



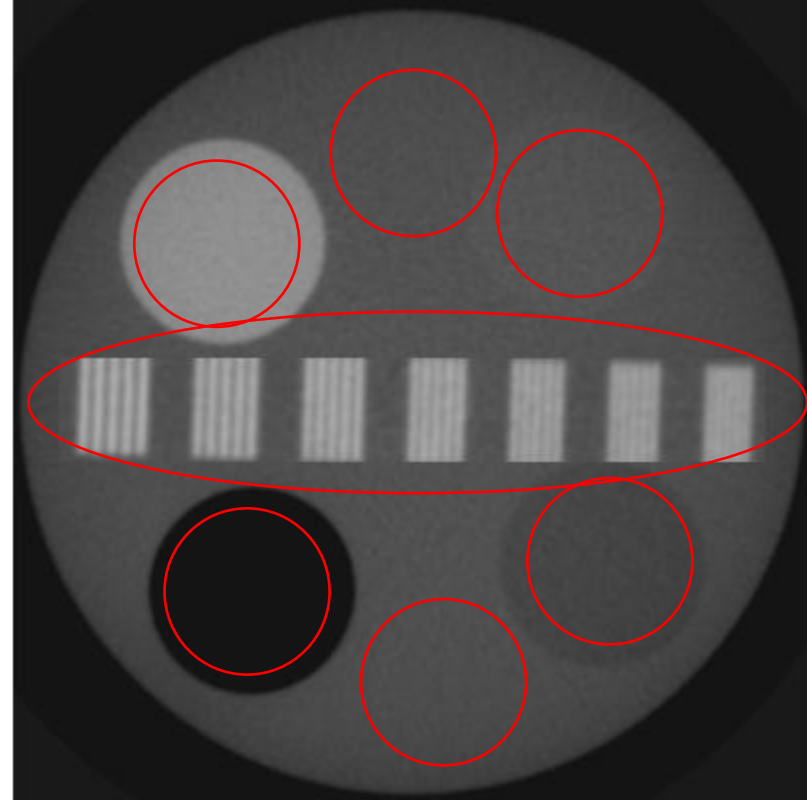
UiO  Det odontologiske fakultet

Gerald Torgersen

Bildekvalitetskontroll på maxillofaciale CBCT-enheter



Bildekvalitet

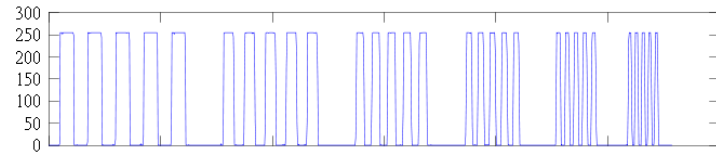
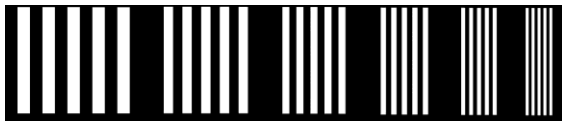


- Bildene skal
 - Gjengi små detaljer
 - Vise forskjellen på materialer (tetthet, attenuasjon)
 - Gjengi like materialer likt (uniformitet)
 - Gjengi lengder og vinkler korrekt
 - Ikke ha artefakter
 - Ha lav støy
- Radiologene og klinikerne avgjør prioriteringene

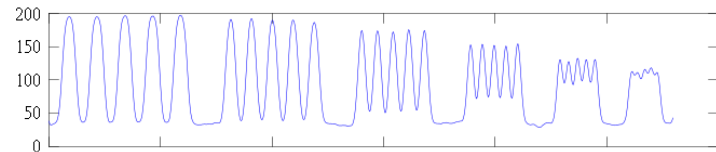
Høykontrastoppløsning

- Evnen til å vise små detaljer
- Oppgis gjerne som
 - Linjepar per mm (lp/mm)
 - Modulation Transfer Function (MTF)
- Linjepar mønster

