MAX-lab

7th ESLS RF Meeting

ANKA (Karlsruhe) 2003

Status of the 100 MHz system for MAX-II and MAX-III

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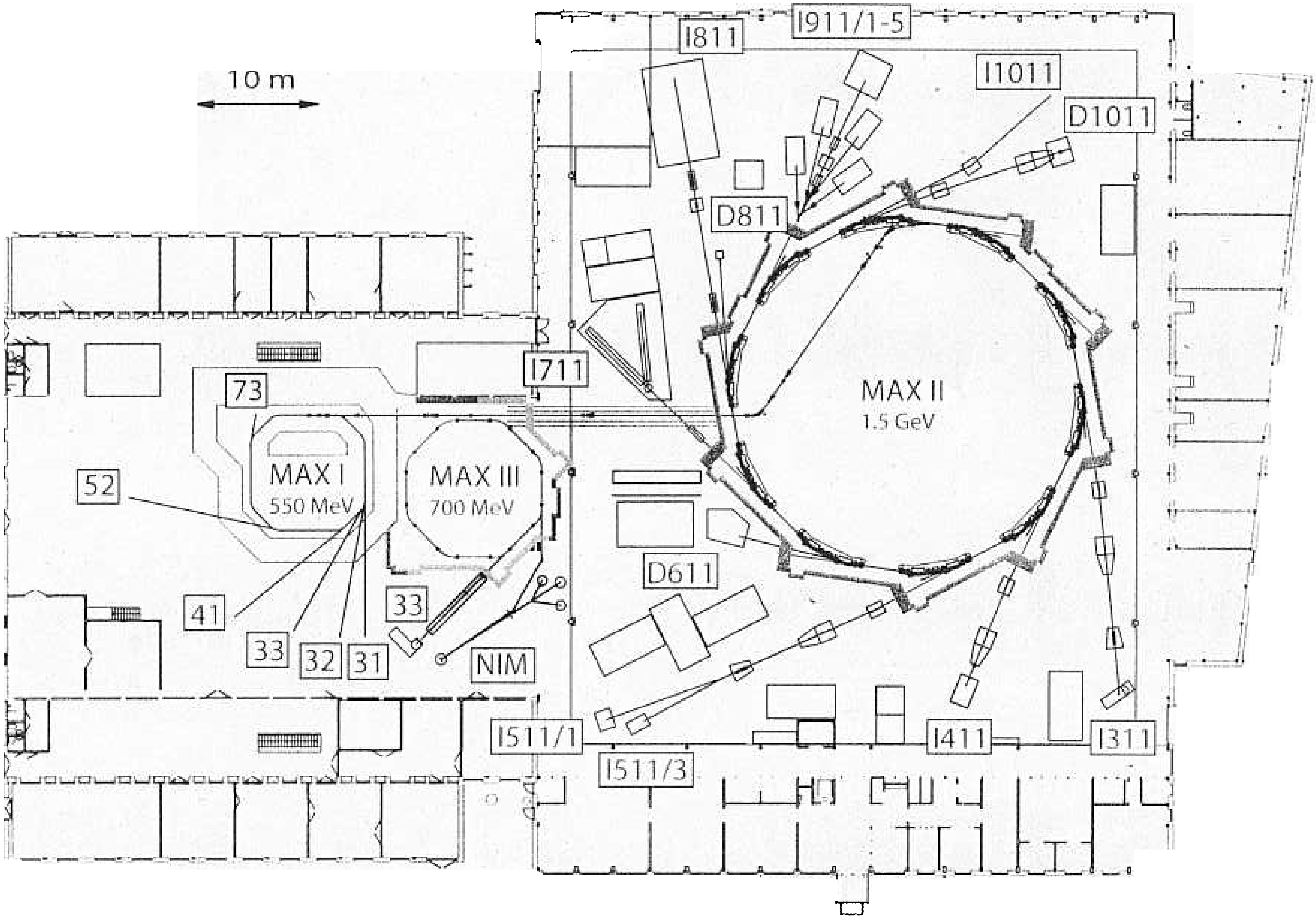

