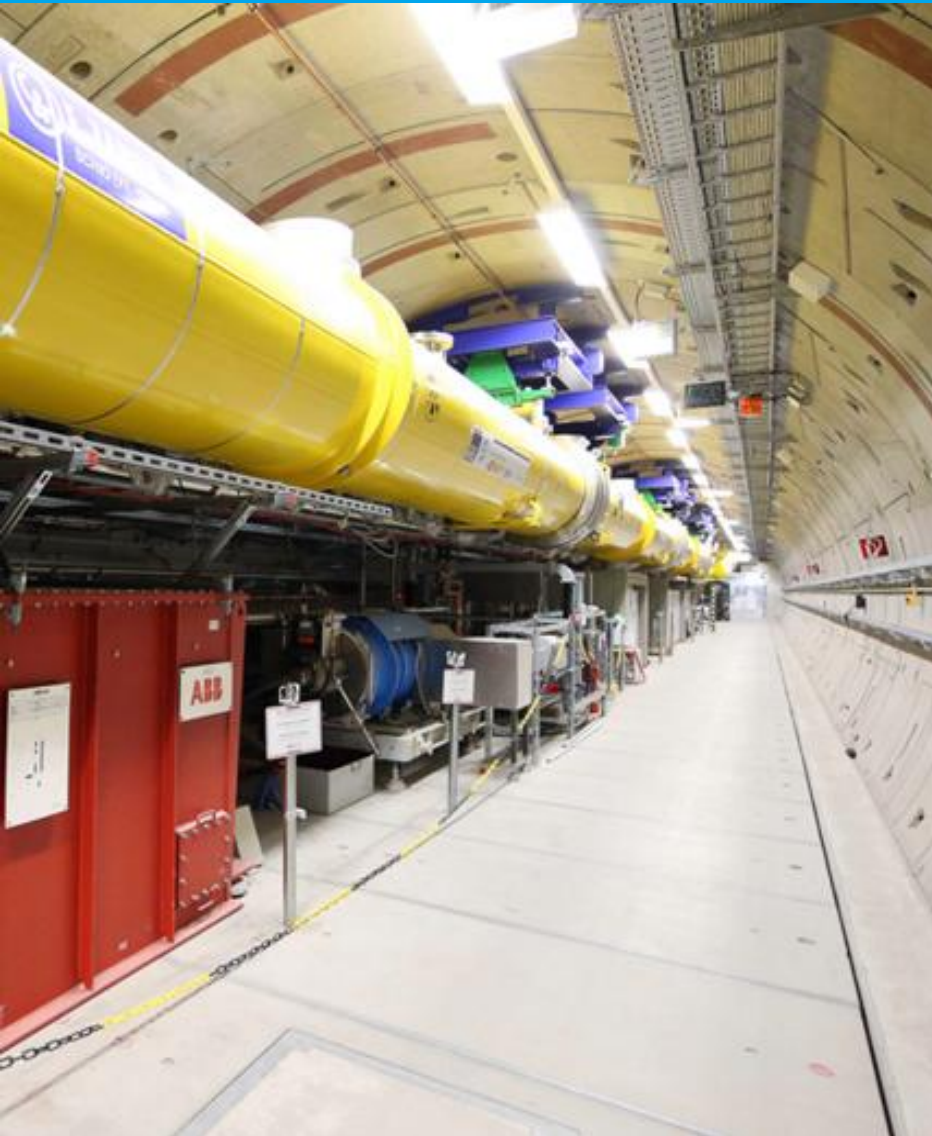


# 4th MicroTCA Workshop 2015



High precision analog measurements  
in high speed modular Standards

Dr. Frank Ludwig  
Dr. Uros Mavric  
DESY, for the LLRF-Team  
DESY, 10.12.2015



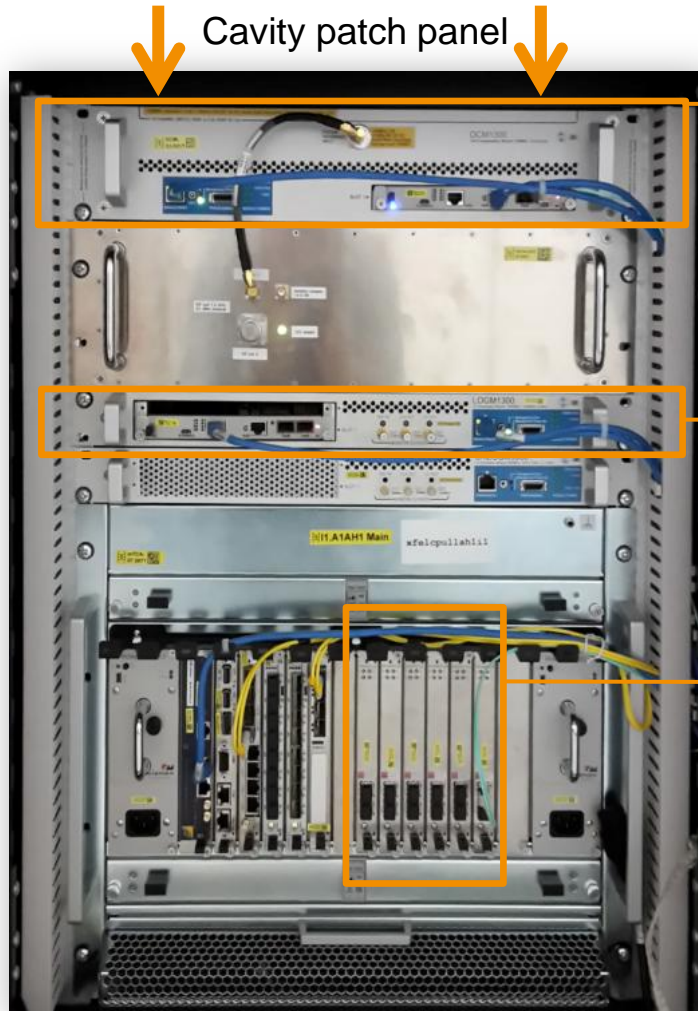
## Content

- 1 Overview
- 2 Short-term Performance
- 3 Concept of EMC Zones
- 4 Grounding in MicroTCA.4 Systems
- 5 System Partitioning for SNRs<-80dB
- 6 Summary and Outlook

