

# HIGH-SENSITIVITY RF DIRECT SAMPLING PROCESSOR REDEFINES THE BEAM DIAGNOSTIC SYSTEM

TUP14

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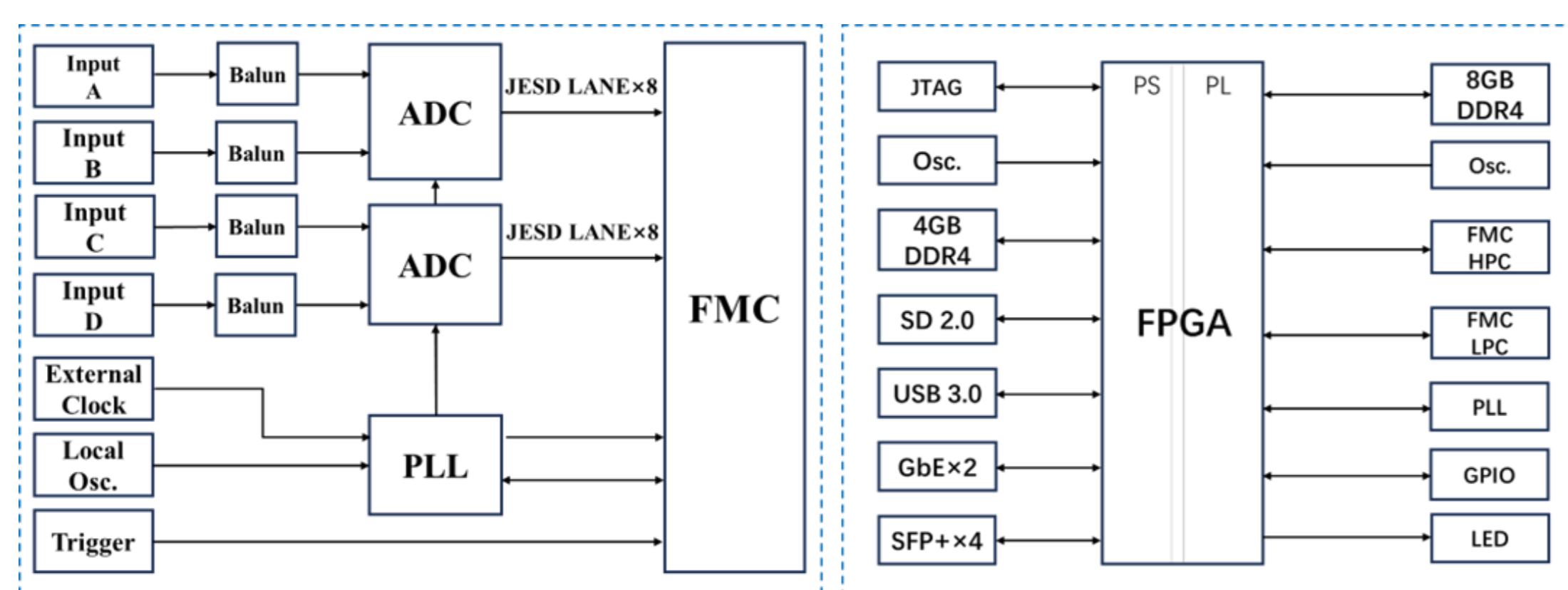
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## •Abstract

RF direct sampling and processing of beam signals has always been the goal pursued in beam diagnostic systems. Now it's time to make it happen. For the first time, a high-sensitivity RF direct sampling processor has been developed for C-band cavity pickups in SHINE/SXFEL. It redefines the beam diagnostic system. There is no longer a need for complex analog down-conversion modules in traditional cavity BPM/BAM systems. In addition, the processor can simultaneously meet the signal processing needs of different cavities with a center frequency below 6 GHz. Obviously, the RF direct sampling processor greatly reduces the complexity and costs of the system, shows great versatility. Meanwhile, compared to the down-conversion electronics, this processor demonstrates much higher sensitivity (twice) due to a significant reduction in analog components. The processor also has a huge advantage in other beam diagnostics because of its wide bandwidth and high sampling rate, such as bunch-by-bunch measurement and feedback system on synchrotron radiation facility. Now it's time to massively apply the RF direct sampling processor to promote the development of beam diagnostic technology.

