PRODUCTION OF S-BAND ACCELERATING STRUCTURES

Kai Dunkel, Christian Piel, Hanspeter Vogel, Peter vom Stein,
ACCEL Instruments GmbH, Bergisch Gladbach, Germany

Abstract

ACCEL currently produces accelerating structures for several scientific laboratories. Multi-cell cavities at S-band frequencies are required for the projects CLIC-driver-linac, DLS and ASP pre-injector linac and the MAMI-C microtron. Based on those projects differences and similarities in design, production technologies and requirements will be addressed.

CLIC DRIVER LINAC

The production of 18 CLIC Driver Linac structures [1] is under way at ACCEL Instrument GmbH [2]. Meanwhile more than 12 structures are delivered and successfully tested at CERN. The structure consists of 35 accelerating cells including the coupling cells with symmetric rf ports. Each cell contains four Silicon Carbide absorbers, which are coupled to the accelerating cells by the slotted cavity iris for HOM suppression. The operating frequency is 2998.55 MHz in $2\pi/3$ mode. The structure is designed for extreme high beam loading of nearly 98 %. The nominal input power is 30 MW at a pulse length of 1.5 µs resulting to an unloaded accelerating voltage of 13.5 MV.

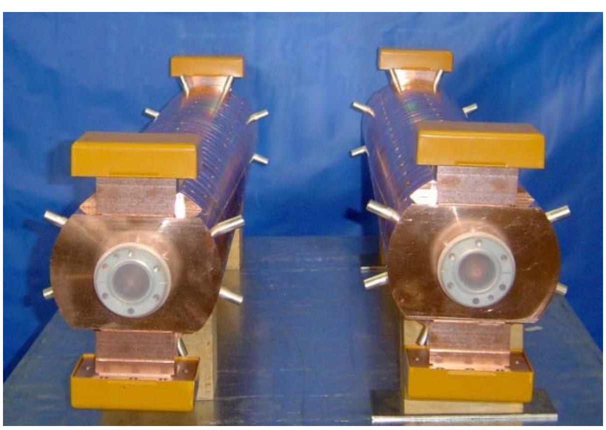

Figure 1: Two 1.22 m long CLIC Drive Linac structures ready for delivery.

The slotted iris geometry of the accelerating cells requires extreme care during the manufacturing process. After the turning and milling operations on the accelerating cells, which is similar to other standard S-Band structures, the cell is cut from the iris up to 10 mm away from the cell equator by wire spark erosion. This makes the cells fragile and sensitive to any mechanical deformations.

To assure the correct phase and amplitude tuning of the finished structure the frequency of each cell is measured before final brazing (Figure 2). A special test setup was built up at ACCEL for the measurement of the 0-mode and π- mode frequencies of each cell. This allows to calculate the $2\pi/3$ mode frequency of the individual cells. After the final brazing the phase advance and field distribution of each structure is checked by a bead pull measurement (Figure 3).

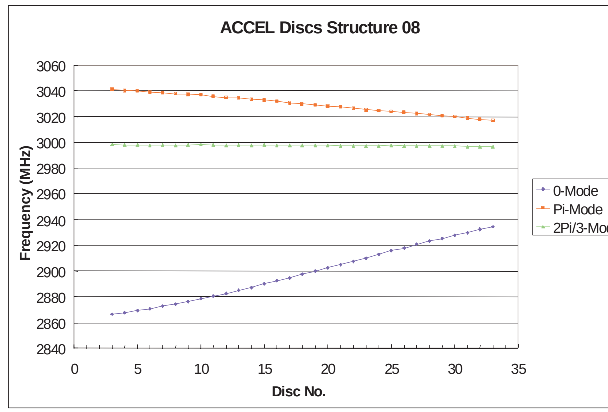

Figure 2: RF measurement of CLIC structure half cells.

