Testing challenges for new BPM electronics

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Solkan, June 16, 2020

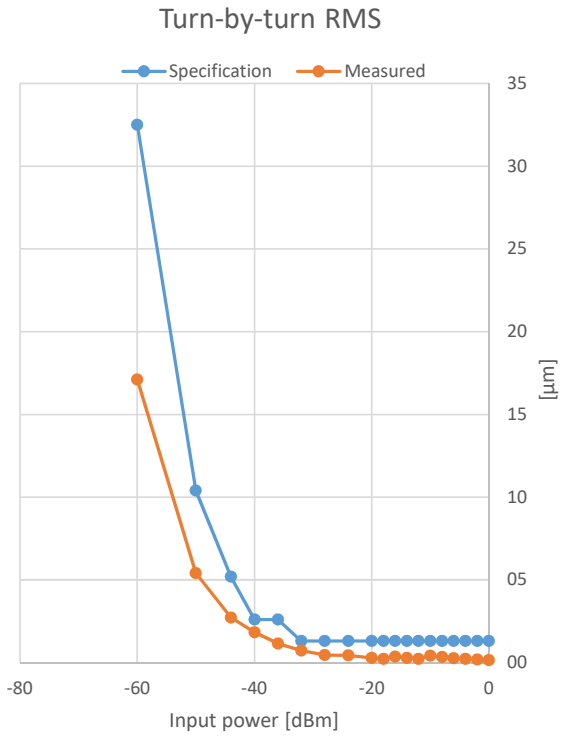
Contents

- New requirements
- New BPM electronics
- Equipment
- Tests and Results

Specifications and requirements

RMS in DC-100 kHz bandwidth

- at -40 dBm: **8 µm** vs **2.6 µm**
- at -60 dBm: **~80 µm** vs **33 µm**

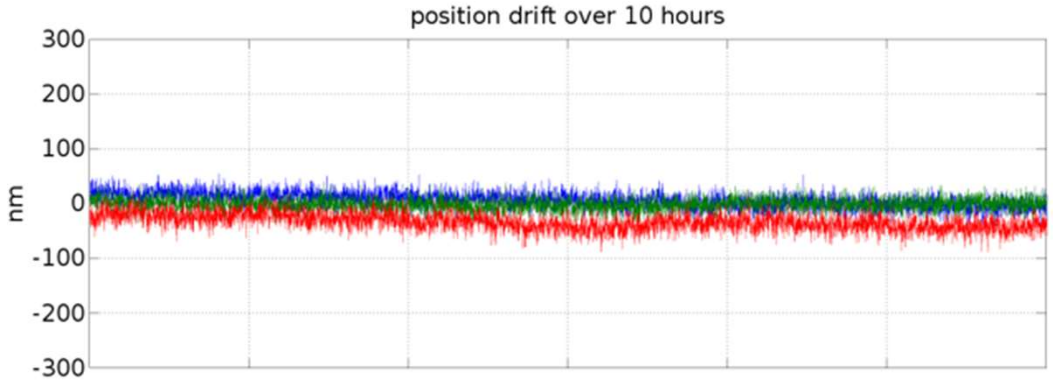


New BPM module

