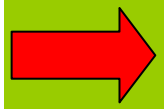
Digitising VHF-FM sound broadcasting with DRM+ (DRM Mode E)

Aspects related to compatibility, coverage and radio network planning

Felix Schad, University of Applied Sciences Kaiserslautern (FH-KL)



Introduction:

DRM+: System, Global trial concept

First DRM+ Field Trial (2008):

Concept, Setup, Outcomes

Second DRM+ Field Trial (2009):

Concept, first Results

► *DRM+: The system*

- **D**igital **R**adio **M**ondiale: (C)OFDM-based digital broadcasting standard up to 30 MHz
- Extended up to Band II (120 MHz) by **DRM+ (= DRM Mode E)**, currently undergoing ETSI's standarization process

Motivation for our work:
DRM+ is a high-potential candidate for digitising analogue VHF-FM sound broadcasting

Net data rate	37-186 kBits/s	Audio Coding	MPEG4 AAC+
No. Channels / service	1 – 4	Subcarrier Spacing	444 4/9 Hz
No. Carriers / symbol	213	Symbol duration	2.25 ms + 0.25 ms guard interval
RF system bandwidth	96 kHz	Subcarrier Modulation	4-/16-QAM

► *DRM+: Things to look at before system's regular introduction*

Compatibility to existing radio services:

→ VHF-FM sound broadcasting (87.5 – 108 MHz, in Band)

→ Aeronautical services (ILS, VOR: above 108 MHz)

→ Emergency service (BOS: below 87.5 MHz)

Compatibility aspects:

→ Lab (2007)

→ **1st field trial** (2008, to be discussed next); VHF-FM, BOS

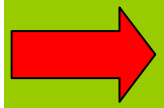
Coverage aspects (2009), to be discussed in a few minutes more)

→ **Lab**

→ **2nd field trial** (2009)

Introduction:

DRM+: System, Global trial concept



First DRM+ Field Trial (2008):

Concept, Setup, Outcomes

Second DRM+ Field Trial (2009):

Concept, first Results

► *Objective and Concept*

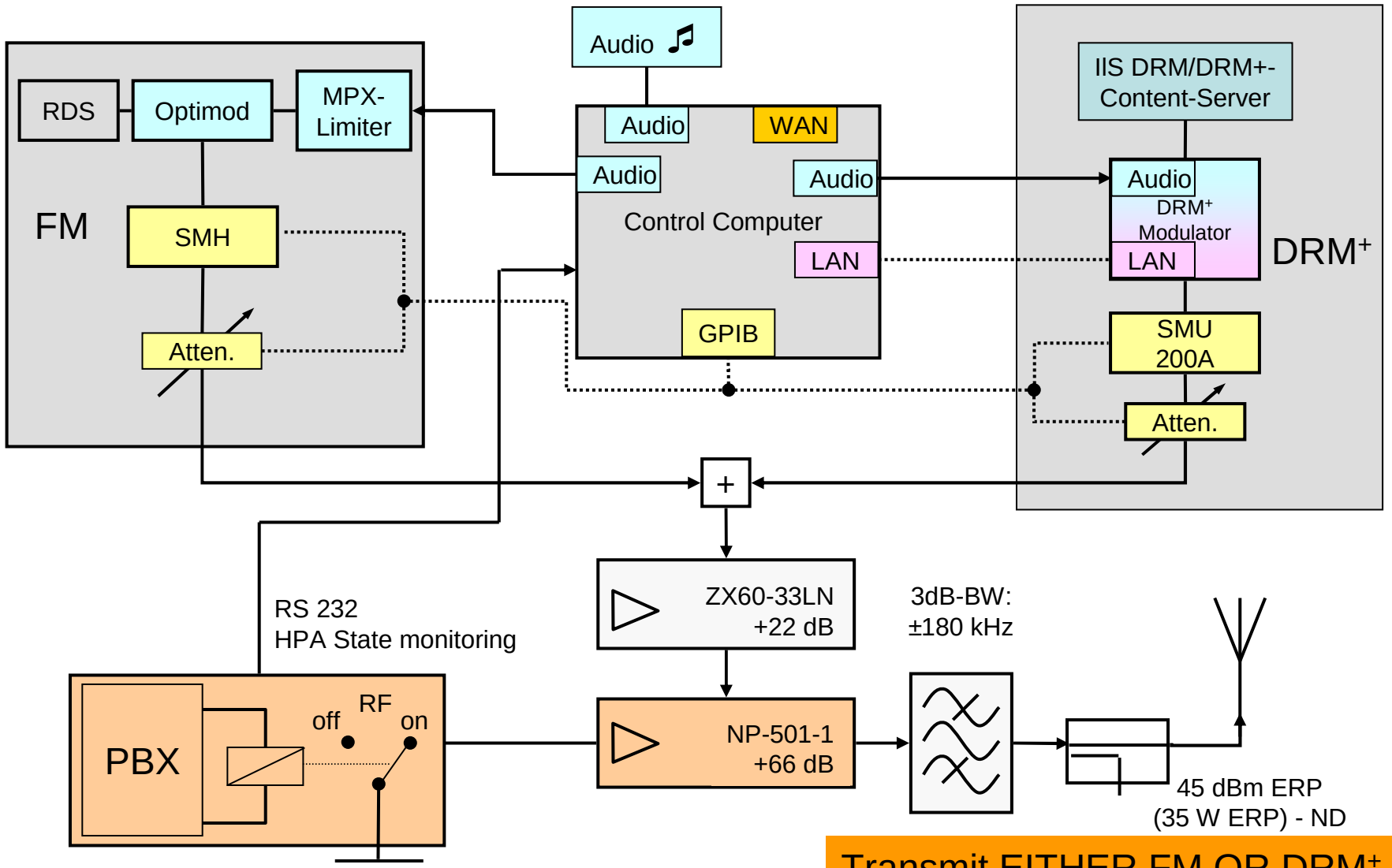
Objective:

- Examine effects to existing FM-services with DRM⁺ ‚on air'
- Extend measurements (lab compatibility, 2007 vs. field compatibility)

Concept:

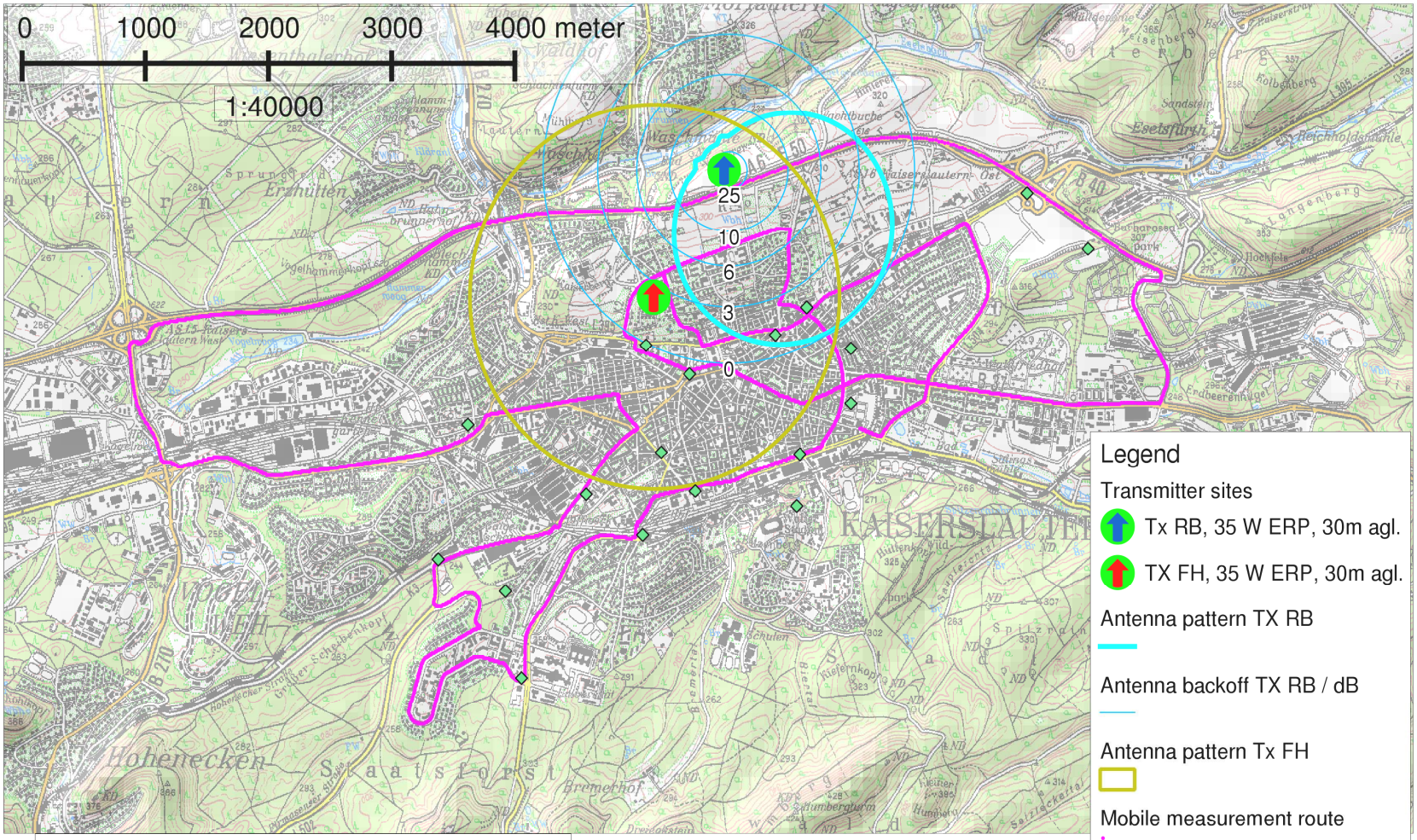
- Use two separate, (remote-)controlable transmitters:
  - ➢ ‚Victim' Tx radiating **FM**, **variable frequency**: Tx RB
  - ➢ ‚Interfering' hybrid Tx radiating **either FM or DRM⁺**, **equal power** for both modulations: Tx FH
- Study interference impact of Tx FH into Rx-signal quality of Tx RB

►Block schematics of hybrid Tx FH



Transmit EITHER FM OR DRM+ !!

