Table of specifications

- In preparation for Snowmass we should establish tables of detailed specifications / design criteria for various component
  - Makes it easier to condense to a baseline design
  - Will structure the discussion about alternative designs
- Information should be structured into 4 categories
  - Technical specifications
  - Design issues
  - Experience with prototypes
  - Work still to be done
- Strategy is to
  - strengthen arguments about a good design
  - Notify well thought thru modifications
  - not to make a list off all possible alternatives

Collection of specification / experience with input/ HOM couplers

- Input couplers, HOM couplers
  - Technical specification
  - Design issues
  - Operating experience
- Discussion of present design:
  - TTF 3 input coupler,
  - TESLA HOM couplers
- Start same procedure with tuners after Carlo`s talk

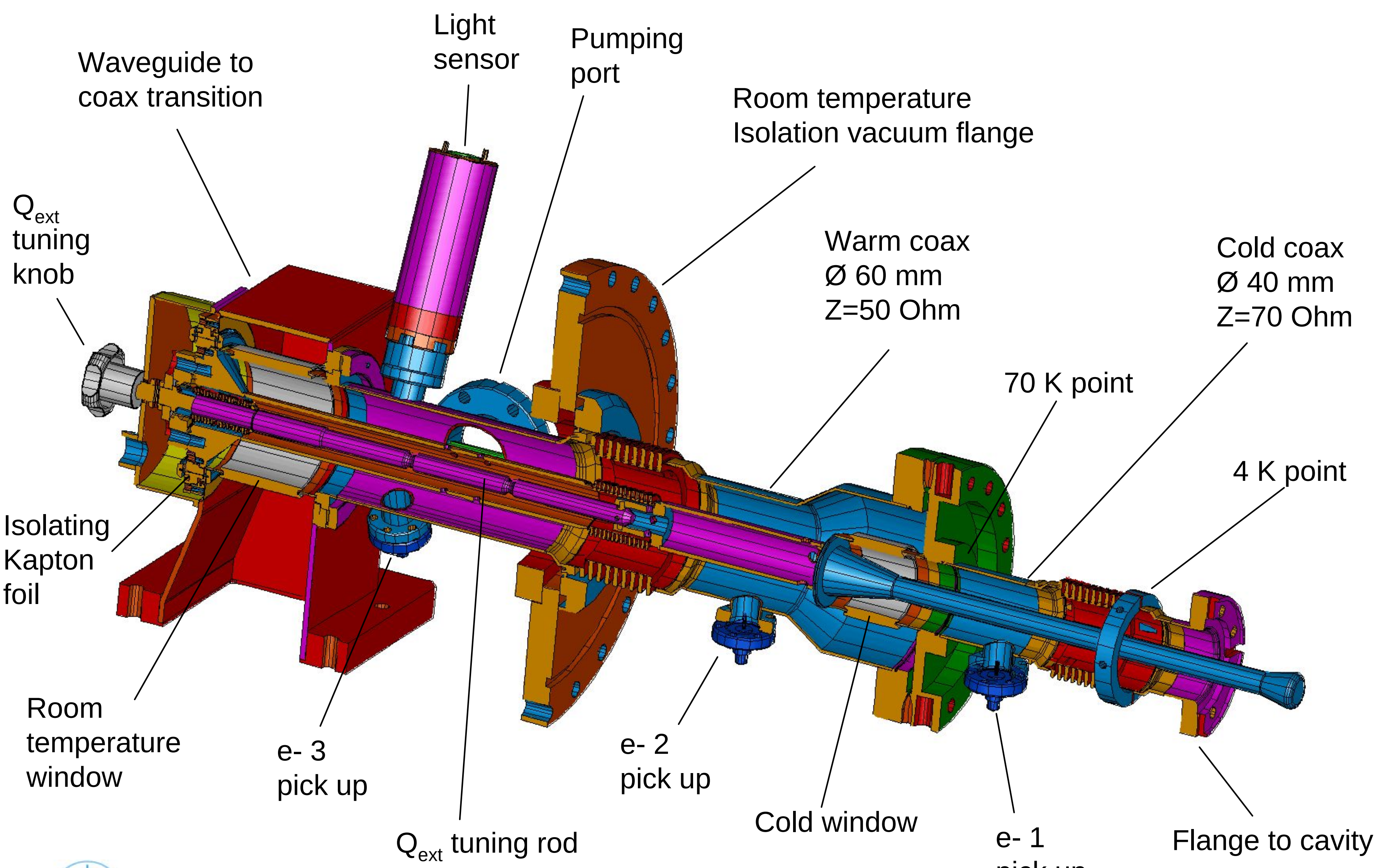
General Parameters

frequency	1.3 GHz
operation	pulsed: 500 µsec risetime, 800 µsec flat top with beam
power for High Power Processing in situ	1 MW at reduced pulse length (500 µsec and repetition rate 1 Hz)
2 K heat load	0.06 W
4 K heat load	0.5 W
70 K heat load	6 W
diagnostic	sufficient for safe operation and monitoring

1. Specification of the TESLA High Power Coupler

	TTF	**TESLA 9-cell / upgrade**	**TESLA superstructure / upgrade**
beam power incl. control margin	250 kW	250 kW / 500 kW	555 kW / 1110 kW
repetition rate	10 Hz	5 Hz	5 Hz
coupling	adjustable (10^6 - 10^7)	Fix / adjustable ($3*10^6$)	Fix / adjustable ($2.5*10^6$)
cavity position during cool down	flexible (15 mm longitudinal)	fix point (2.5 mm longitudinal)	fix point (2.5 mm longitudinal)

The TTF 3 Coupler Design



2. Design criteria for the TESLA Coupler

coax is easy for:	- variable coupling - fabrication - assembly
bias on inner coax:	-suppression of multipacting
two windows for:	- clean assembly of the cavity - save operation
Cylindrical windows	-shadow ceramic from beam sight
flexibility:	- bellows in the warm and cold coax
ceramics:	- Al_2O_3 with TiN coating

