The final qualification of the Tracker Outer Barrel Structures in production: procedures for the XY table scan v1.1 (12/08/2003).

Introduction

The CMS tracker is made of a PIXEL detector close to the pp interaction region and a Silicon Micro-Strip Tracker with about 15000 Modules operated at -10^{o}C. The Silicon Micro-Strip Tracker is subdivided into two end-cap detectors comprising 9 disks each and a barrel detector formed by 10 layers. The 6 outermost central layers form the Tracker Outer Barrel (TOB). The TOB has about 5000 Modules organised in superstructures called ROD. The ROD is the self contained electronic system containing all the electronics and connectivity to power and drive all the Modules and to read them out optically. Single Sided ROD have 6 Modules and will be employed in the outermost layers of the TOB. Double Sided ROD has the same geometry but the Modules are doubled in each position in back to back configuration and 100 micro-radiants relative tilting of the strips. DS ROD will be employed in the two innermost region of the TOB. The goal of the ROD production tests at CERN is to qualify 700 ROD in 18 months benefiting from the experience gained on prototype studies. On top of the functional and noise tests, it is expected to collect physics clusters from a ruthenium source moved by an x-y table integrated in the Data Acquisition (DAQ). It will be possible to integrate a statistics of 100 clusters per strip, corresponding to a test capability of about 3 ROD per day (considering a conservative estimation of 100 Hz for the DAQ speed, a 75% geometrical efficiency and an over-night data analysis scheme). This document concentrates on the definition of the general DAQ settings and run control procedures.

Configuration of the Run Control

The XY table Run Control (RC) environment defines the sequence of runs to be performed and controls the behaviour of the core XDAQ applications. The configuration is fully specified by XML files.
Here it is introduced the concept of set of homogeneous runs (HRUN). For each HRUN the configuration of the high voltages (HV), Fed-Multiplexer (MUX), on detector electronics and off detector electronics is the same. In order to define the sequence of runs and the settings of the XDAQ applications, the information on the tested ROD(s) is retrieved from the Tracker Construction data base.
The XY table set-up allows to test up to 3 ROD at a time.
The "Welcome" panel allows to use the bar-code reader to read the ID of the tested ROD(s). First of all some basic checks are performed:

1) The current status of the XYTable test is retrieved from a local Data Base. The Operations can be "Normal" or "Recovery" depending on the possible presence in the data base of data referring to the tested ROD.
2) If more than one ROD is tested, the IDs have to be different.
3) If more than one ROD is tested, the CCU addresses have to be different.

What does follow refer to the "Normal" operations but can be readapted slightly and be applied to the "Recovery" operations as well.
The result of the "welcome" procedure is the production of various XML files: rc.xml, rodfec_(h).xml, rodfed_(h).xml that specify the configuration of the RC, the configuration of the on detector electronics and the configuration of the off detector electronics respectively, the latter being dependent on the HRUN (h). The configuration depends on the number and on the types of the tested ROD(s). The ROD types are defined in APPENDIX A.

Definition of the RUN sequence, settings of the "slow" devices and book-keeping.

