Commissioning of the topup injection in the collision operation of BEPCII

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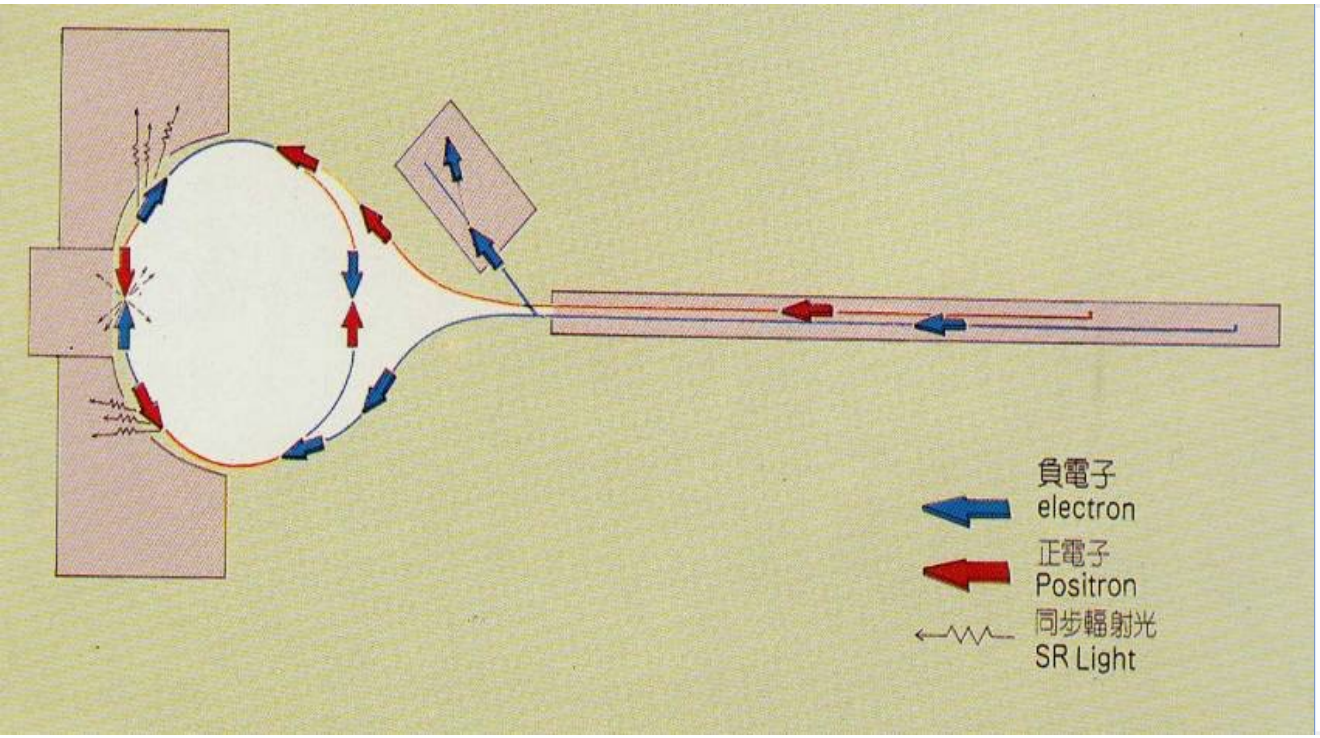
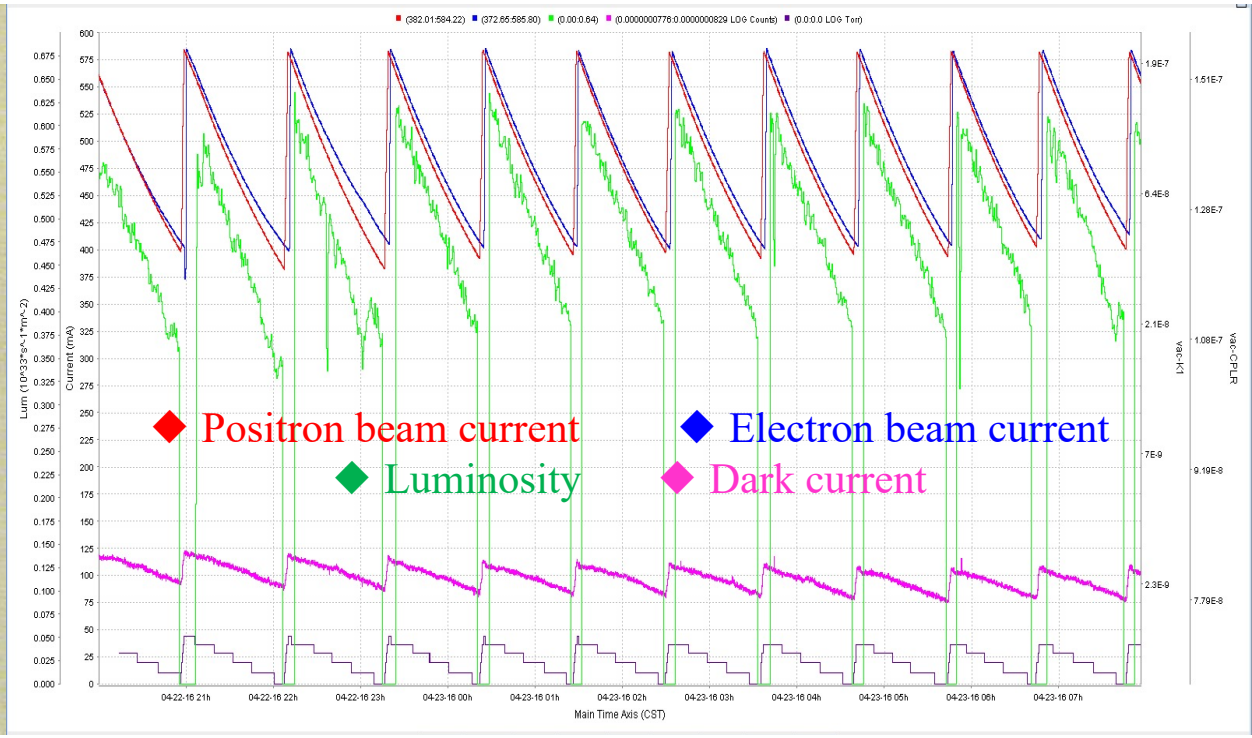
- Introduction
- Key technologies of topup upgrade
- Commissioning of topup operation
- Summary

