PEP-II Progress and SLAC Future

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Stanford Linear Accelerator Center

KEKB ARC Meeting
December 4, 2007

Topics

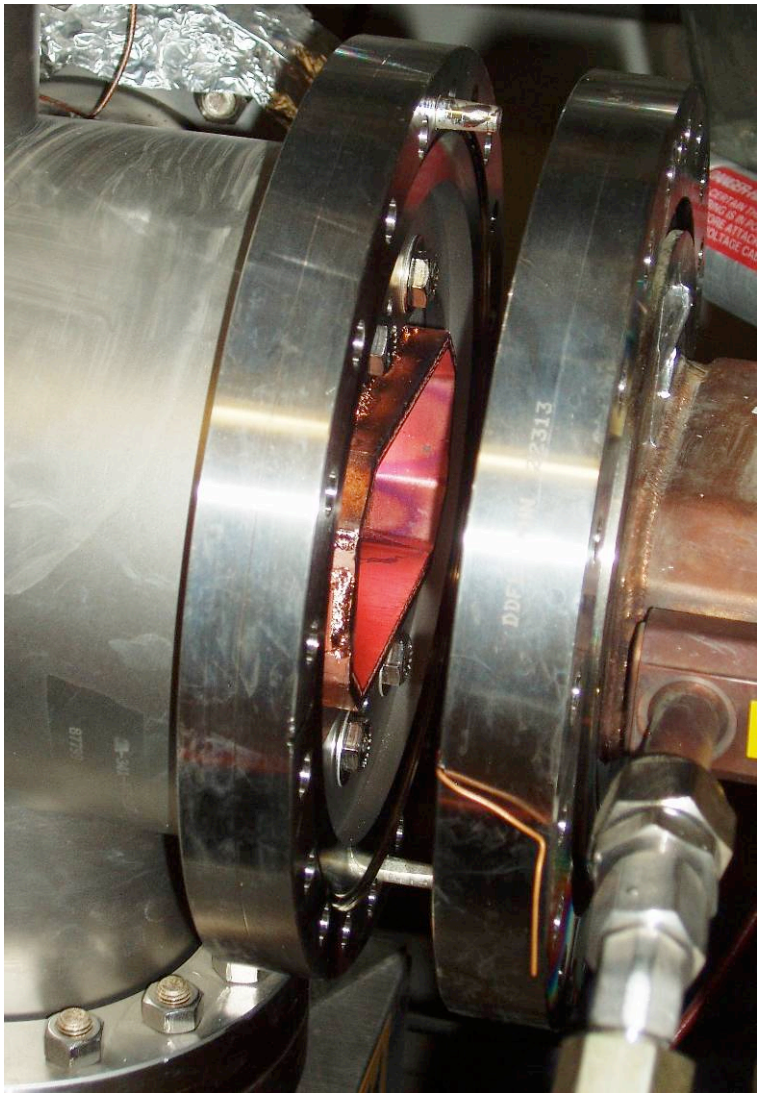
- Highlights of PEP-II Run 6.
- Main activities for Fall 2007 down
- Plan for PEP-II Run 7 in FY2008
- Shut down planning
- Brief SLAC Overview

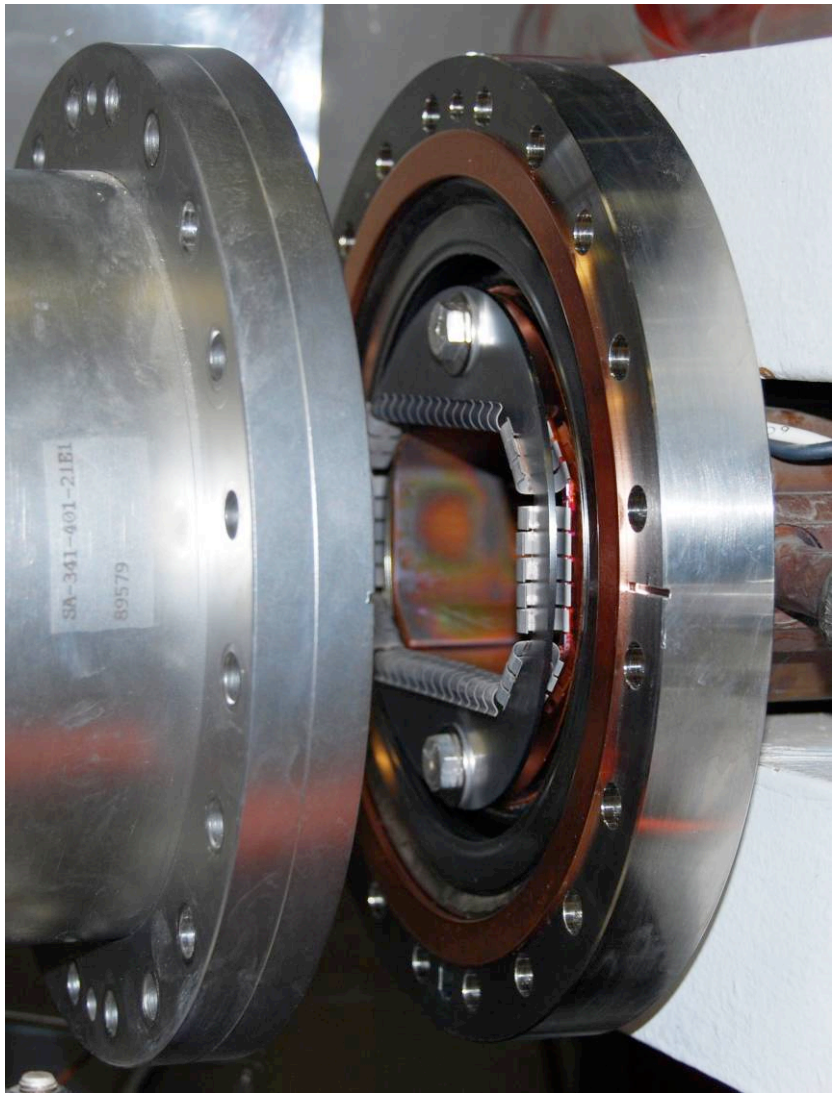
The PEP-II Team

New Items for PEP-II in Run 6

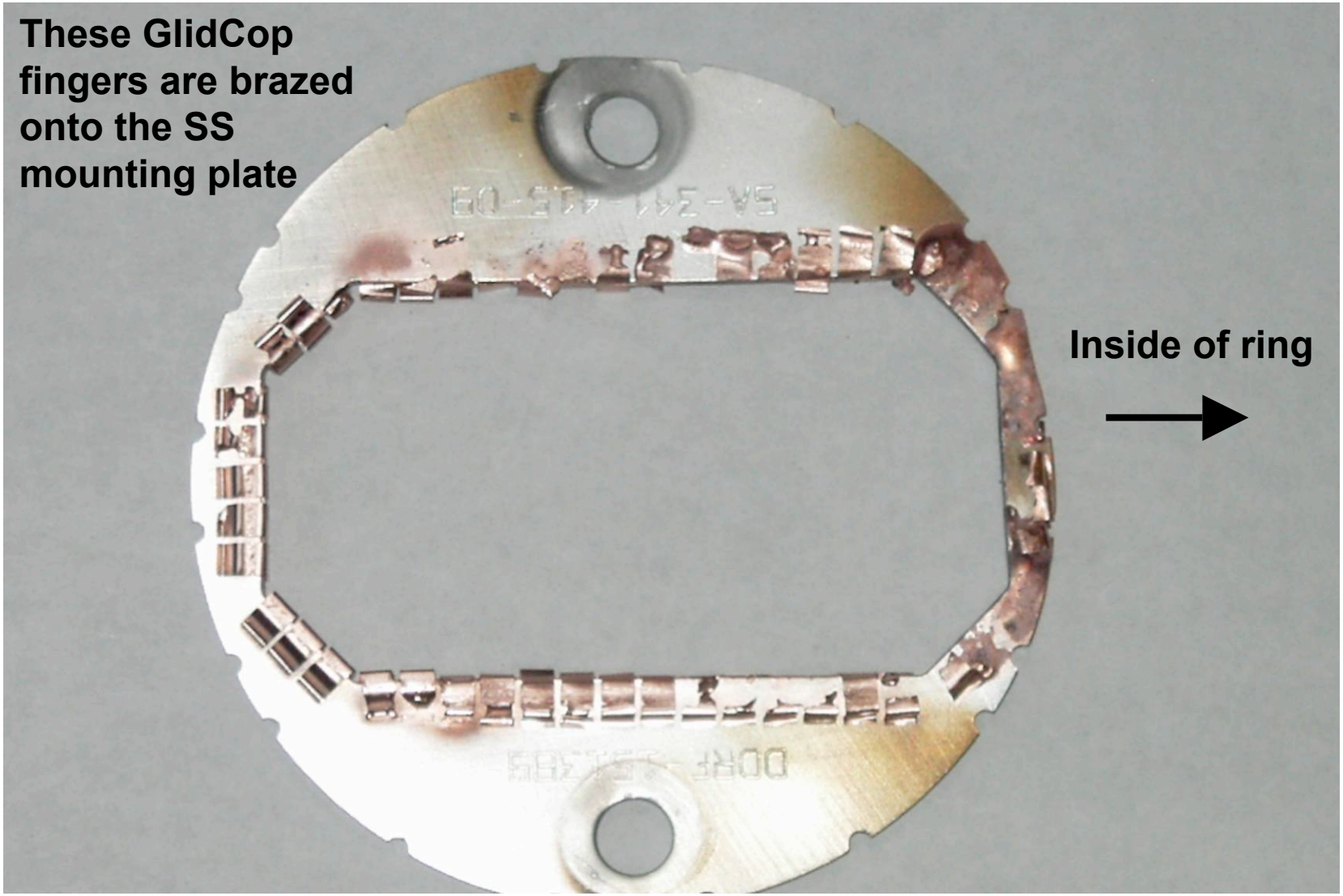
- Advances:
  - Two new HER RF stations.
  - New skew quad fix for IR2 LER x-y coupling found and implemented. Specific luminosity is higher.
  - Fast dither IP feedback in and working (10 Hz).
  - Vertical vibration in IR support tube damped with BaBar's help.
- Problems:
  - Vacuum leak in HER IR Q4 chamber
  - Damaged coils on IR Quadrupole Q2
  - HER flex-flange seals show discharges
  - More PG&E site wide AC power dips than normal.

