

A Platform for high throughput image processing

Application to clinical research and clinical trials

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Translational Imaging Group

Centre for Medical Image Computing

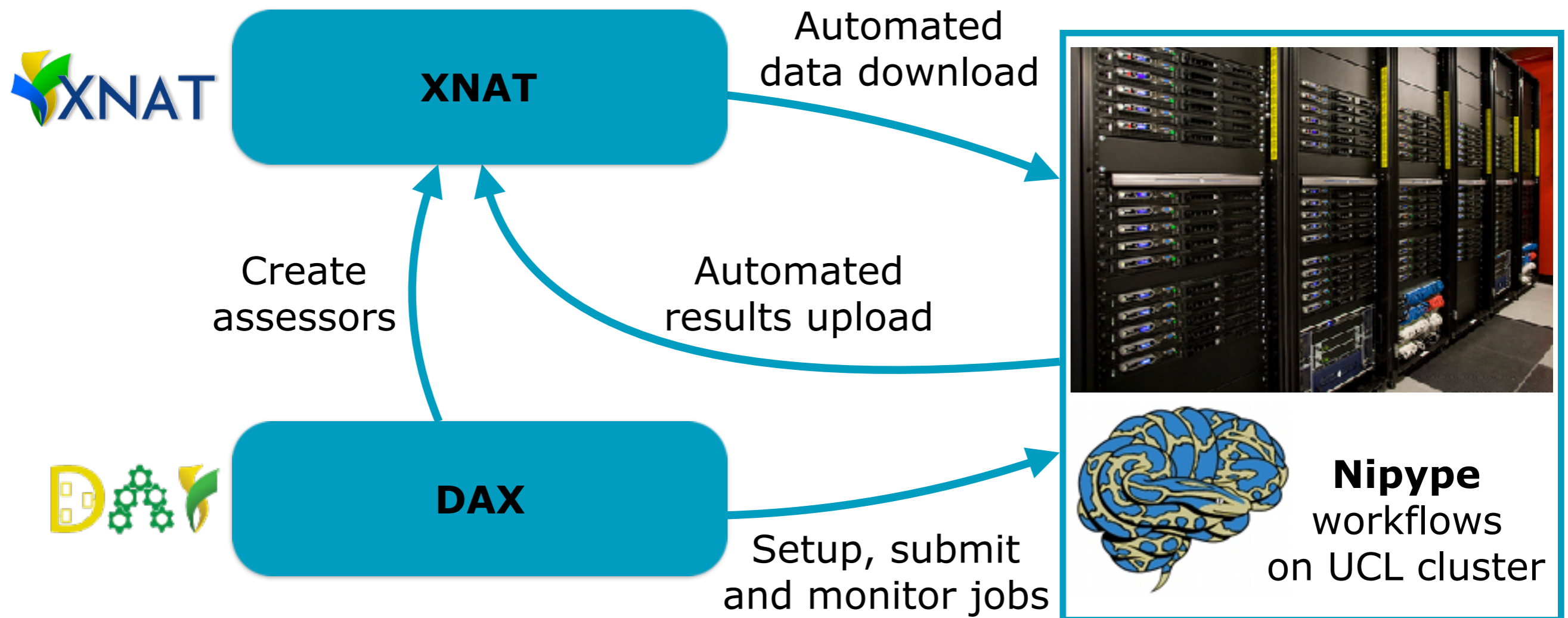
Wellcome / EPSRC Centre Interventional and Surgical Sciences

Dementia Research Centre

Aim

- Platform for data analytics
 - All data in a central place, imaging and non-imaging
 - Available to all collaborators in a secured way
 - Automated data analysis and feature extraction

Overall platform



Data storage - Overview

- In a nutshell
 - XNAT: eXtensible Neuroimaging Archive Toolkit
 - Database developed at Washington University, St Louis, USA
 - Website: <http://www.xnat.org>
 - Manage, import, archive, process, distribute imaging data



- Projects
 - * Subjects
 - + Sessions
 - Scans
 - Assessors

Data storage - Overview

- Primary features



Upload data



Organise and share your data



View and download your data



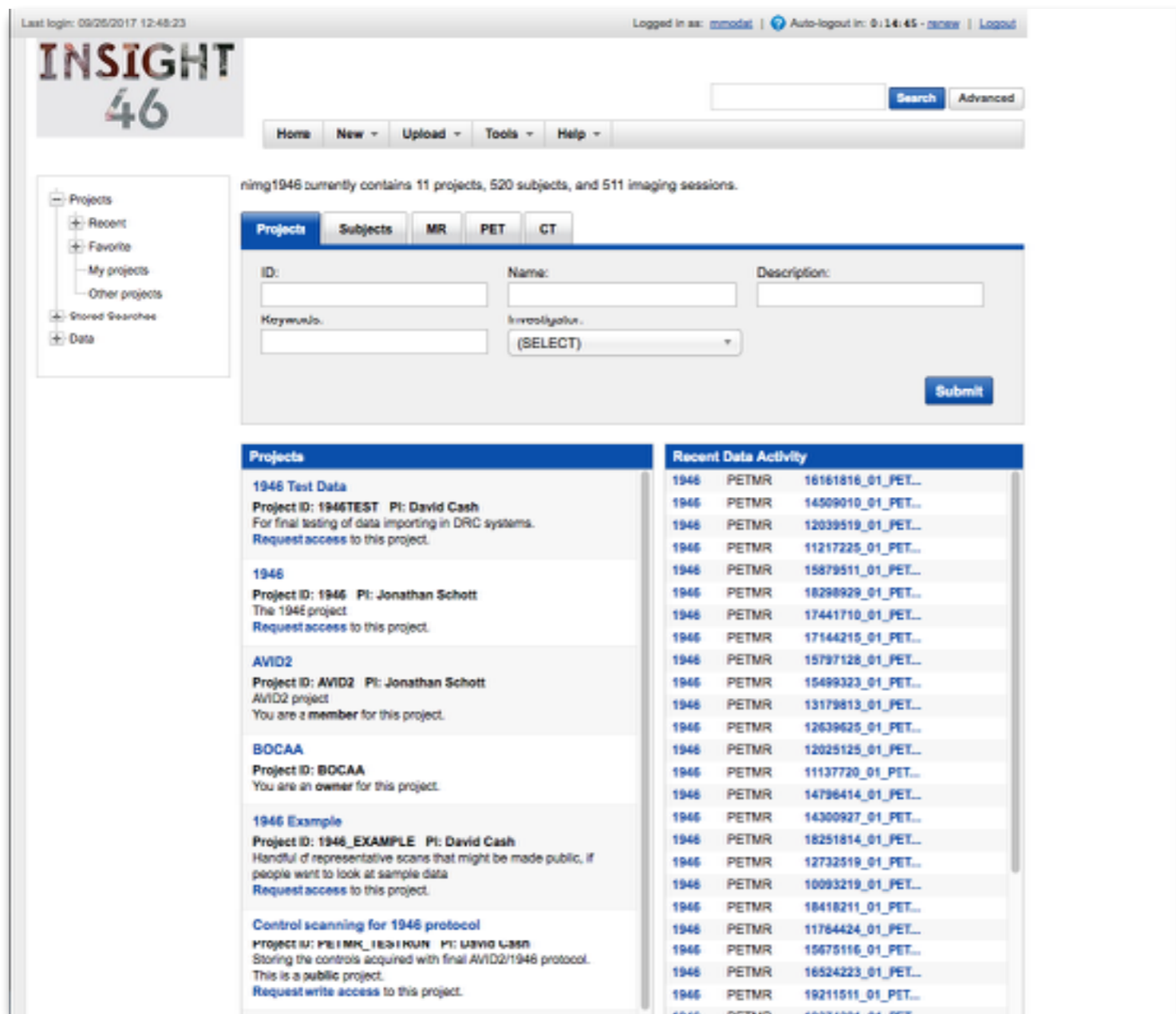
Securing and managing access data



Search and explore large data sets

Data storage - Overview

- Single database to store imaging and non-imaging data



The screenshot shows the INSIGHT 46 web interface. At the top, it displays the user's last login (09/25/2017 12:48:23), the user name (mmodat), and the auto-logout time (0:14:45 - none). The main header includes the INSIGHT 46 logo, a search bar, and navigation tabs for Home, New, Upload, Tools, and Help.

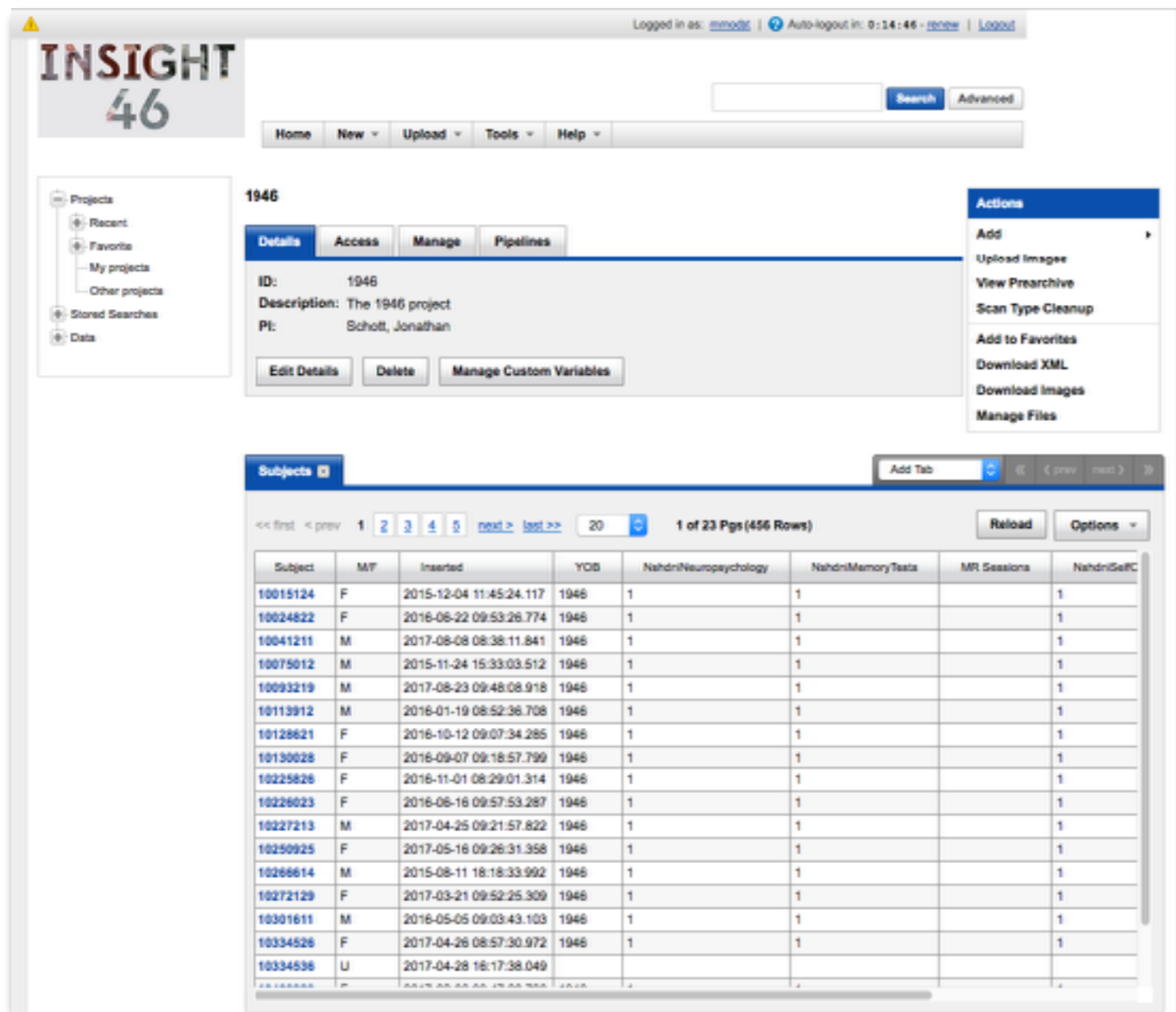
The main content area shows a summary for the 'ning1946' project: 'ning1946 currently contains 11 projects, 520 subjects, and 511 imaging sessions.' Below this is a form to create a new project with fields for ID, Name, Description, Keywords, and Investigation, along with a Submit button.

