


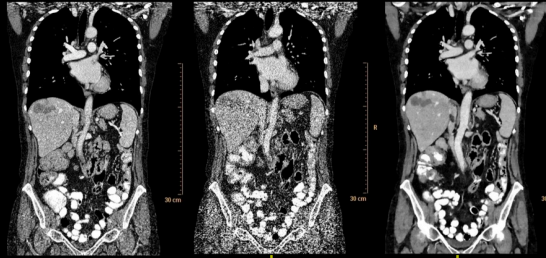
Iterative CT reconstruction: from medical to industrial application.

Peter B. Noël, Ph.D.
Department of Radiology
Technische Universität München




Power of Iterative Reconstruction

FBP reconstruction Iterative reconstruction



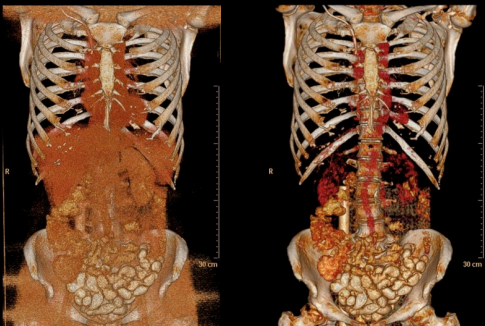
11.14 mSv 1.59 mSv

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Power of Iterative Reconstruction

FBP reconstruction Iterative reconstruction



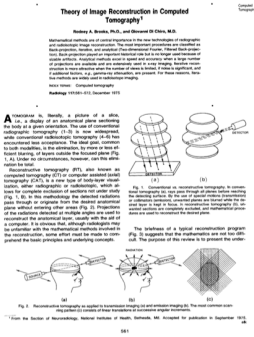
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Iterative Reconstruction

Popular but not new

Quote RA Brooks, G Di Chiro - Radiology, 1975: "... Iterative reconstruction is more attractive when the number of views is limited, if noise is significant, and if additional factors, eg, gamma-ray attenuation, are present. For these reasons, iterative methods are widely used in radioisotope imaging. ..."



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Revival of Iterative Reconstruction

Two Major Factors: Dosis and Speed

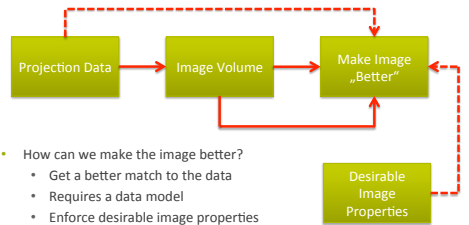


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Iterative Reconstruction

What is the idea behind IR?

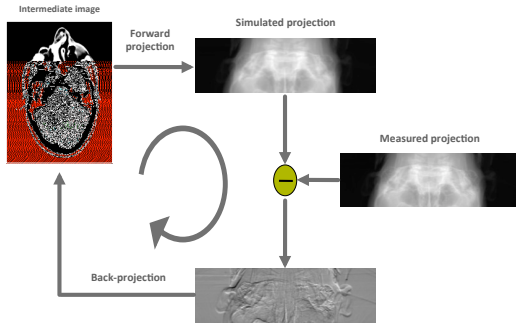


- How can we make the image better?
 - Get a better match to the data
 - Requires a data model
 - Enforce desirable image properties
 - Encourage smoothness, edges, etc.
 - Need a measure of „better“

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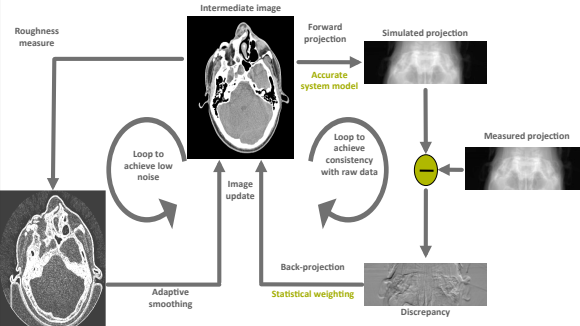
Iterative Reconstruction



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Statistical / Model-based Iterative Reconstruction




