Status of the HPES digital BPM Electronics development

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August 24-25 2021
MTCA/ATCA

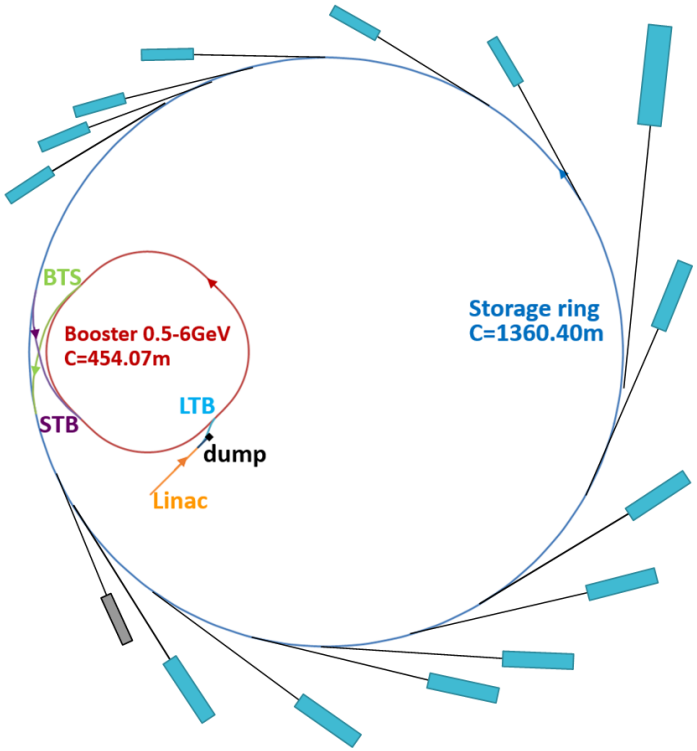
00 Outline

Background

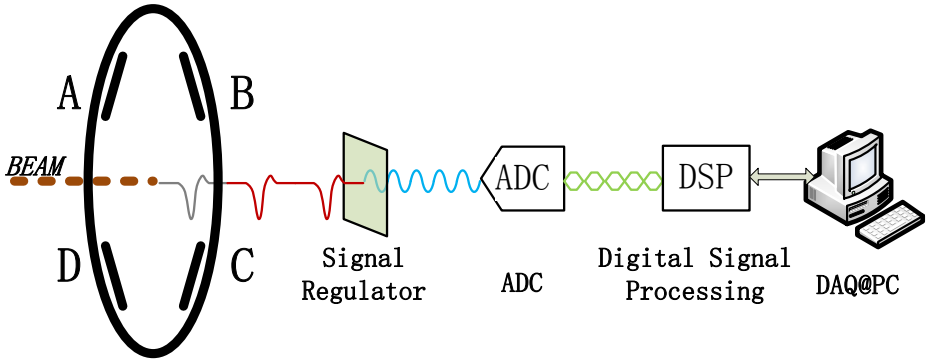
01 Technical features of the HEPS

- The High Energy Photon Source (HEPS) is designed as an ultra-low emittance ring-based synchrotron radiation light ;
- About fourteen beamlines will be constructed in Phase I of the project;

- Storage ring circumference: 1360.4m
- Energy: 6GeV
- Emittance<60pm.rad
- Current: >200mA
- Construction:2019-2025



01 The Digital BPM requirement of HEPS pro



■ HEPS BPM quantities

	BPM Quantities
Linac	8
Transfer Line	30
Booster	80
Storage Ring	48*12+2=578
SUM	696

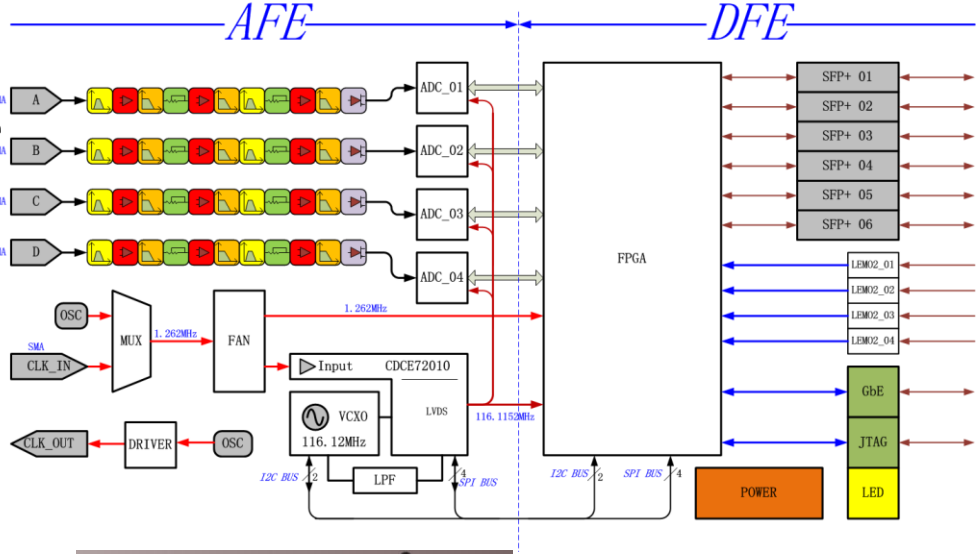
■ Storage ring BPM Parameters

	DBPM@HEPS
Turn by Turn Data	1μm @220kHz
FA data	0.3μm @22KHz
COD data	0.1μm @10Hz

