INSTRUMENTATION
TECHNOLOGIES

LIBERA

Libera Brilliance +

Peter Leban, June 17th 2020

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Motivation

- Libera Brilliance+ was developed end of year 2010
- Received upgrades on the CPU and OS every few years
- BPM module not upgraded
- OS support
- New features

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Meet requirements from new lightsources

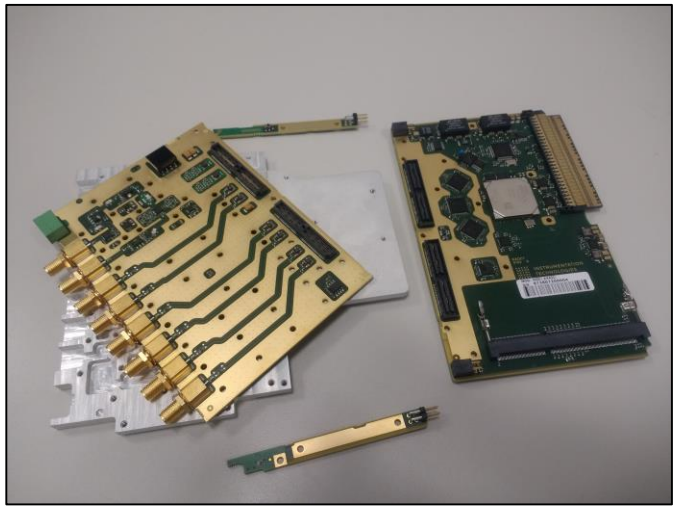
Requirements

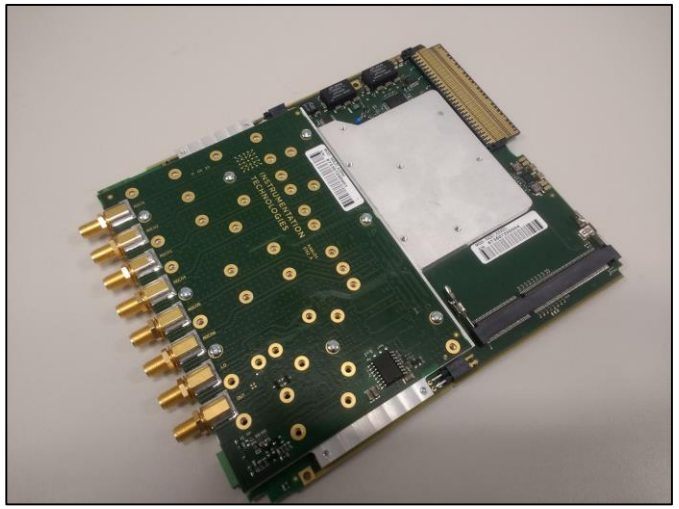
	Requirement
Beam current dependence	< 1 µm
Turn-by-turn RMS	< 1 µm
Long-term stability	100 nm
Hardware and software compatibility with original version	

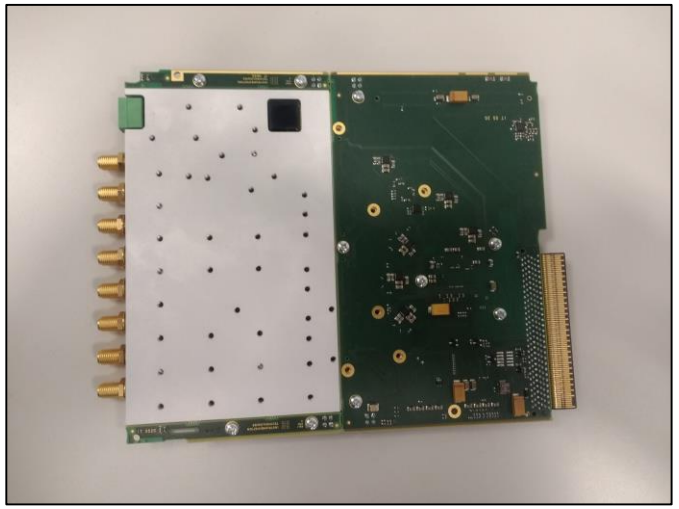
- No change in short-term requirements from original version
- Long-term stability requirements much tighter than original version
- Long-term stability requirement for APS-U project