Original

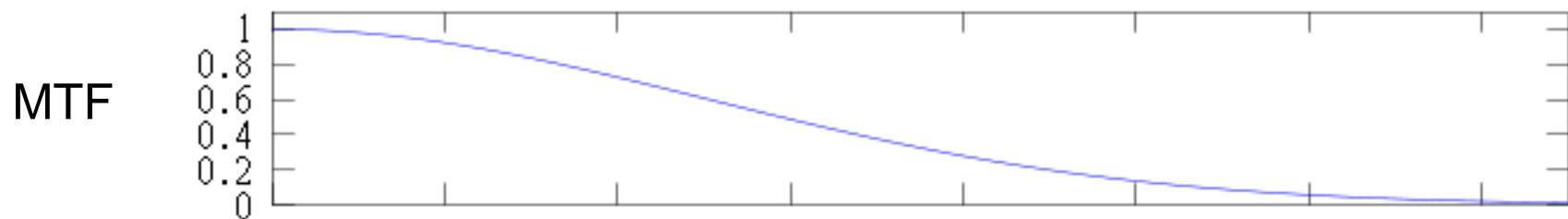
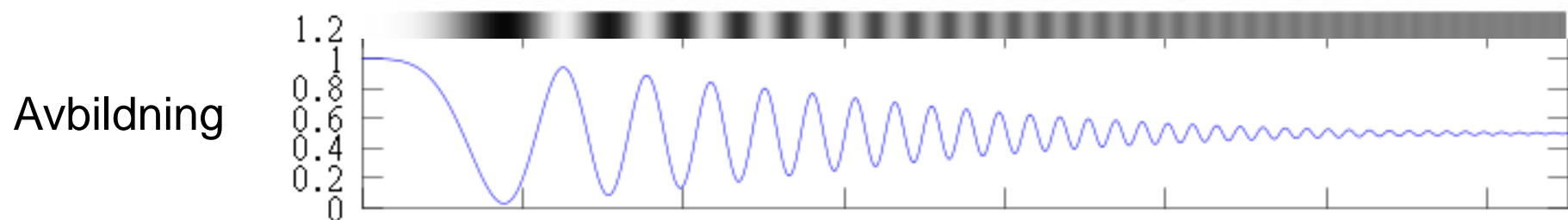
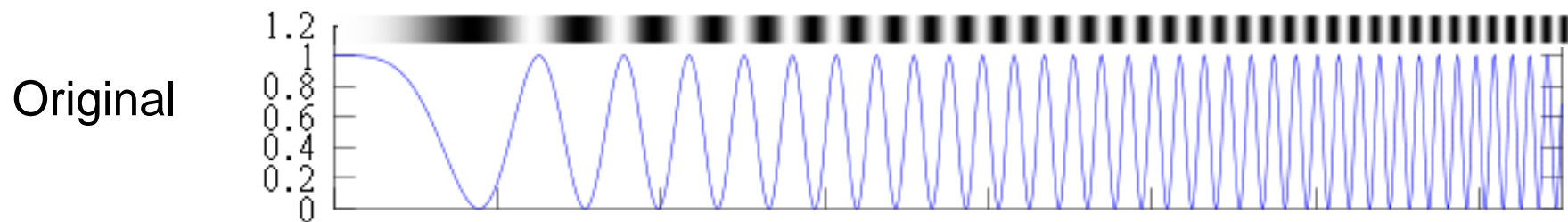