Multipacting as a Design Criteria

in order to avoid multipacting during conditioning and operating one has to:

- choose the right coaxial line diameter (MP level moves up with the 4^{th} power)
- the right impedance (MP level moves up linear)
- lower the secondary electron emission coefficient on the surfaces (especially the ceramic)
- add a bias voltage to the inner conductor to suppress multipacting

2. Tests and Performance

- More than 25 TTF 3 couplers are tested on a coupler test stand at 1 MW, 2Hz, 1.3 ms, traveling wave, baked in situ, two at a time

- TTF 3 couplers are operated at the VUV-FEL for more that 38000 coupler-hours up to 400 kW,

  2-10 Hz, 1.3 ms

- All couplers in the VUV FEL linac could be processed and operated up to the cavity performance limits

High Gradient Test at Horizontal Test Stand

- An electro polished cavity & TTF3 coupler have been operated at 35 MV/m for more than 1100 hours in the horizontal test stand

- Forward power was above 600 kW

  (due to the not compensated Lorentz Force detuning)

- No degradation in the performance of cavity or coupler

  (During setup of LLRF system breakdowns in coupler and quenches in cavity were caused)

Processing times of Couplers

- Coupler test stand: 70 - 125 h
  two at a time, baked in situ
- Horizontal Cryostat: 20 - 120 h
  one at a time, baked in situ
- We have no results from processing a single module equipped with TTF3 couplers only
- Module 6 with TTF3 couplers will be tested on the new module test stand by end of this year
- **Systematic coupler processing studies started at Orsay**

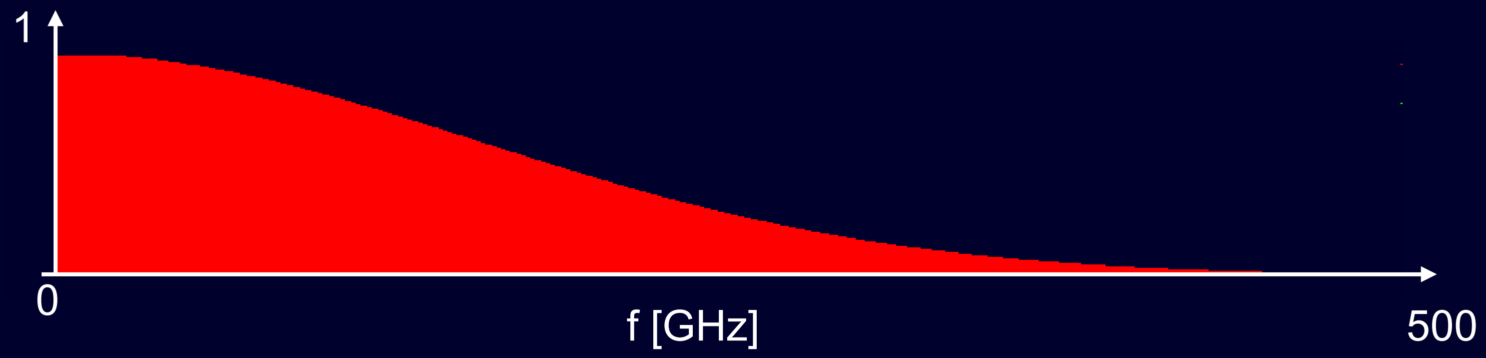
HOM damping

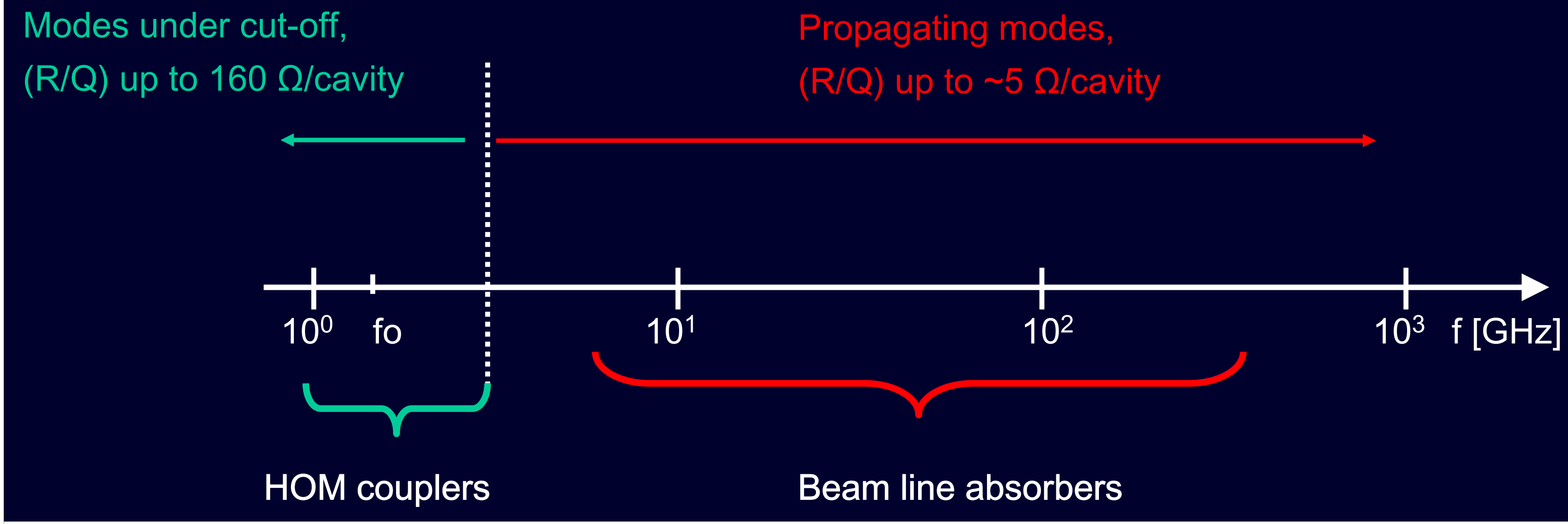
J. Sekutowicz, DESY

1. Introduction
   1.1 Beam spectrum (ILC-500)
   1.2 HOM couplers
   1.3 Beam line absorbers
   1.4 Specification
2. TTF statistics
3. Summary

