QibaPhan: QIBA DWI Phantom Analysis Software

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Overview

"QibaPhan" software package automates derivation and analysis of ADC and SNR maps, as well as basic ROI statistics from DWI DICOM data acquired on the QIBA polyvinylpyrrolidone (PVP) DWI phantom to measure MRI system performance for cross-site comparison of GE, Siemens, and Philips MRI scanners.

Functionality

The SW is designed to read-in DW-MRI standard DICOM images of the PVP DWI Phantom acquired using multiple b-value and repeat scans, and provide: 1) full exam series catalogue; 2) acquisition protocol compliance check; 3) visualization of DWI and derived ADC maps for user-supervised ROI loci definition; 4) statistical analysis of ROIs for DWI and ADC maps; and 4) tabulation of ROI summary statistics for ADC, DWI and SNR for individual b-values and repeat scans.

Distribution

The SW is deployed as a C++ compiled (Matlab 2011(+)) console/GUI application on 64-bit Windows systems, consisting of two independent modules that (1) build ADC and SNR data structures and (2) prompt user to define ROIs for summary statistics. The SW distribution includes two separate packages of the individual SW modules (~0.5 Mb), Matlab Compiler Runtime (MCR) installer (~0.5Gb) for Matlab libraries, binary MAT file with current scanning protocol parameters for QIBA PVP phantom, and this manual. SW requires Microsoft Visual Studio 2008(+) run-time libraries on target computer (not included in the distribution).

Installation

The installer for "QibaPhan" is available from QIBA RSNA. To use the program, download the installation archive and extract its components in a folder called **QibaPhan**. To install the package modules on target computer, browse to **QibaPhan** folder and follow these three steps: (1) double-click on "MCRInstaller" to install Matlab runtime libraries (requires ~1Gb disk space) in your **C:\ProgramFiles** folder and follow the MCR-GUI prompts; (2) double-click on "qiba_mbuild_pkg" file to install first EXE module (NOTE: if asked to re-install MCR, hit "cancel"); (3) double-click on "qiba_mproc_pkg" file to install second EXE module.

Usage (Quick Reference)

To launch the program, start "cmd" (DOS console) and "cd" to **QibaPhan** SW folder location. Type "qiba_mbuild.exe" to run module1 that builds ADC and SNR data structures; then type "qiba_mproc.exe" to execute module2 that defines ROIs and summarizes DWI and ADC statistics. Both EXE modules use console interaction to set processing parameter choices and standard file browser GUI -- to select files and folders. The "qiba_mbuild" displays scan catalogue and protocol compliance check results for inspection in separate windows. The "qiba_mproc" provides interactive GUI to define ROI locations on different slices and displays ROI image montage for inspection before stats calculation. (SEE "Example Workflow" for details.) To interrupt the workflow at any time, either hit "Cancel" in the GUI window, or use "Ctrl-C" in console.

Input Data Structures

Phantom scan parameters recommended by QIBA protocol are summarized in Table 1. Each acquired "DWI" standard DICOM series is expected to contain trace (direction-average) DW images for all b-values and slices. Before launching "qiba_mbuild" module, prepare your DICOM data for analysis by creating the folder tree, e.g.: **../QIBA_Phantom_QC/Your_System_Name** anyplace convenient, and placing a **Your_DICOM_Scan** folder containing (standard, i.e. non-enhanced DICOM) phantom scan series inside. (Note that the data folder names and locations are arbitrary, while the "DWI" DICOM data format has to be a *single-series multi-b* scan.) For convenience, you may copy or move the binary QIBA phantom scan protocol file "masterDNA_QIBAPVP1" from **QibaPhan** distribution folder to **QIBA_Phantom_QC** folder.

Before launching "qiba_mproc" module, locate the **SDYYYYMMDDDataStructsBin** folder (labeled with the phantom scan date) containing the required input binary MAT data structures for DWI, ADC and SNR maps (produced by "qiba_mbuild" module execution.) This folder should be automatically placed one level above **../Your_DICOM_Scan** in the directory tree after "qiba_mbuild" module execution. The name of ***DataStructsBin** folder should NOT be altered for proper subsequent operation and output labeling.

Output Data Structures

Successful execution of "qiba_mbuild" module is expected to produce ***DataStructsBin** folder (one level above **../Your_DICOM_Scan** folder) labeled with your phantom scan date and containing binary MAT files with "ScanDemographics", "DWI", "DNA", "ADC" and (if available) multipass "SIGNALnNOISE" data structures, as well as "scaninfo.txt" catalogue and "CompliChckReport.txt" acquisition compliance report. If the input DICOM data were not split into individual series, **Your_DICOM_Scan_SeriesSplit** (optional) folder will be generated (at the same directory level as original DICOM data folder), containing individual series folders.