Development

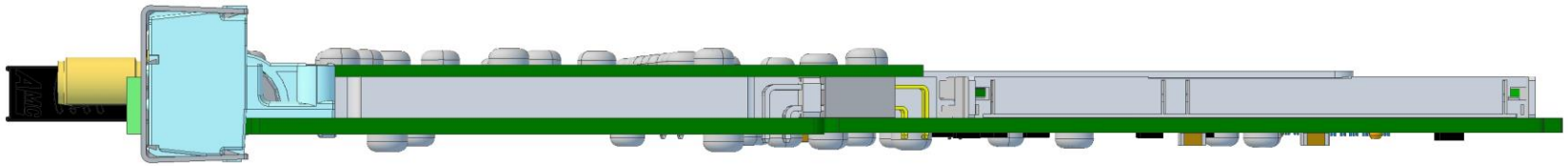
New generation module







Product: LLRF system, based on Kintex FPGA



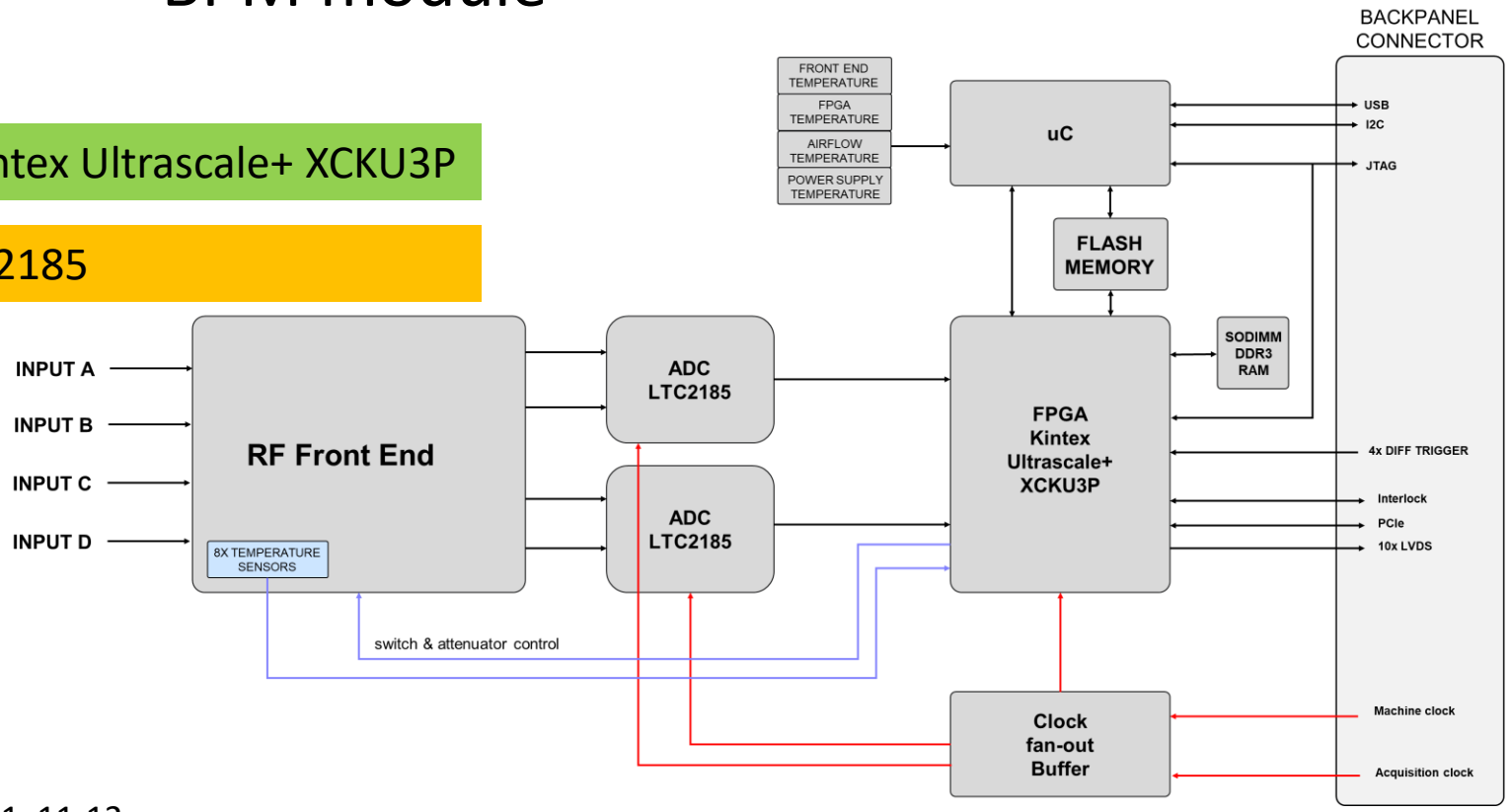
Top and bottom component placement: higher density

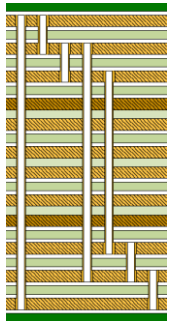
Development

BPM module

FPGA: Kintex Ultrascale+ XCKU3P

ADC: LTC2185





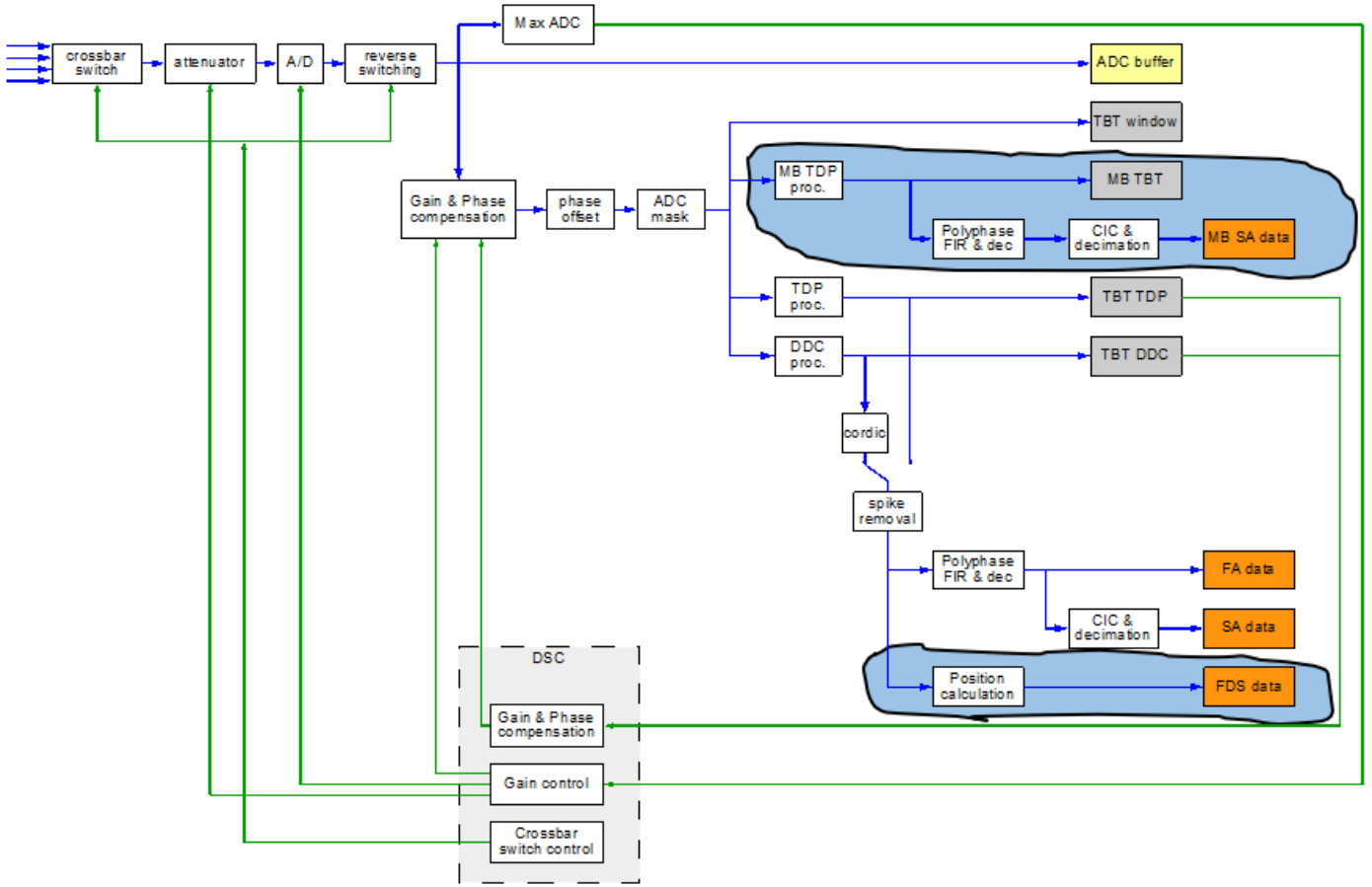
12-Layer HDI PCB:

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

Development

Processing scheme in the BPM module

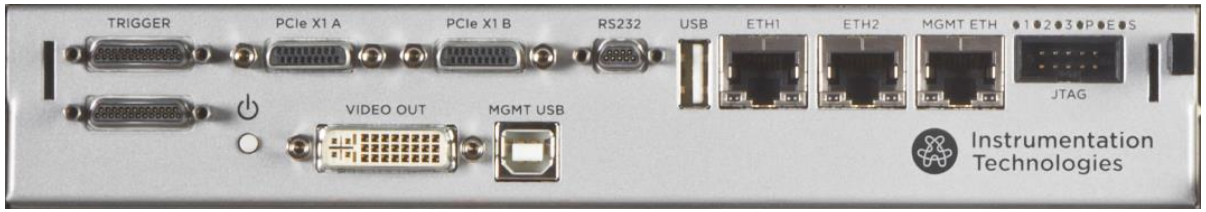
- Multibunch turn-by-turn processing
- FDS (Fast Data Stream) for the Interlock and GDX
- Static calibration for the channel-to-channel differences
- Synthetic generator for fast data stream
- Large buffers (1 GB for every circular buffer, typically)



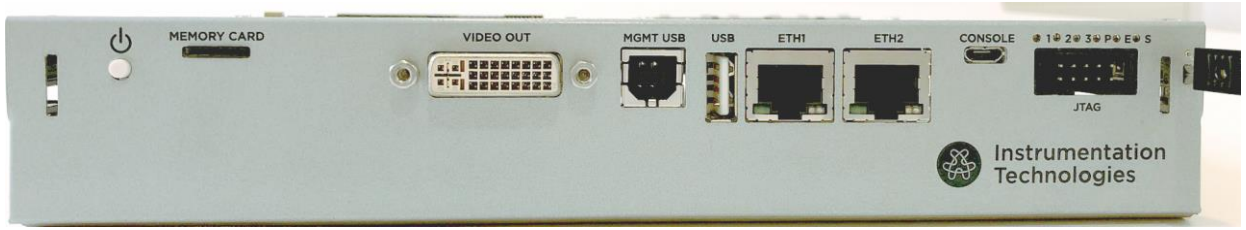
Development

CPU and Operating system

- Replaced the CPU module to newest generation, i5-7440EQ
- 4 GB memory
- microSD card with OS and software
- DVI output
- microUSB console
- Removed unused interfaces
- Upgraded ‘libera’ software



