PEP-II B Factory
Machine Status and Upgrades

John T. Seeman
for the PEP-II Staff

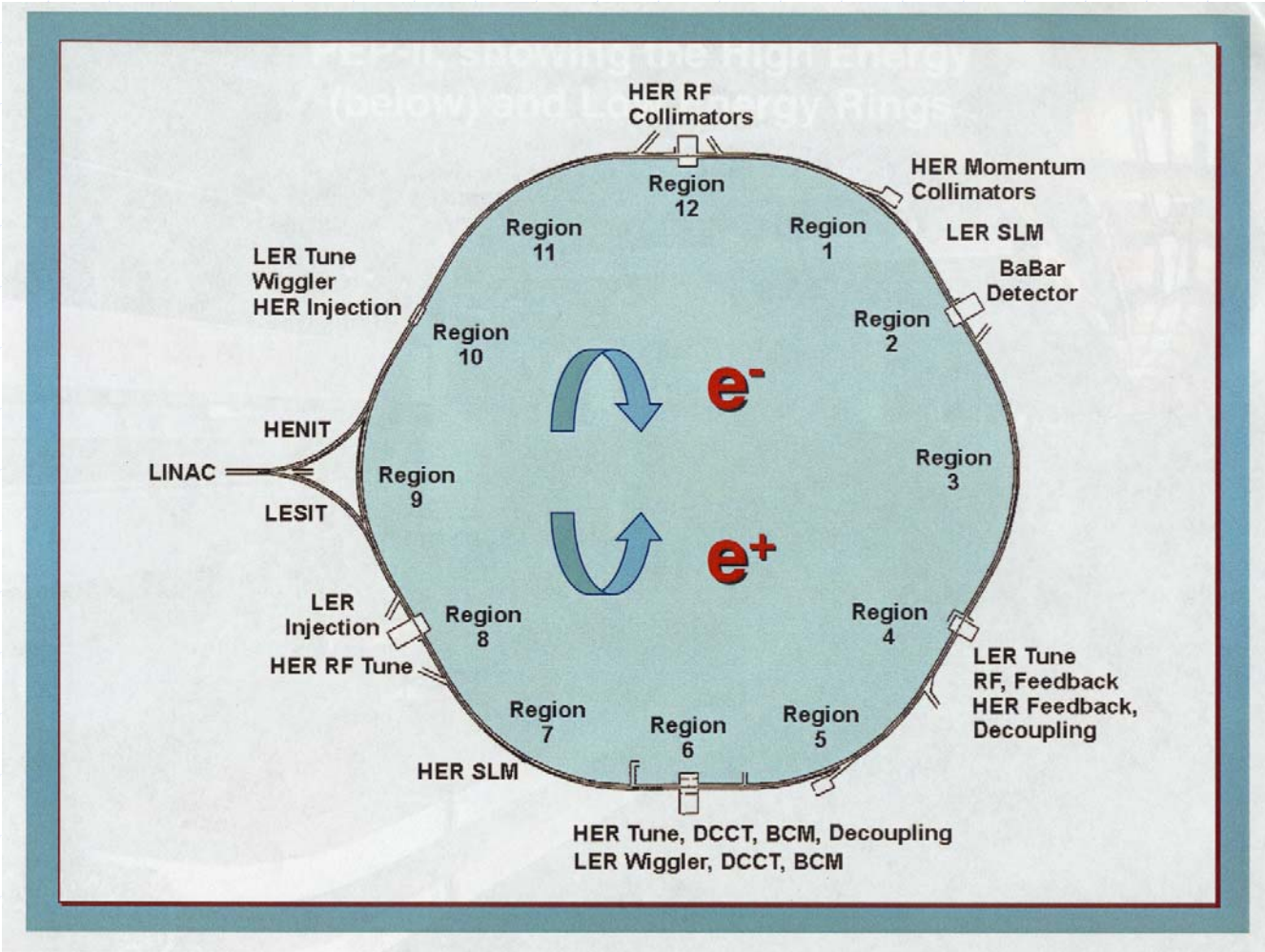
SLAC DOE Site Review

April 9, 2003

PEP-II Topics

- FY2002 Results
- FY2003 Results (first half)
- FY2003 Plans (second half)
- FY2004 Plans and Long Range Plans

PEP-II e^+e^- Collider



PEP-II is a two ring e+e- asymmetric collider

FY2002 Results

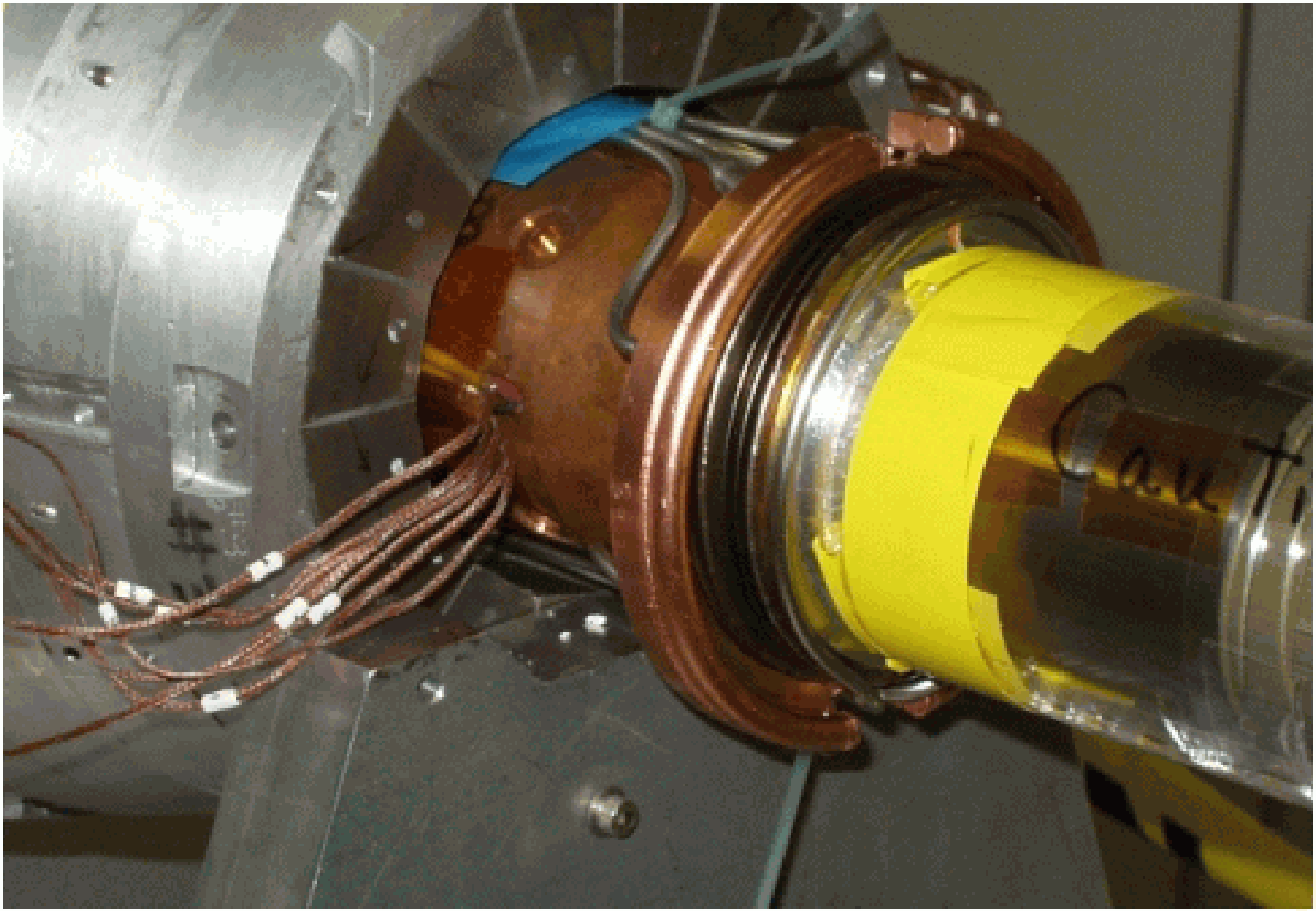
- Run 2 ended June 30, 2003.
- Total integrated luminosity (delivered)= 101 fb^{-1}.
- Highest luminosity = 4.63 x $10^{33} cm^{-2} s^{-1}$.
- Down was 4.5 months long for BaBar IFR repairs and PEP-II IP cooling upgrades.
- Run 3 started November 15, 2003.

