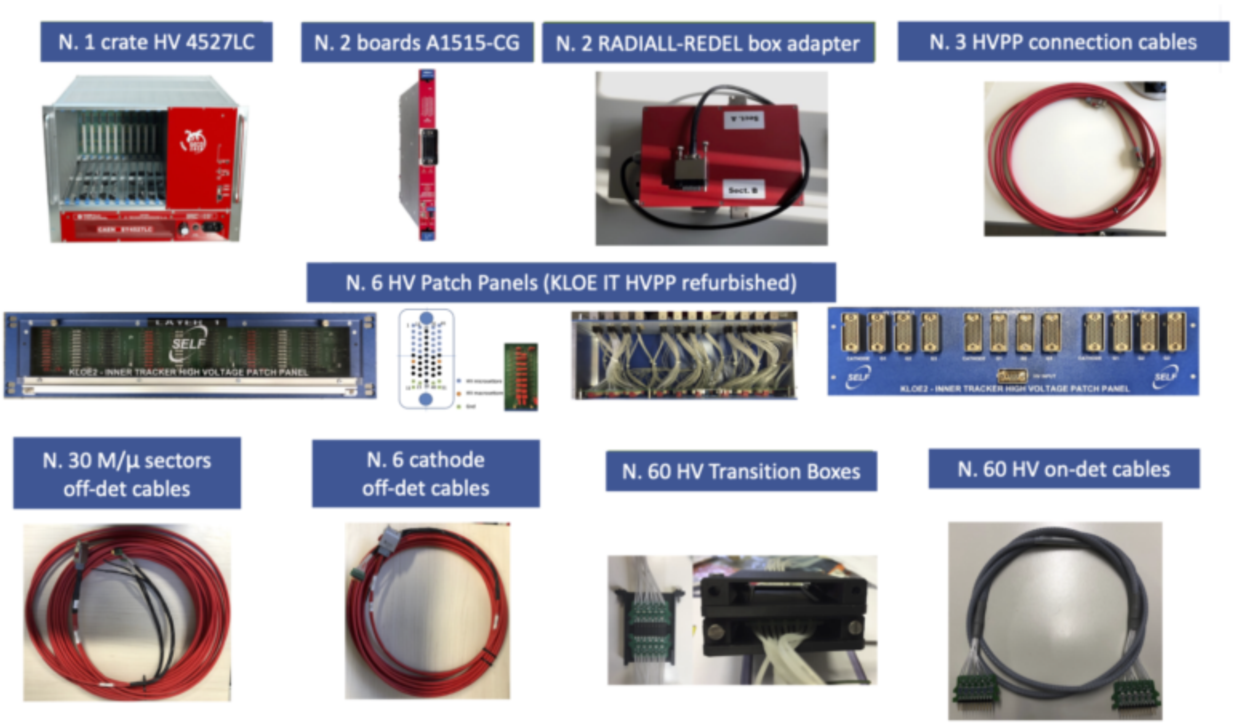
BES C-GEM HV DISTRIBUTION SYSTEM

BES IT HV DISTRIBUTION SYSTEM



AIM OF THE DOCUMENT

This document describes the components of the BES C-GEM IT High Voltage Distribution System (HVPS). The HVPS has been designed to supply independently all the macro/micro sectors of C-GEM layers then allowing the possibility to disconnect a single micro-sector in case of local short. The number of C-GEMs HV lines required for each layer is shown Table 1.

C-GEM LAYER	MACRO-SECTOS	MICRO-SECTORS
1	12	120
2	24	240
3	36	360
	72	720

Table 1: macro/micro sectors for the three C-GEM tracker layers (micro sectors subdivision is required to reduce the energy involved in case of GEM discharges)

HV DISTRIBUTION SYSTEM OVERVIEW

The HV distribution chain is made of an active section (the A1515-CG BOARD) to generate the seven voltages required by GEMs and a passive section required to split active channels according to the number of micro-sectors per layer. The Figure 1 shows the Layer 3 distribution chain for the GAS-IN side (the A1515-CG board and the RADIALL-REDEL INTERFACE are in common for GAS-IN/GAS-OUT sides); 400 HV lines are required to fully supply Layer 3 (36 macro-sectors, 360 micro-sectors and 4 Cathode lines). The numbers in parentheses specify the connectors used in the chain according to Table 2, while the dashed line shows the border between the on-detector/off-detector components (to reduce the C-GEM weight during the insertion the system has been divided in two sections). The block diagram of the full HV distribution system is shown in Appendix 4.