HER Flex flange RF seal

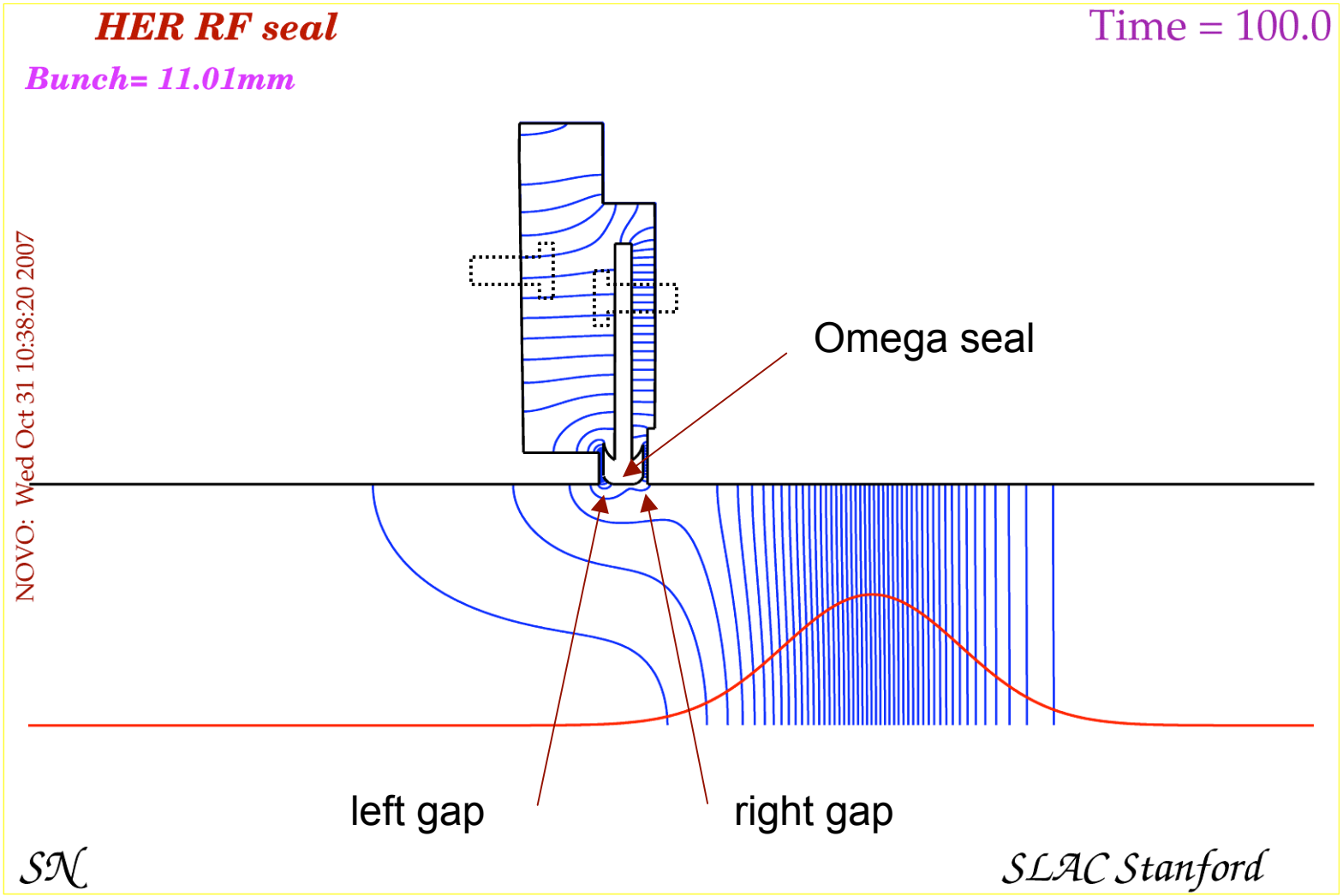




Example of a melted RF seal



Two-gap model of a cavity



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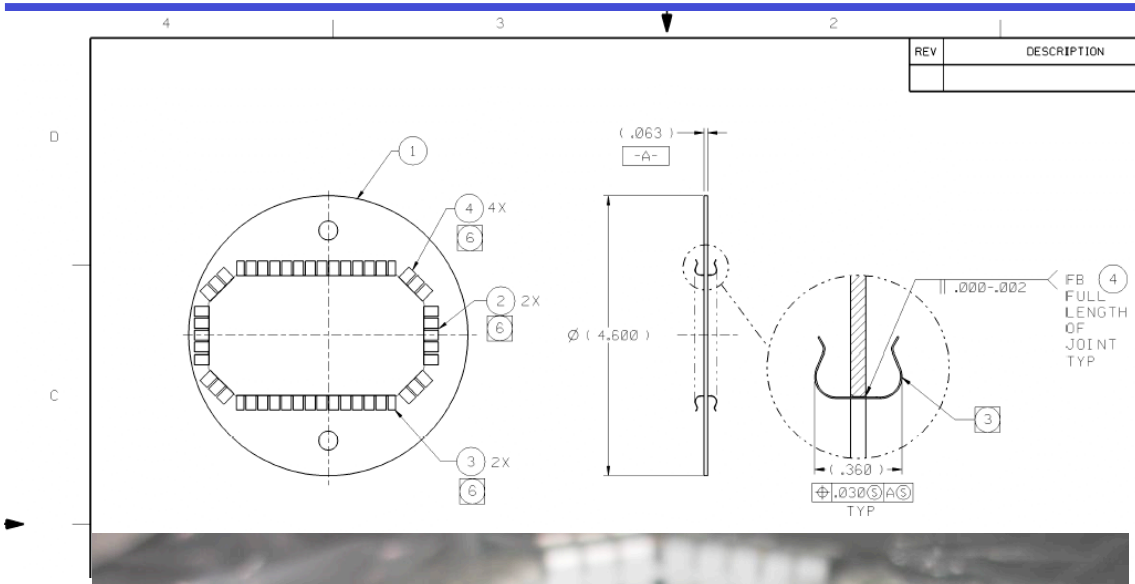
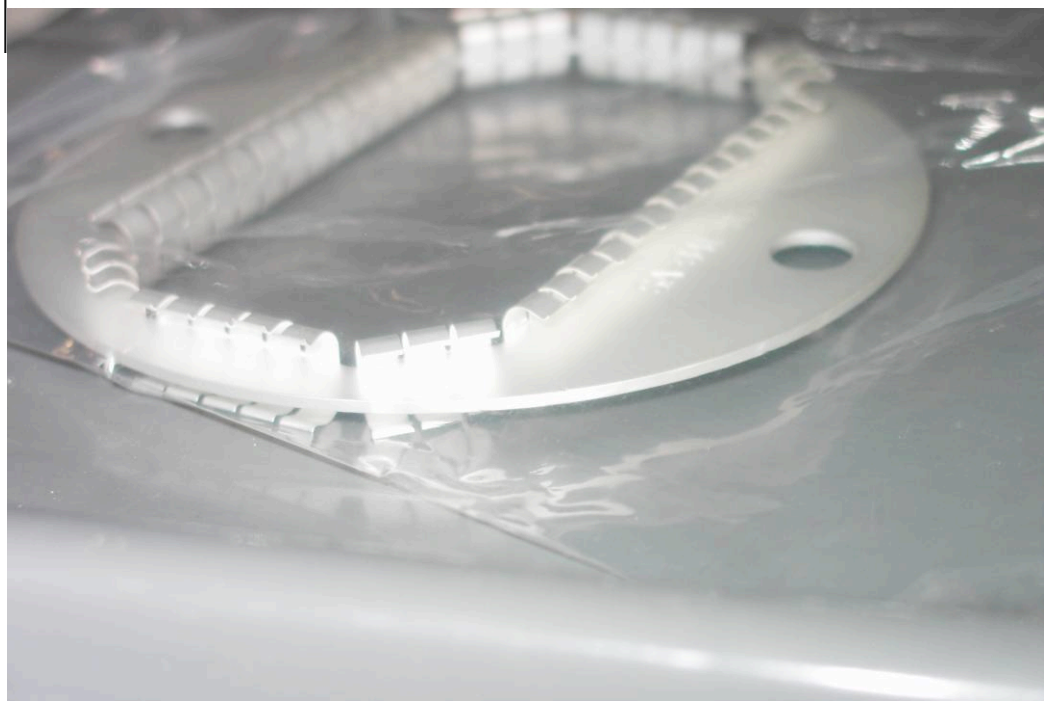
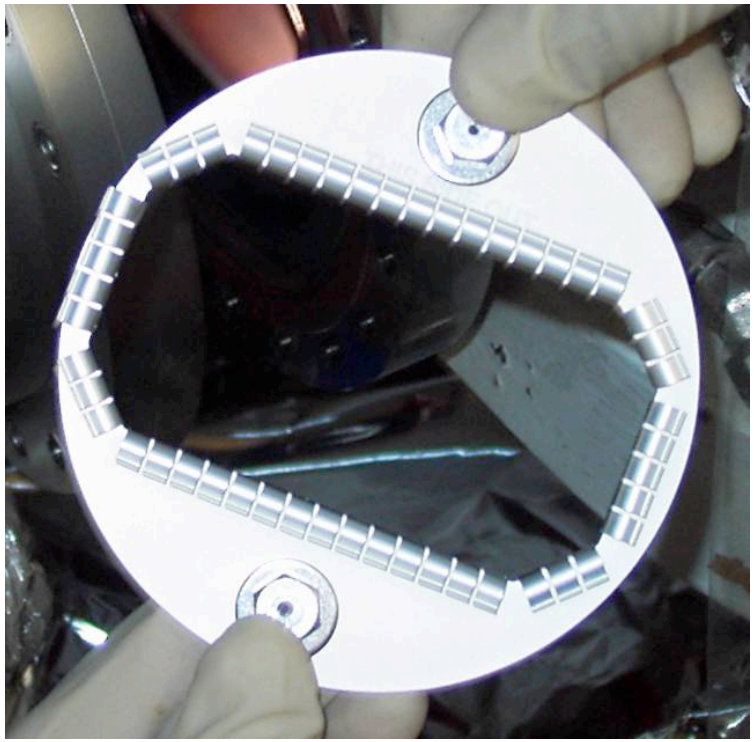
New RF Seal Design: Installed 187 New Seals in Fall 2007

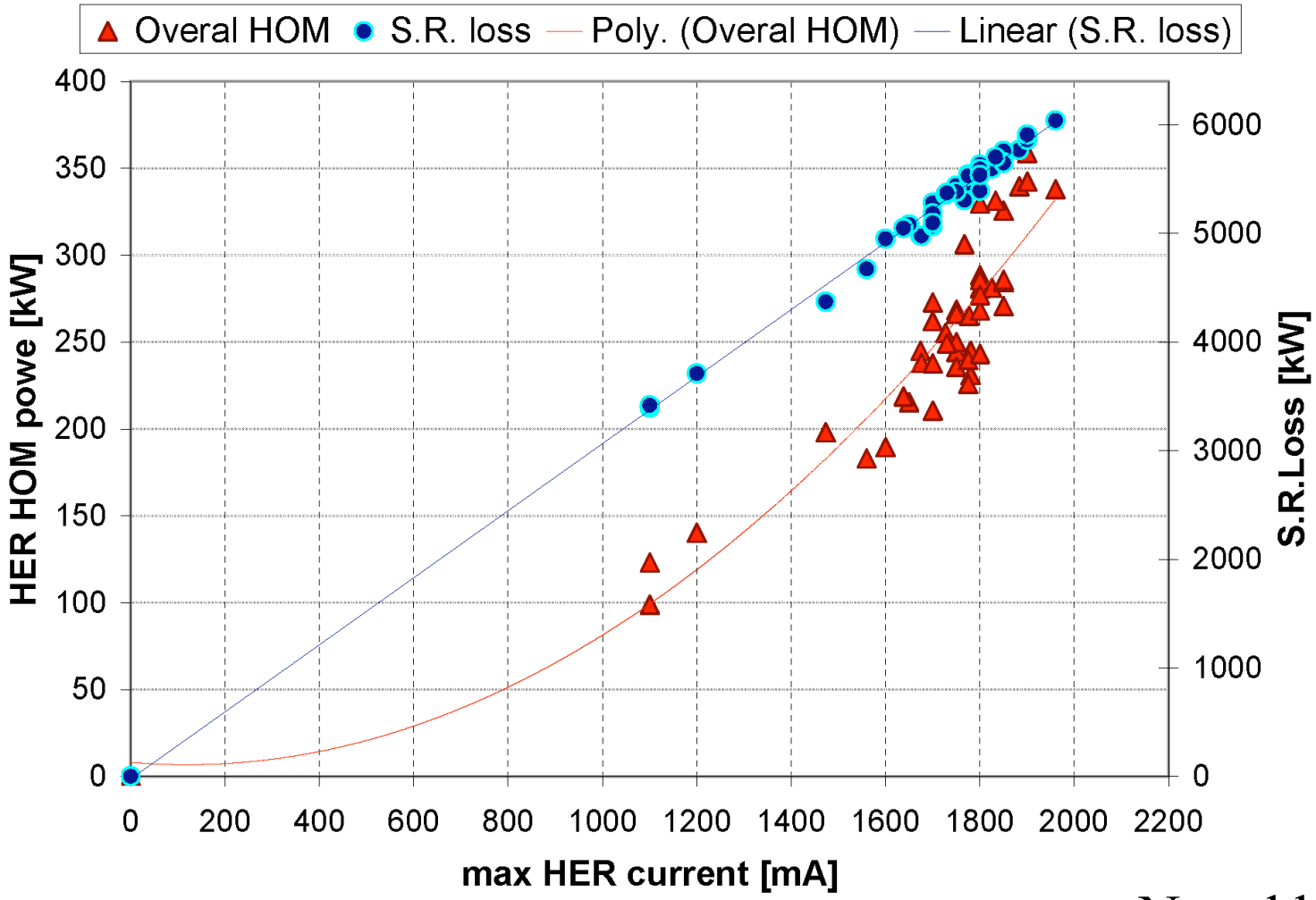


Same as the old design but omega fingers made out of silver plated Inconel. The entire SS plate is silver plated.





HER HOM power



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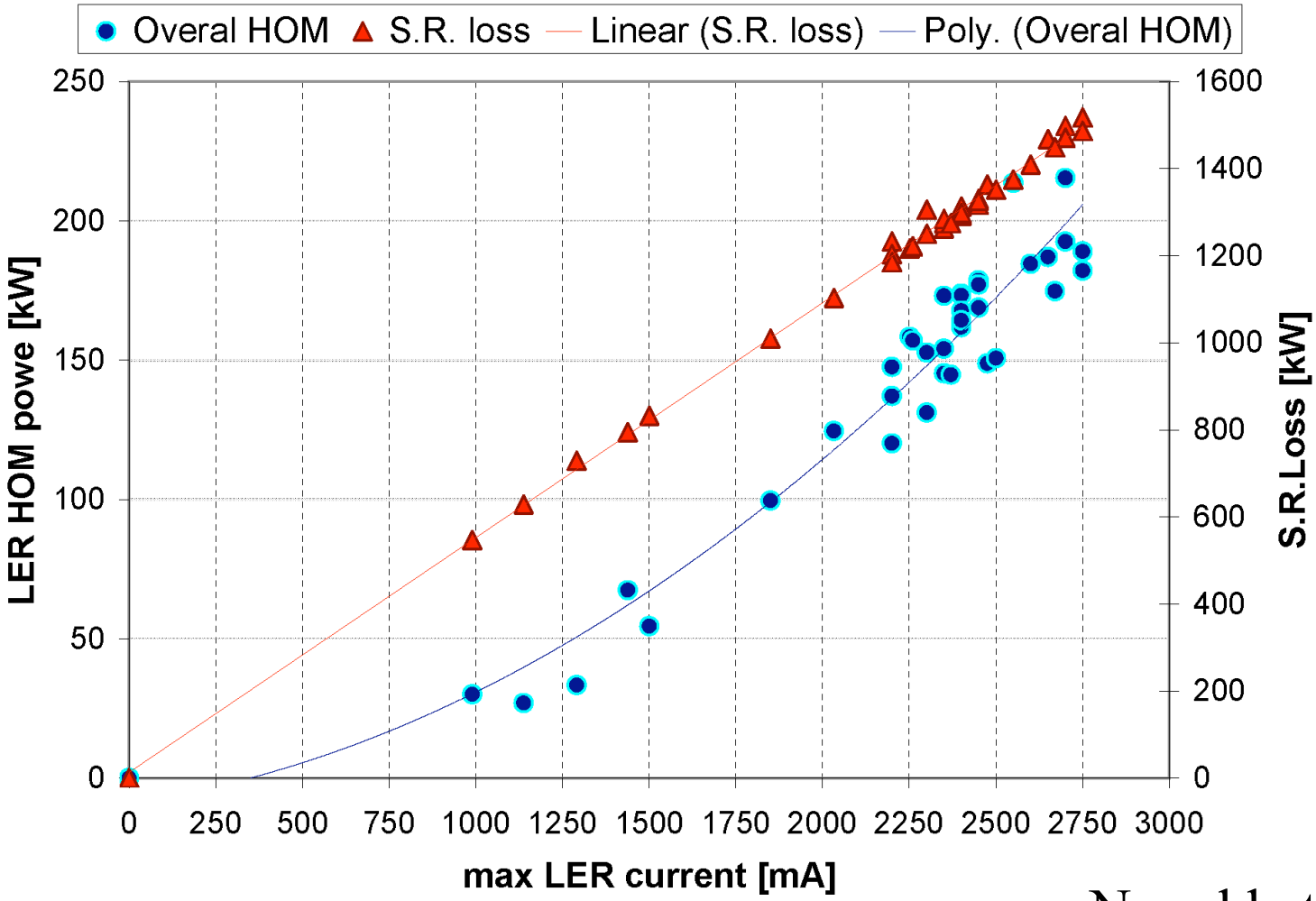
LER HOM power in runs



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RF LER current limits with new Pre-amplifiers

Operational Limits due to LOM Longitudinal Stability

Net System Damping

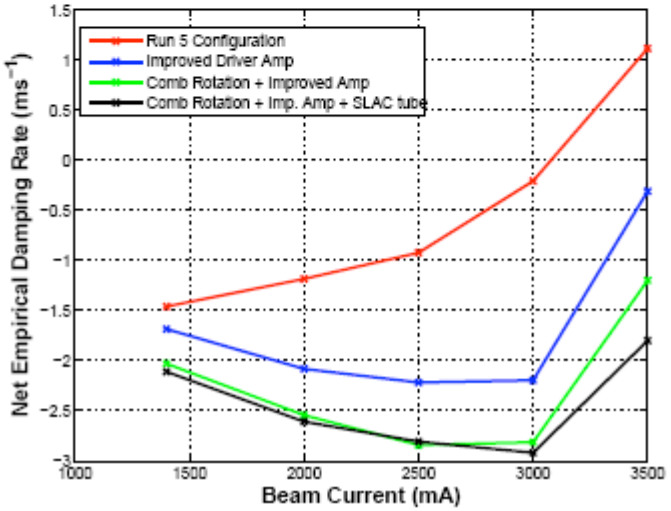
Combining the estimated fast modal growth rate (σ_l) with the damping due to the Longitudinal LGDW (Δ_l), the net system damping for future operation in LER can be estimated.