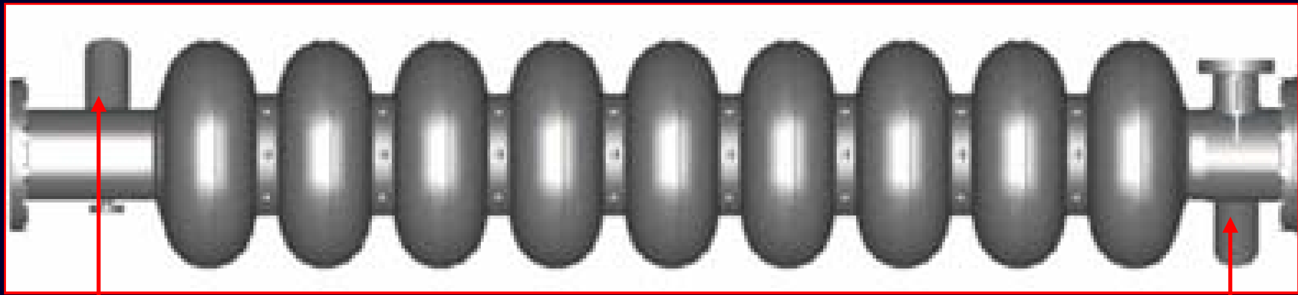
1.1 Introduction; Beam spectrum

Beam spectrum: σ_z = 0.300 mm, $\Delta f_{i,i+1}$ = 2.967 MHz





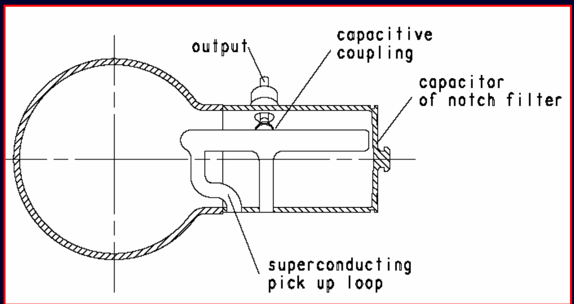
1.2 Introduction; HOM couplers



Two coaxial HOM couplers

Couplers have tunable FM rejection filter.

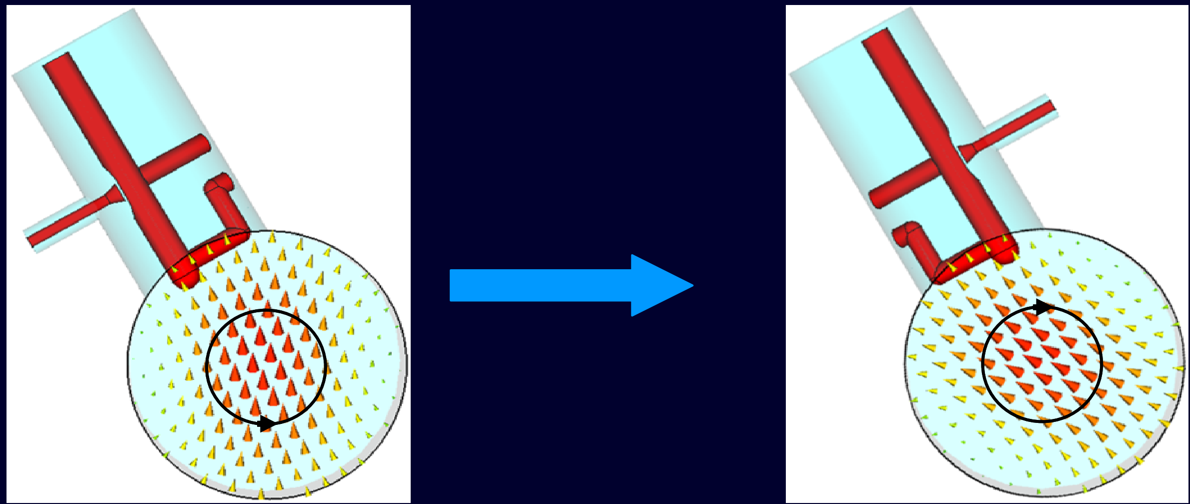
Typical FM $Q_{ext} > 10^{11}$ at 2K.



3. TTF cavities; Statistics 3rd dipole

Insufficient damping of one polarization was first observed by Saclay group using the charge modulation method.

Computer simulation (M. Dohlus) mirrored HOM coupler should provide better damping.



New 30 cavities (fourth production) have the mirrored HOM coupler. Test will follow.

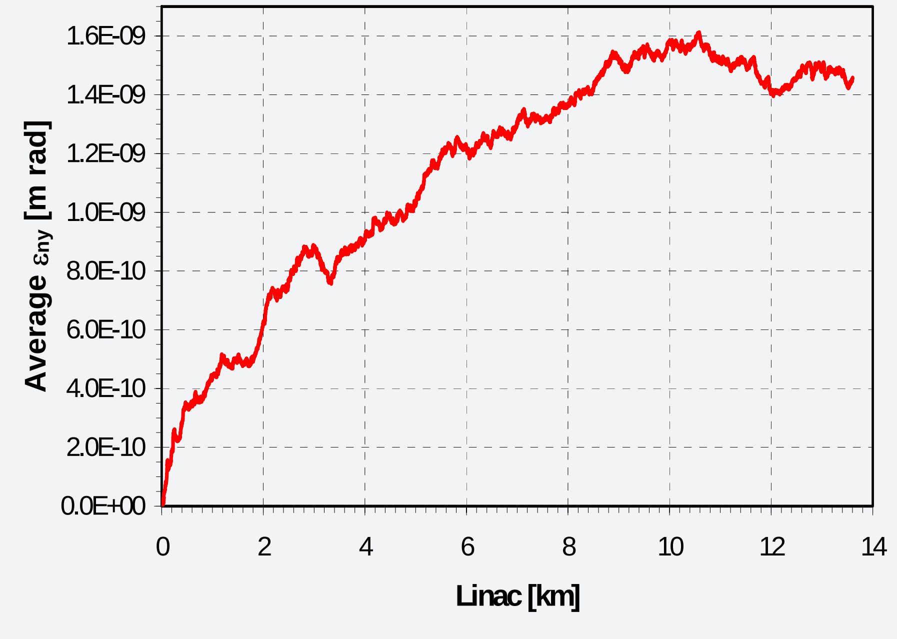
1.4 Introduction: Specification for dipoles

CDR/TDR specification for Qext (not very well balanced spec.)

