COMPASS

COMPASS NOTE

TRIGGER RELATED ISSUES FOR THE DVCS RUNS 2016/2017

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1 Introduction

After the measurement of Drell-Yan (DY) in 2014 and 2015 the it was required to go back to the DVCS setup used in 2012. Therefore the middle horizontal hodoscopes were put back to the position of 2012, also six inner slabs of HO04 and HO03, which were exchanged for DY, had to be exchanged again. In addition a Monte Carlo simulation was done to optimize the outer trigger setup for the 2016/2017 DVCS run taking into account the new z position of the hydrogen target.

2 Trigger studies for DVCS 2016/17

For the DVCS runs in 2016 and 2017 T. Szameitat (Freiburg University) did a simulation with TGEANT to optimize the trigger setup. The beam file of the 2012 DVCS run was taken as a basis and inserted as distribution into HEPGen++ to simulate the DVCS process. Vertices were generated at a random position inside the LH2 target volume and the scattered muons were extrapolated through the magnetic field of SM1 and SM2, to the position of the trigger subsystems (MT, LT, OT, LAST) for determine the optimum hodoscope geometry in order to get the maximum acceptance for DVCS events with $Q^2 > 1$. From this simulation the necessary changes of the trigger system were determined. The result of this simulation is shown in Figures 1-3.

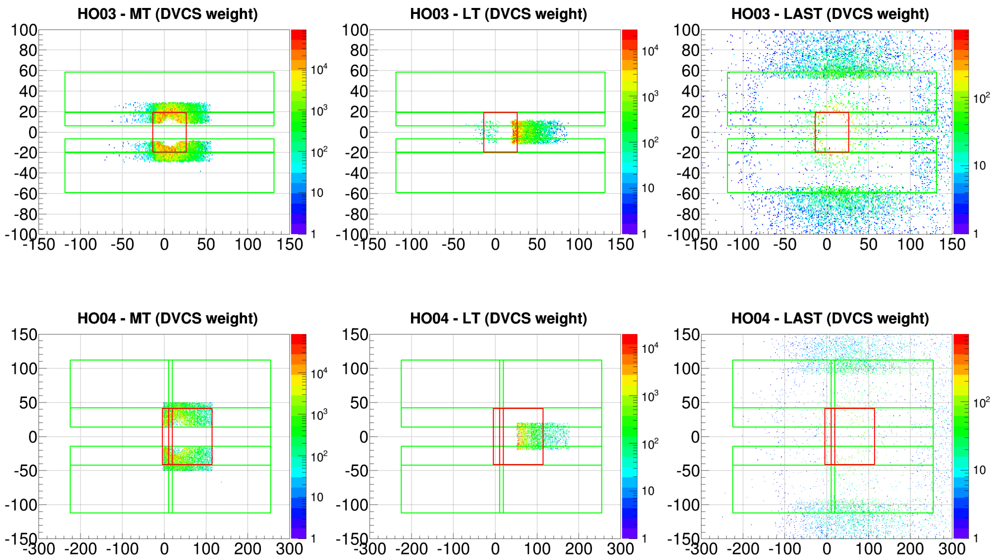


Figure 1: Distribution of events, which are triggered by middle (left), ladder (center) and LAS (right) at the z position of HO03 (top row) and HO04 (bottom row). The green rectangles show the active area of the corresponding outer hodoscope (2012 Setup), the red rectangle shows the dead zone (inactive, 2012 Setup).

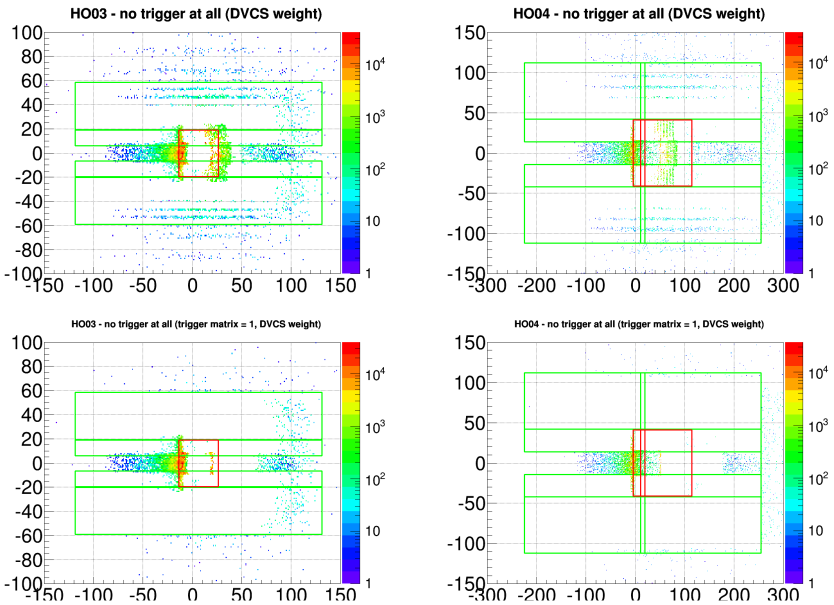


Figure 2: Events without trigger for HO03 (left) and HO04 (right). In the top row the normal outer trigger pattern is used and in the bottom row the whole outer trigger matrix is enabled. The green rectangles show the active area of the hodoscope (2012 Setup) the red rectangle shows the dead zone (inactive, 2012 Setup).

