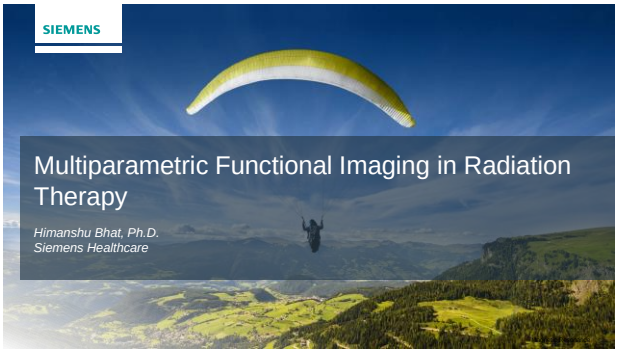
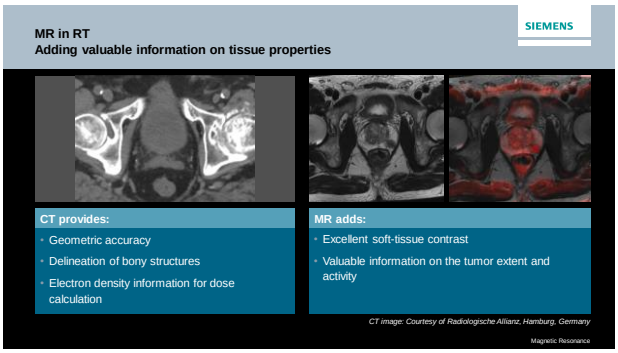
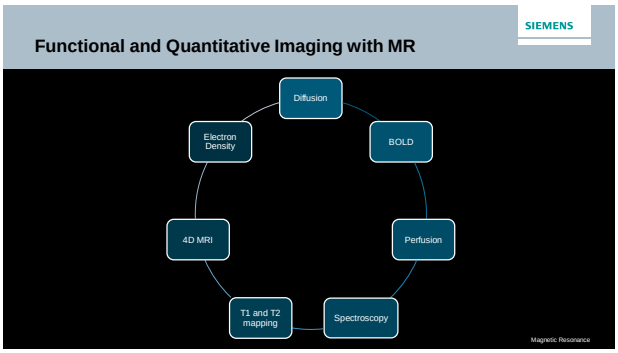

SIEMENS
Multiparametric Functional Imaging in Radiation Therapy
Himanshu Bhat, Ph.D.
Siemens Healthcare


MR in RT
Adding valuable information on tissue properties
SIEMENS
CT provides:
Geometric accuracy
Delineation of bony structures
Electron density information for dose calculation
MR adds:
Excellent soft-tissue contrast
Valuable information on the tumor extent and activity
CT image: Courtesy of Radiologische Allianz, Hamburg, Germany
Magnetic Resonance


Functional and Quantitative Imaging with MR
SIEMENS
Diffusion
BOLD
Perfusion
Spectroscopy
T1 and T2 mapping
4D MRI
Electron Density
Magnetic Resonance

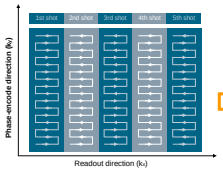
RESOLVE: Readout-segmented, multi-shot diffusion-weighted EPI

SIEMENS

- Reduced susceptibility and blurring artefacts due to reduced TE and echo spacing
- Insensitivity to motion-induced phase errors

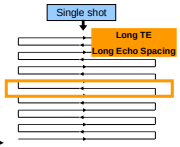
Porter DA et. Al. Magn Reson Med, 62(2), 468-475.

