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Updating the DIRAC muon identification system

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1 Introduction

The proposed experiment [1] is the further development of the DIRAC experiment [2]. The new experiment aims to measure simultaneously the lifetime of $\pi^+\pi^-$ atoms ($A_{2\pi}$), to observe πK atoms ($A_{\pi K}$) and to measure their lifetime.
In order to detect $A_{\pi^+K^-}$ and $A_{K^+\pi^-}$ atoms the setup has been upgraded in order to achieve optimal conditions for detecting πK pairs from $A_{\pi K}$ ionization without affecting the $\pi^+\pi^-$ data taking. The setup upgrading comprises many things but here we mention only the setup aperture increasing.
In this report we describe the updating the DIRAC muon identification system: increasing the width of the absorbers and installation of additional scintillation counters for muon identification.
Scheme of the updated experimental setup with the additional absorbers and additional muon scintillation counters is shown in fig. 1.

2 Tracing of pion-kaon pairs through the magnetic field

Dimensions of the additions to the absorbers and the number of the new scintillation counters were estimated by tracing through the magnetic field of π^- and K^+ with equal velocities (from $A_{\pi K}$ atoms). The π^- and K^+ are kept if they hit the DC and the updated VH and HH.

In fig. 2 the atoms pass along the left side of the collimator (1.0° left). The kaons are detected from 4 GeV/c to 12 GeV/c.
In fig. 3 the atoms pass along their axis of gravity (0.6° left). The kaons are detected from 4 GeV/c to 8 GeV/c.
In fig. 4 the atoms pass along the axis of the secondary particle channel (0.0° center). The kaons are detected from 4.5 GeV/c to 5.5 GeV/c.
When the atoms pass along the right side of the collimator (1.0° right) the detectable pion-kaon pairs are absent.

According to simulation of O. Gortchakov [3] the momenta of the kaons from $A_{\pi K}$ breakup can be only up to 9 GeV/c (fig. 5).
Tracing of pion-kaon pairs with the kaon momenta up to 9 GeV/c going along the left side of the collimator (1.0° left) is in fig. 6 (compare with fig. 2).
So the width of the additional absorbers could be decreased but the decision was taken to install the additional absorbers estimated from tracing without momentum constraint.

3 Updating absorbers

The height of all the absorbers is 1200 mm.

The main absorber (left arm) is in fig. 7.
Dimensions of the main absorber (left arm) are in fig. 8.

Volume of the one main absorber is 4.22 m^3.
The absorber is made of cast-iron.
Density of cast-iron is 7.3 t/m^3.
Weigh of the one main absorber is 30.8 t.

The additional internal absorber (left arm) is in fig. 9.
Dimensions of the additional internal absorber (left arm) are in fig. 10.
Volume of the one additional internal absorber is 0.26 m^3.
The additional internal absorber is made of steel.
Density of steel is 7.8 t/m^3.
Weigh of the one additional internal absorber is 2.05 t.

The additional external absorber (left arm) is in fig. 11.
Dimensions of the additional external absorber (left arm) are in fig. 12.
Volume of the one additional external absorber is 0.056 m^3.
The additional absorber is made of steel.
Density of steel is 7.8 t/m^3.
Weigh of the one additional internal absorber is 0.44 t.

Because the addotional absorbers are made of small steel bricks they fixed (covered) with help of steel sheets and angle bars.
The cover for the additional internal absorber (left arm) is in fig. 13.
The cover for the additional external (left arm) absorber is in fig. 14.

All the absorbers (main and additional ones in the both arms) and covers are in fig. 15.
Full weight is 66.7 t.

4 Updating muon hodoscopes

The muon hodoscope (left arm) before updating is in fig. 16.
The hodoscope consists of two layers of scintillation counters.
The first layer consists of 28 scintillation counters with light guides and photomultipliers placed vertically on the top.
The second layer consists also of 28 scintillation counters with light guides and photomultipliers placed on the bottom.
External bottom 20 photomultipliers are placed horizontally because of lack of free place.
Internal bottom 8 photomultipliers are placed vertically.
Two layers with the photomultipliers placed in opposite directions allow to improve the time resolution.
Dimensions of one scintillation slab are $750 \times 120 \times 5$ mm^3.
The sensitive area (together with gaps) of one hodoscope before updating is 3387×750 mm^2.

The updated muon hodoscope (left arm) is in fig. 17.
The additions are shown separately in fig. 18.
The number of the additional internal muon counters in one arm is 8 (two layers, in each

layer 4 counters.
The number of the additional external muon counters in one arm is 4 (two layers, in each layer 2 counters.

The new counters are fixed on aluminium sheets by screw-bolts.
The sheets are attached to the supporting frames of the hodoscopes.
Dimensions of the internal sheets are $864 \times 492 \times 5$ mm^3.
Dimensions of the external sheets are $864 \times 246 \times 5$ mm^3.

Front and back isometrical views of the internal additional counters are in figs. 19 and 20. The views of the external counters are analogous.
Front and back isometrical views of one additional counter with a photomultiplier on the top of the scintillator are in figs. 21 and 22.

Dimensions of one scintillator are $800 \times 120 \times 10$ mm^3.
The photomultiplier shielding is attached to a small plate through hole with thread.
The small plate is attached to the scintillator by two screw-bolts and nuts through two holes in the scintillator.
The same screw-bolts are used also to fix scintillators on the aluminium plates.

5 Strengthening the support for downstream detectors

Part of the support for downstream detectors is console-like (pendent) and it was strenghtened before installation of the additional absorbers.
For that in each arm three tubes-jackes were used (fig. 23).

6 Overall views

Views of the updated absorbers and muon hodoscopes together with the support for the downstream detectors are in figs. 24, 25 and 26.

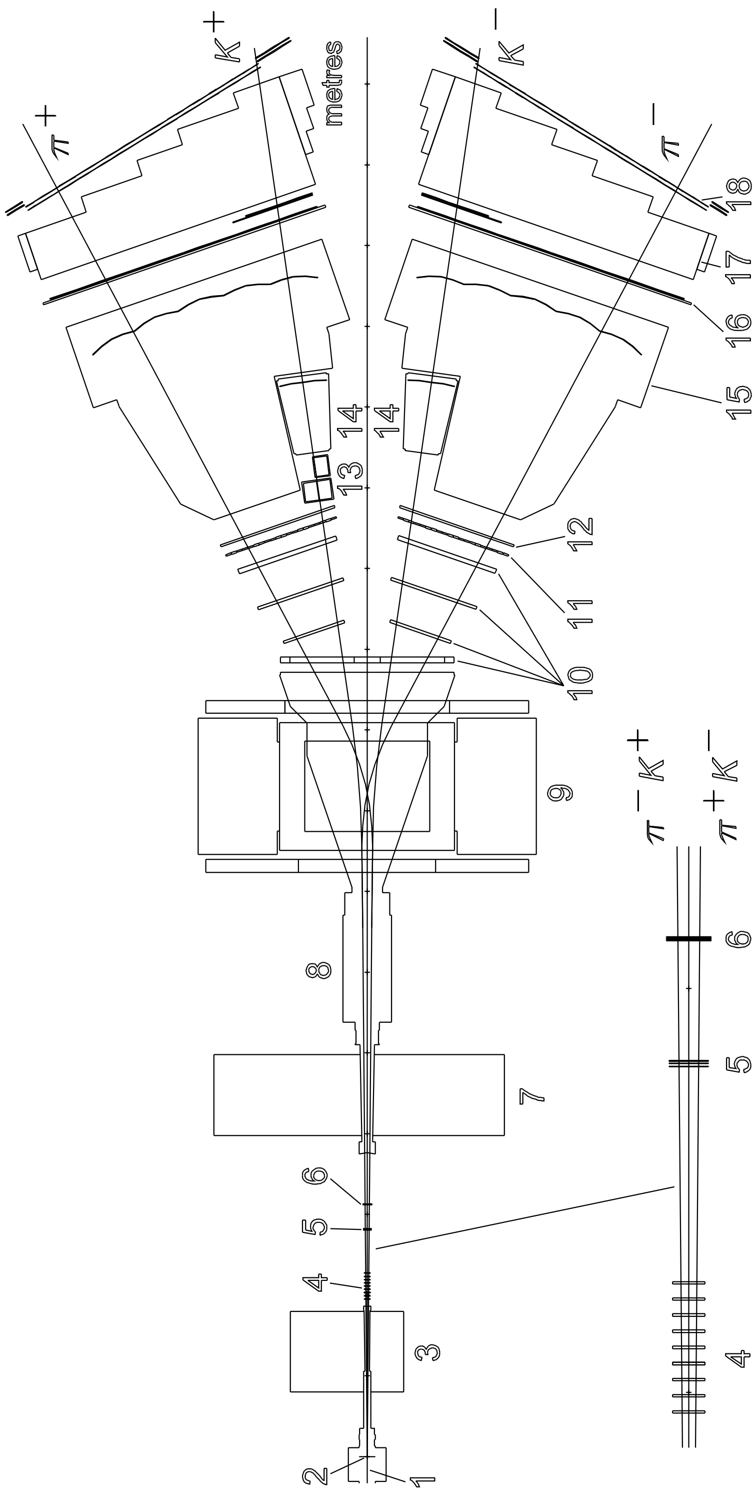

Figure 1: *Scheme of updated two arm spectrometer of charged particles (top view). 1 – proton beam, 2 – target, 3 – shield, 4 – microdrift chambers, 5 – scintillation fiber detector, 6 – ionization hodoscope, 7 – shield, 8 – vacuum, 9 – spectrometer magnet, 10 – drift chambers, 11 – vertical hodoscopes, 12 – horizontal hodoscopes, 13 – aerogel Cherenkov detectors, 14 –* C_4F_{10} *Cherenkov detectors, 15 –* N_2 *Cherenkov detectors, 16 – preshowers, 17 – absorbers, 18 – muon scintillation hodoscopes.* π^+, π^-, K^+, K^- *– trajectories of pions and kaons from* $\pi^\pm K^\mp$ *atom breakup.*

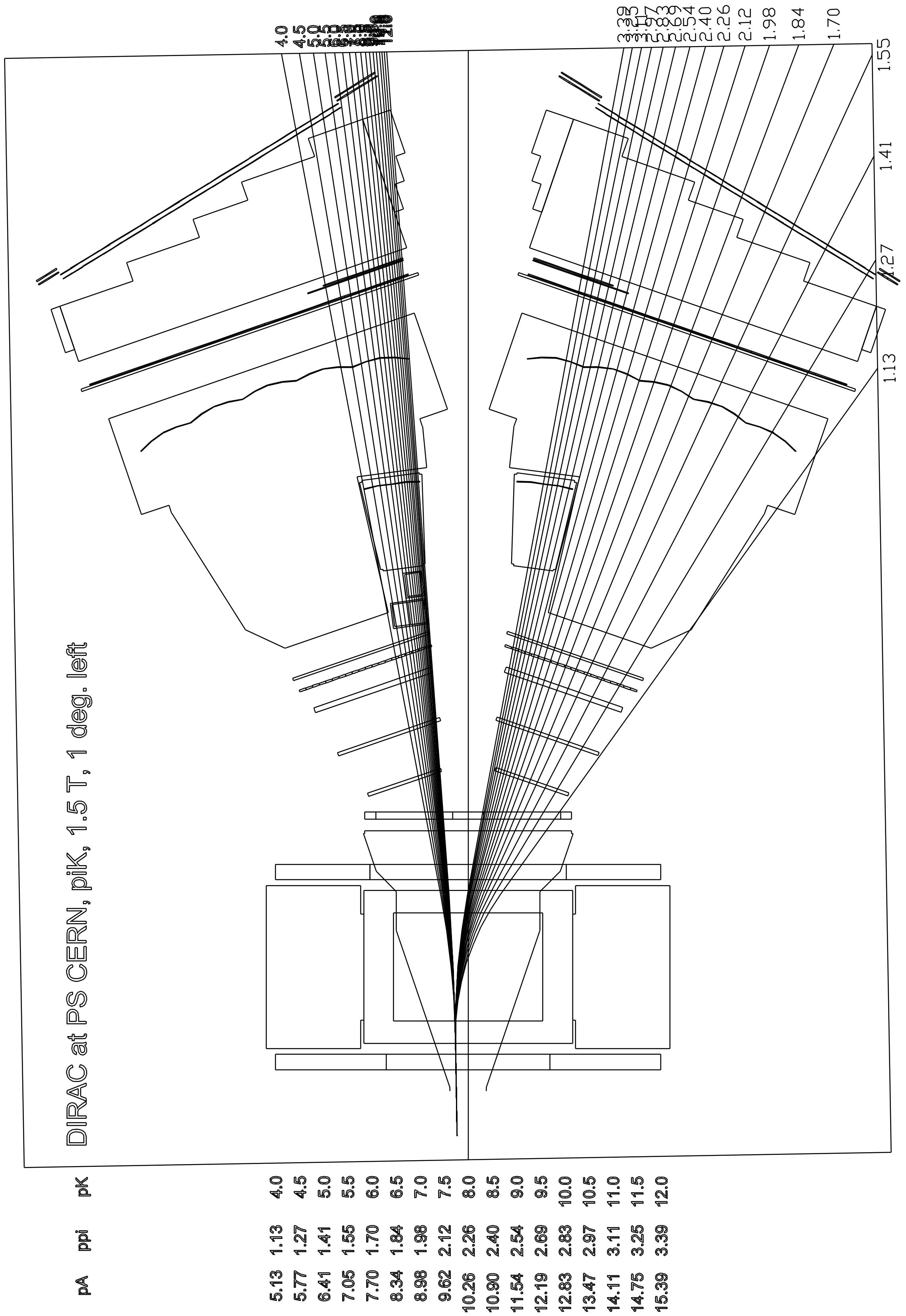

Figure 2: *Tracing of pion-kaon pairs (from $A_{\pi K}$ breakup) going along the left side of the collimator, (1.0° left). Kaons are detected by the DC, VH and HH from 4 GeV/c to 12 GeV/c.*