The HRUN defines the sub-sample of the ROD modules that are tested.
It is convenient to introduce the "ROD Positions" (POS) A, B, C, D, E, F, corresponding respectively to the detectors 1, 2, 3, 4, 5, 6 in the SS ROD (types *.**1**.*.*.*) and to the detectors 1+7, 2+8, 3+9, 4+10, 5+11, 6+12 in the DS ROD (types *.**2**.*.*.*).
For each ROD there are 5 HRUNs. In each HRUN, the modules corresponding to two contiguous positions are configured for the RUNs (for example A+B).
In this context RUN refer to the physics run with external trigger. All the other run types will be referred as SPECIAL RUN.
The first and the last HRUNs have 4 RUNs. The remaining HRUNs have 3 RUNs. A total of 17 RUNs are needed to qualify a ROD, We can refer to them with a SUBRUN index, allowing for possible error-recovery procedures.
Both the RUNs and the SPECIAL RUNs have a unique incremental RUN Number that is automatically documented. The following information has to be saved in the local Data Base (CMSTOBSS) for offline analysis: RUN Number, RUN Type, ROD ID, SUBRUN Number (if applicable), Number of Events, Functional Status (OK or Code of possible functional failure, which is defined in APPENDIX E), BAD RUN Flag, Analysis Status (OK or code of possible discrepancies from the reference values as defined in APPENDIX F). However, the analysis status is available only once the analysis is performed.
Only the HV channels corresponding to the tested Modules are ON. Here we introduce the naming convention for the HV settings. There are 8 HV channels available for each ROD: the notation ABCD… with A,B,C,D,… in the range 0-7, means that the channels A,B,C,D,… are ON. The instructions to cable the SY127 positive units and the list of active HV channels for each HRUN are given in APPENDIX C.
Here we introduce also the naming convention for the MUX settings. There are 8 MUX cards with 10 channel each. The settings will be given only in groups of 4 cards: the notation n+m means that the first 4 cards are set to channel n, while the last 4 cards are set to channel m, where n and m

are in the range 0-9. The instructions to cable the MUX device are given in APPENDIX D.
In the first HRUN, the configuration corresponds to A+B.
In the first RUN of the first HRUN, the source is positioned in the centre of the first half sensor(s) of A (A1); in the second RUN, the source is positioned in the centre of the second half sensor(s) of A (A2); in the third RUN, the source is positioned in the A/B overlap region (A/B); in the fourth RUN, the source is positioned in the first half sensor(s) of B (B1).
In the second HRUN, the configuration corresponds to B+C.
In the first RUN of the second HRUN, the source is positioned in the centre of the second half sensor(s) of B (B1)…

The RUN sequence and the corresponding configuration of the "slow" devices is summarized in Tab.1.

RUN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Events	50K	50K	10K	50K	50K	10K	50K	50K	10K	50K	50K	10K	50K	50K	10K	50K	50K
HRUN	A+B	A+B	A+B	A+B	B+C	B+C	B+C	C+D	C+D	C+D	D+E	D+E	D+E	E+F	E+F	E+F	E+F
POS	A1	A2	A/B	B1	B2	B/C	C1	C2	C/D	D1	D2	D/E	E1	E2	E/F	F1	F2
MUX	0+0	0+0	0+0	0+0	1+0	1+0	1+0	1+1	1+1	1+1	2+1	2+1	2+1	2+2	2+2	2+2	2+2
HV	0123	0123	0123	0123	234	234	234	45	45	45	56	56	56	67	67	67	67

Tab. 1: The 17 RUNs defining the XY table scan of a ROD with the corresponding configuration in terms of HRUN and the relative MUX settings and source position (POS); X1=first half sensor(s) of position X, X2=second half sensor(s) of position X, X/Y=overlap region between the positions X and Y. A shift of 3(6) has to be applied to the MUX settings for the second (third) tested ROD. A shift of 8 (16) has to be applied to the HV settings for the second (third) tested ROD. HV channels 2 and 4 are not used for ROD types *.1.*.*.*.

The RC configuration file (rc.xml) does contain the following information:

1) Number of HRUN(s) to be performed
2) For each HRUN:
    a. The number of RUN to be performed.
    b. The configuration of the FED-Multiplexer.
    c. The configuration of the high voltages (SY127).
    d. For each run
        i. The minimum number of events to be taken.
        ii. The position of the XY table.

In order to start the run sequence in a given NRUN, Five SPECIAL RUNs should be preliminary performed: Time alignment one, Time alignment two, Pedestal in Peak Mode, Pedestal in Deconvolution Mode, Delay scan.

Time alignment is performed in the first SPECIAL RUN, the PLL delays are adjusted accordingly and another Time alignment SPECIAL RUN is performed in order to check if things improved. The subsequent SPECIAL RUNs and RUNs are performed if a reasonable time alignment is obtained (in the range –3ns,3ns), otherwise the corresponding HRUN is skipped.

