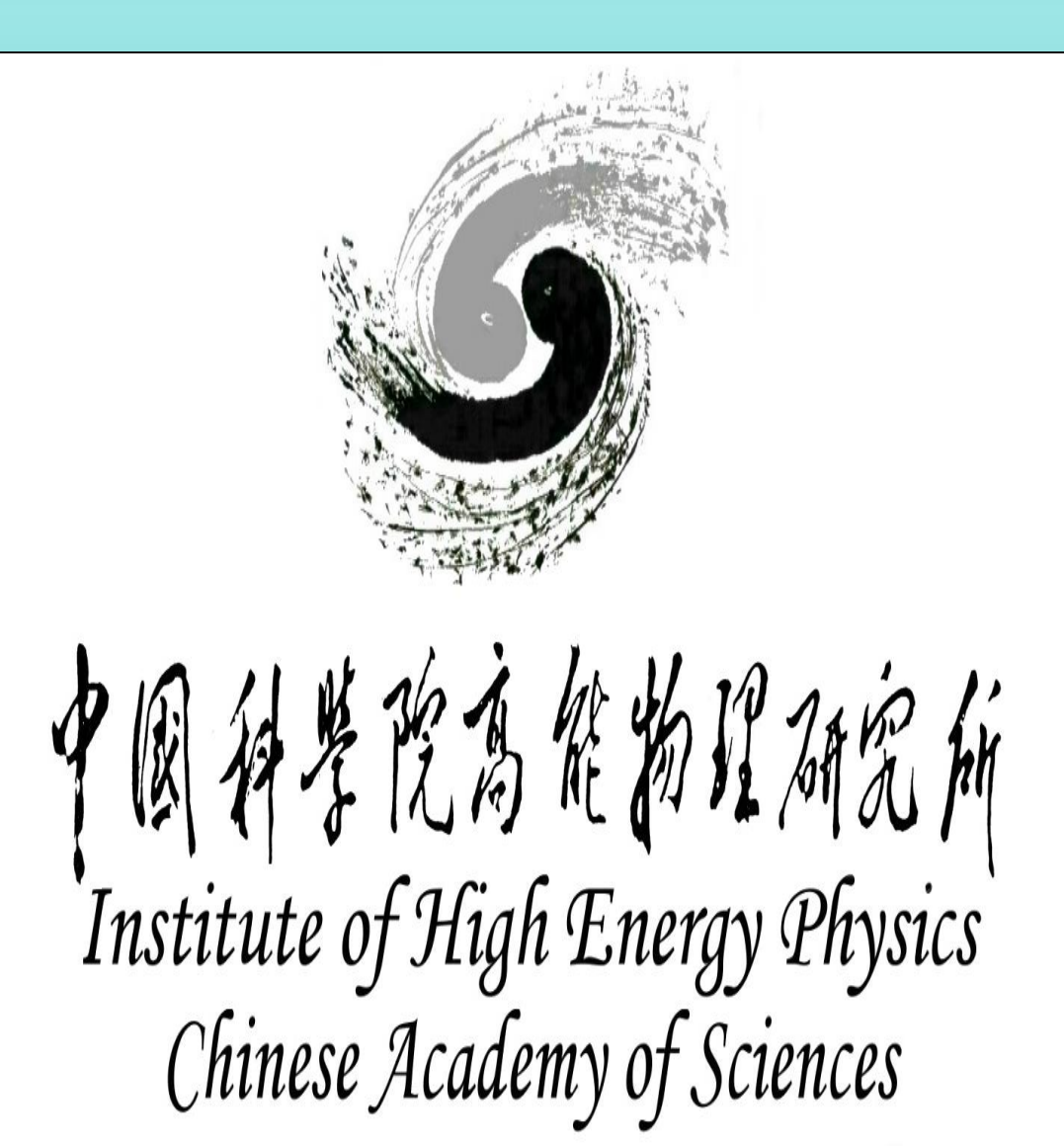


Topup injection in the collision operation of BEPCII and key technology