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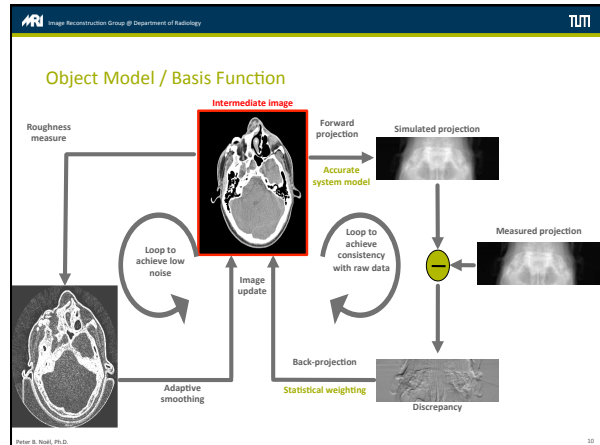
Design of an Iterative Reconstruction

It is like cooking: it is all about the recipe...

- Noise Penalty Model
- System Model
- Prior Information
- Optimization Method
- Basis Function
- Statistical Noise Model
- Object Model

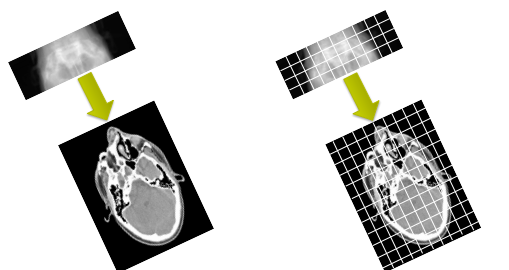


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Continuous vs. Discrete

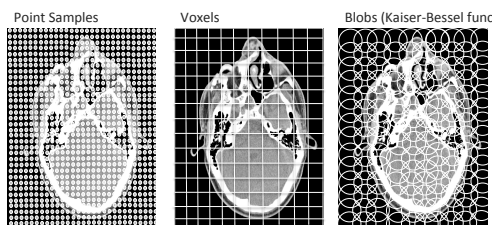


- Continuous
- Discrete

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Object Model / Basis Function



- Advantage Blobs: Blobs projection to same 2D representation
- Advantage Voxels: For high resolution imaging voxels show less artifacts

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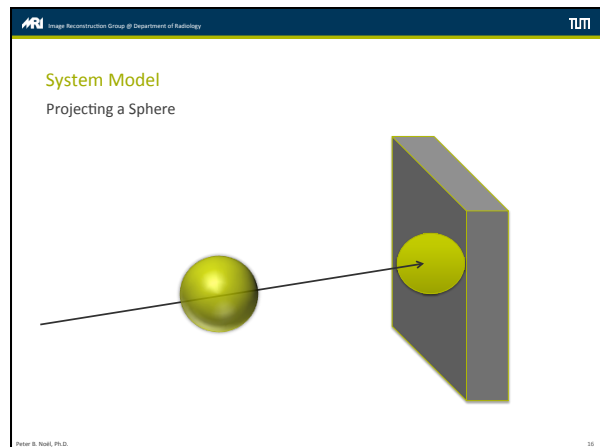
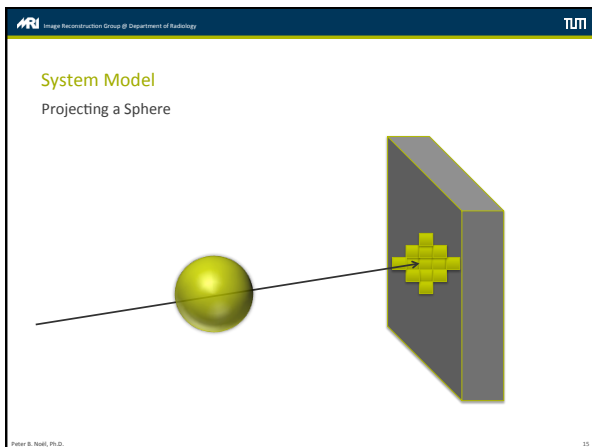
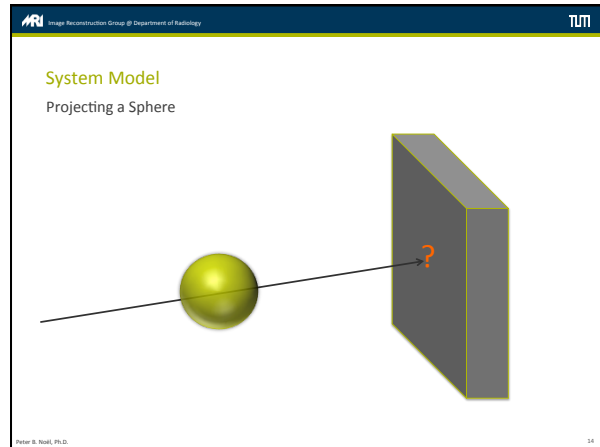
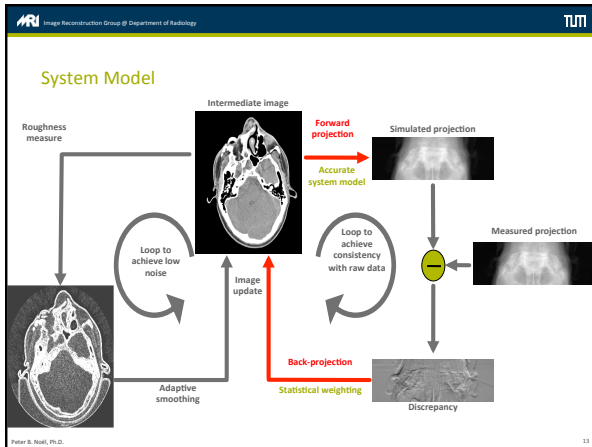