Storage, Analysis and Insertion of the test results in the Construction Data Base

For each FED channel and for each event, about 100 Bytes of data is stored. For each tested ROD about 650K events will be taken. For the ROD types ***.1.*.1.*** there are 4 active FED channels, corresponding to a total storage of 260 Mbytes. For the ROD types ***.1.*.2.*** there are 6 active FED channels (storage = 390 Mbytes). For the ROD types ***.2.*.0.*** there are 8 active FED channels (storage = 0.5 Gbytes). Since the storage requirements to test 700 RODs are very demanding, the BAD RUNs will be discarded immediately.

Data are stored in zebra format in the pcepcmt17 machine (/datad directory): the file name is in the format sirNNNNNNN_MMM.dat, where NNNNNNN=seven digit RUN Number. MMM=three digit index. The file is truncated and another file is open (with increasing MMM) if a size of about 20 Mbytes is reached.

For each SUBRUN that is not flagged as BAD RUN, a script is prepared by the RC to run the analysis. A DAEMON checks that the analysis is performed overnight in the pcepcmt18 machine for the “new” SUBRUNs that are not flagged as BAD RUNs.

A Gbit Ethernet local network does connect three machines (pcepcmt17, pcepcmt18, pcepcmt19) to speedup the transfer of data and files.

The Analysis Status FLAG is logged in the local Data Base at the end of the analysis step.

The results (histograms, list of bad channels etc.) are stored in the pcepcmt18 machine (/anal directory): the file names are in the format analNNNNNNN.ntp, analNNNNNNN.txt and analNNNNNNN.log

A script allows to check that all the 17 SUBRUN analyses are available for the tested ROD. If this is the case, the insertion of the results in the tracker construction data base is prepared through production of an appropriate XML summary file.

Definition of simple error recovery procedures.

Some basic information is saved in order to allow to launch simple recovery procedures. Let’s for instance assume that something does not work with one DAQ process for a given SUBRUN (Refer to APPENDIX E for the definition of the Functional Status Flags) in this case no information will be saved in the local Data Base for this SUBRUN and the subsequent SUBRUN will be tried. If the “welcome” procedure is repeated for this ROD, the user will be prompted for the choice to switch to the “Recovery operations” repeating the missing SUBRUNs.
However it is not mandatory to repeat just the SUBRUNs that are missing or have a value different from OK, one may want to repeat the overall qualification test, in this case the user should select the “Normal operations”.

Configuration of the ON detector electronics

The on detector electronics configuration file (rodfec_(h).xml) is defined for each HRUN and does contain the following information:

1) The reset procedure
2) The configuration of the APV(s)

```
<APV25 fecSlot="0" ringSlot="0" ccuAddress="xxx" i2cChannel="yyy"
i2cAddress="zzz" apvError="0" apvMode="37" cdrv="0" csel="8"
ical="40" imuxin="34" ipcasc="52" ipre="98" ipsf="34" ipsp="55"
isha="80" ispare="0" issf="34" latency="100" muxGain="2" vfp="30"
vfs="15" vpsp="40" />
```

3) The configuration of the APVMUX(s)

```
<APVMUX fecSlot="0" ringSlot="0" ccuAddress="xxx"
i2cChannel="yyy" i2cAddress="67" resistor="15" />
```

4) The configuration of the PLL

```
<PLL fecSlot="0" ringSlot="0" ccuAddress=”xxx” i2cChannel="yyy"
i2cAddress="68" delayFine="ddd" delayCoarse="eee" />
```

5) The configuration of the LaserDriver(s)

```
<LASERDRIVER fecSlot="0" ringSlot="0" ccuAddress="10"
i2cChannel="16" i2cAddress="96" bias0="23" bias1="23" bias2="23"
bias3="23" gain0="2" gain1="2" gain2="2" gain3="2" />
```

