Test Beam Session

Two parts:

A) An overview of available test beam facilities – to map the available TB capacities for the LC detector R&DS

<table>
<thead>
<tr>
<th>TB Facilities in Asia</th>
<th>Yasuhiro Sugimoto</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fermilab Meson Test Beam Facility</td>
<td>Erik Ramberg</td>
</tr>
<tr>
<td>SLAC and other North American TB Facilities</td>
<td>Carsten Hast</td>
</tr>
<tr>
<td>TB Facilities at DESY, Serpukhov and Frascati</td>
<td>Volker Korbel</td>
</tr>
<tr>
<td>CERN TB Facilities</td>
<td>Michael Hauschild</td>
</tr>
</tbody>
</table>
## B) Detector R&D requirements: needs and plans of different working groups

<table>
<thead>
<tr>
<th>Interaction Point &amp; Beam Instrumentation R&amp;D</th>
<th>Mike Woods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertex R&amp;D: CMOS Beam Tests</td>
<td>Damien Grandjean</td>
</tr>
<tr>
<td>Tracking R&amp;D</td>
<td>Bruce Shumm</td>
</tr>
<tr>
<td>Calorimeter R&amp;D</td>
<td>Felix Sefkow</td>
</tr>
<tr>
<td>Muon R&amp;D</td>
<td>Marcello Piccolo</td>
</tr>
<tr>
<td>Discussion</td>
<td>mediated by Erik Ramberg</td>
</tr>
</tbody>
</table>
Mike Woods informed that group of physicists submitted the proposal to DOE:

Y. Kolomensky  
*University of California, Berkeley*

D. J. Miller  
*University College London*

M. Hildreth  
*University of Notre Dame*

*SLAC*

W. Oliver  
*Tufts University*

G. Bonvicini, D. Cinabro  
*Wayne State University*

LC-LEP Measurement Goals

Luminosity, Luminosity Spectrum

- Total cross sections: absolute $\delta L/L$ to $\sim 0.1\%$
- Z-pole calibration scan for Giga-Z: relative $\delta L/L$ to $\sim 0.02\%$
- threshold scans (ex. top mass): relative $\delta L/L$ to $1\%$
- $+L(E)$ spectrum: core width to $<0.1\%$ and tail population to $<1\%$

Energy

- Top mass: 200 ppm (35 MeV)
- Higgs mass: 200 ppm (25 MeV for 120 GeV Higgs)
- W mass: 50 ppm (4 MeV)
- ‘Giga’-Z $A_{LR}$: 200 ppm (20 MeV) (comparable to $\sim 0.25\%$ polarimetry)
  50 ppm (5 MeV) (for sub-0.1% polarimetry with e+ pol)

Polarization

- Standard Model asymmetries: $< 0.5\%$
- ‘Giga’-Z $A_{LR}$: $< 0.25\%$
# Beam Parameters at SLAC ESA, NLC-500, and TESLA-500

<table>
<thead>
<tr>
<th>Parameter</th>
<th>SLAC ESA</th>
<th>NLC-500</th>
<th>TESLA-500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charge/Train</td>
<td>$5 \times 10^{11}$</td>
<td>$14.4 \times 10^{11}$</td>
<td></td>
</tr>
<tr>
<td>Repetition Rate</td>
<td>10-30 Hz</td>
<td>120 Hz</td>
<td>5 Hz</td>
</tr>
<tr>
<td>Energy</td>
<td>25-50 GeV</td>
<td>250 GeV</td>
<td>250 GeV</td>
</tr>
<tr>
<td>e⁻ Polarization</td>
<td>85%</td>
<td>80%</td>
<td>80%</td>
</tr>
<tr>
<td>Train Length</td>
<td>270ns / 340ns</td>
<td>267ns</td>
<td>1 ms</td>
</tr>
<tr>
<td>Microbunch spacing</td>
<td>0.3ns / 340ns</td>
<td>1.4ns</td>
<td>337 ns</td>
</tr>
<tr>
<td>Bunches per train</td>
<td>2</td>
<td></td>
<td>2820</td>
</tr>
<tr>
<td>Bunch Charge</td>
<td>$2.0 \times 10^{10}$</td>
<td>$2.0 \times 10^{10}$</td>
<td></td>
</tr>
<tr>
<td>Energy Spread</td>
<td>0.15%</td>
<td>0.3%</td>
<td>0.1%</td>
</tr>
</tbody>
</table>

⇒ ESA in number of parameters suits the RD requirements
Other SLAC TB Facilities

Carsten Hast provided an additional information about SLAC TB possibilities:

**Final Focus Test Beam**

**Primary Beams**

- 28.5 GeV electrons
- 1-2 x 10^{10} per pulse.
- typically 3ps pulse,
- small emittance, \( \sigma_x = 4 \mu m, \sigma_y = 2.5 \mu m \), or SPPS short pulse with larger energy spread, have achieved \( \sigma_x = 20 \mu m, \sigma_y = 20 \mu m \) and \( \sigma_z = 90 \mu m \) for T465 test beam,
- 1-30 Hz.
- Loss limited to 1 kW by shielding

**Secondary Beams**

- These low intensity beams have been useful for many EMC tests and other tests.
- 1 to 30 GeV,
- usually one electron/pulse,
- several mm spot,
- 10-30 Hz
SLAC Test Beams in the Future

- Running of ESA or FFTB are mutually exclusive
- FFTB will go away in 2006 to make place for LCLS
- Until then there are many opportunities to schedule beam tests in FFTB
- ESA is in principle available for high power or single particle tests starting this summer

For all tests which take a significant amount of beam (= electrical power and time) there is some formality to be dealt with: at least a Test Beam Request for something short (a week or so) or an EPAC presentation
Vertex Detectors

Damien Grandjean informed about experience with Mimosa irradiations at CERN

- **Why do we do the beam tests ?**
  - The best way to have M.I.P
    - pions or muons ~ 120 GeV/c (at CERN SPS)
  - We can investigate:
    - Charge collection
    - Detection efficiency
    - Single point resolution
  - We can do this for:
    - Different temperatures (cooling system)
    - Different beam incidence angles

- **Telescope :**
  - 8 reference detectors (silicon strip)
    - 4 in x direction
    - 4 in y direction
  - 2 coincidence scintillators (trigger)
Mimosa plans:

- **2004 (SPS CERN):**
  - Mimosa 5b (big chip 1M pixels $2 \times 2 \text{ cm}^2$)
  - Mimosa 9 (small chip with opto technology + 20 $\mu$m epitaxy)
  - Mimosa 7 (small CP chip photofET)
  - MimoStar 1 (small chip proto for STAR upgrade)
    - About **50 days from May 10$^{th}$ to November 2$^{nd}$, 2004**
    - Most of the time in parasitic mode (LHCB velo, RD 42)

- **2005 (DESY ?):**
  - CP chip (Mimosa 8)
  - Mimosa 10
  - MimoStar 2

- **2006 (DESY ?):**
  - 3 different chips

Mimosa experience can be valuable also for other R&D groups
Bruce Schumm collected information about plans from different R&D groups:

Primary activities:

- Si sensor development (Korea)
- Gaseous tracking (TPC) R&D, including readout, electronics, gas mixture, etc. (multi-regional)
- Long shaping-time silicon readout (US, Europe)

Asian/ European gaseous tracking R&D: roughly five groups seeking testbeam within next year:

- In few GeV range; mostly \( \pi/\mu \), some electrons
- Envision using CERN, DESY, KEK facilities

European (SiLC) testbeam needs not yet thought through.
Guesstimate Use Schedule (North-American Groups) by B.S.:

All groups request ~2 week runs (1 wk setup, 1 wk actual running with various conditions)

Requests vary from once/year to 2-3 times/year, with intervals to be used for studying acquired data

Anticipation of need for first beams now a bit vague, but probably some in 2005 and most in 2006.

For 3-year period 2004-6; corrected for under-reporting

<table>
<thead>
<tr>
<th>YEAR</th>
<th>ANTICIPATED WEEKS OF RUNNING</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>0</td>
</tr>
<tr>
<td>2005</td>
<td>16 weeks</td>
</tr>
<tr>
<td>2006</td>
<td>24 weeks</td>
</tr>
</tbody>
</table>
Felix Sefkow illustrated needs of beams of different particles in wide interval of energies of $\approx 1$-100 GeV.

10 000 particles, compare Geant 3 (histo) vs. Geant 4 (points).

