Accelerator Physics Summary &
Report on UCLC + LCRD R&D Program

ALCPG04 - SLAC

George Gollin
University of Illinois
January 10, 2004

background image: Halbach permanent magnet quadrupole field, J. Rosenzweig, UCLA
Outline

- Status of UCLC, LCRD accelerator physics

- Overview of UCLC and LCRD accelerator physics projects, as well as ALCPG04 accelerator physics working group presentations
  - beam dynamics & simulation
  - damping rings
  - systems & instrumentation
  - rf & accelerating structures
  - beam delivery & IR
  - sources
Brief UCLC + LCRD history

➢ At UC Santa Cruz (July, 2002):
  • DOE, NSF declared $400k, $500k as accelerator funding goals.
  • USLCSG organized schedule for proposal submission and review

➢ *A University Program of Accelerator and Detector Research for the Linear Collider* ("Big Document") sent to DOE, NSF October 24, 2002.
  • 33 accelerator, 38 detector proposals, 47 universities, 6 labs, 297 authors, 545 pages.
  • accelerator support requests: $625k LCRD, $379k UCLC

background image: copies of Big Doc on its way to Washington
The startup has been bumpy

- Congressional budget was months late: Feb. 14, 2003

- “The cap” on DOE LC accelerator R&D

  - DOE managed to find ~all the funds they had hoped for: $400k/$500k accelerator/detector. (yippee!)
  - Long delay was a problem (some groups didn’t get summer students). Discouraging (and ultimately inaccurate) projections came from some grant officers before funds were actually found.

- NSF hit a pothole. UCLC only received a “planning grant.”
Starting up, renewal proposals

Most groups have started their projects, in spite of budget glitches.


A University Program of Accelerator and Detector Research for the Linear Collider, volume II sent to DOE, NSF November 24, 2003.

- 29 accelerator, 39 detector proposals, 48 universities, 5 labs, 303 authors, 622 pages.

- FY04 accelerator support requests: $772k LCRD, $380k UCLC
Proposal reviews this year

December, 2003 reviews of UCLC, LCRD projects:

• Norbert Holtkamp (ORNL) chaired the accelerator review

• Howard Gordon (BNL) chaired the detector review.

Detector review procedures were adjusted so that reports from the Gordon Committee could be used by DOE to make funding decisions.

DOE chose not to do this with the Holtkamp Committee. There will be another round of reviews required before funding can be provided.

Will there be funding? We’ll see.
HEPAP says LC is important. DOE/NSF need to find ways to support LC work.

- Engagement of (university) community is essential.
- Support from DOE/NSF is necessary to show it’s really worth our time to put aside some of our other activities to do LC work.

<table>
<thead>
<tr>
<th></th>
<th>FY03 request</th>
<th>FY03 award</th>
<th>FY04 request</th>
<th>FY05 request</th>
<th>FY06 request</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCRD</td>
<td>$575k</td>
<td>$400k</td>
<td>$772k</td>
<td>$871k</td>
<td>$713k</td>
</tr>
<tr>
<td></td>
<td>(21 proposals)</td>
<td>(6 of 21 rejected)</td>
<td>(17 proposals)</td>
<td>(17 proposals)</td>
<td>(17 proposals)</td>
</tr>
<tr>
<td>UCLC</td>
<td>$379k</td>
<td>???</td>
<td>$380k</td>
<td>$757k</td>
<td>$889k</td>
</tr>
<tr>
<td></td>
<td>(12 proposals)</td>
<td></td>
<td>(12 proposals)</td>
<td>(12 proposals)</td>
<td>(12 proposals)</td>
</tr>
</tbody>
</table>
A survey of accelerator R&D: UCLC, LCRD, and ALCPG04

ALCPG04 topics
- Beam dynamics & simulation
- Damping rings
- Systems & instrumentation
- RF & accelerating structures
- Beam delivery & IR
- Sources

Holtkamp Committee topics
- Beam simulations and other calculations (6)
- Kickers, magnet technologies, mechanical support systems (4)
- Instrumentation and electronics (9)
- Ground Motion (1)
- Control Systems (1)
- RF Technology (5)
- Non-$e^+e^-$ collisions (1)
- Electron and positron source technology (2)

background image: acoustic wave in copper simulation
Beam Dynamics and Simulation

• simulation of beam dynamics
• rf cavity dark current simulation
• damping ring electron cloud model
• developing better software tools
• modeling machine reliability
## ALCPG04 accelerator WG sessions