Rings_and_beamlines.ai, Ralf Nyholm, 2002-08-22

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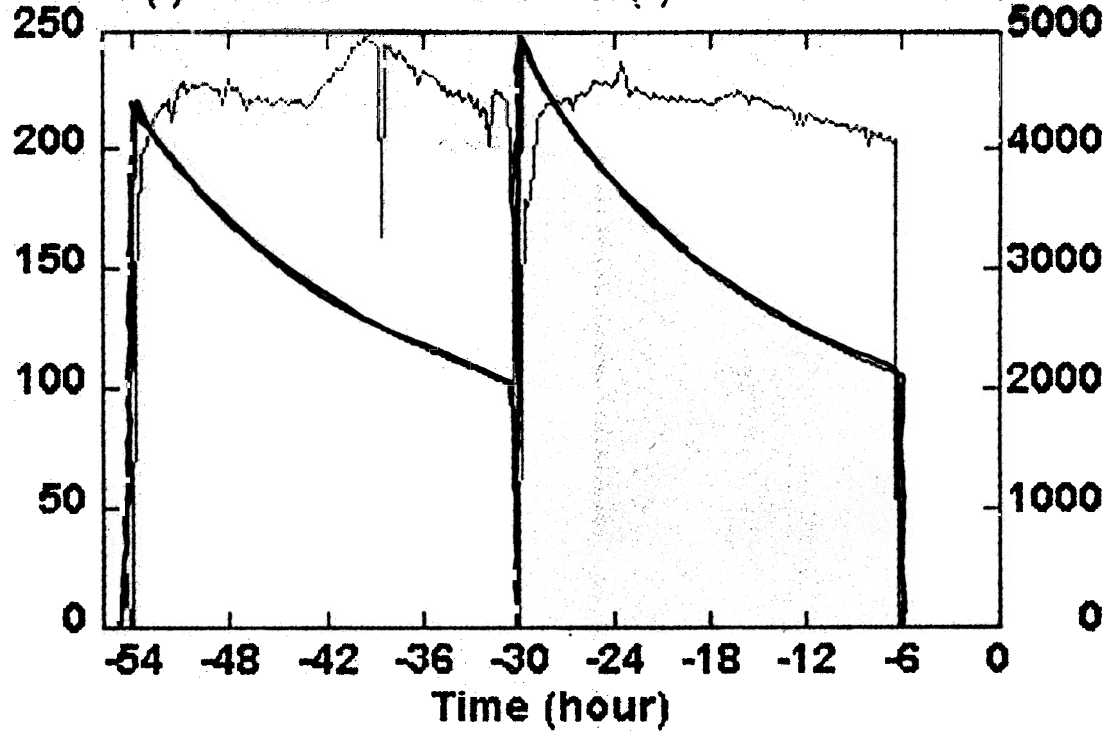
Status MAX 2 storage ring

Time = 16:09:40 Date = 1998-11-16

Current(I)= 0.0 mA Lifetime(t)= 0.0 h I*t= 0 mAh



At 200 mA

$\tau_{gas} \approx 150h$

$\tau_{Tousch.} \approx 25h$

A New RF in MAX-II?

- This question was raised already in the 2nd European RF meeting in Lund 1999. We presented the idea to shift over from our 500 MHz RF system to a 100 MHz system for the MAX-II light source.
- The background was the following:

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- It is seen that at normal operation (with our higher harmonic cavities) the machine give us $I \times \tau \approx 4200\text{mAh}$ pretty constant over a storage period (24 hours) of MAX-II. Thus, at 200 mA we have a total lifetime of 21 h, and our measurements point at $\tau_{gas} \approx 150\text{h}$ and $\tau_{Touschek} \approx 25\text{h}$.

    ⇨ We would gain a lot by increasing Touschek lifetime.

- The MAX-II ring has an energy acceptance of 3 - 3.5 %, mainly due to the lattice scheme with integrated quadrupole-sextupole magnets. Meanwhile, the RF bucket height is now only 1.7%.

    ⇨ We could gain by increasing the bucket height.

- The height is roughly given ΔE (neglecting the effect from a low over-

- Instead of, as today, dissipating 18 kW in our cavity (a 3-cell DESY cavity), we would have to dissipate 112 kW (!!!!!!), to reach 3% bucket height.

- Moreover, the MAX-II ring today houses two SC wigglers, which are both taken into regular operation since September. Each one increases the electron energy loss by 20 keV/ turn, when fully excited. This calls for an even higher cavity voltage, to restore some loss of bucket height.

Power costs!!

⇨ Seems very uneconomical to gain RF acceptance by increasing the voltage!

Look again on the bucket height formula!!

$$\frac{\Delta E}{E} \approx \sqrt{\frac{2e\hat{V}_{RF}}{\pi \alpha h E}}$$

⇨ Instead of *increasing* the cavity voltage we could simply *decrease the harmonic number h* !!!!!!!!!!!!!

