SPECT reconstruction with STIR

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Anaheim, 1st November 2012

UNIVERSITAT DE BARCELONA

Aim

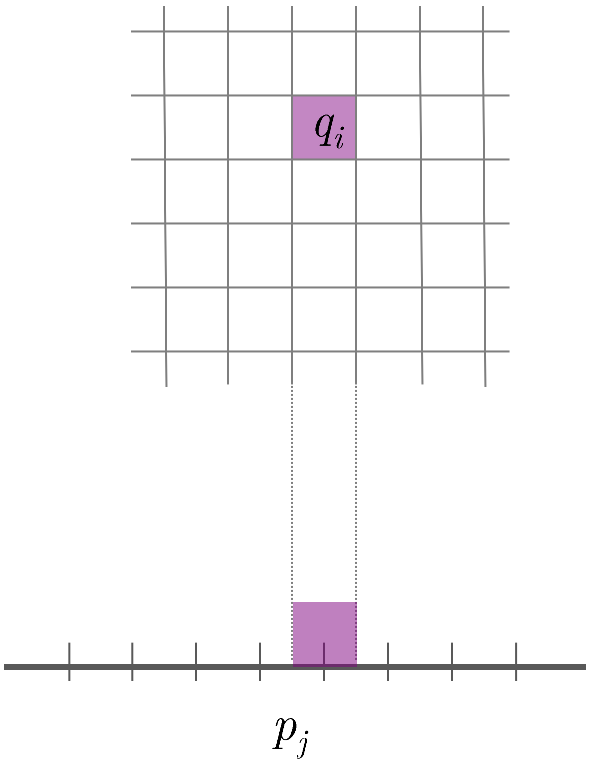
SPECT Reconstruction Library
from UB

Reconstruction
(OSEM
or OSSPS)

Generation of transition matrices

- Spatially variant Point Spread Function (PSF) modelling
- Attenuation modelling

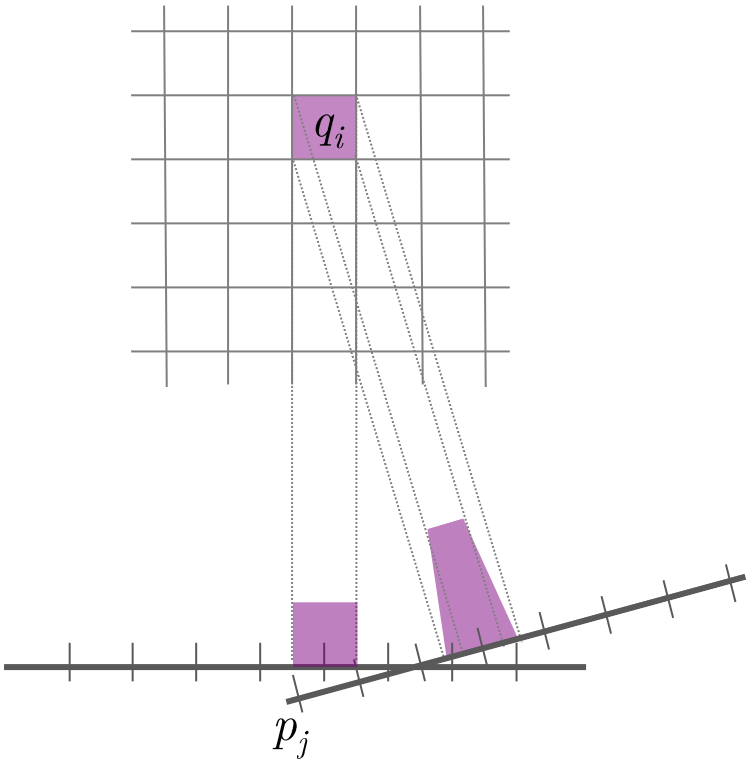
Without Corrections



$$p_j = \sum_i \boxed{A_{ji}} \cdot q_i$$

Geometrical approach

Without Corrections



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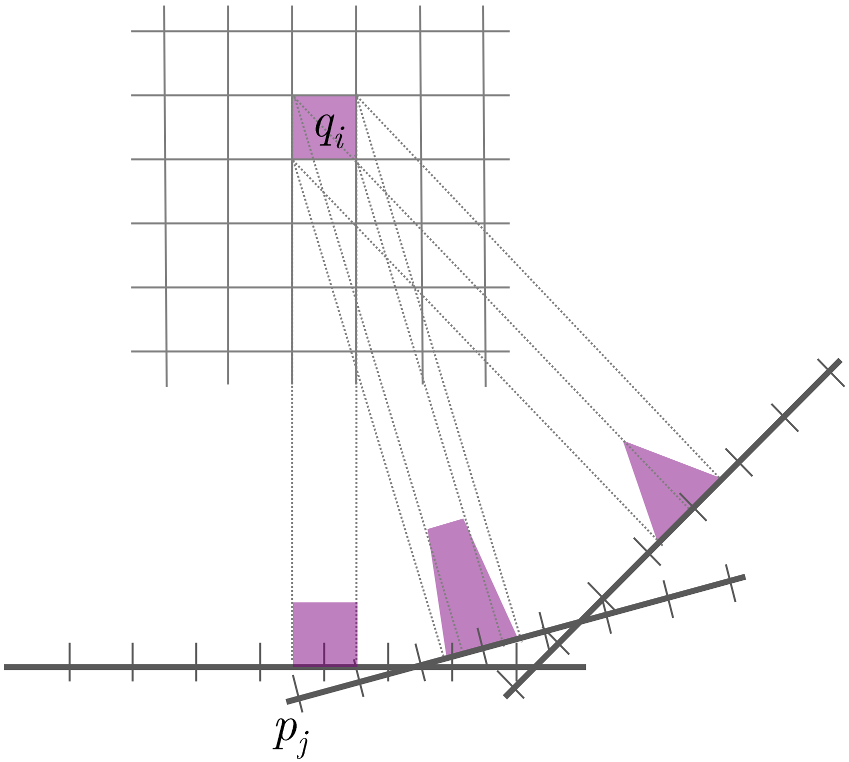

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Geometrical approach

Without Corrections

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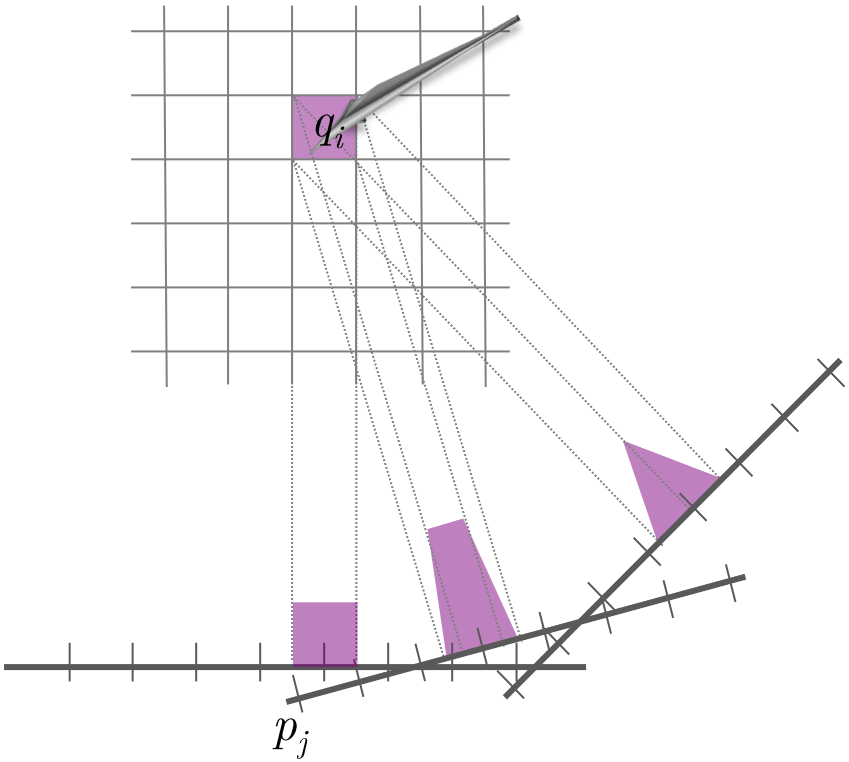

