Development of a digital controlled vertical test system for SC Tesla Cavities

Marc Wenskat – Universität Göttingen @ DESY

Thanks to: Prof. Quadt
Prof. Elsen
Sven Karstensen

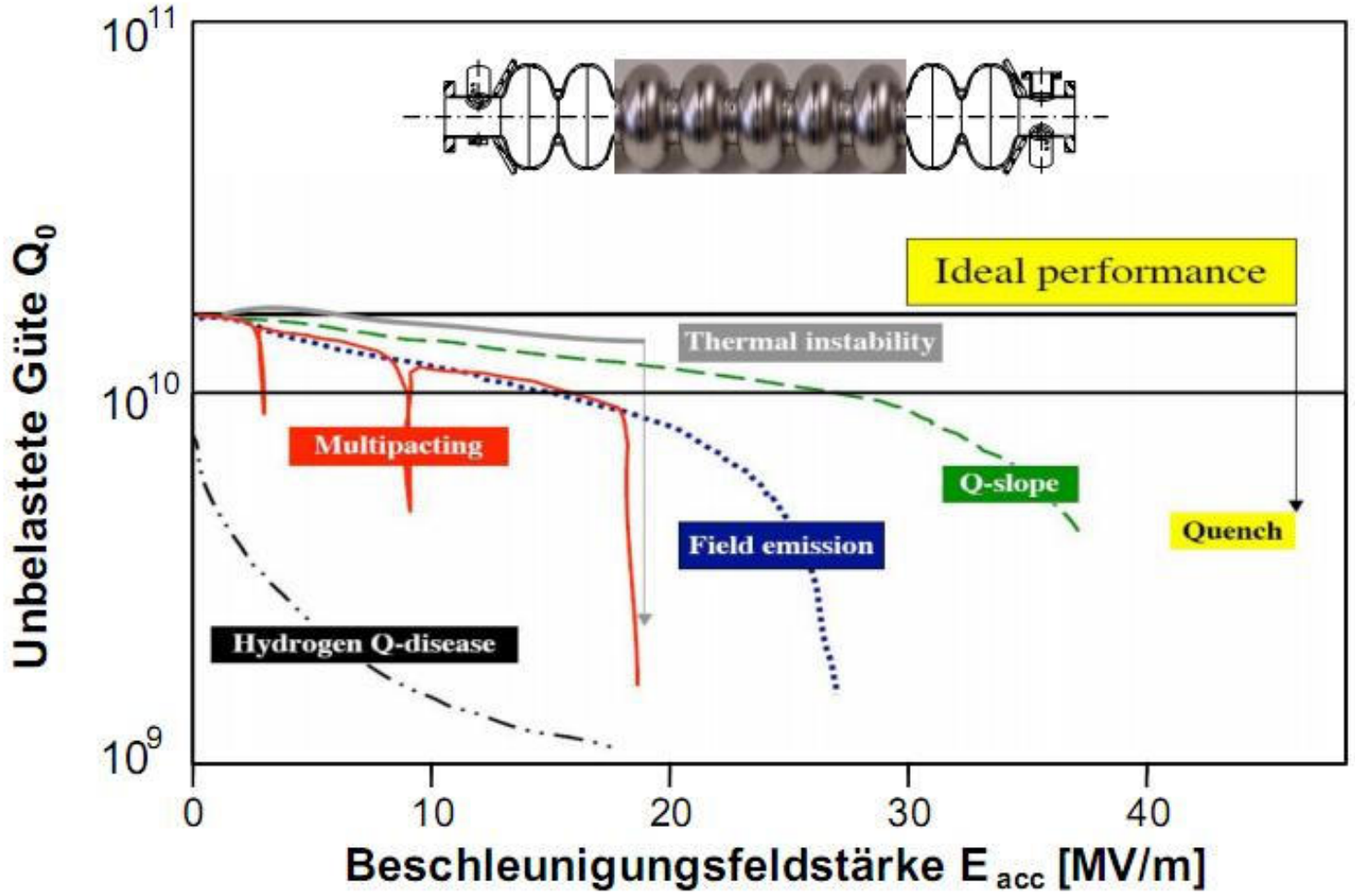
II. Institute of Physics
Atomic and Nuclear Physics

PHYSICS AT THE TERA SCALE
Helmholtz Alliance

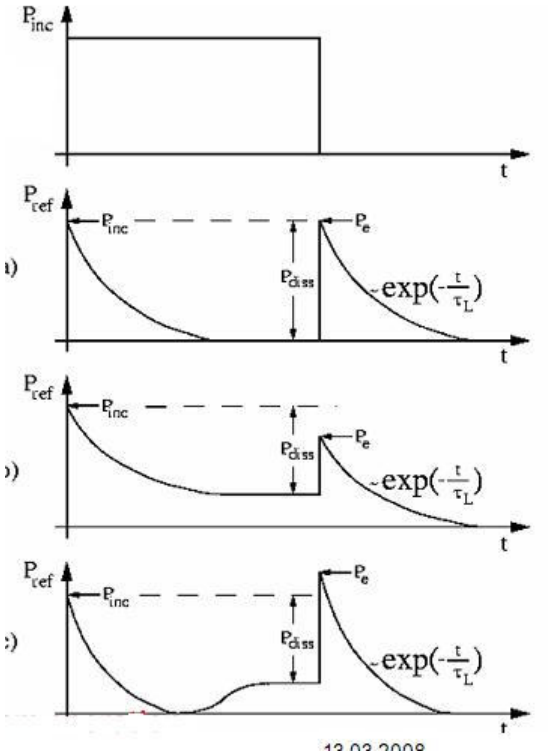
Outline

- motivation for Q-E-measurements
- principles of cavity testing
- short technical description of old and new system & motivation for digital control
- current results

