Using the cathode surface of straw tube for measuring the track coordinate along the wire and increasing rate capability

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Publications:

Using the cathode surface of straw tube for measuring the track coordinates along the wire
V.A. Baranov, V.A. Chekhovskiy, N.P. Kravchuk, A.S. Korenchenko, N.A. Kuchinskiy, N.V. Khomutov, S.A. Movchan, V.S. Smirnov, F.E. Zyazyulya . May 2011. 5 pp.
Published in Instrum.Exp.Tech. 55 (2012) 26-28
e-Print: arXiv:1105.2258

The use of a segmented cathode of a drift tube for designing a track detector with a high rate capability
N.A. Kuchinskiy, V.A. Baranov, V.N. Duginov, F.E. Zyazyulya, A.S. Korenchenko, A.O. Kolesnikov, N.P. Kravchuk, S.A. Movchan, A.I. Rudenko, V.S. Smirnov, N.V. Khomutov, V.A. Chekhovskiy. Oct 18, 2013. 5 pp.
Published in Instrum.Exp.Tech. 57 (2014) 5, 553-557
e-Print: arXiv:1310.5065

2-D straw detectors with high rate capability
N.A. Kuchinskiy, V.A. Baranov, V.N. Duginov, F.E. Zyazyulya, A.S. Korenchenko, A.O. Kolesnikov, N.P. Kravchuk, S.A. Movchan, A.I. Rudenko, V.S. Smirnov, N.V. Khomutov, V.A. Chekhovskiy et al.. Feb 18, 2015. 16 pp.
e-Print: arXiv:1502.05363

JINR (Dubna), NC PHEP BSU (Minsk)

The detectors which are based on thin wall straws with a diameter from 4 to 10 mm are widely used today as coordinate detectors in HEP experiments.

Straw tube detector is a gas filled counter with a central wire (anode) placed along the axis of a thin-walled cylinder (cathode).

The advantages of straw detectors:

- high spatial 2D resolution obtained from drift time
- small amount of material on the path of particles
- modularity, design simplicity
- low cost
- self sufficiency

Traditional methods to measure the longitudinal coordinate:

- method of current division (2% of length); non-uniformity
- direct measurement of the delay between pulses from the anode wire ends (2 cm for 2 m length); short time, noises
- charge ratio method for external cathode strips or pads; extra material
- stereo method; more layers necessary

Traditionally straw tubes are manufactured by winding a Mylar tape on a rod.

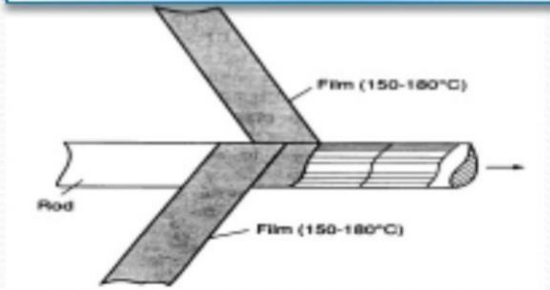
The new method of ultrasonic welding allows us to use various cathode patterns cut of the inner metal layer before welding.

We started with applying a «double wedge» method used before in some experiments for planar detectors.

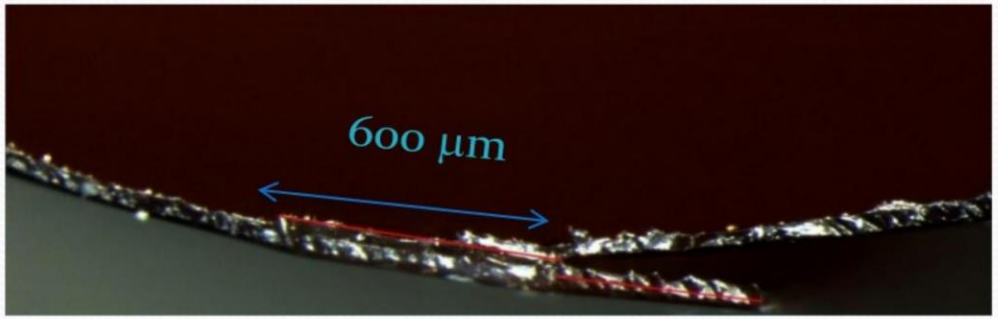
The position of the fired segment is found by one of the traditional methods. The longitudinal coordinate inside the segment is found from the charge ratio.

Ultrasonic welding of straws

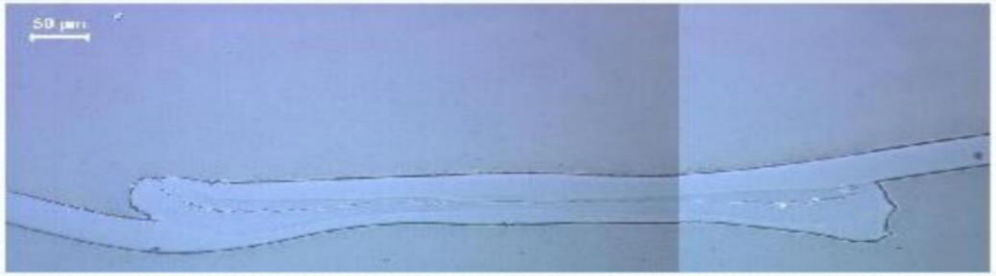
"Classical" straw winding



Microscope pictures of a straw cross- section for quality control of the weld

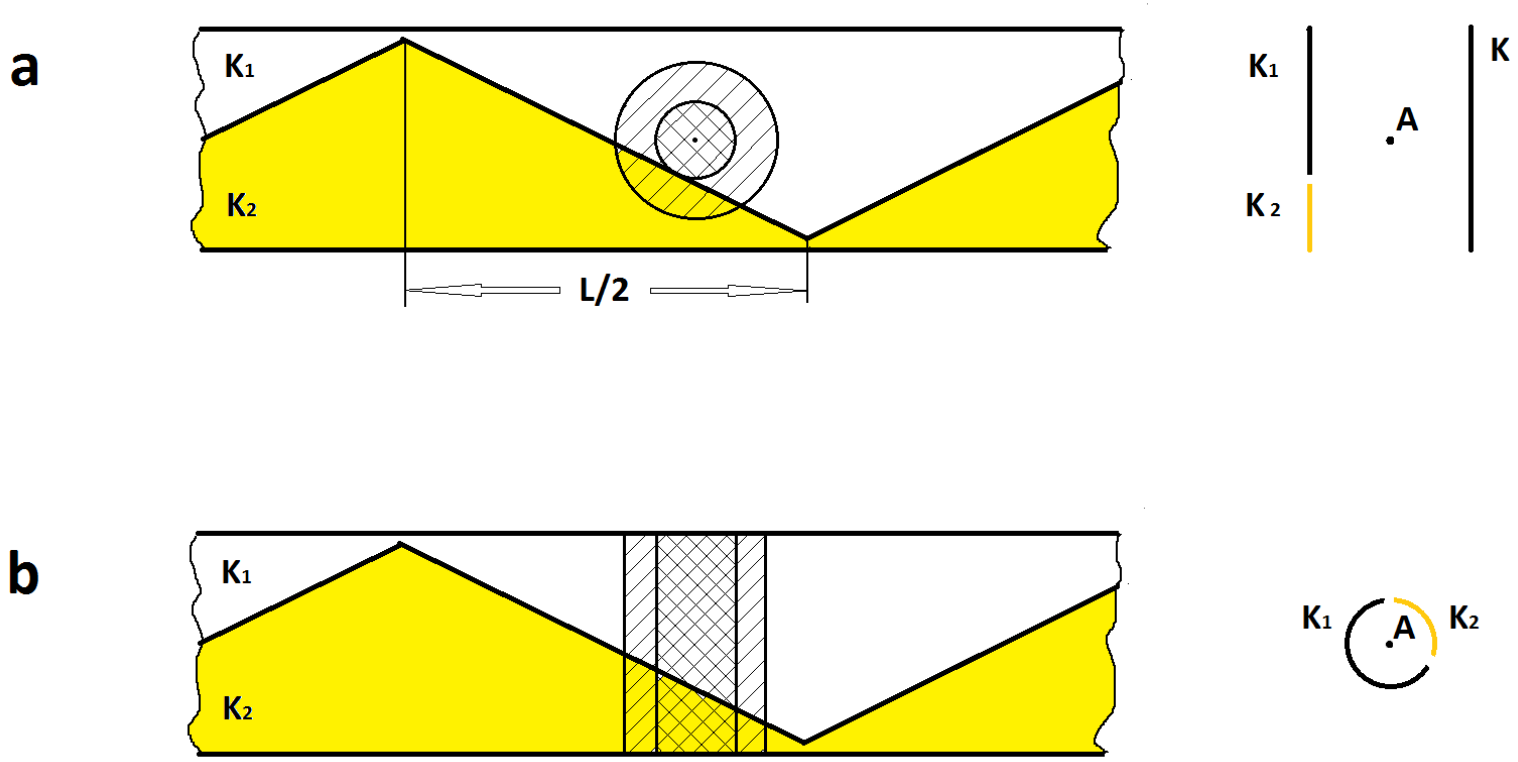


NA62 Ultrasonic welding (Metalized PET)