Typical specifications and requirements

Long-term stability

1 µm over a week changed to **100 nm**

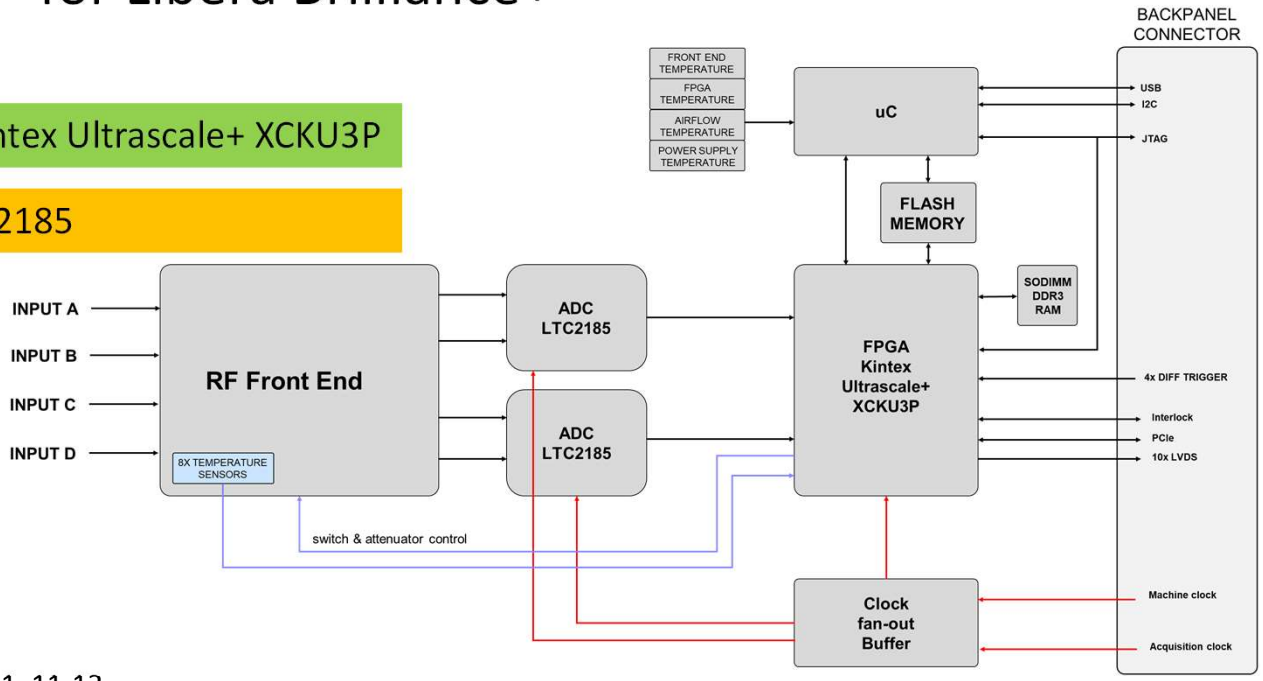


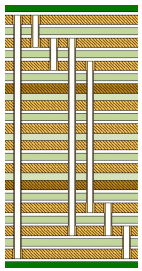
New BPM module

for Libera Brilliance+

FPGA: Kintex Ultrascale+ XCKU3P

ADC: LTC2185

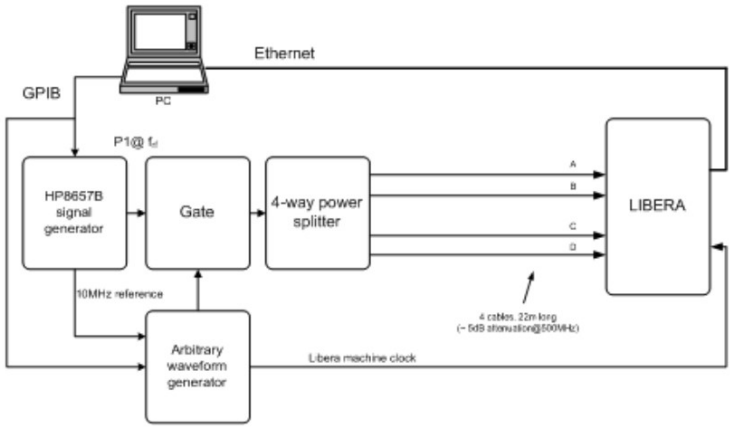


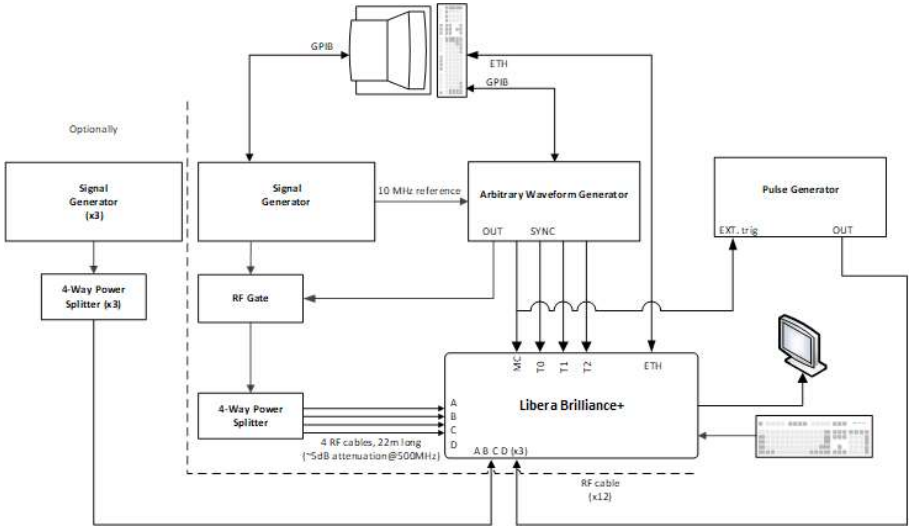


12-Layer HDI PCB:

- via-in-pad
- via pairs: 1-2, 2-3, 2-11, 3-10, 10-11, 11-12
- Controlled impedance on 6 layers

