Commissioning Progress since October 2007

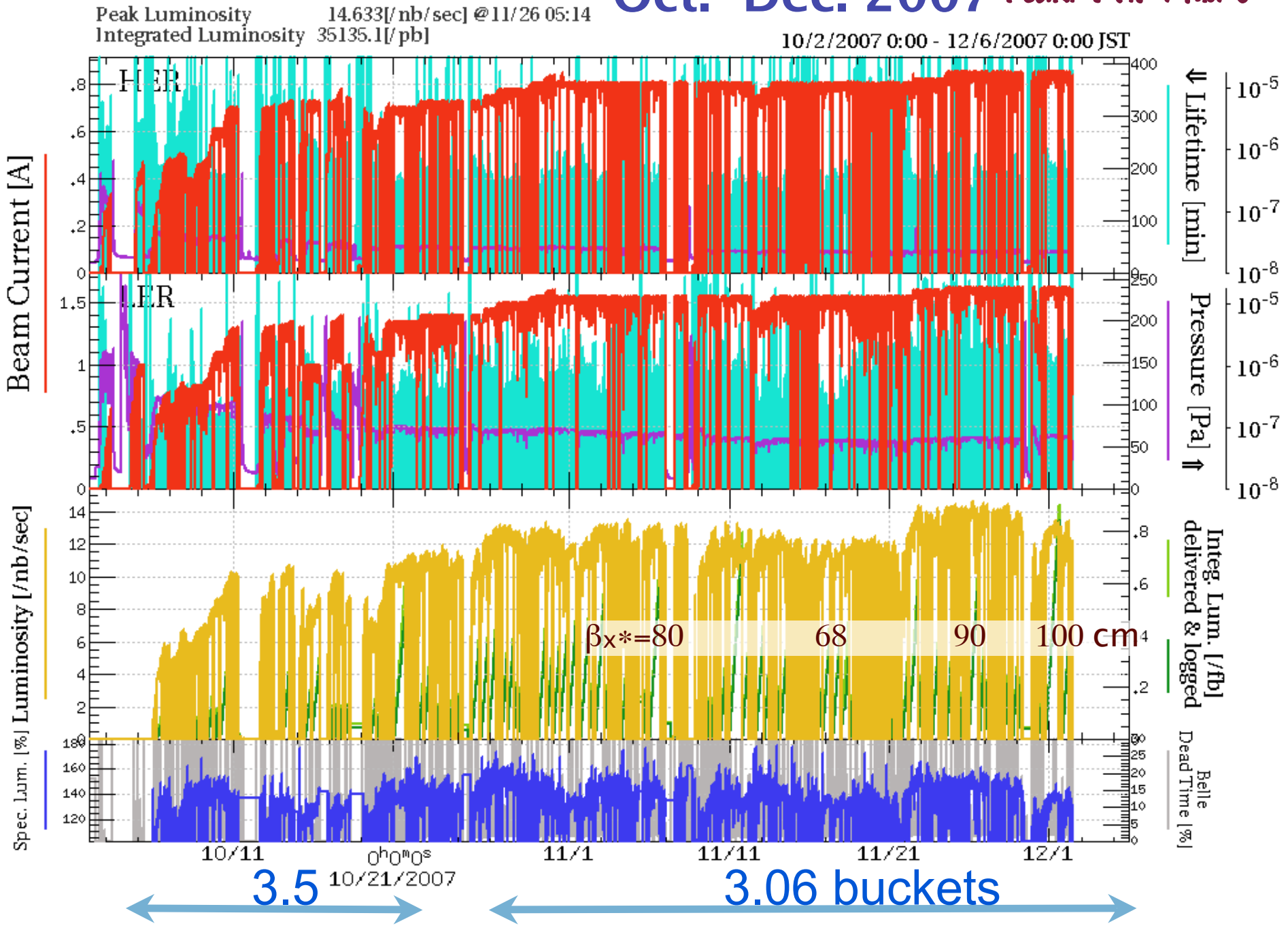
13th KEKB Accelerator Review
Dec. 03, 2007

Haruyo Koiso

Progress

- Higher beam currents with Crab ON.
  - 1300 → 1620 mA (LER), 700 → 850 mA (HER)
- Shorter bunch spacing, more bunches.
  - 3.5 buckets (1389 bunches) → 3.27 (1485) → 3.06 (1585)
- Adjust βx^*
  - 80 → 68 → 90 → 100 cm (both rings)
- Simplex knob scan

