FreeSurfer Version 7
Building a FreeSurfer

Benzinger Imaging Core Laboratory

https://surfer.nmr.mgh.harvard.edu/

Presentation Outline

1) FreeSurfer “recon-all” command overview
2) Running FreeSurfer via a Docker Container
   a) Docker container overview
   b) Running the FS 7 Docker container on a lab machine
   c) XNAT platform overview
   d) Running the FS 7 Docker container on the XNAT platform
3) XNAT walkthrough
   a) XNAT user interface
   b) Launching a container via the XNAT UI

Typical FreeSurfer CLI Build Workflow

1) Set environment variables and source the FreeSurfer setup script
2) Set the SUBJECTS_DIR variable to point to your output directory
3) Run the recon-all command
4) Wait for the recon-all process to complete (6 to 8 hours runtime)

recon-all Required Fields

```
recon-all -s <subject_id> -i <absolute_path_to_T1> -all
```

Input flags:

`-s`	session/subject id. This is what the FreeSurfer folder will be called.
`-i`	the absolute path to your T1 (nifti or dicom). If dicom, just select one of the dicom files.
`-all`	run every part of processing stream

Recon-all Additional Input Options

```
recon-all -s <subject_id> -i <absolute_path_to_T1> -all -<options>
```

TONS of different options can be included as input.

Examples can be found at:
https://surfer.nmr.mgh.harvard.edu/fswiki/OtherUsefulFlags

Or on the command line:

```
recon-all --help
```

Recon-all example

```
recon-all -s bert -i /myfolder/bert-t1/dicom-file.dcm -all -qcache
```

`-qcache`

Produces pre-cached files required for *mri_glmfit* allowing rapid analysis of group data. Creates smoothed surface data files sampled to the 'fsaverage' common-space surface.

More details can be found at:
https://surfer.nmr.mgh.harvard.edu/fswiki/FsTutorial/GroupAnalysis

Benzinger Lab Note

The Benzinger Lab uses the Freesurfer recon-all command line method only for *advanced customization of processing*.

For our *standard data processing* workflow, we are using a **Docker container** with the Freesurfer program installed in it. This allows the recon-all program to run consistently regardless of which system it is run on.

Running FreeSurfer using a Docker Container

What is a Docker container?

- Similar to a virtual machine setup but much more lightweight/faster
- Includes program code and all its dependencies
- Ensures that an application runs reliably across computing environments
- Standalone, executable package of software:
  - Operating system
  - System tools and system libraries
  - Configuration variables and settings
  - Program code
- Typically each software (FS, PUP, dcm2niix, etc.) will have its own container

https://www.docker.com/resources/what-container

Reliability of containers

- Values and output produced by some imaging software can differ based on factors like computer hardware and operating systems
  - FreeSurfer group recommends running all processing on the same system
  - Challenging for large long-term studies like ours
- Containers circumvent this issue
  - Containerized software will always run consistently - identical output
  - Isolated from the computing environment
  - Not affected by base computer hardware, operating system, installed programs, or network infrastructure
  - Simulates running processing on the same system even though we will be using many different machines

Docker container for Freesurfer 7.1.1

- We will be using our Freesurfer 7.1.1 Docker container for processing standardized study data
  - “offline”/“locally” (on computers we have in the lab)
  - “online” (in the cloud using a platform called **XNAT**)
- Specific Linux computers in the lab have the container installed and it is easy to install locally
- Newer XNAT systems that we will use will be configured to have our FreeSurfer container available

Running the FS 7 container locally

- Our lab Linux machines will have Docker Engine and our Freesurfer container installed so you can run it from the command line.
- Running the full container command is complicated, so we provide a shortcut that is runnable once you have the FreeSurfer environment variables and program set up.

```
FS711DockerLaunch bert /myfolder/bert-t1/dicom-file.dcm -all -qcache
```

Running FS 7 on XNAT: XNAT Overview

- What is XNAT?
  - An open source imaging informatics platform
  - Originally developed at WUSTL
  - Web-based – runs in a web browser
- XNAT Functionality:
  - Importing data from scanners
  - Archiving/saving data into the database (scan images, text or number-based data)
  - Secure sharing of imaging and related study data
  - Data processing capabilities (such as Docker containers)

Running FS 7 on XNAT: Accessing XNATs

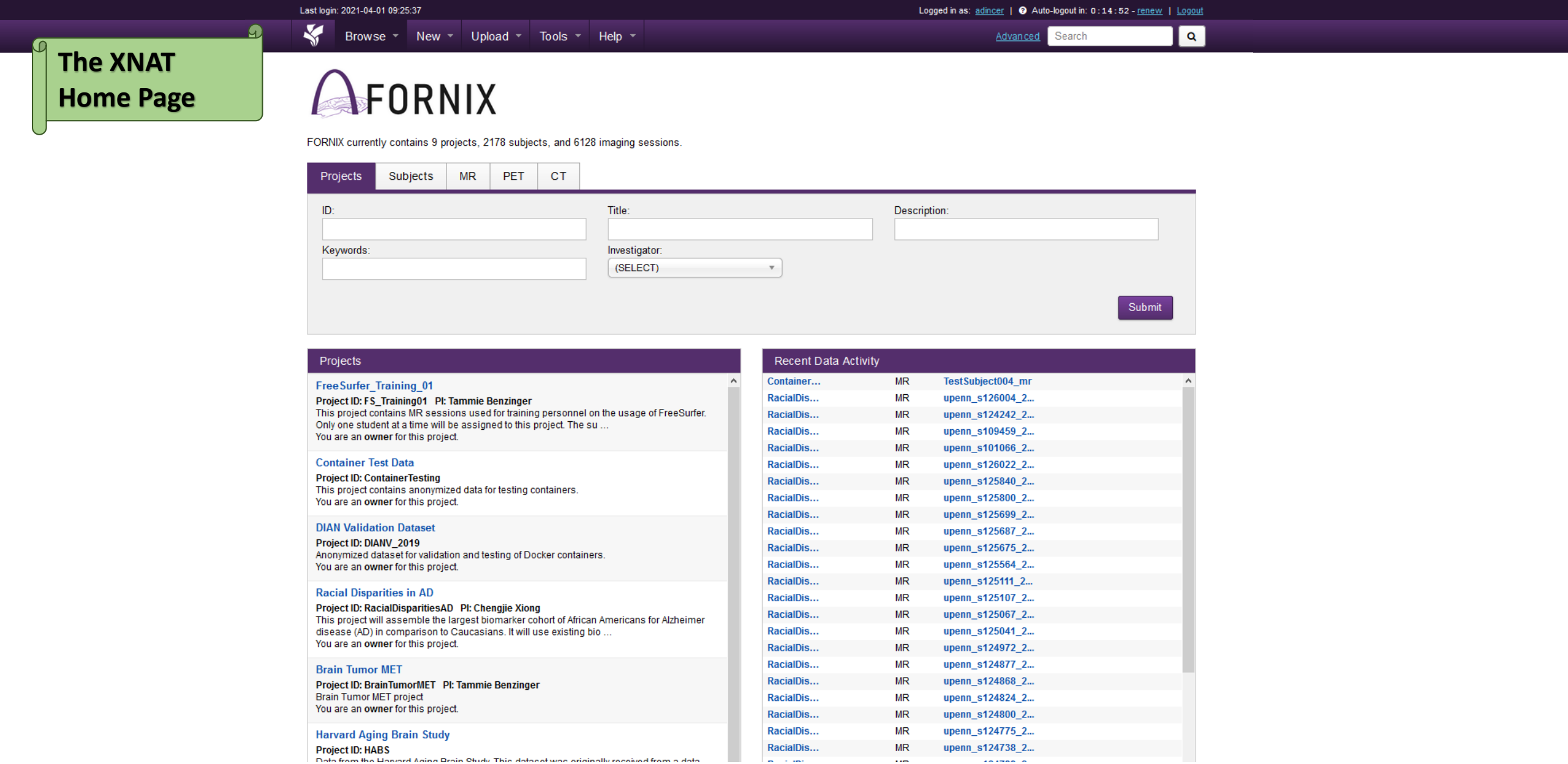
- How to access our lab's XNAT sites?
  - Find out which XNAT site you need to process data on and go to its URL in your web browser.
- **CNDA**: https://cnda.wustl.edu
  - Used by many groups at Wash U
- **FORNIX**: https://fornix.wustl.edu
  - Newer, mostly Benzinger Lab projects
- Others are sometimes used but these are the main ones.

Running FS 7 on XNAT: Workflow

- Access a “MR Session Page”
- Select FreeSurfer 7 in the “Run Containers” menu
  - Request that it be enabled if it isn’t there
- Select the T1 scan ID and file format to use
- Container runs on the XNAT server
- Output gets uploaded to XNAT and you receive a success email
- View newly generated Freesurfer output page and download output data for QC.

XNAT and XNAT FreeSurfer Container Demo

The XNAT Home Page



The XNAT Home Page

Last login: 2021-04-01 09:25:37

Logged in as: adincer | Auto-logout in: 0:14:52 - renew | Logout

Browse | Ne

Find Projects

Advanced | Search

FORNIX

FORNIX currently contains 9 projects, 2178 subjects, and 6128 imaging sessions.

Projects | Subjects | MR | PET | CT

ID:

Title:

Description:

Keywords:

Investigator: (SELECT)

Submit

Projects

FreeSurfer_Training_01
Project ID: FS_Training01 PI: Tammie Benzinger
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DIAN Validation Dataset
Project ID: DIANV_2019
Anonymized dataset for validation and testing of Docker containers.
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Racial Disparities in AD
Project ID: RacialDisparitiesAD PI: Chengjie Xiong
This project will assemble the largest biomarker cohort of African Americans for Alzheimer disease (AD) in comparison to Caucasians. It will use existing bio ...
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Brain Tumor MET
Project ID: BrainTumorMET PI: Tammie Benzinger
Brain Tumor MET project
You are an **owner** for this project.

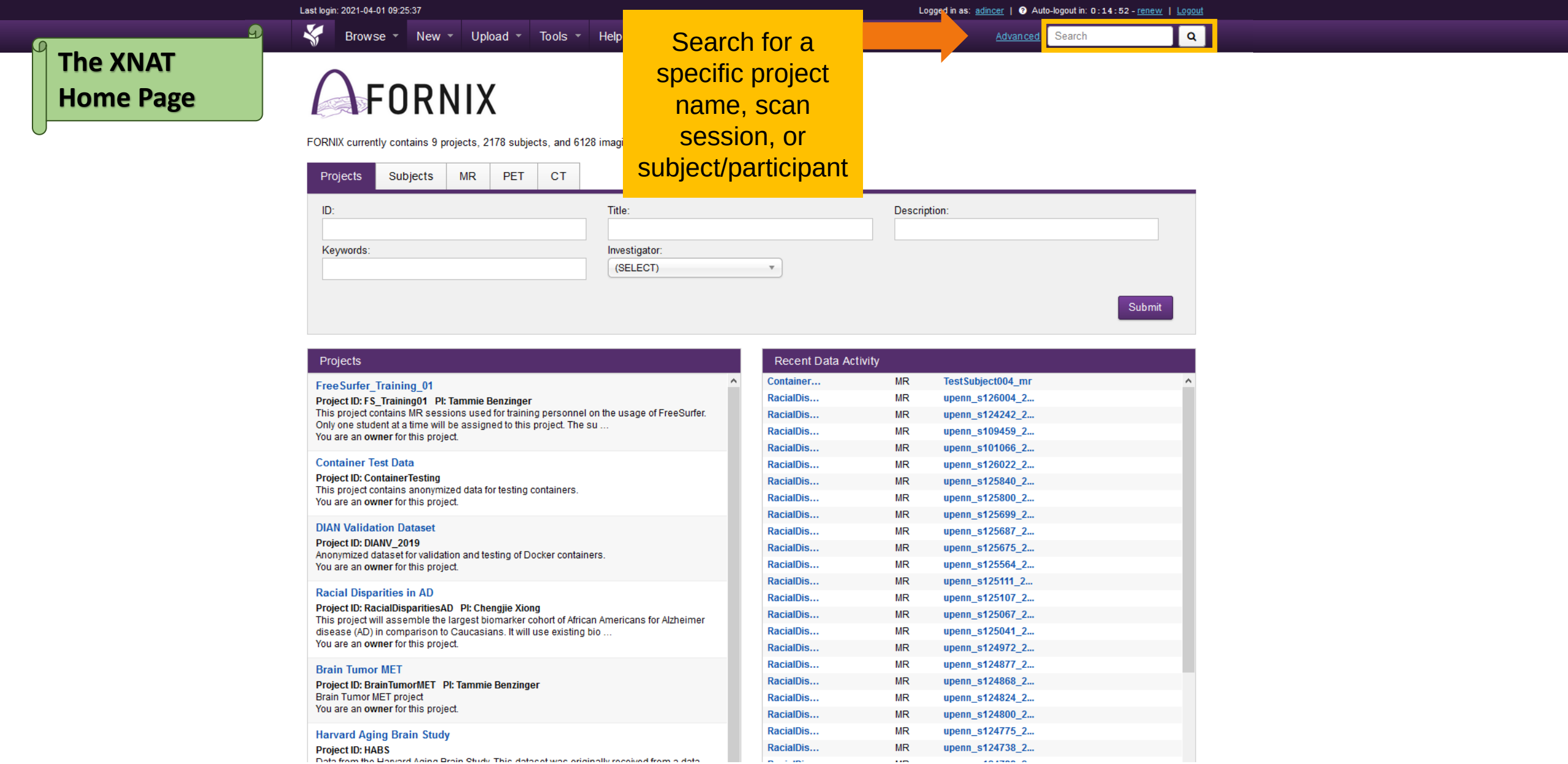
Harvard Aging Brain Study
Project ID: HABS
Data from the Harvard Aging Brain Study. This dataset was originally received from a data

Recent Data Activity

Container...	MR	TestSubject004_mr
RacialDis...	MR	upenn_s126004_2...
RacialDis...	MR	upenn_s124242_2...
RacialDis...	MR	upenn_s109459_2...
RacialDis...	MR	upenn_s101066_2...
RacialDis...	MR	upenn_s126022_2...
RacialDis...	MR	upenn_s125840_2...
RacialDis...	MR	upenn_s125800_2...
RacialDis...	MR	upenn_s125699_2...
RacialDis...	MR	upenn_s125687_2...
RacialDis...	MR	upenn_s125675_2...
RacialDis...	MR	upenn_s125564_2...
RacialDis...	MR	upenn_s125111_2...
RacialDis...	MR	upenn_s125107_2...
RacialDis...	MR	upenn_s125067_2...
RacialDis...	MR	upenn_s125041_2...
RacialDis...	MR	upenn_s124972_2...
RacialDis...	MR	upenn_s124877_2...
RacialDis...	MR	upenn_s124868_2...
RacialDis...	MR	upenn_s124824_2...
RacialDis...	MR	upenn_s124800_2...
RacialDis...	MR	upenn_s124775_2...
RacialDis...	MR	upenn_s124738_2...

The XNAT Home Page

Search for a specific project name, scan session, or subject/participant



The XNAT Home Page

Last login: 2021-04-01 09:25:37

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Browse | New | Upload | Tools | Help

Advanced | Search

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RacialDis...	MR	upenn_s125564_2...
RacialDis...	MR	upenn_s125111_2...
RacialDis...	MR	upenn_s125107_2...
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RacialDis...	MR	upenn_s124824_2...
RacialDis...	MR	upenn_s124800_2...
RacialDis...	MR	upenn_s124775_2...
RacialDis...	MR	upenn_s124738_2...

Snapshot of recent data processing updates

Browsing for Projects

Last login: 2021-04-01 09:25:37

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Browse

Click on Browse dropdown menu

Advanced Search

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RacialDis...	MR	upenn_s124877_2...
RacialDis...	MR	upenn_s124868_2...
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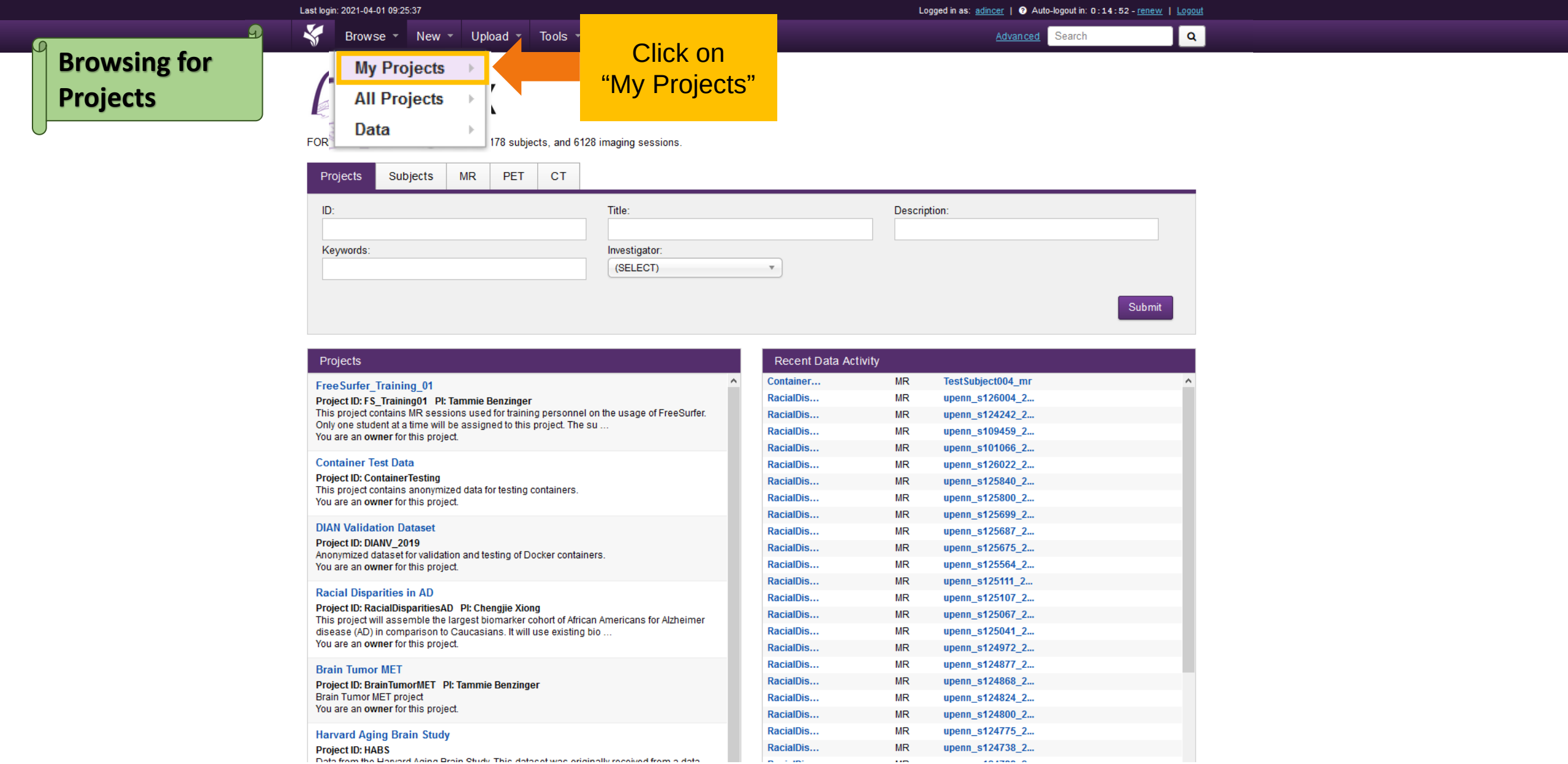
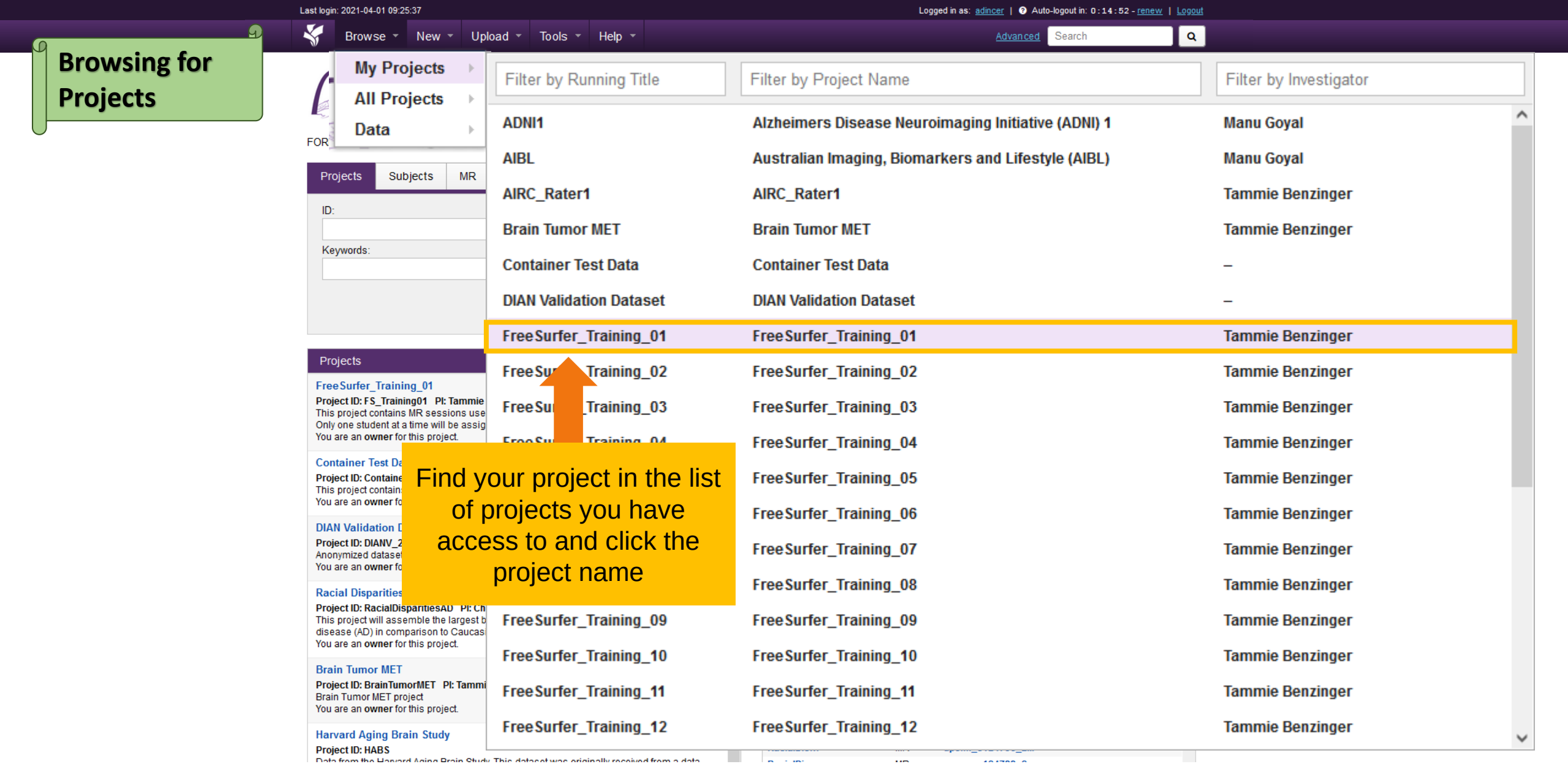
RacialDis...	MR	upenn_s124738_2...

