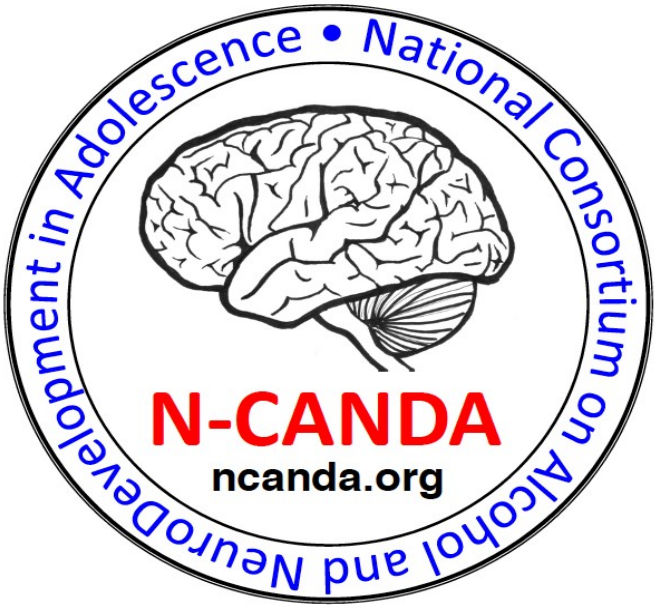
National Consortium on Alcohol and NeuroDevelopment in Adolescence



Magnetic Resonance Imaging and Image Management

Technical Manual

January 12, 2014

Portions of this manual were adapted and reproduced from the "*ADNI 2 MRI Technical Manual*," available from http://adni-info.org/Scientists/ProceduresManuals.aspx, by kind permission of the Alzheimer's Disease Neuroimaging Initiative.

The National Consortium on Alcohol and NeuroDevelopment in Adolescence

Funded by the National Institute on Alcohol Abuse and Alcoholism (NIAAA)

Administrative Component

University of California, San Diego (1 U01 AA021695)
Sandra A. Brown, PhD, and Susan F. Tapert, PhD

Data Integration and Informatics Component

SRI International (1 U01 AA021697)
Adolf Pfefferbaum, MD, and Torsten Rohlfing, PhD

Data Collection Sites

Duke University (1 U01 AA021681)
Michael D. DeBellis, MD

SRI International (1 U01 AA021696)
Ian M. Colrain, PhD, and Fiona Baker, PhD

Oregon Health Sciences University (1 U01 AA021691)
Bonnie J. Nagel, PhD

University of California, San Diego (1 U01 AA021692)
Susan F. Tapert, PhD

University of Pittsburgh (1 U01 AA021690)
Duncan Clark, MD, PhD

For inquiries regarding this manual, contact Torsten Rohlfing, torsten@synapse.sri.com

Table of Contents

1 Subject Scanning

1.1 Scanner Patient Registration

1.1.1 Subject Numbering Scheme

Subject numbers are assigned according to the following scheme:

S-NNNNN-G-C

where:

S ____one-character Site ID Letter, assigned by the Administrative Component. Site IDs have been communicated to the Site PIs. **The assignment of IDs to sites is confidential to avoid geographic localization of subjects.**

N____five-digit subject "sequence" number. Returning subjects are not assigned a new number but keep their previously assigned number.

G____subject gender code, "M" for male and "F" for female, "P" for phantom.

C ____one-digit check sum computed from the subject's birth date as follows:

Write numerical subject birth date, using 4-digit year, e.g., for 24th October 1998, write:

10/24/1998

Add all digits of the birth date and keep last digit of the result as check sum, C. In the example above,

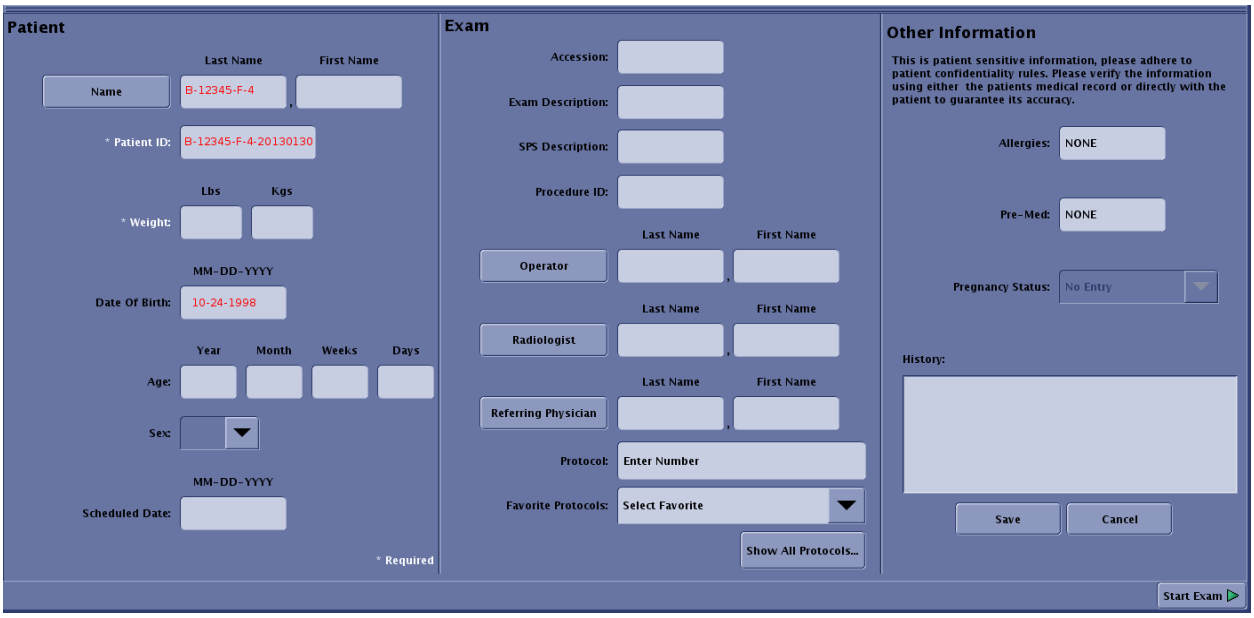
1+0+2+4+1+9+9+8 = 34

C = 4

1.1.2 Data Entry on GE Scanners

Entering subject and session data according to the instructions below will reduce the need to correct these later when uploading images to the XNAT image management system.

Below is an example patient registration screen for GE scanners (different software versions may exhibit differences in the appearance of this screen):



Enter at least the following subject data (example in the format specified by the consortium is shown in red in the above screen shot):

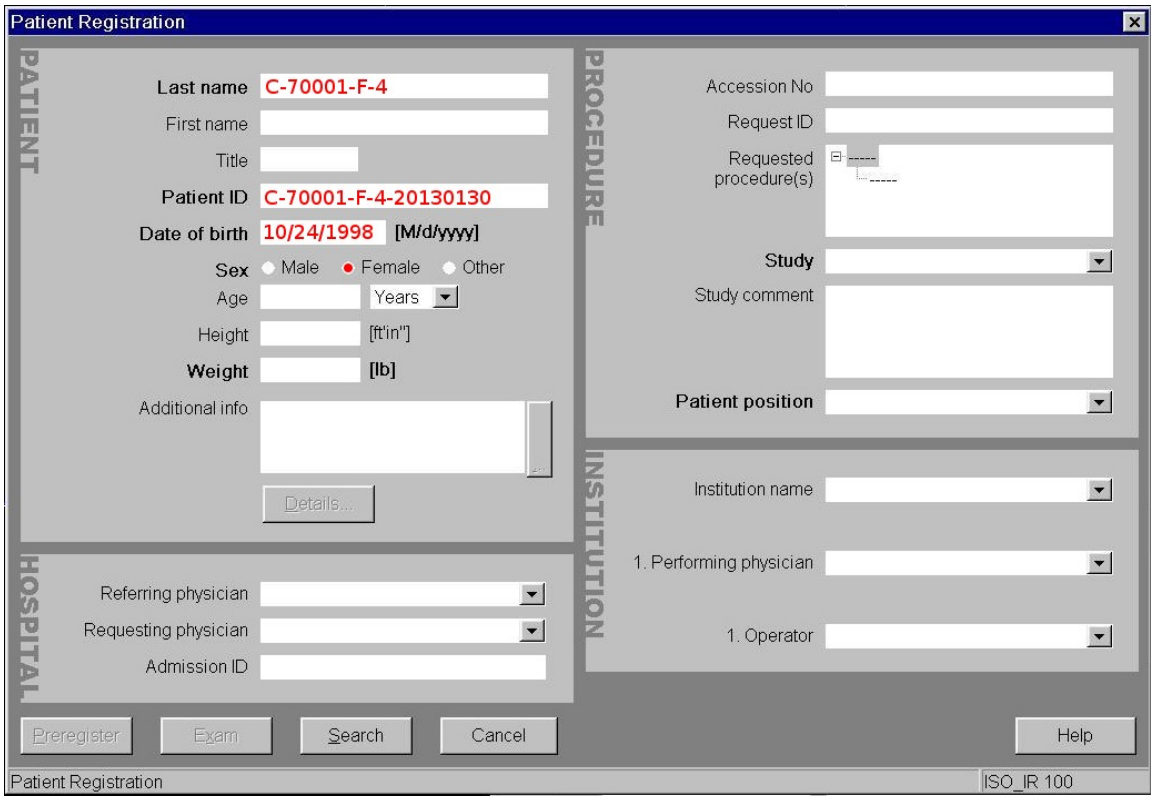
1. In the **"Last Name"** field, enter the subject's Consortium ID. An example entry could be **"B-12345-F-4"**
2. In the **"Patient ID"** field, enter the Consortium ID followed by a hyphen ("-"), followed by the date in eight-digit YYYYMMDD format (year, then month, then day). An example entry could be **"B-12345-F-4-20130130"**
3. If permitted by your site's IRB, enter subject date of birth in the **"Date of Birth"** field. If this is not permitted (e.g., for scans at Stanford), enter subject age in years.
4. Select the applicable subject sex.

When scanning phantoms, use their respective "Subject ID" (i.e., "B-99999-P-9" or "B-00000-P-0" for Site "B", analogous for other sites) in place of the subject ID in the above. That is, enter the phantom ID as "Last Name" and phantom ID, hyphen, and date as "Patient ID."

1.1.3 Data Entry on Siemens Scanners

Entering subject and session data according to the instructions below will reduce the need to correct these later when uploading images to the XNAT image management system.

Below is an example patient registration screen for Siemens scanners (different software versions may exhibit differences in the appearance of this screen):



Enter at least the following subject data (example in the format specified by the consortium is shown in red in the above screen shot):

1. In the **"Patient Name"** field, enter the subject's Consortium ID. An example entry could be **"C-70001-F-4"**
2. In the **"Patient ID"** field, enter the Consortium ID followed by a a hyphen ("-"), followed by the date in eight-digit YYYYMMDD format (year, then month, then day). An example entry could be **"C-70001-F-4-20130130"**
3. If permitted by your site's IRB, enter subject date of birth in the **"Date of birth"** field. If this is not permitted, enter subject age in years.
4. Check appropriate subject sex selection

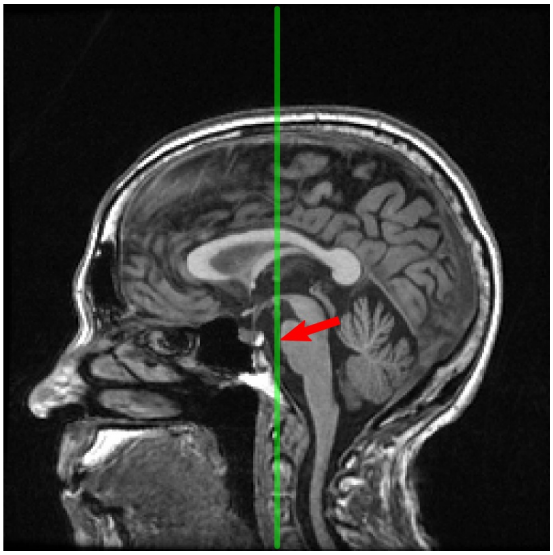
When scanning phantoms, use their respective "Subject ID" (i.e., "C-99999-P-9" or "C-00000-P-0" for Site "C", analogous for other sites) in place of the subject ID in the above. That is, enter the phantom ID as "Patient Name" and phantom ID, hyphen, and date as "Patient ID."

1.2 Subject Positioning

If the head coil's iso center is marked, align it with the subject's nasion (see figure below). Also use the nasion for landmarking of the subject position inside the magnet.

1.3 Scan Prescription

Prescribe the structural imaging series (SPGR and T2-FSE) such that the vertical midline of the sagittal slice (running in the patient I/S direction; see green line in Figure) aligns with the front of the pons (see red arrow in Figure).



1.4 Scan Protocol

1.4.1 GE Scanners

On GE Scanners, the standard imaging session contains the following series, in this order:

1. **ncanda-localizer-v1**
2. **ncanda-calibration-v1**
3. **ncanda-t1spgr-v1**
4. **ncanda-t2fse-v1**
5. **ncanda-dti6b500pepolar-v1**
6. **ncanda-dti60b1000-v1**

7. **ncanda-grefieldmap-v1**
8. **ncanda-rsfmri-v1**

1.4.2 Siemens Scanners

On Siemens scanners, the standard imaging sequence contains the following series, in this order:

1. **ncanda-localizer-v1**
2. **ncanda-mprage-v1**
3. **ncanda-t2fse-v1**
4. **ncanda-dti6b500pepolar-v1**
5. **ncanda-dti60b1000-v1**
6. **ncanda-grefieldmap-v1**
7. **ncanda-grefieldmap-v1**
8. **ncanda-rsfmri-v1**

1.4.3 Recovery from Scan Interruptions

When a session has to be interrupted, e.g., because the subject needs to visit the restroom, the following rules should be applied to determine how to proceed (assuming the subject is willing to continue the scanning and sufficient time is available):

If the interruption occurs during

1. SPGR or MP-RAGE series: Start the entire protocol from the beginning.
2. T2-weighted FSE series: Start the entire protocol from the beginning.
3. Dti6b500pepolar or dti60b1000: Repeat from the dti6b500pepolar series (preceded by localizer and, on GE, calibration scans). Do not repeat only the dti60b1000 series – it is not useful without the dti6b500pepolar series acquired right before.
4. GRE Fieldmap: Repeat from this series.
5. Rs-fMRI: Repeat from the GRE fieldmap (preceded by localizer and, on GE, calibration scan).

2 Phantom Scanning

2.1 Structural Imaging Phantom (ADNI Phantom)

The purpose of the structural imaging phantom is to track and quantify nonlinear spatial distortion of each scanner. Phantom scans can also be used to correct these distortions in subject images acquired on the same scanner and day. The phantom scans are also used to quantify image signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR). A photograph of the phantom is shown on the right.

The structural imaging phantom must be scanned on **every calender day when a subject is also scanned**. If a site uses more than one scanner, the phantom must be scanned **on each scanner** if a subject is scanned using that scanner on that day. This is independent of whether the scanners are identical models or not.

It is suggested that the phantom be scanned immediately after the first subject of the day is removed from the scanner. If this is not feasible or when it has been forgotten, the phantom can be run after subsequent subjects, or separately from any subjects.

Having multiple phantom scans from the same day is always strongly preferred over not having any phantom scan for a given date. Therefore, when in doubt if the phantom has already been scanned on that day, simply scan the phantom again.

2.1.1 Phantom Scan Preparation

The phantom should be handled and positioned in the scanner in accordance with the phantom manual[1], which should accompany each phantom.

The phantom manual states, "t*he established protocol for the ADNI study is to position the phantom's flat side on anterior and then rotate the phantom on the rounded fill port until the L, R (for left and right) and I, S (for inferior and superior) are in the correct position with regard to the patient table. Positioning pads or foam can be used to stabilize the phantom in the correct orientation.*"

At the console:

- Open a new scan session for the phantom to keep phantom and subject images separate.
- As the "Last Name" or "Patient Name" (depending on your scanner) enter the following for the ADNI phantom (**replace "☐" with your Site ID Letter, "A" through "E"**):

☐-99999-P-9

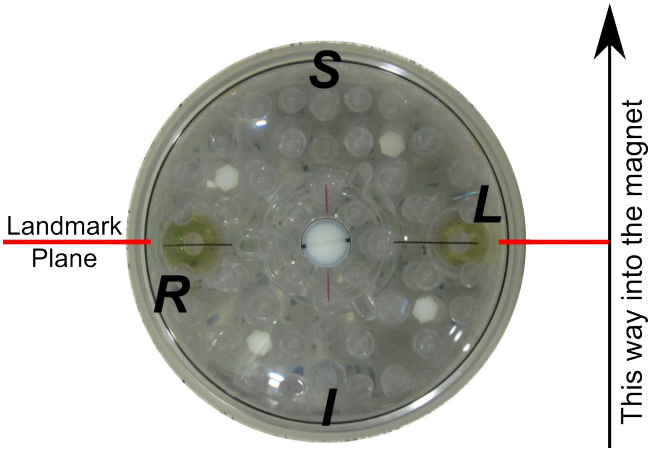
- As the "Patient ID", enter the above ID then a hyphen ("-") and the eight-digit scan date.

