

Optimage

Software Solution for a National Quality Assurance Programme in Medical Imaging

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Motivation

- **How can we improve the Quality Assurance in the hospitals in Luxembourg?**
- A solution for the radiological department:
 - Facilitation and documentation of the quality control
 - Creation of a central tool, ready to be deployed
- Automated processing of the acquired constancy tests
- All tests based on existing phantoms and standards
- Required functionality
 - Flexible and customisable mode of operation
 - DICOM integration
 - Automatic processing of images (as much as possible)
 - Documentation (Reporting)
 - Statistical evaluation of the calculated results
 - Support for the most important modalities

Project Team: multidisciplinary!

- **EHL: medical physics experts and contact point for the hospitals**
 - Martine Grelot, Christina Bokou, Olga Kaphammel, Alex Meyer, Octavian Dragusin,
- **Ministry of Health: regulative and national body**
 - Carlo Back, Alexandra Schreiner, Ferid Shannoun and Nico Harpes
- **CRP Henri Tudor: image processing and informatics**
 - Andreas Jahnen, Christian Moll, Johannes Hermen + students of different professions
- **BK Trier: medical physics and informatics**
 - Prof. Dr. Hans-Peter Busch and Clemens Schilz
- **+ International Collaborations:**
 - Fachhochschule Giessen (Prof. Fiebich, Prof. Zink)
 - Fachhochschule Köln (Prof. Blendl)