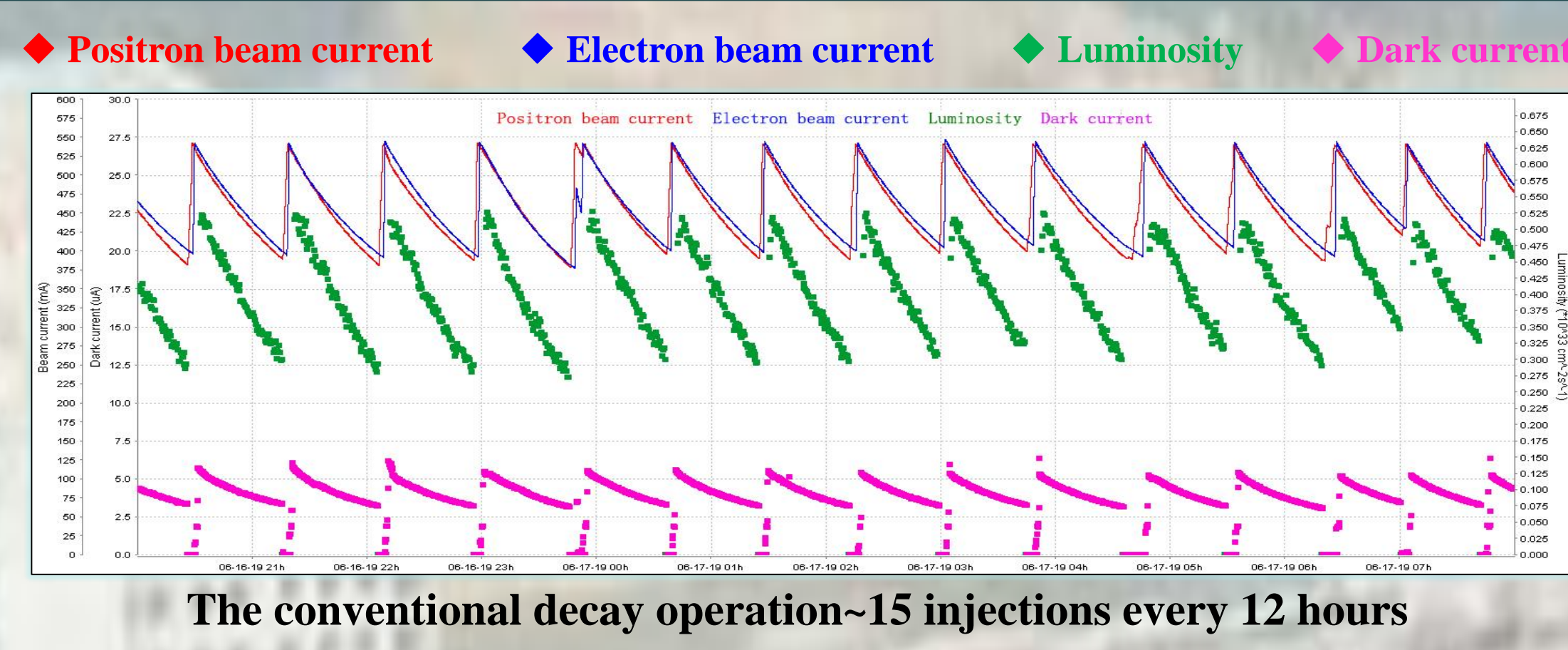
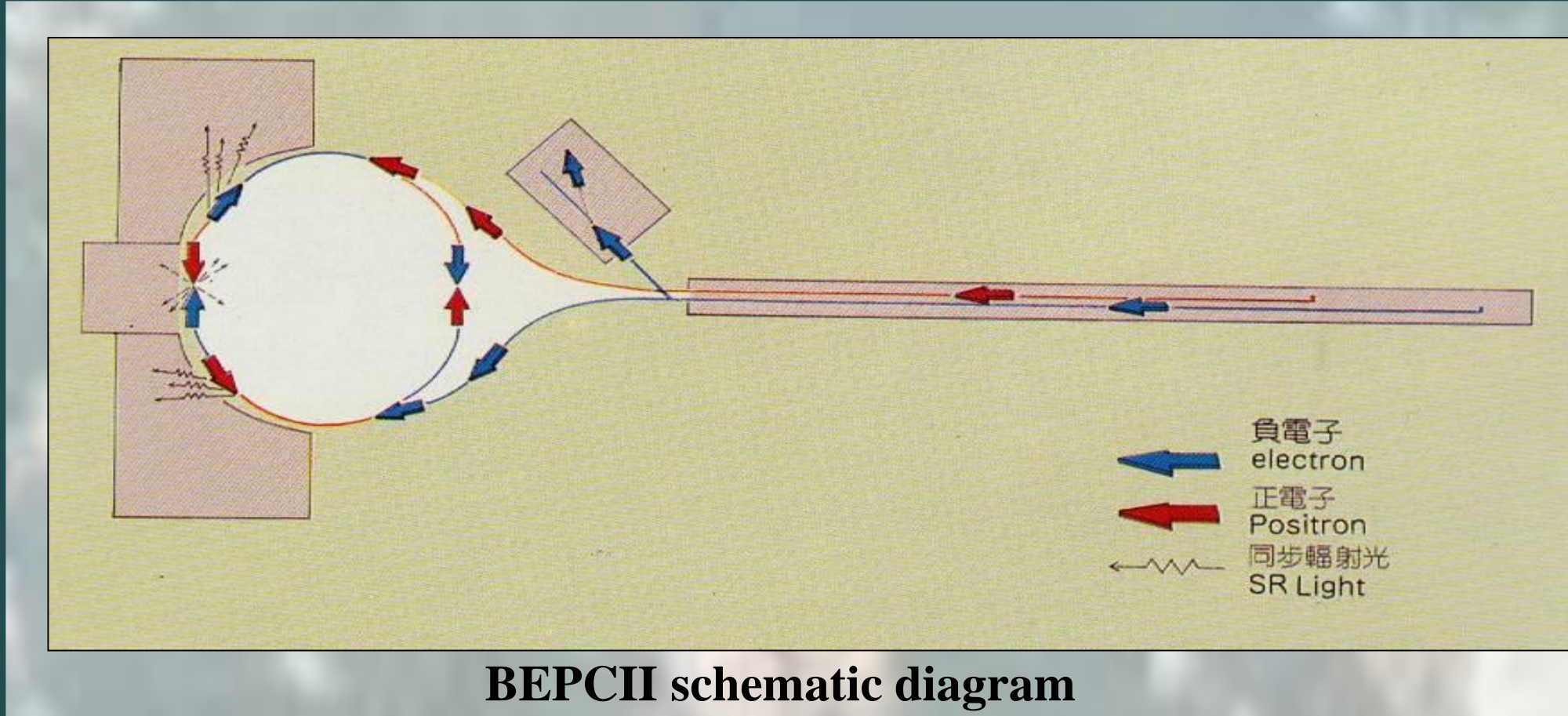
C.H. Yu, J.T.Liu, G.H.Chen



