

CT AutoQA Lite

The QALite software from QA Benchmark (formerly Iris QA) is an industry standard for CT constancy testing in accordance with the IEC 1223-2-6 (1994) guidelines.

It takes Catphan CT images as input, and performs several tests such as HU linearity, MTF, uniformity and so on.

QALite on the CT Scanner

Between 2011 and 2013, we used QALite 3.01 and the Catphan 600 to test our Toshiba Aquilion LB on a regular basis.

Here is a sample evaluation. The five slices relevant for the tests were selected manually. After the table position was zeroed with the small markers at the tip of the phantom being aligned with the scan plane, we evaluated the images at the following slice positions: 0, -33, -73, -112, and -163 mm (Catphan 600, TCOT, 1 mm):

AutoQA Lite v3.00 _ _ X

Analyze Reporting Functions Review Trend Reports Options Quit About

IrisQA KFJ-IRO CT AutoQA Lite Ver 3.01

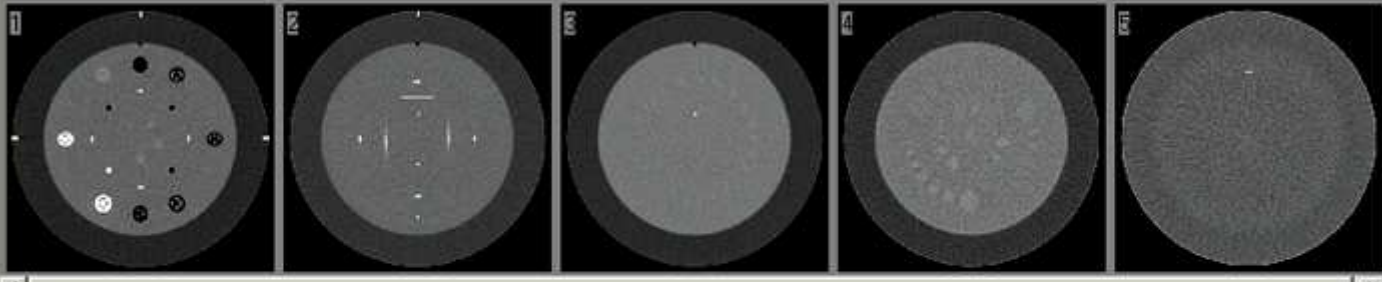


Image #	Test	Status
	Verification	Phantom ID: 600 Series (Phantom Labs) ; Orientation: 1 Phantom Center: 256, 256; CT# of Module Material : 90.74 +/- 5.78 HU
1	Pixel Size	Expected(mm) X-Axis(mm) Y-Axis(mm) 0.41 0.41 0.41 0.41 0.41 Phantom Rotation : 0.0 degrees Phantom Center is 0.00 mm RIGHT OF CENTER and 0.00 mm BELOW CENTER
	CT # Linearity	Contrast Scale: 0.000199 Effective Energy: 60 keV R = 0.999257 Material Teflon Air LDPE Delrin Acrylic Polystyrene PMP CT# 974.3 -1000.0 -103.9 344.5 113.2 -45.1 -194.0
	Slice Thickness	Expected(mm) X-Axis(mm) Y-Axis(mm) 1.00 1.58, 1.55 1.62, 1.61 Avg Slice Width: 1.59 mm Ramp Angle (deg): 23.0 Table Position Offset: 0.22 mm Vertical Angle : 0.1 degrees Horizontal Angle : 0.3 degrees
2	MTF (Wire)	Critical Frequencies (cy/cm) 50% 3.00 10% 5.19 2% 7.25
	Spatial Resolution (MTF)	Critical Frequencies (cy/cm) 50% 3.58 (3.34-3.83) 10% 5.87 (5.51-6.23) 2% 7.67 (7.10-8.25) Note: Average of 2 samples with range shown
	Slice Thickness (Bead Ramp)	Expected(mm) Measured(mm) 1.00 1.43, 1.40 Avg Slice Width: 1.41 mm Ramp Angle (deg): 10.0 Table Position Offset: 0.48 mm Vertical Angle : 0.1 degrees
3	Spatial Resolution (MTF)	Critical Frequencies (cy/cm) 50% 3.31 10% 5.49 2% 7.15
4	Low Contrast (Model)	Contrast (%) 0.49 0.37 0.29 0.24 0.21 0.18 0.16 0.15 0.13 0.12 0.11 0.10 0.10 Detail (mm) 3.00 4.00 5.00 6.00 7.00 8.00 9.00 10.0 11.0 12.0 13.0 14.0 15.0
5	Noise	x(mm) y(mm) Mean(HU) SD(HU) 0.00 50.00 3.24 5.12 50.00 0.00 3.02 4.60 0.00 -50.00 2.86 4.54 -50.00 0.00 1.80 3.78 0.00 0.00 6.66 5.75
	Uniformity	X-Axis Y-Axis Uniformity Index 0.97 1.00 Std Dev (HU): 5.7

© 2004-10 All Rights Reserved Aquilion/L : 1KD10X22 KFJ - IRO 01/31/2013

However, auto-selecting the slices is also possible. In this case, more than one slice per test will be evaluated.

Results can be saved to a database, printed, or saved as PDF ([sample report](#)).