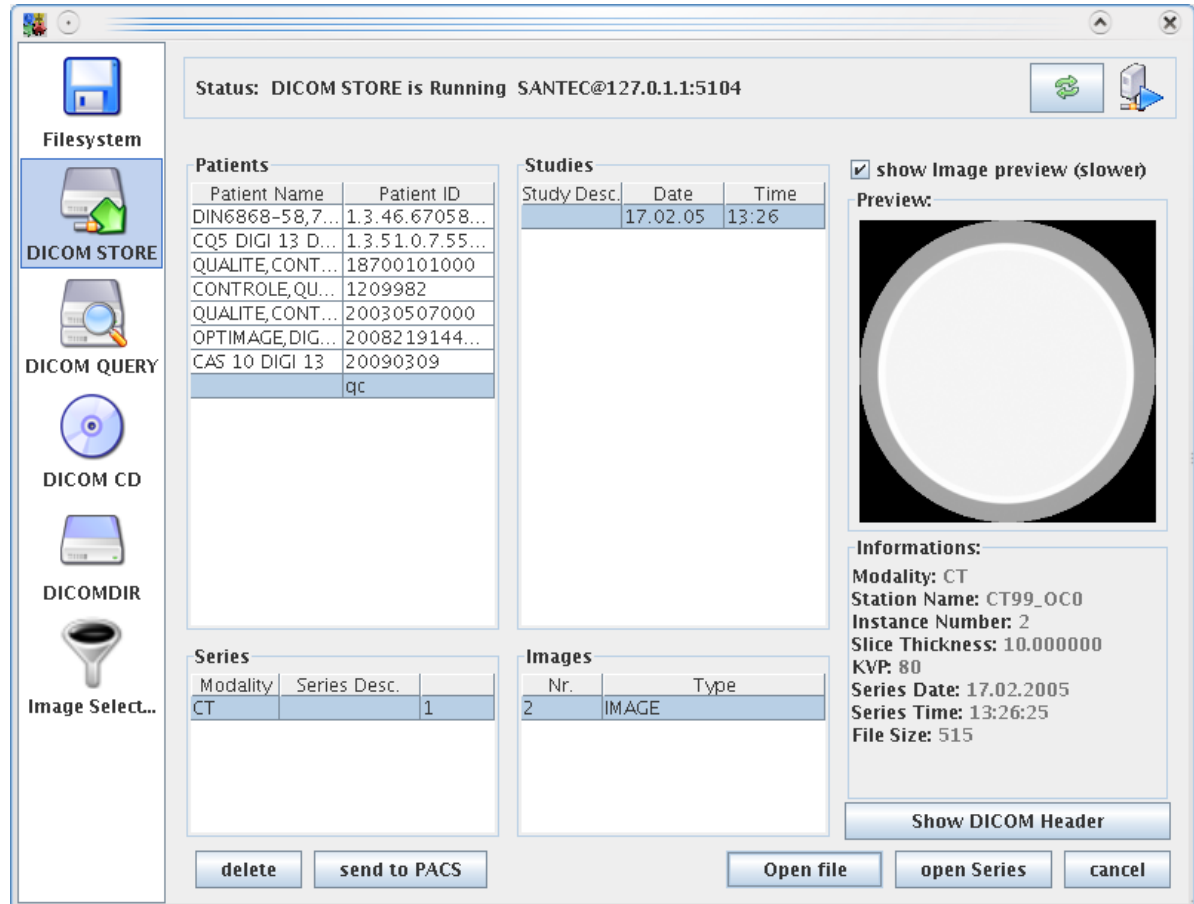
Design of the software

- Development of the **Optimage Framework**:
 - Support for dynamic **modules** (plugins) that implement a new test or support a new phantom type
 - Image processing functionality based on ImageJ [Wayne Rasband, National Institute of Health]
 - Integrated or external relational database
 - **Statistical functionality** including plotting of measurements and export of the data
 - **Reporting** functionality for documentation reasons
 - Integrated help system, to support the users in doing the tests
 - **Multilingual** user interface

Due to this framework, new modules automatically benefit from this functions!

Design of the system

- Images have to be transferred in an easy way to Optimage!



Status: DICOM STORE is Running SANTEC@127.0.1.1:5104

Patients

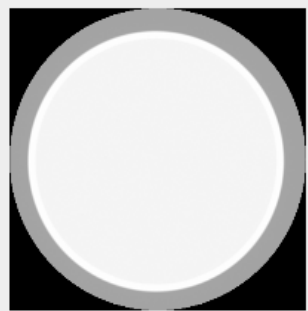
Patient Name	Patient ID
DIN6868-58,7...	1.3.46.67058...
CQ5 DIGI 13 D...	1.3.51.0.7.55...
QUALITE, CONT...	18700101000
CONTROLE, QU...	1209982
QUALITE, CONT...	20030507000
OPTIMAGE, DIG...	2008219144...
CAS 10 DIGI 13	20090309
	qc

Studies

Study Desc.	Date	Time
	17.02.05	13:26

show Image preview (slower)

Preview:



Informations:

Modality: CT
Station Name: CT99_OC0
Instance Number: 2
Slice Thickness: 10.000000
KVP: 80
Series Date: 17.02.2005
Series Time: 13:26:25
File Size: 515

Show DICOM Header

delete send to PACS Open file open Series cancel

Optimage
Mem Info

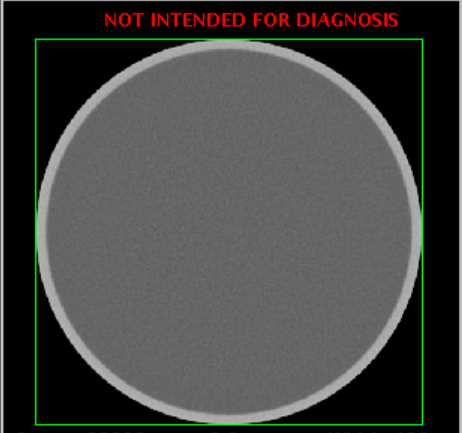
File Edit Help

select User
 anonymous

Control Center
Test Results: Sep 3, 2009
Plot Time Series
View/Export Results

CT Level A

NOT INTENDED FOR DIAGNOSIS



Center: 32808 0.6x Width: 400

no images loaded

Phantom image folder:

Select Image

Profile: **CT 100KV [Standard GE Phantom]**
Select Profile

Details		
checked Parameters	Profile	Image
Manufacturer	GE MEDICAL SYSTEMS	GE MEDICAL SYSTEMS
Model	LightSpeed Pro 16	LightSpeed Pro 16
Station	CT99_OCO	CT99_OCO
Slice Thickness	10.0	10.000000
Voltage	80.0	80
Current	400.0	400
Kernel	STANDARD	STANDARD
Device Serial		

