THE TWO-BEAM TEST-STAND IN CTF3

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Abstract

The acceleration concept for CLIC [1], based on the two-beam acceleration scheme, where the 30 GHz RF power needed to accelerate the high energy beam is generated by a high-intensity but rather low energy drive beam, will be tested in the two-beam test-stand in CTF3. There RF-structures will be tested at full pulse length. The extreme power levels of up to 640 MW warrant a careful diagnostic system to analyze RF breakdown by observing the effect on both probe- and drive-beam but also the RF signals and secondary effects such as emitted light, vibrations, vacuum, temperatures. We describe the experimental setup and the diagnostic system planned to be installed in CTF3 for 2007.

INTRODUCTION

Once the drive beam complex of CTF3 [2] consisting of linac, delay loop and combiner ring is completed and beams with time-structure suitable for 30 GHz power generation are available in the experimental hall (CLEX) an extensive testing program for the power extraction and transfer structures (PETS) and the accelerating structures will commence in the two-beam test-stand (TBTS). The latter will be located in CLEX which is constructed throughout 2006, and after installation of general utilities such as water and electricity in the first quarter 2007 we will begin installing components.

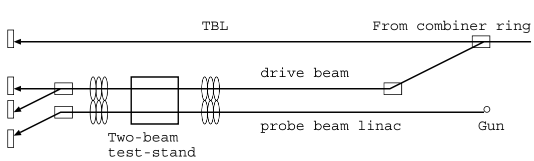

Figure 1: Beam line layout in the CLEX hall.

Figure 1 shows a rough sketch of the beam line layout in the CLEX hall where the beam from the combiner ring passes through TL2 and enters the CLEX area on the top right corner. The upper beam line is the Test beam line that will be used to test the drive beam stability in the PETS structures. The drive beam is also diverted by a chicane to run parallel to the probe beam linac [3]. Both drive- and probe-beam then pass through the TBTS before the beams are sent to their respective beam dumps.

A number of crucial feasibility tests for CLIC will be made for the first time using the two-beam test stand. The first of these tests will be to condition and operate a PETS structure up to the nominal output power of 640 MW and pulse length of 60 ns [4]. The test structure will have the same geometry as a CLIC PETS but only be longer to be able to generate the same power levels with a lower current beam - 30 A rather than 160 A [5]. The next tests will be to measure the effect of rf breakdown on the drive and probe beams. The latter measurement will be made by installing in the probe beam a CLIC accelerating structure which will be driven with the PETS. The measurements are crucial for determining the required breakdown rate for CLIC components. The test stand will then be used to demonstrate operation of a full CLIC module which consists of four accelerating structures driven by a PETS.

LAYOUT AND BEAM OPTICS

The heart of the TBTS are the experimental tables shown in Fig. 2 on which the structures will be located. The distance between the drive and probe-beam was set to 75 cm which is close to that foreseen for CLIC and is also small enough to avoid significant losses of the high power transport from PETS to accelerating structures while allowing sufficient space for installation of magnets and diagnostic elements in the respective beam lines. The height of the beam pipe above ground will be about 1.25 m. The beam pipe immediately adjacent to the experimental tables will contain valves to allow changing of the RF-structures without affecting the accelerator vacuum system. For the drive-beam the vacuum system will be made of aluminum because of the high peak currents, but for the probe beam it will be made of stainless steel. The diameter of the round beam pipe is 40 mm.

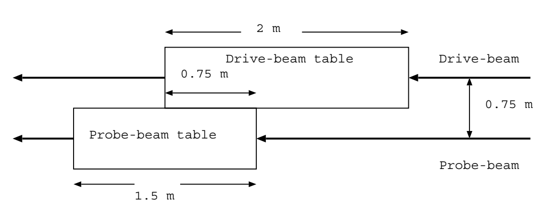

Figure 2: Table geometry

The requirement of small beams in the RF-structures on the experimental tables is most easily fulfilled by using quadrupole triplets. The triplet just upstream of the table will provide a beam waist on the table and the downstream triplet will provide small beam size on the OTR screen

