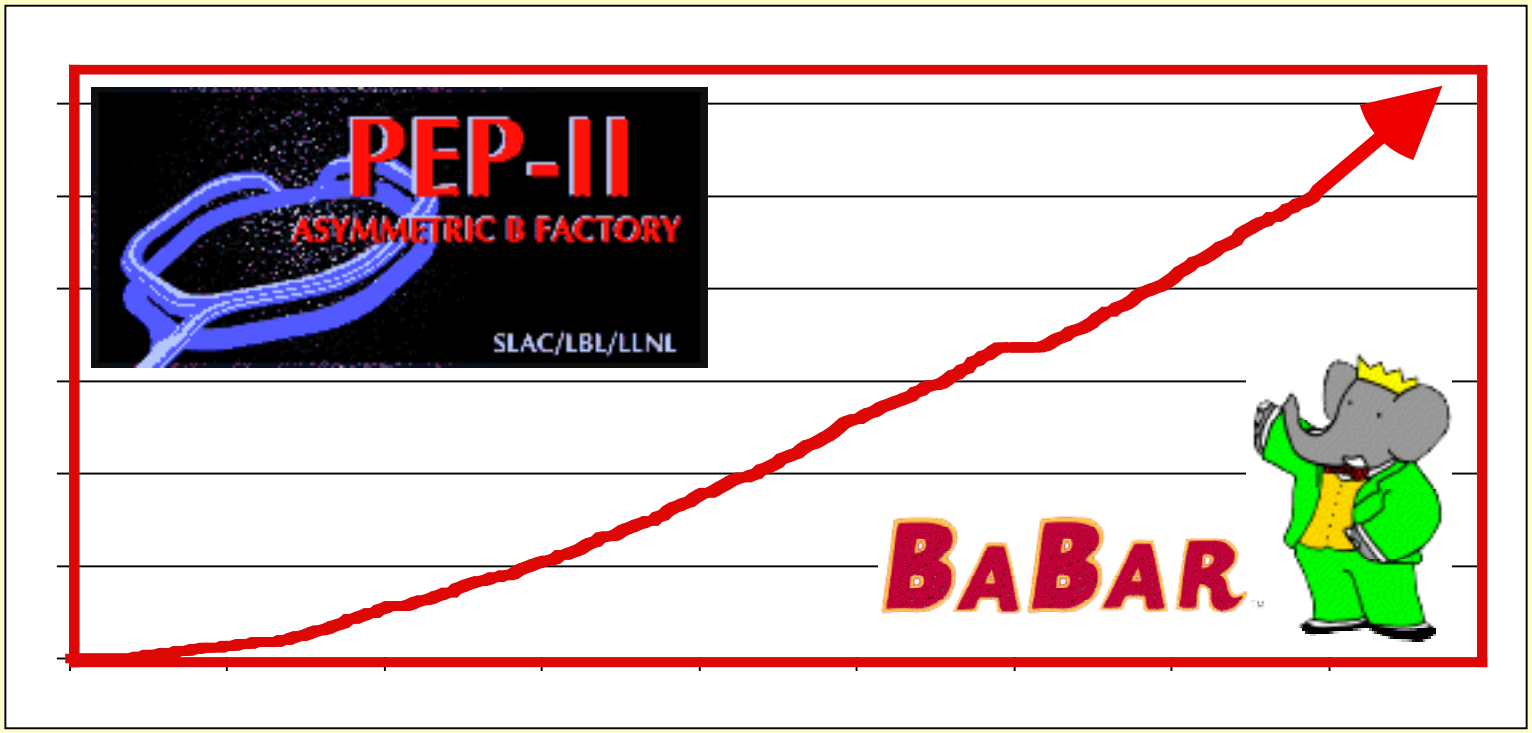
Status of PEP-II

…and Plans for the Near Future

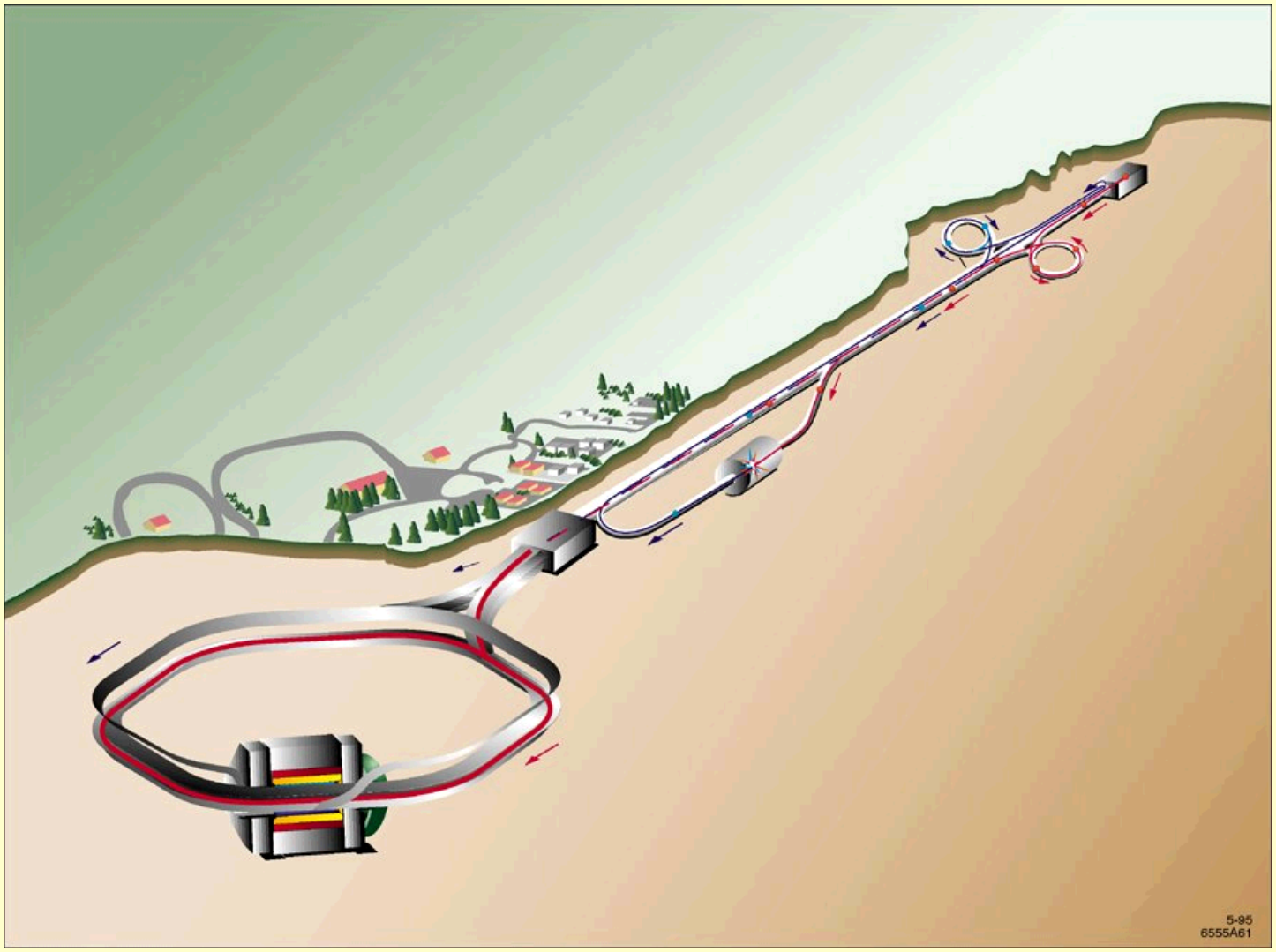


U. Wienands, for the PEP-II Team

Outline of Talk

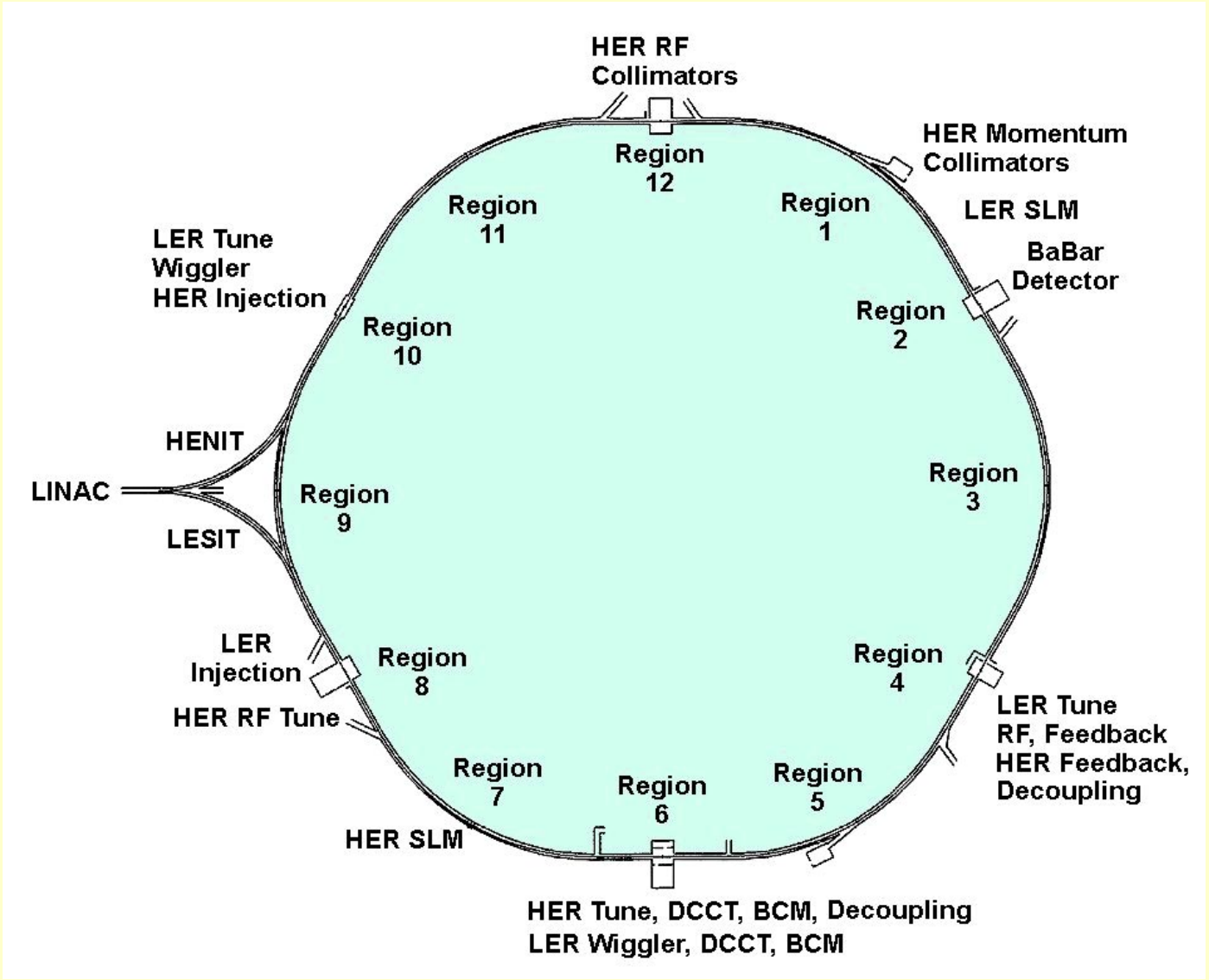
- Introduction & PEP Overview
  - Parameters, Run statistics
- Progress made during the Y2k+1 run
  - How we raised luminosity by 50%
- Improvements 2002 and beyond
  - Raising the bar…
- Summary

SLAC LINAC and PEP-II Ring



U. Wienands, SLAC-PEP-II
PEP Talk. YVR ppt, 14-Feb-02

PEP-II Ring



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PEP-II Parameters

	Design		Achieved (delivery)	
Energies e– / e+ (GeV)	8.973	3.119		
Currents e– / e+ (A)	0.75	2.14	**0.98**	**1.68**
Single beam currents (A)			0.95	2.10
Number of bunches	1658		**762**	
Bunch currents e– / e+ (mA)	0.45	1.29	**1.24**	**2.09**
Bunch spacing (m)	1.26		2.52	
IP spot size σ_x^* / σ_y^* (μm)	155	4.7	147	5
Luminosity ($\times 10^{33}$/cm^2/sec)	3.0		**4.51**	
Tune shift horiz. e– / e+	0.03	0.03	0.059	0.069
Tune shift vert. e– / e+	0.03	0.03	0.027	0.055
Integrated lumi. / 3 shifts (pb^{-1})	135		**308**	
Integrated lumi. / week (pb^{-1})	785		**1836**	
Integrated lumi. / 7 days (pb^{-1})	785		**1865**	
Integrated lumi. / month (fb^{-1})	3.3		**6.35**	
Beam crossing angle	0 (head-on)		0 (head-on)	

