# ESS spoke CM statistic

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# General information for ESS CMs at FREIA

- 6 CMs ( 7 test runs) has been test/ is under test at FREIA till now
- Only 1 out of 4 series CMs so far has passed the acceptance test at the first run
- 2 out of 6 series CMs so far has passed the green light

| CM number | Arrival at FREIA | Departure | Next destination | Comment |
|---|---|---|---|---|
| Prototype | 2/18/2019 | -- | ESS | |
| CM02 | 10/19/2020 | 01/11/2021 | IJCLab | CTS malfunctional |
| CM04 | 1/11/2021 | 03/09/2021 | IJCLab | Cold leak |
| CM02-2nd | 02/19/2021 | 04/09/2021 | ESS | |
| CM05 | 03/17/2021 | 05/09/2021 | ESS | |
| CM03 | 04/22/2021 | 06/28/2021 | IJCLab | CTS malfunctional |
| CM01 | 06/03/2021 | To be decided | To be decided | |

| Goal | | | | Reality 1st cryomodule (CM02) | | | CM04 | | | CM02-2nd | | | CM05 | | | CM03 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| important date at FREIA | dtae | | in bunker [days] | date MM/DD/YYYY | | in bunker [days] | date MM/DD/YYYY | | in bunker [days] | date | | in bunker [days] | date | | in bunker [days] | date | | in bunker [days] |
| arrival date | The time duration from "arrival " to "ready to ship" is sometimes shorter than "GRAND TOTAL weeks *7", for 1) FREIA team many times work extra during weekend and 2) cryogenics procedure are usually taken during weekend | | | 10/19/2020 | | | 1/11/2021 | | | 2/19/2020 | | | 3/17/2020 | | | 4/22/2021 | | |
| waiting in the queue for test | | | | 0 days | | | 0 days | | | 11 days | | | 21 days | | | 17 days | | |
| readay to ship | | | | 12/18/2020 | | | 3/9/2020 | | | 4/9/2020 | | | 5/19/2021 | | | 6/28/2021 | | |
| shipping date | | | | 1/11/2021 | | | 3/17/2020 | | | 4/20/2020 | | | 5/24/2021 | | | 6/30/2021 | | |
| testing step | time [days] | time [weeks] | in bunker [days] | time [days] | time [weeks] | in bunker [days] | time [days] | time [weeks] | in bunker [days] | time [days] | time [weeks] | in bunker [days] | time [days] | time [weeks] | in bunker [days] | time [days] | time [weeks] | in bunker [days] |
| Arrival, unpacking, initial inspection | 2.5 | | | 5 | | | 2 | | | 2 | | | 2 | | | 2 | | |
| Installation, connection to valve box | 3.5 | | 3.5 | 8 | | 6 | 6 | | 5 | 9 | | 5 | 6 | | 5 | 8 | | 5 |
| Warm testing | 3.5 | | 3.5 | 4 | | 4 | 4 | | 4 | 3 | | 3 | 3 | | 3 | 5 | | 5 |
| Cool down | 2 | | 2 | 2 | | 2 | 2+3 | | 5 | 2 | | 2 | 2 | | 2 | 2 | | 2 |
| Cold testing | 5 | | 5 | 8 | | 8 | 5+2 | | 7 | 8 | | 8 | 7 | | 7 | 5 | | 5 |
| Warm-up* | 4 | | 4 | 4 | | 4 | 3 | | 3 | 4 | | 4 | 3 | | 3 | 4 | | 4 |
| Disconnect, packing, shipment | 4.5 | | 3 | 7 | | 3 | 10 | | 5 | 7 | | 3 | 5 | | 4 | 8 | | 4 |
| TOTAL | 25 | 5 | 21 | 38 | 7.5 | 27 | 37 | 7.4 | 29 | 35 | 6.6 | 29 | 28 | 5.6 | 24 | 34 | 7.2 | 25 |
| Spare and wasted time, 20% (DESY statistics) | 5 | | 4.2 | 10 | | 10 | 3 | | 3 | 3 | | 0 | 7 | | 7 | 8 | | 8 |
| **GRAND TOTAL** | **30** | **6** | **25.2** | **48** | **9.5** | **37** | **40** | **8** | **32** | **38** | **7.6** | **29** | **35** | **7** | **31** | **42** | **8.4** | **33** |

Time given in 8h work days, 1 shift, holidays and vacation not included.

