TRIUMF Experiment E614
Technical Note #64

SUMMARY OF THE WIRE CHAMBERS MASS PRODUCTION

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1 Introduction

E614 spectrometer comprises 44 DC planes, 8 PC planes and 4 target PC planes assembled into the modules. It was decided to produce spare 2 UV modules, one dense stack, one PC module and one target module. So, we need 56DC, 12 PC and 8 target PC planes total.

As of today, wires are strung on all of 56 DC planes. Also 7 target PC planes and 9 "regular" PC planes are wired.

More than 10 people have contributed in the wire chambers production.

Requirements to precision of positioning of wires had been get from simulation and they are:

- Random error in positioning of wires within the chamber plane $\leq 20\ \mu$m;
- Cumulative error in positioning of wires within the DC wire plane $\leq 160\ \mu$m/80 wires;
- Cumulative error in Z positioning of wire planes $\leq 2\ \mu$m/4 mm.

2 Equipment and chamber design

A circular glass frame with a laminated lamel and ceramic glass rings - citals are the key parts of the chamber plane.

Drift chambers have eighty 15 μm diameter gold plated W(Re) sense and 4 guard wires with a pitch of 4 mm while proportinal chambers comprise 160 or 48 sense wires of the same diameter plus 6 guard wires with a pitch of 2 mm.

Equipment for gluing of the chamber parts and for wiring includes two precisely made glass plates with a diameter about of 75 cm each and with flatness better than 0.3 μm over all surface. One of the plates is used for gluing plane parts and the second one for wiring.

3 Chambers mass production: procedures and results of quality control

Each plane is checked at each step during the mass production.

- Gluing of chamber parts:

Two glass plates which are used for gluing and wiring have precisely positioned posts. It requires careful lamination of lamels and gluing of citals into the glass frames in order to move plane from one plate to another. During the mass production we had few planes with badly aligned lamels and we had to remove already glued citals and re-glue them. It helped to safe glass frames, lamels and citals.

At the beginning of a mass production we started to check positions of the cathode retaining rings and cathode foils relative to the cital surfaces. It was found that our measurements were non-reproducable when the same cathode had been attached to the same frame few times: for removable cathode this gap depends of force applied to screw on rings. After such a "discovery" we have stopped these measurements. One can define the position of cathode relative to cital surfaces (i.e. anode-cathode gap) when cathode ring is finally attached to ready wire plane or verify it using beam.

- Wire winding control and inspection:

As it was mentioned earlier wiring has been made on one of the glass plates. All equipment and chamber are aligned such way that the wire put into the glass ruler groove is over the soldering pad of the lamel. Each glass ruler is observed by CCD camera with attached zoom lenses and images of wire and grooves are controlled on monitors. Typical magnification is about of 250 and it allows us to control and correct position of each wire in the grooves during wiring and before fixing of all wires with epoxy glue. Disadvantage of this method is that wires are controlled outside of chamber. If wire caught on lamel or edge of glue sometime it still could be positioned in the grooves. Such an error could be discovered during tension test or wire mapping.

- Wire tension check before removing plane from the winding table:

35 g weight is applied to sence wires during a wiring. When wires are strung and soldered on the lamel, each wire is subject of a tension test before removing a wire plane from the winding plate. The wires with low tension are replaced. Luckily, we had to replace just one wire on this stage of chambers production. The typical tension plot of sense wires of plane 058DC is shown on figure 1 (solid line). "Typical" means that this plane has been strung by experienced people. The same figure shows the tension of sense wires on the plane 057DC (dashed line) where the spread (r.m.s.) of sense wires tensions is 0.97 g.

Figure 2 shows the tensions of sense wires on all 56DC planes (4480 sense wires total) and on 8 PC and 4 target PC planes (1472 sense wires total) as well. The difference between an applied weight and the measured tension is due to friction of wires on the equipment surfaces.

Tensions of sense wires of first 20 and last 20 DC planes show that the mean value of tension has decreased during production period (Figure 2, left frame). It seems somehow wire friction on the equipment surfaces has changed.