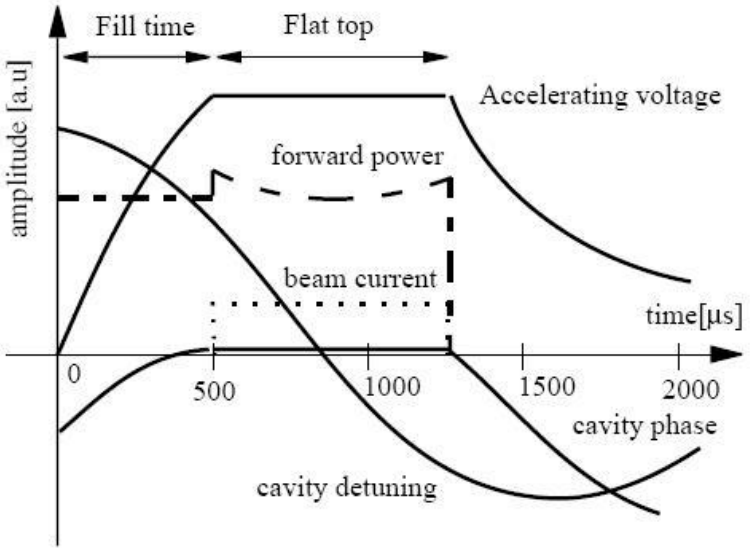
What a Q-E-Plot tells us



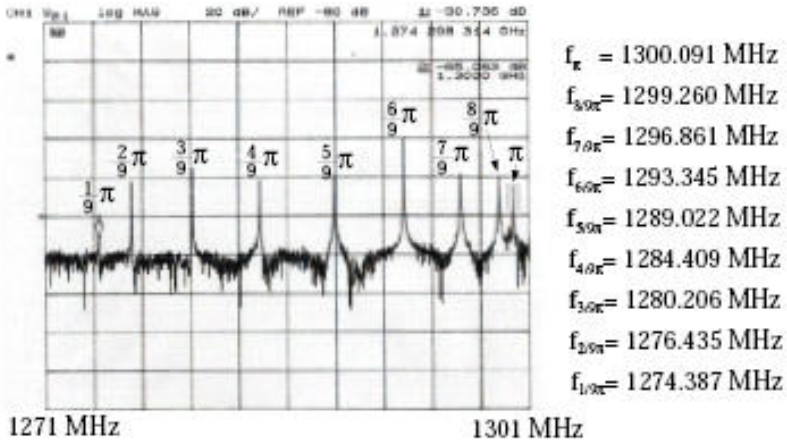
Relevant Signals



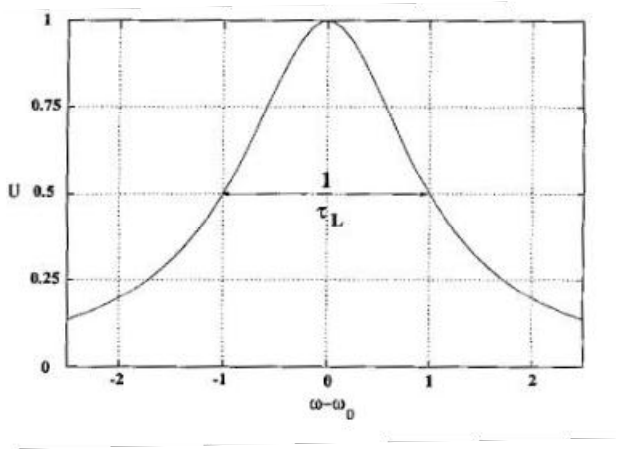
$$\beta = \frac{1}{2\sqrt{\frac{P_F}{P_E}} - 1}$$

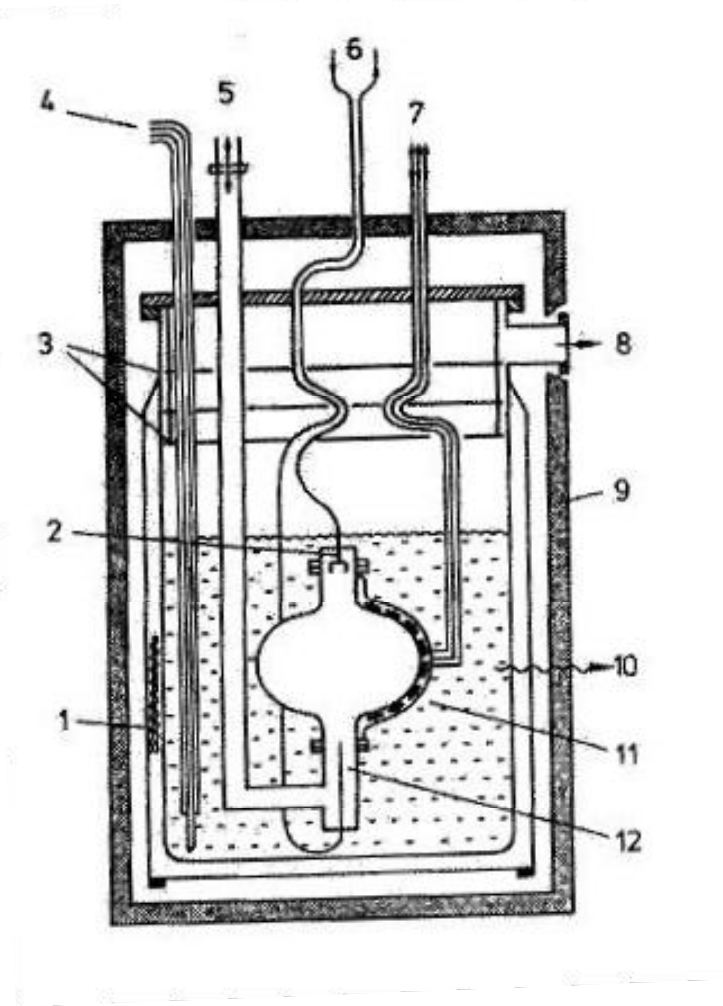


Coupling is defined by $\beta = \frac{Q_0}{Q_L}$ and can be controlled with the antenna depth.



