Industrialization of ILC from a View Point of Industry

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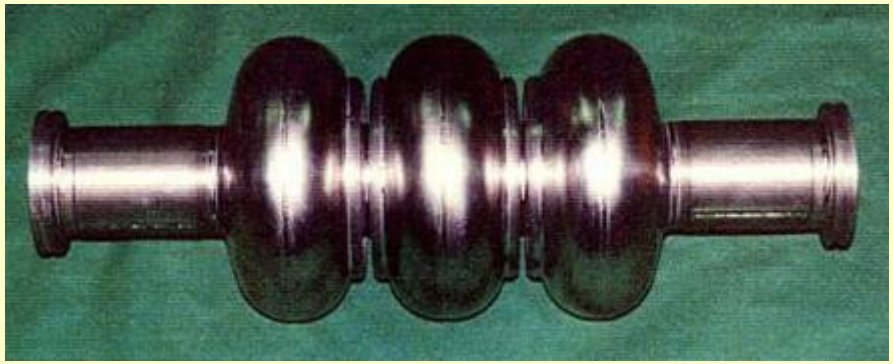
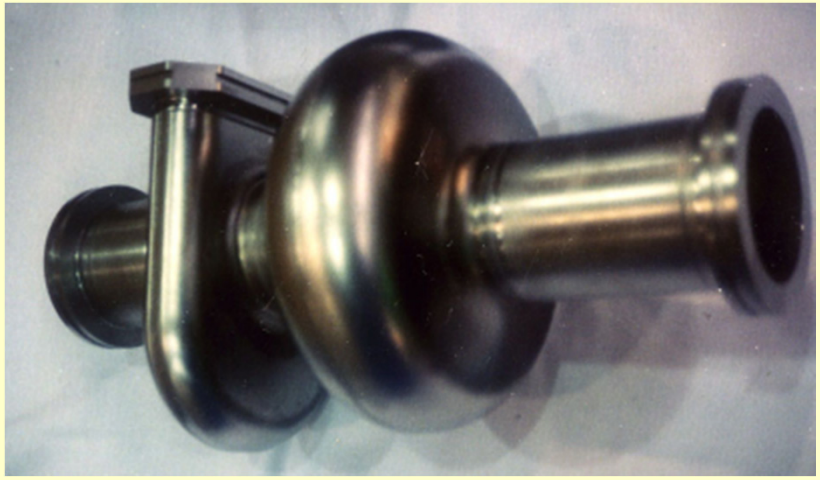
1 SRF activities at MHI

