SDC-93-577

SDC SOLENOIDAL DETECTOR NOTES

RPC Muon System: Trigger Performances, Cost Estimate & Proposed Configuration

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Abstract

The use of *RPC*s in Level 1 trigger for timing purposes could provide the correct bucket identification. An extra trigger, mainly due to neutron and gamma backgrounds in the SDC detector, is expected for 3.2% of the events, at a luminosity of $10^{33}\ cm^{-2}s^{-1}$. The cost of each *RPC* counter for the SDC barrel region has been estimated to be 750 \$, equivalent to 1.5 M\$ for the barrel muon system.

1 RPC trigger performances

One of the major concerns about the detectors that will operate in future supercolliders is the control of the neutron ad γ backgrounds to tolerable limits.

Without careful shielding the background neutrons would not only damage most of the apparatus, but would also generate a very high stochastic noise. The same level of noise would be produced by gamma rays, since the expected neutrons/gammas ratio is close to one, if the gammas from all possible sources are taken into account.

Furthermore, the timing performances of the SDC muon trigger system are proportional to the total physical background, and its accurate estimation is fundamental for a proper evaluation of the trigger performances.

For these reasons, different shielding schemes have been studied for SDC using different Montecarlo programs (GCALOR, LAHET, MARS93). The following results have been obtained with an optimized shielding design for neutrons. Further improvements to reduce the γ background will be considered, but they are not included in the present simulations.

The three different codes still disagree to some extent, and the reported data [1] are either the average of the three values (if they all are in good agreement), or the result of a "two out of three" selection (if one code is in strong disagreement with the two others).

1.1 Neutron flux

The background neutron fluxes listed in Table 1 have been estimated at a luminosity of 10^{33} $cm^{-2}s^{-1}$ and are integrated over the entire energy spectrum.

One of the main advantages of RPCs with respect to scintillators is their higher radiation hardness and transparency to intense neutron fluxes. Measurements with thermal neutrons, made by M. Terrani, show that the RPCs detection probability per neutron is of the order of $10^{-4} \div 10^{-5}$ [2]. Data collected by I. Pless and collaborators using $1 \div 10$ MeV neutrons give a result of 5×10^{-3} for single chamber RPC [3], equivalent to 10^{-2} for double chamber RPCs. The average RPC detection probability over the entire SDC neutron energy spectrum is assumed to be 8.5×10^{-4} on the base of preliminary simulation data. A study of RPCs behavior under intense neutron fluxes at different energies is foreseen for the near future [4].

The scintillators sensitivity to neutrons presents a threshold at a neutron energy of 1.1 MeV, reaches the peak (6%) at 2 MeV and drops slowly with the increasing of the neutron energy (4% at 10 MeV) [5]. The average neutron detection probability for the SDC muon scintillator counters is of the order of 1.5%, about 20 times higher than the RPC one.

The RPC neutron-induced rates are calculated in Table 1 as *(Neutron Flux)* $\times$ *(Detection Probability)*. Since for the BR2 sectors the average RPC module area perpendicular to the Y axis is 8850 cm^2, the counts due to neutrons in the BR2 modules vary within a $170 \div 650$ Hz range. If these neutron background rate estimates will be confirmed by further simulations, neutrons will be a negligible problem at luminosity of 10^{33} $cm^{-2}s^{-1}$ for all SDC muon trigger counters. The random coincidence rate due to neutrons of the FR4 and FR5 counter pairs is completely negligible.

Table 1: Neutron flux in the *SDC* detector

Sector		Neutron flux $neutr/cm^2s$	RPC neutron detection prob.	Rate $counts/cm^2s$
BR2	Z min	20	9.4×10^{-4}	1.9×10^{-2}
BR2	Z max	120	6.1×10^{-4}	7.3×10^{-2}
IR2	R min	295	10.5×10^{-4}	31.0×10^{-2}
IR2	R max	115	10.5×10^{-4}	12.0×10^{-2}
FR4	R min	1950	5.9×10^{-4}	115.0×10^{-2}
FR4	R max	535	5.9×10^{-4}	31.6×10^{-2}
FR5	R min	195	10.8×10^{-4}	21.1×10^{-2}
FR5	R max	320	10.8×10^{-4}	34.6×10^{-2}

1.2 Gamma flux

The background γ fluxes listed in Table 2 have been calculated at a luminosity of 10^{33} $cm^{-2}s^{-1}$ and are integrated over the entire energy spectrum. Only the gammas produced by neutrons have been taken into account, disregarding other sources like π^0 decay. The Montecarlo results are less conclusive than in the case of neutrons; further investigations will have to confirm the present results.

As for the neutrons, *RPC*s seem to be less sensitive to gammas than the *SDC* muon scintillation counters. Data collected by I. Pless and collaborators using $1 \div 10$ MeV energy γ source give a detection probability of 6.6×10^{-3} for single chamber *RPC* [3], equivalent to 1.3×10^{-2} for double chamber *RPC*s. Instead, the γ detection probability for the *SDC* muon scintillator counters, averaged over the entire energy spectrum, is of the order of 6.0%[1].

The *RPC* γ-induced rates are calculated in Table 2 using the only available *RPC* detection probability (1.3%). The counts due to γs in the BR2 modules should be in a $2.7 \div 5.3$ kHz range. As for the case of neutrons, the random coincidence rate due to γs of FR4 and FR5 counter pairs is negligible.

1.3 Background rate and timing performances

The background rate from neutrons and gammas in the barrel region does not exceeds 0.67 Hz/cm^2, equivalent to 6 kHZ in each *RPC* counter. Even taking into account an *RPC* intrinsic stochastic noise of 2 kHz/m^2, the total background in each *RPC* module should not exceed 8 kHZ. Since the signals from four *RPC* are ORed together for triggering purposes, each *RPC* trigger region experiences a background rate of ~ 32 kHz.

[1]Such probability is higher in the forward regions, and lower in the barrel region (4.3%).

Table 2: Gamma flux in the SDC detector

Sector		Gamma flux γ/cm^2s	Rate $counts/cm^2s$
BR2	Z min	23	0.3
BR2	Z max	49	0.6
IR2	R min	175	2.3
IR2	R max	85	1.1
FR4	R min	295	3.8
FR4	R max	275	3.6
FR5	R min	500	6.5
FR5	R max	530	6.9

The probability of erroneous bucket identification, due to the association of the trigger signal from the drift tubes with a spurious hit in the RPCs, is proportional to the total background rate in an RPC trigger region. Such a probability is given by *(Time Gate)* $\times$ *(Noise Rate)*, where *(Time Gate)* corresponds to the maximum drift time of the wire chambers ($\sim$1.0 μs) used in Level 1 trigger. Therefore, the probability of an erroneous bucket identification (in addition to the correct one), is 3.2×10^{-2} at a detector luminosity of 10^{33} $cm^{-2}s^{-1}$. The presence of an extra Level 1 trigger for 3.2% of the events does not represent a problem; in some cases the extra trigger could already be rejected at trigger Level 2.

The dependence of the RPC signal delay on the background rate is expecially important in the SDC case, since the RPC system will be mainly devoted to time measurements. The *R&D* project $RD5$ at $CERN$ has recently obtained new data [2] on RPC time delay, using a (2×1) m^2 double gap RPC operated with standard (flammable) gas mixture. The beam was focused ($\sigma = 7$ cm), and the spill structure was 2.5 s every 14.4 s. The signal delay has been set to t = 0 for a beam flux of 20 Hz/cm^2, and measured every 20 Hz/cm^2 up to 200 Hz/cm^2. A linear increase of the delay has been observed, and the maximum time slewing in the $20 \div 200$ Hz/cm^2 range of beam flux results to be contained within 2 ns.

Such behavior is remarkably better than the one recorded with a single gap RPC during the 1989 $CERN$ test beam [6]. The difference could be explained by the fact that double gap RPCs read the OR of the signals coming from the two inner chambers. Therefore, the timing behavior of a double gap RPC is determined by the first of the two correlated signals reaching the readout plane. The detector is consequently faster and less dependent on the intensity of the interacting beam. The time slewing of the RPC signals should be completely negligible for counting rates of few Hz/cm^2, as in the case of the SDC muon detectors.

2 First cost estimate

The cost estimate of the entire muon system in one important parameter to consider, in order to make a choice among different kind of detectors suitable for trigger timing purposes.

The present cost estimate refers to $(50 \times 180)\ cm^2$ double gap *RPC* modules, to be used in *SDC*. The quoted cost is a realistic one, based on the actual production of 200 m^2 of *RPC*s for *L*3 at *CERN*. Other assumptions for the cost evaluation is a mass production (2000 modules) and a rate exchange of 1 \$ = 1500 lira. A cost per *RPC* of 1030 \$ has been estimated, as reported in Table 3.