2002 Down Time Projects

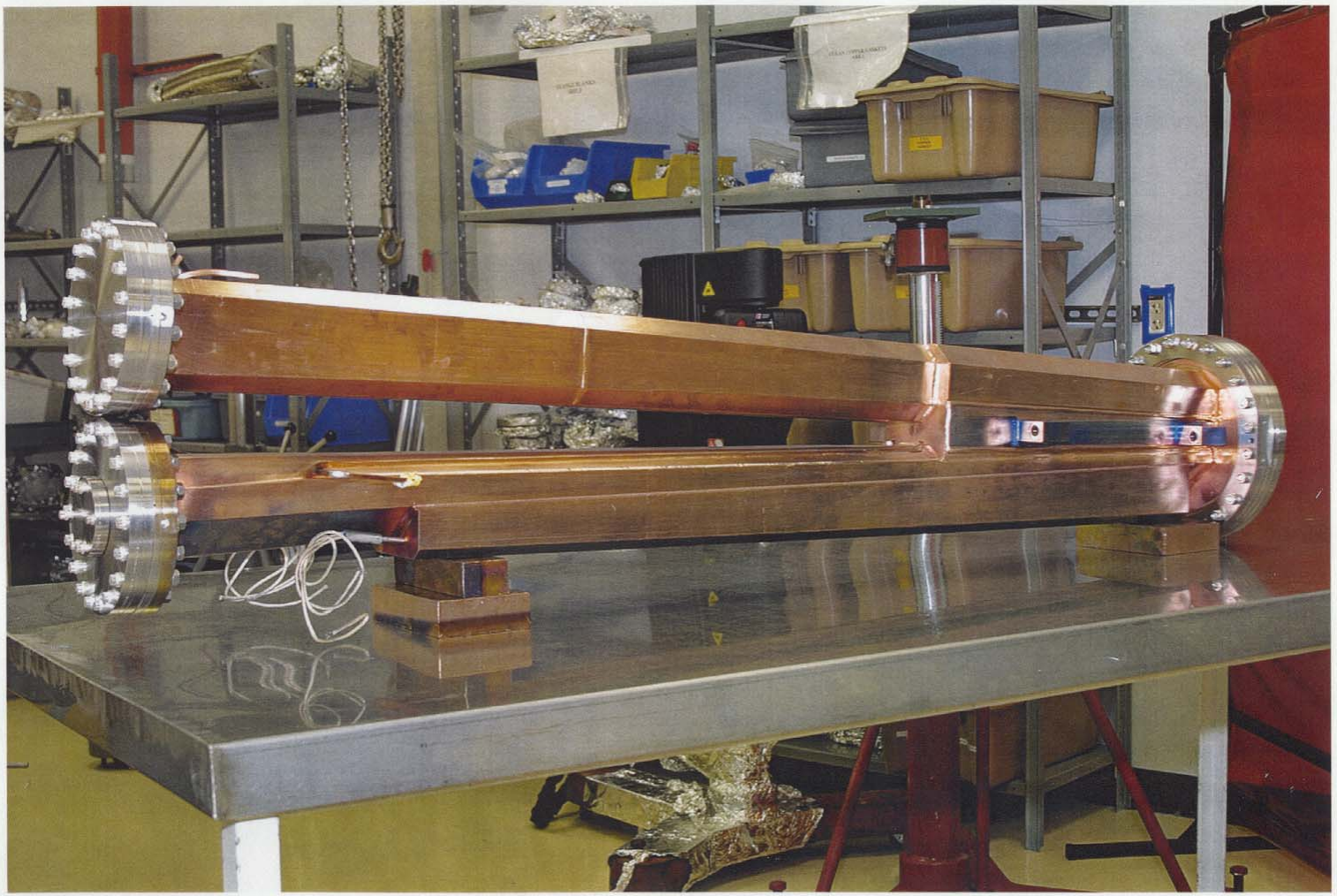
- Major projects finished:
  - Support tube bellows cooling (x5 cooling)
  - Forward Q2 chamber (new)
  - HER #6 RF station (new)
  - HER #7 RF station (new)
  - IR2 valve repairs
  - IR2 valve gap rings (repaired)
  - IR2 LER collimator shielding (new)
  - Shortened abort kicker gaps (5% → 2.5%)
  - New x-y BPMs at ring sextupoles.