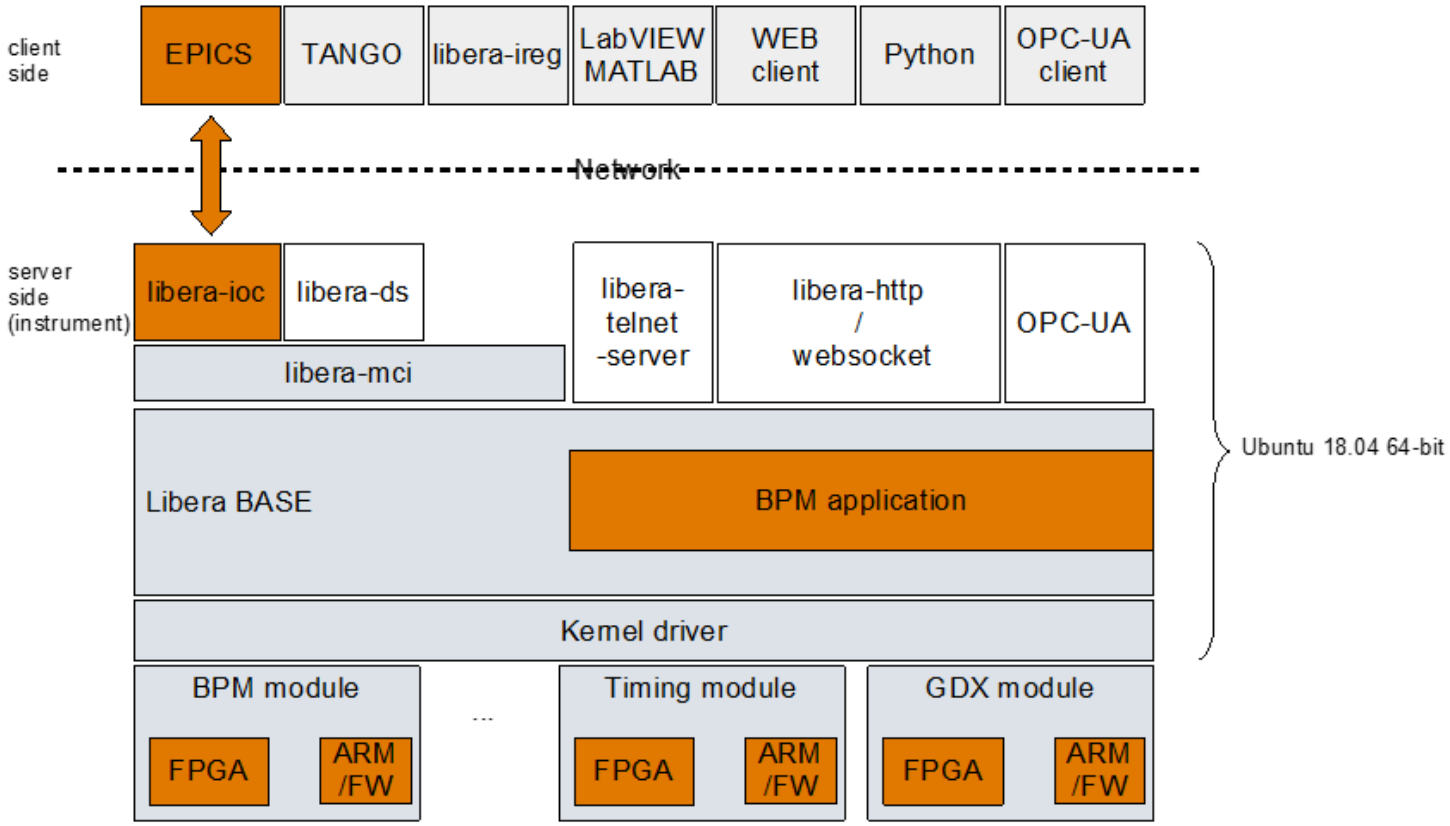
original



new

Development

Software framework

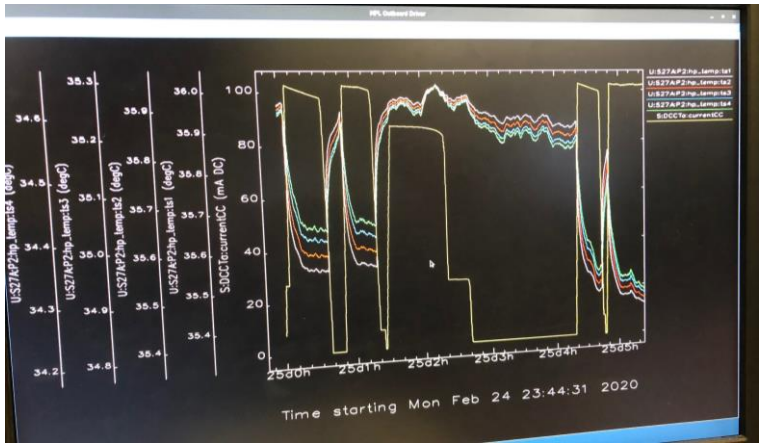


Preliminary tests and issues

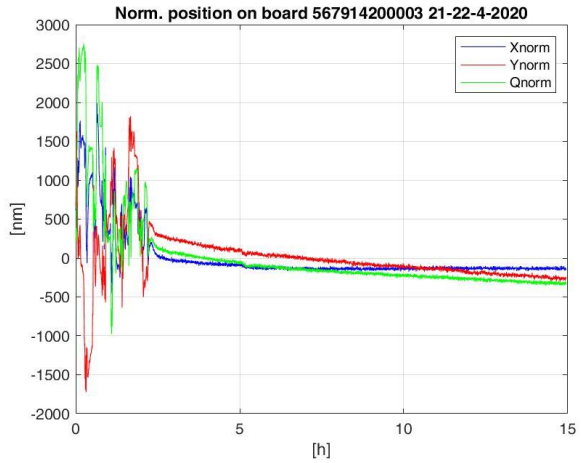
Long-term drift, beam current dependence, etc.

- Done in the laboratory at Instrumentation Technologies (climatic chamber, RF generators, etc.)
- Done at APS end of February (just before the outbreak)

Temperatures in the BPM module increased when beam was off. Resolved in the hardware design.



Continuous position drift (e.g. >500 nm). Disappeared when using better cables.