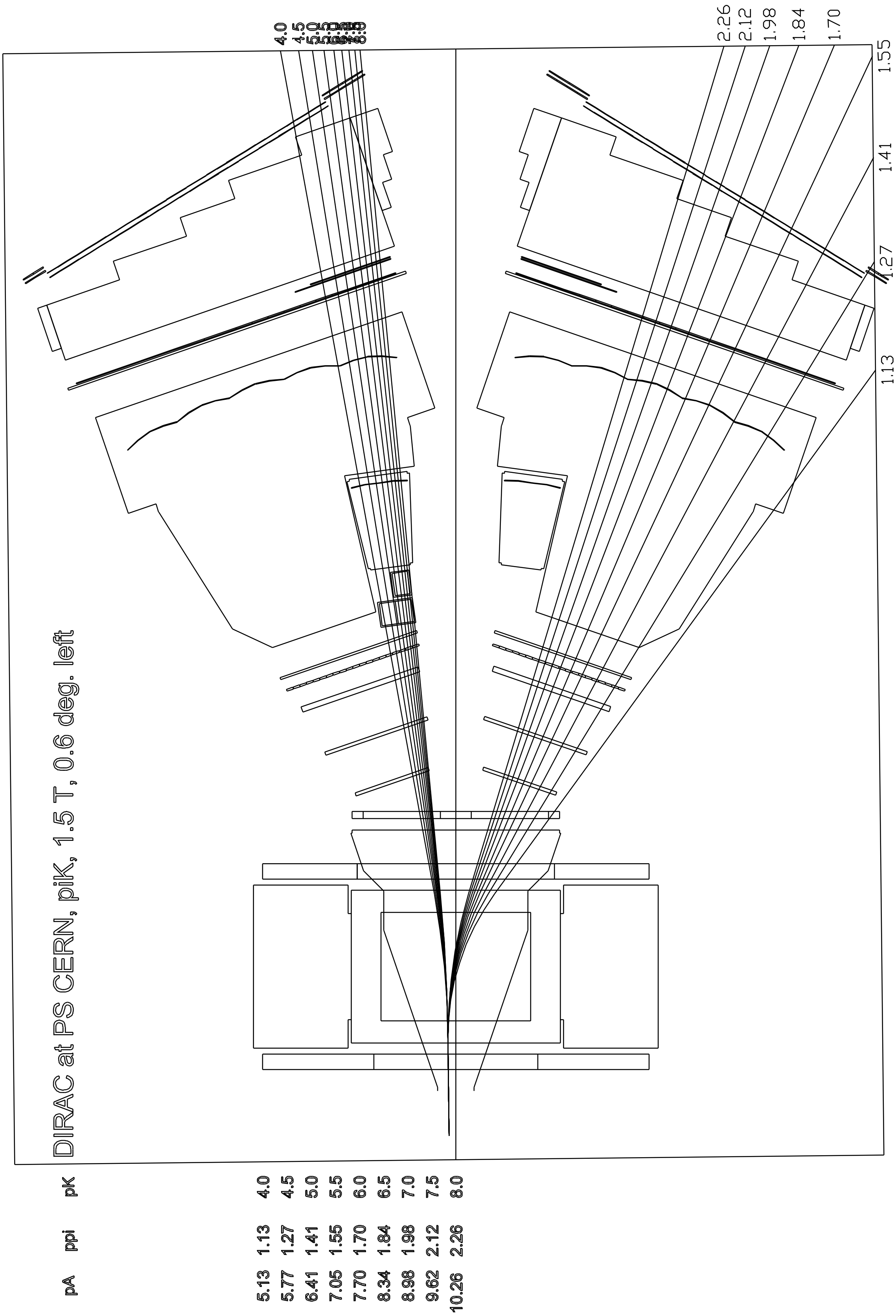

Figure 3: *Tracing of pion-kaon pairs (from $A_{\pi K}$ breakup) going through the axis of gravity of $A_{\pi K}$, ($0.6°$ left). Kaons are detected by the DC, VH and HH from 4 GeV/c to 8 GeV/c.*

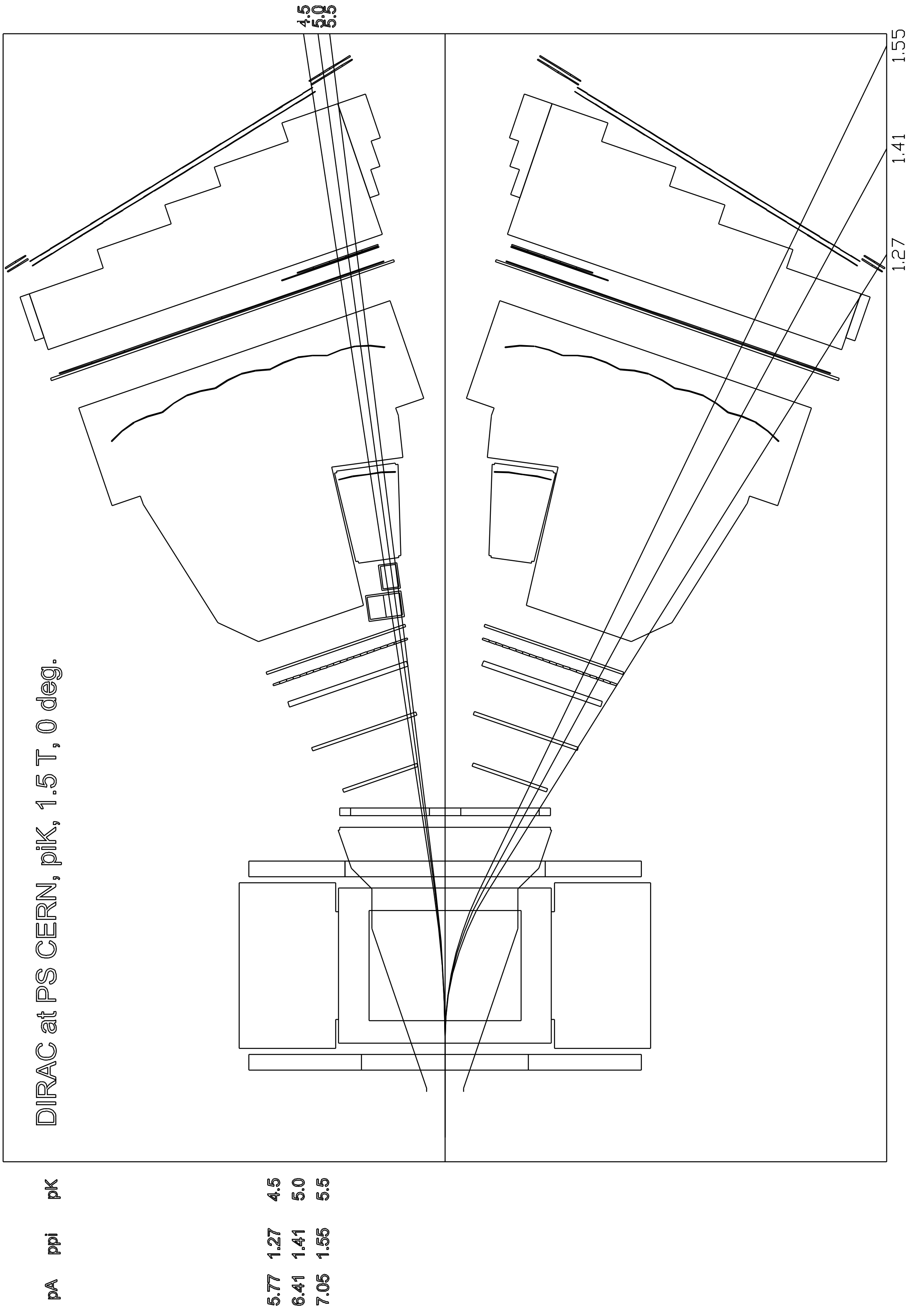

Figure 4: *Tracing of pion-kaon pairs (from $A_{\pi K}$ breakup) going through the channel center, (0.0° center). Kaons are detected by the DC, VH and HH from 4.5 GeV/c to 5.5 GeV/c.*