DESY  
XFEL, XTL-section 2015

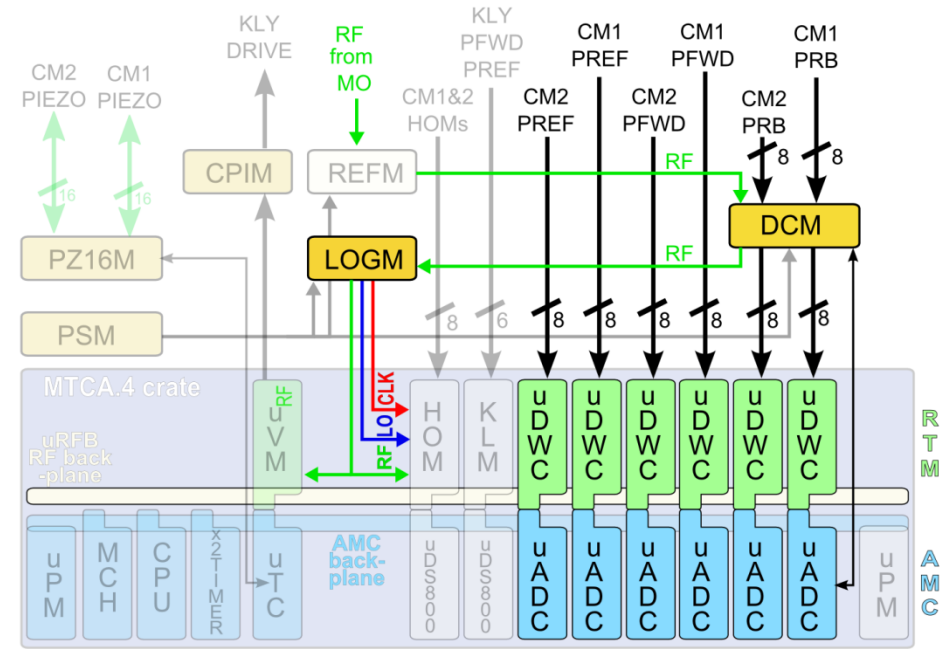
# 1 Overview - LLRF Field detection

## ■ XFEL 48-channel LLRF station:



## ■ Sub-components and signal-flow: (standard non-iq IF sampling scheme)

Drift Compensation	DCM	2U 19" Module
LO-Generation	LOGM	1U 19" Module
Down-Converter	DWC	RTM MicroTCA.4
Low-noise Digitizer	ADC	AMC MicroTCA.4





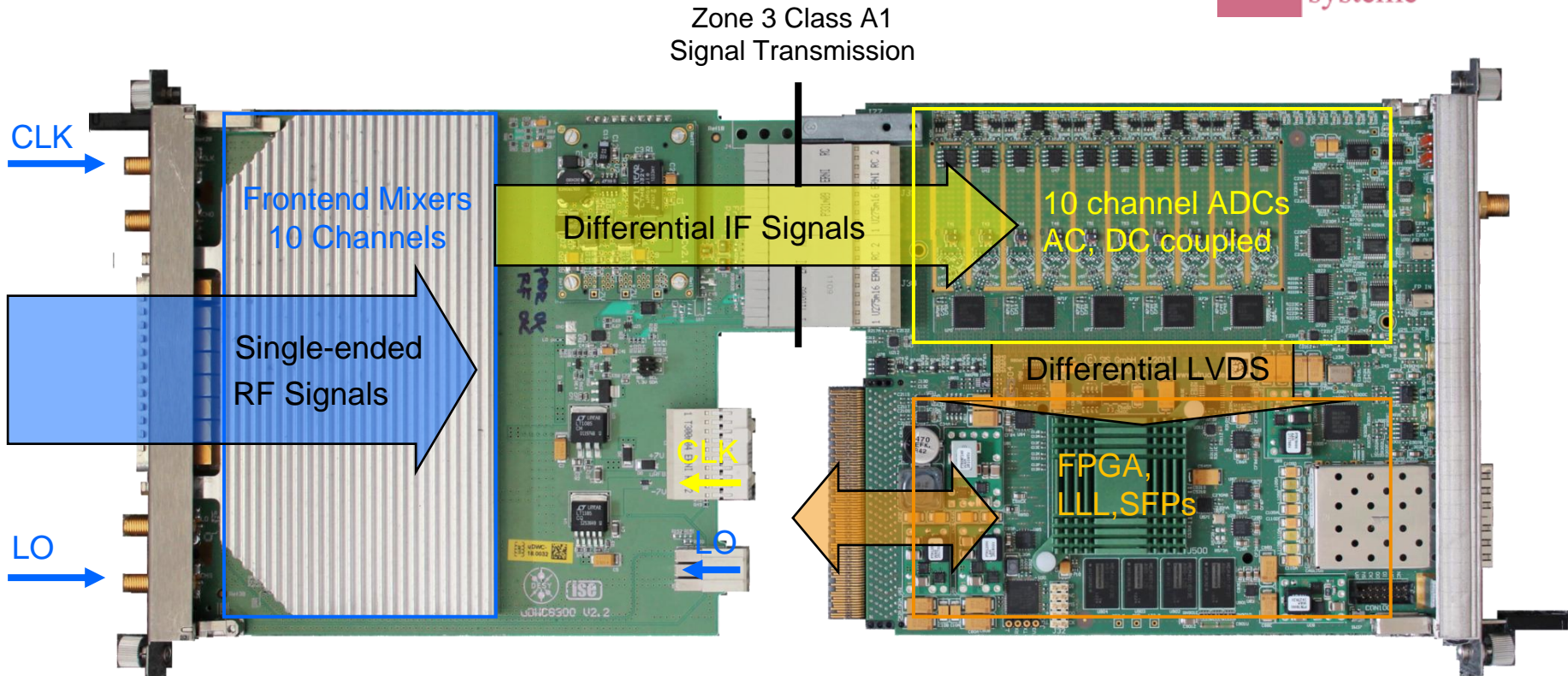
# 1 Overview - Signal Conditioning and Digital Processing

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- High frequency Down-Converter (DRTM-DWC10, under license)

- Multi-Channel fast ADC Digitizer (SIS8300L2)

struck innovative  
systeme



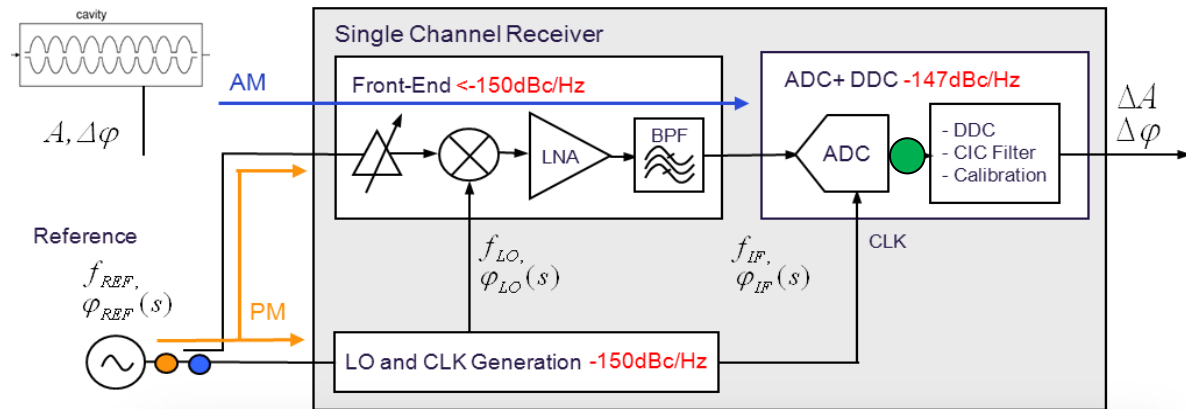
- 10 channel field detection
- S-band (700MHz - 4.0GHz)
- Resolution, 0.003%, < 10fs

