The Miniball double-sided silicon strip detector (CD)

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WARNING: this documentation was written for the old electronics. Now the CD should still use the same RAL108 preamps in the same preamp box, but we no longer use the RAL109 amplifiers in the KM-6 crates. Instead the signals from the preamps should go directly to FEBEX. We no longer need the MADCs or the TDCs. The obviously obsolete things have been greyed out, so they are still there for comparison.

Contents

1 Introduction

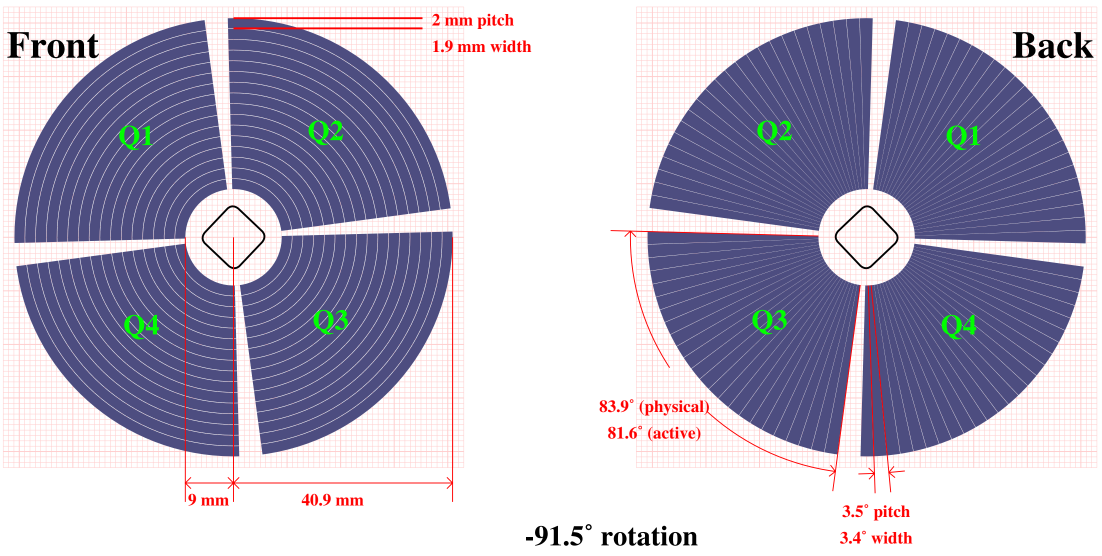

Figure 1: The double-sided silicon strip detector is divided into four quadrants. There are 16 rings of 1.9 mm width 2 mm apart on the front surface and 24 sectors of 3.4° width 3.5° apart on the back. The inner diameter is 9 mm. This is the orientation and quadrant numbering from 2022, corresponding to a -91.5° rotation.

The CD detector is a segmented double-sided silicon strip detector, which is composed of four quadrants. The front consists of 16 annular p^+n junction strips per quadrant at 2 mm pitch while the back consists of 24 sector n^+n ohmic strips at 3.5 degree pitch. This results in a total of 160 discrete detetor elements. Consequently, information on the angular distribution of particles, with $\Delta\phi = 3.4$ degrees and $\Delta\theta = 2.0$ degrees, can be extracted. The inter-strip distance will be between 35 μm and 100μm. The total area of the CD detector is 5000 mm^2, of which approximately 93% is active. The thickness of the silicon wafer will be between 50 μm and 1000 μm having a dead layer of 0.3 to 0.8 μm aluminium. The thickness will depend on whether energy loss or total kinetic energy measurement of the impinging particles is required. An energy loss detector in combination with a stop detector will provide particle identification. Another possibility to achieve this, is to derive a timing signal from the CD detector to measure time-of-flight with respect to a signal from the the accelerator (in our case the EBIS gate).

The CD cost 16 thousand Euro plus tax and was made by Micron Semiconductor Ltd. who sold it under the name "QQQ2/DS".

2 The CD detector

Total area = 50 cm^2 (93% active)
Four quadrants
16 annular p^+n junction strips per quadrant (i.e. 64 total)
24 sector n^+n ohmic strips per quadrant (i.e. 96 total)
In total 160 discrete detectors
Wafer thickness 35 - 1000 μm.

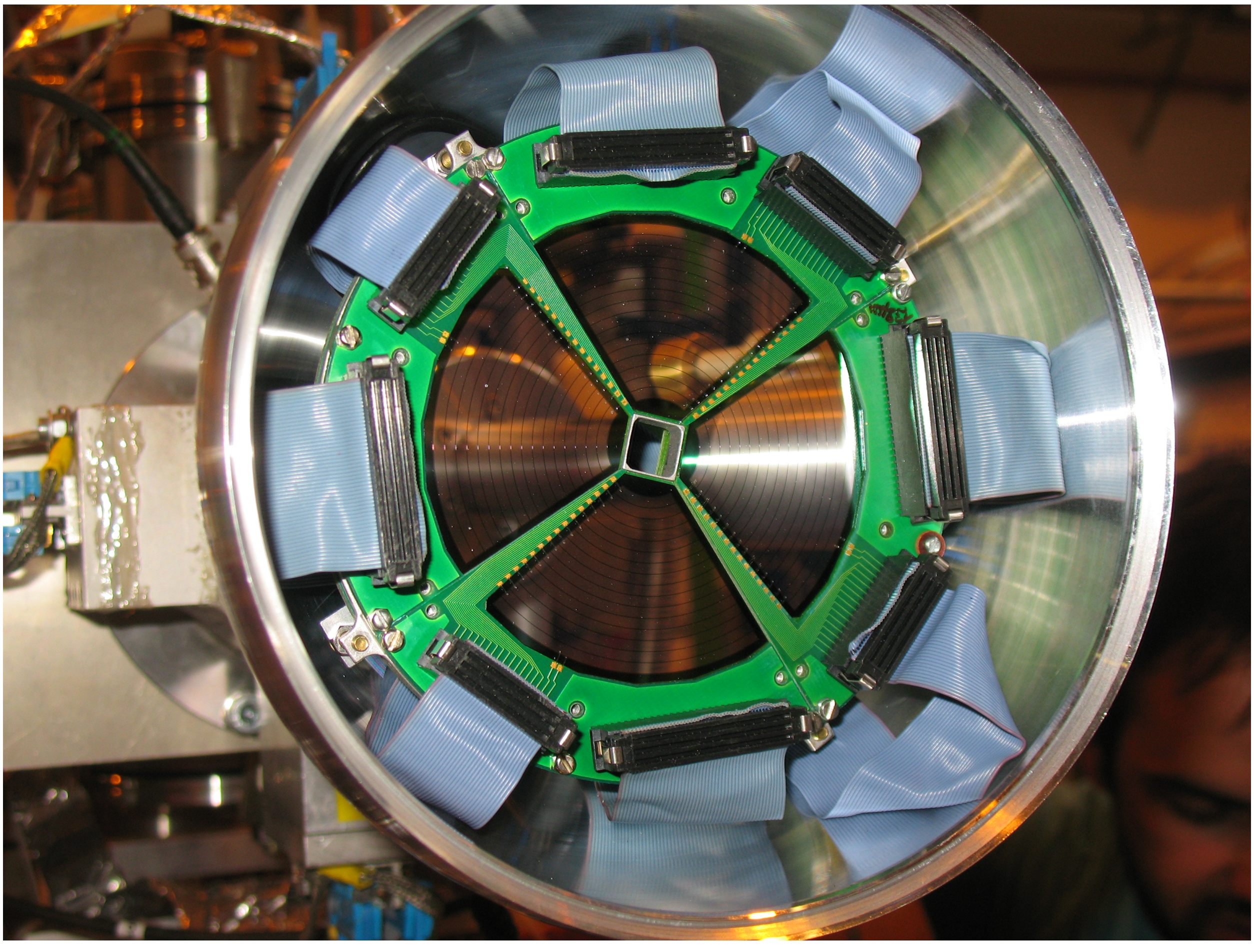

Figure 2: The CD viewed from the front in the plunger chamber in 2017. This was at an angle of $\phi = 240°$.

Dead layer thickness - about 0.4 to 0.5 μm p^+n implantation, 0.2 to 0.3 μm Al metalisation. We usually assume a dead layer of about 0.7 μm Si equivalent.

2.1 Quadrants

The quadrants are numbered from 1 to 4 clockwise wrt. beam direction so that 1 is left, 2 is up, 3 is right and 4 is down.