1 Available online: http://www.phantomlab.com/library/pdf/magphan_adni_manual.pdf

2.1.2 Landmarking

When moving the phantom into the magnet using the scanner table, the phantom should be positioned such that the landmark plane (laser) goes through the center of the phantom.

Ideally, the landmarking plane should line up with the black lines marked on top of the phantom itself (see illustration on the right).

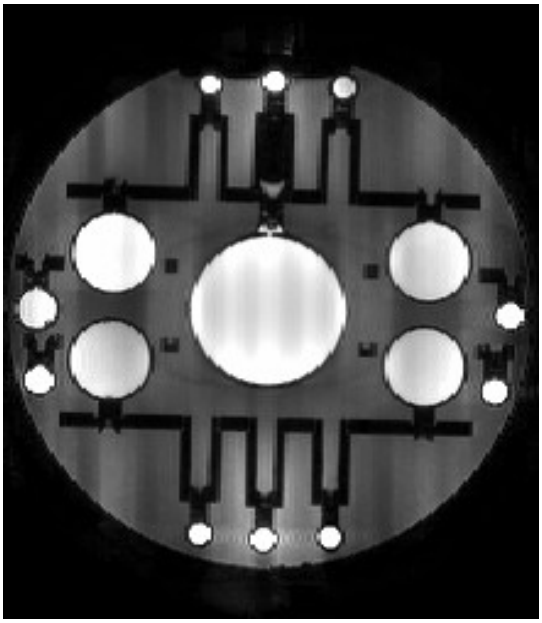
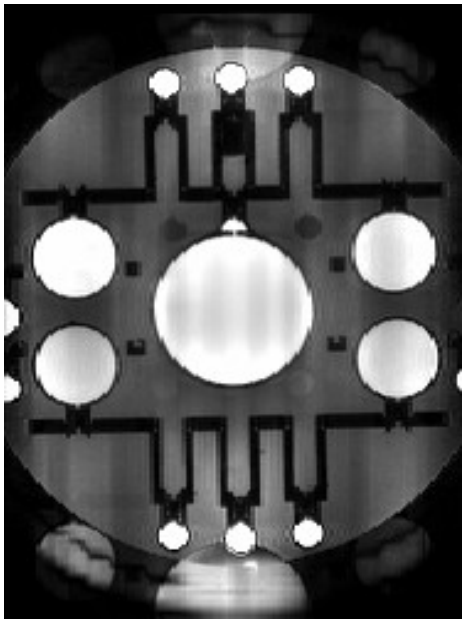


2.1.3 Scanning Instructions

The following imaging series must be run for the ADNI phantom:

1. Localizer, series name "**`ncanda-localizer-v1`**"
2. Calibration, series name "**`ncanda-calibration-v1`**"
3. On GE scanners, T1-weighted SPGR, series name "**`ncanda-t1spgr-v1`**", or, on Siemens scanners, T1-weighted MP-RAGE, series name "**`ncanda-mprage-v1`**"

Because the ADNI phantom is larger than a human head, it is likely that the standard image field of view as it is used for subjects is not sufficient to cover the entire phantom (see below). It is vital, however, that the entire phantom is visible in the acquired images, with no wrap-around. Phantom images with insufficient field of view cannot be used for quantifying and correcting distortion and are, therefore, useless. **To cover the entire phantom, add slices to the SPGR scan (about 200 slices total should be sufficient).**

	
Good phantom scan (axial slice; data acquired in sagittal slice orientation). Complete coverage of the phantom (all 10mm spheres	**Unusable phantom scan**: field of view truncated L/R; wrap-around artifact in A/P direction.

visible), no warp-around artifact.	

2.2 Functional Imaging Phantom (fBIRN Phantom)

The purpose of the fBIRN phantom (Agar phantom) is to quantify and track SNR of the functional imaging series.

- The fMRI phantom must be scanned once per week on every scanner on which a subject is scanned during that week.
- As the "Last Name" or "Patient Name" (depending on your scanner) enter the following for the fBIRN phantom (replace "☐" with your Site ID Letter, "A" through "E"):

☐-00000-P-0

- As the "Patient ID", enter the above ID, then a hyphen ("-") and the eight-digit scan date.

2.2.1 Phantom Scanning Instructions

The following imaging series must be run for the ADNI phantom:

1. Localizer, series name "**`ncanda-localizer-v1`**"
2. Calibration, series name "**`ncanda-calibration-v1`**"
3. Resting state fMRI, series name "**`ncanda-rsfmri-v1`**"

3 The XNAT Image Archive System

3.1 Connecting to the Image Archive

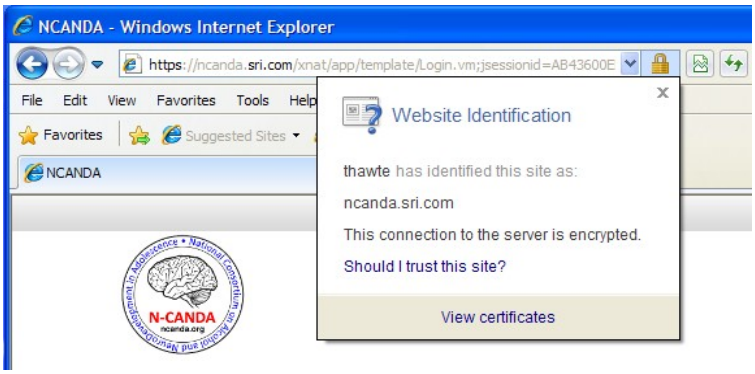
N-CANDA is using the XNAT web-based framework for managing acquired images, specifically to allow data collection sites to submit image files in DICOM format to the Data Integration Site.

To connect to the server, point your web browser to

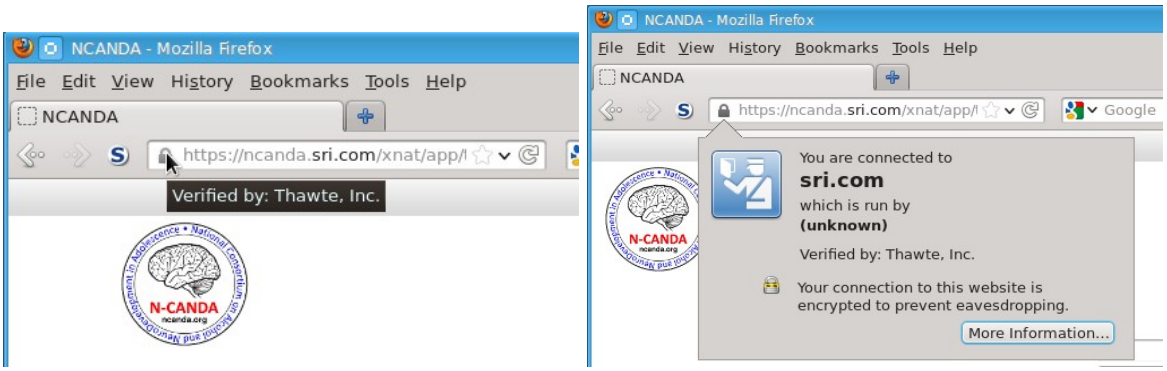
https://ncanda.sri.com/xnat

The server is configured to allow only encrypted connections and transfers. The server itself is authenticated by a valid certificate, issued currently by Thawte, Inc. Security status of your connection to the server can be confirmed by clicking on the “Lock” symbol on or near your browser's URI entry field.

For Internet Explorer, this looks like the following:

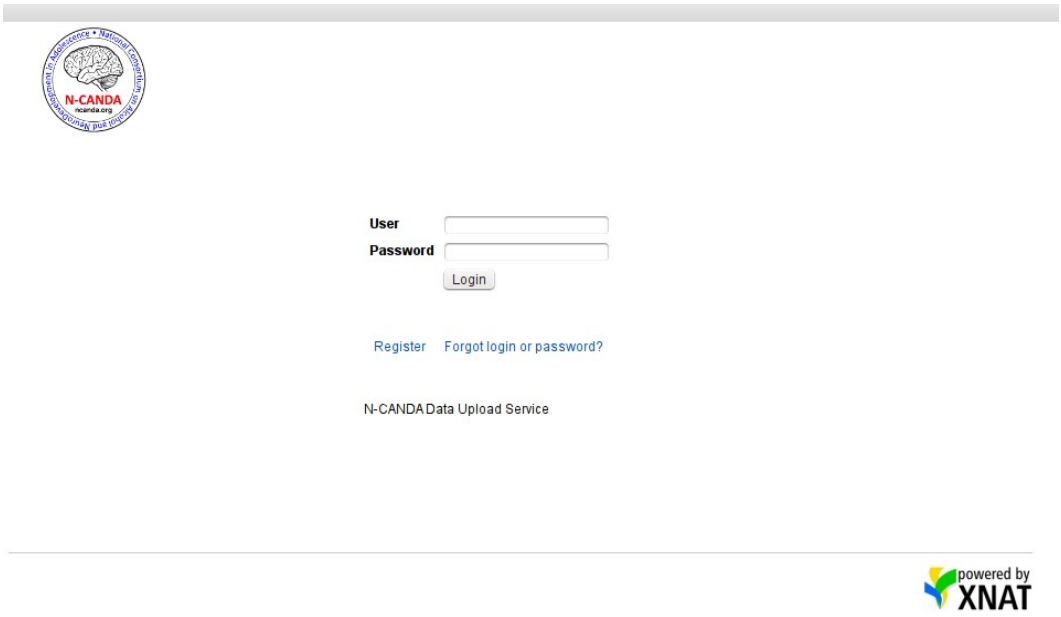


For Firefox browsers, confirming connection security should look similar to one of the the following:



3.2 New User Registration

Prior to uploading images to the Data Integration Site, a user account must be created on the upload server. The login and registration screen is the first page displayed when connecting to the server and will look similar to this:



Follow the "Register" link and enter user data on the following screen:

Only the fields marked by "*" must be entered, all others are optional.

Every new user account must first be activated by the administrator before login is possible. Activation requires that the respective Site PI identifies the newly registered user as an authorized uploader by sending an email to torsten@synapse.sri.com.

After approval, you will receive an email with subject line "Welcome to NCANDA".

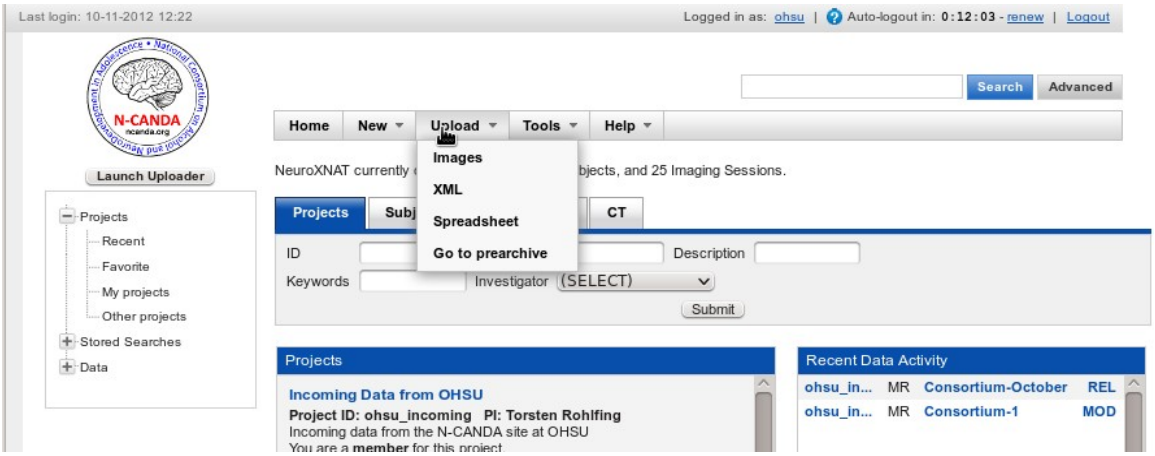
3.3 DICOM Image File Upload

Note that the instructions below refer only to uploading of image files in DICOM format. All other files (such as p-files, physio files, and Stroop results) must be uploaded into an existing imaging session after uploading the DICOM files (see Section 3.5 below). **Any non-DICOM files contained in image archives uploaded via the method described next will be discarded without any warnings or errors!**

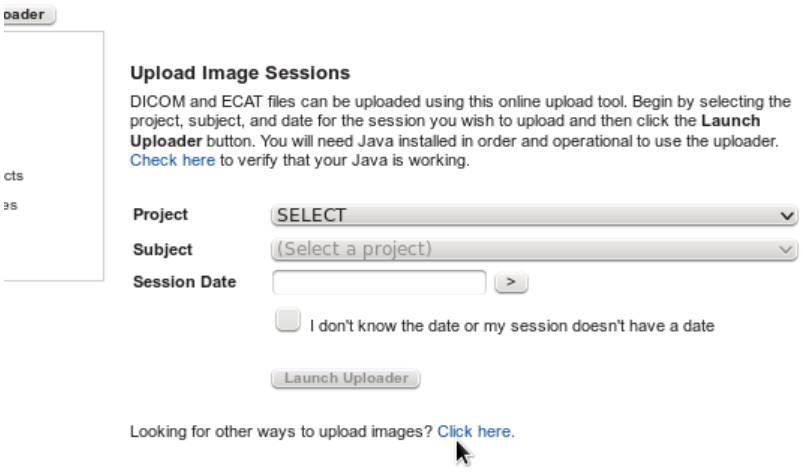
3.3.1 Archive File Upload

The first method of uploading image data is as "ZIP" or "tar.gz" archives, one archive file per scan session (i.e., typically per subject per day).

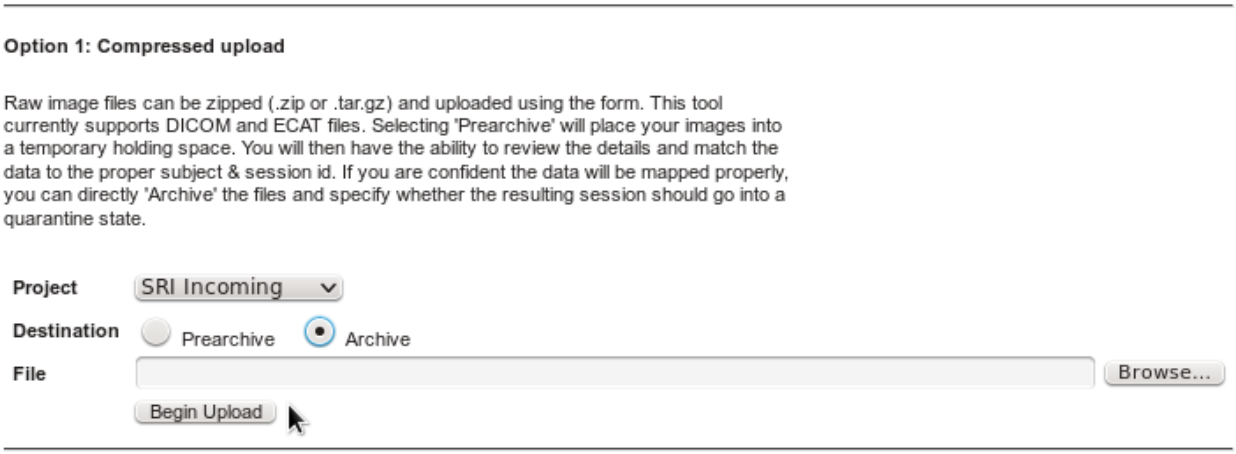
After creating the image archive file with the tool of your choice (e.g., by creating a new "Compressed Folder" on a Windows system and dragging all image files into that folder), select the "Images" item from the "Upload" menu on the NCANDA XNAT front page:



Next, follow the "Looking for other ways to upload images? Click here." link near the bottom of the following screen:

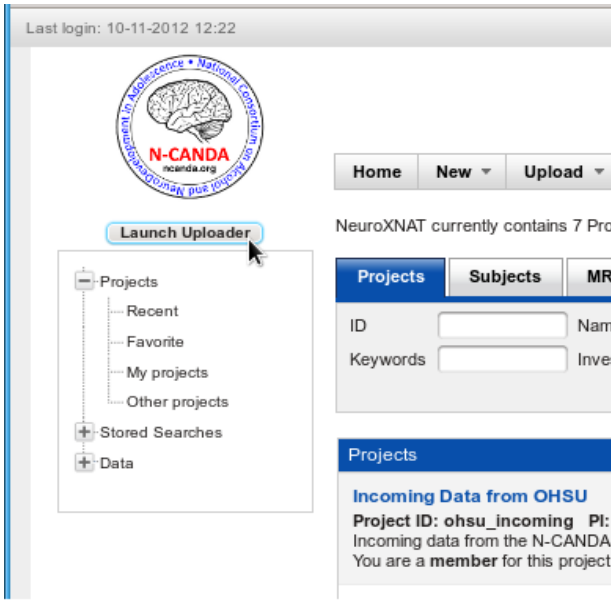


Finally, select the project to upload to (your site's "Incoming" project), set "Destination" to "Archive," and select your previously created ZIP archive using the "Browse..." button. Then click "Begin Upload."



