Bob Siemann:
SLAC Professor and SLC Physicist

Tor Raubenheimer

Robert Siemann Symposium

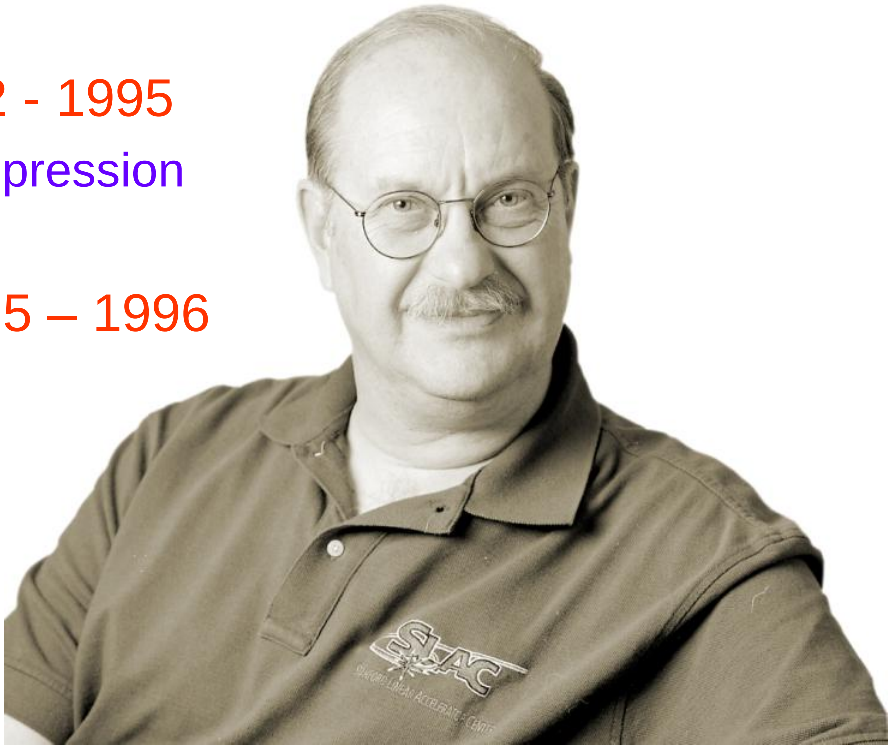
July 7, 2009

SLAC

PPA Particle Physics & Astrophysics

Topics

* Professor
* SLAC Linear Collider
  - Positron task force 1991 - 1993
  - Flat beams 1992 - 1993
  - DR studies and sawtooth 1992 - 1995
    - Beam loading and bunch compression
    - Vacuum chamber upgrade
  - Diagnostic pulse and DFS 1995 – 1996
* ATF Damping ring 1992



Students at SLAC

* Bob always had a large number of students and a larger number of advisees
* Bob was a great professor
* Students were first priority
* He drove people very hard but he was fair and very supportive
* Bob brought both a rigor and an enthusiasm for the academic side of Accelerator Physics to SLAC – he was a great experimentalist and a great teacher

* Students while at SLAC
  - Chris Barnes
  - Ian Blumenfeld
  - Ben Cowan
  - Robert Holtzapple
  - Neil Kirby
  - Chris McGuinness
  - Caolionn O'Connell
  - Boris Podobedov
  - David Pritzkau
  - Bruce Rohrbough
  - Chris Sears
  - Walt Zacherl

1991 SLC Team

- Bob came to SLAC in early 1991, in part, to work on the SLC which was struggling with luminosity
- He believed that the SLC was a prototype for the next collider

BAKER, Al	4849	424-7091
BURROWS, Kathy	3888	424-7715
CHAN, Kathy	3829	
CHAO, Yu-Chiu	2487	424-7235
CHRISTENSEN, Jim	3971	424-7720
CLENDENIN, Jim	2962	424-7133
CORBETT, Jeff	3645	424-7150
DECKER, Franz-Josef	3606	424-7318
ECKLUND, Stan	3182	424-7229
EMMA, Paul	2458	424-7160
FEATHERS, Larry	2496	12-131
FISCHER, Gerry	4198	
FRISCH, Josef	4005	424-7792
GARDEN, Christina	2061	424-7835
GRAY, Robin	3213	424-7138
HSU, Ian	2073	424-7353
HUTTON, Andrew	2976	424-7157
JOBE, Keith	2084	424-7025
KREJCIK, Patrick	2790	424-7183
KULIKOV, Artem	2071	424-7197
LIMBERG, Torsten	4512	424-7315
McCORMICK, Doug	2470	424-7368
NIXON, Robbin	2938	
PENNACCHI, Roz	3665	424-7051
PHINNEY, Nan	2957	424-7817
RITSON, Dave	3476	
ROSS, Marc	3526	424-7237
SCHULTZ, David	2459	424-7247
SEEMAN, John	3566	424-7327
SHEPPARD, John	3498	424-7320
SMITH, Patrick	2413	424-7568
SODJA, Joe	2390	424-7269
SPENCE, Bill	3866	424-7799
STEGE, Bob	3915	11-614
TOGE, Nobu	2631	424-7339
WALKER, Nick	3677	424-7335
WOODLEY, Mark	4081	424-7794
WOODS, Mike	3609	424-7828
YEREMIAN, Dian	4444	424-7340
ZIEMANN, Volker	4775	424-7994
ZOLOTOREV, Max	4670	424-7793

r/n 5/7/91

SLC Task Force (1991 – 1998)

SLC STEERING COMMITTEE

Nan Phinney - Chair
Bill Ash
Stan Ecklund
Tom Himel
Marc Ross
Ron Ruth
John Seeman
Bob Siemann
Nick Walker

ex officio — John Sheppard, Burt Richter

Bob was a cornerstone of the Steering Committee from beginning to end

CHARGE TO THE COMMITTEE:

PLANNING AND COORDINATION

OF 1991 RUN

1) Develop a run plan (with the System Physicists) with reasonable goals and milestones

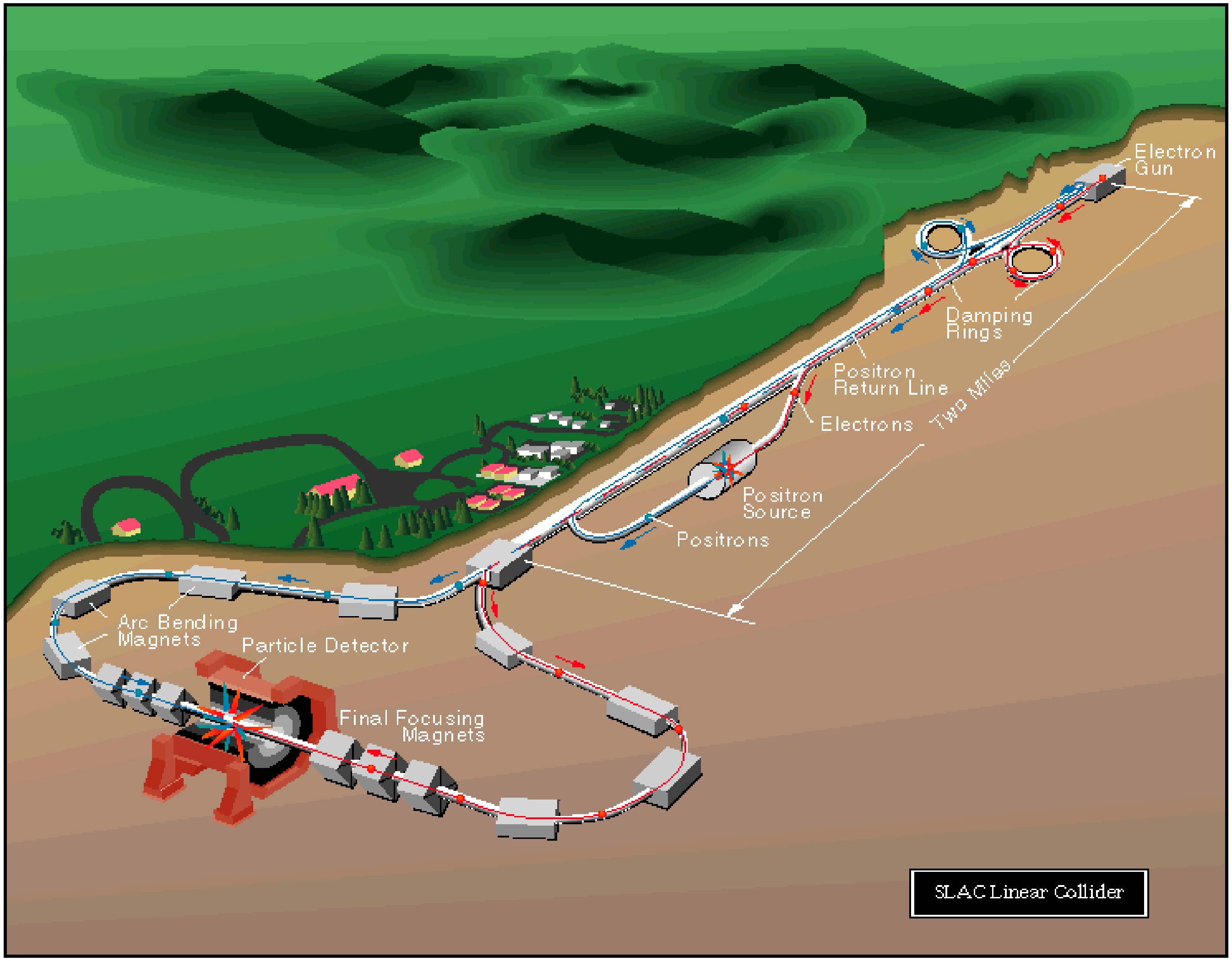
2) Review projects critical to meeting those goals and ensure that they have sufficient priority and resources

3) Review and approve machine physics experiments

4) Schedule the run on a weekly basis with goals, priority experiments and backup alternatives, SLD runs (Detailed scheduling of shifts to be done with the Program Deputy at a weekly scheduling meeting)