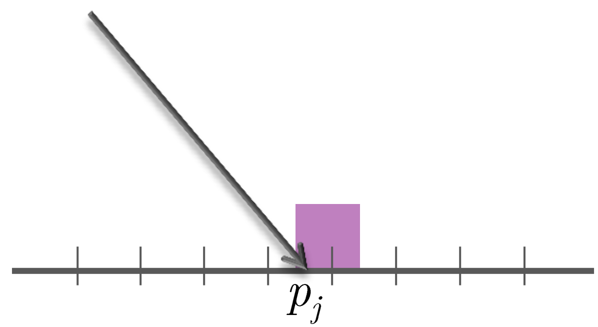

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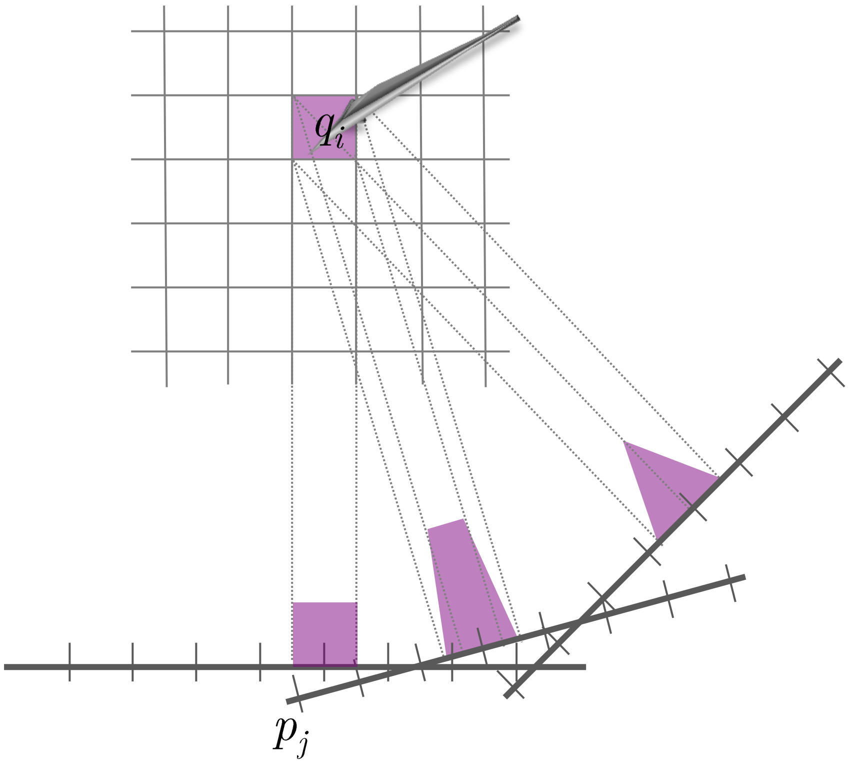

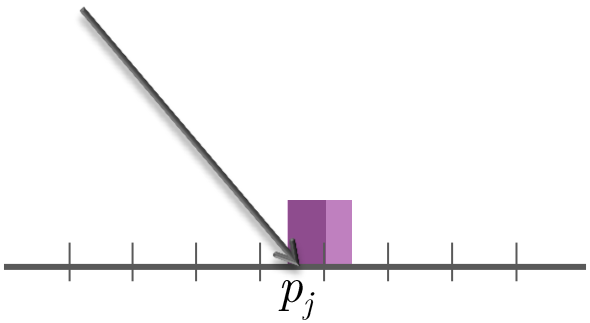

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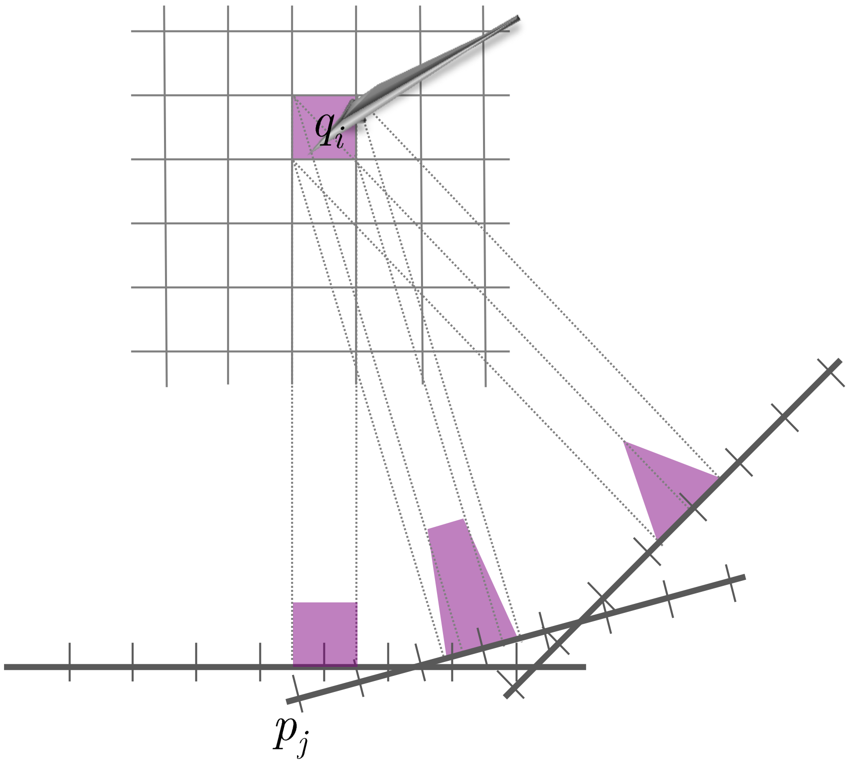

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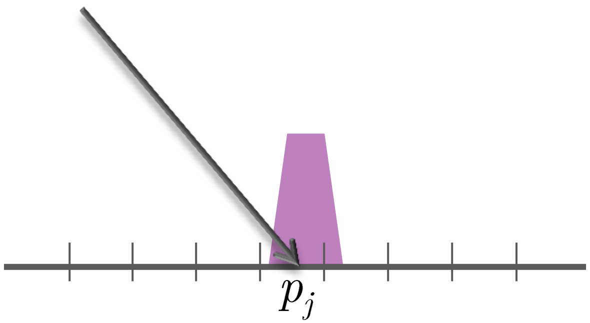

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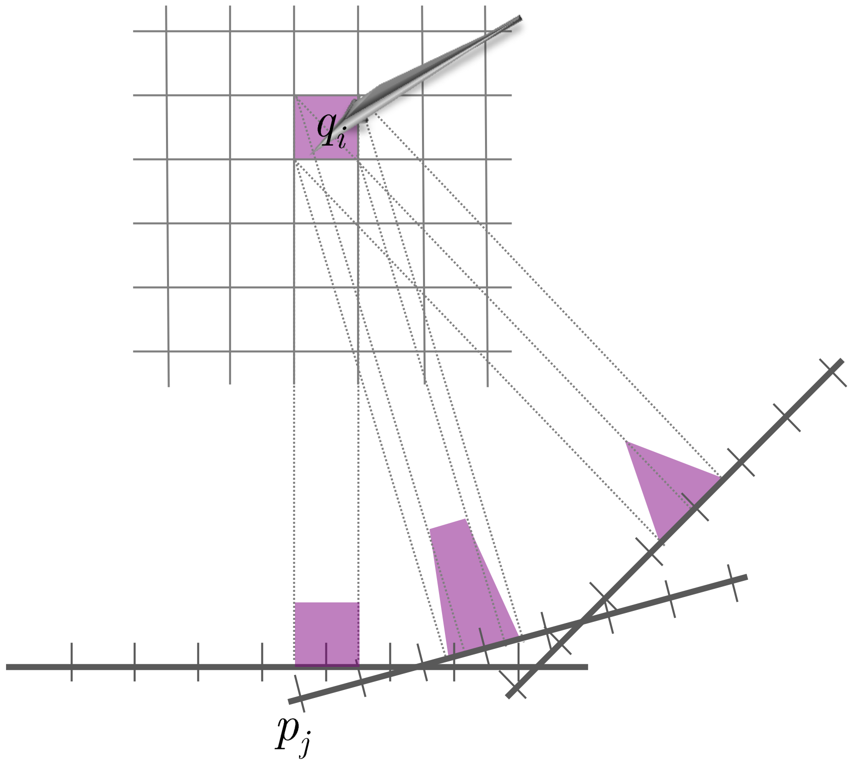

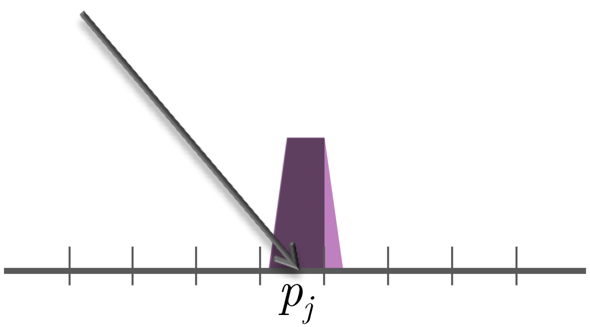

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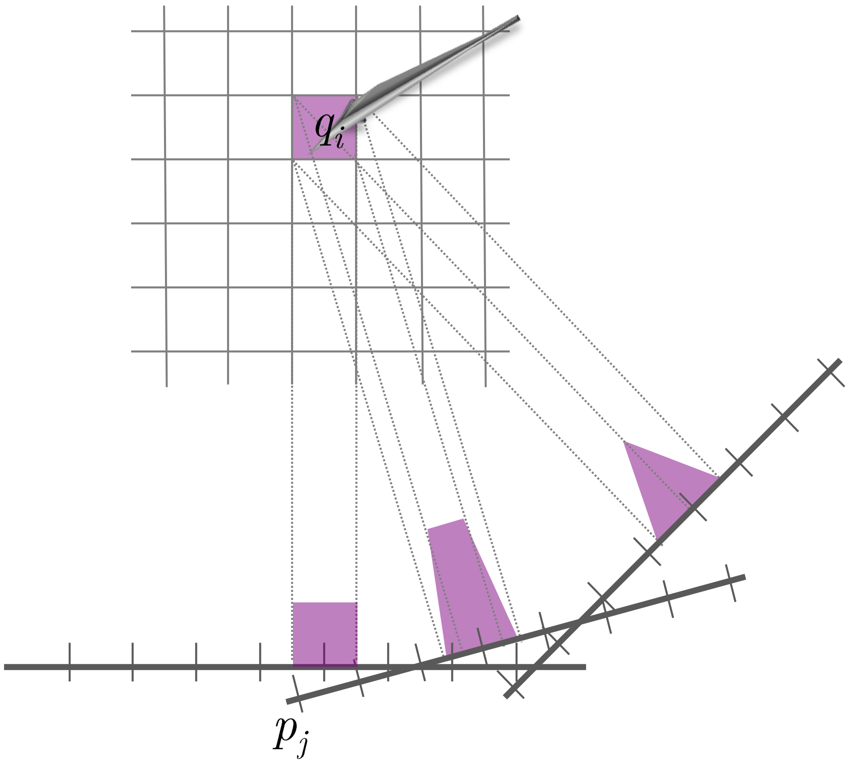