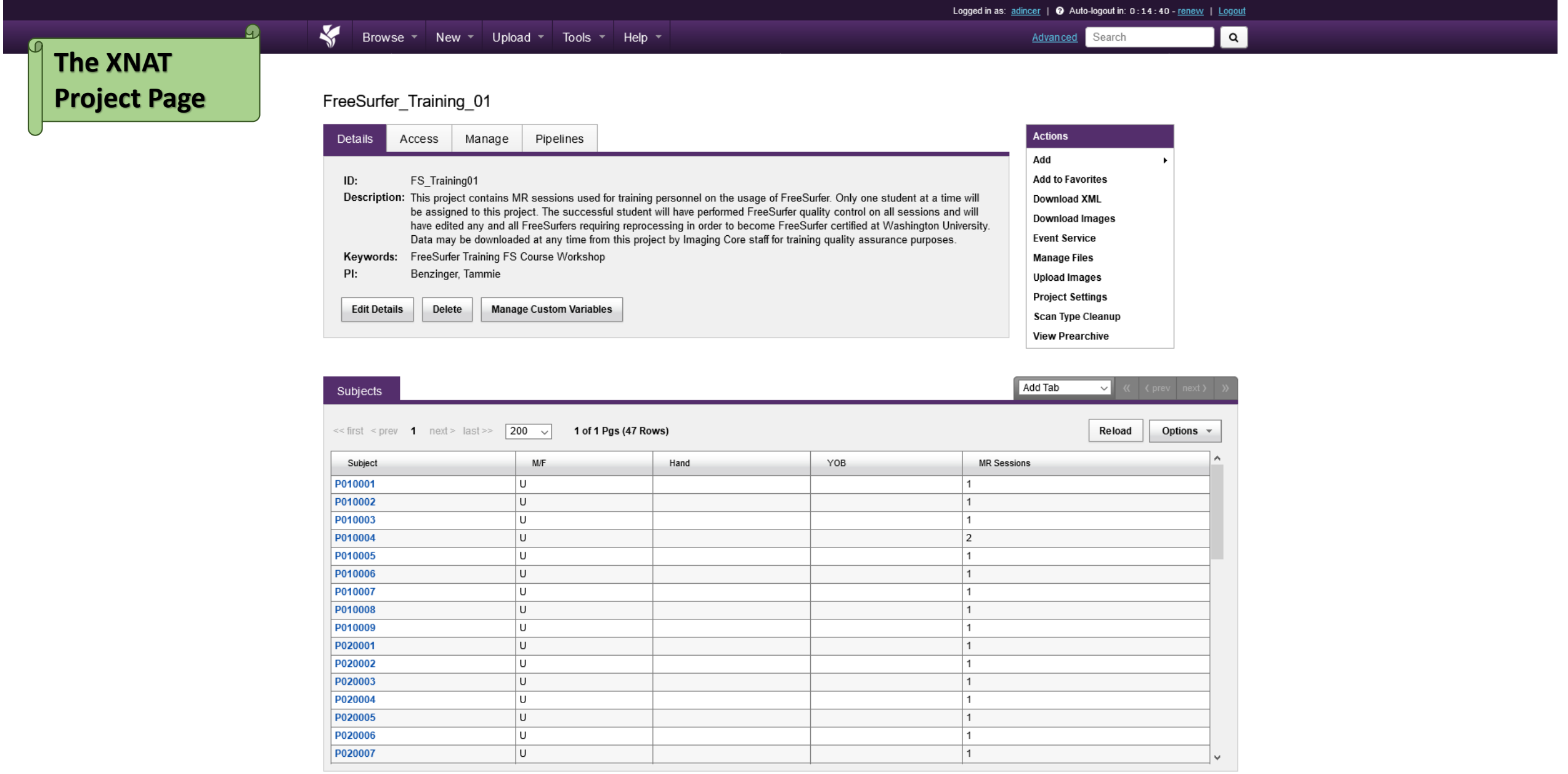
Browsing for Projects



Browsing for Projects

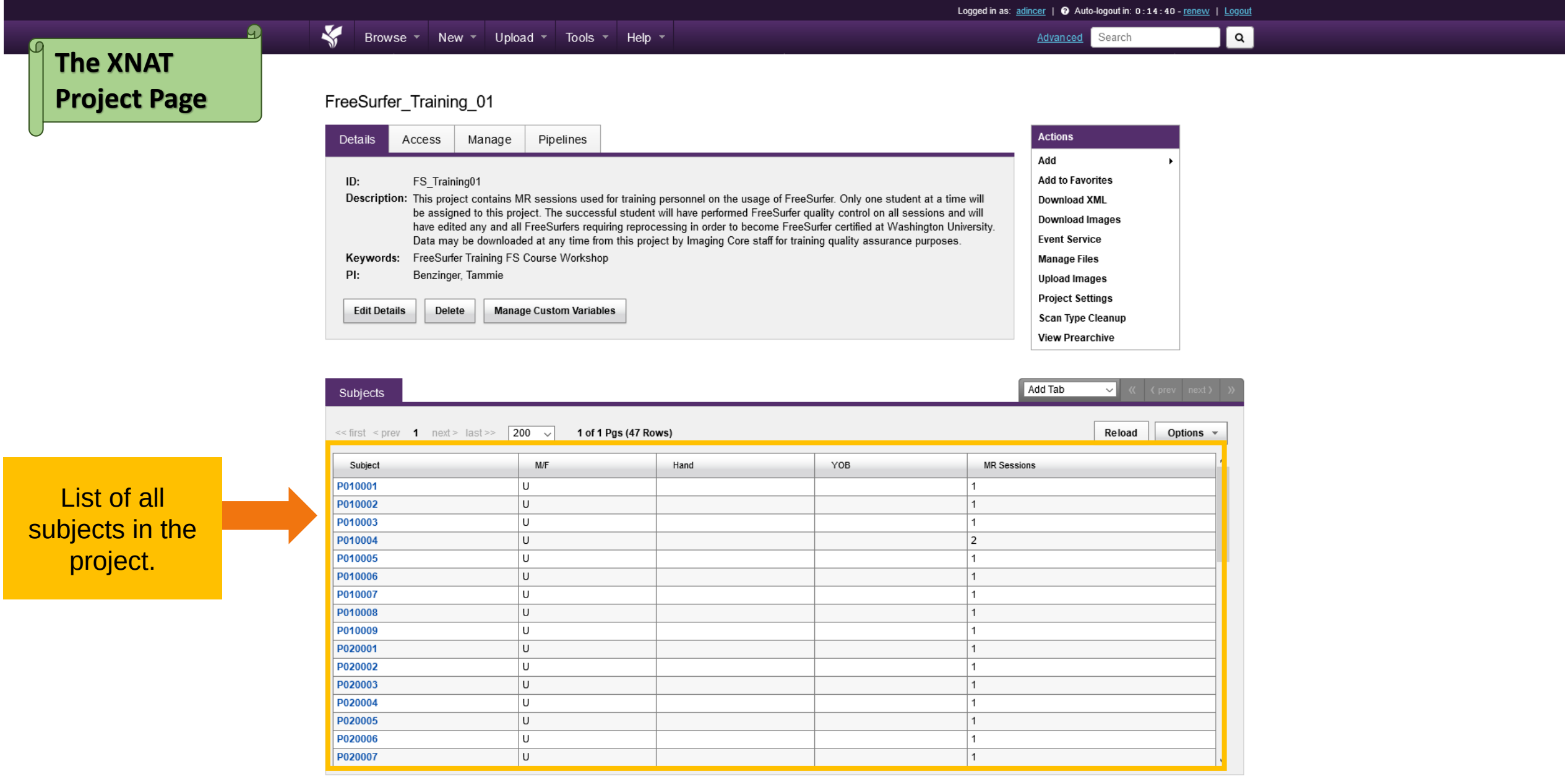


The XNAT Project Page



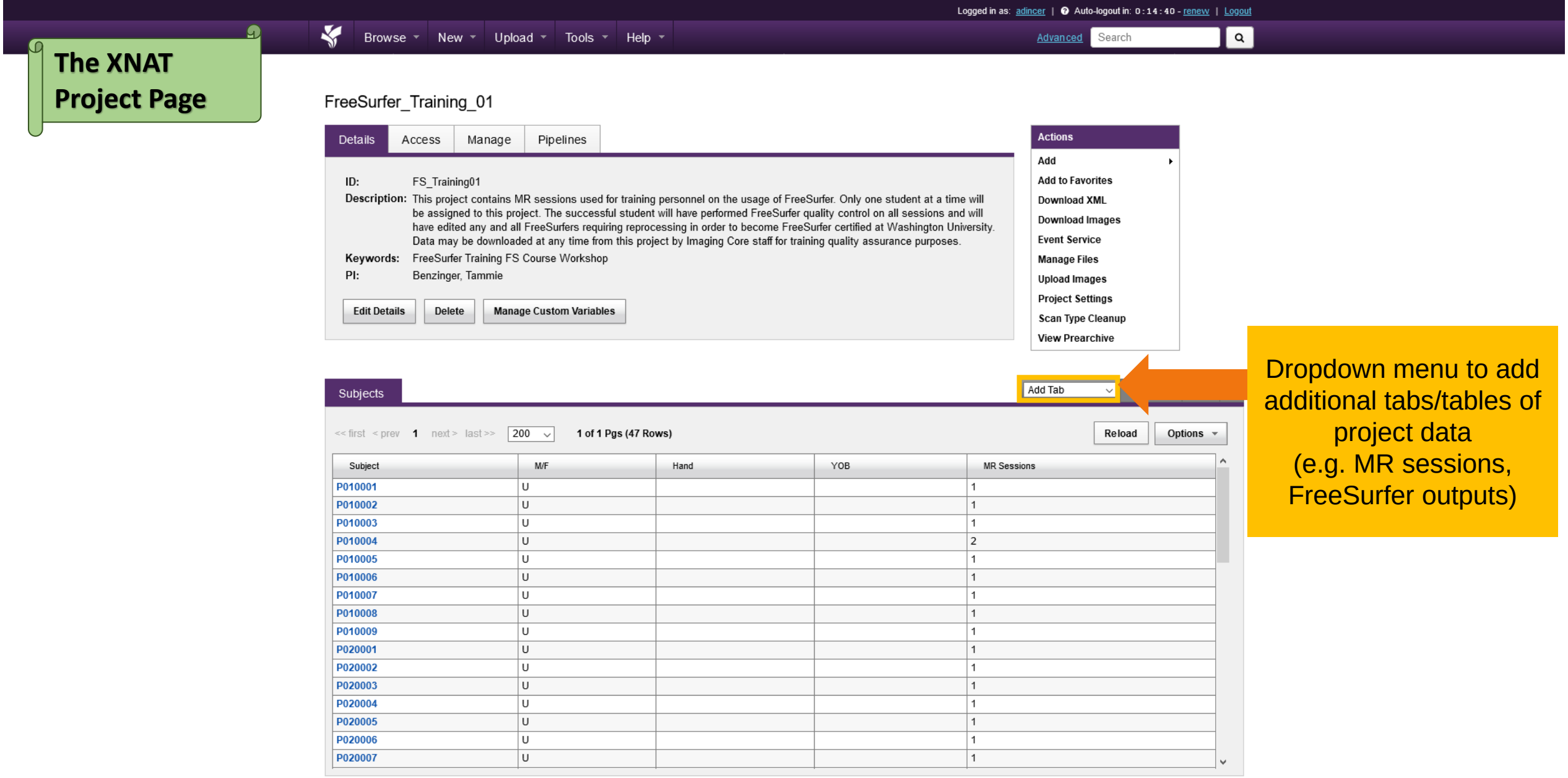
Subject	M/F	Hand	YOB	MR Sessions
P010001	U			1
P010002	U			1
P010003	U			1
P010004	U			2
P010005	U			1
P010006	U			1
P010007	U			1
P010008	U			1
P010009	U			1
P020001	U			1
P020002	U			1
P020003	U			1
P020004	U			1
P020005	U			1
P020006	U			1
P020007	U			1

The XNAT Project Page



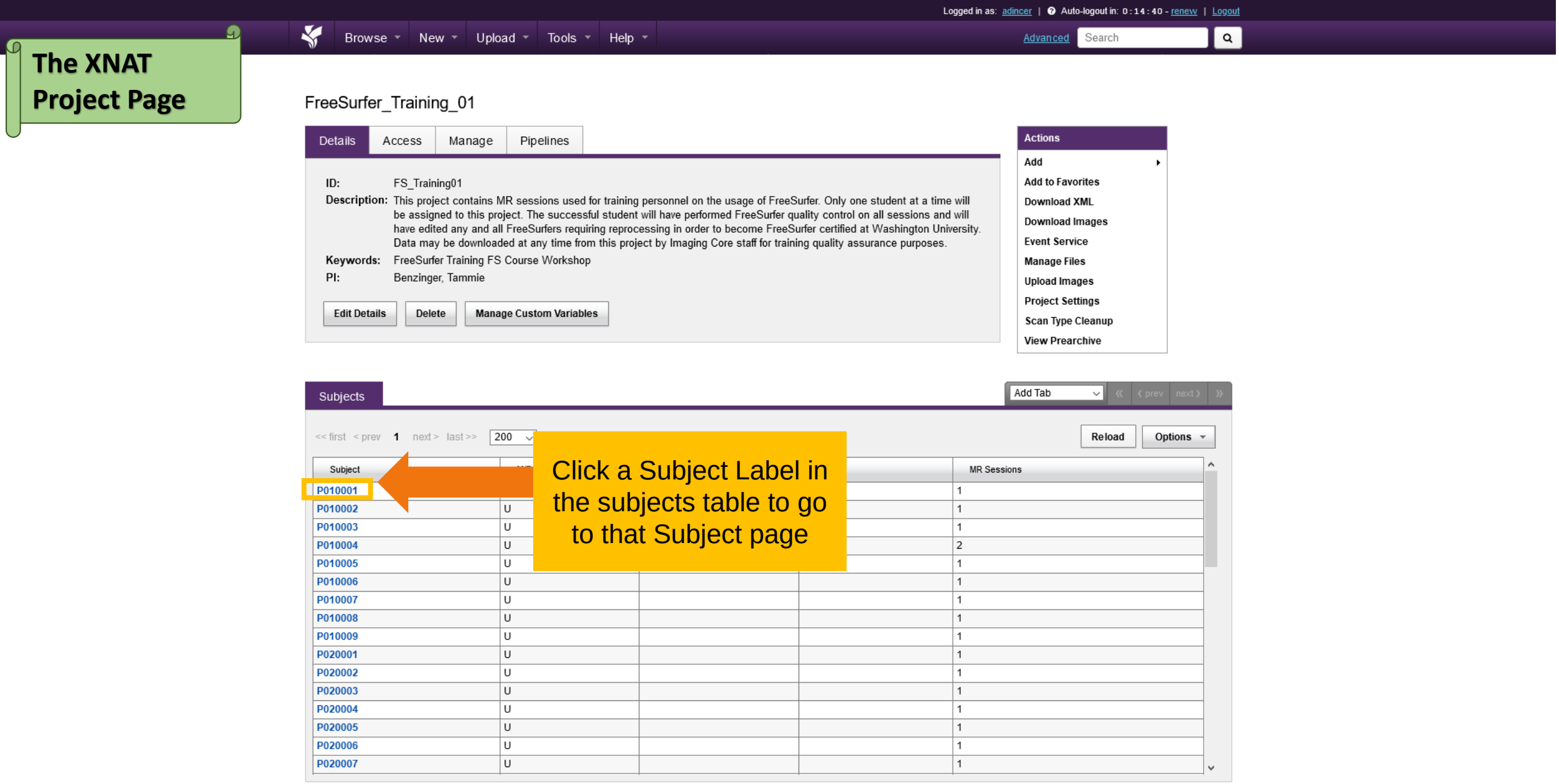
List of all subjects in the project.

The XNAT Project Page

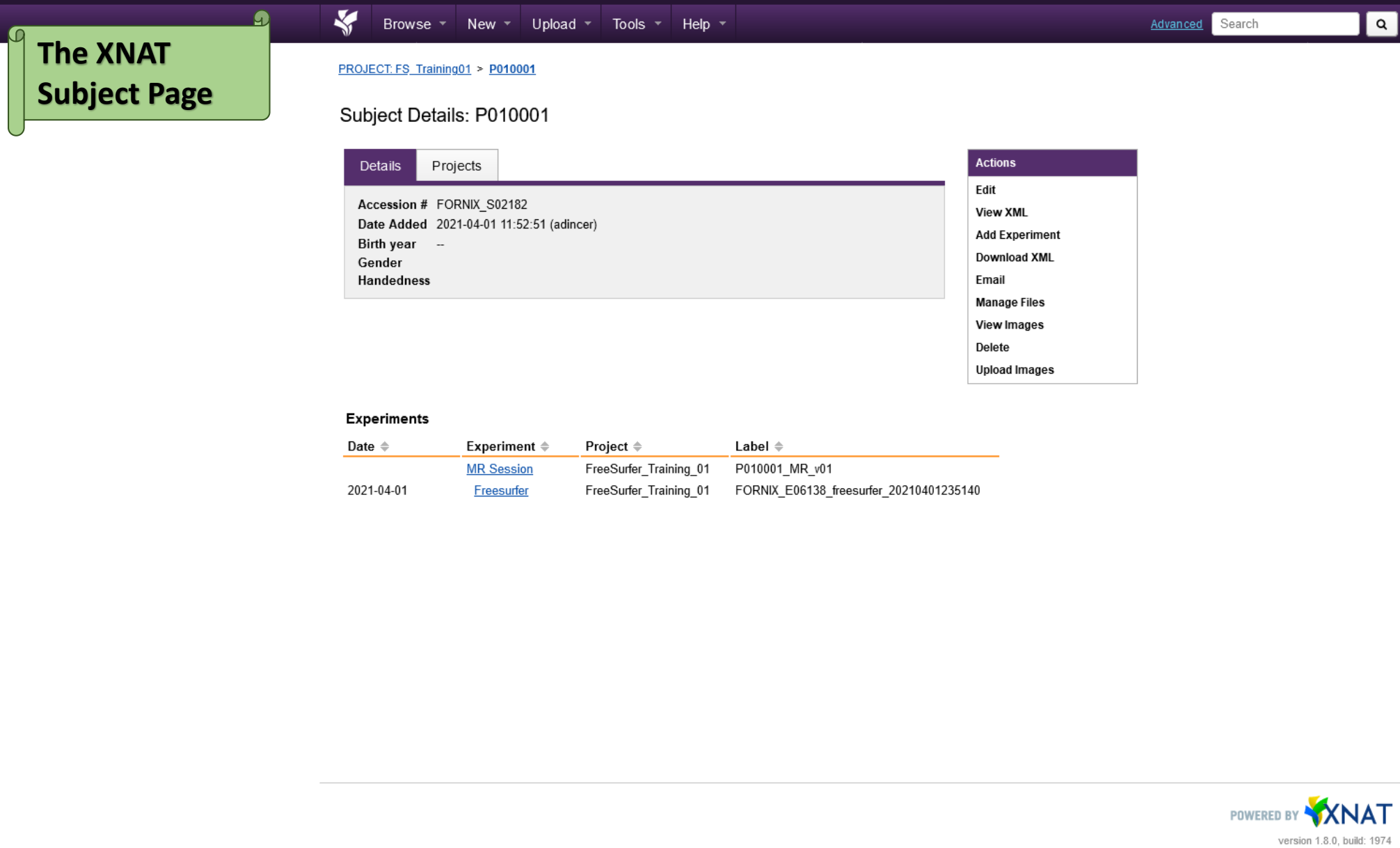


Dropdown menu to add additional tabs/tables of project data (e.g. MR sessions, FreeSurfer outputs)

The XNAT Project Page



The XNAT Subject Page



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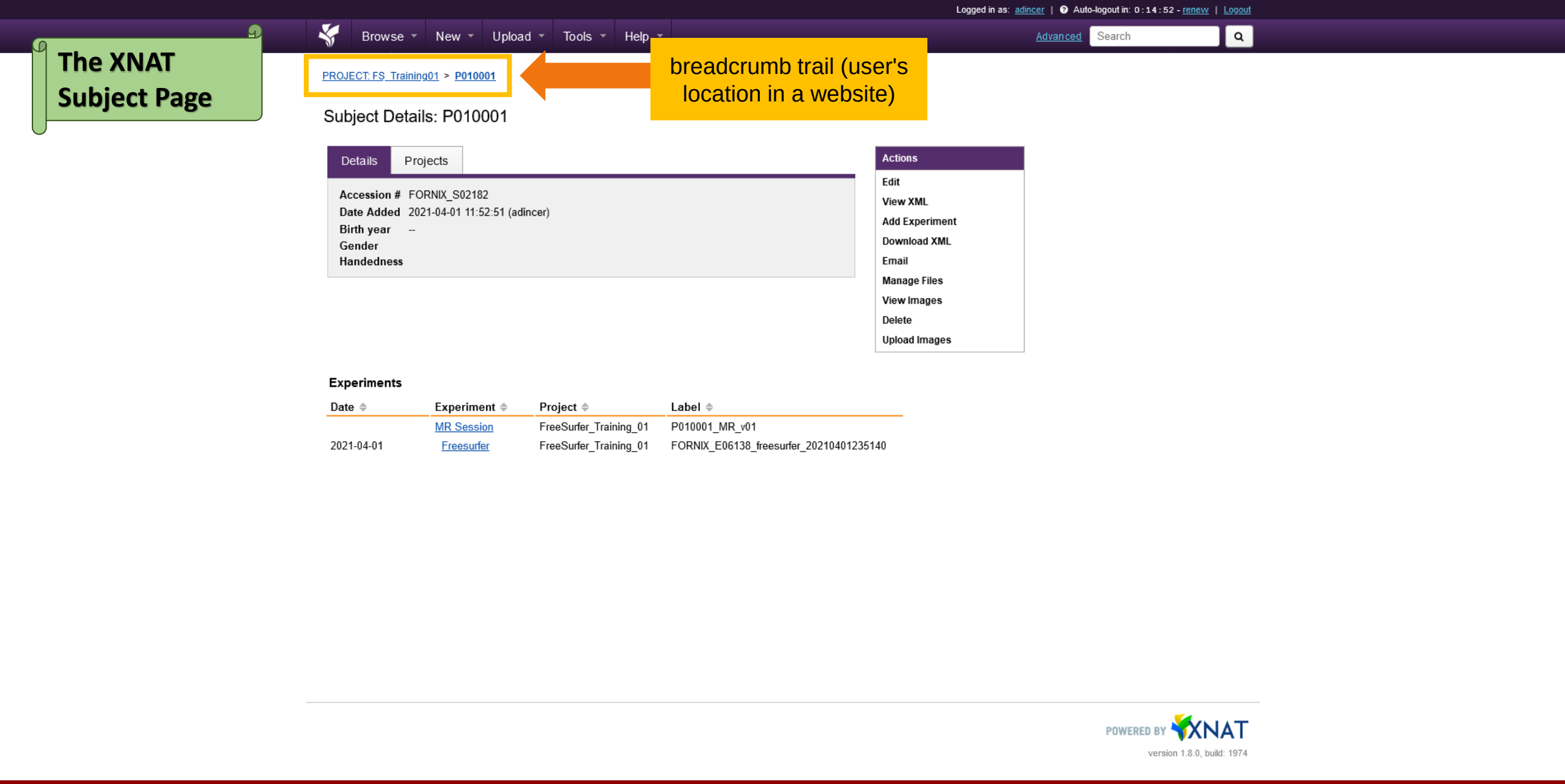

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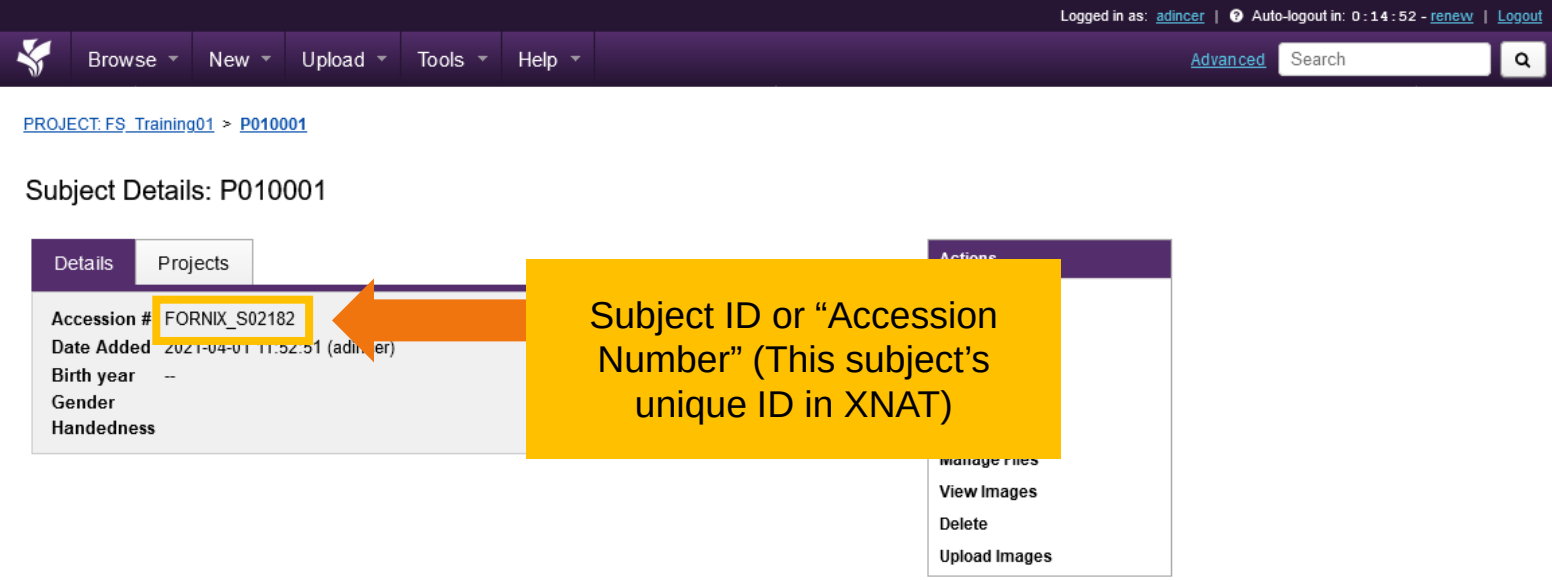

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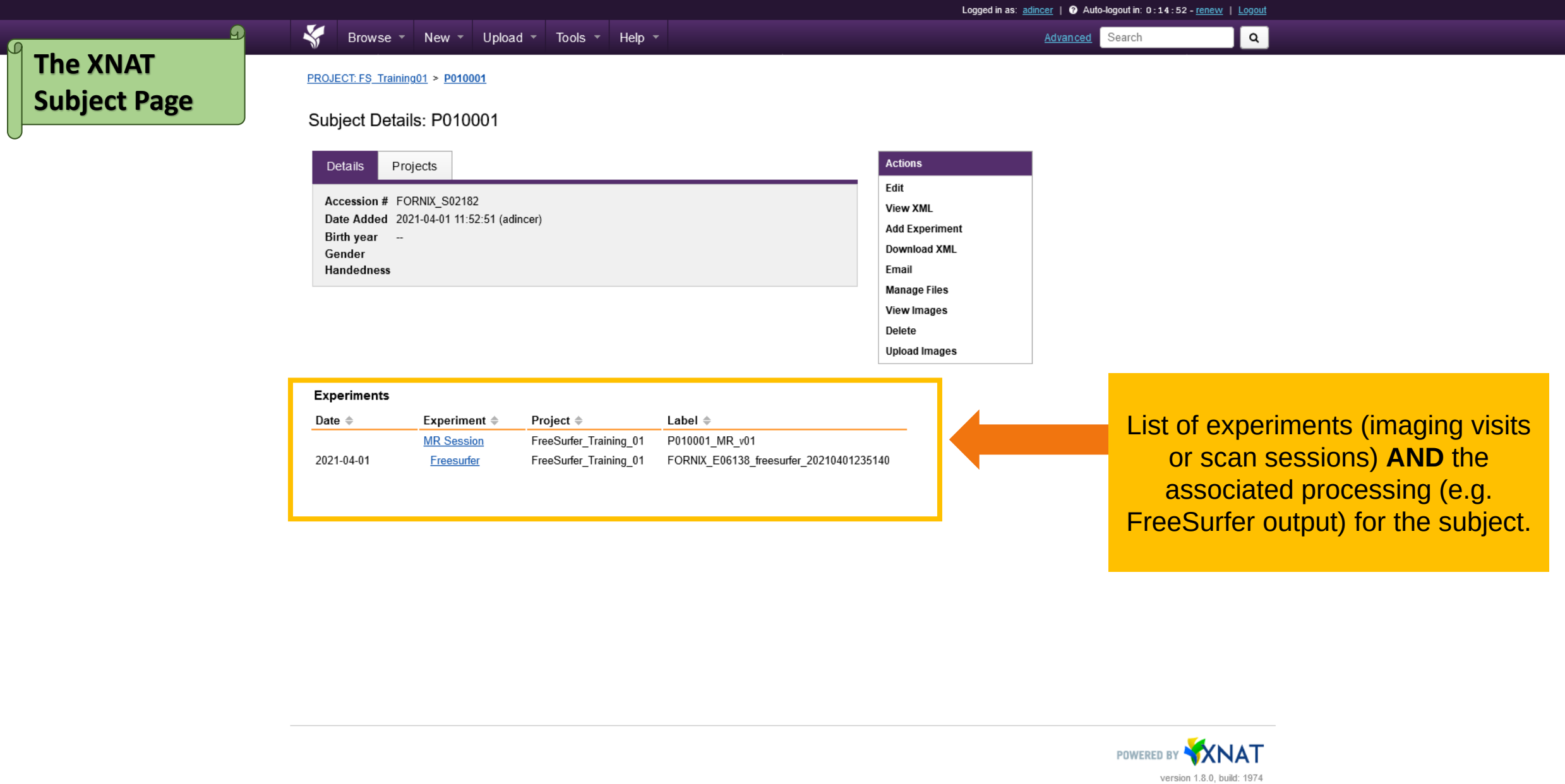

The XNAT Subject Page

Logged in as: adincer | Auto-logout in: 0:14:52 - renew | Logout

Browse | New | Upload | Tools | Help | Advanced | Search

PROJECT: FS_Training01 > P010001

Subject Details: P010001

Details | Projects

Accession # FORNIX_S02182
Date Added 2021-04-01 11:52:51 (adincer)
Birth year --
Gender
Handedness

Actions

- Edit
- View XML
- Add Experiment
- Download XML
- Email
- Manage Files
- View Images
- Delete
- Upload Images

Click on the blue “MR Session” link for a particular MR Session to view the session page.

