

The Diagnosis of Event Timing System in SuperKEKB Linac

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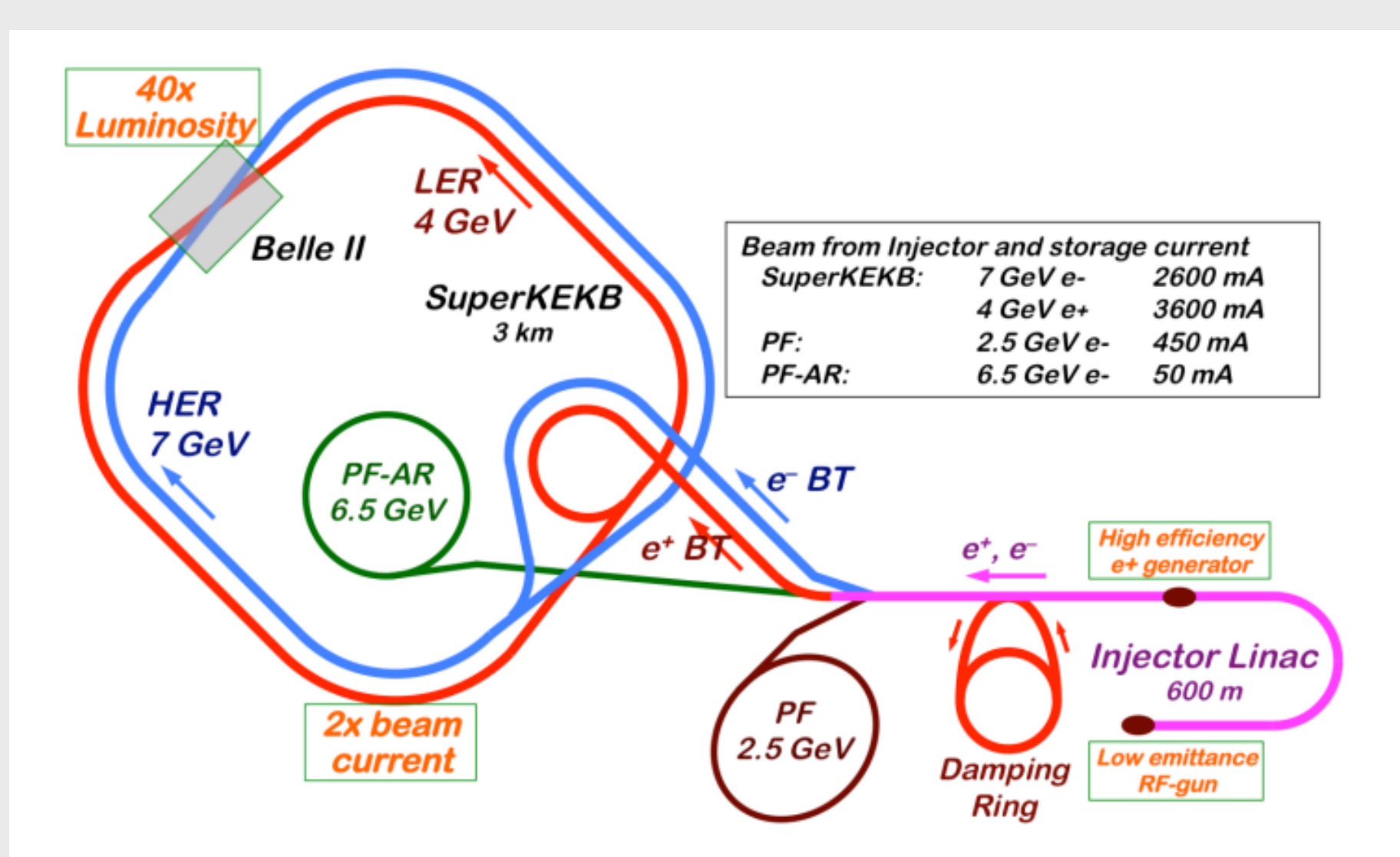
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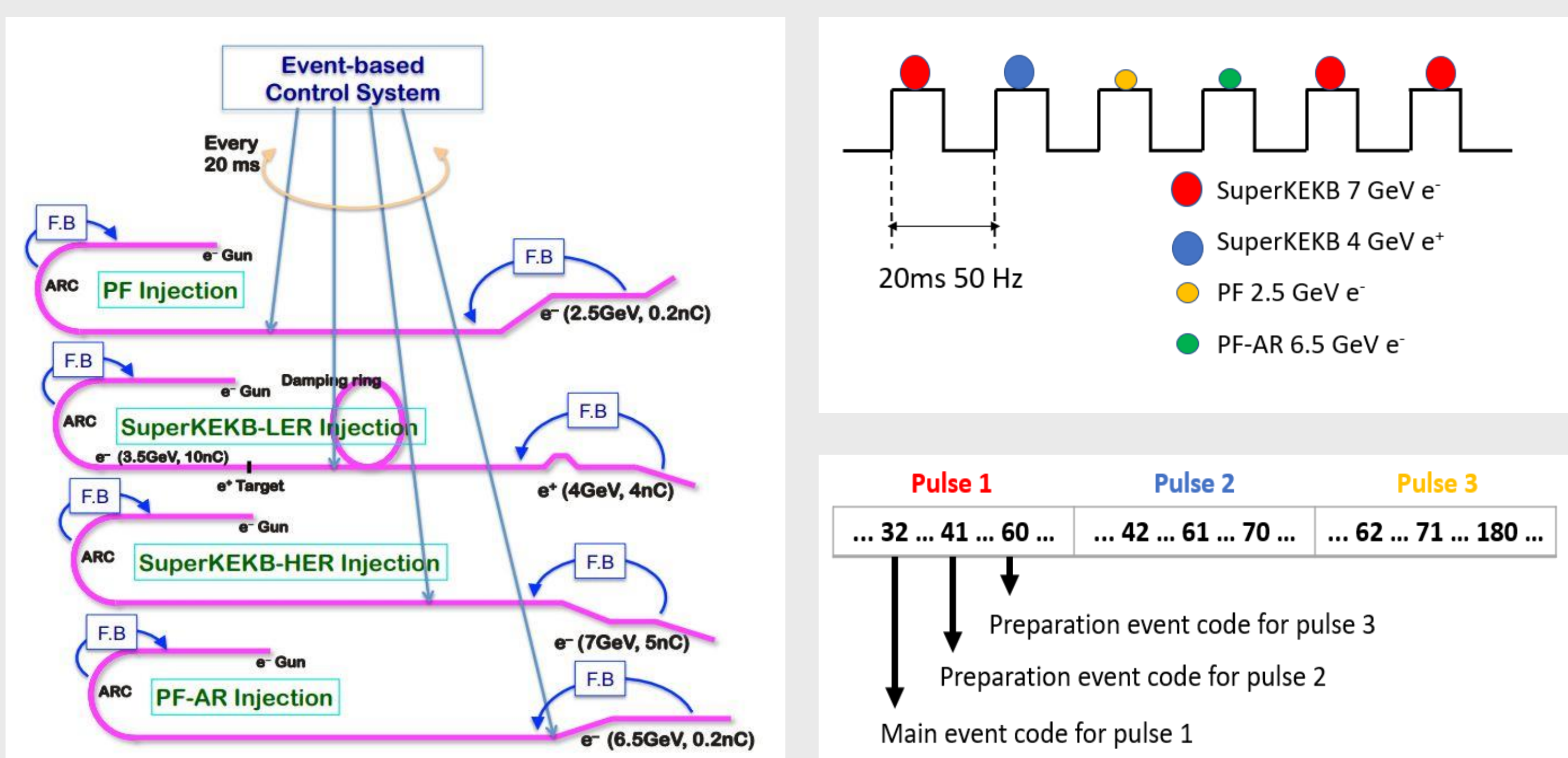
Introduction

