

# Belle Beam Abort System (II)

24 March 2005

Belle SVD monitor group

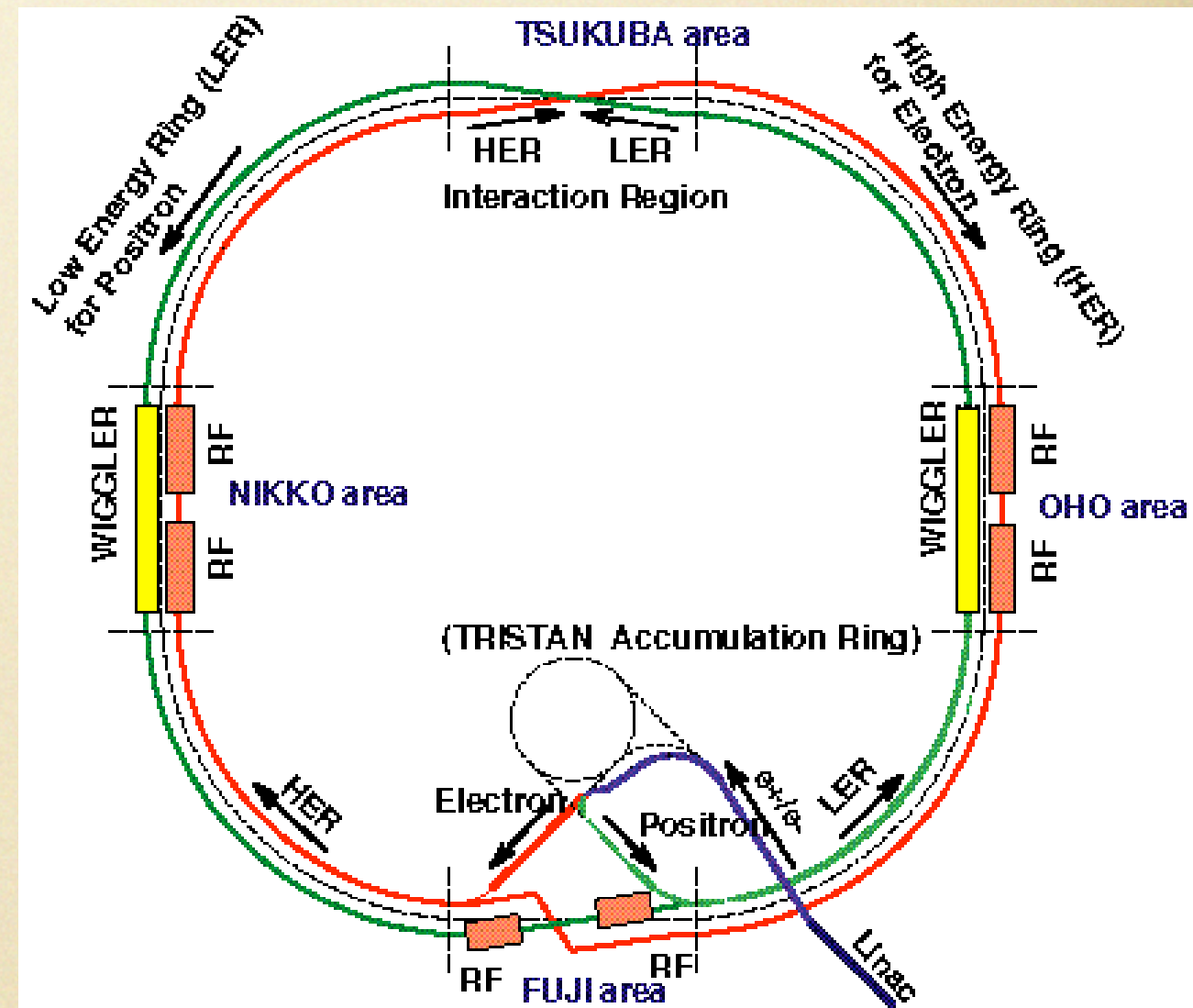
T. Tsuboyama, O. Tajima(KEK)