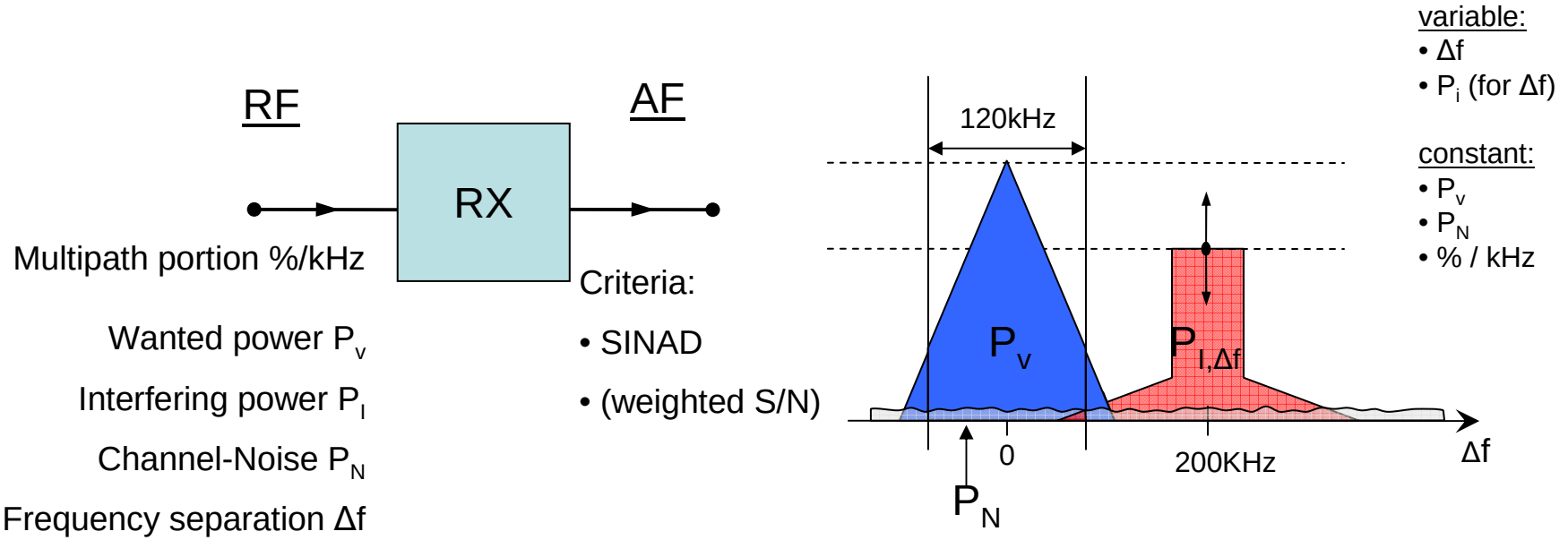
►Transmitter sites and activity spots at the core study area



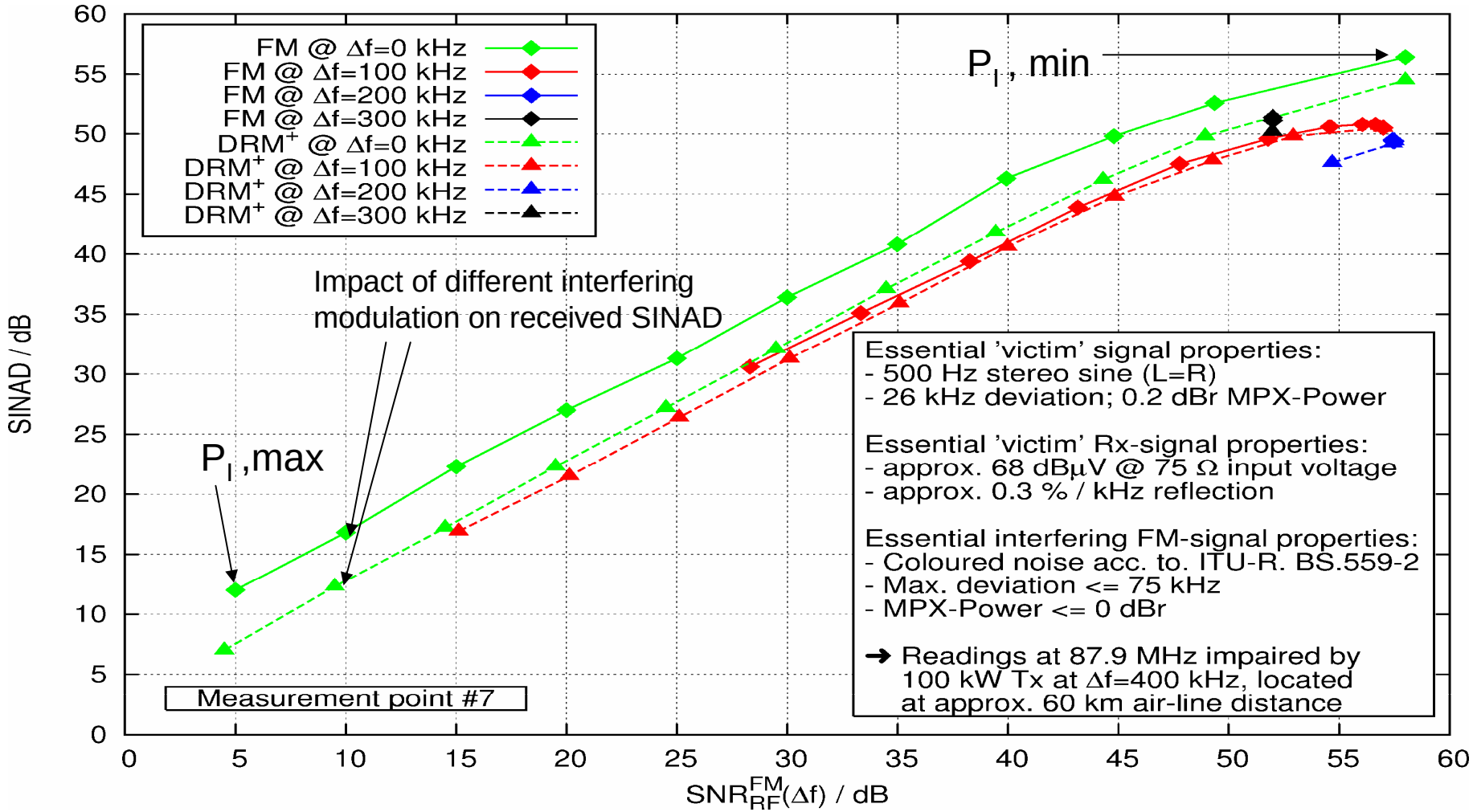
Map data: Bundesamt fuer Kartographie und Geodaesie, Federal Republic of Germany