- 10 channel ADCs (125Mps, 16-Bits)
- FPGA (Virtex6) pre-processing partial cavity vectors
- Low latency links via MTCA-backplane

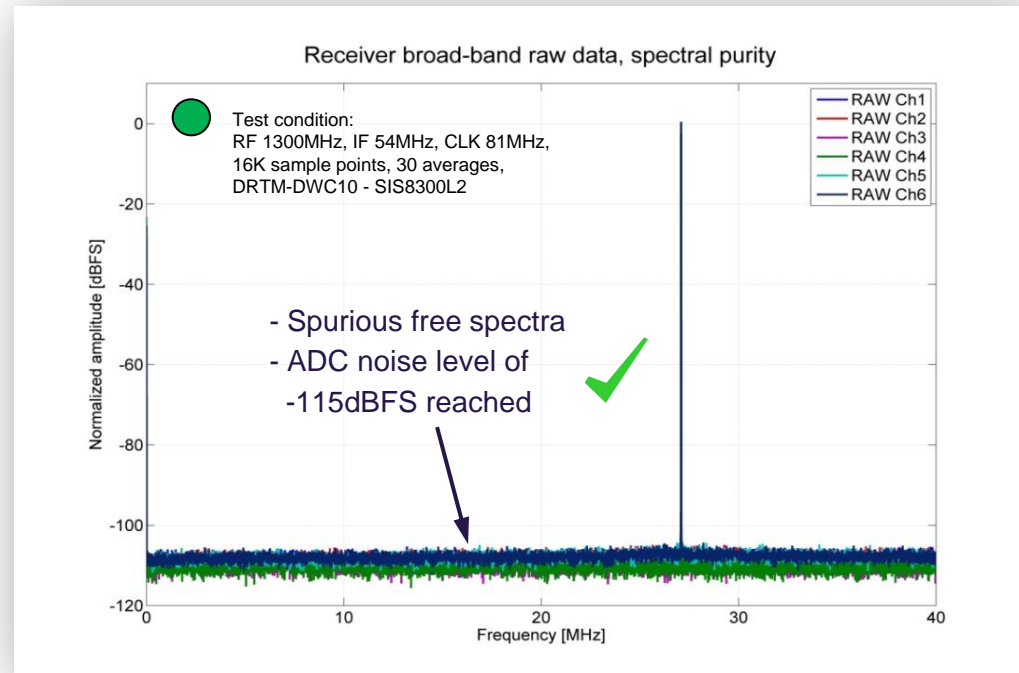
## 2 Channel performance (laboratory) - DWC8300/SIS8300L2

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### ■ Spectral purity : (1DUT)