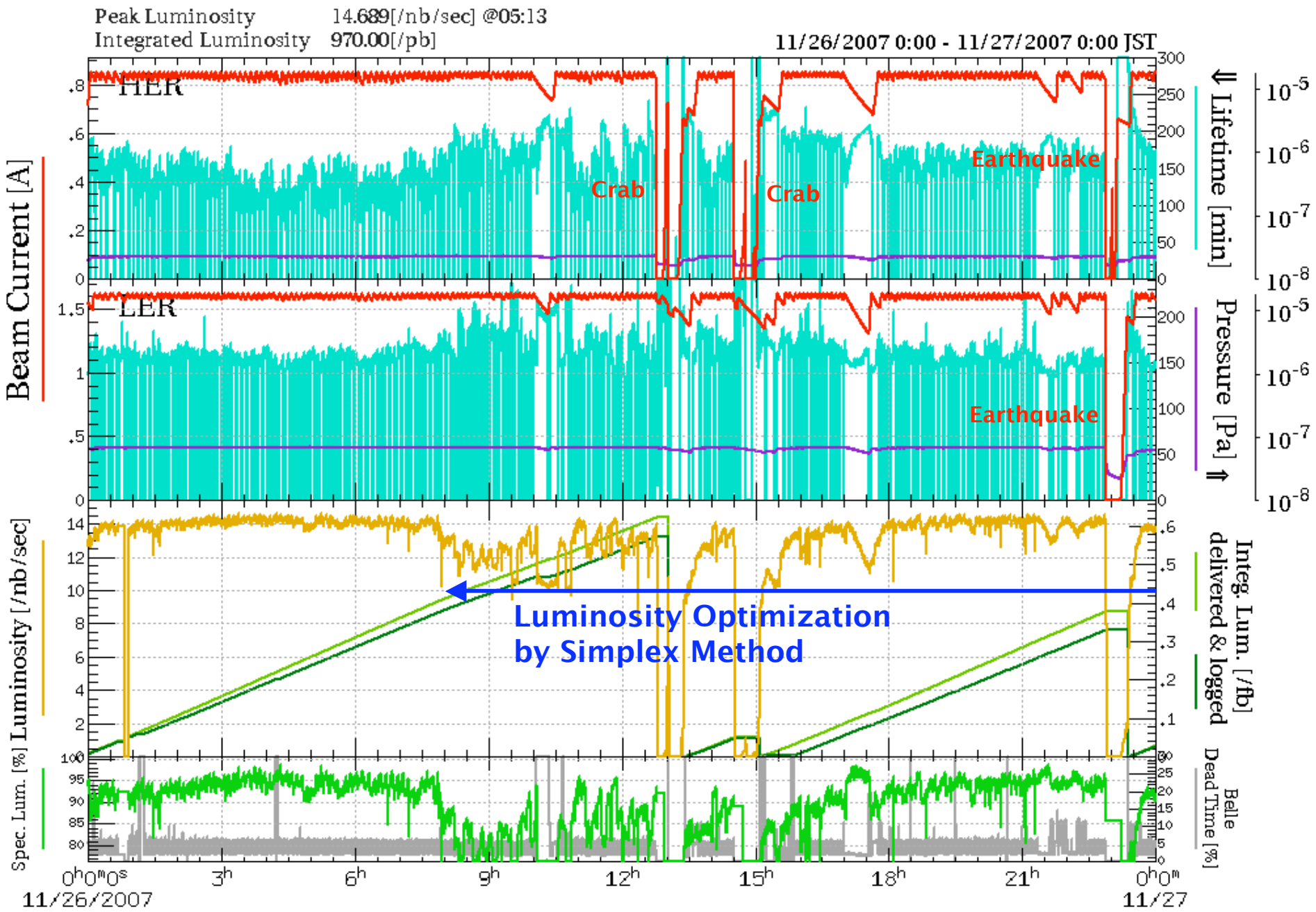
Oct.–Dec. 2007 Peak: 14.7 /nb/s



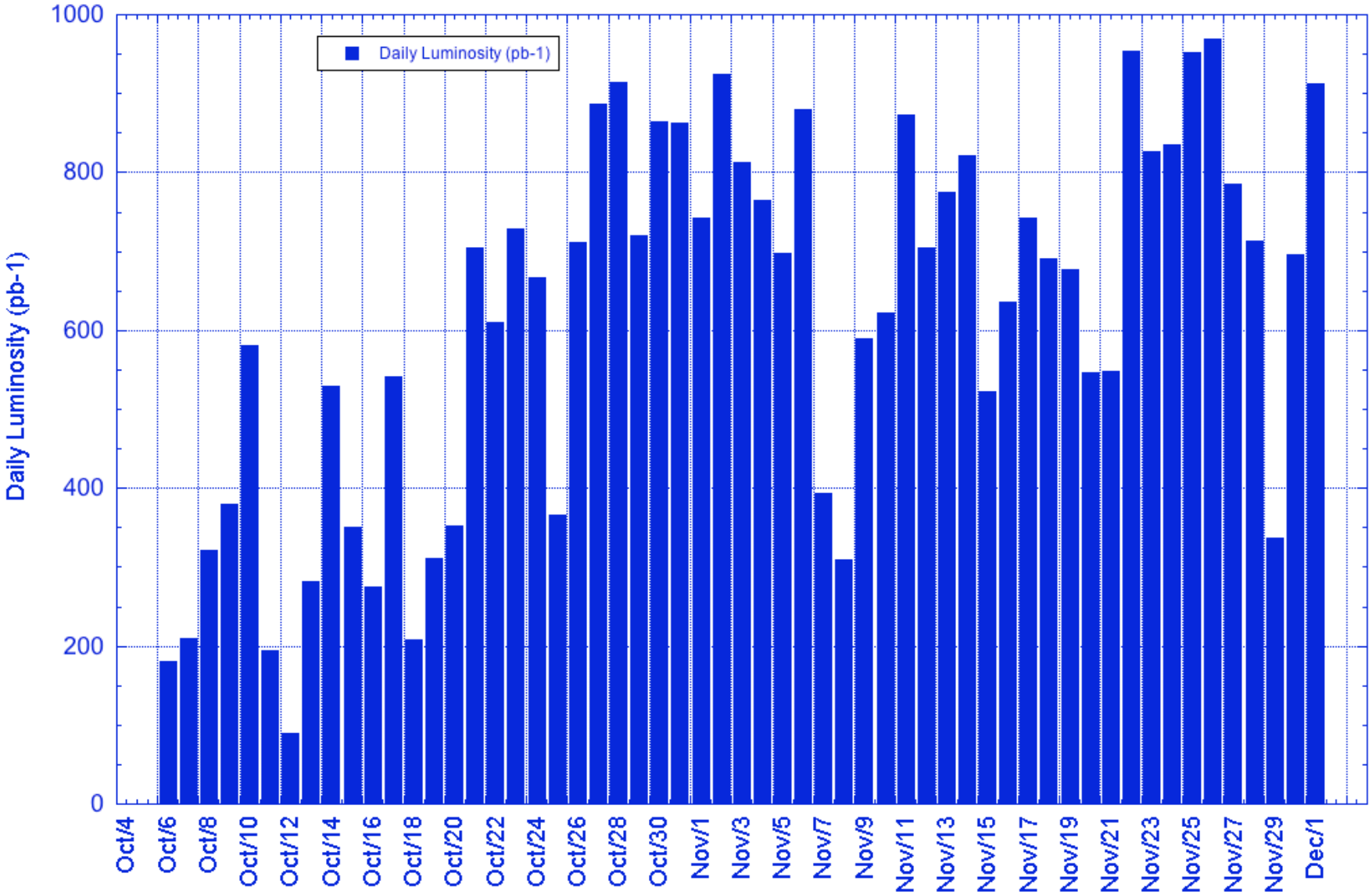
Operation History

- Oct. 2 Beam operation started with Crab OFF.
- Oct. 5 Collision started with Crab ON (0.875(LER) / 1.45(HER) MV). 3.5 rf bucket spacing, 1389 bunches.
  - Oct. 13 Crab voltage scan with 100 bunches.
  - Oct. 22 Knob Optimization by Downhill Simplex Method was put in practical use.
- Oct. 24 3.27 rf bucket spacing, 1486 bunches.
- Oct. 26 3.06 rf bucket spacing, 1585 bunches.
  - Nov. 8 Green Ratio was introduced.
- Nov. 12 βx^* 80 → 68 cm
  - Nov. 19 Crab voltage scan with high currents.
- Nov. 21 βx^* 90 cm
- Nov. 26 Peak luminosity 14.689/nb/s
- Nov. 29 βx^* 100 cm (0.783 (LER) / 1.297 (HER) MV).

Best Day with Crab Cavities (Nov. 26)