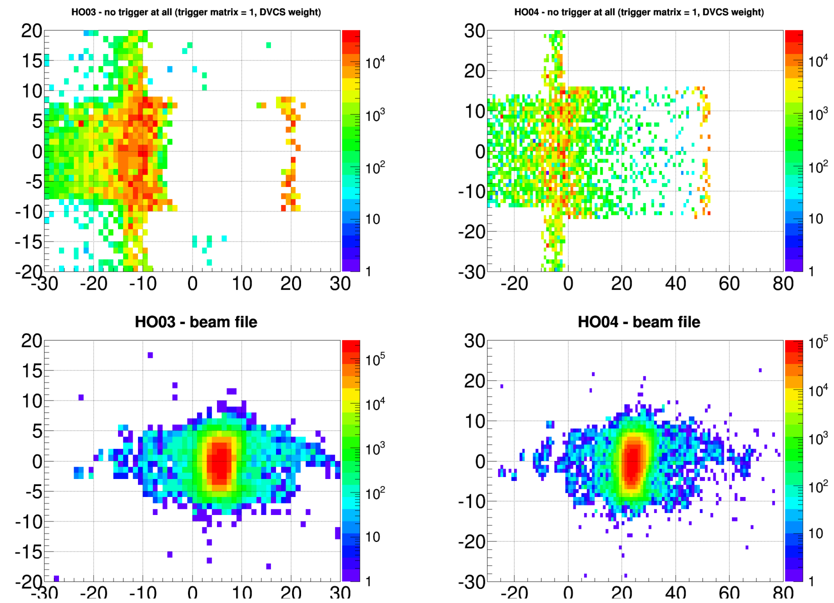


Figure 3: Top row: Blow up of the the central region of HO3 (left) and HO4 (right) showing events without trigger. Bottom row: Distribution of beam particles in the central region of HO3 (left) and HO4 (right.)

3 Modification of the Outer Hodoscopes:

3.1 HO03

The simulation shows (Fig. 2) that the old hole with the two newly added slabs in 2014 did not match well the event distribution of all events which fire any trigger but not the outer trigger. Therefor the new hole was shifted to the left (saleve) by 5.0 cm and its width was enlarged to 45,0 cm except for the two central stripes where the hole was elongated to a total width of 65,0cm. This was done to reduce the rate in these central slabs, as this area is covered by the ladder hodoscopes. The most inner part of the active area was made of acrylic glass except of the first 25cm of the two central slabs on the non-bending site, which were build as air light guides, to minimize the loss of DVCS photons. Figure 1 also shows that the area below and above the central hole of HO03 is covered by the middle hodoscopes. Thus it was decided to extend the height of the hole to 8 slabs.

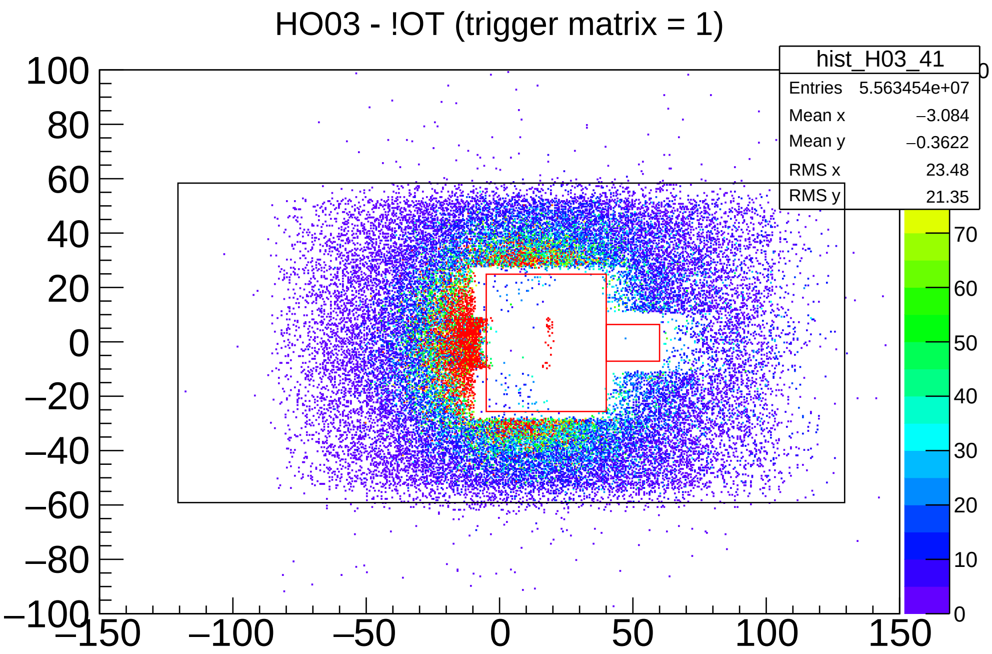


Figure 4: The new geometry of HO03 with the event distribution of all events which are not triggered when the Outer Trigger is excluded from the trigger composition. In black the outer dimension of HO03, in red the dimensions of the dead-zones.

The final geometry of the HO03 is shown in Fig. 3.1. The new slabs were made of BC408 scintillator. The dimension of these new slabs is shown in table 1 and the technical drawing can be found in the appendix.

	Saleve			Jura		
	left (cm)	right (cm)	length (cm)	left (cm)	right (cm)	length (cm)
1	-120.5	-5	115.5	40.0	129.5	89.5
2	-120.5	-5	115.5	40.0	129.5	89.5
3	-120.5	-5	115.5	40.0	129.5	89.5
4	-120.5	-5	115.5	60.0	129.5	69.5
5	-120.5	-5	115.5	60.0	129.5	69.5
6	-120.5	-5	115.5	40.0	129.5	89.5
7	-120.5	-5	115.5	40.0	129.5	89.5
8	-120.5	-5	115.5	40.0	129.5	89.5

Table 1: Saleve (left) and Jura (right) starting/ending points of the new scintillators in the central hole of HO03 for 2016/17 DVCS.