Avbildning

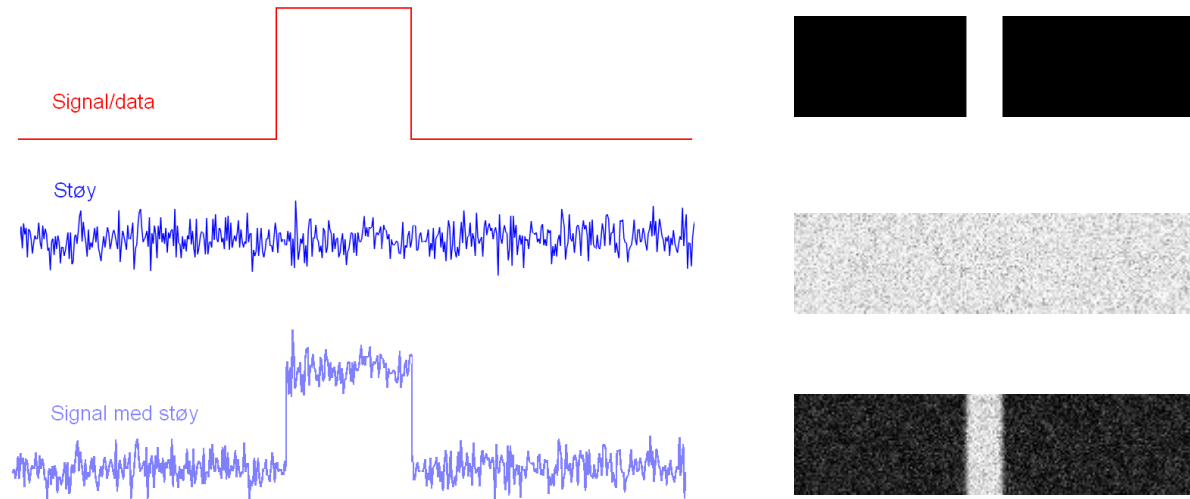


MTF

Variierende gråtonemønster - økende frekvens:



Støy

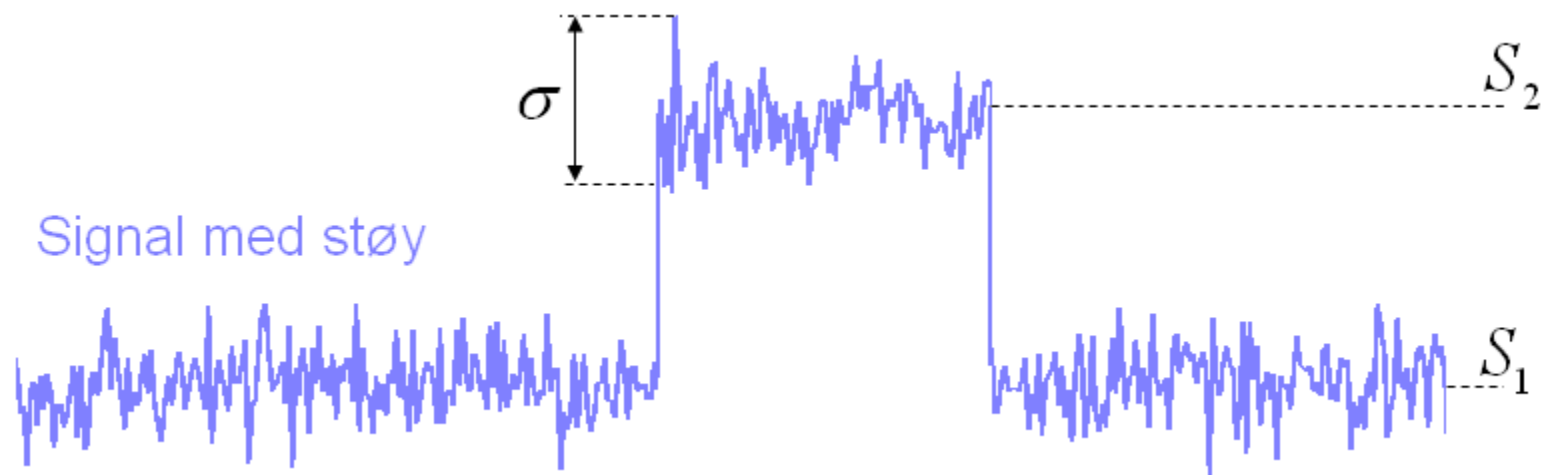


- Hvordan måle/sammenlikne støy?
 - Flere størrelser er utbredt
 - Signal to Noise Ratio
 - Contrast to Noise Ratio
 - ...