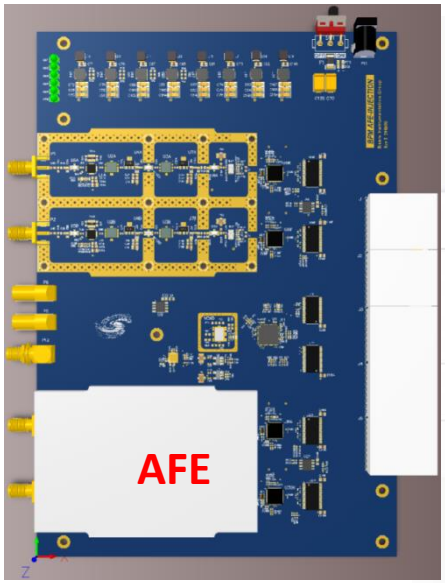
DBPM electronics design and beam test on BEPC II

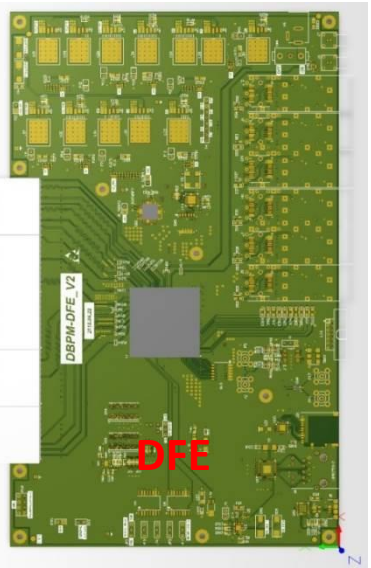
02 DBPM Electronics Design

- For the HEPS will have been built several years later, so we develop the DPBM prototype with BEPCII parameters, and it will be tested on the linac and storage ring of BEPCII.



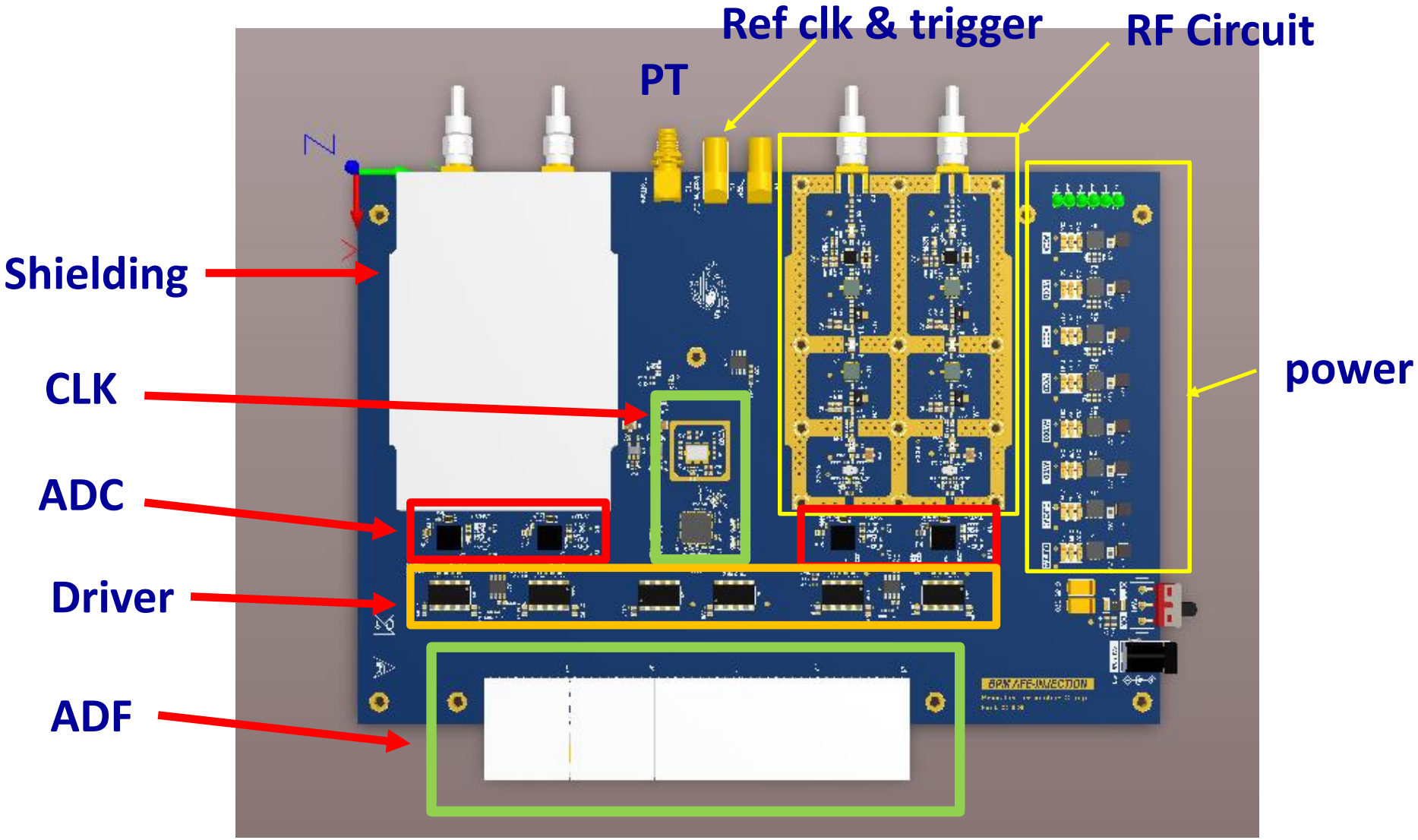
- HW design
  - AFE board Design
  - DFE board Design



