

Multipacting Processing in Cryomodules for LCLS-II and LCLS-II-HE

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ABSTRACT

Multipacting (MP) is a phenomenon which can affect stability in particle accelerators and limit performance in superconducting radio frequency cavities. In the TESLA shaped, 1.3 GHz, 9-cell cavities used in the LCLS-II (L2) and LCLS-II-HE (HE) projects, the MP-band (~17-24 MV/m) lies within the required accelerating gradients. For HE, the operating gradient of 20.8 MV/m lies well within the MP-band and cryomodule testing has confirmed that this is an issue. As such, MP processing for the HE cryomodule test program will be discussed. Early results on MP processing in cryomodules installed in the L2 linac will also be presented, demonstrating that the methods used in cryomodule acceptance testing are also successful at conditioning MP in the accelerator and that this processing is preserved in the mid-term.

MULTIPACTING IN THE FNAL CM TEST STAND

To date, 5 LCLS-II-HE CM have been tested at Fermilab:

- Nominal gradient lies within MP-band: 20.8 MV/m
- 40 cavities tested
- 35 exhibit MP before processing, 4 exhibit MP after processing
 - F24 – CAV6 limited to operation below MP-band due to Field Emission.

Cavity #	vCM	F21	F22	F23	F24
1	YES	YES	YES	YES	YES
2	YES	NO	YES	YES	YES
3	YES	YES	YES	YES	YES
4	YES	NO	NO	YES	YES
5	YES	YES	YES	YES	YES
6	YES	YES	NO	YES	NO*
7	YES	YES	YES	YES	YES
8	YES	YES	YES	YES	YES

Table 1: Before Processing - MP observed during HE CM testing for the prototype CM, vCM, first article CM, F21, and production CM (F22-F24).

Cavity #	vCM	F21	F22	F23	F24
1	NO	NO	NO	NO	NO
2	NO	NO	NO	YES*	NO
3	NO	NO	NO	NO	NO
4	YES	NO	NO	NO	NO
5	NO	NO	NO	NO	NO
6	NO	NO	NO	NO	NO
7	NO	NO	NO	NO	YES
8	NO	NO	NO	YES*	NO

Table 2: After Processing – MP observed during Q0 measurements. Note: F23 warmed to room temp. for minor repair, not fully reprocessed.

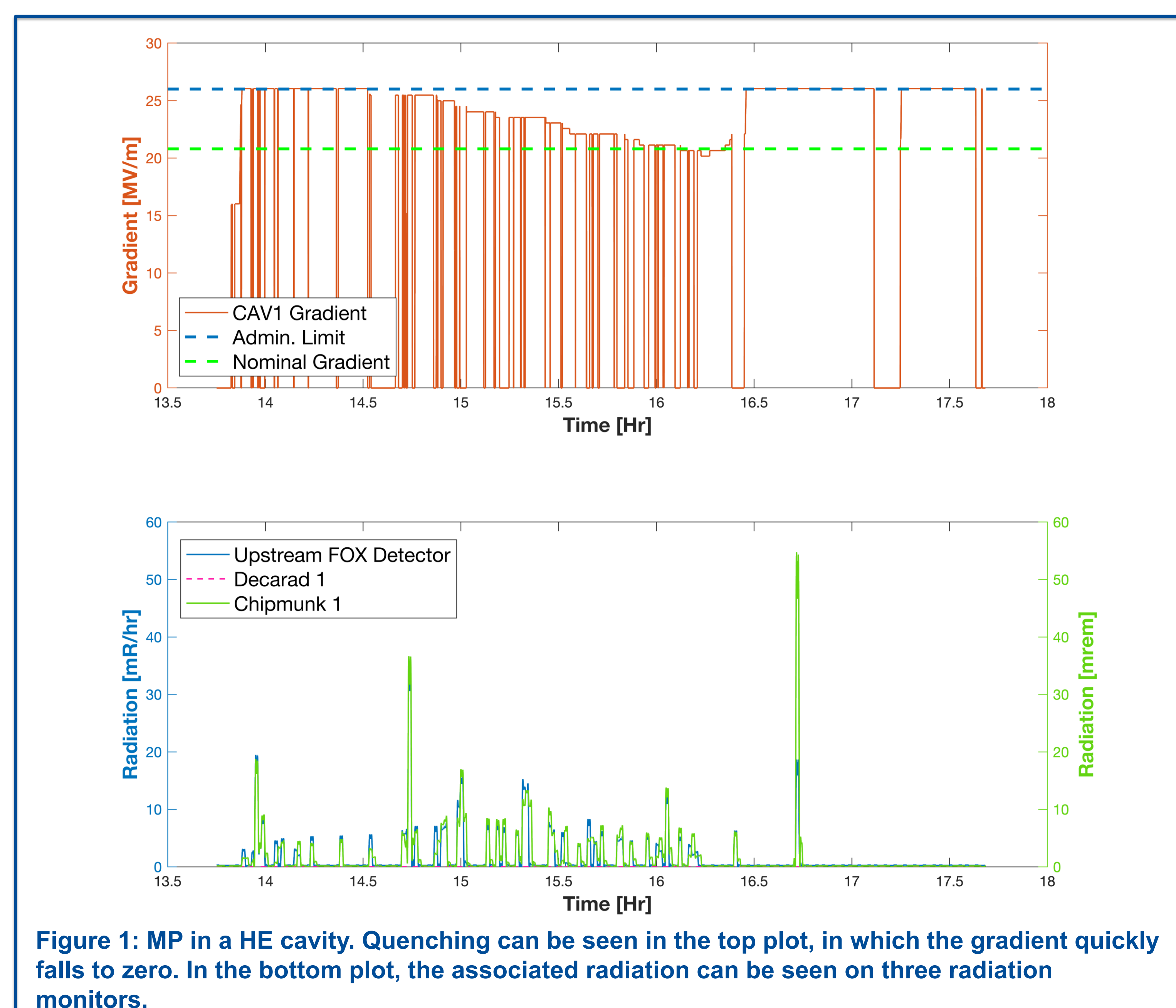


Figure 1: MP in a HE cavity. Quenching can be seen in the top plot, in which the gradient quickly falls to zero. In the bottom plot, the associated radiation can be seen on three radiation monitors.

