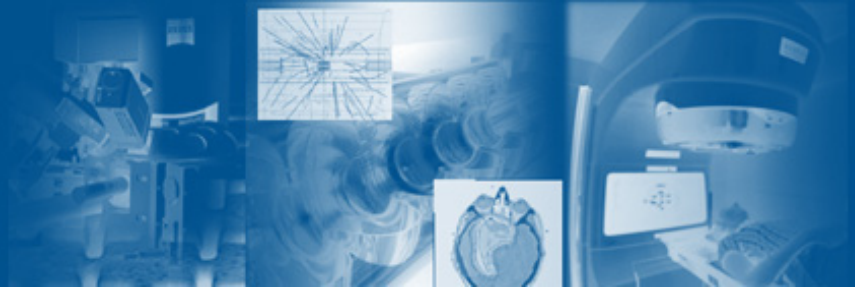


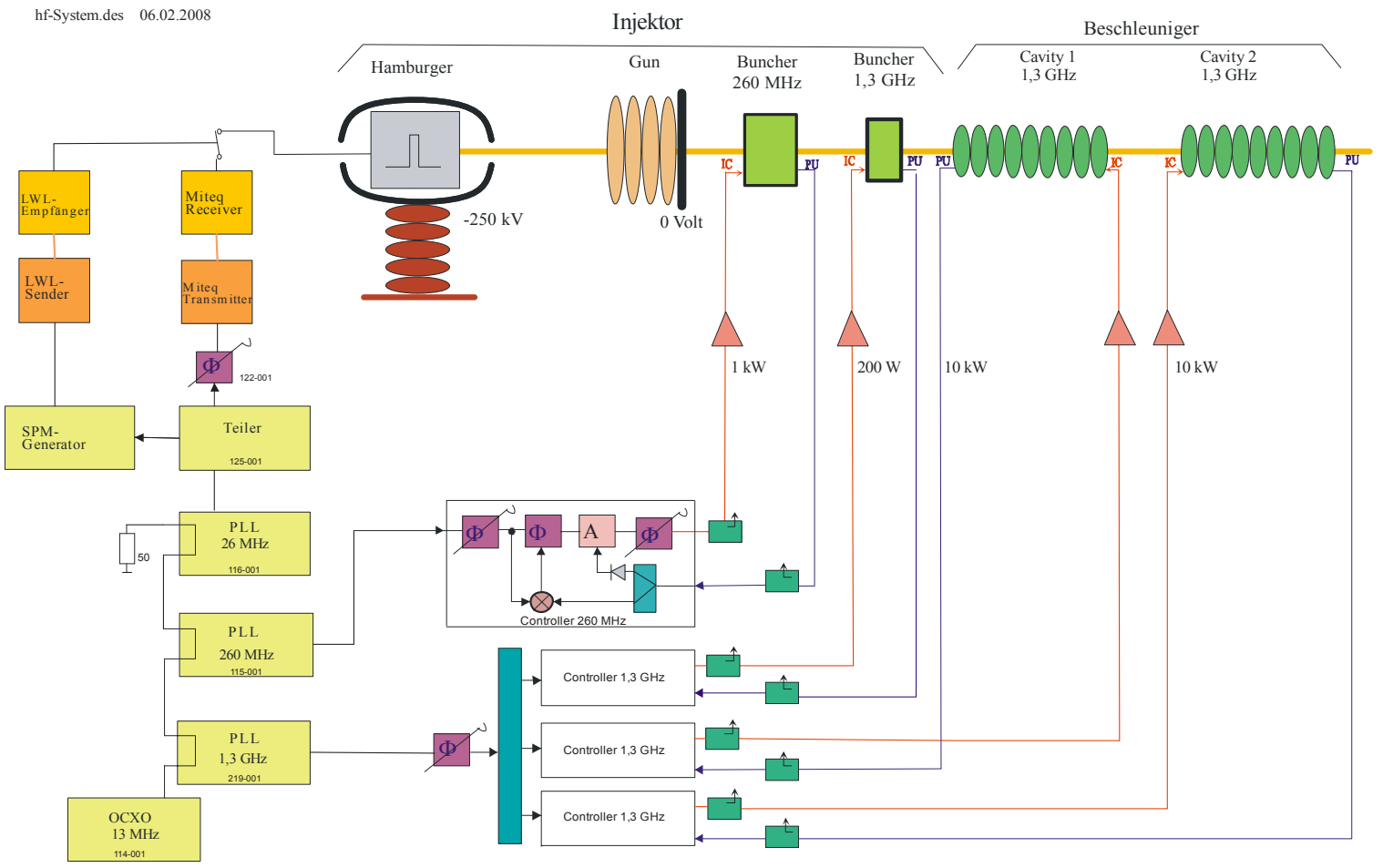
Upgrade and Performance of the Analog Low Level RF at ELBE