6) The configuration of the DCU(s)

```
<DCU fecSlot="0" ringSlot="0" ccuAddress="xxx" i2cChannel="yyy"
i2cAddress="0" channel0="0" channel1="0" channel2="0" channel3="0"
channel4="0" channel5="0" channel6="0" channel7="0" dcuHardId="0"
timeStamp="0" />
```

where xxx is the CCU address of the ROD; yyy runs in the range 16-27 (only even index are used for the ROD types ***.1.*.*.*)**. The value of xxx and yyy depend on the HRUN configuration. Refer to APPENDIX B to get the CCU I2C channel correspondence.
zzz runs in the range 32-37 for the ROD types *.1.*.2.*, for all the other rod types the indexes 34 and 35 are missing. Refer to APPENDIX D to get the FED channel - I2C address association.
ddd and eee are initially set to 10 and 1 respectively, their value is changed as result of the Time Alignment.

Configuration of the OFF detector electronics

The off detector electronics configuration file (rodfec_(h).xml) is defined for each HRUN and has the following nested structure:

```
<TrackerDescription>
      <Fed supervisor="TrackerFedPmc" instance="0" device="0"
      externalclock="true" externaltrigger="true" scopemode="false"
      clockdelay="5" lowthreshold="180" highthreshold="330" sample="512"
      tscinhibittriggercontrol="true" muxon="false" softtriggercontrol="false"
      ttctriggercontrol="false" tsctriggercontrol="false">
             <FedChannel fec="FecSupervisor" channel="iii" ccuAddress="xxx"
             ccuChannel="yyy" apv1="jjj" apv2="kkk" fecInstance="0"
             fecSlot="0" fecRing="0" opto="none" mask="1" />
             ...
      </Fed>
      <Tsc triggerfrequency="40" feddelayclock="aaa" feddelaytrigger="bbb"
      apvlatency="83"    resetlatency="10" fedlatency="100" clockmin="4000"
      TscDevice="0" triggercount="0" triggerregister="8" caliblatency="100"
      gateposition="0" gatewidth="0" pulserdelay="0" interrupt="false" />
      <Monitor>
             <Pedfile Name="/home/control/lastpeddies.hbook" />
             <Detector Number="nnn" Number_of_apv="mmm"
             Ccu_number="xxx" Ccu_channel="yyy" Seed_cut="6"
             Neighbour_cut="2.5" Dead_strip_cut="4.15" instance="0"
             ring="0" slot="0" Opto1="0" Opto2="0" Opto3="0"
             Polarity="1" NCmn="128" />
      </Monitor>
</TrackerDescription>
```

where xxx is the CCU address of the ROD; yyy runs in the range 16-27 (only even index are used for the ROD types *.1.*.*.*). The value of xxx and yyy depend on the HRUN configuration. Refer to APPENDIX B to get the CCU I2C channel correspondence.

jjj = 32, 34, 36 (i.e. three different FedChannel(s) are needed) for the ROD types *.1.*.2.*, for all the other rod types jjj = 32, 36 (i.e. two different FedChannel(s) are needed); kkk=jjj+1; aaa, bbb and ccc are initially set to 16, 20 and 83 respectively, their value is changed as result of the Delay Scan; nnn=1,2 (1,2,3,4) for the ROD types *.1.*.*.* (*.2.*.*.*).

Appendix A: The ROD description in the Tracker Construction Data Base

Definition of the CCU types

Three classes of CCUM are defined, according to their functionality in the control ring, as follows:
CCU1: first CCUM in the ring, with hardware address=1
CCU2: second CCUM in the ring, with hardware address=2
CCU3: any of the other CCUMs, address>2
The three CCUM classes correspond to the split in three further rod types described above. For each CCUM (and for each rod after the integration of the CCUM), the hardware address can be retrieved from the database.