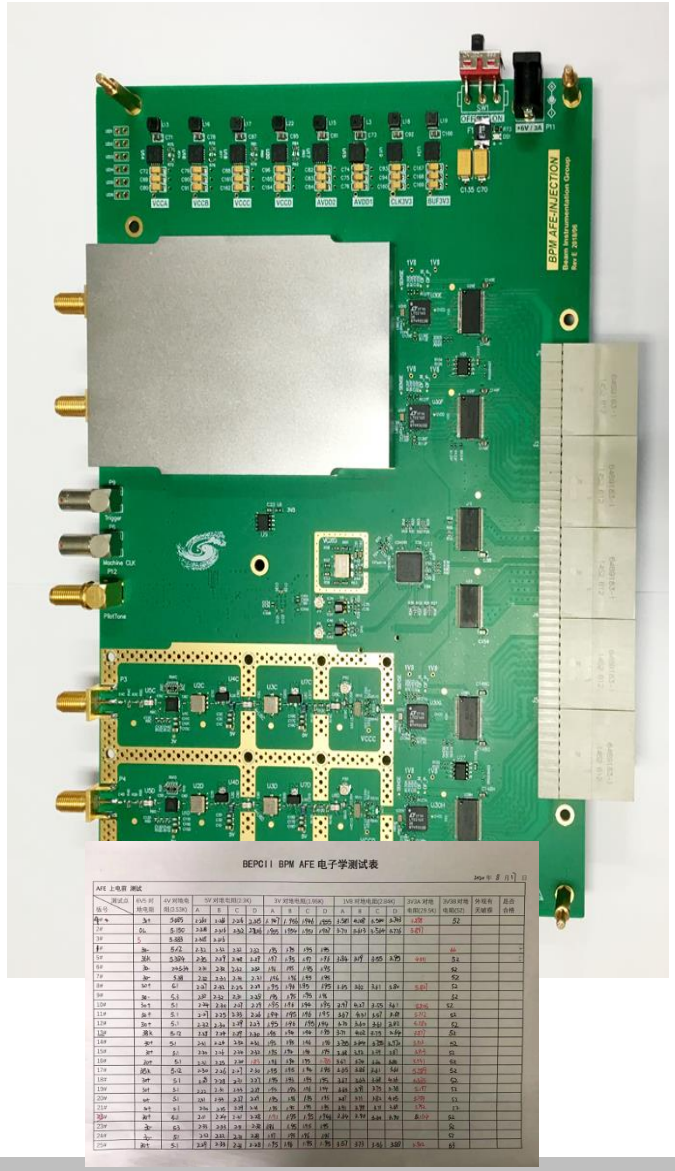


- Test of the DBPM

02 DBPM-AFE Electronic Design



02 DBPM-AFE Analog Logic Testing



S-Parameter Characterization (BPF:good！)