Støy - Contrast to Noise Ratio (CNR)

- Et mål på styrkeforholdet mellom
 - Kontrasten i bildet og støy
 - $\text{CNR} = 1$ - kun støy
 - Jo høyere verdi jo bedre

$$\text{CNR} = \frac{S_2 - S_1}{\frac{1}{2} \cdot (\sigma_1 + \sigma_2)}$$

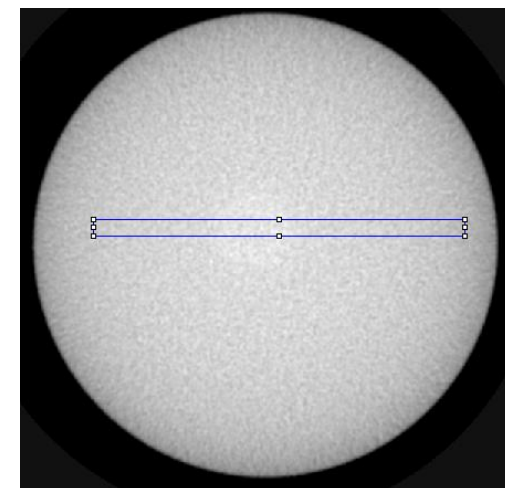
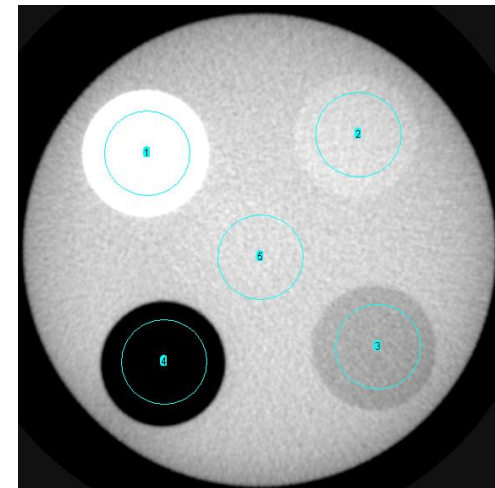
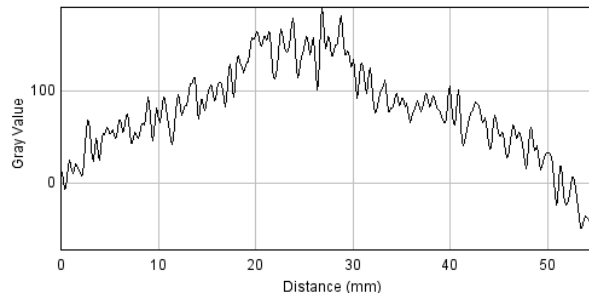


Gråtone (HU) og uniformitet

- Evne til å skille stoffer
- Støy

ROI	Material	HU	StDev
1	Teflon	1151	49
2	PMMA	103	41
3	LDPE	-151	39
4	Air	-1000	0
5	PMMA-center	111	34

- Uniformitet
 - PMMA hele veien
 - HU varierer
 - Støy
 - Systematisk avvik



SedentexCT-fantomet

- Produsert av Leeds Test Objects Ltd
 - Egenskaper
 - GIGANTISK - diameter 16 cm
 - Kan ikke brukes på små FOV
 - DYRT
 - Måler alt
 - Automatisk analyse
 - Mer egnet for produsenter og utviklere av filtre og rekonstrusjonsprotokoller?