If results are saved, reporting is possible via Report Viewer. Here, the HU numbers of the acrylic density plug between Oct 2011 and Oct 2013 is shown in the larger graph:



In 2013, we stopped routine testing our CT scanner, because QA was performed by Toshiba (now Canon) service engineers anyway via service contract.

QALite on the TrueBeams

In Austrian radiotherapy departments, the national standard ON S5290-3 (Medical electron accelerators - Constancy testing of functional performance characteristics of electronic image receptors) demands CBCT constancy testing twice a year. The Catphan is not named explicitly (this would not be allowed in a standard), but it is a natural choice.

Our TrueBeams came with Catphan 504 phantoms as accessory. The standard process of selecting the slices is a little different. First, the couch cannot be zeroed, second, even if it could, this would not be of much use since the couch does not move during the scan.

The correct longitudinal position of the phantom is with the center of the HU module @ iso.

To give QALite a start point, the center of the high density contrast image is selected manually, and then *Auto Select* is chosen. That's all.

180430-1469-HEAD n0

Serial #	Date	S
CFJ - IRO	04/17/2013	z
TrueBeam_GRL	04/17/2013	z

Width : 1166
Center : 368

Table
143.23
147.24
145.25
143.26
141.27
139.28
137.29

65	Ram-Lak	Axial	1.989724	135.3
64	Ram-Lak	Axial	1.989724	133.31
63	Ram-Lak	Axial	1.989724	131.32
62	Ram-Lak	Axial	1.989724	129.33
61	Ram-Lak	Axial	1.989724	127.34
60	Ram-Lak	Axial	1.989724	125.35

Select ALL Skip ALL Auto Select


Delete After Processing
 Reverse Image Order
 Preview Images

Field of View 261.72 mm
kV 100
ma 15
Pulse 10000 msec
CT Max 2174H

The software knows which phantom model is in use,

- 700 Series (Phantom Labs)
- 605 Series (Phantom Labs)
- 604 Series (Phantom Labs)
- 600 Series (Phantom Labs)
- 504 Series (Varian Trilogy)**
- 503 Series (Elekta)
- 500 Series (Phantom Labs)
- 412 Series (Phantom Labs)
- 411 Series (Phantom Labs)
- 410 Series (Phantom Labs)
- InnerVision (Toshiba)
- ACR Accreditation Phantom
- GE CT Phantom
- GE vCT Phantom
- Siemens CT Phantom
- Philips CT Phantom

Select Phantom Model



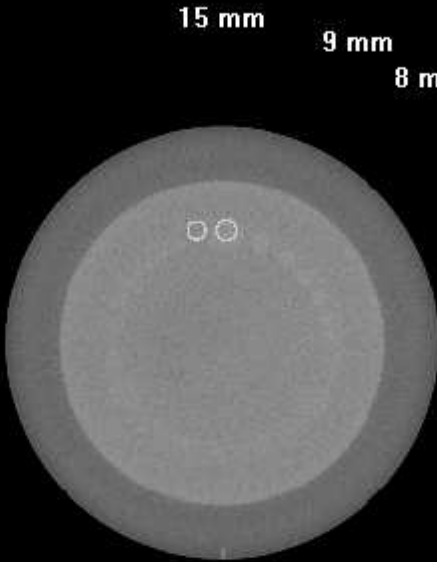
Accept Cancel

and with this information, the correct slices for the other tests are automatically selected.

Only one user action is required. The user has to specify the diameter of the smallest low contrast rod which is visible to him/her, and enter the value via keyboard:

zz-CBCT^zz-Catph : zz-
CBCT
04/24/2019
KFJ-IRD
Slice : 1.98 mm
Patient Ve : 1469
Varian Med

125 kVp 60 mA
0 degrees
Field : 464. mm
Table : -32.81
Filter : Ram-Lak
1788 msec



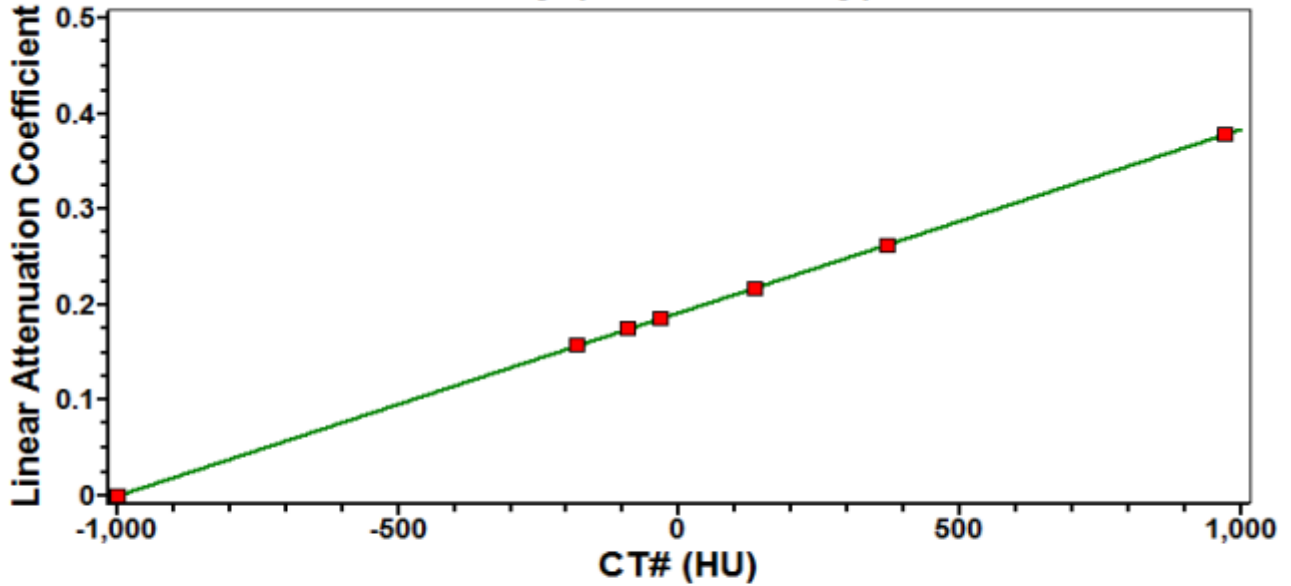
Enter the smallest of the 1% rods visualized (mm) :

