COMMISSIONING OF IFIC HIGH GRADIENT RF LABORATORY TO TEST S-BAND ACCELERATING STRUCTURES FOR HADRON-THERAPY ACCELERATORS

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ABSTRACT

The IFIC RF laboratory will perform the conditioning and high power tests of S-band accelerating structures designed for hadron-therapy, aiming to investigate their high-gradient behaviour. The facility is based on the scheme of the Xbox-3, a X-band test facility at CERN, adapted to operate in S-band. Two medium peak-power (7.5 MW) and high repetition rate (400 Hz) S-band klystrons have been combined to generate the required power on two testing lines. Test stand installation has been finished and commissioning of the laboratory equipment is progressing. This document will present the latest results and progress of the IFIC RF laboratory.

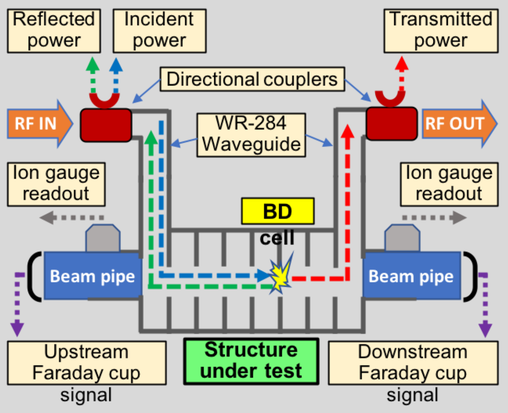
INTRODUCTION

- *High-Gradient (HG) know-how and technology for normal-conducting (or "warm") accelerating Radio-Frequency (RF) electron linac (linear accelerator) structures* has enabled an increase in the achievable accelerating gradient from 20-30 MV/m to 100-120 MV/m.
- General interest has been shown over the last years for compact and more affordable facilities for hadron-therapy.
- High frequency linacs provide a high degree of flexibility for treatment, such as running at 100-400 Hz pulse rate and pulse-to-pulse beam energy (and intensity) variations [3, 4].
- Project studies like TULIP [4] are taking advantage of these developments and pursuing more affordable single room facility medical linacs of reduced size.

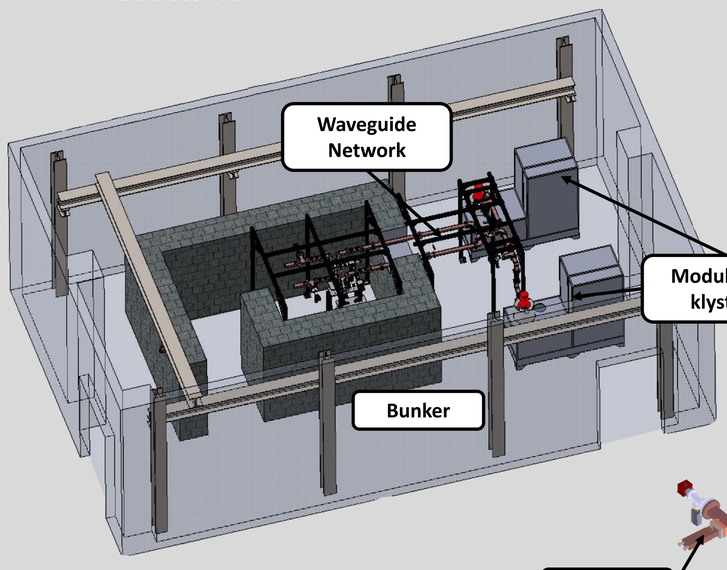
THE S-BAND TEST FACILITY

Experimental capabilities

- Conditioning of S-band RF structures and evaluation the HG performance of components by measuring the breakdown rate (BDR).
- Study of the BDR dependencies with gradient and pulse length for S-band.
- Development of instrumentation and techniques for BD diagnostics.
- Dark current measurements for field emission studies in RF structures.