3.2 HO04:

The HO04 hodoscope system consists of two halves (HO04Y1/Y2) of 16 slabs of BC408 scintillator with a height of 15 cm for each slab. Each half is 250 cm long and has an overlap of 15 cm in between. The overlap between neighboring slabs is 1 cm.

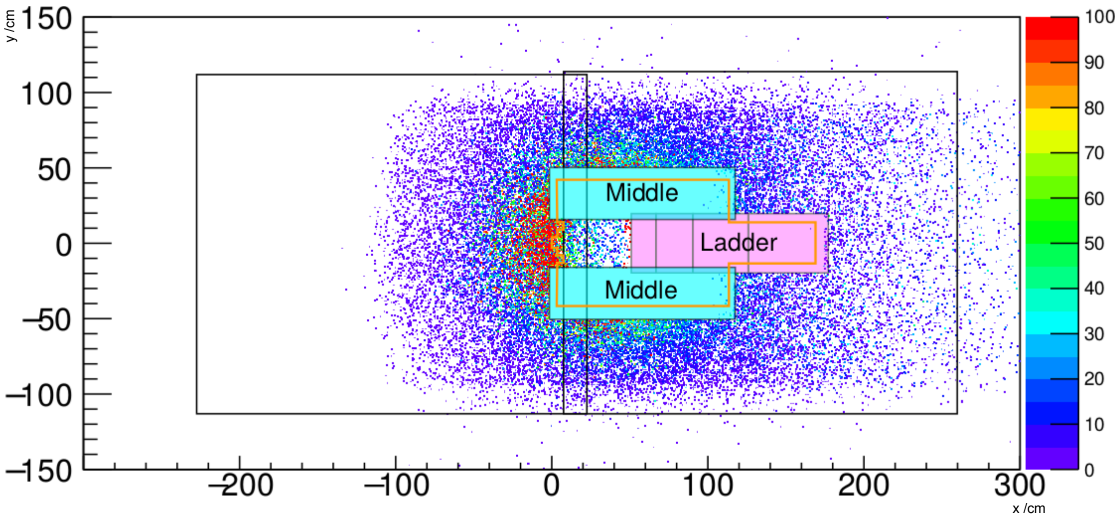


Figure 5: The new geometry of HO04 with the event distribution of all events which are not triggered when the Outer Trigger is excluded from the trigger composition. In black the outer dimension of HO04 in orange the dimensions of the dead-zones. The position and dimension of the other trigger systems is shown in turquoise and purple. The technical drawing can be found in the appendix.

The geometry of the 2012 DVCS test setup is shown in Fig. 2. For 2016/2017 the geometry of the inner six slabs in the central hole region was changed. Again the inactive zone of the two middle slabs was extended on the Saleve side to match the extension of HO03 for the Ladder trigger (see Fig. 5). All slabs on the Saleve side were elongated to x=3.5 cm. The Dimension of the inner slabs is given in table 3.2.

	Saleve [HO04Y2]			Jura [HO04Y1]		
	left (cm)	right (cm)	length (cm)	left (cm)	right (cm)	length (cm)
1	-227.5	3.5	231.0	112.5	257.5	145.0
2	-227.5	3.5	231.0	112.5	257.5	145.0
3	-227.5	3.5	231.0(*)	167.5	257.5	90.0
4	-227.5	3.5	231.0(*)	167.5	257.5	90.0
5	-227.5	3.5	231.0	112.5	257.5	145.0
6	-227.5	3.5	231.0	112.5	257.5	145.0

Table 2: Dimension of the inner six slab of the central region of HO04. * indicates the two slabs with stepped end face.

To cover the scattered muon events with $Q^2 > 1$, which are transversing the scintillator at x >3.5 cm a stepped scintillator end face of the two inner slabs was introduced. Figure 6 shows the distribution of events in the central hole region of HO04 and the new stepped end face design.

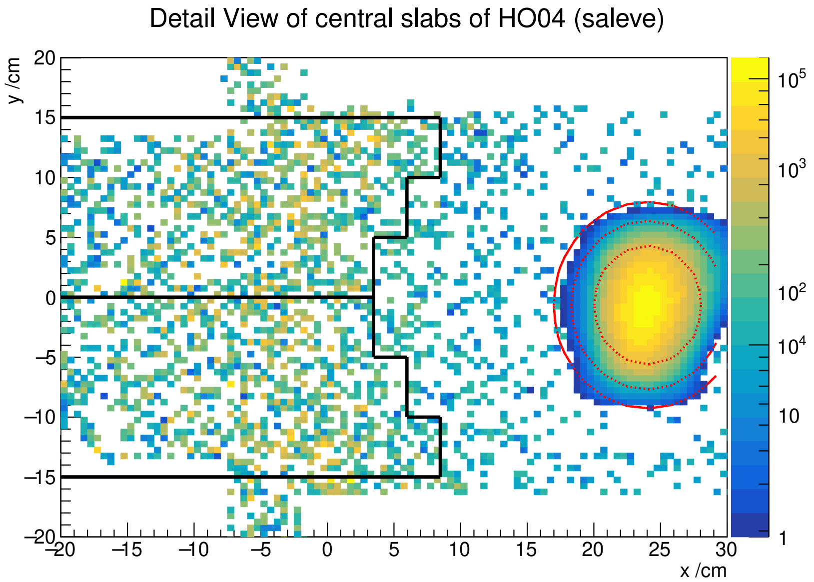


Figure 6: Stepped design of HO04 and beam profile shown on the not by the outer trigger covered events at the y position of HO04.