As a result of "qiba_mproc" module execution, the "ROI" and "SOI" binary MAT files will be added to ***DataStructsBin** folder, while the **ResultsQCstats** folder is created (at the same directory level) to save CSV tables of "ADC" ($x10^{-3}mm^2/s$), "DWI" and "SNR" statistics for all ROIs and b-values of individual repeat scans ("Passes") and multipass summaries. The first row of CSV files will list the corresponding stats header (e.g., b-values (s/mm^2), min, max, mean, etc).The **ResultsQCstats** folder will also contain PDF montage of the phantom images with ROI contours numbered according to the CSV table entries, as well as TXT files of scan catalog ("scaninfo") and compliance check report ("CompliChckReport*") labeled with the corresponding scan date ("YYYYMMDD").

RELEASE NOTES & RECOMMENDATIONS:

(1) Microsoft C++ visual studio 2008(+) runtime libraries SHOULD BE PREINSTALLED on a target computer where the tool is to be deployed.
(2) MCR (Matlab Compiler Runtime) libraries have to be INSTALLED only ONCE: if asked to re-install MCR during installation of other package modules, hit "cancel".
(3) Each acquired "DWI" DICOM series is expected to contain individual images for "trace" (direction-average) DWI of all b-values and slices. DO NOT INCLUDE individual directions or enhanced DICOM.
(4) Multiple DWI passes should be in sequential series without re-planning or re-calibration.
(5) Series sorting component creates binary "image_order" files inside each series directory: by default, NO RE-SORTING is performed while these files exist.
(6) Series cataloging creates binary "ExamDemographics" and text "scaninfo" files inside scan directory: by default, NO RE-CATALOGING is performed while these files exist.
(7) DO NOT CHANGE names of automatically generated folders: **SDYYYYMMDDDataStructsBin** or **Your_DICOM_Scan_SeriesSplit**.

(8) The “system ID” generated from scan demographics (Manufacturer+field+serial#) will be used for AUTOMATIC FILE NAMING of the DWI binary structures.
(9) By default, user is prompted only to choose “DWI” series to build binary structures. The user should look for more than two “Phases” per slice in the scan catalog for guidance.
(10) “ADC” maps are AUTOMATICALLY GENERATED for ALL “DWI” structures inside ***DataStructsBin**. ADC ($x10^{-3}mm^2/s$) maps are calculated using two-point exponential model for b-value pairs, as well as mono-exponential fit over all b-values. Fixed noise threshold of 0.4% peak DWI signal at b=0 is used and all multipass DWI sets are scaled identically.
(11) Multipass SNR is calculated for DWI and ADC according to ACR-NEMA procedure, where images from multiple “Passes” of a common acquisition “Set” are analyzed to derive the temporal mean (signal), and temporal standard deviation (noise) on a pixel-by-pixel basis.
(12) CHOOSE DIFFERENT ROI LABELS (when prompted) if analyzing same system scans for DIFFERENT PASS selection to avoid overwriting the output CSV stats tables.
(13) Rerun “qiba_mproc” module to define separate ROIs for DIFFERENT “SETS”: single ROI stats can be obtained ONLY for multiple passes of the SAME DWI “Set” on which it was defined.
(14) For rectangular ROIs, the first dimension is “horizontal” width. Use aspect ratio >1 if desired vertical (height) is larger than width.
(14) Use “WordPad” to view “CompliChckReport” for better display format.
(15) CSV stats tables, PDF phantom image montage with superimposed ROI contours and TXT of scan catalog and compliance check report are saved in the **ResultsQCstats** folder.
(16) MAKE A NOTE of the full path to **ResultsQCstats** and ***DataStructsBin** folders as displayed in the console window after completion of the module execution.

Disclaimers

(A) SW is distributed by QIBA-RSNA without warranty. No source code, updates or support is provided by the authors. Please contact distributor with any questions regarding this release.
(B) The SW was developed in Matlab 2011b and tested on four Windows 7 (64-bit) hosts for the following vendor-specific DICOM formats: Achieva 2.6.3 and 3.2.2; Ingenia 4.1.3; Syngo MR B17; Signa HDxt 23 and 24 HD16;
(C) As of 09/2014, b-values are not reliably found in “public” DICOM tags, thus were extracted from “private” (vendor-unique) tags for uniform image sorting order. “Private” tags are allowed to change for future (2014+) DICOM format updates, making such data potentially incompatible with current QibaPhan SW.
(D) Since spatial configuration of the PVP phantom is not yet finalized, the flexibility for VOI stats generation is preserved by providing spatial coordinates for each defined ROI in the output table. For further analysis (of ADC linearity and bias estimate), combine provided ROI stats into VOI for known tube geometry and PVP concentration in any third-party software tool (Excel, SPSS, R, etc).
(E) Although the information is believed to be reliable, no warranty expressed or implied is made regarding accuracy, adequacy, completeness, legality, reliability or usefulness of any information. This disclaimer applies to both isolated and aggregate uses of the information.