Experiments

Date	Experiment	Project	Label
	MR Session	FreeSurfer_Training_01	P010001_MR_v01
2021-04-01	Freesurfer	FreeSurfer_Training_01	FORNIX_E06138_freesurfer_20210401235140

POWERED BY XNAT
version 1.8.0, build: 1974

Session or Experiment Page

MR Session: P010001_MR_v01

Details | Projects

Accession #:	FORNIX_E06138	**Subject:**	P010001
Date Added:	2021-04-01 11:52:52 (adincer)	**Gender:**	
Time:	09:16:52	**Handedness:**	
Scanner Name:		**Age:**	--
Scanner Type:	SIEMENS TrioTim		

Actions

- Edit
- View
- Download
- Email
- Manage Files
- View Images
- Delete
- Run Containers

Scans

Bulk Actions: Download | Run Container

Scan	Type	Series Desc	Usability	Files	Note	Run
4	t1_mpr_1mm_p2_pos50	t1_mpr_1mm_p2_pos50	usable	23.8 MB in 174 files		

Total: 23.8 MB in 174 files

History

Assessments

Experiment	Name	Label	Date	Project
Freesurfer			2021-04-01	FreeSurfer_Training_01

Session or Experiment Page

Logged in as: adincer | Auto-logout in: 0:14:47 - renew | Logout

Browse | New | Upload | Tools | Help | Advanced | Search

PROJECT: FS_Training01 > SUBJECT: P010001 > P010001_MR_v01

breadcrumb trail

MR Session: P010001_MR_v01

Details | Projects

Accession #:	FORNIX_E06138	**Subject:**	P010001
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Time:	09:16:52	**Handedness:**	
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Assessments

Experiment	Name	Label	Date	Project
Freesurfer			2021-04-01	FreeSurfer_Training_01

POWERED BY XNAT
version 1.8.0, build: 1974

Session or Experiment Page

Session details tab

Logged in as: adincer | Auto-logout in: 0:14:47 - renew | Logout

Browse | New | Upload | Tools | Help | Advanced | Search

PROJECT: FS_Training01 > SUBJECT: P010001 > P010001_MR_v01

MR Session: P010001_MR_v01

Details | Projects

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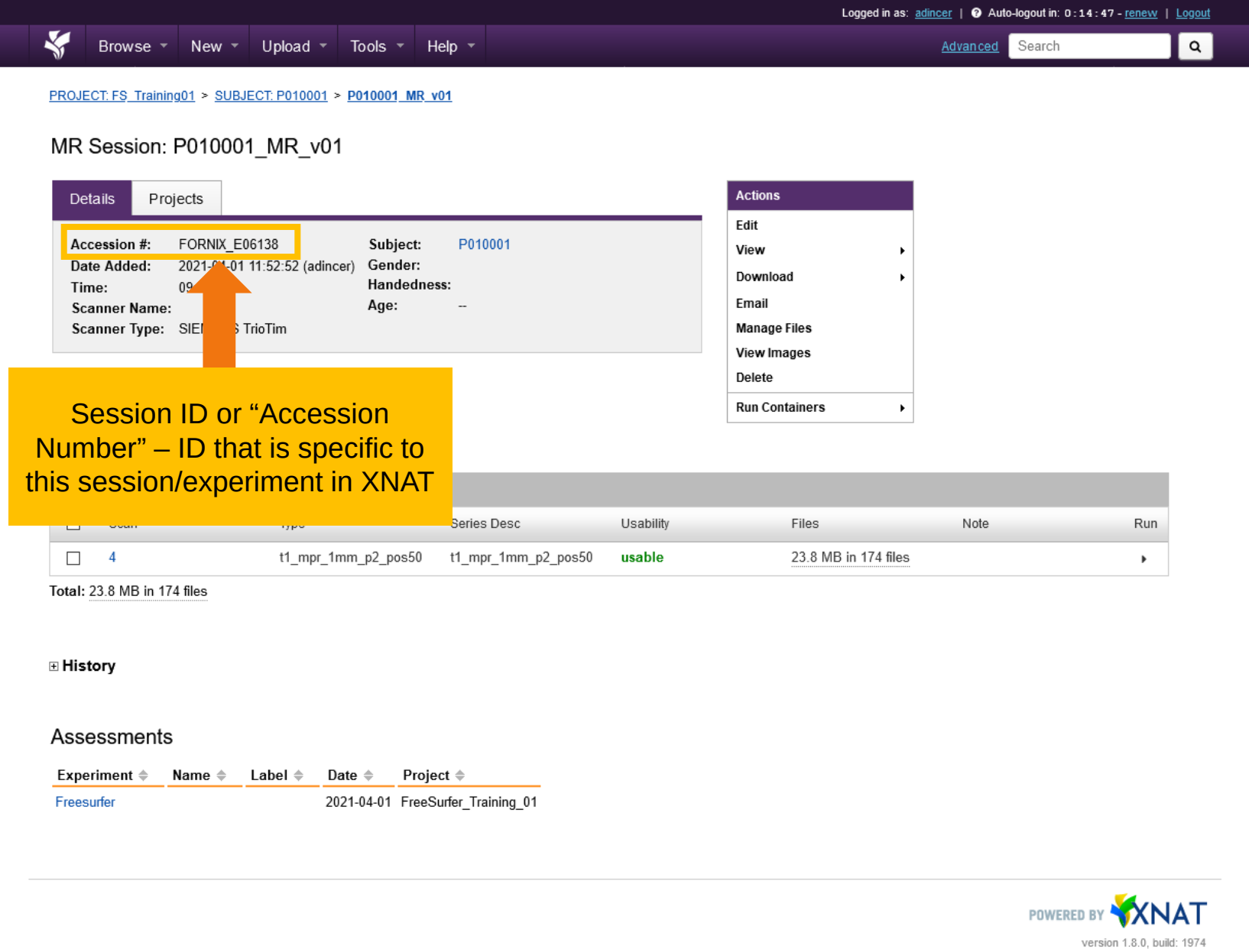

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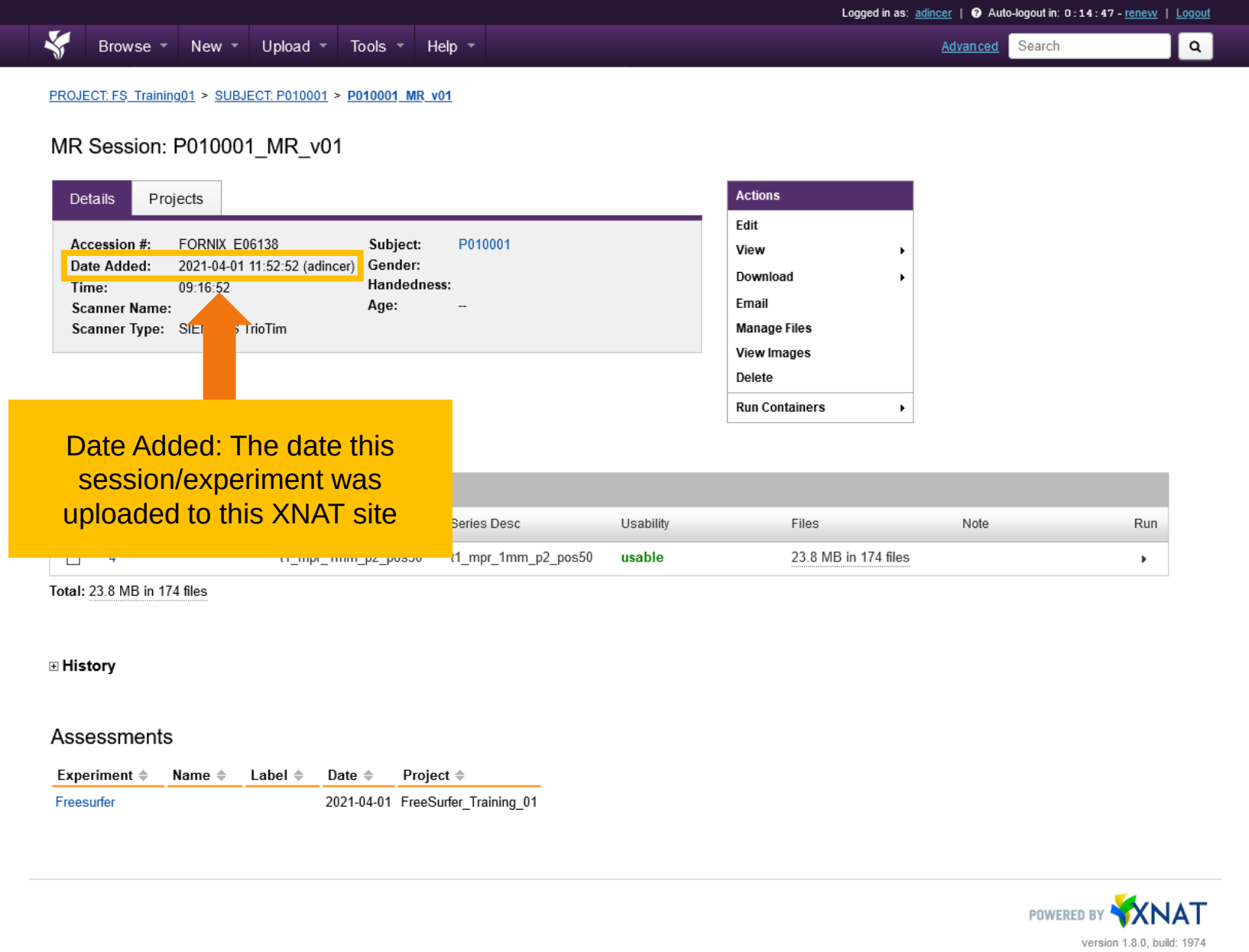

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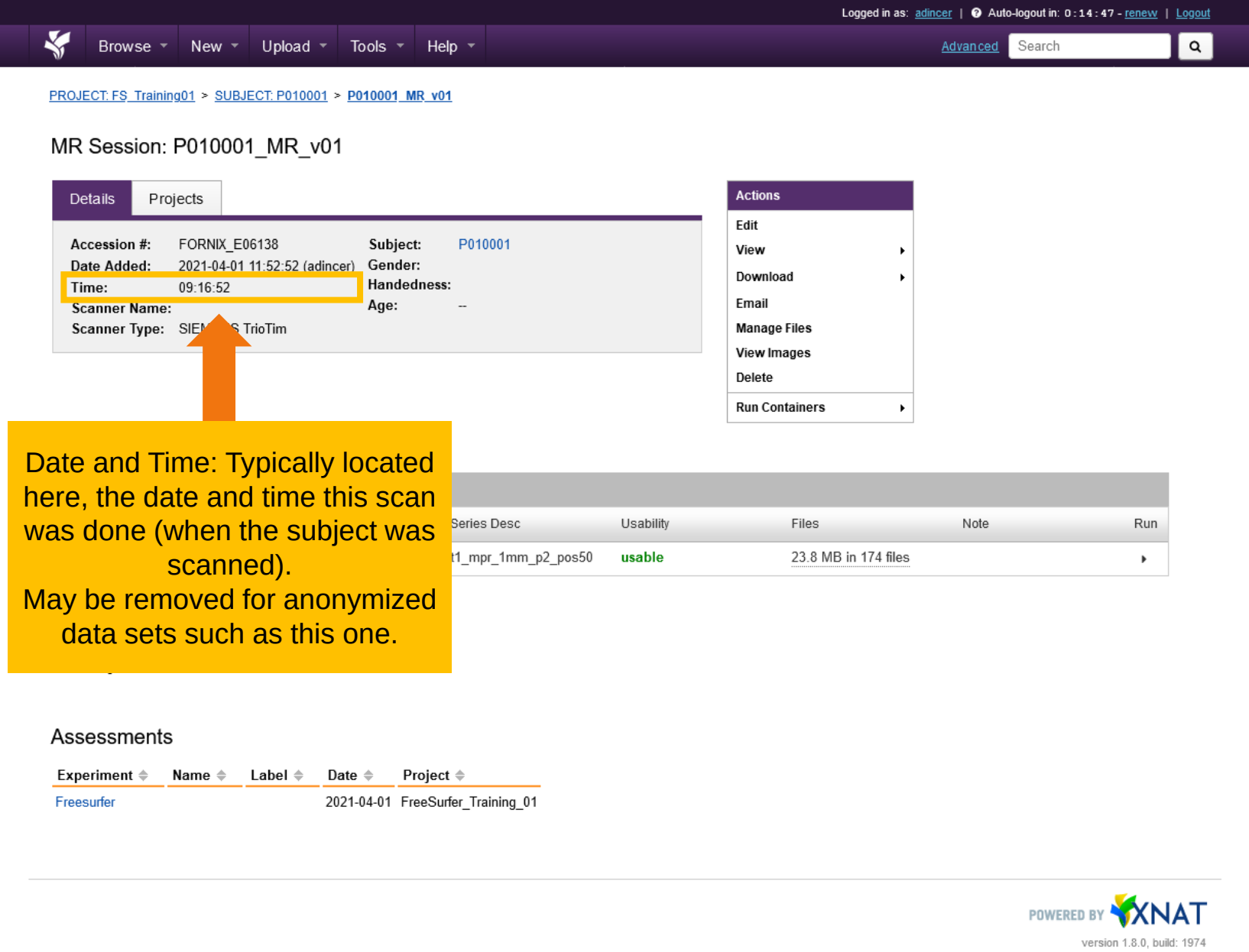
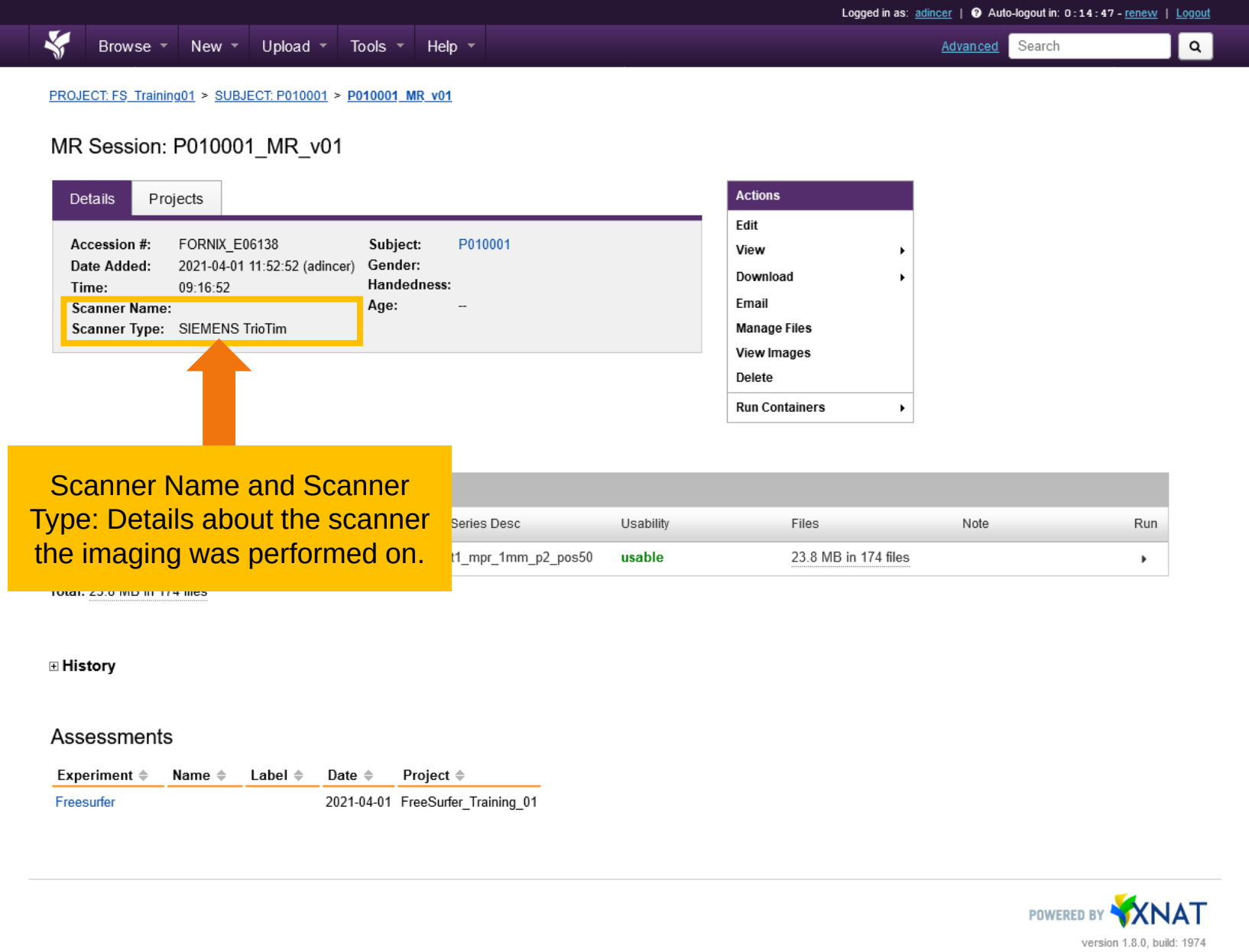


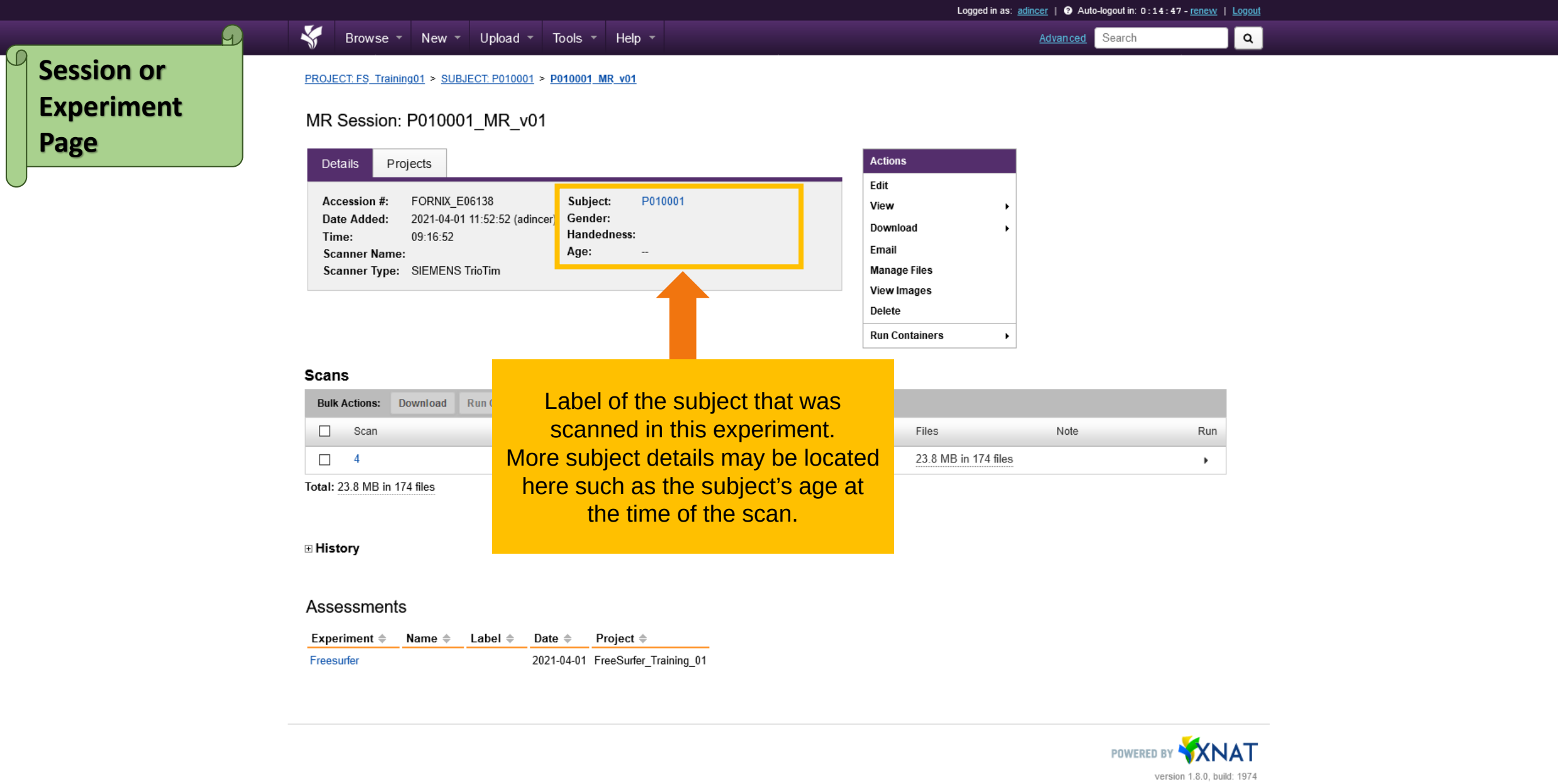
Date and Time: Typically located here, the date and time this scan was done (when the subject was scanned).
May be removed for anonymized data sets such as this one.

Session or Experiment Page

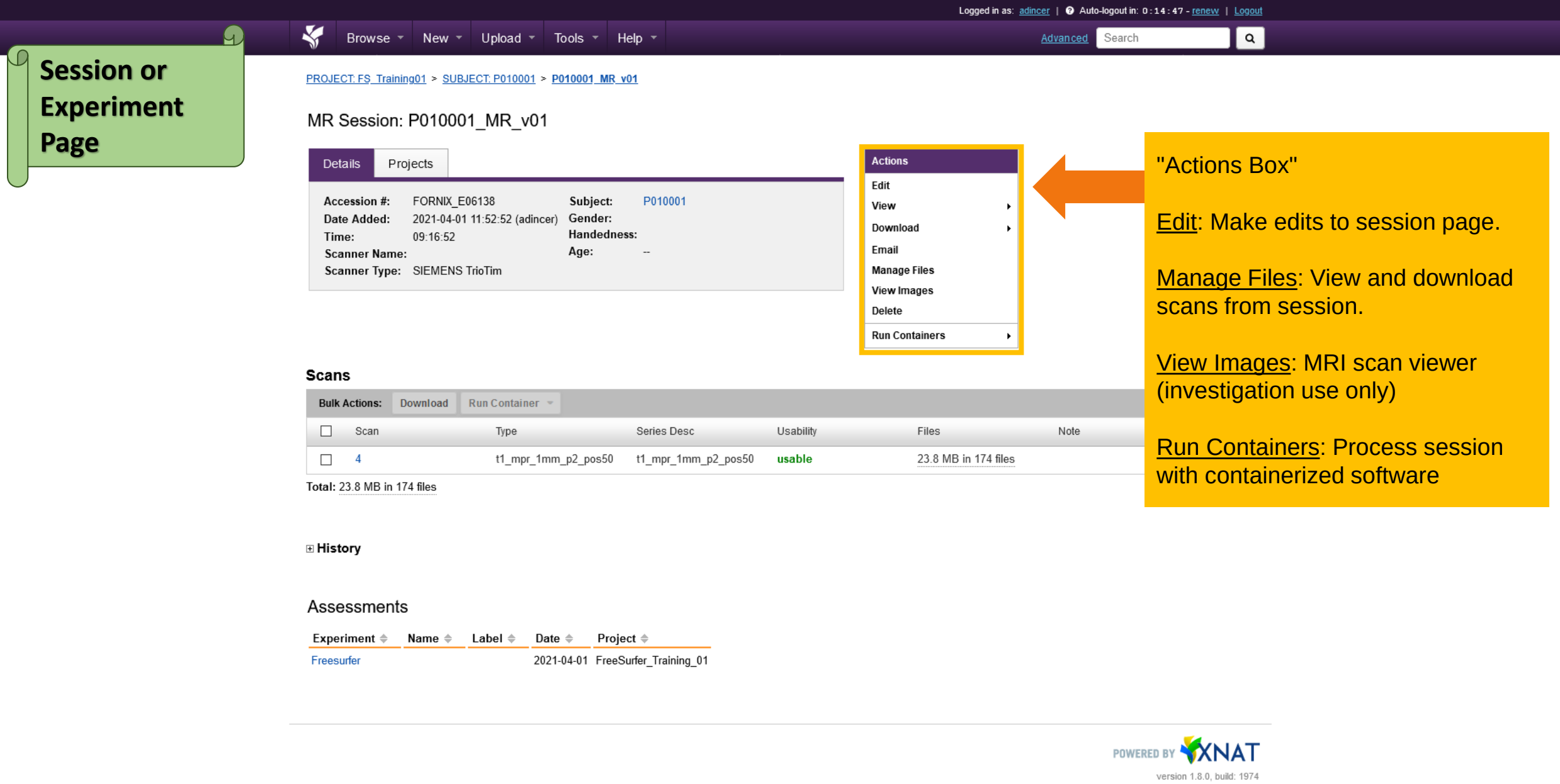


Scanner Name and Scanner Type: Details about the scanner the imaging was performed on.

Session or Experiment Page



Session or Experiment Page



"Actions Box"

Edit: Make edits to session page.

Manage Files: View and download scans from session.

View Images: MRI scan viewer (investigation use only)

Run Containers: Process session with containerized software

Session or Experiment Page

Logged in as: adincer | Auto-logout in: 0:14:47 - renew | Logout

Browse | New | Upload | Tools | Help | Advanced | Search

PROJECT: FS_Training01 > SUBJECT: P010001 > P010001_MR_v01

MR Session: P010001_MR_v01

Details | Projects

Accession #:	FORNIX_E06138	**Subject:**	P010001
Date Added:	2021-04-01 11:52:52 (adincer)	**Gender:**	
Time:	09:16:52	**Handedness:**	
Scanner Name:		**Age:**	--
Scanner Type:	SIEMENS TrioTim		

Actions

- Edit
- View
- Download
- Email
- Manage Files
- View Images
- Delete
- Run Containers

Scans

Bulk Actions: Download | Run Container

Scan	Type	Series Desc	Usability	Files	Note	Run
4	t1_mpr_1mm_p2_pos50	t1_mpr_1mm_p2_pos50	usable	23.8 MB in 174 files		

Total: 23.8 MB in 174 files

History

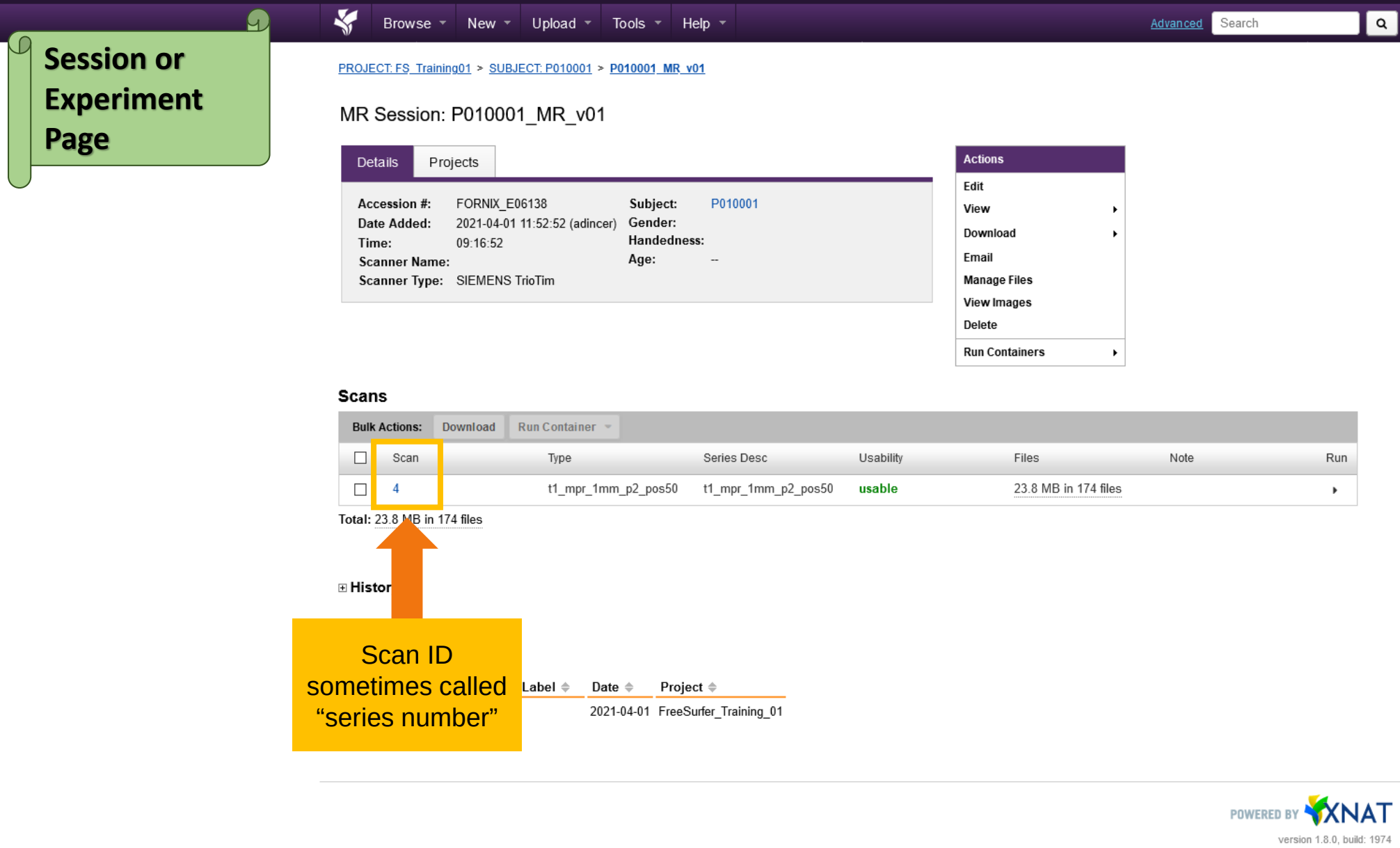
Assessments

Experiment	Name	Label	Date	Project
Freesurfer			2021-04-01	FreeSurfer_Training_01

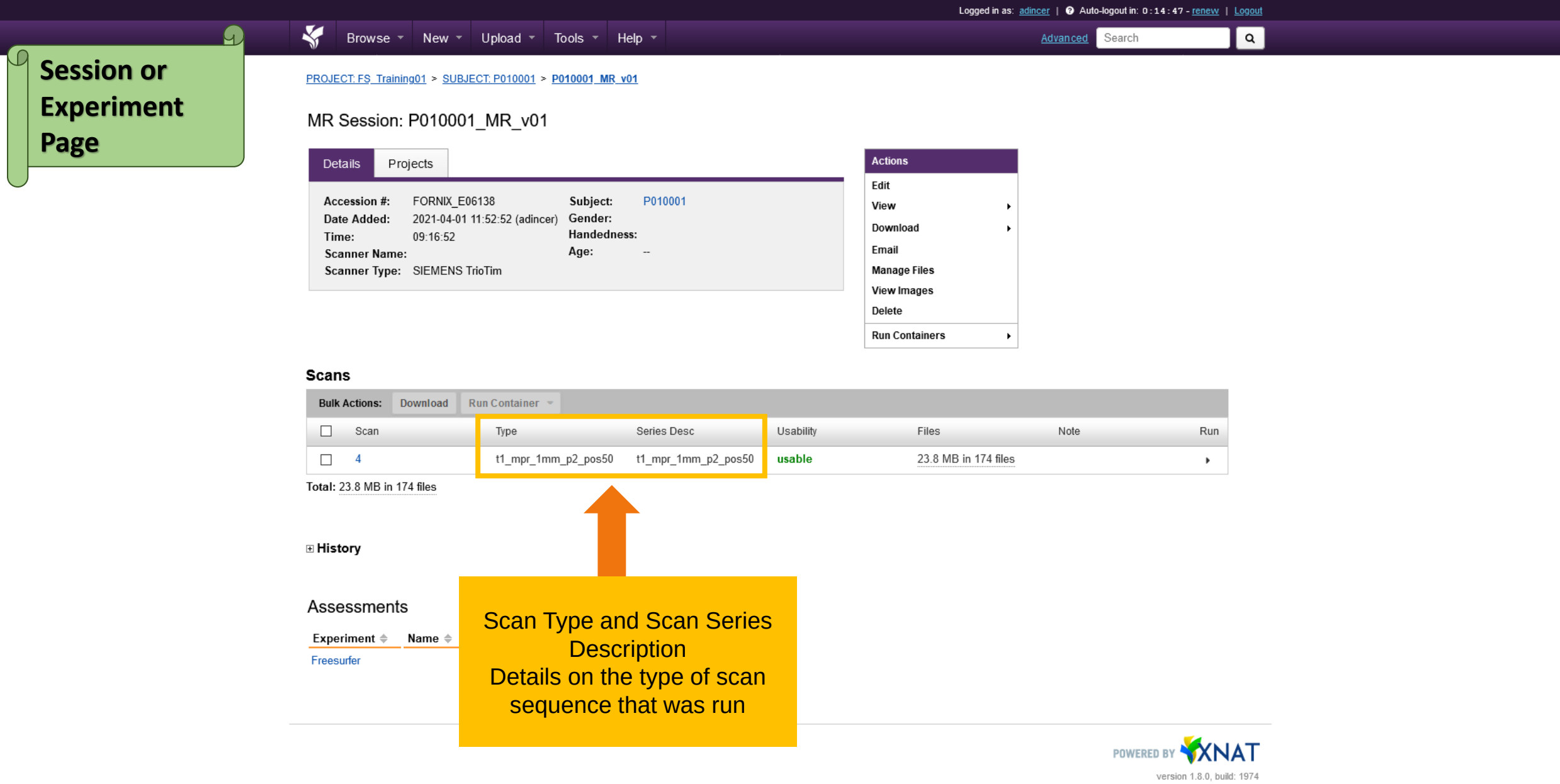
Scan Table/Scan List
List of scans done at this imaging visit.

