Study of aging properties of the wire chamber, operating with high-pressure hydrogen, designed for a precision measurement of the μp-capture rate.

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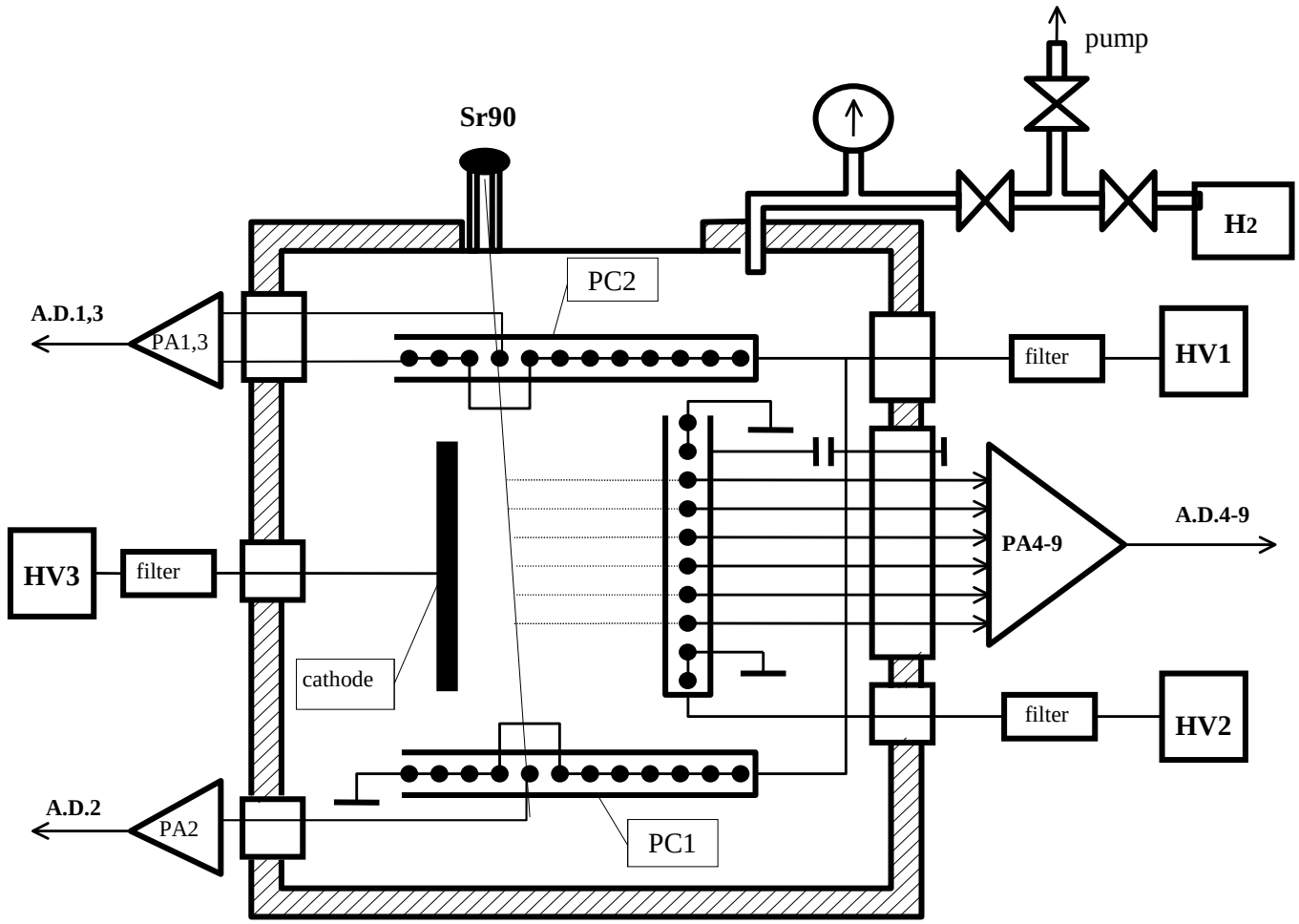
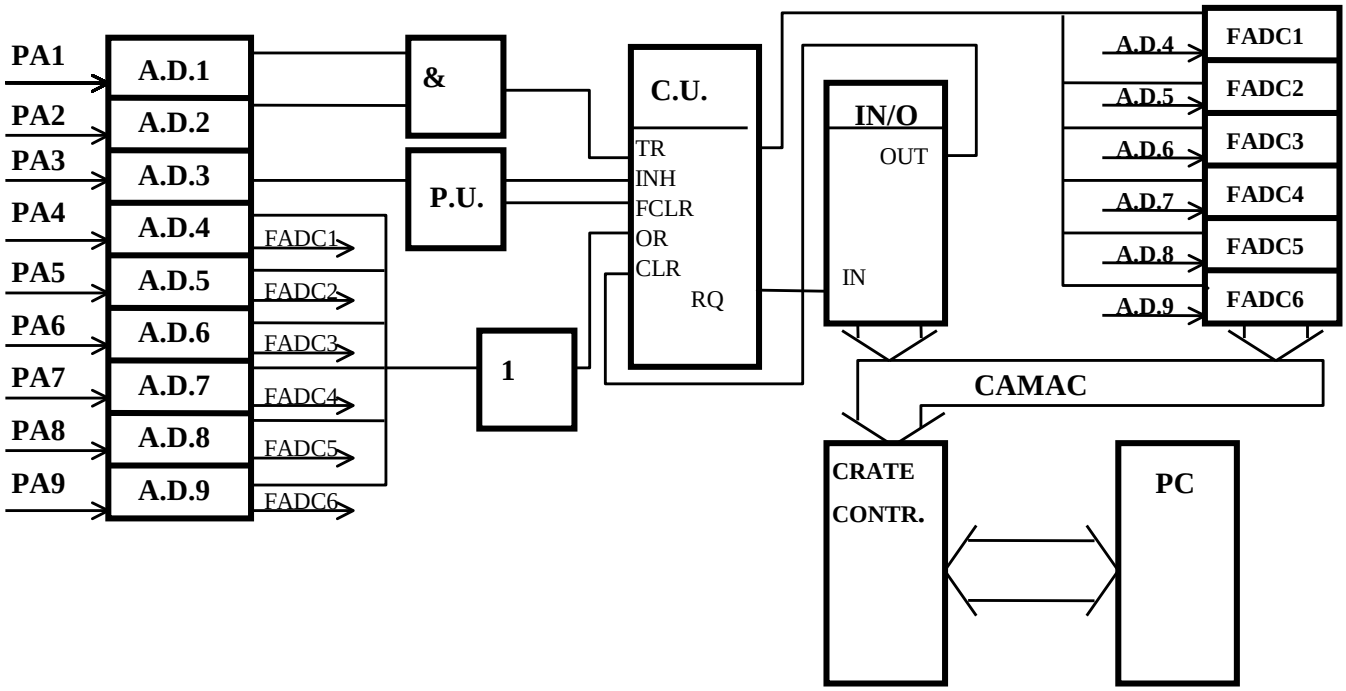
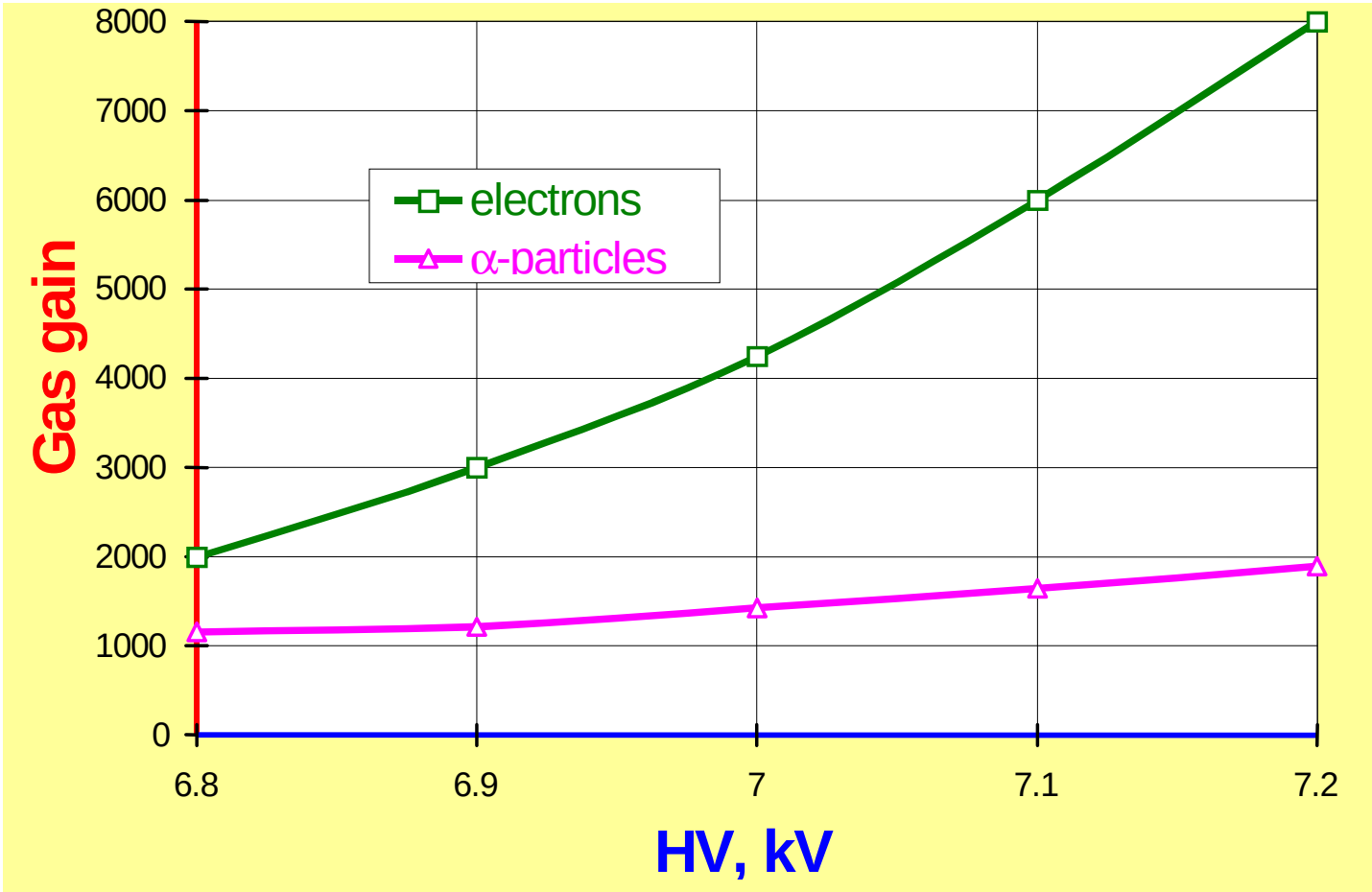
ABSTRACT