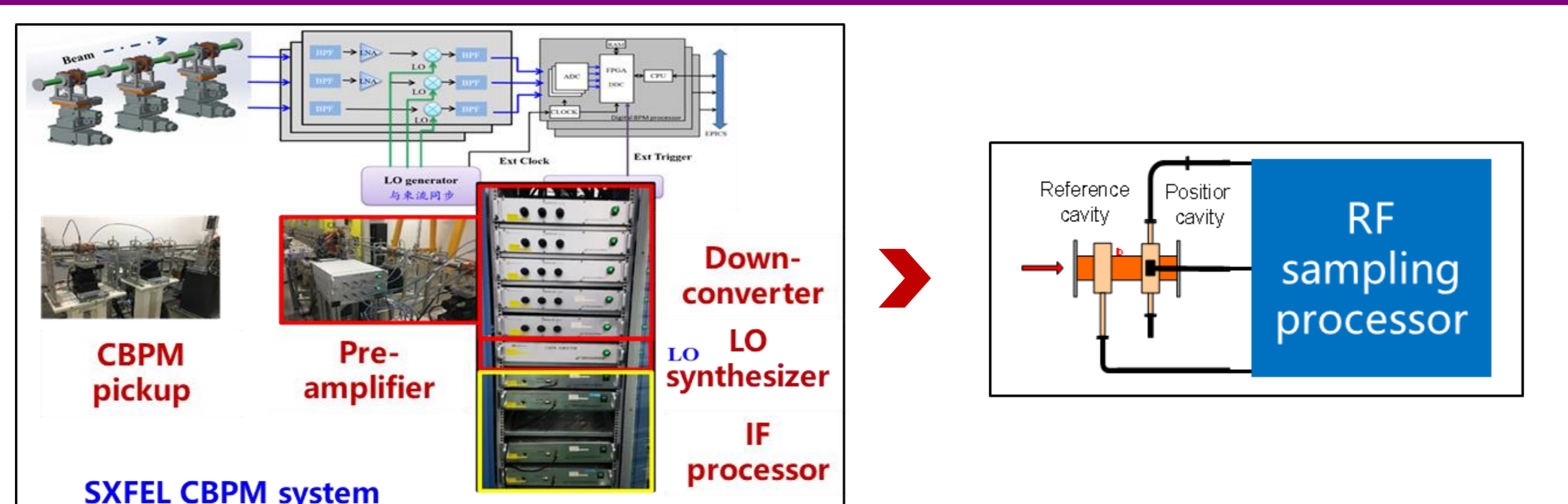
## •RF direct sampling processor

The processor is a 1U high standalone device, consists of an MPSoC Ultrascale+ FPGA carrier board, an ADC board, an FMC slot reserved for White Rabbit timing card.

