Effect of Beam-Loading on the Breakdown Rate of High Gradient Accelerating Structures

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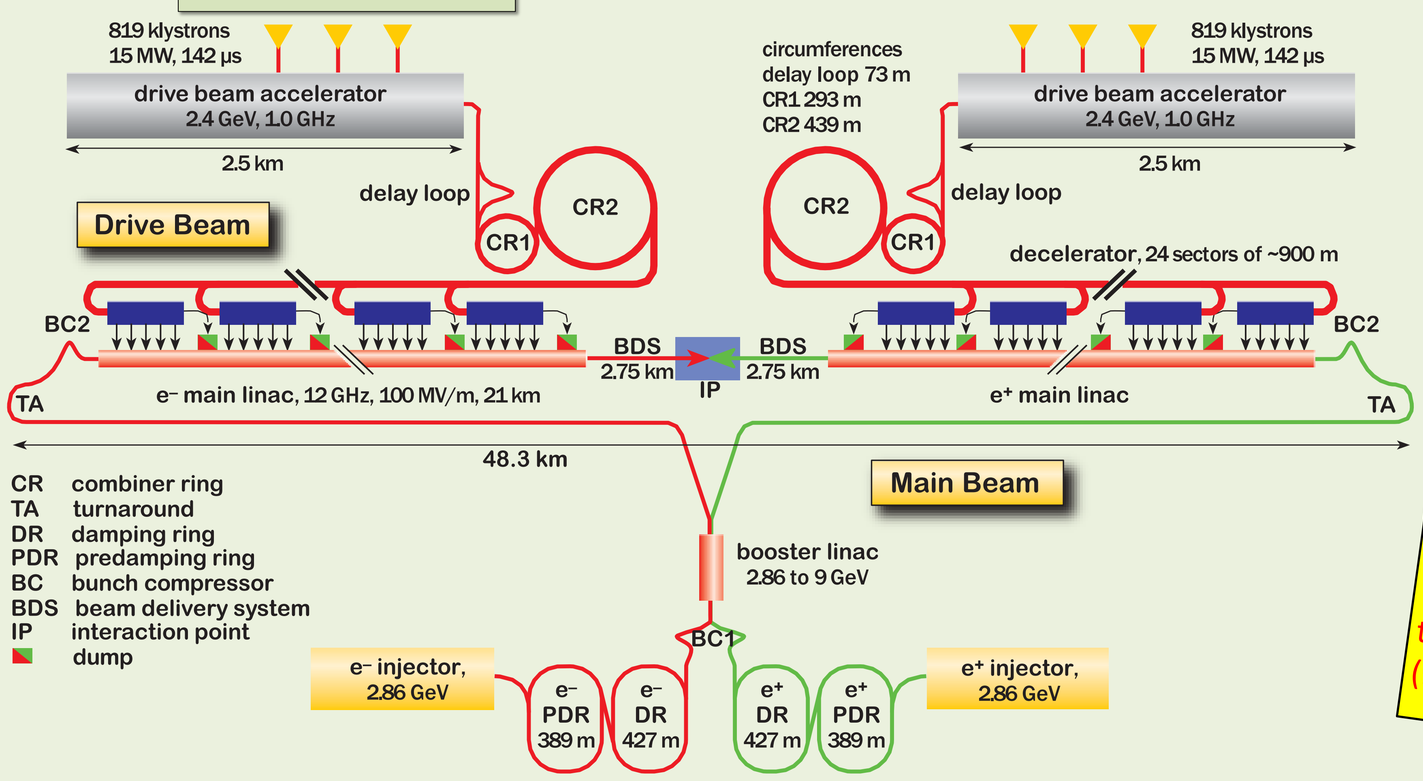
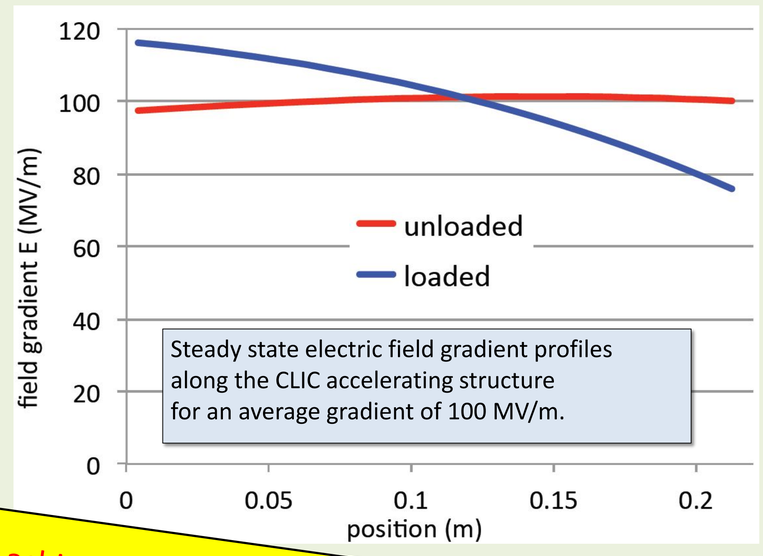
Introduction