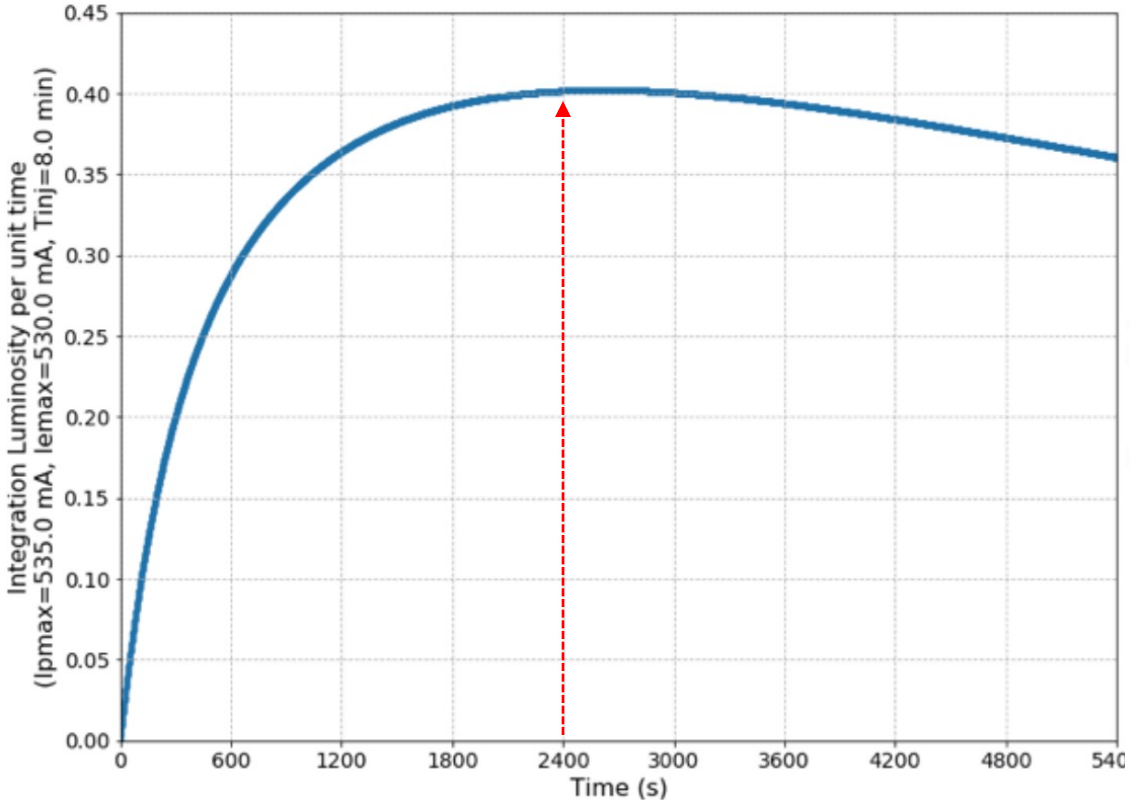
Introduction





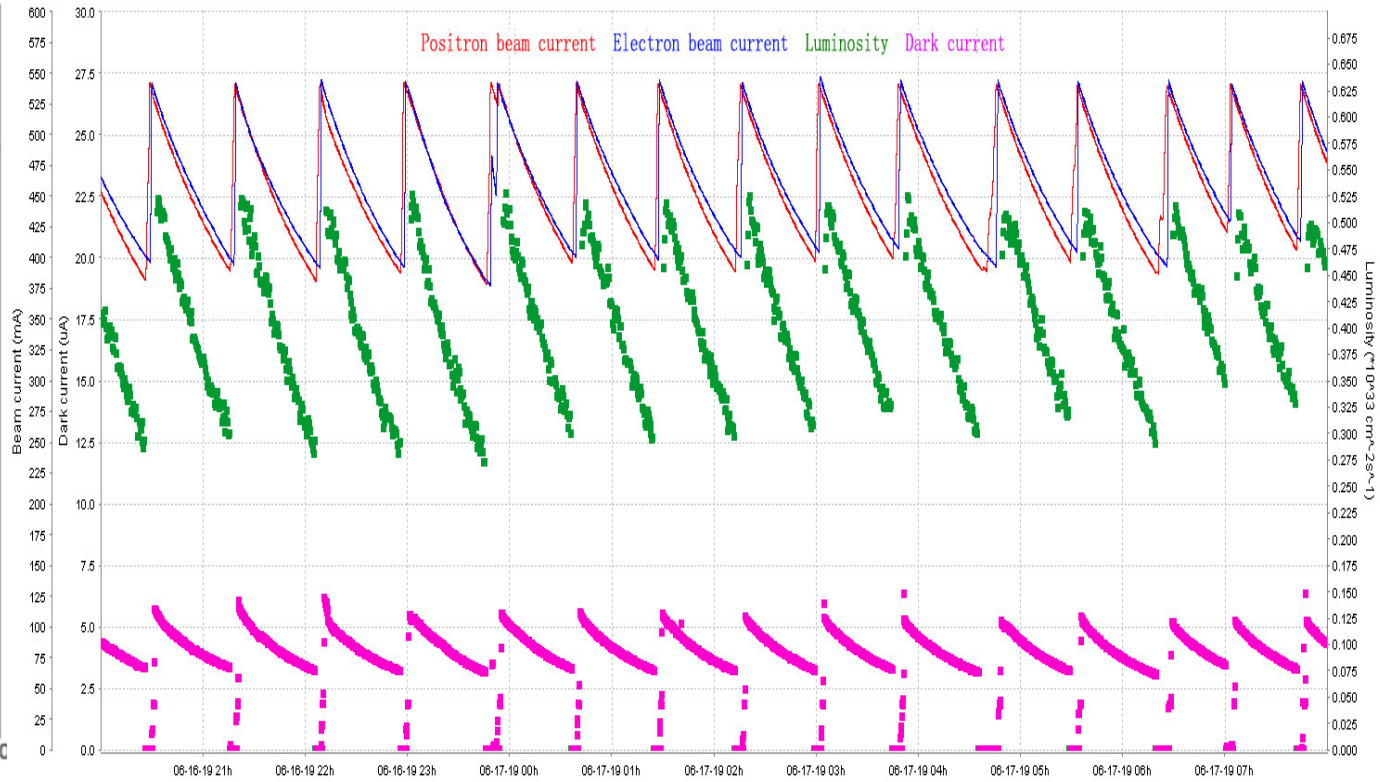
BEPCII is designed as decay operation collider. During the injection period of accelerator, the BESIII don't take data and the high voltage of detector keep 70% of normal setting in order to protect the detector.

Introduction



The optimized data taking time is 2400s

2400s+480s=2880s



The conventional decay operation
~15 injections every 12 hours

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? → Topup operation

Key technologies of topup upgrade

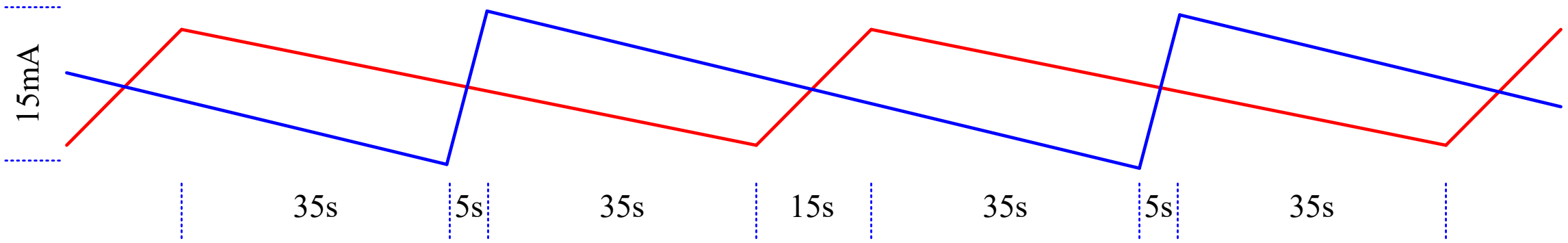
There is no damping ring in BEPCII. At the end of LINAC the beam emittance is 0.1mm·mrad（1σ）and energy spread is 0.5% which are not good parameters to control the lose particle during the transfer.

→ **Reduction of machine performance (Luminosity, background, radiation dose, injection time)**

→ **Challenge to the device aging and machine stability for the frequently injection.**

→ **Risk after changing the existing interlock (Operation process, device function, safety)**

Key technologies of topup upgrade



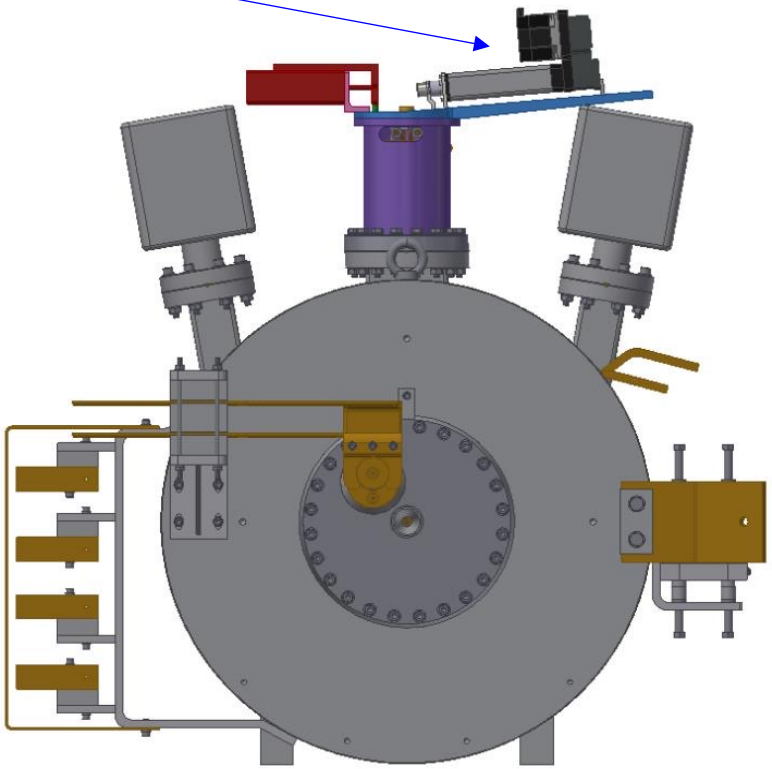
Beam lifetime is around 2 hours. e+ and e- must be filled up once every 90 seconds

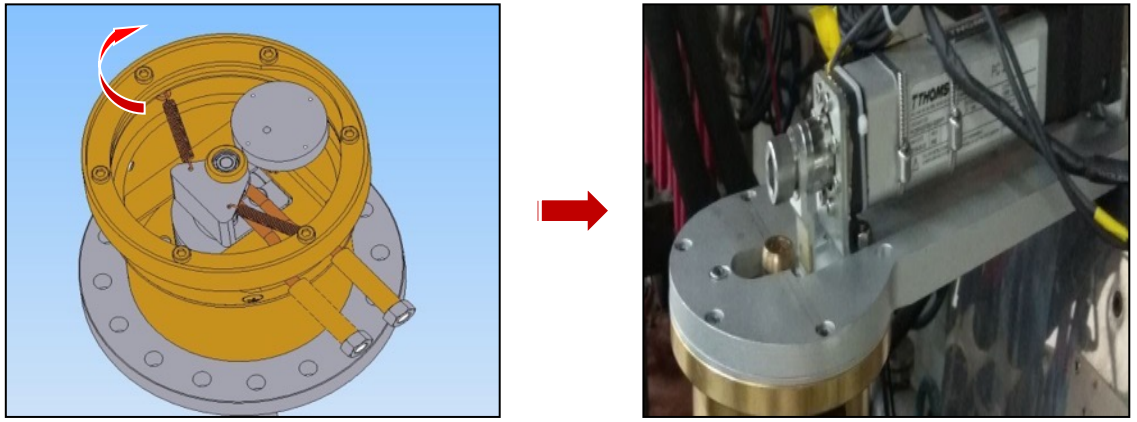
- Remove the luminosity reduction during the injection.
- Keeping enough injection rate with collision conditions.
- Changing the interlock logic for the detector protection.
- Strictly control the lose particle hitting on the detector.
- Fully automated operation management program.

