The timing upgrade project of the TOTEM Roman Pots detectors

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1. The TOTEM Roman Pots upgrade with diamond detectors

The TOTEM upgrade programme [1] focuses on improving the experiment’s capability to explore and measure new physics in Central Diffractive (CD) processes: p+p → p + X + p. Common CMS-TOTEM data taking are foreseen during the LHC Run 2, with a special LHC-optics configuration for which the proton acceptance is optimal (all ξ = Δp/p for |t| > 0.04 GeV²). The installation of proton Time-Of-Flight (TOF) detectors in the TOTEM Roman Pots (RPs) allows us to reconstruct the longitudinal vertex position and thus to assign the proton vertex to the proper vertex reconstructed by the CMS tracker, even in presence of event pileup. Ultimately, 100 pb⁻¹ can be collected in runs with a pile-up μ = 50%. Among the many Physics channels that can be studied with CD, the upgraded system aims to measure with an unprecedented sensitivity low mass resonances (with particular emphasis to Glueball candidates), exclusive CD dijets, charmonium states and events with missing mass signatures. Even at very low pileup, for inclusive CD processes, exclusive CD dijets, charmonium states and events with low mass resonances (with particular emphasis to Glueball can-

We describe the upgrade project developed by the TOTEM Collaboration to measure the time of flight (TOF) of the protons in the vertical Roman Pot detectors. The physics program that the upgraded system aims to accomplish will be addressed. Simulation studies allowed us to define a geometry of the sensor such that the detection inefficiency due to the pile-up of the particles in the same electrode is low even with a small amount of read-out channels. The measurement of the protons TOF with ∼ 50 ps time resolution requires the development of several challenging technological solutions. The arrival time of the protons will be measured by scCVD diamond detectors, for which a dedicated fast and low-noise electronics for the signal amplification has been designed. Indeed, while diamond sensors have the advantage of higher radiation hardness, lower noise and faster signal than silicon sensors, the amount of charge released in the medium is lower. The sampling of the waveform is performed at a rate up to 10 GS/s with the SAMPIC chip. The sampled waveforms are then analysed offline where optimal algorithms can be implemented to reduce the time walk effects. The clock distribution system, based on the Universal Picosecond Timing System developed at GSI, is optimized in order to have a negligible uncertainty on the TOF measurement. Finally an overview of the control system which will interface the timing detectors to the experiment DAQ is given.

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The measurement of the protons TOF with 50 ps time resolution requires several challenging technological solutions. Indeed, while diamond sensors have the advantage of higher radiation hardness, lower noise and a faster signal than silicon sensors, the amount of charge released in the medium is lower. A SiGe BJT preamplifier with low-C feedback has to be placed at less than 1 cm from the diamond electrode: this increases the input impedance to few kΩ (therefore enhancing the S/N) while the straight capacitance seen by the signal is still small (which is important to keep the signal fast). This solution, already developed by HADES [3], was then further elaborated by TOTEM which designed an amplification chain able to keep the time resolution of the order of 100 ps also for the electrodes with larger capacitance (2 pF). The BJT-based amplification chain consists of the preamplifier followed by a single stage voltage amplifier and by a booster who also shapes the signal. Particular care was dedicated to optimize the bias network of the single stage amplifier in order to obtain undistorted phase and gain response. The amplification chain has ~90 dB gain, with a maximum at 226 MHz. The power dissipated by each amplification channel is about 0.3 W. Both metallizations provided by GSI (Cr-50 nm + Au-150 nm) and by PRISM (100 nm of TiW 10%90%) have been successfully tested. Detection efficiency have been characterized in several test beams and satisfactory results on time resolution and detection efficiency have been achieved. The digitization of the signal has introduced a negligible deterioration of the time resolution. The solutions that will be adopted for the TOF clock distribution and for DAQ have been finally summarized.

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