中国科学院 上海高等研究院
SHANGHAI ADVANCED RESEARCH INSTITUTE CHINESE ACADEMY OF SCIENCES

TUP38

Recent progress and experimental results of electro-optic bunch arrival time monitor for SHINE

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Abstract

The timing jitter of electron bunch will affect the temporal and power stability of FEL, as well as the resolution of pump-probe experiment at FEL facilities. In order to improve the temporal stability of electron bunch by beam feedback, Shanghai high-repetition-rate XFEL and Extreme light facility (SHINE) will implement two types of bunch arrival time monitor to accurately measure the electron bunch arrival time, namely the Cavity Bunch Arrival time Monitor (CBAM) and the Electro-Optic Bunch Arrival time Monitor (EOBAM). Here we will introduce design of EOBAM, including the beam pick-up, the electro-optic front-end, and the signal detection. Additionally, the latest research progress of the EOBAM for SHINE and the beam experiment for EOBAM prototype based on SXFEL will also be introduced. The experiment results show that the resolution of EOBAM based on the 18 GHz beam pick-up is 5.6 fs@200pC and 8.9fs@100pC.

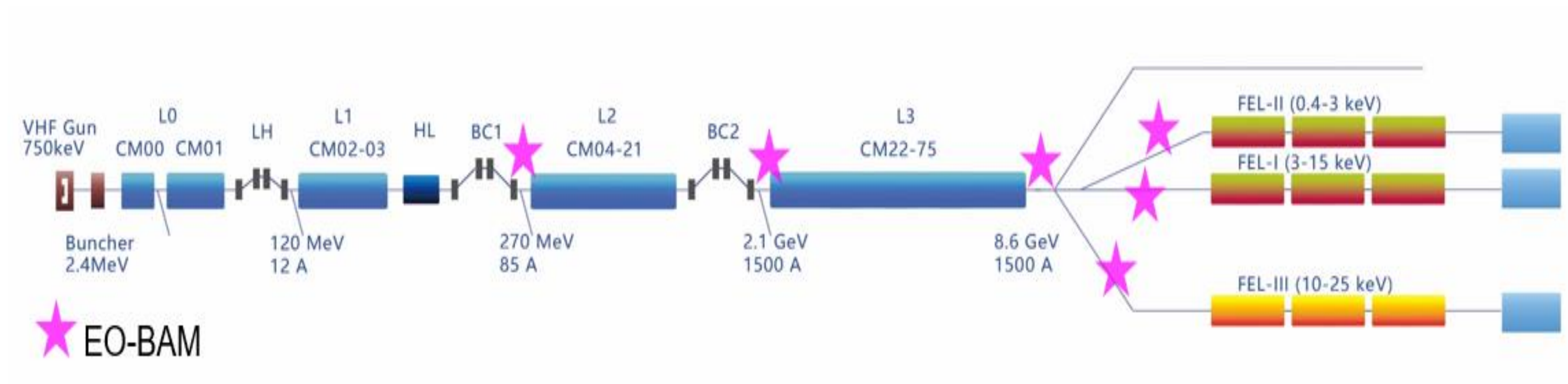
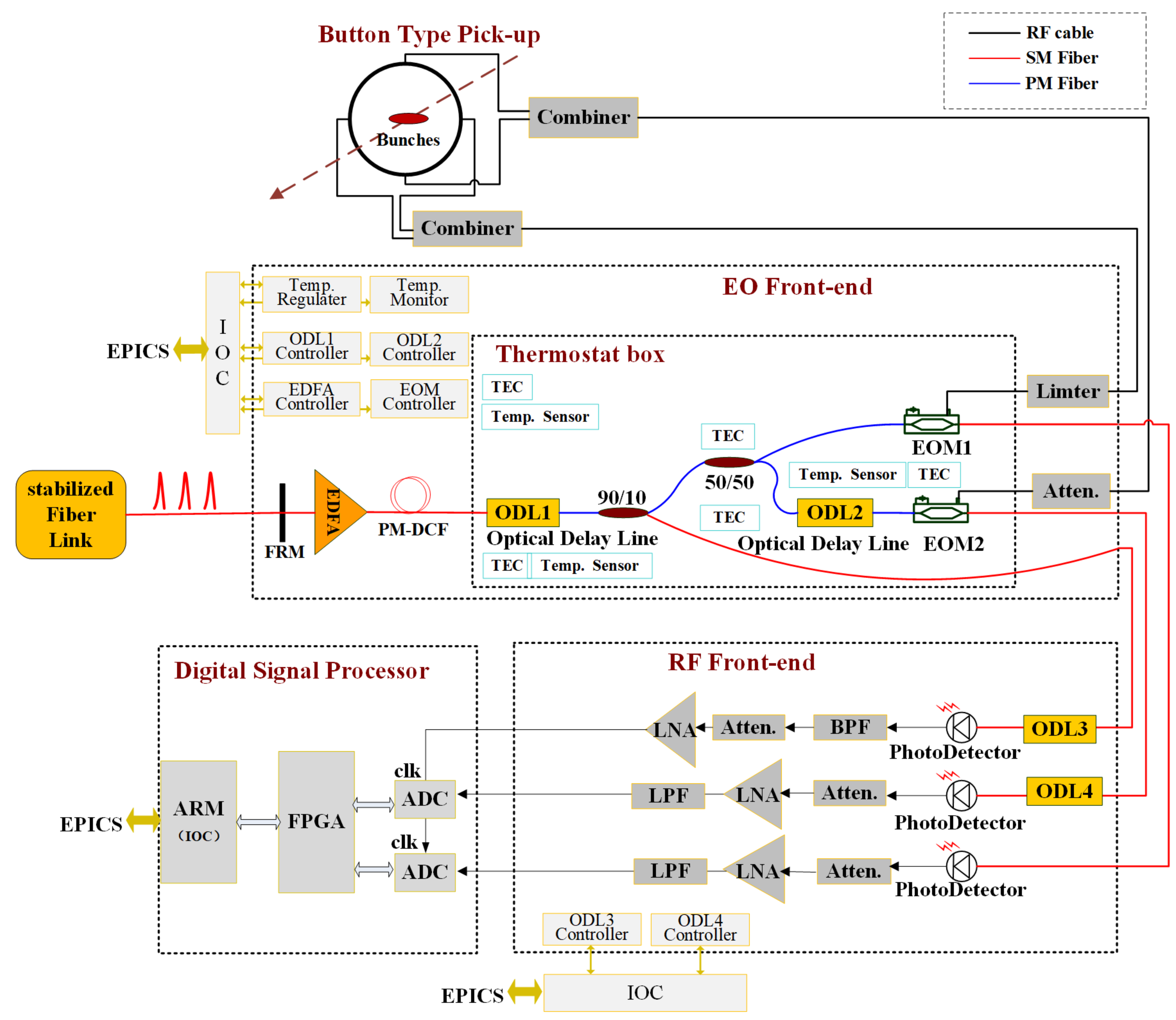


