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Update to the Status of the Bonn R&D Activities for a Pixel Based TPC

Hubert Blank, Christoph Brezina, Klaus Desch, Jochen Kaminski, Martin Killenberg,

Thorsten Krautscheid, Walter Ockenfels, Simone Zimmermann*

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Abstract

We report on the activities at the University of Bonn to set up a laboratory for the development of a pixel based TPC readout. A test stand with a TPC, featuring 26 cm drift distance, and all the infrastructure necessary to operate the detector, like gas system, high voltage supply and readout electronics has been installed.
A readout module with several pixel chips for the large EUDET TPC prototype is under construction. Seven dummy modules without electronics have already been shipped to DESY/Hamburg, where a joint test beam with the large prototype has started.

*all University of Bonn, Bonn, Germany

1 Introduction

To fully exploit the potential of micro pattern gas amplification stages like GEMs[1], the segmentation of the read-out plane needs to be adapted to the pitch of the gas amplification stage. In this context the Timepix ASIC[2] was developed. This pixel chip features a pixel size of 55×55 μm^2 as well as time and charge measuring modes. Therefore it is well suited for a TPC application.
As pointed out in [3] up to the end of 2007 the Timepix ASIC has only been operated in test chambers with a few millimeters drift distance. In order to study the performance of this high granularity readout with long drift distances, the Bonn LC-TPC group has setup a laboratory for a prototype TPC with 26 cm drift distance, a triple GEM stack and a Timepix readout. This setup has successfully been used in measurements with cosmic rays and in a test beam at the ELSA accelerator in Bonn.[4] To compare achieved performance of the Timepix and conventional pads, a combined readout plane with both techniques has been developed.
For high precision measurements at the large EUDET TPC prototype at DESY/Hamburg a module with eight Timepix ASICs has been assembled. Due to the good resolution of the Timepix ASIC, this module can be used as a reference for other devices under test. Additional several dummy end cap modules have been constructed.

2 Infrastructure for the Prototype TPC at Bonn

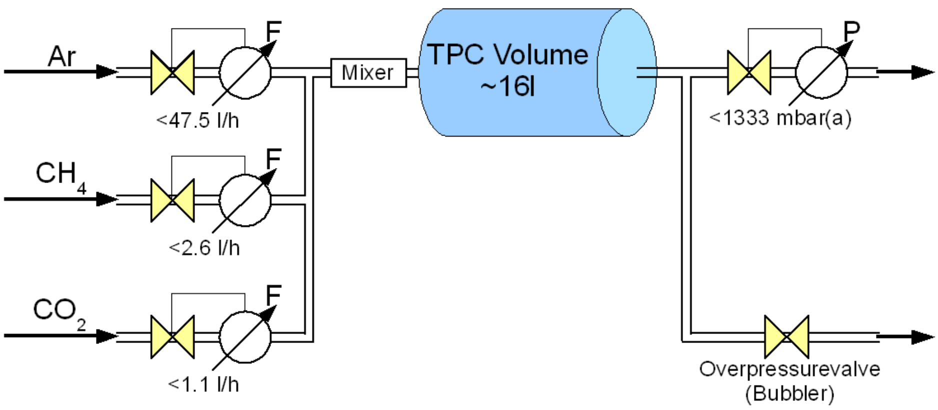

Figure 1: Gas mixing system for the prototype TPC

To be able to switch between different gas mixtures it was decided to design and build a dynamic gas mixing system (fig. 1). This system is able to mix up to three gaseous components within a wide dynamic range. The error on each single flow is kept well under 2% of the measurement over the full operating range.
The absolute pressure in the TPC is held constant by an upstream pressure controller. If the differential pressure to the environment exceeds 30 mbar upwards or gets negative, the chamber pressure is adjusted to stay within 0 to 30 mbar overpressure against

atmosphere. In case of an unforeseen pressure situation or a malfunction of any part, a double sided bubbler is installed to keep the chamber from bursting.
Homogeneity of the mixture is achieved by application of a helical mixer without any moving parts (fig. 2). As the stream passes over one of the eight mixer elements it is divided into two equal halves. Additionally each element rotates the flow.

