Grant agreement no. 667510

GLINT

Research and Innovation Action
H2020-PHC-2015-two-stage

D7.1 Up-to-date steady-state and dynamic MRI sequences for GlucoCEST

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Lead beneficiary:	MPG
Contributors:	UCL
Reviewers:	

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PU	Public	YES
CO	Confidential, only for members of the consortium (including the Commission Services)	
CI	Classified, as referred to in Commission Decision 2001/844/EC	

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1 Version log

Version	Date	Released by	Nature of Change
V1.0	11/09/2016	M. Zaiss	First version
V1.1	27/09/2016	X. Golay	Comments and contribution
V2.0	28/09/2016	M. Zaiss	Revision and finalisation

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2 Definition and acronyms

Acronyms	Definitions
BM	Bloch-McConnell
CEST	Chemical exchange saturation transfer
MT	Magnetization transfer

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3 Introduction

3.1 Background and the need

To make the best choice for both pre-saturation and MR readout of a glucoCEST MR sequence, a simulation is needed that allows for predicting CEST signal intensities for different setups. At the same time here glucose –OH exchange rates and system parameters flow in that can also be fitted using this simulation and experimental in vitro data.

3.2 Objectives

To be able to optimize the glucoCEST signal we want the following degrees of freedom:

1. Arbitrary pulsed RF presaturation: pulse number, pulse amplitude, pulse duration and bandwidth, pulse shape (including composite spin-lock pulses, inter-pulse delay, pulse offsets,
2. Robust and fast readout ready for multiple shots, different reordering schemes, parallel imaging,
3. Arbitrary relaxation delay after readout.

Figure 1 shows the basic sequence scheme that was realized in Siemens software.

Finally, the objective here is that this sequence is demonstrated to be working on a clinical scanner.

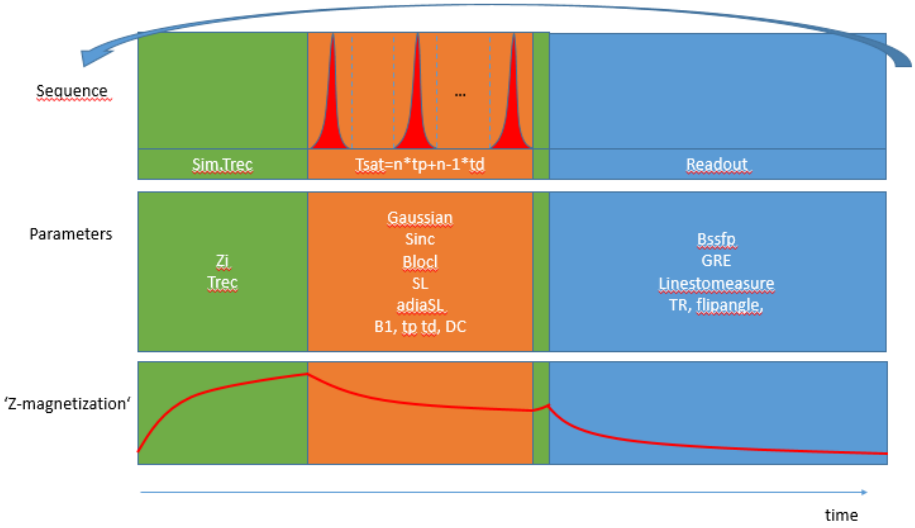

Figure 1: Visualization of the sequence scheme, possible Parameters and dynamic of Z-magnetization during relaxation delay, pulsed RF saturation and MR readout phase in a typical (Gluco-) CEST experiment.

3.3 Position of D7.1 in the project

The MR sequence is the central tool of the GLINT project. With this we will create all further optimization of glucoCEST and a final version of this sequence will establish the clinical glucoCEST imaging protocol.

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4 Methodology and Approach

The actual implementation and protocol is confidential and will be reported in a scientific article. However, the implementation was realized in the sequence development environment IDEA of Siemens. The generated sequences were compiled until now for the VB software version.