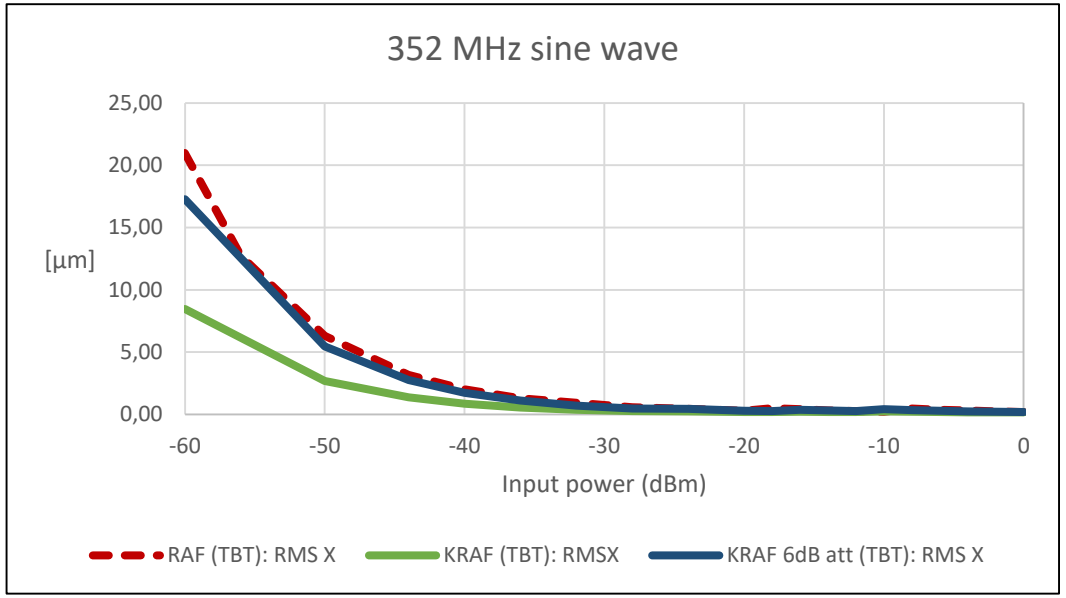
Beam current dependence not as expected. Resolved by optimizing the gain scheme, use different amplifiers, change attenuations.

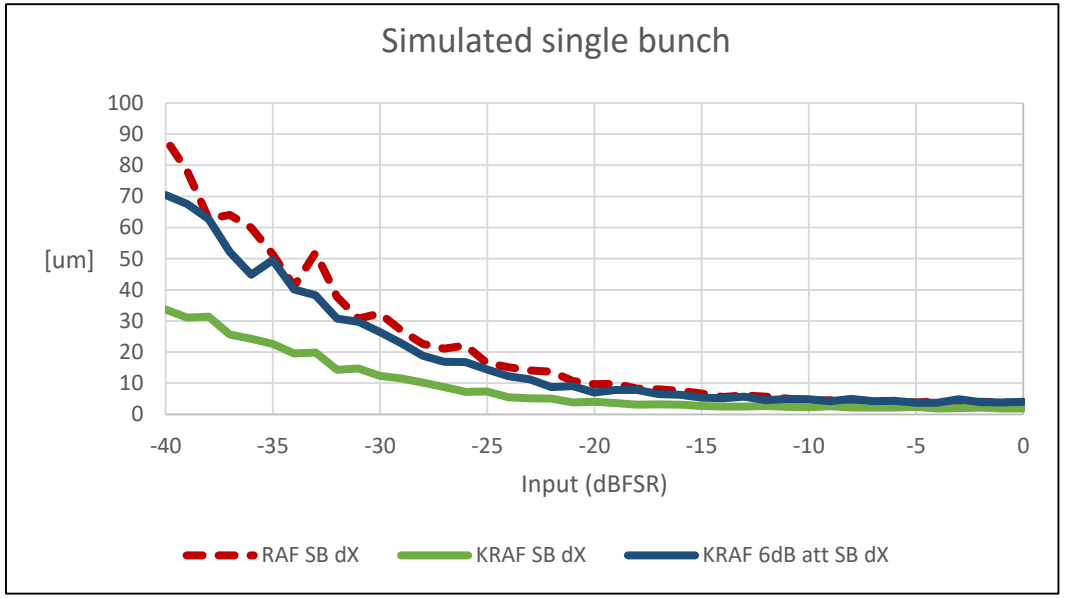
ΔY total[μm]	
required	meas.
0	0.00
1	-1.02
1	-1.53
1	-1.78
1	-1.90
1	-0.86
1	-1.49
1	-1.85
1	-2.00
1	-2.03
1	-1.01
1	-1.94
1.5	-1.95
1.5	-2.00
2	-2.73
2	-2.83
2	-2.80
2	-2.72
3	-2.81
5	-2.78
10	-2.41
20	-2.34
50	-4.14

Laboratory tests

Turn-by-turn measurement performance

- Comparison with previous BPM module (“RAF”)
- 2 assembly variants compared: compromise between single-bunch performance and beam current dependence
- < 1 µm down to -30 dBm (CW)
- < 10 µm down to -20 dBm (single bunch), depending on assembly