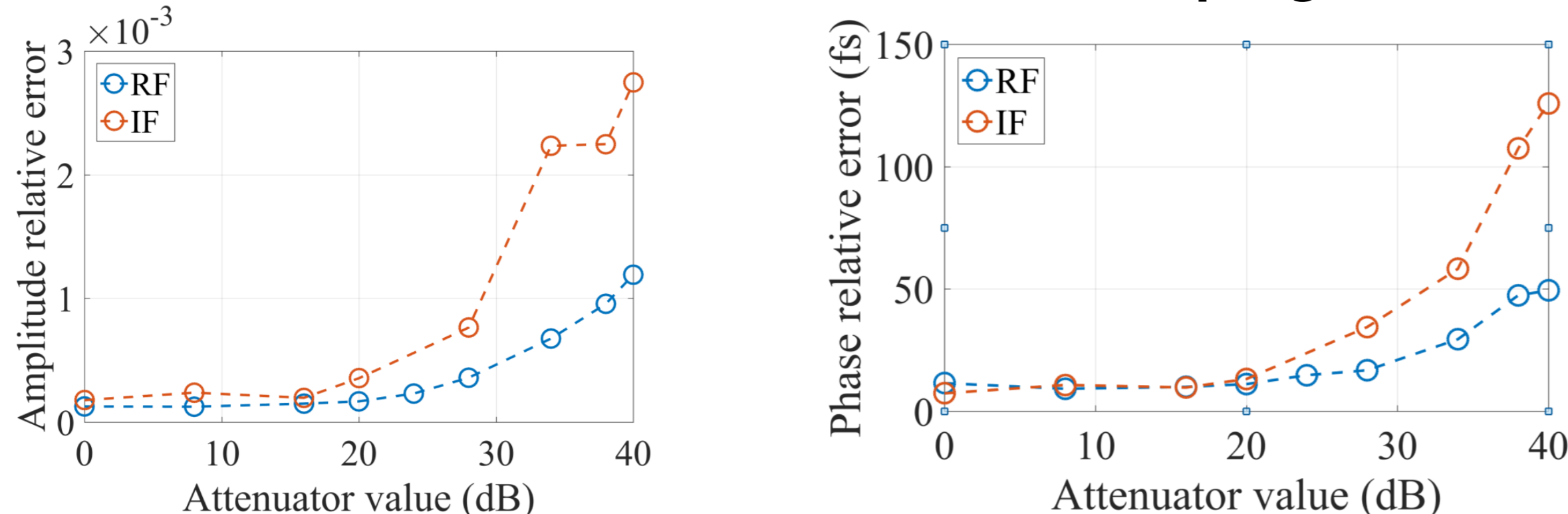


Parameters	value
Channels	4
ADC bits	14
ADC Bandwidth	9 GHz
Max ADC rate	2.6 GSPS
FPGA	Xilinx ZCU15EG
Clock	Ext./Int.
PL DDR4	8GB
PS DDR4	4GB
Trigger	WRN/Ext. SMA /Self/Period
Interlock	Lemo
Ethernet	2×RJ45
SFP	4, UDP&Aurora
Software	Linux/EPICS

