



Hardware and software upgrades for the Libera Brilliance+ BPM system

Peter Leban

Solkan, May 12, 2022



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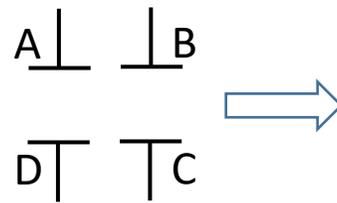
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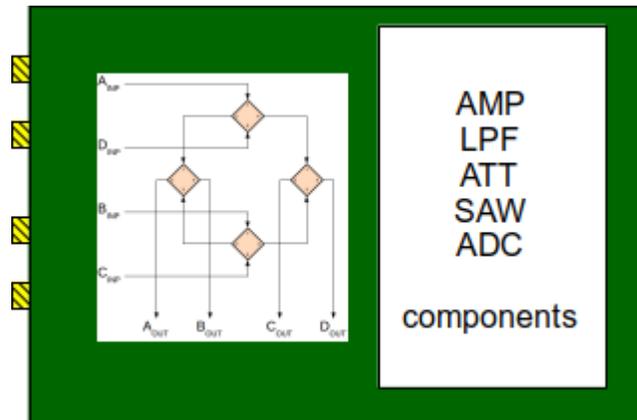
Motivation

1st and 2nd generation BPM modules

BPM pickup



BPM module

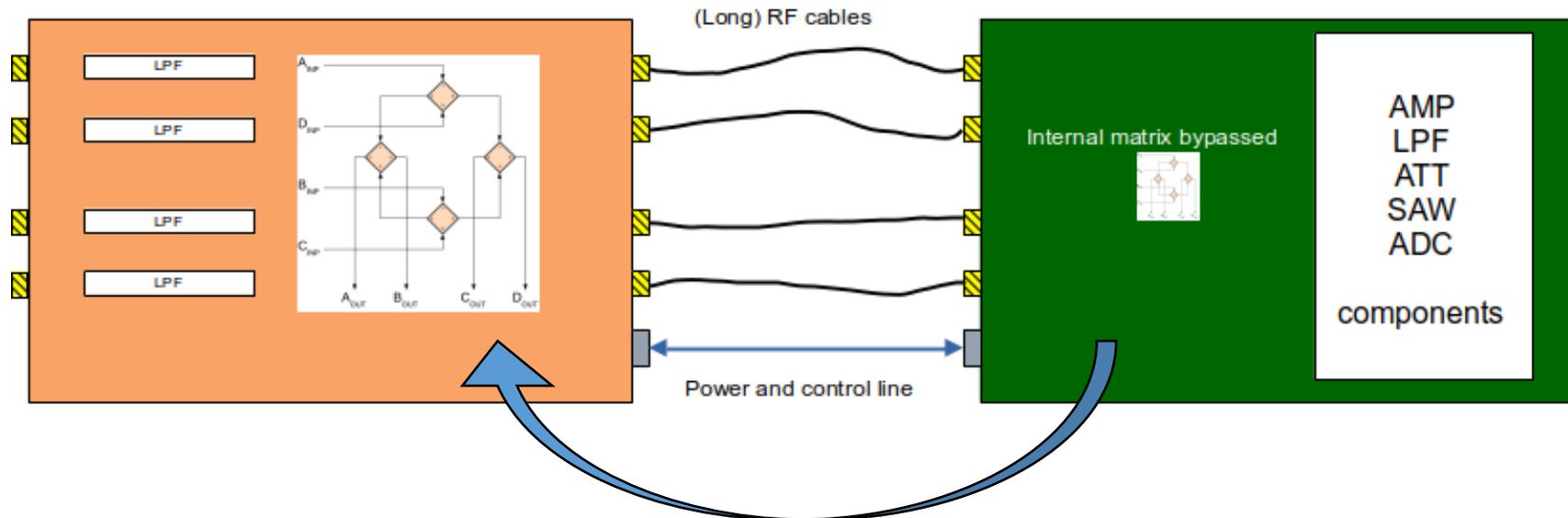


- A cross-bar switch is used to compensate channel-to-channel differences and drifts
- Disturbances from the BPM pickup to BPM electronics are not compensated



