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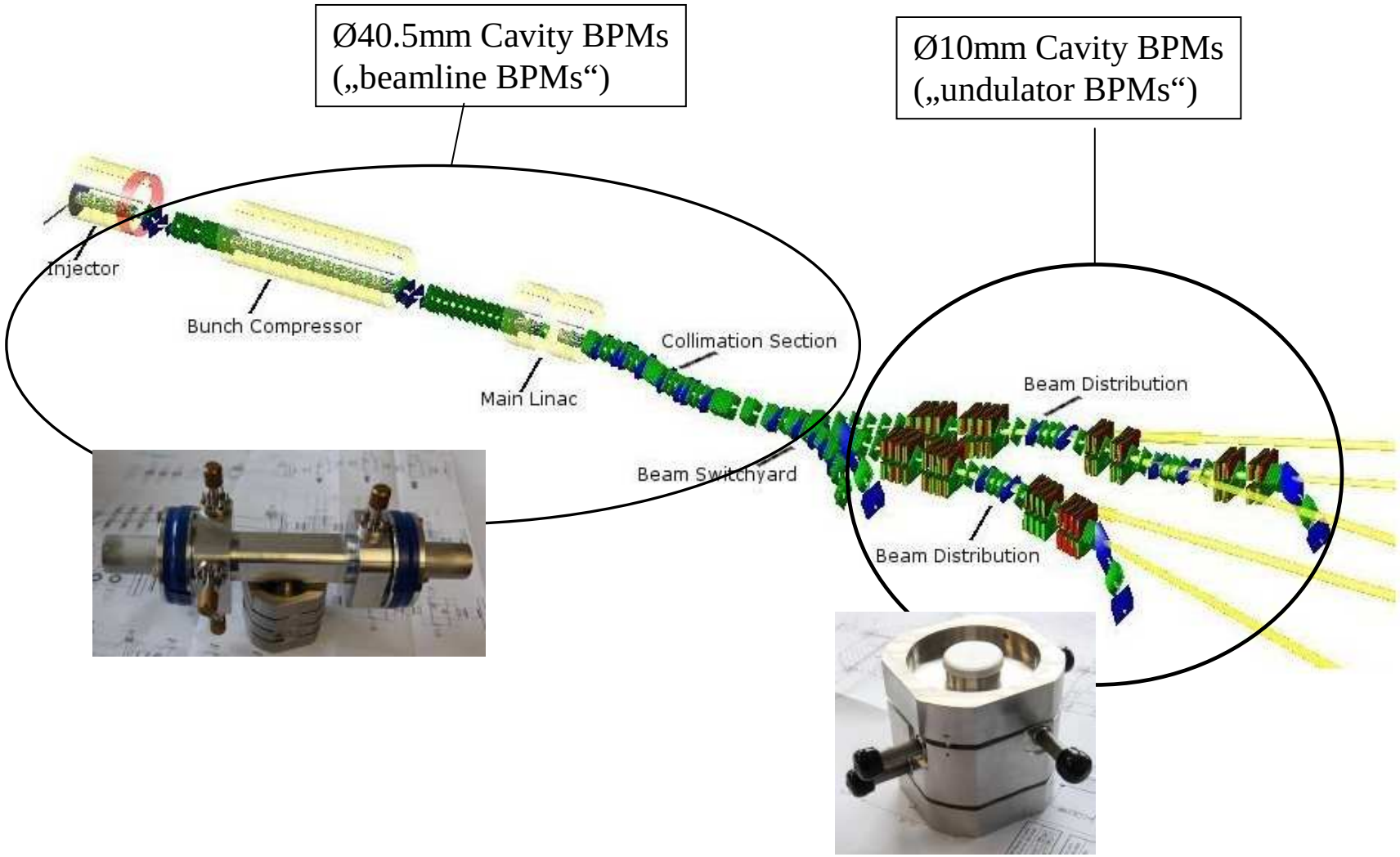