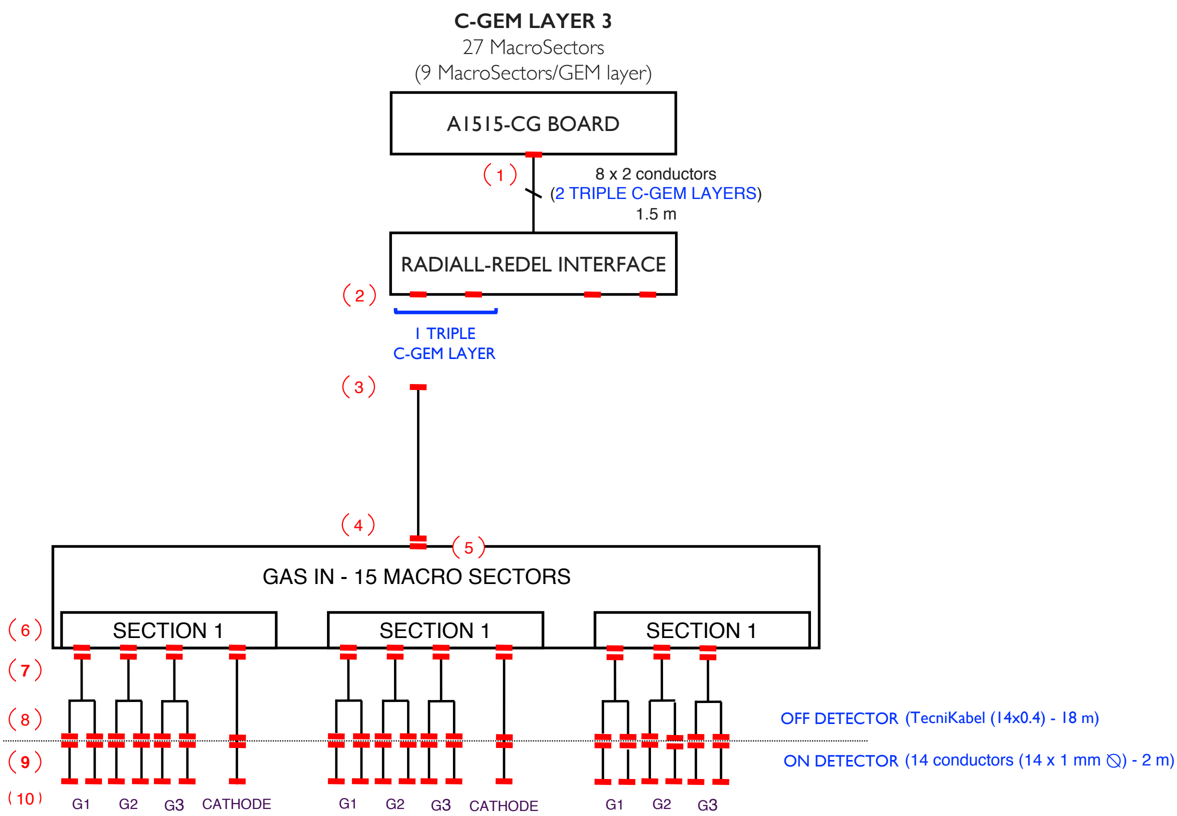


Figure 1: half HV distribution block diagram for Layer 3. Most of the HV chain is located outside the apparatus. Only 1.2 m of light and small HV cables are located near the detector to reduce the C-GEM IT weight during the insertion phase.

	CONNECTOR TYPE		CERN SCEM
1	RADIALL 691 802 002		
2	REDEL KLG.H22.LLZG	Delivering Chassis Base	09.41.34.118.0
3	REDEL - KAG.H22.LLZBG	Receiving Cable Plug	09.41.34.100.0
4	REDEL - KAA.H22.LLZBG	Delivering Cable Plug	09.41.34.110.8
5	REDEL - KLA.H22.LLZG	Receiving Chassis Base	09.41.34.118.0
6	REDEL - SLG.H51.LLZG	Delivery Chassis Base	09.41.34.258.9
7	REDEL - SAG.H51.LLZBG	Receiving CABLE PLUG	09.41.34.250.7
8	CUSTOM - 11 CONTACTS - GND		
9	CUSTOM - 11 CONTACTS - GND		
10	CUSTOM - 11 CONTACTS - PROTECTION RESISTORS		
REDEL FEMALE CONTACT : ERA.05.403.ZLL1 (0.5 mm diam)			09.41.33.200.1
REDEL MALE CONTACT: FFA.05.403.ZLA1 (0.5 mm diam)			09.41.33.210.9

Table 2. HV connector type and CERN SCEM (if any)

HVPS SYSTEM MAIN COMPONENT

THE MAIN POWER SUPPLY

A CAEN A1515-CG 14 channels board will be used as main generator together with a SY5527LC or SY4527LC system crate[1]. The crate can host both High Voltage and Low Voltage boards than allowing to minimize the number of crates required to instrument the detector.