► Compatibility measurements: *Key paradigm*

- Relate RF-Signal-to-Noise and interference ratio to AF quality
- AF quality is characterized by p. e. SINAD of received signal
- **Compare** quality **degradation** by switching interfering modulation @Tx FH
- Alternative indicators used:
  - AF-S/N, phospometrically weighted, highly correlated to SINAD-values
  - Quality Rankings (mobile case only)



► *Example of stationary measurement result:*



SINAD over RF-SNR as function of different modulations, channel spacings and interfering powers (TX FH)

The 1st field trial (2008)

► *Key results of stationary and mobile measurements*

Comparison of AF-quality results at mobile reception in line with stationary results

DRM+ field compatibility to FM easier achieved as in lab

Interference potential of DRM+ into FM higher as compared to FM, esp. due to time-varying amplitude.

► *Consequences from a radio network planner's point of view*

- Trial's results are back to network planning, giving experimental prot. ratios
- Investigation of two different scenarios for a few german VHF FM radio networks:
  (1) Replacement scenario (RS): **convert** existing FM Tx to a DRM$^+$-Tx
  (2) Integration scenario (IS): **insert** a new DRM$^+$ station
- Predictions based on local regulatory rules (with adapted protection ratios)
- RS:
  – a Tx can be converted if it's power is lowered by 5 dB while improving coverage
- IS:
  – a Tx can only be added with low ERP's as compared to the high powers commonly used for FM sound broadcast
  – For local stations, good coverage can be achieved with even low powers
- DRM$^+$ coverage criteria based on theoretical assumptions
- Nonetheless: as long as nominal measurement and planning paradigma are not adapted, **any** digital broadcasting scheme is hardly to integrate into VHF-FM band II !!!!

See paper for details

Introduction:

DRM+: System, Global trial concept

First DRM+ Field Trial (2008):

Concept, Setup, Outcomes

Second DRM+ Field Trial (2009):

Concept, first Results

► *Objective and Concept*

Objective:

- Assess DRM+-coverage in real radio environment
- Propose first planning paradigms for DRM+

Starting point:

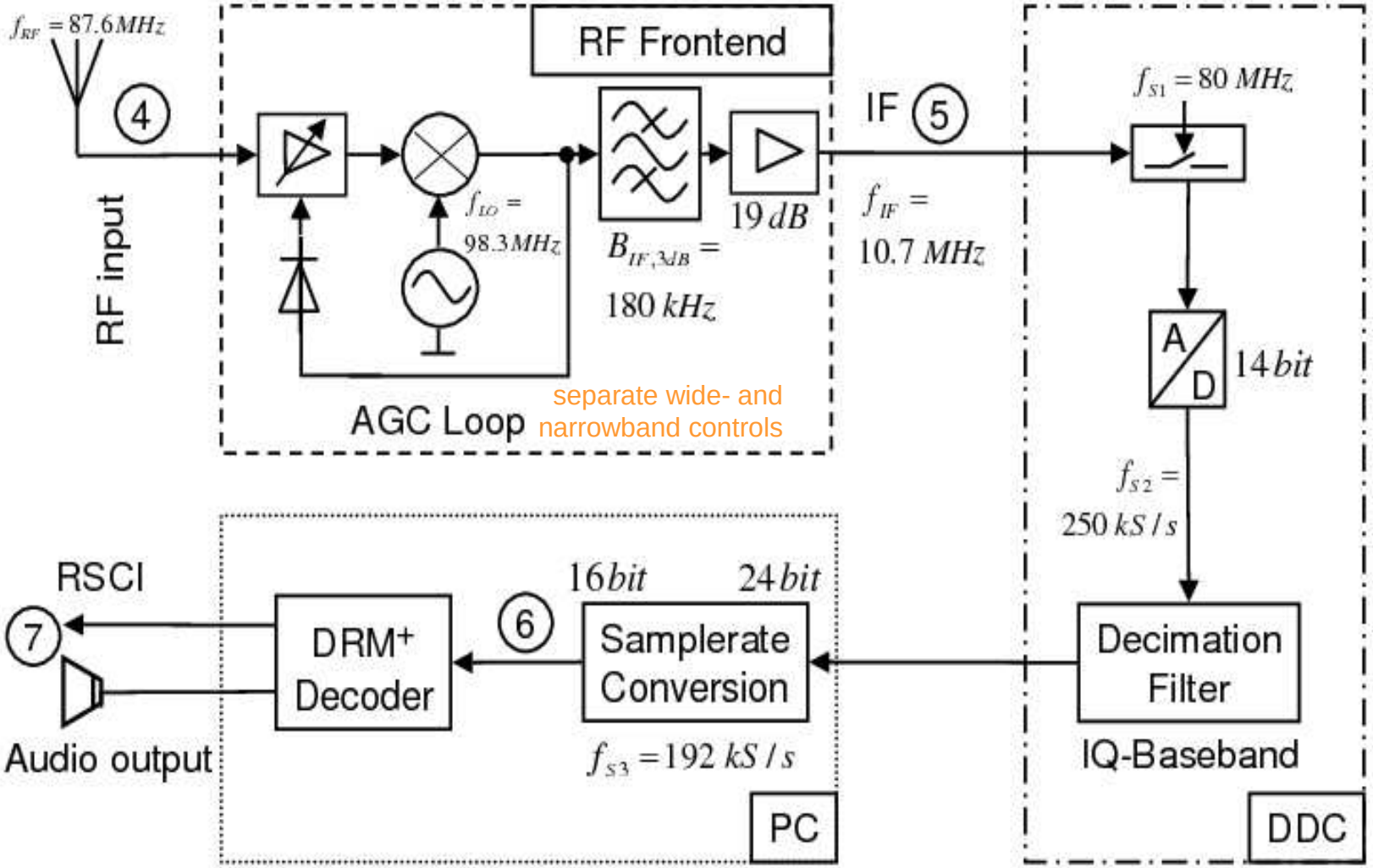
- Coverage criteria for DRM+ not defined yet
- No reference implementations (Tx/Rx) available

Path to goal:

- **Preparative lab measurements:**
  - Characteristic parameters of Tx-Rx chain
  - Define measurement principles and quality rating criteria
  - Protection ratios for DRM+
- **Field trial to validate and extend lab results**

The 2nd field trial (2009)

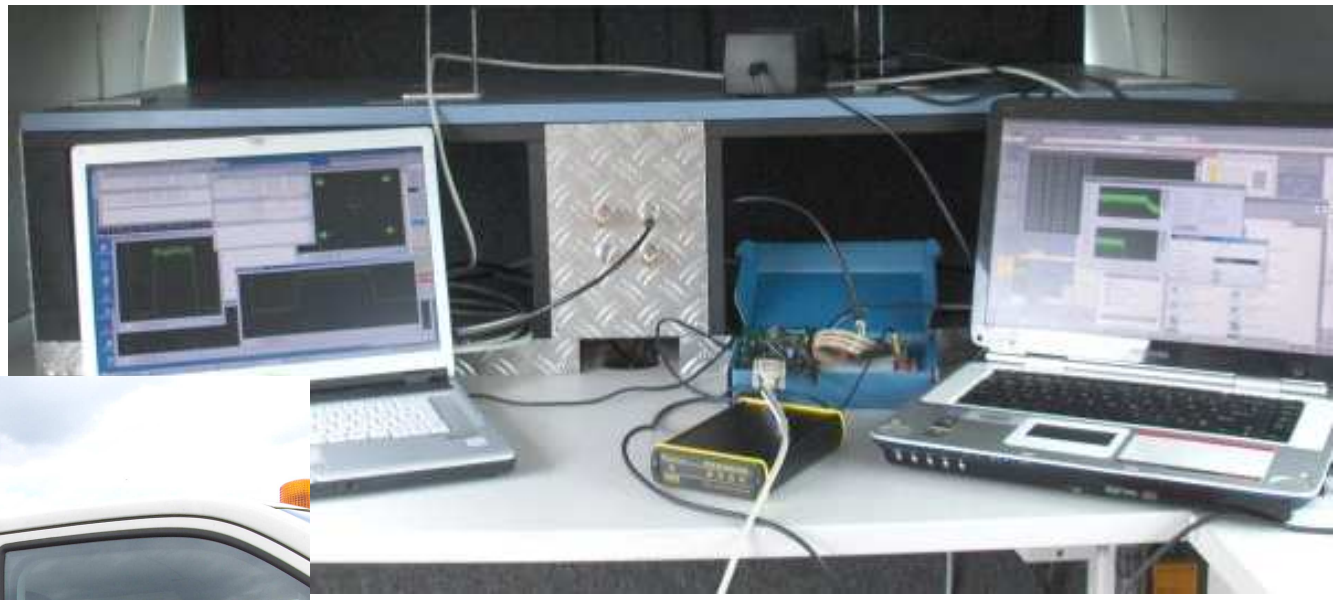
► Prototype receiver (in use since 2008)