Differences vary with energy, particle type, detector material,…

(study by D. Ward)
Calorimetry

More requitements on beams, infrastructure, test beam time, etc.:

• energy spread <2%
• rate ~1kHz (<100 Hz for RPCs)
• Electrons and photons, pions and protons, muons
• tracking (need ~1mm: wire chambers or Si telescope)
• particle ID (Cerenkov)
• infrastructure (crane, cooling, gas, computing & network)
• space (6m wide)
• magnet? (4T @ DESY, cosmics only, for small ECAL or RPCs)

• several phases of running time
• $O(10^2)$ configurations * $O(10^4)$ events * $O(10^2)$ bins = $10^8$ events = 1-10 days running time = several weeks of real time each
Calorimetry

Plans in Asia, US and Europe:

- Asian groups were planning to finalize ECAL tests in spring 2004
- report at this conference
- further plans being discussed

- US groups plan to start with ECAL options at SLAC in 2005,
  all HCAL options till 2008

- Forward calorimeter groups plan
  - high intensity e beam at Frascati 2005-06
  - high energy e beam > 2008 (CERN?)

- CALICE prepares beam test series in 2005-06
- ECAL and HCAL together, different options
  - SiW ECAL
  - HCAL with scintillators, RPCs or GEMs
Test beams for muons - concerted effort with calorimeters:
  - Muon detector should be considered in some extent as a part of the calorimetric system.

Objectives: Muons - Check timing, pedestals, pulse height, etc. for minimum ionizing particles. Measure efficiencies, (u,v) tracking, multiple hit capability, etc.

Hadrons: Measure calorimetry capabilities with other calorimeters upstream (utility as a shower tail-catcher).

Beam Conditions: E = few - 100 GeV; e, π, p, μ. Beam rate < 10^6 Hz.

DAQ: FE will be custom development with FPGA logic and digitization, using CAMAC and LINUX software debugged in cosmic ray running.

Dates: Earliest is probably late 2005.

Where: Fermilab - Mtest.
**Test Beam Facilities in Asia**

Yasuhiro Sugimoto informed about test beam facilities in Asia. His Summary:

<table>
<thead>
<tr>
<th>Facility</th>
<th>Energy Range</th>
<th>Particles</th>
<th>Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>KEK PS</td>
<td>0.2 – 4 GeV</td>
<td>e, μ, π, K, p, p-bar</td>
<td>– Summer 2005</td>
</tr>
<tr>
<td>KEK Linac</td>
<td>0.1 – 4 GeV (8 GeV?)</td>
<td>e, μ(?), π, K, p, p-bar(?)</td>
<td>Fall 2006 –</td>
</tr>
<tr>
<td>IHEP-Beijing</td>
<td>0.2 – 1.2 GeV</td>
<td>e, π, p</td>
<td>Available now Users wellcome</td>
</tr>
<tr>
<td>J-PARC</td>
<td>0.2 – 2 GeV (10 GeV?)</td>
<td>e, μ, π, K, p, p-bar</td>
<td>2008 – Pressure wellcome</td>
</tr>
<tr>
<td>Tohoku STB</td>
<td>0.06 – 1.2 GeV</td>
<td>e, tagged-γ</td>
<td>Available now Users wellcome</td>
</tr>
</tbody>
</table>
Erik Ramberg reported about the status of the Fermilab Testbeam. His Summary:

- Several experiments have taken data or are currently doing so. Other experiments will be installing in the summer.
- 120 GeV, 66 GeV and 33 GeV beams have been delivered. Both fast extraction and slow spill have been tested.
- A low-rate, broad-band muon beam has been established.
- Tracking and DAQ near completion

Summary of Operational Characteristics:

- Either fast spill (0.4-1.6 msec) or slow spill (.02-.6 sec)
- Typical operation of 1 spill/minute. Can request higher rates.
- ~50 K protons/spill at 120 GeV
- ~3 K secondary beam/spill at 66 GeV
- Lower momenta will give lower rates
- Muon filters decrease beam by ~10-3
- Beam spot sizes of ~3 mm square at 120 GeV

Relevant beam line facilities are available: Cerenkov counters, x&y silicon strip detectors, MWPC and corresponding DAQ, cranes, etc.
### Test Beams at CERN

**Michael Hauschild’s report:**

<table>
<thead>
<tr>
<th>Location</th>
<th>Test Beam Lines</th>
<th>Energy Range (GeV/c)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PS East Hall (Meyrin site, Switzerland)</strong></td>
<td>4 test beam lines (T7, T9, T10, T11)</td>
<td>1 – 10, 15, 7, 3.5</td>
</tr>
<tr>
<td><strong>SPS West Area (Meyrin site, Switzerland)</strong></td>
<td>2 test beam lines (X5, X7)</td>
<td>5 – 250</td>
</tr>
<tr>
<td><strong>SPS North Area (Prevespin site, France)</strong></td>
<td>4 test beam lines (H2, H4, H6, H8)</td>
<td>10(2) – 400(450)</td>
</tr>
</tbody>
</table>