Figure 3 presents distribution of r.m.s.'s of sense wires tensions for all 56 DC planes. The best value is r.m.s.=0.33 g (018DC) and worse case is r.m.s.=1.82 g (061DC). For PC and target PC planes r.m.s.'s are in the range of 0.25 g (194PC) - 1.02 g (159PC).

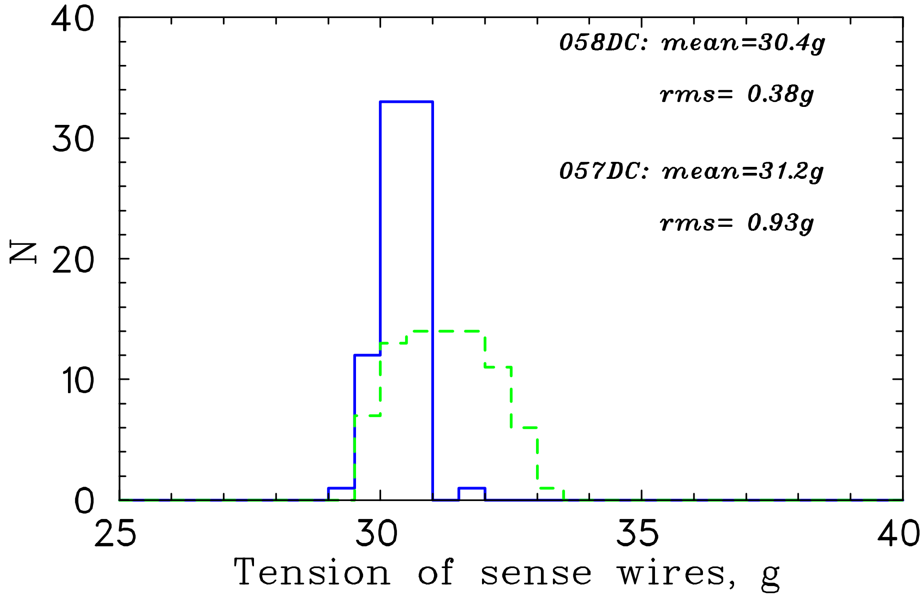


Figure 1: The measured tensions of sense wires on 058DC (solid line) and 057DC (dashed line) planes

Critical tension for 15 μm diameter and 40 cm long W(Re) wire is about of 4 g at 1900 V. Elastic limit of this wire is about of 43 g and wire breaks at about of 52-53 g. So, tensions of all sense wires are far from extreme cases.

- Inspection of wire positions (both in X and Z directions):

After wiring and tension test plane is removed from the winding table and positions of each wire both in X an Z directions are checked using so called travelling microscope.

The travelling microscope consists of two CCD cameras with zoom lenses mounted on a precision linear bearing and rail, and attached to a digital readout system from ACURITE. Each camera has it's own monitor. One camera points down at the wires and measure X position of each wire directly. The second camera observes wires at 45 degree angle and difference between two measurements provides relative Z positions of wires. The rail and bearing is a ultra-precision grade THK rail with tolerance of ± 2 μm over the lenght of the rail. The digital readout is an ACURITE glass scale with a resolution of 1 μm and accuracy of ± 2 μm over all. All system along with measured chamber is placed on the granit slab.

Precision of the measuring system had been checked by measuring of a glass ruler similar to those used for wiring. Figure 4 presents plot of X-scan of of grooves. Every second groove had been measured. Measured σ=2.71 μm includes real ruler tolerance (σ=1.50 μm) plus inaccuracy of our system and a human factor.