The present capabilities of *General Tecnica* (the Italian manufacturer of *RPC*s) guarantee a production rate of 10 *RPC*/day; the full production of 2000 modules could be ready in one solar year. *RPC* modules following the *SDC* specifications could be ordered from GT at the quoted cost by any institution participating to the *SDC* Collaboration.

In order to further reduce the costs, the possibility of a joint effort between *INFN* Pavia (Italy) and *JINR* in Dubna (Russia) has been considered, as a part of a scientific agreement of collaboration between the two institutions. In this scenario, the assembling and testing of the *RPC* modules will be done in Dubna. *INFN* Pavia will provide the two inner chambers and all the materials to build the mechanical frame. A cost per *RPC* of 750 \$ has been estimated, as reported in Table 4.

Assuming that the mass production will be split between Italy and Russia, the cost of each module would be 750 \$, and the detector cost for the entire barrel muon system[2] would result to be 1.5 M\$.

The present cost evaluation is clearly very preliminary, and yet does not take into account many entries important for the final cost evaluation, such as:

- Transportation of the *RPC*s from Europe to SSCL;
- RPC VLSI readout electronics;
- HV suppliers;
- Gas system;
- Gas pipes, signal and HV cables.

The cost of the present baseline detector (scintillators) has been evaluated to be 1750 \$ per counter (including two photomultipliers for each counter), for a total cost of 3.5 M\$ for the entire scintillator muon system.

[2]1850 *RPC* modules will be needed to cover the BR2 area; 150 are considered as contingency.

Table 3: Cost evaluation of GT RPCs

Item	Cost in $
Materials for the two inner chambers	200 $
Construction of two inner chambers	350 $
Materials for the mechanical frame, HV connectors, gas pipes, ...	130 $
Assembling and testing	350 $
Total	1030 $

Table 4: Cost evaluation of GT/Dubna RPCs

Item	Cost in $
Materials for the two inner chambers	200 $
Construction of two inner chambers	350 $
Materials for the mechanical frame, HV connectors, gas pipes, ...	130 $
Assembling and testing	40 $
Transportation Pv/Dubna	30 $
Total	750 $

3 Proposed configuration

A possible *RPC* muon system configuration has been illustrated in previous note [7]. The following set of drawings shows the *RPC* structure and a proposed configuration for the barrel muon system.

Figure 1. Stratigraphy of a double gap *RPC* module with staggered spacers.
Figure 2. *RPC* module for the *SDC* barrel region.
Figure 3. Modules overlapping along Z.
Figure 4. Seamless coverage of *RPC* chambers along X.
Figure 5. Top view of an *RPC* module for *SDC*.
Figure 6. *RPC* section along X showing the overlapping of two nearby modules.
Figure 7. *RPC* section along Z showing gas pipes and plugs.
Figure 8. *RPC* section along Z showing the 50 Ω resistance and the signal cable.
Figure 9. Segmentation of a BR2 octant into 5 sectors.
Figure 10. Alinement of 4 *RPC*s along X to cover the length of a sector (716 *cm*).
Figure 11. Overlapping of the *RPC*s along Z. a) Sectors 1/5; b) Sectors 2/4; c) Sector 3.
Figure 12. Supporting web and *RPC* positioning in Sector 3.
Figure 13. Supporting web and *RPC* positioning in Sectors 2/4.
Figure 14. Supporting web and *RPC* positioning in Sectors 1/5 for an edge *RPC*.
Figure 15. Supporting web and *RPC* positioning in Sectors 1/5 for an internal *RPC*.
Figure 16. Extraction of an internal *RPC* in Sectors 1/5.
Figure 17. Details of the supporting web and *RPC* modules in Sectors 2/4.
Figure 18. Details of the supporting web and *RPC* modules in Sectors 1/5.

References

[1] The Montecarlo results, updated to the 10th of August 1993, have been provided by S. Willis and V. Sirotenko.

[2] R. Santonico, private communication.

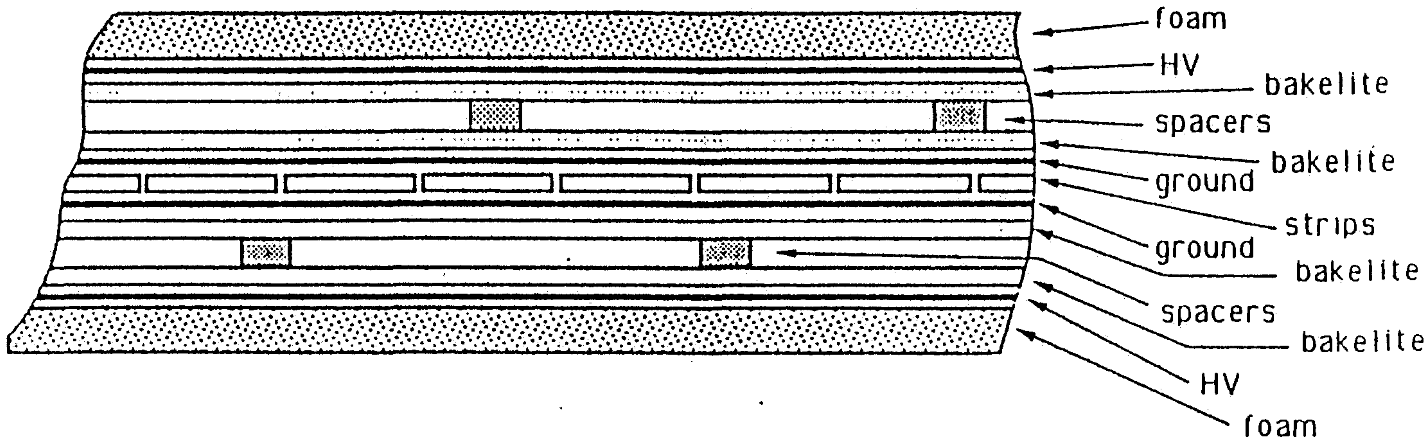
[3] M. Widgoff et al.; *Resistive Plate Chamber Technology Review*; GEM TN-92-206; October 1992.

[4] L. Pontecorvo, private communication.

[5] R. Thun, private communication.

[6] M. Bertino et al.; Nucl. Instr. and Meth.; A283, 654 (1989).

[7] V. Arena et al.; *A status report on RPCs for SDC*; SDC-92-557; May 1993.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bakelite
spacers
bakelite
ground
strips
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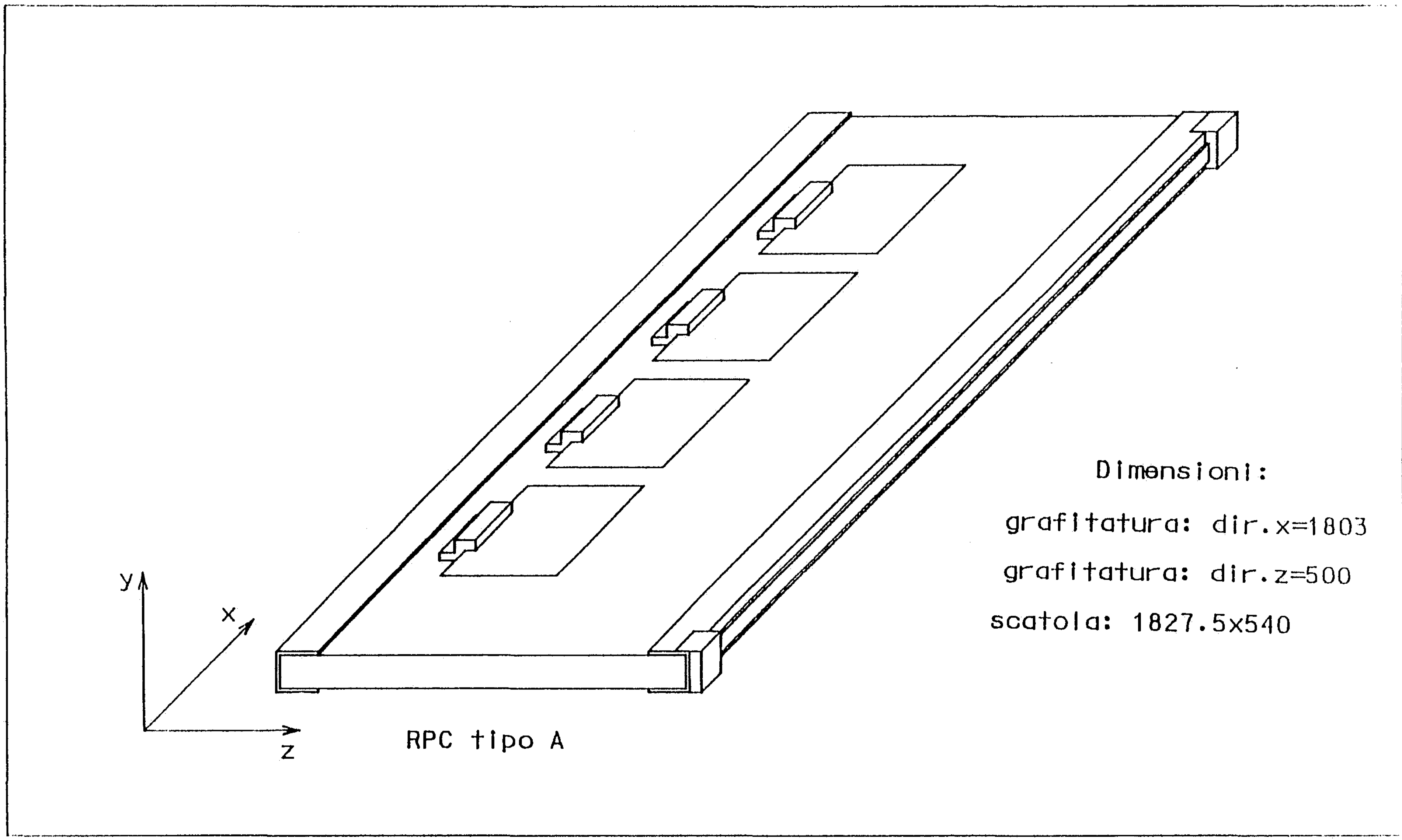
foam


