Accelerator Instrumentation, Controls and Diagnostics

Friday, May 31, 2002
Does Accelerator-Based Particle Physics Have a Future?

- We can't just leave the design of frontier accelerators to the specialists. Inventing clever new ideas requires the same talents that it takes to do experimental physics.

Maury Tigner
Physics Today – January 2001

Assuming this to be basically correct …

How can we make it work?
This talk:

- Only suggests the nature of collaborative efforts (phase change?)
  - Not a set of requisitions carved up in detail
- Does not detail ‘plug and play’ activities
- Is not a ‘status’ update
  - Does not detail who is up to what
- Illustrates technologies and hints at opportunities
- is NLC/TESLA/CLIC neutral
  » (other projects….?)

- SLC Experience:
- Substantial contributions from collaborators
  - especially software
Limiting LC technology:

- (not including physics of beams)
- gradient & RF power & associated diagnostics
- Low power μwave circuitry
- Lasers
- Positioning/alignment/vibration stabilization
- mm wave & FIR diagnostics
- Data flow – control system
- Radiation effects
- Vacuum
- Feedback
- Engineering – fabrication, packaging, testing
Block diagram of the ‘simple’ part of an LC

LINAC

control

data

LLRF

amp

distribution

timing, $\phi$

pickup

beam

signal

processor

acc
“Precision” microwave

- High power controls and monitoring + position monitors + beam phase monitors
  - Cavity tuning at TESLA; lorentz force compensation + coupling control
- programmed phase control
- external measurements of phase and amplitude
  - TESLA Test Facility uses a sequence of stabilization loops and associated processors
  - NLC/SLC uses thermal stabilized power and phase measurements
DLDS Waveforms with Beam Loading Compensation

Amplitude at each DLDS Output

Time (ns)
Linac LLRF Drive

DDS Update Memory
- High Speed DDS
- Lowpass 120 MHz

Timing System
- LO₁ 625 MHz
- LO₂ 10.7 GHz

MIXER
- IF₁ 89.25 MHz
- IF₂ 714 MHz

Bandpass 714 MHz
- Bandpass 11.4 GHz

DLDS

Klystron
- Modulated 11.424 GHz

DDS States 100 MHz
DDS Clock 300 MHz

State | Transition Time | Amplitude | Frequency | Phase | df/dt |
-----|-----------------|-----------|-----------|-------|-------|
1    | xxx             | xxx       | xxx       | xxx   | xxx   |
2    | xxx             | xxx       | xxx       | xxx   | xxx   |
3    | xxx             | xxx       | xxx       | xxx   | xxx   |

Linear Collider R&D Opportunities Workshop
SLAC-WP-23
## NLC Linac LLRF

### Measurement Requirements

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth</td>
<td>&gt; 100 MHz</td>
<td>at -3 dB</td>
</tr>
<tr>
<td>Rise time</td>
<td>&lt; 5ns</td>
<td>10% to 90%</td>
</tr>
<tr>
<td>Phase resolution</td>
<td>1 degree</td>
<td>At 11.424 GHz</td>
</tr>
<tr>
<td>Dynamic Range</td>
<td>&gt; 20 dB</td>
<td></td>
</tr>
<tr>
<td>Amplitude Resolution</td>
<td>10^{-3} of full scale</td>
<td></td>
</tr>
<tr>
<td>Beam phase wrt RF</td>
<td>1 degree</td>
<td>At 11.424 GHz</td>
</tr>
<tr>
<td>Beam signal / RF</td>
<td>-40 dB</td>
<td>(!)</td>
</tr>
<tr>
<td>Reflected power detector max input</td>
<td>&lt; 100 mW</td>
<td>Peak</td>
</tr>
<tr>
<td>Reflected power detector rise time</td>
<td>&lt; 10 ns</td>
<td></td>
</tr>
</tbody>
</table>
TTF LLRF Drive Controls

S. Simrock

Also have tuners, coupling etc.

May 31, 2002
Final Doublet support girder

- Internal to detector
- Compact Superconducting Quads are the superior technology because of their flexibility and are the most likely candidate for the final doublet
- R&D in SC Quads is still in the conceptual state
- SLAC team working with PM
LCD-L2 (3T) with 3.8m L* Optics