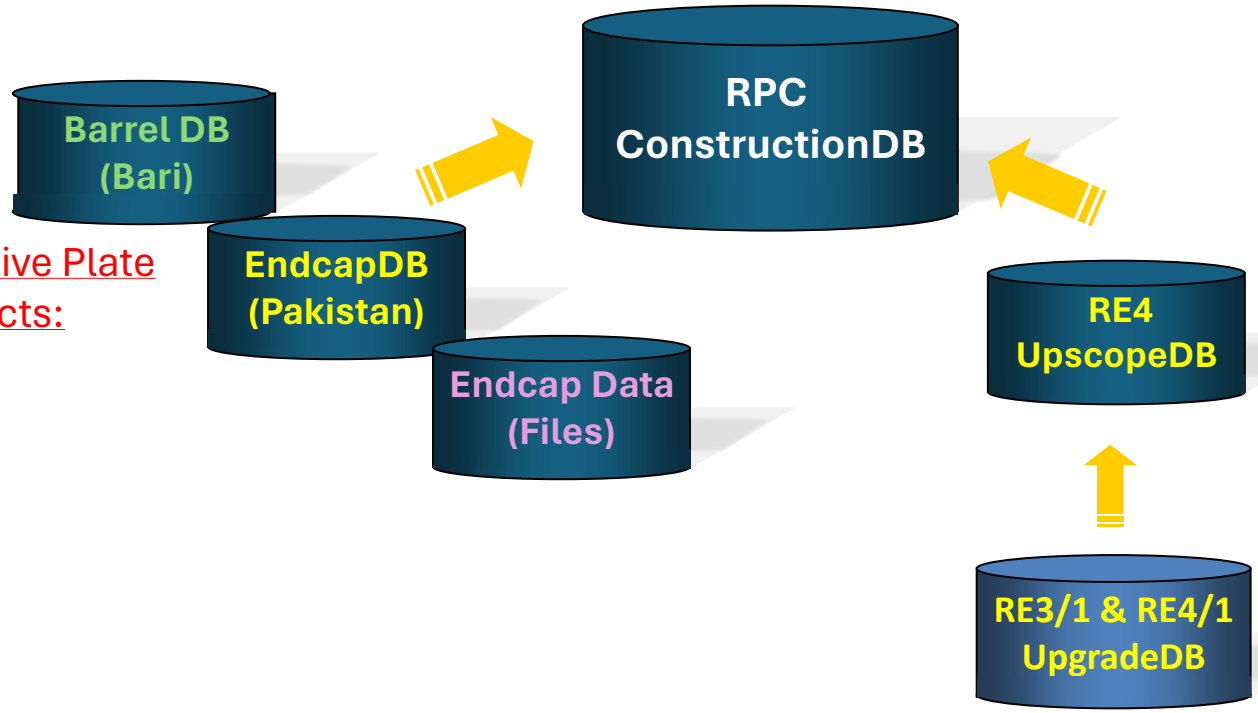
The CMS RPC Construction Database

Lifecycle Traceability and Quality Assurance Across Detector Generations

Anton Dimitrov
on behalf of the CMS Muon Group

Ideology:



The database **stores** all construction period data for the CMS Resistive Plate Chamber (RPC) detector, provides **order** and **relation** between objects:

- Chamber Components
- Chamber Construction
- Chamber Certification

- Production
- Validation
- Certification

Home Page- https://apex.cern.ch/pls/htmldb_cmsr/f?p=125:1

Full history of each chamber:

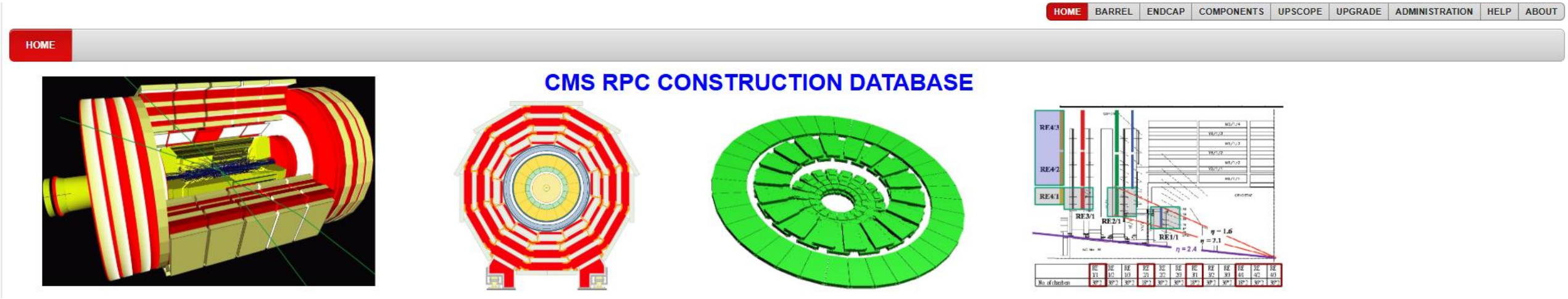
- **Construction period**: chamber components & tests – bakelite, gaps, chambers, (super modules)
- **Cosmic test period**: efficiency, cluster size, noise, occupancy
- **Commissioning period**: current monitoring in time, noise rate

RPC Construction DB web Interface



Main Features:

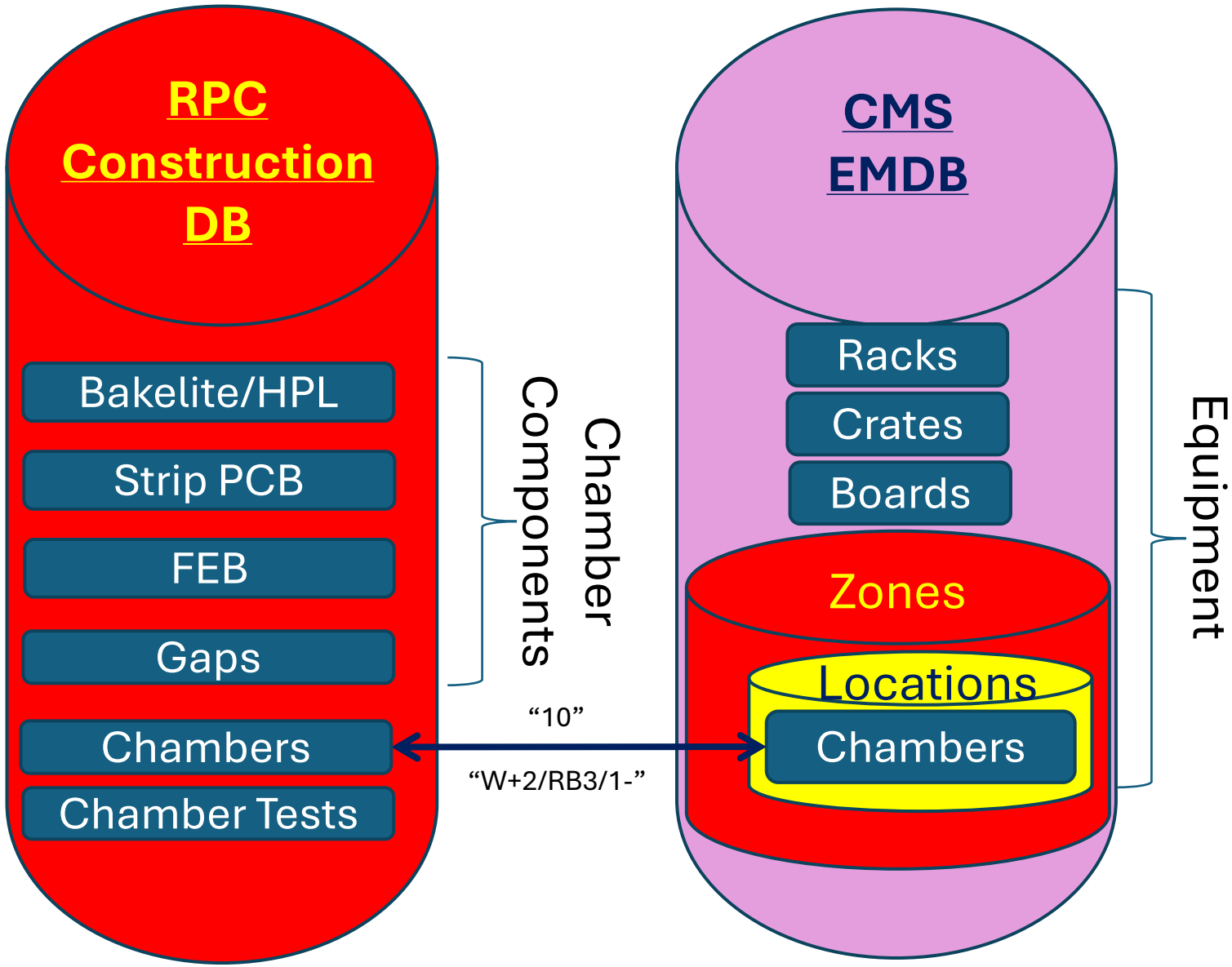
- **The RPC Construction DB is a CERN IT based ORACLE database hosted on CMSR instance with ORACLE APEX web interface**
- GU Interface realized in 6 main tabs
  - HOME, BARREL, ENDCAP, COMPONENTS, UPSCOPE, UPGRADE
- CERN User Single Sign-On (SSO) authentication
- User Privileges – administrator, expert, public user



- **RPC chambers in RPC Construction DB are linked to the RPC chambers in CMS Equipment Management Database (EMDB).**

Main Concept:

- ❖ 1:1 relation between object “chamber” in RPC Construction DB & CMS EMDB!
- ✓ Chambers in EMDB are not black boxes, but have their contents
- ❖ Essential for object Traceability
- ✓ Make sense to have both databases stay on the same physical Oracle DB instance: **CMSR**



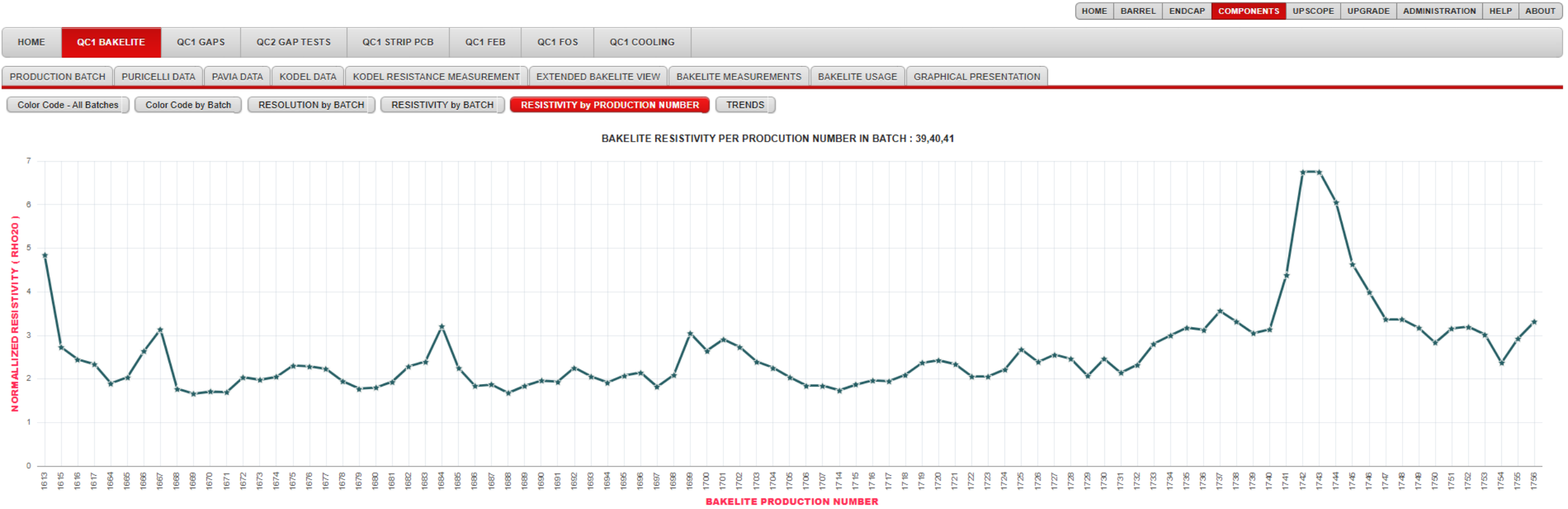
CMS RPC Quality Certification Levels

Quality Certification (QC) Level is being incremented after any chamber component or chamber transport

QC1	**Component qualification**	HPL, Strip PCB, front-end boards (FEB), fiber optic sensors (FOS), cooling components
QC2	**Gas-gap qualification**	Visual, gas leak, resistivity, dark current 1 (DC1), DC2 tests, global QC2 test result, gap passport
QC3	**Chamber assembly**	Component integration, QC3.1 assembly tests, QC3.1 test results, chamber passport
QC4	**Final chamber validation**	Gas leak/cooling, long-term current stability, cosmic/FEB/DC1/connectivity tests
CMS	**Installation**	Construction ID mapped to the physical CMS detector location

QC1 – High Pressure Laminate (HPL) Resistivity Validation

Normalized resistivity values for improved-RPC (iRPC) HPL production batches 39–41