Key technologies of topup upgrade

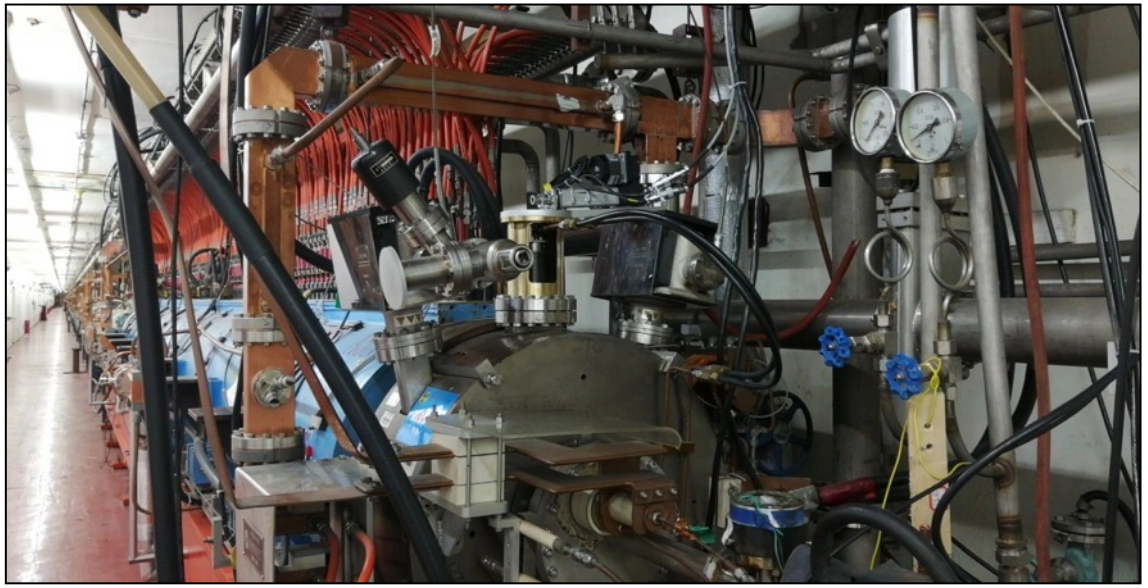
Upgrade of positron source

- 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



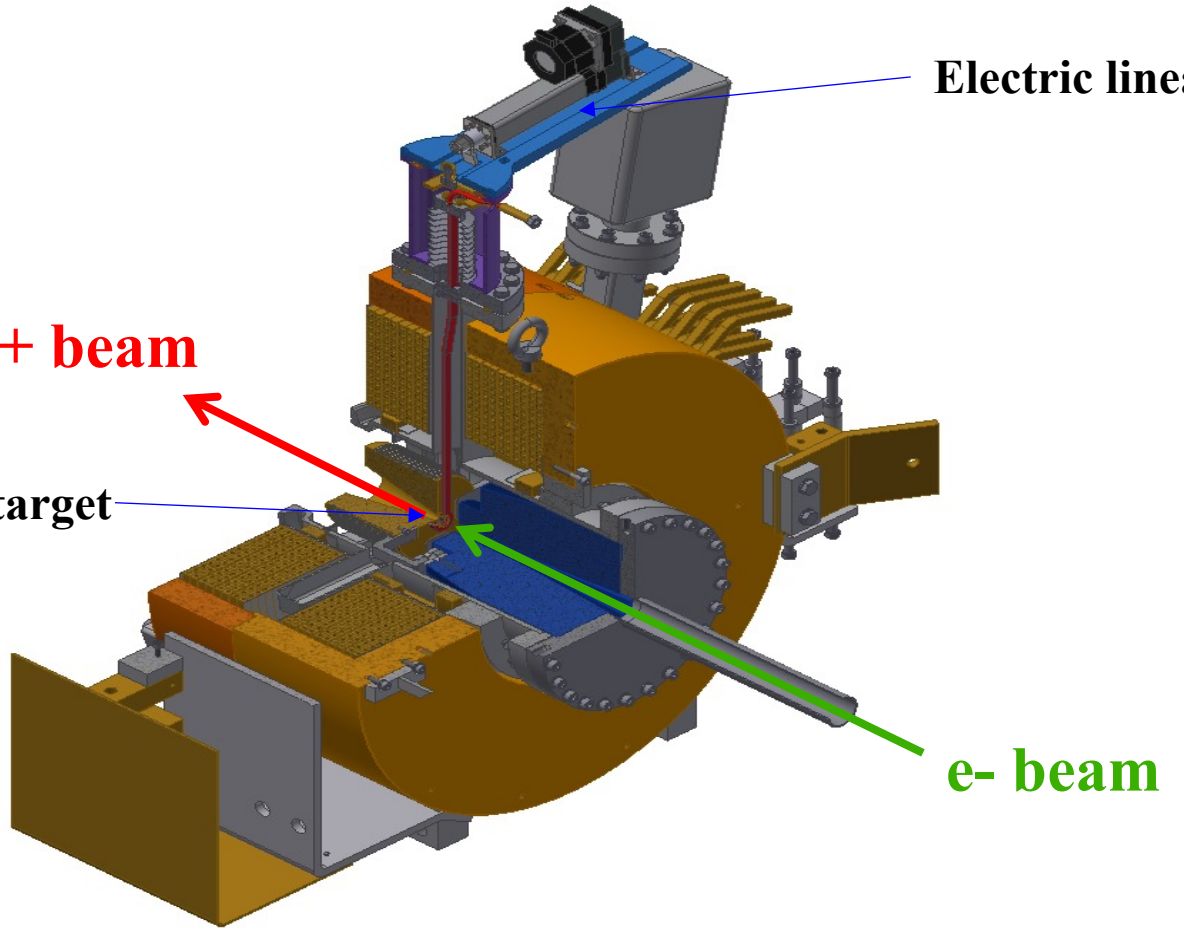


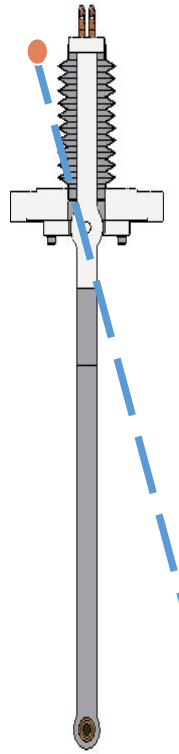
Upgrade of W target motion



Key technologies of topup upgrade

Upgrade of positron source

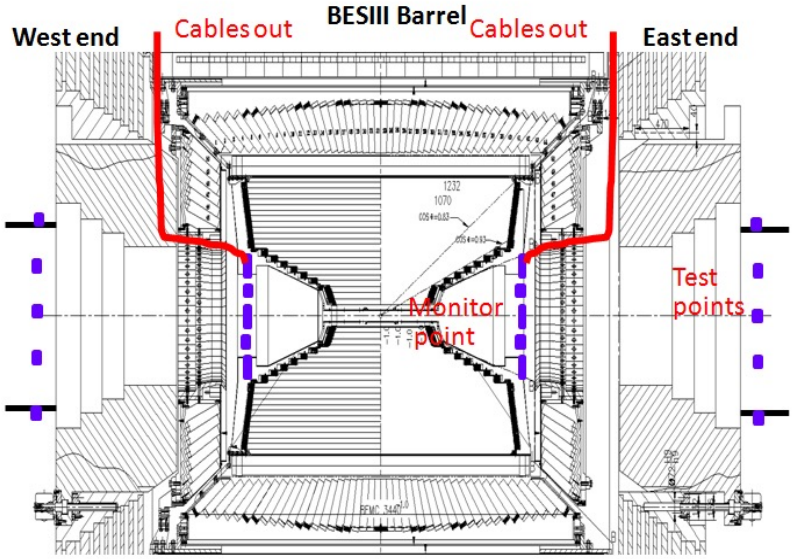


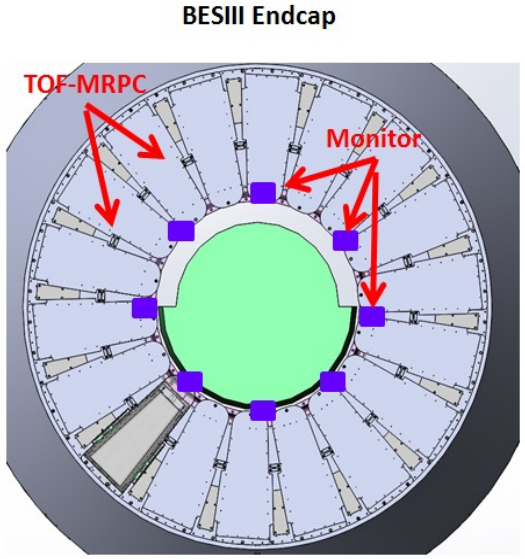


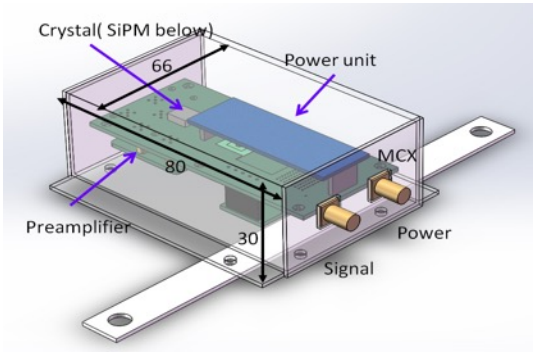
W target motion

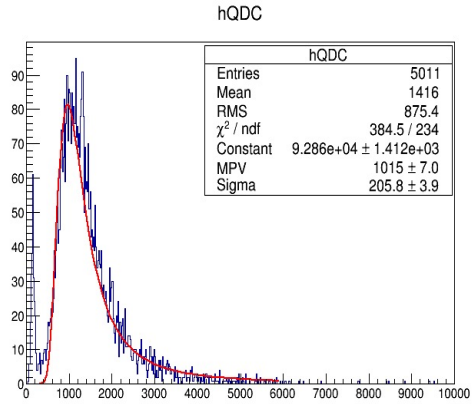
Key technologies of topup upgrade

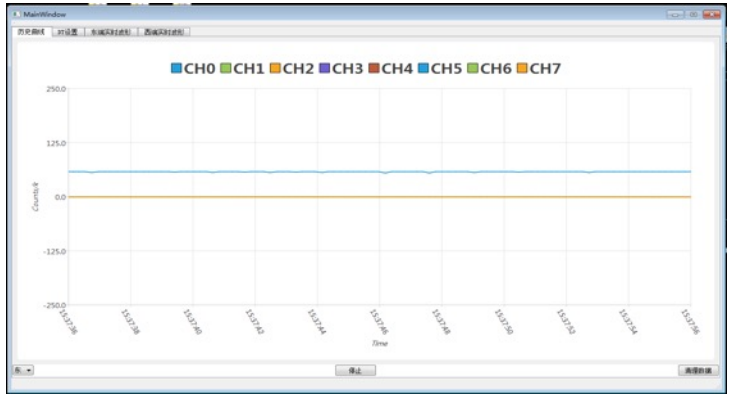
Lose particle detectors around the BESIII

