

Machine performance since Feb. 2002

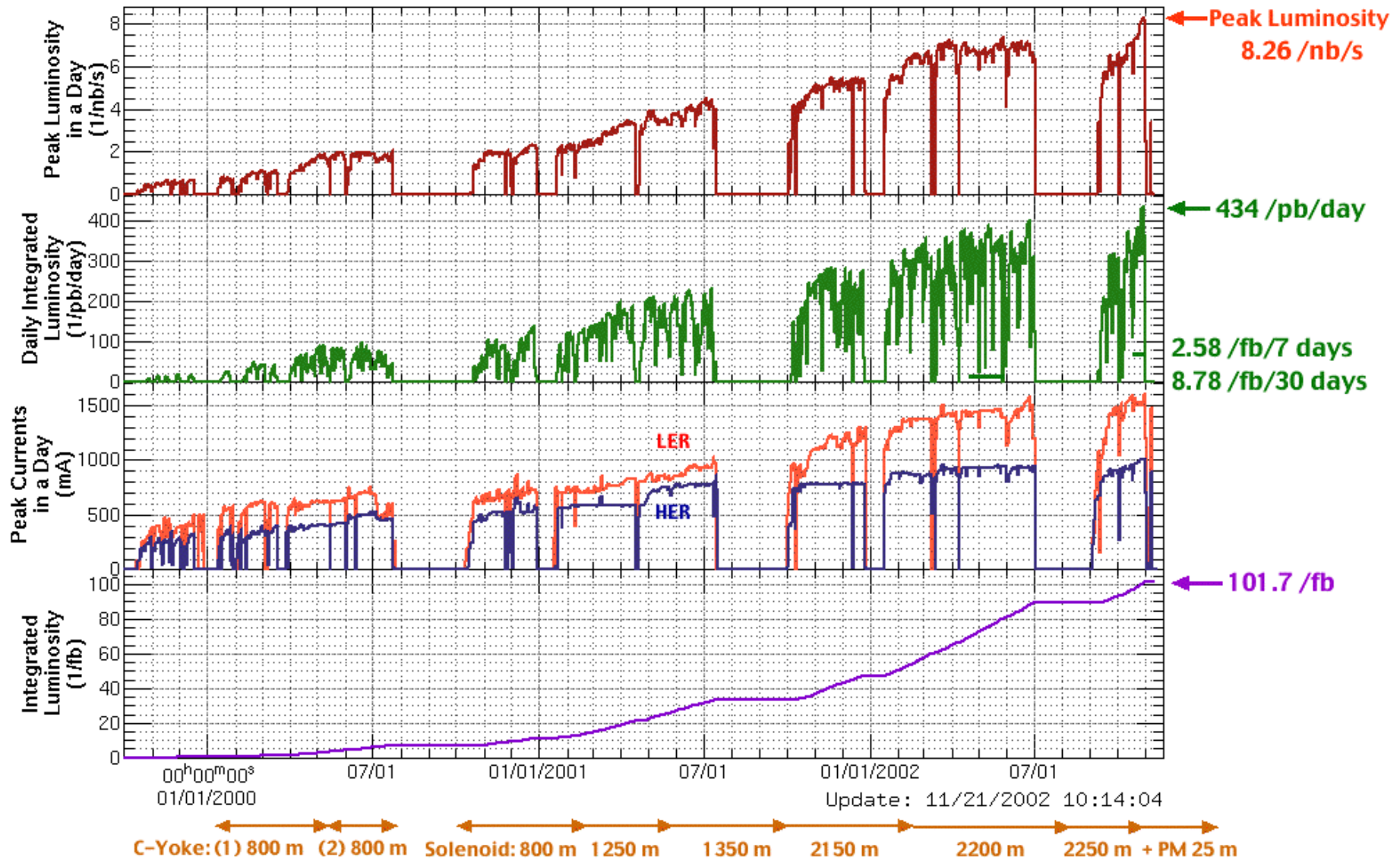
Y. Ohnishi

2/10/2003

The 8th Machine Advisory Committee

- 1. Present status**
- 2. Progress since the last MAC**
- 3. Operation stability**
- 4. Short/long term plans**

Luminosity of KEKB Oct. 1999 - Oct. 2002



Date	10/29/2002		2/21/2002		
Ring	LER	HER	LER	HER	
Horizontal Emittance	18	24	18	24	nm
Beam current	1454	949	1333	822	mA
Number of bunches	1184		1223		
Bunch current	1.23	0.80	1.09	0.67	mA
Bunch spacing	2.4		2.4		m
Bunch trains	1		1		
Horizontal size at IP *_x	103	121	103	121	μm
Vertical size at IP *_y	2.9	2.9	2.7	2.7	μm
Emittance ratio $^*_y / ^*_x$	7.5	5.0	6.3	4.4	%
$^*_x / ^*_y$	59/0.62	61/0.7	59/0.65	61/0.70	cm
Beam-beam parameters					
x / y	0.090/0.053	0.078/0.045	0.069/0.046	0.074/0.042	
Beam lifetime at collision	68 @1454 mA	197@949 mA	180@1200 mA	250@800 mA	min
Luminosity (Belle Csl)	8.26		6.62		/nb/s
Luminosity records					

per day/7 days/30 days

434/2579/8617

329/2060/7560

/pb 3

Performance

- **Luminosity increases by 25 % since the last MAC.**

- c.f. “Luminosity has been more than doubled since the last MAC.”

- *From K.Oide / MAC 2002*

- **Luminosity has been achieved more than 80 % of the design luminosity.**

- $L_{\text{peak}} = 8.26 \times 10^{33} \text{ /cm}^2/\text{s}$

- **Total int. luminosity reached 100 /fb.**

- “KEKB Project Leader predicted that the conservative lower limit for the monthly int. luminosity would increase to 9 /fb; the Committee agree that...”

