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Leading Innovation

Fabrication of STF-type couplers for the plug-compatible with TTF3-type couplers

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- STF2 / TTF-III (history)
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- Summary

Product lines

型式 Type	周波数(MHz) Frequency	入力電力 Input Power	CW/PULSE	フランジ /Flange 入力 Input	フランジ /Flange 出力 Output	冷却 Cooling	質量(kg) Weight	全長(mm) Length
COUPLERS								
E4277	324	400kW	620μs	WX-152D	ICF203	L	60	1,230
E4294	324	400kW	620μs	WX-152D	WX-77D	L	70	819
■E4251	500.1	150kW	CW	WR1,500	ICF203	L,FA	40	482
E4262	500.1	300kW	CW	WR1,500	ICF203	L,FA	50	708
E4261	508.6	300kW	CW	WR1,500	ICF203	L,FA	50	903
E4263	508.6	300kW	CW	WR1,500	ICF203	L,FA	50	990
E4268	508.9	800kW	CW	WR1,500	ICF203	L,FA	50	703
E42107	508.9	800kW	CW	WR1,500	ICF203	L,FA	55	765
E4274	508.9	40kW	CW	ICF203	WX-120D	L	30	820
E4253	714.0	50kW	CW	WR1,500	ICF152	L,FA	40	650
E42109	1,300	20kW	CW	WR650	coaxial	–	25	750
E42111	1,300	300kW	CW	WR650	coaxial	L,FA	13	603
E42100*	1,300	1MW/500kW	400μs/1.3msec	WR650	coaxial	–	25	730
E42101*	1,300	1MW	1.5msec	WR650	coaxial	–	25	750
E42102*	1,300	1MW	1.5msec	WR650	coaxial	–	25	730
WIND OWS								
E4271	508.6	350kW	CW	152D coaxial	152D coaxial	L	15	377
E4278	805.0	550kW	1.3msec	coaxial	coaxial	FA	10	408
E4279	972.0	350kW	1.3msec	WX-120D	WX-120D	FA	8	153
E4264	2,450.0	5kW	CW	WR430	WR430	L	8	68
E4295	2,856.0	5MW	15μs	UG-53/U	UG-53/U	L	10	305
E4258	2,856.0	40MW	4μs	WR284	WR284	L	10	321
VT-68423	5,712.0	25MW	2.5μs	WR187	WR187	–	6	204
VT-68423,A	5,712.0	7MW	4μs	WR187	WR187	L	6	204

Super
Normal

Product lines

E42101
750mm

E42111
688mm

cold part

E42109
266mm

E4278
408mm

E4268
703mm

E4262
708mm

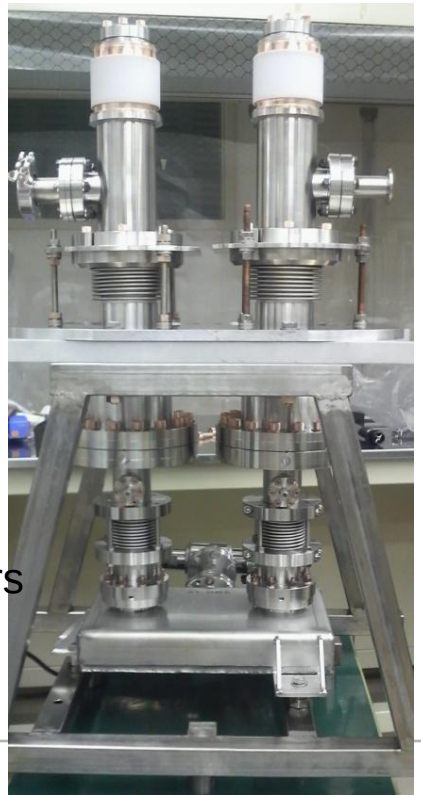
E4277
1,230mm

E4294
819mm

TTF-III type / STF2 (Toshiba Production history)

TTF-III type couplers : Toshiba has some experience in producing TTF3 type coupler include R&D with LAL/DESY.

STF2 type couplers : Toshiba has more than twenty pieces of production experience include some modifications in collaboration with KEK.



