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

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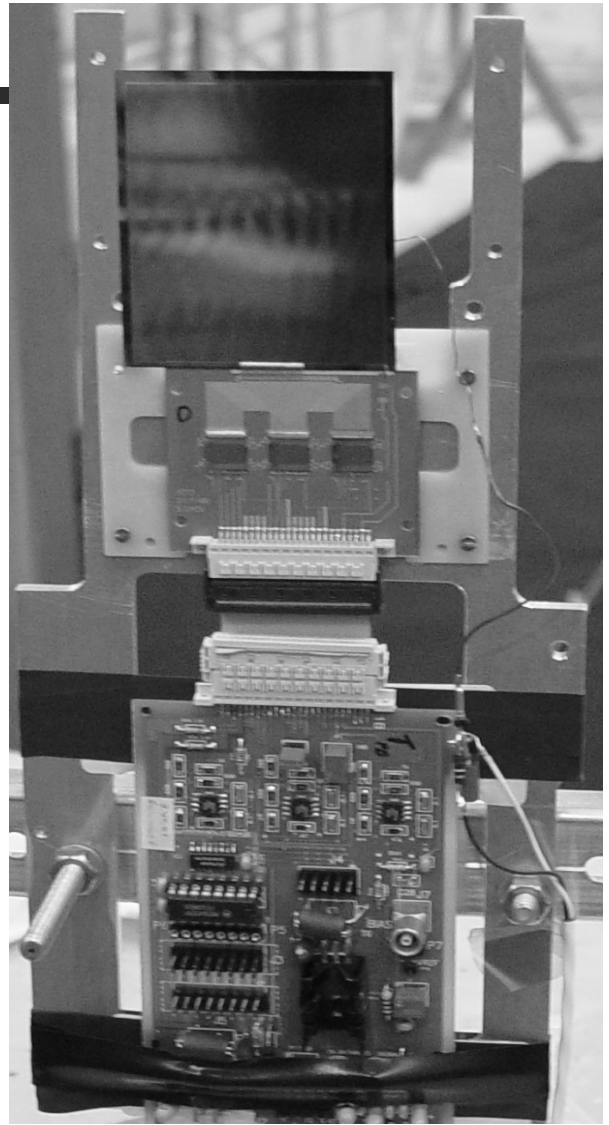
The Cz Detector

- 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_{dep} measured =420 V (CV)
  - 40 MHz analogue readout SCTA chips



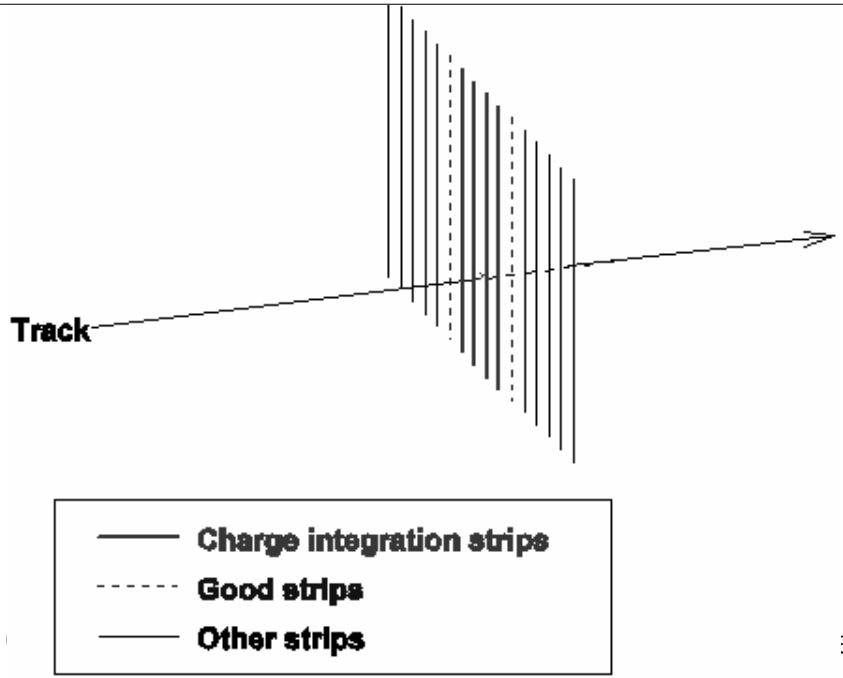
Procedure

- Test beam of Cz detector (2002)
- Harsh irradiation using CERN PS Facility (24 GeV protons)
- Annealing simulations (Hamburg model)
- A 2nd 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 μ &/or π's
- Extrapolated the track to the Cz detector. Integrate the charge with ±2 strips (strip pitch = 50 μm)