‘86~ Tristan Cavity 36sets

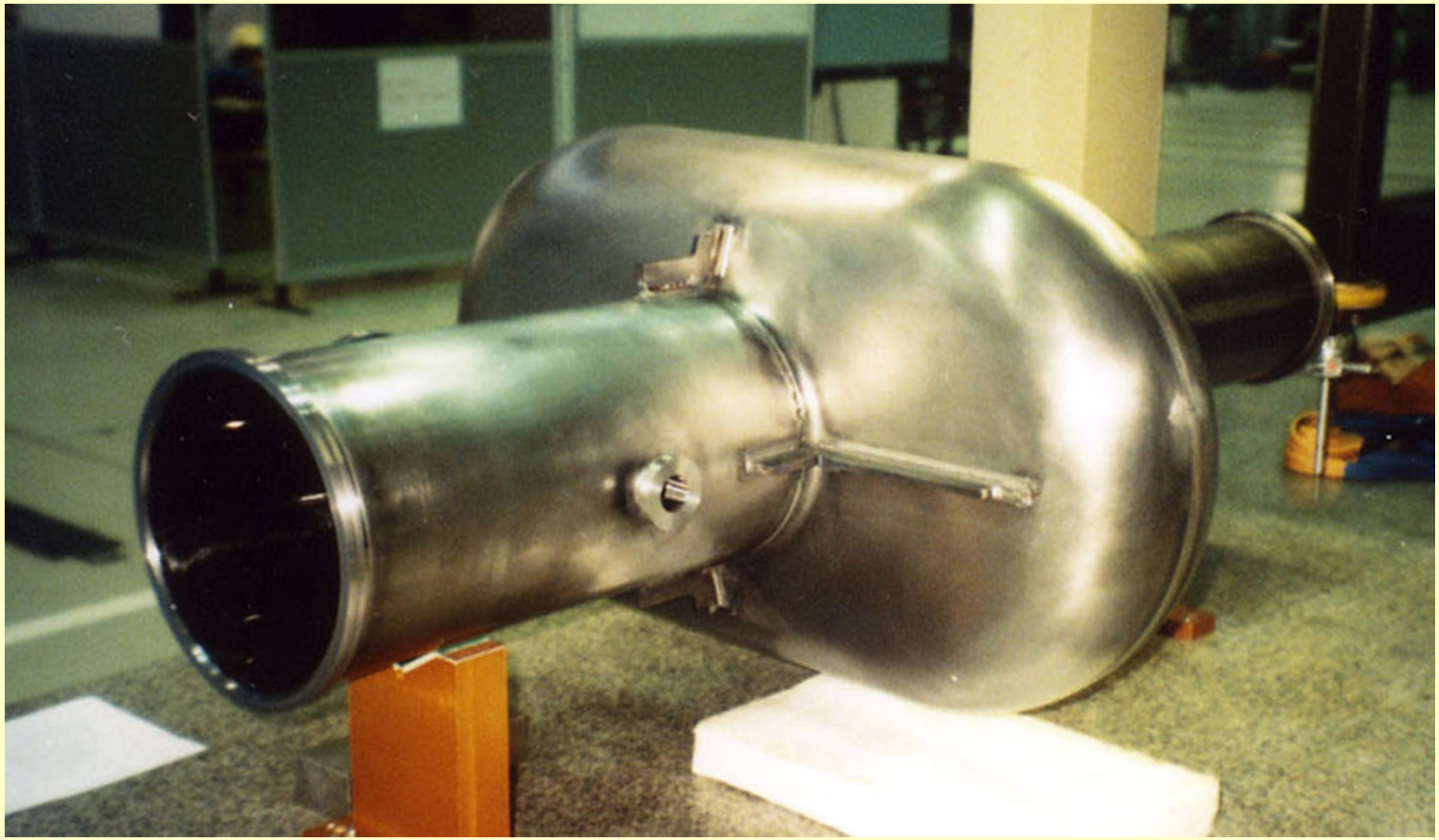
1 SRF activities at MHI





’90~ L-band Cavity

1 SRF activities at MHI



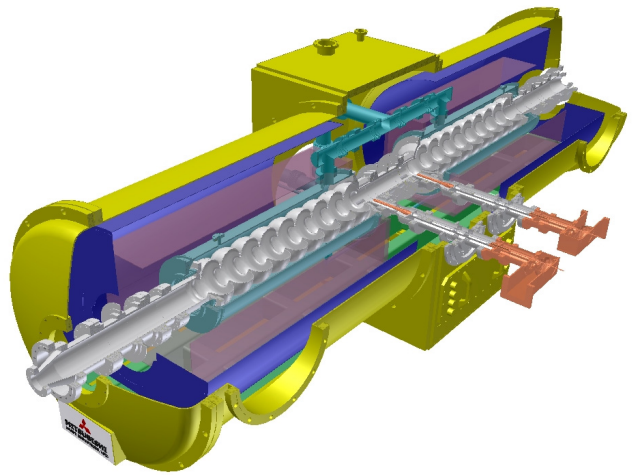
’02~ Crab Cavity 2 sets

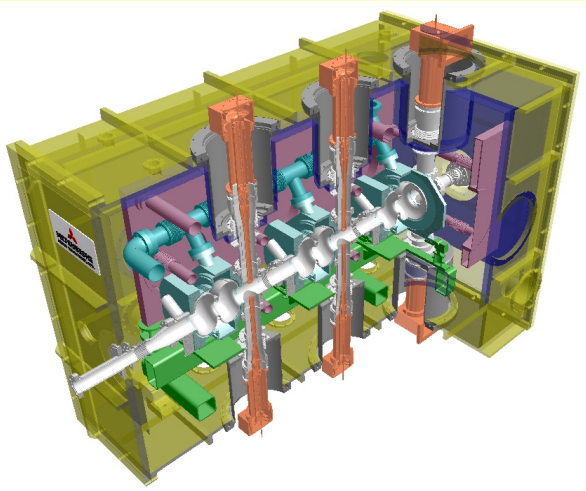
1 SRF activities at MHI

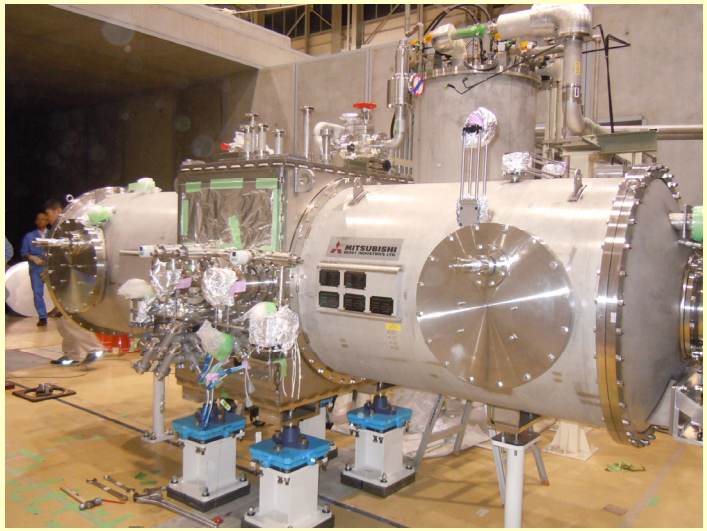
Courtesy of KEK

’06~ ERL Cavity 9 sets

1 SRF activities at MHI







C-ERL injector and main Linac under beam comissioning
(T. Miyajima will report on Friday)

1 SRF activities at MHI

’05~ STF Cavity 22 sets delivered
4 sets under fabrication

2-1 Indicators of Industrialization

Almost industry consider about **QCD** in industrialization

As the case of ILC,

Quality : It is important how we can maintain the higher performance of cavity. (Eacc=31.5MV/m $Q_0=1\times10^{10}$)

Cost : Industry needs to know the **target price** of all expenses and make efforts to the target to realize the ILC project. Construction costs are about 8 billion dollars and the level of a cavity cost is $50k to $100k.

Delivery time : Now we assume for 16,000 cavities as below ,
Preparation : 2 years
Construction : 8 years
Production of cavity with jacket : 6 years