Frequency (ave. meas.) [GHz]	Loss factor (simulation) [V/pC/m^2]	R/Q (simulation) [Ω/cm^2]	Q (meas.)
TE_{111}-like			
1.6506	19.98	0.76	$7.0 \cdot 10^4$
1.6991	301.86	11.21	$5.0 \cdot 10^4$
1.7252	423.41	15.51	$2.0 \cdot 10^4$
1.7545	59.86	2.16	$2.0 \cdot 10^4$
1.7831	49.20	1.75	$7.5 \cdot 10^3$
TM_{110}-like			
1.7949	21.70	0.77	$1.0 \cdot 10^4$
1.8342	13.28	0.46	$5.0 \cdot 10^4$
1.8509	11.26	0.39	$2.5 \cdot 10^4$
1.8643	191.56	6.54	$5.0 \cdot 10^4$
1.8731	255.71	8.69	$7.0 \cdot 10^4$
1.8795	50.80	1.72	$1.0 \cdot 10^5$
TE-like			
2.5630	42.41	1.05	$1.0 \cdot 10^5$
2.5704	20.05	0.50	$1.0 \cdot 10^5$
2.5751	961.28	23.80	$5.0 \cdot 10^4$

$Q_{ext} < 10^5$

Emittance growth $\Delta\varepsilon/\varepsilon \approx 5\%$



1.4 Introduction: Specification for dipoles

EPAC2000 specification for Qext of 31 dipole modes (N. Baboi et al.)

Dipole modes number	Q	R/Q [Ω//cm²]	max ε_n [m·rad]
27 4	$5 \cdot 10^5$ $1 \cdot 10^5$	> 15	$2 \cdot 10^{-8}$
27 4	$5 \cdot 10^5$ $5 \cdot 10^4$	> 15	$1.5 \cdot 10^{-8}$
27 4	$2 \cdot 10^5$ $5 \cdot 10^4$	> 15	$5 \cdot 10^{-9}$
24 7	$2 \cdot 10^5$ $5 \cdot 10^4$	> 10	$2 \cdot 10^{-9}$
27 4	$2 \cdot 10^5$ $1 \cdot 10^5$	> 15	$8 \cdot 10^{-9}$
31	$2 \cdot 10^5$		$2 \cdot 10^{-8}$