Example Workflow (Detailed Usage)

The SW work-flow consisting of two modules: module1 = “qiba_mbuild” and module2 = “qiba_mproc”. The “qiba_mbuild” module prepares binary DWI data structures by sorting original DICOM images based on multiple header attributes including: slice location, echotime order (if exists), b-value (if exists), image type (if exists) etc. Currently images are sorted based on thirteen distinct criteria. The original DICOM images remain unaltered while the sort-order key is retained in an “image_order.mat” binary file inserted in each image series

folder. To reduce influence of potential vendor-applied filtering in vendor-generated ADC maps, this software independently creates ADC maps of the QIBA phantom (starting from original DICOM DWI) identically for all vendors. Module1 may be run once per phantom scan. The "qiba_mproc" module visually prompts the user to select ROI loci on each slice then generates a tabulated statistical report for all ROIs stored in a standard format (CSV) for flexible subsequent analyses by the user. Module2 may be run multiple times for the phantom scan, e.g., to define ROIs for different "Set" or "Pass". Below is a step-by-step workflow example:

(1) Acquire DWI series for the QIBA PVP phantom according to the protocol, and export the results as single series for multiple b-values in standard DICOM. (Non-DWI series may also be included.)

(2) Copy the folder with the scan DICOM series into pre-created system **SysXX** folder, e.g., inside **QIBA_Phantom_QC** folder on a target computer. The full exam (all DWI plus non-DWI series) may be copied.

(3) Install "QibaPhan" software on the target computer following above installation instructions.

(4) Start "cmd" console and "cd" to **QibaPhan** folder location.

(5) Run "qiba_mbuild.exe" (module1) from console. User interaction is via console and dialog windows:

The first dialog window appears and prompts the user to browse to DICOM series folder with the QIBA scan data (Figure 1). Select the parent scan folder itself, but do not go as deep as to select individual series. (The parent folder may contain each series already split into individual folders, or all images from all series combined in the parent folder.) If the scan series are not split into folders, the module will automatically attempt to split and display the message:

" (FYI) Selected DICOM data is NOT SPLIT into series: SPLITTING ..... "

When individual series are separated into folders, the cataloging (sorting) will be performed for the detected series and the following message is displayed:

" (FYI) Cataloging detected ## scan series ..... "

The sort-order key will be retained in an "image_order" binary file inserted in each image series folder (Figure 2). Upon catalog completion, the "SiteScanDemographics" will be displayed in console window, followed by the "assigned System ID" string consisting of first 2 letters for Manufacturer, field strength and system serial number (without initial zeros). If required info is missing, the user will be prompted to enter a system ID manually. This generated system ID will be used for automatic file naming of the DWI binary structures. The "SiteScanDemographics" along with key acquisition parameter catalog for individual series will be recorded in a "scaninfo" text file (Figure 2). This catalog will also be displayed in a separate window for inspection (Figure3a). Next, for the series containing more than 2 images per slice, user will be prompted to build DWI structures:

" *** Build DWI data structures for this series? (y/n) *** : *y* "

Inspect the catalog (for "Number of Phases" > 2) to insure that the selected series should be processed as a QIBA-DWI pass, and enter "y" to proceed or "n" to move to the next eligible series. The info message showing the path to the DICOM source will be displayed while the DWI data structure is built. The software will automatically create a folder **SDYYYYMMDDDataStructsBin** for the corresponding scan date and place the binary MAT files in there. The binary "DWI" files will be automatically labeled as different "Passes" of the same "Set" when key acquisition conditions are identical for DWI series (eg, TR/TE; Nave; #slices; slice thickness; slice locations; slice angulation; FOV; Matrices; phase-direction; b-values; etc) and the series are immediately sequential. If a discordant set of acquisition conditions is

encountered, then “Pass1” of the next available “Set#” is created. In this way, all DWI series acquired under identical conditions are labeled by a unique “Pass#” but grouped within a common “Set#”.

When the last DWI structure is built from legitimate series, the browser will appear asking user to select the master protocol file “masterDNA_QIBAPVP1” to check the acquisition compliance with the master QIBA phantom protocol (supplied in binary format with this “QibaPhan” distribution). “Compliance” infers the acquisition settings were within a tight range of values shown in Table 1. The results of compliance check for key acquisition parameters of the selected DWI series will be displayed for inspection in a separate window (Figure3b) and save in “CompliChckReport” text file.

The SW will then automatically proceed to building “ADC” map structures for all selected DWI data, informing of the progress in the console window. (SEE “RELEASE NOTES” above for specific “ADC” models, units and thresholds used.) After individual “ADC” structures are built, the SW checks for existence of multiple repeat scans for the same “Set”. If “multipass” data are found, the SW proceeds to build SNR structures and prompts for each “Pass” to be included (the operator may respond with “n” to exclude any given series if desired). The current QIBA DWI phantom scan protocol (Table 1) calls for at least two sequential “Passes” for each DWI series. That is, collection of two (or more) sequential DWI series acquired under identical conditions allows derivation of SNR of the DWI by analysis of (temporal) variance with respect to pass number. Images from multiple “Passes” of a common acquisition “Set” are analyzed to derive the temporal mean (signal), and temporal standard deviation (noise) on a pixel-by-pixel basis. These full 3D “SIGNALnNOISE” maps for each b-value condition are store on disk, again in a uniform data structure format in ***DataStructsBin** folder.