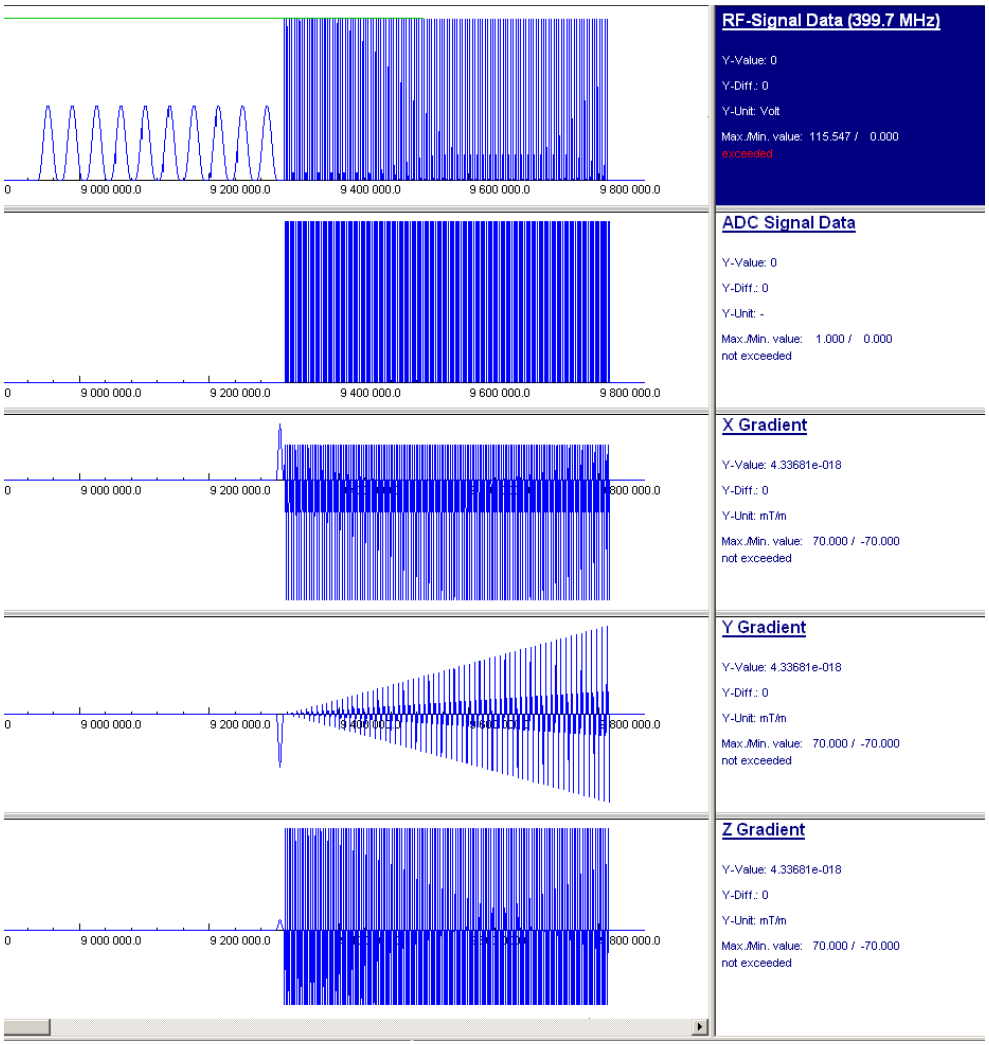

Figure 2: Simulation within the Siemens IDEA environment of the pulse sequence: A Train auf Gaussian pulses followed by a crusher gradient in x, y and z and a fast centric reordered gradient echo readout. This part is then repeated for each saturation frequency offset of the chosen sampling lists.

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5 Report Activities carried out and results

Figure 3 demonstrates the usage of the created CEST sequence on a clinical 3T scanner by Benjamin bender, a radiologist at University Clinic of Tübingen. The scan was performed at June 27 2016 together with the sequence developer Moritz Zaiss from Max-Planck institute in Tübingen. Figure 4 and 5 show enlarged the user interface of the CEST sequence protocol at the scanner also visible in Figure 3. Figure 4 shows e.g. that the reordering can be chosen, and Figure 5 shows all the CEST parameters at the right hand side.

