BESSY

Berliner Elektronenspeicherring-Gesellschaft
für Synchrotronstrahlung m.b.H.

HOM Damped Cavity Development at BESSY

Ernst Weihreter, Frank Marhauser / BESSY

- Review of HOM Damped Cavity Prototype
- Layout of Homogenious Damping Waveguides
- Cavity for the Metrology Light Source
- Outlook

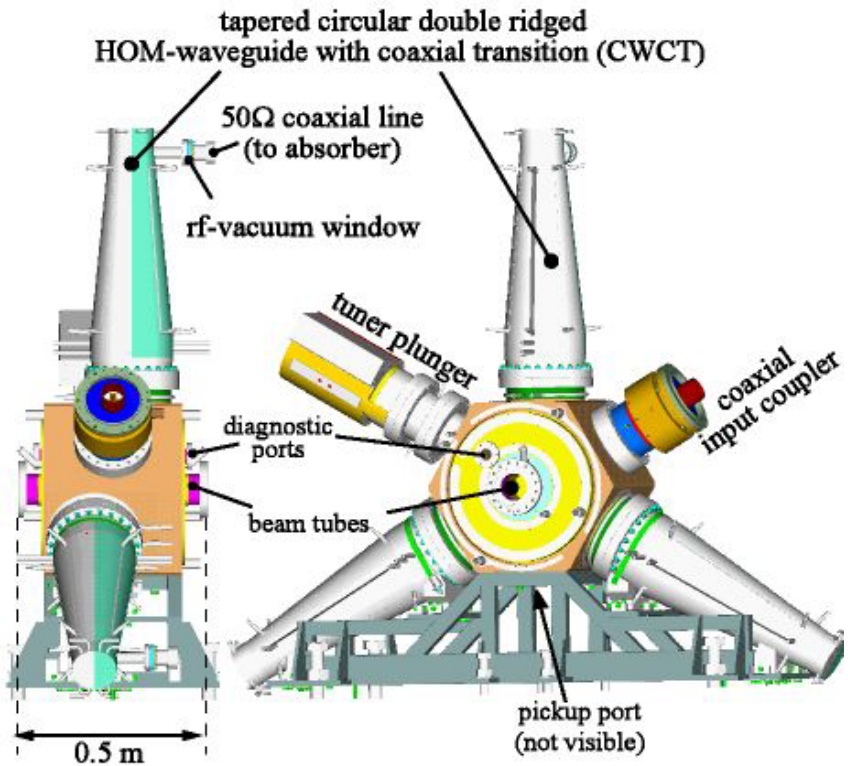
Leibniz Gemeinschaft

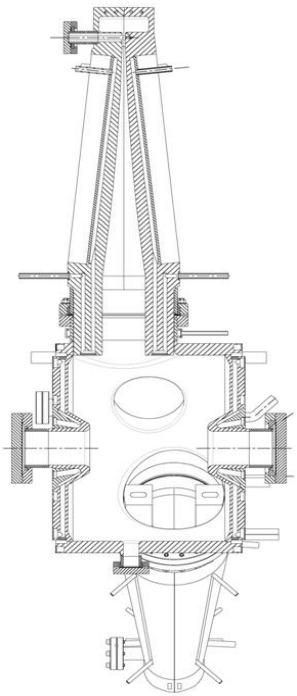
BESSY HOM Damped Cavity

Project collaboration: BESSY / Germany
(EC funded) Daresbury Lab / England
DELTA / Dortmund University, Germany
National Tsing Hua University / Taiwan

Design Goal

- **Frequency**
  f_{rf} = 500 MHz
- **Insertion length**
  L < 0.7 m
- **Shunt impedance**
  R < 3 MΩ
- **Max. thermal power**
  P = 100 kW
- **Compact design to fit existing ring tunnels**