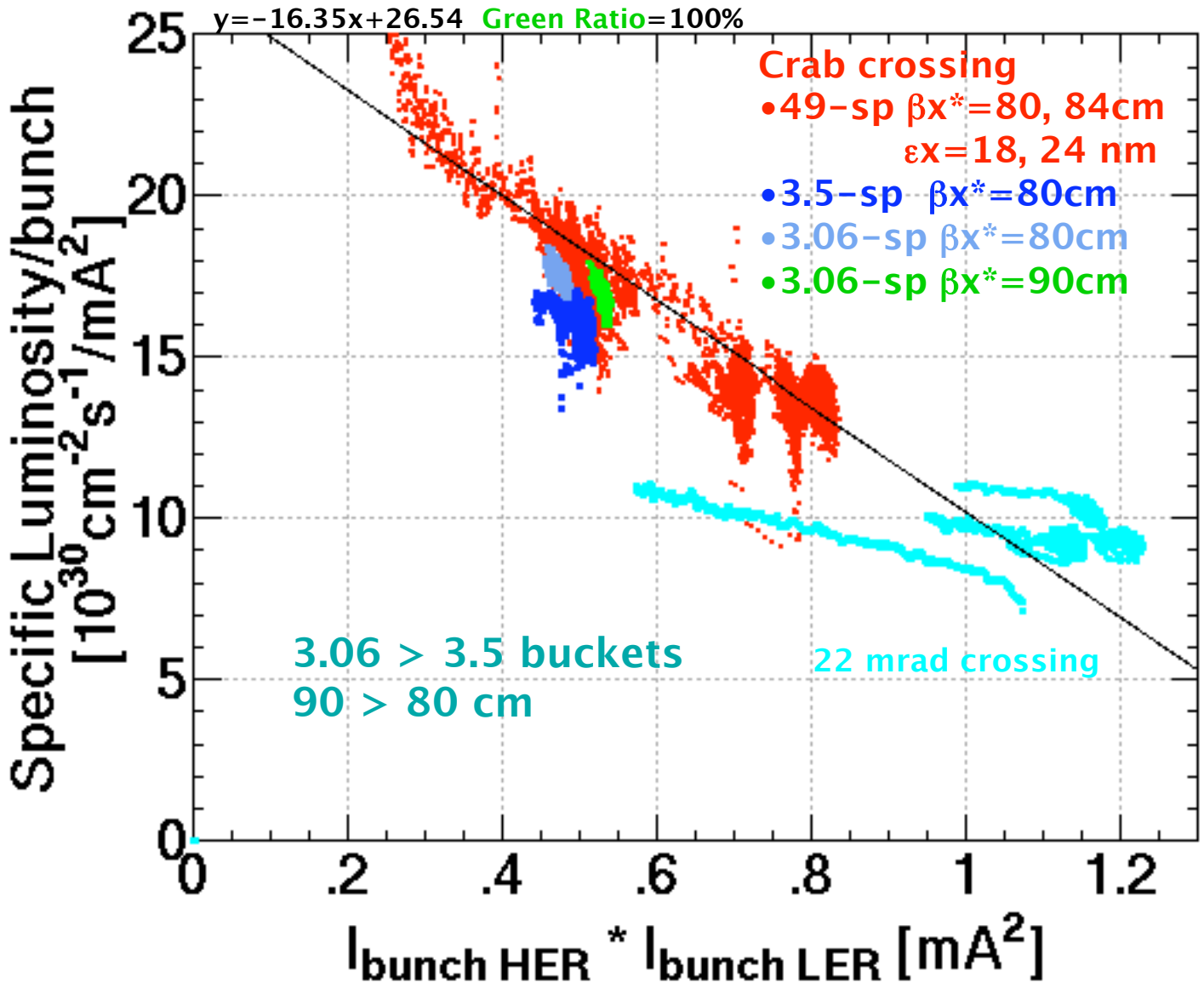


Daily Luminosity

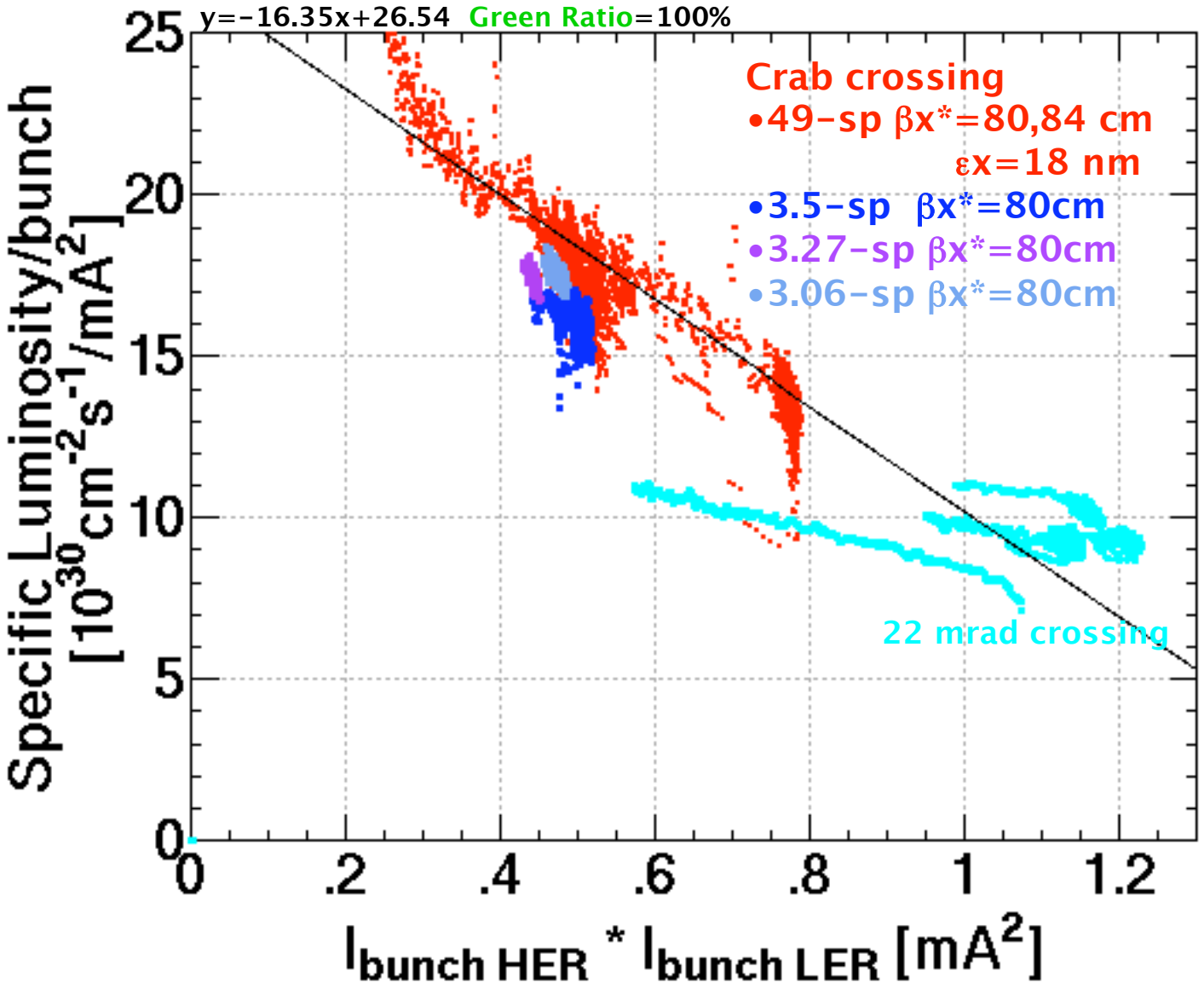


We must obtain 710/pb/day to achieve 800/fb till March 31, 2008.

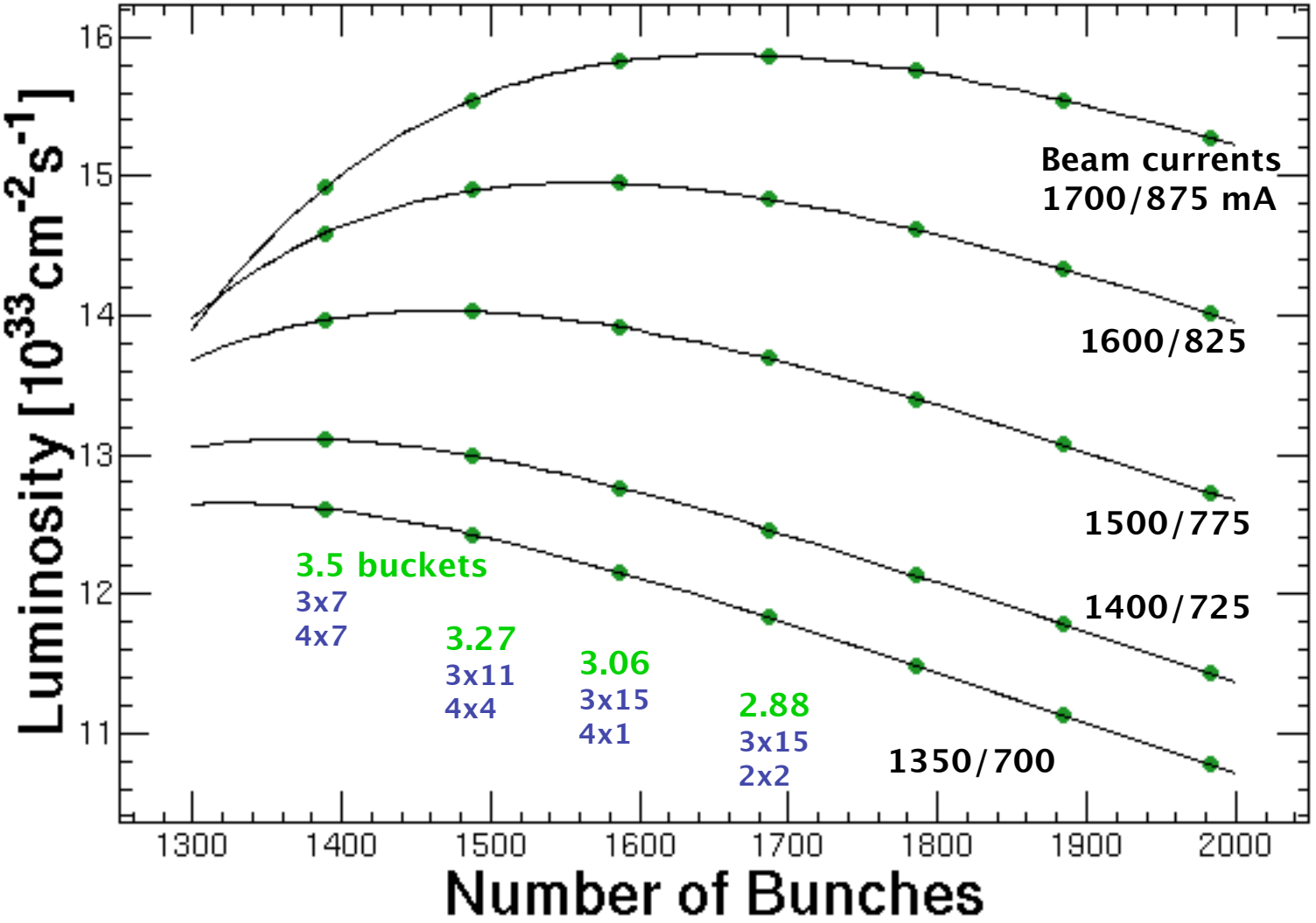
Specific Luminosity



Specific Luminosity



Luminosity (estimated)



The specific luminosity is assumed to be on the line Green Ratio=1.

Machine Parameters (Nov. 28 2007)

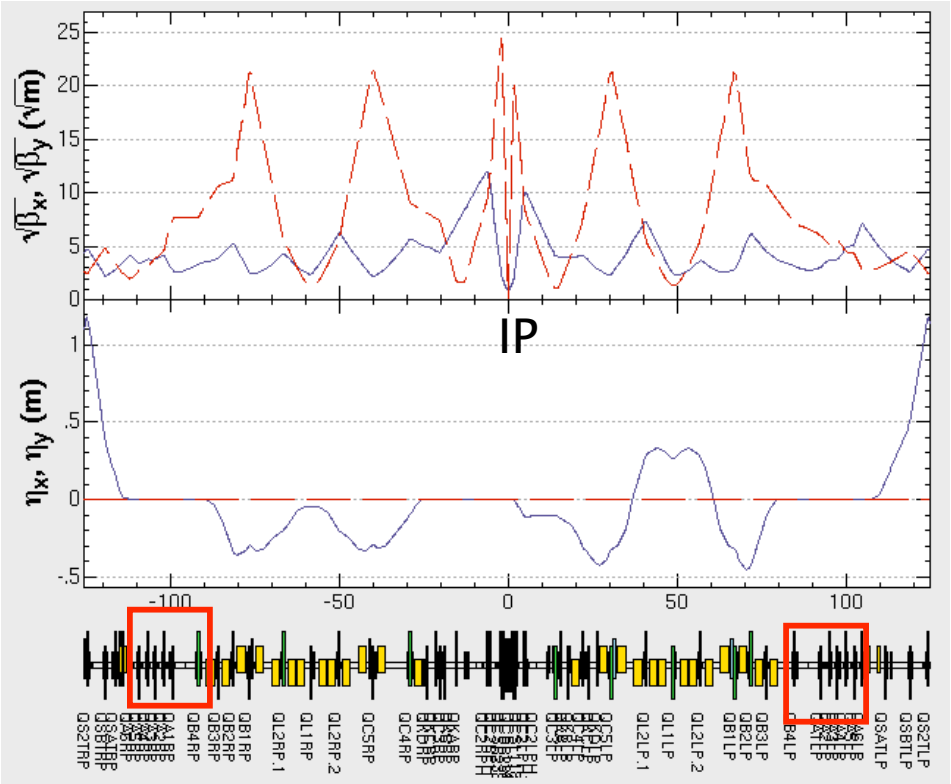
	LER	HER	
Circumference	3016		m
RF Frequency	508.88		MHz
Horizontal Emittance	18	24	nm
Beam current	1582	839	mA
Number of bunches	1584		
Bunch current	0.998	0.530	mA
Bunch spacing	2.1		m
Bunch trains	1		
Total RF volatage Vc	8.0	13.0	MV
Synchrotron tune ν_s	-0.0246	-0.0204	
Betatron tune ν_x / ν_y	45.506/43.570	44.511/41.590	
beta's at IP β_x^* / β_y^*	90/0.59	90/0.59	cm
momentum compaction α	3.31×10^{-4}	3.38×10^{-4}	
Estimated vertical beam size at IP σ_y^*	1.1	1.1	μm
beam-beam parameters ξ_x / ξ_y	0.089/0.093	0.098/0.088	
Beam lifetime	150@1600	132@839	min.@mA
Luminosity (Belle CsI)	14.60		$10^{33}/cm^2/sec$
Luminosity records per day / 7days/ 30days	1.232/7.809/30.21		/fb

This is almost equal to the value achieved at collision with longer bunch spacing.