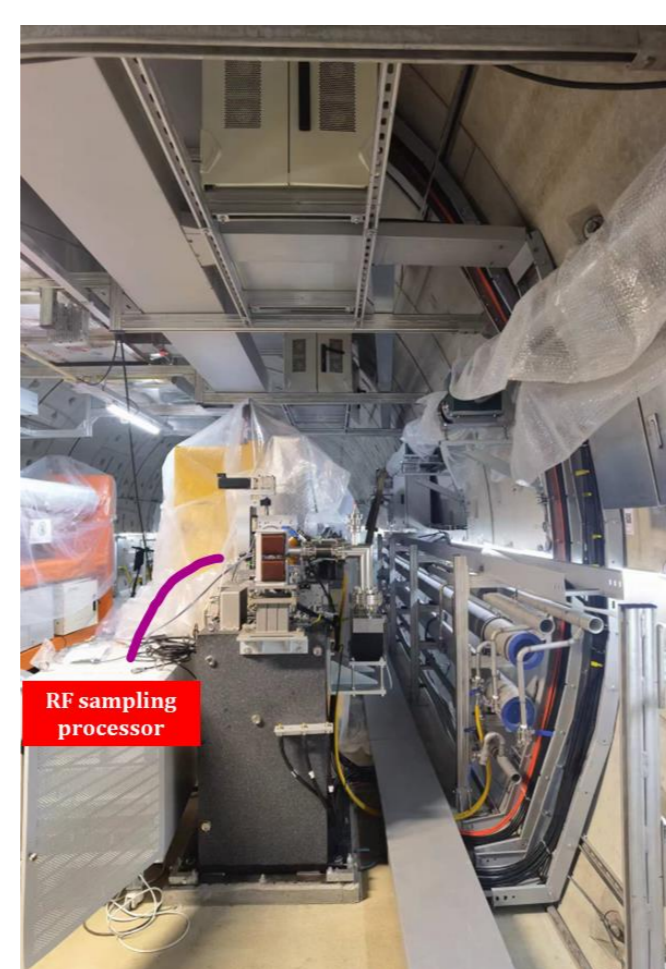
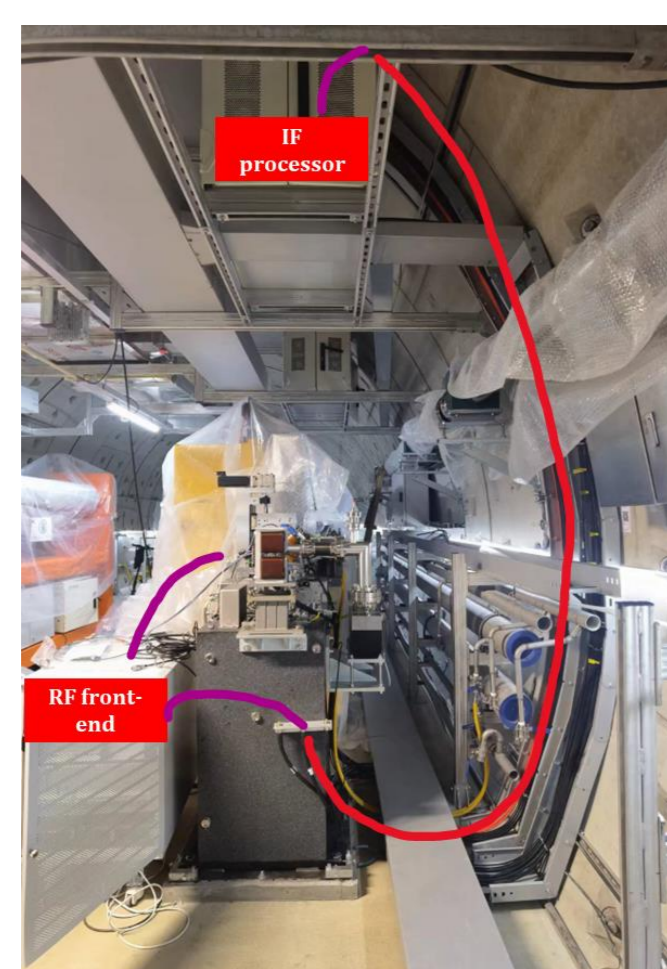
## •Cavity BPM/BAM signal processing



