MAX-lab

MAX II RF system

100 MHz technology

Lars Malmgren

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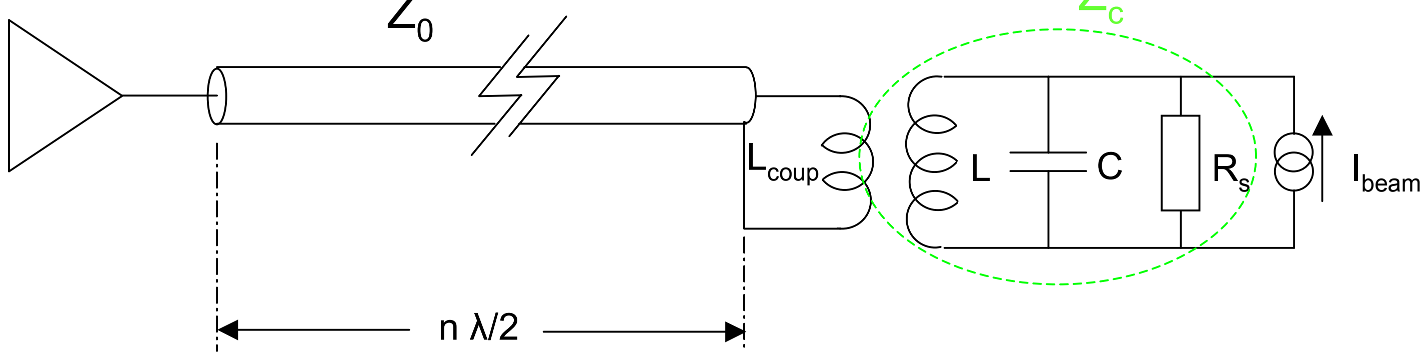
Facts and figures

	MAX-II
Frequency [MHz]	99.956
Harmonic number	30
No of cavity cells	3
No of transmitters	3
Cell radius [m]	0.41
Tot length of cavities [m]	1.5
Tot R_{shunt} ($\equiv V*V/P$) [MΩ]	9.6
Q-value	19000
Tot Voltage [kV]	450 (530)
Cu losses [kW]	21 (29)
Beam power @ 250mA [kW]	35 (50)
Available power [kW]	90
Net power [kW]	93(135)
Bucket height [%]	3.0
Synchrotron frequency [kHz]	8
Rms bunch length [cm]	1.7

Simple circuit model of the RF-system with beam

Z_c=cavity impedance



$L_{coup} \ll L$

$$\beta = \frac{R_S}{Z_0} \cdot \frac{L_{coup}}{L}$$

$$Z_0 = \frac{R_S}{\beta} \cdot \frac{L_{coup}}{L}$$

N^2

N=transformer ratio

RF-system with beamloading

$$Z = \frac{\beta \cdot Z_0}{1 + \frac{2 \cdot I_{DC} \cdot R_s}{U_c} \cdot \sin\phi_s + i\left(Q_0 \cdot \xi - \frac{2 \cdot I_{DC} \cdot R_s}{U_c}\cos\phi_s\right)}$$

Φ_s is the phase angle between the synchronous electron and the zero crossing of the cavity voltage.