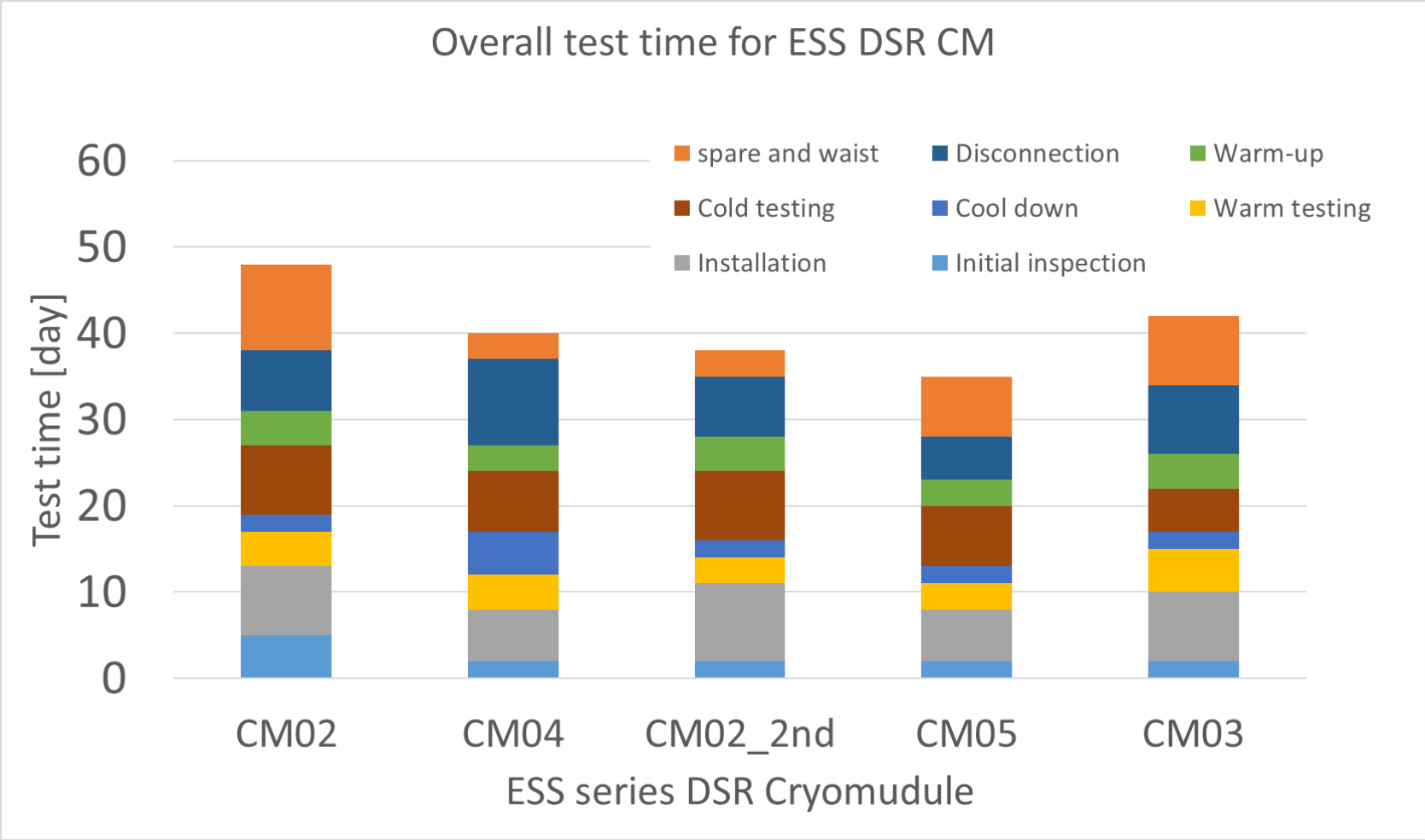
Details in separate document send to the committee.

*) Warm-up is shorter if during weekend

| Wasted time include | Extra time include | Wasted time include | Extra time include | Extra time include |
|---|---|---|---|---|
| 1 week for optical window change | 1 week for thermal cycle and second cooldown + RF test | 3 days wait for doorknob outer conducter | 2days for DB brocken component replaysment (analog signal converters CV1 & CV3) | 5 days wait for overlap CM work and CM05 takes the priority |
| 1 week system component adjustment | 2 days for extra leak test + extra CTS test | | 2days for Esys brocken and repair | perform extra leak test investigate |
| | 3 dayss due to Covid-19 constriction+ project overlap+lack people on Friday | | 3 days for Eacc discrepancy investigation | 3 days due to stuck CTS and investigation |