y
x
z
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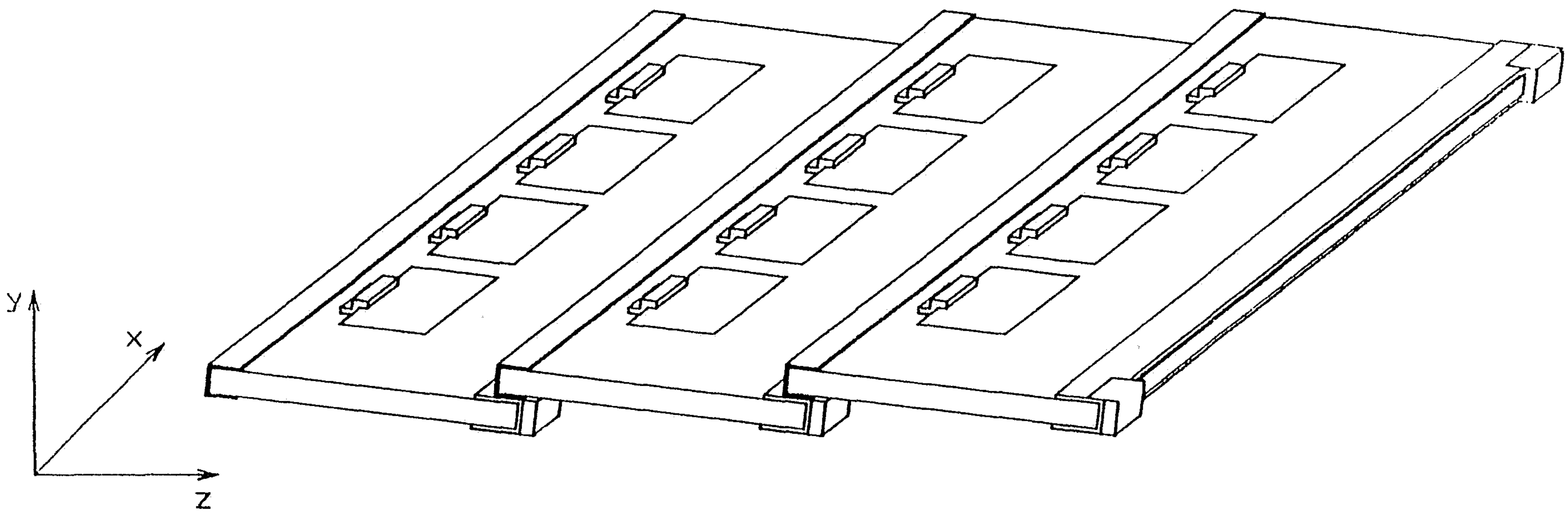
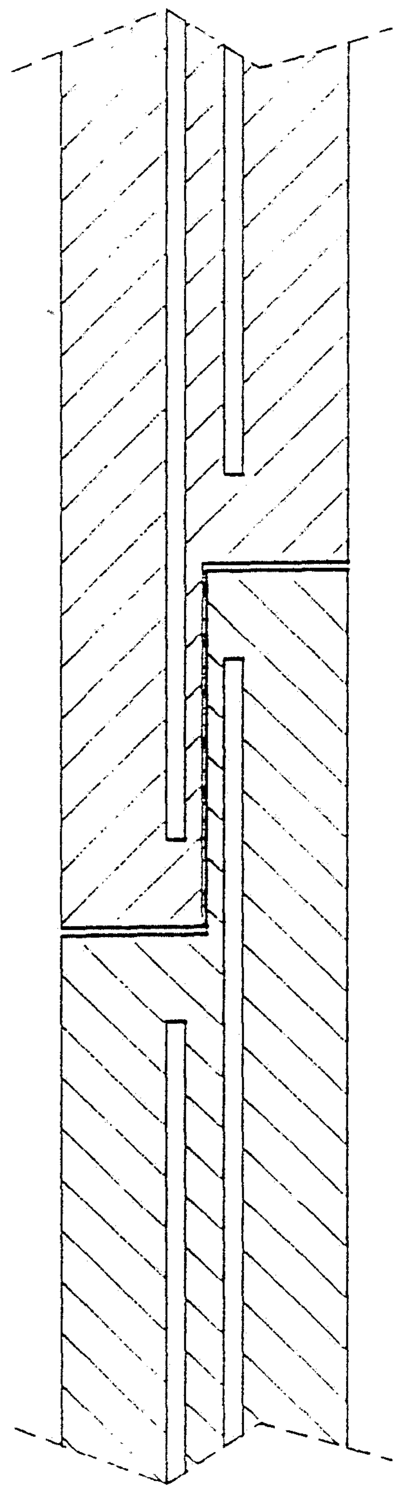
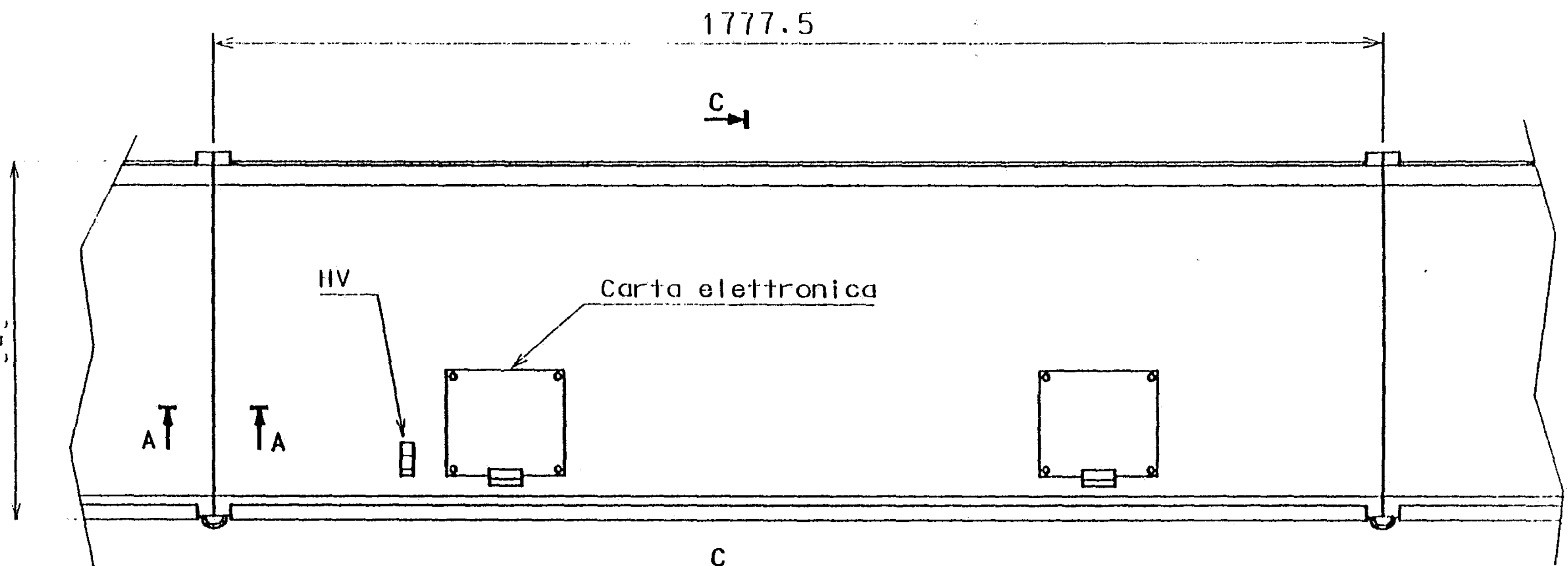
grafitatura: dir.z=500
scatola: 1827.5x540