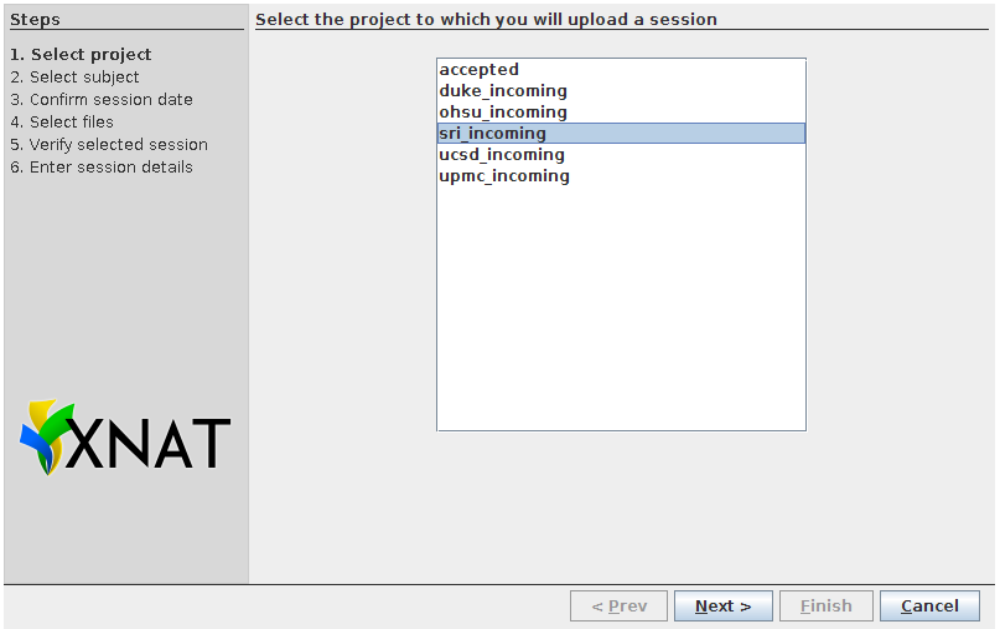
3.3.2 Using the Image Uploader Applet

An alternative method of uploading images is to use the "Uploader Applet," which can be conveniently started using the button in the top-left corner of the NCANDA XNAT front page:

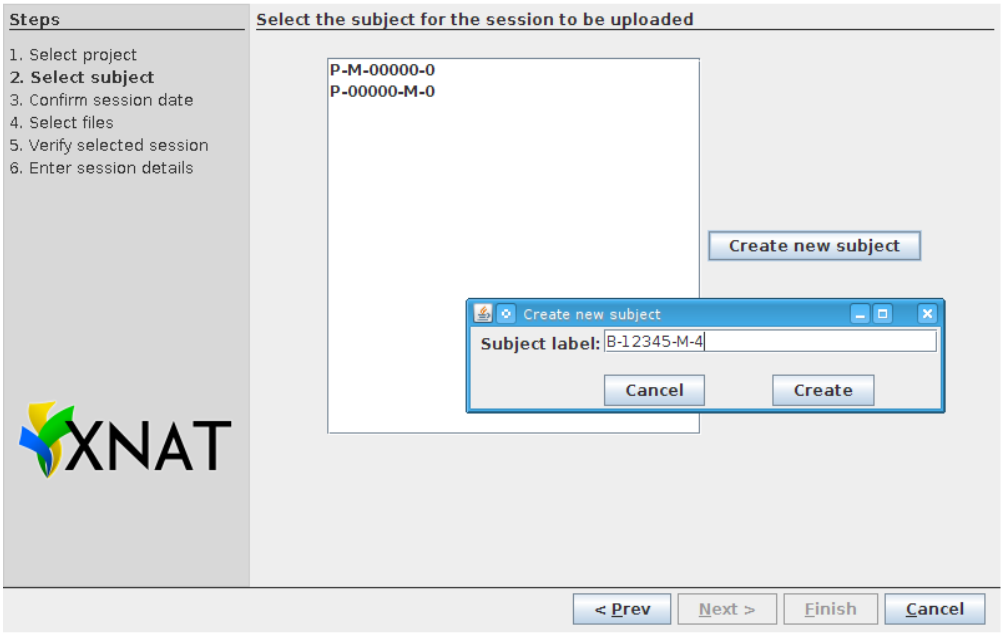


When using the Uploader for the first time, a security warning may appear. In this case, check the "Always trust content from this publisher" box and confirm by clicking the "Yes" button.

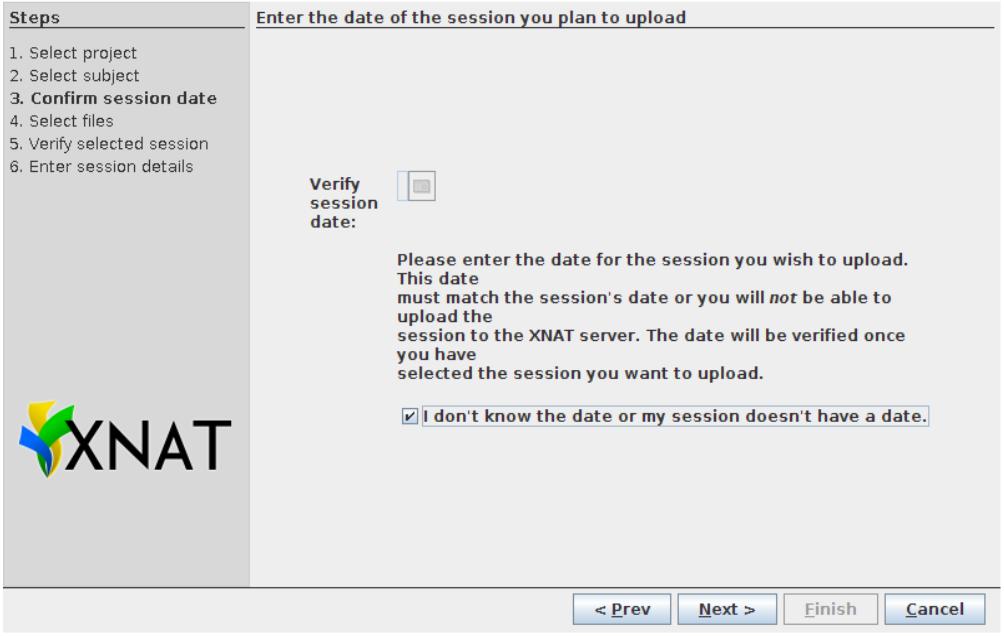
As the first step, select the project to upload images to. This should be your site's “incoming” project, and most users will see only that project in the list of available projects. Select the appropriate project and continue by pressing the “Next” button at the bottom of the screen:



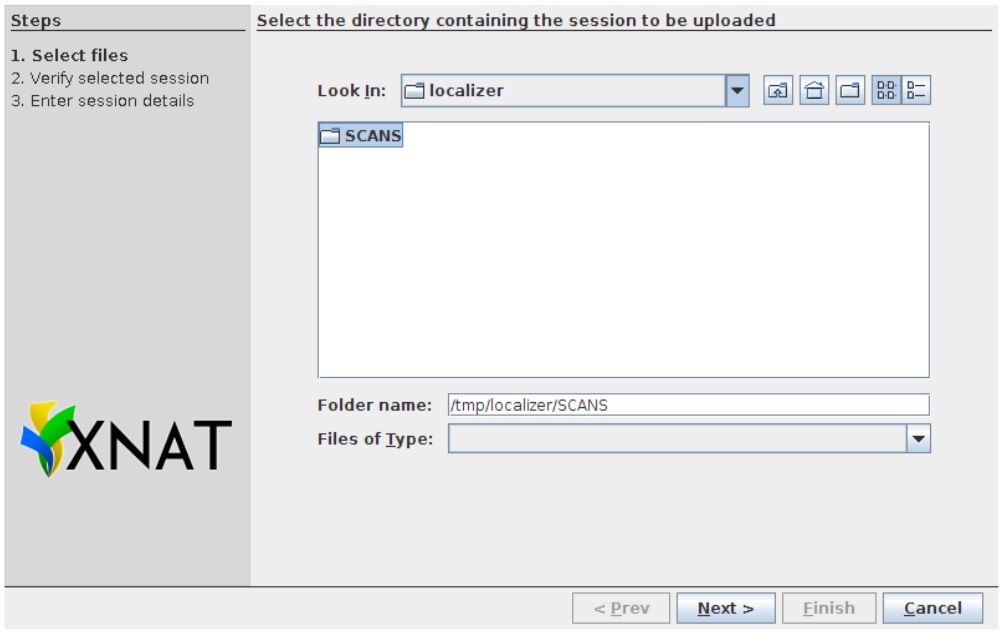
Second, select or create the subject to upload to. If the subject already exists, select it from the list of available subjects. Otherwise, use the “Create new subject” button to open a dialog for entering the new subject's label (this is the subject's Consortium ID). After selecting the target subject, continue again by pressing the “Next” button.



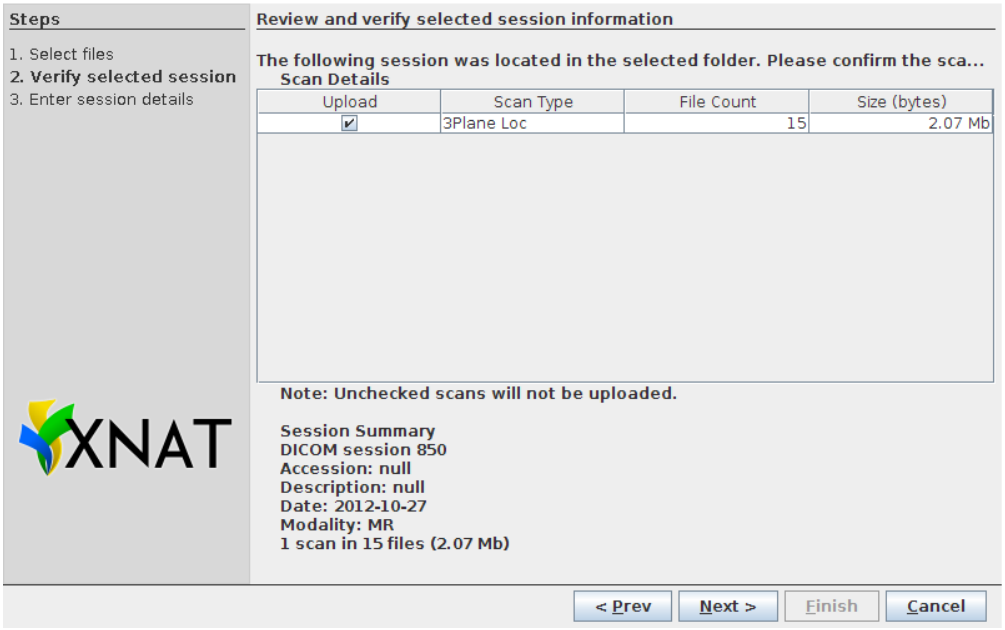
Third, verify the session acquisition date. It will usually be easiest to simply check the “I don't know” box and have the Uploader determine the session date from the uploaded images:



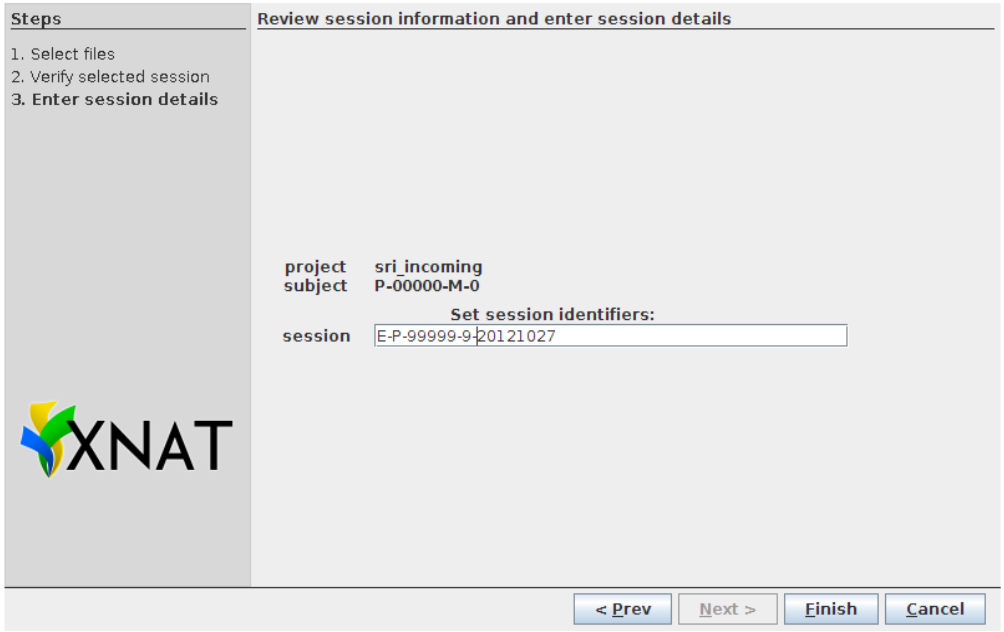
Fourth, select the directory containing the DICOM files to be uploaded. Note that all subdirectories of the selected directory will also be searched for images, so it is okay to organize the files in folders by image series, keep all series folders in a common study folder, and select the study folder for uploading:



Sixth, the Uploader will show a list of imaging series found in the files of the selected upload directories. Make sure all series that should be uploaded are checked in the “Upload” column. Series that were determined to be of unsuitable quality and unusable for analysis should be unchecked and excluded from upload.

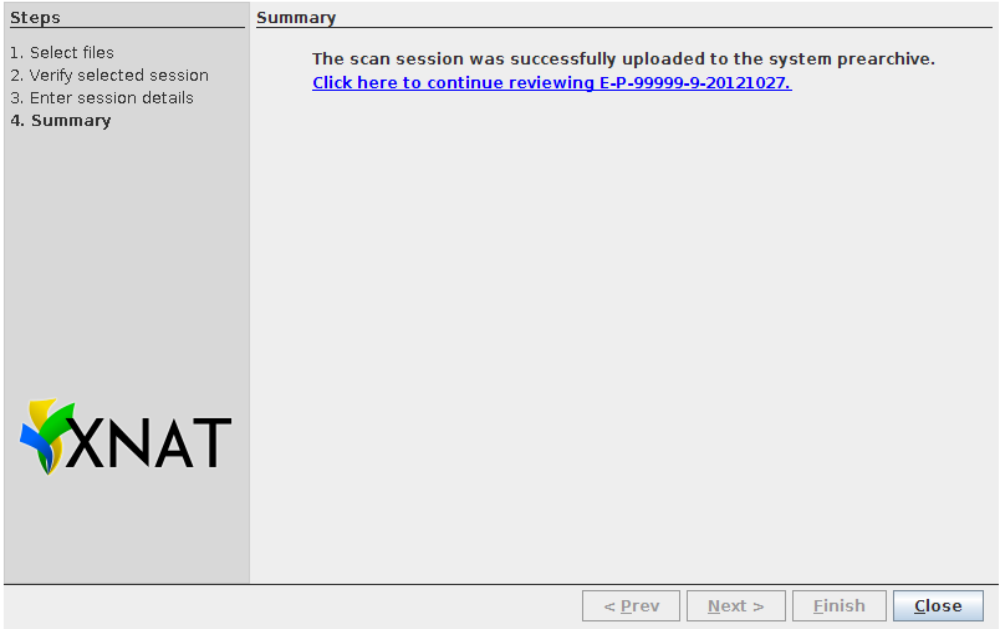


Finally, confirm the target project and subject and enter the session identifier. The session identifier should be the subject's Consortium ID, a hyphen (“-”), and the scan date. This should have been pre-set by the uploader but should be confirmed:



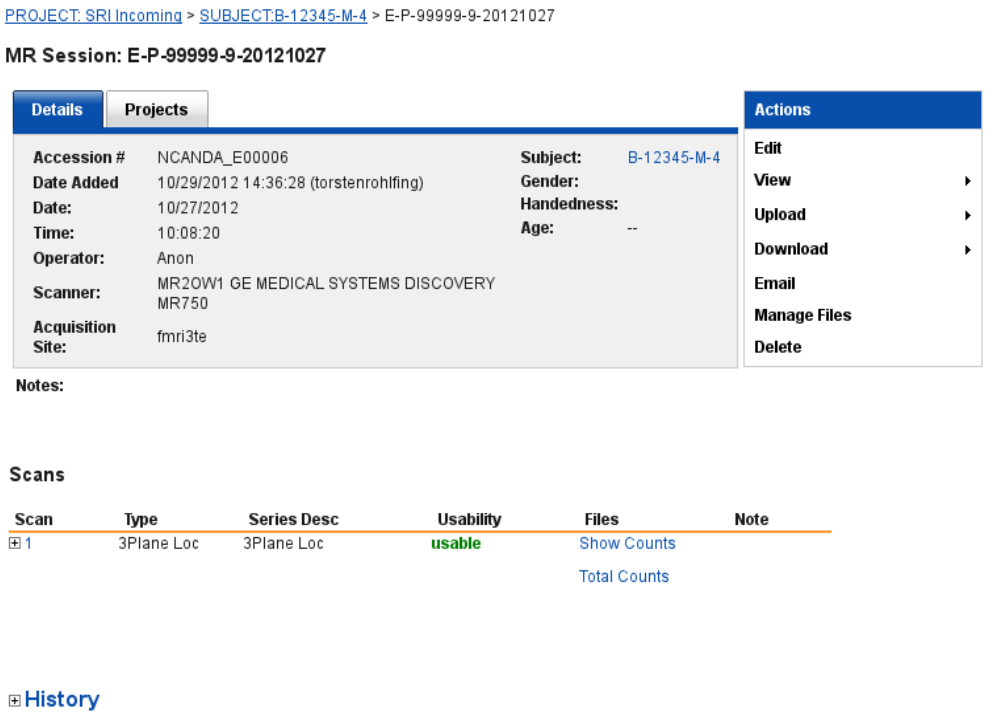
Pressing the “Finish” button on this last screen will start the upload process.