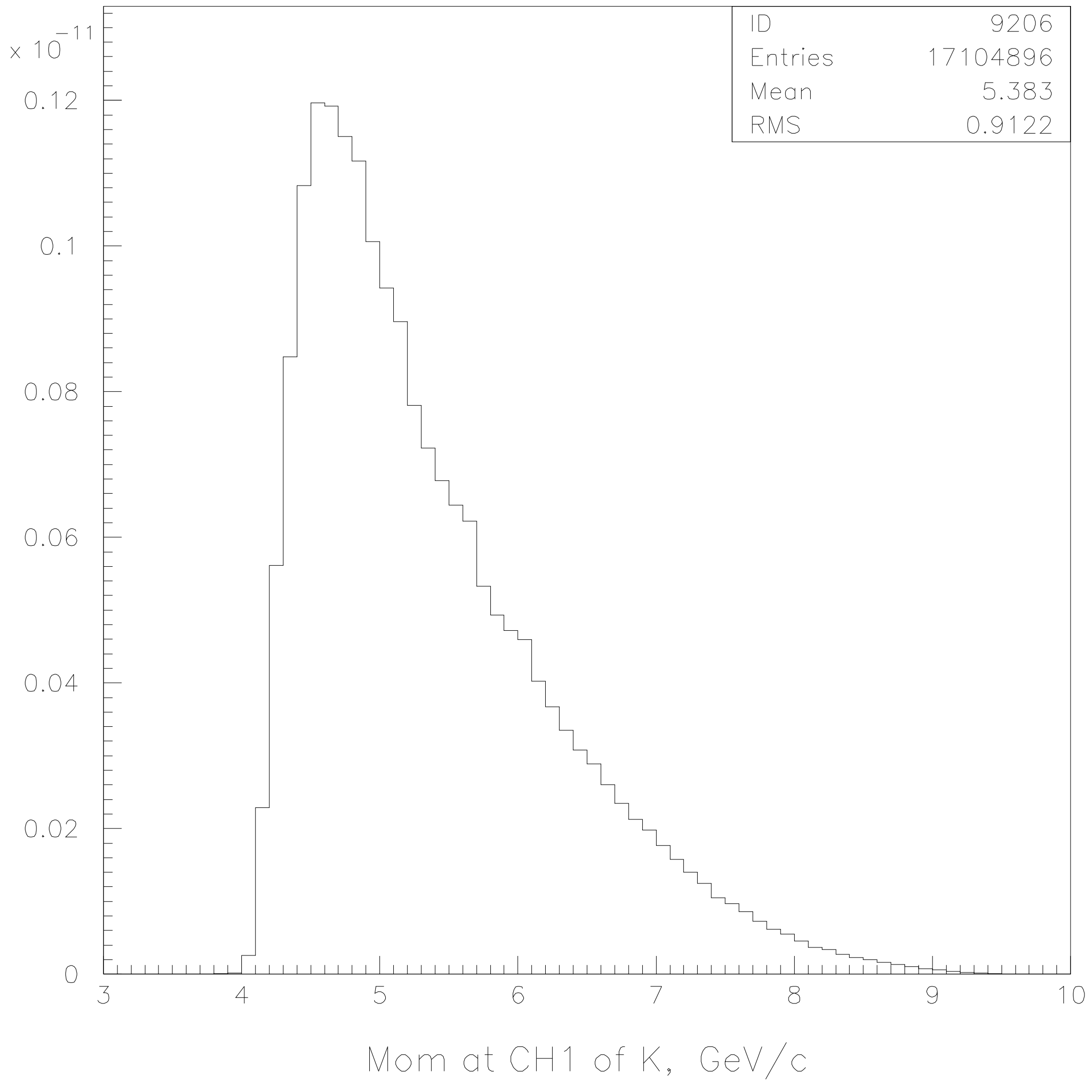

Figure 5: *Kaon p-distribution in front of CH.*

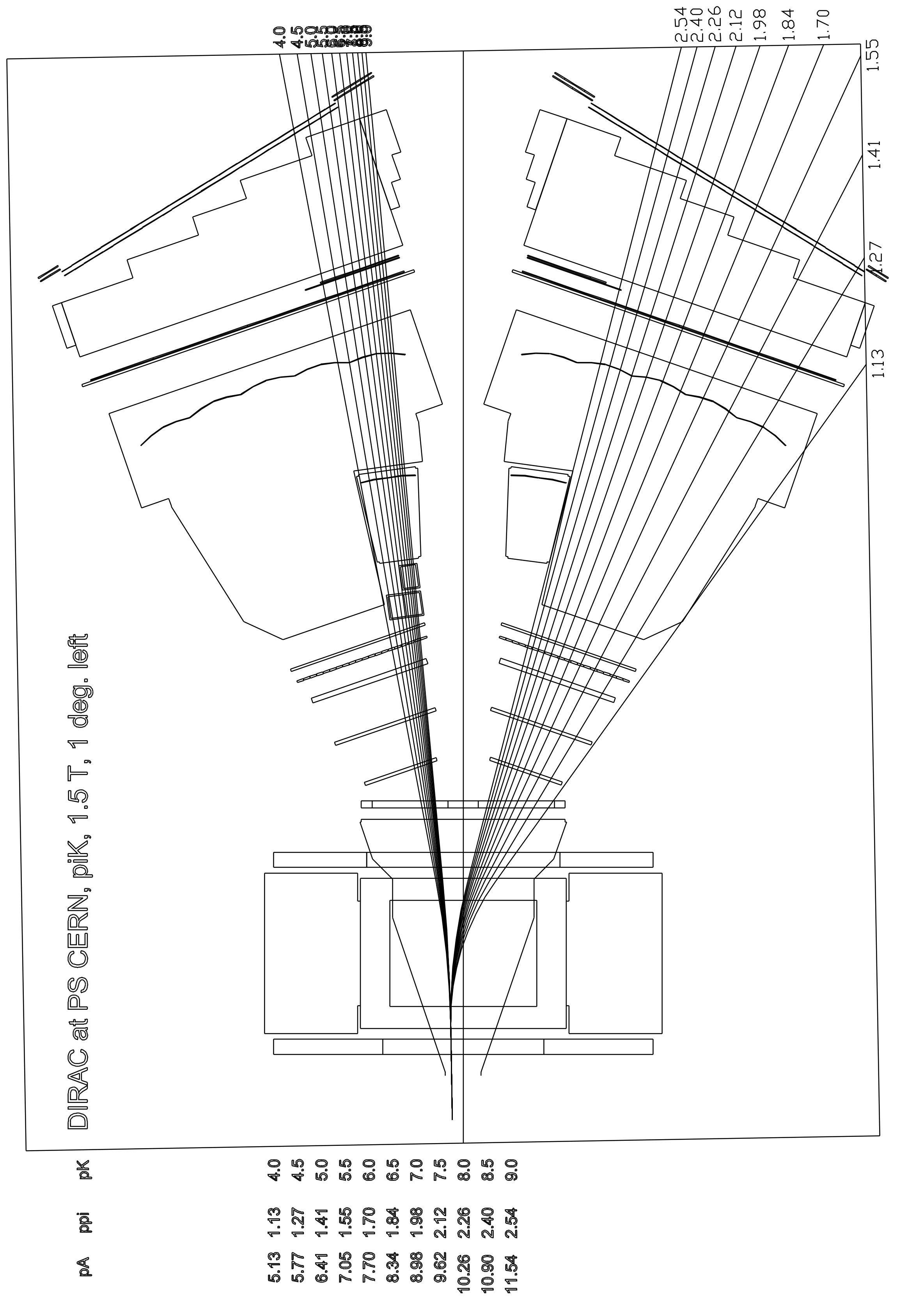

Figure 6: *Tracing of pion-kaon pairs (from $A_{\pi K}$ breakup) going along the left side of the collimator, (1.0° left). The kaons are kept if their momenta are <9 GeV/c in accordance with the simulation of O.Gortchakov.*