### Down-conversion electronics VS RF direct sampling electronics



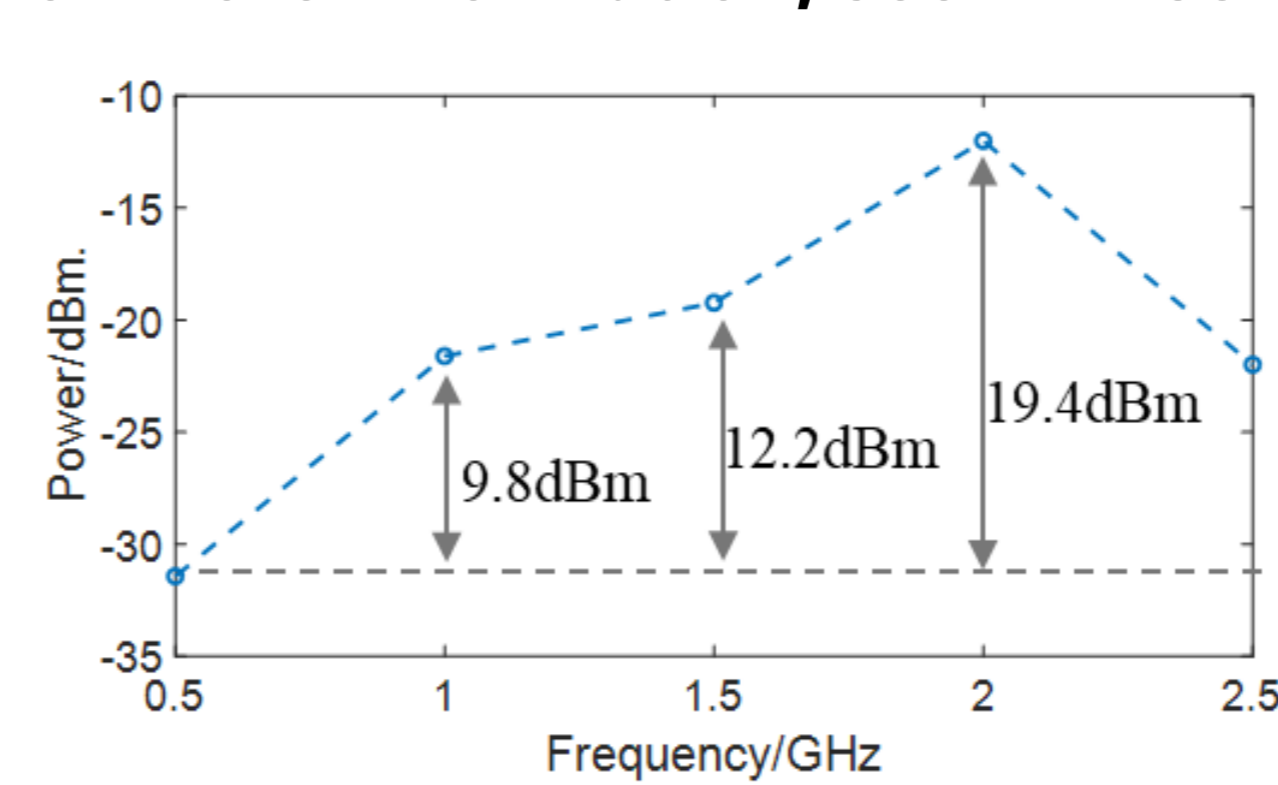
Performance comparison between