Width : 400

Center : 40

The other tests are fully automated. Here are some more test results of a typical TrueBeam PELVIS scan:

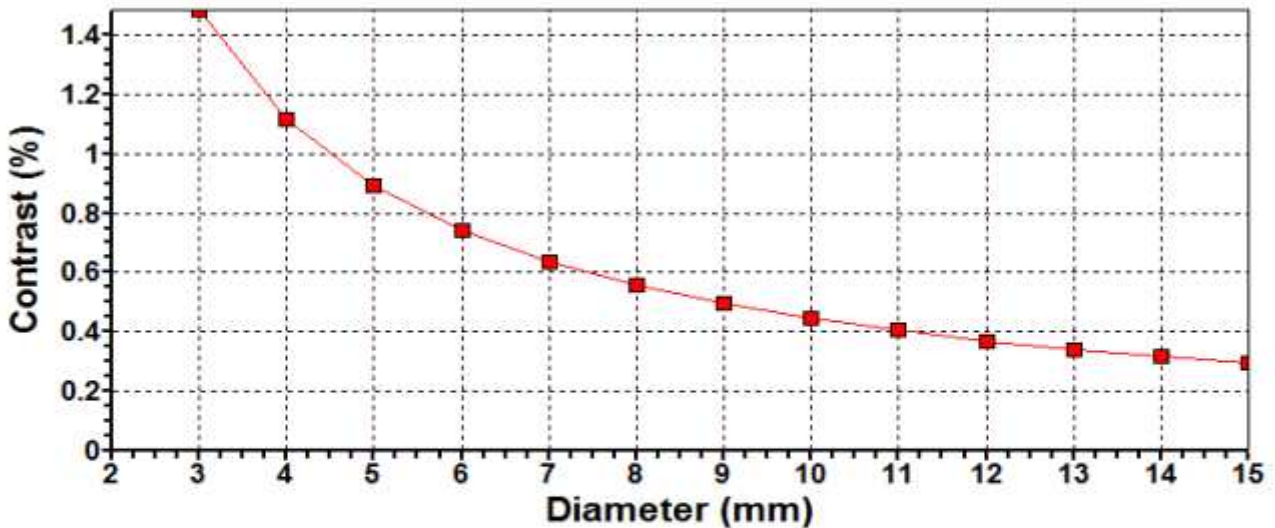
Linearity (Sensitometry)



Contrast Scale: 0.000192 Intercept: -1001.2H
 Teflon Air LDPE Delrin Acrylic Polysty PMP
 971.7 -999.1 -91.5 370.5 133.3 -34.5 -183.3

KFJ-IRO 04/24/2019 504 Series (Varian Trilogy)
 Patient Ve SN: 1469 Image #2 CT # Linearity
 125kV, 60mA, 1788nsec, 464.cm, Filter:Ram-Lak, 1.98mm, @ 0.9942, Axial