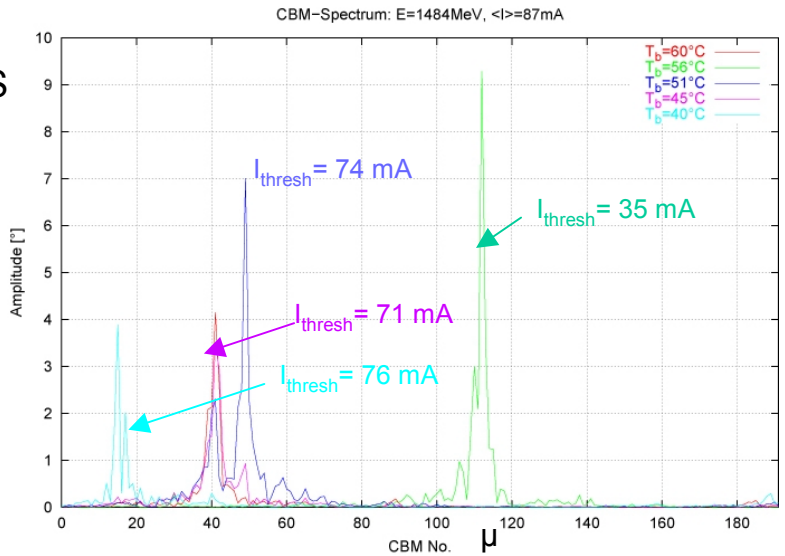


First Beam Tests in DELTA

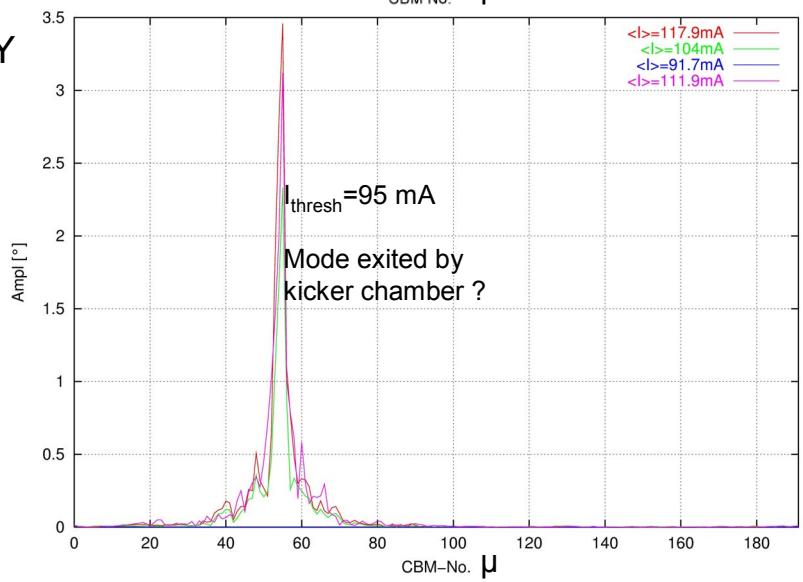
CBM beam spectra: (longitudinal case)