Definition of the AOH types

Two different opto-hybrids are used in the TOB:
AOH type 2.2.1 (2 lasers)
AOH type 2.2.2 (3 lasers)

Definition of the Detector types

type 3.3.13.11 122 micron rphi layers 5-6 (SS)
type 3.4.12.11 183 micron rphi layers 3-4 (SS)
type 3.4.12.12 183 micron rphi layers 1-2 (DS) connector up
type 3.4.14.12 183 micron rphi layers 1-2 (DS) connector down
type 3.4.15.13 183 micron stereo layers 1-2 (DS) connector up
type 3.4.16.13 183 micron stereo layers 1-2 (DS) connector down

meaning of the indexes a.b.c.d

a = TOB
b = sensor mask type
c = hybrid + pitch adapter type
d = kapton geometry

Definition of the ROD types

The ROD types are defined at different stages. The insertion of a new element usually implies the introduction of a new index. Although only the complete ROD, with modules installed will be used in the production tests, the definition of the intermediate types is essential to define the final configuration.

ROD (rod frame)
type 1 = L (LOW)
type 2 = H (HIGH)

ROD (rod frame + cooling pipe)
type 1.1 = L-S (single-sided)
type 1.2 = L-D (double-sided)
type 2.1 = H-S
type 2.2 = H-D

ROD (rod equipped with PCBs)
type 1.1.1 = L-S-CCU1
type 1.2.1 = L-D-CCU1
type 2.1.1 = H-S-CCU1
type 2.2.1 = H-D-CCU1
type 1.1.2 = L-S-CCU2
type 1.2.2 = L-D-CCU2
type 2.1.2 = H-S-CCU2
type 2.2.2 = H-D-CCU2
type 1.1.3 = L-S-CCU3
type 1.2.3 = L-D-CCU3
type 2.1.3 = H-S-CCU3
type 2.2.3 = H-D-CCU3

ROD (cabled rod, including opto-hybrids)
type 1.1.1.1 = L-S-CCU1-2L
type 1.2.1.1 = L-D-CCU1-2L
type 1.1.1.2 = L-S-CCU1-3L
type 2.1.1.1 = H-S-CCU1-2L

type 2.2.1.1 = H-D-CCU1-2L
type 2.1.1.2 = H-S-CCU1-3L
type 1.1.2.1 = L-S-CCU2-2L
type 1.2.2.1 = L-D-CCU2-2L
type 1.1.2.2 = L-S-CCU2-3L
type 2.1.2.1 = H-S-CCU2-2L
type 2.2.2.1 = H-D-CCU2-2L
type 2.1.2.2 = H-S-CCU2-3L
type 1.1.3.1 = L-S-CCU3-2L
type 1.2.3.1 = L-D-CCU3-2L
type 1.1.3.2 = L-S-CCU3-3L
type 2.1.3.1 = H-S-CCU3-2L
type 2.2.3.1 = H-D-CCU3-2L
type 2.1.3.2 = H-S-CCU3-3L

ROD types *-*-*-2L mount AOH type 2.2.1, as defined in the prod. db.
ROD types *-*-*-3L mount AOH type 2.2.2, as defined in the prod. db.

ROD (complete rod, with modules installed)
type 1.1.1.1.3 = L-S-CCU1-2L-L3
type 1.2.1.1.1 = L-D-CCU1-2L-L1
type 1.2.1.1.2 = L-D-CCU1-2L-L2
type 1.1.1.2.3 = L-S-CCU1-3L-L3
type 2.1.1.1.3 = H-S-CCU1-2L-L3
type 2.2.1.1.1 = H-D-CCU1-2L-L1
type 2.2.1.1.2 = H-D-CCU1-2L-L2
type 2.1.1.2.3 = H-S-CCU1-3L-L3
type 1.1.2.1.3 = L-S-CCU2-2L-L3
type 1.2.2.1.1 = L-D-CCU2-2L-L1
type 1.2.2.1.2 = L-D-CCU2-2L-L2
type 1.1.2.2.3 = L-S-CCU2-3L-L3
type 2.1.2.1.3 = H-S-CCU2-2L-L3
type 2.2.2.1.1 = H-D-CCU2-2L-L1
type 2.2.2.1.2 = H-D-CCU2-2L-L2
type 2.1.2.2.3 = H-S-CCU2-3L-L3
type 1.1.3.1.3 = L-S-CCU3-2L-L3
type 1.2.3.1.1 = L-D-CCU3-2L-L1
type 1.2.3.1.2 = L-D-CCU3-2L-L2
type 1.1.3.2.3 = L-S-CCU3-3L-L3