Once all files have been uploaded, the Uploader will show a confirmation screen with a direct link to the uploaded data in the Prearchive:



Following this link will open a new window. All entered data can be confirmed here one final time before submitting the subject via the "Submit" button. **Notes for each image series as well as for the entire acquisition can also be entered here, and the quality of each series marked.**

After pressing “Submit,” the new MR session will be created and the browser will switch to the Series information page:



3.3.3 Comparison of Upload Methods

While using the Uploader avoids the need to create a ZIP archive containing all images, it requires a web browser with installed Java plug-in.

In detail, the **advantages** of using the Uploader are:

- Easily accessed from the NCANDA XNAT front page.
- No need to create a ZIP file containing all DICOM files.

On the other hand, the Uploader has the following **disadvantages**:

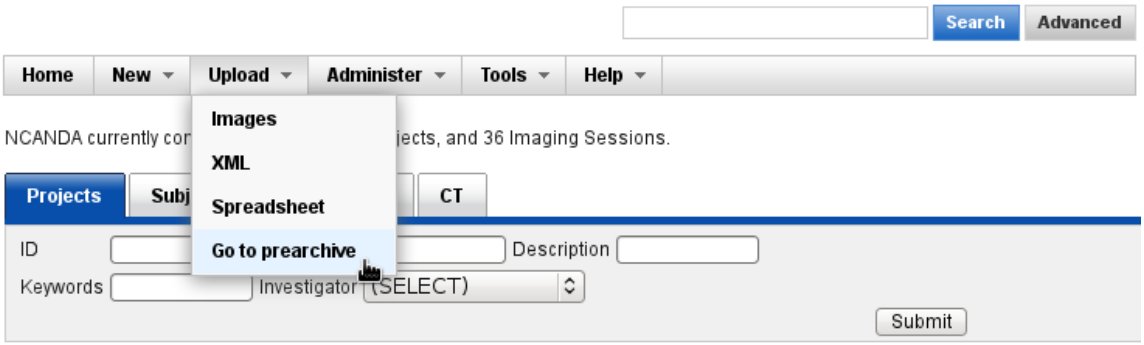
- Requires browser with Java applet.
- Requires execution of downloaded Java code on the user's machine (could potentially be considered a security risk).
- Is **not currently working on all platforms and with all browsers**. On some browsers, the applet window currently remains empty or shows an error message.
- Cannot create a new subject “on the fly” but requires the target subject to be created manually first.

3.4 Moving Data from Prearchive to Archive

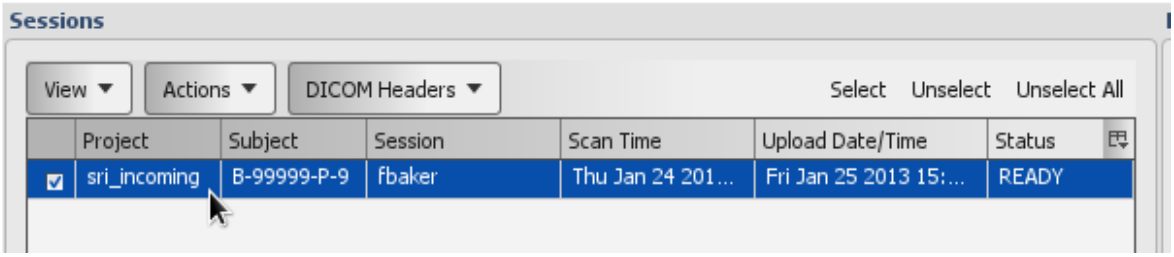
When "Archive" is not selected as the destination for uploaded data as described above, then the data will instead be uploaded to the "Prearchive."

If you did not see the "Add New MR Session" (see screenshot on page 20) after upload, then you uploaded to the Prearchive. Only in the Archive will the data be inspected and become unavailable for processing. It is, therefore, important that data uploaded into the Prearchive be moved to the Archive.

To access the Prearchive, select the "Go to prearchive" command from the "Upload" menu on the XNAT front page:

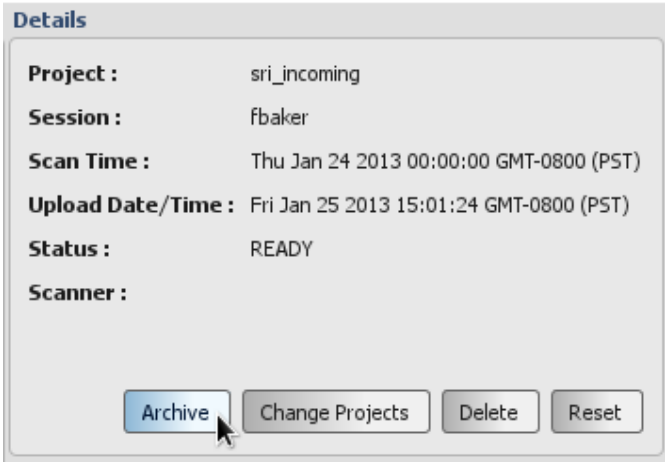


You should see your uploaded data in the table on the left-hand side of the prearchive screen. Select the session you want to move to the Archive:

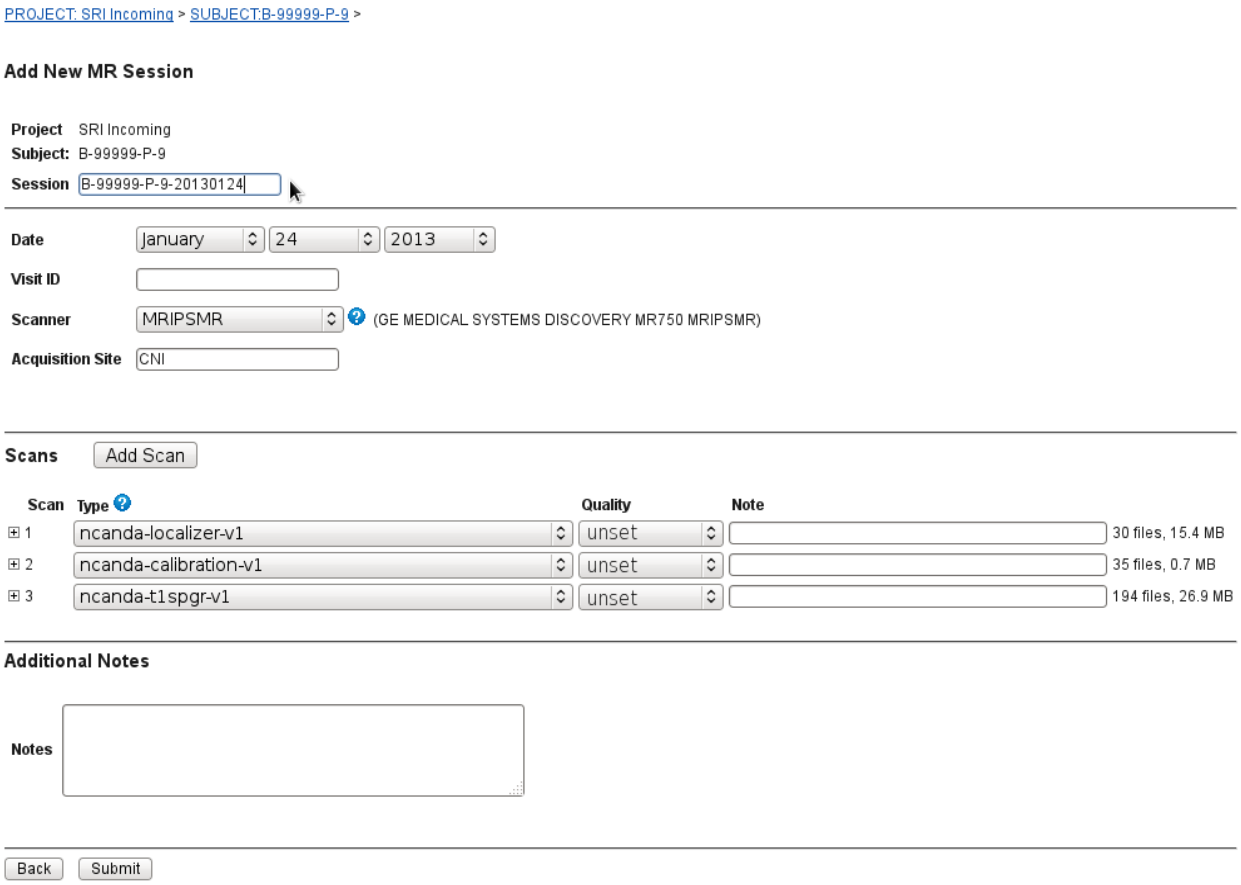


It is important that the session be highlighted in blue. The check mark in the first column has a different purpose.

After selecting the session to move into the archive, press the "Archive" button in the panel on the right-hand side of the screen.



You should now see the “Add New MR Session” screen, where you should enter or confirm the correct MR Session name. (This is the Subject ID, then hyphen, then Scan Date in YYYYMMDD format; see example below.)



If any, scan notes should also be entered in this form, either by imaging series or for the entire session (entry field at the bottom).

If any of the imaging series in the session have questionable quality, also mark this in the “Quality” column. Otherwise, leave quality “unset.” Do not mark a series as “usable” - this is to be done by QA staff of the N-CANDA Data Core.

When all data are correct, finalize archiving the scan session by pressing the “Submit” button at the bottom of the screen.

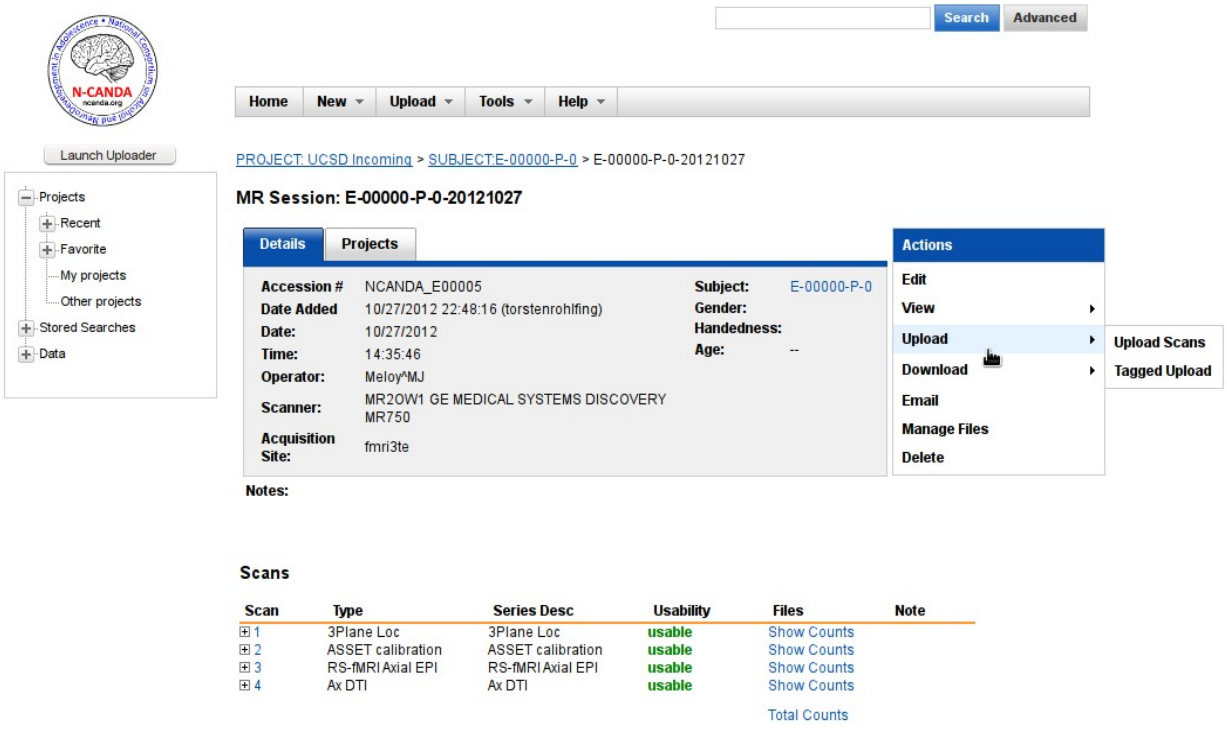
3.5 Uploading and Attaching Non-Image Files

3.5.1 Tagged Upload

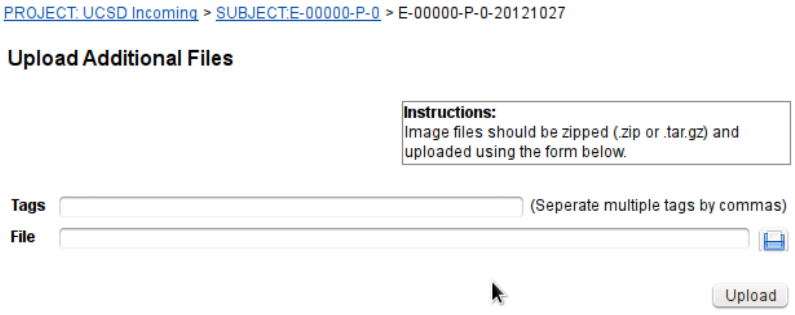
Arbitrary files (up to about 1GB in size) can be attached to existing MR Sessions via "Tagged Upload." These can be scan notes, protocol files, fMRI physio files, etc.

This procedure is also to be used for Stroop data acquired using ePrime during a functional MRI session, which should be uploaded in both "txt" and "edat2" file formats and labeled using the "stroop" tag during upload. This procedure should **not** be used for Stroop data acquired outside the scanner, which are instead submitted to the Data Component via the Subversion transfer setup on the data capture laptops.

To upload files to an existing session, first navigate to the desired MR Session by selecting first the appropriate **Project**, next **Subject**, and finally **Session** within the subject. In the session view, move the mouse to the "Upload" item in the menu on the right and select "Tagged Upload":



A file upload page will then appear, where file tags can be entered and a file selected for upload:



For consistency, it is recommended to use one of the following standard tags:

physio	Physio files for task and resting-state fMRI acquisition(s)
behavior	Behavioral data, e.g., eye tracking, including also cardiac and respiration data
stroop	Stroop data (fMRI only), exported from ePrime in CSV format
pfiles	GE p-files
spiral	Files for spiral fMRI acquisition on GE
protocol	Imaging protocol summary information
eeg	EEG recordings
readme	Acquisition notes, such as problems that occurred, explanation of non-standard images, etc.

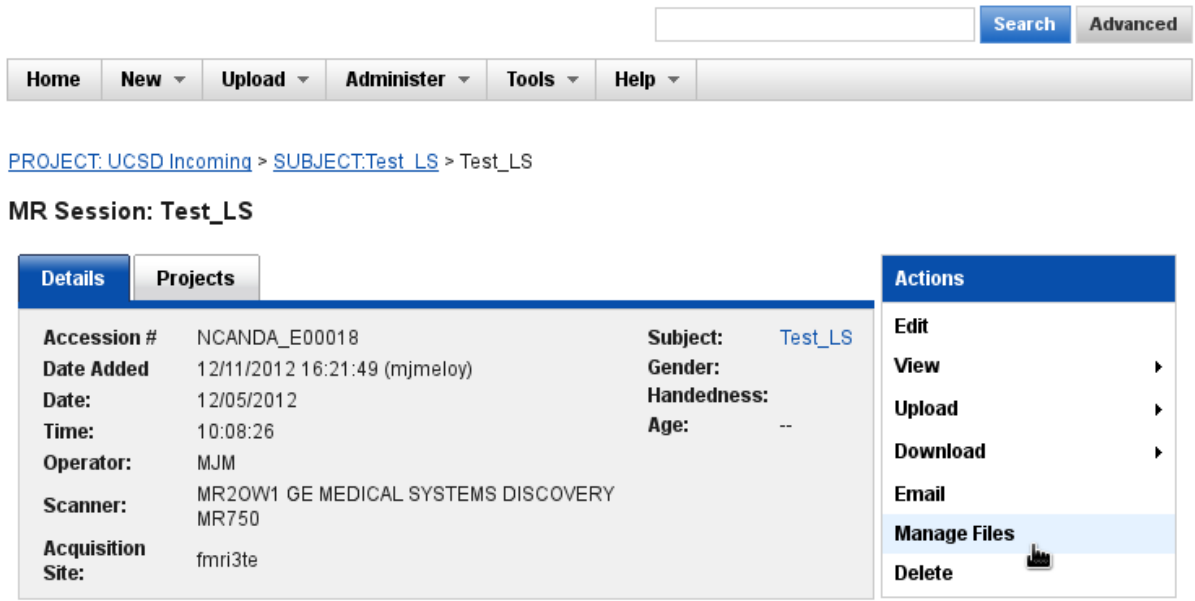
Note that ZIP and tar archives uploaded to the server will be automatically unpacked, and the files contained within them will be added to the file manager separately.