Receiver S-Parameter Characterization

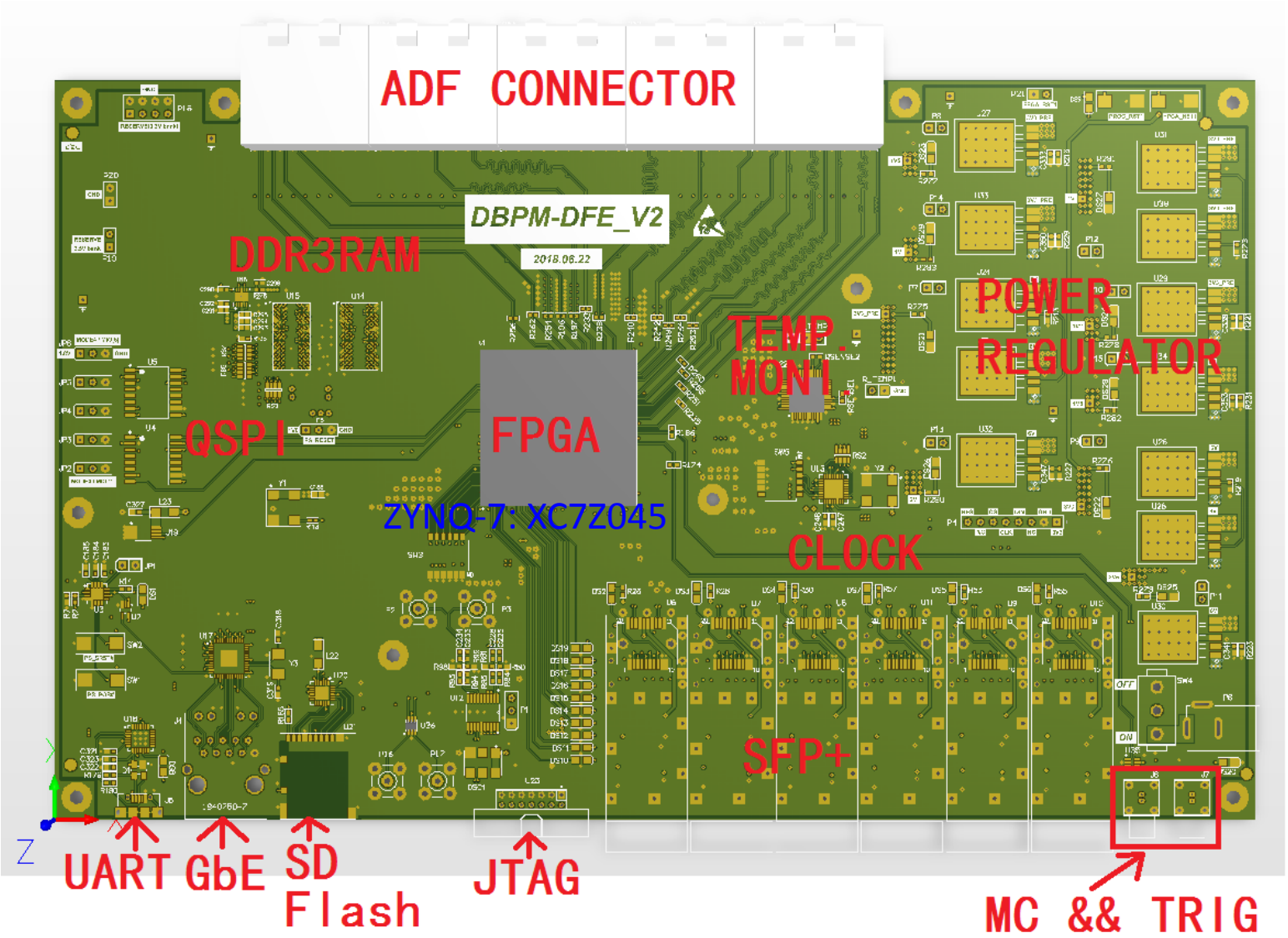
S21-Parameter Characterization

Channel to Channel Isolation > 60dB

A→B

B→A

02 DBPM-DFE Electronic Design

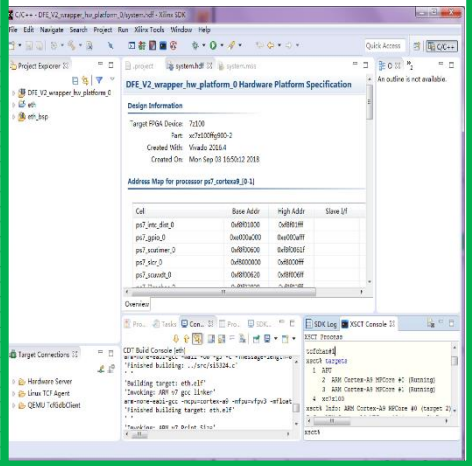


02 DBPM-DFE Hardware Testing

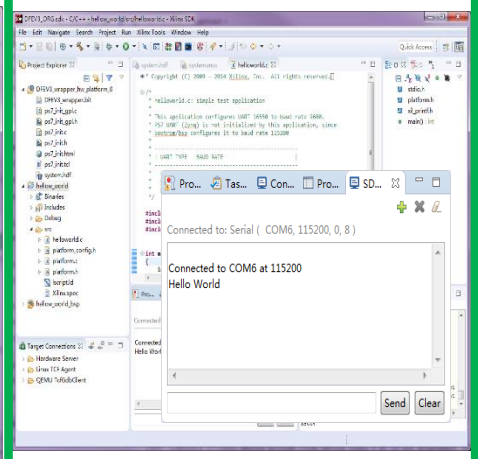
1 POWER

Net	电阻值Ω	电压 V
VCCINT_1.0V (1V)	32.2	0.992
VCCINT1V	6K	0.993
MGTAVTT_1.2V	3K	1.207
MGTAVTT_1.2V_P	3K	1.207
1.5V	2K	1.496
1V5_P	2K	1.496
1.8V	440	1.784
1.8V_P	2K	1.785
1.8V_ETH	440	1.784
1.8V_I2C	440	1.784
1.8V_SD_CARD	440	1.784
1.8V_UART	440	1.784
2.0V	1K	2.003
2.0V_P	4K	2.003
2.5V	100K	2.473
2.5V_P	3K	2.47
3.3V	5K	3.247
3.3V_P	4K	3.248
3.3V_PRE	200K	6.1
3.3V_PRE_P	4K	6.1
3V3_CLK	5K	
3.3V_ETH	5K	
6V	OL	
DDR1_1.5V	2K	
DDR2_1.5V	2K	
DDR3_0V75	100K	
FPGA_RST1	3K	
VTTREF	193K	