A. Matched condition of resistive part: ReZ=Z_0

$$\beta = 1 + \frac{2 \cdot I_{DC} \cdot R_S}{U_C}\sin\phi_s$$

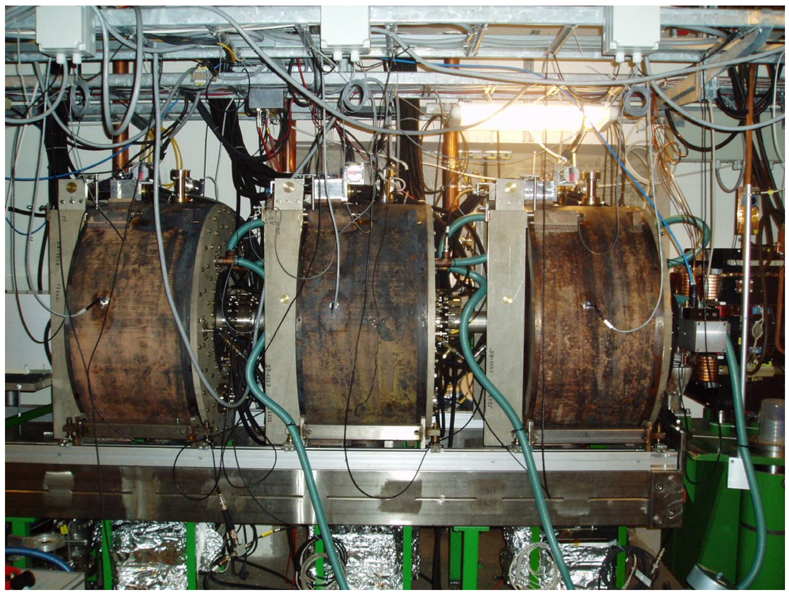
$$\beta = 1 + \frac{2 \cdot I_{DC} \cdot U_C \cdot R_S}{U_C^2}\sin\phi_S = 1 + \frac{2 \cdot R_S}{U_C^2} \cdot P_{beam} = 1 + \frac{P_{beam}}{P_C}$$

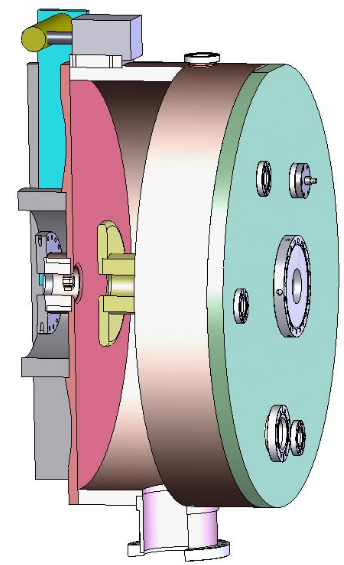
B. Matched condition of reactive part: ImZ=0

$$Q_0 \cdot \xi = \frac{2 \cdot \Delta f}{f_c} Q_0 = \frac{2 \cdot I_{DC} \cdot R_s}{U_C}\cos\phi_S$$

A. Defines the coupling factor of the cavity
B. Defines the necessary detuning of the cavity

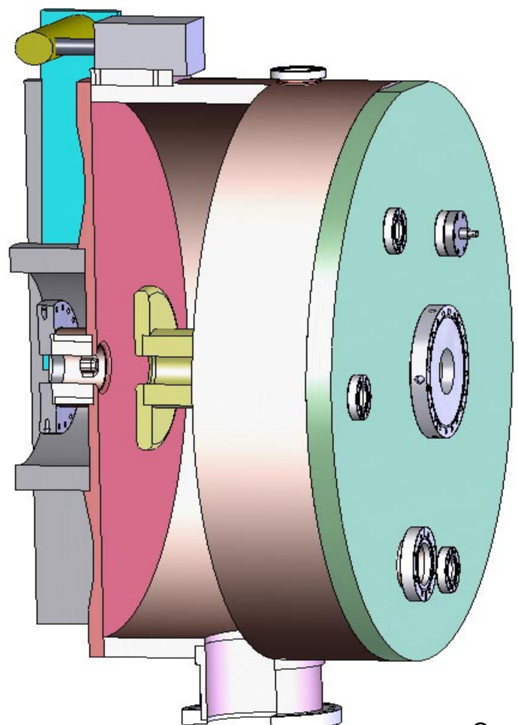
Cavity





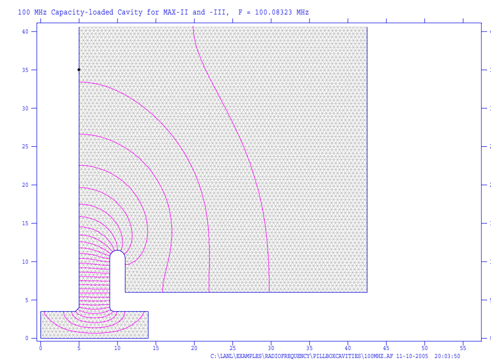
A. The main cavities are of the capacity-loaded type.
B. The tuning is made by squeezing the cavity side.