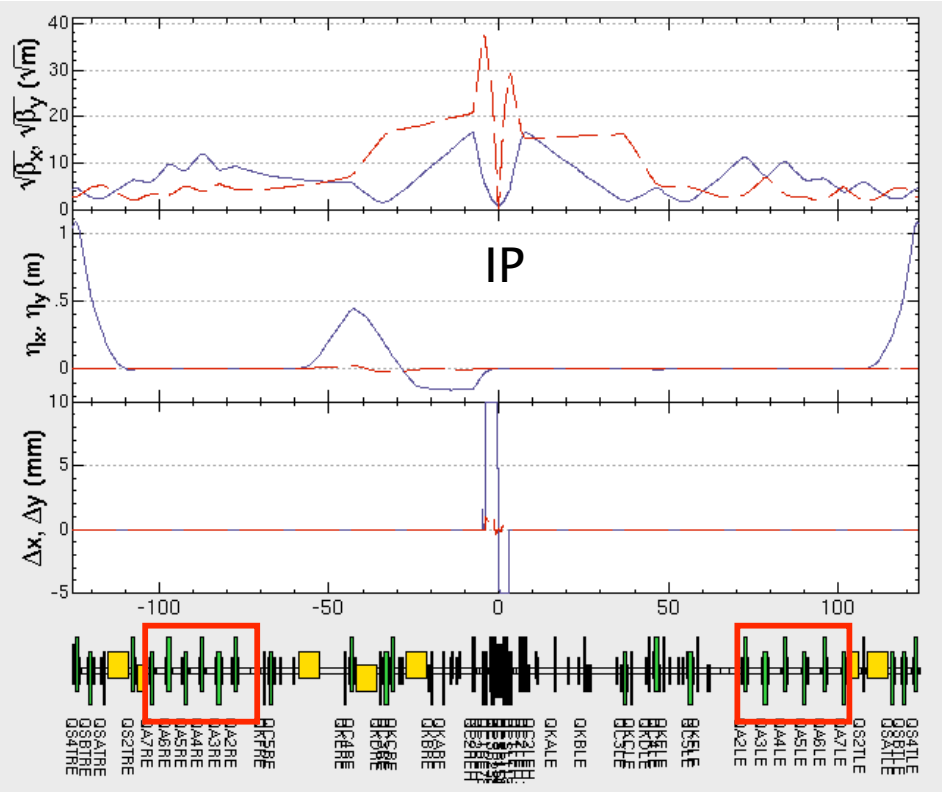
Effects of high current and short spacing are not so big?

IR Optics

LER

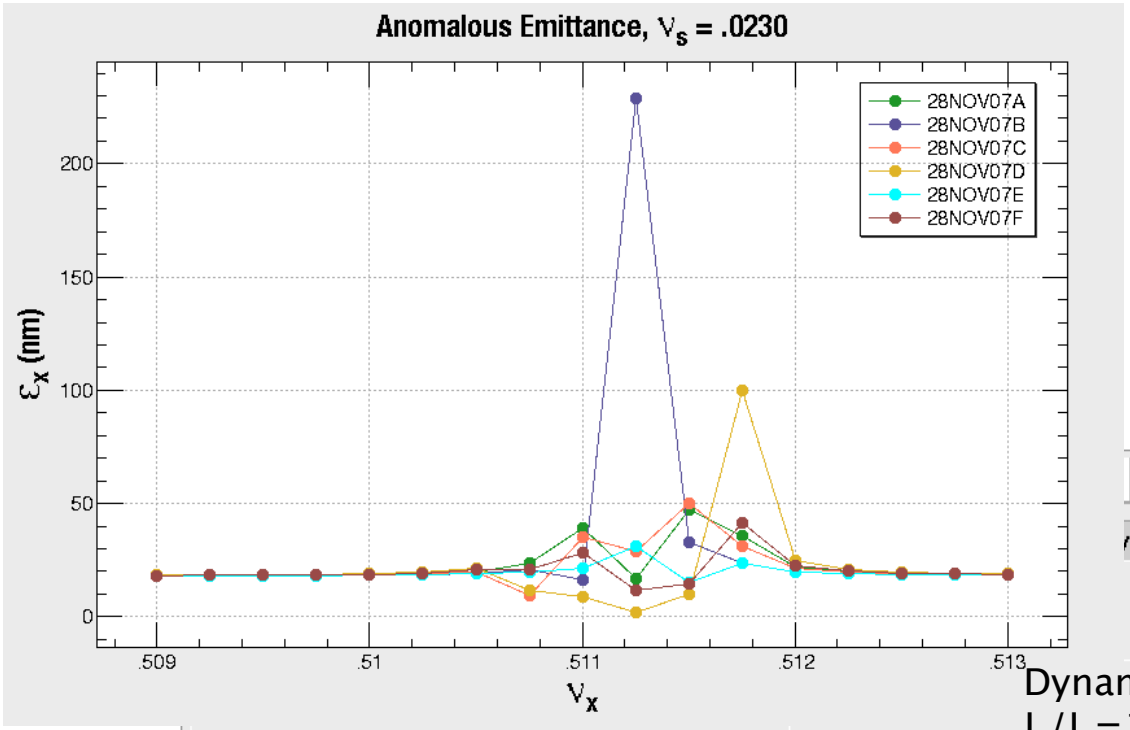


HER



$\beta_{x,y}^*$ can be adjusted by using only 7 (LER)/6 (HER) quadrupoles on each side of IP.

Estimation of dynamic aperture and emittance growth (LER)



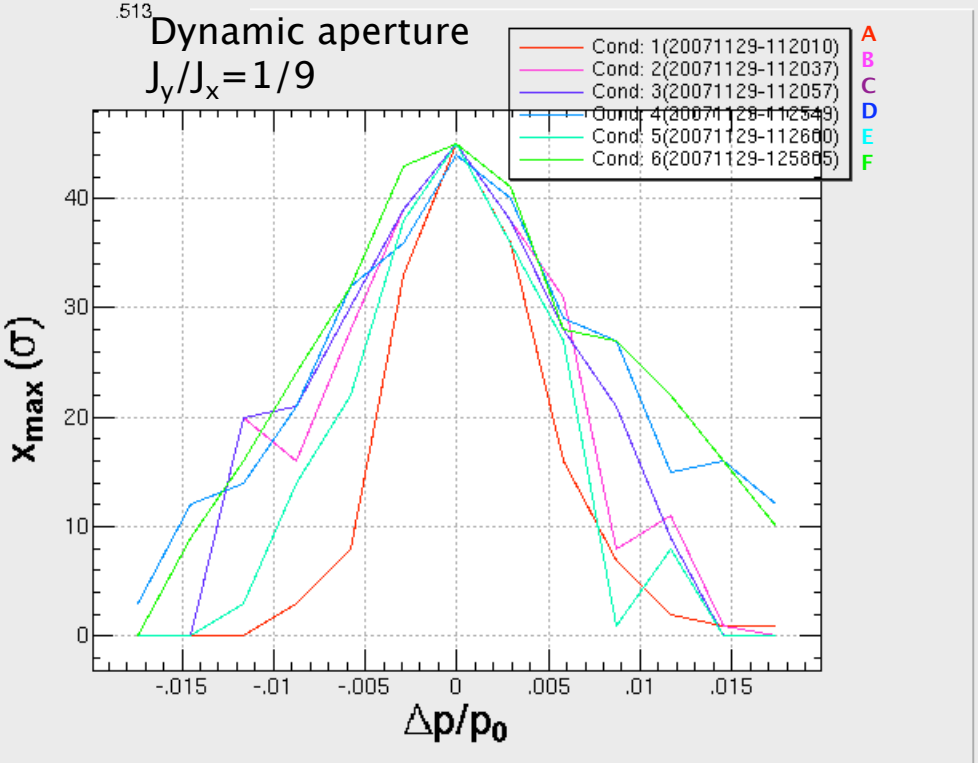
1	Done	071129-112010	2007/11/28NOV07A
2	Done	071129-112037	2007/11/28NOV07B
3	Done	071129-112057	2007/11/28NOV07C
4	Done	071129-112549	2007/11/28NOV07D
5	Done	071129-112600	2007/11/28NOV07E
6	Done	071129-125805	2007/11/28NOV07F