3.5.2 File Manager Upload (Large Files)

Very large files (typically 1GB or more) may cause problems when uploading via the aforementioned "Tagged Upload" procedure. These files can, however, be uploaded through the session "file manager," so long as their size does not exceed 2GB

To enter the file manager, select an MR imaging session, then find and click on the "Manage Files" item in the "Actions" menu on the right-hand side:

.

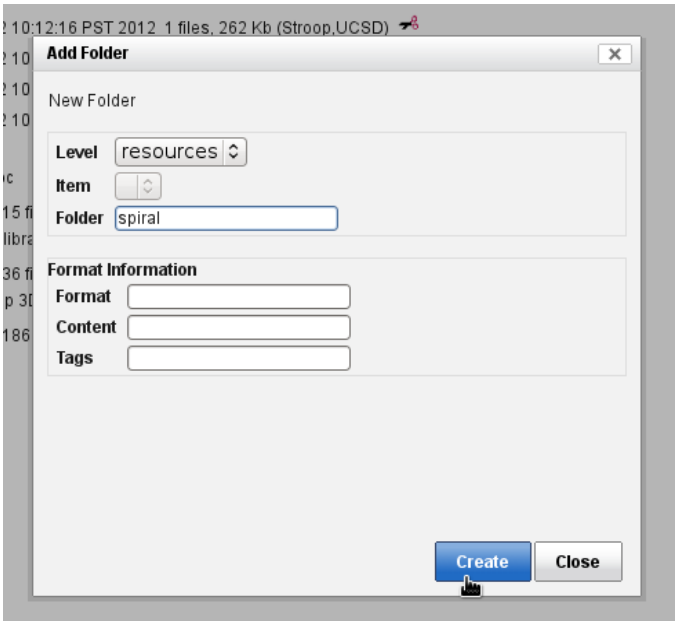


The file manager will appear, showing “Resources” (i.e., non-image files) on top, and “scans” (i.e., DICOM image series) below:

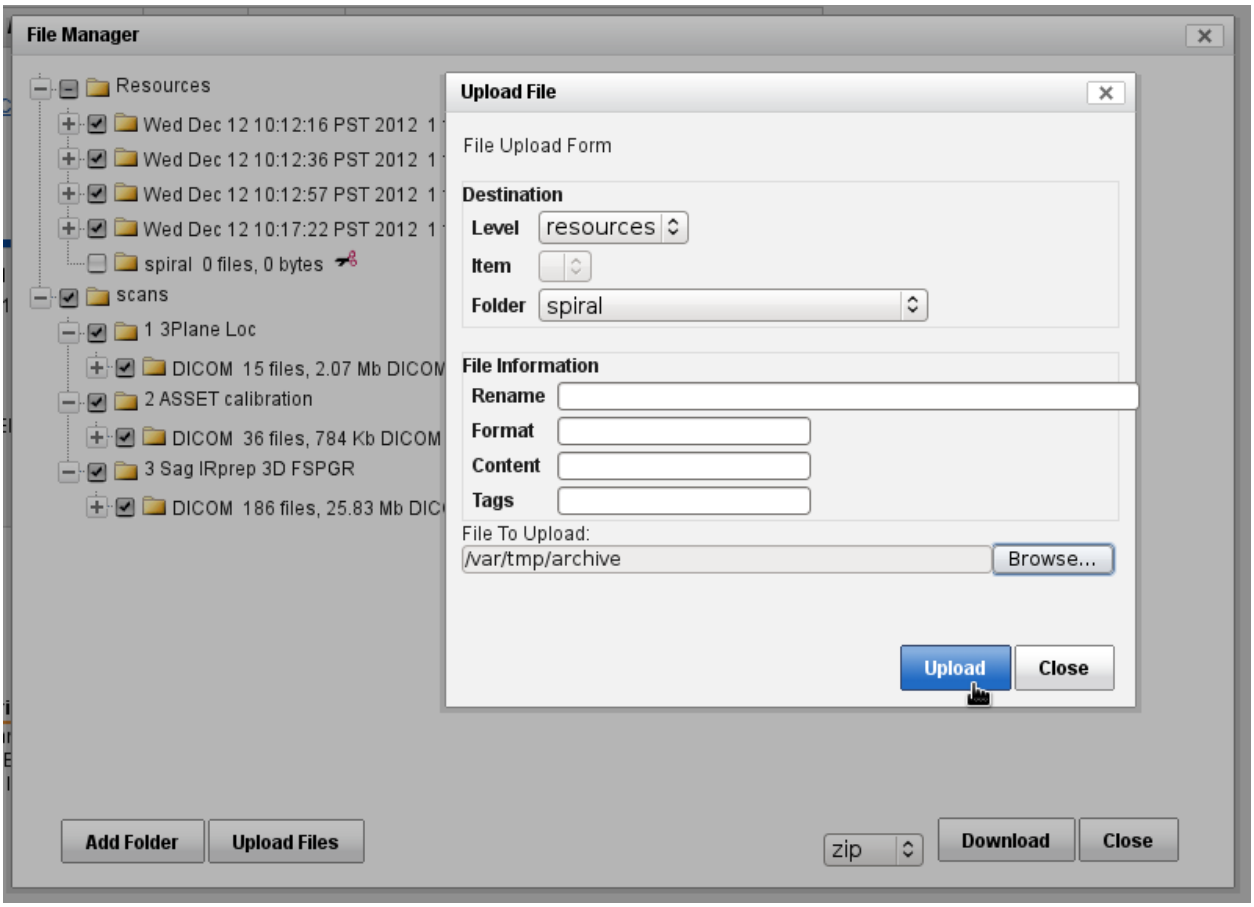
You may first want to create a folder for your files by clicking on the “Add Folder” button in the bottom left corner. (Skip this step if a suitable folder already exists under “Resources”.)

An “Add Folder” dialog will then appear. Select “resources” as the “Level” for the new folder and enter a meaningful folder name in the “Folder” entry field. In the example here, we choose “spiral” for upload of spiral fMRI data.

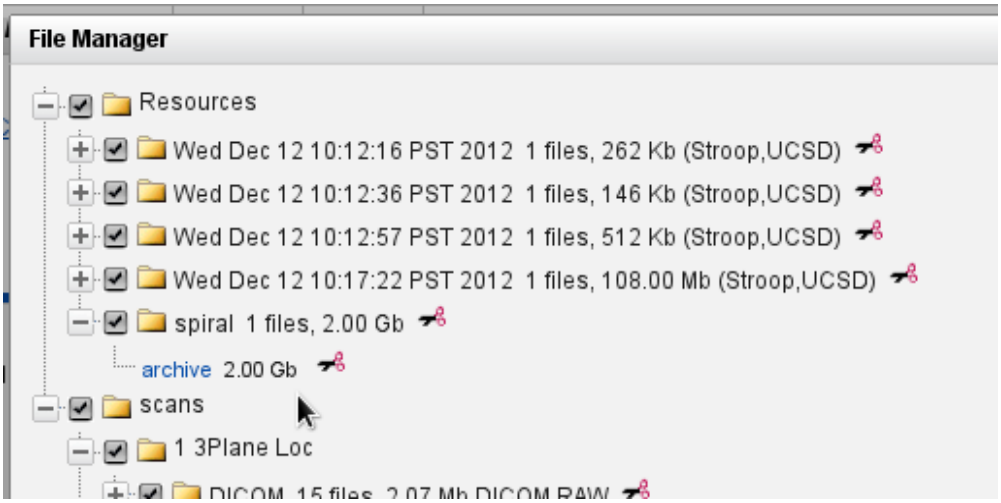
Click on “Create” to create the new folder.



Next, in the “File Manager” window, press the “Upload Files” button to open the file upload dialog (see below). Here, select “resources” as the “Level”, then select your previously created (or already existing) folder in the “Folder” selection box. Finally, use the “Browse...” button to select the file to upload, then press the “Upload” button.



Once the upload completes, you should find yourself back in the “File Manager” window, which should now show your uploaded file in its correct folder location:



3.6 Correcting Uploaded Imaging Session Information

All data on the XNAT system are identified by two primary keys: the Subject ID and the MR Session name (which combines subject ID and acquisition date). It is vitally important that these two pieces of information are correct.

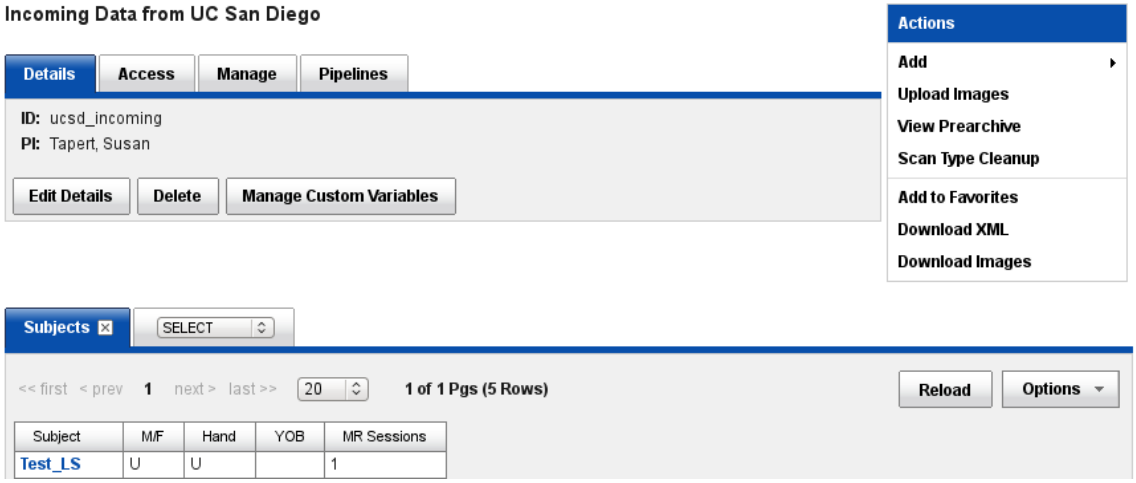
Occasionally, IDs may be entered incorrectly. Also, while entered automatically, the series date may not always be detected correctly from the DICOM images. Finally, some sites may have constraints that preclude them from filling the Patient Registration input fields at the scanner console according to the instructions in Sections 1.1.2 and 1.1.3 above.

Whenever uploaded image data are not assigned the correct Subject ID and MR Imaging Session name, these must be corrected immediately after the upload. Incorrectly labeled data will not be entered into the consortium data set or included in any analyses.

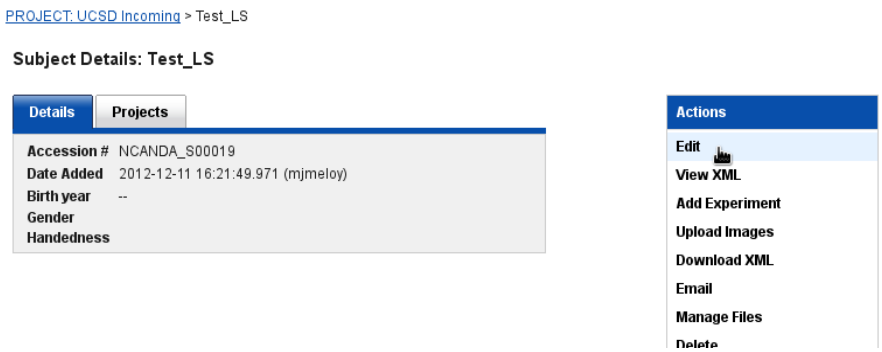
Below, we describe the procedure for editing the Subject ID and MR Imaging Session name. If both are incorrect, the Subject ID should be corrected first.

3.6.1 Correcting the Subject ID

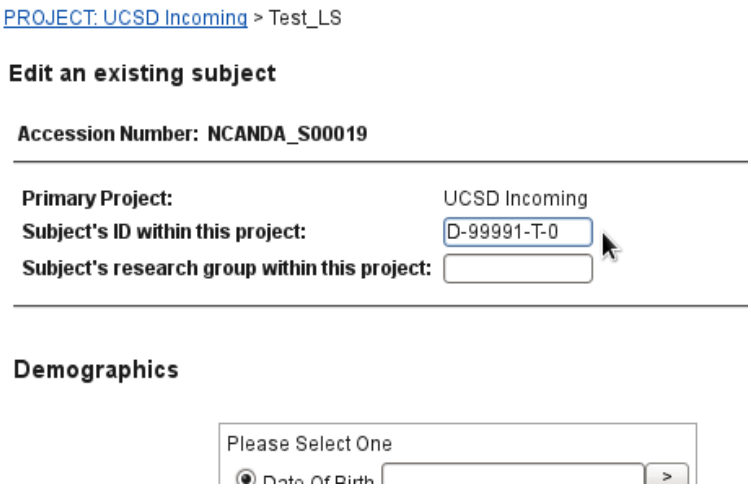
First, find the subject with the incorrect ID in the "Incoming" project for your site. In the example below, the incorrect ID is "Test_LS." Click on this subject ID to select the subject.



Next, in the subject screen, find the "Edit" link in the menu on the right-hand side (this is the first command in that menu):



Finally, in the “Edit” screen, enter the correct subject ID, then press the “Submit” button at the bottom of the screen:

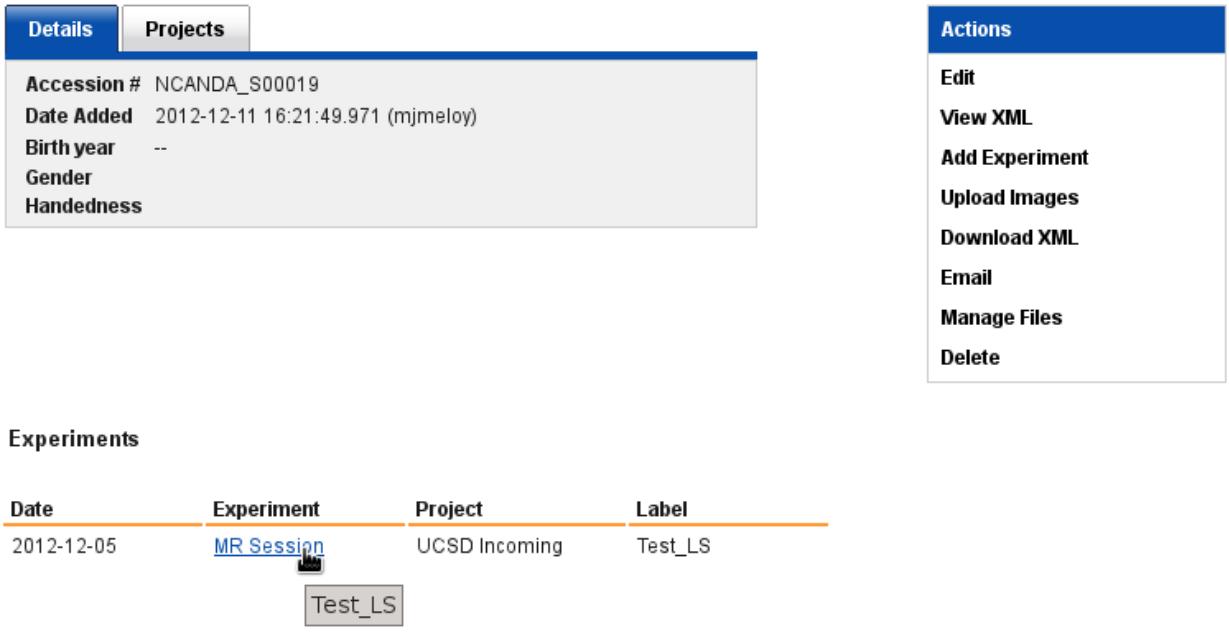


NOTE: If the new subject ID already exists, renaming the subject will fail and an error will be displayed. In this case, instead of renaming the subject, enter the MR session associated with the incorrect subject ID and assign it to the correct subject ID (see next section below for instructions).