Table 2: Multibunch emittance for various choices of Q

Vertical emittance spec. < 3E-8 m·rad

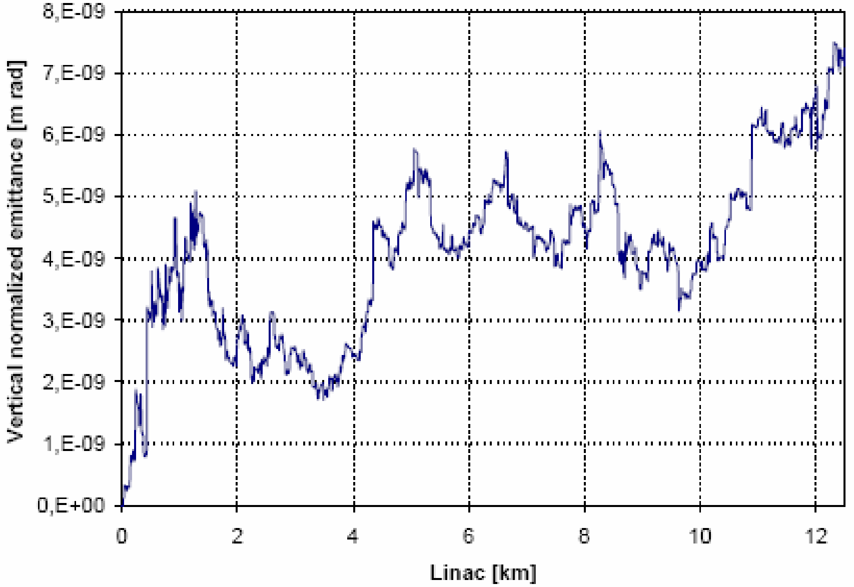


Figure 3: Multibunch emittance along the linac

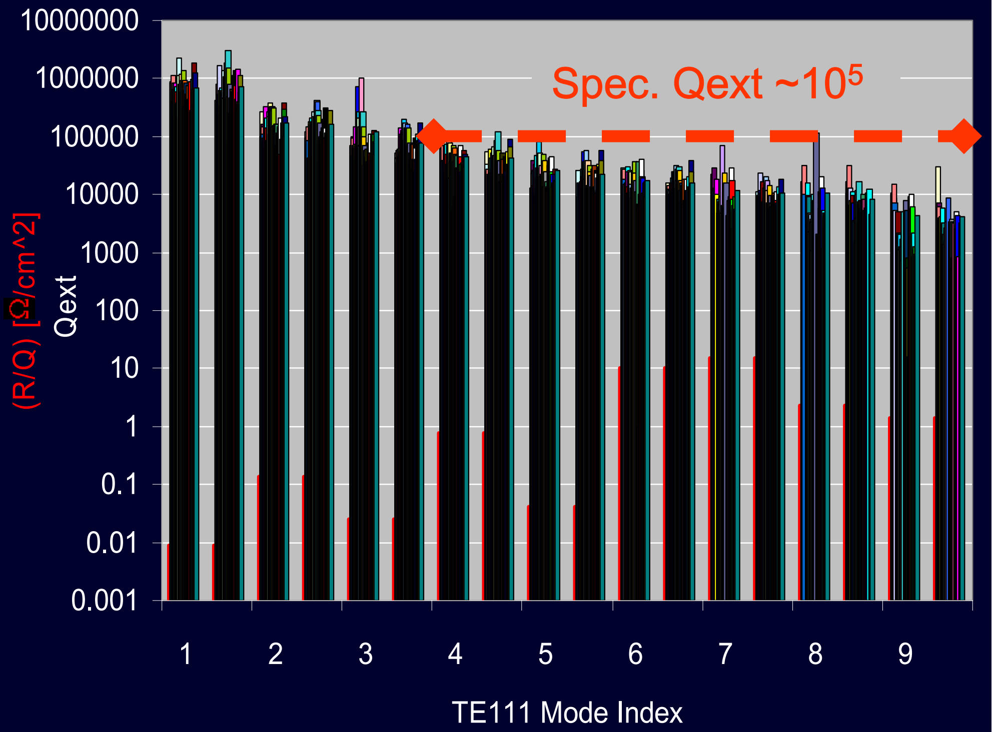
3. TTF cavities; Statistics 1st dipole

9-cells statistics: 50 cavities measured at 2K

1st dipole passband TE111

f =<1620-1790> MHz ±5MHz

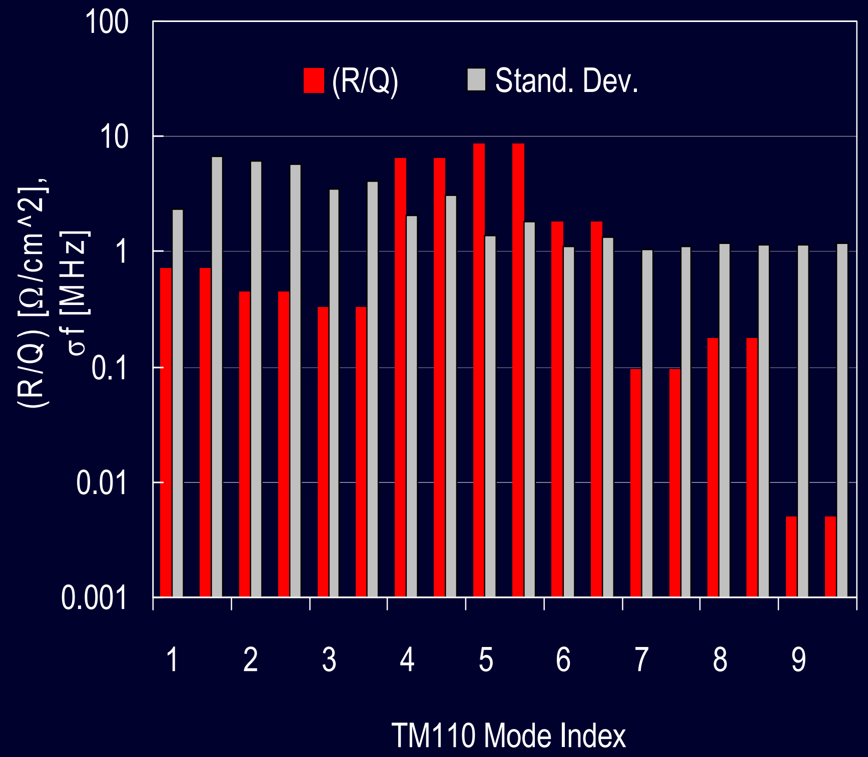
Qext (50 cavities => 900 modes)