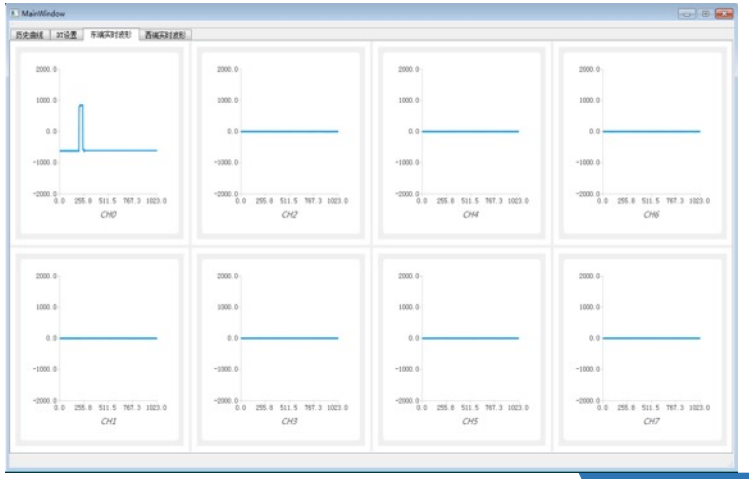








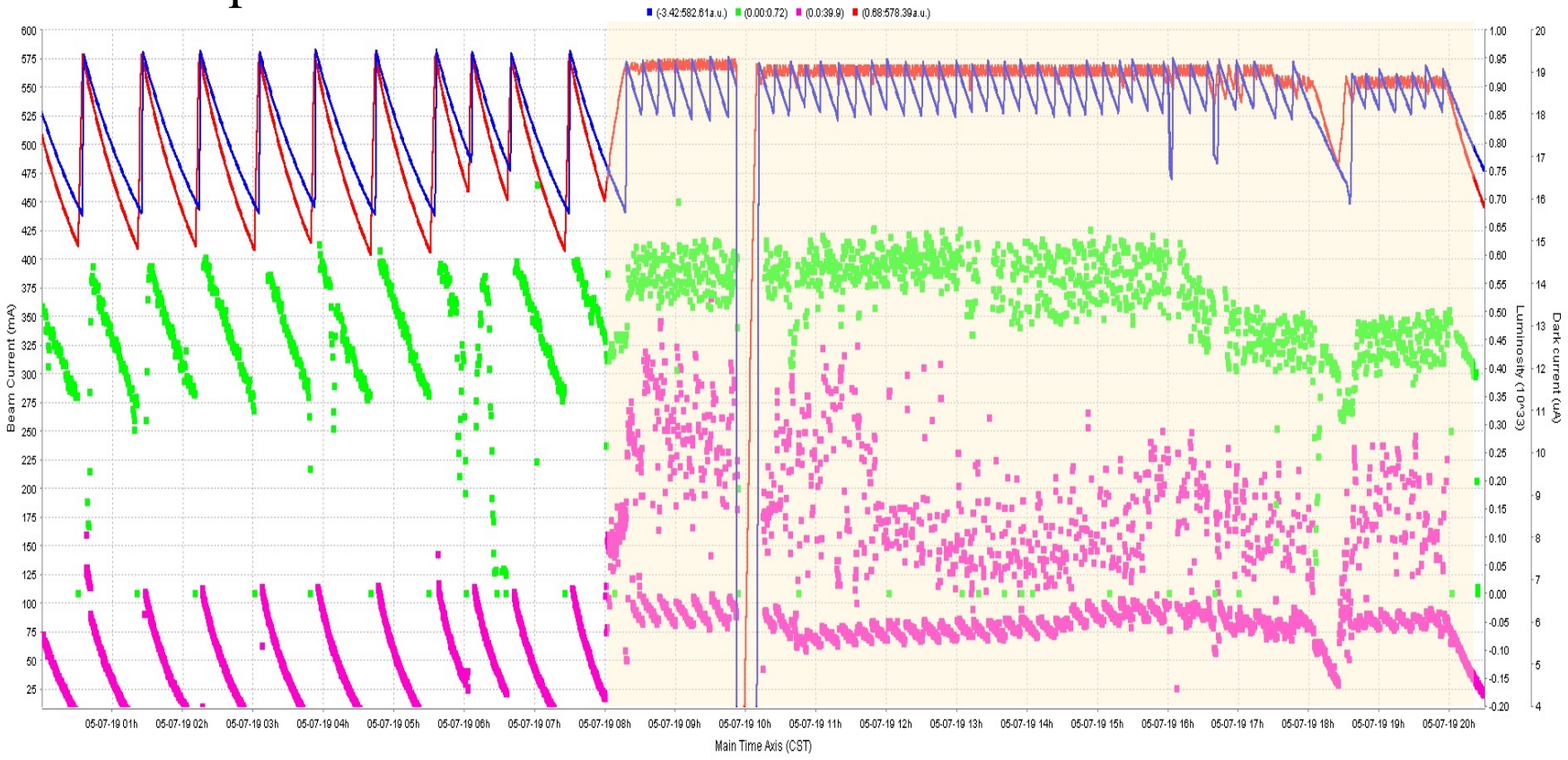


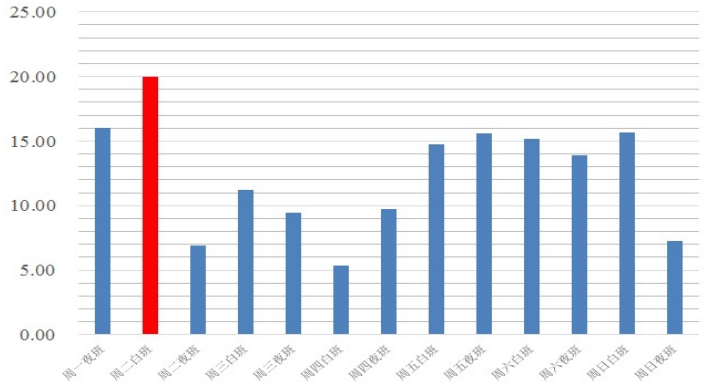


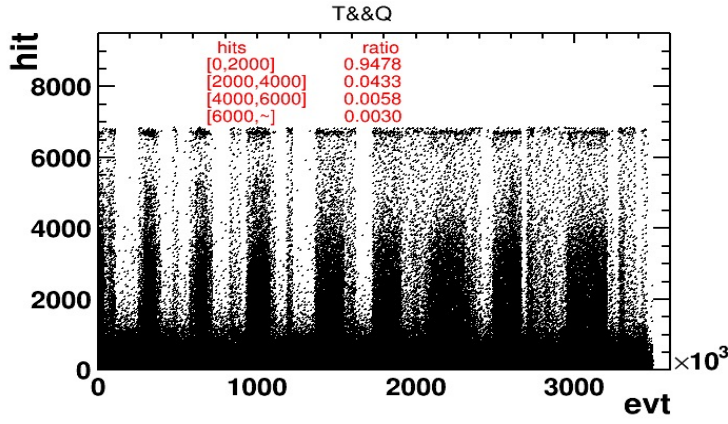
The dark current must be less than 15μA

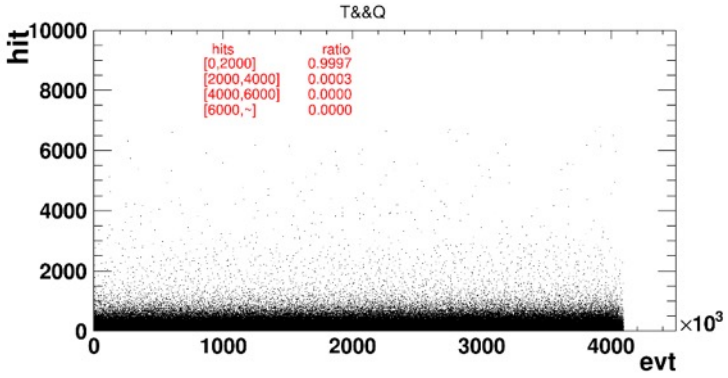
Commissioning of topup operation

- 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.