How to get the unloaded Q



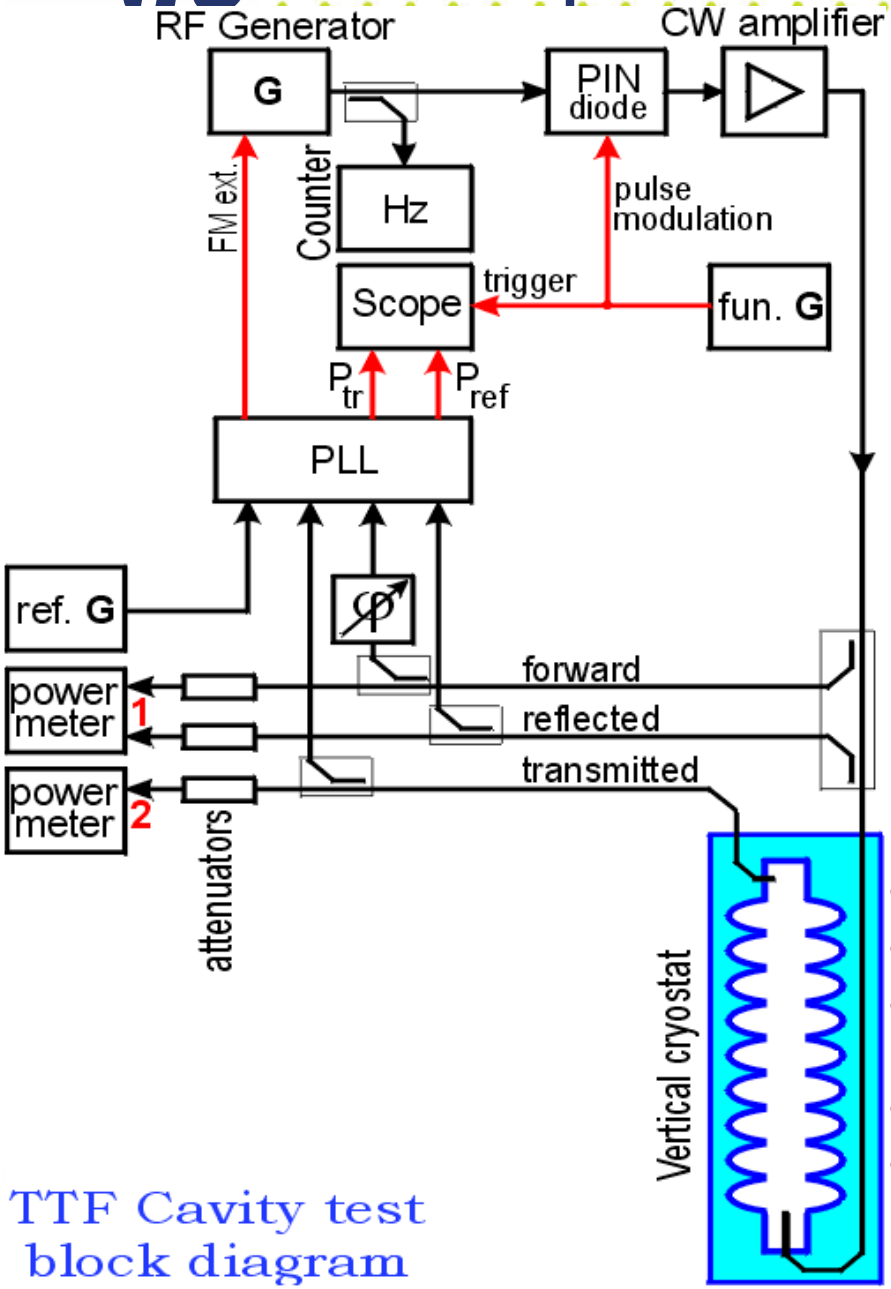


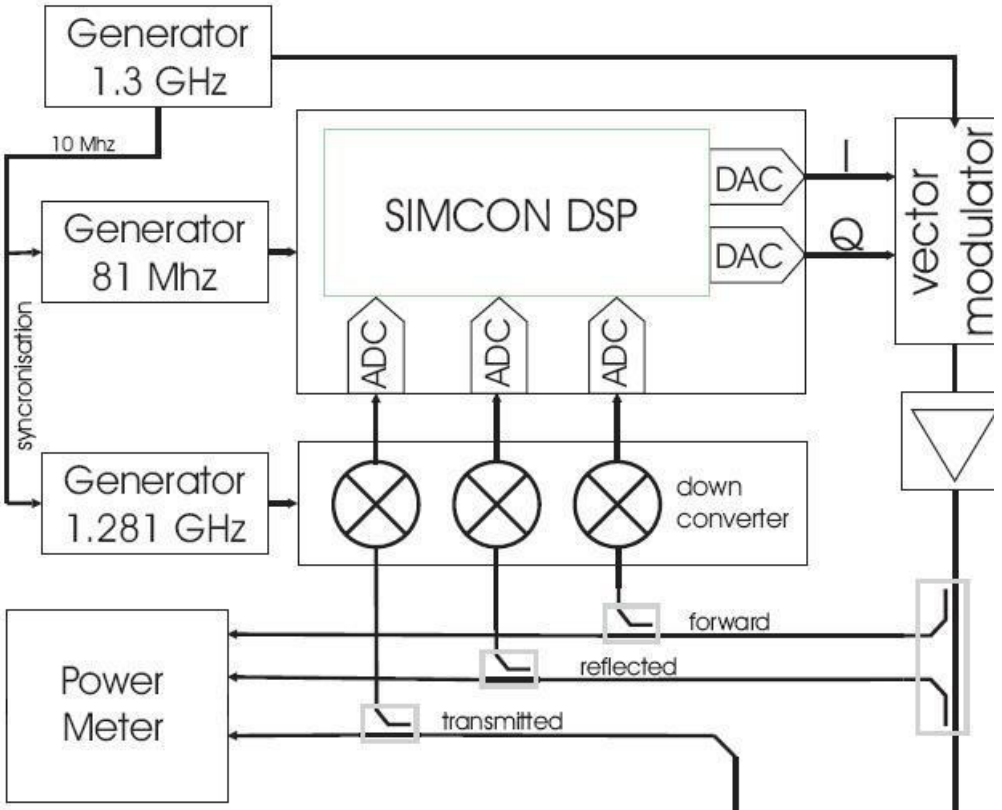
$$\Delta\omega = \pm\frac{\omega_0}{2Q_L}$$