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Our Best 24 h

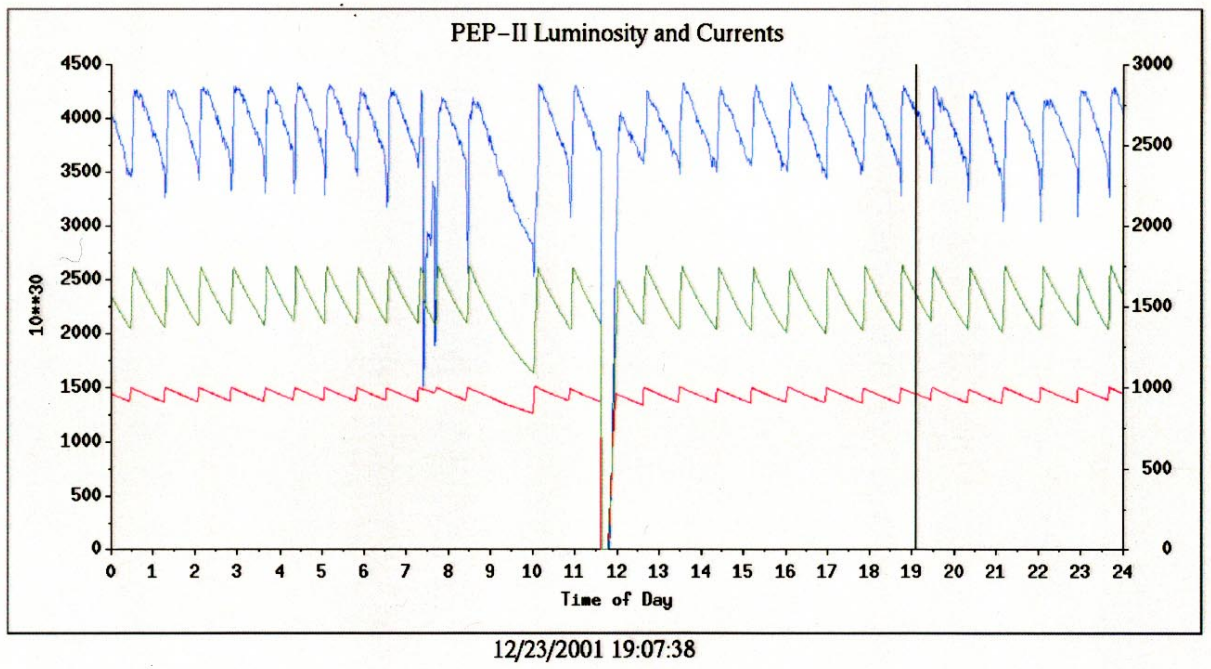
I HER	I LER	Luminosity	Spec Lum	E HER	E LER	E CM
955.33 mA	1563.52 mA	4023 10^30	2.14 N*10**30 / mA**2	8992 MeV	3120 MeV	10594 MeV

N Buckets/HER Pattern: 796 by4_trains_of_23_off_by_2_her

N Buckets/LER Pattern: 796 by4_trains_of_23_off_by_2

Last Owl/Day/Swing/24 Hr: 105.0 97.6 106.2 308.8 Shift: 40.39 /pb

Peak Luminosities: 4339 4353 4395 4353



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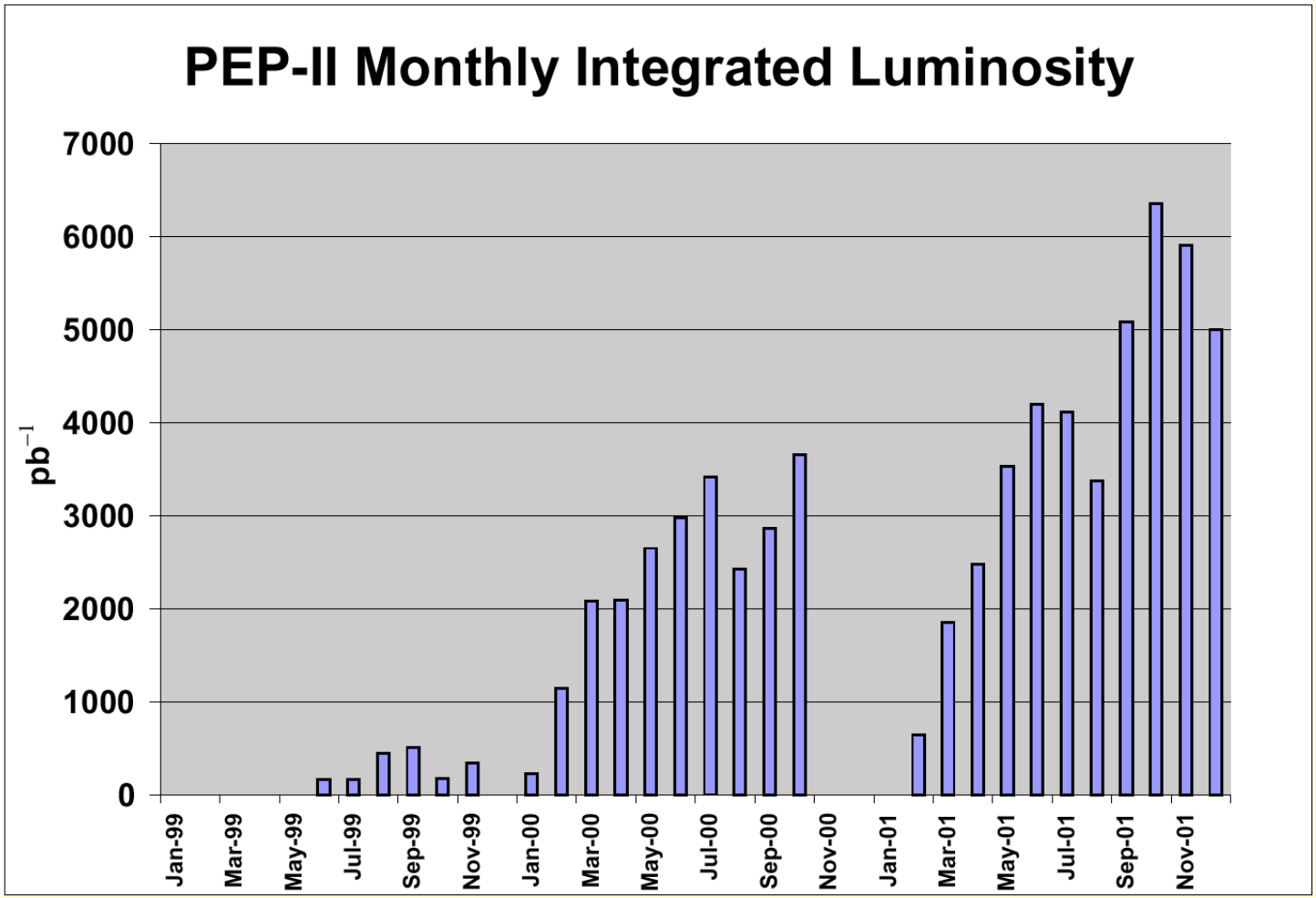
∫Luminosity by Month

M. Sullivan



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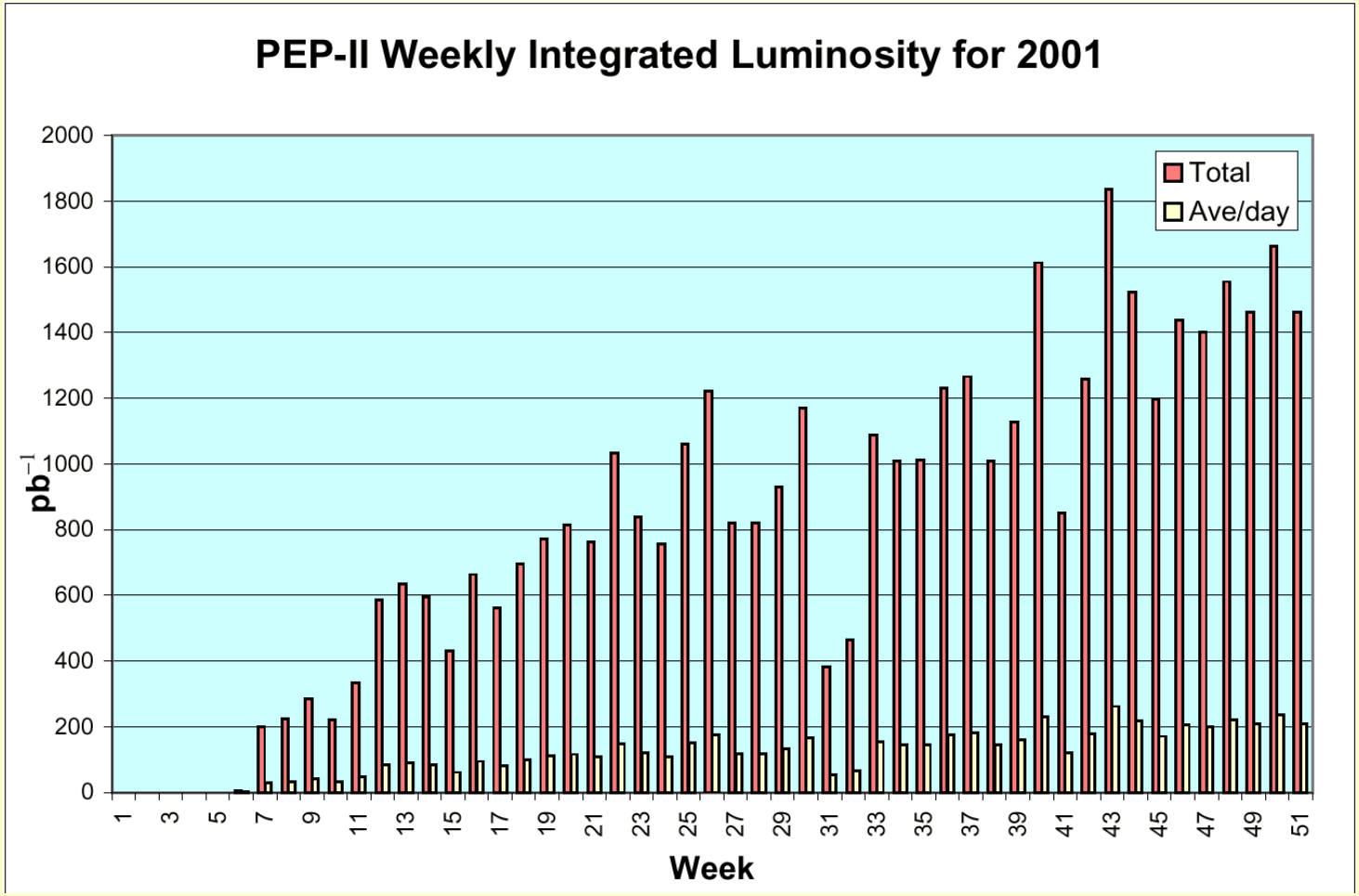
∫Luminosity by Week

M. Sullivan



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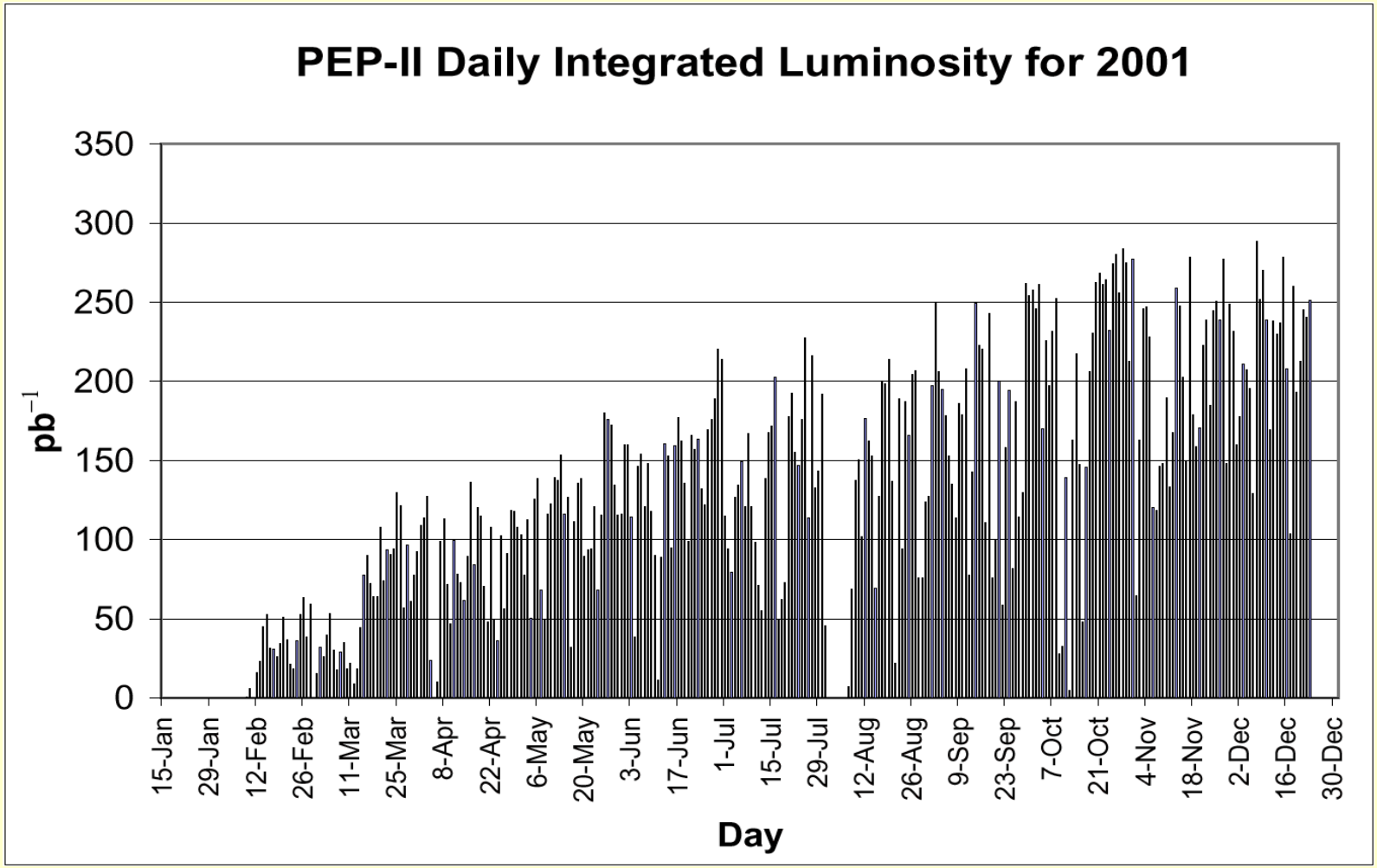
∫Luminosity by Day