Image Infos	
Modality	CT
image Number	2
Date of Exposure	20050217
Time of Exam	132625
Rows	512
Columns	512
Protocol Name	STANDARD

State: Verification of image successful! i

100%

Results

Load Results
View/Export
Statistique
Creation of Reports

Evaluation

Verify
Calculate

Optimage
Mem Info

File Edit Help

select User
 anonymous

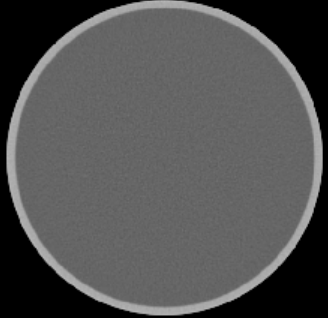
CT Level A

Control Center
Test Results: Feb 17, 2005
Test Results: Sep 3, 2009
Plot Time Series
View/Export Results

CT 100KV [Standard GE Phantom]

Feb 17, 2005 1:26:25 PM

NOT INTENDED FOR DIAGNOSIS



Center: 32808 0.5x Width: 400

Parameter	Value	Reference	Tolerance	State
Results				
Comment				
CT Numbers				
Water	1.96 HU	0.00 HU	± 10.00 HU	✓
Air	-1,001.38 HU	-1,000.00 HU	± 20.00 HU	✓
Uniformity				
Center Region	1.08 HU	0.00 HU	± 10.00 HU	✓
North Region	1.39 HU	0.00 HU	± 10.00 HU	✓
South Region	0.63 HU	0.00 HU	± 10.00 HU	✓
West Region	1.02 HU	0.00 HU	± 10.00 HU	✓
East Region	1.31 HU	0.00 HU	± 10.00 HU	✓
Maximal Difference [(South Region)]	0.45 HU	0.00 HU	± 4.00 HU	✓

Details

Double-Click the preview image to get a larger view with extended features.

Please select the different rows in the result table to explore the measurement details.

Use the [All Results] Button to see additional Results.

Info

[All Results]

Save

Close

Module	Test procedure	Phantom type	Measured parameter
CT level A	Basic measurements	Manufacturer phantoms	Noise, SNR, homogeneity, CT numbers (water, air)
CT level B	CATPHAN Manual ⁽³⁾	CATPHAN 500	Noise, SNR, homogeneity, CT numbers (air, LDPE, acryl, teflon), low contrast, resolution, pixel size, slice thickness, table incrementation
MRI level A	IPEM recommendations ⁽⁴⁾	Standard bottle phantom	Noise, SNR, homogeneity
X-ray level A	DIN 6868-13 ⁽⁵⁾	DIN 6868-13 phantoms	Noise, homogeneity, low contrast, resolution, dynamic range, collimation
CDRAD Mammography level A	CDRAD Manual ⁽⁶⁾ European Guideline ^{s(7)} and PAS 1054 ⁽⁸⁾	CDRAD phantom PAS 1054 phantom and PMMA block	Number and position of detected points Noise, SNR, CNR, grey-area reference, homogeneity, resolution, dynamic range, boundary
Mammography level B	European Guideline ^{s(7)} and PAS 1054 ⁽⁸⁾	PAS 1054 phantom with LCD24 insert	Noise, SNR, CNR, grey-area reference, resolution, dynamic range, boundary, low contrast detail
Nuclear Medicine level A	DIN EN 60789 ⁽⁹⁾	No phantom needed	Intrinsic non-uniformity

Level A describe basic tests performed by the MTA and Level B advanced tests performed by the medical physical expert

- Profiles are the reference for every measurement done
 - Contain information about the phantom used
 - Manufacturer, Model, Methods of calculation
 - Contain the most important measurement parameters
 - We can only “compare” measurements taken with the same machine settings
 - Contain reference and tolerance values
 - Individual settings of the tolerance are possible

