CT Reconstruction Workflow

NeCTAR Project Team

24th October 2013

CSIRO Mathematics Informatics and Statistics
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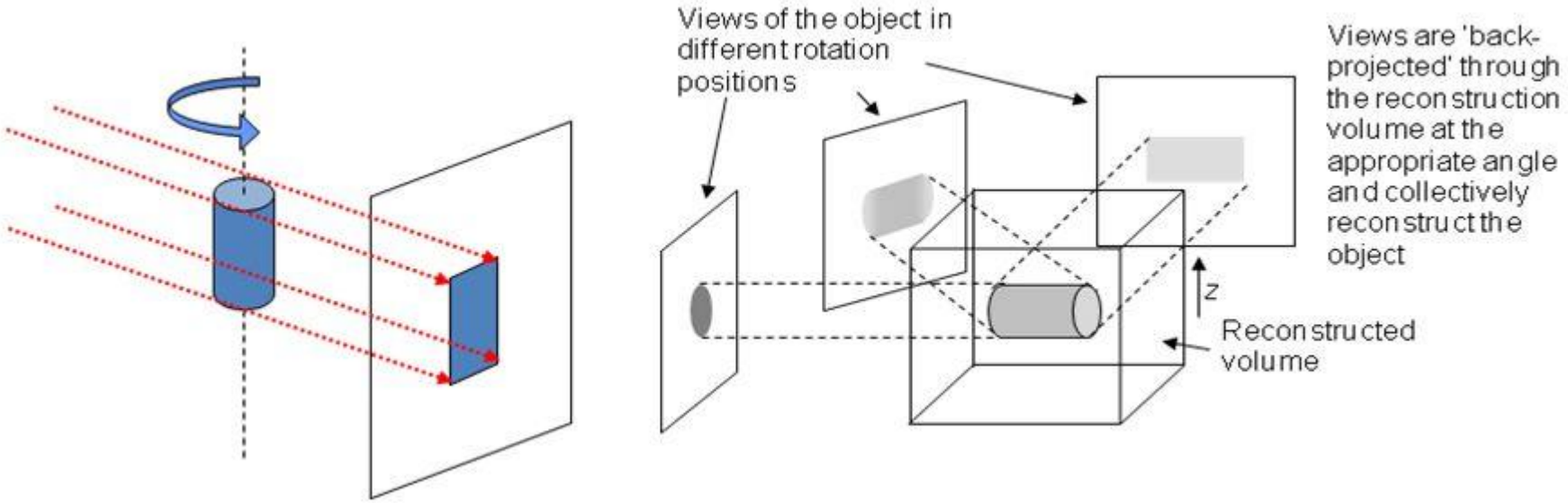
Computed Tomography (CT)

- Non-destrictive method for producing a 3D digital reconstruction of an object from a series of x-ray transmission images of the object acquired at different rotation angles