Motivation

External switching module & 3rd generation BPM module



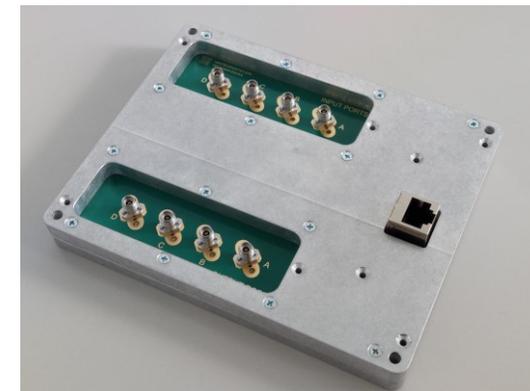
- Cross-bar switch moved to an external module; tunnel installation is foreseen
- RF cables become part of the processing chain
- BPM module provides power and control to the external switch module

External Switching module

- Analog low-pass filters
- Cross-bar switch matrix (same as in the BPM module)
- Switching control and power provided from the BPM module
- Switches rotate at 13 kHz (default); other frequencies supported, too
- 3 prototypes produced, 1 tested in Petra-3 tunnel
- Final version will be adapted for easy installation, evaluation for radiation resistance (e.g., connectors) planned



Prototype version

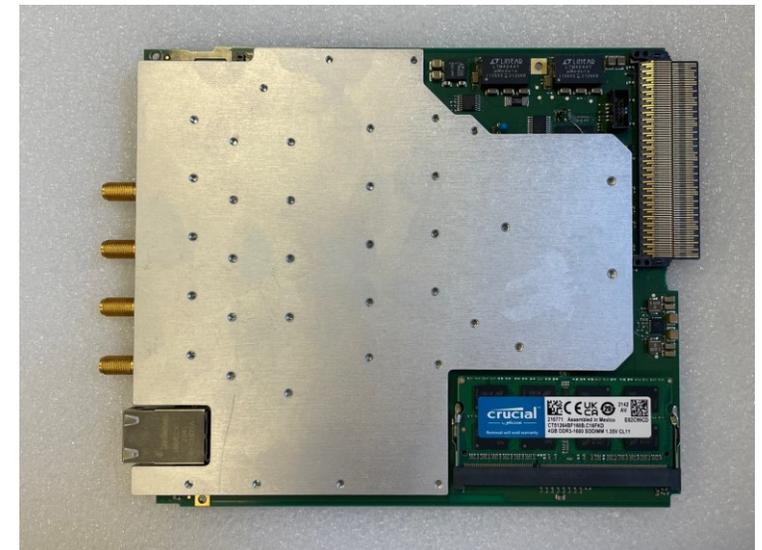
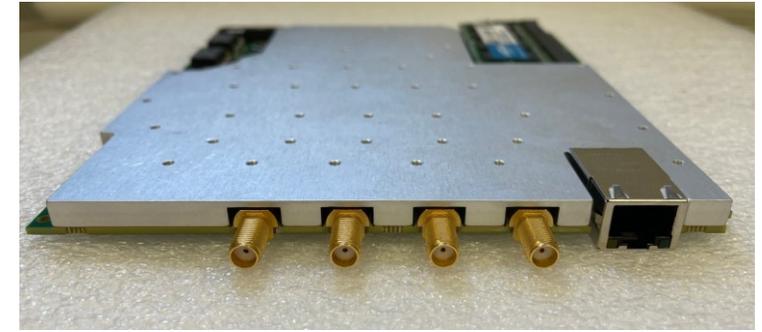


Final version
(May 9, 2022)