RESOLVE



k-space trajectory

Conventional single shot epi



k-space trajectory

Magnetic Resonance

RESOLVE Minimal susceptibility artifacts for better detection and delineation of lesions

SIEMENS

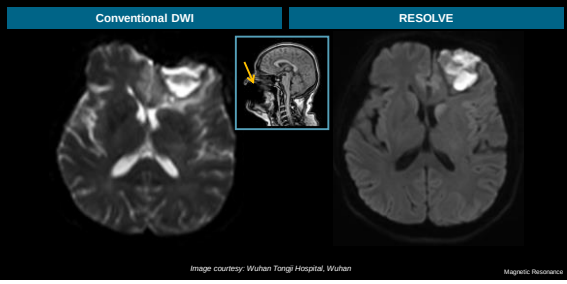


Image courtesy: Wuhan Tongji Hospital, Wuhan

Magnetic Resonance

RESOLVE is recommended by experts for RT planning

SIEMENS

Study performed on a 3T Skyra comparing single shot epi and resolve based DWI for prostate imaging

"We have shown that this technique [RESOLVE] provides the most robust and reliable data set and would seem to be the preference for RT planning studies."

Results from the contouring study from the two observers

Sequence	Observer 1		Observer 2	
	Volume difference (cm^3)	DSC	Volume difference (cm^3)	DSC
Echoplanar imaging	4.11	0.695	5.99	0.708
RESOLVE	3.56	0.737	3.77	0.739

Liney GP et al., Br J Radiol. 2015 May;88(1049):20150034.

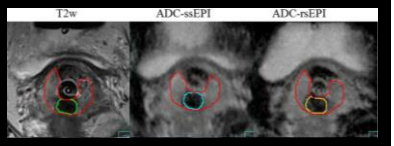
Magnetic Resonance

SIEMENS

RESOLVE is recommended by experts for RT planning

Study performed on a 3T Verio (IMRIS) comparing single shot epi and resolve based DWI for cervical and prostate imaging

"[RESOLVE] […] provided superior geometric performance […] in phantom studies and in vivo, applied to patients enrolled on genito-urinary trials including cervix and prostate MRI at 3 T."



	ssEPI to T_2w		rsEPI to T_2w		p-Value	
	DC	HD (mm)	DC	HD (mm)	DC	HD (mm)
HRCTV	0.76 ± 0.14	5 ± 2	0.91 ± 0.05	3 ± 2	0.012	0.048
GTV_B	0.62 ± 0.26	5 ± 2	0.85 ± 0.08	3 ± 2	0.014	0.022

Foltz WD et al., Radiotherapy and Oncology 117 (2015) 525–531.

SIEMENS

Simultaneous Multi-Slice for MR imaging
Analogous to the revolution brought to CT by multi-slice technology

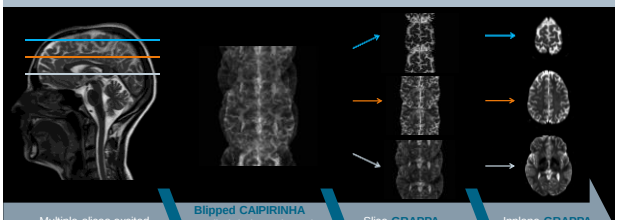
Single-Slice CT

Multi-Slice CT

Multi-slice technology was the key behind the significant acceleration of CT imaging

SIEMENS

Simultaneous Multi-Slice
Simultaneous excitation of multiple slices with blipped CAIPIRINHA



Multiple slices excited **simultaneously** → **Blipped CAIPIRINHA** applied during echo train *Minimization of g-factor related SNR loss* → Slice **GRAPPA** based unaliasing → Inplane **GRAPPA** based unaliasing

Setsompop, K. et. al. (2012). Magn Reson Med, 67, 1210-1224.

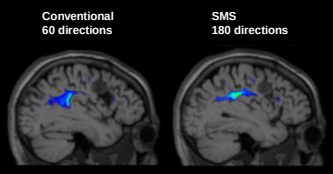
Investing SMS into more diffusion directions (3 time more) to improve diffusion tractography results for better presurgical planning

SIEMENS

Study performed on a 3T Skyra

Comparisons of results of probablistic tractography for conventional vs SMS.

Tripling the number of diffusion directions by SMS increased conditional probabilities to reconstruct the superior longitudinal arcuate fasciculus.