Bilde © 2011 Leeds Test Objects Ltd

SedentexCT-fantomet



SEDENTEXCT
DENTAL CBCT

A PMMA cylinder (160 mm diameter) with recesses to house test inserts (fig. 1). Within the body of the cylinder are features for the following tests;

Noise/Uniformity

- The lower section of the phantom is uniform PMMA (density 1.20 +/- 1.00%)

Geometric Distortion

- An array of 2.0 mm diameter, 3.0 mm deep Air gaps are uniformly pitched through one slice of the cylinder



Test Inserts are included to perform the following measurements:

Spatial Resolution

- Line Spread Function (LSF) - PMMA/PTFE interface (fig. 2)
- Point Spread Function (PSF) - 0.25mm diameter stainless steel wire suspended in air (fig. 3)
- LP/mm - alternating Aluminium/polymer (XY) (1.0 to 5.0 LP/mm) (fig. 4)
- LP/mm - alternating Aluminium/polymer (Z) (1.0 to 5.0 LP/mm) (fig. 5)

Contrast Resolution (fig. 6)

- 1.0, 2.0, 3.0, 4.0, 5.0 mm diameter PTFE, delin, LDPE, Aluminium, Air, Water (PMMA) rods suspended in PMMA

Pixel Intensity (fig. 7)

- 10.0 mm diameter PTFE, delin, LDPE, Aluminium, Air, Water (PMMA) rods suspended in PMMA

Beam Hardening Artefacts (fig. 8)

- A line of three 5.0 mm diameter rods of Ti and Pb suspended in PMMA

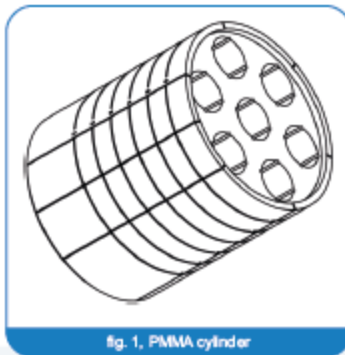


fig. 1, PMMA cylinder



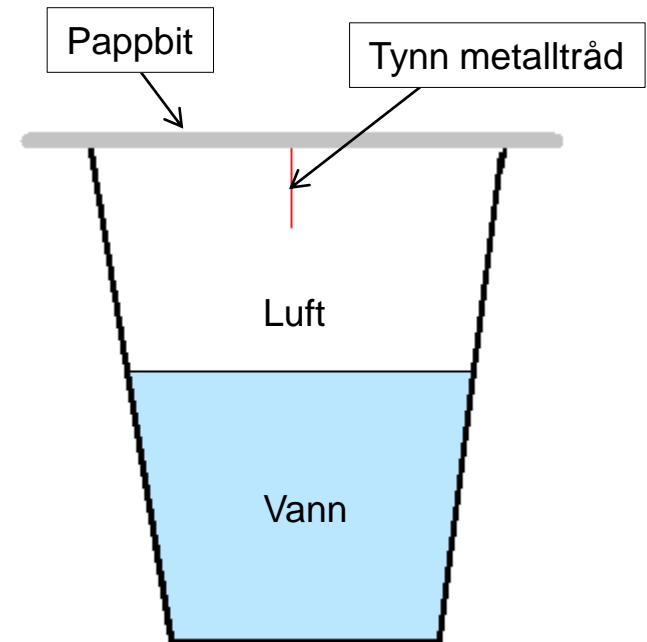
7 insert columns (6 peripheral, 1 central)



6 layers of inserts (labelled 1 to 6)

Vannkopp med tråd

- Tannlegekopp halvfull* med vann
- Kort metalltråd
 - Egenskaper
 - Alltid tilgjengelig
 - Gratis
 - Kan brukes på alle FOV
 - Måler få ting
 - Automatisk analyse
- Leter etter stoff for CNR



Analyse av vannkoppdata

Imaging date: 20101229
 Model: SOREDEX Scanora3D
 Serial number: SZ900158

Imaging protocol:
 Tube voltage: 85 kVp
 Tube current: 15 mA
 Exposure time: 4.5 s
 Field of View (d x h): 60x60 mm
 Voxel size: 0.133 mm