System allows us to measure wire positions close to end of the wires (about of 12 cm from the chamber center). These ends are referred as readout side (close to readout electronic) and pad side. Measurement of wire positions provides precision of relative positions of wires about of 2-3 μm in X direction. For Z direction these measurements are not as precise as for X one. Wire plane stays free on the horizontal granite slab and Z positions of wires reflect

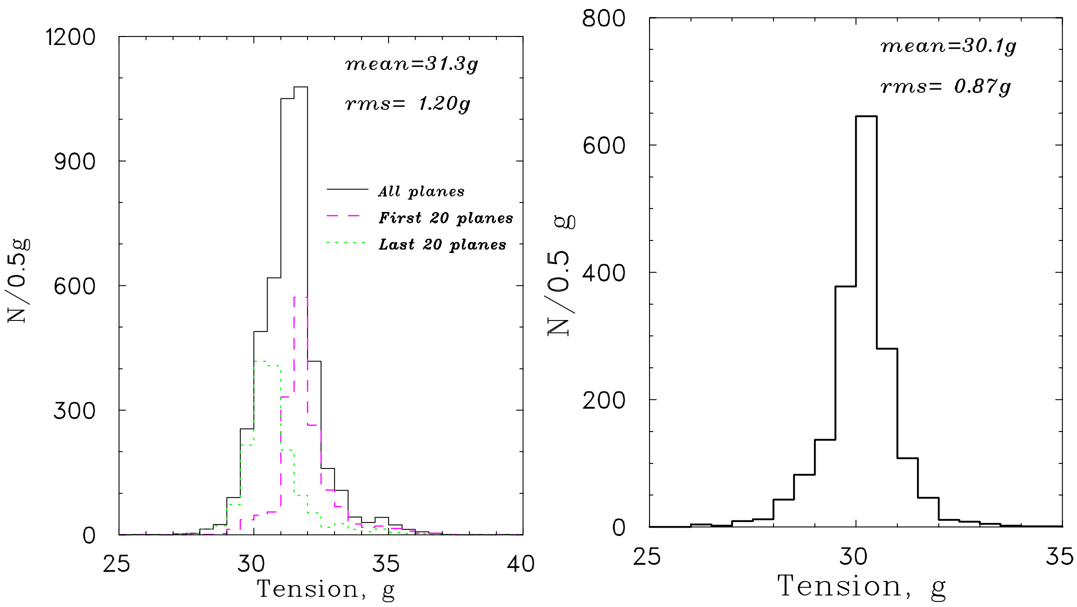


Figure 2: The measured tension of sense wires on all 56 DC planes (4480 wires total, left frame) and on 9 PC and 7 target PC planes (1776 wires total, right frame)

shape of glass frames. Figure 5 shows different Z shapes of wire positions for pad sides of two planes 025DC and 046DC. Nevertheless, these measurements give us possibility to define imperfectly positioned wires.

Figure 6 is very informative example. It presents X and Z scans of sense wires on pad side on 016DC plane. This plane had been installed in the upstream dense stack during November-December, 2001 run. Three wires (# 17, 21 and 25) were broken at that time. These three wires and wire #27 (it had residual about of 20 μm) had been replaced on January, 2002. Figure 6 shows X and Z scans taken on September, 2000 and on February, 2002 by two different people. One can see good reproducibility on X position measurements and high precision of wires replacement. At the same time it is visible that the Z scans have different shapes. Most likely it reflects the shape of a glass frame.

Typical measured wire pitches in DC planes are in the range of 3.99987-4.00002 mm. The difference from a nominal value (4.00mm) is much smaller than it requied by specification. The similar numbers have been obtained for PC planes.

Typical σ's of sense wires positioning are in the range of 3-5 microns for drift and proportional chambers. Figure 7 shows σ of wire positioning for 48 DC planes for readout and pad sides and for center of chambers. Wire positions on the readout and pad sides had been measured and it were calculated for chamber centers. Note, the specification for random error in the positioning wires within the wire plane is 20 μm.

