Results from the First Test Beam of a Large Microstrip Czochralski Silicon Detector Equipped with LHC Speed Electronics

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The Cz Detector

First ever Czochralski silicon detector equipped with LHC speed electronics

- 380 µm thick
- p-on-n MCz
- 1150 Ωcm (after processing)
- 50 µm pitch parallel strips
- $V_{\text{dep}}$ measured =420 V (CV)
- 40 MHz analogue readout SCTA chips

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Helsinki Institute of Physics
Procedure

- Test beam of Cz detector (2002)
- Harsh irradiation using CERN PS Facility (24 GeV protons)
- Annealing simulations (Hamburg model)
- A 2\textsuperscript{nd} test beam to look at the irradiated Cz performance

**Aim** to study the CCE & S/N of the detector as a function of radiation and voltage
Test Beam Procedure

- Align the VELO telescope (8 VELO PR01 sensors)
- Use the aligned telescope to reconstruct the tracks left by 120 GeV $\mu$ &/or $\pi$'s
- Extrapolated the track to the Cz detector. Integrate the charge with +2 strips (strip pitch = 50 $\mu$m)

Cz alignment accuracy:

Un-irradiated Cz test beam,
$26.7 \pm 0.4 \ \mu$m

Irradiated Cz test beam,
$\sim 47 \ \mu$m
Annealing

Unirradiated Cz $V_{dep}$ measured to be 420 V

Annealing simulations for FZ silicon show expected $V_{dep}$ to be:

- $7 \times 10^{14}$ 24 GeV p/cm$^2$ = 1070 V
- $4.25 \times 10^{14}$ 24 GeV p/cm$^2$ = 650 V
- $1.25 \times 10^{14}$ 24 GeV p/cm$^2$ = 150 V
Charge Collection Efficiency

$V_{\text{dep}}$ measured as 420V

N.B. The ADC values cannot be directly compared for the 2 test beams

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Alison Bates
Un-irradiated Cz Signal

Black = 500V
Blue = 400V
Red = 350V

Example Landau*Gaussian fits
Black = 700 V
Red = 550 V
Blue = 500 V
Black (---) = 400 V
Red (---) = 350 V

Peak S/N = 23.5±2.5 (for 380 μm)
VELO TDR starting S/N for 220 μm is 14
……scaled Cz S/N = 13.6±1.5 (for 220 μm)
S/N irradiated Cz (under-depleted)

290V Irradiated Czochralski Detector

Black = $1.25 \times 10^{14}$ 24 GeV p/cm$^2$ S/N = 15
Blue = $4.25 \times 10^{14}$ 24 GeV p/cm$^2$ S/N = 11
Red = $7.0 \times 10^{14}$ 24 GeV p/cm$^2$ S/N = 7

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Conclusions

First successful study on Cz micro-strip detector with LHC speed electronics

Un-irradiated S/N = \(23.5 \pm 2.5\)

S/N still good after harsh irradiation:
- 0.5 years of VELO radiation environment S/N = 15
- 2 years of VELO radiation environment S/N = 11
- 3.5 years of VELO radiation environment S/N = 7

\(\text{(1 year max. VELO fluence} = 1.6 \times 10^{14} 24 \text{ GeV p/cm}^2 / \text{year})\)

While under-depleted!