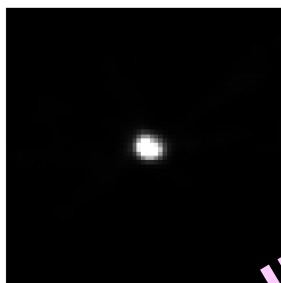
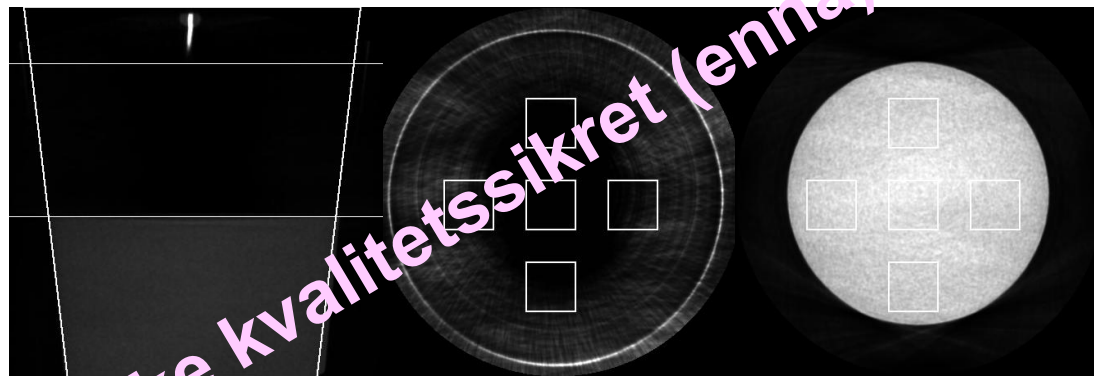


Figure 3 - Image of wire slice

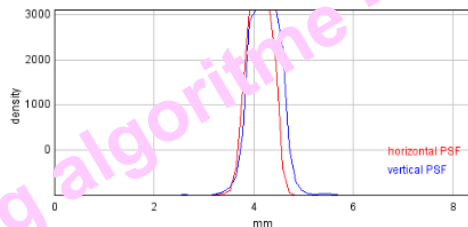


Figure 4 - PSF in horizontal and vertical direction

Material: Water							
Measure	Slice number	Center	West	East	North	South	Average
Mean density	418	-280,7	-325,8	-336,8	-320,3	-360,6	-324,8
StDev	418	35,2	35,1	33,3	33,1	28,0	32,9
Mean density	352	-272,4	-345,1	-315,8	-313,1	-352,5	-319,8
StDev	352	26,3	33,0	30,7	34,9	26,2	30,2
Mean density	286	-280,9	-340,9	-324,5	-332,6	-339,5	-323,7
StDev	286	24,4	31,8	28,1	28,1	38,5	30,2

