Acquisition of Diamond Ionization Signal Bunch-by-Bunch

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Bunch-by-Bunch Forward Calorimeter

• Supersymmetry search requires bunch-by-bunch veto of energetic forward e.
• Large pile-up background of low-energy e’s.
• Warm LC needs forward EM calorimeter which can cleanly separate 1.4 ns bunches in forward calorimeter
• Is sampling calorimeter with diamond readout fast enough?
• Check it out at KEK/ATF
• Single bunch / multibunch extracted beam
  – 20 bunch extraction at 2.8 ns bunch spacing
Large Diamond
Beamline
Single Bunch, Large Diamond

Large Diamond, Single Bunch

Amplitude (mV)

Time (ns)

0 5 10 15 20 25 30 35 40

0 10 20 30 40 50 60
Multibunch

- ~20 bunches hitting scanning wire
  - Head and tail hitting wire more than center of train
- 2.8 nS bunch spacing
- 25mm x 10 mm diamond
  - High capacitance, significant inductance in wiring
- Limited by capacitance, inductance, 500 MHz Amplifier.
Small Diamond

- Small Sample
- 10 x10mm diamond film
- Electrode 9mm x 9mm
- Low capacitance ~ 10pF
- Low inductance
- Courtesy Y. Sugimoto (KEK)
Single Bunch

- Bias 700 V
- Digitized on Tek 694 scope
- 10 G samples/sec
- 3 GHz bandwidth

- Two stages of pre-pulse
  - ionization in cable?
- Fast central pulse
- Slow tail (~12 ns)
  - Trap/release?
Fast Peak

- Full width half max ~ 500 ps
- Consistent with 10 pF x 50 Ω
- Ringing @ 2 GHz may be from contact wire loop inductance
Fast / Slow Component

- $\tau_{\text{fast}} = 0.5 \text{ ns}$
- $\tau_{\text{slow}} = 12.2 \text{ ns}$
Bunchtrain

- Simulated 40-bunch train
- Convolution of Single bunch response with 1.4 ns comb filter
Bunchtrain, AC Coupled

Simulated Bunchtrain AC Coupled

Amplitude

Time (ns)
Diamond Calorimetry Results

• Pulse has a fast component
• It may have a slow component
  – Or we may be seeing backscatter, etc.
• If there is a slow component,
  – Is it due to trapping?
• Then might use higher quality material (low trapping)
  – In thin layers (100 microns) for speed.
• Readout at lower impedance for speed.
• Even if slow tail is fundamental, an appropriate high-pass filter cleanly selects fast component.
Conclusion

- Diamond sampling calorimeter appears to meet needs
- Silicon may still be better
  - Ease of fab
  - May be sufficiently rad-hard
  - May be fast enough