IF sampling and RF direct sampling



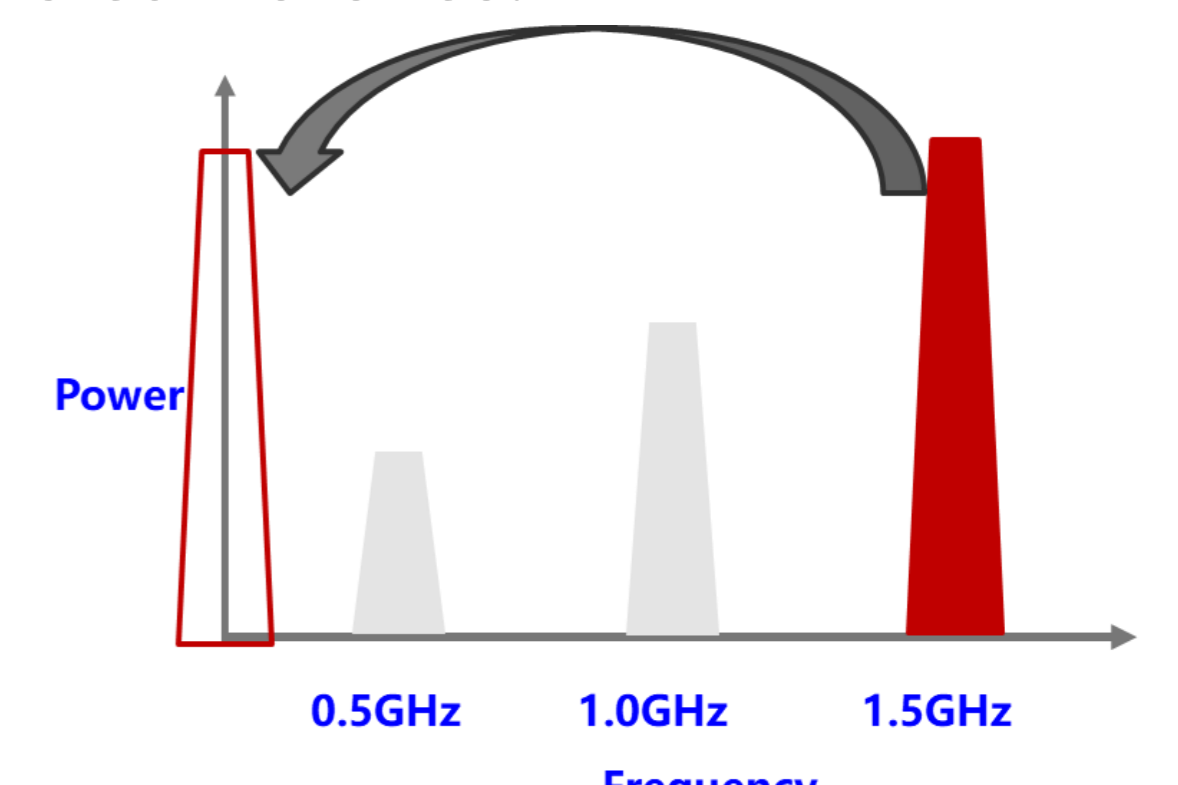
Field comparison between IF sampling and RF direct sampling