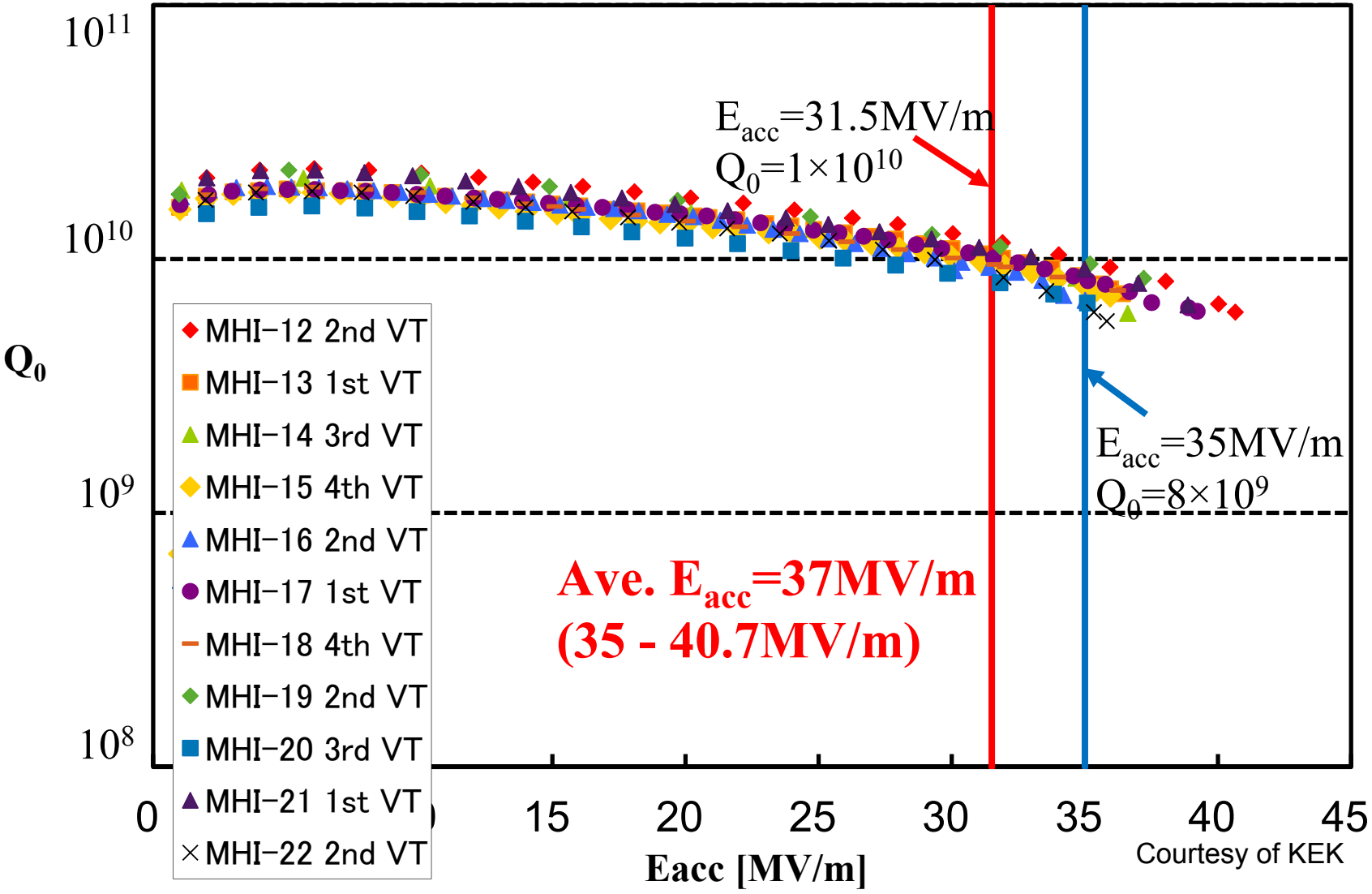
2-2 Improvement of Quality

We have to achieve and keep the ILC goal of cavity performance.

In case of KEK STF cavities

Phase	Cavity No.	Thickness of thinning	Shape of groove	Bead condition	Frequency of chemical polishing	Management of cleanness	High pressure gas safety law
STF1.0	#1-4	2.5 mm	Butt	Bumpy	Only after thinning	Air duster	–
STF1.5	#5-6 #7-9	2.0 mm		Smoother	Each step (just before EBW)	Clean area	–
	#10-11		Step	Flatter			–
STF2.0	#12-22			More stable		Air top gun	Adapted

2-3 Recent result of vertical test for STF cavity



MHI-12 to 21 cavities are governing high pressure gas safety law in Japan.

2-4 Quality

Monitoring or inspection system is important to keep the cavity performance.

But the criteria of some inspection or condition are not clear.