Table 1

A graph of the MTF is shown in Figure 5

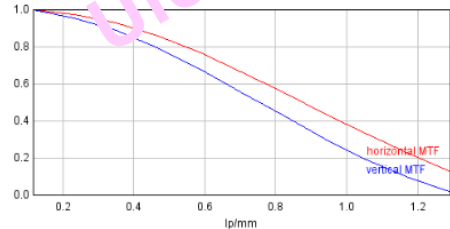


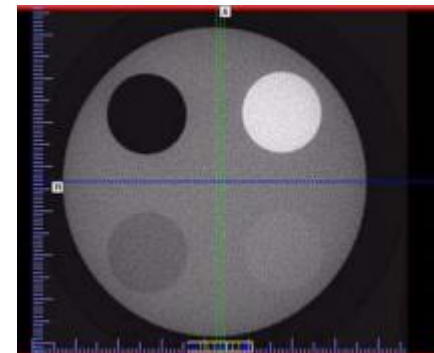
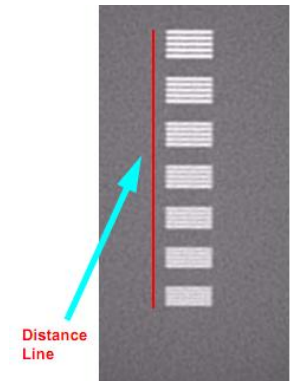
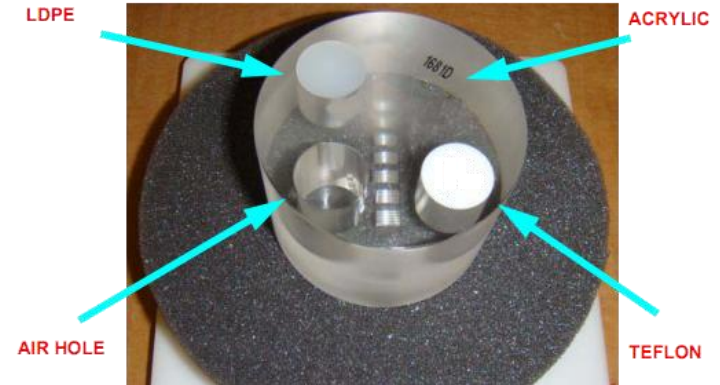
Figure 5 - PSF in horizontal and vertical direction

Material: Air							
Measure	Slice number	Center	West	East	North	South	Average
Mean density	221	-999,0	-982,4	-981,0	-998,4	-985,8	-989,3
StDev	221	0,0	7,1	11,5	1,2	8,1	5,6
Mean density	160	-999,0	-980,3	-982,6	-998,5	-988,7	-989,8
StDev	160	0,0	6,9	10,6	1,3	7,9	5,4
Mean density	99	-999,0	-987,1	-990,5	-998,7	-994,7	-994,0
StDev	99	0,0	9,4	8,3	1,1	5,5	4,9

Table 2

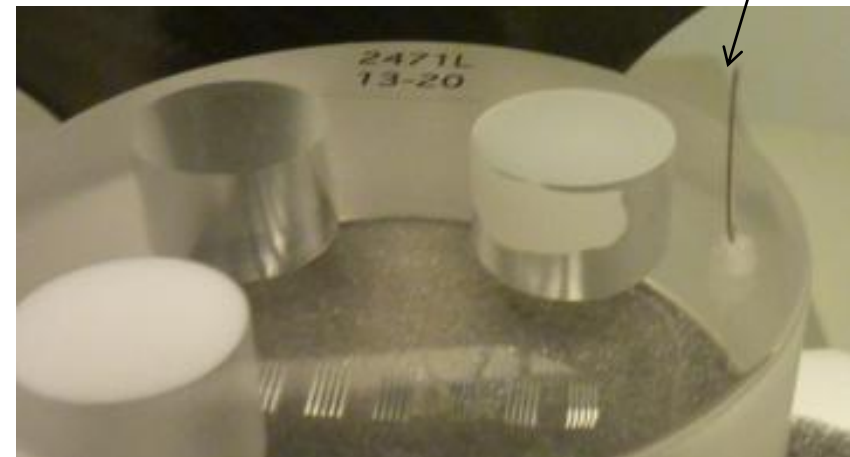
Gendex-fantom

- Leveres med uniten
- Kan bestilles som reservedel
- Tekniske data
 - PMMA-sylinder med innlegg av
 - Linjeparmønster (høykontrast og geometrisk nøyaktighet)
 - Lavkontrastdetaljer: LDPE, Teflon, PMMA, luft
 - PMMA-sokkel til støymåling

