

03.–06.09.2017

EUROSENSORS, Paris, France
Special session II on Sensors for Factory of the future

STRANGERS IN THE NIGHT – SMART PROCESS SENSORS IN OUR CURRENT AUTOMATION LANDSCAPE

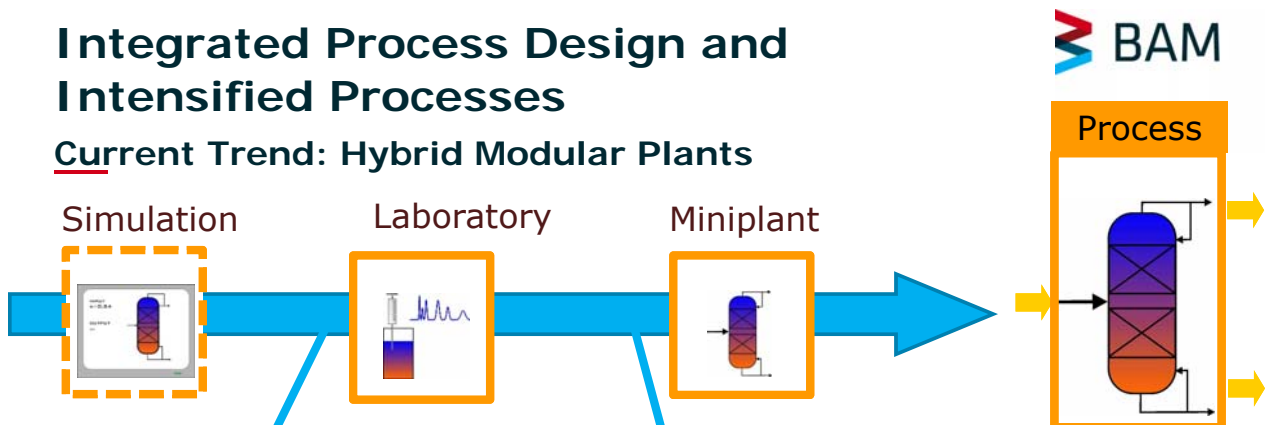
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Svetlana Guhl, Klas Meyer, Simon Kern

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Division 1.4 Process Analytical Technology

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Integrated Process Design and Intensified Processes

Current Trend: Hybrid Modular Plants



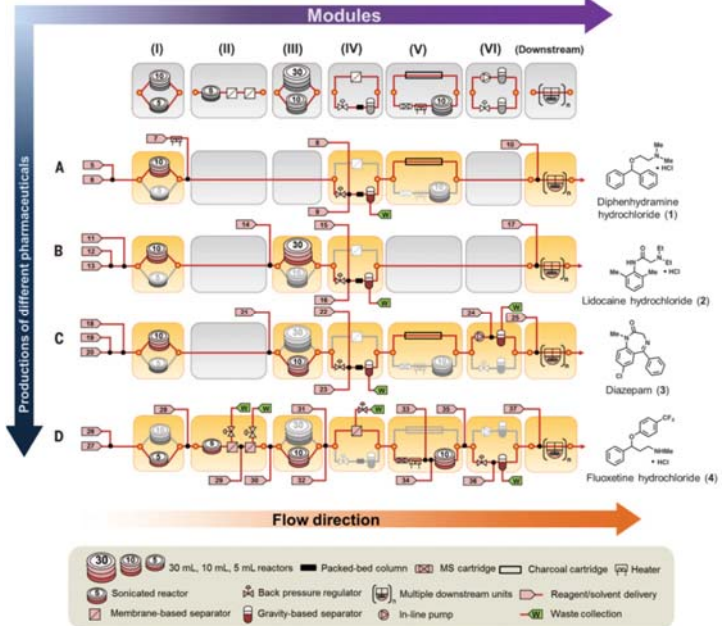
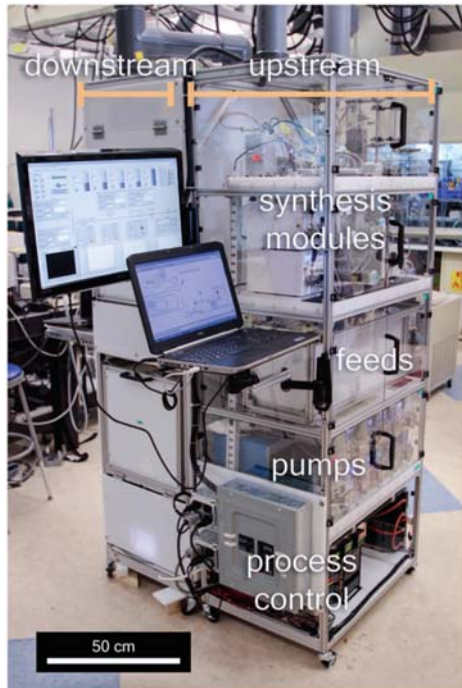
Micro Reaction Technology
(Example: Fraunhofer ICT, Pfinztal/D)



Modular Production
(Example: Foster Wheeler AG, Zug/CH)

Integrated Process Design and Intensified Processes

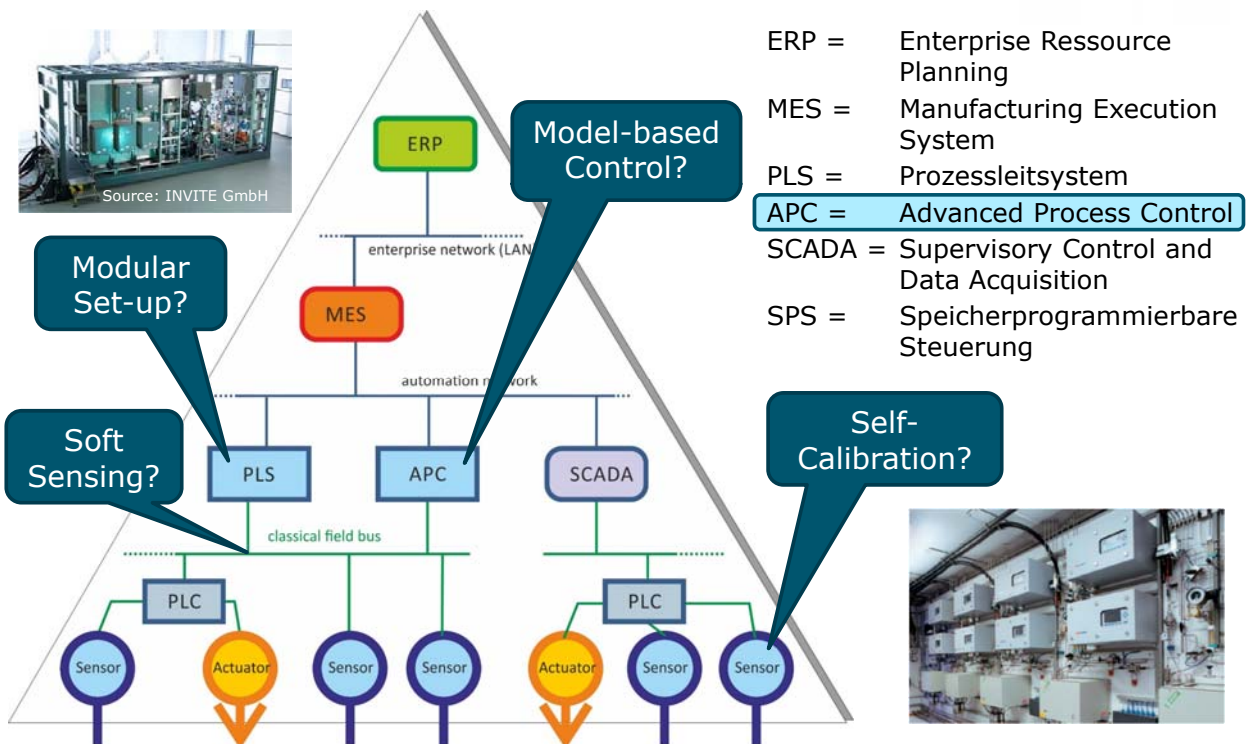
Example: Continuous Flow Production of Pharmaceuticals