Finally, the local path to directory with resulting data structures ***DataStructsBin** is displayed in console window before the program quits. The user must manually close the auxiliary info windows (with scan catalog and compliance check results which are automatically saved in text files) to proceed to the next processing module or return to console prompt.

(6) In Windows environment, browse to the **SDYYYYMMDDDataStructsBin** to inspect its content. This folder should contain the set of binary files for the acquired DWI series: “DWI”, “ADC”, “DNA”, “SIGNALnNOISE” (if multipass performed), and “ExamDemographics”; as well as “scaninfo” and “CompliChckReport” text files.

(7) From **QibaPhan** console run “qiba_mproc.exe” to define ROIs and calculate statistics:

Browse to ***DataStructsBin** folder containing “DWI” and “ADC” data structures for the desired scan date. When prompted, enter “n” to define [n]ew ROIs and provide an informative (short) ROI label. For example:

“ *** Define (n)ew ROIs or use (o)ld (n/o)? *** : *n* ”

“ *** Provide unique label for ROI group (eg, A, B1, CC12,...) *** : *AA1* ”

Next, you can specify ROI shape ([c]ircular or [r]ectangular) and dimensions (width and aspect ratio) or answer *“y”* to use the default settings:

(FYI) DEFAULT PROCESSING OPTIONS

****

* ROI type (c)ircle = "c"

* ROI size = "10mm"

****

“ *** Use DEFAULT proc options? (enter "n" to change defaults -- y/n)*** : *y* “

The dialog window will appear to choose the “DWI: data structure to define ROI center locations. When file is selected, “ADC” and b=0 maps of the phantom slice will be displayed above the console window. On the right (b=0) figure use the left mouse click to define ROI centers on different tubes, then press “space” or right-click to proceed to next slice (Figure 4). When done, the dialog window will appear to select an “ROI” location file to inspect. The selected ROIs will be superimposed on the “ADC” map of the same “set” and “pass” for inspection. To proceed with statistics evaluation within the inspected ROIs, answer “n” to the console prompt (or answer “y” to inspect a different ROI file, if exists). For example:

“ (FYI) Selected "SI15T26049_Set1_Pass1_ROIAA1" file has 31 ROIs for application “

“ *** Inspect another "ROI" file? (Enter "n" to proceed with stats-evals for CURRENT ROIs)(y/n) *** : *n* “

The user will now be asked to select “passes” of the same set to calculate ROI statistics. To exclude a “Pass”, answer *“n”*. Next, the same ROI will be automatically used for “SNR” statistics calculation for multipass “SIGNALnNOISE” structure (if found) for this “Set”. Resulting stats of interest (SOI) binary structures will be saved in the ***DataStructsBin** folder, and output CSV stats tables, PDF montage with superimposed ROI contours, as well as, TXT of scan catalog and compliance check will be saved in the **ResultsQCstats** (Figure 5). The path to the QC result folder will be displayed in the console window before the program quits. The CVS tables (Figure 6) are provided for individual passes and “multipass” set and contain standard ROI statistics (mean, median, SD, Npts, etc) for each PVP phantom ROI.

Table1: Recommended Protocol for Diffusion-weighted MRI of QIBA PVP phantom

Rec Coil	8ch/15 head
Uniformity	CLEAR/NONE
Plane	*Ax (4 repeats), Sag, Cor (2 repeats)
FOV (cm)	22
Acquisition voxel size	1.72×1.72×4mm
Acquisition matrix	128×128
Rec voxel size	0.98×0.98×4mm
Rec matrix	256×256
SENSE	A/P (phase) factor=2
Phase encoding direction	A/P (Ax, Sag); R/L (Cor)
Fat-shift Direction	P
Foldover –sup /oversampling	No
Slices	25
Stack & package	1
Slice thickness (mm)	4
Slice gap (mm)	1
Shim	Volume
Scan mode	MS/2D
Technique	SE
Acq mode	Cartesian
Fast imaging mode	EPI
Shot mode	Single shot
Echoes	1
Partial echo	no
TE (ms)	Shortest (100-125ms)
Flip angle	90
TR (ms)	15000
Half scan factor	0.65
Water fat shift	minimum
Fat-suppression	no
Diffusion mode	DWI
Direction	MPS/ALL
b-value	0, 500, 900, 2000
Average high b value	no
PNS mode	High
Gradient mode	Maximum (optimization off)
NSA	1
Images	magnitude
Prep phases	Full
EPI 2D phase correction	No/default
Save raw data	no
Geometry correction	Default/none
EPI factor	67
Bandwidth in freq-dir	1.414K/1.534 K
Acquisition time	~3 mins

*"Repeat" scans (i.e. multiple "Passes") should be in sequential series without replanning or re-calibration.

