Fast Beam Loss Monitor

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Summary

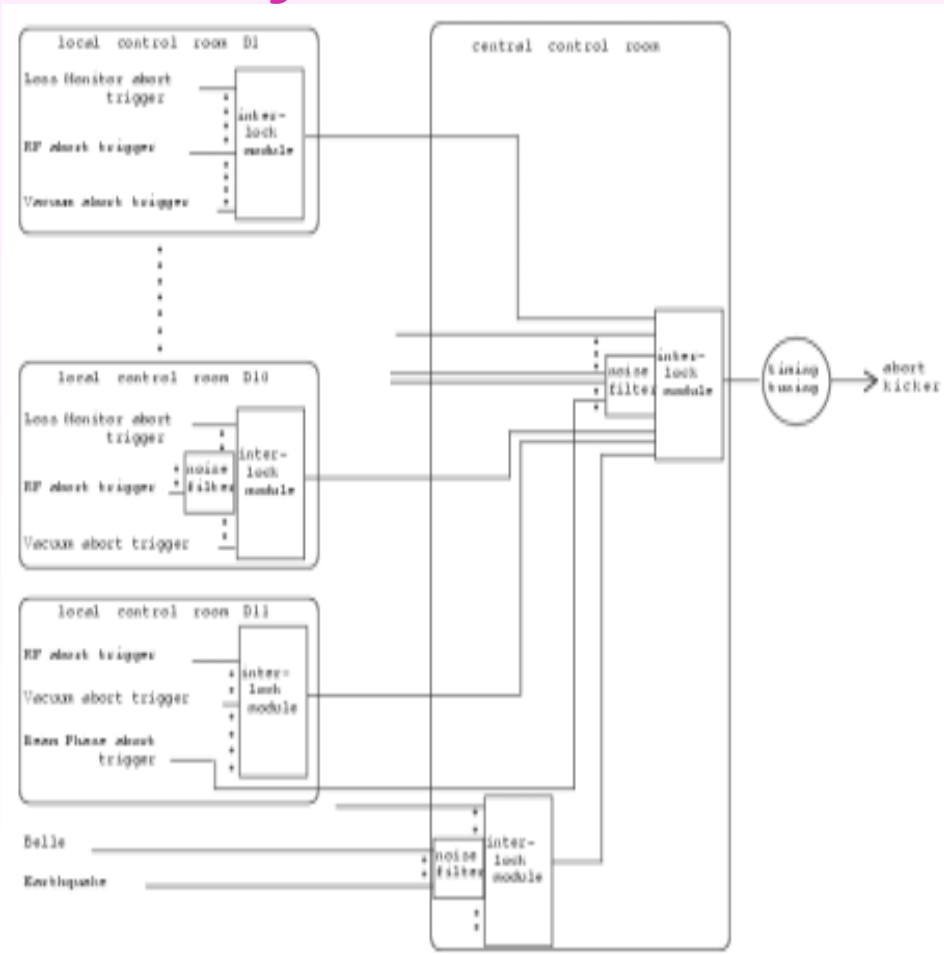
Introduction

- KEKB is high current machine in order to get the high luminosity and Belle (SVD) is placed as close to the beam line as possible to obtain the best position resolution.
- A controlled beam abort system is necessary for protection of the hardware components of accelerator and detector from the high beam current. At the beginning of experiment, abort system was installed, but movable masks were damaged and Belle detector received a huge radiation dose.

- PIN PD was installed at the movable masks to get a fast response from the beam loss and abort the beam before the mask is damaged.
- Data logger was installed to monitor the beam loss directly and find the method of hardware protection. By using this system, we identified the reason of the beam abort and decided the best condition and method of the beam abort.

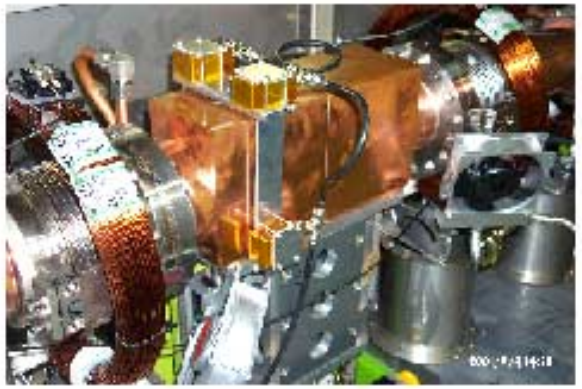
KEKB Beam Abort System

- The kicker magnet is activated with a rise time of less than 1 μs and an entire beam is aborted in one turn (The kicker timing is synchronized to an abort gap).
- HER/LER have independent interlock module in each local control room.
- Trigger signal = Loss Monitor, RF, Belle B.G. etc.
- Time necessary from the input of the interlock module to the termination of the beam abort = 80 -160 μs.