- Why profiles?
 - As a reference point in the database
 - As the entry point for statistics, export function and reporting
 - To not compare data, that is not comparable due to the selected parameters

select Profile
✕

Select Institution

[0] anonymous

select Profile:

profilename	Status
A EFFACER [Standard GE Phantom]	Archived
CT 100 kV [Standard GE Phantom]	Active
A EFFACER [Standard GE Phantom]	Archived
CT2 120 kV [Standard GE Phantom]	Active
A EFFACER [Standard GE Phantom]	Archived
CT2 140 kV [Standard GE Phantom]	Active
CT1 100kv newid [Standard GE Phantom]	Active
CT1 120KV newid [Standard GE Phantom]	Active
a effacer [Standard Siemens Phantom]	Archived
CT1 140KV newid [Standard GE Phantom]	Active
ww [Standard Siemens Phantom]	Archived
A EFFACER [Standard Siemens Phantom]	Archived
A EFFACER [Standard GE Phantom]	Archived
CT 100kV [Standard GE Phantom]	Active
CT 100KV [Standard GE Phantom]	Active

Profile Name

CT 100KV
 Archived

Reference Values

<p>CT Number of water</p> <p>Reference Value: Tolerance:</p> <div style="border: 1px solid gray; padding: 2px; display: flex; justify-content: space-between;"> 0.0 10.0 </div>	<p>CT Number of air</p> <p>Reference Value: Tolerance:</p> <div style="border: 1px solid gray; padding: 2px; display: flex; justify-content: space-between;"> -1000.0 20.0 </div>
<p>Noise</p> <p>Reference Value: Tolerance:</p> <div style="border: 1px solid gray; padding: 2px; display: flex; justify-content: space-between;"> 0.0 10.0 </div>	<p>Relative Noise</p> <p>Reference Value: Tolerance:</p> <div style="border: 1px solid gray; padding: 2px; display: flex; justify-content: space-between;"> 0.0 1.5 </div>
<p>Uniformity</p> <p>Reference Value: Tolerance:</p> <div style="border: 1px solid gray; padding: 2px; display: flex; justify-content: space-between;"> 0.0 10.0 </div>	<p>Relative Uniformity</p> <p>Reference Value: Tolerance:</p> <div style="border: 1px solid gray; padding: 2px; display: flex; justify-content: space-between;"> 0.0 1.5 </div>
<p>Uniformity max. Difference</p> <p>Reference Value: Tolerance:</p> <div style="border: 1px solid gray; padding: 2px; display: flex; justify-content: space-between;"> 0.0 4.0 </div>	