POWERED BY XNAT
version 1.8.0, build: 1974

Session or Experiment Page



Session or Experiment Page



Session or Experiment Page

Logged in as: adincer | Auto-logout in: 0:14:47 - renew | Logout

Browse | New | Upload | Tools | Help | Advanced | Search

PROJECT: FS_Training01 > SUBJECT: P010001 > P010001_MR_v01

MR Session: P010001_MR_v01

Details | Projects

Accession #:	FORNIX_E06138	**Subject:**	P010001
Date Added:	2021-04-01 11:52:52 (adincer)	**Gender:**	
Time:	09:16:52	**Handedness:**	
Scanner Name:		**Age:**	--
Scanner Type:	SIEMENS TrioTim		

Actions

- Edit
- View
- Download
- Email
- Manage Files
- View Images
- Delete
- Run Containers

Scans

Bulk Actions: Download | Run Container

Scan	Type	Series Desc	Usability	Files	Note	Run
4	t1_mpr_1mm_p2_pos50	t1_mpr_1mm_p2_pos50	usable	23.8 MB in 174 files		

Total: 23.8 MB in 174 files

History

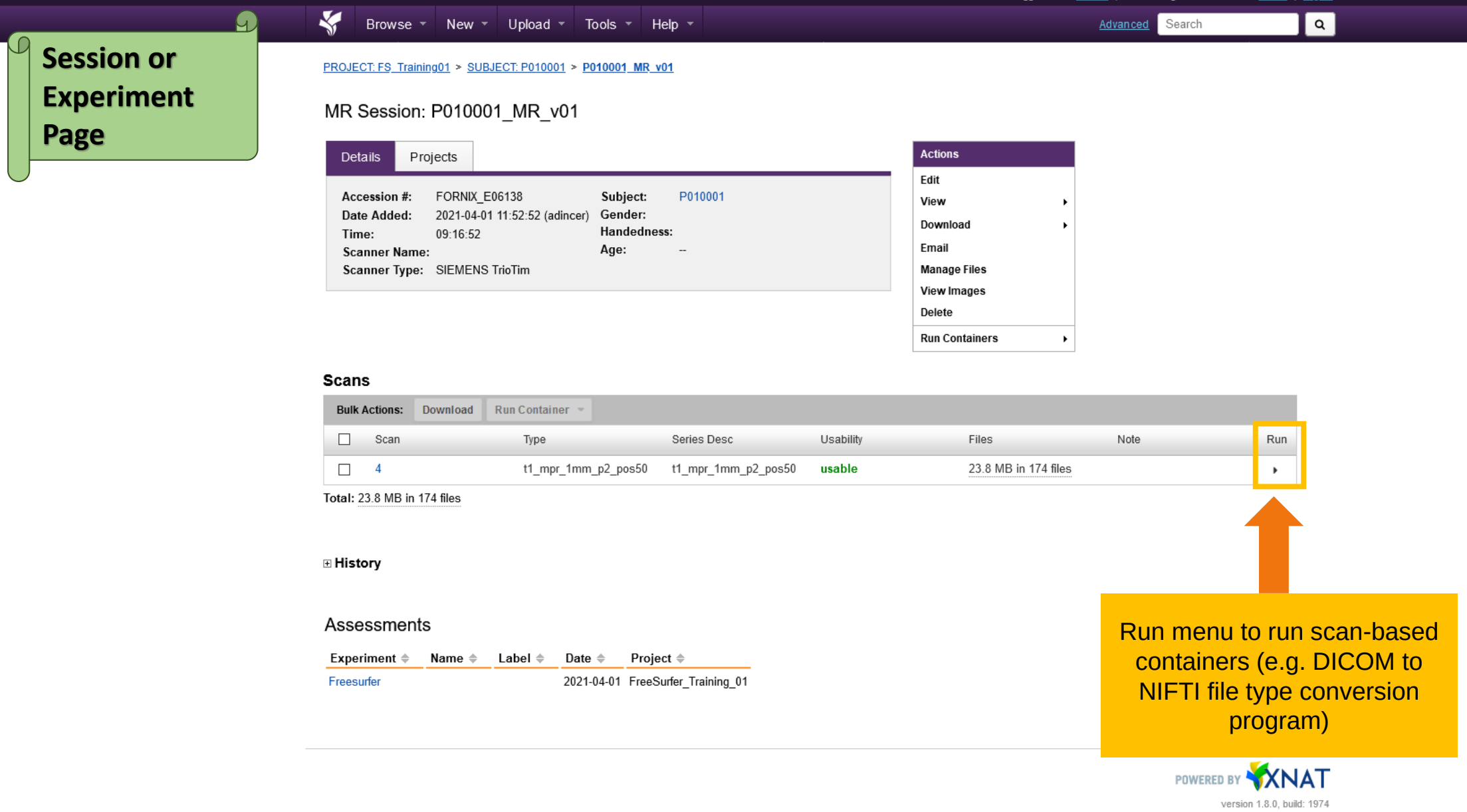
Assessments

Experiment	Name	Label	Date	Project
Freesurfer			2021-04-01	FreeSurfer_Training_01

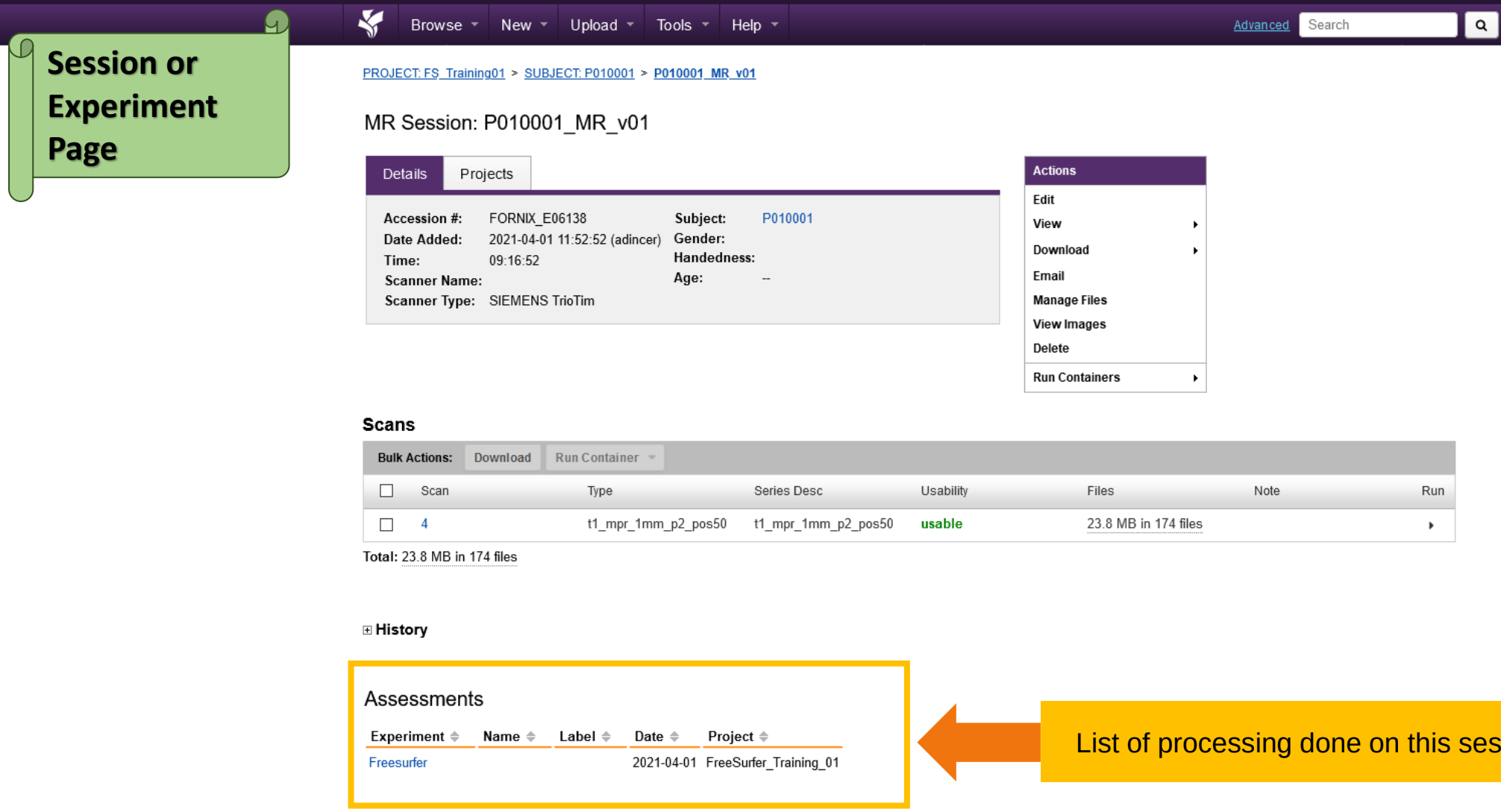
Number of files stored for this scan sequence and the total file size.
Can hover your cursor over it to see file types that are stored.