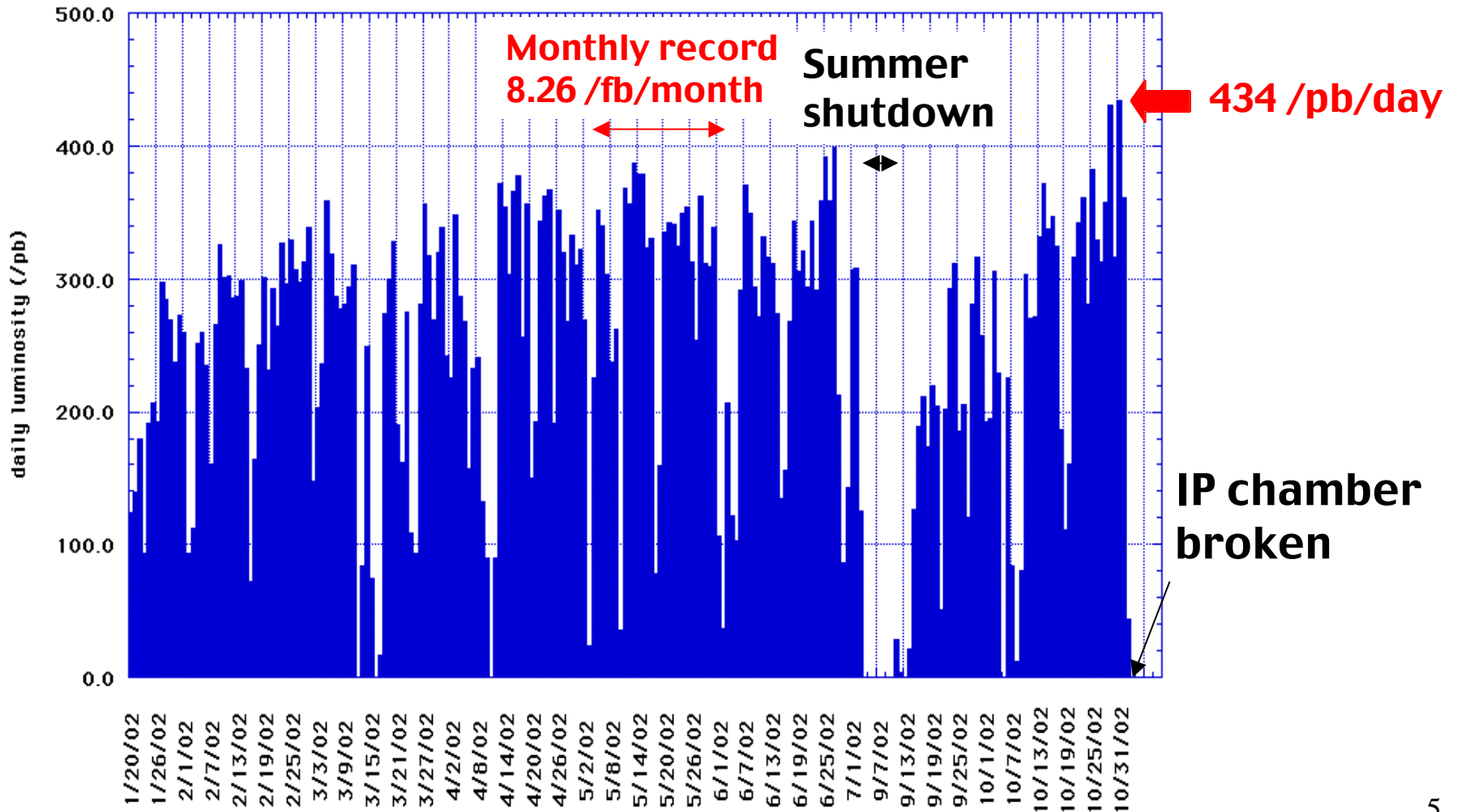
- *From recommendations / MAC 2002*

- **Monthly record = 8.26 /fb/month**

- **Yes, we can guarantee more than 9 /fb/month to Belle.**

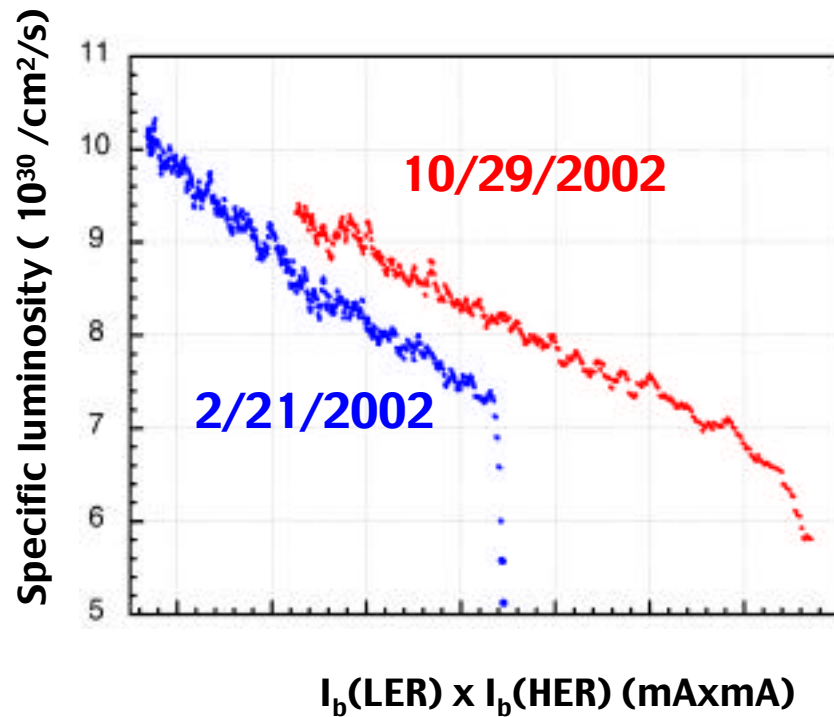
Daily Luminosity in 2002

More than 400 /pb/day !



Specific luminosity

- Specific luminosity is much improved.
- Better working point is found.



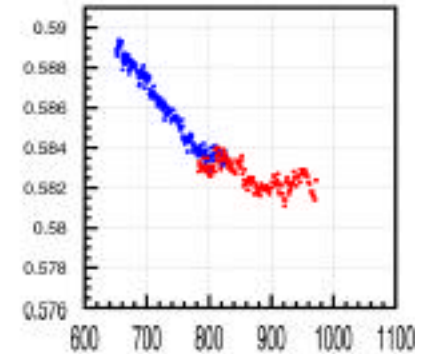
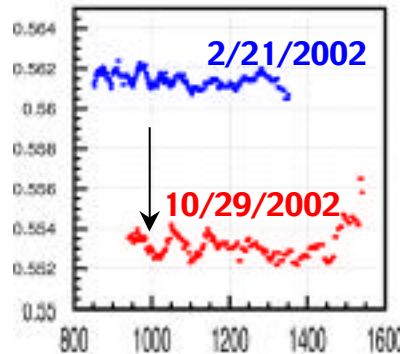
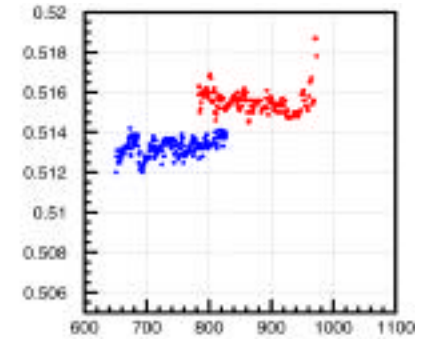
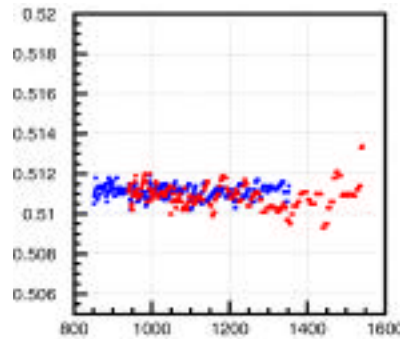
Pilot bunch tunes (off-collision)