THE RADIAL-REDEL INTERFACE

The RADIALL-REDEL interface (Figure 2) is required to match the 52 contacts CAEN A1515-CG board output connector (RADIALL PN 691 802 002) to the 22 contacts LEMO-REDEL distributor input connector (REDEL PN KAG.H22.LLZBG). Because each

[1] crate packaging and delivering power are different: the SY4527LC is a 19"-wide, 8U-high Euro 600 W crate that can host up to 10 boards, while the SY5527LC is a 19"-wide, 4U-high Euro 400 W crate that can host up to 4 boards.

layer must be supplied both in the GAS IN and GAS OUT side the interface must split each group of A1515-CG board (seven voltages and related GND return wires). shows the interface interconnections, while Figure 3 shows the Interface connections.

Figure 2: Radial-Redel interface

PIN a1515	Lemo redel		PIN a1515	Lemo redel
	Sect. A			**Sect. B**
36	**7, 12**		**16**	**7, 12**
35	**1, 17**		**15**	**1, 17**
34	**2, 18**		**14**	**2, 18**
49	**3, 19**		**28**	**3, 19**
48	**4, 20**		**27**	**4, 20**
47	**5,21**		**26**	**5,21**
46	**6, 22**		**25**	**6, 22**
45	**11,16**		**24**	**11,16**

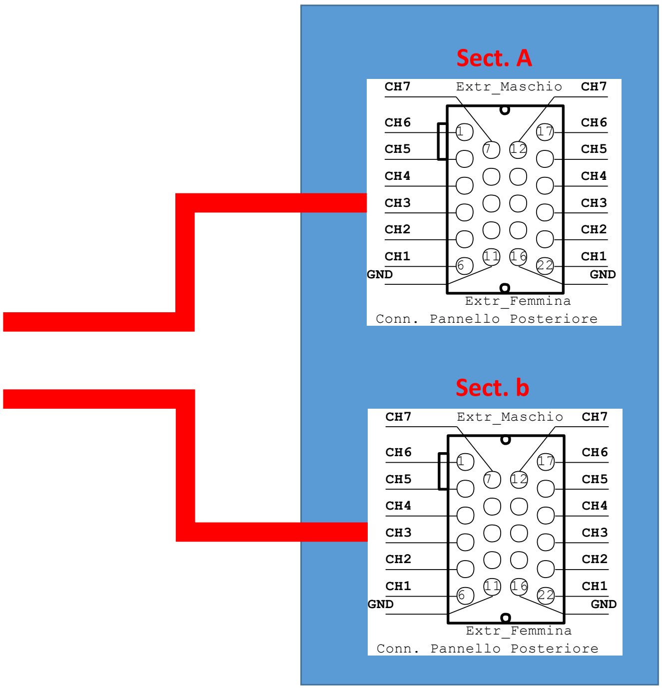
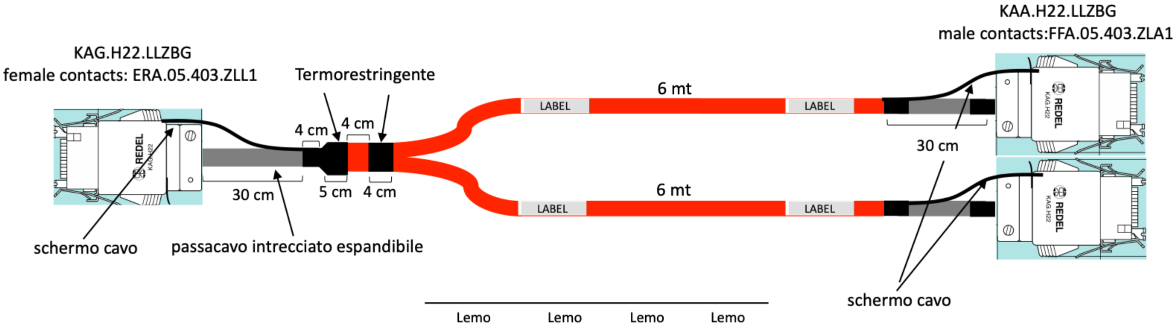
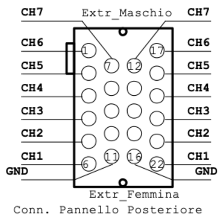


Figure 3: Radiall-Redel interface connections

The connection to the HV Patch Panels is implemented by means of special cables providing further splitting of main voltages as shown in Figure 4.





