



HOM-based Beam Diagnostics: from FLASH to the European XFEL

N. Baboi for WP12, Task 4

HOM-based Beam Diagnostics

EuCARD-2 Annual Meeting, 20 May 2014



Universität
Rostock



Traditio et Innovatio



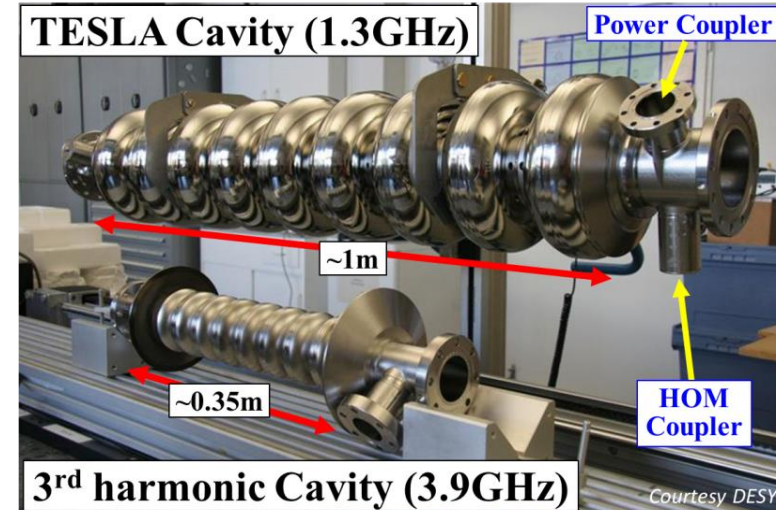
The Cockcroft Institute
of Accelerator Science and Technology

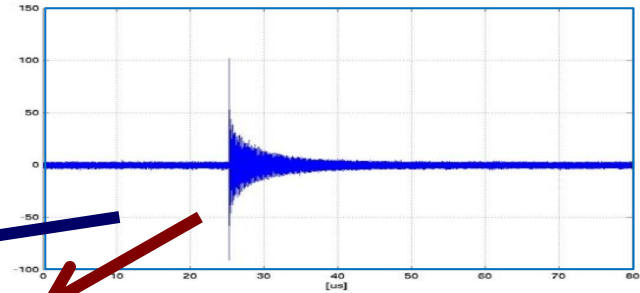


EuCARD-2 is co-funded by the partners and the European Commission under Capacities 7th Framework Programme, Grant Agreement 312453

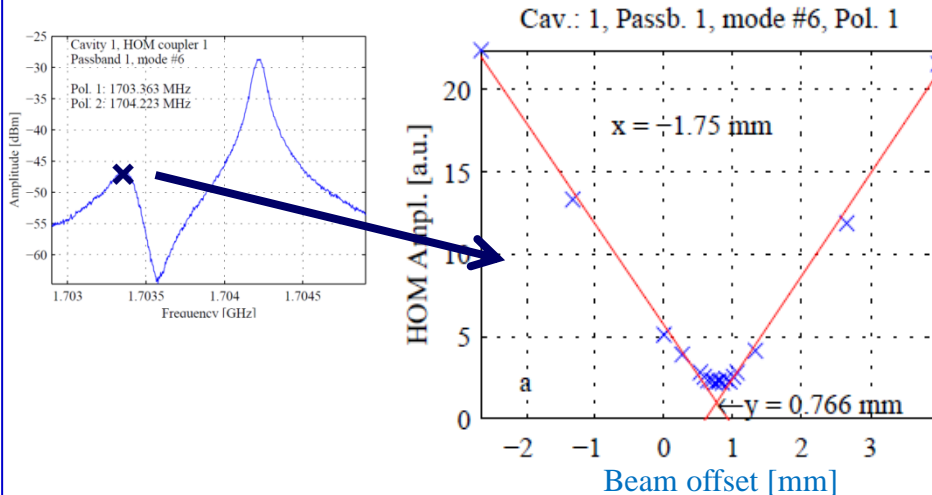
- Aim, principle, benefits
- HOMBPMs for 1.3 GHz cavities
 - Experience at FLASH
 - Status of work for the E-XFEL
- HOMBPMs for 3.9 GHz cavities
 - Experience at FLASH (EuCARD)
 - Status for XFEL
- HOM-based beam phase
- Summary

- **HOM-based beam diagnostics for the European XFEL (E-XFEL)**
 - Beam phase (wrt RF) and position (HOMBPM)
 - In 3.9 GHz and 1.3 GHz cavities
 - Strong interconnection to the FLASH linac