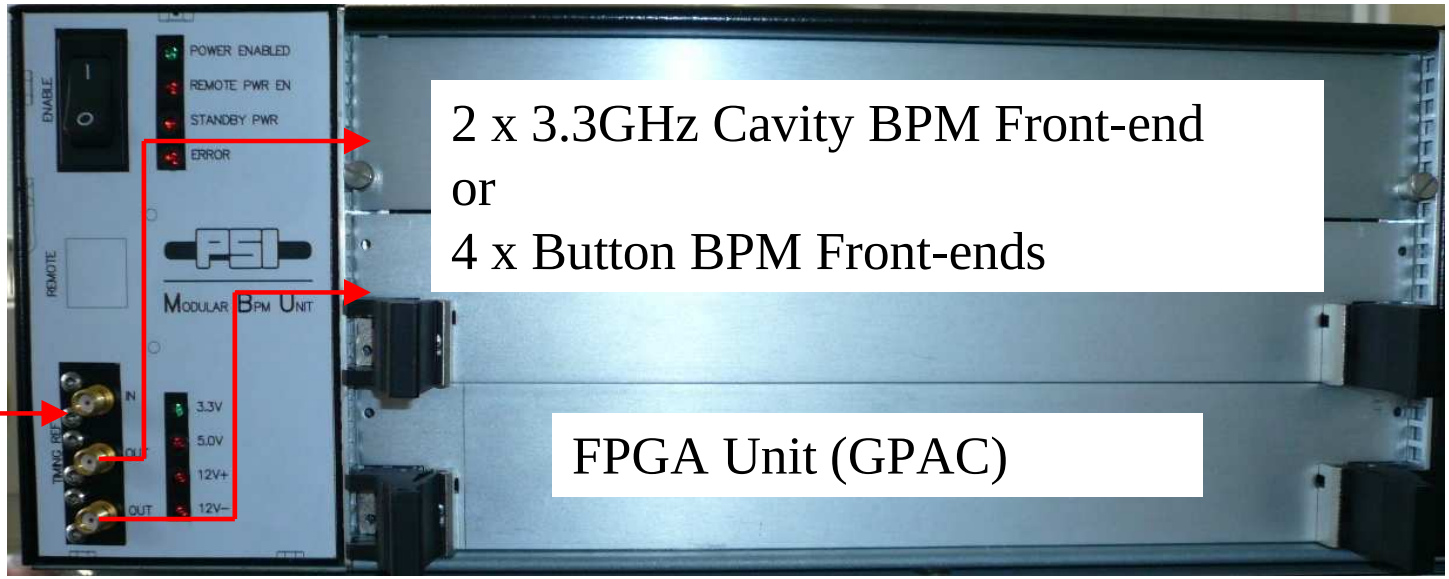
Undulator and 40.5mm Cavity BPM System Synchronization Requirement