Assuming for operation a safety margin (SM) equal to $SM = \sigma_l$,

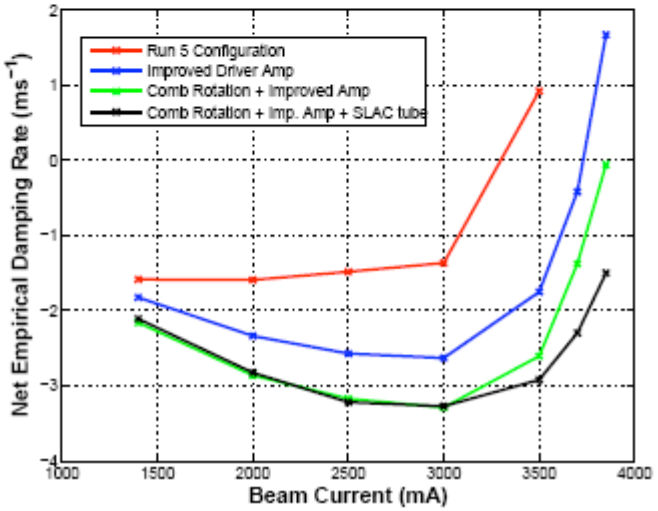
$$\sigma_{NET_l} = \Delta_l - \sigma_l - SM = \Delta_l - 2\sigma_l.$$

(Rivetta)

- $V_G = 4.05MV$

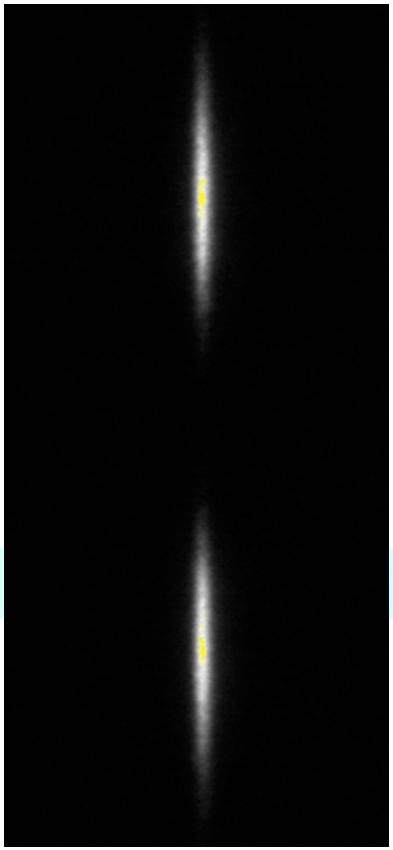


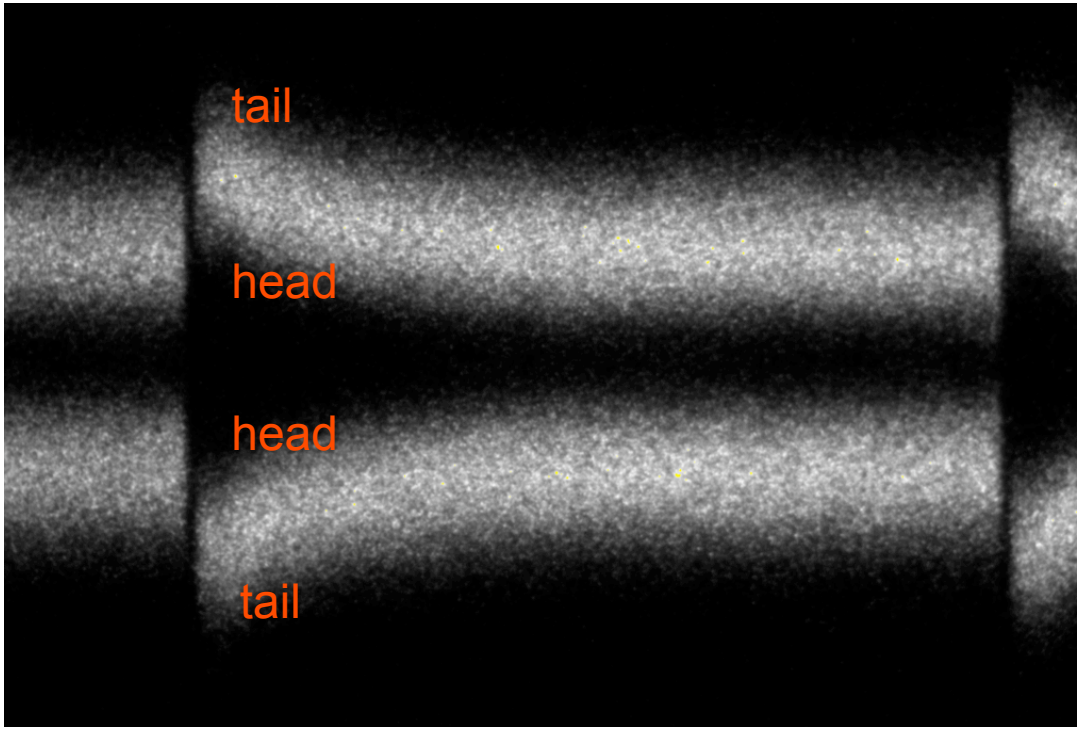
- $V_G = 4.5MV$



Measurement of phase transients along bunch train

LER)





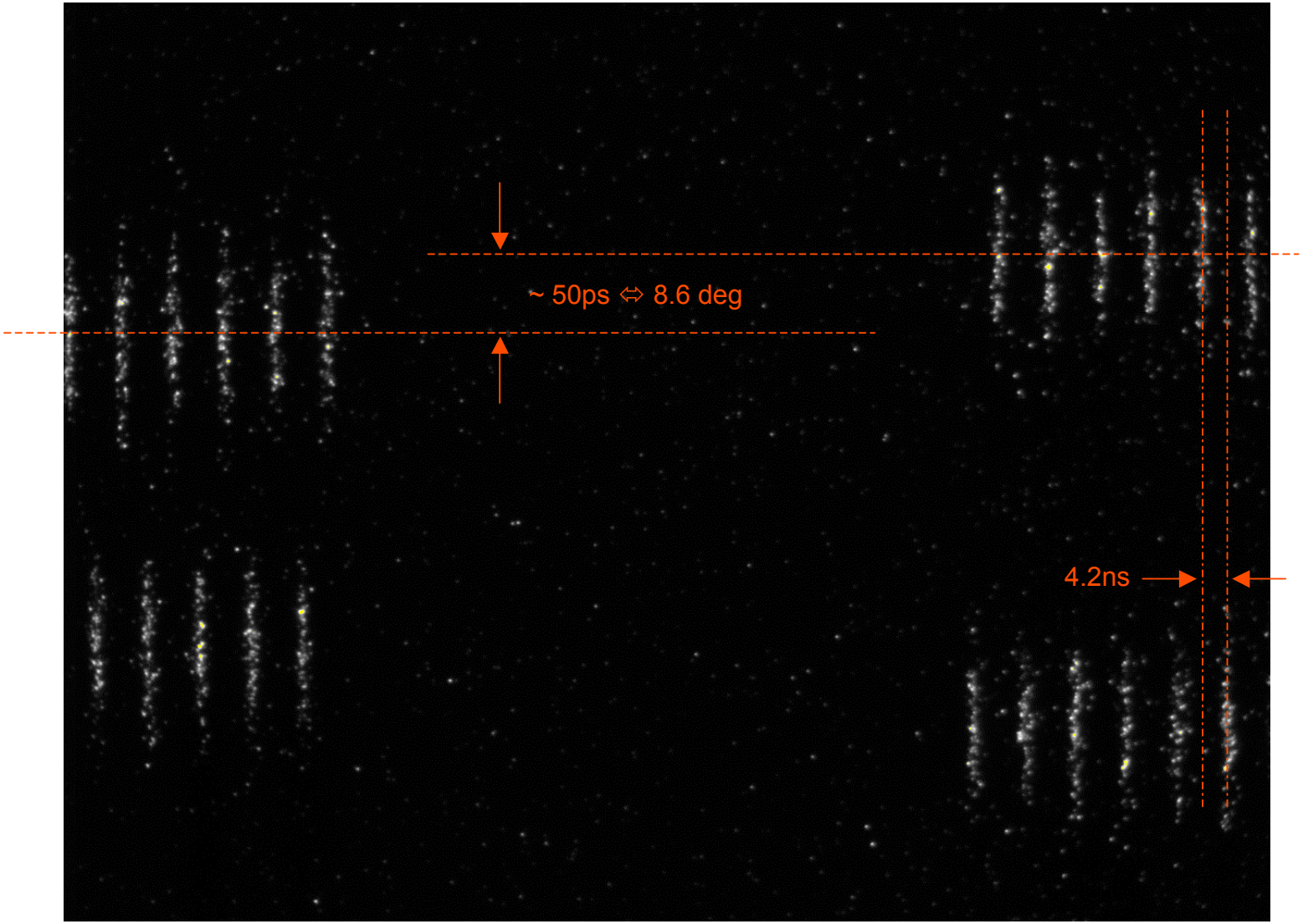
7.3 μsec

Streak camera image

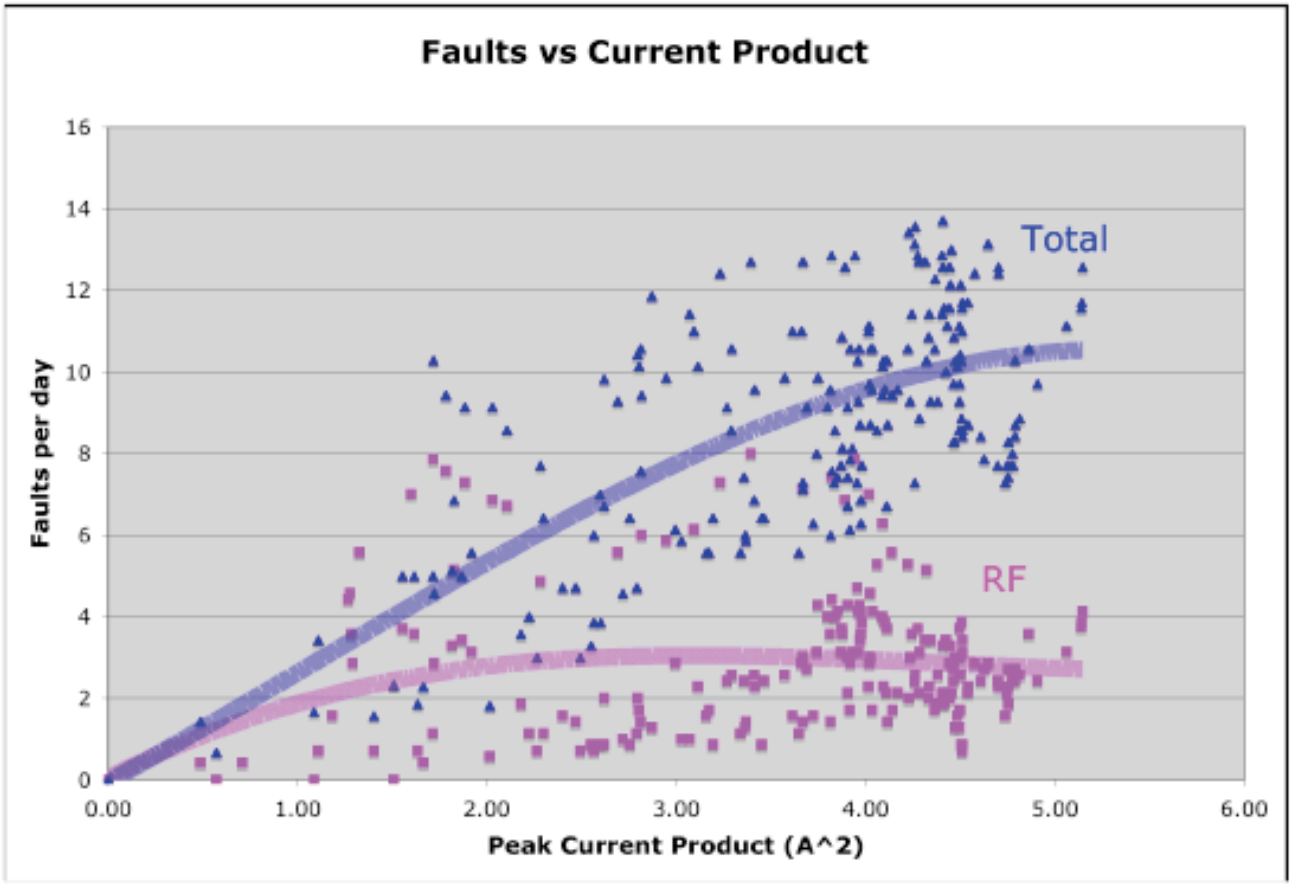
(Cheng)

200ns horizontal scale

Near the bunch train gap, 1722 bunches with 24 bunches gap



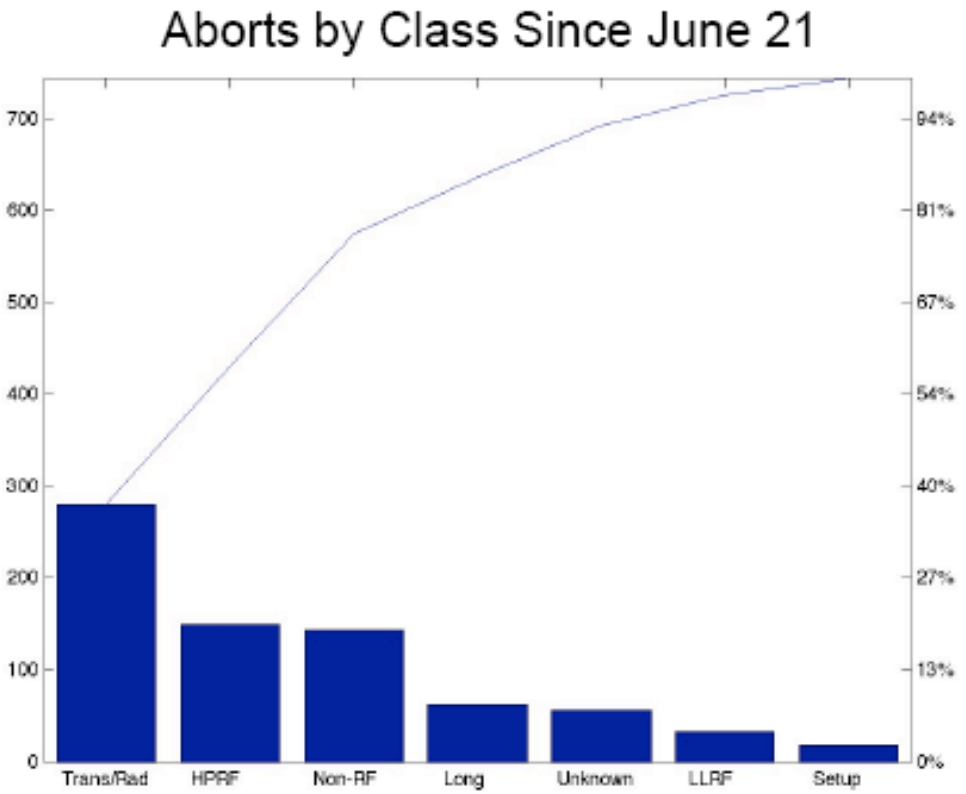
Beam Aborts Statistics

- 

•Total fault rate roughly proportional to beam power
•Lots of scatter, especially for RF (processing)

