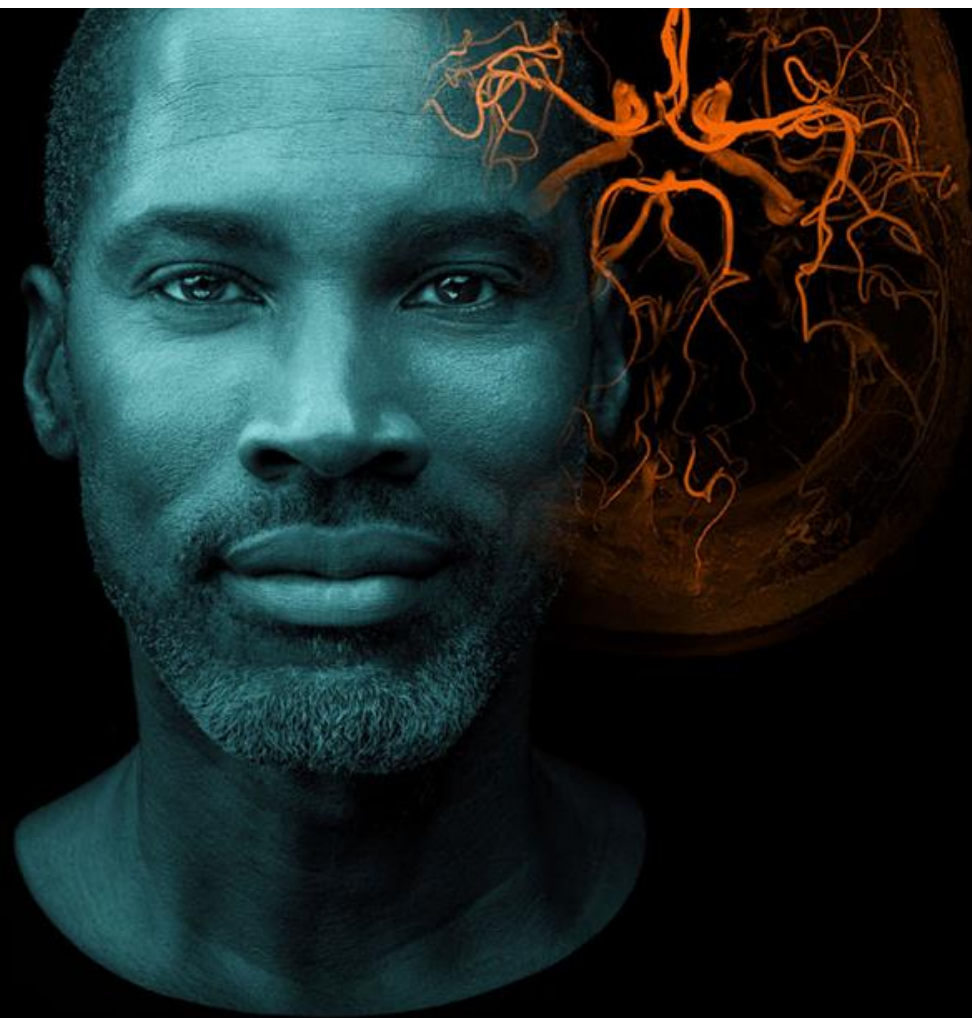
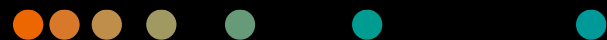
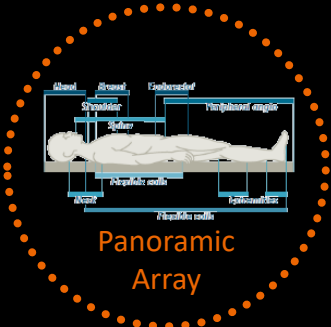


Recent MRI Applications

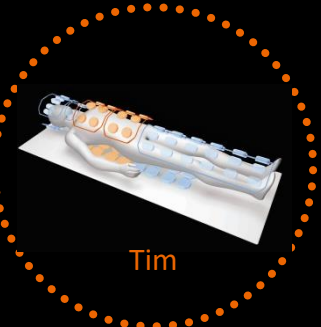
Foteini Zacharopoulou
Medical Physicist, Application Specialist
SIEMENS HEALTHCARE ABEE
February 2019



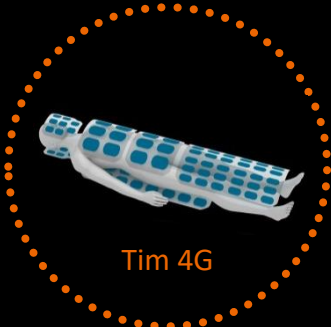
Continuously driving speed and quality in MRI



Panoramic Array



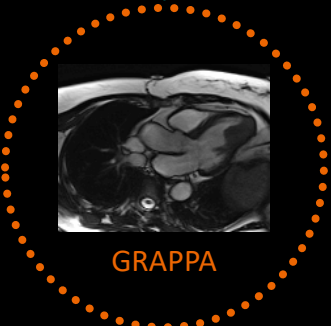
Tim



Tim 4G



FREEZEit



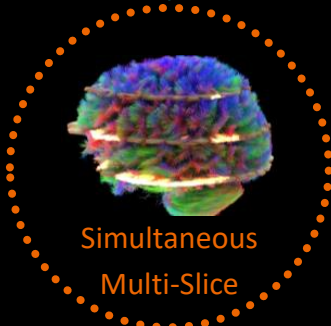
GRAPPA



TWIST



CAIPIRINHA



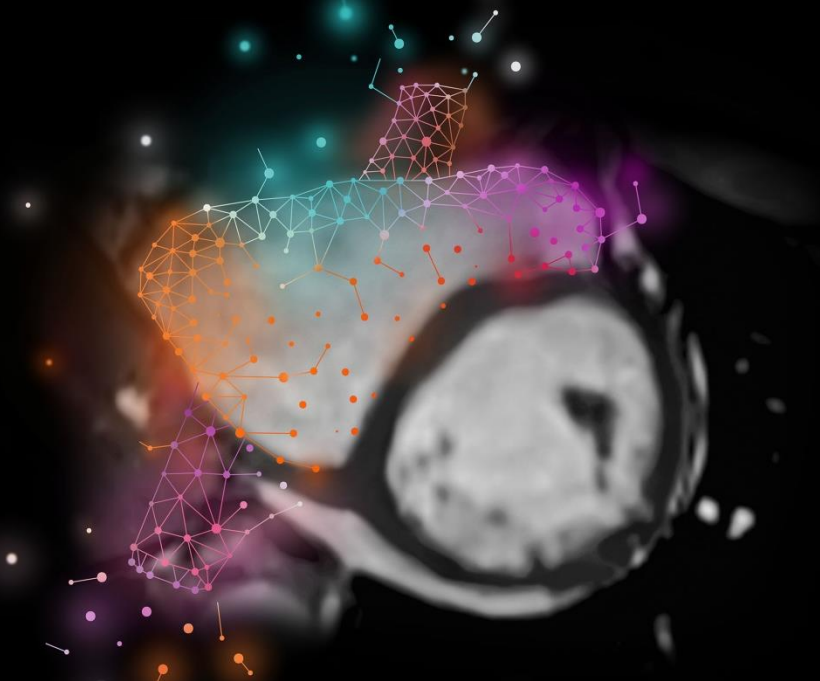
Simultaneous Multi-Slice

 A history of success with Siemens Healthineers

Expand the patient population eligible for MRI With Compressed Sensing. Beyond Speed.



Compressed Sensing GRASP-VIBE
Beyond speed. Beyond motion.



Compressed Sensing Cardiac Cine
Beyond speed. Beyond breath-holds.

If this ...



... is possible with no significant loss in image quality, why sample the **complete MR data in the k-space?**

“ If it is possible to compress measured data, one might argue that **too many measurements** were taken.¹ ”

David J. Brady, M.S., Ph.D.

Professor of Electrical and Computer Engineering in the Pratt School of Engineering at Duke University, USA

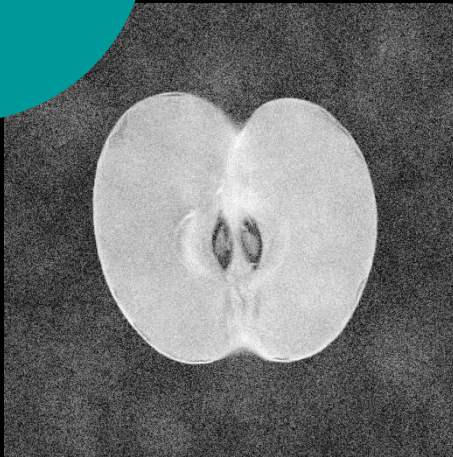
¹Optical Imaging and Spectroscopy; John Wiley & Sons, 27.04.2009; ISBN 0470443723, 9780470443729

The statements by Siemens' customers described herein are based on results that were achieved in the customer's unique setting. Since there is no "typical" hospital and many variables exist (e.g., hospital size, case mix, level of IT adoption) there can be no guarantee that other customers will achieve the same results. This statement is from a person, who or whose institution is engaged in a collaboration with Siemens.

Compressed Sensing

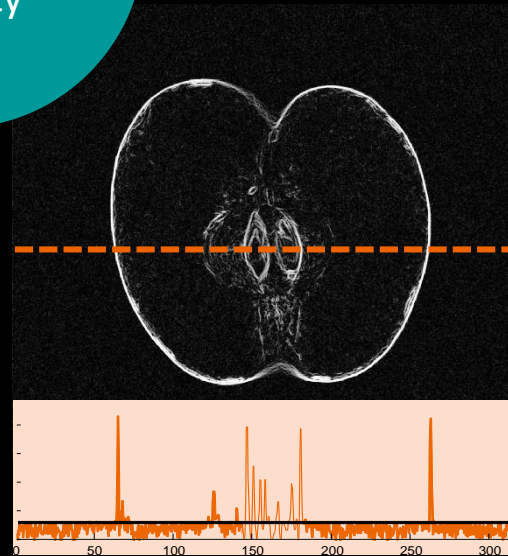
Three golden rules for quality and speed

1. Incoherent
subsampling



Achieve high
acquisition speed

2.
Transform
sparsity



Concentrate image Information-
Remove noise from image content

3.
Non-linear
iterative
reconstruction



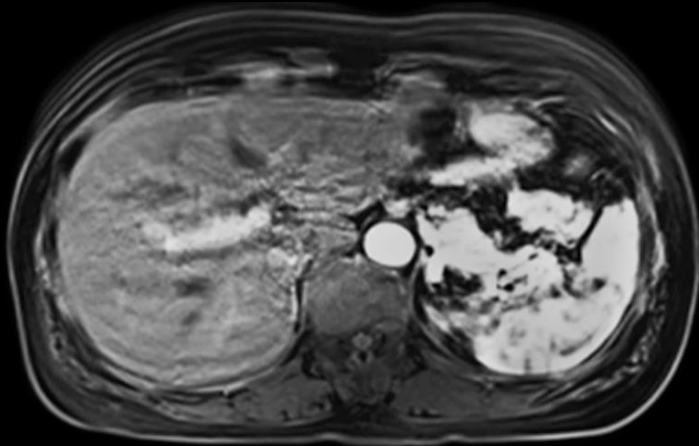
Optimize the balance of
data consistency and sparsity

**Beyond speed.
Beyond motion.**

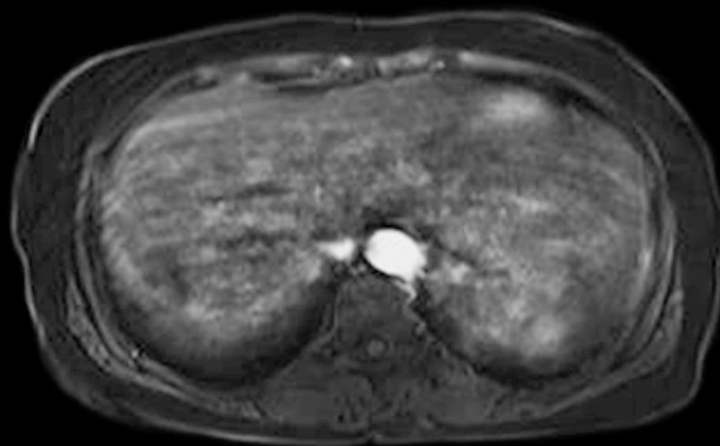


Patients with difficulties holding their breath

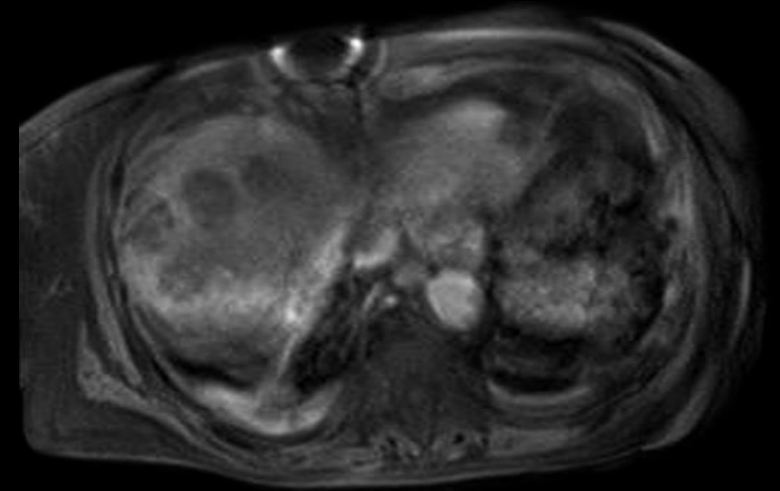
Daily challenges in liver MRI



50-year-old woman,
transient dyspnea



63-year-old man,
hearing impairment

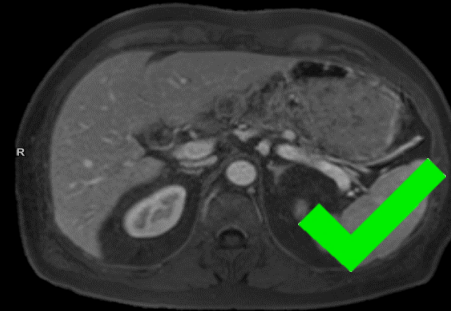
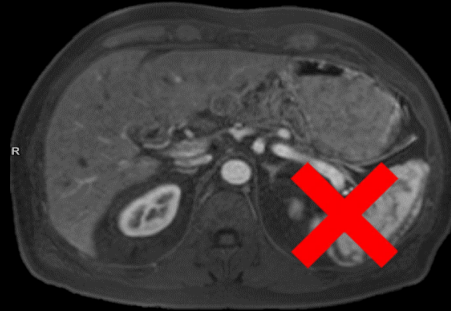
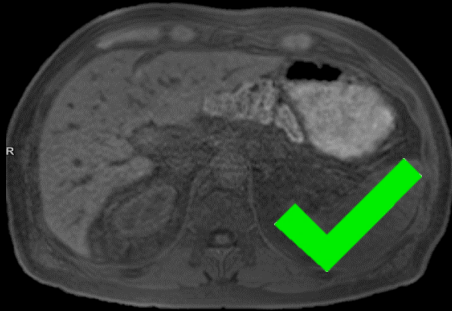