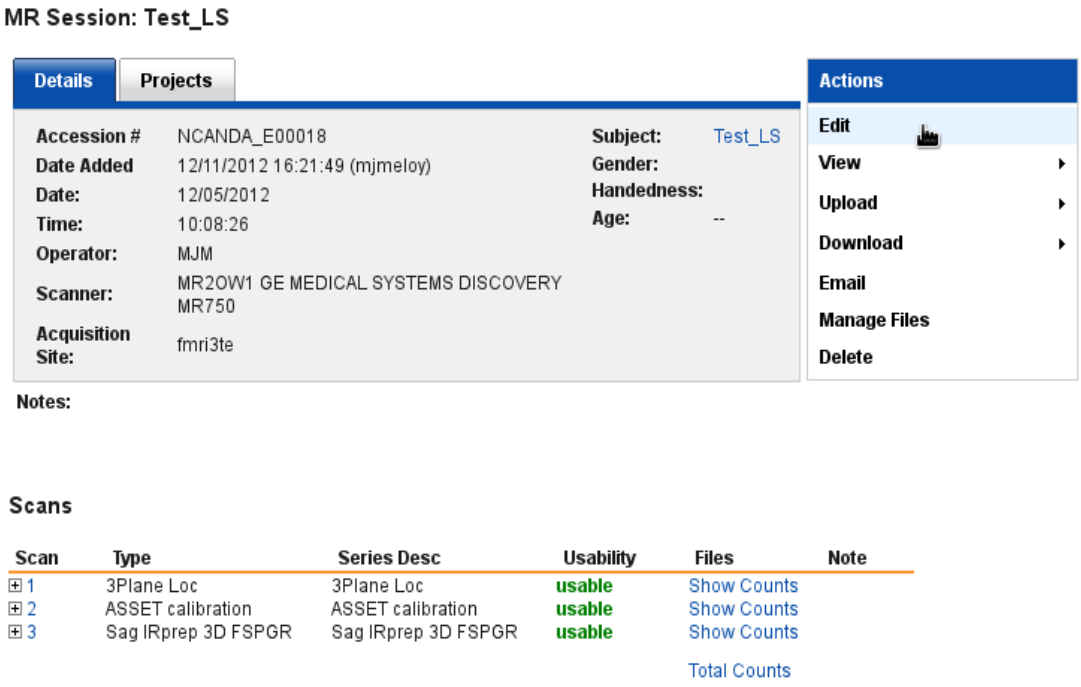
3.6.2 Correcting the MR Session Name

In the “Subject Details” screen, find the incorrectly labeled Session in the list at the bottom. (Note - If the Subject ID was previously corrected, the “Subject Details” screen is the screen displayed immediately after clicking the “Submit” button.).

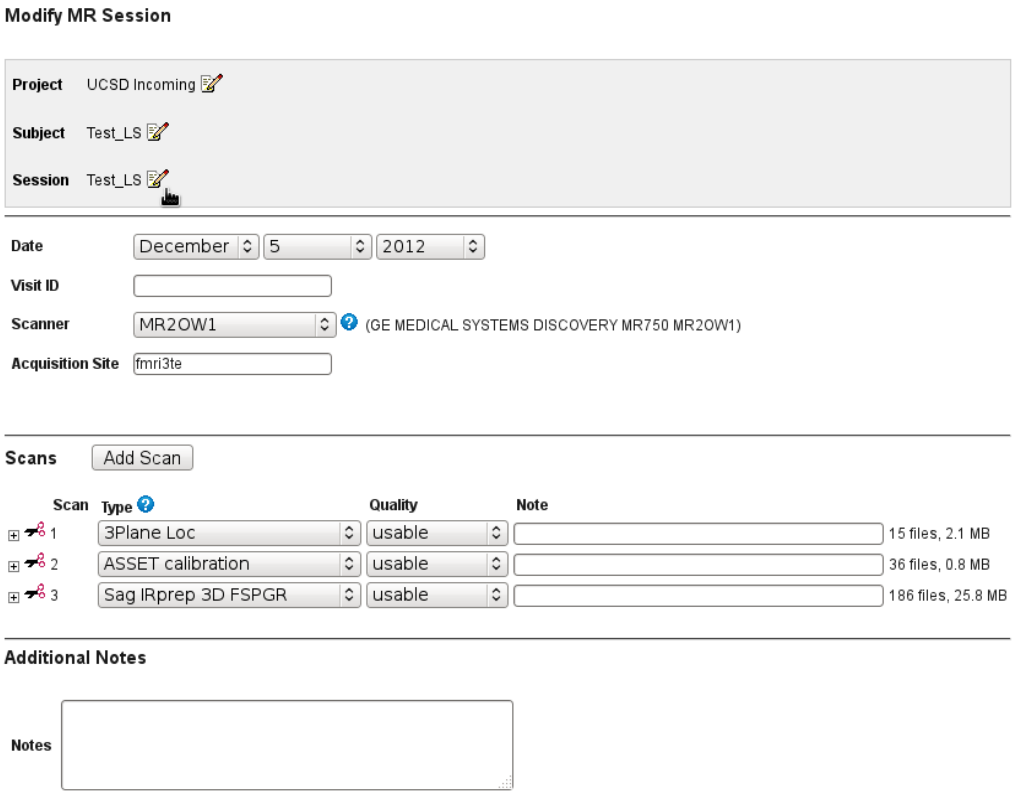
Click on the “MR Session” link of he incorrectly named session. The current Session Name, in the example here “Test_LS,” is displayed in the column on the right in the table of “Experiments.”



Next, in the “MR Session” screen, select the “Edit” action from the menu on the right-hand side:

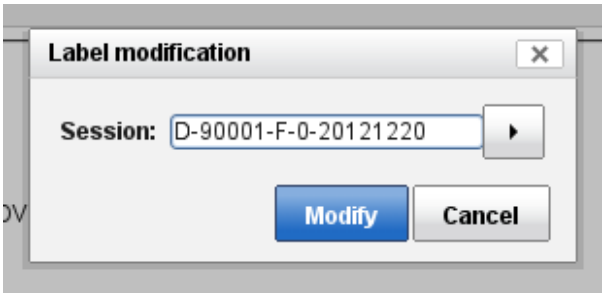


Then, on the “Modify MR Session” screen, click the “edit” icon after the current “Session” label:



(If you are editing the session in order to assign it to a different subject ID, use the “edit” icon after the “Subject” label instead. This is typically done when a Subject ID is incorrect but the subject cannot be renamed because the correct Subject ID already exists.)

A small “Label modification” window will then pop up, in which the correct Session Name should be entered. This correct session name is the Subject ID, followed by a hyphen, “-”, followed by the scan date in 8-digit YYYYMMDD format:

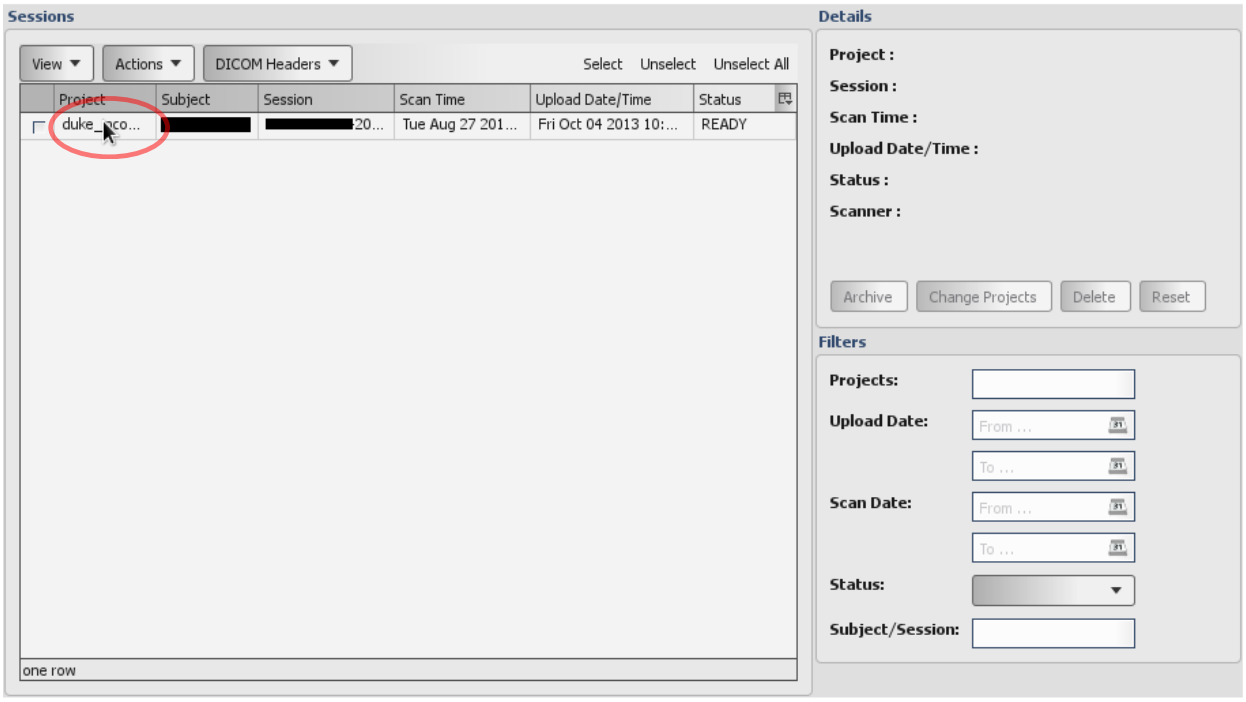


After pressing the “Modify” button, a confirmation dialog will explain that renaming a session involves moving files on the server which can take significant time. This should be acknowledged by pressing the “OK” button.

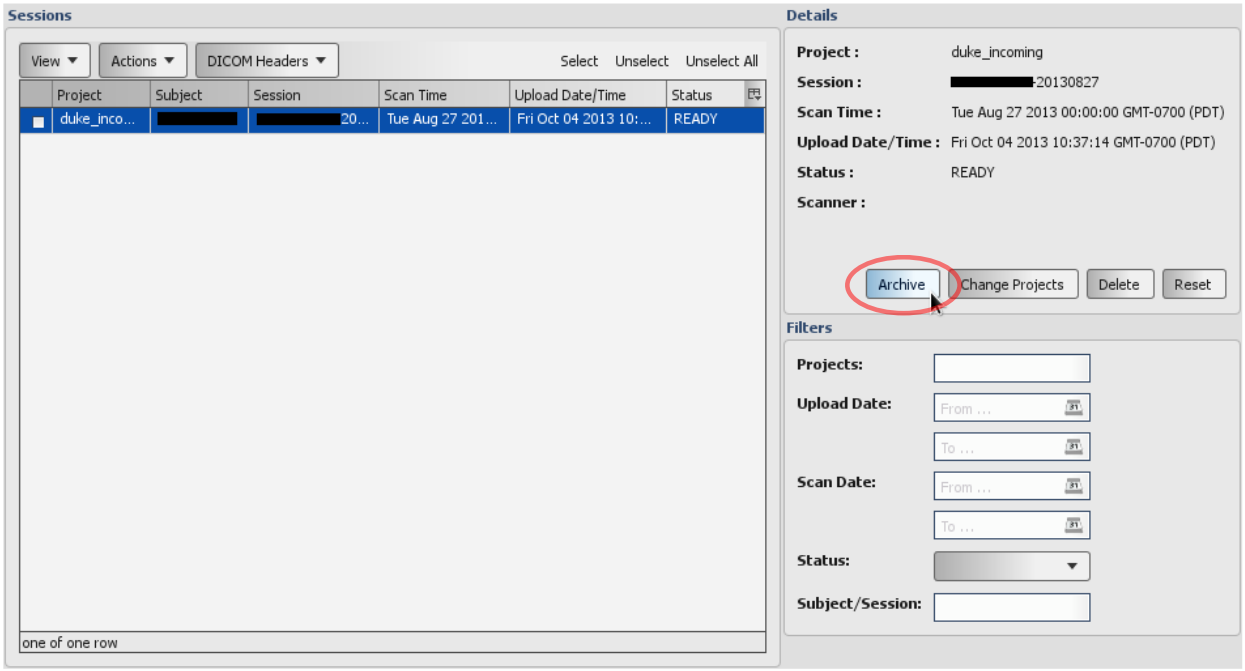
When renaming large sessions (as are most N-CANDA imaging sessions), the rename operation may return with an error message. In this case, repeat the process above, beginning with clicking the “edit” icon after the (still incorrect) session name. After confirming the correct session name one more time, the renaming operation usually succeeds.

3.7 Adding an Imaging Series to an Existing MR Session

First, upload a ZIP archive with the DICOM files for the additional imaging series to the Prearchive. Next, in the Prearchive, find and select the uploaded data by clicking anywhere in correct row of the “Sessions” table:



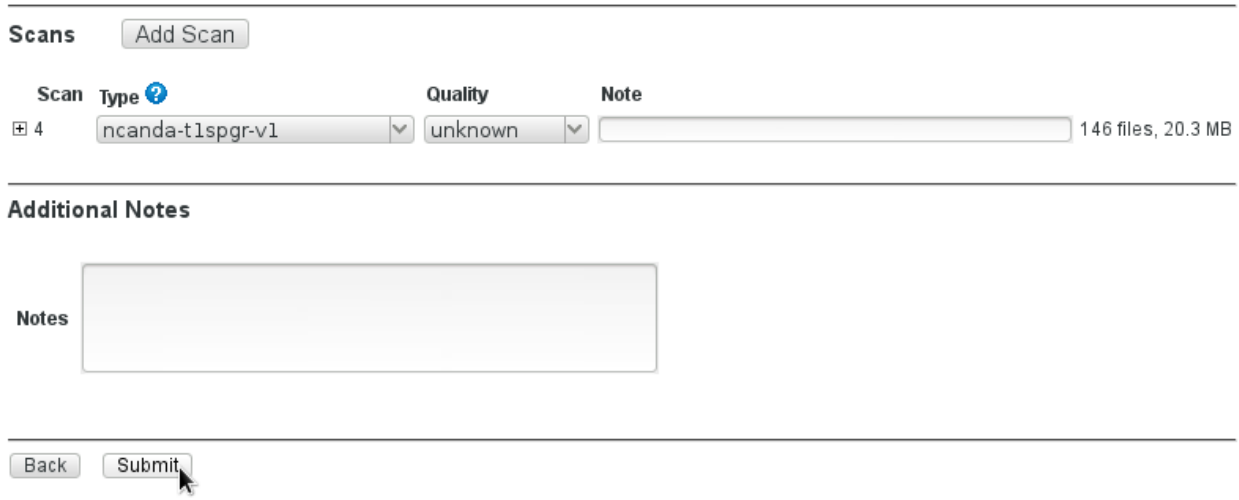
After selecting the series, it should be highlighted, and the “Achive” button on the right should be clickable. Proceed to click this button:



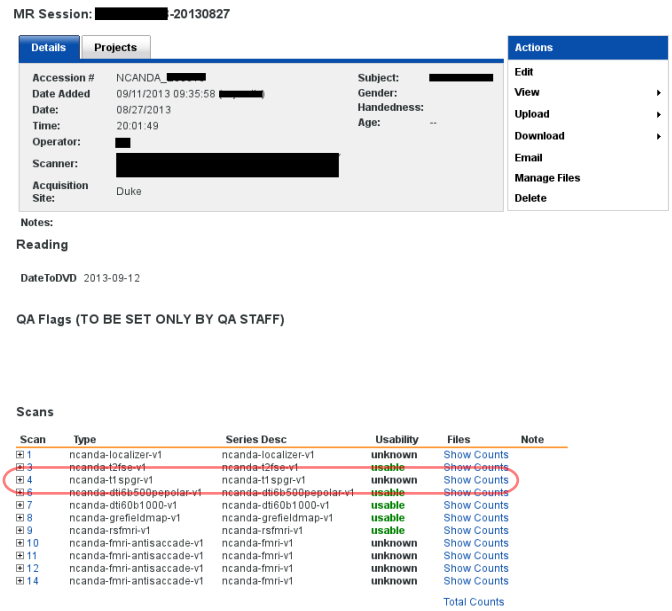
XNAT should now display the “Archiving” screen. Make sure that the correct session name is entered in the “Session” entry field. At the top, a warning should then be displayed that the named session already exists.

Make sure that the drop-down selection after the “Session” entry field is set to “APPEND” before proceeding.

At the bottom of the same screen find and click on the “Submit” button:



After a brief wait, you should be taken to the “MR Session” screen for the merged session. If the merge was successul, the newly added scan series should appear in the correct place among the previously uploaded series (as shown on the right).



3.8 Image Upload Checklist

After uploading an imaging session, the following items should be checked immediately:

1. Has the data been uploaded directly to the "Archive"? Does it show up in the "Recent Data Activity" box on the right-hand side of the XNAT front page? If not, find the session in the "Prearchive" and manually move it to the archive (in the process, be sure to assign proper Subject ID and Session Name).
2. Did all imaging series in the session upload? If not, upload missing series, or upload complete session again.
3. Is the Subject ID correct in XNAT (regardless of whether it was entered correctly at the scanner)? Is it in the correct format, such as "A-90001-F-9"? If not, see Section 3.6.1 above for instructions to correct the Subject ID.
4. Is the MR Session named correctly in XNAT? The correct name should be "SubjectID", "hyphen", "scan date" with the scan date in YYYYMMDD format. An example for a well-formed Session Name is "A-90001-F-9-20121224". If the session is not correctly named, correct it by following instructions in Section 3.6.2 above.
5. Have all non-image files been attached to the MR Session? If not, follow instructions in Section 3.5 above for uploading these files.
6. Have imaging series of questionable quality been marked as such? If not, edit the MR Session by setting the respective series' "Quality" to "questionable."
7. Have scan notes been entered into XNAT? Examples of situations where notes should be entered are:
    - A series is missing, e.g., due to early termination of the session. Enter this in the "Notes" entry field at the bottom of the MR Session screen.
    - One or multiple series have been acquired repeatedly, e.g., due to insufficient quality of the first attempt. (In this case, also mark the bad series as "unusable", or remove it altogether). This should be explained in the "Notes" entry field at the bottom of the "MR Session" screen. Short notes specific to one of the imaging series (e.g., "subject moved", "subject fell asleep") can also be entered in the "Notes" field next to the respective series on the same screen.