$$\Delta\omega = \frac{1}{2\tau_L}$$

$$\Rightarrow Q_L = 2\cdot\pi\cdot f\cdot\tau$$

Compare analog vs. new





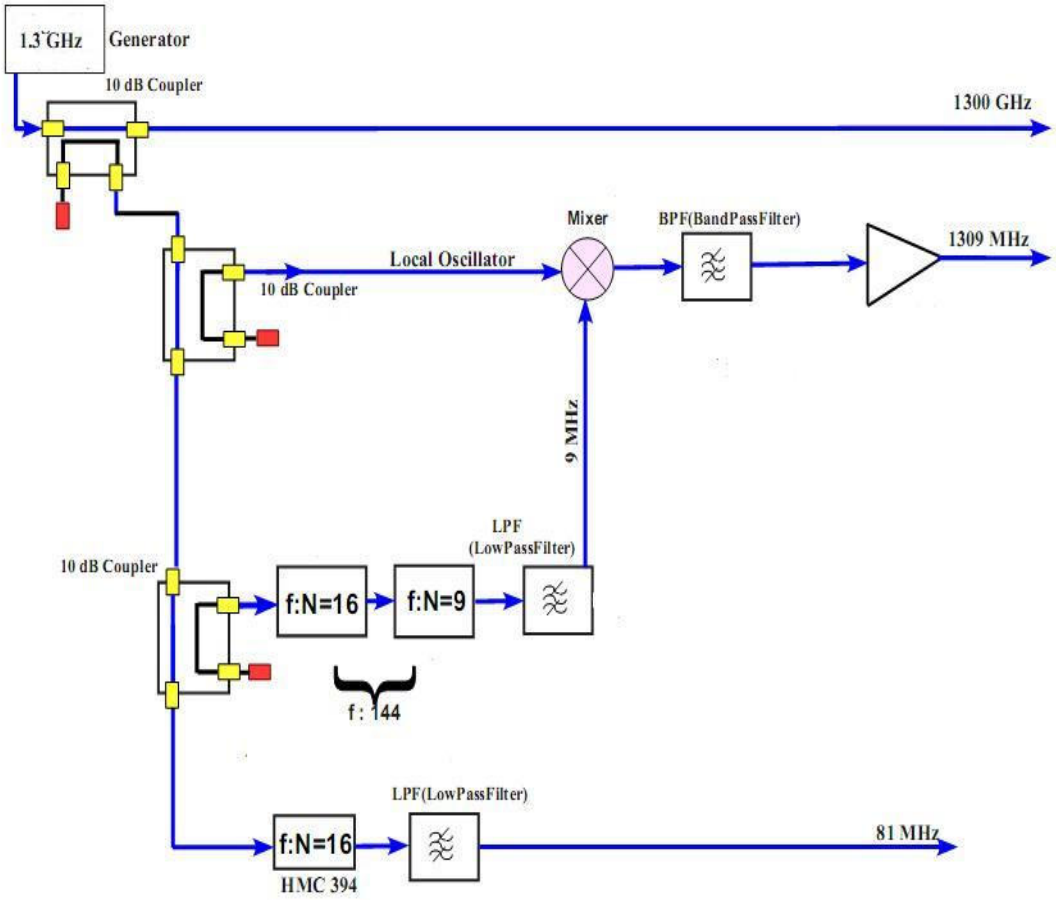
- flexibility
- easy to operate
- DAQ already needs conversion of analog signal to digital
- remote controllable
- time saving & cost reducing

TTF Cavity test block diagram

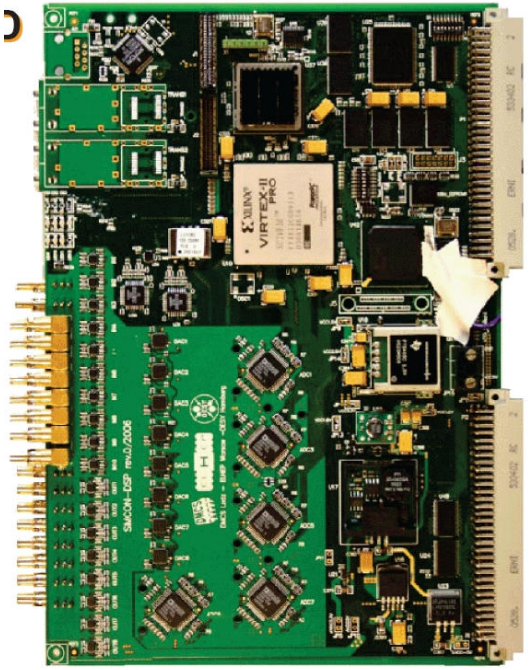
Essential Part‘s

- Frequencybox:

  3 Frequencies in Phase and in rational ratio to each other

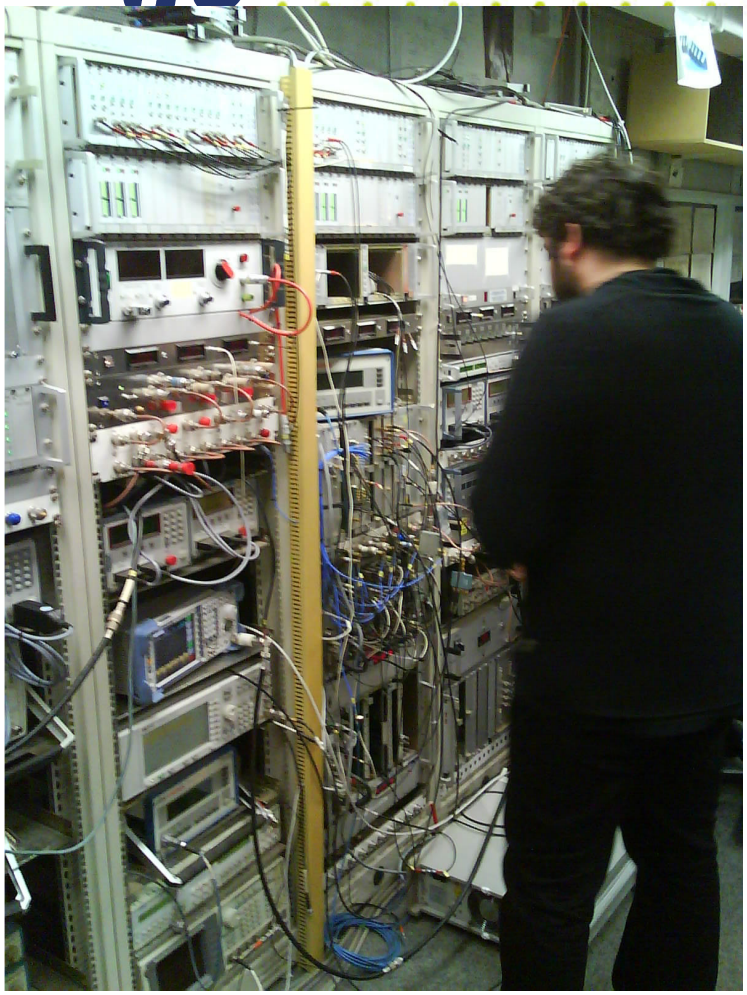


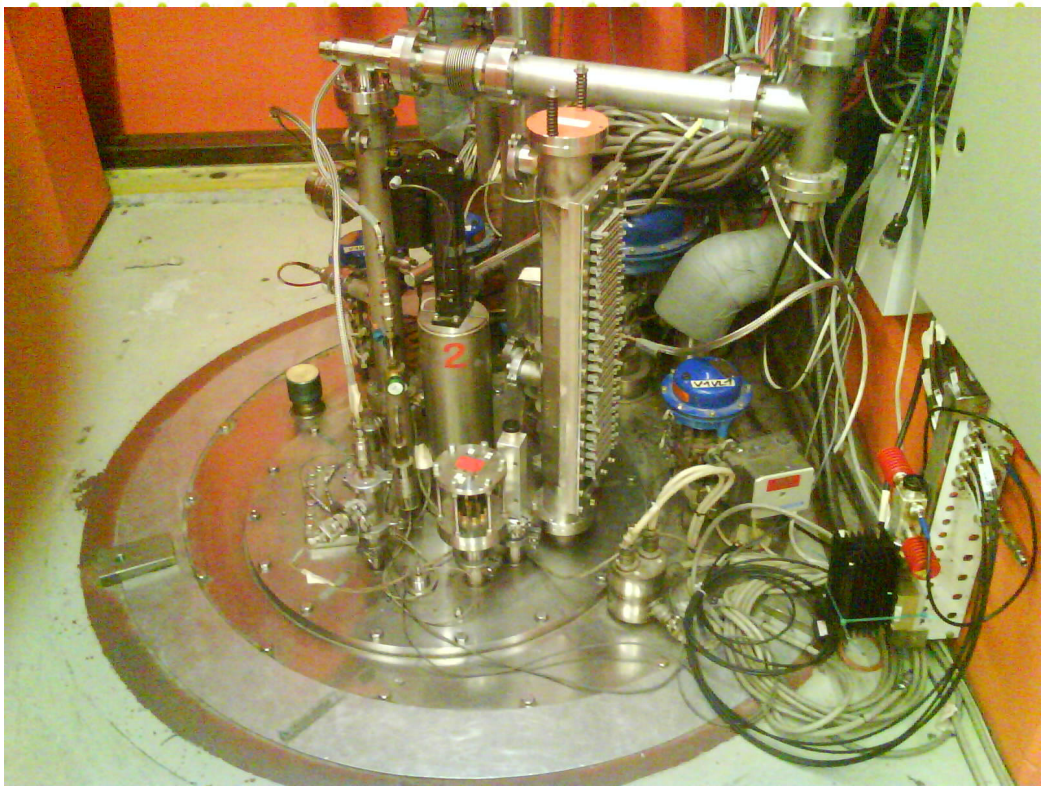
- SIMCON DSP:
  - XilinxVirtexII
  - TigerSharkDSP
  - 10 ADCs (14 Bit) (900ns)
  - 8 DACs (16 Bit) (500ns)
  - 2 optogigalinks
  - VME interface