Survey Condition

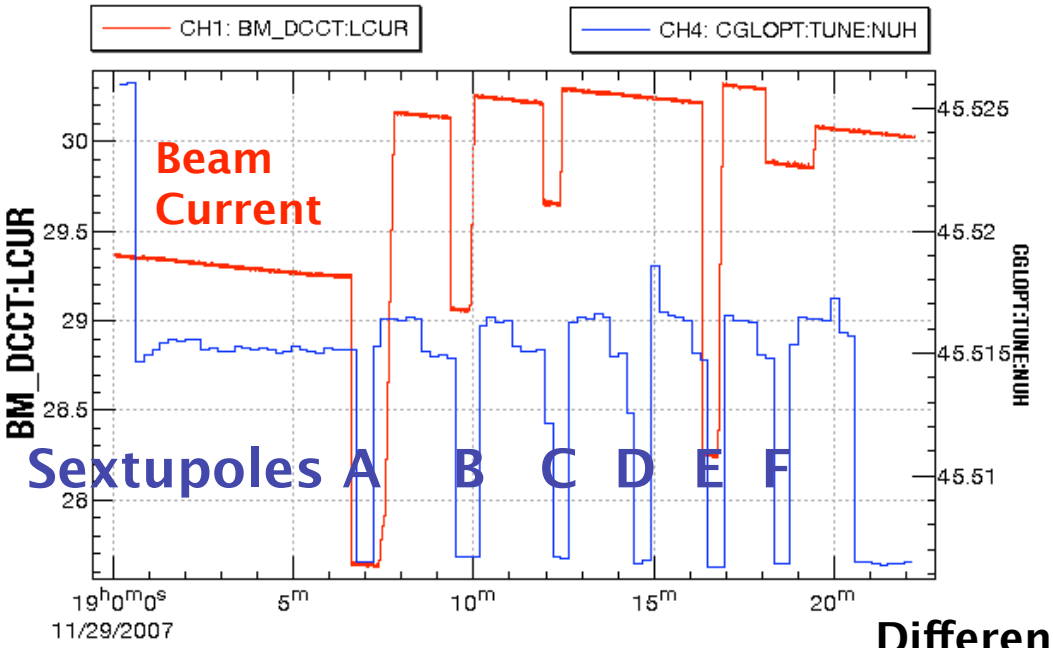
x range min	0	max	50
y range min	0	max	16.7
z range min	-24	max	24
Radiation Dumping		step	4
		Turns	1000

Default | Read Condition | Start New Survey | Break | Restart | Read Optics | Show Result

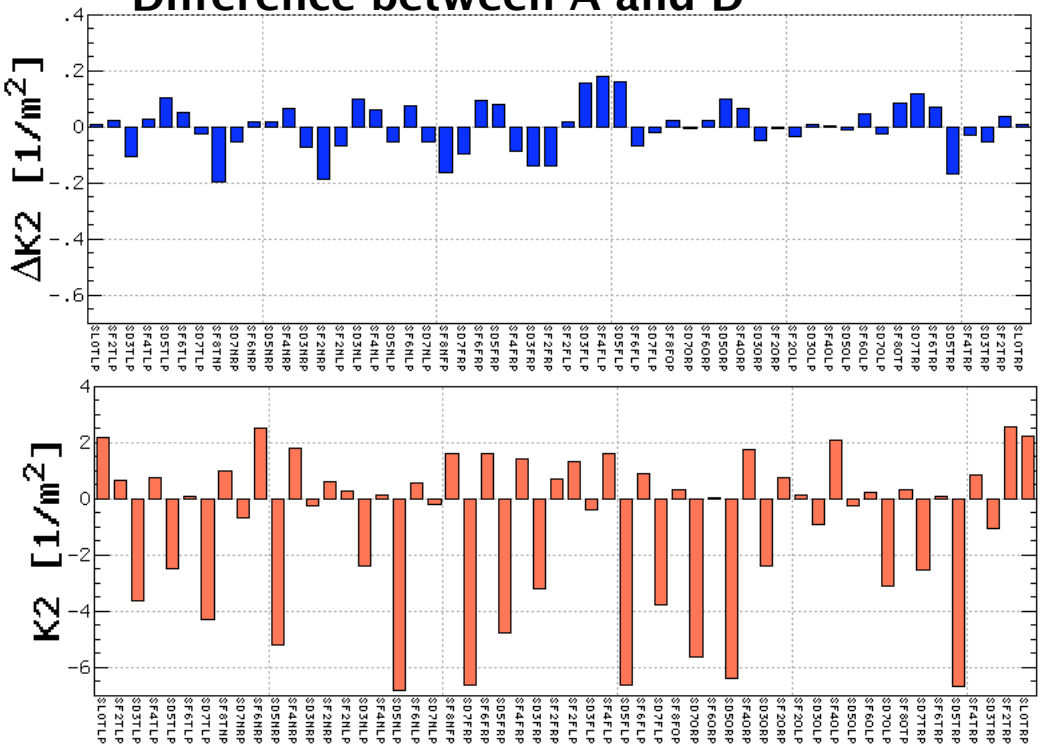
Dynamic aperture
J_y/J_x=1/9



Beam Loss at Tune Jump (LER)



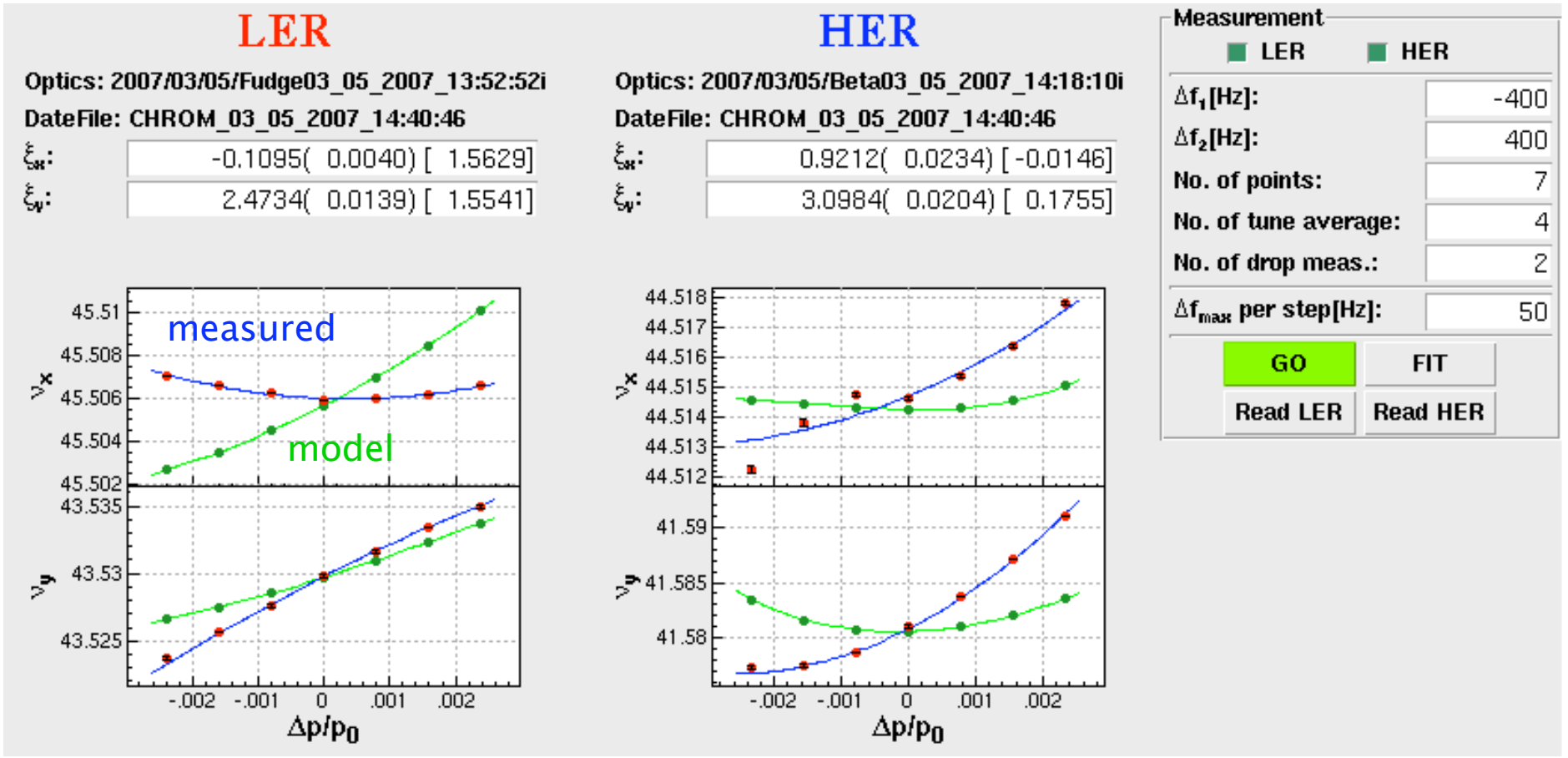
Difference between A and D



Changed from νx=0.516 to 0.506.
νx=.512 is on 2νx+νx=integer.