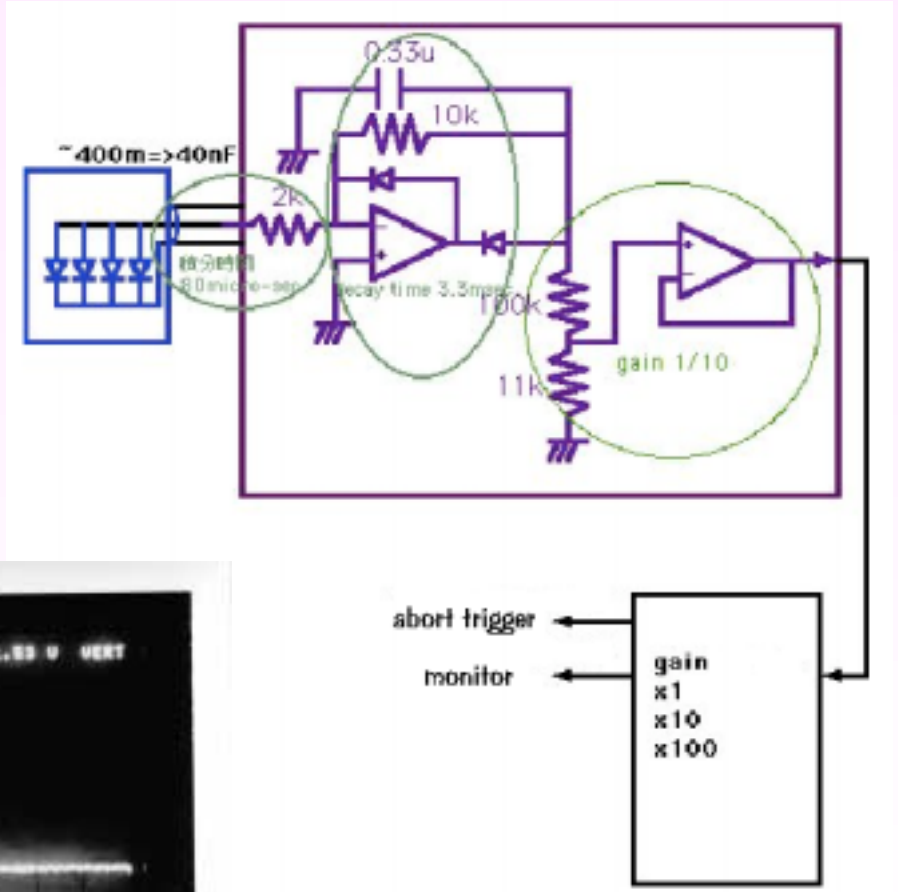
Loss Monitor

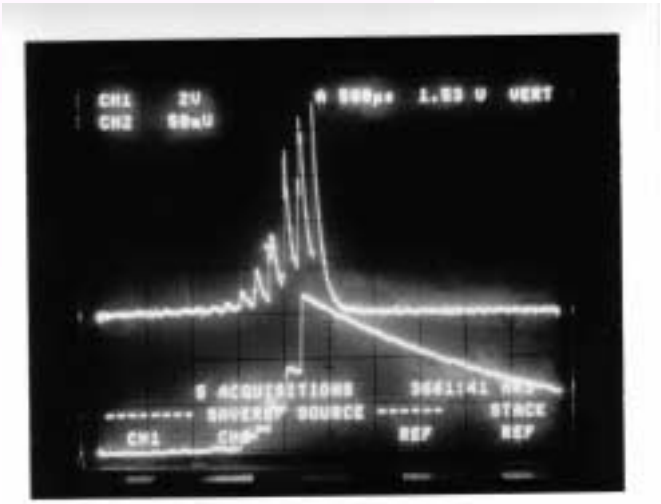
- Ionization Chamber =>installed in the tunnel when the KEKB accelerator was constructed.
- PIN photo-diode => replaced with ionization chambers to protect the movable masks after two year operation.
  - Fast trigger signal = 20 μs (fast enough compare with the delay in abort system.)
  - All of the movable mask = 16/ring,
  - PIN PD 2x4/mask,
  - acceptance surface= 2.65mm x 2.65mm