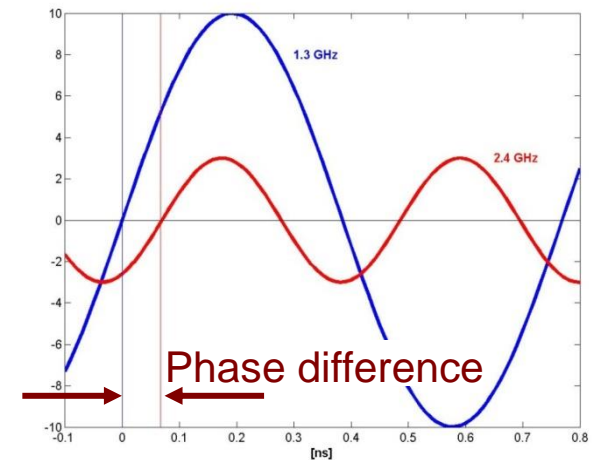




➤ Filter higher dipole mode for beam position

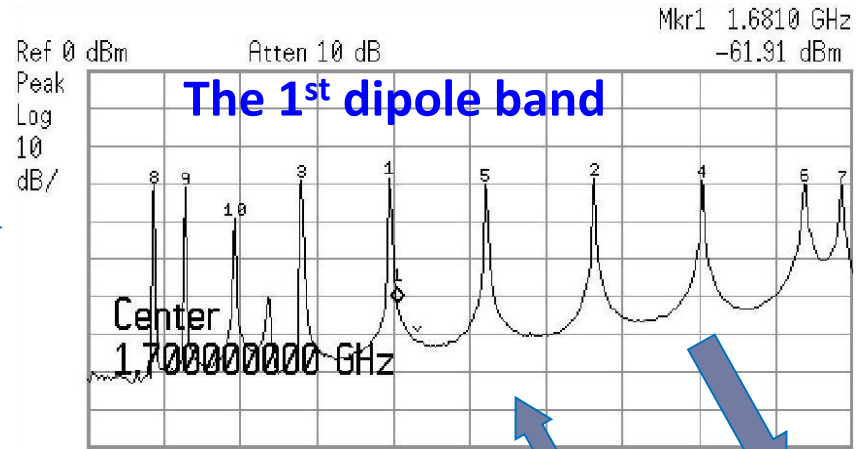
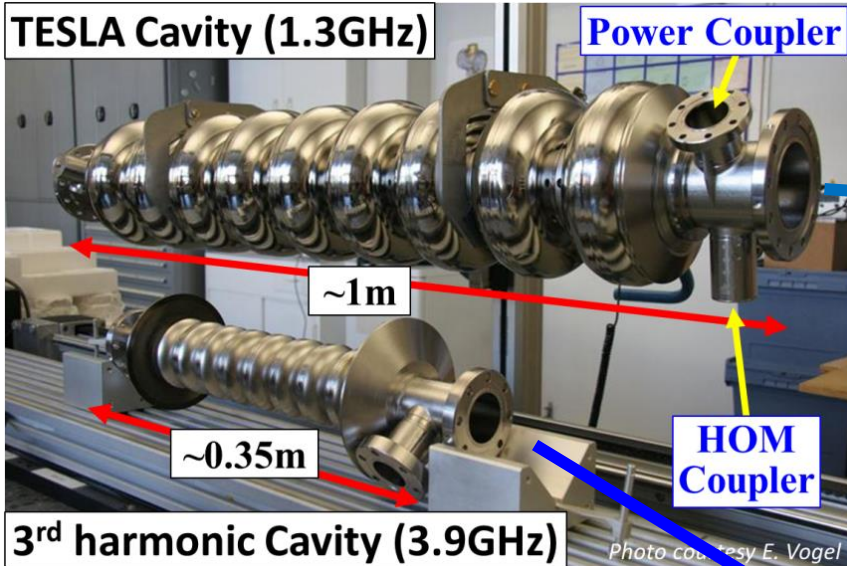


➤ Filter higher monopole mode for beam phase



- Additional beam diagnostics without additional vacuum component
 - Additional information on cavity alignment
- Reduction in emittance dilution from transverse wakefields by centering beam in accelerating cavities
- Direct, on-line measurement of beam phase wrt RF phase

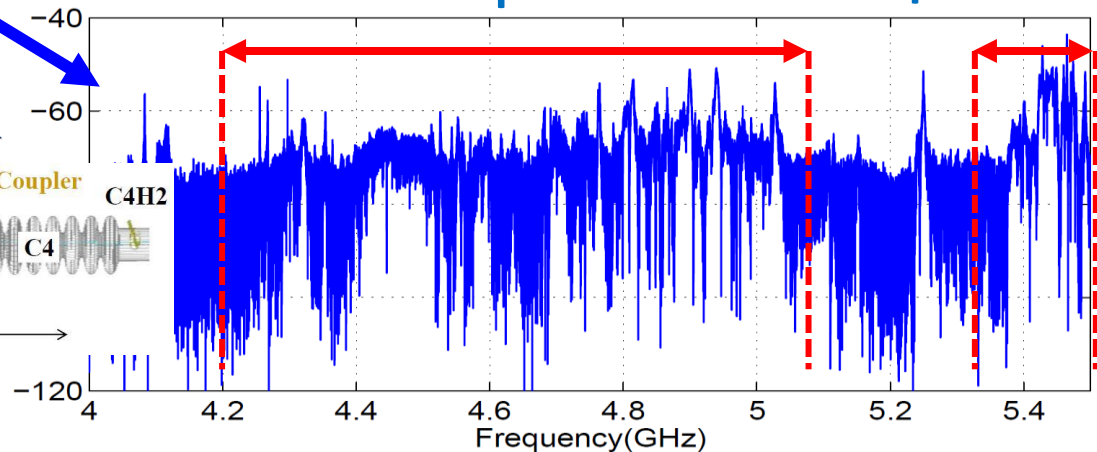
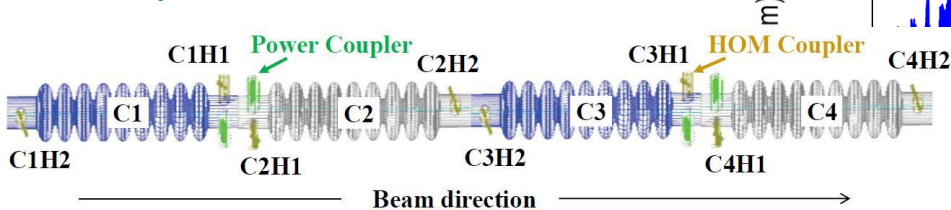
Accelerating Cavities in the E-XFEL and FLASH