### Beam Dynamics and Simulation

**AGENDA**

*updated 1/7/04*

**Wednesday, January 7, 1:30-3:30 pm**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Chair</th>
<th>Room</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:30 - 2:00</td>
<td>LC Availability Simulation done for the LC Comparison Task Force</td>
<td>Tom Himel, SLAC</td>
<td></td>
</tr>
<tr>
<td>2:00 - 2:15</td>
<td>Beam Simulation Efforts at Cornell (UCLC progress report)</td>
<td>David Sagan, Cornell University</td>
<td></td>
</tr>
<tr>
<td>2:15 - 2:30</td>
<td>Beam Simulation Efforts at Northwestern-ICAR</td>
<td>Armen Apyan, Northwestern University, ICAR</td>
<td></td>
</tr>
<tr>
<td>2:30 - 2:45</td>
<td>Dark Current Simulation for Linear Collider Structure R and D</td>
<td>Valentin Ivanov, SLAC</td>
<td></td>
</tr>
<tr>
<td>2:45 - 3:05</td>
<td>The Next Generation of Linear Collider Simulations</td>
<td>Peter Tenenbaum, SLAC</td>
<td></td>
</tr>
<tr>
<td>3:05 - 3:25</td>
<td>Critical Issues in Beam Dynamics for the Linear Collider</td>
<td>Tor Raubenheimer, SLAC</td>
<td></td>
</tr>
</tbody>
</table>

**Friday, January 9, 8:30-10:30 am**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Chair</th>
<th>Room</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30 - 8:50</td>
<td>Collective Effects in Damping Rings</td>
<td>Andy Wolski, LBNL</td>
<td></td>
</tr>
<tr>
<td>8:55 - 9:15</td>
<td>Electron Cloud in the NLC and TESLA</td>
<td>Mauro Pivi, SLAC</td>
<td></td>
</tr>
<tr>
<td>9:20 - 9:50</td>
<td>Collimator Wakefields</td>
<td>Peter Tenenbaum, SLAC</td>
<td></td>
</tr>
<tr>
<td>9:55 - 10:10</td>
<td>Compact Wakefield Facility (LCRD progress report)</td>
<td>John Power, ANL</td>
<td></td>
</tr>
<tr>
<td>10:15 - 10:30</td>
<td>A Simplified Method to Compute Single-Pass CSR with Shielding</td>
<td>Gabriele Bassi, University of New Mexico</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(LCRD progress report)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Beam simulation and general calculations
(6 LCRD + UCLC projects)

• LCRD 2.27: Effects of Coherent Synchrotron Radiation in Linear Collider Systems (James Ellison)

• UCLC 2.29: Improved simulation codes and diagnostics for high-brightness electron beams (Court Bohn)

• UCLC 2.30: Beam simulation: main beam transport in the linacs and beam delivery systems, beam halo modeling and transport, and spin transport (Dave Rubin)

• UCLC 2.32: Damping ring studies for the LC (Sekazi Mtingwa)

• LCRD 2.33: A Compact Wakefield Measurement Facility (Young-Kee Kim)

• UCLC 2.34: Experimental, simulation, and design studies for linear collider damping rings (Joe Rogers)
Gabriele Bassi: A Simplified Method to Compute Single-Pass Coherent Synchrotron Radiation with Shielding (LCRD progress report)

LCRD 2.27: funded FY03, $20k.

Funds arrived too late to support a new student, but (analytic) calculations are ongoing.

2D spacetime Green’s function; method-of-images shielding.

Benchmark system: magnetic chicane for bunch compressor coming from a bunch with a linear chirp, evolving only in response to fields of dipoles.

next step: self-consistent of the charge distribution allowing the distribution to be affected by CSR.
Progress Report on UCLC Simulations at Cornell

Presenter: David Sagan

UCLC 2.30: Beam simulation: main beam transport in the linacs and beam delivery systems, beam halo modeling and transport, and spin transport

(Dave Rubin et al.)
Recent Progress

Bmad has been extended for LINAC simulation:

- Macroparticle tracking implemented
  - Full 6 x 6 sigma matrices
  - Ability to track through bends
- LCavity element with wakefields implemented.
- XSIF (Extended Standard Input Format) parser implemented.
- I_Beam element implemented*
- Initial comparison with LIAR shows agreement.

Other progress:

- Bmad Documentation [http://www.lepp.cornell.edu/~dcs].
- Fortran to C structure conversion standard (Fortran2003).
Tor Raubenheimer: Critical Issues in Beam Dynamics for the Linear Collider

- Sources, especially $e^+$: target damage, yield, polarization…
- Damping rings: lots of accelerator physics. Large sensitivity of downstream systems to fluctuations in DR behavior.
- Low emittance transport: DR to IP. Both designs have ~100% dilution.
- IR and backgrounds: feedback, collimators and masking,…

- Need to study details of design performance
- Many tools have been developed or are under development but new tools needed
- Goal: DR $\rightarrow$ IP $\leftarrow$ DR simulation
Andy Wolski : Collective Effects in Damping Rings

Gas ionization can lead to a coupled-bunch instability

- Results from KEK-ATF
- Yosuke Honda, presented at ISG 11
Andy Wolski: Collective Effects in Damping Rings