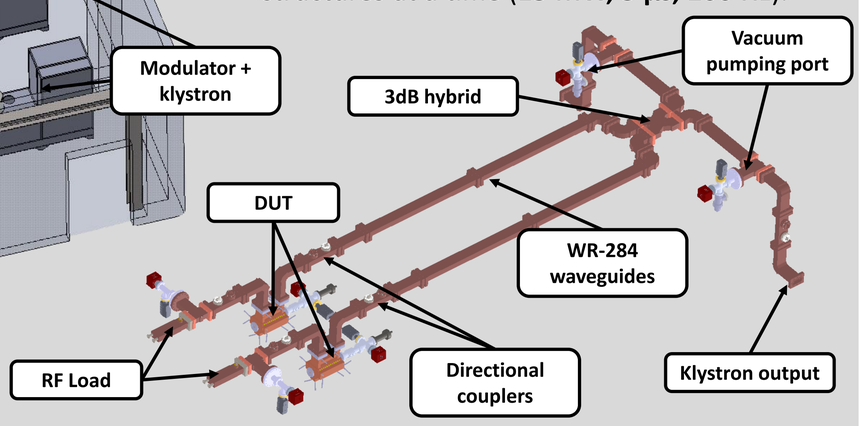


Layout of the device under test and the diagnostic systems. The arrows show the signals read out by the acquisition system

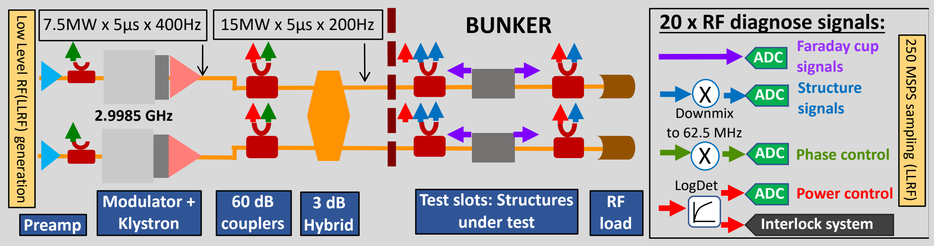


Waveguide Network

- The waveguide RF network allows to test two structures at a time (**15 MW, 5 µs, 200 Hz**).



THE S-BAND TEST FACILITY



First stage layout of the high-power system of the IFIC HG RF laboratory

- On a first stage, the test facility has been designed to combine the power of two 7.5 MW S-band (2.9985 GHz) klystrons through a 3dB hybrid and feed simultaneously two test slots.
- With the nominal repetition rate of 400 Hz, the test facility will be capable of performing the conditioning, up to 15 MW, of two structures at 200 Hz simultaneously or one structure at 400 Hz.

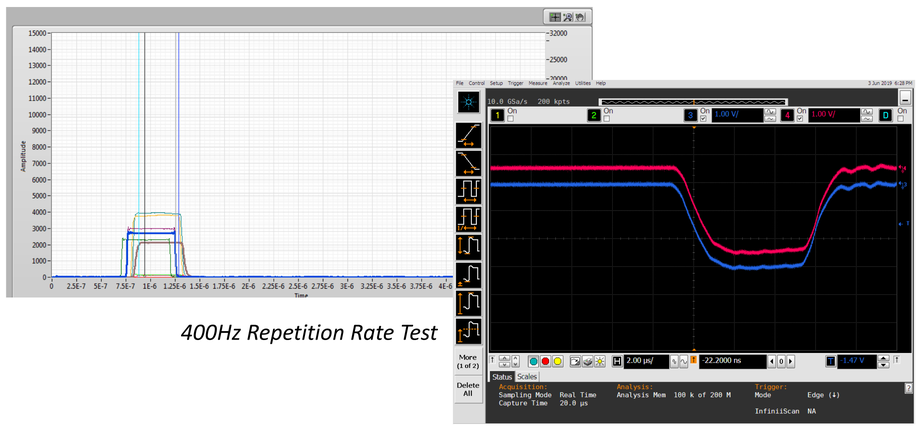
JEMA Modulator

Nominal specs:
Klystron max. RF power: 7.5 MW
Modulator pulse voltage: 145 kV
Modulator pulse current: 105 A
Modulator flat-top pulse length: 5 µs
Rep. rate: 400 Hz
Voltage ripple: <= 0.25%
Stability, pulse to pulse: <= 0.1%
Rise-time (10->90%): <= 2 µs
Fall-time (90->10%): <= 2 µs

Measured specs:
(@ 130 kV and 5 µs flat-top):
Voltage ripple @130 kV:<= 0.8%
Stability, pulse to pulse: <= 0.025%
Rise-time @130 kV: <= 2.4 µs
Fall-time @130 kV: <= 2.1 µs