INTRODUCTION

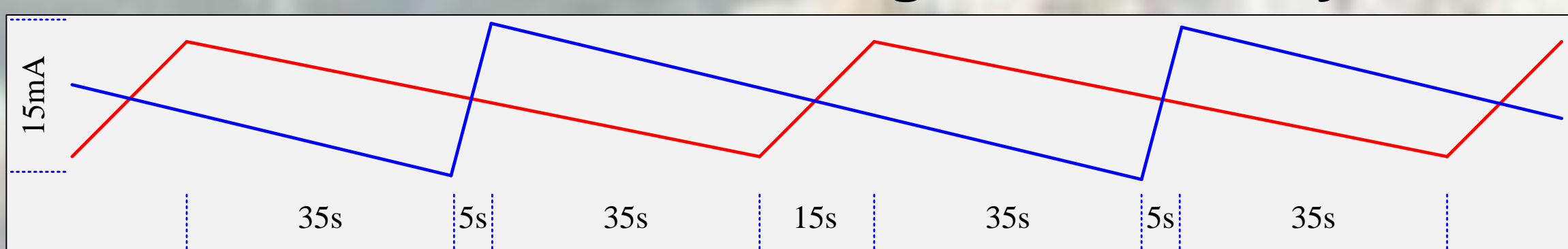
The BEPCII is designed as an e+/e- attenuating operational collider. In order to improve the BESIII data acquisition, BEPCII has carried out an upgrade project of topup injection operation of high-energy physics experiments. Based on the injection rate, injection interval, beam lifetime and luminance evolution of e+ and e-, the optimized data acquisition time can be calculated. The collision mode topup injection operation has been realized in 2019. The positron target is the core equipment to realize e+/e- beam switching. The positron target has been improved in the case that the positron source system is not expanded, the overall system performance index and operation function have reached the expected result.