M. Sullivan



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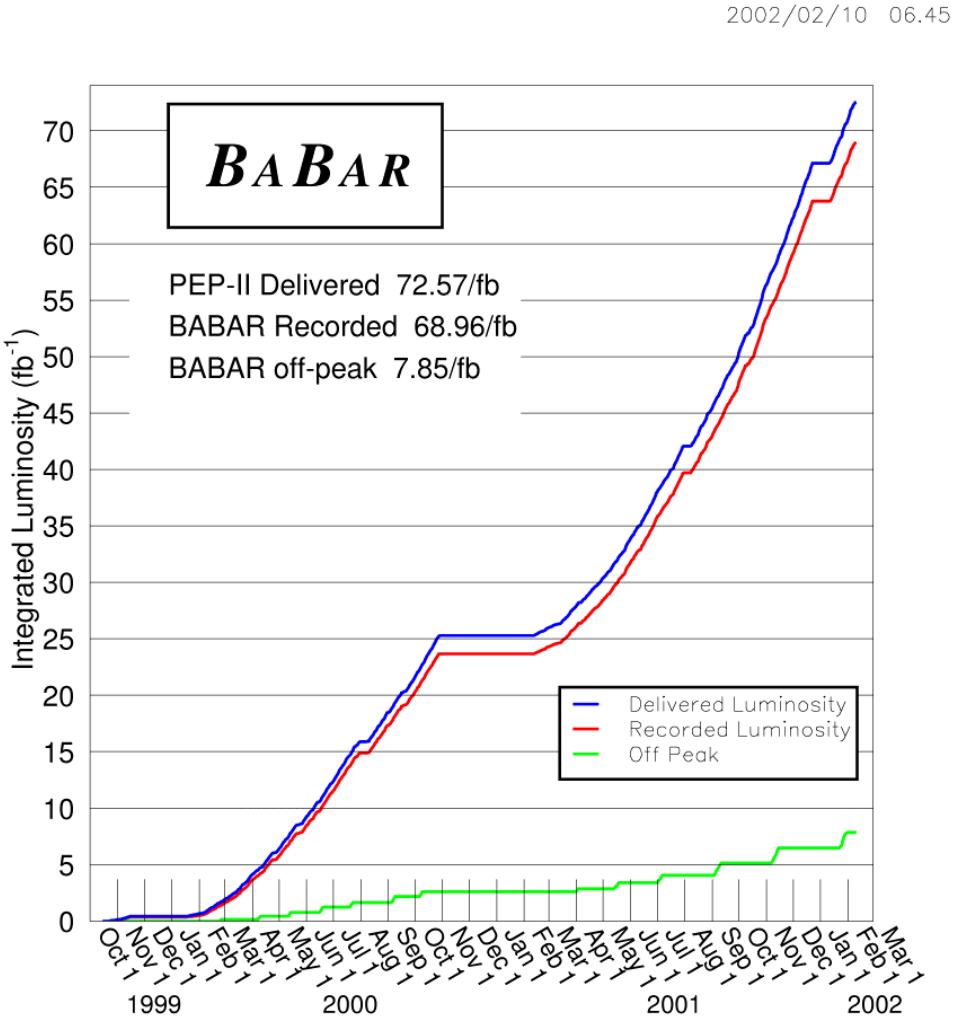
BABAR ∫Luminosity



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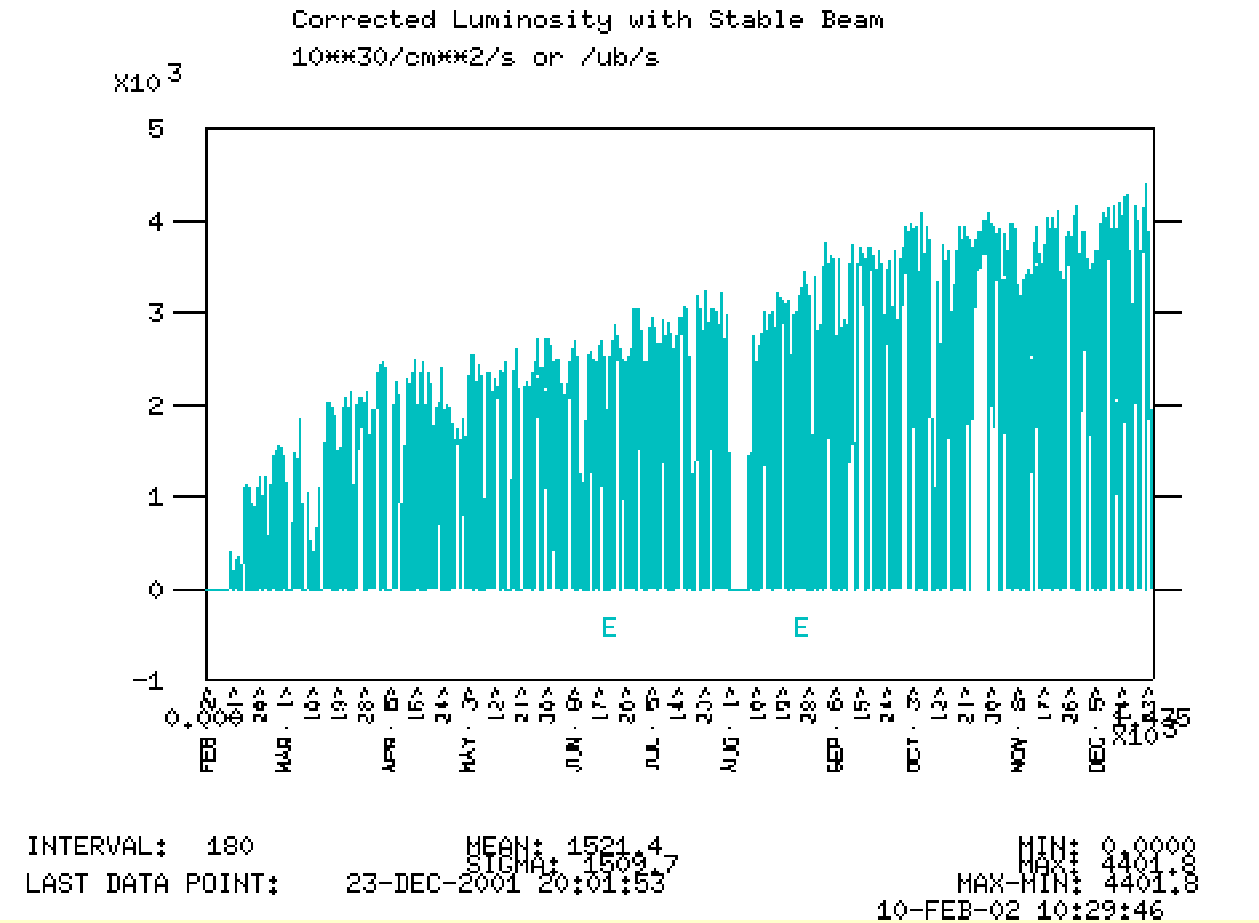
Luminosity History



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PEP-II Running

- 95% of the running time is spent on collision delivery. Machine Development accounted for 5% of run time in 2001
- Hardware availability is typically about 85% for PEP and Linac combined
- A fill cycle typically has 45…50 min coast followed by 2…3 min top-up.
- A fill from scratch takes 6…10 min.

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Raising Luminosity

Luminosity equation:

$$L = \frac{I_+ I_-}{n_b \cdot f_{rev} \cdot q^2 \cdot 2\pi \sqrt{\Sigma_x^2 \cdot \Sigma_y^2}}$$

=> raise beam currents *I*

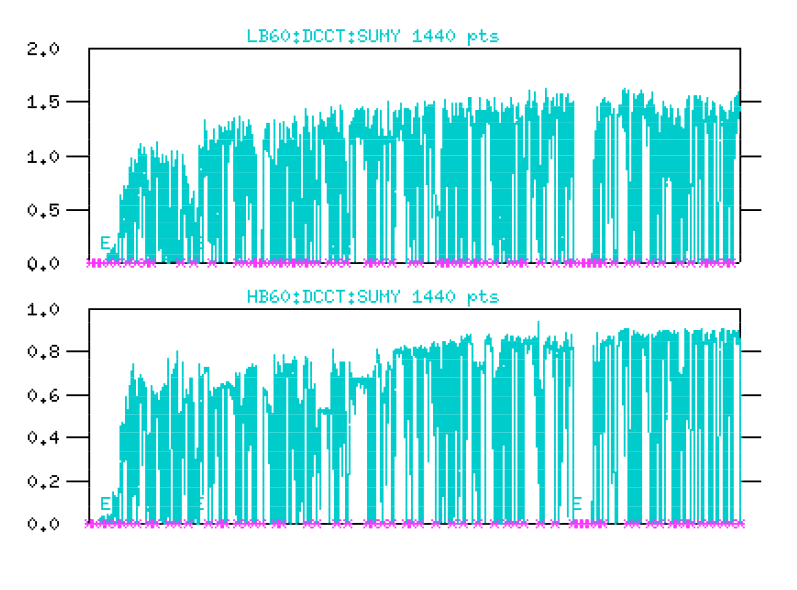
=> lower beam sizes Σ
… emittances, β^*

=> keep number of bunches n_b small

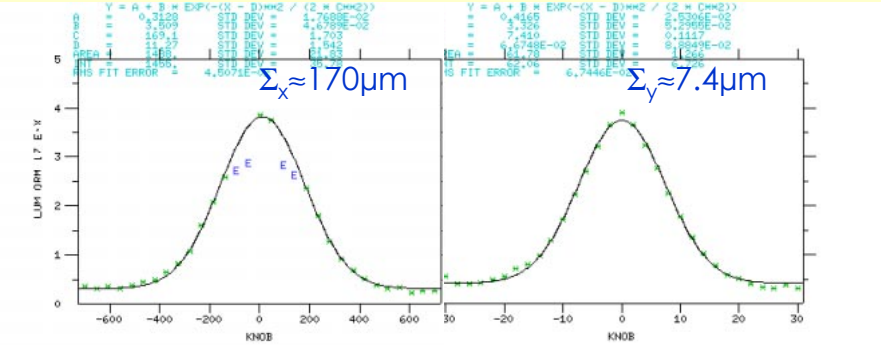
… until beam-beam limit reached

Luminosity: Beam Current/Size

- **Beam currents gradually increased**
  - **1.68 A (LER),**
  - **0.98 A (HER)**



- **Luminosity further improved by reducing beam size**
  - **thus increasing L_{sp}.**



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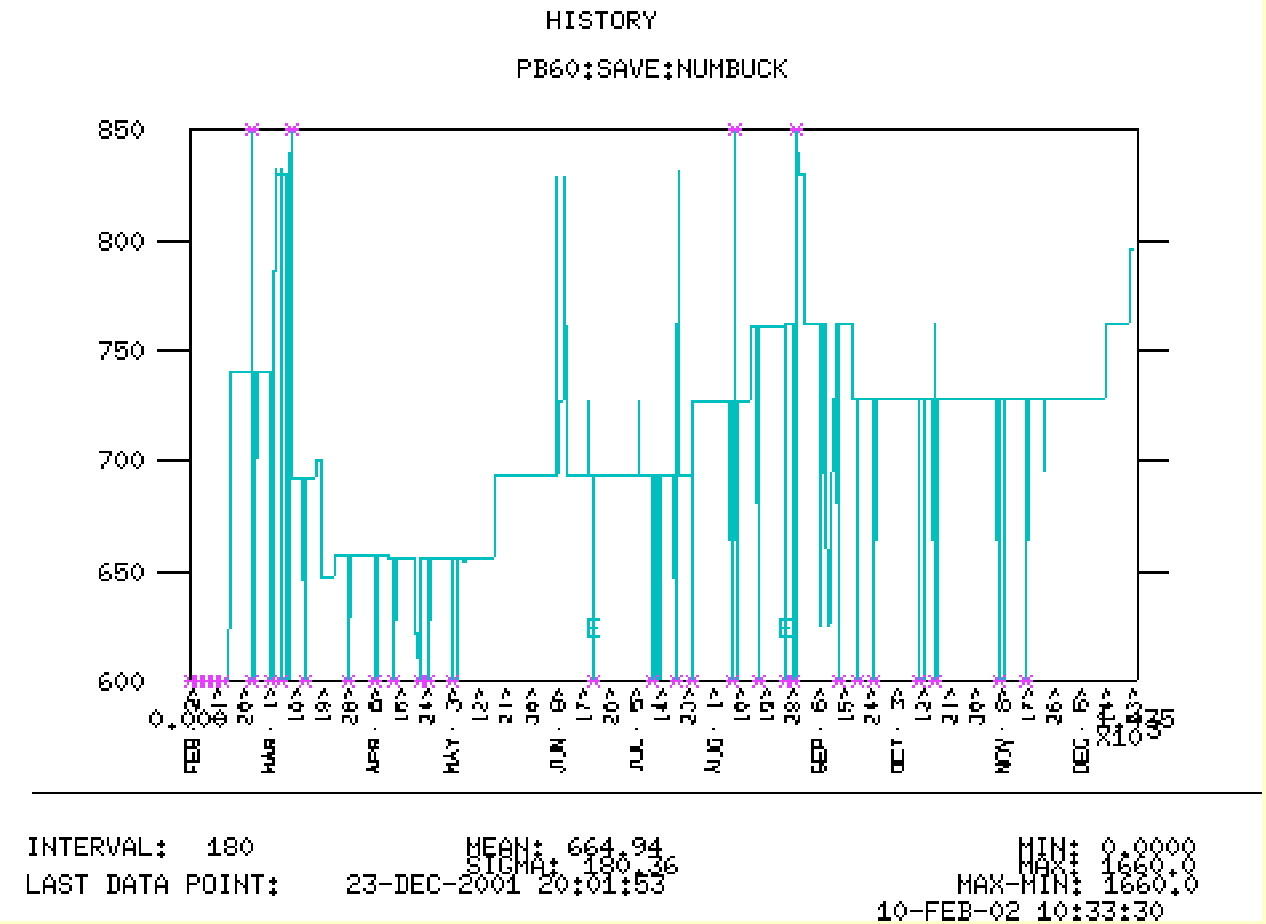
Fill-Pattern History