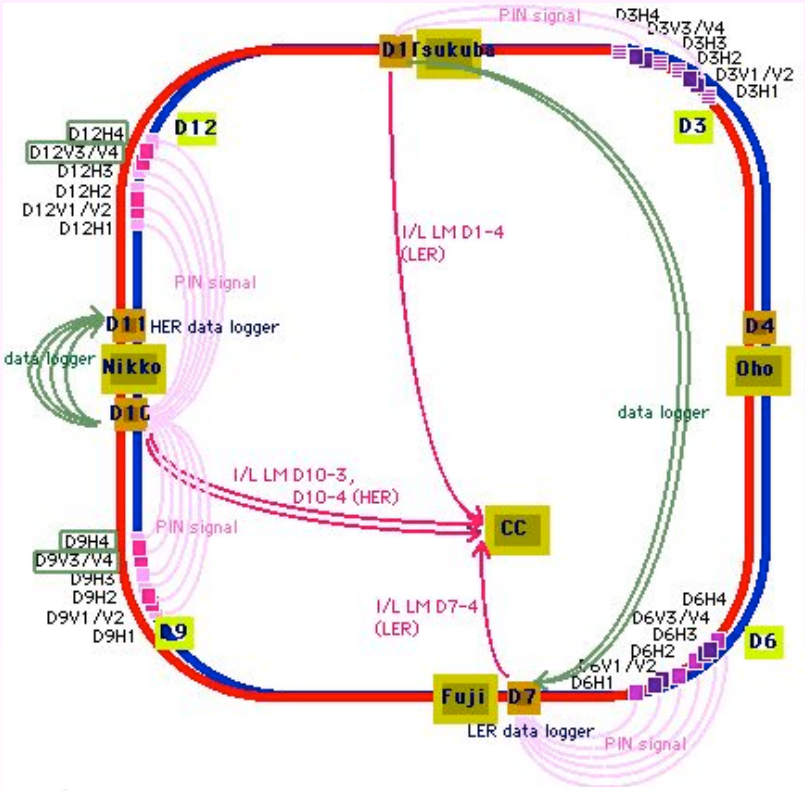
Loss Monitor

- PIN PD is used without bias.
- Pulse signal is shaped by track and hold (3.3 ms decay time) circuit for ADC readout.
- Compatible with ion chamber signal after gain adjustment.





Installation of Data Logger



(D11)

CH1	HER DCCT	CH9	D10 LA Vc	CH17	D10 LA Tuner Phase
CH2	LER DCCT	CH10	D10 LB Vc	CH18	D10 LB Tuner Phase
CH3	HER Beam Phase	CH11	D10 LC Vc	CH19	D10 LC Tuner Phase
CH4	HER Beam Phase Abort	CH12	D10 LD Vc	CH20	D10 LD Tuner Phase
CH5	D12V3/V4 マスクPIN信号	CH13	D11 LA Vc	CH21	D10 LA Pin
CH6	D9H4 マスクPIN信号	CH14	D11 LB Vc	CH22	D10 LB Pin
CH7	D9V3/V4 マスクPIN信号	CH15	D11 LC Vc	CH23	D10 LC Pin
CH8	D12H4 マスクPIN信号	CH16	D11 LD Vc	CH24	D10 LD Pin