3rd generation BPM module

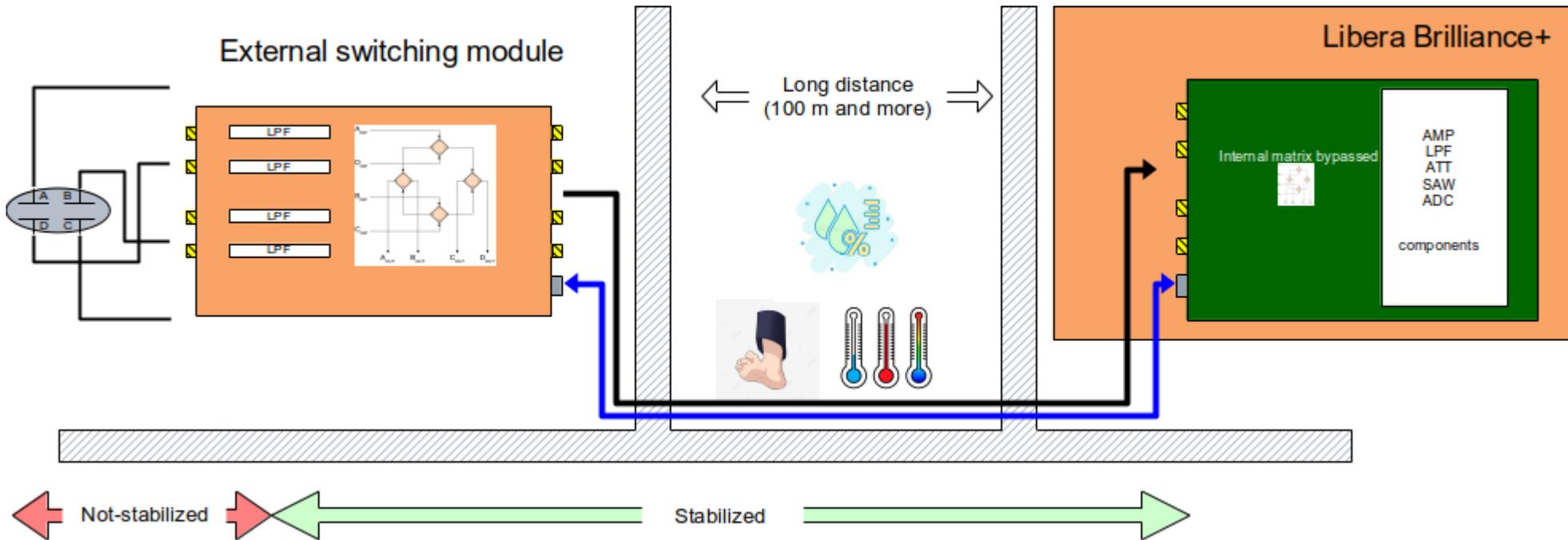
Compared to 2nd generation:

- Added RJ-45 interface for power and control for external switching module
- Internal cross-bar switch is bypassed when external switching module is connected
- Can be used in identical configuration as 1st and 2nd generation module (no external switching module)
- Nicer front panel 😊



Connection diagram

External switch matrix + 3rd generation BPM module



Long-term stability comparison (1)

External switching vs standard setup

Laboratory installation:

- Common RF generator source
- BPM module 1 with external switching
- BPM module 2 standard
- No temperature or humidity control
- Few-day test

Results (peak-to-peak), **including initial settling**:

Peak-to-peak	External switching	Standard
ΔX position	40 nm	65 nm
ΔY position	100 nm	180 nm
Δ temp, hum	1.1°C / 4.5%	



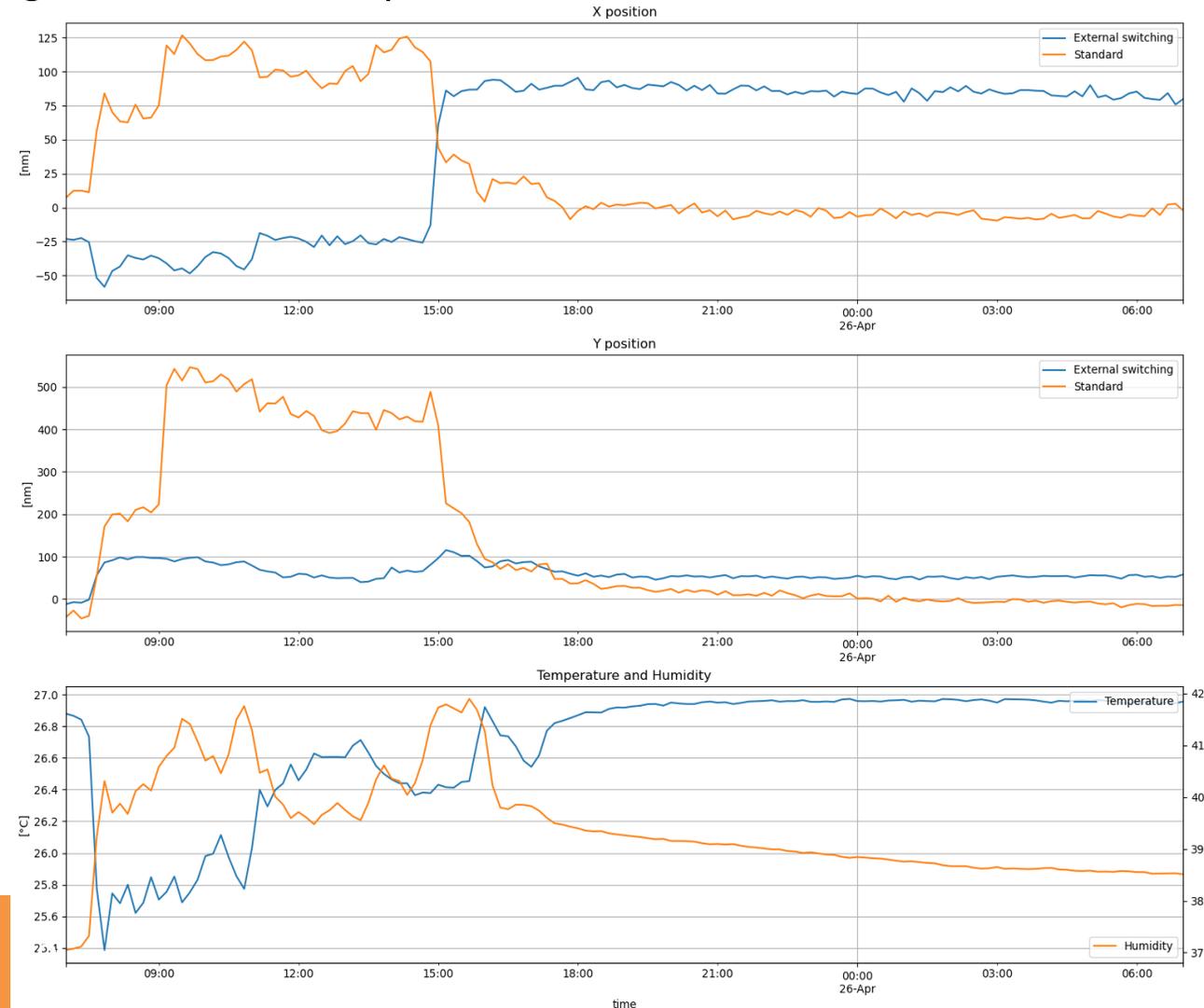
Long-term stability comparison (2)