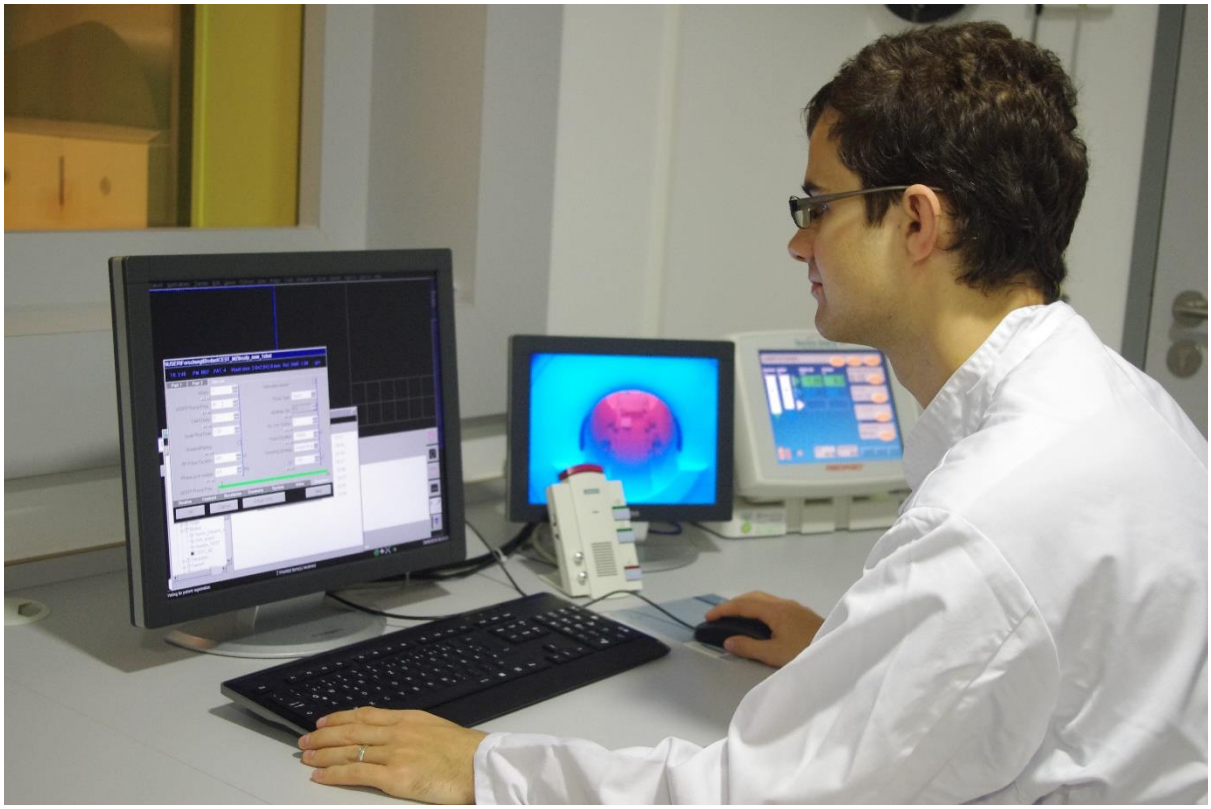

Figure 3: Radiologist Dr. Benjamin Bender using the CEST sequence at the 3T PET-MR system at the Unviversity Clinic of Tübingen, Germany.