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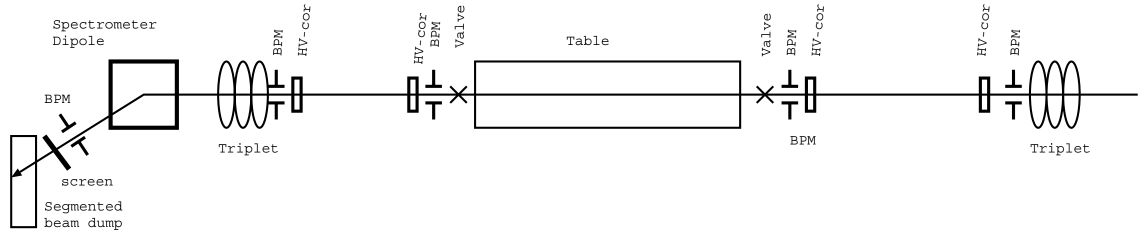

Figure 3: Schematics of the two-beam test-stand.

near the beam dump in order to optimize the energy measurement for which a spectrometer dipole will be installed downstream of the table. The spaces between the table and the triplets will contain a steerer dipole pair to allow easy control of angle and position on the table by ± 4 mm and ± 1 mm on the drive- and probe-beam respectively. For an overview of the equipment in the beam lines see Fig. 3 and for a 3D visualization refer to Fig. 4.

The PETS structures that will be tested on the experimental table in the drive beam occupy a length of 1.2 m with an aperture diameter of 16 mm. The beta function at the waist that optimizes the acceptance is 0.6 m. We found however that the most stringent aperture restriction comes from the central quadrupole in the triplets which favors a slightly increased minimum beta function of 1 m. Fig. 5 shows the corresponding beta functions. We have tuned the downstream triplet in such a way as to make an upright elliptical spot on the OTR screen near the beam dump to maximize the resolution of the energy measurement while relaxing the local power density on the screen. The beam optics in the probe-beam is very similar to that in the drive beam.

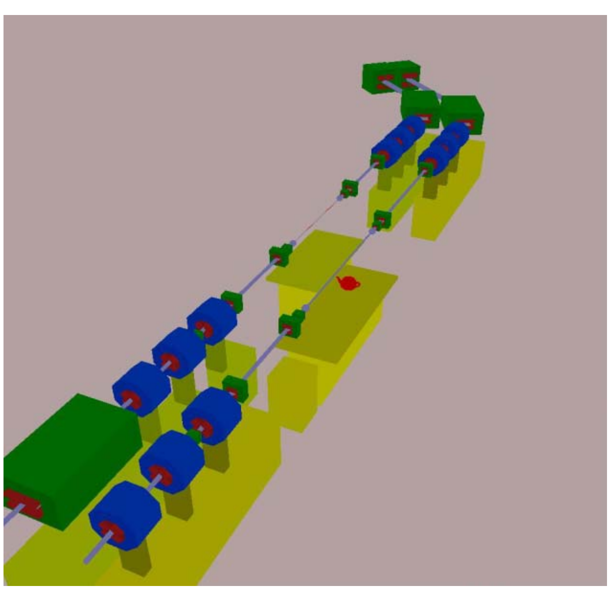

Figure 4: Visualization.

DIAGNOSTICS

The analysis of the RF signals will be done in much the same way as is done at the high gradient test-stand [6] where directional couplers are used to extract the 30 GHz signals, which are subsequently mixed down, detected, and sampled on a fast oscilloscope or fast digitizers [7].

The beam lines around the two-beam test-stand will be equipped with standard inductive BPM [8] that are used in most parts of the CTF3 complex and with screens [9] where we will use OTR screens in the drive-beam and, due to the lower current, more sensitive luminescence screens in the probe-beam. The BPMs for the probe beam will be slightly modified by reducing the number of turns on the secondary transformer and adjusting some resistors. This will increase the low frequency cutoff of the BPM but will make them more sensitive at lower currents will also improve their high frequency behavior at the expense of a droop, which, however, can be tolerated due to the short pulse length of the probe beam. The bandwidth of the BPMs is sufficient to resolve rise times on the order of 2 ns with standard electronics but with the mentioned changes this can be reduced by a factor 3 or more.