2.2 p^+n junction annular strips (front)

Number of strips	16
Inner radius of active area	9.000 mm
Outer radius of active area	40.900 mm
Strip pitch	2.000 mm
Strip width	1.900 mm
Phi	81.6°

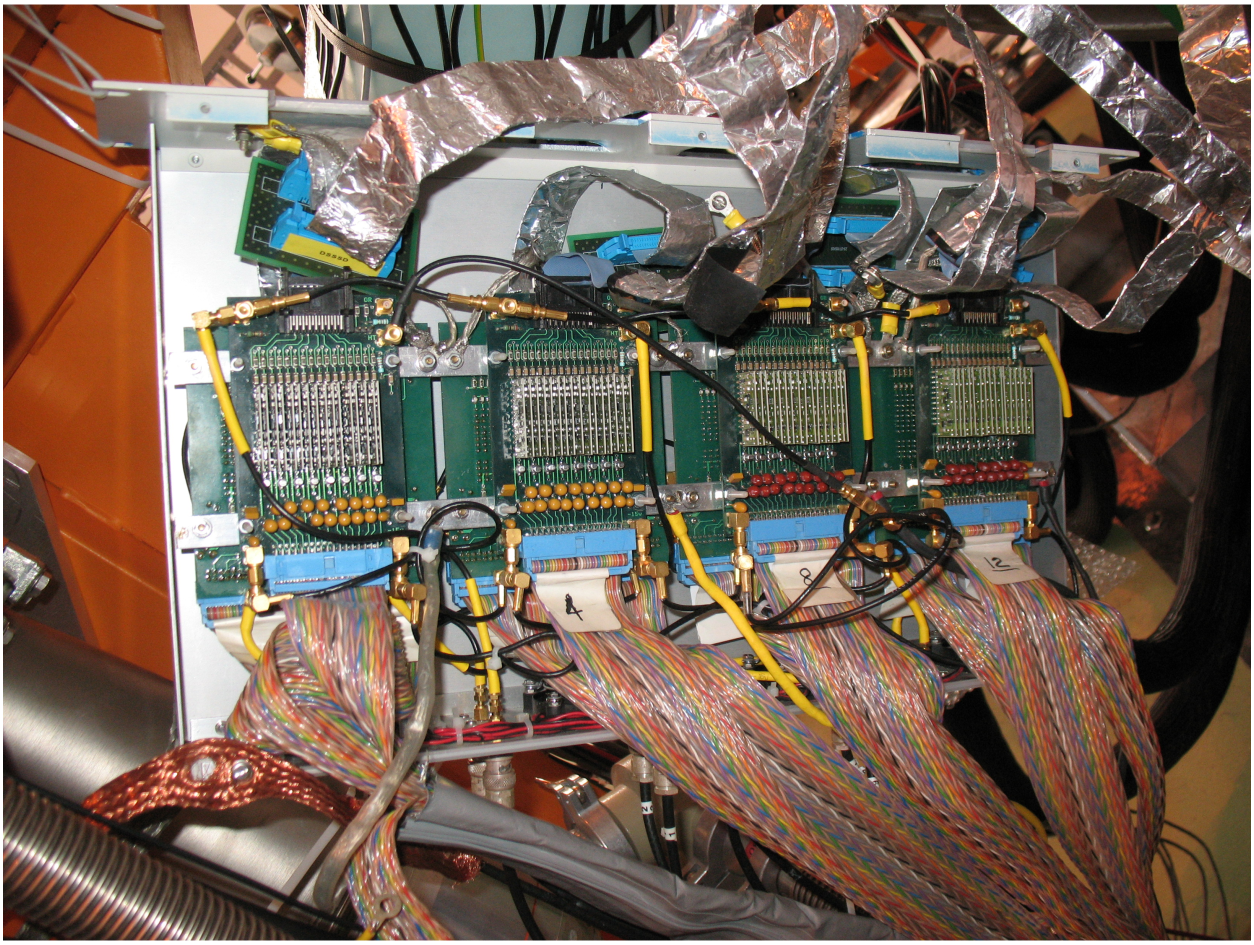

Figure 3: The CD preamp box, which hangs under the beamline. The silver foil wrapped cables (one 34 way and one 50 way per quadrant) go to the vacuum feedthroughs. The 15 m 34-way multicoloured IDC cables go to the junction box behind rack 2. Cables 0, 4, 8 and 12 go to the upper board and are for the front strips, while cables 1, 2, 5, 6, 9, 10, 13 and 14 go to the lower board and are for the back strips. The 24 back strips are combined into 12 pairs by the boards which are loose that the cables from the feedthroughs are connected to. You can see the four preamp motherboards for the rings. The ones for the sectors are at the back, hidden by the metal plate.

The strips are numbered from the outermost (strip 0) to the innermost (strip 15).
These front annular strips provide the trigger for the logic.

2.3 n^+n ohmic sector strips (back)

Number of strips	24
Strip pitch	3.4°
Strip length	31.900 mm
Inner-strip distance	0.100 mm

The strips are numbered from 0 to 23 clockwise as viewed from the front (the annular strip side) of the CD

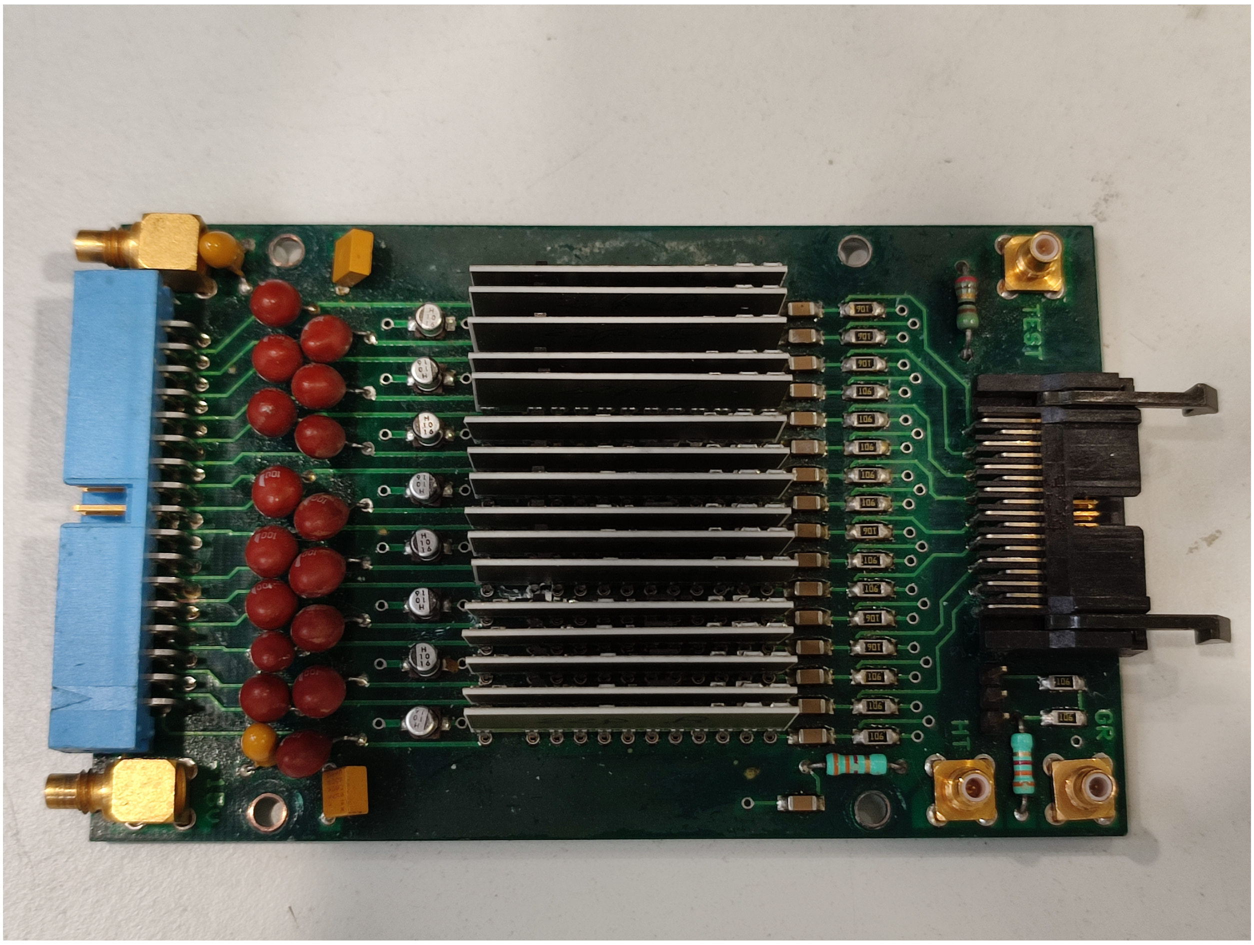

Figure 4: A CD preamp motherboard with 16 CD preamp cards for all the rings of one quadrant. (Photo from Thorsten Kröll).

sector.

3 The CD PAD detector

This is a Micron Semiconductor Ltd. type QQQ1. It has the same dead layer thickness as the CD.

Like the CD, the bias is applied to the $p^{+}n$ junction (front), so it needs negative polarity to reverse bias it. This is provided by the second Silena 7710 quad bias supply in rack 1.

It uses four Cooknell EC572 preamplifiers (nickel plated flat box units - 8 cm × 8 cm × 3 cm - which are mounted at the downstream end of the target chamber, clamped to the beam line with G-clamps.

It needs +24 Volts preamp power, which is provided by a special module in rack 1. 4 grey cables run from this module to the preamp boxes (one for each box).