QC1 – Gas-gap passport

HOME | BARREL | ENDCAP | COMPONENTS | UPSCOPE | UPGRADE | ADMINISTRATION | HELP | ABOUT

HOME | QC1 BAKELITE | QC1 GAPS | QC2 GAP TESTS | QC1 STRIP PCB | QC1 FEB | QC1 FOS | QC1 COOLING

BAKELITE SUMMARY VIEW | REGISTER NEW GAP | GAP PASSPORT | GAP OVERVIEW | GAP TYPES | GAS MIXTURES | HW TOOLS

NEW SEARCH

GAP SERIAL NUMBER
CMS-KODEL-RE31-027

GAP TYPE
RE3-1 / Ring 1

Size : Volume/ Active area
Size 1: 1.776/ 1.282

GROUND HPL BAKELITE
2A38E220427311595

AVG RESISTANCE GND HPL
412 Ohm per square

HV HPL BAKELITE
0B38E220427331586

AVG RESISTANCE HV HPL
393 Ohm per square

MANIFACTURED BY
KODEL

PRODUCTION DATE
25/10/2022

Shipment Date (Assembly)
07/11/2022

Reception Date (Assemly)
26/01/2023

Assembly Site
904

GAP TEST RESULT
ACCEPTED

CHAMBER DC TEST RESULT
NOT TESTED

GAP STATUS
OPERATIONAL

VISUAL INSPECTION - Latest Test

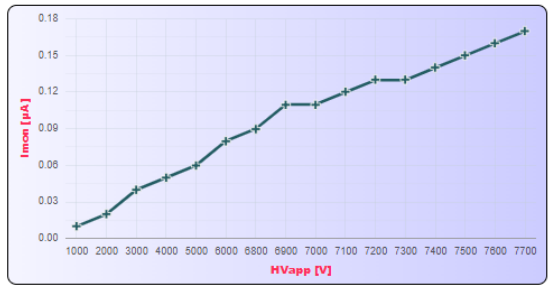
TEST DATE	SITE	TEST RESULT	GRN BAK LABEL	HV BAK LABEL	HV Cable	Gnd Cable	HV block	GND Conn.	HV Graphite Layer	GND Graphite Layer	HV PET Coating	GND PET Coating	Edges & Gas Corner	Gas Inlets & Outlets	BENDING	COMMENTS
26-JAN-23	Ghent	ACCEPTED	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	-

LEAK TEST - Latest Test

TEST DATE	SITE	TEST RESULT	Test Pressure [mbar]	Hardware Tool	Overpressure [mbar]	Bad Spacers	Slope [mbar/ms]	Pressure drop [mbar/10min]	Leak Rate [mbar.l/h]	COMMENTS
08-APR-26	904	ACCEPTED	20	BARC Leak ADC	14.86	0	3.83E-07	2.3E-01	2.45E+00	-

RESISTIVITY - NOT TESTED | Bakelite ResistivityTrend

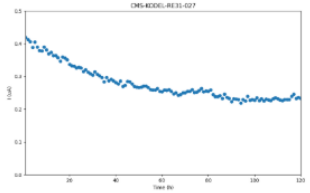
DARK CURRENT TEST I



GAS MIXTURE	iRPC mixture: Freon 95.2% + Isobutan 4.5% + SF6 0.3%
TEST ID	622
SITE	KODEL
DATE	25-NOV-2024
GAS FLASH START	14-NOV-2024 14:18
Ohmic Current	0.060
Dark Current	0.140
Comments	DC1 test after DC2 for CMS-KODEL-RE31-027, RE31-028, RE31-073, RE31-083, RE31-086, RE31-105, RE31-123, RE31-124, RE31-127, RE31-128, RE31-130

TEST RESULT : ACCEPTED | View Imon Trend

DARK CURRENT TEST II

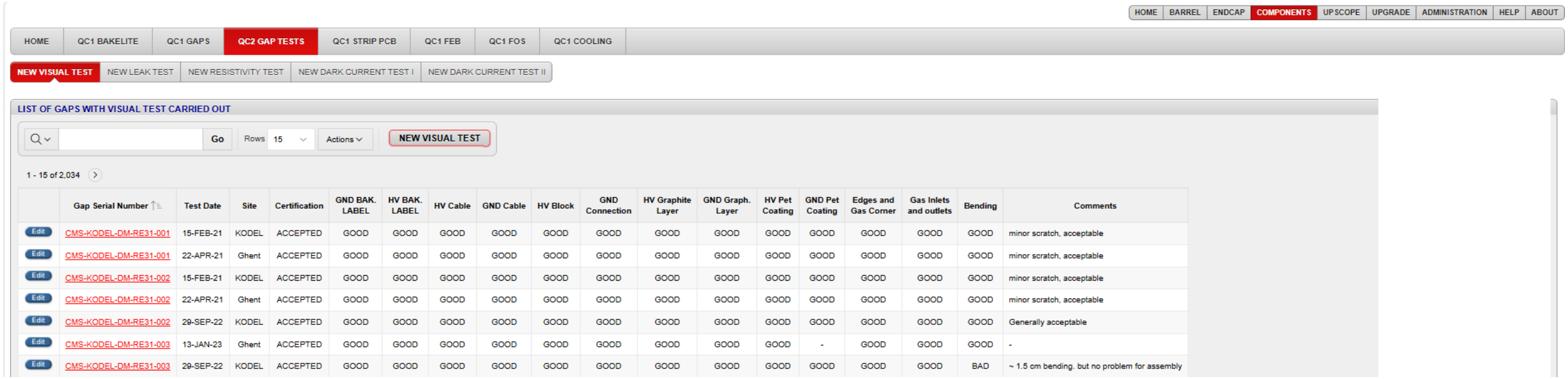


TEST ID	623
SITE	KODEL
GAS MIXTURE	iRPC mixture: Freon 95.2% + Isobutan 4.5% + SF6 0.3%
START DATE	18-NOV-2024 17:00
END DATE	25-NOV-2024 14:00
COMMENTS	DC2 test for CMS-KODEL-RE31-027, RE31-028, RE31-073, RE31-083, RE31-086, RE31-105, RE31-123, RE31-124, RE31-127, RE31-128, RE31-130