5) Review the progress of the run and make necessary mid-course corrections

SLC: The 1st Linear Collider



Built to study the Z_0 and demonstrate linear collider feasibility

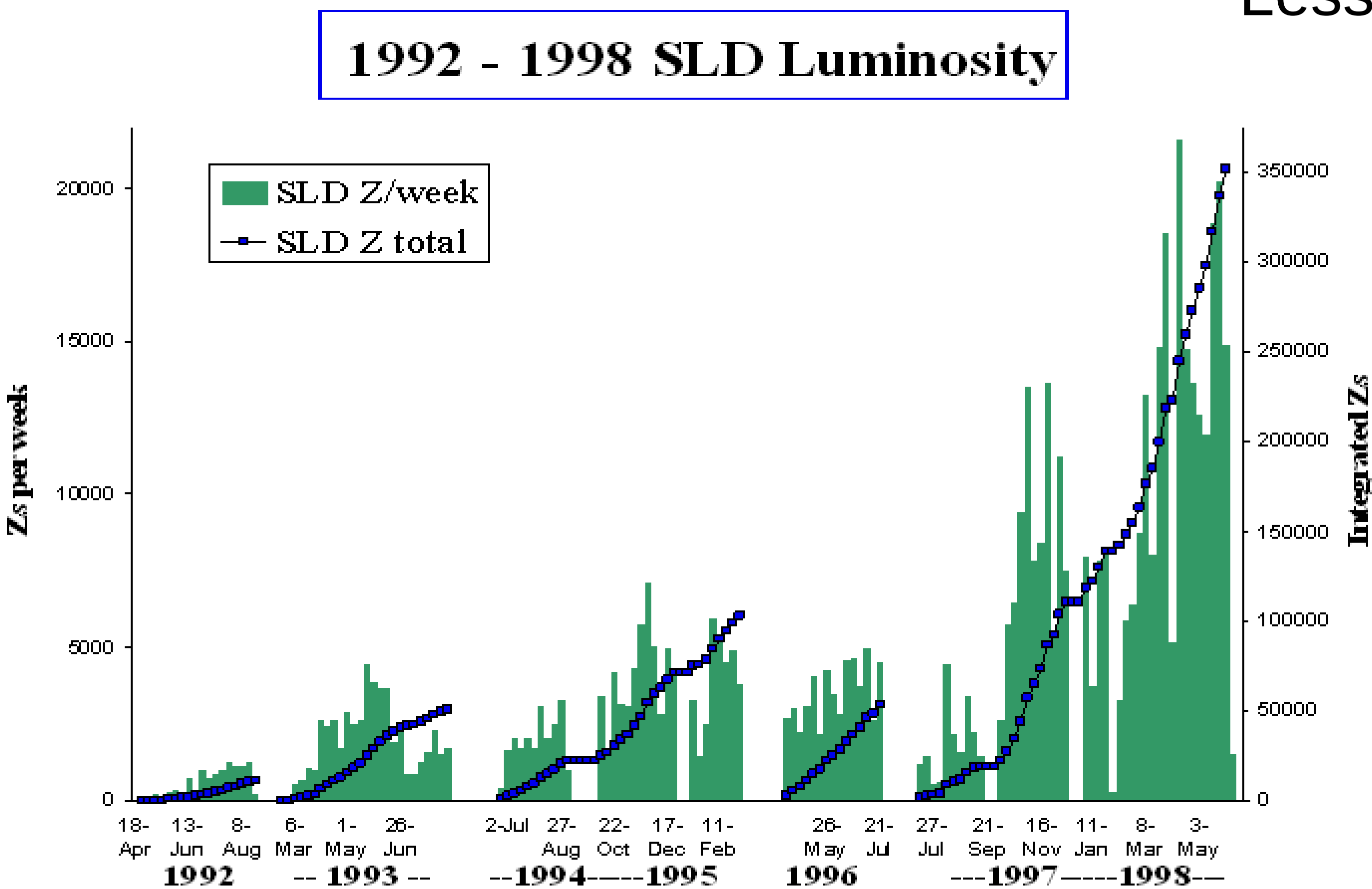
Energy = 92 GeV

Luminosity = 3e30

Had all the features of a 2nd gen. LC except both e+ and e- shared the same linac

Much more than a 10% prototype

SLC luminosity: Many Challenges



Lessons learned:

- Flexible design to allow parameter optimization
- Extensive diagnostics for troubleshooting and tuning
- Reliable and stable operation
- Well designed collimation to limit backgrounds

→ Provides the basis for the next generation LC

SLC POSITRONS

The e^+ yield is in reasonable agreement with shower and beam transport Monte Carlo's through the West Turn-Around.

- Monte Carlo gives 2.2 e^+/e^- at this point
- Measured yield during last cycle was 2.0 e^+/e^-

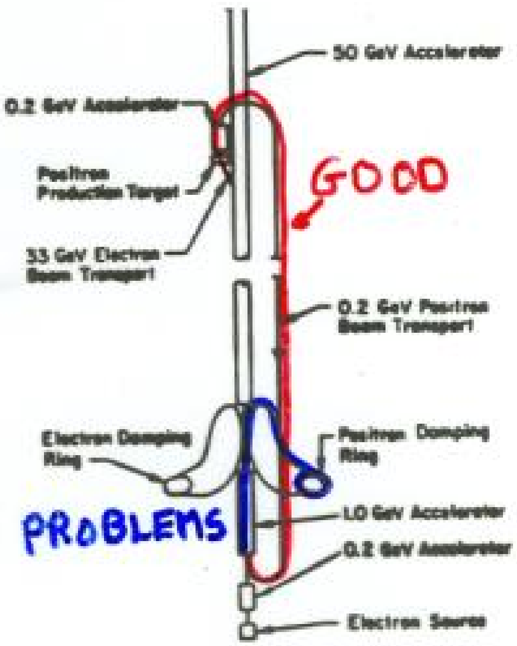
The problems are in the acceleration from 0.2 to 1.2 GeV, the transfer line from linac to damping ring, and the damping ring.

- Final Monte Carlo yield is 1.4 e^+/e^-
- Measured yield was 0.6 e^+/e^-

For the 1 GeV accelerator we are developing beam-based alignment procedures to position quadrupoles and increase the acceptance.

- Present quadrupole alignment is ~200 µm rms
- This needs to be reduced to 150 µm for adequate acceptance.
- Work is in progress. Some displaced quadrupoles have been identified and moved.