LER

HER

Hor. Tune

Ver. tune

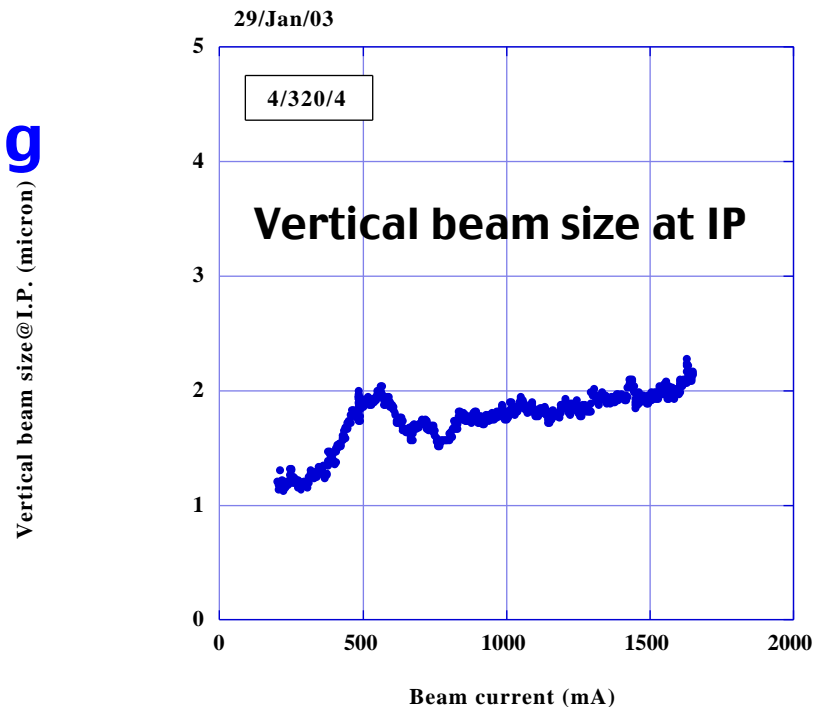


Progress

- LER current increases to **1.5 A** and HER to **1 A**.
 - RF cavities are fully installed in LER. (20 ARES)
 - HER (8 SCC + 10 (design: 12) ARES)
 - **Great success to operate SCC at 1 A !**
 - Additional solenoids for LER: 1850 m to 2275 m.
- **2-bunch injection of positrons** is applied at standard operation.
 - Integrated luminosity increases with short inj. time (e^+).
 - Bunch current monitor/equalizer is cured.
- Heating of synch. light mask at IP is cured by making cooling power strong.
- HOM (TE mode) heating of NEG cartridge near the movable masks is cured by RF shield.

LER beam size blow-up

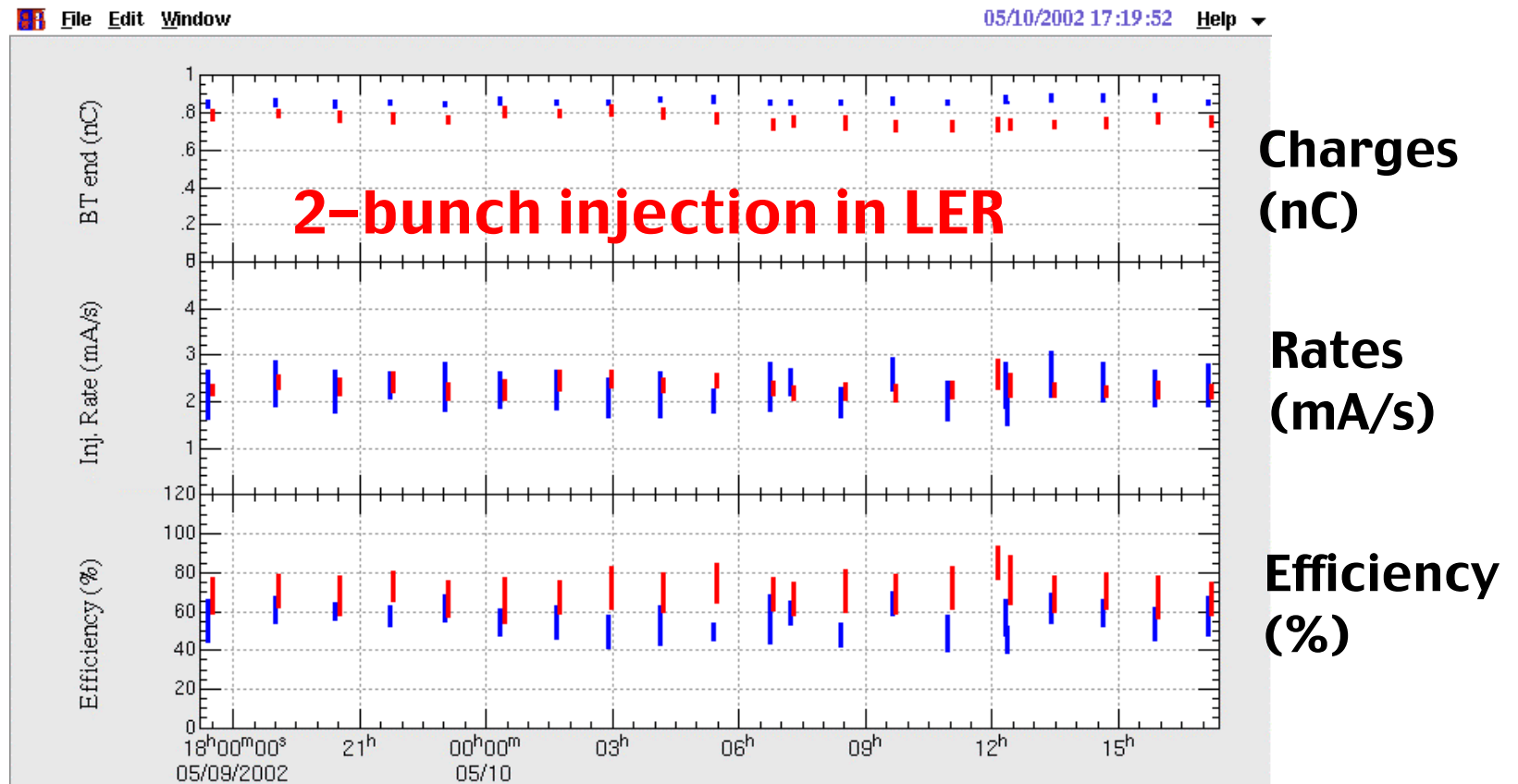
- Photoelectron cloud effect
- Solenoid windings (total = 2275 m) > 90%
- Positron beam blow-up was not observed up to 1.6 A (January 2003).
 - Single train
 - 4 bucket spacing
 - #bunch = 1224



Typical injection (24 hours)

Red bar for LER and blue bar for HER.

Bottom end shows average and top end shows max. value.



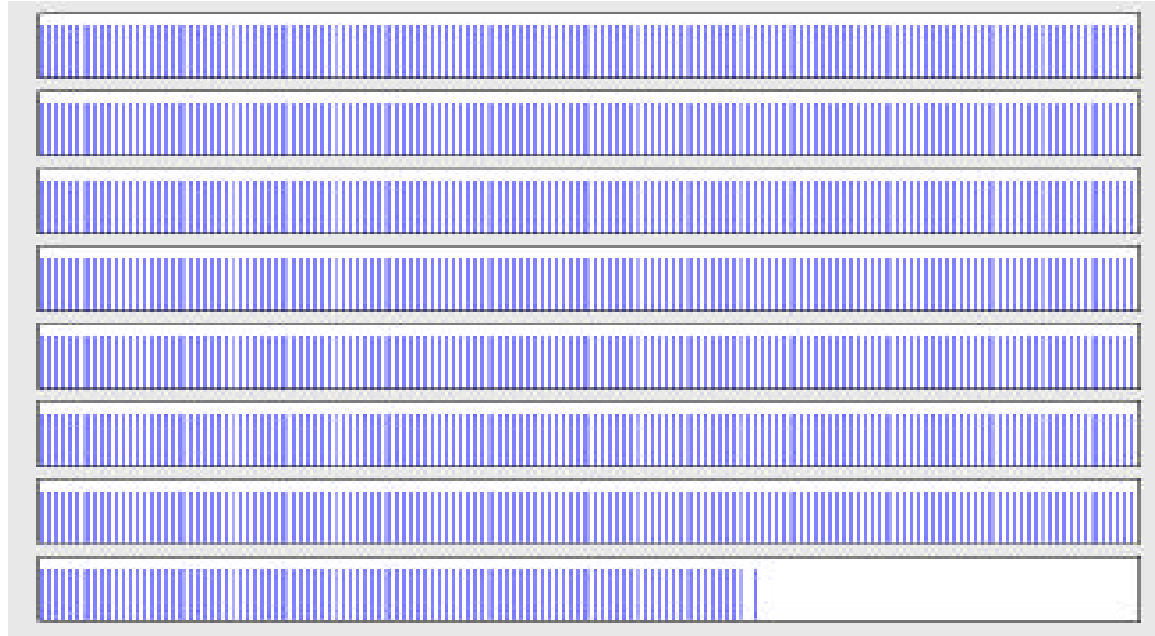
Positron injection rates are improved from 1.2 mA/s to 2.4 mA/s with 2-bunch injection.