Testing setup 2010 vs 2020

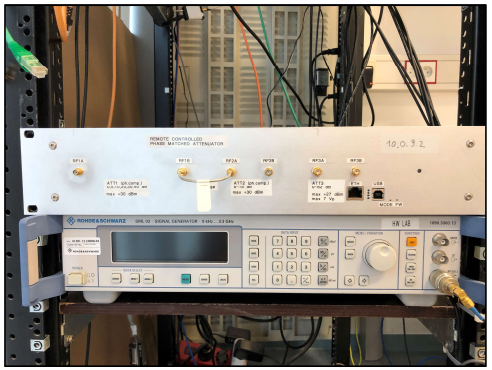


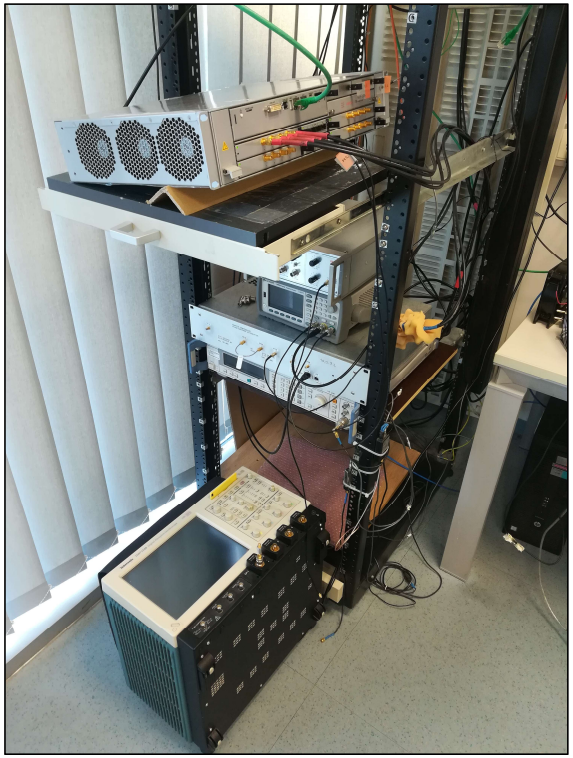


Equipment

Performance tests

- Turn-by-turn RMS measured on the CW (sine) at nominal RF
- More realistic conditions are simulated with a diode that generates short pulses – not used for performance tests
- Single bunch is simulated by the pulse generator (max. 15 V, ~2 ns pulse)
- Channel-to-channel cross-talk measured by the pulse generator
- Most equipment is remotely controlled





Equipment

Temperature dependence and stability

Tests in a single climatic chamber (instrument and generators)

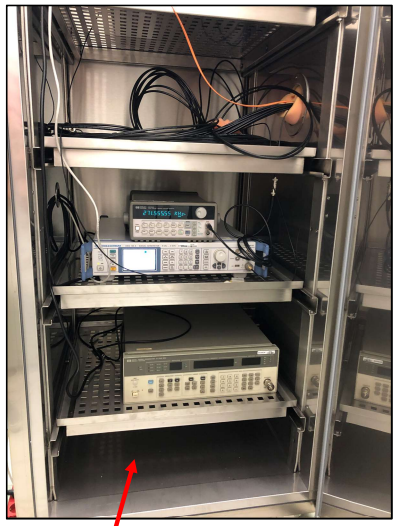
- Temperature variation (±5°C or ±10°C) may have influence also on the generators and splitter(s)
- Not possible to separate the temperature dependence of the BPM module from other components

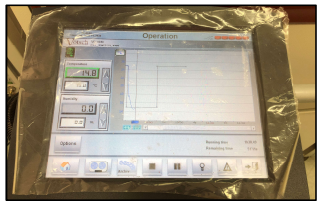
Tests in two climatic chambers

- Generators and splitters kept at stable temperature (25°C)
- Instrument exposed to controlled temperature (profile or stable)
- More reliable results and measured dependence