The interface is divided into two main sections: 'Projects' and 'Recent Data Activity'.

Projects	Recent Data Activity
<p>1946 Test Data Project ID: 1946TEST PI: David Cash For final testing of data importing in DRC systems. Request access to this project.</p>	<p>1946 PETMR 16161816_01_PET...</p>
<p>1946 Project ID: 1946 PI: Jonathan Schott The 1946 project. Request access to this project.</p>	<p>1946 PETMR 14509010_01_PET...</p>
<p>AVID2 Project ID: AVID2 PI: Jonathan Schott AVID2 project You are a member for this project.</p>	<p>1946 PETMR 12039519_01_PET...</p>
<p>BOCAA Project ID: BOCAA You are an owner for this project.</p>	<p>1946 PETMR 11217225_01_PET...</p>
<p>1946 Example Project ID: 1946_EXAMPLE PI: David Cash Handful of representative scans that might be made public, if people want to look at sample data. Request access to this project.</p>	<p>1946 PETMR 15879511_01_PET...</p>
<p>Control scanning for 1946 protocol Project ID: PETMR_TECHNUN PI: DAVID CASH Storing the controls acquired with final AVID2/1946 protocol. This is a public project. Request write access to this project.</p>	<p>1946 PETMR 18298929_01_PET...</p>
	<p>1946 PETMR 17441710_01_PET...</p>
	<p>1946 PETMR 17144215_01_PET...</p>
	<p>1946 PETMR 15797128_01_PET...</p>
	<p>1946 PETMR 15499323_01_PET...</p>
	<p>1946 PETMR 13179813_01_PET...</p>
	<p>1946 PETMR 12639625_01_PET...</p>
	<p>1946 PETMR 12025125_01_PET...</p>
	<p>1946 PETMR 11137720_01_PET...</p>
	<p>1946 PETMR 14796414_01_PET...</p>
	<p>1946 PETMR 14300927_01_PET...</p>
	<p>1946 PETMR 18251814_01_PET...</p>
	<p>1946 PETMR 12732519_01_PET...</p>
	<p>1946 PETMR 10093219_01_PET...</p>
	<p>1946 PETMR 18418211_01_PET...</p>
	<p>1946 PETMR 11764424_01_PET...</p>
	<p>1946 PETMR 15675116_01_PET...</p>
	<p>1946 PETMR 16524223_01_PET...</p>
	<p>1946 PETMR 19211511_01_PET...</p>
	<p>1946 PETMR 18374331_01_PET...</p>

Data storage - Overview

- Single database to store imaging and non-imaging data



The screenshot displays the INSIGHT 46 web application interface. At the top, it shows the user is logged in as 'mmodat' with an auto-logout timer of 0:14:46. The main header includes the 'INSIGHT 46' logo and a search bar. Below the header is a navigation menu with options: Home, New, Upload, Tools, and Help.

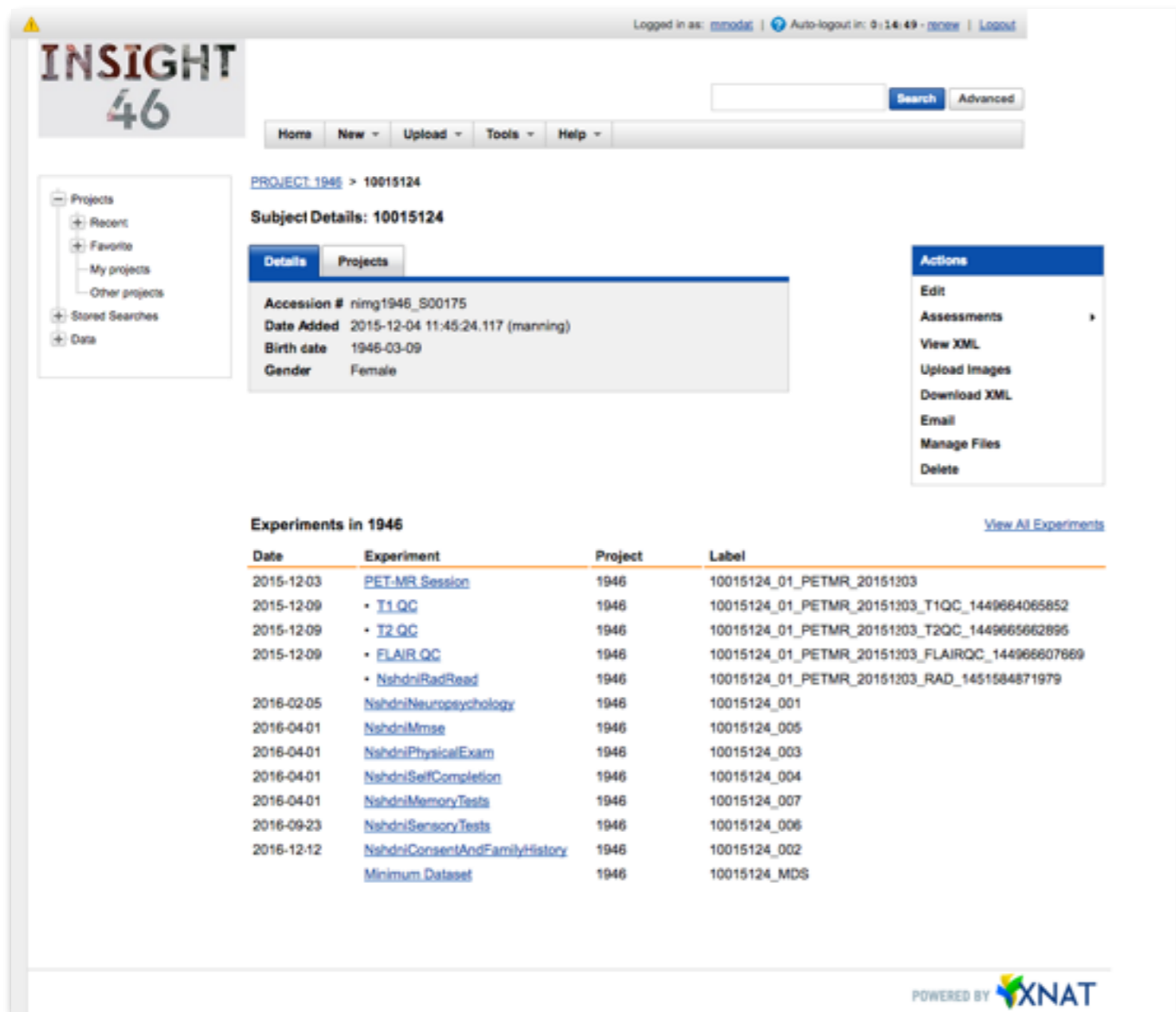
The main content area is divided into two sections. The top section is for project '1946', showing details such as ID (1946), Description ('The 1946 project'), and PI ('Schott, Jonathan'). It includes buttons for 'Edit Details', 'Delete', and 'Manage Custom Variables'. To the right of the details is an 'Actions' menu with options like 'Add', 'Upload Images', 'View Prearchive', 'Scan Type Cleanup', 'Add to Favorites', 'Download XML', 'Download Images', and 'Manage Files'.

The bottom section is a 'Subjects' table with a pagination control showing '1 of 23 Pgs (456 Rows)'. The table has the following columns: Subject, MF, Inserted, YOB, NahnriNeuropsychology, NahnriMemoryTests, MR Sessions, and NahnriGeFC. The table contains 23 rows of subject data.

Subject	MF	Inserted	YOB	NahnriNeuropsychology	NahnriMemoryTests	MR Sessions	NahnriGeFC
10015124	F	2015-12-04 11:45:24.117	1946	1	1		1
10024822	F	2016-08-22 09:53:26.774	1946	1	1		1
10041211	M	2017-08-08 08:38:11.841	1946	1	1		1
10075012	M	2015-11-24 15:33:03.512	1946	1	1		1
10093219	M	2017-08-23 09:48:08.918	1946	1	1		1
10113912	M	2016-01-19 08:52:36.708	1946	1	1		1
10128621	F	2016-10-12 09:07:34.285	1946	1	1		1
10130028	F	2016-09-07 09:18:57.799	1946	1	1		1
10225826	F	2016-11-01 08:29:01.314	1946	1	1		1
10226023	F	2016-06-16 09:57:53.287	1946	1	1		1
10227213	M	2017-04-25 09:21:57.822	1946	1	1		1
10250925	F	2017-05-16 09:26:31.358	1946	1	1		1
10266614	M	2015-08-11 18:18:33.992	1946	1	1		1
10272129	F	2017-03-21 09:52:25.309	1946	1	1		1
10301611	M	2016-05-05 09:03:43.103	1946	1	1		1
10334526	F	2017-04-26 08:57:30.972	1946	1	1		1
10334536	U	2017-04-28 16:17:38.049					

Data storage - Overview

- Single database to store imaging and non-imaging data



INSIGHT 46

Logged in as: mmodat | Auto-logout in: 0:14:49:0000 | Logout

Home New Upload Tools Help

PROJECT 1946 > 10015124

Subject Details: 10015124

Details Projects

Accession # nimg1946_S00175
 Date Added 2015-12-04 11:45:24.117 (manning)
 Birth date 1946-03-09
 Gender Female

Actions

- Edit
- Assessments
- View XML
- Upload Images
- Download XML
- Email
- Manage Files
- Delete