HOMBPM **The 2nd dipole band**

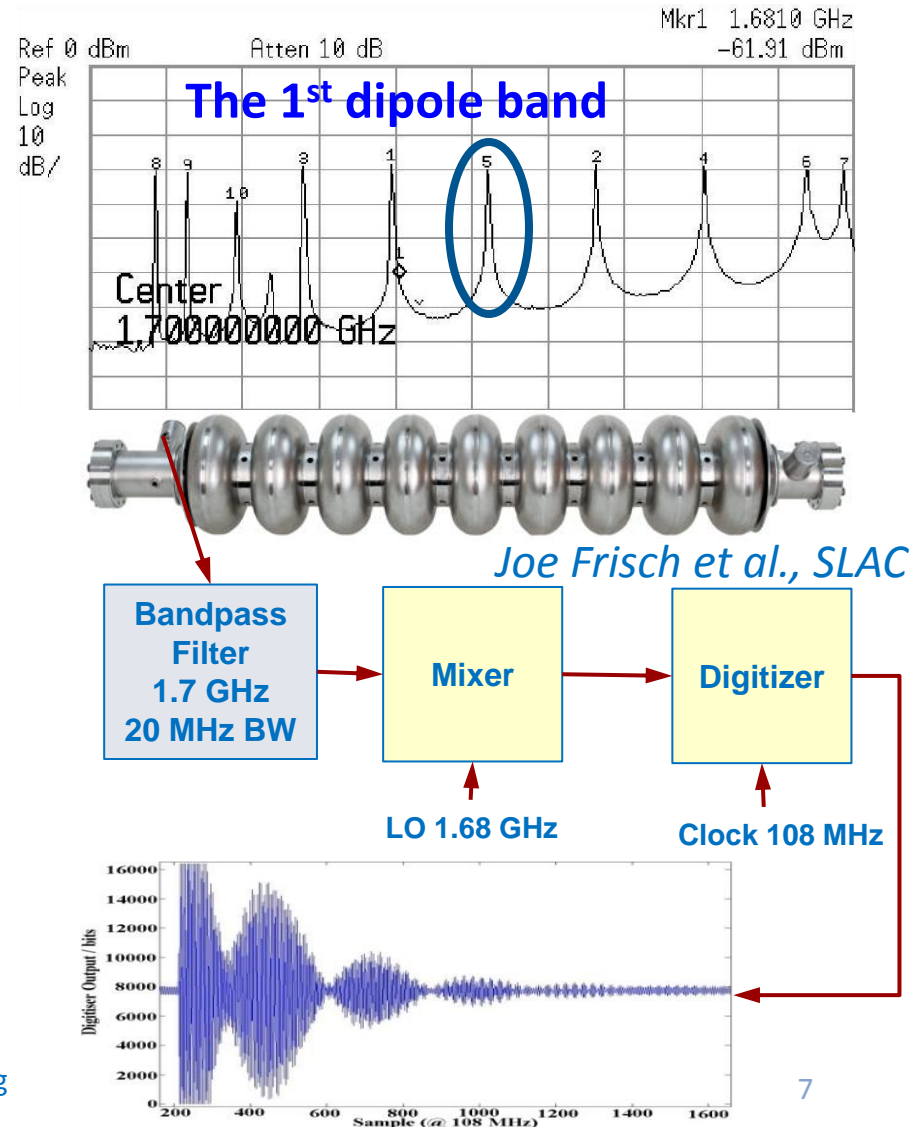
The 1st dipole band **The 2nd dipole band**

Coupled cavities

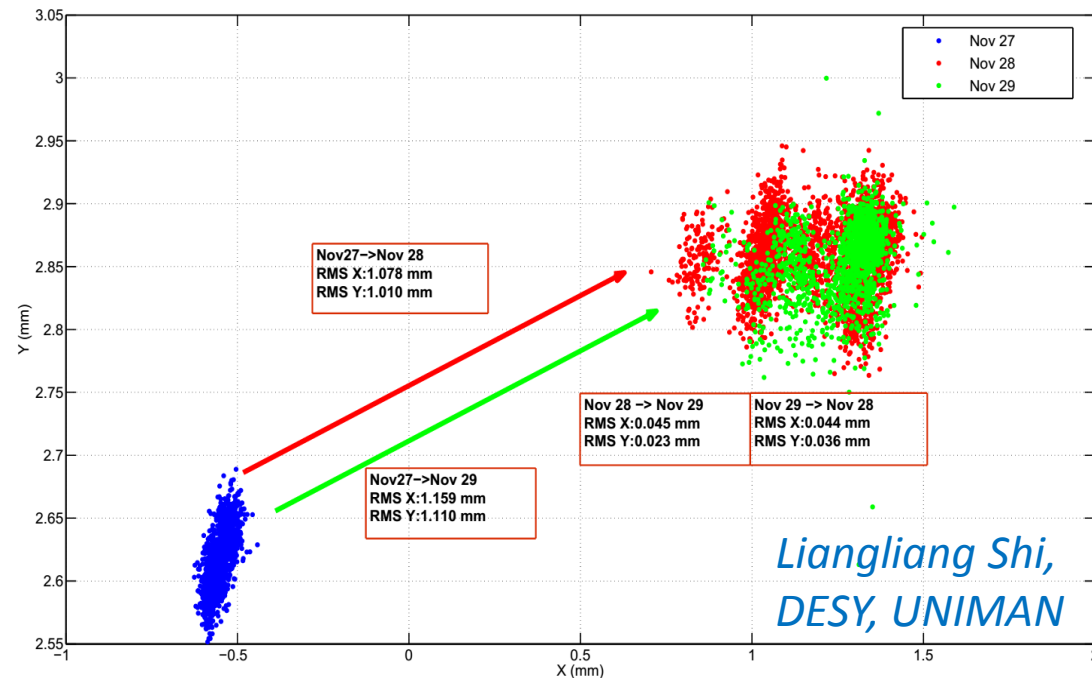


HOMBPMs at FLASH: 1.3 GHz Cavities

- Electronics built by SLAC
- HOMBPM-electronics installed in 40 cavities in FLASH
 - Use 1 dipole mode at 1.7 GHz
 - Used as operator tool for beam alignment
 - Used for measurement of cavity alignment
 - Demonstrated use as BPM
10 μm rms resolution
- **EuCARD-2**
 - Study stability of calibration into BPM-signals



