



Application Note: Field-Cycling NMR Illuminator for Shuttle Photo-CIDNP

Introduction

For laboratories equipped with a **High-Field Field-Cycler (HFFC)**, the Field-Cycling NMR Illuminator adds a critical third dimension to relaxometry experiments: light. By combining rapid sample shuttling with in-situ irradiation at variable stray fields, researchers gain access to field-dependent photo-CIDNP — a capability unavailable with fixed-field illumination alone.

This Application Note covers the FC-illuminator as an add-on to the HFFC. For fixed-field photochemistry applications, see also: **Application Note — In-situ NMR Illuminator for Fixed-Field NMR**.

Core Technology: Shuttle-Illumination Mechanism

The FC-illuminator is mounted directly onto the HFFC shuttle rail, with an adjustable position along the stray field axis. This design enables two key capabilities that distinguish it from conventional laser/fiber optic setups:

- **No optical fiber during shuttling:** Unlike fiber-coupled laser systems, the FC-illuminator irradiates the sample at the stray field position without attaching a fiber to the NMR tube. The sample moves freely between the illumination spot and the acquisition center, preserving full shuttling speed and precision.
- **Variable irradiation field:** The illumination position along the stray field can be adjusted, allowing researchers to select the magnetic field strength at which the sample is irradiated. This is essential for field-dependent CIDNP studies, where the polarization enhancement factor varies strongly with field.
- **Non-coherent LED source:** LED-based illumination delivers homogeneous, interference-free irradiation — eliminating the uneven light distribution common with coherent laser sources.

Key Advantages over Laser/Fiber Setups

- **No power loss from fiber transmission:** LEDs positioned proximal to the sample eliminate the significant optical losses inherent in long fiber paths used in laser setups.
- **Simplified synchronization:** Illumination timing is controlled via TTL trigger, fully synchronized with the HFFC shuttle motion and NMR pulse program through a single GUI — no separate laser control hardware required.
- **Lab safety:** LED sources operate at lower safety classification than high-power lasers, reducing lab safety requirements.
- **Exclusive to HFFC:** The FC-illuminator is designed specifically as an add-on to the HFFC and cannot be replicated with a standard fixed-field illuminator.



Primary Scientific Applications

Field-Dependent Photo-CIDNP

The primary application of the FC-illuminator is measuring the **magnetic field dependence of the photo-CIDNP effect**. By irradiating the sample at different stray field positions during the shuttle cycle, researchers can map how the CIDNP enhancement factor varies across a wide field range — providing mechanistic insight into radical-pair dynamics that fixed-field experiments cannot capture.

Radical-Pair Mechanism (RPM) Studies

The combination of variable field and light activation allows precise investigation of spin-correlated radical pair behavior. Researchers can probe the interplay between singlet-triplet mixing rates and magnetic field strength, yielding quantitative parameters for radical-pair kinetics and hyperfine interactions.

Metabolic Pathway and Biomolecular Photochemistry

Shuttle photo-CIDNP enables selective signal enhancement of aromatic amino acid residues (Tryptophan, Tyrosine, Histidine) at **nanomolar to micromolar concentrations**, which is far below the detection threshold of conventional NMR. This makes it a powerful tool for studying protein surface accessibility, folding intermediates, and light-driven biochemical processes.

Technical Specifications

- **Illumination position:** Adjustable along the HFFC shuttle rail, covering the stray field range of the host spectrometer.
- **Light source:** High-power LEDs; available wavelengths match the In-situ NMR Illuminator portfolio (Royal Blue 450 nm, Blue 475 nm, Green 530 nm, Red 625 nm; custom wavelengths available).
- **Contact with sample:** None — no optical fiber is attached to the NMR tube during shuttling.
- **Synchronization:** TTL trigger interface, integrated with HFFC motion control and NMR pulse program via FCNMR GUI.
- **Compatibility:** Exclusive add-on to the High-Field Field-Cycler (HFFC). Requires HFFC installation.

Conclusion

The Field-Cycling NMR Illuminator extends the HFFC from a relaxometry platform into a full photochemical research system. For laboratories already operating an HFFC, it is the most direct path to field-dependent photo-CIDNP — opening new experimental dimensions in radical-pair chemistry, biomolecular photochemistry, and hyperpolarization research, without additional infrastructure.

Field Cycling Technology Ltd.

<http://www.fcnmr.com>



See also: **Application Note — High-Field Field-Cycler (HFFC) for Advanced Relaxometry and Spin Dynamics** | **Application Note — In-situ NMR Illuminator for Fixed-Field NMR.**

Contact Information: For technical consultations or demonstration requests, please contact: shuttle@fcnmr.com | www.fcnmr.com