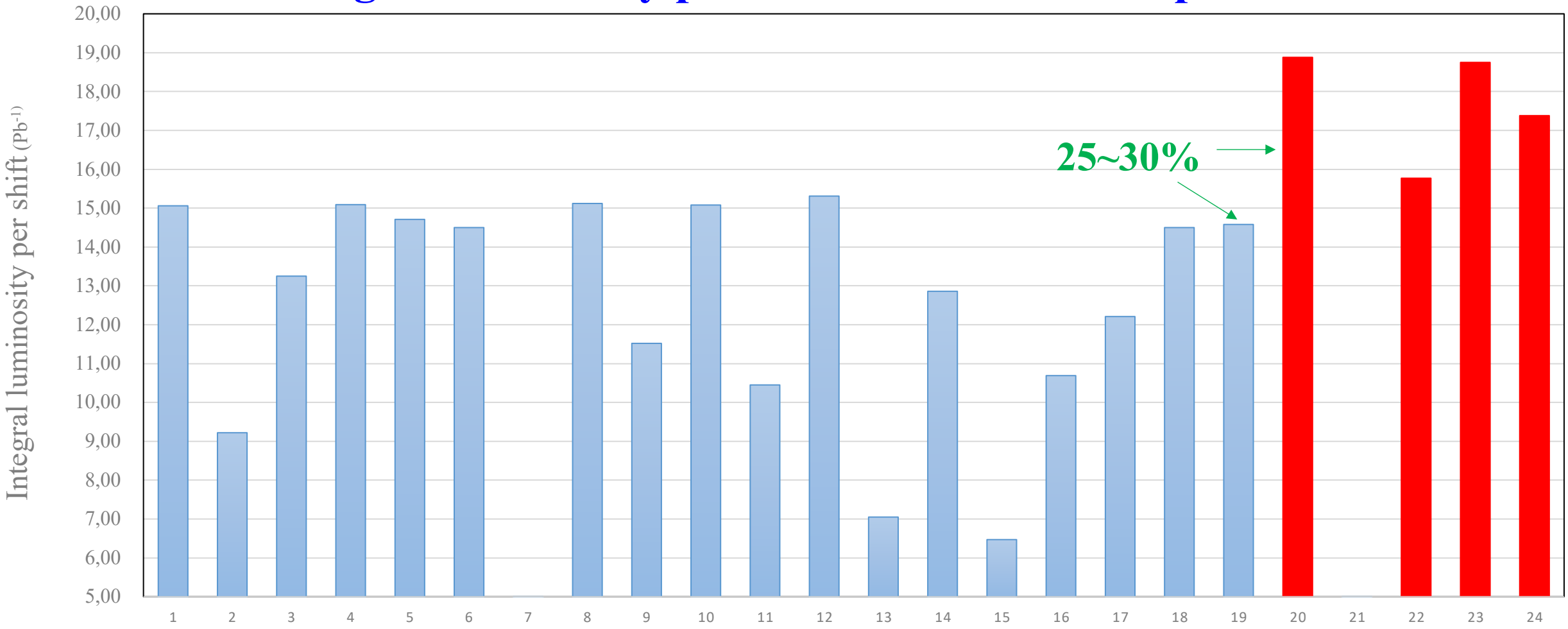




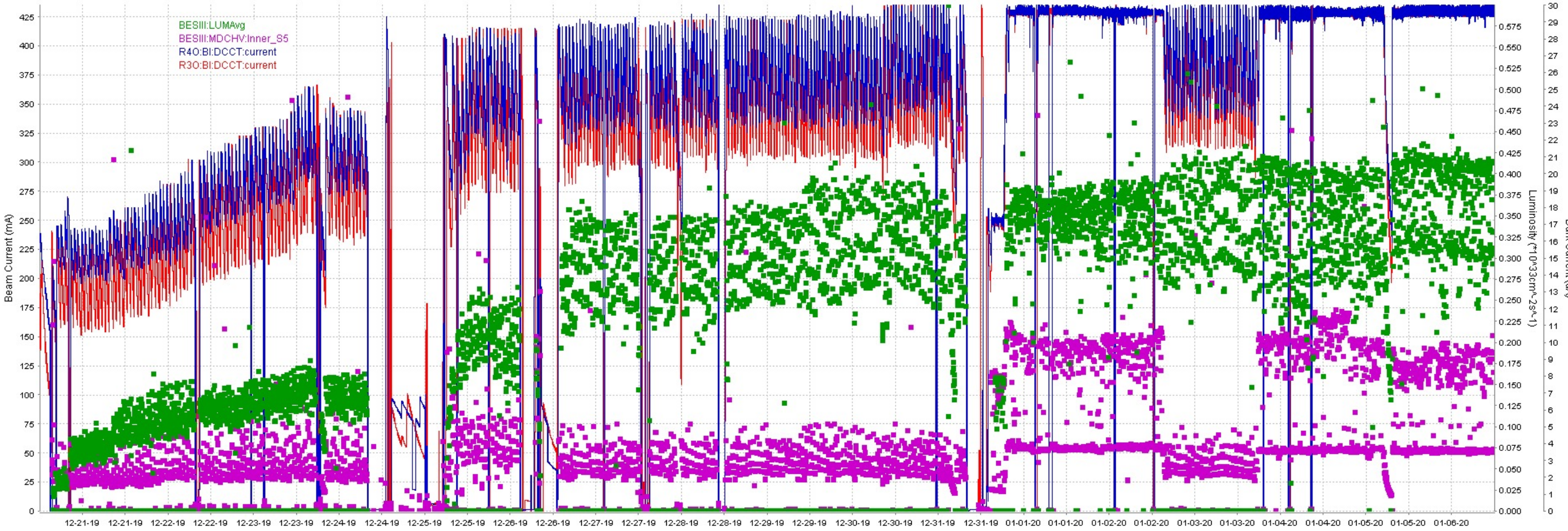
First commissioning of topup operation @ **2.2GeV**

Commissioning of topup operation

Statistic of integral luminosity per shift with different operation modes



Commissioning of topup operation



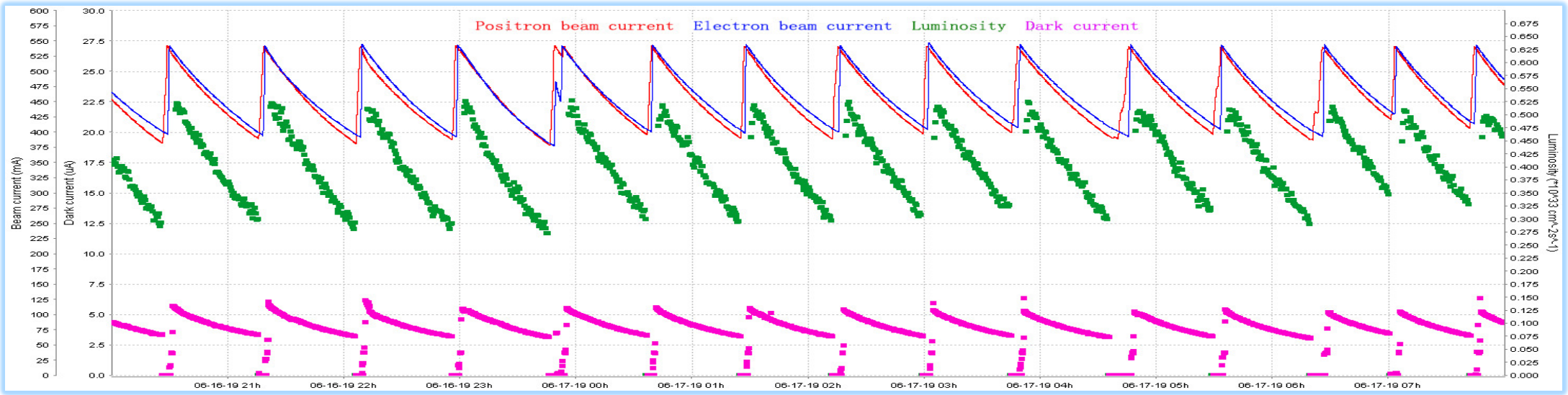
◆ Positron beam current ◆ Electron beam current ◆ Luminosity ◆ Dark current

- Timing setting to shield the noise data acquisition is 12ms for each injection plus. If beam is stable it could be 8ms
- The injection repetition is selected as 16.67Hz (Plus interval is 60ms) to control **the dark current**.
- **12ms/60ms = 20% luminosity reduction** during the injection.