XNAT version 1.8.0, build: 1974

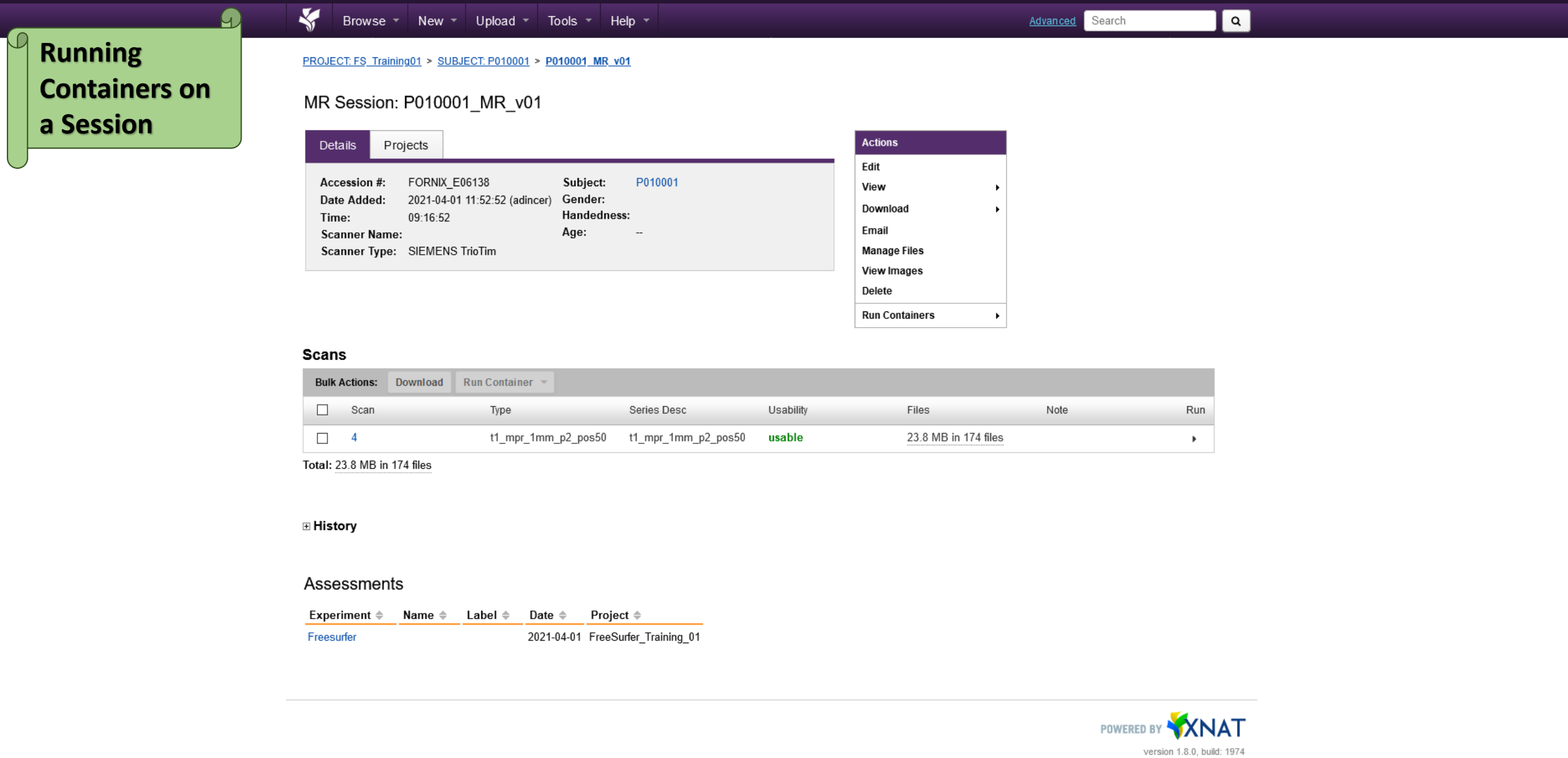
Session or Experiment Page



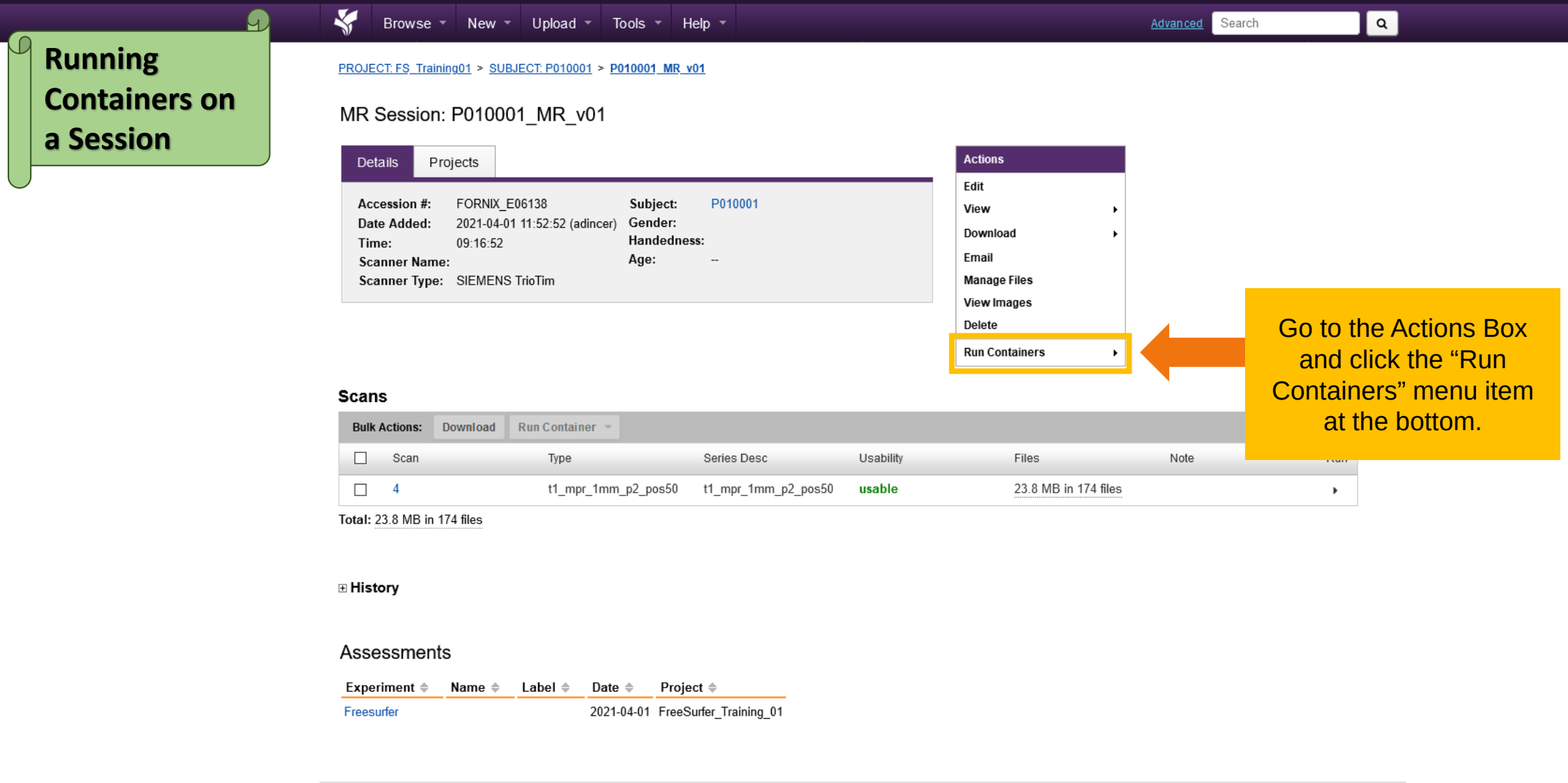
Session or Experiment Page



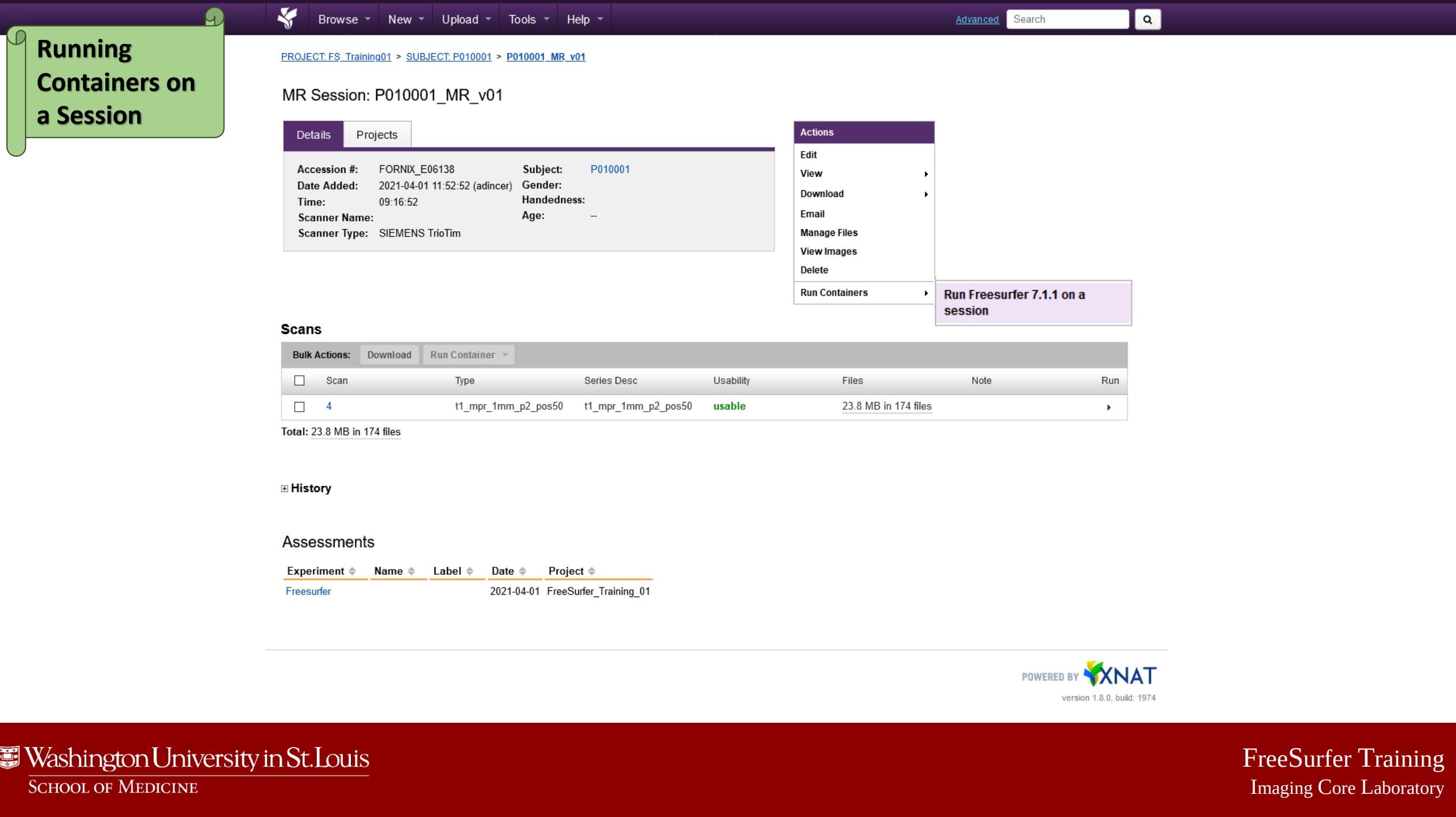
Running Containers on a Session



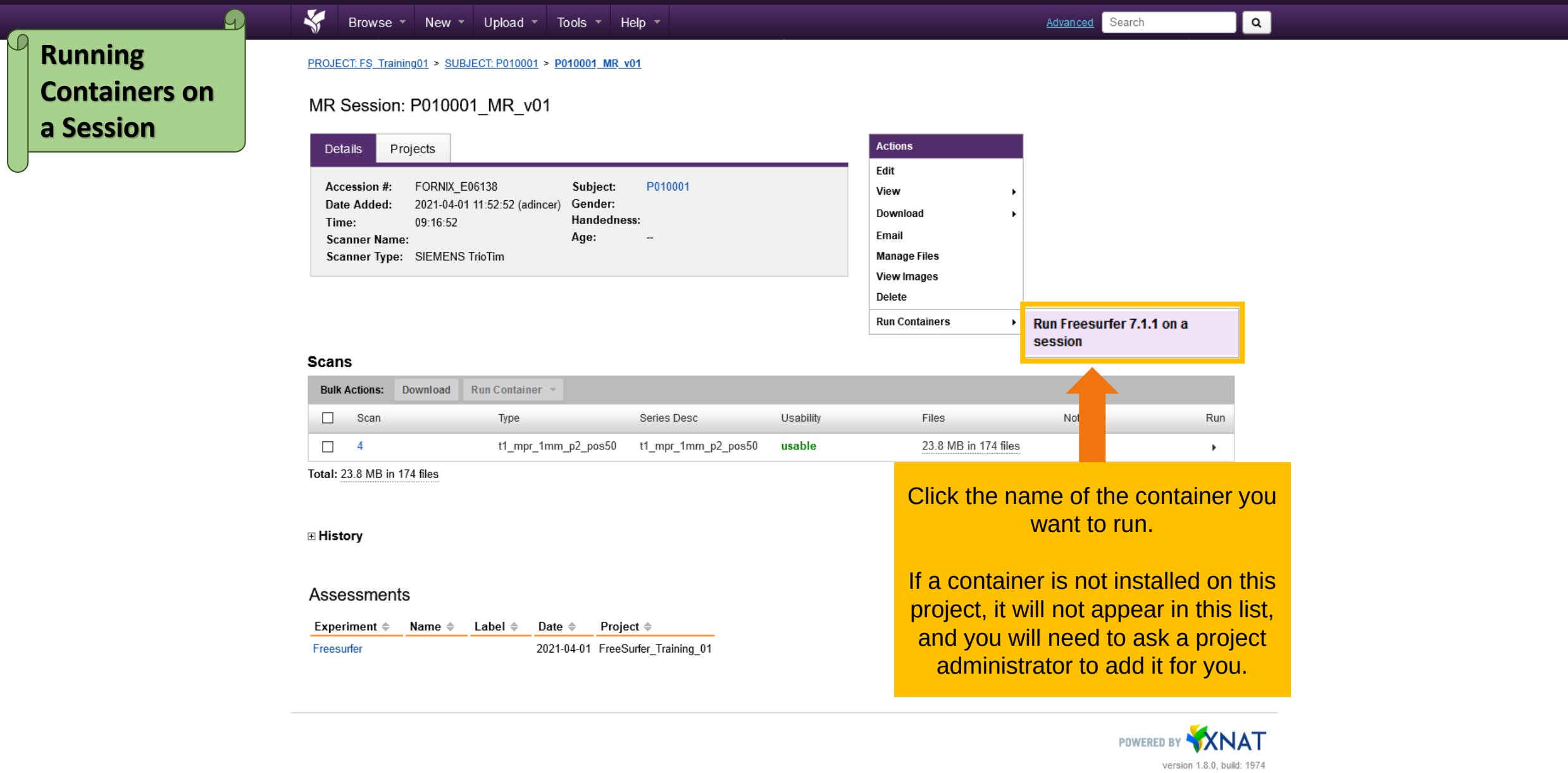
Running Containers on a Session



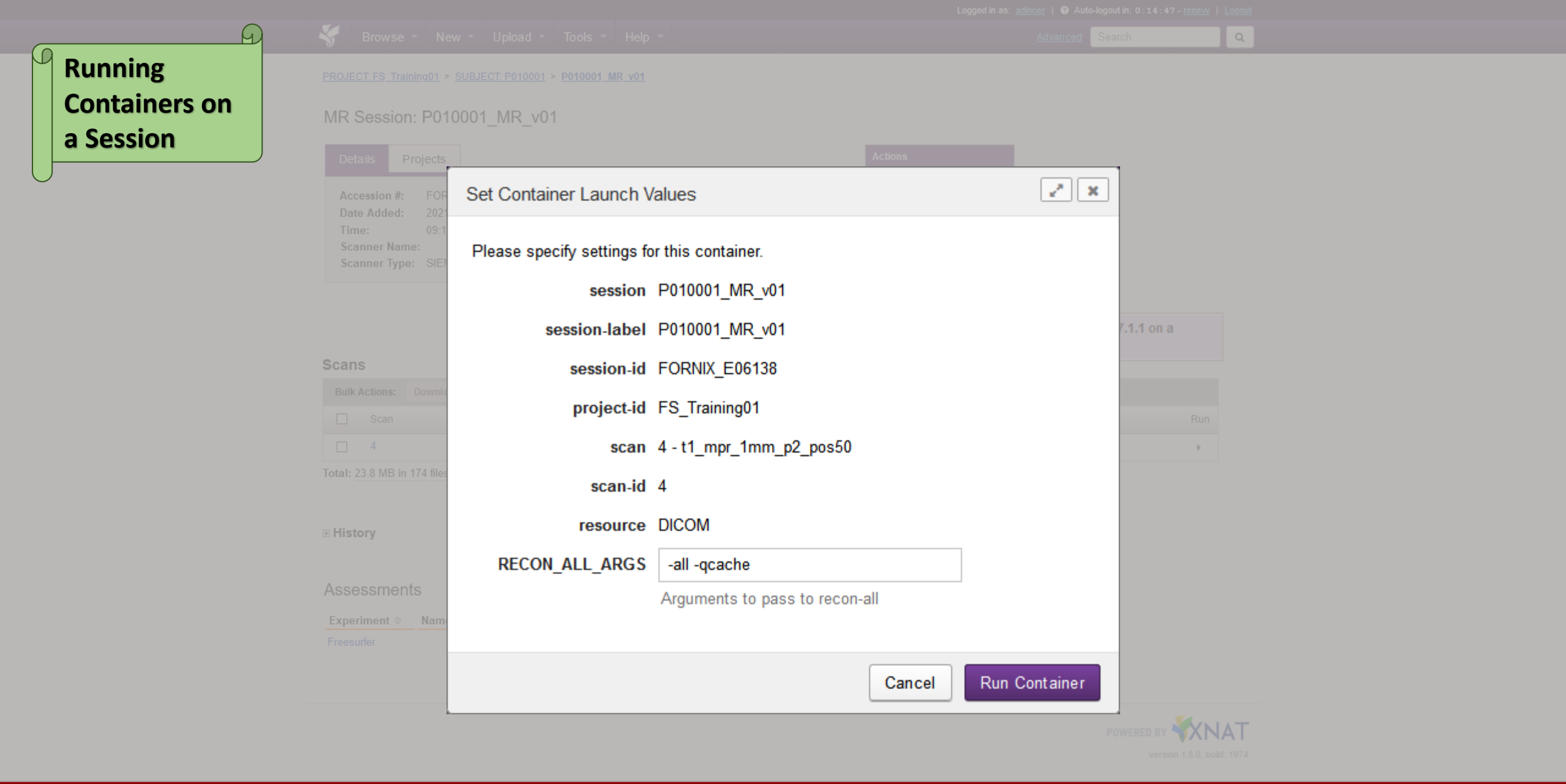
Running Containers on a Session



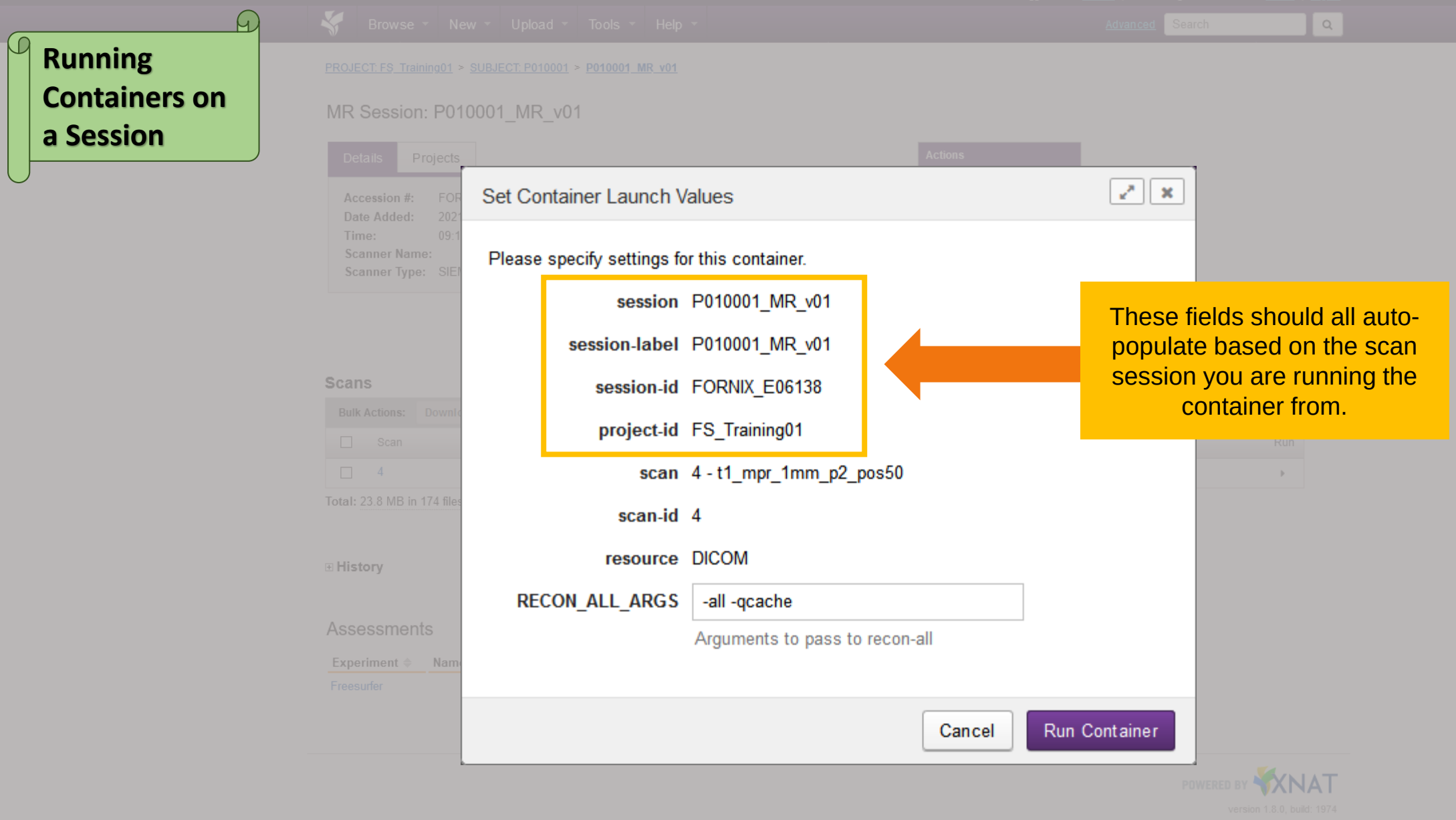
Running Containers on a Session



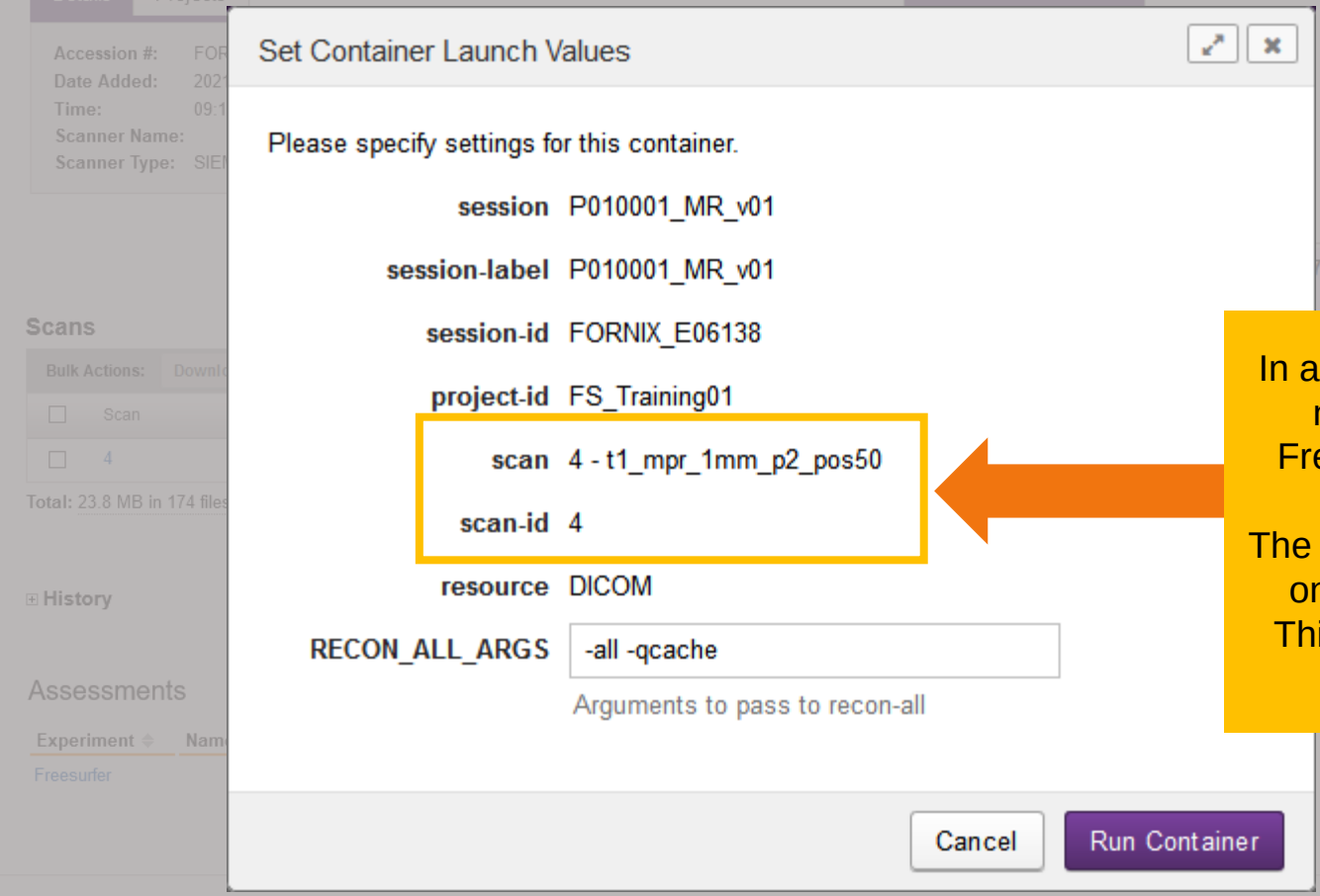
Running Containers on a Session



Running Containers on a Session

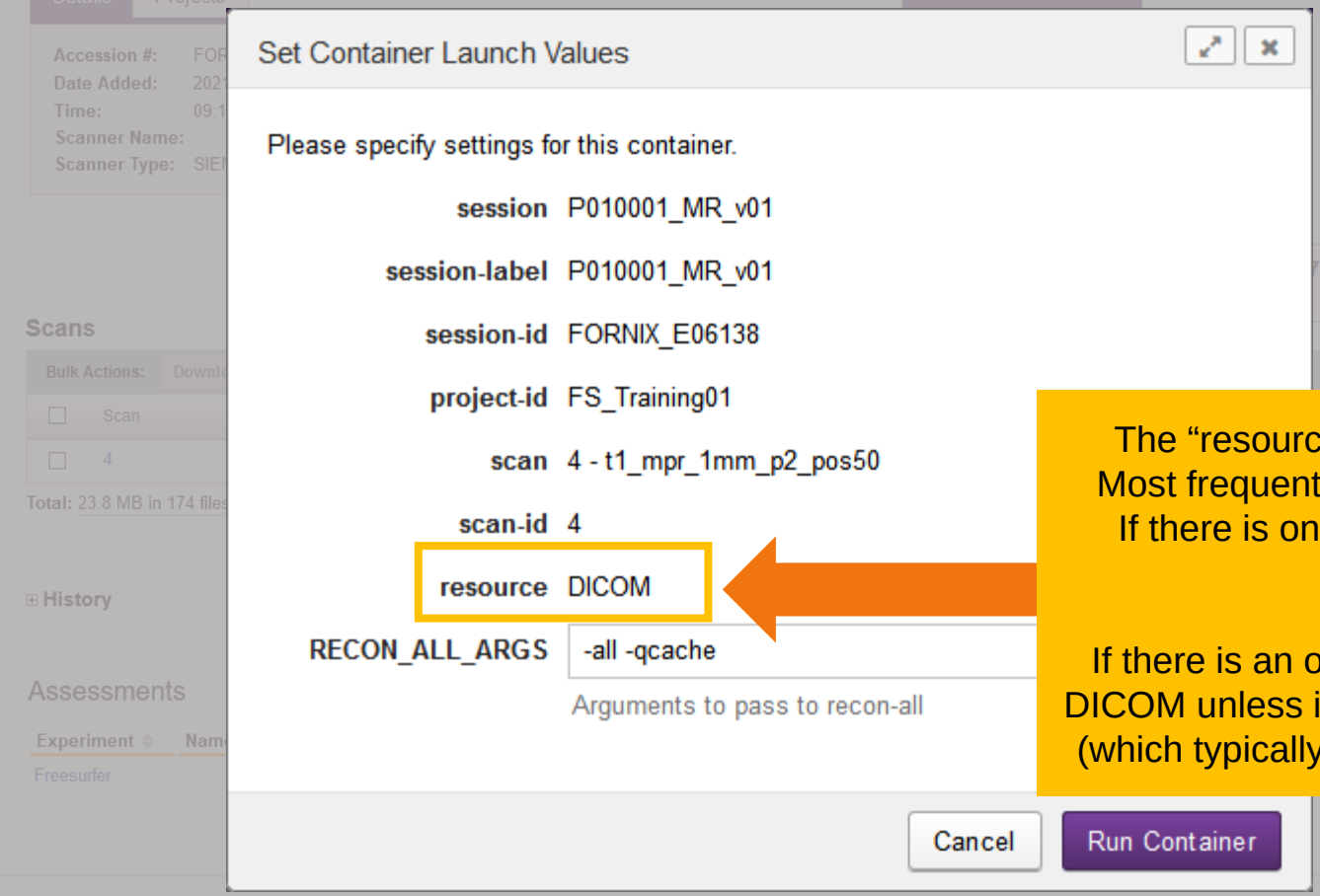


Running Containers on a Session



In a session with multiple scans, you will need to choose which scan to run Freesurfer on from a “scan” dropdown menu.
The scan-id field will auto-populate based on what is selected in the dropdown.
This session has only one scan so it is chosen automatically.

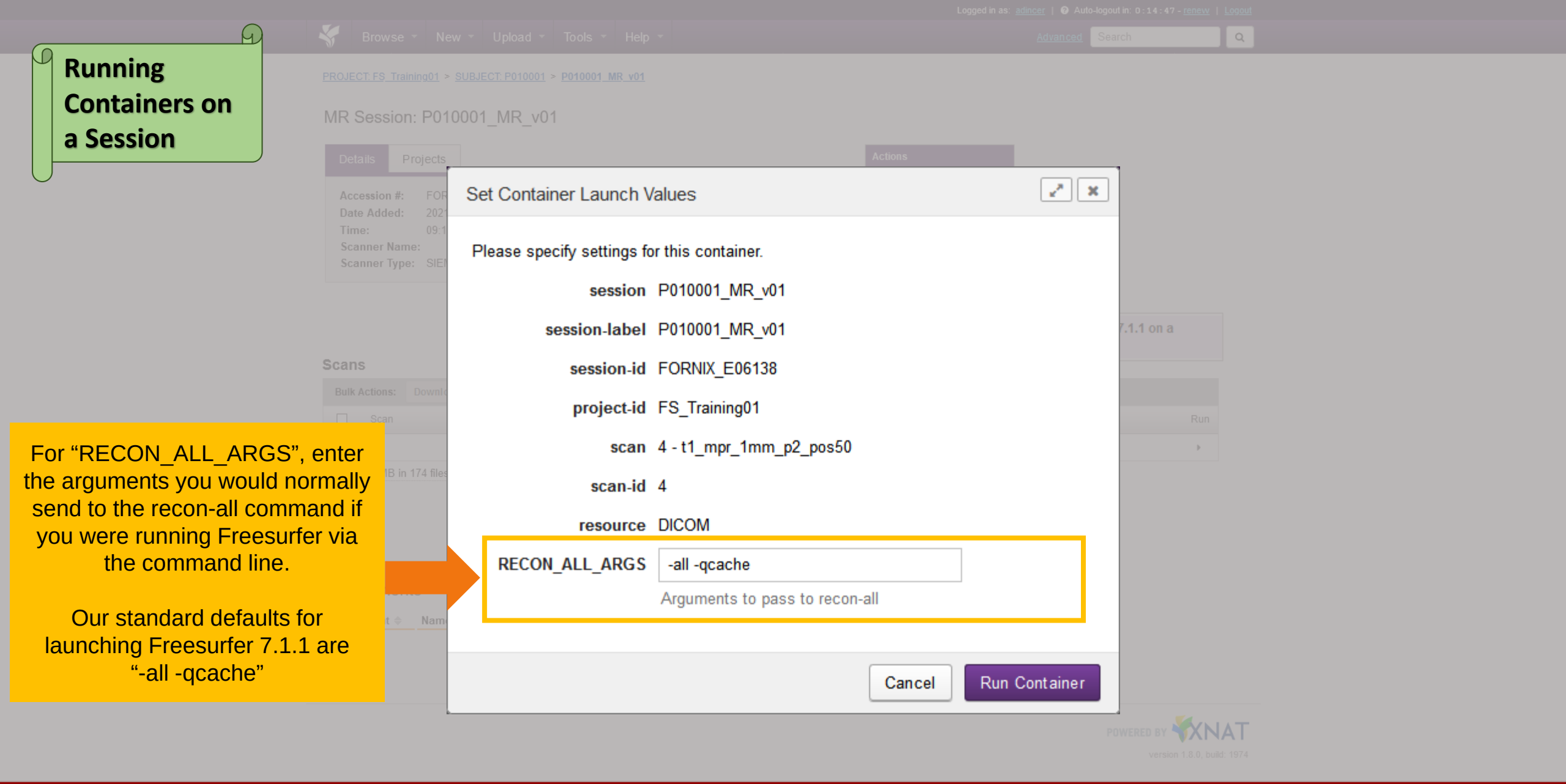
Running Containers on a Session



The “resource” here means which file type to use. Most frequently the options will be DICOM or NIFTI. If there is only one resource available, this will be chosen automatically.

If there is an option to choose, you will typically want DICOM unless it is an “enhanced” DICOM formatted file (which typically has only one file in the DICOM folder).

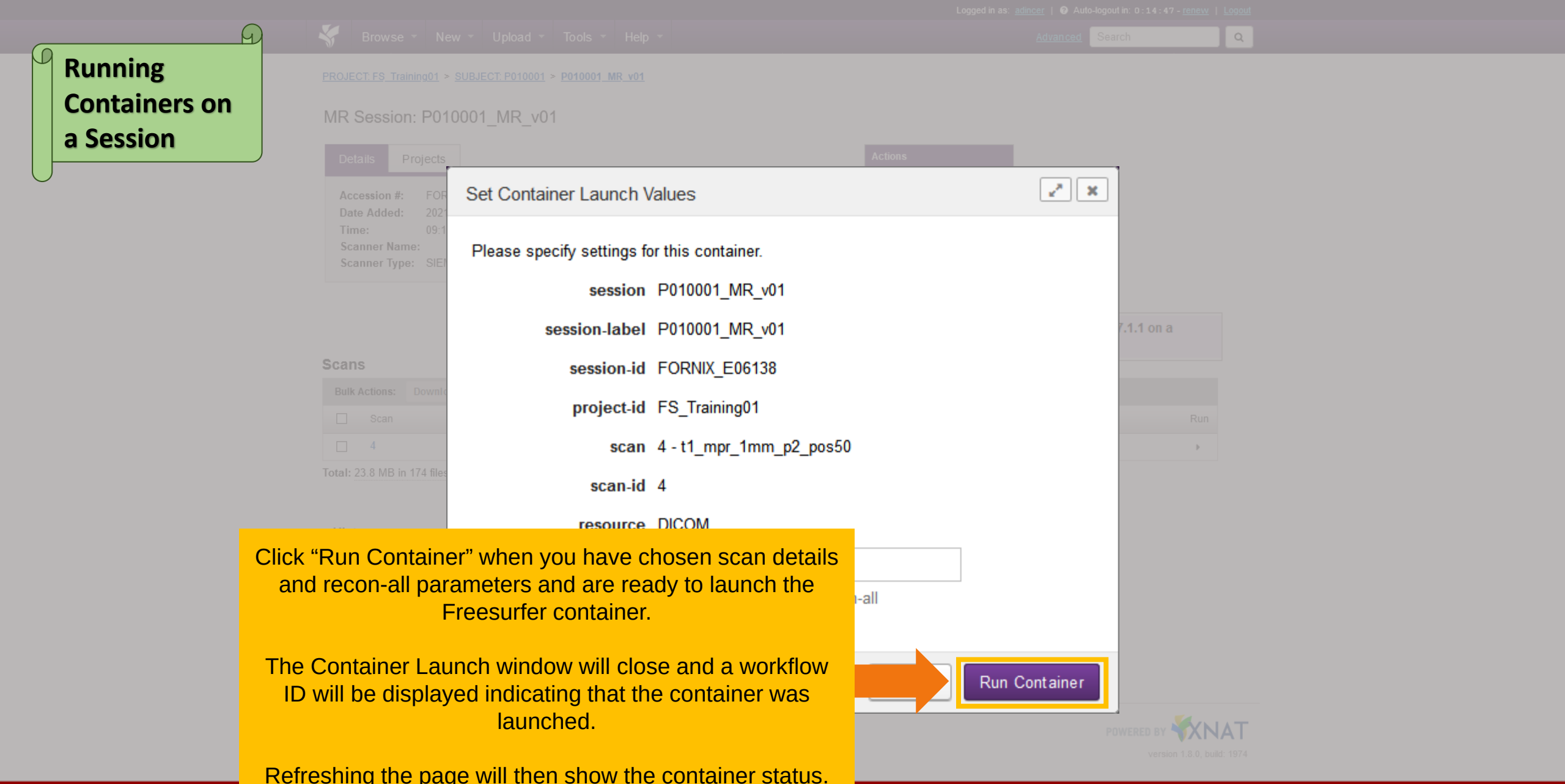
Running Containers on a Session



For “RECON_ALL_ARGS”, enter the arguments you would normally send to the recon-all command if you were running Freesurfer via the command line.

Our standard defaults for launching Freesurfer 7.1.1 are “-all -qcache”

Running Containers on a Session



Click “Run Container” when you have chosen scan details and recon-all parameters and are ready to launch the Freesurfer container.

The Container Launch window will close and a workflow ID will be displayed indicating that the container was launched.

Refreshing the page will then show the container status.

Running Containers on a Session

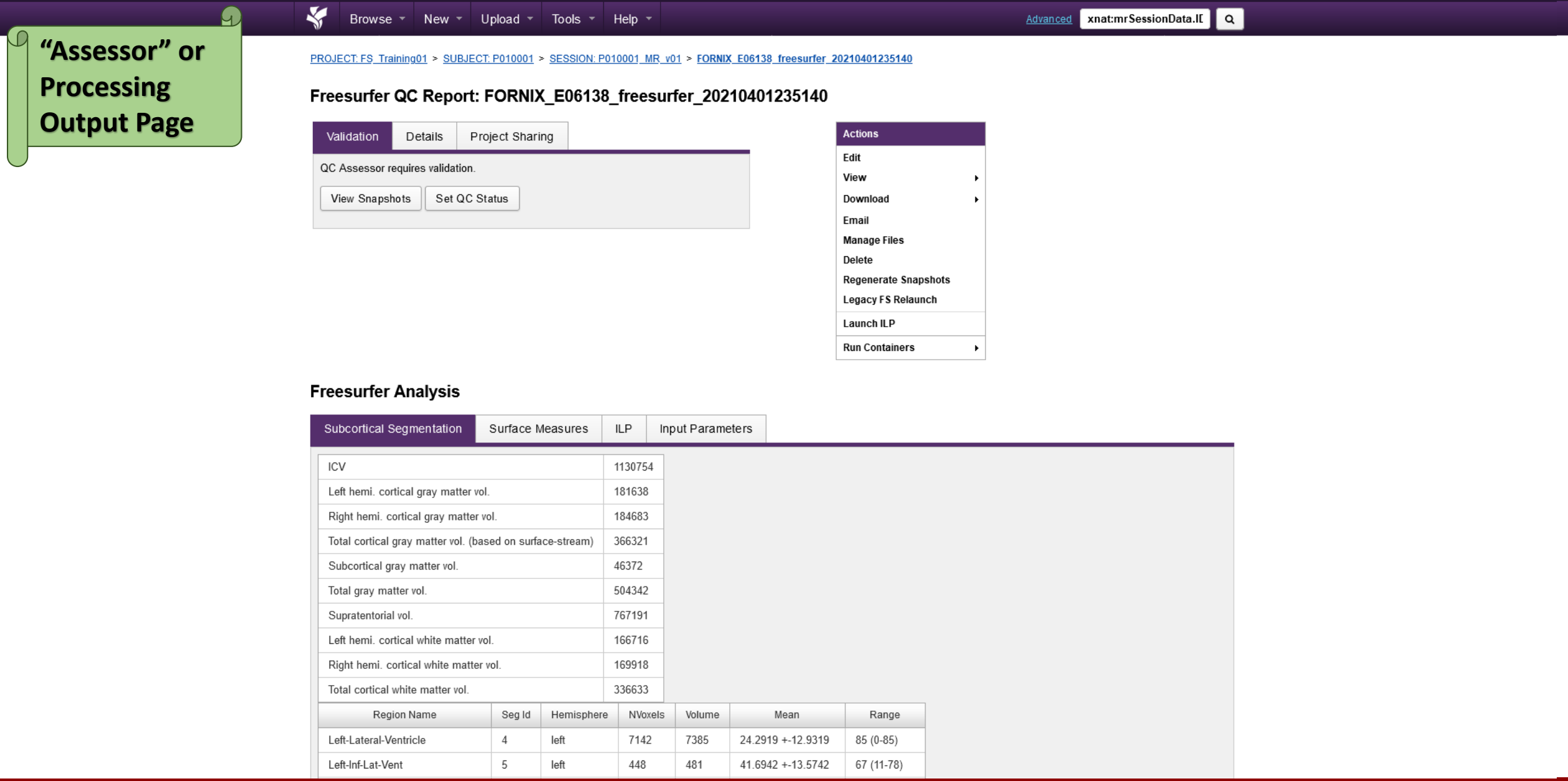
When you click “Run Container”, the container will launch and should run for the standard Freesurfer processing time (typically 6-8 hours).

If there is an error and the container fails to complete, you will receive an email with the error log files attached which can help you figure out what went wrong.

If the container completes successfully, you will receive a success email.

Then you can log back in to the XNAT site you are using and access the processing output page, also called the “assessor” page.

"Assessor" or Processing Output Page



"Assessor" or Processing Output Page

Logged in as: adincer | Auto-logout in: 0:14:21 - renew | Logout

Browse | New | Upload | Tools | Help

Advanced | xnat:mrSessionData.ID

PROJECT: FS_Training01 > SUBJECT: P010001 > SESSION: P010001_MR_v01 > FORNIX_E06138_freesurfer_20210401235140

breadcrumb trail

Freesurfer QC Report: FORNIX_E06138_freesurfer_20210401235140

Validation | Details | Project Sharing

QC Assessor requires validation.