A. Adamo, R. L. Beingessner, M. Behnam et al., On-demand continuous-flow production of pharmaceuticals in a compact, reconfigurable system, *Science* 352(6281), 2016, 61-67

Process Automation

The Classical Automation Pyramid → is Outdated!



Current and future requirements to process sensors

Sensors go smart

- Use of „complicated“ sensors has to be simplified towards „plug and play“



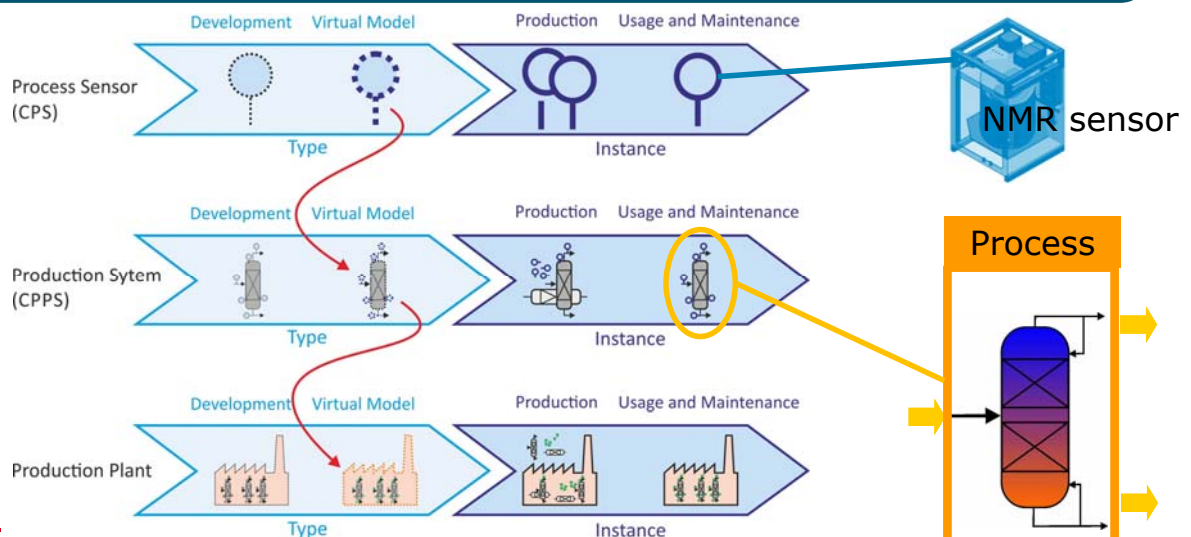
- Smart process sensors are important parts of cyber-physical production systems and generate new business cases for users, instrument manufacturers, and service providers.
- „Smart“ sensors provide services within networks and use information out of the network.

Virtual Description, Simulation

Towards Cyber-Physical Production Systems (CPPS)

“Cyber-Physical Systems (CPS) are integrations of computation with physical processes. Embedded computers and networks monitor and control the physical processes, usually with feedback loops where physical processes affect computations and vice versa”.