Cavity Beam Position Monitors: Locations

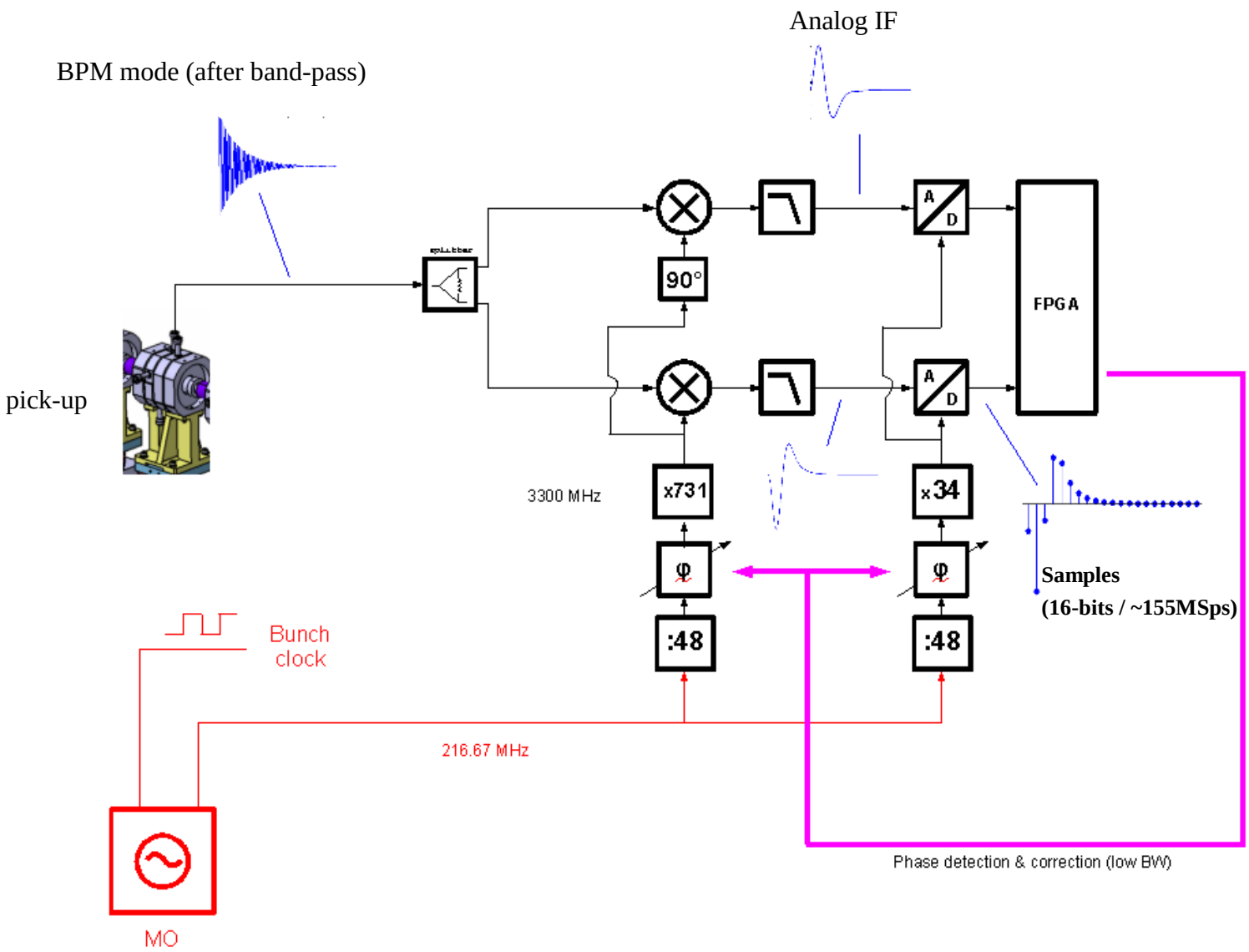


MBU (Modular BPM Unit) Rack



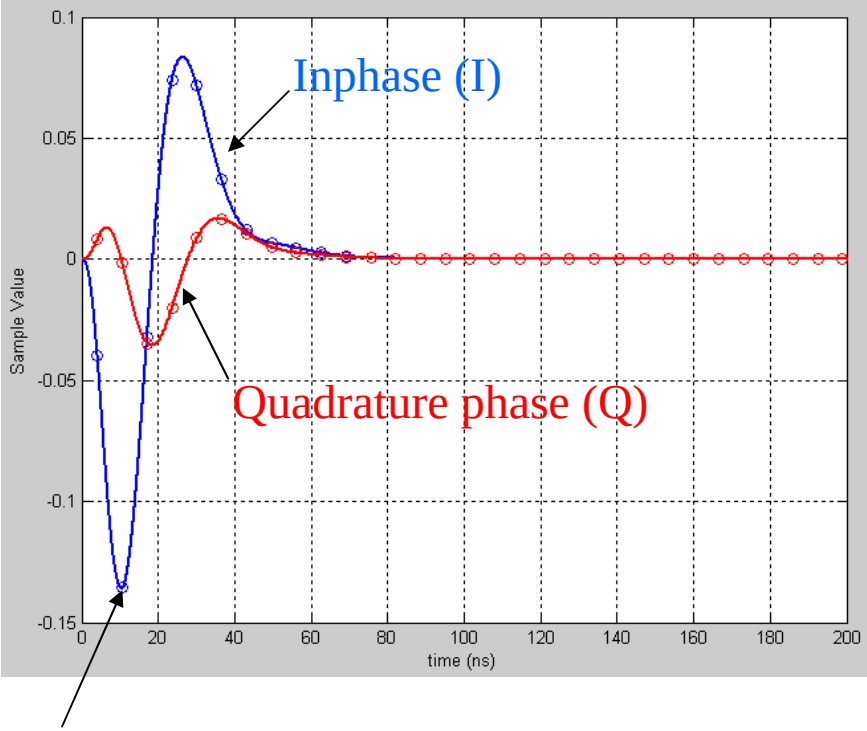
216⅔ MHz Reference Signal Input

Brief Explanation of Cavity-BPM System



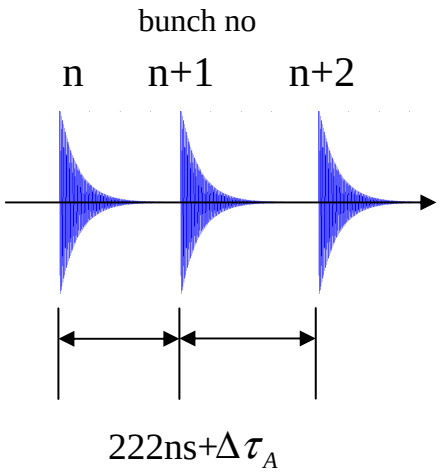
IF Data Signals

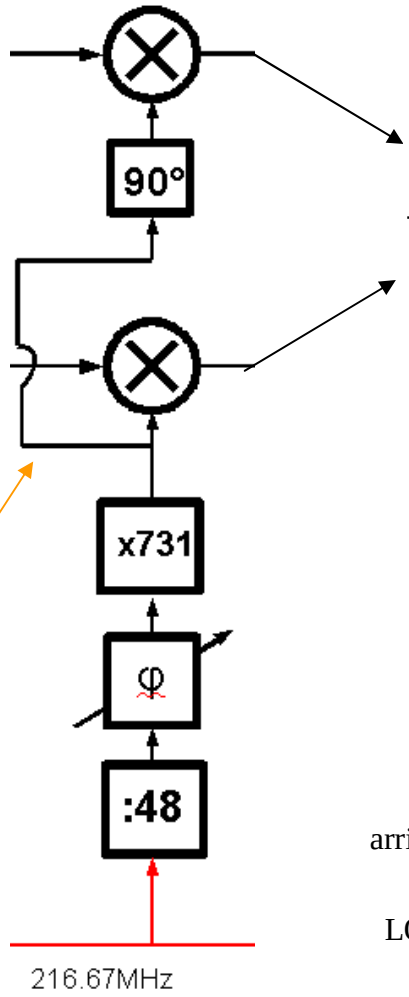
- Do a downconversion for Y-, Z- and Reference cavity signal
- Extract position information from amplitudes of sampled IF waveforms

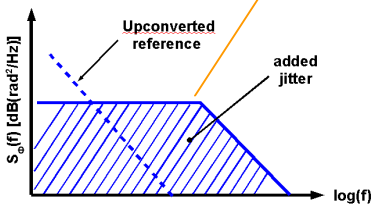