Fill patterns

Feb 2002

1224 bunches

4-bucket spacing



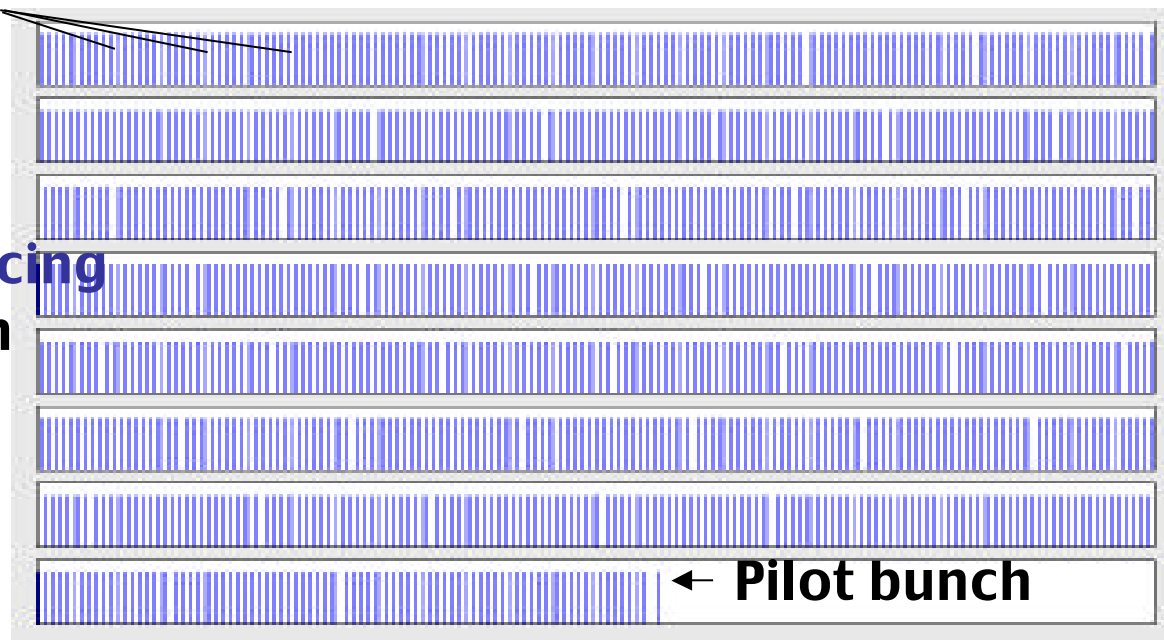
5-bucket spacing
at every 11x4 bucket

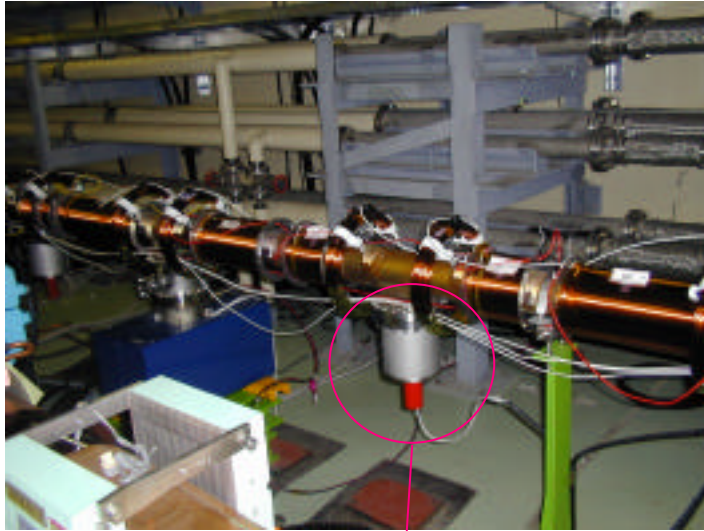
Oct 2002

1184 bunches

Pseudo 4-bucket spacing

for 2-bunch positron
injection

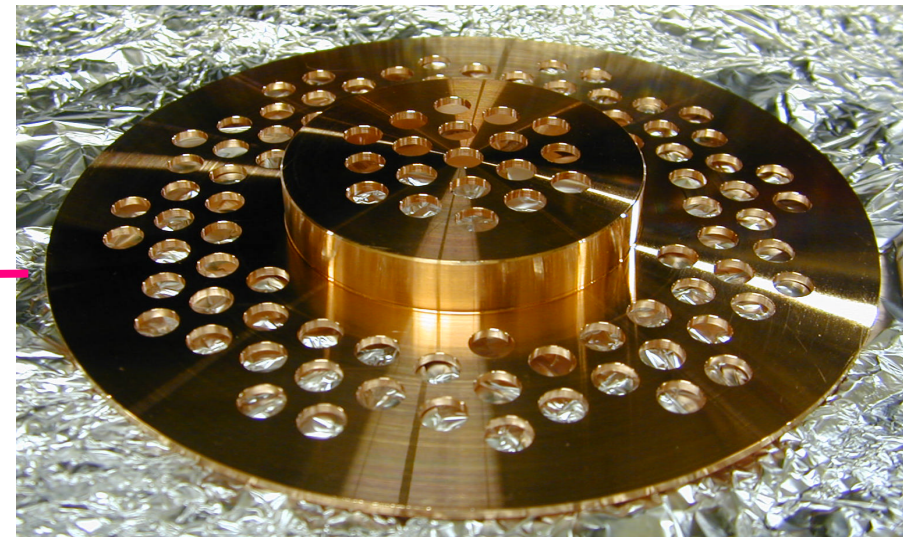
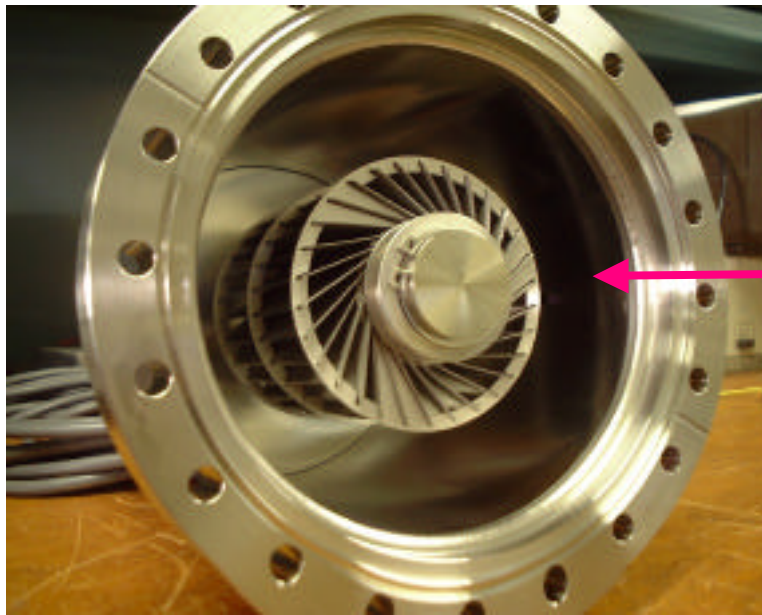




RF shield for NEG

HOM comes from Mask.
Pressure decreases by 25 %.
Temperature is 30 °C lower.
Allows continuous injection