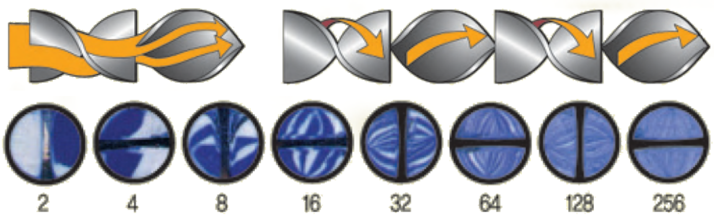

Figure 2: Helical mixer without any moving parts. The lower picture shows the number of divisions that have taken place after n elements.[5]

In future the mixtures quality (ratios and impurities) will be monitored by a micro gas chromatograph in the exhaust line. This chromatograph will be able to separate all relevant gases like Ar, He, CO_2, CH_4, O_2, H_20 with a lower detection limit of 10 ppm (1 ppm with an upgrade).
Since the used mass flow controllers were obtained from the dismantled ZEUS experiment at DESY there is no modern digital interface. Certainly each controller contains a control loop, therefore no fast communication is needed. Only the set point has to be transmitted, which is done by an analog 0 to 5V signal. The needed analog communication and the user interface are realized in an embedded PC with a small graphics display. This device features 16 ADC as well as 8 DAC ports. Beneath the gas flow other important parameters as barometric pressure and several different temperatures (cathode/gas/ambient) are monitored with this PC. For easy operation it can be remote controlled via RS232, an ethernet interface may be integrated if needed.
A photograph of the complete gas mixing system is shown in fig. 3. The whole system measures approximately 90 cm. The embedded PC is in the center of the panel.

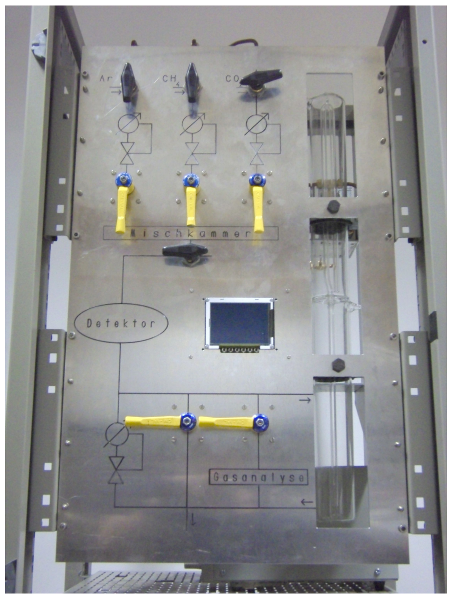

Figure 3: Photograph of the gas mixing system.

3 Dummy Modules

The large TPC prototype at DESY has seven slots where different exchangeable readout modules can be placed. Each module is sized and shaped as it would be when placed in the the final ILC-TPC.
Since it cannot always be expected that all seven slots are equipped with full functional read out structures, dummy modules are needed. These modules have to close the TPC gas tight and to fit into the anode plane without exciting any field disturbances. Therefore the surface has to be plane within ±100 µm. These modules have been build in Bonn. Fig. 5 shows that the deviations are within the allowed range.
Seven of these dummy modules where already shipped to DESY and are placed in the large prototype, as depicted in fig. 4.

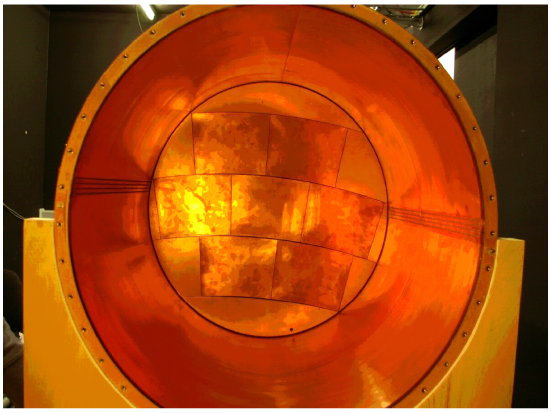

Figure 4: View into the large prototype TPC with the dummy modules mounted.

