describe the workflow of parallel transmit experiments with the guidance of the developed GUIs.

A.1 RF Shimming GUI

An RF shimming GUI was developed for and used in the maximum efficiency RF shimming study described in Chapter 2. Figure A.1 shows the workflow of the RF shimming experiment with numbers in parentheses indicating corresponding locations in the GUI that can be found in Figure A.2.

B_1^+ distributions of individual transmit channels can be visualized inside the GUI after including them from either MR images obtained with turbo FLASH based flip angle mapping techniques as described in Section 1.3.6 or Matlab .mat files which contain flip angle information from any imaging method or simulation. Using a data cursor, flip angles inside figures can be displayed and, if needed, a colorbar can be included with any figure within the GUI.

RF shimming requires a desired shimming ROI to be defined. Four different ROI selection mechanisms are implemented as shown in the *Shim ROI Select* panel (Figure A.2-**2**). The shimming ROI can be interactively selected from an additional MR image or an image obtained with sum of squares (SoS) combination of the B_1^+ profiles. Additionally, the shimming ROI can be defined as the whole sample or incorporated from a saved .mat file. After choosing the shimming ROI, the user needs to specify the coils to be used in RF shimming weights calculation. Initially all eight coils (the maximal coil set of our 8-channel parallel transmit system) are pre-selected.

The user can choose any subset of transmit coils by using check boxes and for convenience odd and even coils can be selected easily by pressing the corresponding button from the *Select channels* panel (Figure A.2-**3**).

Four different RF shimming methods were implemented in the current GUI. Two of them are amplitude and phase RF shimming methods indicated by the *RF Shim* panel (Figure A.2-**4a**) and the rest are phase only RF shimming methods indicated by the *Phase Only RF Shim* panel (Figure A.2-**4b**). Push buttons (Figure A.2-**4**) initiate calculation of the RF shimming values aiming to match the shim ROI defined in Figure A.2-**2**. Pushing the *Calculate Shim* button calculates RF shimming weights using a regularization parameter, and if available, the **Φ**-matrix as explained in Section 1.3.4 using Eq. [1.14]. When only the magnitude of the shim profile is targeted, whim weights are calculated by an iterative search algorithm using Matlab's *fminsearch* function. Results of both methods are shown in Figure A.2-**5**. *Maximum Tx Efficiency* button calculates the maximum and minimum transmit efficiency RF shimming values as described in Section 2.3.1. The *No Amplitude Target* button calculates unit amplitude phase only shim weights aiming to align the phases of the transmit elements inside the chosen ROI. In this type of RF shimming the amplitude of the ROI is not considered but uniform phase distribution is targeted. We successfully used this shimming approach to obtain Birdcage-type profiles by prescribing a small ROI at the center of the phantom on a transmit array with azimuthally distributed individual elements. The *With Amplitude Target button*

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calculates the unit amplitude RF shimming weights aiming to match only the amplitude of the shim ROI. Both *Phase Only RF Shim* panel algorithms use iterative search algorithms employing Matlab's *fminsearch* function. Transmit efficiencies of the calculated RF shimming weights aligned with minimum and maximum possible transmit efficiencies are displayed in the *Transmit Efficiency* panel.

Changing the amplitude and phase of calculated RF shimming weights, which are displayed in Figure A.2-**5**, automatically updates the displayed RF shimming results and transmit efficiency metrics. This feature enables interactive changes to the calculated RF shimming weights, with immediate visualization. This helps users to understand the phase and amplitude relationships in a multi-channel transmit system. If those changes result in unsatisfactory results, the user can press the *Go to Original Shim* button to recover previously calculated RF shimming weights. Additionally, RF shimming weights can be saved to any folder by using the *Save to .txt* button.

Bloch simulations for adiabatic RF pulses were used in Section 2.3.3 in order to compare RF power benefits of using the maximum transmit efficiency RF shimming method (Chapter 3). Choosing an adiabatic RF pulse using *Choose RF from .mat* button in Figure A.2-**6** enables the *Bloch Simulations for Adiabatic RF Pulse* panel. This panel can be used to run Bloch simulations of the chosen adiabatic RF pulse with the specified maximum voltage. An image of z-magnetization in the sample resulting from Bloch simulations is shown in Figure A.2-**6** with the mean and standard deviation of the z-magnetization. The frequency response of the adiabatic RF pulse for

the given voltage is displayed for the weakest B_1^+ spatial location with an additional plot in order to determine whether the adiabatic condition over the ROI is met or not. In Section 2.3.3, the adiabatic condition in the sample was met by increasing or decreasing the maximum RF voltage and checking the Bloch simulation results interactively. Peak and mean power of the RF pulse is predicted and displayed by including a power correlation matrix, **Φ**, with the defined calibration voltage.