NEG-port shield



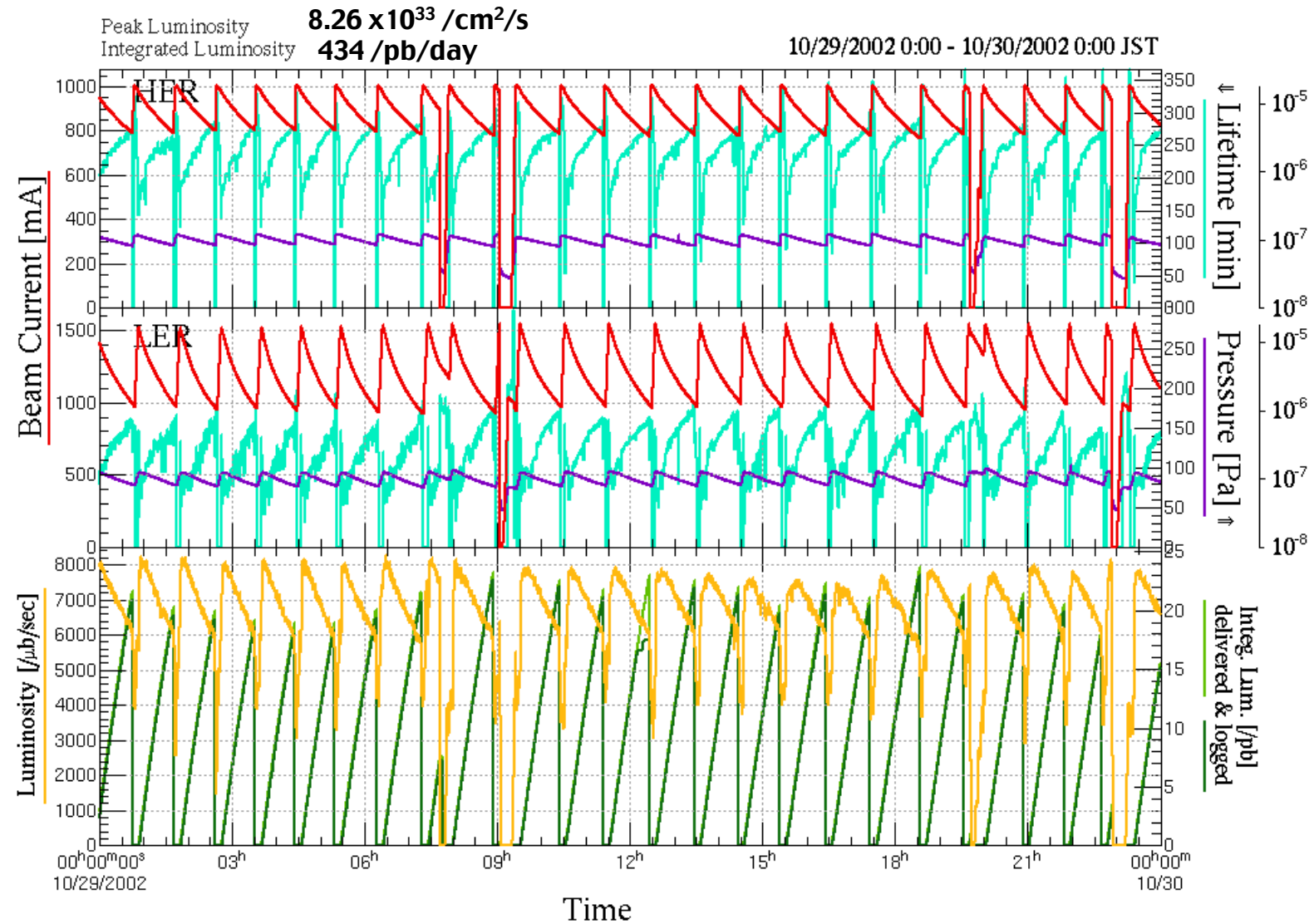
NEG port

* NEG: Non Evaporable Getter (SAES)

Progress (cont'd)

- **KEKB is ready for continuous injection.**
 - HOM heating at NEG is cured by RF shields.
 - Waiting for Belle trigger system upgrade.
- **Abort chamber was redesigned and installed.**
 - Vacuum leak was sometimes occurred at abort chamber. (Aborted beam hits the chamber.)
 - New abort chamber has larger aperture .

