THE 13th INTERNATIONAL CONGRESS ON MRI &
30th ANNUAL SCIENTIFIC MEETING OF KSMRM &
7th ANNUAL MEETING OF ASMRM

ICMRI & ASMRM 2025

Illuminating the Invisible: Advances in MRI
OCTOBER 31 - NOVEMBER 1, 2025
Grand Walkerhill Seoul, Seoul, Korea
https://icmri.ksmrm.org/2025m/

MR Physics & Engineering 1

SY06-1

A Dual-Mode RF Coil for X-Nuclei MRI Beyond Dual-Tuning Techniques

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X-nuclei MRI provides valuable metabolic and physiological information that cannot be obtained with conventional proton MRI. However, the practical application of X-nuclei imaging is challenged by its inherently low signal-to-noise ratio, necessitating high-resolution proton anatomical reference for accurate localization. To eliminate the need for patient repositioning and subsequent image co-registration, a single RF coil capable of operating at both proton and x-nucleus frequencies is required.

Conventional dual-tuning techniques—such as active switching, four end-ring birdcage configurations, and frequency-blocking or frequency-shifting trap circuits—enable dual-frequency operation but are associated with notable drawbacks. These include sensitivity reduction due to forward-biased diodes, limited patient accessibility, performance degradation, and increased circuit complexity. Such factors may compromise both overall efficiency and reliability. Moreover, most conventional designs inherently involve a trade-off, where optimization at one resonance frequency diminishes performance at the other.

The dual-mode RF coil provides an advanced approach to address these limitations. By employing a single resonant structure—such as a birdcage coil—it intrinsically generates two distinct frequency modes without requiring active components. The dual-mode RF coil can be independently tuned to two different resonant frequencies, and its design is applicable across both small and large frequency separations. This self-isolated dual-mode configuration minimizes performance degradation at both proton and x-nucleus frequencies, thereby avoiding the compromises common to conventional dual-tuning methods. The combination of structural simplicity, passive operation, and robust dual-frequency performance establishes the dual-mode coil as a highly reliable and efficient platform for multinuclear applications.

Keywords: *X-nuclei imaging, Dual-tuned RF coil, Dual-mode RF coil*