

Process Monitoring of an Intensified Continuous Production Unit with Compact NMR Spectroscopy

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NMR Basics

NMR stands for **N**uclear **M**agnetic **R**esonance

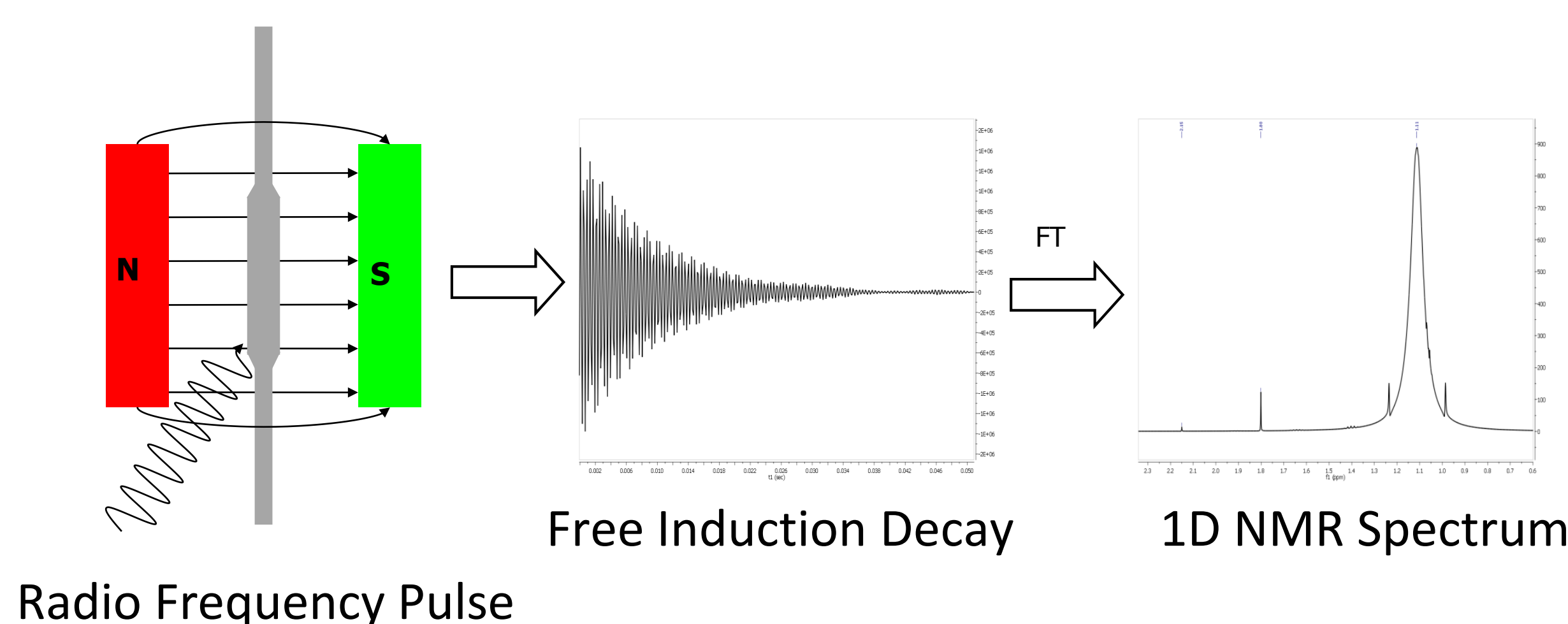


Fig. 1: NMR acquisition scheme

- NMR active nuclei, e.g., ^1H , ^{19}F , ^{31}P , ^{13}C
- Signal intensity in the spectrum is directly proportional to the number of nuclei (Fig. 1)
- High dispersion of signals
- Calibration-free quantification is possible

Field integration of the NMR Unit

The presented NMR Unit is provided in an explosion proof housing (Fig. 2) and involves a compact 43.5 MHz NMR spectrometer together with an acquisition unit for automated data preparation (phasing, baseline correction) and data evaluation. Additionally, a programmable logic controller is implemented for sensor data acquisition (sample throughput, temperature control, triggering of NMR) and data communication.