New Profile

Edit

Select

edit result visibility

Save

1. Selection of images



2. Verification



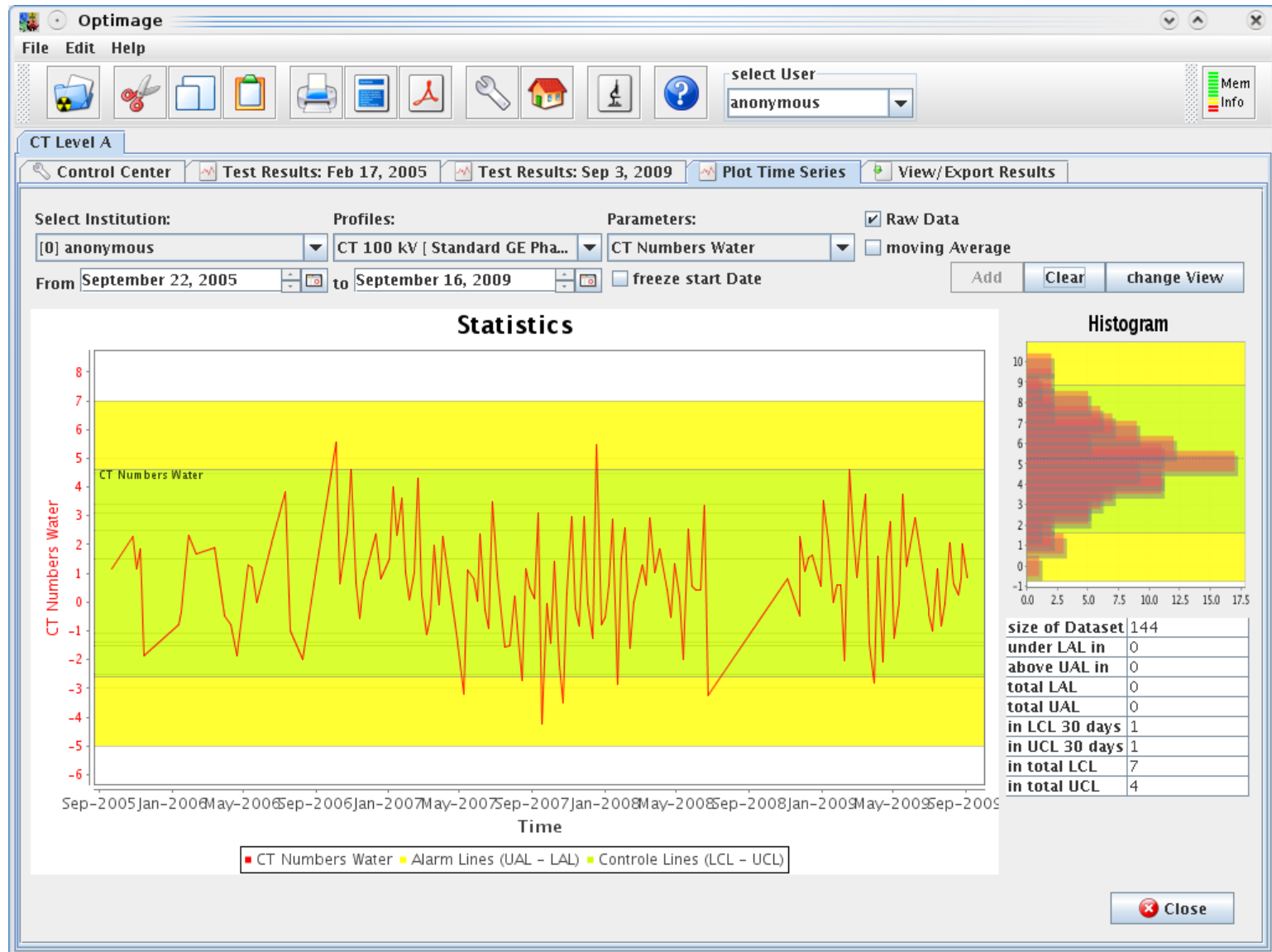
3. Calculation

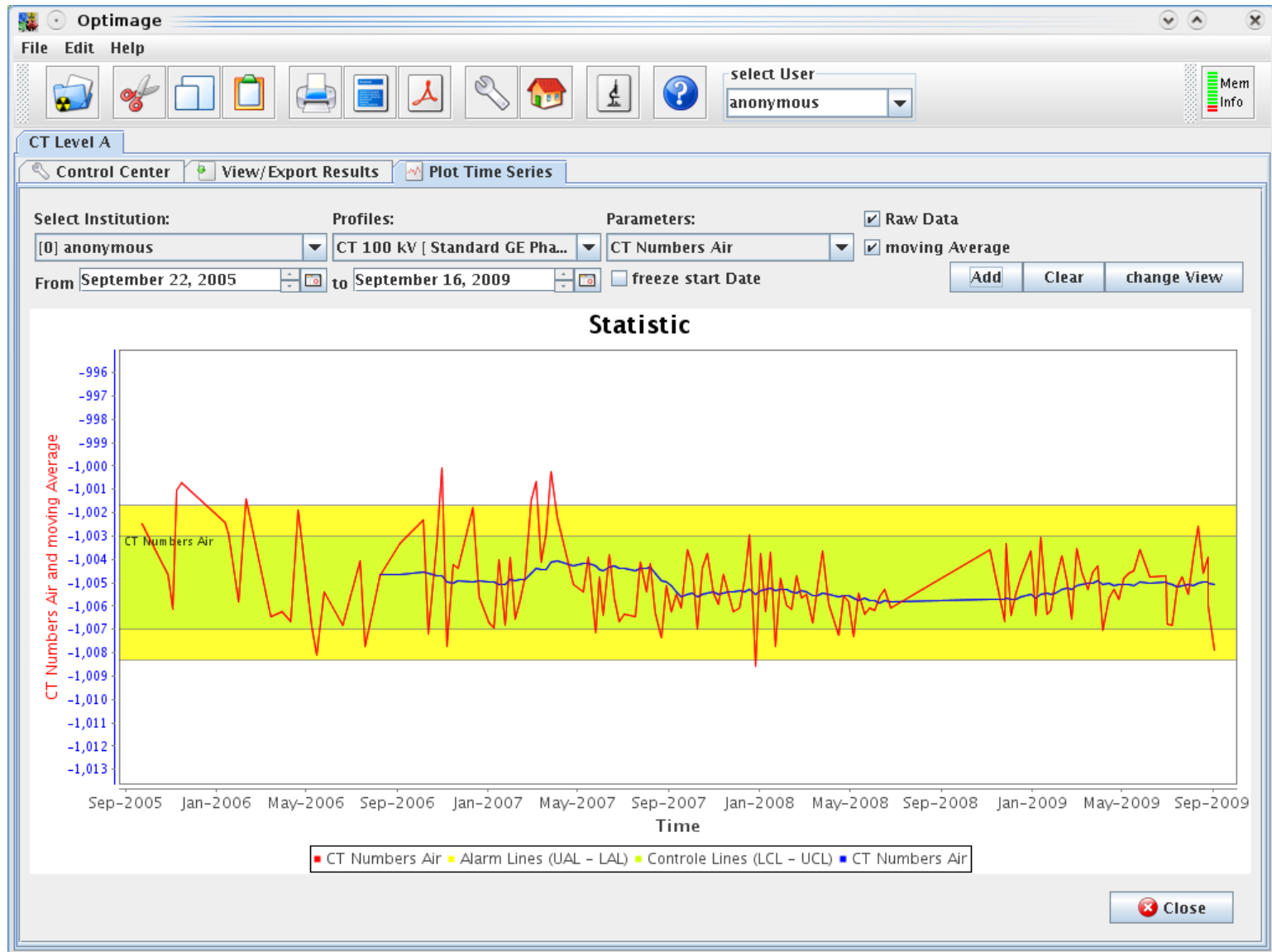


4. Work with Results

Save / Load into the database
Statistics: Visualisations and export
Reports: per profile; over time; ...

- We need to find out, if the measurement is within the acceptable range.
 - Strategy A: Read the particular guidelines and use the specified limits
 - Strategy B: Use Statistics (mean \pm 2 sigma)
- Plot the measurements over time to discover a change in performance.
- Statistical Process Control: Discover trends as soon as possible ($n > 30$)
 - UCL: Upper control line
 - LCL: Lower control line
 - UAL: Upper alarm line
 - LAL: Lower alarm line





Optimage

File Edit Help

select User
anonymous

Mem Info

CT Level A

Control Center Plot Time Series View/Export Results

[0] anonymous CT 100 kV [Standard GE Phan... From September 22, 2005 to September 16, 2009