Equipment

Climatic chamber(s)





varying temperature
and profile for the instrument

stable temperature
for the generators

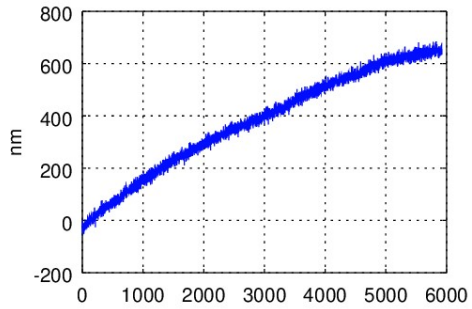
Long-term tests

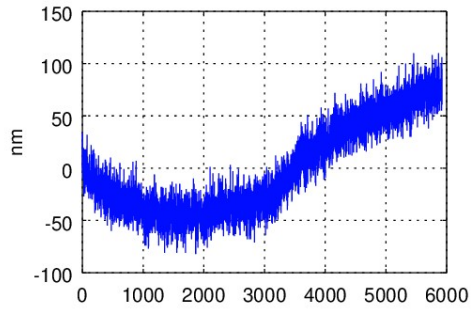
Long-term test #1

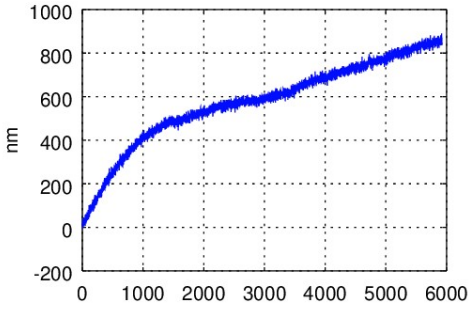
- 4 BPM modules tested in parallel
- “Standard” setup with an RF generator, locked to the MC generator
- Cross-bar switch and DSC enabled, stable temperature 25°C
- Typical test duration is ~16 hours

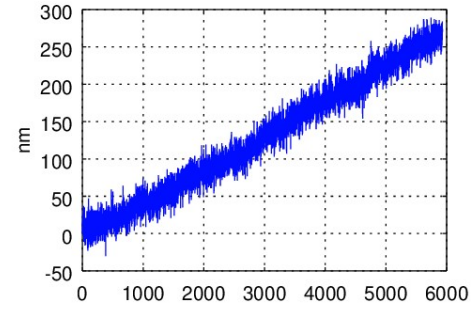
- Mixed results, drifts in range from nm to µm
- Continuous drift, not related to temperature change
- The drift continues even on longer test period

- ???









Long-term tests

Why the drift? Brainstorming for possible causes and solutions:

- Long-term test of multiple BPM modules in parallel (cross talk, impedance mismatch, etc. ?)
- GPS-lock for the RF generator
- Use EVG for hard lock between the RF and revolution clock
- …

Long-term tests

Why the drift? Brainstorming for possible causes and solutions:

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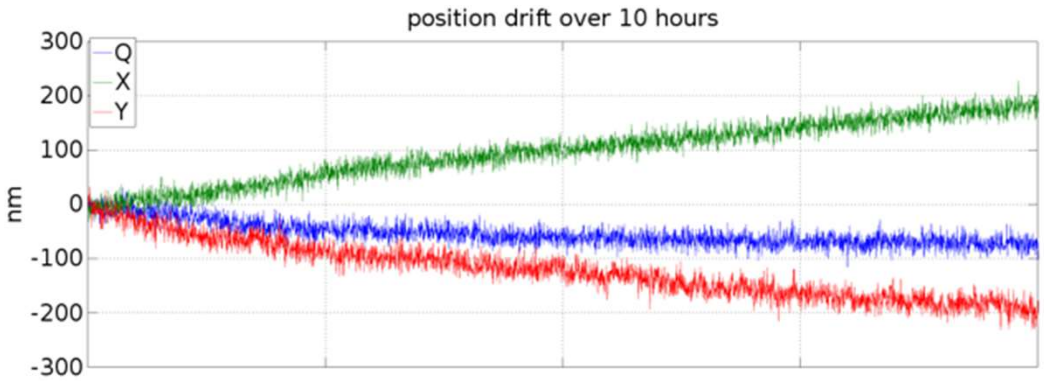
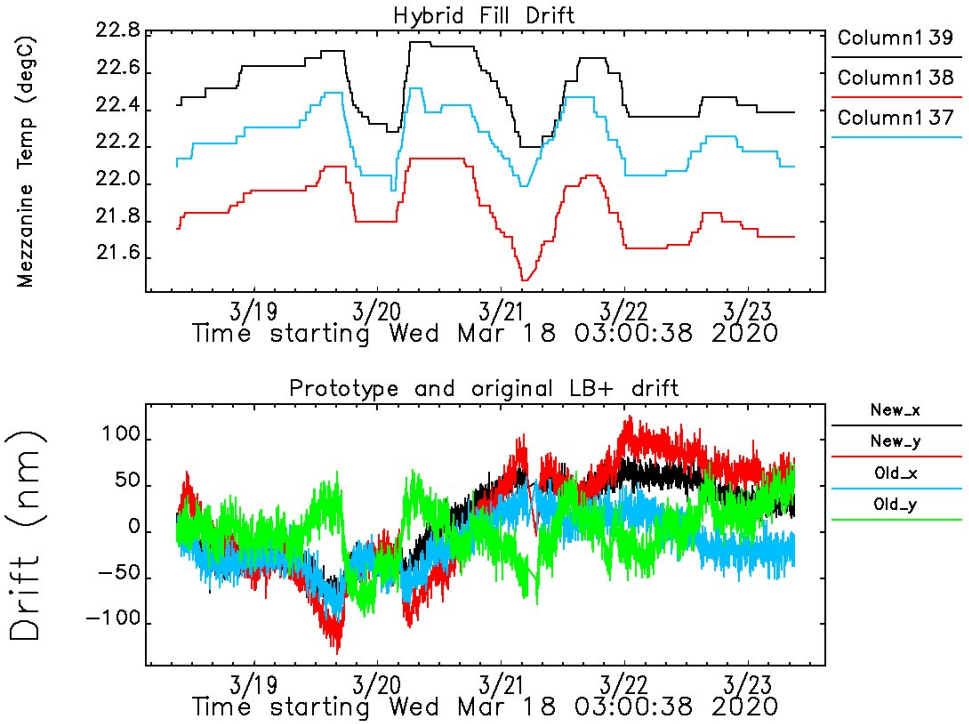