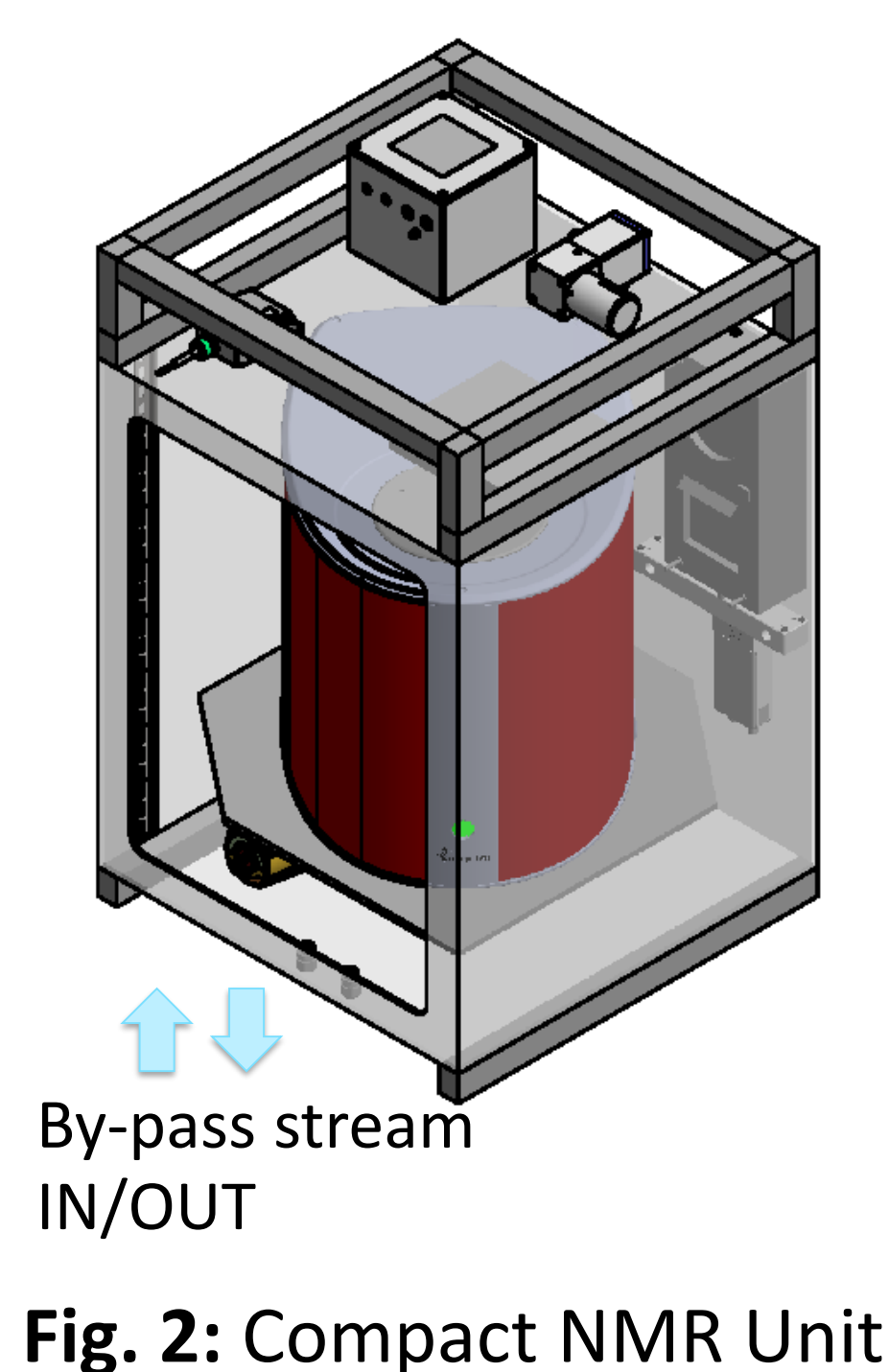


Fig. 2: Compact NMR Unit

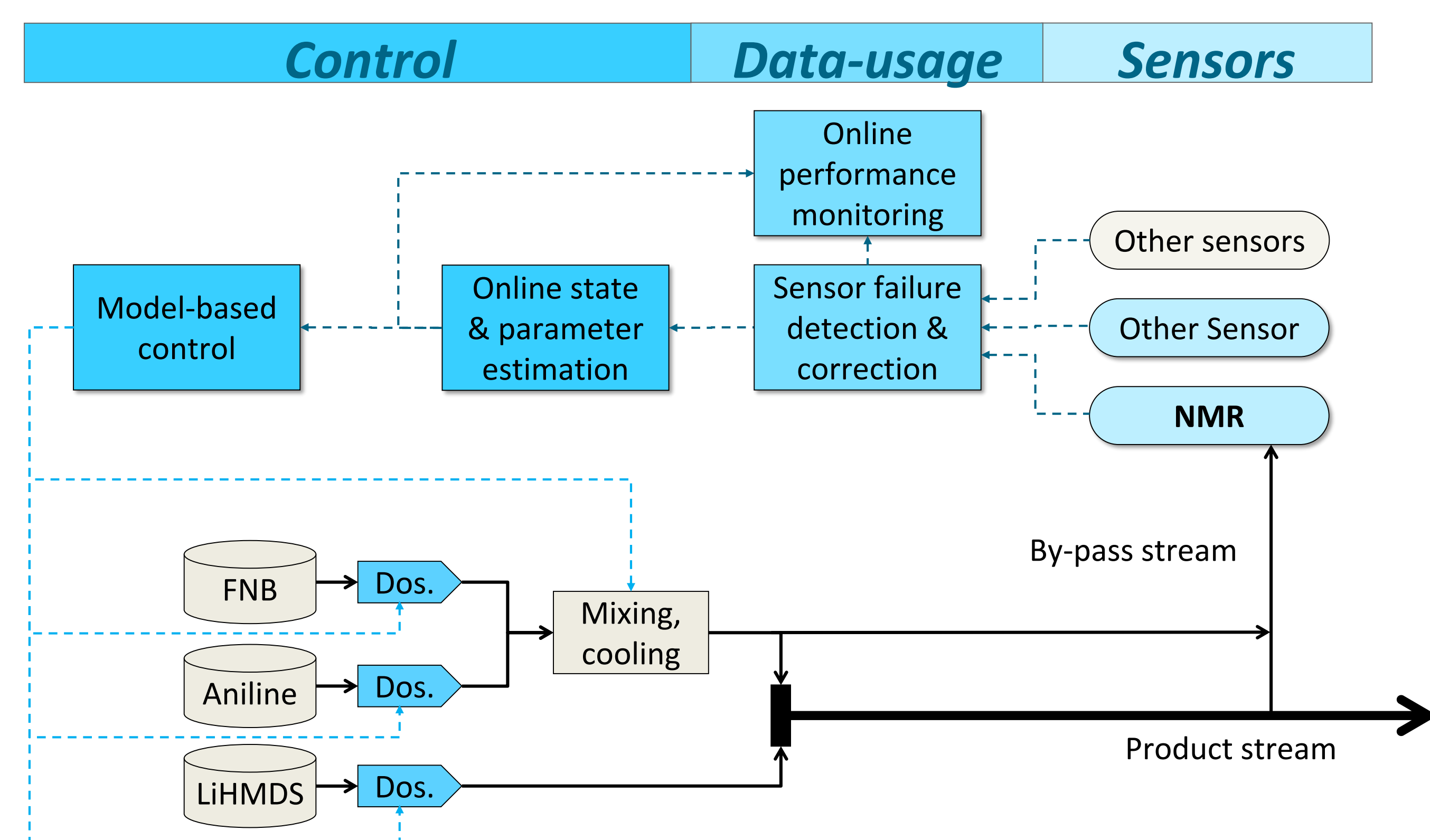


Fig. 3: Concept for process control within a continuous chemical production plant based on an Online NMR Analyzer