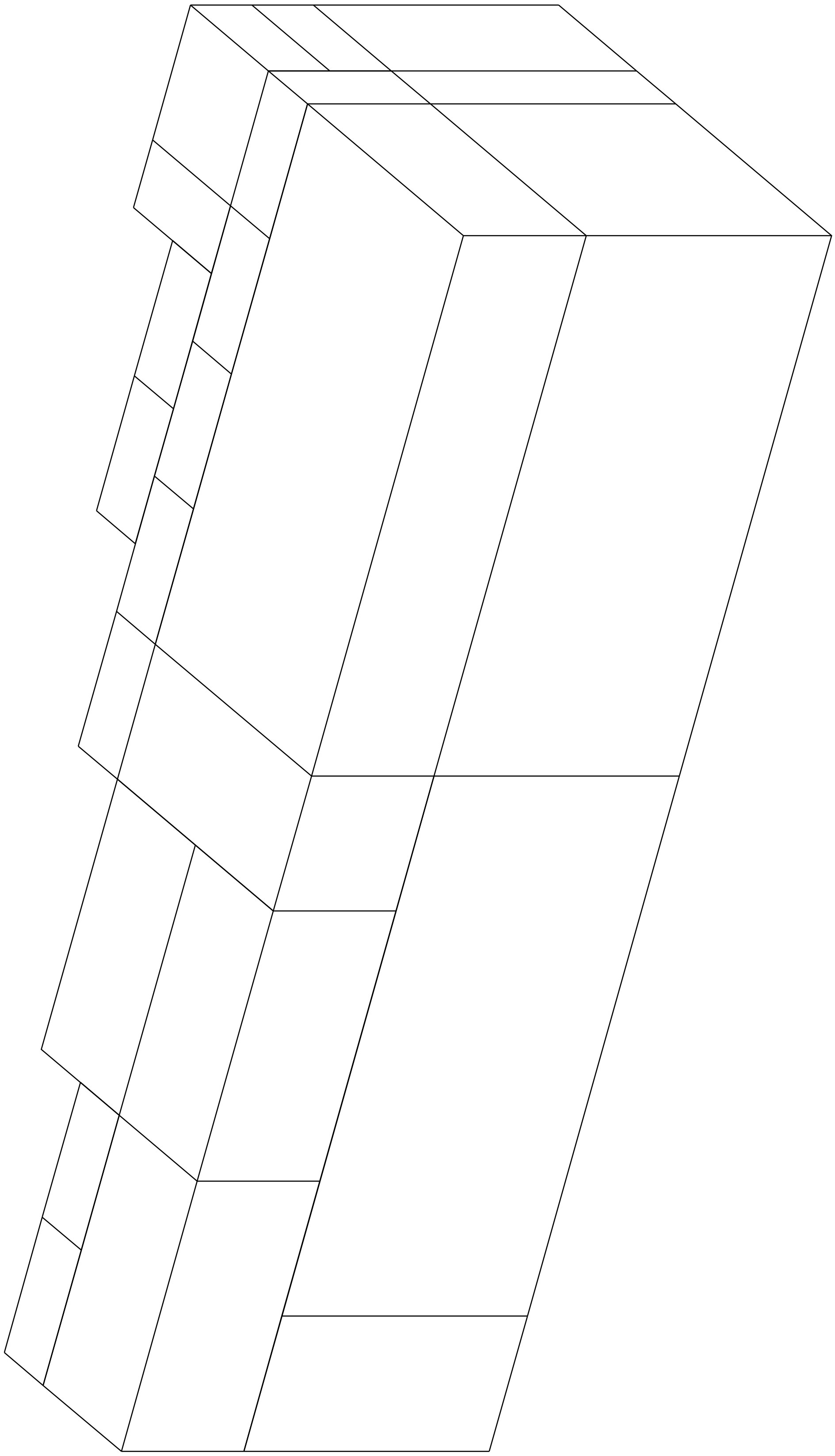

Figure 7: *Main absorber (left arm).*

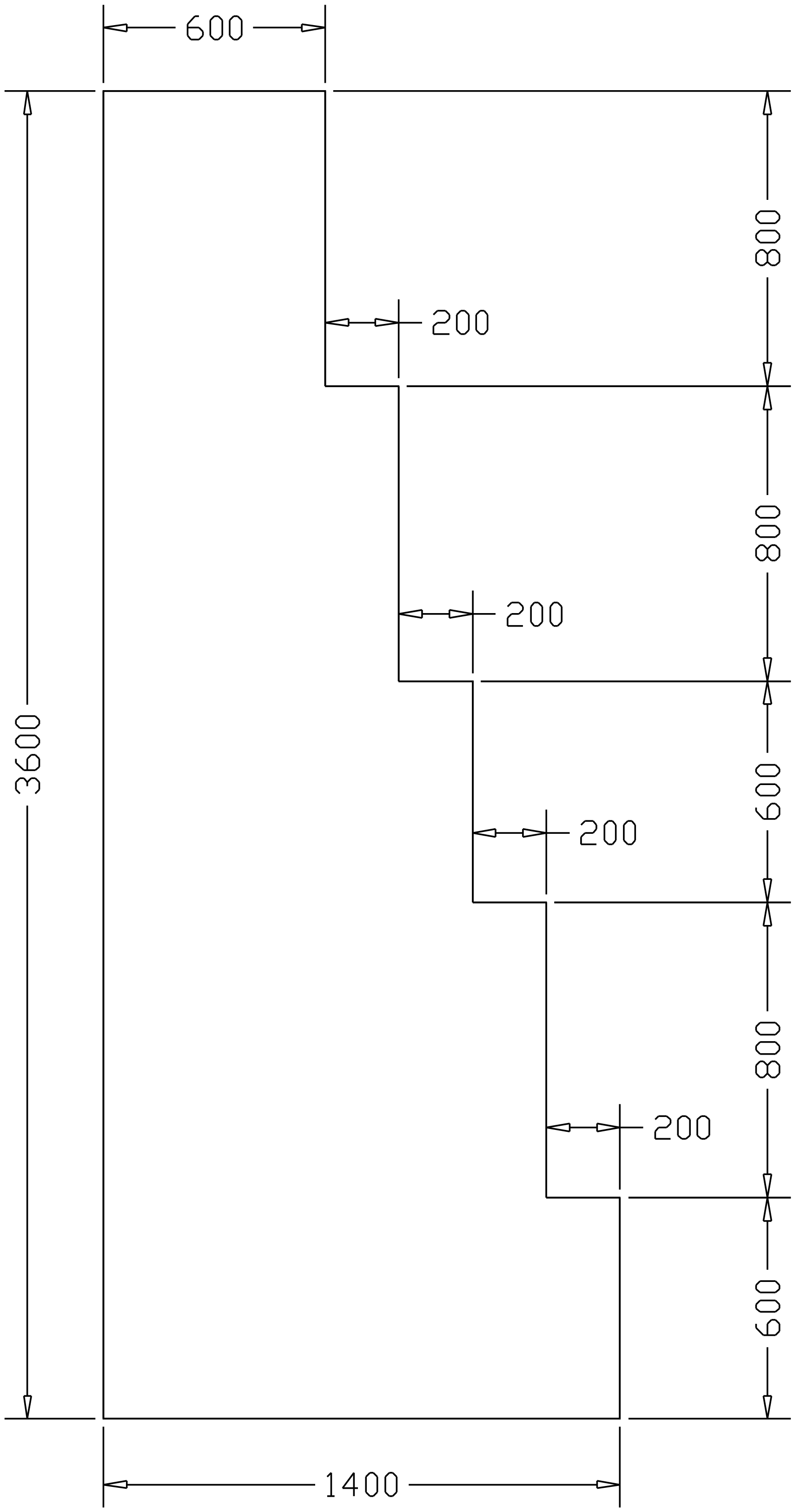

Figure 8: *Dimensions of the main absorber (left arm).*

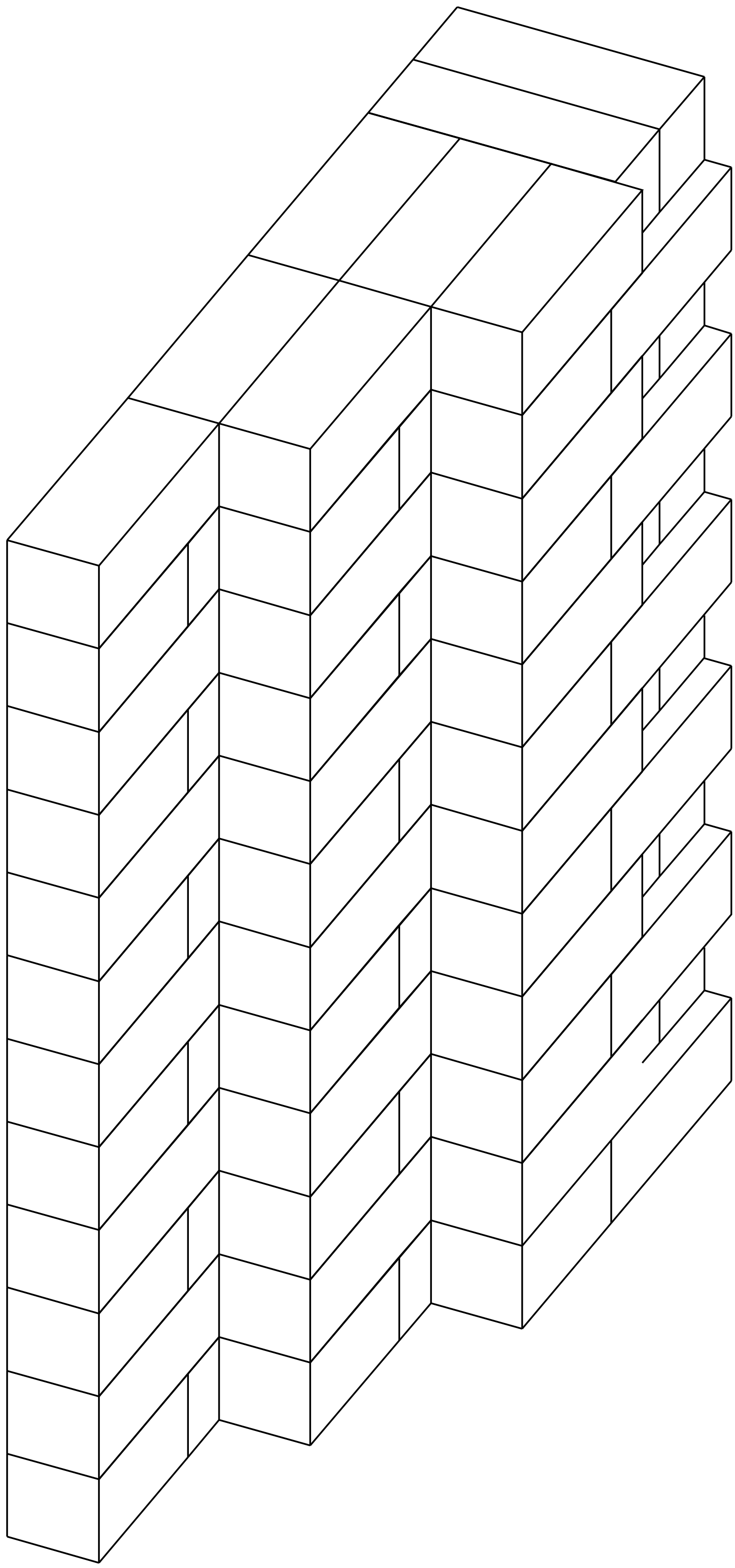

Figure 9: *Additional internal absorber (left arm).*

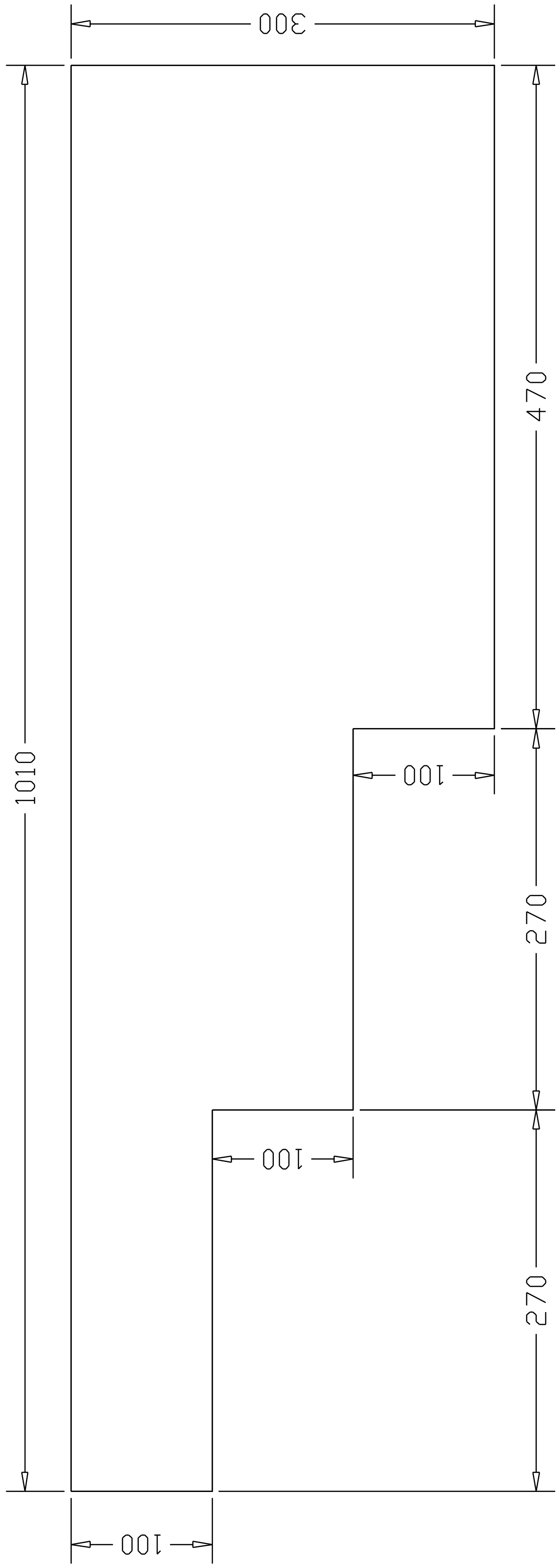

Figure 10: *Dimensions of the additional internal absorber (left arm).*

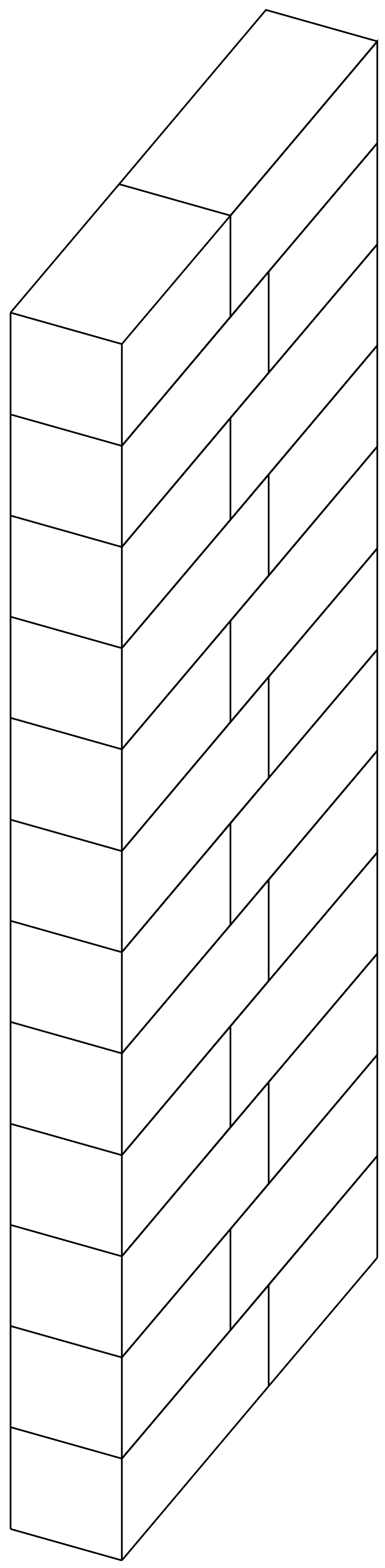