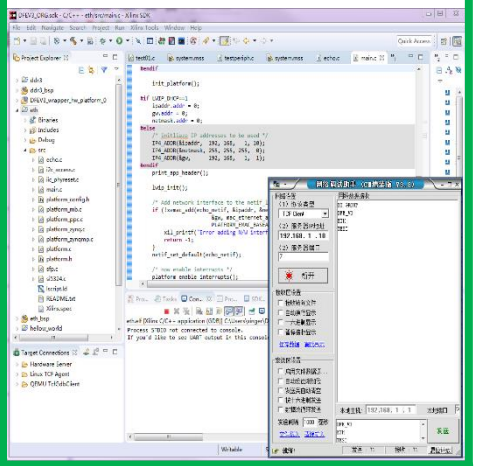
2 ZYNQ



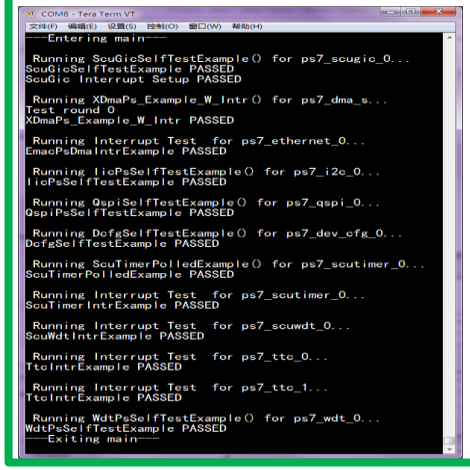
3 SERIAL PORT



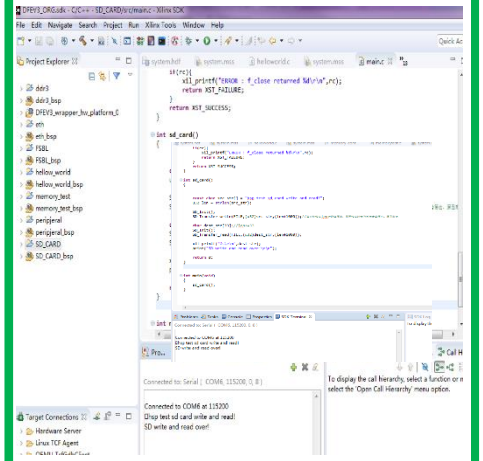
4 NETWORK



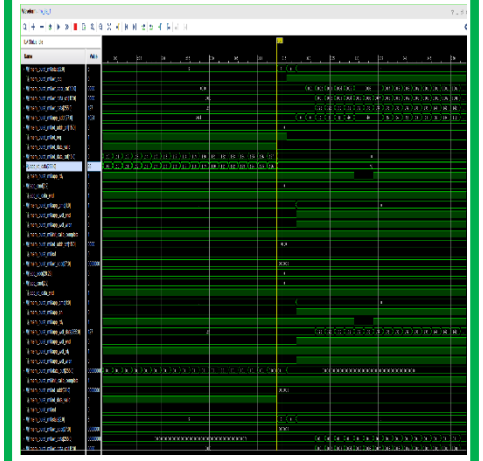
5 FLASH



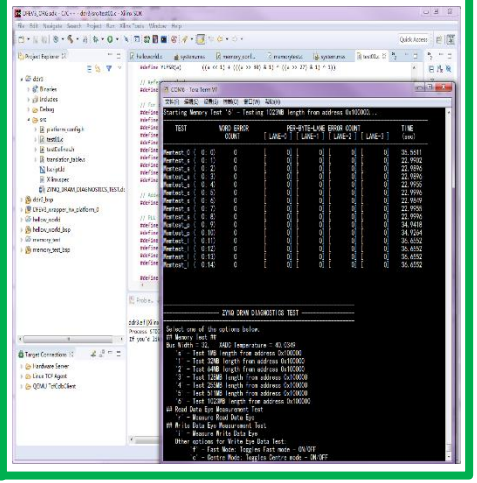
6 SD_CARD



7 DDR3_FPGA



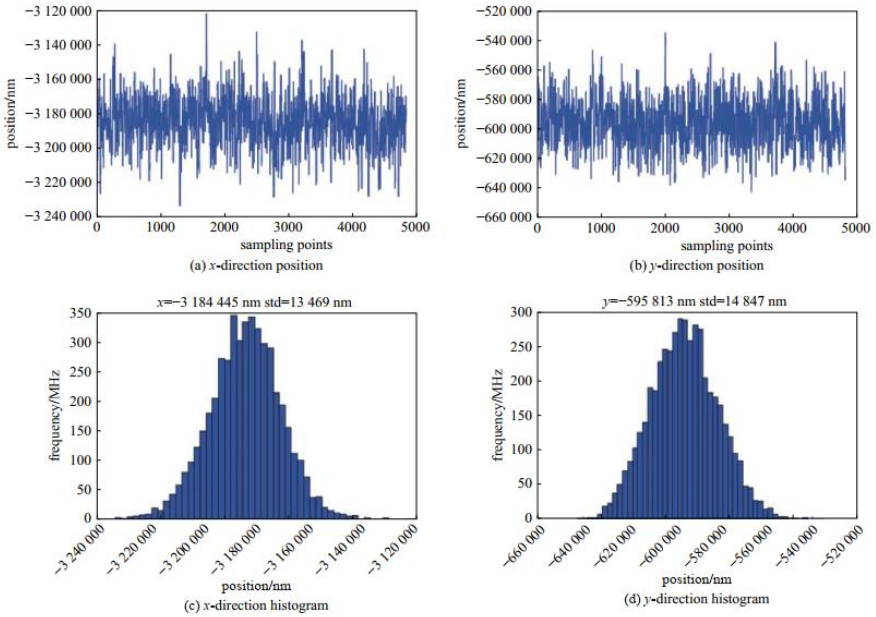
8 DDR3_ARM



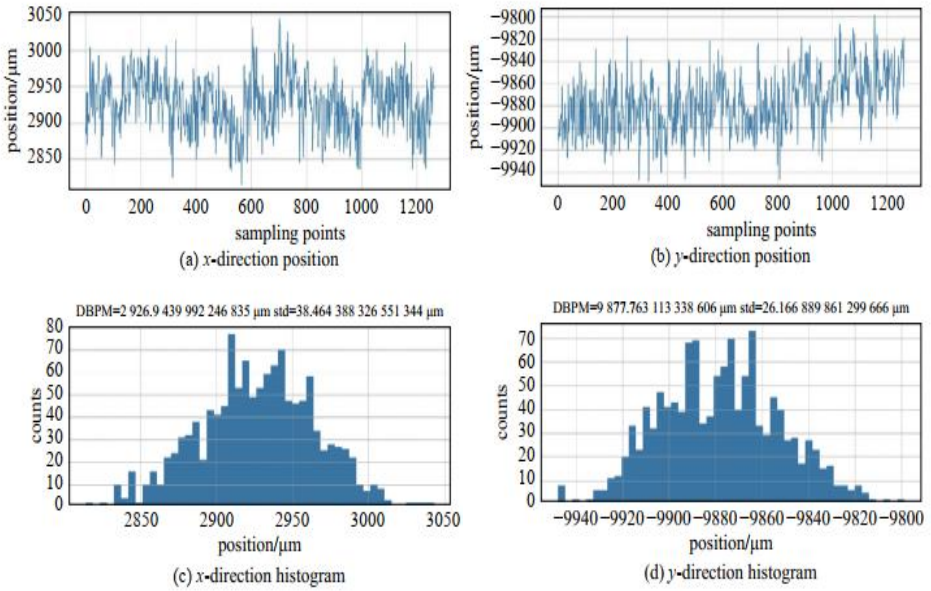
02 DBPM electronics Testing on BEPCII Linac

- The resolution tests results comparison of laboratory (left) and BEPC II Linac(right).