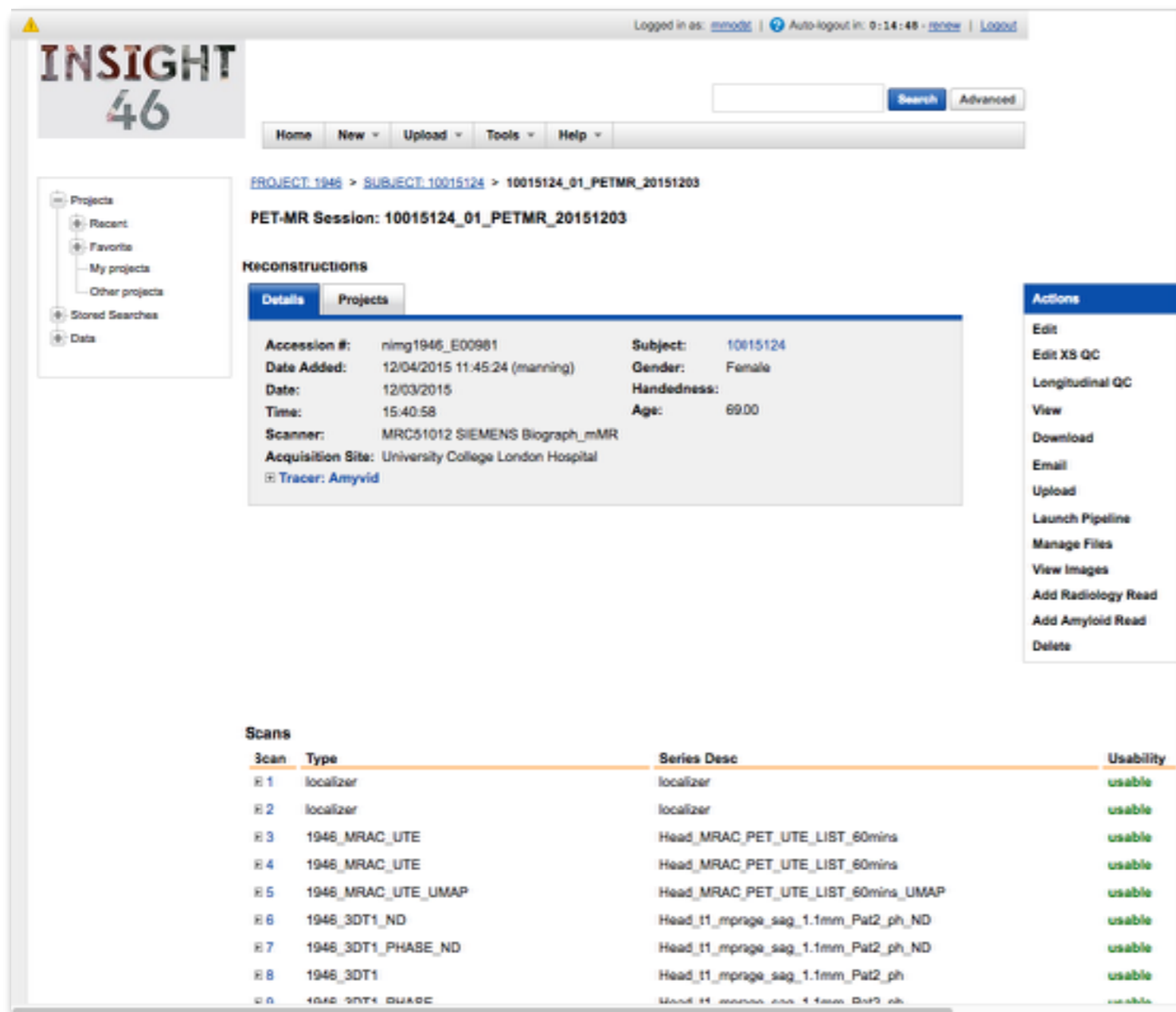
Experiments in 1946 [View All Experiments](#)

Date	Experiment	Project	Label
2015-12-03	PET-MR Session	1946	10015124_01_PETMR_20151203
2015-12-09	• T1_QC	1946	10015124_01_PETMR_20151203_T1QC_1449664065852
2015-12-09	• T2_QC	1946	10015124_01_PETMR_20151203_T2QC_1449665662895
2015-12-09	• FLAIR_QC	1946	10015124_01_PETMR_20151203_FLAIRQC_144966607669
2015-12-09	• NshdniRadRead	1946	10015124_01_PETMR_20151203_RAD_1451584871979
2016-02-05	NshdniNeuropsychology	1946	10015124_001
2016-04-01	NshdniMmse	1946	10015124_005
2016-04-01	NshdniPhysicalExam	1946	10015124_003
2016-04-01	NshdniSelfCompletion	1946	10015124_004
2016-04-01	NshdniMemoryTests	1946	10015124_007
2016-09-23	NshdniSensoryTests	1946	10015124_006
2016-12-12	NshdniConsentAndFamilyHistory	1946	10015124_002
	Minimum Dataset	1946	10015124_MDS

POWERED BY XNAT

Data storage - Overview

- Single database to store imaging and non-imaging data



The screenshot displays the INSIGHT 46 web application interface. At the top, it shows the user is logged in as 'mmodat' with an auto-logout timer of 0:14:48. The main navigation bar includes 'Home', 'New', 'Upload', 'Tools', and 'Help'. A search bar is also present.

The breadcrumb trail indicates the current view: PROJECT: 1946 > SUBJECT: 10015124 > 10015124_01_PETMR_20151203. Below this, the session is identified as 'PET-MR Session: 10015124_01_PETMR_20151203'.

The 'Reconstructions' section is active, showing a 'Details' tab. The details include:

- Accession #: nimg1946_E00981
- Date Added: 12/04/2015 11:45:24 (manning)
- Date: 12/03/2015
- Time: 15:40:58
- Scanner: MRC51012 SIEMENS Biograph_mMR
- Acquisition Site: University College London Hospital
- Tracer: Amyvid
- Subject: 10015124
- Gender: Female
- Handedness:
- Age: 69.00

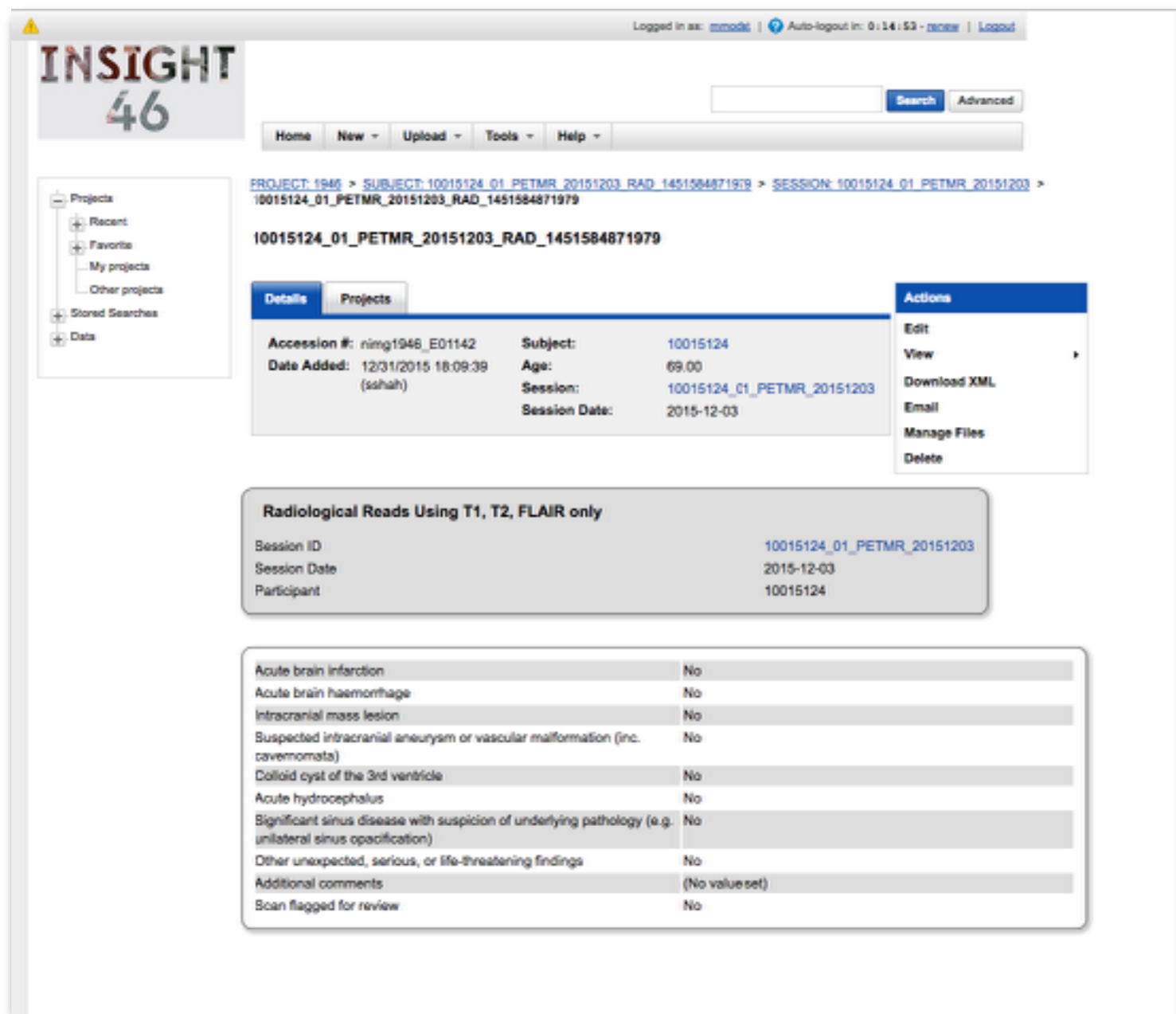
An 'Actions' menu on the right side offers various options such as Edit, Edit XS QC, Longitudinal QC, View, Download, Email, Upload, Launch Pipeline, Manage Files, View Images, Add Radiology Read, Add Amyloid Read, and Delete.

The 'Scans' section at the bottom contains a table with the following data:

Scan	Type	Series Desc	Usability
R 1	localizer	localizer	usable
R 2	localizer	localizer	usable
R 3	1946_MRAC_UTE	Head_MRAC_PET_UTE_LIST_60mins	usable
R 4	1946_MRAC_UTE	Head_MRAC_PET_UTE_LIST_60mins	usable
R 5	1946_MRAC_UTE_UMAP	Head_MRAC_PET_UTE_LIST_60mins_UMAP	usable
R 6	1946_3DT1_ND	Head_t1_mprage_sag_1.1mm_Pat2_ph_ND	usable
R 7	1946_3DT1_PHASE_ND	Head_t1_mprage_sag_1.1mm_Pat2_ph_ND	usable
R 8	1946_3DT1	Head_t1_mprage_sag_1.1mm_Pat2_ph	usable
R 9	1946_3DT1_PHASE	Head_t1_mprage_sag_1.1mm_Pat2_ph	usable

Data storage - Overview

- Single database to store imaging and non-imaging data



The screenshot displays the INSIGHT 46 web interface. At the top, it shows the user is logged in as 'mmodat' with an auto-logout timer of 0:14:53. The main header includes the 'INSIGHT 46' logo and a search bar. A navigation menu contains 'Home', 'New', 'Upload', 'Tools', and 'Help'. On the left, a sidebar lists 'Projects', 'Recent', 'Favorites', 'My projects', 'Other projects', 'Stored Searches', and 'Data'. The main content area shows the breadcrumb path: PROJECT: 1946 > SUBJECT: 10015124_01_PETMR_20151203_RAD_1451584871979 > SESSION: 10015124_01_PETMR_20151203 > 10015124_01_PETMR_20151203_RAD_1451584871979. Below this, the project ID '10015124_01_PETMR_20151203_RAD_1451584871979' is displayed. A table with 'Details' and 'Projects' tabs shows the following information:

Details	Projects	Actions
Accession #: ning1946_E01142	Subject: 10015124	Edit View Download XML Email Manage Files Delete
Date Added: 12/31/2015 18:09:39 (sshah)	Age: 69.00	
	Session: 10015124_01_PETMR_20151203	
	Session Date: 2015-12-03	