82-year-old woman,
dementia

A real world case

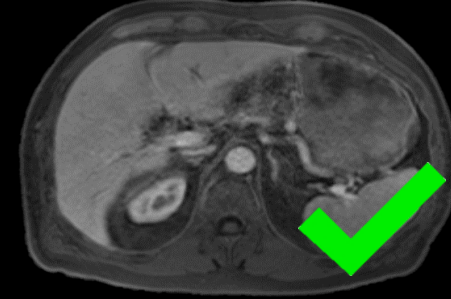
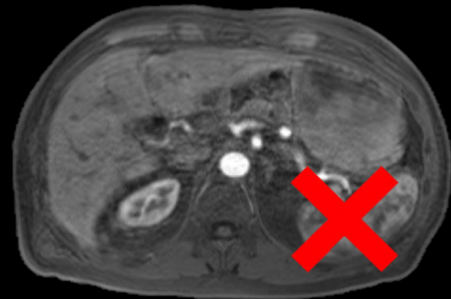
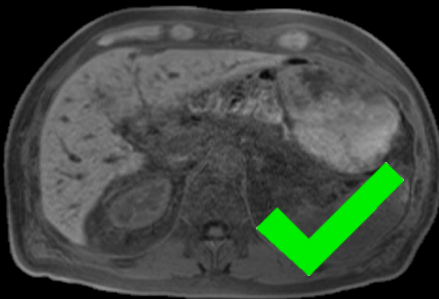
72 y/o patient, follow-up after cholangiocellular carcinoma

1st exam



Bad Timing

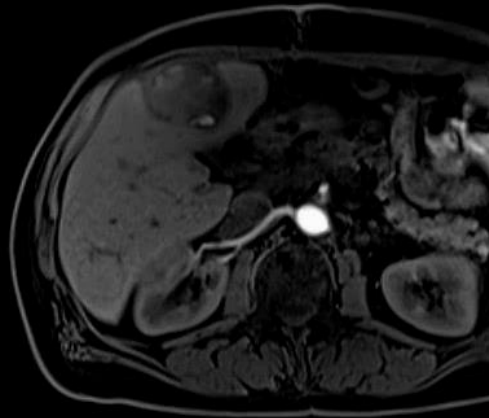
2nd exam



Breathing artifacts

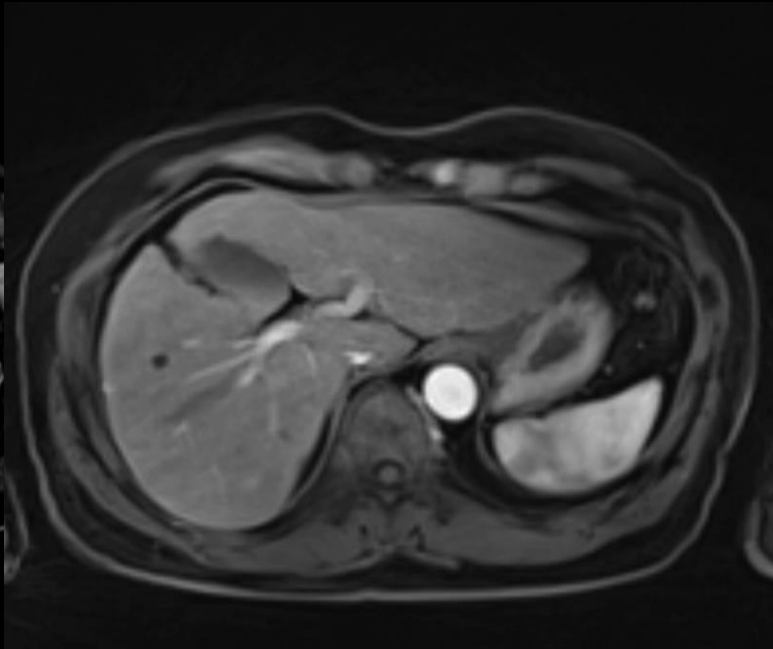
- contrast agent applied twice (costs and GAD retention)
- both studies add limited value for clinical management
- Reduced revenue for the hospital (one DRG payment per case)

Evolved from FREEZEit, Compressed Sensing GRASP-VIBE combines high spatial resolution with robustness toward motion



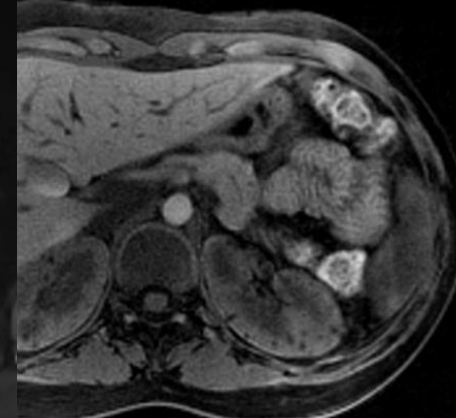
TWIST-VIBE

Always the right contrast in **dynamic** liver MRI.



Compressed Sensing GRASP-VIBE

Free-breathing liver **dynamics**.

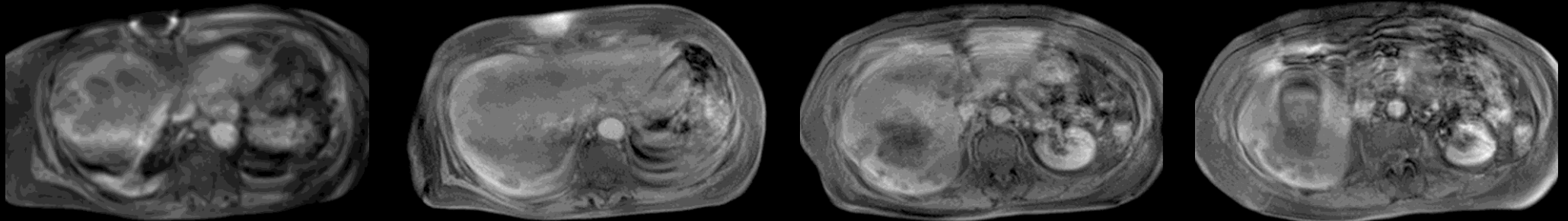


Free-breathing, contrast-enhanced **imaging**.

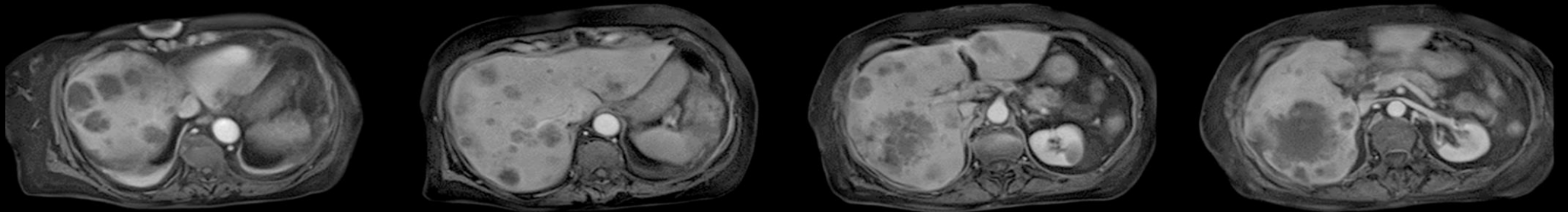
Reduce failure rates and avoid non-diagnostic exams in abdominal MRI with free-breathing liver dynamics