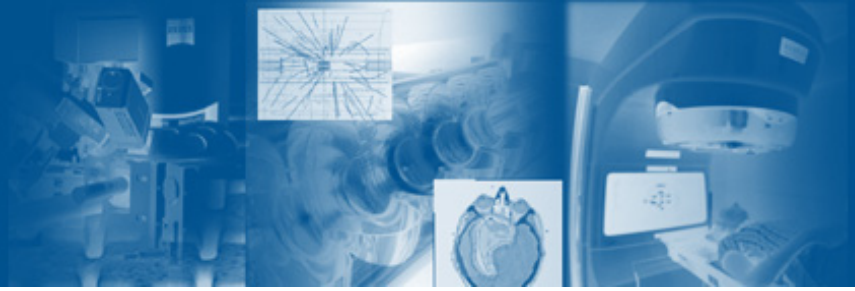
A. Büchner

Helmholtz-Zentrum Dresden-Rossendorf e.V.

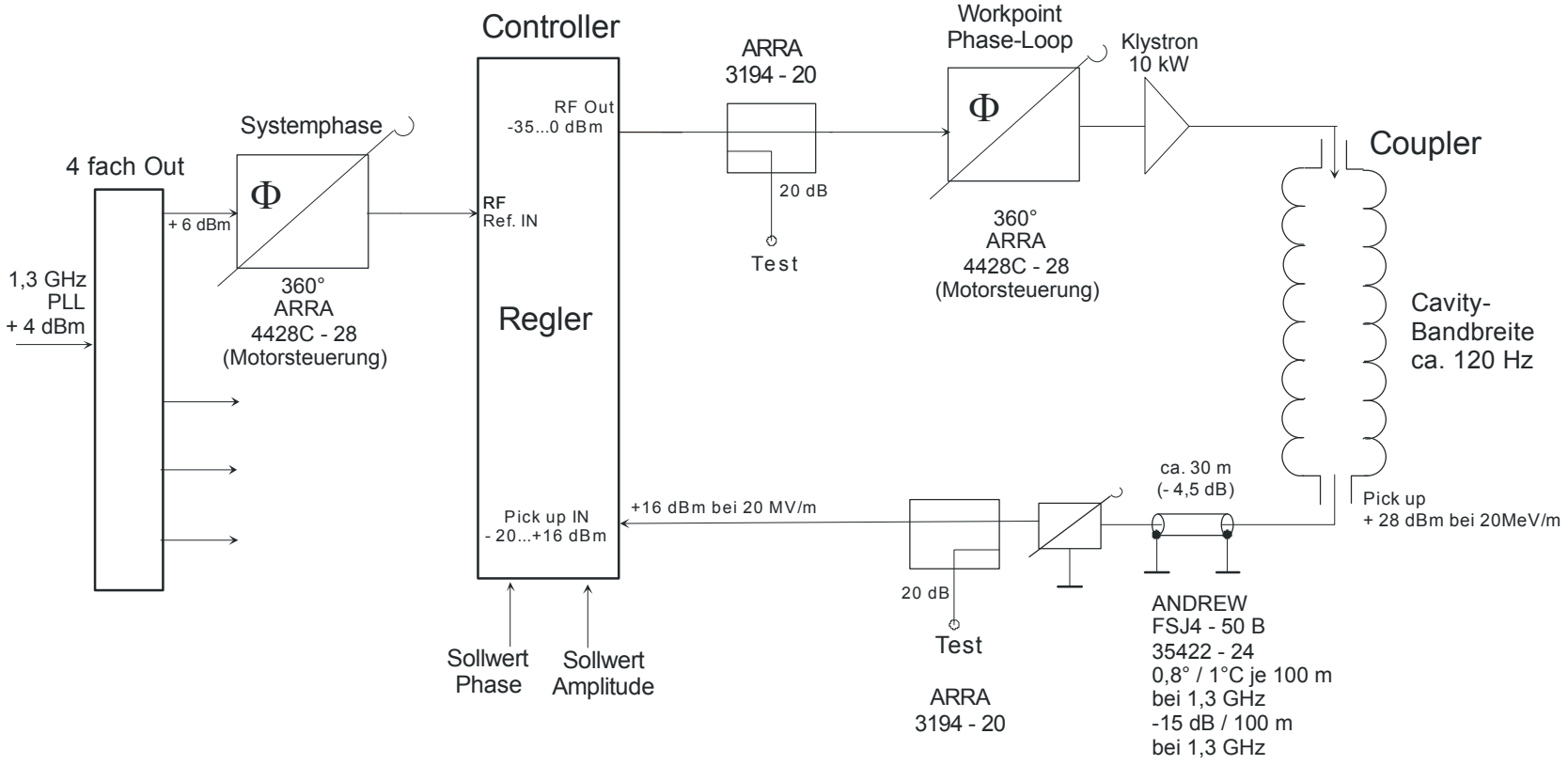
- General overview
- Amplitude and phase control loops (Principle, Realization)
- Upgrade necessity
- RF – Pulsing (Principle, Realization)
- Results