Below the table, a section titled 'Radiological Reads Using T1, T2, FLAIR only' contains the following data:

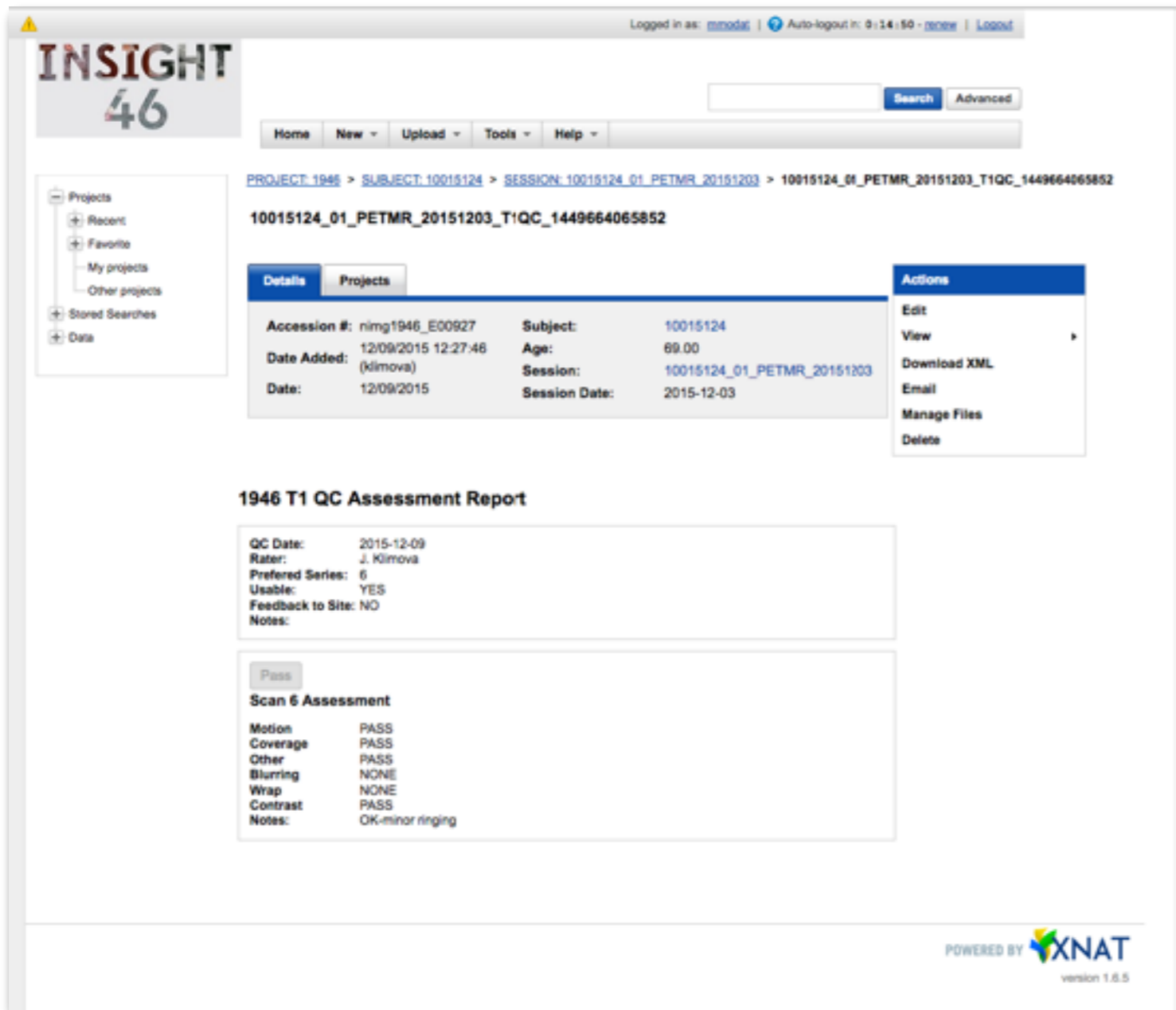
Session ID	10015124_01_PETMR_20151203
Session Date	2015-12-03
Participant	10015124

At the bottom, a table lists various radiological findings:

Acute brain infarction	No
Acute brain haemorrhage	No
Intracranial mass lesion	No
Suspected intracranial aneurysm or vascular malformation (inc. cavernomata)	No
Colloid cyst of the 3rd ventricle	No
Acute hydrocephalus	No
Significant sinus disease with suspicion of underlying pathology (e.g. unilateral sinus opacification)	No
Other unexpected, serious, or life-threatening findings	No
Additional comments	(No value set)
Scan flagged for review	No

Data storage - Overview

- Single database to store imaging and non-imaging data



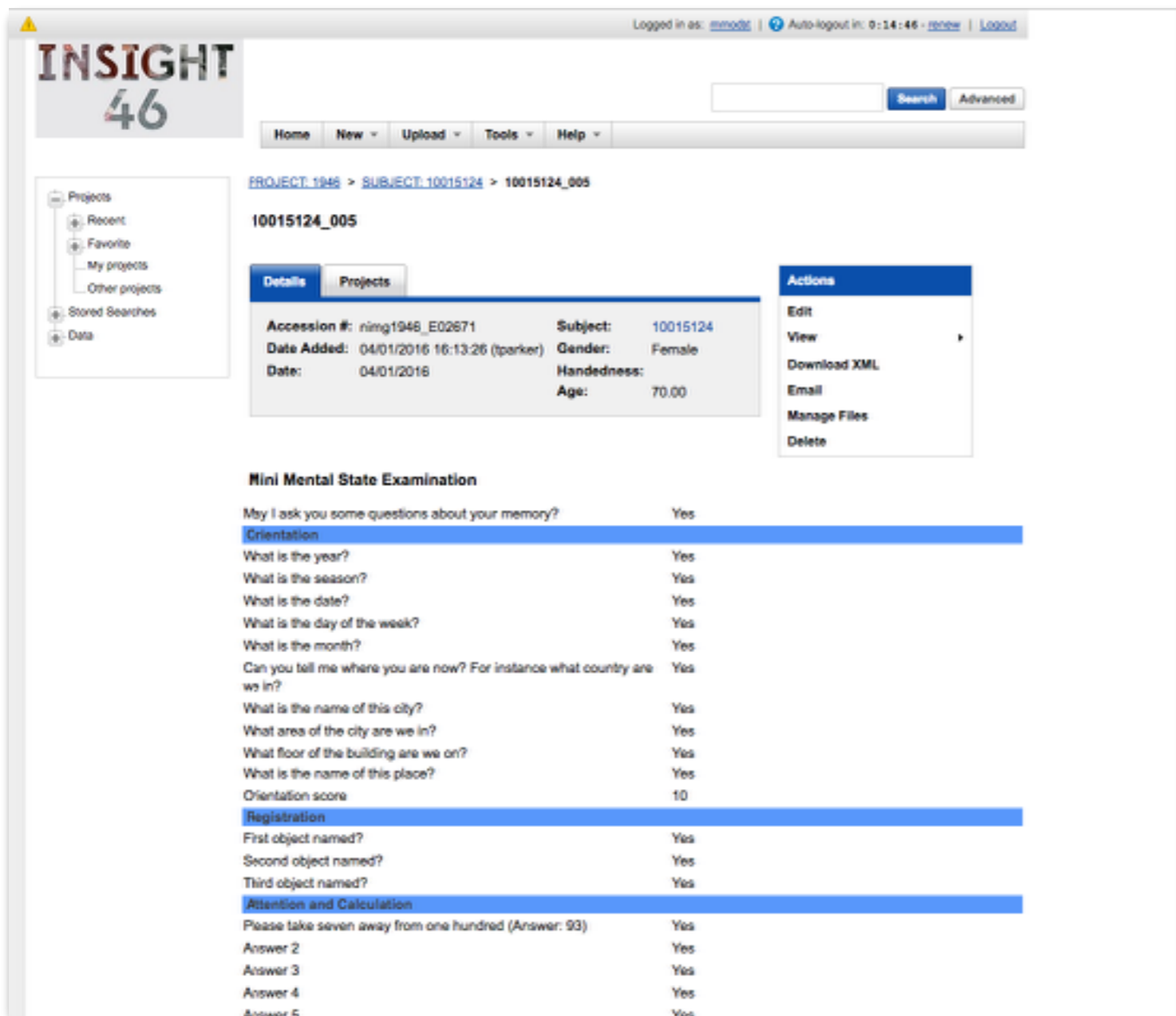
The screenshot displays the INSIGHT 46 web interface. At the top, it shows the user is logged in as 'mmodat' with an auto-logout timer of 0:14:50. The main navigation bar includes 'Home', 'New', 'Upload', 'Tools', and 'Help'. A search bar is also present. The breadcrumb trail indicates the current view: PROJECT: 1946 > SUBJECT: 10015124 > SESSION: 10015124_01_PETMR_20151203 > 10015124_01_PETMR_20151203_T1QC_1449664065852. The main content area shows the project ID '10015124_01_PETMR_20151203_T1QC_1449664065852' and a table of details. To the right of the table is an 'Actions' menu with options like Edit, View, Download XML, Email, Manage Files, and Delete. Below the table is a '1946 T1 QC Assessment Report' section, which includes a 'QC Date' of 2015-12-09, a 'Rater' of J. Klimova, and a 'Scan 6 Assessment' table with results like 'Motion: PASS', 'Coverage: PASS', and 'Notes: OK-minor ringing'. The footer indicates the system is 'POWERED BY XNAT version 1.8.5'.

Details		Projects		Actions	
Accession #:	nimg1946_E00927	Subject:	10015124	Edit	
Date Added:	12/09/2015 12:27:48 (Klimova)	Age:	69.00	View	
Date:	12/09/2015	Session:	10015124_01_PETMR_20151203	Download XML	
		Session Date:	2015-12-03	Email	
				Manage Files	
				Delete	

1946 T1 QC Assessment Report	
QC Date:	2015-12-09
Rater:	J. Klimova
Preferred Series:	6
Usable:	YES
Feedback to Site:	NO
Notes:	
Pass	
Scan 6 Assessment	
Motion	PASS
Coverage	PASS
Other	PASS
Blurring	NONE
Wrap	NONE
Contrast	PASS
Notes:	OK-minor ringing

Data storage - Overview

- Single database to store imaging and non-imaging data



The screenshot shows the INSIGHT 46 web application interface. The top navigation bar includes 'Home', 'New', 'Upload', 'Tools', and 'Help'. A search bar is located on the right. The main content area displays the following information:

PROJECT: 1946 > SUBJECT: 10015124 > 10015124_005

10015124_005

Details | **Projects**

Accession #:	ning1946_E02671	Subject:	10015124
Date Added:	04/01/2016 16:13:26 (tparker)	Gender:	Female
Date:	04/01/2016	Handedness:	
		Age:	70.00