A. Igarashi, S. Iwaida, T.Kameshima,  
S. Stanic, Y. Asano (Tsukuba)



# Introduction

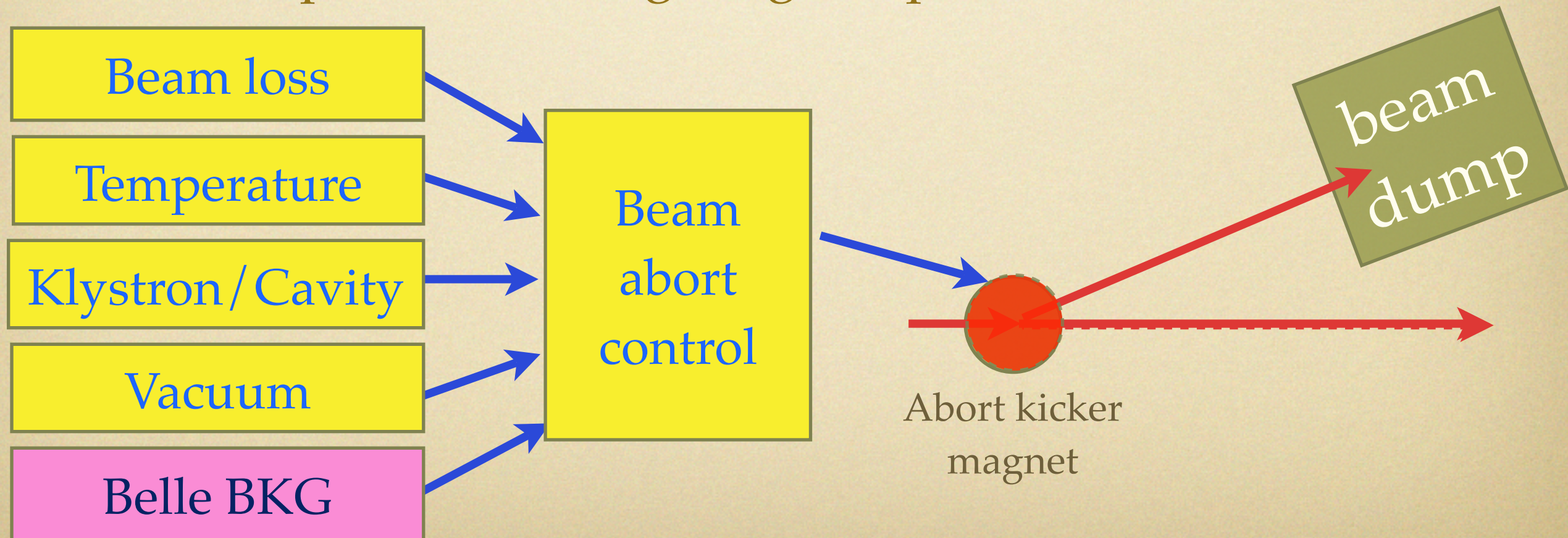
- KEKB is running at high current in extremely stable condition
  - LER:  $\sim 1.7$  A, 3.5 GeV,  $e^+$  beam
  - HER:  $\sim 1.3$  A, 8.0 GeV  $e^-$  beam
- Once beam becomes unstable, however, a horrible radiation BKG can enter to Belle.
  - The beam also destroy accelerator components.
- In order to protect the Belle detector and accelerator components, KEKB has the “beam abort system”.





# Beam abort system of KEKB

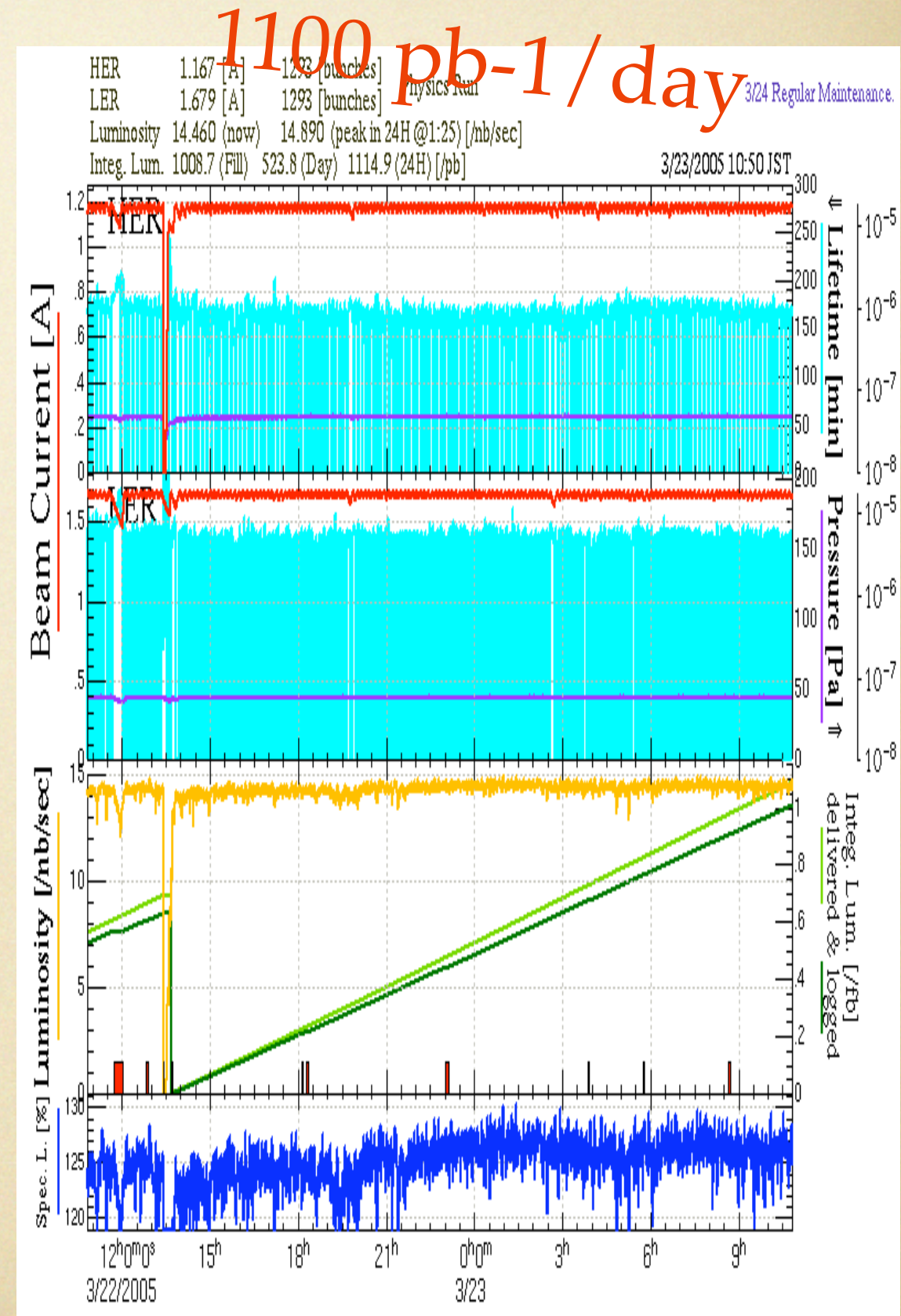
- There are many sensors that detect beam instability
  - Beam loss (radiation level) in tunnel
  - Klystron and Cavities
  - Vacuum components and temperatur
  - Background measured by Belle Detector
    - Huge background sometimes causes LVPS trip and Super conducting magnet quench.





