Transconductance calibration of n-XYTER 1.0*

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Motivation

Since long, the n-XYTER 1.0 [1] has been used as a prototype readout chip for the Silicon Tracking System (STS), the muon and Cherenkov detectors of the CBM experiment. Transconductance calibration of the n-XYTER was already reported [2]. However, it was done with only one channel of one chip, only at one polarity and without thermal stabilization of the chip. An inconsistency between this calibration and results of measurements with various microstrip detectors done by the CBM-STS group [3] necessitated to repeat the calibration thoroughly.

Calibration setup

To generate reference charge pulses, voltage steps were applied to the n-XYTER input over a capacitor. The injected charge in this case is $C \cdot \Delta V$. The voltage steps were generated with an ordinary laboratory pulser and attenuated down to the millivolt level with passive attenuators. In order to minimize the systematic error the actual attenuation factors were measured with high precision, and also their independence of the freqency was checked. The capacitance (including parasitics) was also measured precisely (1.051±0.001 pF). As a cross-check, the calibration of one channel was repeated with a capacitor of a different type and value, and a good agreement was observed.

Finally, the independence of the n-XYTER response of the width of the injected pulse was checked (as expected, observed roughly up to 50 ns).

The n-XYTERs were operated on front-end boards rev. D, with thermal stabilization and in conjunction with a 12-bit ADC (AD9228, dynamic range –1..1 V).

Results

The calibration was done on 3 chips and 42 channels at negative polarity and 10 channels at positive. Within the same polarity the data from all channels were combined and fitted with a 4$^{\text{th}}$ order polynomial (Fig. 1). The results are[1]:

$$Q_- = 0.2025 + 2.053 \cdot 10^{-2} \cdot A - 6.733 \cdot 10^{-6} \cdot A^2 + 1.324 \cdot 10^{-8} \cdot A^3 - 3.566 \cdot 10^{-12} \cdot A^4$$

$$Q_+ = 0.3966 + 1.921 \cdot 10^{-2} \cdot A + 2.603 \cdot 10^{-6} \cdot A^2 - 1.062 \cdot 10^{-8} \cdot A^3 + 1.227 \cdot 10^{-11} \cdot A^4$$

where $Q_\pm$ is the input charge in fC, and A is the n-XYTER output amplitude in ADC LSB (least significant bit).

A straight-line fit in the linear range (0–700 LSB) yields:

$$Q_- = 0.07757 + 0.02051 \cdot A = 0.07757 + 1.002 \cdot 10^{-2} \cdot U$$

$$Q_+ = 0.3718 + 0.01960 \cdot A = 0.3718 + 9.573 \cdot 10^{-3} \cdot U$$

Here U — is the n-XYTER output amplitude in mV.

The dominant contribution to the calibration uncertainty comes from the fact that a single calibration curve is applied to all channels, even though they have slightly different gains. This uncertainty was parametrized with a 2$^{\text{nd}}$ order polynomial w.r.t. the amplitude and estimated by requiring that it compares to the dispersion of the data. Because of the small number of data points at positive polarity the uncertainty was assumed to be the same for both polarities (ΔQ in fC, A in ADC LSB):

$$\Delta Q = 0.1 - 4 \cdot 10^{-4} \cdot A + 1.4 \cdot 10^{-6} \cdot A^2$$

Cross-check with a Si-detector and a γ-source

As a cross-check against possible systematic errors a planar silicon detector was connected to one n-XYTER channel, and the amplitude corresponding to the 59.6 keV line of ^{241}Am was measured (114 ADC LSB). According to the calibration of the same channel, the amplitude corresponds to a charge of 2.57 fC, which is in a very good agreement with the expected value of 2.64 fC (2.7 % difference).

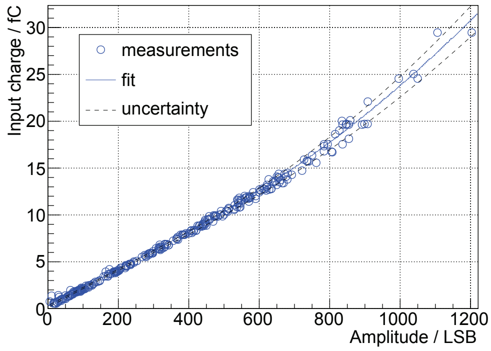

Figure 1: n-XYTER calibration at negative polarity.

References

[1] A.S. Brogna et al., Nuclear Instruments and Methods in Physics Research Section A 568 (2006) 301–308

[2] GSI Scientific Report 2009 84, Darmstadt 2010

[3] GSI Scientific report 2010 26, Darmstadt 2011

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[1]Parameter values were not rounded because their uncertainties were not calculated. Instead the total uncertainty will be specified below.