Actions

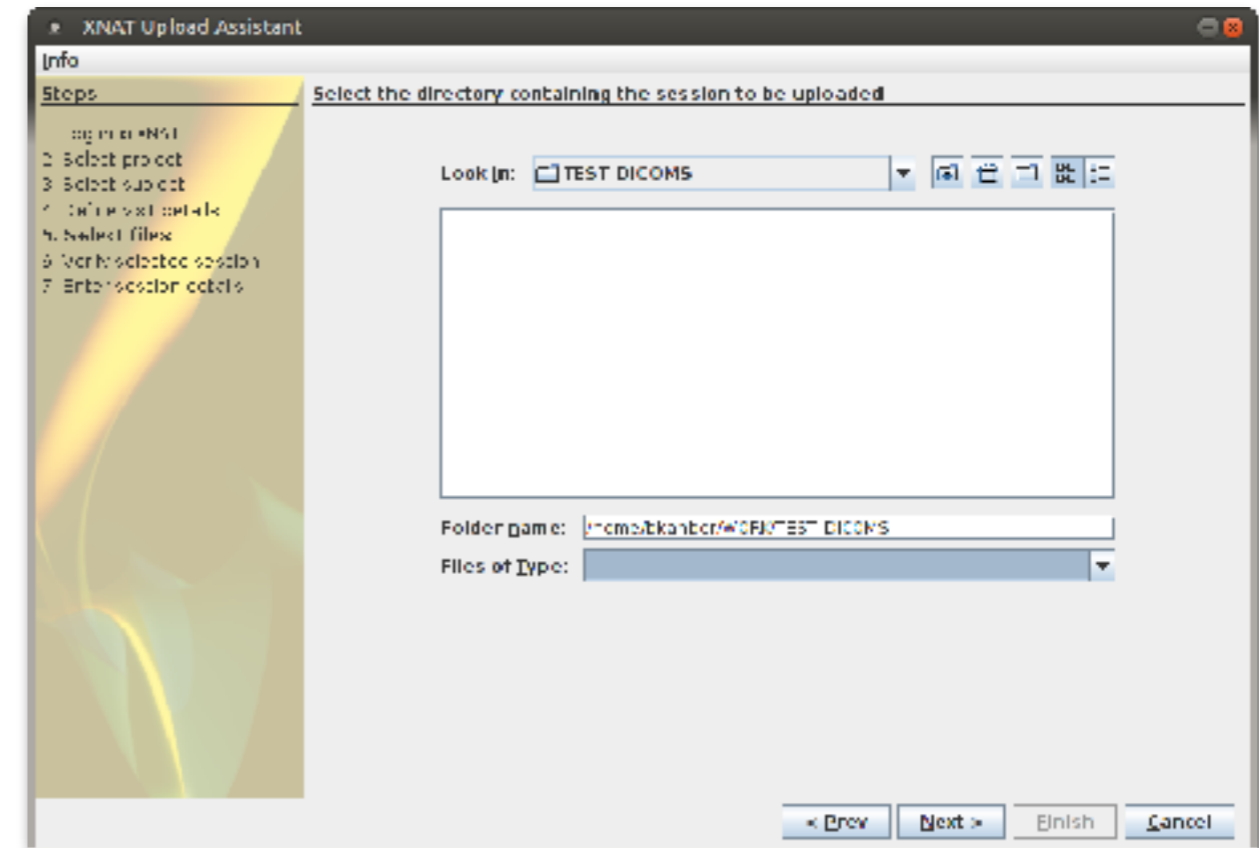
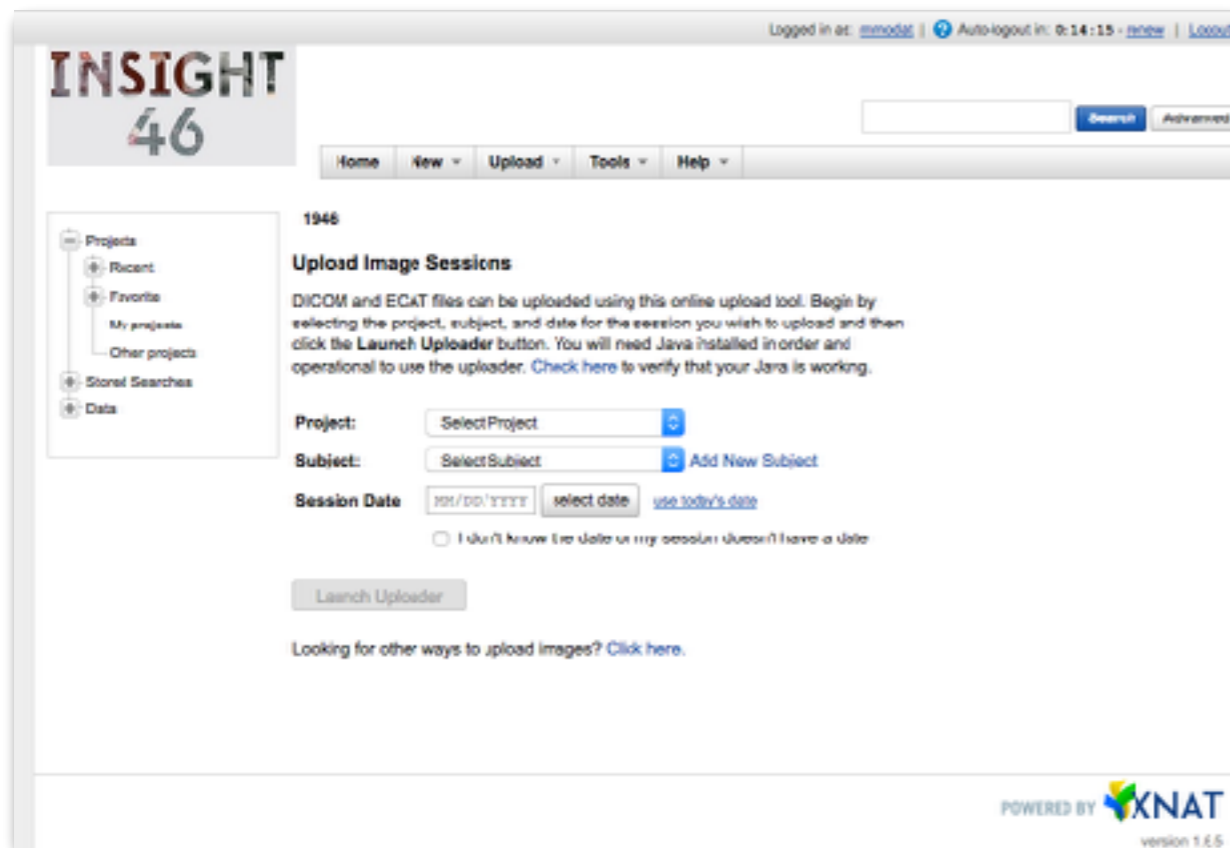
- Edit
- View
- Download XML
- Email
- Manage Files
- Delete

Mini Mental State Examination

May I ask you some questions about your memory?	Yes
Orientation	
What is the year?	Yes
What is the season?	Yes
What is the date?	Yes
What is the day of the week?	Yes
What is the month?	Yes
Can you tell me where you are now? For instance what country are we in?	Yes
What is the name of this city?	Yes
What area of the city are we in?	Yes
What floor of the building are we on?	Yes
What is the name of this place?	Yes
Orientation score	10
Registration	
First object named?	Yes
Second object named?	Yes
Third object named?	Yes
Attention and Calculation	
Please take seven away from one hundred (Answer: 93)	Yes
Answer 2	Yes
Answer 3	Yes
Answer 4	Yes
Answer 5	Yes

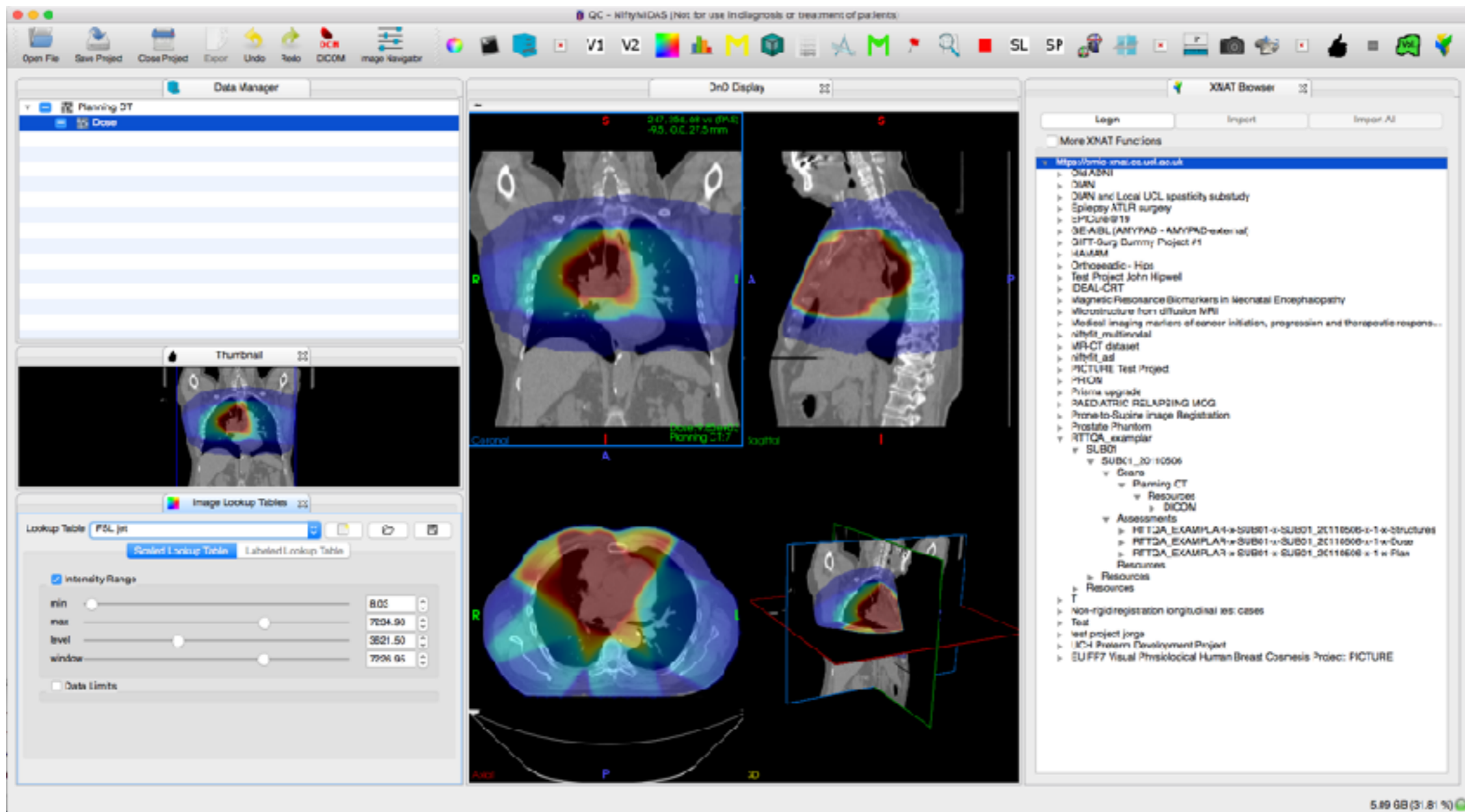
Data storage - Interaction

- Several solutions for data upload
 - DICOM Push (pre-archiving system)
 - Rest-API (https)



Data storage - Interaction

- Data access and interaction
 - Possibility to automate download for visualisation






Automated processing

- Expected outcome: Processed data made available automatically into the same framework