TTF-III type Couplers

STF2 type Couplers

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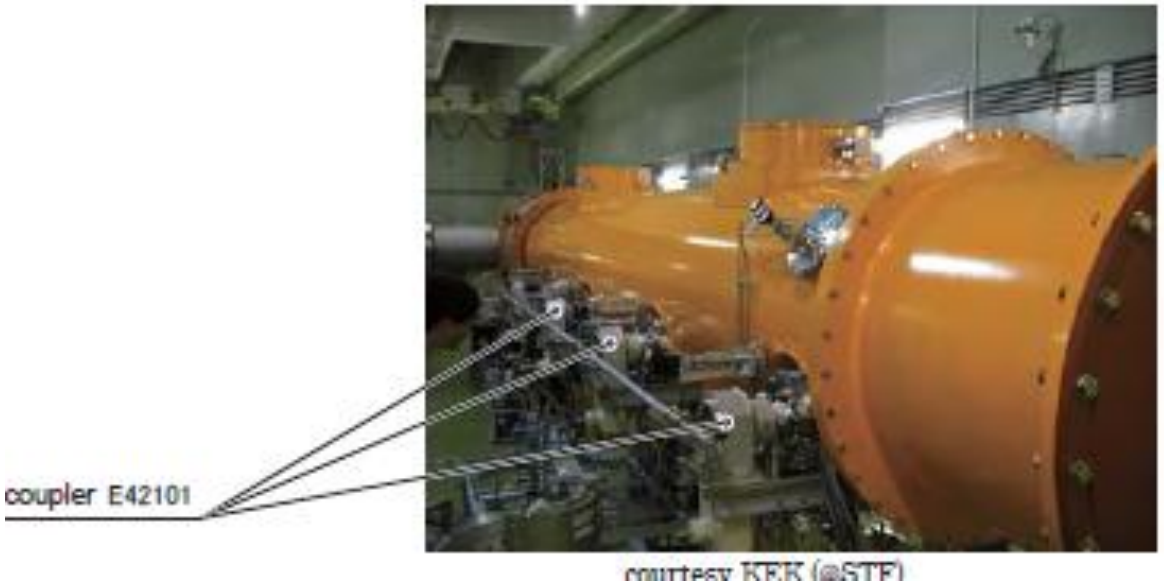
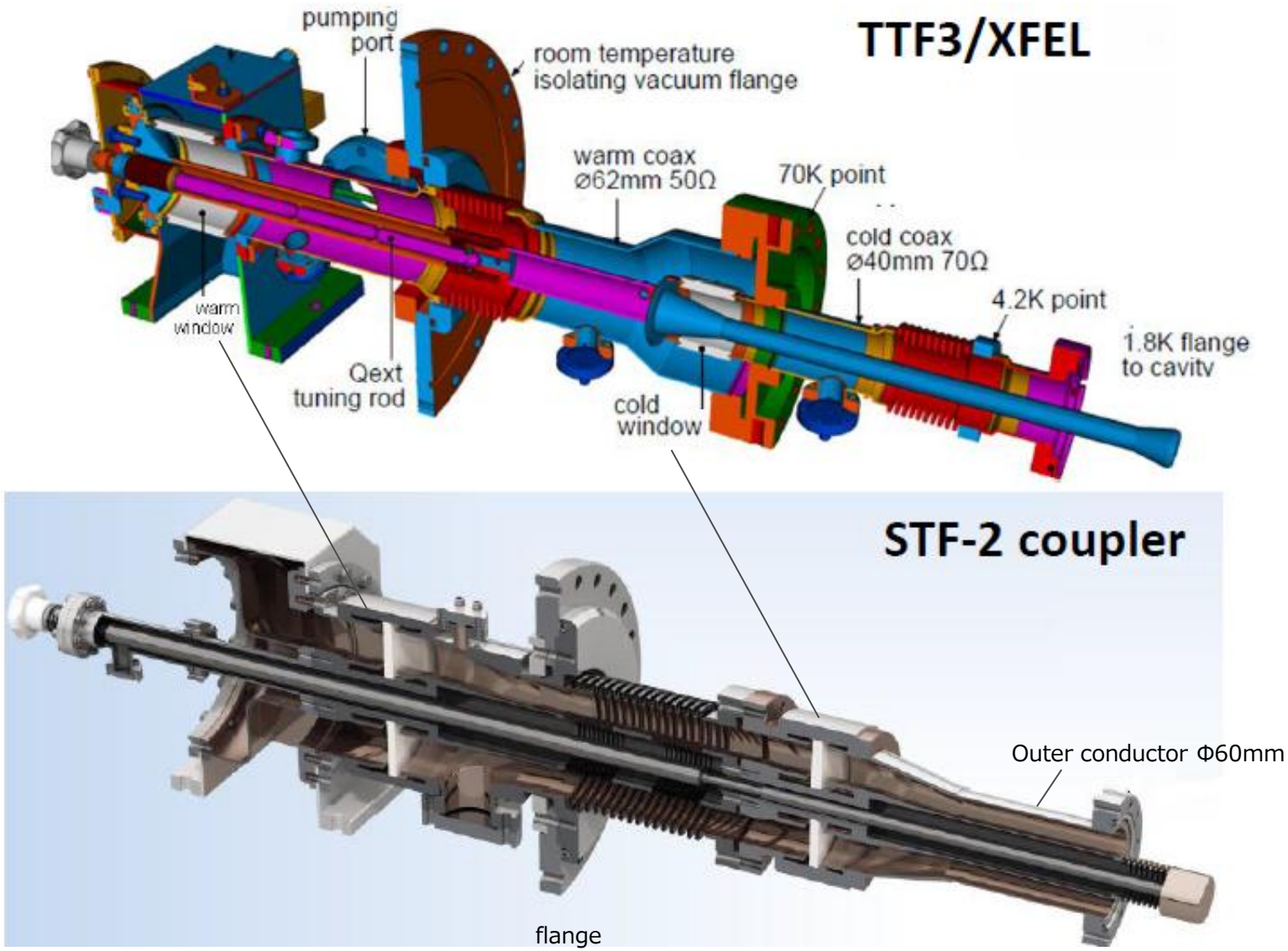
TTF-III type Couplers



STF2 type Couplers

TTF-III type / STF2 compaison



LCWS2013 - summary(1)

ILC specification

- Power requirements
  - We recommend to match the coupler to 30 MV/m for reduced filling time and smaller Qext range
  - Max coupler power at operation 450 kW (for 8.8 mA, 10Hz, Eacc=31.5 MV/m ±20%)
  - RF processing to at least four times max input power ~ 1.8 MW up to 500 us at test stand TW
  - Surface field not a problem for both designs, i.e. 40mm and 60mm are both ok
  - Should check flattop regulation at 25 MV/m and Qext ~ 1e7 (LFD)
  - TW testing on test stand up to 1.8MW has to be done for both: TTF3 and STF2
- Q-ext
  - Variable coupling is needed, remote operation
  - QL tuning range: 2-7x10^6 is needed, but we recommend 1-10 x 10^6
  - 1-10·10^6 is achieved with TTF3
  - STF2 has to be improved
- Antenna alignment:
  - Design should be +-2mm
  - For TTF3 coupler the most sensitive parameter is a horizontal antenna shift/tilt. 3mm shift change QL by ~20%. Vertical tolerances are relaxed.
  - For STF-2 coupler this is not issue, mechanical design guarantee small shift.
  - TTF3 has to be improved