On the right hand side of the histogram we see the distribution of beam tracks extrapolated to the z Position of HO04. In red the 1,2 and 3 σ regions of the beam are shown. Due to the small space between the end face of the scintillator and the 3σ region of the beam a new readout of these two slabs was introduced. The usual readout by a fishtail lightguide and 2 Zoll PMT was replaced by three 1 Zoll PMT (XP2900 by photonis) without a lightguide. To attach the PMTs directly to the end face of the scintillator a new holder was developed (ref. Appendix) which allows the installation of three PMTs on the stepped geometry with the ability to stack several slabs with an overlap to each other.

The trigger matrix demands one signal per slab so the analogue output signals of the PMTs were summed at the detector with an LeCroy F428 Analogue Summation Module and sent via an coaxial cable to the trigger barrack, where this signal is fed directly into the discriminators for the two middle slabs (Figure 7).

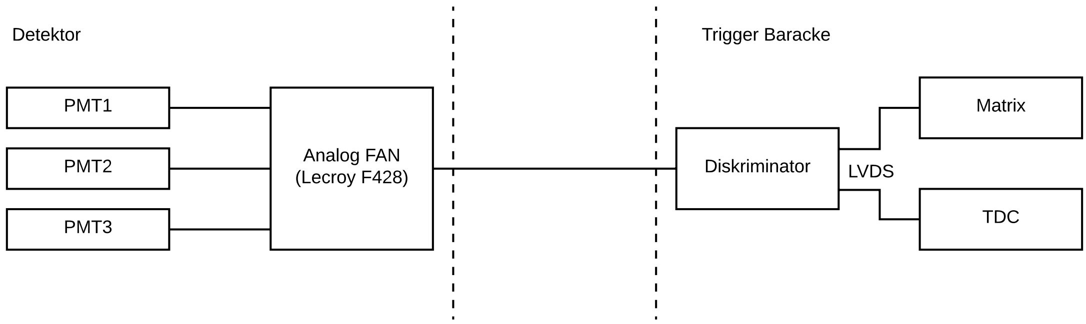


Figure 7: Readout chain of the stepped scintillators.

4 Re-measurement of the Outer position

A manual re-measurement of the outer position was done. They showed a wrong length in the detectors.dat of the HO04 slabs and a shift of the detectors along the x-axis:

detector	left edge	right edge	source
HO03	-120.5	129.1	measured
HO03	-118.8	131.2	detectors.dat
HO04Y1	-227.0	23.0	measured
HO04Y1	-225.0	20.0	detectors.dat
HO04Y2	8.0	258.0	measured
HO04Y2	10.0	255.0	detectors.dat

The results are:

- Slabs above and below the hole are 5 cm longer → total length: 250 cm instead of 245 cm
- Each hole was shifted by 2.5 cm (Saleve and Jura)
- HO04: overlap HO04Y1 and HO04Y2 is 15 cm instead of 10 cm

According to these measurements, the detectors.dat was updated.

5 Shift of the ladder hodoscopes

The distribution of events without a trigger in Fig. 2 (top row) shows events at x=20 cm (left, HO03) and x=50 cm (right, HO04). By moving both of the ladder hodoscopes 3 cm to the beam these events are covered. The new x positions are:

- $x_{HL04} = 118,0\,\mathrm{cm}$
- $x_{HL05} = 149,3\,\mathrm{cm}$

6 Other Modifications

6.1 Installation of Scalers

For monitoring the rate of the single photomultiplier tubes the discriminator outputs of the outer, ladder and middle hodoscopes were split with LVDS splitter modules (made by the university of Freiburg [ref]). This was done at the beginning of the 2017 run. One part of the split signals is fed into the matrix electronics, the other part is feeded into CATCH scaler cards. The TBnames nomenclature of the scaler cards is as follow:

- SCH03Y1s, SCH03Y1j
- SCH04Y1s, SCH04Y1s
- SCH04Y2s, SCH04Y2s
- SCHL4X1_u, SCHL4X1_d
- SCHL5X1_u, SCHL5X1_d

In order to determining the working point of the PMTs of all hodoscopes all the other hodoscpes were equipped by scaler temporarily during the commissioning.

These new working points of the hodoscopes were activated at the beginning of P08 in 2016.

6.2 Installation of un-prescaled TDC for trigger bits

An additional TDC was installed on 28 September 2017 for the not prescaled trigger bits. They are available on the HMSC5 TDC. The time distributions of the triggers is shown in Fig. 8

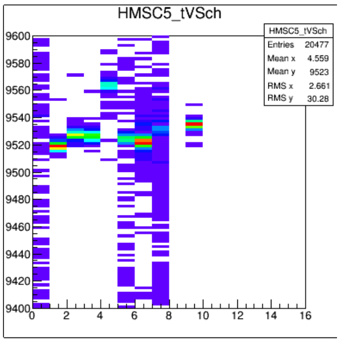


Figure 8: Time distribution of Triggers in HMSC5 TDC during the 2017 run.

Logbook entry: 58799

7 Trigger matrices 2016/2017

The trigger matrices used during the runs 2016 and 2017 are shown below. The channels on the x-axis represent the upstream hodoscope, the channels on the y-axis represent the downstream hodoscope.