Best luminosity run of the day

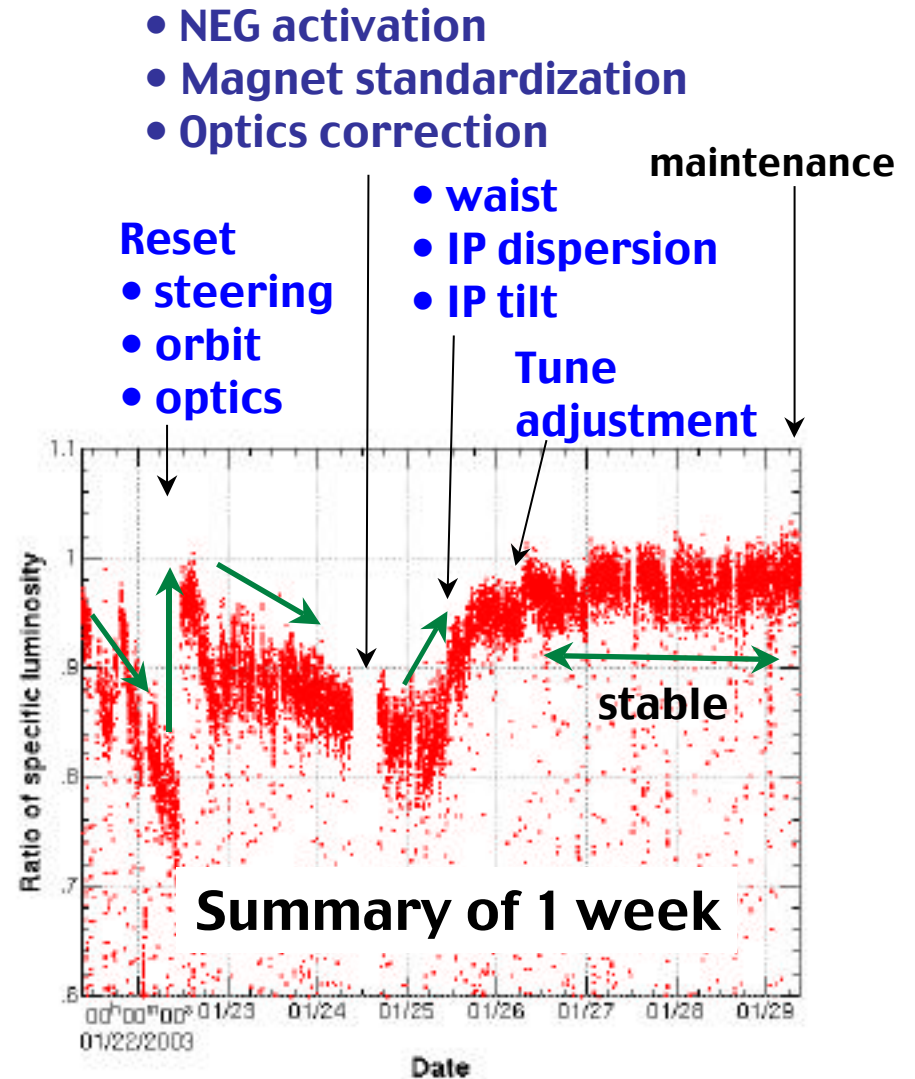


Operation stability

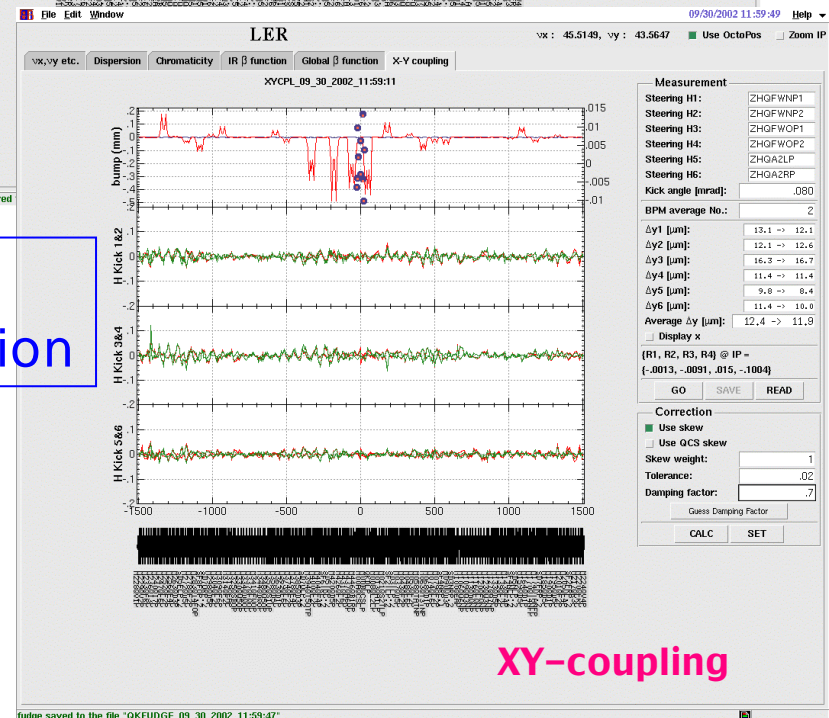
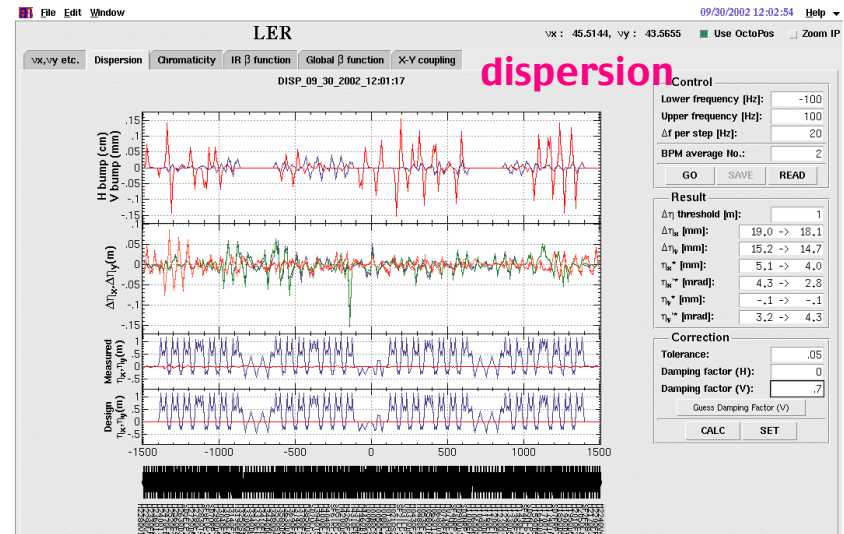
1. Optics measurement and correction
2. Betatron tune management
 - gated tune meter/programmable tune changer
3. Collision feedback
 - iBump feedback (collision orbit optimization)
 - beam size / lifetime feedback for horizontal offset at IP (optimization by experiences)
 - iSize feedback (beam size optimization)
4. Luminosity tuning : Establishment of knobs
 - Adiabatic tuning of waist (s^*) / IP dispersion (y^* , y'^*) / IP tilt (r_1, r_2, r_3, r_4)
5. Circumference adjustments with COD correction
6. Injector linac : beam quality control
 - optics measurement using wire scanner / energy feedback / orbit feedback, etc.

Stability of specific luminosity

- Luminosity sometimes degrades gradually.
- Luminosity comes back with setting steering, gold orbit, optics when luminosity was good.
- Luminosity also comes back with adiabatic tuning(waist, IP disp., IP tilt, tunes) after optics correction.



Optics measurement and correction

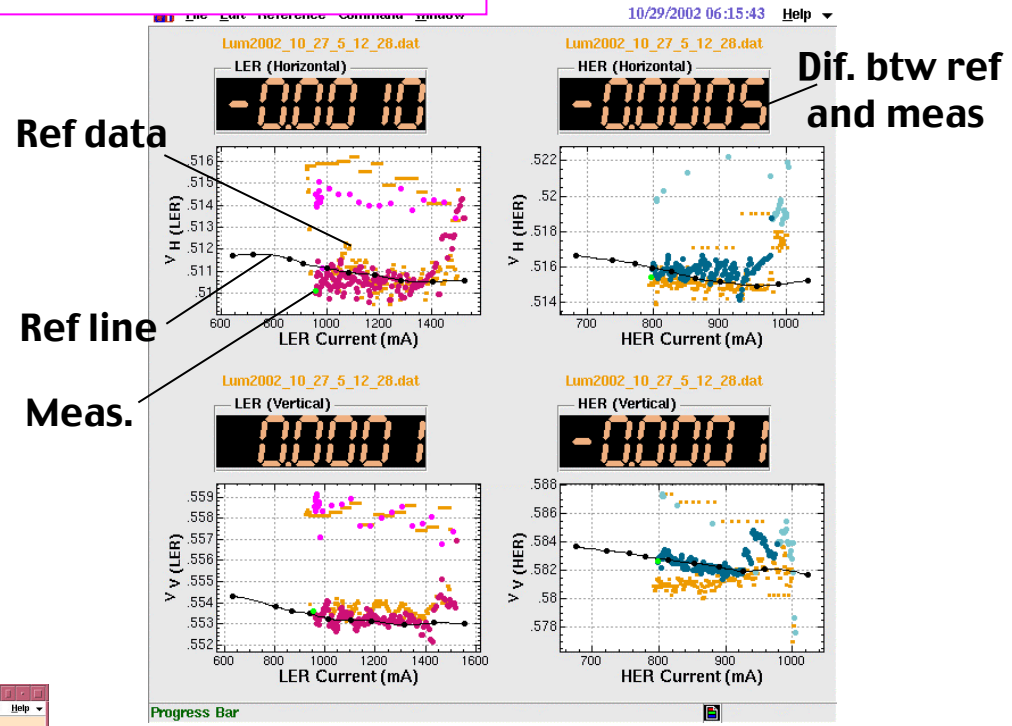
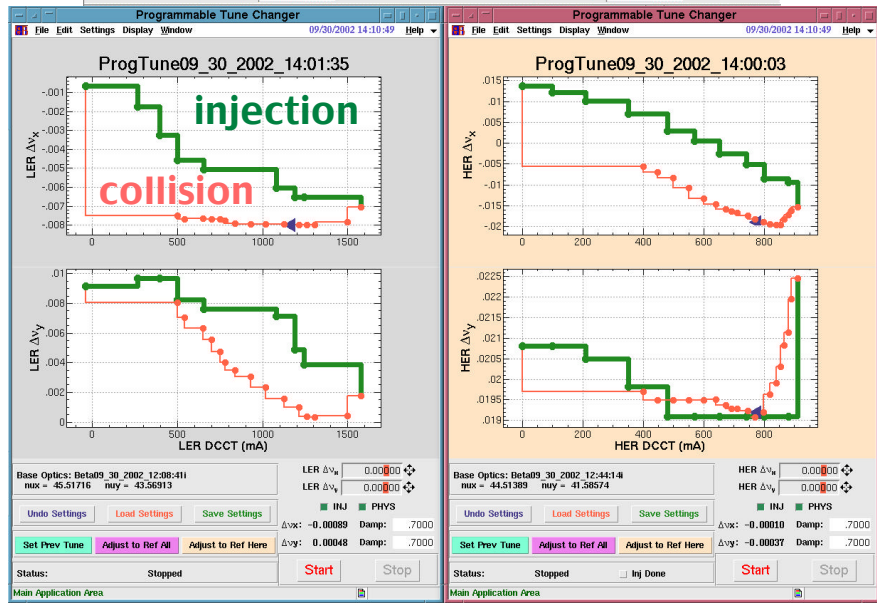
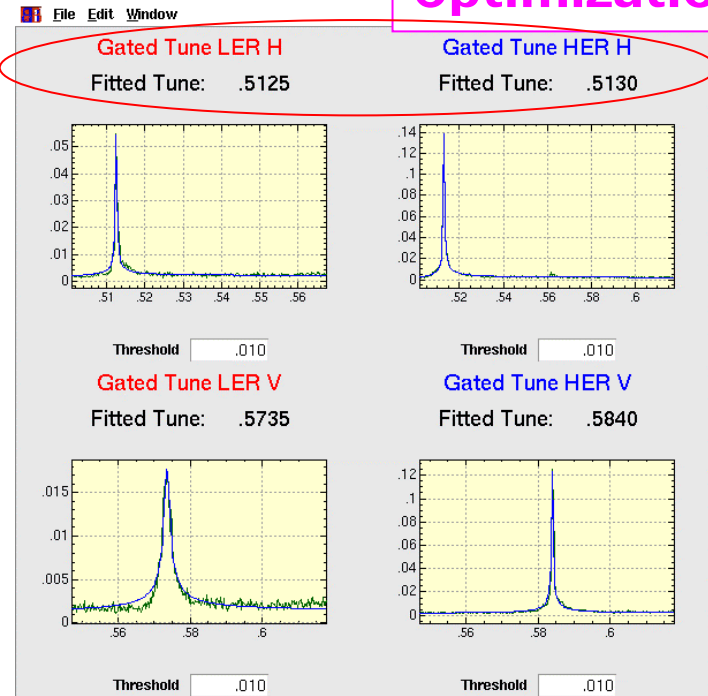


