PUBLIC RESEARCH CENTRE HENRI TUDOR

PerMoS: Automated data collection from PACS based on DICOM

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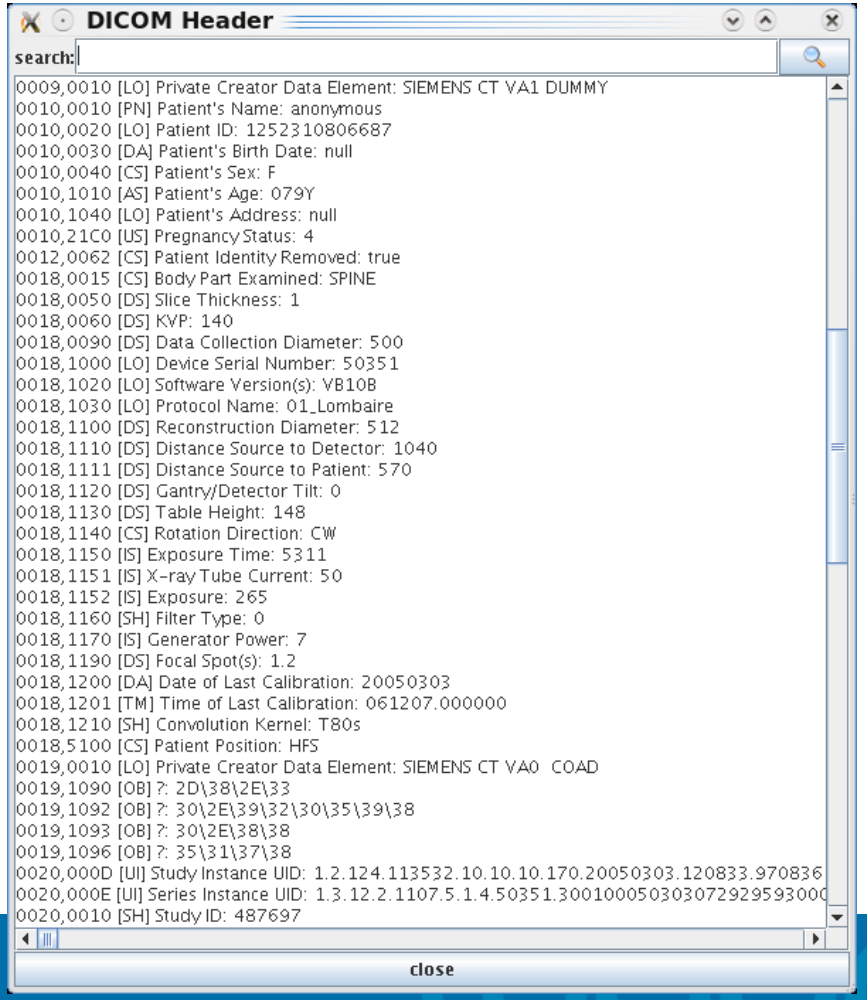
Agenda

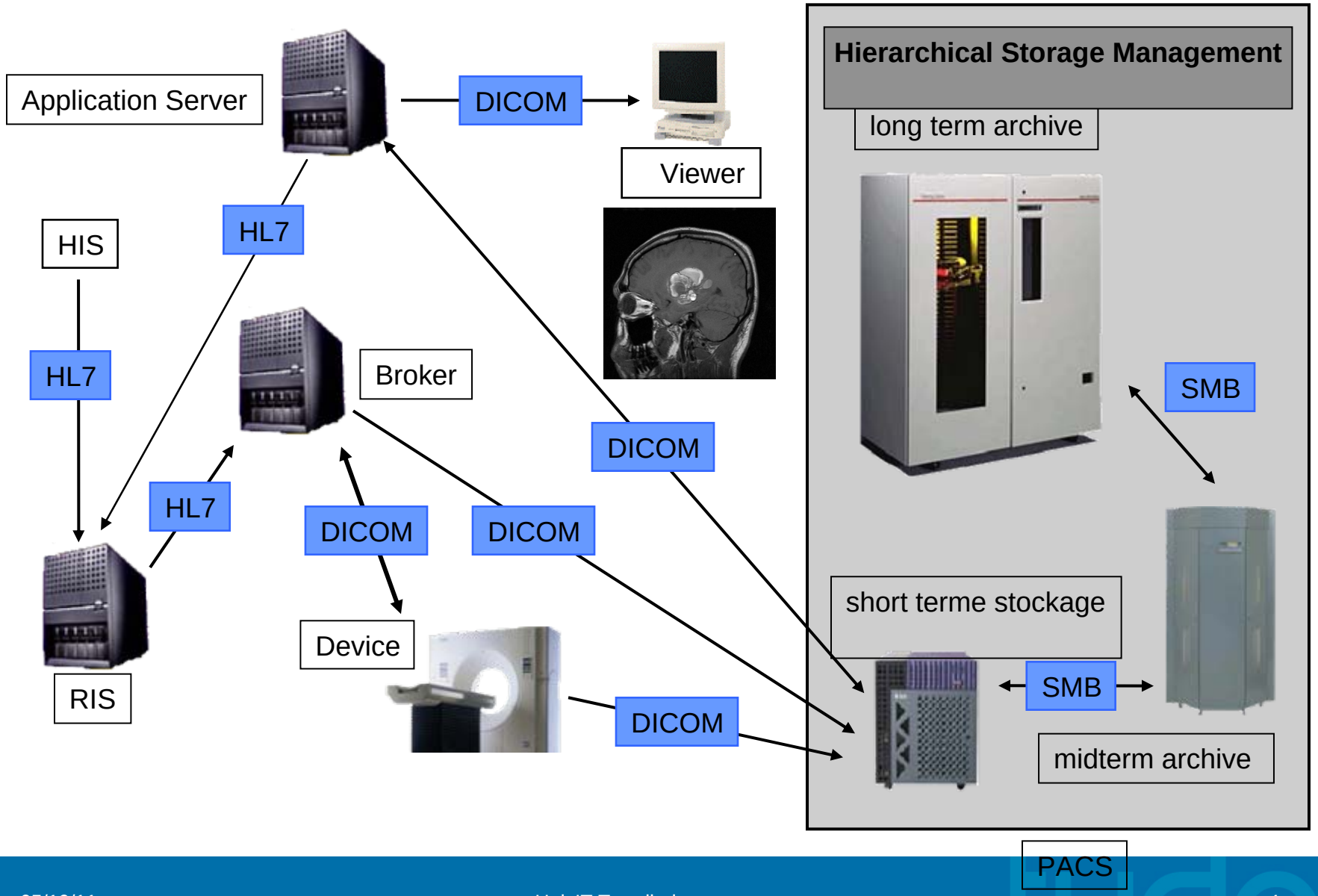
1. Introduction
2. Performance and Monitoring Server for Medical Data (PerMoS) - an Overview
3. PerMoS Data Collector
4. Security
5. PerMoS Data Manager
6. Dosimetry and other evaluations
7. PerMoS and EPICT: Initial Experiences

1. Introduction: What is DICOM?

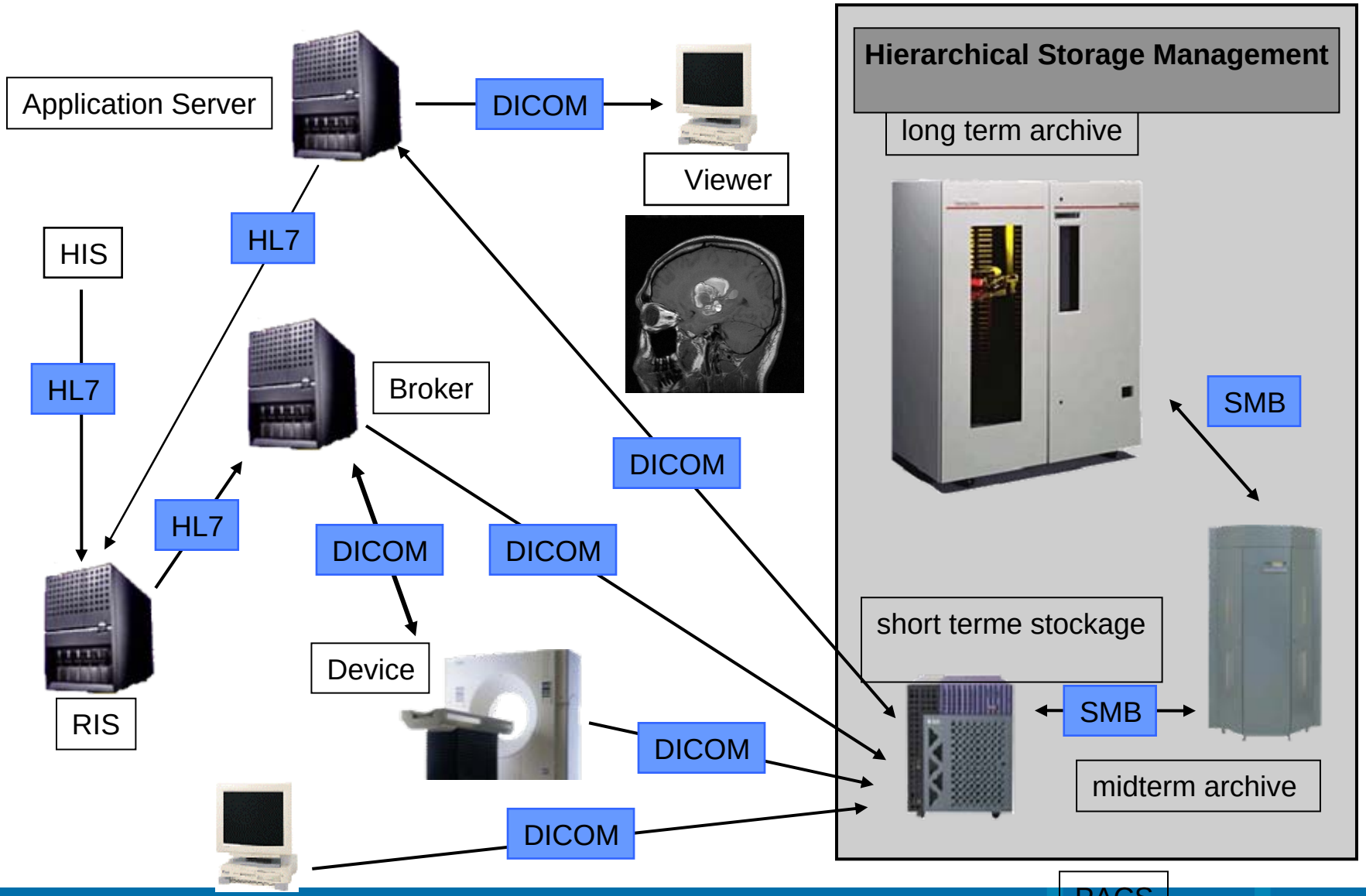
- DICOM images consist of image- and meta-data (header).
- Header contains various information:
  - Examined Patient
  - Medical Treatment
  - Used Modality
- **Technical parameters of scanner used to calculate CT dose values**.
- Objective: Support of national dose studies



1. Introduction: RIS/PACS Communication



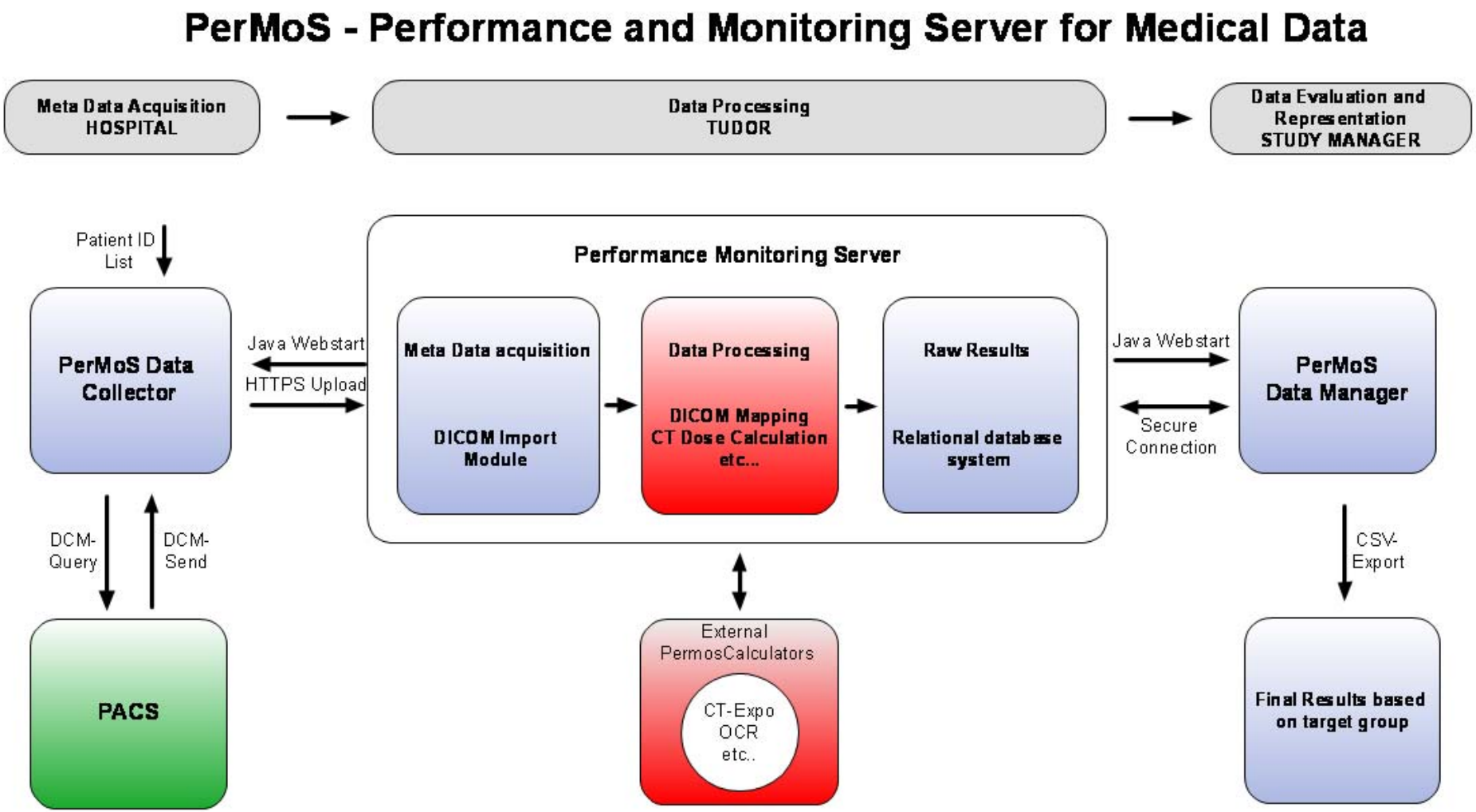
1. Introduction: RIS/PACS Communication



2. PerMoS Overview

- Software framework for acquisition and evaluation of DICOM meta-data.
- Generic way to access DICOM meta-data from hospital systems.
- Developed for in-house and multi-center studies.
- (Developed for live monitoring in the clinical environment)
- Supports multi-user and multi-studies.
- Pluggable applications for specific use cases.
- Access to result data via dedicated interface or data mining tools.

2. PerMoS: Technical Infrastructure



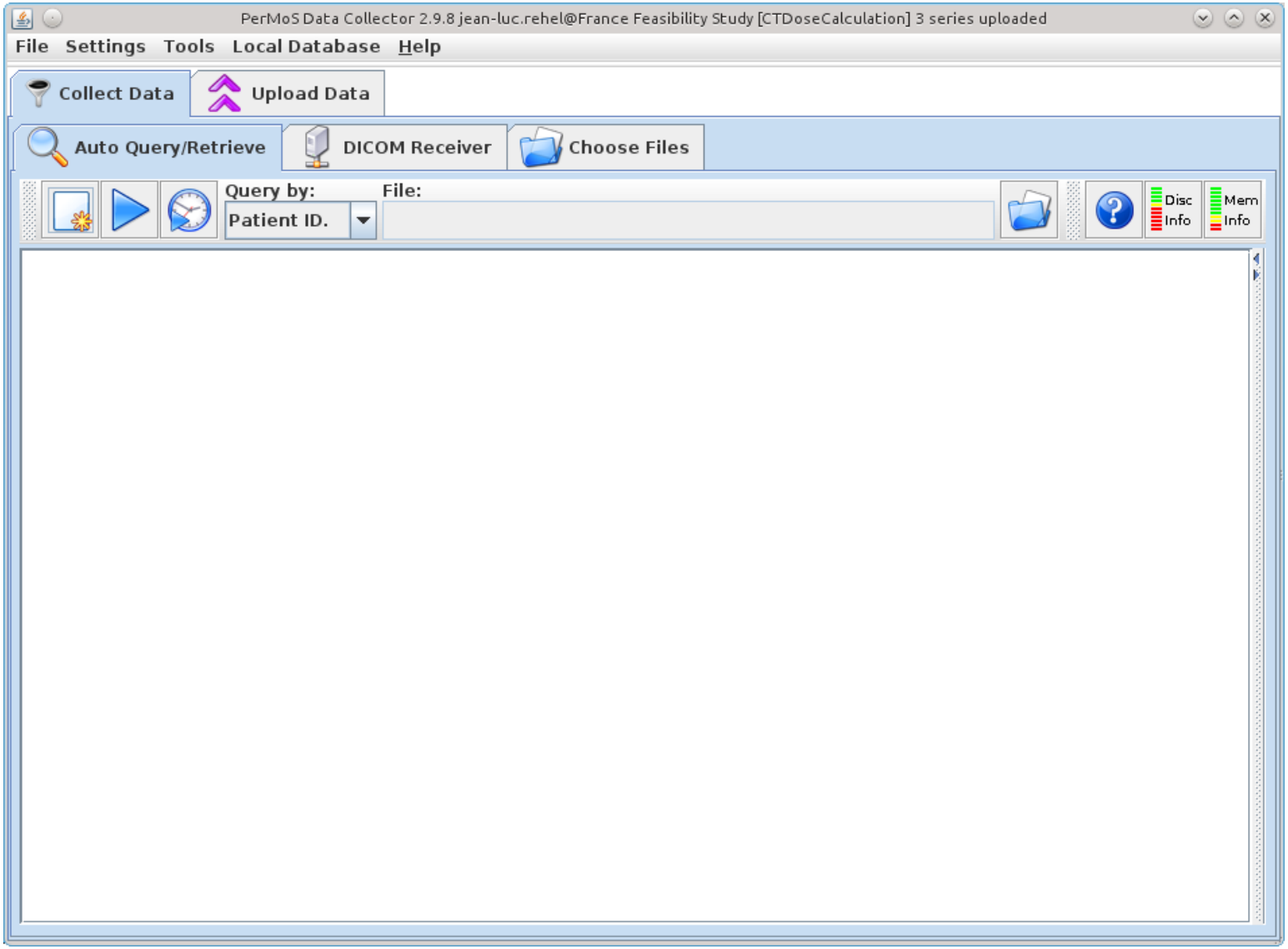
2. PerMoS: Data Processing

- Header-data is retrieved from the database, processed and written to application specific output tables.
- Vendor specific DICOM implementations are taken into account using a mapping and unit conversation table.
- Applications are implemented in Java / Java Script but may although run/control external software.
- PerMoS Data Manager:
  - to validate, control and complete the uploaded data.
  - To access and download data