100 MHz cavity

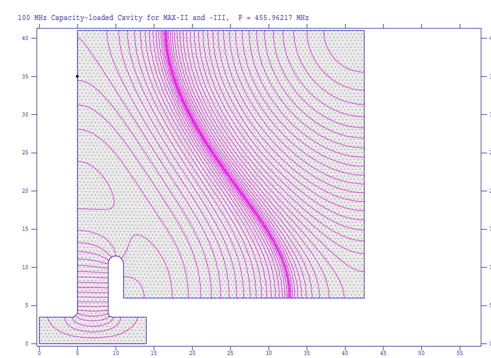


Q-value 19000

Tot. R_{shunt} 3.2 MΩ



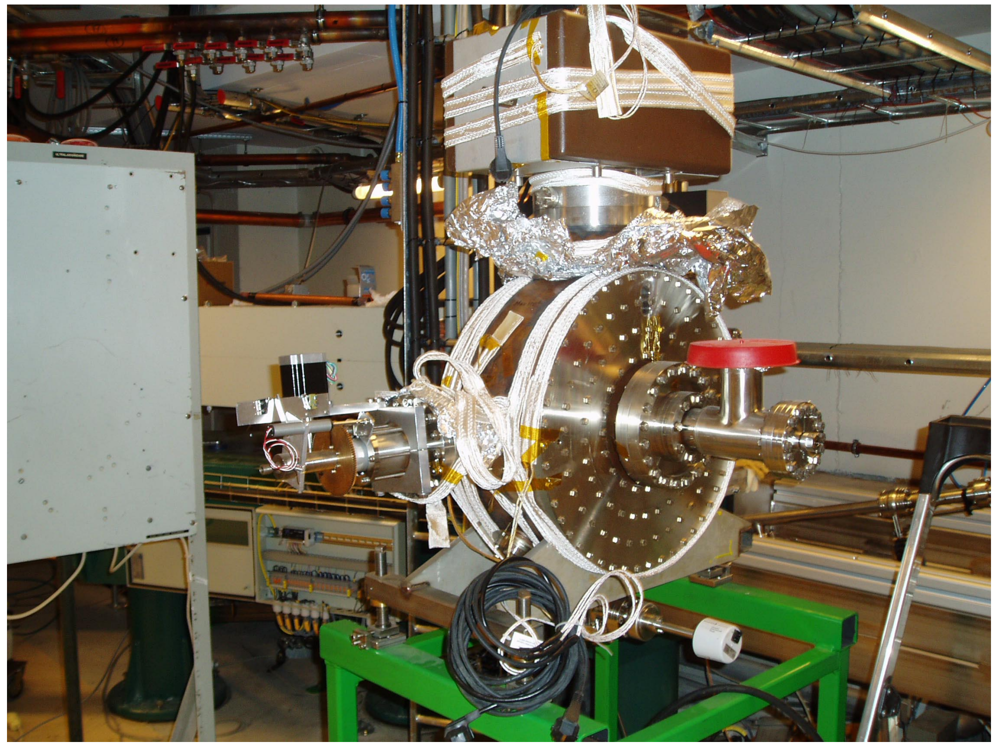
100 MHz cavity profile with fundamental mode E-field lines



E-field lines of the high order mode at 456 MHz

The high order modes are damped by antennas in the endplate. This endplate is convenient to use since the fundamental mode is not affected.