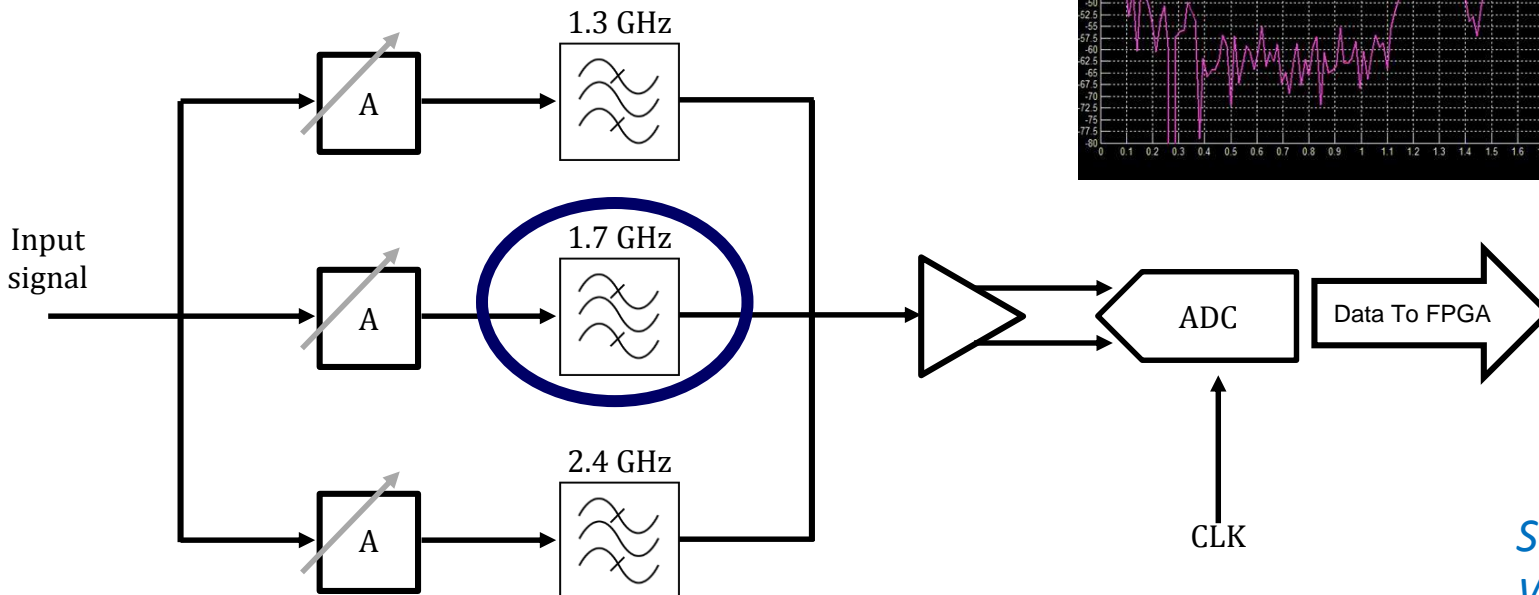
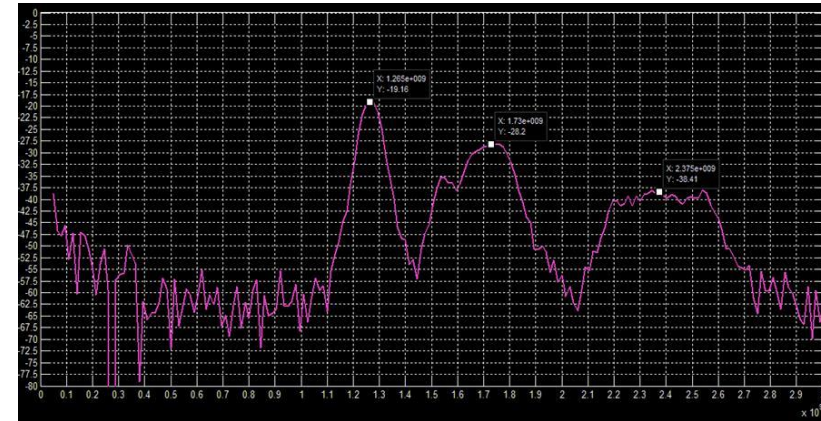
- Preliminary stability study
 - Mostly parasitical measurements
 - It seems that there is a strong correlation between calibration stability and the data position
- Relevant for the E-XFEL as well