	Laboratory	BEPC II Linac
X	13μm	38μm
Y	15μm	26μm



Resolution test results of Laboratory



Resolution test results of BEPC II Linac

02 DBPM electronics Testing on BEPCII Linac

- Positron mode
- Change the attenuation value of DBPM electronics

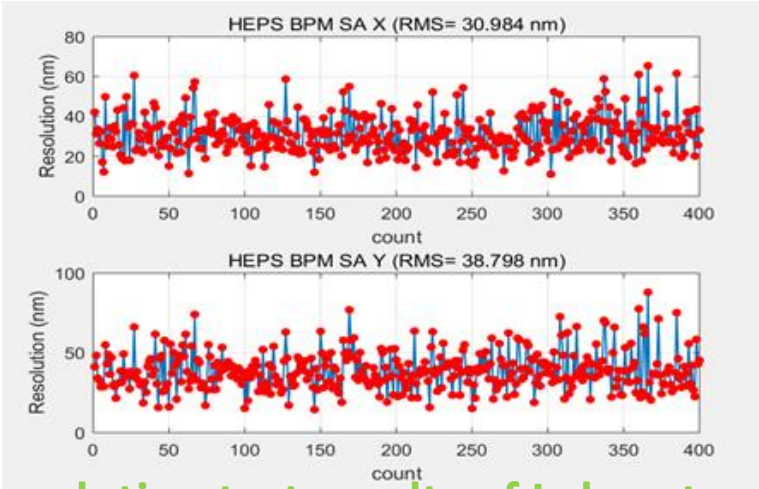
  (4 stages:0dB→-10dB→-20dB→-30dB→0dB)
- experimental time:20mins(18:18 – 18:38)

Time	ATT Set	Std
18:18—18:23	0dB	X: 38μm Y: 26μm
18:23—18:28	-10dB	X: 55μm Y: 40μm
18:28—18:32	-20dB	X: 85μm Y: 70μm
18:32—18:35	-30dB	X: 120μm Y: 100μm
18:35—18:38	0dB	X: 38μm Y: 26μm

Test results with positron beam

02 DBPM electronics Testing on BEPCII Storage Ring

- The resolution tests results comparison of laboratory (left) and BEPC II Storage Ring (right).

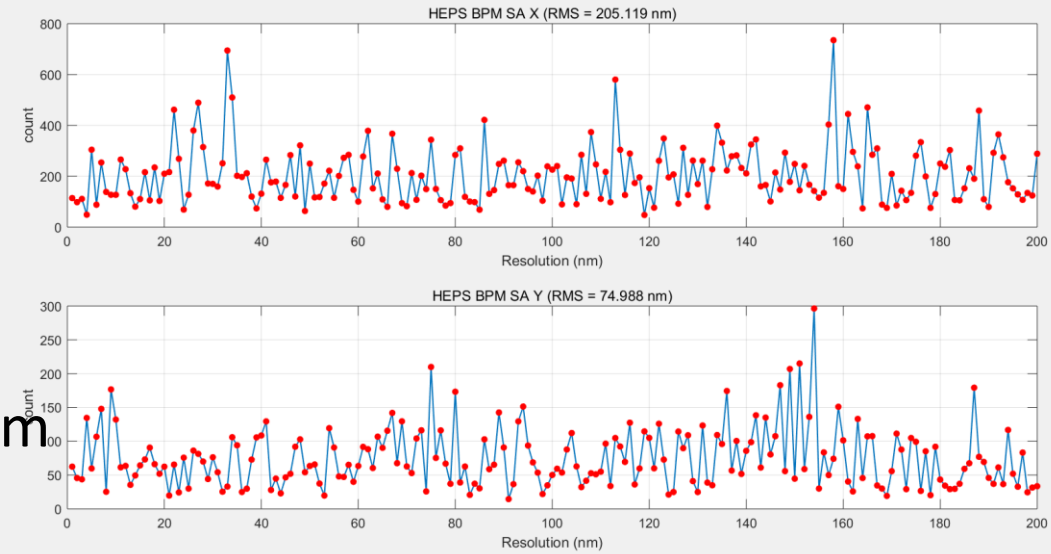


Resolution test results of Laboratory

- SA data STD testing (Kx=Ky=8.26mm)