LX	MY	OY	LAST
00000000000000000000000000000111	00000000000000000000000000000011	00000000000000010000000000000001	00000000000000000000000000000001
00000000000000000000000000001111	00000000000000000000000000000111	00000000000000110000000000000011	00000000000000000000000000000011
00000000000000000000000000011111	00000000000000000000000000001110	00000000000001100000000000000110	00000000000000000000000000000111
00000000000000000000000000111111	00000000000000000000000000011100	00000000000011000000000000001100	00000000000000000000000000001110
00000000000000000000000001111111	00000000000000000000000000111000	00000000000110000000000000011000	00000000000000000000000000011100
00000000000000000000000011111111	00000000000000000000000001110000	00000000001100000000000000110000	00000000000000000000000000111000
00000000000000000000000111111111	00000000000000000000000011100000	00000000011000000000000001100000	00000000000000000000000001110000
00000000000000000000001111111111	00000000000000000000000111000000	00000000110000000000000011000000	00000000000000000000000011100000
00000000000000000000011111111111	00000000000000000000001110000000	00000011000000000000000110000000	00000000000000000000000110000000
00000000000000000000111111111111	00000000000000000000011100000000	00000110000000000000001100000000	00000000000000000000001100000000
00000000000000000001111111111111	00000000000000000000111000000000	00001100000000000000011000000000	00000000000000000000011000000000
00000000000000000011111111111111	00000000000000000001110000000000	00011000000000000000110000000000	00000000000000000000110000000000
00000000000000000111111111111111	00000000000000000011100000000000	00110000000000000001100000000000	00000000000000000001100000000000
00000000000000001111111111111111	00000000000000000111000000000000	01100000000000000011000000000000	00000000000000000011000000000000
00000000000000011111111111111111	00000000000000001110000000000000	11000000000000000110000000000000	00000000000000000110000000000000
00000000000000111111111111111111	00000000000000001100000000000000	10000000000000001000000000000000	00000000000000001000000000000000
00000000000001111111111111111111	00000000000000110000000000000000	00000000100000000000000010000000	00000000000000010000000000000000
00000000000001111111111111111111	00000000000001110000000000000000	00000001000000000000000100000000	00000000000001100000000000000000
00000000000011111111111111111111	00000000000011100000000000000000	00000000000000000000000000000000	00000000000011000000000000000000
00000000000111111111111111111111	00000000000111000000000000000000	00000000000000000000000000000000	00000000000110000000000000000000
00000000001111111111111111111111	00000000001110000000000000000000	00000000000000000000000000000000	00000000001100000000000000000000
00000000011111111111111111111111	00000000011100000000000000000000	00000000000000000000000000000000	00000000011000000000000000000000
00000000111111111111111111111111	00000000111000000000000000000000	00000000000000000000000000000000	00000000110000000000000000000000
00000001111111111111111111111111	00000001110000000000000000000000	00000000000000000000000000000000	00000001100000000000000000000000
00000011111111111111111111111111	00000011100000000000000000000000	00000000000000000000000000000000	00000111000000000000000000000000
00000111111111111111111111111111	00000111000000000000000000000000	00000000000000000000000000000000	00001110000000000000000000000000
00001111111111111111111111111111	00001110000000000000000000000000	00000000000000000000000000000000	00011100000000000000000000000000
00011111111111111111111111111111	00011100000000000000000000000000	00000000000000000000000000000000	00111000000000000000000000000000
00111111111111111111111111111111	00111000000000000000000000000000	00000000000000000000000000000000	01110000000000000000000000000000
01111111111111111111111111111111	01110000000000000000000000000000	00000000000000000000000000000000	11100000000000000000000000000000
11111111111111111111111111111111	11100000000000000000000000000000	00000000000000000000000000000000	11000000000000000000000000000000
11111111111111111111111111111111	11000000000000000000000000000000	00000000000000000000000000000000	10000000000000000000000000000000

8 Veto dead time in 2017

The veto dead time in 2017 for each trigger system was measured on October 20th for the μ^+ beam and on October 21st for the μ^- beam. The values were calculated as an average of 4 consecutive spills. The veto was delayed by $\approx 40\,\mathrm{ns}$. The results are summarized in Table 3.

	MT /%	LT /%	OT /%	CT /%	LAST /%
dead time μ^+	9.5	8.0	10.4	16.1	8.9
dead time μ^-	7.3	5.9	8.2	13.4	6.7

Table 3: Dead time of the different trigger systems as measured on 20th/21th of October 2017.

The intensity on T6 was close to the nominal value of 150 units. The accuracy of this measurement is estimated to be $\pm 0.5\%$.
Logbook entry: 59116

9 Remarks for the data taking

9.1 Change of composition for Beam Trigger

At the beginning of the 2017 Run the X and Y plane of SF1 and SF2 were changed to generate the Beam Trigger signal. So the following configurations are valid for the different years:

2016	Scifi1Y	and	Scifi2X
2017	Scifi1X	and	Scifi2Y

9.2 2017 HCAL1 Trigger crate issue

Several times in 2017 the HCAL1 VME crate failed. This resulted in a lowered CALO trigger rate during the affected runs. The CALO trigger is only used for monitoring purpose of the Hodoscope triggers. The physics data taking is not affected, except of an minor change in the dead time due to the lower total trigger rate.

9.3 Swap of cables in Outer hodoscopes in 2016

Due to a swap in the cabeling of the central slabs of the HO03 hodoscope the coincidence in the trigger matrix was wrong. The impact of the rates is shown in Fig. 9.