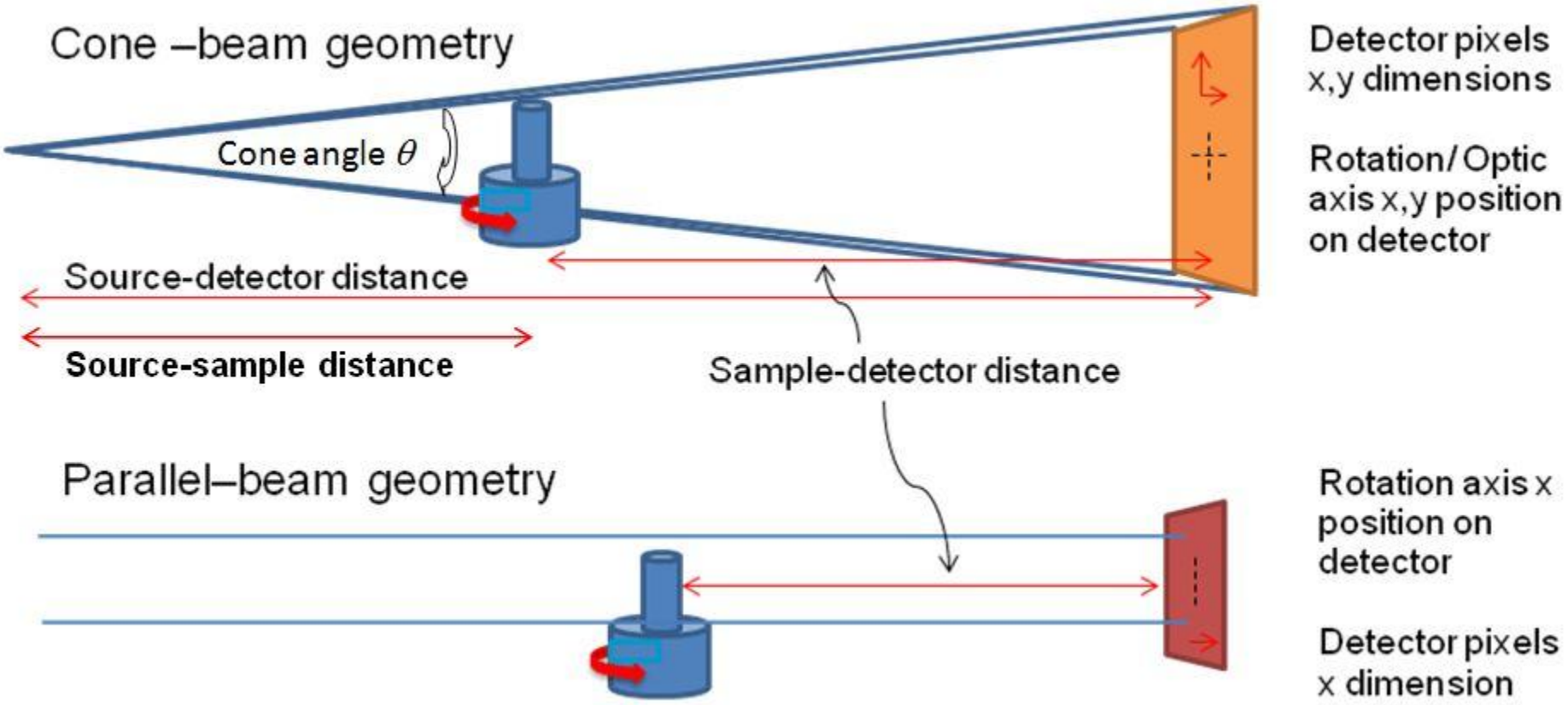
CT's challenges

- Computationally intensive!
  - FBP CT Reconstruction is $O(N^4)$
- Data intensive! (Big Data)
- Infeasible to compute/store large datasets from Synchrotrons and lab equipment on single PC's
- On the plus side – highly parallelizable!
  - Multi-core/GPUs

Typical CT reconstruction data sizes

N / M*	N^2 float (projection / slice)	NM float (sinogram)	N^2M float (all sinograms)	N^3 float (all slices)
1k / 720	4 MB	2.8 MB	2.8 GB	4 GB
2k / 1,440	16 MB	11¼ MB	22½ GB	32 GB
4k / 2,880	64 MB	45 MB	180 GB	256 GB
8k / 5,760	256 MB	180 MB	1.4 TB	2 TB
16k / 11,520	1 GB	720 MB	11¼ TB	16 TB