"D" was adopted.

Chromaticity Measurement (Mar. 05)



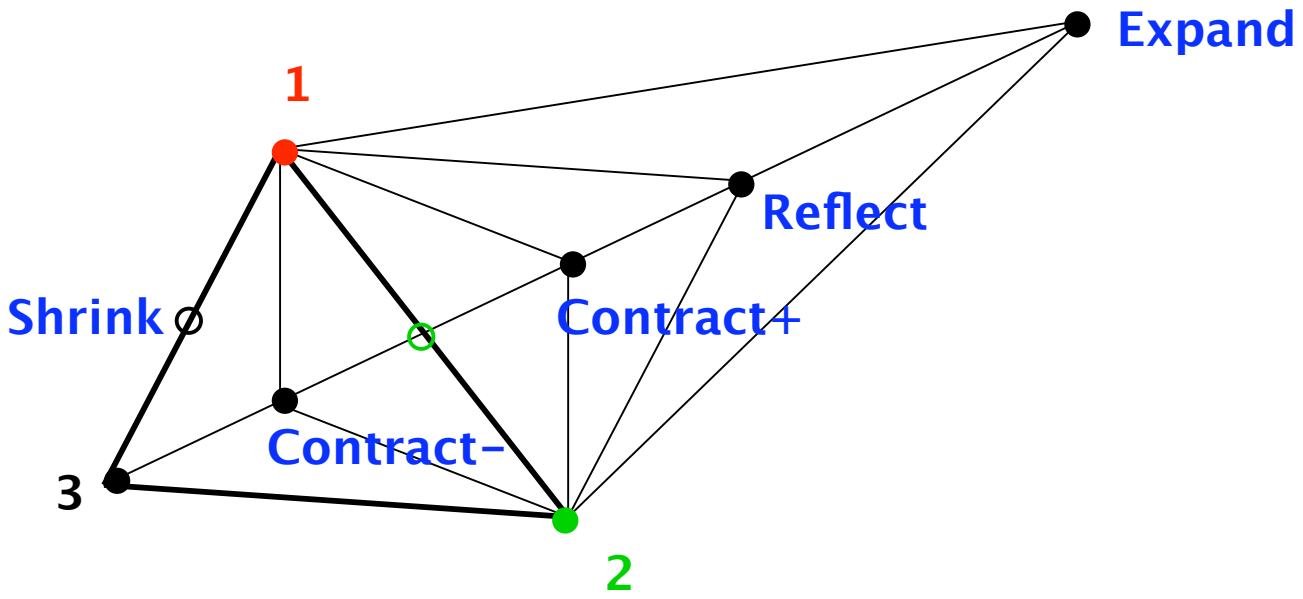
$\delta\xi_H = -1.7,\ \delta\xi_V = +0.9$

$\delta\xi_H = +0.9,\ \delta\xi_V = +2.9$

Downhill Simplex Method

Method of Minimization

- {1, 2, 3} 1(best)<2(next-to-the worst)<3(worst)
- Evaluate 3_R
- If $3_R<1$,
  - If $3_E<3_R$, $\{1, 2, 3_E\}$: **Expand** , if not, $\{1, 2, 3_R\}$: **Reflect**
- If $1<3_R<2$, $\{1, 2, 3_R\}$: **Reflect**
- If $2<3_R<3$, **Reflect 2** proposed by A. Hutton
  - If $3_{C+}<3_R$, $\{1, 2, 3_{C+}\}$: **Contract+** , if not, $\{1, 2, 3_R\}$: **Reflect**
- If $3<3_R$, **Reflect 2**
  - If $3_{C-}<3$, $\{1, 2, 3_{C-}\}$: **Contract−** , if not, $\{1, 2_S, 3_S\}$: **Shrink**/Reflect2



Luminosity Optimization (Nov. 30)

Start (Center of Mass) 79.43%

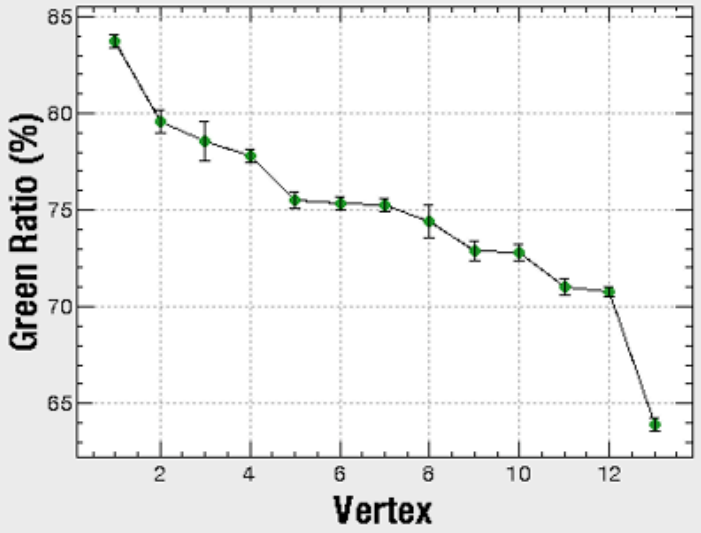
Green Ratio

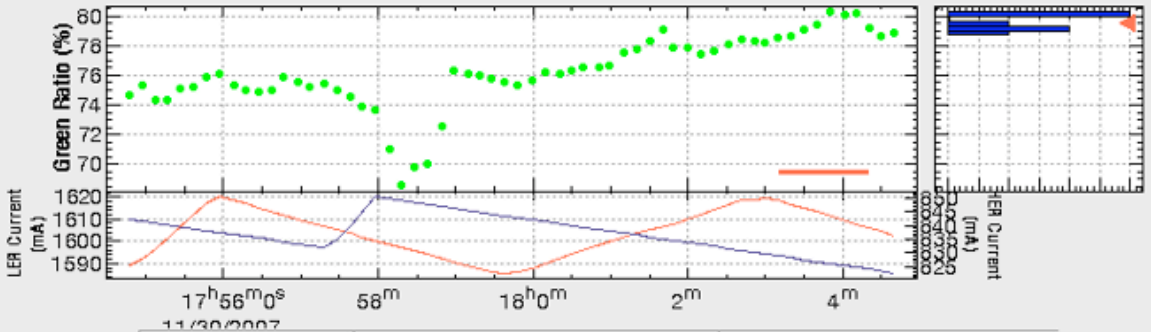
Best 83.74

Initial Simplex (List View)

<< Double click each line to set knob >>

#	R1L	R2L	R3L	R4L	EYL	EPYL	R1H	R2H	R3H	R4H	EYH	EPYH	Green Ratio	Time
NEXT:	0.51	4.55	0.95	-0.74	0.43	-0.31	3.97	-5.07	-0.88	-1.92	0.22	-0.45	---	---
SET:	0.51	4.55	0.95	-0.74	0.43	-0.31	3.97	-5.07	-0.88	-1.92	0.22	-0.45	---	---
LAST:	0.51	4.55	0.95	-0.74	0.43	-0.31	3.97	-5.07	-0.88	-1.92	0.22	-0.45	79.56	---
START:	0.63	4.79	1.19	-0.50	0.31	-0.07	3.73	-4.83	-1.00	-1.68	0.34	0.55	79.43	---
1	0.51	4.55	0.95	-0.74	0.43	-0.31	3.97	-5.07	-0.88	0.32	0.22	0.67	83.74	---
2	0.51	4.55	0.95	-0.74	0.43	-0.31	3.97	-5.07	-0.88	-1.92	0.22	-0.45	79.56	---
3	0.51	4.55	0.95	1.50	0.43	-0.31	3.97	-5.07	-0.88	-1.92	0.22	0.67	78.56	---
4	0.51	4.55	0.95	-0.74	0.43	-0.31	3.97	-5.07	-2.00	-1.92	0.22	0.67	77.83	---
5	0.51	4.55	3.19	-0.74	0.43	-0.31	3.97	-5.07	-0.88	-1.92	0.22	0.67	75.49	---
6	0.51	4.55	0.95	-0.74	0.43	-0.31	3.97	-2.83	-0.88	-1.92	0.22	0.67	75.35	---
7	0.51	4.55	0.95	-0.74	0.43	-0.31	3.97	-5.07	-0.88	-1.92	1.34	0.67	75.26	---
8	0.94	5.41	1.81	0.12	0.00	0.55	3.11	-4.21	-1.31	-1.06	0.65	0.24	74.38	---
9	0.51	6.79	0.95	-0.74	0.43	-0.31	3.97	-5.07	-0.88	-1.92	0.22	0.67	72.85	---
10	0.51	4.55	0.95	-0.74	0.43	-0.31	1.73	-5.07	-0.88	-1.92	0.22	0.67	72.78	---
11	0.51	4.55	0.95	-0.74	0.43	1.93	3.97	-5.07	-0.88	-1.92	0.22	0.67	71.01	---
12	0.51	4.55	0.95	-0.74	-0.69	-0.31	3.97	-5.07	-0.88	-1.92	0.22	0.67	70.75	---
13	1.63	4.55	0.95	-0.74	0.43	-0.31	3.97	-5.07	-0.88	-1.92	0.22	0.67	63.94	---