Proiezione parte grafitata sul piano (dir.z)= 496.27

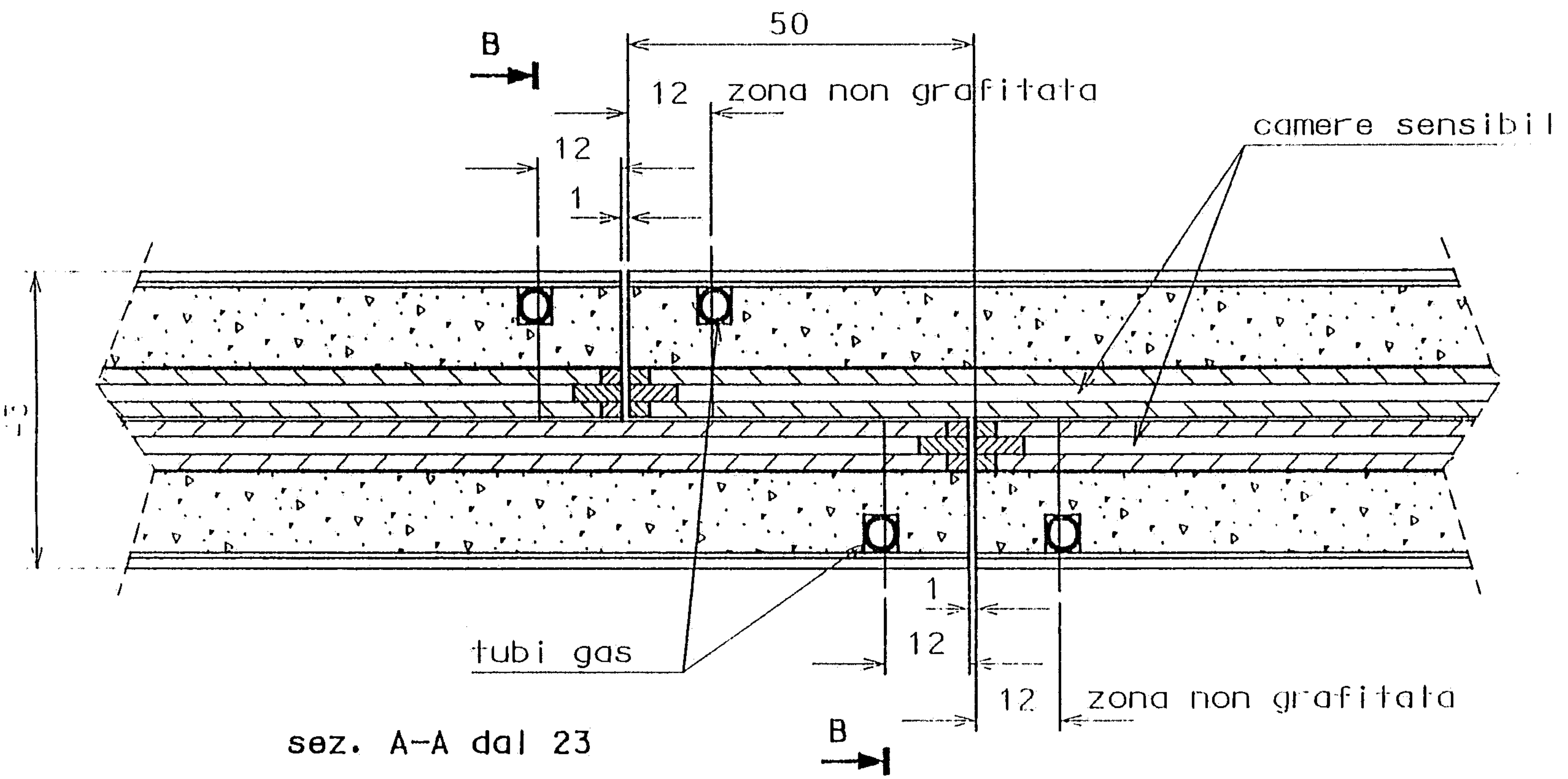
Inclinazione RPC = 7°





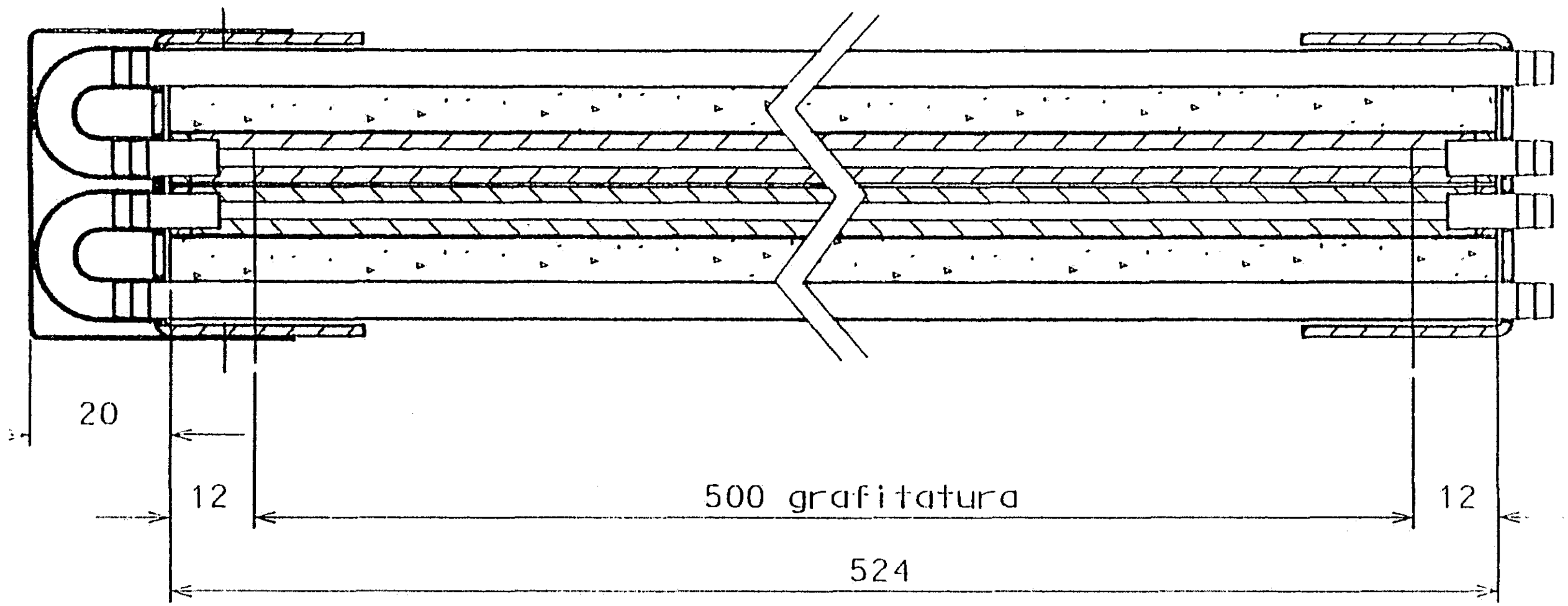
RPC tipo B

scala 1/10



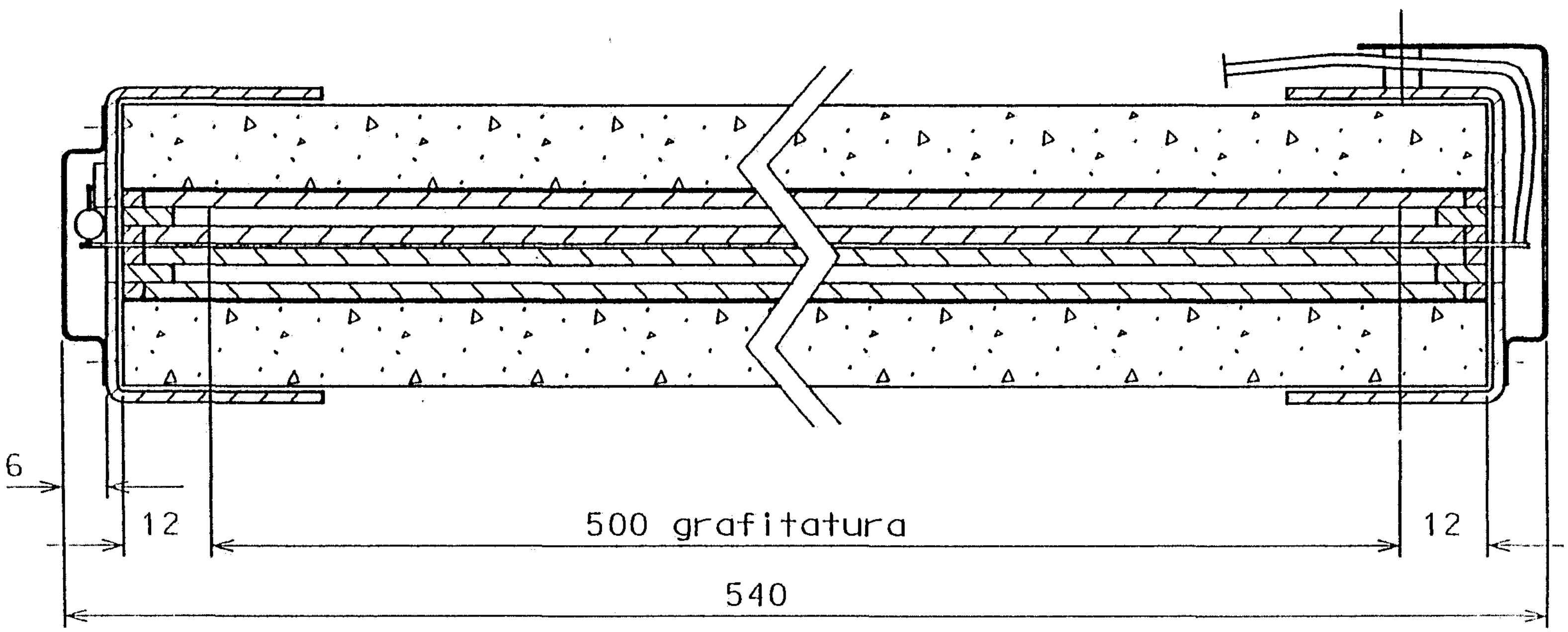