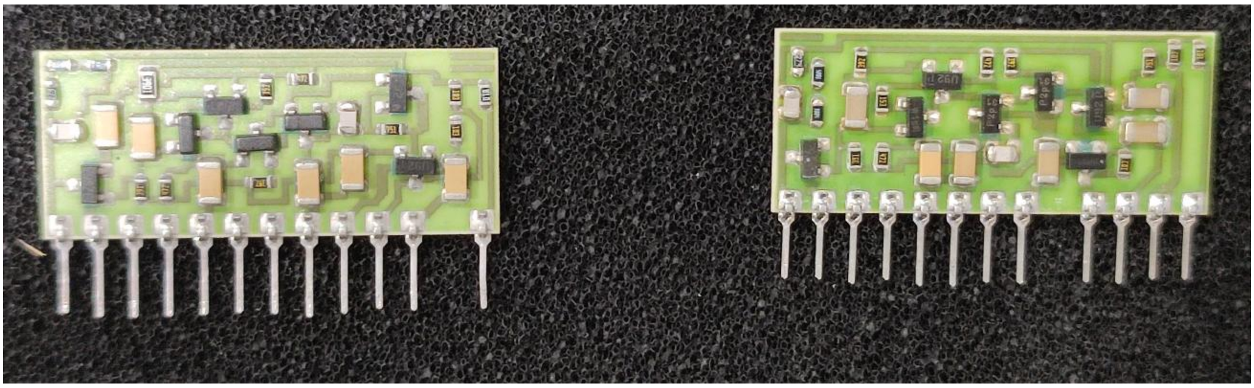

Figure 5: The individual CD preamp cards. The one on the left is type B for the rings and the one on the right type A for the sectors. Note that they have different pins. They are very similar but have different unipolar output drivers. (Photo from Thorsten Kröll).

The signals are transported along 4 BNC cables in the same bundle as the preamp power cables, which go to short LEMO cables and from there to a flat cable, which goes to the back of n additional RAL 109 shaper in the upper KM-6 crate. The cables going from the RAL 109s to the MADCs have been modified, so for each quadrant there is a single twisted pair for the PAD. The ECL outputs go to the same ECL to NIM converter as the MALUs, using the next four channels.

To test it, it needs a negative pulse on the test input and send the NIM output from the ECL to NIM converter to the dual gates used by the CD. i.e. just moving the four LEMO cables from the first four channels of that module, to the next four.

4 Bias voltages

- The CD may be operated at atmospheric pressure or at pressures below 8×10^{-5} mbar, but not at intermediate pressures.

- The Silena 7710 quad bias supply in rack 2 provides the bias voltages. The screw potentiometers are used to set the desired voltage[1] and the switches used to ramp up to that voltage or ramp down to zero. Once the voltage is set, it should not be necessary to use the potentiometers. Just use the switches (one for each quadrant) to ramp up and down.
- The detector bias is applied to the p^+n junction strips, so to reverse bias the detector we need to apply negative voltage.
- A knob is used to select the channel to display and the voltage and leakage current for that channel is displayed on the digital indicator.

- They are usually operated at about twice the depletion voltage.

Typical values are:

[1]The bias depends on the thickness of the CD and how much leakage current it draws.

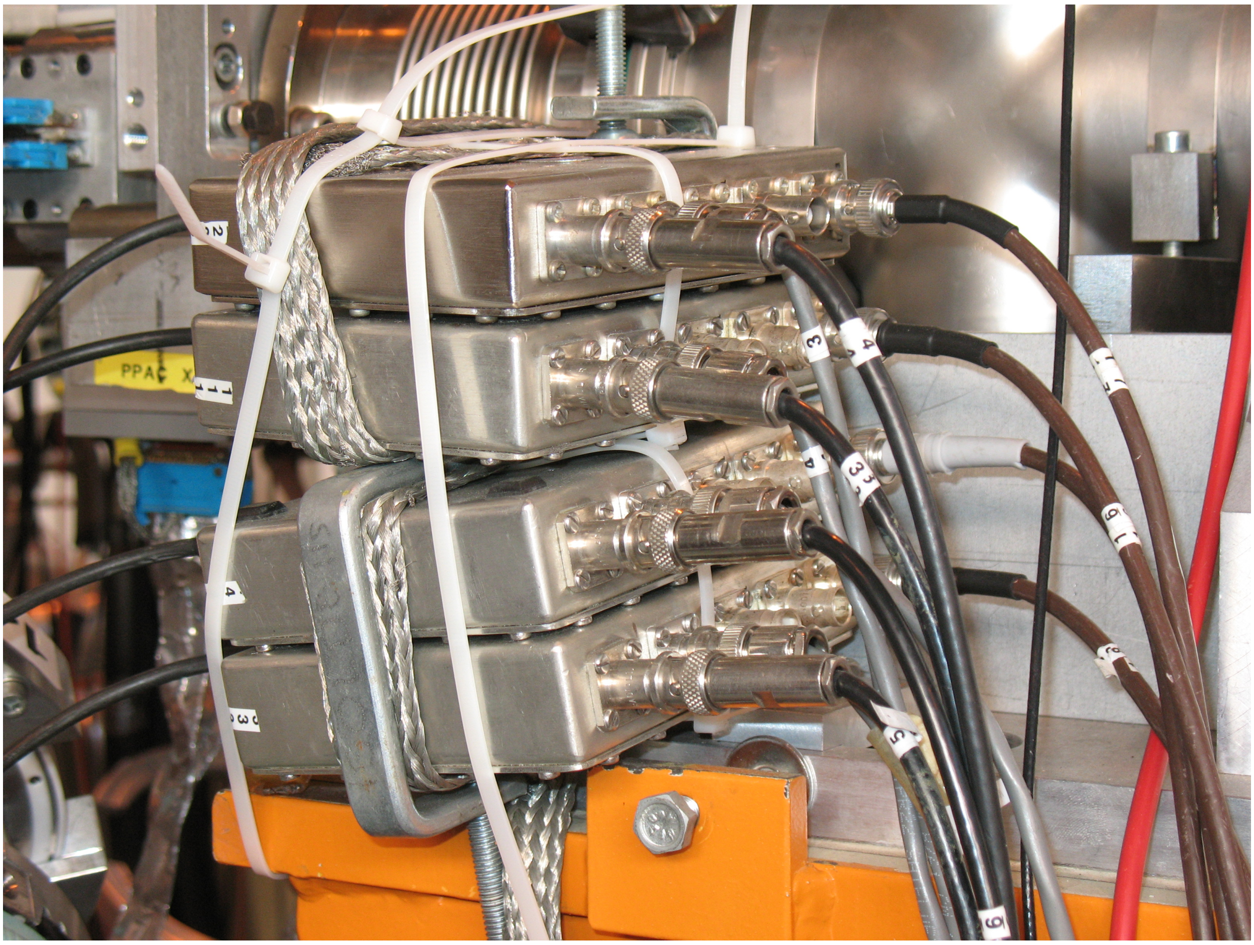

Figure 6: The preamps for the PAD detector which are clamped at on the beam line at the downstream end of the target chamber.

Serial number	Quadrant	Position	Depletion voltage [Volts]	Operating voltage [Volts]	Wafer thickness mm	Leakage current μA
1935-5	spare		43	-73.0	0.481	
1935-6	spare		38	-68.0	0.491	
1935-7	spare		38	-68.0	0.493	
1935-13	Q1	Left	36	-66.1	0.479	0.85
1935-14	Q3	Right	40	-70.4	0.476	1.20
1935-15	Q4	Down	34	-65.0	0.481	0.38
1936-16	Q2	Up	37	-68.0	0.479	0.60

Note that the leakage currents are a sensitive indicator of radiation damage. The values above are from August 2004. They might increase as the CD is damaged more.

The thicknesses are provided by the manufacturer.

5 The old RAL108 charge-sensitive preamplifier

- Limited to a signal equivalent to about 200 MeV particles. They have 10 mV/MeV and use a 2.2 pF feedback capacitor with a 22.7 MΩ feedback resistor.

- Output impedance 100 Ω.

- The power supply for the preamps is ± 15 V and is located at the back of rack 2. With a complate CD (160 RAL108 charge-sensitive preamplifiers) the nominal load is 2.05 A at +15 V and 0.70 A at -15 V. There is also a ± 12 V supply (above the ± 15V power supply unit) which is for the preamp cooling fans.

- There are two different kinds of RAL108 (see fig. 5. Type A with negative input and positive output for the 24 n^+n ohmic sector strips and type B with positive input and negative output for the 16 p^+n junction annular strips. The two types are similar except that they can deliver 2 Volts maximum into 100 Ω only in the correct direction, while in the reverse direction they will deliver less voltage and will be less linear. The type A have a single horizontal bar in the top left-hand corner, while the type B have two horizontal bars in the top right-hand corner.

- There are two test inputs for negative and positive test signals, the former for the type A preamplifiers and the latter for the type B.

Preamp gain	10 mV/MeV (silicon) or 37 nV/electron into 100 W
Noise	2.2 keV FWHM (255 electrons rms)
Noise slope	72 eV/pF FWHM (8 electrons rms/pF)
Rise time (10-90%)	5 ns (0 pF), 40 ns (100 pF detector capacitance)
Fall time (100-37%)	50 ± 4 μs
Dynamic range	0-200 MeV (± 2 V into 100 W)
Integral non-linearity	< 0.1 %

6 The new RAL108 charge-sensitive preamplifiers

In August 2007, we received 104 new RAL108A and 72 RAL108B preamplifiers. The former are for the back sector strips (n+n Ohmic) and the latter for the front annular strips (p+n Ohmic). They have 22 pF feedback capacitors.

These new preamps have about 2 GeV full scale range (2 Volts into 100 Ohm impedance). i.e. about 1 mV per MeV, which is a factor of ten less than the old ones which were 10 mV/MeV (with the 100 Ohm termination). This means that the values for the full scale range need to be multiplied by ten.

WARNING: there is a known issue with using the new RAL108 without the termination for the n^+n back sector strips. In 2015, this resulted in bad data for the sectors. So ALWAYS use either the 100 Ω or 1 kΩ terminators on the back strips!

7 The junction box

From 2022, we go directly from the preamps into FEBEX, so this section is obsolete, but as some information about how things were in the past might still be useful, it is just in grey and not removed altogether.