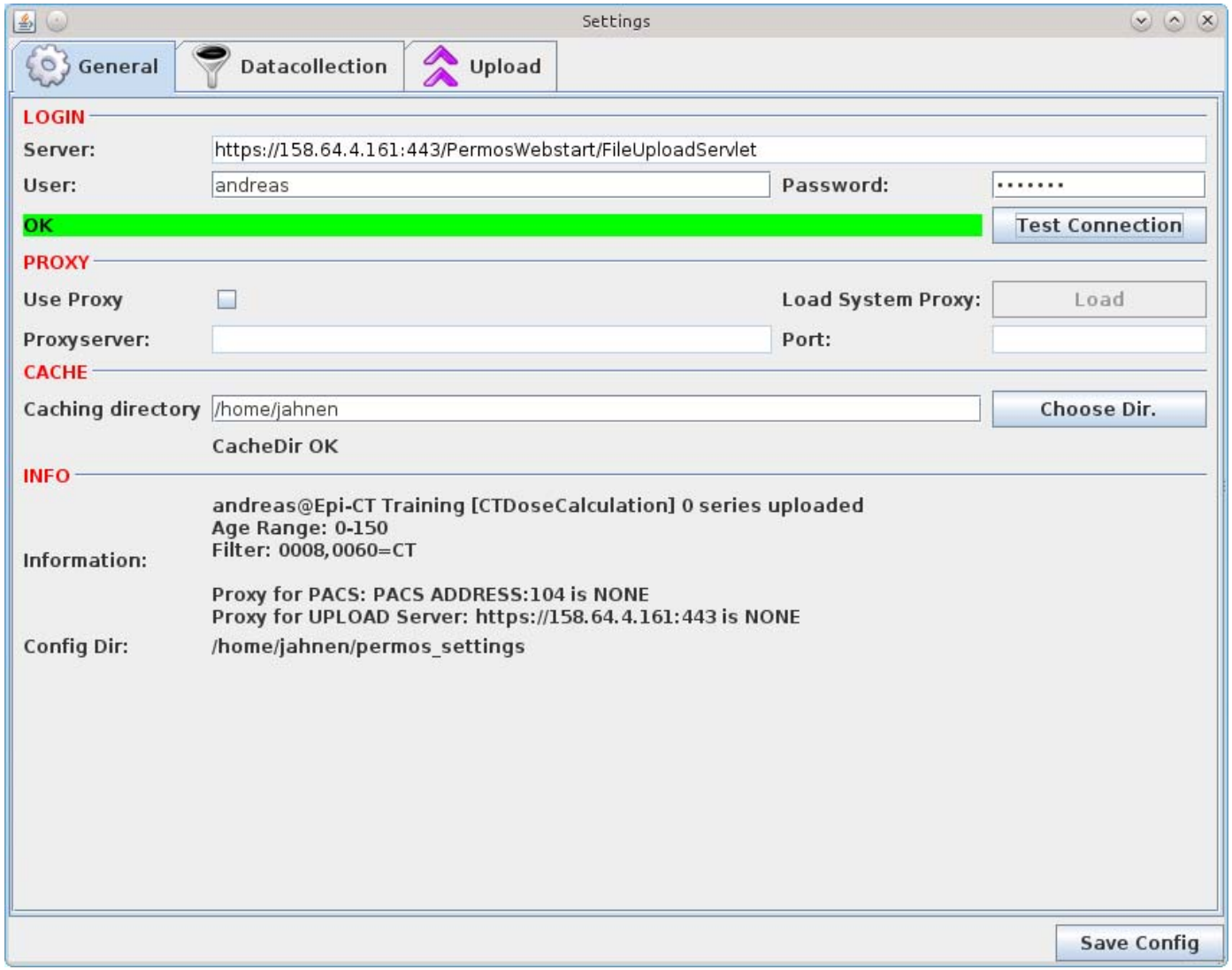
3. PerMoS Data Collector: technical requirements

- **PerMoS Data Collector**
  - Computer with Java 1.6 installed
  - Internet access to download and Update the software (Java WebStart) .
  - For data collection:
    - DICOM connectivity to the PACS
    - 5 Gbyte Hard disk space for 1000 patients
  - For data upload to the database:
    - Internet connection (https); in the moment: no proxy support

3. PerMoS Data Collector: Query Retrieve

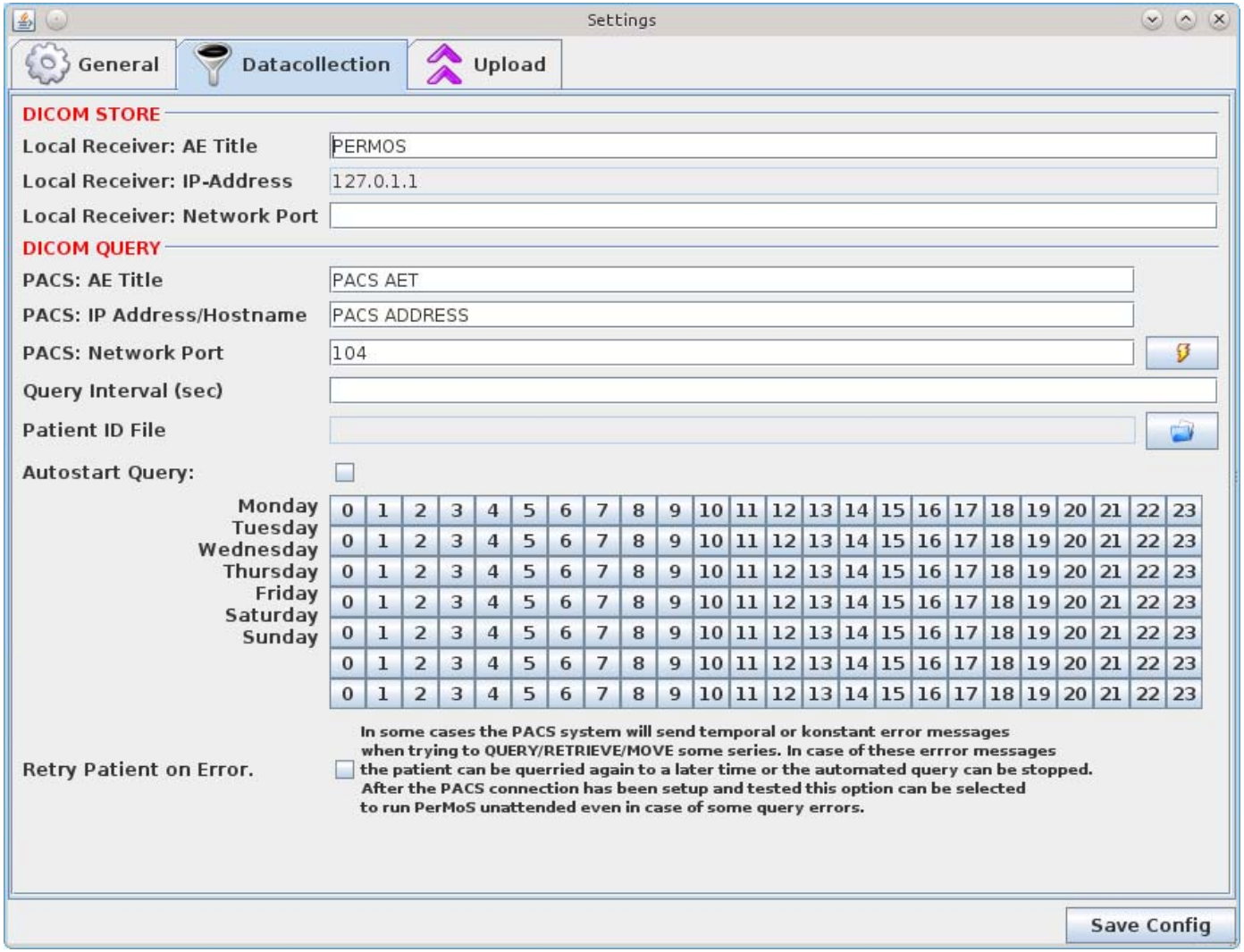


3. PerMoS Data Collector: Configuration



Configuration in collaboration with the hospital staff (RIS/PACS administrators)

3. PerMoS Data Collector: Configuration



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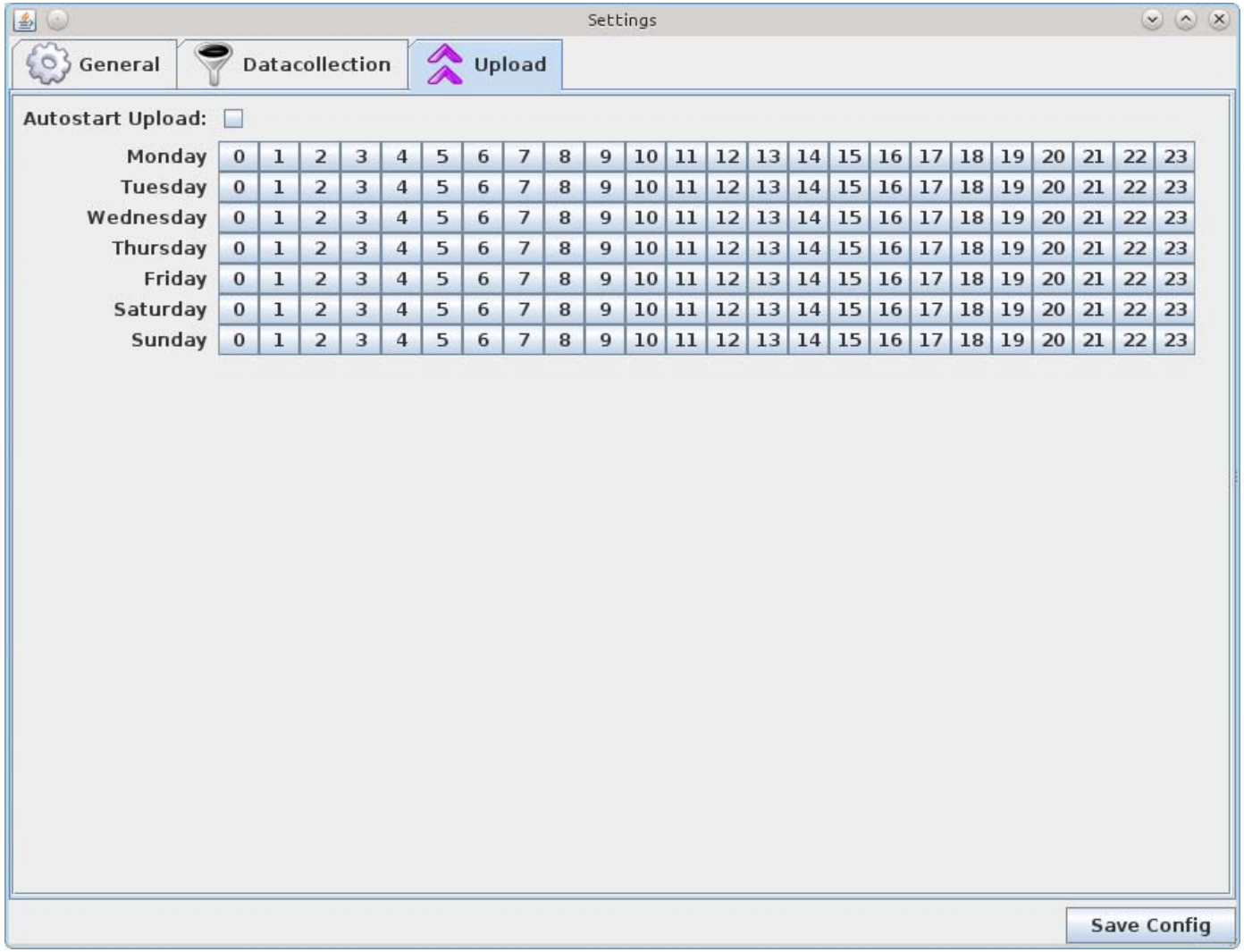
3. PerMoS Data Collector: Configuration



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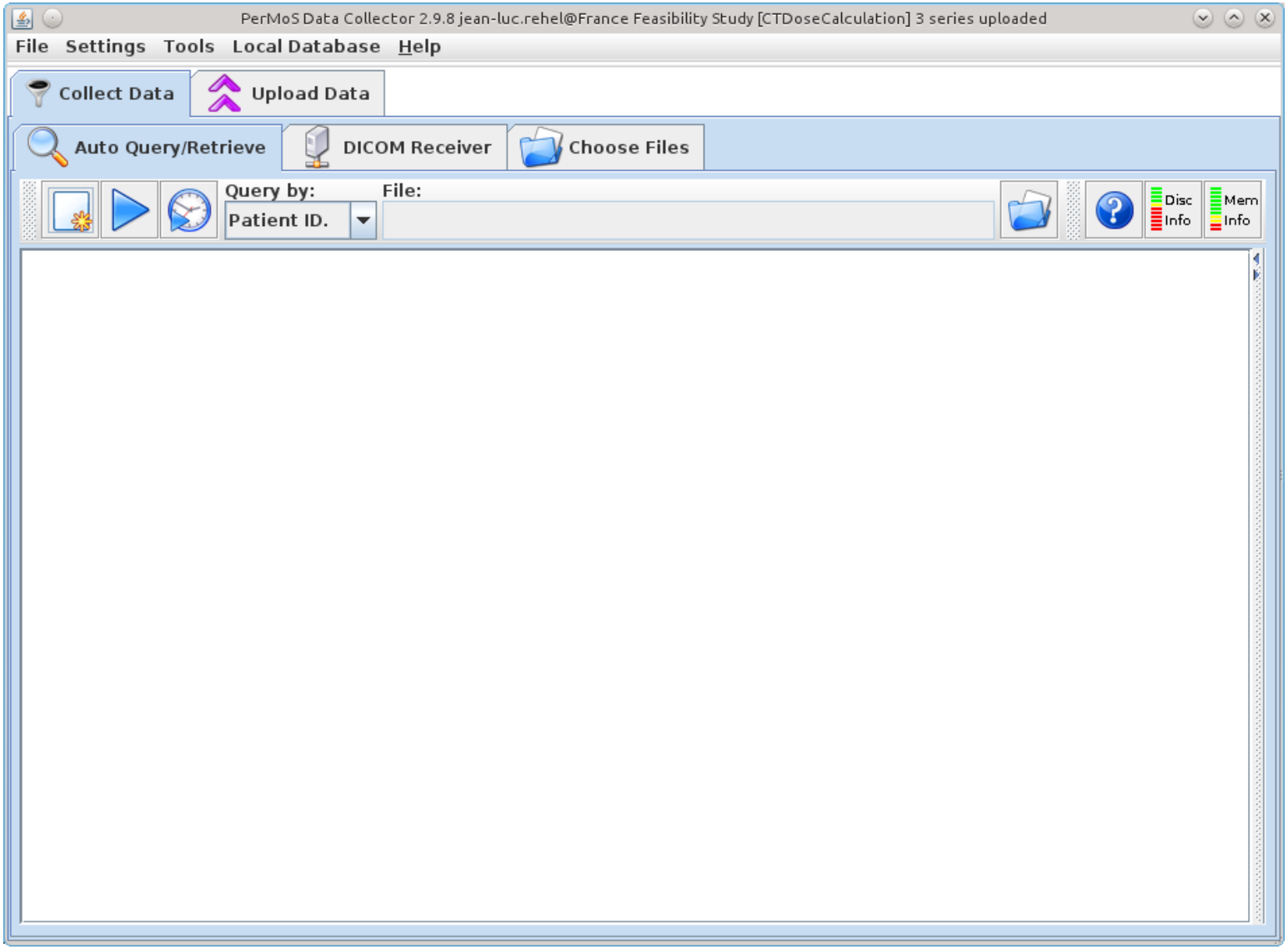
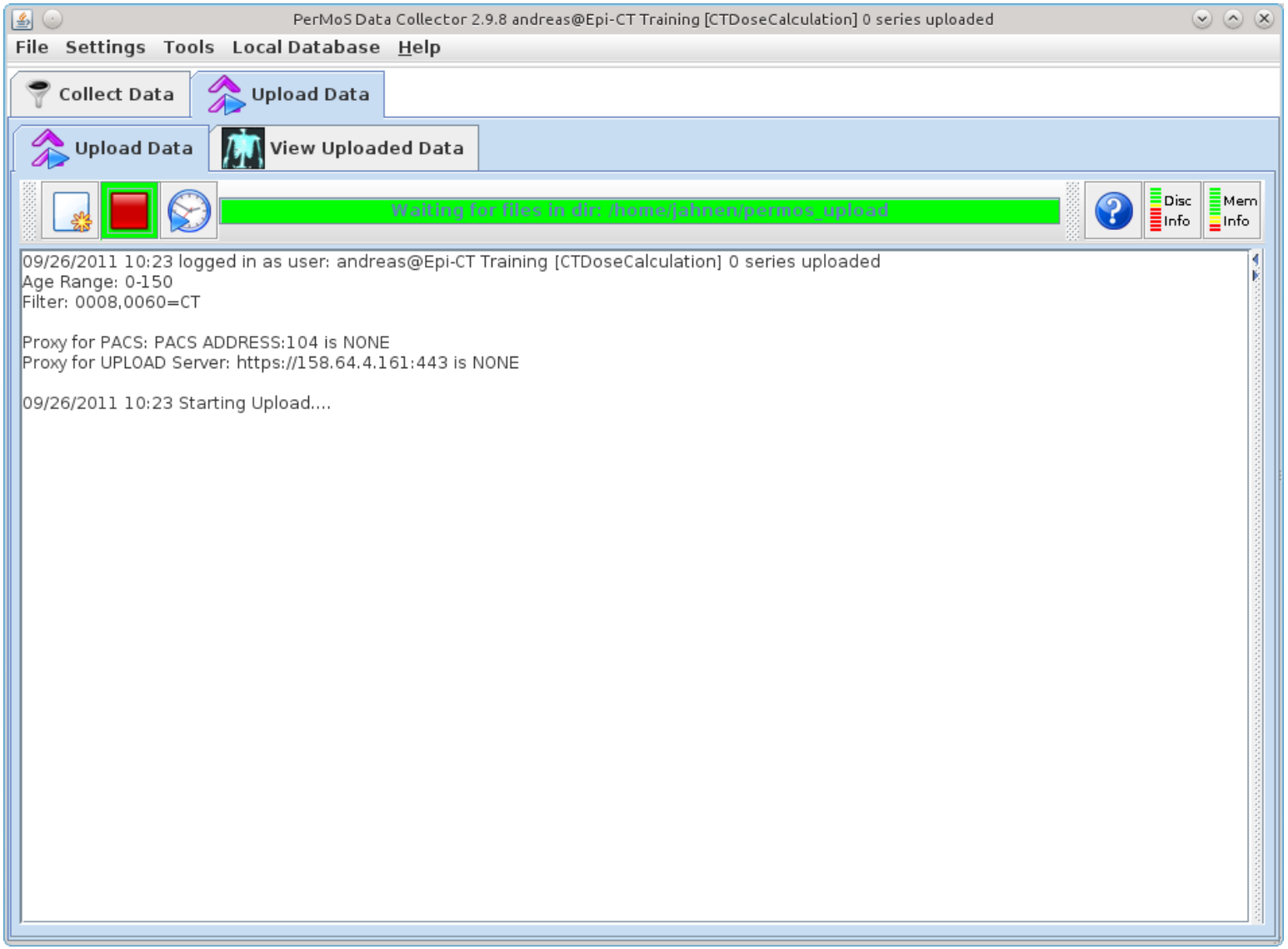
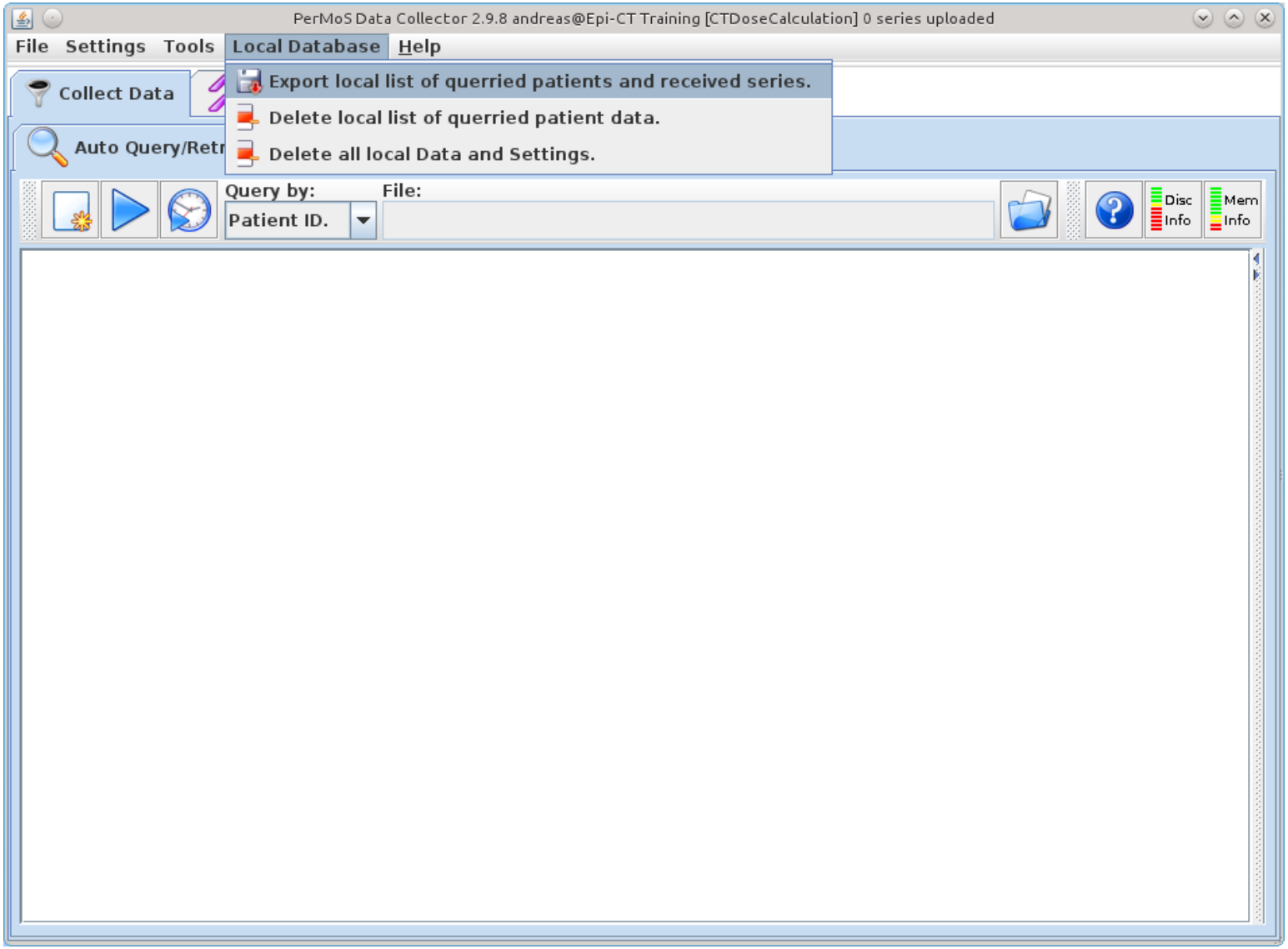
3. PerMoS Data Collector: Query Retrieve



