PAUL SCHERRER INSTITUT

PSI

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An experimental approach for quantitative scattering correction in neutron imaging

11th World Conference on Neutron Radiography, Sydney, 2018

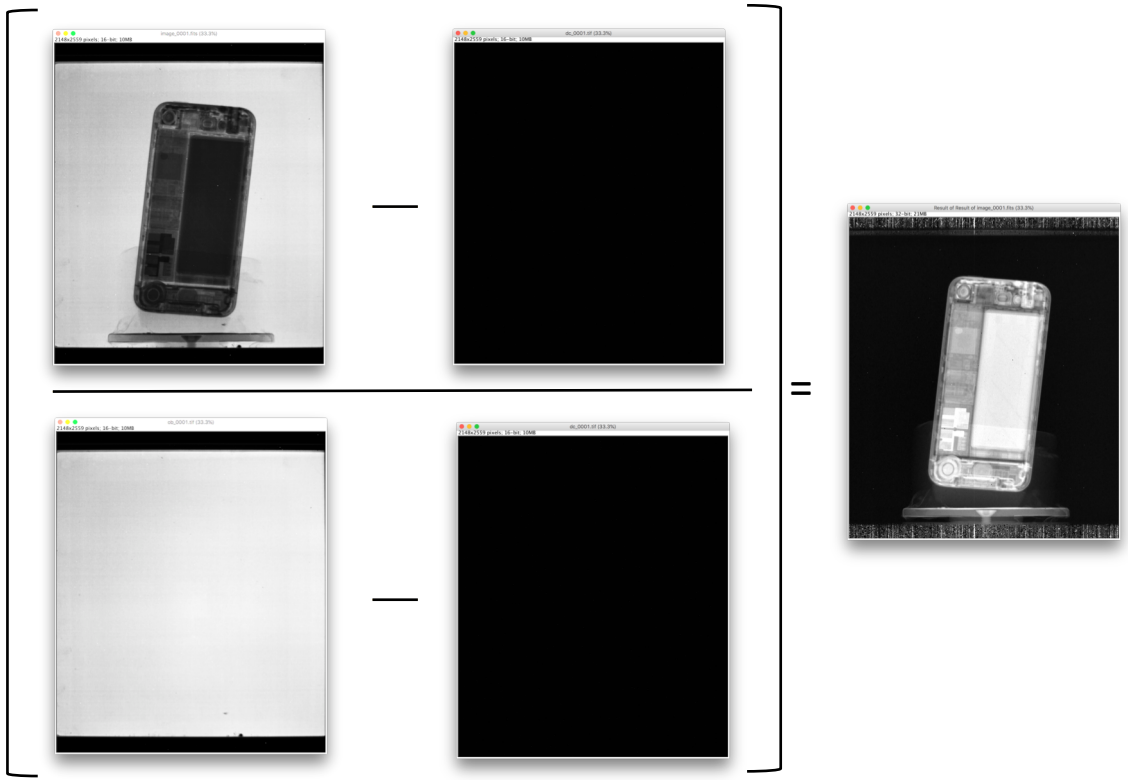
Outline

- Scattering and background/biases correction for quantitative neutron imaging
- Image model
- Experimental data
- Dedicated data processing
- MuhRec 4.0
- Development within SINE2020

Introduction

Lambert-Beer‘s law

$$\int \sum(s)ds = -\log\frac{(I-DC)}{(OB-DC)} = \text{-log}$$



Data taken at NEUTRA, PSI

Introduction: non linearities

“Sample scattering”

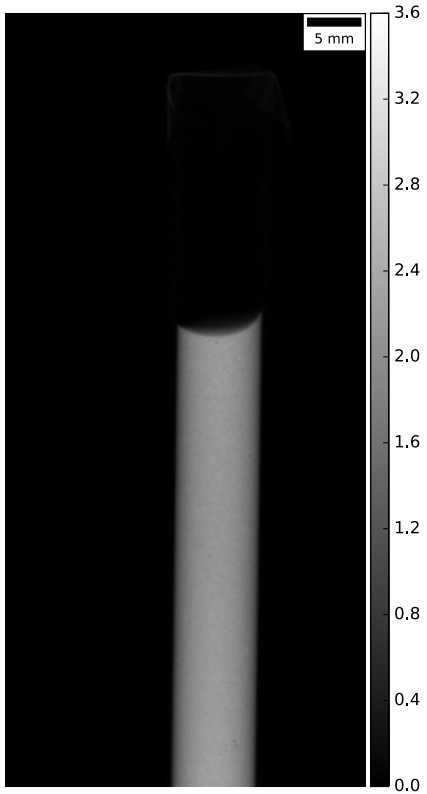
- Incoherent scattering caused by neutrons colliding with the sample
- Sample geometry and composition
- Detector distance

“Background scattering” (systematic biases)

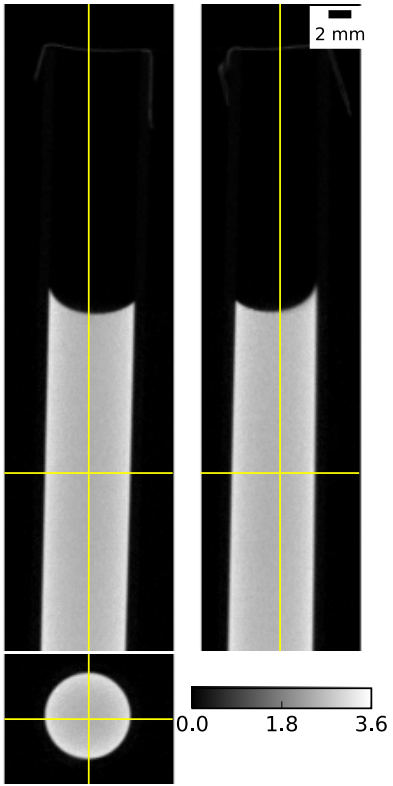
- Additional neutrons scattered at the shielding or the instrumentation
- Light backscattered from the mirror of the camera box