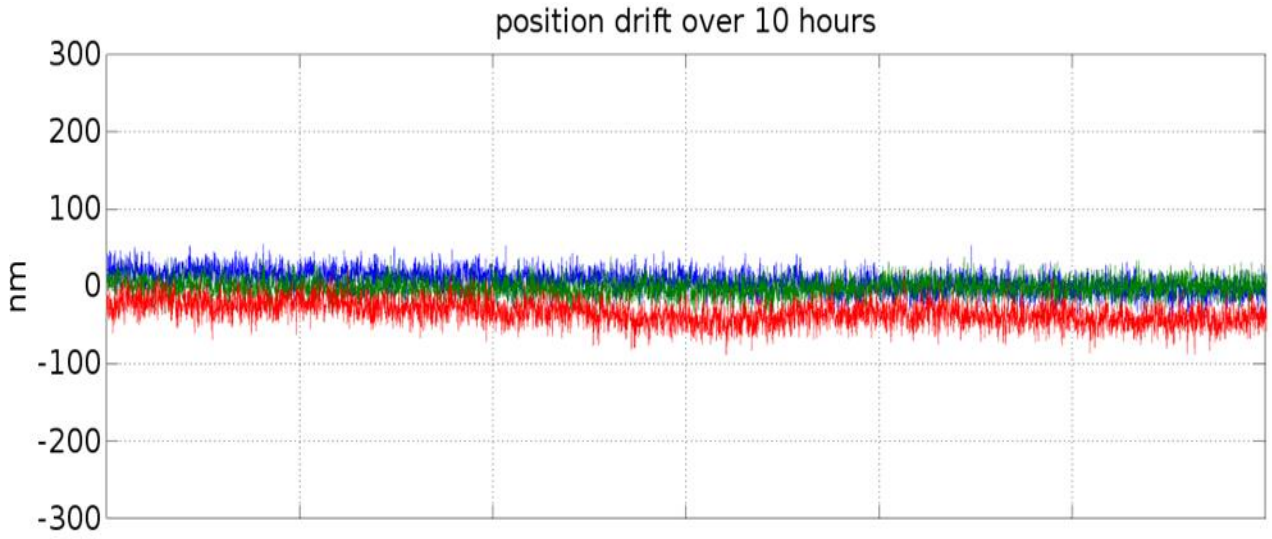




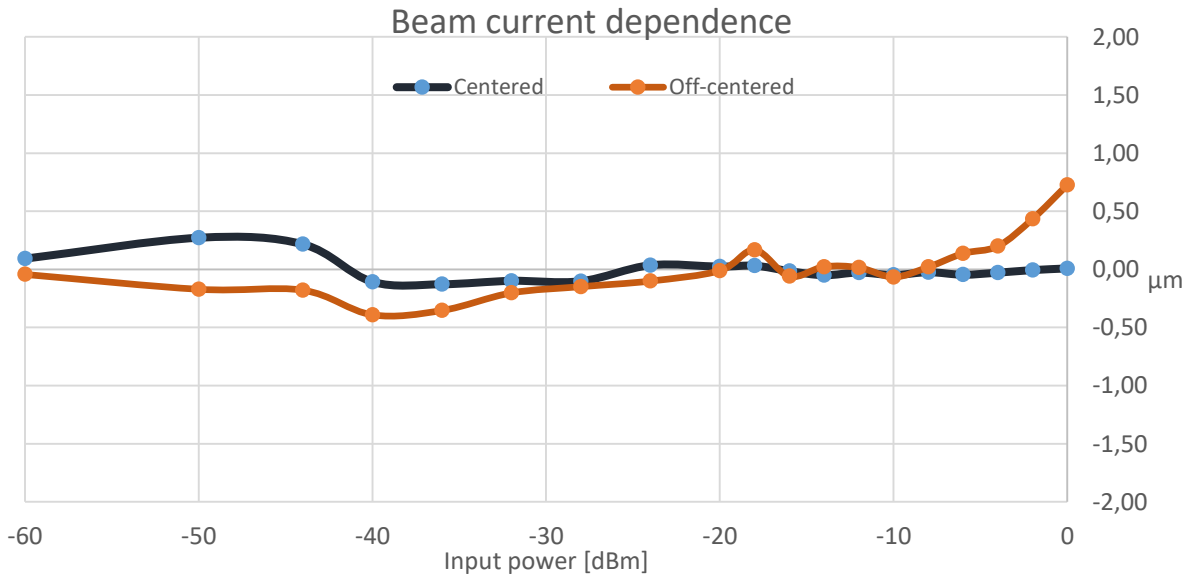
Laboratory tests

Long-term drift and linearity

- 25°C stable temperature
- Semi-rigid cables VT-085C-FORM_LL
- ±100 nm stability



±1 µm typical beam current dependence



Tests with beam

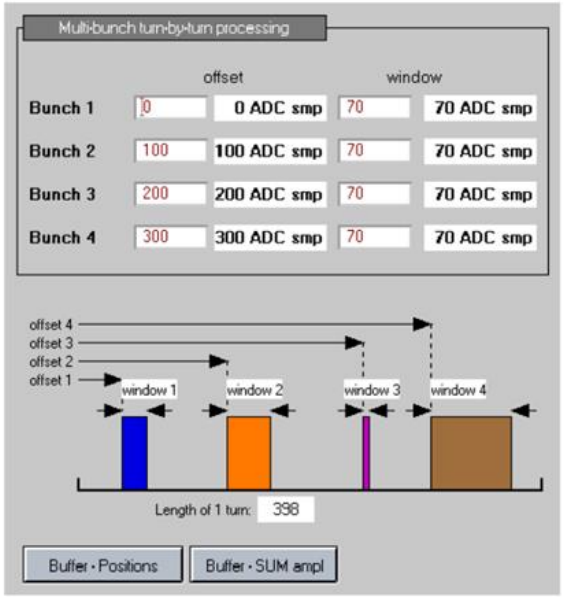
APS, sector 27

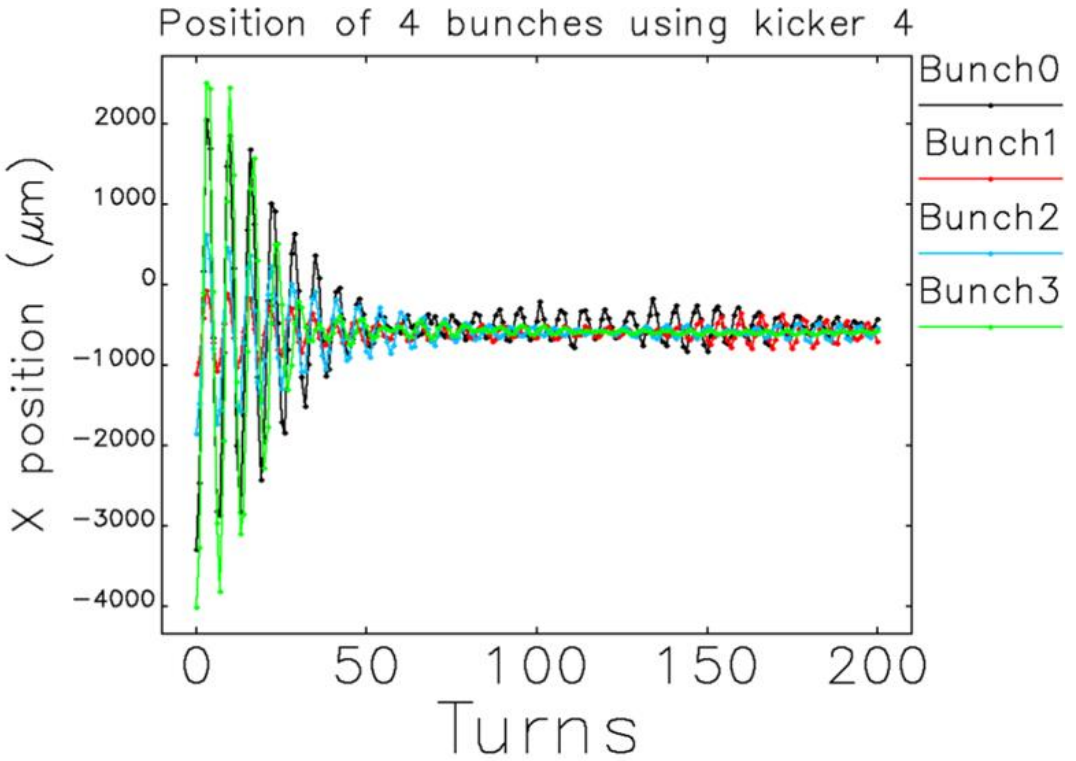
- Connected to pickups P0-P3
- Combiner-splitter configuration to observe stability of the front-end only
- Comparison of 2 assembly options and with previous BPM module
- Installed in the “APS-U” rack with standard airflow, mezzanine temperature stable within degrees Celsius
- Patch panel for cables
- Parasitic measurements during user run