Figure 11: *Additional external absorber (left arm).*

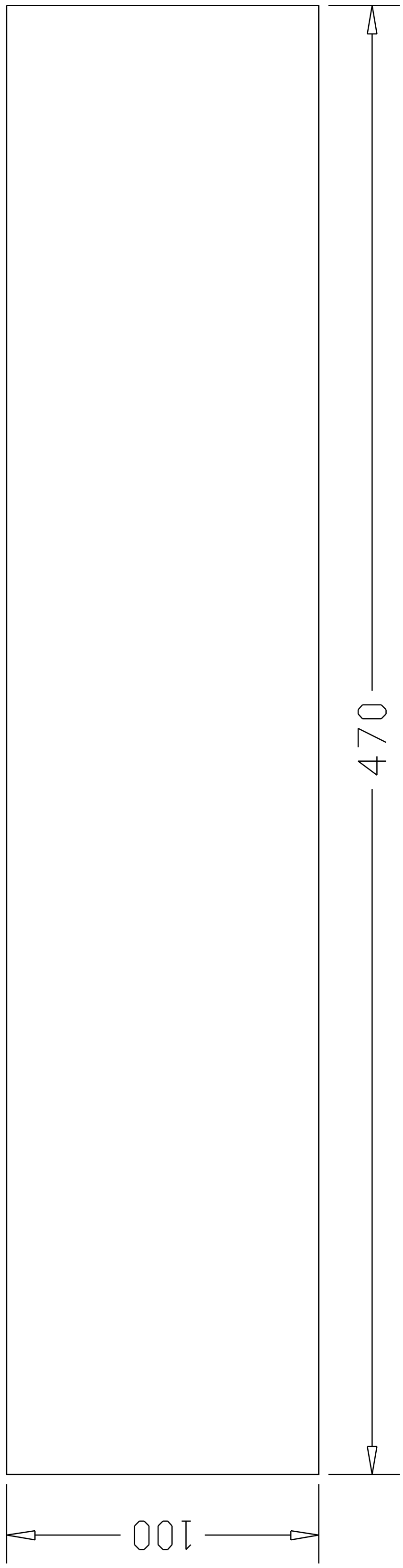

Figure 12: *Dimensions of the additional external absorber (left arm).*

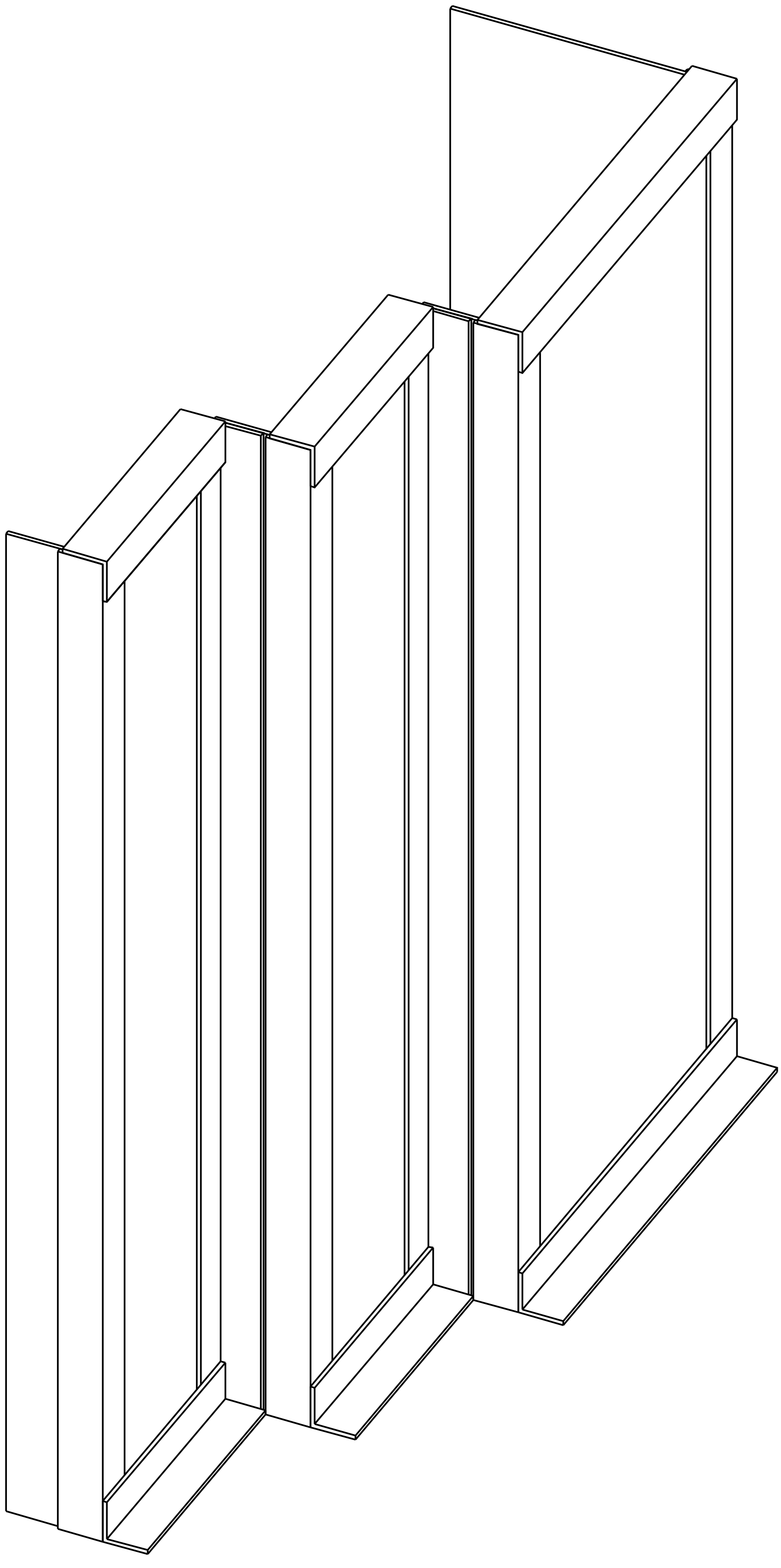

Figure 13: *Cover for the additional internal absorber (left arm).*

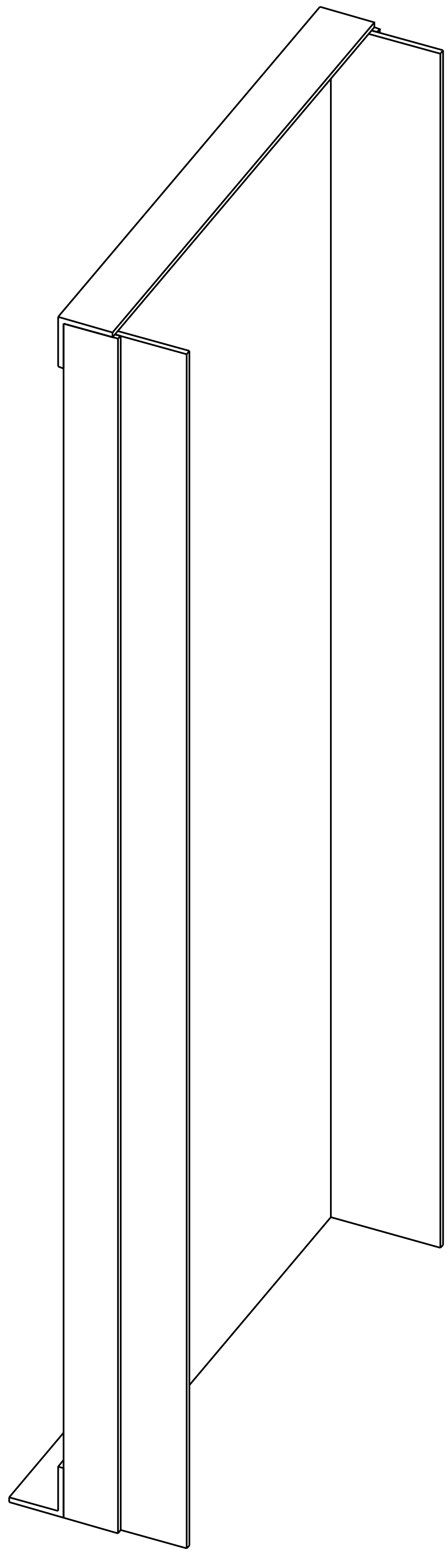

Figure 14: *Cover for the additional external absorber (left arm).*

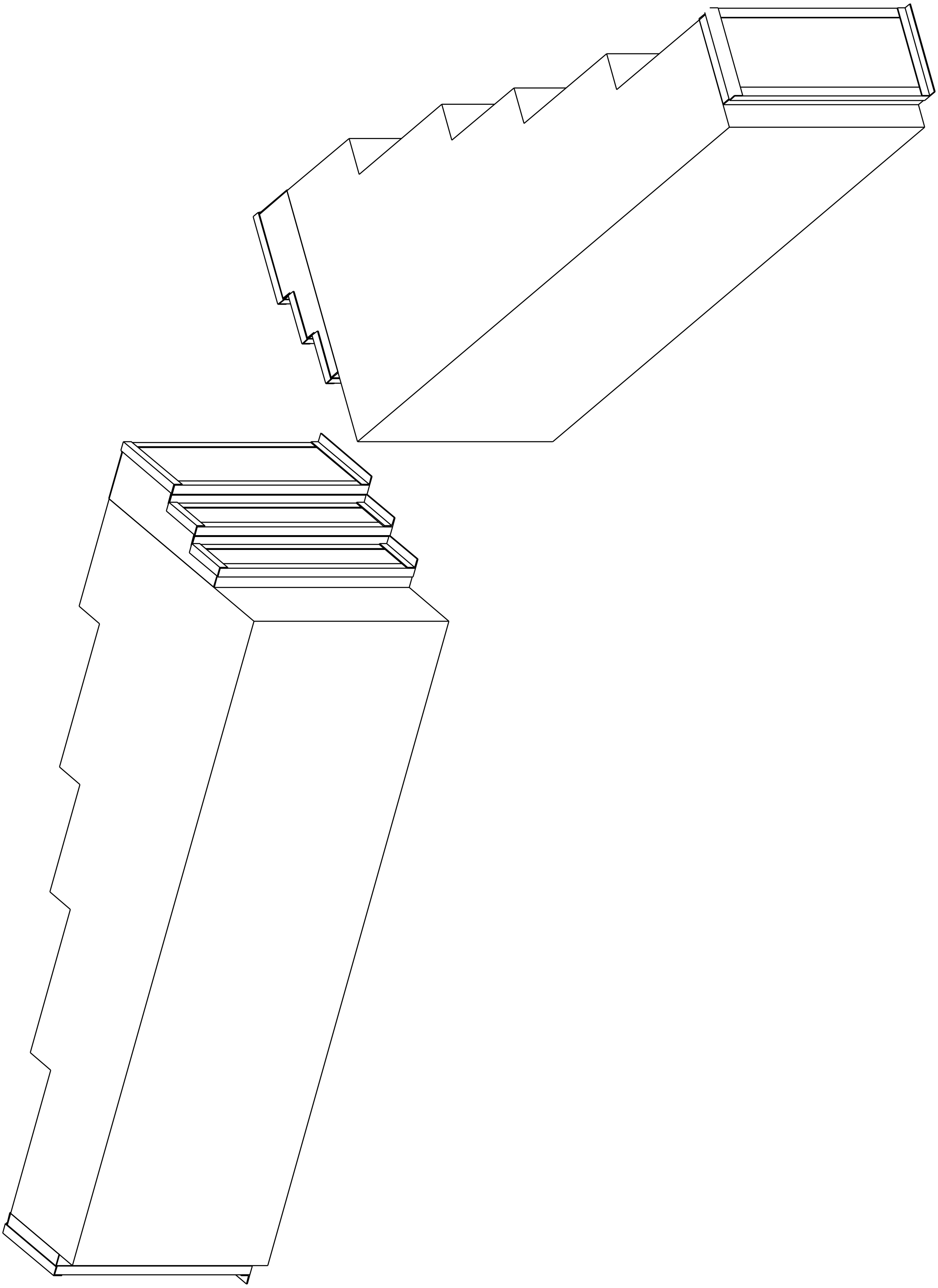