Positron Task Force



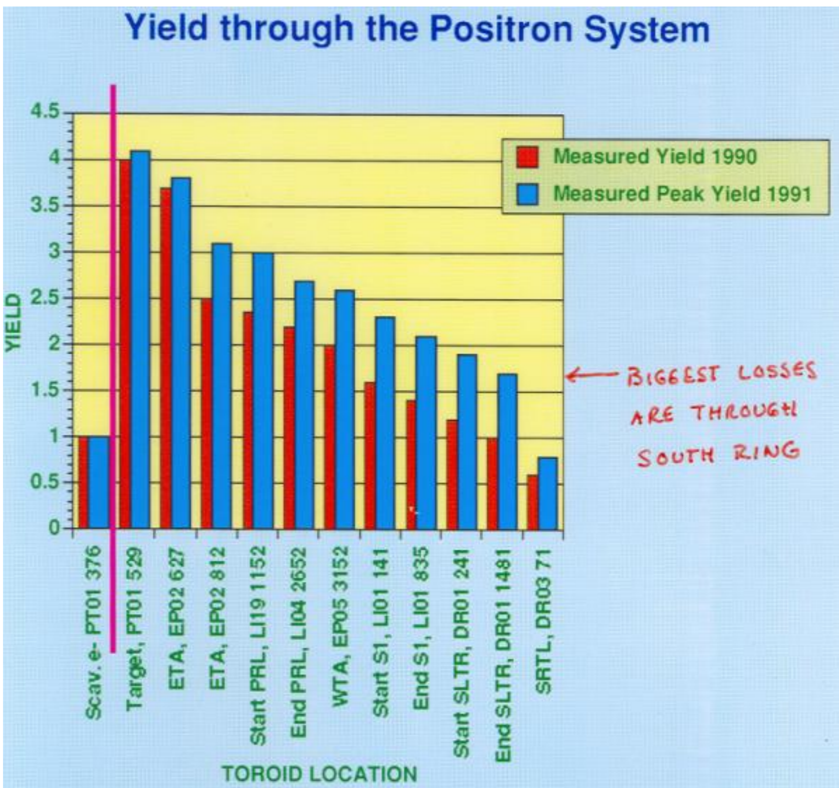
When Bob started at SLAC and worked on the positron system he was thrown into the deep end. He brought mathematical rigor to our data analysis procedures and guided us towards proper error analysis in the results.

Bob Siemann
for the
Positron Task Force

Particle Physics & Astrophysics

SLC Positrons

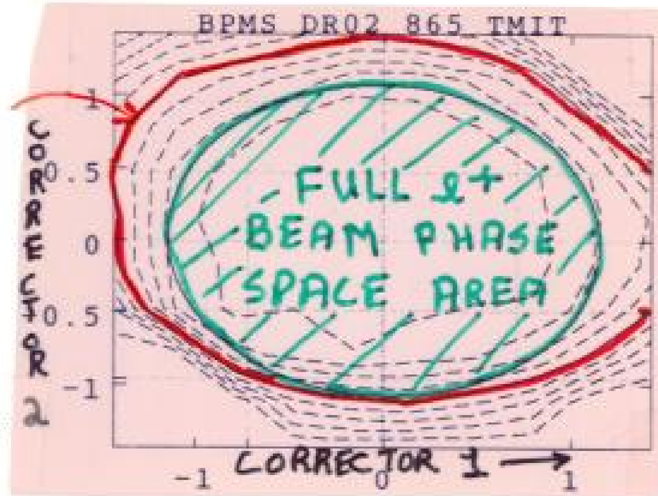
* Much improvement in transport systems
* Final scans of SDR aperture in 1992



ACCEPTANCE MEASURED WITH e^- BEAM

SCAN DIPOLES 90° APART IN PHASE

MEASURE TRANSMISSION



- TIGHTEST APERTURES ARE EXPECTED FROM DESIG
  ENLARGED FOR 1992
- FEW UNEXPECTED APERTURES DUE TO MECHANICAL AND/OR ALIGNMENT ERRORS
  CORRECTED

⇒ MEASURED APERTURES ARE LARGE ENOUGH FOR e^+ BEAM

IF STEERING AND OPTICS ARE CORRECT

Flat Beams in the SLC

* Issues
  – Damping rings
  – Emittance preservation
  – Spin control
  – Diagnostics

* 1990 SLC White paper
  – No luminosity improvement expected from flat beams
  – Do not pursue!

SLAC–PUB–6118
May 1993

Bob strongly supported experimental study of flat beams

Flat Beams in the SLC*

C. Adolphsen, T. Barklow, D. Burke, F.-J. Decker, P. Emma, M. Hildreth, T. Himel, P. Krejcik, T. Limberg, M. Minty, N. Phinney, P. Raimondi, T. Raubenheimer, M. Ross, J. Seeman, R. Siemann, W. Spence, N. Walker, M. Woodley
Stanford Linear Accelerator Center
Stanford, California 94309

