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Contribution of coherent and incoherent scatter in grating-based phase-contrast imaging

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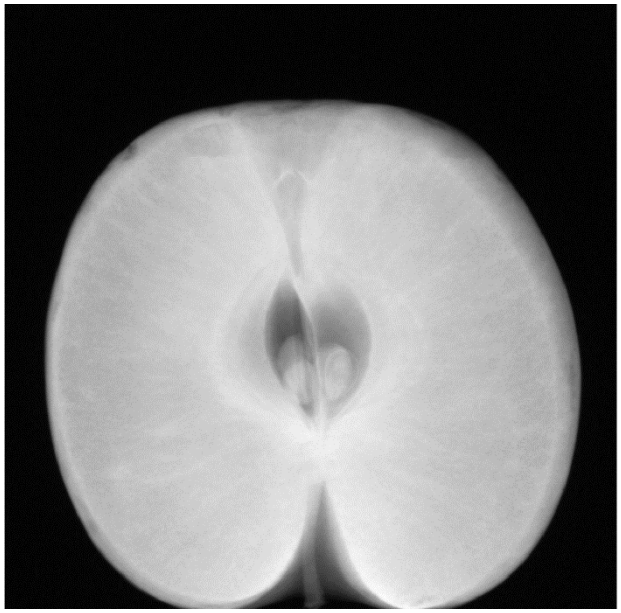
[3]SCK CEN, Research in Dosimetric Applications Group, Mol, Belgium

INTRODUCTION

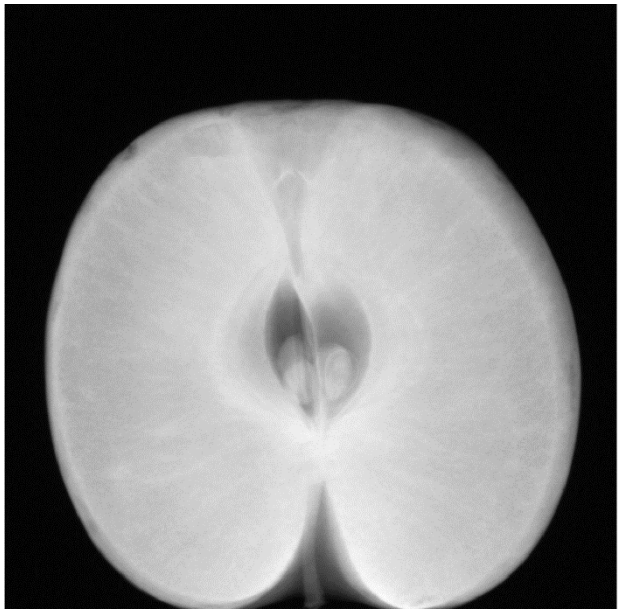
Grating-based phase-contrast imaging



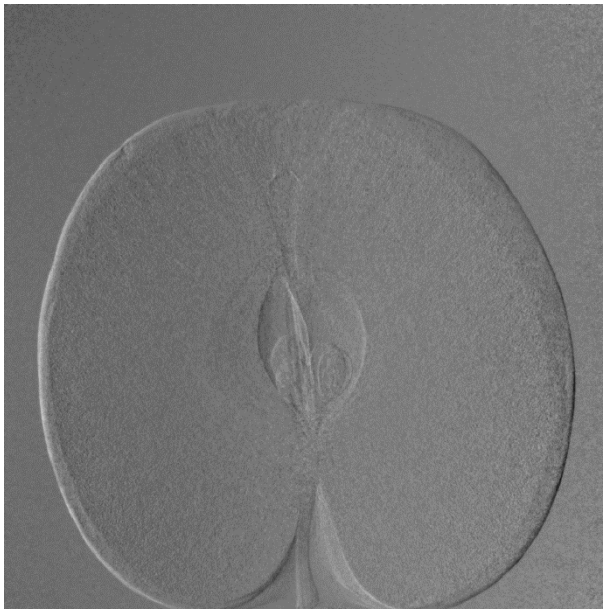
Transmission

INTRODUCTION

Grating-based phase-contrast imaging



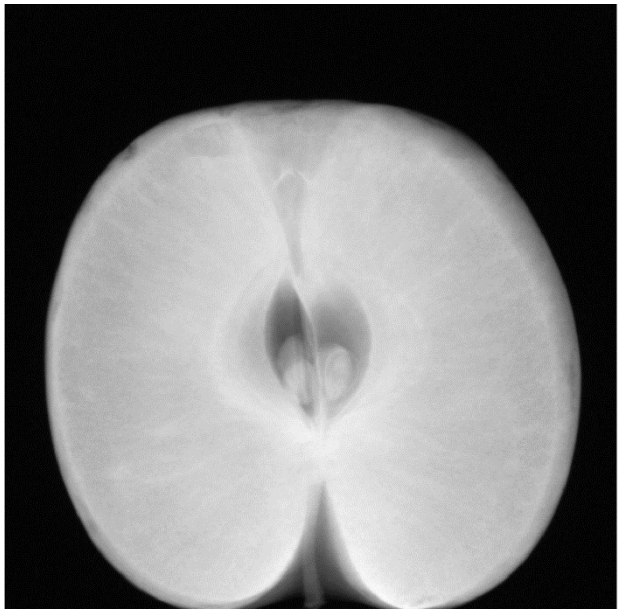
Transmission



Differential phase

INTRODUCTION

Grating-based phase-contrast imaging



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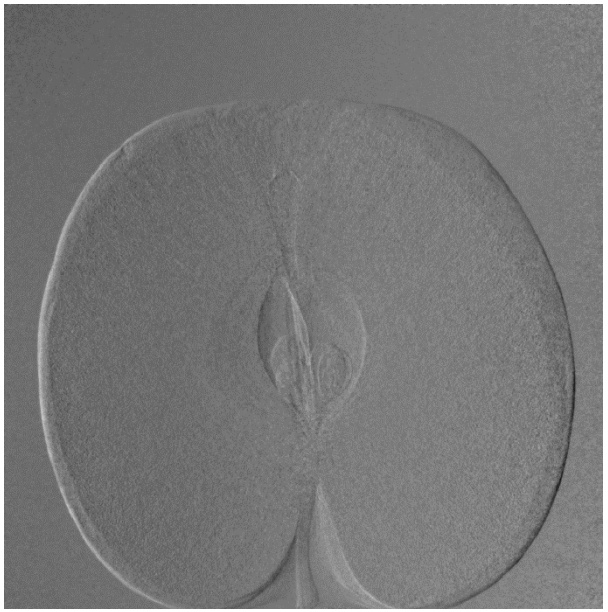
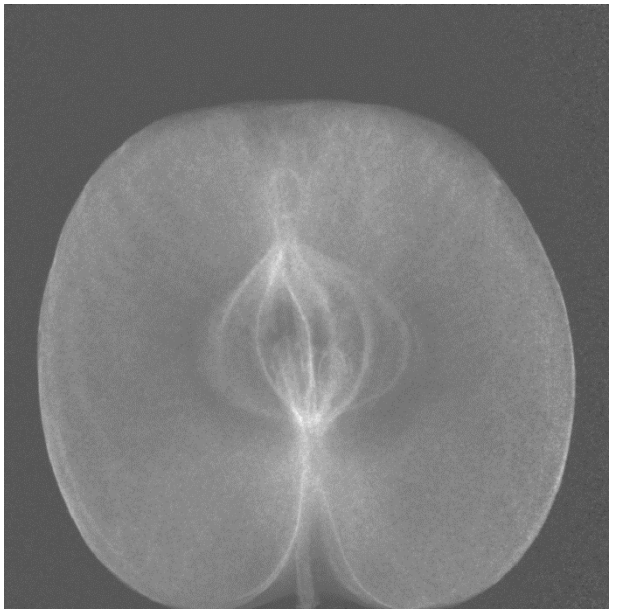


Differential phase

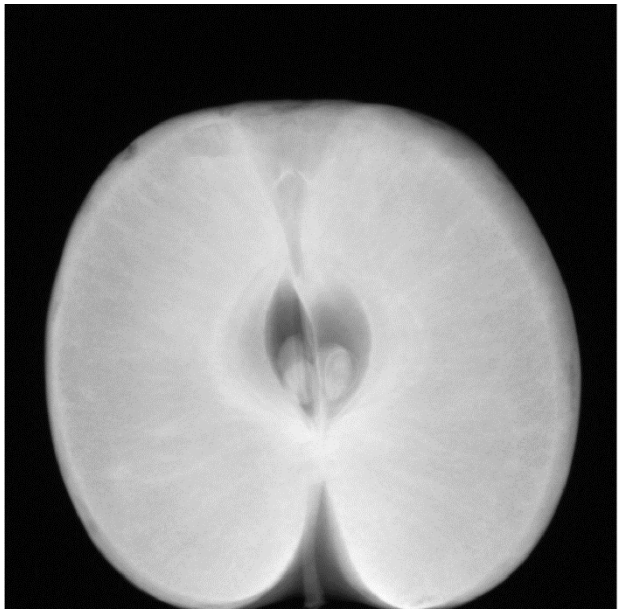


Dark field

INTRODUCTION

Grating-based phase-contrast imaging

In the case of scatter…



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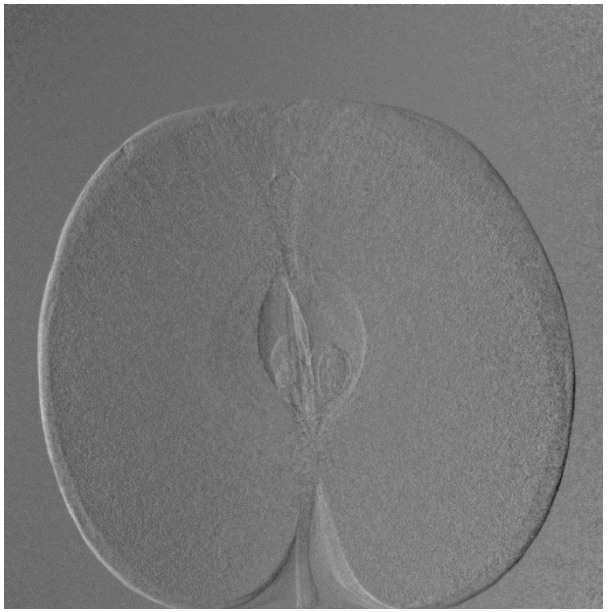
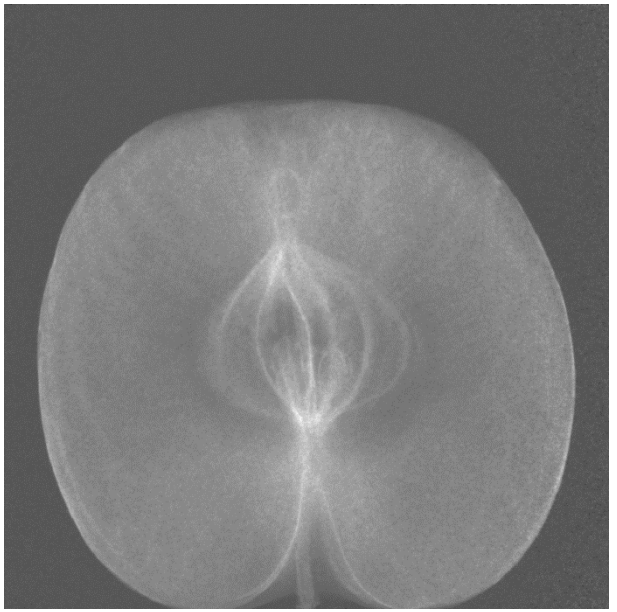