Lemo KAG.H22	Lemo KAA.H22	Lemo KAG.H22	Lemo SLG.H51
7	7	12	7
1	1	17	1
2	2	18	2
3	3	19	3
4	4	20	4
5	5	21	5
6	6	22	6
11	21,22	16	21,22

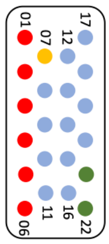


Figure 4: Radiall-Redel Interface/HV Patch Panels interconnection cable

HV PATCH PANEL

The HV Distribution Patch Panels (Figure 5 and Figure 6) are used to split the seven input voltages (from Radiall-Redel Interface) to the lines required to fully supply a C-GEM Layer. The spitting is passive (Figure 7) and each output connector supplies a couple of macro-sectors (and related micro-sectors) as shown in Figure 1. A single Patch Panel can manage up to 18 macro-sectors (and related micro-sectors) belonging to the same layer.

Figure 5: IT Patch Panel (back side)

Figure 6: IT Patch Panel (front side)

The HV Patch Panel allows to disconnect a single micro-sector in case of GEM local damaging; the damaged micro-sector is connected to the GEM macro-sector voltage (Figure *8*).

HV SYSTEM CABLING

Both main power supply and patch panel will be located on the platforms to simplify debug operations (in case of excess of current drown from a micro-sector), then cables are required to route the HV lines to the Inner Tracker.

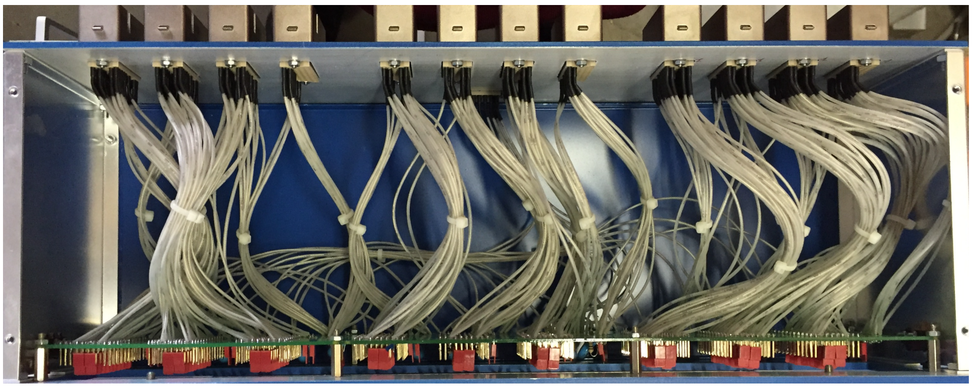


Figure 7: IT Patch Panel internal connections

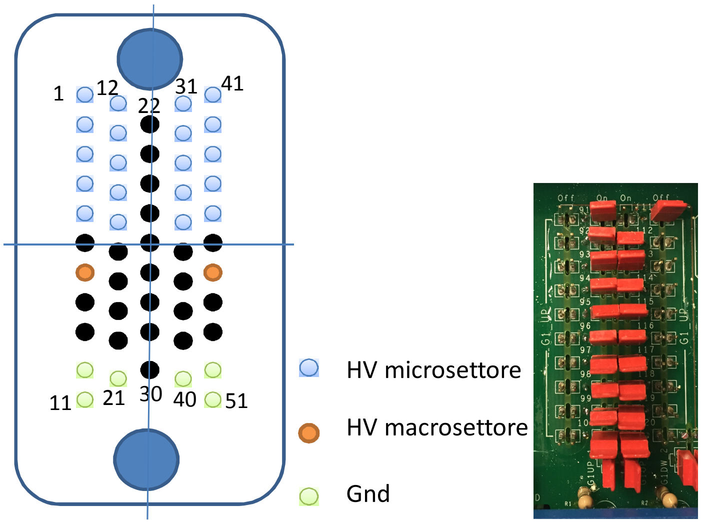


Figure 8: PATCH PANEL connector and jumper setting for micro-sector disconnection

Both main power supplies and patch panels will be located on the platforms to simplify debug operations (in case of excess of current drown from a micro-sector), then HV cables must be routed from platforms to the detector. Because the different requirements in terms of hardness and shielding (off-detector routing) or lightness (on-detector routing) different types of cables will be used in the routing.