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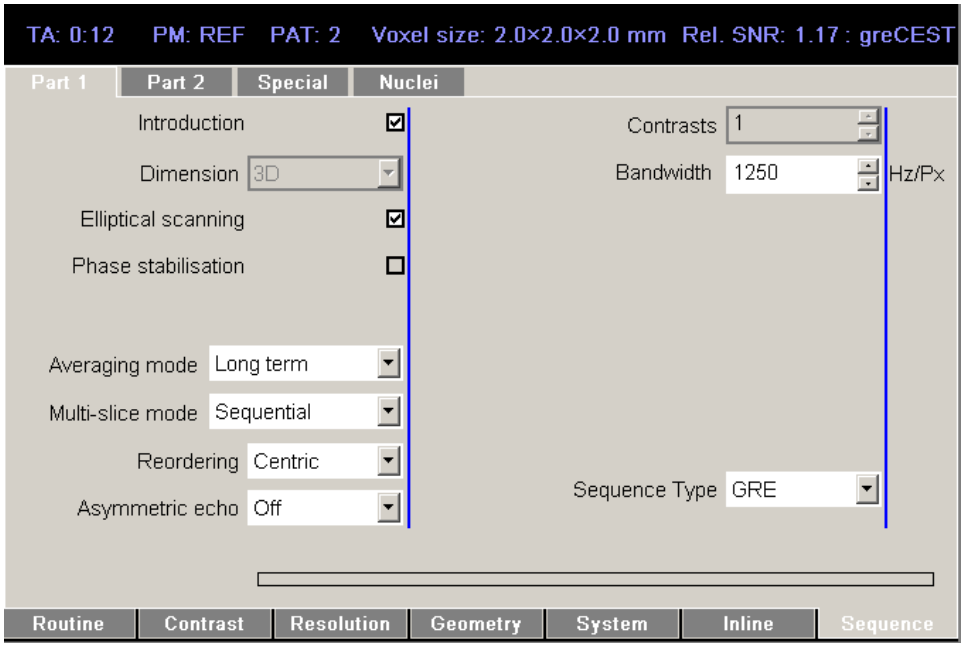

Figure 4: Protocol of the CEST sequence as visible at the scanner. Here, e.g. the reordering can be changed from linear to centric.

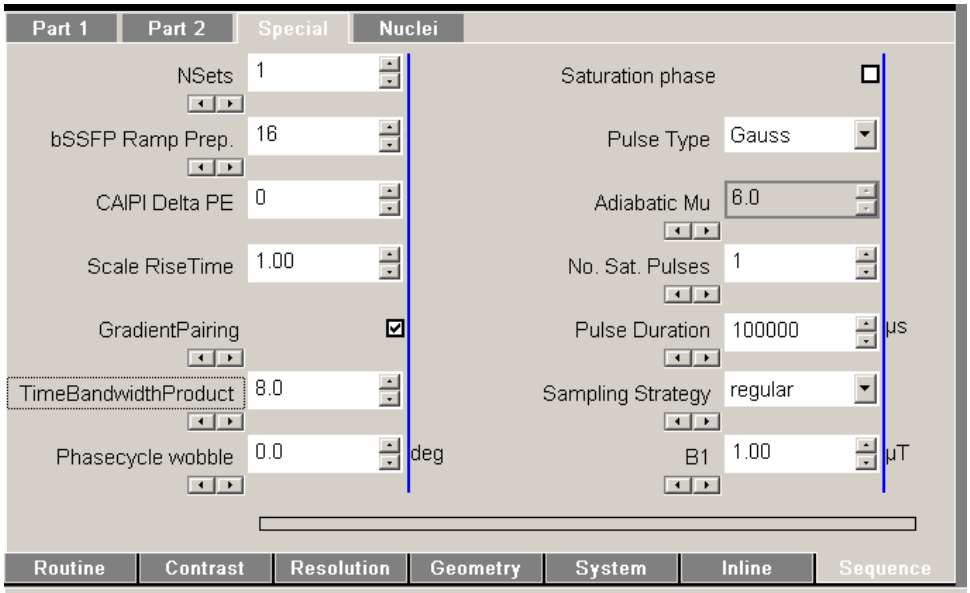

Figure 5: Protocol of the CEST sequence as visible at the scanner. Here, on the special card e.g. the CEST parameters can be changed (pulse type, pulse number, pulse duration, offset sampling strategy, and B1 power).

Figure 6 and 7 show the achieved data in a volunteer processed with matlab. Figure 6 shows a typical Z-spectrum and thus demonstrates that the CEST presaturation is working and yields the typical negative asymmetry around 3.5ppm. Figure 7 shows the outcome of a repeated measurement at a single offset which is the important method for fast glucoCEST but also shows here how stable the sequence is, or the so called tSNR. It is with about 75 in principle already good enough for glucose detection.