Summary

- Vacuum chamber impedance can lead to single-bunch and multi-bunch instabilities
  - Concerns for both NLC and TESLA
  - Should be possible to build vacuum chamber to stay below single-bunch instability thresholds
  - Should be possible to use feedback systems to suppress multi-bunch instabilities
- Space-charge forces are a concern for TESLA
  - Large circumference means relatively large tune shifts
  - Use of "coupling bumps" should minimize effects
- Intra-beam scattering is a concern for NLC MDR
  - Effect is strongly dependent on energy
  - Present lattice may have sufficient margin in emittance
- Ion effects are a concern
  - Various effects in TESLA and NLC
  - More work needed to specify necessary vacuum pressure
- Electron cloud is the most serious concern
  - See talk by Mauro Pivi...
A dedicated facility for high-resolution wakefield measurements of NLC structures. Work needed:

1. A 20 MeV, high-brightness, Drive Beam excites wakefield
2. A 5 MeV Witness Beam probes the wakefield
3. Downstream Optics measures the witness beam deflection
Armen Apyan: Beam Simulation Efforts at Northwestern-ICAR

Analytic solution techniques for various lattice studies in LC (CLIC) design

• modeling techniques which hunt for solutions in parameter space can get lost; they need good starting points in order to find the “right” solution. There is virtue in analytic techniques.

• working on designs for “turn around loop” for CLIC.

• results are checked with MAD simulation
Valentin Ivanov: Dark Current Simulation for Linear Collider Structure R&D

Dark current simulation code

• includes particle tracking in $E$, $B$ fields

• has modeling of thermal emission, field emission, secondary emission…

• filling of realistic NLC cavities and structures are modeled. (Cool animations!)
Benchmarking Particle Trajectories

Comparing 2D and 3D models

G = 50 MV/m

G = 100 MV/m
Modeling Single Cell Experiment – Track3P

X-ray Spectrum, P=25 MW

X-ray Spectrum, P=50 MW

Gollin, 1/10/04

ALCPG04 Accelerator R&D summary
Mauro Pivi: Electron Cloud in the NLC and TESLA

- a problem for LC damping rings
- development of detailed models for electron cloud in progress
- investigation of methods to reduce secondary emission underway
Peter Tenbaum: Collimator Wakefields

Beam which passes off-axis though collimator jaws gets a transverse kick

• Collimator Wakefields likely to play important role in dynamics of beam delivery system
  – With tail-folding octupoles, theory says present design’s OK
  – Without tail-folding octupoles, present design is marginal to unacceptable

• Theoretical estimates of wake kicks not yet at acceptable level
Peter Tenenbaum, LC simulation tools

Where I think the Future Lies

- The LC world needs a fast simulation tool aimed at operations and tuning sims – like LIAR but better
- Should have 1 beam representation (pointlike rays?)
- 1 lattice representation
- Should be able to simulate from DR exit to IP more smoothly than LIAR-DIMAD hybrid
- Amount of compiled code should be minimized
- Any compiled code should probably be in C
  - third-party support for FORTRAN pretty bad these days
- Use of Matlab “wrapper” maximized
  - Why waste our time coding parsers, graphics engines, SVD, etc, when The MathWorks will do it for us?

January 2004

Peter Tenenbaum
LC availability Simulation done for the LC comparison task force

Warm DR+Linac,
downtime by system

See Tom’s talk for
the subtleties and
caveats.

Tom Himel
Damping Rings
Kickers
Permanent Magnets
**ALCPG04 accelerator WG sessions**

**Accelerator/Damping Ring Working Group**

**AGENDA**

<table>
<thead>
<tr>
<th>Time</th>
<th>Topic</th>
<th>Chair</th>
<th>Room</th>
</tr>
</thead>
<tbody>
<tr>
<td>16:00 - 16:40</td>
<td>A Damping Ring Primer (625 kB pdf; 974 kB ppt [here])</td>
<td>Joe Rogers, Cornell University</td>
<td>TBA (Bldg 48)</td>
</tr>
<tr>
<td>16:40 - 17:00</td>
<td>Fourier Series Kicker for TESLA (465 kB pdf; 548 kB ppt [here])</td>
<td>George Gollin, University of Illinois</td>
<td></td>
</tr>
<tr>
<td>17:00 - 17:20</td>
<td>Novel Schemes for Damping Rings (298 kB pdf; 507 kB ppt [here])</td>
<td>Joe Rogers, Cornell University</td>
<td></td>
</tr>
<tr>
<td>17:20 - 18:00</td>
<td>Open Discussion: Fermilab and Linear Collider Studies</td>
<td>Shekhar Mishra, Fermilab</td>
<td></td>
</tr>
</tbody>
</table>
Kickers, magnets, mechanical support systems (4)

• LCRD 2.22: Investigation of Novel Schemes for Injection/Extraction Kickers (George Gollin)

• LCRD 2.23: Ring-tuned, permanent magnet-based Halbach quadrupole (James Rosenzweig)

• UCLC 2.25: Investigation and prototyping of fast kicker options for the TESLA damping rings (Gerry Dugan)

• LCRD 2.26: Continuing Research and Development of Linac and Final Doublet Girder Movers (David Warner)
Injection/extraction from trailing edge of a train (J. Rogers)

Advantages:
• Bunches are always extracted and injected at the end of a bunch train, so the injection/extraction kickers need only have a fast rise time. The damping ring can be much smaller than the dogbone design.
• Positron bunch production rate is greatly reduced, allowing use of a conventional positron source.