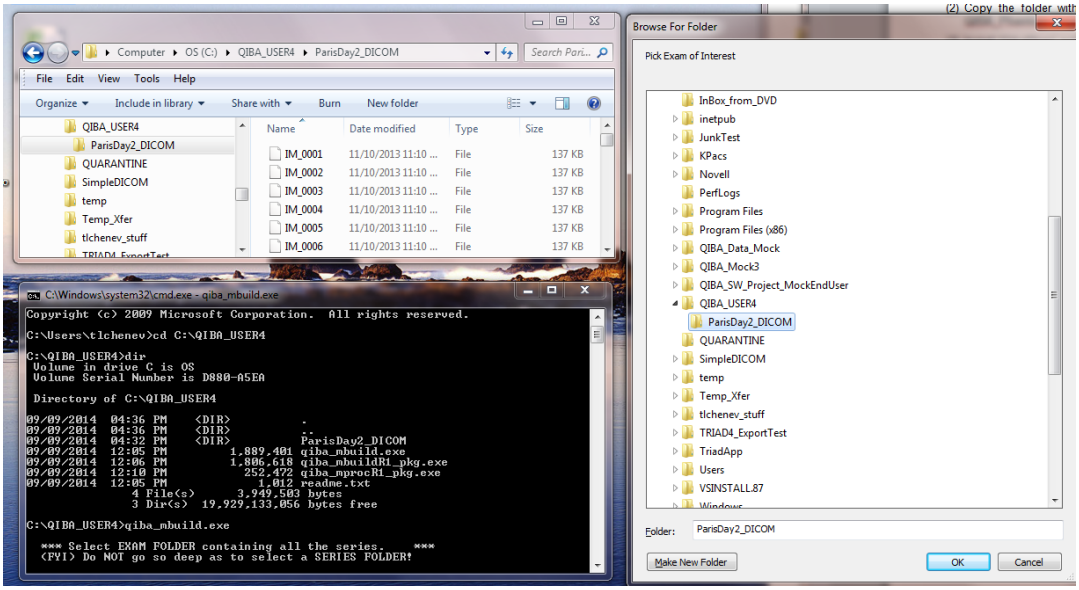


Figure 1: The console window in lower-left corner illustrates “qiba_mbuild” module execution. Use pop-up browser (right figure pane) to select parent folder containing all DICOM images in one folder (as in this example), or parent folder containing all series in individual folders.

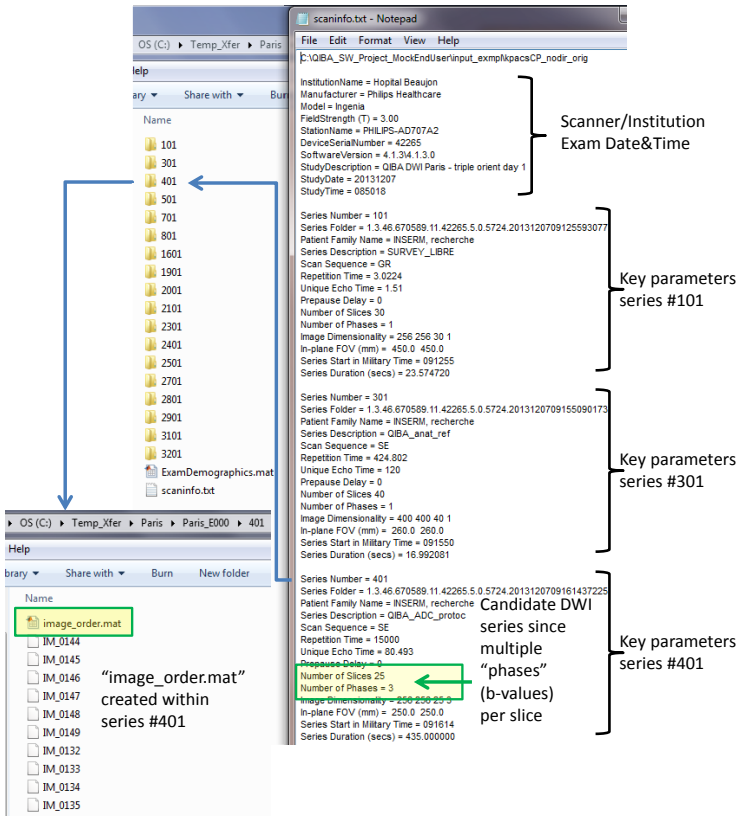
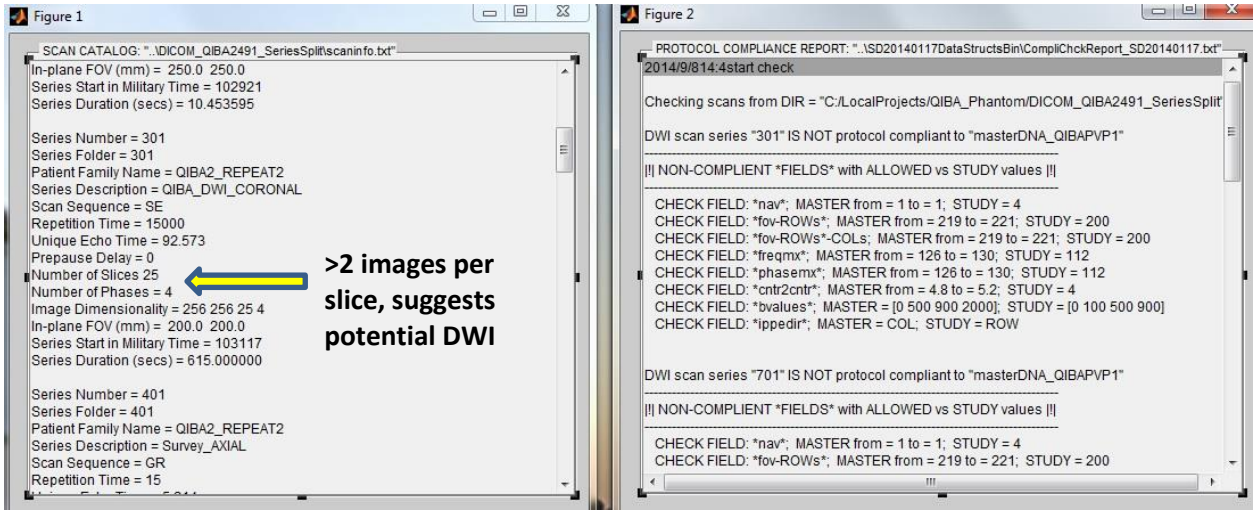