## •Bunch-by-bunch TFB signal processing

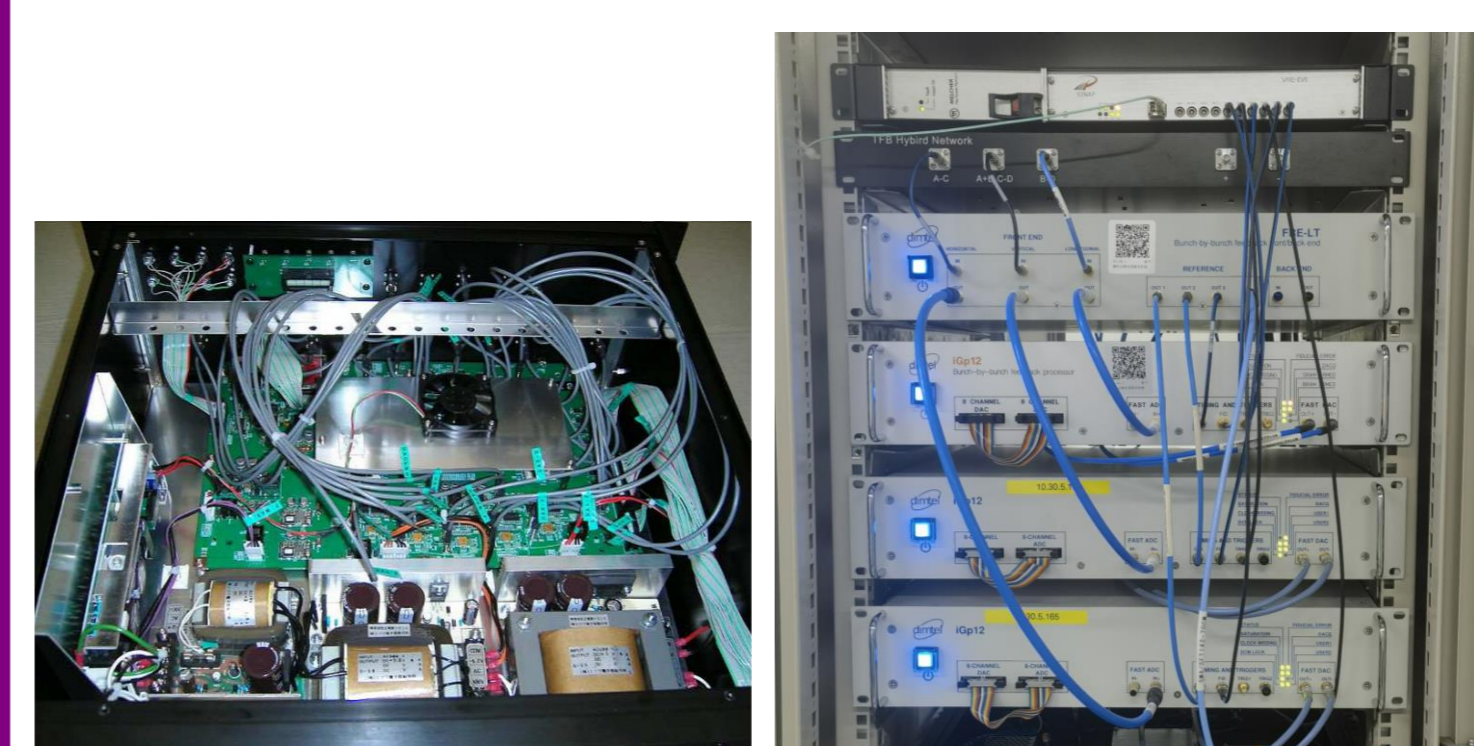
For more information, see WEP39 in this conference.