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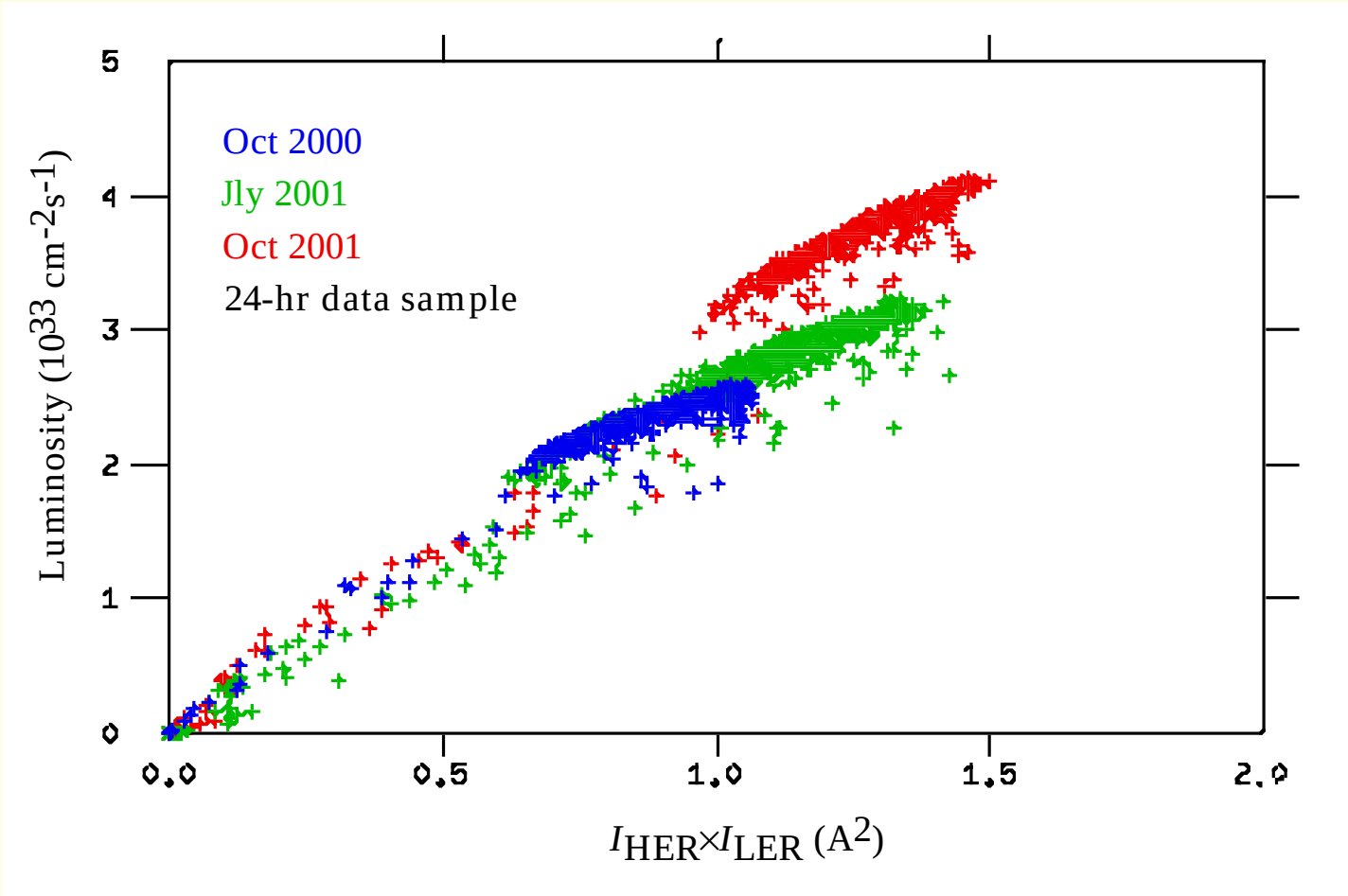
Luminosity *vs* Beam Currents



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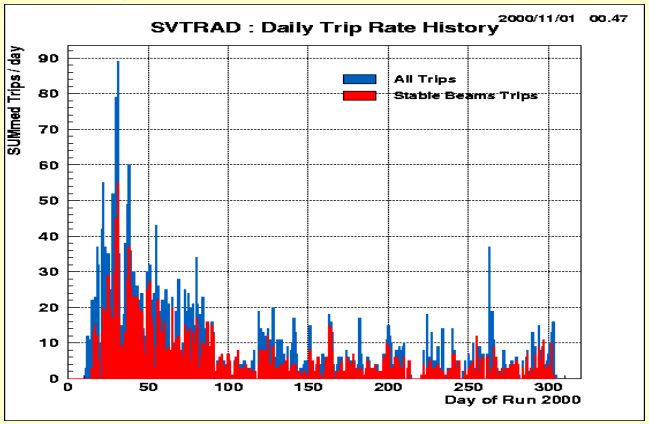
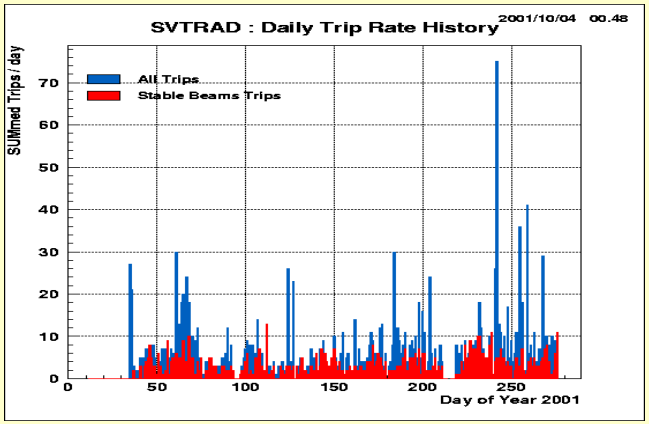
Backgrounds, spikes

- **Compare Y2k with**
- **Y2k+1 trip rates**
  - **"Dust trapping" much reduced from early Y2k rates**

T. Meyer/BaBar





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Rf Performance

- At PEP we rely heavily on rf feedback to lower the cavity impedance
  - Much progress in improving setup of loops
  - LER up to 1700 mA with 2 stations
  - HER has run reliably up to 975 mA

- Trip rate reduced by redistributing voltage
  - Lower in 1st HER cavities (8-1 A, 12-1 A)
  - Somewhat lower overall voltage

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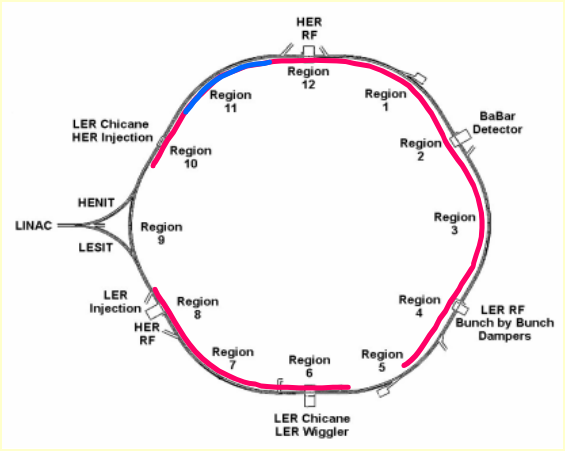
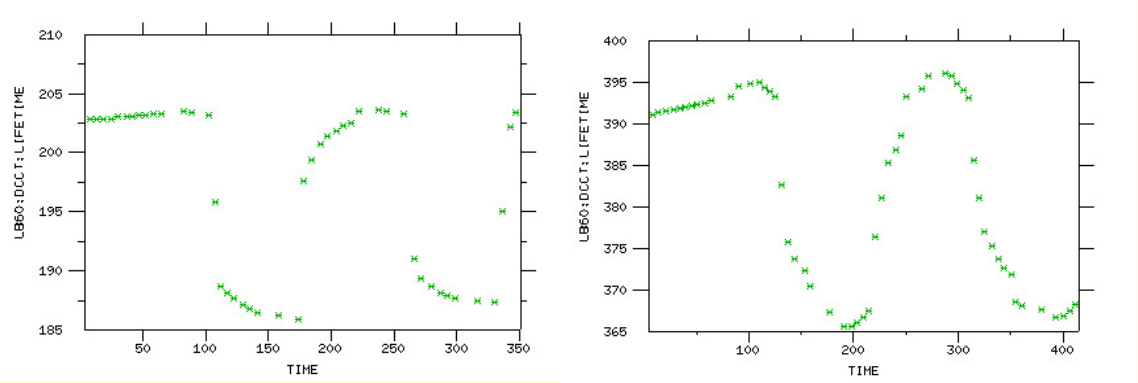
LER Beam-pipe Solenoids

- **All arcs now wrapped with solenoids**
  - **Arc 9 just completed**



- **Effect of arc-3 solenoid on beam life time**

low beam current (A. Kulikov) high beam current



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Solenoid Winding LER Arc 5

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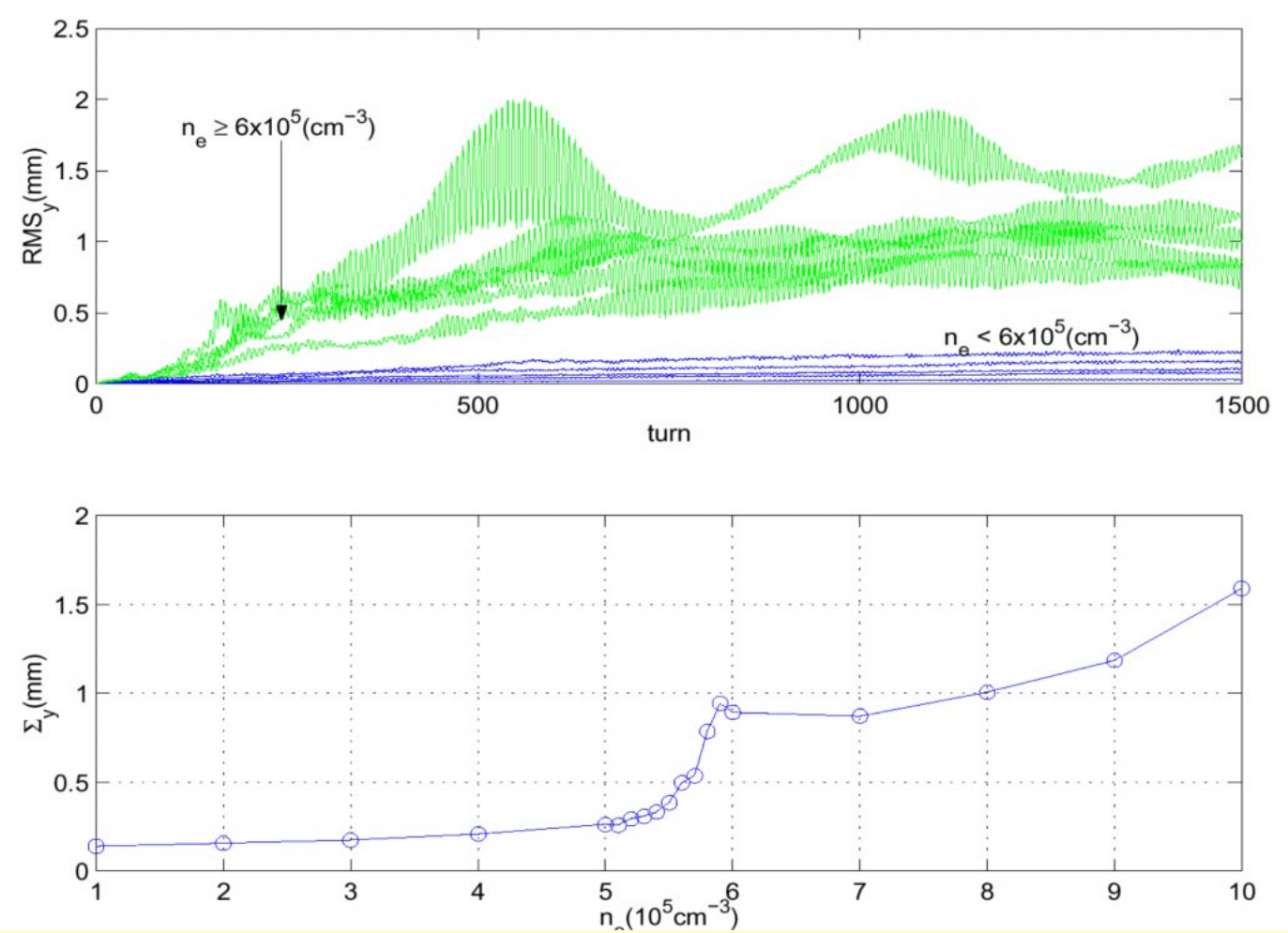
Electron Cloud Instability

Y. Cai et al., Simulation of e-c induced head-tail instability



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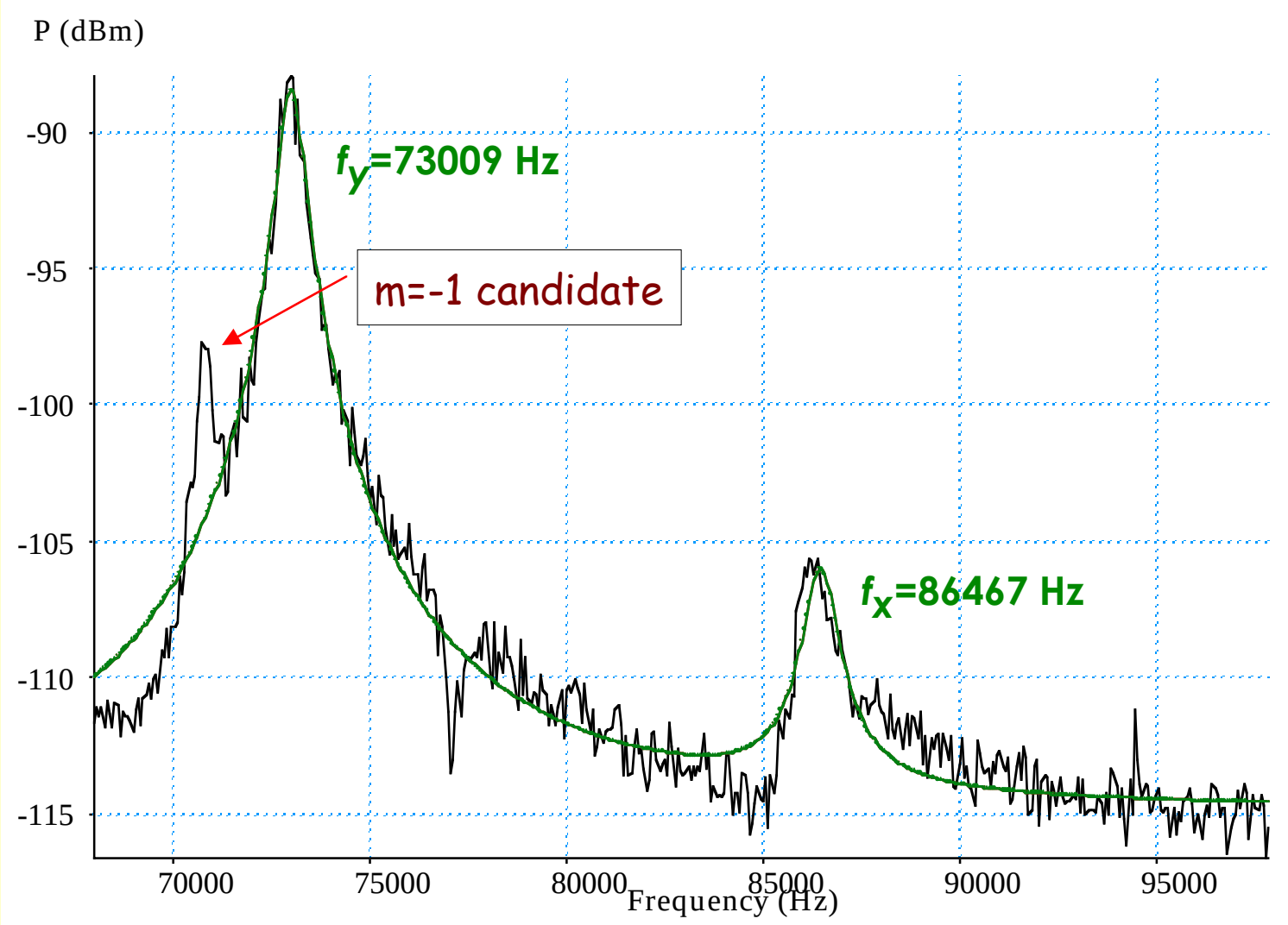
Electron Cloud (cont'd)