The project for high precision studies of the muon capture in hydrogen is based on application of a multi-wire proportional chambers (MWPC) operating in ultra pure deuterium-depleted hydrogen (protium) at high pressure. A special test setup was constructed at PNPI to investigate the MWPC performance at the expected experimental conditions. The chambers were tested inside of the vessel filled with a clean hydrogen at 10 bar pressure. The aging studies of the MWPCs were performed under intense irradiation from the alpha-source (Am^{241}) and beta-source (Sr^{90}). For example, after 45 days of continuous irradiation by alpha-particles with four intermediate gas refillings we did not see any changes in the currents,in the signal shapes, and in the counting rates. It was demonstrated that the MWPCs can operate without degradation at least up to accumulated charges of 0.1 C/cm.wire. These irradiation conditions are much more severe than in the real experiment. The electron microscopic and X-ray analysis of the anode and cathode wires revealed no serious signs of destruction of the wire surfaces. However, in several radiation tests an appearance of the dark currents was observed (up to 10mkA), the nature of which is not yet clearly understood. During the study of the MWPC we have observed the appearance of short duration signals with the amplitudes an order of magnitude larger than of normal signals from the alpha-particles. The number of such signals ("streamers") strongly depends on HV. We shall continue these tests in the future with the goal to obtain more detail information about aging properties of the MWPCs, operating with high-pressure hydrogen.

The test setup for studies of MWPCs and TPCs in hydrogen.







