Journal of Physics: Conference Series

PAPER • **OPEN ACCESS**

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To cite this article: V O Tikhomirov *et al* 2016 *J. Phys.: Conf. Ser.* **675** 012018

International Conference on Particle Physics and Astrophysics (ICPPA-2015) IOP Publishing
Journal of Physics: Conference Series **675** (2016) 012018 doi:10.1088/1742-6596/675/1/012018

Visualization tool for X-ray scanner for sTGC detector production quality control

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Abstract. The ATLAS experiment at the Large Hadron Collider has an ambitious program of the detector upgrade to meet an expected rise of accelerator luminosity. The first large system which supposed to be installed in 2019 is the New Small Wheel (NSW) for ATLAS muon spectrometer. In order to ensure high quality and reliability of NSW chambers an X-ray scanning technique is being developed. One of the main components of the X-ray scanner is a special software visualization tool which would allow a fast and clear representation of scanning results and an identification of possible chamber defects.

1. Introduction

ATLAS [1] is one of the largest experiment at the CERN Large Hadron Collider (LHC). To meet an expected rise of LHC luminosity, ATLAS is going to upgrade several detector components during next LHC Long Shutdown period. One of the systems which supposed to be installed in 2019 is the New Small Wheel (NSW) for ATLAS muon spectrometer [2]. To test the quality of muon "small-strip Thin Gap Chambers" (sTGC) at production sites (Canada, Chili, China, Israel and, possibly, Russia) an approach based on scanning of the chambers by X-ray was proposed. A special X-ray scanner was developed by Moscow Institutes involved in the NSW project (MEPhI, LPI and SINP MSU). The first scanner prototype was produced and now is being tested at MEPhI. Description of the scanner and corresponding methodical results can be found in reports [3,4] presented at this Conference.

For X-ray scanner operating, drive and control of scanning process and for visual presentation of results a dedicated software package has to be developed. This package will be an indivisible component of the delivered scanner equipment. An overview of this software tool is presented in this paper with the emphasis on visualization and presentation possibilities of the results obtained during scanning process.

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2. X-ray scanner software

The general task of the scanner software development is to integrate into one package the hardware control (scanning process itself, X-ray tube control, high voltage power supply and multimeter) with fast and visual presentation of results obtained during scanning process. The program is based on the ROOT package [5] in Graphical User Interface (GUI) and in analysis/presentation parts. For the hardware control a low-level C/C++ coding is provided.

General view of GUI is shown in figure 1. The program can work under Linux, Windows and Mac operating systems. In the hardware control part the program is still under development. The part for visualization and presentation of the data is in the final stage of development and is described in more details below. Some real results obtained by manual scan of sTGC chambers with a pentane gas mixture are shown below.