Forward Cooling Collars

Forward Vertex Chamber Bellows Cooling Installation



New Q2 chamber

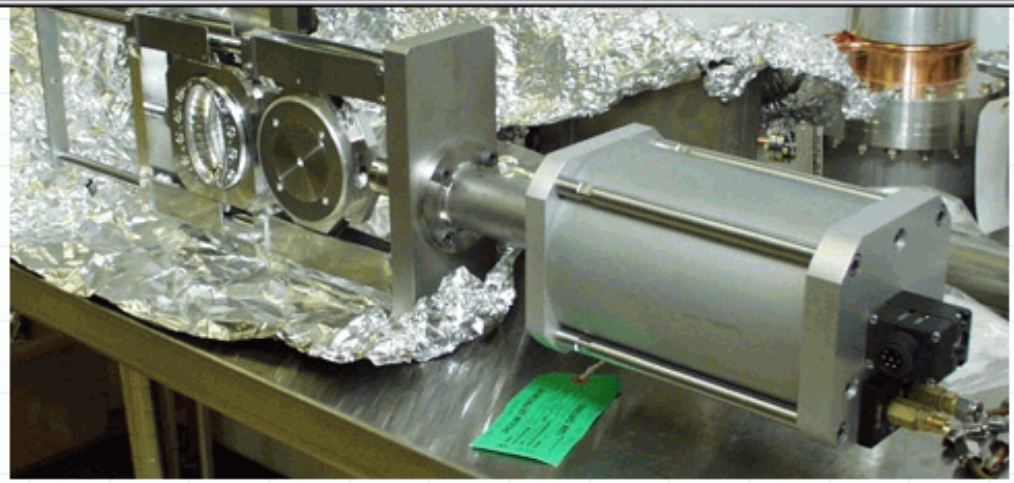


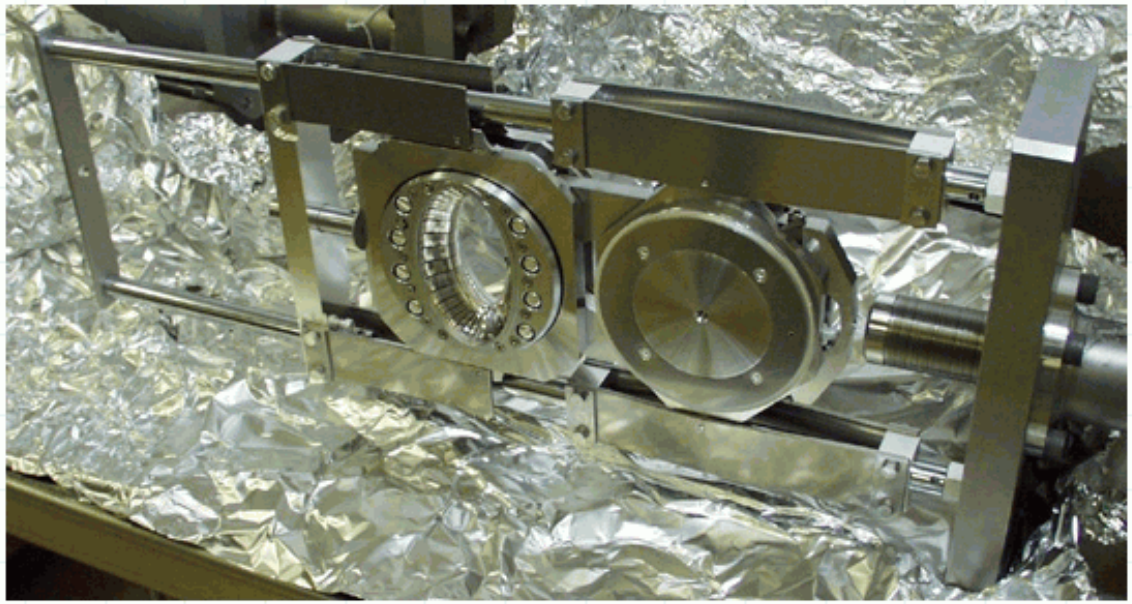
New PEPII forward Q2 vacuum chamber

CRW_0415L, S.J.Metcalfe, 5/18/02

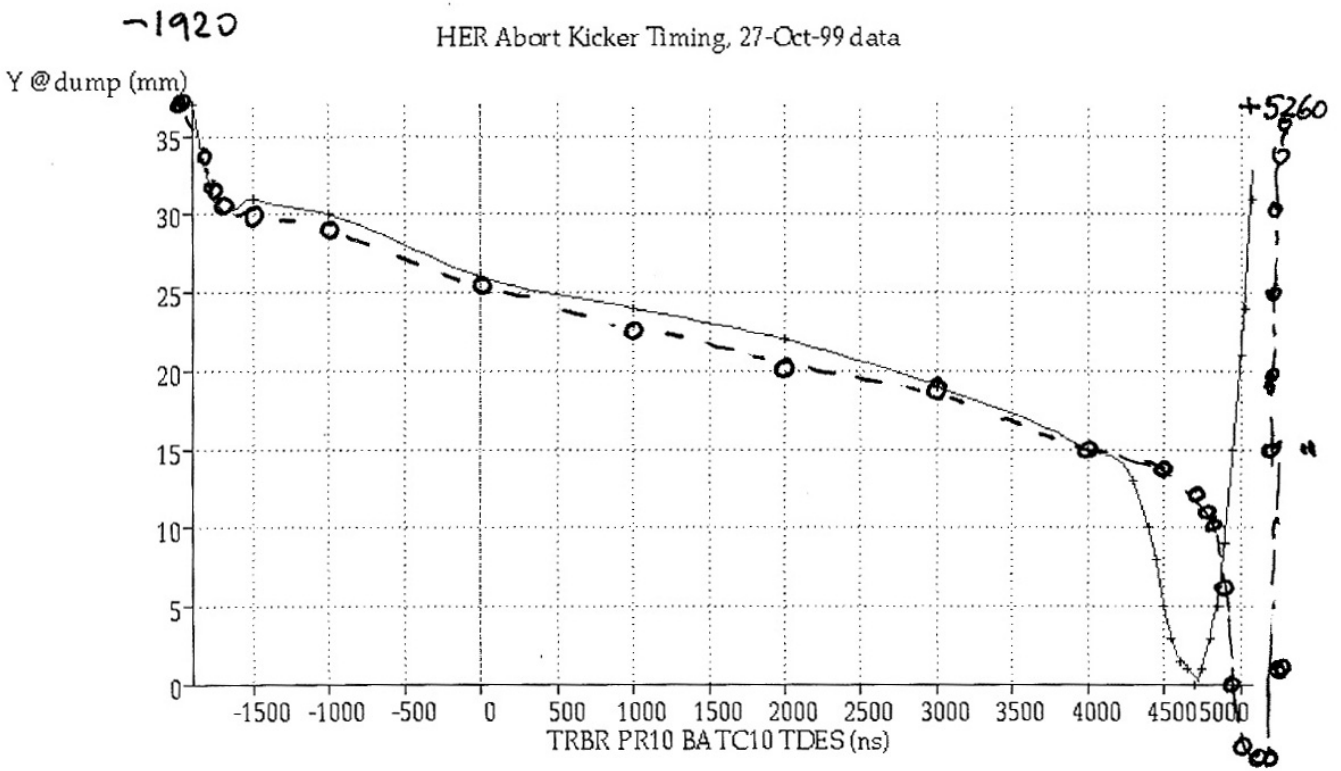
IR2 Valve HOM Damage

PEP-II IR2 Vacuum Valve





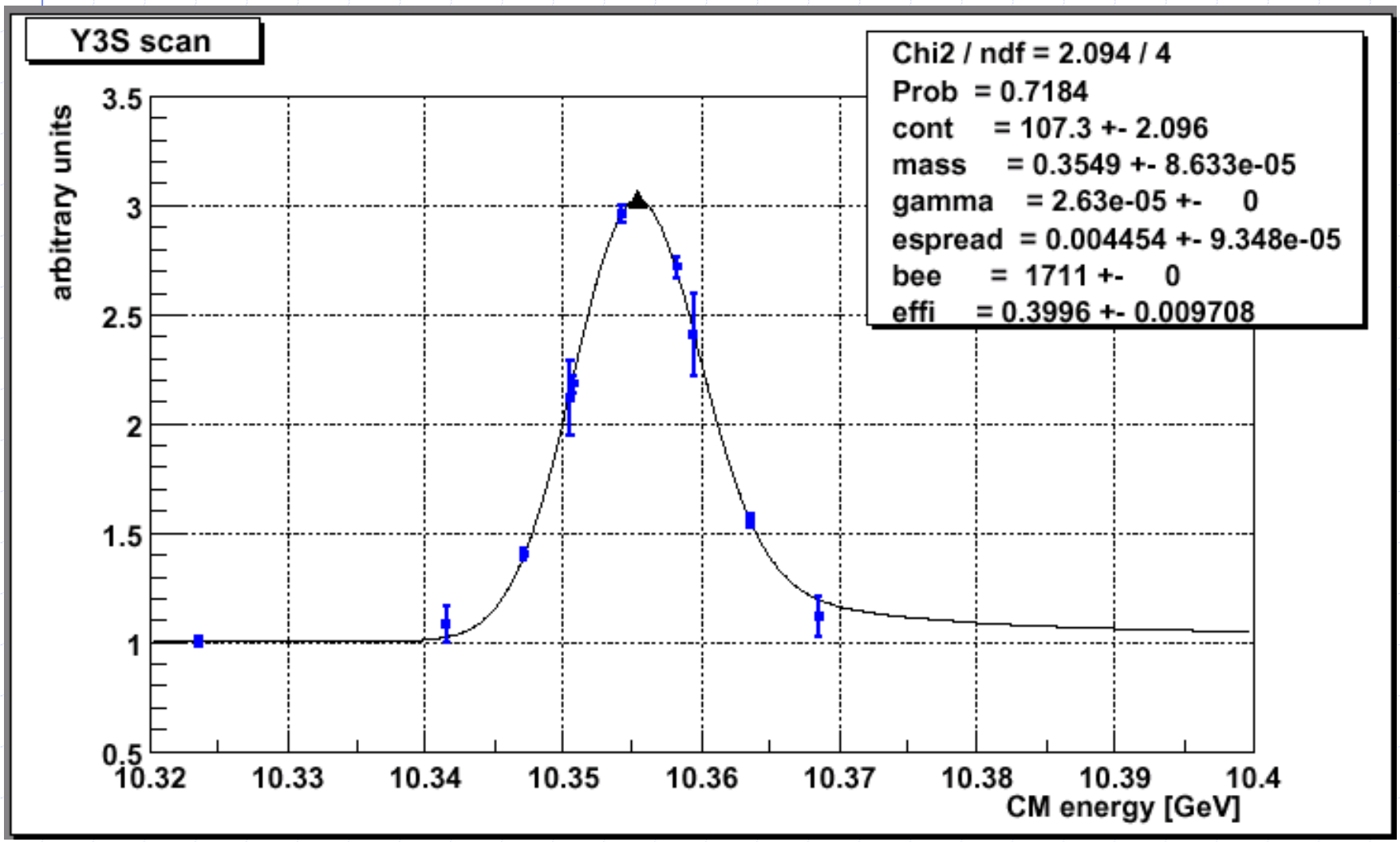
Shortened Abort Gap



PEP-II FY2003 Run Status (half way)

- Turn-on started November 15.
- Winter shutdown December 23-January 1.
- Power outages (spikes) in December caused hardware damage and run delays.
- Running has now stabilized.
- Present data run will end June 30.
- Run 4 starts September 5, 2003.
- Run 4 stops July 11, 2004, for 10 months.