OFF-DETECTOR CABLE

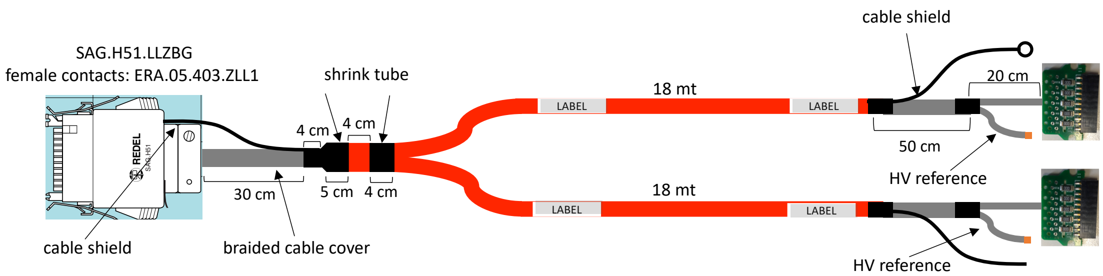


Figure 9: C-GEM HV Off-Detector cable

Hardness, shielding, halogen free are the main requirements for cables used to route high voltages from Patch-Panels to the apparatus. Besides, because more voltages are required to supply a macro sector (and its related 10 micro-sectors), multiple conductor, multicore cables rated up to 4.5/5 kV must be used. A 14 cores cable with these specifications has been already produced by TecniKabel for the KLOE2 Inner Tracker

Hardness and shielding are the main requirements for cables used to route high voltages from Patch-Panels to the apparatus. Besides, because more voltages are required to supply a macro sector and the related micro-sectors, multicore braid shield and halogen free sheath cables rated up to 4.5/5 kV must be used. A 14 cores cable with these specifications has been produced by TecniKabel for the KLOE2 Inner Tracker instrumentation (Appendix 1); the same cable will be used for C-GEM instrumentation.

ON-DETECTOR CABLE

Figure 10: C-GEM HV On Detector Cables

The cable used for on-detector interconnections must be light and flexible to allow easy routing in tight spaces. Because both the shielding and the halogen-free sheath of standard cables greatly reduce cable flexibility and standard HV connectors are quite bulky, custom cable together with custom connectors have been designed for the on-detector interconnections.

The cable has been assembled starting from extruded FEP insulated wires. By means of such wires a cable bundle with small diameter and small bending radius can be assembled. In Appendix 2 are shown several FEP insulated wires produced by Teledyne Reynolds, a 18 kV AWG 28 wire size has been used in the cable bundle. No shielding is used inside the apparatus.

Concerning off-detector/on-detector interconnections custom connector based on light and compact PCB has been designed. The design has been greatly simplified by the low value of voltage clearance/creepage required (the maximum voltage difference between contacts is of the order of 350/400 V then allowing the use of 2.54 mm pitch connector assuming clean assembling procedure). The PCB layout is shown in Figure *11* together with its dimensions (female and male connections are implemented soldering male and female strips contact on the PCB).

Even though the voltage difference between contacts is limited the absolute voltage value can be quite high (more than 4 kV) then proper insulation must be used; as shielding is not required a very simple enclosure can be used as shown in (Figure *12*).

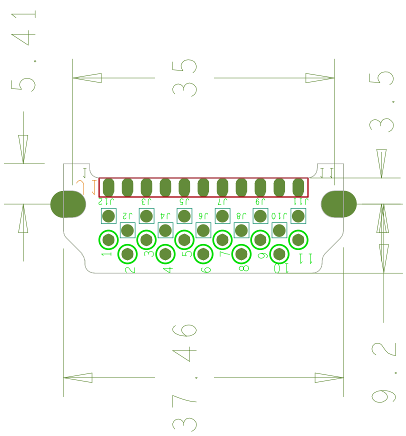


Figure 11: custom HV connector PCB

Figure 12: On-Detector/Off-Detector interconnections

CONCLUSIONS

The HV distribution system has been designed to provide the 792 macro/micro sectors voltages and related cathode voltages to the three C-GEM layers. The system is divided in two sections: on-detector and off-detector. The two sections make use of different types of cables and connectors to ensure suitable mechanical strength (off-detector) or small bending radius and lightness (on-detector). The system allows to disconnect a single micro-sector in case of trouble in the GEM foil.

APPENDIX

Appendix 1:TechniKabel cable specifications

Tecni Kabel srl	**Technical Specification**	**N° 32816**

	Description : FE(14x0,14)ccST/M Red 4,5kV

Conductor

		u/m
Material	Tinned Copper	
Construction	7 x 0,16	mm
Nominal Section	0,14 (AWG26)	mm²

Insulation

		u/m
Material	High Density Polyethylene (Cern Tis n° 790)	
Colours	*Natural Numbered 1 ÷ 14 in Black*	
Nominal Diameter	1,50	mm

The 14 elements assemblied in layers.Total laiyd-up protective by Polyester/Glass/Polyester Tape.