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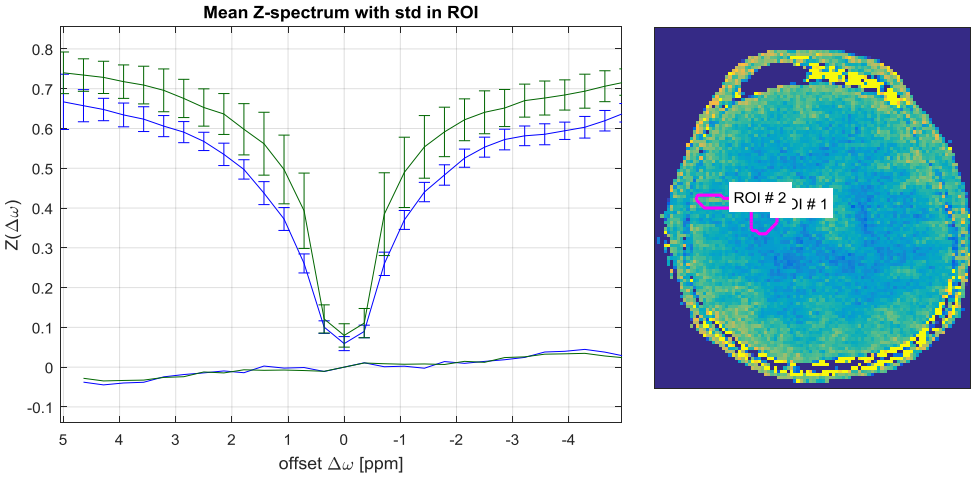

Figure 6: B0 corrected and normalized Z-spectrum acquired in vivo with the presented sequence at 3T.

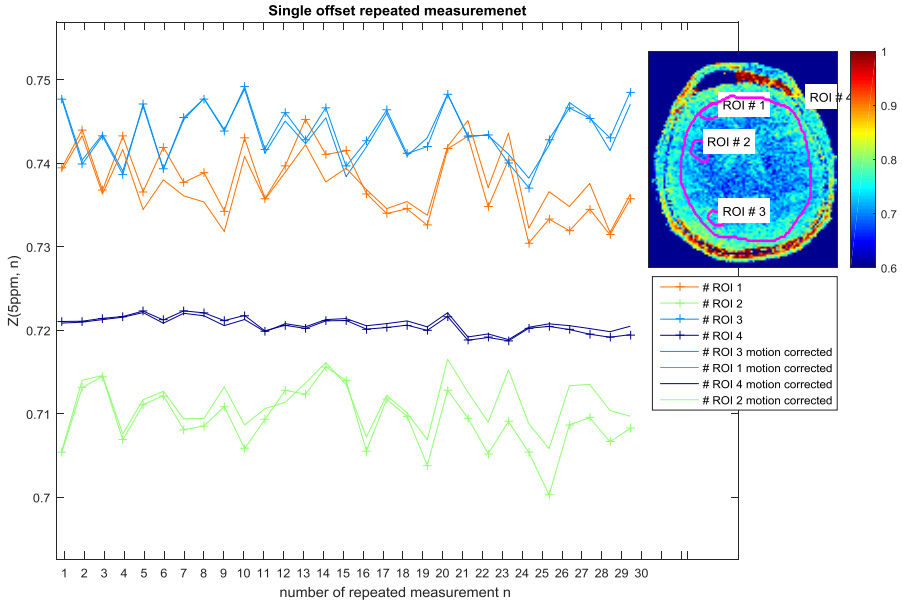

Figure 7: Repeated single offset irradiation method (or tSNR) acquired in vivo with the presented sequence at 3T.

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6 Conclusions

We created a sequence with all required degrees of freedom, demonstrated its usability by a radiologist and showed first in vivo data acquired by radiologists and processed with the developed matlab tools of deliverable 3.1.

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