MULTIPACTING PROCESSING

Method: repeated quenching, minimal time between quenches (seconds), CW operation.

Cavities processed during three stages of testing:

- **Max. Gradient** – during power rise to determine max. field.
- **Usable Gradient** – during 1hr stability tests, typically process through the MP-band and up to quench field/admin. limit.
- **Q0 Measurement** – prior to Q0 measurement, 2-4hr operation at nominal gradient with 2-4 cavities concurrently. Want to avoid Q0 degradation due to quenching and trapped flux.

LCLS-II COMMISSIONING

- Implemented methods developed by HE CM test team.
- 37 cavities processed: all cavities achieved some level of processing, ~3 MV/m avg. gain in gradient.
- After 3 months, processing is preserved in the linac.
- Further processing planned after maintenance period.

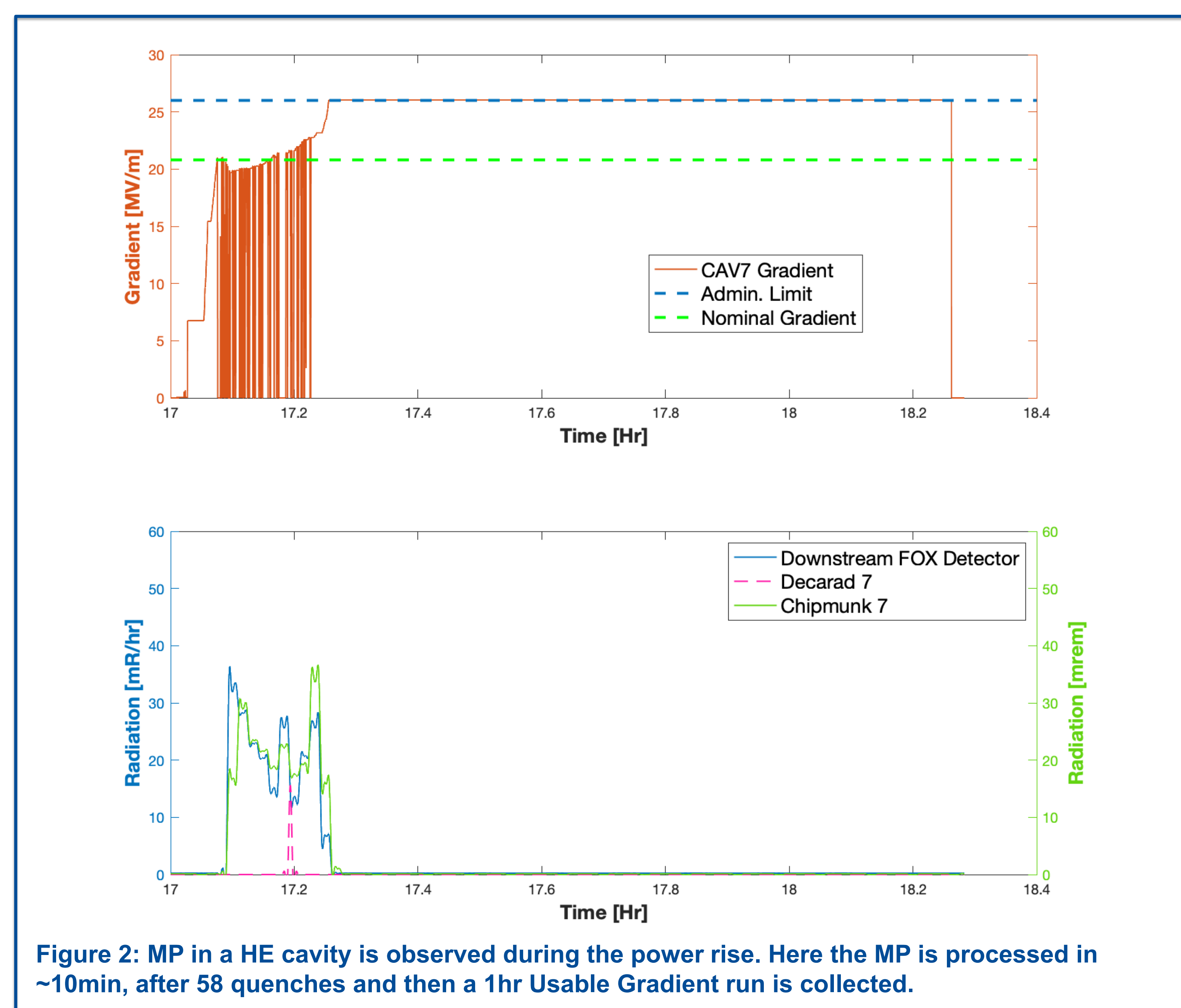


Figure 2: MP in a HE cavity is observed during the power rise. Here the MP is processed in ~10min, after 58 quenches and then a 1hr Usable Gradient run is collected.

