RF and acoustical methods for breakdown localization in high gradient accelerating structures

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BD Cell location with RF signals

- Quite sensitive to threshold detection levels (~3ns/cell)
- Based on assumption that transmission falling edge and reflected raising edge are simultaneous events when BD
- Based on the assumption that electrons and X-rays emissions are synchronous with structure RF characteristics modifications when BD
- Very accurate (based on signals correlation)
- Confidence measurable
- Relies on a signal structure on the pulse tail.

Nota:
- the 3 first methods detect the BD location at its onset, the 4th method at the end of the RF pulse (meanwhile the BD can have migrated).
- No information can be gained on the transverse position of the BD

Considering the above limitations/uncertainties alternative BD location methods are to be sought.

BD Cell location with acoustic signals

Sensitivity: Dynamic range: Frequency range(-3dB): Resonant Frequency: Dynamic range: Sensitivity:
10 mV/g 10 kHz - 200 kHz > 70 kHz +/- 500 g 10 mV/g

Comparison of the results

- So far time delay location method with acoustic signals as not been successful (complex wave propagation in such a structure).
- But possible: ref 1, 3, 5.
- Method of maximum detected signal was used instead -> increase the number of sensors for higher resolution, and azimutal resolution also.

Possible future BD localization methods

Time resolved methods are required to understand the dynamic of multiple BDs during a pulse, as BD migration.

Refinement using RF Reflected phase

- Phase of the reflected signal after BD are distributed on 3 groups (2x/3 phase advance structure)
- Phase information is used to reallocate BD to adjacent cells, correcting time measurement inaccuracy.

Structure vibration model

No BD: excitation by thermal expansion applied on all the irises
BD: excitation on the central iris only

Bibliographie

5. Use of Acoustic Emission to Diagnose Breakdown in Accelerator RF Structures, J. Nelson et al., SLAC-PUB-9808, August 2002
7. Acoustic Measurements of RF Breakdown in High Gradient RF Structures, SLAC-PUB-8580, August 2000
8. Acoustic Monitoring System of RF-Breakdowns inside the Electrodynamic Structures at Kurchatov SR Source Accelerators, M. Gangeluk et al., Kurchatov Institute

Histogram of BD locations

Histogram of the errors

Simulated spectrum

Measured spectrum