We introduced MRF event timing system in injector linac in SuperKEKB to satisfy our demands. The event timing system is utilized to distribute high-level precise timing signals and accompanying control instructions to synchronize different subsystems and machines. EVG generates beam pulse pattern 50Hz which contains several event codes while EVR receives them. The Event rate is 114.24 MHz thus the minimal event time interval is about 9 ns. To certain that events are consistent between EVG and EVR, recording them one by one is essentially needed. Owing to some hardware and network restrictions it is difficult to continuously send every event by EVR through EPICS Channel Access. An EVR based events diagnostic system is thus developed by modifying the device support of some records as well as EVR driver mrfioc2 to send the event codes thus comparing the received event codes with the beam-pattern control orders from beam operation and detecting the event timing interval fault as well as providing a logging system of persistent event data. Then, we are able to locate the fault, analyze the data, fix bugs or replace hardware and resume accelerator operation quickly.

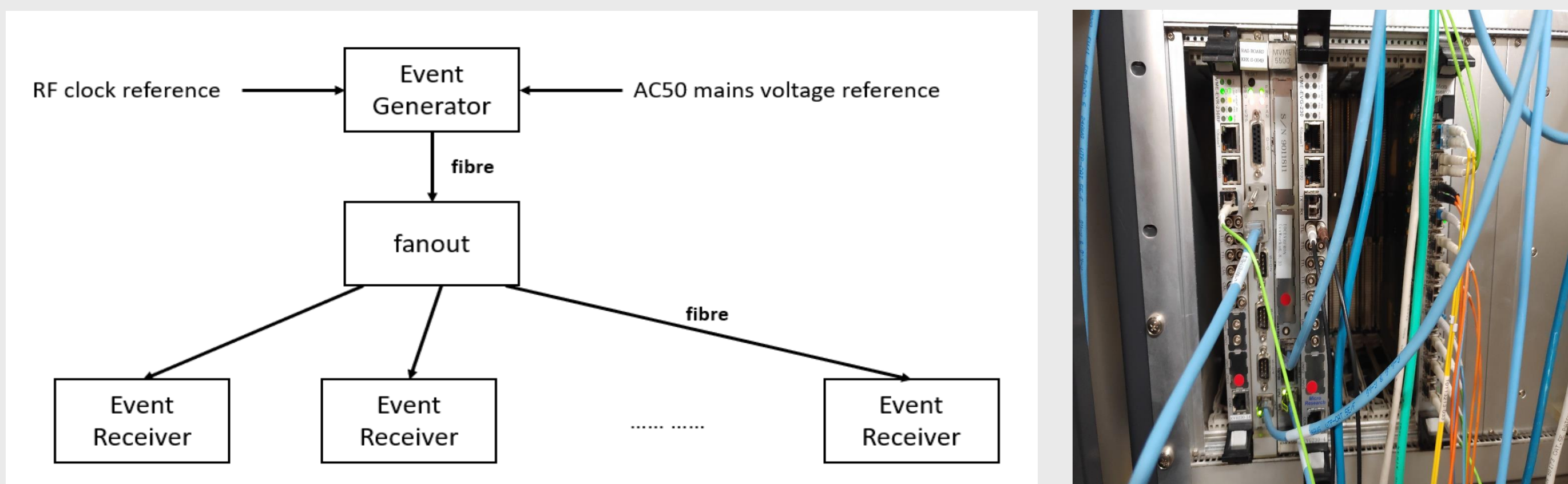
Event Based Timing Control System



SuperKEKB Accelerator



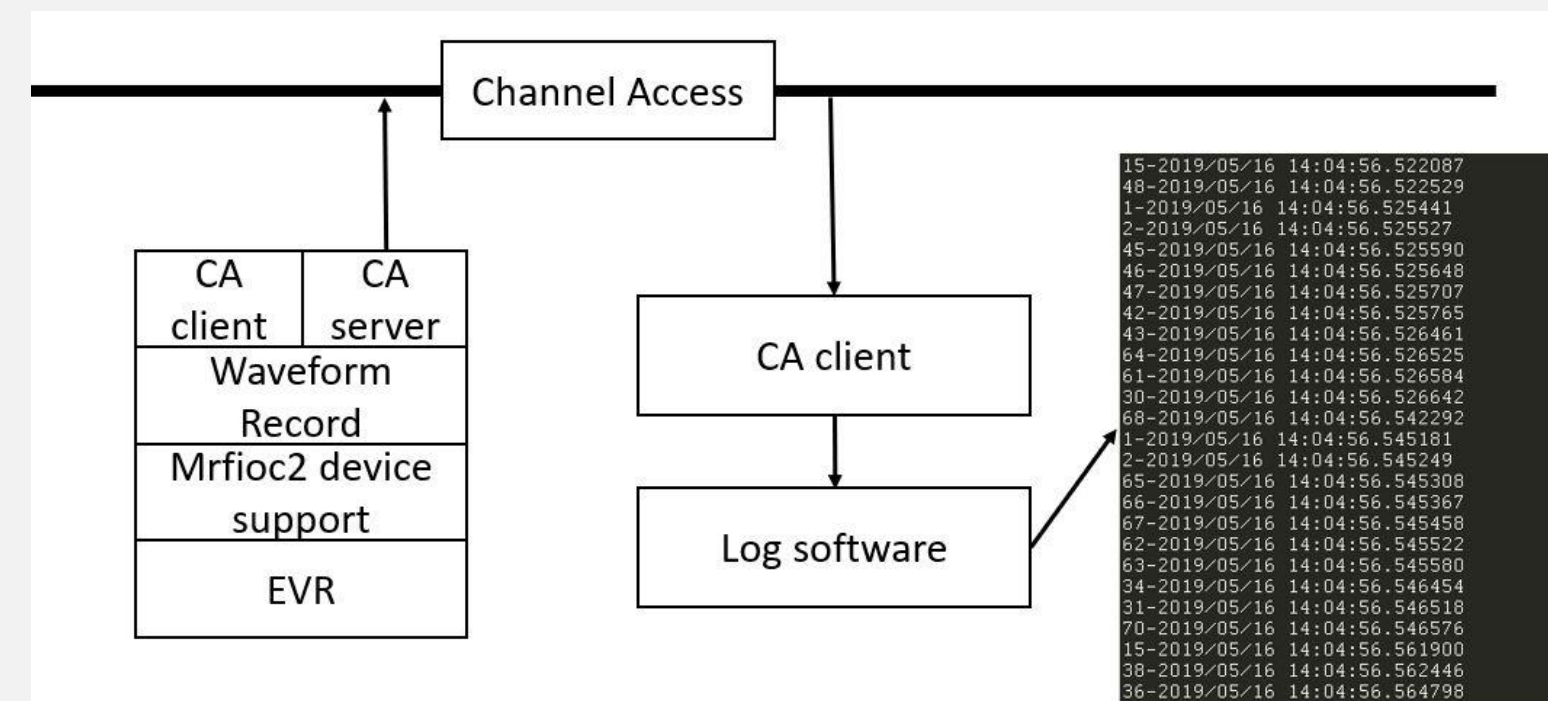
- Simultaneous top-up injection for 5 independent rings.
- Pulse-to-Pulse Modulation (PPM) every 20 ms (2 ms width of fluctuation).
- (SKB e⁻/e⁺, e⁺ damping ring, PF, PF-AR) w/ different beam energies.
- Beam pattern buffer length can be 2 to 500 (40 ms to 10 seconds).
- More than **10 events** are transferred every pulse.



- Event based system (EVG and EVR)
 - 256 Event codes, one event code/cycle (7 ns - 20 ns or 50 MHz to 142 MHz)
- 114.24 MHz is used in SuperKEKB Linac.
- Event stream based on 8B10B encoding

- Abnormal beam pulse interval was noticed during operation occasionally.
- Some devices like klystron will be triggered twice during 20 ms.
- *Event log system is needed.*