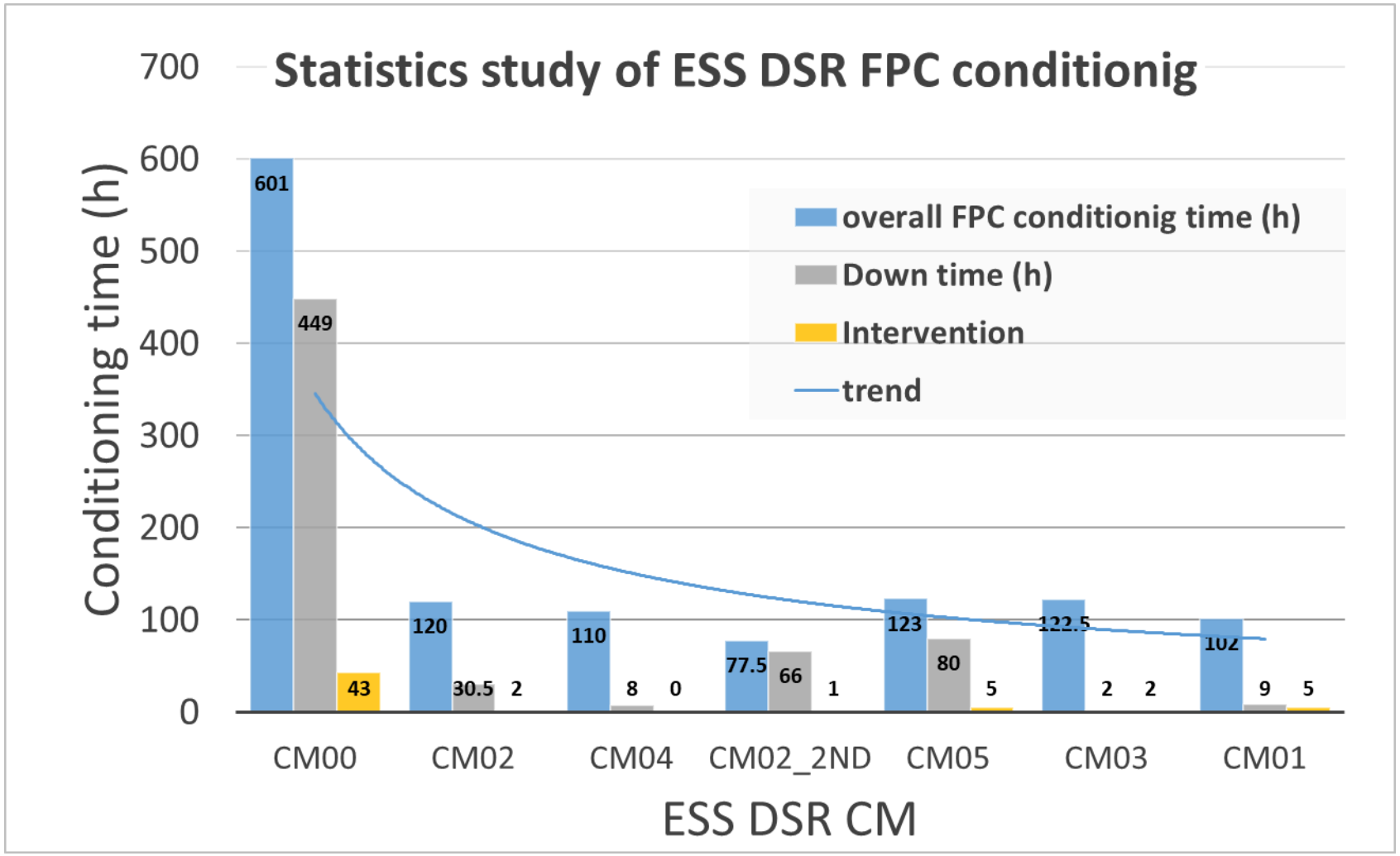
# General information for Cryomodule test time

- Average actual testing rate is about 34 days/CM
- Average overall testing rate is about 40 days/CM