- Recall that SPEAR-3 is installed this summer.

PEP-II Energy width measured on the Upsilon 3S resonance



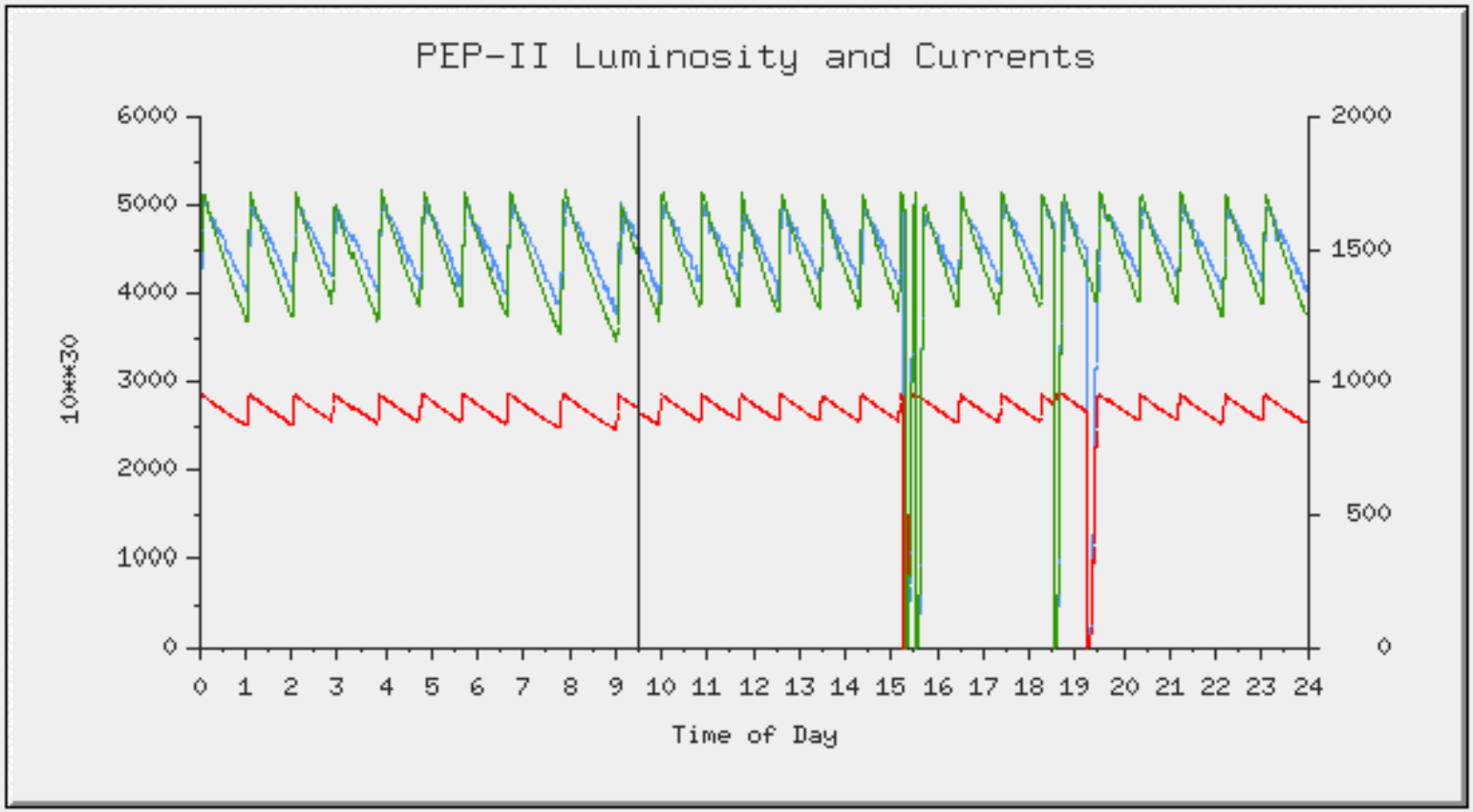
Recent Accelerator Advances

- By-4 bunch pattern of last spring had very little room to add bunches. Now with By-3 pattern and mini-trains we have open slots to expand the number of bunches and increase the currents. By-3 pattern has extra HOM heating.
- Poor beam orbits from last spring have been fixed but lowered the luminosity. Restored with selected orbit bumps in LER chicanes and sextupoles have reduced the electron cloud effect, vertical dispersion, and horizontal dispersion. (We now, mostly, know why the orbits had to be poor last spring.)
- Shortened Abort Gap has allowed 2.5% more bunches and smoother RF operation.