Interactive procedure of measurement + analysis + correction

Knobs:
 Local bumps at sextupoles
 Fudge factors for quads/skews

Works very well !

Optimization of betatron tunes



1. Pilot bunch is monitored by gated tune meter.
Off-collision / No BxB FB
2. Tune patterns as a function of beam current
3. Horizontal tunes close to the half integer

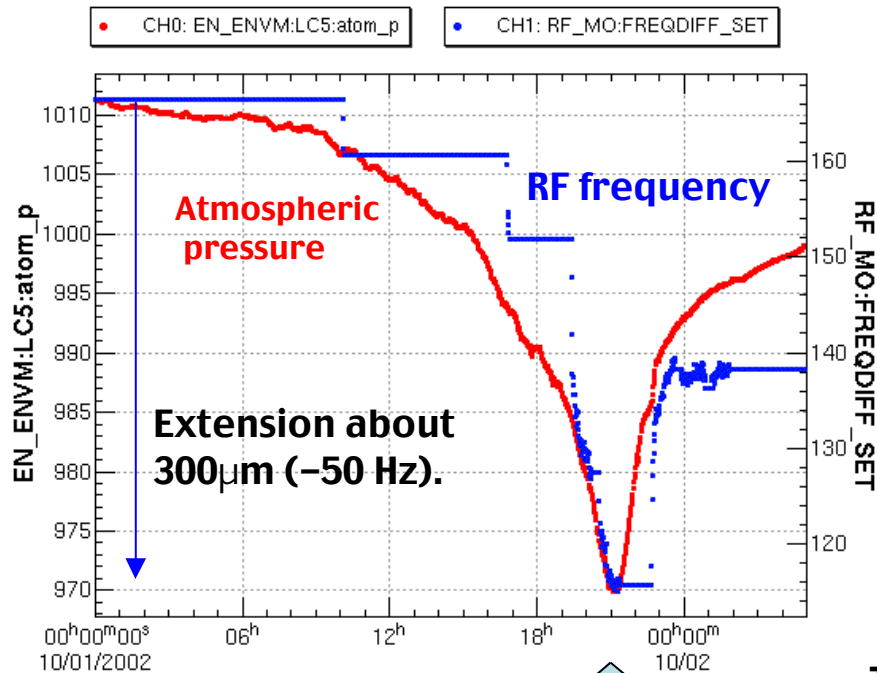
Good control/manage of tunes !

Circumference adjustment

Circumferences are adjusted by RF frequency with looking at HER orbit.
 LER has an independent knob to adjust circumference with “Chicane”.
 Orbit correction (CCC) applies circumference correction simultaneously.

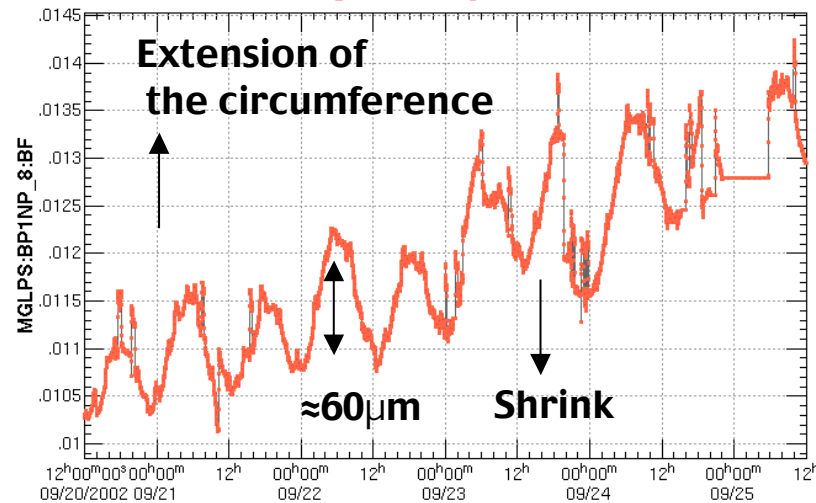
$$\frac{C}{C} = -\frac{f}{f} \quad \frac{C}{C} = \alpha \frac{p}{p} = \alpha \frac{x}{\eta}$$