Figure 2: Full exam example split into distinct series with “scaninfo.txt” catalog to identify candidate DWI series.



(a) (b)

Figure 3: (a) Display of scan catalog and (b) acquisition compliance check report.

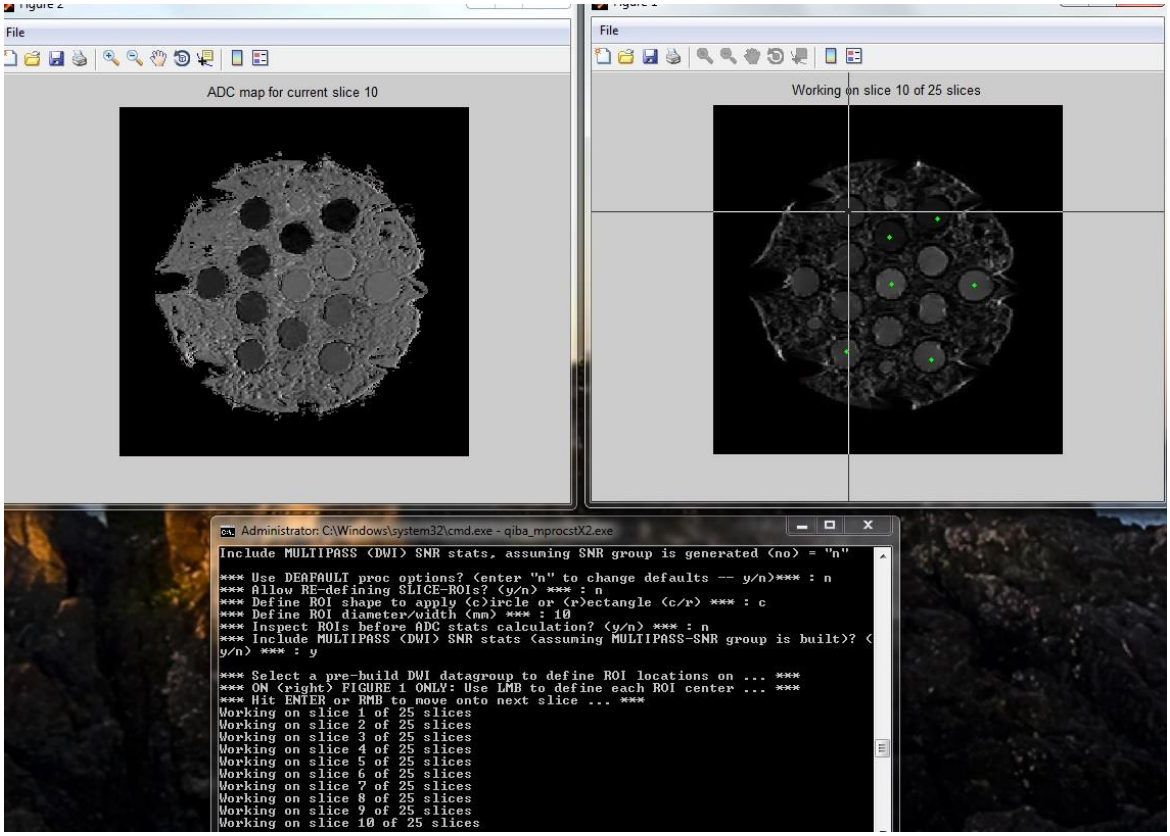


Figure 4: "qiba_mproc" GUI to define ROI centers on all (or subset) of PVP tubes. A "left-mouse-button" click defines an ROI on b=0 slice image. (Corresponding slice ADC map is displayed in the left pane.) Actual ROI size and shape are preset based on user input. Cross-hair shows next pending ROI center, green dots are already-defined ROI centers. The progress is captured in console window.