HF - System


hf-System.des 06.02.2008
Injektor
Beschleuniger
Hamburger
Gun
Buncher 260 MHz
Buncher 1,3 GHz
Cavity 1 1,3 GHz
Cavity 2 1,3 GHz
-250 kV
0 Volt
IC
PU
1 kW
200 W
10 kW
10 kW
LWL-Empfänger
LWL-Sender
Miteq Receiver
Miteq Transmitter
122-001
SPM-Generator
Teiler
125-001
50
PLL 26 MHz
116-001
PLL 260 MHz
115-001
PLL 1,3 GHz
219-001
OCXO 13 MHz
114-001
A
Controller 260 MHz
Controller 1,3 GHz
Controller 1,3 GHz
Controller 1,3 GHz

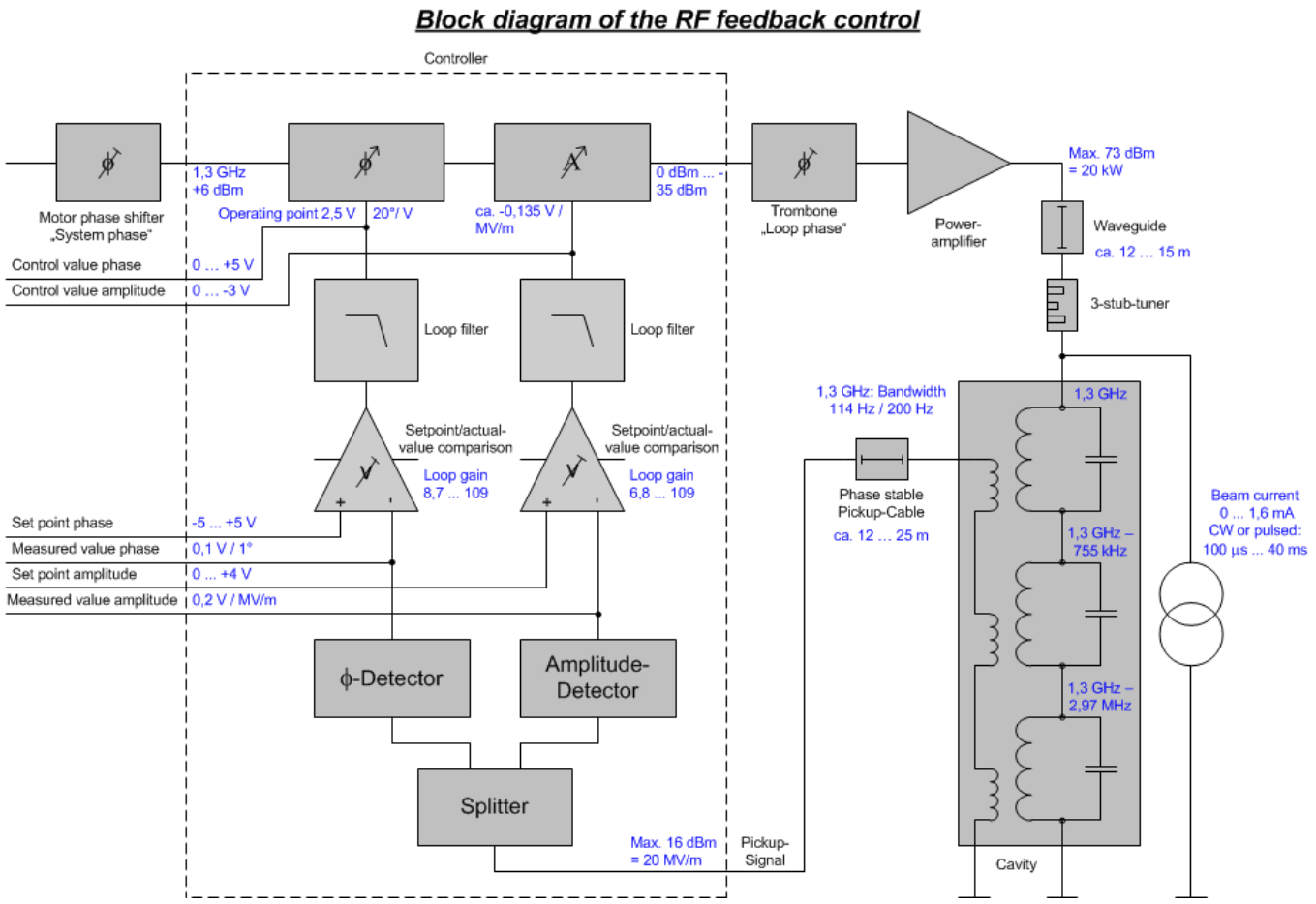


Block Diagram: Cavity RF-Stabilization