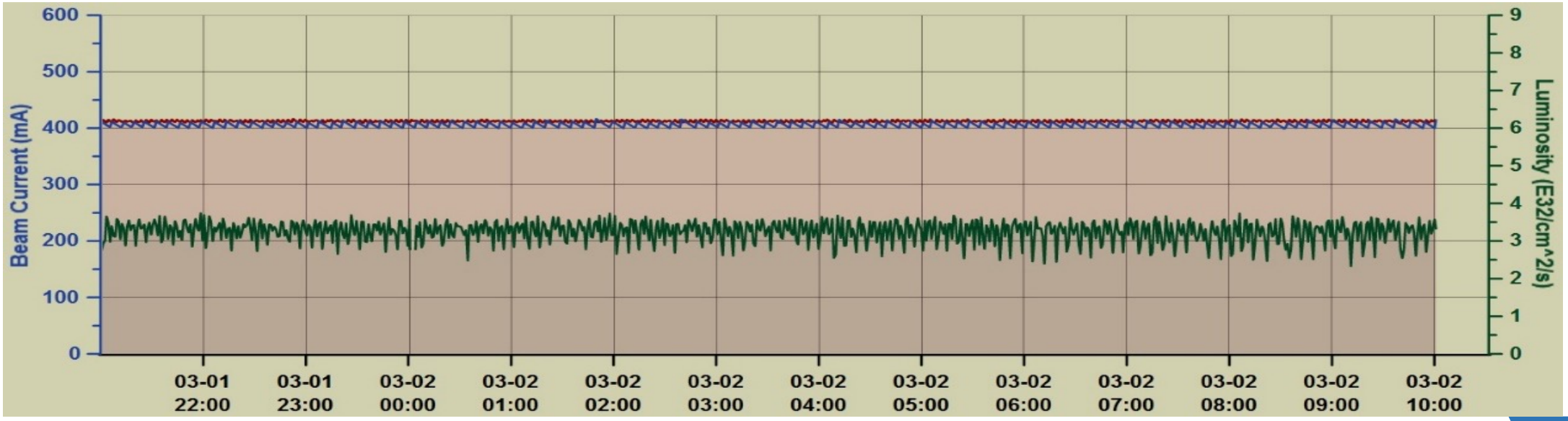
Topup operation at the energy 2.3GeV

Commissioning of topup operation

Decay 12 hours

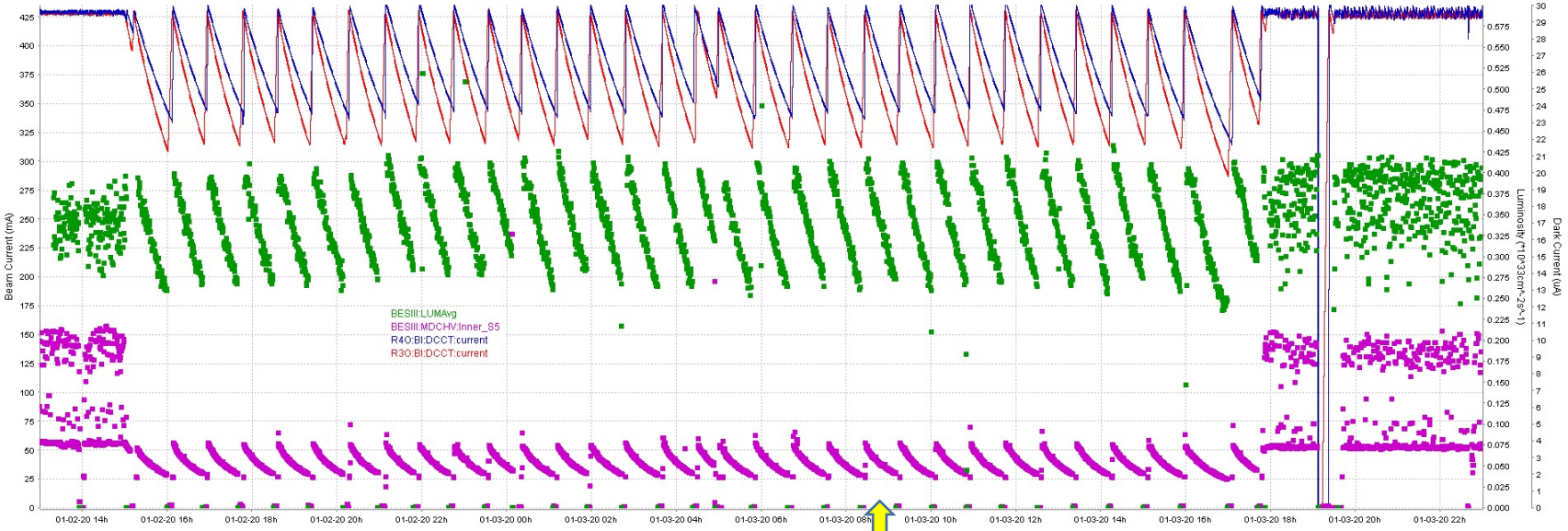


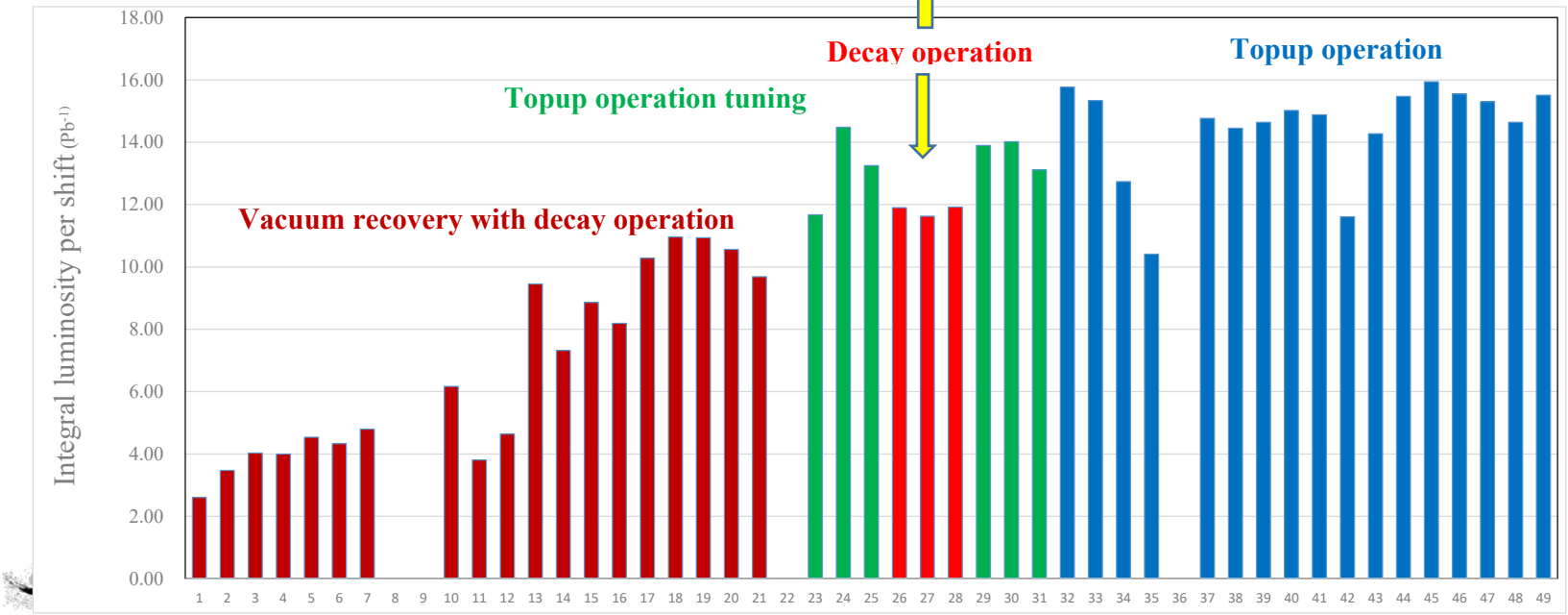
Topup 12 hours



Topup operation at the energy 2.3GeV

Commissioning of topup operation





Comparison of integral luminosity

Topup / Decay

15.94 pb^{-1} / 11.92 pb^{-1}

integral luminosity 33% higher

Commissioning of topup operation

We found a strange beam loss signal with frequency of 50Hz from Mar.19, 2020.

12ms/60ms = 20% luminosity reduction during the injection

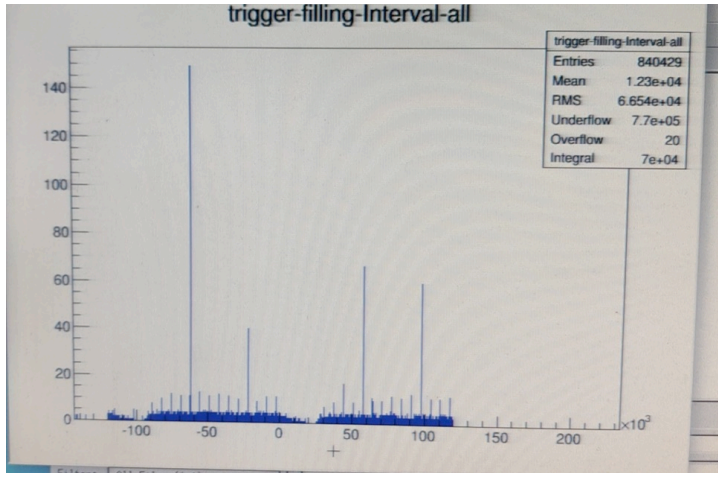
Before Mar.19

8ms/20ms = 40% luminosity reduction during the injection

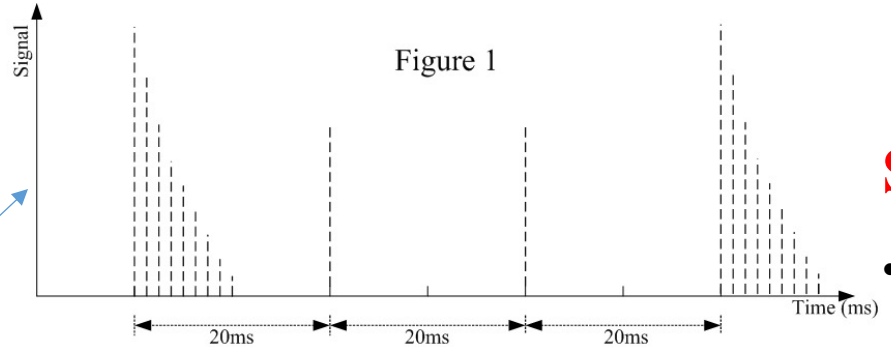
After Mar.20

→ 5% integral luminosity loss

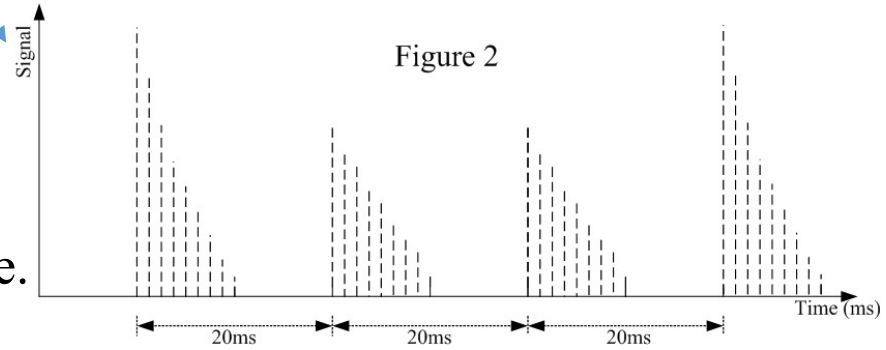
TauX / TauY / TauZ=13ms / 13ms /7ms @ 2.3GeV