View Snapshots | Set QC Status

Actions

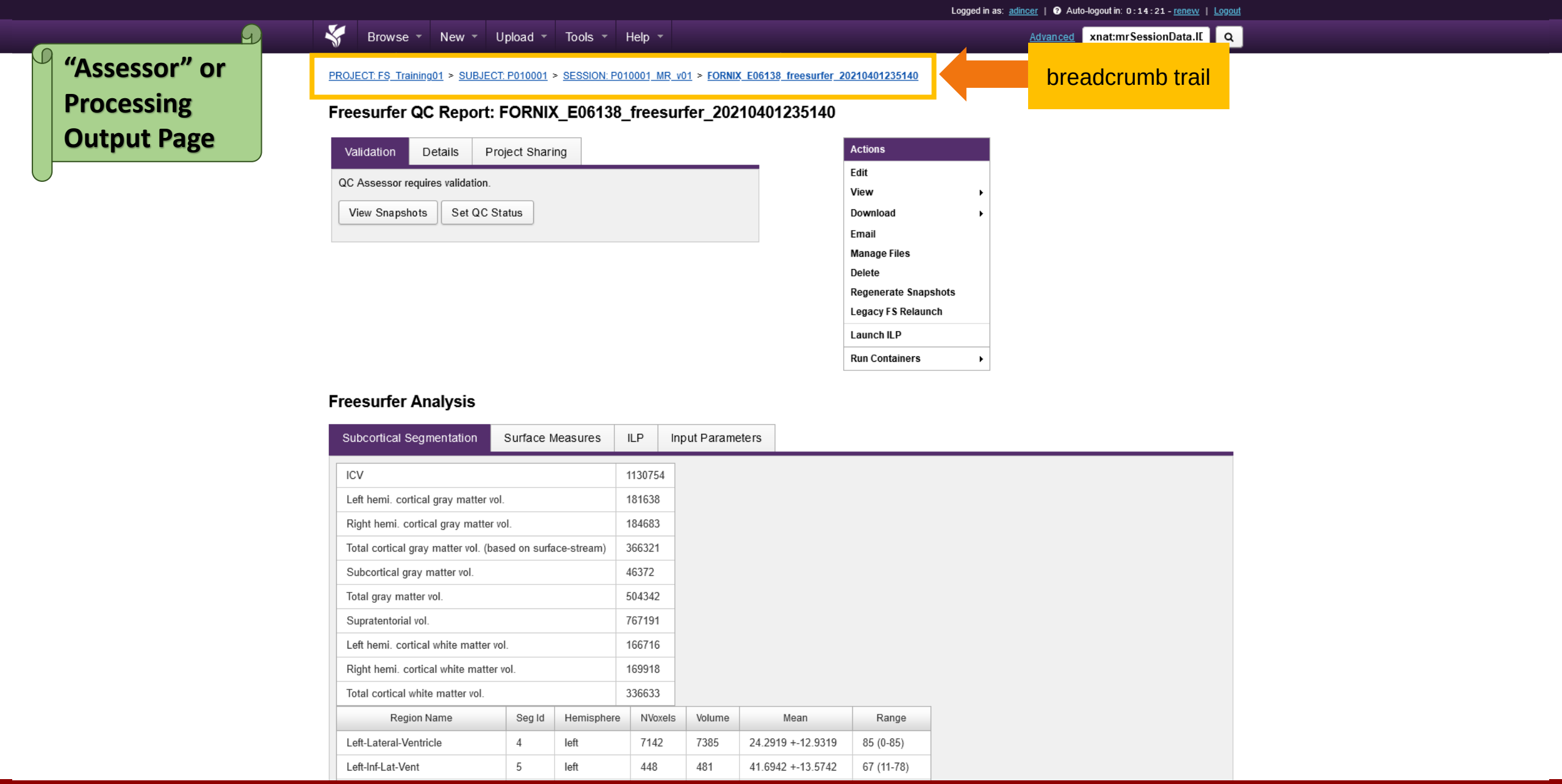
- Edit
- View
- Download
- Email
- Manage Files
- Delete
- Regenerate Snapshots
- Legacy FS Relaunch
- Launch ILP
- Run Containers

Freesurfer Analysis

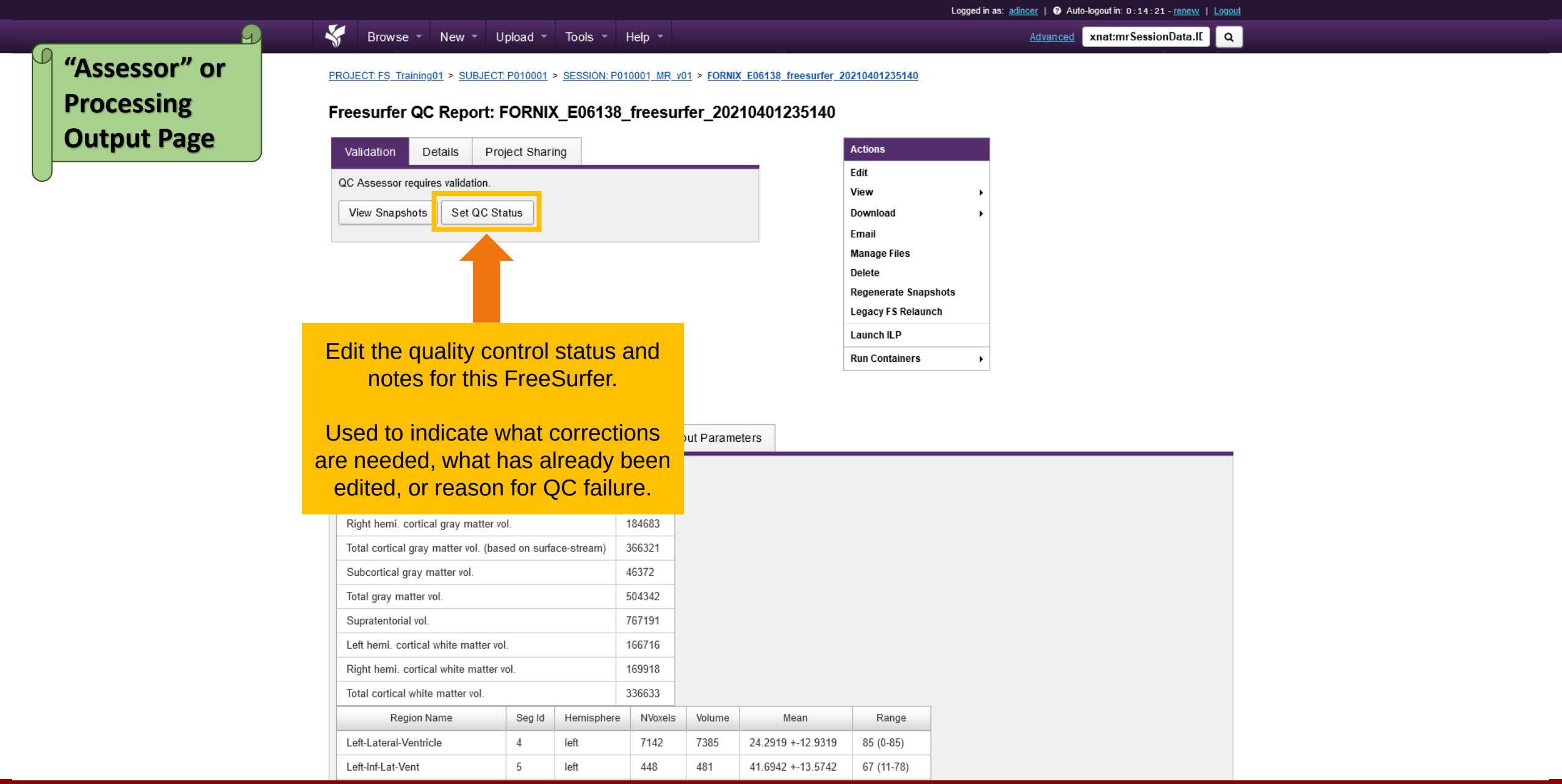
Subcortical Segmentation | Surface Measures | ILP | Input Parameters

ICV	1130754
Left hemi. cortical gray matter vol.	181638
Right hemi. cortical gray matter vol.	184683
Total cortical gray matter vol. (based on surface-stream)	366321
Subcortical gray matter vol.	46372
Total gray matter vol.	504342
Supratentorial vol.	767191
Left hemi. cortical white matter vol.	166716
Right hemi. cortical white matter vol.	169918
Total cortical white matter vol.	336633

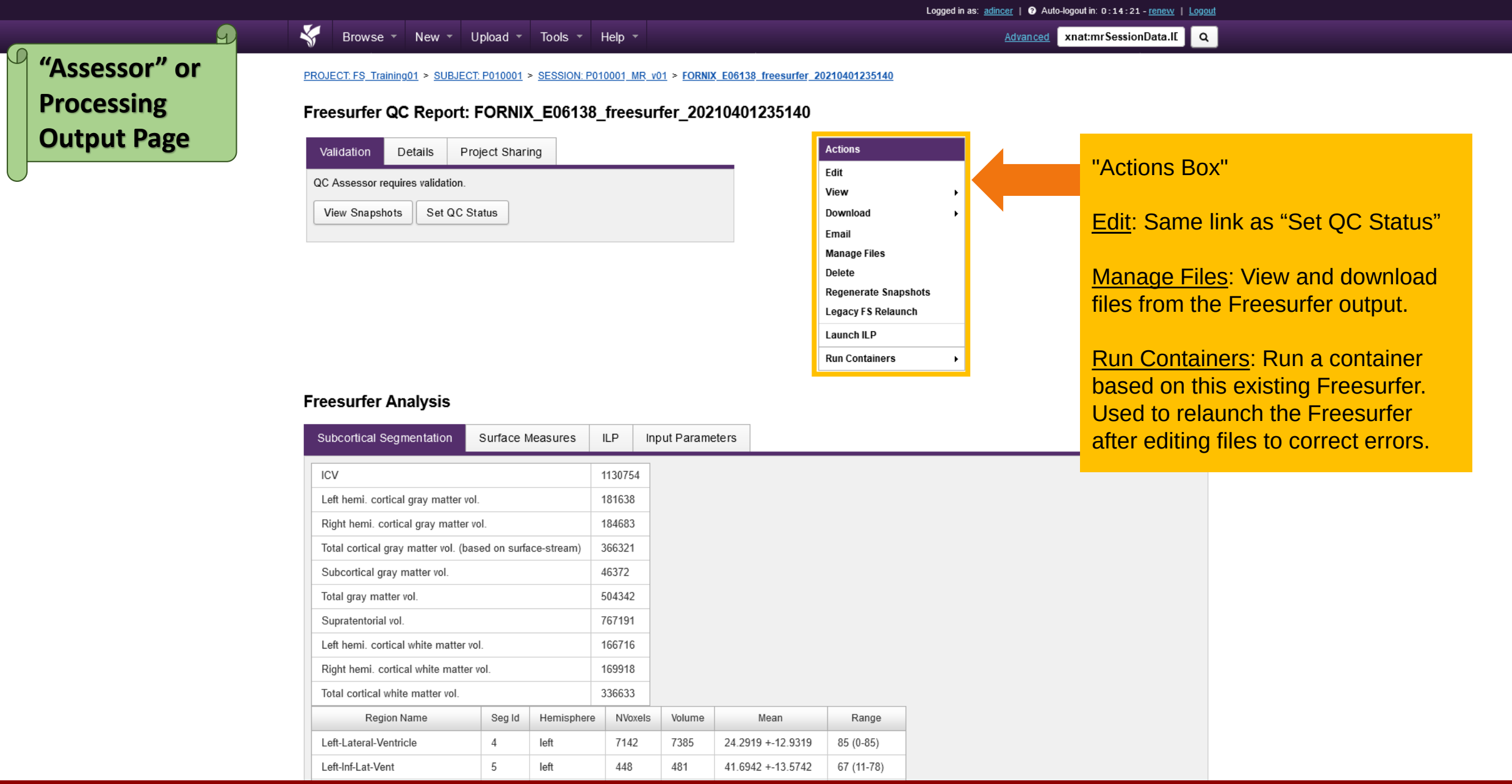
Region Name	Seg Id	Hemisphere	NVoxels	Volume	Mean	Range
Left-Lateral-Ventricle	4	left	7142	7385	24.2919 +-12.9319	85 (0-85)
Left-Inf-Lat-Vent	5	left	448	481	41.6942 +-13.5742	67 (11-78)



"Assessor" or Processing Output Page



"Assessor" or Processing Output Page



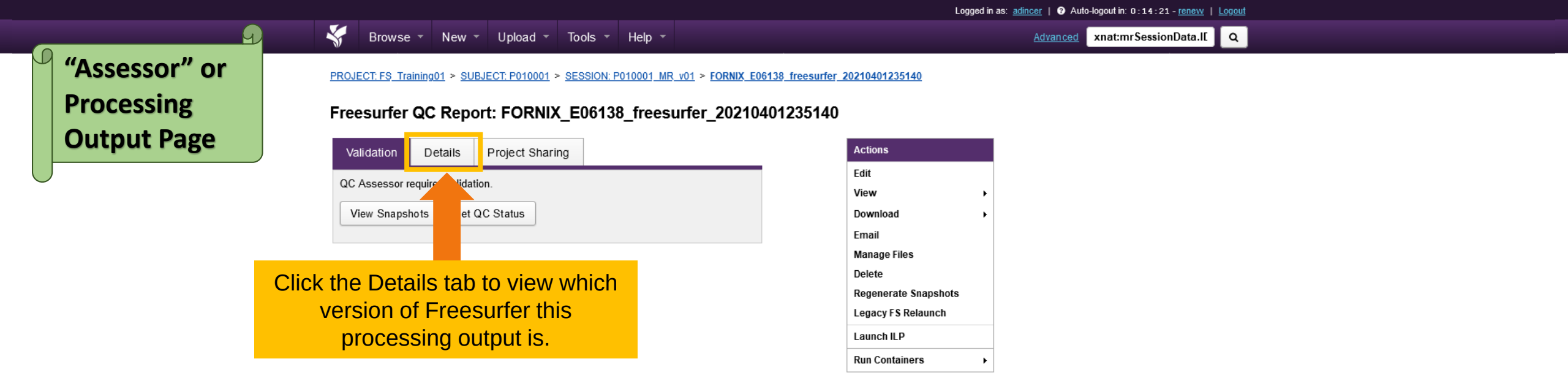
"Actions Box"

Edit: Same link as "Set QC Status"

Manage Files: View and download files from the Freesurfer output.

Run Containers: Run a container based on this existing Freesurfer. Used to relaunch the Freesurfer after editing files to correct errors.

"Assessor" or Processing Output Page



Click the Details tab to view which version of Freesurfer this processing output is.

Freesurfer Analysis

Subcortical Segmentation | Surface Measures | ILP | Input Parameters

ICV	1130754
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"Assessor" or Processing Output Page

Logged in as: adincer | Auto-logout in: 0:14:21 - renew | Logout

Browse | New | Upload | Tools | Help | Advanced | xnat:mrSessionData.ID

PROJECT: FS_Training01 > SUBJECT: P010001 > SESSION: P010001_MR_v01 > FORNIX_E06138_freesurfer_20210401235140

Freesurfer QC Report: FORNIX_E06138_freesurfer_20210401235140

Validation | Details | Project Sharing

MRSession	P010001_MR_v01
Date	2021-04-01
Note	
ID	FORNIX_E06138_freesurfer_20210401235140
Project	FS_Training01
Freesurfer version	freesurfer-linux-centos7_x86_64-7.1.1-20200723-8b40551

Actions
- Edit
- View
- Download
- Email
- Manage Files
- Delete
- Regenerate Snapshots
- Legacy FS Relaunch
- Launch ILP
- Run Containers

Freesurfer Analysis

Subcortical Segmentation | Surface Measures | ILP | Input Parameters

ICV	1130754
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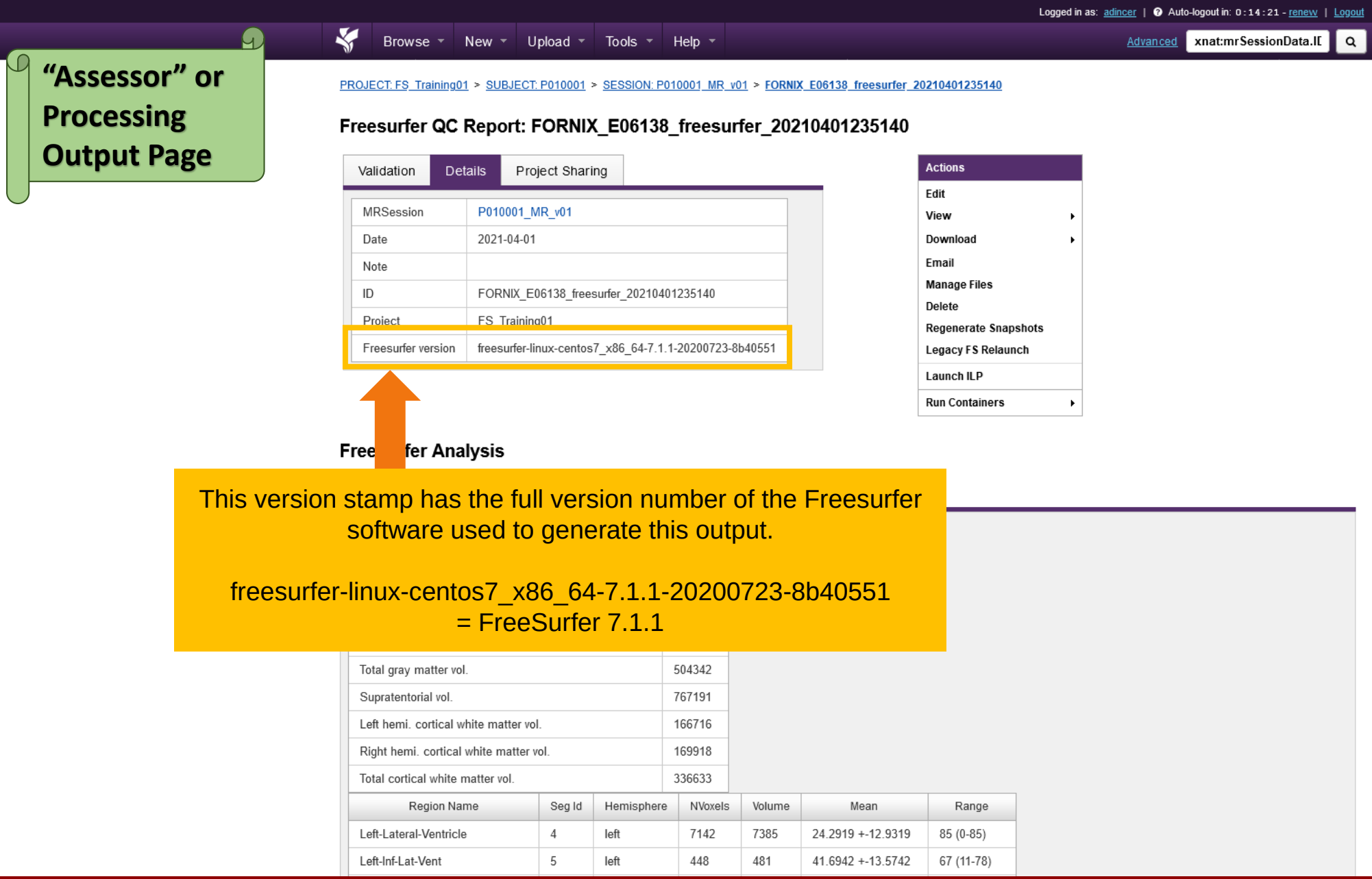
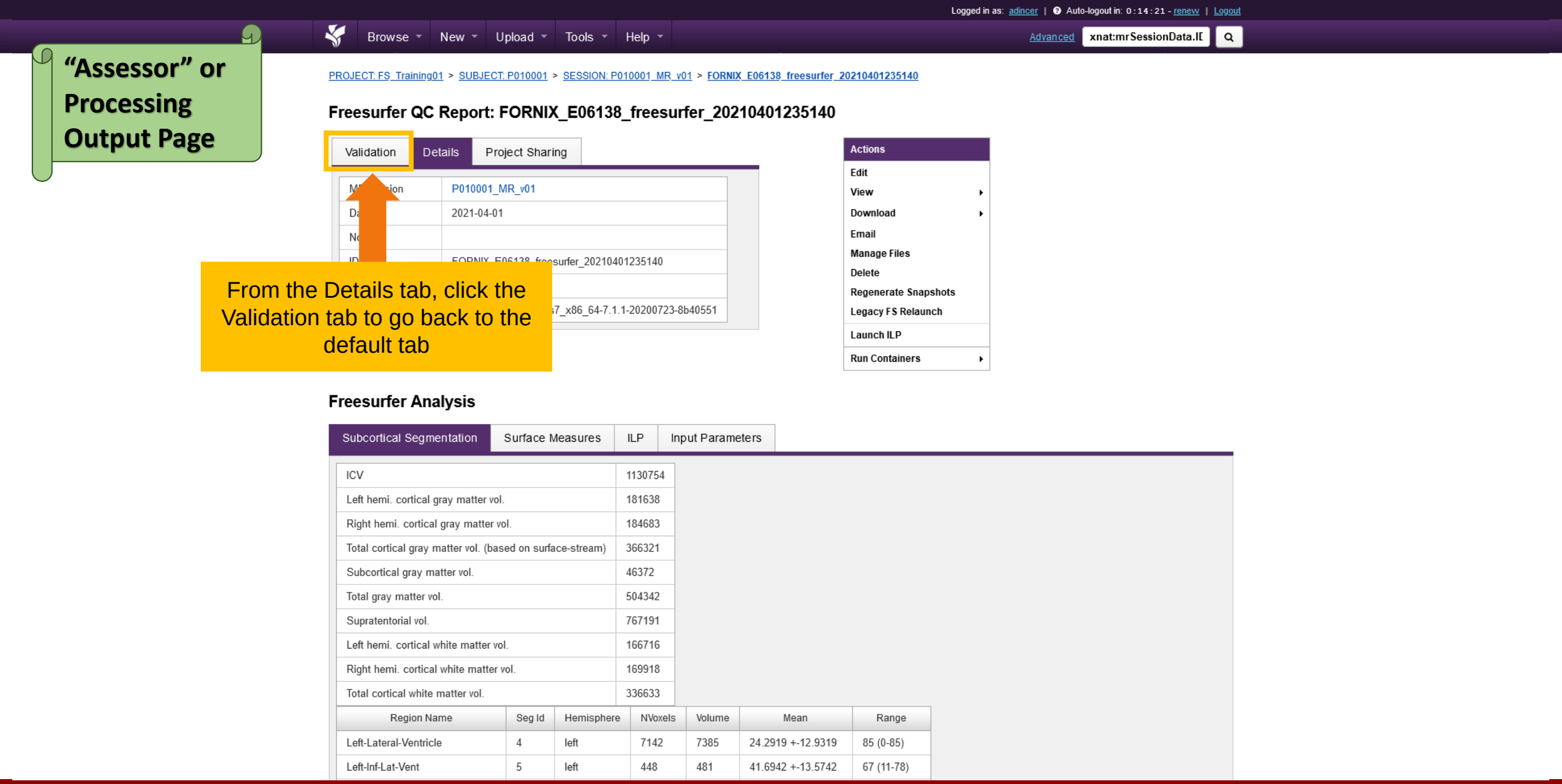
"Assessor" or Processing Output Page



This version stamp has the full version number of the Freesurfer software used to generate this output.

freesurfer-linux-centos7_x86_64-7.1.1-20200723-8b40551
= FreeSurfer 7.1.1

"Assessor" or Processing Output Page



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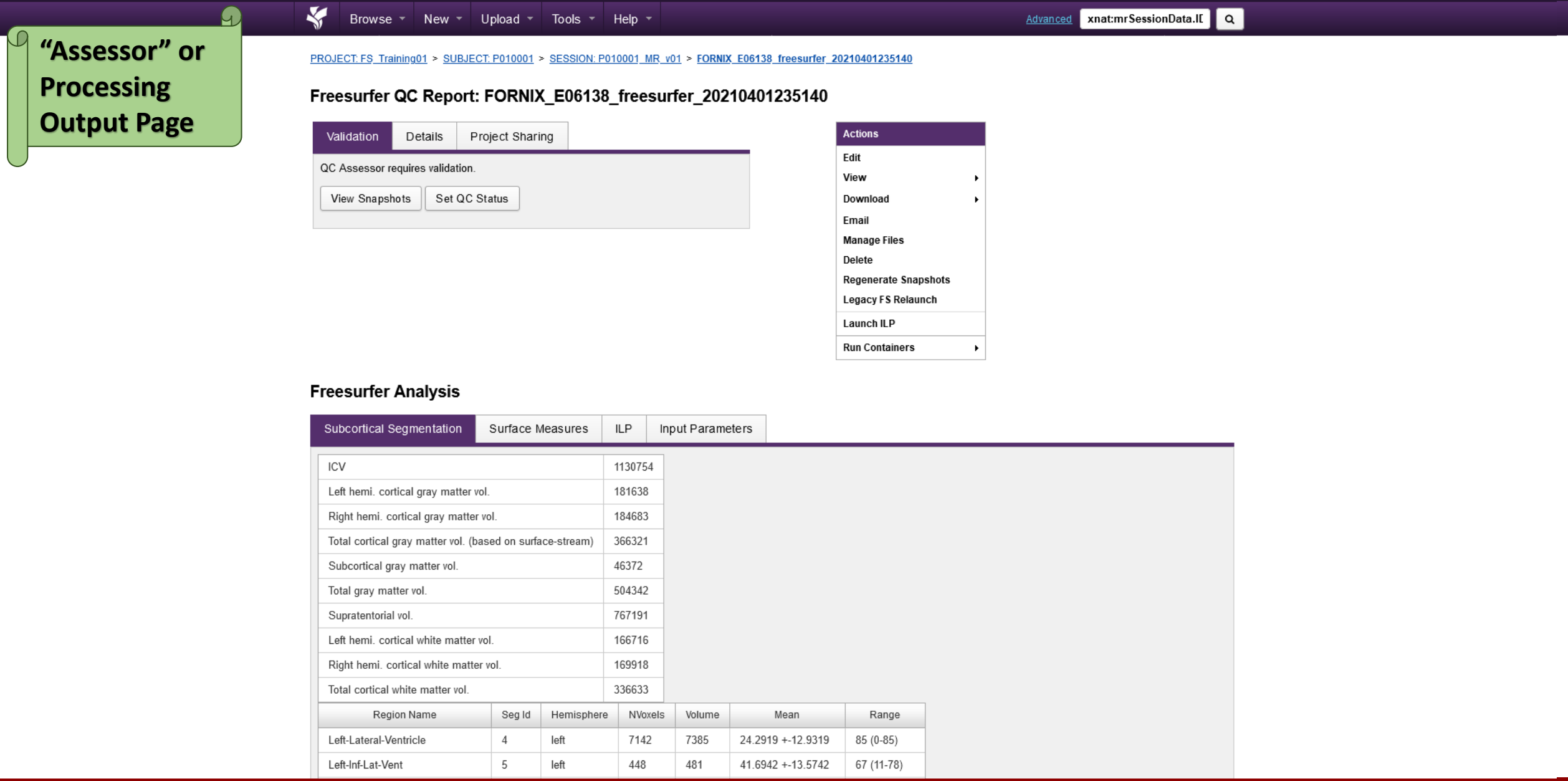
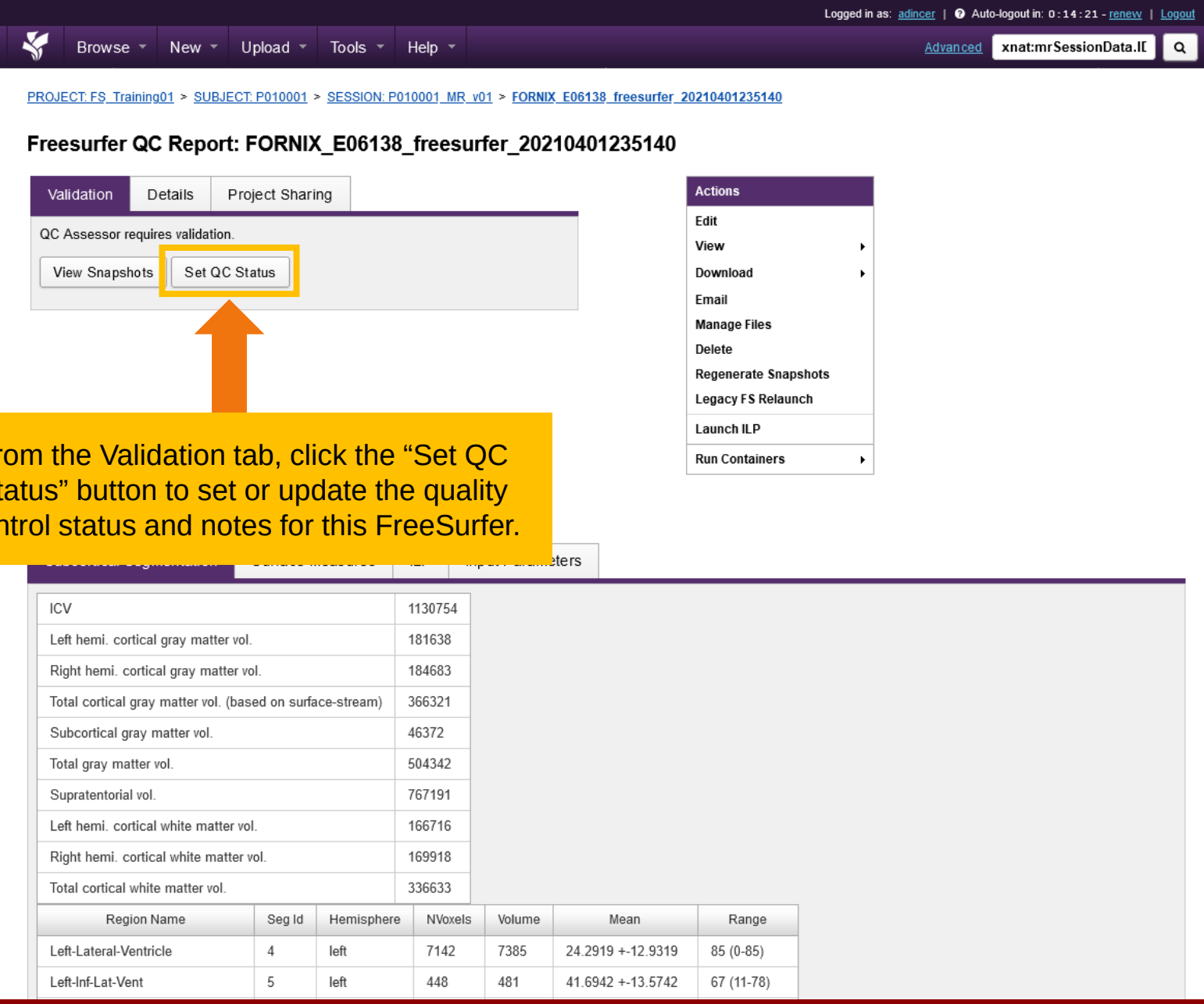
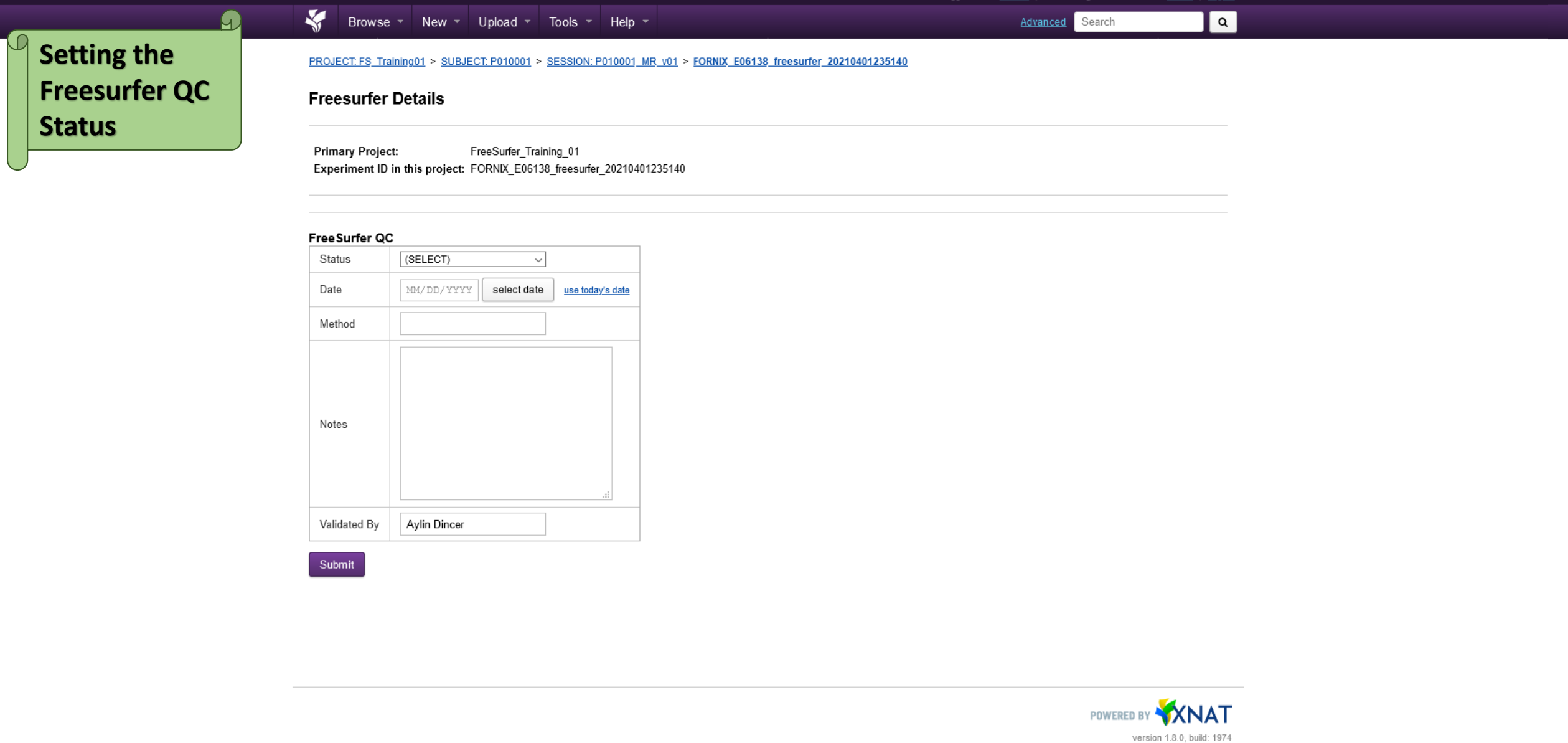
"Assessor" or Processing Output Page



