RT Dot Engine

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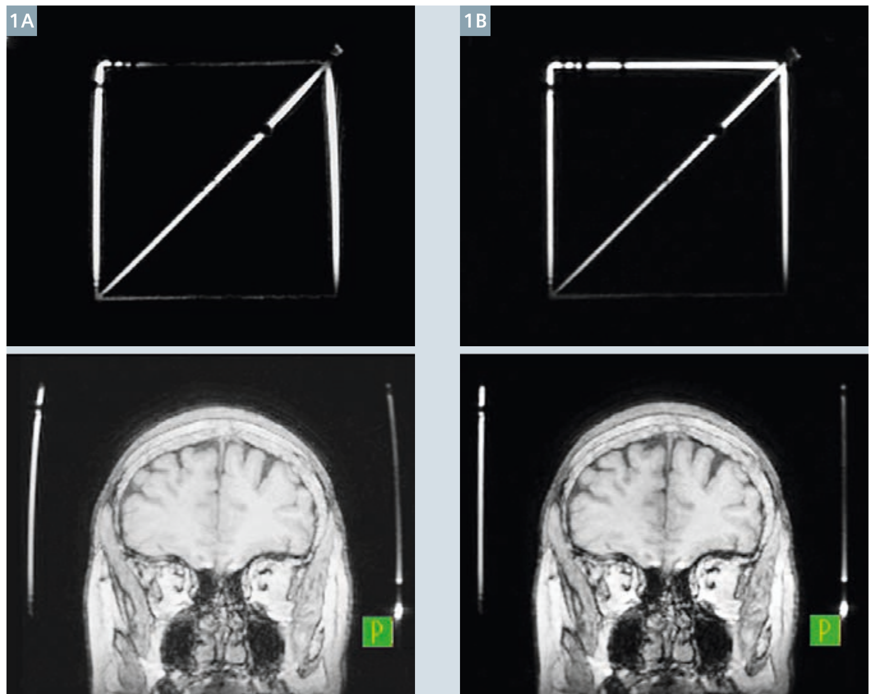
Background

Magnetic resonance imaging (MRI) is based on different *pulse sequences*, a combination of radio-frequency pulses and gradients that are switched on and off according to a specific scheme. The strength, duration, and spacing of these 'building blocks' are defined by imaging *parameters*. This allows the depiction of tissue in various ways, e.g. for the visualization of vessels, fat or edema, and with different spatial and temporal resolution, depending on the concrete clinical question. An imaging *protocol* allows predefined or customized parameter sets to be saved and retrieved [1].

Standard MR imaging protocols for diagnostic purposes are typically not optimized to meet the requirements of radiation therapy (RT), but can be adjusted for high spatial integrity, isotropic voxels and reduced susceptibility to motion artifacts via the underlying imaging parameters. To do so, however, the user had to be familiar with the complex system of parameters and their mutual interference up to now [2].

RT Dot Engine

With the RT Dot[1] Engine, a comprehensive package became available addressing specifically the requirements of MR imaging for radiation therapy. The imaging protocols it provides have been developed in collaboration with RT departments experienced in using MR, in particular the group of Prof. James Balter (Michigan University, Ann Arbour, USA). Features like automatic axial image reconstruction and 'one click' integration of external laser bridges are easily accessible. All protocols in the RT Dot Engine were carefully optimized to improve spatial integrity, e.g. via high bandwidths [2] and automatic 3D distortion correction (Fig. 1). In the "Dot mode", only a limited set of routine geometry parameters is shown to the user (Fig. 2), while the "Detail mode" provides full access to imaging parameters. The product features different predefined strategies for brain and head & neck imaging and a protocol to perform external Laser QA (Fig. 3). Using this technology, Radiation Oncology staff can perform MR exams in a reliable and reproducible way. Furthermore, pictograms and hints that exemplary show how to plan an exam can be used to guide less MR-experienced users troughout the workflow. More advanced customers can use the dedicated RT Dot AddIns to build their own RT Dot Engines for other body regions. To support this, Siemens has a team of MR application specialists specifically trained for RT.



1 Left column **(1A)** shows uncorrected MR images with distortions due to gradient non-linearity. In the right column **(1B)**, these distortions are automatically corrected with 3D distortion.