Solution:

RF=100 MHz !!

$$\left.\begin{array}{l} h=30 \\ \hat{V}_{RF}=450\text{kV} \end{array}\right\} \Rightarrow \frac{\Delta E}{E}=3\%$$

We have made a design of a 100 MHz capacity-loaded type cavity, with a $R_{sh} \equiv \frac{\hat{V}_{RF}^{\ 2}}{P_{Cav}} = 3.54\text{M}\Omega$ and a Q-value of 20500 (*ideal values*).

Three of these cavities will provide the needed voltage, and

$\Rightarrow$ $P_{Cav.Tot} = 19\text{kW}$

We will use one radio transmitter (ITELCO; eff≅60%) for each cavity,

$\Rightarrow$ modular system; operable even if one station fails

How about the Touschek lifetime, when the number electrons per bunch is increasing with a factor of 5?

Since the bunch length roughly increases by the same factor, the effects pretty much cancel out.

⇨ Touschek lifetime of 50 to 60 h at 200 mA, (5% coupling, as it is now).

Solution (cont'd):

Landau cavities???

Of course!!!!!

But only one!!!

Since, $f_s = \sqrt{\frac{h\alpha\cos\phi_s}{2\pi T^2}\frac{e\hat{V}_{RF}}{E}} = 8\text{kHz}$, in the new 100 MHz system, the shunt impedance demand to ensure Robinson stability, becomes quite relaxed.

⇒We plan then to use one 500 MHz pill-box type cavity as a *fifth harmonic passive (Landau) cavity*. It will alone provide sufficient shunt impedance $R_{sh} \equiv \frac{\hat{V}_{RF}^{\,2}}{P_{Cav}} = 3.65\text{M}\Omega$; Q-value : 25200 (*ideal values*).

With such a cavity the bunches should be elongated roughly a factor of three.

⇨ Touschek lifetime of above 150 h at 200 mA, matching the gas lifetime.

