CMS GEM Workshop – Commissioning and Operations

QC7 and QC8 summary

Balashangar Kailasapathy, Nimantha Perera
Giovanni Mocellin, Johny Jaramillo, Federica Simone

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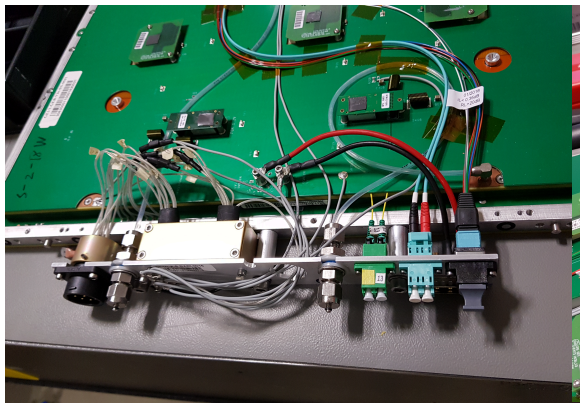
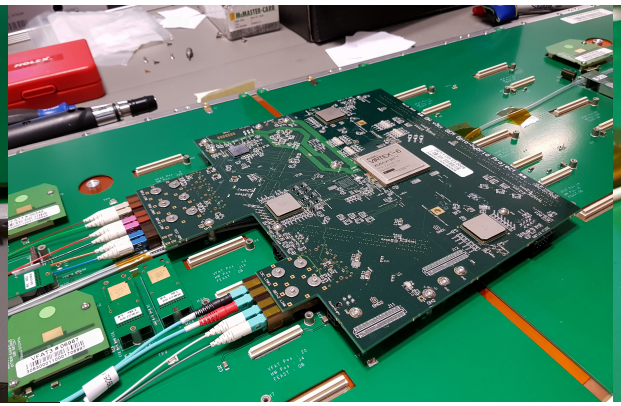
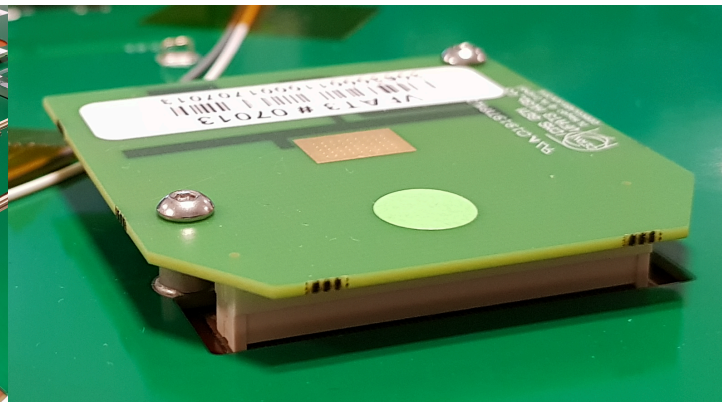
Outline

- QC7 – Frontend electronics installation and connectivity test
  - Typical output and time needed
  - Systematic problems and solution implementation
  - Frequent issues
  - Status
- QC8 – Final validation of SC at cosmic test stand
  - Typical output and time needed
  - Common issues
  - Status
- Validation results in the database

Frontend electronics installation

- Chambers equipped with electronics (67/144 => 93% of the first endcap)
- Mounting of GEBs and routing of cables, fibers and gas pipes
- Installation of FEASTs (voltages check) + Opto-Hybrids + VFATs (all screwed to GEBs)
- Connection of all GND cables to the star-point

QC7 electronics connectivity test

Steps:

1. Establish connectivity and frontend calibration (GBT phases, FPGA programming, DAC scans)
2. Scurve scan:
   - gives ENC and mean at default threshold (CFG_ARM_DAC=100)
   - gives list of hot and dead channel to be masked
3. Sbit rate vs threshold scan:
   - check integrity of Sbit lines
   - it gives threshold values to be applied
4. new Scurve scan → ENC and mean at thresholds corresponding to 100Hz noise
5. noise rate vs threshold scan → check analog path per channel

Repeated 2 times:

1. initial test
2. w/ cooling system and aluminium chimney

Time needed:

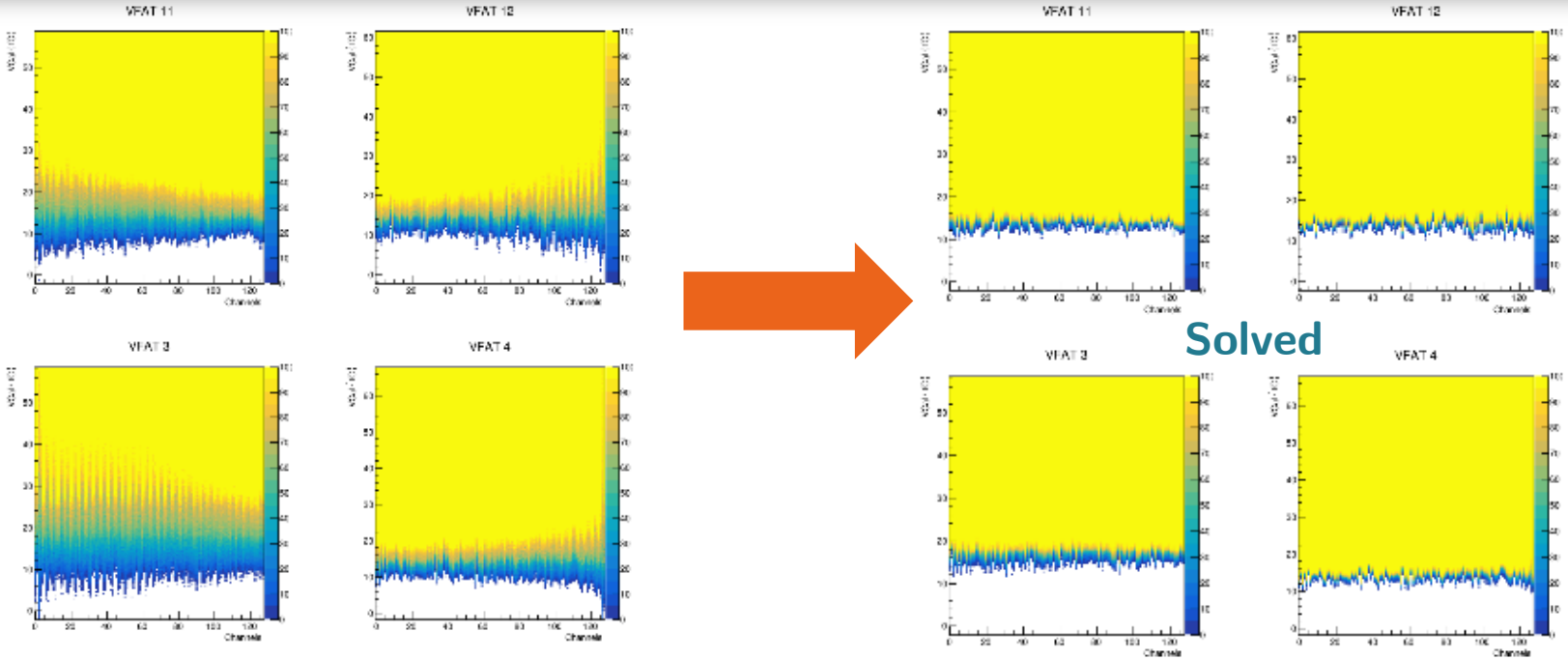
- ❖ 1/1.5 hours for the first test without cooling plate
- ❖ 1/1.5 hours for cooling plate and al. chimney installation
- ❖ 1/1.5 hours to retest with cooling and chimney