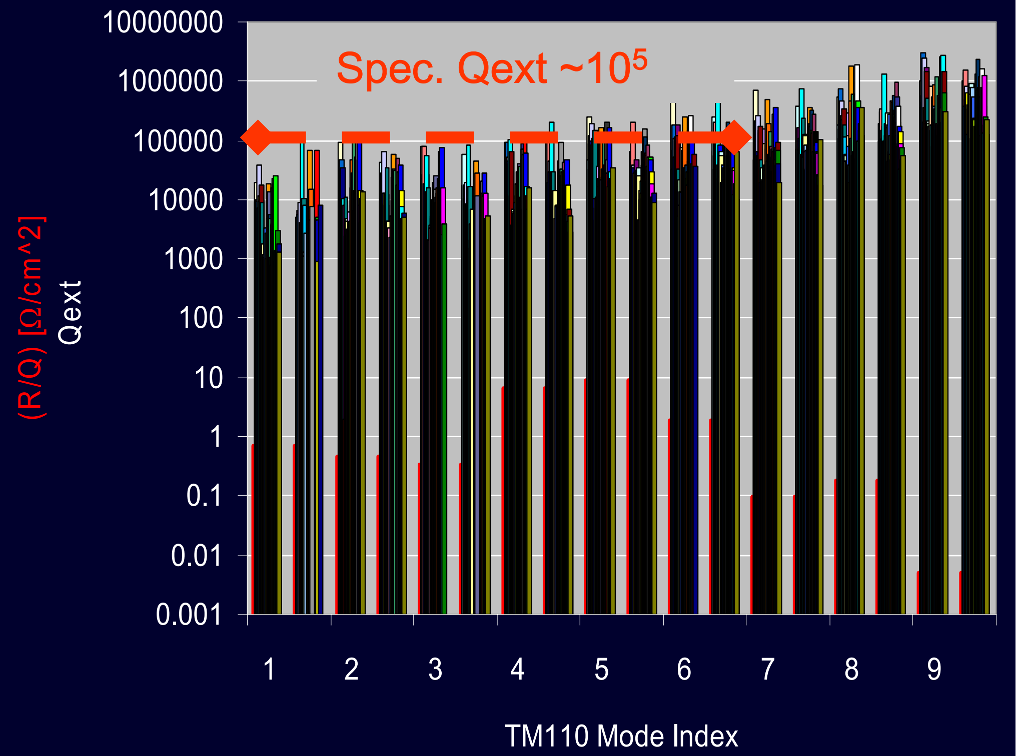


3. TTF cavities; Statistics 2nd dipole

2nd dipole passband TM110

f =<1790-1890> MHz ±1 MHz to ±6 MHz

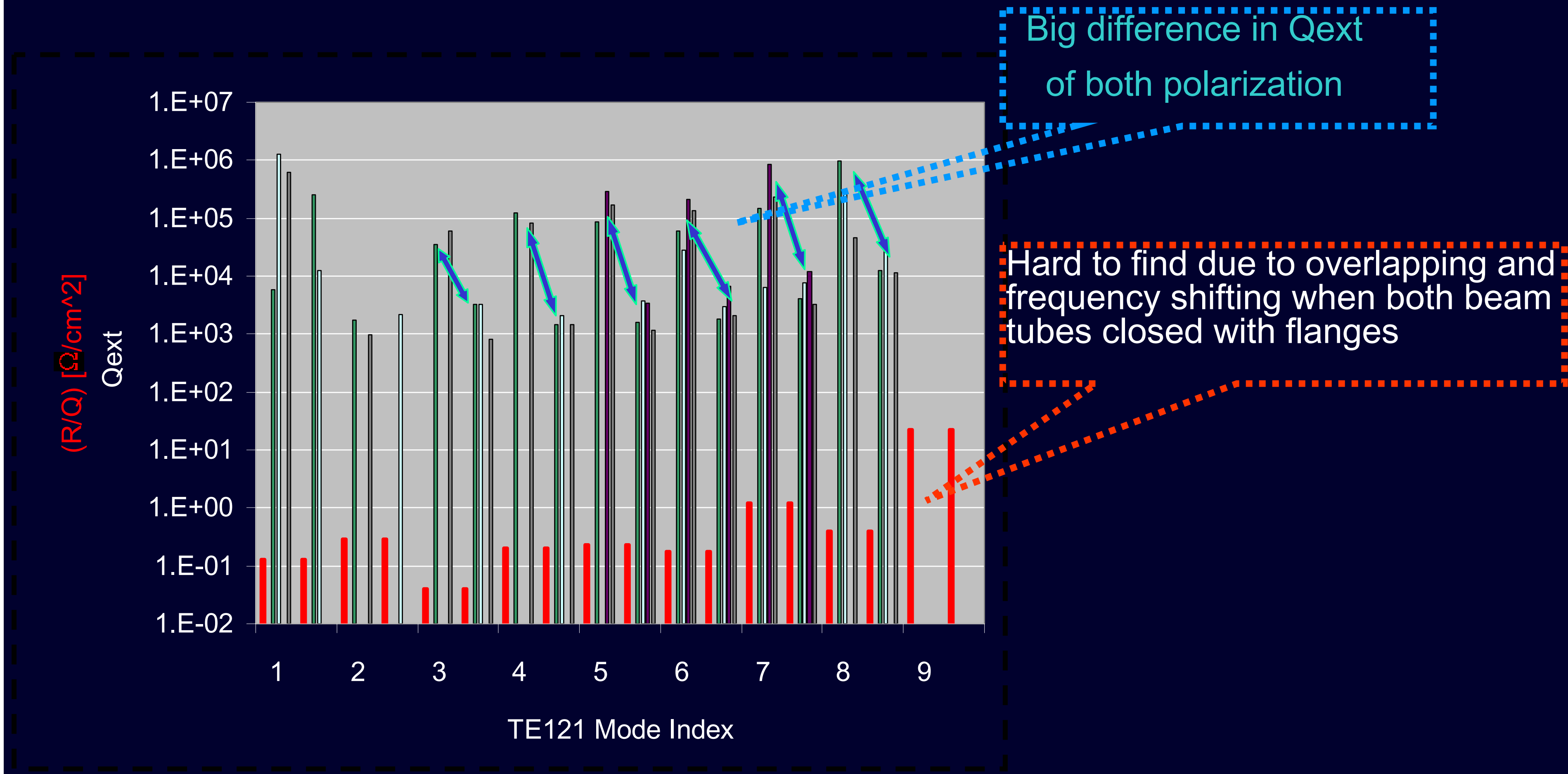




3. TTF cavities; Statistics 3rd dipole

Qext of 3rd dipole passband TE121

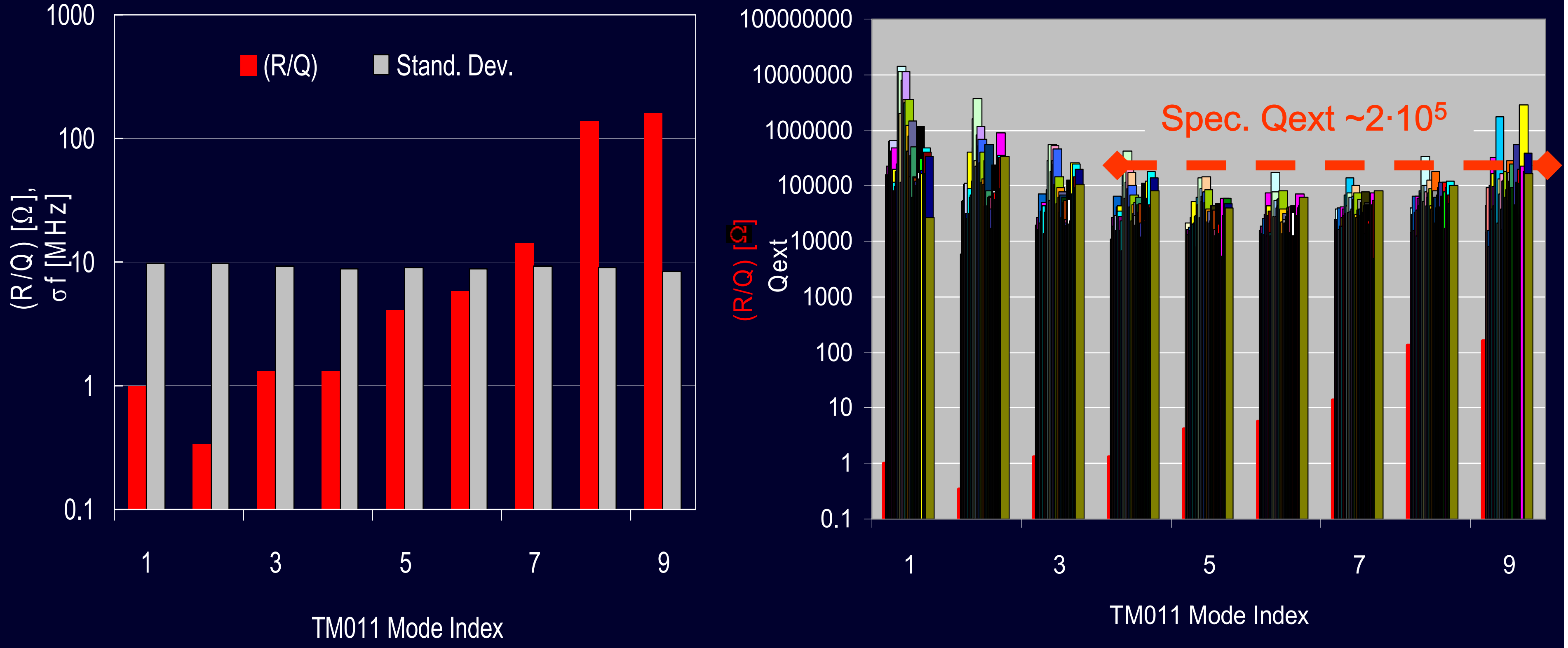
(7 cavities measured in the horizontal cryostat CHECHIA)



3. TTF cavities; Statistics monopole

1st monopole passband TM011

f = <2370-2450> MHz ± 9 MHz