LCWS2013 - summary(2)

- Cryogenic loss:
  - Coupler contribution to cryogenic losses at 2K is ~5%. = not critical.
  - Major contribution from coupler is 70K
- Conditioning time
  - Both designs are ok
  - The nominal conditioning time of < 50h is achieved/demonstrated.
- Multipacting
  - DESY and SLAC simulations, tests and operation show no problem with TTF3
  - STF2 will be simulated, tests show no problem
- One vs. two windows
  - Many single window coupler are successful under operation
  - The single window would need to seal-off the cavity before the cavity-string installation into the cryomodule.
  - Single window coupler for ILC would need complete new development and test program of coupler (and module)
  - But it could be a significant cost saving
- Compatibility
  - Cavity and attached parts (power coupler, tuner, HOM coupler, feedthroughs, He vessel, thermal connections, magnetic shield…) are tuned/balanced, it is not easy to exchange only parts of this composition
  - STF2 coupler design does not fit in the compatibility requirements of the TDR (40mm cavity coupler flange)

LCWS2013 - summary(3)

- Cost
  - CPI: STF2 price is 1.9 higher
  - Toshiba: STF2 slightly lower price
  - RI: about same price
  - Industrial study of STF2 for design optimization and cost reduction is recommended
  - The TTF3 coupler mass fabrication has to be investigated

Recommendation:

- STF2 coupler has to demonstrate stable long time (>6 month) beam operation in a CM (TTF3 coupler has a long history in FLASH)
- The ILC management recommend an adapted STF2 design with 40mm cavity flange. In this case more development steps have to follow in order to realize the compatible design. The new design has to be proven with beam operation.
- The concept of plug compatibility has to be further developed in view of a spare part concept. We recommend spare modules, not individual parts.
- An industrial study of mass production for both designs is recommended
- Industrial study of STF2 for design optimization and cost reduction is recommended.

LCWS2013 summary(4)

ILC RF Power Coupler design criteria comparison

	ILC Spec	TTF3 / XFEL	STF-2
Frequency	1.3 GHz	1.3 GHz	1.3 GHz
Operating pulsed RF power	450	100 .. 600 kW	450
Operating RF pulse length / rep.rate	1.65 ms / 5 Hz	1.3 ms / 10 Hz	1.5 ms / 5 Hz
Max. RF conditioning power (20 .. 500µs)	1.8 MW	1 MW	1.2 MW
Max. average power	3.7 kW	4.5 kW (tested and calculated limit)	3.0 kW (not the limit, but tested)
copper coating inner/outer conductor	nn	30 µm / 10 µm	25 µm / 10 µm
copper coating RRR	nn	30 .. 60	10-20
Max. cryogenic losses at 2K / 4.2K / 70K dynamic + static	need to check	0.06 W / 0.5 W / 8 W static+dynamic	0.06W / 0.8 W / 9 W simulated static
window	2 windows	2 cylindrical	2 disc
Warm coax		60 mm, 50 Ohm	82 mm, 50 Ohm
Cold coax		40 mm, 75 Ohm	60 mm, 43 Ohm
Qext range	1.0 – 10 x10^6	$1.0 – 15 \times 10^6$	$2.0 – 6.0 \times 10^6$
bias	yes	yes	no
lateral movement	5mm (including fabr. Error)	± 15mm	± 5mm
max surface field (inner cond cold part) @500kW TW		1MV/m	0.5MV/m
max voltage, (inner cond cold part) @500kW TW		14kV	7.5kV
MP levels		150 kW, 250 kW, 450 kW	
Insertion loss		less 0.1 dB	

Comparison of TTF-III and STF2

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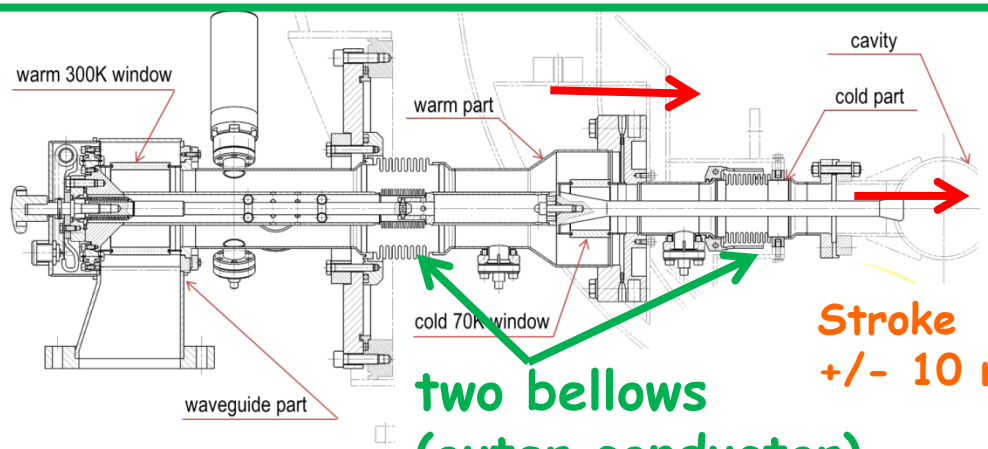
	TTF-III	STF
beam pipe diameter	78 mm	80 mm
inner conductor diameter	12.4 mm (20.7 mm @head part)	30 mm
outer conductor diameter	40 mm	**60 mm**
distance from end-cell center to input coupler center	101 mm	114.7 mm
distance from end-cell edge to input coupler center	45 mm	54 mm
stroke range	±10 mm (23~43mm)	**±3 mm**
Q_L	1 ~ 10 x 10^6	**2~ 4 x 10^6**

Should be improved!