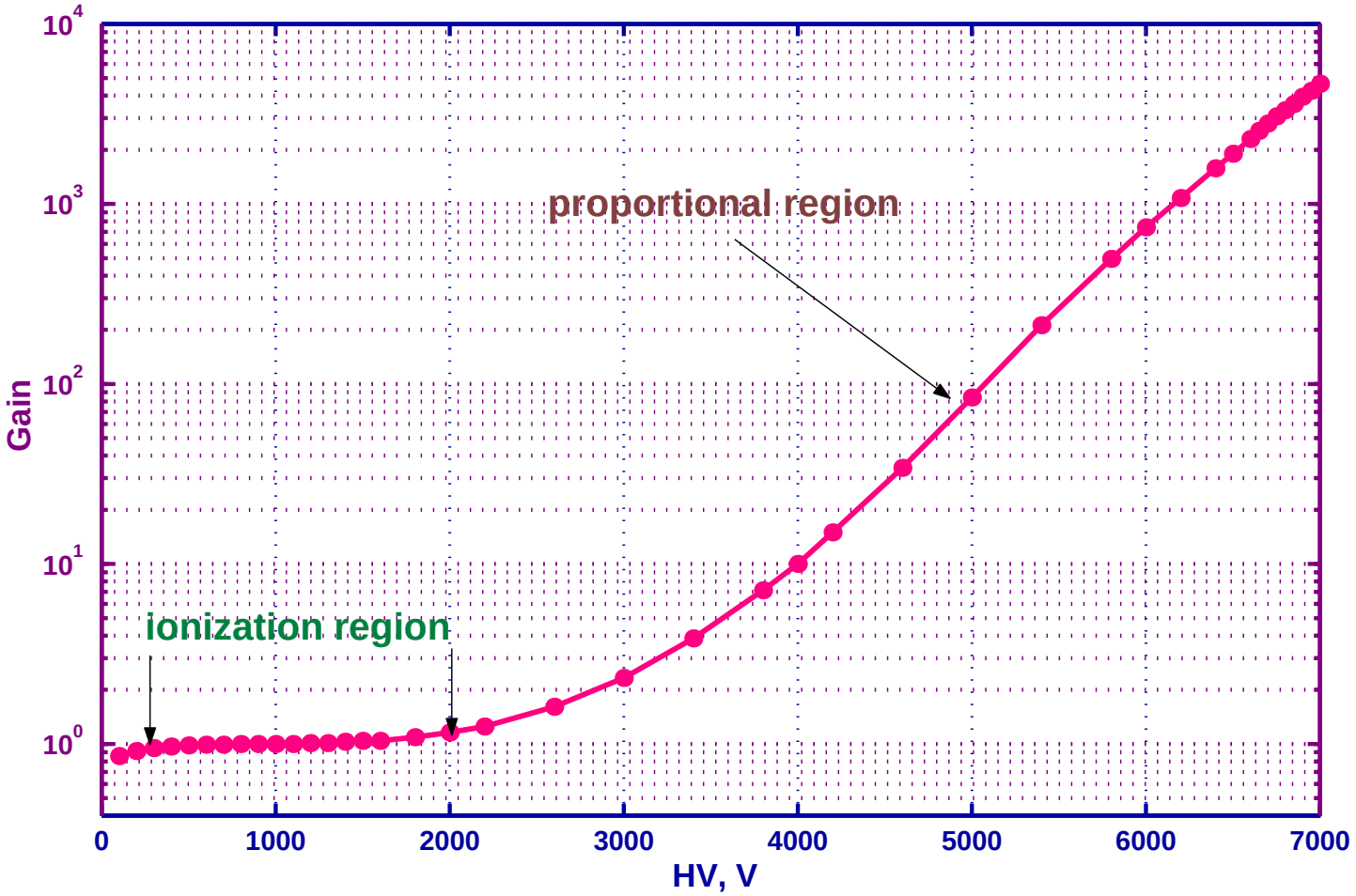
Gas gain vs HV. Measurement with the MWPC operating in 10 bar hydrogen gas irradiated by α- and β-sources. The basic parameters of MWPC are:

Anode wire plane: W(Au) wires, diameter 25 μm, 2mm wire spacing.

Cathode wire plane: Fe wires, diameter 50 μm, 0.5mm wire spacing.

Anode-cathode gaps: 2.5 mm

The MWPC's showed stable operation up to HV=7.2 kV (E=900 kV/cm on the surface of the anode wire) providing the effective gas gain up to $2{\cdot}10^3$ and $8{\cdot}10^3$ while detecting α-particles and relativistic electrons, respectively. The difference in gas gains between α and β-particles is due to the space charge effect.

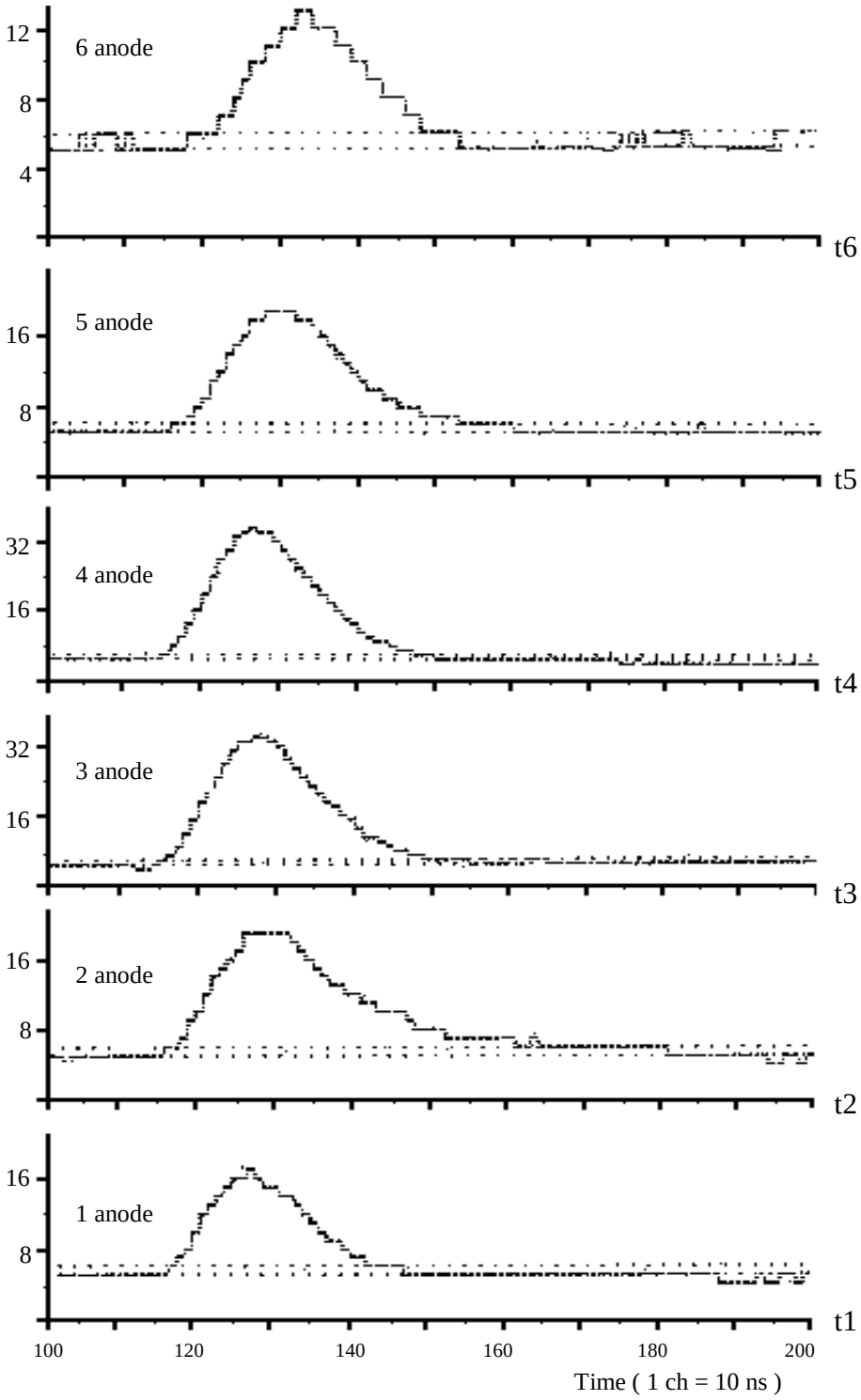


Gas gain vs HV. Measurement with the MWPC operating in 10 bar hydrogen gas irradiated by α-source. The basic parameters of MWPC are:

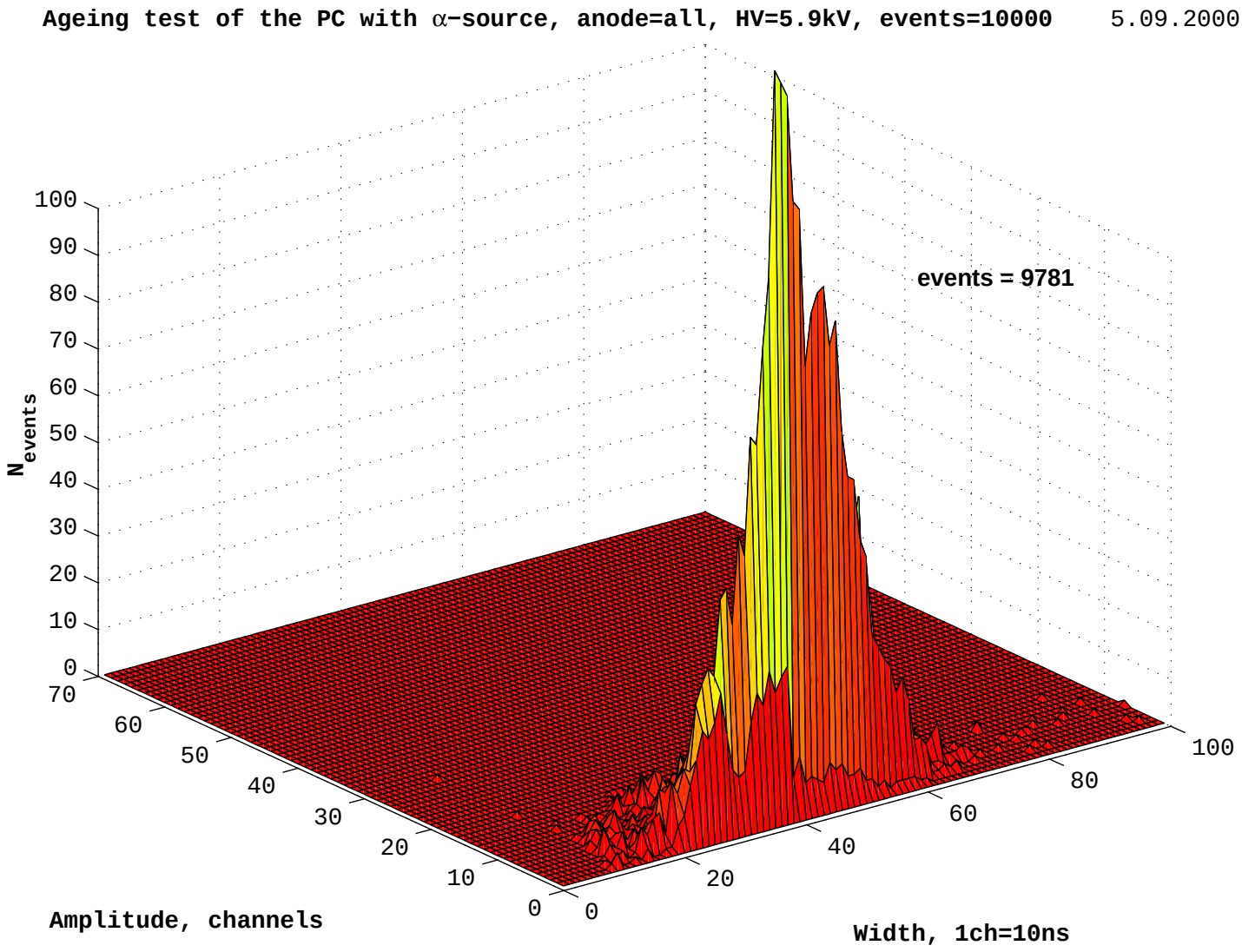
Anode wire plane: W(Au) wires, diameter 25 μm, 4mm wire spacing.

Cathode wire plane: Fe wires, diameter 50 μm, 1mm wire spacing.