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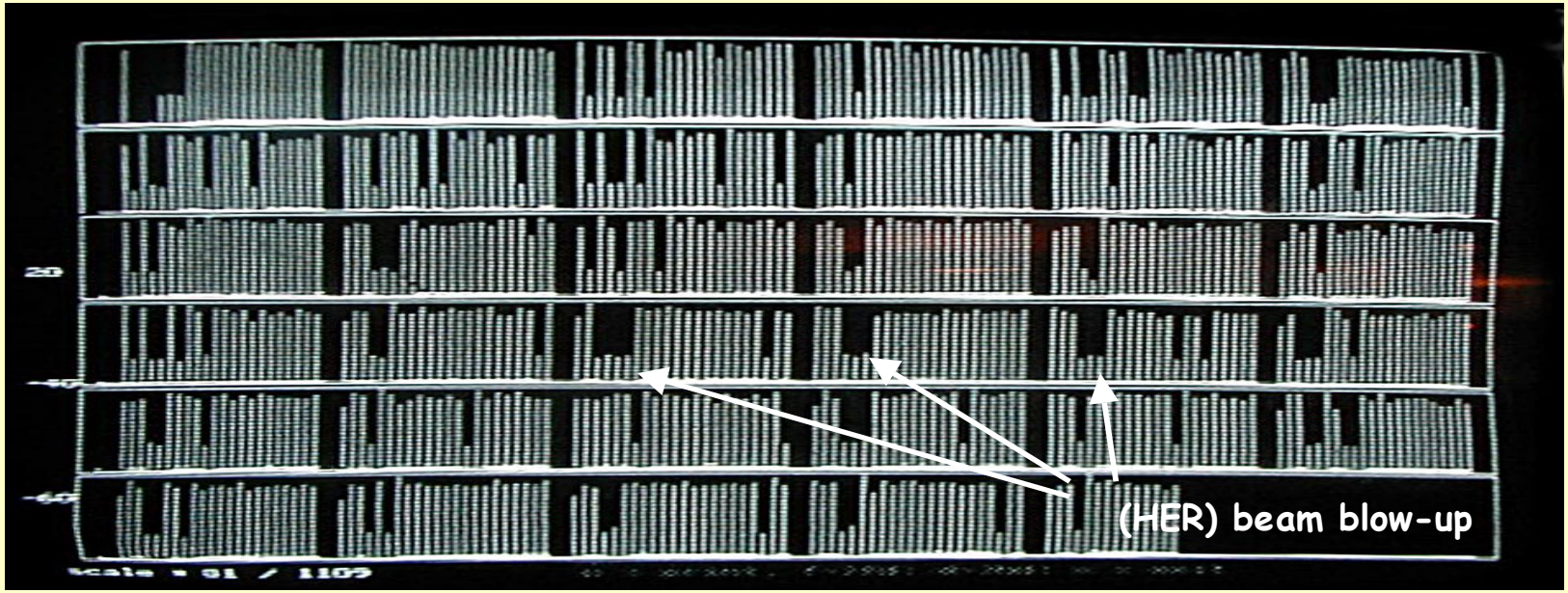
Flip-Flop Effect

- **HER beam blowup when LER too small**
- **Strongly affected by tunes**

Luminosity by bunch



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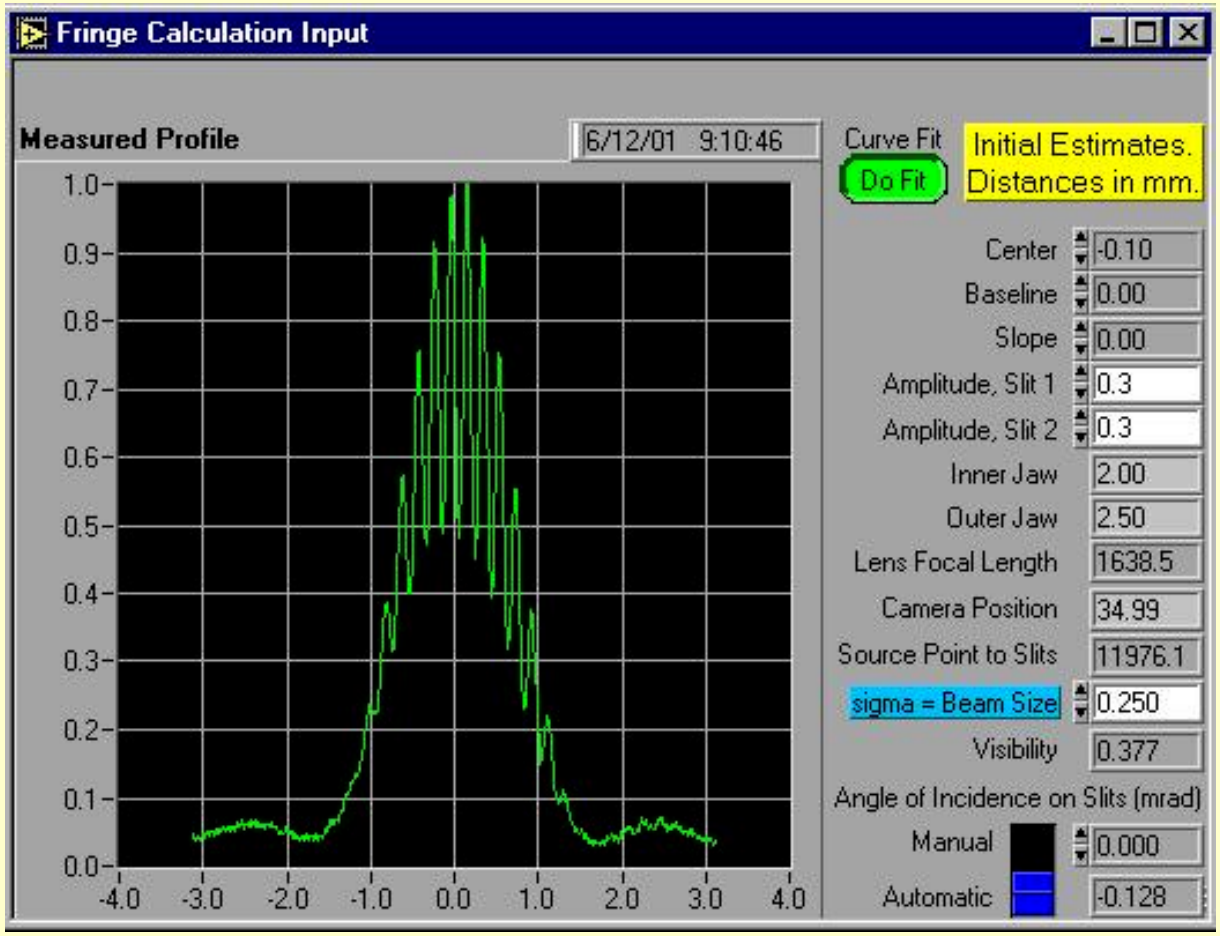
New diagnostics:

- **Interferometer**
  - HER
  - LER

HER Interferometer interface (A. Fisher)



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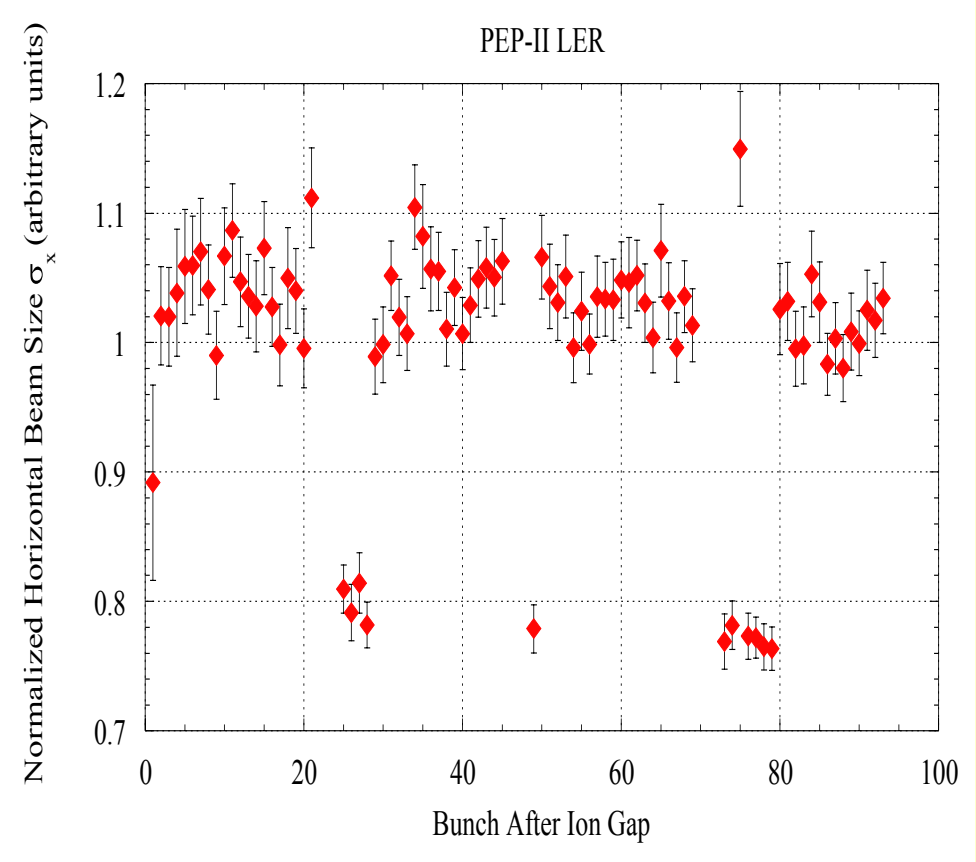
New Diagnostics:

(R. Holtzapple)

- **Gated Camera**
  - **Beam size by bunch**
  - **Compare to luminosity by bunch**



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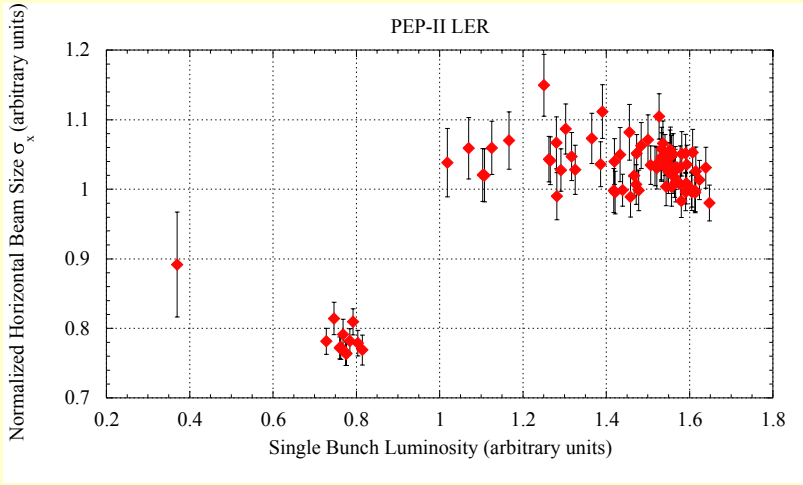
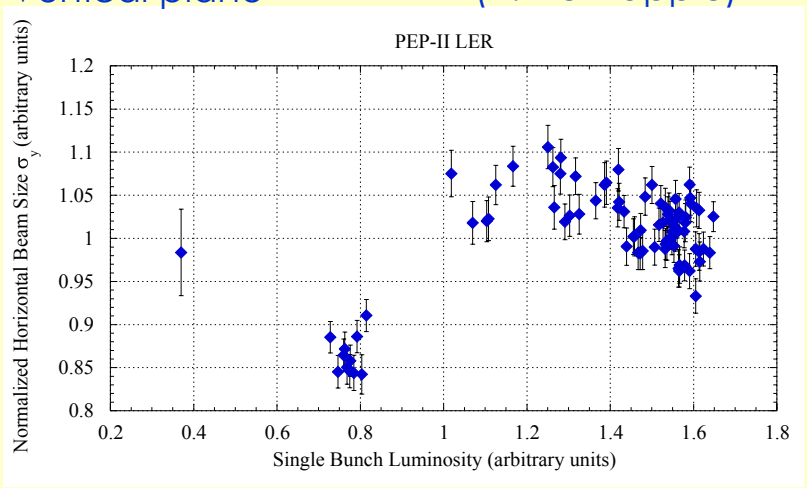
Flip-Flop (again)

- **Correlate bunch luminosity with LER beam size:**
- **HER appears to blow up**

Horizontal plane (R. Holtzapple)



Vertical plane (R. Holtzapple)



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Optics Work to Increase Luminosity

- Lower the beam sizes at the IP
  - Lower β_x* (50 cm to 35 cm)
  - Lower β_y* (1.25 cm to 1.00 cm)
  - Move tunes closer to 0.5
  - Lower HER emittance
- Need to implement these sequentially
  - Full understanding of side effects essential for success