Disadvantage:
An additional small ring is required.

UCLC 2.34 progress:
simulations, as well as CESR-c machine studies concerning damping ring issues. Some novel designs for damping rings being considered.
Injection/extraction from trailing edge of a train

Simplified timing example: 3 trains of 3 bunches

circumference of large ring
circumference of small ring
damping in large ring

eextraction from large ring
injection to small ring
transfer from small to large ring

eextraction to bunch compressor & linac

refill large ring

time

Joe Rogers
LCRD 2.22: Investigation of Novel Schemes for Injection/Extraction Kickers

(George Gollin)

LCRD 2.22: rejected by DOE in FY03.

We’re working on it anyway. We have a configuration with which unkickled bunches experience both zero $p_T$ and zero $dp_T/dt$. 
LCRD 2.23: Ring-tuned, permanent magnet-based Halbach quadrupole
(James Rosenzweig)

LCRD 2.23: funded FY03, $35k.

Good progress, both in modeling and in fabrication of prototypes for studies.

Figure 3. (a) Rendered picture of Halbach ring-tuned permanent magnet-based hybrid quadrupole, from 3D magnetostatic simulation code RADIA. (b) Arrow plot of magnetic field in symmetry plane of the quad.
Long Range Planning at Fermilab

• Fermilab is going through long range planning.

• There are two accelerator projects that are being considered:
  • Proton Drive (A high intensity Proton machine at 8 GeV)
  • Linear Collider

• Commitment and leadership at the highest levels of Fermilab management to establish Fermilab as the preferred host.

• Develop Fermilab capability to provide technical leadership on the LC construction project.

  - Engagement in the critical accelerator technology issues and demonstration project(s). Suggest identifying a limited number (two) of areas in which to concentrate accelerator physics effort with goal of establishing leadership, e.g.
    ➢ Damping ring
    ➢ Main linac

Shekhar Mishra
Thoughts on the Scope of ETF

• It must be done with International collaboration.

• It should have the capability to do perform beam studies.

• ETF could be 1% demonstration machine for the technology chosen by ITRP.

• It could have an Injector, Linac (5 GeV), Damping Ring, post damping ring Linac (~0.5 GeV)

• It could be a development facility for the Instrumentation, controls etc needed for the LC.

• It could be a development facility for one of a kind device.

• It could be used for industrialization/ later testing of the major component.
Systems & Instrumentation

- beam position/size monitors
- active collimators
- beam loss, rf, ground motion monitors
- control systems
# ALCPG04 accelerator WG sessions

## Accelerator: Systems + Instrumentation Working Group

### AGENDA

#### Thursday, January 8, 08:30-10:30

<table>
<thead>
<tr>
<th>Time</th>
<th>Topic</th>
<th>Chair</th>
<th>Room</th>
</tr>
</thead>
<tbody>
<tr>
<td>08:30 – 08:50</td>
<td>Introduction to instrumentation issues</td>
<td>P. Burrows</td>
<td>XXX</td>
</tr>
<tr>
<td>08:50 - 09:20</td>
<td>Beam halo monitor</td>
<td>Marc Ross, SLAC</td>
<td></td>
</tr>
<tr>
<td>09:20 - 09:40</td>
<td>Beam loss monitor, beam dynamics, group motion studies</td>
<td>Lucien Cremaldi, U. Miss.</td>
<td></td>
</tr>
<tr>
<td>09:40 – 10.00</td>
<td>ODR beam size monitor</td>
<td>Mayda Velasco, Northwestern U.</td>
<td></td>
</tr>
<tr>
<td>10:00 – 10.20</td>
<td>PETRA laserwire project</td>
<td>Yasuo Fukui, UCLA</td>
<td></td>
</tr>
</tbody>
</table>

#### Friday, January 9, 10:50-12:50

<table>
<thead>
<tr>
<th>Time</th>
<th>Topic</th>
<th>Chair</th>
<th>Room</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:50 – 11.10</td>
<td>NanoBPM movers</td>
<td>G. Blair</td>
<td>XXX</td>
</tr>
<tr>
<td>11.10 – 11.30</td>
<td>NanoBPM analysis</td>
<td>Jeff Gronberg, LLNL</td>
<td></td>
</tr>
<tr>
<td>11.30 – 11.50</td>
<td>Bunch length interferometry</td>
<td>Yury Kolomensky, UC Berkeley</td>
<td></td>
</tr>
<tr>
<td>11.50 – 12.10</td>
<td>Design and Fabrication of a Rad Hard 500MHz digitizer using deep submicron technology</td>
<td>Uwe Happek, University of Georgia</td>
<td></td>
</tr>
<tr>
<td>12.10 – 12.50</td>
<td>Discussion</td>
<td>KK Gan, Ohio State</td>
<td></td>
</tr>
</tbody>
</table>

G. Gollin, 1/10/04
Instrumentation and electronics (9 projects)

• LCRD 2.1: Beam Halo Monitor & Instrumented Collimators (Lucien Cremaldi)