sez. A-A dal 23

scala 1/1



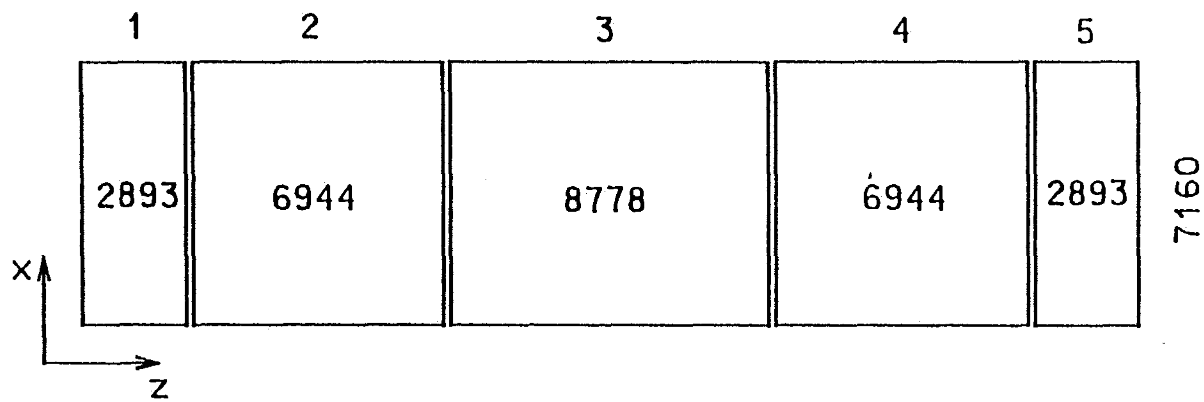
sez. B-B dal 24

scala 1/1



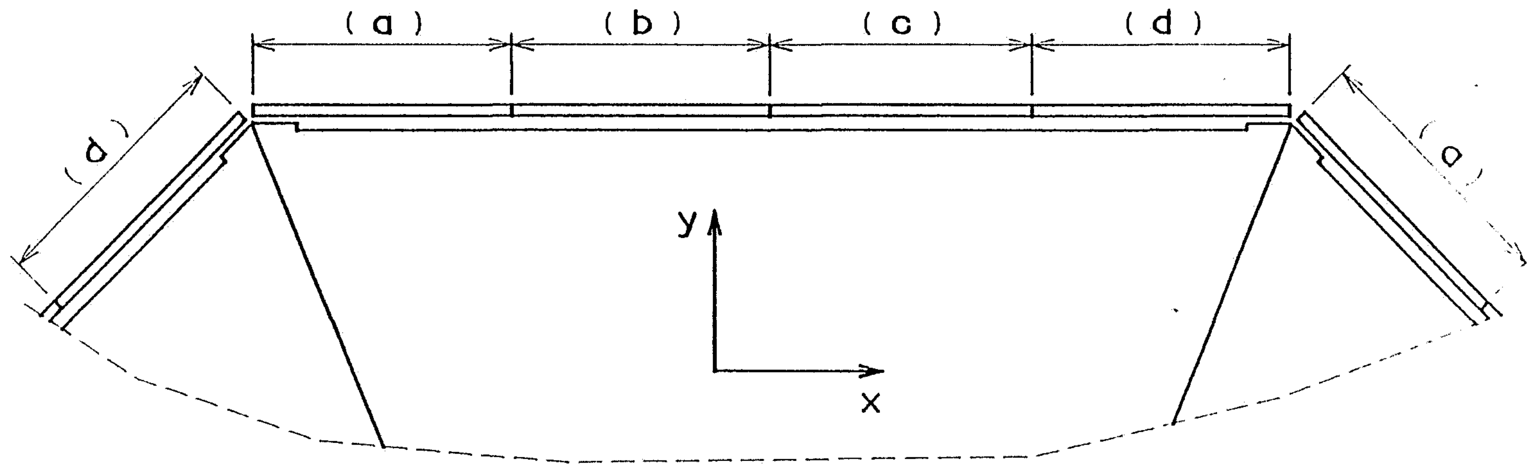
sez. C-C

scala 1/1

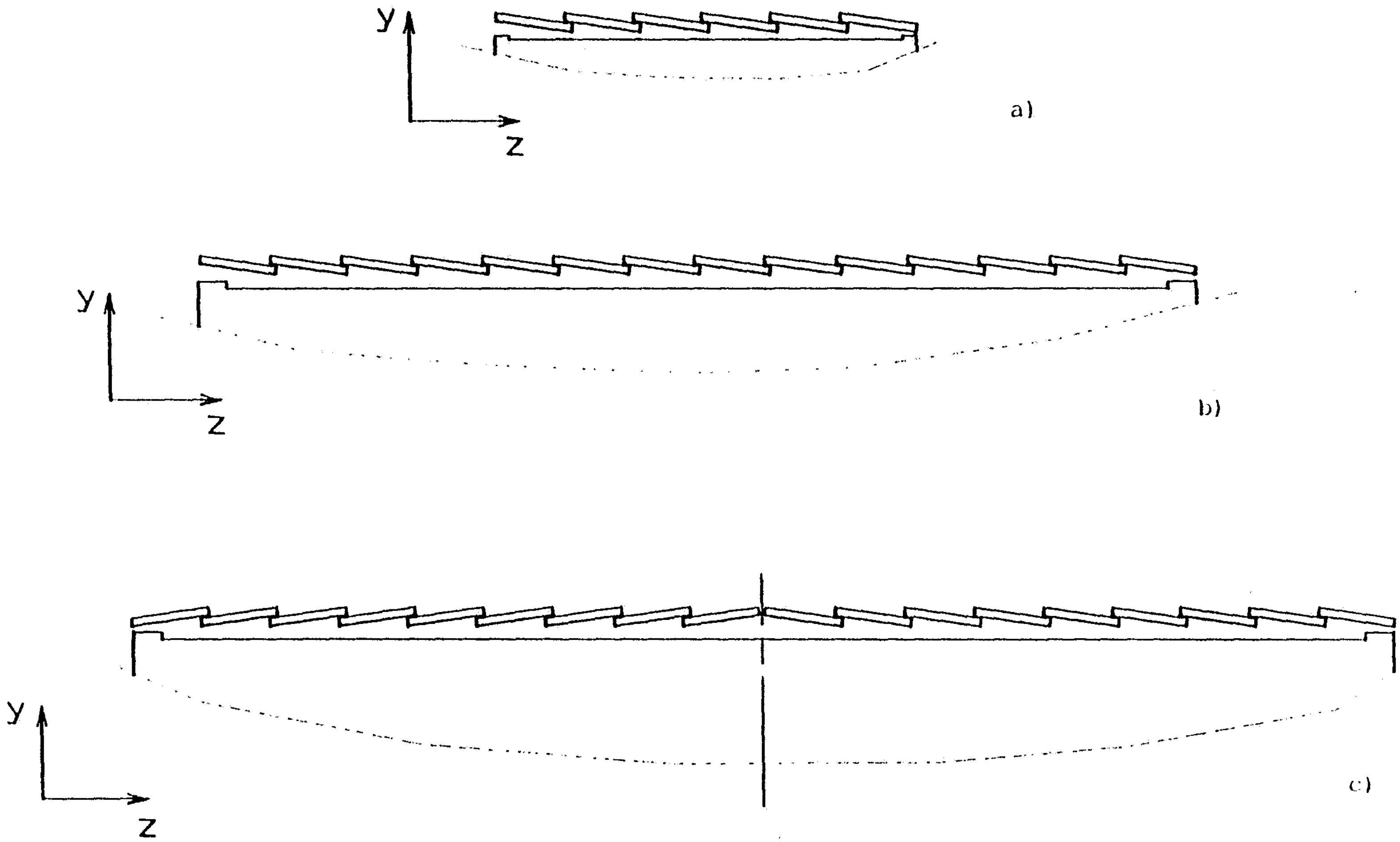