Cz alignment accuracy:

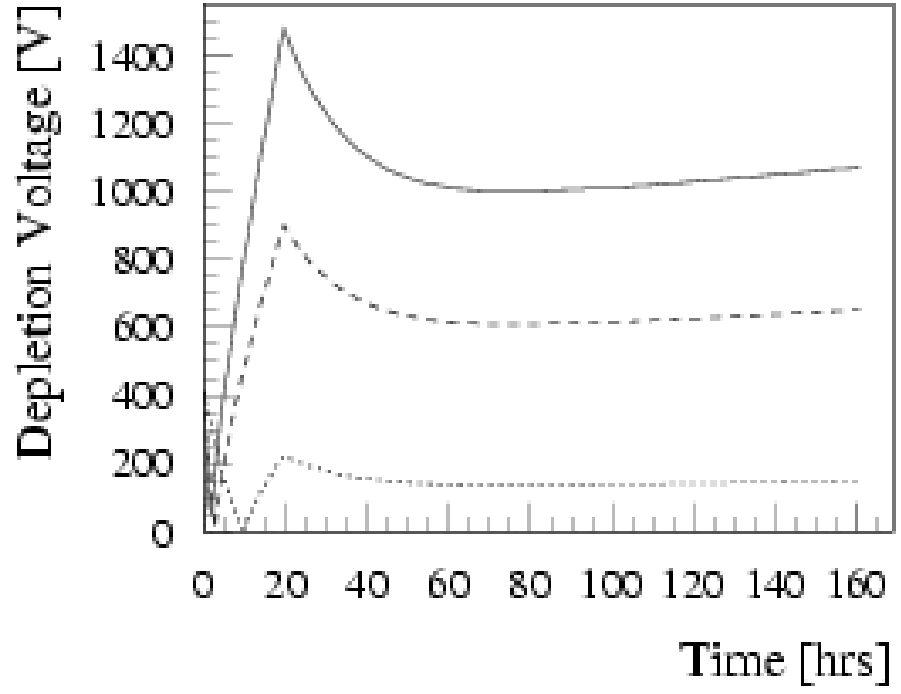
Un-irradiated Cz test beam,
26.7 + 0.4 μm

Irradiated Cz test beam,

~ 47 μm

Annealing

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



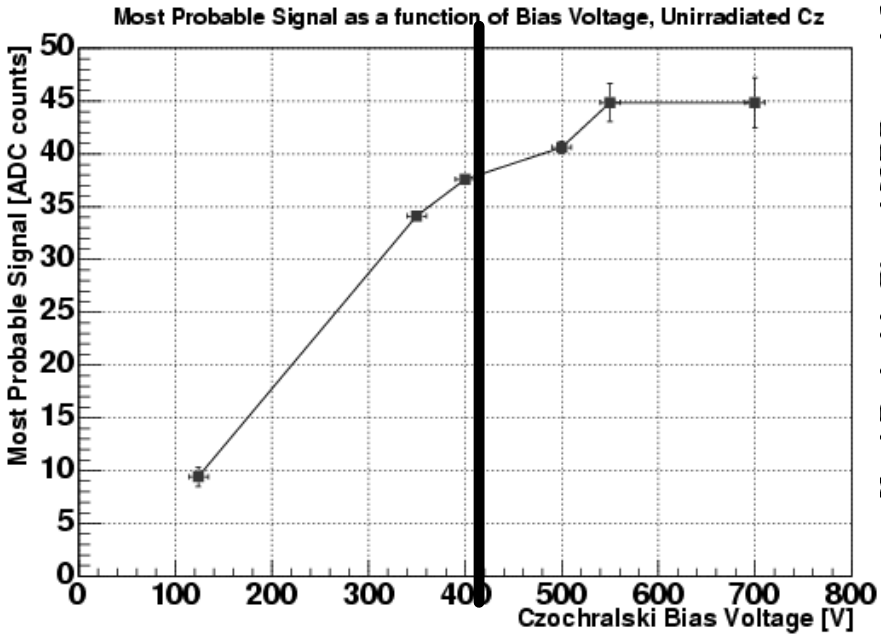
Annealing simulations for FZ silicon show expected V_{dep} to be:

7×10^{14} 24 GeV p/cm^2 = **1070 V**

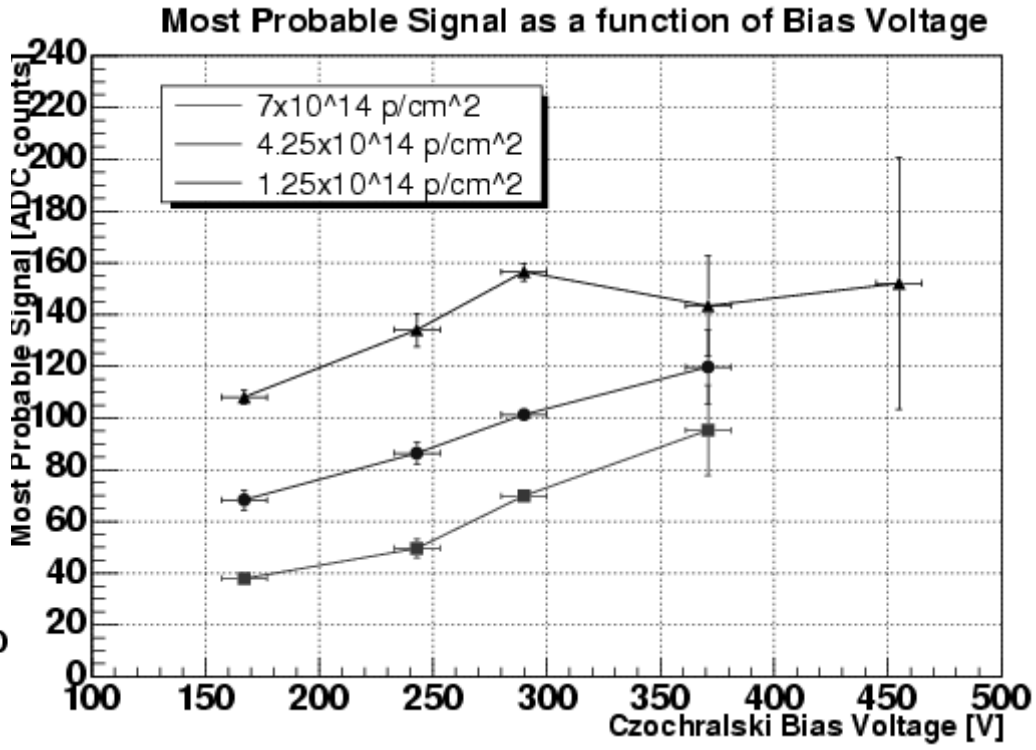
4.25×10^{14} 24 GeV p/cm^2 = **650 V**

1.25×10^{14} 24 GeV p/cm^2 = **150 V**

Charge Collection Efficiency

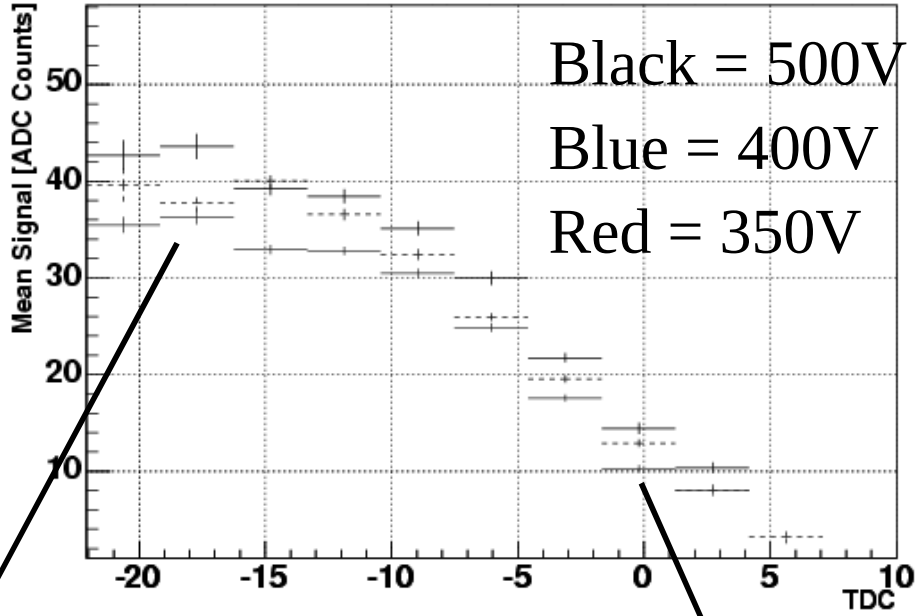


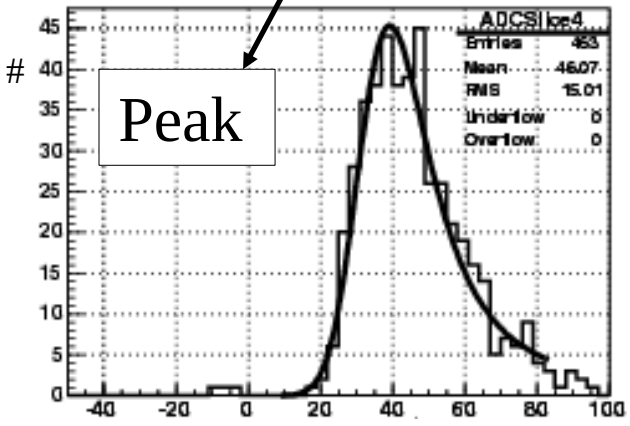
V_{dep} measured as 420V

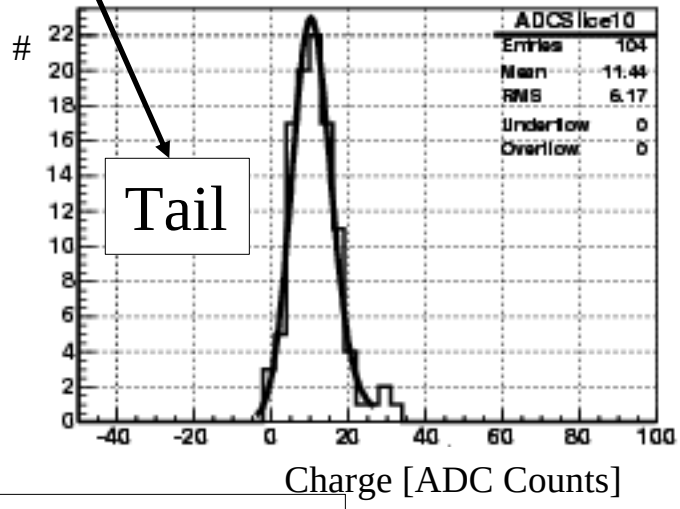