Failure to follow this check list will cause delays in getting the uploaded data accepted into the consortium data set and started with the image analysis pipelines. **Specifically, data will not be accepted until they are properly labeled with correct, well-formed Subject ID and MR Session name.**

4 Troubleshooting

4.1 Subject and Session Naming

Problem:

There is more than one session for the same subject ID and date. Thus, the MR Session name is not unique.

This can happen when, for example, a subject had to leave the scanner and returned later, or when a phantom was scanned more than once on the same day.

Solution:

Name the first uploaded session as per the instructions in this manual, i.e., Subject ID, then hyphen, then eight-digit date. Name subsequent sessions by appending "`-1`", "`-2`", and so on to the basic session name.

Thus, we may expect to see sessions such as:

`F-99999-P-9-20130130`

`F-99999-P-9-20130130-1`

`F-99999-P-9-20130130-2`

and so on.

Please make sure that the uploaded sessions are indeed distinct acquisitions and not simply the same session uploaded multiple times by mistake.

4.2 XNAT

4.2.1 Renaming a subject fails

Problem:

Attempting to rename a subject (e.g., to correct a mis-entered ID) results in an error, " Edit an existing subject. Matched previous subject. Save aborted."

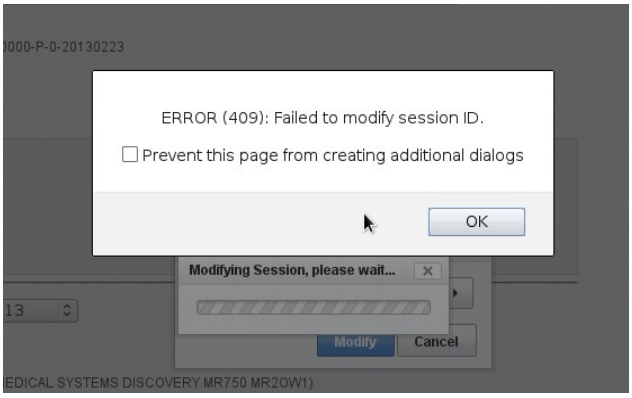
Solution:

This happens because the new Subject ID already exists , so renaming a different subject to the same name does not work.

If the correct, new Subject ID is indeed the same as an already existing subject, then that typically means we have two MR Imaging Sessions for that subject stored under different subject IDs (one correct, one not).

So the solution here is to not rename the incorrectly entered Subject ID, but instead move the Imaging Session from the incorrect to the correct Subject ID. See Section 3.6.2 above for details.

4.2.2 Renaming an MR Session fails



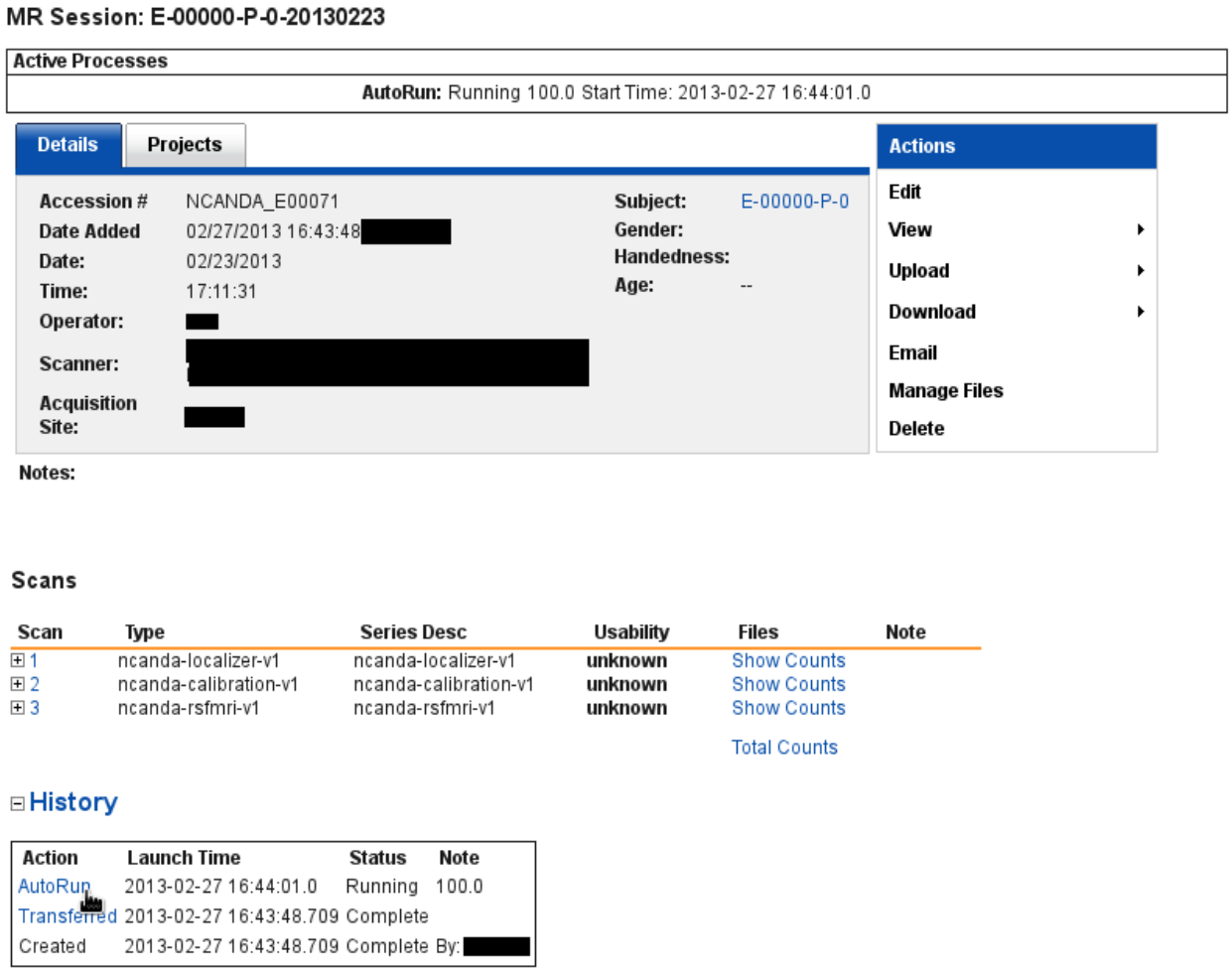
Problem:

Renaming a session fails with "ERROR 409" (see example on the right).

Solution:

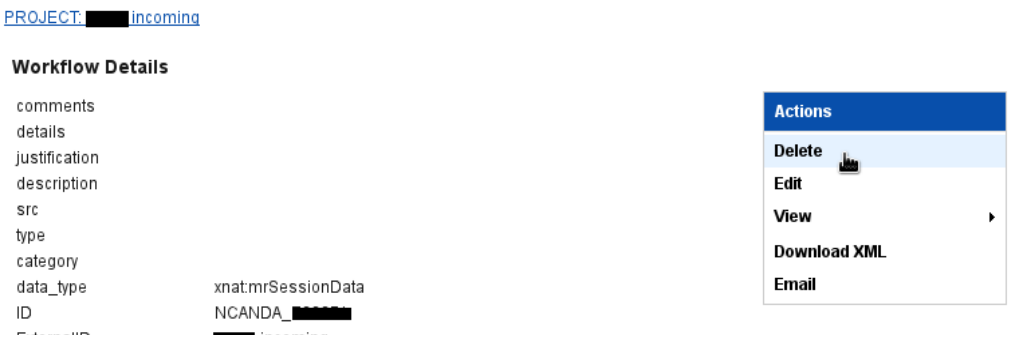
This happens most commonly when some processing is still actively running and using the session, or, more likely, processing terminated but XNAT did not properly record its termination.

To confirm that this is the case, check the MR Session screen for "Active Processes" at the top, or an "Action" with status "Running" in the "History" section at the bottom.

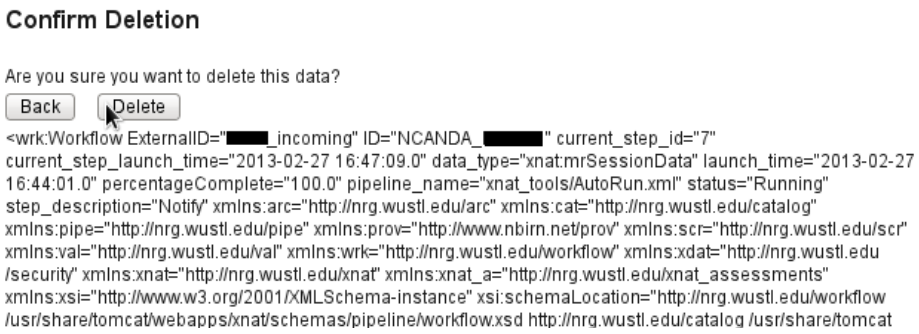


If there is no Active Process or Running Action, then your problem has a different cause and you should contact the N-CANDA XNAT server administrators.

If there **is** a Running action in the "History" list, click on its link in the left column of the "History" table as shown in the previous picture for the "AutoRun" action. You will then see a "Workflow" screen such as this:



Here, select the "Delete" action in the menu on the right-hand side. Then, on the following screen (opens in new window), confirm the deletion by pressing the "Delete" button:



Afterwards, navigate back to the MR Session screen (you may close the newly opened window and use the browser "Back" button in the original window). Make sure there are no additional Active Processes or Running Actions.

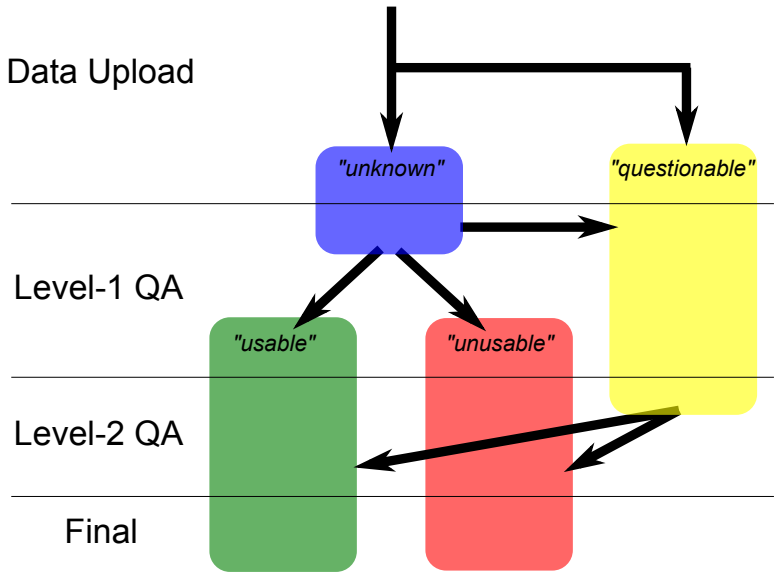
When all running actions have been deleted, try renaming the session again. If you still experience the same error as before, then there are additional problems and you should contact the N-CANDA XNAT server administrators.

5 Quality Control Procedures

5.1 Quality Labels

The following labels can be assigned to each uploaded scan series. Some are intended to be assigned by the uploader, while others should be reserved for QA staff in the N-CANDA Data Core.

- **“unknown”** – This is the default – it labels a scan that has not been inspected for image quality. In general, uploaded series should keep quality “unset”, unless a scan is suspected (“questionable”) or known to be bad (“unusable”)
- **“questionable”** -- This is assigned either by the uploader or, after first-level inspection, by staff at the N-CANDA Data Core. Scans marked with this label will receive inspection with priority.
- **“unusable”** -- Scans determined to be of insufficient quality are labeled as “unusable” and are excluded from all analyses (not that exclusion applies only to the specific scan labeled as unusable, not any usable scans in the same session).
- **“usable”** -- Scans labeled “usable” have been visually inspected and found to be of sufficient quality.



5.2 Phantom QA

5.2.1 Structural (ADNI) Phantom

Within about one hour of upload, an automated ADNI phantom detection routine is run and the results are uploaded to XNAT, where they can be obtained from the “File Manager” of the respective imaging session.

Up to three files are currently uploaded to the "QA" folder:

- **`t1.nii.gz`** – The T1-weighted phantom image, converted to NIFTI format, compressed using gzip.
- **`phantom.nii.gz`** – The label image of detected phantom spheres, also in NIFTI format (and compressed using gzip).
- **`phantom.xml`** – The XML description of the detected phantom and various QA measures.

The **`phantom.xml`** file in particular contains some useful information to assess the quality of the phantom scan:

```
<phantom>
  <phantomType>MagphanEMR051</phantomType>
  <snr>136.491870</snr>
  <cnr>44.459767 47.324354 60.340065 69.824359</cnr>
  <scale>1.000258 0.994778 0.997075</scale>
  <nonlinear>0.203371 0.141993 0.200118</nonlinear>
  <landmarkList coordinates="physical" space="RAS"
     count="165">
...
```

The key pieces of information here are:

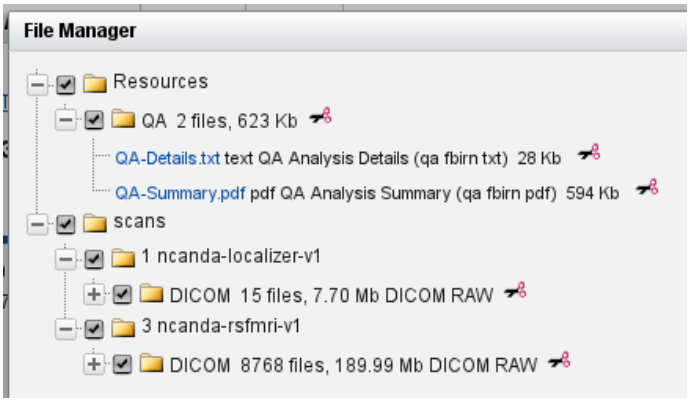
1. The estimated Signal-to-Noise ratio (SNR) based on the large SNR sphere in the center of the phantom.
2. The anisotropic scale factors – deviation of these from 1.0 indicates scale mis-calibration.
3. The nonlinearity – this is the average difference between the actual phantom sphere positions and their expected positions, based on the fitted least-squares linear transformation.
4. The number of successfully detected landmarks ("count"; here: 165). If this number is smaller than 165, some spheres were not successfully detected. This can indicate problems with the phantom (.e.g, broken or low-contrast spheres) or insufficient image field of view.

More details on the phantom detection algorithm and the XML results file can be found in this document:

http://www.nitrc.org/docman/view.php/212/1149/UnwarpPhantom.pdf

5.2.2 Functional (fBIRN) Phantom

For each scan session of the fBIRN phantom, automated QA generates two files, which can be found in the File Manager for the session, in the "Resources" / "QA" folder.



The first file, "QA-Details.txt," is a text file that contains the detailed output of the fBIRN fMRI phantom QA script[2].

The second file, "QA-Summary.pdf," is a higher-level summary, with graphical illustrations, in PDF format.

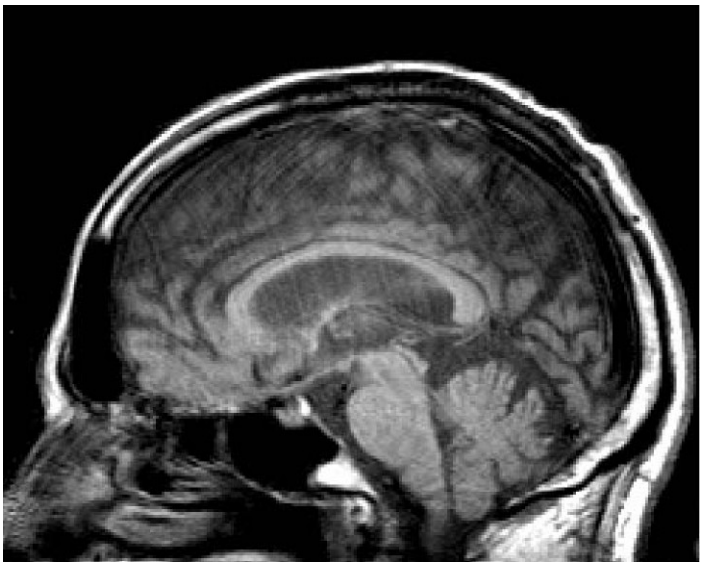
2 https://xwiki.nbirn.org:8443/xwiki/bin/view/Function-BIRN/AutomatedQA

6 Imaging Artifacts

6.1 Movement

Problem:

In this example movement has caused motion artifacts. Acquisitions with major motion artifacts will not be accepted and a repeat scan may be requested.