TEST RESULT: ACCEPTED

QC2 – Gas-gap quality control sequence

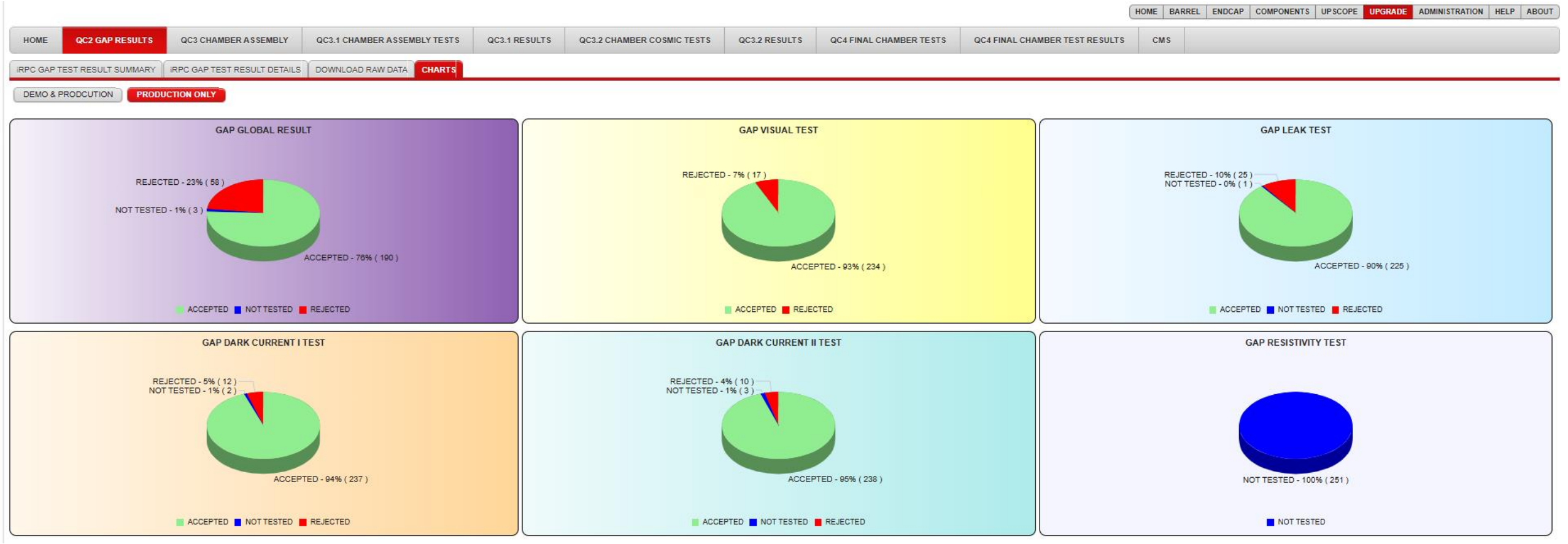
Visual, gas-leak, resistivity, dark-current, and current-stability testing



	Gap Serial Number	Test Date	Site	Certification	GND BAK. LABEL	HV BAK. LABEL	HV Cable	GND Cable	HV Block	GND Connection	HV Graphite Layer	GND Graph. Layer	HV Pet Coating	GND Pet Coating	Edges and Gas Corner	Gas Inlets and outlets	Bending	Comments
Edit	CMS-KODEL-DM-RE31-001	15-FEB-21	KODEL	ACCEPTED	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	minor scratch, acceptable
Edit	CMS-KODEL-DM-RE31-001	22-APR-21	Ghent	ACCEPTED	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	minor scratch, acceptable
Edit	CMS-KODEL-DM-RE31-002	15-FEB-21	KODEL	ACCEPTED	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	minor scratch, acceptable
Edit	CMS-KODEL-DM-RE31-002	22-APR-21	Ghent	ACCEPTED	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	minor scratch, acceptable
Edit	CMS-KODEL-DM-RE31-002	29-SEP-22	KODEL	ACCEPTED	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	Generally acceptable
Edit	CMS-KODEL-DM-RE31-003	13-JAN-23	Ghent	ACCEPTED	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	-	GOOD	GOOD	GOOD	-
Edit	CMS-KODEL-DM-RE31-003	29-SEP-22	KODEL	ACCEPTED	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	BAD	~ 1.5 cm bending. but no problem for assembly

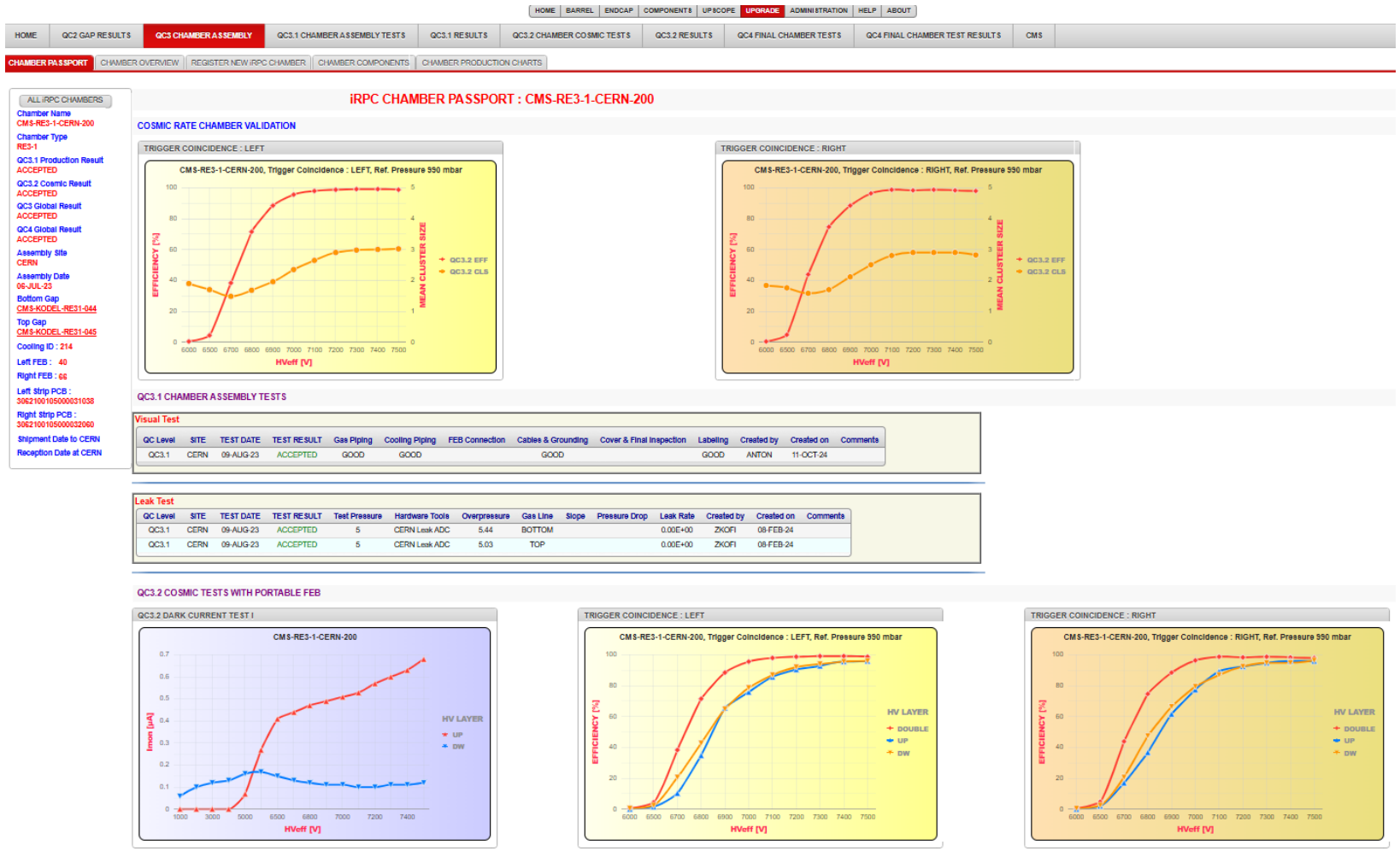
QC2 summary and gas-gap certification status

