Extending Dynamic Range of Generic Electronics for Time Projection Chambers (GET)

Extending Dynamic Range of Electronics in a Time Projection Chamber

Extending Dynamic Range of GET Electronics

Abstract

1. State the principal objectives and scope of the investigation
2. Describe the methodology employed
3. Summarize the results
4. State the principal conclusions

A common issue to all using any amplifying electronics in a Time Projection Chamber (TPC) is correctly setting the electronic’s gain to fit the most amount of physics in the dynamic range as possible. The TPC discussed here was set to a high gain setting, allowing the small signal of pions to be read out while heavier charged particles saturated the electronics. It is well known principle of a TPC that the charge distribution shape is fixed by the avalanche electrode geometry. By using the non-saturated tails of this distribution, the saturated, central pads, could be accurately estimated. This simple method effectively extends the dynamic range of the TPC electronics with surprising success.

It is a delicate balance to correctly set the dynamic range of your electronics to extract the signal of interest, while not letting other potentially useful events saturate your electronics. The Time Projection Chamber discussed here was set to a high gain setting allowing the small signal of pions to be seen while heavier charged particles saturated the electronics.

As with all experiment involving amplifying electronics, it is up to the researcher to correctly set the gain setting for their particular signal of interest. The Time Projection Chamber discussed here was set to a high gain setting allowing the small signal of pions to be seen while heavier charged particles saturated the electronics. By using the tails of the pad response function distribution, the charge of the saturated channels can be accurately reconstructed. Knowing only the pad response function of your TPC once can effectively extend the dynamic range of any electronics system.

Outline

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Introduction

As the name describes the SAMURAI Pion-Reconstruction and Ion-Tracker (SπRIT) Time Projection Chamber (TPC) was designed to measure pions and other light charged particles in heavy ion collisions (HICs). A radioactive beam of 132Sn and 108Sn were impinged on stable Sn targets. By measuring such a neutron rich system we intend to extract more information on the nuclear Equation of State (EoS). The focus of this paper will be the discussion of extending the electronics for a TPC. For this reason only the avalanche and electronics will be briefly discussed leaving all other construction details for the reader to reference [REF shane]. The method of extending the dynamic range is not limited to this particular TPC and could be applied to a host of other TPCs. The procedure only requires an understanding of the pad response function of the induced signal on the charge sensitive pads, also known as the pad plane.

The SpiRIT TPC utilizes the General Electronics for TPCs (GET) to measure and shape the signals from the pad plane[CITE GET]. The main signal of interest was to measure pions. Thus the highest setting of the GET electronics was used to pick up the relatively small pion signal. The dynamic range set was 120 fC over the 12 bit ADC’s. The shaping time constant was set to 117ns. Being that it was the highest gain meant the other massive particles measured, (p,d,t,He,Li,..), tended to saturate the electronics. Extending the dynamic range of the electronics and recovering the saturated signals of these particles gives us the ability to perform more meaningful EoS physics over a greater range of momentum.

TPC geometry

As described in [SHANE] the SpiRIT TPC consists of three wire grids below the two dimensional, charge sensitive, readout pads. The first two wire grids operate as a gate and a shielding or ground grid. They are not important for the purposes of this paper. The wire grid closest to the pad plane is the high voltage anode grid. In the near vicinity of the wires the avalanche of the preliminary electrons occurs. Here the preliminary electrons, deposited from the particle’s energy loss in the gas, are multiplied 1000 times and the slow moving ions moving away induce a signal on the read out pads below. The resulting distribution on the read out pads is fixed by the geometry of the anode grid, be it wires, GEMs, or some other avalanche technology. Naturally the pads charge is the integral of this charge distribution and it is more convenient to define a more convenient function the pad response function (PRF). The PRF is no more than the integrated charge distribution over a single pad, as a function of distance from the avalanche location.

Pad plane

The SpiRIT TPC read out plane is a 2 dimensional plane of charge sensitive pads. Each pad being rectangular in shape is layed out on a grid measuring 112 pads along and 108 pads perpendicular to the beam axis. The avalanche wires run perpendicular to the beam axis. The direction the wires go in is referred to as the row direction and the direction in the beam axis is the layer direction.

Experimental PRF

Some TPC anode grid geometries have analytical expressions for the PRF which are well studied and may be looked up [Blum & Rolandi] using a Gatti distribution. Though theoretical PRF’s may be available, Blum & Rolandi still suggest an effective PRF may be required [BLUM]. But especially when analytical PRF’s do not exist an effective PRF may be calculated from experimental data. This is the method used here.

Experimental PRF

When calculating the effective PRF from experiment, it is important to select data well within the dynamic range. I.e. it did not saturate any pad. Although one or several layers may have a saturated pad in a particular track, other layers may be included as long as within a layer there were no saturated pads. The PRF is given in equation [Bla.] where i is the index over the pads, Q is the total charge within the layer. In Figure [Figure label] λi is the distance of the center of the ith pad to the estimator for the avalanche center . The estimator can be either the mean value obtained from a fit or through the weighted mean value. For the SpiRIT TPC the weighted mean value is used.

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