First modulator, klystron and waveguide network at the IFIC laboratory

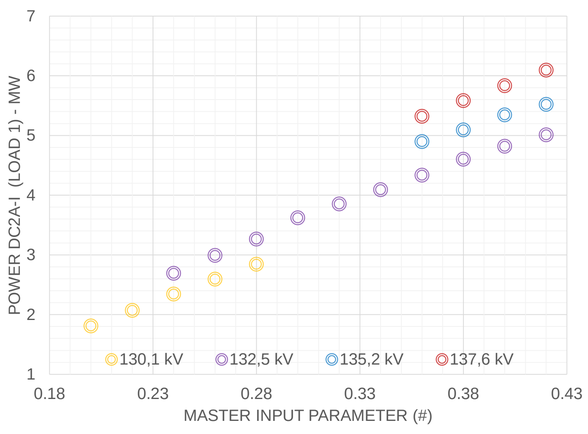
PERFORMANCE: HIGH REPETITION RATE.

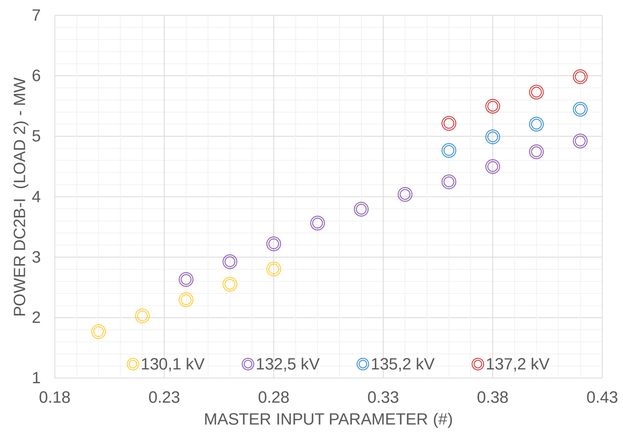


400Hz Repetition Rate Test

The facility is capable of working at 400 Hz repetition rate with only one line in operation, or 200 Hz, with both lines operating simultaneously. Tests at high repetition rate have been performed, proving a good pulse stability in both scenarios

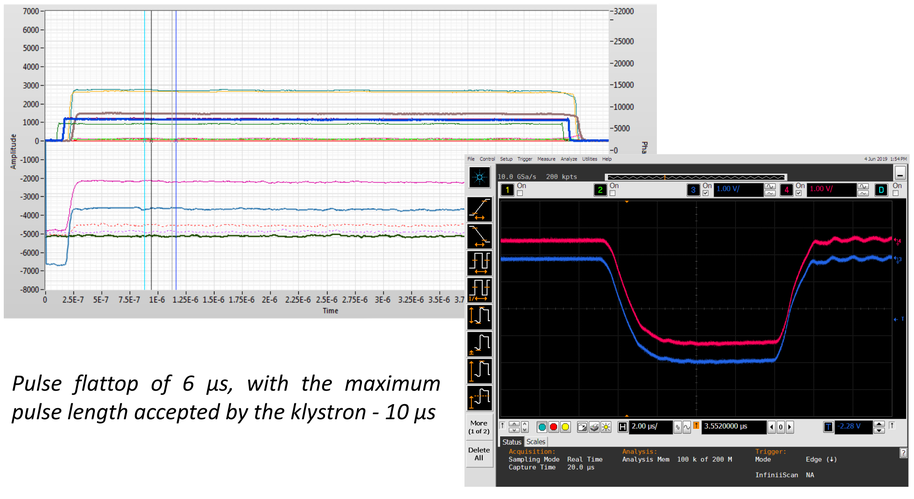
HPRF CONDITIONING STATUS





In the current conditioning status, the maximum power achieved was over 6 MW, in both lines (at the directional coupler before de loads).
Using a pulse length of 1.2 µs and 50 Hz (25 Hz per line) repetition rate

PERFORMANCE: VERY LONG PULSES.



Pulse flattop of 6 µs, with the maximum pulse length accepted by the klystron - 10 µs

The facility is capable of injecting 5 µs RF with the expected stability and the planarity. These long pulses are required in order to be able to operate the BOC Pulse Compressor.

CONCLUSIONS

HG RF technology offers the possibility to construct very compact linear accelerators for different applications. However, the performance of HG linacs is limited by the occurrences of breakdowns or vacuum arcs. The IFIC HG-RF test facility, which is currently under commissioning, is intended to support the development of a wide experimental programme of testing HG accelerating structures and breakdown phenomenology studies for S-band HG linacs.

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