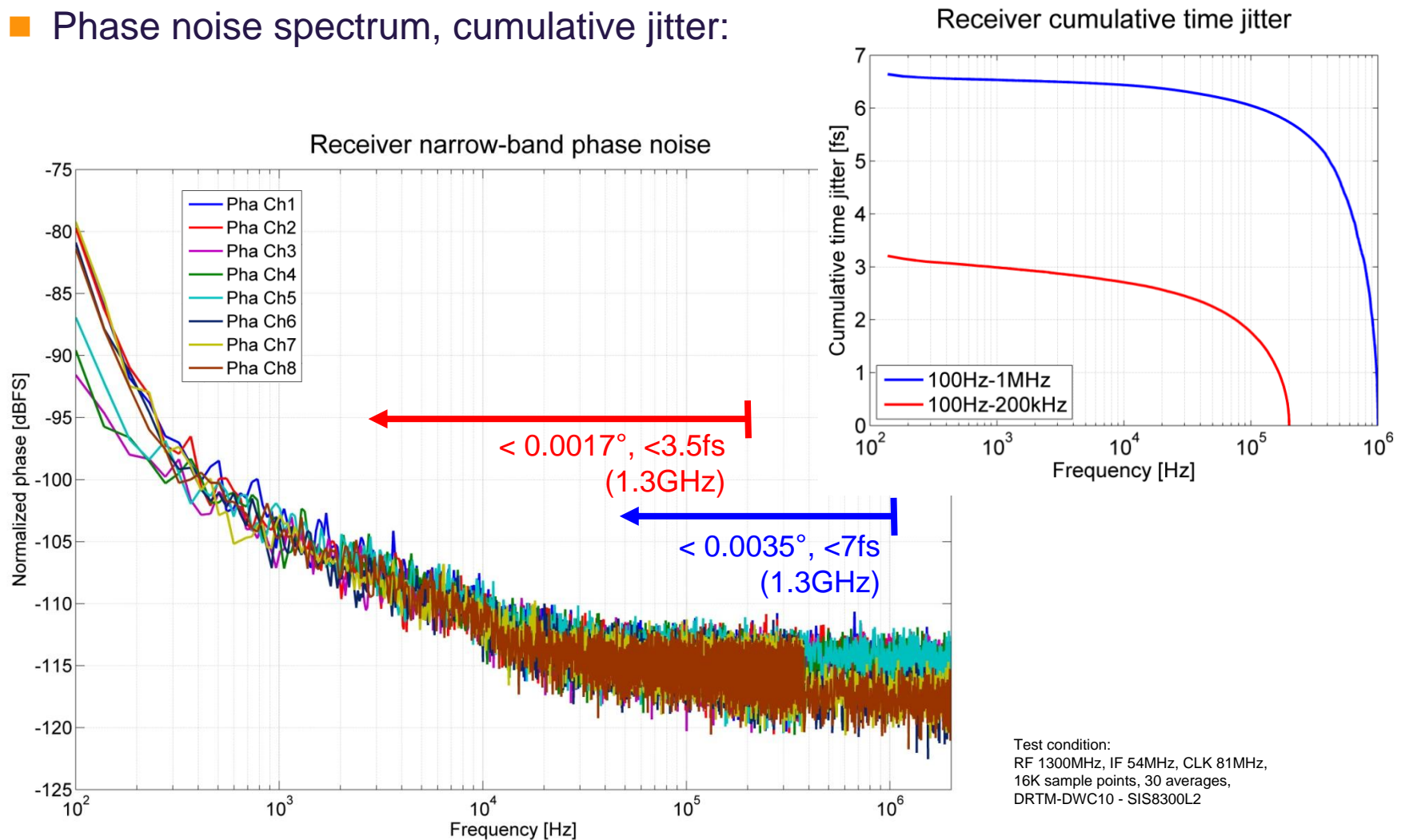
System's  
Fingerprint



## 2 Channel performance (laboratory) - DWC8300/SIS8300L2

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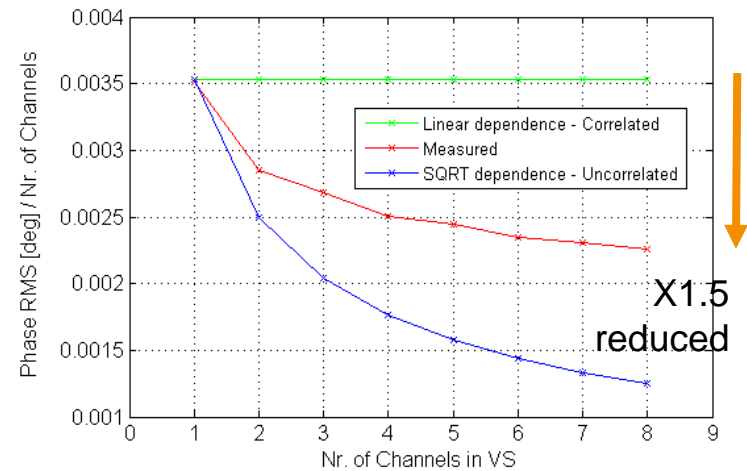
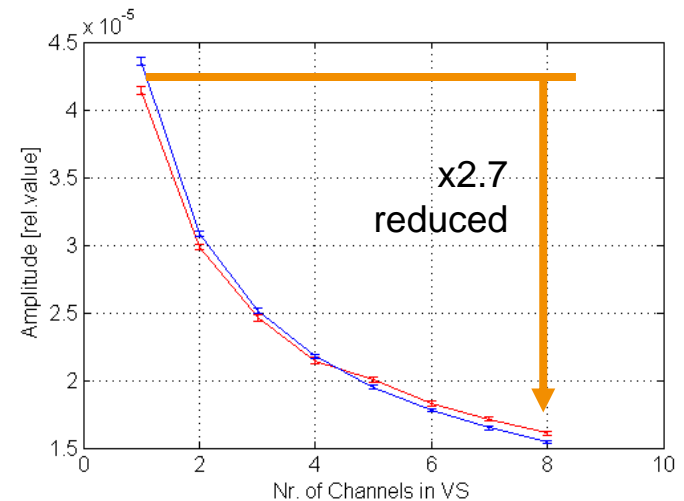
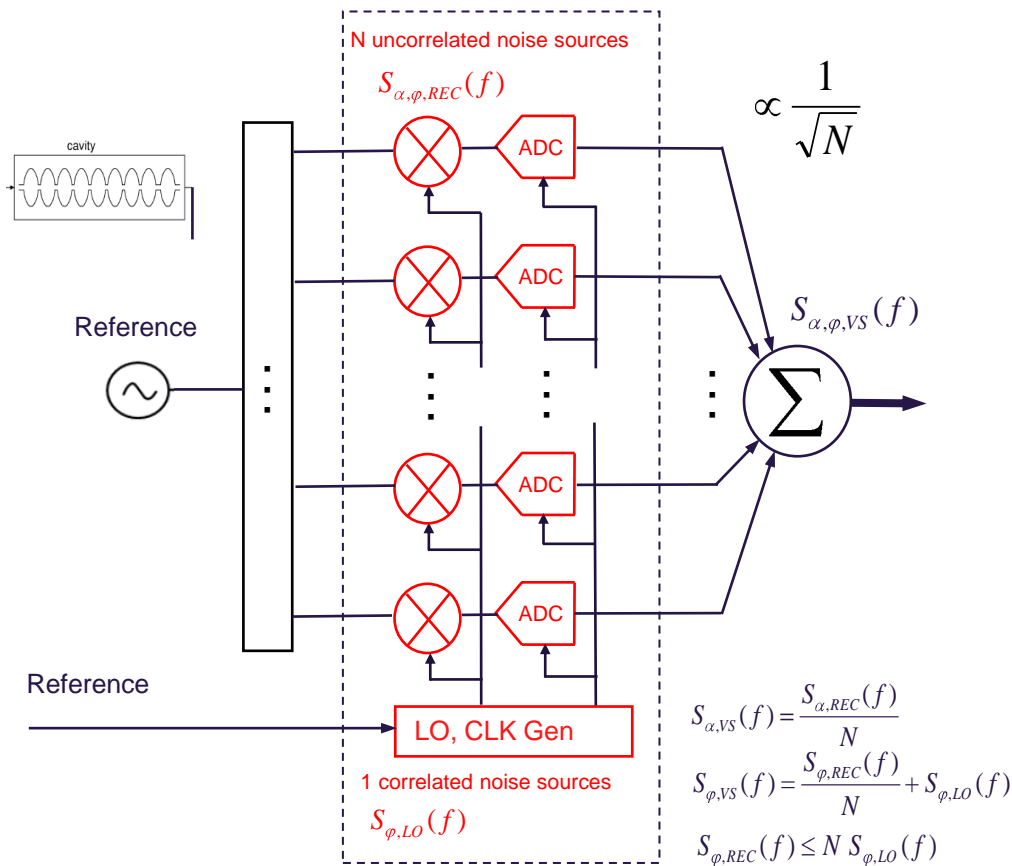
### Phase noise spectrum, cumulative jitter:



## 2 Scaling Performance (laboratory) - DWC8300/SIS8300L2

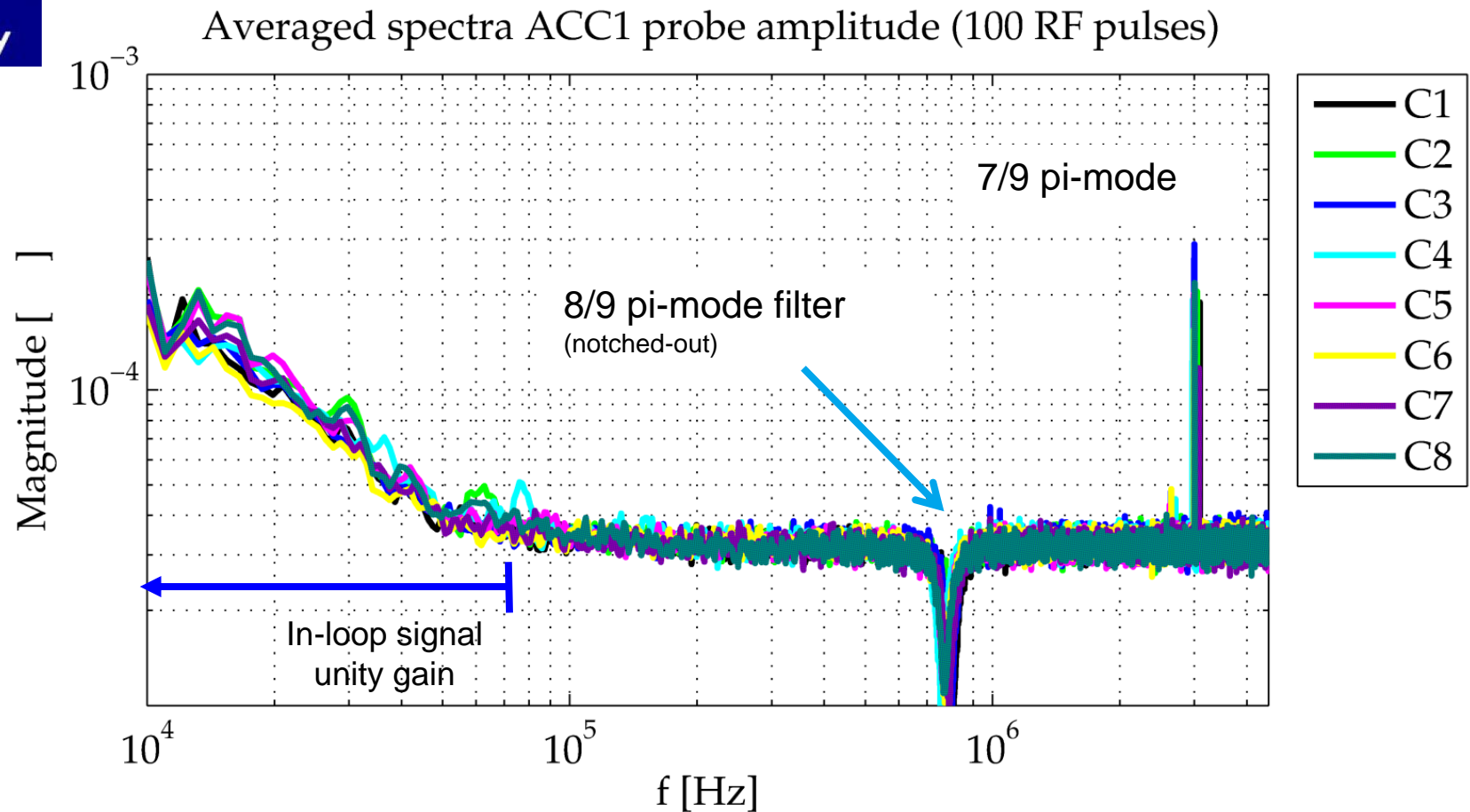
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### ■ AN, PN channel scaling behavior:



## 2 Channel performance (FLASH ACC1) - DWC8300/SIS8300L2

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## 2 Sources of Errors

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### ■ Summary of 4 years PCB development errors (DWC and ADC) :

01/2011	#17	Power supply chain design violations
	#13	Signal integrity issues
	# 8	Specification changes
	# 6	Matching, level and crosstalk violations
	# 5	Mechanical violations
3/2014	# 1	Grounding issue on a level of -150dBc/Hz



- Most of the errors were “simple errors” on the active side of the circuit and not related to the MicroTCA.4 standard.
- To push the limits for future applications we investigate the “black magic” side of the system: The Grounding and EMC (Electro-Magnetic Compatibility).