Obtain B_1^+ distribution and add to GUI from (1)	
an MR experiment (1a)	a simulation (1b)

Select targeted RF shimming ROI (2) from			
an MR image	the whole sample	an image obtained with SoS combination of B_1^+	a saved .mat file

Select channels to be used in RF shimming (3)

Select type of the RF shimming method to be used (4)	
Magnitude and phase RF shimming (4a)	Phase only RF shimming (4b)
• Maximum efficiency RF shimming (Section 2.3.1) • RF shimming aiming target distribution (Section 1.3.4)	• Aiming to align only the phases of transmit elements • Aiming to align phases and match the uniform amplitude distribution

Visualize and change the calculated RF shimming values (5)

Bloch simulations, if needed, for an RF pulse to obtain frequency response (6)
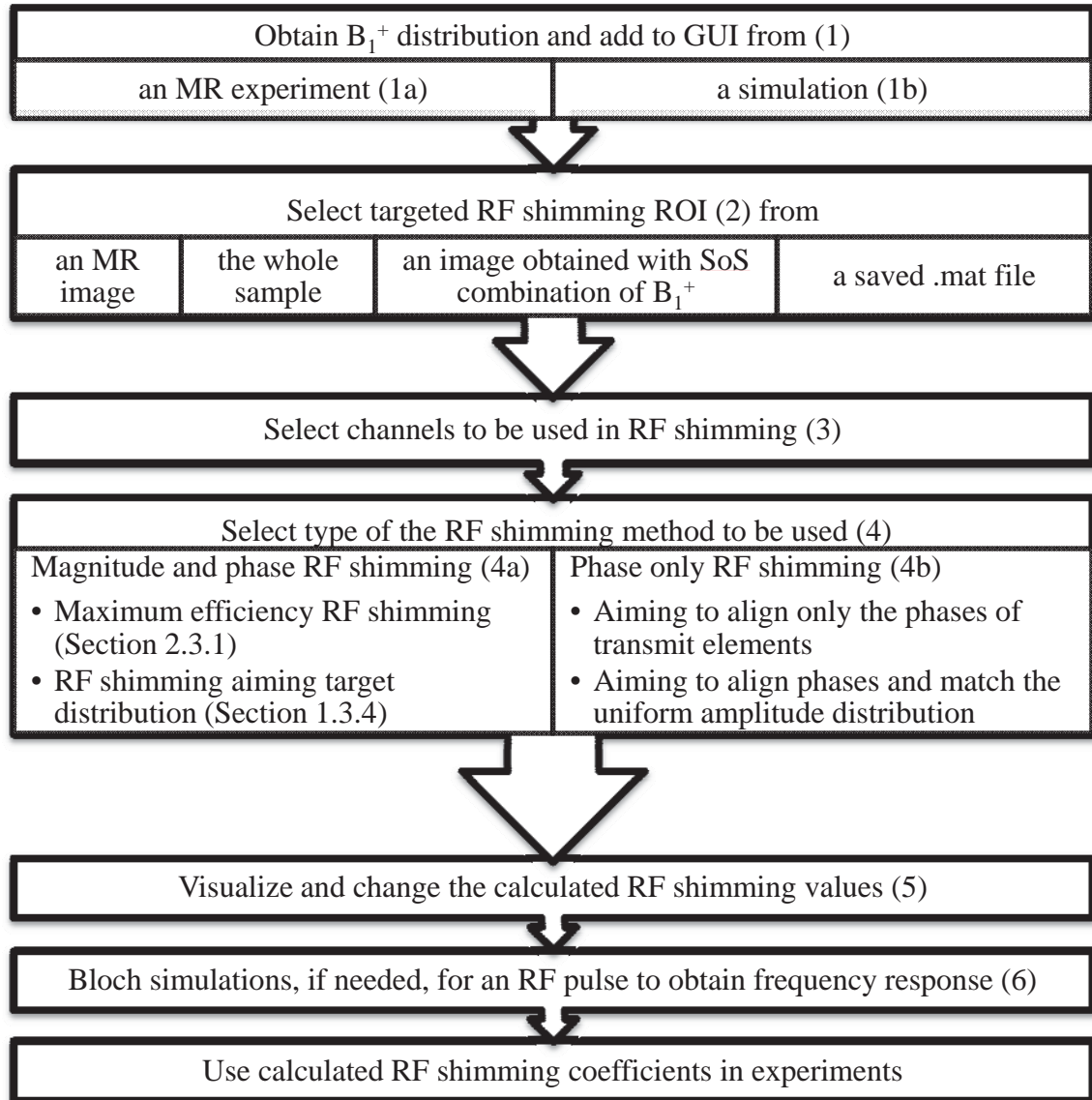
Use calculated RF shimming coefficients in experiments