Bartsch A. SMS imaging for presurgical BOLD fMRI and diffusion tractography: Case illustrations. MAGNETOM Flash 2015; 63: 58-64

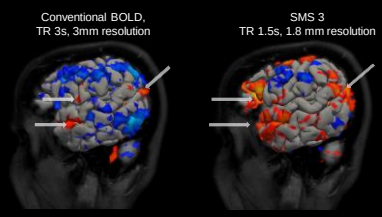
Magnetic Resonance

High temporal sampling improves detection of resting state networks to map functional cortices in individuals

SIEMENS

Study performed on a 3T Skyra

SMS improves mapping of language networks with resting-state single subject fMRI at higher spatial resolutions



Miller K. et al. SMS imaging for resting-state fMRI. MAGNETOM Flash 2015; 63 (Special SMS Supplement): 70-77.

Magnetic Resonance

SMS RESOLVE* for low distortion DWI in the same scan time as conventional diffusion

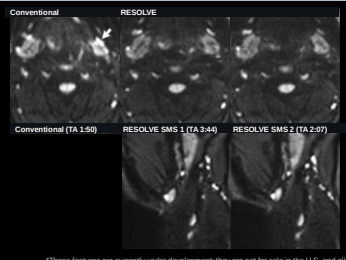
SIEMENS

Study performed on a 3T Skyra

Distortions with conventional DWI of soft neck tissue leads to projection of lymph node (arrow) over the submandibular gland.

With RESOLVE, distortions are significantly reduced. Equivalent image quality of RESOLVE with and without SMS, with slice acceleration reducing scan time by nearly a factor of 2.

Runge VM, et al. MAGNETOM Flash 2015; 63 (Special SMS Supplement): 92-95



*These features are currently under development; they are not for sale in the U.S. and all other countries. Their future availability cannot be guaranteed

Magnetic Resonance

SIEMENS

Dynamic Contrast Enhanced (DCE) Perfusion Imaging

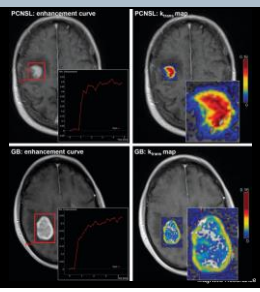
Study performed on a 3T Verio

Processing done using Tissue4D

Primary central nervous system lymphoma demonstrated significantly higher volume transfer constant and flux rate constant values compared with glioblastoma

elevated K_{trans}

low K_{trans}



Kickingereder P . et al. AJNR Am J Neuroradiol. 2014 Aug;35(8)

SIEMENS

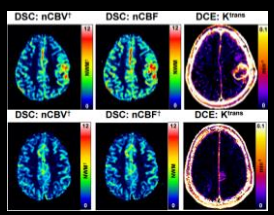
Perfusion Imaging: DSC (T2* weighted imaging) or DCE (T1 weighted imaging)

Multi-Center Study including Siemens 1.5T and 3T systems

"Increased tumor perfusion, vascular volume, vascular permeability, are negative prognostic markers in newly diagnosed GBM patients and these important physiological markers can be measured safely and reliably using MRI"

elevated K_{trans}, CBF and CBV

low K_{trans}, CBF and CBV



Gerstner ER. et al. Clinical Cancer Research - May 2016

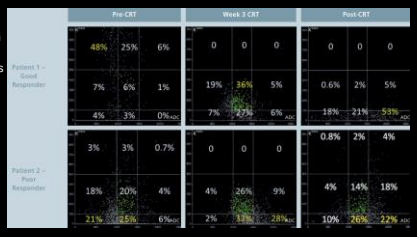
Magnetic Resonance

SIEMENS

Combination of Diffusion and Perfusion for therapy response assessment in rectal cancer

Patient 1: Week 3 histograms and maps showed both a shift in distribution of ADC of voxels to higher values and K_{trans} of voxels to lower values compared to the pre-CRT histogram.

Patient 2: Low K_{trans} values pre-CRT (may indicate hypoxic tumor, which is predictive of a radio-resistant tumor), without much change in the values of voxels over the time-points.