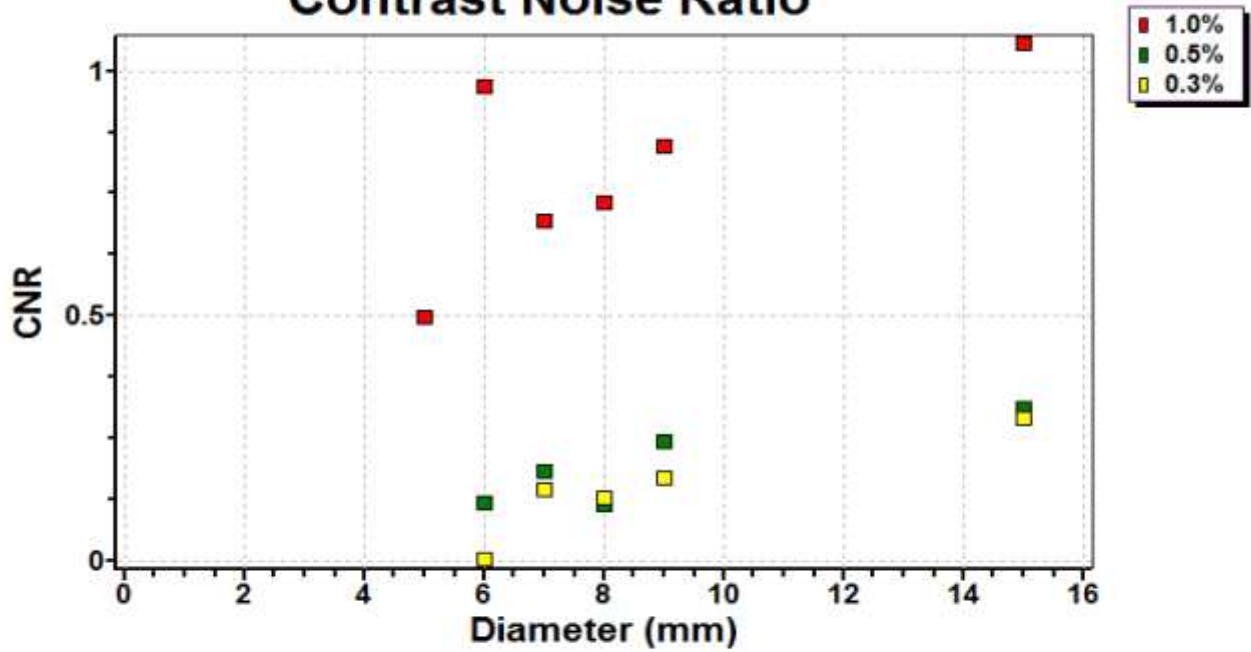
Low Contrast Model



Contrast(%) 1.48 1.11 0.89 0.74 0.64 0.56 0.49 0.45 0.40 0.37 0.34 0.32 0.30
 Diameter(mm) 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0
 Factor: 1.00

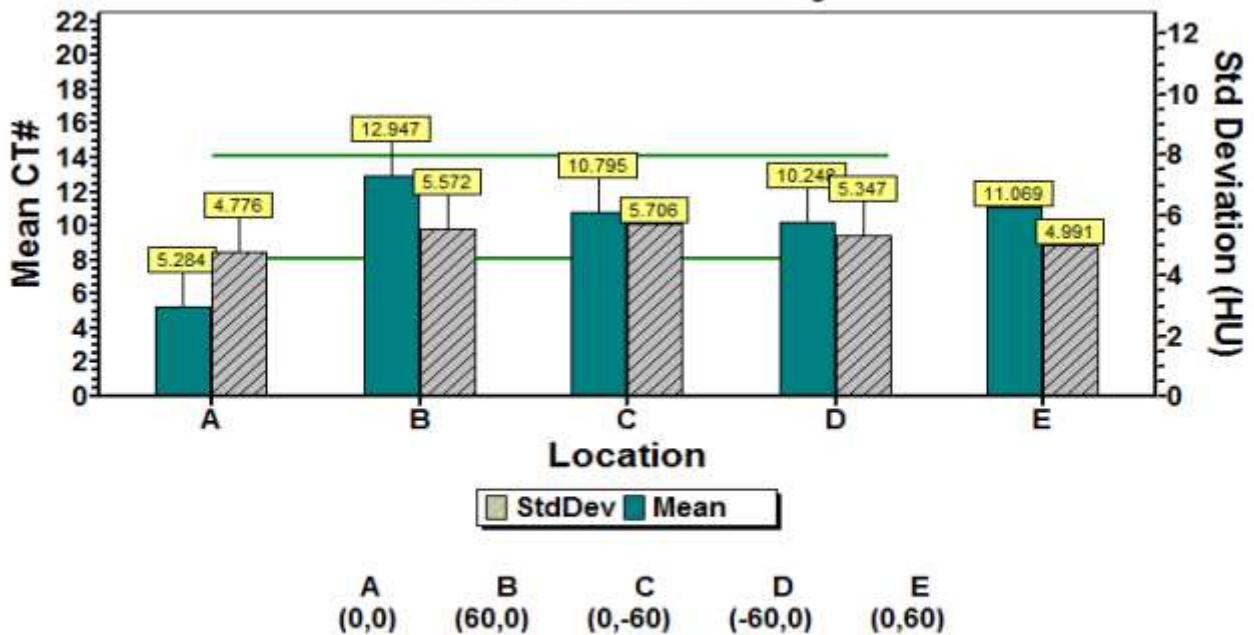
KFJ-IRO 04/24/2019 504 Series (Varian Trilogy)
 Patient Ve SN: 1469 Image #3 Low Contrast (Model)
 125kV, 60mA, 1788msec, 464.cm, Filter:Ram-Lak, 1.98mm, @ -32.81, Axial