The junction box located at the back of rack 2 performs several tasks:

- Singals from the RAL108 preamplifier units are delivered by 34-way twist-n-flat ribbon cable. The inputs to the RAL 109 shaper amplifiers are 16-way twist-n-flat ribbon cable. The junction box adapts between the two.
- It makes it easy to have all eight RAL 109 shaper amplifiers for the $p^{+}n$ junction annular strips in the top KM-6 crate and the twelve for the $n^{+}n$ ohmic sector strips in the second KM-6 crate.
- It provides jumpers to allow the disconnection of individual channels, if one strip starts breaking down or becomes noisy, without having to modify the cables.
- It provides a way to invert the polarity.

8 The RAL 109 shaper amplifier

From 2022, we go directly from the preamps into FEBEX, so this section is obsolete, but as some information about how things were in the past might still be useful, it is just in grey and not removed altogether.

- One module has a mother board and eight daughter boards. Each daughter board handles one channel, so there are eight channels per RAL 109.

- We need 64 channels (4 quadrants with 16 annuli each) for the $p^{+}n$ junction annular strips (i.e. 8 modules) and 96 channels (4 quadrants with 24 sectors each) for the $n^{+}n$ ohmic strips (i.e. 12 modules).

- These modules sit in two KM-6 crates in rack 2 of the Miniball electronics.

- Can have different resistor packs to set the gain. These are dual inline (DIL) 16-pin packages. Each package contains 8 individual resistors. They are located between the power and input signal connections at the back of the RAL 109 PCB motherboard.

- Has a possiblity of 100 Ω input termination or not. The termination resistors are two single inline (SIL) 8-pin packages, each of which contains four individual resistors. This reduces the gain by a factor of two. Note that the $n^{+}n$ ohmic strip channels need either 100 Ω or 1 kΩ, while the $p^{+}n$ junction strip channels should be either 100 Ω or without termination resistors. These are located near the gain resistors.

- The full-scale range (FSR) in volts depends on the ADC which is used. The Silena 4418/V has a full scale range of 9.375 Volts, the CAEN V785 AA to V775 AD have 3.84 Volts and the CAEN V785 AG (which Miniball uses) has 7.5 Volts. The Mesytec MADC32 (which Miniball has started using in May 2009) has a register selectable range: 4, 8 or 10 Volts. This is set in the ADC settings configuration file for Marabou. Normally it should be set to 10 Volts. **This setting is done in the adc1Settings.rc etc. files. Be careful. If the file doesn't exist when you run Config.C, it is created with default values, which have only 4 Volts full range!**

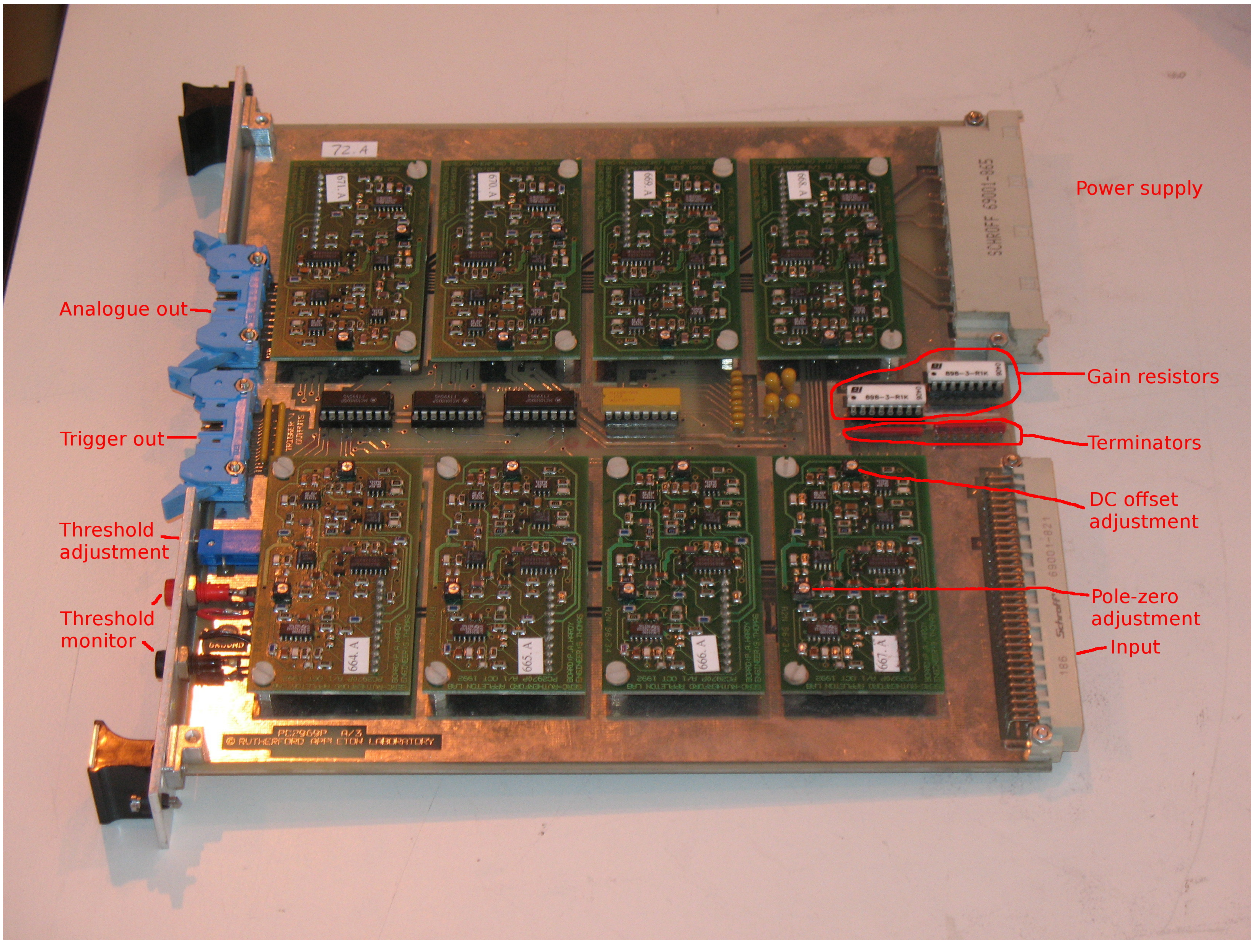

Figure 7: The eight channel RAL 109 shaper amplifier. The two white chips (middle right) are the resistors that need to be changed in order to change the gain. The red 100 Ω resistors are shown here just below them.

- The minimum value for the lower-level discriminator (LLD) is about 10 mV (front panel monitor) with the 100 Ω termination and about 20 mV without. This corresponds (in terms of energy) to about 1.5 % of the FSR. The LLD is set with a twenty-turn potentiometer accessible from the front panel. There are also a 3 mm jack points where the LLD can be monitored.

- Note that the old RAL108 preamplifier is limited to about 200 MeV, so even if the gain of the shaper amplifier is turned right down, particles with more than 200 MeV will saturate the preamp and all give the same amplitude into the shaper amplifier. This is not the case with the new version.

- There is a special cable with a 16-way IDC cable on one end and 16 LEMO connectors on the other. Since the preamplifiers are terminated to 100 Ω only the absolute minimum of 50 Ω cable should be used from these connectors to the oscilloscope.

8.1 With 100 Ω input termination using old RAL108 preamps

With the 100 Ω input termination, the gain when using the **old** RAL108 preamps is given by:

$$gain[V/MeV] = \frac{0.45}{(1 + R[k\Omega])} \quad (1)$$

R [$k\Omega$]	label	gain [V/MeV]	FSR[1] [MeV]	FSR[2] [MeV]	min LLD[1] [MeV]	min LLD[2] [MeV]
0.022	R22	0.440	17.1	22.7	0.3	0.4
1.0	R1K	0.225	33.3	44.4	0.6	0.8
2.2	R2K2	0.141	53.2	70.9	1.0	1.3
3.3	R3K3	0.105	71.4	95.2	1.3	1.7
4.7	R4K7	0.079	94.9	127	1.8	2.4
5.6	R5K6	0.068	110	147	2.1	2.8
6.8	R6K8	0.058	129	172	2.4	3.2
8.2	R8K2	0.049	153	204*	2.9	3.9
10	R10K	0.041	183	244*	3.4	4.5
22	R22K	0.0196	383*	510*	7.2	9.6
33	R33K	0.0132	567*	757*	11	14
47	R47K	0.0094	800*	1064*	15	20

[1] Full-scale range and lower level discriminator assuming the 7.5 Volts limit of the CAEN V785 ADC.

[2] Full-scale range and lower level discriminator assuming the 10 Volts limit of the Mesytec MADC32. Note that the MADC32 can have full-scale ranges of 4, 8 or 10 Volts according to the settings, so check adc1Settings.rc etc. to make sure it is set correctly.

$*$ This is the nominal value for the amplifier, but the preamp limits to about 200 MeV, so these values cannot be attained in practice.

8.2 With 100 Ω input termination using new RAL108 preamps

With the 100 Ω input termination, the gain when using the **new** RAL108 preamps is given by:

$$gain[V/MeV] = \frac{0.045}{(1 + R[k\Omega])} \quad (2)$$

i.e. a tenth of the value with the old RAL108.