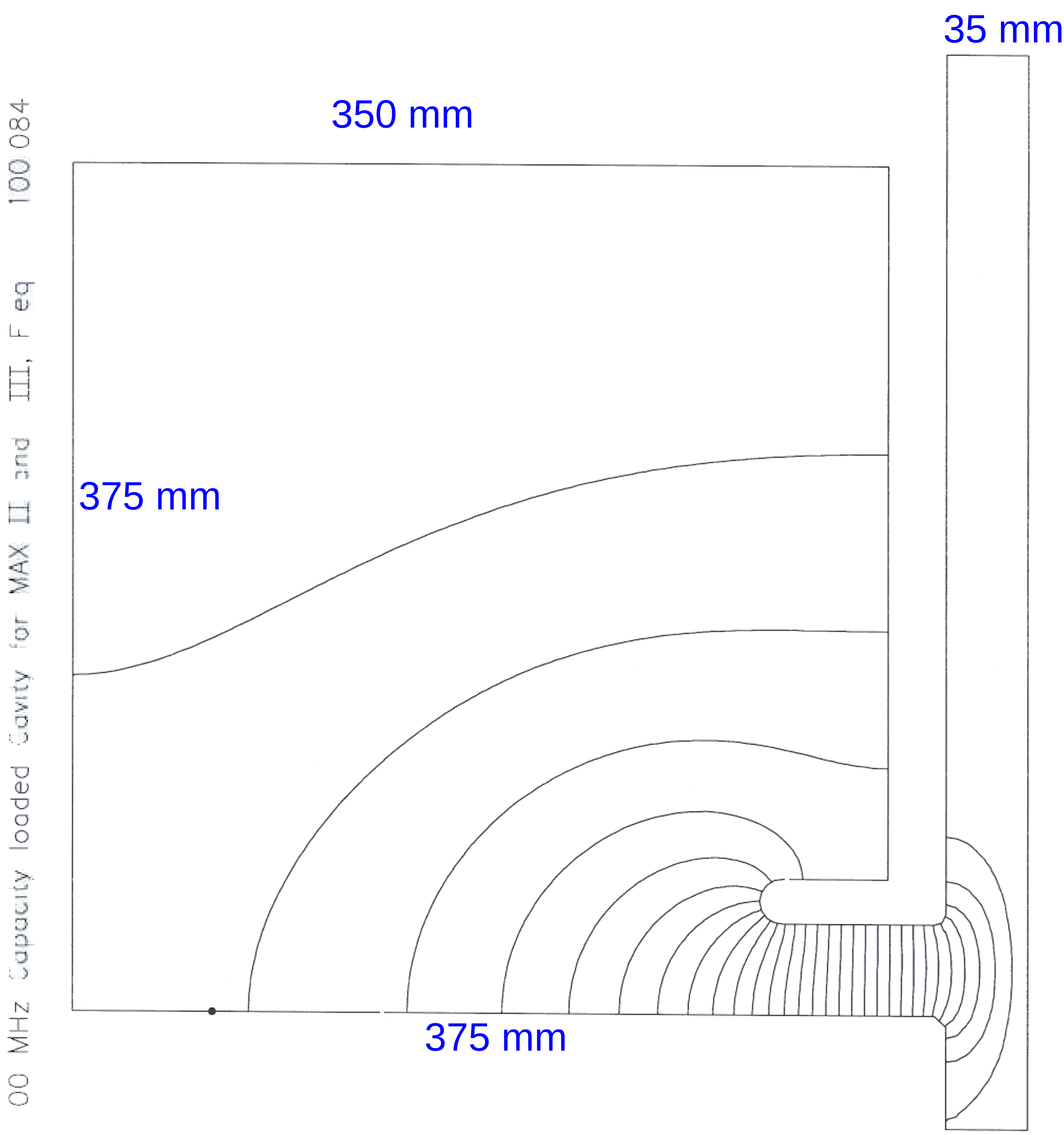
	MAX-II present	MAX-II future
Main RF system		
Frequency [MHz]	499.780	99.956
Harmonic number	150	30
No of cavity cells	3	3
No of transmitters	1	3
Cell radius [m]	0.23	0.41
Tot length of cavities [m]	1.1	1.5
Tot R_{shunt} (≡V*V/P) [MΩ]	20	9.6
Q-value	40000	19000
Tot Voltage [kV]	600 (700)	450 (530)
Cu losses [kW]	18 (25)	21 (29)
Beam power @ 250mA [kW]	35 (50)	35 (50)
Available power [kW]	75	90
Net power [kW]	106 (150)	93 (135)
Bucket height [%]	1.7	3.0
Synchrotron frequency [kHz]	20	8
Rms bunch length [cm]	0.66	1.7
Landau cavity system		
Frequency [MHz]	1499.340	499.780
No of cavities	4	1
Tot R_{shunt} (≡V*V/P) [MΩ]	8	3.4
Q-value	16000	24000
Cu losses @ opt tuning [kW]	5	2.4 (3.3)
Double RF bunch length [cm]	1.9	5.3
Touschek lifetime [Ah]	8	38

MAX-III	
Main RF system	
Frequency [MHz]	99.956
Harmonic number	12
No of cavity cells	1
No of transmitters	1
Cell radius [m]	0.41
Tot length of cavity [m]	0.5
R_{shunt} (≡V*V/P) [MΩ]	3.2
Q-value	19000
Voltage [kV]	200
Cu losses [kW]	12.5
Beam power @ 500mA [kW]	6.5
Available power [kW]	30
Net power [kW]	32
Bucket height [%]	2.0
Synchrotron frequency [kHz]	36
Rms bunch length [cm]	2.8
Landau cavity system	
Frequency [MHz]	499.780
No of cavities	1
R_{shunt} (≡V*V/P) [MΩ]	3.4
Q-value	24000
Cu losses @ opt tuning [kW]	0.5
Double RF bunch length [cm]	6.7
Touschek lifetime @10% coup [Ah]	4.5

Q s.f. = 20500

Q meas = 19000 (92%)

R shunt = 3.2 MOhm




DB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100 MHz cavities
3
BE CAREFUL, PLEASE!
DO NOT TOUCH THIS TUBE!!!!!