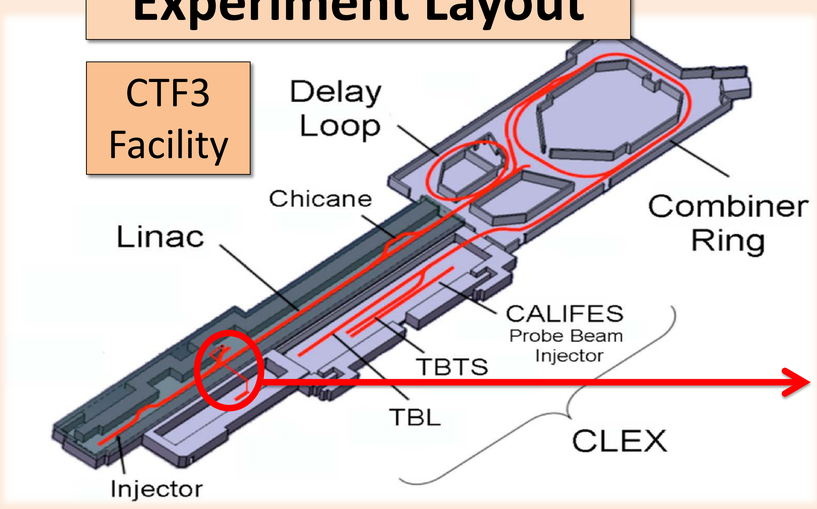


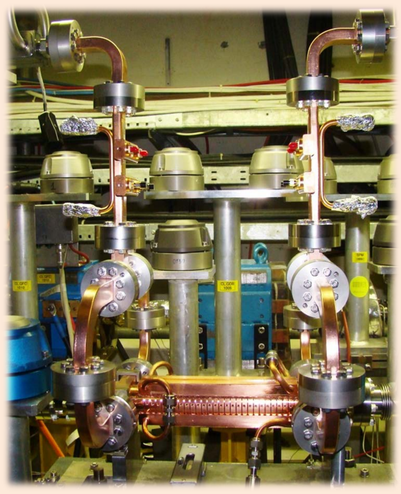
BD rate already achieved without beam!!! but...

... RF beam loading changes field profile in travelling waves (TW) accelerating structure (BD rate never measured with beam)

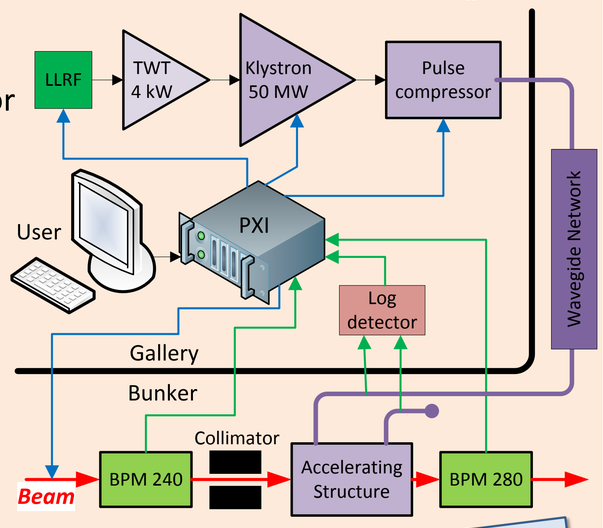
- **CLIC (Compact Linear Collider)** is a **multi-TeV** high luminosity **e^+ e^- linear collider** project.
- CLIC relies on the **two beam acceleration concept:** 12 GHz RF power for acceleration of the **"main beam"** is generated decelerating a high current **"drive beam".**
- Acceleration in CLIC is based on **normal conducting** travelling wave accelerating **cavities** working at a gradient as high as **100 MV/m.**
- **CLIC luminosity is limited by RF breakdowns (BD)** which produces beam deflection.
- Maximum Breakdown Rate (BDR) allowed = 3 10^{-7} BD/(pulse m) for operation at 3 TeV.

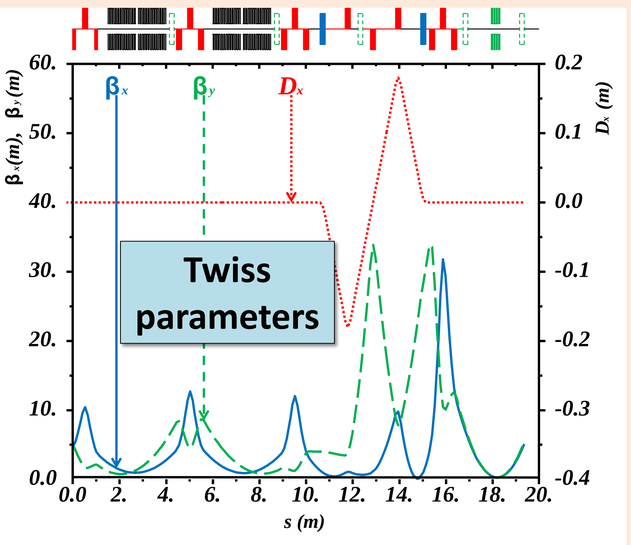
Experiment Layout





- Experiment installed in the **CLIC Test Facility CTF3 at CERN**
- Reused existing beam line branching off mid-linac with 24 cell CLIC accelerating structure installed
- 12 GHz, 50 MW RF klystron, pulse compressor and 24 cell structure connected by low-loss waveguide
- BPMs upstream and downstream structure
- NI PXIe8133 for control and acquisition
- Novel beam loss monitors surrounding structure to detect scattered particules