External switching vs standard setup

Dynamic conditions (window open/close):

- Humidity changes by $\sim 4.5\%$
- Temperature changes by -1.5°C then raises back

Peak-to-peak	External switching	Standard
ΔX position	130 nm	120 nm
ΔY position	50-100 nm	520 nm
$\Delta \text{temp, hum}$	$-1.5^\circ\text{C} / 4.5\%$	



Hardware module generations

Summary table

BPM module

	“raf”	“kraf”	“kraf2”
Generation	1 st	2 nd	3 rd
Year introduced	2010	2020	2022
FPGA	Virtex5	Kintex Ultrascale+	
Memory	0.25 GB	4 GB	
A/D conversion	4x 130 MHz	2x 130 MHz dual channel	
Compensation	Cross-bar switch		
	internal	internal	internal or external

ICB module

	ICB		
Version	C	F	H
CPU model	Atom N270	i5-3230M	i5-7440EQ
Memory	1 GB	2 GB	4 GB
Supported OS	lucid 32bit trusty 32bit	trusty 32bit bionic 64bit	bionic 64

ICB / CPU (in)compatibilities:

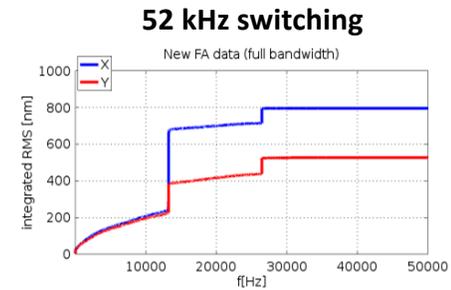
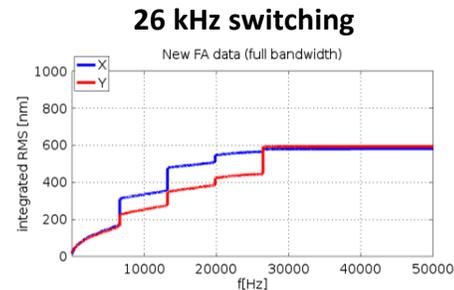
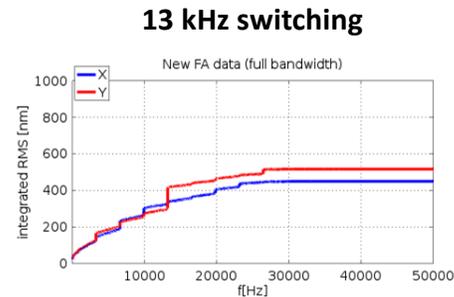
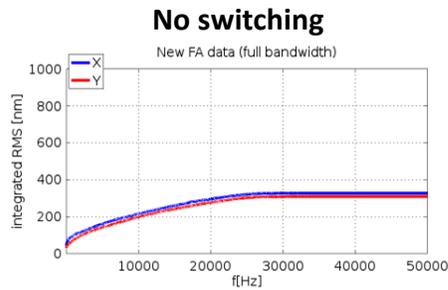
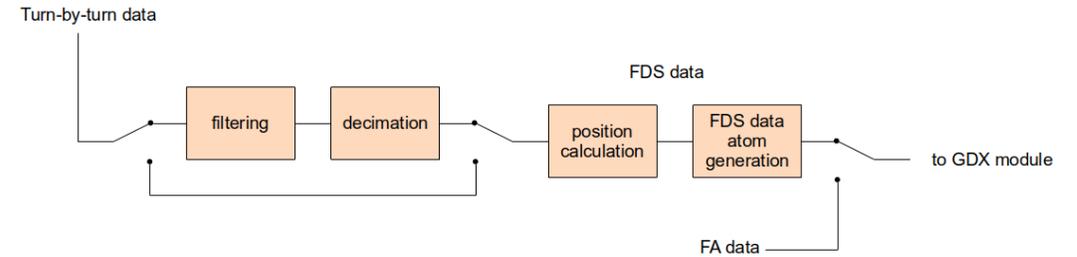
- Firmware & FPGA version
- Timing module (TIM vs EVRX)
- OS versions
- Most reliable OS versions: lucid and bionic