Investigated Chemistry

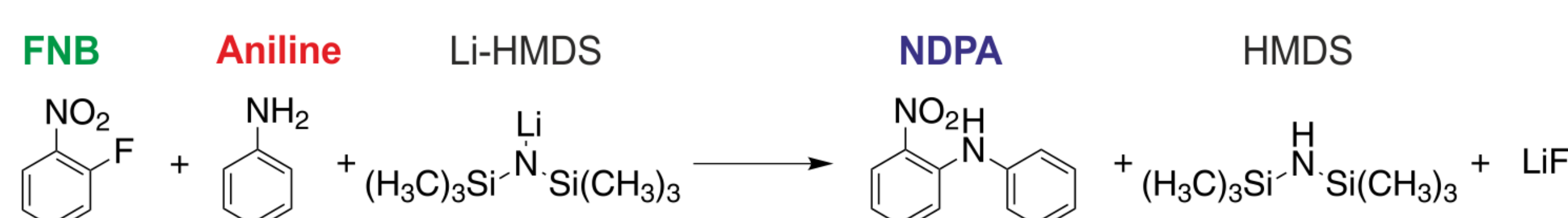
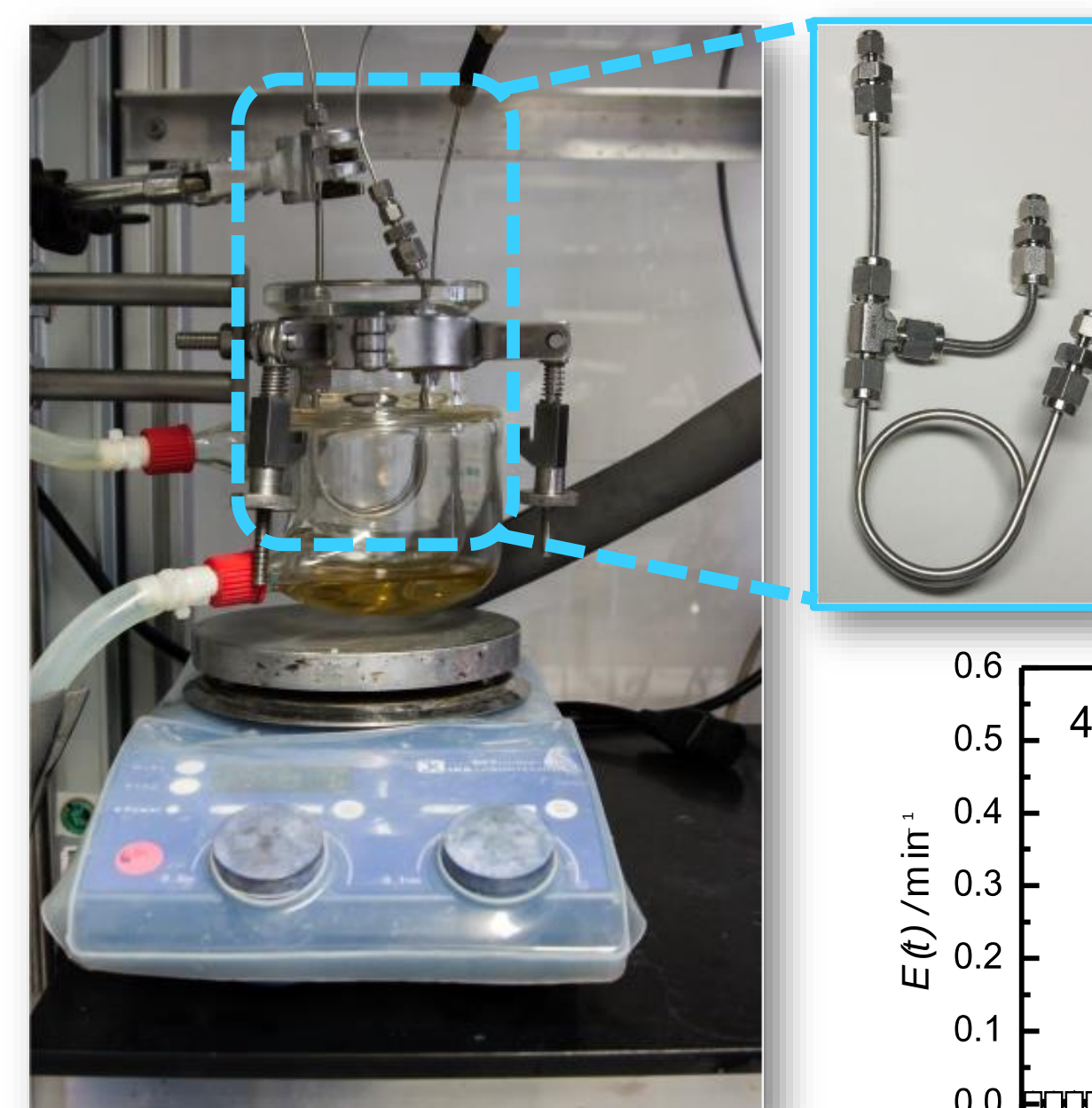


Fig. 4: Coupling of two aromatic compounds initiated by lithiation as an example for a pharmaceutical reaction step.