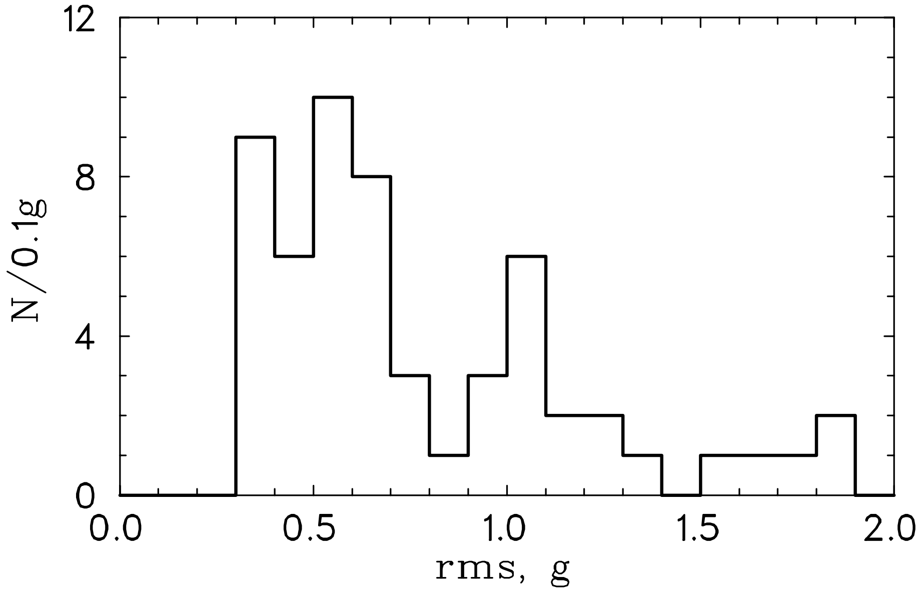


Figure 3: Distribution of r.m.s.'s of wire tensions for all 56 DC planes

4 Conclusion: some lessons from the chambers production and maintenance

All steps of production and repaire should be done very carefully and by using an adecuate equipment and technique. Due to extremely fragilness of all chambers and module parts we have to avoid moving modules into the cradle and out without of serious reasons (one can break citals, wires, sealing).

Removable cathodes option has made process of wiring more convenient and helped to keep foils clean. But we have to pay for this convenience. We have never had failed foils on prototype chambers. The lower tension which had been applied to foils on prototype chambers is one explanation but not only one. We had to use narrower G10 rings on the removable cathodes. It resulted in decreasing of ring stiffness. Also these cathodes demand additional procedures (such as punching of glue from the holes) and have been processed few times before installation into the planes. All these steps could cause of appearing of micro damages on foils which could lead to foil's failure.

