Status of the SwissFEL BPM System

Boris Keil, Raphael Baldinger, Robin Ditter, Daniel Engeler, Waldemar Koprek, Reinhold Kramert, Alessandro Malatesta, Fabio Marcellini, Goran Marinkovic, Markus Roggli, Martin Rohrer, Markus Stadler (PSI, Villigen, Switzerland)

Abstract

SwissFEL is a 5.8GeV free electron laser facility presently under construction at PSI. The electron beam position will be measured by three types of cavity beam position monitors. For the injector, linac and beam transfer lines, low-Q 3.3GHz cavity BPMs with 38mm and 16mm aperture (CBPM38 and CBPM16) will be used to measure the position and charge of two bunches with 28ns spacing individually. A fast kicker system distributes each bunch to a different undulator line, where 4.9GHz high-Q cavity BPMs with 8mm aperture (CBPM8) are used in the undulator intersections. The production of the CBPM38 pickups is finished, while the CBPM16 production is in progress. For CBPM8, a prototype pickup has been successfully tested, and a 2nd preseries prototype with reduced dark-current sensitivity is currently in production. The development of the common 3.3GHz CBPM electronics for CBPM38 and CBPM16 is finished, while the CBPM8 electronics is currently in the prototyping phase. This poster gives an overview of the present pickup, electronics, firmware and software design and production status, including test results and methods to control and maintain the quality during series production.



• 10-200pC bunch charge • 2 bunches with 28ns spacing @ 100Hz • Fast kicker: 1 Bunch per undulator line

Injector()	inac 1()	Linac 2()	nac 3 () //////		
0.35 <u>GeV</u>	2.0 GeV	3.0 <u>GeV</u>	2.1-5.8 <u>GeV</u>	Aramis 0.1-0.7 nm	

BPM Pickups

• Based on SACLA/E-XFEL design. Optimized for SwissFEL (high sensitivity / low charge, low cost, 28ns bunch spacing) • Each pickup: 3 body parts brazed together. No tuning. Brazing/welding for series @ PSI, body part production by ext. company. • Quality control: RF parameters (frequency, Q) measured before ("loose") & after brazing / welding for all pickups.





Pickup position and angle alignment: First with laser tracker, then beam-based angle measurement/correction

CBPM16





3.287 3.286 3.285 3.284

Length	250 mm	100 mm	100 mm
Inner Aperture	38 mm	16 mm	8 mm
Pos. Range	±10 mm	±5 mm	±1 mm
Pos. Noise	<10 µm*	<5 µm*	<1 µm**
Drift/Week	<10 µm	<5 µm	<1 µm
Charge Noise***			
Charge Range			
#Bunches/Train	1-3		1
Train Rep. Rate	100 Hz		
Bunch Spacing	28 ns		-

* Within 30% of max. range. ** Within 50% of max. range. *** Or 30fC, whatever is larger.

Pickup Parameters

Position Resonator	CBPM38	CBPM16	CBPM8
Aperture [mm]	38 16		8
Gap [mm]	14	7	12
Q _L	40		1000
TM ₁₁₀ Frequency [GHz]	3.2844		4.9266
TM ₀₁₀ Frequency [GHz]	2.389	2.252	3.150
Position Signal [V/mm/nC]	5.74	7.07	4.3
Angle Signal [µm/mrad]	15.5	4.3	6.3

Reference Resonator	CBPM38	CBPM16	CBPM8
Gap [mm]	7		14
Q _L	40		1000

CBPM16 Production Statistics



3.283 3.279 3.278 3.277 Pickup No. Pickup No. 🔷 fr-fxy loose 🛛 🔳 fr-fxy brazed 0.008 0.006 0.00 0.0040 -2.00 • **z**] 0.0020 **D**O 0.000 4 -8.00 -0.0040 Pickup No.

◆x ■y ▲ref

CBPM38 Production Statistics

No. 1-8: Batch 1 (produced for KIT/FLUTE), no. 9-16: **Batch 2 (for SwissFEL)**

BPM Electronics & Software/Firmware

Common/Generic

- Temperature-stabilized intelligent crate •
- 2-4 RF front-ends (RFFEs)

CBPM16/CBPM38

- Analog IQ mixing to baseband
- 6 ADCs/BPM (16-bit 160MSPS)

CBPM8 (High-Q)

◆x ■y ▲ref

10

- Analog mixing to 133MHz IF
- 3 ADCs / BPM, 160 MSPS

TM₀₁₀ Frequency [GHz] 3.2844 4.9266 66.4 135 Charge Signal [V/nC] 58 No. of Couplers 2

Material: Stainless steel 316LN (BPM38/BPM16), copper core with steel hull/flanges (BPM8).

RF Feedthroughs



- Feedthroughs: PSI design (F. Marcellini, M. Rohrer).
- Borosilicate glass isolator, bakeout > 250°C
- Produced by Swiss company BC-Tech (www.bctech.ch), specialized in low-cost high-volume glass ceramics

- FPGA carrier board (Artix-7/Kintex-7) with two ADC mezzanines (6 ADCs each) & direct timing-system interface (no extra timing board needed, only FPGA with MGT).
- Interfaces: 1G/10G Ethernet, PCIe Gen2/3, custom fiber optics (0.5-10Gbps), ...
- Also used by other labs (with EPICS, DOOCS, TANGO)



- Beam test: <0.8µm RMS position noise (@135pC, range >2mm pp)
- Digital feedbacks for ADC clock
- phase (DDS) & LO/IQ phase Digital auto-range control





feedthroughs for automotive, aerospace, medicine, ... • S11 measured for each feedthrough (3.3GHz & 4.9GHz) with test adapter (PSI design, see above) before welding.



3.3GHz (left: CBPM38, CBPM16) and 4.9GHz (right: CBPM8)