# Cost of beam aborts

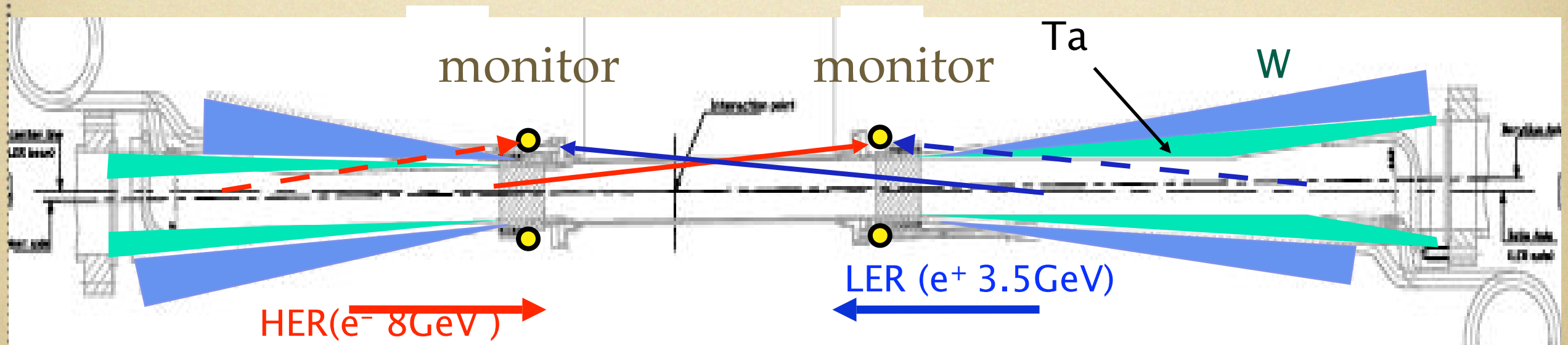
- KEKB / Belle is running with very high efficiency.
- Average luminosity  $\sim$  Peak luminosity
- Belle DAQ  $\epsilon$  (dead time & DAQ trouble)  $> 90\%$
- Once a beam is aborted, beam injection takes
  - HER --- 5 minutes
  - LER --- 10 minutes
- When HER beam is not stable, we like to abort HER beam only, vice versa.





# Discrimination of background

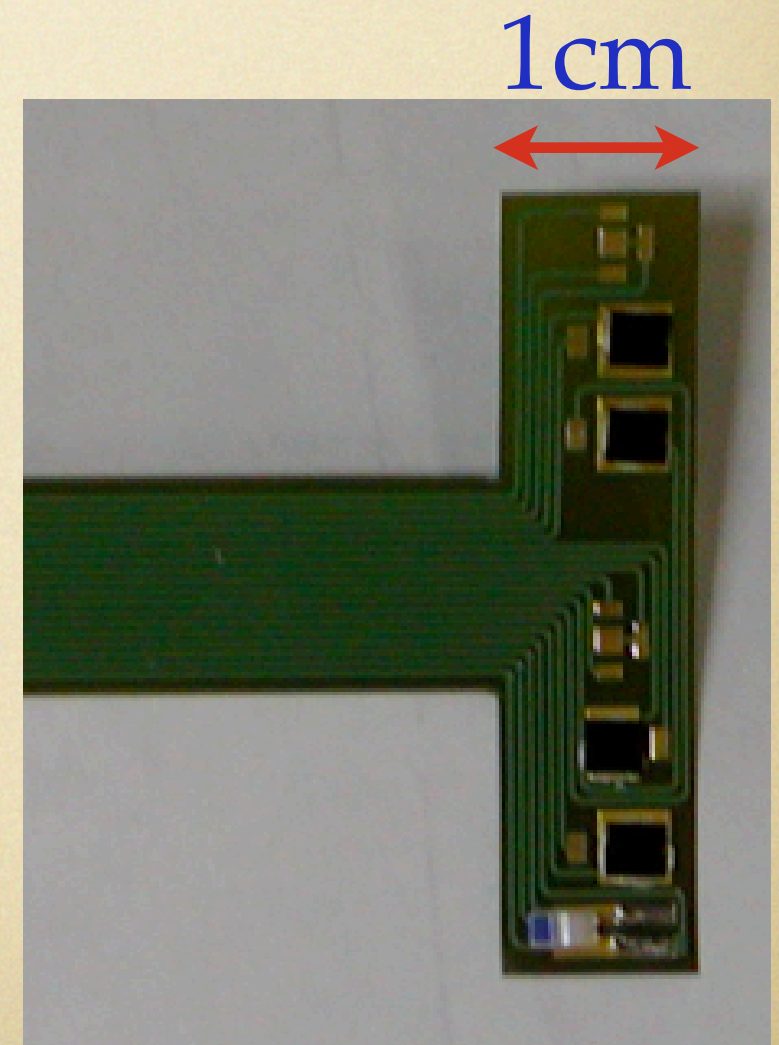
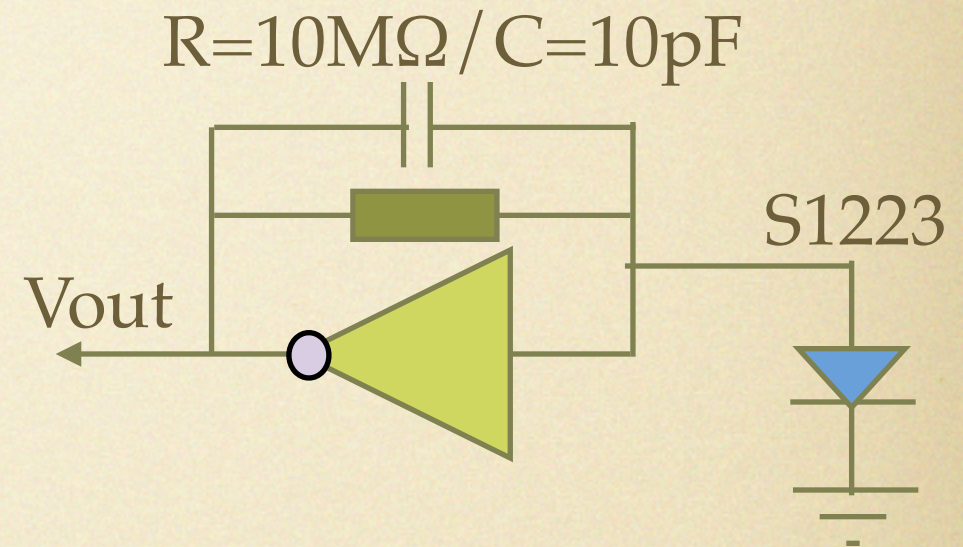
- IP chamber-II was installed in 2003 summer.
  - Central part: ~1 mm thick Beryllium.
  - Support part: made of Tantalum and Tungsten.
- Shower made by HER beam mainly hits forward PIN diodes and the shower made by LER beam hits mainly backward PIN diodes.
- Discrimination of the BKG source possible.