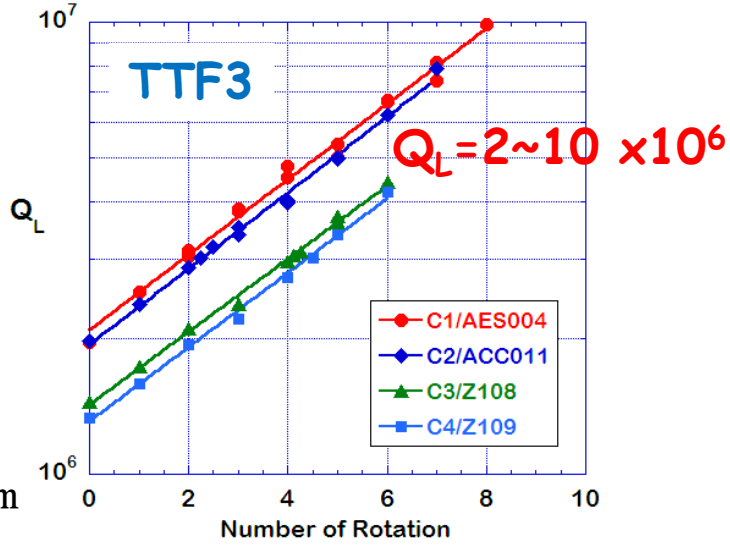
Comparison between STF-2 and TTF-3

Dr. Yasuchika YAMAMOTO@KEK)

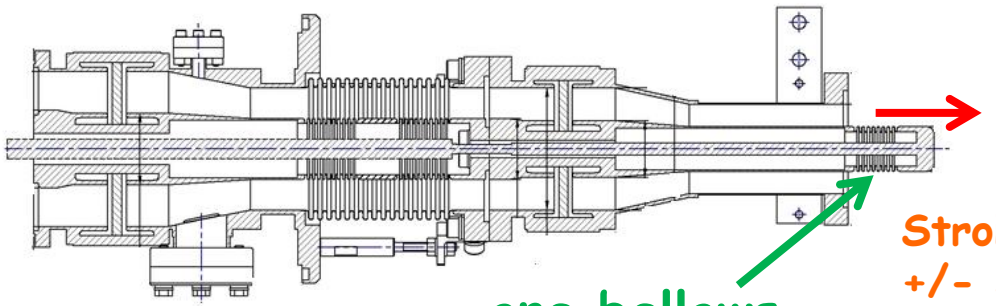


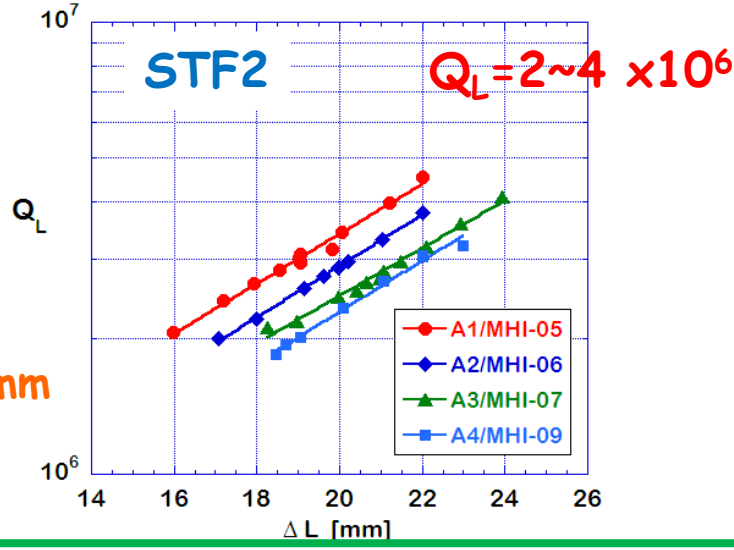
TTF3 Input Coupler

内導体外径12.4mm
先端部20.7mm



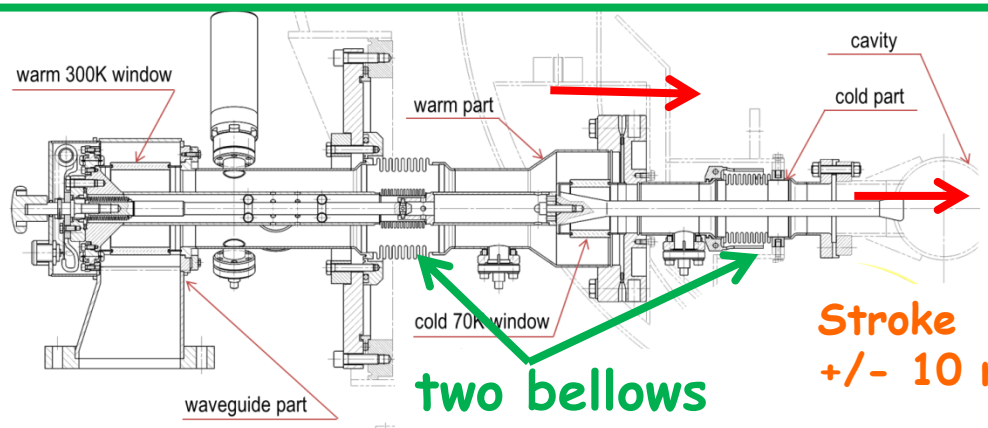
STF2 Input Coupler





Comparison between STF-2 and TTF-3

Dr. Yasuchika YAMAMOTO@KEK)

