Radiation Source ELBE

Forschungszentrum Rossendorf

FIELD PROFILE MEASUREMENT OF THE 3½ CELL SRF GUN

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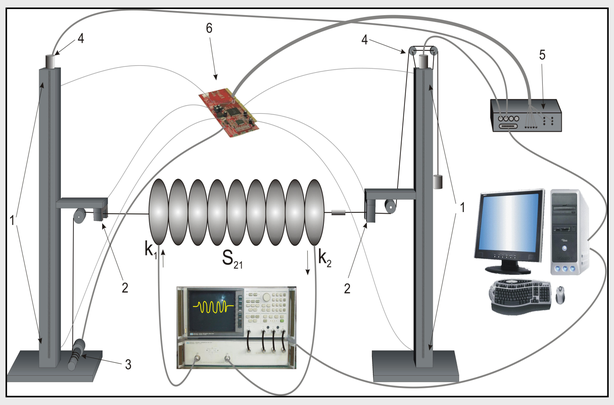
Introduction

Since the proof-of-principle experiment on the SRF gun in 2002 [1] progress was made to build a 3 ½-cell prototype injector at the ELBE facility at FZ-Rossendorf. Fabrication of two 3 ½-cell cavities at ACCEL (RRR 40 and RRR 300) has been finished. Before etching and rinsing the cavities at DESY, the field profile has been measured before and after tuning at FZ-Rossendorf by using the hardware and software presented here.

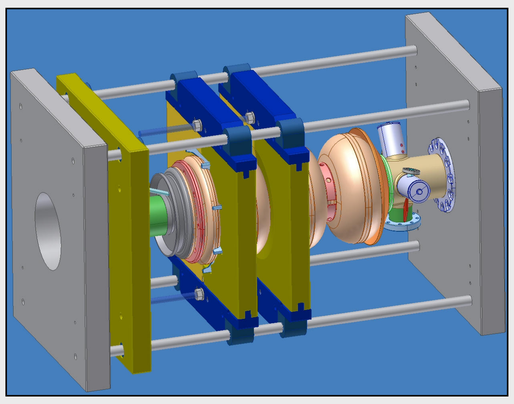
Hardware

A cavity tuning machine with integrated bead pull measuring device has been built. In a first step the pc-controlled bead pull measuring device was developed and tested with several cavities. A pillbox resonator was machined and used to calibrate different beads /2/.

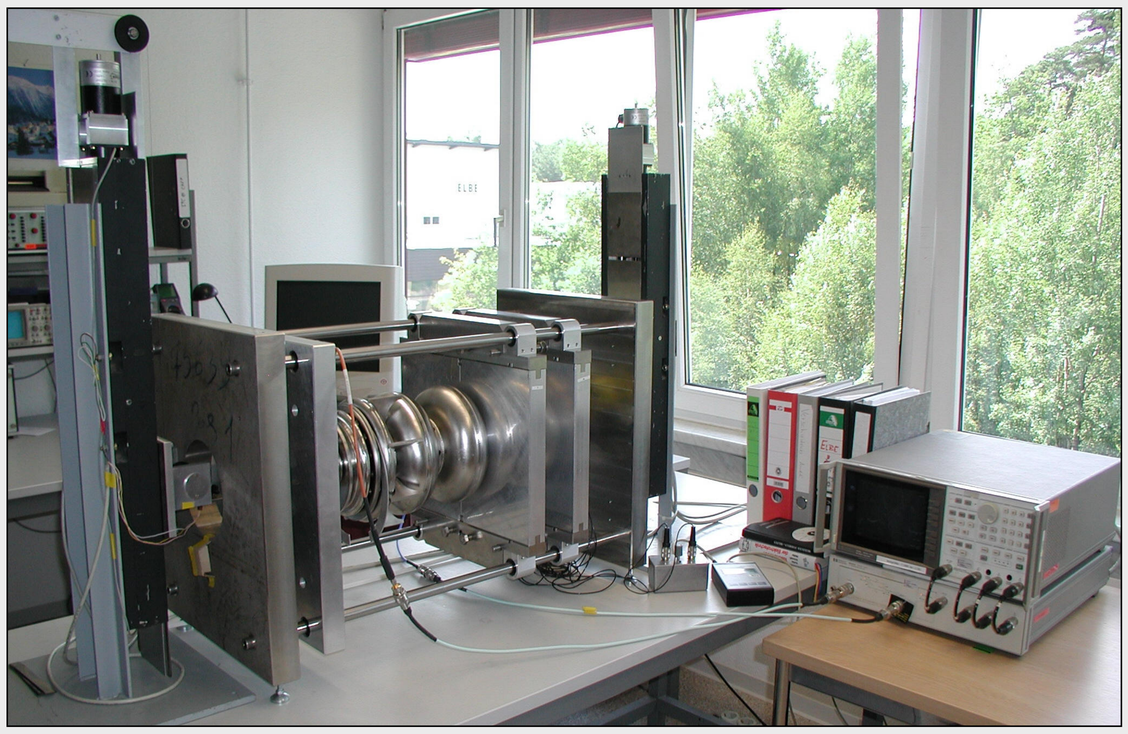
In a second step this device has been integrated into the tuning machine.