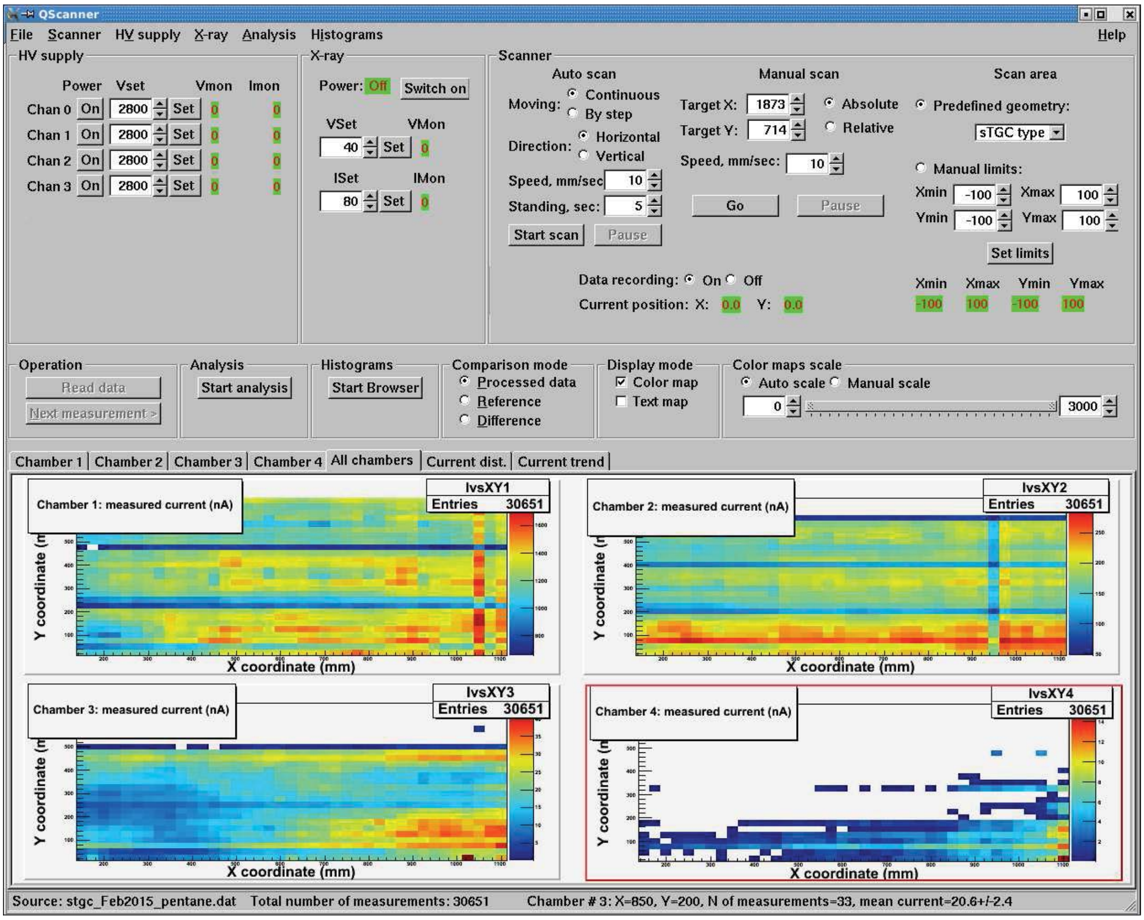

Figure 1. General view of the program GUI. The upper part is dedicated to drive the scanner hardware: high voltage power supply, X-ray tube and stepper motors. The lower part is for results presentation.

3. Visualization tool

During the scanning process the sTGC detectors connected to HV power supply are irradiated by X-ray tube and the current from sTGC anode wires is measured. Any possible local defects in the chambers being tested (non-uniformity in chamber geometry, anode wire defects, loss of

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gas gain etc) lead to rise or drop in measured chamber current. The easiest and most evident way for quick detection of such current variation is to present the results of current measurement as a two-dimensional map – in numbers or in colors – in XY plane of the irradiated sTGC. As the sTGC is a quadruplet of four identical planes glued together, the map has to be presented for each chamber in the quadruplet. On the lower part of figure 1 an example of such a maps for four chambers is shown. Each channel of two-dimensional ROOT histogram corresponds to X and Y coordinates of sTGC chamber irradiated by X-ray tube and the color presents the measured chamber current at this point – according to adjustable color palette on the right side of histograms.

A user can also mark "Text" check-box to show value of the current in numbers directly on the map field and also on the status bar in the bottom of the GUI. For more detailed view of a particular chamber area one can do double-left mouse click on the map field to open new window with zoomed view (figure 2). Horizontal and vertical sliders can then be used to move to any other map position.

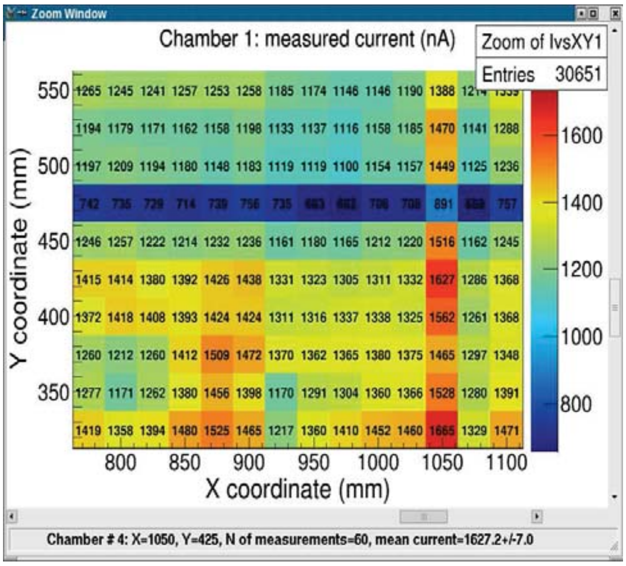

Figure 2. Zoom window with color/text map of currents measured in first sTGC chamber.