Contrast Noise Ratio

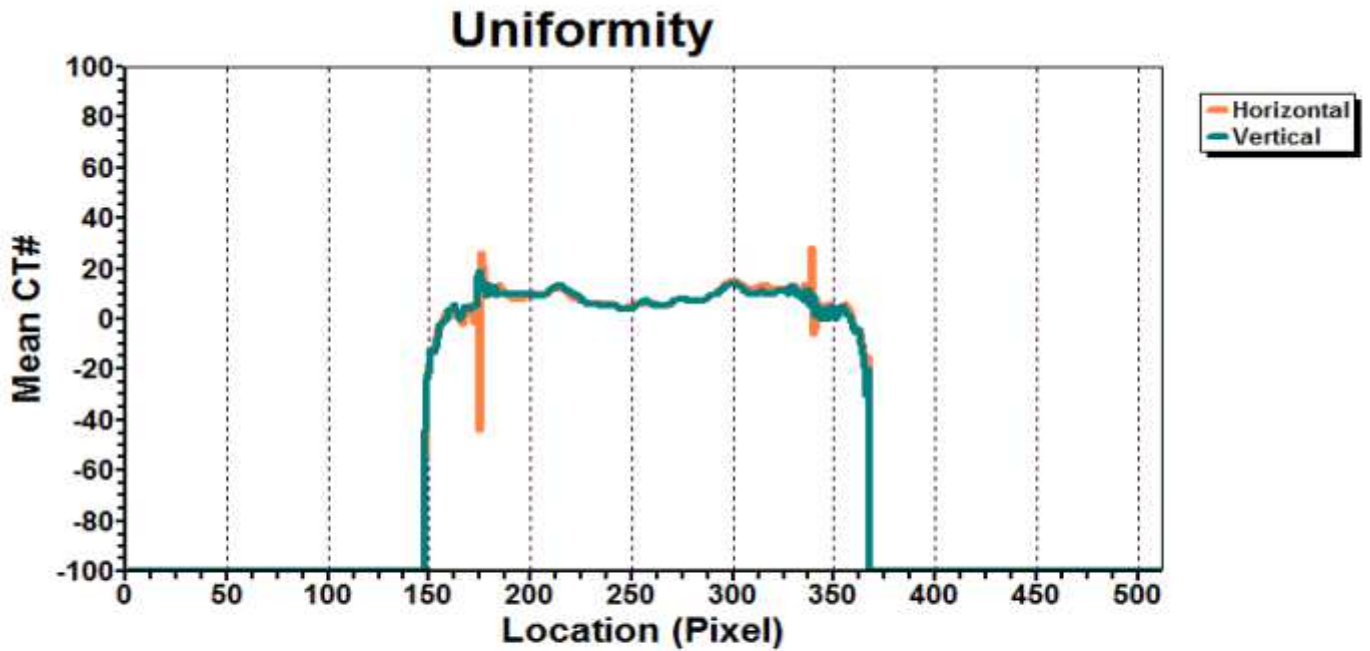


KFJ-IRO 04/24/2019 504 Series (Varian Trilogy)
 Patient Ve SN: 1469 Image #3 CNR
 125kV, 60mA, 1788msec, 464.cm, Filter:Ram-Lak, 1.98mm, @ -32.81, Axial

Noise/Uniformity



KFJ-IRO 04/24/2019 504 Series (Varian Trilogy)
 Patient Ve SN: 1469 Image #4 Image Uniformity
 125kV, 60mA, 1788msec, 464.cm, Filter:Ram-Lak, 1.98mm, @ -72.57, Axial



Horizontal Fractional Uniformity: 1.00
 Vertical Fractional Uniformity: 1.00
 KFJ-IRO 04/24/2019 504 Series (Varian Trilogy)
 Patient Ve SN: 1469 Image #4 Uniformity Index
 125kV, 60mA, 1788msec, 464.cm, Filter:Ram-Lak, 1.98mm, @ -72.57, Axial

Software Evolution

A little detail in version 3.01 prevented us from using the reporting functionality together with TrueBeam CBCT images. Looking at the DICOM tags of an image file, one can see that there are three tags which display the same date (*Series Date*, *Acquisition Date*, *Image Date*), and one tag which displays a different date (*Study Date*). QALite 3.01 reported the *Study Date* (DICOM tag 0008,0020) to mark the date of the scan, not the *Acquisition Date* (0008,0022).

Implicit VR Little Endian

CT.zz-CBCT.Image 13.dcm

Position	Tag	Length	VR	VM	Description	Value
00000000	(0002,0000)	00000004	UL	1	Group 0002 Length	188
0000000c	(0002,0001)	00000002	OB	1	File Meta Information Version	0x0\0x1
00000016	(0002,0002)	0000001A	UI	1	Media Stored SOP Class UID	=CT Image Storage
00000038	(0002,0003)	0000003A	UI	1	Media Stored SOP Instance UID	1.2.246.352.62.1.5308698994767282439
0000007a	(0002,0010)	00000012	UI	1	Transfer Syntax UID	=Implicit VR Little Endian
00000094	(0002,0012)	00000018	UI	1	Implementation Class UID	1.2.246.352.70.2.1.160.3
000000b4	(0002,0013)	00000008	SH	1	Implementation Version Name	DCIE 2.2
000000c4	(0008,0008)	00000016	CS	2-n	Image Type	ORIGINAL\PRIMARY\AXIAL
000000e2	(0008,0012)	00000008	DA	1	Instance Creation Date	20190425
000000f2	(0008,0013)	00000006	TM	1	Instance Creation Time	144216
00000100	(0008,0016)	0000001A	UI	1	SOP Class UID	=CT Image Storage
00000122	(0008,0018)	0000003A	UI	1	SOP Instance UID	1.2.246.352.62.1.5308698994767282439
00000164	(0008,0020)	00000008	DA	1	Study Date	20130417
00000174	(0008,0021)	00000008	DA	1	Series Date	20190424
00000184	(0008,0022)	00000008	DA	1	Acquisition Date	20190424
00000194	(0008,0023)	00000008	DA	1	Image Date	20190424
000001a4	(0008,0030)	00000006	TM	1	Study Time	083819
000001b2	(0008,0031)	0000000A	TM	1	Series Time	160921.907
000001c4	(0008,0032)	0000000A	TM	1	Acquisition Time	160810.937
000001d6	(0008,0033)	0000000A	TM	1	Image Time	160810.937
000001e8	(0008,0050)	00000004	SH	1	Accession Number	3548
000001f4	(0008,0060)	00000002	CS	1	Modality	CT
000001fe	(0008,0070)	00000016	LO	1	Manufacturer	Varian Medical Systems
0000021c	(0008,0090)	00000000	PN	1	Referring Physician's Name	
00000224	(0008,1010)	0000000E	SH	1	Station Name	TrueBeam_GRUEN
0000023a	(0008,1070)	0000000E	PN	1-n	Operators Name	DICOM Service
00000250	(0008,1090)	00000014	LO	1	Manufacturer's Model Name	Patient Verification
0000026c	(0008,114a)	000000E8	SQ	1	Referenced Instance Sequence	[Sequence with 1 items]
0000035c	(0008,3010)	0000003A	UI	1	Irradiation Event UID	1.2.246.352.62.30.5270220888541935333
0000039e	(0010,0010)	00000016	PN	1	Patient's Name	zz-CBCT^zz-Catphan504
000003bc	(0010,0020)	00000008	LO	1	Patient ID	zz-CBCT
000003cc	(0010,0030)	00000000	DA	1	Patient's Birth Date	


