

LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

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RADIO FREQUENCY QUADRUPOLES (RFQ)

STUDY OF VACUUM BREAKDOWN PHENOMENOLOGY OF

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ABSTRACT

The high-gradient (HG) performance of a RFQ is an important aspect of this study. In the frame of the program on medical applications, CERN has built a compact 750 MHz RFQ to be used as an injector for a hadron therapy linac. This RFQ has about double the frequency of other existing RFQs. Two structures with different frequencies have been chosen for further study, where the high gradient value is of significant importance. A data acquisition system for breakdown (BD) studies in the RFQ at LINAC 4 and test bench of ADAM was developed. During the tests, data has been collected without influencing normal operation regime. The results presented include ultimate performance and long term behaviour.

Motivation

- □ Investigate high-field limits in new parameter ranges, in particular at low frequency and a very different field profile, based on the experience of BDs research in CLIC accelerating structures.
- Study the **high-gradient performance** of the RFQ, define limiting factors.
- Achieve a high surface electric field in the RFQ while minimising risk of sparking and damage.
- Use knowledge gained to optimize the design of structures.

The RFQ LINAC 4: Technical specification

3 MeV	50 MeV 102 MeV 160 MeV
P CHOPPER ←	
	Schematic layout of the Linac 4.
352.20 MHz	A CONTRACTOR OF THE OWNER OF THE
3.06 m	
78.27 kV	
34 MV/m	
600 kW	 4-vane structure with 2 brazing steps
1.84	 3 elementary modules of 1 m
45 keV	• Operation: 480 kW, 750 us, 1.2 Hz
3.0 MeV	
	^{3 MeV} CHOPPER Hz Value 352.20 MHz 3.06 m 78.27 kV 34 MV/m 600 kW 1.84 45 keV 3.0 MeV

LIGHT = Linac for Image Guided Hadron Therapy





The BD diagnostics

✓ RF signals:

- Directional coupler: incident and reflected signals;
- Pick up: signal of field in the RFQ cavity;
- Oscilloscope: additional recording the signals.
- ✓ **Vacuum** diagnostic signals (vacuum gauges).



Benefits of a high field for the RFQ

- High peak fields increase **performance** in areas of:
- Higher acceptance (larger emittance beams);
- ✓ Greater space charge capability;
- Accept heavy ions with lower charge state;
- ✓ Shorter RFQ.

But also have the effect of:

- Increased probability of sparking;
- \succ More RF power required;
- Tighter machining and alignment tolerances.

RFQ at ADAM

200

150

HIGH POWER MEASUREMENT



100

pulse width 10 μ s, BDR = 1.28 e-07 [1/pulse]

Number of pulses [M]

50

Objective: to understand the distribution of the field during BD, depending on its location in the structure



(a) Transverse section electric and magnetic field distribution of the RFQ in designed model (TE210-mode) and (b) in case of BD.

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□ The first study of BD phenomena was performed in the RFQ of Linac 4 and test bench of ADAM.

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Number 0

of

- Non resonant frequency occurred at BD
- Comparison of 16 pickup signals along the structure give possibility to identify the BD locations.
- Preliminary analyse shows that the main number of BD happened after full filling of the cavity during beam loading.
- Dominant number of BDs at the end of the RFQ at LINAC 4 due to higher energy beam.
- □ The high gradient experience in development and construction of CLIC structures cannot be directly scaled to the RFQ because the operating regime is completely different: *pulse length and way of filling* (SW structure + ion source).

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