TWEPP 2013 - Topical Workshop on Electronics for Particle Physics

Contribution ID: **159** Type: **Oral**

Development of Dedicated Front–end Electronics for Straw Tube Tracker in PANDA Experiment

Thursday, 26 September 2013 10:15 (25 minutes)

The design and measurements of front–end electronics for straw tubes tracker (STT) at PANDA experiment are presented. The challenges for front–end electronics are discussed and the proposed architecture comprising switched gain preamplifier, pole–zero cancellation circuit (PZC), variable peaking time shaper, ion tail cancellation circuit (TC) and baseline holder (BLH) is described. The front–end provides analogue amplitude output and leading edge discriminator (LED) output for time and time–over–threshold (ToT) measurements. The first prototype ASIC comprise four channels was fabricated in 0.35˜μm CMOS technology. The results of measurements on ion tail cancellation, gain, noise, time walk and jitter are presented.

Summary

The STT detector at the PANDA experiment needs a front–end electronics which can meet requirements of high speed, time resolution around 1 ns, amplitude measurement and low noise. For high event rate experiment the specificity of gaseous detectors requires to eliminate the long ion tail from the signal. In addition, to obtain high resolution the stabilisation of baseline level is needed.

To fulfill the discussed requirements the front–end architecture comprising a switched gain preamplifier, a PZC, a second order variable peaking time shaper, a TC circuit and a BLH was developed. The front–end solution provides both the amplitude measurement and the timing and ToT information. The preamplifier works with resistive feedback in charge sensitive mode, its gain can be varied in the range between 0.5 and 2 mV/fC. The preamplifier is followed by PZC circuit and the first shaper stage. The peaking time of the shaper can be varied between 20 and 40 ns. The TC circuit following first shaper stage is designed as RC ladder providing two time constants used for the long ion tail cancellation. These time constants can be trimmed in wide range (3-43 and 17-512 ns) and thus can be matched to detectors with different gas mixtures. In addition, it is possible to switch off a part of TC responsible for one time constant or switch off the whole TC circuit and work with classic CR–RC^2 shaping. To stabilize baseline a BLH was designed. The BLH contains folded cascode OTA with slew rate limitation, followed by RC filter driving a current sink. To obtain high value of RC filter time constant ($\sim$ 1s for default settings) an active resistor was used. To perform time measurement a fast LED with LVDS driver is placed after the last shaper stage.

The first prototype was fabricated in two–poly four–metal 0.35˜μm CMOS technology. A number of measurements for different modes of operation were done both for test delta–like pulse and with signals from straw tubes. The measurements with delta–like pulse were done for CR–RC^2 configuration (with TC switched off) for the whole range of preamplifier gains and shaping times and for wide range of input capacitanes (between 5 and 100 pF). The measured charge gain is in the range between 3.8 and 23 mV/fC for C_{in} = 22 pF, and the obtained ENC is on the level $\sim$ 2400 and 980 for lowest and highest charge gain respectively. The discriminator time walk is below 9 ns with jitter around 0.14 ns (for highest gain settings). The measurements with straw tubes show very good performance of TC circuit. Setting correctly the TC time constants an output pulse with quasigaussian shape lasting around 150 ns and without undershoot is obtained. To check the BLH performance various measurements at different supply voltage, temperature and input signal rates were done showing very good stability of the baseline.

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Session Classification: ASICs