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Forward / Backward Projector

Pixel Driven
 image pixel
 nearest-neighbor, linear, and cubic interpolation
 detector pixels
 (inverted grayscale)

Area Weighted
 image pixel
 f_{1st} f_{2nd} f_{3rd} f_{4th}
 exact projection
 detector pixels
 (inverted grayscale)

Distance Driven
 image pixel
 extended projection
 detector pixels
 (inverted grayscale)

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Forward / Backward Projector

Pixel Driven
 image pixel
 nearest-neighbor, linear, and cubic interpolation
 detector pixels
 (inverted grayscale)

Distance Driven
 image pixel
 extended projection
 detector pixels
 (inverted grayscale)

3.5x
 PDP_{min} PDP_{lin} PDP_{cub} DDP
 0° 45° 90° 135° 180°

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Statistical Noise Model

Roughness measure
 Intermediate image
 Forward projection
 Simulated projection
 Accurate system model
 Measured projection
 Loop to achieve low noise
 Loop to achieve consistency with raw data
 Adaptive smoothing
 Image update
 Back-projection
 Discrepancy
 Statistical weighting

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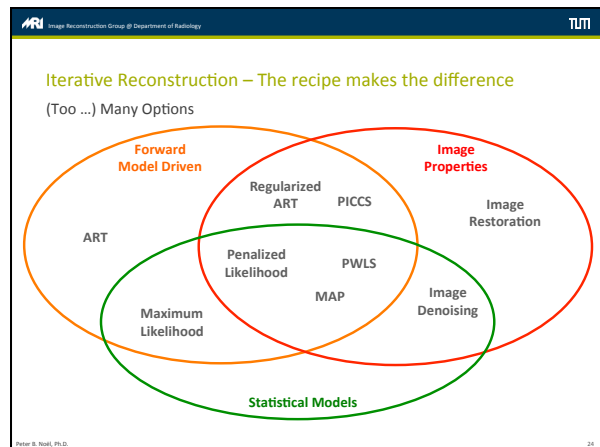
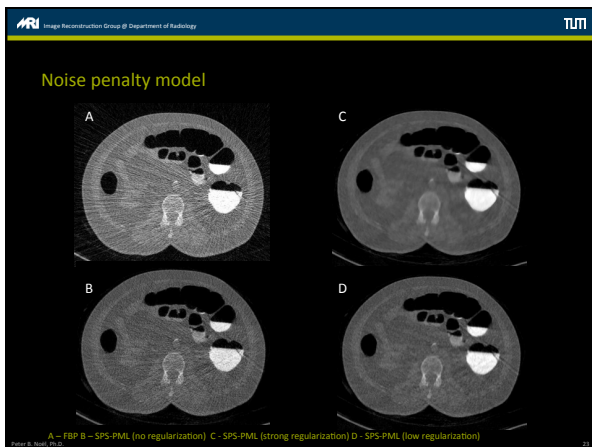
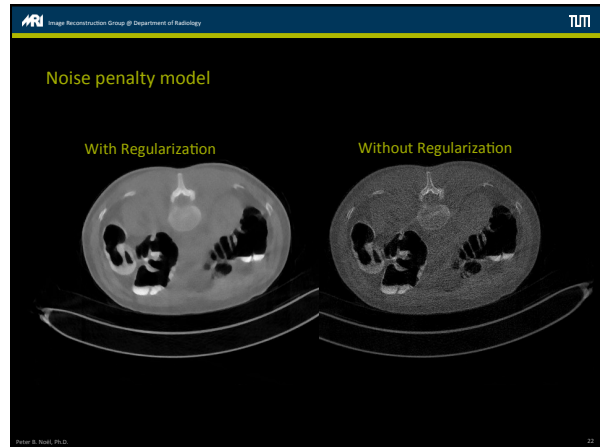
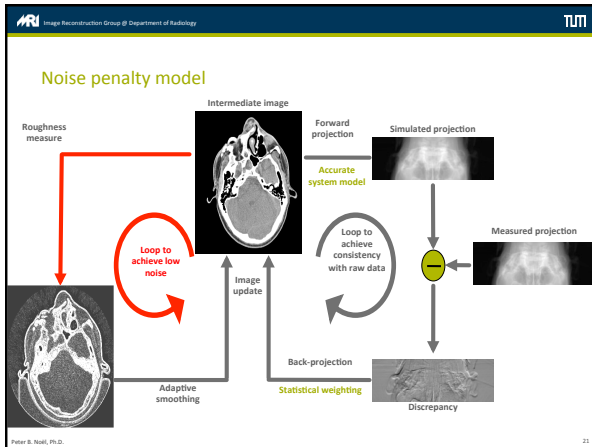
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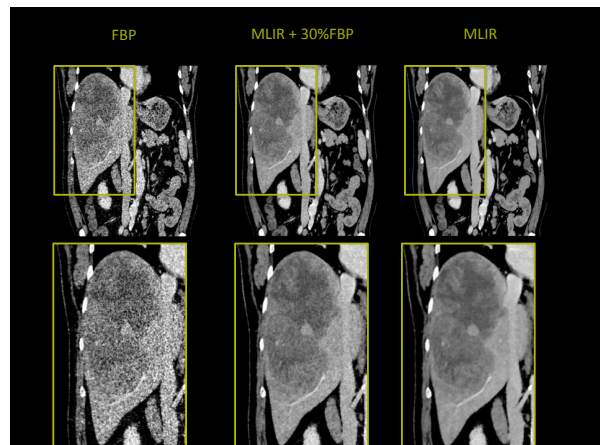
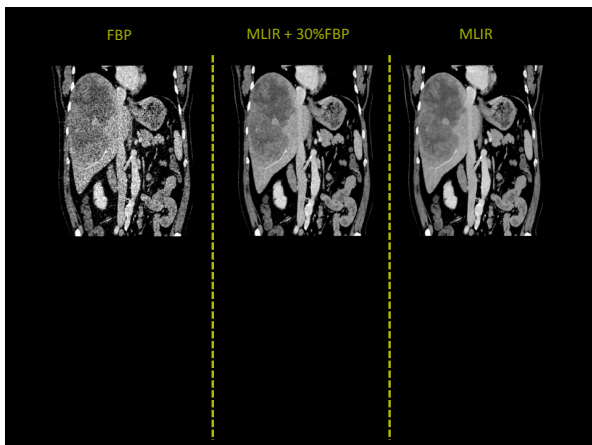
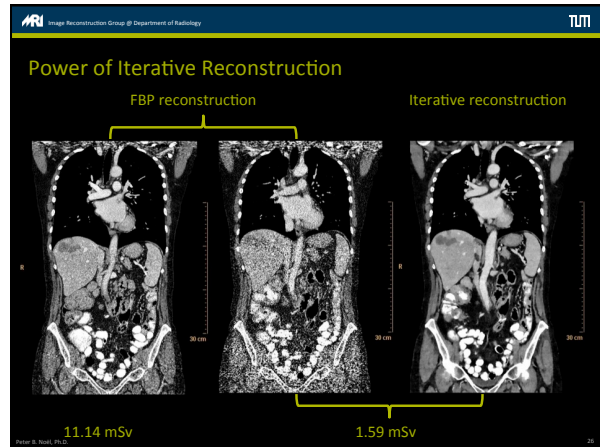
Statistical Noise Model