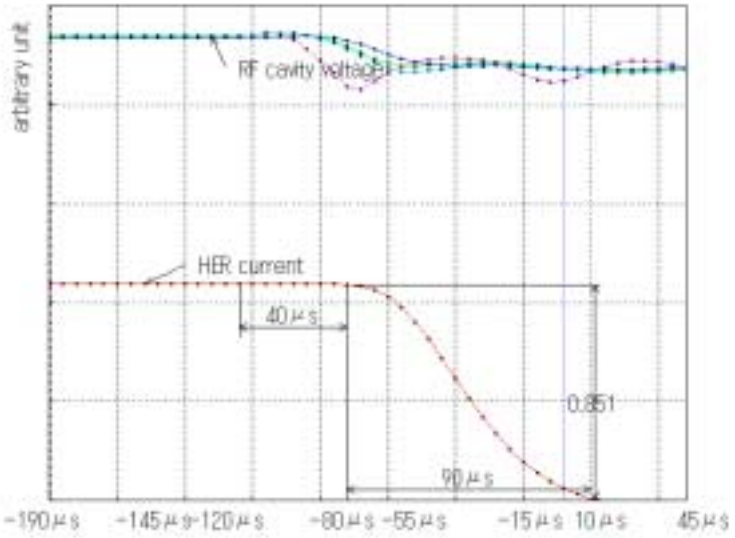
In order to monitor the beam loss directly and diagnose the reason of the beam abort, input signals are expected to have a strong relation with the beam condition.

- Input signal = beam current, PIN Loss monitor signal, RF status signal.
- Set up in local control rooms.
- Logged time = 600ms.
- Sampling interval = 5 μs.

Using this information, we could identify how much beam loss was caused and which mask responded.

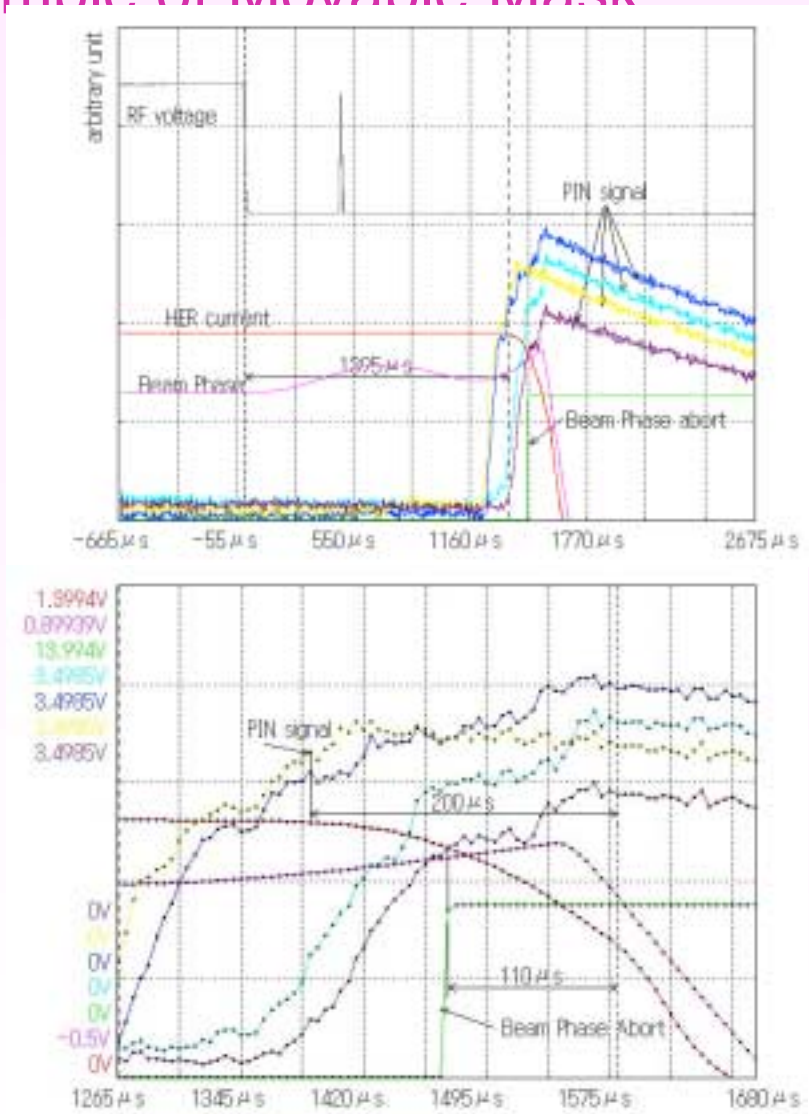
Data Analysis : Manual Abort

- An example of manual abort is shown to identify the correct abort signal.
- Monitor beam current = 40 μs +90 μs delay (inside the cable and the electronics circuit).
- Real beam current = aborted in 10 μs.
- If the decay time and slope is different from this example, we consider the abort is abnormal and analyze the data logger information to determine the reason of the beam abort.