CT beam geometry

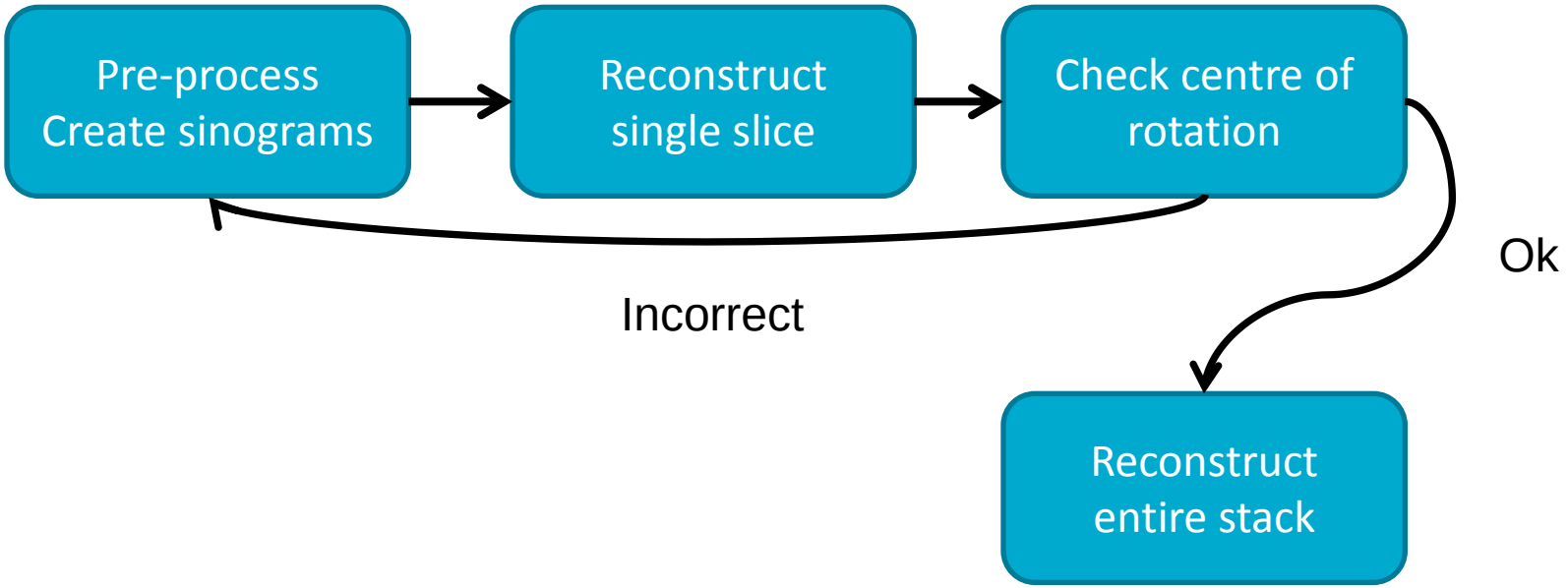


CT Reconstruction tools

- Copy Dataset to FTP folder
- Sinogram Creation and Preprocessing Create sinograms from projections
- Center of Rotation Find center of rotation in a sinogram
- CT Reconstruction Create a slice from a sinogram

CT Reconstruction workflows

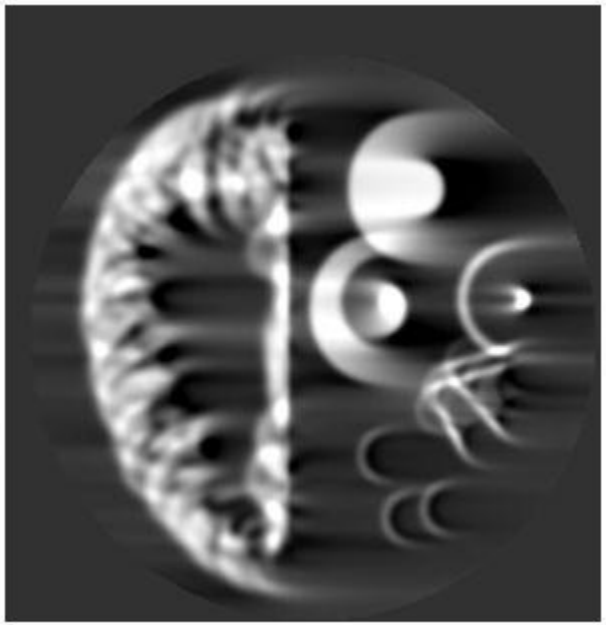
Manual (Iterative) workflow



Centre of rotation

Position error = -5

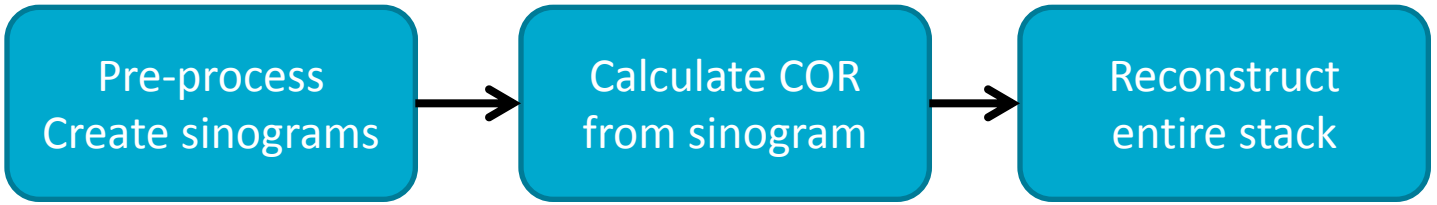
Position error = 0 (correct)