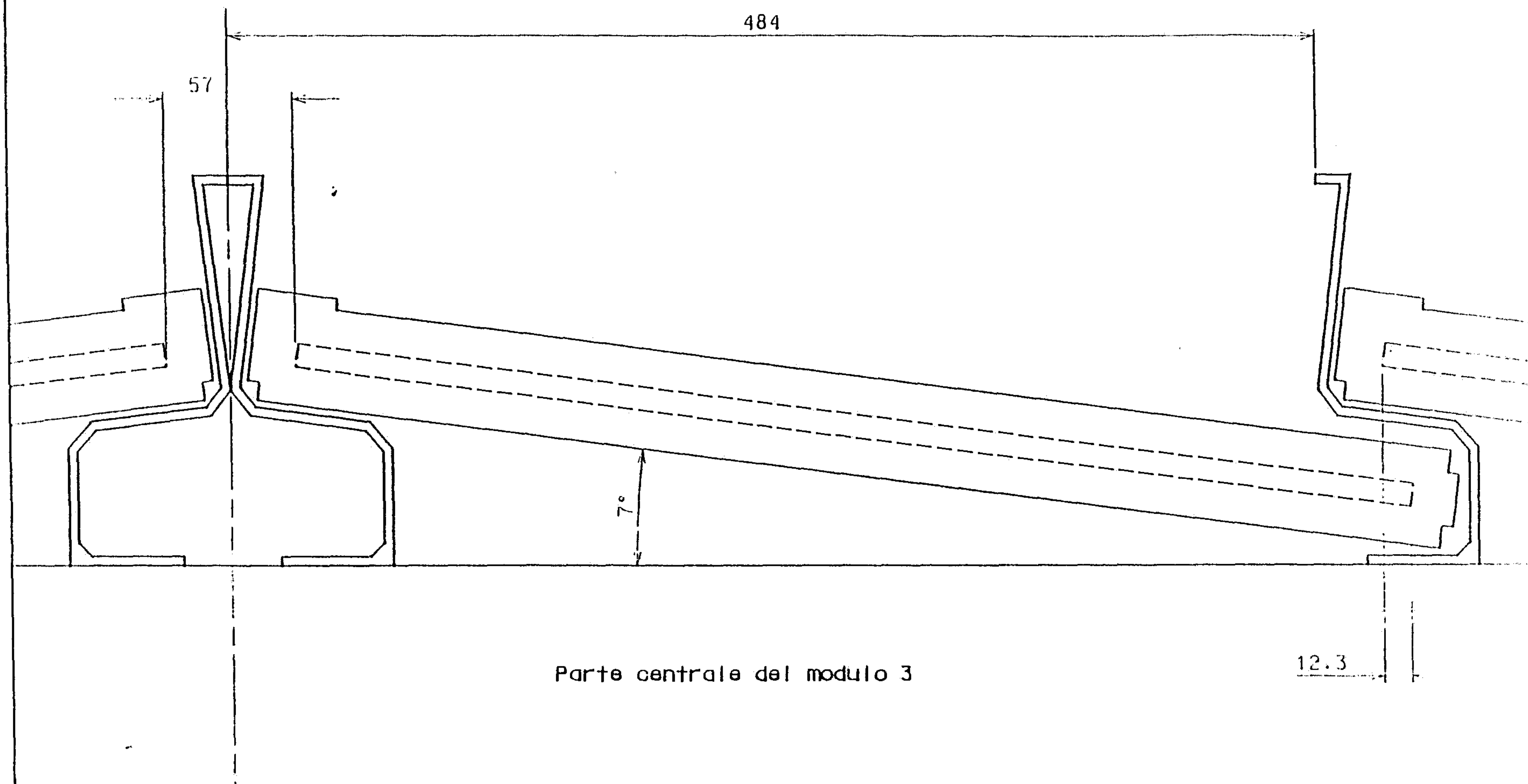
	N° RPC in dir.Z	Passo webs
Blocco 1-5	6	482.17
Blocco 2-4	14	496
Blocco 3	18	484

Scala 1/200



Scala 1/50

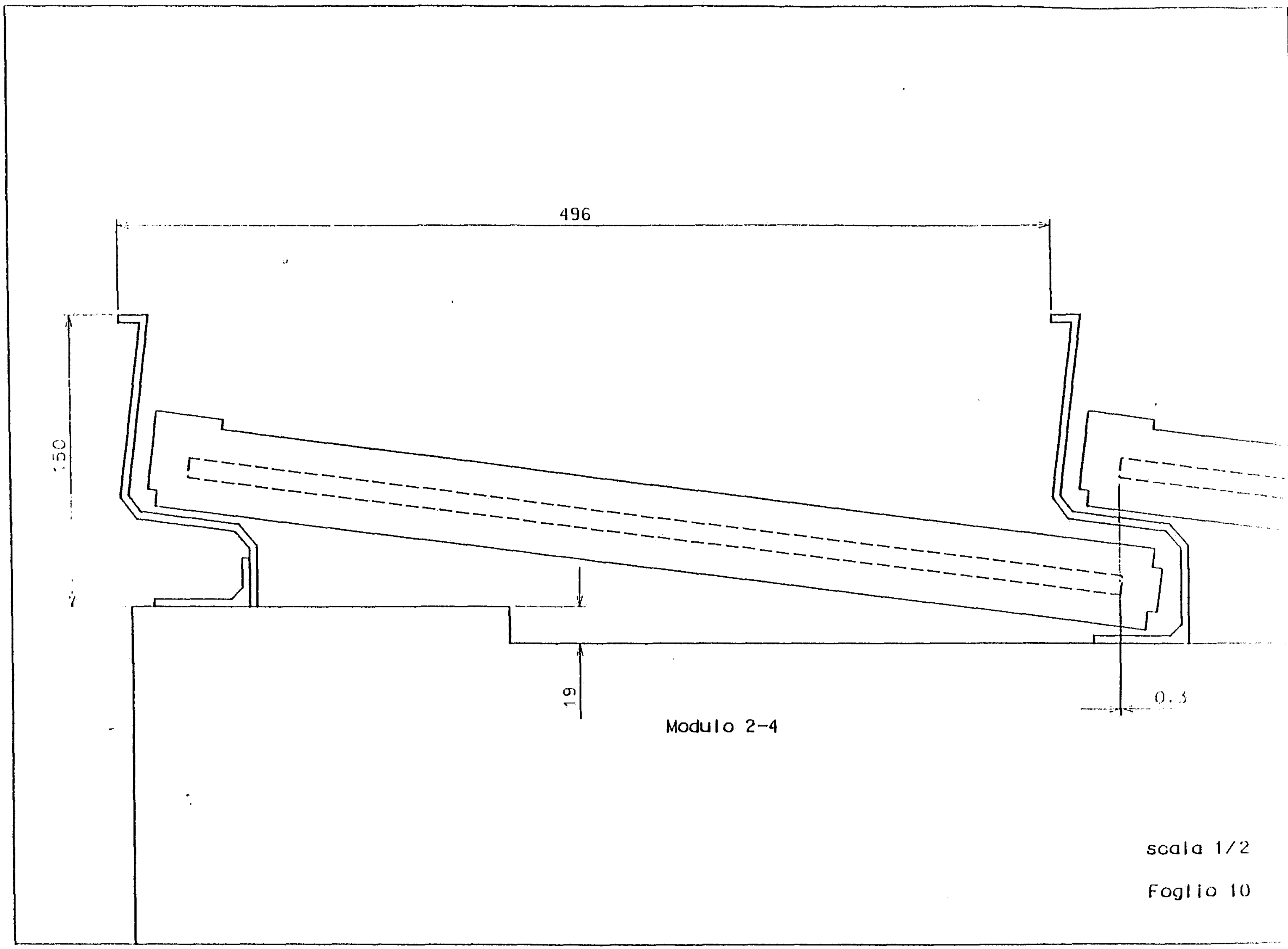

y
z
a)
y
z
b)
y
z
c)