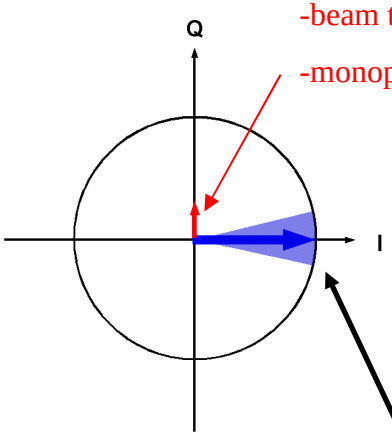
→ one top-sample per bunch bears most of the amplitude information
→ Corrupted by LO phase and Sampling phase jitter (and others ….)

Effect of Timing Jitter



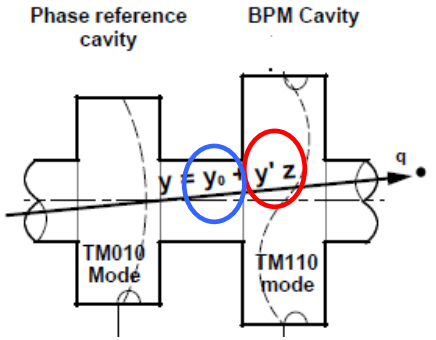






-beam tilt signal

-monopole leakage signal



RF phase aligned so that distance information is located in one channel (I or Q) only.

angular jitter → measurement jitter

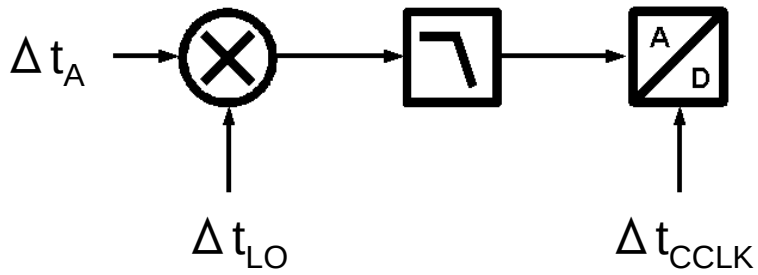
arrival time jitter: $E[(\Delta\tau_A)^2] = \sigma_{\tau_A}^2$