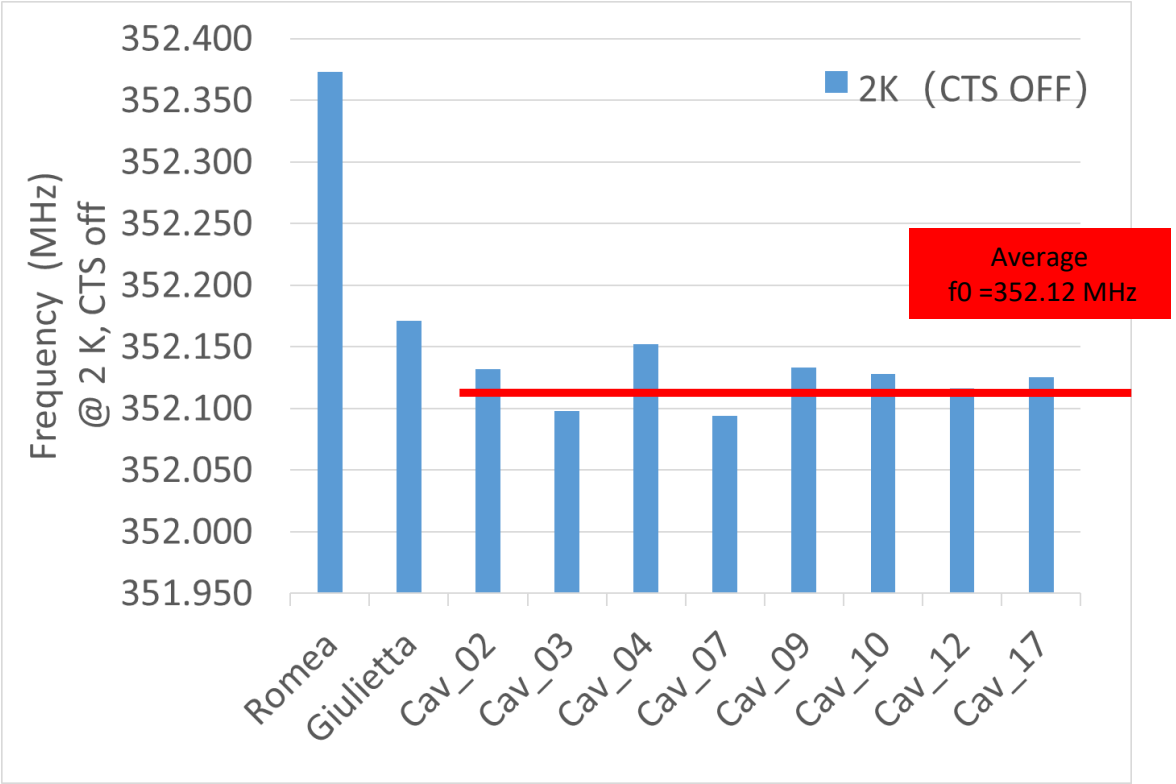
# FPC conditioning

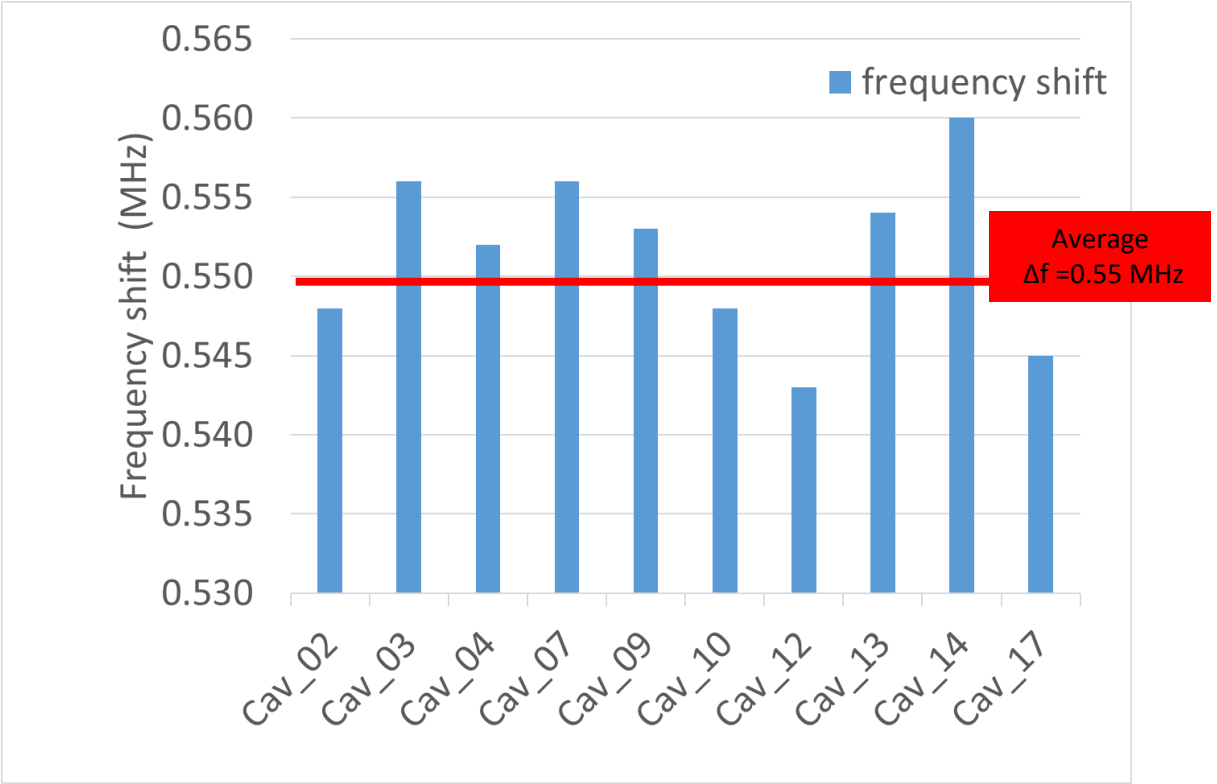
- FPCs' conditioning are done by FREIA auto conditioning program at 353 MHz
- CM05 was with two pumping charts and only need 3 days Up-time
- Reliable hardware (RF station) has become the bottle-neck of the FPC conditioning