- **Electronics Design**

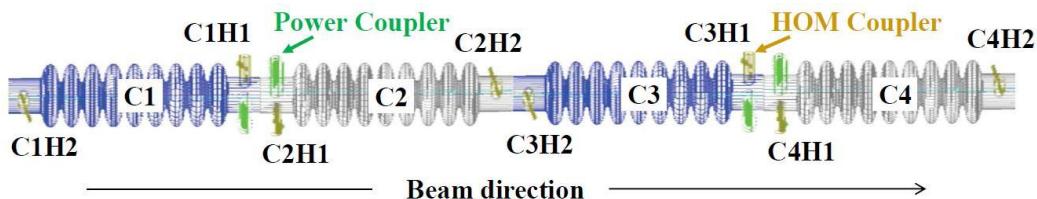
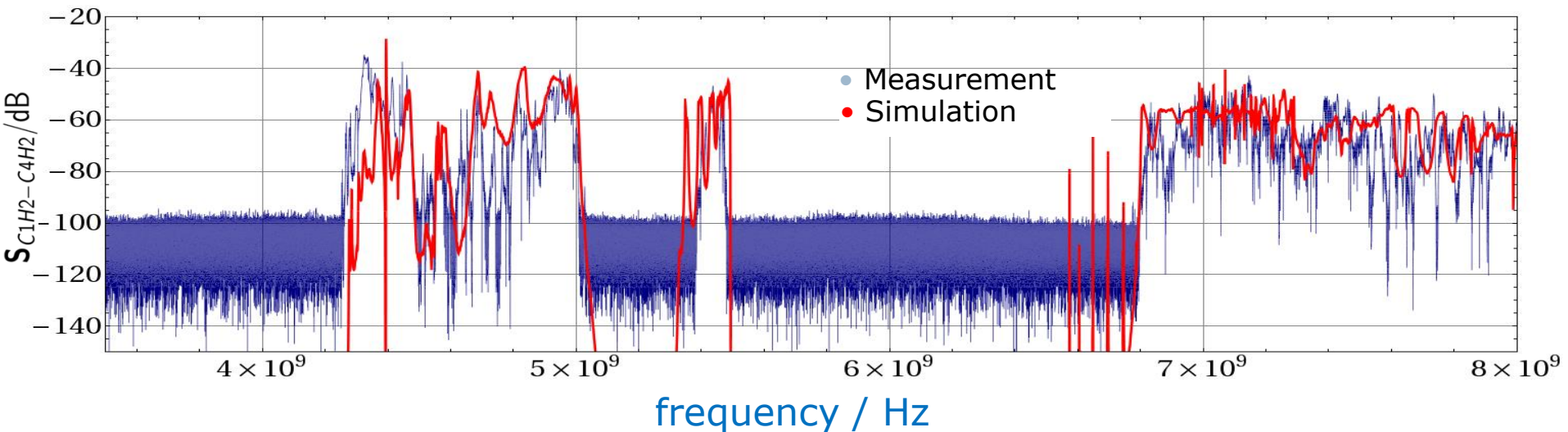
- Direct sampling of all three frequencies without any DCW
- MTCA standard
- Multiple filtering

Not object of EuCARD-2



*Samer Bou-Habib,
WUT, DESY*

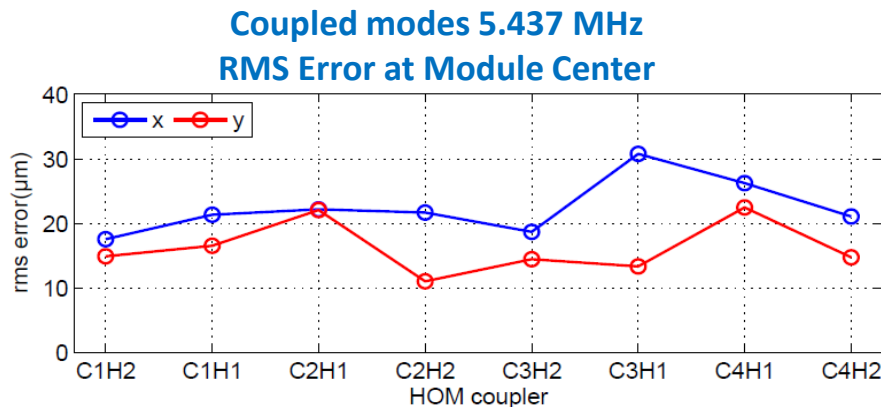
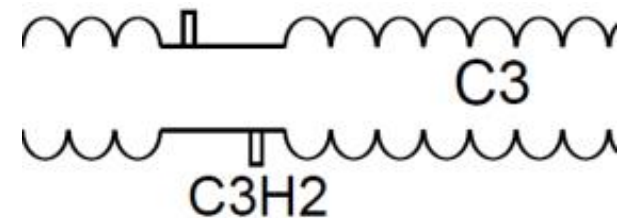
- Theoretical studies made within EuCARD
 - 4 coupled cavities



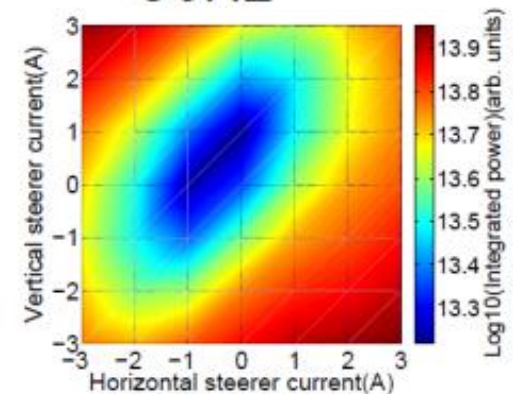
T. Flisgen et al., Phys. Rev. ST Accel. Beams, 17:022003, February 2014

*Thomas Flisgen,
UROS*

- Experimental studies made within **EuCARD**
 - Specs for FLASH and E-XFEL
- **EuCARD²: Stability study**