Introduction: effect on uncorrected images

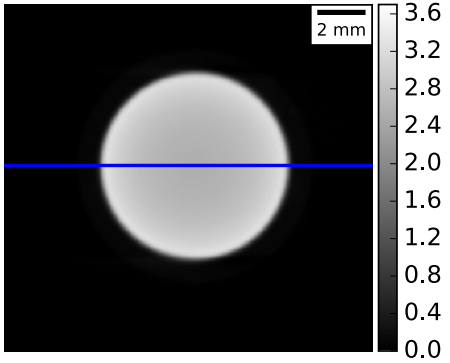
Referenced projection

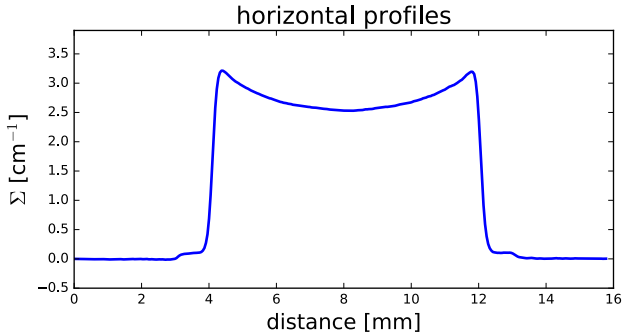


Reconstructed CT



Averaged slice



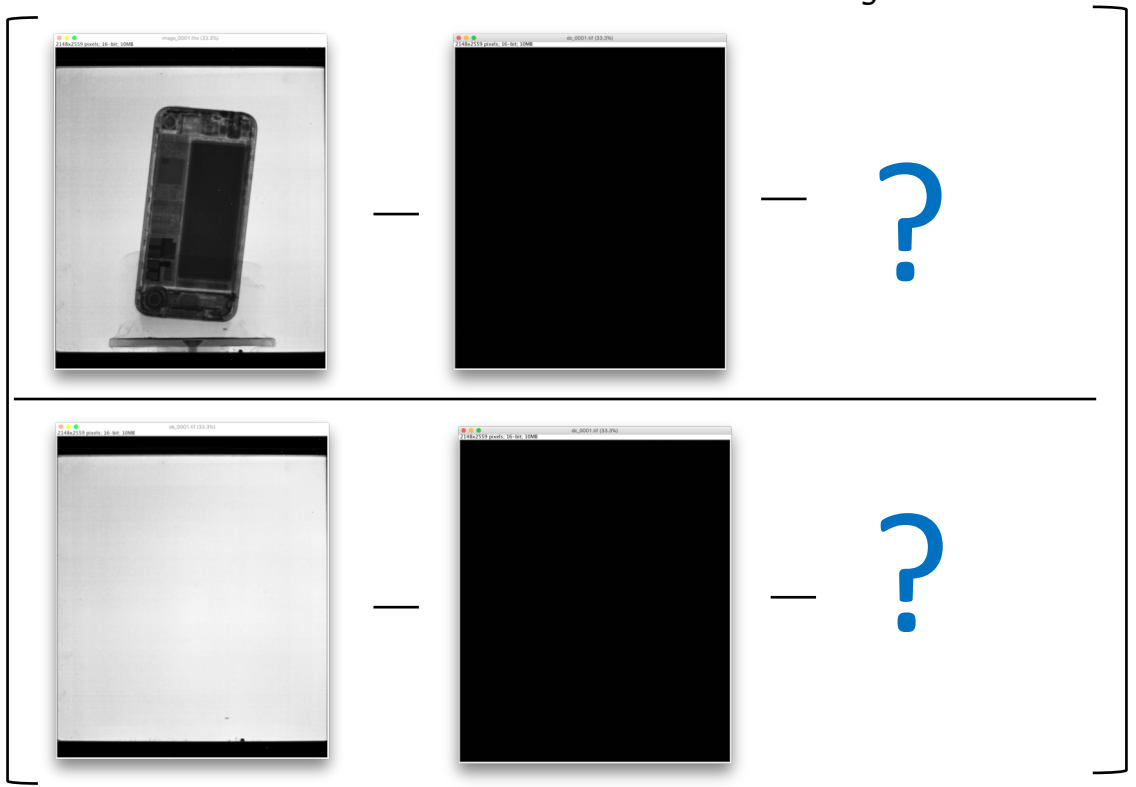


Method: image model

Lamber Beer‘s law

$$\int \sum(s)ds = -\log\frac{(I-DC-S)}{(OB-DC-BG)} = \text{-log}$$

Sample and background scattering

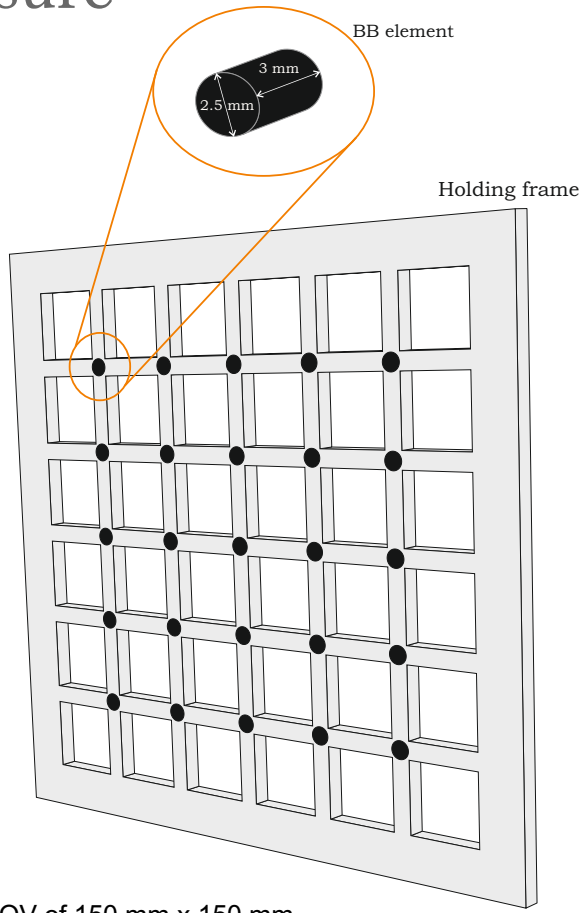


Background scattering

Method: how to measure

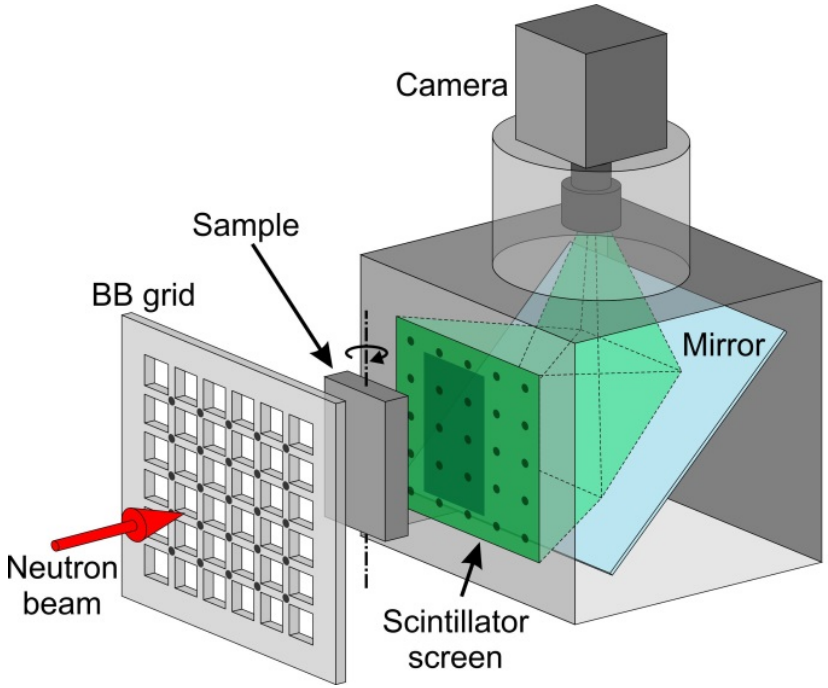
Holding frames with ”black bodies” (BB):

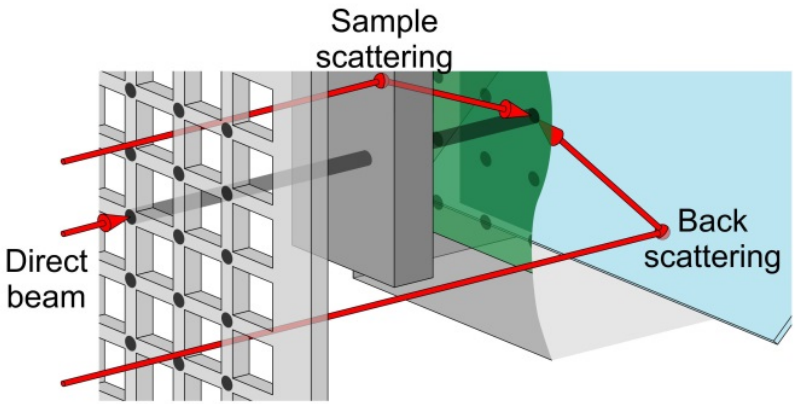
- aluminium frame
- BBs = cylindrical objects made of $^{10}B_4C$