- Material inspection using eddy current
- Dimension inspection
- Welding condition
- Visual test of cavity inner surface and welding bead

Kyoto-KEK optical inspection camera and local grinding tool are good for industrialization

- Inspection of HP-code
- Vacuum test
- Condition of EP and HPR

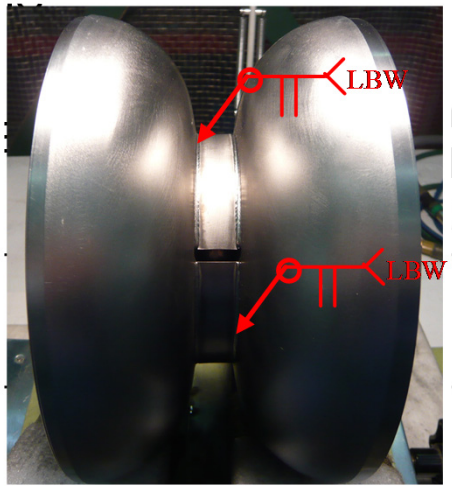
2-5 Productivity

We should improve the productivity to reduce the manufacturing cost and to keep the delivery time.

Phase	Cavity No.	Assy direction	Stiffener welding	Baseplate welding	Cavity quantity at final welding in one batch	New Procedure or new design
-	MHI-A 9cell	Horizontal	LBW	EBW	1	
	MHI-B 2cell	Vertical	-	-	1	Seamless dumbbell
	MHI-C 9cell		LBW	LBW	1	
STF 2-a	#23-26			EBW	2	Retainer flange for monitor port
future	-			LBW	4	

2-5 Productivity

We should improve the productivity to reduce the manufacturing cost and to keep the delivery time



Phase	Cavity No.	Assy direction	Stiffener welding		ntity at ing in tch	New Procedure or new design
-	MHI-A 9cell	Horizontal	LBW			
	MHI-B 2cell	Vertical	-			Seamless dumbbell
	MHI-C 9cell	↓	LBW	LBW	1	
STF 2-a	#23-26	↓	↓	EBW	2	Retainer flange for monitor port
future	-	↓	↓	LBW	4	↓

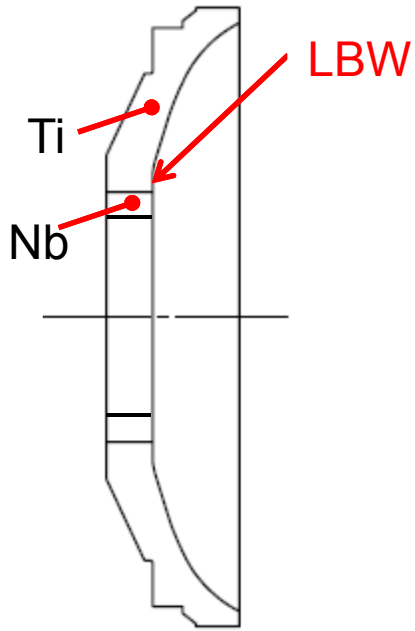
2-5 Productivity

We should improve the [illegible] acturing cost and to keep the de[illegible]

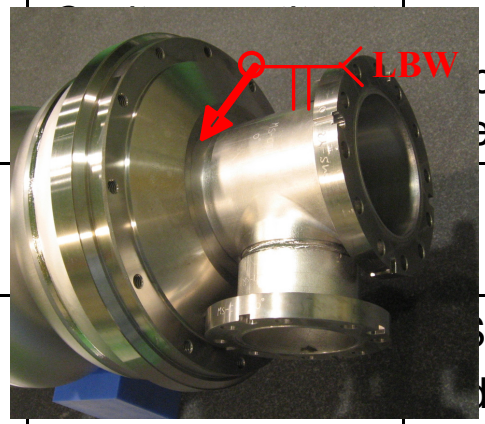
Phase	Cavity No.	Assy direction	S[illegible] w[illegible]	[illegible]	[illegible] t	New Procedure or new design
-	MHI-A 9cell	Horizontal				
	MHI-B 2cell	Vertical	-	-	1	Seamless dumbbell
	MHI-C 9cell	↓	LBW	LBW	1	
STF 2-a	#23-26	↓	↓	EBW	2	Retainer flange for monitor port
future	-	↓	↓	LBW	4	↓