R [$k\Omega$]	label	gain [V/MeV]	FSR[1] [MeV]	FSR[2] [MeV]	min LLD[1] [MeV]	min LLD[2] [MeV]
0.022	R22	0.0440	171	227	3	4
1.0	R1K	0.0225	333	444	6	8
2.2	R2K2	0.0141	532	709	10	13
3.3	R3K3	0.0105	714	952	13	17
4.7	R4K7	0.0079	949	1266	18	24
5.6	R5K6	0.0068	1100	1471	21	28
6.8	R6K8	0.0058	1290	1724	24	32
8.2	R8K2	0.0049	1530	2041*	29	39
10	R10K	0.0041	1830	2439*	34	45
22	R22K	0.00196	3830*	5102*	72	96
33	R33K	0.00132	5670*	7576*	106	140
47	R47K	0.00094	8000*	10638*	150	200

[1] Full-scale range and lower level discriminator assuming the 7.5 Volts limit of the CAEN V785 ADC.

[2] Full-scale range and lower level discriminator assuming the 10 Volts limit of the Mesytec MADC32. Note that the MADC32 can have full-scale ranges of 4, 8 or 10 Volts according to the settings, so check adc1Settings.rc etc. to make sure it is set correctly.

$*$ This is the nominal value for the amplifier, but the new preamp limits to about 2 GeV, so these values cannot be attained in practice.

8.3 Without 100 Ω input termination using old RAL108 preamps

Do NOT use the n^+n back sector strips without termination (either 100 Ω or 1 kΩ)!

Without the 100 Ω input termination, the gain when using the **old** RAL108 preamps is given by:

$$gain[V/MeV] = \frac{0.9}{(1 + R[k\Omega])} \tag{3}$$

R [$k\Omega$]	label	gain [V/MeV]	FSR[1] [MeV]	FSR[2] [MeV]	min LLD[1] [MeV]	min LLD[2] [MeV]
0.022	R22	0.880	8.5	11.4	0.15	0.2
1.0	R1K	0.450	16.7	22.2	0.3	0.4
2.2	R2K2	0.282	26.6	35.5	0.5	0.65
3.3	R3K3	0.210	35.7	47.6	0.65	0.9
4.7	R4K7	0.158	47.6	63.3	0.9	1.2
5.6	R5K6	0.136	55.2	73.5	1.05	1.4
6.8	R6K8	0.116	64.7	86.2	1.2	1.6
8.2	R8K2	0.098	76.5	102	1.45	1.9
10	R10K	0.082	91.5	122	1.7	2.3
22	R22K	0.039	192	256*	3.6	4.8
33	R33K	0.026	284*	385*	5.3	7.1
47	R47K	0.0192	400*	521*	7.5	10

[1] Full-scale range and lower level discriminator assuming the 7.5 Volts limit of the CAEN V785 ADC.

[2] Full-scale range and lower level discriminator assuming the 10 Volts limit of the Mesytec MADC32. Note that the MADC32 can have full-scale ranges of 4, 8 or 10 Volts according to the settings, so check adc1Settings.rc etc. to make sure it is set correctly.

$*$ This is the nominal value for the amplifier, but the preamp limits to about 200 MeV, so these values cannot be attained in practice.

8.4 Without 100 Ω input termination using new RAL108 preamps

Do NOT use the n^+n back sector strips without termination (either 100 Ω or 1 kΩ)!

Without the 100 Ω input termination, the gain when using the **new** RAL108 preamps is given by:

$$gain[V/MeV] = \frac{0.09}{(1 + R[k\Omega])} \tag{4}$$

i.e. a tenth of the value with the old RAL108.

R [$k\Omega$]	label	gain [V/MeV]	FSR[1] [MeV]	FSR[2] [MeV]	min LLD[1] [MeV]	min LLD[2] [MeV]
0.022	R22	0.0880	85	114	1.5	2
1.0	R1K	0.0450	167	222	3	4
2.2	R2K2	0.0282	266	354	5	6.5
3.3	R3K3	0.0210	357	476	6.5	9
4.7	R4K7	0.0158	476	633	9	12
5.6	R5K6	0.0136	552	735	10.5	14
6.8	R6K8	0.0116	647	862	12	16
8.2	R8K2	0.0098	765	1020	14.5	19
10	R10K	0.0082	915	1220	17	23
22	R22K	0.0039	1920	2564*	36	48
33	R33K	0.0026	2840*	3846*	53	71
47	R47K	0.00192	4000*	5208*	75	100

[1] Full-scale range assuming the 7.5 Volts limit of the CAEN V785 ADC.

[2] Full-scale range assuming the 10 Volts limit of the Mesytec MADC32. Note that the MADC32 can have full-scale ranges of 4, 8 or 10 Volts according to the settings, so check adc1Settings.rc etc. to make sure it is set correctly.

$*$ This is the nominal value for the amplifier, but the new preamp limits to about 2 GeV, so these values cannot be attained in practice.

9 Electronics

9.1 The FEBEX modules

From 2022, the signals go directly from the preamplifier box at the beam line via long cables to the FEBEX modules at the electronics rack (R3.C3). We use two FEBEX modules for each quadrant: the first for the

16 channels of the rings and the second for the 12 pairs of sectors. The last four channels of this second FEBEX module are, therefore, unused, and should be disabled in the software.

9.2 The LeCroy 4532 MALUs

This subsection is obsolete as we now use FEBEX.

The RAL 109 shaper amplifiers also generate a logic signal and four LeCroy 4532 MALUs (one for each quadrant) are used to generate the logical OR of all the signals for the p^+n junction annular strips each quadrant. These are CAMAC modules, but as we don't need to program them, we don't actually need a CAMAC crate controller in that crate, which simply provides power.

The orientation of the cable is indicated by the markings on the front panel of the MALU and the IDC connector on the cable has an arrow to indicate pin 1 and the "positive" side of the connector.

We use the ORO output, which is just a logical OR of all the inputs.

We have about 750 ns to decide if we want to generate a gate for the ADC, since the CAEN V785 ADC needs the gate to start about 250 ns before the peak of the analogue signal, which is 1 μs after about the logic pulse.

Note that originally we used only two of these 32-channel modules for the whole CD, but then we split up the acquisition treating each quadrant independently, so now we need four MALUs but only use half the channels for each one.

9.3 The CAEN V785 AG ADCs

This subsection is obsolete as we now use FEBEX.

We used to use CAEN V785 ADCs to readout the energy signals from the CD. In 2003 we used such CAEN ADCs to read out the whole CD and we were able to read out all 160 channels (16 rings and 24 sectors per quadrant) using five CAEN V785 32-channel ADCs. However, in 2004 we switched to a readout where each quadrant was handled separately. This would mean 40 channels per quadrant, but the CAEN V785 ADCs only have 32 channels each, so we would have to use two ADCs for each quadrant with this configuration, but we don't have eight V785 ADCs, so we can't do this. Instead, we use one V785 per quadrant and read out all 16 front rings, but join the 24 back sectors together in pairs at the preamplifier. The big disadvantage of this is that two physical channels are mixed together and cannot be separated afterwards, so you get two spectra superimposed.

Note that for some experiments we also have PAD detectors (E detectors) as well, added in. These are wired onto additional channels on the same flat cable going to the ADCs.

9.4 The CAEN V775 TDCs

This subsection is obsolete as we now use FEBEX.

We use four CAEN V775 TDCs, one for each quadrant of the CD. Each of these 32-channel modules receives 24 signals from the n^+n ohmic sector strips for one quadrant.

9.5 The Mesytec MADC32s

This subsection is obsolete as we now use FEBEX.

From May 2009, we have Mesytec MADC32 ADCs instead of the CAEN V785 modules. Supposedly they are similar to the V785 modules, but there are differences.

For example, the input range is register selectable to 4 Volts, 8 Volts or 10 Volts for the Mesytec modules and is 7.5 Volts for the CAEN V785. The "standard" settings Roman Gernhäuser posted in the electronic logbook (entry 7608) give 10 Volts range.
The cabling between the RAL 109s and the Mesytec MADC32s is the same as for the CAEN V785 modules (i.e. the same cables are used). The big difference is that the Mesytec MADC32 provides a busy signal directly in NIM, while the CAEN V785 provides it in ECL, so it has to be converted to NIM with an additional module.

A configuration file is needed for each ADC. They have names like adc1Settings.rc ... adc4Settings.rc. There are many configuration options in this file. It is important to make sure you have the right full-scale range in volts (4, 8 or 10 Volts full scale) and the right ADC resolution (2K, 4K and 8K). Note however that you can have 4K and 8K resolution in two different ways. The "normal" 4K resolution has 1.6 μs conversion time, but there is a "high resolution" 4 K resolution which combines pairs of samples and has a 3.2 μs conversion time. We normally use the normal 4K 1.6 μs version to keep down the dead time. This is the critical point for our dead time, because although the DAQ is supposed to be dead-time free for the readout, it is not for the conversion time, and the main advantage of the MADC32 is that we can have the lower conversion time.

10 CD Cabling

Much of this section is obsolete, but not all. In particular, we still use same cables from the CD to the high-density IDC vacuum feedthrough inside the chamber, the same cables from the high-density IDC vacuum feedthrough to preamplifier PCBs and the same cables from the CD preamplifier PCB but now they go to FEBEX rather than the junction box.