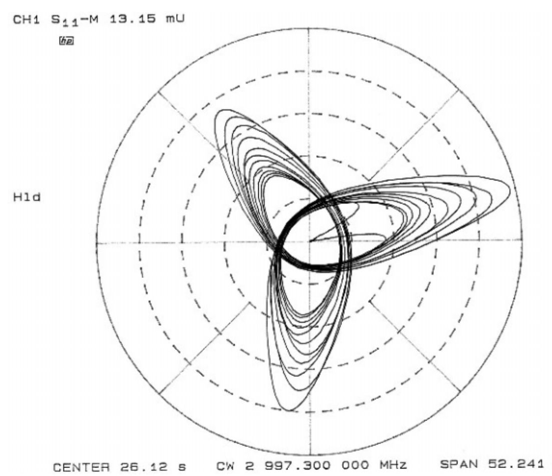

Figure 3: Bead pull measurement of a CLIC structure.

DLS AND ASP INJECTOR LINAC

ACCEL currently manufactures the 100 MeV injector linacs for the Diamond Light Source DLS [3],[4] and for the Australian Synchrotron Project ASP [5] based on $2\pi/3$ mode travelling wave S-Band structures, operating at 2.997912 GHz.

Already four structures of this type had been delivered in the past. Two structures serve the SLS [6] injector linac at moderate accelerating fields of 11 MeV/m very reliable since April 2000. Another two structures are used at MaxLab at much higher gradients of 25 MeV/m. The manufacturing technology and design allow as well the production of 6m long structures. The design of the 5.2m long structures has been transferred from DESY to ACCEL under a technology transfer contract.

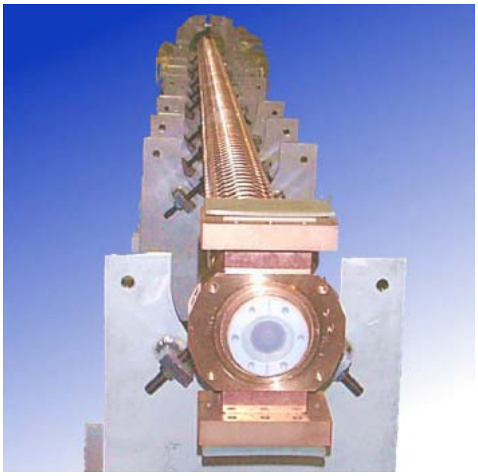

Figure 4: 5.2 m long S-Linac structure ready for delivery.

The accelerating structure incorporates the rf absorbers in the last cells, were the absorbing material is sputtered directly to the cell surface, so that only one ceramic window is required at the rf input coupler, this increase reliability of this structures and reduce required investment.

Required manufacturing technologies as precise turning, chemical cleaning, vacuum bracing of subassemblies and induction bracing of stacks, are well established technologies at ACCEL.

The quality is assured during the manufacturing process by rf measurements beside standard technologies as dimension control and vacuum leak checking. Each individual cell is measured according to its rf properties prior to stack brazing.

The final structure is tuned based on beat pull measurements and finally characterised by its field profile and cell to cell phase advance (Figure 5).

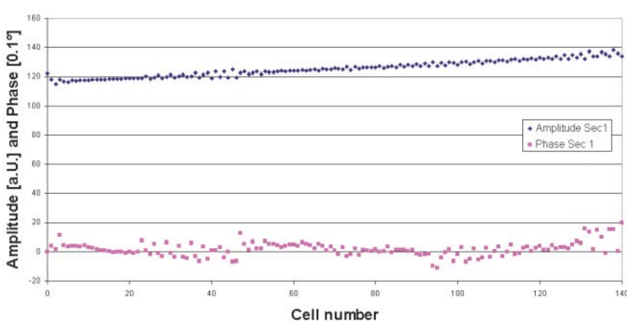

Figure 5: Bead-pull measurement after final tuning of the accelerating structure.