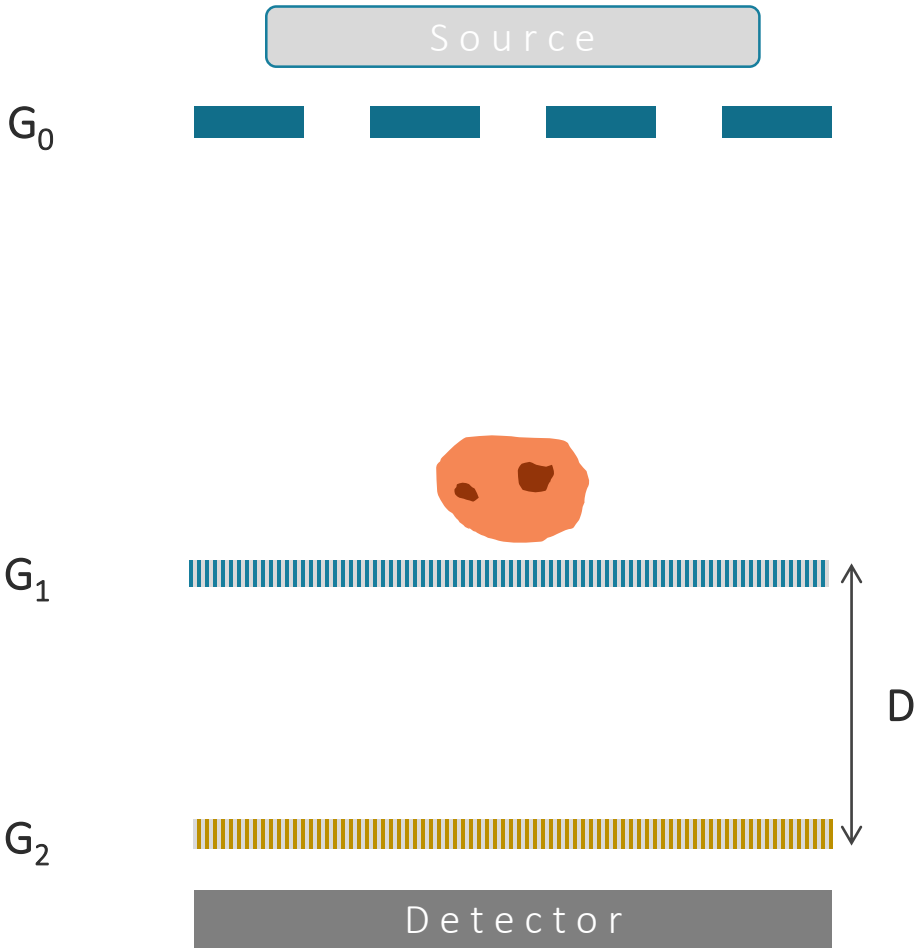
Differential phase



Dark field

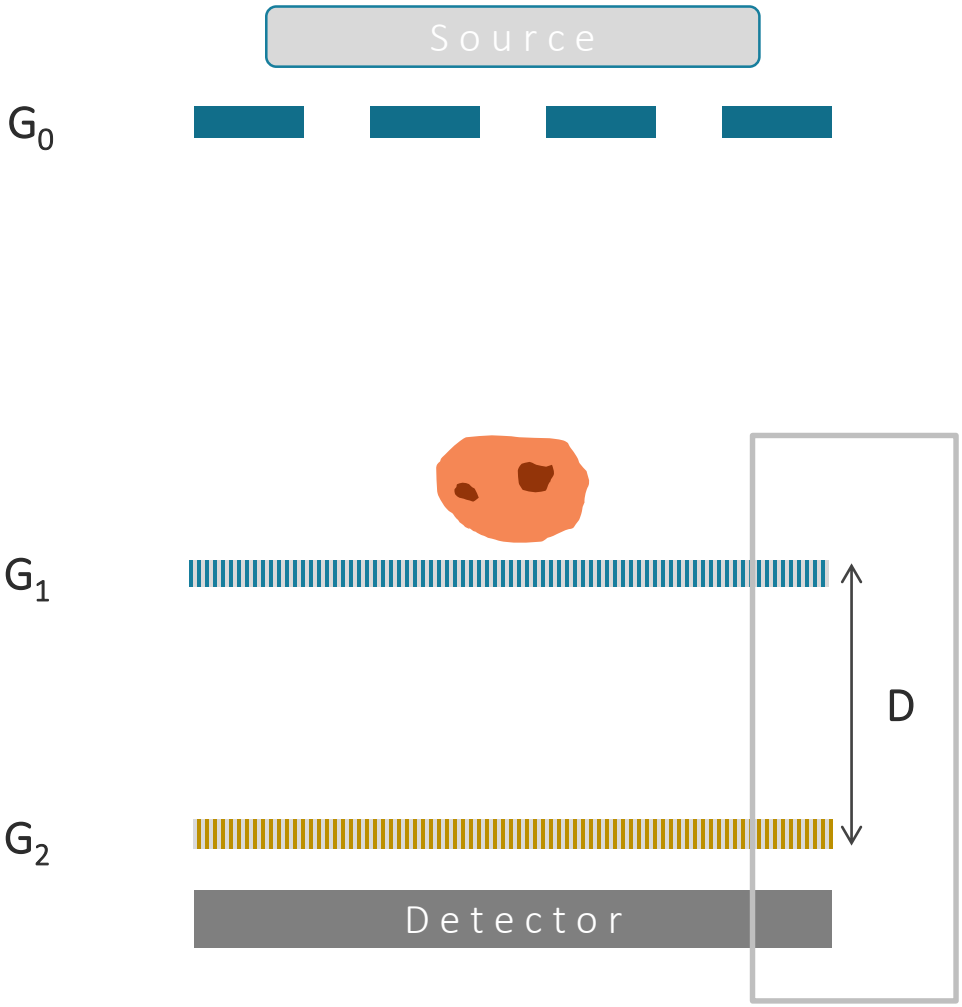
INTRODUCTION

2 aspects expecting to limit the scatter contribution



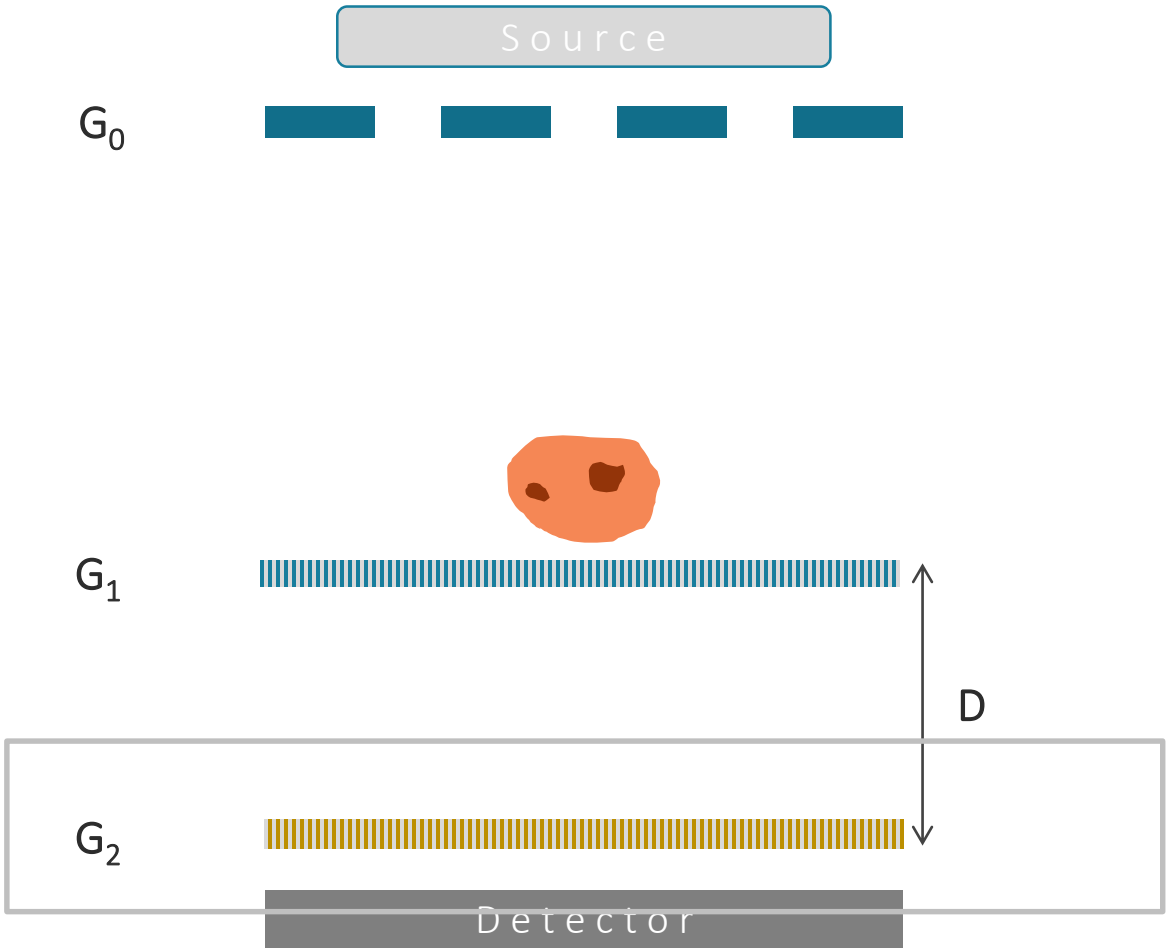
INTRODUCTION

2 aspects expecting to limit the scatter contribution



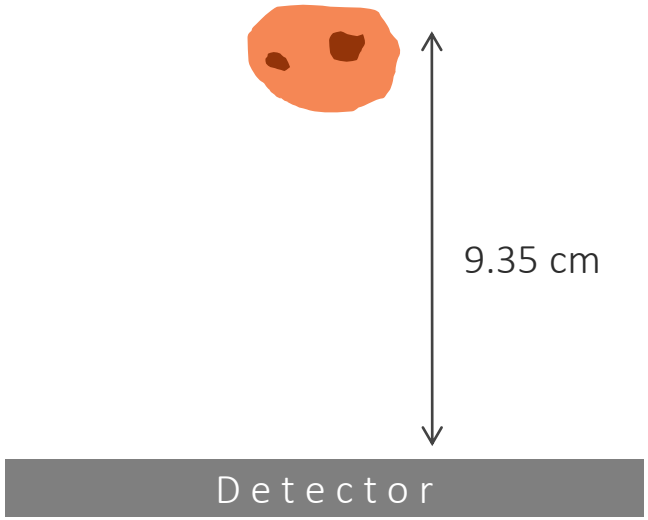
INTRODUCTION

2 aspects expecting to limit the scatter contribution



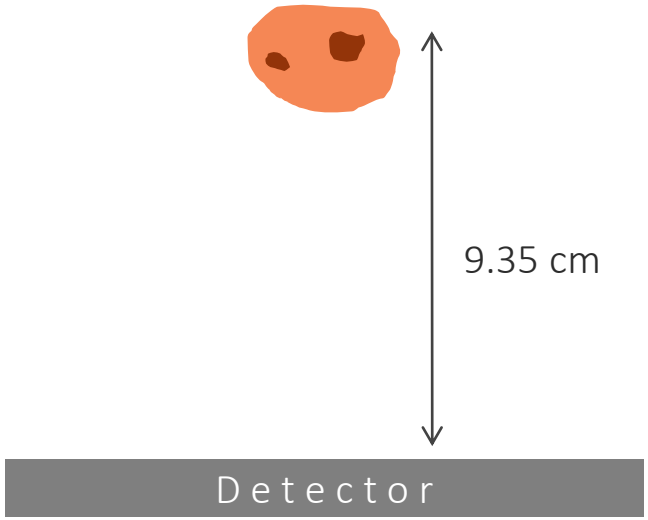
INTRODUCTION

1. Large object-to-detector distance



INTRODUCTION

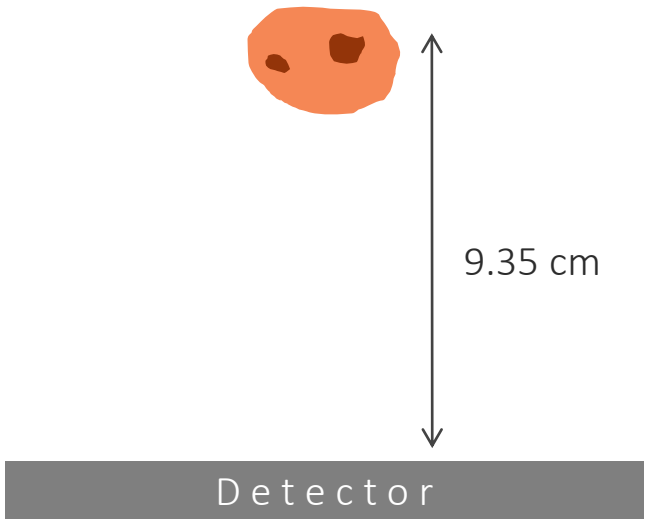
1. Large object-to-detector distance



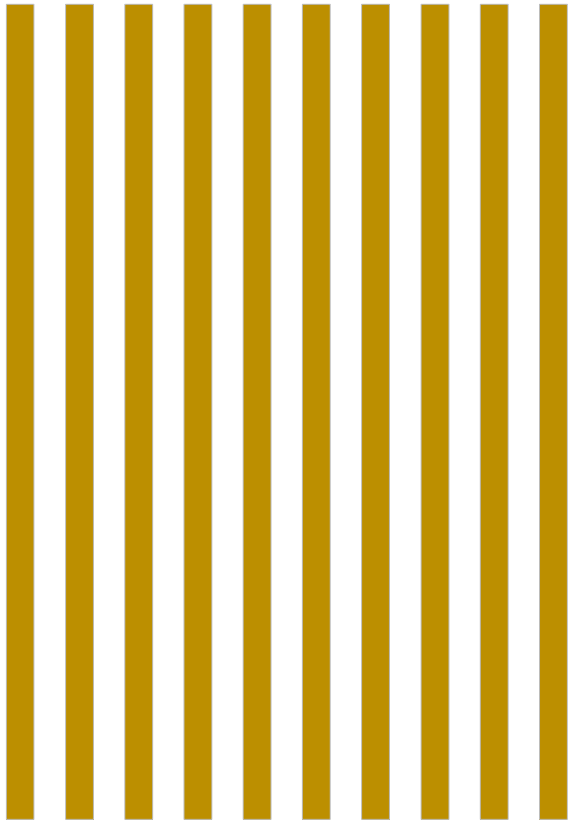
2. Grating G2

INTRODUCTION

1. Large object-to-detector distance



2. Grating G2



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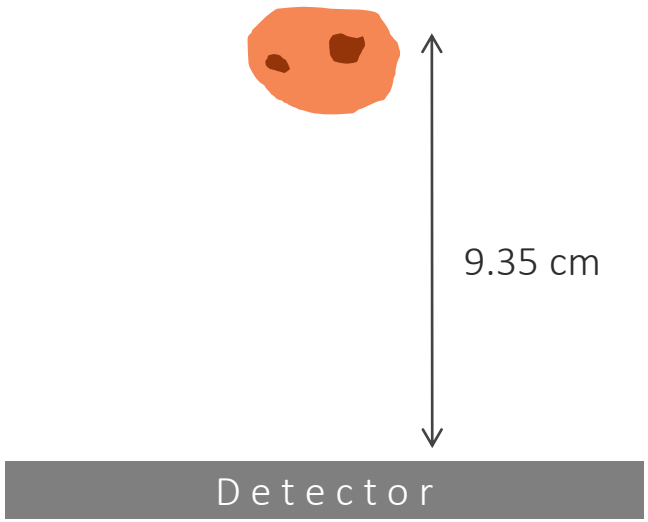
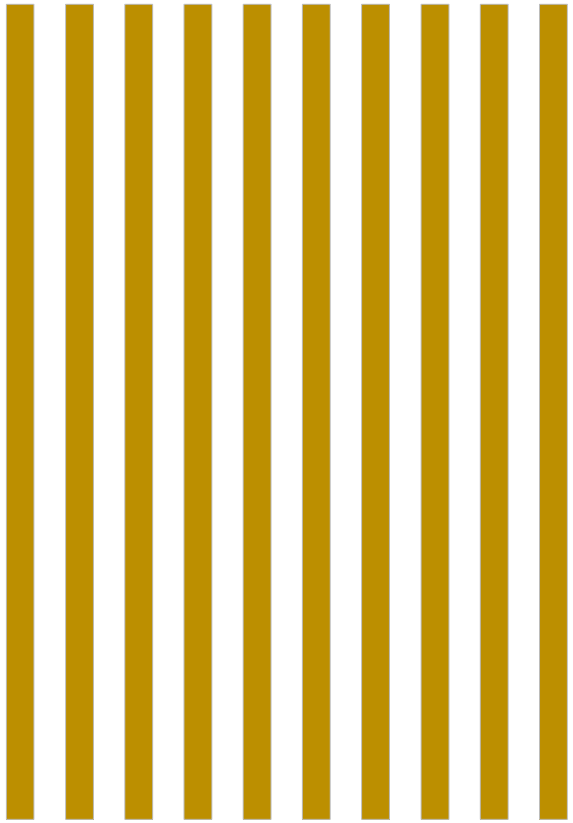
INTRODUCTION