Scans

Scan	Type	Series Desc	Usability	Files	Note
0002	MPRAGE	Sag_MPRAGE	usable	8.8 MB in 1 files	Xnatupload
0015	ep2d_diff_MDDW_p2FAD_2.5mm_iso_B0	ep2d_diff_MDDW_p2FAD_2.5mm_iso_B0	usable	3.3 MB in 1 files	Xnatupload
0016	ep2d_diff_MDDW_p2FAD_2.5mm_iso_4D	ep2d_diff_MDDW_p2FAD_2.5mm_iso_4D	usable	26.0 MB in 4 files	Xnatupload
0022	FLAIR	t2_tirm_tra_dark-fluid	usable	5.6 MB in 1 files	Xnatupload
0023	gre_field_mapping_4x4x4_baseline	gre_field_mapping_4x4x4_baseline	usable	315.7 KB in 1 files	Xnatupload
0024	gre_field_mapping_4x4x4_baseline	gre_field_mapping_4x4x4_baseline	usable	322.5 KB in 1 files	Xnatupload
				Total: 44.3 MB in 9 files	

Processing

Type	PDF	Proc Date	Proc ID	Job Status	QC Status	Files
BaMoS_v1		2016-12-21	prion-x-009LSF37PC-x-009LSF37PC_20090702-x-BaMoS_v1	COMPLETE	Needs QA	Show Counts
GIF_Parcellation_v1		2016-02-15	prion-x-009LSF37PC-x-009LSF37PC_20090702-x-0002-x-GIF_Parcellation_v1	COMPLETE	Needs QA	Show Counts
GIF_Parcellation_v2		2016-12-16	prion-x-009LSF37PC-x-009LSF37PC_20090702-x-0002-x-GIF_Parcellation_v2	COMPLETE	Needs QA	Show Counts

Automation of the processing

- DAX - Distributed Automation for XNAT
<https://github.com/VUIIS/dax>
- Python open-source project
- Developed at Vanderbilt University, Nashville, US
- Interact with XNAT through the rest-API
- Automatically sync/manage/maintain interactions between XNAT and a computer cluster

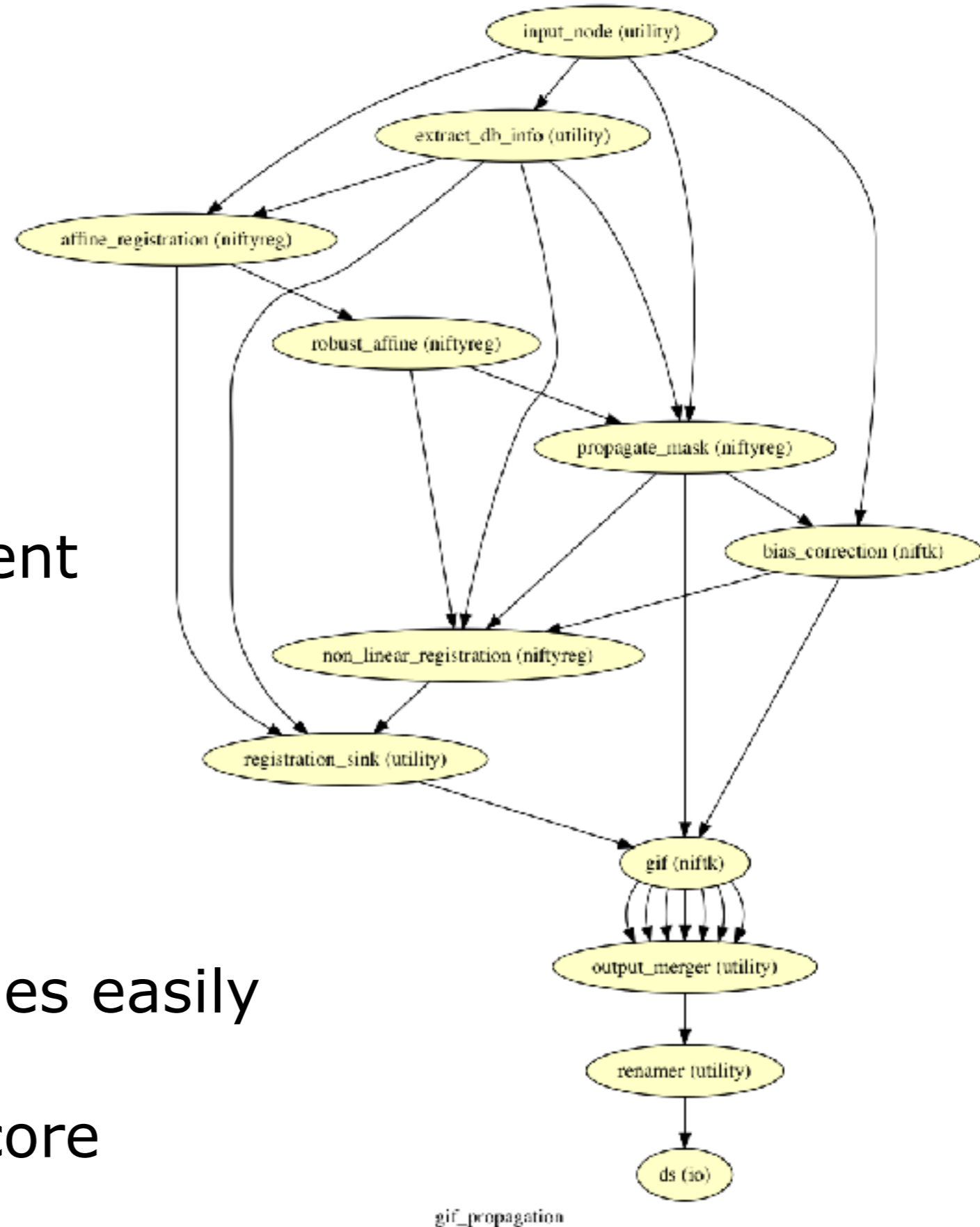
Image Processing

- Harmonisation of the processing pipelines to:
 - avoid re-inventing the wheel
 - avoid duplicates with small alterations
 - ensure we maximise expertise



What is Nipype?

- Processing framework in Python
- Enables inter-operability between tools from different packages
- Facilitate the creation of analytical pipelines
- Possibility to share pipelines easily
- Take advantage of multi-core or cluster environment



What is Nipype?

- Interface to popular tools

AFNI

ANTS

BrainSuite

Camino

CMTK

dcm2nii

diffusion tk

dipy

Elastix

Freesurfer

FSL

MINC

mrtrix

NiftyFit

NiftyReg

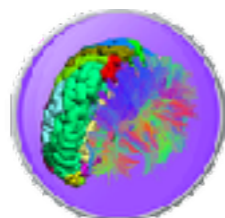
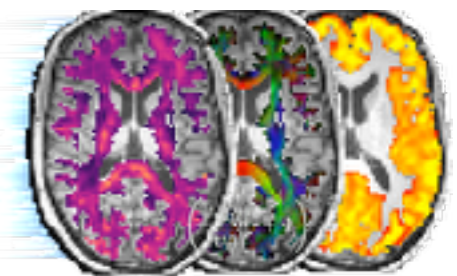
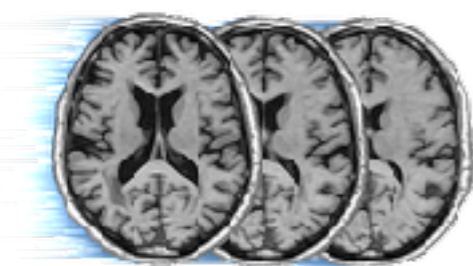
NiftySeg

Semtools

Slicer

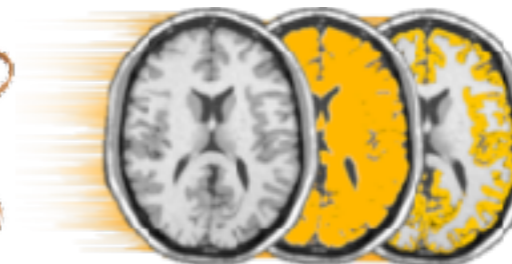
SPM

...