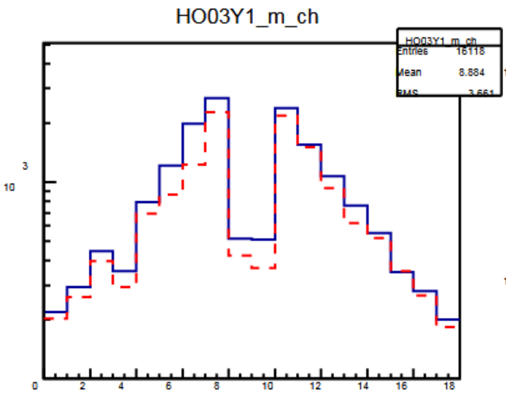


Figure 9: Count distribution for HO03 in 2016

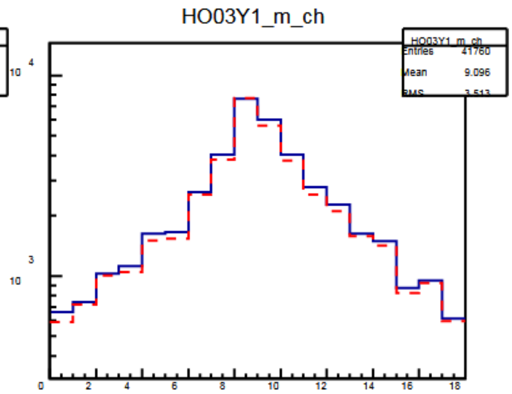


Figure 10: Count distribution for HO03 in 2017

This issue was solved at the beginning of the 2017 run.

9.4 Additional peaks in trigger timing

From time to time the coool plots of the trigger timing distribution are showing additional peaks (Fig. 11).

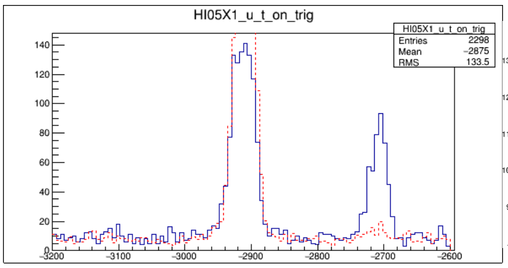


Figure 11: Trigger time distribution.

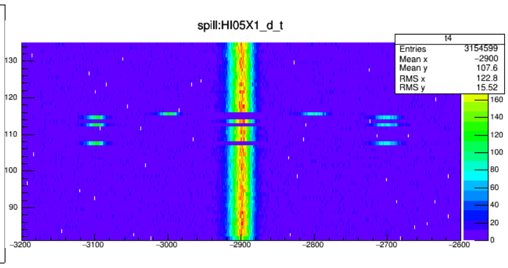


Figure 12: Trigger time vs. Spill.

In Fig. 12 the timing peak for each spill is shown. It can be seen that the jump of the timing only occurs for single spills (order of 100 tdc-ticks equals $\approx$ 128 ns). The explanation is an instability of the F1-TDC which is used to get the master time.

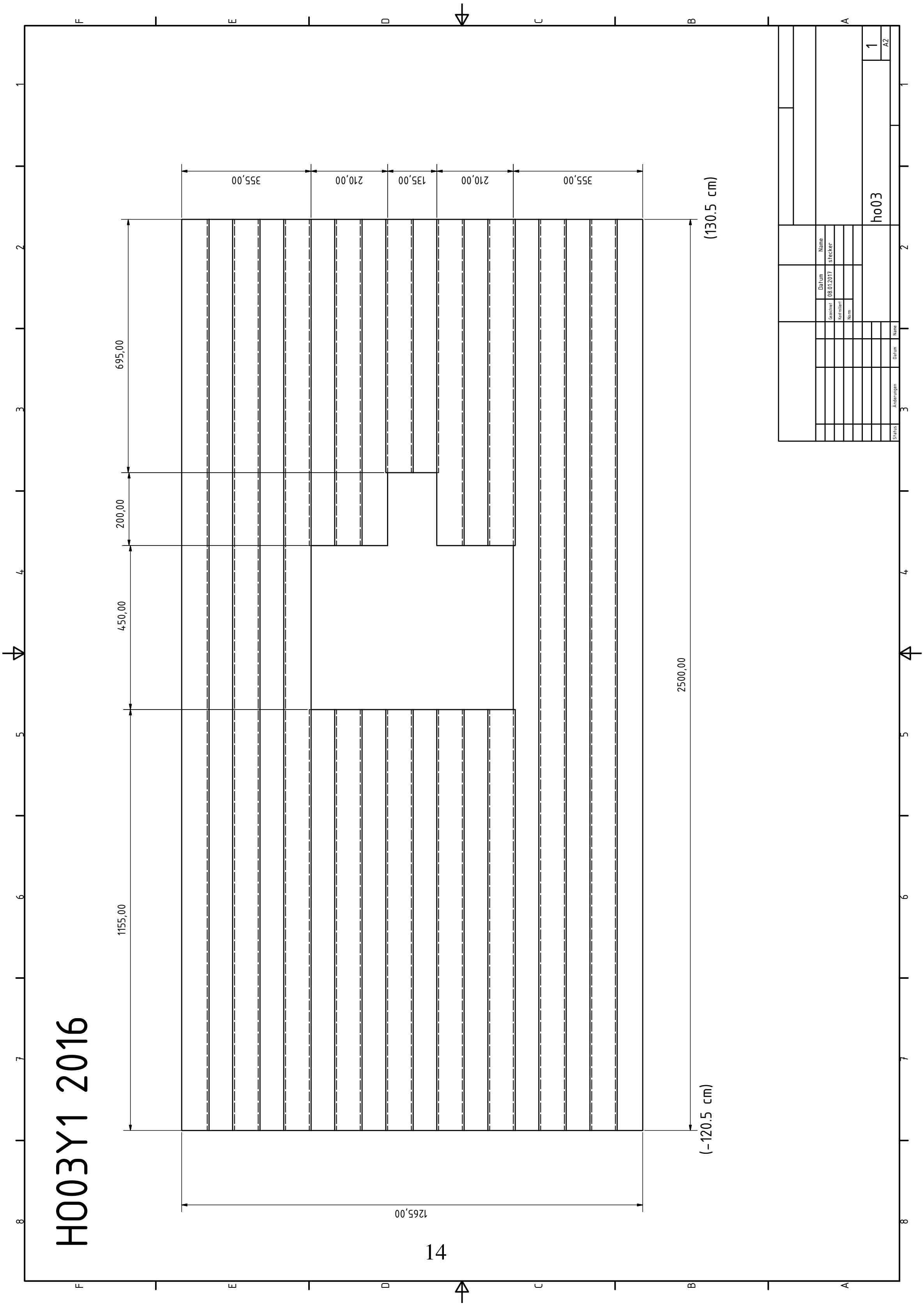
10 Usefull TDCs and SCALER for data analysis