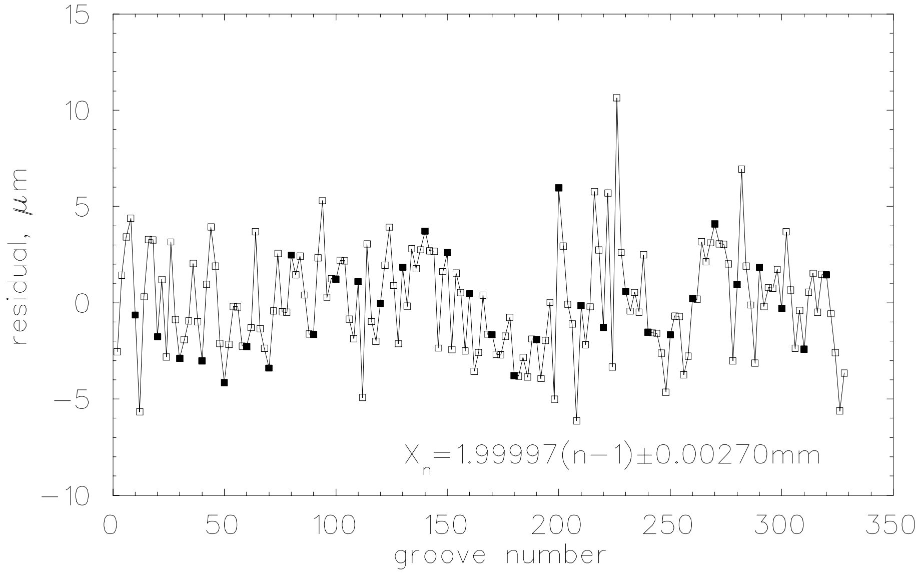


Figure 4: X-scan of glass ruler grooves obtained using of travelling microscope

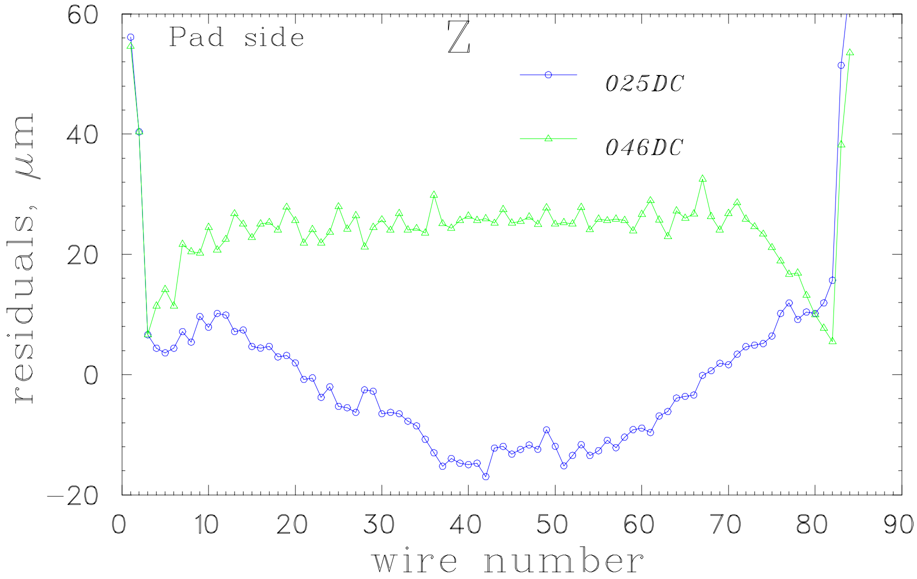
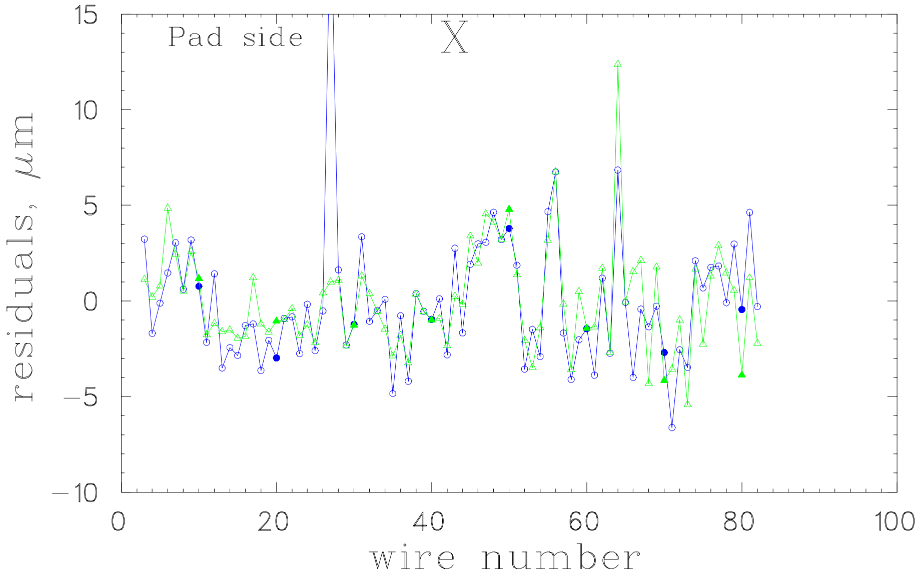