Event Log System



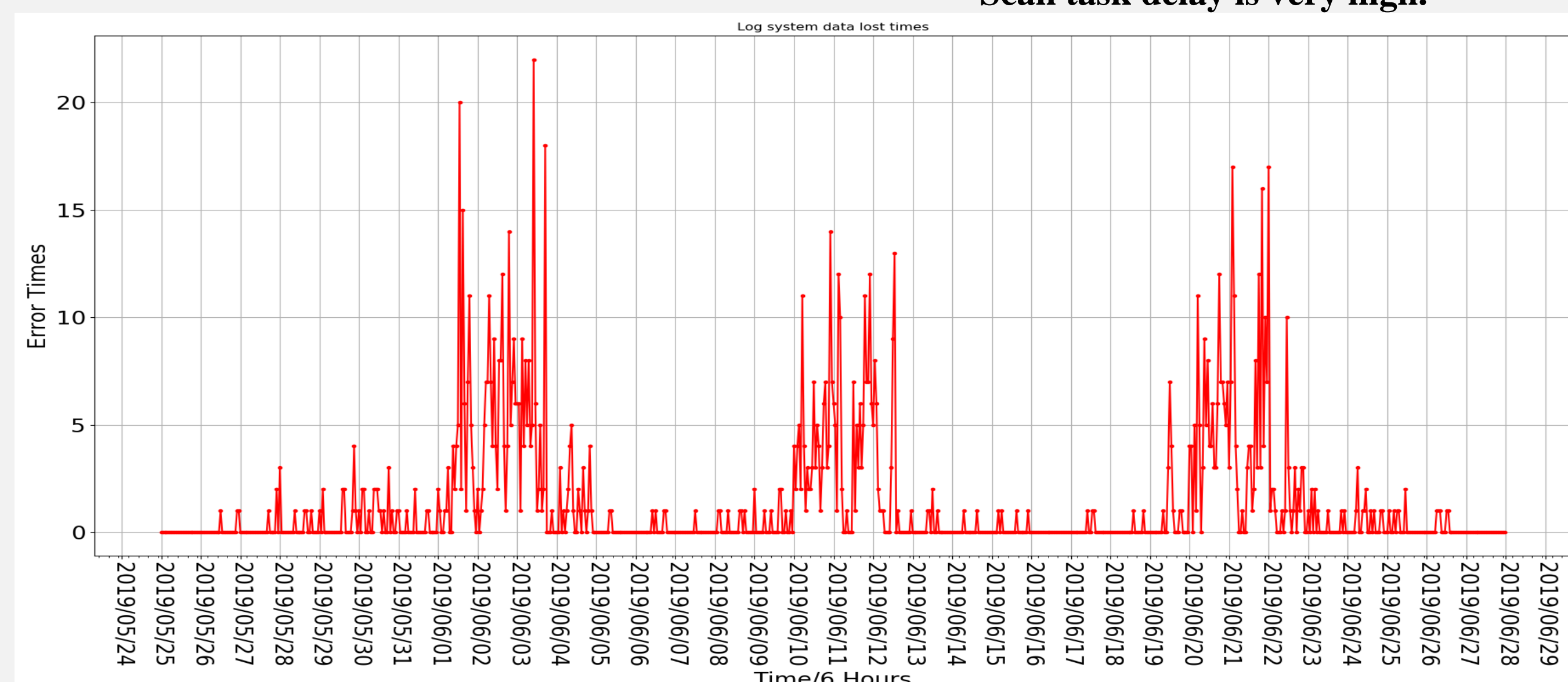
- 32-bit wide FIFO memory (8-bit event code and 24-bit timestamp).
- EPICS 3.15.5
- VxWorks 6.8
- More than 300 records
- Self-defined waveform record, updated every 5 seconds
- Python 3.7 CA Client (pyepics-3.3.3)

- MVME5500 CPU frequency is 1 GHz, by contrast, the minimal interval between linac event code is 9 ns.
- VxWorks clock tick is 1000
- i.e. scan-5 task delay is 4.579 second.

NAME	ENTRY	TID	PRI	STATUS	FC	SP	ERRNO	DELAY
l3obTask	l3obTask	10054	0	PEND	24ec6c	8b5d0	0	0
l3excTask	l3excTask	10054	0	PEND	24ec6c	302970	0	0
l3logTask	l3logTask	40e570	0	PEND	24ec6c	40e40	0	0
l3btTask	l3btTask	4e1e90	0	PEND	24ec6c	4e1e0	0	0
l3shel11	shel11Task	517d60	1	PEND	24ec6c	517a30	0	0
l3shel12	shel12Task	614790	1	READY	257178	612990	ad0007	0
l3ppcm_tick	l3ppcm_tick	201100	20	DELAY	26155c	5bb390	0	91
l3l3et0	l3ppcmTask	40e1c0	50	READY	24ec6c	40e30	3d0001	0
l3ppcm_sys1	l3ppcm_sys1	5a2e70	50	PEND	24ec6c	5a2e0	0	0
l3ppcm_sys2	l3ppcm_sys2	5a2e70	50	PEND	24ec6c	5a2e0	0	0
l3ppcm_sys3	l3ppcm_sys3	5a2e70	50	PEND	24ec6c	5a2e0	0	0
l3ppcm_sys4	l3ppcm_sys4	5a2e70	50	PEND	24ec6c	5a2e0	0	0
l3ppcm_sys5	l3ppcm_sys5	5a2e70	50	PEND	24ec6c	5a2e0	0	0
l3ppcm_sys6	l3ppcm_sys6	5a2e70	50	PEND	24ec6c	5a2e0	0	0
l3ppcm_sys7	l3ppcm_sys7	5a2e70	50	PEND	24ec6c	5a2e0	0	0
l3ppcm_sys8	l3ppcm_sys8	5a2e70	50	PEND	24ec6c	5a2e0	0	0
l3ppcm_sys9	l3ppcm_sys9	5a2e70	50	PEND	24ec6c	5a2e0	0	0
l3ppcm_sys10	l3ppcm_sys10	5a2e70	50	PEND	24ec6c	5a2e0	0	0

CPU burden is too heavy !