10.1 CD to High-Density IDC Vacuum Feedthrough

Quadrant 1	1x 40cm 50-way Amp System 50 HD IDC to 50-way Yammaichi HD IDC
	1x 40cm 34-way Amp System 50 HD IDC to 34-way Yammaichi HD IDC
Quadrant 2	1x 40cm 50-way Amp System 50 HD IDC to 50-way Yammaichi HD IDC
	1x 40cm 34-way Amp System 50 HD IDC to 34-way Yammaichi HD IDC
Quadrant 3	1x 40cm 50-way Amp System 50 HD IDC to 50-way Yammaichi HD IDC
	1x 40cm 34-way Amp System 50 HD IDC to 34-way Yammaichi HD IDC
Quadrant 4	1x 40cm 50-way Amp System 50 HD IDC to 50-way Yammaichi HD IDC
	1x 40cm 34-way Amp System 50 HD IDC to 34-way Yammaichi HD IDC

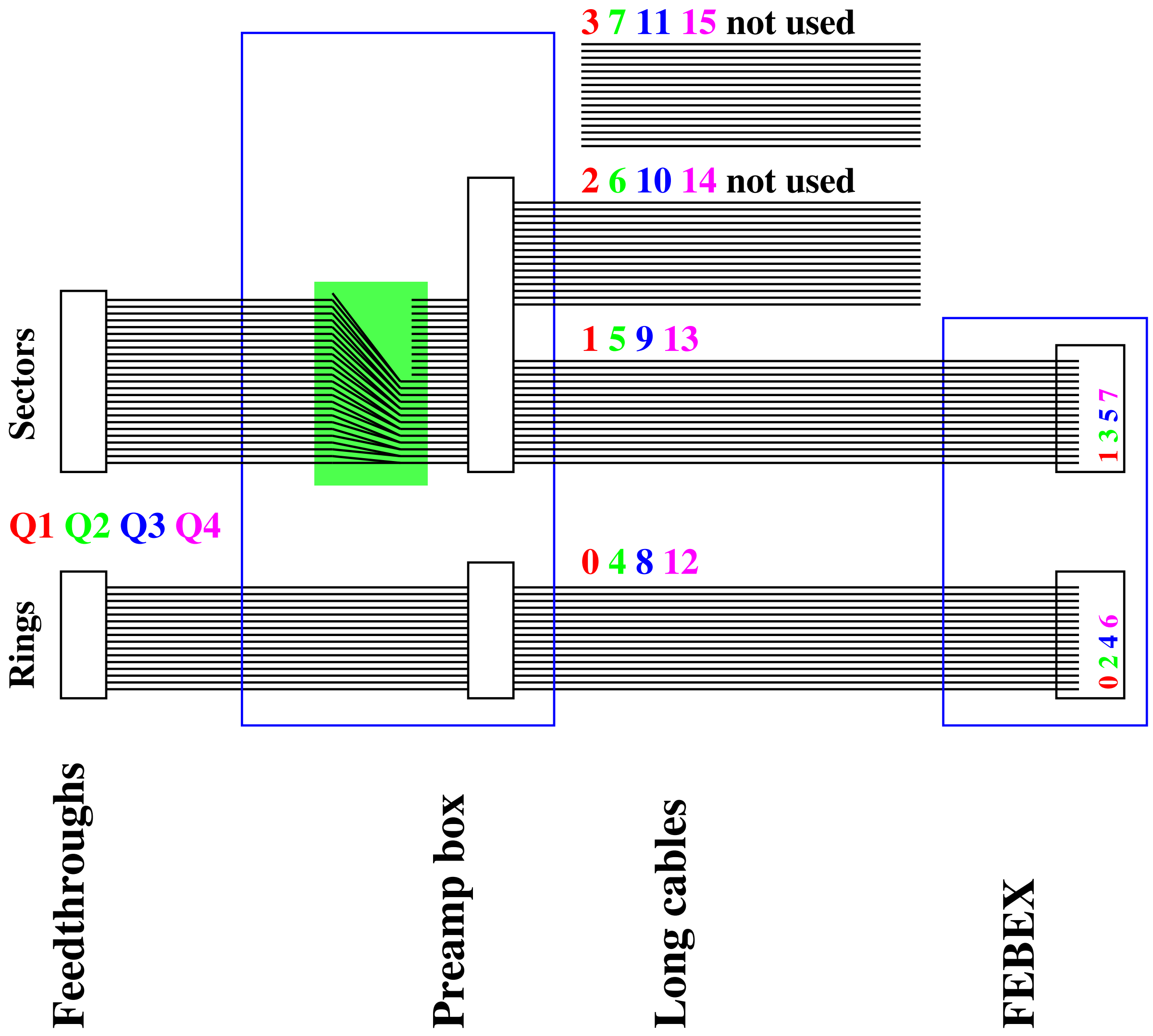

Figure 8: The cabling for one quadrant. A colour code is used to indcate the quadrant number, cable number and FEBEX module number. Inside the preamp box, a PCB (shown in green) joins the sectors pairwise.

10.2 High-density IDC Vacuum Feedthrough to CD Preamplifier PCBs

Quadrant 1	1x	100cm 50-way Amp System 50 HD IDC to 50-way Yammaichi HD IDC (pair inverted)
	1x	100cm 34-way Amp System 50 HD IDC to 34-way Yammaichi HD IDC (pair inverted)
Quadrant 2	1x	100cm 50-way Amp System 50 HD IDC to 50-way Yammaichi HD IDC (pair inverted)
	1x	100cm 34-way Amp System 50 HD IDC to 34-way Yammaichi HD IDC (pair inverted)
Quadrant 3	1x	100cm 50-way Amp System 50 HD IDC to 50-way Yammaichi HD IDC (pair inverted)
	1x	100cm 34-way Amp System 50 HD IDC to 34-way Yammaichi HD IDC (pair inverted)
Quadrant 4	1x	100cm 50-way Amp System 50 HD IDC to 50-way Yammaichi HD IDC (pair inverted)
	1x	100cm 34-way Amp System 50 HD IDC to 34-way Yammaichi HD IDC (pair inverted)

10.3 CD Preamplifier PCB to 4x34-way/8x16-way Junction Box

From 2022, this goes to FEBEX instead of the junction box.

Quadrant 1	3x 15m 34-way IDC to 34-way IDC	
	p^+n Junction Strips	cable 0
	n^+n Ohmic Strips	cable 1, 2
Quadrant 2	3x 15m 34-way IDC to 34-way IDC	
	p^+n Junction Strips	cable 4
	n^+n Ohmic Strips	cable 5, 6
Quadrant 3	3x 15m 34-way IDC to 34-way IDC	
	p^+n Junction Strips	cable 8
	n^+n Ohmic Strips	cable 9, 10
Quadrant 4	3x 15m 34-way IDC to 34-way IDC	
	p^+n Junction Strips	cable 12
	n^+n Ohmic Strips	cable 13, 14

Notes:

1) The 4x34-way to 8x16-way Junction Boxes are located at the rear of the ‘CD’ 19” rack.

2) Cables from the n^+n Ohmic strips are connected to a custom PCB which wire-ORs adjacent preamplifier signals, e.g. strip #0 OR strip #1, strip #2 OR strip #3 etc. The output from this custom PCB is then connected to 4x34-way/8x16-way junction box by one 34-way IDC to 34-way IDC cable. This means that the number of n^+n Ohmic strips per sector is reduced from 24 to 12.

10.4 4x34-way/8x16-way Junction Box to RAL109 Shaping Amplifier Modules

This subsection is now obsolete.

Quadrant 1	5x 2m 16-way IDC to DIN4612	
	p^+n Junction Strips	cable 0, 1
	n^+n Ohmic Strips	cable 16, 17, 18
Quadrant 2	5x 2m 16-way IDC to DIN4612	
	p^+n Junction Strips	cable 2, 3
	n^+n Ohmic Strips	cable 19, 20, 21
Quadrant 3	5x 2m 16-way IDC to DIN4612	
	p^+n Junction Strips	cable 4, 5
	n^+n Ohmic Strips	cable 22, 23, 24
Quadrant 4	5x 2m 16-way IDC to DIN4612	
	p^+n Junction Strips	cable 6, 7
	n^+n Ohmic Strips	cable 25, 26, 27

Notes:

1) Cables 0-15 are attached to the top KM-6 sub-rack; cables 16-31 to the bottom KM-6 sub-rack. The numbering is sequential from left to right as viewed from the front of the KM-6 sub-racks.

10.5 RAL109 Shaping Amplifier Modules to CAEN V785-AG VME ADCs

This subsection is now obsolete.

These signals come from the analogue output of the RAL 109 shaping amlifier modules and go to the VME ADCs.

The cables for the back sector strips are a bit special. They are not numbered and they have the penultimate channel of each bunch of sixteen separated out, so it can be plugged individually into the PAD detector's energy signal (the analogue output of an additional RAL 109). This is true for the second, third and fourth quadrants of the PAD detector, but for the first one, the corresponding cable, which was used in 2004, was not used afterwards because of modifications to include the laser power on the same flat cable. So now we have one cable for quadrant one back energy and laser power (a blue and white one) and another cable for quadrant one back energy and quadrant one PAD energy (multicoloured, like the ones for the other quadrants). It is not possible to have both without changing the cable, but as they use different ADC channels, this should be done.