Pham T. et al. MAGNETOM Flash (65) 2/2016: 48-51

Magnetic Resonance

SIEMENS

MR Spectroscopy: Choline as a biomarker for GBM progression*

Study performed on a 3T TimTrio

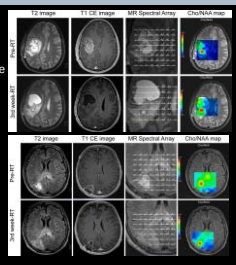
"Patients with a decreased or stable mean or median Cho/NAA values had less risk of progression"

"Patients with an increase in mean or median Cho/NAA values at the 3rd week RT scan had a significantly greater chance of early progression"

Muruganandham M et. al. Int J Radiat Oncol Biol Phys. 2014 Sep 1; 90(1): 181–189.

Progressive disease

Stable disease



*These features are currently under development; they are not for sale in the U.S. and all other countries. Their future availability cannot be guaranteed

Magnetic Resonance

SIEMENS

MR Spectroscopy: 3D MRSI based Spectral Editing for 2-hydroxyglutarate (2HG) Detection*

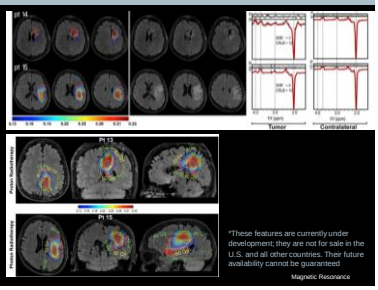
Study performed on a 3T TimTrio

2HG is not present in healthy or non mutated tumor its presence in the spectrum is a strong marker for the IDH mutation

For a substantial number of patients, the 2HG volumetric assessment of tumor burden is more extensive than FLAIR volume.

There is only partial overlap and asymmetric displacement between the centers of FLAIR and 2HG ROIs

Jafari-Khouzani K. et al. Neuro-Oncology 2016;



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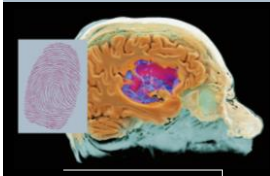
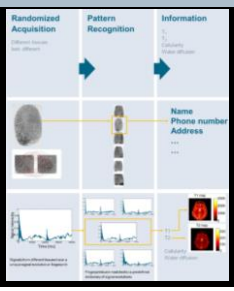
Magnetic Resonance

SIEMENS

Magnetic Resonance Fingerprinting*
Paradigm shift in quantitative MR



"MRF has the potential to quantitatively detect and analyze complex changes..."



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Magnetic Resonance

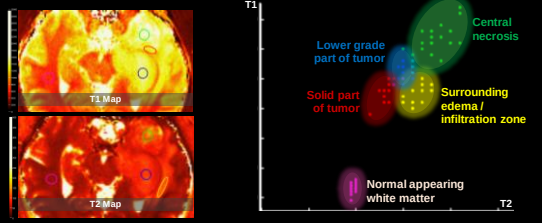
SIEMENS

Further developing MR Fingerprinting*

*These features are currently under development; they are not for sale in the U.S. and all other countries. Their future availability cannot be guaranteed

SIEMENS

Magnetic Resonance Fingerprinting*
Ongoing clinical studies in oncology patients



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Medical University of Vienna, Austria

Magnetic Resonance

SIEMENS

StarVIBE: Motion-insensitive, T1-weighted brain imaging

Images courtsey Jan Ypermann, Ieper, Belgium

Magnetic Resonance

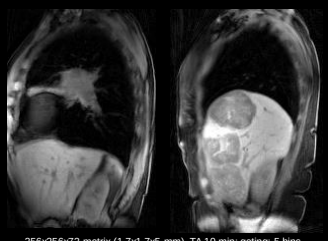
SIEMENS

4D MRI with StarVIBE* – Visualization & Quantification of Respiratory Motion

Self gated StarVIBE

Detection of expiration and Inspiration position

Creation of Vector Maps



Grimm et al. Medical Image Analysis 2015;19:110-20

256x256x72 matrix (1.7x1.7x5 mm), TA 10 min; gating: 5 bins

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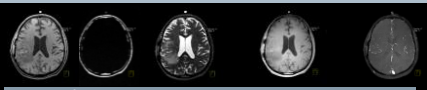
Magnetic Resonance