I HER	I LER	Luminosity	Spec Lum	E HER	E LER	E CM
899.82	1465.49	4631	3.26	8993	3121	10595
mA	mA	10**30/Sec	N*10**30 / mA**2/Sec	MeV	MeV	MeV

HER N Buckets / Pattern		LER N Buckets / Pattern	
921	by3_t10_10_9_her_ratiot	928	by3_t10_10_9_ler

Last Owl/Day/Swing/24hr	117.0	112.1	117.9	347.0	Shift:	23.02 /pb
Peak Luminosities	5105	5075	5103			5037



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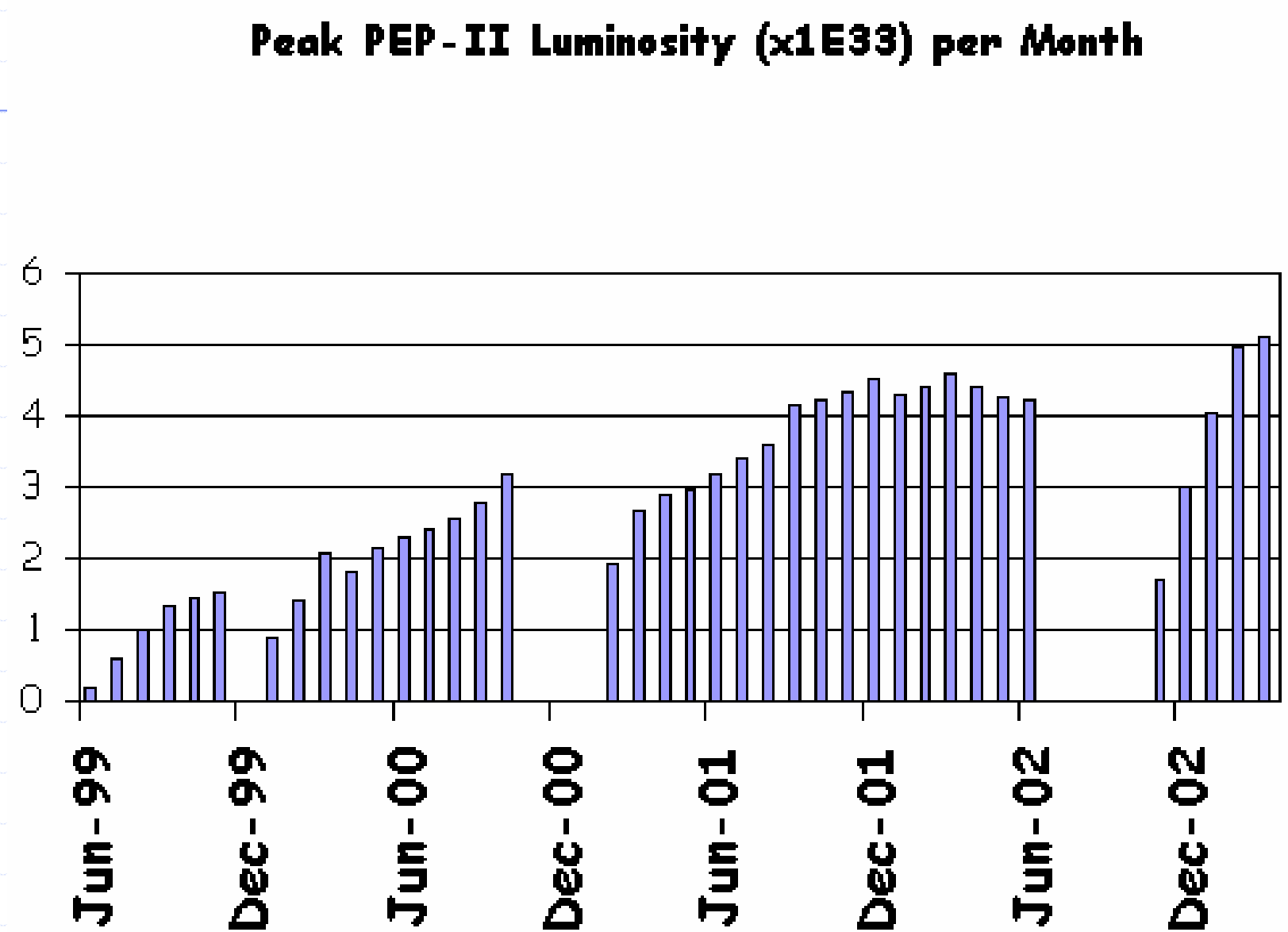
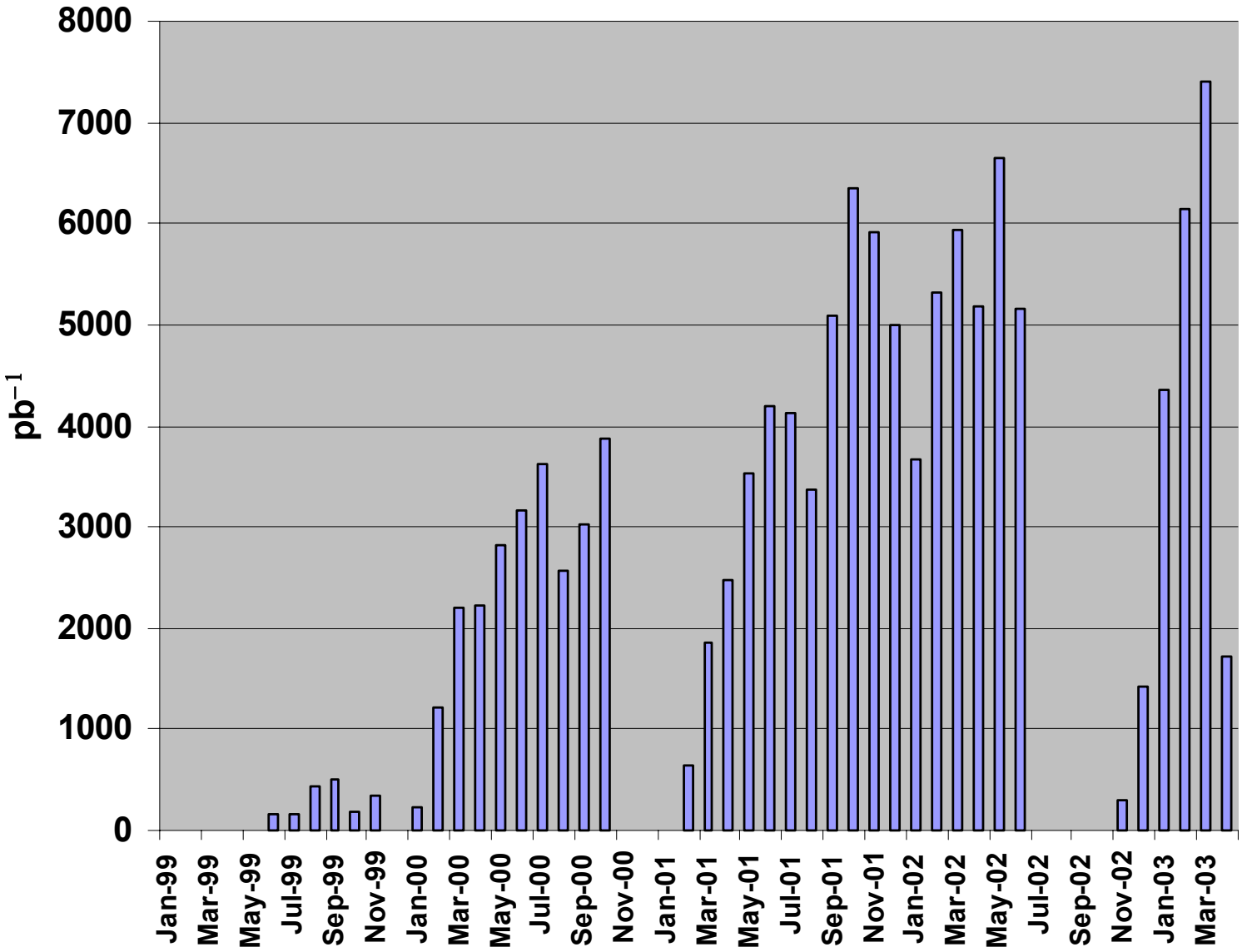
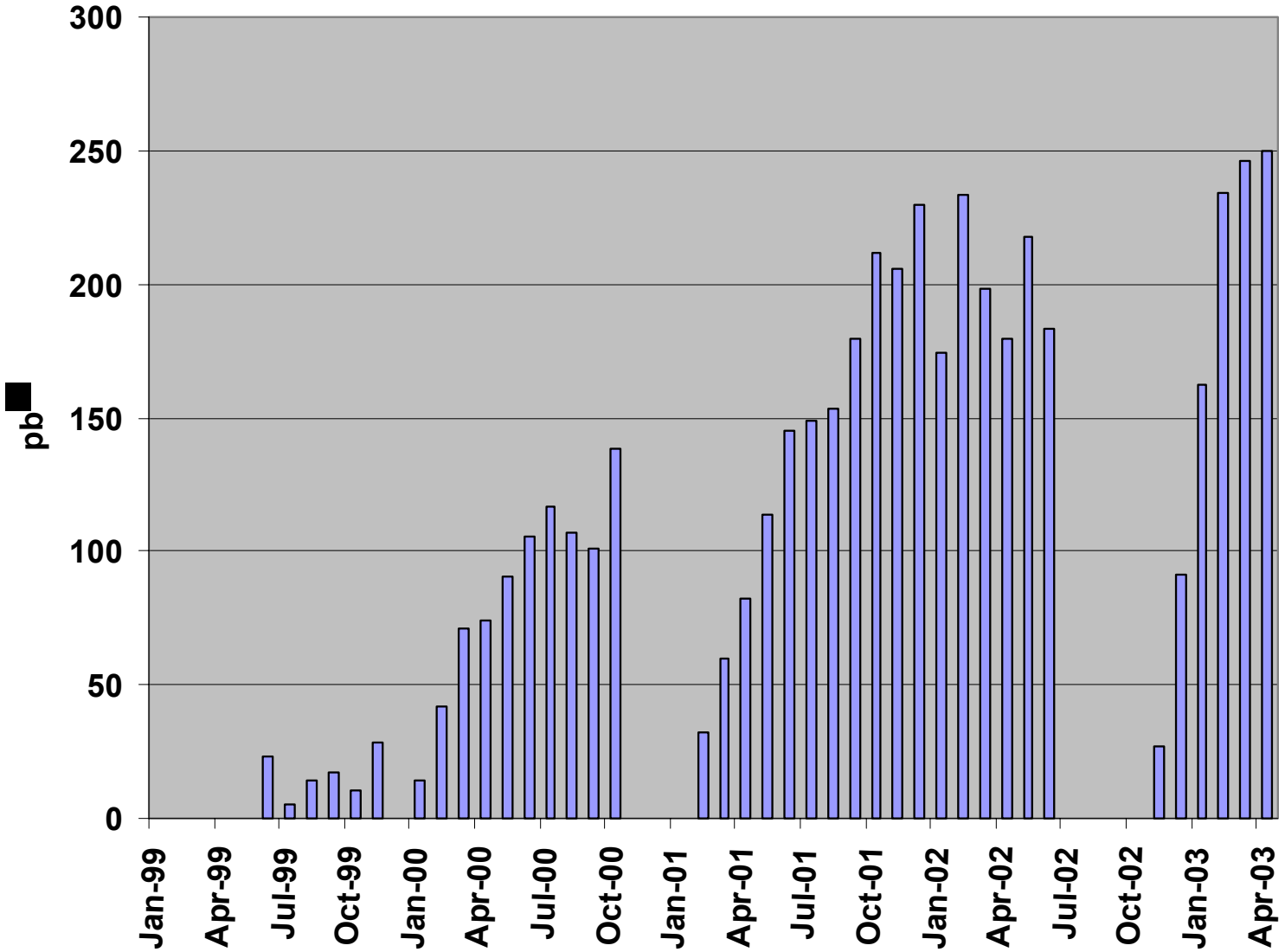