Strange 50Hz noise signal



Caused by electromagnetic interference



Caused by injected beam

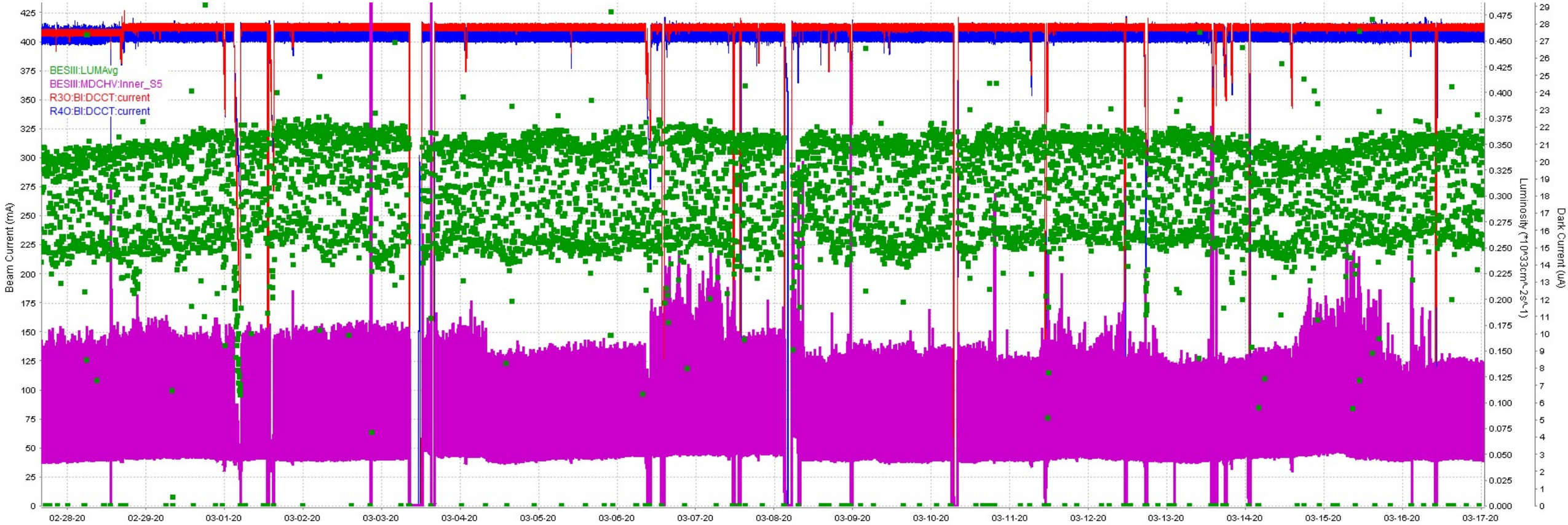
Solutions:

- Find the source and remove it
- Adopt 50Hz injection instead of 50Hz/3 with low dark current.

- Lots of dedicated studies have been done.
- Still not clear.

Commissioning of topup operation

Topup operation at the energy 2.3GeV

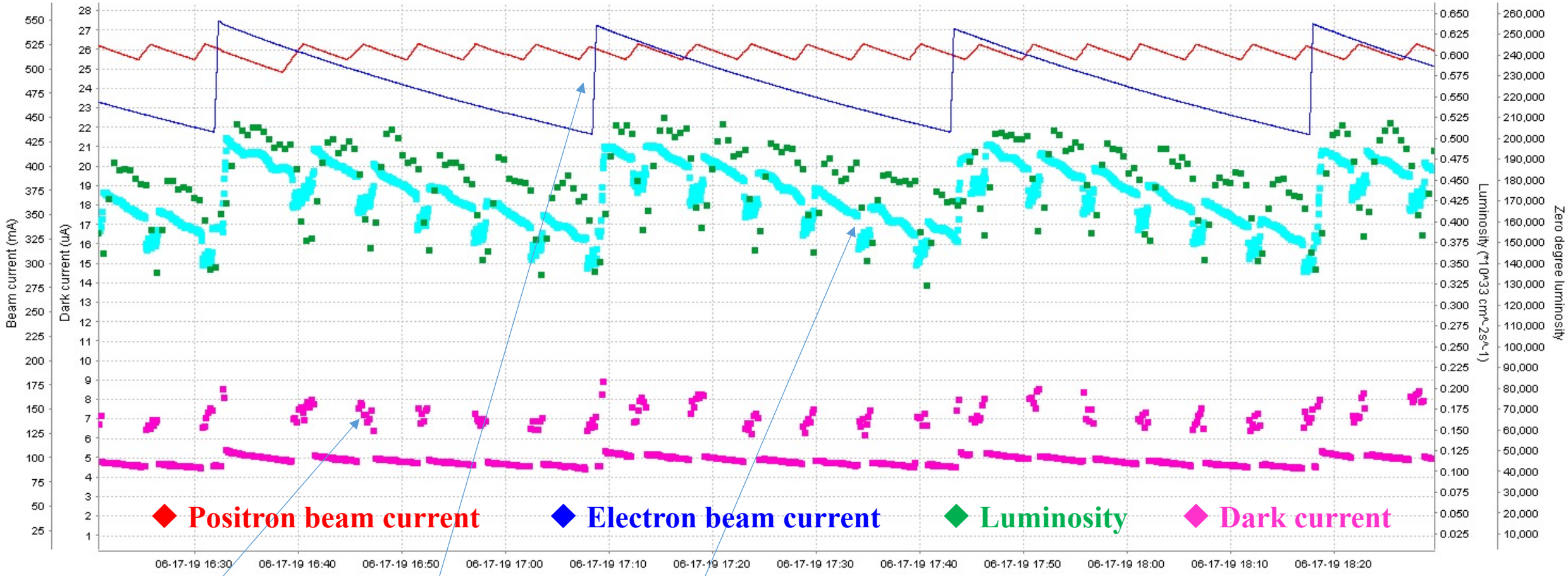


◆ Positron beam current ◆ Electron beam current ◆ Luminosity ◆ Dark current

3Weeks from Feb. 27 to Mar. 17, 2020

Commissioning of topup operation

Topup operation at the energy 2.3GeV

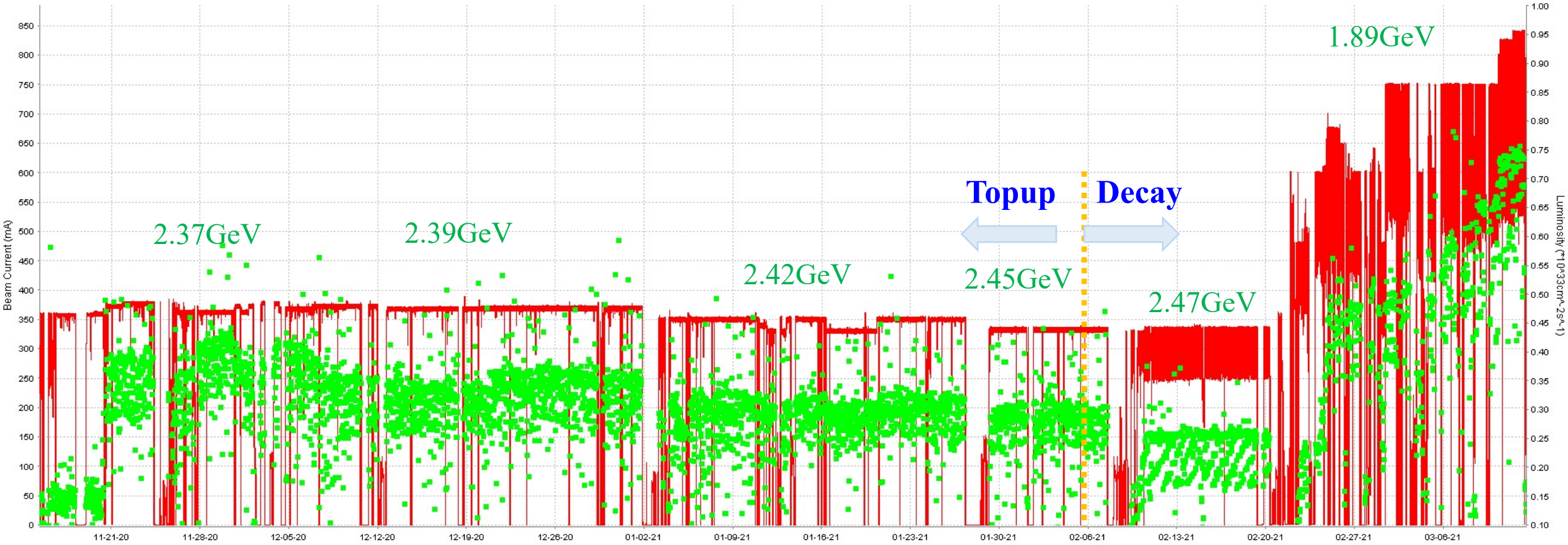


- Timing shield of data acquisition and residual oscillation cause 20% luminosity reduction during the injection.
- The dark current distortion is mainly from injected beam.