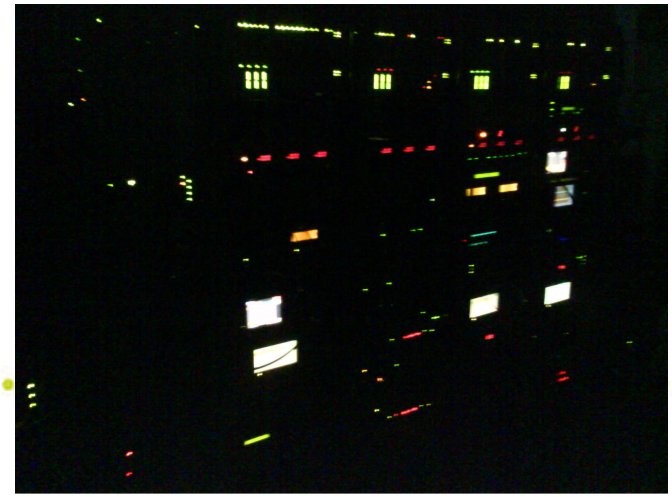


Courtesy S. Simrock

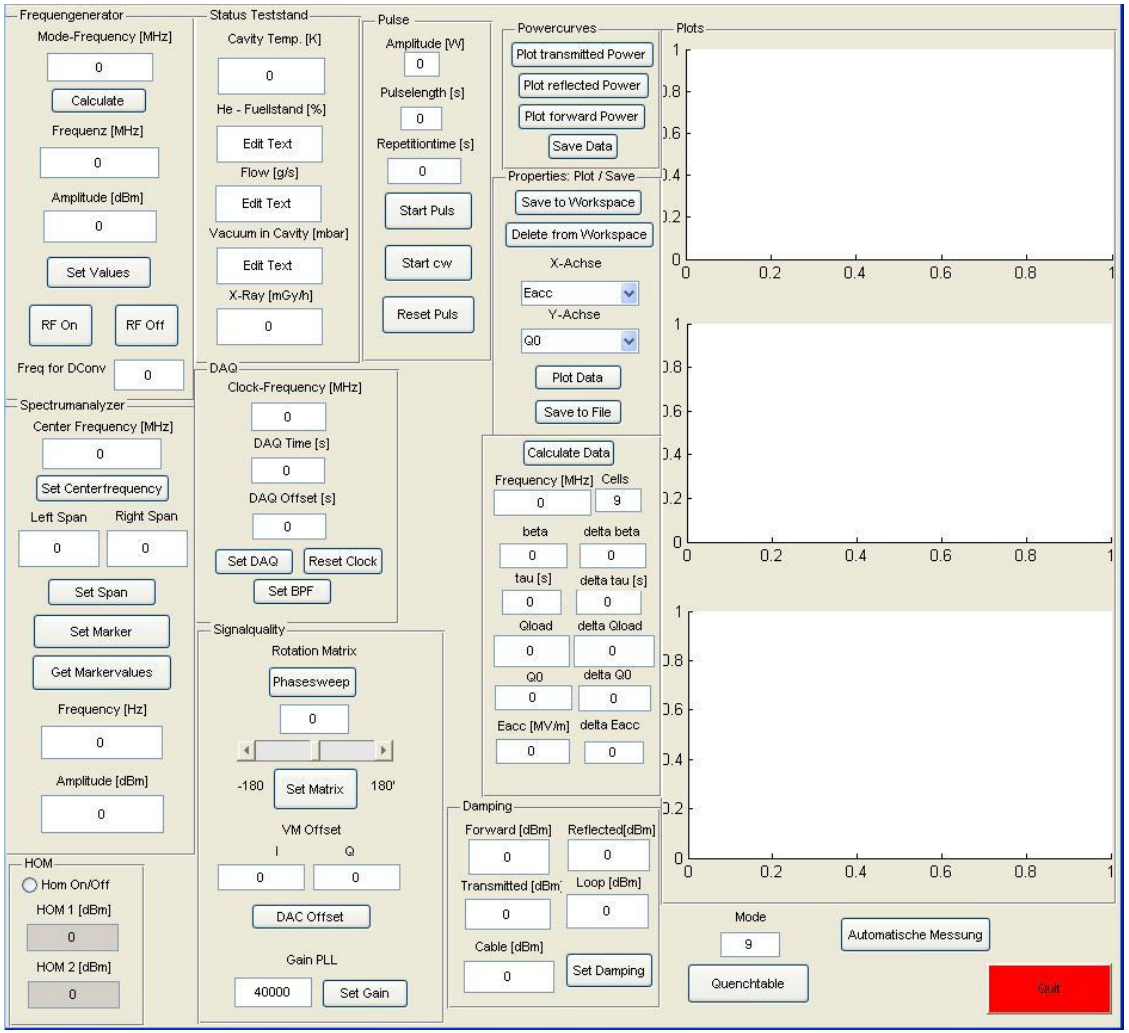
How it really looks

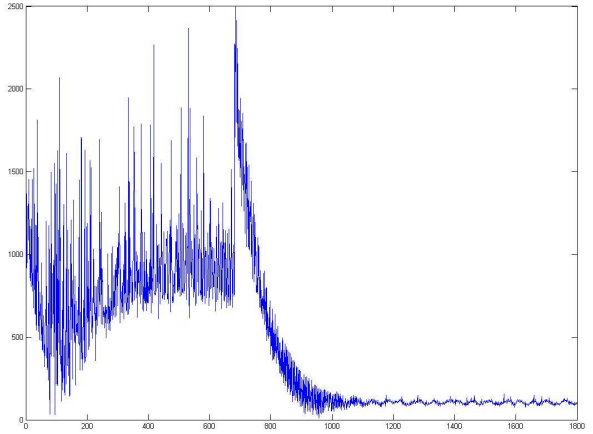


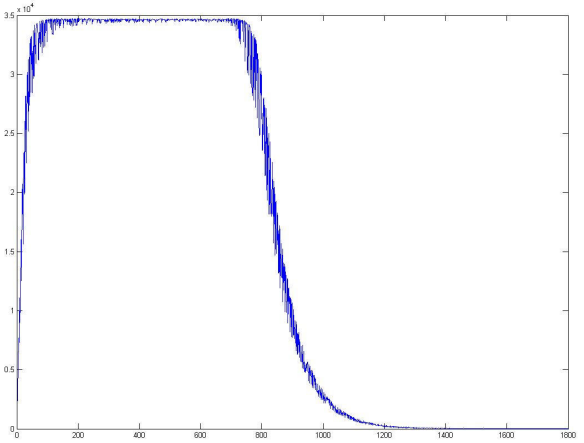




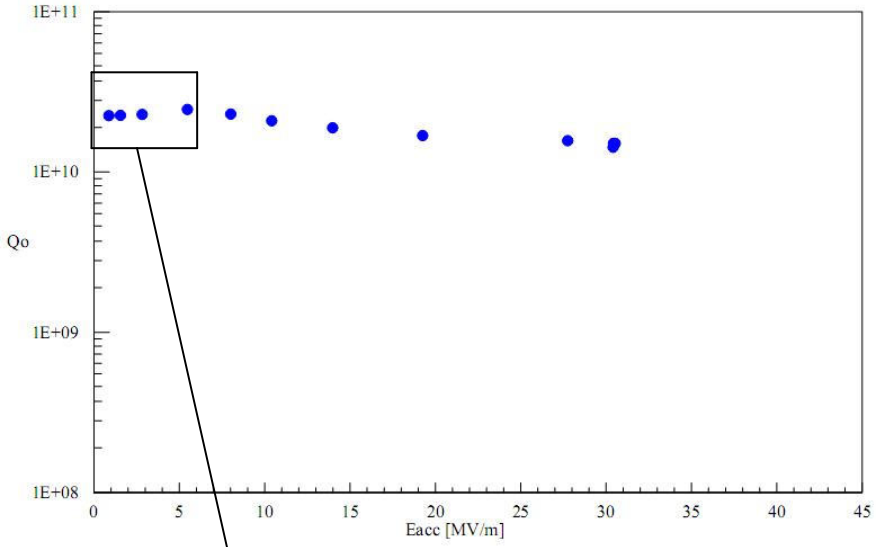
Graphical User Interface (GUI)

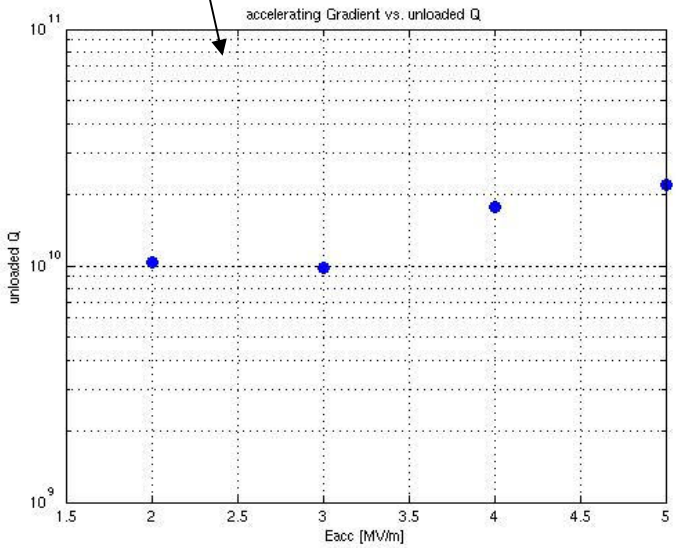






Summary & Preliminary Results