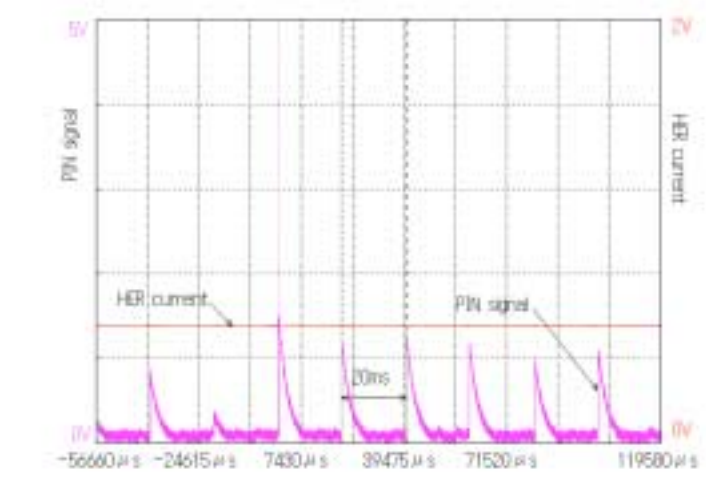
Data Analysis : an Example of Movable Mask Damage

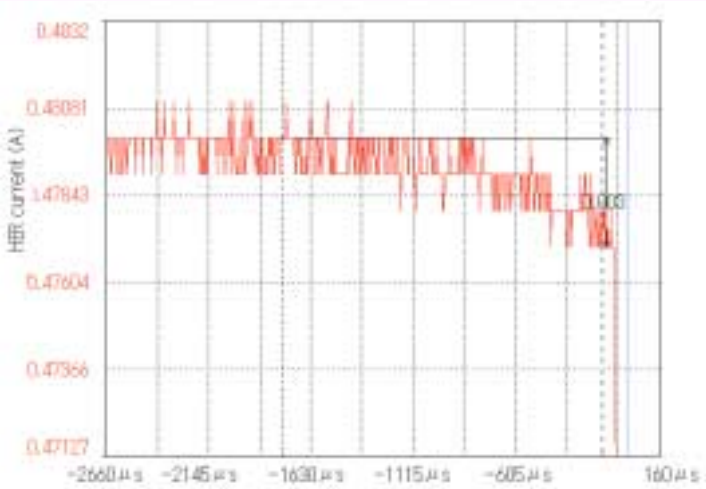
- PIN showed the large signal with beam loss when the movable mask was damaged.
- RF down -> Beam Phase signal start to rise -> 1.4ms -> Beam Loss -> Loss Monitor Abort & Beam Phase Abort request.
- Beam abort request was too late and the beam hit the movable mask directly.
- Each abort trigger level were tuned carefully after this trouble.



Data Analysis : an Example of Movable Mask Damage

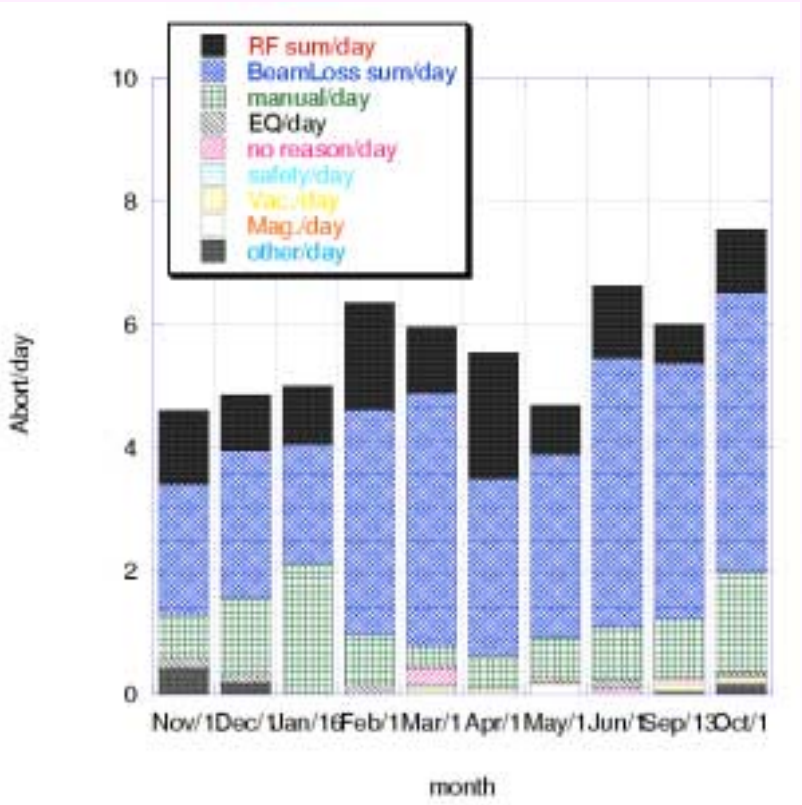
- Injected beam hit the mask and produced a large signal when the injection tuning was not fine. Since this dose not damage the mask, the generation of the abort is vetoed for 3 ms in synchronous with the injection timing.
- After applying this veto, the trigger level of loss monitor was tighten and the trigger level became to a few mA beam loss.
- We expect the loss monitor abort is generated in time to protect the KEKB and Belle hardware.