Initialize Simplex

Start

Idle

Simplex: Stop

Set Knob for the next point

Start Data Taking

Green Ratio (%): 79.5598

Accept Data

Hold Auto Accept

Cancel & Restart Data Taking

Set Knob Again

Set Best Knob

Set Start Knob

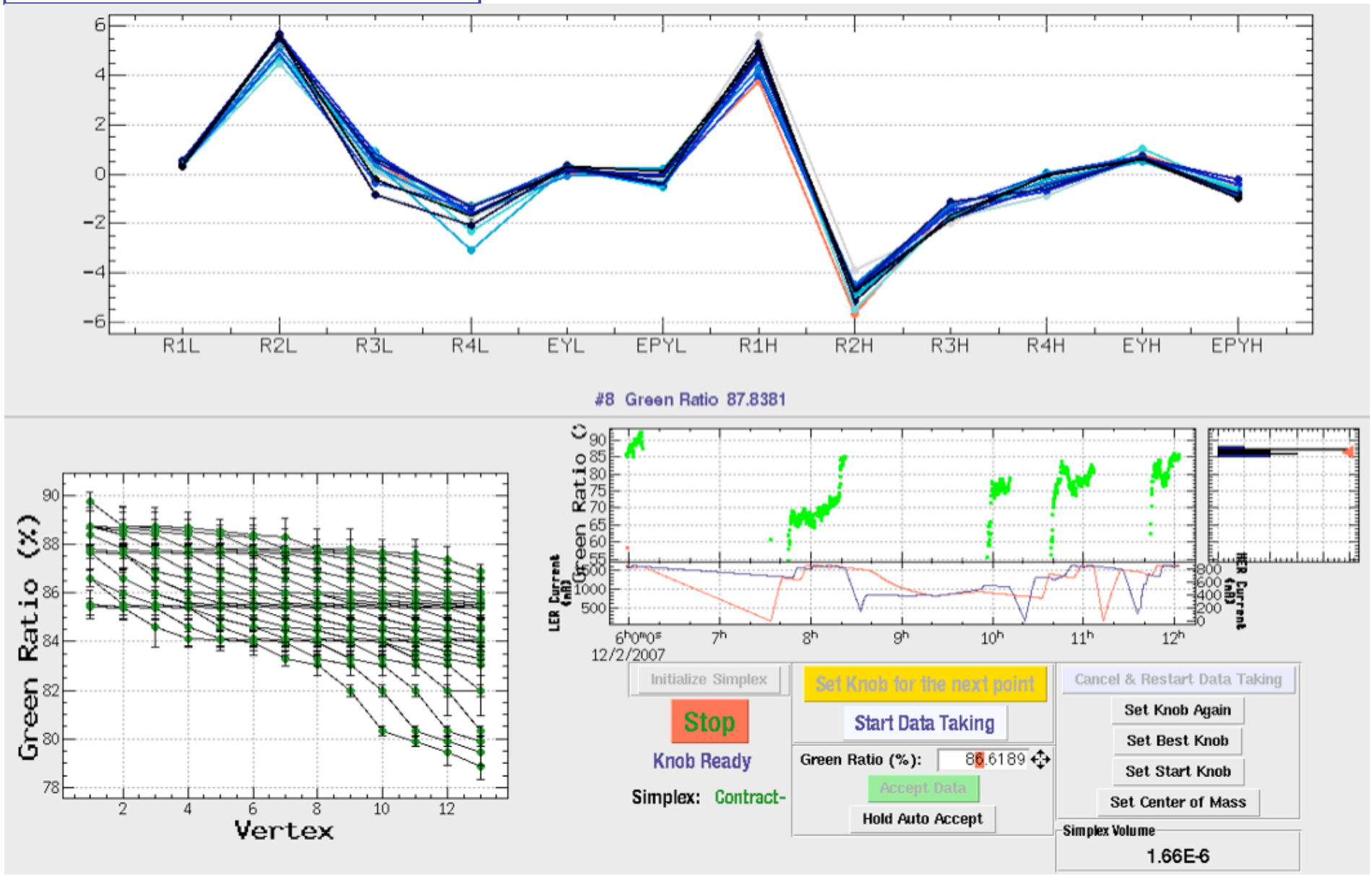
Set Center of Mass

Simplex Volume

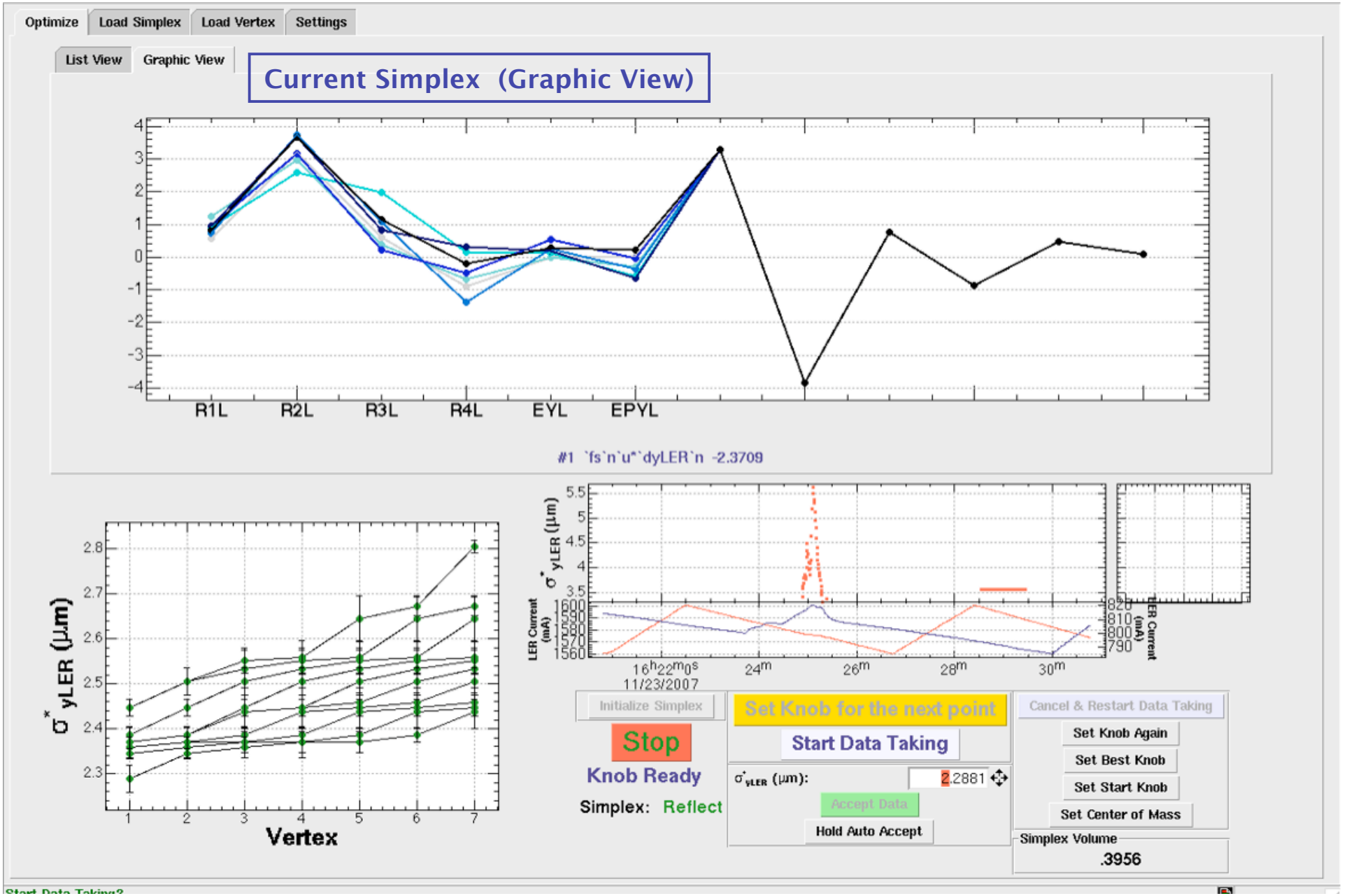
13.9162

Luminosity Optimization (Dec. 2)

