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ATLAS Transition Radiation Tracker (TRT) Electronics Operation Experience at High Rates

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The ATLAS Transition Radiation Tracker (TRT) is the outermost of the three subsystems of the ATLAS Inner Detector. ATLAS is one of two general-purpose detectors built for the Large Hadron Collider at CERN. The TRT front-end electronics use two custom-built, radiation-hard ASICs: the analog Amplifier, Shaper, Discriminator, Baseline Restorer (ASDBLR) chip and the Digital Time Measurement, ReadOut Chip (DTMROC). We report on how these chips performed during the ATLAS 2011 run where the TRT experienced much higher rates than previously encountered.

Summary

The ATLAS Transition Radiation Tracker (TRT) is the outermost of the three sub-systems of the ATLAS Inner Detector. ATLAS is one of two general-purpose detectors built for the Large Hadron Collider at CERN. The TRT contains close to 300000 thin-walled proportional-mode drift tubes (straws) providing on average 30 two-dimensional space points with ˜130 μm resolution for charged particle tracks with $|\eta| < 2$ and $pT > 0.5$ GeV. Along with continuous tracking, the TRT provides electron identification capability through the detection of transition radiation X-ray photons. During the ATLAS 2011 proton-proton data run, the TRT operated successfully while being subjected to the high rates of incident particles (up to ˜10 MHz). These high rates challenged the TRT front-end electronics.

The TRT use two custom-built, front-end ASICs: the analog Amplifier, Shaper, Discriminator, Baseline Restorer (ASDBLR) chip and the Digital Time Measurement, ReadOut Chip (DTMROC). These two ASICs were designed to function at instantaneous hit rates of up to 20 MHz and integrated radiation doses of up ˜3 Mrad. The ASDBLR has two discriminators for each straw: one with a lower threshold (˜300 eV) for tracking and one with a higher threshold (˜6000 eV) for particle identification. The ASDBLR output is a 3 state logic signal (0 no hit, 1 LT hit, 2 LT+HT hit). The DTMROC digitizes the LT signals with a time binning of 3.125 ns over 75 ns (24 bins) and digitizes the HT signals with a time binning of 25 ns over 75 ns (3 bins). The 75 ns time span is sufficient to measure the leading and trailing edges for an in-time hit. A lossless compression scheme based on Huffman encoding is used in the TRT Readout Driver (ROD) chip. Thus the whole TRT read-out chain is highly optimized for read-out of the large numbers pile-up hits at high LHC luminosity. In this presentation we will describe how the TRT electronics works well at the maximum 2011 proton-proton luminosity of ˜6 x 1033 s-1cm-2. While shadowing effects are noticeable at these high rates, the TRT continue to perform significantly better than the expectations for spatial resolution. It should also be noted that during heavy ion running the TRT continues to contribute to measuring track pT even in events where the TRT overall occupancy exceeds 50%.

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