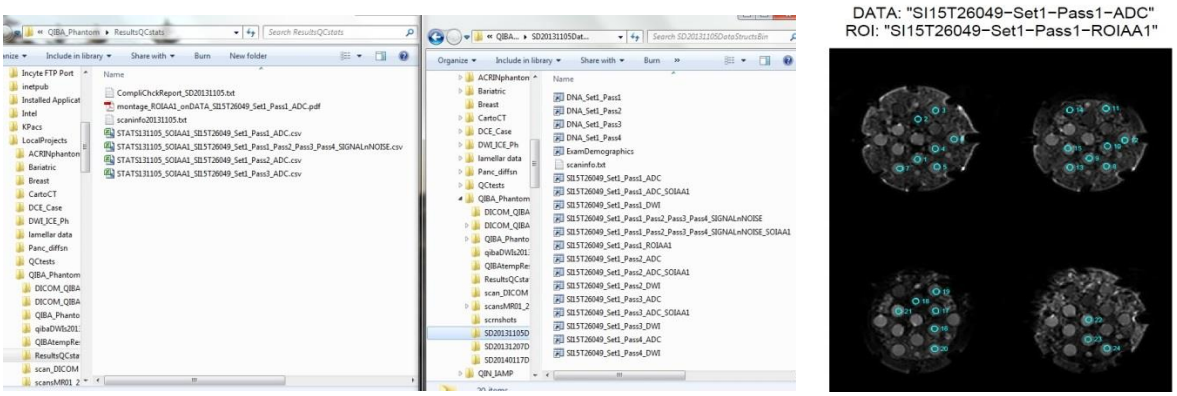


Figure 5: Example of the resulting directories and files created by “qiba_mproc” and “qiba_mbuild” (left). Montage of ROI locations automatically documented in a PDF file (right). ROI index # is displayed immediately to the right of its associated ROI. This number corresponds to that stored in statistics results CSV file.