Commissioning of topup operation



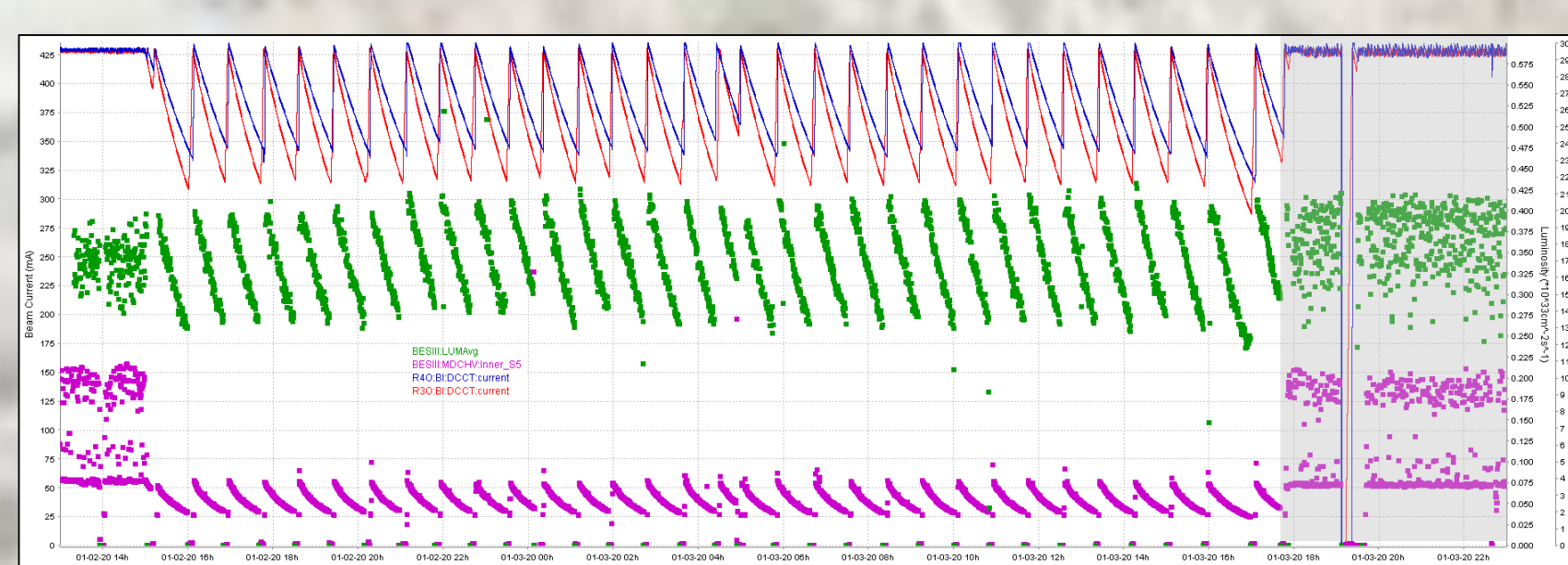
BEPCII is designed as decay operation collider. During the injection period of accelerator, the BESIII don't take data and the high voltage of detector keep 70% of normal setting in order to protect the detector. According to injection rate of e+ and e-, injection interval, beam lifetime and the luminosity evolution, the optimized data taking time can be calculated. How to improve the integral luminosity without major upgrade? We started topup operational study.

Topup upgrade was performed from beginning of 2018. The commissioning of topup operation began from May 7, 2019. The topup operation was realized with beam energy >2.2GeV & <600mA and integral luminosity can be 33% higher than decay operation.



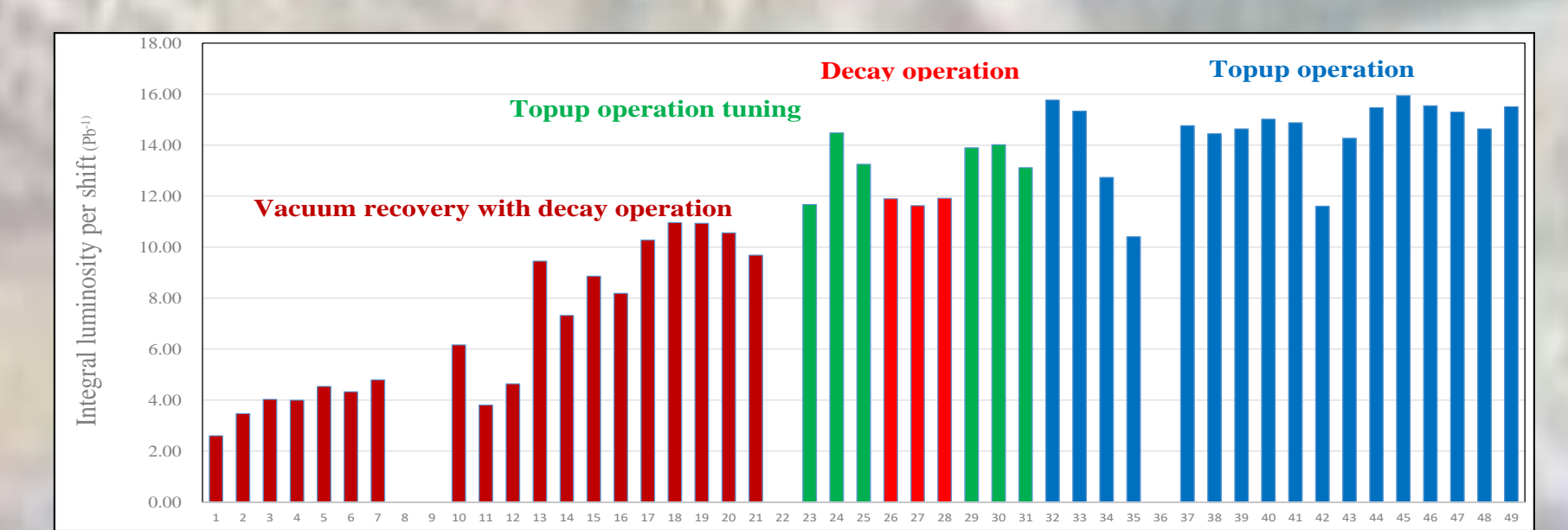
Beam lifetime is around 2 hours. e+ and e- must be filled up once every 90 seconds