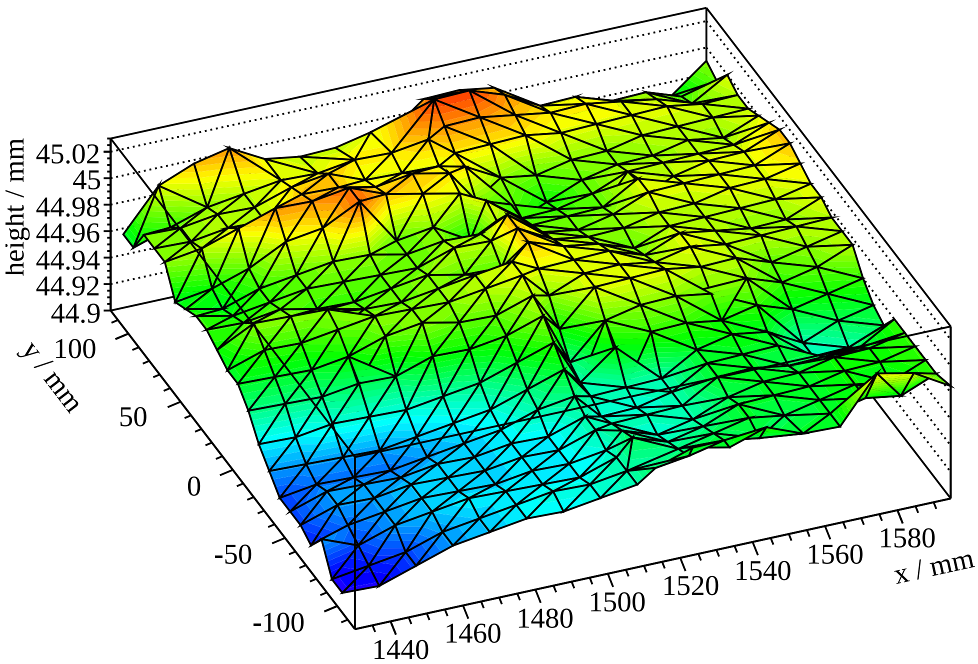

Figure 5: Planarity measurement of one dummy module

4 Read out Modules

Two of the GEM readout modules for the large prototype are planed and prepared in Bonn. These are a module with eight Timepix ASICs and a module with conventional pads.
The multi chip module consists of two quad chip boards[6] which were designed at NIKHEF. As in the small prototype in Bonn the gas amplification is achieved with a triple GEM stack. Transfer and induction gaps are 1 mm each. These quad boards are read out by two USB interfaces, which were originally designed in Prague for Medipix read out.[7] The modules architecture is shown in fig. 6, the constituents in fig. 7.
Onto the back frame the readout and the anode plane are mounted. Between readout and anode plane small spacers are placed to keep enough room for the stack of three standard CERN GEMs. To avoid field disturbances the top of the GEM stack is flush with the top of the anode plane. For thermal conductivity and reinforcement there is an aluminum board glued onto the back of the readout plane. This carries the two quad boards. The ASICs on the quad boards fit into the holes in the readout plane and are flush with the plane surface.

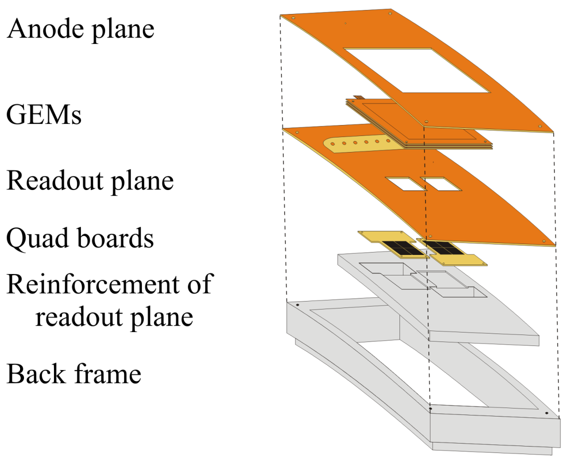

Figure 6: Exploded view of the multi chip readout module for the large prototype TPC.

Figure 7: Readout plane, back frame, anode plane with GEM stack, reinforcement of the readout plane with one quad board (w/o chips), two USB devices, quad board with 4 Timepix ASICs (clockwise)

A conventional module with approximately 1700 pads of $4 \times 1\text{mm}^2$ has been designed in Bonn. Data from this module shall be digitized with the ALTRO electronics [8] which was originally designed for usage at the ALICE TPC. This electronics will be the standard at the large prototype TPC for most of the tested modules. A comparable module with a stack of two thick GEMs is build in Japan.

5 Conclusion

The Bonn LC-TPC group has set up a laboratory to operate a small TPC prototype. This includes the implementation of a Timepix based pixel readout with a triple GEM gas amplification structure and design and construction of a versatile gas mixing system. The same ASIC is used in the readout module for the large EUDET prototype TPC. To enhance the active area from 2 cm^2 to 16 cm^2 eight chips are combined on one module beneath a triple GEM stack of standard CERN GEMs for gas amplification. This module will deliver a high resolution measurement of particle trajectories and therefore can be used as a reference for other devices under test.

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