# Frequency shift study

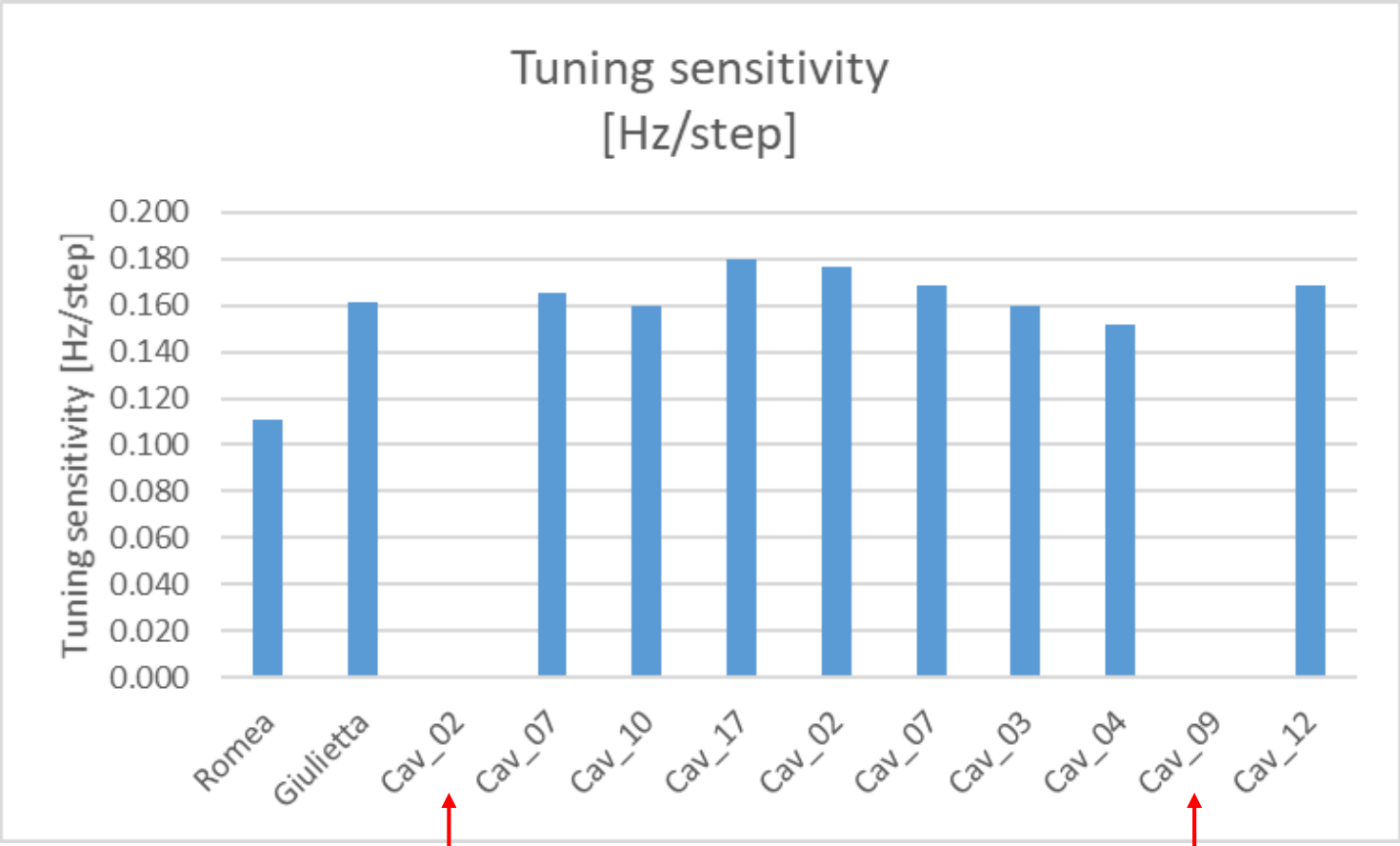
- Cavity resonant frequency is monitored during cooldown with VNA S parameter
- Average cavity resonant frequency at 2K for series CMs is 352.12 MHz
- Average frequency shift/control from RT to 2 K for the first 5 CMs is 0.55 MHz



# CTS study

- 2 out of 11 CTS (step motor) are malfunctional
- Average tuning sensitivity for series CM is 0.167 Hz/step