The 2nd field trial (2009)

► Prototype receiver in the field

Early Rx-Implementation stage during 1st realtime radio transmission using DRM+ worldwide (April 23rd, 2008)



Measurement van FH KL, currently being upgraded to a full grown mobile metering system
(exterior view of rx-loc shown above)

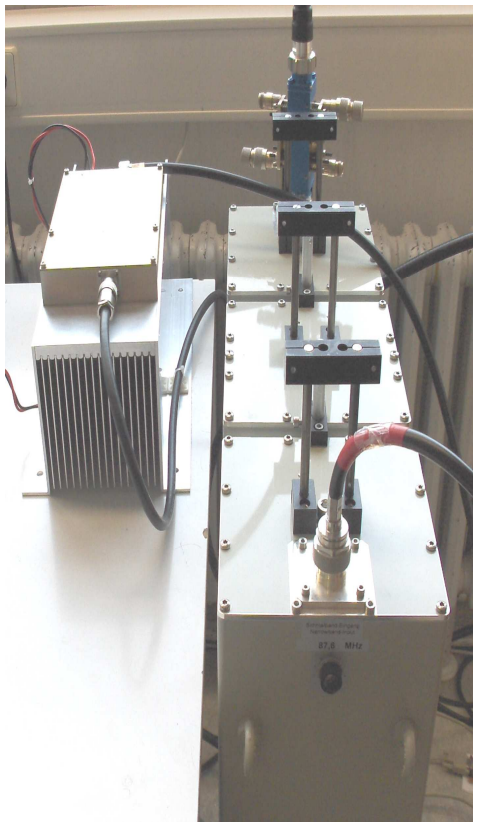
► **Measurement of essential Rx & Tx key parameters**

Rx-characteristics:

- Total Noise Figure: 11 dB
- Total gain: 19 dB
- High linearity: Shoulder distance of max. 54 dB
- Phase noise: -75 dBc/Hz (worst value)
  [-90 … -85 dBc/Hz] (typical value)
- Sensitivity for BER = 1E-4:
  - -1 dBµV (4QAM)
  - 6 dBµV (16QAM)

Tx-characteristics :

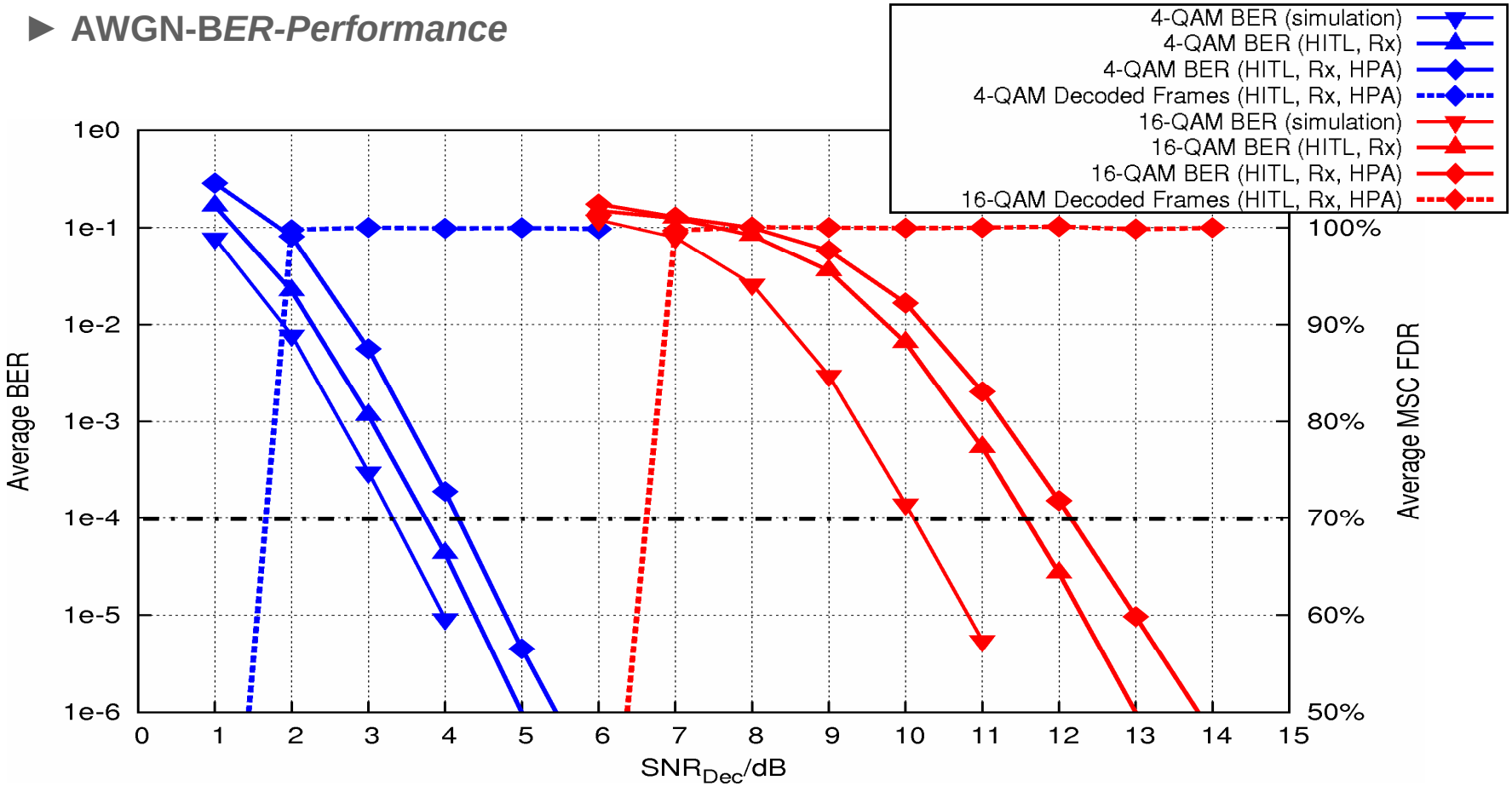
- IP3@ subcarrier spacing: 60 dBm
- Phase noise: -90 dBc/Hz @ 1st subcarrier
  -110 dBc/Hz (typical value)