Ideal case:
from 3 to 4.5 hours

QC7 systematic problems and solution implementation (1.1)

Ground-loops between chamber and cooling plate:

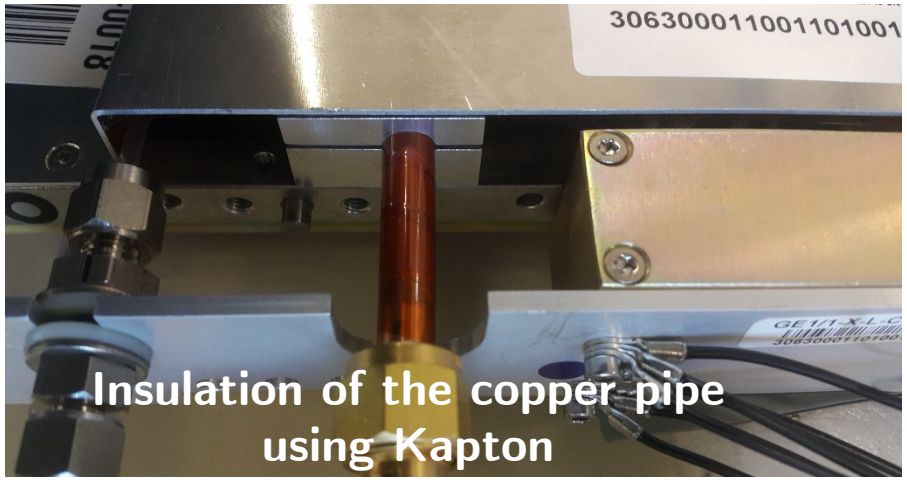
Scurves depicted high noise level on the electronics due to current loops formed on the cooling plate.



QC7 systematic problems and solution implementation (1.2)

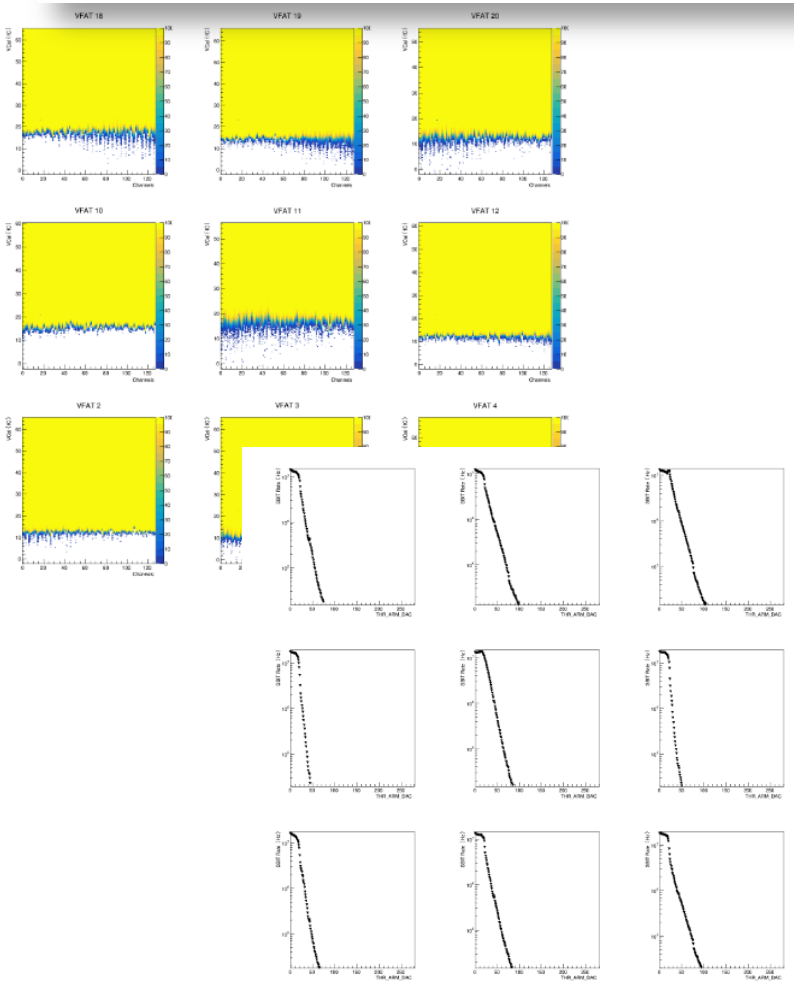
Ground-loops between chamber and cooling plate: Solution

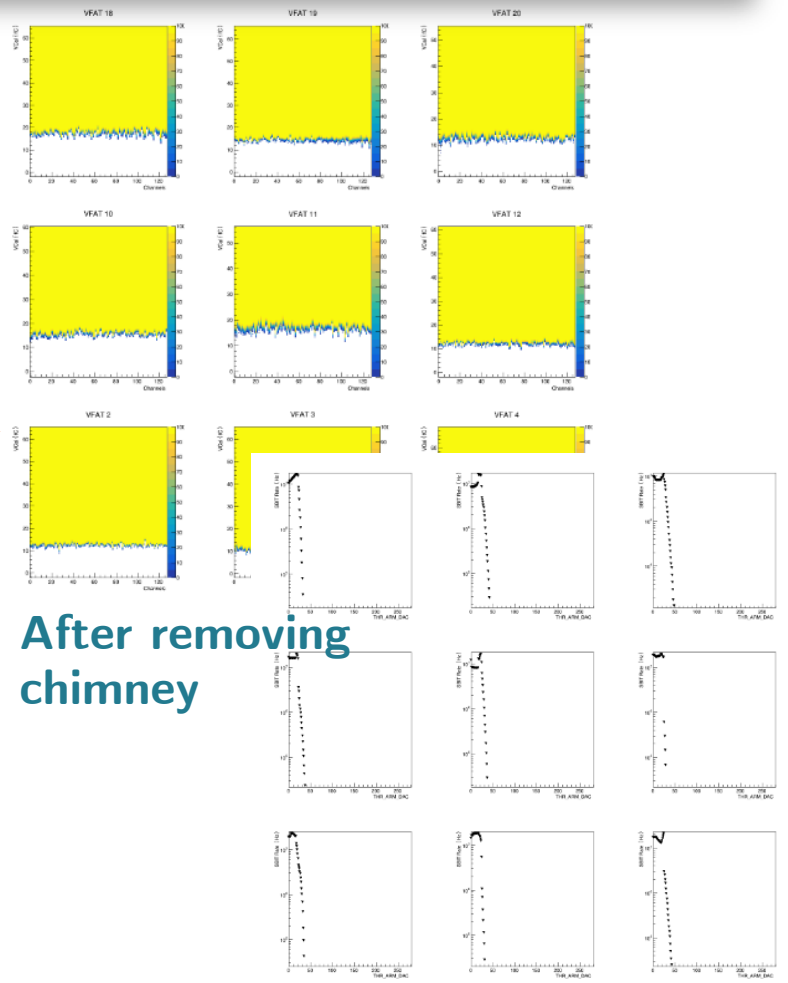
insulation of the cooling plate with a single grounding connection to the star-point