SIEMENS

syngo.via Frontier syntheticCT prototype* for the brain



MR protocol

T1 VIBE Dixon	T2 SPACE	PETRA	Vascular image
Voxel size: 1.0 x 1.3 x 1.3mm ipat factor:2x2 TA:1:59min	Voxel size: 1.0mm isotropic TA: 2:29min	Voxel size: 1.0mm isotropic Radial view: 8000 TA: 0:58min	Slice thickness: 3 mm Matrix: 256 x 230 TA: 0:35min

Used for:

• Contouring (e.g. T1 contrast) • Generation of fat and water image	• Contouring (e.g. T2 contrast) • Identification of edematous area	Identification of air for the purpose of defining an air mask to exclude such voxels from classification	Creating a threshold-based intensity mask to separate flowing blood

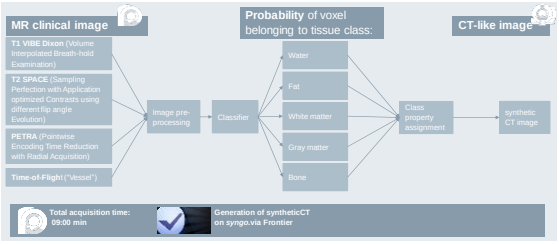
*These features are currently under development; they are not for sale in the U.S. and all other countries. Their future availability cannot be guaranteed

Images courtesy James Balter, University of Michigan

Magnetic Resonance

SIEMENS

syngo.via Frontier syntheticCT prototype* for the brain



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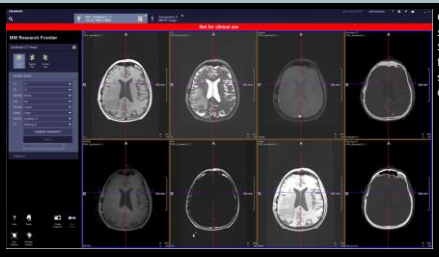
Paradis et al, Int J Radiation Oncol Biol Phys, Vol. 93, No. 5, p. 1154e1161, 2015

Magnetic Resonance

SIEMENS

syngo.via Frontier syntheticCT prototype* for the brain



One-click export to *syngo*.via RT Image Suite for contouring and further investigations such as dosimetric evaluation

*These features are currently under development; they are not for sale in the U.S. and all other countries. Their future availability cannot be guaranteed

Magnetic Resonance

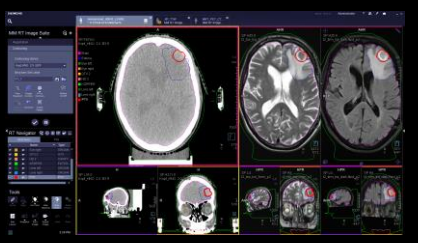
SIEMENS

syngo.via RT Image Suite: Visualization, Contouring, Registration …

Access a comprehensive view of your patient

- View up to 4 single or 8 fused series concurrently over up to 2 monitors*
- Concurrently view information acquired with multiple PET tracers or multi-parametric MRI's, or all information needed for analyzing moving tumors

View all information needed to make a decision on how to treat or to assess change as treatment progresses.

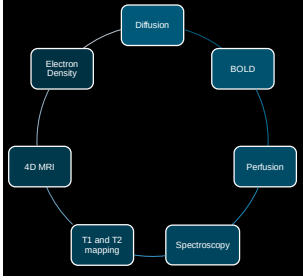


*Optional
Courtesy of Radiologische Allianz, Hamburg, Germany

Magnetic Resonance

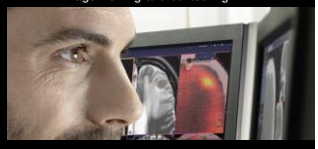
SIEMENS

Thank you for your attention !!!



syngo.via RT Image Suite

A dedicated imaging-for-RT software solution - enabling advanced multi-modality image viewing and contouring



Magnetic Resonance