Shield

		u/m
Material	Tinned Copper	
Type of shield	Braid	
Diameter of strands	0,15	mm
Coverage	≥ 75	%
Drain Wire	Tinne Copper AWG26 under braid	%

Sheath

		u/m
Material	LSZH Polyolefine Compound (UV Resistant) (Cern Tis n° 954)	
Colour	Red Ral 3000	
Overall Diameter	*9,4*	mm

Marking : TECNIKABEL (TO) – ITALY – **(YearWweek)** – 14x0,14 – (Metric Marking) MT

(YearWweek) = Year 2006 – Week 18 - Example = **06W18**

Fire Performance

- Halogen acid gas emission ≤ 0,3 % when tested accordance to CEI 20-37/2-1 (EN 50267-2-1)
- Degree of acidity of gases evolved during of the combustion (pH value ≥ 4,3 and Conductivity ≤10µS/mm) when tested accordance to CEI 20-37/2-2 - CEI 20-37/2-3 (EN 50267-2-2 - EN 50267-2-3).
- Smoke emission (Transmittance) ≥ 60 % when tested accordance to CEI 20-37/3-0 - CEI 20-37/3-1 (IEC 61034-1 - IEC 61034-2).
- Toxicity of evolved gas ≤ 2 when tested accordance to CEI 20-37/7 (Similar to but not equivalent to Nes 713)
- Fire propagation complying with CEI 20-22/3-4 (EN 50266/2-4 - IEC 60332-3-24 Cat.C)

Tecni Kabel srl	Technical Specification	N° 32816

	Description : FE(14x0,14)ccST/M Red 4,5kV

Other Characteristics

- Temperature Range : ≤ +80°C
- Resistance of the conductor at 20 °C : ≤ 139 Ω/km
- Insulation Resistance at 20°C : ≥ 10 MΩxkm
- Dielectric Strength : 25 kV d.c.
- Test Voltage : 15 kV d.c.
- Operating Voltage : 4,5kV d.c.
- Static Bending Radius : 90 cm
- Nominal Weight : 130 kg/km

- Cable Radiation Resistant according to IEC 60554/2-4 – Cern IS 23 Rev.2 and TIS IS 41

- The radiation resistance of each cable must extend to an accumulated dose of 100 kGy.

Insulation :

- Tensile strength (initial) : 25 MPa
- Elongation break at 100 kGy : ≥ 110%

Sheath :

	Dose	Dose 100 Gy
- Tensilestrength (initial)	: 8 MPa	50% initial value
- Elongation	: 200 %	50% absolute value
- Dielectric strength	: 100%	75% initial value

Technical Office	*Date*
Rev.01 Added insulation resistance and changed static bendino radius	**30/05/2011**
BRUNI LEONARDO	**25/05/2011**

For Further information on this product or any other product within our range, or for any advice, Please contact
Tecnikabel s.r.l., Via Brandizzo 243, 10088 - Volpiano (TO), Italy ☎ 011-9951997, Fax 011-9953062
All information on this sheet is believed to be reliable. Users should however consult Tecnikbel s.r.l.
The information's and Data on this specification could be changed without notice