① <50nm @Laboratory

② <100nm@ BEPCII Real beam

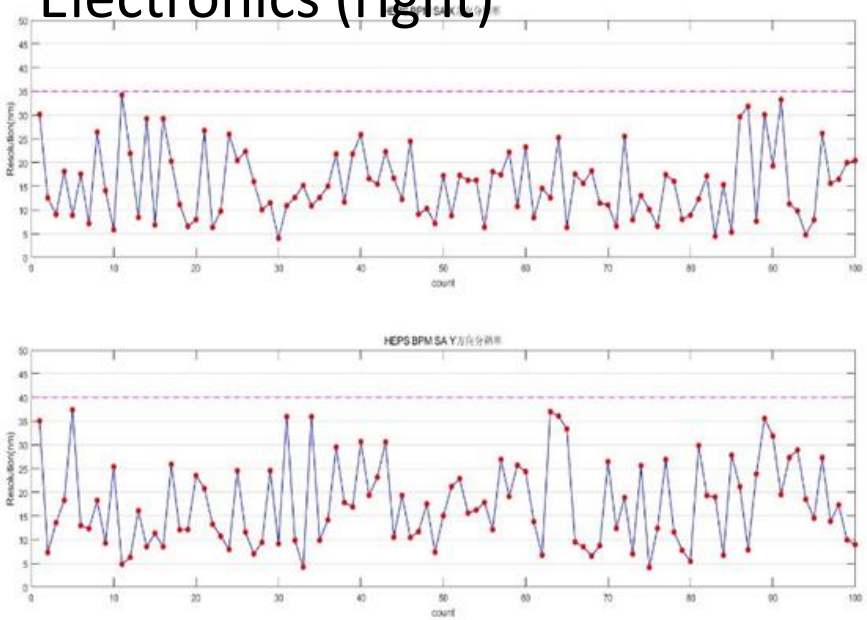


Resolution test results of BEPC II Storage Ring

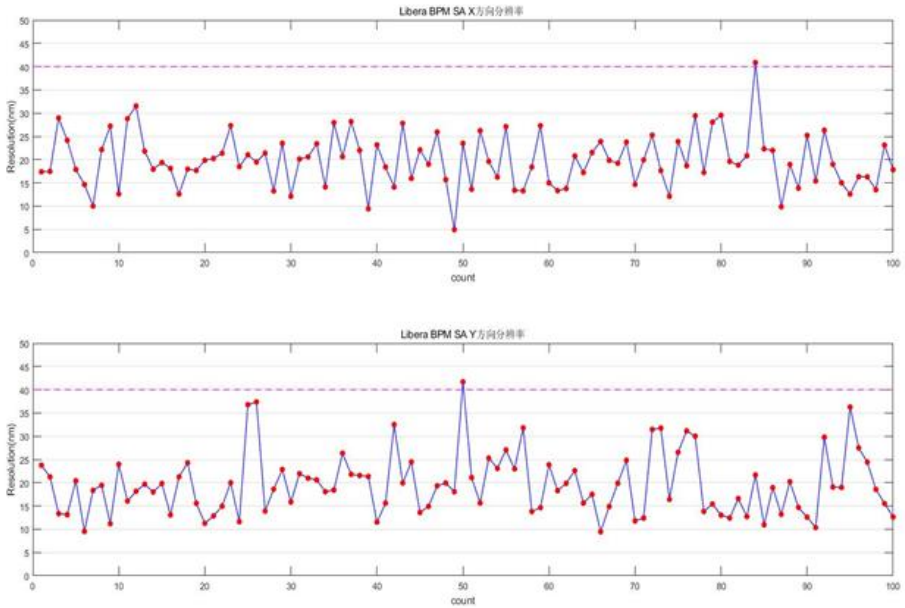
02 DBPM electronics Testing on BEPCII Storage Ring

- The laboratory resolution tests results comparison between self-developed(IHEP) DBPM electronics (left) and Libera BPM Electronics (right)

	IHEP	Libera
X	35μm	41μm
Y	40μm	42μm



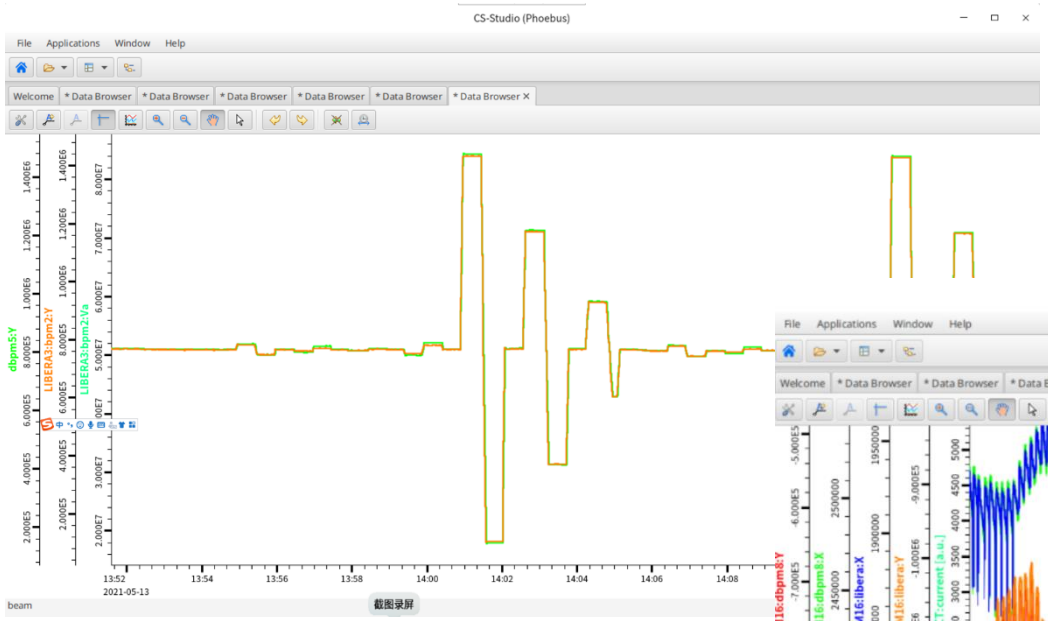
Laboratory resolution test results of IHEP DBPM electronics



Laboratory resolution test results of Libera BPM Electronics

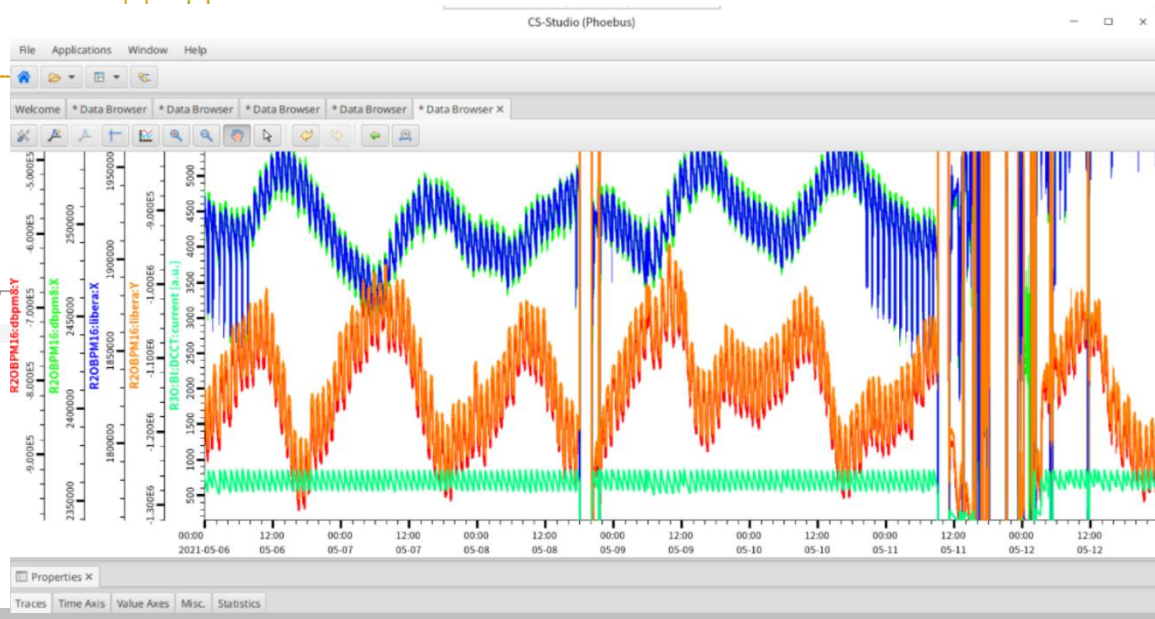
02 DBPM electronics Testing on BEPCII Storage Ring