- automatic measurement up to 5MV/m possible
- algorithm finds correct phase, sweeps forward power and calculates every needed value

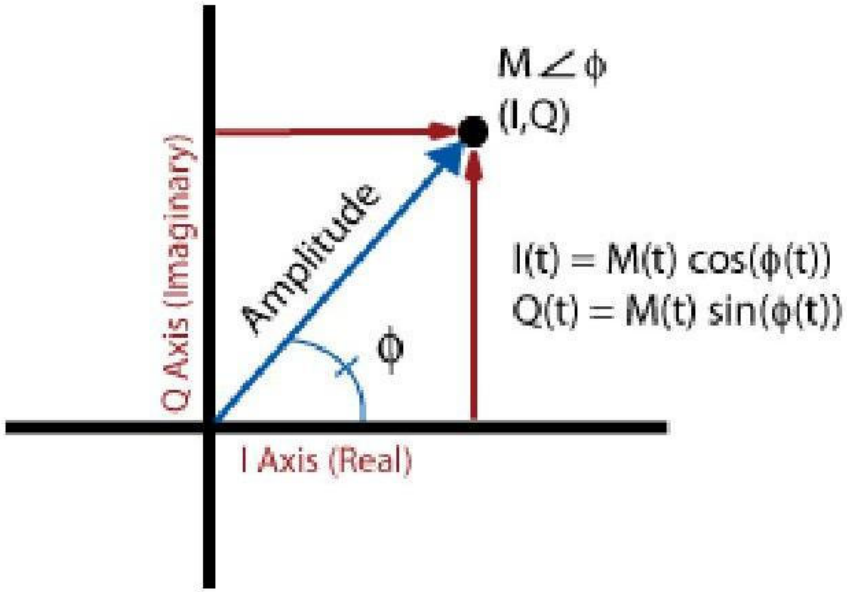
still needed to be done:

- implement algorithm for automatic frequencysearch
- correct calibration of ADC with new controllable attenuator
- get rid of the noise
- communication with DOOCS