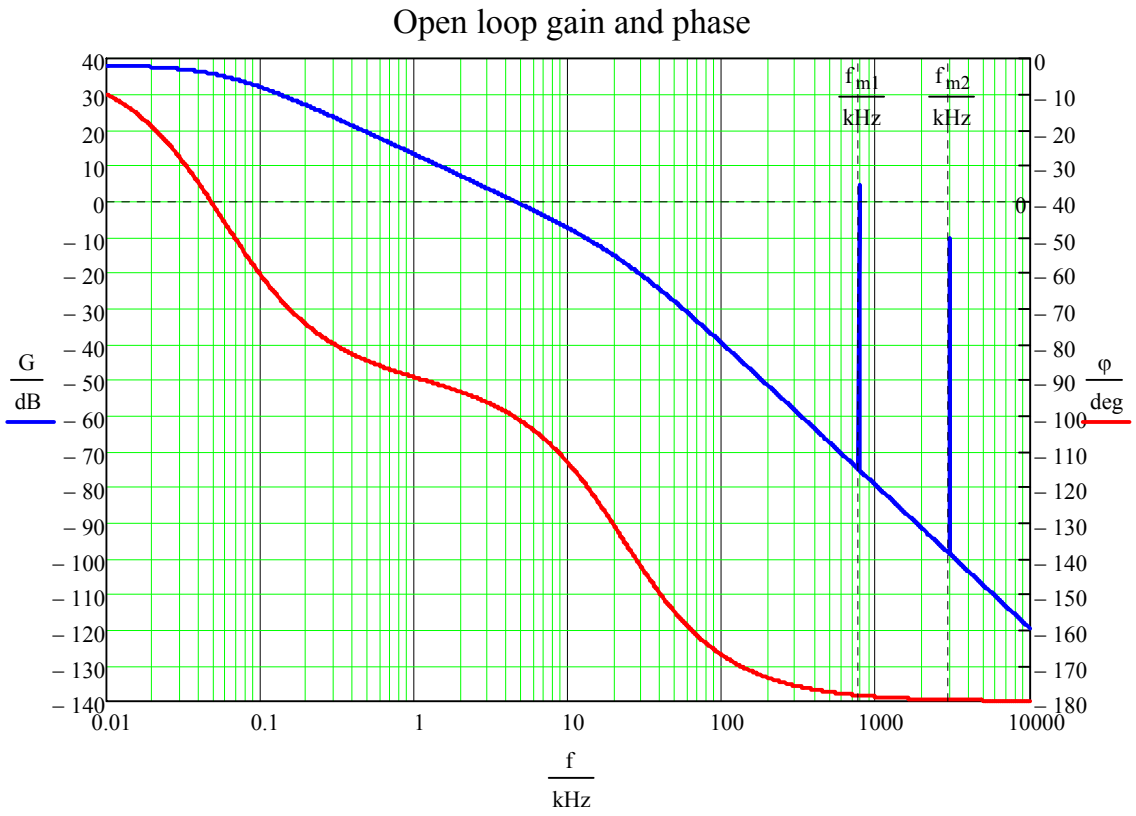
Old Controller 1.3 GHz

Old RF Feedback Control Block Diagram



Service Unit

Low Level RF problems with the new Solid State Amplifiers



Control loop Bode diagram:

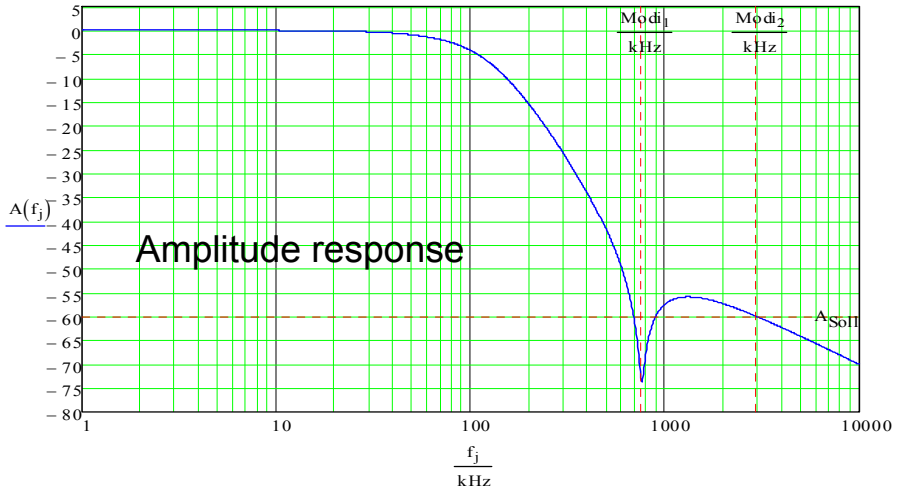
- 1st pole by cavity bandwidth
- Assumptions: Loop gain 80; 2nd pole at 23 kHz by electronics

Higher order modes (HOMs) at -770 kHz, -3 MHz, … are almost NOT damped at the detector!

HOM phases are not stable

→ Instability is easily possible by HOMs!