Figure 15: *Main absorbers, additional absorbers and covers.*

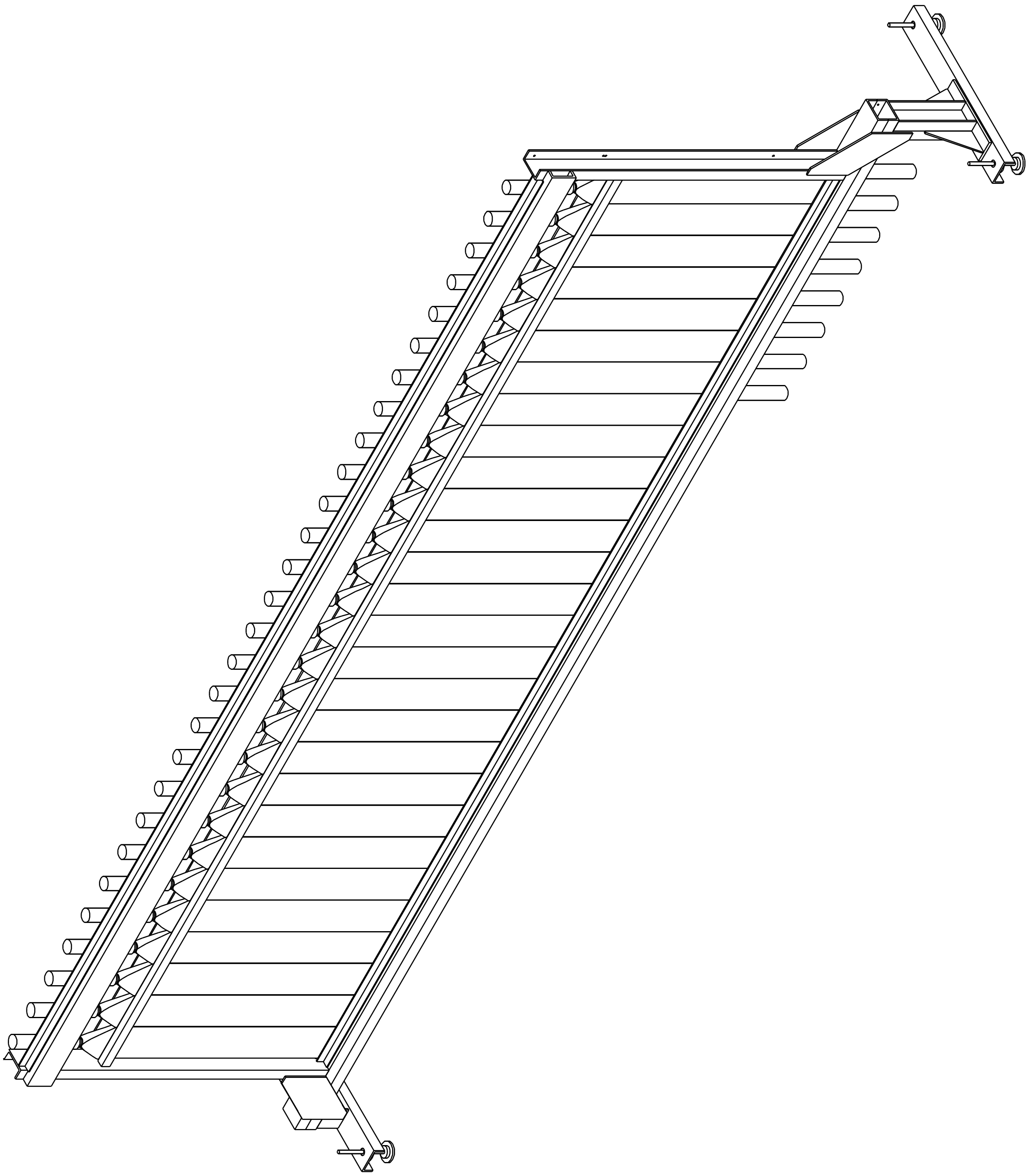

Figure 16: *Muon hodoscope before updating (left arm).*

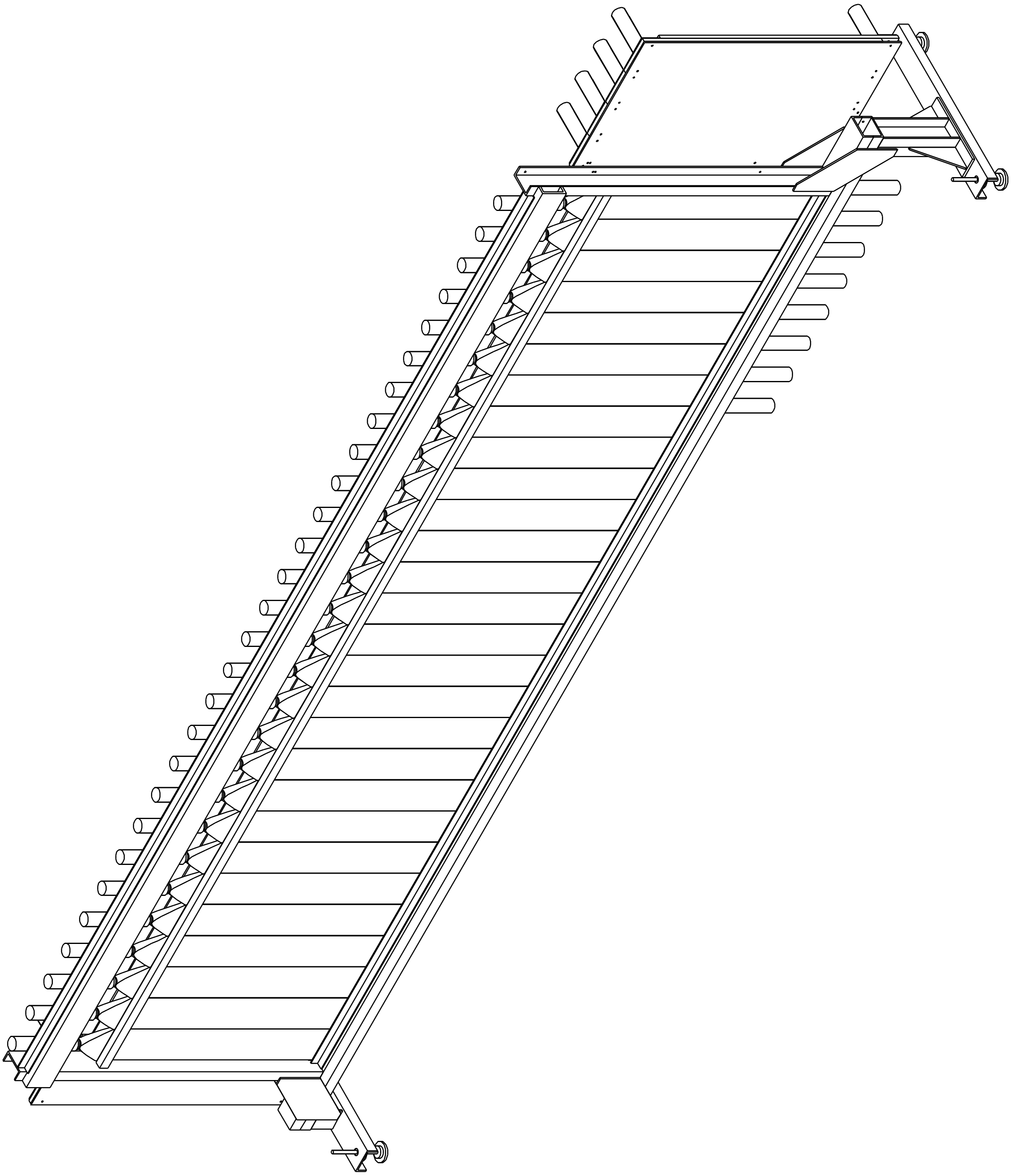

Figure 17: *Muon hodoscope after updating (left arm).*

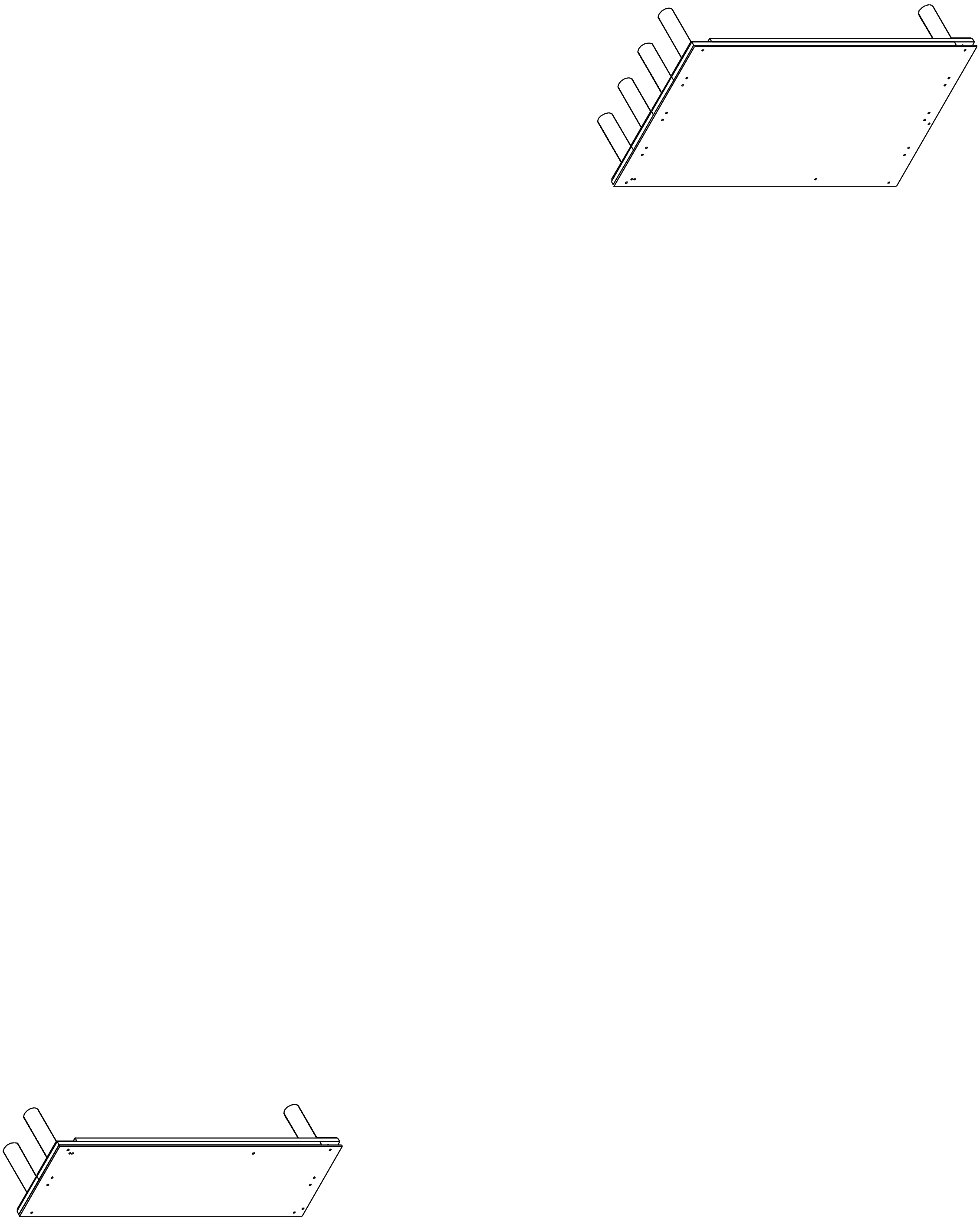

Figure 18: *Additions to the muon hodoscope (left arm).*

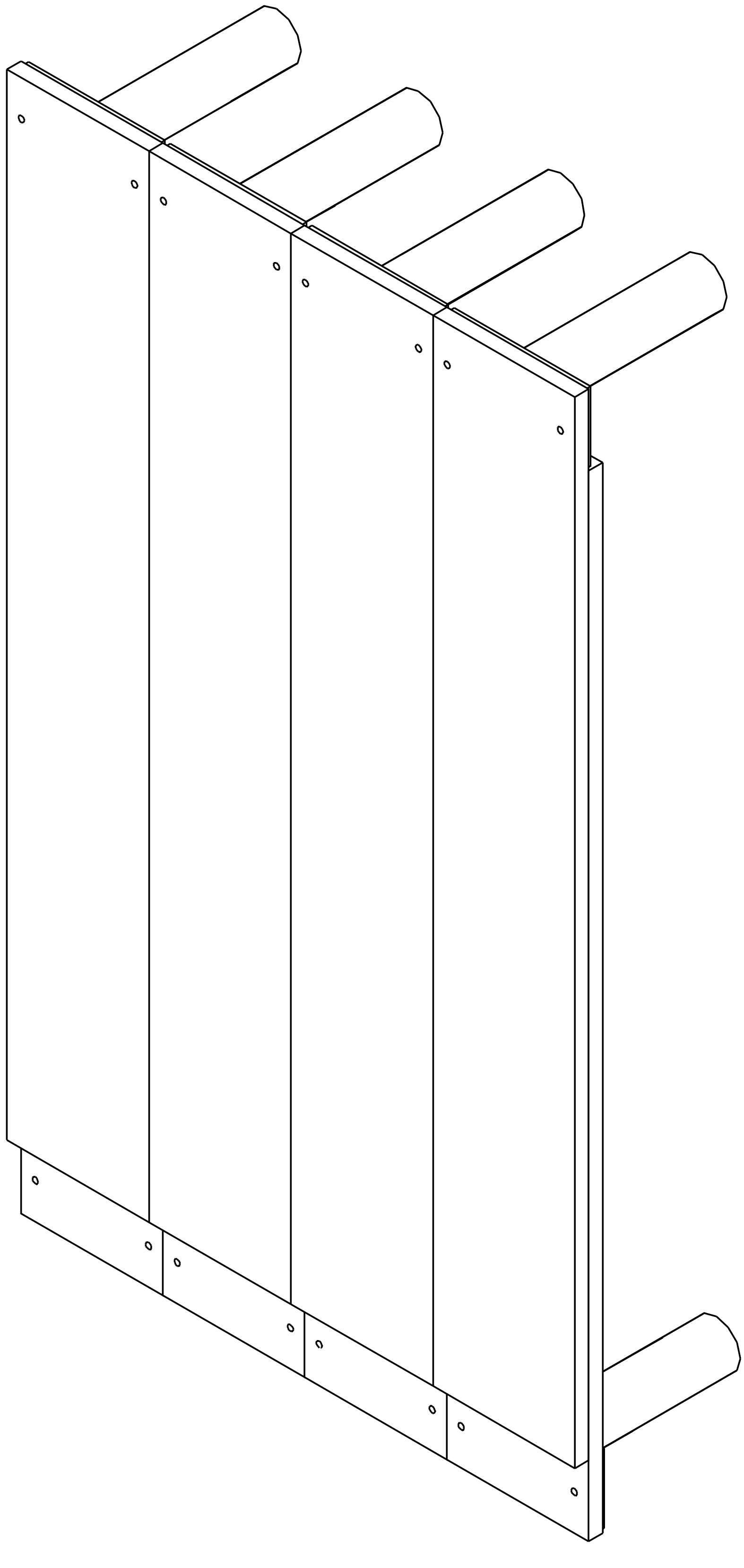

Figure 19: *Front isometrical view of the internal additional counters.*