Position error = +10

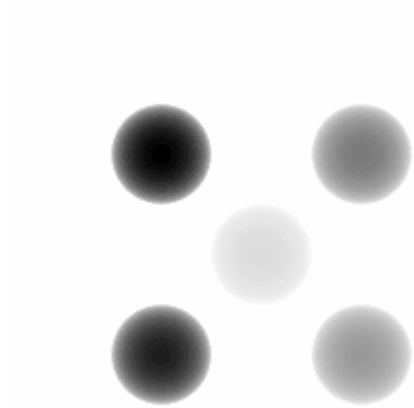
CT Reconstruction workflows

Automatic centre of rotation workflow

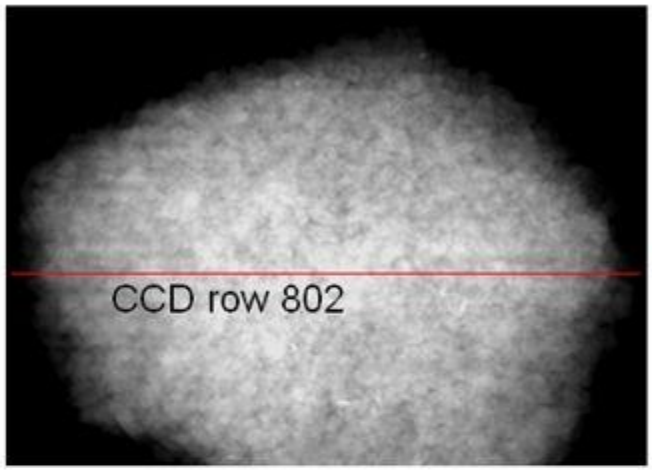


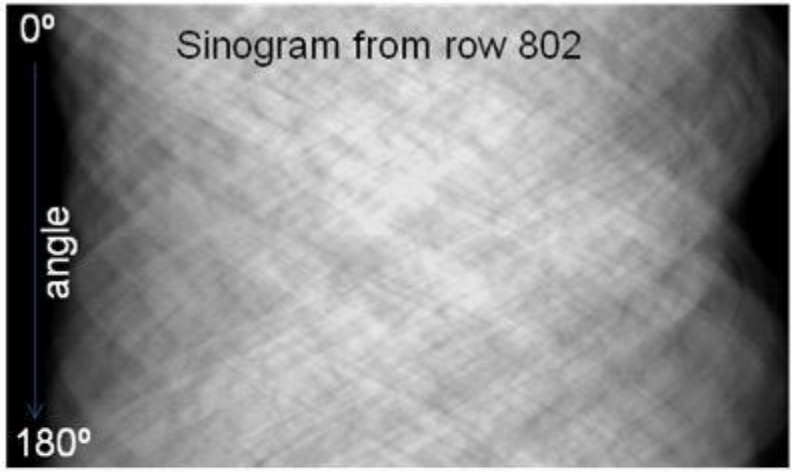
Simple small CT Reconstruction

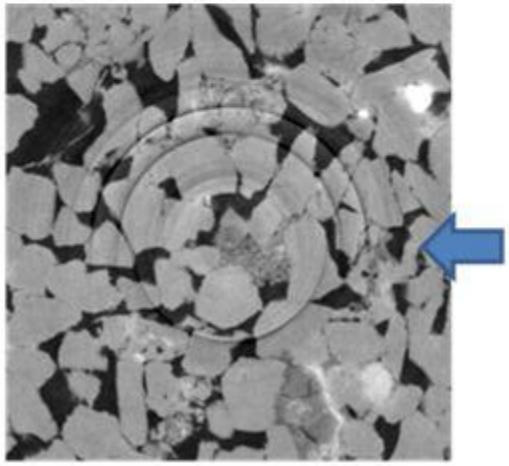
- “cube256” – Synthetic projection dataset
  - 180 256x256 projection files (4-byte float VOD, 45Mb total)



Sinograms ???