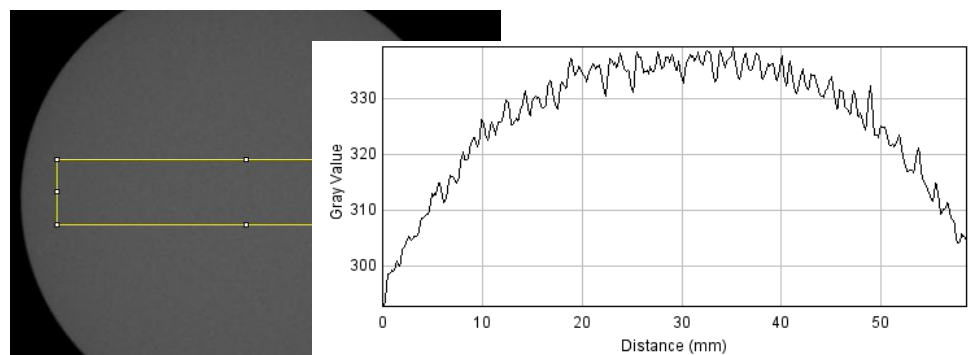
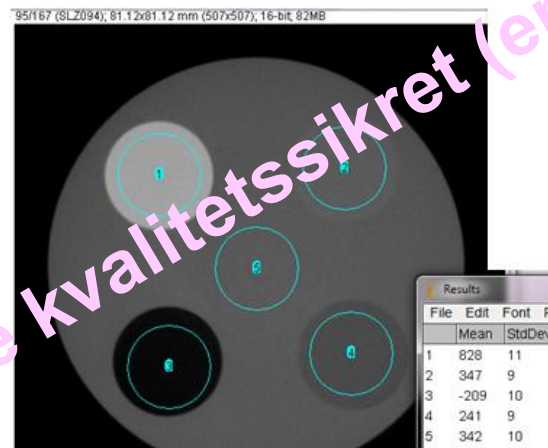
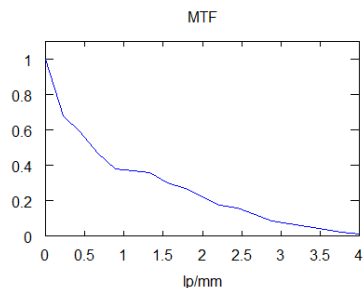
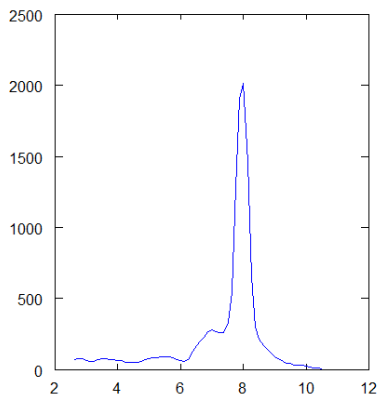


Modifisert Gendex-fantom

- Ståltråd festes på toppen (eller i toppen av lufthullet)
 - Egenskaper
 - Liten 5 x 7 cm
 - Kan brukes på de fleste FOV
 - Billig (tror jeg)
 - Måler mange ting
 - Automatisk analyse utvikles



Analyse av Gendex-fantom data



Bilder og data fra en Morita 3D Accuitomo

Bruksområde for fantomer

Fantom:	SedentexCT	Gendex	Vannkopp
Høykontrast (MTF)	X	X	X
Attenuasjon (HU/gråskala)	X	X	X*
Støy	X	X	X
SNR/CNR	X	X	-**
Geometrisk nøyaktighet	X	X	-
Artefakter	X	-	-
Mye annet	X		

* kun luft/vann

* hvis egnet "standard" stoff finnes

Referanser

- Bildebehandling teori til fordypning
 - MTF: <http://www.normankoren.com/Tutorials/MTF.html>
 - SNR/CNR: http://en.wikipedia.org/wiki/Signal-to-noise_ratio
 - Artikkel som omhandler disse størrelsene mhp CBCT
 - Suomalainen, A., T. Kiljunen, et al. (2009). "Dosimetry and image quality of four dental cone beam computed tomography scanners compared with multislice computed tomography scanners." *Dentomaxillofac Radiol* **38(6)**: 367-378. (<http://dmfr.birjournals.org/cgi/content/abstract/38/6/367>)
- [SedentexCT](#) fantomet
 - [Leeds Test Objects Ltd brosjyre](#)
 - [Sedentext Project Periodic Report \(First period, 2008\)](#)
- ImageJ: [Image Processing and Analysis in Java](#)
- Gendex
 - <http://www.gendex-dental.com>