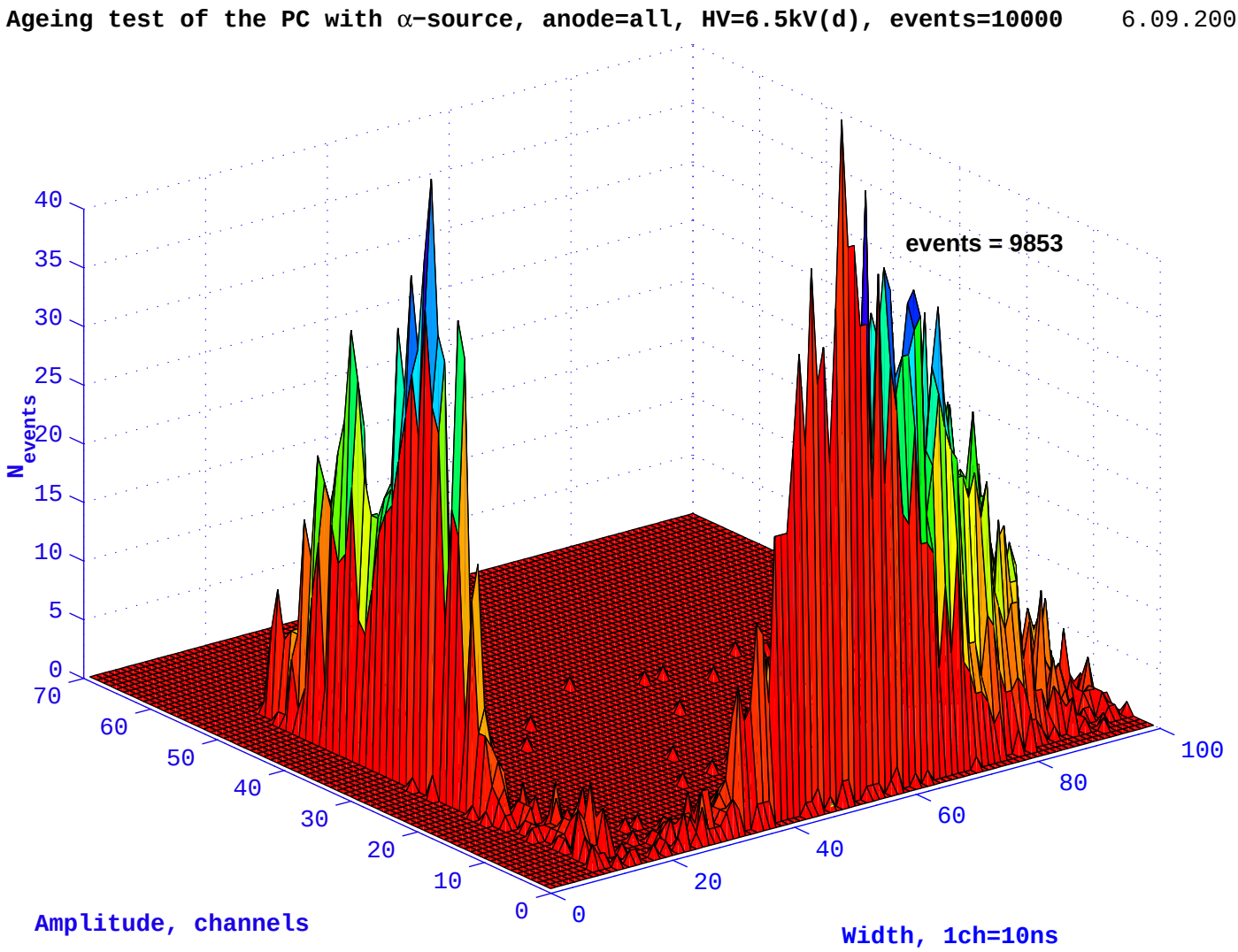
Anode-cathode gaps: 3.5 mm



Sequence of signals from FADC created by a β-particle from Sr^{90} crossing TPC nearly parallel to the anode plane.

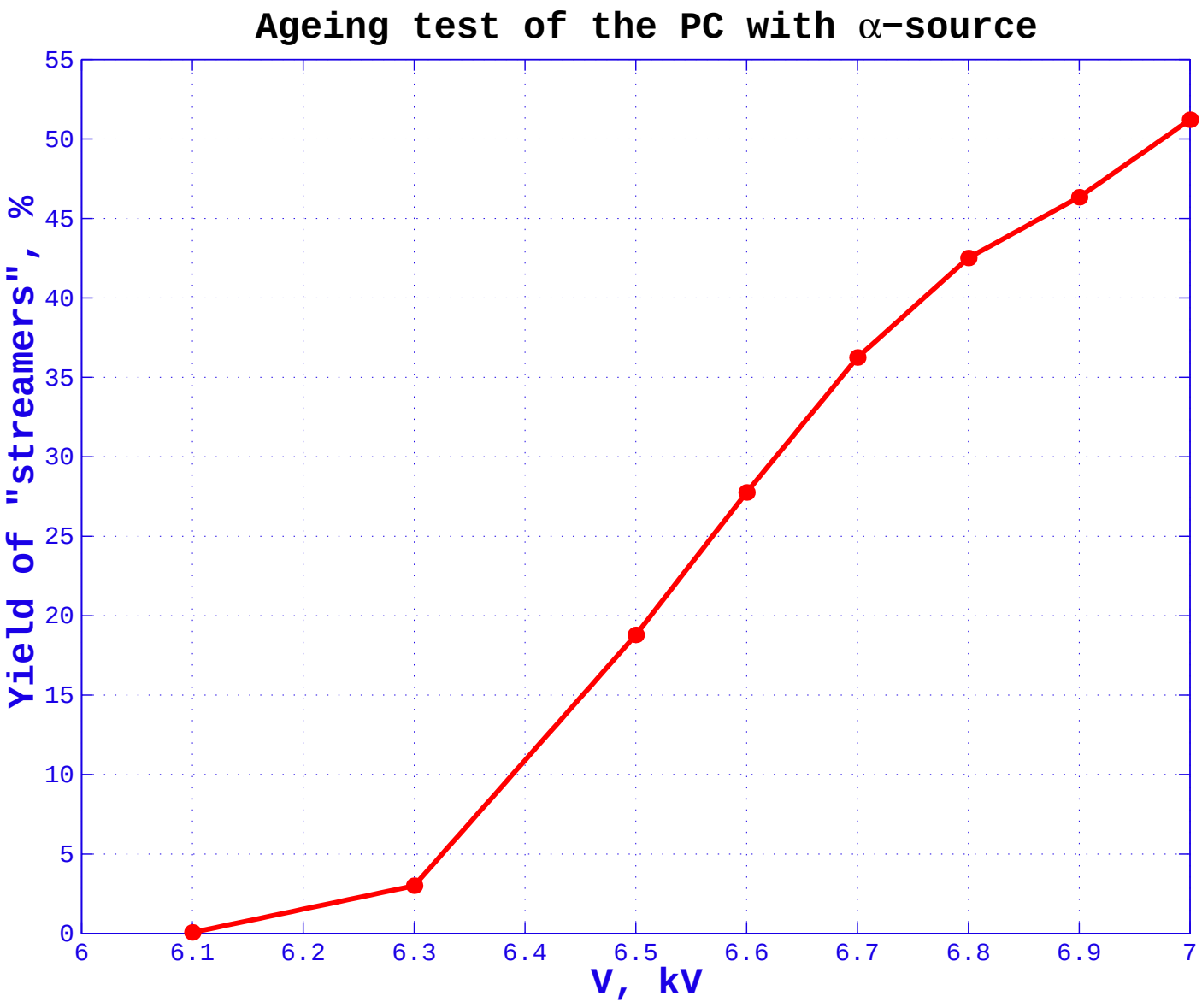


The amplitude-width correlation of the signals from α-source (Am^{241}) at HV=5.9kV.