PC-Controlled Bead Pull Measuring Device (Principle)
1: Sensors-vertical position, 2: Sensors horizontal Pos.,
3: DC-Motor (bead pull drive), 4: Stepper motor (vertical pos.),
5: Motor control box, 6: Sensor hardware,



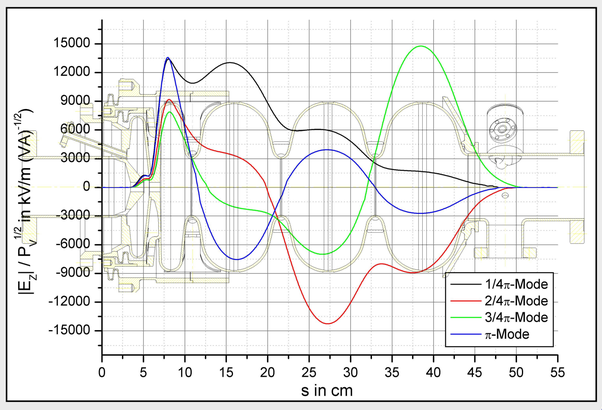
3D-CAD-Model of the tuning machine used to push and pull each cell to the right frequencies



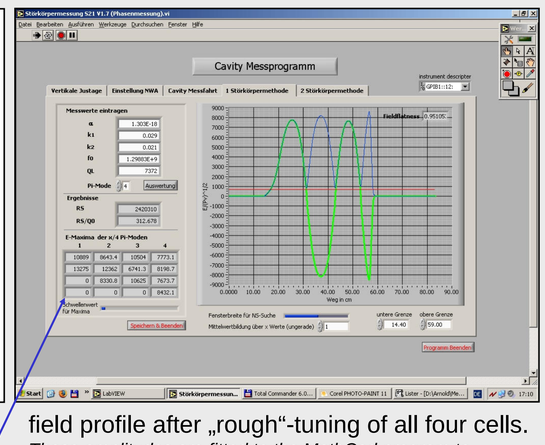
setup of the cavity tuning machine with integrated bead pull measuring device

Software

Based on the work presented in /3,4,5,6/ a LabView based program was written to control the bead pull measuring device.



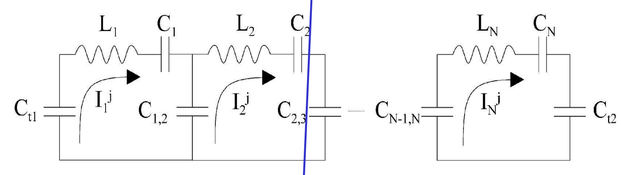
field profiles of the Passband-Modes before tuning



field profile after „rough“-tuning of all four cells.
These amplitudes are fitted to the MathCad program to calculate the next tuning step.

Tuning Algorithm

Equivalent network of an arbitrary cavity



With Kirchhoff's loop rules one receive the eigenvalue matrix equation for the equivalent network with Ω^j as the eigenvalues and I_n^j as the corresponding j^{th} column eigenvector.

$$A \bullet I^j = \Omega^j I^j \quad , \quad \Omega^j = \left(\frac{\omega^j}{\omega_0}\right)^2 \qquad (1.1)$$

$$\omega_0^2 = \frac{1}{LC}, \quad 1+\delta_n = \frac{C}{C_n}, \quad k_{n,n+1} = \frac{C}{C_{n,n+1}}, \quad \gamma_{1..2} = \frac{C}{C_{t1..2}} \qquad (1.2)$$

$$A = \begin{bmatrix} 1+\delta_1+k_{1,2}+\gamma_1 & -k_{1,2} & 0 & \cdots & 0 \\ -k_{1,2} & 1+\delta_2+k_{2,1}+k_{2,3} & -k_{2,3} & \cdots & 0 \\ 0 & -k_{2,3} & 1+\delta_3+k_{3,2}+k_{3,4} & \cdots & \vdots \\ \vdots & \vdots & \vdots & \ddots & -k_{N-1,N} \\ 0 & 0 & \cdots & -k_{N-1,N} & 1+\delta_N+k_{N-1,N}+\gamma_2 \end{bmatrix} \qquad (1.3)$$