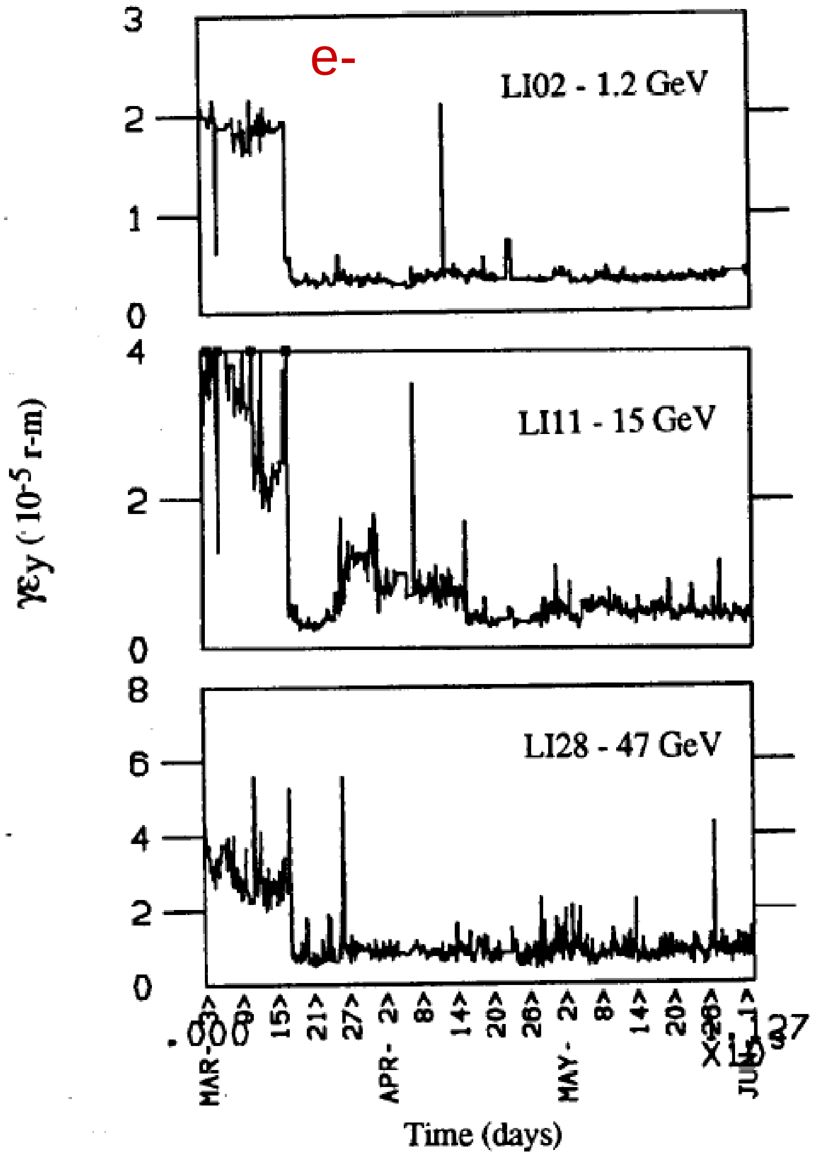
ABSTRACT

The Stanford Linear Collider was designed to operate with round beams [1]; horizontal and vertical emittance made equal in the damping rings. The main motivation was to facilitate the optical matching through beam lines with strong coupling elements like the solenoid spin rotator magnets and the SLC arcs.

electron and positron ring tunes is historical. For normal SLC operation, simply splitting the horizontal and vertical tunes is sufficient; producing beams with normalized rms emittances of $\gamma\varepsilon_x$=3×10^{-5} m-rad and $\gamma\varepsilon_y$=0.3×10^{-5} m-rad.

The vertical emittance could be reduced further with more sophisticated coupling and dispersion correction. However, in the electron damping ring, the beam is stored for only 2.4 damping times and thus the extracted vertical emittance is

Flat Beams in the SLC



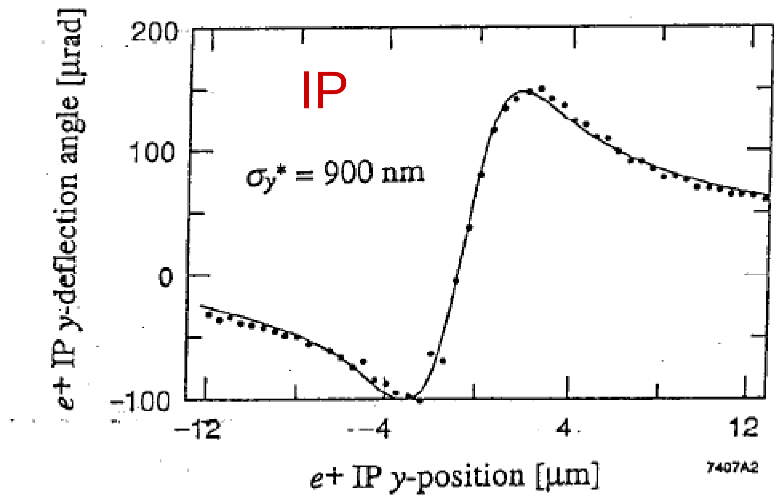


Fig 2. Flat beam-beam vertical deflection scan which measures the quadratic sum of the e^- and e^+ vertical beam sizes. The individual vertical beam sizes are <0.9 μm. The horizontal beam sizes (not shown) are typically 2.2-2.5 μm.

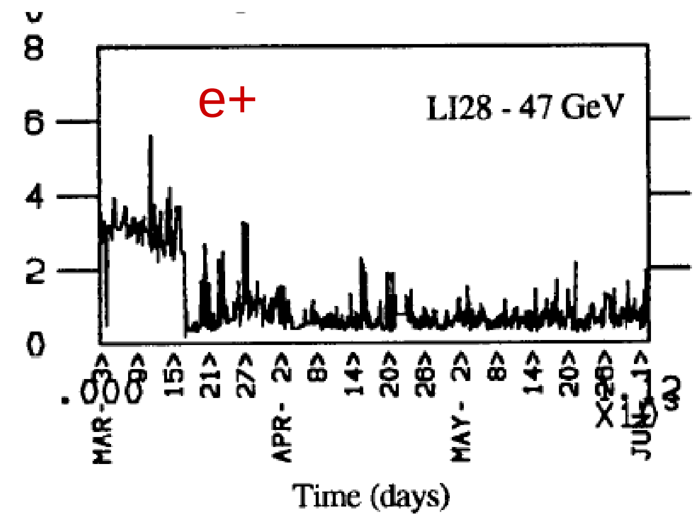


Figure 1 Histories of SLC invariant vertical emittances for e⁻ (left) and e⁺ (right) at 3 x 10^{10} at linac locations: entrance (1.2 GeV, top), 1 km (15 GeV, center), and exit at 3 km (47 GeV, bottom). The period is March 3 - June 2, 1993.