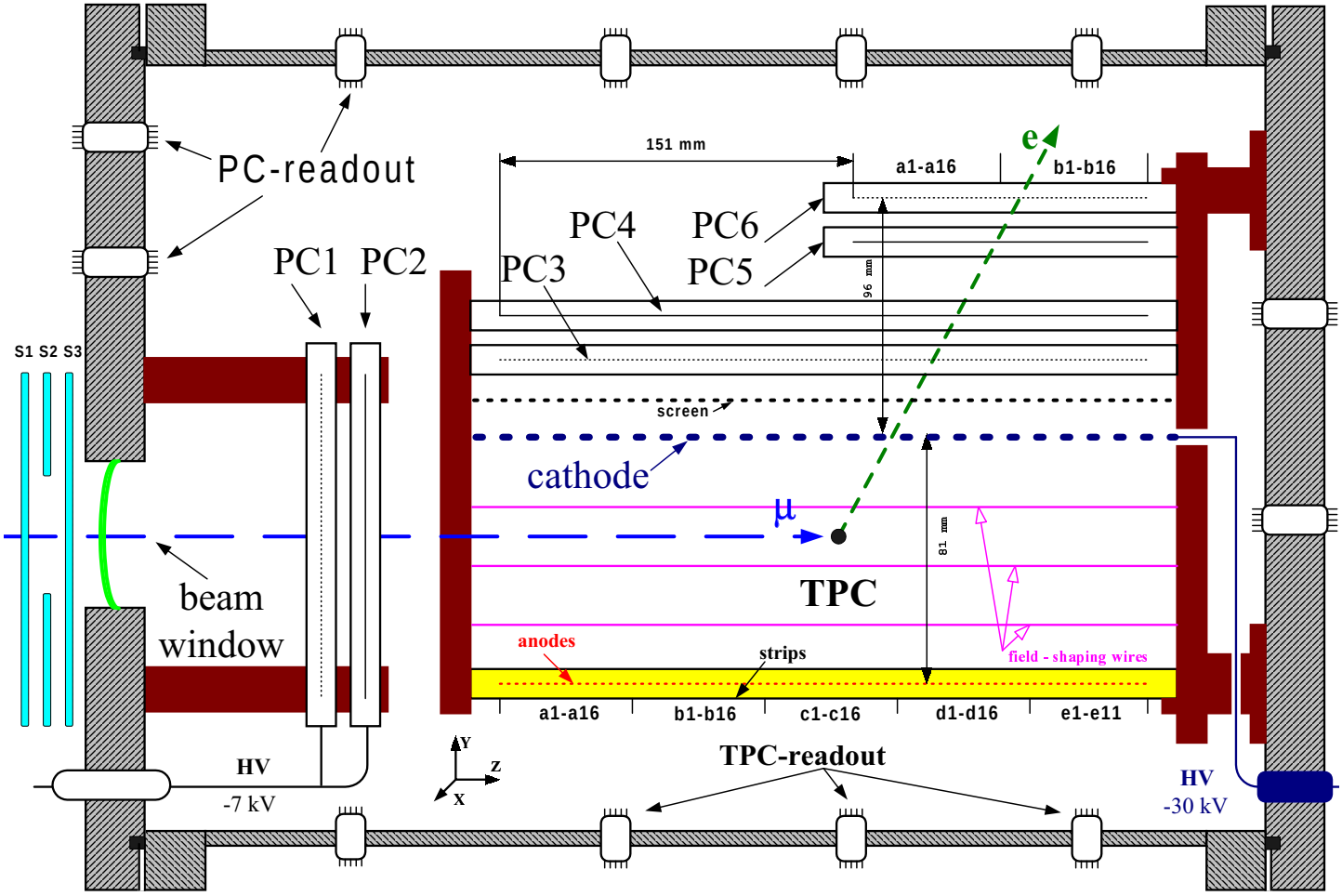
The amplitude-width correlation of the signals from α-source (Am^{241}) at HV=6.5kV.

During the studying of MWPC was observed the appearance of short width signals "streamers" (left region) with amplitude larger then normal signals of α-particles (right region). Their intensity strongly depends on HV. Below 6 kV they are absent, and at 7 kV they contribute $\sim$ 50% of the total number.

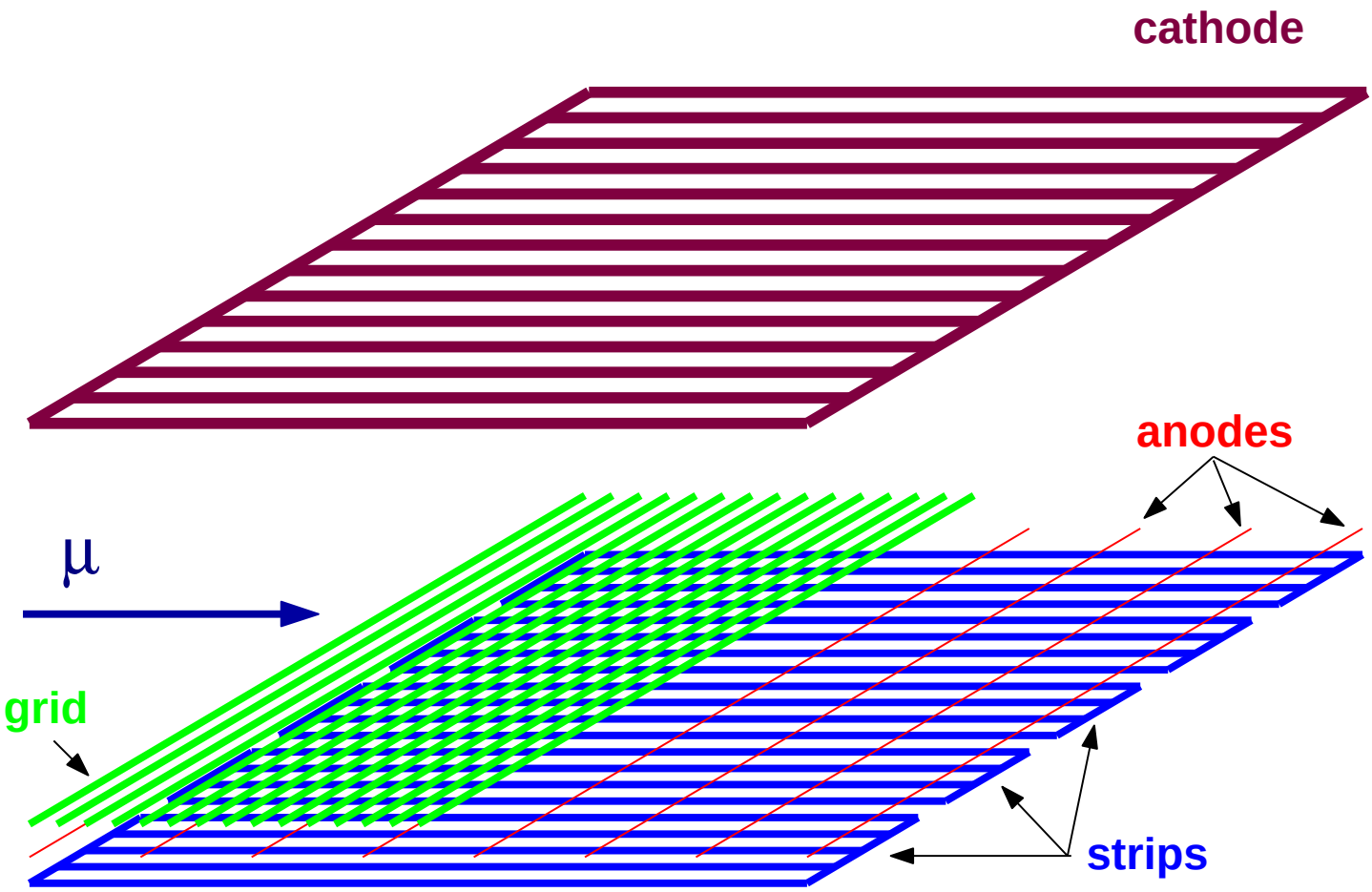


Intensity of the "streamer" signals vs HV.