3DSlicer

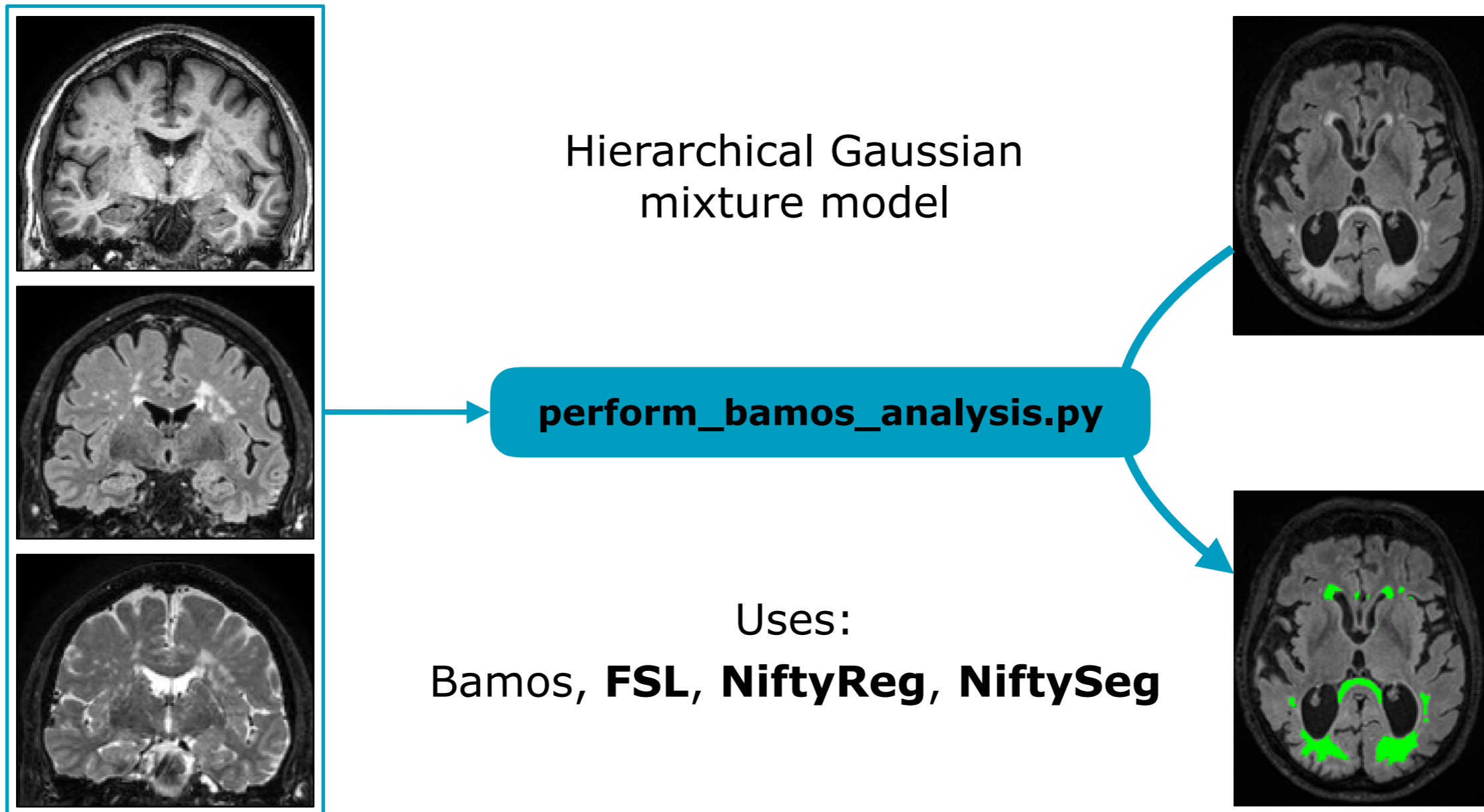
elasti





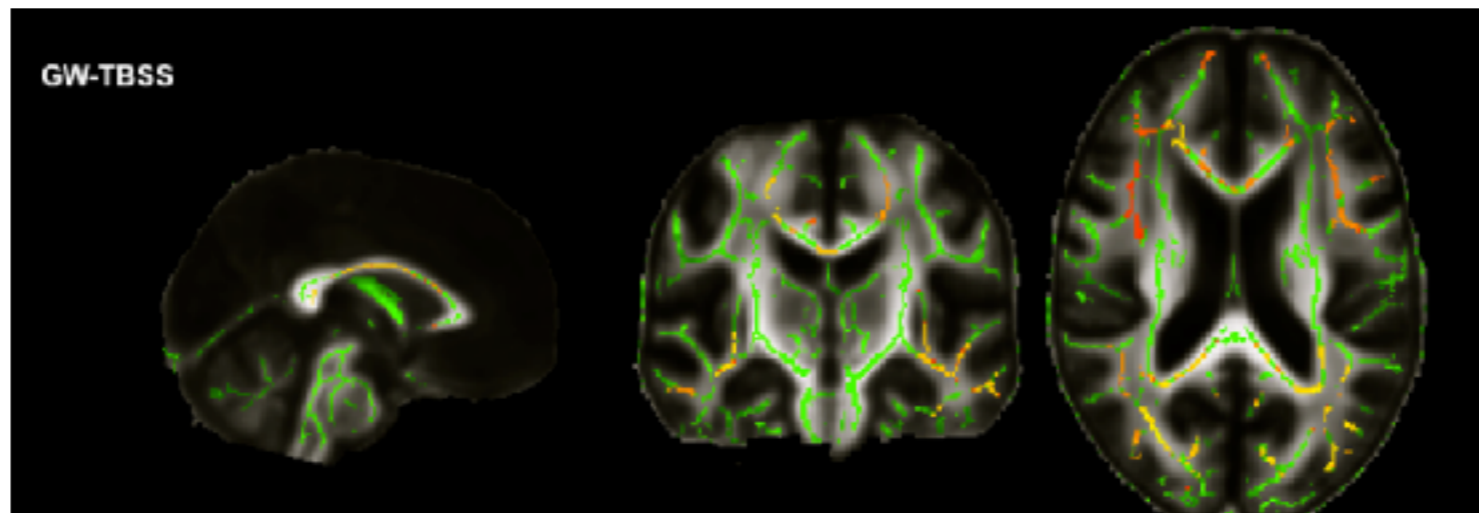
Examples of processing pipeline

- Using structural MRIs: White Matter Lesion Segmentation by Sudre *et al.*, TMI, 2015



Examples of processing pipeline

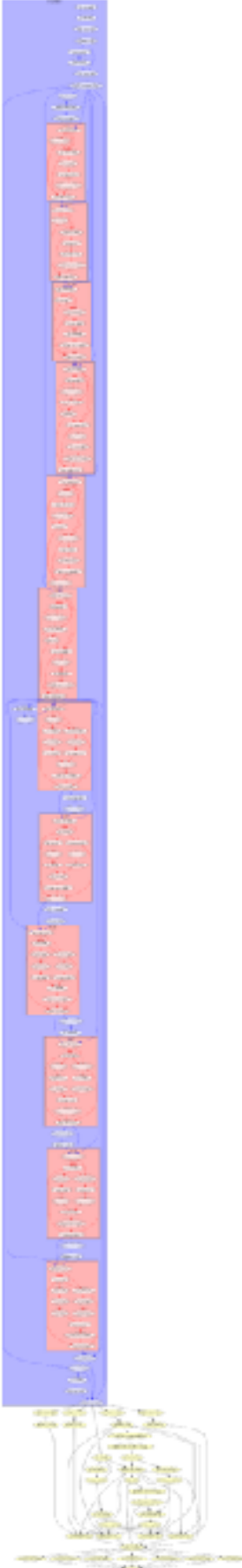
- Diffusion MRI: GroupWiseTract-Based Spatial Statistics as in Keihaninejad *et al.*, PlosOne, 2012



`perform_dti_tbss_cross_sectional.py`

Uses:

DTI-TK, **FSL**, **NiftyReg**, **NiftySeg**

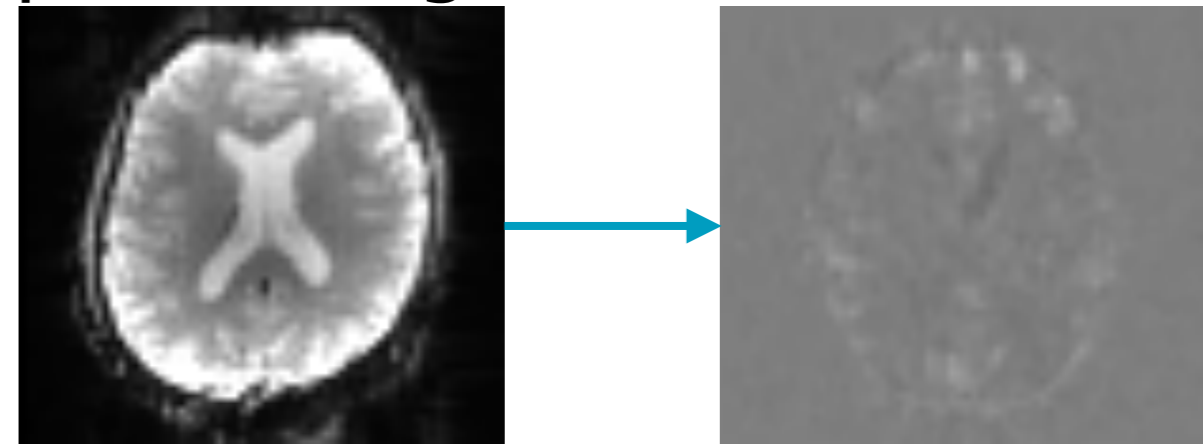




Examples of processing pipeline

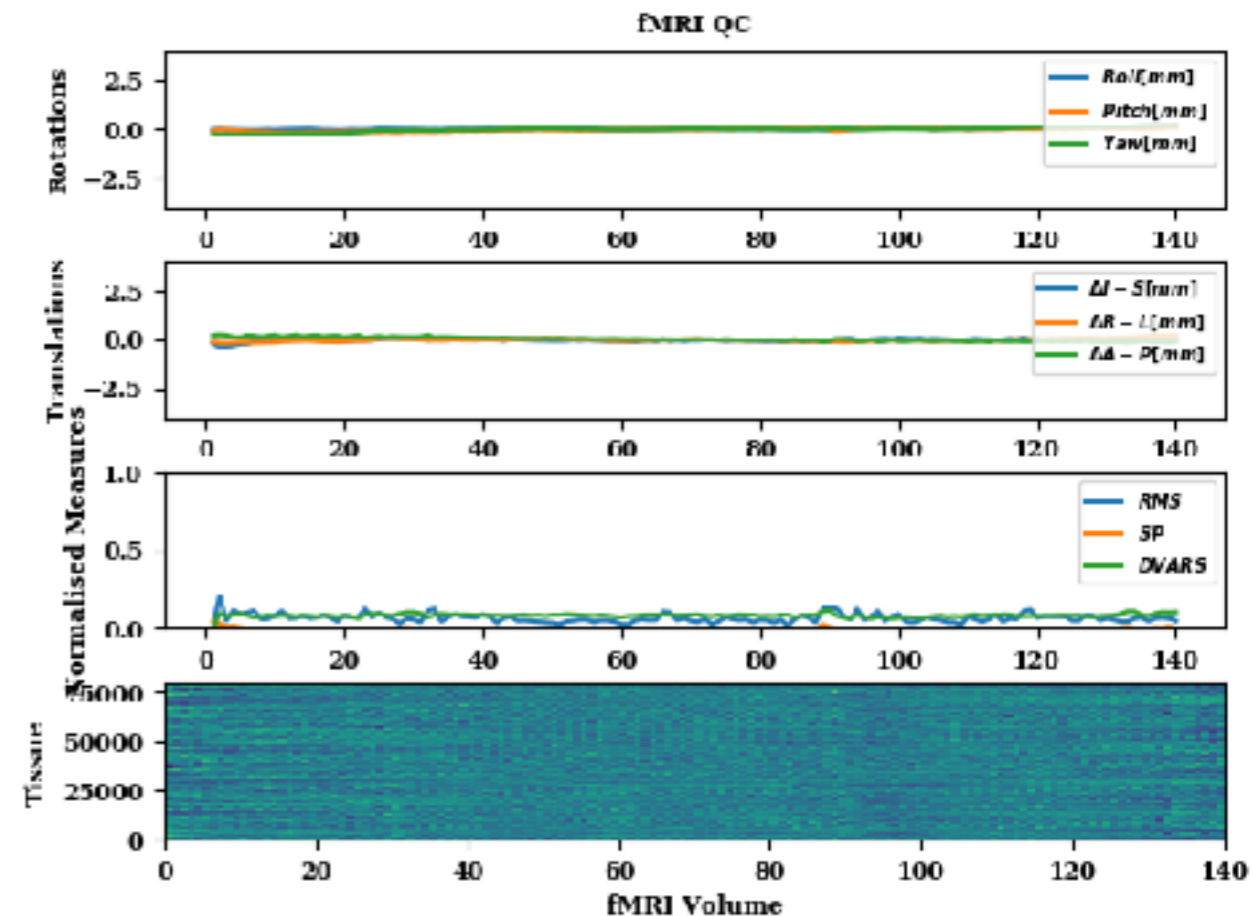
- resting-state function MRI: Preprocessing

Motion correction (as in DWI processing)
 EPI distortion (as in DWI processing)
 Frequency filtering
 Baseline removal
 Parcelation propagation (from GIF)