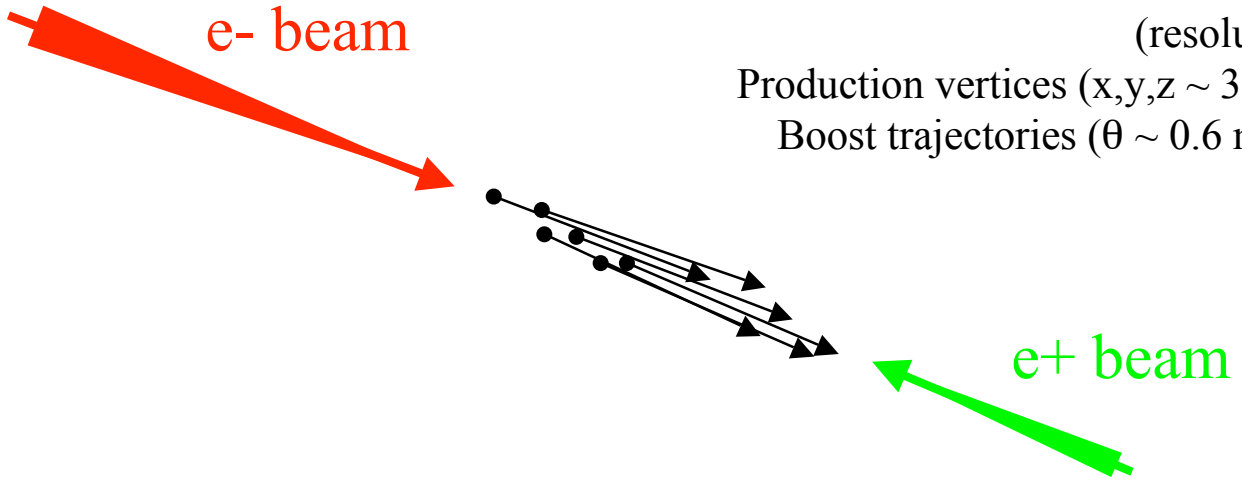
Beam Aborts

- 7 classes of aborts tracked since June 21:
  - 9.7 total aborts per day
  - 2.6 RF aborts per day
- 73% -- Non-RF Aborts
  - 38% Transverse & Radiation
  - 19% Misc Non-RF
  - 8% Longitudinal
  - 8% Unknown Non-RF
- 27% -- RF Aborts
  - 20% HPRF
  - 4% LLRF
  - 2% RF Setup



IP Characterization

- Use BaBar's tracking resolution and prime venue for measuring important parameters at the IP



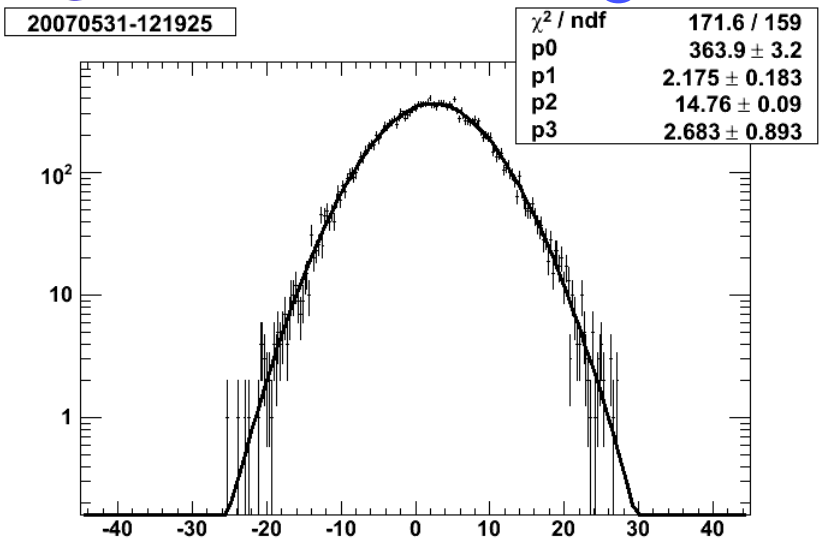
(resolution)
Production vertices (x,y,z ~ 30μm)
Boost trajectories (θ ~ 0.6 mrad)

  - Three analyses each measuring ε_y, β^*_y
    - dLumi / dz vertexing e^+e^- and $\mu^+\mu^-$ events
    - $\sigma_{yLumi}(z)$ $\mu^+\mu^-$ events
    - $\sigma_{y'Lumi}(z)$ $\mu^+\mu^-$ events

BaBar IP measurements reported online

- Luminous Region
  - centroids { x, y, z}
  - sizes { x, z } } every 10 minutes
  - tilts { dx/dz, dy/dz }
  - dL/dz fit { Σ_z, β^*_y, z_w, z_c} every ~hour
- Boost Trajectory
  - mean { x', y' } every 10 minutes
  - spread { x'_{HER}, y'_{HER} } every 30 minutes

Bunch Length Extraction from dL/dz Fits

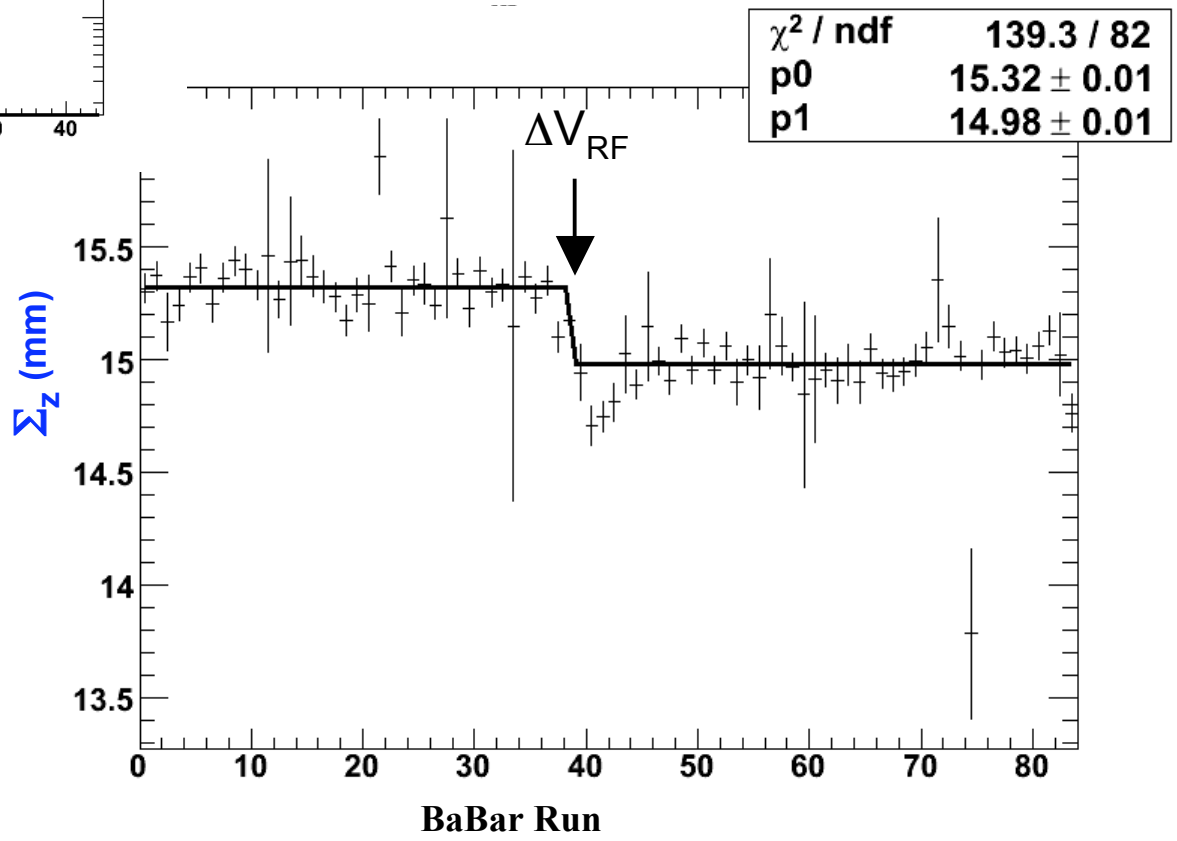


$\beta_y^* = 13\text{mm}$

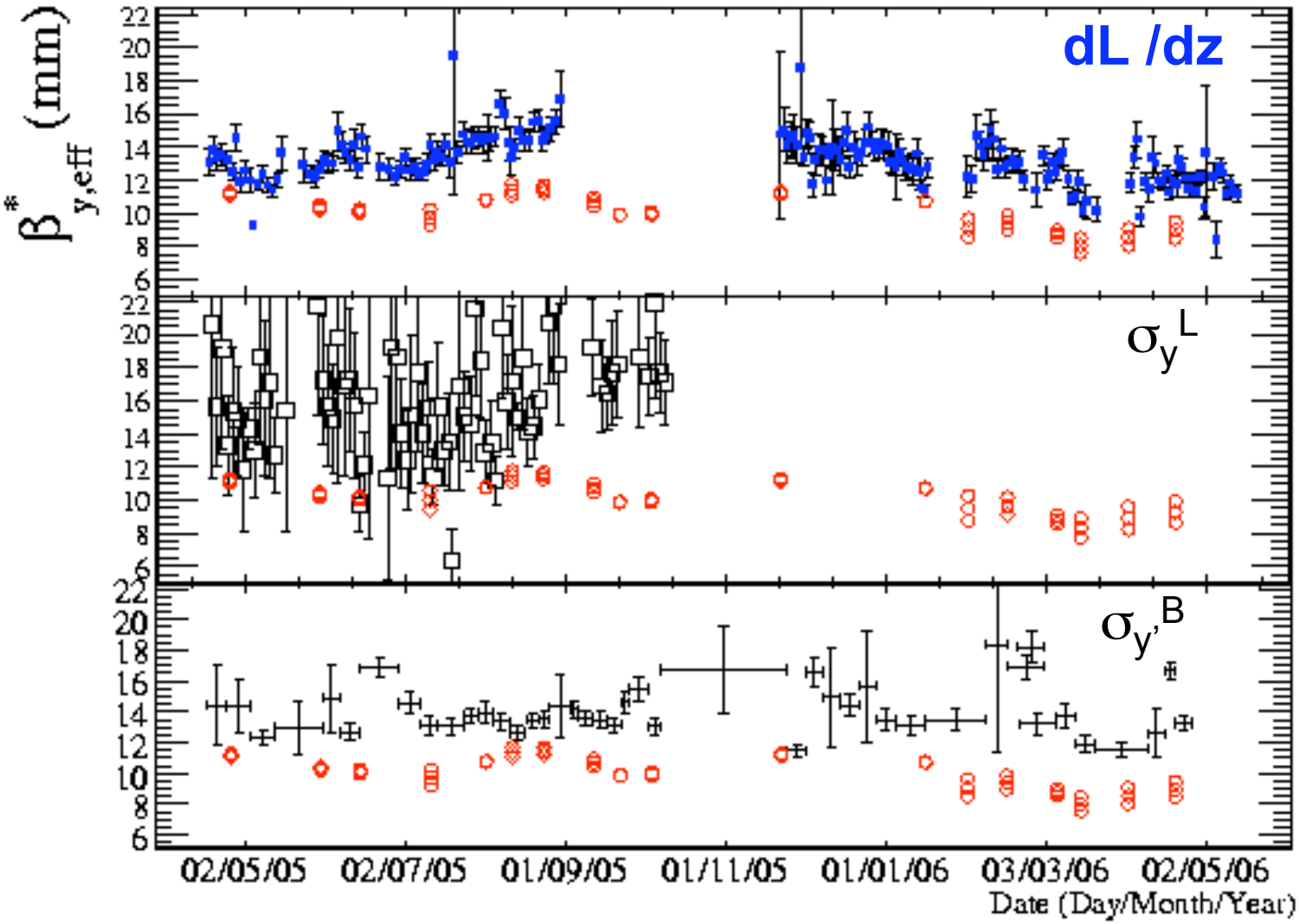
$\Delta\Sigma_z^2 = 10.3\ \text{mm}^2 \pm 0.4\ \text{mm}^2$

$\sigma_{z,H}$ 10.9 mm / 10.4 mm ± 0.2 mm

$\sigma_{z,L}$ 10.8 mm ± 0.2 mm



IP Beta Function Measurements (BaBar)



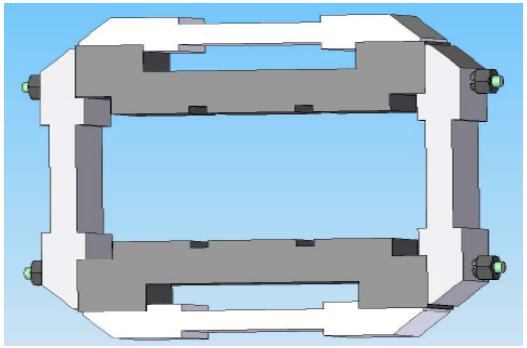
PEP phase advance β_2

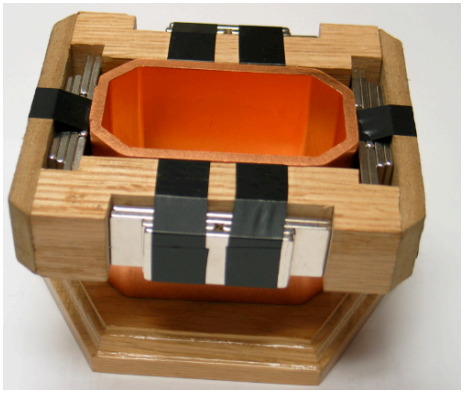
New Skew Magnets to Improve LER Vertical Emittance

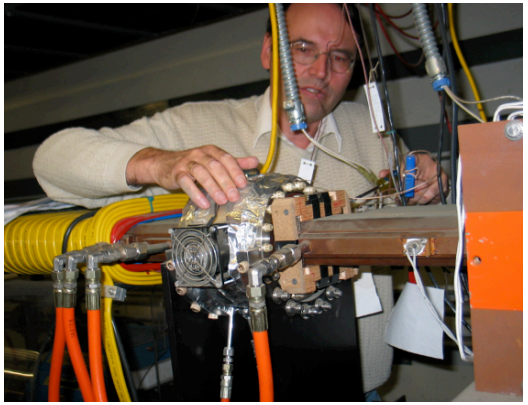
→10 to 50% gain at fixed currents

$$\varepsilon_{x,y} = 3.84 \cdot 10^{-13} \gamma^2 \frac{\langle H_{x,y} / |\rho^3| \rangle}{J_{x,y} \langle 1/\rho^2 \rangle}, \quad \text{where} \quad H = \beta\eta'^2 + 2\alpha\eta\eta' + \frac{1+\alpha^2}{\beta}\eta^2 .$$