Still no success…

Long-term tests

In the meantime… no such drift observed at APS

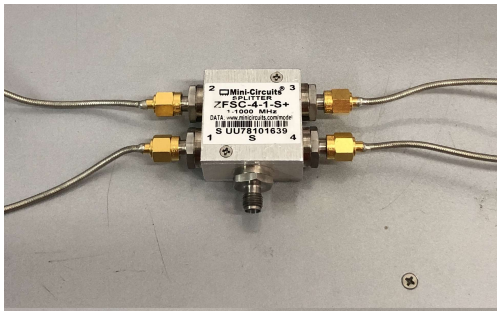


Property of A.Brill, APS

Long-term tests

Further brainstorming

- Splitters?
- Cables?
- Cleanliness?
- Tightening torque?

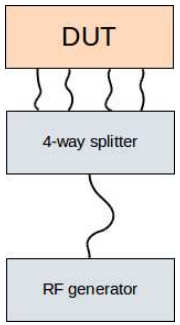


LMR-195

Long-term tests

Further brainstorming – test setup scheme

Setup 1:
1 BPM



Long-term tests

Further brainstorming – test setup scheme

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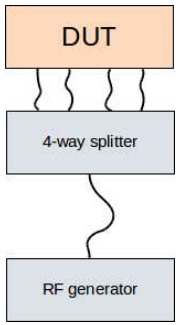
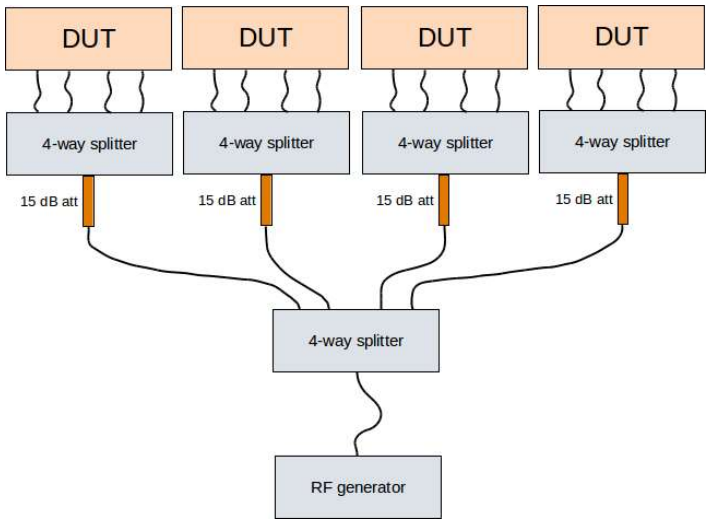


Setup 2:
4 BPMs



Long-term tests

Further brainstorming – test setup scheme

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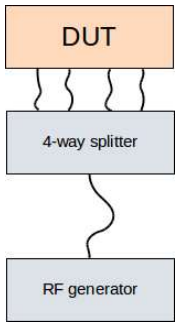