- Remove the luminosity reduction during the injection.
- Keeping enough injection rate with collision conditions.
- Changing the interlock logic for the detector protection.
- Strictly control the lose particle hitting on the detector.
- Fully automated operation management program.



Comparison of integral luminosity

Topup / Decay
15.94 pb⁻¹ / 11.92 pb⁻¹
integral luminosity 33% higher



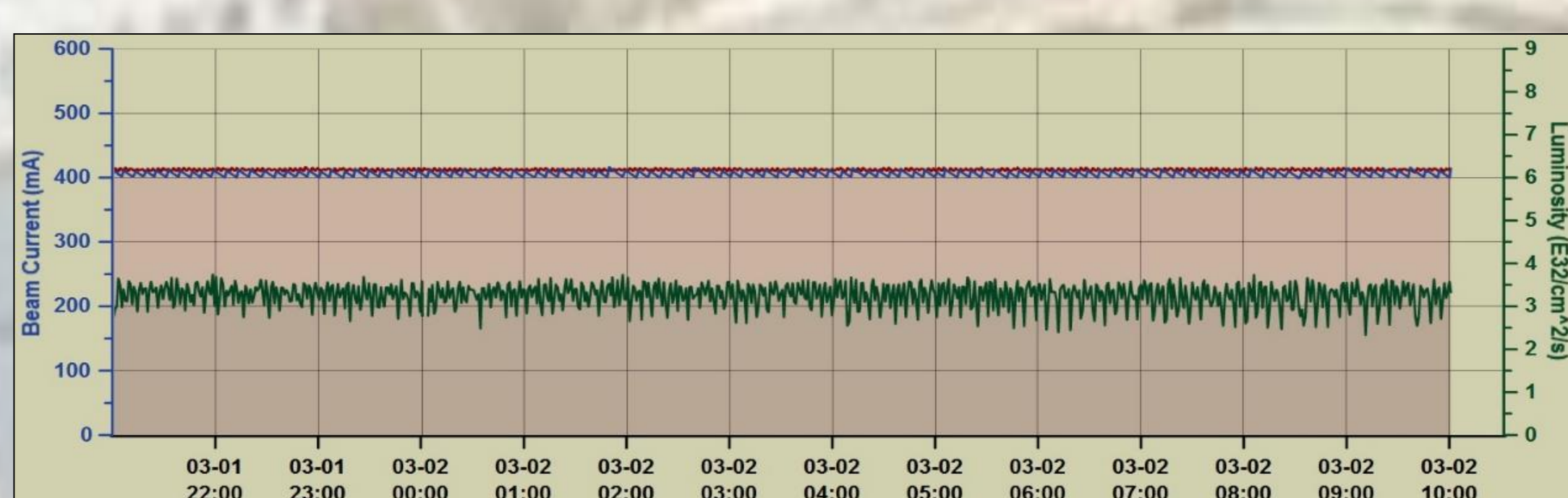
Commissioning of topup operation

- The commissioning of topup operation began on May 7, 2019.
- Integral luminosity can be improved obviously.

First commissioning of topup operation @ 2.2GeV

- The commissioning of topup operation began on May 7, 2019.
- Integral luminosity can be improved obviously.
- Timing shield for each injection plus is needed to avoid the noise data acquisition.