knob measurement



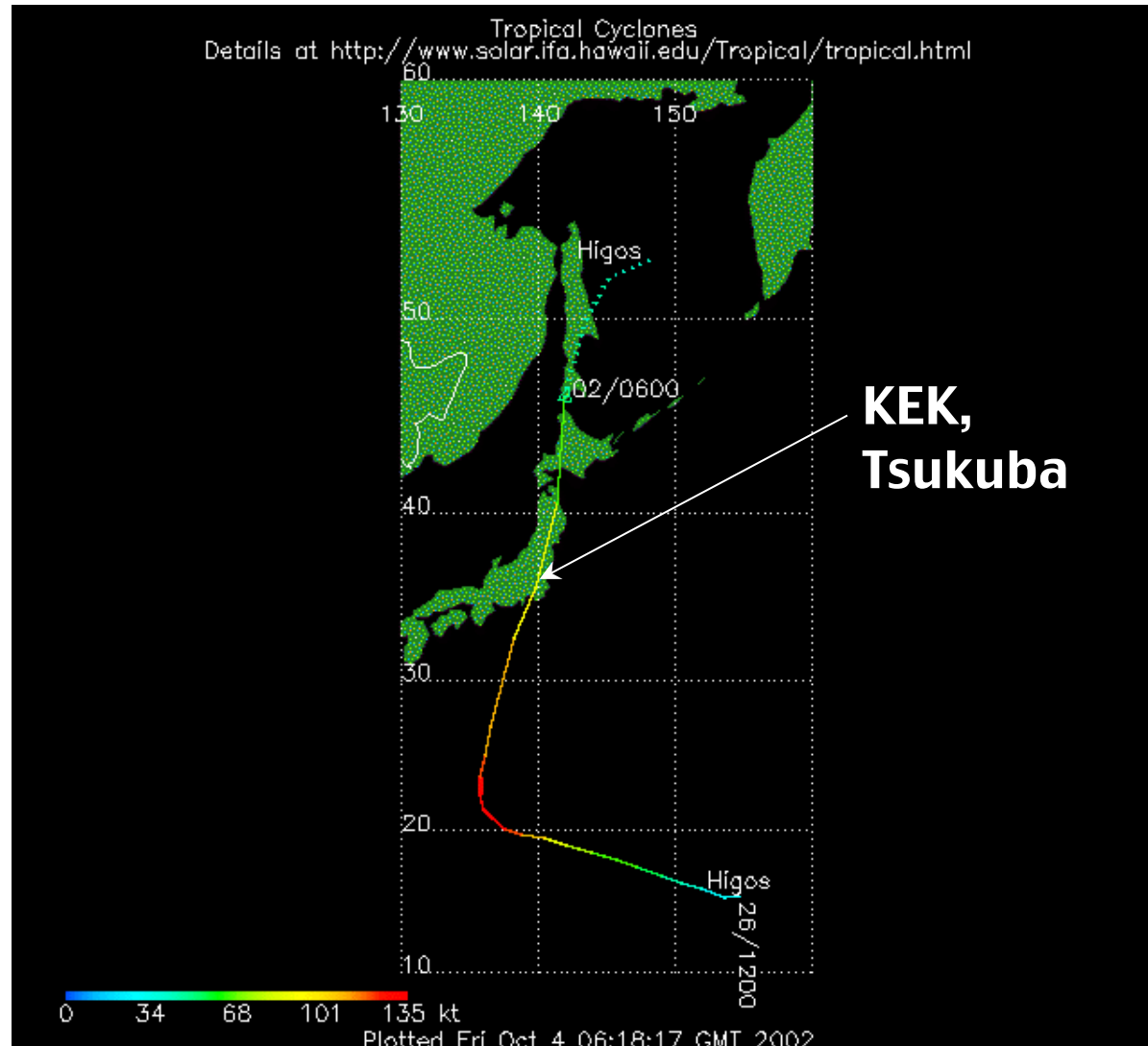
Typhoon #21 (970 hPa)
 (9 p.m. October 1, 2002)

**Bending angle of the chicane
 (LER circumference adjustment
 w/o RF frequency)**

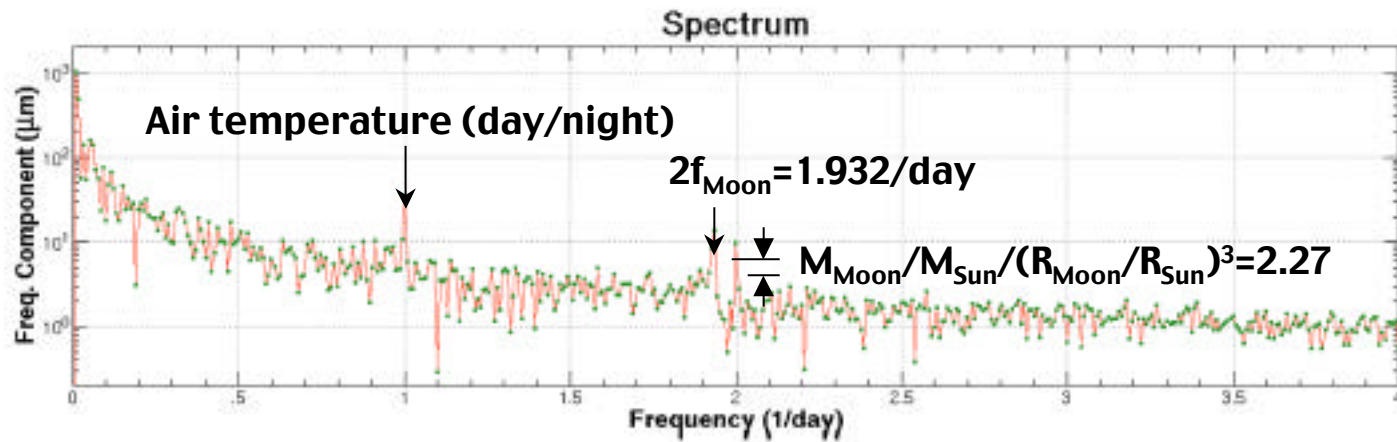
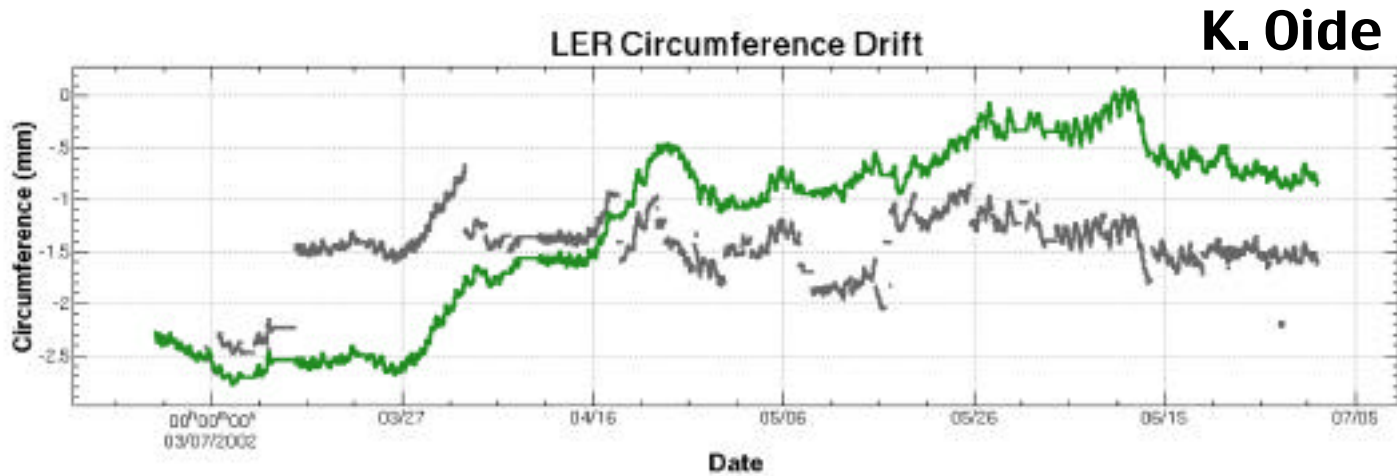


**This behavior is consistent with tidal effect.
 We observe tidal effect by ground motion ??**

Path of Typhoon #21 (October, 2002)



Circumference drift (long term)



Present status

- **Physics run starts in January 2003.**
 - **Total beam current is now limited to 2.2 A** (from Belle).
 - **Condition is good. More than 300 /pb/day**
 - **We plan to increase currents gradually with checking I.P chamber.**

To Do List

- **Replacement of SVD/IP chamber** during summer shutdown.
- **Continuous injection**
- **3.5 bucket spacing** or less than 3 bucket spacing
- **Increase HER to 1.1 A** (design).
- **Increase LER** as long as luminosity increases.

Long term plan

- **Test of ante-chamber/new bellows**
- **Test of C-band accelerating structure for e^+ to energy upgrade**
- **Test of 3.5 GeV e^- in LER**
(Need change polarity)
- **Test of crab crossing in 2005**
 - 1 cavity at Nikko section in HER

Next milestone

- **Design luminosity : 10^{34} /cm²/s**
- **100 /fb/year**