QC7 systematic problems and solution implementation (2.1)

Ground-loops between chamber and aluminium chimney:



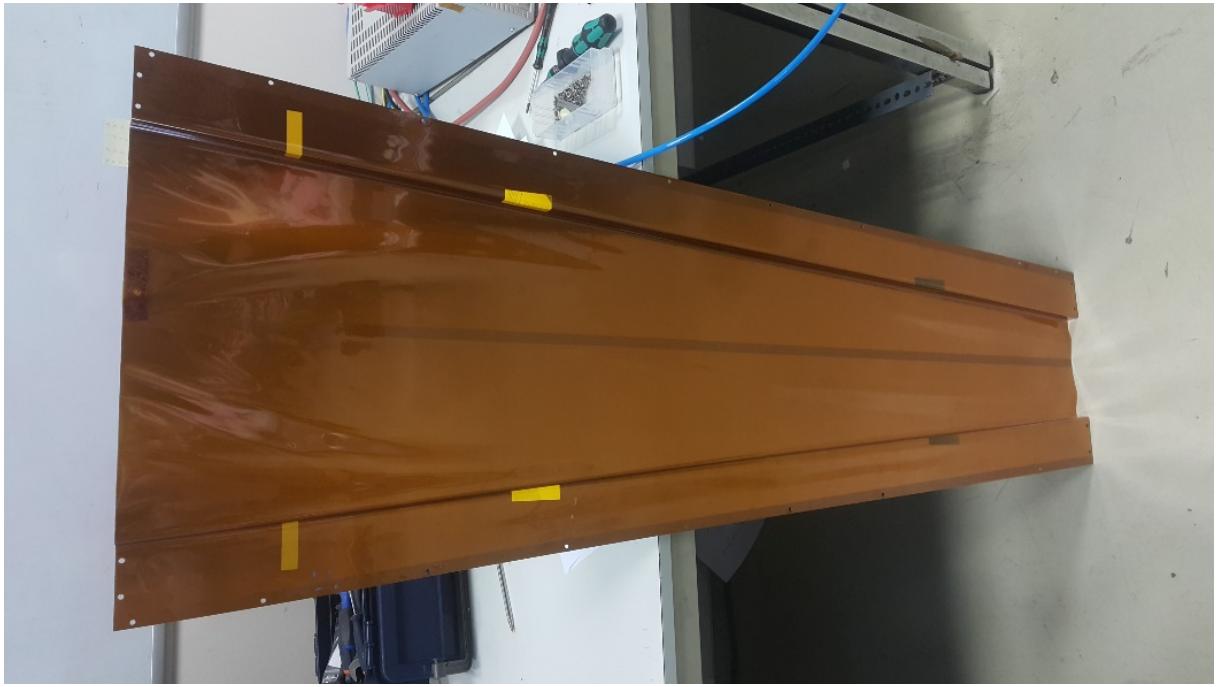


After removing chimney

QC7 systematic problems and solution implementation (2.2)

Ground-loops between chamber and aluminium chimney: solution

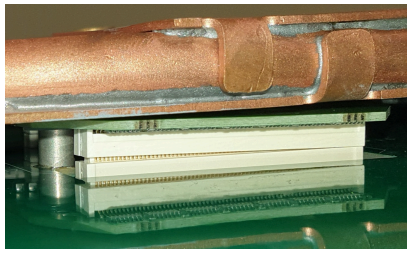
Isolation of Chimney using Kapton foil

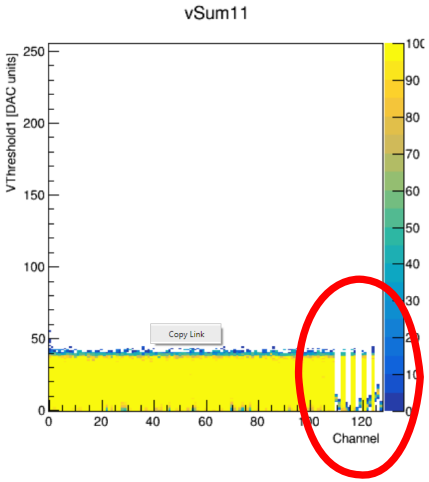


QC7 - Frequent issues

❖ Improper connection of VFATs in the readout board

✓ Spotted by threshold scan



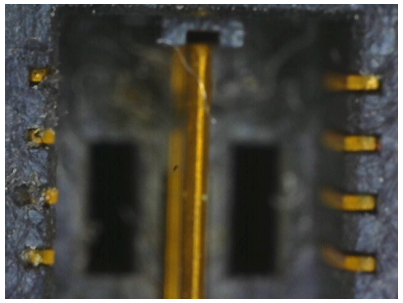


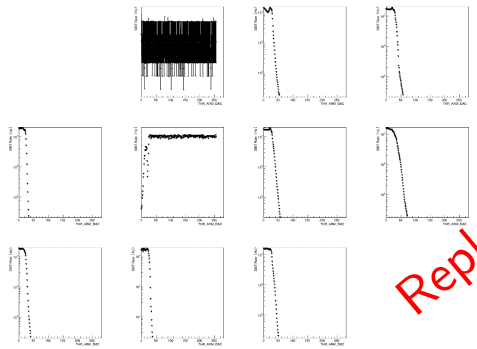
❖ Broken Sbit links:

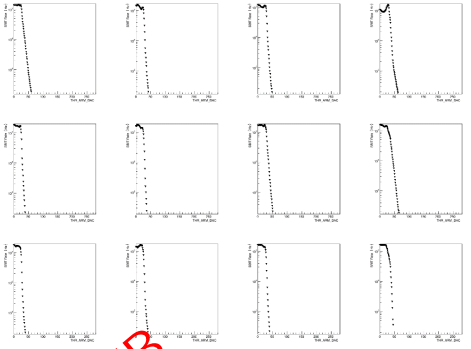
Caused by: Dirty VFAT slots

Damaged traces in the GEB

Bad OH-GEB connection (SAMTEC)







QC7 - Frequent issues

❖ Faulty FEASTs
- non-working, unstable
- inducing noise
  - bad shielding around the inductors, noise observable only after chimney installation (completing the Faraday cage)

❖ Mechanical stress due to cooling plate

Most of these issues require component replacement/cleaning

- All steps from 2 to 5 to be repeated
- Time taken for validation +1h for every debugging attempt