Landau cavity

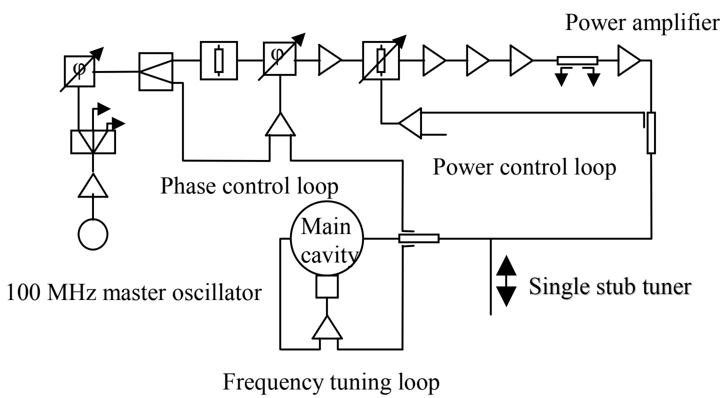


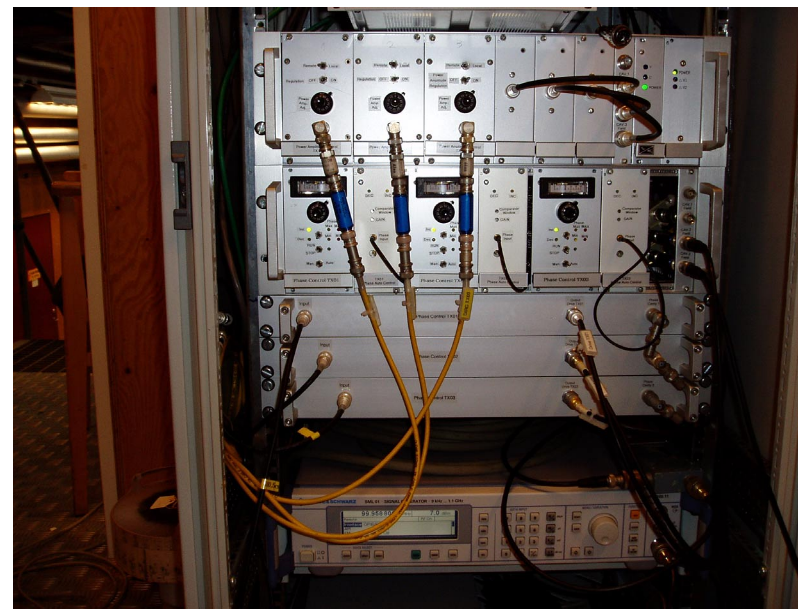
The Landau cavities are of simple pill-box type. Tuning is done both by plunger and temperature.

RF amplifier and feeder line

- The generator system consists of three 30 kW FM transmitters (Itelco T254T) feeding one cavity each
- The power stages are tetrode amplifiers
- Class C operation for high efficiency
- An integer λ/2 long coaxial 3 1/8” transmission line is feeding the cavity input coupler. The reflected wave will add in phase with the wave at the generator

RF path



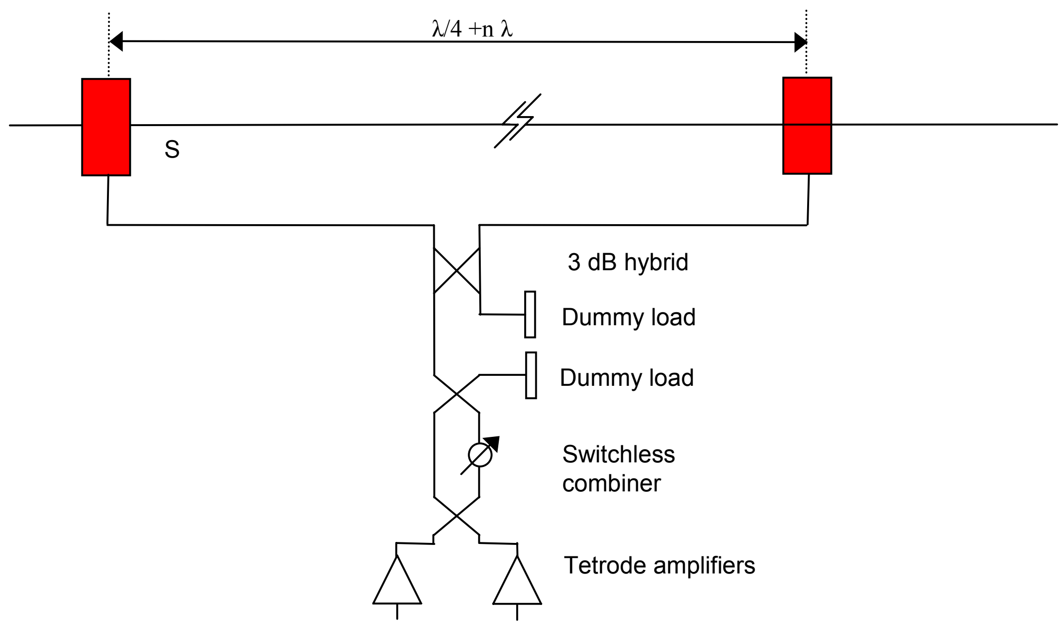


The power control makes the cavity to see a matched condition at the generator.
A phase control system is used to control the phase difference between the cavities.