$$f^{\pm}_{\mu m} = nf_{rf} \pm (\mu f_0 + mf_s)$$

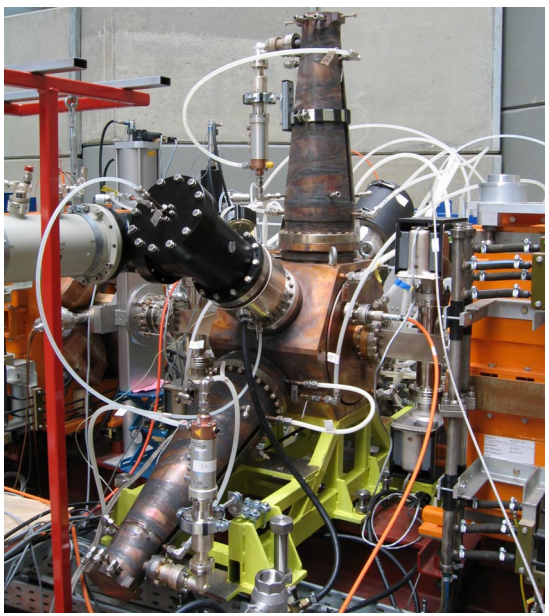
DORIS Cavity



BESSY Cavity



Prototype cavity installed in the DELTA ring



No cavity driven CBMs excited in DELTA

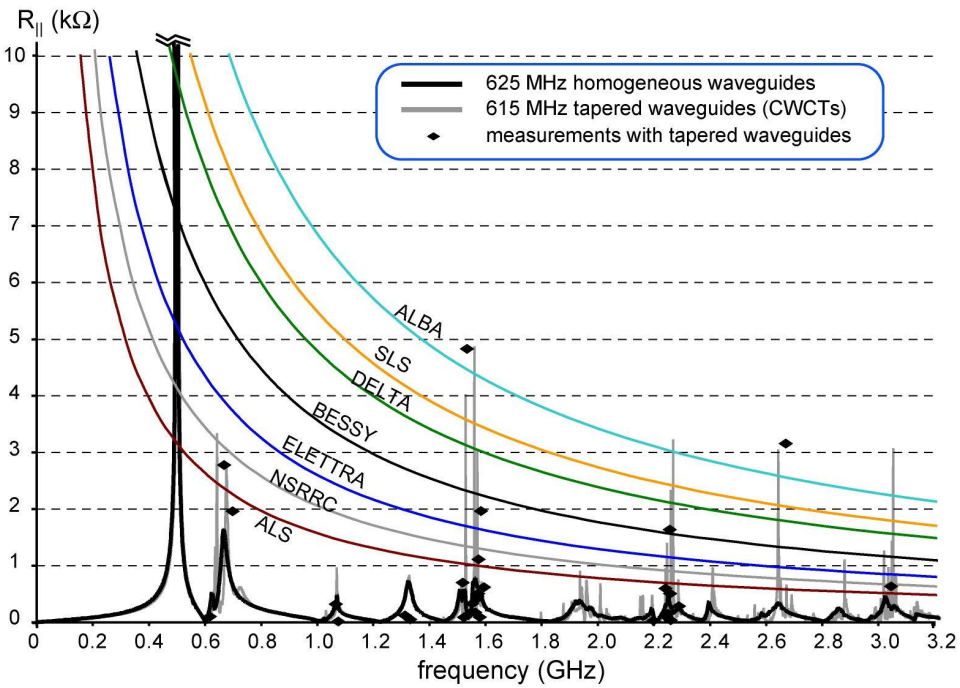
Impedance Spectra and Critical Impedances

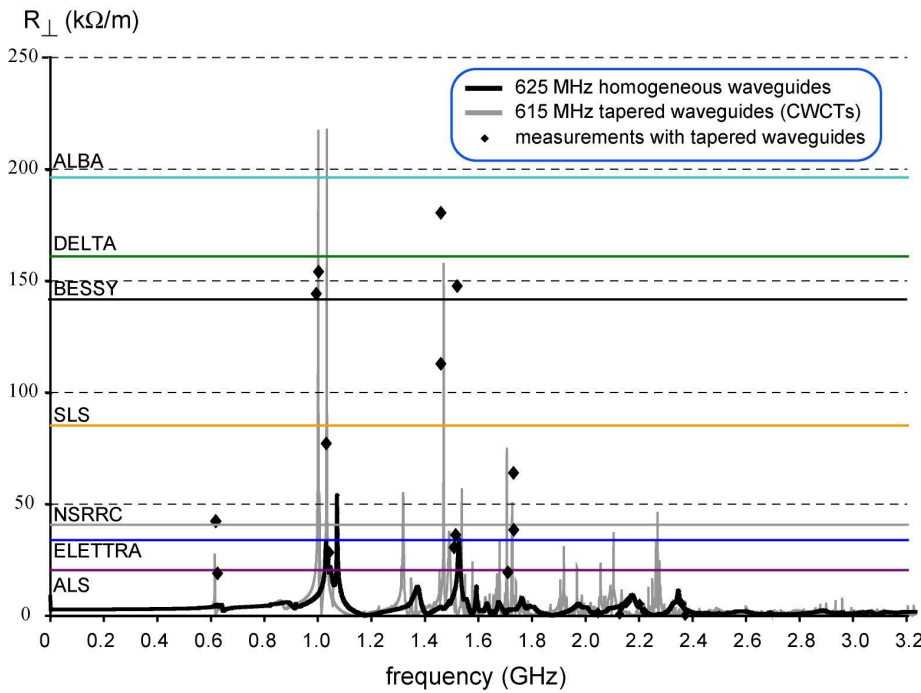
Longitudinal Impedance

$$Z_{\parallel}^{thresh} = \frac{1}{N_C} \cdot \frac{1}{f_{\parallel HOM}} \cdot \frac{2 \cdot E_0 \cdot Q_s}{I_b \alpha \tau_s}$$

Transverse Impedance

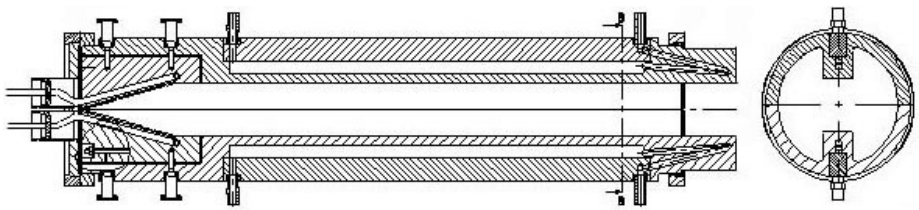
$$Z_{x,y}^{thresh} = \frac{1}{N_C} \cdot \frac{2 \cdot E_0}{f_{rev} I_b \beta_{x,y} \tau_{x,y}}$$