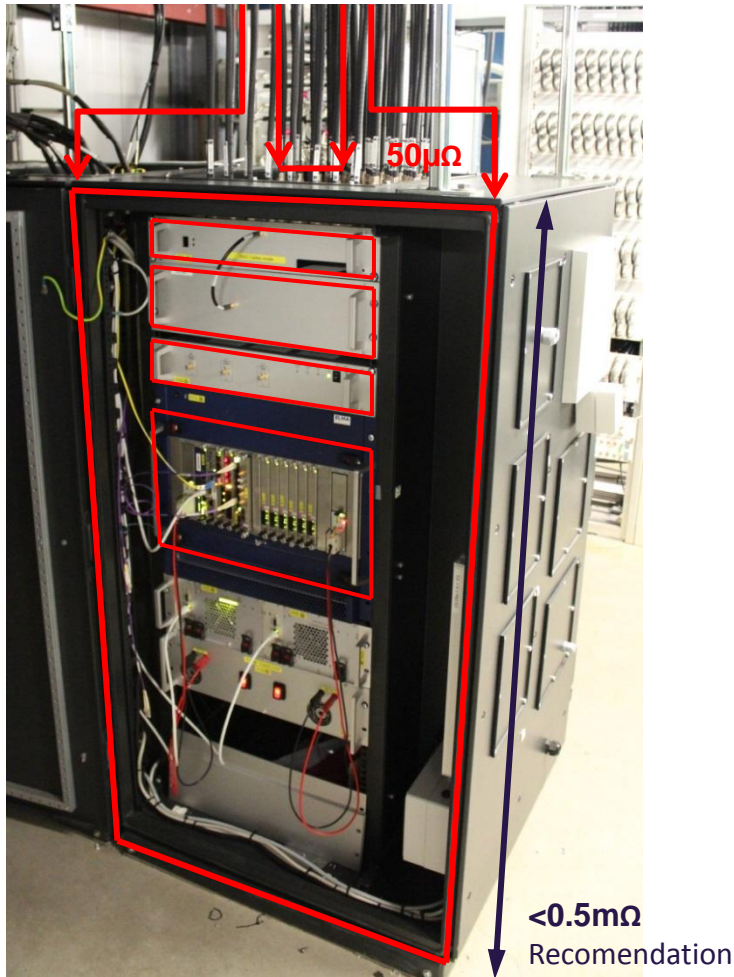


<https://pixabay.com>, CC0 Public Domain

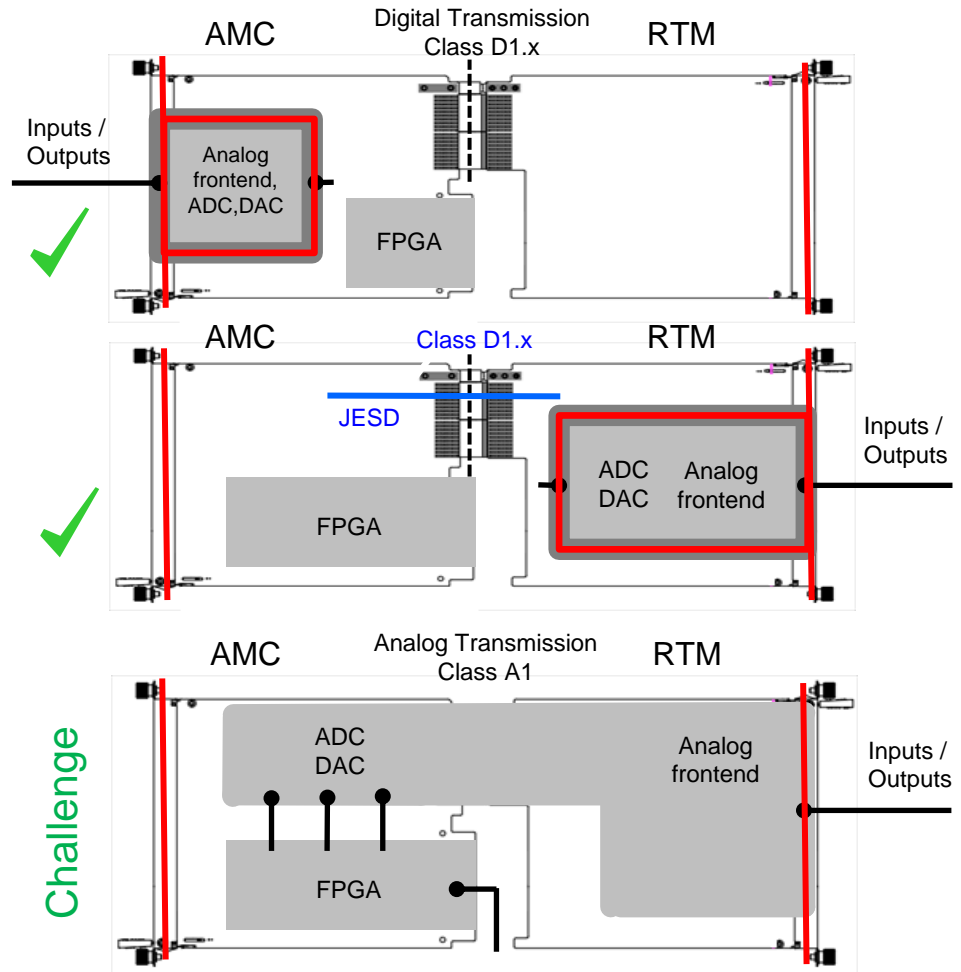
# 3 EMC Zones – System Robustness to External Distortion

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## ■ Rack-Level



## ■ Crate-Level (Modular systems e.g. MicroTCA.4)

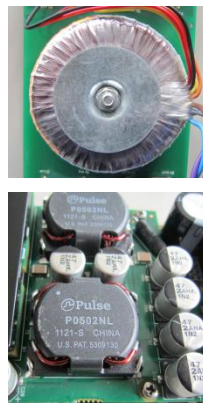
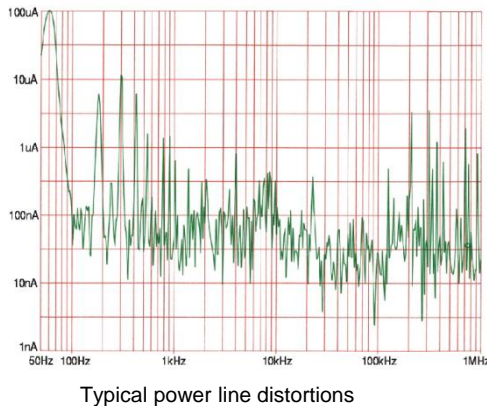
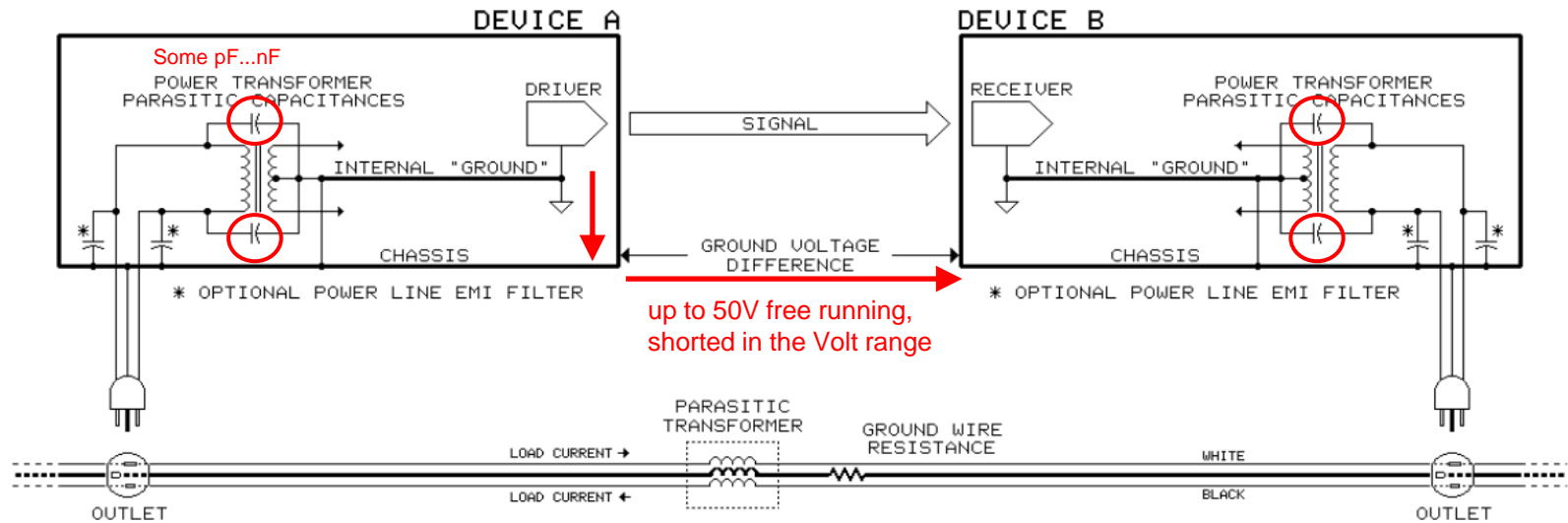


# 3 Grounding and Interfacing

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## ■ Leakage currents between systems due to parasitic capacitances :

[Whitlock]