Integrated power



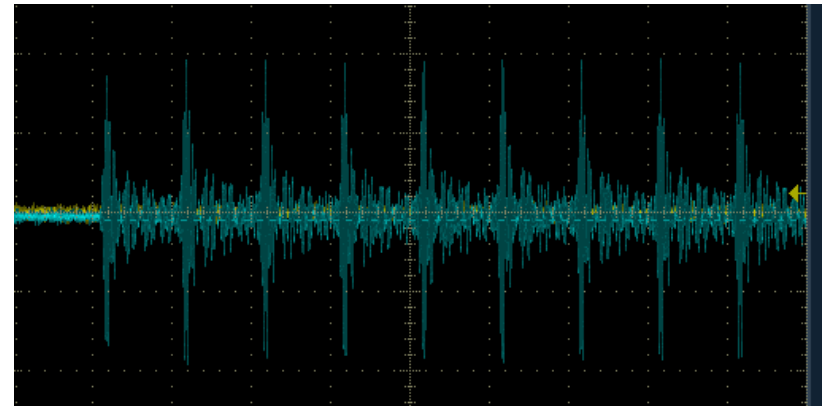
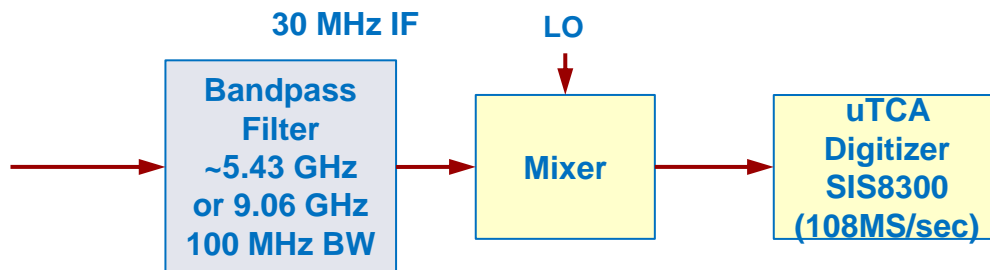
Pei Zhang,
ex-DESY
(now CERN)

| Position type | Resolution | # of channels |
|---------------------------------|------------|----------------|
| Local position in the cavity | ~ 50 µm | 6 HOM couplers |
| Global position over the module | ~ 20 µm | 2 HOM couplers |

- Electronics built at FNAL
 - Now under commissioning
 - Will serve as prototype for the E-XFEL

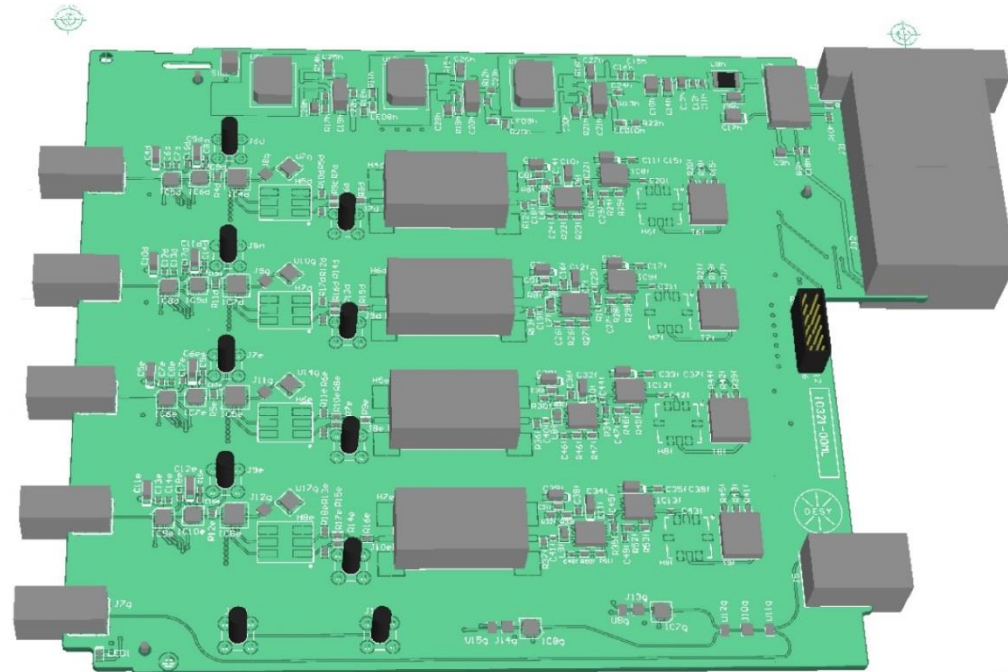
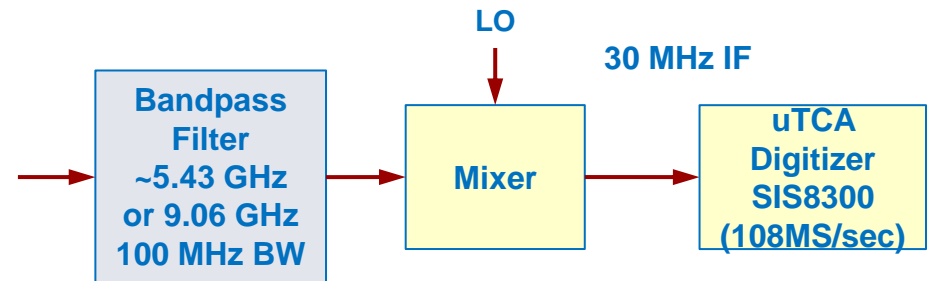