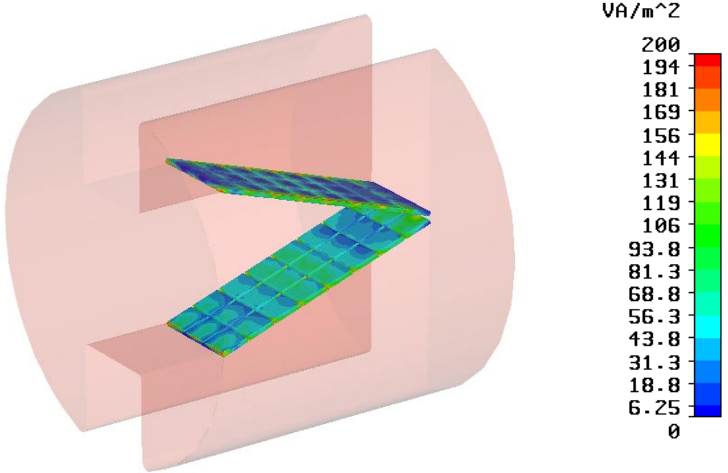


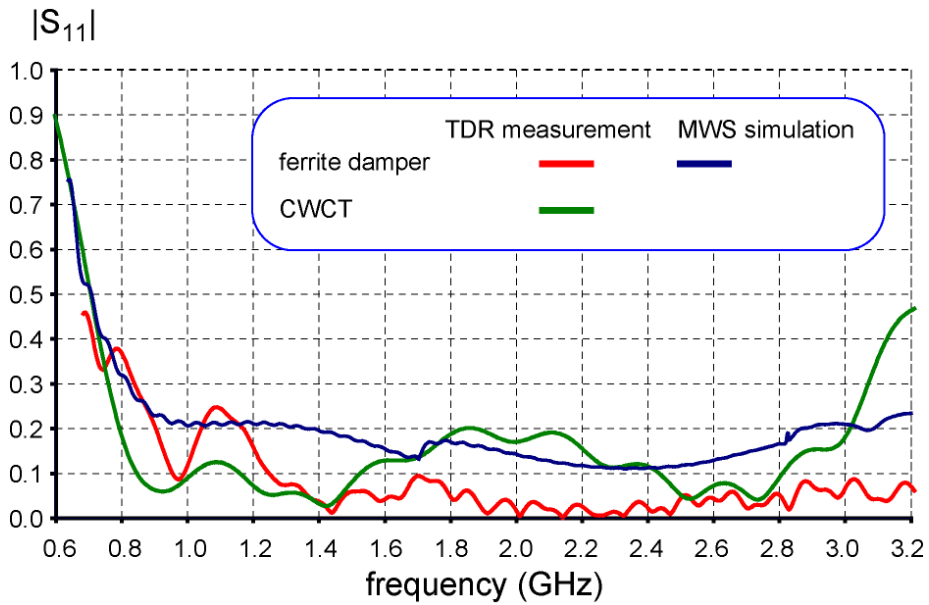


Homogenous Wave Guide Dampers

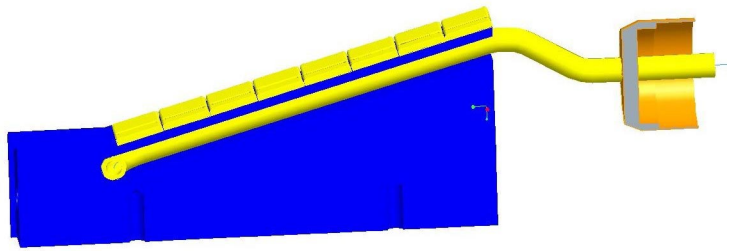
	Tapered WG	Homogenious WG
Max. Z_{long} [kΩ]	5.	1.8
Max. Z_{transv} [kΩ/m]	200.	50.