Tx FH:
Power Amp.,
cavity filter

The 2nd field trial (2009)

► AWGN-BER-Performance



- Slight degradation due to hardware implementation
- Rx-phase noise & Tx amplitude compression dominating factor @ higher SNR-values
- BER = 1e-4 reasonable threshold for minimum reception quality
- Measurements confirmed by sensitivity-values shown before

The 2nd field trial (2009)

► Visualization of the term protection ratio

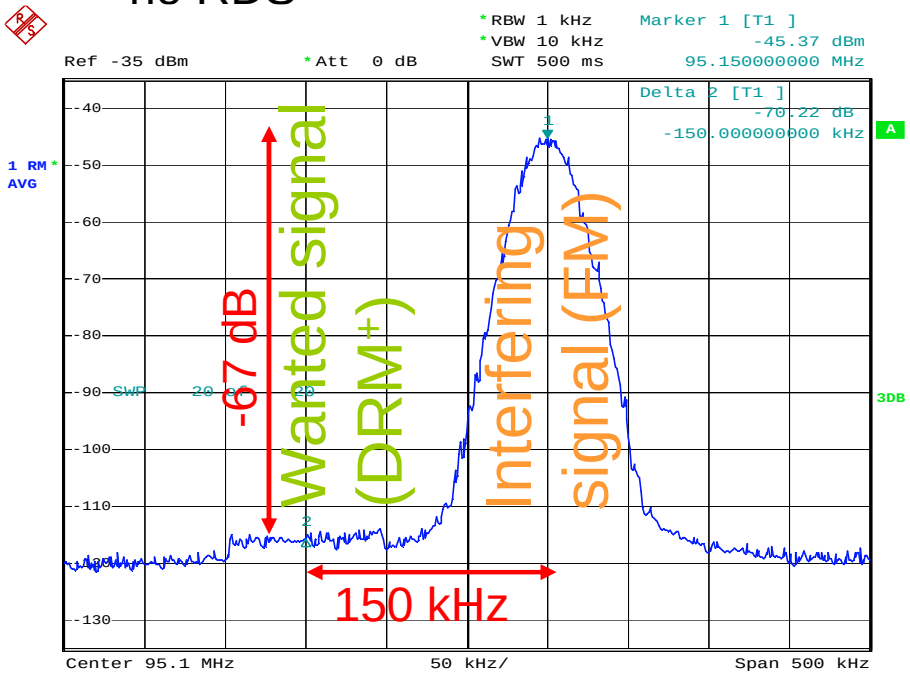
Please note: results too new to be included in the paper!