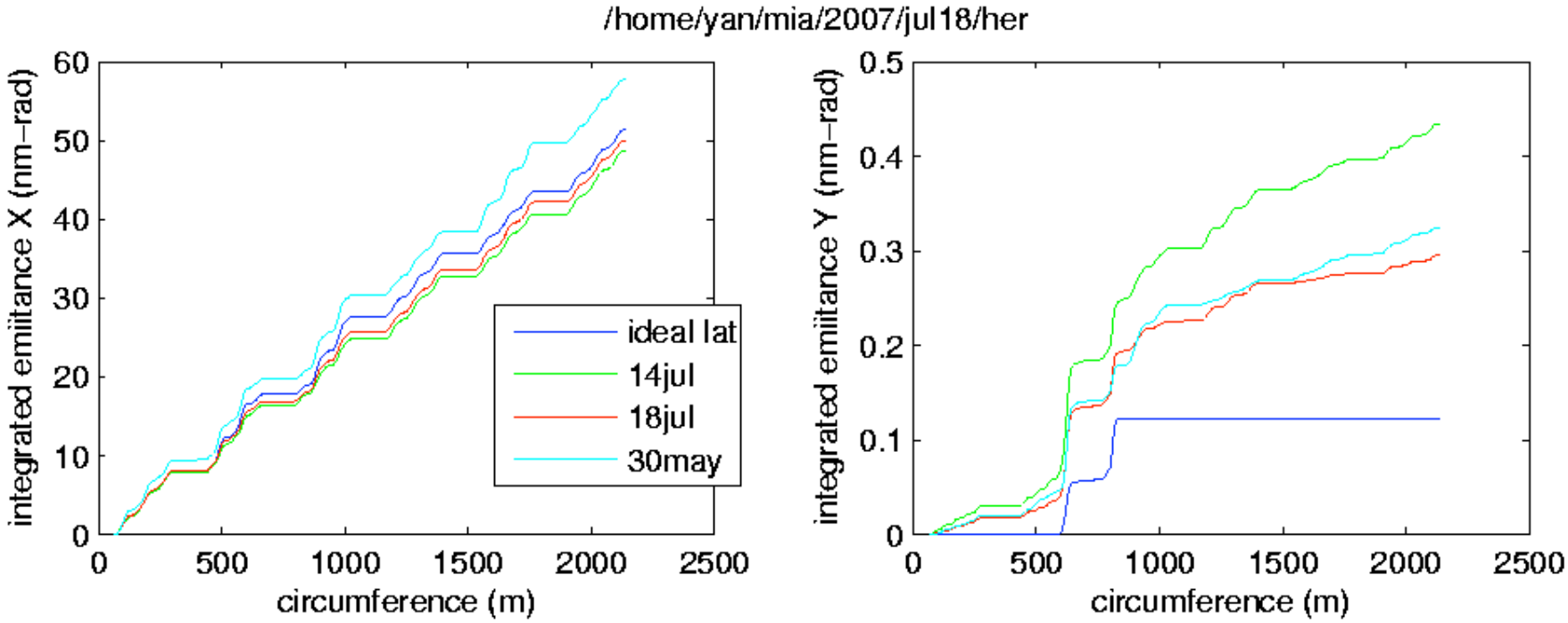
Physicist design (F-J. Decker)



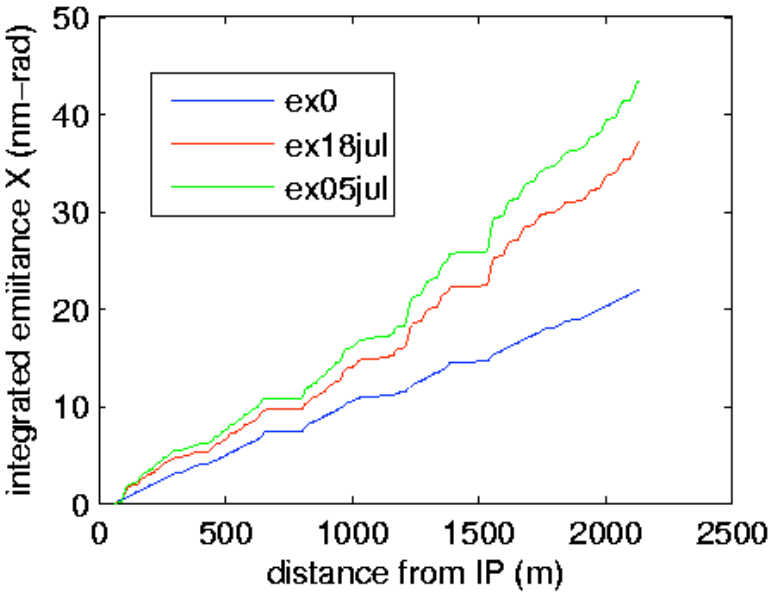


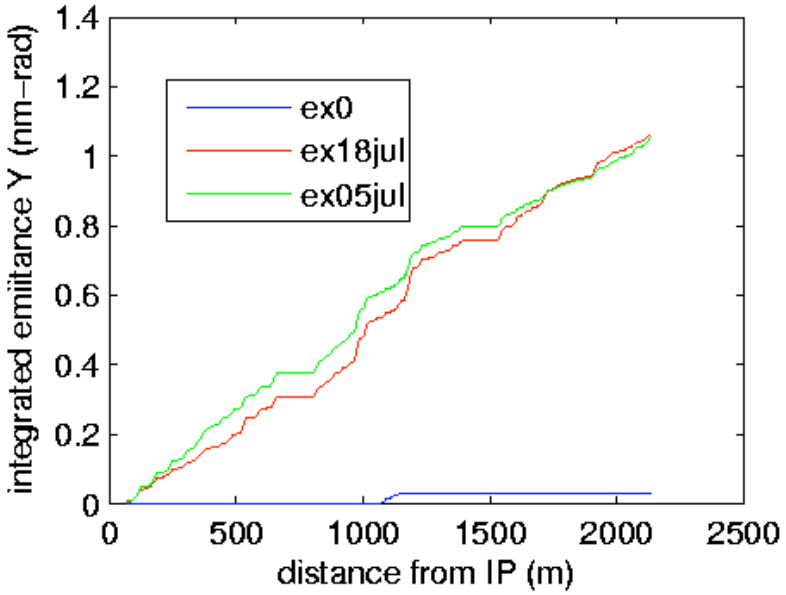


HER emittance on July 18 (red), 2007

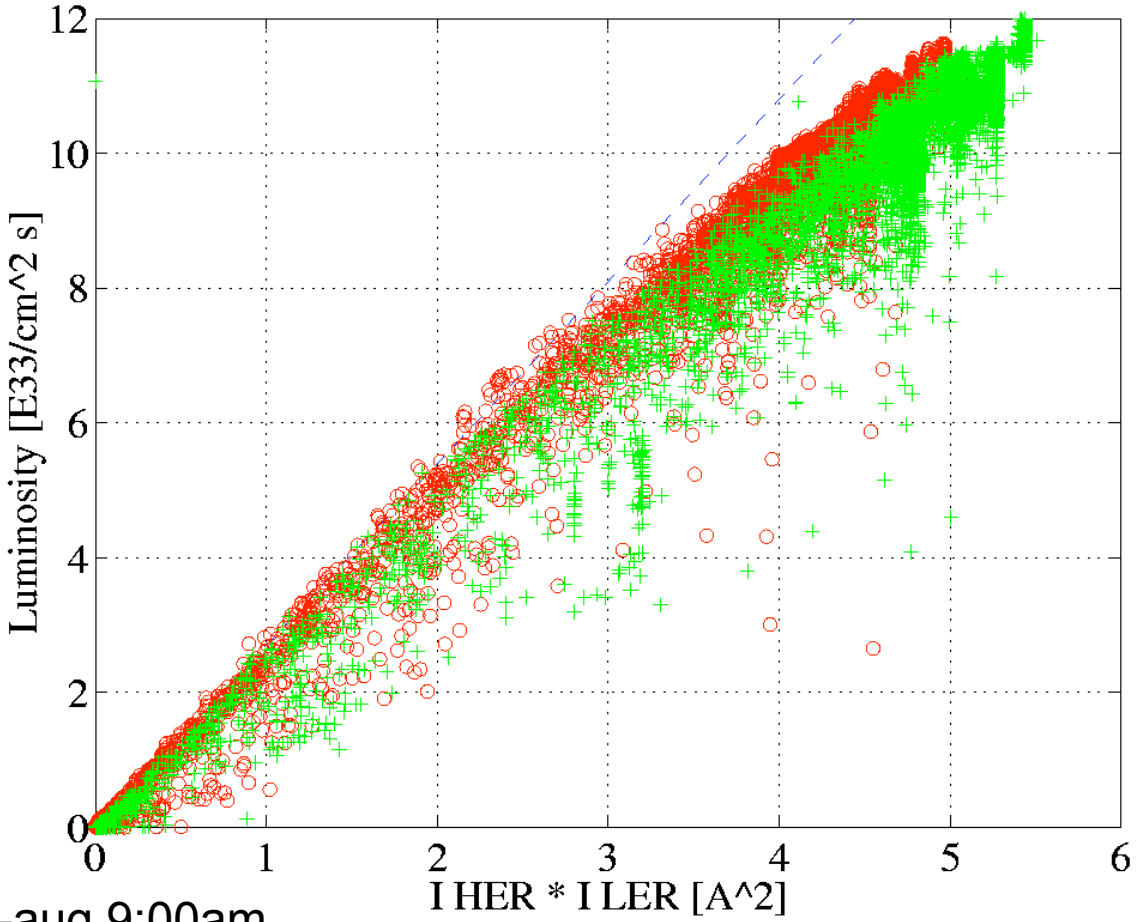


LER emittance in July, 2007





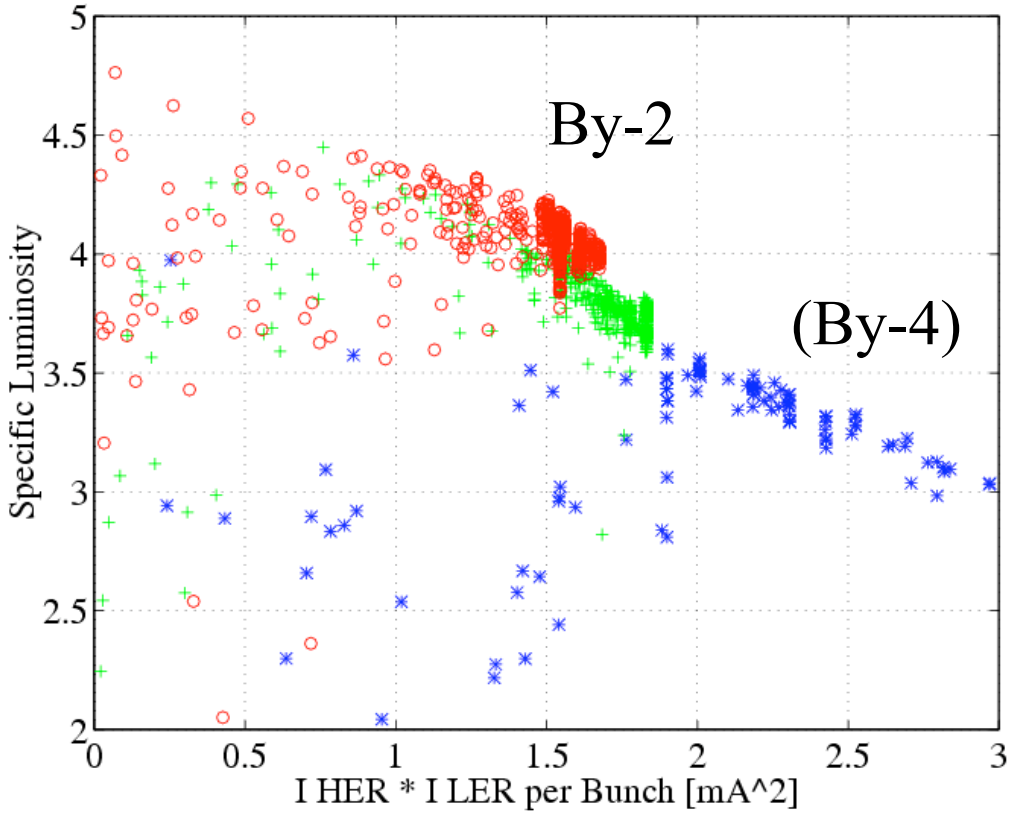
Record peak specific luminosity obtained in 2007 after reducing LER coupling for lower Y emittance



28-aug 9:00am, peplog

Managed to get a peak specific luminosity (as shown on red) with a lower LER current.

Specific Luminosity in PEP-II

- 

PEP-II Records

Last update:
September 4, 2007

Peak Luminosity

12.069×10^{33} cm^{-2}sec^{-1} — August 16, 2006

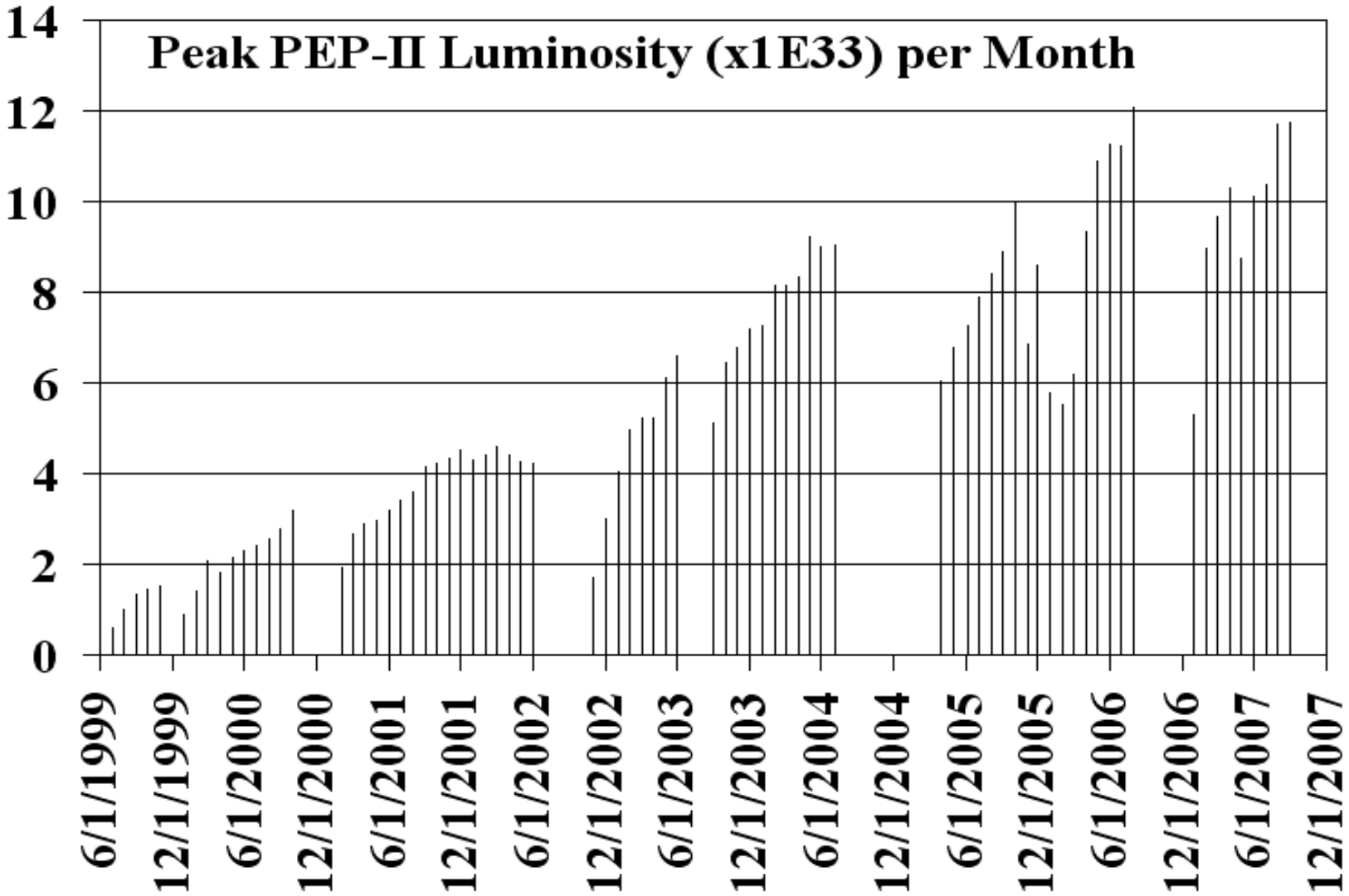
1722 bunches 2900 mA LER 1875 mA HER

Run 6 nos.