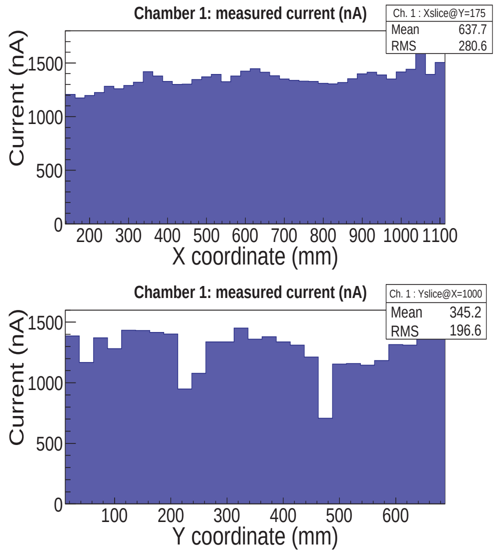

Figure 3. Slices of measured current along X (top) and Y (bottom) axis.

Middle button mouse click on the map opens a new window with two slices – histograms of the current values along X and Y axis (figure 3). It can be useful for quick detection of possible problems in the direction along and across the anode wires orientation.

Since the information about scanning process and the results are kept as ROOT histograms, a user can directly display these histograms via standard ROOT browser. The most important ones (current distributions in the chambers and current trends in time) can also be presented directly in the main GUI window if the corresponding tab button is selected (figures 4 and 5).

4. Examples of usage

Two examples of visualization tool usage are demonstrated in figures 6 and 7. Visible horizontal strip structures are due to chambers design and are not interesting for analysis. The examples also show evident problems in vertical direction which corresponds to the direction of anode wires, at the coordinate with X≈1050 mm in first chamber of the sTGC quadruplet and X≈950 mm in the second chamber. Such fast fault diagnosis will help in sTGC quality control at the chambers production sites.

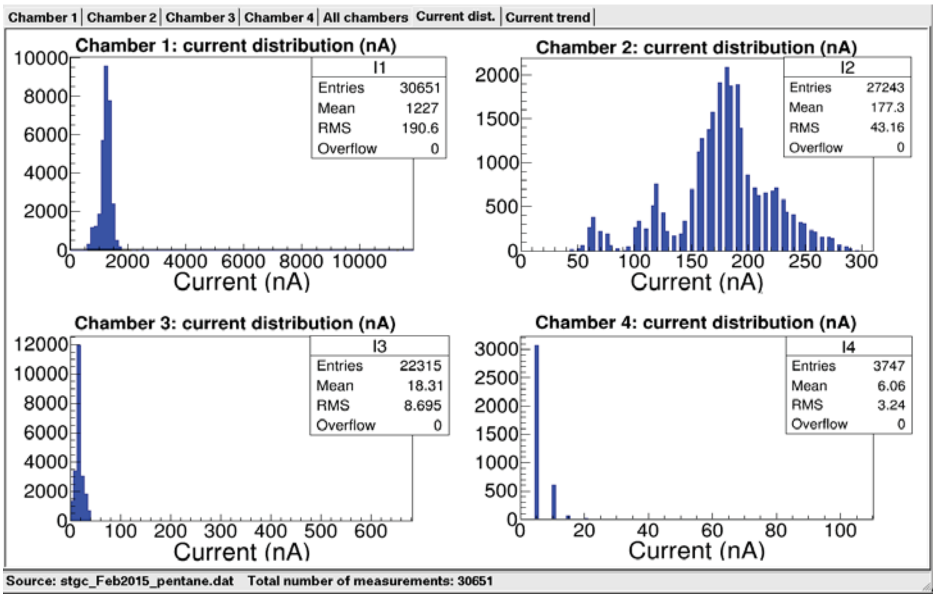

Figure 4. Measured current distributions for four detectors of sTGC quadruplet.