Appendix 2: Teledyne Reynolds FEP insulated wires

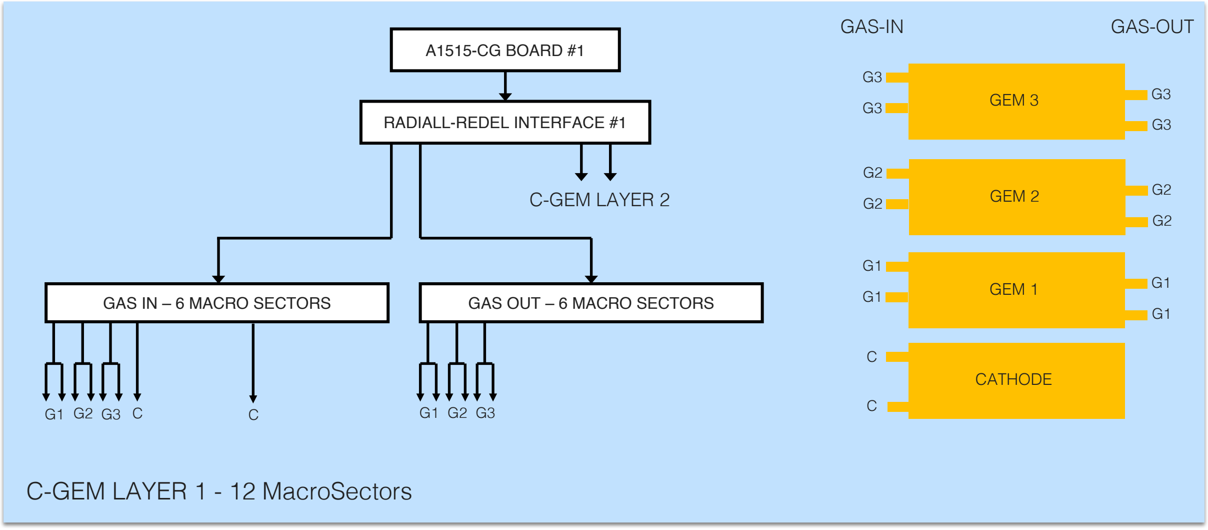
FEP Wire Attributes

Operating Voltage (KVDC)	Conductor		Plating	Conductor	Cover Insulation	Part Number
	AWG	Strands		Ø In./ mm	In./MM	
5	28	19/40	SPC	.015/0.40	.040/1.0	178-9912
10	20	19/32	SPC	.039/1.01	.060/1.5	178-9560
12	16	19/29	SPC	.056/1.43	.080/2.0	178-5626
12	28	41/44	SPC	.014/0.36	.042/1.0	178-5079
18	28	19/40	SPC	.015/0.40	.040/1.0	178-5790
18	26	19/38	SPC	.019/0.50	.045/1.1	178-5792
18	28	19/40	SPC	.015/0.40	.050/1.2	178-8751
18	26	19/38	SPC	.019/0.50	.050/1.2	178-7680
18	24	19/36	SPC	.025/0.64	.050/1.2	178-8072
18	22	19/34	SPC	.031/0.80	.055/1.4	178-8073
18	24	19/36	SPC	.025/0.64	.060/1.5	178-8523
20	22	19/34	SPC	.031/0.80	.060/1.5	178-8679
22	22	19/34	SPC	.031/0.80	.080/2.0	178-7435
21	20	19/32	SPC	.039/1.01	.090/2.2	178-8883
22	14	19/26	TPC	.070/1.80	.150/3.8	178-8545
22	14	19/26	SPC	.070/1.80	.150/3.8	700038
25	26	19/38	SPC	.019/0.50	.080/2.0	178-9490
22	20	19/32	SPC	.039/1.01	.080/2.0	178-8316
25	16	41/32	SPC	.059/1.50	.125/3.1	178-9824
30	20	19/32	SPC	.039/1.01	.100/2.5	167-7628
30	16	19/29	SPC	.056/1.43	.180/4.5	167-9611

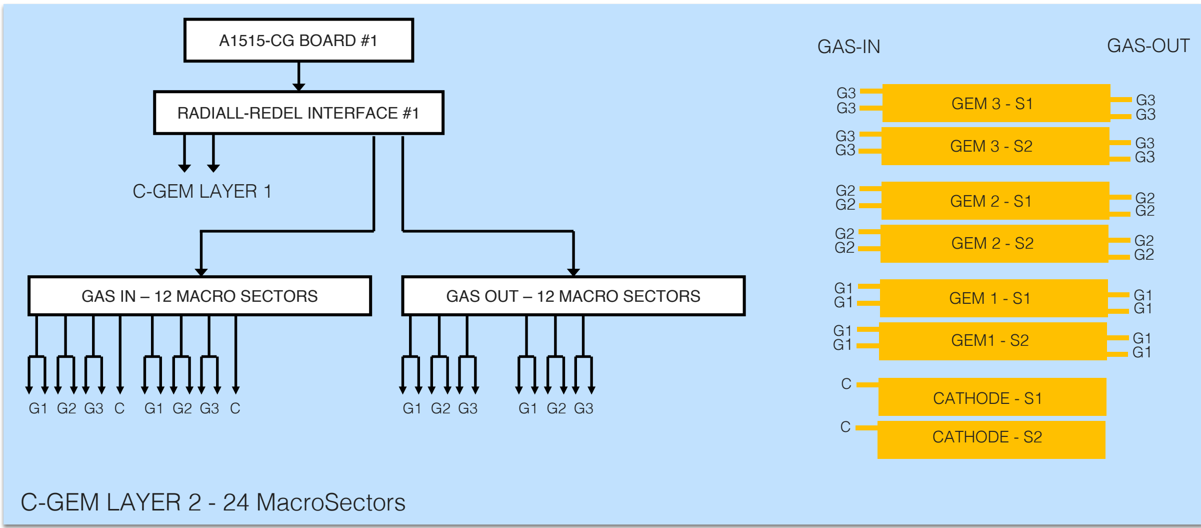
Appendix 3: Lemo-Redel HV connector reference