Patient case: 82-year-old woman, dementia, unable to hold breath

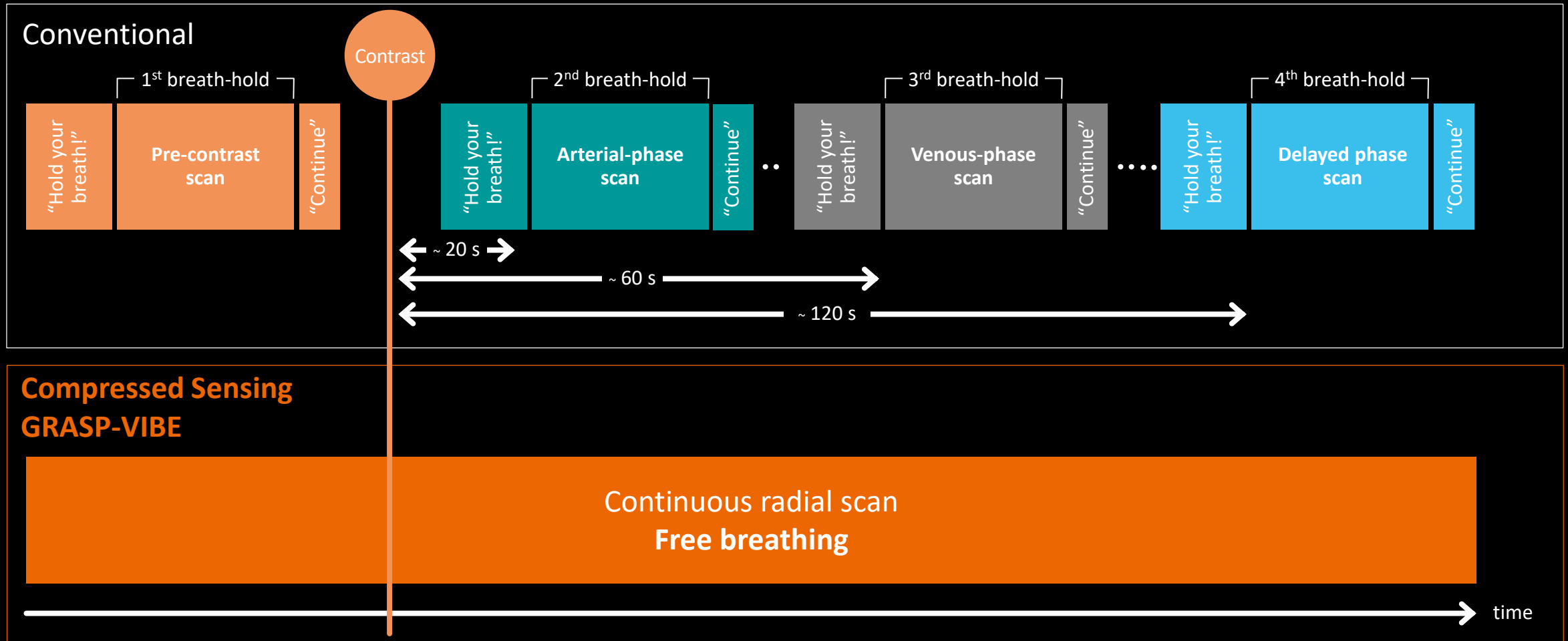
Conventional



Compressed Sensing
GRASP-VIBE

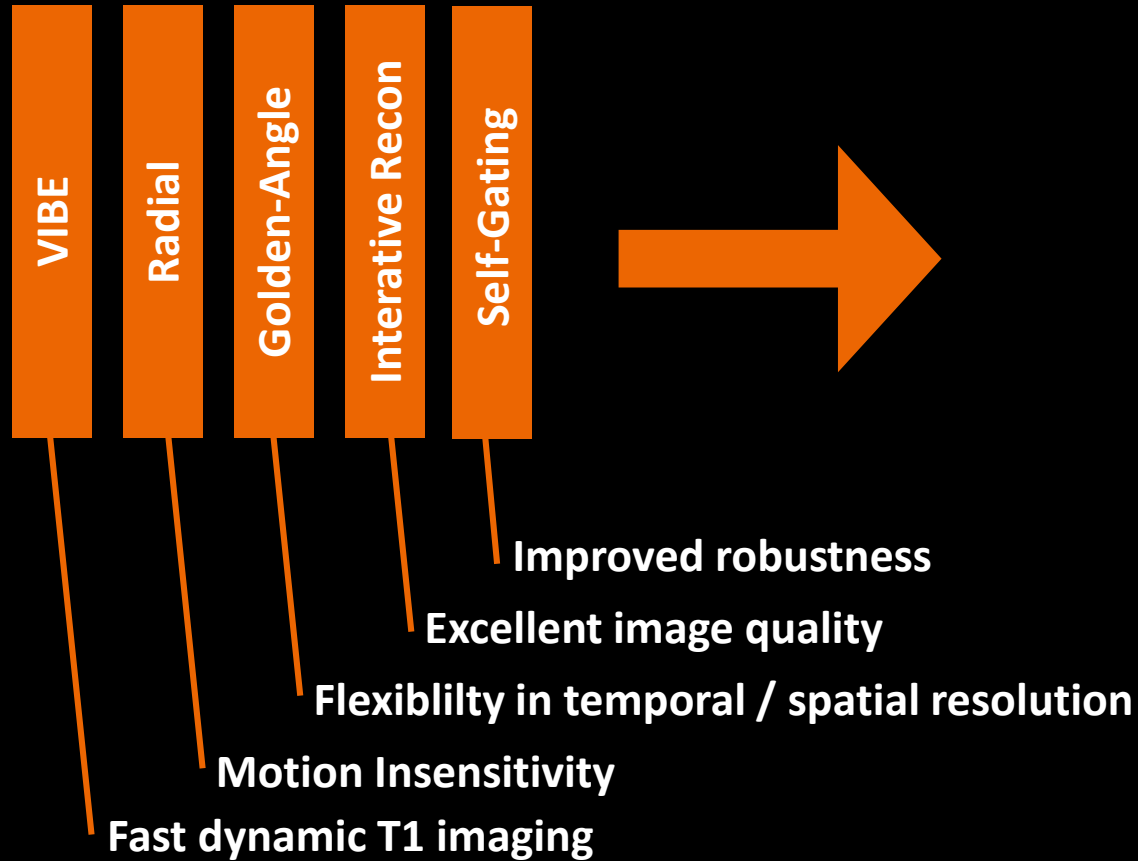


Push-button scan instead of several breath-hold scans with complex timing



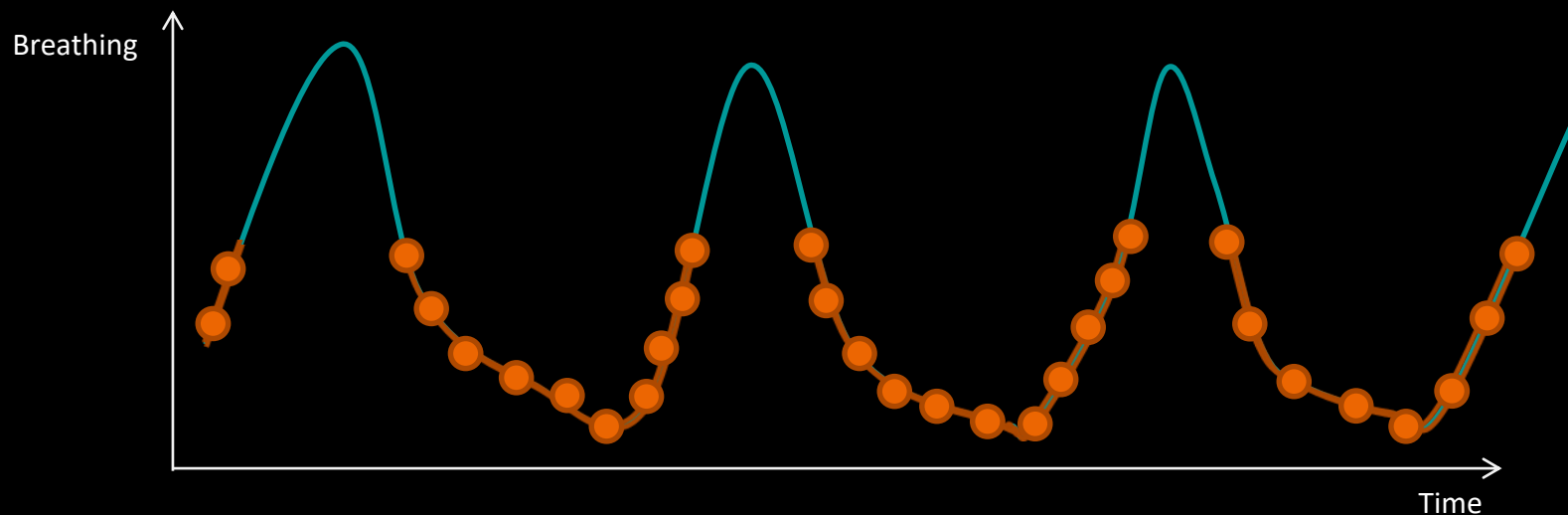
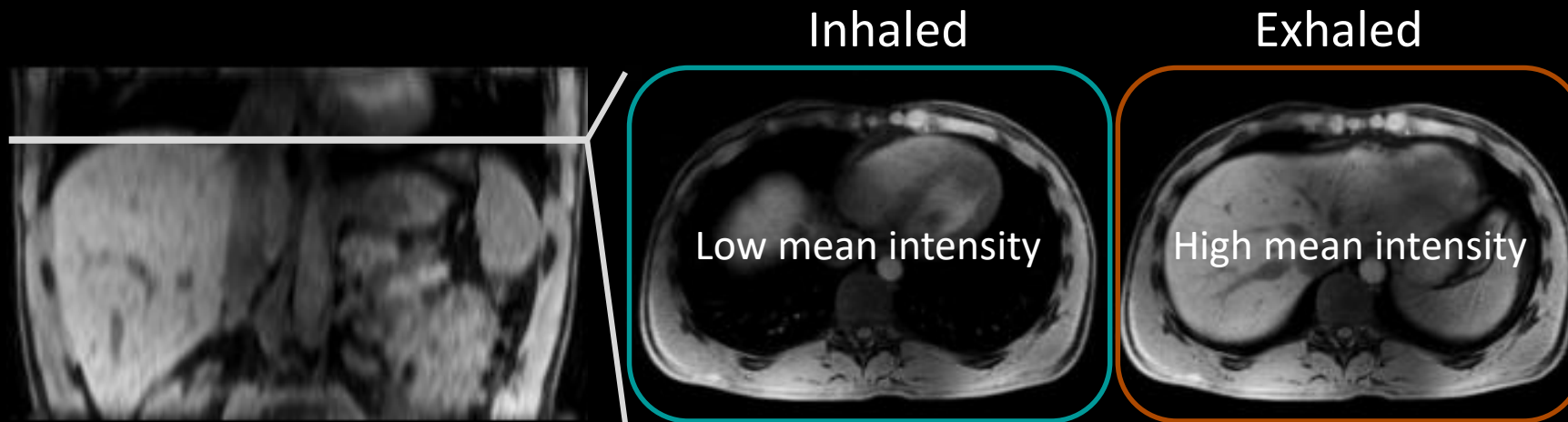
Compressed Sensing GRASP-VIBE

Golden-Angle Radial Sparse Parallel MRI



Reduce failure rates and avoid non-diagnostic exams in abdominal MRI with free-breathing liver dynamics

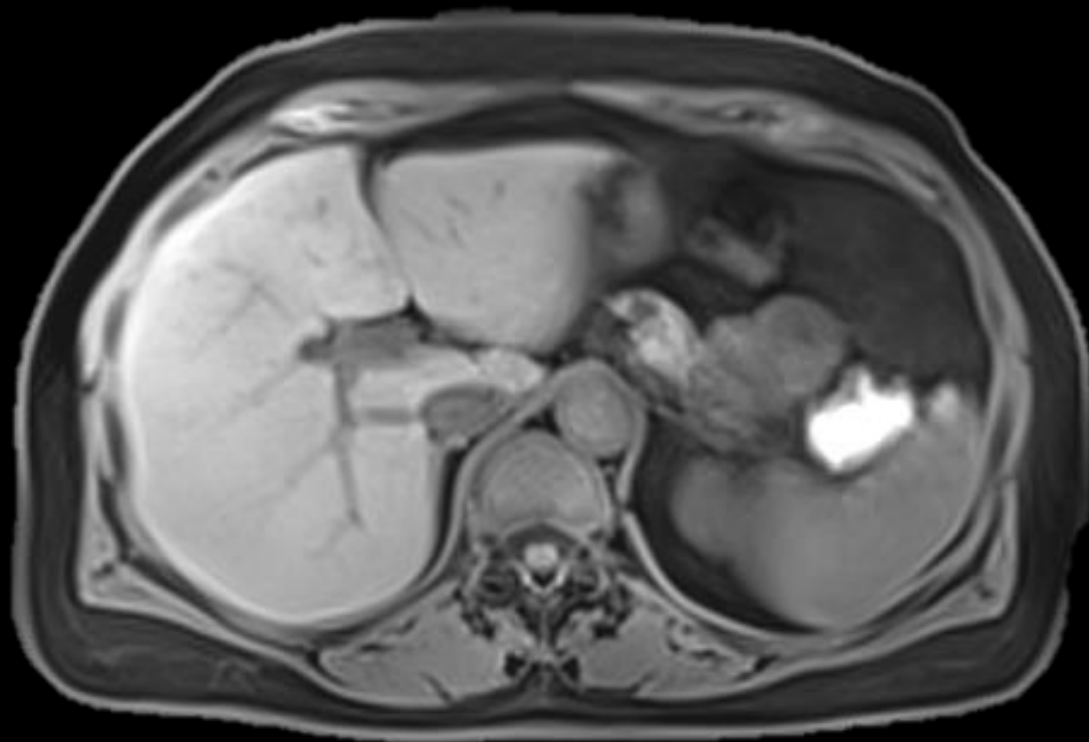
Retrospective Self-Gating further optimizes image quality by automatically selecting expiratory phase data



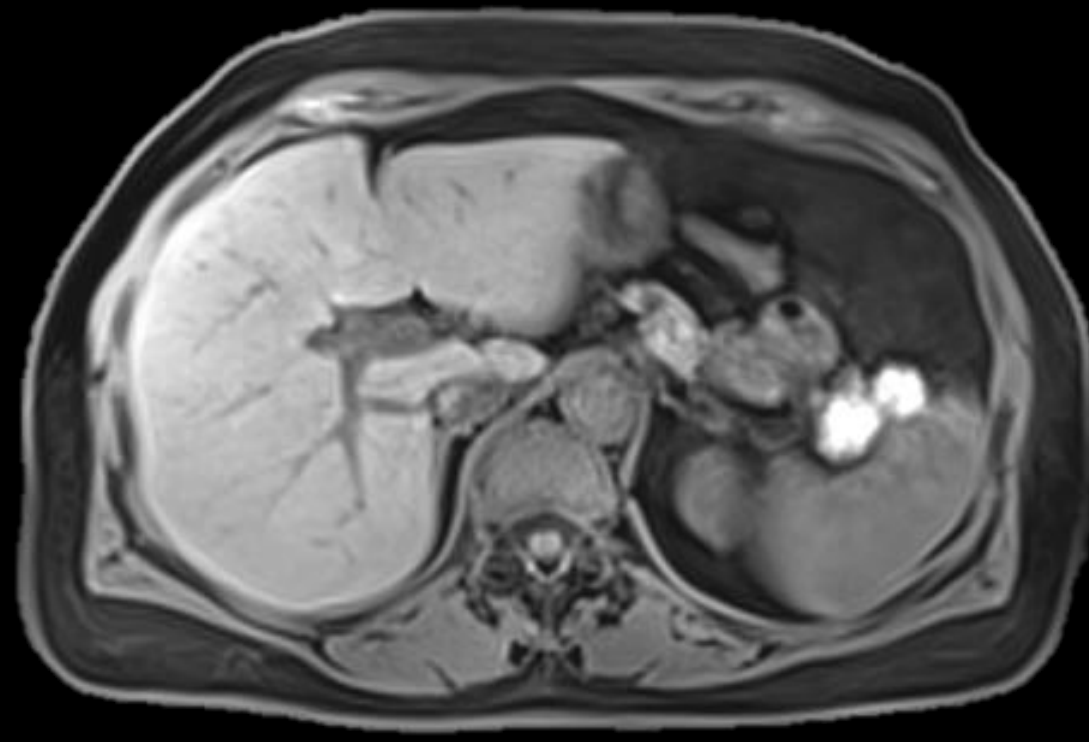
Selection of 50% of spokes acquired during expiration

Gated vs. Non-Gated Compressed Sensing GRASP-VIBE

Sharper edge delineation with Self-Gating



Compressed Sensing GRASP-VIBE, non-gated



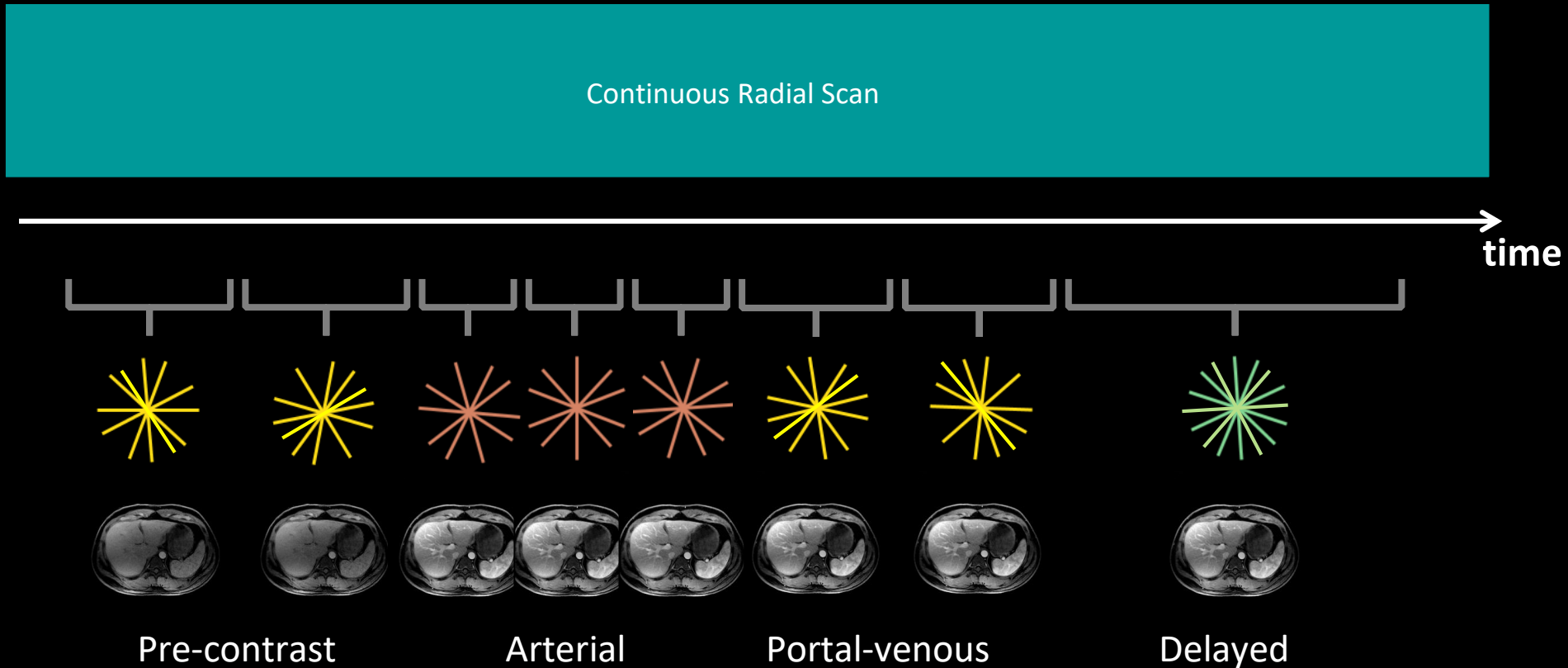
Gated Compressed Sensing GRASP-VIBE, 50% acceptance Window