Experimental set-up



- 1/8" stainless steel reactor
- Temperature controlled
- Syringe pumps for feeds

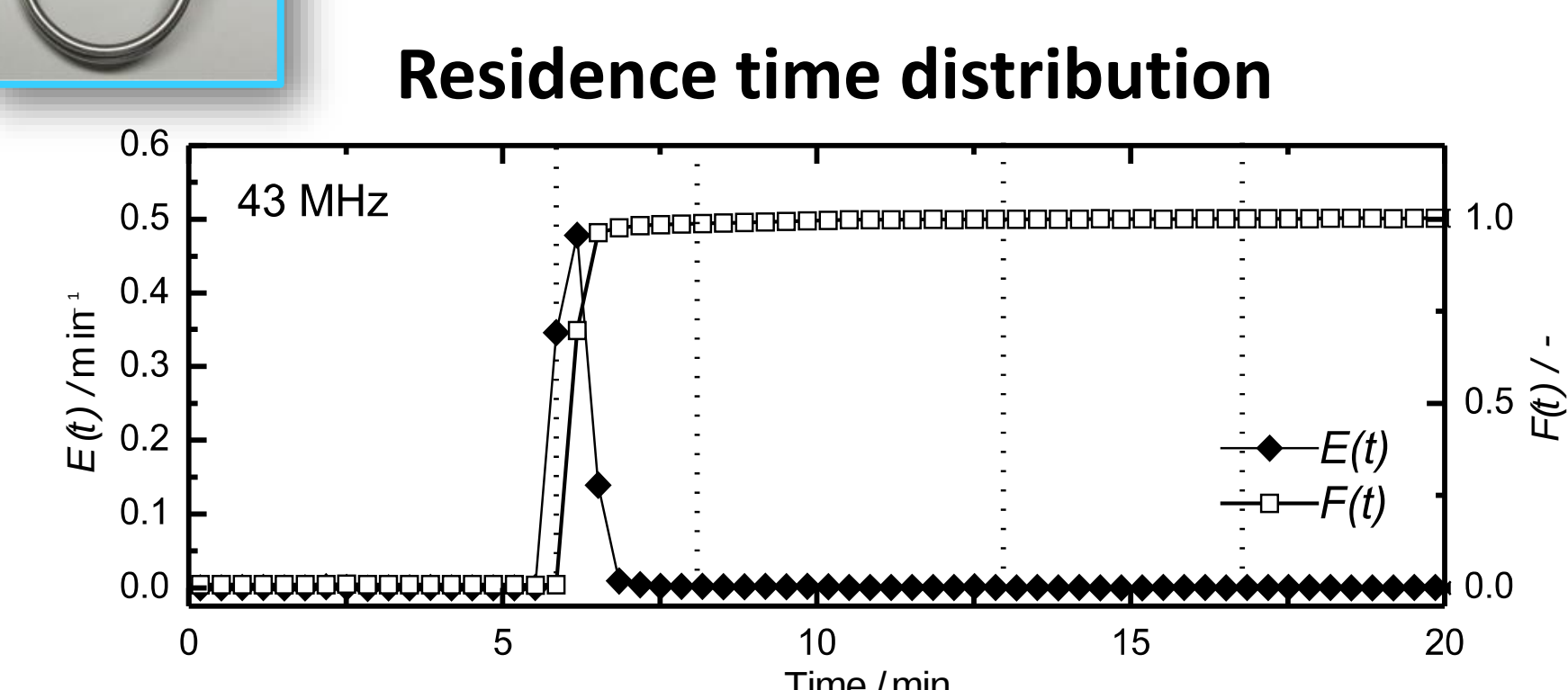


Fig. 5: Tubular reactor in thermostated bath (left), Residence time distribution of low field NMR device is hyphenated in a bypass setup (right).