# PIN diode system

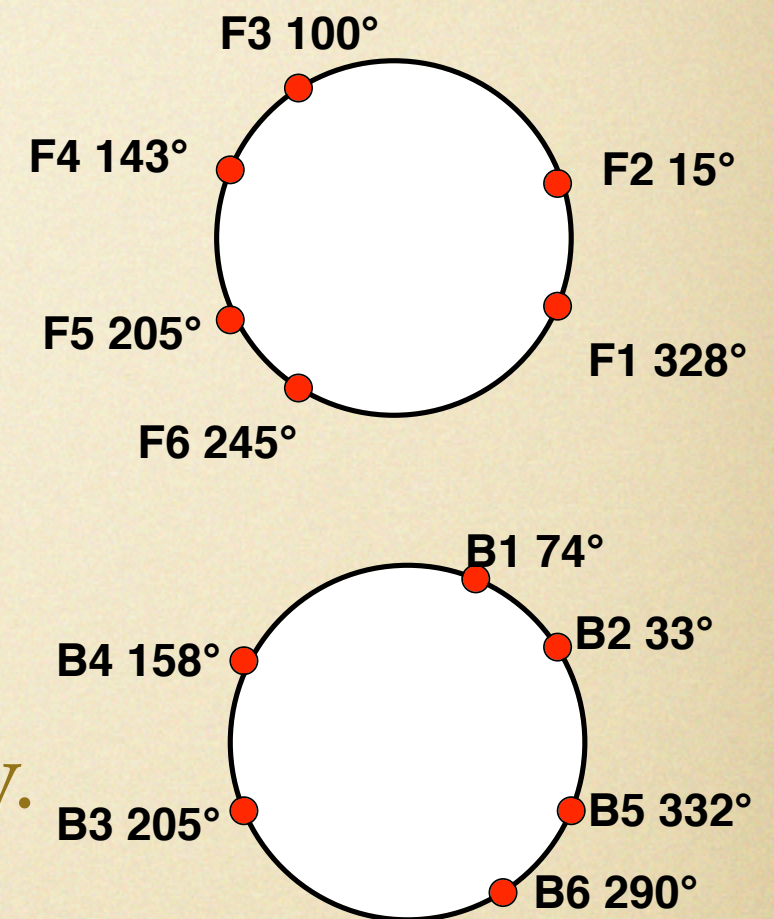
- The radiation level in normal operation is 2 mrad / sec.
- The threshold of the beam abort is 100 rad / sec.
- Si PIN diodes HPK S1223 operated without bias voltage.
- Sensitive area: 4mmx6mm.
- Each diode is read out by charge amplifier.
- Gain  $\sim (10 \text{ rad / sec}) / \text{V}$