Ready | CAP | NUM | SCRL

While the *Study Date* is a good choice for CT scanners, it resulted in all our CBCT scans having the same date, as displayed by QALite. On the CT, a new study is created every time the patient is scanned, but on the linac, the same plan is loaded repeatedly for CBCT acquisition, and the *Study Date* tag gets filled by ARIA with the date of QA plan creation, which typically only happens once¹ (in our case, on 17 Apr 2013). ARIA of course also "knows" the date of each CBCT acquisition, but QALite was simply reading a different DICOM tag.

This is now changed. QALite 3.1.5.11 displays the time of acquisition in its user interface:

DICOM Directory
190425-1469-PELVIS

Facility	Serial #	Date	Study	Series	Description
KFJ-IRO	1469	04/24/2019	zz-CBCT zz-Calphan5		



Begin Analysis

Delete Images

Exit

Sort Images by Series

Delete After Processing


Reverse Image Order

Preview Images

Select ALL

Skip ALL

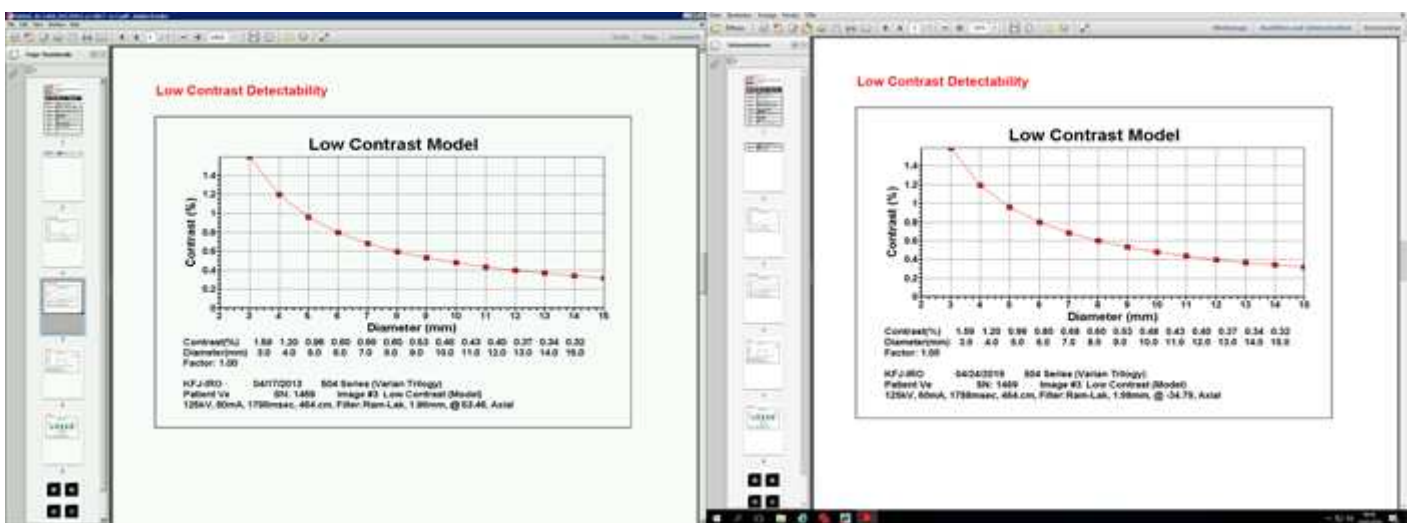
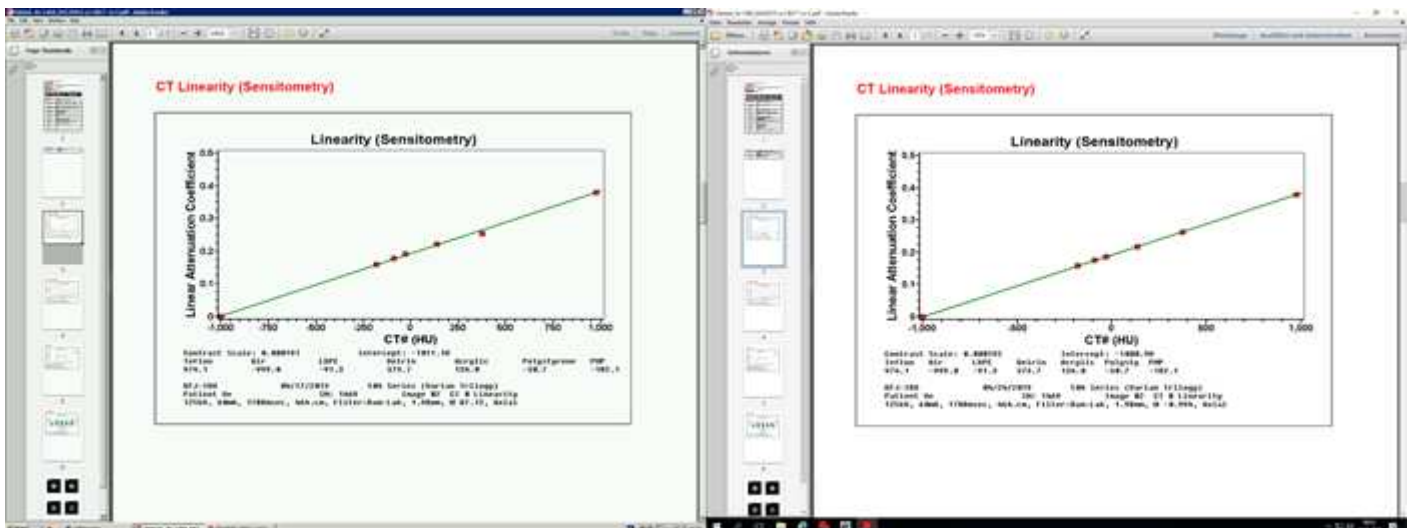
Auto Select