STATS131105_SOIAA1_SI15T26049_Set1_Pass1_Pass2_Pass3_Pass4_SIGNALnNOISE.csv

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
1	ROI#	X(lab)	Y(lab)	Z(lab)	npts(DWI)b0	snr(DWI)b0	nptsAllb	mean(ADC)allb	rerror(ADC)allb	npts(ADC)	mean(ADC	rerror(ADC	npts(DWI)	snr(DWI)b	npts(ADC)	mean(ADC	rerror(ADC	npts(DWI)	snr(DWI)b	npts(ADC)	mean(ADC	rerror(ADC	npts(DWI)	snr(DWI)b900
2	1	1.7611	-2.2518	-3.2829	51	138.26	51	0.60442	0.011049	51	0.64238	0.067946	51	155.77	51	0.60366	0.01682	51	178.24	51	0.60673	0.011894	51	140.31
3	2	2.6975	-2.2518	58.96	52	44.327	13	0.03012	0.054293	13	0.054758	0.09366	52	72.742	47	0.04952	0.033664	52	75.032	52	0.065258	0.027012	52	53.261
4	3	31.726	-2.2518	72.064	50	76.301	50	0.2519	0.022655	50	0.26627	0.096114	50	119.57	50	0.24952	0.026475	50	154.75	50	0.25809	0.015919	50	159.27
5	4	30.79	-2.2518	13.097	51	112.18	51	0.40546	0.0089286	51	0.45012	0.069861	51	152.18	51	0.40919	0.015068	51	191.49	51	0.40757	0.010411	51	207.6
6	5	33.599	-2.2518	-14.749	51	126.77	51	0.61184	0.010227	51	0.64144	0.059218	51	148.51	51	0.60589	0.019248	51	154.49	51	0.61435	0.010722	51	185.89
7	6	61.691	-2.2518	27.839	51	86.739	51	0.38663	0.011677	51	0.42392	0.12078	51	125.09	51	0.38512	0.023335	51	128.96	51	0.389	0.015072	51	152.08
8	7	-27.268	-2.2518	-17.206	50	141.76	50	0.84613	0.0090124	50	0.87327	0.065204	50	168.96	50	0.84178	0.015238	50	198.63	50	0.84829	0.009804	50	184.98
9	8	30.79	2.7482	-13.93	47	102.11	47	0.60931	0.012741	47	0.63916	0.061798	47	134.02	47	0.6138	0.019754	47	219.88	47	0.61044	0.013504	47	202.08
10	9	2.6975	2.7482	-1.6449	50	127.54	50	0.60691	0.0088837	50	0.61566	0.072906	50	202.76	50	0.60865	0.016863	50	190.26	50	0.60719	0.010525	50	180.36
11	10	32.663	2.7482	17.192	52	100.49	52	0.40763	0.010168	52	0.4553	0.078208	52	123.85	52	0.41895	0.014812	52	138.99	52	0.40891	0.012583	52	146.61
12	11	29.853	2.7482	75.34	52	128.13	52	0.26473	0.0086783	52	0.28708	0.073285	52	224.23	52	0.26735	0.020754	52	167.95	52	0.26568	0.009111	52	199.85
13	12	60.755	2.7482	26.201	50	88.076	50	0.40379	0.010286	50	0.45357	0.053512	50	115.18	50	0.4128	0.018142	50	152.6	50	0.40549	0.010802	50	146.36
14	13	-29.14	2.7482	-15.568	50	136.65	50	0.85201	0.01184	50	0.86878	0.053759	50	187.86	50	0.84773	0.016934	50	254.96	50	0.85355	0.012535	50	154.08
15	14	-29.14	2.7482	72.883	51	81.241	51	0.10806	0.038695	51	0.16848	0.10618	51	131.79	51	0.1342	0.024798	51	164.99	51	0.12949	0.013459	51	131.91
16	15	-31.95	2.7482	13.916	51	100.36	51	0.8504	0.010904	51	0.87697	0.05461	51	124.02	51	0.85605	0.015266	51	182.44	51	0.8512	0.011416	51	180.97
17	16	29.853	7.7482	15.554	51	146.28	51	0.40228	0.0088443	51	0.43081	0.064948	51	182.21	51	0.40924	0.01412	51	210.18	51	0.40302	0.010053	51	182.76
18	17	31.726	7.7482	43.399	51	113.13	51	0.24753	0.014845	51	0.26647	0.10974	51	119.88	51	0.2621	0.018926	51	131.26	51	0.24928	0.012633	51	150.85
19	18	-1.0481	7.7482	58.141	50	57.579	50	0.097057	0.058285	50	0.1336	0.1339	50	96.232	50	0.11891	0.038211	50	124.21	50	0.12894	0.02256	50	121.36
20	19	32.663	7.7482	72.883	51	75.135	51	0.26471	0.012019	51	0.29554	0.10586	51	133.74	51	0.26925	0.024913	51	114.15	51	0.2659	0.01385	51	134.61
21	20	29.853	7.7482	-15.568	52	133.23	52	0.6145	0.0090455	52	0.61944	0.050495	52	194.61	52	0.61656	0.017369	52	273.59	52	0.61451	0.010082	52	179.85
22	21	-29.14	7.7482	42.58	50	148.35	50	1.1153	0.0079767	50	1.1385	0.047269	50	187.49	50	1.1225	0.010521	50	208.63	50	1.1157	0.009076	50	145.61
23	22	1.7611	12.748	29.477	51	117.31	51	1.1035	0.013094	51	1.0818	0.071937	51	146.02	51	1.0814	0.018437	51	121.49	51	1.1052	0.014998	51	92.897
24	23	0.82469	12.748	-0.82591	48	129.95	48	0.60589	0.0088436	48	0.62036	0.069601	48	192.82	48	0.60384	0.0156	48	260.33	48	0.60701	0.010529	48	224.63
25	24	31.726	12.748	-14.749	51	140.6	51	0.61551	0.009293	51	0.62949	0.059989	51	191.56	51	0.61507	0.015911	51	211.3	51	0.61639	0.010345	51	235.17
26	25	0.82469	17.748	60.598	48	34.231	5	0.035858	0.071717	5	0.028175	0.05635	48	57.213	13	0.016508	0.025537	48	60.111	36	0.045636	0.03174	48	54.304
27	26	-31.95	17.748	43.399	51	128.11	51	1.1178	0.01012	51	1.1382	0.052686	51	185.09	51	1.1204	0.01303	51	157.21	51	1.1187	0.011522	51	143.45
28	27	34.535	17.748	15.554	47	112.7	47	0.39262	0.0086283	47	0.42786	0.079224	47	201.08	47	0.40123	0.017132	47	216.69	47	0.39353	0.010925	47	171.4
29	28	-0.1117	17.748	-2.4639	52	140.5	52	0.60183	0.0095049	52	0.60384	0.059036	52	167.3	52	0.60315	0.018329	52	177.5	52	0.60177	0.009877	52	220.25
30	29	30.79	17.748	-15.568	51	142.28	51	0.62136	0.0095473	51	0.6131	0.052746	51	195.49	51	0.62025	0.016612	51	220.58	51	0.62103	0.010122	51	223.13
31	30	60.755	17.748	29.477	50	91.93	50	0.38846	0.009638	50	0.39381	0.11572	50	142.32	50	0.37581	0.02552	50	197.76	50	0.39044	0.011466	50	144.55
32	31	28.917	17.748	45.856	52	99.976	48	0.2305	0.026372	48	0.21251	0.086183	52	123.81	52	0.24532	0.021698	52	111.77	52	0.24022	0.011711	52	141.84

Figure 6: Table of multipass ADC and SNR statistics for each ROI (rows) as stored in the “STATS” CSV file.