# Beam abort decision

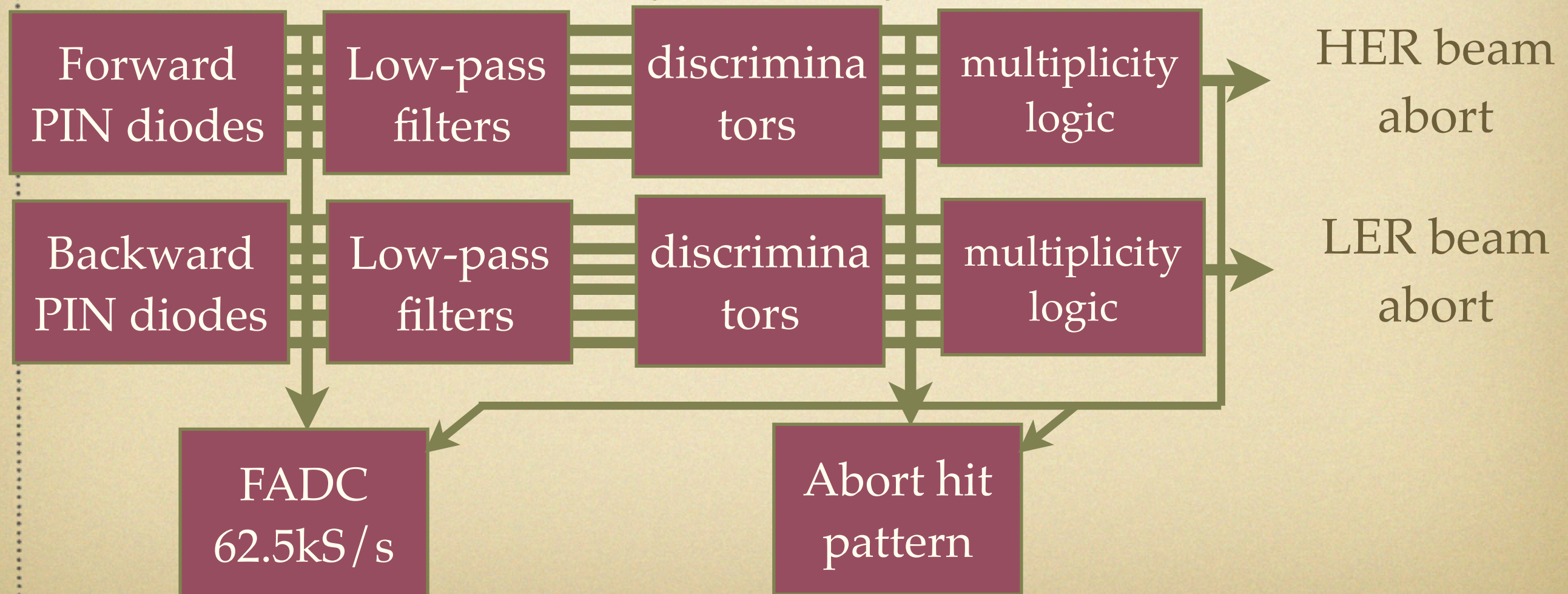
- Output of 6 PIN diodes is lead to a discriminator, multiplicity logic then sent to beam abort system of KEKB.
- Independent circuits for forward and backward PINs.
- Evaluation of performance is necessary.





# Monitor system

- Monitor system: Evaluation of the performance.
  - PIN diode wave form sampling
  - Digital hit pattern
- Comparison with KEKB beam abort data and estimate the reliability of the system