type 2.1.3.1.3 = H-S-CCU3-2L-L3
type 2.2.3.1.1 = H-D-CCU3-2L-L1
type 2.2.3.1.2 = H-D-CCU3-2L-L2
type 2.1.3.2.3 = H-S-CCU3-3L-L3

Rphi and stereo detectors are mounted differently for rods that populate layer 1 and rods that populate layer 2 (see http://cern.ch/abbaneo/cms/TOB/misc/ROD_positioning.html) There is no further split in different types for single-sided rods, at the level of module installation.

ROD assembly rules and Detector numbering

type *.1.*.1.* contains 6 optohybrids of type 2.2.1
type *.2.*.1.* contains 12 optohybrids of type 2.2.1
type *.1.*.2.* contains 6 optohybrids of type 2.2.2

type *.*.x.*.* contains CCUM of type x, with x=1,2,3

type *.1.*.1.* contains 6 detectors of type 3.4.12.11
type *.1.*.2.* contains 6 detectors of type 3.3.13.11
type *.2.*.1.* contains 3 detectors of type 3.4.12.12
and 3 detectors of type 3.4.14.12
and 3 detectors of type 3.4.15.13
and 3 detectors of type 3.4.16.13

On SS rods, detectors have to be registered in the order in which they are installed in the rod. Location 1 identifies the detector that sits at Z=0 and location 6 refers to the detector opposite to the CCUM.

In DS rods, the numeration is as follows: detectors close to the BUS are numbered 1 to 6 as in SS rod, then detectors further from the BUS are numbered from 7 to 12 starting again from Z=0. In this way a DS rod is equal to a SS rod with another layer of modules.
Detectors with hybrid connector "up" are mounted on the inside of the rod in positions 1-6, while detectors with connector "down" are mounted on the outside, in positions 7-12 (this rule is impossible to violate if the

kapton cable is properly bent). One DS module is therefore formed by a (phi/up, stereo/down) pair, or by a (stereo/up, phi/down) pair. A DS rod contains three (phi/up, stereo/down) on one side, and three (stereo/up, phi/down) on the other side. There is one remaining ambiguity in the assembly, and therefore one remaining assembly rule to define: which pairs go on which side. This last assembly rule is not implemented in the database.

The rule is as follows:

RODs of type H layer 1 have (phi/up, stereo/down) on the CCUM side

RODs of type L layer 1 have (stereo/up, phi/down) on the CCUM side

RODs of type H layer 2 have (stereo/up, phi/down) on the CCUM side

RODs of type L layer 2 have (phi/up, stereo/down) on the CCUM side

Effectively, once the assembly is completed, it can be cross-checked in the following way:

looking at the CCUM side, you see a stereo detector for a rod H of layer 1 or a rod L of layer 2, you see an rphi detector for a rod L of layer 1 or a rod H of layer 2.

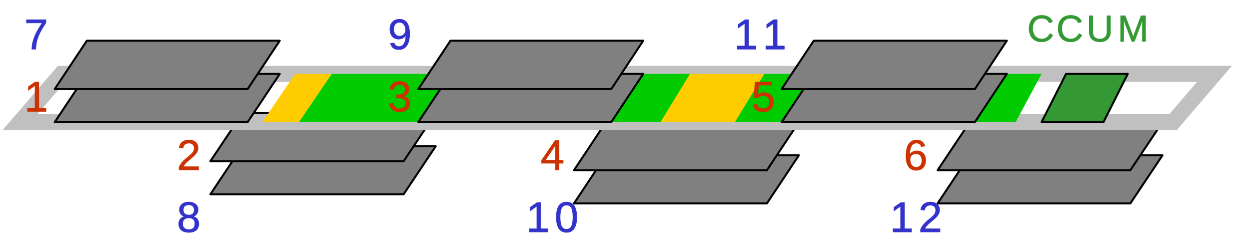

Fig. 1 Detector numbering in the DS ROD and in the SS ROD. In the latter case, only the red numbers have to be considered.