E. A. Lee, Cyber Physical Systems: Design Challenges, EECS Department, University of California, Berkeley, 2008

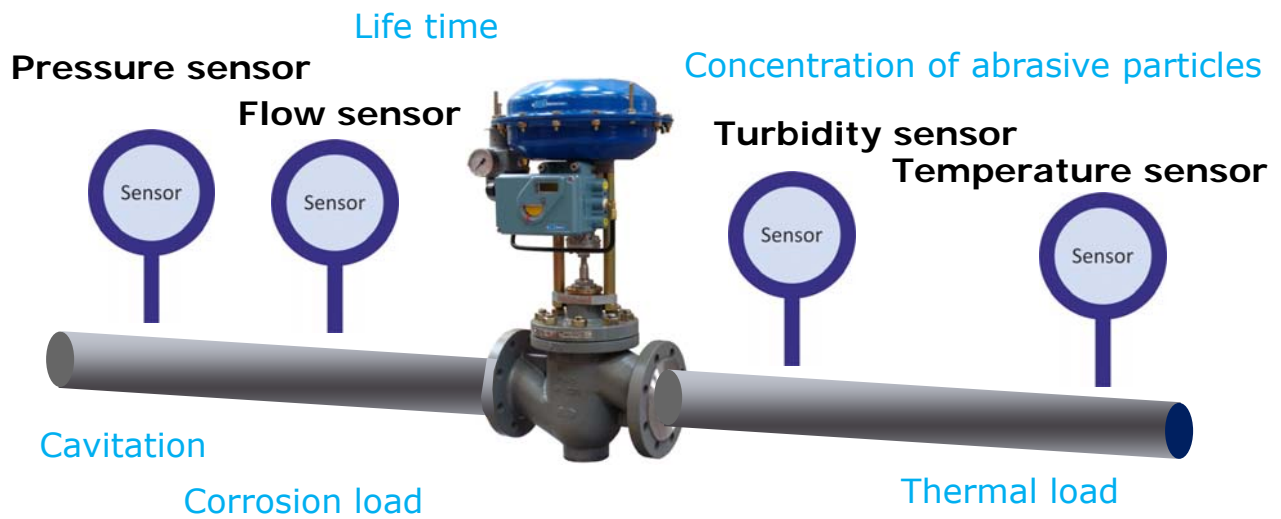


Maintenance and Internal Functions

Example: Revision Planning of Control Valves

Sensors in direct vicinity of valve

Revision schedule

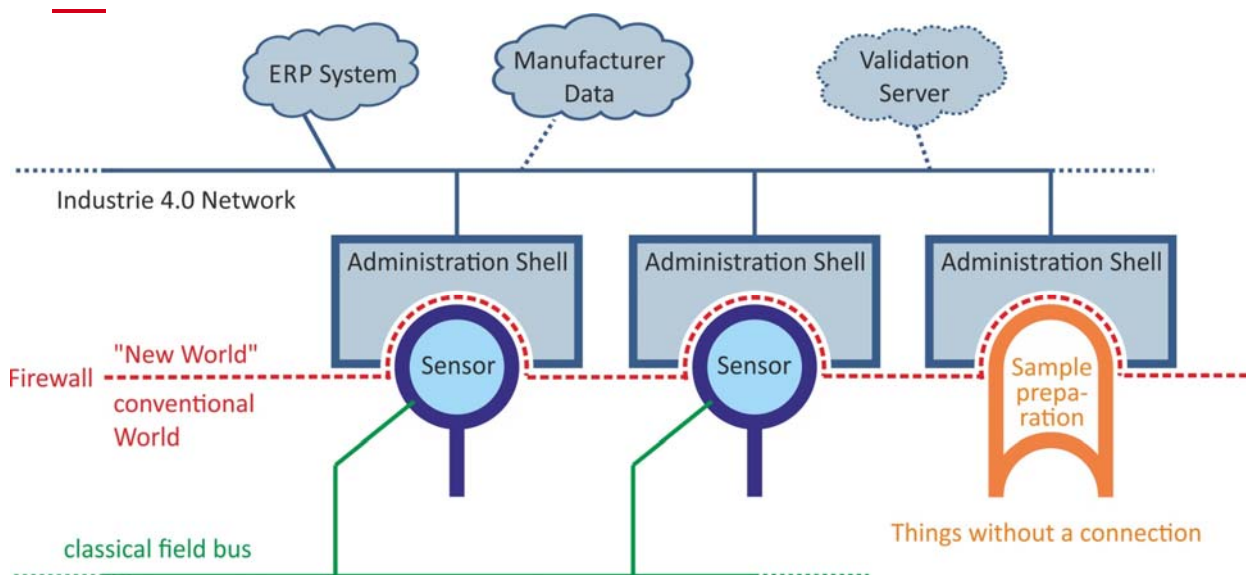


Maintenance actions are directly ordered by Enterprise Resource Planning (ERP) Software



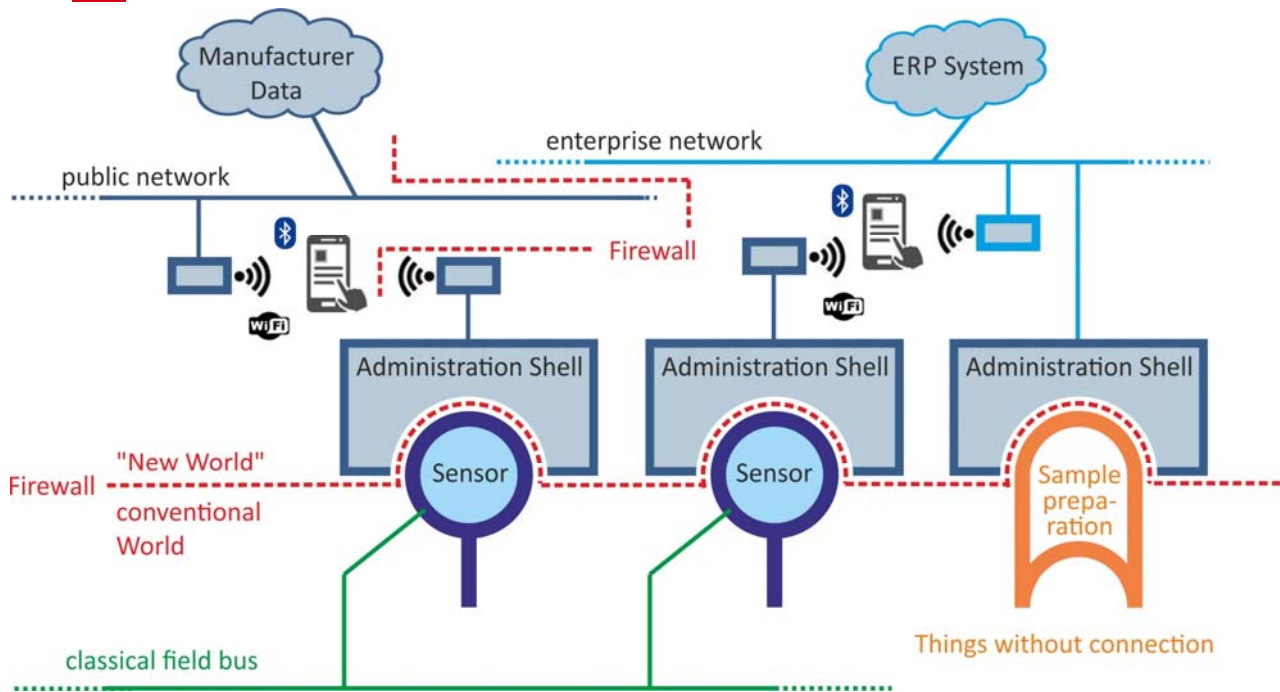
Perspectives

Sensor Image within Industrie 4.0/IIoT Network



Perspectives II

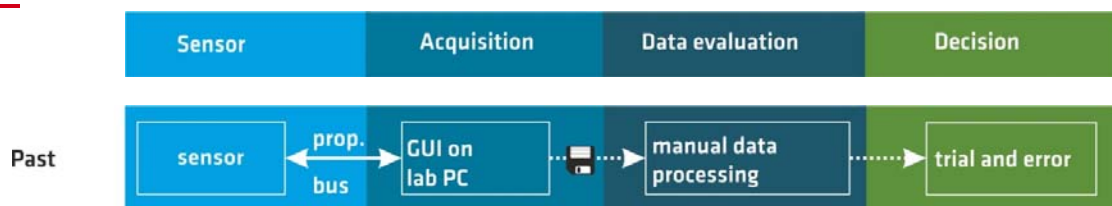
Simplified Programming using Mobile Devices



Perspectives III

From Lousy Interfaces to "Industrie 4.0"