11.69
2650x1900

Integration records of delivered luminosity

Best shift (8 hrs, 0:00, 08:00, 16:00)	339.0 pb^{-1}	Aug 16, 2006	311
Best 3 shifts in a row	910.7 pb^{-1}	Jul 2-3, 2006	858
Best day	858.4 pb^{-1}	Aug 19, 2007	
Best 7 days (0:00 to 24:00)	5.411 fb^{-1}	Aug 14-Aug 20, 2007	
Best week (Sun 0:00 to Sat 24:00)	5.137 fb^{-1}	Aug 12-Aug 18, 2007	
Peak HER current	1960 mA	Jul 29, 2007	
Peak LER current	3026 mA	Sep 1, 2007	
Best 30 days	19.776 fb^{-1}	Aug 5 – Sep 3, 2007	
Best month	19.732 fb^{-1}	August 2007	
Total delivered	500 fb^{-1}		


Peak PEP-II Luminosity (x1E33) per Month
14
12
10
8
6
4
2
0
6/1/1999
12/1/1999
6/1/2000
12/1/2000
6/1/2001
12/1/2001
6/1/2002
12/1/2002
6/1/2003
12/1/2003
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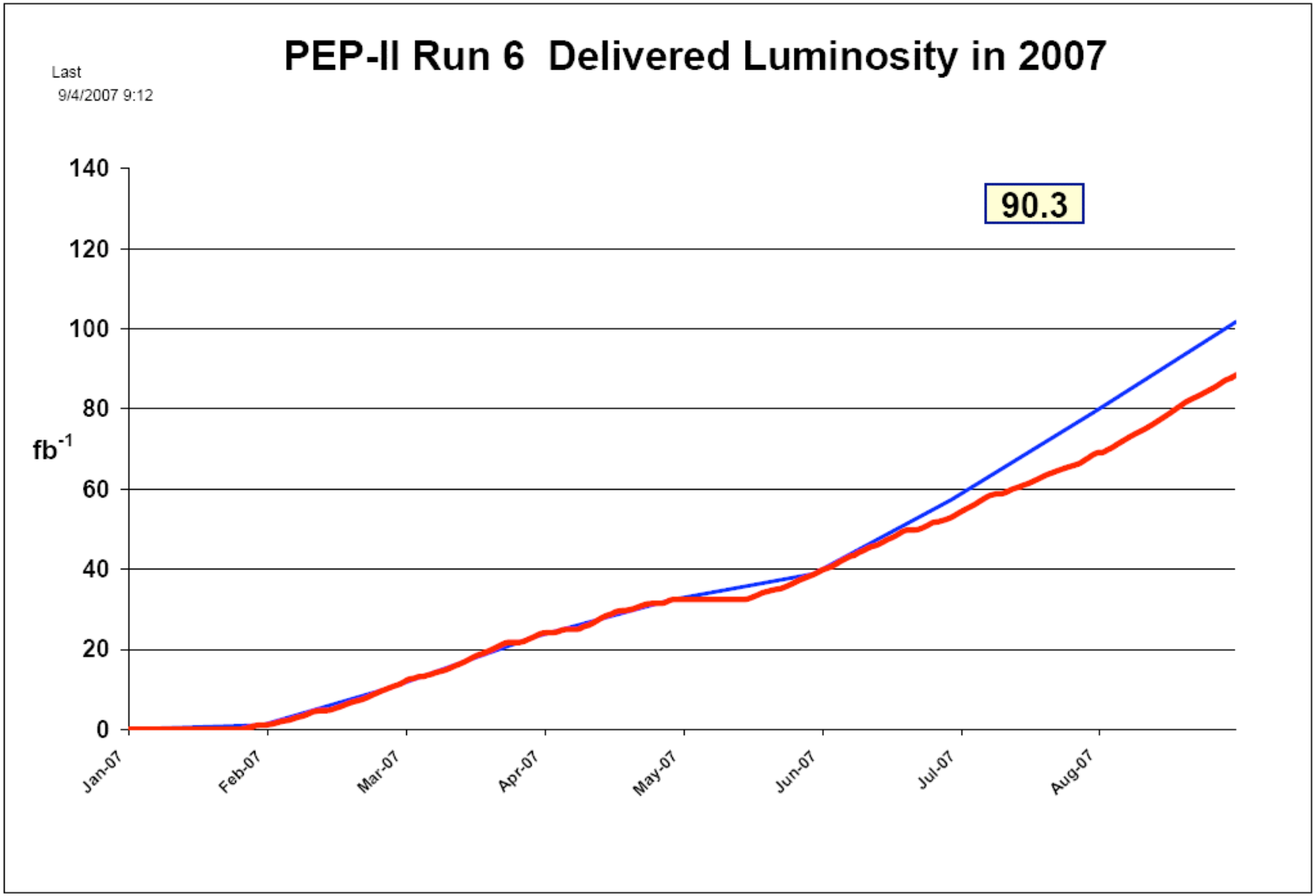
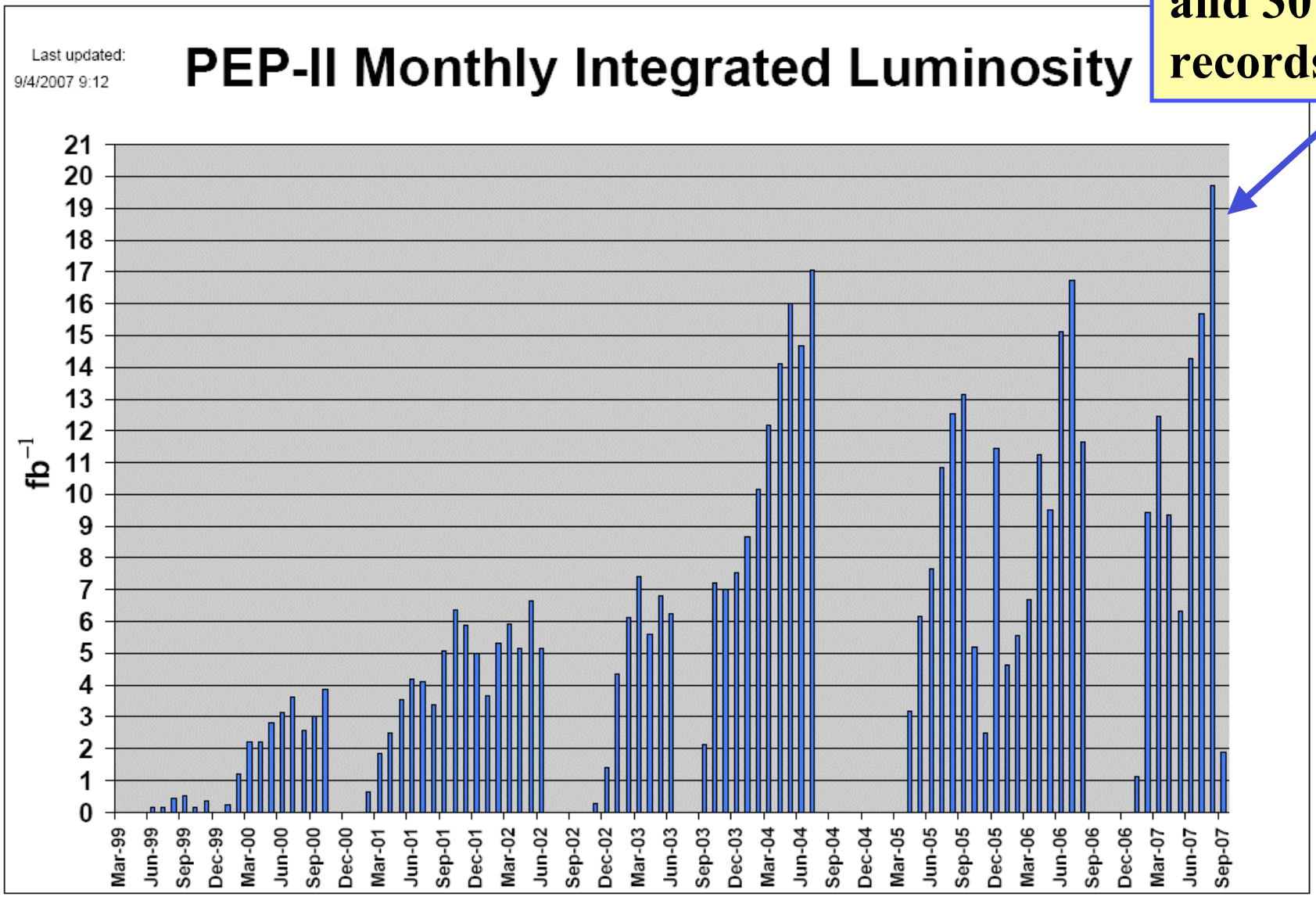
6/1/2006
12/1/2006
6/1/2007
12/1/2007


PEP-II Run 6 Delivered Luminosity in 2007
Last
9/4/2007 9:12
90.3
140
120
100
80
60
40
20
0
fb-1
Jan-07
Feb-07
Mar-07
Apr-07
May-07
Jun-07
Jul-07
Aug-07

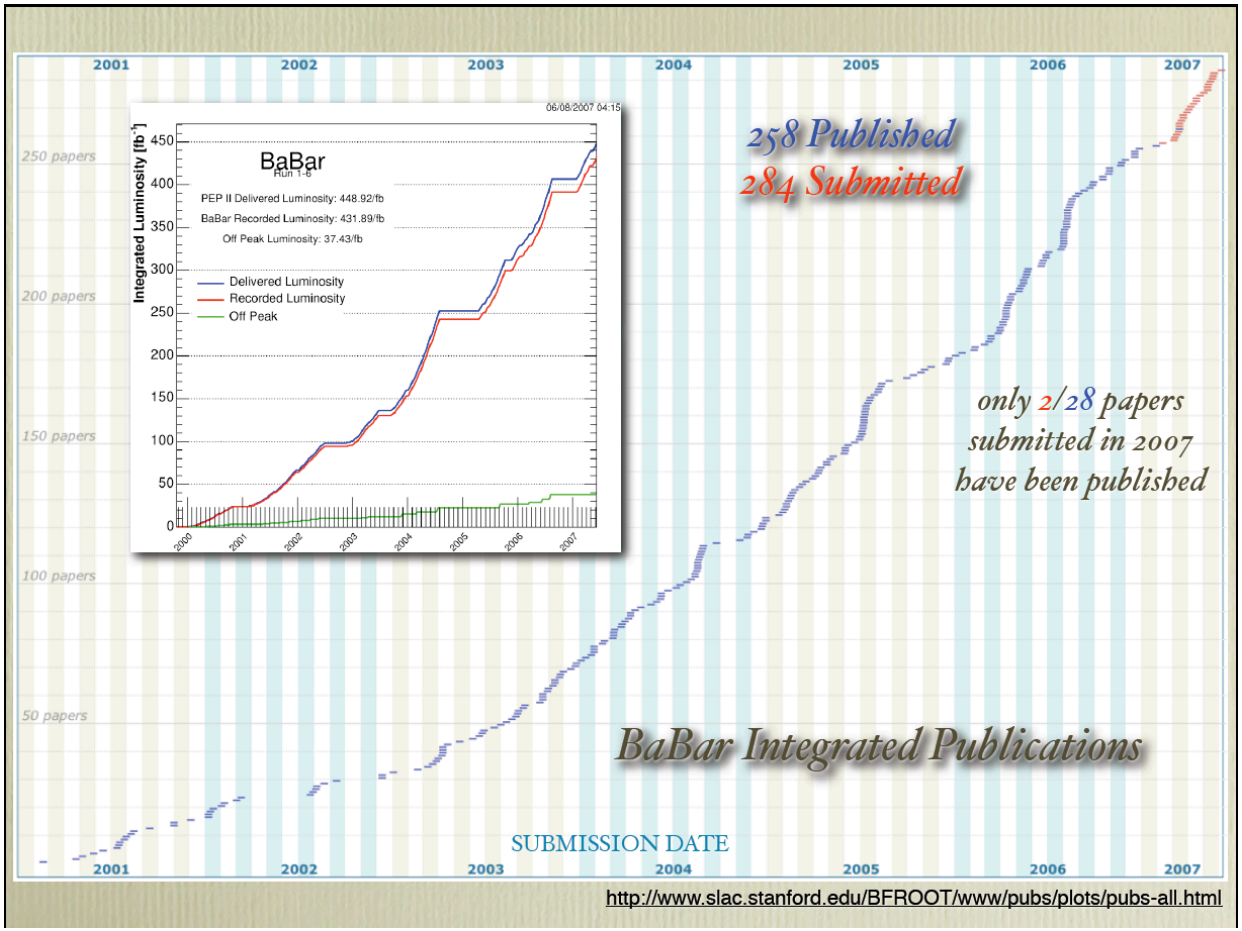
August 2007 was our Best month

New month and 30 day records



A look at the timeline of BaBar data collection vs physics output

From BaBar



- There are more than 200 ongoing analyses of BaBar data.
- More than 317 papers published & submitted for publication.

PEP-II Parameter Goals have not changed!