Topup 12 hours

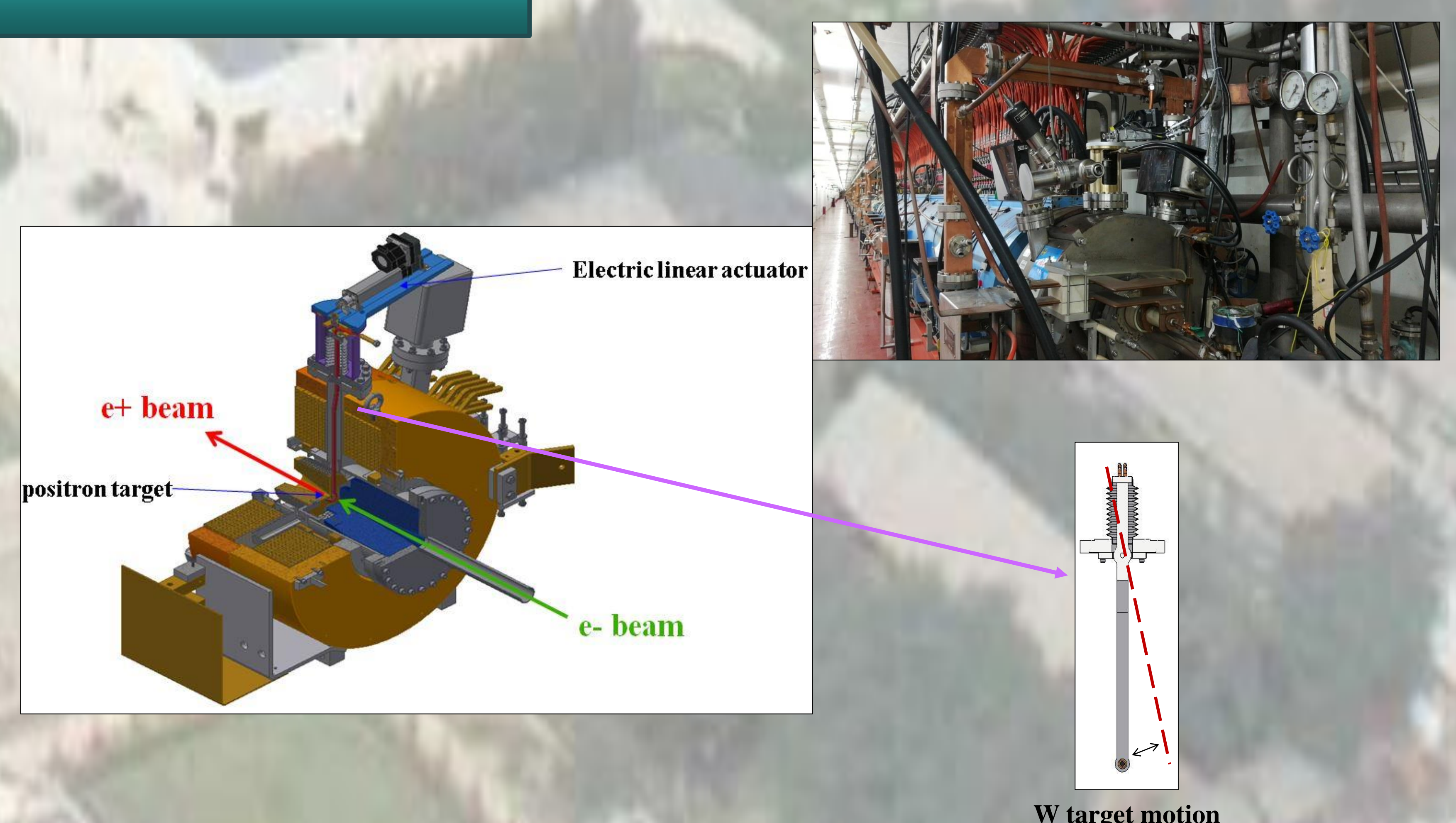


Topup operation at the energy 2.3GeV

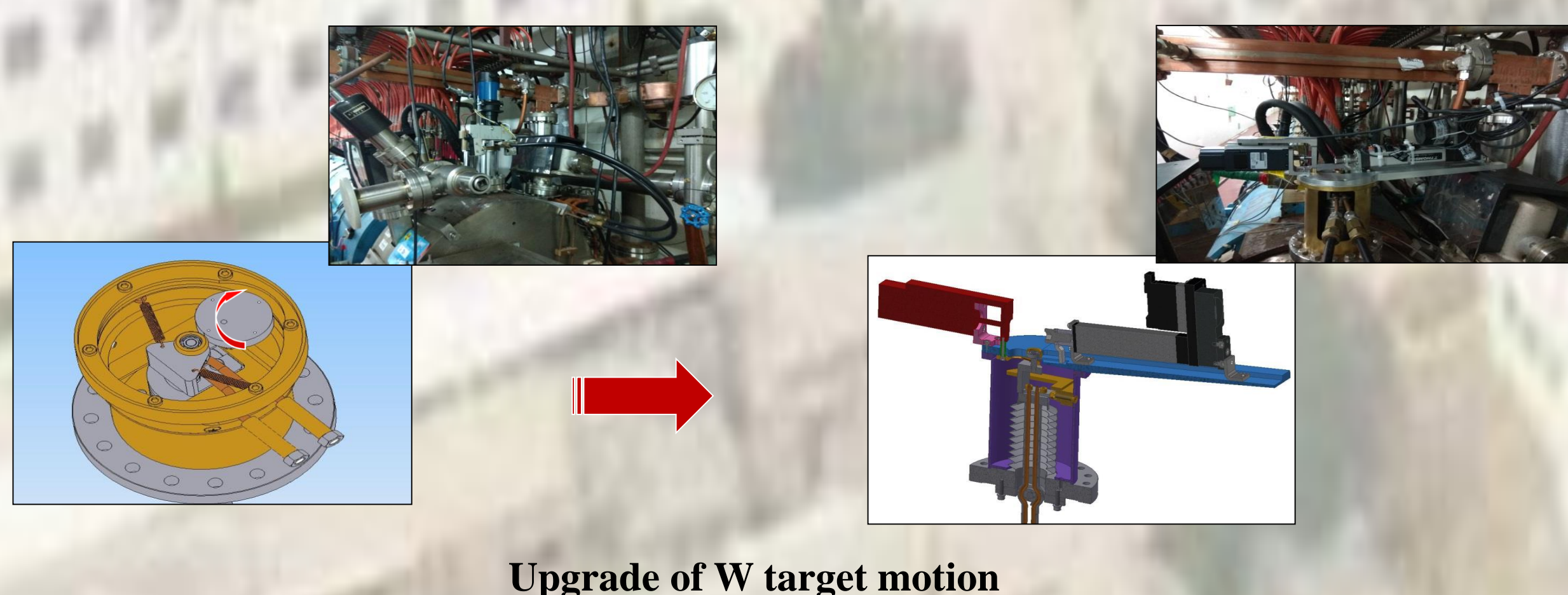
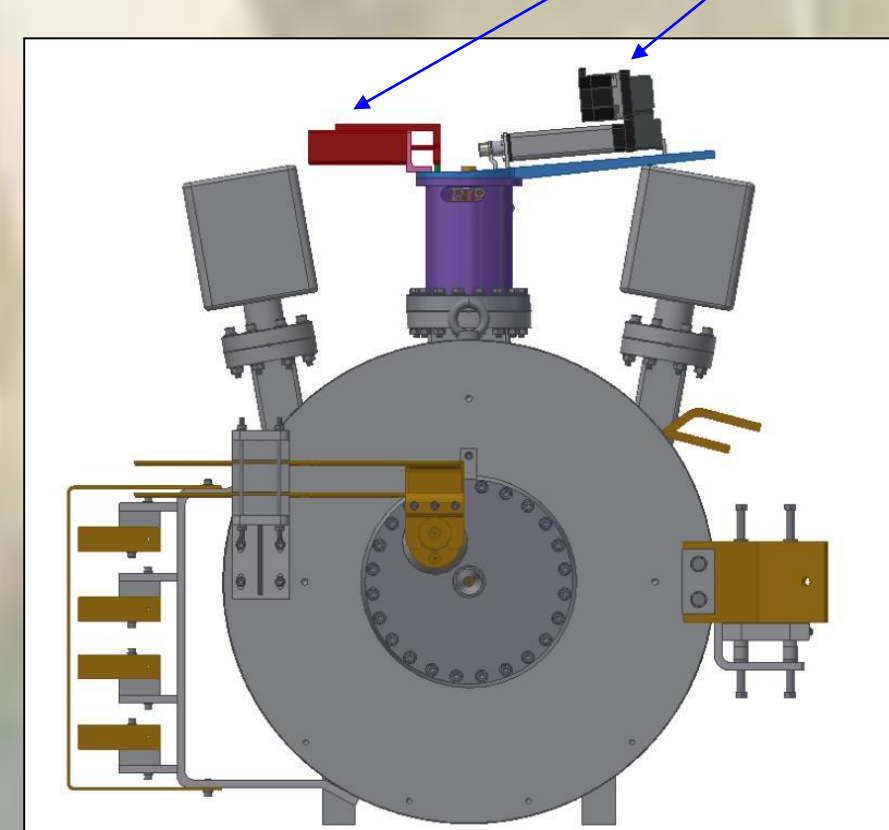
Since 2017, constant current operation of Beijing Electron Positron Collider has been improved. Through continuous efforts of various systems, several key technical difficulties have been overcome. On June 17, 2019 and December 3, 2019, constant current operation of collision mode, synchrotron radiation and test beam were respectively realized. The beam performance index and operation function have reached the expected target, and the subsequent improvement work is still advancing steadily. The stability degree, automation degree and integral brightness of constant current operation will be further improved. Dark current distortion mainly comes from injected beams and unstable feedback systems restrict commissioning of topup operation. The BEPCII collision energy and integral luminosity upgrade project will be implemented in 2024.