Graphical summary of individual QC2 tests and global QC2 qualification



QC3 — Chamber assembly and component integration

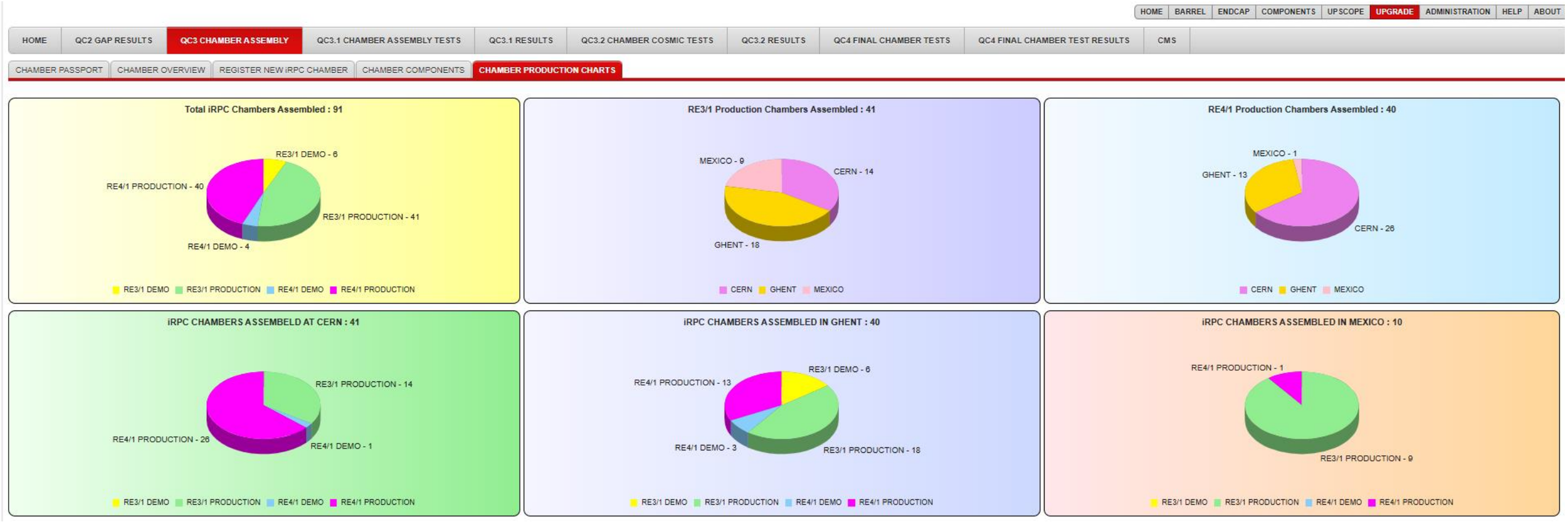
QC3 Chamber Passport



- ✓ Contains basic information about chamber type and name
- ✓ Contains information about chamber components, including links to gas-gap passports
- ✓ Contains the latest QC3.1 chamber assembly test result
- ✓ Contains QC3.2 cosmic results, if available

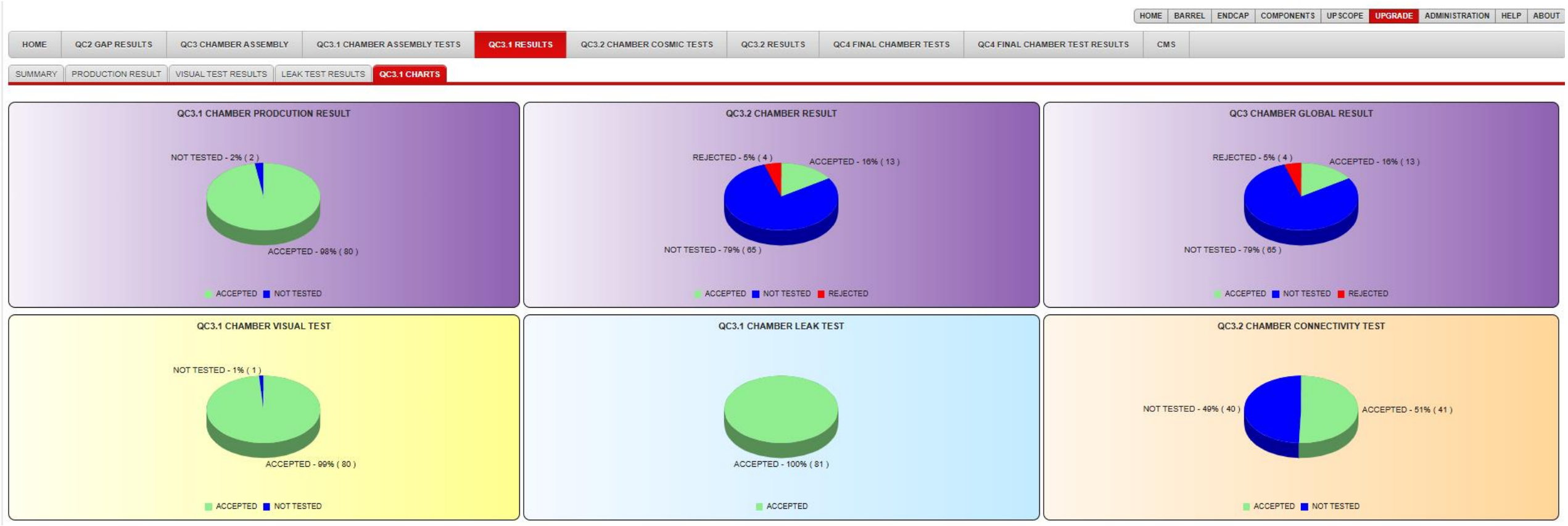
iRPC chamber production by type and assembly site

Produced chamber distribution across participating assembly centers



QC3.1 — Chamber assembly quality-control results

Graphical representation of QC3.1 test outcomes across assembled chambers



QC4 — Final iRPC chamber validation

Final chamber status after QC4.1, QC4.2, and QC4.3 validation stages

HOME | BARREL | ENDCAP | COMPONENTS | UPSCOPE | UPGRADE | ADMINISTRATION | HELP | ABOUT

HOME | QC2 GAP RESULTS | QC3 CHAMBER ASSEMBLY | QC3.1 CHAMBER ASSEMBLY TESTS | QC3.1 RESULTS | QC3.2 CHAMBER COSMIC TESTS | QC3.2 RESULTS | QC4 FINAL CHAMBER TESTS | QC4 FINAL CHAMBER TEST RESULTS | CMS