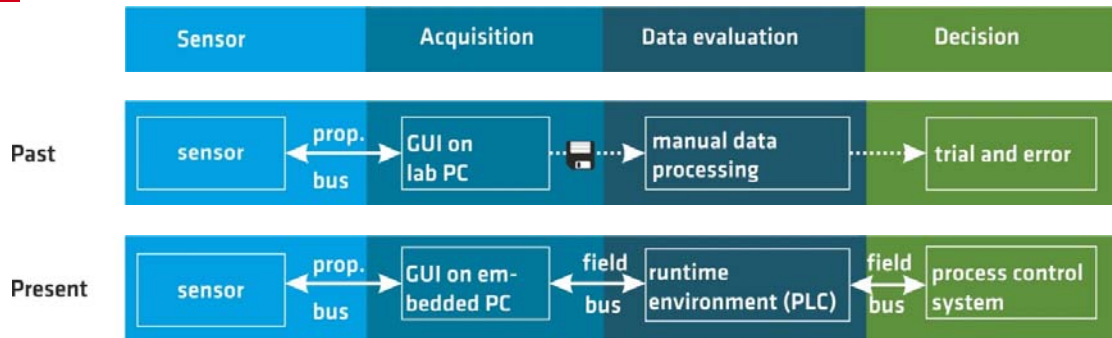
Use of Runtime Environments



Perspectives III

From Lousy Interfaces to "Industrie 4.0"

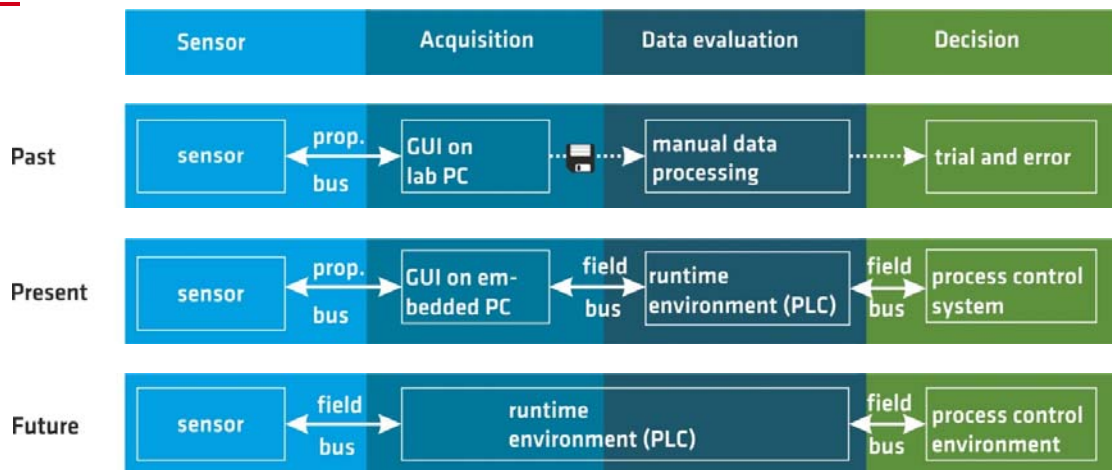
Use of Runtime Environments



Perspectives III

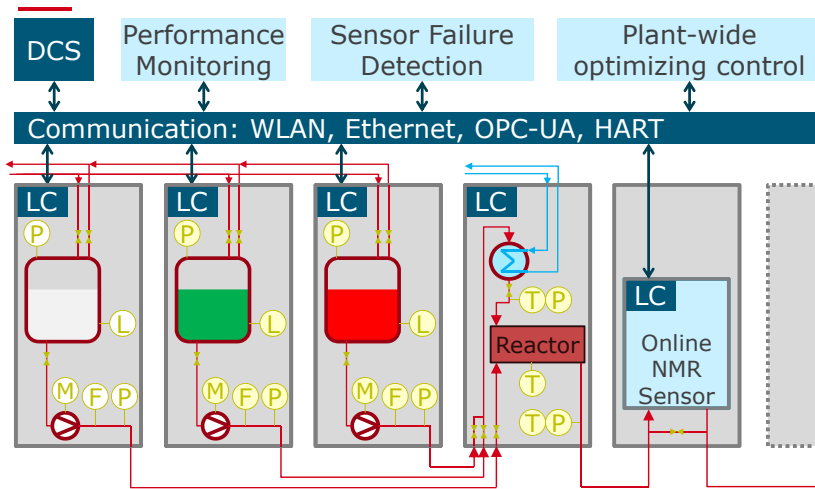
From Lousy Interfaces to "Industrie 4.0"

Use of Runtime Environments



Continuous Lithiation Reaction Set-up

Flexible Intensified Continuous Plant

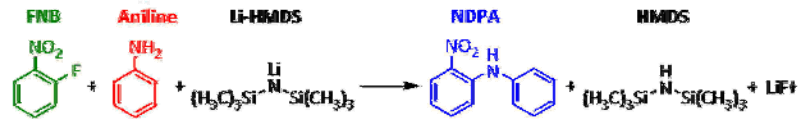


Containerized modular plant
Source: INVITE GmbH

- Standardized plant modules
- "Plug & Produce"
- Miniaturized flexible equipment
- Local control (LC)

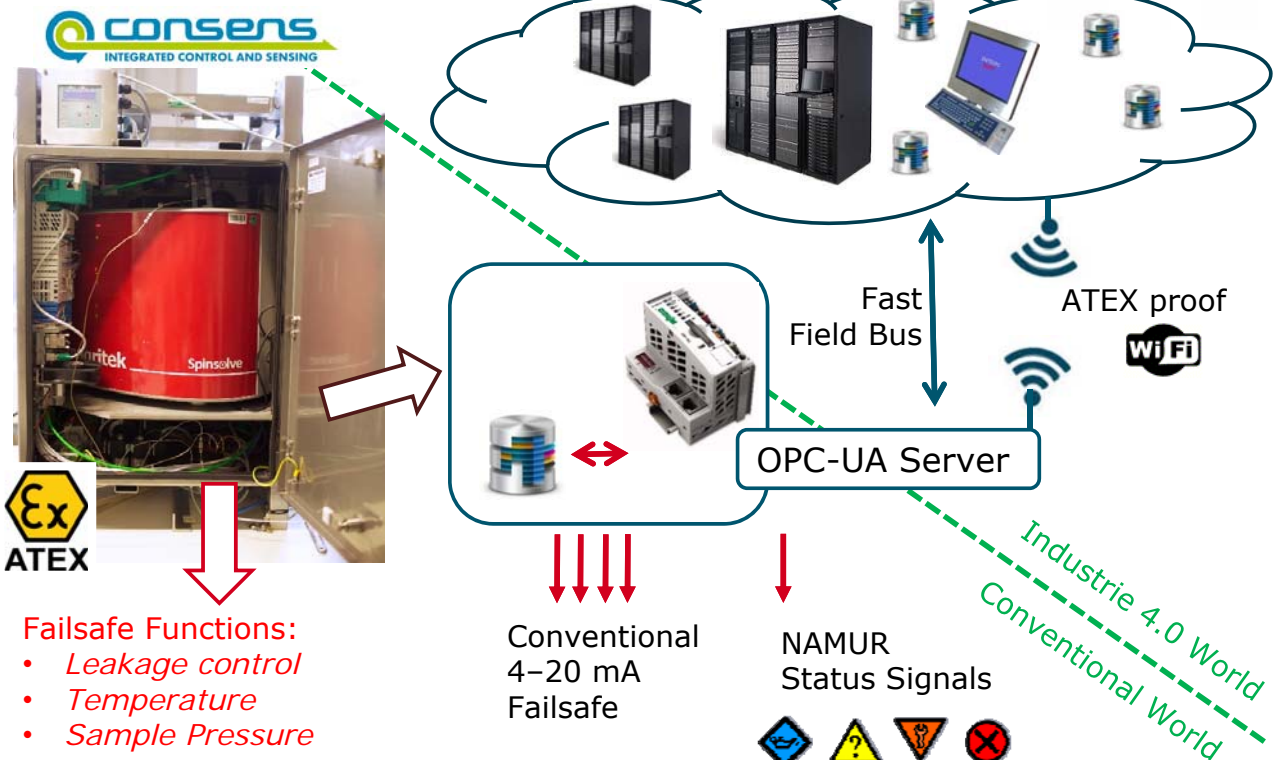
- Fast and complex exothermic reaction
- Hazardous and inflammable substances
→ Explosion protection!
- Prone to fouling & clogging
- Multi-objective constrained optimization