• LCRD 2.2: Beam Test Proposal of an Optical Diffraction Radiation Beam Size Monitor at the SLAC FFTB (Yasuo Fuki)

• LCRD 2.3: Design and Fabrication of a Radiation-Hard 500-MHz Digitizer Using Deep Submicron Technology (K. K. Gan)

• LCRD 2.4: RF Beam Position Monitors for Measuring Beam Position and Tilt (Yury Kolomensky)

• UCLC 2.5: Non-intercepting electron beam size diagnosis using diffraction radiation from a slit (Bibo Feng)

• UCLC 2.6: Single-shot, electro-optic measurement of a picosecond electron bunch length (Bill Gabella)

• UCLC 2.7: Fast Synchrotron Radiation Imaging System for Beam Size Monitoring (Jim Alexander and Jesse Ernst)

• LCRD 2.9: Radiation damage studies of materials and electronic devices using hadrons (David Pellett)

• LCRD 2.42: Transverse Phase Space Measurements for a Magnetic Bunch Compressor by Using Phase Space tomography (Feng Zhou)
LCRD 2.1: Beam Halo Monitor & Instrumented Collimators (Lucien Cremaldi)

LCRD 2.1: funded FY03, $28k.

Progress in seeing signals from a diamond detector. (Diamond since radiation damage will be an issue.)

Other possibilities being considered: W-quartz fiber, for example.

Figure 1: Sketch of a proposed 2 stage collimator with upstream spoiler and final instrumented absorber.
LCRD 2.2: Beam Test Proposal of an Optical Diffraction Radiation Beam Size Monitor at the SLAC FFTB (Yasuo Fuki)

LCRD 2.2: funded FY03, $40k.

Simulation work so far.

ODR Yield in 0.1/γ angle range
σ: rms transverse beam size
LCRD 2.3: Design and Fabrication of a Radiation-Hard 500-MHz Digitizer Using Deep Submicron Technology  
(K. K. Gan)

LCRD 2.3: funded FY03, $40k.

Some of the circuit functional blocks have been designed, but none fabricated for test yet.

Figure 2. Schematic of a 3-bit cell.
LCRD 2.4: RF Beam Position Monitors for Measuring Beam Position and Tilt

(Yury Kolomensky)

LCRD 2.4: funded FY03, $30k.

Some data analysis of test beam data from KEK ATF using SLAC-built position monitor.
UCLC 2.7: Fast Synchrotron Radiation Imaging System for Beam Size Monitoring  
(Jim Alexander and Jesse Ernst)

UCLC 2.7: exploring possible parameters, configuration. discussions only so far.

Design for a Synchrotron Radiation Camera for Beamsize Measurement

Basic concept:
1. Refocus SR in the damping rings to make a projected image of the passing bunch.
2. Diffraction limit on source size forces us into the x-ray regime

Goals:
1. **definite**: Measure $\sigma_x$ and $\sigma_y$
2. **possible**: Single-bunch resolution
3. **optimistic**: Intrabunch measurement (i.e. z)
   - Don't yet know if this will be possible.
   - Still working on ideas for this.

Status:
Have started simple simulations for studying optics and detector choices:
1. Optics
   - point-to-point with sufficient magnification
   - Zone plates are one candidate
2. Detection
   - small pixel array is one candidate

**Relevant times**

<table>
<thead>
<tr>
<th></th>
<th>tesla</th>
<th>nlc</th>
</tr>
</thead>
<tbody>
<tr>
<td>cycle</td>
<td>57us</td>
<td>743ns</td>
</tr>
<tr>
<td>interbunch</td>
<td>20ns</td>
<td>1.4ns</td>
</tr>
<tr>
<td>bunchlength</td>
<td>20ps</td>
<td>13ps</td>
</tr>
</tbody>
</table>
LCRD 2.9: Radiation damage studies of materials and electronic devices using hadrons
(David Pellett)

LCRD 2.9: funded FY03, $20k.
Neutron irradiation of permanent magnet materials is underway.
Pellett gets reactor time, has student(s) helping with analysis.
LCRD 2.42: Transverse Phase Space Measurements for a Magnetic Bunch Compressor by Using Phase Space tomography (Feng Zhou)

LCRD 2.42: new proposal FY04

A schematic diagram of the ATF beam line with bunch compressor is shown in the following figure. The first triplet is used to match different twiss parameters in the compressor. The second triplet is used for matching the compressor with other beam line.
Ground motion (1 project)

• LCRD 2.11: Ground Motion studies versus depth (Mayda Velasco)

Has used ICAR funds to purchase equipment, some installed.