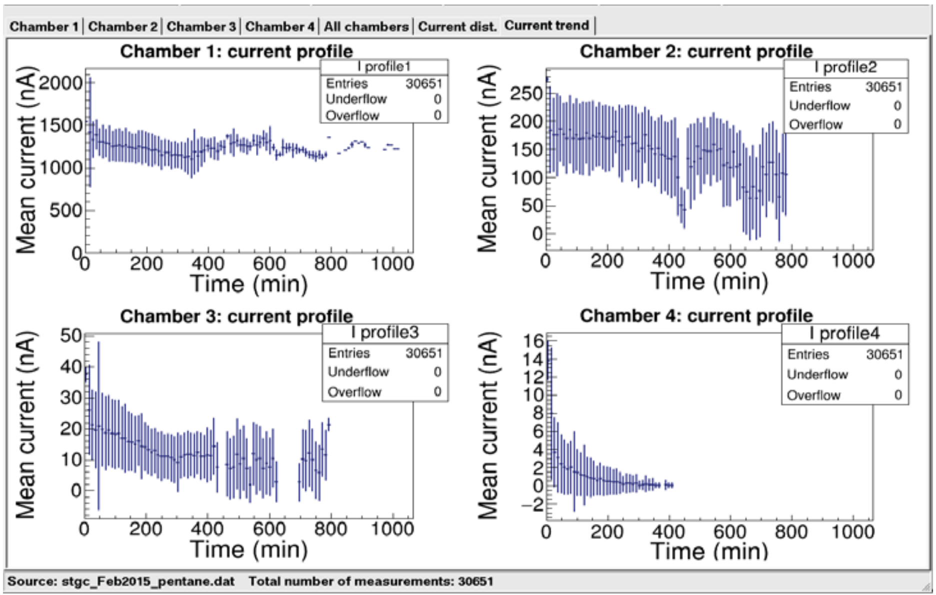

Figure 5. Time evaluation of measured current in four detectors of sTGC quadruplet.

5. Conclusion

A dedicated software tool for operation of X-ray scanner and visualization of the results obtained during scanning is under development. Visualization software provides wide possibilities for results presentation and analysis. It has a key role for identification of possible defects in muon chambers being tested. By the end of 2015 first scanners with corresponding software have to be delivered to ATLAS muon chambers production sites.

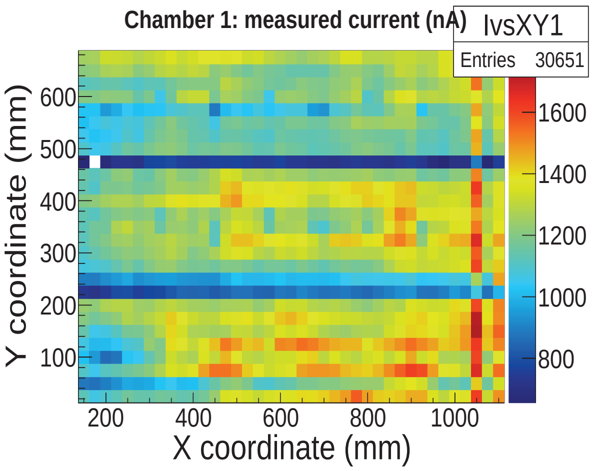

Figure 6. "Hot" area in the chamber at X coordinate ≈1050 mm: possible problem with anode wire offset.

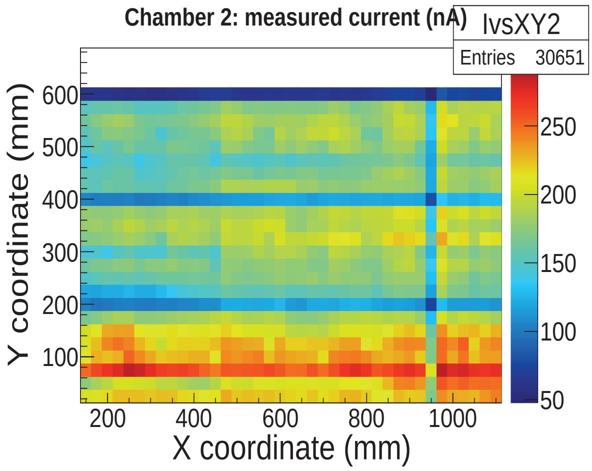

Figure 7. "Cold" area in the chamber at X coordinate ≈950 mm: possible missing anode wire or drop in gas gain.

Acknowledgments
This work was performed within the framework of the Center of FRPP supported by MEPhI Academic Excellence Project (contract number 02.a03.21.0005, 27.08.2013). We gratefully acknowledge the financial support from the Ministry of Education and Science of Russian Federation (R&D Project RFMEFI61014X0005) and grant No.14-22-03053 from the Russian Foundation for Basic Research.

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