Example: Lithiation reaction



Conventional and Smart Functions

Enabling Runtime Environments



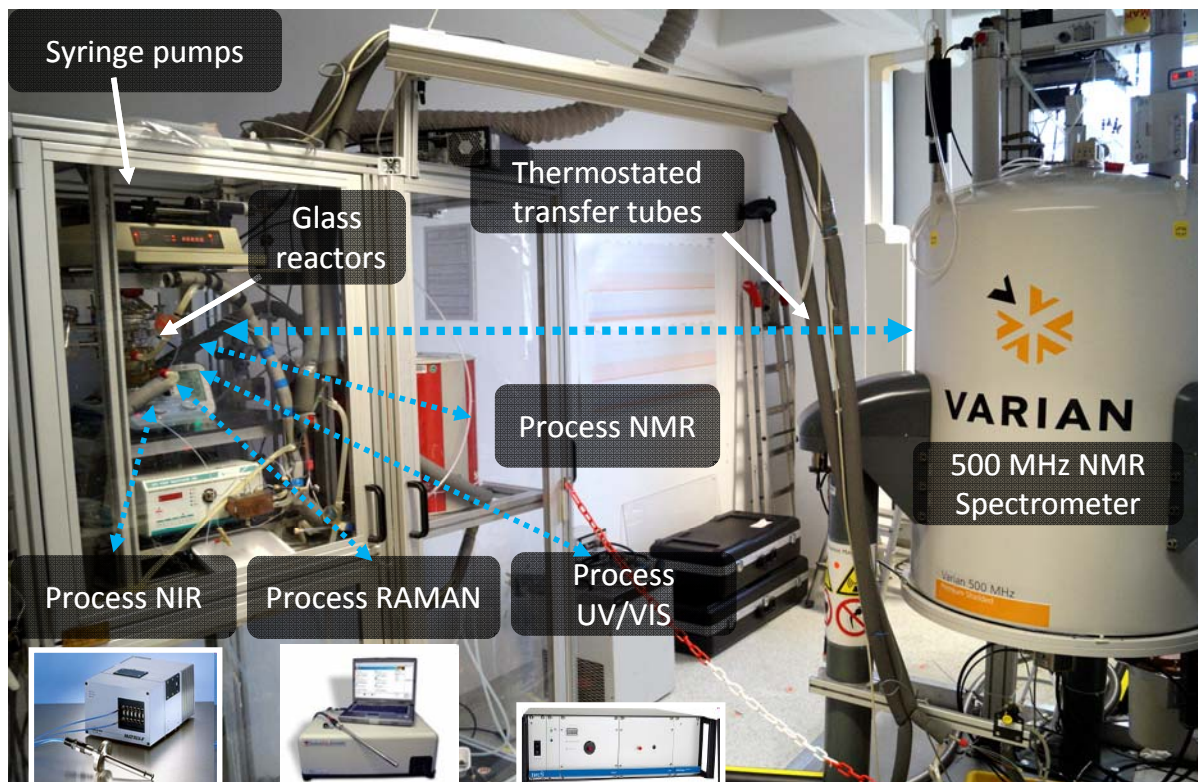
- Failsafe Functions:**
- Leakage control
 - Temperature
 - Sample Pressure

Conventional
4-20 mA
Failsafe

NAMUR
Status Signals



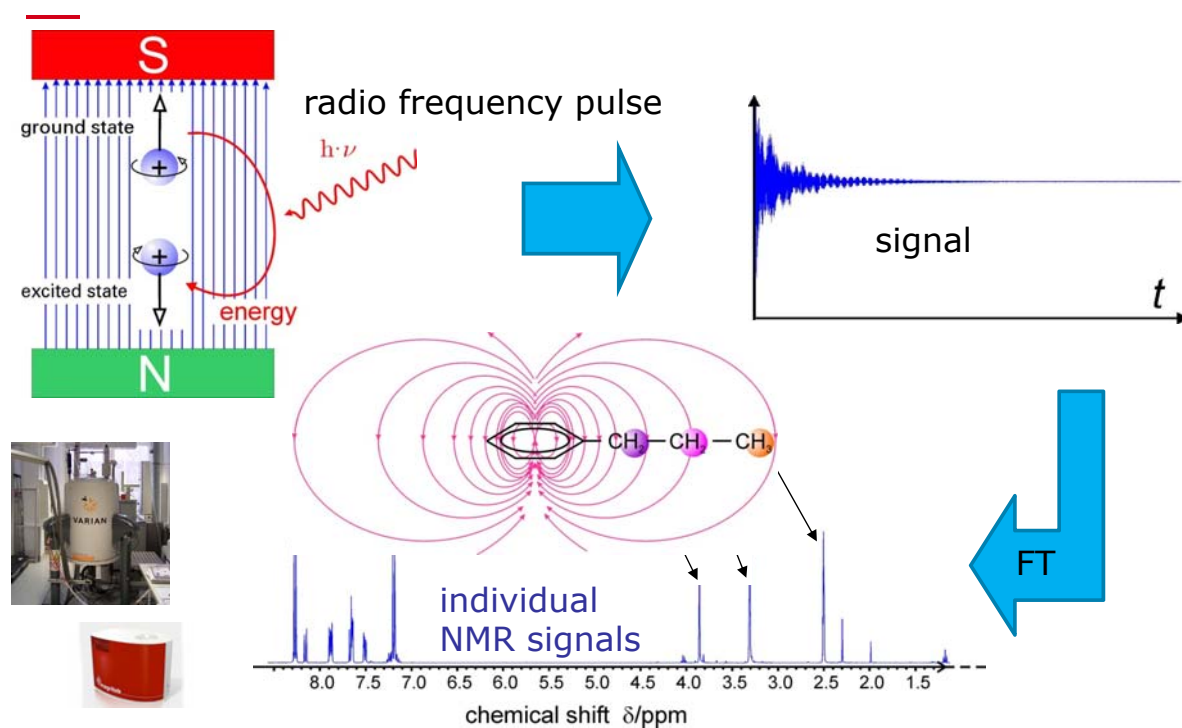
Reaction Monitoring in Lab-scale at BAM



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Nuclear Magnetic Resonance (NMR) Direct Comparison Method → Calibration Free!