Tests with beam

Multibunch turn-by-turn processing

- Define up to 4 separate processing windows within a turn
- Test shows data from 4 equally spaced bunches with different charges
- Beam was pinged with a kicker; response from each bunch was measured

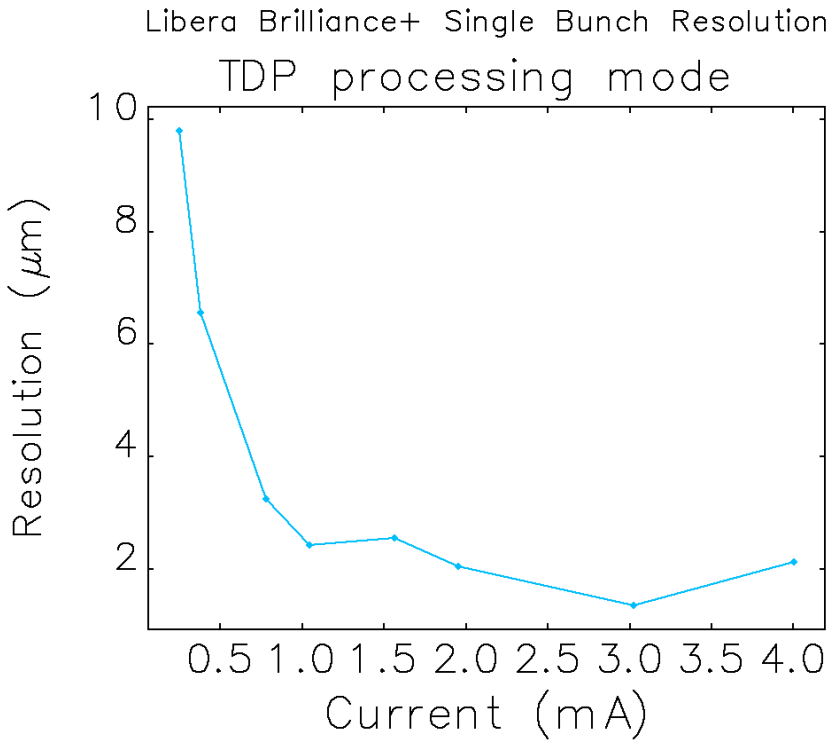




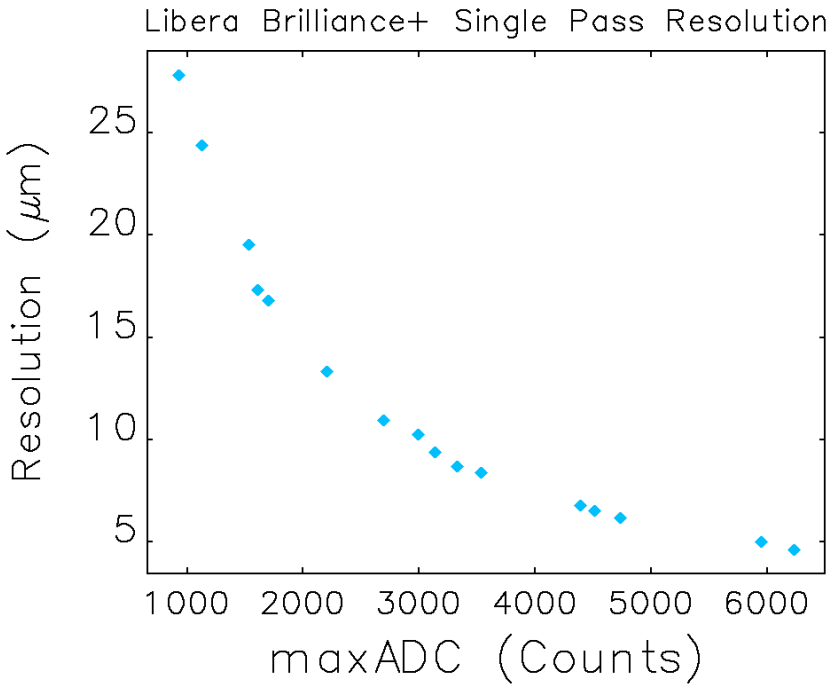
Property of N.Sereno (ANL), February 2020