SUMMARY | QC4 GLOBAL RESULT | QC4.1 COOLING RESULTS | QC4.1 LEAK RESULTS | QC4.2 CURRENT STABILITY RESULTS | QC4.3 DARK CURRENT RESULTS | QC4.3 FEB RESULTS | QC4.3 CONNECTIVITY RESULTS | QC4.3 COSMIC RESULTS | VIEW COSMIC DATA

iRPC CHAMBERS IN CONSTRUCTION PHASE

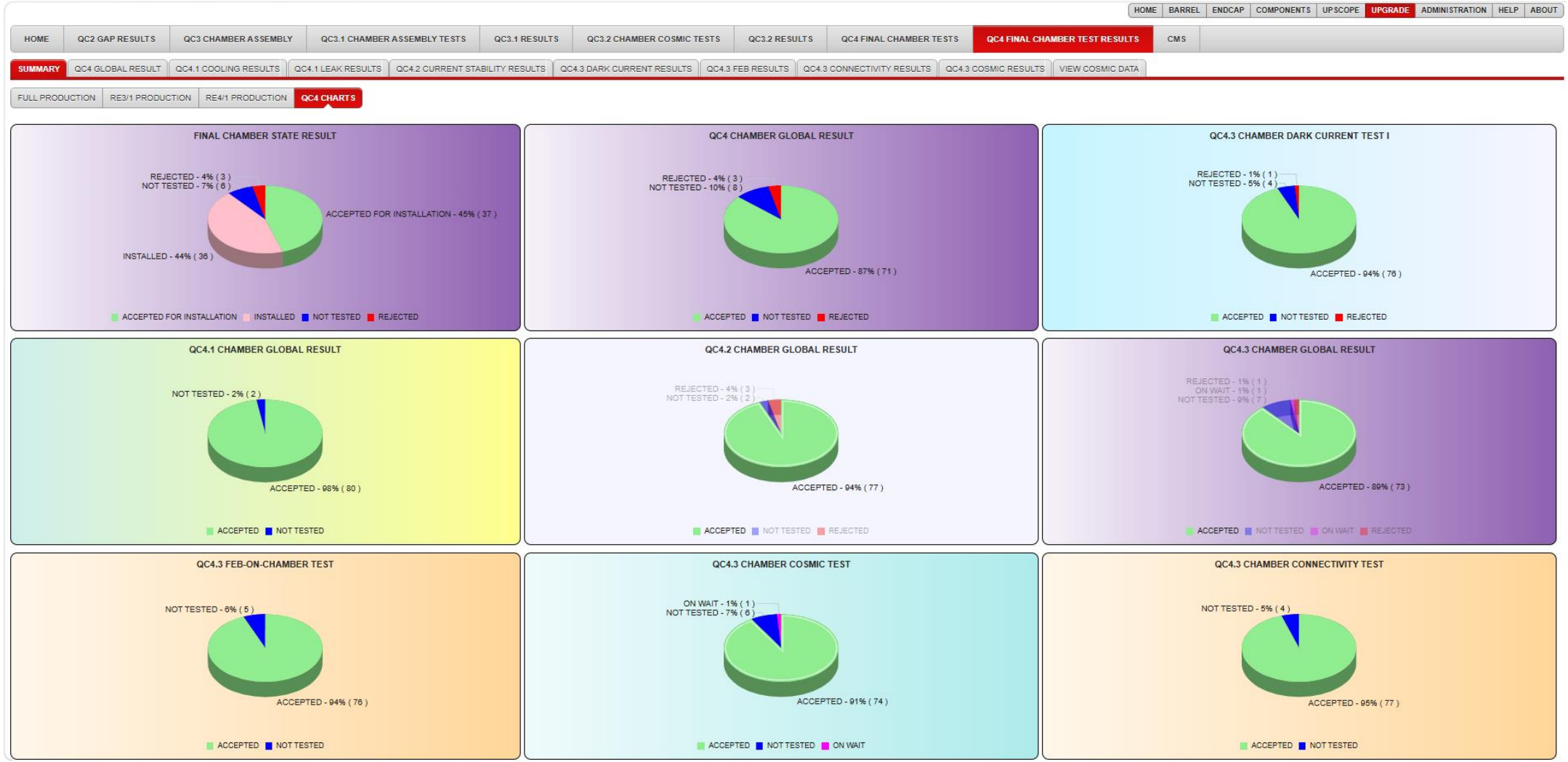
Go | Rows 100 | Actions

Chamber ID > 193

Chamber ID	Chamber Name	Chamber Type	Assembly Date	QC 3.1 Result	QC 3.2 Result	QC3 Global Result	QC 4.1 Result	QC 4.2 Result	QC 4.3 Result	QC4 Global Result	Final Result
194	CMS-RE3-1-Ghent-194	RE3-1	22-MAY-23	ACCEPTED	NOT TESTED	NOT TESTED	ACCEPTED	ACCEPTED	ACCEPTED	ACCEPTED	INSTALLED
195	CMS-RE3-1-Ghent-195	RE3-1	08-JUN-23	ACCEPTED	NOT TESTED	NOT TESTED	ACCEPTED	ACCEPTED	NOT TESTED	NOT TESTED	INSTALLED
196	CMS-RE3-1-Ghent-196	RE3-1	29-JUN-23	ACCEPTED	ACCEPTED	ACCEPTED	ACCEPTED	ACCEPTED	ACCEPTED	ACCEPTED	INSTALLED
197	CMS-RE3-1-CERN-197	RE3-1	29-JUN-23	ACCEPTED	NOT TESTED	NOT TESTED	ACCEPTED	ACCEPTED	ACCEPTED	ACCEPTED	READY FOR INSTALLATION
198	CMS-RE3-1-CERN-198	RE3-1	04-JUL-23	ACCEPTED	NOT TESTED	NOT TESTED	ACCEPTED	ACCEPTED	ACCEPTED	ACCEPTED	READY FOR INSTALLATION
199	CMS-RE3-1-Ghent-199	RE3-1	06-JUL-23	ACCEPTED	NOT TESTED	NOT TESTED	ACCEPTED	ACCEPTED	NOT TESTED	NOT TESTED	INSTALLED
200	CMS-RE3-1-CERN-200	RE3-1	06-JUL-23	ACCEPTED	ACCEPTED	ACCEPTED	ACCEPTED	ACCEPTED	ACCEPTED	ACCEPTED	INSTALLED
201	CMS-RE3-1-CERN-201	RE3-1	11-JUL-23	ACCEPTED	NOT TESTED	NOT TESTED	ACCEPTED	ACCEPTED	NOT TESTED	NOT TESTED	NOT TESTED
202	CMS-RE3-1-CERN-202	RE3-1	14-JUL-23	ACCEPTED	NOT TESTED	NOT TESTED	ACCEPTED	ACCEPTED	NOT TESTED	NOT TESTED	NOT TESTED
203	CMS-RE3-1-Ghent-203	RE3-1	27-JUL-23	ACCEPTED	NOT TESTED	NOT TESTED	ACCEPTED	ACCEPTED	ACCEPTED	ACCEPTED	INSTALLED
204	CMS-RE4-1-CERN-204	RE4-1	03-JUL-23	ACCEPTED	NOT TESTED	NOT TESTED	ACCEPTED	ACCEPTED	ON WAIT	NOT TESTED	NOT TESTED
205	CMS-RE3-1-Ghent-205	RE3-1	27-JUL-23	ACCEPTED	NOT TESTED	NOT TESTED	ACCEPTED	ACCEPTED	ACCEPTED	ACCEPTED	INSTALLED
206	CMS-RE4-1-CERN-206	RE4-1	04-AUG-23	ACCEPTED	NOT TESTED	NOT TESTED	ACCEPTED	ACCEPTED	ACCEPTED	ACCEPTED	READY FOR INSTALLATION

iRPC chamber QC and certification summary

Global table combining QC-level test results and final chamber status



QC4 — Chamber passport

QC4 FINAL CHAMBER TESTS

Cooling Test

QC Level	SITE	TEST DATE	TEST RESULT	Fluid	Overpressure	Delta T	Delta P	Leak Rate [mbar.l/s]	Pressure Drop	Created by	Created on	Comments
QC4.1	CERN	15-AUG-24	ACCEPTED	Ar	19.95	964	130	.000101141078838174273858921161825726141079	8.09	ANTON	25-DEC-24	old 14

Leak Test

Not Tested !