Data Analysis : Abort Reason

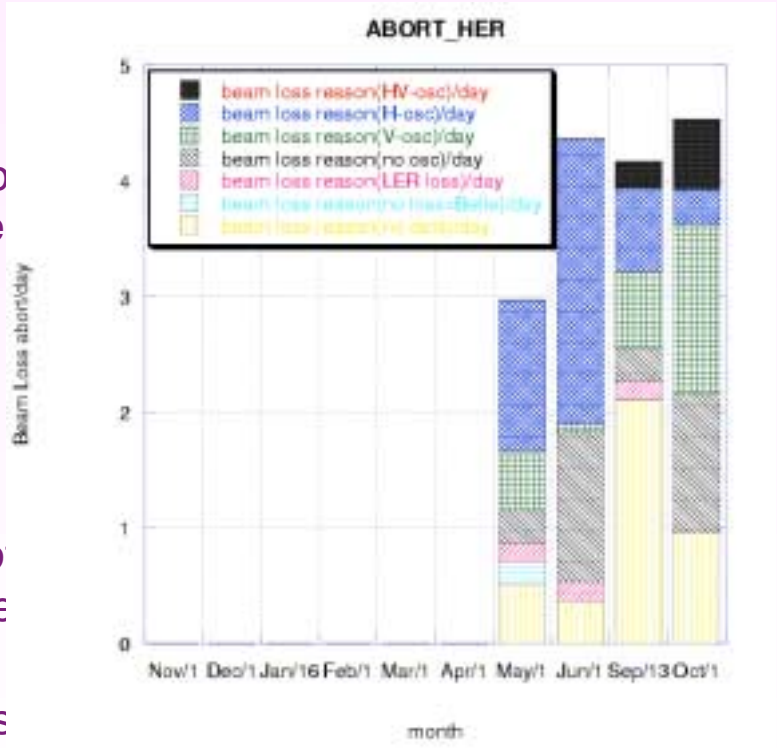
- In order to decrease the number of aborts, the reason of abort was checked one by one. (The data logger data can be check in control room within 3 minutes after a beam abort.) -> Main reasons are beam loss and RF trouble.
- It is important to know the beam loss.



Data Analysis :

Relation between Beam Loss and Beam Oscillation

- Relation between beam loss and beam oscillation was checked using beam oscillation recorder (BOR).
  - Most of the beam loss were caused b the beam oscillation and several type of beam oscillation is observed.
  - When a LER beam is aborted, an instability of the HER beam is generated and the horizontal oscillation is observed.
  - When we find no oscillation despite o a large beam loss, we often found the tune was shifted off.
- We figured out the reason of the beam los and it is used to improve the control parameters of the accelerator.



Summary

- A controlled beam abort system was installed at the KEKB accelerator to protect the hardware component from the loss of the high current beams, but the movable masks were damaged and Belle detector received a huge radiation dose due to the delay of trigger signal in some abort.
- We installed PIN PD loss monitor at the movable masks to get a faster response (20 μs) from a beam loss.
- And the signal of PIN PD and the RF status signal are supplied to a data logger to make a diagnosis of the beam abort. By analyzing the data, the reason of beam loss and beam abort have been identified and the best condition of the beam abort has been determined. As the result of the optimized beam abort, we succeeded to eliminate catastrophic beam losses which has caused a serious damage to movable mask. A radiation dose to the Belle detector also decreased.