Golden-Angle Acquisition Scheme for robustness, sparsity and highest flexibility in reconstruction



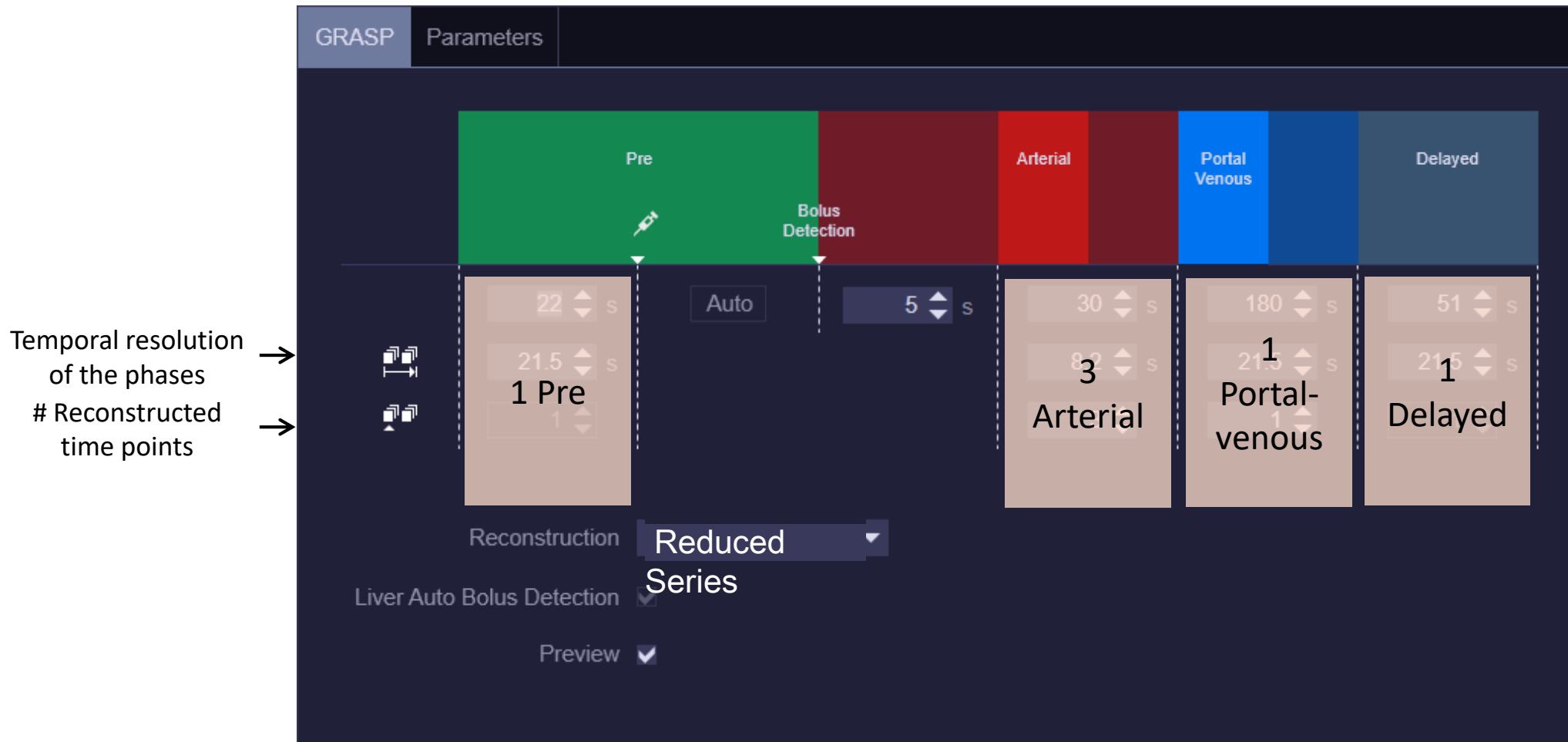
- Angle continuously increased by 111.25°
- Never acquires same spoke twice
- Next spoke fills largest angular gap
- Spokes always cover k-space uniformly

Golden-Angle Ordering Scheme allows to reconstruct images with any desired temporal resolution



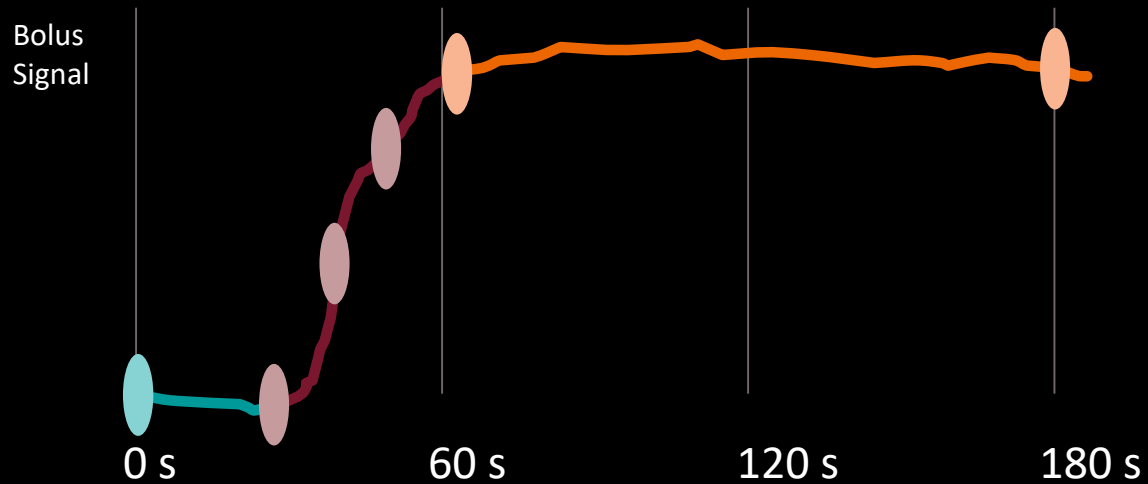
Intuitive definition of reconstruction parameters

Compressed Sensing GRASP-VIBE



Automatic recognition of liver phases

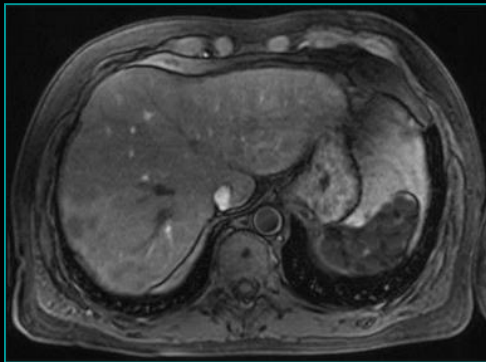
Reconstruction & labeling of key images



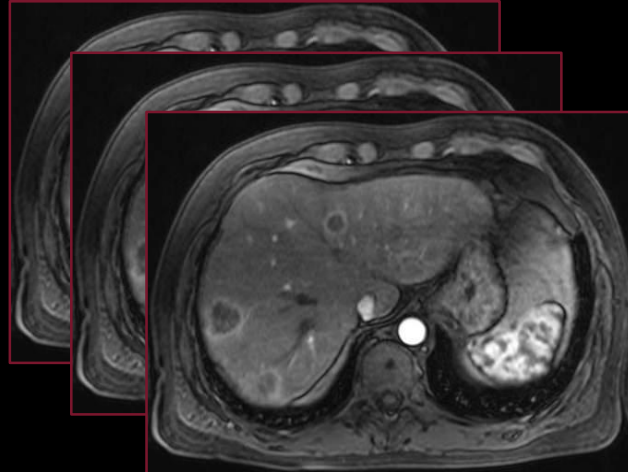
Clinical Mode

Instead of thousands of images, only the **clinically relevant** series can be selected for reconstruction

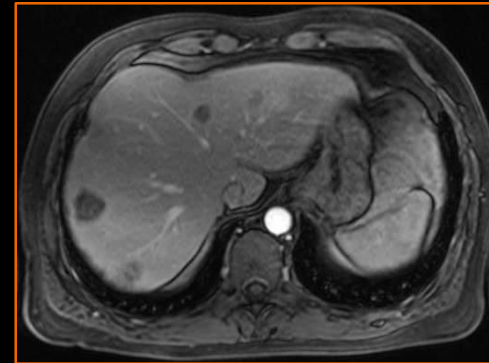
Pre-contrast



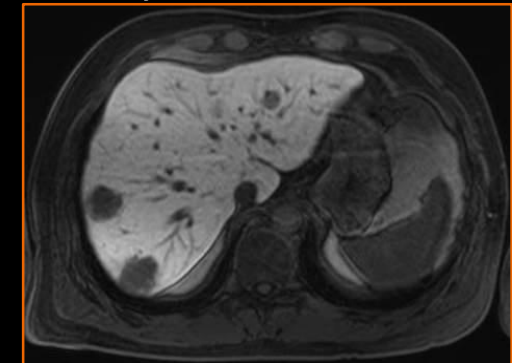
Arterial



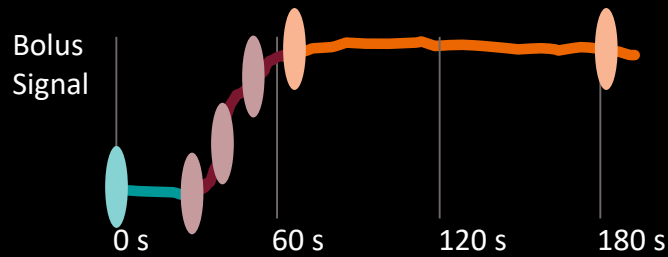
Portal-venous



Delayed

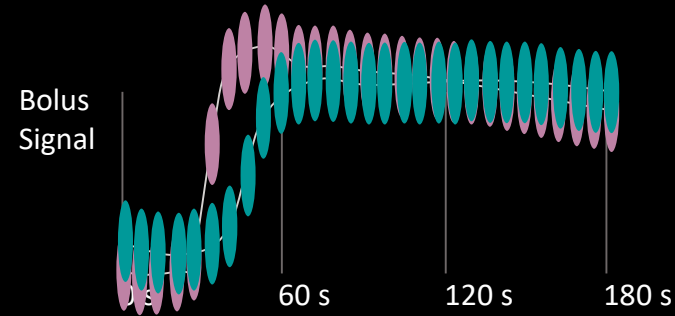


Different reconstruction modes for both daily clinical practice and advanced purposes



For use in clinical routine

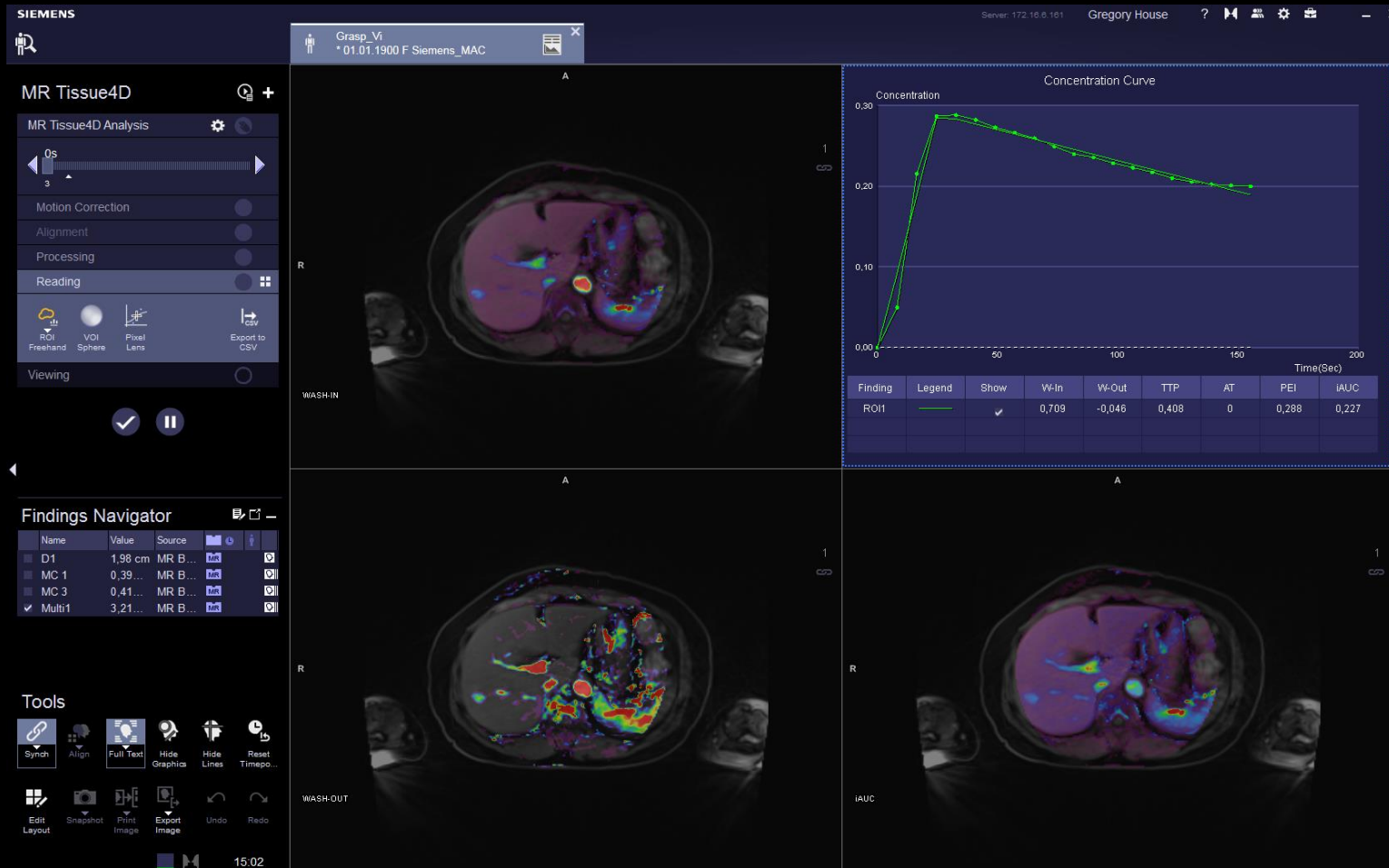
Instead of thousands of images, only the **clinically relevant** series can be selected for reconstruction