FEB-on-chamber Test

QC Level	Chamber Name	FEB Test ID	FEB ID	Chamber ID	Feb Chirality	Test ID	Test Location	Measure Date	Result	FEB Mounting	2V Imon Before Init	4V Imon Before Init	2V Imon After Init	4V Imon After Init	Pedestal Calibration	Loaded by	Loaded on
QC4.3	CMS-RE3-1-CERN-200	1	40	200	LEFT	44	1	07-OCT-24	ACCEPTED	1	.7	.38	6.25	2.3	1	ANTON	20-DEC-24
QC4.3	CMS-RE3-1-CERN-200	2	41	200	RIGHT	44	1	07-OCT-24	ACCEPTED	1	.7	.38	6.25	2.3	1	ANTON	20-DEC-24

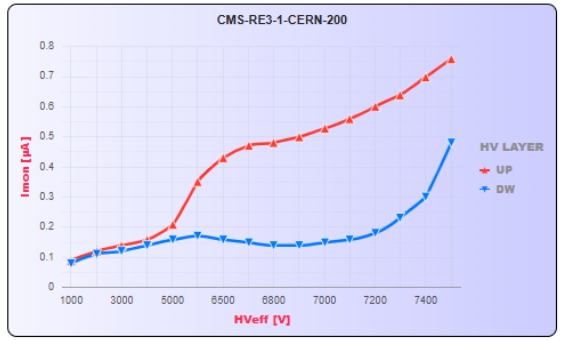
Connectivity Test

QC Level	SITE	TEST DATE	TEST RESULT	Created By	Created On	COMMENTS
QC3.2	CERN	04-APR-24	ACCEPTED	CAAGUILA	09-AUG-24	-
QC4.3	CERN	07-OCT-24	ACCEPTED	ANTON	12-NOV-24	-

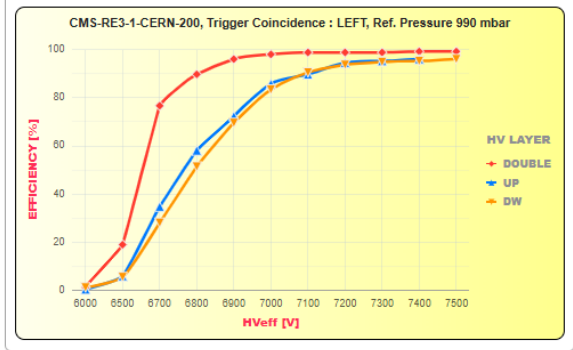
- ✓ Contains the latest QC4 chamber test results
  - QC4.1 – cooling and gas leak test
  - QC4.2 – current stability test (DC2)
  - QC4.3 – dark current (DC1), LV FEB, Cosmic and Connectivity tests
- ✓ Contains QC4.3 cosmic results - dark current, efficiency, cluster size , noise

QC4.3 COSMIC TESTS WITH FINAL INDIVIDUAL FEBS

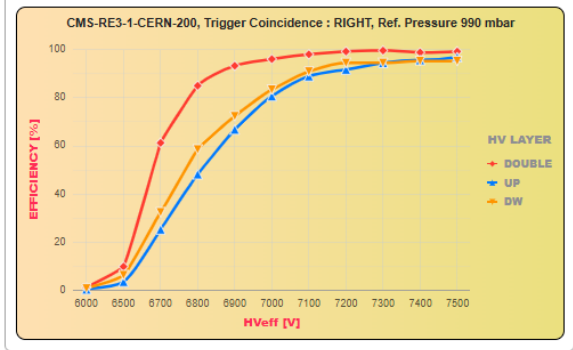
QC4.3 DARK CURRENT TEST I



QC4.3 TRIGGER COINCIDENCE : LEFT



QC4.3 TRIGGER COINCIDENCE : RIGHT



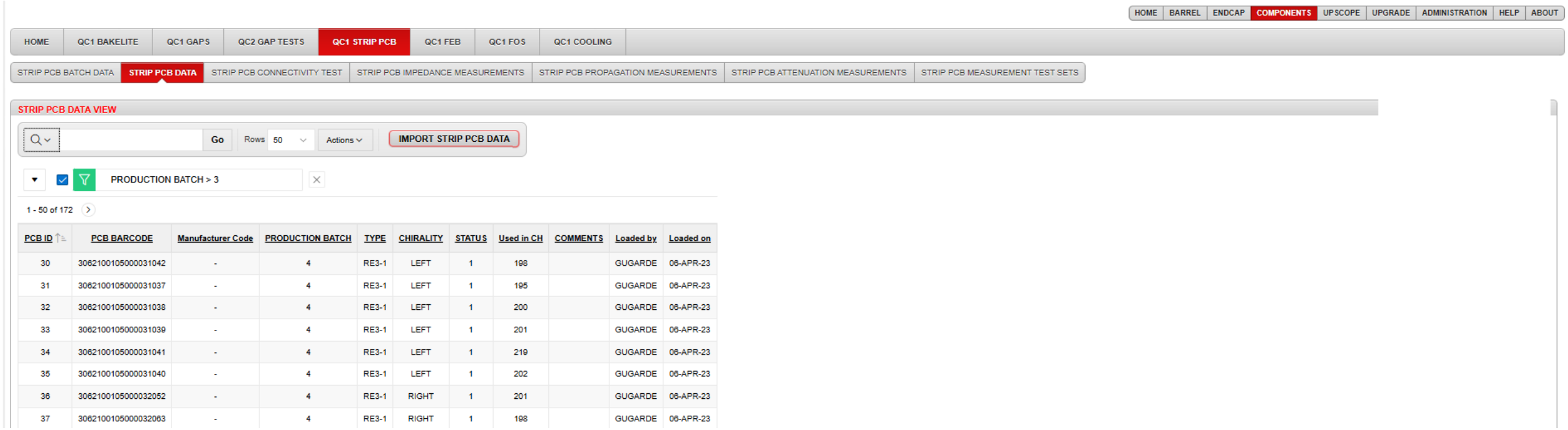
Conclusions

- The RPC Construction Database remains the **reference repository for RPC chamber construction, assembly, testing and quality-control history**.
- It provides complete **traceability at chamber level**, preserving the link between each detector element and its production data.
- A well-structured iRPC construction database will provide the long-term traceability needed for **installation, commissioning, maintenance and future interventions**.