Nathan Eddy, FNAL



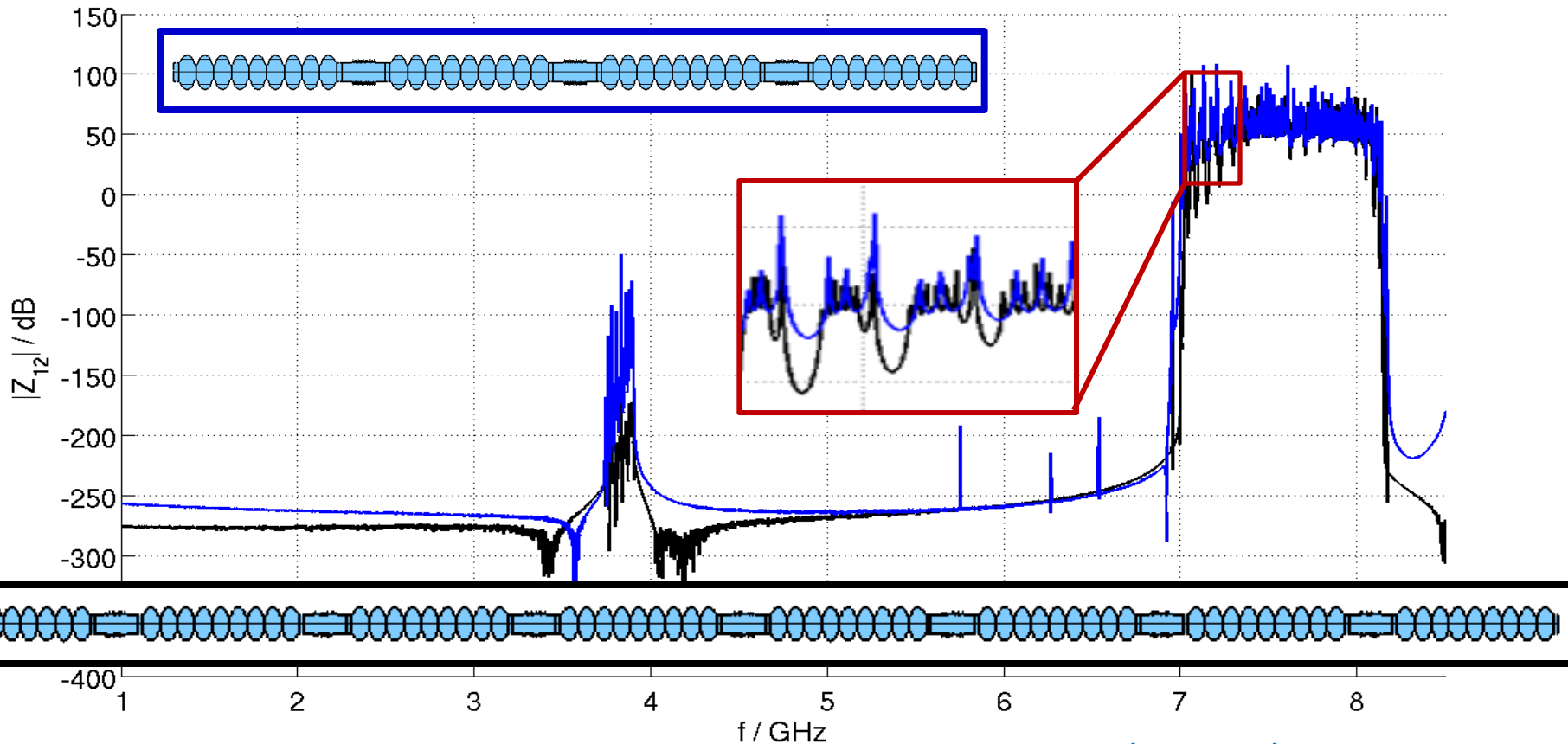
- Electronics under design, based on same specifications as for FLASH
 - Designed at DESY
 - Design of 5GHz DCW and PLL ready

*Thomas Wamsat,
DESY*

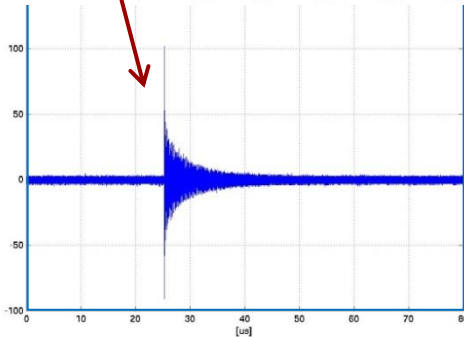


- **But much more challenging:**
 - 8 coupled cavities cf. 4
 - 4.5 cf 1 MHz bunch frequency
 - Different orientation of cavities
- **EuCARD²:** Need significant theoretical and experimental studies
 - Prototype cavity arrived at DESY and will be measured soon
 - SSC (State Space Concatenations) approach developed at Uni Rostock and ready for simulation of 8-cavity simulations
 - Direct simulations of full module started at Uni Manchester

