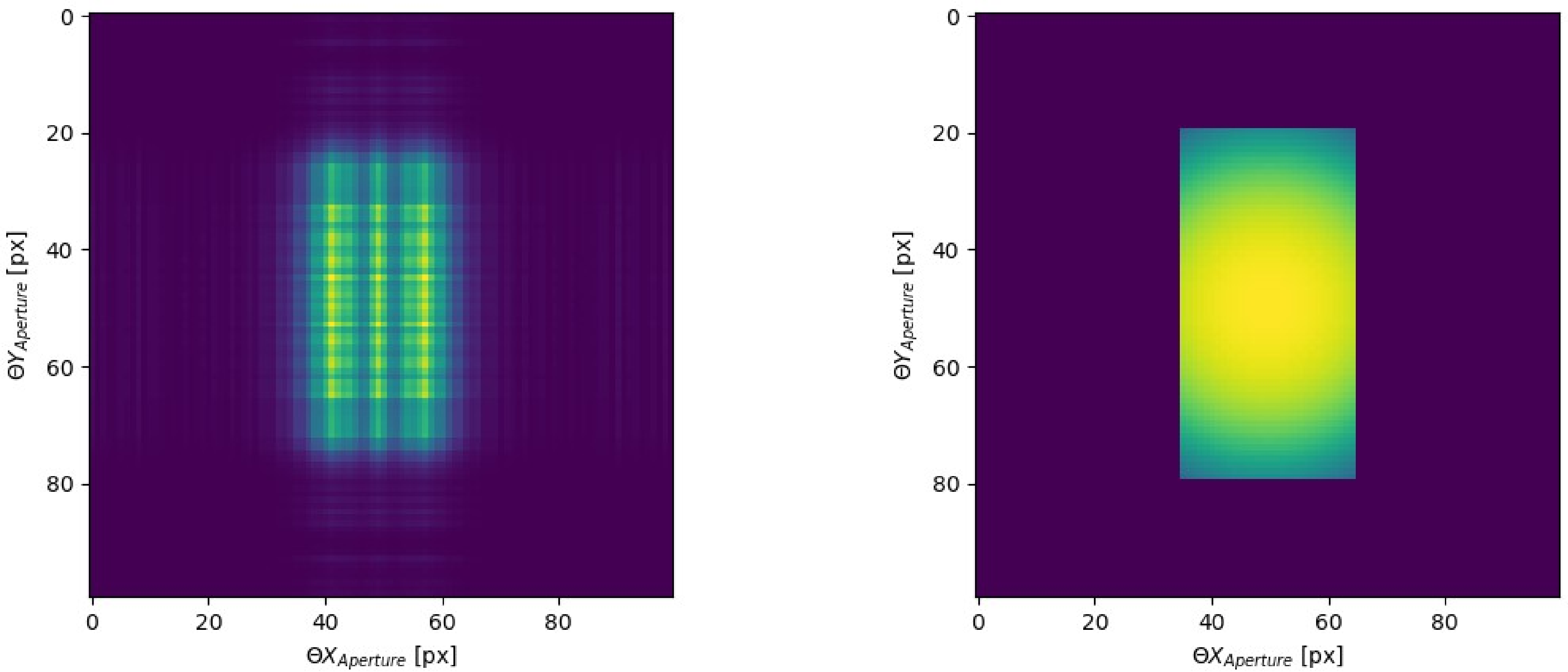

$\Delta d + d = 88$
$\Delta d + d = 88$
$\Delta d + d = 108$
$\Delta d + d = 108$
$\Delta d + d = 128$
$\Delta d + d = 128$
Intensity [a.u.]
Position on Aperture [mm]


0
20
40
60
80
ΘY_Aperture [px]
0
20
40
60
80
ΘX_Aperture [px]


0
20
40
60
80
ΘY_Aperture [px]
8mm
4mm
0
20
40
60
80
ΘX_Aperture [px]



2.5
2.0
1.5
1.0
0.5
0.0
0
20
40
60
80
1(
ΘY_Aperture [px]
Intensity a.u.
0.025
0.020
0.015
0.010
0.005
0.000
0
20
40
60
80
100
ΘY_Aperture [px]


0
20
40
60
80
ΘY_Aperture [px]
0
20
40
60
80
ΘX_Aperture [px]
0
20
40
60
80
ΘY_Aperture [px]
0
20
40
60
80
ΘX_Aperture [px]