1. Large object-to-detector distance



2. Grating G2 as anti-scattering grid



INTRODUCTION

How significant is the scatter contribution in grating-based phase-contrast imaging?

MATERIALS & METHODS

MATERIALS & METHODS

Monte Carlo Simulations using the PENELOPE framework

- Coherent scatter
- Incoherent scatter
- Multi Scatter
- Primaries

Scatter fractions (SF)

$$= \frac{\text{scatter contribution}}{\text{total}}$$

MATERIALS & METHODS

Monte Carlo Simulations using the PENELOPE framework

- Coherent scatter
- Incoherent scatter
- Multi Scatter
- Primaries

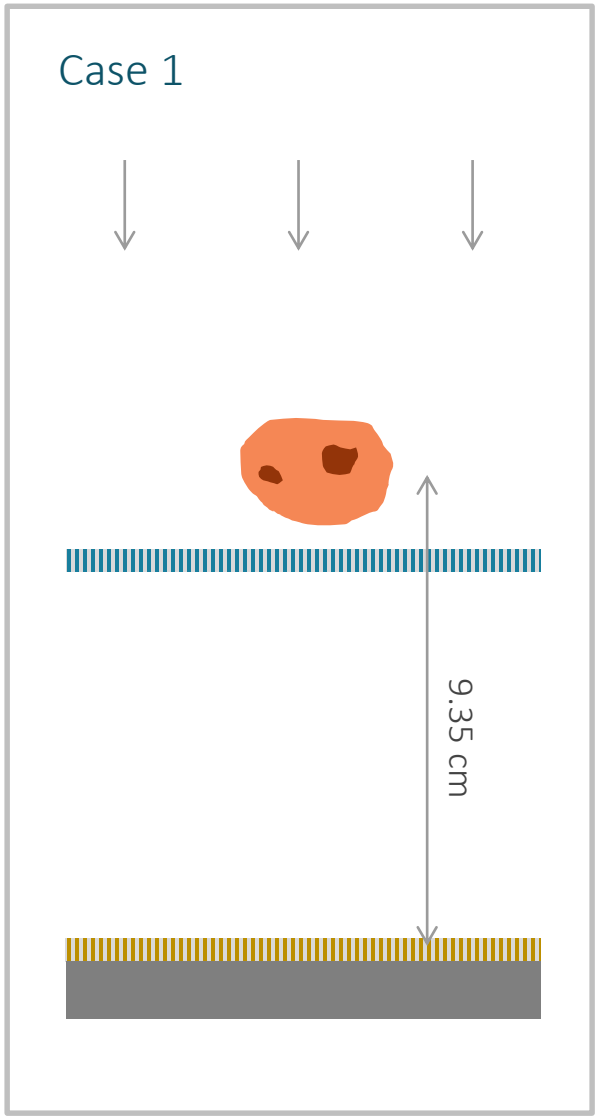
Scatter fractions (SF)

$$= \frac{\text{scatter contribution}}{\text{total}}$$

The impact of large distance and G2 on scatter fractions

- 3 cases
- 2 objects

MATERIALS & METHODS



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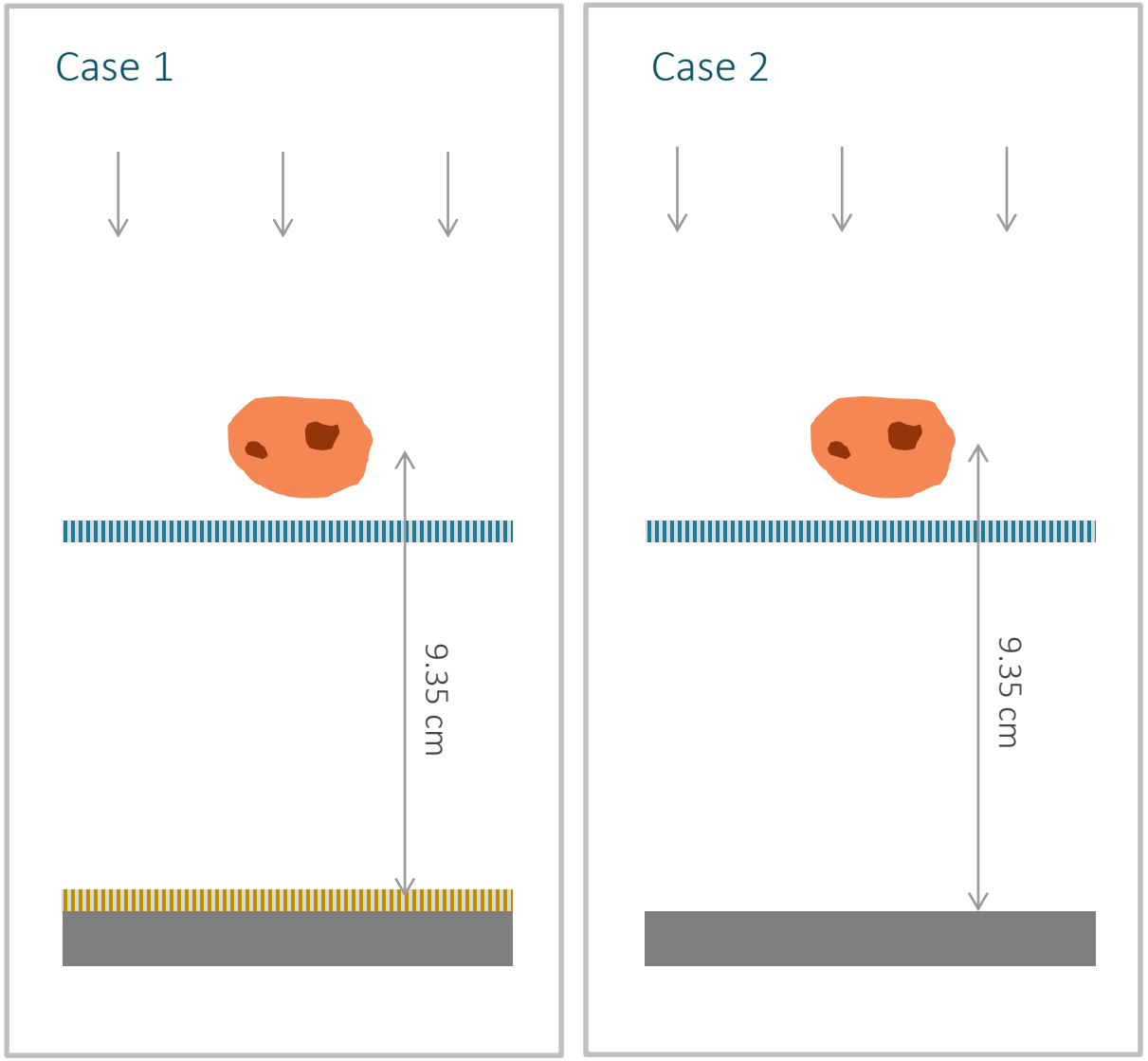
MATERIALS & METHODS