Peak PEP-II Luminosity (x1E33) per Month
6
5
4
3
2
1
0
Jun-99
Dec-99
Jun-00
Dec-00
Jun-01
Dec-01
Jun-02
Dec-02

PEP-II Monthly Integrated Luminosity

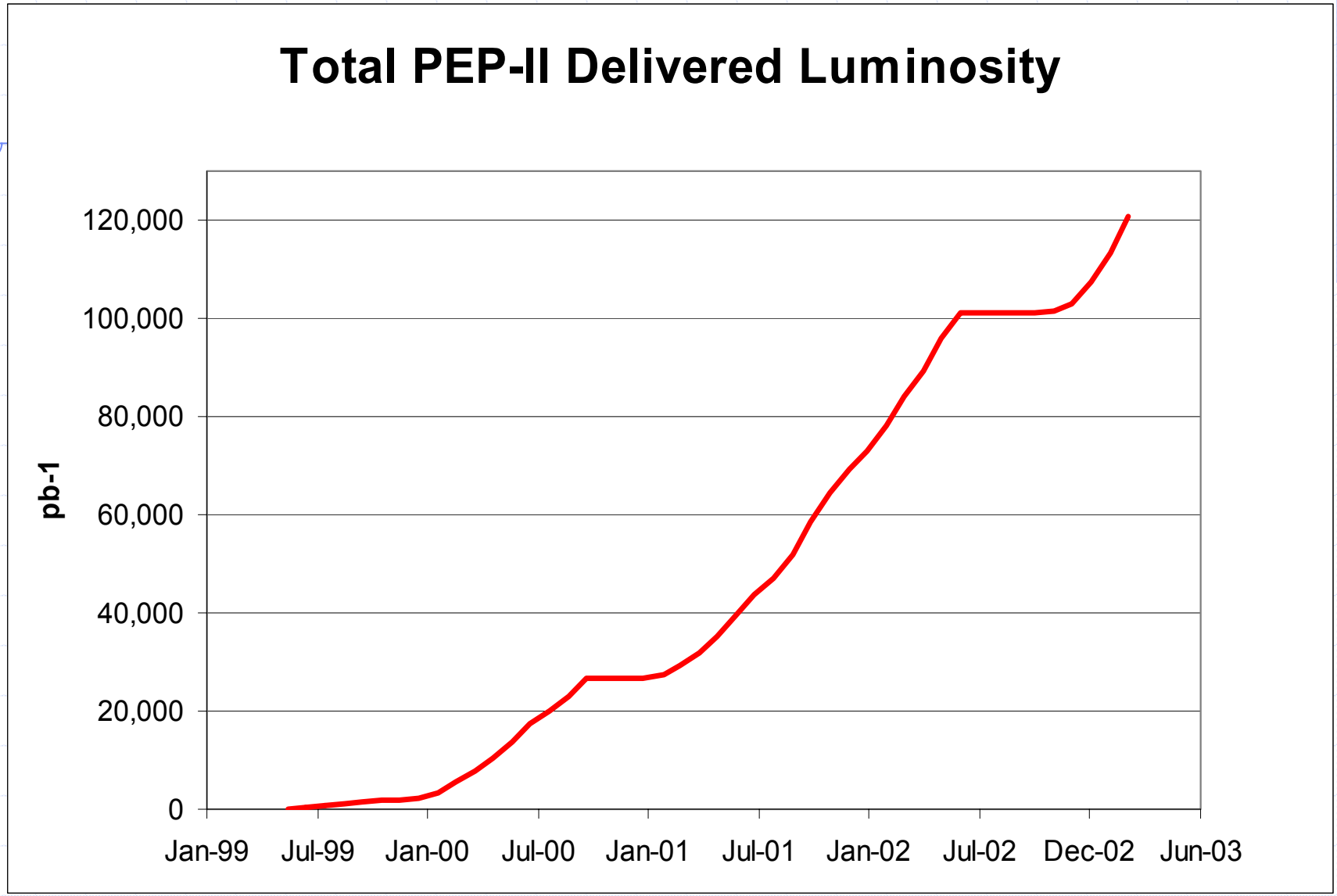


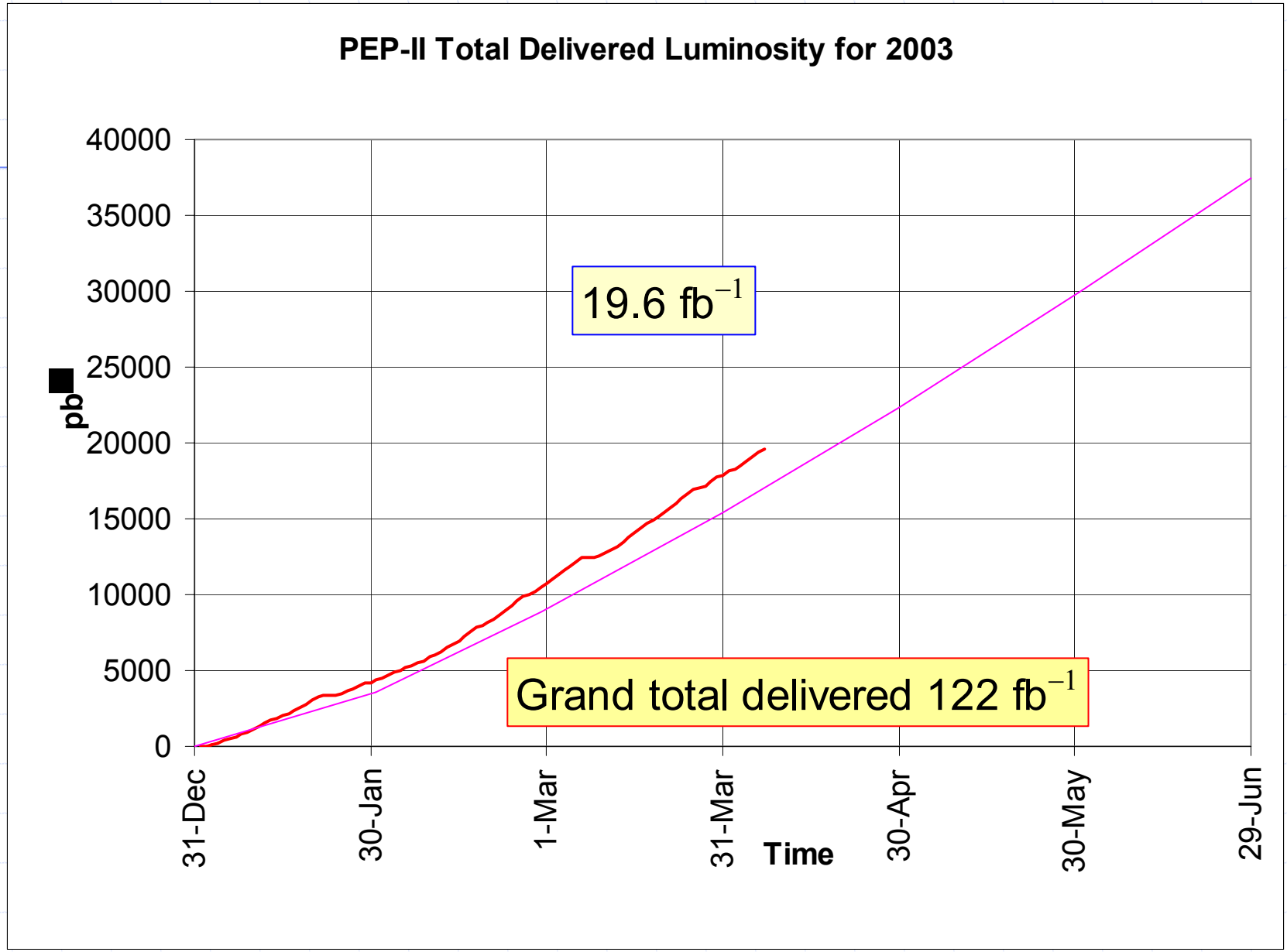
PEP-II Daily Average for each Month



Predicted Integrated Luminosity FY2003

PEP-II Integrated Luminosity for Run 2002-2003								J. Seeman		Dec 4, 2002	
Year	Month	Days	Peak to Average Luminosity Ratio	Peak luminosity xE33 (at end)	Integrated luminosity per period fb-1	Cumulative integrated luminosity fb-1	Positron current (mA)	Electron current (mA)	Beta y* (cm)	Beta x* (cm)	Number bunches
2002	November	15	0.20	2.1	0.3	0.3	1100	650	1.20	50	642
2002	December	22	0.45	3.5	2.4	2.7					
2003	January	27	0.45	4.5	4.2	6.9	1800	1000	1.20	50	800
2003	February	28	0.45	5.0	5.2	12.0					
2003	March	31	0.45	5.5	6.3	18.4	2200	1100	1.00	47	950
2003	April	30	0.45	6.0	6.7	25.1					
2003	May	31	0.45	6.5	7.5	32.6					
2003	June	30	0.43	7.0	7.5	40.1					
2003	July	31	0.40	7.5	7.8	47.9	2500	1300	0.90	45	1050


Total PEP-II Delivered Luminosity
pb-1
120,000
100,000
80,000
60,000
40,000
20,000
0
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Dec-02
Jun-03


PEP-II Total Delivered Luminosity for 2003
40000
35000
30000
25000
20000
15000
10000
5000
0
pb
19.6 fb^{-1}
Grand total delivered 122 fb^{-1}
31-Dec
30-Jan
1-Mar
31-Mar
30-Apr
30-May
29-Jun
Time

PEP-II Records

Last update:
Apr. 1, 2003

Peak Luminosity

5.213×10^{33} $cm^{-2}sec^{-1}$ — **March 24, 2003**

921 bunches 1850 mA LER 960 mA HER

Integration records of delivered luminosity

Best shift (8hrs)	**119.9** pb^{-1}	**Mar 23, 2003**
Best 3 shifts in a row	**347.0** pb^{-1}	**Mar 16-17, 2003**
Best day	**326.1** pb^{-1}	**Mar 16, 2003**
Best 7 days	**2.062** fb^{-1}	**Mar 20-26, 2003**
Best week (Sun 0:00 to Sat 24:00)	**2.023** fb^{-1}	**Mar 16-22, 2003**

Luminosity Equation

- When vertical beam-beam parameter limited.
- $\xi_y \sim 0.06$ in PEP-II and KEKB.
- To raise luminosity: lower β_y^*, raise I & ξ_y.

$$\xi_y^+ = \frac{r_0 N_b^- \beta_y^{*+}}{2\pi\gamma^+ \sigma_y^{*-} \sigma_x^{*-}} (flatbeams)$$

$$L = 2.17x10^{34} \frac{n\xi_y EI_b}{\beta_y^*}$$

FY2003 (second half of year) Luminosity Improvements to PEP-II

- New ring correction algorithms (MIA) –Now works globally to fix beta beats and coupling. So far does not work locally (IR).
- New local β_y* knobs in HER/LER. HER works and LER to be tried this week. Try for 9 mm.
- Move horizontal tunes to near half integer. We will try soon as MIA now works globally.
- Increase number of bunches and currents. Need to watch RF trips, vacuum heating, and backgrounds.
- Try continuous injection.

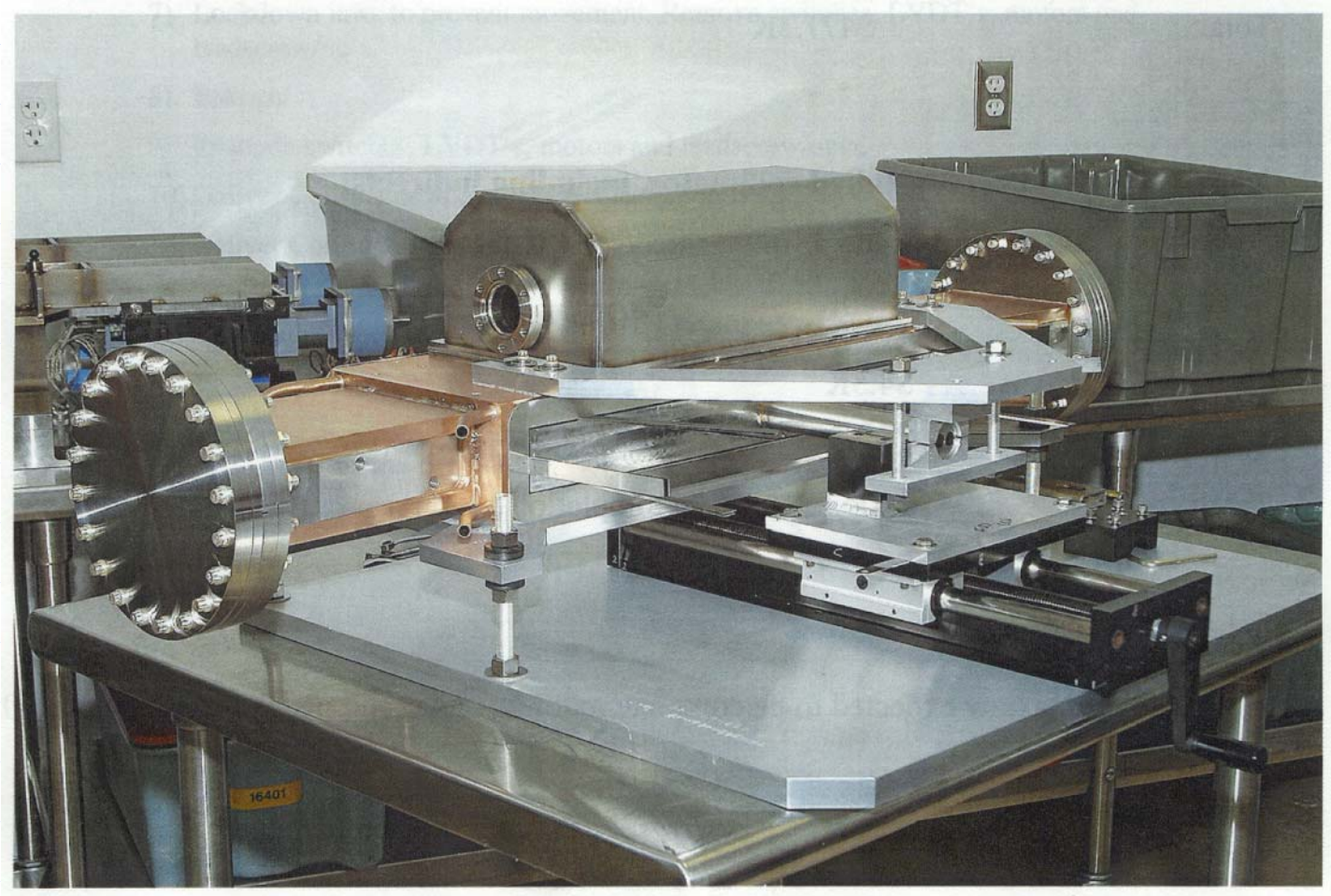
Scaling factors:

- Lower β_y^* in HER/LER with luminosity gain = 12/9 or ~x1.25. "Difficulty = low to medium"
- Raise currents and number of bunches by x1.3. "Difficulty = hard" (several over heating components)
- Move tunes to half integer to get lower tune shifts. Gain is about x1.25. "Difficulty = medium to hard"
- Continuous LER injection: "Difficulty: easy for PEP-II; hard for BaBar". Gain in integrated luminosity is about x1.2.
- Total luminosity gain is x2.0. Hope to get x1.4 by July. (Luminosity to 7.0 by July with more later.)