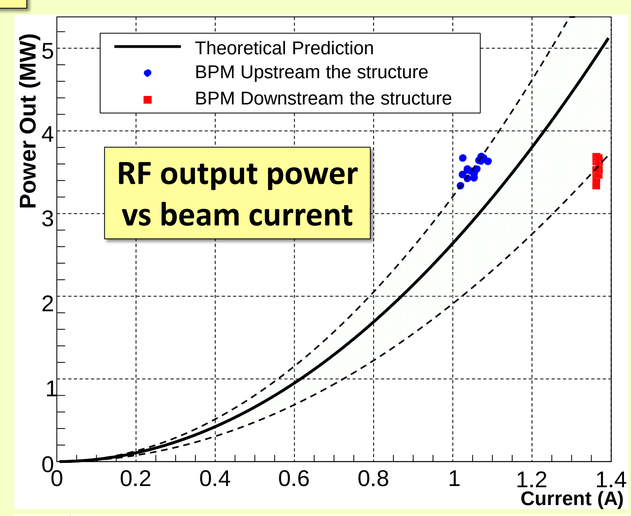
Beam properties:
- Electron beam at 130 MeV/c
- Beam current 1.2 A
- Pulse length up to 250 ns
- Pulse rep. freq. 25Hz

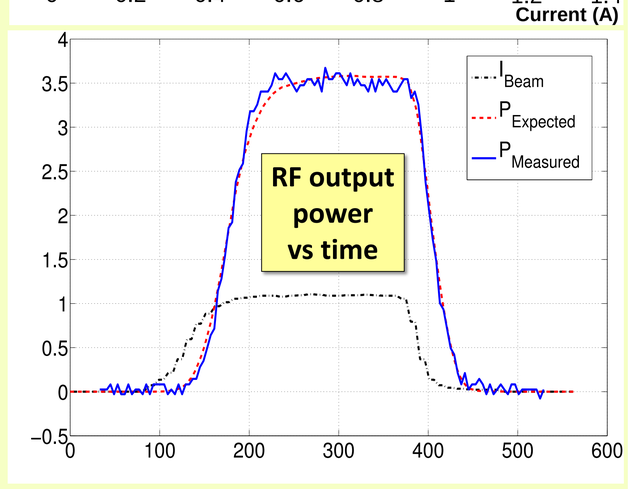
- Beam optics set to minimize beam losses inside the structure => waist towards the smaller iris
- Optimized placement of an 8 mm aperture collimator upstream the structure

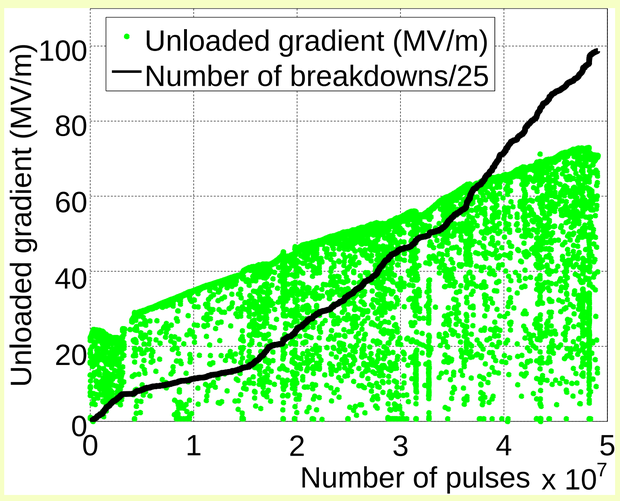
First Results

First stage (finished):

Only with beam loading → observe beam induced RF signals:
- beam transmission of 85-95% achieved
- RF signals measured for different levels of beam current
- Calibration error < 1.3 dB in power (on total 80-90 dB)
- Theoretical expectation within uncertainties of experimental measurements
- Time evolution of produced power (corrected for calibration error) at the structure output fits the analytical model







Second stage (Running):

RF + beam loading:
- Structure already connected to klystron
- Conditioning of the CLIC accelerating structure with RF progressing successfully

Next steps:
- measure RF breakdown rate without and with presence of the beam

For the first time, breakdown rate with beam-loading will be measured

Conclusion

- 1st Dedicated experiment to **measure** the **BD rate in presence of beam-loading**.
- Hardware and acquisition channels installed and commissioned.
- Initial RF conditioning progressing well.
- First loaded – unloaded comparisons coming soon.

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