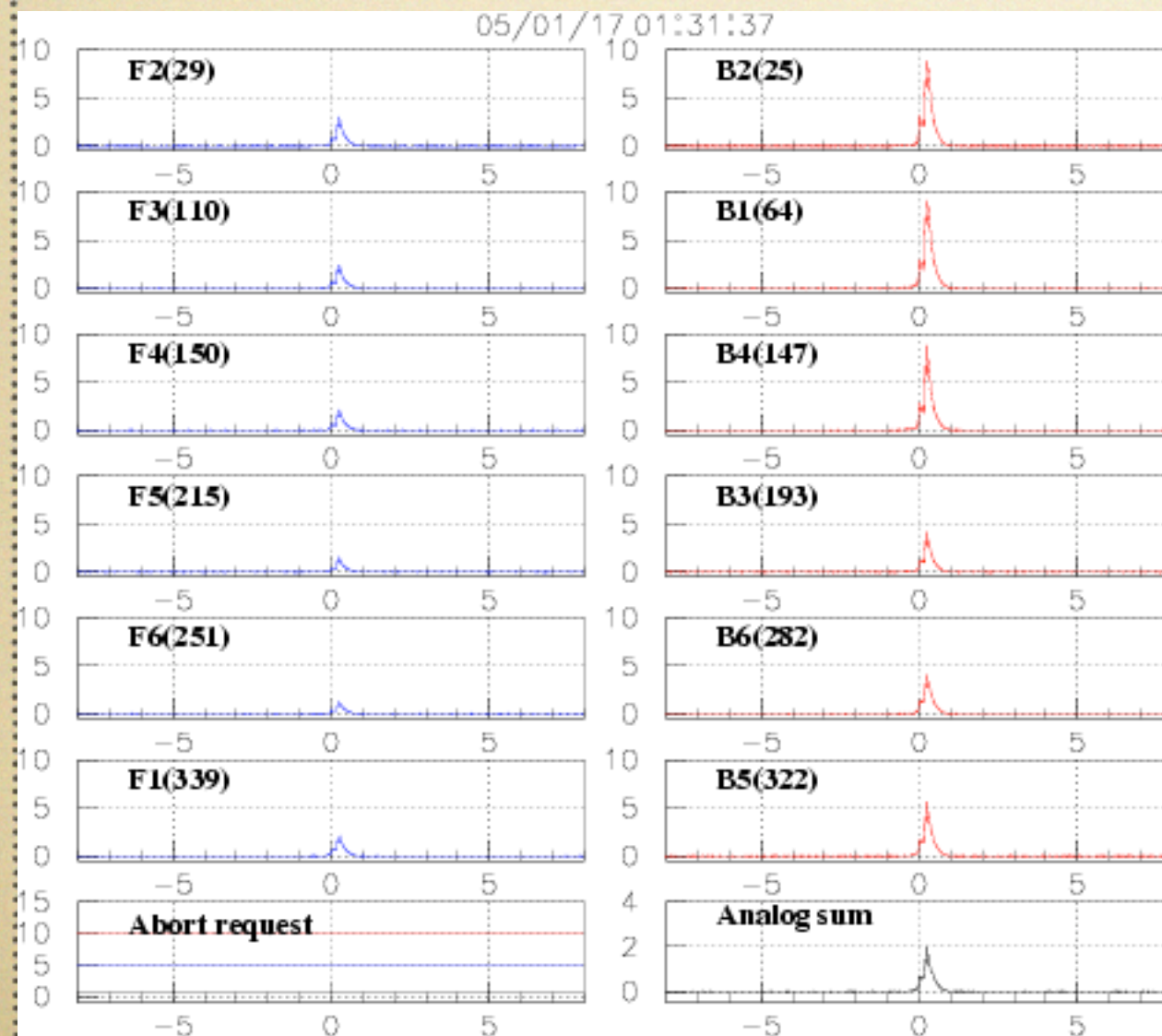
# PIN diode response

- LER induced BKG

Hit pattern FFFFFFFBBBBBB  
DATE TIME 123456123456  
05/01/17 01:31:35 000000110100

Diagnose by KEKB

05/01/17 01:31:33 LER D7  
05/01/17 01:31:33 LER Belle

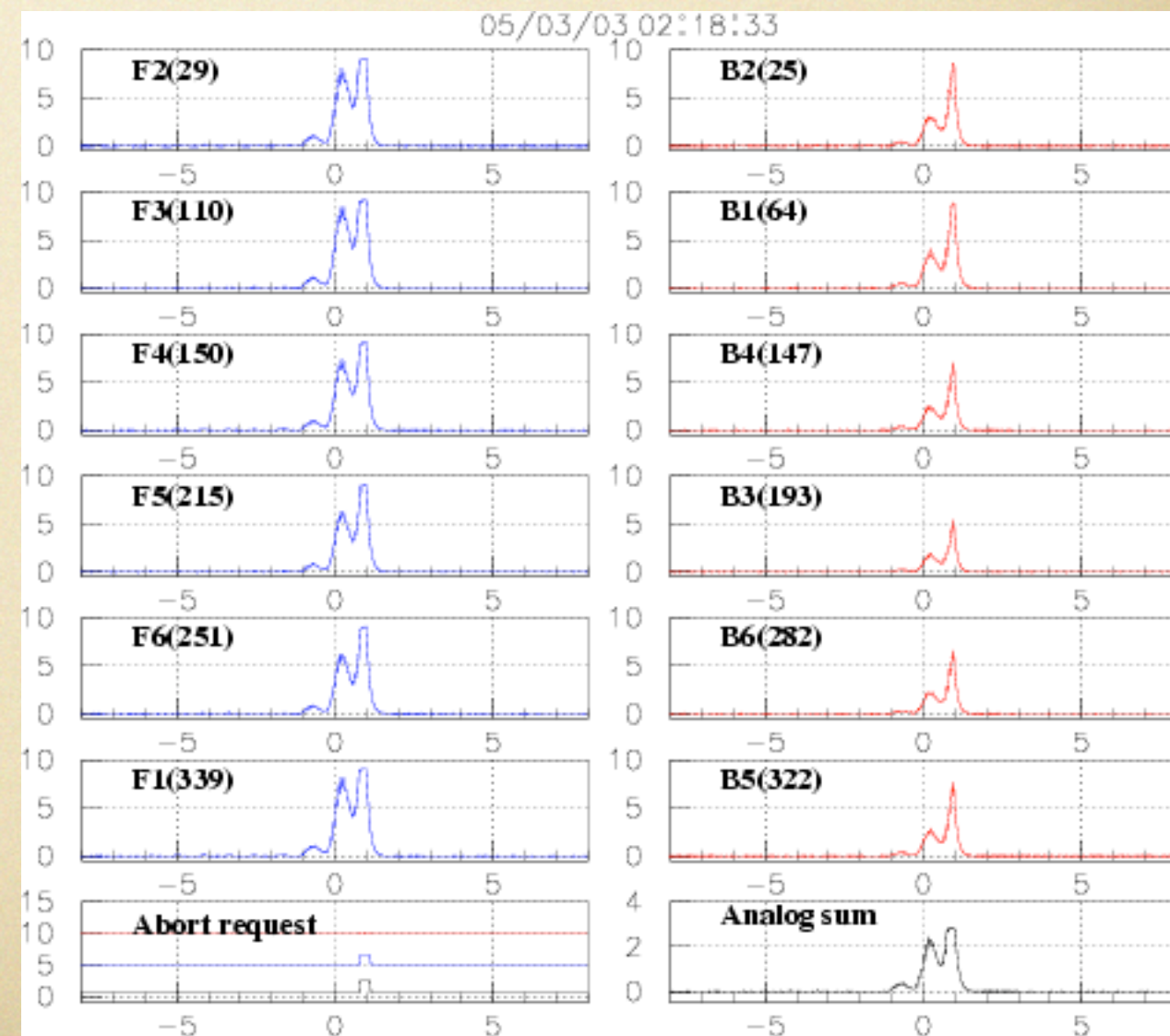


## HER induced BKG

Hit pattern Belle FFFFFFFBBBBBB  
DATE TIME 123456123456  
05/03/03 02:18:30 101111000000