2-5 Productivity

We should imp … reduce the manufacturing cost and to ke …



Base plate

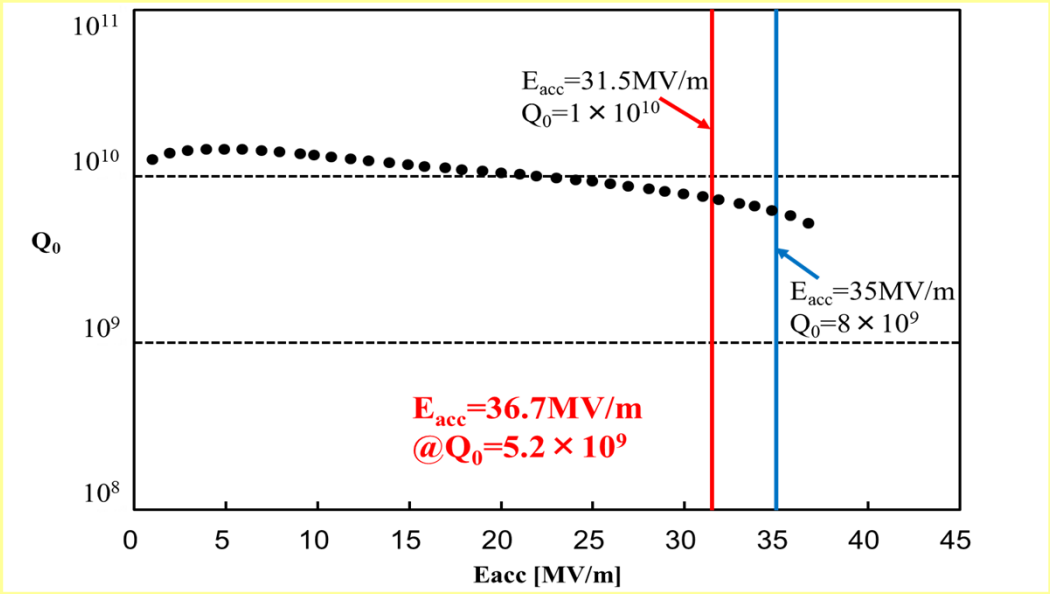


Phase	Cavity No.	di…	…	…e	New …ocedure or …ew design
-	MHI-A 9cell	Ho…			
	MHI-B 2cell	V…			…Seamless …dumbbell
	MHI-C 9cell		LBW	LBW	1	
STF 2-a	#23-26			EBW	2	Retainer flange for monitor port
future	-			LBW	4	