**Irradiation facilities**

- **Gamma Irradiation Facility (GIF), SPS West Area**
  - Cs137 source, 662 keV photons, 720 GBq + parasitic muons from X5 test beam
- **Proton/Neutron irradiation facilities, PS East Hall**
  - 24 GeV/c primary protons from PS, 2 * 2 cm² beam spot, 2.5 * 10¹¹ protons/spill
  - Neutrons from proton beam dump, spectrum similar to LHC environment
Test Beams at CERN

**PS East Hall beam characteristics:**

**Momentum range:**
- min. 1 GeV/c (all beams)
- max. 3.5 GeV/c (T11), 7 GeV/c (T10), 10 GeV/c (T7), 15 GeV/c (T9)

**Spill structure from PS:**
- 400 ms spill length, typical 2 spills every 16.8 s, more on request

**Particle type and intensity:** electrons (lower momenta), hadrons, muons
- Max. 1-2 * 10^6 particles/spill, typically 10^3 – 10^4 used

**SPS North Area:**

- **H2, H4 and H8 beams**
  - 10 - 400 GeV/c, up to 10^8 particles/spill (π+)
  - **H4** can be set-up for very clean electron beam (up to ~300 GeV/c)
  - **H2 and H8** also have low energy tertiary beams (2 – 10 GeV/c)

- **H6 beam:** 10 – 205 GeV/c, up to 10^8 particles/spill (π+)
## Time Schedule

Beam requests should be submitted until **October of the foregoing year**

**2004**  
PS East Hall and SPS West + North Area running from May – October  
end of 2004: SPS West Area is closing and will be dismantled

**2005**  
NO BEAM at PS and SPS

**2006**  
PS East Hall + SPS North Area running (?) (under revision...)

**2007**  
LHC start, PS East Hall + SPS North Area running
Report on Worldwide Linear Collider Test Beam Effort
Worldwide LC Test Beam Working Group

Abstract
This report summarizes the needs for the test beam facilities to satisfy current beam instrumentation and detector R&D developments efforts in the world-wide LC community. This document is to provide the summary to directors of test beam facilities to anticipate and prepare for upcoming test beam activities supporting the needs. This document should layout how we, as a combined community of Linear Collider detector R&D groups, organize ourselves for a concerted effort of all different test beam activities in

Test Beam discussion list:
lc-testbeam@fnal.gov

Please subscribe to the list by sending an e-mail to listserv@fnal.gov a subjectless message with the following in the body

subscribe lc-testbeam you@e-mail.add firstname lastname
Conclusions

- The worldwide detector R&Ds are ramping up their efforts
- The significant rise of Test beam activities is expected in 2006 and after

- To facilitate these efforts the world wide test beam discussion list was established
- The document mapping TB needs and possibilities is under preparation
CALICE near and medium term plans:

- start with ECAL end 2004 at DESY
- then integrate (scintillator) HCAL with ECAL
- goal: move both to hadron beam in 2005
  - and high energy e beam, …
- vary readout options: 2006 +
- possible scenario:

<table>
<thead>
<tr>
<th>Year</th>
<th>Calorimeter</th>
<th>Beam time request</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>ECAL (CALICE)</td>
<td>3 weeks (electrons)</td>
</tr>
<tr>
<td></td>
<td>Analog HCAL</td>
<td>4 weeks (hadrons, muons)</td>
</tr>
<tr>
<td>2006</td>
<td>Digital HCAL (RPCs)</td>
<td>4 weeks (hadrons, muons)</td>
</tr>
<tr>
<td></td>
<td>ECAL + Analog HCAL + Tail catcher</td>
<td>5 weeks (hadrons)</td>
</tr>
<tr>
<td></td>
<td>ECAL + Digital HCAL + Tail catcher</td>
<td>5 weeks (hadrons)</td>
</tr>
<tr>
<td></td>
<td>ECAL (US)</td>
<td>3 weeks (electrons)</td>
</tr>
<tr>
<td>2007</td>
<td>ECAL + Analog HCAL + Tail catcher</td>
<td>5 weeks (hadrons)</td>
</tr>
<tr>
<td></td>
<td>ECAL + Digital HCAL + Tail catcher</td>
<td>5 weeks (hadrons)</td>
</tr>
<tr>
<td></td>
<td>Digital HCAL (different active media)</td>
<td>8 weeks (hadrons, muons)</td>
</tr>
<tr>
<td>2008</td>
<td>ECAL + Digital HCAL + Tail catcher</td>
<td>5 weeks (hadrons, muons)</td>
</tr>
</tbody>
</table>

Calorimetry