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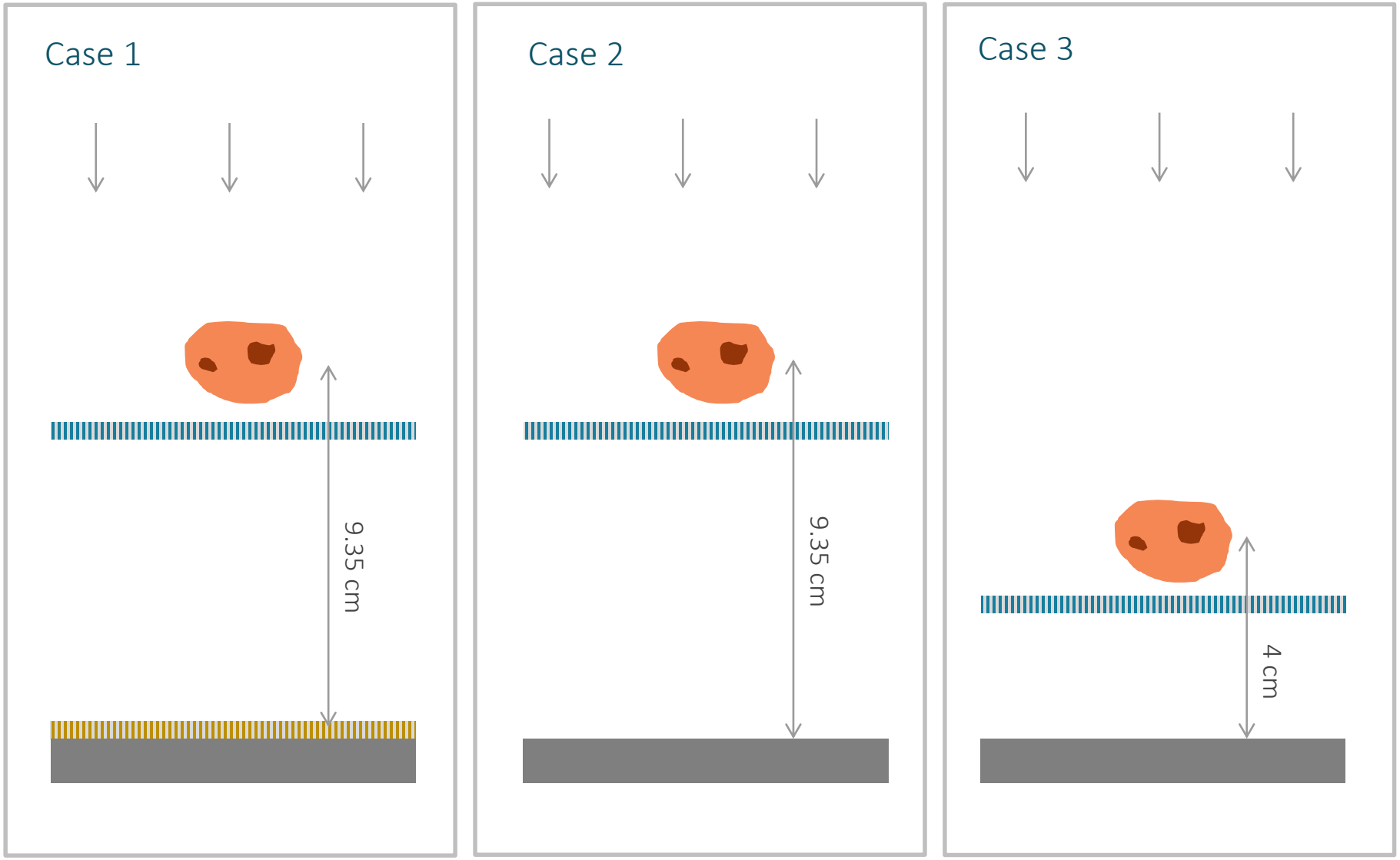
MATERIALS & METHODS



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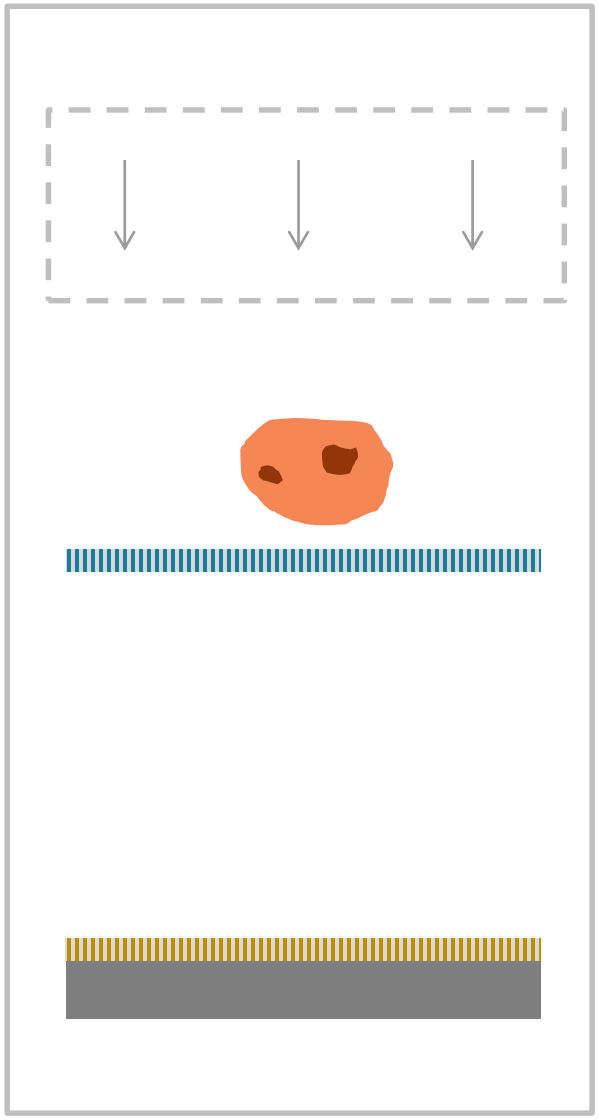
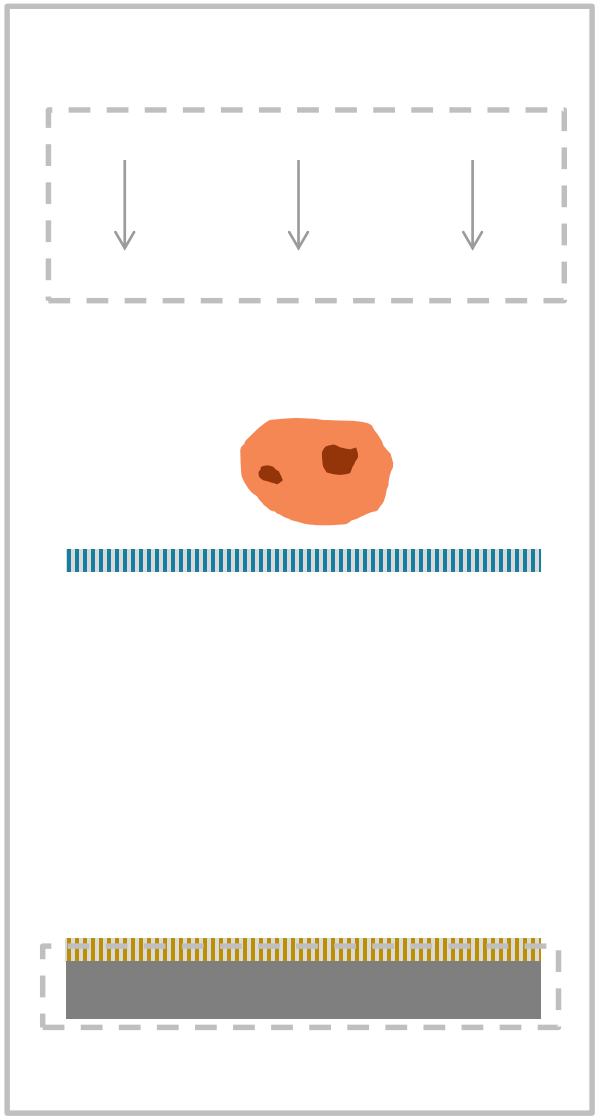
MATERIALS & METHODS