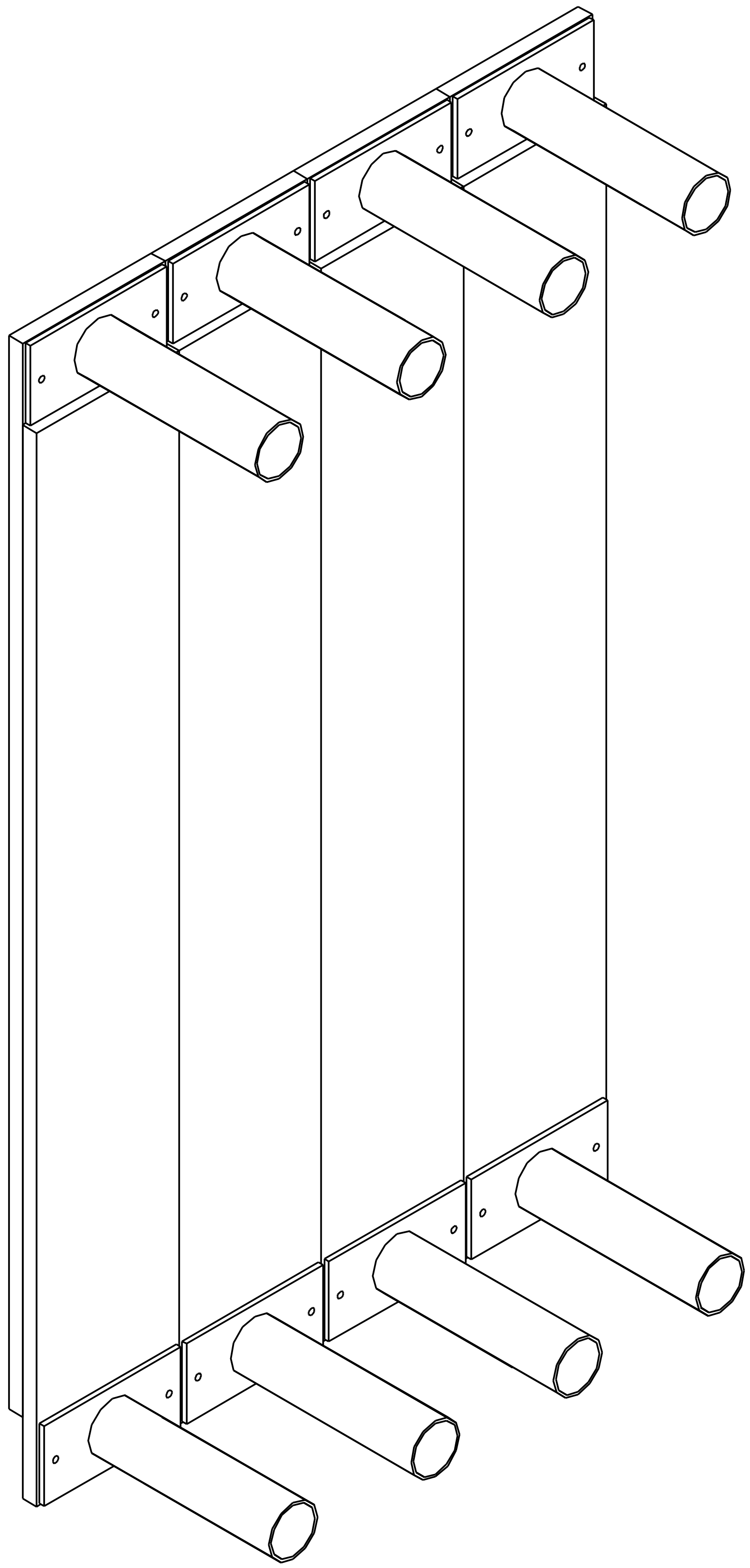

Figure 20: *Back isometrical view of the internal additional counters.*

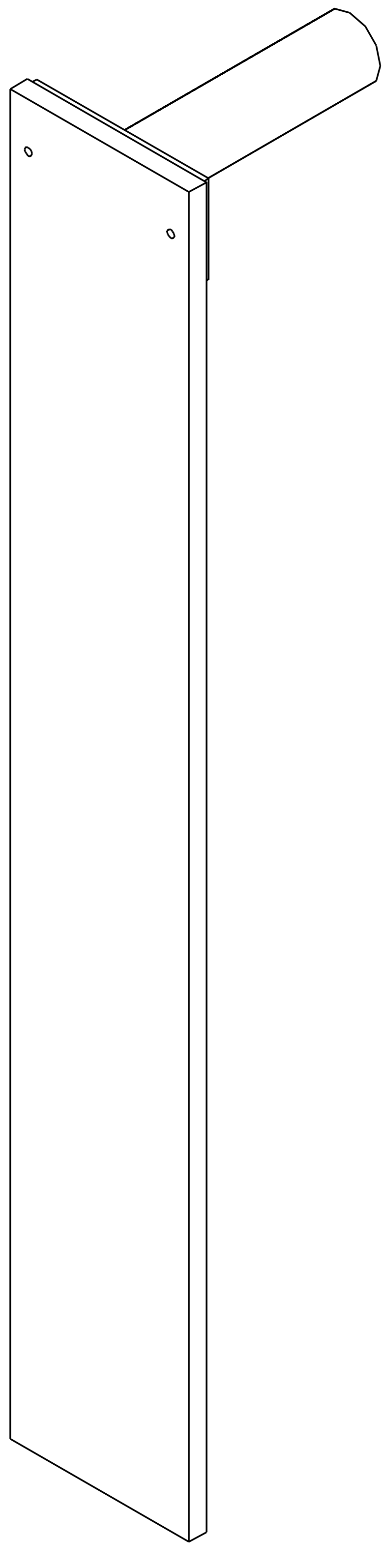

Figure 21: *Front isometrical view of one additional counter with a photomultiplier on the top of the scintillator.*

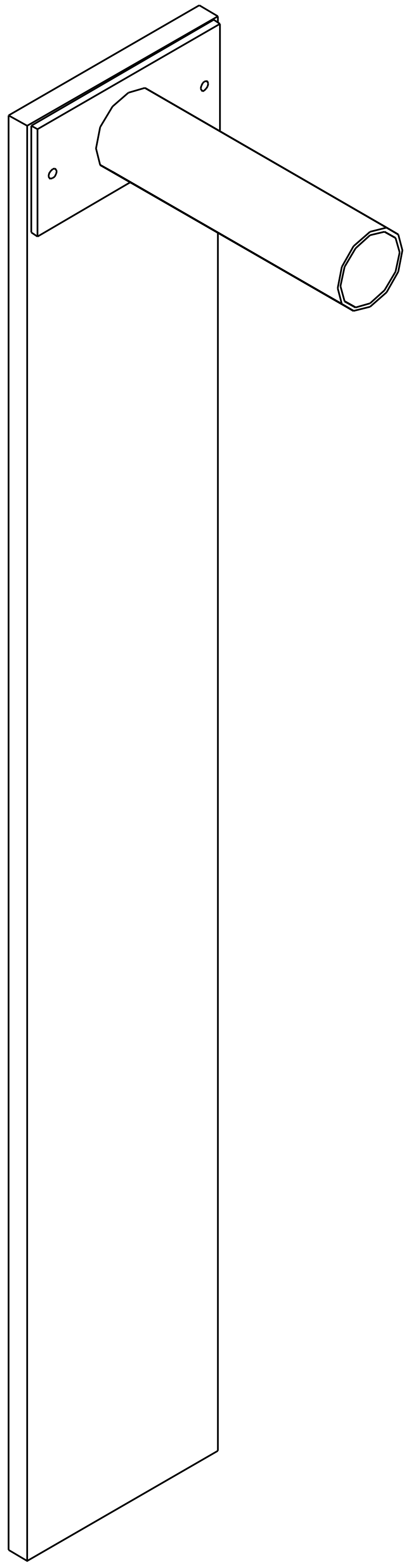

Figure 22: *Back isometrical view of one additional counter with a photomultiplier on the top of the scintillator.*