The sinogram for a CCD row is compiled from the same row taken from all the views over the range of data collection rotation angles

Bad pixels in that CCD row would appear as vertical lines on the sinogram. These lead to ring artifacts in the reconstructed slice (half-rings for 180° data)

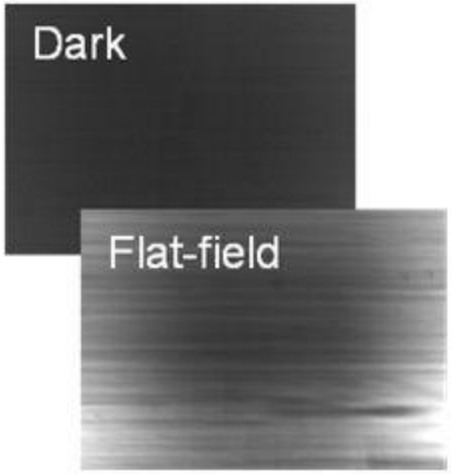
Filtering of the sinogram can reduce these artifacts.

Simple small CT Reconstruction

- Step 2: Reconstruct Slices
  - Reconstruction method, Gridrec vs FBP
  - Set angle step to 1 degree

CT Reconstruction – Real Synchrotron data

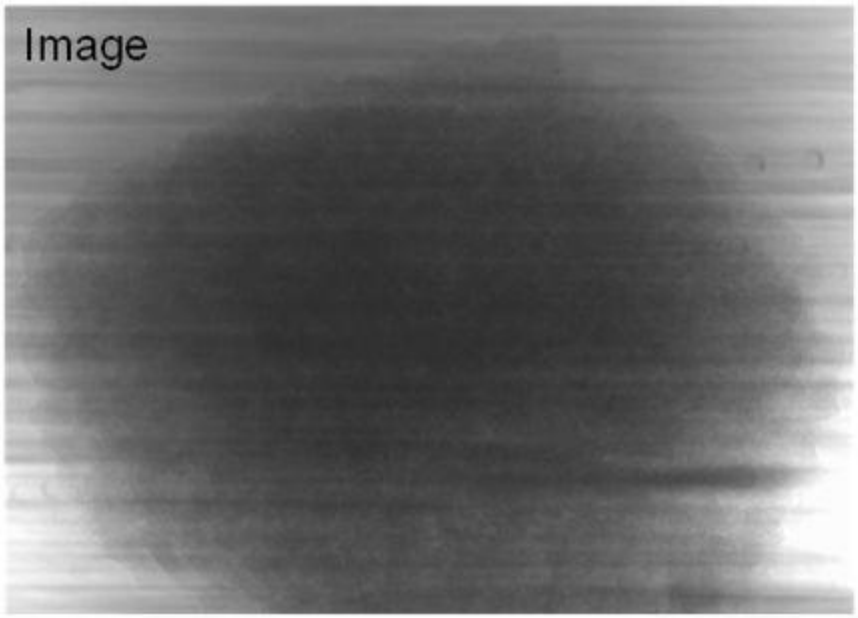
- Small dataset – 721 1020x130 16bit TIFF projections (186MB) + Flats & Darks
  - Flat & dark field correction
  - Ring filter
  - Phase retrieval
  - Centre of rotation