SLC Damping Rings

* The SLC damping rings were critical for the collider performance
  – Errors were amplified by linac and made tuning FFS difficult
* Many challenges in the rings
  – Space was tight – hard to install new diagnostics
  – Magnets pushed to their limits
  – High single bunch charge and injection/extraction meant single bunch instabilities and beam loading issues turned into downstream jitter
* Bob wanted to turn the rings into precision machines
* The damping rings were ideal for Bob and his students because we could create every known instability plus some new ones

SLC Damping Ring RF Feedback & Transients

Bob was the driving force behind the RF studies which were useful for SLC and critical for PEP-II

Simulation and Analysis of RF Feedback Systems on the SLC Damping Rings

M. Minty, T. Himel, P. Krejcik, R.H. Siemann, R. Tighe

Stanford Linear Accelerator Center, Stanford University, Stanford CA 94305 *

Abstract

The rf system of the SLC Damping Rings has evolved since tighter tolerances on beam stability are encountered as beam intensities are increased. There are now many feedback systems controlling the phase and amplitude of the rf, the phase of the beam, and the tune of the cavity. The bandwidths of the feedback loops range from several MHz to compensate for beam loading to a few Hz for the cavity tuners. To improve our understanding of the interaction of these loops and verify their expected behavior, we have simulated their behavior using computer models. A description of the models and the first results are discussed.

1. Introduction

During the 1992 SLC/SLD run, accelerator operation became sensitive to the microwave instability[1] at beam currents above 3×10^{10} particles per bunch. To avoid the onset of bunch lengthening at higher currents, an rf voltage ramp was implemented. However, the depth of the ramp was limited by a Robinson-like instability[2,3], which was corrected for using direct rf feedback[3,4]. With these modifications, the parameter space has become more complex. Operating conditions must be adjusted and optimized such that the rf system operates stably under varying condi-

The rf system is modelled by calculating the dynamics of the beam cavity interaction. These equations along with measured loop characteristics and klystron saturation data are then incorporated into numerical integration programs such as Matrix-x[5] and Simulink[6]. These algorithms use state space representations of the system to solve the differential equations. The system can be analyzed in both the time and frequency domains.

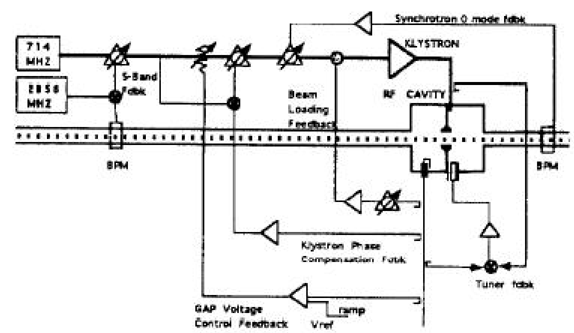


Figure 1. SLC damping ring rf system.

SLC longitudinal Phase Space

Measurements of Longitudinal Dynamics in the SLC Damping Rings*

R.L. Holtzapple, R.H. Siemann, and C. Simopoulos
Stanford Linear Accelerator Center, Stanford University, Stanford, CA 94309 USA

I. Abstract

Measurements of longitudinal beam properties in the Stanford Linear Collider (SLC) damping rings have been made using a Hamamatsu, model N3373-02, 500-femtosecond streak camera[1]. The dependence of bunch length on current and accelerating RF voltage was measured. The energy spread dependence of current was also measured. The turbulent instability threshold for the SLC damping ring is at the current of I=1.5-2.0x10^{10} particles per bunch.

II. Data Analysis and Systematic Errors

The measurements were performed on either the SLC electron or positron damping ring when the opportunities for beam time became available. We are not aware of any

and the incident light was filtered until the bunch length measurement was stable over a range of light intensities. Figure 1 exhibits the intensity effects on bunch length measurement and in this example the light is filtered by 50% to eliminate this effect.

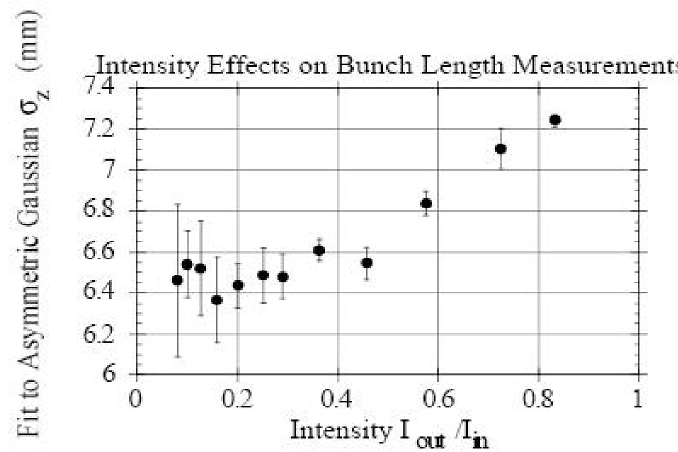


Figure 1. The bunch length dependence on light intensity measured at the damping ring with a current of I=3.6x10^{10}.

SLC Damping Ring Instabilities

* In the early 1990's, jitter at the IP was tracked back to a bursting longitudinal instability in the SLC damping rings
  – Small changes in DR phase and energy caused large changes at the IP
* A number of fixes were developed including complicated rf tricks to 'pin' the instability onset