Table 1: Main parameters of EOBAM

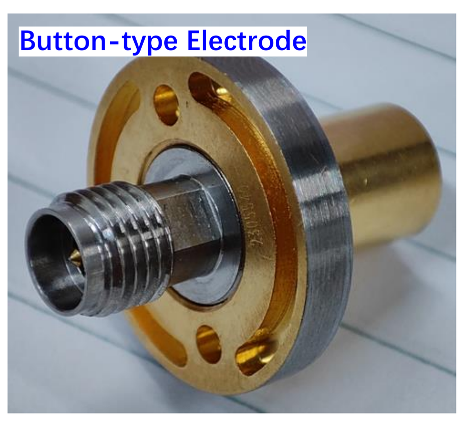
Parameter	Value
Installation locations	BC1/BC2/L3 Exit/ Entrances of FEL-I/II/III
Diameter of vacuum chamber	35mm
Length of vacuum chamber	200mm
Resolution	15fs @100pC
Bunch charge	10-300pC
Bunch repetition frequency	0~1MHz



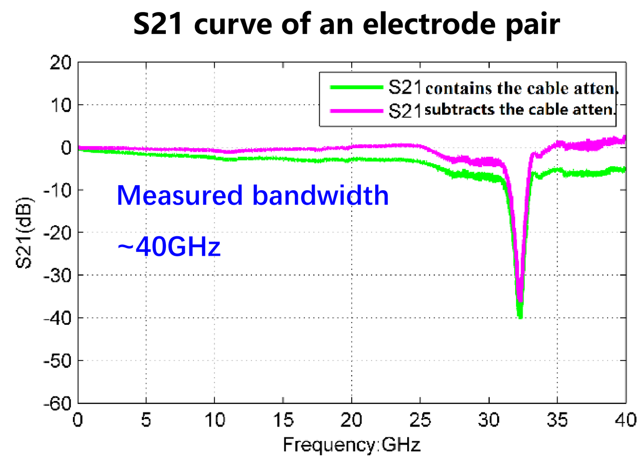
Schematic design of SHINE EOBAM

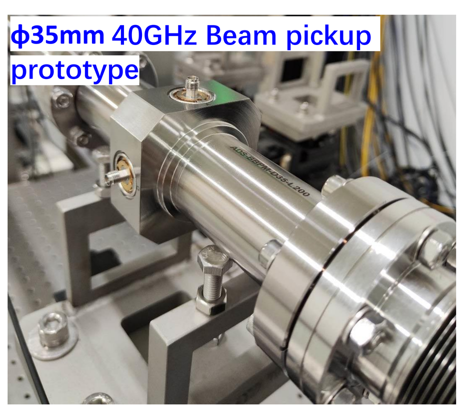
Buton Type pickup

- The Manufacturing and performance testing of the button-type beam pickup has been completed. The measured bandwidth is approximately 40GHz, and the measured signal slope is 365 mV/ps (using the electro-optic sampling method).

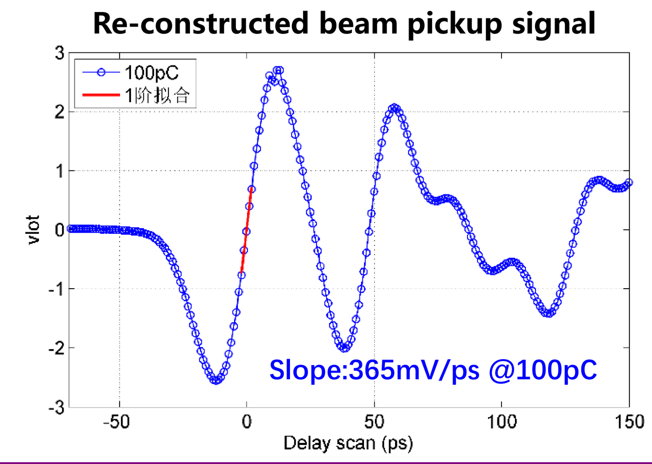


S21 curve of an electrode pair





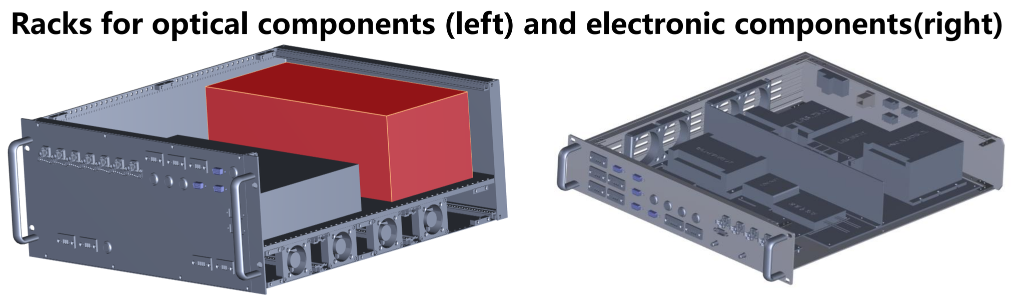
Re-constructed beam pickup signal



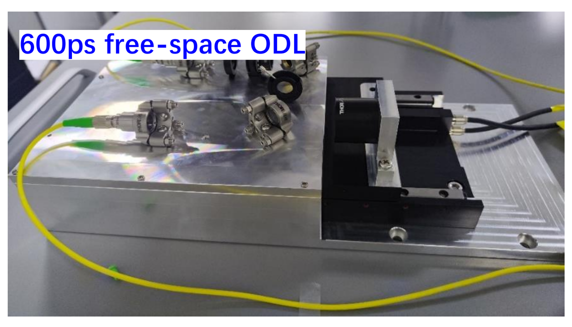
EO front-end

- EO front-end is housed within two racks: one rack , which is configured with temperature controller, will house the optical components, while the other rack will house the electronic components, including EOM bias controller , ODL controller and so on.

Racks for optical components (left) and electronic components(right)