show all Values freeze start Date

September to September 16, 2009

Select

Measurements Table

Date	CT Numbers Air	CT Numbers Water	Noise Noise	Relative Values Noise %	Relative Values Uniformity %	Uniformity Maximal Difference
Sep 22, 2005	-1,002.450	1.140	9.796	-0.857	0.133	-1.525
Oct 27, 2005	-1,004.640	2.270	9.282	-0.407	0.019	-0.443
Nov 3, 2005	-1,006.150	1.160	9.467	-0.811	0.123	-1.433
Nov 8, 2005	-1,001.060	1.830	9.421	-0.514	0.081	-1.489
Nov 15, 2005	-1,000.730	-1.860	10.193	0.548	-0.074	-1.372
Jan 12, 2006	-1,002.400	-0.770	10.155	1.316	-0.182	-1.402
Jan 17, 2006	-1,002.950	-0.350	9.969	2.840	-0.385	-1.351
Jan 30, 2006	-1,005.840	2.320	9.447	-0.405	0.032	-0.749
Feb 10, 2006	-1,001.410	1.680	9.779	-0.581	0.078	-1.319
Mar 15, 2006	-1,006.460	1.910	9.633	-0.501	0.059	-1.125
Mar 30, 2006	-1,006.230	-0.490	9.249	1.876	-0.204	-1.004
Apr 11, 2006	-1,006.640	-0.780	10.051	1.280	-0.085	-0.668
Apr 20, 2006	-1,001.890	-1.840	9.528	0.517	-0.101	-1.862
May 9, 2006	-1,006.900	1.280	9.786	-0.759	0.058	-0.743
May 16, 2006	-1,008.090	1.220	9.933	-0.808	0.113	-1.396
May 25, 2006	-1,005.370	0.010	9.505	-94.541	9.651	-0.970
Jun 20, 2006	-1,006.830	2.250	10.130	-0.447	0.062	-1.400
Jul 12, 2006	-1,004.050	3.850	9.610	-0.249	0.041	-1.571
Jul 20, 2006	-1,007.710	-1.010	9.517	0.935	-0.119	-1.212
Aug 9, 2006	-1,004.710	-1.980	9.375	0.471	-0.075	-1.501
Sep 4, 2006	-1,003.300	1.480	9.541	-0.643	0.036	-0.541
Oct 5, 2006	-1,002.330	5.560	10.164	-0.182	0.026	-1.429

Result Table

View/Export Results	CT Numbers Air	CT Numbers Water	Noise Noise	Relative Values Noise %	Relative Values Uniformity %	Uniformity Maximal Difference
mean	-1,005.026	0.722	9.847	-∞	∞	4.121
2 sigma	3.372	3.725	0.69	□	□	23.847

Export to File Close

- We want to document the measurements:
 - Print one or more individual measurements
 - Create an overview for machine XX for the year YYYY
 - Print over time the SNR for machine XX
 - Which tests have been done for machine XX
 - ...

- Every report starts at the profile
- Report generation based on templates, which are “easy” to customize with a graphical editor
- Reports can be created in several different formats:
 - Direct printing
 - Export to PDF, HTML, RTF, ...

JasperViewer [Icons] 55.71%

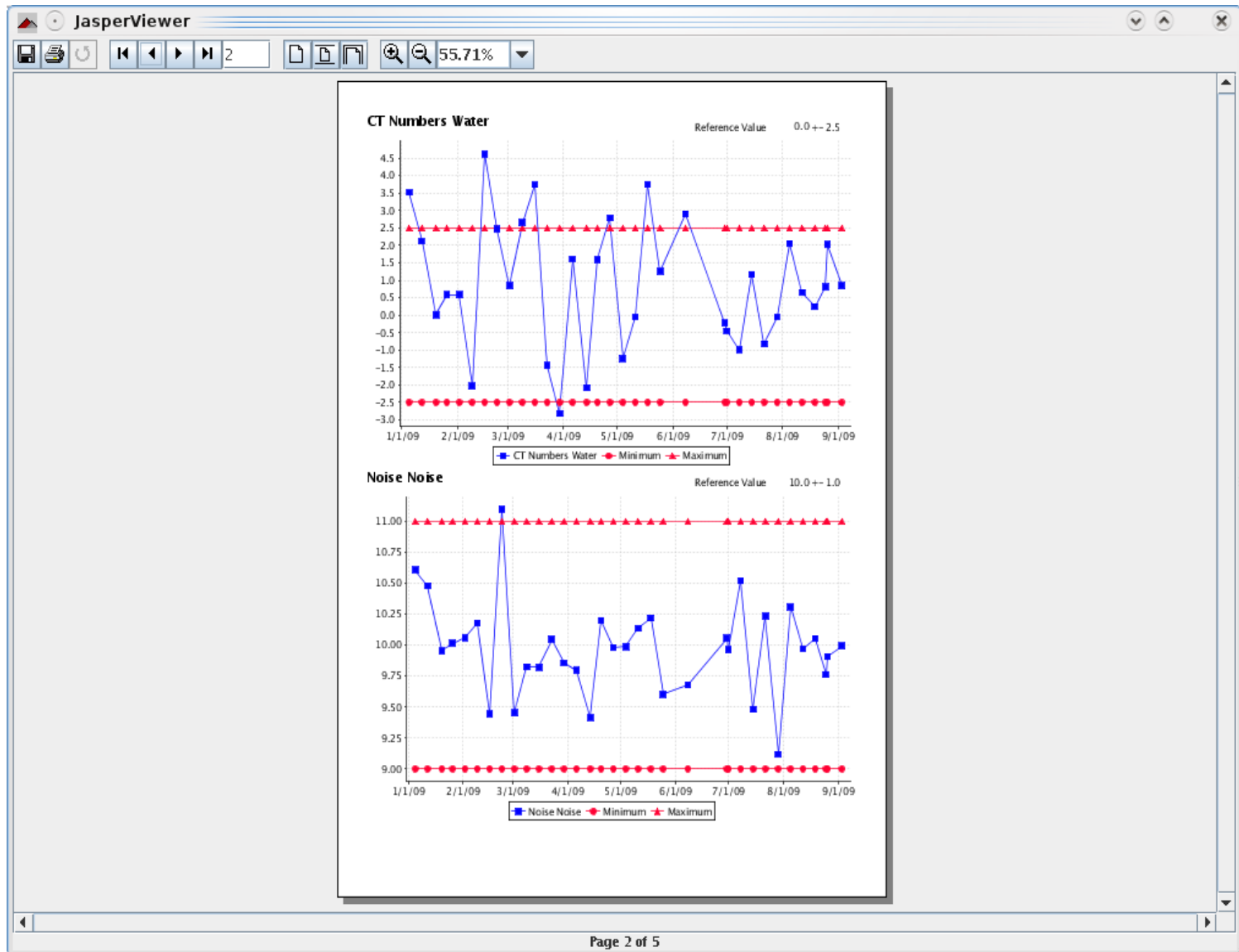
Contrôle de Constance d'après CT Level A anonymous Thu Feb 17 13:26:25