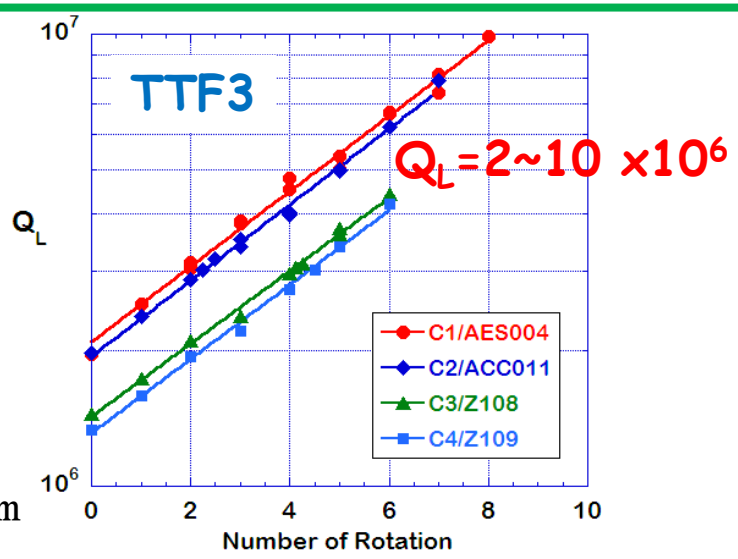


two bellows
(outer conductor)