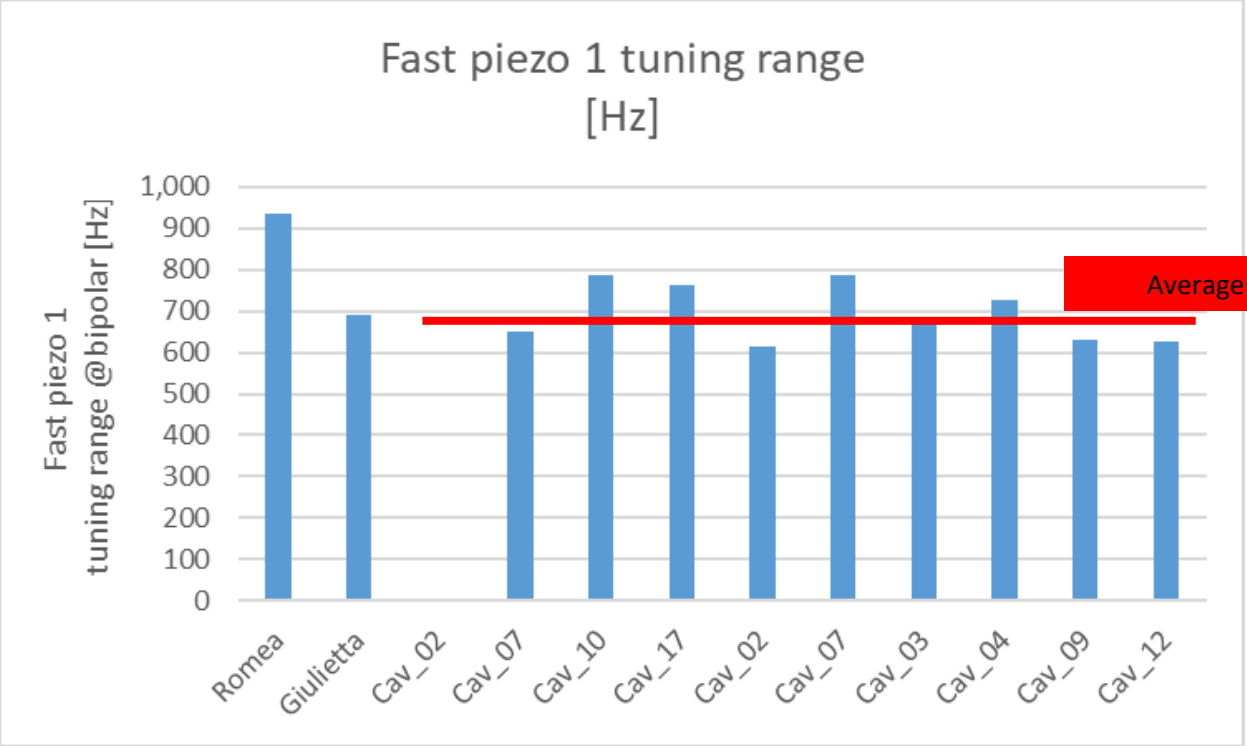


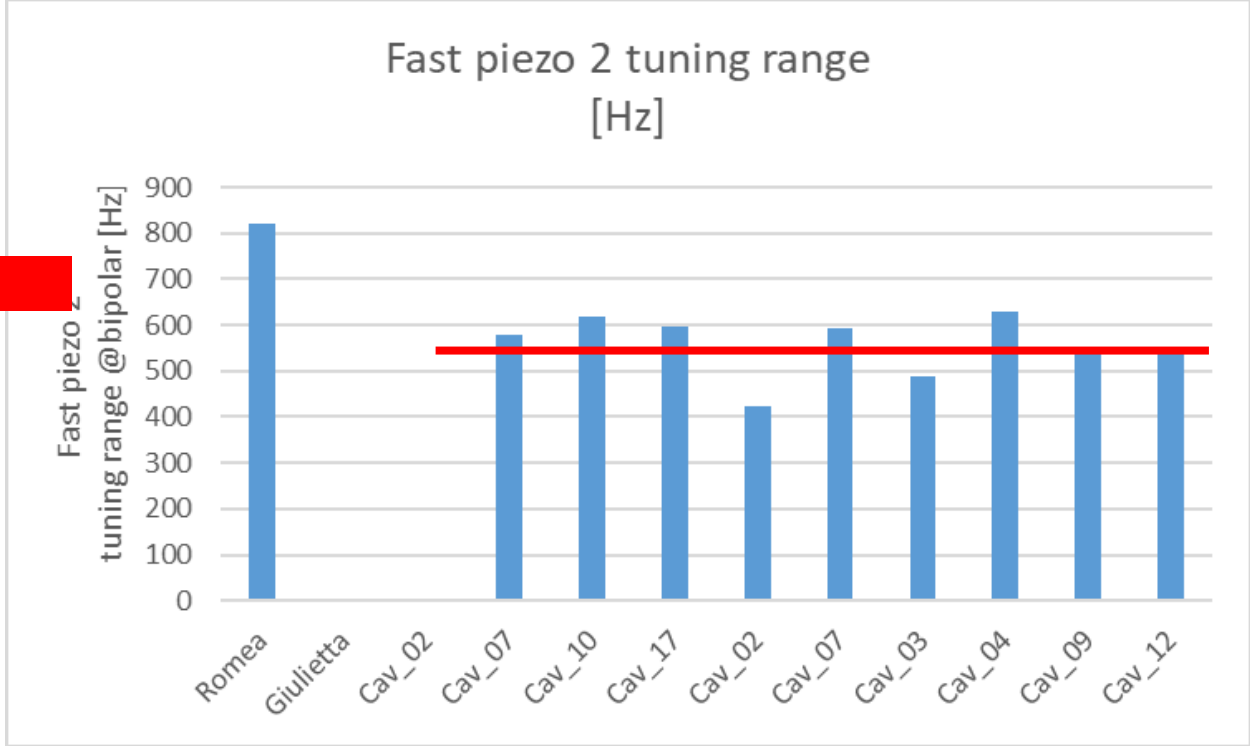

Malfunctional CTS

Malfunctional CTS

# CTS study

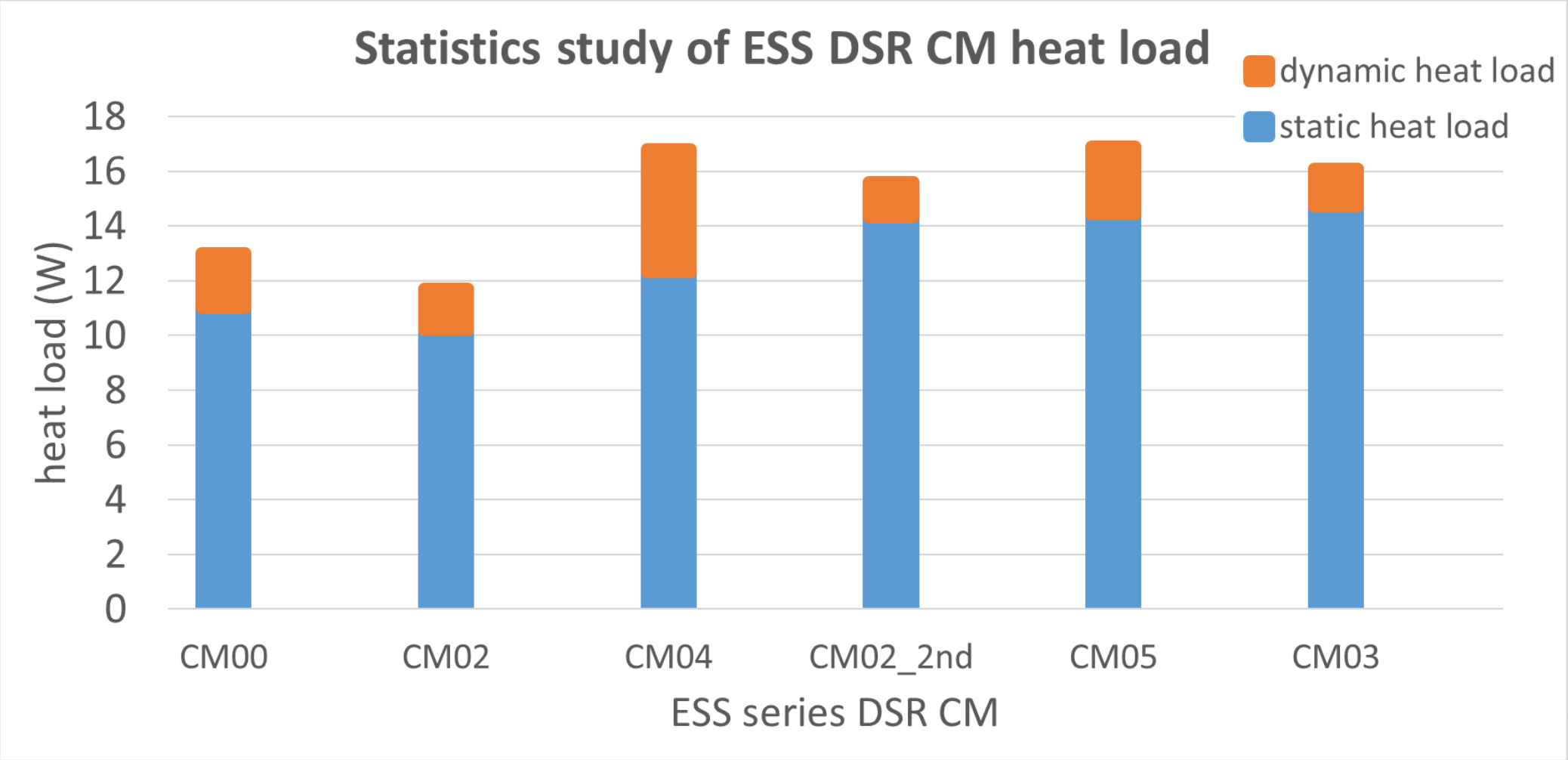
- Piezo 1 is observed higher tuning range (about 25% ) than Piezo 2
- Average tuning sensitivity for Piezo 1 is 695 Hz @ bipolar  for series CM
- Average tuning sensitivity for Piezo 2 is 558 Hz @ bipolar  for series CM