Gain luminosity without tune shift

(dynamic beta focusing)

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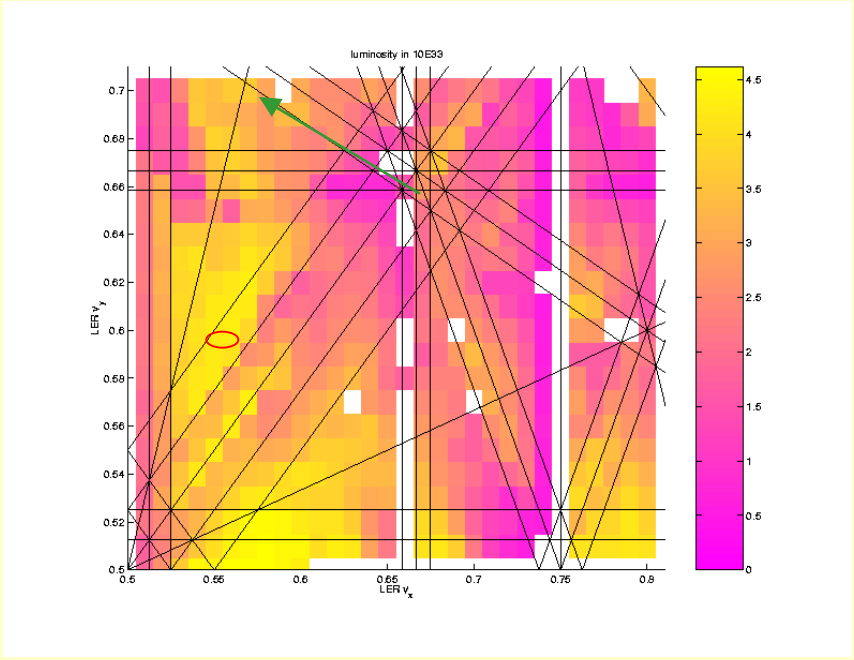
Change Working Point(s)

- **Lower LER ν_x to 0.52…0.53**
- **Strong ß beat prevented luminosity gain**
- **Recent progress towards fix**

LER tune-scan simulation (I. Reichel)



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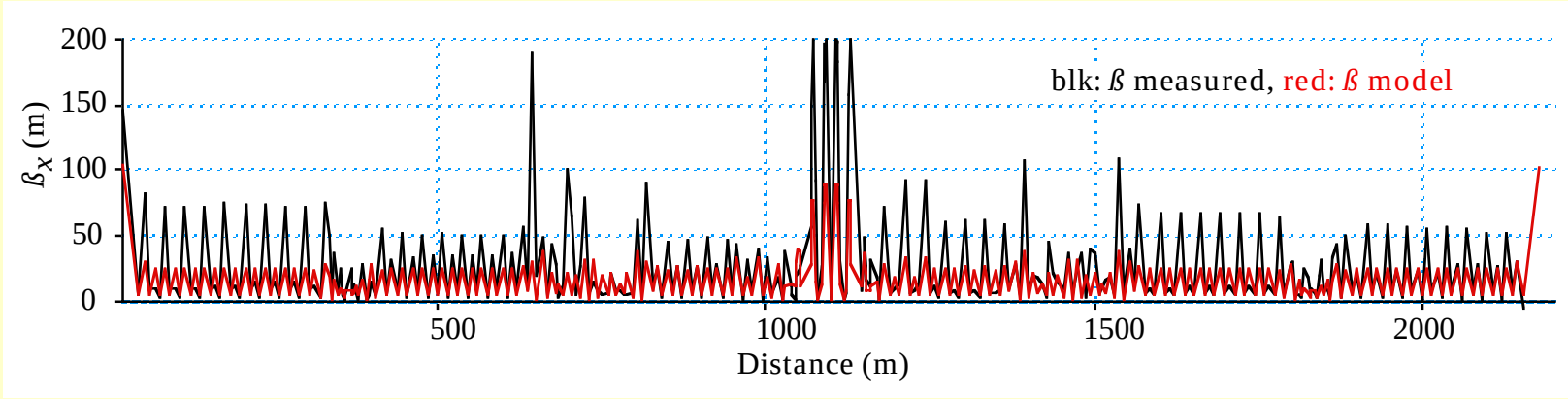
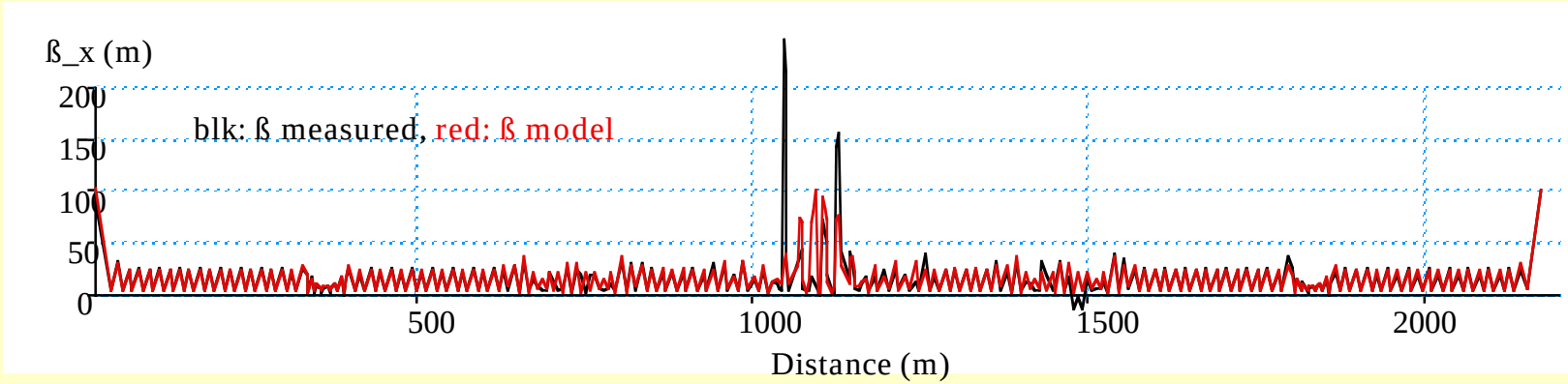
LER ß at low ν_x

After moving tune



After ß fix



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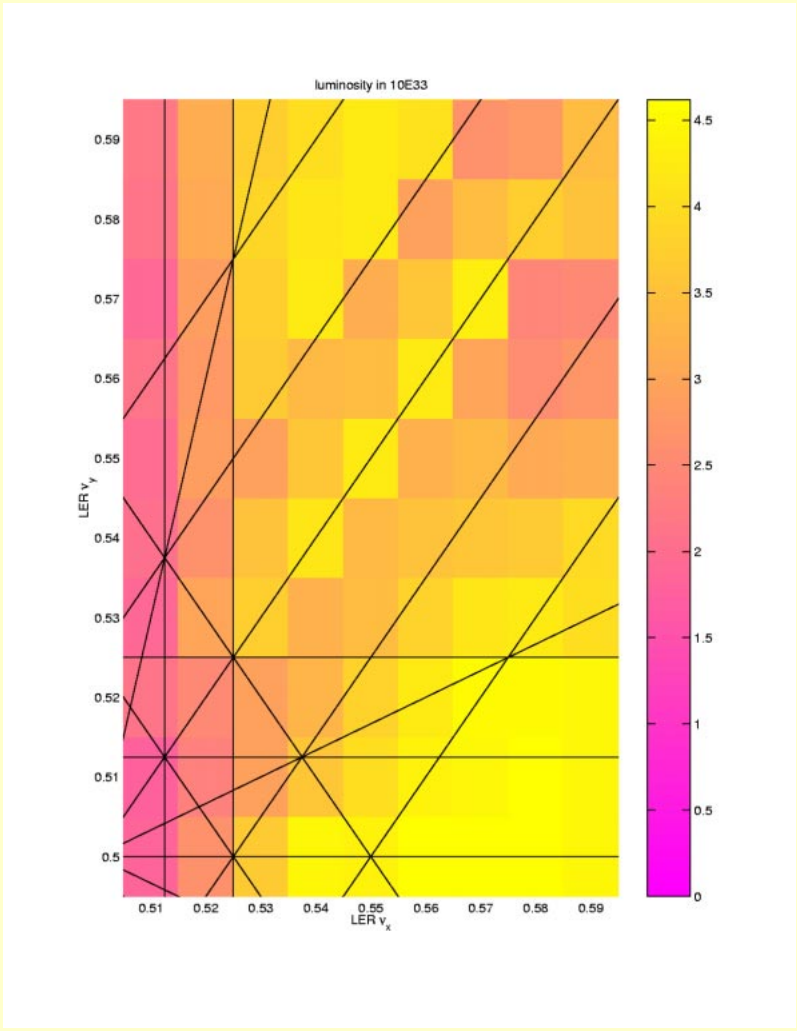
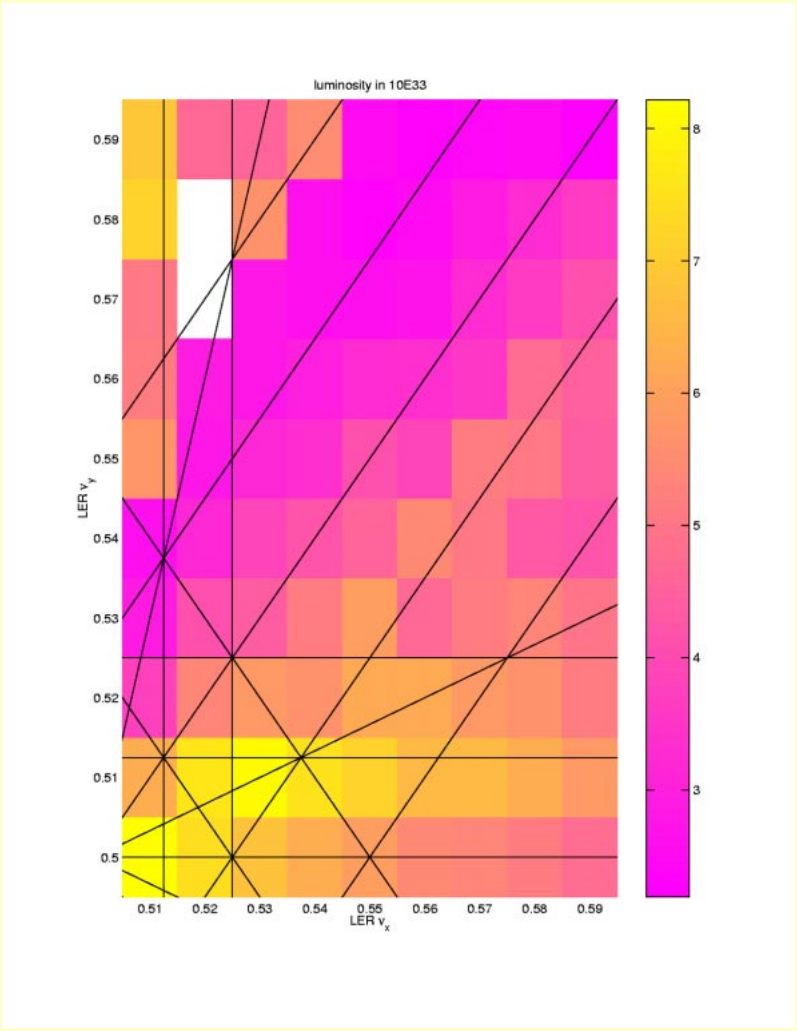
Tune Scans (B-B Simulation)

LER-only **(I. Reichel)** **LER & HER equal tunes**





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Fill Patterns

- In 2001 we used a fundamental 119 MHz pattern (“by 4”) with “micro gaps” to ameliorate ECI
- To increase # of bunches we will go to a 238 MHz pattern (“by-2”)
  - Parasitic crossings and ECI potential issue
- 158.7 MHz (“by-3”) intermediate step
  - But heating may be an issue

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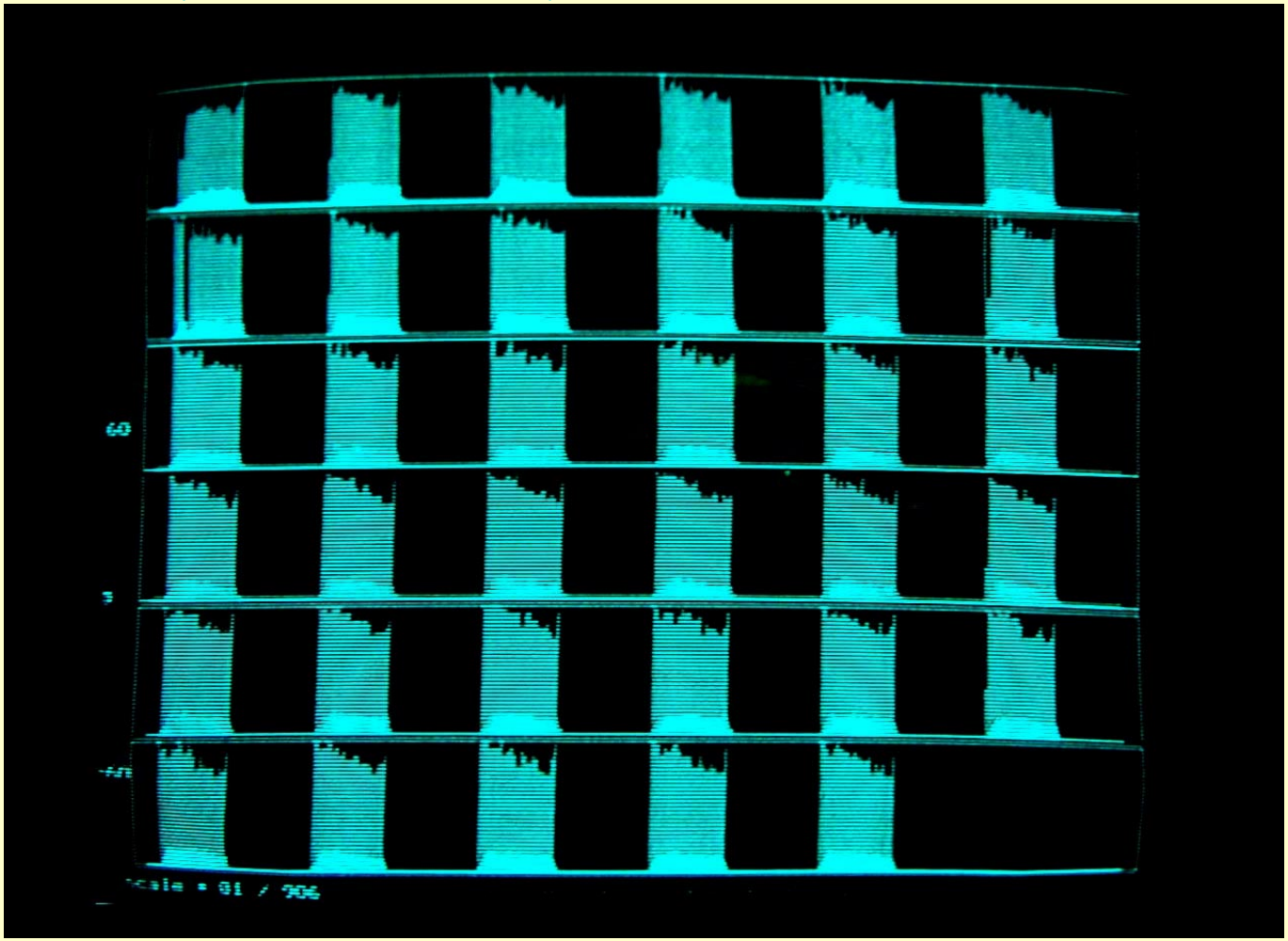
Test with 238 MHz pattern