Parte centrale del modulo 3

scala 1/2

Foglio 9



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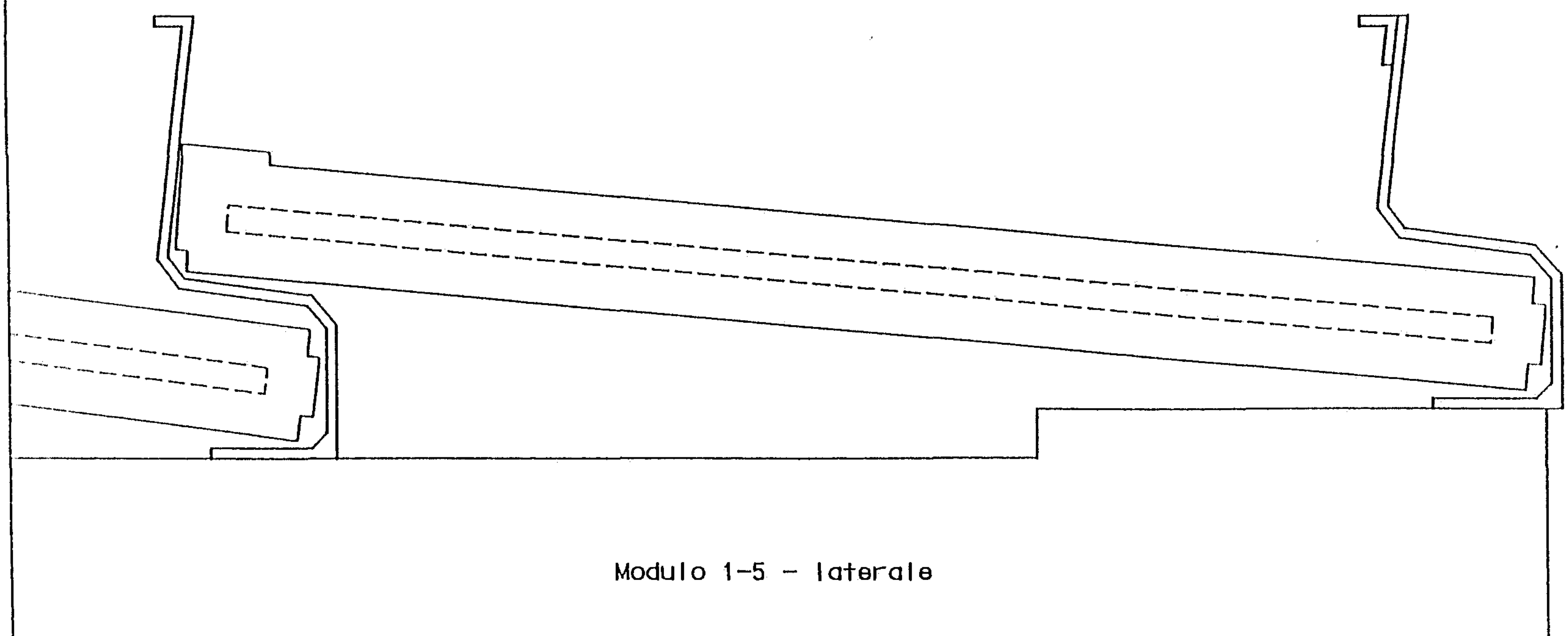
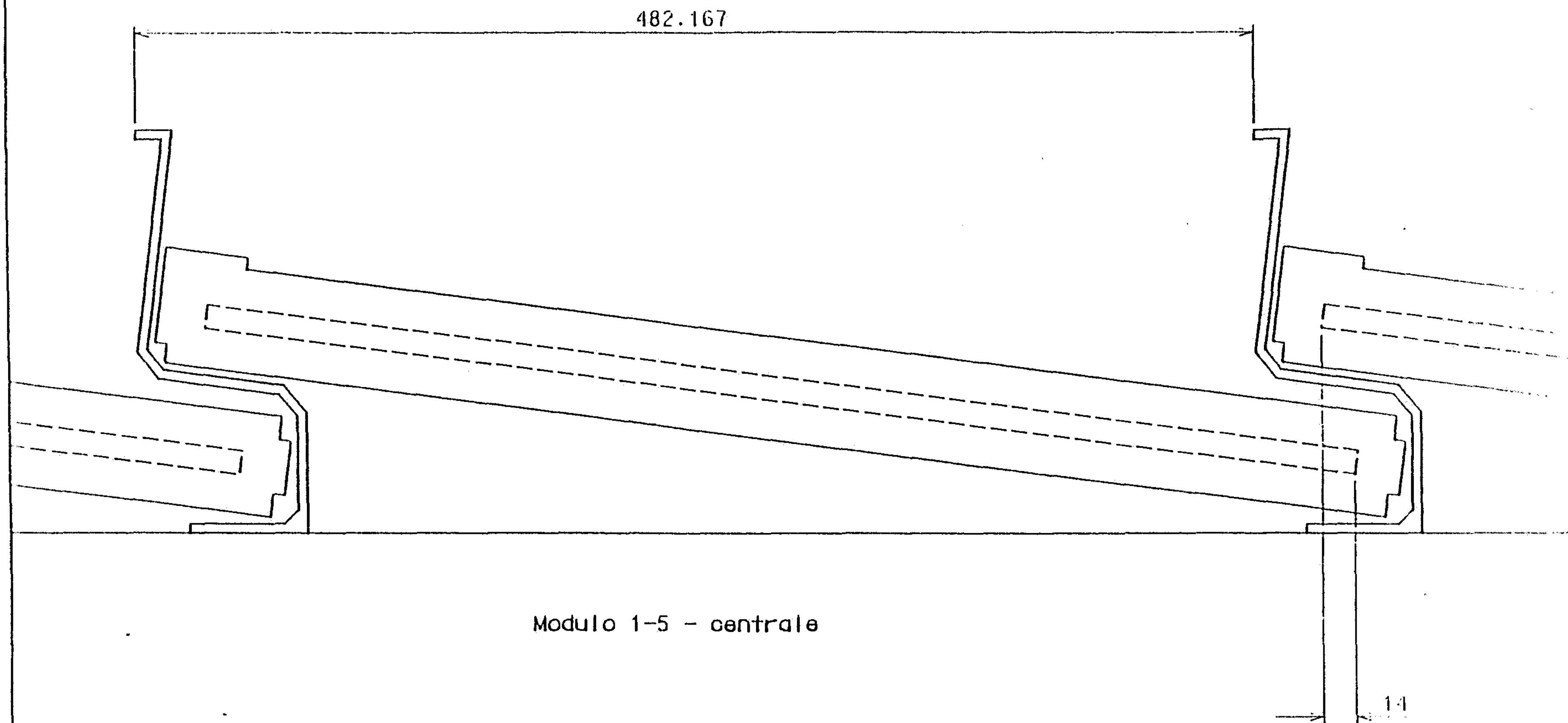