One click integration of external lasers

After patient preparation and positioning with MR compatible immobilization accessories, an external laser bridge (DORADOnova, LAP, Germany) can be used to exactly define the target position on the patient's body. In the past, the technologist had to perform this step with the built-in laser crosshair of the MRI system again; a handicap of the workflow and a source of inaccuracy. Now, a Dot AddIn takes care with 'one click' ("Laseroffset-Scan", see Fig. 3) that the position defined with the external laser beam directly goes to the center of the magnet where imaging conditions are optimal. One enabler of this technology is the ±0.5 mm positioning accuracy of the Tim Table[2].

2 User interface shows the predefined scan strategy for a brain exam with the RT Dot Engine. The queue with RT protocols is displayed in the lower half to the left. In "Dot mode" a limited set of geometry parameters is displayed on the right side to adapt scanning to patient's anatomy. By clicking the magnifying glass symbol in the lower right corner you can access and define all imaging parameters on expert level.

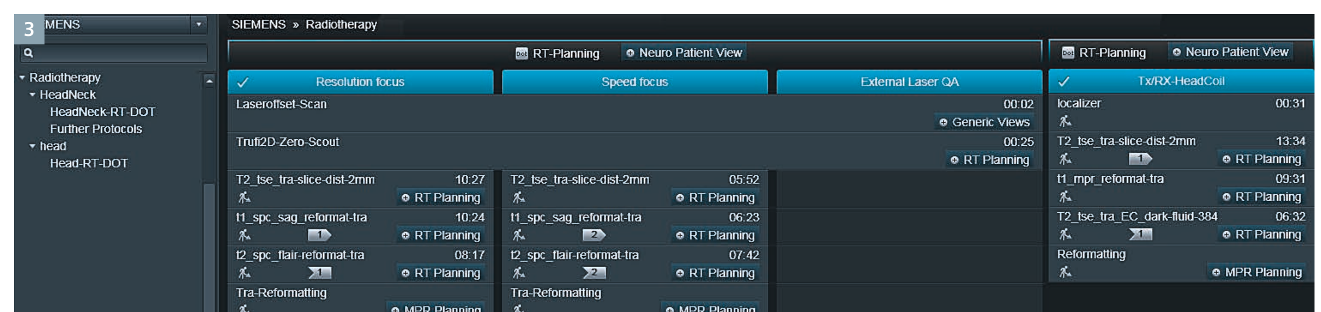
Fine structured scanning and spatial integrity

Imaging in the treatment position with thermoplastic masks and other equipment requires the use of flexible surface coils. Two such coils wrapped around the patient's head form an '8-channel head coil' providing 17% increase in signal-to-noise-ratio (SNR) compared to a setup with two loop coils positioned left and right of the skull. Nonetheless, the received SNR is still approximately 25% higher with a dedicated 20-channel head & neck coil.

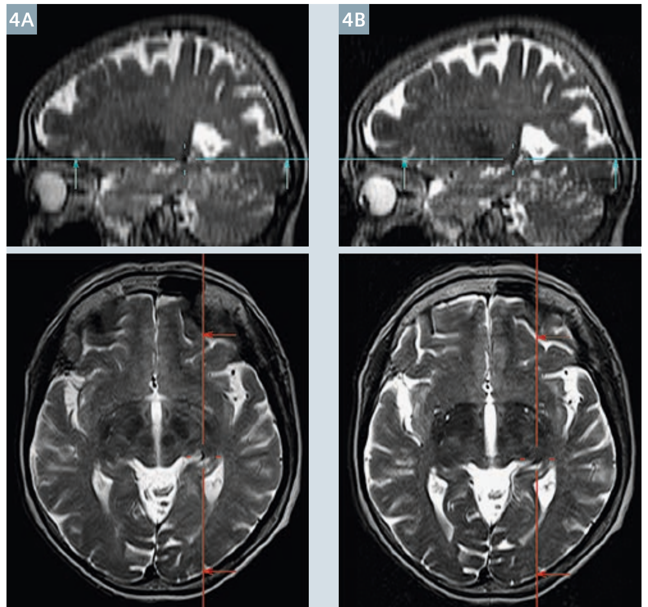
To address this challenge, the RT Dot Engine allows acquisition of two interleaving datasets with an overlap ('negative distance factors') of the neighboring slices. To give an example: 3 mm slice thickness and a negative distance factor of 50% corresponds to an effective interslice distance of only 1.5 mm. This technique of fine structured 2D scanning not only improves the SNR of reconstructed images, it also supports 3D reformatting capabilities (Fig. 4)