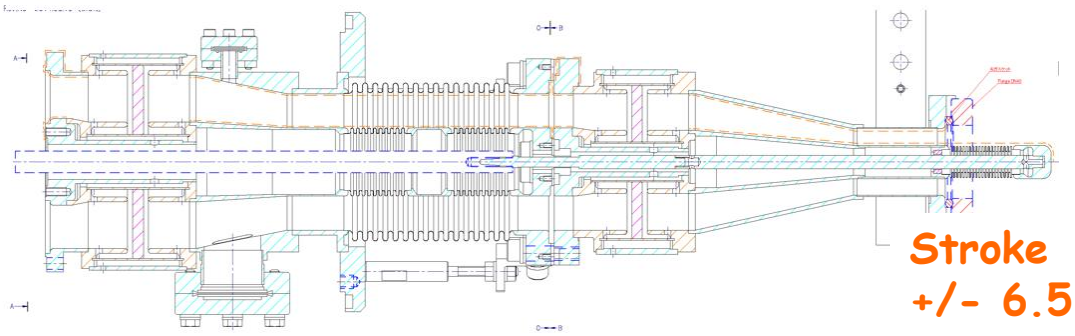
Stroke
+/- 10 mm

TTF3 Input Coupler

内導体外径12.4mm
先端部20.7mm

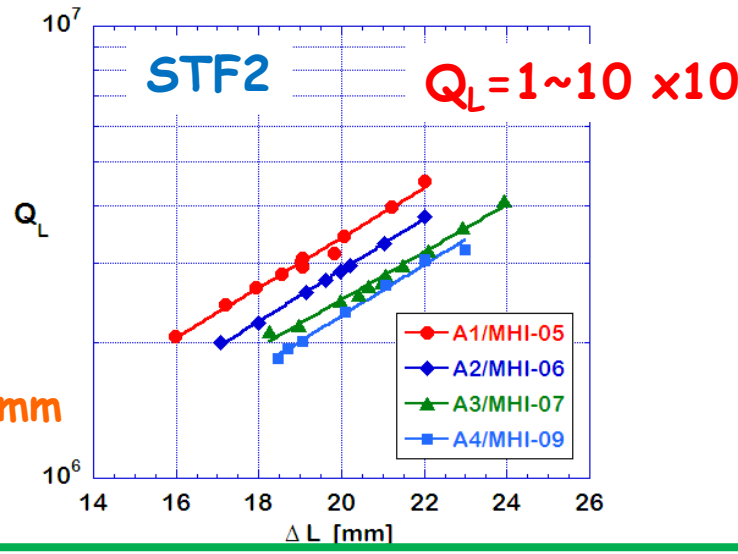


STF2 Input Coupler



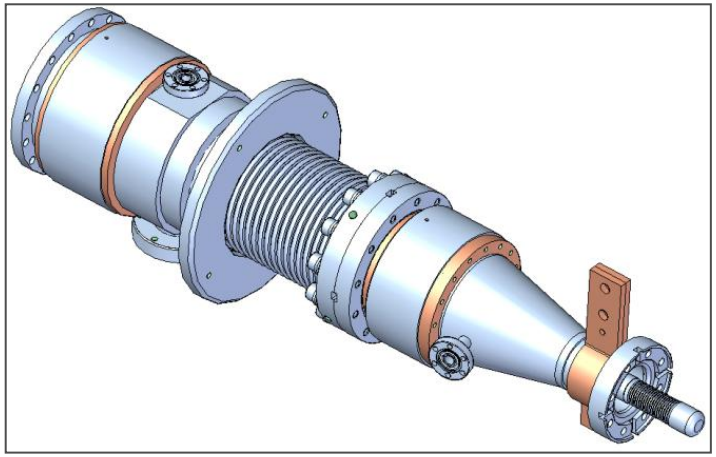
Stroke
+/- 6.5 mm

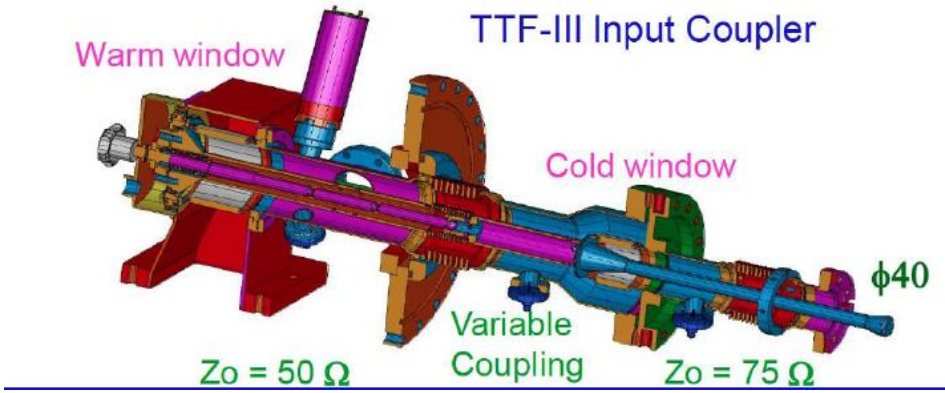
(inner conductor)



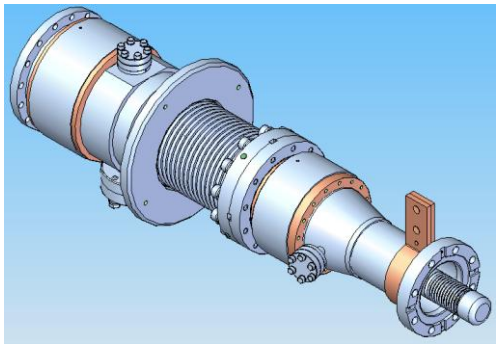
Comparison : TTF-III / STF2, STF2-plug comparable

STF2 plug comparable



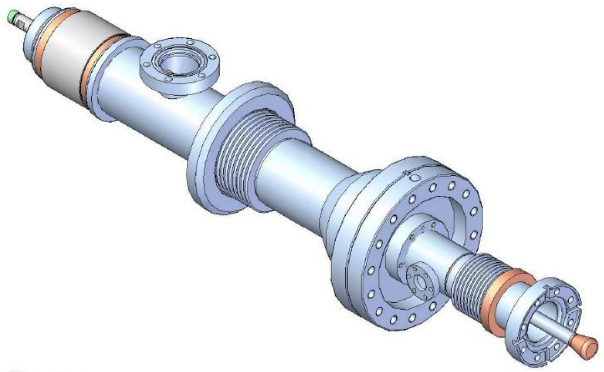


TTF-III type Coupler



Windows and Coaxial parts of
STF2 type Coupler

To compare



Windows and Coaxial parts of
TTF-III type Coupler

Comparison table : TTF3 / TTF3 by TETD

	TTF-III	TTF-III TETD version
Warm Window Ceramic	Cylindrical (with V-shaped groove)	Cylindrical (with V-shaped groove)
Cold Window Ceramic	Cylindrical (with V-shaped groove)	Cylindrical (with V-shaped groove)
Ceramic Purity	97.6%	97.6%
Number of parts *	37	33
Brazing Type	Vacuum	Vacuum
EBW points *	4	0
Number of Processes	20	20
Brazing *	6	11
EB Welding	2	0
TiG Welding	5	2
TiN coating	3	3
Copper Plating	3	4
Vacuum Treatment	more than 4	some
Materials *	* SUS316LN/316L/ 304L/304	* SUS316LN/316L/ 304L/304
	Cu OFE	Cu OFE

* Excluding Waveguide, Capacitor, Adjusting mechanism and Support brackets

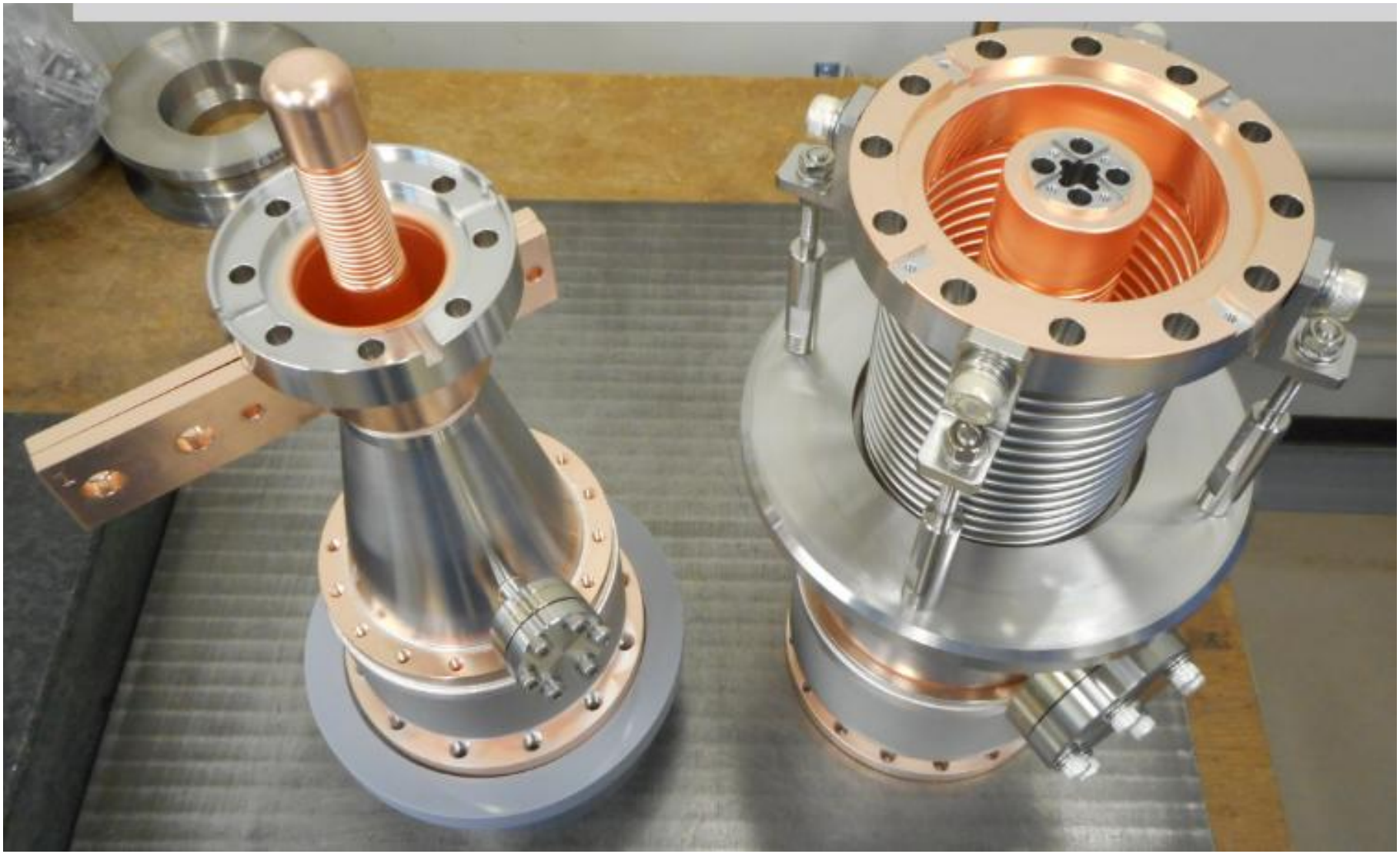
Comparison table: STF2 / STF2 plug comparable