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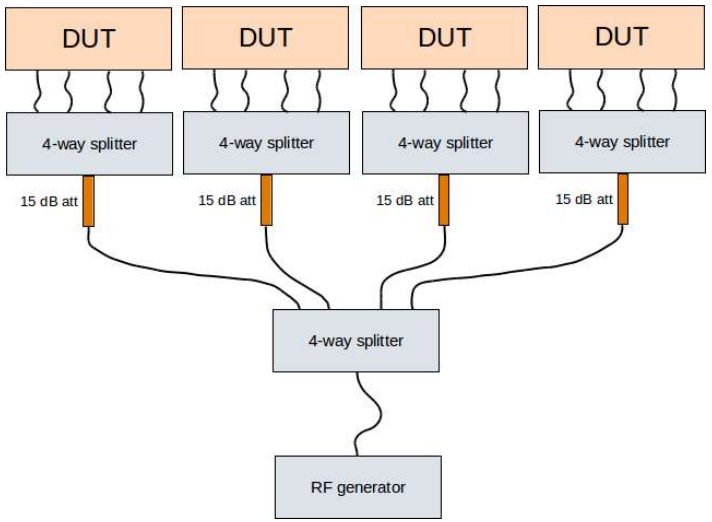
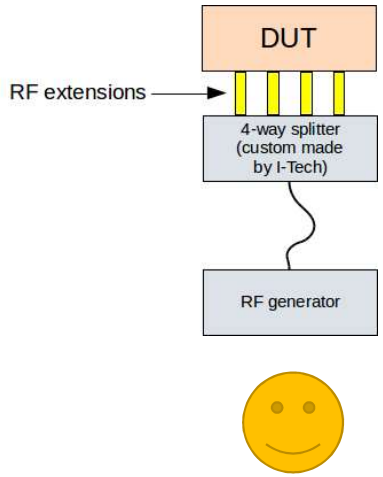


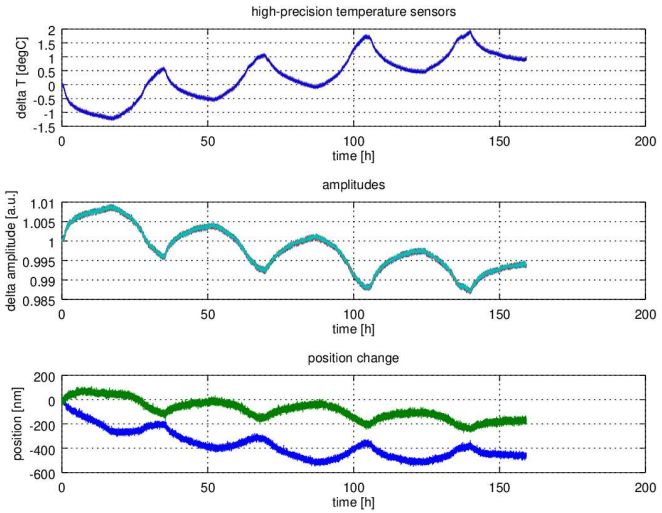
Setup 3:
1 BPM

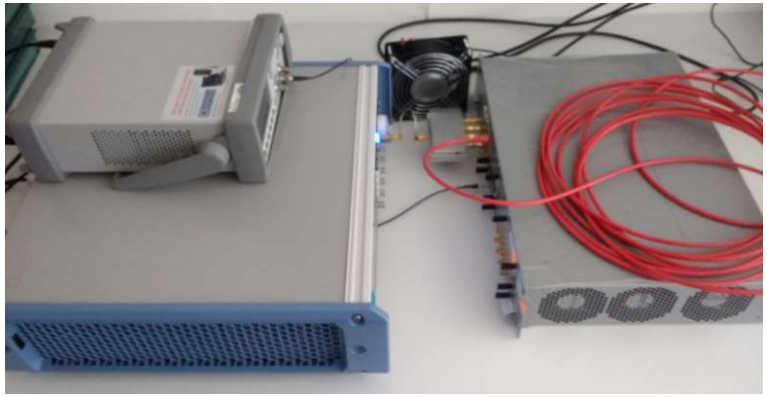


Long-term tests

No drift when using RF extensions (no cables)

- Temperature varied in correspondence to external temperature
- Position drift correlated to temperature variation