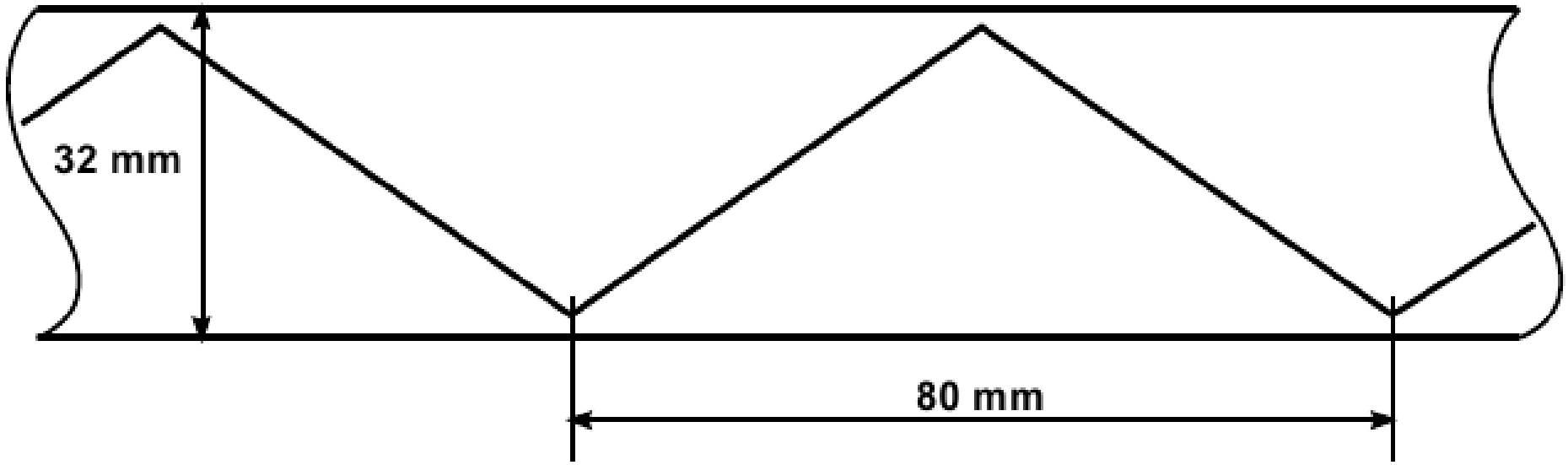


Delicate tuning of production parameters for welding

Double Wedge



a. Planar drift cell with a periodical pattern on the cathode.
b. Unrolled straw tube cathode surface with a double-wedge periodical pattern

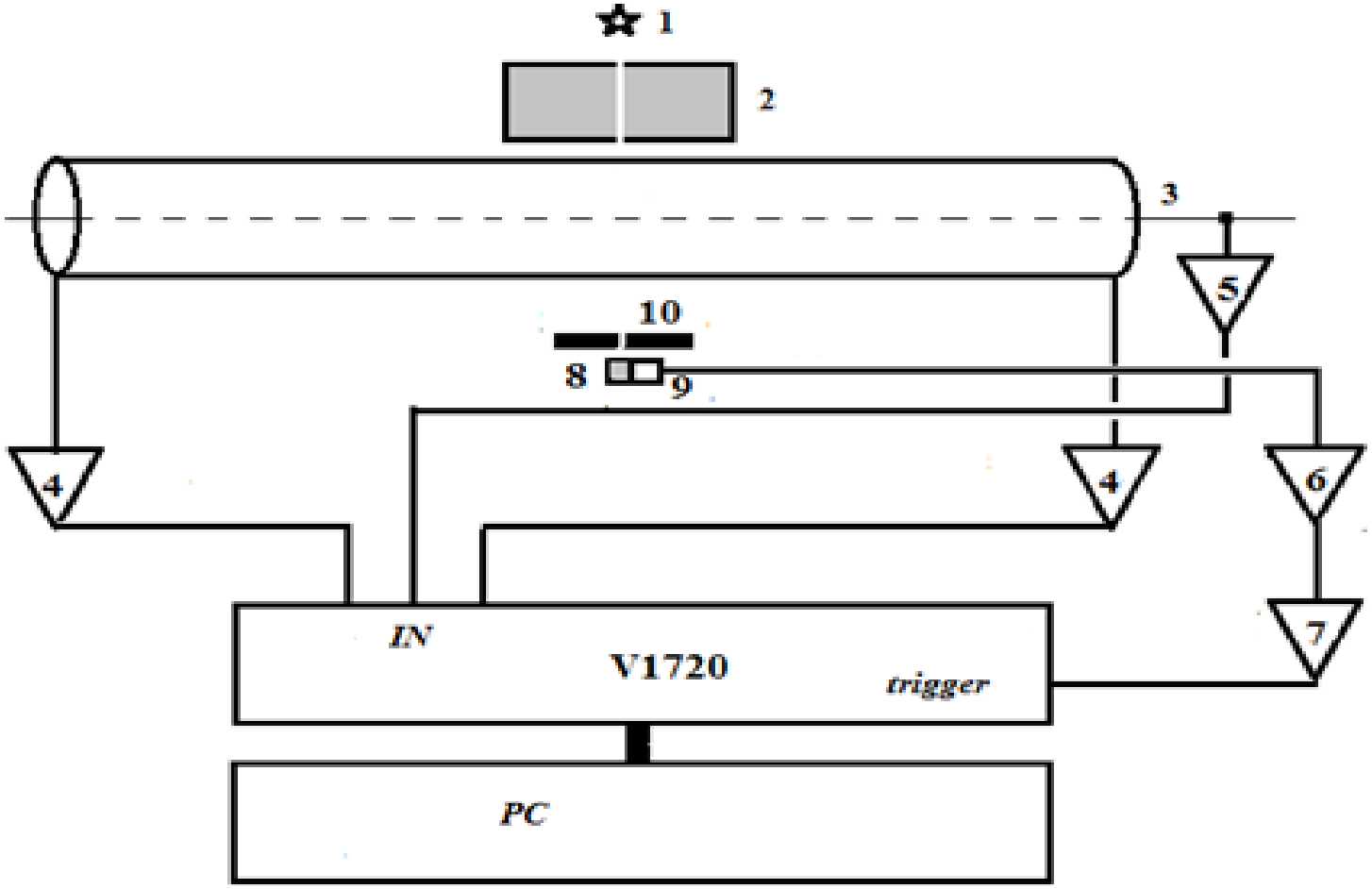


Unfolded cathode surface electrically separated into two zigzag stripes

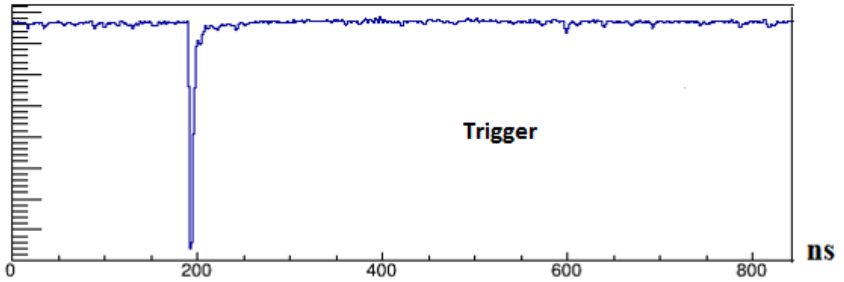
The parameters common for our straws:

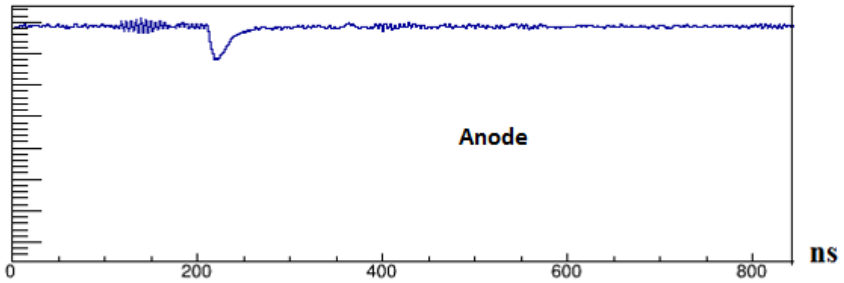
- Anode: Ø 20-30 μm, W (Au coated)
- Cathode: Ø 10 mm, 20-30 μm Mylar (Cu + Au, C coated)
- + HV is applied to the anode
- The cathodes are grounded via amplifiers
- Working gas: 70% Ar + 30% CO_2 at normal pressure
- Radioactive source: ^{90}Sr