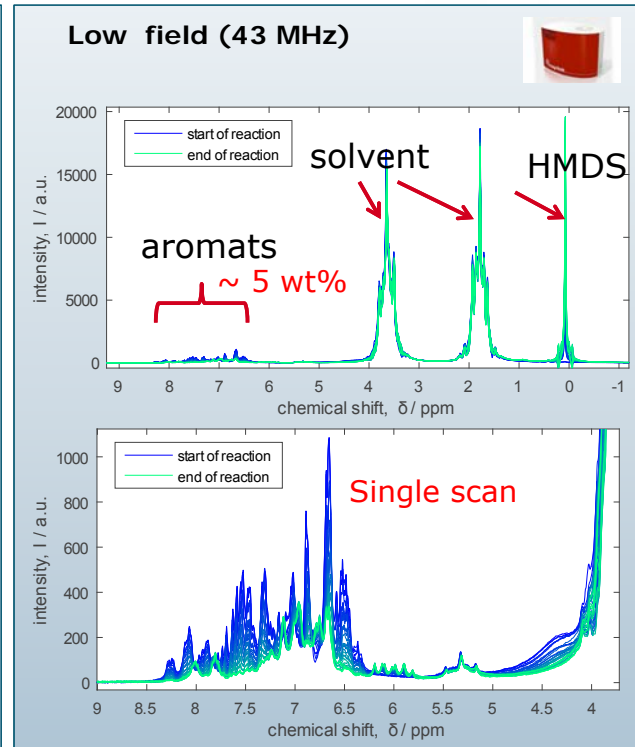
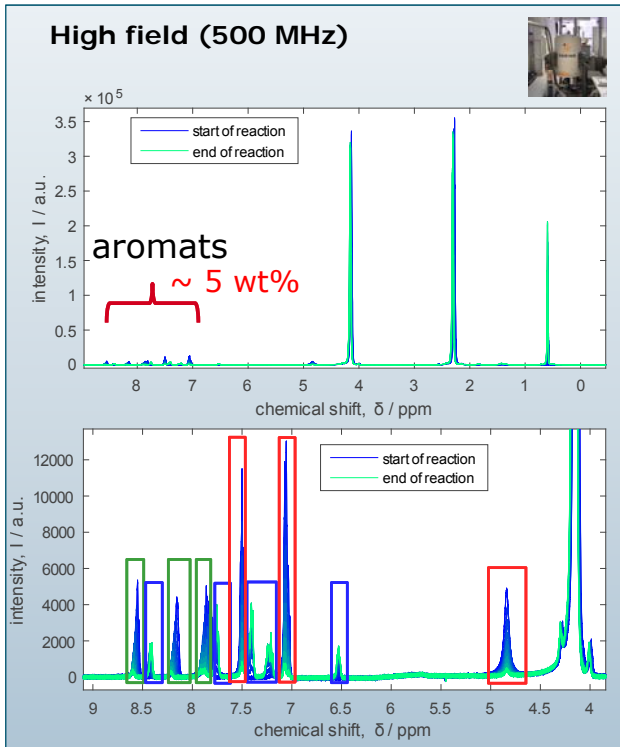


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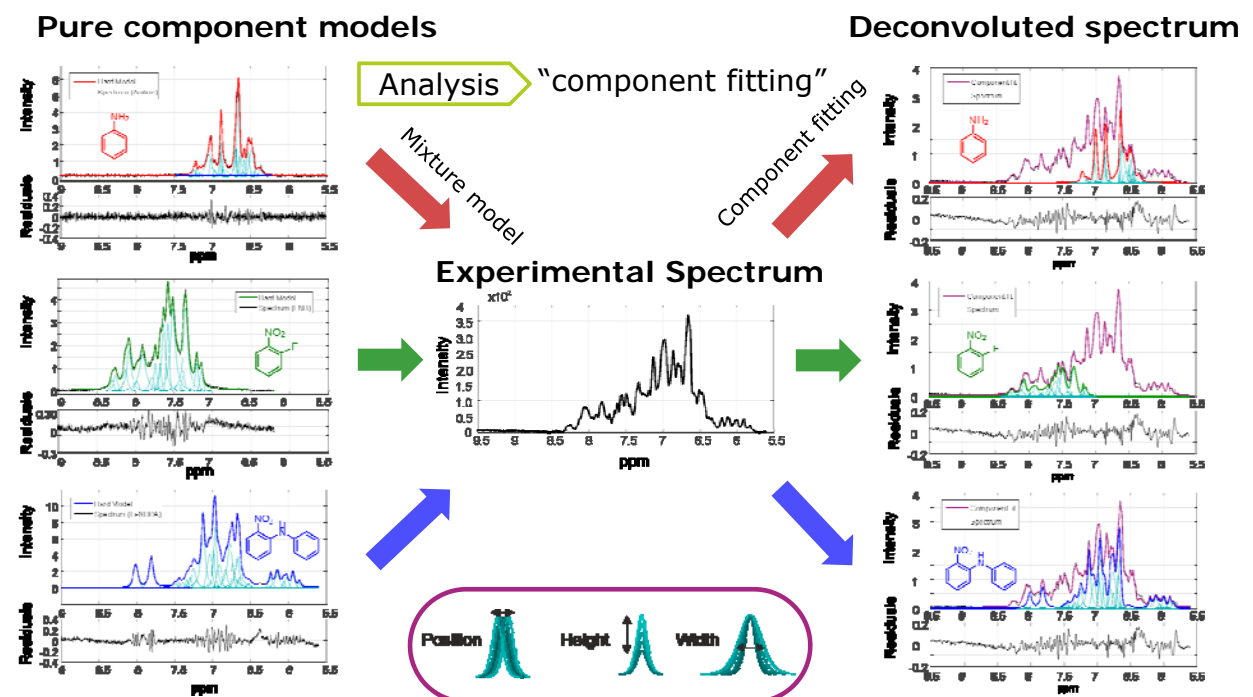
Proton NMR Spectra 500 MHz vs 43 MHz