FOV of 150 mm x 150 mm

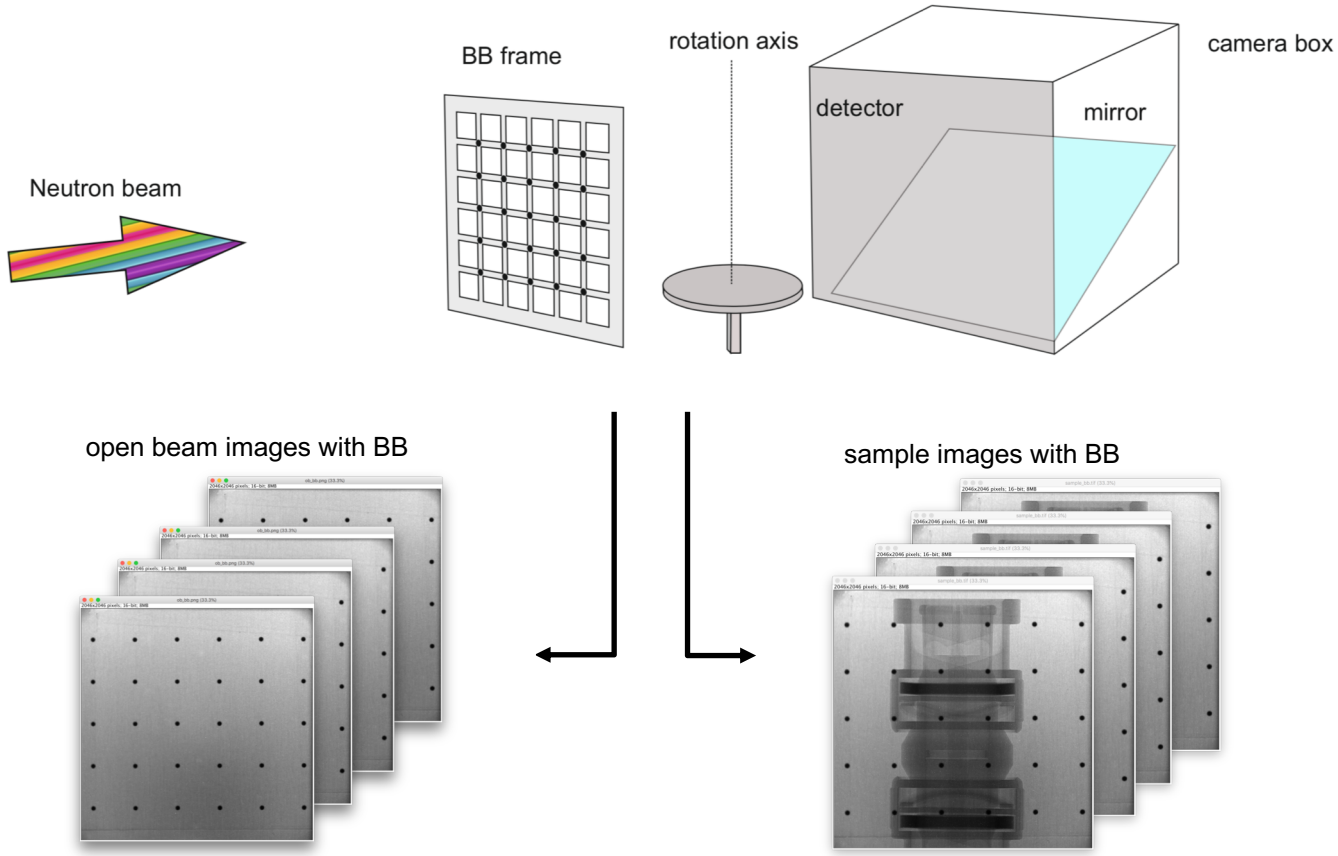
Method: how to measure





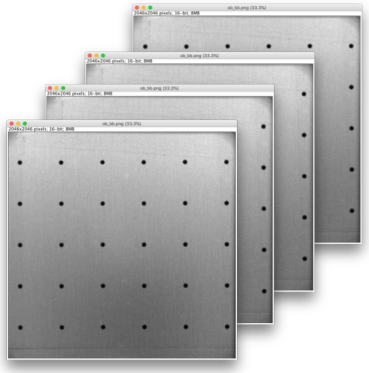
Boillat 2018, Optics Express

Method: how to measure

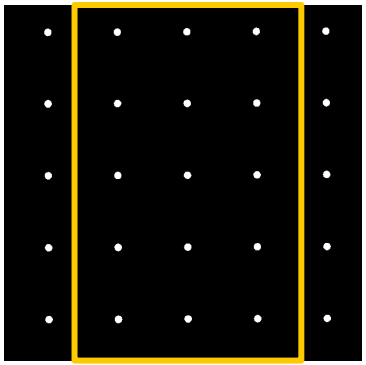


Method: how to process

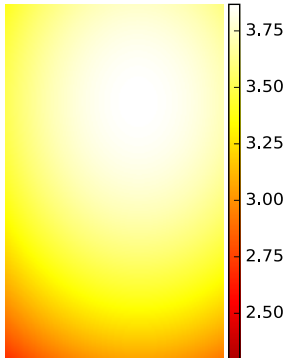
open beam image with BB



BB mask