Commissioning of topup operation

Topup operation tuning at the energy 1.9GeV

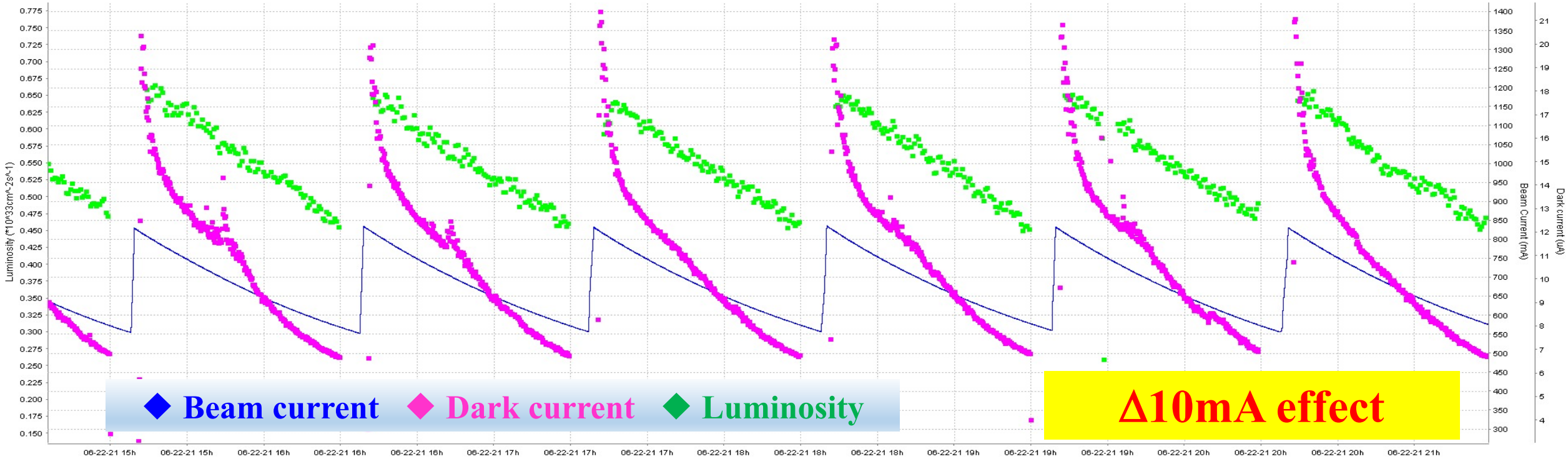
The lose particles from both circulating and injected beams are the constraints of topup operation



Commissioning of topup operation

Topup operation tuning at the energy 1.9GeV

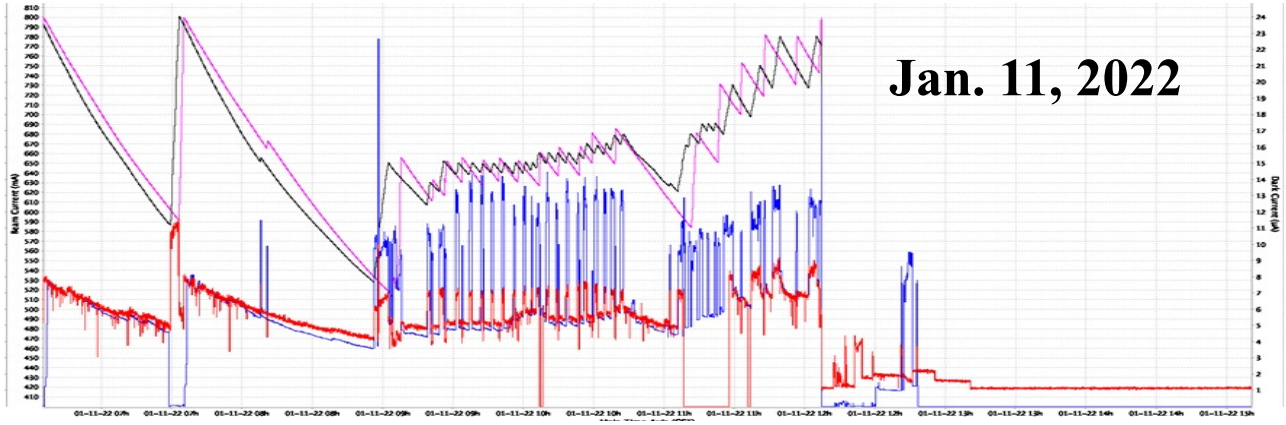
Dark current is the strong restriction for the high beam performance, especially at energy of 1.9 GeV with 900mA

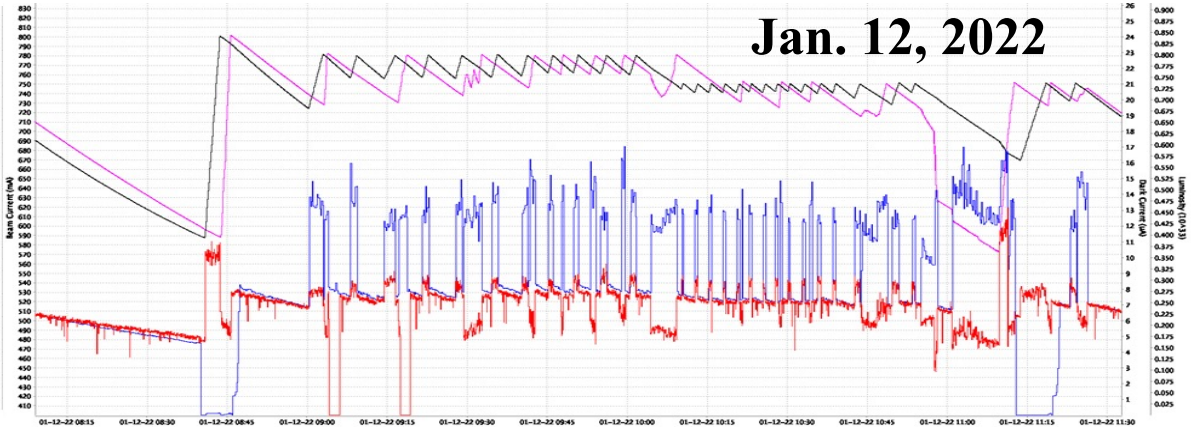


Mainly contributed by circulating beams. Beam-beam limitation? Unstable feedback system?

Commissioning of topup operation

Topup operation tuning at the energy 1.9GeV

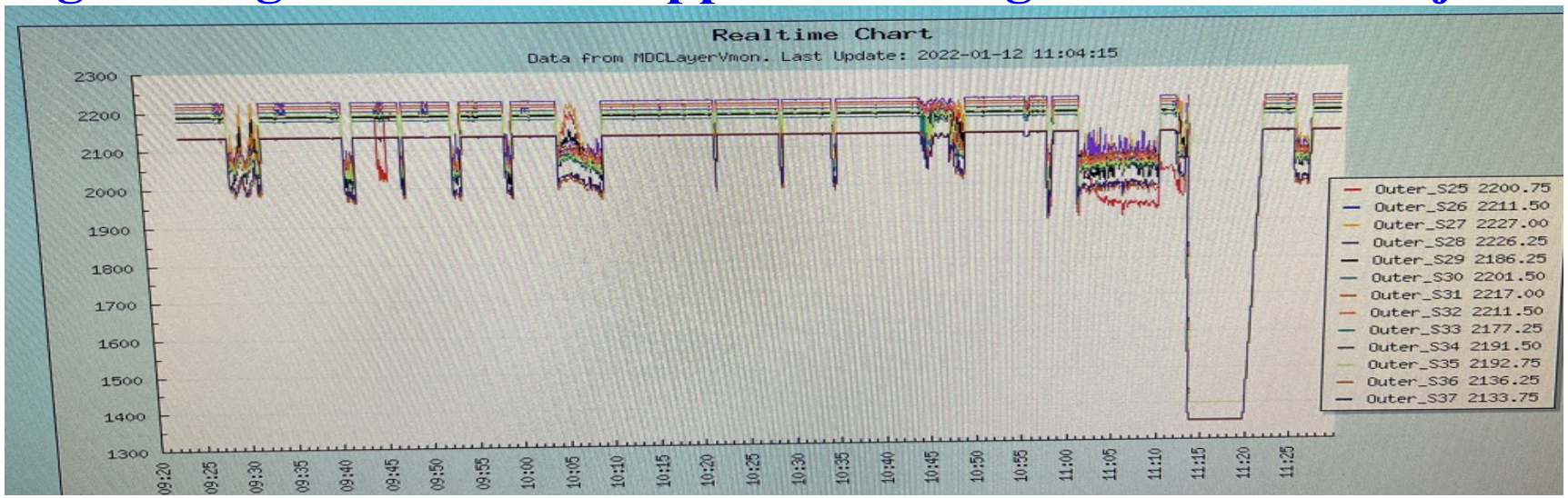




The dark current was controlled by collimators.

But the high voltage of BESIII dropped following each e- beam injection plus.

2×800mA



Summary

- 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 (TauX, TauY=16ms) and integral luminosity can be 33% higher than decay operation.
- The topup operation at beam energy 1.9GeV & 900mA (TauX, TauY=25ms) is still under tuning. The lose particles from both circulating beam and injected beam are the main constraints.