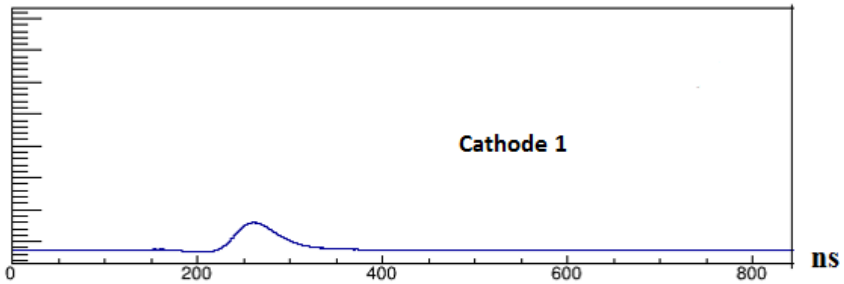
- Z – the coordinate along the wire
- X – the coordinate perpendicular to the wire

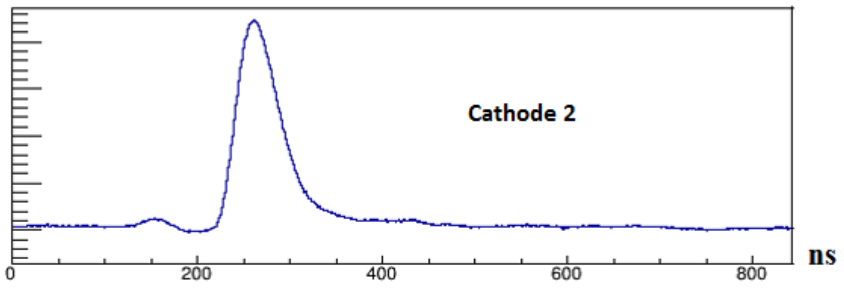


The test measurement set-up: 1 - ^{90}Sr, 2 – lead collimator (Ø 2 mm), 3 – anode, 4 – cathode amplifiers, 5 –anode amplifier, 6 – SiPM amplifier, 7 – discriminator, 8 – scintillator counter (2x2x5 mm^3), 9 – SiPM, 10 – slit collimator (1x5 mm^2).