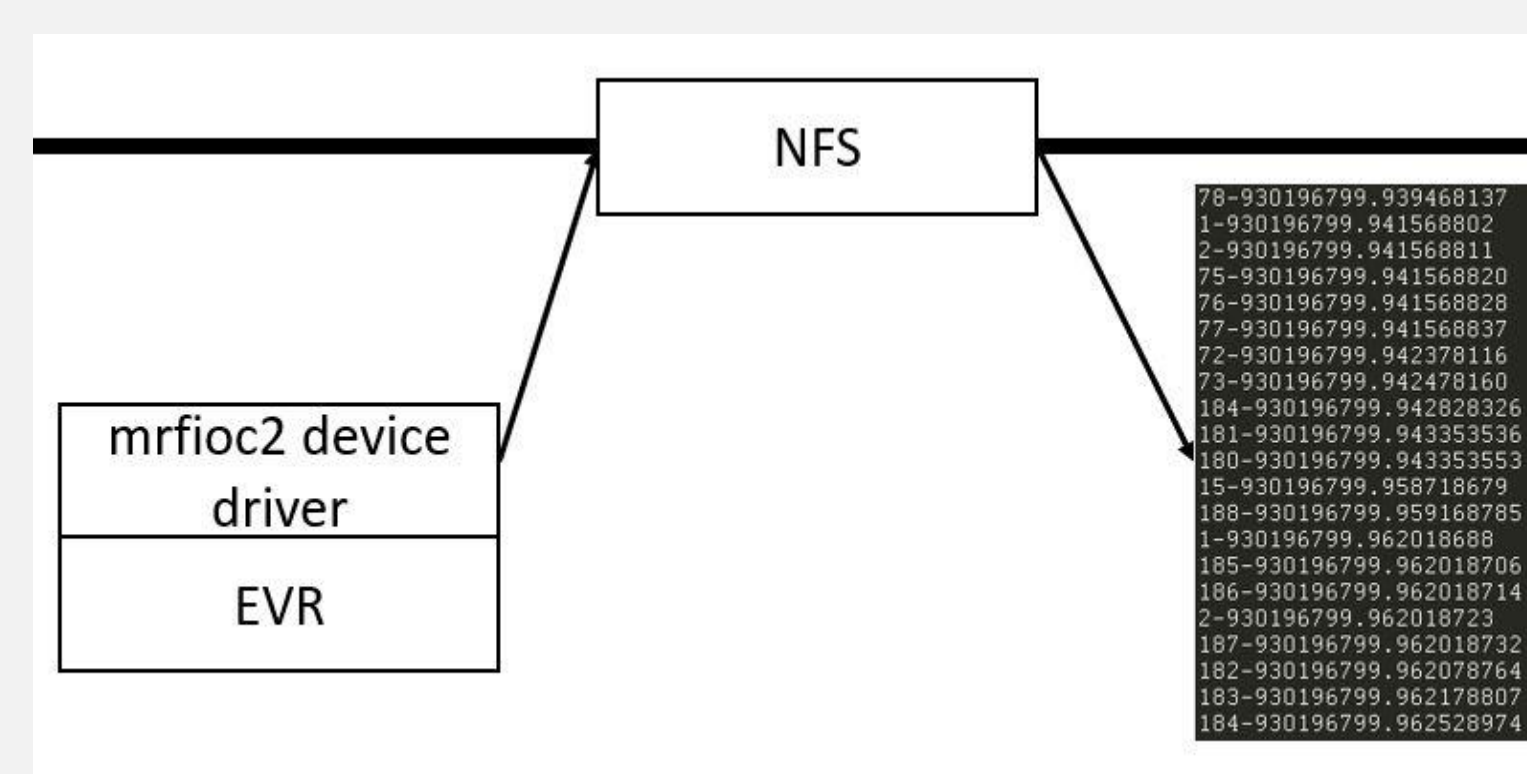
Scan task delay is very high.