Several trigger signals are connected to the Misc Channels Scaler and TDC (TBnames `HMSC1` and `SCMSC1__`). Table 4 gives an overview.

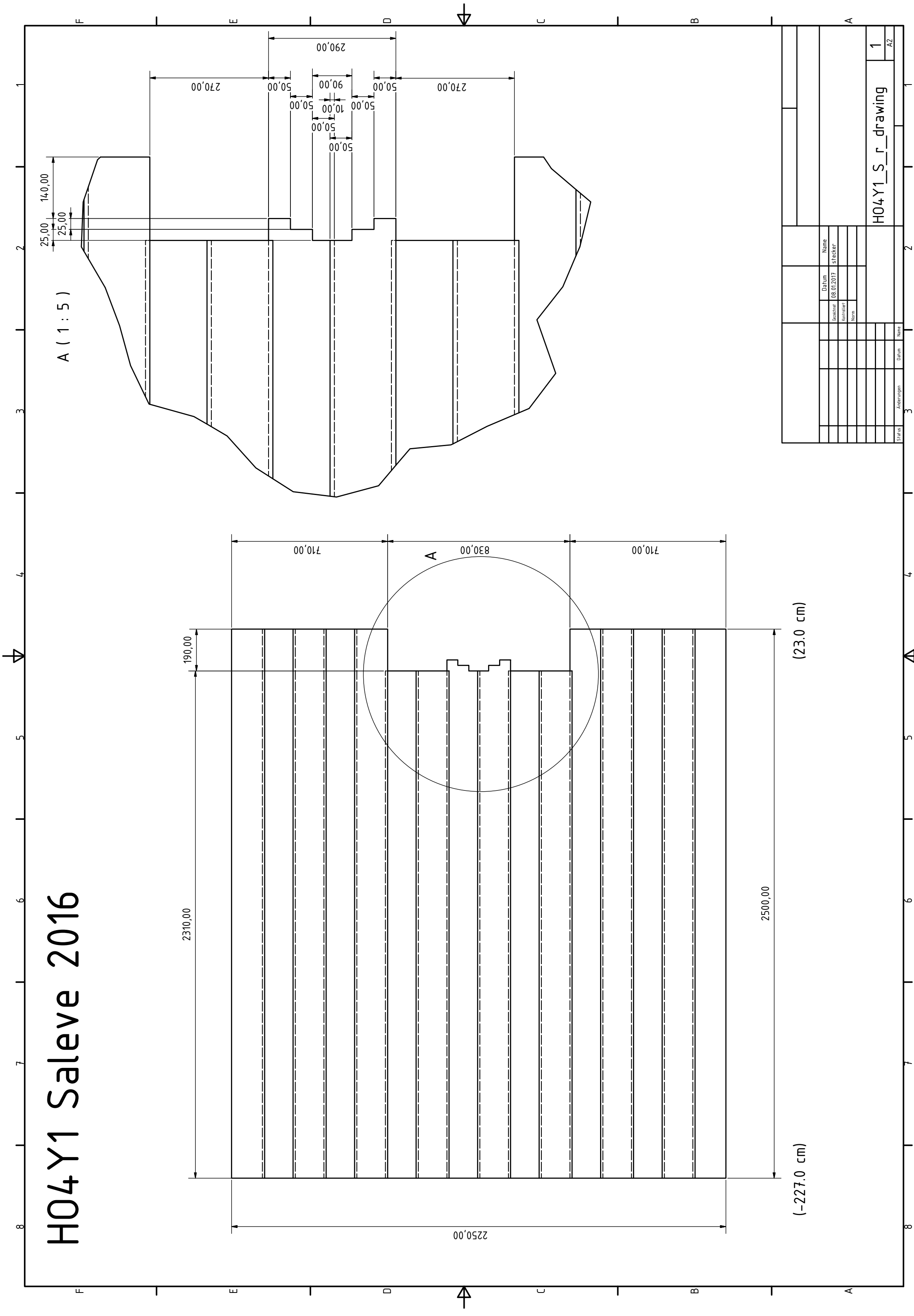
channel	Description
0	Beam Killer 1
2	Random
3	Outer Trigger (after coincidence unit)
4	Horizontal Middle matrix output (a.r.d.)
6	Outer matrix output (a.r.d.)
8	Middle trigger (after coincidence unit)
9	Random vetoed
11	Veto Inner (a.r.d.)
13	Trigger attempt (after final logic Fan out)
14	Ladder matrix out
15	MT with delayed veto
16	TigerDT0 trigger
20	Ladder Trigger (after coincidence unit)
22	Calo trigger
28	OR of Outer 4 hodoscope (a.r.d.)
29	True Random Trigger attempts
31	LAST: LAS trigger