https://www.lemo.com/catalog/ROW/UK_English/HV_05_5G_REDEL_K-S.pdf

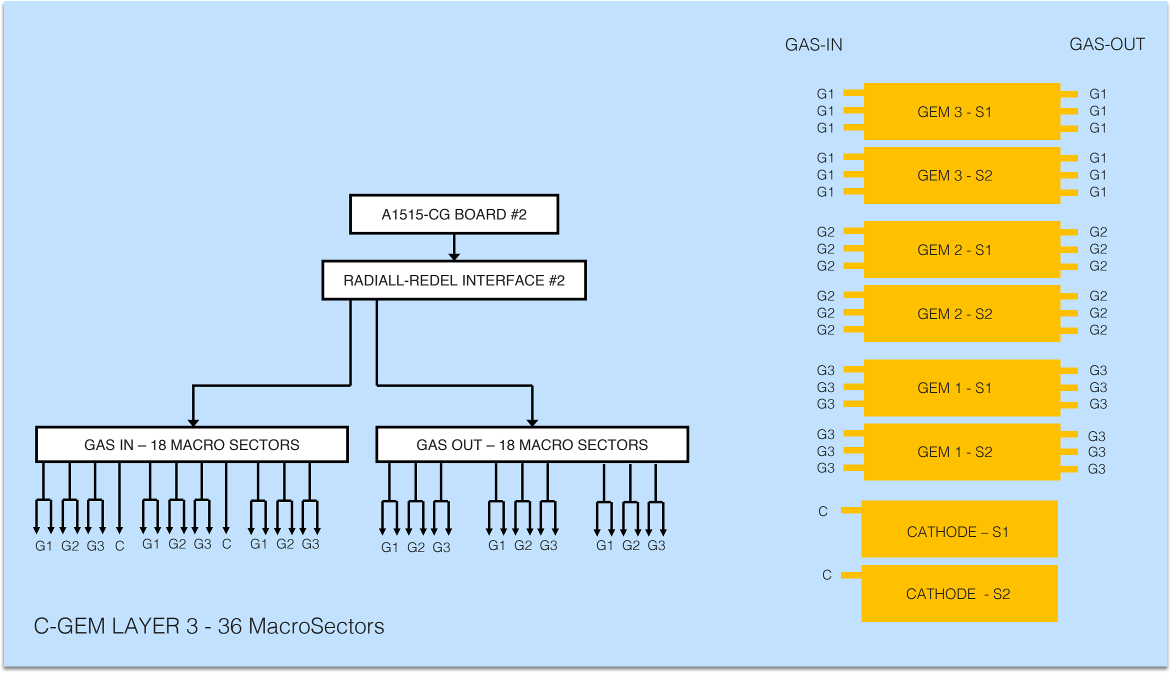
Appendix 4: C-GEM Layer 1 HV Distribution System



Appendix 5: C-GEM Layer 2 HV Distribution System Block Diagram



Appendix 6: C-GEM Layer 3 HV Distribution System Block Diagram



Appendix 7: H (Off V System Bill of Materials

Desctiption	Type	Number	Comment
HVPS Board	A1515-CG	2	
HV Crate	SY4527LC	1	
A1515-CG - Patch Panel Interface	RADIAL-REDEL INTERFACE	2	
HV Patch Panel	HV PATCH PANEL (PP)	6	
Cables Type #1	Off-Detector - Double - 18 m	36	C-GEM Sectors (two cables x HVPP connector)
Cables Type #2	Off-Detector - Single - 18 m	6	Cathode
Cables Type #3	On-Detector - Custom - 2 m	78	C-GEM Sectors & Cathode

Appendix 8: REDEL connectors Bill of Materials (single chain)

Single Chain REDEL Connectors and Contacts					
Part Number	Ref	Nb of Connectors	Nb of Contacts/Conn	Nb of contacts (Total)	Contact Type
KAG.H22.LLZBG	3	2	11	22	Female
KAA.H22.LLZBG	4	2	11	22	Male
KLA.H22.LLZG	5	2	11	22	Female
SLG.H51.LLZG	6	24	28	672	Male
SAG.H51.LLZBG	7	24	28	672	Female

Full System Connectors and Contacts (3 Chains)			
Part Number	Ref	Nb of Connectors	Nb of contacts
KAG.H22.LLZBG	3	6	66
KAA.H22.LLZBG	4	6	66
KLA.H22.LLZG	5	6	66
SLG.H51.LLZG	6	72	2016
SAG.H51.LLZBG	7	72	2016