Source

- Plane wave
- 40 kVP tungsten spectrum

MATERIALS & METHODS



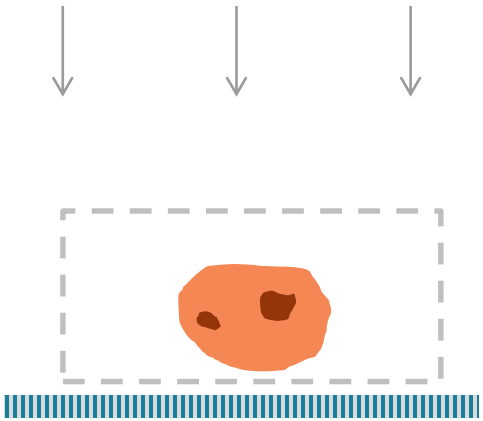
Source

- Plane wave
- 40 kvP tungsten spectrum

Detector

- Energy integrating detector
- eV/cm³

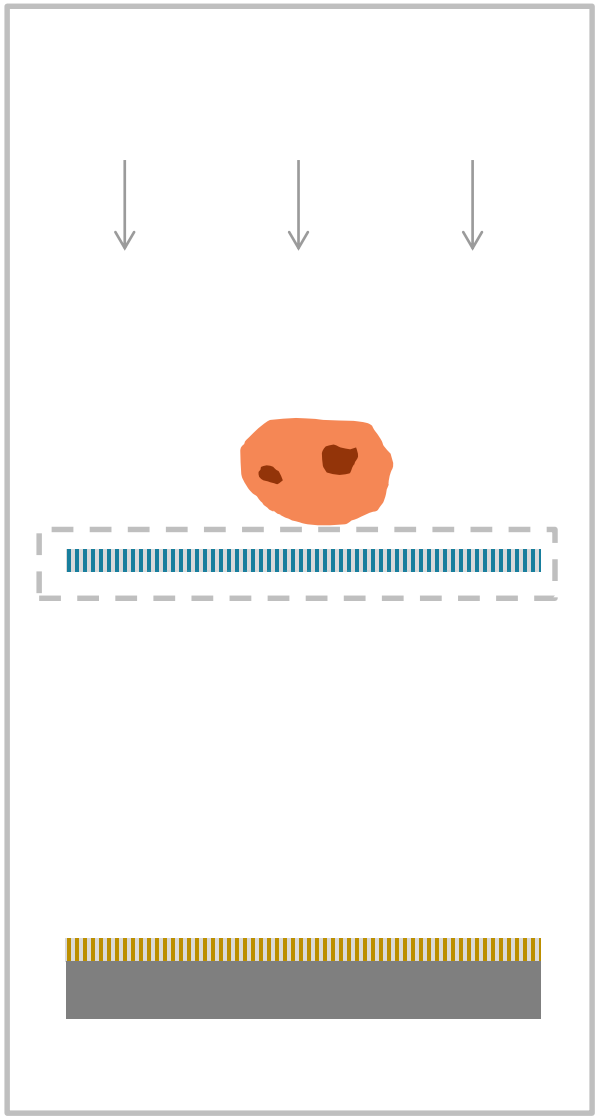
MATERIALS & METHODS



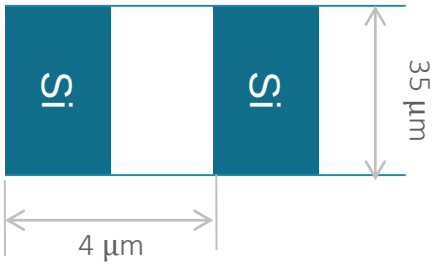
Object 1 : finger

Object 2 : 5 cm tissue slab

MATERIALS & METHODS



Grating G1



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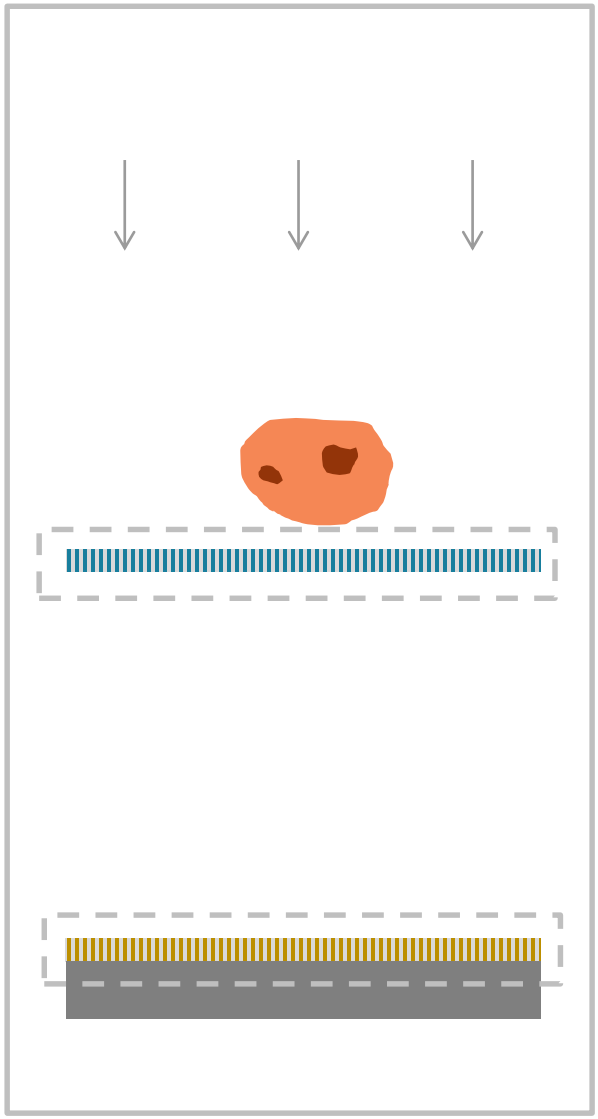
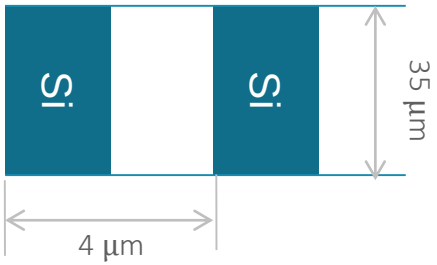
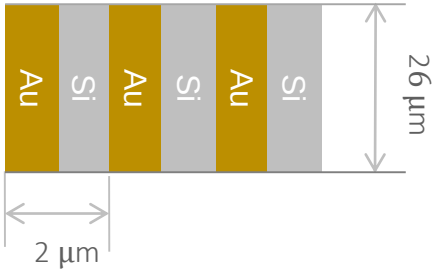
MATERIALS & METHODS



Grating G1



Grating G2



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RESULTS :

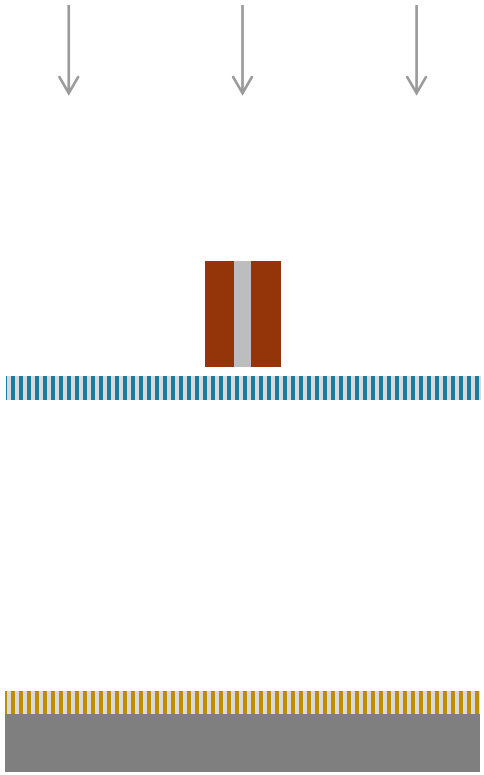
RESULTS :

Object 1

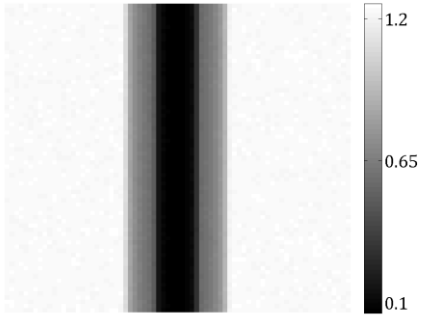
RESULTS :

Object 1

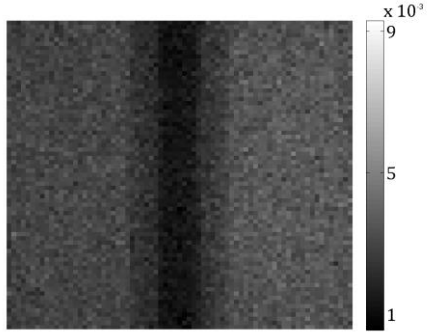
Case 1



Primary

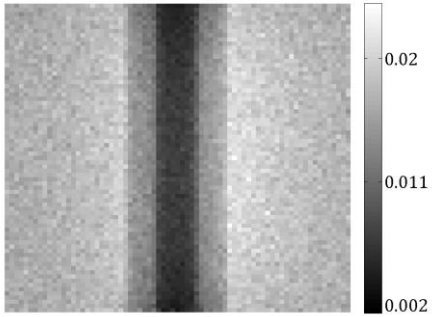


Incoherent



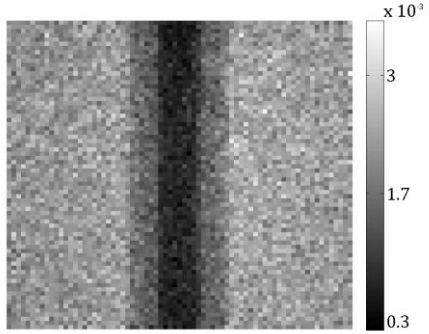
SF = 0.29%

Coherent



SF = 1.60%

Multi



SF = 0.20%

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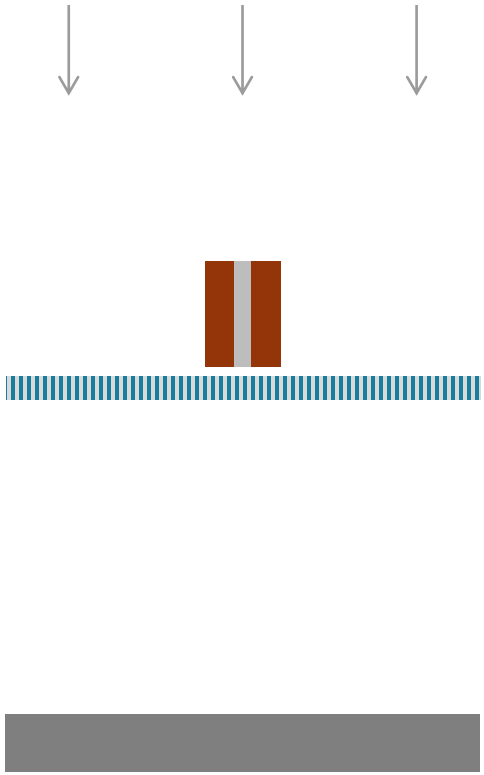
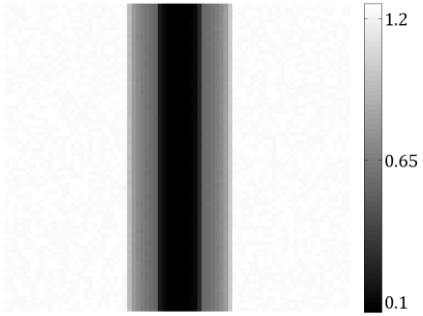
RESULTS :

Object 1

Case 2



Primary



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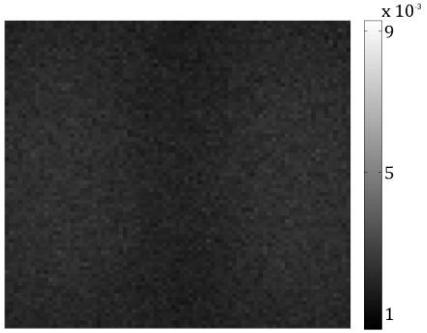
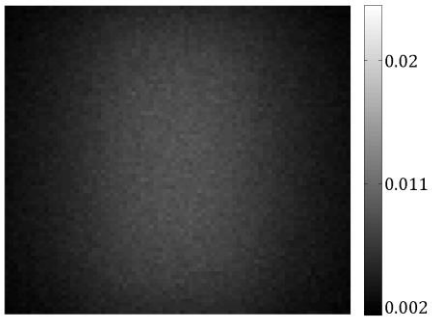


SF = 0.20%

Coherent



SF = 0.56%

Multi

SF = 0.06%

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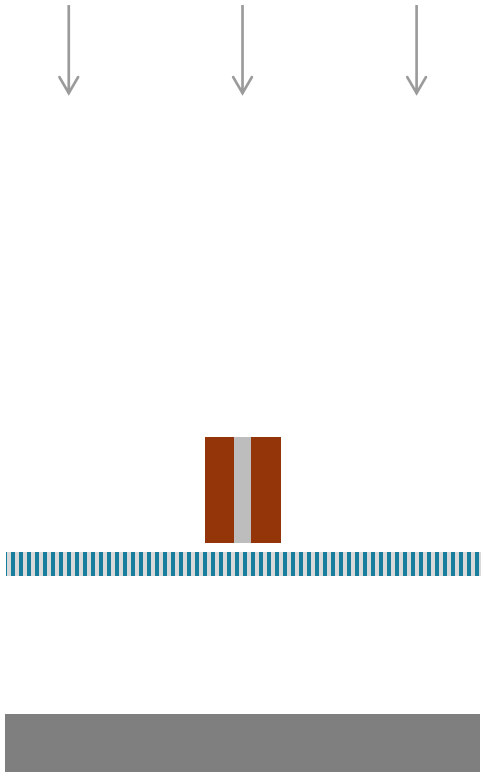
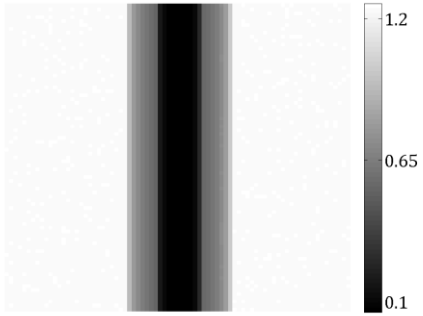
RESULTS :