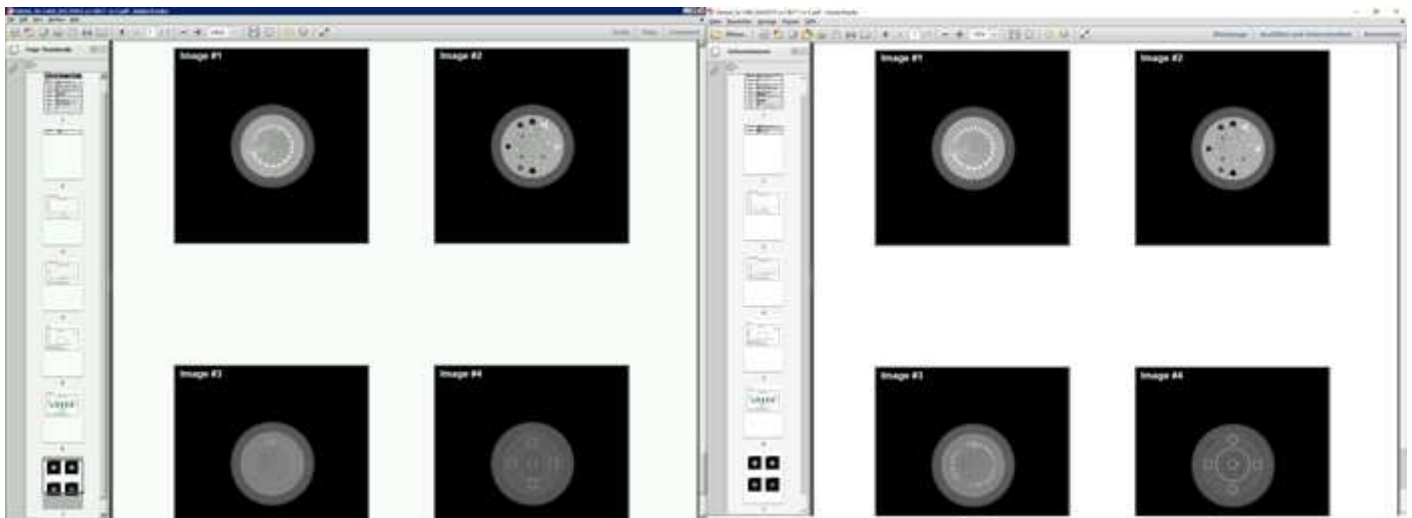
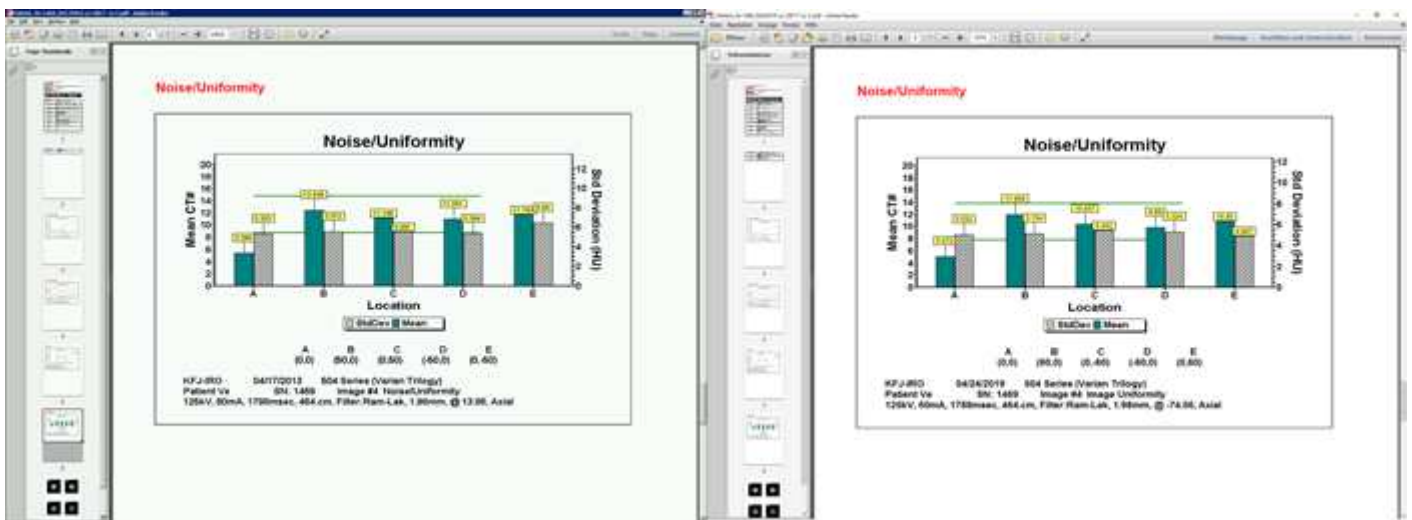
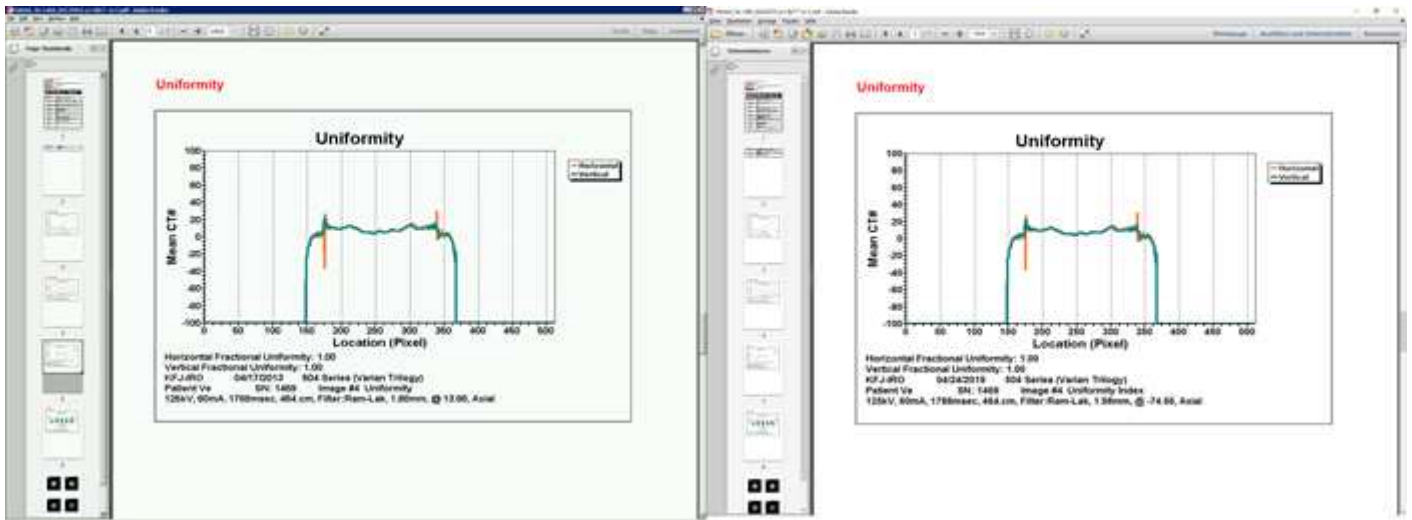


Field of View 464.90 mm
kV 125
mA 60
Pulse 17880 msec
CT Max 1713H

of Studies: 1
of Images: 88
File Name: CT_zz-CBCT_Image 61.0001.dcm

Some other small changes between versions 3.01 and 3.1.5.11 can be seen if the results for the same test data are compared side by side (click screenshots to enlarge). For instance, the linear attenuation coefficient of Delrin seems to have increased a little. CT# is the same (373.7 HU), but in the newer version, the Delrin point sits nicely on the CT linearity curve:





There was also a small change in the slice thickness analysis, which now includes a smoothing function that is based on thickness and image noise.

You can also download the reports generated with versions [3.01](#) and [3.1.5.11](#) as PDF.

Summary

Catphan phantoms are often shipped together with linacs to give the physicist some tool for CBCT image QA, but usually the phantom comes without analysis software. While manual evaluation of CT or CBCT images is theoretically possible, it starts to get complex when the Fourier transform of line spread function data has to be calculated in order to get the MTF curve.

This is where automated software programs come in handy. QALite has proven to be an indispensable and reliable tool for performing the Catphan tests.

Notes

¹ Of course it would be possible to create a new QA plan in ARIA every time the Catphan is scanned. In this case, Study Date and the other Dates would be identical.

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