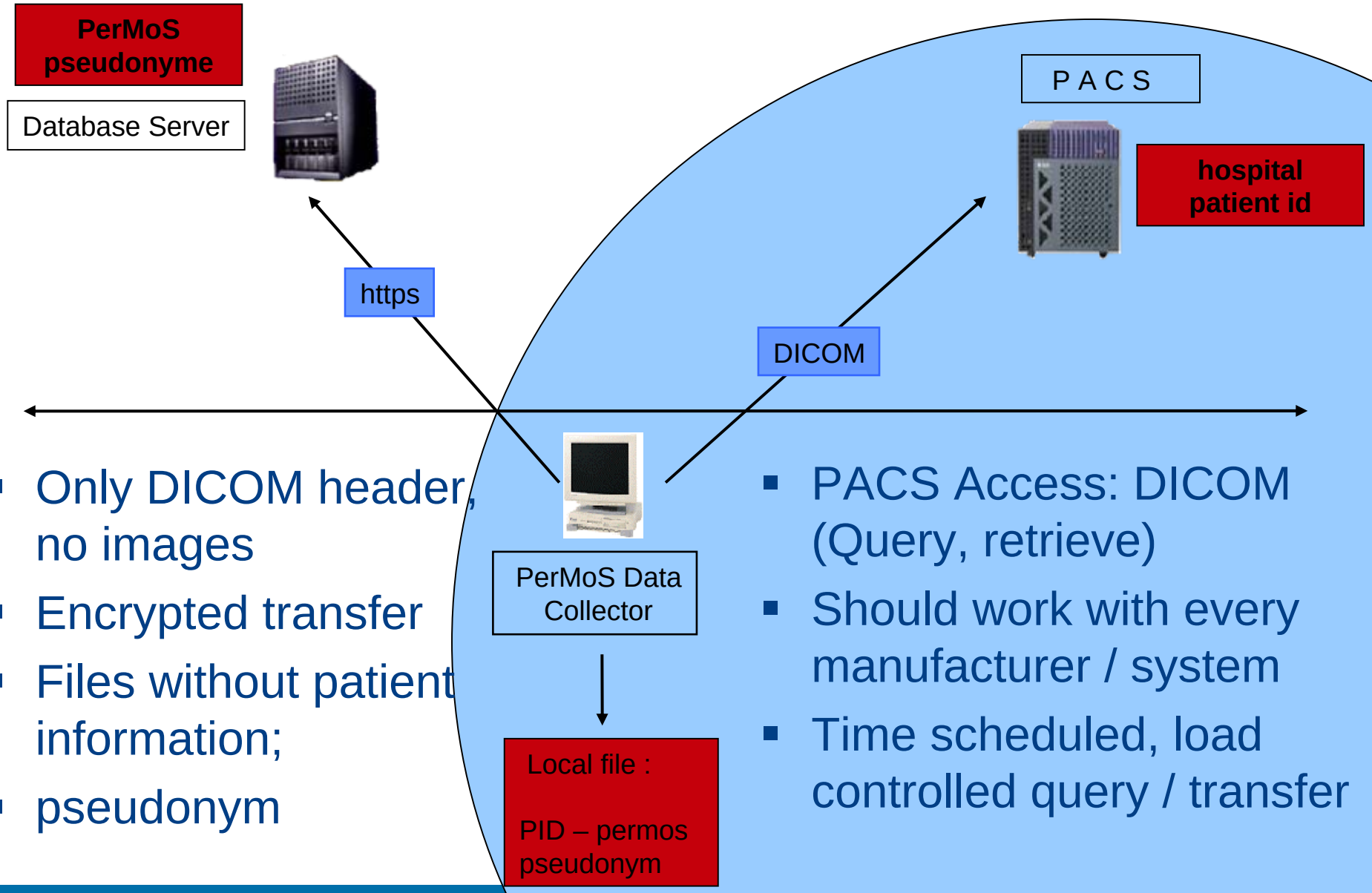
3. PerMoS Data Collector: Upload



3. PerMoS Data Collector: Export of patients



4. PerMoS: Security



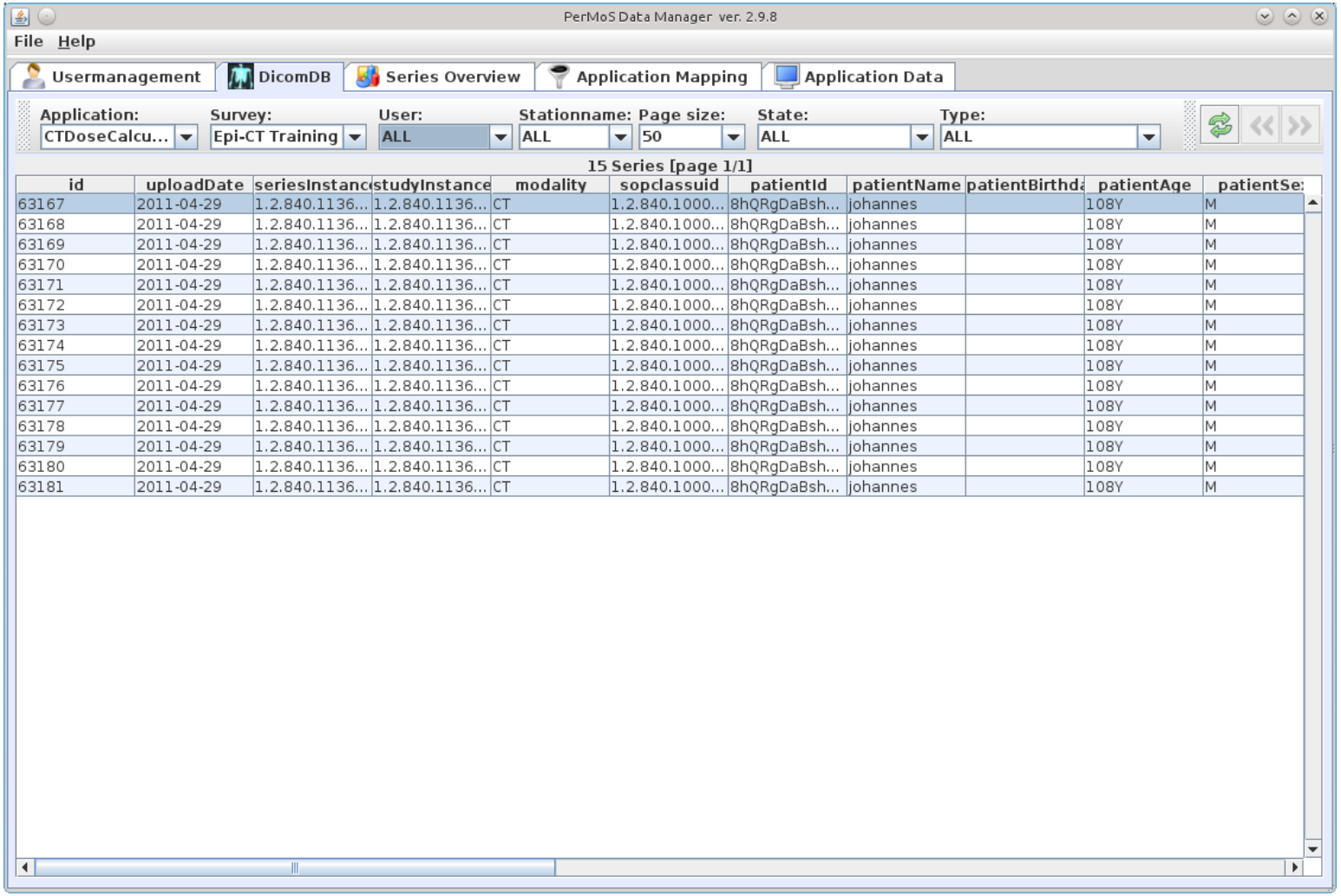
- Only DICOM header, no images
- Encrypted transfer
- Files without patient information;
- pseudonym

- PACS Access: DICOM (Query, retrieve)
- Should work with every manufacturer / system
- Time scheduled, load controlled query / transfer

5. PerMoS Data Manager: technical requirements

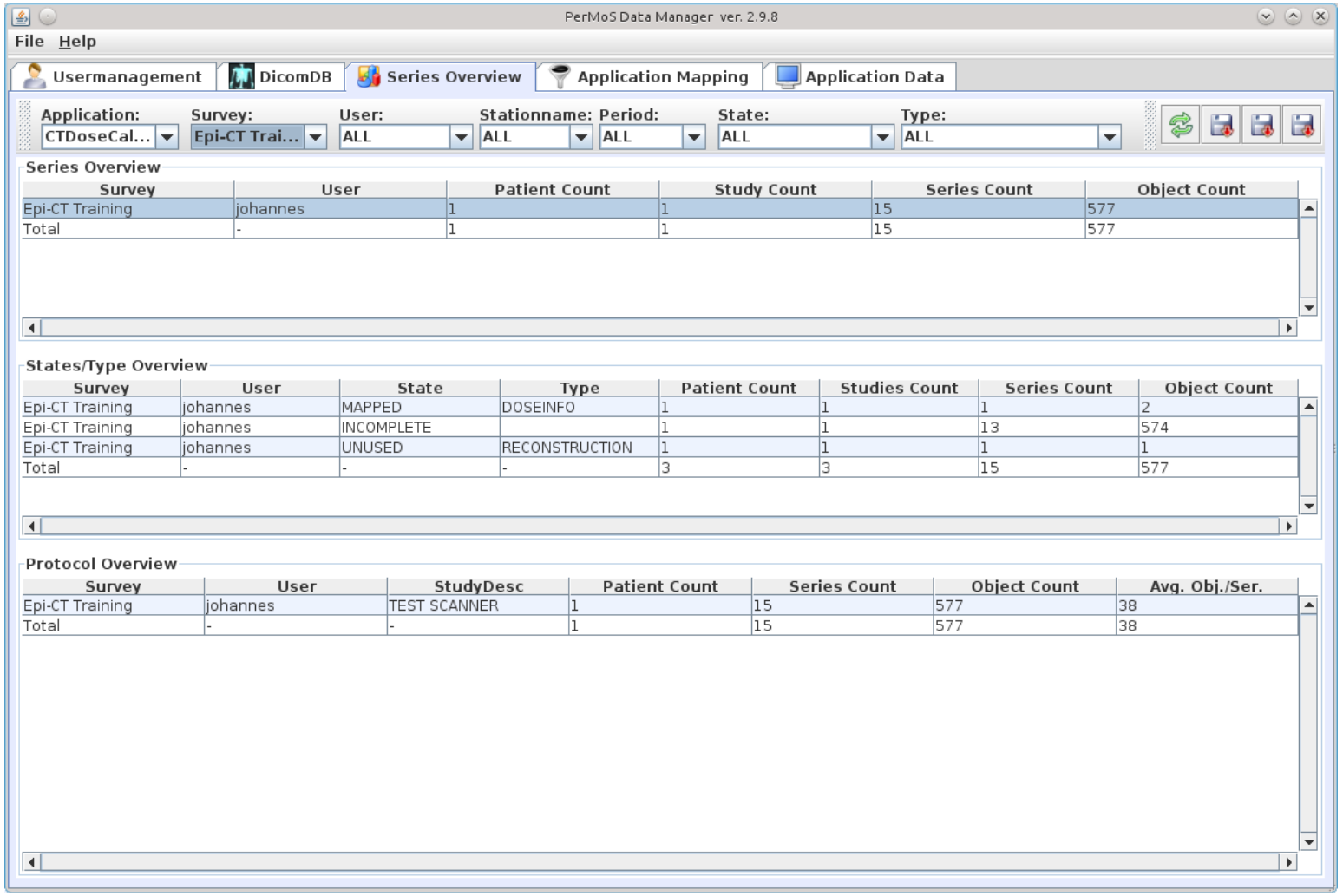
- **PerMoS Data Manager**
  - Computer with Java 1.6 installed
  - Internet access to download, update the software (Java WebStart).
  - Internet access to run the software:
    - 80 (http),
    - 443 (https) and
    - 3873 (jboss-ejb3).
  - The PerMoS Data Manager does not support a proxy configuration currently. The proxy settings will be available in one of the next versions.

5. PerMoS Data Manager: Uploaded Data

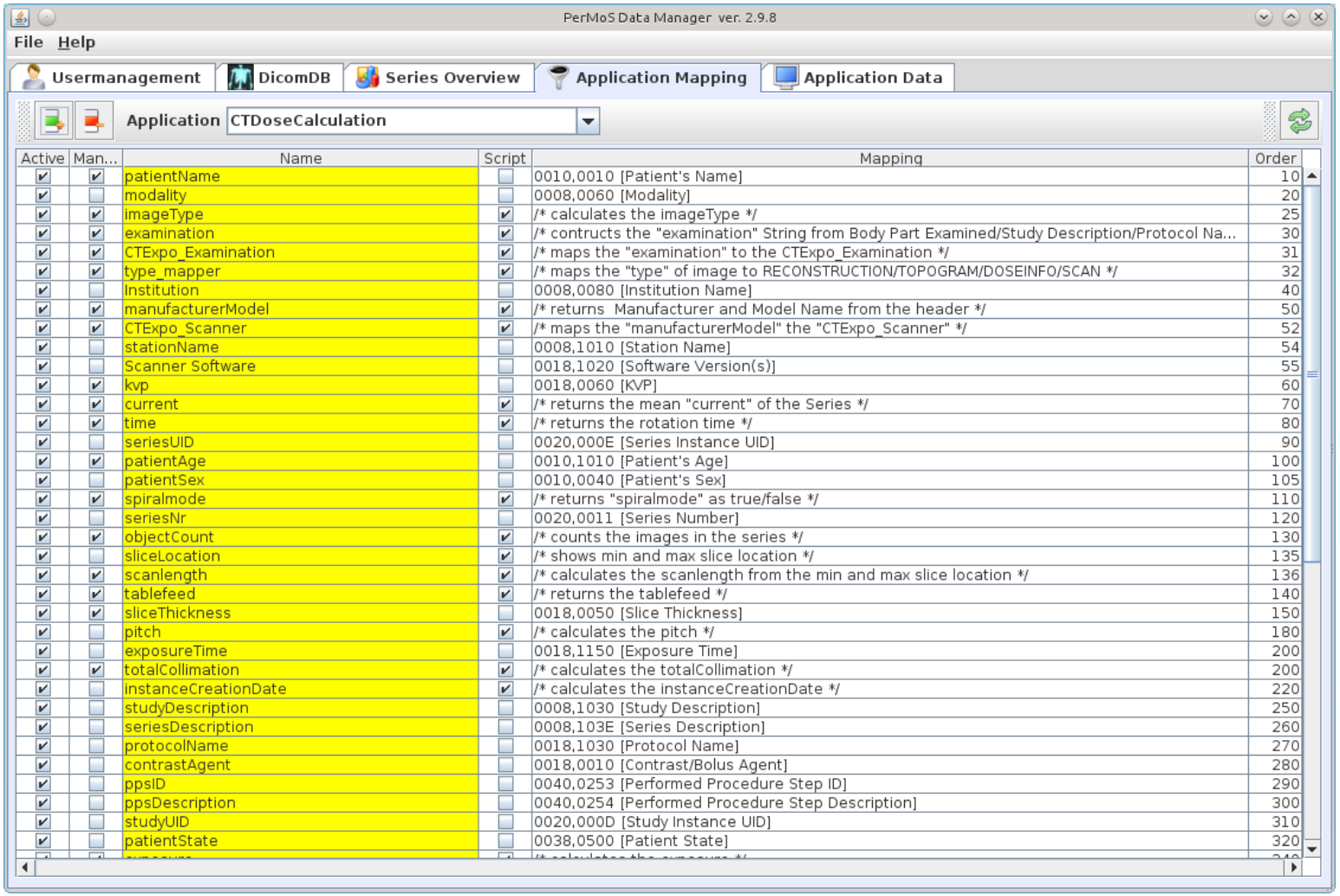


id	uploadDate	seriesInstanc	studyInstance	modality	sopclassuid	patientId	patientName	patientBirthda	patientAge	patientSe:
63167	2011-04-29	1.2.840.1136...	1.2.840.1136...	CT	1.2.840.1000...	8hQRgDaBsh...	johannes		108Y	M
63168	2011-04-29	1.2.840.1136...	1.2.840.1136...	CT	1.2.840.1000...	8hQRgDaBsh...	johannes		108Y	M
63169	2011-04-29	1.2.840.1136...	1.2.840.1136...	CT	1.2.840.1000...	8hQRgDaBsh...	johannes		108Y	M
63170	2011-04-29	1.2.840.1136...	1.2.840.1136...	CT	1.2.840.1000...	8hQRgDaBsh...	johannes		108Y	M
63171	2011-04-29	1.2.840.1136...	1.2.840.1136...	CT	1.2.840.1000...	8hQRgDaBsh...	johannes		108Y	M
63172	2011-04-29	1.2.840.1136...	1.2.840.1136...	CT	1.2.840.1000...	8hQRgDaBsh...	johannes		108Y	M
63173	2011-04-29	1.2.840.1136...	1.2.840.1136...	CT	1.2.840.1000...	8hQRgDaBsh...	johannes		108Y	M
63174	2011-04-29	1.2.840.1136...	1.2.840.1136...	CT	1.2.840.1000...	8hQRgDaBsh...	johannes		108Y	M
63175	2011-04-29	1.2.840.1136...	1.2.840.1136...	CT	1.2.840.1000...	8hQRgDaBsh...	johannes		108Y	M
63176	2011-04-29	1.2.840.1136...	1.2.840.1136...	CT	1.2.840.1000...	8hQRgDaBsh...	johannes		108Y	M
63177	2011-04-29	1.2.840.1136...	1.2.840.1136...	CT	1.2.840.1000...	8hQRgDaBsh...	johannes		108Y	M
63178	2011-04-29	1.2.840.1136...	1.2.840.1136...	CT	1.2.840.1000...	8hQRgDaBsh...	johannes		108Y	M
63179	2011-04-29	1.2.840.1136...	1.2.840.1136...	CT	1.2.840.1000...	8hQRgDaBsh...	johannes		108Y	M
63180	2011-04-29	1.2.840.1136...	1.2.840.1136...	CT	1.2.840.1000...	8hQRgDaBsh...	johannes		108Y	M
63181	2011-04-29	1.2.840.1136...	1.2.840.1136...	CT	1.2.840.1000...	8hQRgDaBsh...	johannes		108Y	M