Results of laboratory experiments

- Reaction was investigated under various stoichiometries by adjustment of feed rates
- Automated data evaluation using spectral modeling

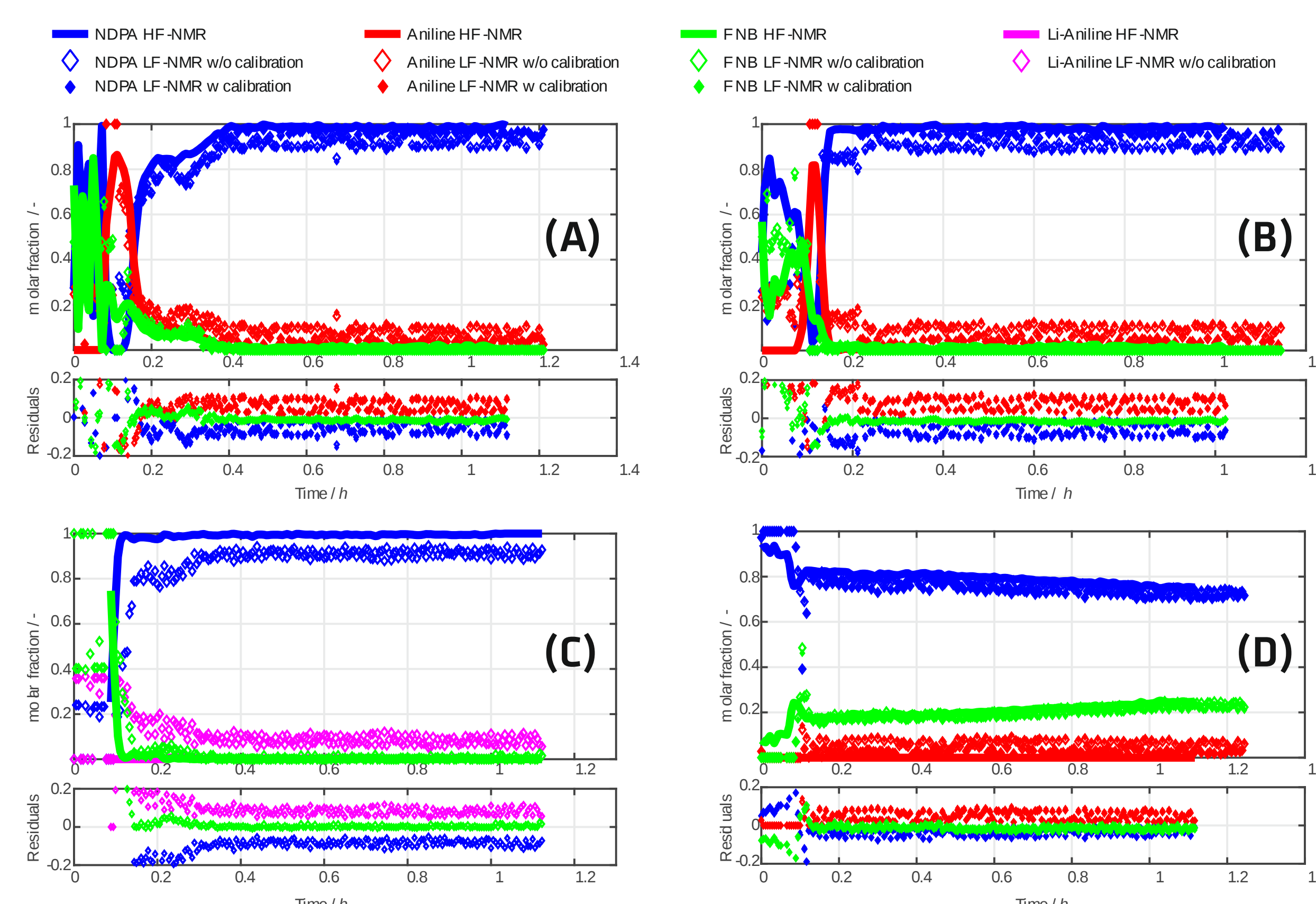


Fig. 6: Results of compact NMR and reference method on process runs at varying excess of Li-HMDS: (A) +20%, (B) -10 %, (C) ideal, (D) +10 %.

Results of laboratory experiments

- Good agreement with reference method (high field NMR)
- Compact NMR is suitable for monitoring the reaction step
- ATEX proof housing is currently in construction

References and Acknowledgements

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