**Linear collider R&D:** Preparing ground motion study in NUMI noise versus depth

- Northwestern University joined the study, is providing equipment and will participate in the study
- Measurements needed to determine the best depth to locate the next linear collider
- Test at Aurora Mine already done
- Next... Numi Tunnel
  ➔ This was classified as a high priority project (1.5)
  **Szleper, Velasco, Serye**
Mayda Velsaco: beam loss monitors for LC

Secondary emission detectors, tested at CLIC test facility at CERN. Fast, rad hard, large dynamic range.
Marc Ross: introduction to (and comments concerning) instrumentation issues

• HEP must aggressively attack Controls/Instrumentation issues

• Real impact (of instrumentation) is the leverage on other aspects of the design – esp. high cost systems
Grahame Blair: Laser beam wire system at PETRA

- Vertical beam size
  \[ \sigma_e = \sqrt{\sigma_m - \sigma_L} \]
  
  Laser \( \sigma_L = (40 \pm 10) \mu m \)
  
  \( \sigma_e = (170 \pm 23 \pm 37) \mu m \)
Jeff Gronberg: Nanometer BPM movers
Uwe Happek: Bunch length interferometry

Intensity $I \propto \frac{N^2}{\sigma}$

- Coherent radiation: $I \propto N^2/\sigma$
- Incoherent radiation: $I \propto N$

$\lambda \sim \sigma \quad \lambda <\ll \sigma$

$\lambda_c \sim \sigma$
Uwe Happek: Bunch length interferometry

PATH DIFFERENCE: $2y \alpha$
RF Technology and Structures

- acoustic sensors
- klystron studies
- rf cavity studies
- 2 TeV NLC
RF Technology & Structures Working Group

Preliminary AGENDA

Thursday, January 8, 1:45-3:45

1:45 - 2:15  Comparison of warm and superconducting rf technology  
            Chair: Valery Dolgashev  
            Room: TBD  
            Chris Adolphsen, SLAC

2:20 - 2:35  Technology of 2 TeV warm collider  
             Perry Wilson, SLAC

2:40 – 2:55  Acoustic monitoring of rf cavities  
             Lucien Cremaldi, University of Mississippi

3:00 - 3:15  Modeling acoustic signatures of rf cavity breakdown  
             George Gollin, University of Illinois at Urbana-Champaign
RF Technology (5)

- LCRD 2.15 Investigation of acoustic localization of rf cavity breakdown (George Gollin)
- LCRD 2.17: RF Cavity Diagnostics, Design, and Acoustic Emission Tests (Lucien Cremaldi)
- LCRD 2.18: Control of Beam Loss in High-Repetition Rate High-Power PPM Klystrons (Mark Hess)
- UCLC 2.20 Research in Superconducting Radiofrequency Systems (Hasan Padamsee)
- UCLC 2.21: RF Breakdown Experiments at 34 GHz (J. Hirschfeld).
LCRD 2.15: Investigation of acoustic localization of rf cavity breakdown

(George Gollin)

LCRD 2.15: funded FY03, $9k.

Pinging copper dowels with ultrasound transducers and building models of acoustic wave propagation. Currently working at reconciling details of models and data.
LCRD 2.17: RF Cavity Diagnostics, Design, and Acoustic Emission Tests

(Lucien Cremaldi)

LCRD 2.17: funded FY03, $23k.

Bench tests, working at understanding results.
LCRD 2.18: Control of Beam Loss in High-Repetition Rate High-Power PPM Klystrons
(Mark Hess)

LCRD 2.18: funded FY03, $40k.

My impression is that they have made very nice progress in their modeling efforts.

Fig. 2 Plot of (a) normalized current threshold vs. $\alpha$ for the point-charge and finite size bunches, and (b) a close-up of (a) together with the operating points of the five PPM klystrons listed in Table 1.
UCLC 2.20 Research in Superconducting Radiofrequency Systems (Hasan Padamsee)

UCLC 2.20 FY03 progress:

1) Completed one single cell niobium cavity of the improved (re-entrant) shape with Hpk/Eacc 10% less than the TESLA design. The half-cells were purified at the half-cell stage by an improved heat treatment cycle that reduces the depth of titanium diffusion. This cavity is now at KEK for electropolishing.

2) We are pursuing a less expensive method of electropolishing and have successfully electropolished a single cell 1.3 GHz cavity. We are preparing to test this.
UCLC 2.21: RF Breakdown Experiments at 34 GHz  
(J. Hirschfeld)

UCLC 2.21 progress:

High-power millimeter-wave components have been received for connecting the surface fatigue test cell to one output arm of the 34-GHz magnicon. Magnicon output power is already sufficient for initial fatigue tests, with anticipated surface temperature excursions of >500 deg C possible in localized areas within the test cell. These tests are to precede mm-wave breakdown tests, to demonstrate the magnicon's utility in powering resonant loads. Design for the support and alignment structure needed for installing the components is underway.
Chris Adolphsen: Comparison of warm and superconducting rf technology

...many concerns are common to both warm and cold, e.g. klystron lifetime... cryo couplers are complicated: warm on the outside, cold on the inside.
Perry Wilson: Technology of 2 TeV warm collider

Copper structures; study a possible machine with 22 km length, 1.6 TeV, L=2.4 x 10^{34}

NLCTA unloaded gradient ~ 60 MV/m in traveling wave structure. Since want ~100 MV/m, perhaps could use a standing wave structure instead. RF guns have been made with ~80 MV/m standing wave structures so this is encouraging.