Modulo 1-5 - laterale

scala 1/2

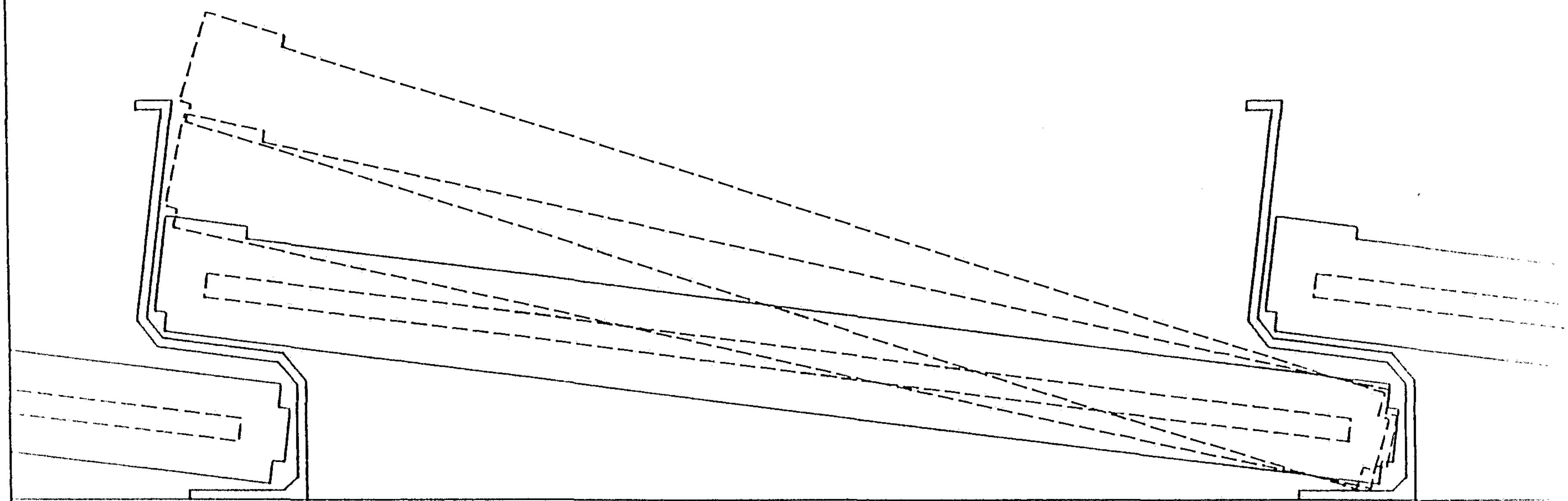
Foglio 11



Modulo 1-5 - centrale

scala 1/2

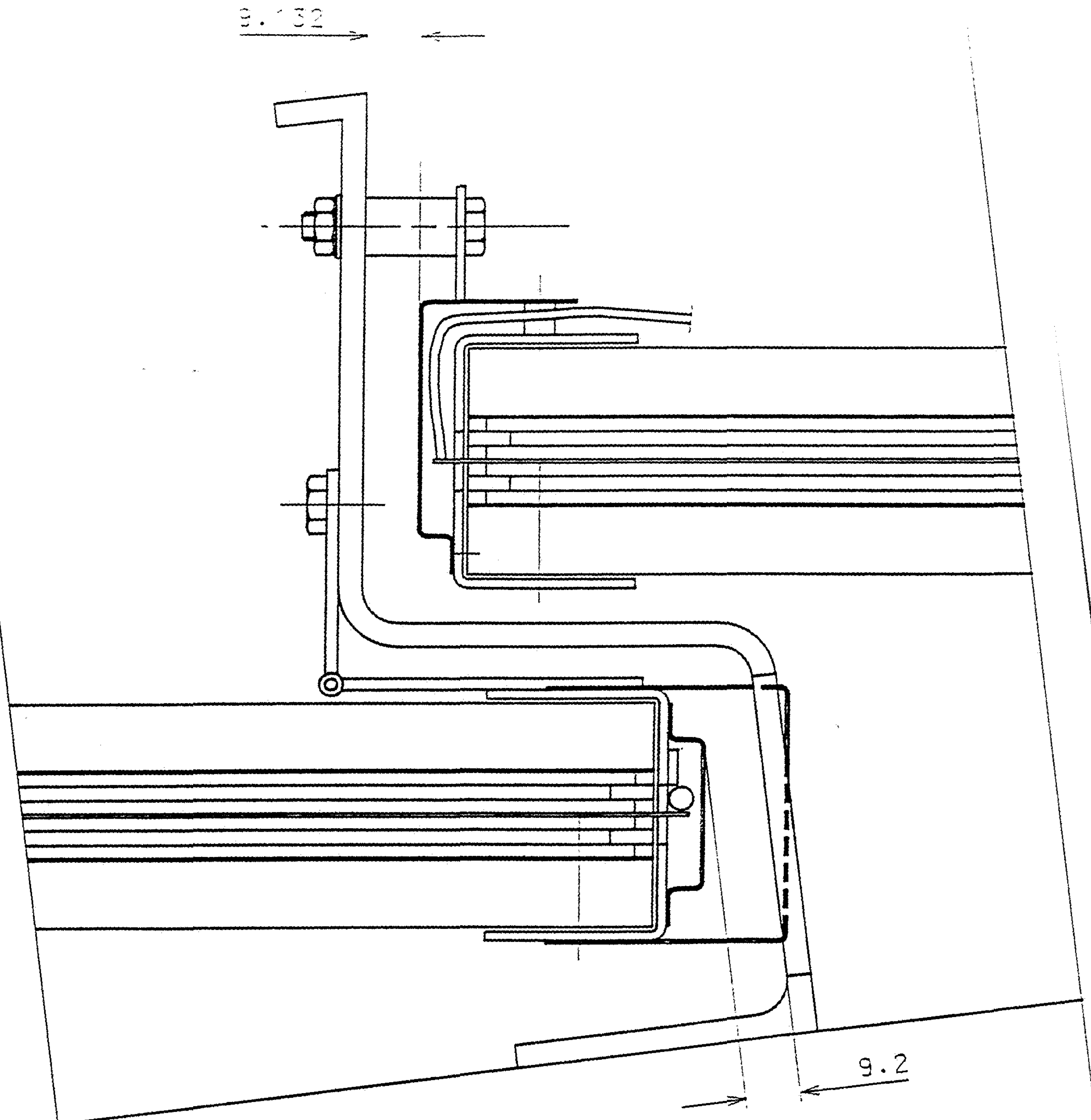
Foglio 12



Modulo 1-5 - estrazione

scala 1/2

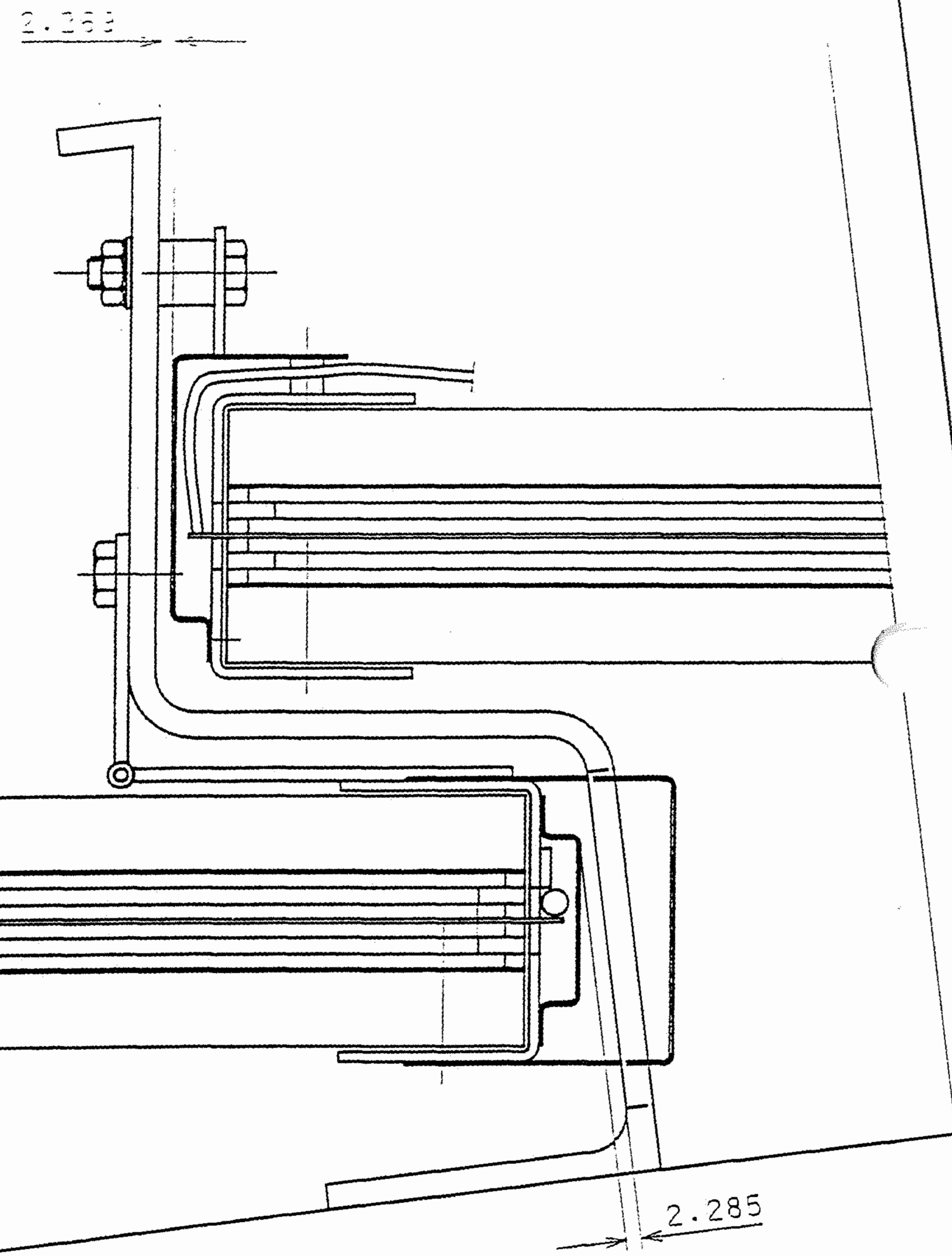
Foglio 13



Modulo 2-4, passo 496

scala 1/1

Foglio 18



Modulo 1-5, passo 482.17

scala 1/1

Foglio 19