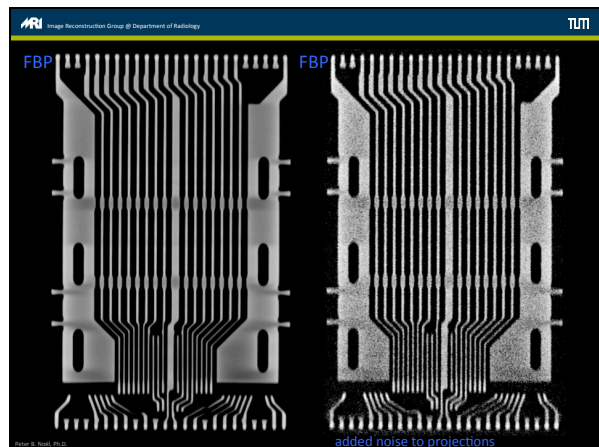
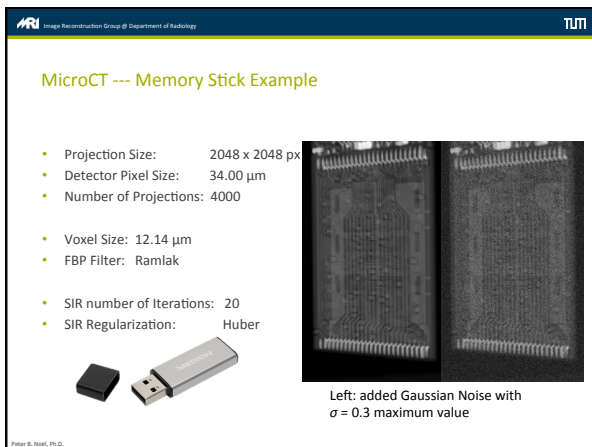
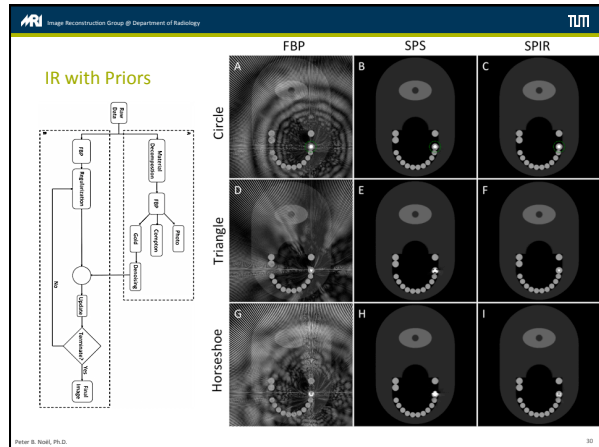
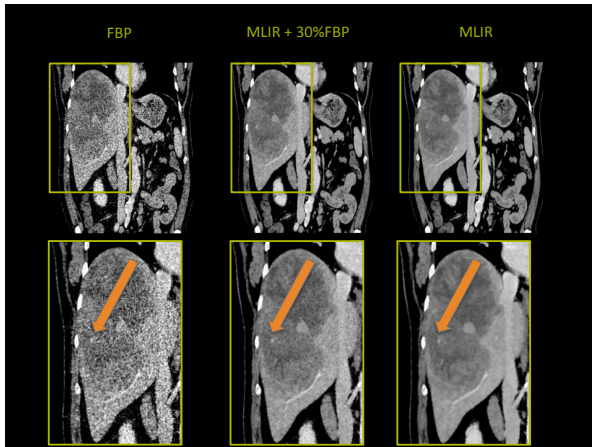
$P(f | g) \propto P(g | f) P(f)$