Diagnose by KEKB

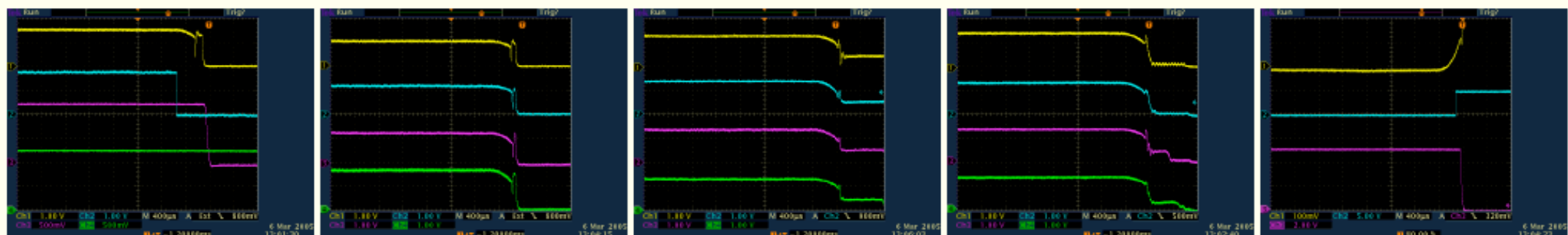
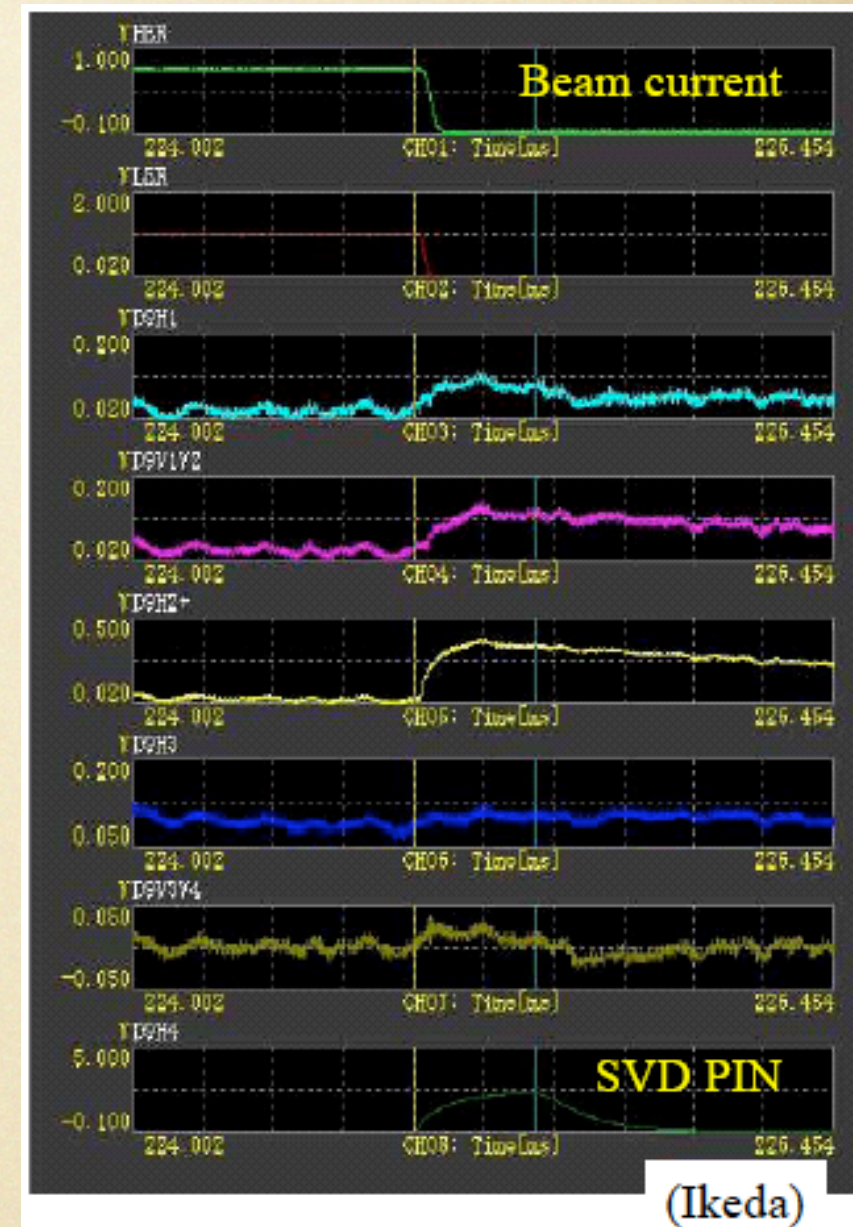
05/03/03 02:18:29 HER Loss Monitor D10-4  
05/03/03 02:18:29 HER Belle