Identification:	Rapport de mesure : CT 100KV Standard GE
Institution: anonymous	Appareil: CT99_OC0
Adresse: 29, Avenue John F. Kennedy L-1855 Luxembourg - Kirchberg	Constructeur: GE MEDICAL SYSTEMS
Téléphone: 00352 42 59 91 250	Modèle: LightSpeed Pro 16
Téléfax: 00352 42 59 91 250	Conditions: Current: 400,0
Supplément: This is a default	Device Serial: Institution Name: Centre Hospitalier de Luxembourg Kernel: STANDARD
	Fantôme utilisé: Standard GE Phantom
	Version de Optimage: 1.7.3

Paramètre	Valeur	Référence	Tolérance	Stat.
CT Numbers				
Water	1.96 HU	0.0 HU	±10.0 HU	✓
Air	-1,001.38 HU	-1000.0 HU	±20.0 HU	✓
Uniformity				
Center Region	1.08 HU	0.0 HU	±10.0 HU	✓
North Region	1.39 HU	0.0 HU	±10.0 HU	✓
South Region	0.63 HU	0.0 HU	±10.0 HU	✓
West Region	1.02 HU	0.0 HU	±10.0 HU	✓
East Region	1.31 HU	0.0 HU	±10.0 HU	✓
Maximal Difference	0.45 HU	0.0 HU	±4.0 HU	✓
Noise				
Noise	5.20 HU	0.0 HU	±10.0 HU	✓
Relative Values				
Uniformity %	-0.02 %	0.0 %	±1.5 %	✓
Noise %	-0.27 %	0.0 %	±1.5 %	✓

Commentaire:	En conclusion:
	The Test was SUCCESSFUL

Page 1 of 1



- It was complex to implement the image processing methods (different phantoms, different manufactures,...)
- It is important to have enough test images during the implementation!
- Tests have to be performed in the same way.
- It provides a tool for a better evaluation and documentation of quality control measurements
- It calculates objective results
- We assume, that the evaluation with Optimage is more efficient and time saving as manual reading.
- Future: More tests, improved usability

Thank you for your attention

The software is available at the project homepage:

<http://santec.tudor.lu/project/optimage/>

With the support of the MCSR Luxembourg