By measuring the amplitudes I_n^j of all j^{th} TM_{010}-Modes in each n^{th} cell one obtain the characteristic matrix A by the matrix equation

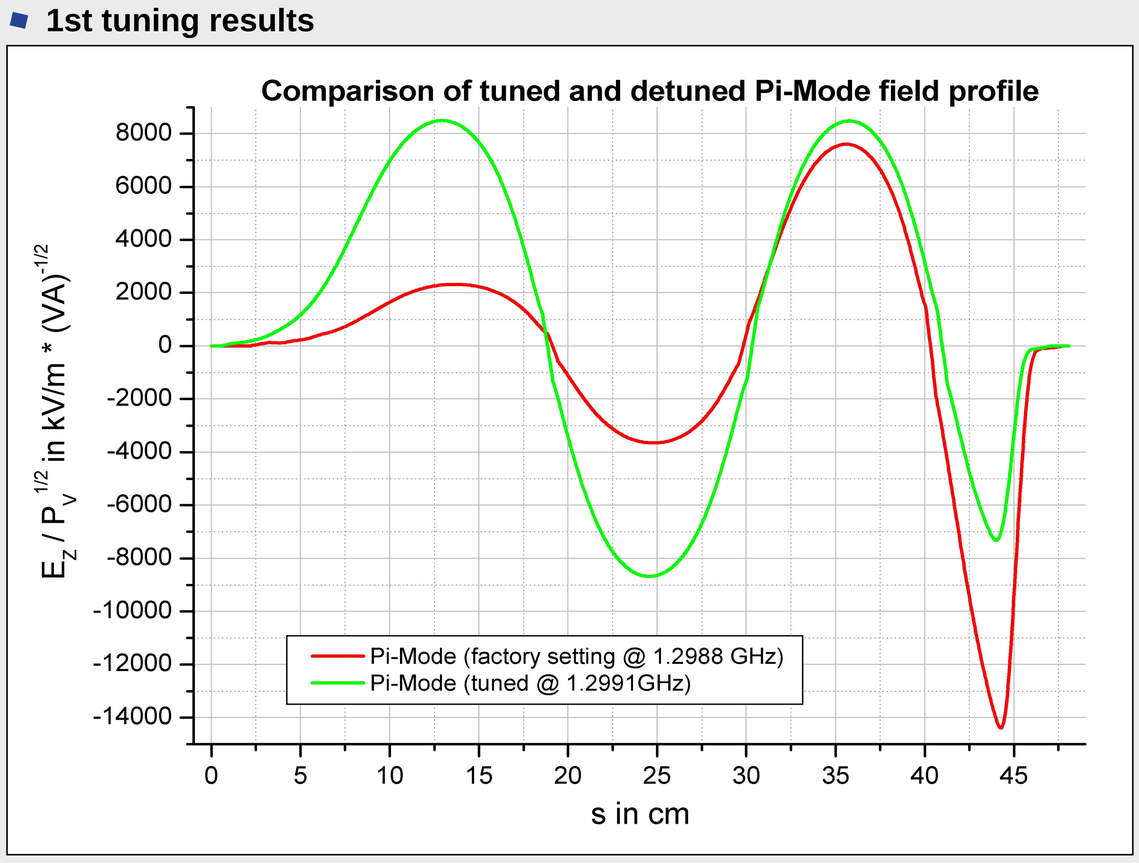
$$A = J \bullet D \bullet J^{-1} \quad , \quad J = \begin{bmatrix} I_1^1 & \cdots & I_1^j \\ \vdots & \ddots & \vdots \\ I_n^1 & \cdots & I_n^j \end{bmatrix} \quad , \quad D = E \bullet \begin{pmatrix} \Omega^1 \\ \vdots \\ \Omega^j \end{pmatrix} \qquad (1.4)$$

By solving the correction matrix P with the favoured current magnitudes at the π-Mode frequency, one get the amount to tune each capacitor for the desired field profile.

$$(A+P) I_{tuned}^j = \Omega_{tuned}^j I_{tuned}^j \qquad (1.5)$$

$$P = \begin{bmatrix} P_{1,1} & 0 & \cdots & 0 \\ 0 & P_{2,2} & \cdots & \vdots \\ \vdots & \vdots & \ddots & 0 \\ 0 & \cdots & 0 & P_{N,N} \end{bmatrix} \quad , \quad I_{tuned}^N = \begin{bmatrix} 1 \\ -1 \\ \vdots \\ (-1)^{N-1} \end{bmatrix} \qquad (1.6)$$

1st tuning results



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References

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