3D imaging and automatic axial image reconstruction

A majority of imaging protocols in the RT Dot Engine is based on 3D sequences. 3D images inherently provide superior SNR compared to 2D imaging, allow for isotropic voxel size and can be reformatted in any desired orientation. From the point of MR physics it is sometimes beneficial to acquire these datasets with non-axial slice orientation. For some therapy planning systems, however, axial image orientation is mandatory.

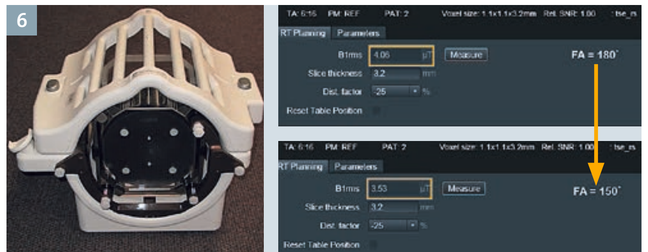


3 Scan strategies within the RT Dot Engine for MAGNETOM Skyra [204x48].



4 Comparison of a standard axial 2D TSE scan with no gap between the slices **(4A)** and a fine structured 2D TSE volume scan **(4B)**. These images provide both better SNR and good delineation of anatomical structures along the slice axis. The technique is applicable to every 2D sequence protocol.

5 Screenshot of multiplanar reconstruction (MPR) planning AddIn. Assigned image data sets (here: 4 t1_spc_sag_reformat_tra and 5 t2_spc_flair_reformat_tra) are automatically reconstructed according to the defined parameters.



6 Left: Coordinate Frame G inside a Tx/Rx (transmit/receive) head coil. By clicking "measure" the B1 rms value for a protocol is calculated. In the example shown here, the flip angle, which correlates with the power of the applied refocusing RF pulses was reduced from 180° to 150° resulting in a respective decrease of the applied average RF power.

In the RT Dot Engine an AddIn ensures that axial images are automatically reconstructed in a predefined way which then can be sent to the planning system (Fig. 5). If a user always wants to have 1.5, 3 and 6 mm axial slices, for example, this can be defined via a respective preset.

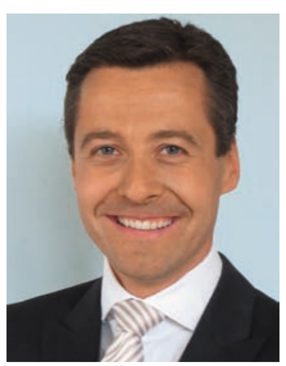
B1 rms calculation

Some radiation therapy scenarios involve the use of special equipment, like dedicated stereotactic head-frames to fixate the patient's skull. For some devices special regulations exist, i.e. to operate these devices with protocols under restricted RF-deposition in order to reduce the risk of heating during imaging[3]. The functionality "B1 rms" (Root mean square of the B1 field) enables easy access to SAR (specific absorption rate) deposition with a specific imaging protocol (Fig. 6). Before starting the actual measurement, the user can verify if certain safety conditions are fulfilled and change imaging parameters if necessary.

References

1 Rumpel H, et al. How Modules of Imaging Sequences Fit Together: An Overview of Recent Advances in MR Imaging. MAGNETOM Flash #60 (5/2014) p86-92.

2 Graessner J. Bandwidth in MRI? MAGNETOM Flash #52 (2/2013) p122-127. http://www.healthcare.siemens.com/magnetic-resonance-imaging/magnetom-world/clinical-corner/application-tips/bandwidth-mri



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[1] Dot (Day optimizing throughput) includes different features like Dot AddIns to assist the user, standardize procedures and automate recurrent workflow steps.

[2] Specifications MAGNETOM Aera and MAGNETOM Skyra. Datasheet.

[3] Specifications and terms of use are defined and provided by the manufacturer of the equipment.