For advanced purposes

Reconstruction with up to 2 seconds temporal resolution unveils **previously unseen information** for pharmacokinetic modelling

Pharmacokinetic modelling of tissue characteristics with Compressed Sensing GRASP-VIBE and Tissue 4D



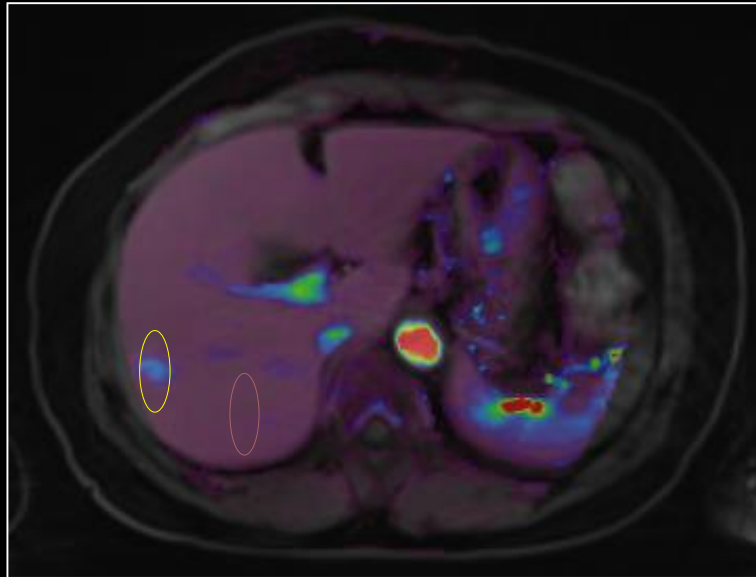
Compressed Sensing GRASP-VIBE & Tissue 4D

High-temporal resolution allows for pharmacokinetic modelling of tissue characteristics in the abdomen

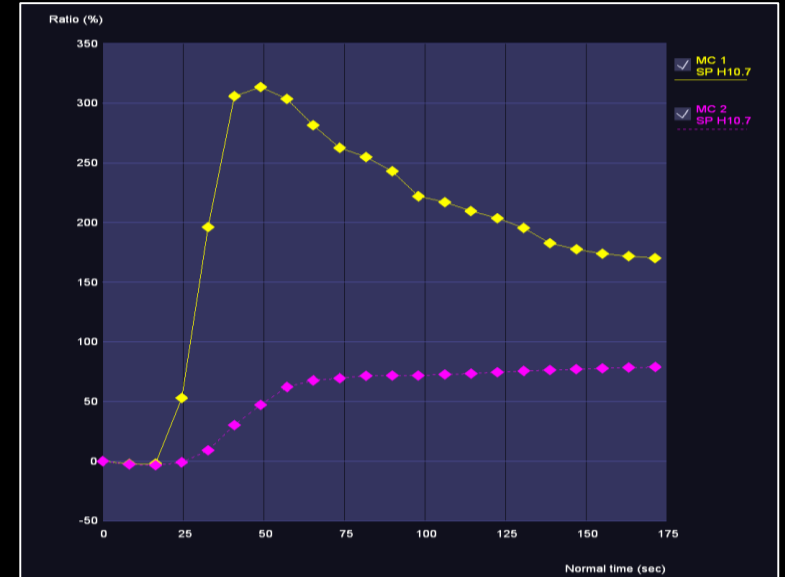
Pharmacokinetic modelling of tissue characteristics with Compressed Sensing GRASP-VIBE and Tissue 4D



Dynamic series
3 seconds/ frame



Wash-in map

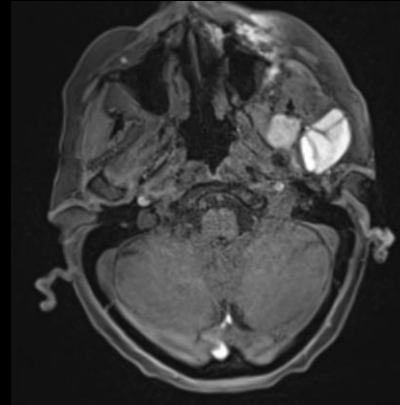


Curve characteristics

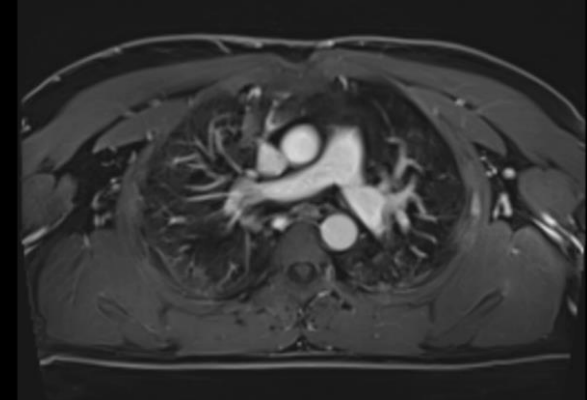
Compressed Sensing GRASP-VIBE is designed to provide high robustness towards involuntary motion

“Compressed Sensing GRASP-VIBE is very useful for many applications [...] due its inherent robustness towards involuntary motion”

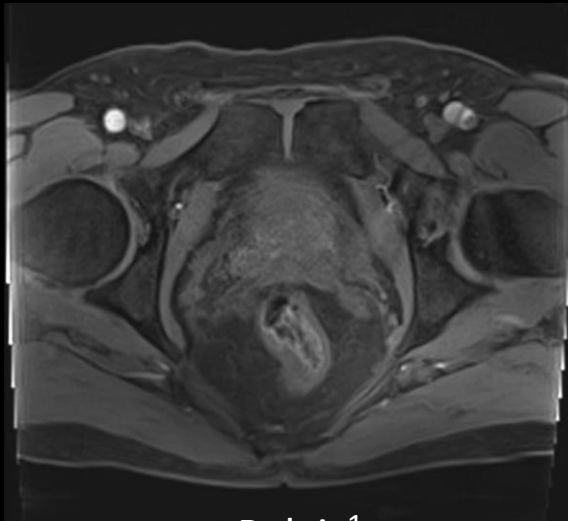
Dr. Sergios Gatidis, Tübingen



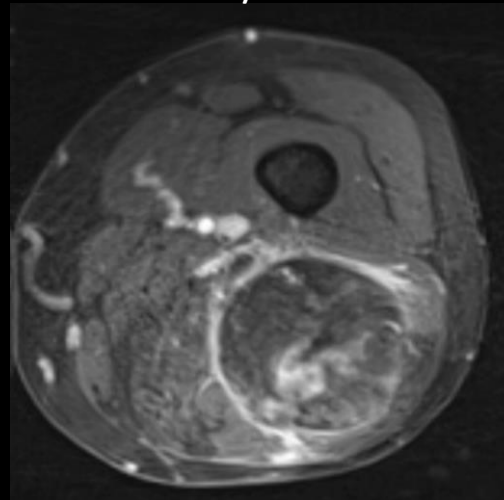
Head / neck¹



Thorax¹



Pelvis¹



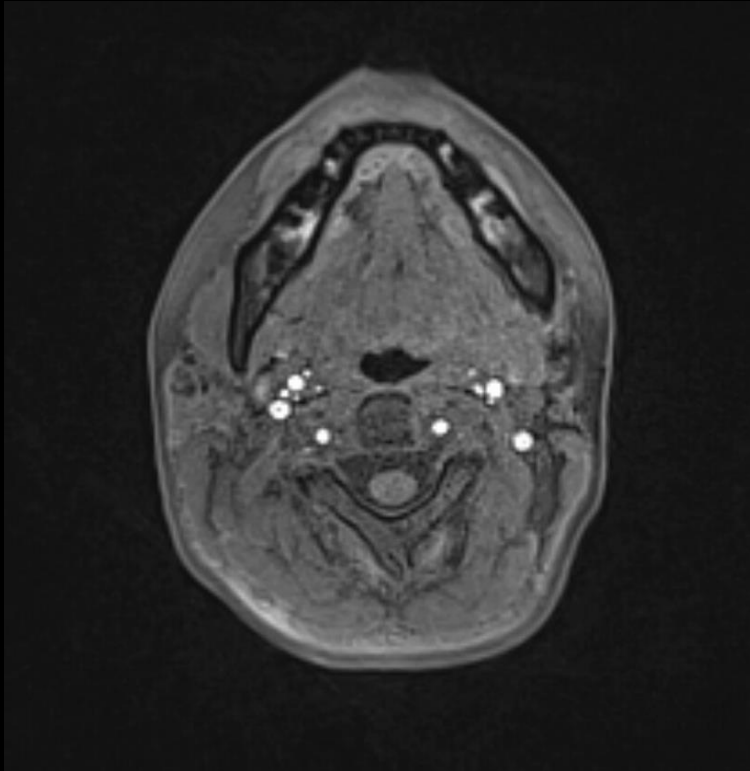
Vascular malformations¹



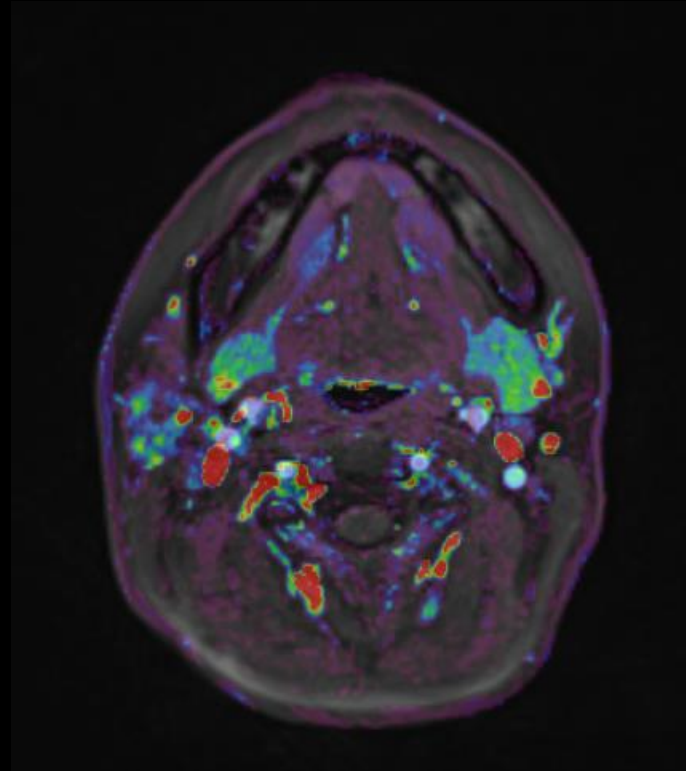
Rectum¹

Compressed Sensing GRASP-VIBE in head/neck¹ exams

Designed for isotropic, motion-robust perfusion assessment



CS GRASP-VIBE^{1,2}, 2.67 sec / frame
ISO 1.5x1.5x1.5 mm, TA 5:36 min



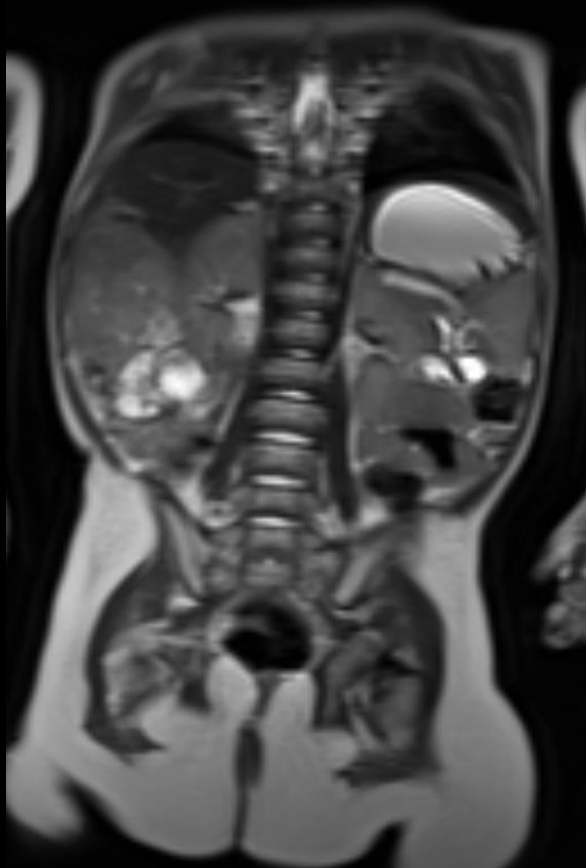
Tissue4D evaluation
Fusion T1 / iAUC



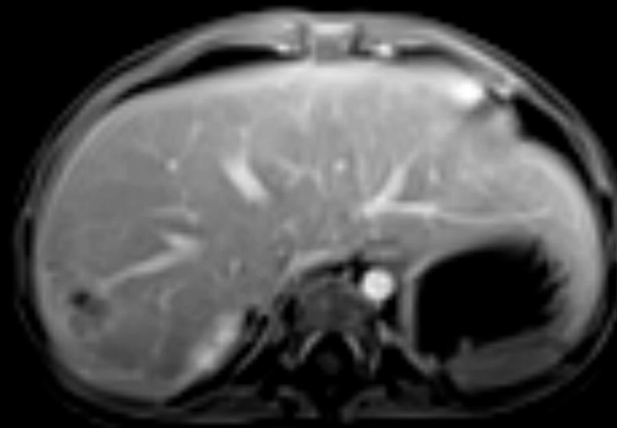
MIP recon of phase 14
provides additional vessel status

2-year old with Hepatoblastoma in light sedation

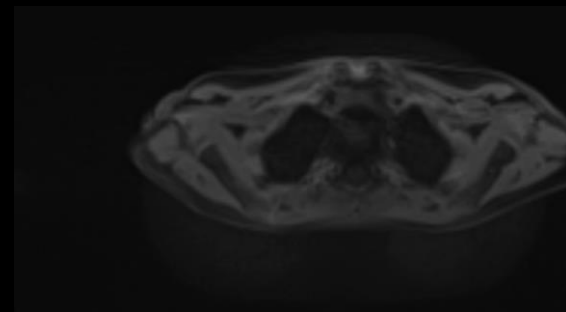
Full free-breathing exam with unique imaging techniques