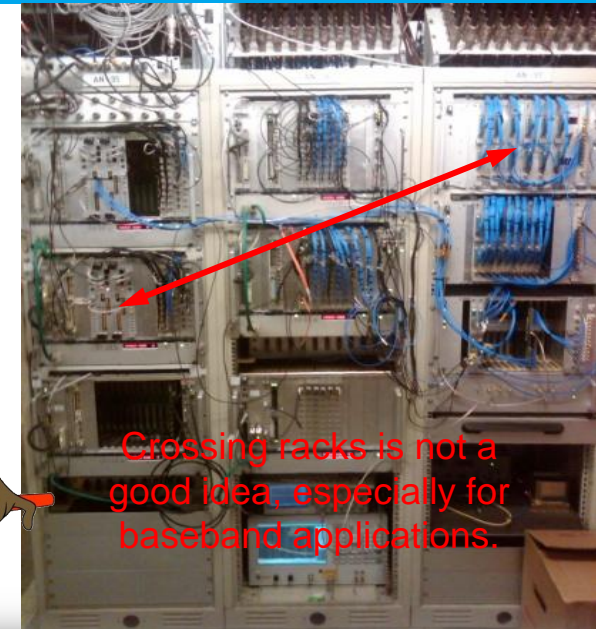
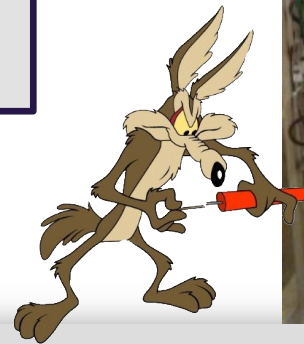
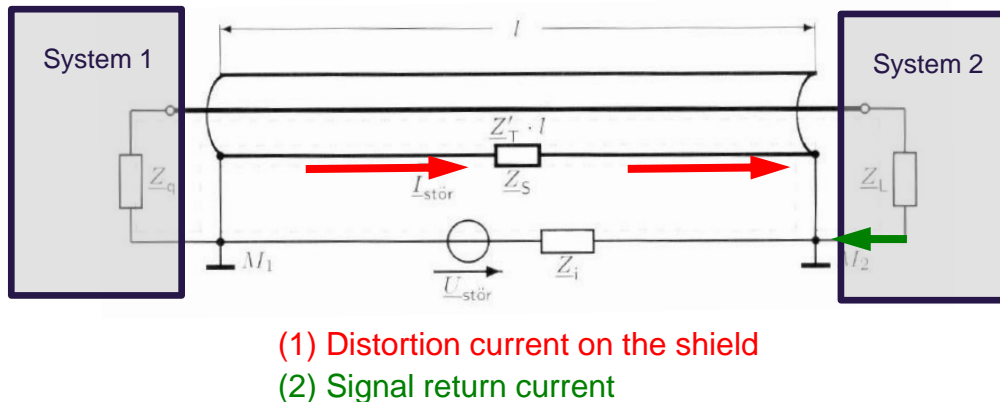
Good isolation



- Isolation quality depends on the power supply
- Isolation is never perfect
- Chassis-Chassis, Ground-Chassis distortions exists (V range, up to MHz)

### 3 Grounding and Interfacing

#### ■ Interfacing signals (two sided-grounded) :



Crossing racks is not a good idea, especially for baseband applications.

- Similar effect for differential interfaces, e.g. over Zone 3 in xTCA  
CM ground distortions convert to DM distortions via the finite CMR of the receiver.
- > Requires exceptional good EMC planning of your infrastructure!
- > Methods to break the ground loop fail if distortions are in your information band

↪ Performance and operation reliability depends strongly on the system packaging!



# 4 Grounding configurations in MicroTCA.4

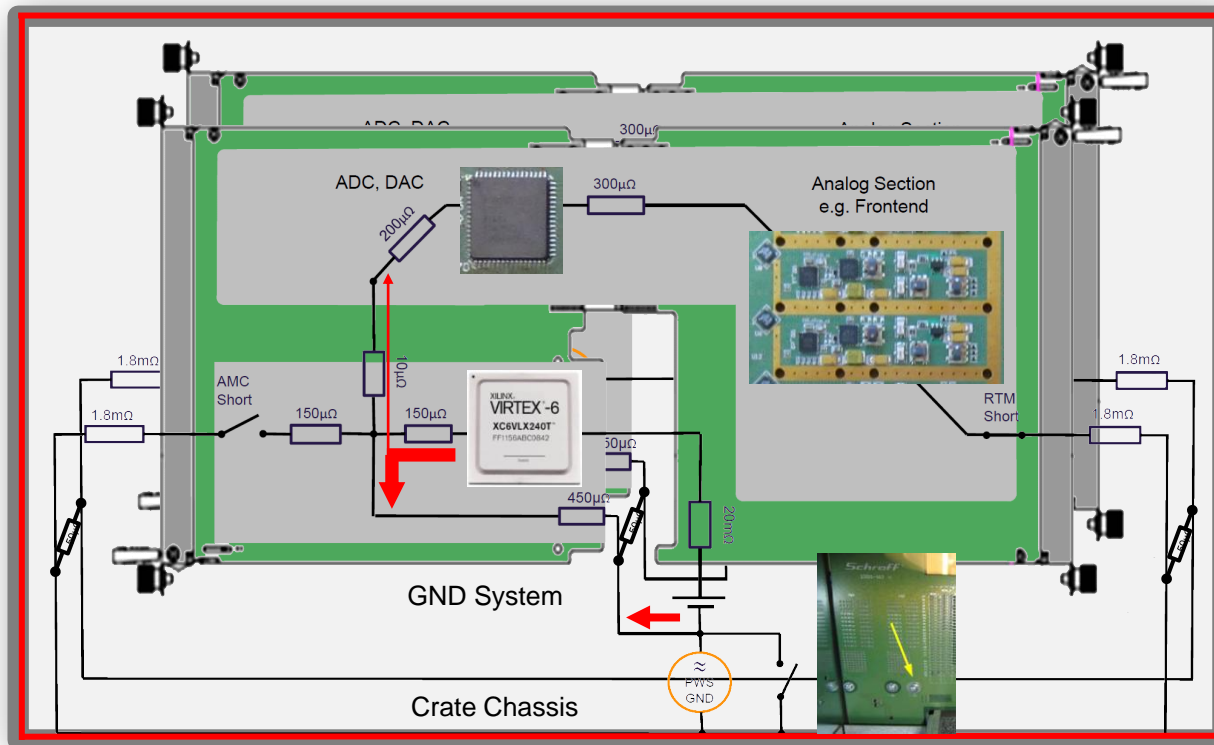
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## ■ Properties of the Ground System in MicroTCA.4 for Z3 analog transmission:

- Return currents and signals share the same ground, all slots share one ground.
- Available shorts: Chassis-to-Ground (MicroTCA.4), Chassis-to-AMC, Chassis-RTM.
- No bypass structures for boards, the ground is unshielded.



(No Bypass for the Ground)