Klystrons… will want to double the pulse width relative to NLC, and up the efficiency form 50% to 60%.

“only reasonable extrapolations of current NLC technology are needed to go to 2 TeV.”
Beam Delivery and Interaction Regions

- overall warm/cold differences and BDS risks
- jitter and stability comparisons: warm/cold
- nanosecond time scale feedback
- international cooperation on BDS
# ALCPG04 accelerator WG sessions

## Session 6: Beam Delivery & the Interaction Region
### Thursday, January 8, 16:05-18:05

<table>
<thead>
<tr>
<th>Time</th>
<th>Topic</th>
<th>Speaker</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 min</td>
<td>Fundamental Warm/Cold differences vs. Design Choice:</td>
<td>Tor Raubenheimer, SLAC</td>
</tr>
<tr>
<td></td>
<td>a. dE/E</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. E vs. z correlation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c. Bunch Length</td>
<td></td>
</tr>
<tr>
<td></td>
<td>d. L*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>e. Positron production</td>
<td></td>
</tr>
<tr>
<td></td>
<td>f. Flexibility of parameters for special running</td>
<td></td>
</tr>
<tr>
<td></td>
<td>g. Off-energy running: updated parameter lists(?)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>h. IP1 vs. IP2 Performance</td>
<td></td>
</tr>
<tr>
<td>20 min</td>
<td>Review of Jitter stability requirements and stabilization schemes for warm/cold LC designs:</td>
<td>Andrei Seryi, SLAC</td>
</tr>
<tr>
<td></td>
<td>a. Mechanical</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. Intertrain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c. Intrain</td>
<td></td>
</tr>
<tr>
<td>20 min</td>
<td>FONT-Run 2 results</td>
<td>Phil Burrows, QMUL</td>
</tr>
<tr>
<td>20 min</td>
<td>Beam Delivery Risk Assessment for warm / cold LC</td>
<td>Tor Raubenheimer, SLAC</td>
</tr>
<tr>
<td>15 min</td>
<td>International cooperation on Beam Delivery, Instrumentation &amp; Backgrounds</td>
<td>David Miller, UCL</td>
</tr>
<tr>
<td></td>
<td>a. Mumbai meeting</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. Montpelier Meeting</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c. Plans for Paris meeting</td>
<td></td>
</tr>
<tr>
<td>25 min</td>
<td>Discussion</td>
<td>ALL</td>
</tr>
</tbody>
</table>
Tor Raubenheimer: Warm/Cold beam delivery system differences

• Beam Delivery System is very similar for warm and cold LC’s
• Few intrinsic differences:
  – Larger correlated energy spread in the warm $\Rightarrow$ for cases that matter, $\Delta E/E$ can be traded against luminosity
  – Larger longitudinal phase space in cold DR makes further bunch compression difficult (not impossible!)
• Further bunch compression could be used to reduce disruption or increase the luminosity
Andrei Seryi: Review of Jitter stability requirements and stabilization schemes for warm/cold LC designs

- Warm LC jitter requirements are more tight
  - But based on prototype measurements
  - Stability is provided by several systems
  - Each of systems allowed to work not perfectly
  - Accessible quads make ad-hoc fixes easy

- Cold LC jitter requirements are less tight
  - Stability of quads in cryomodules was not demonstrated
  - Collision stability provided solely by intratrain feedback
  - This single system is not allowed to fail
  - Quads hidden in cryostats make ad-hoc fixes difficult
Phil Burrows, Feedback on nanosecond timescales (FONT)

![Graphs showing FONT Performance with different kicker gains and delay loop statuses](image)

- **Kicker Gain 0**
- **Kicker Gain 0.8, Delay Loop Off**
- **FONT Preliminary**
- **Kicker Gain 0.8, Delay Loop On**
Tor Raubenheimer: Beam Delivery Risk Assessment for warm / cold LC

• A number of risk issues identified in BDS
  – Collective effects
  – Magnet jitter in BDS
  – Heating of SC IR magnets
  – Collimator performance and MPS limitations
  – Aberration tuning procedures
  – Crab cavity

• The upper 3.5 items are also issues that can only really be determined late in the project cycle

• Risks in the BDS are high because, although unlikely, there is significant luminosity impact and little time for remediation

• Given present knowledge, the risks in warm and cold BDS are very similar
David Miller: International cooperation on Beam Delivery, Instrumentation & Backgrounds

• Crossing angle or not?
• Lots to do, and much of it needs to be done internationally.
Sources

• undulator $e^+$ production
• polarized $e^-$ sources
• lasers
## Sources Working Group

### AGENDA

**Friday, January 9, 1:45 PM-3:45 PM**

1:45 PM - 2:15 PM  
Polarized Electron Sources for Future Colliders: Present Status and Prospects for Improvement  
J. E. Clendenin, SLAC

2:15 PM - 2:45 PM  
Laser Development for NLC Related Photocathode Research  
A. Brachmann, SLAC