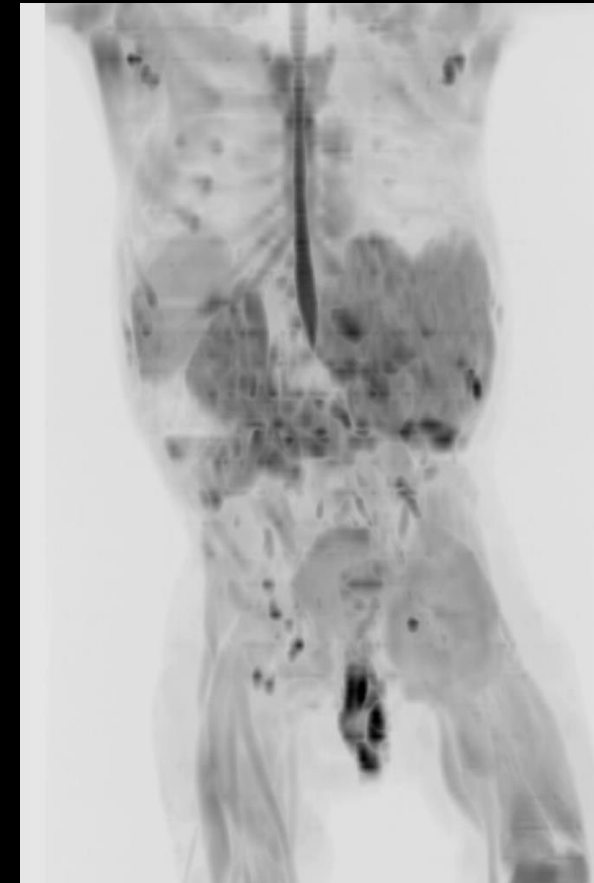
High-resolution, motion-robust
T2 HASTE



Compressed Sensing GRASP-VIBE,
free-breathing liver dynamics

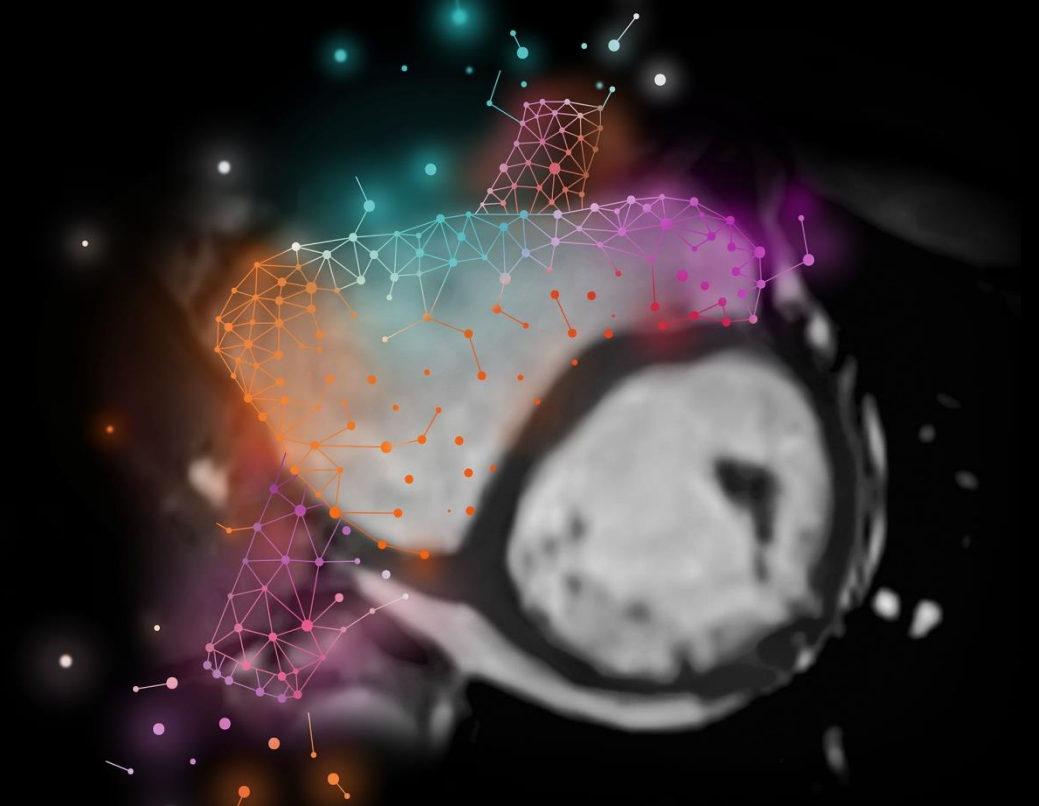


Motion-robust, high-resolution whole-
body StarVIBE



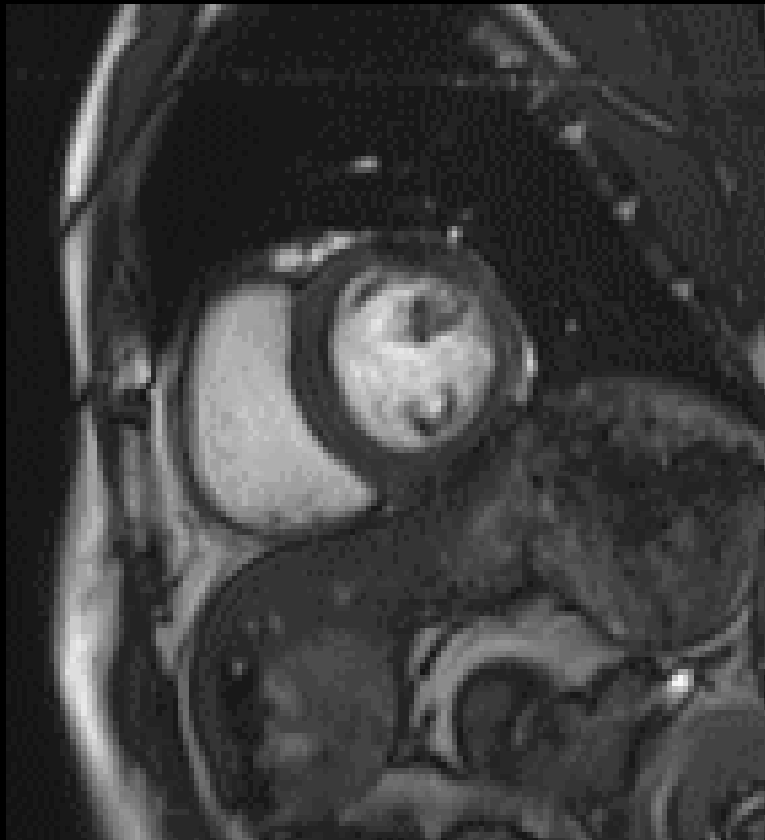
Whole-body DWI, b800 MIP
Liver tumor and metastases

**Beyond speed.
Beyond breath-holds.**



Patient case: 50-year-old with atrial fibrillation

Reliable ventricular function quantification not feasible



Segmented poor image quality



Real-time poor resolution

Needs:

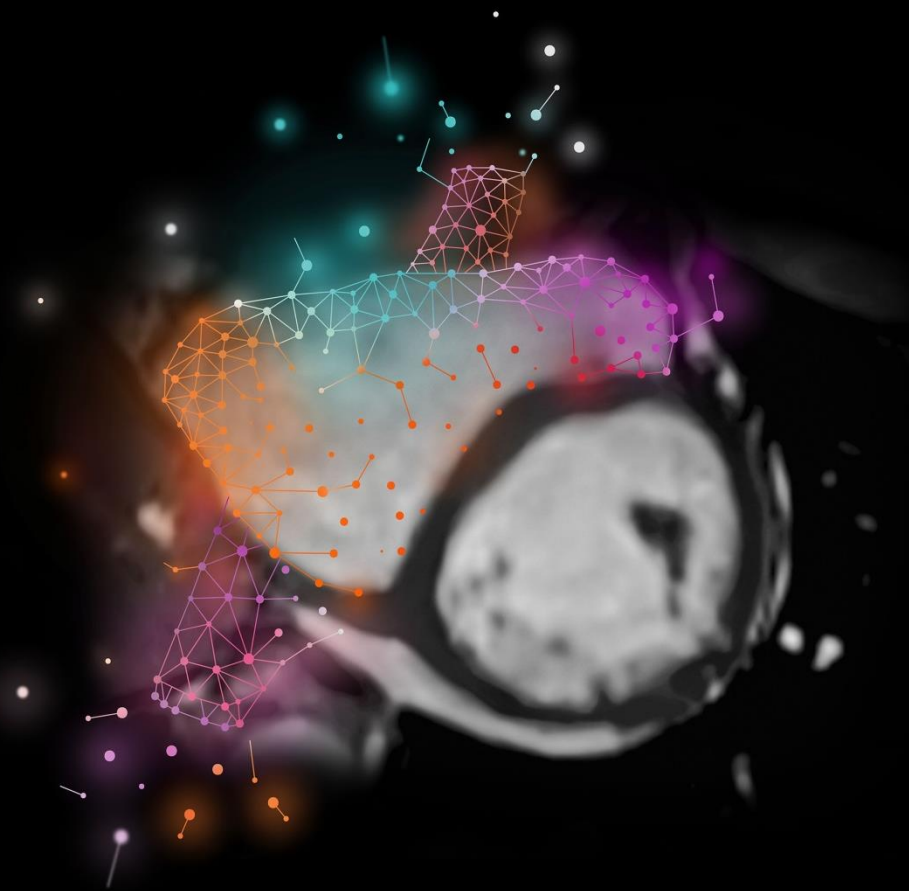
- **Fast acquisition** covering the whole ventricle
- **Fewer breath-holds** to improve patient compliance
- **High spatial resolution** to delineate ventricular borders for analysis
- **High temporal resolution** for accurate determination of end-diastole and end-systole at high heart rates

The new way: Compressed Sensing Cardiac Cine Beyond speed. Beyond breath-holds.

Acquire **free-breathing**, high-resolution **Cardiac Cine** images.

Capture the **whole cardiac cycle** for **precise quantification**.

Expand patient population eligible for cardiac MRI.

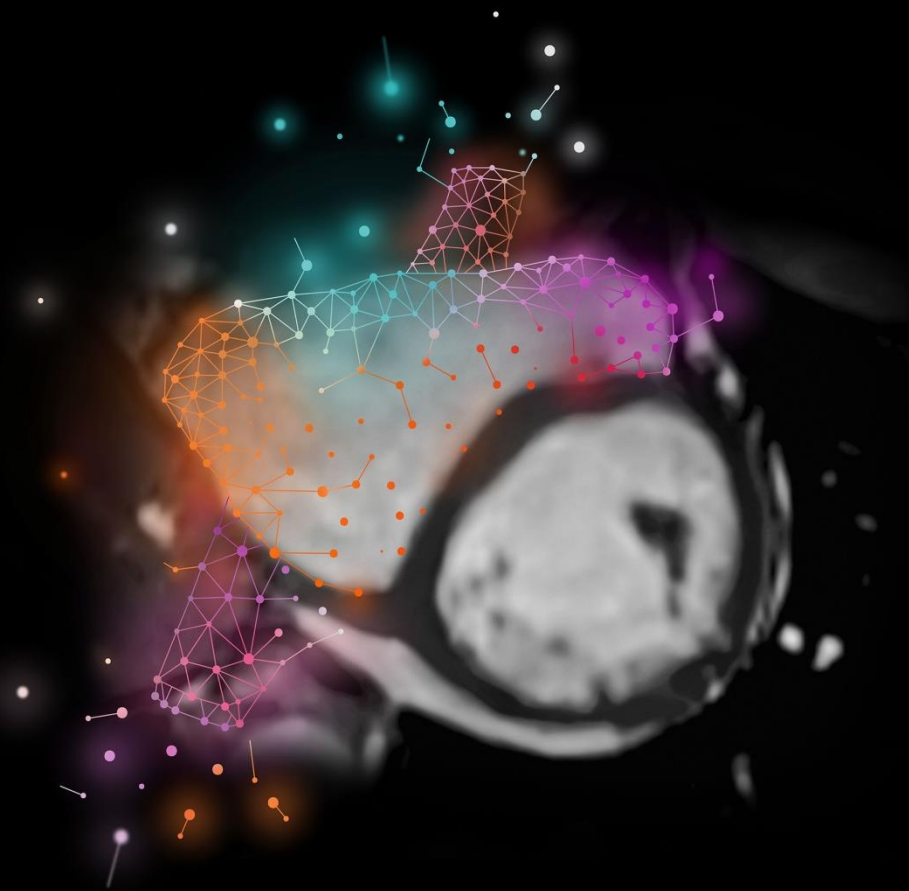


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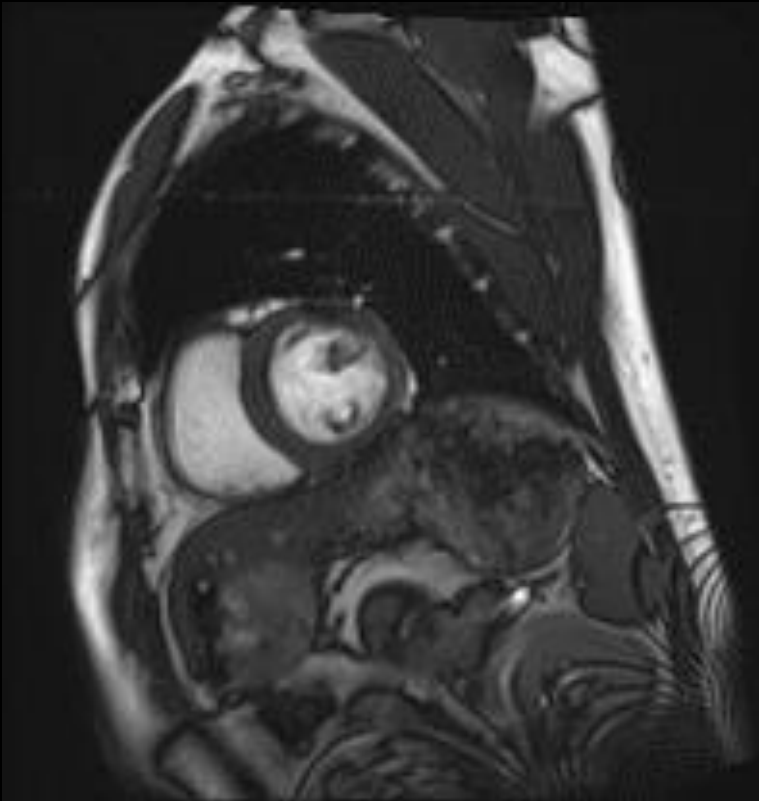
Capture the **whole cardiac cycle** for **precise quantification**.