Object 1

Case 3



Primary



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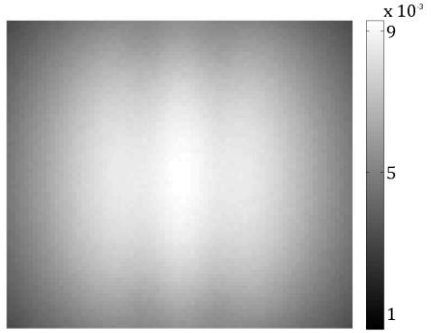
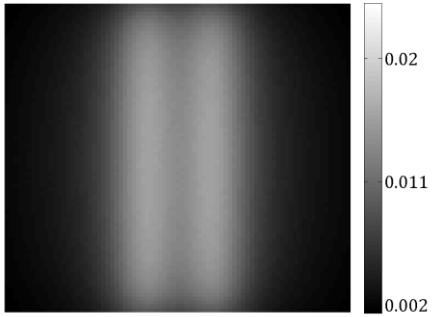


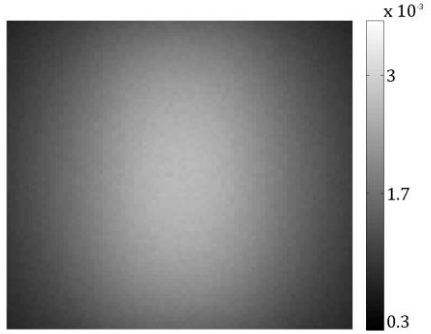
SF = 0.66%

Coherent



SF = 0.76%

Multi



SF =0.17%

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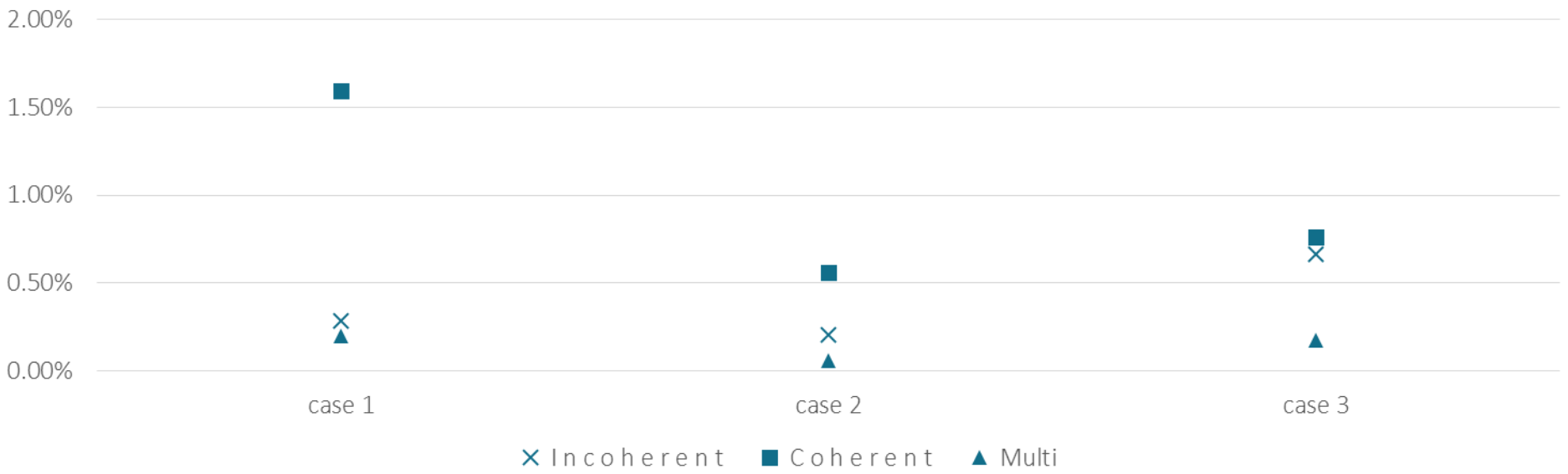
RESULTS :

Object 1



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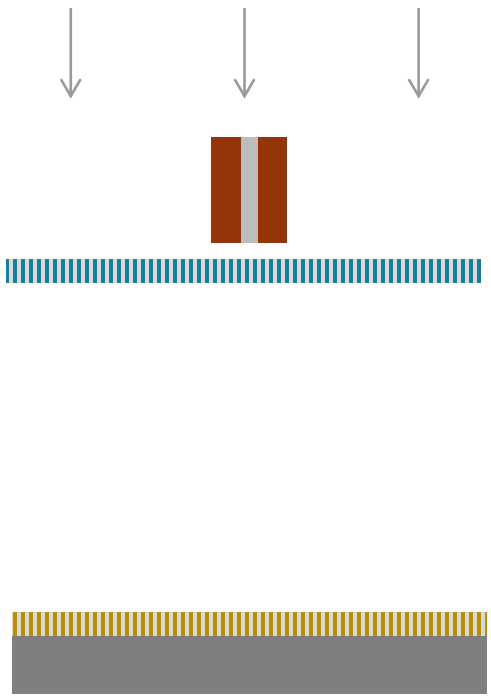
RESULTS :

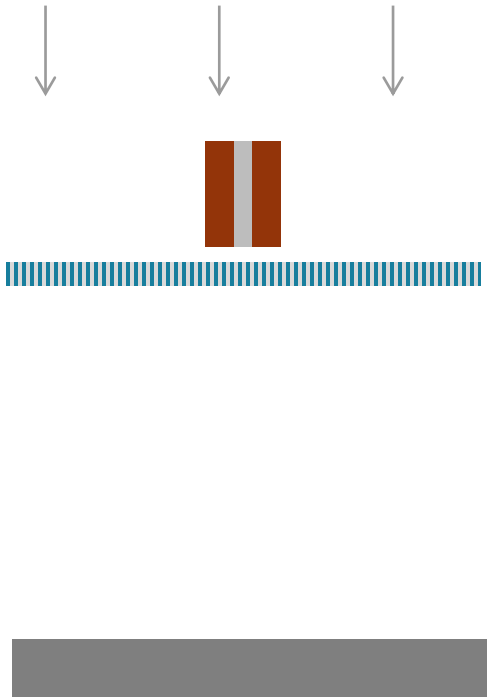
Object 1

Case 1



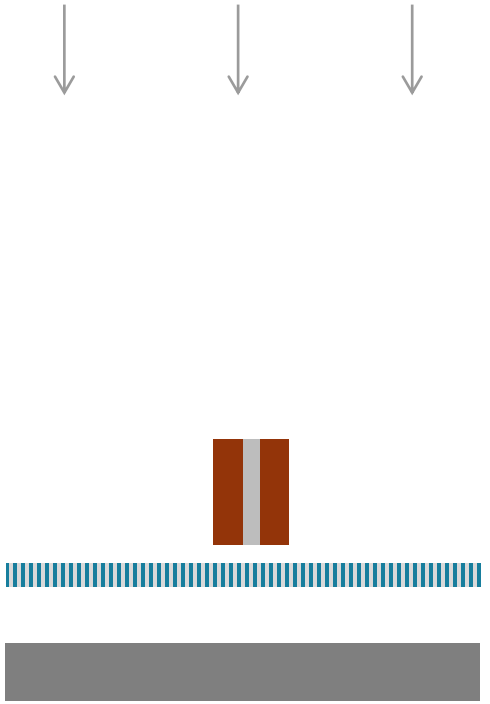
2.08%

Case 2



0.82%

Case 3



1.60%

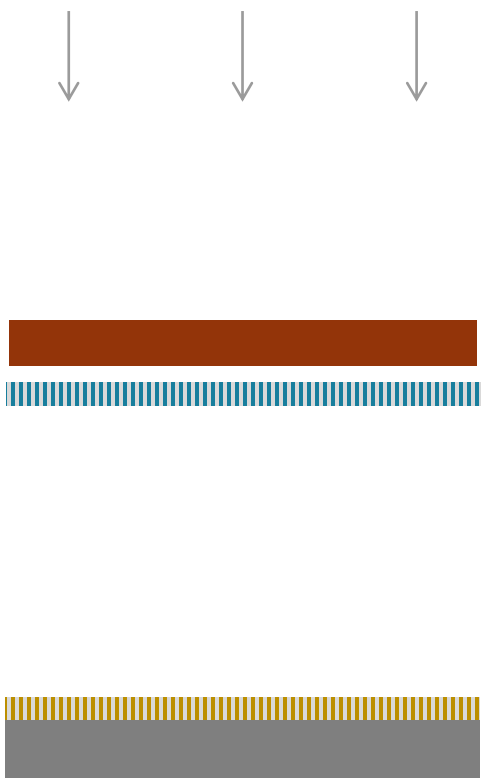
RESULTS :

Object 2

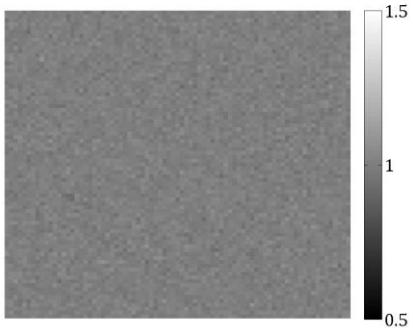
RESULTS :

Object 2

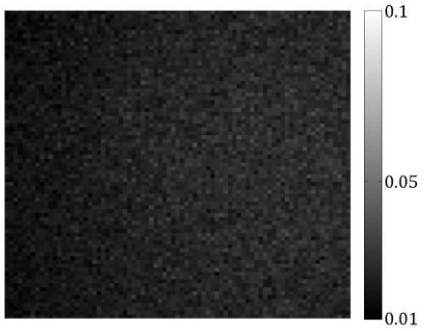
Case 1



Primary

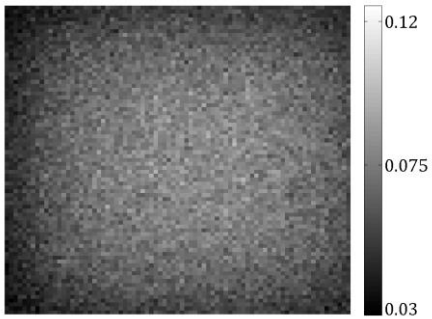


Incoherent



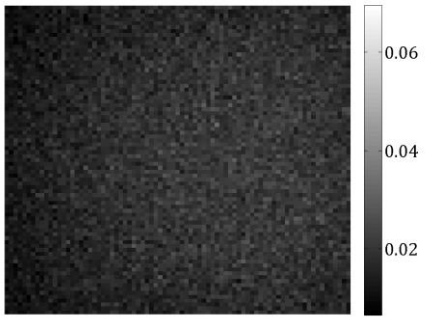
SF = 2.05%

Coherent



SF = 6.02%

Multi

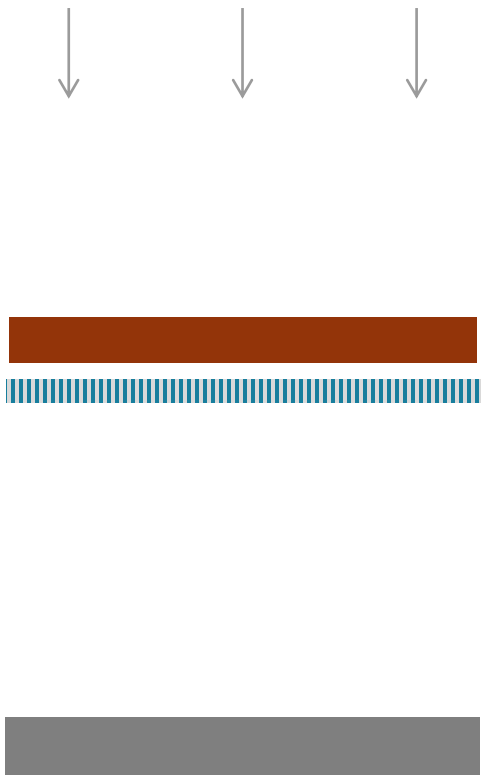


SF = 1.66%

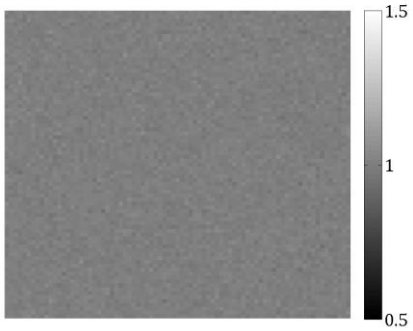
RESULTS :