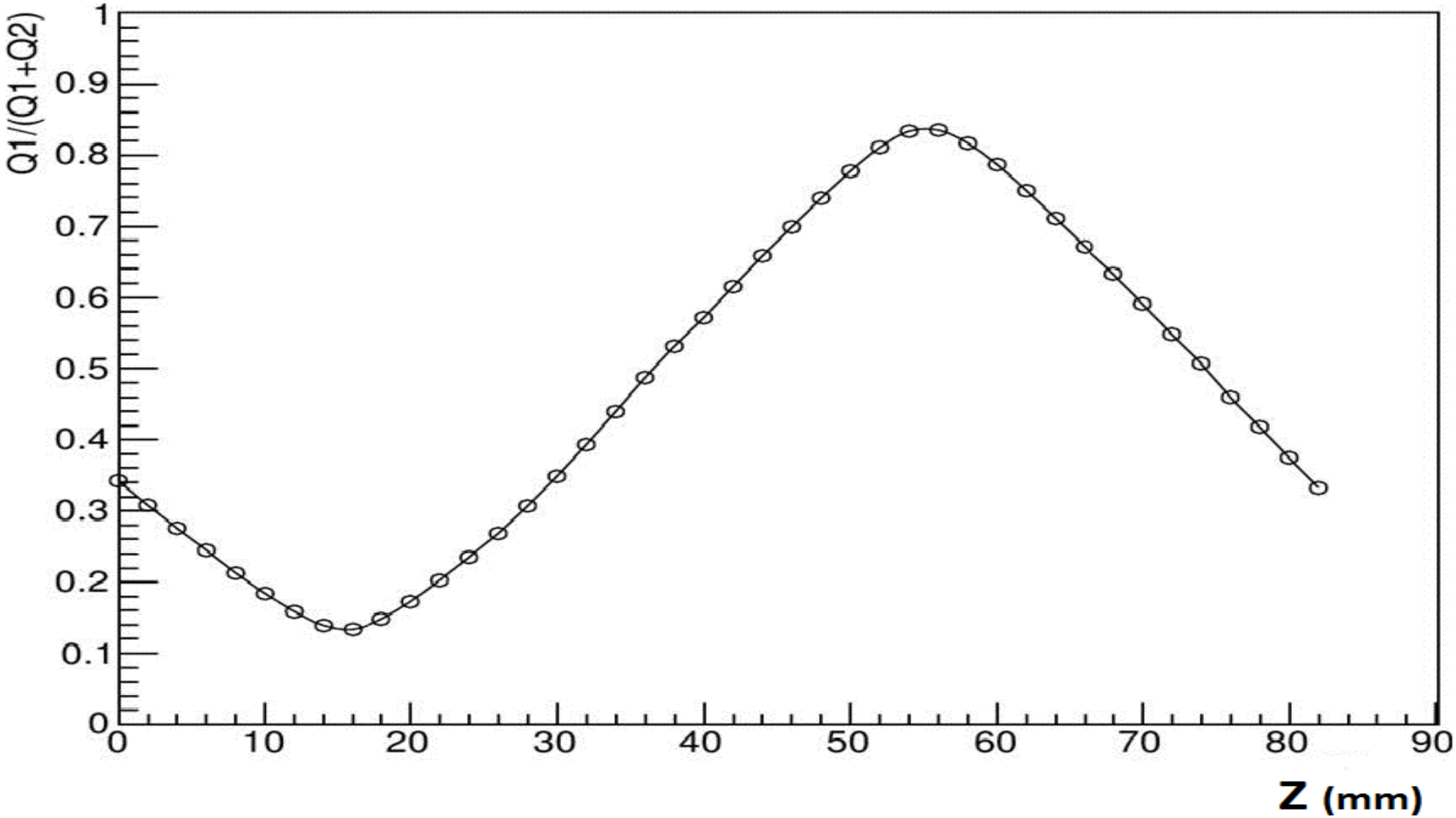




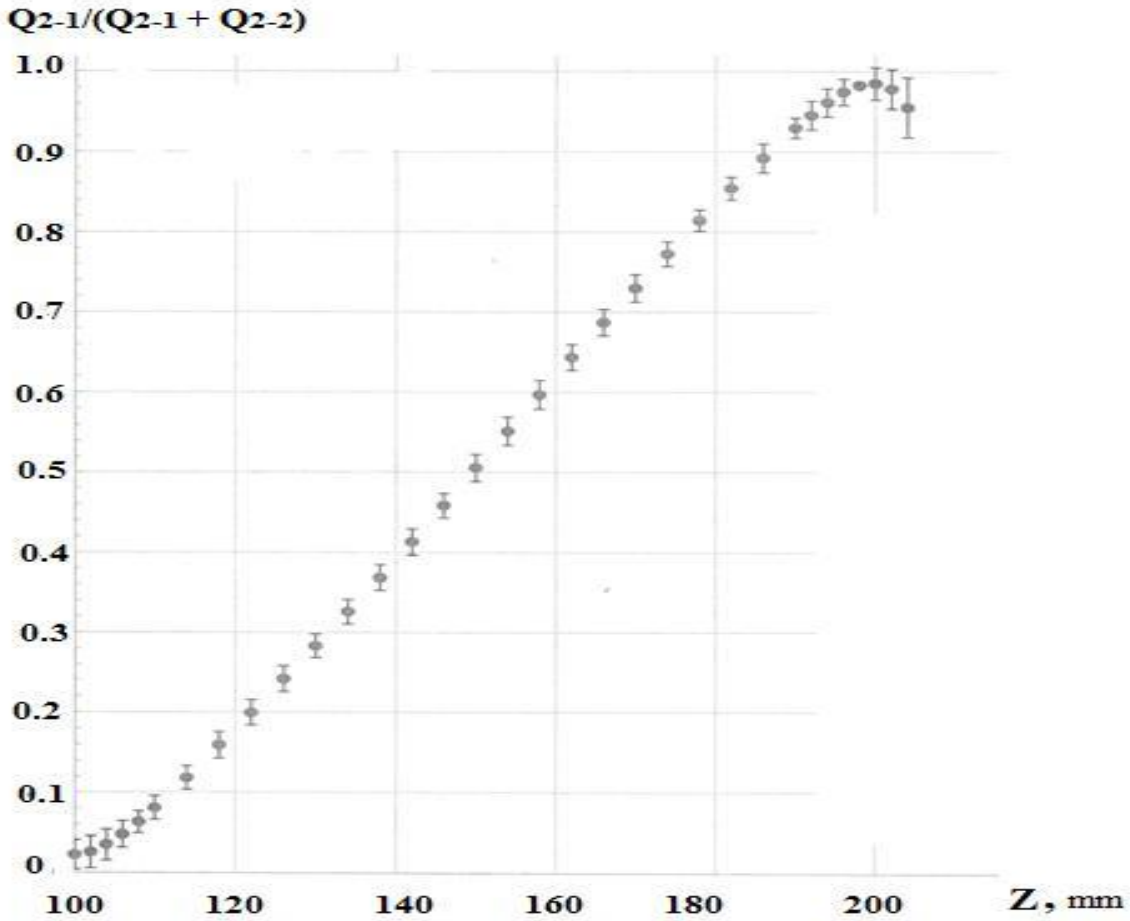




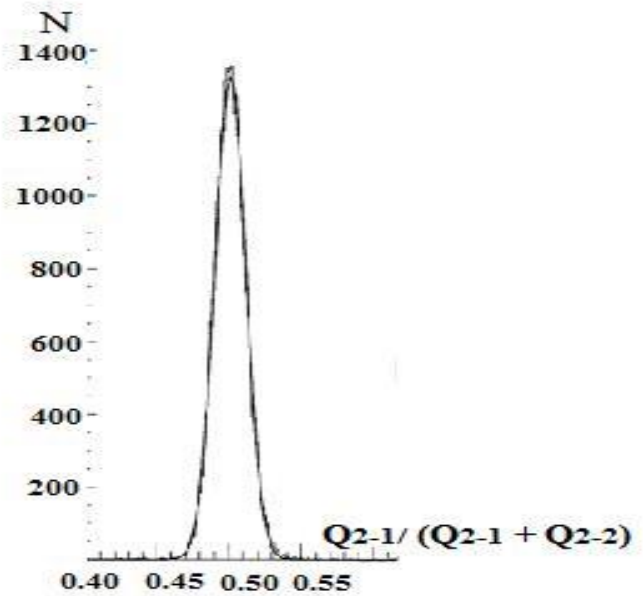
Typical signals for a straw tube with a cathode divided into two zones



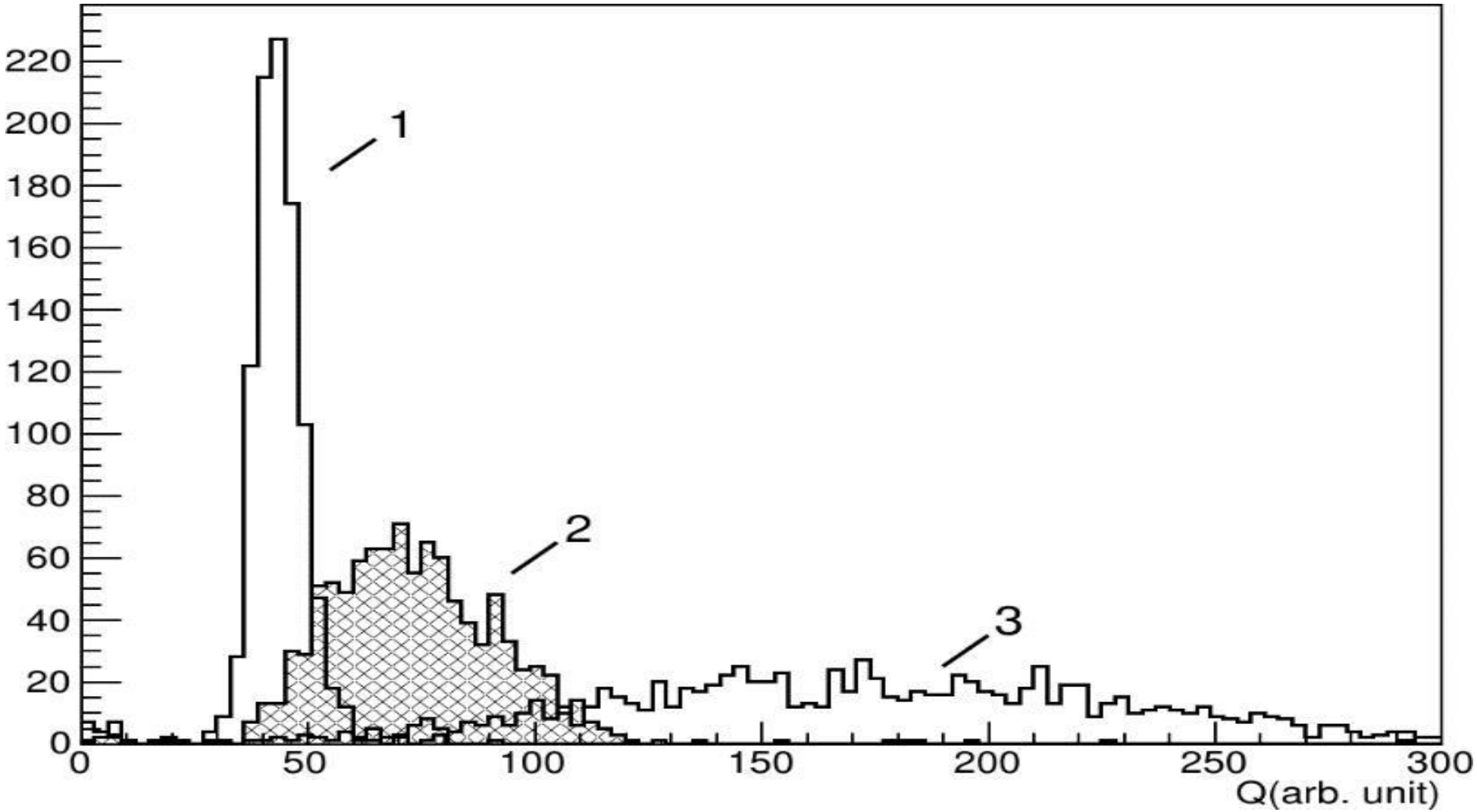
The ratio of the one strip induced charge Q1 to the total induced charge Q1+Q2 as a function of radioactive source position along the straw