1.4 Introduction: Specification for monopoles

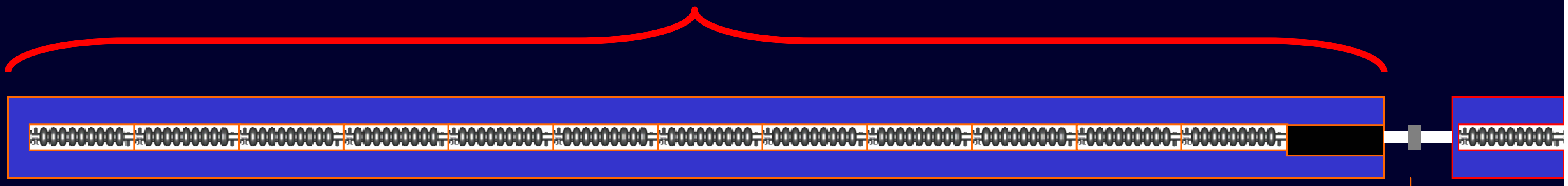
When the excitation is asynchronous : ~ 2 W/cavity

Losses per cryomodule (12x9cells):
(M. Dohlus)

P	=	23.3 W
P (f > 5 GHz)	=	17.4 W
P (f > 10 GHz)	=	12.7 W
P (f > 20 GHz)	=	8.1 W
P (f > 50 GHz)	=	3.0 W
P (f >100 GHz)	=	0.7 W

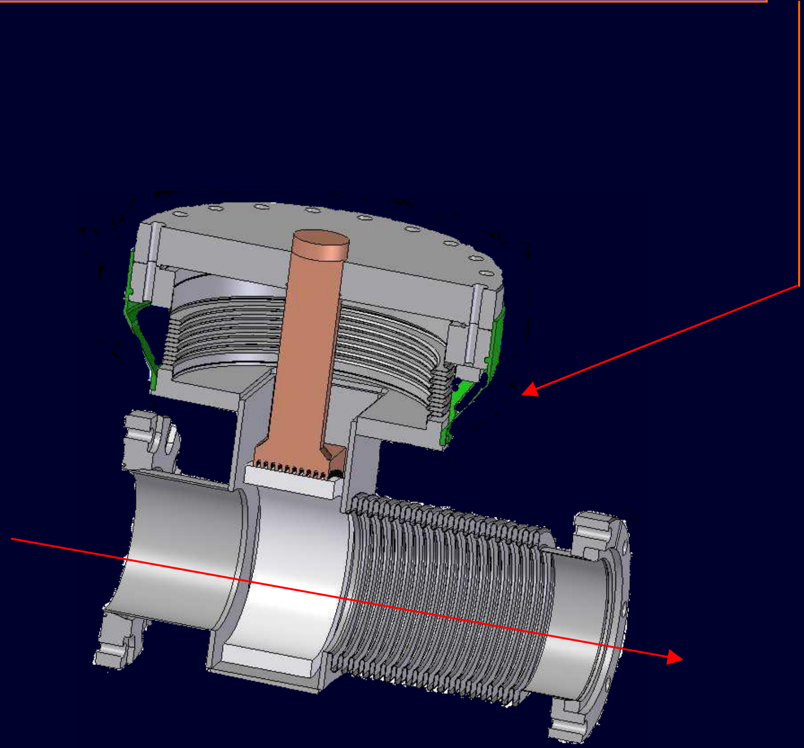
1.3 Introduction: Beam line absorber

17 m long TDR cryomodule: 12 cavities.



70 K beam line absorber.

First prototype will be ready in August 2005.