Quadrant 1	2x 2m 2x16-way IDC to 34-way IDC		
	Front p^+n Junction Strips	cable 0A-0B/0	→ ADC
	Back n^+n Ohmic Strips	cable	→ ADC
Quadrant 2	2x 2m 2x16-way IDC to 34-way IDC		
	Front p^+n Junction Strips	cable 1A-1B/1	→ ADC
	Back n^+n Ohmic Strips	cable	→ ADC
Quadrant 3	2x 2m 2x16-way IDC to 34-way IDC		
	Front p^+n Junction Strips	cable 2A-2B/2	→ ADC
	Back n^+n Ohmic Strips	cable	→ ADC
Quadrant 4	2x 2m 2x16-way IDC to 34-way IDC		
	Front p^+n Junction Strips	cable 3A-3B/3	→ ADC
	Back n^+n Ohmic Strips	cable	→ ADC

10.6 RAL109 Shaping Amplifier Modules to LeCroy 4532 Majority Logic Unit (MALU) and CAEN V775 32-channel TDC

This subsection is now obsolete.

These signals come from the ECL outputs of the RAL 109 shaping amplifier modules. The front annular strips go to the MALU and from there to a TDC and also we have the ORO output for each quadrant. The back strips go directly to the TDC.

Quadrant 1	2x 2m 2x16-way IDC to 34-way IDC		
	Front p^+n Junction Strips	cable 4A-4B/4	→ MALU
	Back n^+n Ohmic strips	cable 8A-8B/8	→ TDC
Quadrant 2	2x 2m 2x16-way IDC to 34-way IDC		
	Front p^+n Junction Strips	cable 5A-5B/5	→ MALU
	Back n^+n Ohmic strips	cable 9A-9B/9	→ TDC
Quadrant 3	2x 2m 2x16-way IDC to 34-way IDC		
	Front p^+n Junction Strips	cable 6A-6B/6	→ MALU
	Back n^+n Ohmic strips	cable 10A-10B/10	→ TDC
Quadrant 4	2x 2m 2x16-way IDC to 34-way IDC		
	Front p^+n Junction Strips	cable 7A-7B/7	→ MALU
	Back n^+n Ohmic strips	cable 11A-11B/11	→ TDC

Notes:

1) The LeCroy 4532 MALUs do not have protective headers with bump polarisation slots to guarantee the correct cable orientation. Note the input connector orientation prompts on the front panel of the LeCroy 4532 MALUs.

2) The LeCroy 4532 MALUs do not require CAMAC dataway access - just power.

3) Use the front panel ORO (OR Output) signal of the LeCroy 4532 MALUs to obtain a simple 'OR' of all input signals.

4) A logical OR of the two front panel ORO signals of the LeCroy 4532 MALUs represents the OR of all p^+n junction strips, i.e. 'something happened in CD'.

10.7 Sixteen black coaxial (50 Ω) cables

This is a bunch of 16 black cables bound together. The first four go to the power supply unit at the back of rack 2. The next two come to the front of rack two, where they can be accessed. Sometimes we plug in the CD pulser into them. The next one is unused. The one after that is plugged into the 12 Volt power supply which sits on top of rack 2. The last eight cables go to the pair of bias supplies in R2.C3.S3 and R2.C3.S5[2].

1	+15V
2	-15V
3	+15V
4	-15V
5	Test + (to RAL108 type B preamps, p^+n junction strips)
6	Test - (to RAL108 type A preamps, n^+n ohmic strips)
7	Spare
8	+12V (Preamplifier unit cooling fans)
9	Silena 7710 Quad Bias Supply #1 to CD DSSSD Quadrant 1 HT-
10	Silena 7710 Quad Bias Supply #2 to CD DSSSD Quadrant 2 HT-
11	Silena 7710 Quad Bias Supply #3 to CD DSSSD Quadrant 3 HT-
12	Silena 7710 Quad Bias Supply #4 to CD DSSSD Quadrant 4 HT-
13	Silena 7710 Quad Bias Supply #4 to CD PAD Quadrant 1 HT-
14	Silena 7710 Quad Bias Supply #4 to CD PAD Quadrant 2 HT-
15	Silena 7710 Quad Bias Supply #4 to CD PAD Quadrant 3 HT-
16	Silena 7710 Quad Bias Supply #4 to CD PAD Quadrant 4 HT-

Notes:

1) The +/-15V PSU to supply power the CD preamplifier units is located to the rear of the 'CD' 19" rack. The +/-15V PSU has mains switches on the front **and** back panels of the unit.

2) The +12 V PSU for the fans is located on top of rack 1.

3) CD detector bias is supplied to the p^+n junction strips - negative polarity HT is required.

4) CD detector bias is adjusted by the 20-turn potentiometers on the front panel of the Silena 7710 Quad Bias Supply. Detector biases ramp up/down automatically as each channel is switched on/off - typically the ramping takes 1 minute.

5) To send test signals to the p^+n Junction Strips select positive output from the EG&G Ortec 480 Pulser and connect the output to coaxial cable #5. For n^+n Ohmic Strips select negative output and connect the output to coaxial cable #6. Cables #5 and #6 can be found to the left of the 19" rack containing the KM-6 sub-racks with the RAL109 shaping amplifier modules.

[2]In 2022, they were moved to R3.

10.8 Six grey twin-core coaxial cables

These are for +/-24 Volt power and go to the module in R2.C3.S9[3]. They have special connectors, so you can't plug them in anywhere else.

1-6 15m BNC/2 to BNC/2 Cooknell EC572 Preamplifier +/-24V power

Notes:

1) that there are six cables and the module has six outputs, but one of the outputs is labelled as being broken.

10.9 Four brown coaxial (50 Ohm) cables

These are for the CD E detector. Wheres the signals from the CD ΔE detector (i.e. the main part of the CD) all come on the grey-wrapped flat cables from downstairs up to the platform and into the back of the junction boxes round the back of rack 2, making their connections on the inside of those junction boxes, the equivalent cables for the E detector are four brown coaxial which were added on later.

They go from BNC to Lemo with a normal connector and then go onto a lemo to flat cable connector which is then connected at the back of the junction box (channel 9) at the back of rack 2.

17 Cooknell EC572 Preamplifier output CD PAD Quadrant 1
18 Cooknell EC572 Preamplifier output CD PAD Quadrant 1
19 Cooknell EC572 Preamplifier output CD PAD Quadrant 1
20 Cooknell EC572 Preamplifier output CD PAD Quadrant 1

11 How to remove/install the CD detector assembly

- DO follow the written instructions when venting the Miniball chamber.
- DO use latex/vinyl examination gloves.
- DO NOT touch the silicon wafer or bond wires.
- DO NOT attempt to remove **individual CD sectors** from the CD detector assembly whilst it is still in the Miniball chamber.

11.1 Removal of CD

1) Remove the target wheel and CD protection plate from the Miniball chamber to provide physical access to the CD detector.

2) Use the ejection clips on the four 34-way and four 50-way high-density IDC connectors on the PCBs of the four CD detector sectors to disconnect the high-density IDC cables.

3) Ensure that the cables will not obstruct the movement of the CD detector assembly towards the centre of the Miniball chamber.

4) Loosen the two M1.6(?) hex grub screws (see Figure. 10) which secure the CD detector assembly to the three Miniball chamber support rods.

[3] In 2022, this was moved to R3.

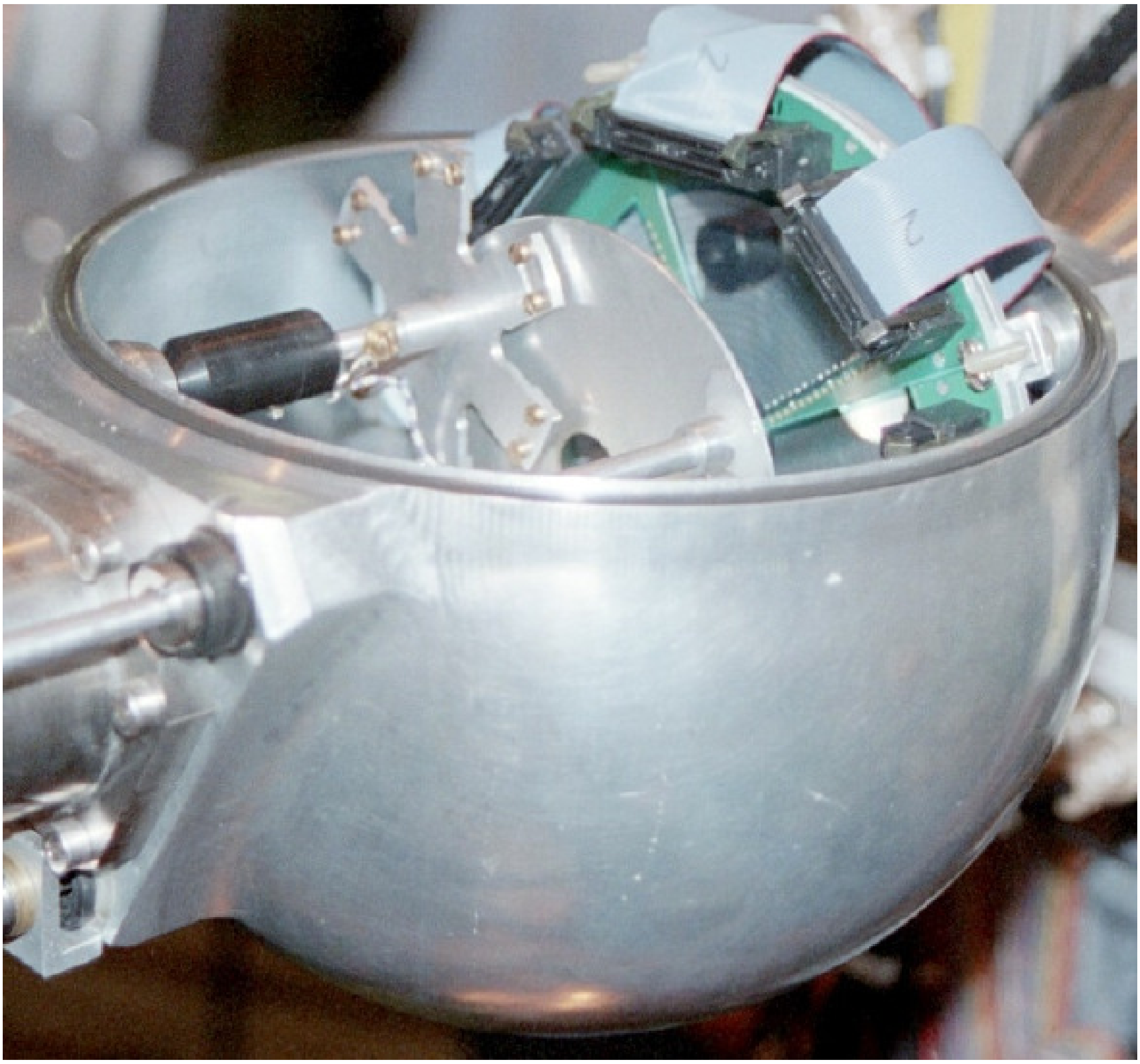

Figure 9: The CD mounted in the target chamber. You can see the target wheel and the CD protection plate (which is no longer used) with the CD behind it.