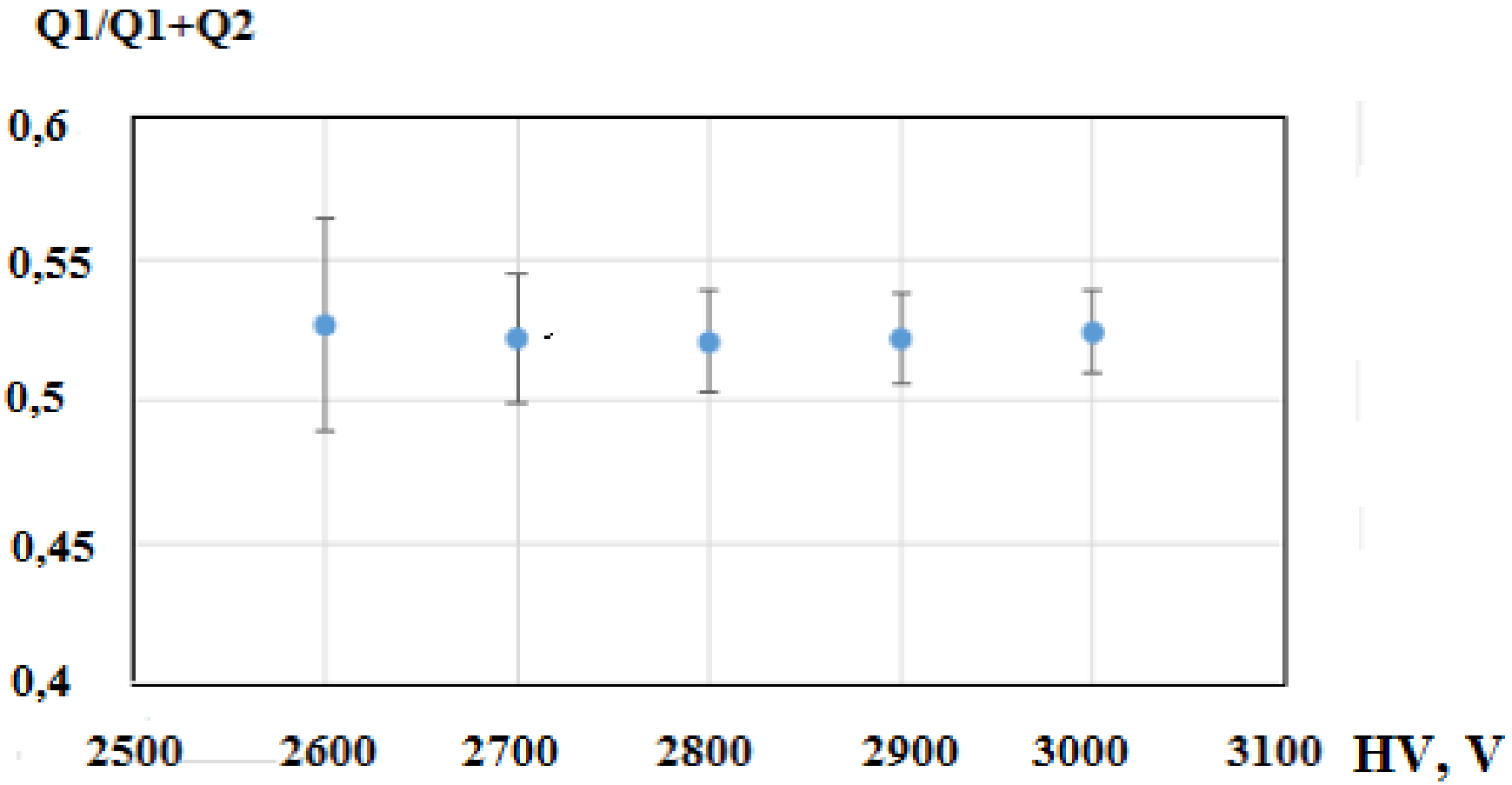
Charge ratio vs Z



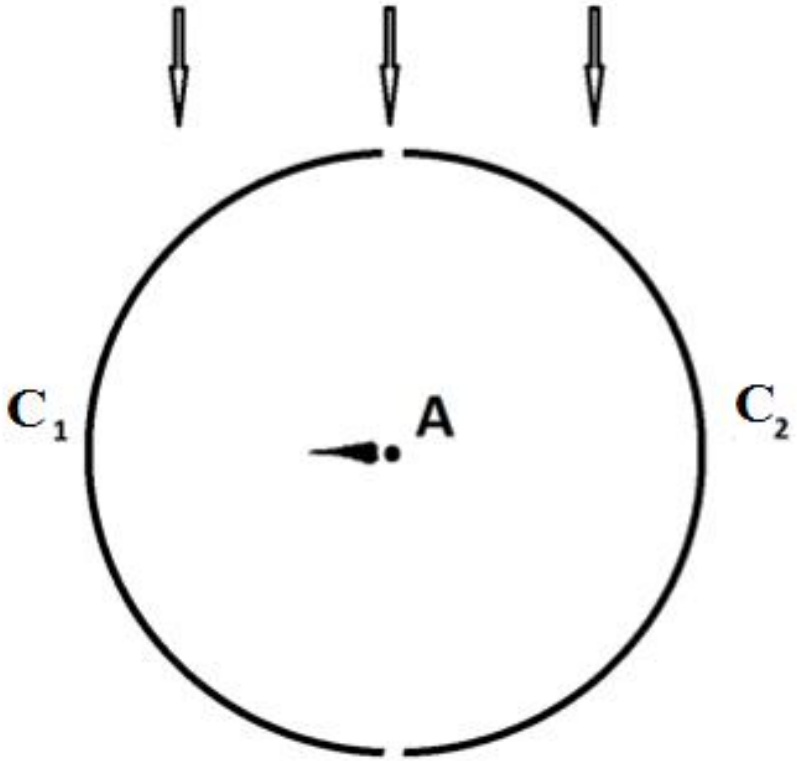
Charge ratio distribution for z = 150 mm



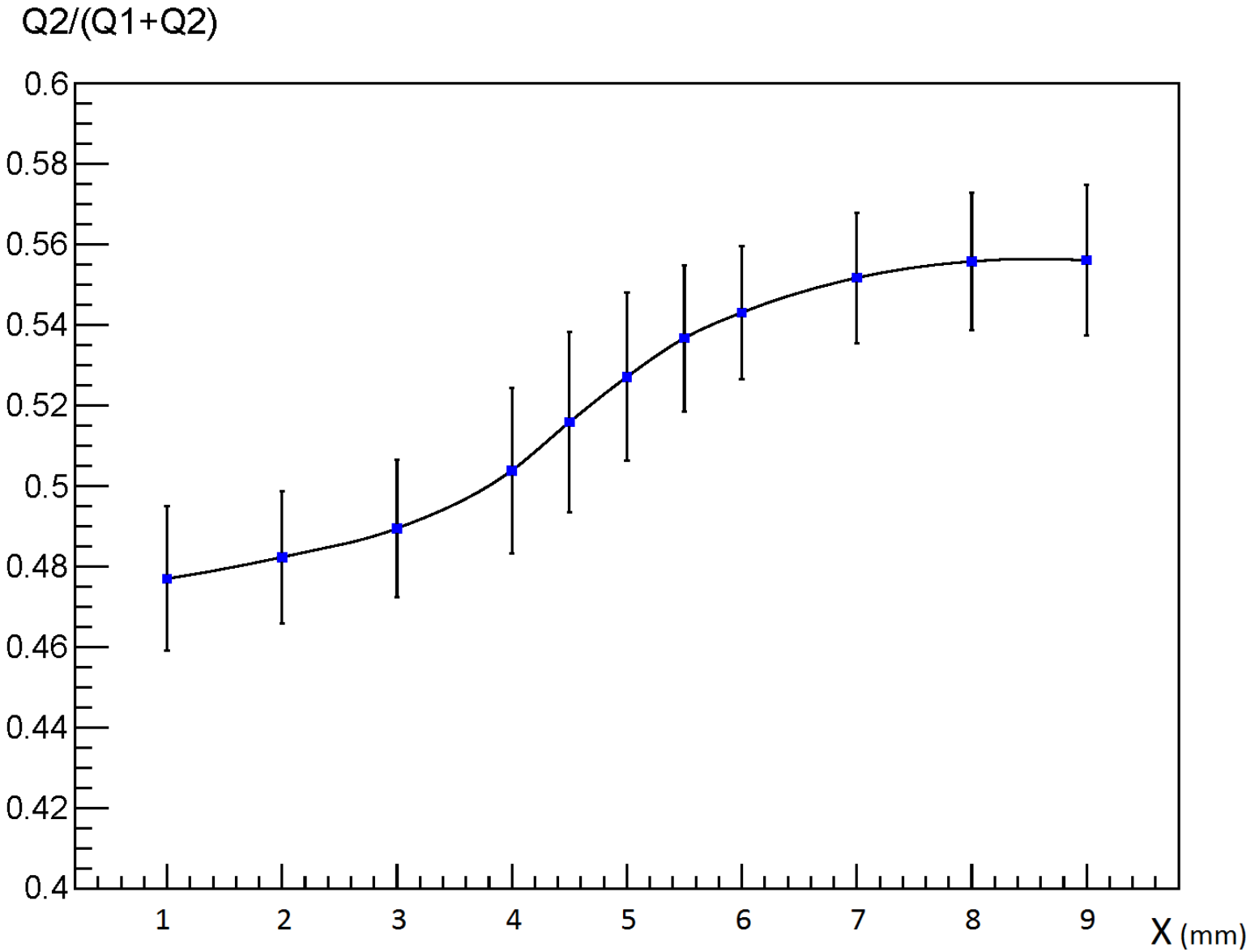
Cathode amplitude spectra for different voltages: 2650V (1), 2725V (2), 2800V (3)



Charge ratio vs straw high voltage for a fixed Z



A scheme of test measurement for a straw detector with a cathode cut along the cylinder generatrix into two zones C_1 and C_2


Q2/(Q1+Q2)
0.6
0.58
0.56
0.54
0.52
0.5
0.48
0.46
0.44
0.42
0.4
1
2
3
4
5
6
7
8
9
X (mm)