Interpolated background



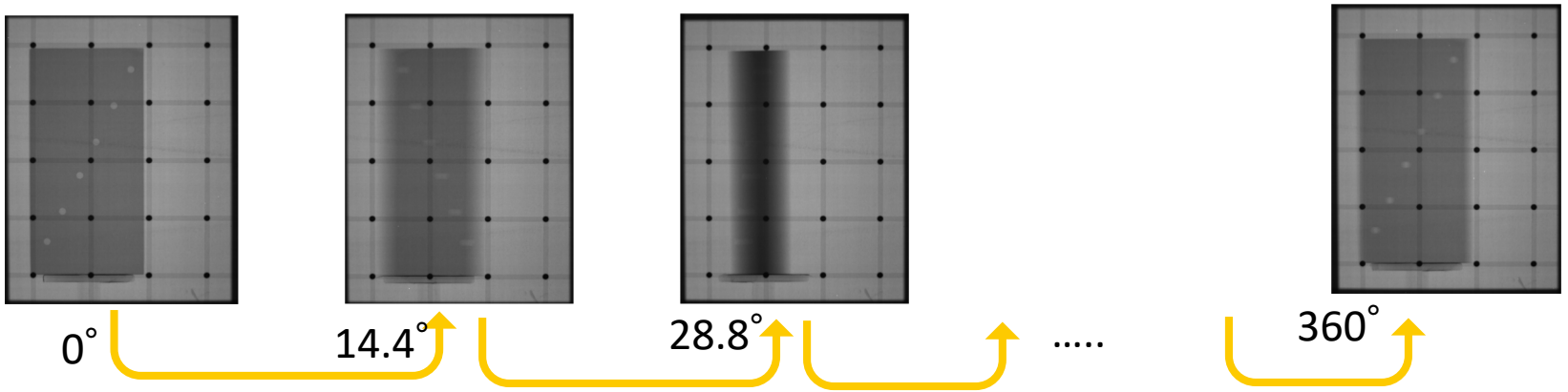
Poster A. Kaestner: WCNR11

$$\int \sum(s)ds = -\log \frac{(I-DC-S)}{(OB-DC-BG)}$$

background scattering

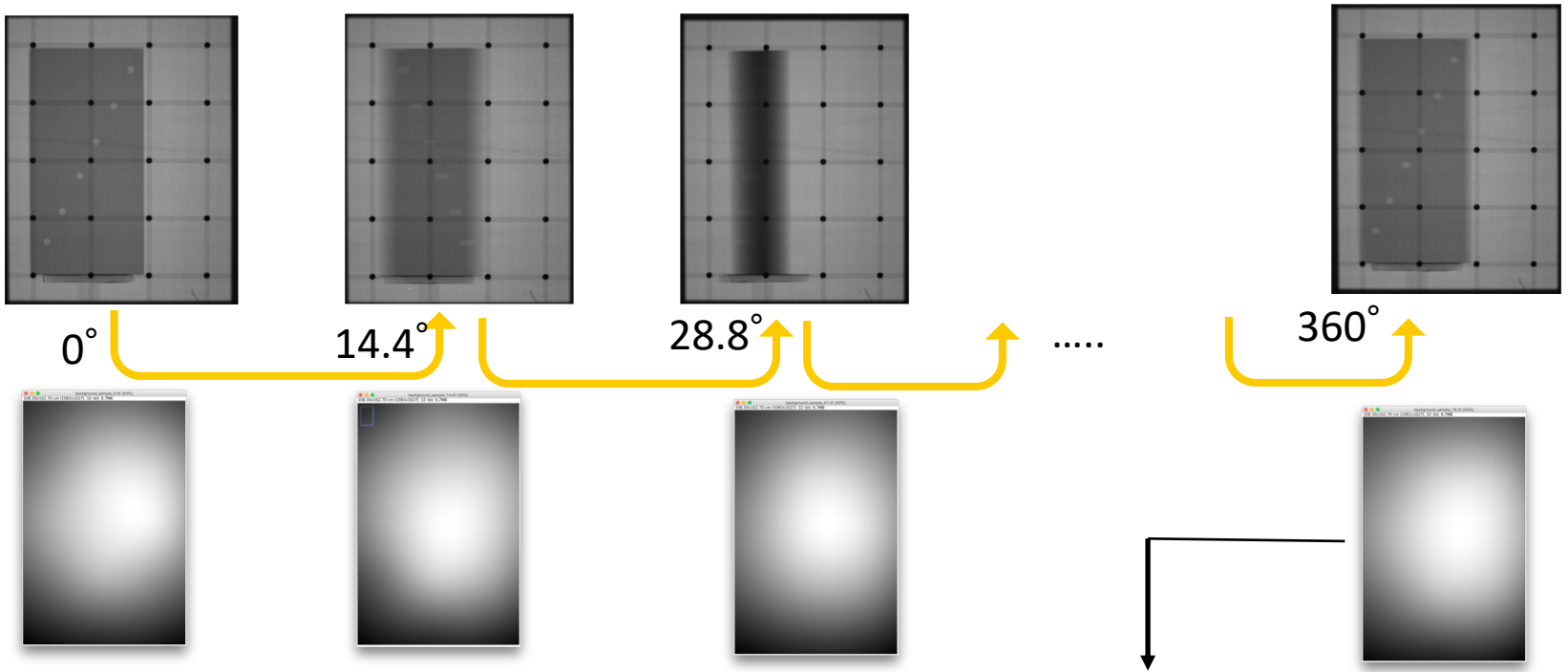
Method: how to process

Sample images with BB – sparse CT



Method: how to process

Sample images with BB – sparse CT