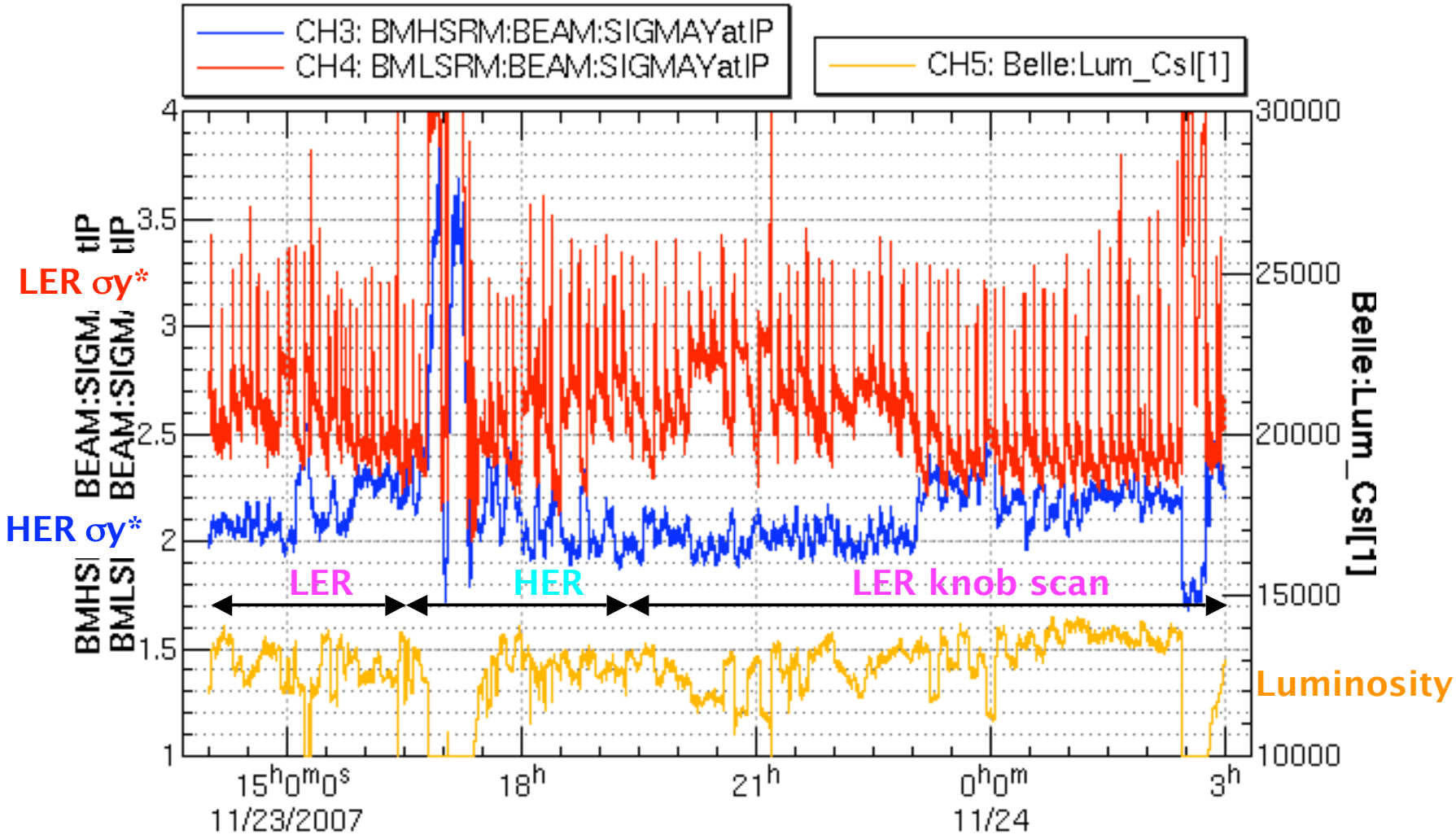
Current Simplex (Graphic View)



σ_y^* Minimization

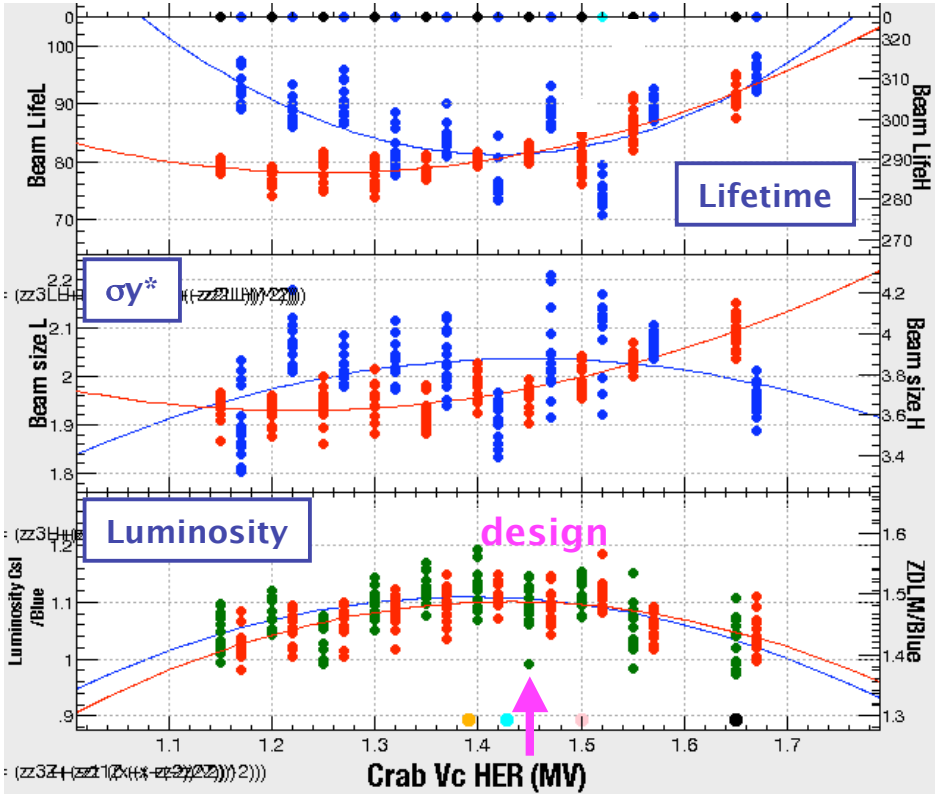


σ_y^* Minimization by Downhill Simplex Method



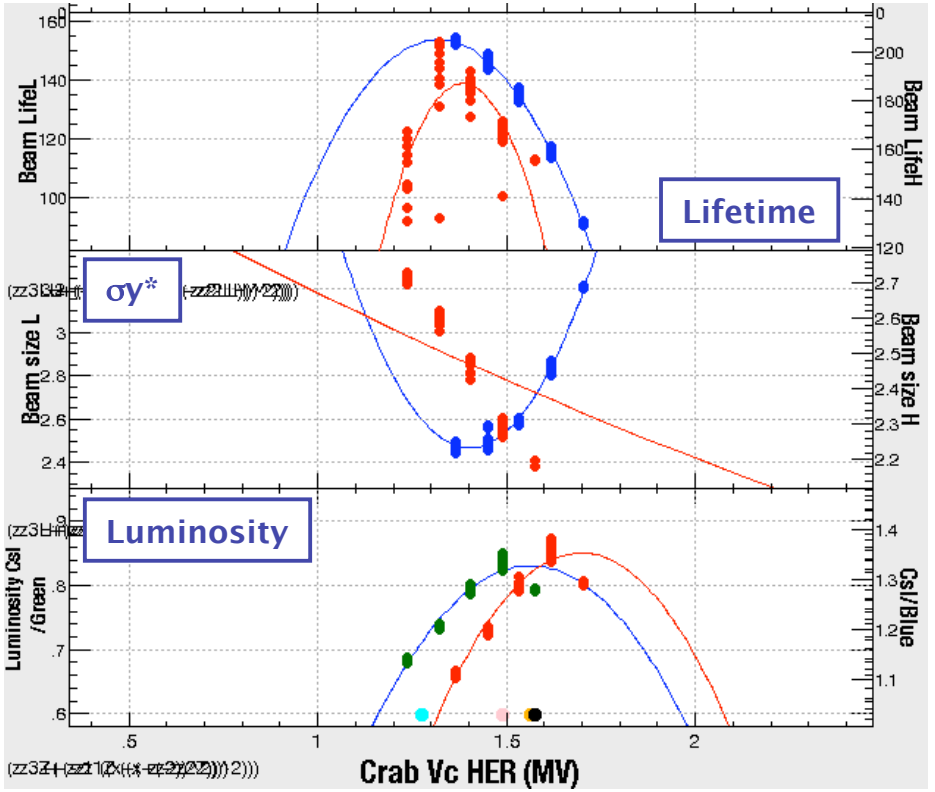
Crab Voltage Scan

Oct. 13 100 bunches



4.6 mrad

Nov. 19 1585 bunches



The ratio of crab voltages was adjusted to give the same kick in both rings. The scan was done, keeping the voltage ratio.

Plans

- Collision at long bunch spacing (49 buckets)
- Higher currents
- Adjustment of β_x^* and horizontal emittance
- Improvement of simplex scan
  - Modified algorithm proposed by A. Hutton
  - Include other knobs (horizontal dispersion, etc.)
- Larger dynamic aperture to cure lifetime degradation
  - Better choice of sextupoles
  - Better correction of both on- and off-momentum optics
- Reduction of vertical emittance
  - Better optics correction
- More knobs, better method of knob optimization