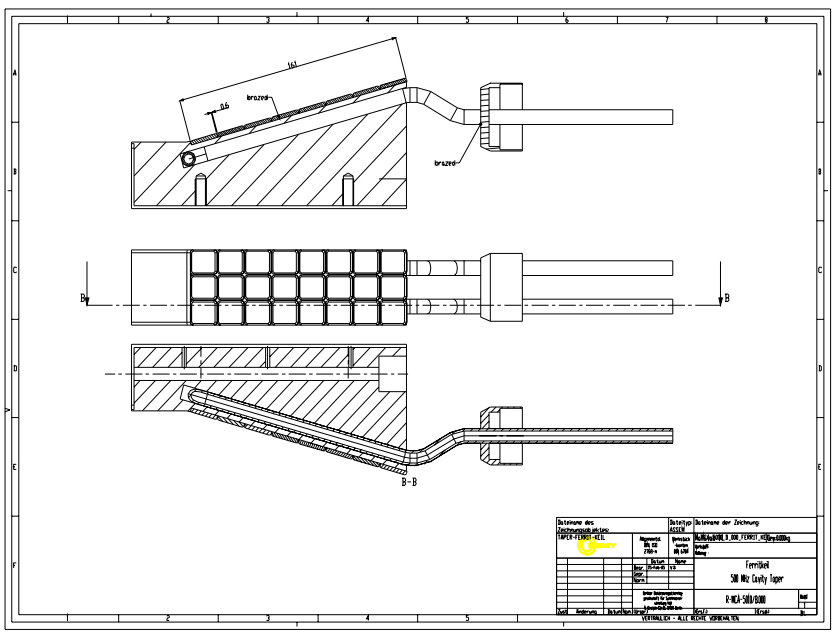






Time domain reflectrometry measurement of S11

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HOM Power Considerations

	BESSY-II		ELETTRA	ALS	SLS	ANKA	SRRC	MAX-II
σ [mm]	4.8		5.4/11	9	4	9	7.5	6
$k_{\parallel,HOMs}$ [V/pC]	**0.7**		**~0.64/0.41**	**0.5**	**0.8**	**0.5**	**0.52**	**0.6**
E_0 [GeV]	1.7		2	1.5	2.4	2.5	1.5	1.5
U [m]	240		259.2	196.8	288	110.4	120	90
multibunch-mode								
I_{beam} [mA]	400	250	300	400	500	400	240	200
n_b max.	260 400	260 400	432	328	480	184	200	150
$T_b = 1/f_{rf}$ [ns]	2							
Q_b [nC]	1.231 0.8	0.769 0.5	0.6	0.8	1	0.8	0.24	0.4
P_{HOMs} [W]	**530/ 224**	**207/ 88**	**115/74**	**160**	**400**	**160**	**60**	**48**
singlebunch-mode								
I_{beam} [mA]	30		-	2*20 (two-bunch mode)	-	-	25	-
T_b = [ns]	800		-	328	-	-	400	-
Q_b [nC]	24		-	2*6.56	-	-	10	-
P_{HOMs} [W]	**504**		-	**66**	-	-	**130**	-

Maximum HOM-power per BESSY type cavity in various SR sources using 500 MHz RF-systems for longitudinal multibunch oscillations

$$P_{HOM} = (I_b / n_b)^2 \, (1/T_b) \, k(\sigma)$$

Max HOM power per cavity: P_{long} = 600 W
P_{trans} = 600 W

Safety factor for future upgrades: 2

→ P_{HOM} = 2.4 kW per cavity

Test power density on ferrite: 14 W/cm^2

→ P_{HOM} = 6.6 kW per cavity

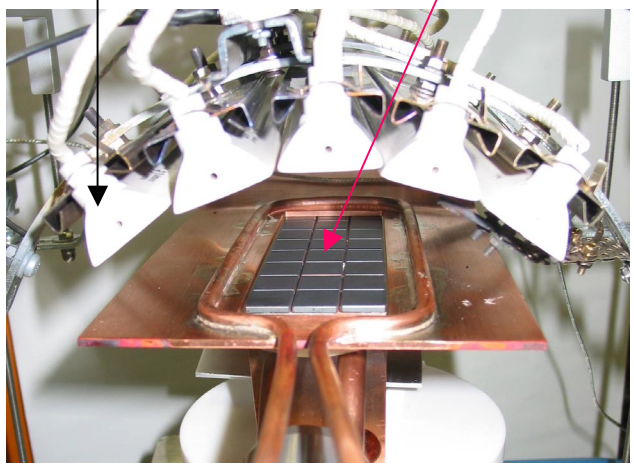
Fabrication and Test of Ferrite Absorber Elements