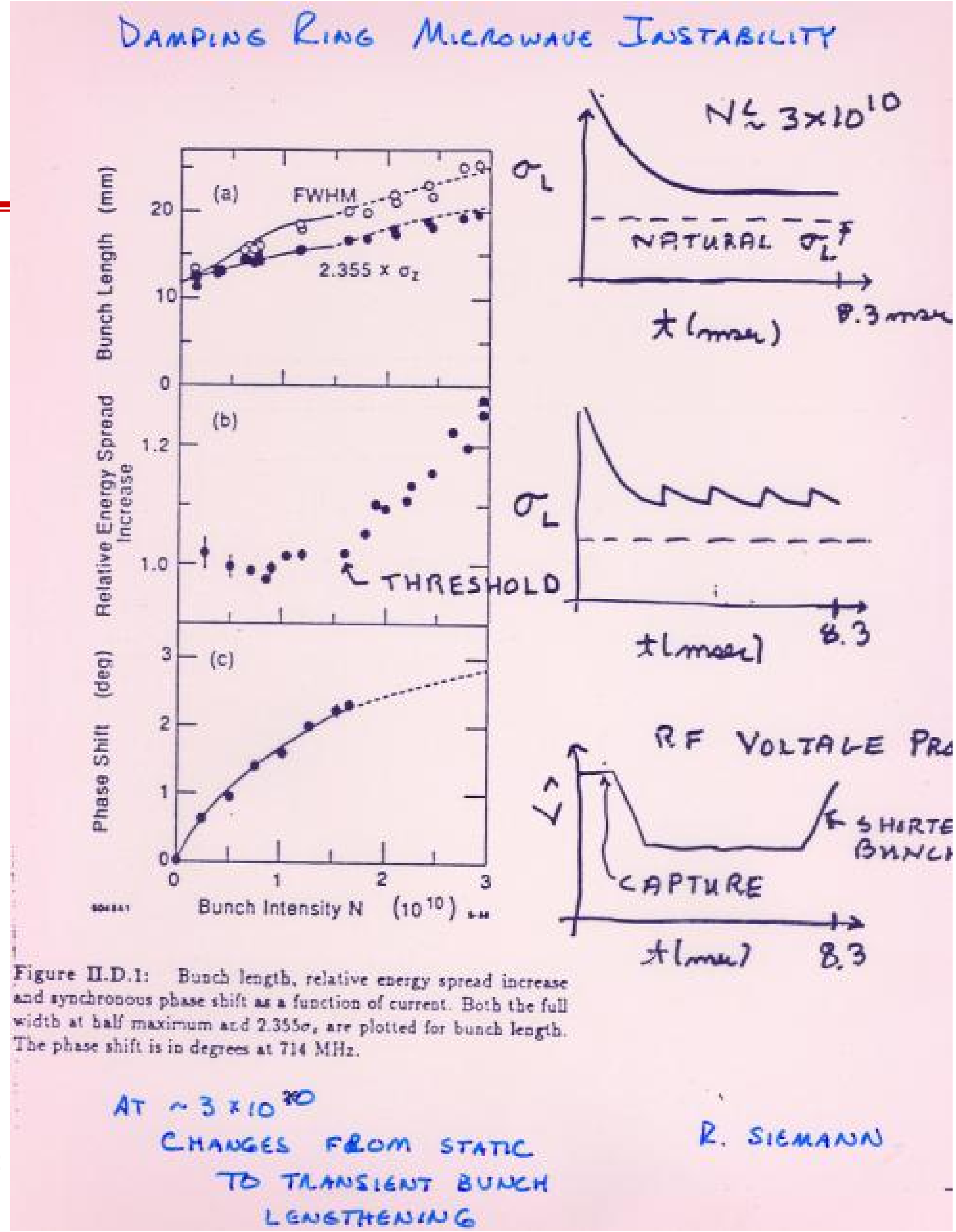


Figure II.D.1: Bunch length, relative energy spread increase and synchronous phase shift as a function of current. Both the full width at half maximum and 2.355σz are plotted for bunch length. The phase shift is in degrees at 714 MHz.

SLC Damping Ring Upgrade

* The bursting instability was identified in the early 1990's as the longitudinal microwave instability
  - Shielding of the bellows in 1989 increased the threshold by 2 as expected but was to $3x10^{10}$
  - Measurements agreed fairly well with modeling which predicted a further increase in threshold by smoothing the ring chamber
  - Bob led the effort with Torsten Limberg
  - Karl Bane provided the theoretical calcs
  - In 1994 when the threshold was measured to be 2x lower!

When an issue arose, Bob was great at pulling the experts together, listening to what they had to say and then making a decision