PEP-II Summer 2003 Projects

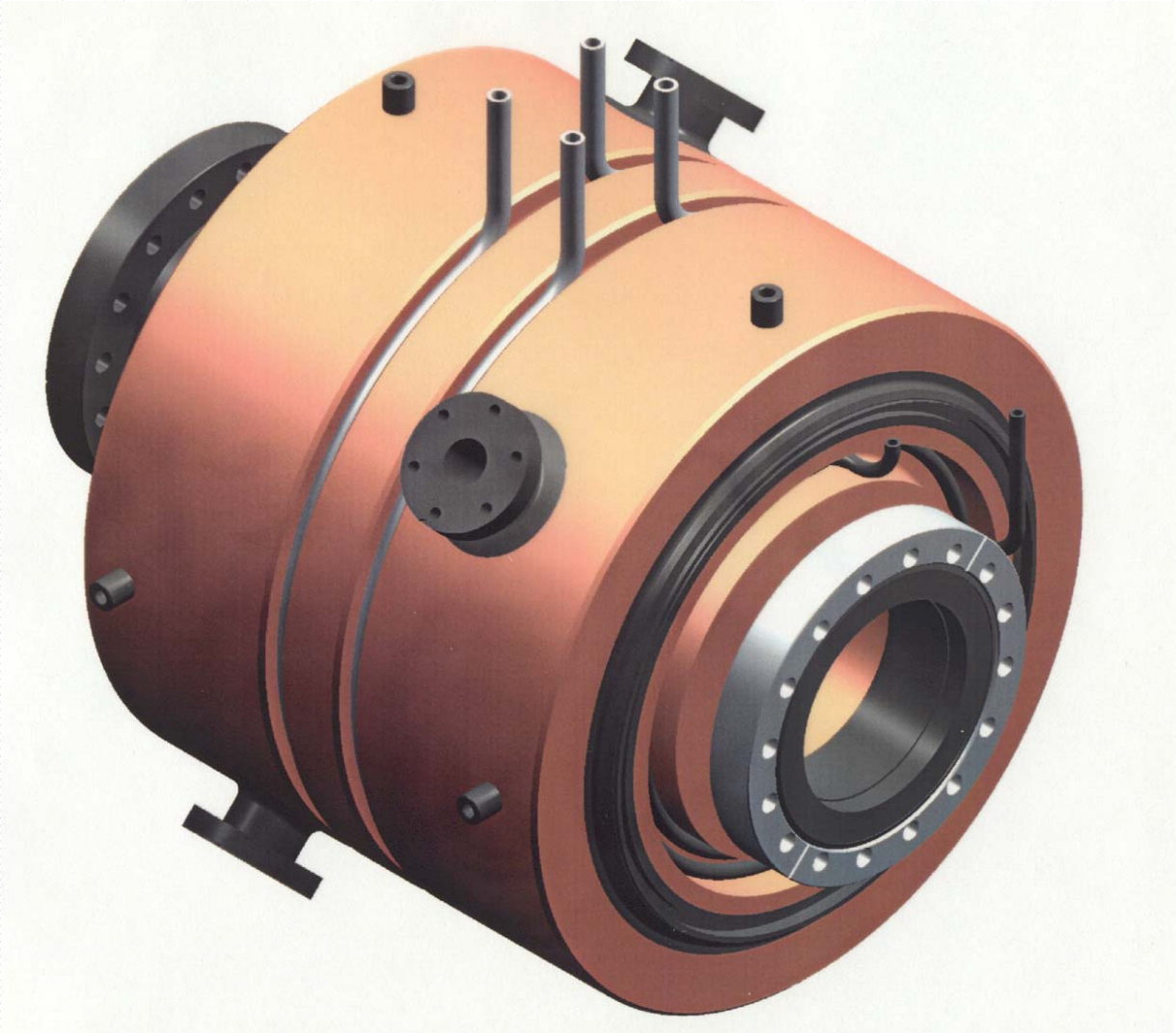
- New HER # 8 RF station (+200 mA).
- New HER collimator (30 m upstream).
- New Longitudinal feedback kickers.
- Improved transverse feedback kickers.
- Improved low level RF feedback circuits (higher I).
- More x-y BPMs in IR2 region.
- LER straight section and Arc 11 solenoid upgrade.
- Octupoles for tune shift with amplitude studies.
- Bellows fans on all LER bellows (~240)
- Fix IR vacuum gate valves
- Air cooling of Feedback Kicker cables
- More background shielding of PEP-II in IR2

HER Collimator

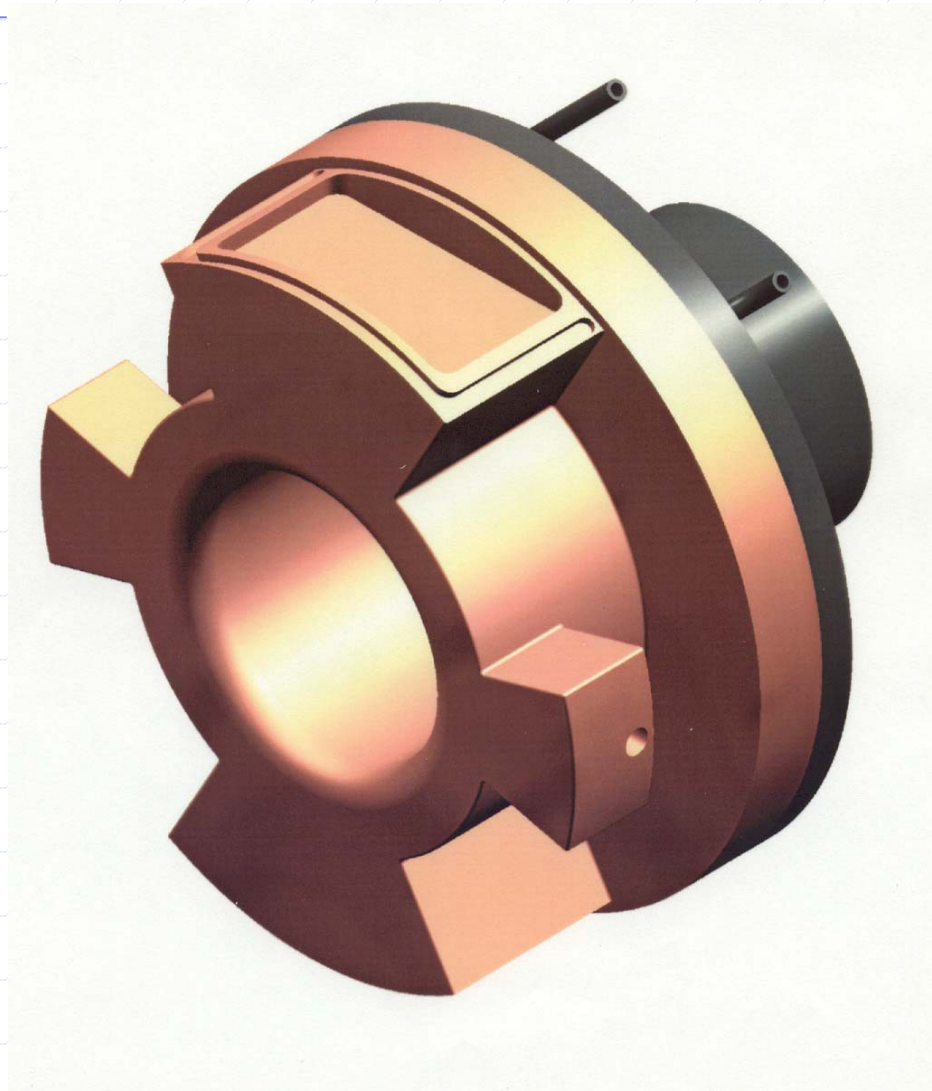


Old Longitudinal Kicker

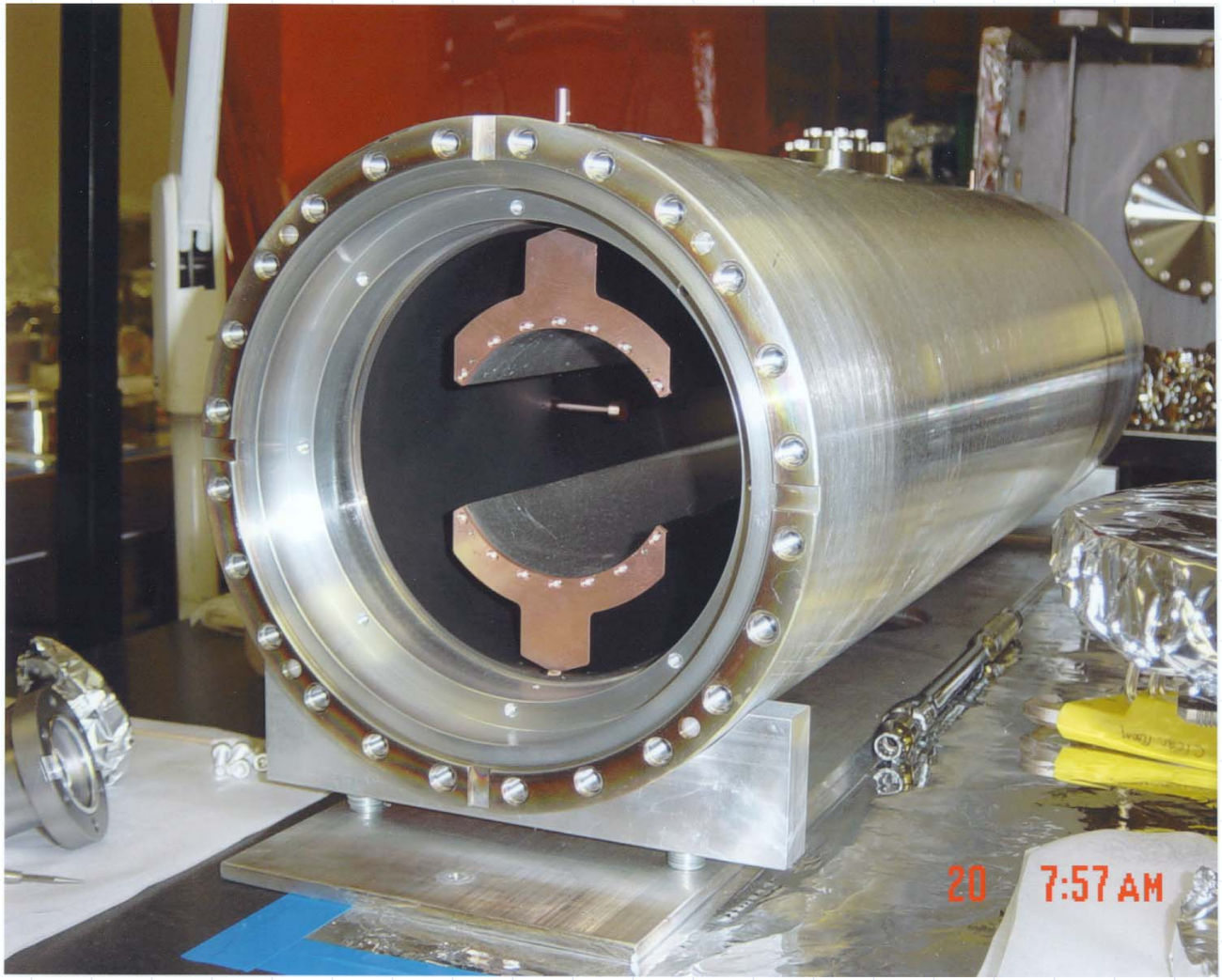
New Longitudinal Feedback Kicker Assembly