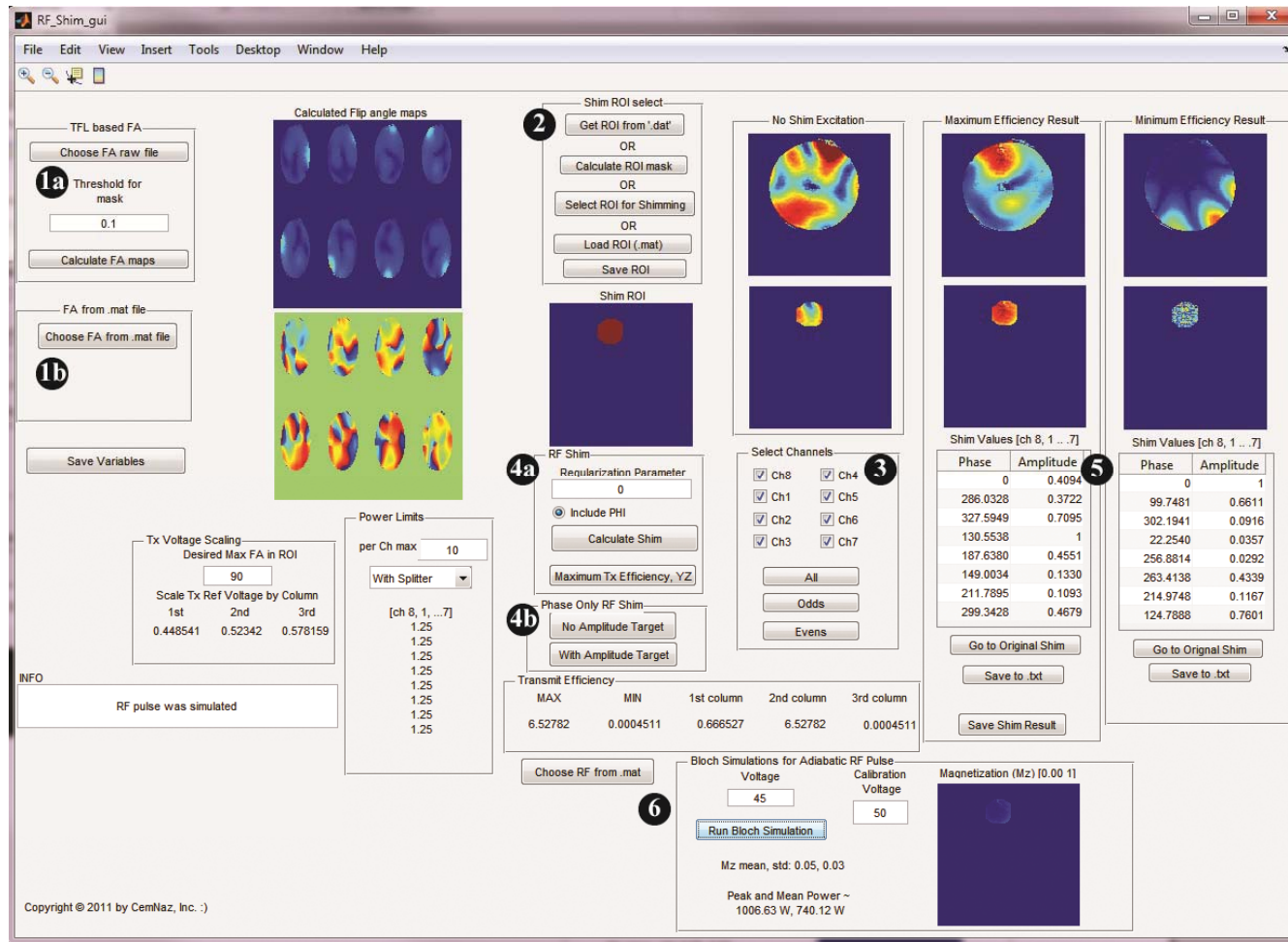Figure A.1 Workflow of an RF shimming experiment. Relation to the RF shimming GUI is indicated by the numbers in parentheses.

Figure A.2 Screenshot of RF Shimming GUI