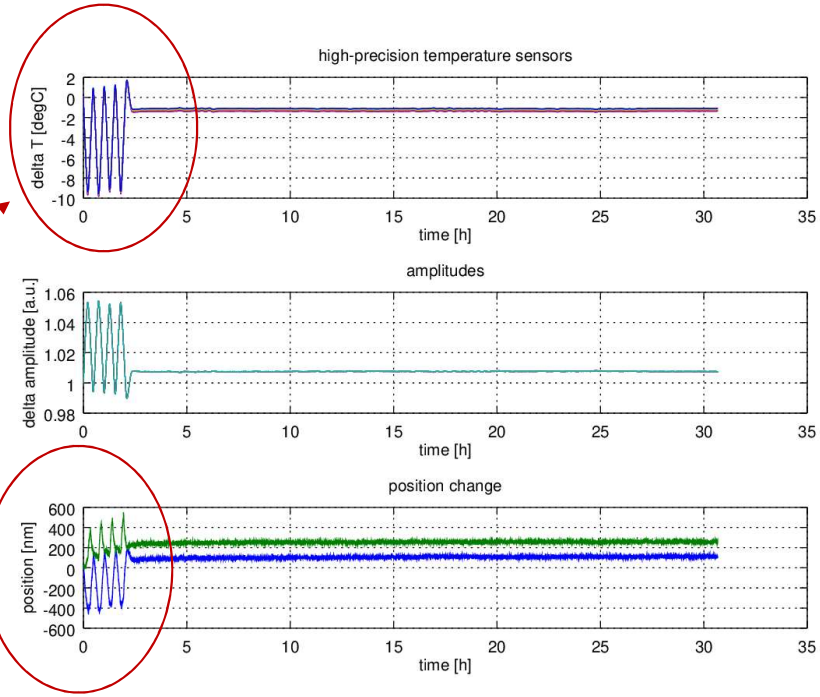




Long-term tests

Much better results with different cables!

- delta T = 12°C
- delta X/Y = ~0.6 µm



VT-085C-FORM_LL

More results

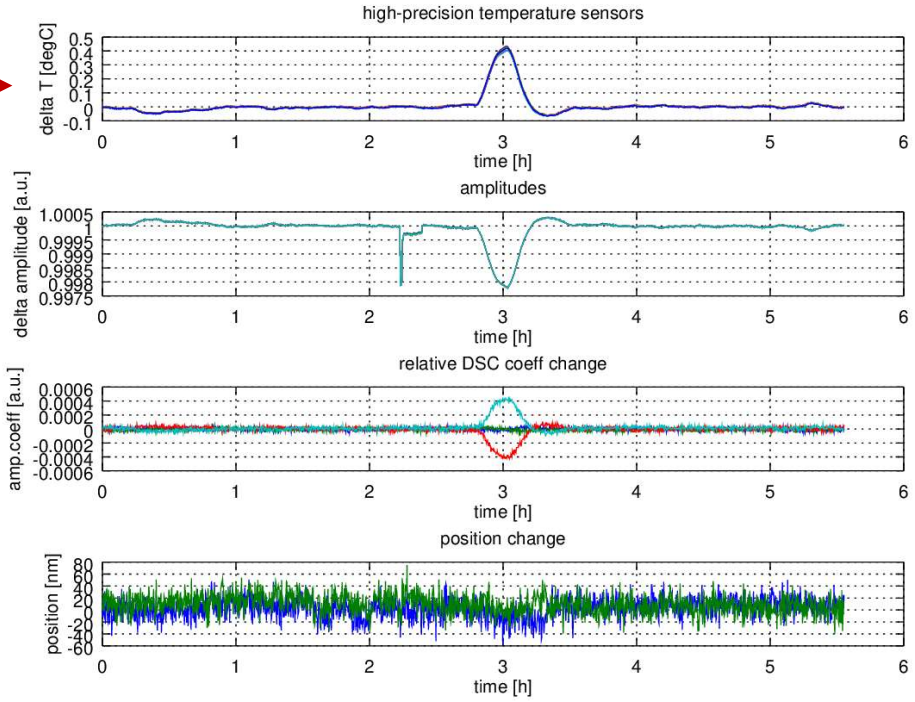
Light bulb in the temperature chamber turned ON to take pictures…