5. PerMoS Data Manager: Study Overview

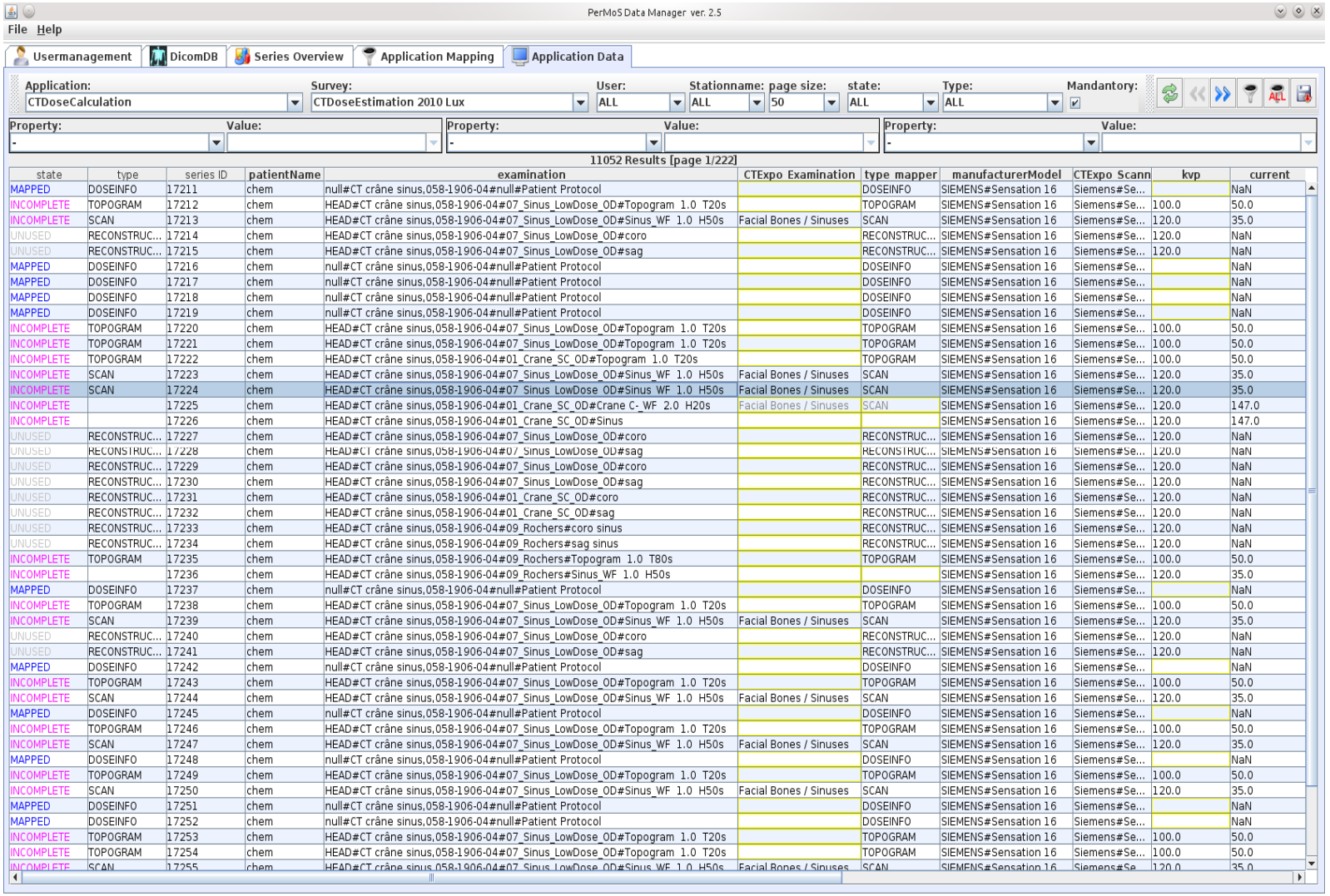


5. PerMoS Data Manager: Application Mapping



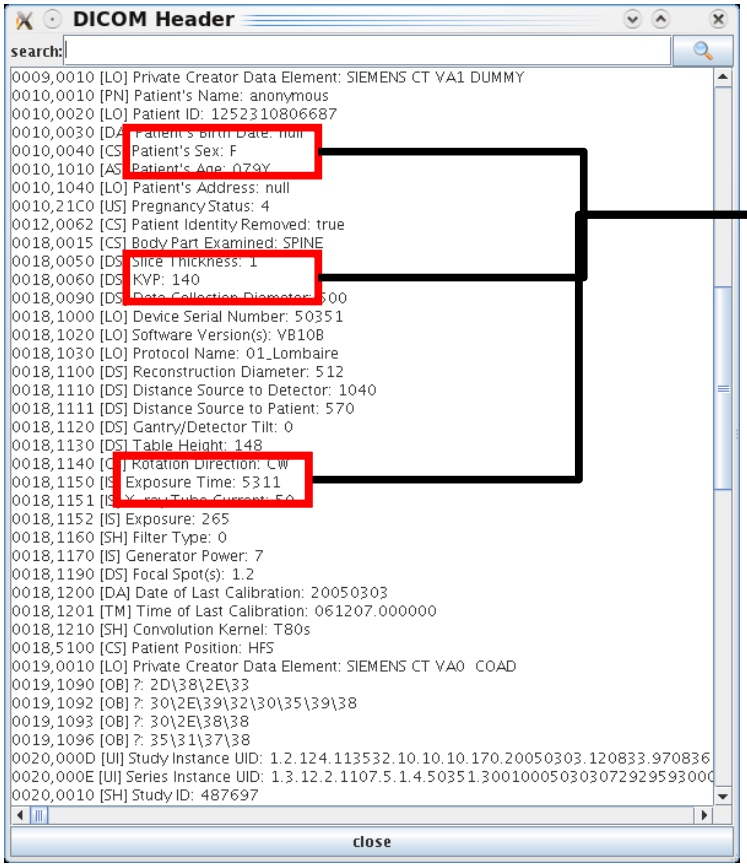
Active	Man...	Name	Script	Mapping	Order
☑	☑	patientName	☐	0010,0010 [Patient's Name]	10
☑	☐	modality	☐	0008,0060 [Modality]	20
☑	☑	imageType	☑	/* calculates the imageType */	25
☑	☑	examination	☑	/* contructs the "examination" String from Body Part Examined/Study Description/Protocol Na...	30
☑	☑	CTExpo_Examination	☑	/* maps the "examination" to the CTExpo_Examination */	31
☑	☑	type_mapper	☑	/* maps the "type" of image to RECONSTRUCTION/TOPOGRAM/DOSEINFO/SCAN */	32
☑	☐	institution	☐	0008,0080 [Institution Name]	40
☑	☑	manufacturerModel	☑	/* returns Manufacturer and Model Name from the header */	50
☑	☑	CTExpo_Scanner	☑	/* maps the "manufacturerModel" the "CTExpo_Scanner" */	52
☑	☐	stationName	☐	0008,1010 [Station Name]	54
☑	☐	Scanner Software	☐	0018,1020 [Software Version(s)]	55
☑	☑	kvp	☐	0018,0060 [KVP]	60
☑	☑	current	☑	/* returns the mean "current" of the Series */	70
☑	☑	time	☑	/* returns the rotation time */	80
☑	☐	seriesUID	☐	0020,000E [Series Instance UID]	90
☑	☑	patientAge	☐	0010,1010 [Patient's Age]	100
☑	☐	patientSex	☐	0010,0040 [Patient's Sex]	105
☑	☑	spiralmode	☑	/* returns "spiralmode" as true/false */	110
☑	☐	seriesNr	☐	0020,0011 [Series Number]	120
☑	☑	objectCount	☑	/* counts the images in the series */	130
☑	☐	sliceLocation	☑	/* shows min and max slice location */	135
☑	☑	scanlength	☑	/* calculates the scanlength from the min and max slice location */	136
☑	☑	tablefeed	☑	/* returns the tablefeed */	140
☑	☑	sliceThickness	☐	0018,0050 [Slice Thickness]	150
☑	☐	pitch	☑	/* calculates the pitch */	180
☑	☐	exposureTime	☐	0018,1150 [Exposure Time]	200
☑	☑	totalCollimation	☑	/* calculates the totalCollimation */	200
☑	☐	instanceCreationDate	☑	/* calculates the instanceCreationDate */	220
☑	☐	studyDescription	☐	0008,1030 [Study Description]	250
☑	☐	seriesDescription	☐	0008,103E [Series Description]	260
☑	☐	protocolName	☐	0018,1030 [Protocol Name]	270
☑	☐	contrastAgent	☐	0018,0010 [Contrast/Bolus Agent]	280
☑	☐	ppsID	☐	0040,0253 [Performed Procedure Step ID]	290
☑	☐	ppsDescription	☐	0040,0254 [Performed Procedure Step Description]	300
☑	☐	studyUID	☐	0020,000D [Study Instance UID]	310
☑	☐	patientState	☐	0038,0500 [Patient State]	320

5. PerMoS Data Manager: Data View



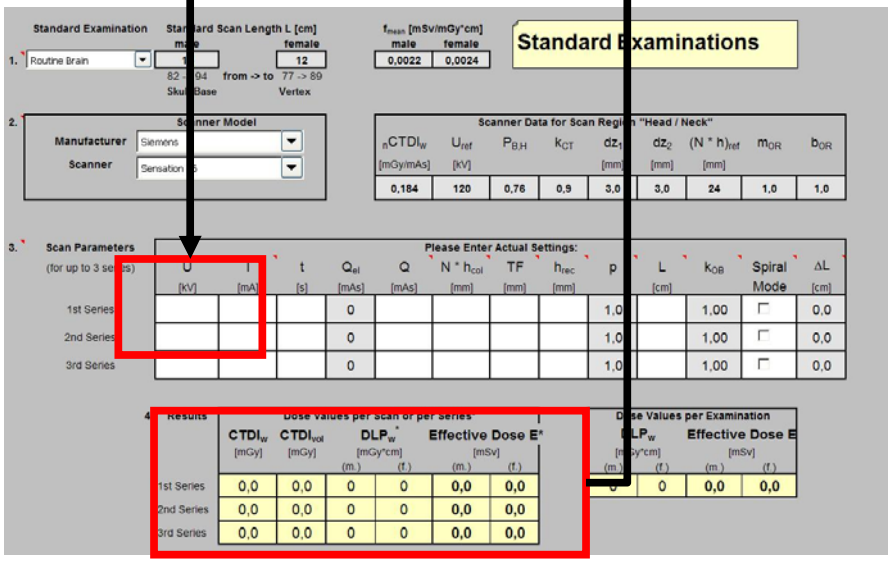
state	type	series ID	patientName	examination	CTExpo Examination	type mapper	manufacturerModel	CTExpo Scann	kvp	current
MAPPED	DOSEINFO	17211	chem	null#CT crâne sinus,058-1906-04#null#Patient Protocol		DOSEINFO	SIEMENS#Sensation 16	Siemens#Se...		NaN
INCOMPLETE	TOPOGRAM	17212	chem	HEAD#CT crâne sinus,058-1906-04#07_Sinus_LowDose_OD#Topogram 1.0 T20s		TOPOGRAM	SIEMENS#Sensation 16	Siemens#Se...	100.0	50.0
INCOMPLETE	SCAN	17213	chem	HEAD#CT crâne sinus,058-1906-04#07_Sinus_LowDose_OD#Sinus_WF 1.0 H50s	Facial Bones / Sinuses	SCAN	SIEMENS#Sensation 16	Siemens#Se...	120.0	35.0
UNUSED	RECONSTRUC...	17214	chem	HEAD#CT crâne sinus,058-1906-04#07_Sinus_LowDose_OD#coro		RECONSTRUC...	SIEMENS#Sensation 16	Siemens#Se...	120.0	NaN
UNUSED	RECONSTRUC...	17215	chem	HEAD#CT crâne sinus,058-1906-04#07_Sinus_LowDose_OD#sag		RECONSTRUC...	SIEMENS#Sensation 16	Siemens#Se...	120.0	NaN
MAPPED	DOSEINFO	17216	chem	null#CT crâne sinus,058-1906-04#null#Patient Protocol		DOSEINFO	SIEMENS#Sensation 16	Siemens#Se...		NaN
MAPPED	DOSEINFO	17217	chem	null#CT crâne sinus,058-1906-04#null#Patient Protocol		DOSEINFO	SIEMENS#Sensation 16	Siemens#Se...		NaN
MAPPED	DOSEINFO	17218	chem	null#CT crâne sinus,058-1906-04#null#Patient Protocol		DOSEINFO	SIEMENS#Sensation 16	Siemens#Se...		NaN
MAPPED	DOSEINFO	17219	chem	null#CT crâne sinus,058-1906-04#null#Patient Protocol		DOSEINFO	SIEMENS#Sensation 16	Siemens#Se...		NaN
INCOMPLETE	TOPOGRAM	17220	chem	HEAD#CT crâne sinus,058-1906-04#07_Sinus_LowDose_OD#Topogram 1.0 T20s		TOPOGRAM	SIEMENS#Sensation 16	Siemens#Se...	100.0	50.0
INCOMPLETE	TOPOGRAM	17221	chem	HEAD#CT crâne sinus,058-1906-04#07_Sinus_LowDose_OD#Topogram 1.0 T20s		TOPOGRAM	SIEMENS#Sensation 16	Siemens#Se...	100.0	50.0
INCOMPLETE	TOPOGRAM	17222	chem	HEAD#CT crâne sinus,058-1906-04#01_Crane_SC_OD#Topogram 1.0 T20s		TOPOGRAM	SIEMENS#Sensation 16	Siemens#Se...	100.0	50.0
INCOMPLETE	SCAN	17223	chem	HEAD#CT crâne sinus,058-1906-04#07_Sinus_LowDose_OD#Sinus_WF 1.0 H50s	Facial Bones / Sinuses	SCAN	SIEMENS#Sensation 16	Siemens#Se...	120.0	35.0
INCOMPLETE	SCAN	17224	chem	HEAD#CT crâne sinus,058-1906-04#07_Sinus_LowDose_OD#Sinus_WF 1.0 H50s	Facial Bones / Sinuses	SCAN	SIEMENS#Sensation 16	Siemens#Se...	120.0	35.0
INCOMPLETE		17225	chem	HEAD#CT crâne sinus,058-1906-04#01_Crane_SC_OD#Crane C-_WF 2.0 H20s	Facial Bones / Sinuses	SCAN	SIEMENS#Sensation 16	Siemens#Se...	120.0	147.0
INCOMPLETE		17226	chem	HEAD#CT crâne sinus,058-1906-04#01_Crane_SC_OD#Sinus			SIEMENS#Sensation 16	Siemens#Se...	120.0	147.0
UNUSED	RECONSTRUC...	17227	chem	HEAD#CT crâne sinus,058-1906-04#07_Sinus_LowDose_OD#coro		RECONSTRUC...	SIEMENS#Sensation 16	Siemens#Se...	120.0	NaN
UNUSED	RECONSTRUC...	17228	chem	HEAD#CT crâne sinus,058-1906-04#07_Sinus_LowDose_OD#sag		RECONSTRUC...	SIEMENS#Sensation 16	Siemens#Se...	120.0	NaN
UNUSED	RECONSTRUC...	17229	chem	HEAD#CT crâne sinus,058-1906-04#07_Sinus_LowDose_OD#coro		RECONSTRUC...	SIEMENS#Sensation 16	Siemens#Se...	120.0	NaN
UNUSED	RECONSTRUC...	17230	chem	HEAD#CT crâne sinus,058-1906-04#07_Sinus_LowDose_OD#sag		RECONSTRUC...	SIEMENS#Sensation 16	Siemens#Se...	120.0	NaN
UNUSED	RECONSTRUC...	17231	chem	HEAD#CT crâne sinus,058-1906-04#01_Crane_SC_OD#coro		RECONSTRUC...	SIEMENS#Sensation 16	Siemens#Se...	120.0	NaN
UNUSED	RECONSTRUC...	17232	chem	HEAD#CT crâne sinus,058-1906-04#01_Crane_SC_OD#sag		RECONSTRUC...	SIEMENS#Sensation 16	Siemens#Se...	120.0	NaN
UNUSED	RECONSTRUC...	17233	chem	HEAD#CT crâne sinus,058-1906-04#09_Rochers#coro sinus		RECONSTRUC...	SIEMENS#Sensation 16	Siemens#Se...	120.0	NaN
UNUSED	RECONSTRUC...	17234	chem	HEAD#CT crâne sinus,058-1906-04#09_Rochers#sag sinus		RECONSTRUC...	SIEMENS#Sensation 16	Siemens#Se...	120.0	NaN
INCOMPLETE	TOPOGRAM	17235	chem	HEAD#CT crâne sinus,058-1906-04#09_Rochers#Topogram 1.0 T80s		TOPOGRAM	SIEMENS#Sensation 16	Siemens#Se...	100.0	50.0
INCOMPLETE		17236	chem	HEAD#CT crâne sinus,058-1906-04#09_Rochers#Sinus_WF 1.0 H50s			SIEMENS#Sensation 16	Siemens#Se...	120.0	35.0
MAPPED	DOSEINFO	17237	chem	null#CT crâne sinus,058-1906-04#null#Patient Protocol		DOSEINFO	SIEMENS#Sensation 16	Siemens#Se...		NaN
INCOMPLETE	TOPOGRAM	17238	chem	HEAD#CT crâne sinus,058-1906-04#07_Sinus_LowDose_OD#Topogram 1.0 T20s		TOPOGRAM	SIEMENS#Sensation 16	Siemens#Se...	100.0	50.0
INCOMPLETE	SCAN	17239	chem	HEAD#CT crâne sinus,058-1906-04#07_Sinus_LowDose_OD#Sinus_WF 1.0 H50s	Facial Bones / Sinuses	SCAN	SIEMENS#Sensation 16	Siemens#Se...	120.0	35.0
UNUSED	RECONSTRUC...	17240	chem	HEAD#CT crâne sinus,058-1906-04#07_Sinus_LowDose_OD#coro		RECONSTRUC...	SIEMENS#Sensation 16	Siemens#Se...	120.0	NaN
UNUSED	RECONSTRUC...	17241	chem	HEAD#CT crâne sinus,058-1906-04#07_Sinus_LowDose_OD#sag		RECONSTRUC...	SIEMENS#Sensation 16	Siemens#Se...	120.0	NaN
MAPPED	DOSEINFO	17242	chem	null#CT crâne sinus,058-1906-04#null#Patient Protocol		DOSEINFO	SIEMENS#Sensation 16	Siemens#Se...		NaN
INCOMPLETE	TOPOGRAM	17243	chem	HEAD#CT crâne sinus,058-1906-04#07_Sinus_LowDose_OD#Topogram 1.0 T20s		TOPOGRAM	SIEMENS#Sensation 16	Siemens#Se...	100.0	50.0
INCOMPLETE	SCAN	17244	chem	HEAD#CT crâne sinus,058-1906-04#07_Sinus_LowDose_OD#Sinus_WF 1.0 H50s	Facial Bones / Sinuses	SCAN	SIEMENS#Sensation 16	Siemens#Se...	120.0	35.0
MAPPED	DOSEINFO	17245	chem	null#CT crâne sinus,058-1906-04#null#Patient Protocol		DOSEINFO	SIEMENS#Sensation 16	Siemens#Se...		NaN
INCOMPLETE	TOPOGRAM	17246	chem	HEAD#CT crâne sinus,058-1906-04#07_Sinus_LowDose_OD#Topogram 1.0 T20s		TOPOGRAM	SIEMENS#Sensation 16	Siemens#Se...	100.0	50.0
INCOMPLETE	SCAN	17247	chem	HEAD#CT crâne sinus,058-1906-04#07_Sinus_LowDose_OD#Sinus_WF 1.0 H50s	Facial Bones / Sinuses	SCAN	SIEMENS#Sensation 16	Siemens#Se...	120.0	35.0
MAPPED	DOSEINFO	17248	chem	null#CT crâne sinus,058-1906-04#null#Patient Protocol		DOSEINFO	SIEMENS#Sensation 16	Siemens#Se...		NaN
INCOMPLETE	TOPOGRAM	17249	chem	HEAD#CT crâne sinus,058-1906-04#07_Sinus_LowDose_OD#Topogram 1.0 T20s		TOPOGRAM	SIEMENS#Sensation 16	Siemens#Se...	100.0	50.0
INCOMPLETE	SCAN	17250	chem	HEAD#CT crâne sinus,058-1906-04#07_Sinus_LowDose_OD#Sinus_WF 1.0 H50s	Facial Bones / Sinuses	SCAN	SIEMENS#Sensation 16	Siemens#Se...	120.0	35.0
MAPPED	DOSEINFO	17251	chem	null#CT crâne sinus,058-1906-04#null#Patient Protocol		DOSEINFO	SIEMENS#Sensation 16	Siemens#Se...		NaN
MAPPED	DOSEINFO	17252	chem	null#CT crâne sinus,058-1906-04#null#Patient Protocol		DOSEINFO	SIEMENS#Sensation 16	Siemens#Se...		NaN
INCOMPLETE	TOPOGRAM	17253	chem	HEAD#CT crâne sinus,058-1906-04#07_Sinus_LowDose_OD#Topogram 1.0 T20s		TOPOGRAM	SIEMENS#Sensation 16	Siemens#Se...	100.0	50.0
INCOMPLETE	TOPOGRAM	17254	chem	HEAD#CT crâne sinus,058-1906-04#07_Sinus_LowDose_OD#Topogram 1.0 T20s		TOPOGRAM	SIEMENS#Sensation 16	Siemens#Se...	100.0	50.0
INCOMPLETE	SCAN	17255	chem	HEAD#CT crâne sinus,058-1906-04#07_Sinus_LowDose_OD#Sinus_WF 1.0 H50s	Facial Bones / Sinuses	SCAN	SIEMENS#Sensation 16	Siemens#Se...	120.0	35.0

6. Dosimetry and other evaluations: CT Expo Dose



Calculation of values

PERMOS database



Depending on the protocol, up to 32 parameters from the DICOM Header are used.