We will use the BPM to observe the kick that the beam receives due to RF-breakdown in the PETS and accelerating structures in drive and probe-beam, respectively. Determining the kick Δ and relative energy change $\Delta p/p$ that the beam experiences in the structures is conceptually similar to the determination of the beam-beam deflections in SLC [10]. We use the five BPM as indicated on Fig. 3 to determine the four parameters, incoming orbit x, x', kick Δ, and $\Delta p/p$. Kicks with a voltage of 2 kV correspond to a kick of about $10\,\mu$rad. Initial estimates of the sensitivity of the method indicate that BPM resolutions of around $10\,\mu$m are required to resolve them both transversely and longitudinally.

Of course one of the most important quantities to measure is the energy loss or gain in the drive- or probe-beam. It is the purpose of the spectrometer dipoles after the test-stand to generate dispersion which will allow to measure the energy distribution spatially resolved. First, there is a high bandwidth BPM that will be used to measure the center-of-mass energy distribution along the bunch train and a screen to observe the width of the energy distribution. The use of a segmented beam dump for time resolved

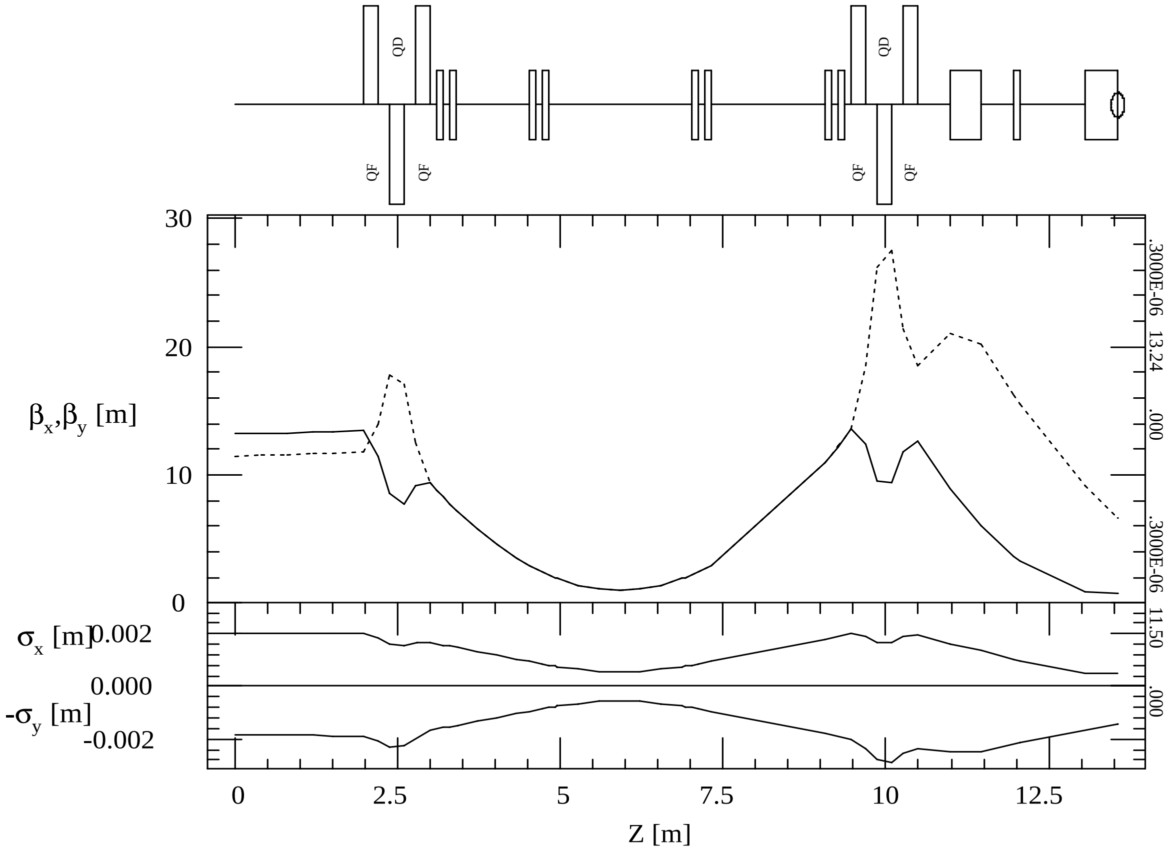

Figure 5: Drive-beam optics

distributions is under discussion.

We intend to complement the standard diagnostic items with sensors for emitted light, mechanical shocks, and cooling water temperature once the essential items are in place. A discussion of the data acquisition system can be found in ref. [11].

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