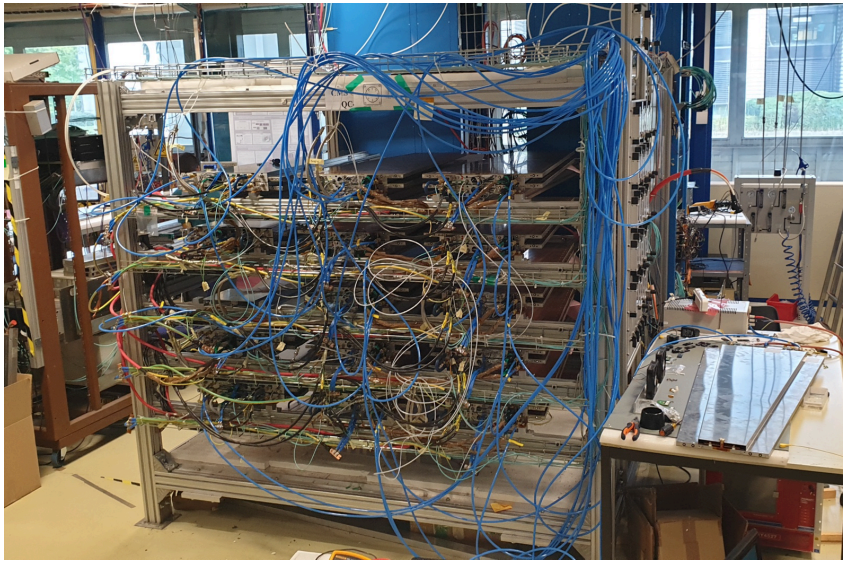
QC7 - Status

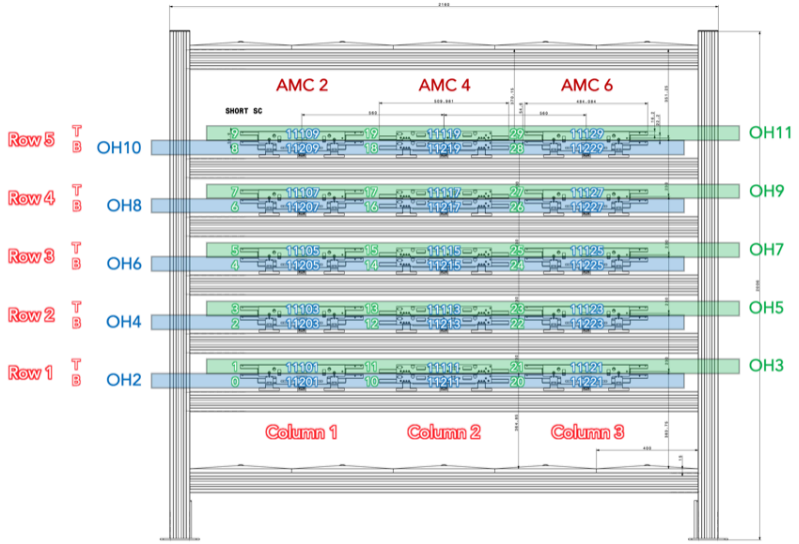
- Tested 67/144 => 93% of the first endcap
- 3 GEB rejected, 6 OH sent back for inspection
- Validation rate: ~4 chambers per week, operations slowed down by several issues

QC8 – final validation at cosmic stand

Steps:

1. Connection of SC to all services (gas, cooling, LV, HV, DAQ)
2. First scurve scan to check connectivity and check hot/dead channels
3. Sbit rate vs threshold scan to measure thresholds at given noise rate
4. Frontend configuration
5. Powering the chambers at HV corresponding to given average effective gas gain
6. Data taking with cosmics (approx. 12 hours)
7. Repeat 5 and 6 to complete HV scan



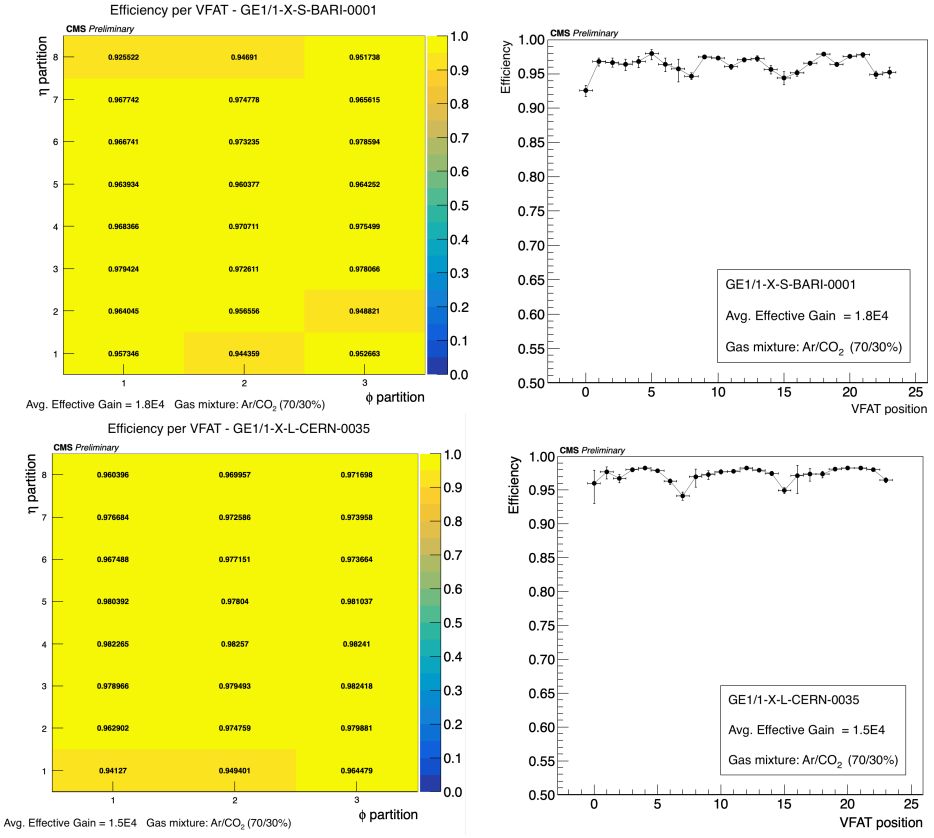


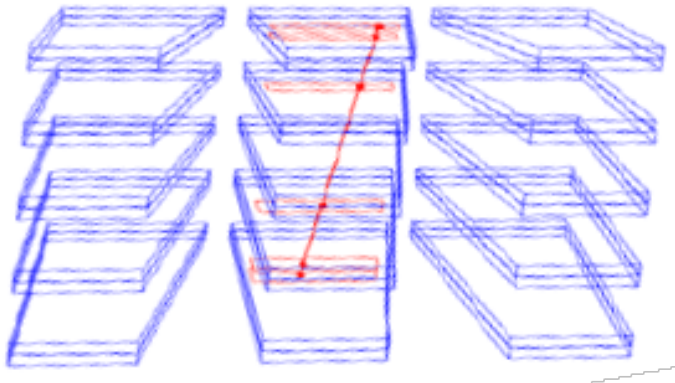
QC8 – typical output and time needed

Time needed:

- 1 day for installation and initial configuration
- 5 X 12h-long runs to complete HV scan

Typical case:
1 week to validate a full bunch of chambers
(average rate 5 SC/week)



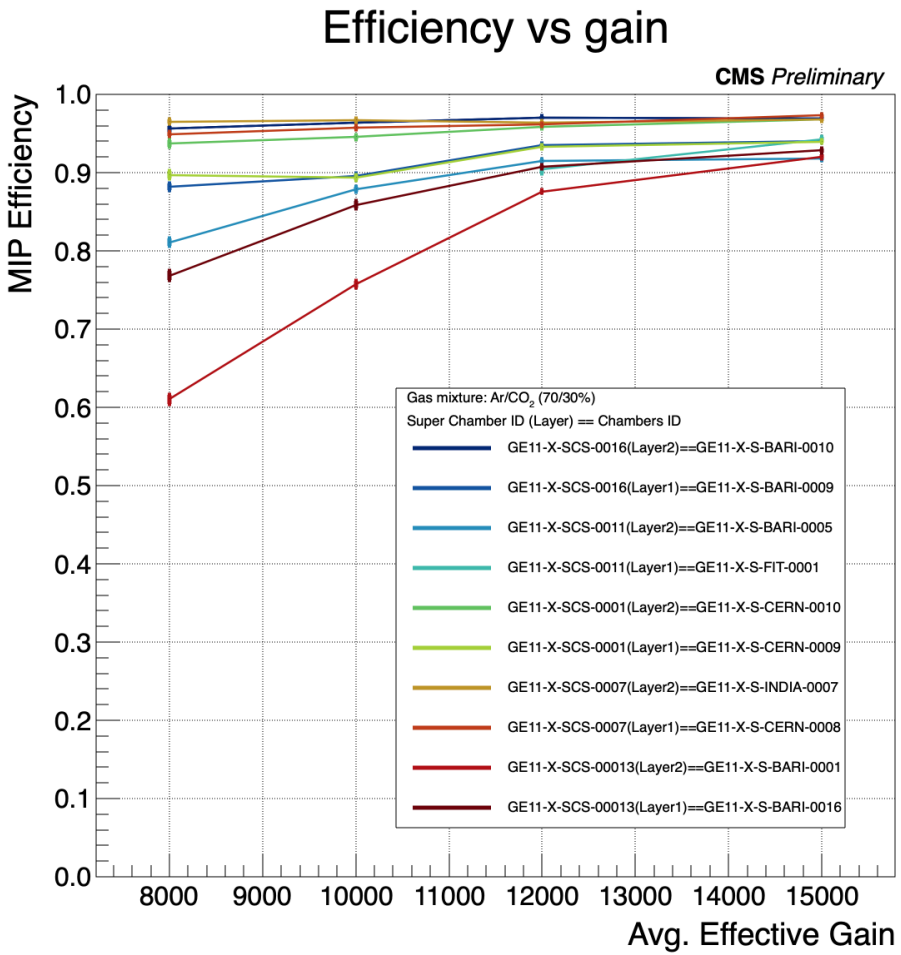


- Gas mixture: Ar/CO2 (70/30%)
- Cosmic muon tracks giving hits in columns of 10 "stacked" chambers
- Track-based analysis => Muon track reconstruction

QC8 – typical output

Final validation:

- Efficiency of both chambers in the SC > 90%



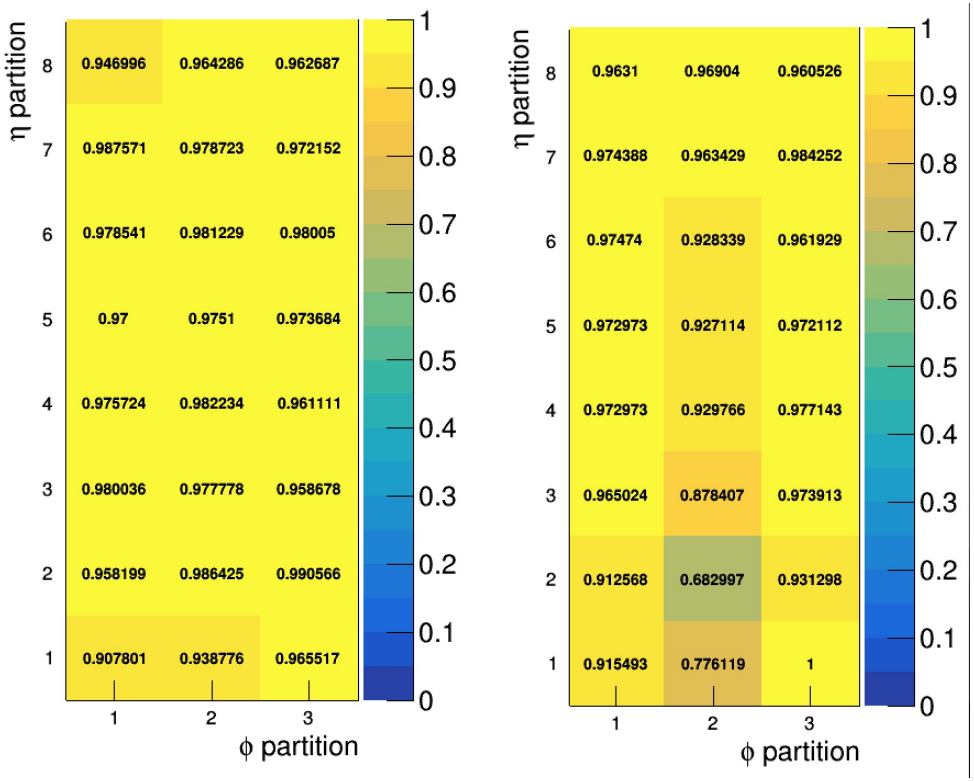
QC8 – Issues

High noise related to services in the stand

- ENC go from ~0.5 fC at QC7 to ~4 / 5 fC at QC8

Gain non-uniformity in long chambers

- Lower efficiency in some readout sectors related to QC5 uniformity map

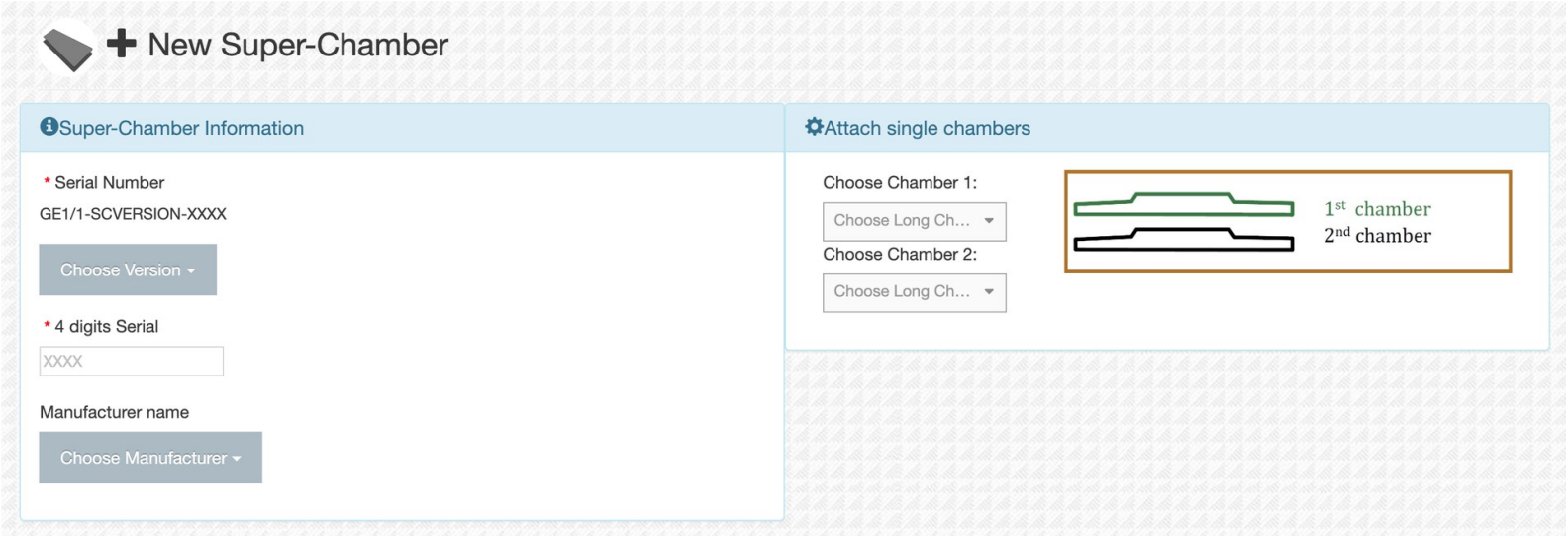


QC8 – Status

- QC8 has characterized and validated (14 Short + 7 Long) / 72 = 58% of the super-chambers of the negative endcap
- The first 2 SC's installed in P5 have already given very encouraging results
- Following the installation schedule of 2 SCs per day
- Including VFAT channel trimming:
  - Help in reducing the thresholds to be applied
  - Have a uniform response of the VFAT channels
- Good exercise to fully test the DAQ software
- Good exercise to spot any issue related to services

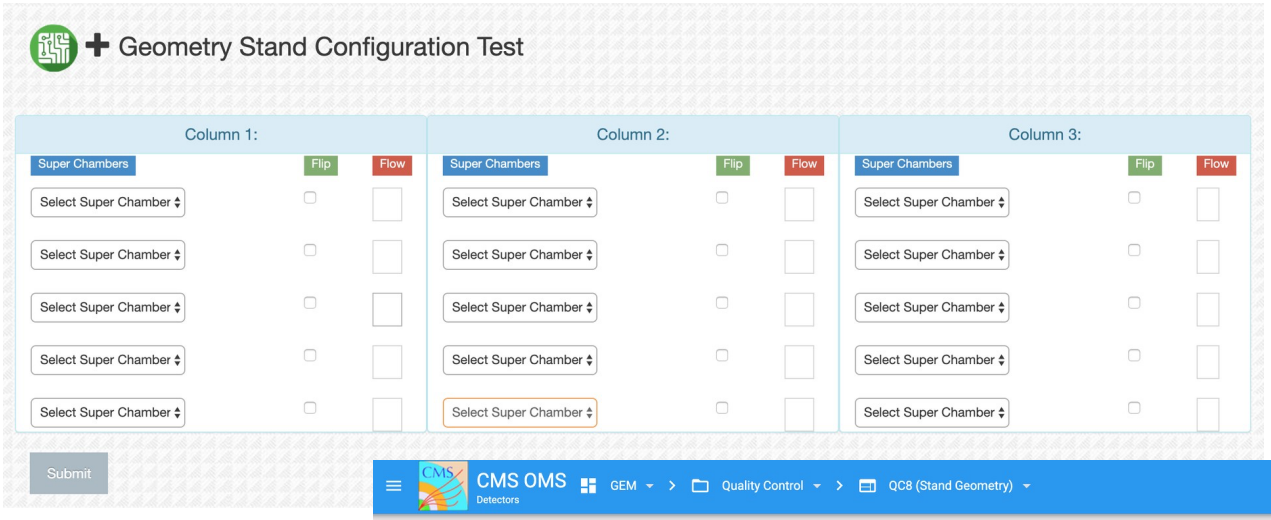
Validation results and database

Assembled SC in DB



Validation results and database

During validation: QC8 stand configuration



CMS OMS Detectors > GEM > Quality Control > QC8 (Stand Geometry) — 18:13 UTC / 20:13 Local