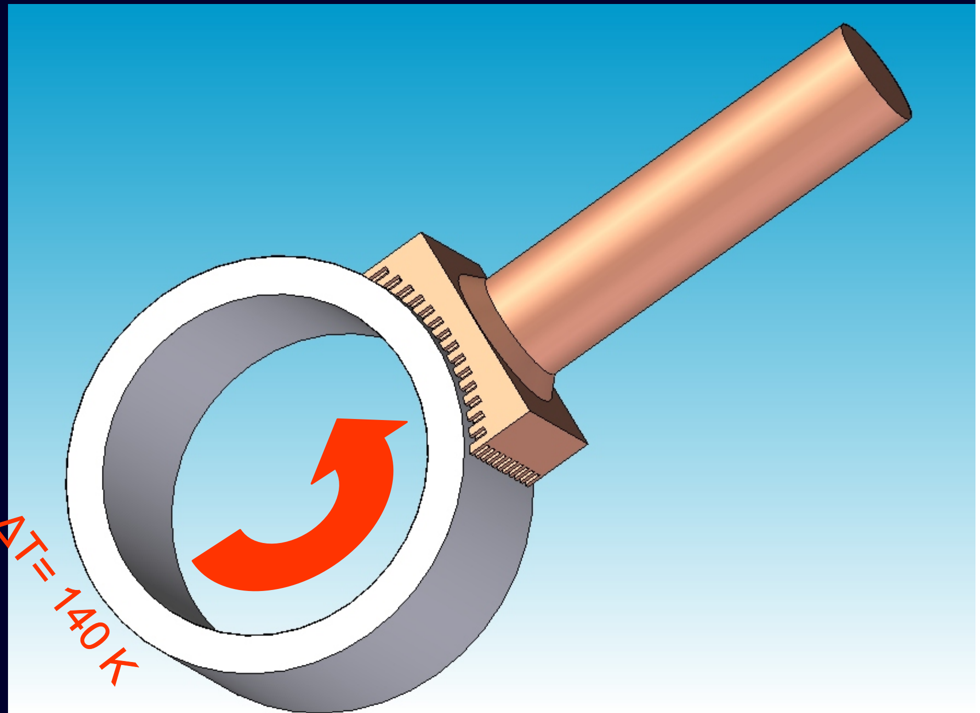
1.3 Introduction: Beam line absorber

Performed tests:

✓ 2x fast cool-down to 70 K

✓ 140 k ΔT across the ceramic

✓ 10x cool-down to 2K *(in progress)*



4. Summary

TTF 9-cell structures:

- Damping of two first dipole pass-bands within the spec.
- Improvement towards better damping of 3rd dipole pass-band will be tested soon.
- Non propagating monopoles are damped sufficiently.
- The prototype of beam line absorber will be ready for beam test next year.

- Frequency spread of HOMs is rather big if not too big
- Does the production of cavities ensure the design shape of cells?
- Is the frequency spread so big that some propagating modes (~ 9 GHz) will be trapped within cryostat before they reach beam line absorber?
- We need more computer simulation of the whole 12-cavity string

1.4 Introduction: Specification for monopoles

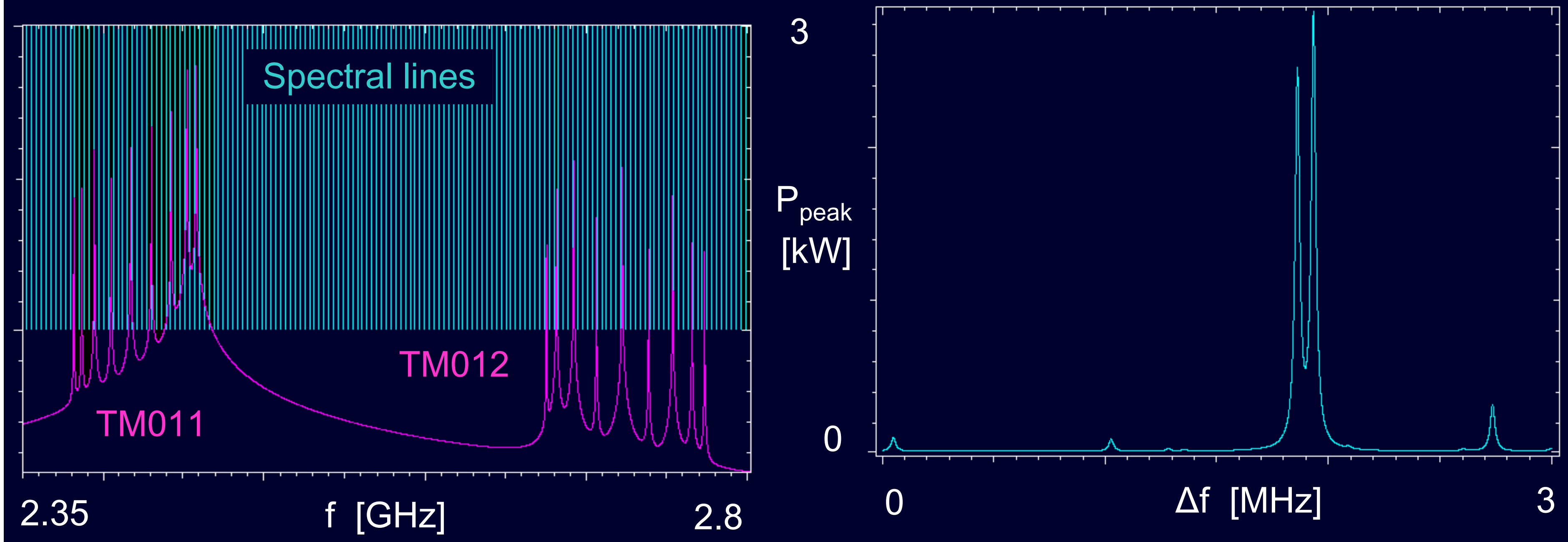
ILC 500GeV with TDR like parameters:

f_{rep} = 5 Hz
t_{HF} = 0.95 ms
t_{bunch}=337 ns

σ_{bunch} = 300 μm
N_{bunch} = 2820
q_{bunch} = 3.2 nC (9.5 mA)

Very pessimistic estimation $Q_{ext}=2\cdot10^5$:

all nine TM011 and nine TM012 modes excited resonantly : <P> = 22 W/cavity



We have tested HOM couplers in CHECHIA up to 2 kW peak power.

3. Energy exchange between two polarizations *(SLAC)*