New Longitudinal Feedback Kicker End Plug



Transverse Feedback Kicker

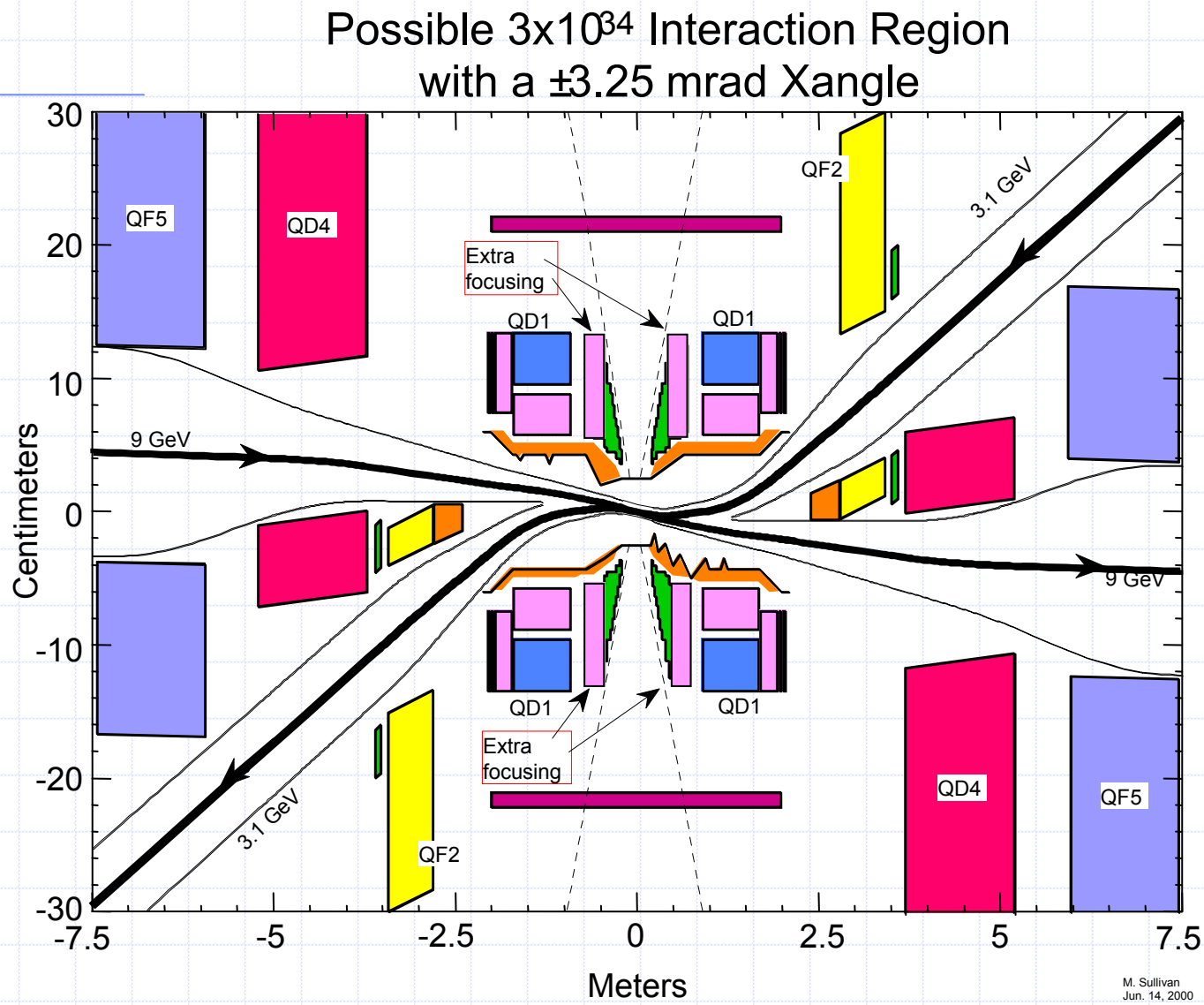


Octupole Magnets (from CERN)

FY2004 and longer plans

- Continue to increase luminosity each year → AIP funding (Accelerator Improvement Projects)
- Big upgrade in the summer of FY 2004 by moving quadrupoles closer the the interaction region and lowering β_y^* to 6-7 mm.
- Continue to add RF stations (one station per year for five years)
- Some higher power vacuum chamber upgrades needed.
- Better beam controls needed: bunch-by-bunch feedbacks, injection, backgrounds, Electron Cloud Instability,…

PEP-II upgrade with Permanent Magnet Quadrupoles



Path to higher PEP-II luminosity

Luminosity	4.8E33	7.5E33	1.5E34	2.5E34	Units
I+	1650	2400	3300	4500	mA
I-	950	1250	1600	2000	mA
Beta y*	14	10	8.0	6.5	mm
Beta x*	50	50	50	50	cm
Bun. Length	1.3	1.05	0.9	0.8	cm
# bunches	898	1180	1450	1700	
Vert. emit	2.5	1.4	0.9	0.9	nm
Horiz. Emittance	40/50	35/45	35/45	40/53	nm (+/-)
Crossing angle	0	0	0	+/-8 (?)	mrad
Beam-beam para.(x/y)	7.5/4.2	7.5/4.4	7.5/5.6	8.2/5.8	x100
Number RF stations	7	10	13	15	
Date hardware ready	Nov 02	Mar 03	Nov 05	Nov 07	
Date for luminosity	Feb 03	July 03	Fall 06	Fall 08	

PEP-II Eight Year Run Plan for FY2003 Thru FY2010												J. Seeman		Jan 13, 2003	
Year	Months	Days	Average to peak lumin. ratio	Peak luminosity xE33 (at end)	Integrated luminosity per period fb-1	Cumulative integrated luminosity fb-1	e+ current (mA)	e- current (mA)	Beta y* (cm)	Beta x* (cm)	Emit horiz (nm) +/-	B-B tune shift (vert/horiz)	Num Bunch	Cont. Inj. factor	MD time factor
	Start		0.5	4.4		103.0	1675	975	12.5	50	25/50	0.035/0.07	762	1.00	0.95
2003	Jan-July	200	0.5	7.53	46.4	149.4	2400	1250	10	50	30/50	0.044/0.073	1180	1.00	0.90
2003	Aug-Sept	60	0	0	0.0	149.4									
2003	Oct-Dec	80	0.4	7.53	10.4	159.8									
2004	Jan-June	170	0.55	11.4	72.3	232.0	2700	1500	9	50	30/45	0.053/0.076	1400	1.05	0.90
2004	July-Sept	90	0	0	0.0	232.0									
2004	Oct-Dec	80	0.4	11.4	15.8	247.8									
2005	Jan-June	170	0.55	15.4	107.2	355.0	3300	1600	8	50	35/50	0.056/0.074	1450	1.10	0.90
2005	July-Dec	180	0	0	0.0	355.0									
2006	Jan-Mar	80	0.4	15.4	21.3	376.3									
2006	Apr-July	120	0.5	19.1	97.7	474.0	3600	1760	7	50	32/47	0.056/0.077	1650	1.15	0.95
2006	Aug-Sept	60	0	0	0.0	474.0									
2006	Oct-Dec	80	0.4	19.1	26.4	500.4									
2007	Jan-July	200	0.55	20.4	205.1	705.4	3600	1980	7	50	35/54	0.057/0.078	1550	1.15	0.95
2007	Aug-Sept	60	0	0	0.0	705.4									
2007	Oct-Dec	80	0.45	20.4	31.7	737.2									
2008	Jan-July	200	0.6	25	274.0	1011.1	4500	2000	6.5	50	35/50	0.057/0.082	1700	1.20	0.97
2008	Aug-Sept	60	0	0	0.0	1011.1									
2008	Oct-Dec	80	0.45	25	38.9	1050.0									
2009	Jan-July	200	0.6	25	311.0	1361.0	4500	2000	6.5	50	35/50	0.057/0.082	1700	1.20	1.00

PEP-II Summary

- PEP-II has delivered 22 fb^{-1} in Run 3 and 123 fb^{-1} since May 1999.
- Starting to take advantage of FY2002 summer down projects. We still have several advances to go!
- Integrated luminosity is ahead of predicted track.
- Luminosity has increased to 5.2 x 10^{33} $cm^{-2}s^{-1}$.
- Upgrades for Summer FY2003 are on track.
- Long range plans lead towards >2.5 x 10^{34} $cm^{-2}s^{-1}$.