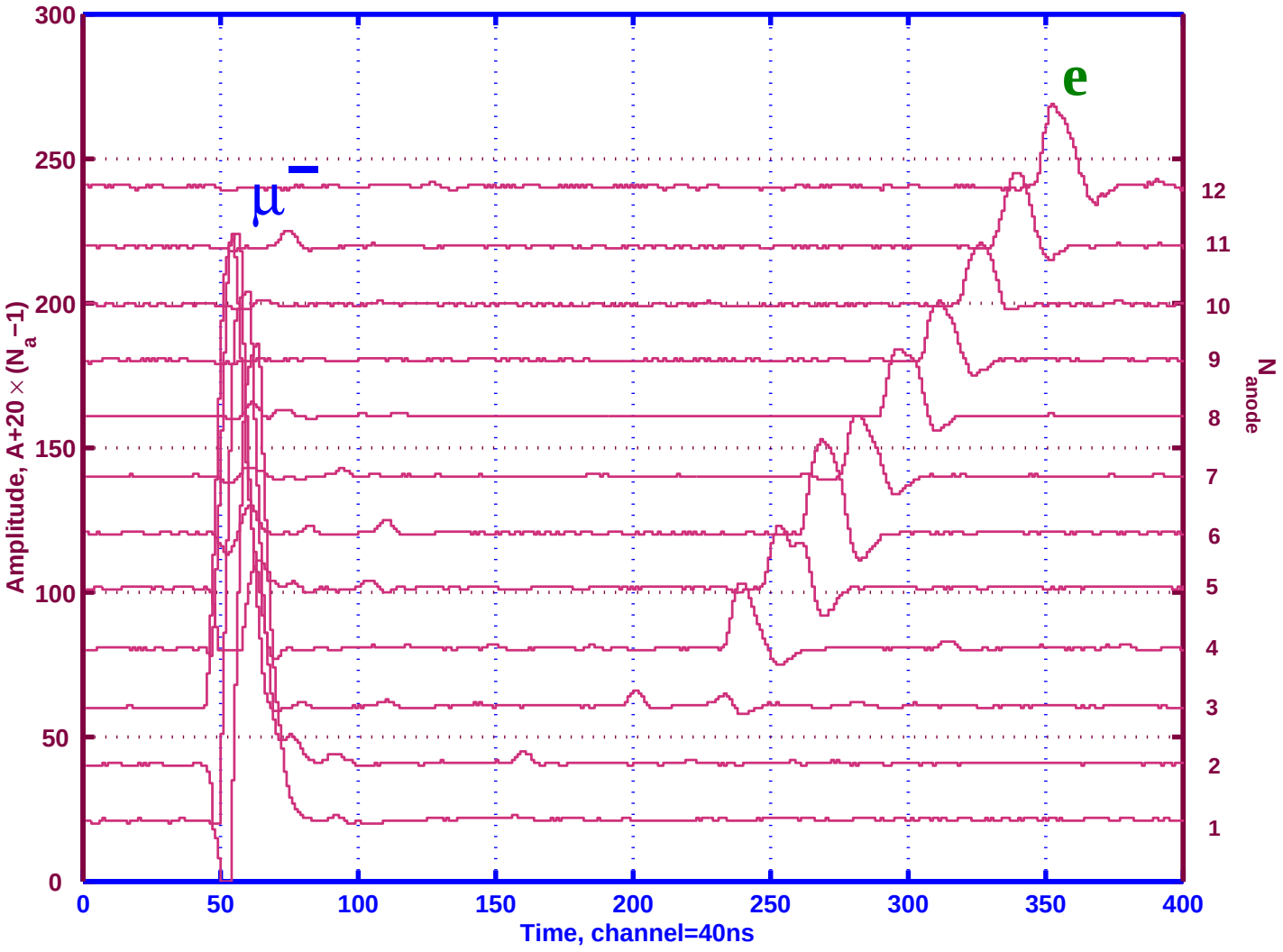
Prototype of the detector for μCAP experiment.



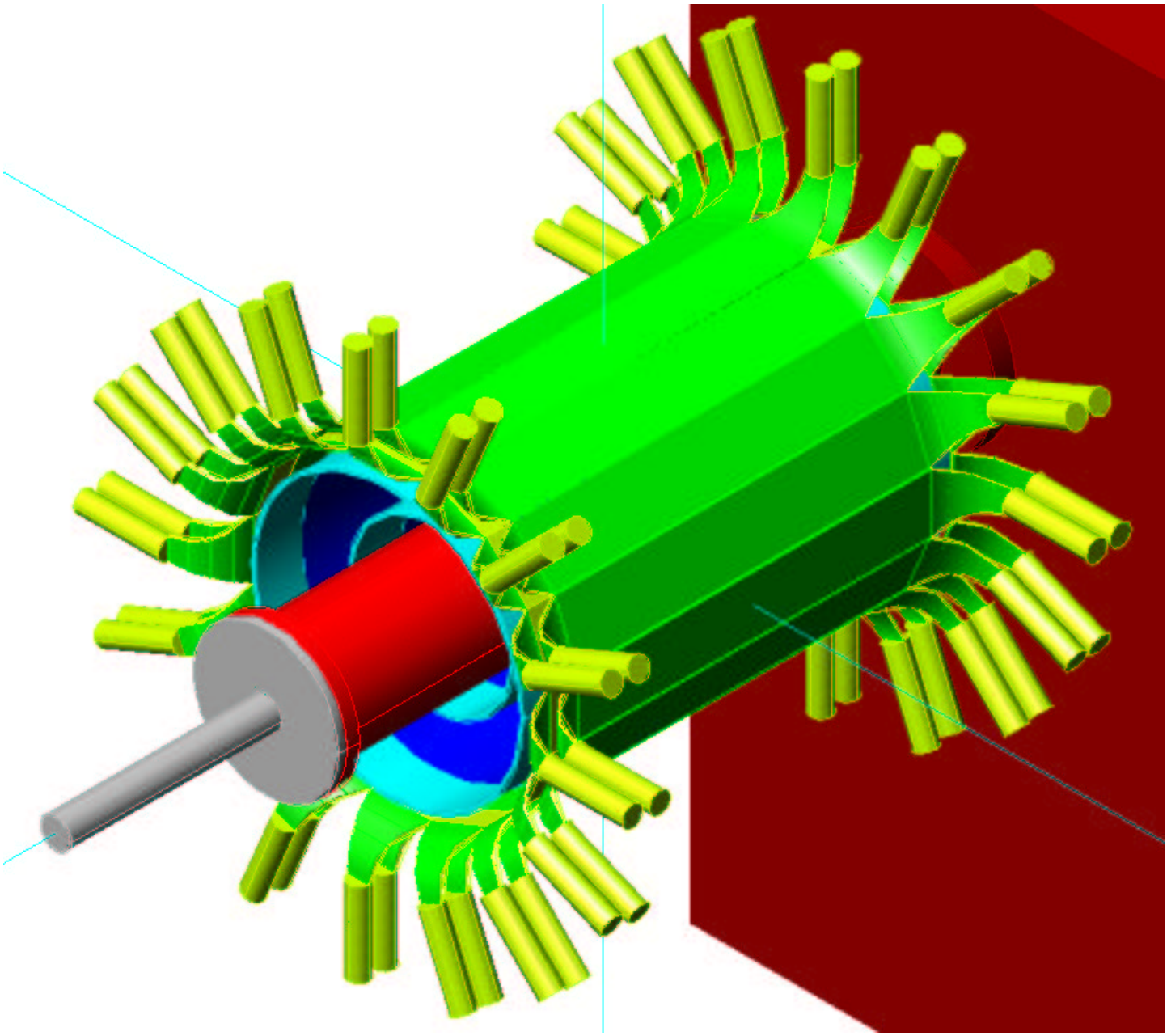
Prototype of the μp-capture detector was designed and tested in a muon beam at PSI. It consisted of two muon beam MWPCs the TPC, and four planes of electron MWPCs located above the TPC. The anode wires in the detection plane were oriented in the X-direction (75 wires). The wires in the strip plane oriented along the Z-direction were joint in 4 mm strips to detect the X-coordinate of the stopped muon (38 strips). The 3 coordinates of the muon stop were measured with the resolution of $\pm$ 1 mm (Y), $\pm$ 2 mm (X) and $\pm$ 2 mm (Z). This device is designed to select clean muon stops in 3D space and also to measure the muon decay electron trajectory.