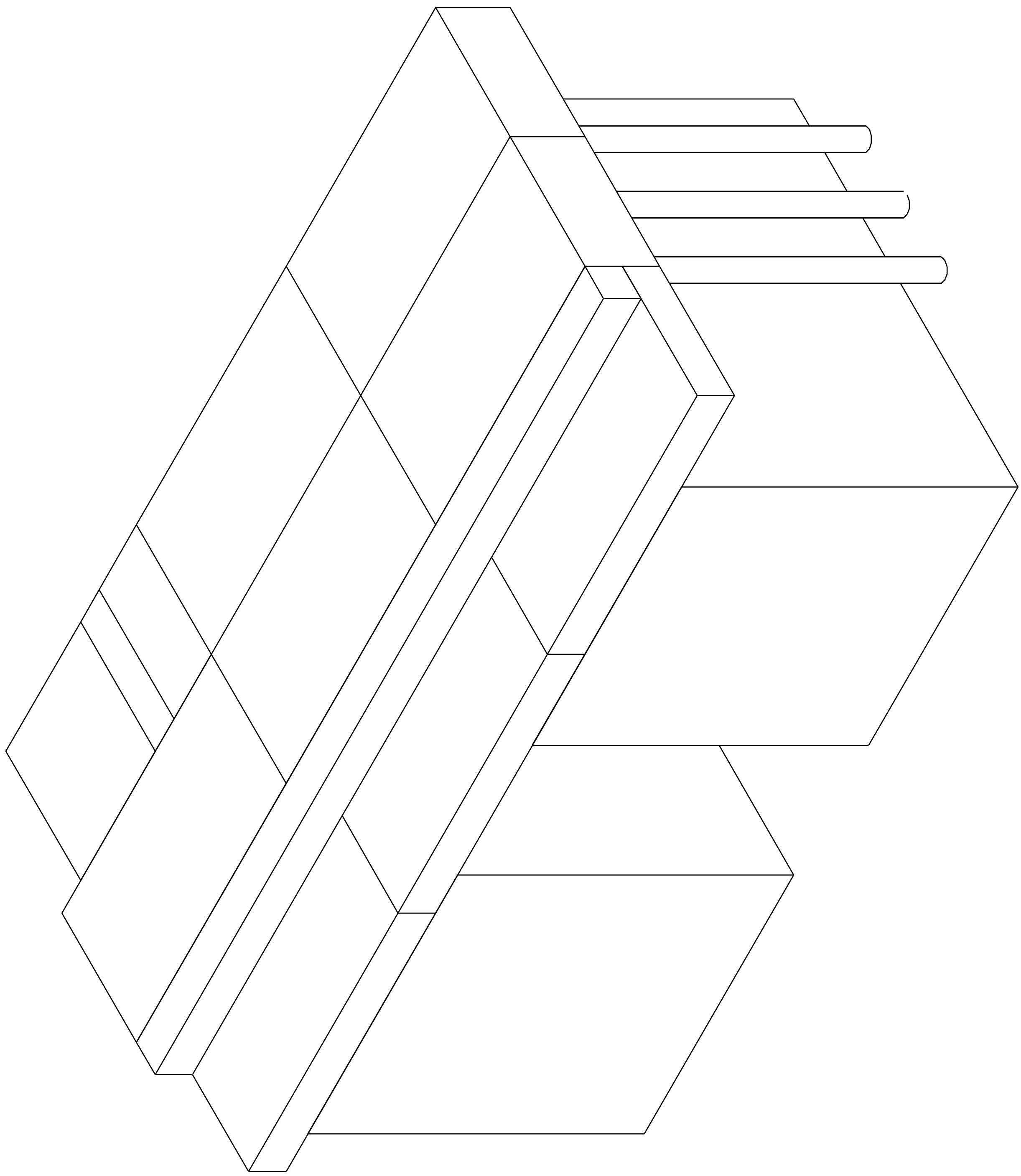

Figure 23: *Strengthening the support for downstream detectors by tubes-jackes.*

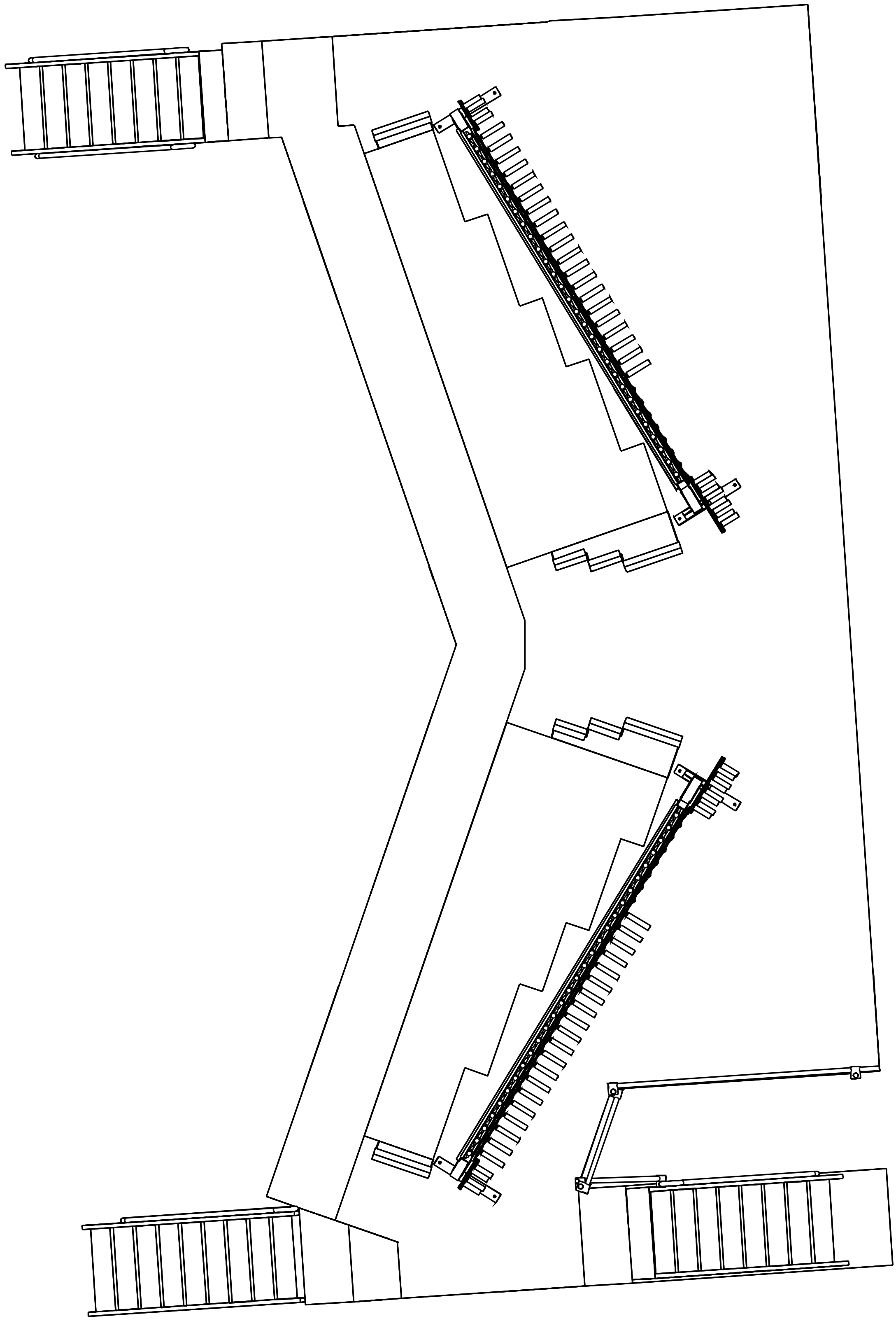

Figure 24: *Top view of the updated absorbers and muon hodoscopes together with the support for downstream detectors.*

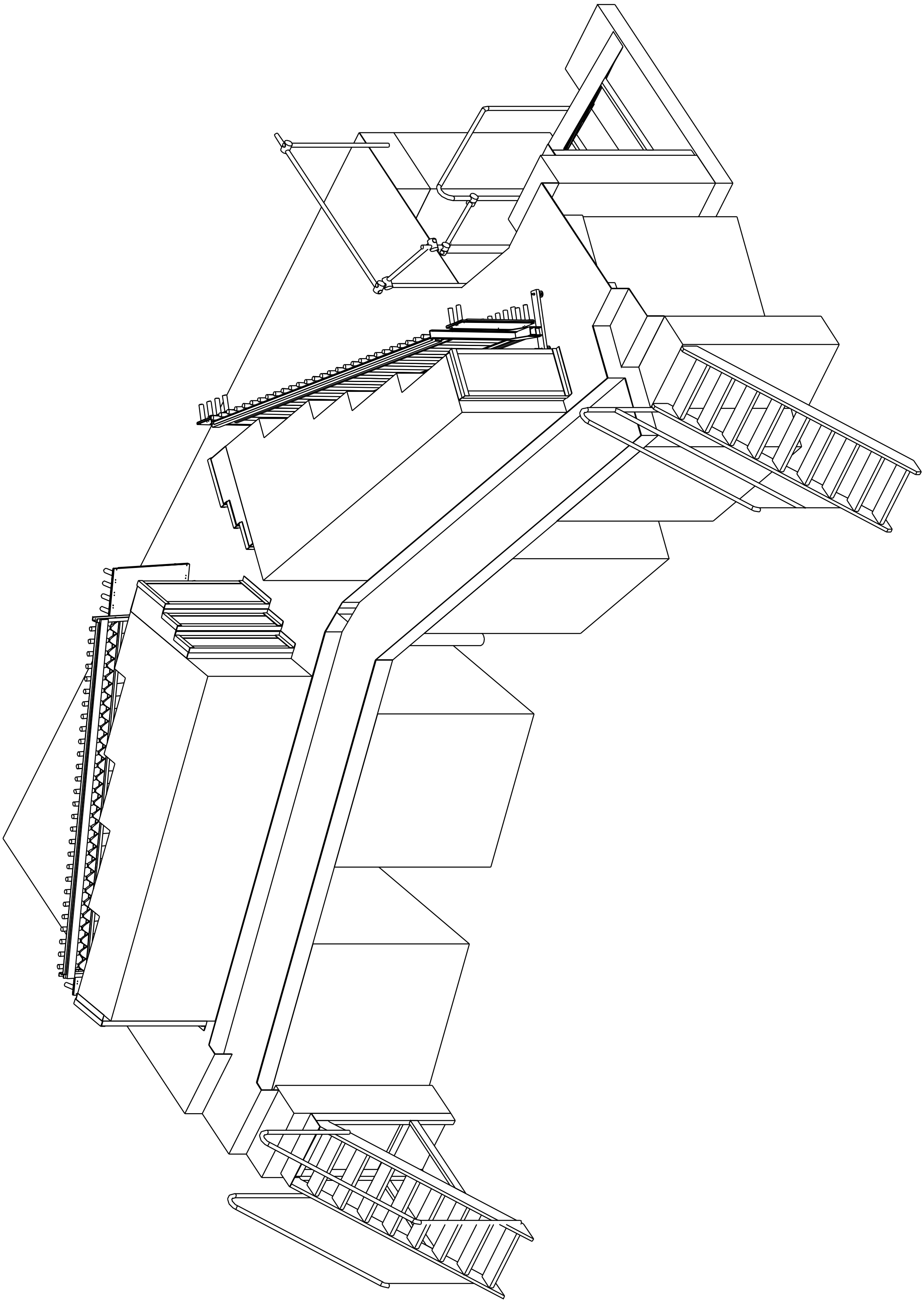

Figure 25: *Front isometrical view of the updated absorbers and muon hodoscopes together with the support for downstream detectors.*

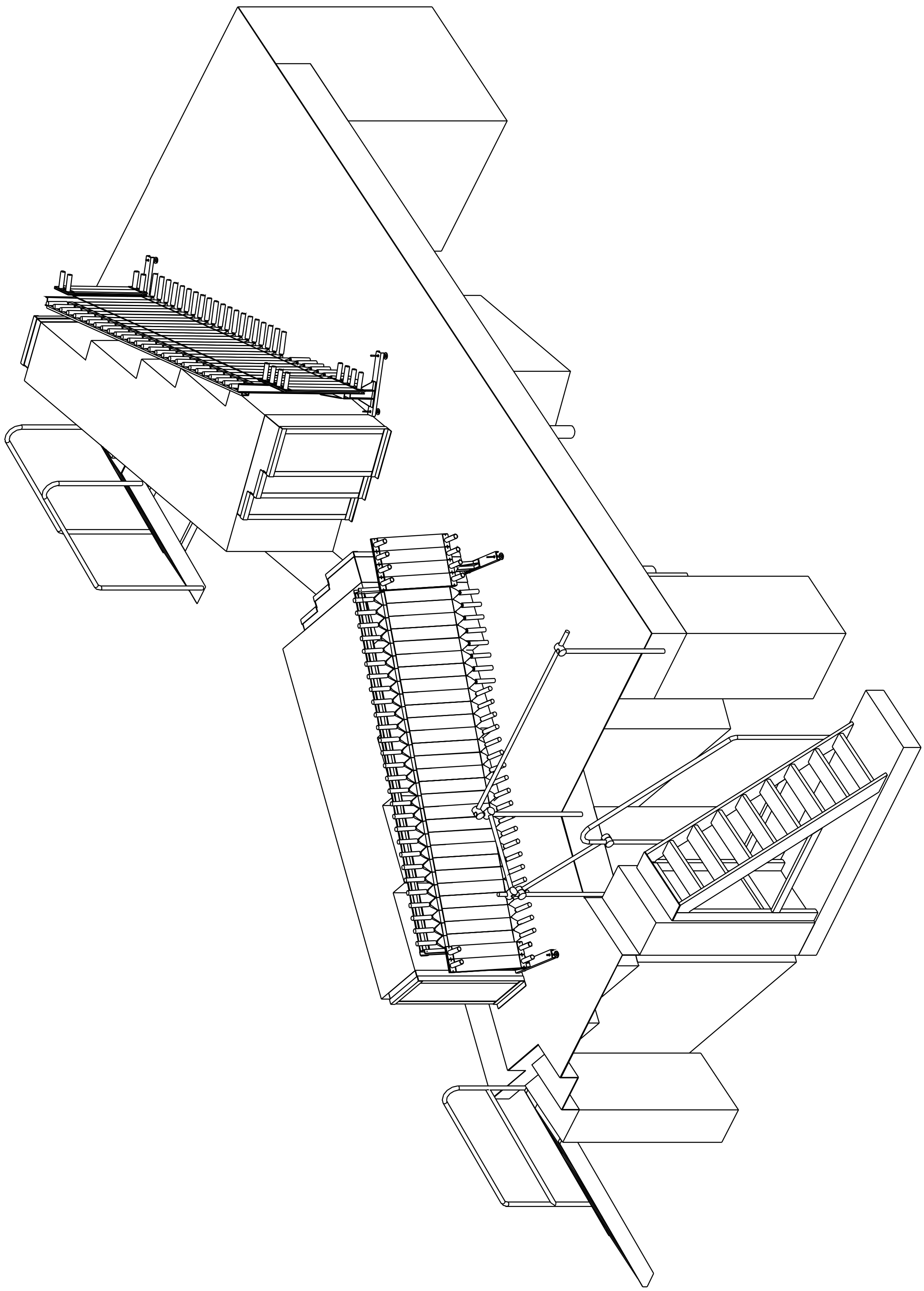

Figure 26: *Back isometrical view of the updated absorbers and muon hodoscopes together with the support for downstream detectors.*

References

[1] B. Adeva et al., Lifetime measurement of $\pi^+\pi^-$ and $\pi^\pm K^\mp$ atoms to test low energy QCD (Addendum to the DIRAC proposal) CERN-SPSC-2004-009, SPSC-P-284 Add.4, 21 April 2004.

[2] B. Adeva et al., CERN/SPSLC 95–1, SPSLC/P 284, Geneva 1995.

[3] O. Gortchakov, Space and momentum distributions of pions and kaons from $A_{\pi^+K^-}$, DIRAC note 05-23, 2005.