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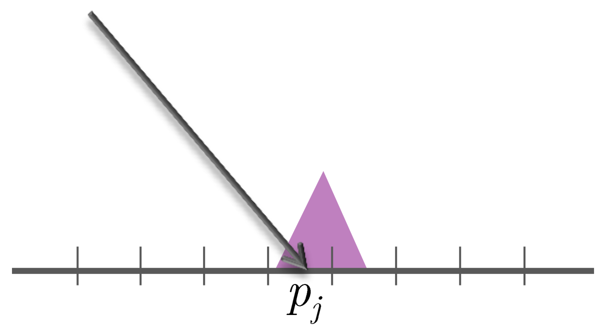
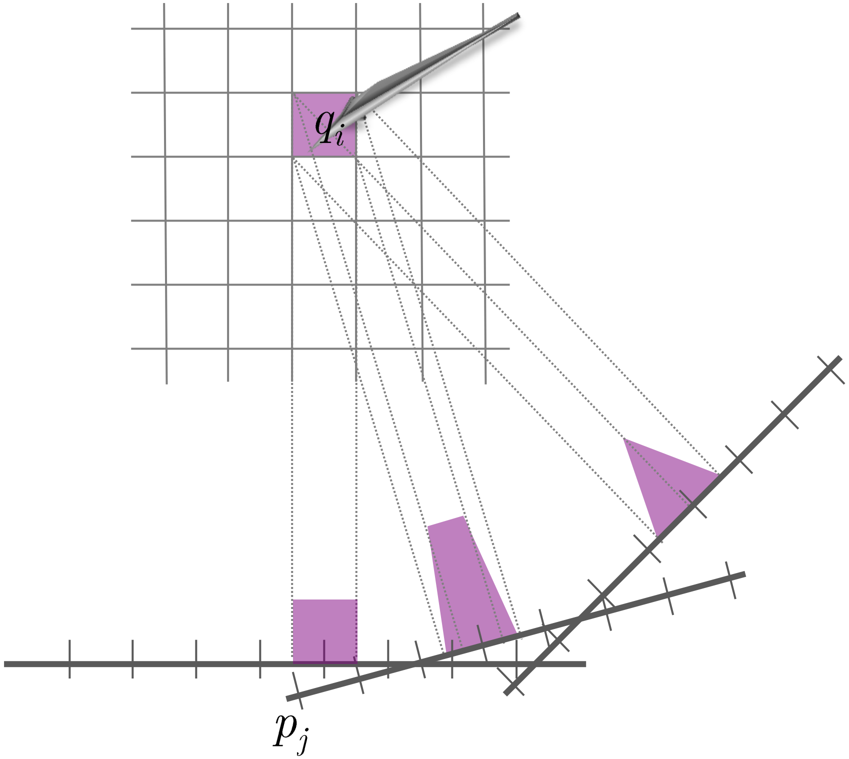


Without Corrections



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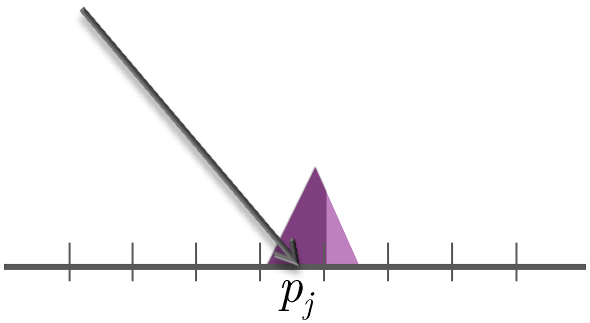
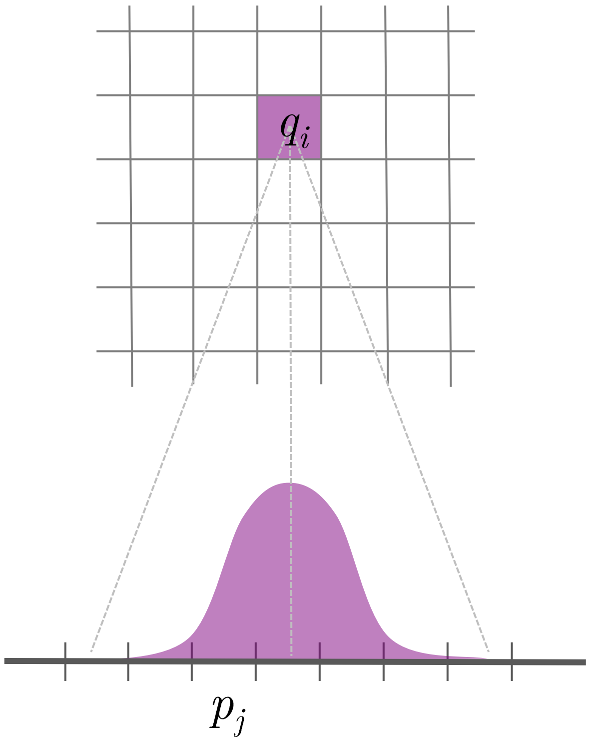


PSF Modelling



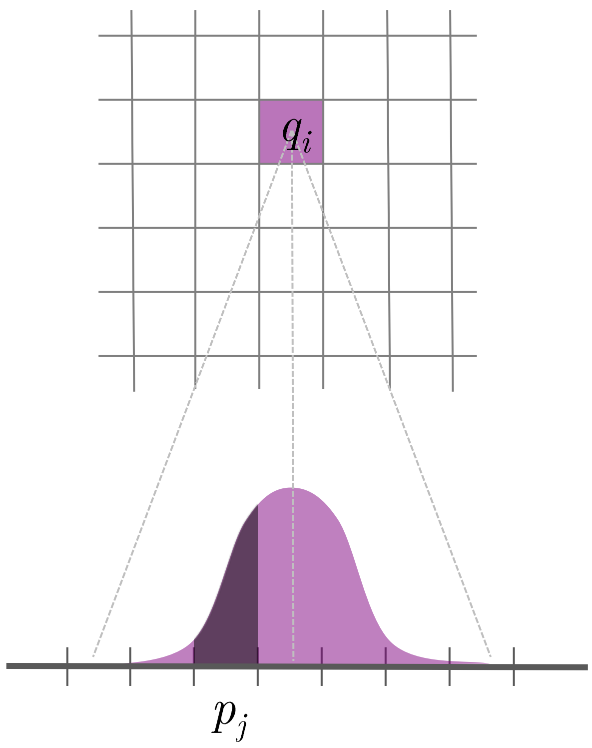
PSF tends to a Gaussian distribution

PSFs are spatially variant

2D-PSF correction

3D-PSF correction

PSF Modelling



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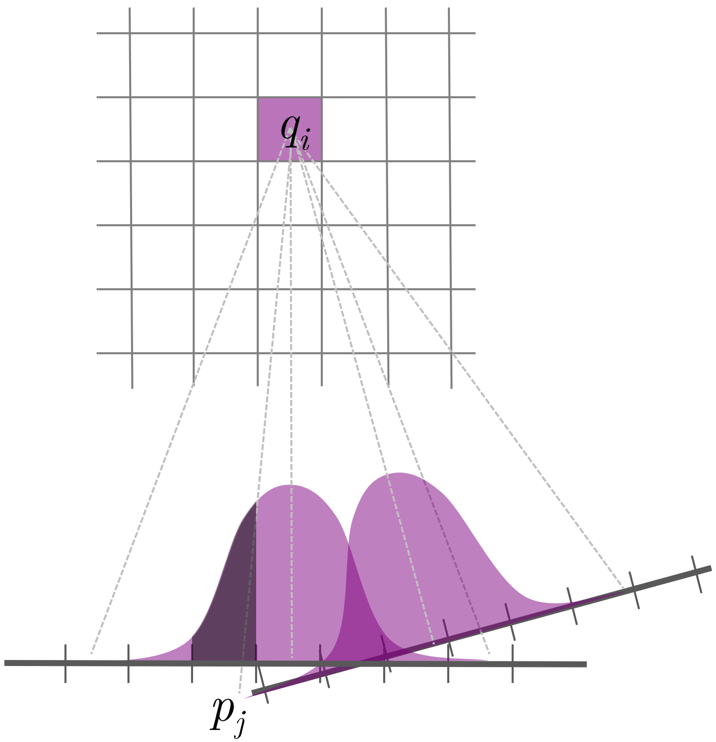