New Loop Filters for Amplitude and Phase

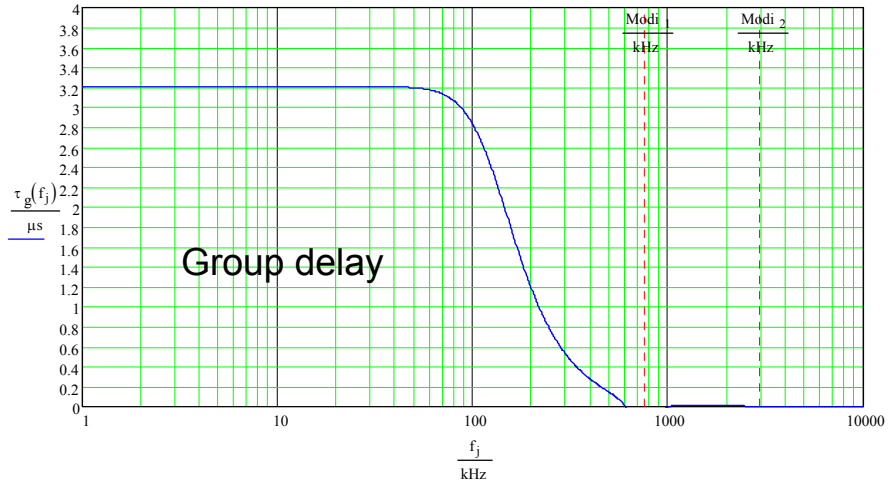


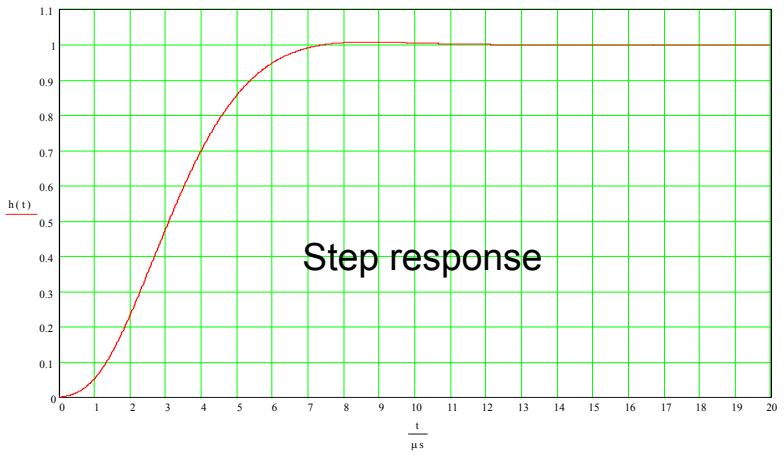
Design Goals:

- Higher Order Mode rejection > 60 dB
- Minimum influence on loop response

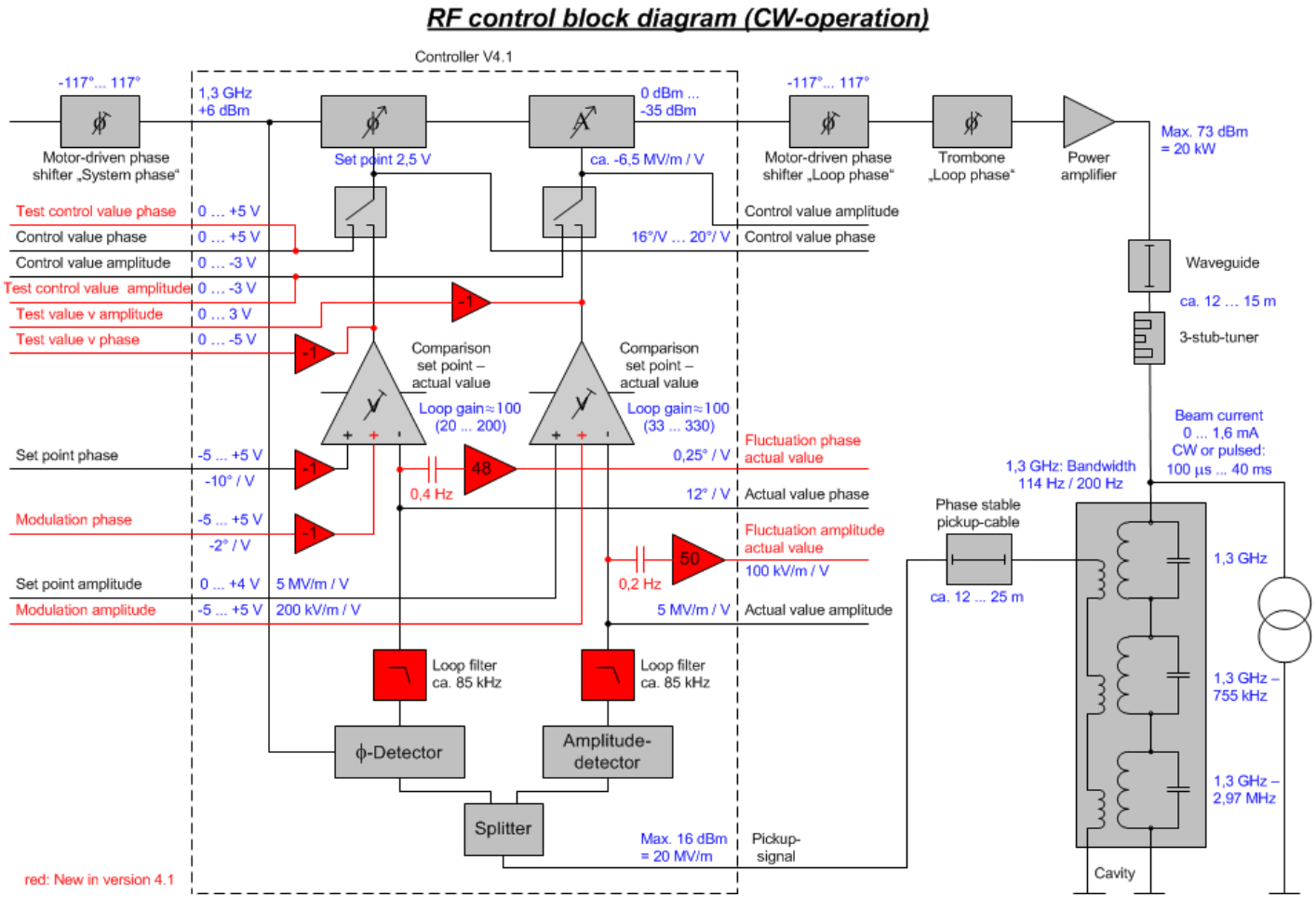
Realization:

- 3rd order Bessel filter with notch at HOM1
- -3 dB at 85 kHz
- Loop gain of 300 possible without problems

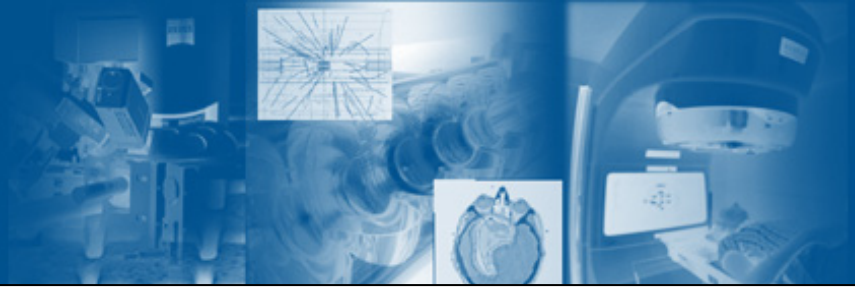




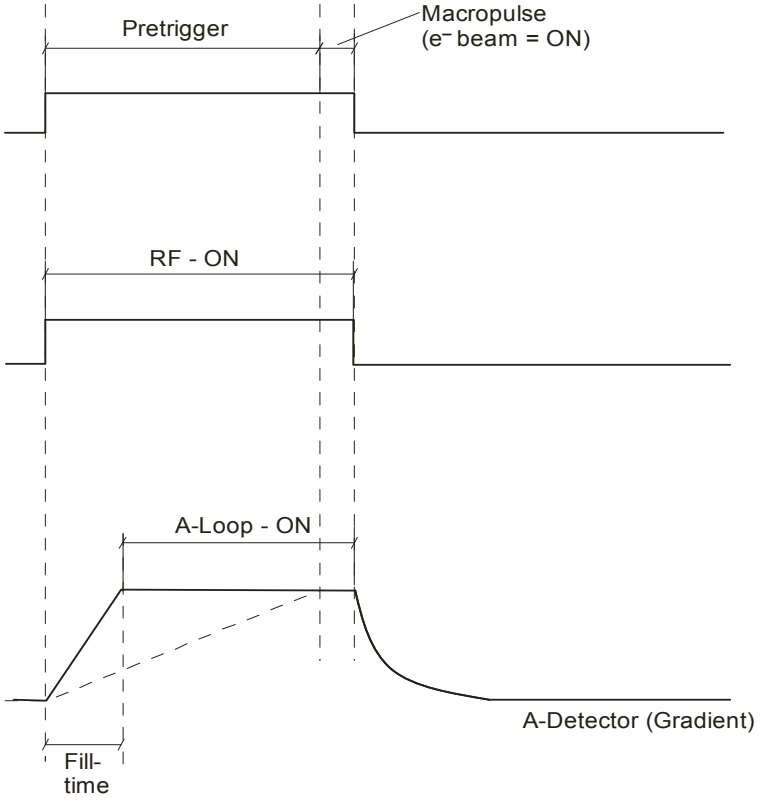
New RF Feedback Control Block Diagram



New Controller 1.3 GHz

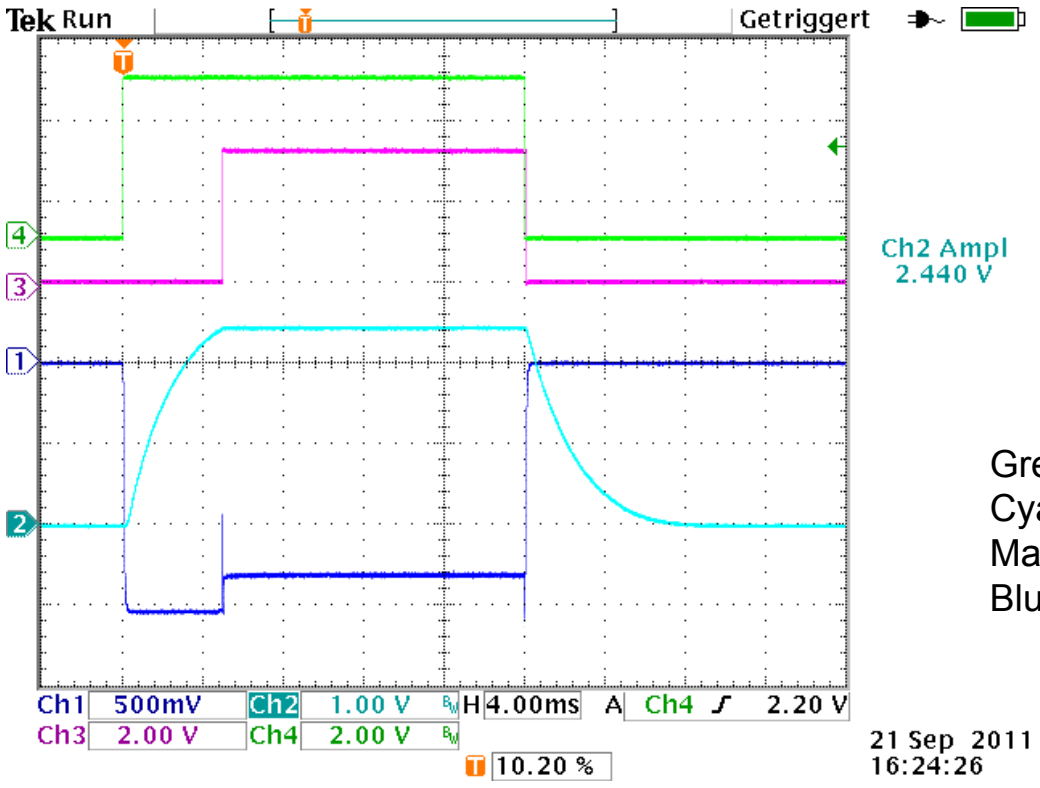


RF - Pulsing



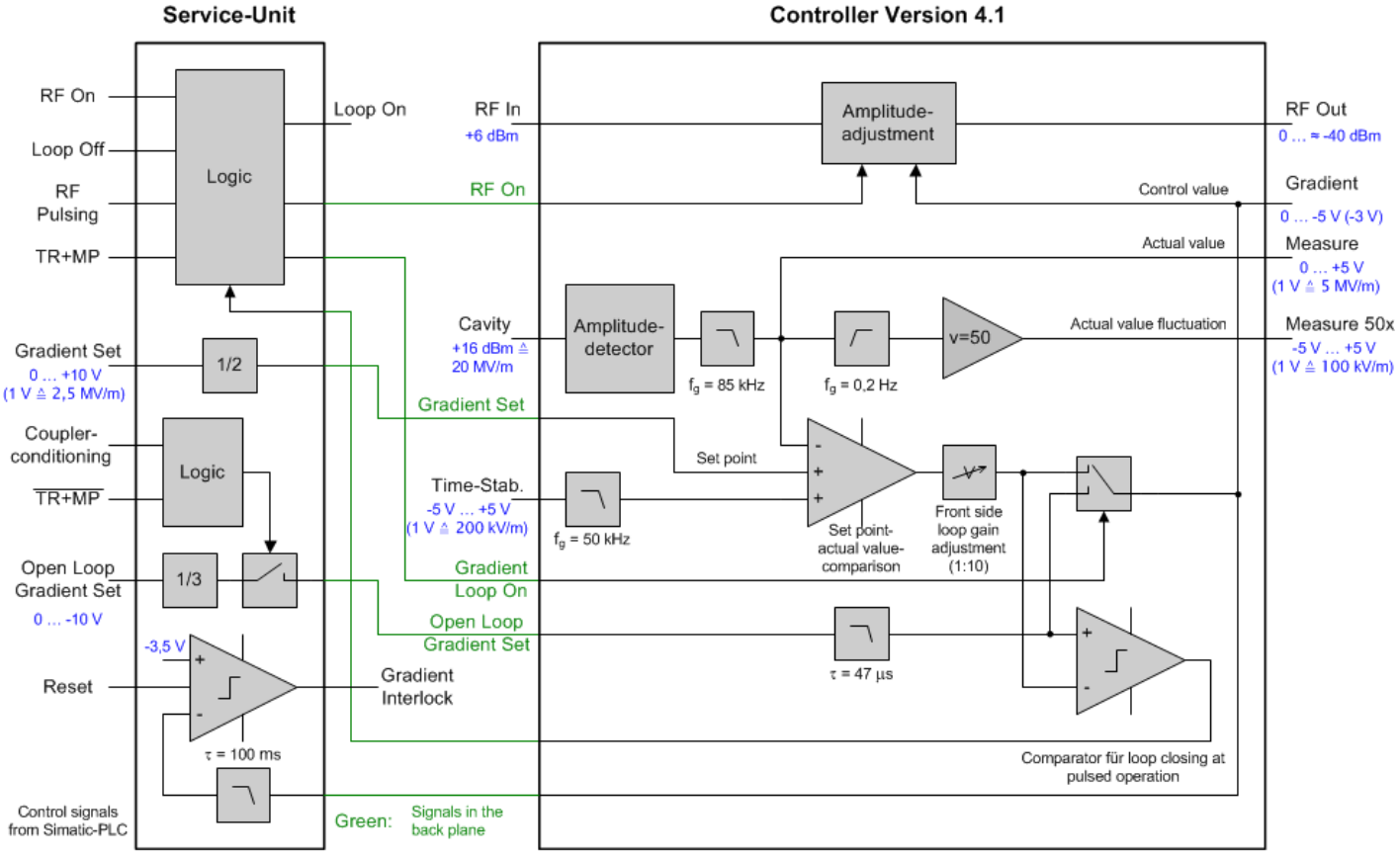
Timing Diagram

Timing Diagram for RF Pulsing

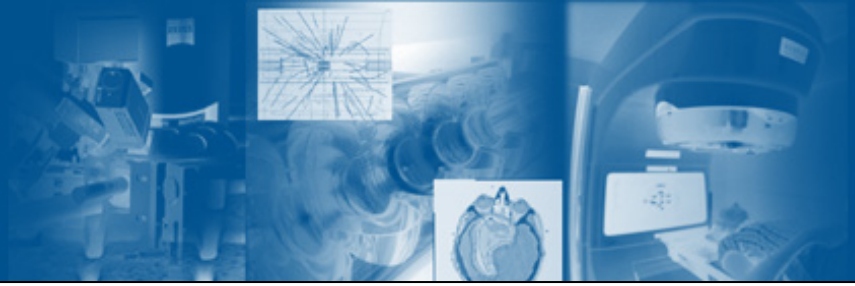


Green:	Pretrigger + Macropulse
Cyan:	Gradient in the cavity
Magenta:	Loop closed
Blue:	Control value (≙ RF power)

Amplitude loop block diagram for RF pulsing