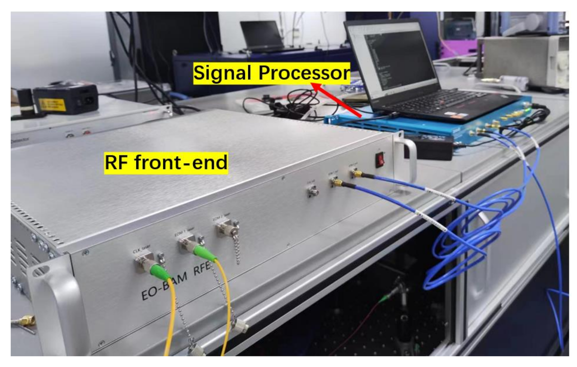


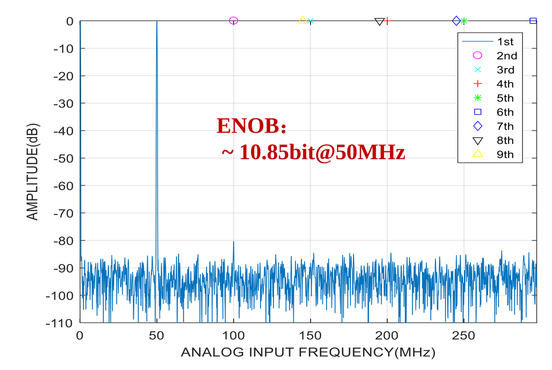
- The free-space ODL utilizes a linear stage with a position accuracy less than 1 um. The insertion loss of ODL is measured to be -1.8±0.01dB over 600ps range.

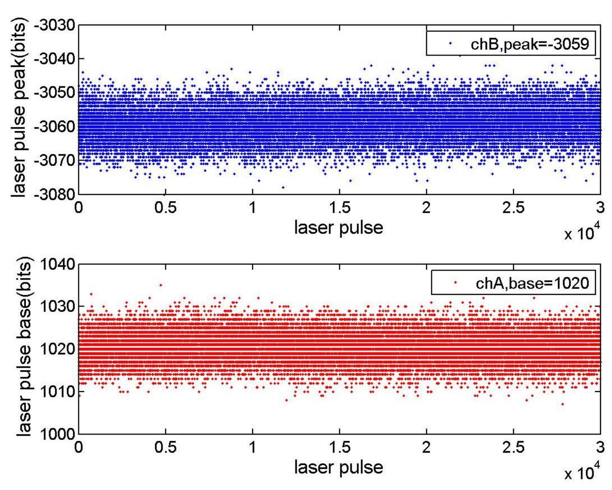


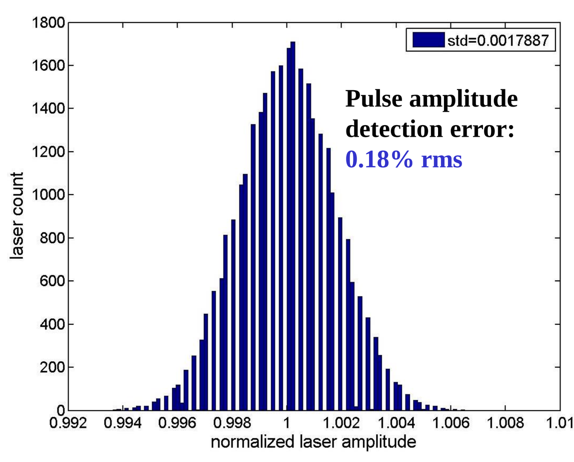
RF front-end and Digital Signal Processor

- Digital Signal Processor has an ENOB of 10.85bit@50MHz, more information about DSP pleaser refer to WEP53 in this conference.
- Pulse amplitude detection error of RF front-end and the DSP is 0.18% rms, and efforts are ongoing to further optimize this parameter.