Challenge: Bonding of ferrite on copper

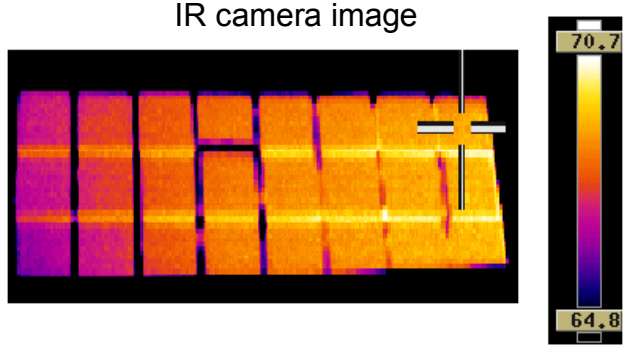
- NiZn ferrite tiles soldered on „soft“ copper
- Bonding layer: sputtering of Ti and Cu
- SnAg(0.1%) solder material, T_{melt}= 295 °C
- Quality test of solder process:
  Homogeniety of surface temperature

RF power test: P_{rf} = 600 W @ 1.3 GHz

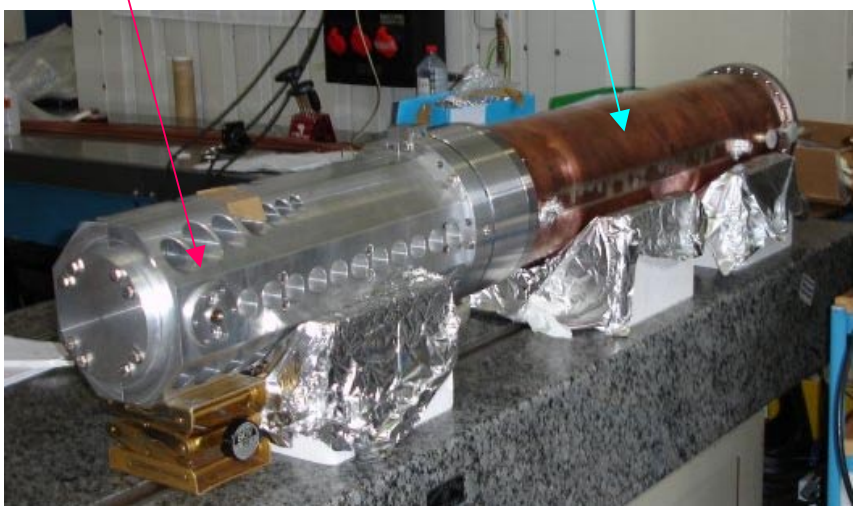
IR Test: Thermal power density up to 14 W/cm2 ,
test system will be upgraded to 20 W/cm2



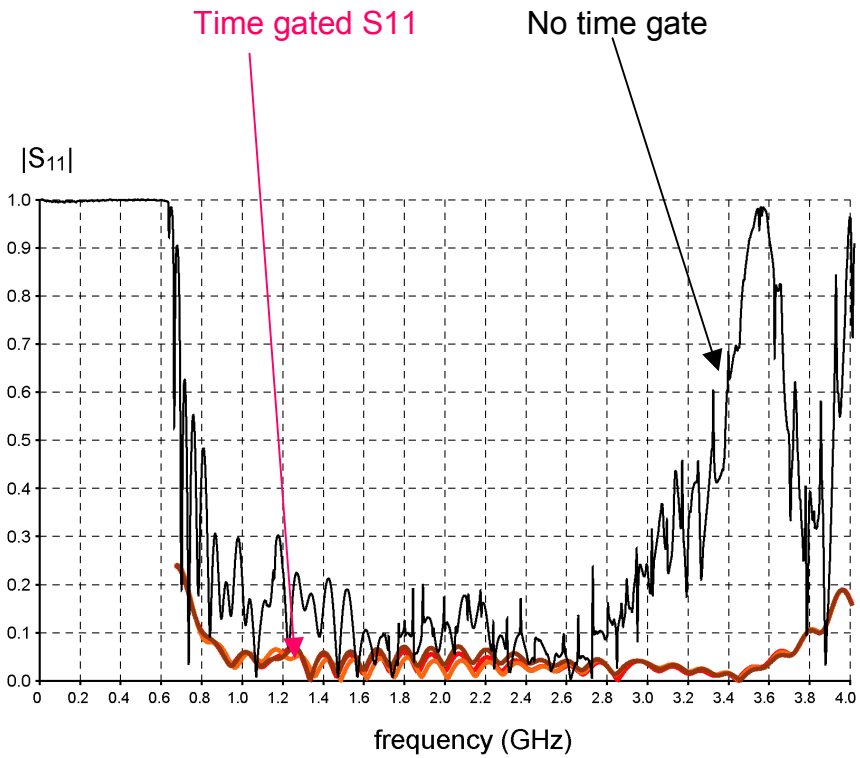
IR camera image



Low Power Test of Damping waveguides



Set-up for TDR measurements



TDR measurement results

Cavity for Metrology Light Source

Factory acceptance tests at ACCEL finished

Next steps:

- Low power HOM impedance measurements in Okt. 2006
- Vacuum conditioning end of Okt. 2006
- High power tests up to 80 kW in Nov. 2006
- Beam tests starting beginning of Jan. 2007

Superconducting vs Normal Conducting Cavities

SC cavities:

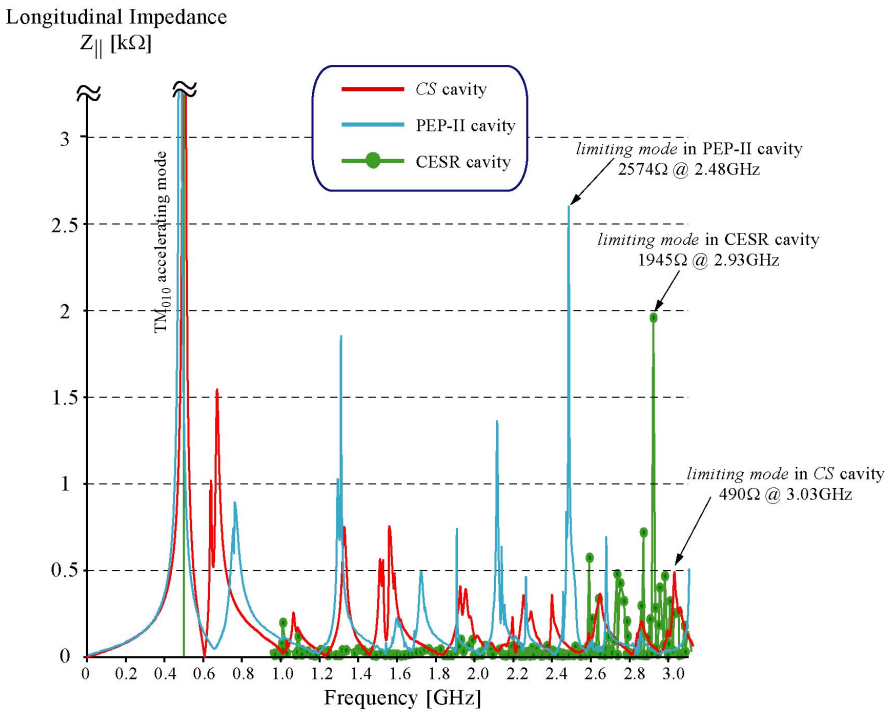
- high rf voltage per cavity
- lower electic power cost for higher energy rings
- need for cryogenic system
- high complexity
- MTBF:
  7 days/cavity @NSRRC
  23 days/cavity @CERN/LEP

NC cavities:

- HOM impedance per cell competitive with sc cavities
- cost efficient and simple technology
- MTBF: 28 days/cavity @BESSY II

Table 1. Performance parameters of several cavities ($R_s = V_{cy}^2/2P_{cy}$, L insertion length)

	f_0	V_{cy}	R_s/Q	Q_0	P_{cy}	L	f_{HOM} ∥	R∥	f_{HOM} ⊥	R⊥
	MHz	MV	Ω		kW	m	MHz	kΩ	MHz	kΩ/m
CESR	500.	2.5	44.5	-	-	2.9	2253.	0.18	715.	32.
SOLEIL	352.	2.5	45.	-	-	3.65	699.	2.1	504.	49.
		V_{cy}	R_s							
		kV	MΩ							
PEP II	476.	850.	3.8	32400	103.	~1.5	1295.	1.83	1420.	144.
DAPHNE	368.2	250.	2.	33000	16.	1.9	863.	259.	-	-
ARES	509.	500.	1.75	118000	72.	~1.1	696.	1.35	989.	10.
VEPP2000	172.1	120.	0.23	8200	29.	0.95	2460	0.4		<10.
DUKE-2	178.5	730	3.46	39000	77	3.16	-	-	-	-
BESSY	500.	780.	3.1	26700	100.	0.5	670.	1.6	1072.	54.