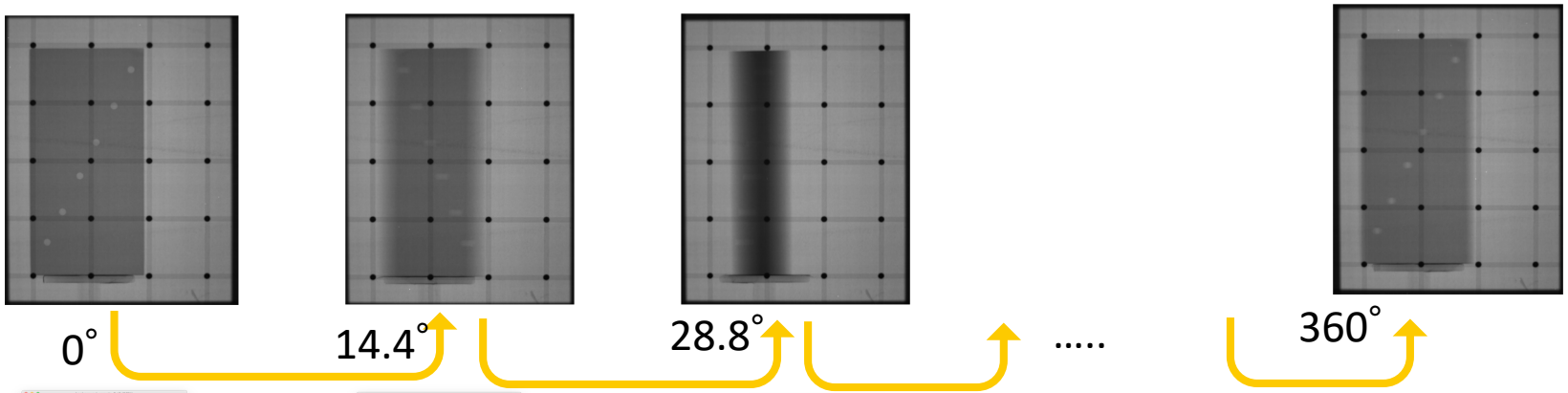


$$\int \sum(s)ds = -\log \frac{(I-DC-S)}{(OB-DC-BG)}$$

sample scattering

Method: how to process

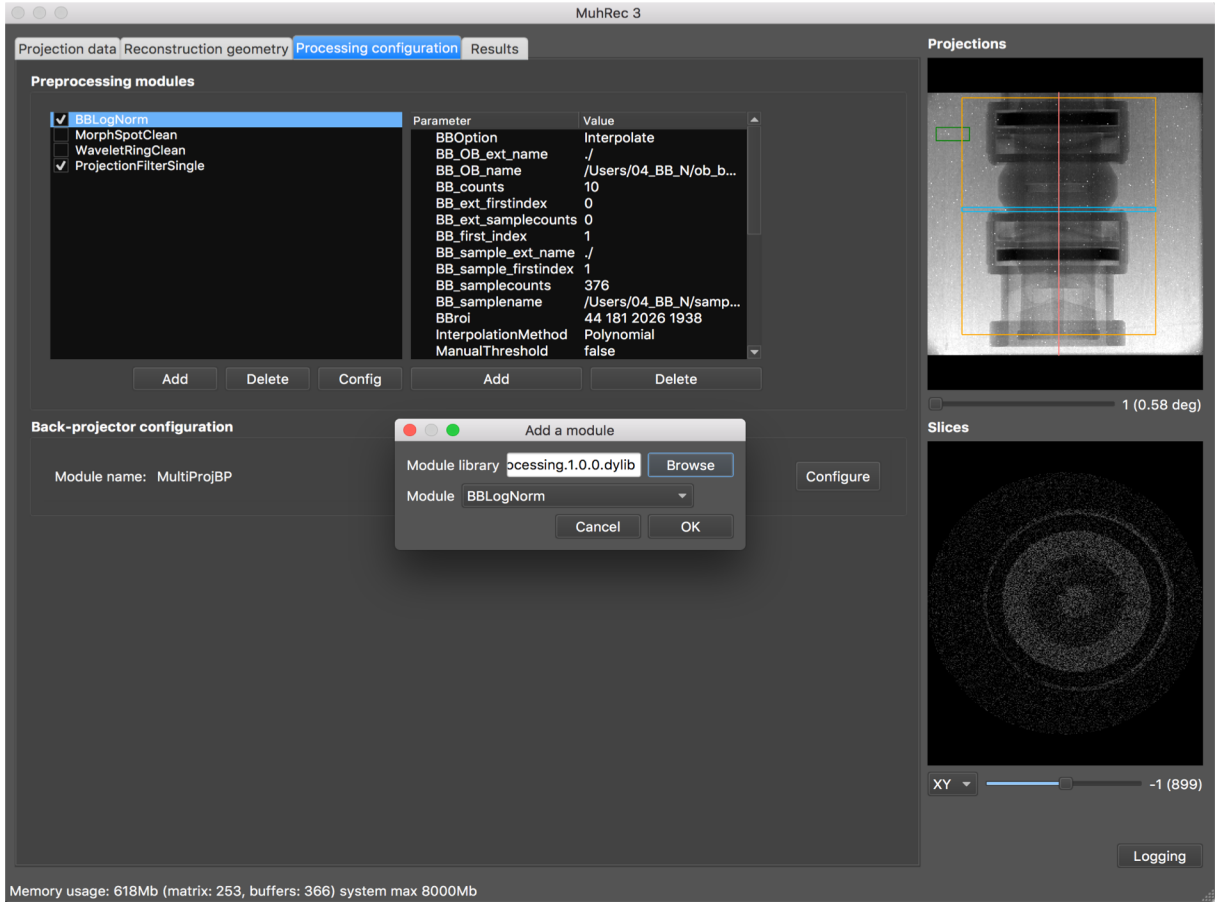
Sample images with BB – sparse CT



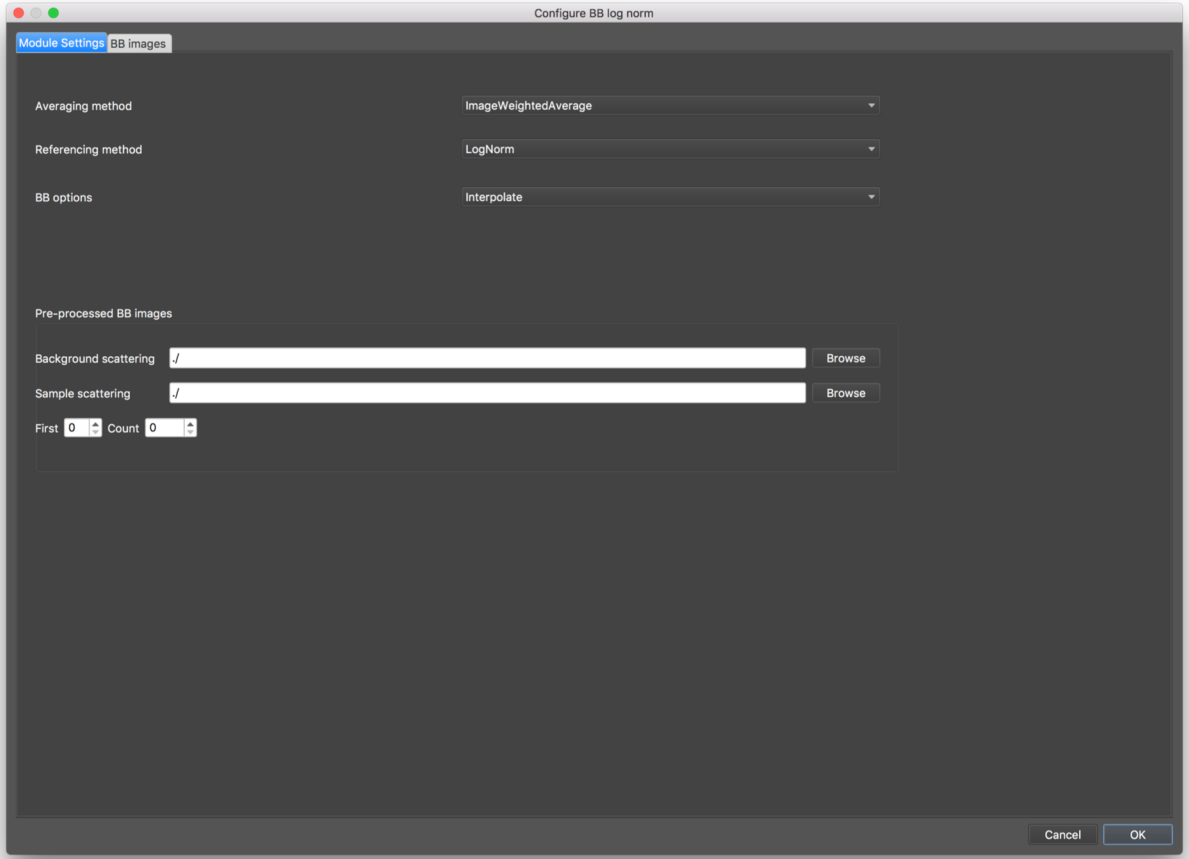
$$\int \sum(s)ds = -\log \frac{(I-DC-S)}{(OB-DC-BG)}$$