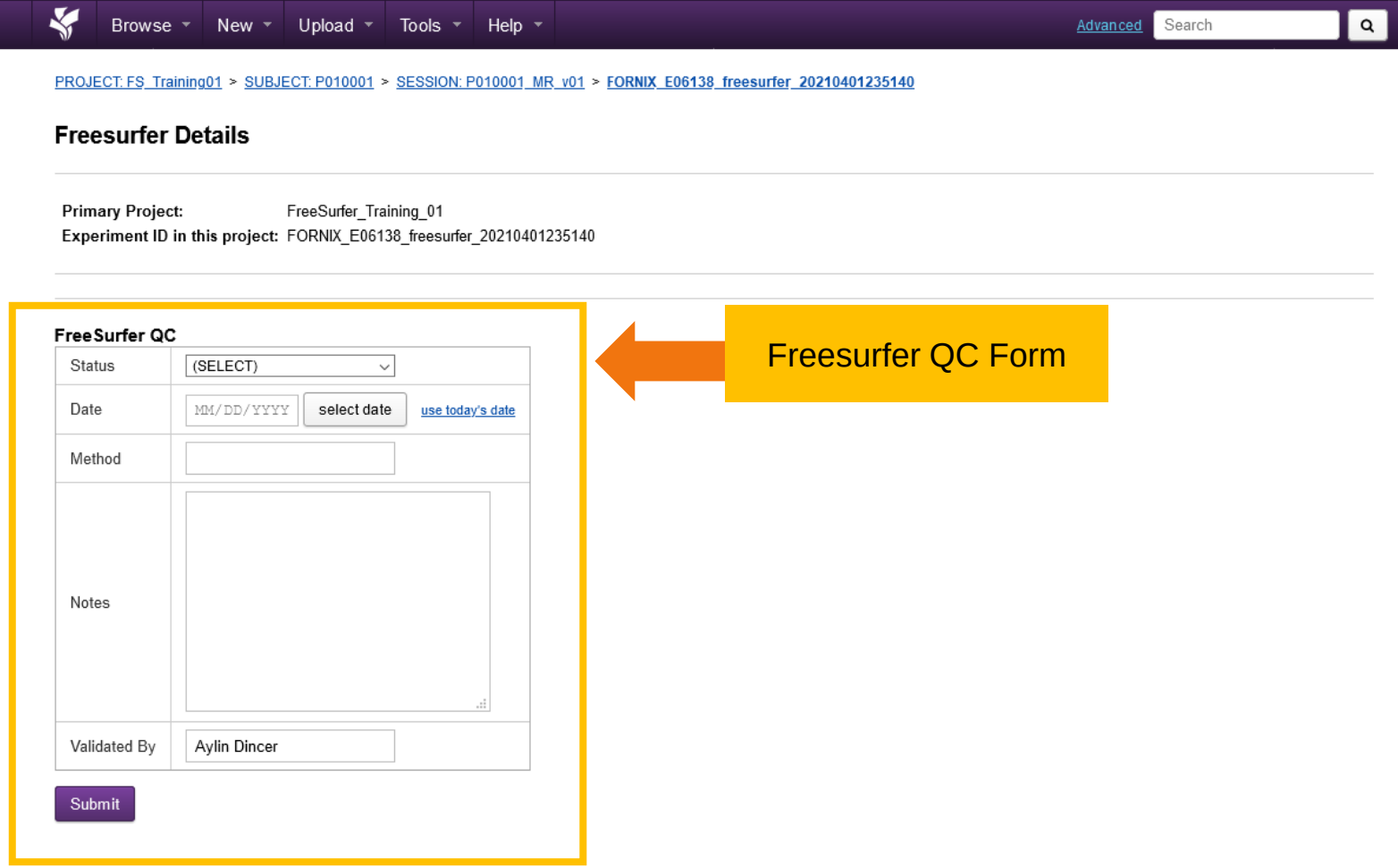
"Assessor" or Processing Output Page



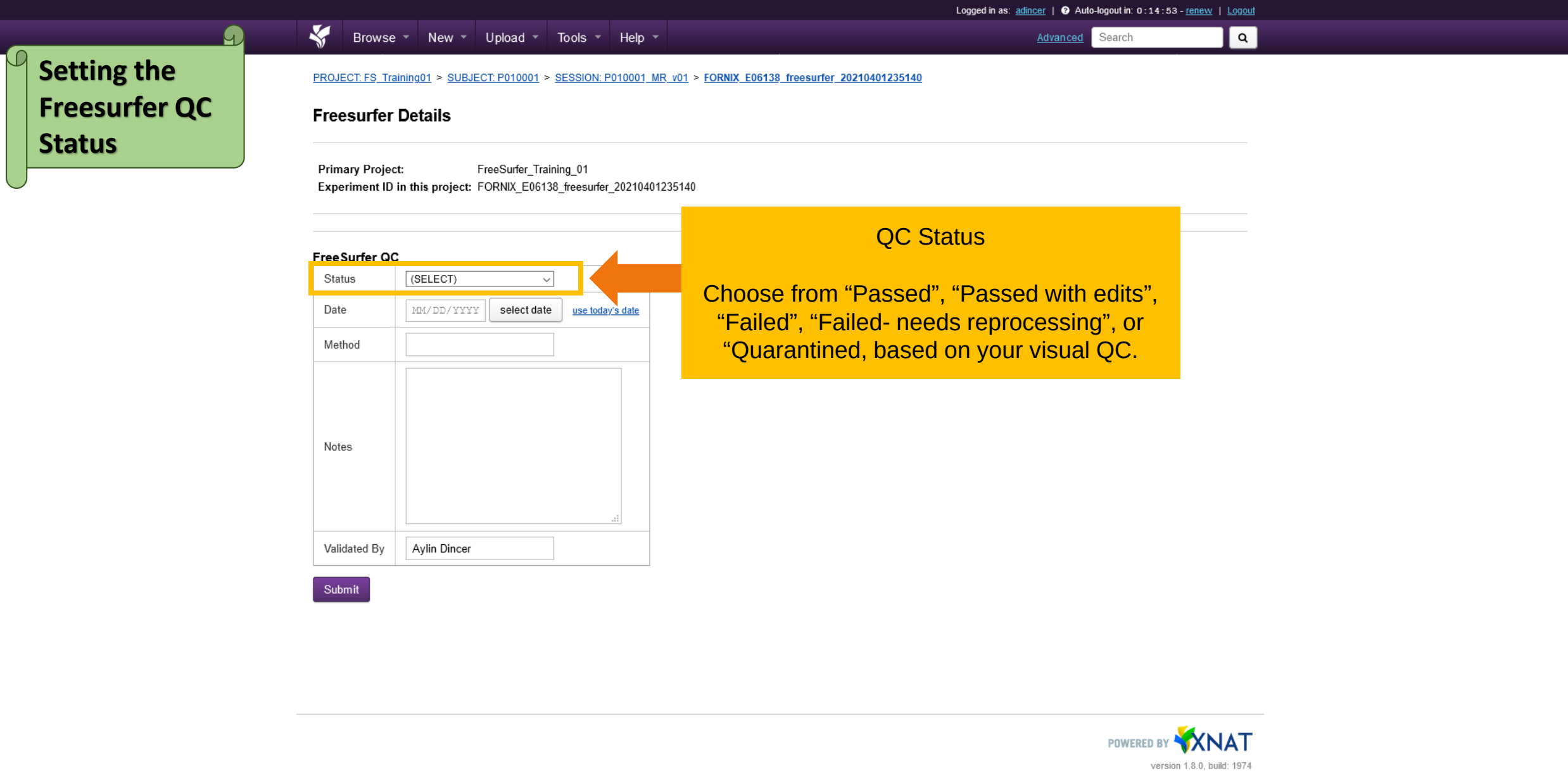
Setting the Freesurfer QC Status



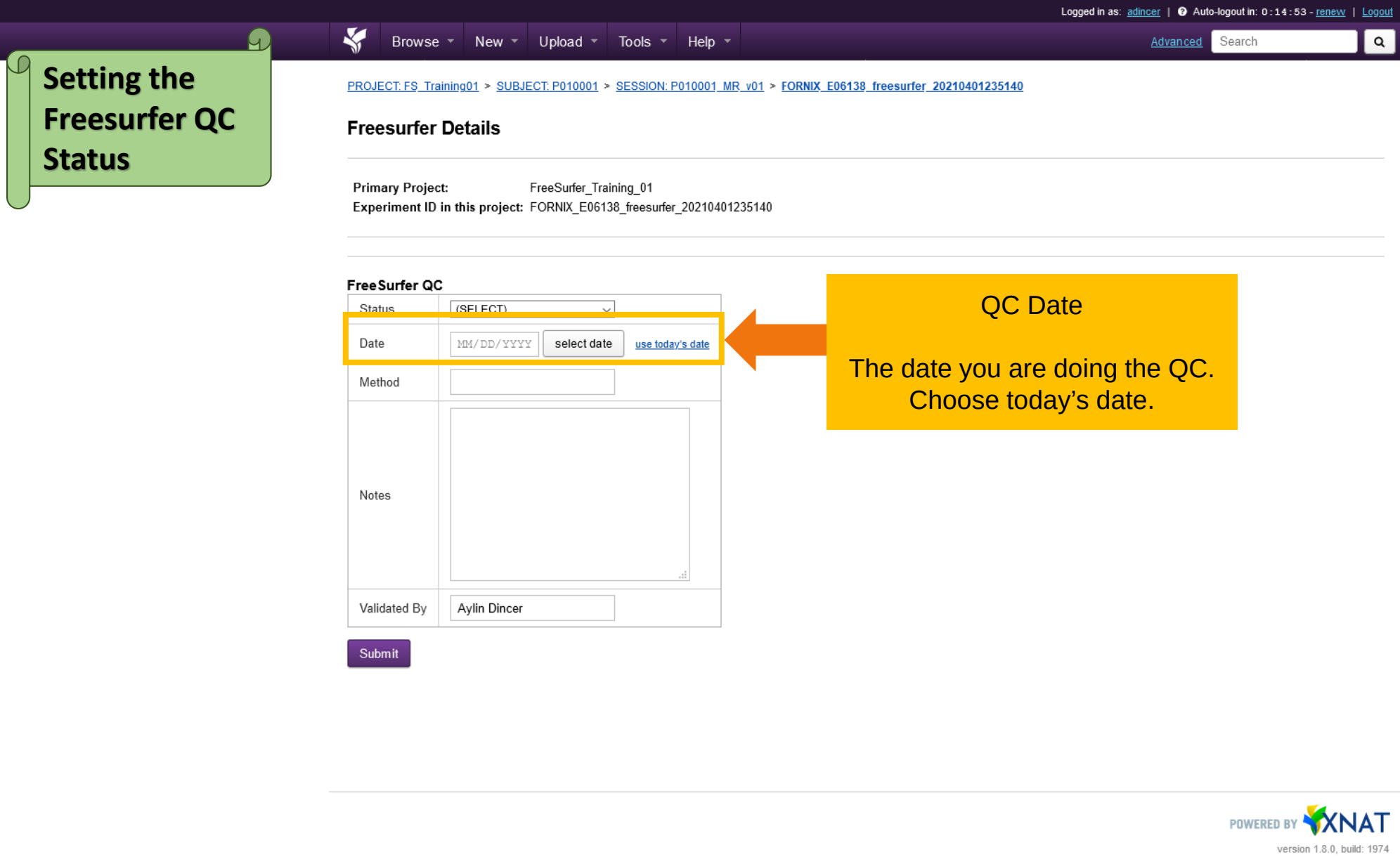
Setting the Freesurfer QC Status



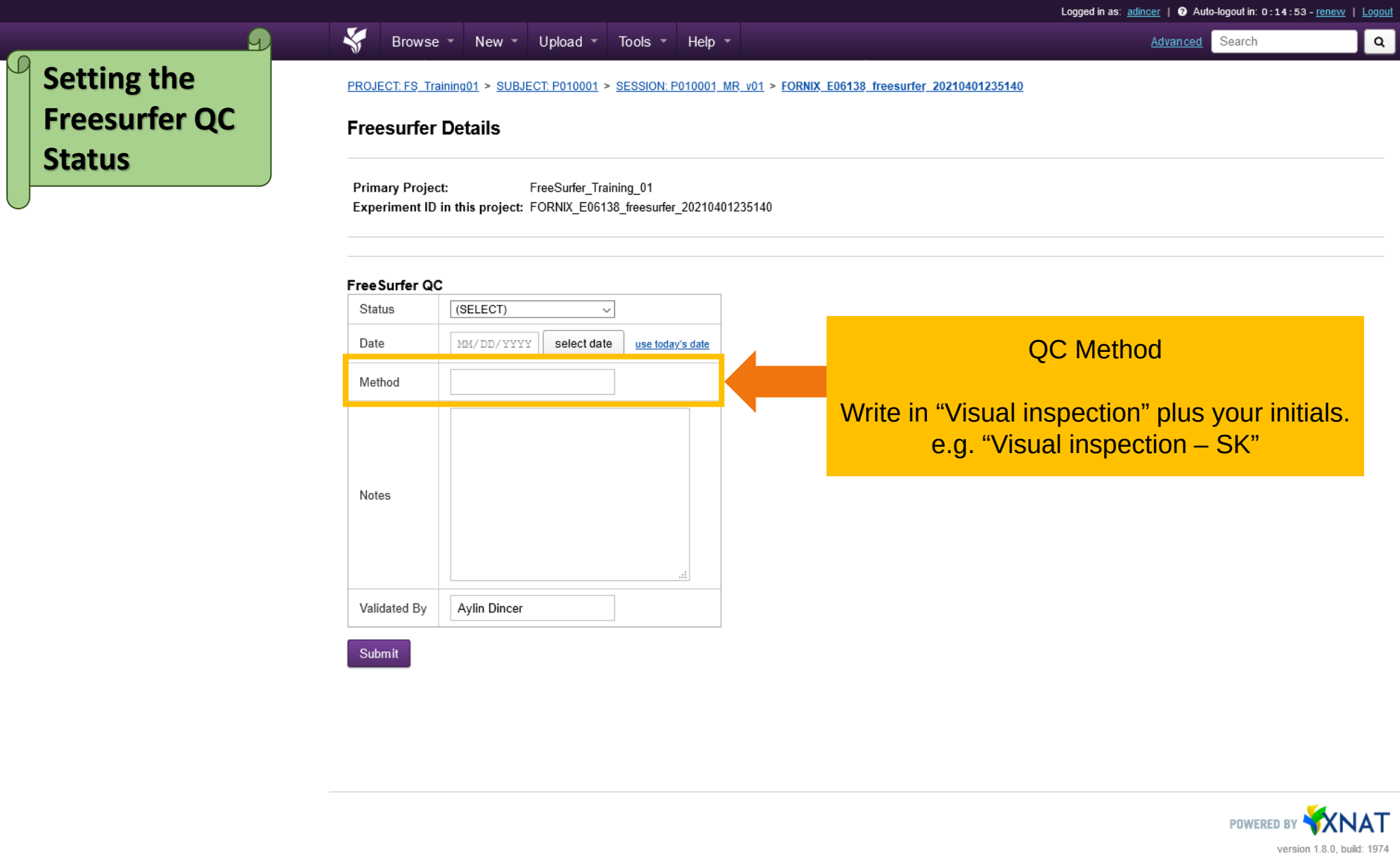
Setting the Freesurfer QC Status



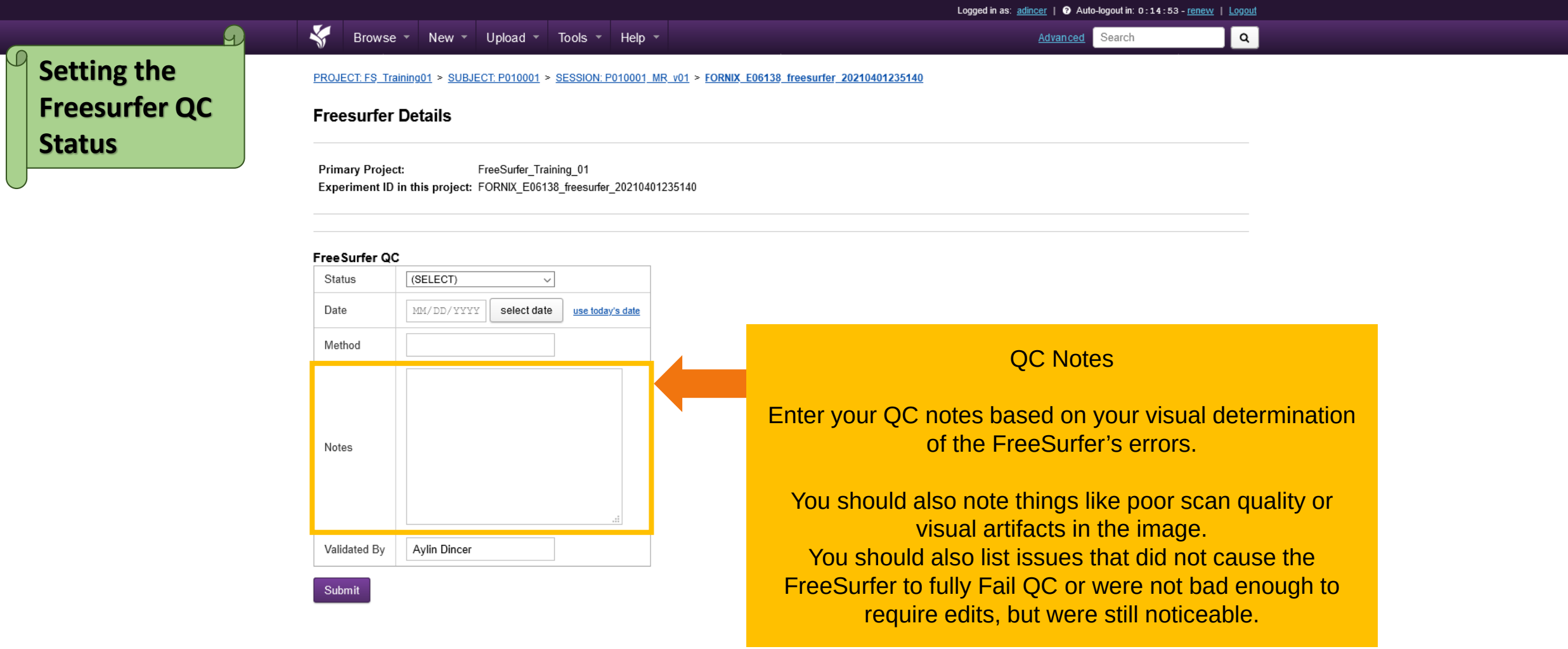
Setting the Freesurfer QC Status



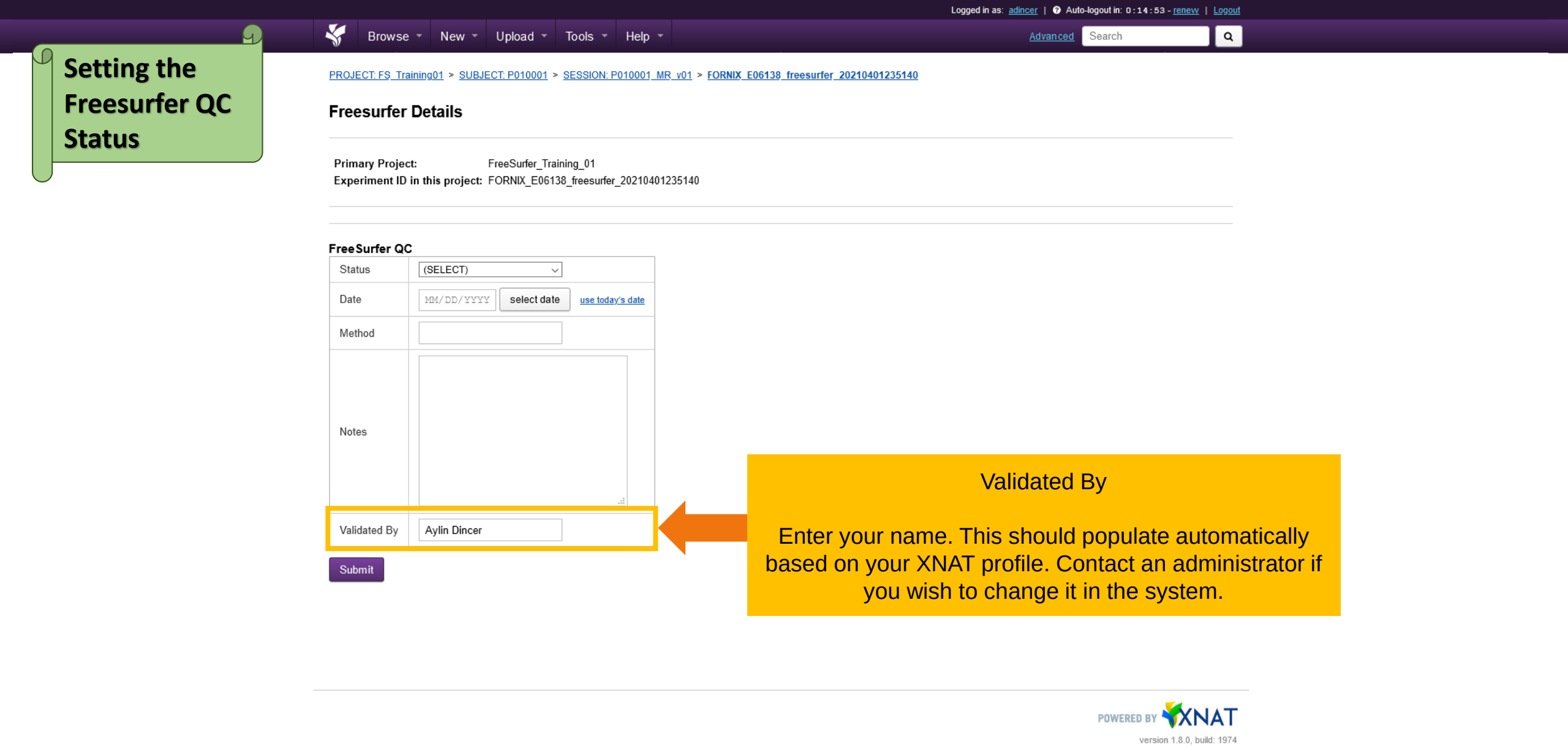
Setting the Freesurfer QC Status



Setting the Freesurfer QC Status



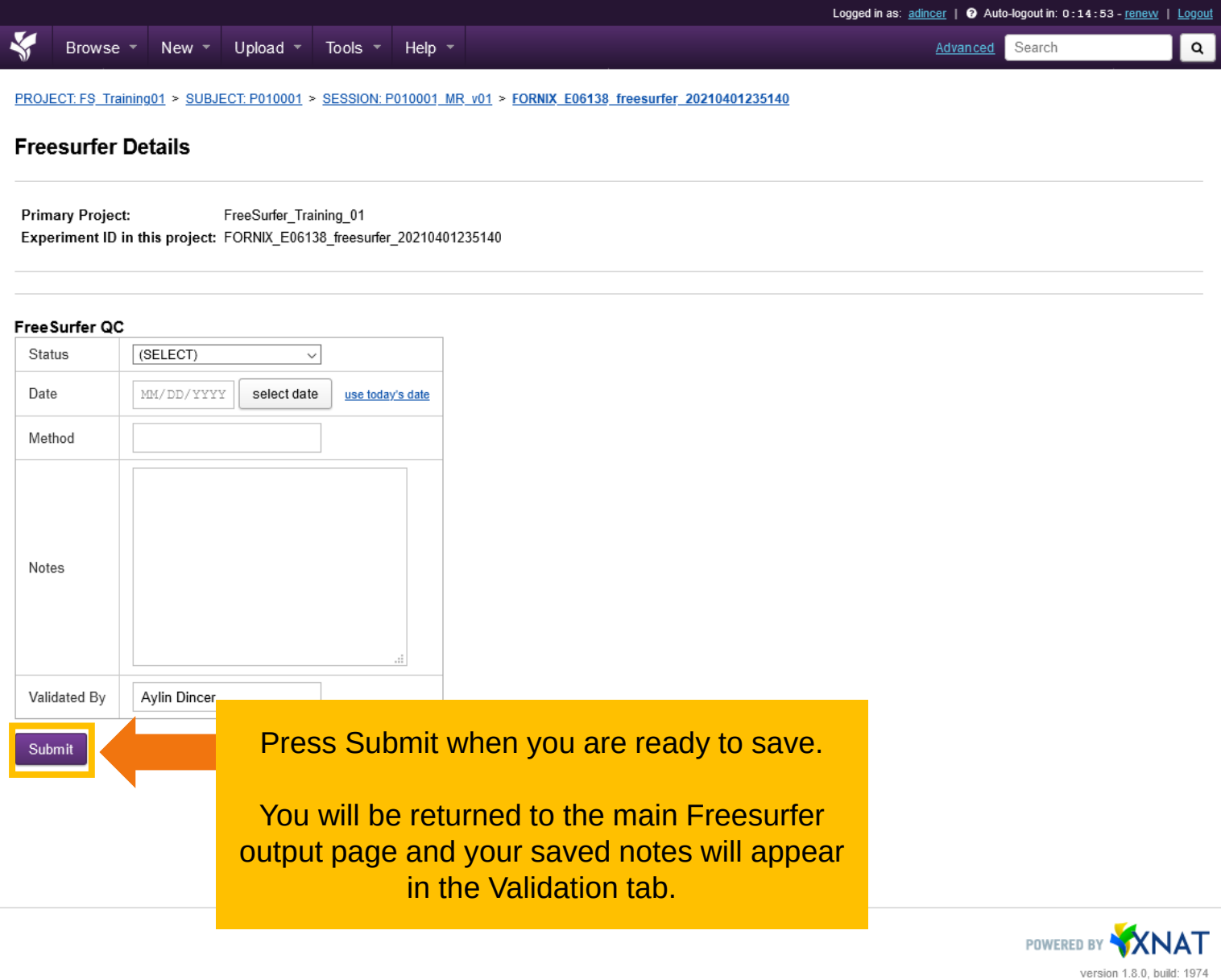
Setting the Freesurfer QC Status



Validated By

Enter your name. This should populate automatically based on your XNAT profile. Contact an administrator if you wish to change it in the system.