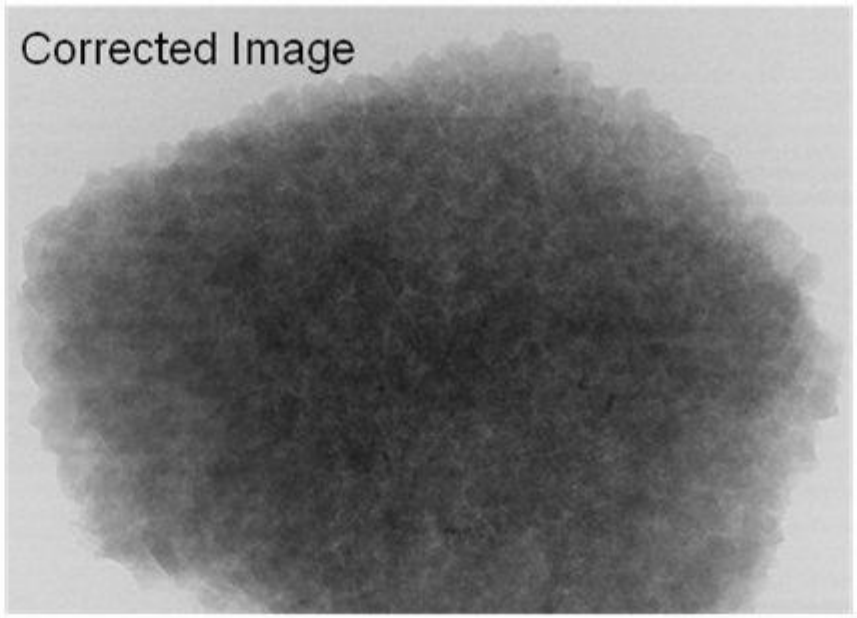


Correcting CCD artefacts:

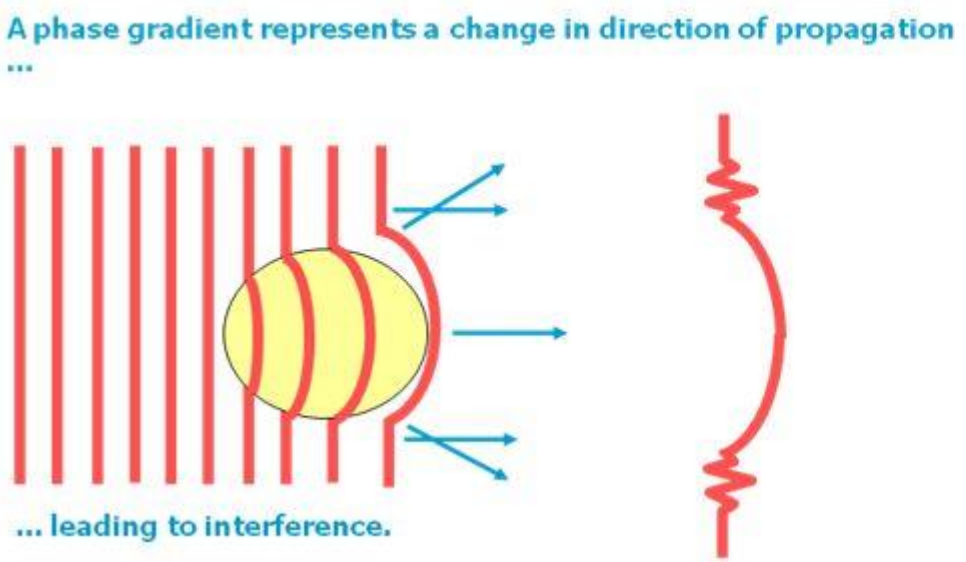
1) Dark current (the CCD signal with no illumination)
   Several dark current files are collected at the beginning/end of a data collection
2) Flat-field (The x-ray illumination distribution)
   Flat-field files are often collected at regular intervals during data collection

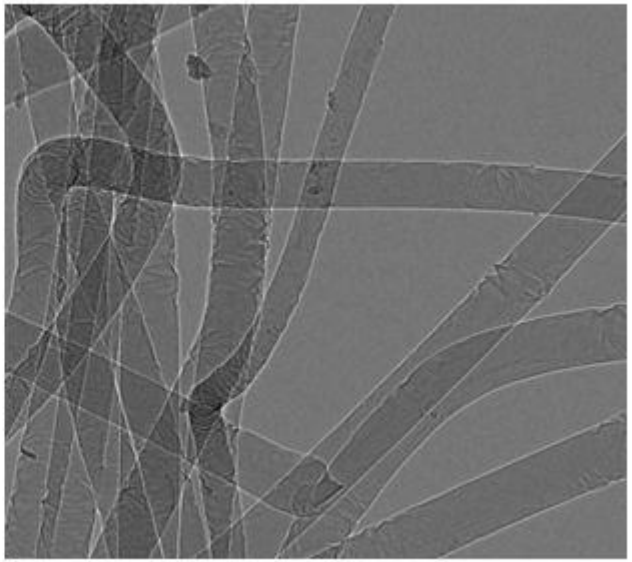
$$\text{Corrected Image} = \frac{\text{Image - Dark}}{\text{Flat-field - Dark}}$$