Longitudinal impedance spectra as calculated for the *BESSY(CS)*, PEP-II and CESR cavity

Project collaboration:

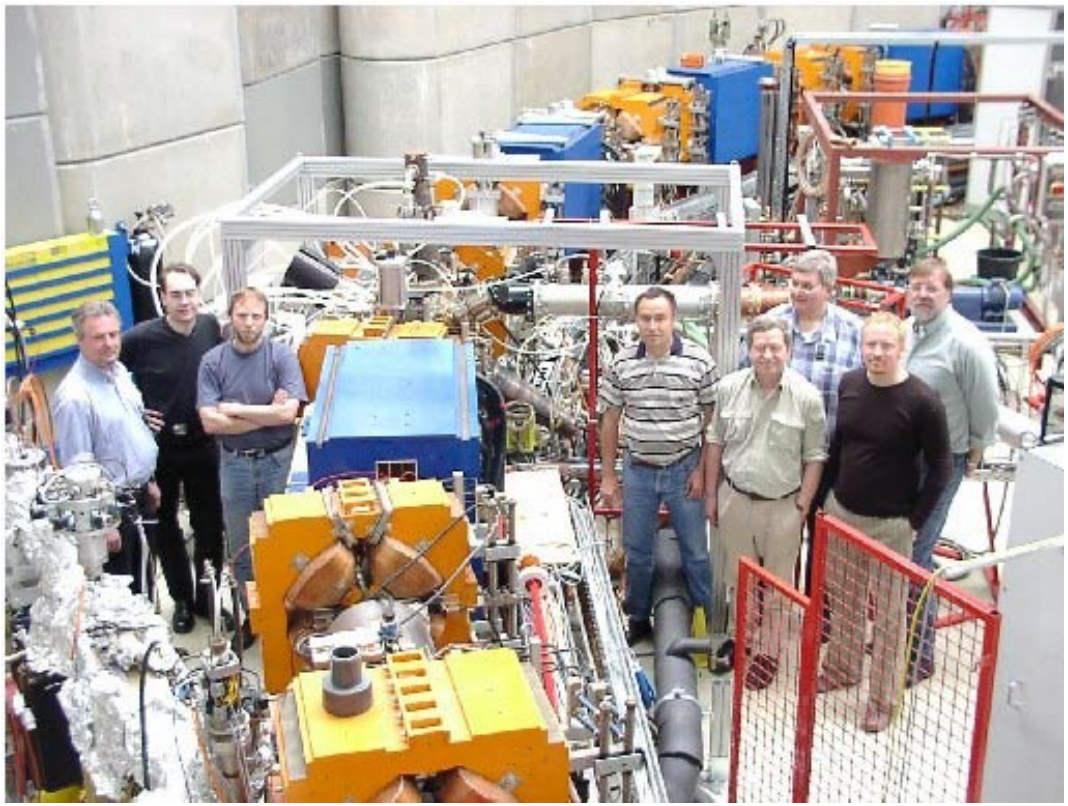
- BESSY / Germany
- Daresbury Lab / England
- DELTA / Dortmund University, Germany
- National Tsing Hua University / Taiwan

Funded by

- European Community
- Ministry for Education and Science, Germany
- Deutscher Akademischer Austausch-dienst, DAAD, Germany
- NSC National Science Council / Taiwan

Cavity will be used for

- Metrology Light Source PTB / Berlin
- ALBA Project / Spain
- Upgrade of BESSY II



Conclusions and Outlook

- A first cavity with homogenous damping waveguides is ready for the PTB Metrology Light Source in Berlin. Tests with 80 KW input power are foreseen in November 2006. Sensitive beam tests will follow in early 2007 during commissioning of the Metrology Light Source

- With homogenous damping waveguides the residual HOM impedances can be reduced by a factor of ~ 4, which allows to operate all existing 3rd generation rings with 500 MHz rf-systems below threshold for longitudinal multibunch oscillation modes

- Technical challenges of „in vacuum“ rf-absorbers can be met: Brazing technology for the ferrite tiles on copper Ferrite absorber elements was qualified up to 14 W/cm2 prior to the installation in the damping waveguides using IR radiation

- The cavity will be used for the MLS, the ALBA ring in Spain, the upgrade of BESSY II, and, after the high power tests in November 2006, it will be qualified for the use in other SR sources based on 500 MHz rf Systems