Appendix B: The ROD Cabling

The cabling of the ROD is described at the following page:
http://cms-tk-opto.web.cern.ch/cms-tk-opto/tk/integ/rod/2nd_rod2.html
and is summarised in Fig. 2 and Tab. 2.

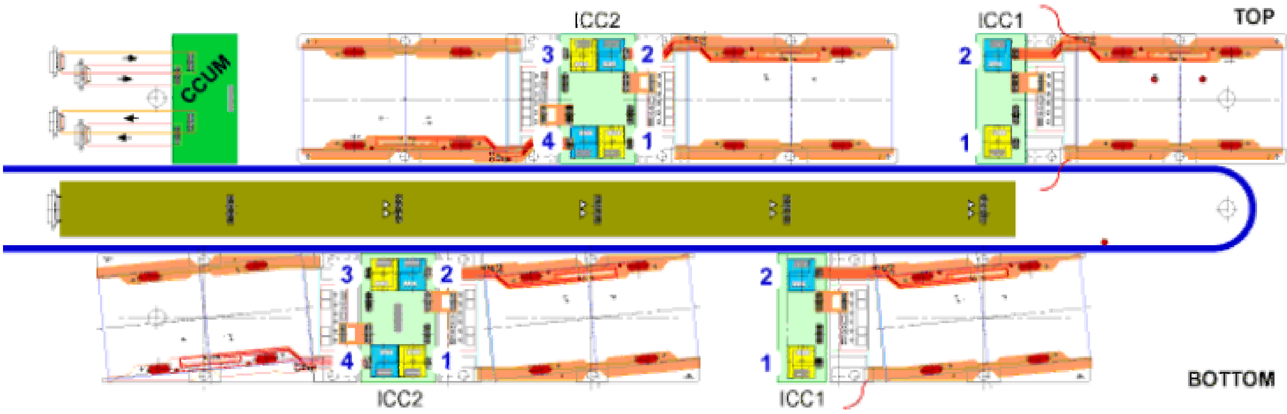

Fig. 2: The correspondence between the module and the interconnect card positions in the DS ROD (for the SS ROD it is sufficient to consider just the yellow part.

I2C channel	Ch. 16	Ch. 17	Ch. 18	Ch. 19	Ch. 20	Ch. 21	Ch. 22	Ch. 23	Ch. 24	Ch. 25	Ch. 26	Ch. 27
ICC1	OP1	OP2					OP1	OP2				
ICC2			OP1	OP2	OP4	OP3			OP1	OP2	OP4	OP3
MOD	7	1	9	3	5	11	8	2	10	4	6	12
POS	A	A	C	C	E	E	B	B	D	D	F	F

Tab. 2: The correspondence between the interconnect card positions and the CCU I2C channel. The module numbers (MOD) following the convention described in APPENDIX A, and the module positions (POS) are also reported. (Swap between OP3 and OP4 ??? → to be verified!!!)

Appendix C: The HV cabling

To bias a ROD, 2 positive units driven by a SY127 units of 4 channels each are needed. ROD types ***.2.*.*.*.*** have 8 independent HV channels. ROD types ***.1.*.*.*.*** have 6 independent HV channels.
The channel assignment for the first tested ROD reflects Tab. 3, for the second (third) tested ROD it is sufficient to add 8 (16) to the HV channel number (HV CH). Refer to APPENDIX A for module numbering.

HV CH	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**8**
Module	**1**	**7**	**2**	**8**	**3+9**	**4+10**	**5+11**	**6+12**

Tab. 3 The HV cabling scheme valid for the ROD types *.2.*.*.*. The same scheme can be extended to the ROD types *.1.*.*.* taking into account that only the modules from 1 to 6 have to be connected.