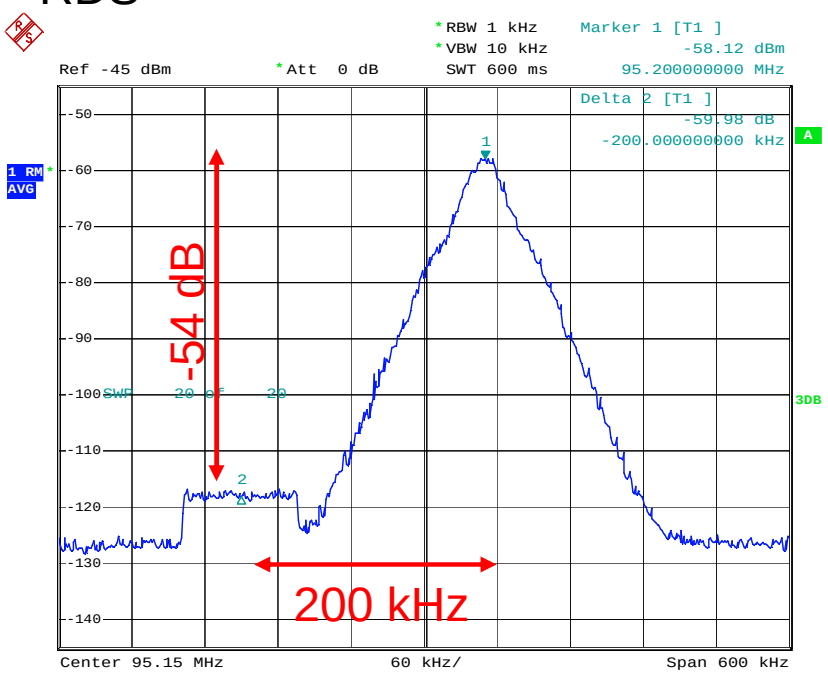
ITU-R BS.641 interferer

- mono, col. Noise
- no compression
- no RDS

Stereo interferer

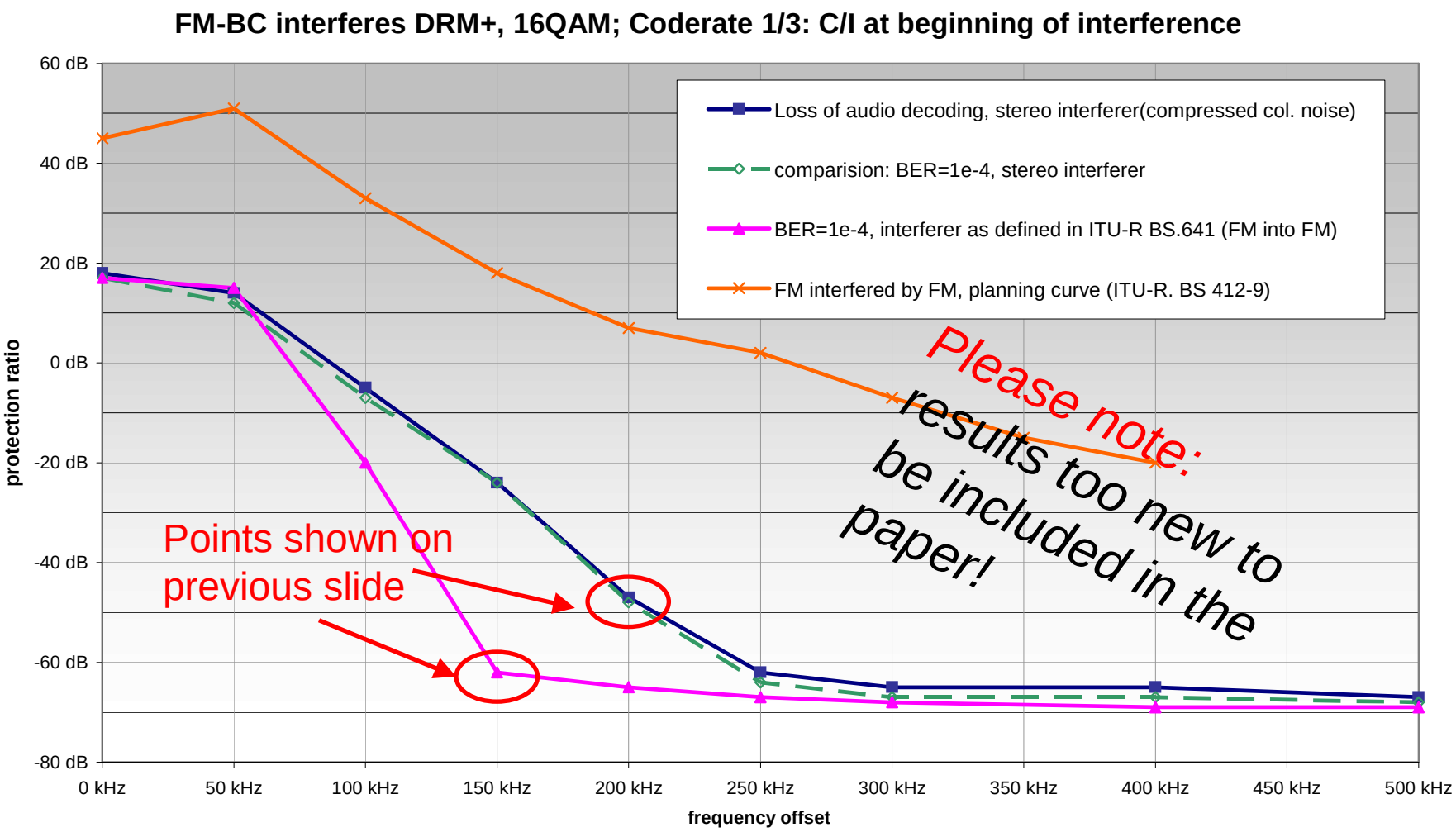
- **lifelike for today's transmitters**
- stereo, col. Noise, compressed
- RDS





PDS @ BER = 1E-4 (4-QAM; Coderate 2/5);
Power difference (wanted – interfering signal): protection ratio

► Protection ratio measurements



The 2nd field trial (2009)

► ***Proceedings up to today***

- ✓ Key Tx- / Rx-Chain parameters assessed
- ✓ DRM^{+-}Coverage criterion defined
- ✓ System immunity / Rx behaviour to interfering signals known
- ✓ Coverage predictions calculated, to be verified

Next steps:

- ➢ Stationary field-measurements
- ➢ Compare BER / Audio dropouts at rx-loc. to FM audio performance
- ➢ Mobile measurements, compare DRM^{+} to FM performance under fading conditions

Thanks for your attention!

These slides and more information covering the whole of FH Kaiserslautern's and partners DRM activities can be found at:

http://www.drm-radio-kl.eu