Object 2

Case 2



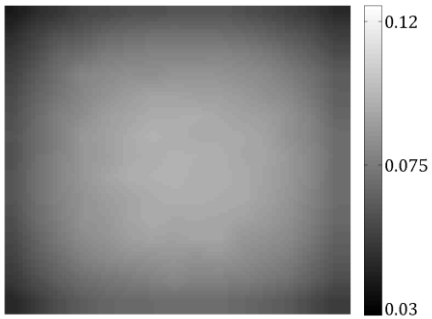
Primary



Incoherent

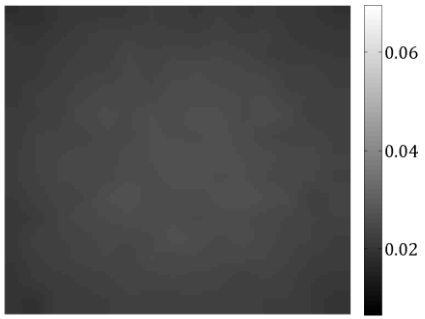
SF = 2.70%

Coherent



SF = 6.79%

Multi



SF = 2.09%

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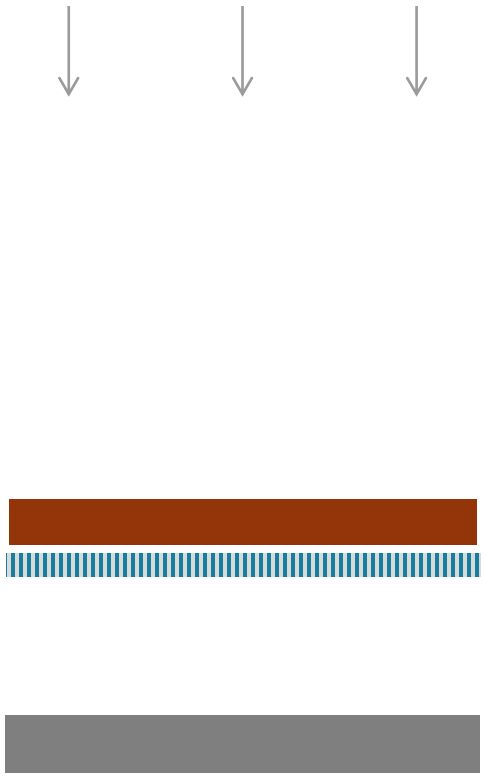
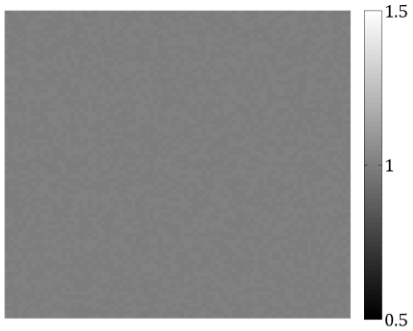
RESULTS :

Object 2

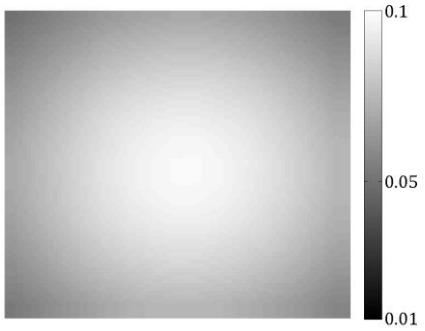
Case 3



Primary

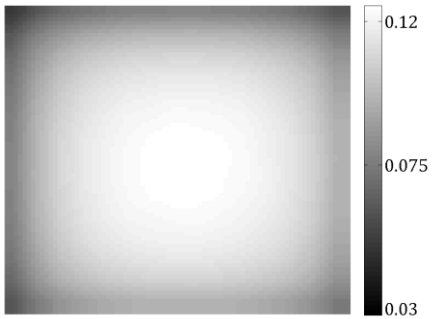


Incoherent



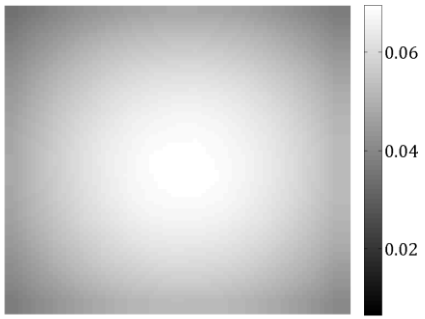
SF = 6.37%

Coherent



SF = 8.51%

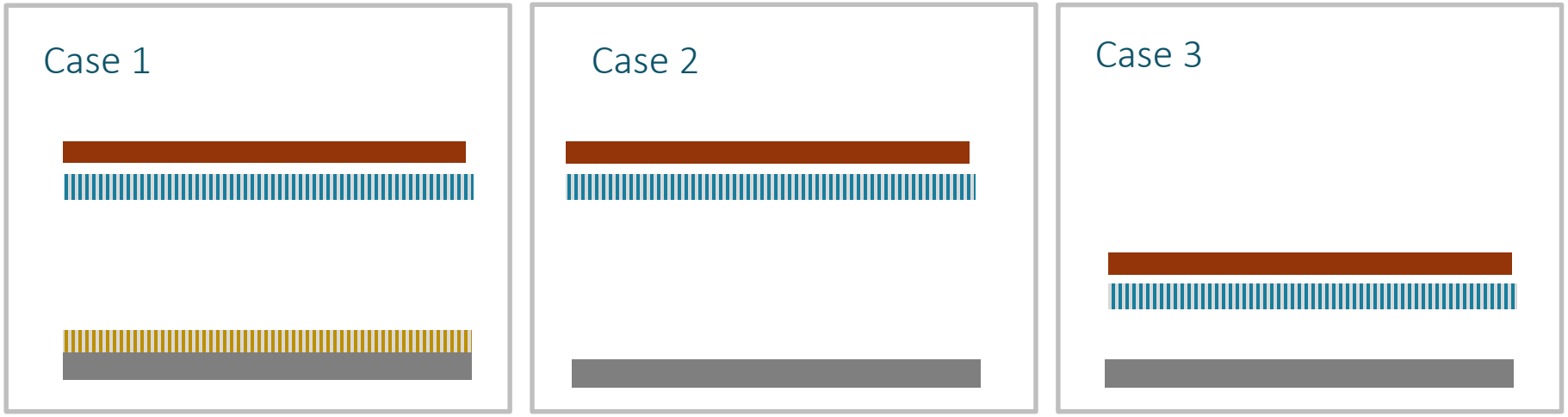
Multi

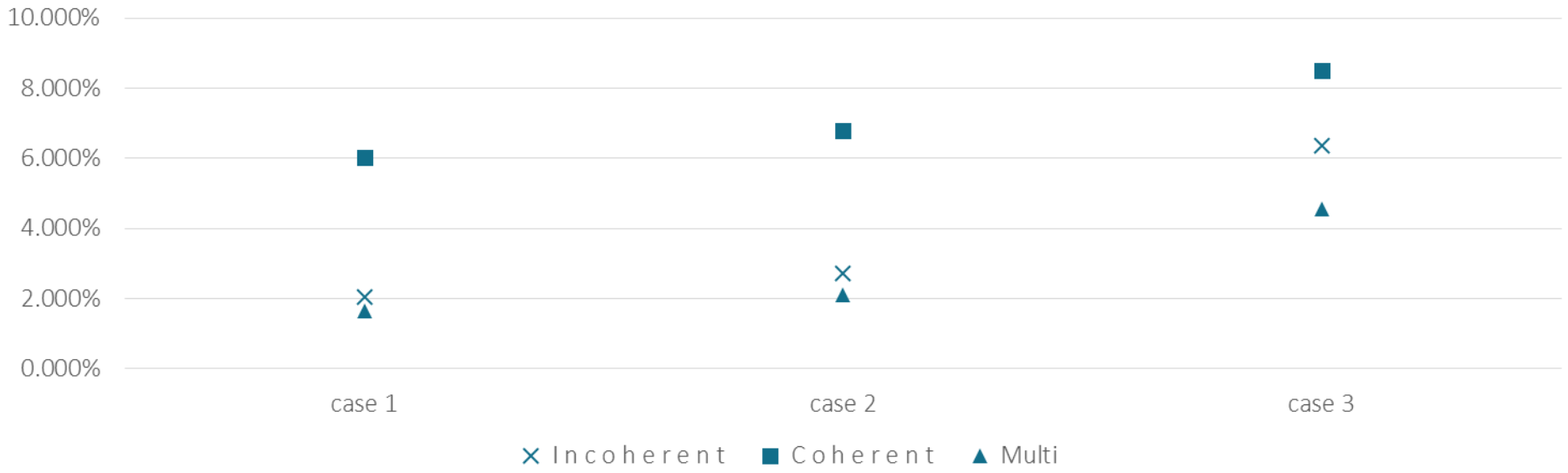


SF = 4.55%

RESULTS :

Object 2





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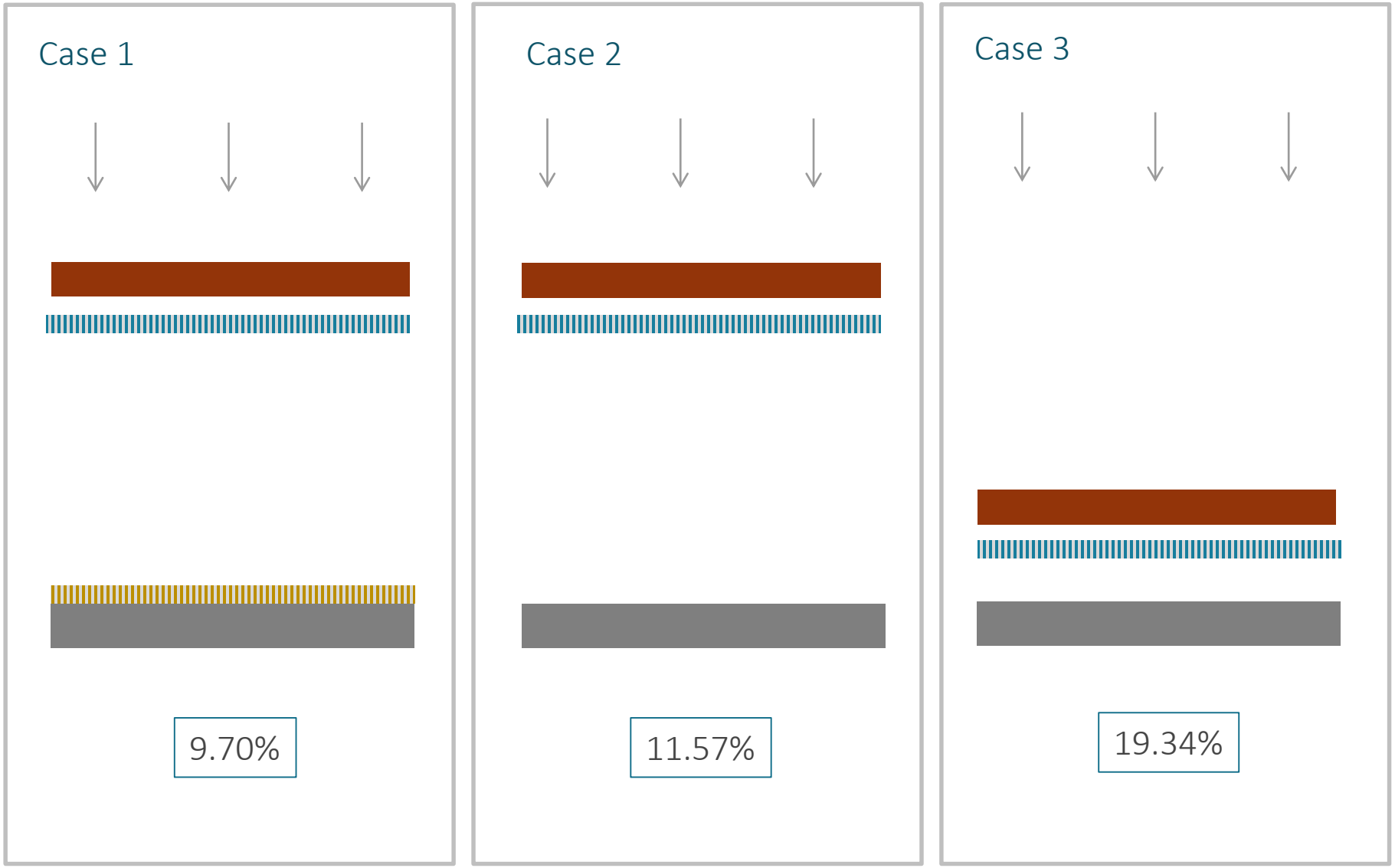
RESULTS :