2:45 PM - 3:15 PM  
Positron Capture in Linear Colliders  
Y. K. Batygin, SLAC

3:15 PM - 3:45 PM  
E166 Update  
J. C. Sheppard, SLAC

Chair: V. Bharadwaj  
Room: ROB Redwood Room B
Electron and positron sources (2)

- LCRD 2.37: Undulator Based Production of Polarized Positrons (William Bugg)
- LCRD 2.40: Development of Polarized Photocathodes for the Linear Collider. (Richard Prepost)
**Accelerator Physics LCRD 2.37 (funded FY03, $25k)**

**Undulator Based Production of Polarized Positrons for Linear Colliders**
*(SLAC Experiment E-166: presented by JC Sheppard)*

S. Berridge, W. Bugg, Y. Efremenko, T. Handler, Y. Kamychkov, S. Spanier, *University of Tennessee*
C. Lu, K.T. McDonald, *Princeton University*

- E-166 uses the 50 GeV FFTB beam in conjunction with a 1 m-long, helical undulator ($\lambda = 2.4$ mm, ID = 0.9 mm) to make 10-MeV polarized photons.

- These photons are converted in a ~ 0.5 rad. len. Thick target into e+ (and e-) with ~ 50% polarization.

- The polarization of the positrons and photons will be measured.


**Hardware:**
- Silicon calorimeters (U.Tennessee), Aerogel Cerenkov, Positron transport magnets (Princeton).

---

**Figure 24:** The silicon tungsten calorimeter consists of 20 longitudinal samples of 1 $X_0$ each, grouped into 4 segments of 5 $X_0$ each. The transverse sampling is via a 4 x 4 array of pads, each 1.6 x 1.6 cm$^2$ each.

**Figure 25:** The photon flux counter, consisting of a 2-cm-thick block of aerogel of index $n = 1.007$, viewed by a photomultiplier tube at the end of an air light pipe.
J. E. Clendenin, Polarized Electron Sources for Future Colliders: Present Status and Prospects for Improvement

Polarization Achieved, strained GaAs

<table>
<thead>
<tr>
<th>Cathode Structure</th>
<th>Growth Method</th>
<th>$P_{\text{e} \text{max}}$</th>
<th>$\lambda_0$ (nm)</th>
<th>$QE_{\text{max}}(\lambda_0)$</th>
<th>Polarimeter</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a GaAsP/GaAs strained SL</td>
<td>MOCVD</td>
<td>0.92</td>
<td>775 warm</td>
<td>0.005</td>
<td>Mott Nagoya</td>
<td>a</td>
</tr>
<tr>
<td>1b GaAsP/GaAs strained SL</td>
<td>MBE</td>
<td>0.86</td>
<td>783 warm</td>
<td>0.006</td>
<td>CTS Mott SLAC</td>
<td>b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.90</td>
<td>780 cold</td>
<td>0.008</td>
<td>Møller E158-III SLAC</td>
<td>c</td>
</tr>
<tr>
<td>2 GaAsP/GaAs strained-layer</td>
<td>MOCVD</td>
<td>0.82</td>
<td>805 warm</td>
<td>0.001</td>
<td>CTS Mott SLAC</td>
<td>d</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.85</td>
<td>800 cold</td>
<td>0.004</td>
<td>Møller E158-I SLAC</td>
<td>e</td>
</tr>
</tbody>
</table>

SLC $P_{\text{e} \text{max}} \sim 78\%$ (at source), $\sim 76\%$ at Compton polarimeter
LCRD 2.40: Development of Polarized Photocathodes for the Linear Collider
(Richard Prepost)

LCRD 2.40: new proposal FY04, but work underway with SBIR funding.
“Bandgap engineering of strained GaAs.”
A. Brachmann, Laser Development for NLC Related Photocathode Research

General description of NLC and TESLA requirements for lasers
discussion of Q-switched laser operation.
SUMMARY

1. Start-to-end simulations of positron capture were done from positron target until injection into positron pre-damping ring.
2. Two schemes for positron production were considered:
   - conventional scheme, utilizing 6.2 GeV electron beam interacting with a high-Z positron production target,
   - polarized positron production scheme based on polarized photons generated in helical undulator by 150 GeV electron beam and interacting with positron production target.
3. Positron yield (ratio of positrons captured into pre-damping ring to primary electrons, $Y_{e^+}/Y_{e^+ \text{target}}$) in conventional scheme can reach the value of 1.5.
4. Injection of polarized positrons requires optimization of the collection system to insure high positron capture into pre-damping ring ($Y_{e^+}/Y_{e^+ \text{target}} = 0.25$) while keeping the high value ($P = 0.6$) of positron beam polarization.
End Matter
Conclusions

• Status of both warm and cold rf cavity development is very encouraging: cavities with adequate gradients can be fabricated

• A very large amount of detailed work (e.g. beam dynamics, emittance preservation, industrialization, design of control/instrumentation system) is still ahead

• The university groups need clear indications that DOE, NSF will support their LC efforts.

• There’s a LOT to do.

• Integration of new participants (e.g. university groups) into LC is underway, but still in its early stages. This will be smoother after the technology choice is made.