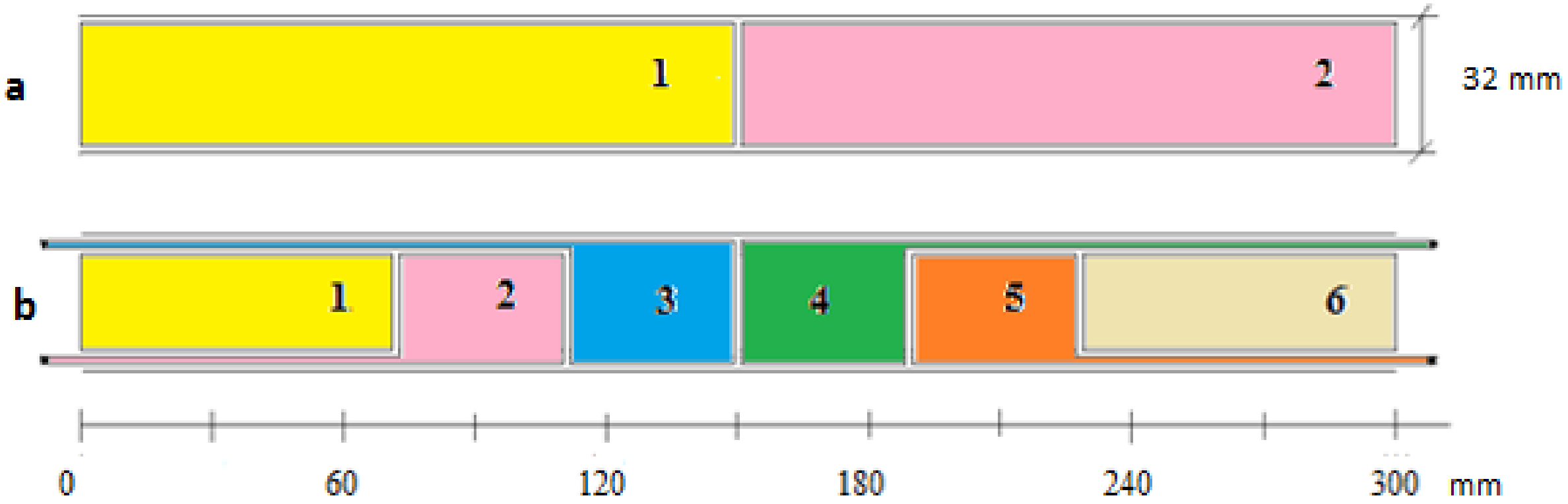
Other factors affecting coordinate determination accuracy in our tests :

- Geometrical (mechanical) inaccuracy (0.2 mm)
- Source beam size = 2 mm
- Electronics (different amplification in different channels)
- Software processing algorithms
- Cosmics (random coincidences)
- Ambiguity
- Zigzag skew angle: less accuracy for smaller angles (longer period)

Estimated Z determination accuracy ≈ 0.8 mm

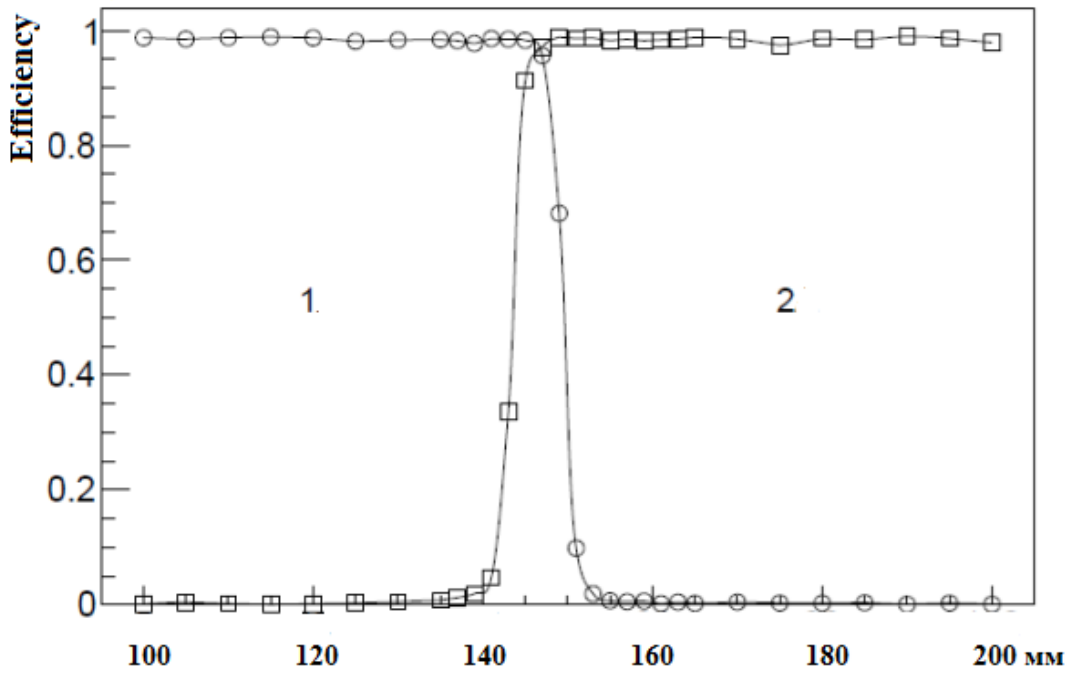
Methods to increase straw detector rate capability:

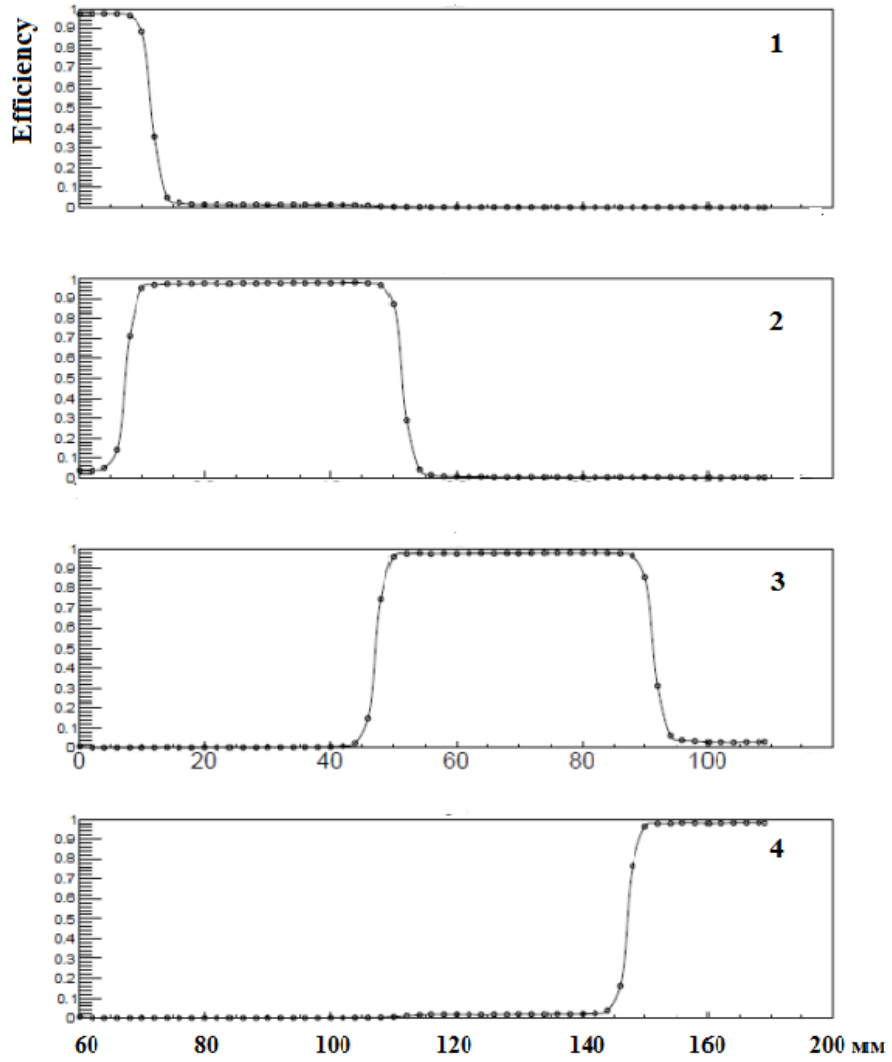
- use a gas with a fast drift speed
- improve parameters of the electronics
- use smaller tube dimensions (diameter, length)
- electrode segmentation



Unfolded tape for making segmented cathodes:

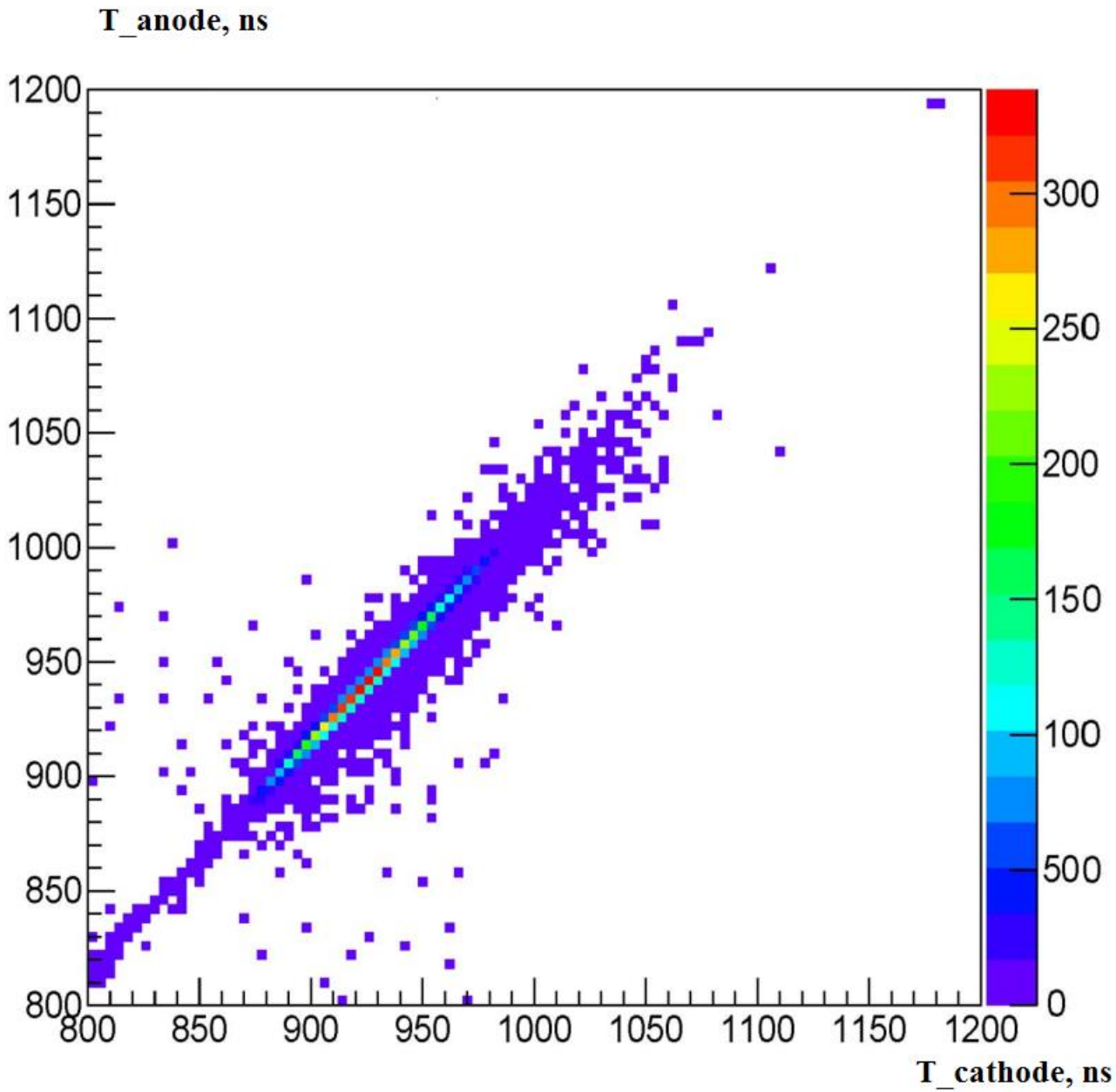
a) 2 segments; b) 6 segments

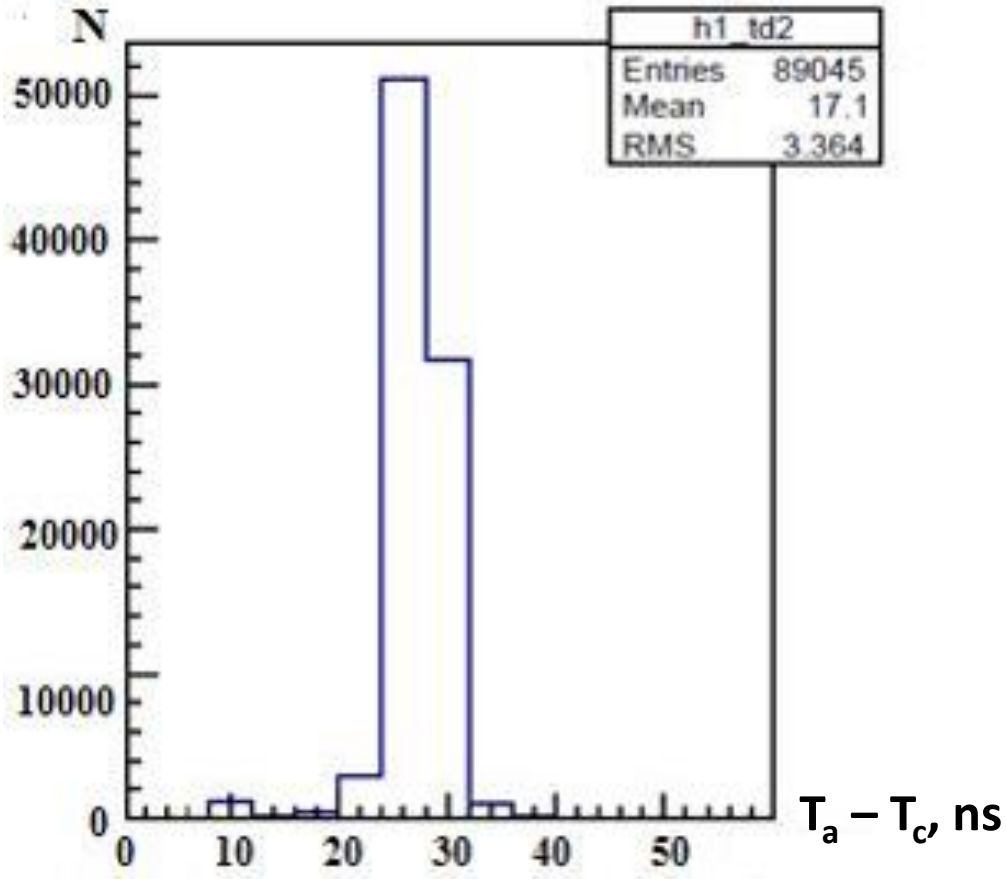




Straw efficiency vs Z for a 2-segment straw and
for 6-segment straw (4 segments out of 6 are shown)

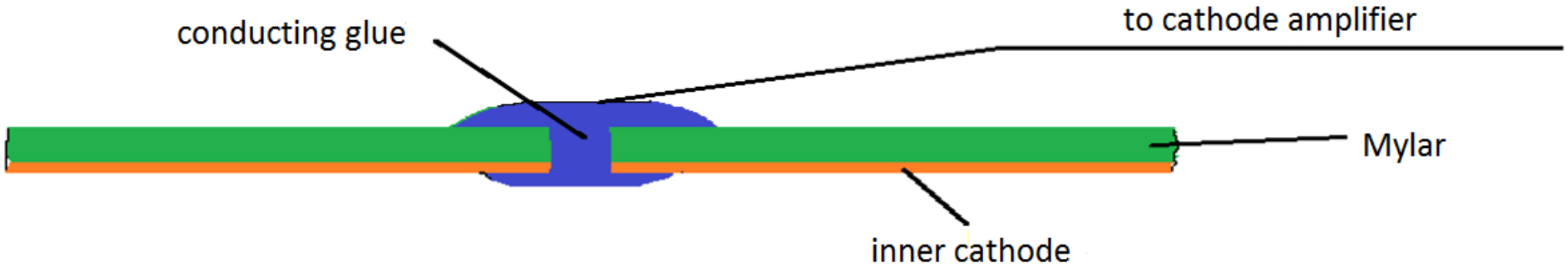
Anode and cathode drift times correlation





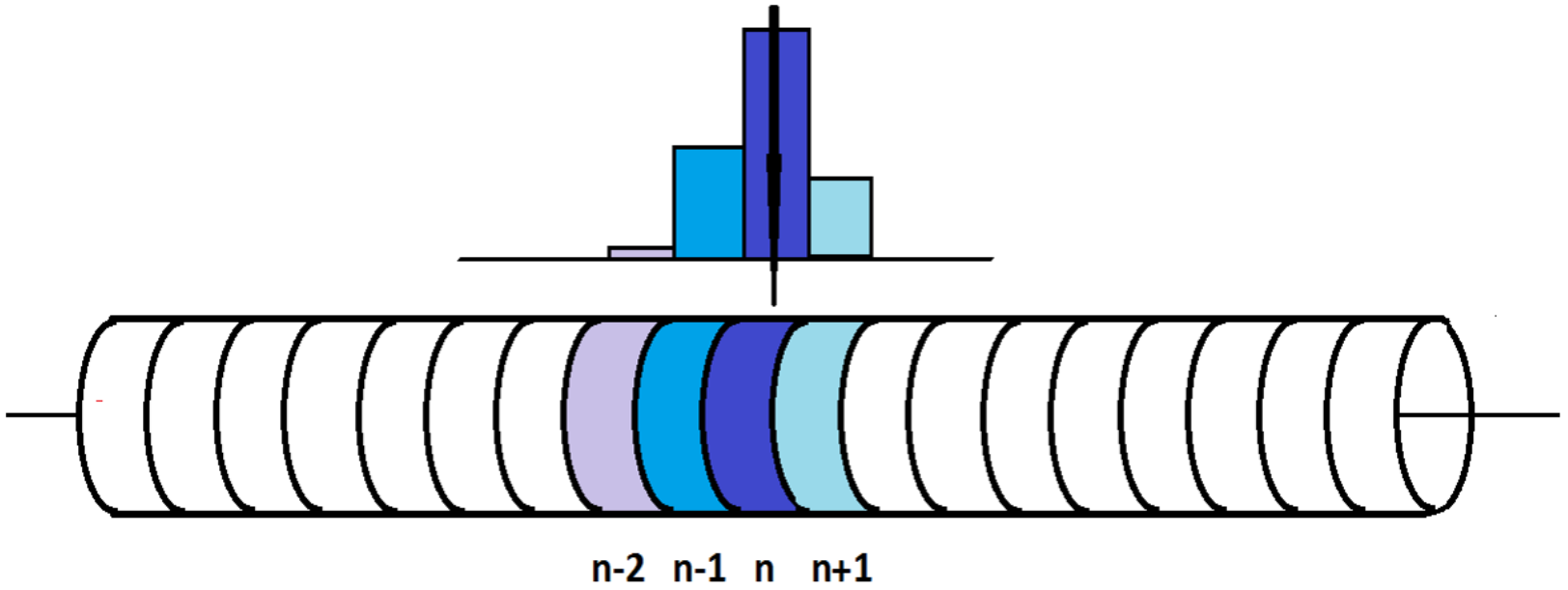
Signal readout:

- through flanges
- by induction coupling between inner and outer electrodes
- via holes in tube walls using conductive glue
-



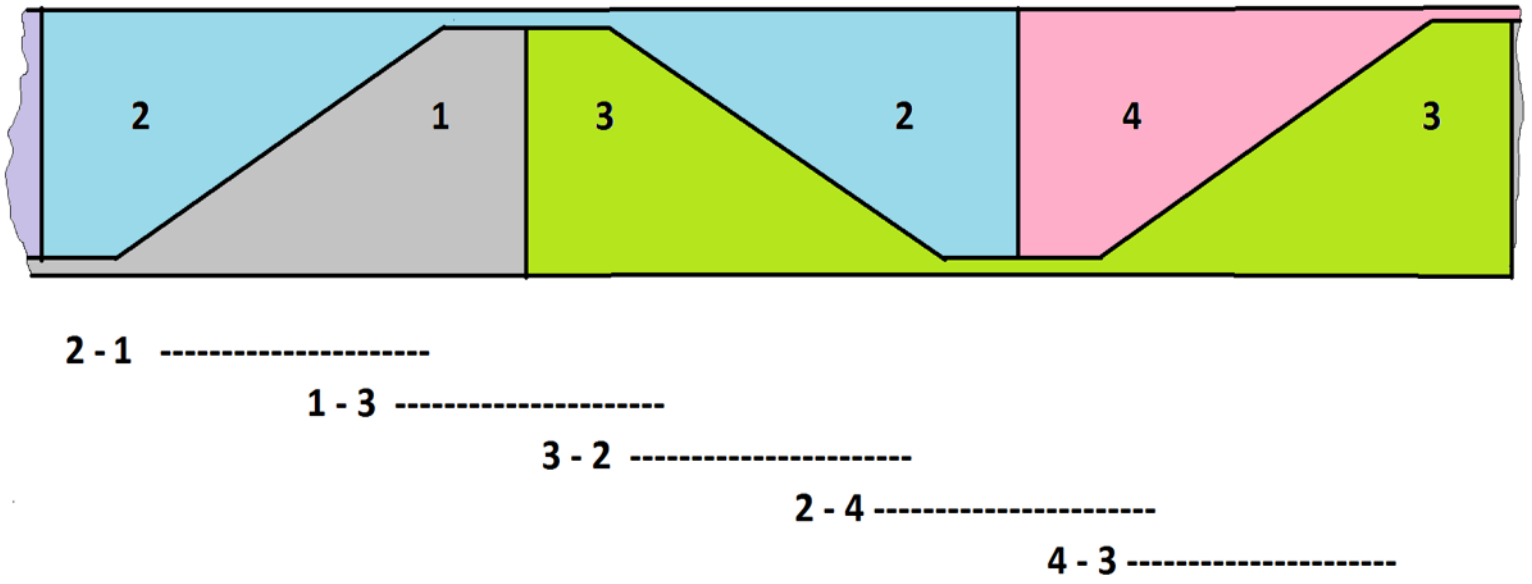
- Use outer electrodes made from a semitransparent material (0,5-1000 Ω/square)

A 15 mm wide zone could be used for Z determination

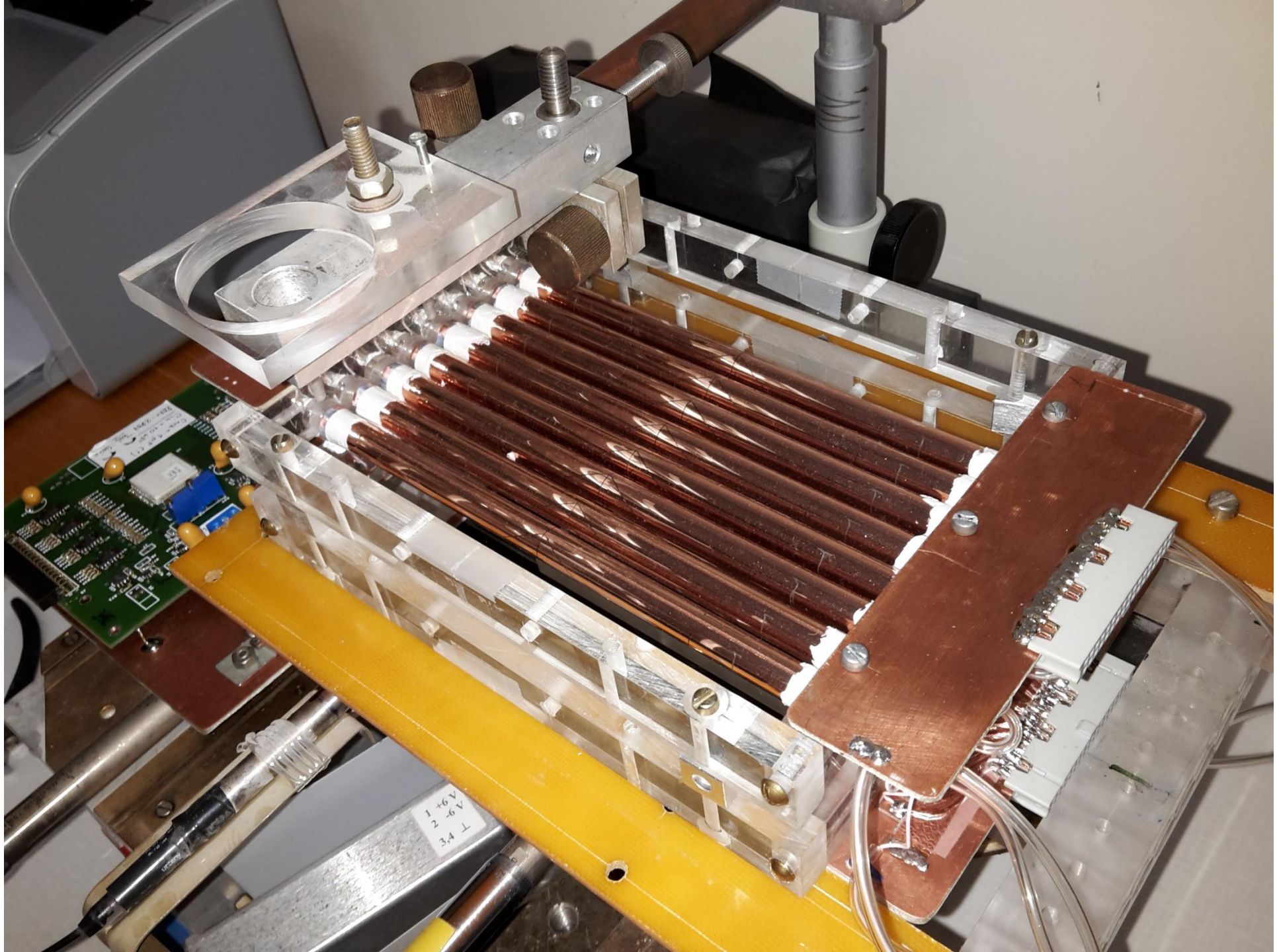


Using COG method for a cathode broken in 5 mm long cylinders

An example of a straw detector optimized for the accuracy of the position measurement along the anode wire, the rate capability, the simplicity of design and low cost



A hit is counted if the signals in two neighboring zones are above the threshold


1 +6 V
2 -6 V
3,4 ⊥

Thank you for your attention!