sample scattering

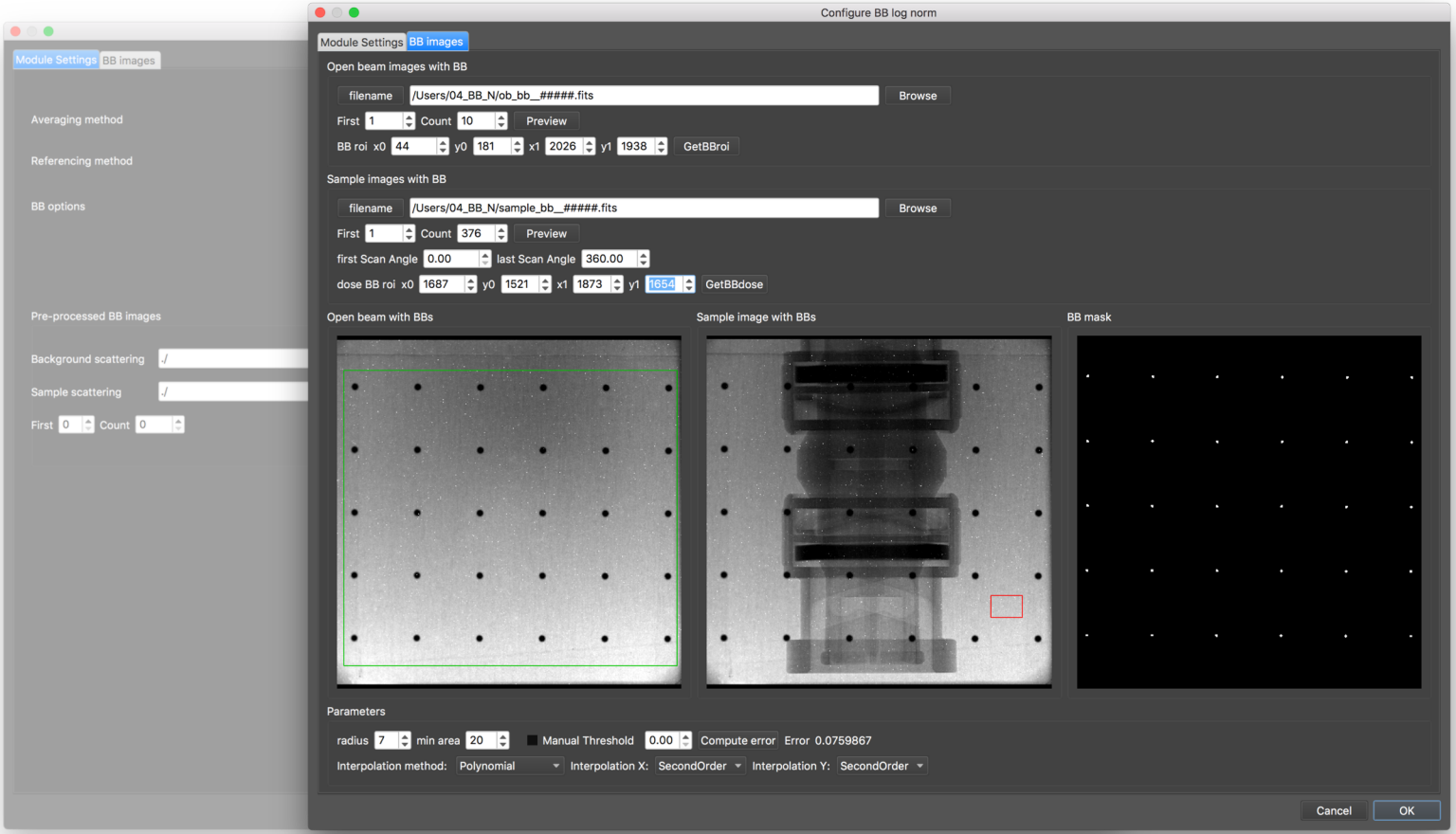
Method: MuhRec implementation



Method: MuhRec implementation

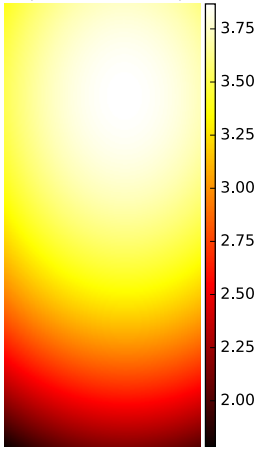


Method: MuhRec implementation

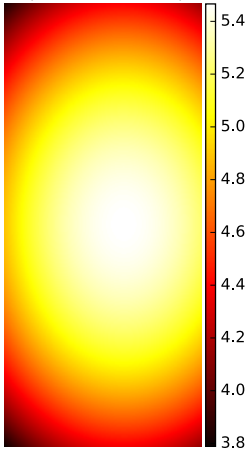


Results

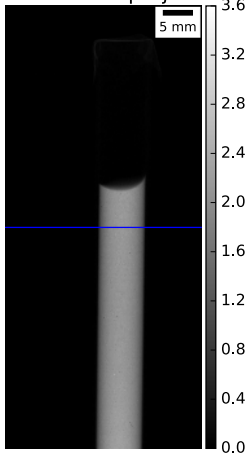
Background scattering (fraction of OB)



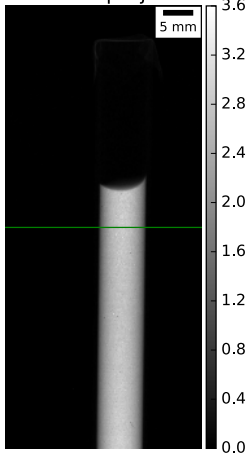
Sample scattering (fraction of OB)