LO phase jitter: $E[(\Delta\Phi_{LO})^2] = \sigma_{\Phi_{LO}}^2$

Effective timing jitter: $\sigma_{\Delta t}^2 = E[(\Delta\tau_A - \frac{\Delta\Phi_{LO}}{2\pi \cdot f_{LO}})^2]$

Effect of timing jitter

- Long therm phase drifts (>10sec) can be detected and corrected electronically
- frequency drifts cannot be corrected



arrival time: Δt_A

local osc.: Δt_{LO}

sampling clk: Δt_{CCLK}

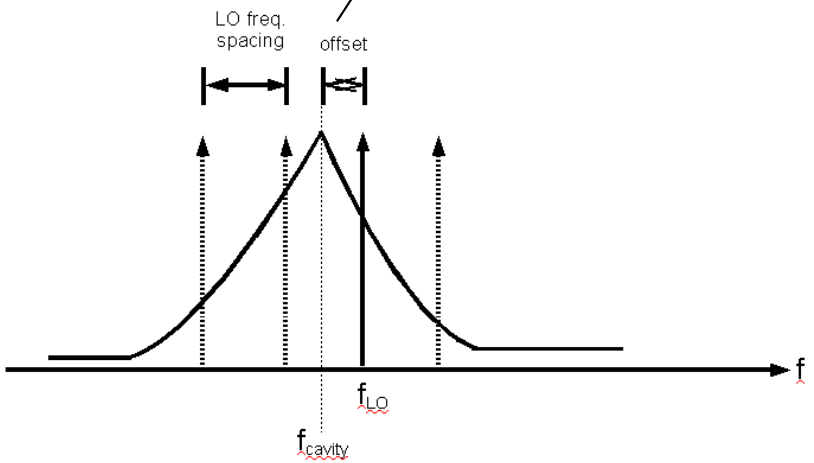
	overall max:	reference timing:	time scale:
RF jitter (Δt_A - Δt_{LO})	350 fs-rms	<100 fs-rms	10 s
Sampling jitter (Δt_A - Δt_{CCLK})	1 ps-rms	<100 fs-rms	10 s

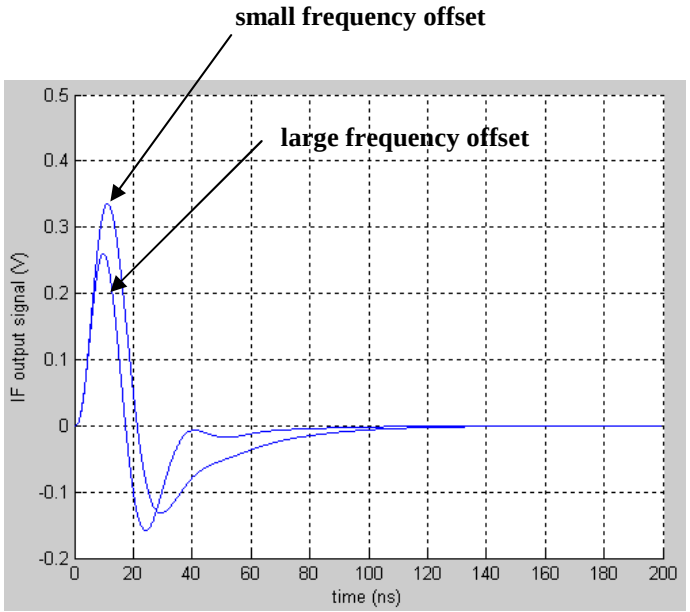
beam parameters (orbit, bunch timing,..) should remain constant during this time !