Lab Experiments in Batch Along Reaction Co-ordinate



IHM – „Component Fitting“

Interpretation of Experimental Data with Pure Components

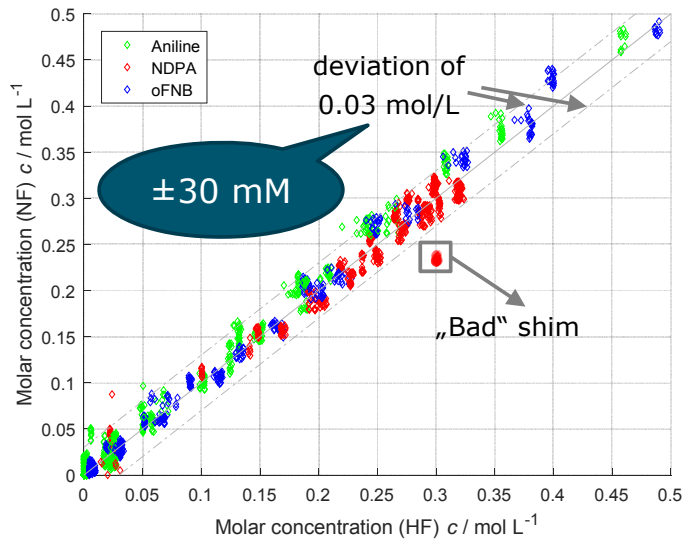


Results: Reaction Characterization

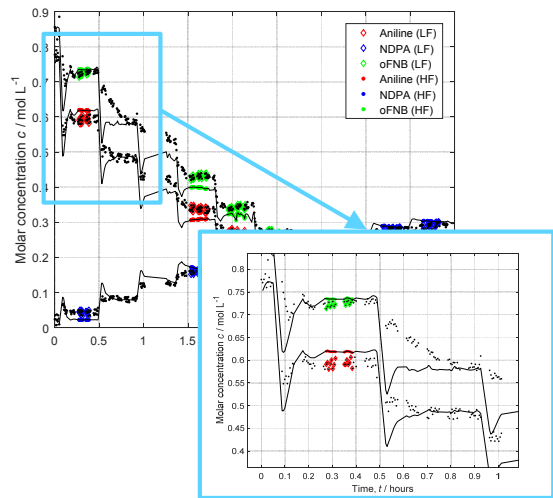
Lab Experiments in Batch along Reaction Co-ordinate

3 semi-batch reaction with varying starting concentrations

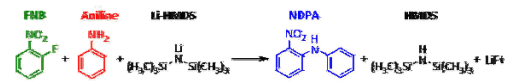
1500 Spectra for each HF- and NF-NMR



Classification of steady states

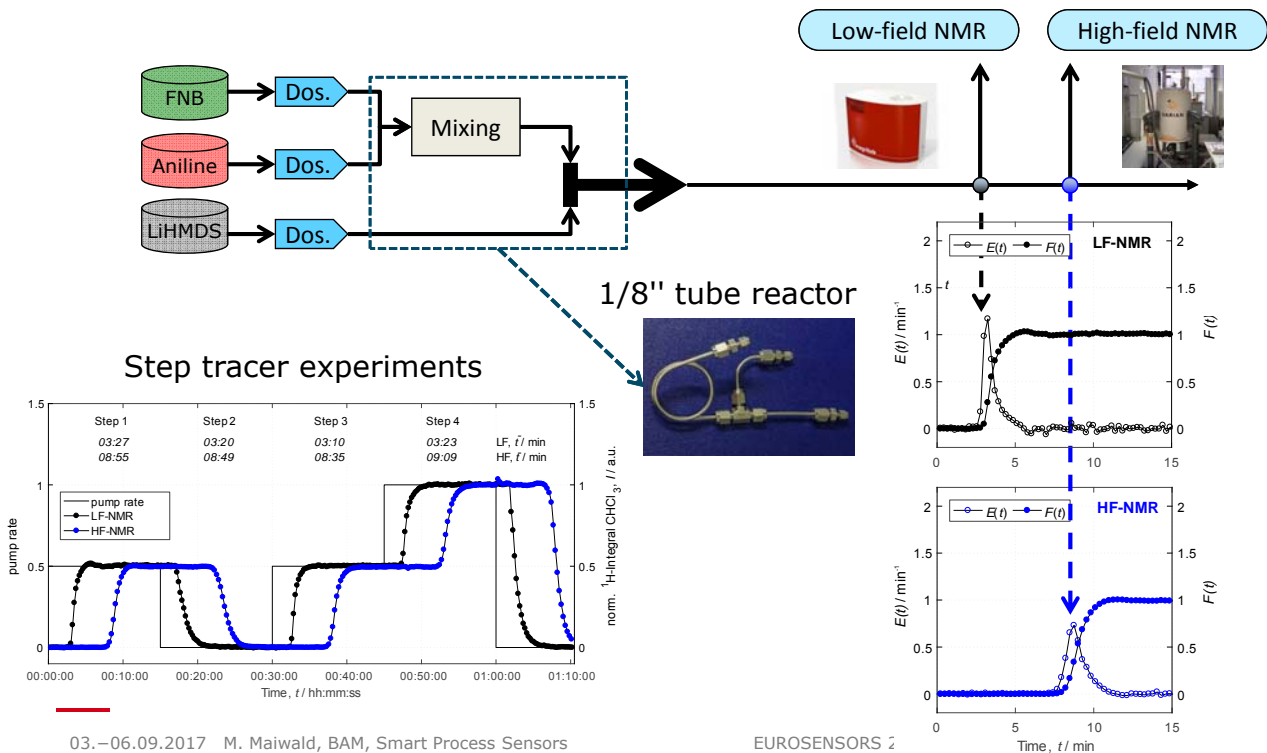


Reaction Scheme:



Validation of Lab Experiments in Tube Reactor

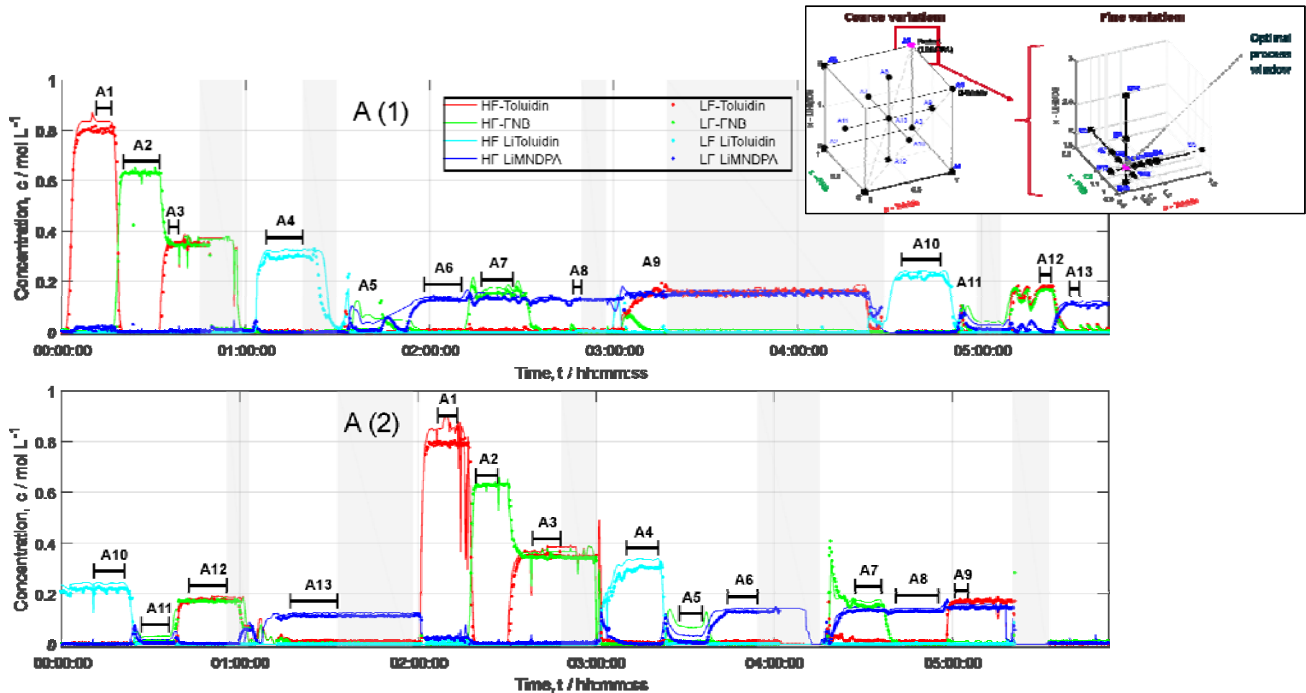
Continuous Lithiation Reaction Set-up at BAM



Validation Instead of Calibration

Variation of Set-Points according to Experimental Design

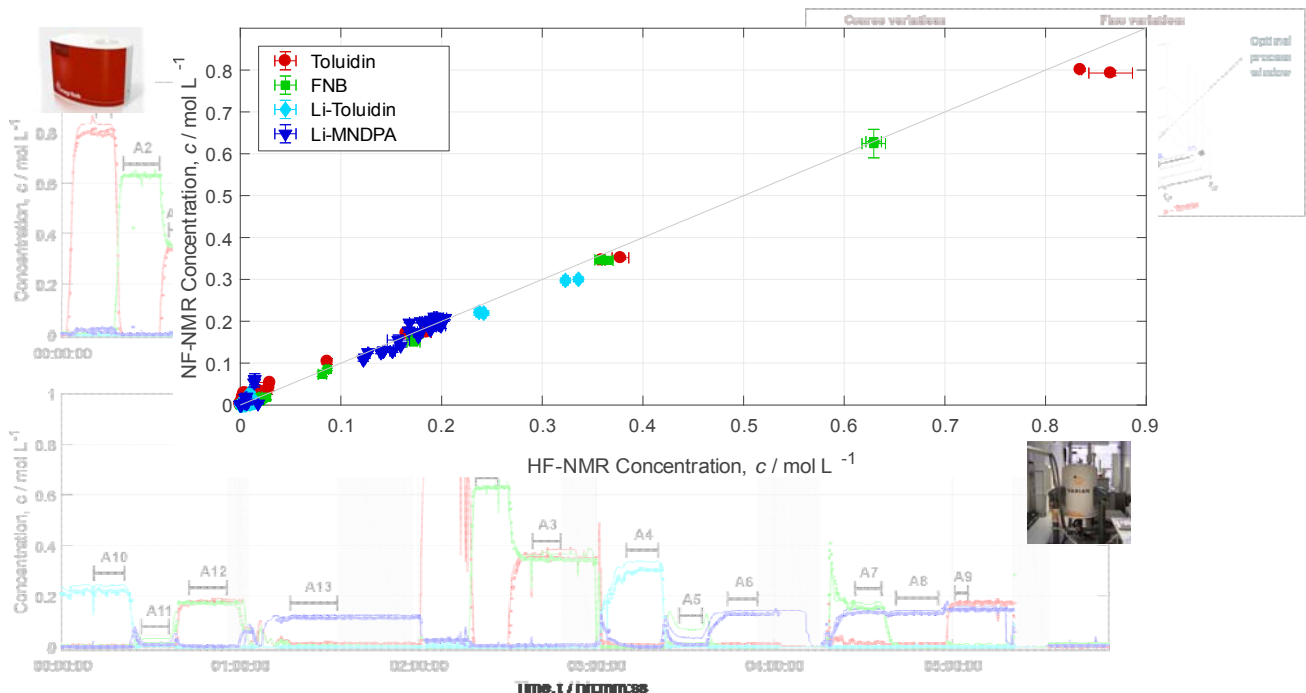
Low-Field versus High-Field NMR Spectroscopy



Validation Instead of Calibration

Variation of Set-Points according to Experimental Design

Low-Field versus High-Field NMR Spectroscopy



Example: Smart Online NMR Sensor Validation at Bayer/INVITE in Leverkusen



Source: INVITE GmbH

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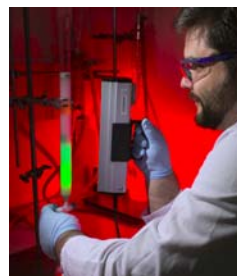
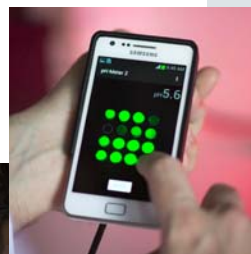
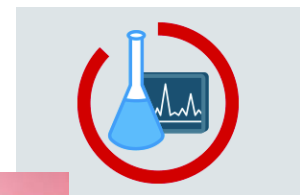
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Further Sensor Projects at BAM



The range of areas covered includes

- Development of sensor materials
- Impact of traffic loads on bridges
- Detection of air pollution
- Spread of flammable gases following traffic and industrial disasters
- ...



<https://www.bam.de>
→ Topics → Analytical-Sciences

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— Thank You!

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Magritek
Magritek
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NAMUR Roadmap Team

PTB
S-Pact
S-Pact

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