Block diagram of the amplitude loop (all amplitude-switches at the Service-Unit and the Controller are set to „Remote“)



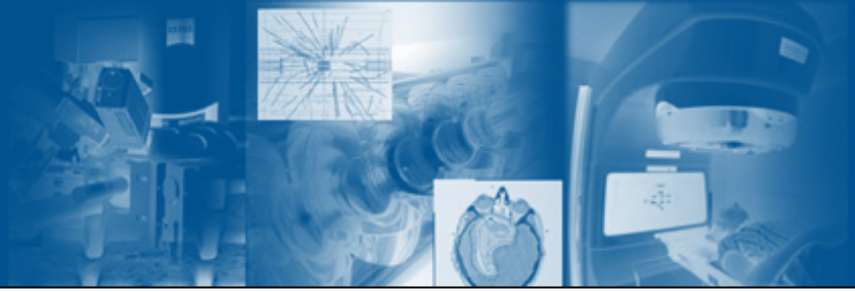
Results

3 operating modes: CW, pulsed RF and cavity / coupler conditioning

- Amplitude loop gain adjustable between 33 … 330 (depends from outer gain!)
- Phase loop gain adjustable between 20 … 200
- Loops are stable at all loop gains

Controller noise in the lab at closed loops for a gradient of 10 MV:

- At output „48 * Phase“ ≈ 8,2 mV_{eff} ≙ 0,002° = 4,4 fs; ≲ 70 mV_{pp}
- At output „50 * Meas“ ≈ 5 mV_{eff} ≙ 500 V/m at 10 MV/m resp. $5*10^{-5}$; ≲ 40 mV_{pp}
- At cavity bandwidth and maximum loop gain ≈ 26% overshoot, t_r ≈ 4,8 µs, but stable



Controller 1.3 GHz

RF_{ref} IN:	Level	+6 dBm (±1 dB)
	S_{11}:	-18 dB
RF_{out}:	Level	-40 dBm (-45 dBm) ... 0 dBm (+2 dBm)
	S_{22}:	-8 dB
Pick Up IN:	Level	max. 20 dBm
	Operating Range:	+16 dBm = 20 MV/m = 4 V till -24 dBm
	S_{11}:	-20 dB

Coupling φ / A:

- Δ A = 0,5 ... +4 V at A-$Det._{out}$ → ± 5 mV_{ss} at φ-Det_{out} with A-loop off; φ-loop on, φ-Gain max
- Δ φ = 3 V_{ss} = 36° → A-$Det._{out}$ < 5 mV_{ss} (Detection limit) with φ -loop off; A-loop on, φ-Gain max