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- 2D-PSF correction
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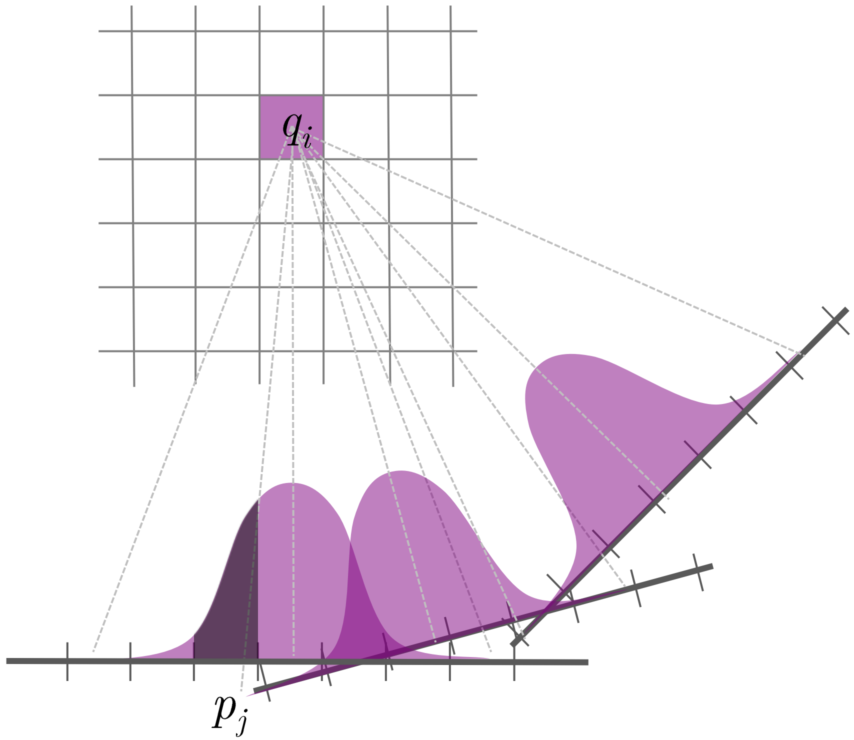

PSF tends to a Gaussian distribution

PSFs are spatially variant

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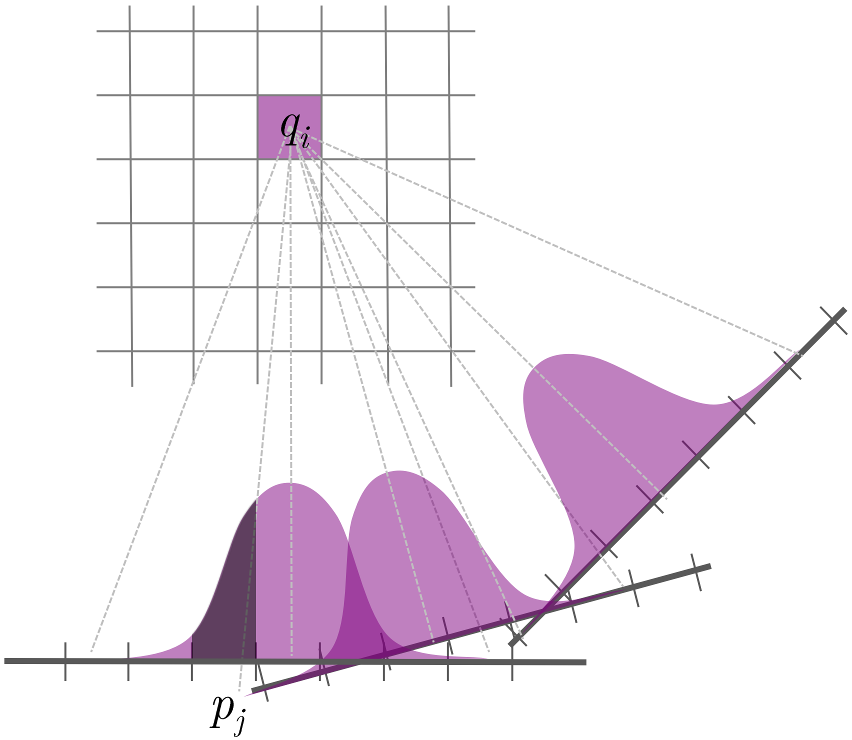


PSF tends to a Gaussian distribution

PSFs are spatially variant

- 2D-PSF correction
- 3D-PSF correction

Requirements for PSF correction:

Characterization of each collimator

PSF Modelling

Parallel:

$$\sigma = A \cdot d + B$$

ECAM (SIEMENS)
Infinia Hawkeye (GE Healthcare)
Elscint

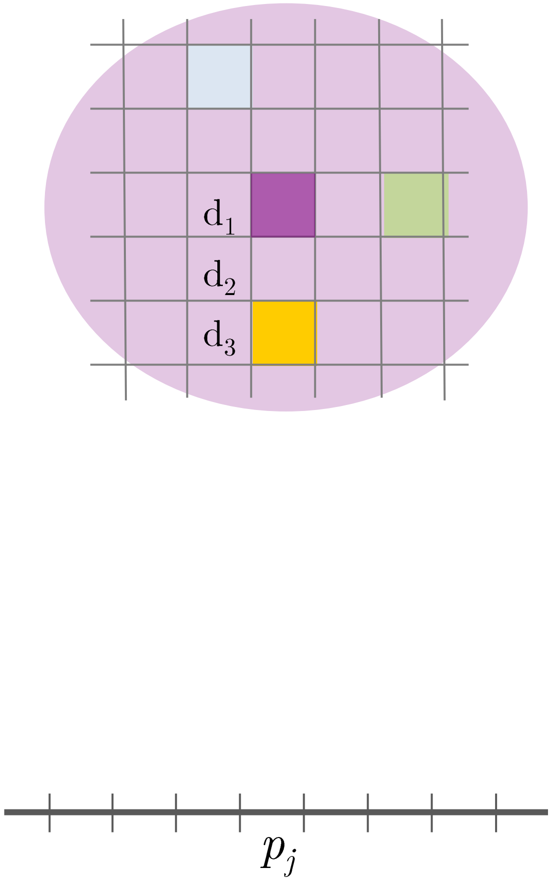
Fan-beam collimator:

$$\sigma\ (d, \theta)$$

Elscint

D. Pareto et al. Geometrical Response Modeling in Fan-beam collimators. A numerical simulation, *Trans. Nucl. Sci.*, 49 (February 2002), pp. 17 – 24.

Attenuation Modelling



$$A_{ji} = a_{ji}^{PSF} \cdot a_{ji}^{att}$$

$$a_{ji}^{att} = \exp(-\sum_k \mu_k d_k)$$

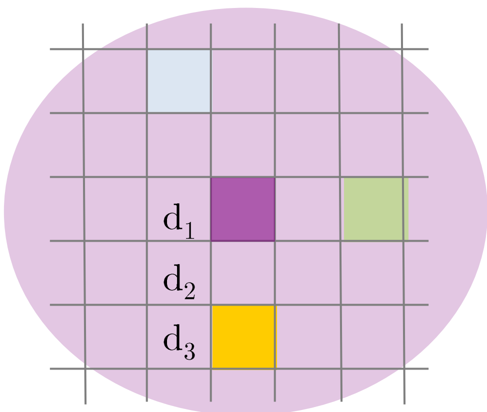
Simple correction

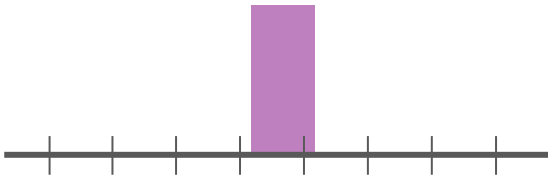
Full correction

Requirements:

Attenuation map
- reconstruction dimensions
- μ_k in cm^{-1}

Attenuation Modelling





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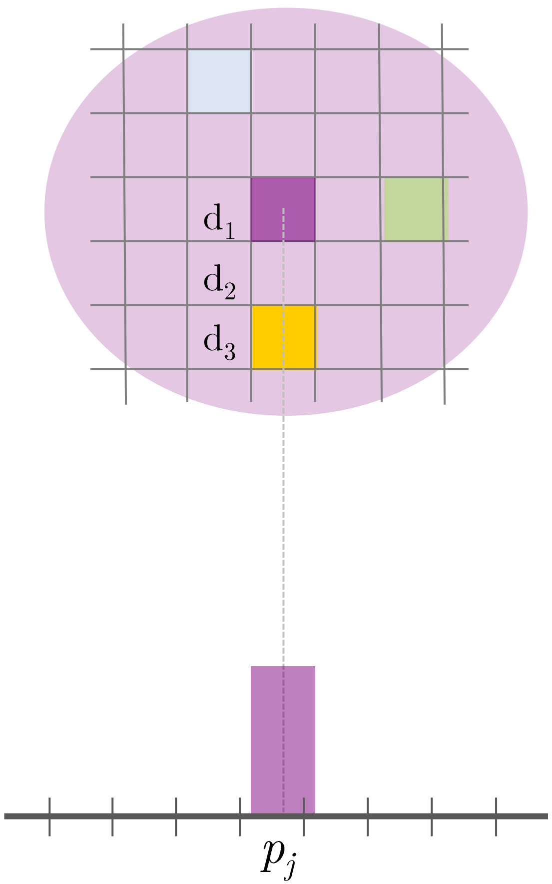