Appendix D: The MUX cabling

The main requirement for the MUX cabling is to allow to perform tracking for the RUNs in the overlap region with one single FED card and one MUX unit (8 MUX cards plus the relative controller).
Each MUX card is identified by the FED channel it is connected with (Fed ch#), each channel of the MUX card can be connected to two APVs of one module, therefore the connection status will be identified by the module number (see appendix A) and by the decimal I2C addresses of the interested APVs. MUX channels 0 to 2 are allocated to the first tested ROD, channels 3 to 5 are allocated to the second tested ROD (if present), channels 6 to 8 are allocated to the third tested ROD. In the following Tables it is reported the cabling for the first ROD. In order to get the one for the second (third) ROD, it is sufficient to shift by 3 (6) the MUX channel number.

	Fed ch 0	**Fed ch 1**	**Fed ch 2**	**Fed ch 3**	**Fed ch 4**	**Fed ch 5**	**Fed ch 6**	**Fed ch 7**
Mux ch 0	**M1 32,33**	**M1 36,37**	**M7 32,33**	**M7 36,37**	**M2 32,33**	**M2 36,37**	**M8 32,33**	**M8 36,37**
Mux ch 1	**M3 32,33**	**M3 36,37**	**M9 32,33**	**M9 36,37**	**M4 32,33**	**M4 36,37**	**M10 32,33**	**M10 36,37**
Mux ch 2	**M5 32,33**	**M5 36,37**	**M11 32,33**	**M11 36,37**	**M6 32,33**	**M6 36,37**	**M12 32,33**	**M12 36,37**

Tab. 4 The MUX cabling scheme valid for the ROD types *.2.*.*.*. The same scheme can be extended to the ROD types *.1.*.1.* taking into account that only the modules from 1 to 6 have to be connected. A different scheme is needed for the ROD types *.1.*.2.* (see Tab. 5).

	Fed ch 0	**Fed ch 1**	**Fed ch 2**	**Fed ch 3**	**Fed ch 4**	**Fed ch 5**	**Fed ch 6**	**Fed ch 7**
Mux ch 0	**M1 32,33**	**M1 34,35**	**M1 36,37**	**x**	**M2 32,33**	**M2 34,35**	**M2 36,37**	**x**
Mux ch 1	**M3 32,33**	**M3 34,35**	**M3 36,37**	**x**	**M4 32,33**	**M4 34,35**	**M4 36,37**	**x**
Mux ch 2	**M5 32,33**	**M5 34,35**	**M5 36,37**	**x**	**M6 32,33**	**M6 34,35**	**M6 36,37**	**x**

Tab. 5 The MUX cabling scheme valid for the ROD types *.1.*.2.* (x means “not connected”).

Appendix E: The Functional Status Codes and the BAD RUN Flag.

The status of the “slow” devices is verified before and after each SUBRUN a corresponding status code is defined, the status codes, ordered by absolute value of the index, follow:
0) OK.
1) XDAQ: One (or more) executive(s) is (are) not running.
2) High Voltages: One (or more) channel(s) is (are) in the status Trip or Off .
3) MUX: One (or more) switch(es) is (are) in a different status with respect to the nominal one depending on the HRUN.
4) XY Table: The read-out position is different with respect to the nominal one depending on the HRUN.
5) Temperature/Humidity: One (or more) probe(s) is (are) in outside limits.
6) Interlock: An Interlock has been set.

The BAD RUN Flag is set if the Functional Error is such that it does affect the tested position(s). In this case the functional status code will be reported as FATAL (negative values). Otherwise it will be reported as WARNING (positive values).
If the BAD RUN Flag is set at the start of the SUBRUN, the RC is reconfigured and the subsequent SUBRUN is considered. If the BAD RUN Flag is produced at the end of the SUBRUN, the corresponding functional error codes are documented in the local data base.