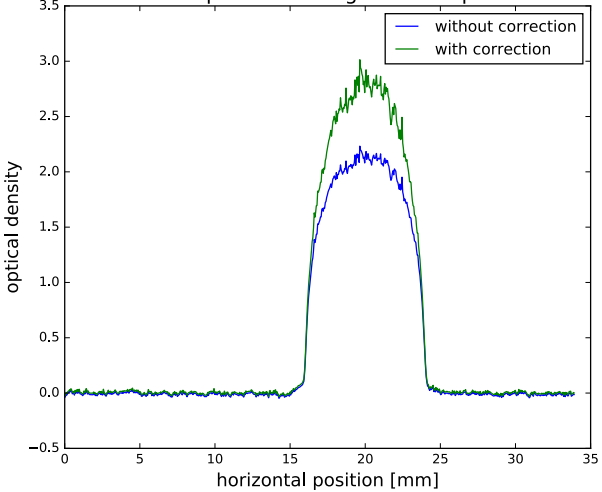
Non corrected projection



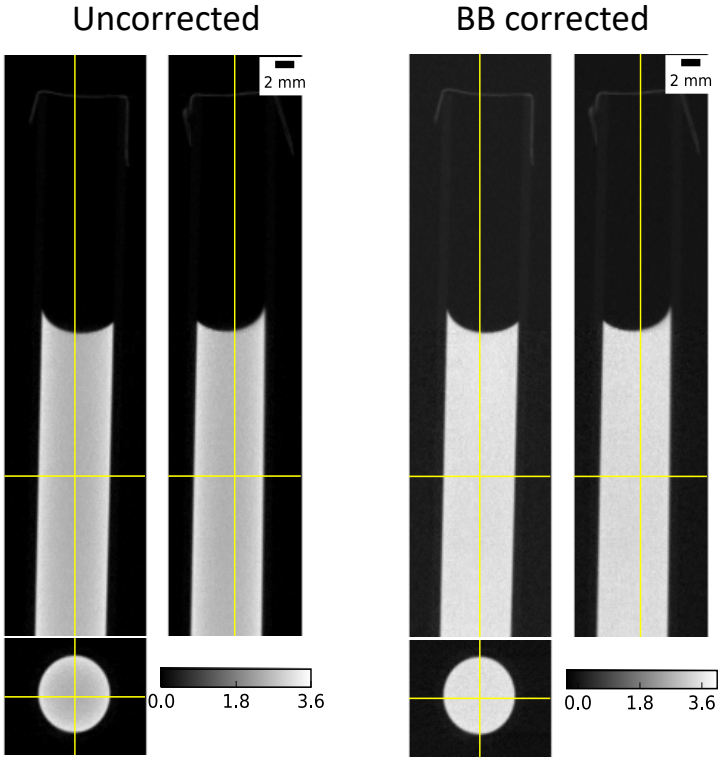
Corrected projection

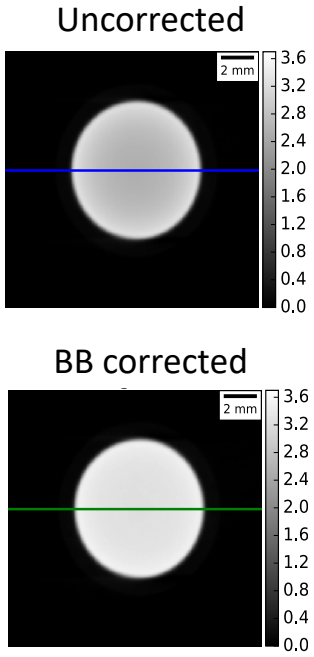


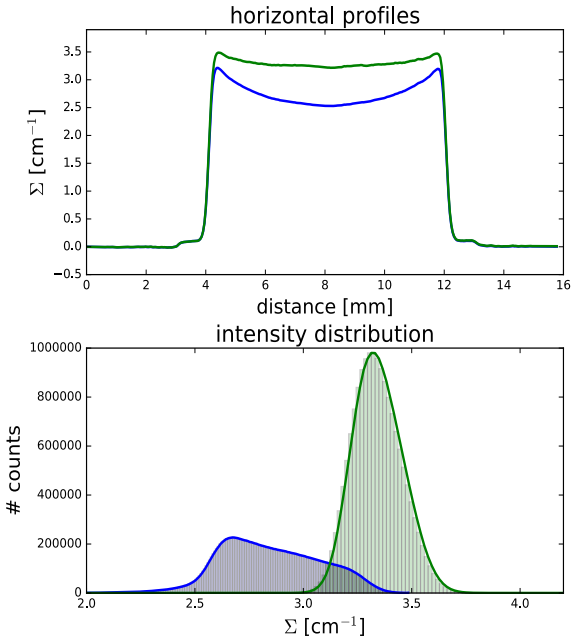
line profiles through the sample



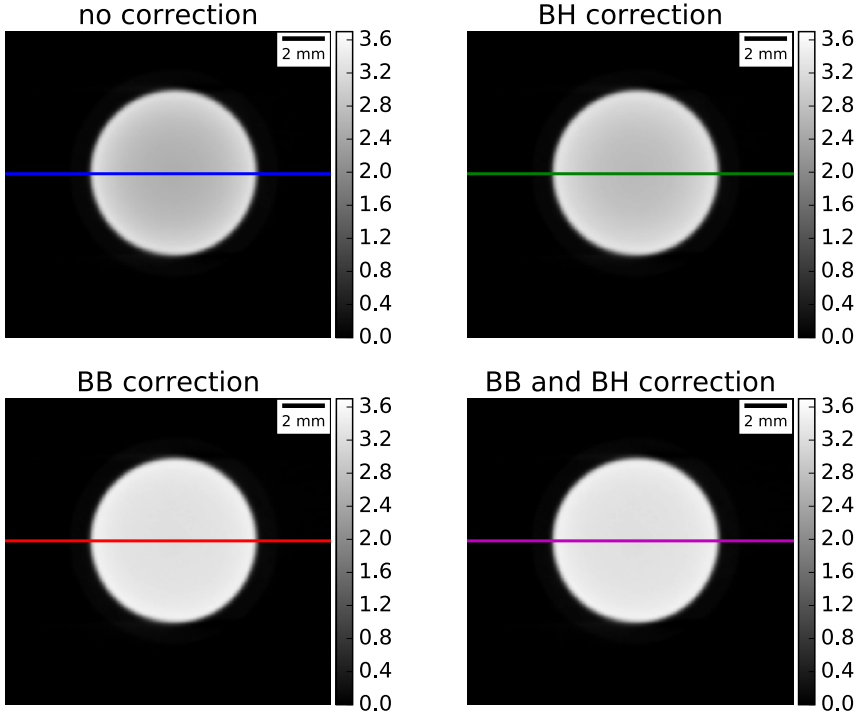
Results

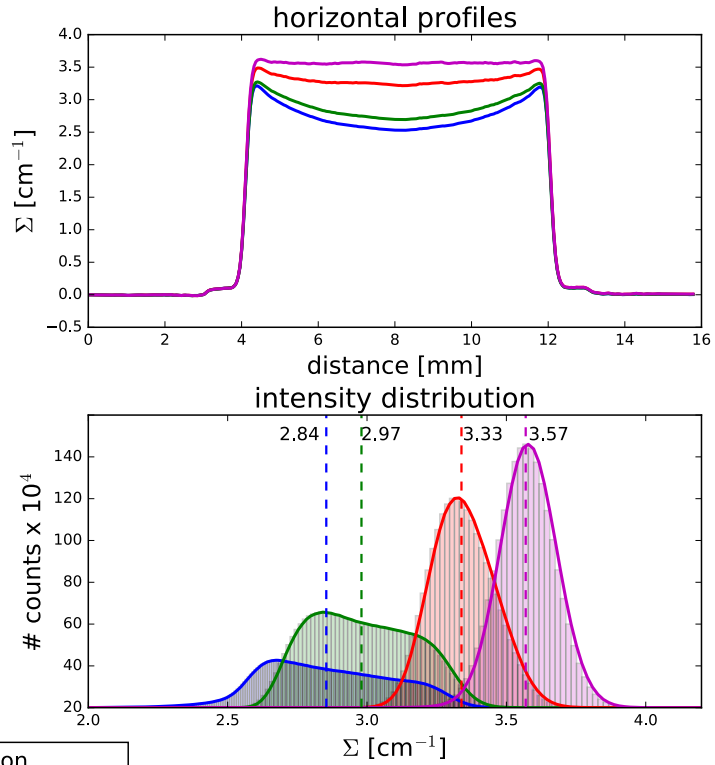

Uncorrected
BB corrected
2 mm
2 mm
0.0
1.8
3.6
0.0
1.8
3.6


Uncorrected
2 mm
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0.0
BB corrected
2 mm
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0.0


horizontal profiles
Σ [cm⁻¹]
distance [mm]
intensity distribution
counts
Σ [cm⁻¹]

Results


no correction
BH correction
BB correction
BB and BH correction
2 mm
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0.0


horizontal profiles
Σ [cm⁻¹]
distance [mm]
intensity distribution
counts x 10⁴
2.84
2.97
3.33
3.57
Σ [cm⁻¹]
no correction
BH correction
BB correction
BB and BH correction

Conclusions

- Acknowledgements: NIAG

- Validation with experimental datasets
- Simulated datasets (McStas)
- Several parameters were tested (#BB projections, interpolation scheme, mathematical formulation..)
- Integration in KipTool

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Thank you