Bunch-by-bunch luminosity



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Hardware Improvements (2002)

- Q2 chamber replacement
  - Remove beam current limit
- Two additional HER rf stations
  - Current capability up to 1.5 A
- New LER LFB Kickers
  - Higher power handling for higher beam current
  - Higher shunt impedance for stronger kick

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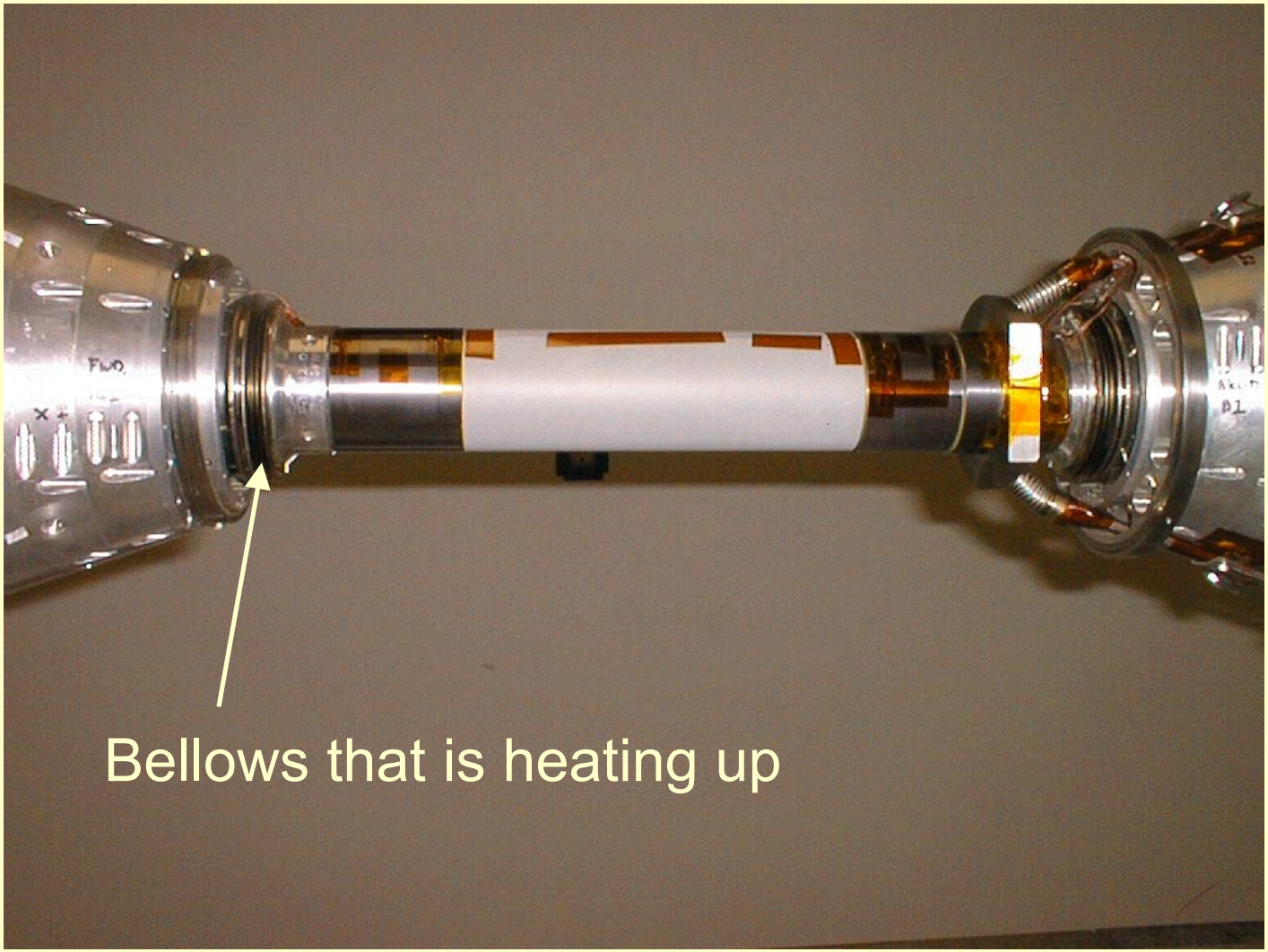
Be beam pipe at the center of BABAR



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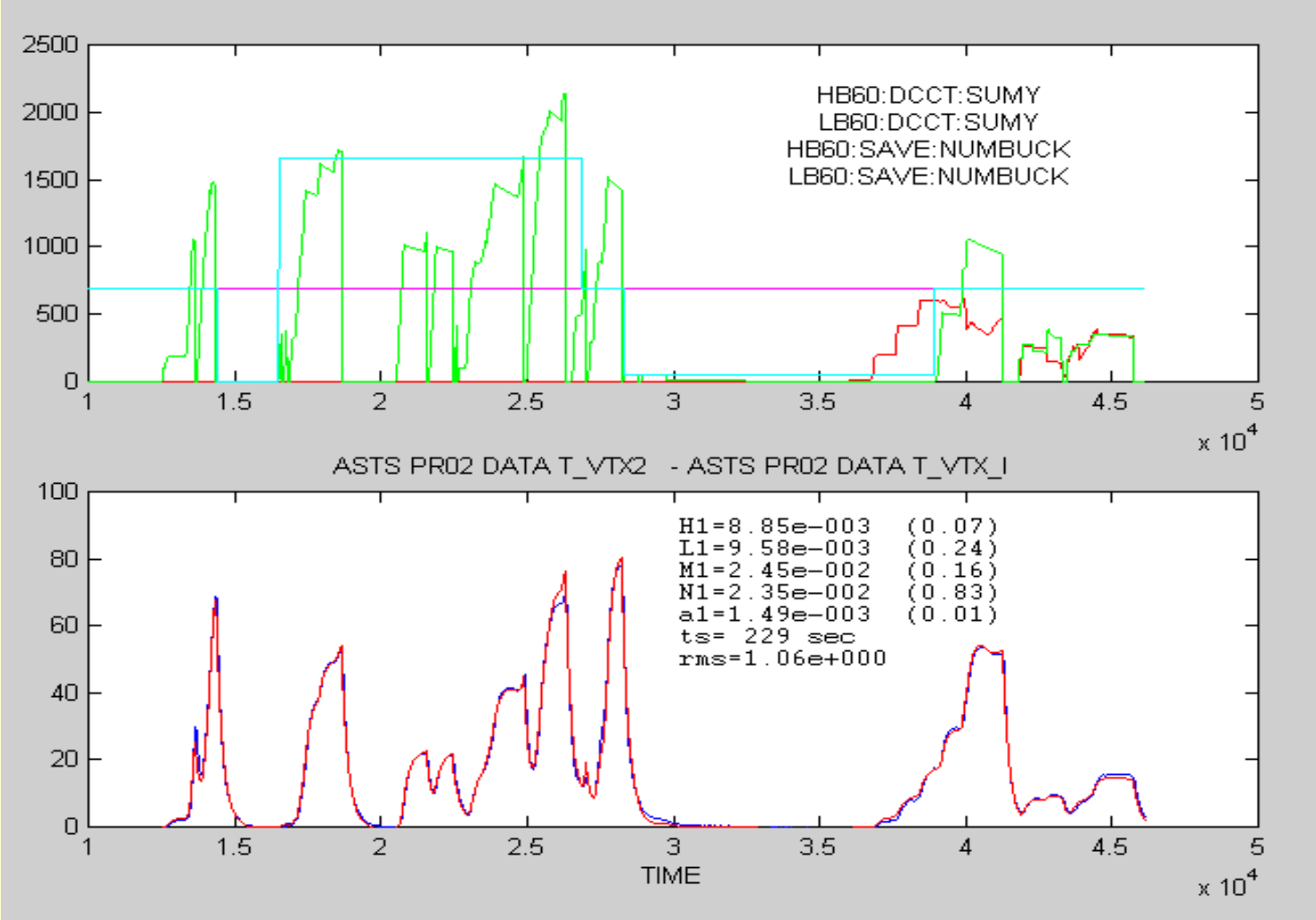
VTX pipe Temperature

VTX beam pipe thermocouple compared to model (S. Ecklund)



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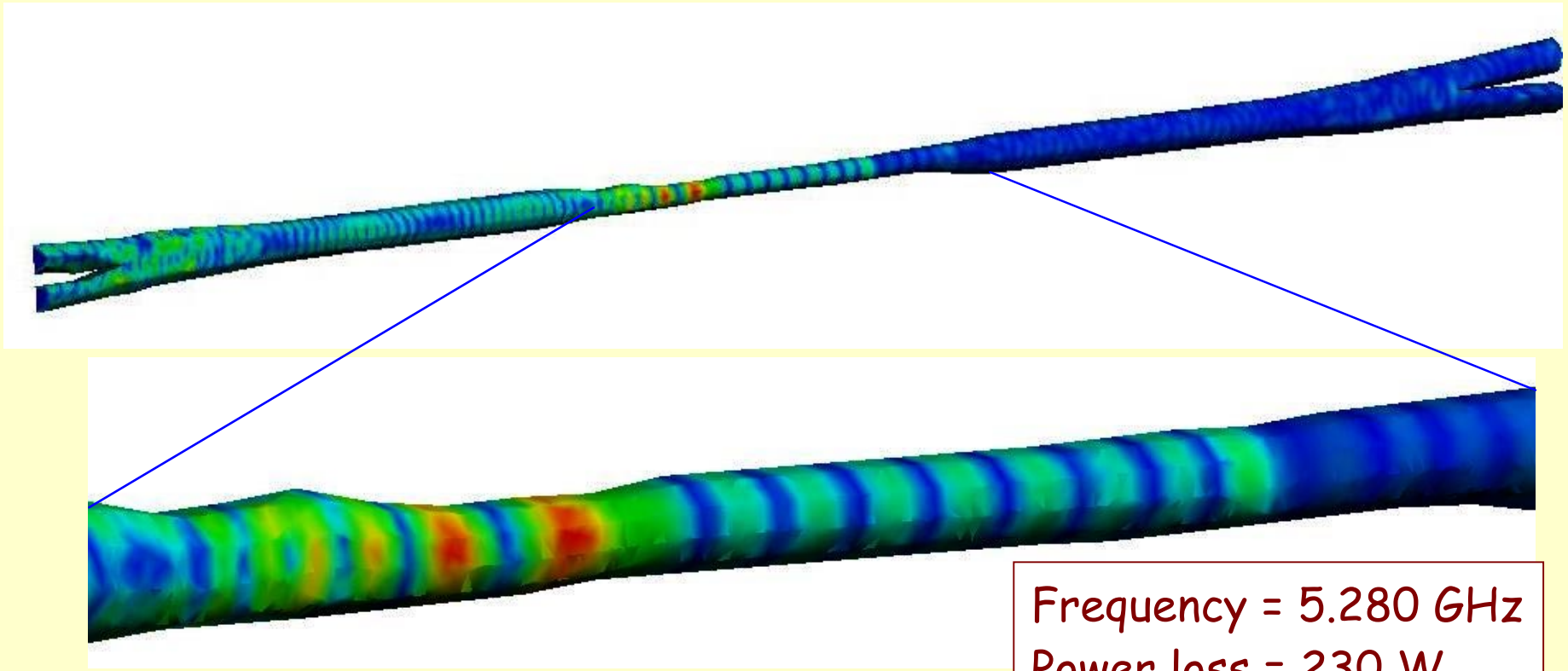
Mode at Forward Mask

N. Folwell, C. Ng



Frequency = 5.280 GHz
Power loss = 230 W

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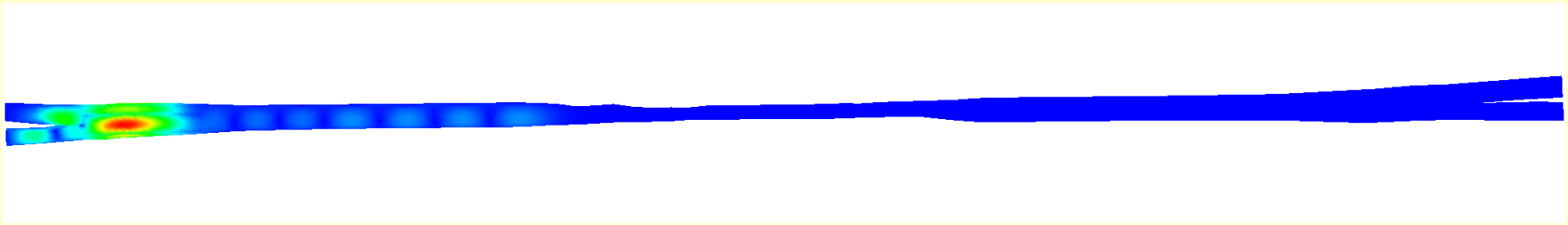
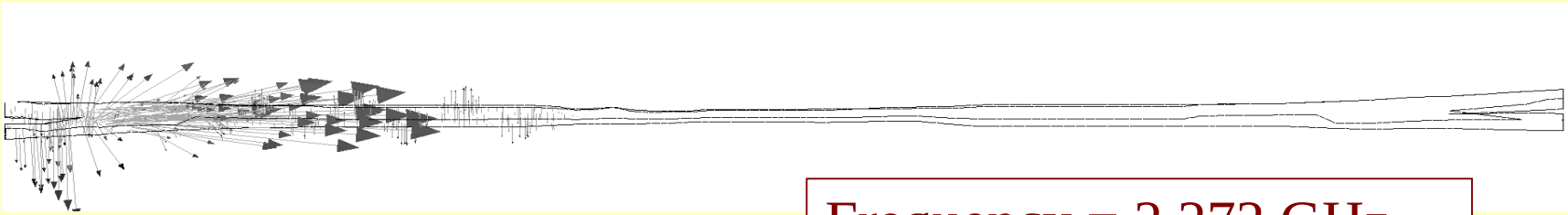
Mode near Forward Crotch