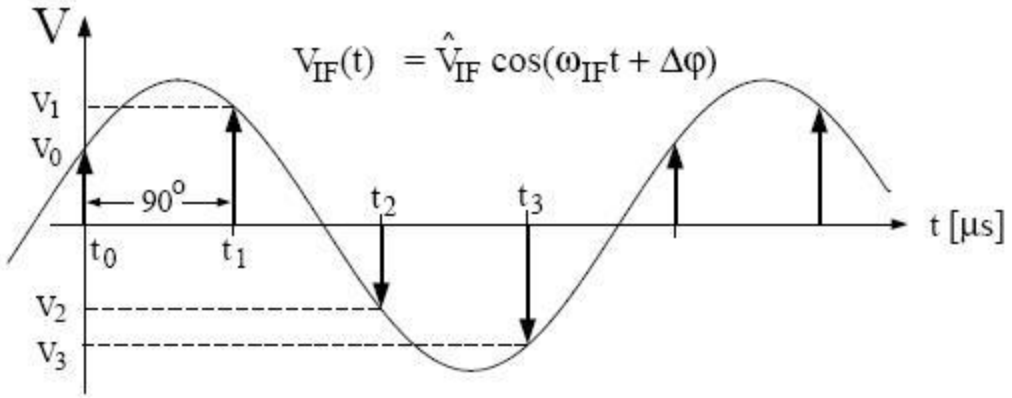
Bibliography

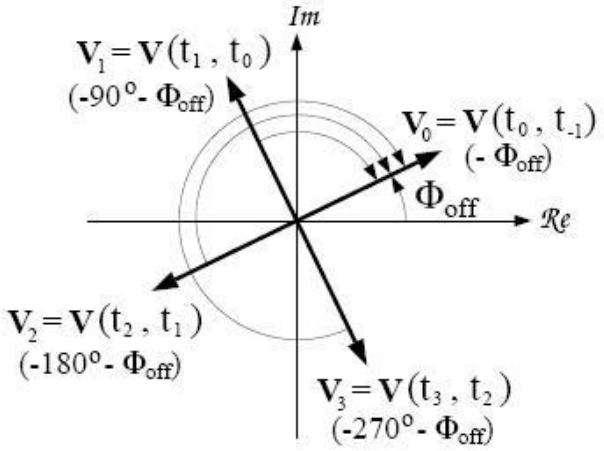
- [1] T. Schilcher - Vector Sum Control of Pulsed Accelerating Fields in Lorentz Force detuned Superconducting Cavities (Thesis)
- [2] H. Padamse - RF Superconductivity for Accelerators (Book)
- [3] V. Ayvazyan - LLRF Systems for TTF / VUV-FEL
- [4] H. Weise - Neuentwicklungen in der Beschleunigertechnologie (held at DPG2008)
- [5] S. Simrock - Experience with the Control of the vector sum at the TTF
- [6] S. Simrock - Measurements for low level RF control systems
- [7] W. Jalmunza - Performance of 24 Cavity Vector Sum Controller with distributed Architecture
- [8] L. Lilje - Superconducting Radiofrequency Accelerating Structures (held at TAS)
  - Experimental Investigations on SC Nb Cavities at High RF Fields
- [9] J. Sekutovic - Superconducting high beta cavities (held at SRF 07)

IQ Vector modulation

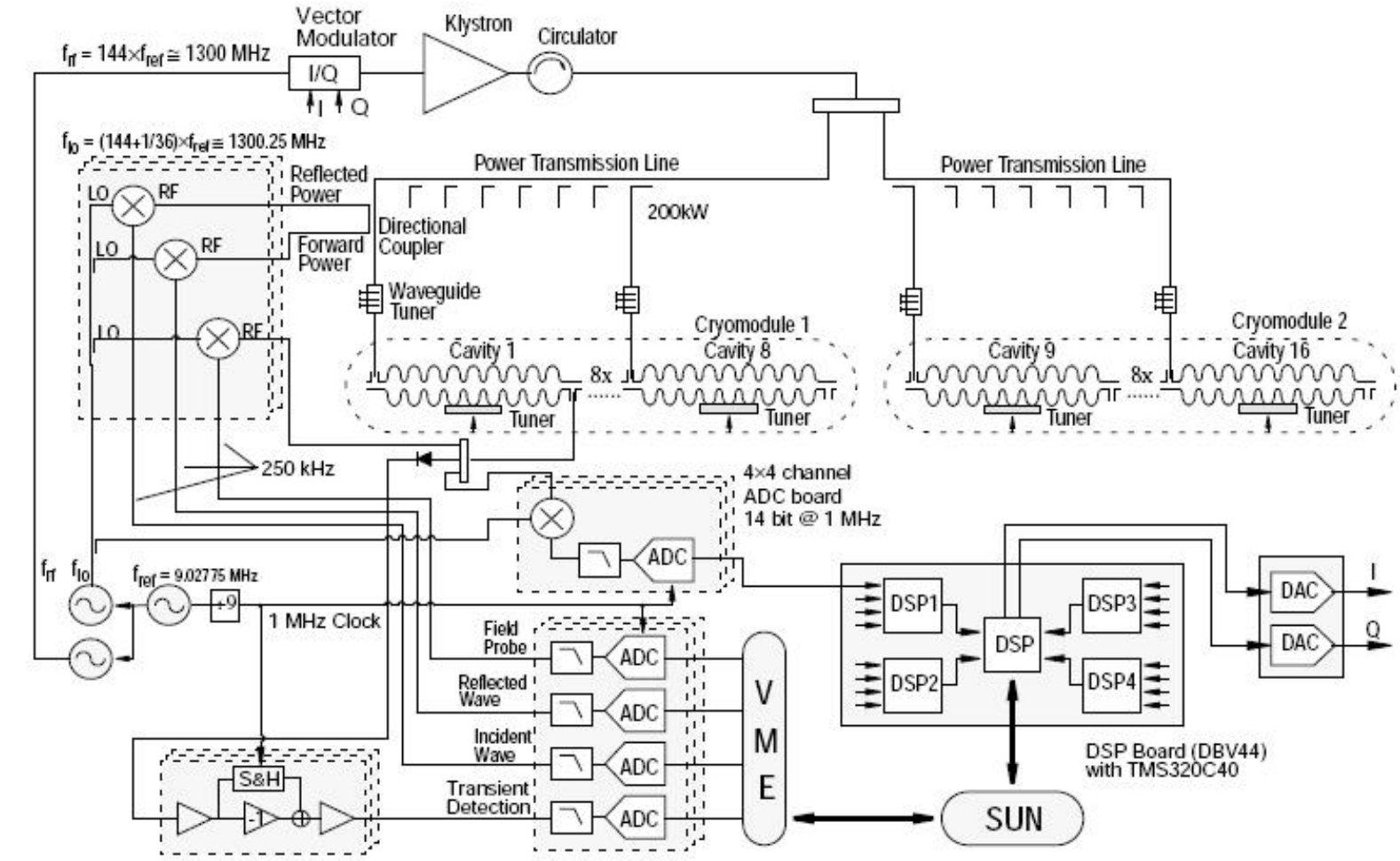


- Representation of Amplitude and Phase in State space normally in polar coordinates – IQ means Cartesian Coordinates
- Sampling Frequency 4 x IF
- To compare values, need to rotate the IQ-Vector
- With modulating I and Q in time you control Amplitude, Phase and Frequency of Sign





Layout of LLRF Control



$$\vec{V}_{sum}\cos(\phi_{sum}) = \sum_i \vec{V}_{i,cal}\cos(\phi_{i,cal}) = \sum_i \begin{pmatrix} a & b \\ b & -a \end{pmatrix} \vec{V}_{i,cav}\cos(\phi_{i,cav})$$

Example Q-E Plots