## Main distortions sources:

- AMC,RTM Loads

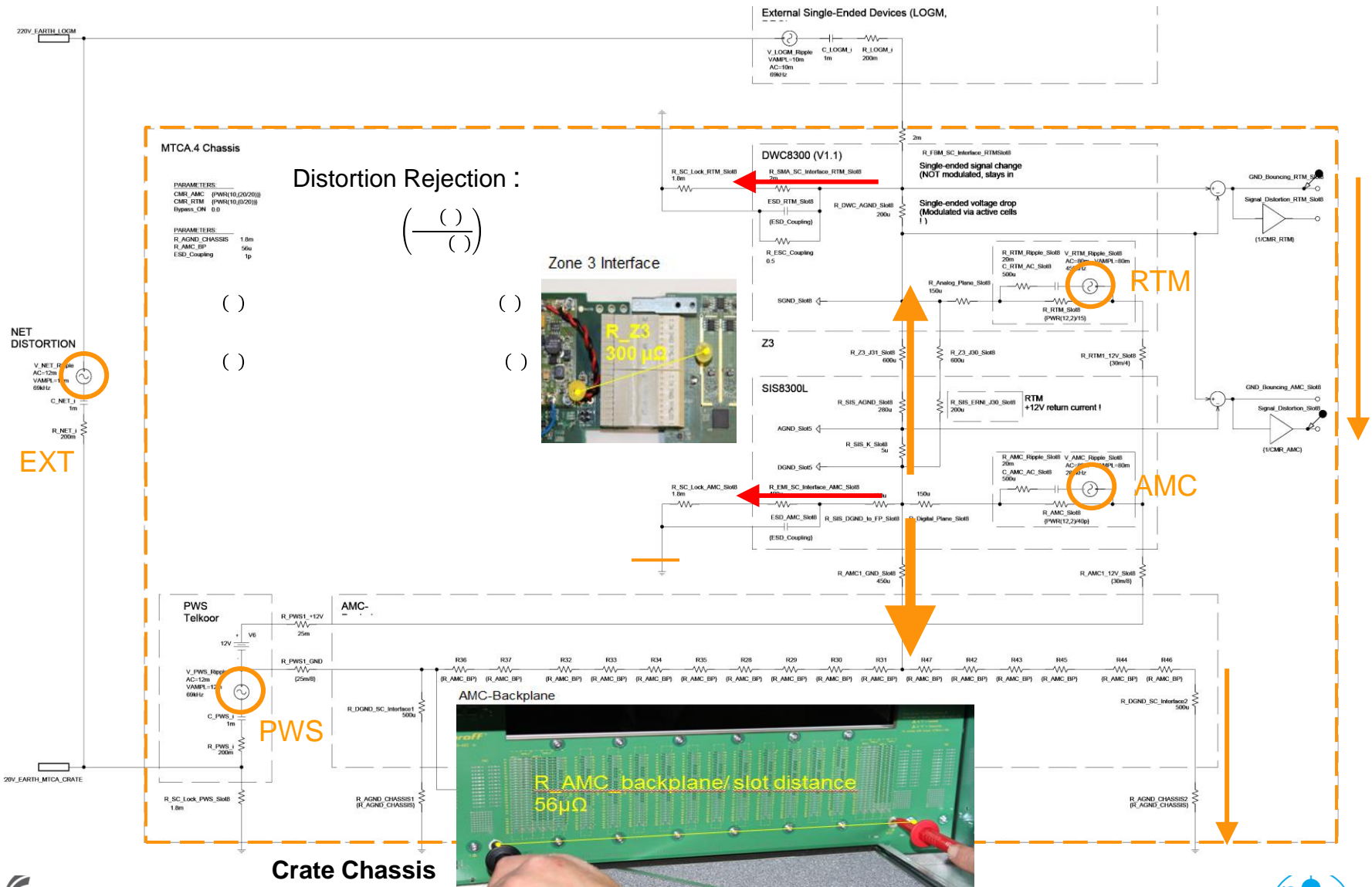


- Power Supply Module



# 4 Crate Ground Modelling – Example: Z3 Analog Transmission

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# 4 Crate Ground Modelling – Results

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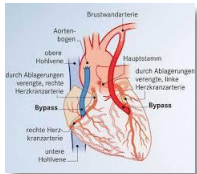
Reduced local AMC, RTM ripples (active side)  
approx. 10...20dB



Industry reduced power-supply ground-chassis distortions  
approx. 10...20dB, 600mVpp (2011) -> 20mVpp (2014)



Short ground-chassis distortions of the power supplies  
approx. 10...20dB



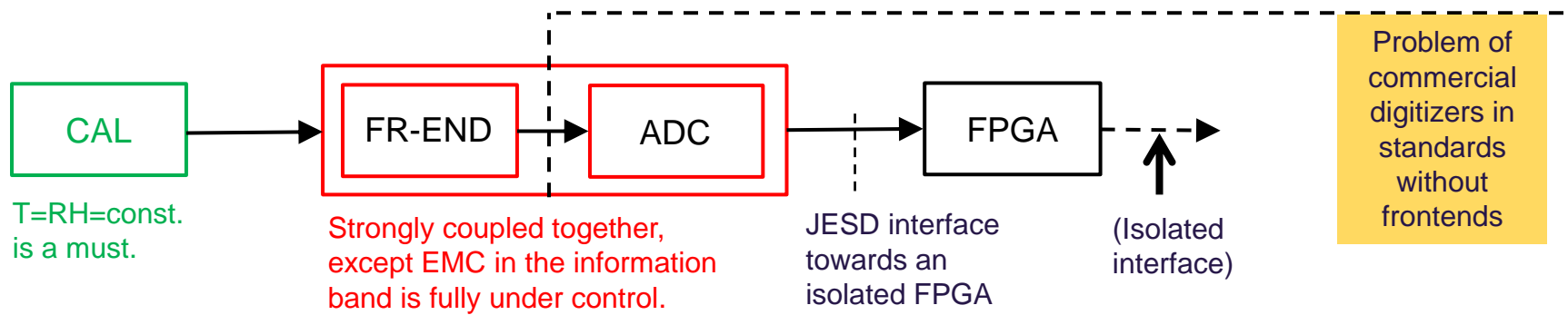
Bypass AMC, RTM ground distortions into the chassis  
approx. 10dB





Improved the receivers CMR (project specific)  
approx. 10dB

# 5 System Partitioning / Packaging for < -80dB Stability

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High frequency Applications	MicroTCA.4 Configuration	AMC: ADC ext. : FR-END	AMC or RTM: FR-END + ADC	AMC: ADC RTM: FR-END	Proprietary
	Signal integrity by external distortions	Depend on EMC	Good, Excellent for optical inputs	Good, Excellent for optical inputs	Excellent
	Signal integrity by internal distortions	Very good	Very good	Good	Excellent
	Modularity	Excellent	Excellent	Excellent with Z3 Class	Poor
Baseband Applications	MicroTCA.4 Configuration	AMC: ADC ext. : FR-END	AMC or RTM: FR-END + ADC	AMC: ADC RTM: FR-END	Proprietary
	Signal integrity by external distortions	Depend on EMC (strongly)	Depend on EMC, Excellent for optical inputs	Depend on EMC, Excellent for optical inputs	Excellent
	Signal integrity by internal distortions	Very good	Very good	open - to be tested	Excellent
	Modularity	Excellent	Excellent	Excellent with Z3 Class	Poor



- Spurious free short-term amplitude and phase detection below  $<10\text{fs}$  [1MHz BW] at 1.3GHz is achieved in MicroTCA.4



## Thanks for your attention!

### References :

[Joffe]

Elya B. Joffe, Kai-Sang Lock, Grounds for Grounding,  
ISBN: 978-0-471-66008-8, 01/2010, Wiley-IEEE Press

[Whitlock]

Bill Whitlock, Understanding Finding & Eliminating Ground Loops,  
CEDIA Class EST016, Jensen Transformers, Inc. Chatsworth, CA