6. Dosimetry and other evaluations: OCR Dose

OCR of Image → PerMoS database

Siemens works, GE and Philips are in development

7. PerMoS and EPICT: Initial Experiences

- Thanks to Peter Scholz and Lucian Krille from Mainz for their feedback.
- Based on experiences of the use of PerMoS during data collection in the University hospital Mainz
- **Setting:**
  - **Approx. 4,500 patients with 8,300 examinations**
  - **200 Patients per night requested, roundabout 70,000 files a day uploaded**
  - **31800 series uploaded**

7. PerMoS and EPICT: Initial Experiences

Radiology

- Manage the main patient database of the hospital
- Protect the data against access from out of the network
- Protect private information of patients against misuse
- Guarantee an all-time fast access to medical data

Study-Team

- Manage a multi-centre study on cancer

- Need access to the database for data-mining and upload data by Internet

- Try to get as much information on any patient as possible

- Need to move a huge amount of data in short time

[Scholz2011]

7. PerMoS and EPICT: Initial Experiences

- **Main Concerns of the Radiology Admin:**
  - One Laptop having both: connection to PACS and to the Internet at the same time
  - Possible uncontrolled upload of data to a external server
  - High traffic on PACS interfering clinical routine
  - Lots of traffic for little information
  - Loss of privacy protection
  - No guarantee for the completeness of the data
- **Solutions:**
  - Different access to PACS and Internet via scheduler
  - Starting the upload manually after checking the data
  - Scheduling the Queries to time slots with low traffic (night, weekend) and pausing between two queries
  - Precise filtering for relevant cases
  - Anonymisation as early as possible

[Scholz2011]

7. PerMoS and EPICT: Initial Experiences

- **Settings used:**
  - **Laptop:**
    - Installed in a server-room
    - Maintenance via remote-desktop-connection
  - **Receiver:**
    - Schedule 7:00 pm to 6:00 am next day, 7 days a week
    - Delay between two requests: 120 seconds
    - 180-200 ID in one night
    - Between 30s and 20min for one request
  - **Uploader:**
    - Schedule 8:00 am to 6:00 pm, 7 days a week
    - ~ 70,000 files/day
    - 4-5 hours uploading every day
    - Average 80kb/s

[Scholz2011]

7. PerMoS and EPICT: Initial Experiences

- **Checklist:**
  - Contact the admin in charge as early as possible!
  - Get information on the security directives of the department for your laptop
  - Discuss the data structure with your admin
    - Which ID first
    - Since when are images stored
    - Age of data to be transferred to archive server
  - Find appropriate time slots for request and upload
  - Give the admin access to PerMoS
  - Discuss the query results with the radiology for optimizing the query strategy

[Scholz2011]

PUBLIC RESEARCH CENTRE HENRI TUDOR

Optimage and Tudor DICOM Tools:

Software tools for automated dose reporting and quality assurance in radiology based on DICOM

Andreas Jahnen[1], Christian Moll[1], Johannes Hermen[1], Alex Meyer[2], Martine Grelot[2,] Octavian Dragusin[2], Christina Bokou[2],Olga Kaphammel[2], Alexandra Schreiner[3], Carlo Back[3]

[1]CRP Henri Tudor Luxembourg, [2]EHL Luxembourg, [3]Ministry of Health, Luxembourg

www.tudor.lu

HelsIT Trondheim, 29. September 2011

1. Introduction and Motivation

A quality assurance 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 and reporting
- Statistical evaluation of the calculated results
- Support for the most important modalities

2. Design of the system

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!

3. Profiles

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

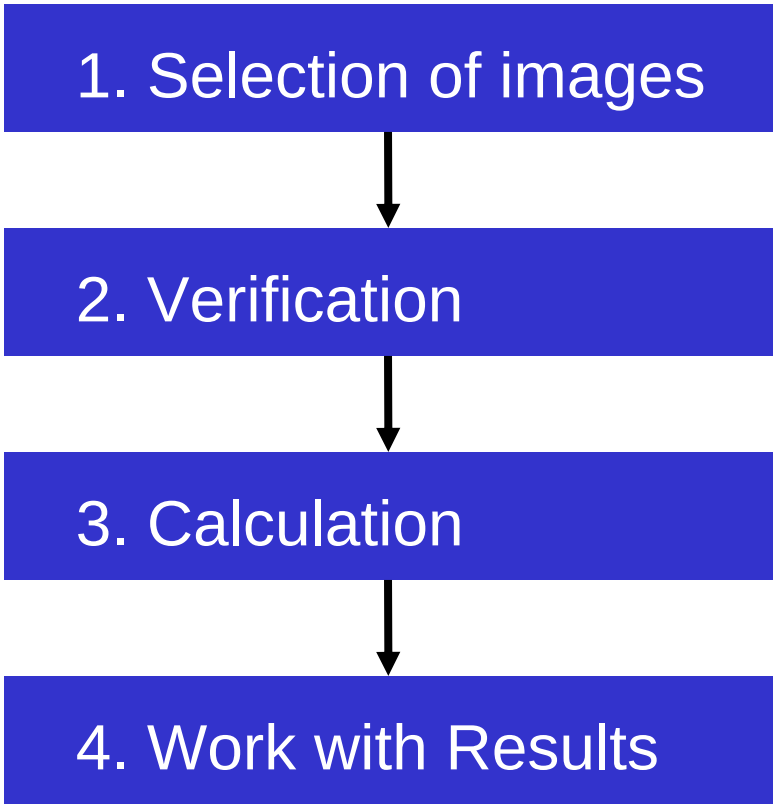
Why profiles?

(1) As a reference point in the database

(2) As the entry point for statistics, export function and reporting

(3) To not compare data, that is not comparable due to the selected parameters

4. Workflow of measurements



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

6. Statistics

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 +- 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

7. Reporting

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
- …

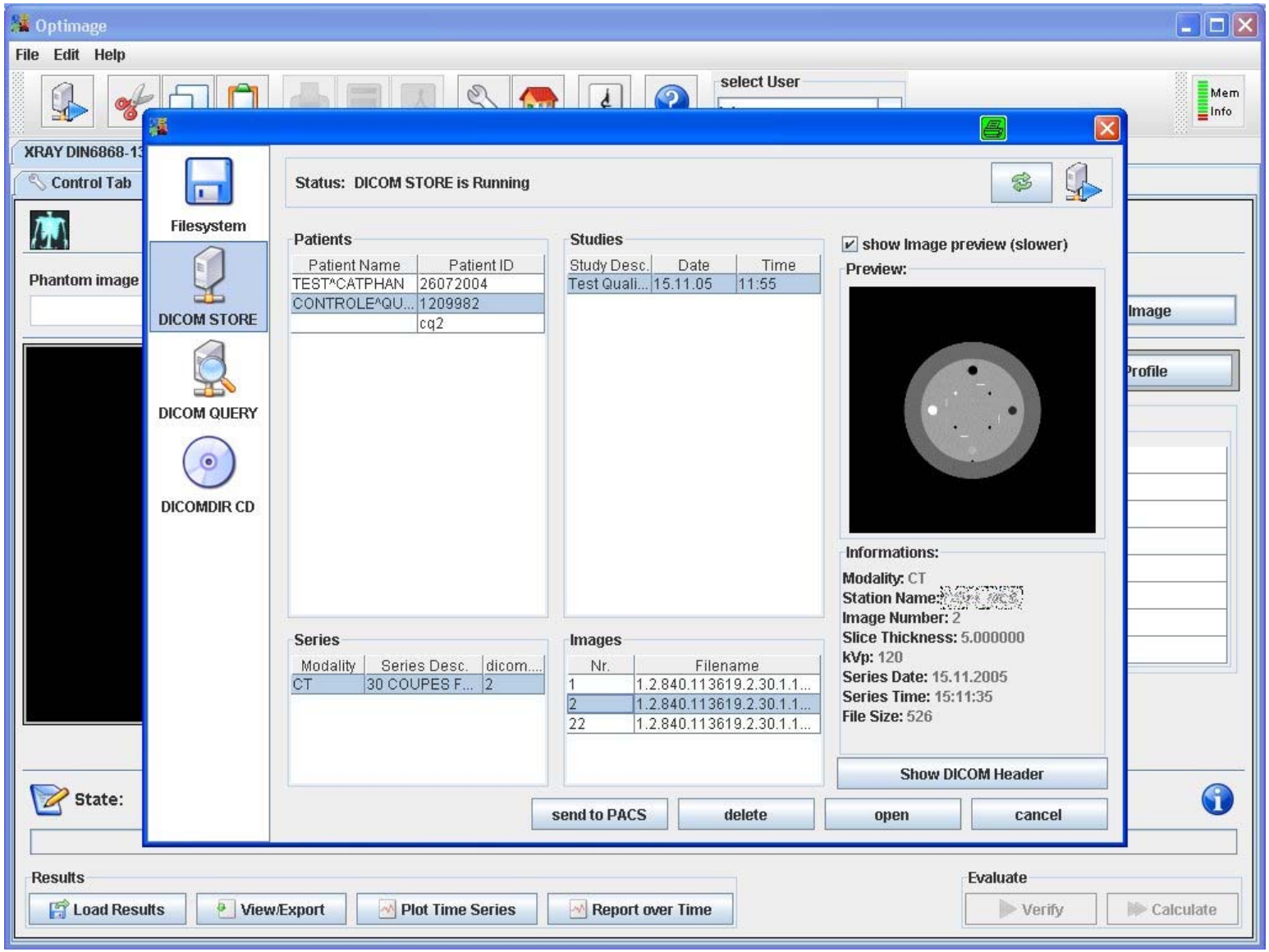
Every report starts at the profile

Report generation based on templates, which are “easy” to customize with a graphical editor

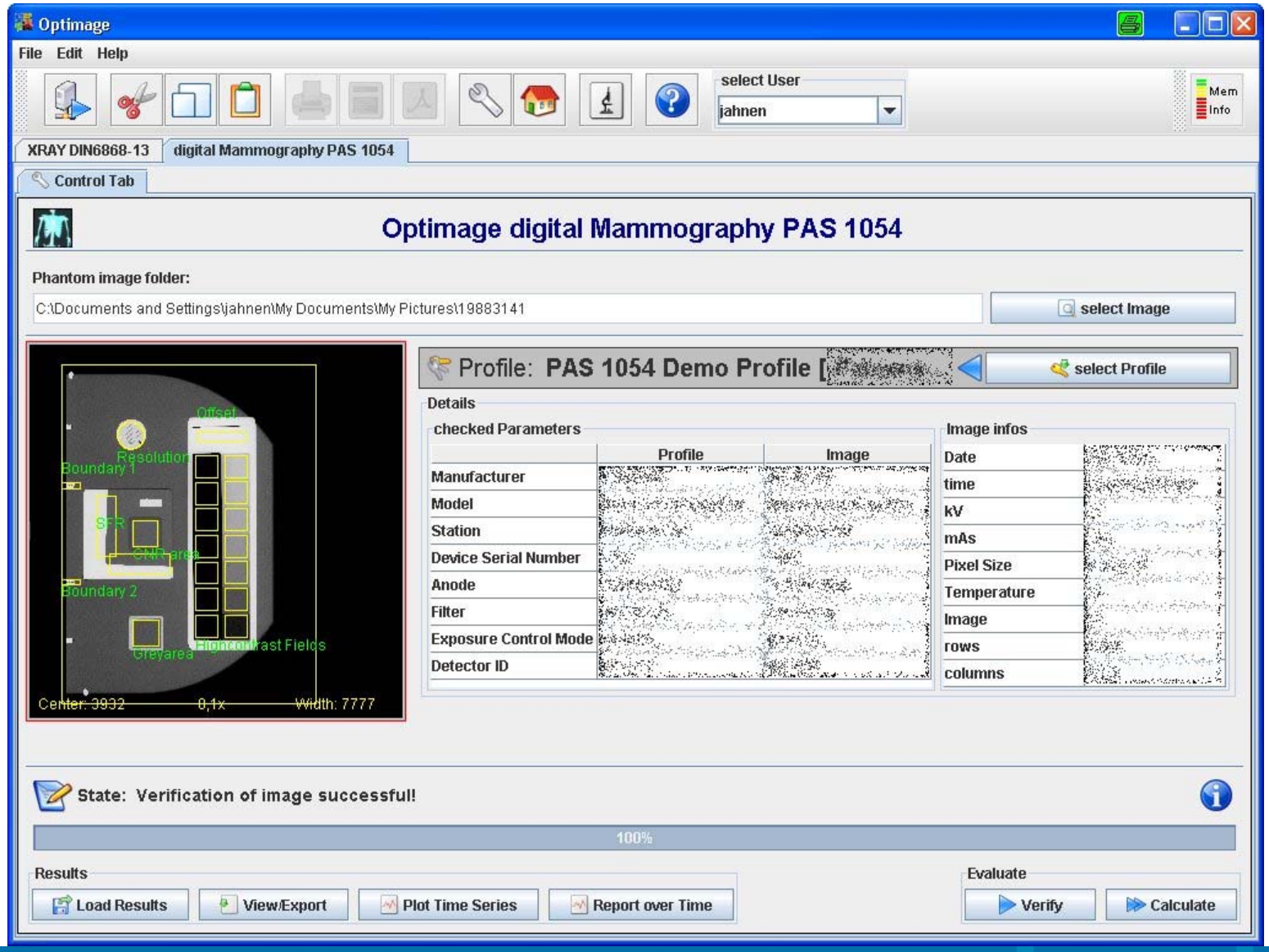
Reports can be created in several different formats:

- Direct printing
- Export to PDF, HTML, RTF, …

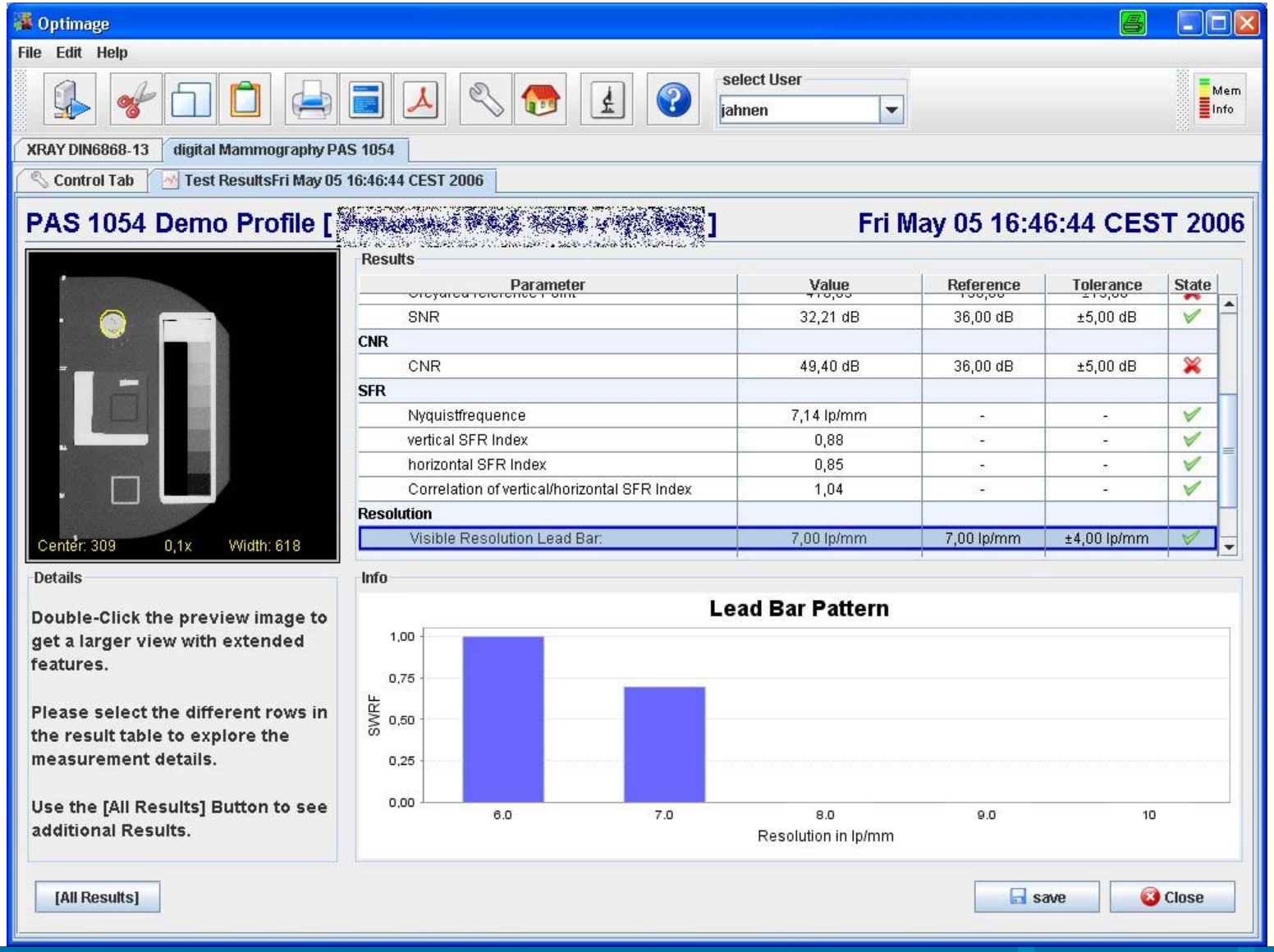
The software in action: Selection



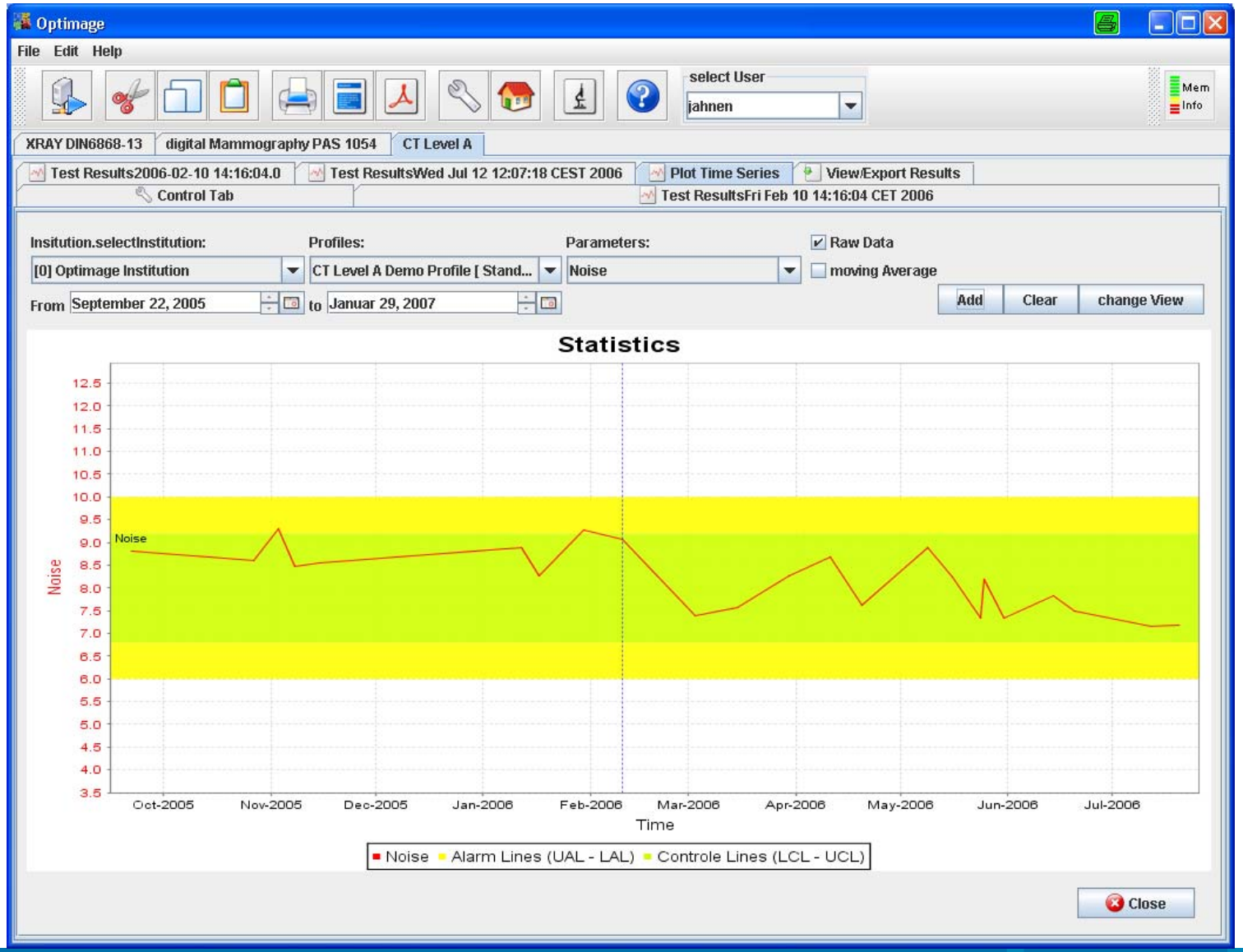
The software in action: Verification



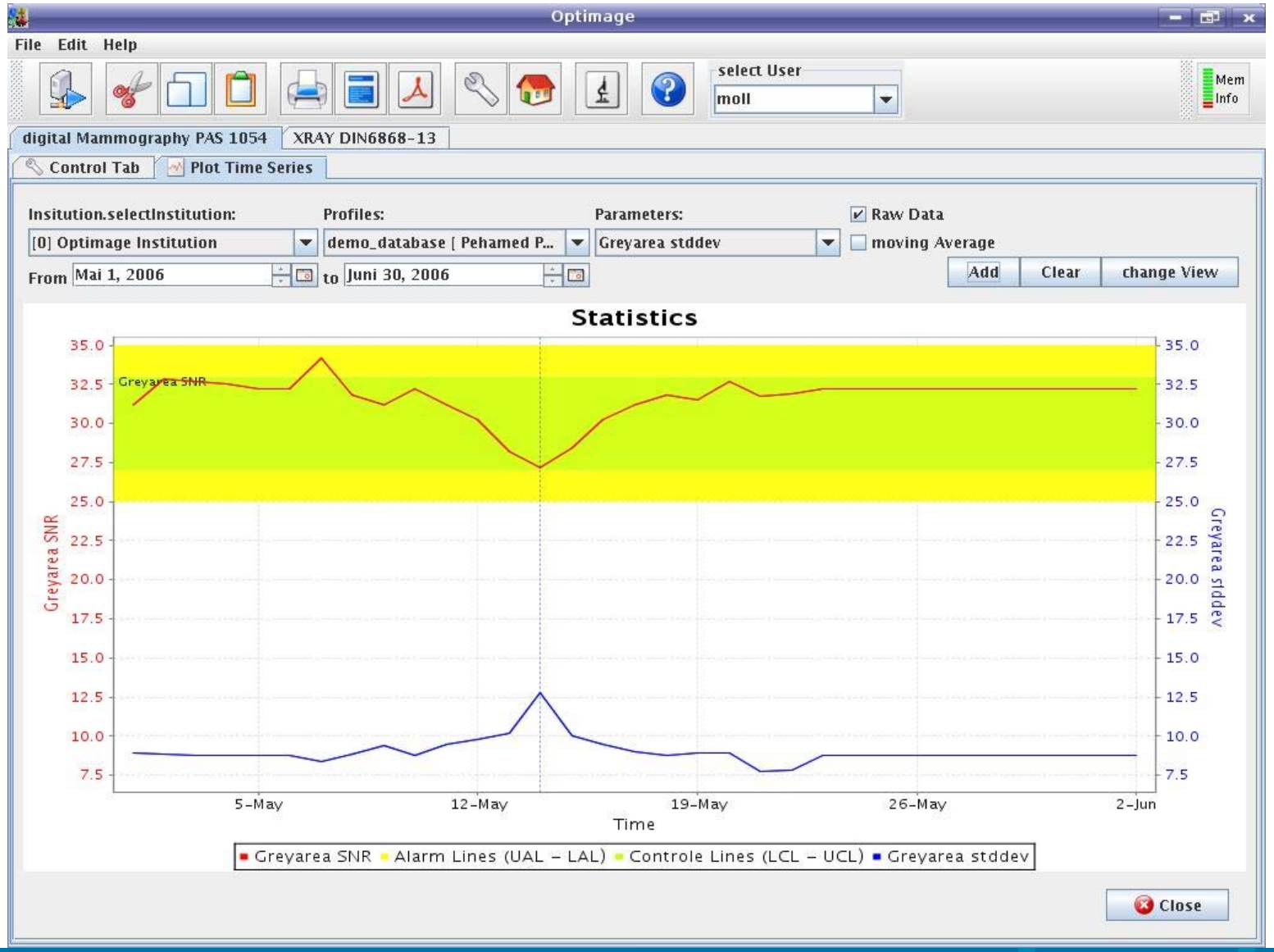
The software in action: Results



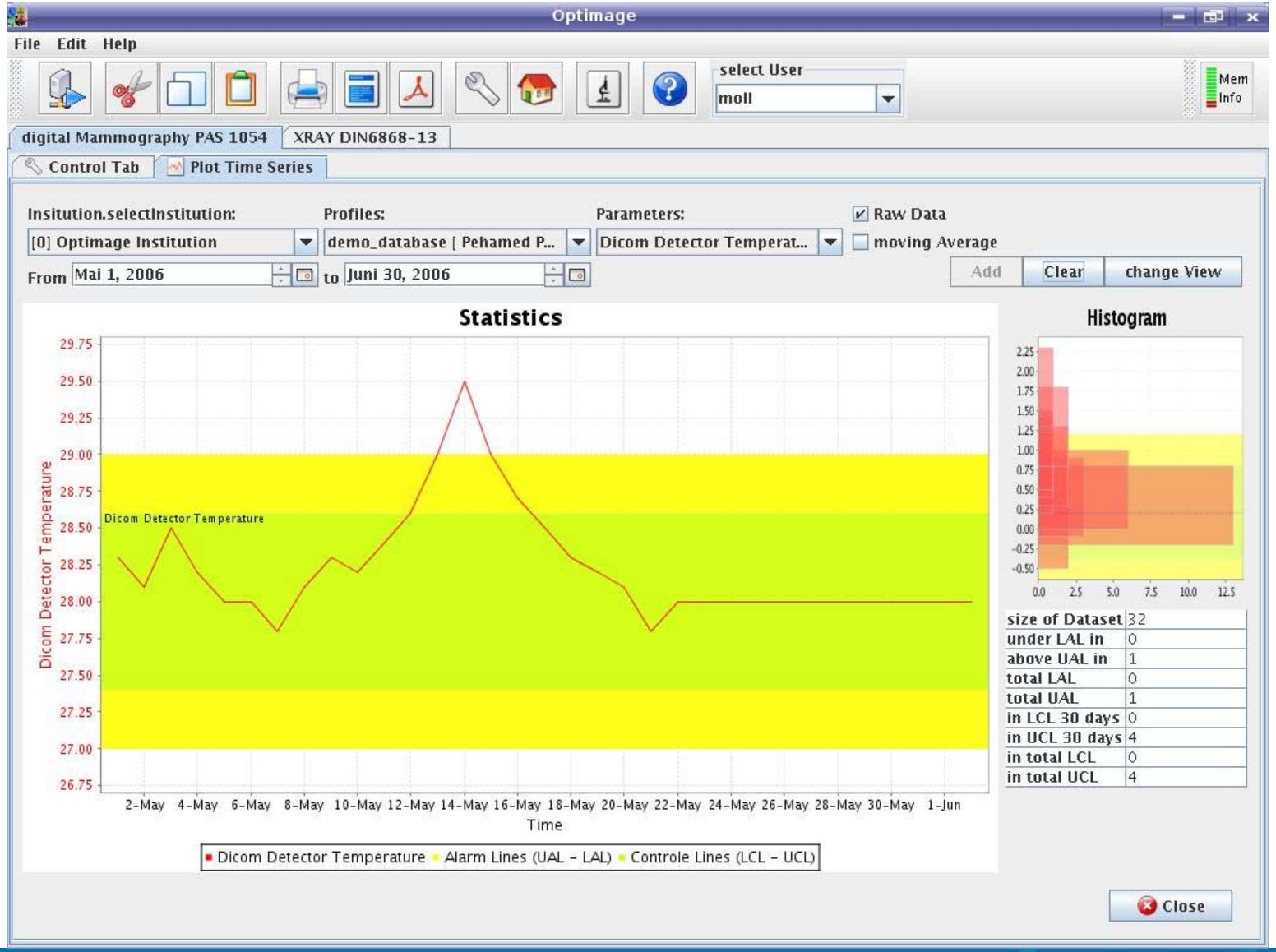
The software in action: Statistics



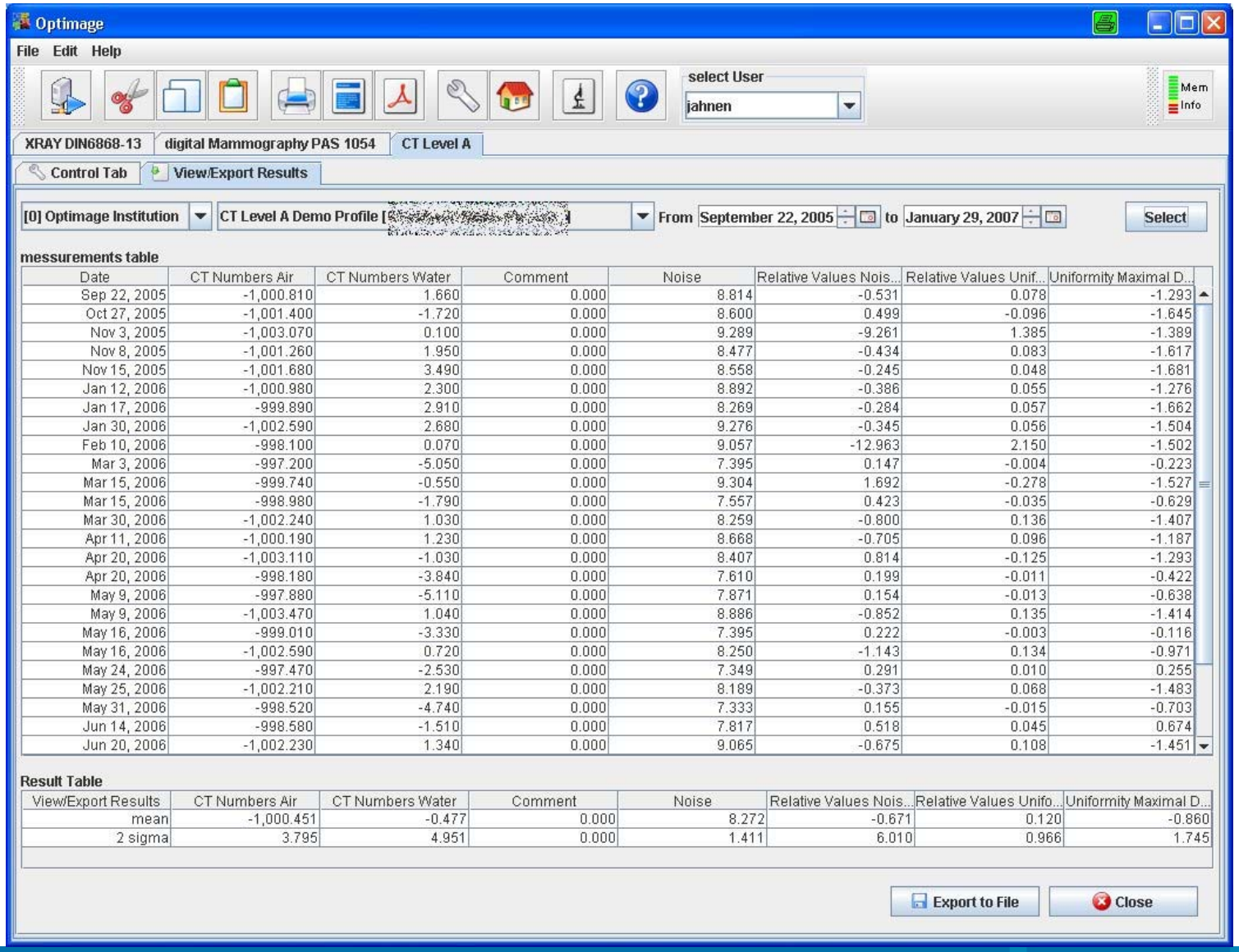
The software in action: Statistics



The software in action: Statistics



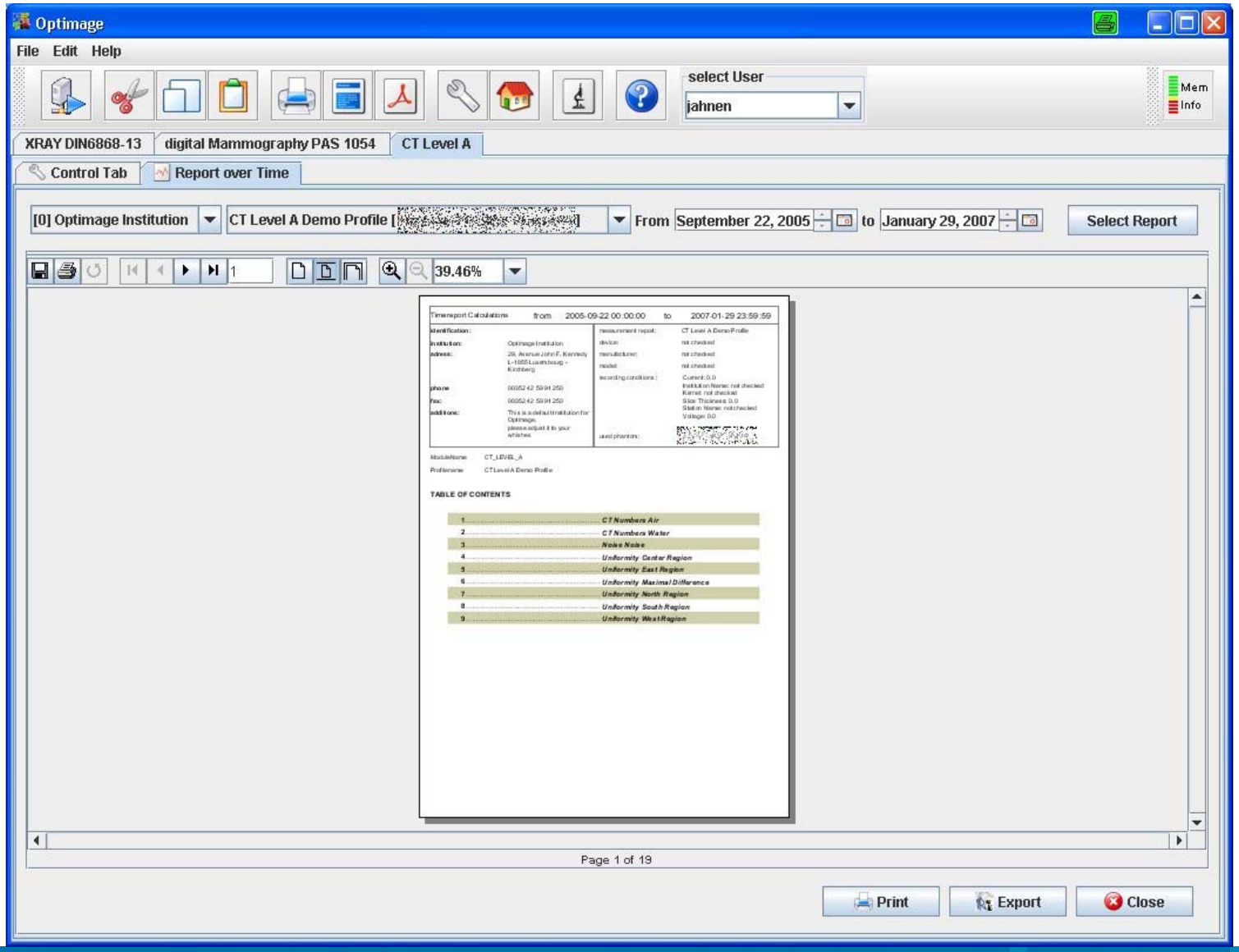
The software in action: Statistics



Date	CT Numbers Air	CT Numbers Water	Comment	Noise	Relative Values Nois...	Relative Values Unif...	Uniformity Maximal D...
Sep 22, 2005	-1,000.810	1.660	0.000	8.814	-0.531	0.078	-1.293
Oct 27, 2005	-1,001.400	-1.720	0.000	8.600	0.499	-0.096	-1.645
Nov 3, 2005	-1,003.070	0.100	0.000	9.289	-9.261	1.385	-1.389
Nov 8, 2005	-1,001.260	1.950	0.000	8.477	-0.434	0.083	-1.617
Nov 15, 2005	-1,001.680	3.490	0.000	8.558	-0.245	0.048	-1.681
Jan 12, 2006	-1,000.980	2.300	0.000	8.892	-0.386	0.055	-1.276
Jan 17, 2006	-999.890	2.910	0.000	8.269	-0.284	0.057	-1.662
Jan 30, 2006	-1,002.590	2.680	0.000	9.276	-0.345	0.056	-1.504
Feb 10, 2006	-998.100	0.070	0.000	9.057	-12.963	2.150	-1.502
Mar 3, 2006	-997.200	-5.050	0.000	7.395	0.147	-0.004	-0.223
Mar 15, 2006	-999.740	-0.550	0.000	9.304	1.692	-0.278	-1.527
Mar 15, 2006	-998.980	-1.790	0.000	7.557	0.423	-0.035	-0.629
Mar 30, 2006	-1,002.240	1.030	0.000	8.259	-0.800	0.136	-1.407
Apr 11, 2006	-1,000.190	1.230	0.000	8.668	-0.705	0.096	-1.187
Apr 20, 2006	-1,003.110	-1.030	0.000	8.407	0.814	-0.125	-1.293
Apr 20, 2006	-998.180	-3.840	0.000	7.610	0.199	-0.011	-0.422
May 9, 2006	-997.880	-5.110	0.000	7.871	0.154	-0.013	-0.638
May 9, 2006	-1,003.470	1.040	0.000	8.886	-0.852	0.135	-1.414
May 16, 2006	-999.010	-3.330	0.000	7.395	0.222	-0.003	-0.116
May 16, 2006	-1,002.590	0.720	0.000	8.250	-1.143	0.134	-0.971
May 24, 2006	-997.470	-2.530	0.000	7.349	0.291	0.010	0.255
May 25, 2006	-1,002.210	2.190	0.000	8.189	-0.373	0.068	-1.483
May 31, 2006	-998.520	-4.740	0.000	7.333	0.155	-0.015	-0.703
Jun 14, 2006	-998.580	-1.510	0.000	7.817	0.518	0.045	0.674
Jun 20, 2006	-1,002.230	1.340	0.000	9.065	-0.675	0.108	-1.451

View/Export Results	CT Numbers Air	CT Numbers Water	Comment	Noise	Relative Values Nois...	Relative Values Unifo...	Uniformity Maximal D...
mean	-1,000.451	-0.477	0.000	8.272	-0.671	0.120	-0.860
2 sigma	3.795	4.951	0.000	1.411	6.010	0.966	1.745

The software in action: Reporting



7. Modules / Methods available

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	CDRAD Manual[6]	CDRAD phantom	Number and position of detected points
Mammography level A	European Guideline[s(7)] and PAS 1054[8]	PAS 1054 phantom and PMMA block	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

Jahnen, A., Schilz, C., Shannoun, F., Schreiner, A., Hermen, J., & Moll, C. (2008). **Optimage central organised image quality control including statistics and reporting.** Radiation protection dosimetry, 129(1-3), 253-7. doi:10.1093/rpd/ncn015

The software is available as Open Source (LGPL) at the project homepage:

http://santec.tudor.lu/projects/optimage/

Acknowledgements (alphabetical order):

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- Martine Grelot, EHL, Luxembourg
- Johannes Hermen, CRP Henri Tudor, Luxembourg
- Olga Kaphammel, EHL, Luxembourg
- Christian Moll, CRP Henri Tudor, Luxembourg
- Clemens Schilz, Brüderkrankenhaus Trier, Germany
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- Dr Ferid Shannoun, Ministry of Health, Luxembourg
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PUBLIC RESEARCH CENTRE HENRI TUDOR

Tudor DICOM Tools:

Software tools for automated dose reporting and quality assurance in radiology based on DICOM

Johannes Hermen[1], Andreas Jahnen[1], Christian Moll[1]

[1]CRP Henri Tudor Luxembourg,

HelsIT Trondheim, 29. September 2011

Agenda

1. Introduction
2. Tudor DICOM Viewer, simple DICOM Viewer
3. Tudor DICOM Viewer, special functions for quality assurance
4. DICOM Tools for ImageJ
5. Case 1: Control of dose values in fluoroscopy
6. Case 2: Automatic modifications of DICOM files