N.B. The ADC values can not be directly compared for the 2 test beams

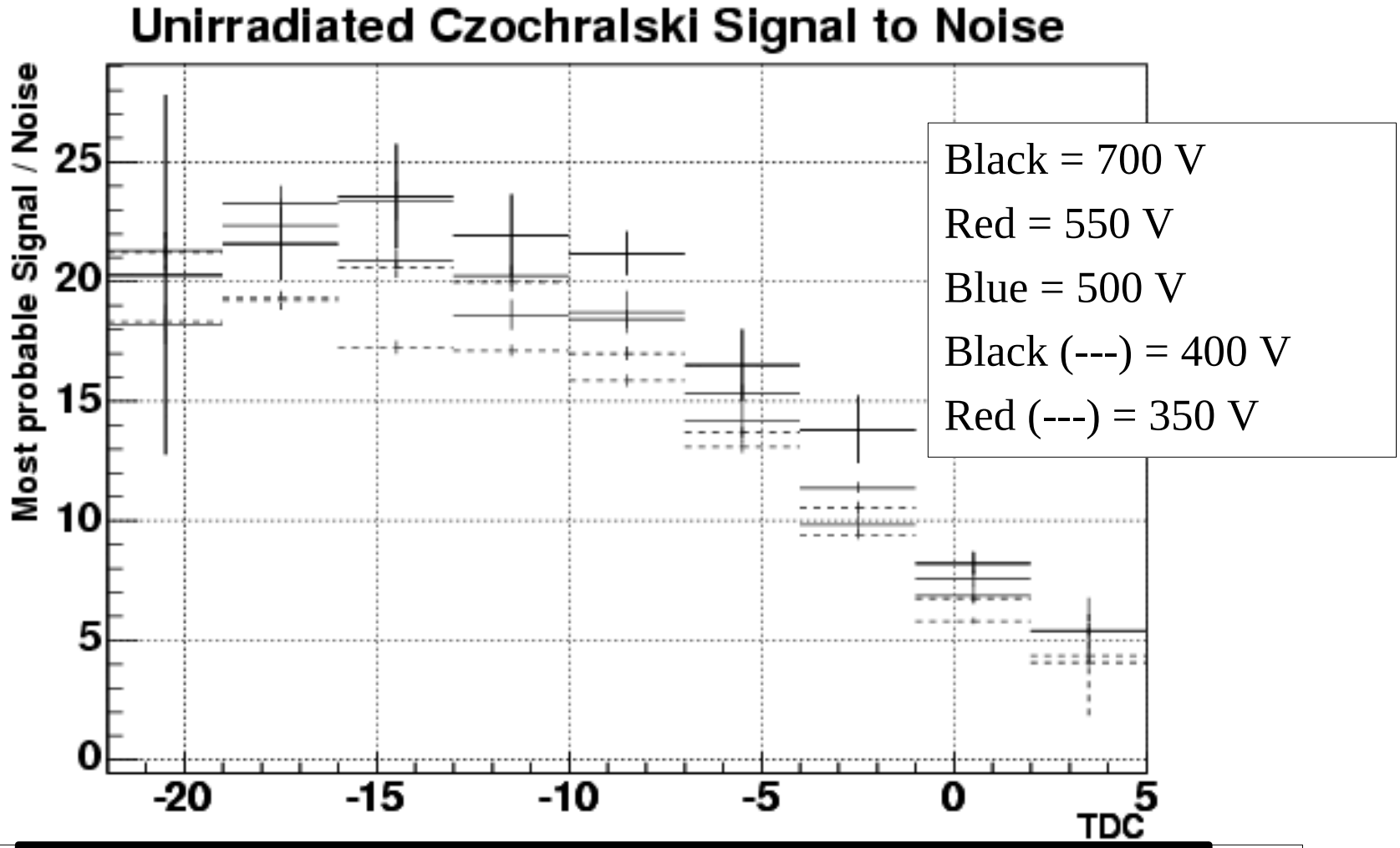
Un-irradiated Cz Signal







Example Landau*Gaussian fits

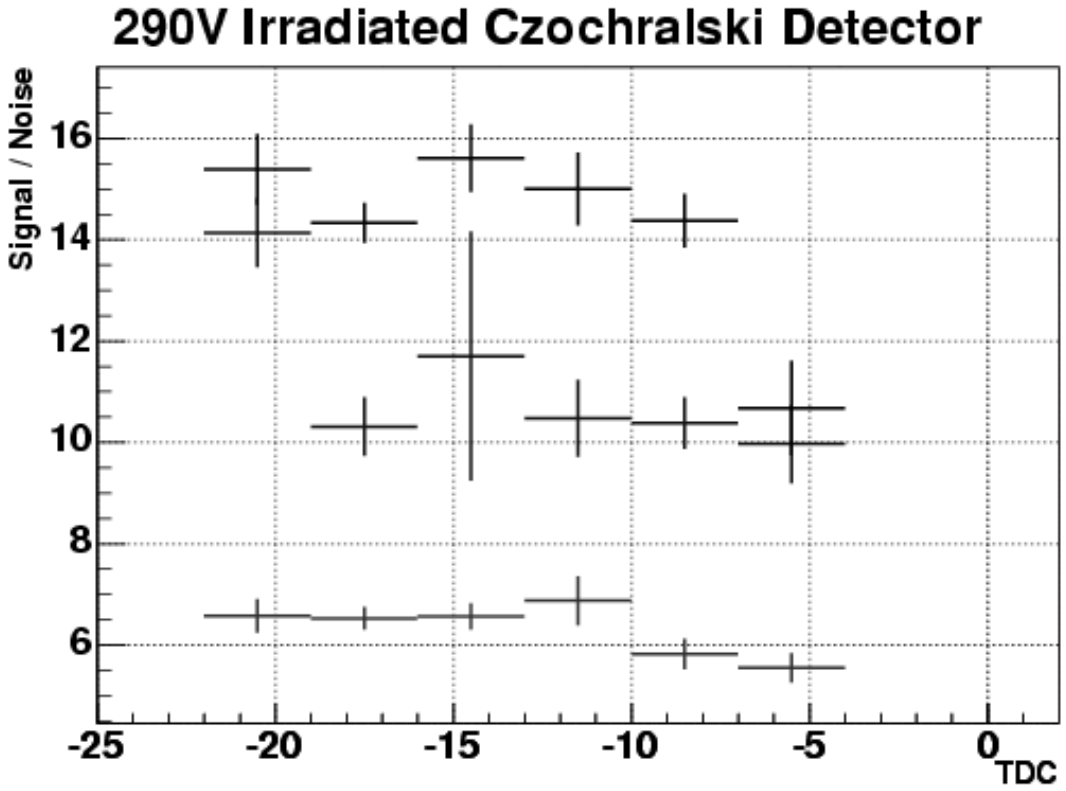


Peak S/N = 23.5±2.5 (for 380 μm)

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)



Black = 1.25 x 10^{14} 24 GeV p/cm^2 S/N = 15

Blue = 4 .25 x 10^{14} 24 GeV p/cm^2 S/N = 11

Red = 7.0 x 10^{14} 24 GeV p/cm^2 S/N = 7

Conclusions

- First successful study on Cz micro-strip detector with LHC speed electronics
- Un-irradiated S/N = 23.5±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

} While under-depleted!

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