`perform_restingstate_preprocessing.py`

Uses:
AFNI, NiftyReg





Examples of processing pipeline

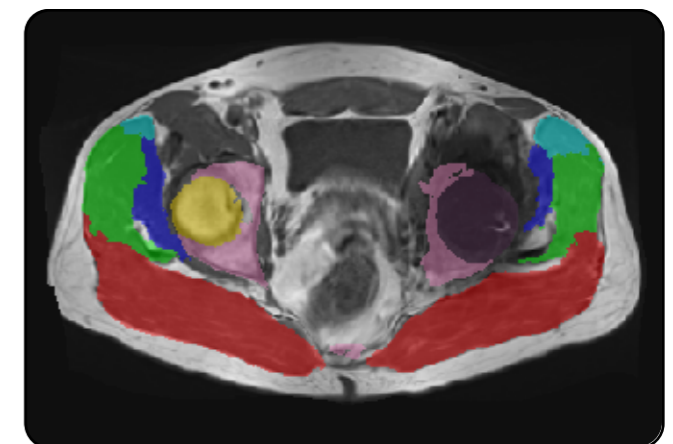
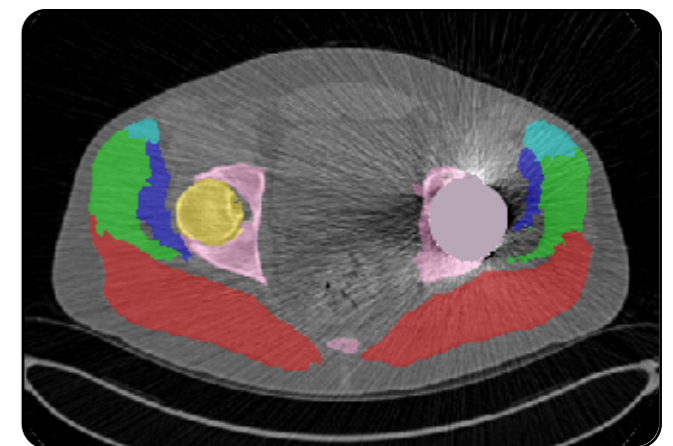
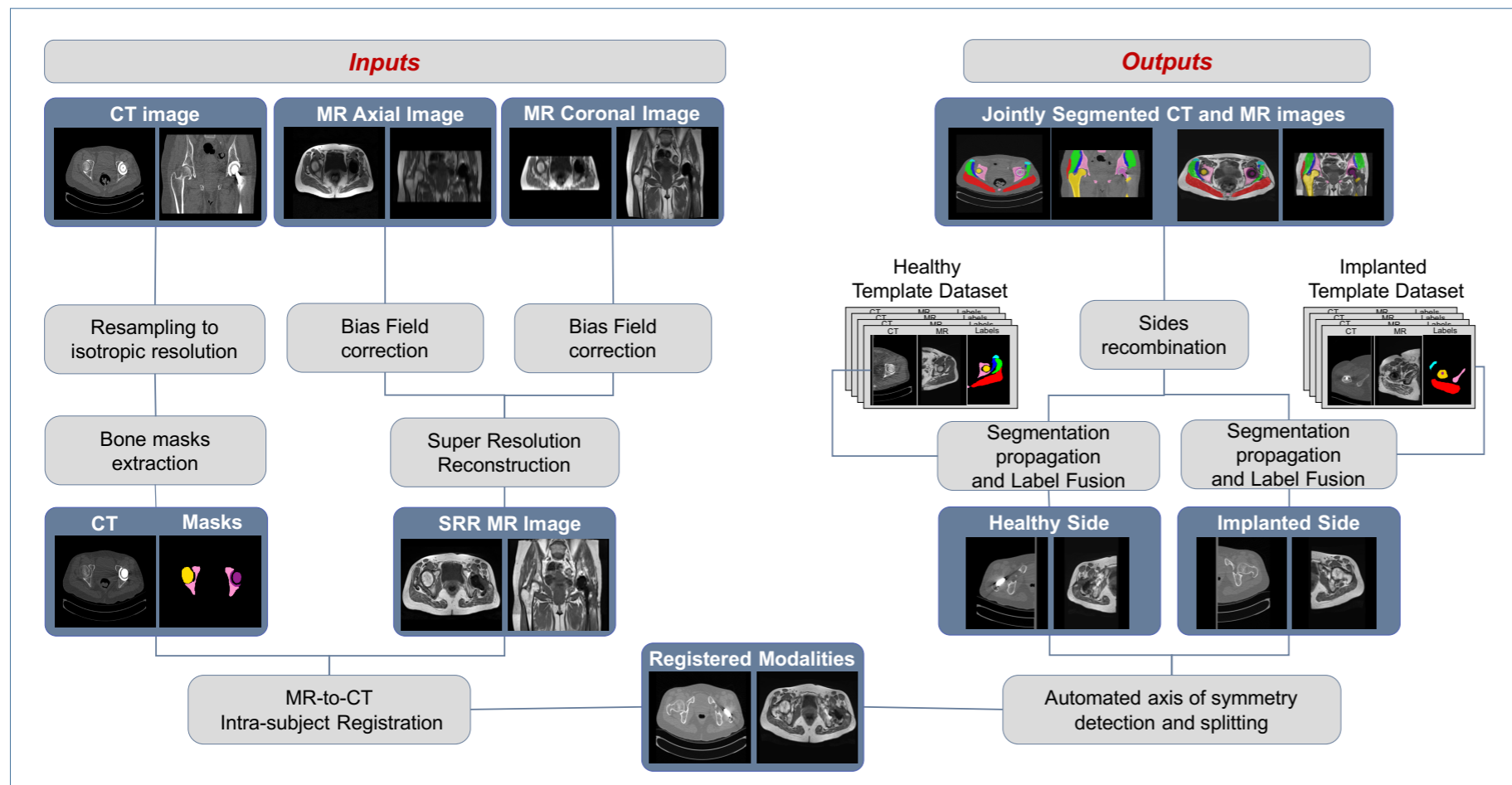
- PET-MRI: CT Synthesis





Examples of processing pipeline

- Musculoskeletal: muscles and bones segmentation

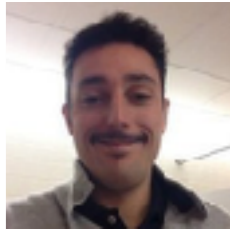
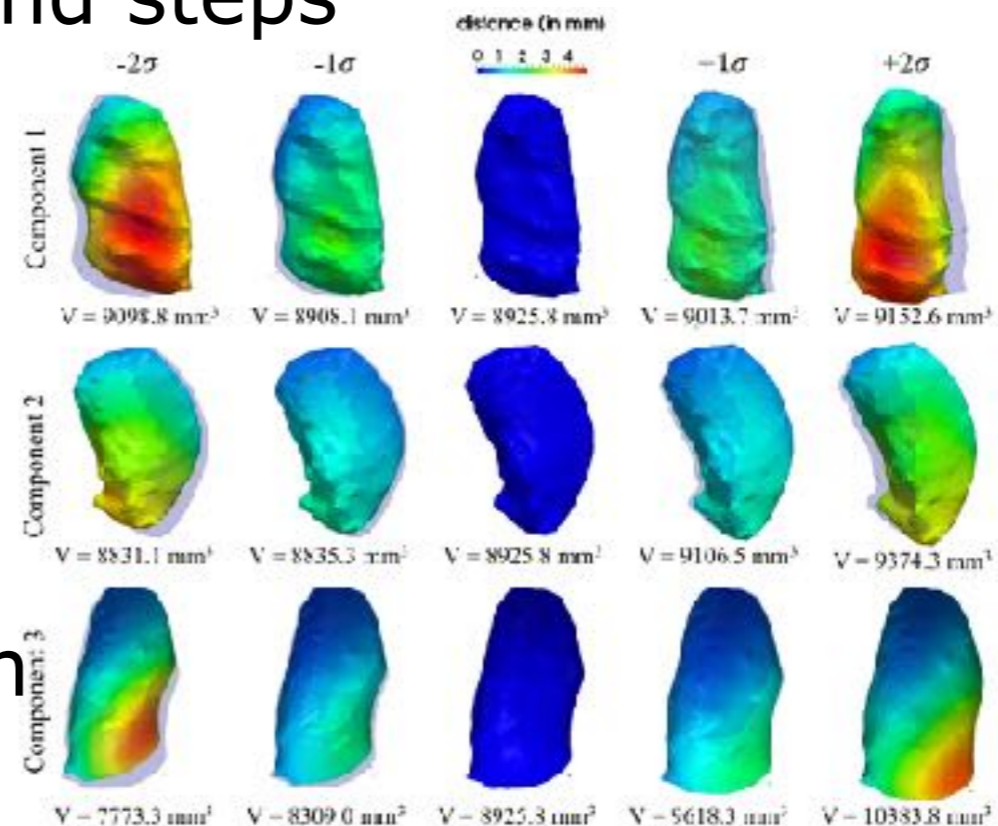


Uses:

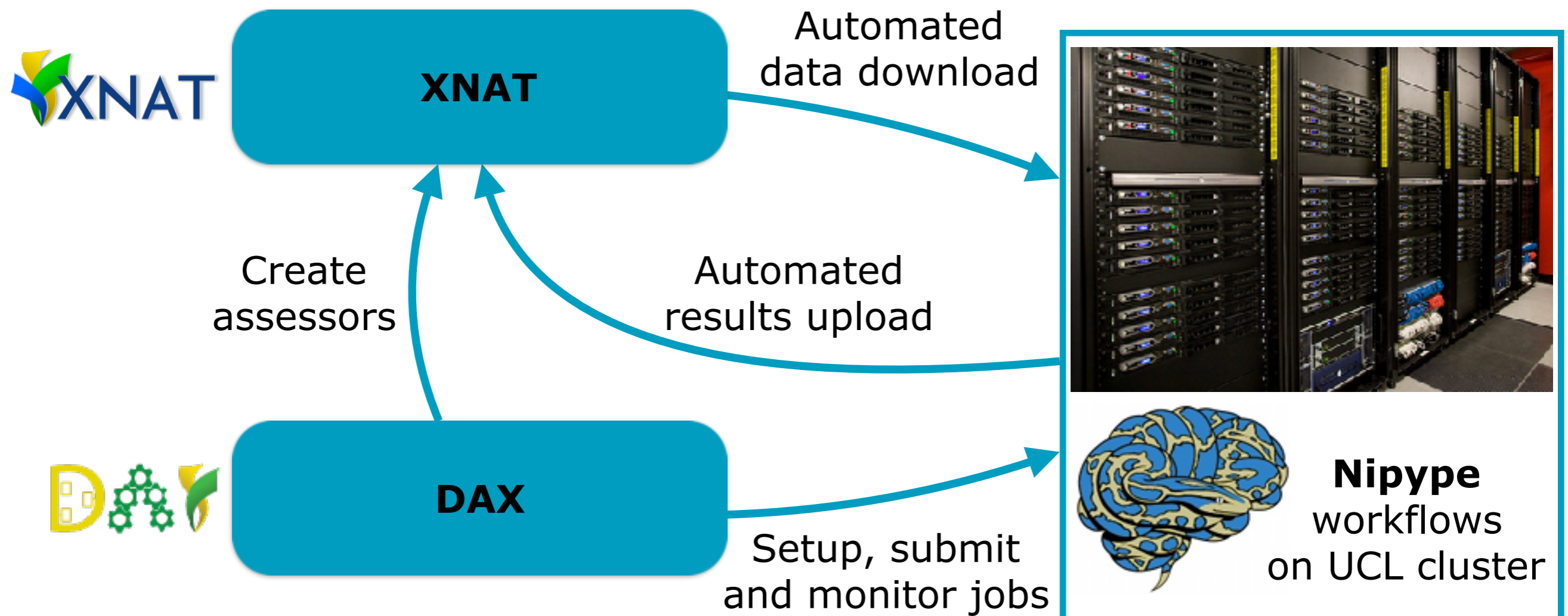
FSL, NiftyReg, NiftySeg

Examples of processing pipeline

- Some more have been implemented
 - Boundary Shift Integral
 - Geodesic Information Flow and steps
 - Regional statistics
 - Bias field correction
 - DTI and NODDI processing
 - fMRI processing
 - Gradwarp correction
 - Freesurfer
 - PET partial volume correction
 - ...



Overall platform





Thank you for your attention

Comments? Questions?

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