MAMI-C 2.45 GHZ AND 4.9 GHZ STRUCTURES

ACCEL is currently manufacturing 2.45 GHz and 4.9 GHz accelerating structures for MAMI-C at the "Institut für Kernphysik" (IKPH), University of Mainz [7],[8].

Design

The 2.45 GHz accelerating structure based on a Chalk River design and modified by IKPH is an on-axis-coupled biperiodic $\pi/2$ standing wave structure with 33 accelerating cells (AC) and 32 coupling cells (CC) and the RF input in the middle AC (Figure 7). It is vacuum brazed consisting out of 66 half cells of copper. The water cooling is realised by integrated cooling channels (Figure 6).

Figure 6: Pre-machined 4.9 GHz half cells (before coupling slot milling) and a 2.45 GHz half cell including coupling slots and tuner port.

The 4.9 GHz accelerating structure design is based on a scaled version from the 2.45 GHz structure, but has 35 AC, 34 CC and a higher coupling [9].

Figure 7: Complete brazed and assembled 2 m long MAMI-C 2.45 GHz structure.

Low-Level-RF Measurements

The frequency preset for machining of the half-cells is +1.5 MHz to allow a tuning step before brazing. The accuracy of machining can be determined by the frequency spread, which is σ=0.19 MHz for the manufacturing of the 2.45 GHz prototype structure. The pre-braze tuning has to be done carefully, since a post-braze tuning is not foreseen. The average difference to target frequency of all accelerating cells of the prototype structure is df_{avg}=-0.021 MHz with σ=0.049 MHz (Figure 8).

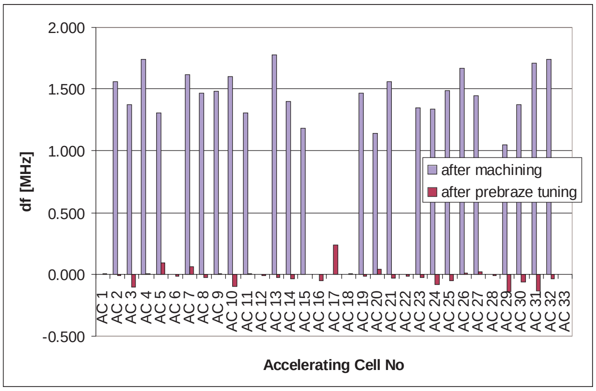

Figure 8: Frequency difference to target frequency before and after pre-braze tuning.

Bead-pull Measurements

The final proof of correct manufacturing and tuning is given by a bead-pull measurement of the complete structure after brazing and assembly. Figure 9 shows the bead-pull measurement of the 2.45 GHz prototype structure with nearly constant field in the accelerating cells. The fluctuation at the bottom line between the accelerating cells is artificial and caused by the small, but unavoidable spread of the lace diameter.

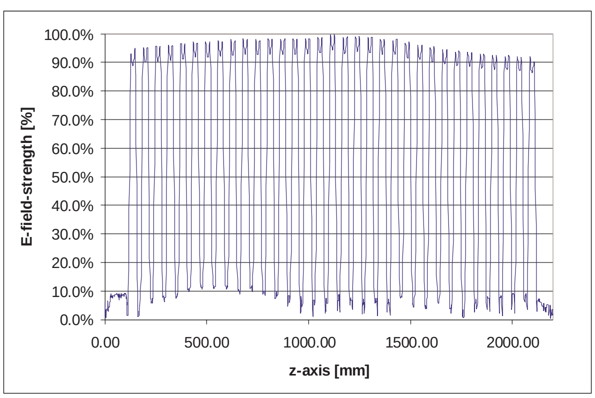

Figure 9: Bead-pull measurement after brazing at plunger norm position.

SUMMARY

Various types of S-Band type accelerating structures had been designed and/or produced at ACCEL Instruments. All projects require precise machining, brazing and close quality control by leak checks and intense rf measurements during the entire manufacturing process, generally ending in a bead pull to check amplitude distribution and cell to cell phase advance as our final quality control before delivery.

REFERENCES

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