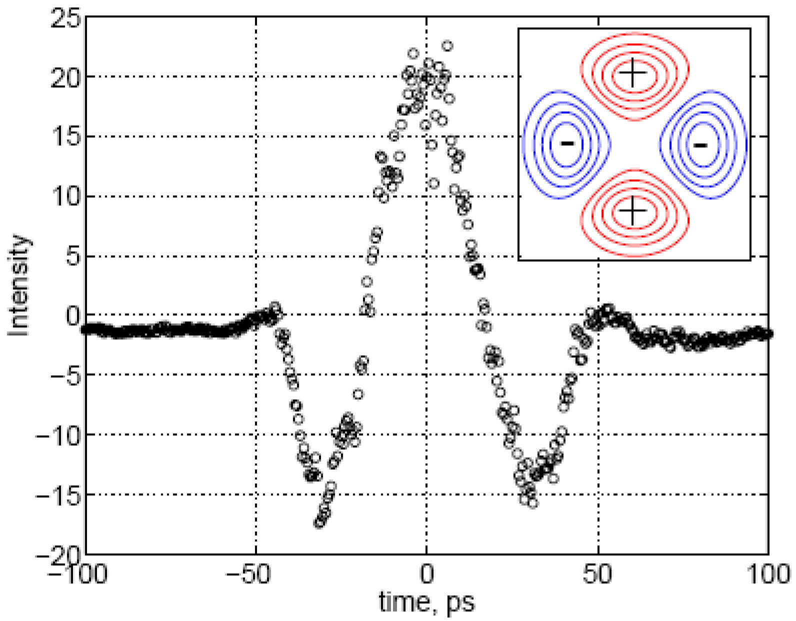
Particle Physics & Astrophysics

Sawtooth Instability version 2.0

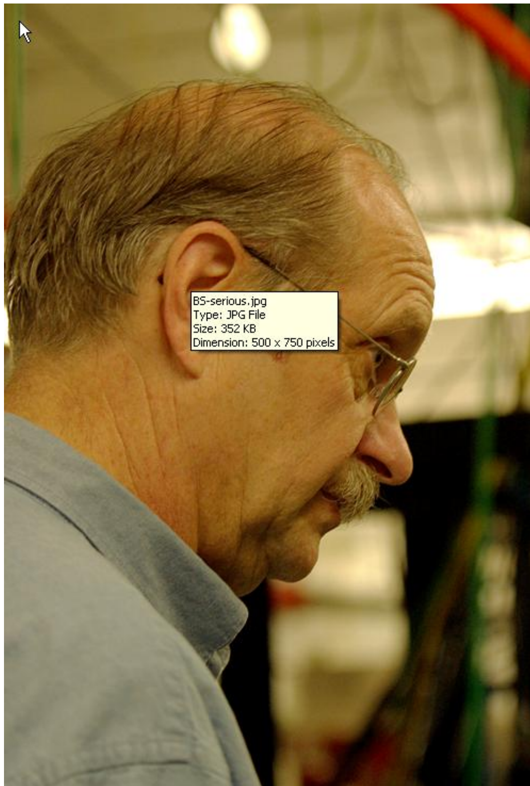
High-Intensity Single Bunch Instability Behavior In The New SLC Damping Ring Vacuum Chamber*

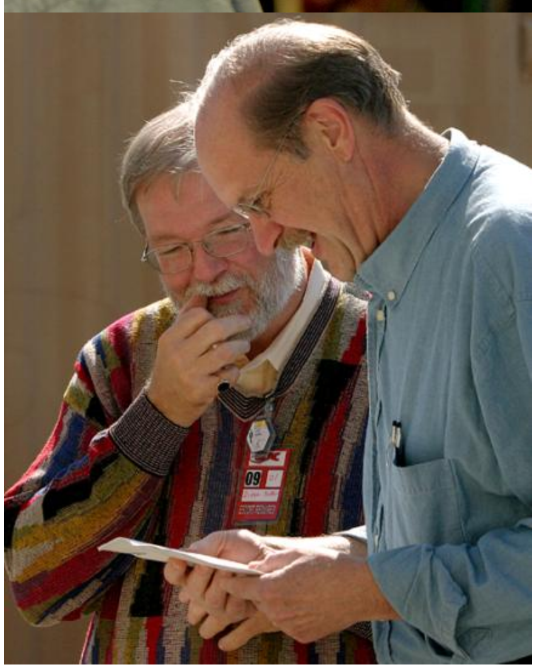
K. Bane, J. Bowers, A. Chao, T. Chen, F. J. Decker, R. L. Holtzapple, P. Krejcik, T. Limberg, A. Lisin, B. McKee, M. G. Minty, C.-K. Ng, M. Pietryka, B. Podobedov, A. Rackelmann, C. Rago, T. Raubenheimer, M. C. Ross, R. H. Siemann, C. Simopoulos, W. Spence, J. Spencer, R. Stege, F. Tian, J. Turner, J. Weinberg, D. Whittum, D. Wright, F. Zimmermann
Stanford Linear Accelerator Center, Stanfc

New low-impedance vacuum chambers were installed in the SLC damping rings for the 1994 run after finding a single bunch instability with the old chamber. Although the threshold is lower with the new vacuum chamber, the instability is less severe, and we are now routinely operating at intensities of 4.5×10^{10} particles per bunch (ppb) compared to 3×10^{10} ppb in 1993. The vacuum chamber upgrade is described, and measurements of the bunch length, energy spread, and frequency and time domain signatures of the instability are presented.

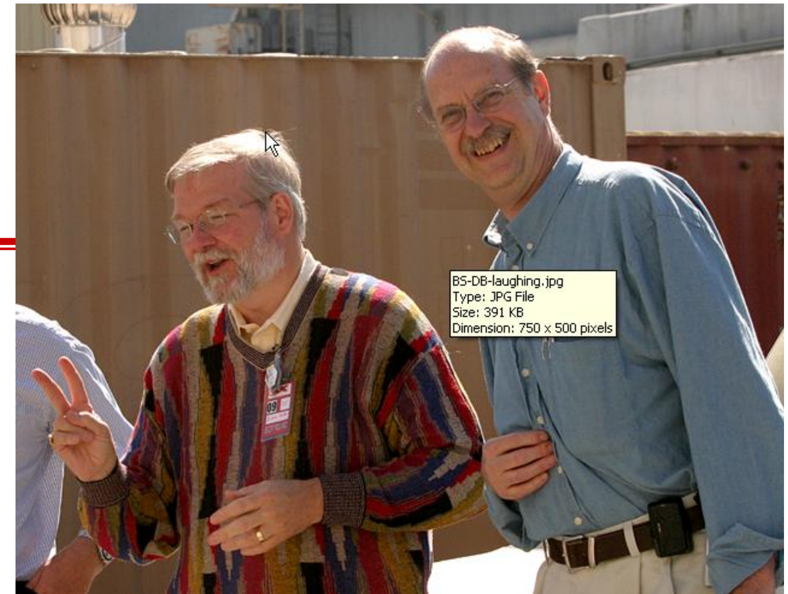


I. VACUUM CHAMBER UPGRADE





Bob Siemann



Bob loved experimental physics and loved designing experiments to get at the physics.

Bob was sometimes gruff, sometimes measured and sometimes excited, but he was always a model of intellectual integrity.

He pushed us to think for ourselves and provided guidance by asking the right questions.

We will all miss him greatly!