Object 2



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DISCUSSION

1. Large object-to-detector distance

2. Grating G2 as anti-scattering grid

DISCUSSION

1. Large object-to-detector distance

	Case 2	*Case 3*
	0.82 %	1.60%
	11.57 %	19.34%

2. Grating G2 as anti-scattering grid

DISCUSSION

1. Large object-to-detector distance

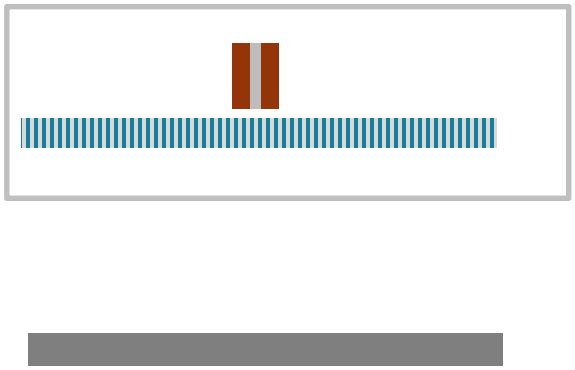
	Case 2	*Case 3*
	0.82 %	1.60%
	11.57 %	19.34%

2. Grating G2 as anti-scattering grid

	Case 1	*Case 2*
	2.08 %	0.82%
	9.70 %	11.57%

DISCUSSION

Case 2 : only object scatter



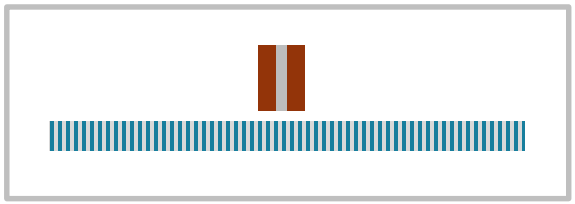
+ SF_{obj}

2. Grating G2 as anti-scattering grid

	Case 1	*Case 2*
	2.08 %	0.82%
	9.70 %	11.57%

DISCUSSION

Case 1 : 2 sources of scatter

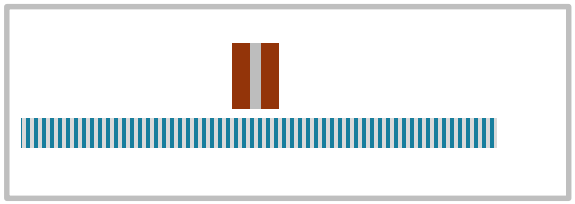


$+ SF_{obj}$

$- \epsilon SF_{obj}$

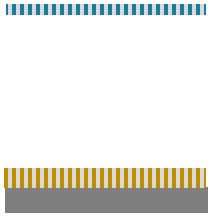
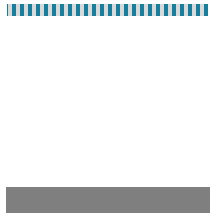
$+ SF_{G2}$

Case 2 : only object scatter



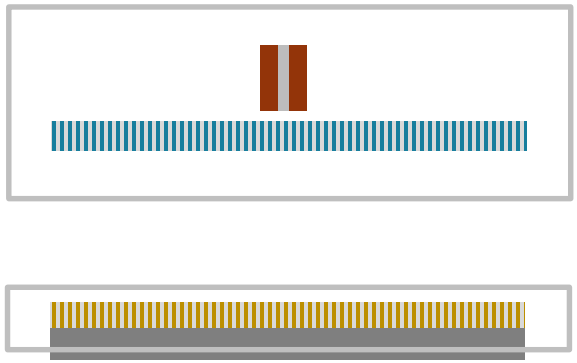
$+ SF_{obj}$

2. Grating G2 as anti-scattering grid

	Case 1 	*Case 2* 
	2.08 %	0.82%
	9.70 %	11.57%

DISCUSSION

Case 1 : 2 sources of scatter

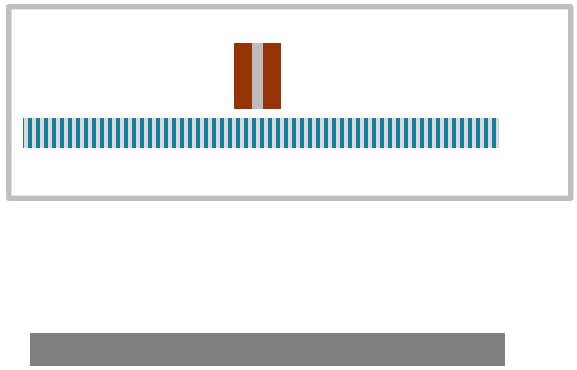


$+ SF_{obj}$

$- \epsilon SF_{obj}$

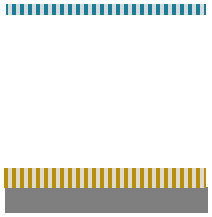
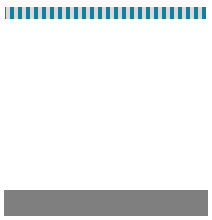
$+ SF_{G2}$

Case 2 : only object scatter



$+ SF_{obj}$

2. Grating G2 as **an inefficient** anti-scattering grid

	Case 1	*Case 2*
		
	2.08 %	0.82%
	9.70 %	11.57%

DISCUSSION

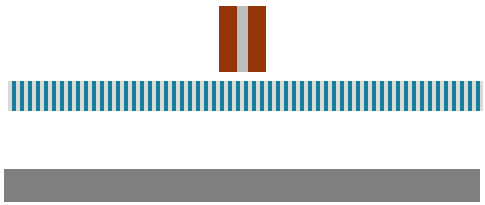
The more scatter created by the object, the more efficient grating G2 as an anti-scattering grid

2. Grating G2 as **an inefficient** anti-scattering grid

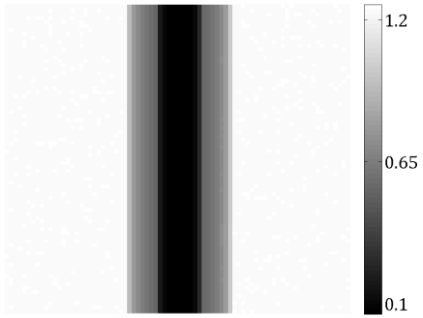
	Case 1	*Case 2*
	2.08 %	0.82%
	9.70 %	11.57%

DISCUSSION

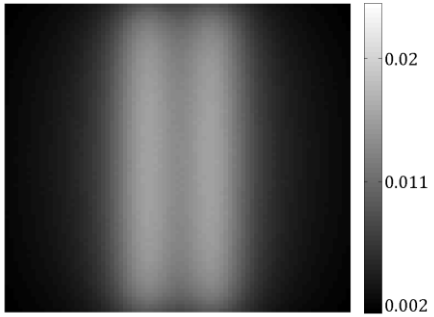
Case 3



Primary

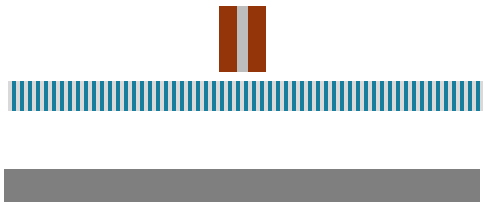


Coherent

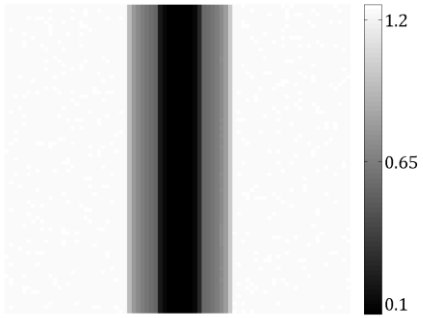


DISCUSSION

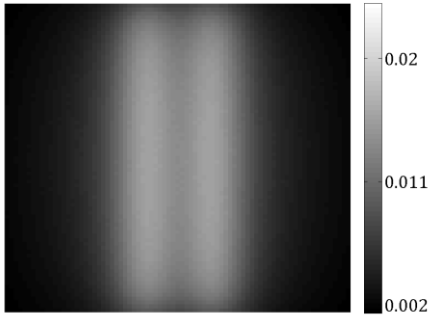
Case 3



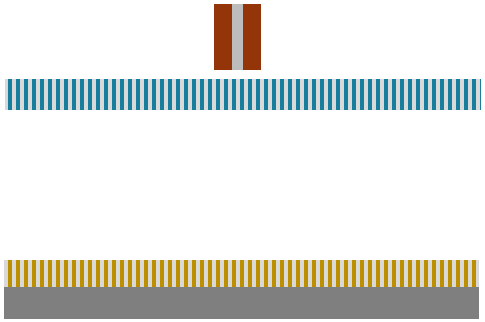
Primary



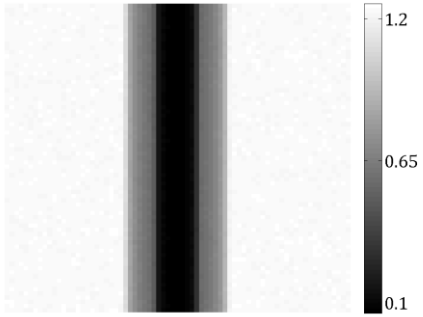
Coherent



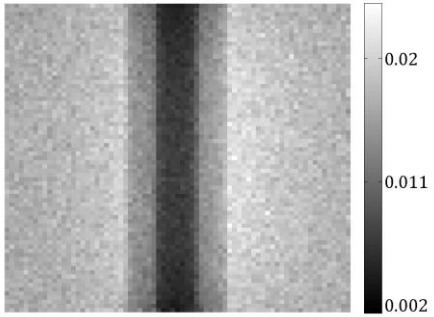
Case 1



Primary



Coherent



CONCLUSION

How significant is the scatter contribution in grating-based phase-contrast imaging?

CONCLUSION

Two aspect expected to limit scatter contribution

— Large object-to-detector distance

yes, 50% less scatter

— Grating G2 as anti-scattering grid

depends on the object

CONCLUSION

Two aspect expected to limit scatter contribution

— Large object-to-detector distance

yes, 50% less scatter

— Grating G2 as anti-scattering grid

depends on the object

How significant is the scatter contribution?

— For current objects of interest, scatter fractions very low.

— For high scatter objects contribution becomes more important.

Thank you

KU LEUVEN