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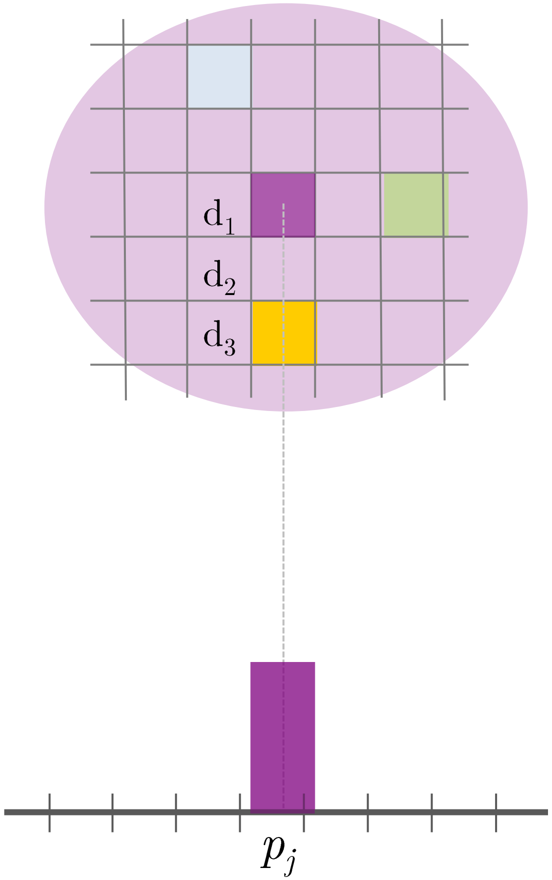

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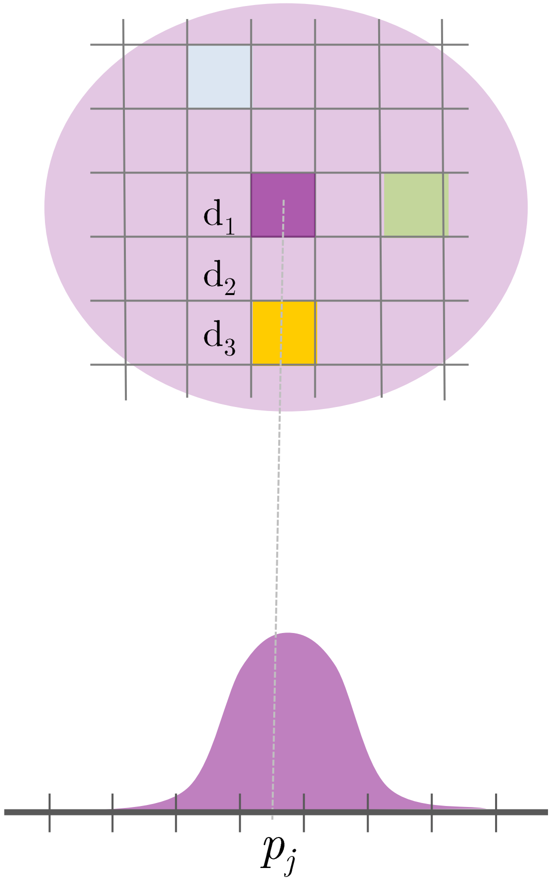

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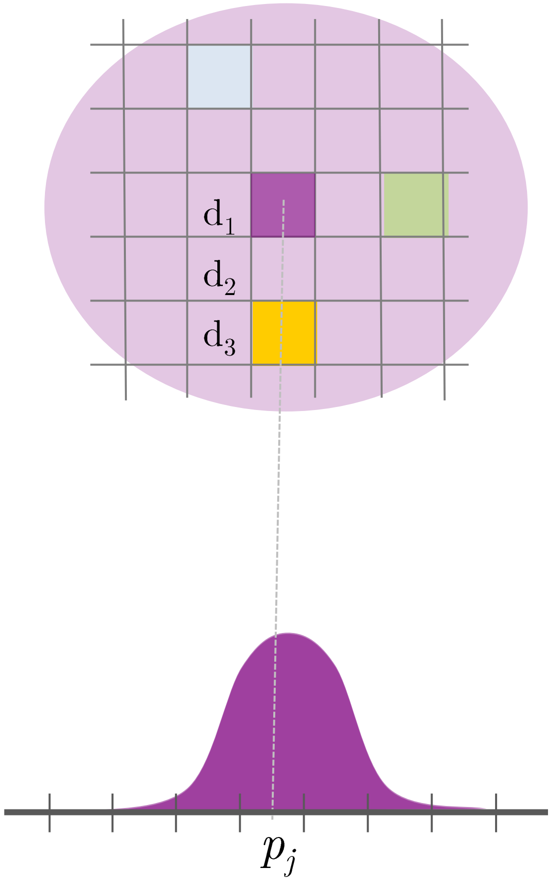

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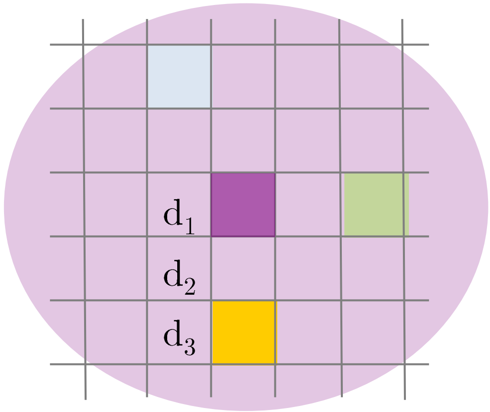

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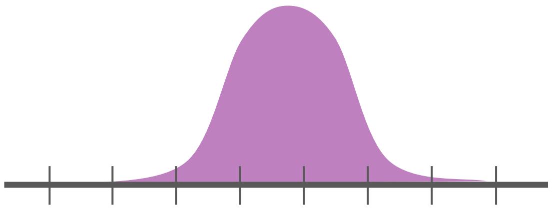

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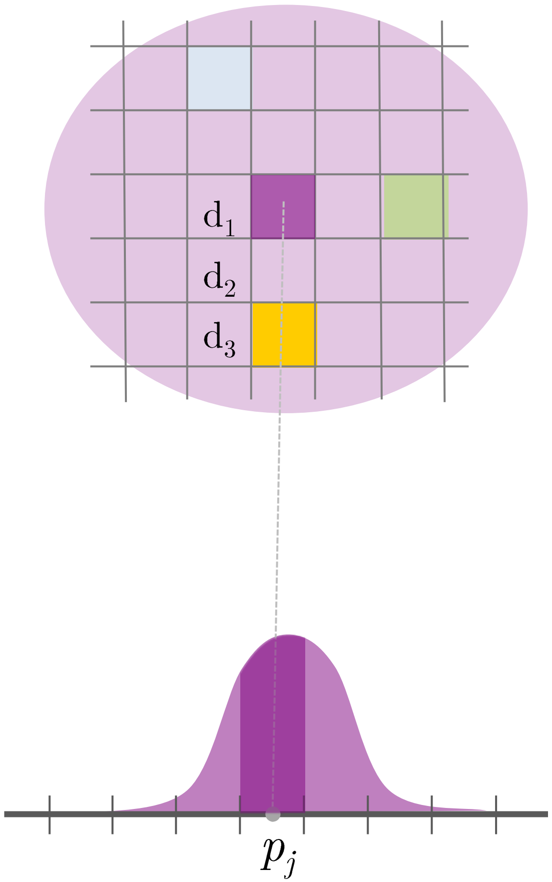

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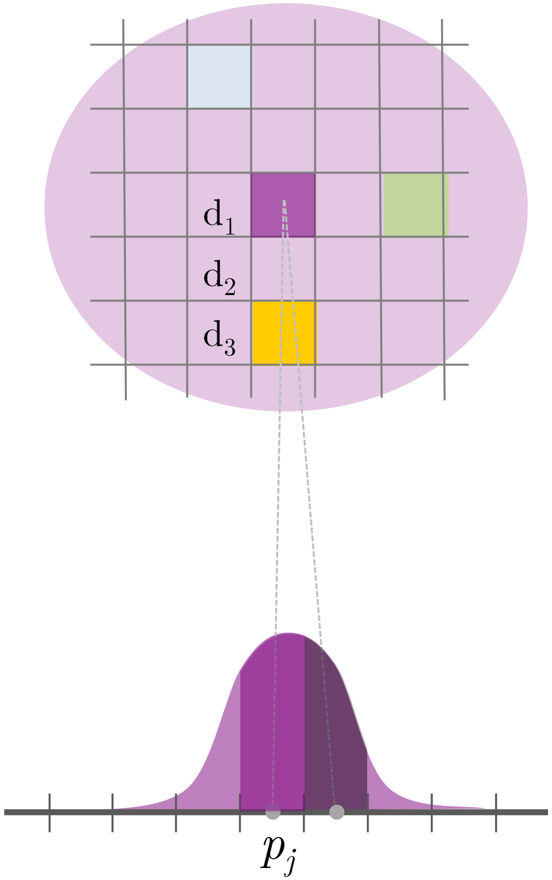

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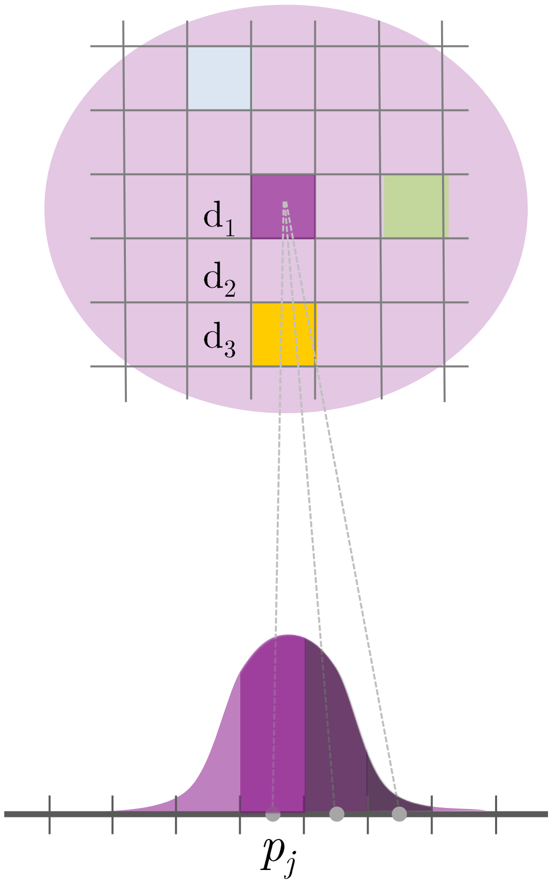