	STF2	STF2 plug comparable
Warm Window Ceramic	Disk	Disk
Cold Window Ceramic	Disk	Disk
Ceramic Purity	95%	95%
Number of parts *	49	51
Brazing Type	Hydrogen	Hydrogen
EBW points *	0	0
Number of Processes	21	21
Brazing *	12	12
EB Welding	0	0
TiG Welding	2	2
TiN coating	3	3
Copper Plating	4	4
Vacuum Treatment	0	0
Materials *	* SUS316L/304L/ 304 (no 316LN)	* SUS316L/304L/ 304 (no 316LN)
	Cu OFE	Cu OFE

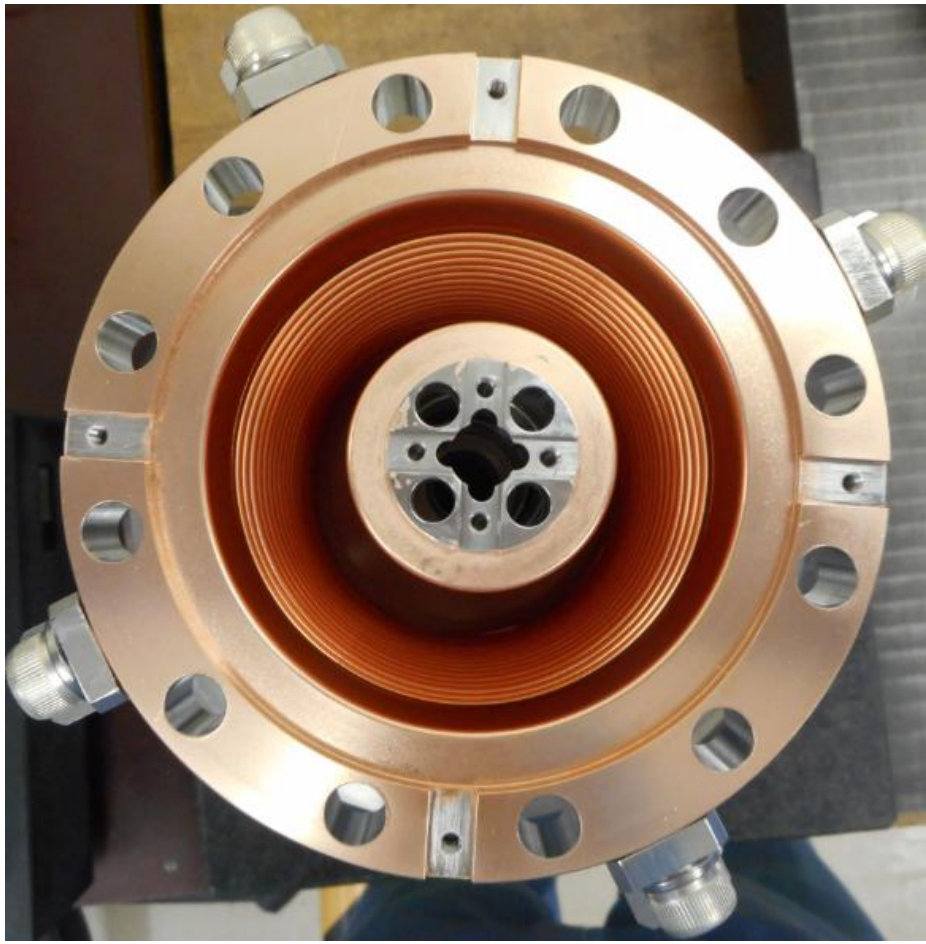
Number of parts isn't a problem at all.
By the cost saving study, these numbers can be bring down.