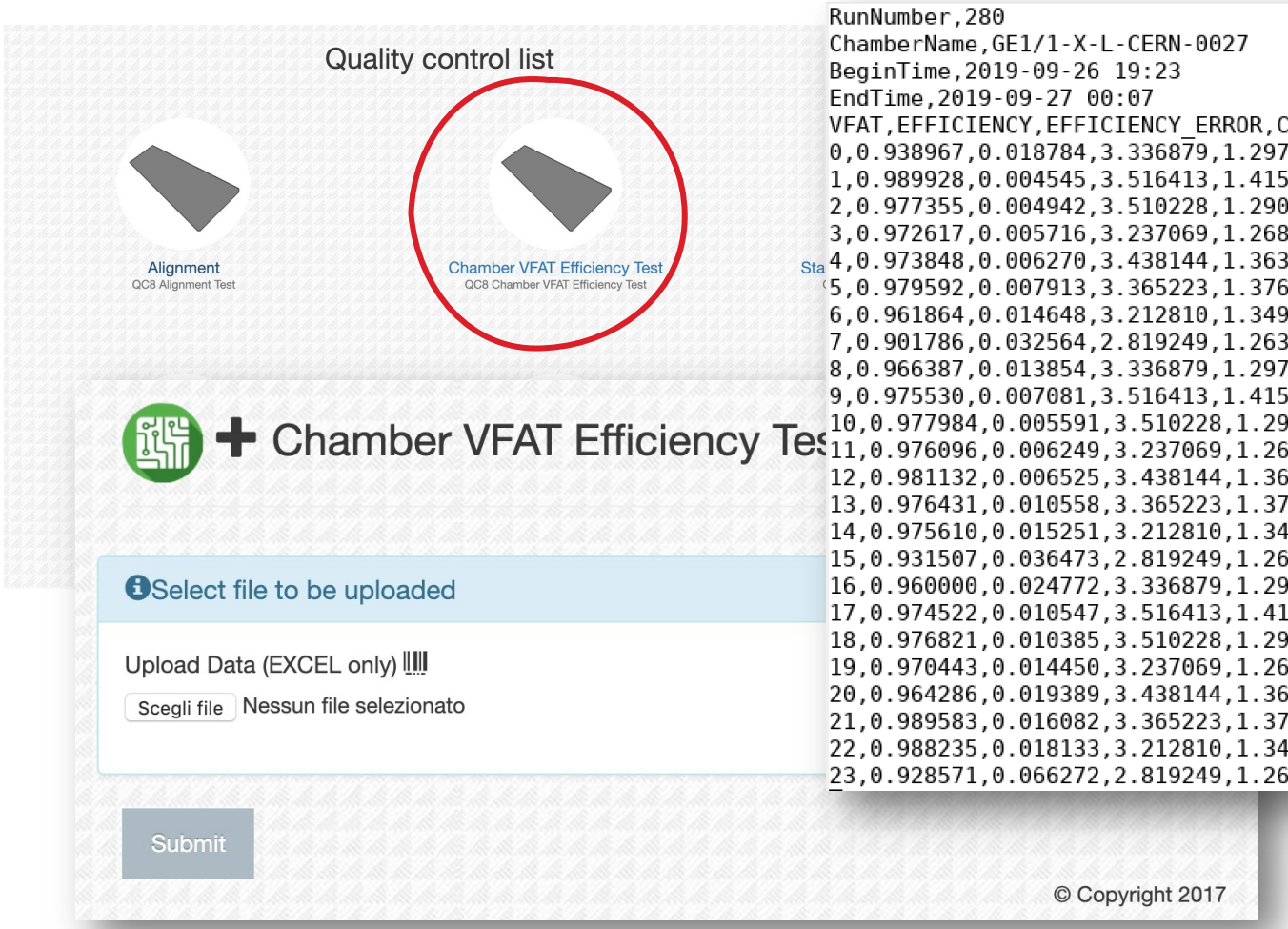
GEM QC8 Stand Geometry

CH_SERIAL_NUMBER	GEM_NUM	POSITION	CH_TYPE	FLIP	AMC	OH	FLOW_METER	TIME
GE1/1-X-L-CERN-0039	11129	5/3/T	L	0	6	11	6	2019-09-27 11:51:38
GE1/1-X-L-CERN-0013	11221	1/3/B	L	0	6	2	6	2019-09-27 11:51:38
GE1/1-X-L-CERN-0008	11121	1/3/T	L	0	6	3	6	2019-09-27 11:51:38
GE1/1-X-L-GHENT-0024	11223	2/3/B	L	0	6	4	6	2019-09-27 11:51:38
GE1/1-X-L-GHENT-0018	11123	2/3/T	L	0	6	5	6	2019-09-27 11:51:38
GE1/1-X-L-CERN-0015	11225	3/3/B	L	0	6	6	6	2019-09-27 11:51:38
GE1/1-X-L-GHENT-0020	11125	3/3/T	L	0	6	7	6	2019-09-27 11:51:38
GE1/1-X-L-CERN-0006	11227	4/3/B	L	0	6	8	6	2019-09-27 11:51:38
GE1/1-X-L-CERN-0010	11127	4/3/T	L	0	6	9	6	2019-09-27 11:51:38
GE1/1-X-L-CERN-0011	11229	5/3/B	L	0	6	10	6	2019-09-27 11:51:38

Rows per page: 10 Page 1 of 107

Validation results and database

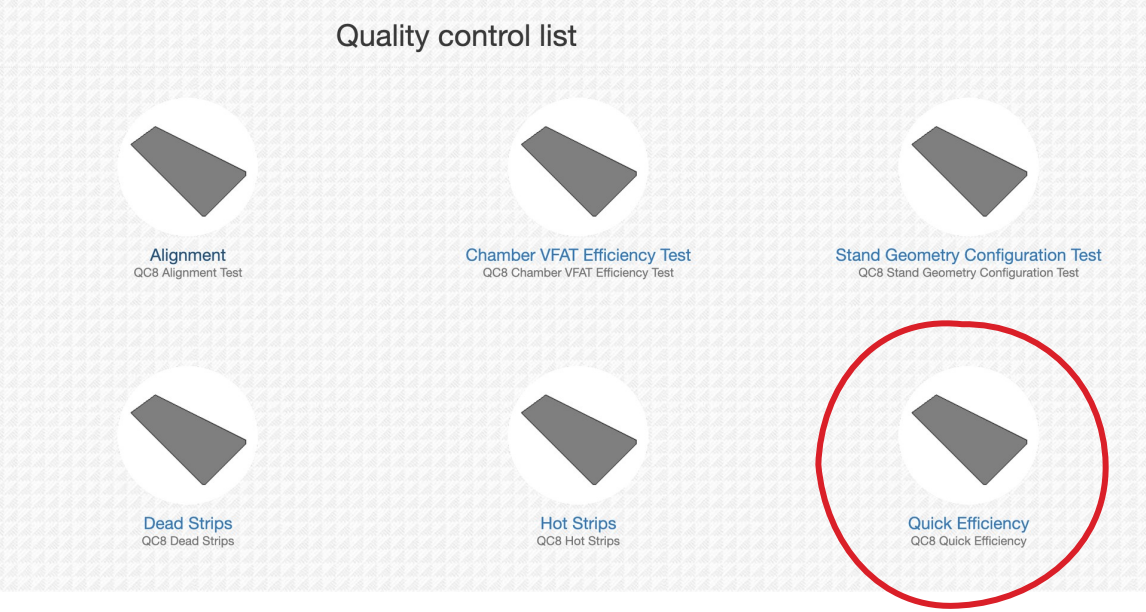
After validation: efficiency per VFAT




```
RunNumber,280
ChamberName,GE1/1-X-L-CERN-0027
BeginTime,2019-09-26 19:23
EndTime,2019-09-27 00:07
VFAT,EFFICIENCY,EFFICIENCY_ERROR,CLUSTER_SIZE_AVG,CLUSTER_SIZE_SIGM
0,0.938967,0.018784,3.336879,1.297155,0.000000
1,0.989928,0.004545,3.516413,1.415193,0.000000
2,0.977355,0.004942,3.510228,1.290774,0.000000
3,0.972617,0.005716,3.237069,1.268333,0.000000
4,0.973848,0.006270,3.438144,1.363348,0.000000
5,0.979592,0.007913,3.365223,1.376660,0.000000
6,0.961864,0.014648,3.212810,1.349227,0.000000
7,0.901786,0.032564,2.819249,1.263966,0.000000
8,0.966387,0.013854,3.336879,1.297155,0.000000
9,0.975530,0.007081,3.516413,1.415193,0.000000
10,0.977984,0.005591,3.510228,1.290774,0.000000
11,0.976096,0.006249,3.237069,1.268333,0.000000
12,0.981132,0.006525,3.438144,1.363348,0.000000
13,0.976431,0.010558,3.365223,1.376660,0.781250
14,0.975610,0.015251,3.212810,1.349227,0.781250
15,0.931507,0.036473,2.819249,1.263966,0.000000
16,0.960000,0.024772,3.336879,1.297155,0.000000
17,0.974522,0.010547,3.516413,1.415193,0.000000
18,0.976821,0.010385,3.510228,1.290774,0.000000
19,0.970443,0.014450,3.237069,1.268333,0.000000
20,0.964286,0.019389,3.438144,1.363348,0.000000
21,0.989583,0.016082,3.365223,1.376660,0.000000
22,0.988235,0.018133,3.212810,1.349227,0.000000
23,0.928571,0.066272,2.819249,1.263966,0.000000
```