Software

New features

libera-ebpm application was upgraded with several new functionalities

- Configurable Fast Data Stream
 - Turn-by-turn data for the GDX module (FOFB)
 - Selectable decimation factor
 - Configurable IIR filter
- Configurable switching frequency
 - Default 13 kHz can be lowered to raised
 - Tested from 6.5 kHz to 52 kHz
 - DSC adjusts to different switching frequencies



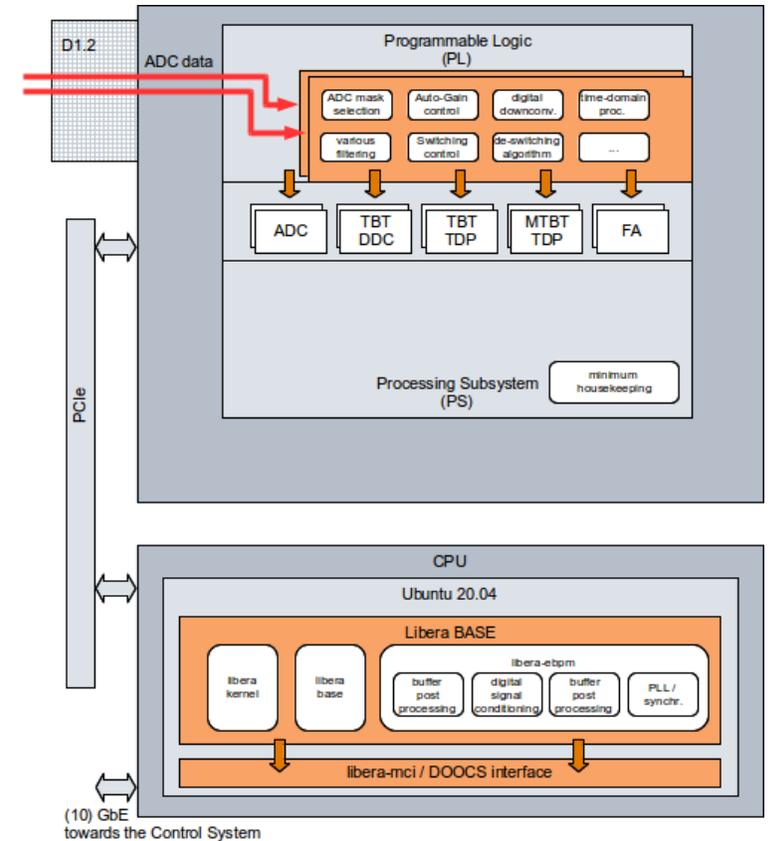
← Integrated RMS plots of 100 kHz Fast Data Stream



Software

Operating System and Framework upgrades

- **Libera BASE** was extended for new module types:
 - 3rd generation BPM module for Libera Brilliance+
 - 2BPMRTM for μ TCA platform
- **libera-ebpm** application works in the μ TCA platform with 2BPMRTM modules (8-channel module, 6 in crate)
- Libera BASE compiled for Ubuntu 20.04 (runs in the μ TCA platform)
- Network boot for Libera Brilliance+ supported



Libera software in μ TCA platform

Conclusion



- External switching enables cable compensation
- 3rd generation BPM module contains best knowledge in the BPM design so far
- Long-term stability in 10s of nanometers
- Added processing options and OS updates



Thank you for your attention

☐ support@i-tech.si



☐ info@i-tech.si



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