Figure 5: Z scans of wires on pad sides of planes 025DC and 046DC



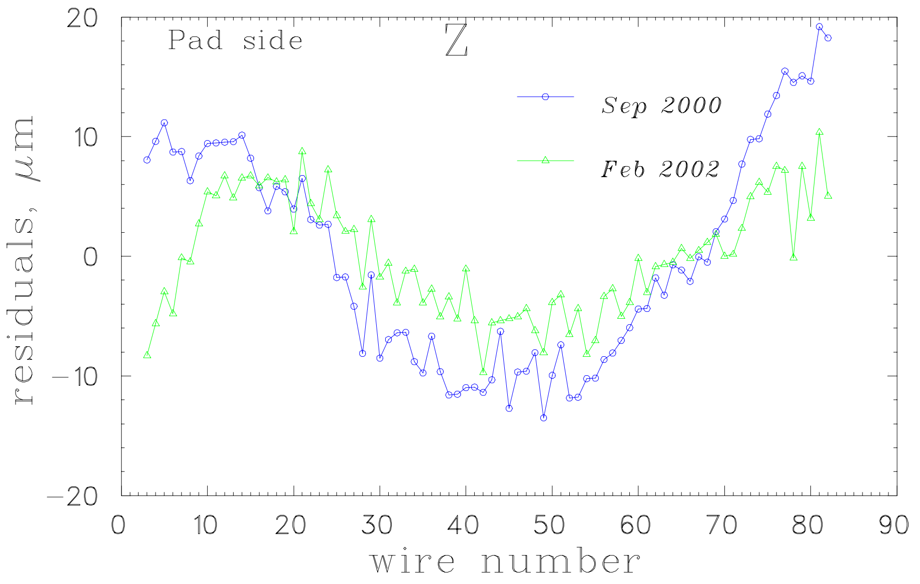


Figure 6: X and Z scans of sense wires on plane 016DC: first measurement (circles) - September, 2000; second measurement (triangles) - February, 2002. Wires # 17, 21, 25 and 27 had been replaced on January, 2002

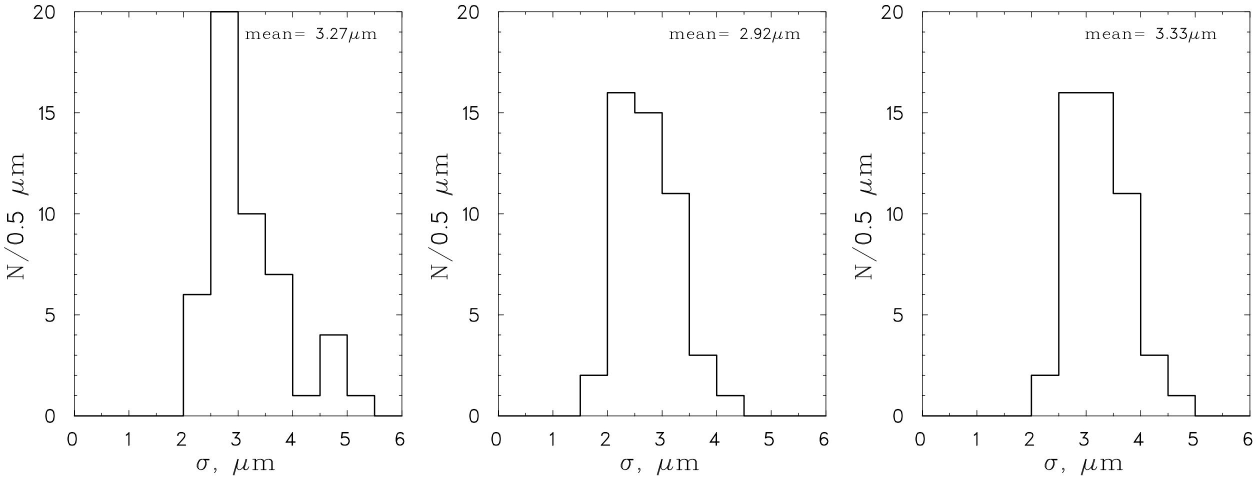


Figure 7: Precision of positioning of wire in 48 DC planes for pad sides (left frame), center of chambers (center) and readout sides (right frame)