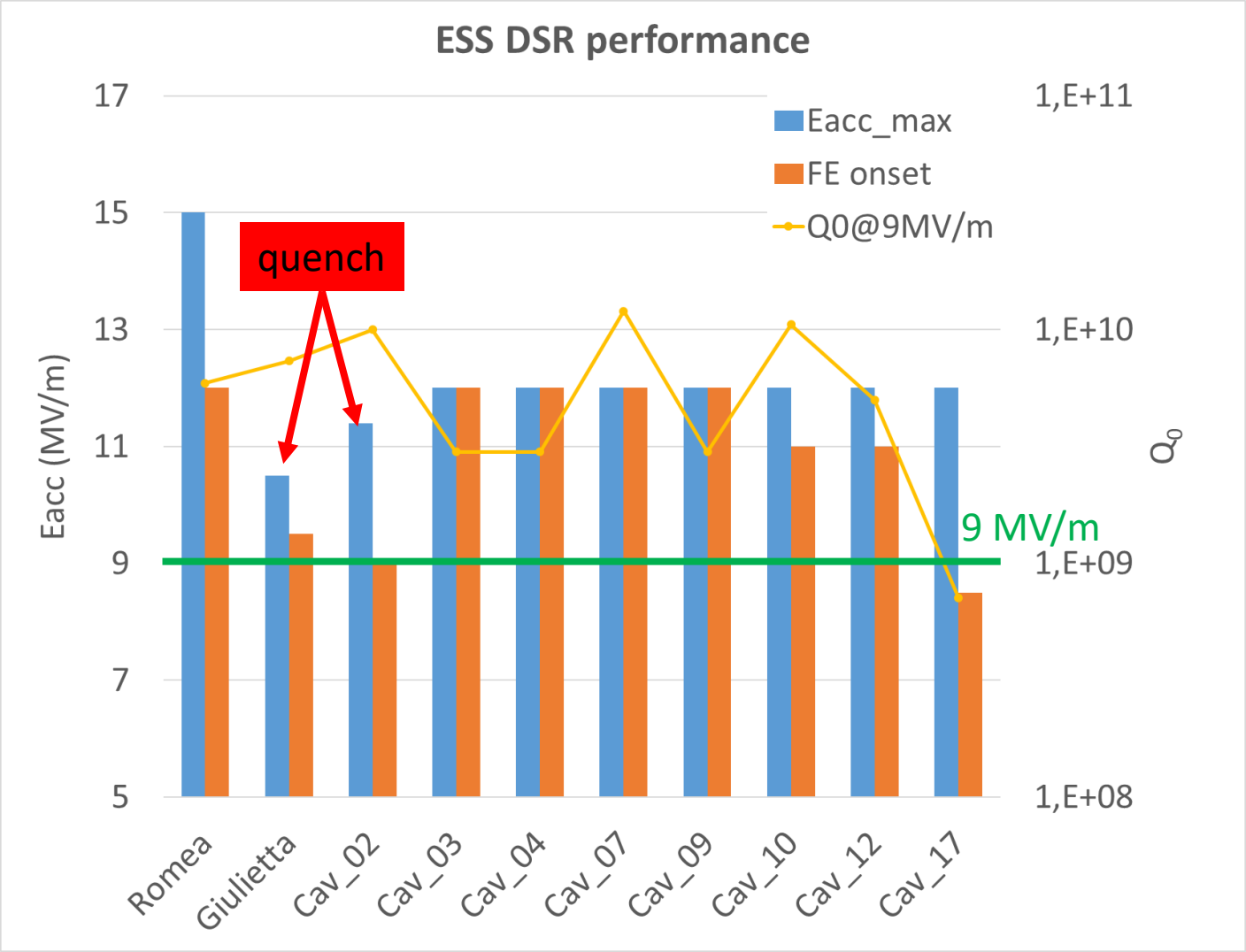
# Heat load study

- Dynamic heat load is measured at 9MV/m and is usually within the measurement uncertainty
- Static heat load is the dominant part for ESS DSR heat load
- Average static heat load for series CM is about 13 W



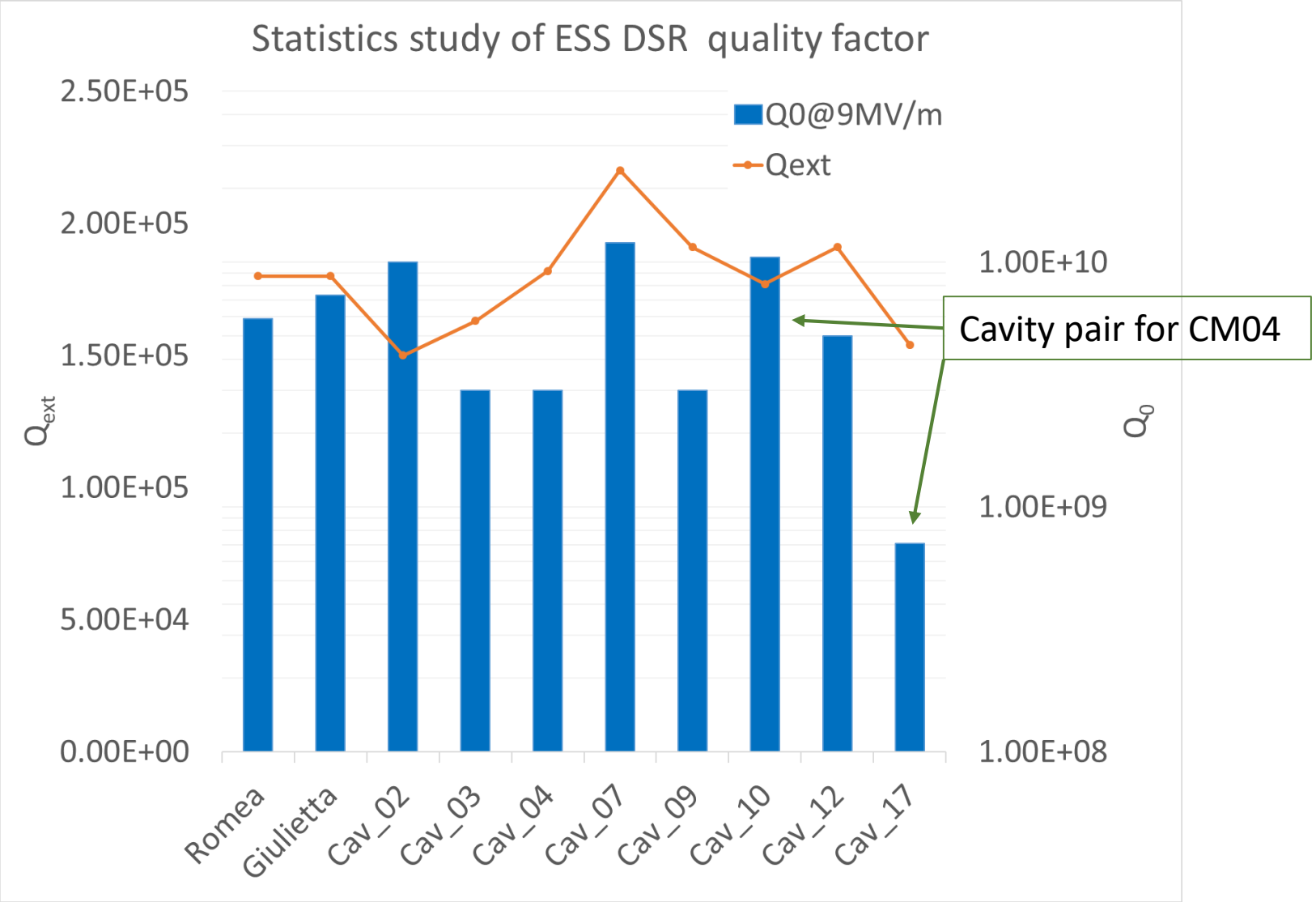
# Cavity performance

- Dynamic heat load is usually within the measurement uncertainty
- All cavities achieve the nominal gradient of 9 MV/m, and 7 out of 8 series cavities achieve 12 MV/m
- Lowest FE onset is 8 MV/m



# Cavity performance

- 7 out of 8 series cavities achieve Q0 higher than 1.5E9 @ 9MV/m



# Cavity performance

- 3 out of 8 series cavities' Qext are out of specification