- The long-term stability comparative study between self–developed (IHEP) DBPM electronics and Libera BPM electronics



Long-term stability study (0.5 hours)

Long-term stability study (7 days)



DBPM electronics upgrading work for BEPC II

03 The importance of upgrading work

- The Bergoz BPM electronics in BEPCII have been worked more than 10 years, and some of them broke down now.
- The work can bring benefit to the HEPS' BPM building.

① Discover and resolve the existing design flaws in BPM electronics during BEPCII BPM upgrade work

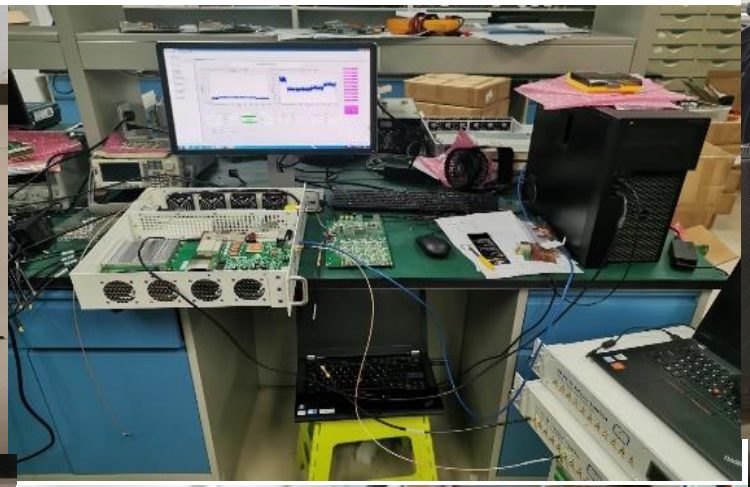
② Test the long-term stability of BPM electronics

③ Verify BPM electronics production capability

④ Verify the functionality and performance of HEPS's BPM electronics

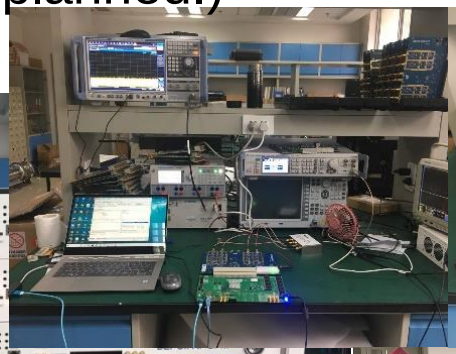
03 DBPM upgrading on BEPCII Linac

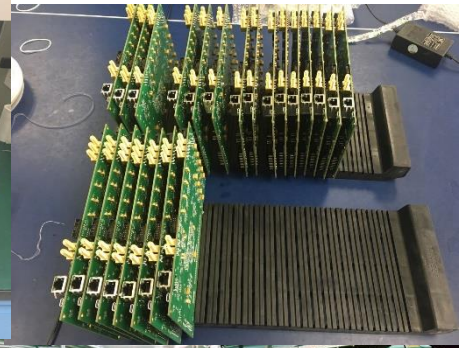
- The DBPM electronics upgrading work of BEPCII Linac have been finished in 2019. About 20 Linac DBPM electronics upgrading were completed.

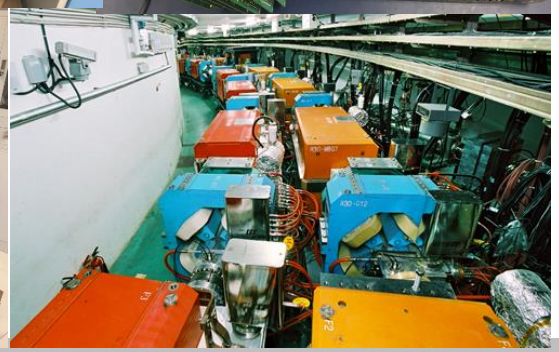




03 DBPM upgrading on BEPCII Storage Ring

- The DBPM electronics upgrading work of BEPC II storage ring is expected to be completed by the end of 2021.
- Approximately 100 DBPM electronics are expected to be completed .(21 BPM electronics have been installed, The rest of the electronics installation is proceeding as planned.)







Summary

04 Summary

- Digital BPM Electronics hardware has been designed carefully and had been tested in laboratory;
- The digital BPM electronics have been tested with the calibration bench and the real beam on BEPCII(Linac and storage ring);
- The digital BPM electronics have been used to replace the BEPCII's old Bergoz BPM electronics(BEPCII Linac,2019);
- Part of the digital BPM electronics have been installed on the BEPC II storage ring;
- DBPM electronics based on pilot tone is under development.

Thanks for your attention!