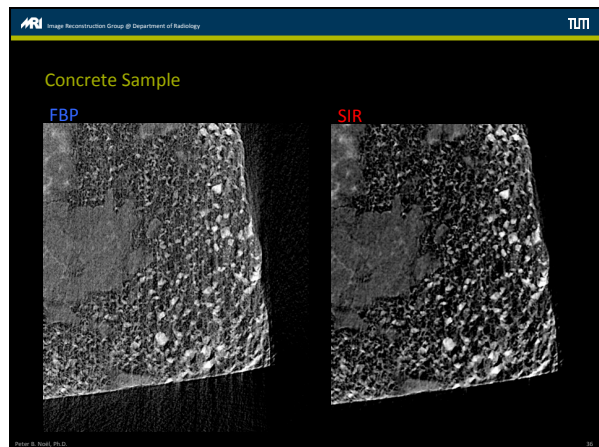
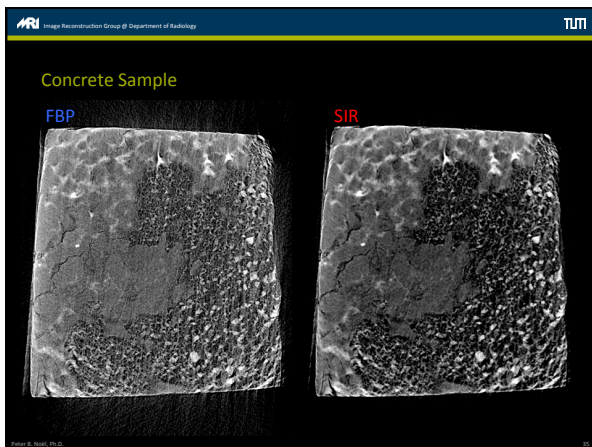
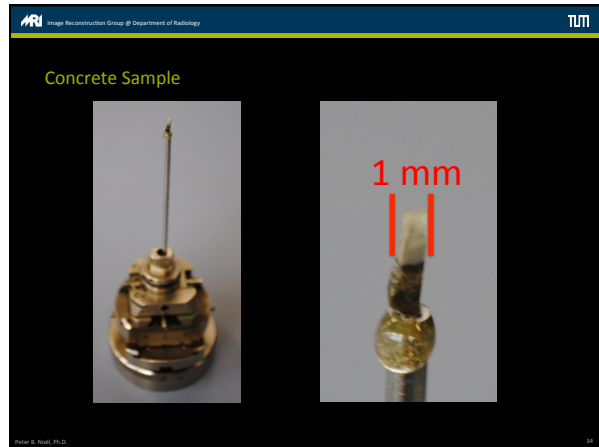
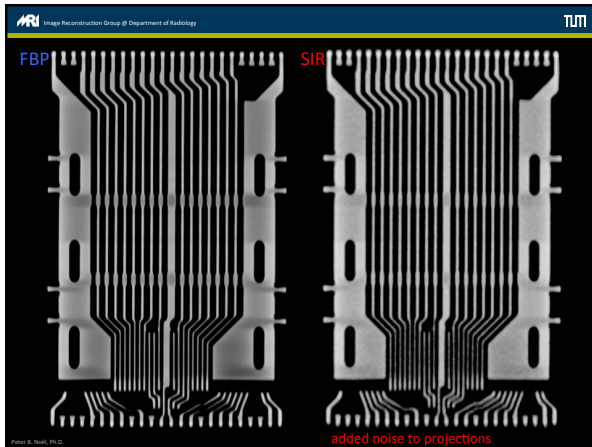
measurements
 Most probable solution
 $P(f)$
 $P(g|f)$
 Image space
 Reconstruction via Likelihood Maximization (LM) / Bayesian (MAP)

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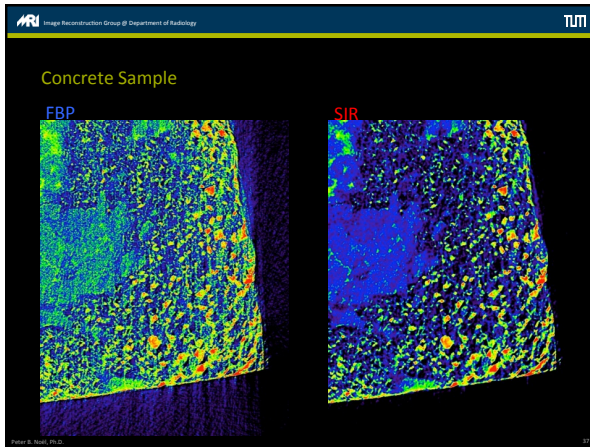


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Conclusion

Iterative Reconstruction a Powerful Tool

- Iterative Reconstruction offers:
 - Flexible image models, e.g. trajectories, number of projection
 - Discretization of the problem
 - Computational modeling of the imaging setup
 - Use of prior knowledge
 - ...
- It is like cooking: it is all about the recipe...

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