BPM module's sensors detected ~0.4°C temperature increase

Amplitudes correlated to temperature variation

DSC coefficients reacted

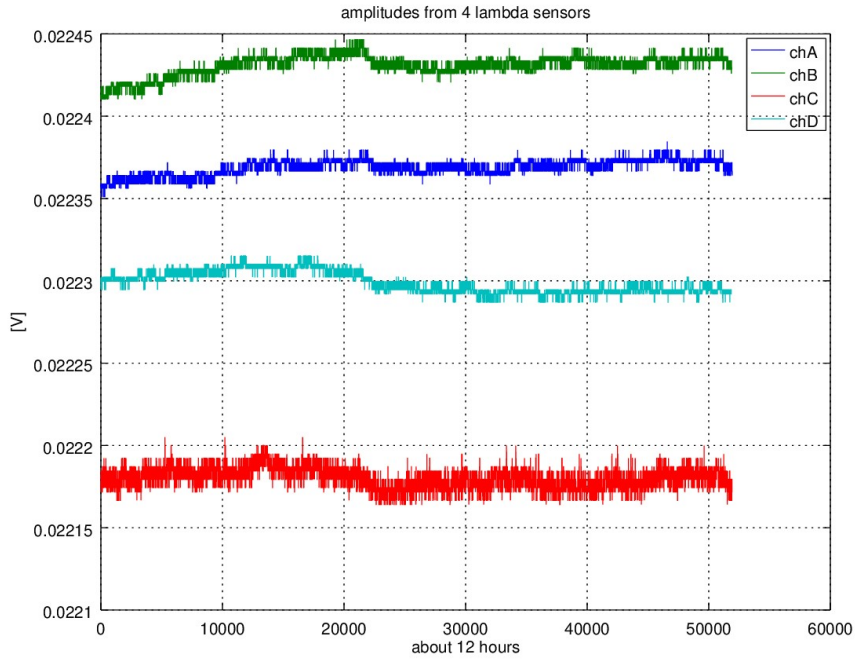
Position stability practically not affected



More results

LMR-195 under stable temperature

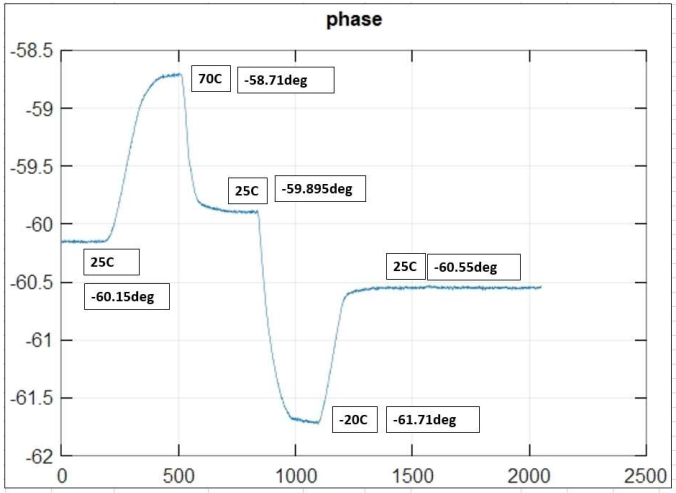
- Power loggers connected to the cables (BPM module not connected)
- Amplitudes vary from cable to cable
- Position calculated from power shows a drift
- Another confirmation the cables have large contribution to drift

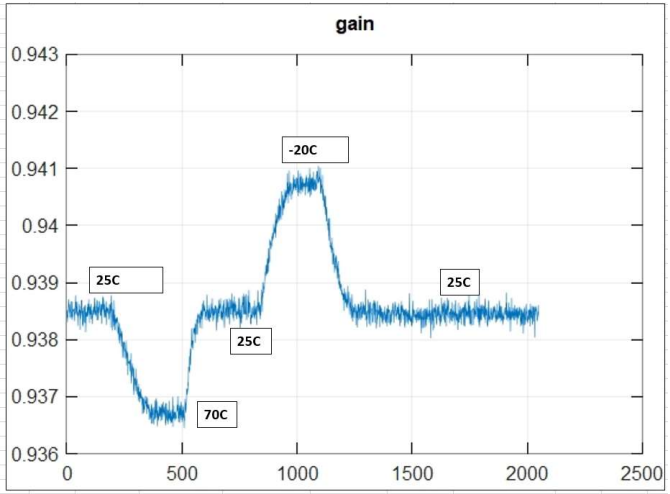


More results

LMR-195 under varying temperature

- LMR-195 exposed to large temperature variation
- Measured gain and phase during transitions
- Gain/attenuation is reproducible
- Phase is NOT reproducible





transient	start phase (deg)	stop phase (deg)	diff (deg)	diff T (K)	coefficient (deg/K)
25>70	-60,15	-58,71	1,44	45	0,032
70>25	-58,71	-59,895	-1,185	-45	0,026
25>-20	-59,895	-61,71	-1,815	-45	0,040
-20>25	-61,71	-60,55	1,16	45	0,026

transient	start gain (lin)	stop gain (lin)	diff (lin)	diff T (K)	coefficient (lin/K)
25>70	0,9385	0,9367	-0,0018	45	-0,000040000
70>25	0,9367	0,9385	0,0018	-45	-0,000040000
25>-20	0,9385	0,9407	0,0022	-45	-0,000048889
-20>25	0,9407	0,93845	-0,00225	45	-0,000050000

Conclusion

- Turn-by-turn RMS within specifications
- Beam current dependence within specifications
- Long-term stability within specifications
- Test setup documented and fixed (like a tool)

Thank you for your attention

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- info@i-tech.si