* Excluding Waveguide, Capacitor, Adjusting mechanism and Support brackets

STF2 plug comparable - production photo

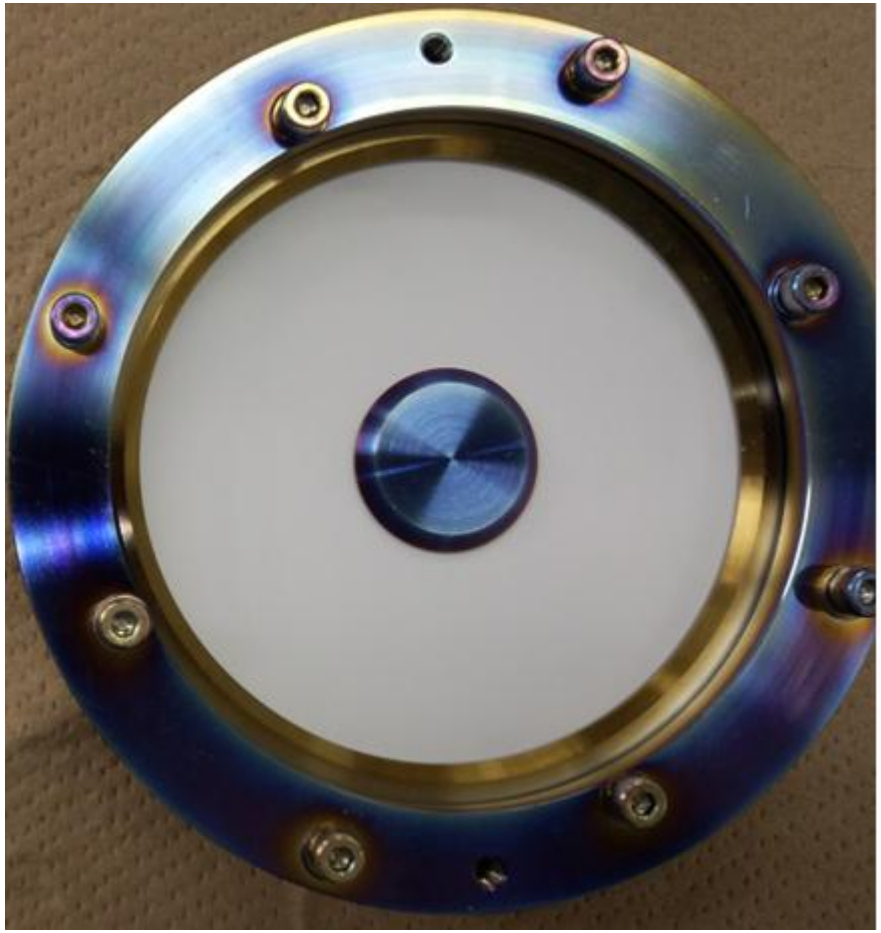


STF2 plug comparable - production photo

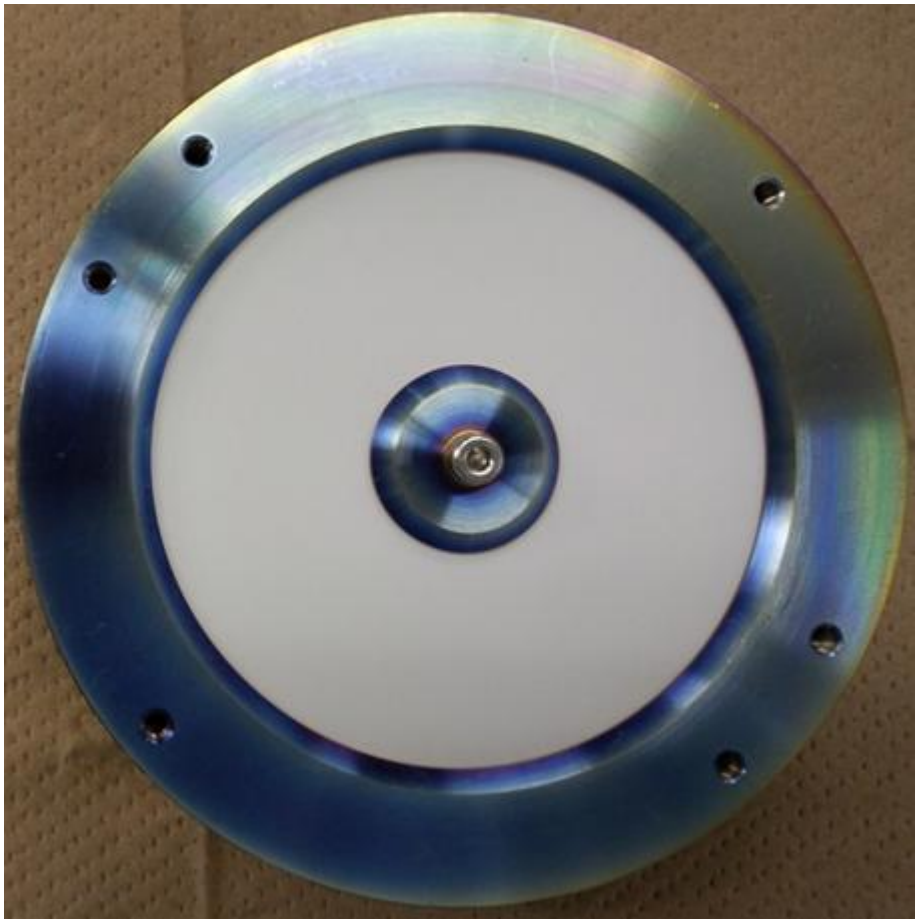


STF2 plug comparable + new CERAMICS

This work is collaborated with KEK/CERN.



Cold Window



Warm Window

Summary

- Toshiba has produced two types of "STF2 plug comparable" couplers in collaboration with KEK and CERN.
- The main important parameters to plug in are inner conductor diameter and stroke range.
- New Sample ceramic, which was improved from AH100A, has some possibilities to skip the TiN coating process.
- Toshiba is going to progress next challenging studies after the RF conditioning results.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