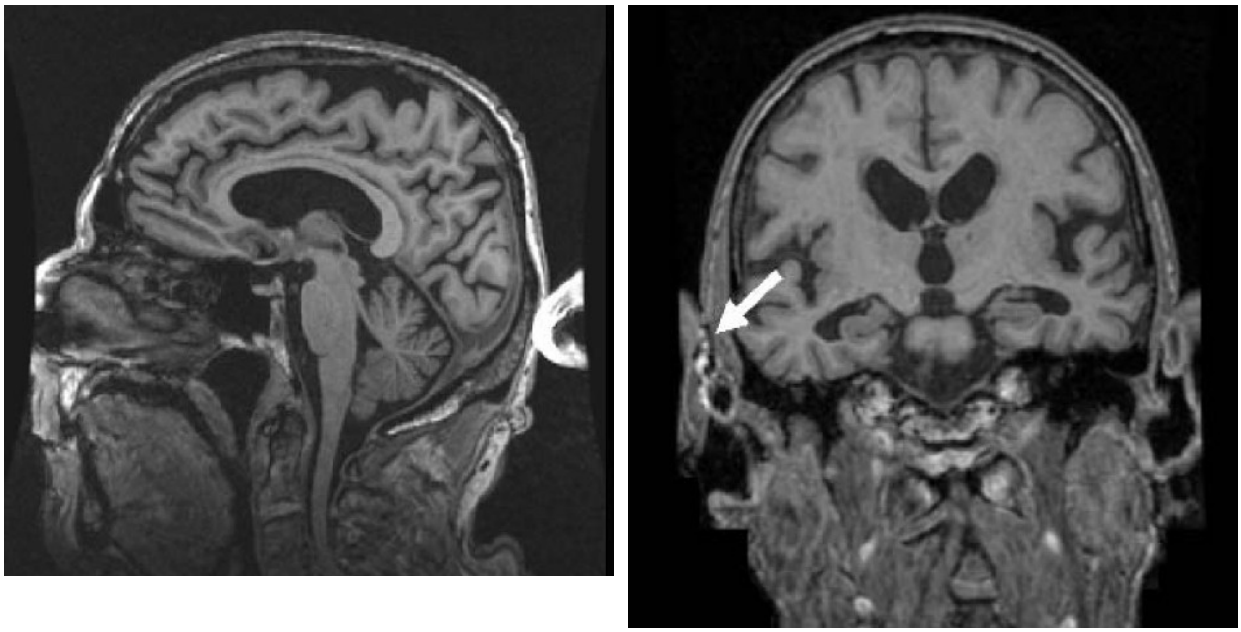
Possible Remedies:

- If movement is due to the subject's head moving, reacquire MP-RAGE after tightly securing the subject's head with additional restraints and discussions with subject to hold their head still.
- If the subject is not moving it is possible the artifact is the result of mechanical problems. Please discuss with your service engineer.

6.2 Wrap-Around

Problem:

In this example, wrap around occurs in the MP-RAGE image above. In the figure on the left, the nose folds into the back of the skull. In the figure on the right, the ear wraps into the side of the skull. Acquisitions with wrap-around artifacts will not be accepted and a repeat scan will be requested.



Possible Remedy:

- Wrap around generally occurs when the subject's head size is larger than the acquisition box. Please try to position the acquisition box so that the wrap can be avoided.

6.3 Signal Loss

Problem:

In this example, the image has a loss of signal at the top of the brain due to incorrect positioning in the head coil. The subject was placed too high in the coil. Please note the lack of contrast between gray and white matter at the top of the brain only. Acquisitions with signal loss, especially due to incorrect positioning, will not be accepted and a repeat scan will be requested.

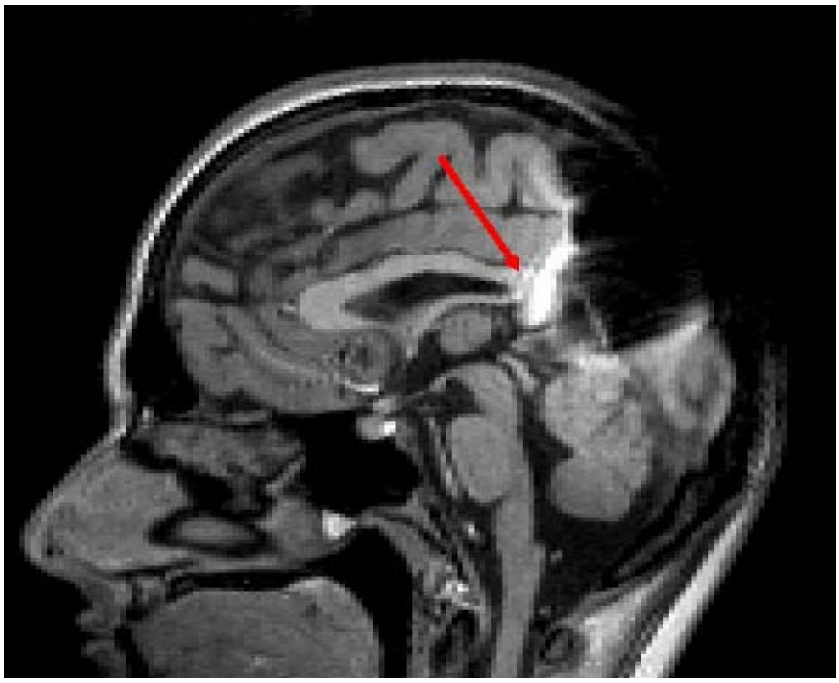
Possible Remedies:

- Check to be sure subject is positioned correctly in the head coil. Please see "Subject Positioning" for information on positioning.
- Make sure head coil is properly secured

6.4 Metal

Problem:

Magnetic field distortions: In this example there is a signal void due to the presence of metal near the subject's head. Acquisitions with metal artifact will not be accepted any circumstances and a repeat scan will be requested.



Possible Remedy:

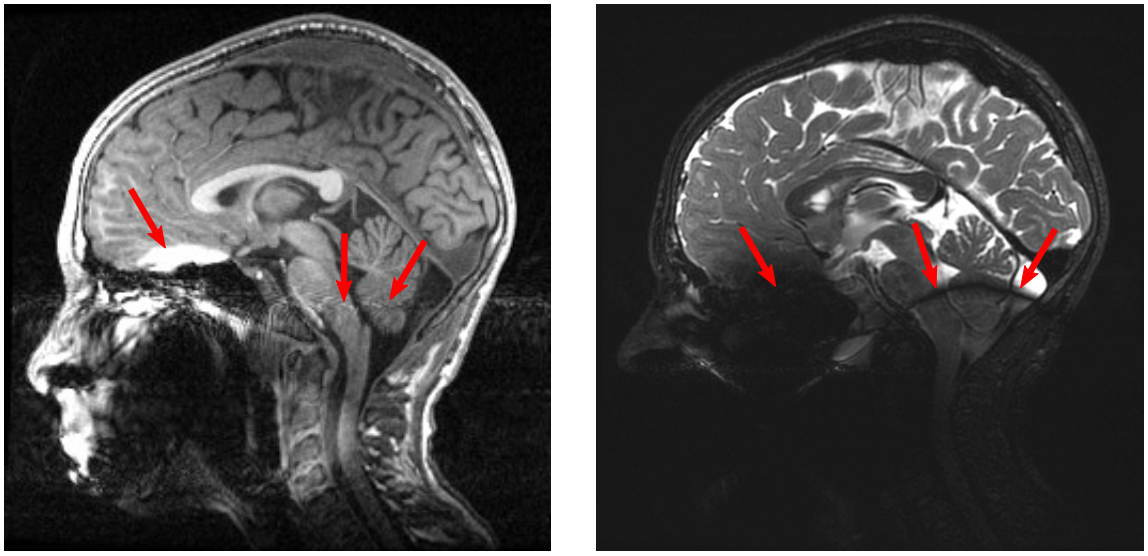
Make sure the subject is not wearing any metal. Check for hair clips, metallic makeup (i.e. permanent eyeliner), necklace, safety pins, removable dentures, and facial jewelry. Remove metal and rescan.

6.5 Metal Retainers, Jaw Wires, Dental Work

Problem:

Depending on size and position of metal dental work, artifacts may be localized to the mouth area or have effects into the brain.

Below, metal clips caused signal pileup in the frontal lobe and noise in the brainstem and cerebellum in the T1-weighted image. The T2-weighted image shows signal void in the jaw area, extending into the brain, and a dark line across the cerebellum.



Possible Remedy:

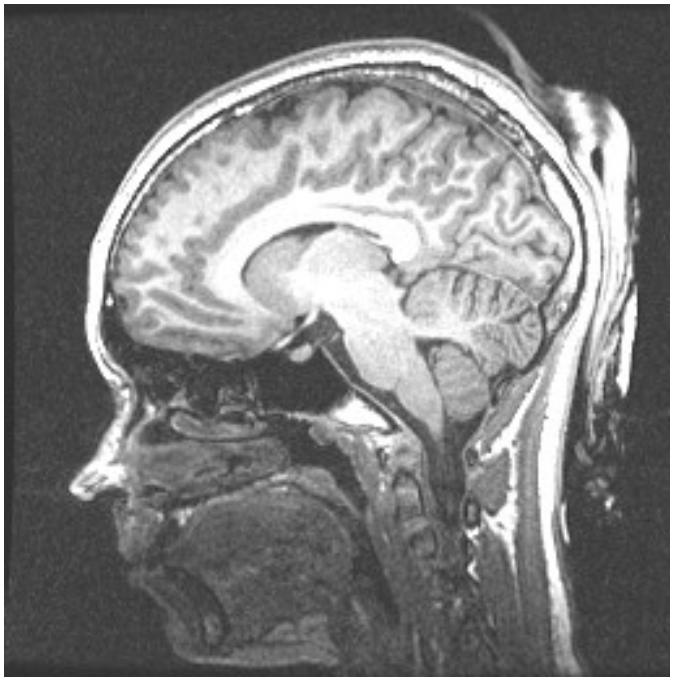
If possible remove all dental work, wires, retainers prior to scanning.

Carefully screen for metal effects in the brain and **put a remark in the "Notes" field for the scan session when uploading the data to XNAT.** Final determination about data usability will be made by the QA staff at the N-CANDA Data Component.

6.6 Hair Products

Problem:

Hair produces high-intensity imaging signal, most likely in T1-weighted (SPGR or MP-RAGE) acquisition. This is likely due to the presence of fat-containing hair product.



Possible Remedy:

While it is impossible to remove the hair product, long hair (e.g., ponytail) can be positioned to minimize its impact on the imaging.

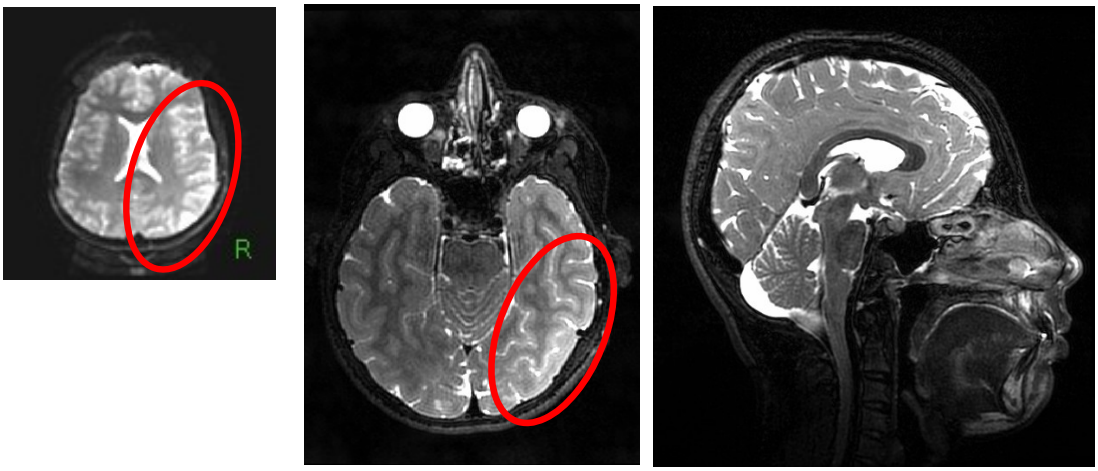
For example, rather than rest the subject's head on the ponytail (as in the image above), straighten the hair and lay it out on the scanner table, pointing away from the head.

6.7 Unusual Intensity Bias Field

Problem:

In the images shown below, a coil problem cause a left/right intensity bias field in the b=0 image of the DWI series and the T2-weighted FSE image (a lesser bias field was also visible in the T1-weighted image). This is markedly different from the typical B1 field inhomogeneity-related intensity bias field (e.g., brighter in the center, darker in the periphery).

Note that the problem is not apparent in the original, sagittal FSE image.



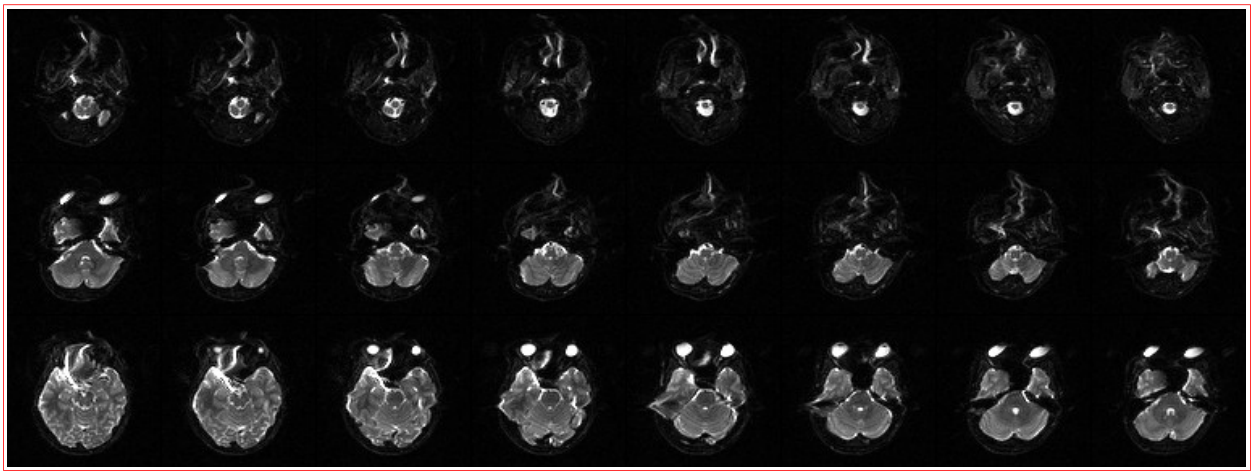
Possible Remedy:

- Verify that the subject's head is correctly positioned in the center of the head coil and securely padded.
- Verify that all cables to the coil are attached correctly.
- Contact service staff to diagnose and fix scanner problem, if problem persists after checking subject position and cables.
- **Imaging series showing local intensity variations as seen above must be repeated!**

6.8 Non-Phase Encode-Direction DWI Distortion

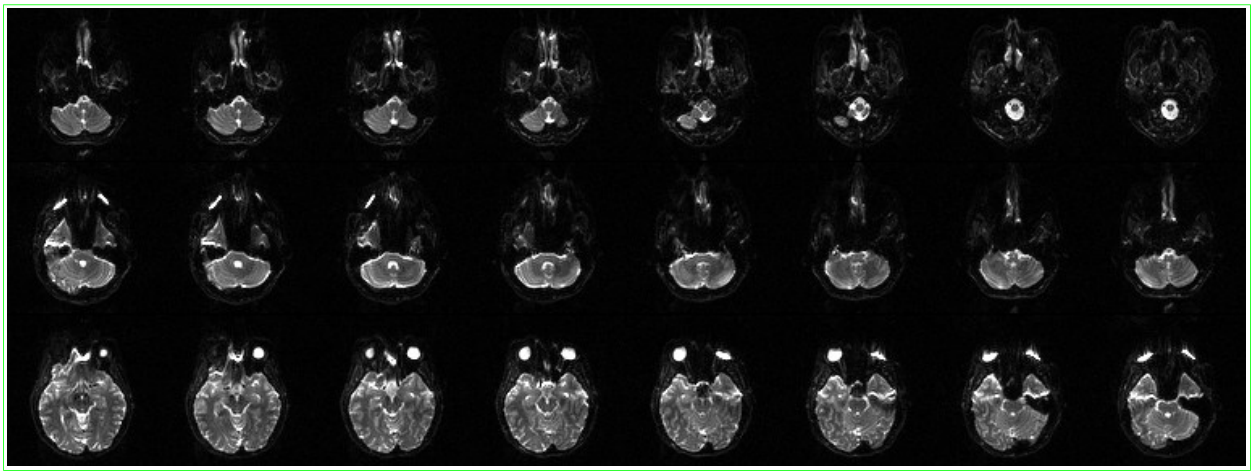
Echo-planar (specifically, diffusion-weighted) images show strong spatial distortion in the direction of phase encoding (PE). For the N-CANDA acquisition protocols, this is the Anterior-Posterior direction.

On one scanner (Siemens), we have observed a transient problem (underlying cause still unidentified), which lead to distortion outside the PE direction. This is easily recognized from the "sideways" distortion in the axial images, which is particularly strong near air-filled cavities, i.e., around the sinuses or ears. Note in the following example specifically the "diagonal" appearance of the eyeballs:



This non-standard distortion appears to affect the b=0 as well as all diffusion-weighted images, cannot be corrected, and makes the collected DWI data unusable.

For comparison, see a typical example below of DWI data with only the expected distortion along the PE direction (which can be corrected):



Unfortunately, the underlying cause of the non-PE distortion is still unknown, as the problem disappeared before it could be diagnosed.

If you observe unusual distortion in newly collected DWI data, contact your site's scanner maintenance staff immediately.