Tests with beam

Single bunch stored beam



Single bunch single pass

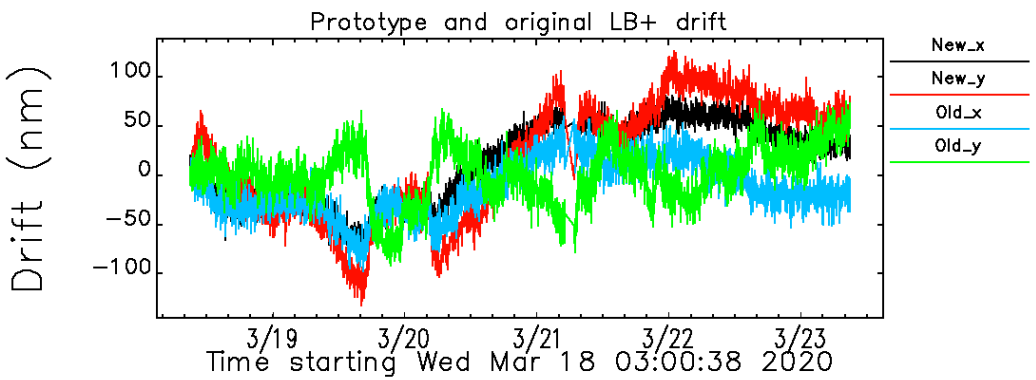


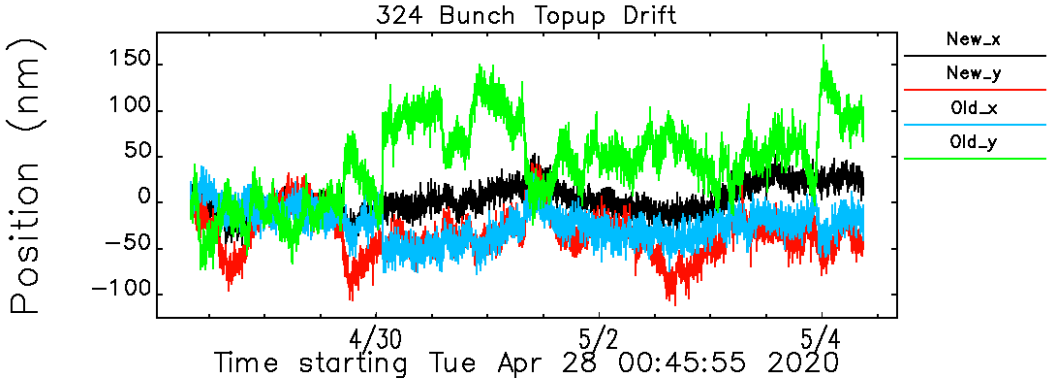
Kx=Ky=~8 mm

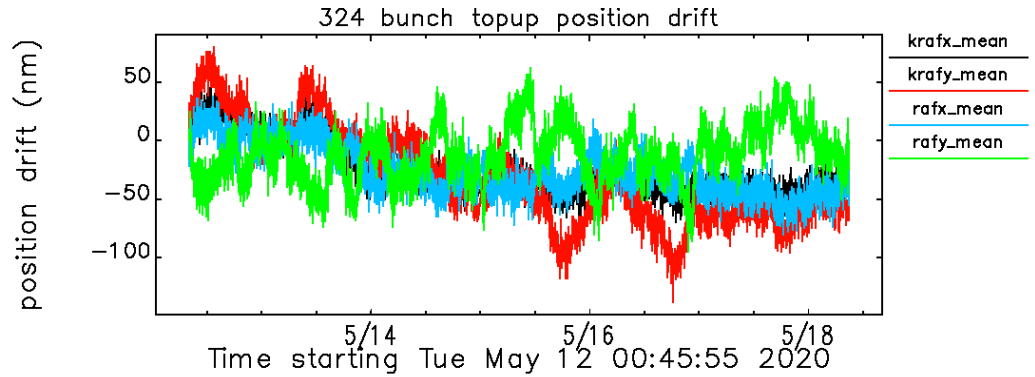
All data is property of A.Brill (ANL), June 2020

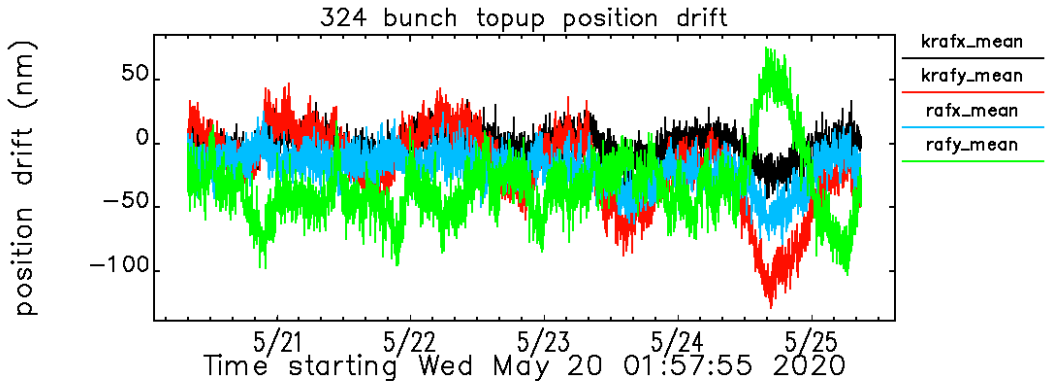
Tests with beam

Long-term stability tests









Property A.Brill (ANL), March-May 2020

Future options

- Explore cross-bar switch options and optimization (better “spike removal”)
- Adaptation for the Pilot tone (same module, same chassis)
- Adaptation for the microTCA.4

All developments and adaptations in collaboration with users!

Conclusion

- Hardware development cycle relatively short
- Software integration very smooth and “silent”
- Vast majority of effort dedicated to testing and understanding the drifts
- Great open collaboration with APS team
- Looking forward to new adaptations and developments for other lightsources

Thank you for your attention