Setting the Freesurfer QC Status



Manage Files from FS Page

Freesurfer QC Report: FORNIX_E06138_freesurfer_20210401235140

Validation | Details | Project Sharing

QC Assessor requires validation.

View Snapshots | Set QC Status

Actions
- Edit
- View
- Download
- Email
- Manage Files
- Delete
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- Legacy FS Relaunch
- Launch ILP
- Run Containers

Freesurfer Analysis

Subcortical Segmentation | Surface Measures | ILP | Input Parameters

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Total cortical white matter vol.	336633

Region Name	Seg Id	Hemisphere	NVoxels	Volume	Mean	Range
Left-Lateral-Ventricle	4	left	7142	7385	24.2919 +-12.9319	85 (0-85)
Left-Inf-Lat-Vent	5	left	448	481	41.6942 +-13.5742	67 (11-78)

Manage Files from FS Page

Logged in as: adincer | Auto-logout in: 0:14:21 - renew | Logout

Browse | New | Upload | Tools | Help | Advanced | xnat:mrSessionData.ID

PROJECT: FS_Training01 > SUBJECT: P010001 > SESSION: P010001_MR_v01 > FORNIX_E06138_freesurfer_20210401235140

Freesurfer QC Report: FORNIX_E06138_freesurfer_20210401235140

Validation | Details | Project Sharing

QC Assessor requires validation.

View Snapshots | Set QC Status

Actions
- Edit
- View
- Download
- Email
- Manage Files
- Delete
- Regen... Snapshots
- Legac... elaunch
- Launc...
- Run C...ers

Click “Manage Files” in the Actions Box on the Freesurfer page to view and download the files from Freesurfer processing output that was run via XNAT.

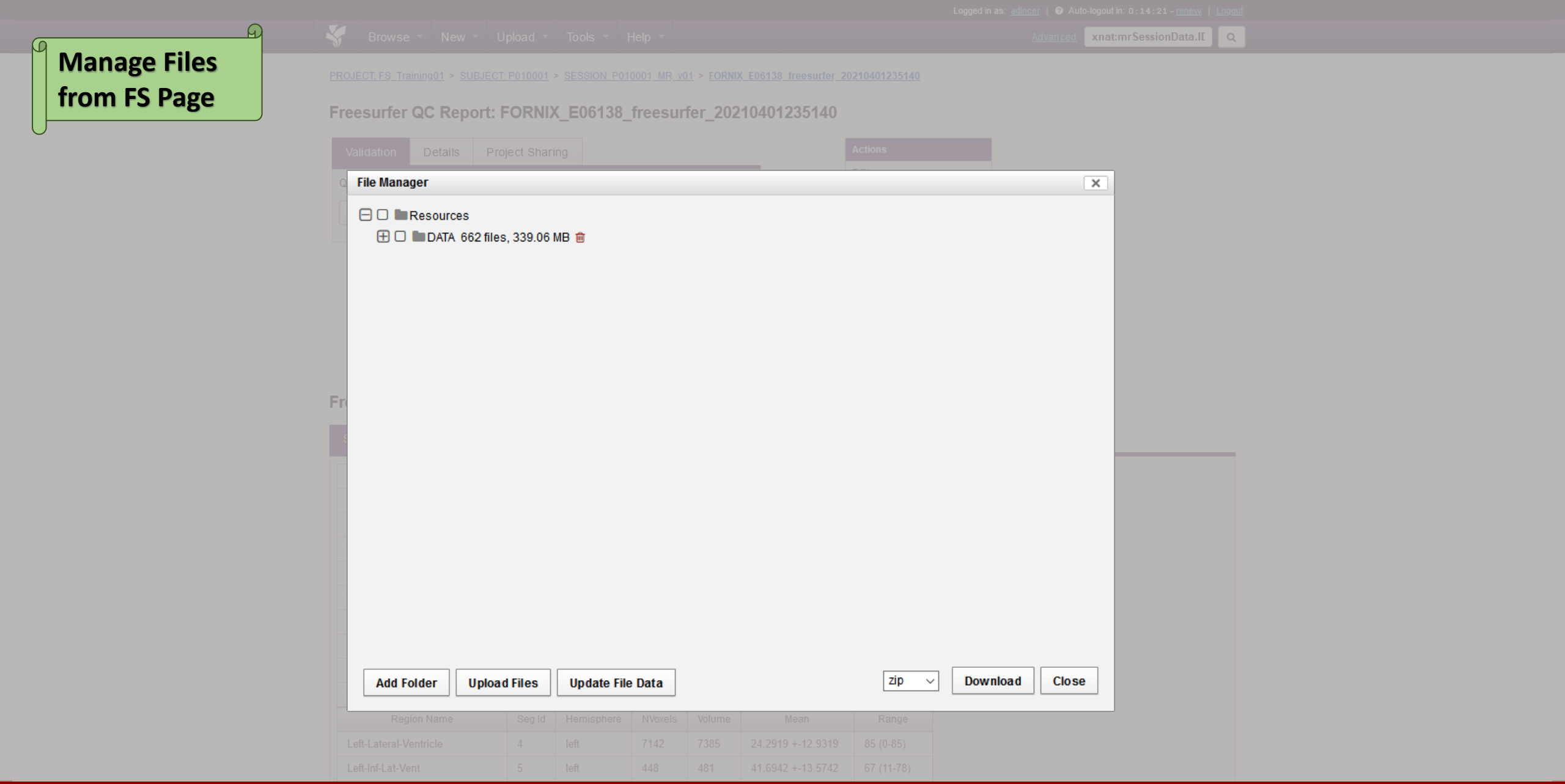
Freesurfer Analysis

Subcortical Segmentation | Surface Measures | ILP

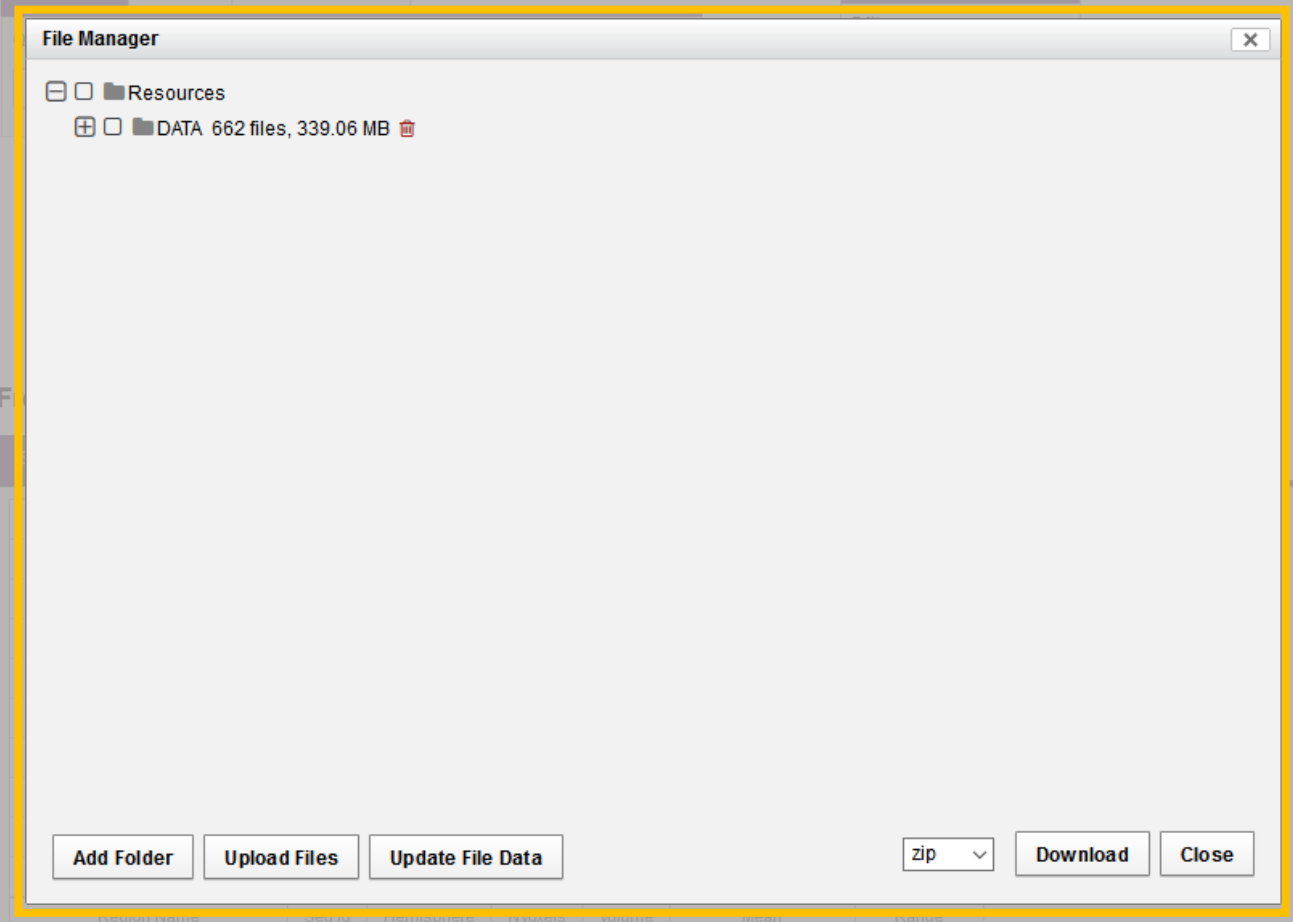
ICV	113075
Left hemi. cortical gray matter vol.	181638
Right hemi. cortical gray matter vol.	184683
Total cortical gray matter vol. (based on surface-stream)	366321
Subcortical gray matter vol.	46372
Total gray matter vol.	504342
Supratentorial vol.	767191
Left hemi. cortical white matter vol.	166716
Right hemi. cortical white matter vol.	169918
Total cortical white matter vol.	336633

Region Name	Seg Id	Hemisphere	NVoxels	Volume	Mean	Range
Left-Lateral-Ventricle	4	left	7142	7385	24.2919 +-12.9319	85 (0-85)
Left-Inf-Lat-Vent	5	left	448	481	41.6942 +-13.5742	67 (11-78)

Manage Files from FS Page



Manage Files from FS Page



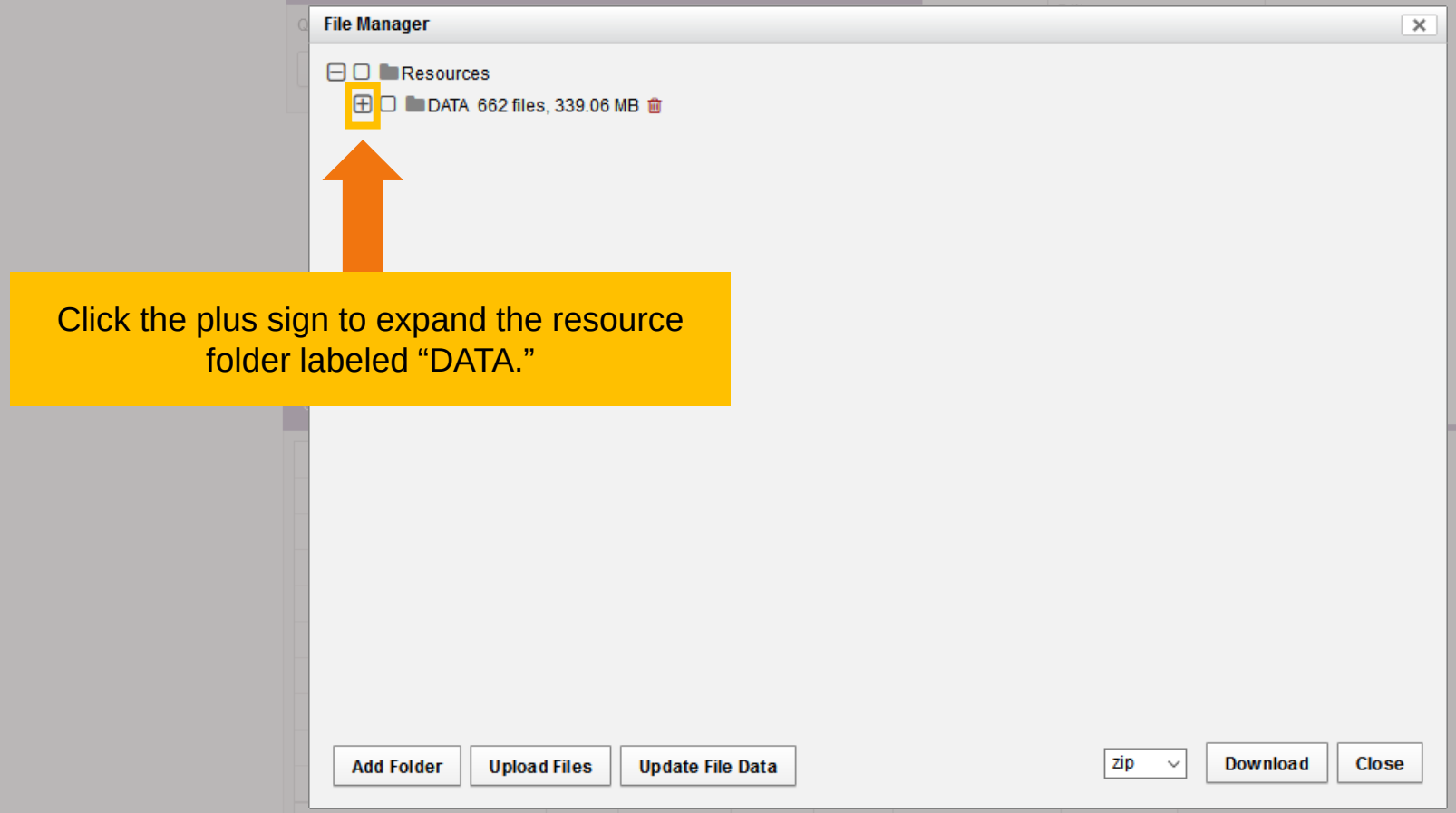
File Manager dialog lets you:

Download scan files or processing output files

Upload files (such as edits of Freesurfer output)

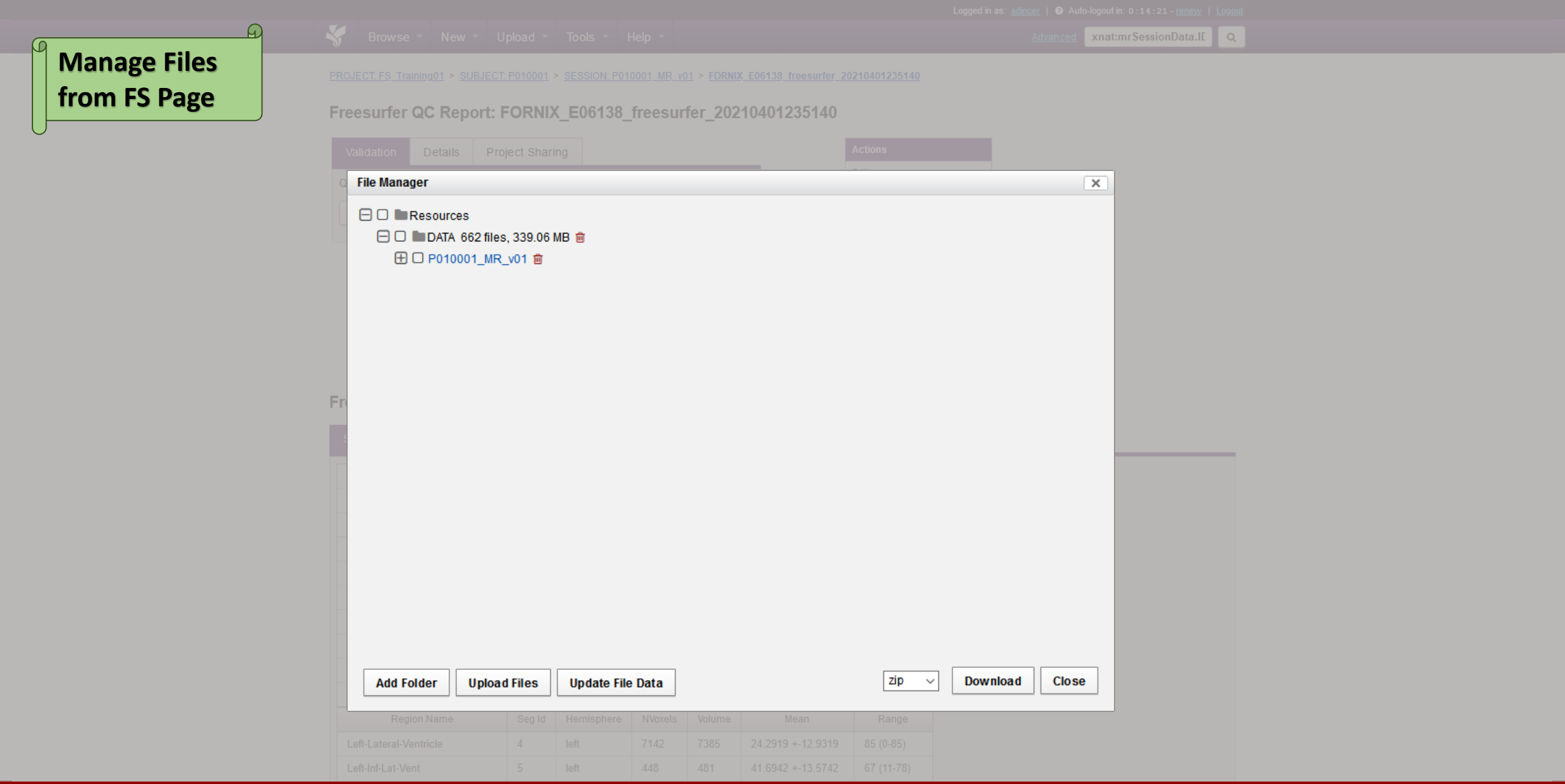
Delete files (Only if you have permission)

Manage Files from FS Page

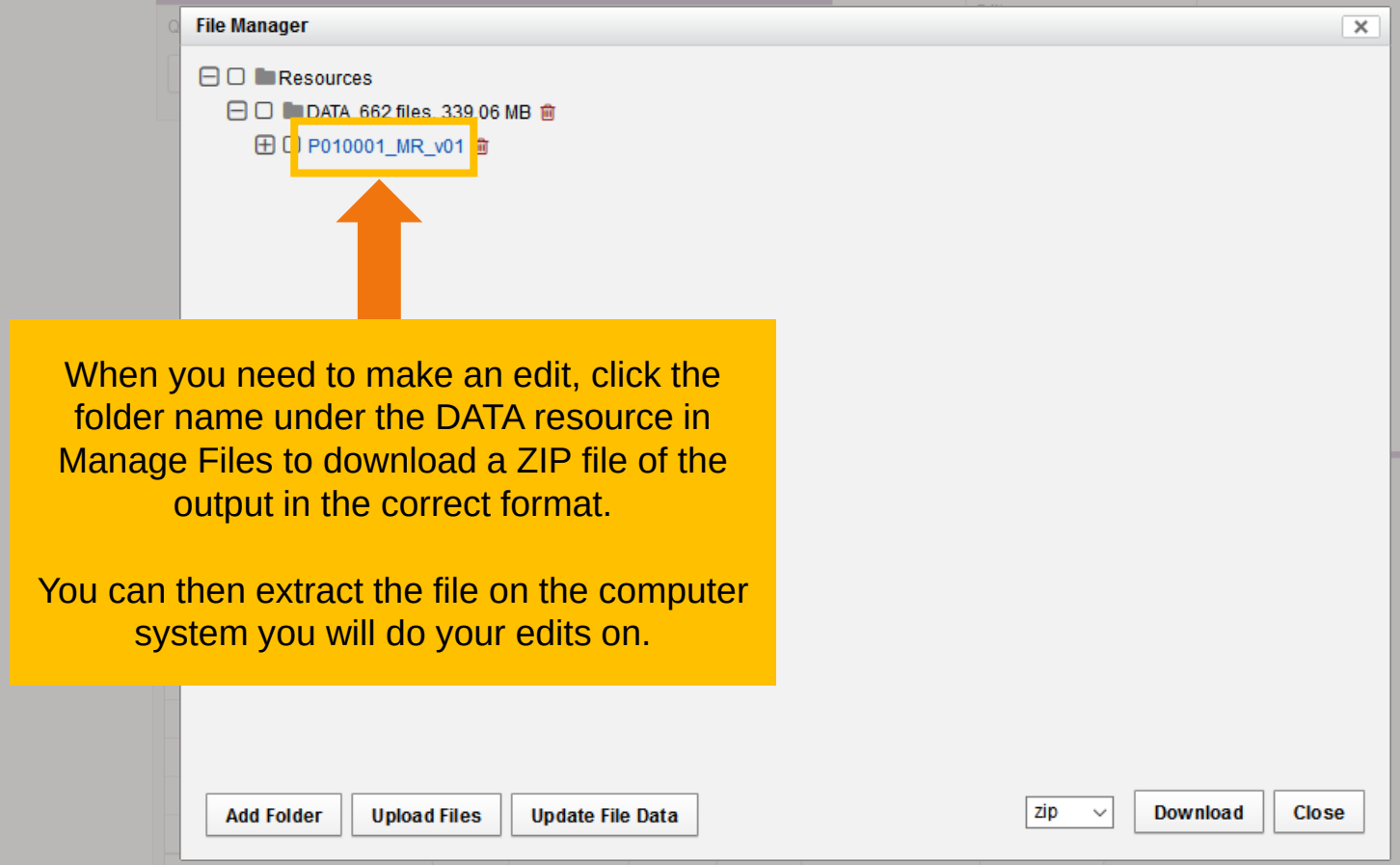


Click the plus sign to expand the resource folder labeled “DATA.”

Manage Files from FS Page



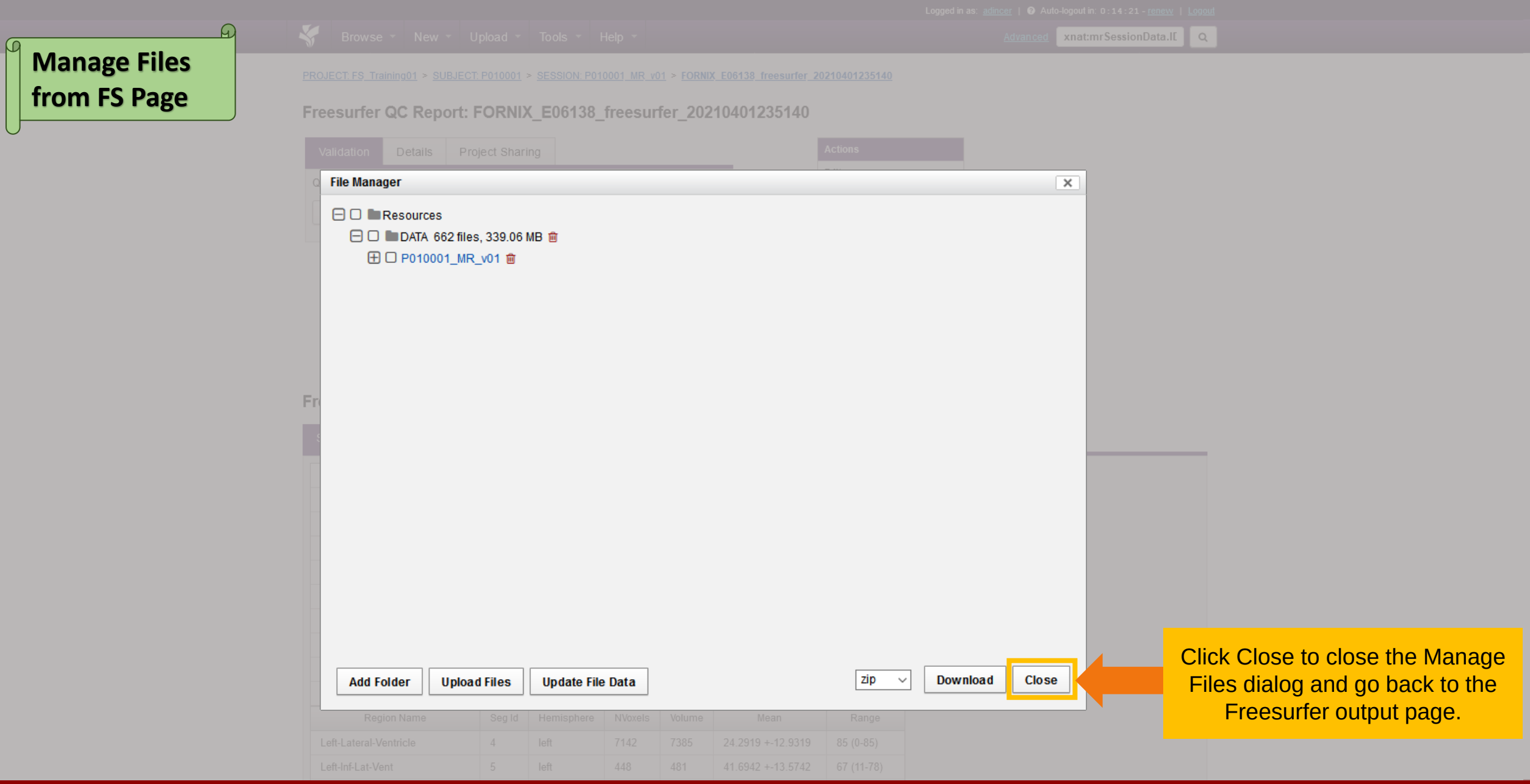
Manage Files from FS Page



When you need to make an edit, click the folder name under the DATA resource in Manage Files to download a ZIP file of the output in the correct format.

You can then extract the file on the computer system you will do your edits on.

Manage Files from FS Page



Click Close to close the Manage Files dialog and go back to the Freesurfer output page.

Q&A Time

Any questions?