Reference Freqeuncy Stability

IF signal: $\approx A \cdot e^{-t/\tau} \cdot \cos(2\pi \cdot \Delta f \cdot t + \theta_{RF}) * h_{IF}(t)$

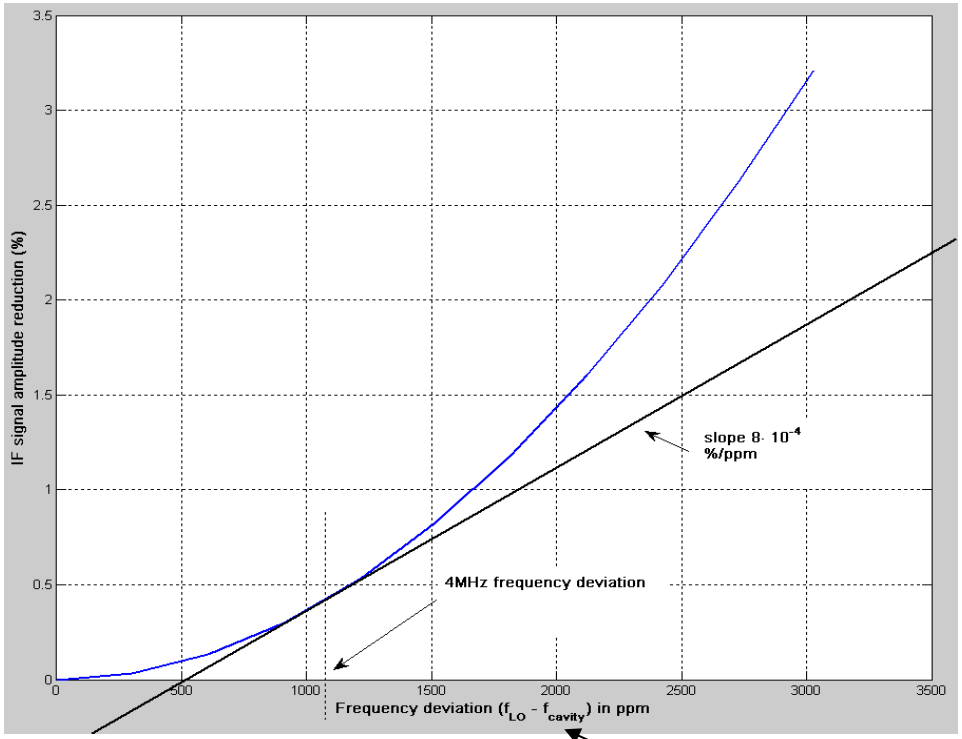
IF-chain impulse response

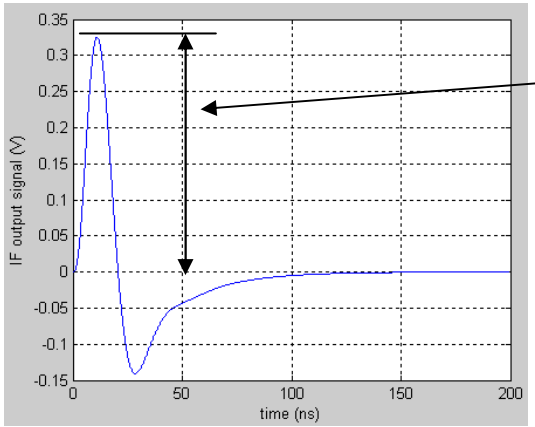




Offset frequency drifts cannot be detected → short&long therm drift requirements

Effect of Frequency Drift





Amplitude = Function of (bunch charge x position, RF-phase, frequency deviation, ….)

Result: frequency deviation < 25ppm (worst case)
Desired stability : 30ppm (peak-peak, short&long therm)

Requirements Summary

Summary list of timing requirements for the Cavity BPM Systems [1)]

Table 3-4: Machine Reference Clock & Beam Timing Requirements for Cavity BPM RFFE

No.	Property	Min.	Typ.	Max.	Unit	Comment
1	Phase Noise @ 10Hz			-95	dBc/Hz	
2	Phase Noise @ 100Hz			-115	dBc/Hz	
3	Phase Noise @ 1kHz			-135	dBc/Hz	
4	Signal Level	7.5	8	8.5	dBm	
5	Frequency		216.666667		MHz	
6	Peak-Peak Frequency Drift (Short & Long Term)			30	ppm	
7	Beam Arrival Time Jitter & Drift Relative To Reference Clock			100	fs peak-peak	
8	Bunch Spacing		N*48		Ref. clock periods	N=Integer
9	Connector Type @ MBU		SMA			

1) B. Keil: Infrastructure Requirements for the European XFEL Beam Position Monitor and Intra Bunchtrain Feedback Electronics


THANK
YOU