Parameter	Units	Design	Present best	2008 goal
I+	mA	2140	2940	4000
I-	mA	750	1940	2200
Number bunches		1658	1722	1740
β_y^*	mm	15-20	10	8-8.5
Bunch length	mm	15	11-12	8.5-9
ξ_y		0.03	0.047-0.065	0.054-0.07
Luminosity	$x10^{33}$	3	12	20
Int lumi / day	pb^{-1}	130	911	1300

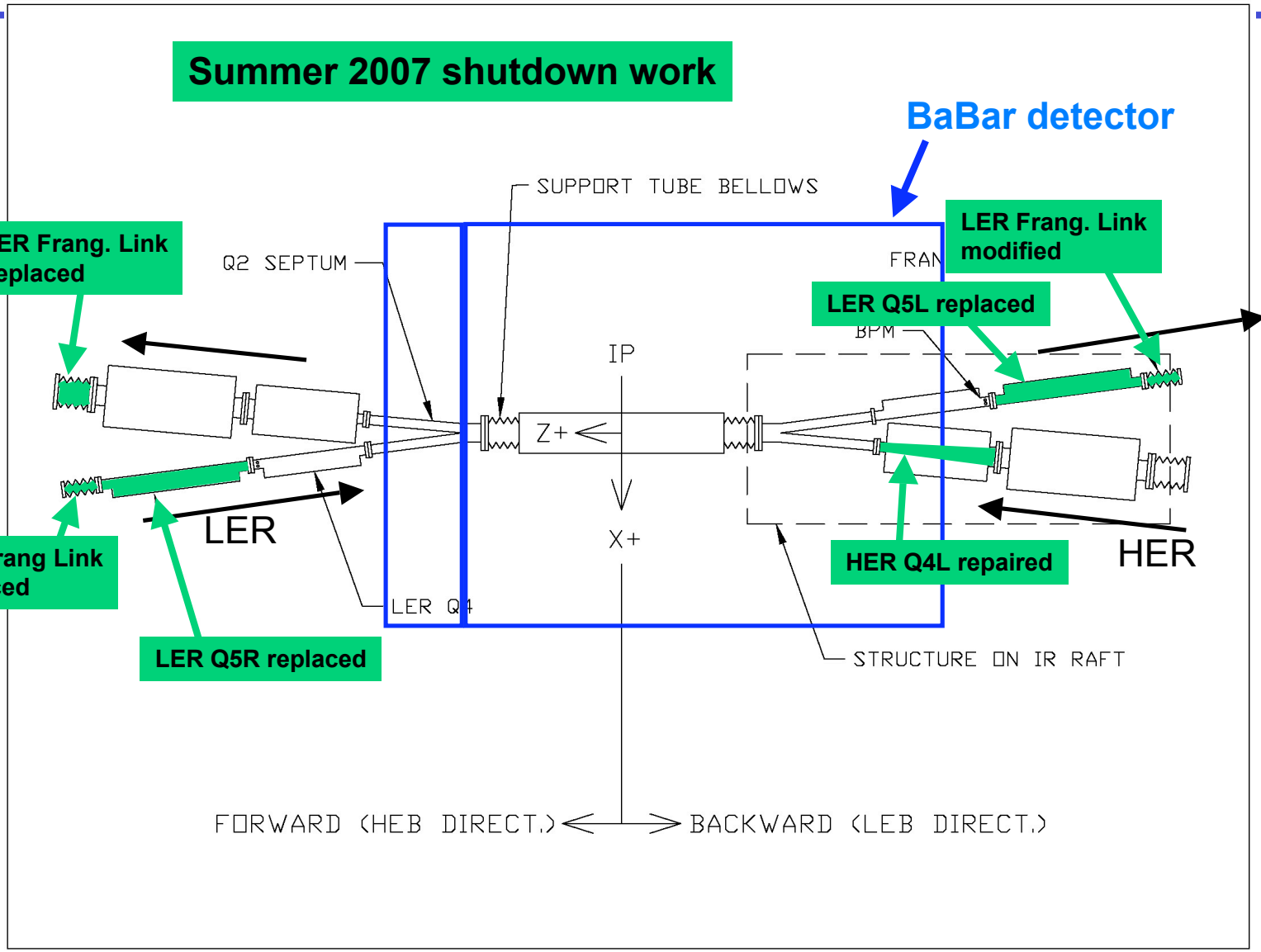
4 times design

7 times design

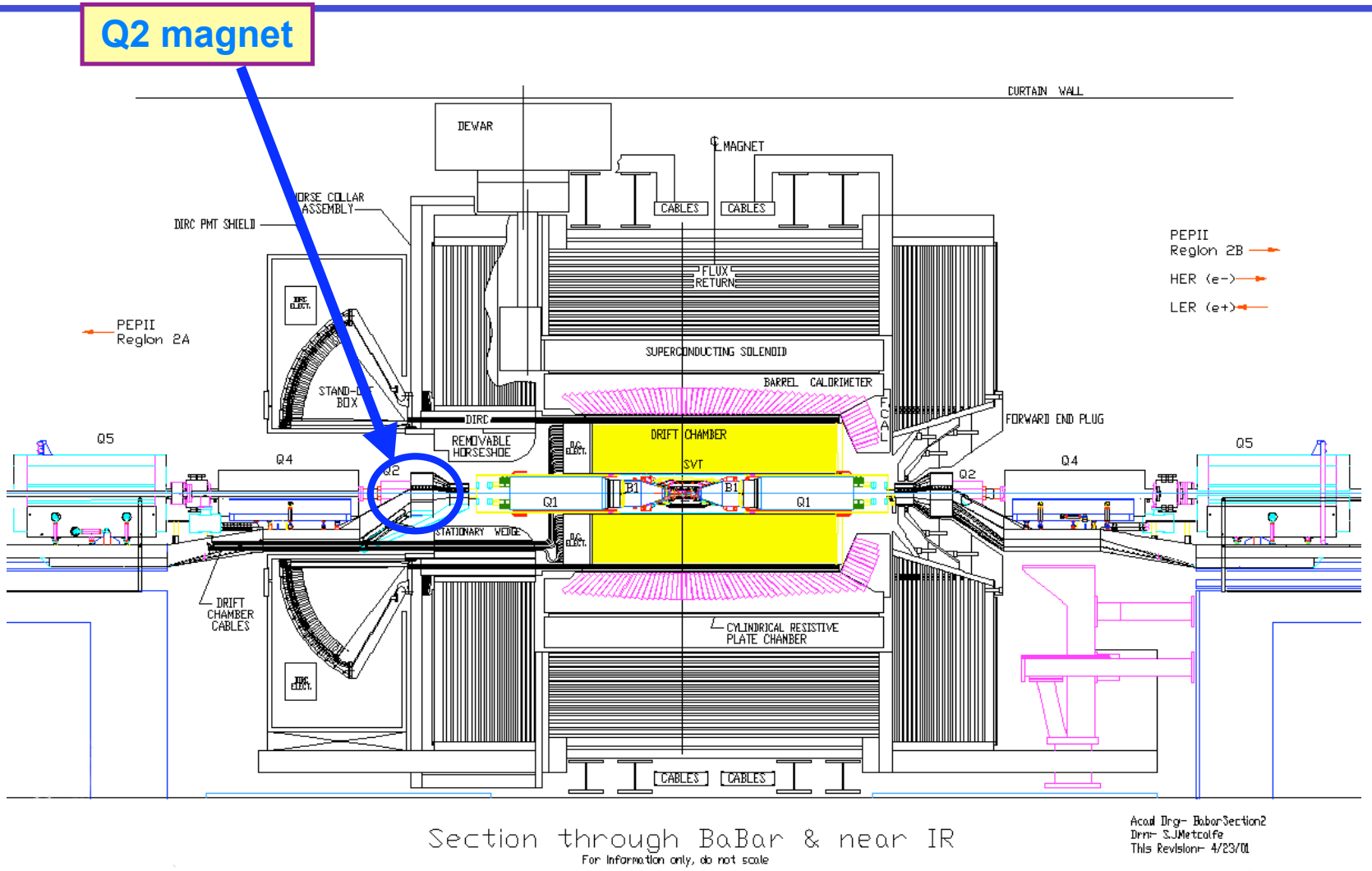
Fall 2007 Down Activities (September 4-December 3)

- Finished LER BPM replacement.
- Added 5 HER Arc HOM bellows.
- Added 12 LER IR2 HOM bellows.
- Replaced 187 HER Arc flex-flange RF “Omega Seals”.
- Installed two new LER Q5 chambers in IR2.
- Installed repaired HER Q4L chamber.

Interaction Region Layout



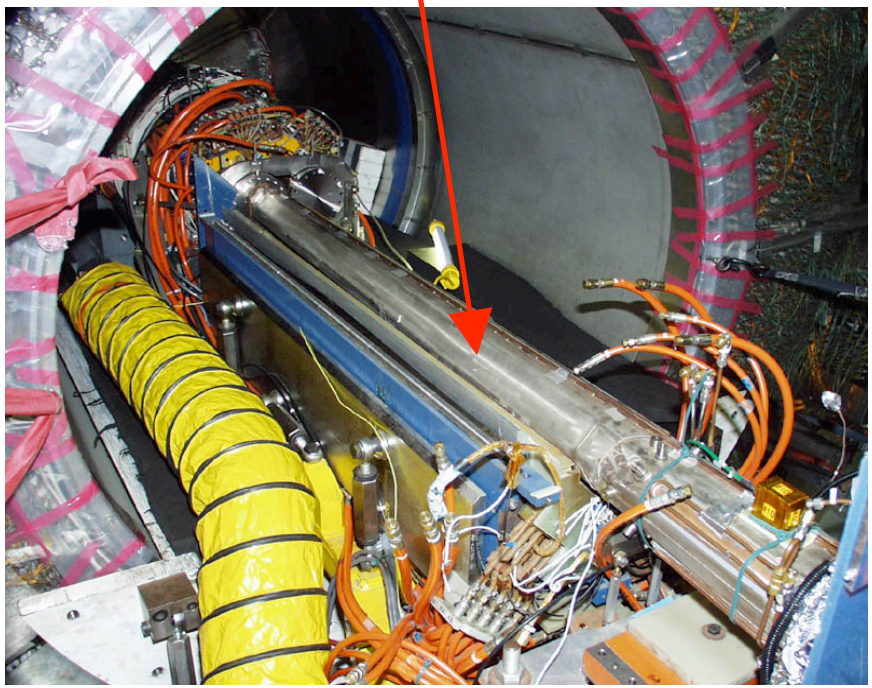
Side view of BaBar



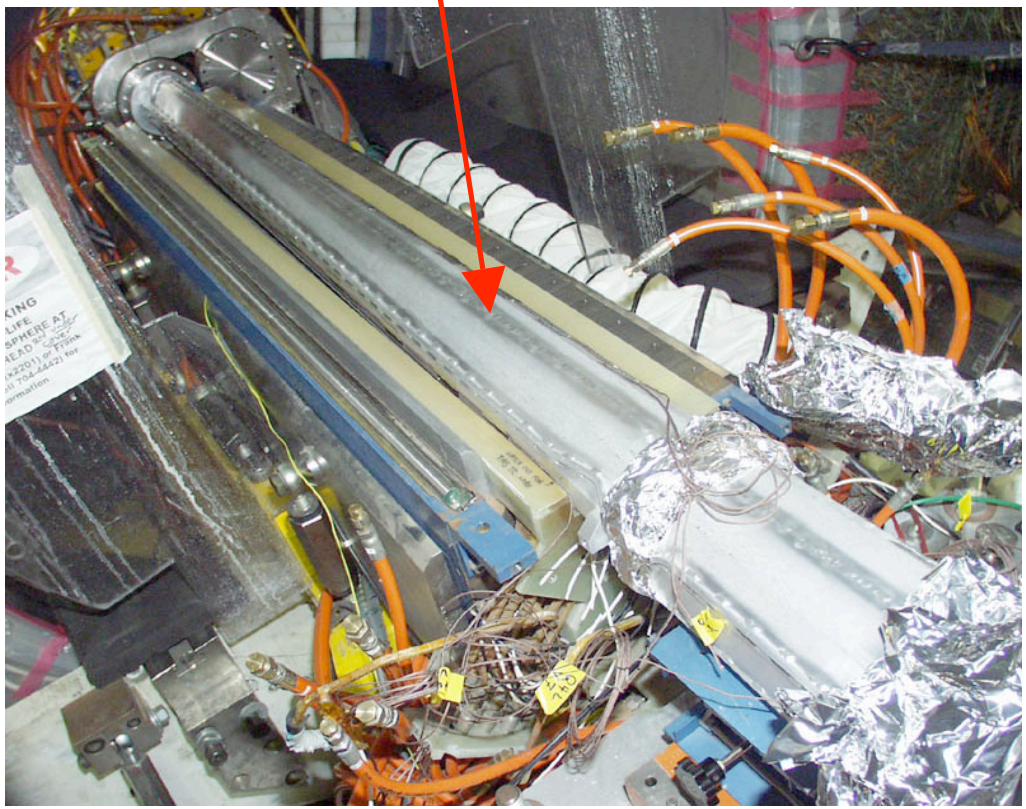
HER Q4L chamber

- Installed new, larger aperture, Al chamber during 2006 down
- Flexflange weld failed April 2007, temporary repair with Vacseal
- Removed Al chamber and reinstalled old StSt chamber while Al chamber repaired
- Flexflange replaced with fixed flange