Expand patient population eligible for cardiac MRI.



Patient case: 50-year-old male with atrial fibrillation

Good image quality without artifacts



Standard segmented
(iPAT 3), 8 heart beats



Standard real-time
(TPAT 3), 1 heart beat



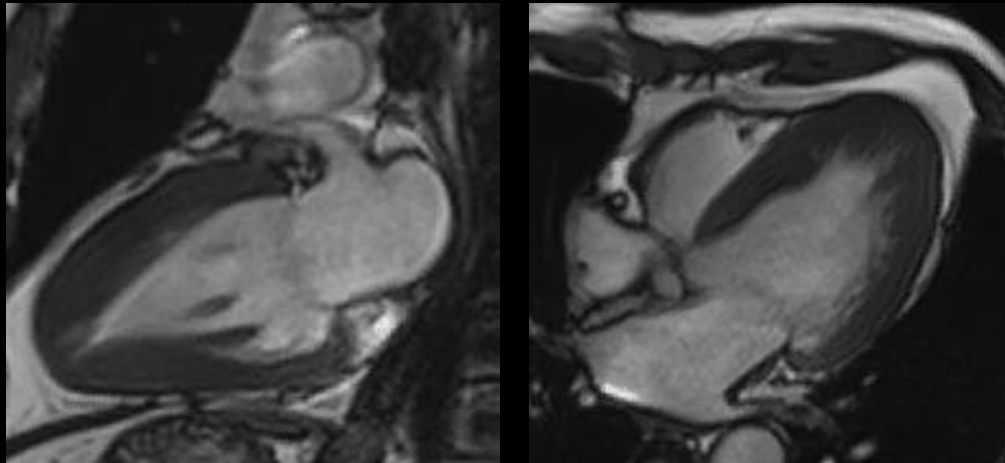
Compressed Sensing Cardiac Cine
(Acc. 11.5), 1 heart beat

Better patient compliance due to fewer breath-holds

A patient case from the MAGNETOM Skyra: Hypertrophic Cardiomyopathy

Retrogated Cardiac Cine

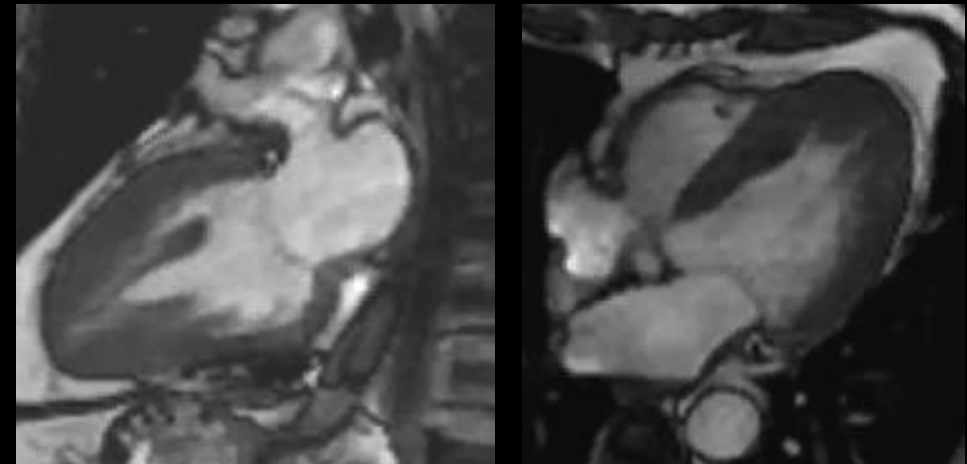
Segmented



iPAT 2; 10 heart-beats per slice
10 breath-holds

Compressed Sensing Cardiac Cine with Adaptive Triggering

Real-time

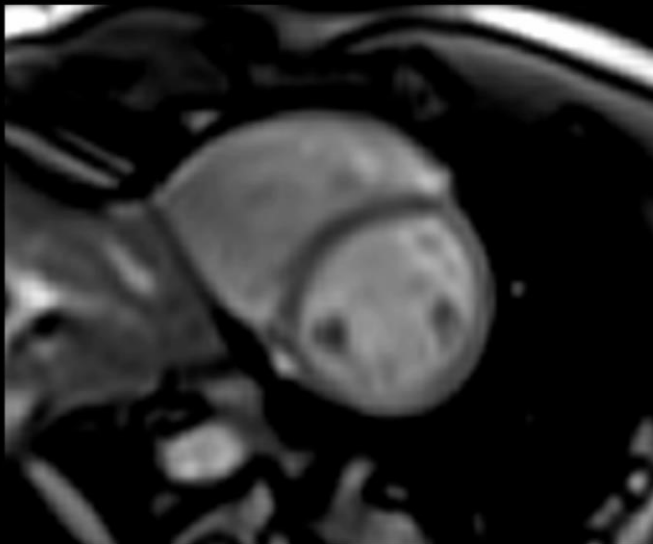


Acc. 9.6; 1 heart-beat per slice
1 breath-hold

Better patient compliance due to fewer breath-holds

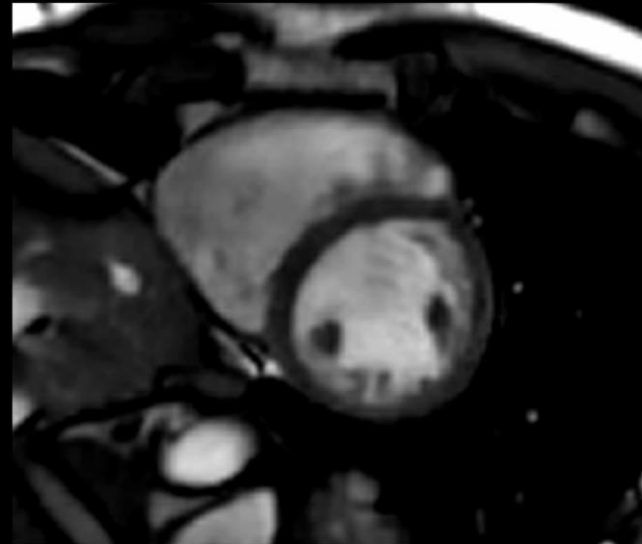
Scan on MAGNETOM Vida:

Standard Real-time Cardiac Cine

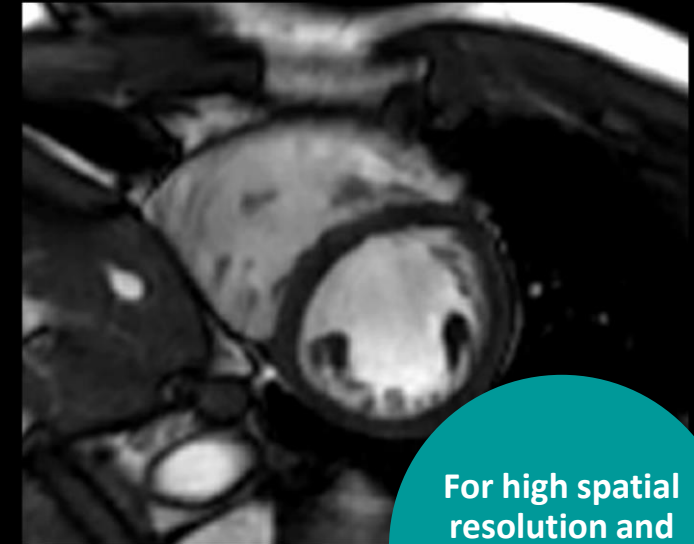


Cine Real-time
1 heart-beat
Breath-hold
Matrix 128x66, TR 60.9

Compressed Sensing Cardiac Cine



Cine Real-time
1 heart-beat
Free-breathing
Matrix 208x158, TR 46.2



Cine Segmented
5 heart-beats
Breath-hold
Matrix 240x155 TR 12

For high spatial
resolution and
best image
quality

Better overall image quality with Compressed Sensing Cardiac Cine

The study compared the image quality in 30 patients with atrial fibrillation

Sequence	Overall image quality			Exam time (s)
	Base	Mid	Apex	
Standard segmented (iPAT 3), 8 HB, 1.6 x 1.6 x 8.0 mm	2.4 ± 0.5	2.7 ± 0.7	2.8 ± 0.4	98.0 ± 15.3
Standard real-time (TPAT 3), 1 HB, 2.8 x 2.8 x 8.0 mm	3.2 ± 0.4	3.1 ± 0.3	3.4 ± 0.3	9.7 ± 2.8
Compressed Sensing Cardiac Cine (Acc. 11.5), 1 HB, 2.0 x 2.0 x 8.0 mm	3.3 ± 0.3	3.6 ± 0.5	3.7 ± 0.3	18.6 ± 3.3

- + Compressed Sensing Cardiac Cine**
 - High-resolution images in **one heartbeat**
 - **Significantly better image quality**

Underlying rating: 1 = poor; 4 = good

No need to exclude patients due to arrhythmia

MAGNETOM Skyra



Dr. Christoph Tillmanns,
Diagnostikum Berlin,
Berlin, Germany

*“I am using Compressed Sensing Cardiac Cine often especially because **38% of my patient population suffers from arrhythmia** (10% of them having A.Fib). In patients with suspected pericarditis constrictiva where I want to **visualize the movement of the septum during free-breathing Compressed Sensing Cardiac Cine provides diagnostic image quality.**¹”*

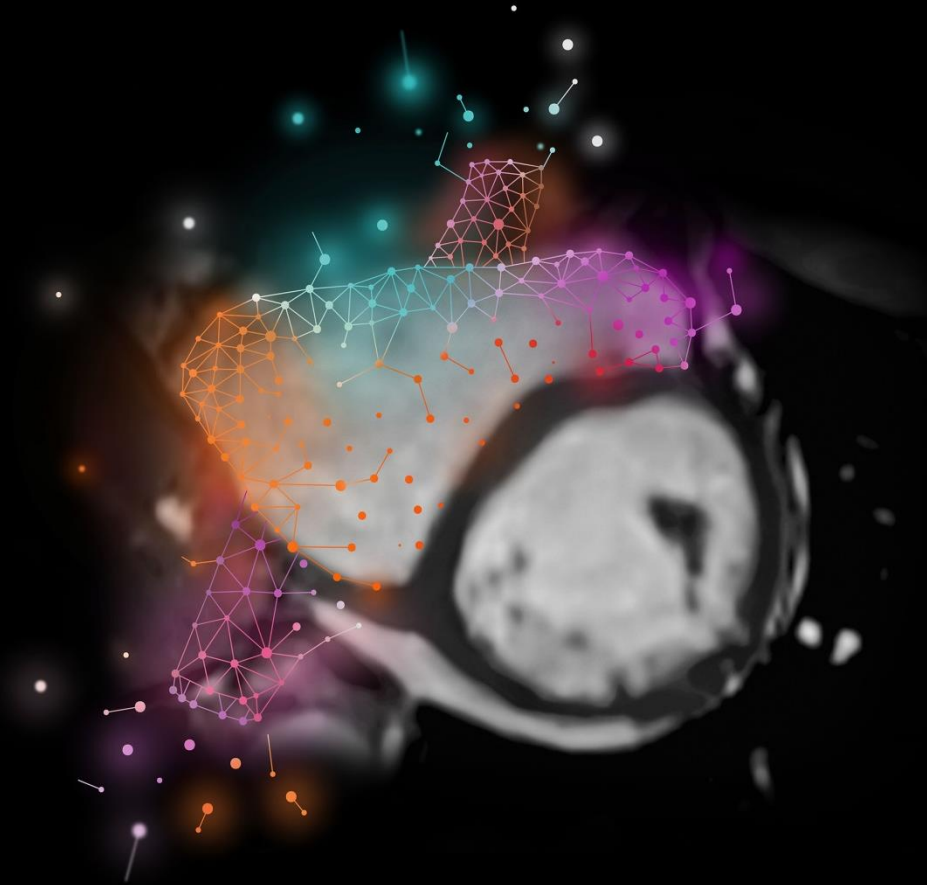
¹The statements by Siemens' customers described herein are based on results that were achieved in the customer's unique setting. Since there is no "typical" hospital and many variables exist (e.g., hospital size, case mix, level of IT adoption) there can be no guarantee that other customers will achieve the same results. This statement is from a person, who or whose institution is engaged in a collaboration with Siemens.

The new way: Compressed Sensing Cardiac Cine Beyond speed. Beyond breath-holds.

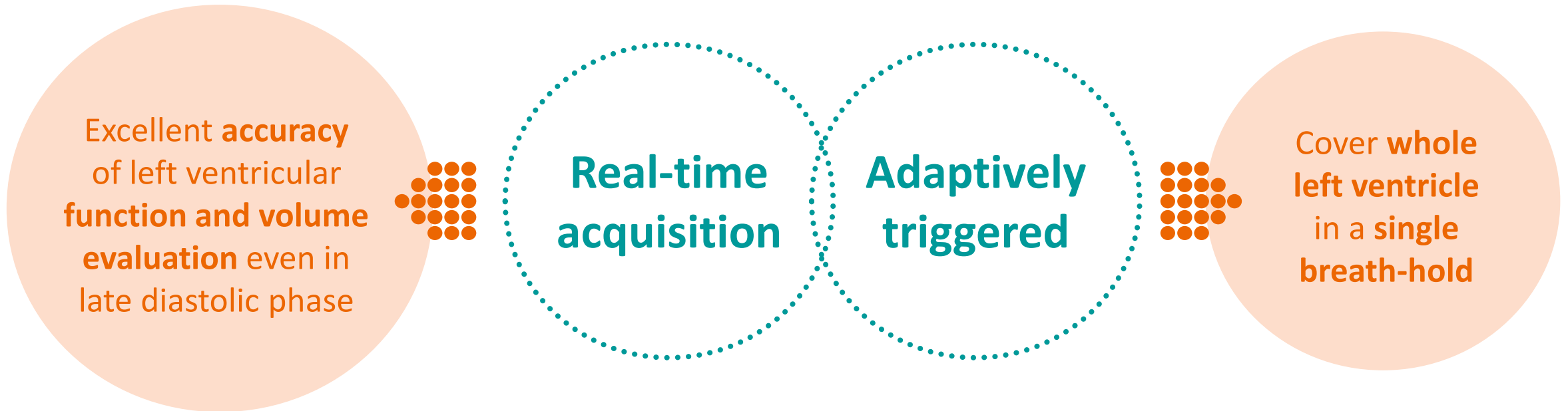
Acquire **free-breathing**, high-resolution **Cardiac Cine** images.