Upgrade of positron target actuator

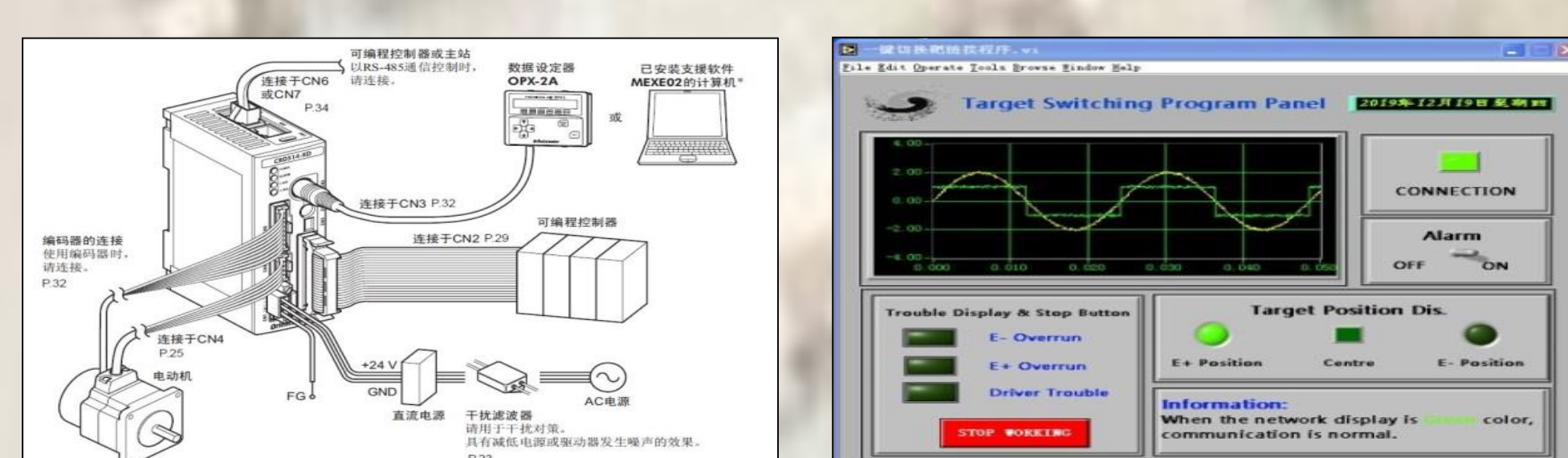
Positron targets are the core equipment for switching between positive and negative electron beams. The mechanical device that controls the movement of the target is designed to operate in a natural decay mode of current intensity, with a slow e+/e-switching time, and the service life of the actuator is about ten thousand times. According to the design, the actuator needs to be replaced once a year. However, if the constant current operation mode is adopted, the injection frequency will be increased from the current one hour to one minute, and the usage frequency of the positron target will be increased by 60 times. It is expected that the transmission device of the positron target will need to be replaced every three months. Moreover, constant current injection requires that the switching time of the positron target be less than 15 seconds, so this device can not meet the requirements of constant current operation, it is necessary to improve the positron target transmission device and a new motor structure is proposed to improve the switching speed, develop a new type of high-precision transmission device to increase its service life to a million times.



- The beam switching time is shortened from 12s to 3.5s
- The drive device is chosen as electric linear actuator for its high stability and reliability
- Adjust the position of W target and use precision actuator



Upgrade of W target motion



Control system display

BEPCII is a multi-purpose scientific device, including Beijing spectrometer, Beijing synchrotron radiation device and Beijing experimental beam. High energy physics experiments put forward higher and higher requirements for integral brightness. Now BEPCII has started to adopt constant current operation mode, which not only significantly improves the integral brightness of the collider, but also effectively improves the amount taking efficiency of BEPCII. Constant current operation has become the standard operation mode of modern ring accelerators. Positron target is the core equipment to realize the switching of positron beam, after two years of system improvement, it has been put into use stably and reliably, suitable for the needs of topup operation. In the last four operation years, there have been no failures.

Reference

Commissioning of the topup injection in the collision operation of BEPCII—C.H.Yu, BESIII Collaboration Meeting in Autumn of 2022, Sep.14, 2022.