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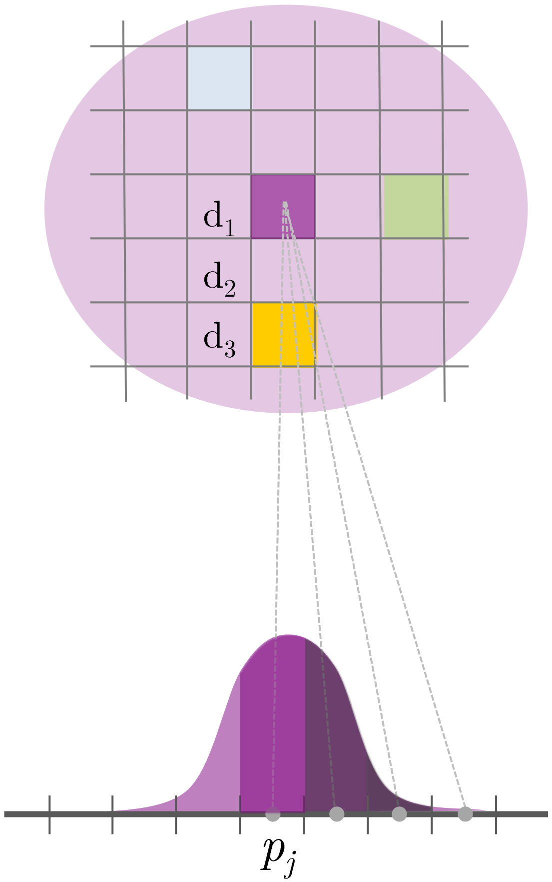

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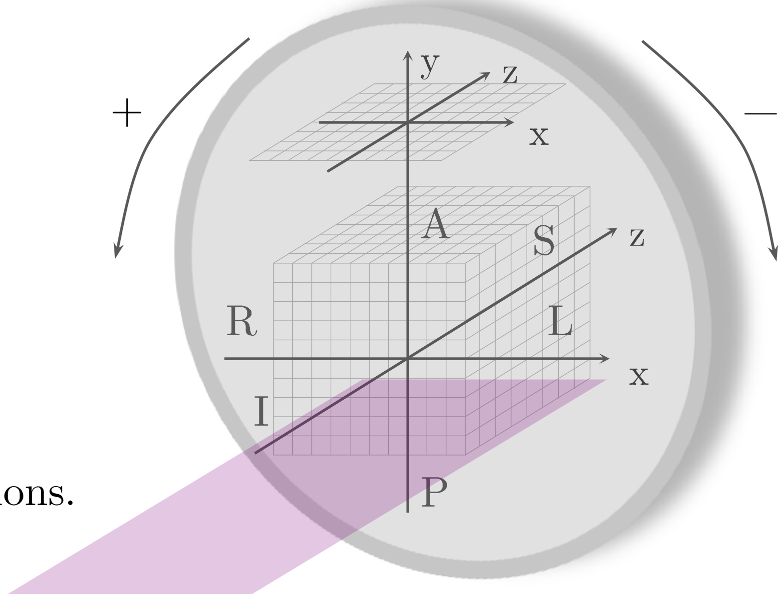
Matrix Parameters File



- Parameters are read and assigned sequentially
- % is a comment
- # and % are comments delimiters
- Double vertical bar indicates encoded options.
- Double slash into braces to separate encoded options. Encoded options are case sensitive.
- Single slash indicates alternatives depending on previous parameters.

argv[1]	#	matrix.m	% Matrix file: Weight matrix filename (without extension index)
argv[2]	#	128	% Image box: Number of rows (int)
⋮			
argv[21]	#	yes	% Matrix: Predefined collimator. If no correction for PSF, set to yes || { yes // no }
argv[22]	#	17	% Matrix: File with collimator parameters / predefined collimator number. (see help for options for COL.num)

Simulation Data

SimSET Simulation

SRL-UB matrices

Transition matrices:

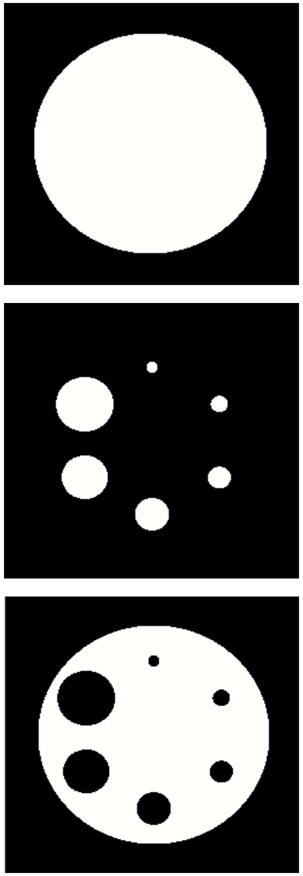
- no Correction
- PSF Correction
- Attenuation Correction
- PSF and Attenuation Correction

(8 subsets -128x128x64 -3.32x3.32x3.32 mm^3)

STIR reconstruction

OSEM/OSSPS (8 subsets - 10 it $\approx$ 80 it)

- no Correction
- PSF Correction
- Attenuation Correction
- PSF and Attenuation Correction



Activity/Attenuation map:

- 256x256x200
- 1x1x1 mm^3

Simulation parameters:

- Infinia Hawkeye GE
- Rotation radius = 15 cm
- Planar detector
- $2.5 \cdot 10^7$ counts

Simulation Data

SimSET Simulation

SRL-UB matrices

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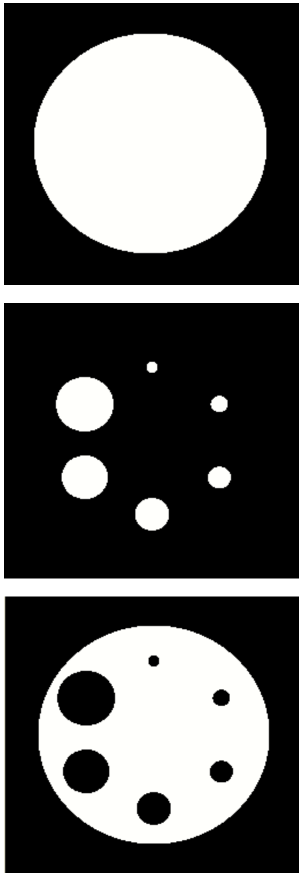

SimSET

STIR with Att + PSF

Simulation Data

SimSET Simulation

SRL-UB matrices

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STIR reconstruction

OSEM/OSSPS (8 subsets - 10 it ≈ 80 it)