Validation results and database

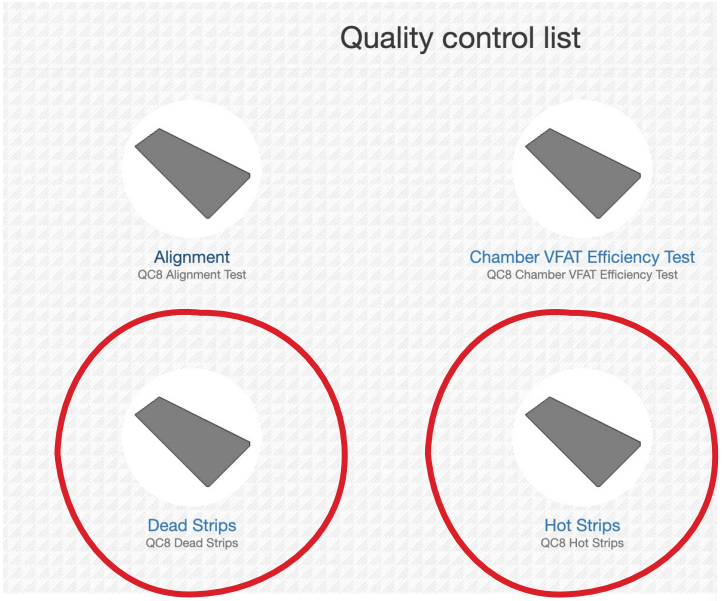
After validation: «Fast efficiency» per chamber




```
RunNumber,266
ChamberName,GE1/1-X-S-INDIA-0009
OverallEfficiency,0.940652
ErrorEfficiency,0.000403
```

Validation results and database

After validation: hot/dead strips tables



DeadStrips_run280_ToDB.csv

```
RUN_NUMBER,280
CH_SERIAL_NUMBER,GEM_NUM,POSITION,VFAT,CHANNEL,STRIP
GE1/1-X-L-CERN-0008,11121,1/3/T,15,-1,225
GE1/1-X-L-CERN-0008,11121,1/3/T,15,-1,226
GE1/1-X-L-CERN-0008,11121,1/3/T,21,-1,261
GE1/1-X-L-CERN-0008,11121,1/3/T,20,-1,381
GE1/1-X-L-GHENT-0025,11223,2/3/B,7,-1,76
GE1/1-X-L-GHENT-0025,11223,2/3/B,8,-1,192
```

HotStrips_run280_ToDB.csv

```
RUN_NUMBER,280
CH_SERIAL_NUMBER,GEM_NUM,POSITION,VFAT,CHANNEL,STRIP
GE1/1-X-L-CERN-0013,11221,1/3/B,23,-1,264
GE1/1-X-L-CERN-0013,11221,1/3/B,6,-1,112
GE1/1-X-L-CERN-0013,11221,1/3/B,6,-1,117
GE1/1-X-L-CERN-0013,11221,1/3/B,14,-1,128
GE1/1-X-L-CERN-0013,11221,1/3/B,14,-1,135
GE1/1-X-L-CERN-0013,11221,1/3/B,13,-1,249
GE1/1-X-L-CERN-0013,11221,1/3/B,21,-1,383
GE1/1-X-L-CERN-0013,11221,1/3/B,4,-1,4
GE1/1-X-L-CERN-0013,11221,1/3/B,11,-1,136
GE1/1-X-L-CERN-0013,11221,1/3/B,1,-1,4
GE1/1-X-L-CERN-0013,11221,1/3/B,1,-1,22
GE1/1-X-L-CERN-0013,11221,1/3/B,1,-1,33
GE1/1-X-L-CERN-0013,11221,1/3/B,9,-1,143
GE1/1-X-L-CERN-0013,11221,1/3/B,0,-1,13
GE1/1-X-L-CERN-0013,11221,1/3/B,16,-1,355
GE1/1-X-L-CERN-0008,11121,1/3/T,7,-1,0
GE1/1-X-L-CERN-0008,11121,1/3/T,7,-1,112
GE1/1-X-L-CERN-0008,11121,1/3/T,7,-1,113
GE1/1-X-L-CERN-0008,11121,1/3/T,7,-1,114
```

Validation results and database

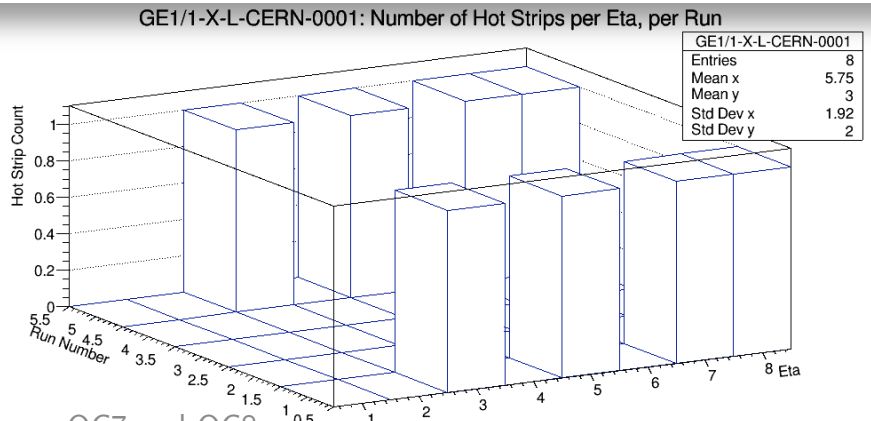
Summary plots:

Code to query the DB and produce summary plots almost finalized and working (done by Woo Chee Yuan). It will extract:

- inclusive distribution of VFAT efficiency for a given chamber and run
- distribution of number of hot/dead strips per chamber for a given run
- distribution of number of hot/dead strips per eta partition and chamber for a given run
- evolution of such distributions per chamber across all runs

Putting together information from production DB and DCS DB:

- VFAT efficiency per chamber vs HV setting at time of acquisition (done by Simone Calzaferri)



Validation results and database - Status

- Interface to database is working fine (thanks to NCP team)
- Information on assembled Super-Chambers up-to-date
- QC8 stand configuration up-to-date (used by analysis framework)
- Validation data to be loaded in the DB (Kuwait - link Yasser Maghrbi)
- Code to produce summary plots ready to be used as soon as the data are available

Conclusions

- QC7:
  - Tested 67/144 => 93% of the first endcap
  - Validation rate: ~4 chambers per week
  - Several hardware issues spotted
- QC8:
  - Validated (14 Short + 7 Long) / 72 => 58% of the first endcap
  - Validation rate: ~5 SC per week
  - DAQ software fully working
- Validation and database
  - Assembly info inserted in DB
  - Validation info from QC8 analysis ready for DB
  - Code to produce summary plots ready