N. Folwell, C. Ng





Frequency = 2.272 GHz
Shunt impedance = 0.4 kΩ
Power loss = 90 W

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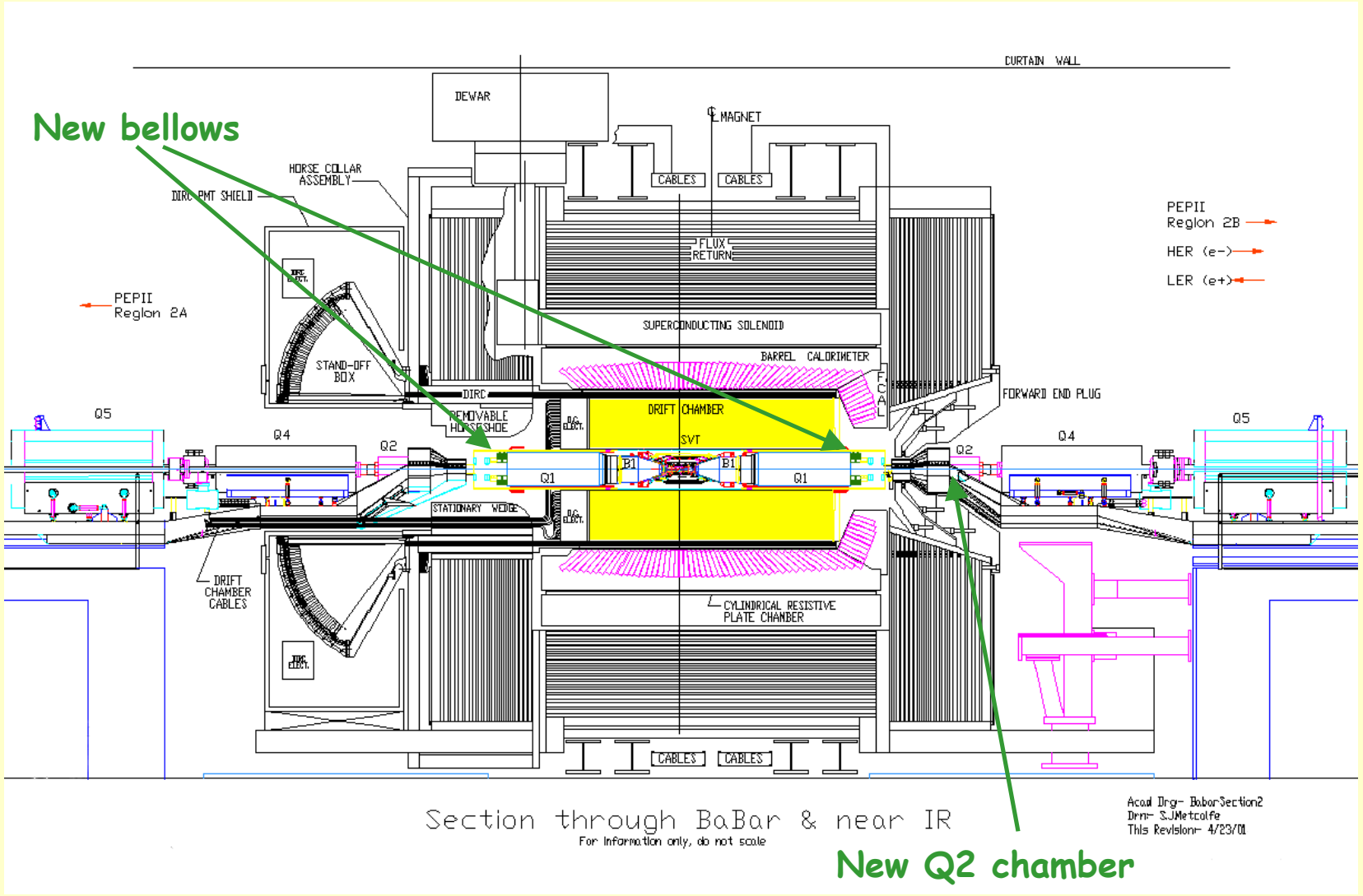
Side view of the BABAR Detector



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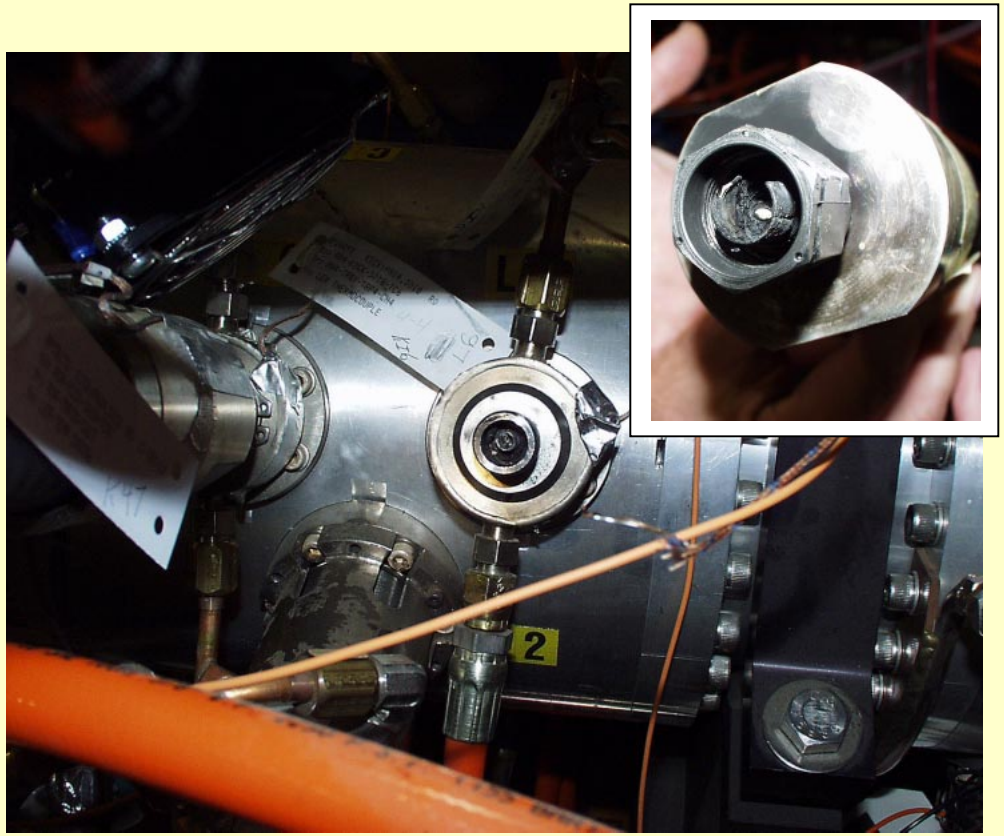
Longitudinal Feedback

- **Feedthrough burned up twice**
  - Specific mode?
- **New feedthrough with larger connector**
- **New kicker**



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Rf Upgrades

- HER rf stations #6&7
  - 2 cavities/klystron: power rather than voltage
  - Up to 1.5 A beam current
  - Shorter bunches possible
- LER already sufficient rf for ≈ 3.5 A
- Vacuum & feedbacks need to keep up

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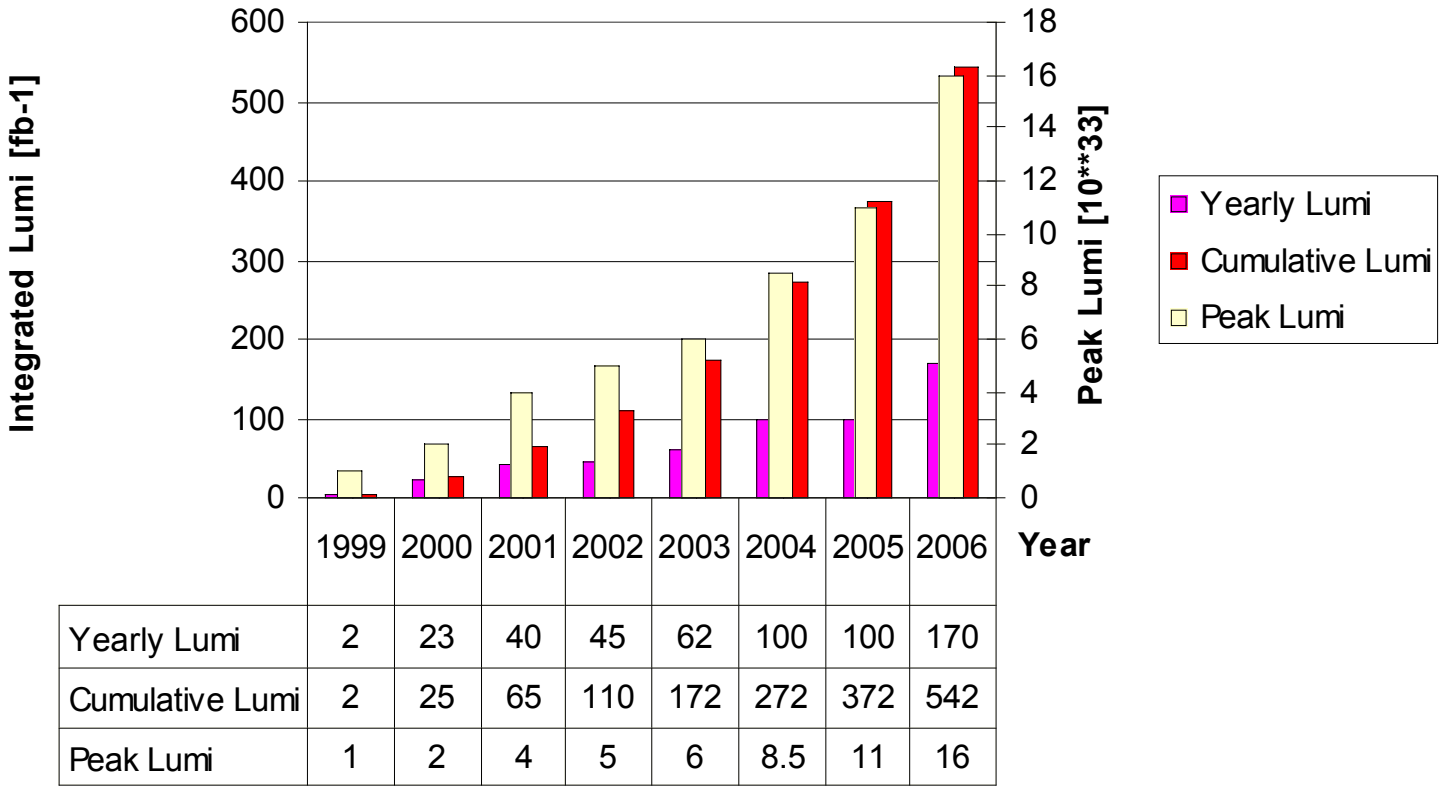
Luminosity Projection to 2006



Yearly Lumi	2	23	40	45	62	100	100	170
Cumulative Lumi	2	25	65	110	172	272	372	542
Peak Lumi	1	2	4	5	6	8.5	11	16

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Beyond the present machine…

- A new IR with a crossing angle would
  - Raise the beam-current limit
  - Allow for more bunches (up to 3496–gap)
  - Lower β^* by moving IR quads closer in
  - Lower lost-particle backgrounds
  - Potential increase in luminosity by factor ≈3
- To go further, new rings would be required

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PEP-II Upgrade Scenarios

J. Seeman

	New IR, present rings	New IR, New LER constant LER injection	New IR, New rings, constant injection
#bunches	**1700**	**3400**	**3400**
Beam currents	**HER: 2 A, LER: 4.5 A**	**HER:2 A, LER: 24.5 A**	**HER: 8.5 A, LER: 24.5 A**
IP ß functions	**x: 18 cm, y: 0.45/0.5 cm**	**x: 15/23 cm, y: 0.4 cm**	**x: 15 cm, y: 0.15 cm**
Beam-beam ξ	**0.075**	**0.075**	**0.112**
Luminosity	**4.5×10^{34}**	**1×10^{35}**	**1×10^{36}**

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PEP-II Upgrade Issues

- Some issues identified at recent workshop:
  - New IR design with 10…20 mr crossing angle
    - will likely use s/c quads
    - Split s.r. power upstream/downstream
  - New rings for extremely high beam currents:
    - No bellows, welded vacuum system
    - Possibly want to increase rf frequency, s/c cavities
    - Want to lower α to shorten bunches
    - Need continuous injection to deal with beam life times of a few minutes
- Gradual upgrade process (as much as possible)

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PEP-II Upgrade issues (cont'd)

- Backgrounds
  - Crossing angle with no B1 helps, factor 2…10
  - Luminosity background has to be dealt with by detector
  - Touschek & other beam-life time backgrounds require careful collimation
  - Tough!

Summary

- **PEP now exceeds the CDR performance parameters by 50…≥100%.**
- **We continually strive to raise luminosity**
  - by lowering beam sizes,
  - by raising beam-currents.
- **Hardware improvements will raise the ceiling of PEP performance.**
- **Planned "strategic" improvements would yield one or two orders of magnitude more luminosity**

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