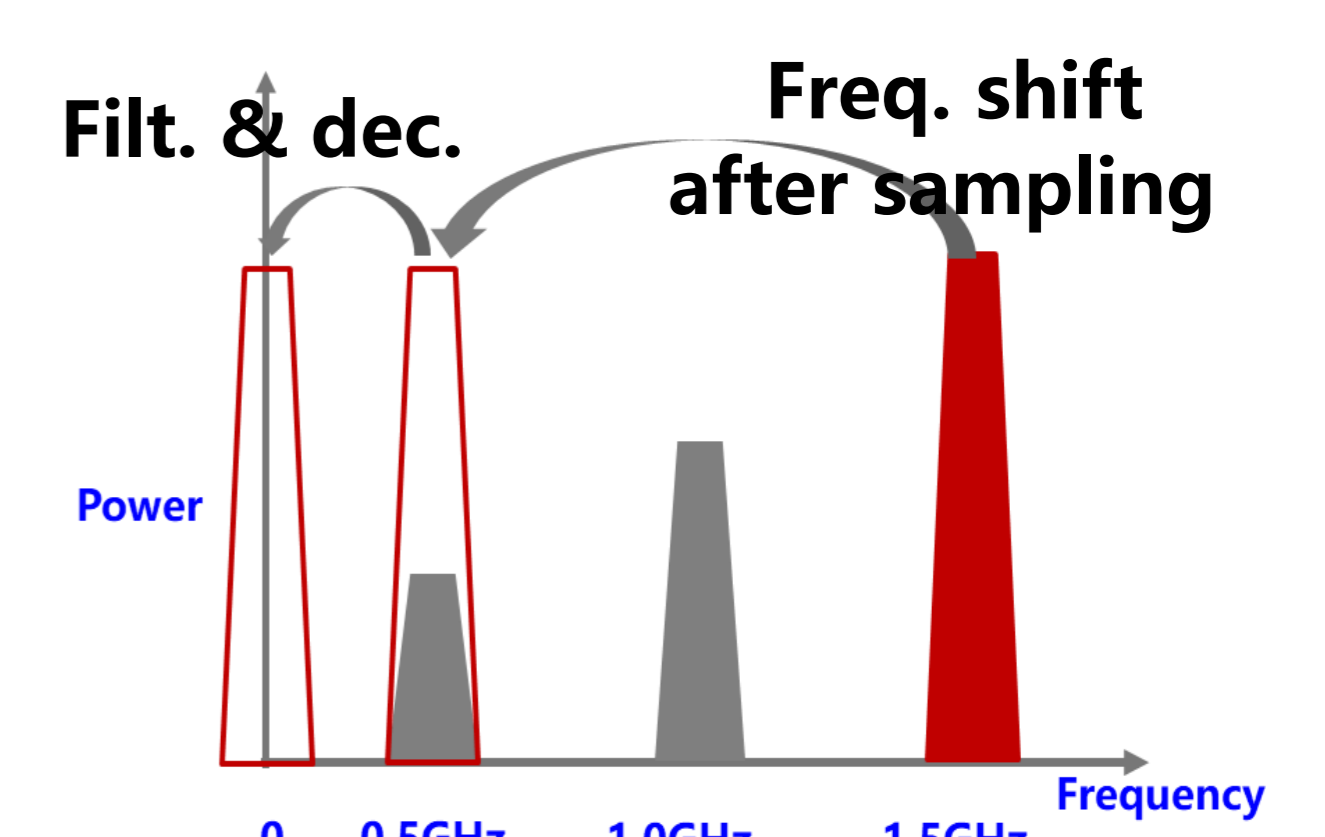
BPM hybrid signal amplitude



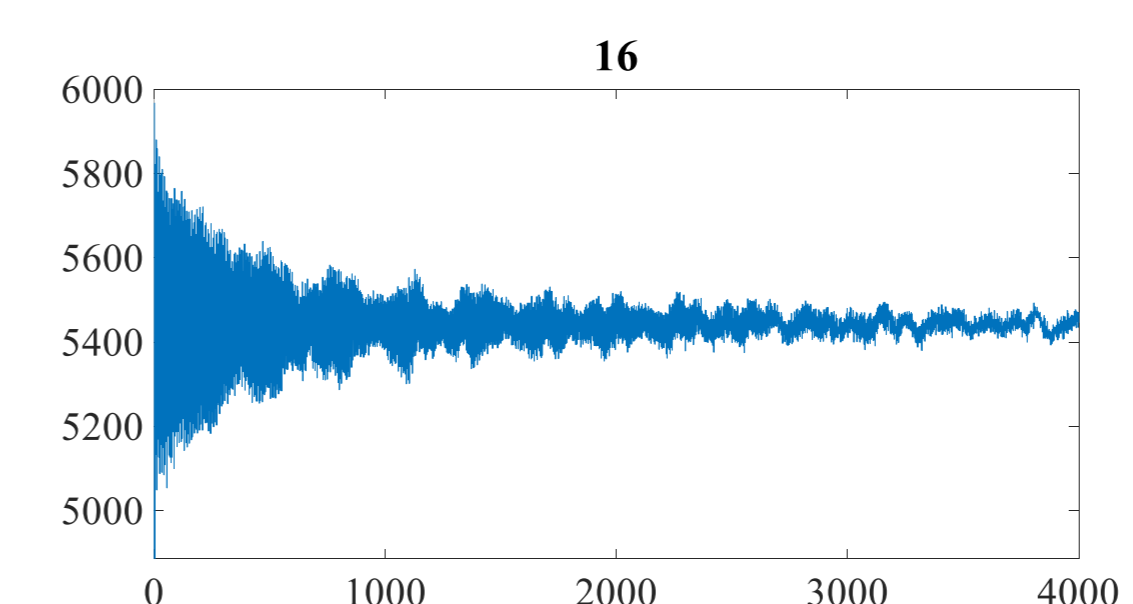
Traditional analog downconversion



Downconversion TFB electronics in SSRF from Spring-8 & Dimeil



RF direct sampling @2GSPS



RF direct sampled bunch 16 turn-by-turn oscillation during injection

## •Conclusion

We have developed an RF direct sampling processor to explore applications in beam diagnostics. The RF direct sampling processor samples signals without down-conversion. The measurement of amplitude and phase has higher sensitivity compared to down-conversion electronics. The prototype RF direct sampling processor was used to measure the bunch-by-bunch tune value on the SSRF storage ring. The design of the RF direct sampling TFB processor is in progress.