2333-20
4868
2333-25
322721
2333-25
322721

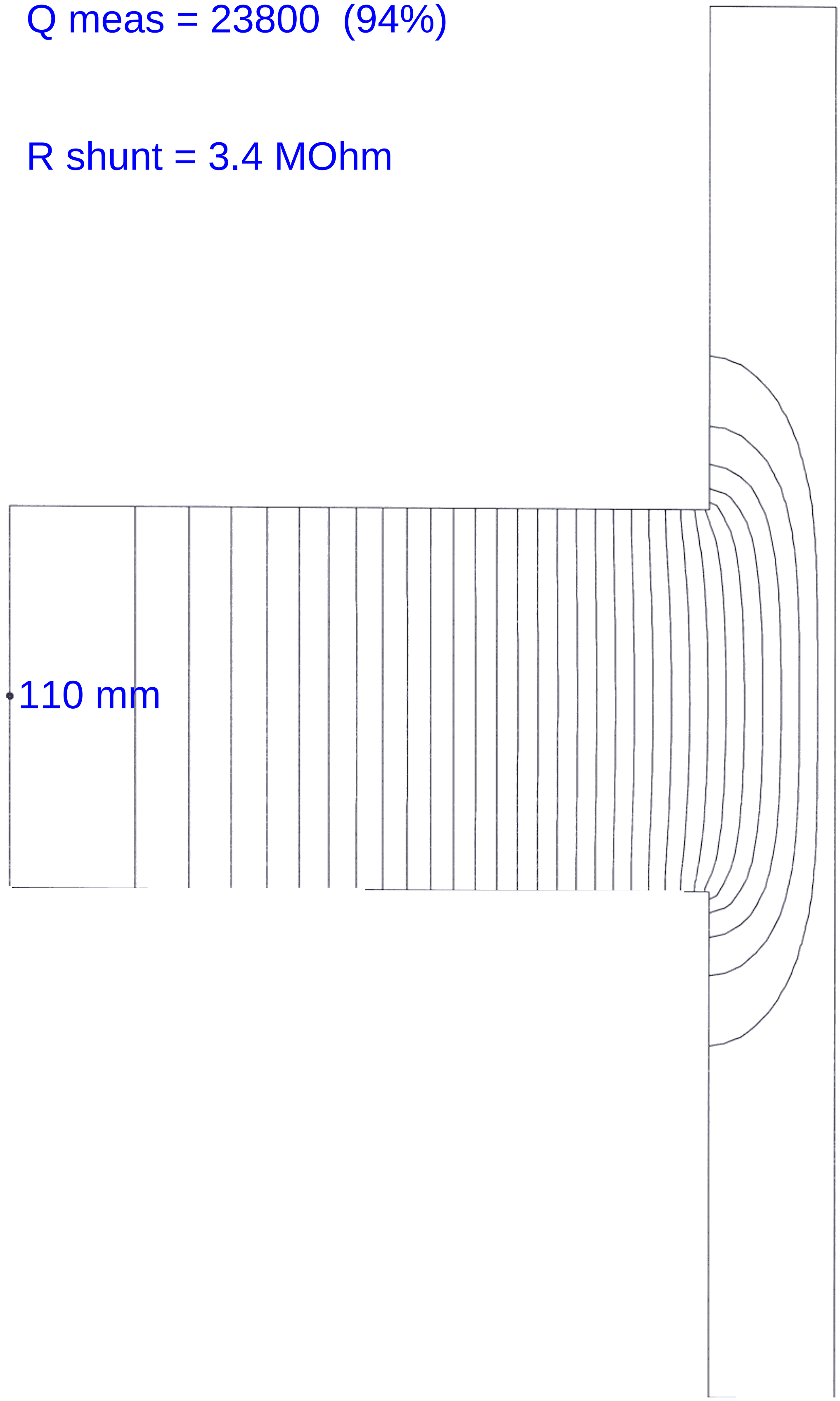

VEXTA
STEPPING MOTOR
MODEL
PK268-E2.0A
2-PHASE


2333-20

Q s.f = 25200

Q meas = 23800 (94%)

R shunt = 3.4 MOhm



500 MHz Landau Cavity for MAX II and MAX III, Freq 50 4 5


EUROTHERM


SWEDEWATER
ACETO
READ THIS

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SUMMARY

- Both for MAX-II and MAX-III it is favourable to choose a 100 MHz instead of a 500 MHz active system, to reach a large RF acceptance without too large power consumption.
- We get thus a modular system, four stations, with comparatively cheap FM-band transmitters.
- Together with one 500 MHz Landau cavity in each ring we can reach a quite long Touschek lifetimes in both rings.
- The same RF system is also attractive for a high-brilliance 3 GeV ring like MAX IV (see EPAC 2002).

However, one ring at a time!!!!

TIME PLAN (revised)

Shift of RF in MAX-II: Easter (or Summer) 2004.

Commissioning of MAX-III: End of 2004.

Commissioning of MAX-IV: A little later