Capture the **whole cardiac cycle** for **precise quantification**.

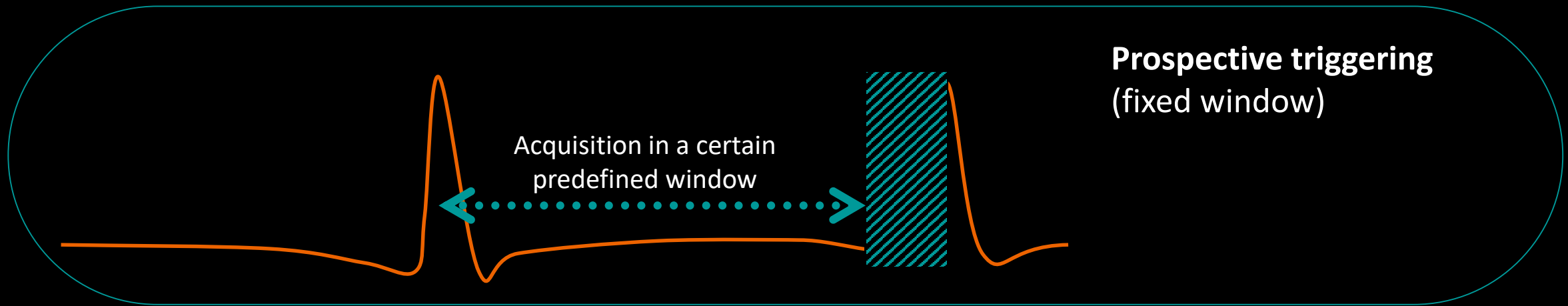
Expand **patient population** eligible for cardiac MRI.



Capture the whole cardiac cycle for precise quantification.



Adaptively triggered real-time – Compressed Sensing Cardiac Cine covers entire R-R interval



Similar correlations of left ventricular function analysis of standard and Compressed Sensing Cardiac Cine

Head-to-head comparison with retro-gated segmented Cine

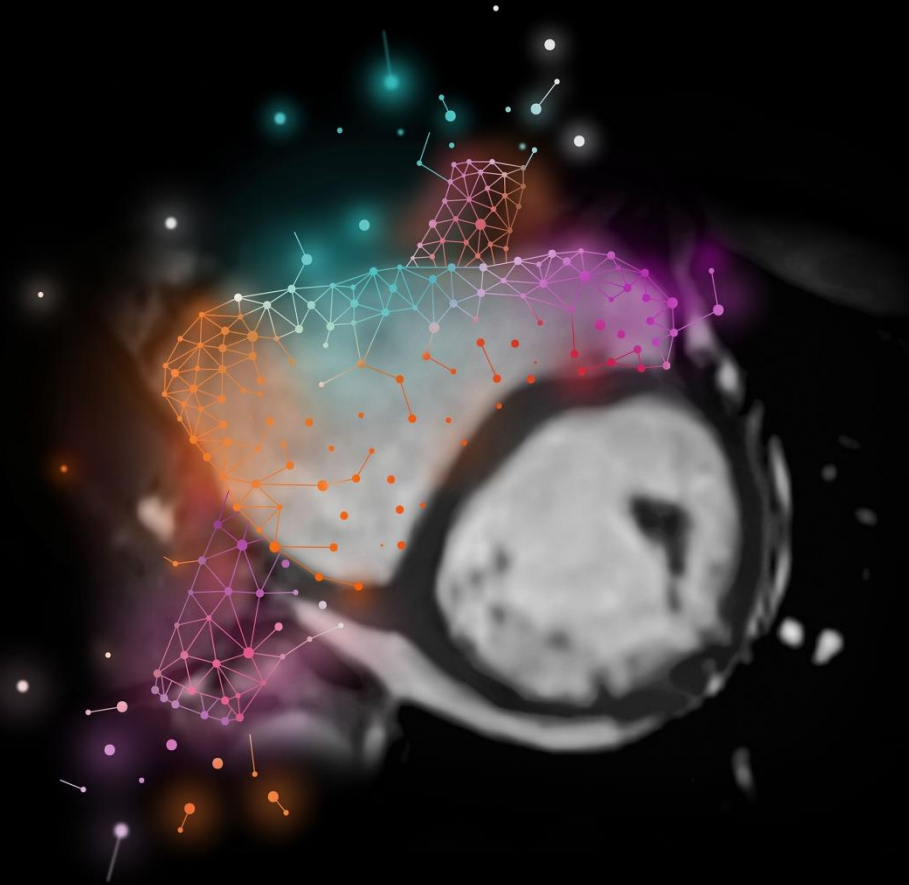
Authors	Compressed Sensing Cardiac Cine, EF (%)	Standard Cine, EF (%)
Vincenti et al. (2014)	48.5 ± 15.9	49.8 ± 15.8
Kido et al. (2015)	58.1 ± 8.6	59.1 ± 8
Fernandes et al. (2015)	66.7	67.3
Sudarski et al. (2016)	48.8 ± 11.8	49.3 ± 11.9
Kido et al. (2016)	58.8	61.3

The new way: Compressed Sensing Cardiac Cine Beyond speed. Beyond breath-holds.

Acquire **free-breathing**, high-resolution **Cardiac Cine** images.

Capture the **whole cardiac cycle** for **precise quantification**.

Expand patient population eligible for cardiac MRI.

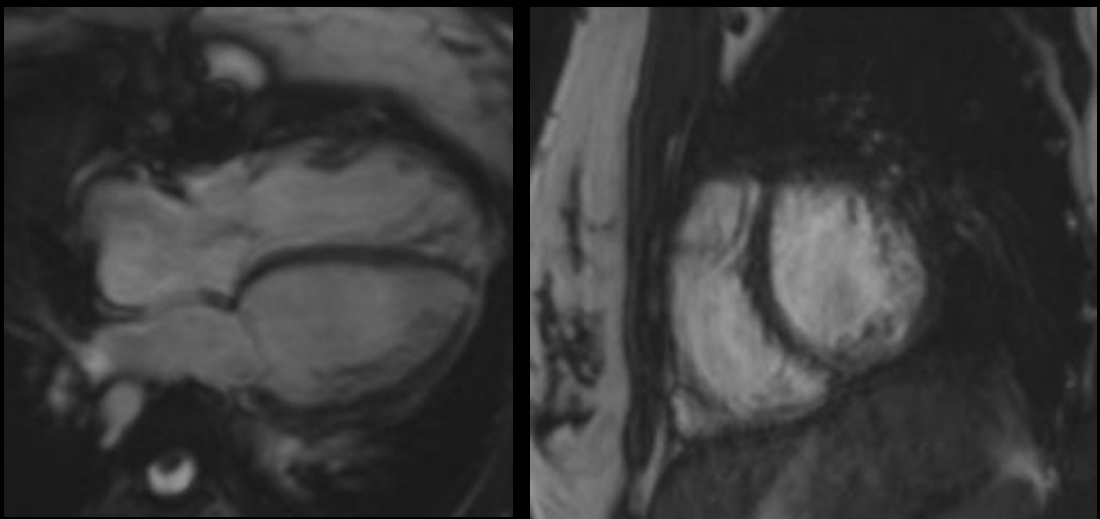


Diagnostic image quality in only 23 seconds for patients with dyspnea and complex anatomy

A patient case from MAGNETOM Aera: Tetralogy of Fallot, irregular heart-rate & poor breath-hold capabilities

Retrogated Cardiac Cine

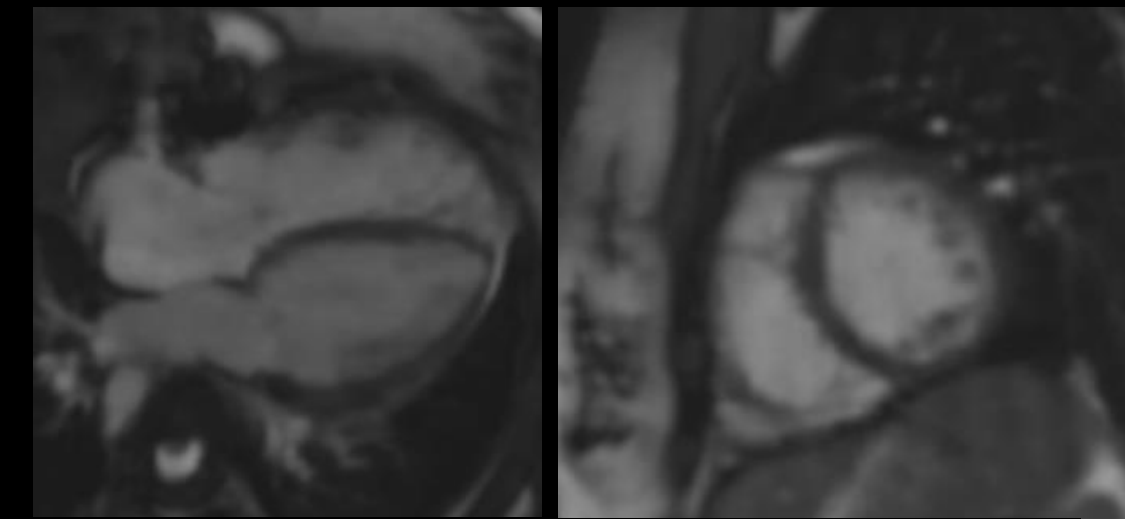
Segmented



Acc 2; 14 heartbeats per slice
Acquisition time 8 min 30 sec

Compressed Sensing Cardiac Cine
with Adaptive Triggering

Real-time

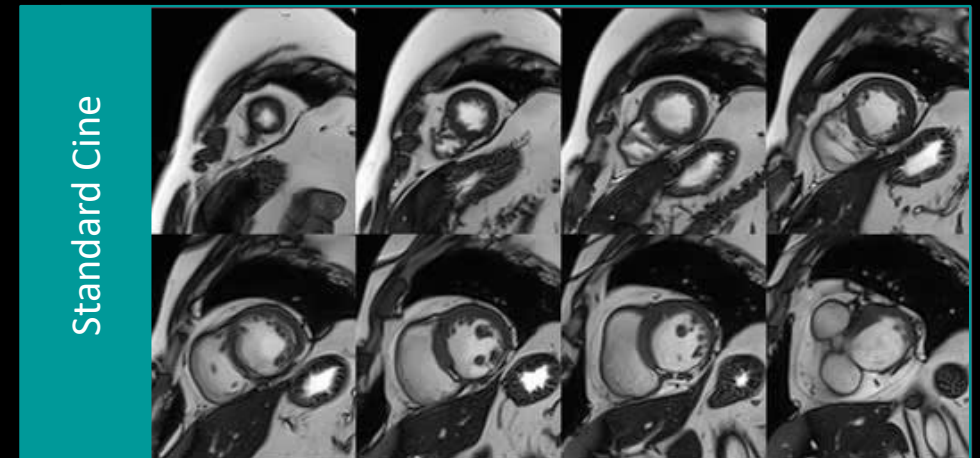
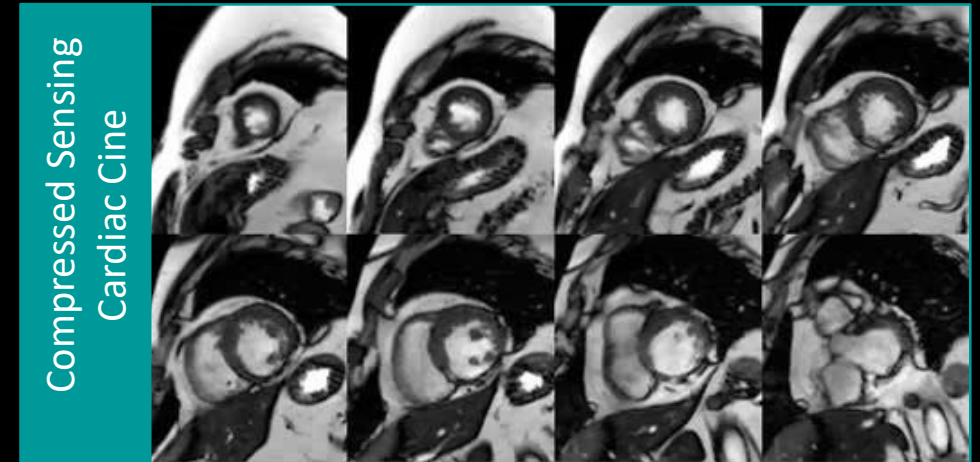


Acc 2; 14 heartbeats per slice
Acquisition time 8 min 30 sec

Comparison of quantitation of LV volume parameters between standard SSFP Cine and Compressed Sensing¹

Single breath-hold
Compressed Sensing Cardiac Cine
(TA ~ 25 s) is designed to meet equivalent image quality and LV volume assessment.¹

Compared to segmented multi breath-hold Cine
(TA ~ 6 min).¹



One additional patient a day possible MAGNETOM Aera



Dr. Juliano de Lara Fernandes,
Jose Michel Kalaf Research Institute,
Campinas, Brazil

“The Compressed Sensing Cardiac Cine allows for improvement in clinical throughput of at least one additional patient a day in a busy CMR unit by offering the flexibility to scan patients with arrhythmias, dyspnea or just by significantly decreasing the time to acquire cine images in routine patients while keeping the same exam quality.¹”

¹The statements by Siemens' customers described herein are based on results that were achieved in the customer's unique setting. Since there is no "typical" hospital and many variables exist (e.g., hospital size, case mix, level of IT adoption) there can be no guarantee that other customers will achieve the same results. This statement is from a person, who or whose institution is engaged in a collaboration with Siemens.

Thank you!

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