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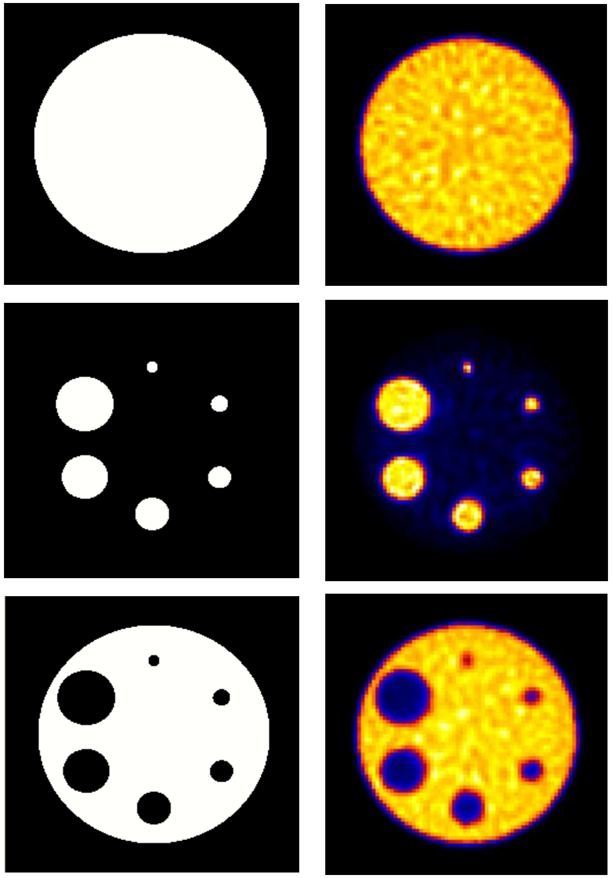
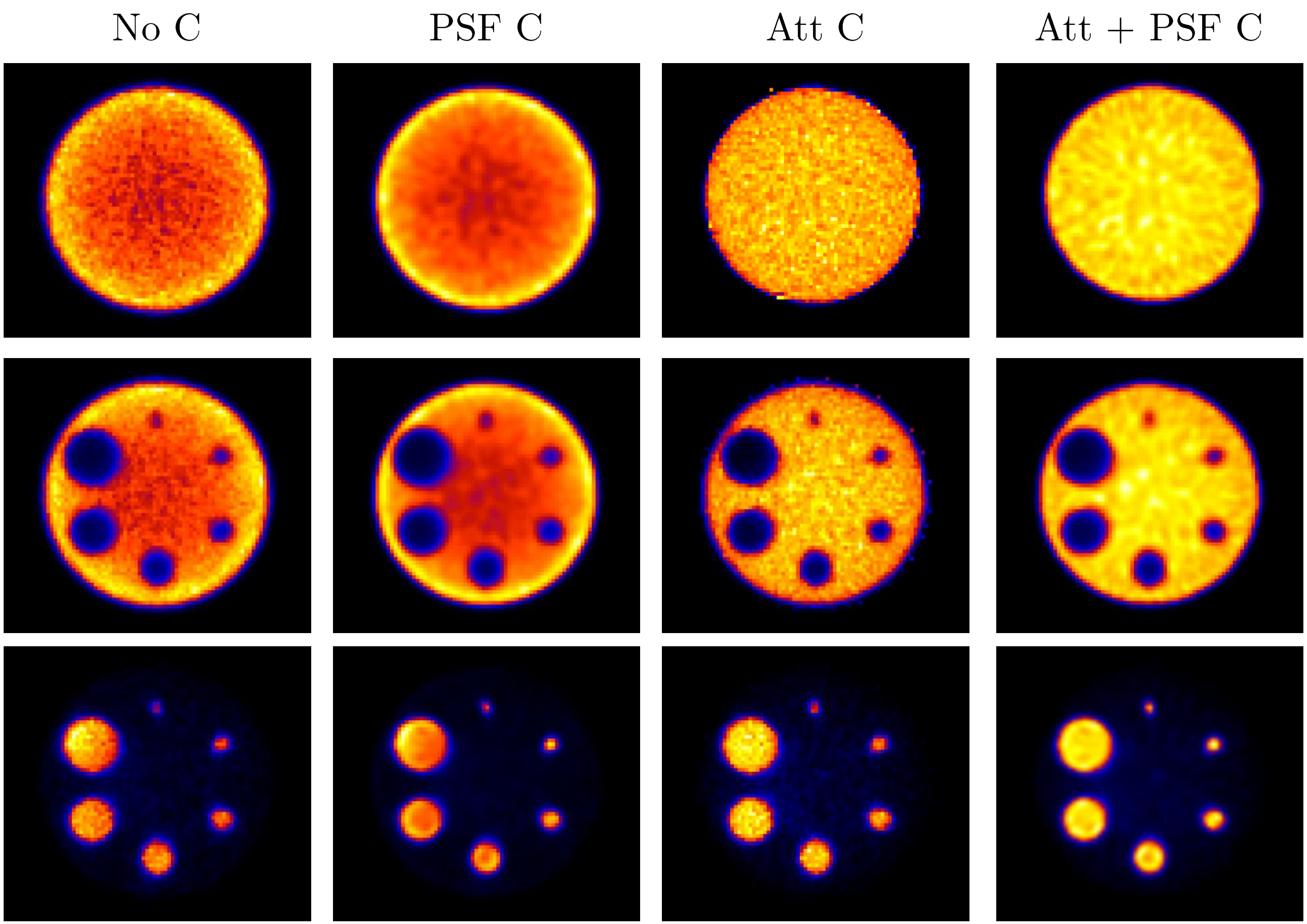


OSEM reconstruction Att + PSF

Simulation Data

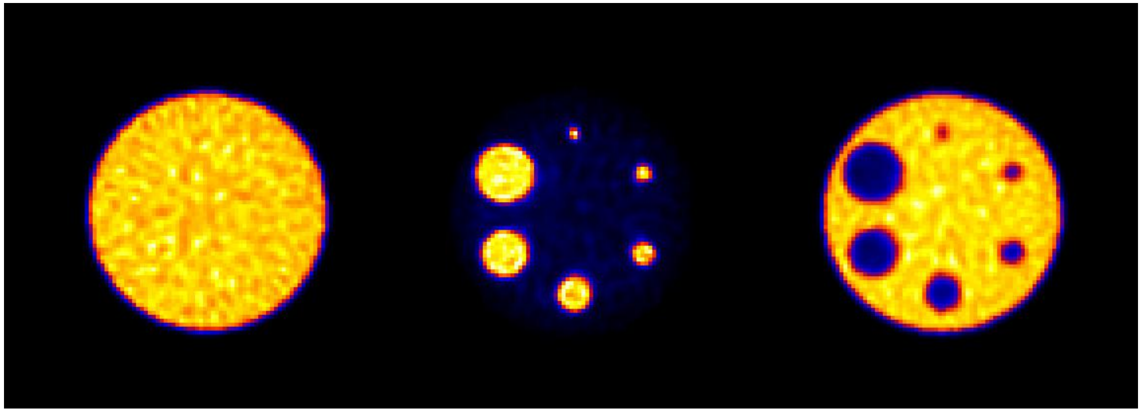
OSEM(it 5)