2. Tudor DICOM Viewer, simple DICOM Viewer

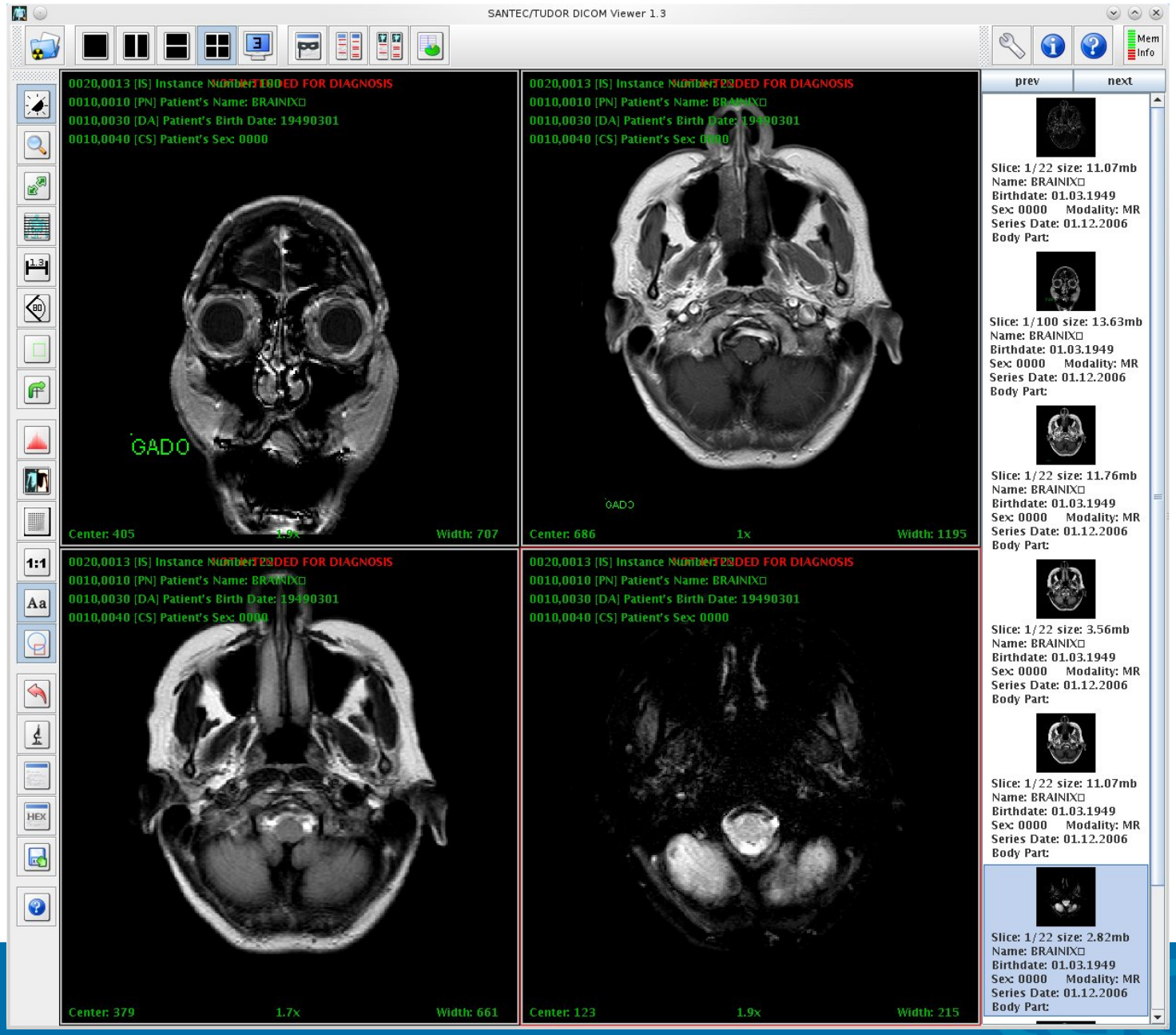
- Viewing images: The Toolkit offers components to view DICOM images with features like windowing, zooming, shifting, measuring etc. The Tudor DICOM Viewer, a simple but yet powerful DICOM viewer application is able to display multiple images in several splitscreen or multi-monitor configurations. Multiple series can be loaded and managed in the viewer from different available image sources.
- Opening and writing The toolkit offers functionality to read DICOM files in various image compressions and formats from a disc or DICOMDIR fileset (DICOM CD). Images from any kind can be saved as uncompressed DICOM files. It is easy to create a lightweight, but standard conform STORAGE-SCP that is able to receive DICOM objects via network and store them into a DICOMDIR file-set or directory

2. Tudor DICOM Viewer, simple DICOM Viewer

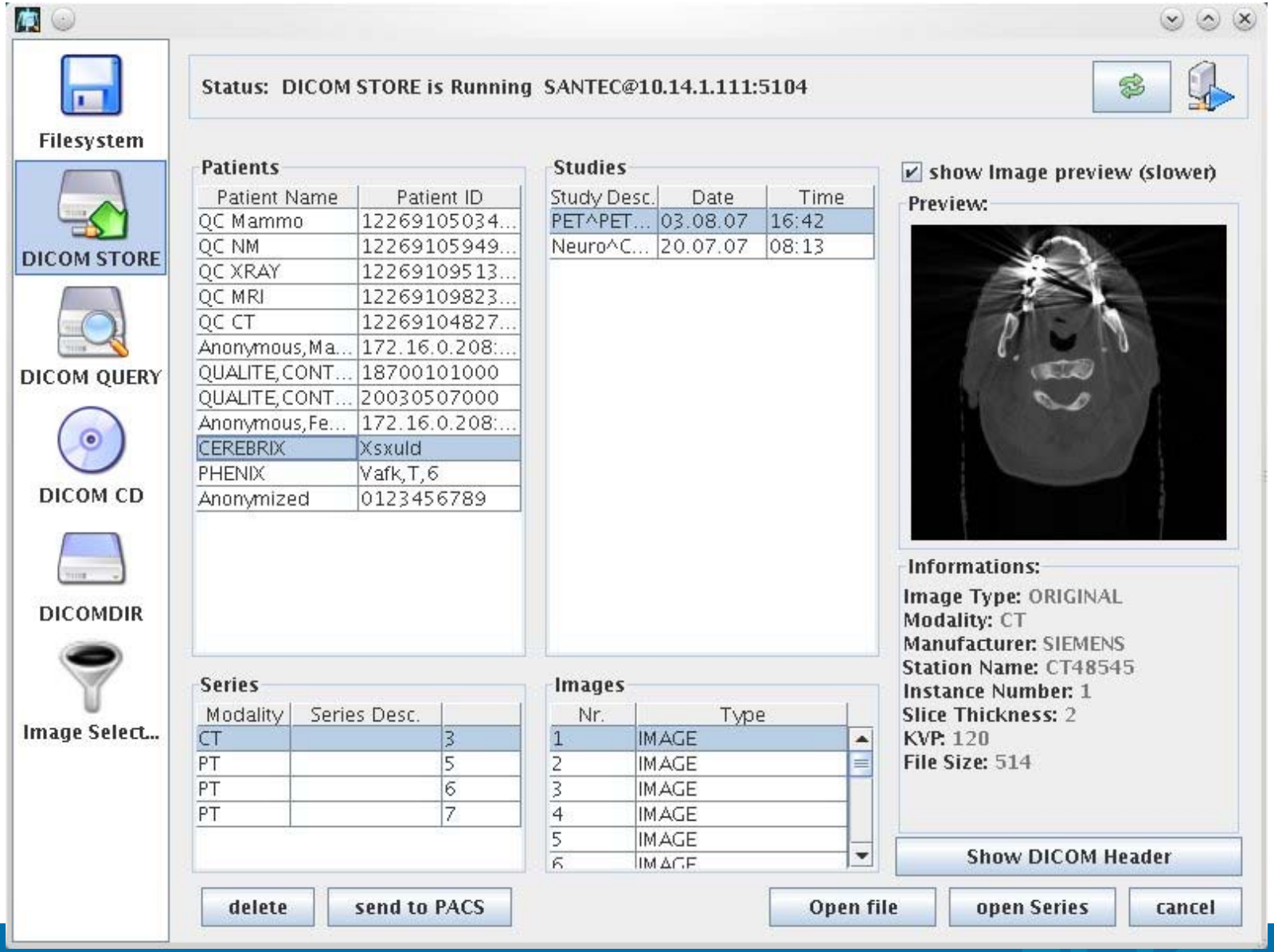
Sending and receiving DICOM objects can be queried from a PACS by their patient name, study, series and image UID using the integrated QUERY/RETRIEVE-SCU. A DICOM sender (STORAGE-SCU) can be used to send images to any configured DICOM node in the network.

DICOM header handling It is possible to change the DICOM metadata for example to anonymise images or fix meta data related problems. Header data can be used in conditions to take decisions depending on the provided data. Headers can be viewed as text or hexadecimal values for debugging purposes. A comparison of headers from different files is possible too. Software framework for acquisition and evaluationof DICOM meta-data.

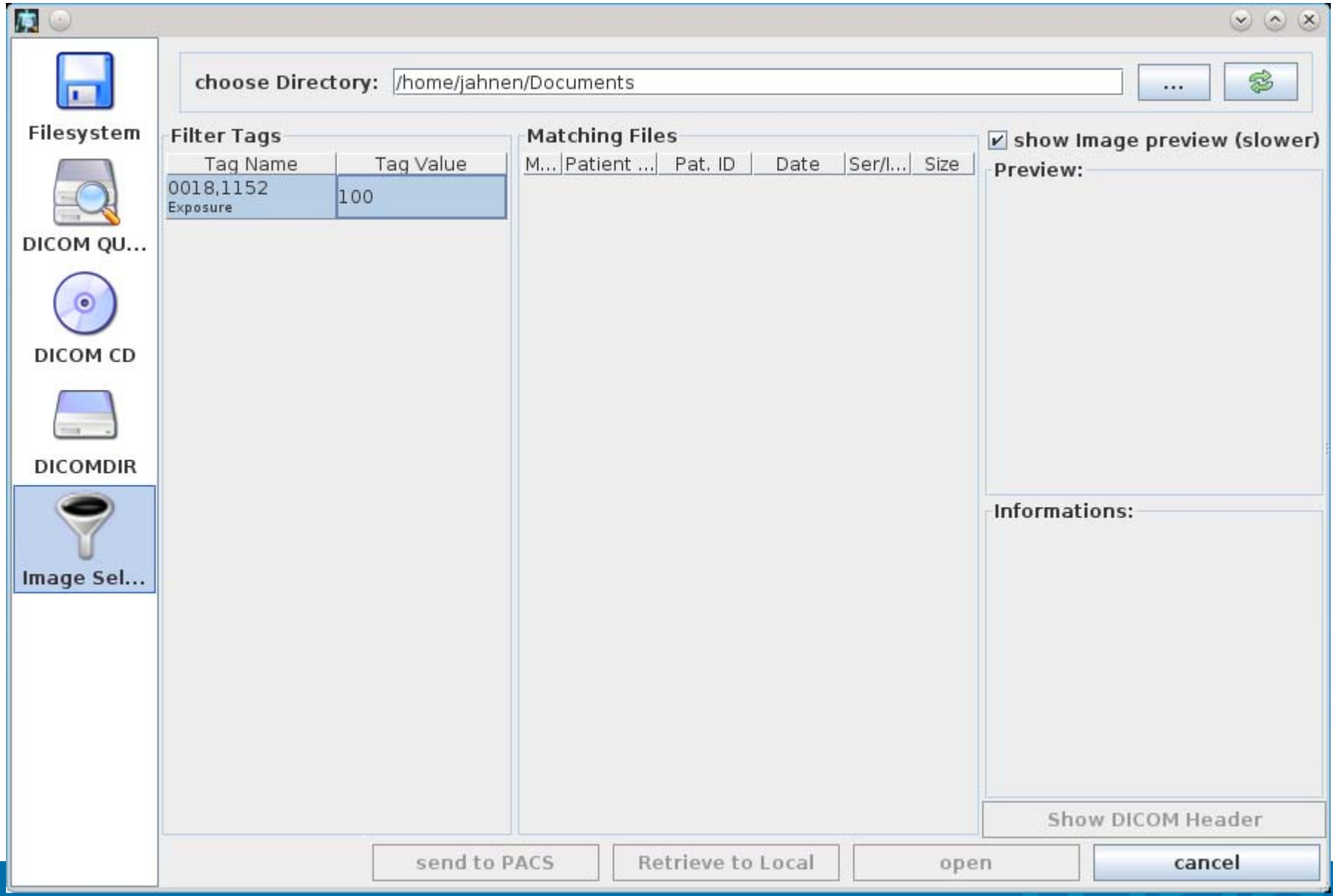
2. Tudor DICOM Viewer, simple DICOM Viewer



2. Tudor DICOM Viewer, simple DICOM Viewer



2. Tudor DICOM Viewer, special functions



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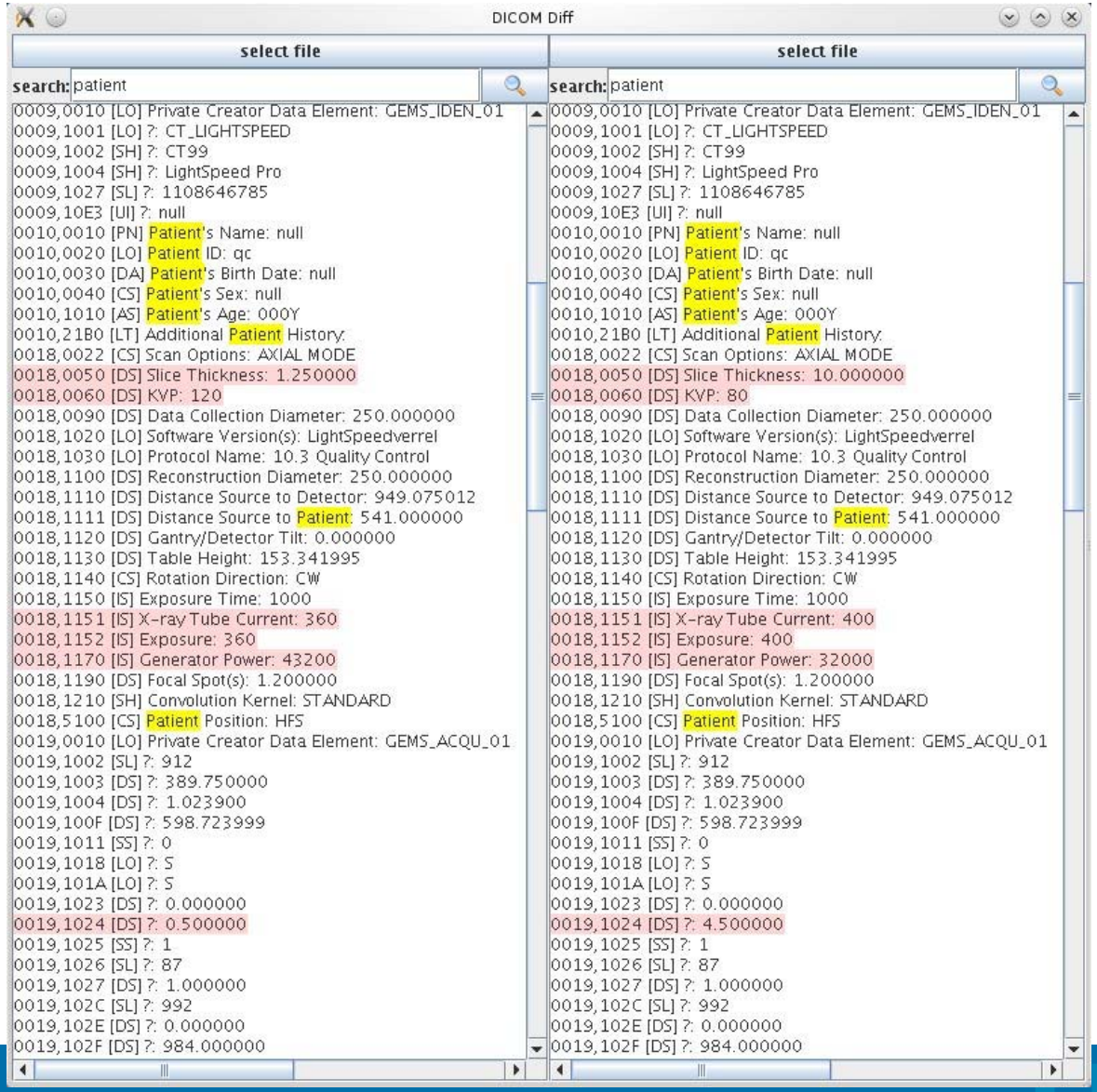

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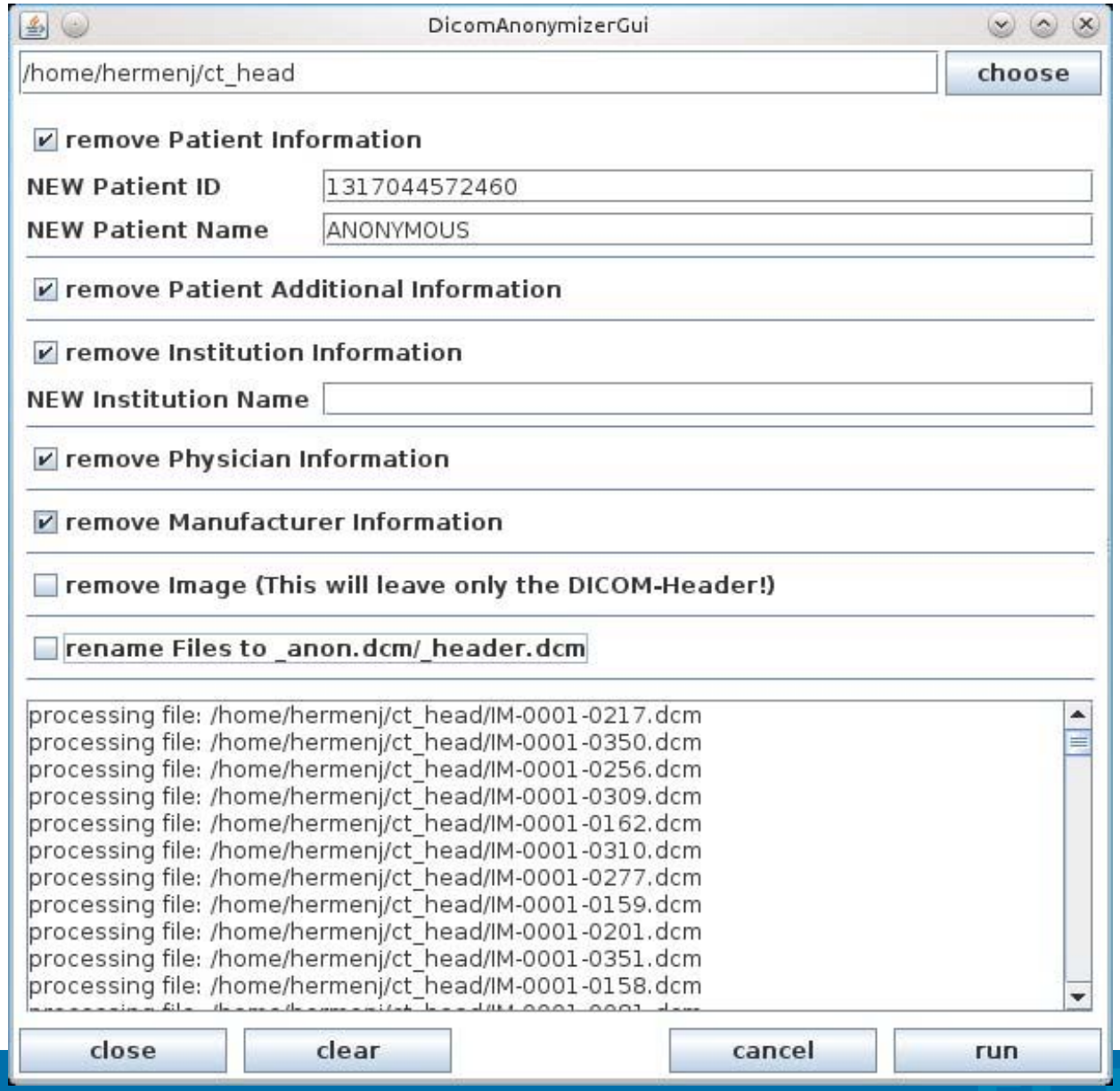
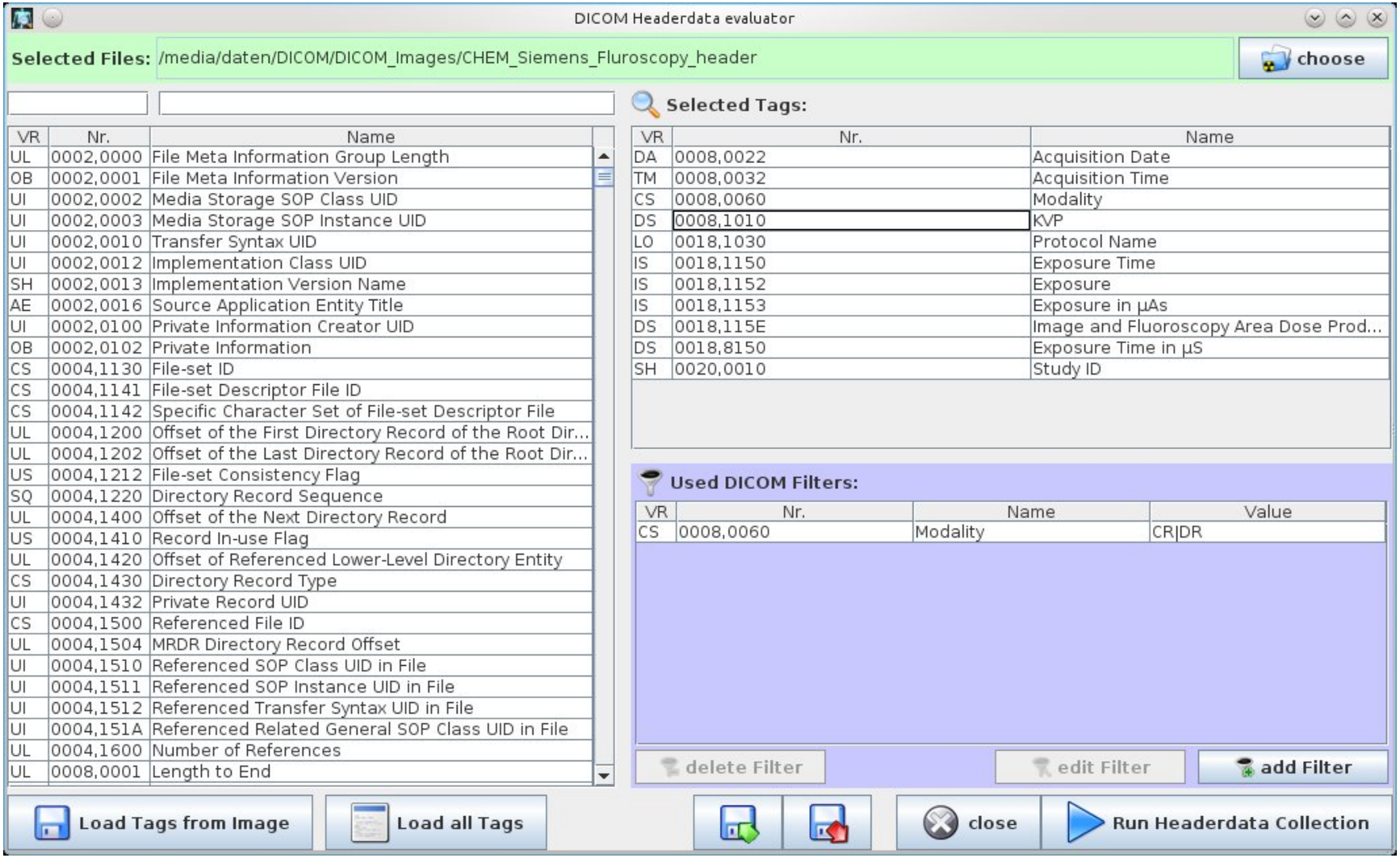