BACKUP SLIDES

QC1 – iRPC Strip PCB production data

Component-level record for the readout plane of the iRPC detector



PCB ID	PCB BARCODE	Manufacturer Code	PRODUCTION BATCH	TYPE	CHIRALITY	STATUS	Used in CH	COMMENTS	Loaded by	Loaded on
30	3062100105000031042	-	4	RE3-1	LEFT	1	198		GUGARDE	06-APR-23
31	3062100105000031037	-	4	RE3-1	LEFT	1	195		GUGARDE	06-APR-23
32	3062100105000031038	-	4	RE3-1	LEFT	1	200		GUGARDE	06-APR-23
33	3062100105000031039	-	4	RE3-1	LEFT	1	201		GUGARDE	06-APR-23
34	3062100105000031041	-	4	RE3-1	LEFT	1	219		GUGARDE	06-APR-23
35	3062100105000031040	-	4	RE3-1	LEFT	1	202		GUGARDE	06-APR-23
36	3062100105000032052	-	4	RE3-1	RIGHT	1	201		GUGARDE	06-APR-23
37	3062100105000032063	-	4	RE3-1	RIGHT	1	198		GUGARDE	06-APR-23

QC1 – iRPC Front-End Board (FEB) production data

Production and integration information for chamber front-end electronics

HOME | BARREL | ENDCAP | COMPONENTS | UPSCOPE | UPGRADE | ADMINISTRATION | HELP | ABOUT

HOME | QC1 BAKELITE | QC1 GAPS | QC2 GAP TESTS | QC1 STRIP PCB | QC1 FEB | QC1 FOS | QC1 COOLING

IRPCROC | FEB DELIVERY BATCH | FEB MAP TABLE | FEB CHANNEL MAPPING | FEB DATA | FEB VALIDATION | FEB DOCUMENT LIBRARY

Go | Rows 50 | Actions | IMPORT FEB DATA

FEB Version = 'V2.3'

1 - 50 of 171

FEB ID	Barcode	Manufacturer Code	Batch ID	Map ID	FEB Version	FEB Location	Golden FW	Silver FW	Firmware Update	Petiroc Version	FPGA Type	FEB Status	Used In Chamber	iRPCROC0B	iRPCROC0T	iPRCROC1B	iRPCROC1T	iRPCROC2B	iRPCROC2T	Shipment To Assembly Site	Reception At Assembly Site	Loaded
20	3062100101000023025	-	4	3	V2.3	CMS	V4.5	-	-	2C	Cyclone-V	OPERATIONAL	199	-	-	-	-	-	-	-	-	ANTC
21	3062100101000023026	-	4	3	V2.3	904	V4.5	-	-	2C	Cyclone-V	OPERATIONAL	-	-	-	-	-	-	-	-	-	MGOU2
22	3062100101000023027	-	4	3	V2.3	CMS	V4.5	-	-	2C	Cyclone-V	OPERATIONAL	199	-	-	-	-	-	-	-	-	ANTC
23	3062100101000023028	-	4	3	V2.3	CMS	V4.5	-	-	2C	Cyclone-V	OPERATIONAL	195	-	-	-	-	-	-	-	-	ANTC
24	3062100101000023029	-	4	3	V2.3	CMS	V4.5	-	-	2C	Cyclone-V	OPERATIONAL	195	-	-	-	-	-	-	04-MAR-25	04-MAR-25	MGOU2
25	3062100101000023030	-	5	3	V2.3	IP2I-Lyon	V4.6	v4.6	26-JAN-24	2C	Cyclone-V	OPERATIONAL	-	-	-	-	-	-	-	-	-	MGOU2
26	3062100101000023031	-	5	3	V2.3	CMS	V4.6	-	-	2C	Cyclone-V	OPERATIONAL	255	-	-	-	-	-	-	26-JAN-24	26-JAN-24	MGOU2
27	3062100101000023032	-	5	3	V2.3	904	V4.6	-	-	2C	Cyclone-V	OPERATIONAL	218	-	-	-	-	-	-	26-JAN-24	-	KMASL
28	3062100101000023033	-	5	3	V2.3	IP2I-Lyon	V4.6	v4.6	26-JAN-24	2C	Cyclone-V	DEFECTIVE	-	-	-	-	-	-	-	-	-	MGOU2
29	3062100101000023034	-	5	3	V2.3	GIF++	V4.6	-	-	2C	Cyclone-V	OPERATIONAL	202	-	-	-	-	-	-	-	-	ANTC
30	3062100101000023035	2.4	6	3	V2.3	904	V4.8	V4.8	15-OCT-24	2C	Cyclone-V	REPAIRED	220	2535	2288	2551	2273	2552	2263	23-OCT-24	23-OCT-24	MASH

CMS installation and chamber location traceability

Mapping the construction chamber identifier to the installed CMS detector location

HOME | BARREL | ENDCAP | COMPONENTS | UPSCOPE | UPGRADE | ADMINISTRATION | HELP | ABOUT

HOME | QC2 GAP RESULTS | QC3 CHAMBER ASSEMBLY | QC3.1 CHAMBER ASSEMBLY TESTS | QC3.1 RESULTS | QC3.2 CHAMBER COSMIC TESTS | QC3.2 RESULTS | QC4 FINAL CHAMBER TESTS | QC4 FINAL CHAMBER TEST RESULTS | CMS

INSTALLATION

IRPC CHAMBERS INSTALLED IN CMS DETECTOR

Go | Rows 50 | Actions | INSTALL NEW CHAMBER

#	CMS Location	Disk	Sector	Chamber ID	Barcode	Intervention Date	Status	User Name	Last Mod	Comments
1	RE-3/1/1	-3	1	225	3062180500030100225	16-JAN-25	INSTALLED	ANTON	19-APR-25	-
2	RE-3/1/2	-3	2	222	3062180500030100222	16-JAN-25	INSTALLED	ANTON	19-APR-25	-
3	RE-3/1/3	-3	3	196	3062180500030100196	17-JAN-25	INSTALLED	ANTON	19-APR-25	-
4	RE-3/1/4	-3	4	251	3062180500030100251	17-JAN-25	INSTALLED	ANTON	19-APR-25	-
5	RE-3/1/5	-3	5	213	3062180500030100213	17-JAN-25	INSTALLED	ANTON	19-APR-25	-
6	RE-3/1/6	-3	6	203	3062180500030100203	17-JAN-25	INSTALLED	ANTON	19-APR-25	-
7	RE-3/1/7	-3	7	200	3062180500030100200	17-JAN-25	INSTALLED	ANTON	19-APR-25	-
8	RE-3/1/8	-3	8	205	3062180500030100205	16-JAN-25	INSTALLED	ANTON	19-APR-25	-
9	RE-3/1/9	-3	9	217	3062180500030100217	16-JAN-25	INSTALLED	ANTON	19-APR-25	-
10	RE-3/1/10	-3	10	209	3062180500030100209	16-JAN-25	INSTALLED	ANTON	19-APR-25	-