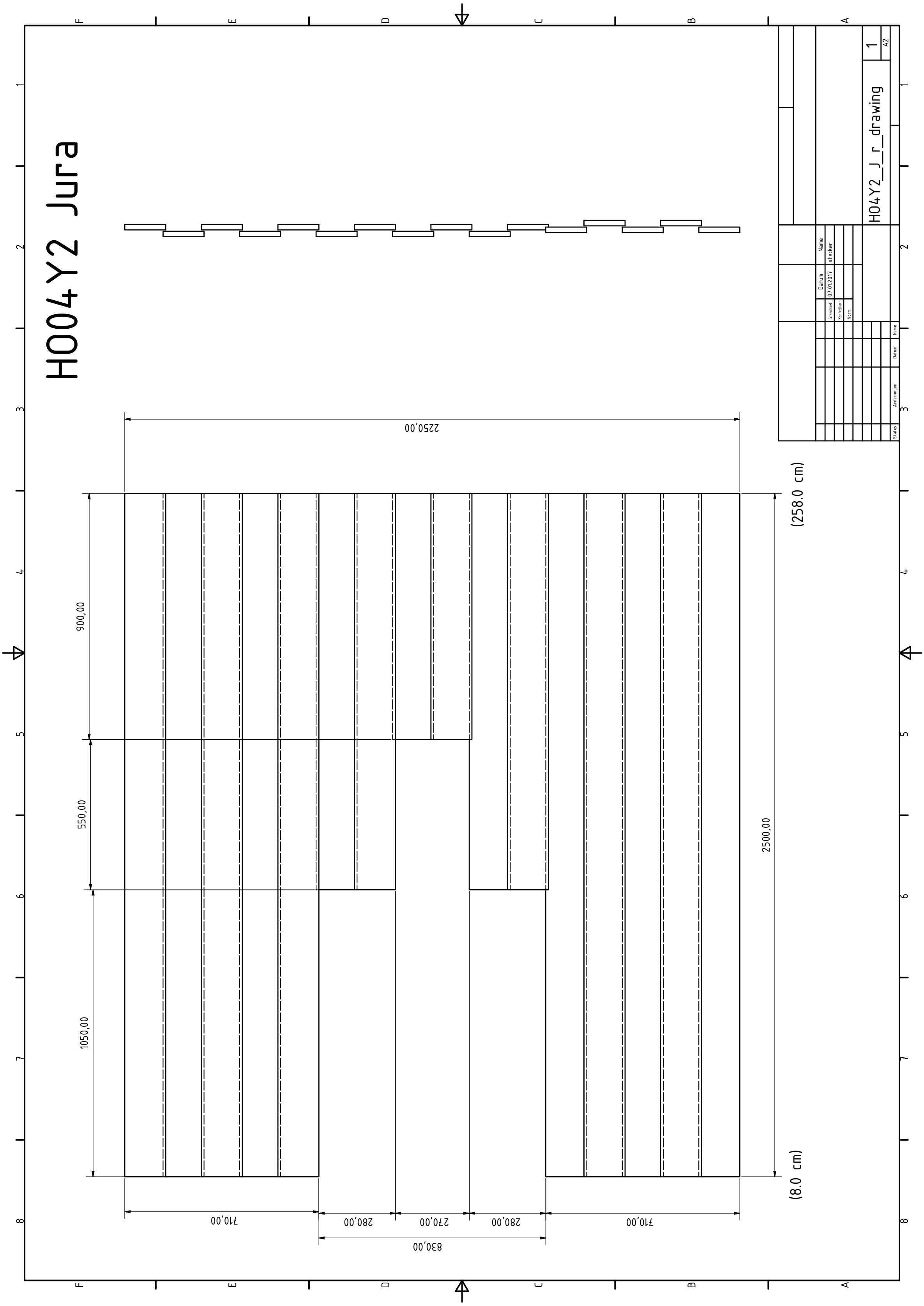
Table 4: Trigger signals on the Misc Channels TDC and Scaler (a.r.d. means after signal refreshing discriminator)

11 Appendix



HO03Y1 2016
355,00
210,00
135,00
210,00
355,00
695,00
200,00
450,00
1155,00
2500,00
1265,00
(130.5 cm)
(-120.5 cm)
ho03


H04Y1 Saleve 2016
A (1 : 5)
H04Y1_S_r_drawing
(23.0 cm)
(−227.0 cm)
2250,00
2310,00
2500,00
190,00
710,00
830,00
710,00
290,00
270,00
50,00
90,00
10,00
140,00
25,00
A



H004Y2 Jura
H04Y2_J_r_drawing
2250,00
900,00
550,00
1050,00
2500,00
(258.0 cm)
(8.0 cm)
710,00
280,00
270,00
280,00
710,00
830,00