2. Tudor DICOM Viewer, special functions

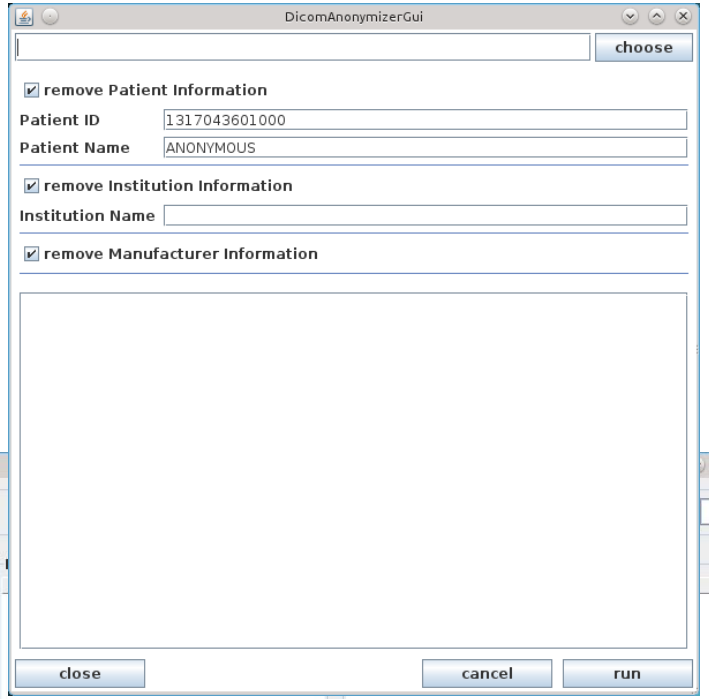


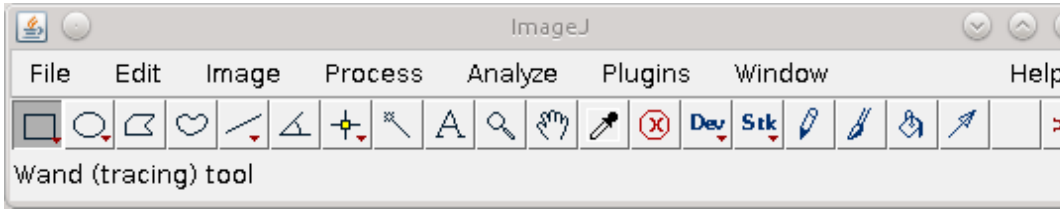
VR	Nr.	Name
UL	0002,0000	File Meta Information Group Length
OB	0002,0001	File Meta Information Version
UI	0002,0002	Media Storage SOP Class UID
UI	0002,0003	Media Storage SOP Instance UID
UI	0002,0010	Transfer Syntax UID
UI	0002,0012	Implementation Class UID
SH	0002,0013	Implementation Version Name
AE	0002,0016	Source Application Entity Title
UI	0002,0100	Private Information Creator UID
OB	0002,0102	Private Information
CS	0004,1130	File-set ID
CS	0004,1141	File-set Descriptor File ID
CS	0004,1142	Specific Character Set of File-set Descriptor File
UL	0004,1200	Offset of the First Directory Record of the Root Dir...
UL	0004,1202	Offset of the Last Directory Record of the Root Dir...
US	0004,1212	File-set Consistency Flag
SQ	0004,1220	Directory Record Sequence
UL	0004,1400	Offset of the Next Directory Record
US	0004,1410	Record In-use Flag
UL	0004,1420	Offset of Referenced Lower-Level Directory Entity
CS	0004,1430	Directory Record Type
UI	0004,1432	Private Record UID
CS	0004,1500	Referenced File ID
UL	0004,1504	MRDR Directory Record Offset
UI	0004,1510	Referenced SOP Class UID in File
UI	0004,1511	Referenced SOP Instance UID in File
UI	0004,1512	Referenced Transfer Syntax UID in File
UI	0004,151A	Referenced Related General SOP Class UID in File
UL	0004,1600	Number of References
UL	0008,0001	Length to End

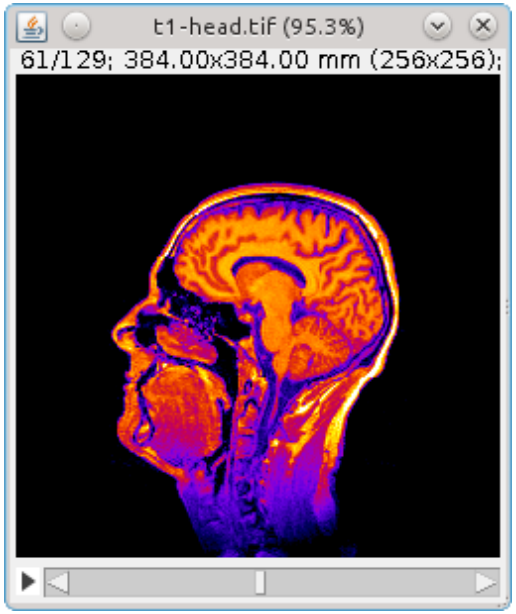
VR	Nr.	Name
DA	0008,0022	Acquisition Date
TM	0008,0032	Acquisition Time
CS	0008,0060	Modality
DS	0008,1010	KVP
LO	0018,1030	Protocol Name
IS	0018,1150	Exposure Time
IS	0018,1152	Exposure
IS	0018,1153	Exposure in µAs
DS	0018,115E	Image and Fluoroscopy Area Dose Prod...
DS	0018,8150	Exposure Time in µS
SH	0020,0010	Study ID

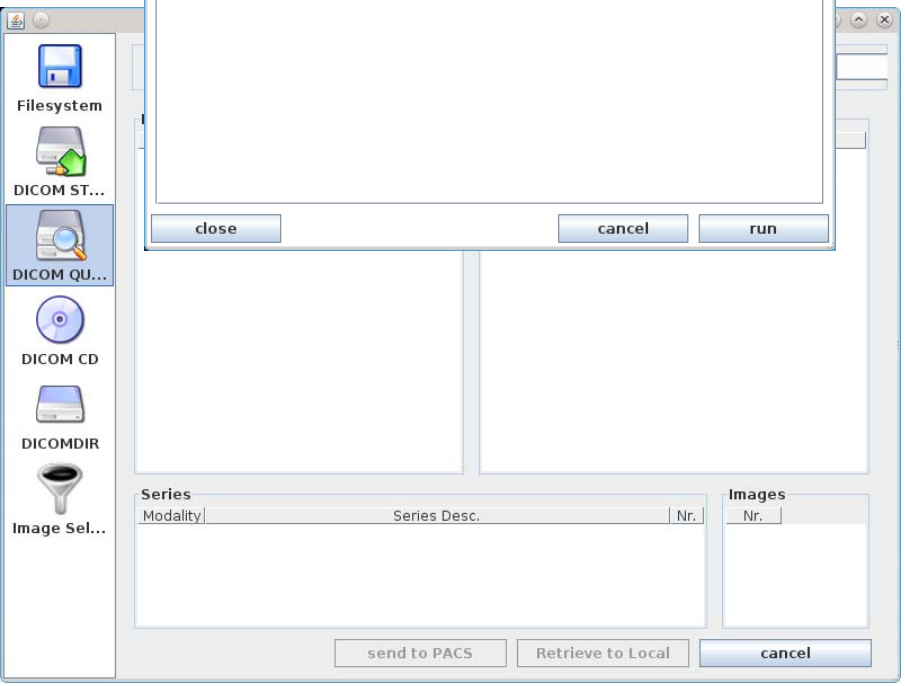
VR	Nr.	Name	Value
CS	0008,0060	Modality	CR|DR

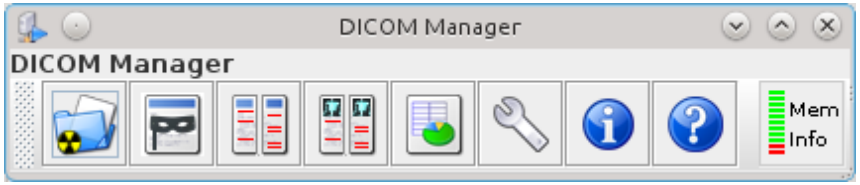
2. Tudor DICOM tools for ImageJ



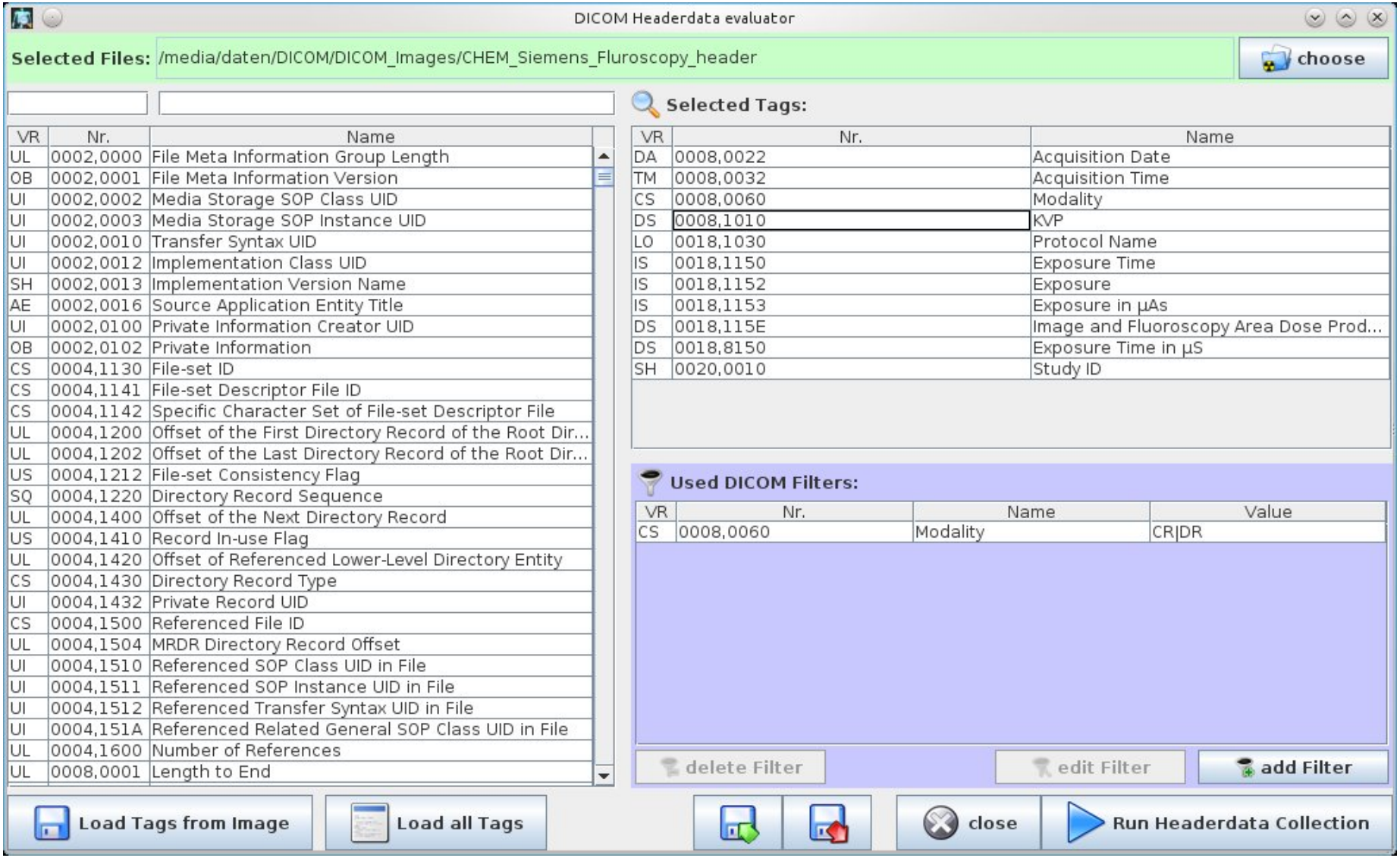








5. Case 1: Control of dose values in fluoroscopy



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UI	0002,0003	Media Storage SOP Instance UID
UI	0002,0010	Transfer Syntax UID
UI	0002,0012	Implementation Class UID
SH	0002,0013	Implementation Version Name
AE	0002,0016	Source Application Entity Title
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UL	0004,1420	Offset of Referenced Lower-Level Directory Entity
CS	0004,1430	Directory Record Type
UI	0004,1432	Private Record UID
CS	0004,1500	Referenced File ID
UL	0004,1504	MRDR Directory Record Offset
UI	0004,1510	Referenced SOP Class UID in File
UI	0004,1511	Referenced SOP Instance UID in File
UI	0004,1512	Referenced Transfer Syntax UID in File
UI	0004,151A	Referenced Related General SOP Class UID in File
UL	0004,1600	Number of References
UL	0008,0001	Length to End

VR	Nr.	Name
DA	0008,0022	Acquisition Date
TM	0008,0032	Acquisition Time
CS	0008,0060	Modality
DS	0008,1010	KVP
LO	0018,1030	Protocol Name
IS	0018,1150	Exposure Time
IS	0018,1152	Exposure
IS	0018,1153	Exposure in µAs
DS	0018,115E	Image and Fluoroscopy Area Dose Prod...
DS	0018,8150	Exposure Time in µS
SH	0020,0010	Study ID

VR	Nr.	Name	Value
CS	0008,0060	Modality	CR|DR

5. Case 1: Control of dose values in fluoroscopy

DICOM Headerdata evaluator

Selected Files: /media/daten/DICOM/DICOM_Images/CHEM_Siemens_Fluroscopy_header — choose

VR	Nr.	Name
UL	0002,0000	File Meta Information Group Length
OB	0002,0001	File Meta Information Version
UI	0002,0002	Media Storage SOP Class UID
UI	0002,0003	Media Storage SOP Instance UID
UI	0002,0010	Transfer Syntax UID
UI	0002,0012	Implementation Class UID
SH	0002,0013	Implementation Version Name
AE	0002,0016	Source Application Entity Title
UI	0002,0100	Private Information Creator UID
OB	0002,0102	Private Information
CS	0004,1130	File-set ID
CS	0004,1141	File-set Descriptor File ID
CS	0004,1142	Specific Character Set of File-set Descriptor File
UL	0004,1200	Offset of the First Directory Record of the Root Dir...
UL	0004,1202	Offset of the Last Directory Record of the Root Dir...
US	0004,1212	File-set Consistency Flag
SQ	0004,1220	Directory Record Sequence
UL	0004,1400	Offset of the Next Directory Record
US	0004,1410	Record In-use Flag
UL	0004,1420	Offset of Referenced Lower-Level Directory Entity
CS	0004,1430	Directory Record Type
UL	0004,1432	Private Record UID

Selected Tags:

VR	Nr.	Name
DA	0008,0022	Acquisition Date
TM	0008,0032	Acquisition Time
CS	0008,0060	Modality
DS	0008,1010	KVP
LO	0018,1030	Protocol Name
IS	0018,1150	Exposure Time
IS	0018,1152	Exposure
IS	0018,1153	Exposure in µAs
DS	0018,115E	Image and Fluoroscopy Area Dose Prod...
DS	0018,8150	Exposure Time in µS
SH	0020,0010	Study ID

Used DICOM Filters:

VR	Nr.	Name	Value
CS	0008,0060	Modality	CR|DR

DICOM Data-Table: 13 Results

Acquisition Date	Acquisition Time	Modality	KVP	Protocol Name	Exposure Time	Exposure	Exposure in µAs	Image and Fluoroscopy Area Dose Product	Exposure Time in µS
20110817	073655.0375	CR	CHEST	RAD THORAX FACE PA	1	0	600	0.322	1800
20110817	073750.0171	CR	CHEST	RAD THORAX PROFIL	4	1	1800	0.866	4000
20110817	100554.0468	CR	HIP	RAD HANCHE D FACE	31	24	24900	1.488	31200
20110817	100617.0390	CR	HIP	RAD HANCHE D AXIALE	28	22	22800	1.554	28300
20110817	100918.0750	CR	CHEST	RAD GRIL COSTAL G BAS AP	24	10	10100	1.212	24100
20110817	100943.0187	CR	CHEST	RAD GRIL COSTAL G BAS AP	29	12	12600	1.654	29900
20110817	101011.0343	CR	CHEST	RAD GRIL COSTAL G BAS AP	14	5	5900	0.697	14200
20110817	100856.0734	CR	TSPINE	RAD COL DORS FACE	29	23	23200	1.330	29100
20110817	101053.0812	CR	TSPINE	RAD COL DORS PROFIL	39	31	31400	2.113	39200
20110817	101521.0843	CR	FOOT	W Pied G Face 3/4	5	2	2000	0.289	5100
20110817	101600.0562	CR	FOOT	W Pied G Prof	8	3	3200	0.606	8100
20110817	101416.0437	CR	FOOT	W Cheville G Face	9	4	4000	0.913	9300
20110817	101444.0218	CR	FOOT	W Cheville G Profil	9	4	4000	1.028	9400

export to .csv — close

1. Case 2: Automatic modifications of DICOM files

```java
// from TransCodeNode.java
public void fireDicomEvent(DicomEvent event) {

logger.info("event: " + event);

File inFile = event.getFile();
File outFile = new File(inFile.getAbsolutePath() + ".converted.dcm");

// read orig file
DicomInputStream in;
in = new DicomInputStream(file);
DicomObject dcmobj =  in.readDicomObject();
in.close();

// modify header
dcmobj.putDouble(Tag.DoseValue, dcmobj.vrOf(Tag.DoseValue), 08.15)

// write file
FileOutputStream fos = new FileOutputStream(outFile);
BufferedOutputStream bos = new BufferedOutputStream(fos);
DicomOutputStream dos = new DicomOutputStream(bos);
dos.writeDicomFile(dcmobj);
dos.close();

// send converted file
this.dicomSender.send(outFile);
}
```

Online resources

EPI-CT and PerMoS

- EPI-CT Homepage: http://epi-ct.iarc.fr/
- Tudor Resources: http://santec.tudor.lu/project/epict/

Optimage

- Homepage: http://santec.tudor.lu/project/optimage

Tudor DICOM Tools

- Homepage: http://www.santec.lu/project/dicom/
- ImageJ Homepage: http://rsbweb.nih.gov/ij/