5) Gently rock the CD detector assembly about the beam axis to loosen the CD detector assembly from the the three Miniball chamber support rods. It is a tight fit - patience is required for this step!

6) When the CD detector assembly is loosened from the three Miniball chamber support rods, move the CD detector assembly slowly towards the centre of the Miniball chamber until it is clear of any obstruction to it's complete removal from the Miniball chamber.

7) Remove the CD detector assembly from the Miniball chamber.

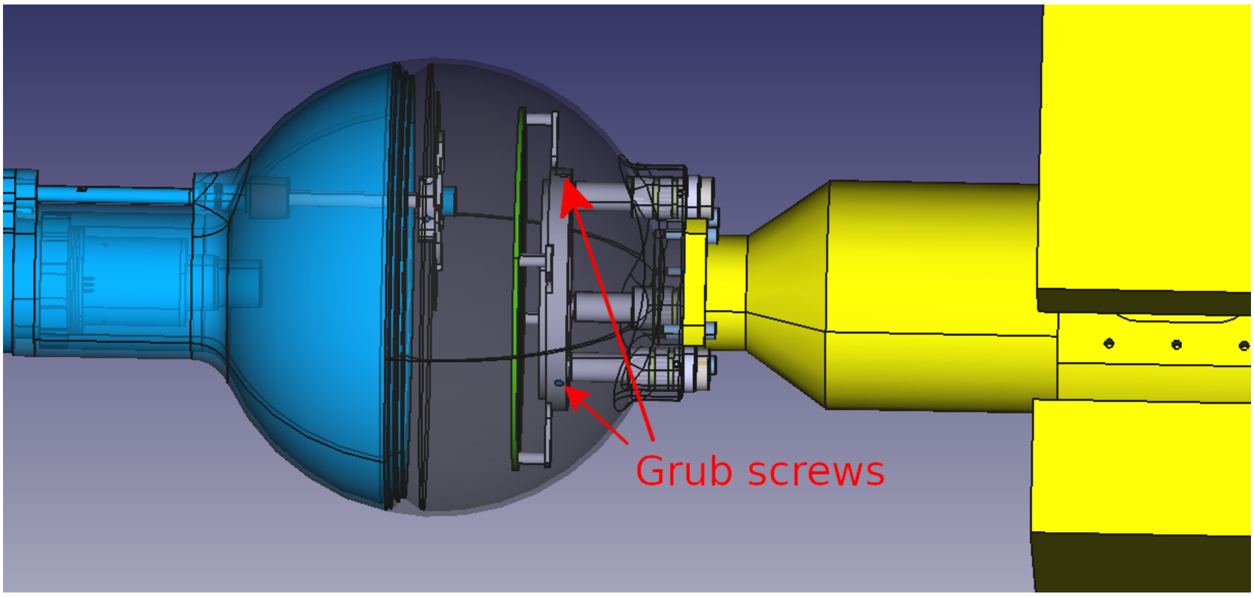

Figure 10: Two of the three grub screws behind the CD, which fix the backplate of the CD to the rods of the target chamber.

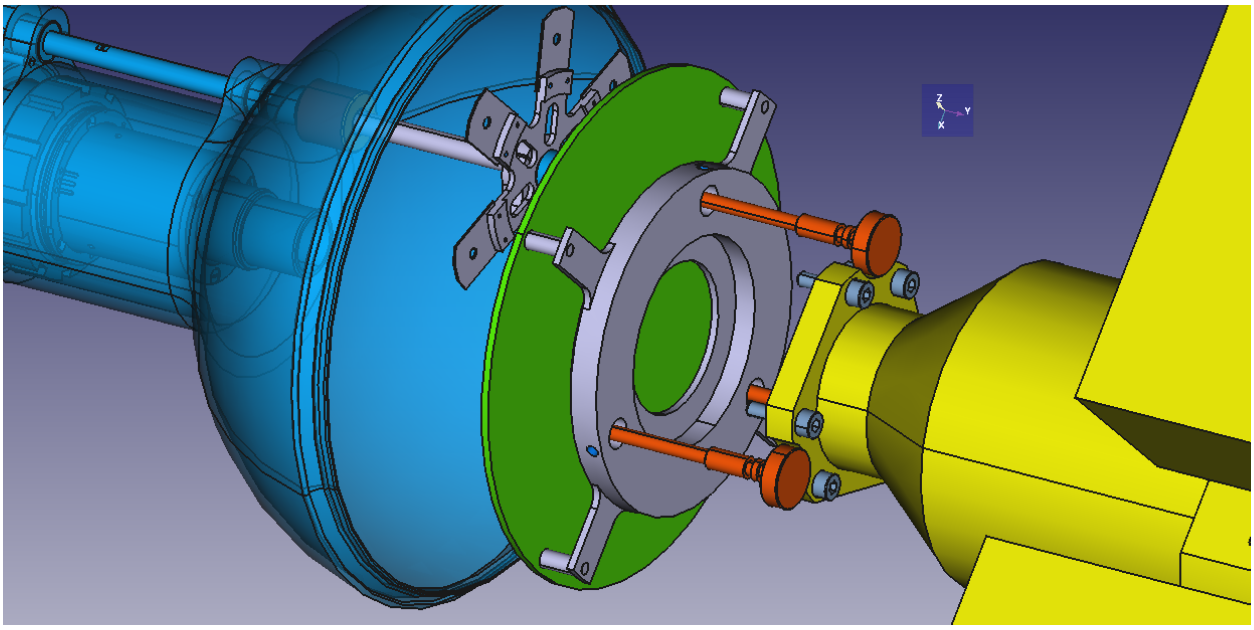

Figure 11: The two top rods, shown in orange and the bottom one (barely visible) go through the downstream part of the target chamber (not shown) and through holes in the backplate of the CD. The grub screws (shown in blue) fix the backplate (shown in grey) to them.

8) Place the CD detector assembly within a 'sample box' (or, similar) to protect it from contamination (e.g.

dust) and place in a secure location.

9) Ensure the four 34-way and four 50-way high-density IDC cables are secured and will not interfere with the beam as it exits the Miniball chamber.

11.2 Installation of CD

1) Remove the target wheel and CD protection plate from the Miniball chamber to provide physical access.

2) Ensure the four 34-way and four 50-way high-density IDC cables are secured and will not interfere with the installation of the CD detector assembly.

3) Establish the required orientation of the CD detector assembly with respect to the three Miniball chamber support rods and to which detector is 'Quadrant 1', which 'Quadrant 2' etc.

4) Position the CD detector assembly (in the required orientation) by the three Miniball chamber support rods.

5) Gently rock the CD detector assembly about the beam axis to move the CD detector assembly onto the three Miniball chamber support rods. It is a tight fit - patience is required for this step!

6) When the CD detector assembly is fully and evenly mounted onto the three Miniball chamber support rods, tighten the two M1.6(?) grub screws to secure the CD detector assembly to the Miniball chmaber. Note that there is a small gap between the rear surface of the CD detector assembly and the end of the machined section of the three Miniball chamber support rods.

7) Connect the four 34-way and four 50-way high-density IDC cables to the appropriate high-density IDC connectors on the four PCBs of the CD sectors. Ensure that the ejection clips are engaged on cable connectors.

12 Testing the electronics

This section needs completely rewriting since we no longer have the RAL109s.

To check the electronics for the front strips, send a positive signal from the CD pulse to the test+ input (this is normally connected to cable 5, which is available at the back of rack 1). Then you can look at the signals coming out of the junction box or those coming out of the RAL109s.

To check the electronics for the back strips, send a negative signal from the CD pulse to the test- input (this is normally connected to cable 6, which is available at the back of rack 1). Then you can look at the signals coming out of the junction box or those coming out of the RAL109s.

To look at these signals, use the IDC to LEMO adaptor, but use the shortest LEMO cable you can find (usually 0.5 ns).

Note that the junction box has jumpers to turn on/off individual channels or change the polarity, so make sure these are correct if the signal is wrong.

If there is no signal out of the RAL109, but there is a signal going in, make sure the cable is not damaged between the junction box and the KM-6 crate. In the past, several bad cables were found!