Waveform data lost about 1000 times in one month owing to scan task delay

upgrade

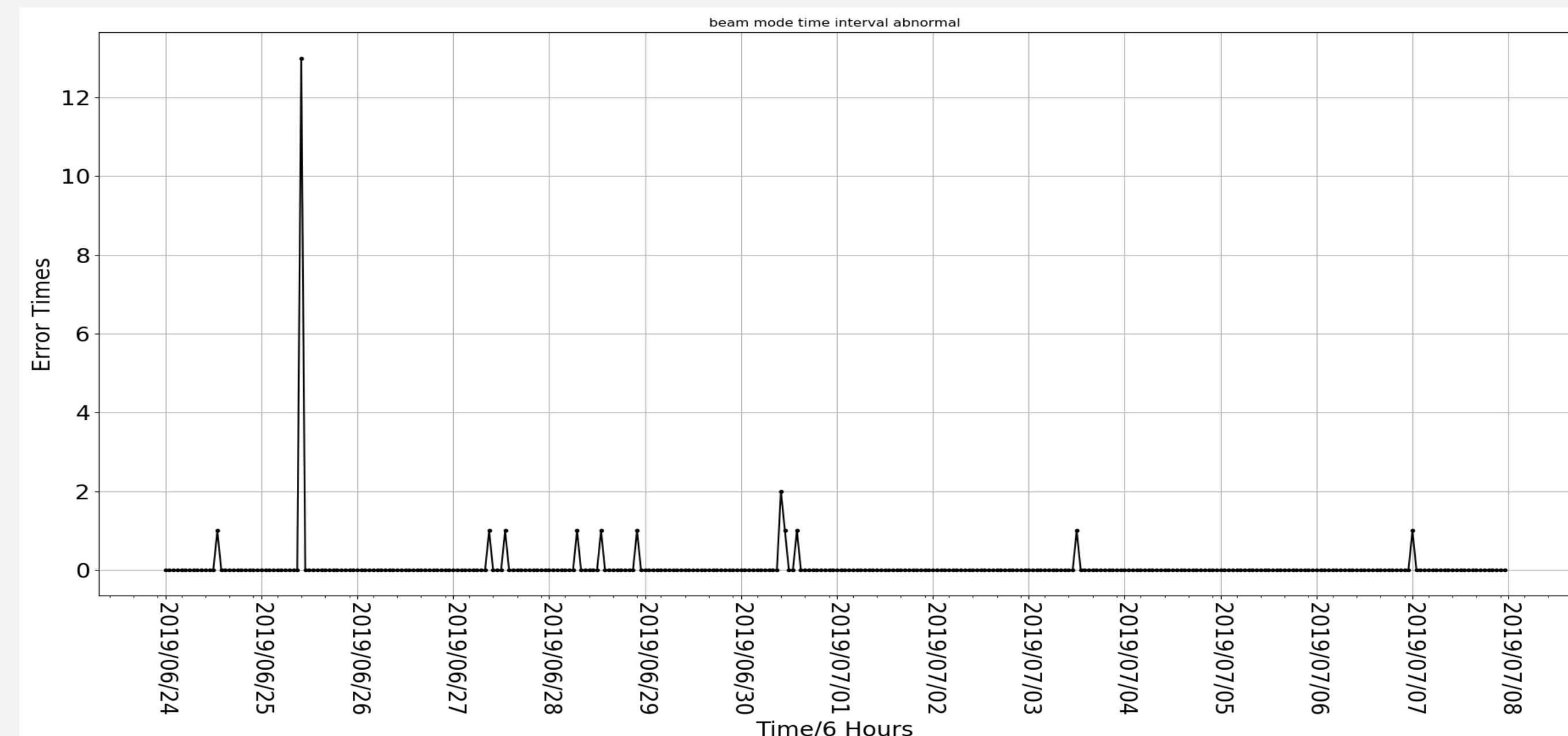
Low-level system



- Lower MVME CPU burden.
- Only some EVR configuration records and event code I/O interrupt records are retained.
- Mrfioc2 module is modified.
- Using binary format to transit event and timestamp
- About 429 MB data every day.
- Python analyzing program will check the log as well as sending email every day (using crontab)

No log system data lost error occurs !

Results



Abnormal beam mode interval information.

Outlook

In the near future, after the SuperKEKB injector linac operate on October, much more event code data will be saved and analyzed. Subsequently, we hope to utilize some the feature extraction algorithm to figure out the reason of abnormal beam mode intervals with the help of these event code timestamp information.