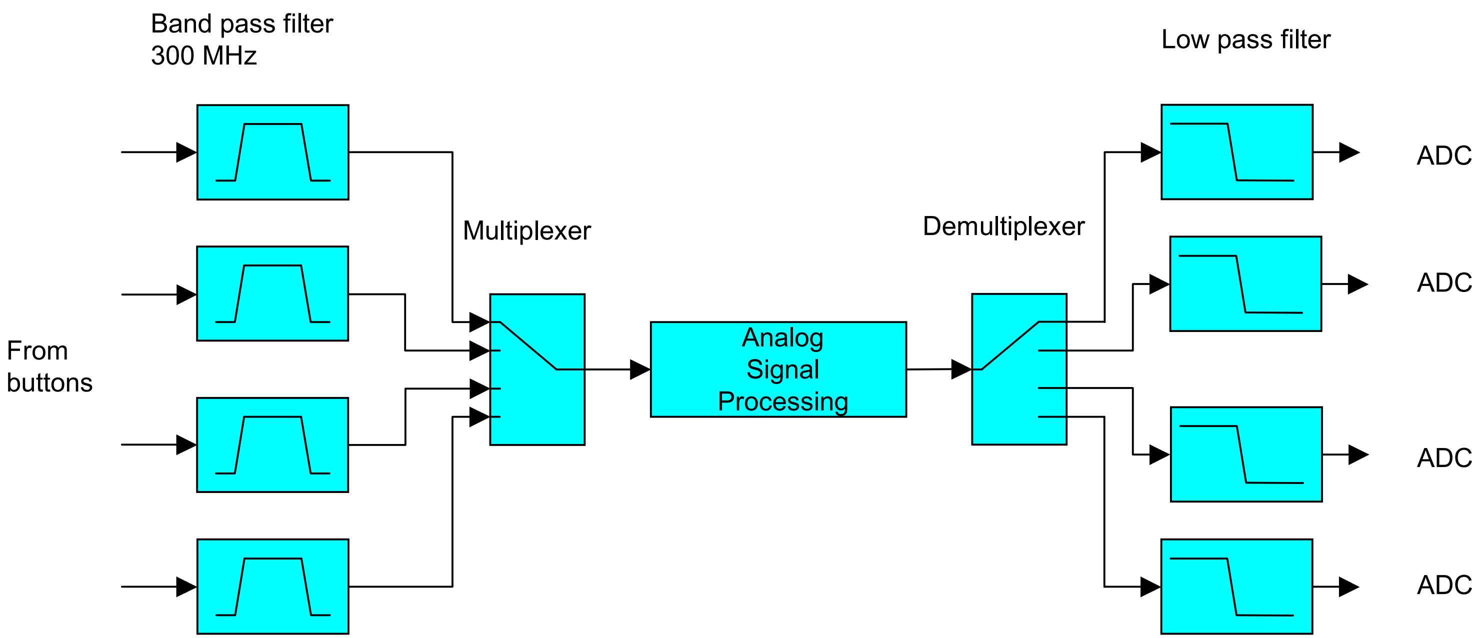
Stub matching network

A stub matching network is installed to keep an optimal match of transmitter and cavity for every beam current.

An alternative to a circulator



BPM system



The BPM receivers are working at the third harmonic. This minimizes the risk of 100 MHz leakage from the transmitters.

Resolution << 1μm

CONCLUSION

- The 100 MHz 90 kW RF system has been in operation since September 2004. The system is now running at 240 mA with two wigglers at 150 and 200A.
- Beam lifetime I*t=6000mAh with Landau cavity in operation.
- BPM system resolution <<1 µm.
- The transmitter tubes must have high anode loss capability when working without circulator. This is an disadvantage but a solution is presented.