Simulation Data

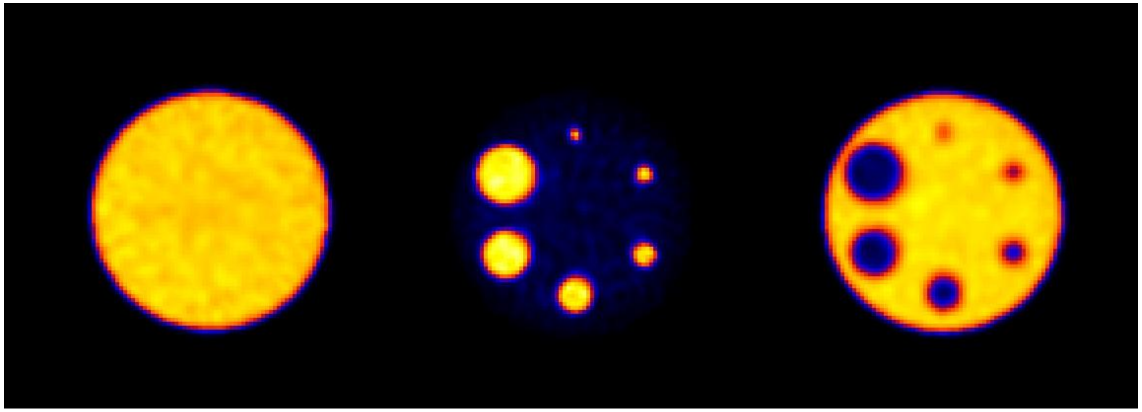
C_v (Coefficient of variation)= σ/μ

OSEM it 80



$C_v = 6.8\%$

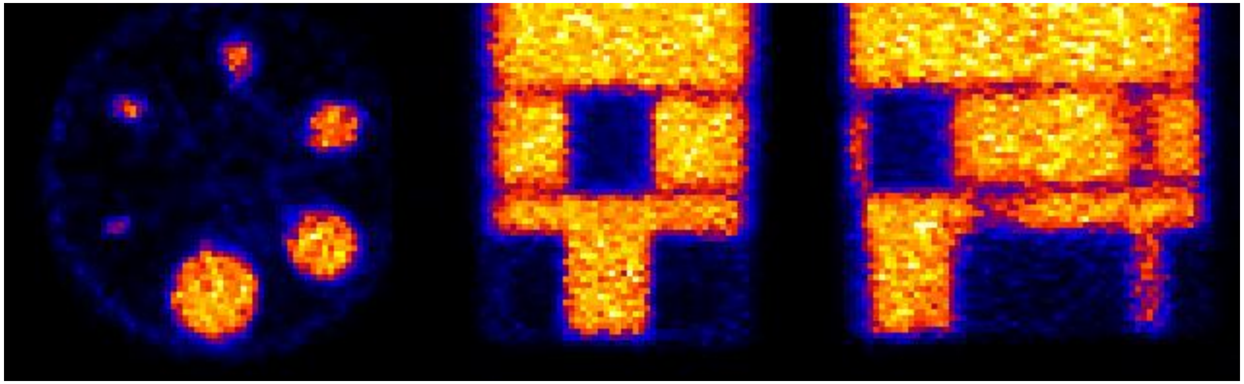
OSSPS it 80



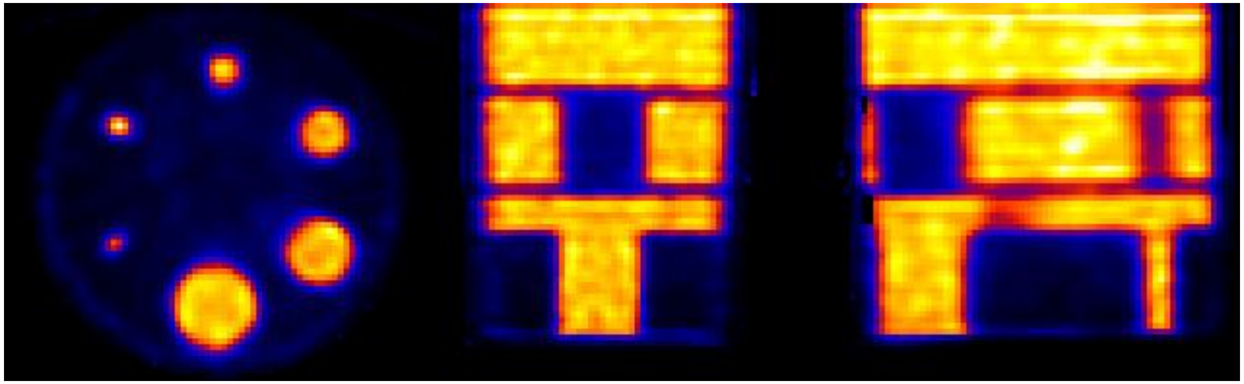
$C_v = 2.5\%$

Acquisition Data

Hawkeye Rec



SRL-UB - STIR

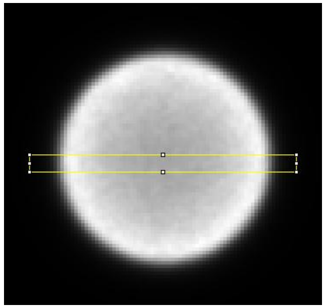


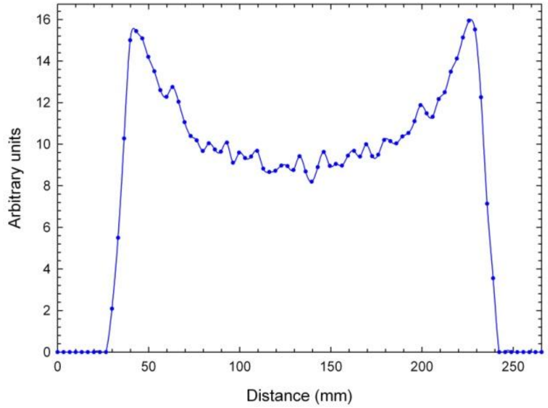
Simulation Data

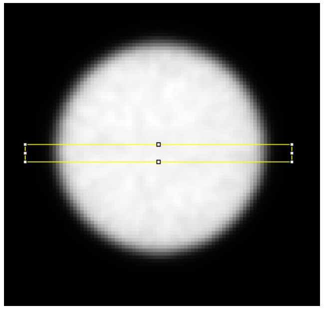
Attenuation correction effect:

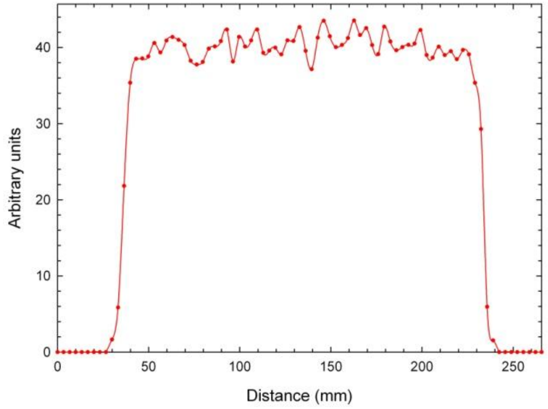
Linear profiles:

- no Correction
- Attenuation Correction







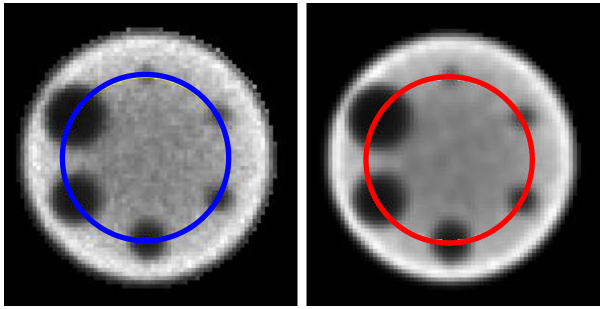


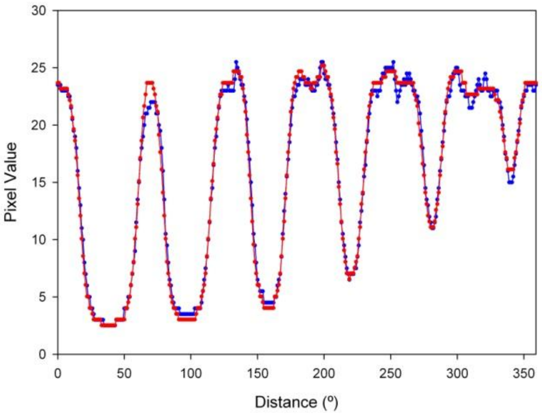
Simulation Data

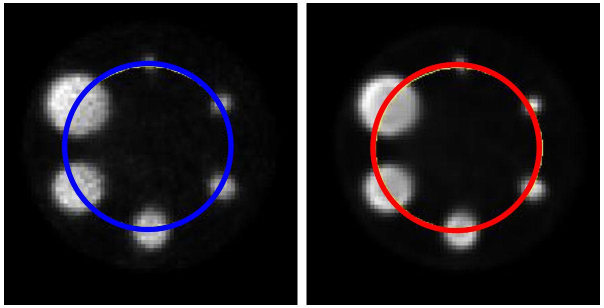
PSF correction effect:

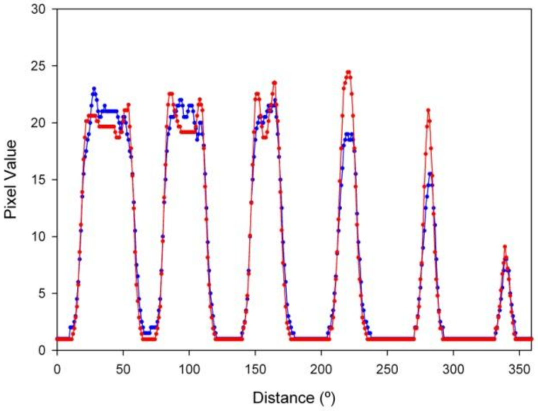
Circular profiles:

- no Correction
- PSF Correction









Simulation Data

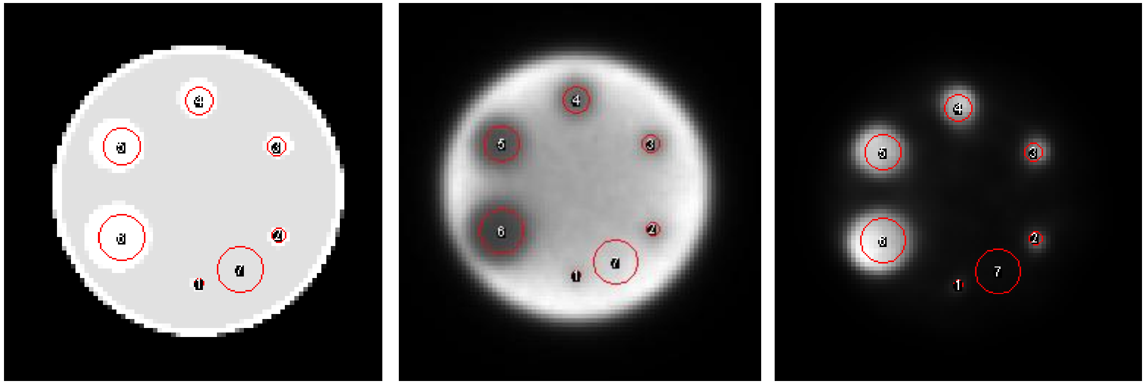
PSF correction effect:

Circular profiles:

- no Correction
- PSF Correction

Contrasts:

- no Correction
- PSF Correction



	Cold		Hot	
	no C	PSF C	no C	PSF C
Cylinder 1 (1mm)	0.30	0.32	0.84	0.91
Cylinder 2 (1.5mm)	0.40	0.43	0.87	0.91
Cylinder 3 (2mm)	0.59	0.62	0.89	0.92
Cylinder 4 (3mm)	0.71	0.75	0.91	0.93
Cylinder 5 (4mm)	0.80	0.84	0.91	0.92
Cylinder 6 (5mm)	0.84	0.89	0.92	0.93

$$CON = \left|\frac{A_i - A_{ref}}{A_i + A_{ref}}\right|$$

Possible Extensions

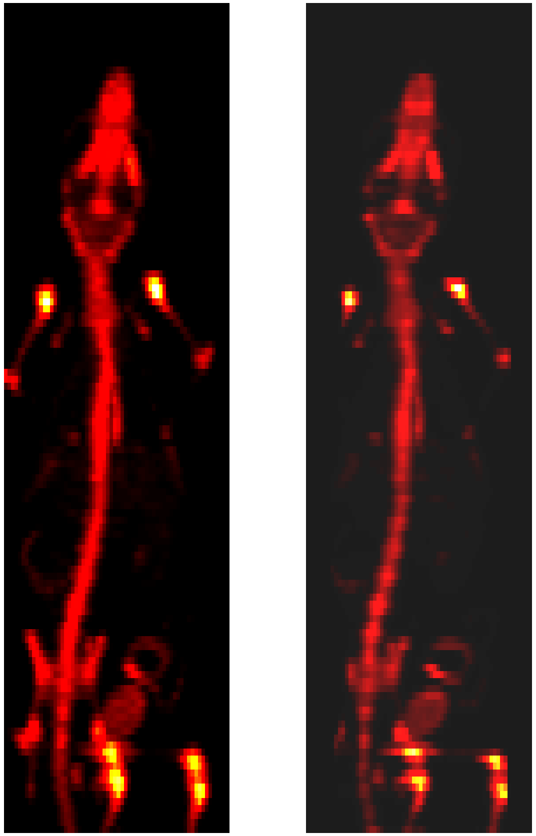
Small animal reconstruction

Pin-hole reconstruction

Scatter correction using SimSET

A. Cot, et al. Absolute quantification in dopaminergic neurotransmission SPET imaging **using a monte carlo-based scatter correction** and fully 3D reconstruction, J. Nucl. Med., (46)(2005), pp. 1497–1504.

MIP Mouse SPECT



OSEM 2D OSEM 3D

Parallel collimator

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