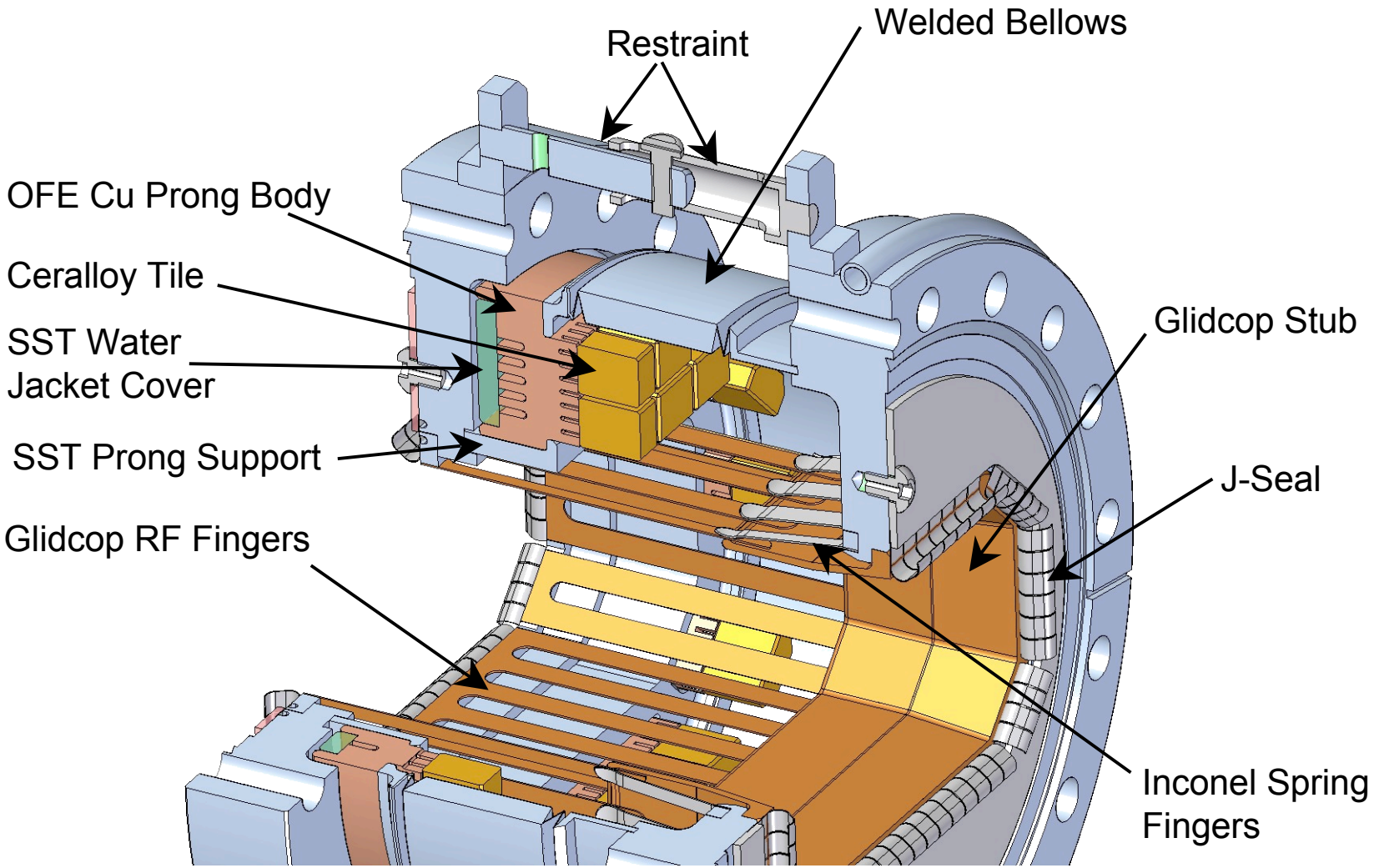
Old StSt chamber



New Al chamber



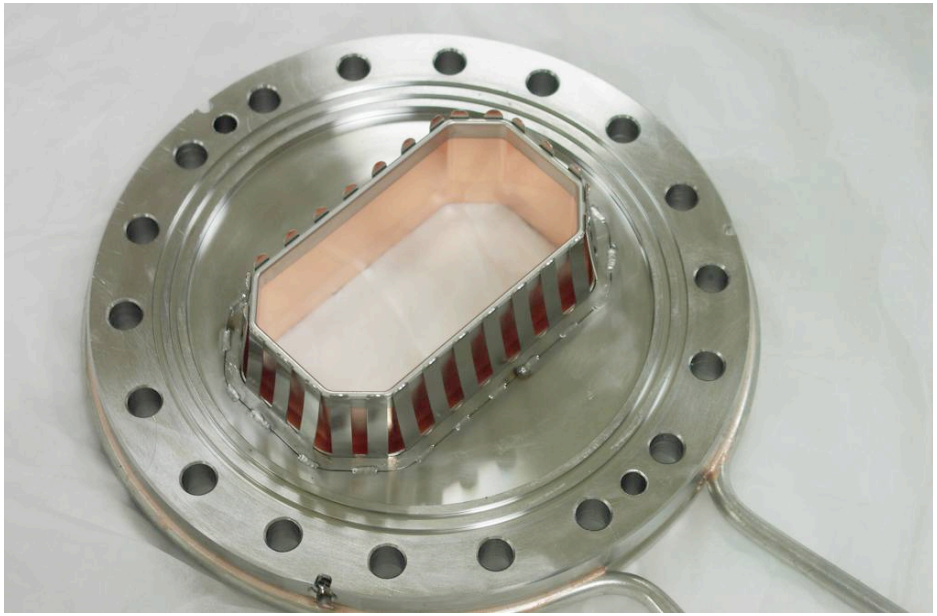
HOM absorbing bellows Components

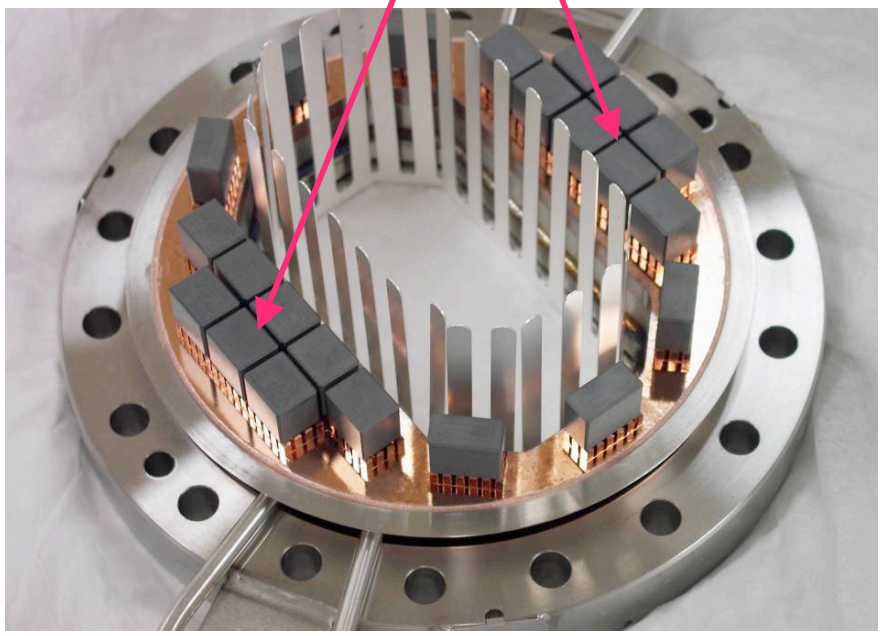


HOM absorbing bellows

In IR 2 we are replacing 5 bellows sections in the upstream LER and HER and 7 units in the downstream LER with bellows modules that contain HOM absorbing tiles. We hope to reduce the HOM power in this area

Novokhatski
Weathersby
Kurita
Reeck
Metcalfe

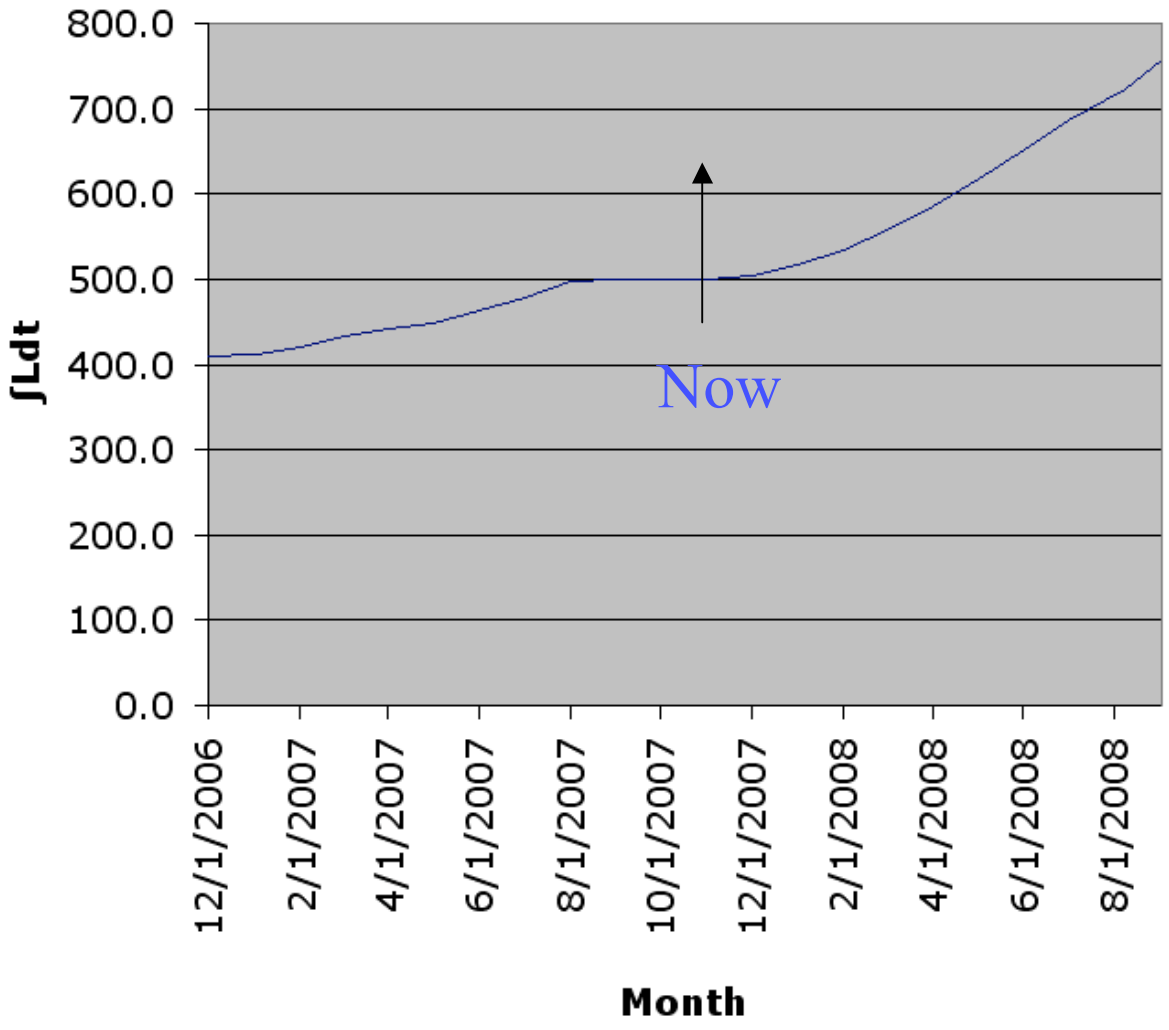




General Overall Plan for Run 7 (Dec 2007-Sept 2008)

- Start the linac and PEP-II on December 7.
- Run through the holidays.
- Do more machine studies (MD) early to increase luminosity at the beginning of the run.
- Find the optimum luminosity condition by early spring.
- Run through September 30 with best steady state conditions.

- **PEP II Integrated Luminosity (1/fb)**



PEP-II Shut Down

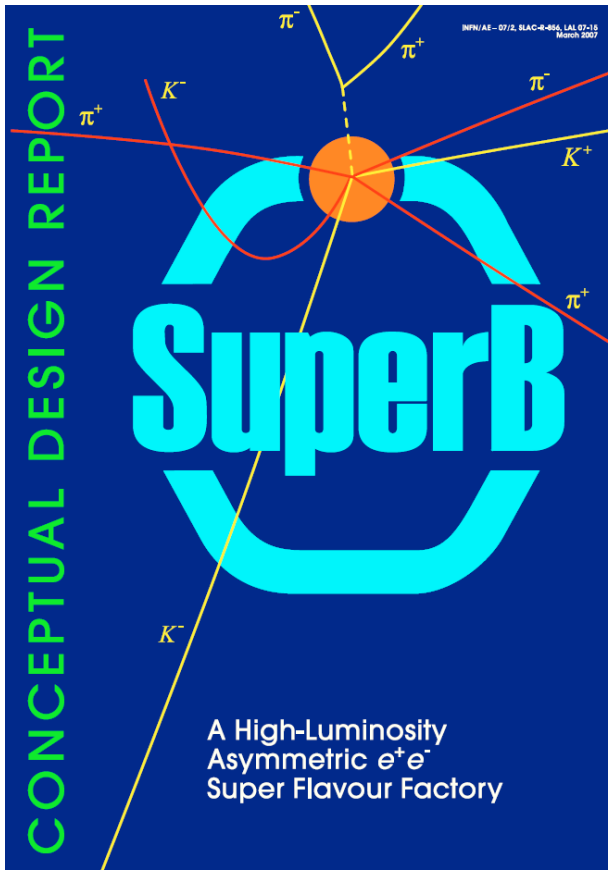
- PEP-II will stop producing data for BaBar on September 30, 2008, about ten months from now.
- PEP-II and BaBar will then transition rapidly into a “Minimal Maintenance State (MMS)” which takes just over a year.
- In the medium time frame, PEP-II will be at this MMS with some effort going into tunnel maintenance, safety lighting, electrical safety and mechanical safety. Valuable items will be preserved.
- For long term, D&D of PEP-II is being studied. A DOE review was held August 6-7, 2007.

SLAC Future Options

- Ongoing programs: ILC, PEP-II, SPEAR-3, ATLAS, LARP, Astrophysics, EXO-200
- Near term projects: LCLS
- Possible future projects: LSST, SNAP, ATLAS upgrades, LCLS upgrades, PEP-LS, LHC upgrades, High Gradient program, EXO2000, Super-B, …
- SLAC has started a long range planning exercise looking at these future projects. Study not finished yet.

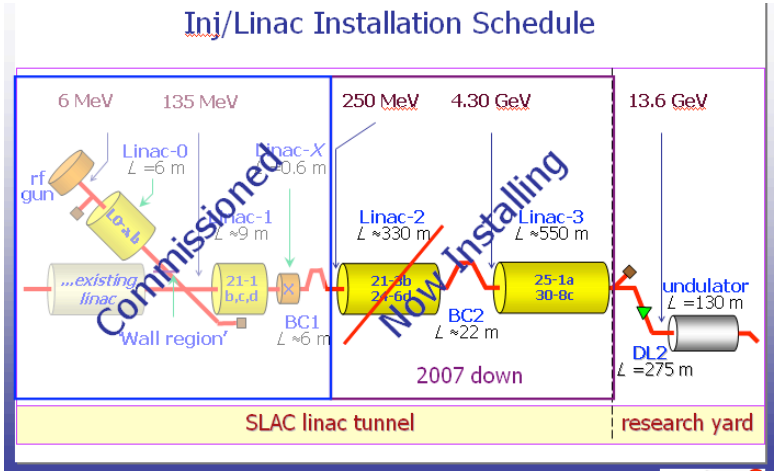
Super-B Factory Design

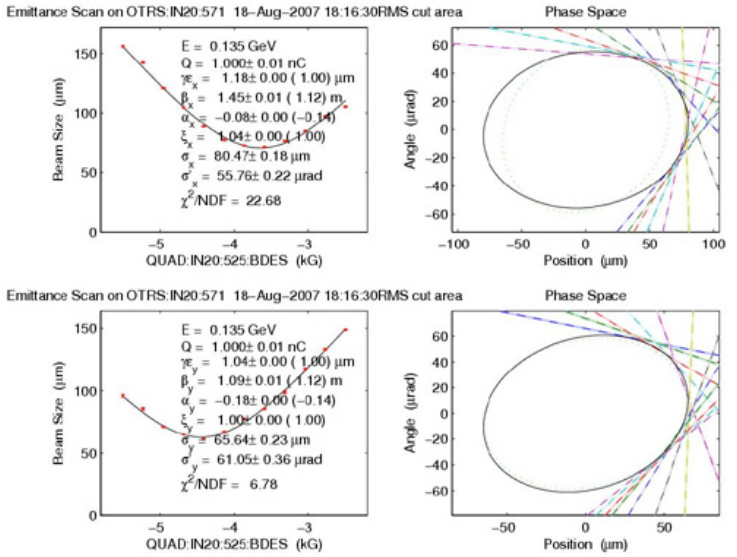
- SLAC is contributing modestly to the design effort for a Super-B Factory. Helped produce a Design Report in Spring 2007 (SLAC Report R-856). The goal is a factor of 100 increase in luminosity over PEP-II. Uses “ILC-like” damping rings with very small emittances, crab-waist at the IP, and smaller beam currents to save power.
- Supporting modestly the effort of INFN in Italy leading towards a Super-B accelerator and detector to be built near Rome.
- SLAC could consider contributing in-kind accelerator and detector components after September 2008 when PEP-II and BaBar are turned off. Perhaps starting in FY2011.



LCLS Progress

- Injector installed Spring 2007.
- Injector and first bunch compressor successfully tested by August 2007.
- Beam achieved 15 GeV.
- Second bunch compressor installed Fall 2007.
- New compressor will be tested January 2008.
- Downstream LCLS with undulator to be installed spring-Fall 2008 and commissioned in December 2008.
- First users in Summer 2009.
- Full set of users in Spring 2010.





PEP-II Conclusions

PEP-II accelerator in Run 6 was more difficult than planned but the run ended well.

Execution of the Fall 2007 shut down went well.

Upgrades towards ~2×10^{34} are done with the aim of 250 fb^{-1} more to 750 fb^{-1} total.

The luminosity will be ramped as fast as possible in Run 7.

PEP-II will integrate as much luminosity as possible.

PEP-II will turn off September 30, 2008.