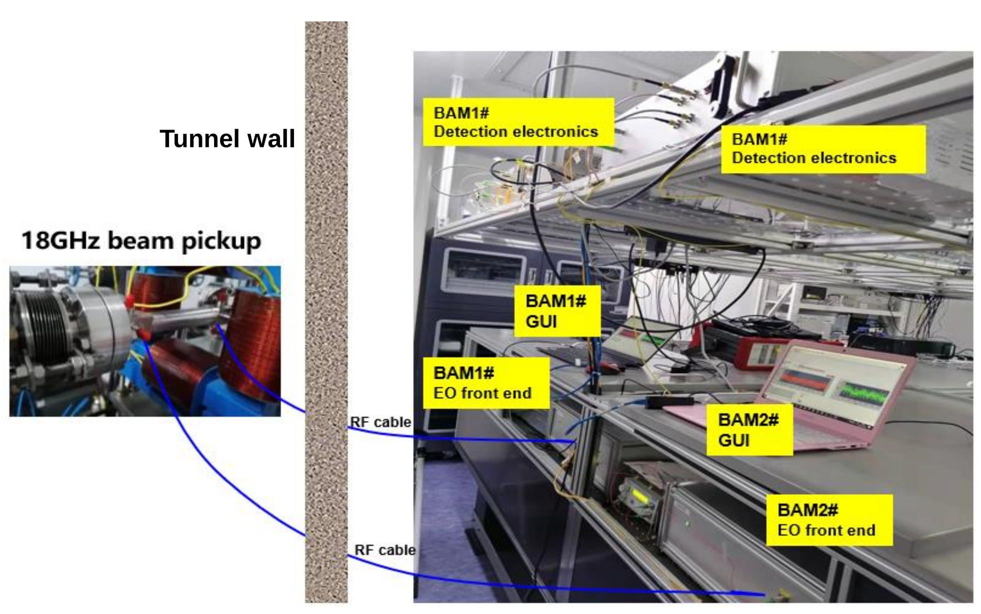


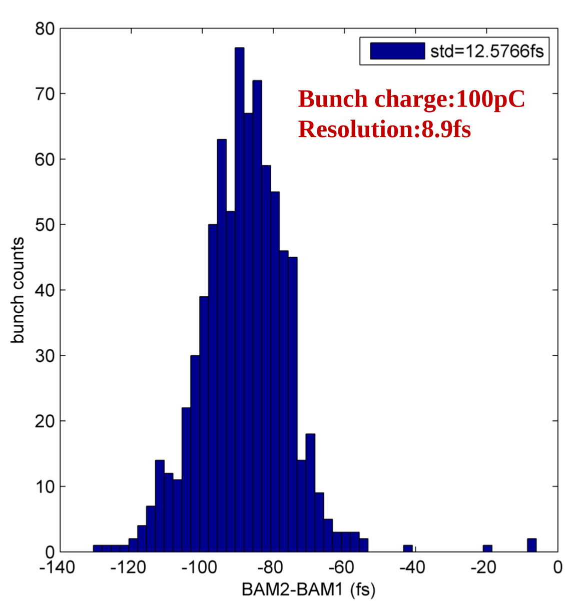


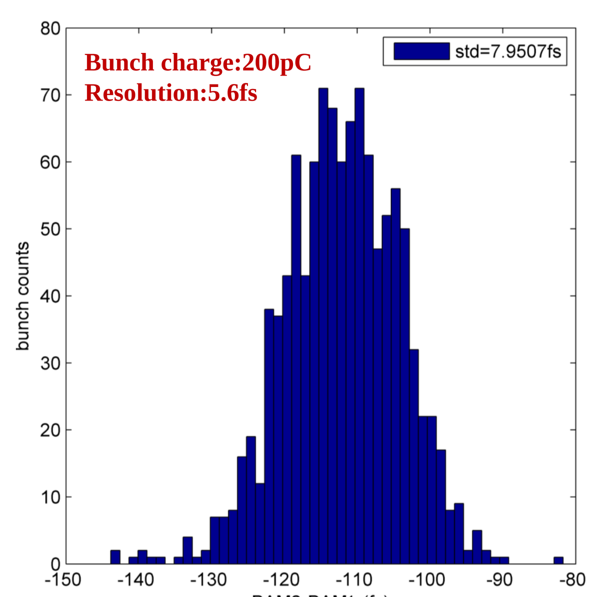


Beam test at SXFEL

- The EO front-end of SHINE EOBAM is still under construction and the high-level software supporting it is also under development. Before both the hardware and software are ready, we have built an EOBAM test platform at SXFEL to verify the principle of EOBAM.
- The test platform contains two identical simplified EOBAM prototypes, each based on 18GHz beam pickup. The EO front-end of the prototype contains only one EOM to simply the structure. Two 18 GHz beam pickups are integrated into a single vacuum with a length of 200 mm and a diameter of 16mm, the distance between two beam pickups is 134mm. They are install at the exit of SXFEL LINAC. The pickup signals are transmitted through RF cable of 22 meters to the EO front-end at the laser hutch, while the optical signal from the optical master oscillator is divided into two parts to serve as the optical references of the two EOBAM prototype.
- By monitoring the electron bunch arrival time using the two EOBAM prototype simultaneously, we can verify the time resolution of the EOBAM prototypes. The experiment results show that the resolution of EOBAM based on the 18 GHz beam pickup is 5.6 fs@200pC and 8.9fs@100pC.







Conclusion

- There will be 6 EOBAMs installed at different locations of SHINE.
- SHINE EOBAM will implement 40GHz beam pickup, with its vacuum chamber having a diameter of 35 mm. The ϕ35mm 40GHz beam pickup prototype has been installed at SXFEL for test, and the slope of the pickup signal is measured to be 365mV/ps@100pC.
- The EO front-end of SHINE EOBAM is still under construction. The free-space ODL built for EO front-end is based on a linear stage with <1um position accuracy, implies a delay accuracy of approximately 6fs.
- Pulse amplitude detection error for both the RF front-end and DSP is 0.18% rms.
- To verify the principle of EOBAM, a test platform has been built at SXFEL, and the measurement results indicate that the EOBAM based on the 18 GHz beam pickup achieves a time resolution of 5.6 fs@200pC and 8.9fs@100pC.