- Impedance Parameter Comparison with SSC



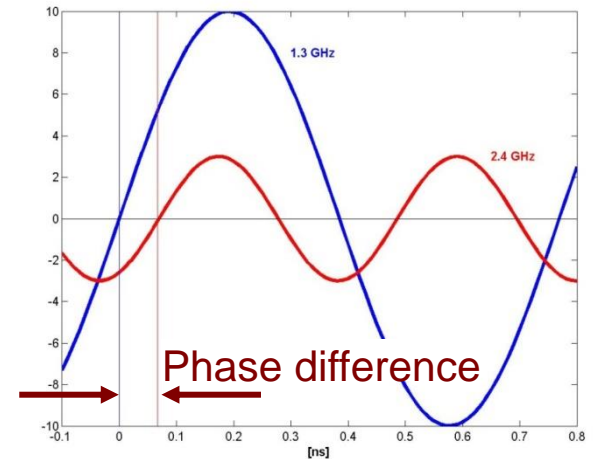
Thomas Flisgen,
UROS



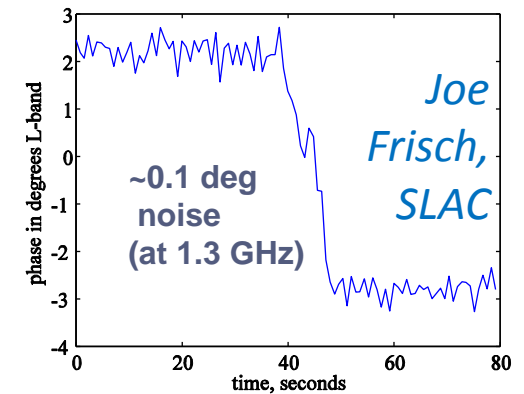
1.3 GHz
(leaking through HOM-coupler)



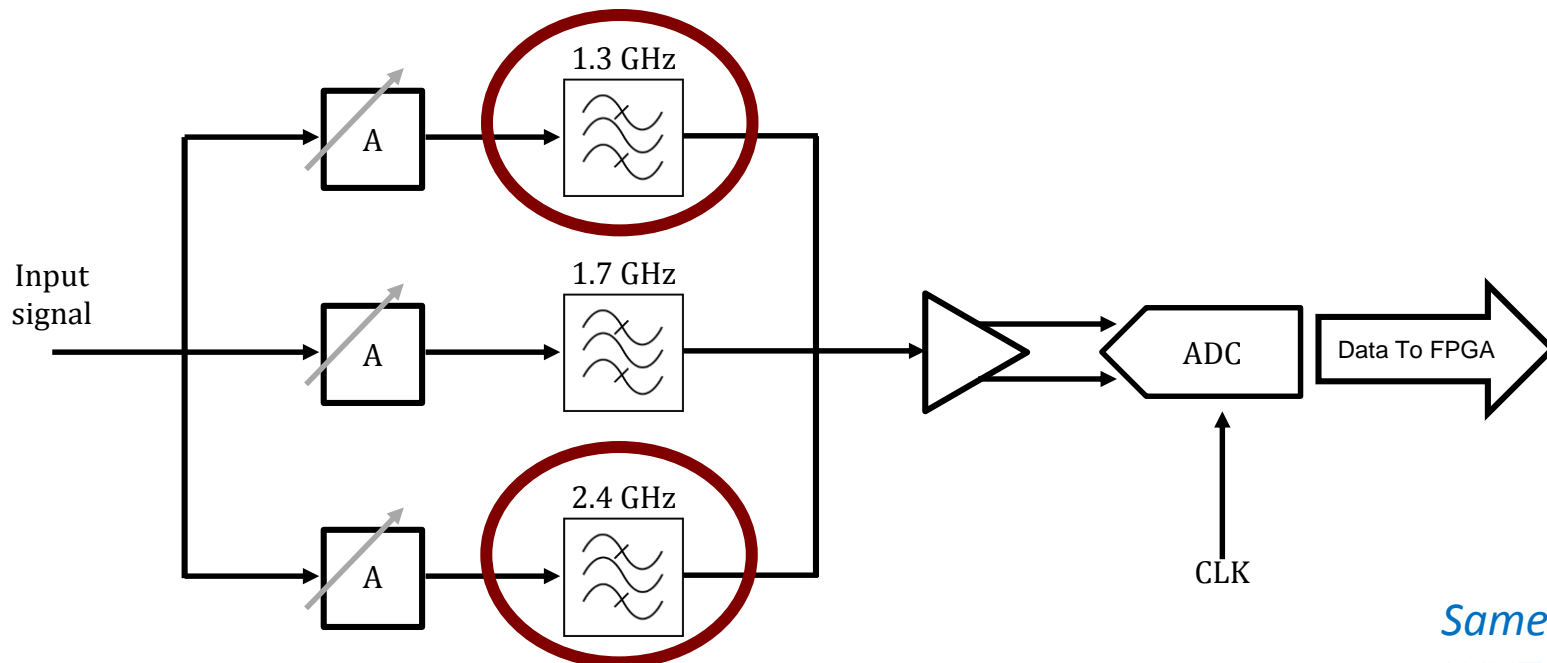
~2.4 GHz



- Proof-of-principle made at FLASH
- **EuCARD²:**
 - Phase monitors for 1.3 GHz cavities
 - No nice monopole mode found for 3.9 GHz cavities



- Same electronics as for HOMBPMs / 1.3GHz / E-XFEL
 - Prototype under construction
 - First beam tests expected in the next few months



*Samer Bou-Habib,
WUT, DESY*

- Aim: HOM-based beam diagnostics for the E-XFEL
- Based on large previous experience at FLASH
 - 1.3 GHz cavities: same specs as FLASH
New concept for electronics, no DCW, multiple filter
New: beam phase
 - 3.9 GHz cavities: same specs as in FLASH, but much more challenging:
 - 8 coupling cavities instead of 4
 - different orientation of cavities
 - 4.5 MHz beam instead of 1 MHz



R.M. Jones, P. Jain

Simulations (direct + cascading GSM)

Participation to **measurements**
at FLASH

Universität
Rostock



Traditio et Innovatio

U. van Rienen, T. Flisgen, T. Galek

Simulations (cascading CSC, CTC, SSC)

Participation to **measurements**
at FLASH



HELMHOLTZ
ASSOCIATION

N. Baboi, L. Shi, T. Wamsat, S. Bou-Habib

Experimental tests at FLASH
and the XFEL