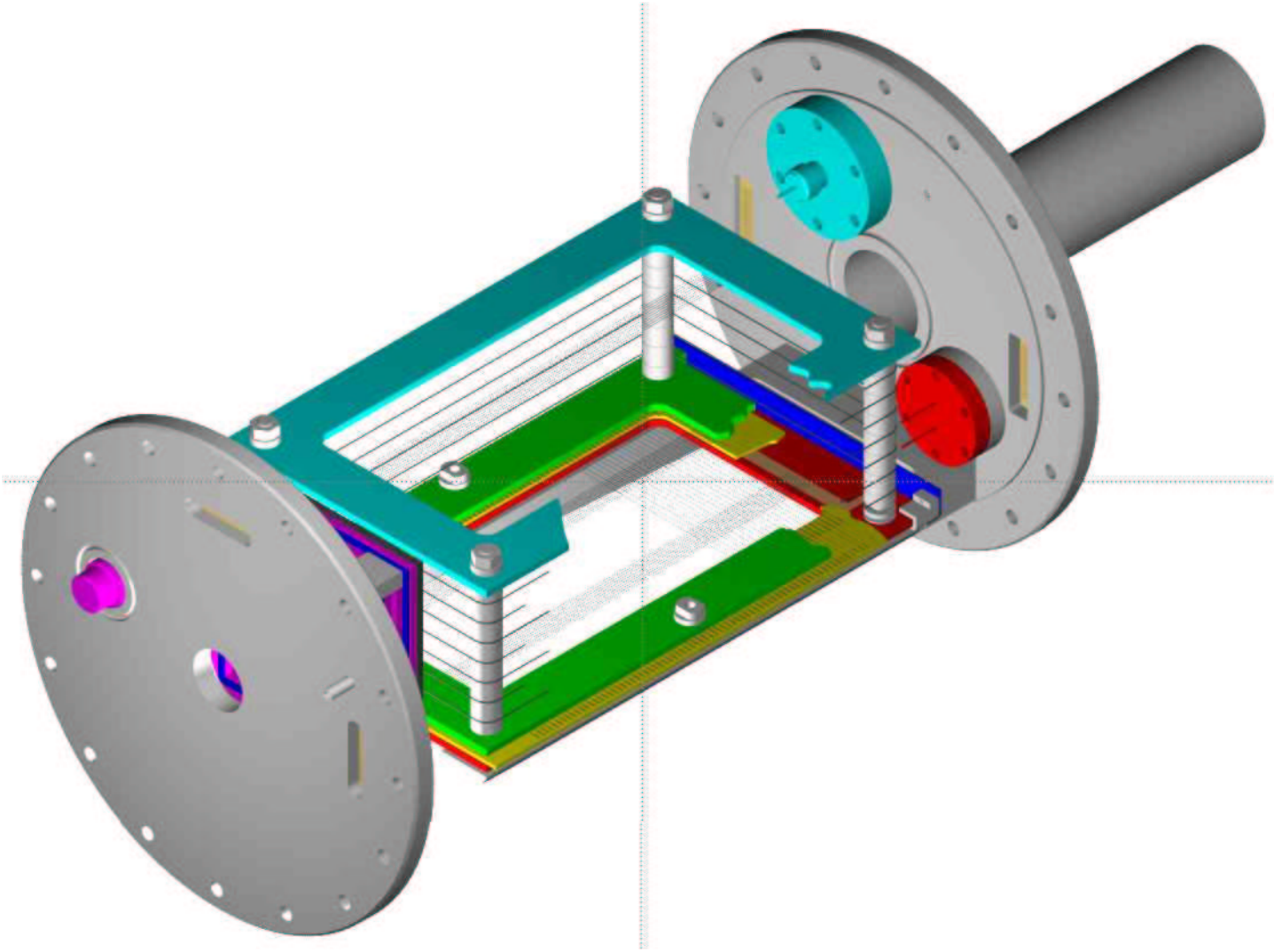
This figure shows a schematic view of the time projection chamber (TPC). The TPC contains four wire planes. The drift space between the cathode and the grid planes is 12 cm. The ionization electrons are driven through the grid plane to the anode wire plane, and create avalanches around the anode wires. The signals are detected from the anode wires and also from the cathode strips (groups of wires) in the strip plane.



The signals on TPC anode wires from μ-e decay event. The muon can be seen stopping in the region of anode 4. The decay electron is seen on anodes 4-12 going to the upper left.



Stereoview of the final setup for μCAP experiment (scintillator array, wire chambers and TPC vessel).



Stereoview of TPC of the final setup for μCAP experiment.