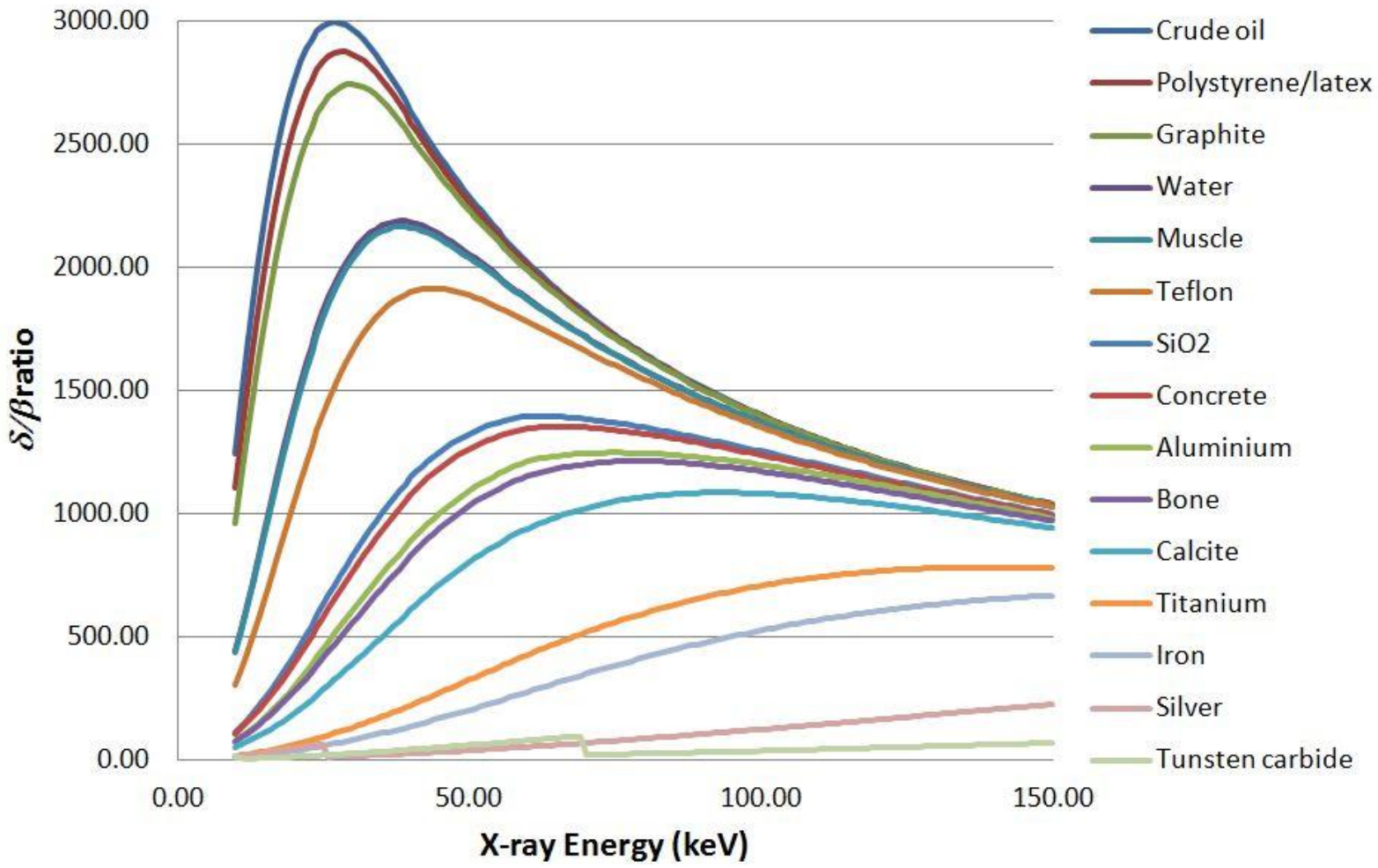


Phase contrast





Phase contrast



Thank you

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