# Beam abort diagnose

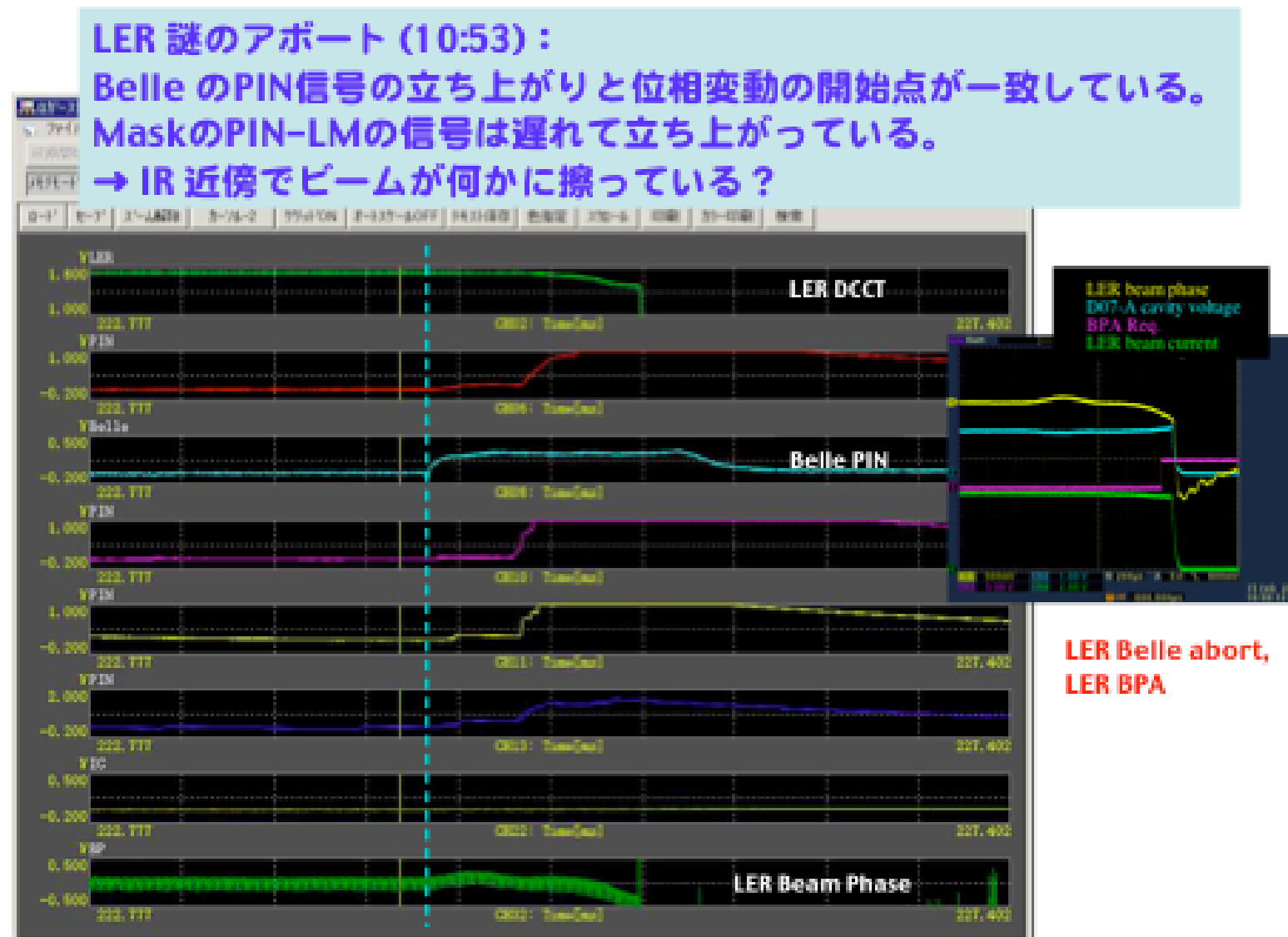
- Diagnose of LER/HER beam instability is important issue for stable accelerator operation.
- Beam orbits, vibration, Klystron & RF cavity voltage, RF phase, beam background, temperature of components... are recorded to identify the reason of beam instability.





# Another Example

- This kind of detail beam diagnoses is done for every beam abort.





# Statistics

Reasonable  
decision

$$\epsilon = 49 / 82 \\ = 60 \%$$

KEKB Unstable beam	Requests from Belle			
	HER	Both	LER	Total
HER	15	2	5	22
Both	0	11	0	11
LER	1	18	23	42
Unknown	0	5	2	7
Total	16	36	30	82

- Total 82 beam-abort requests after installation of this program.
- 49 (15 HER, 23 LER and 11 Both) abortions were correct.
- There were many LER instability with high dose.
  - Both-beam-abort were requested.
  - Reason has not been understood by KEKB people.



# Summary-I

- New IP chamber enabled us to distinguish HER instability and LER instability.
- The yield of correct decision is 60 %.
- In previous beam abort system, HER was always aborted first. If BKG is still high, LER is aborted.
- In  $\sim 1/2$  cases, all PIN diodes saturated at once and LER and HER beam abort requests are sent.



# Summary-II

- The so-called X-aborts leaves large radiation dose in a short time.
- In February all PIN diodes saturated and we requested both beam abort.
- In March, we adjusted  $\tau$  to 200 nsec in order to request LER beam abort only.
- It means larger dynamic range and faster response will allow more reliable abort decision.
- Diamond sensors are useful for this purpose.



# Diamond R&D

- Diamond sensors: on the Nikko side only.
  - Signal is processed with  $\tau=0.75\ \mu\text{sec}$  amplifier
  - Slow signal is from a PIN diode ( $\tau=200\ \mu\text{sec}$ ).
- Upper figure: taken at a so-called LER-X abort. No signal is observed.
- Center figure: taken at a HER beam abort. Diamond sensor show large pulse.
- Lower figure: Magnified view, the signal width is consistent with amplifier time constant. Real signal from diamond may be much narrower.
- We will measure with a faster ( $\sim 50\ \text{nsec}$ ) amplifier and a faster oscilloscope.