We
cos

1 cavity／1 batch

Q-E curve of MHI-C

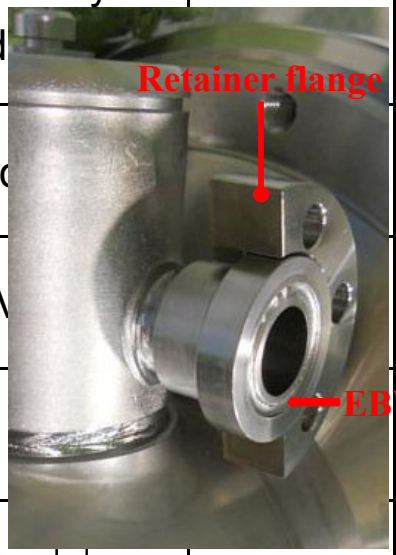


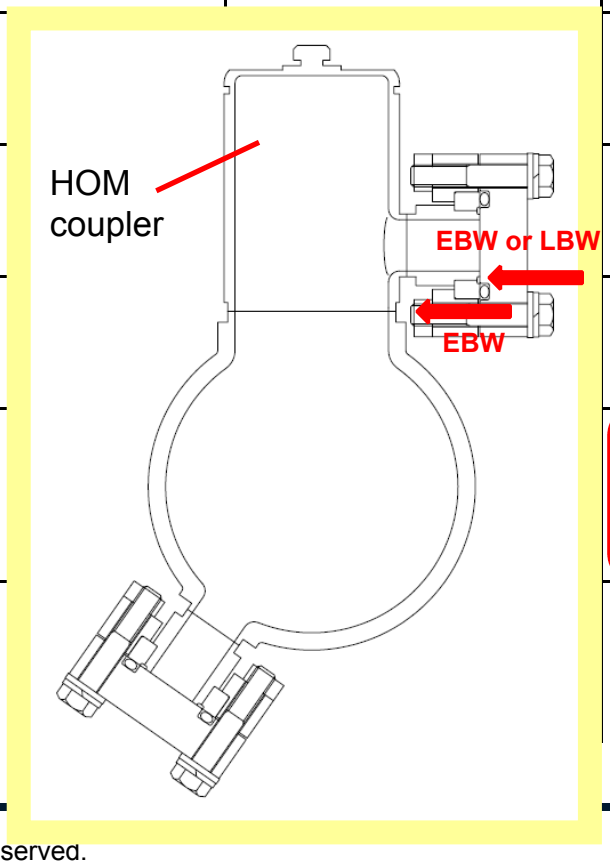
Phase						
-						dumbbell
	MHI-C 9cell		LBW	LBW	1	
STF 2-a	#23-26			EBW	2	Retainer flange for monitor port
future	-			LBW	4	

2-5 Productivity

We should improve the productivity to reduce the manufacturing cost and to keep the delivery time.

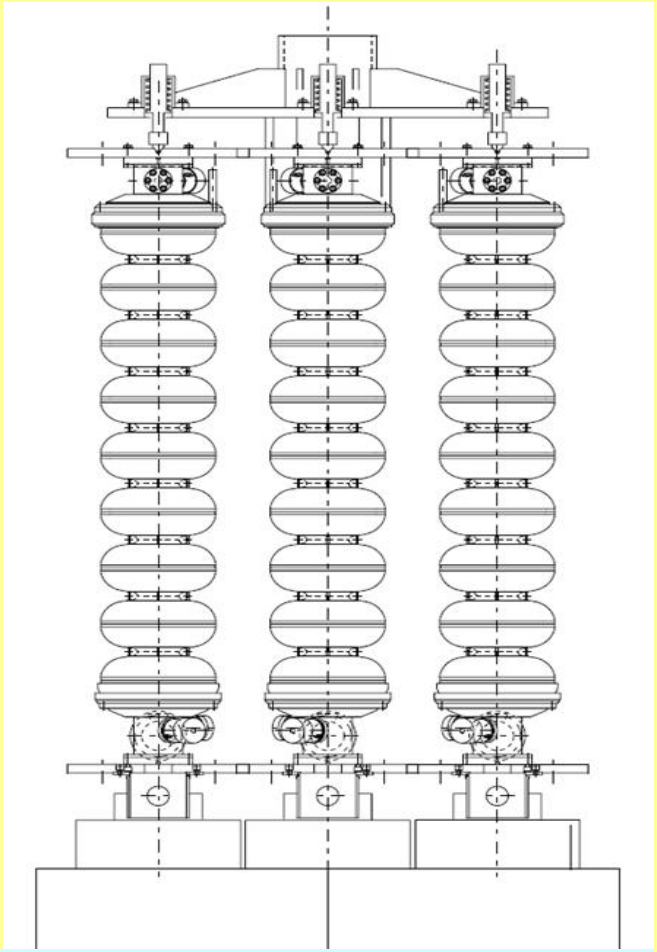
Phase	Cavity No.	Assy d	Stiffener	Baseplate welding	Cavity quantity at final welding in one batch	New Procedure or new design
-	MHI-A 9cell	Hc				
	MHI-B 2cell	V				Seamless dumbbell
	MHI-C 9cell					
STF 2-a	#23-26					Retainer flange for monitor port
future	-					





2-5 Productivity

to reduce the manufacturing

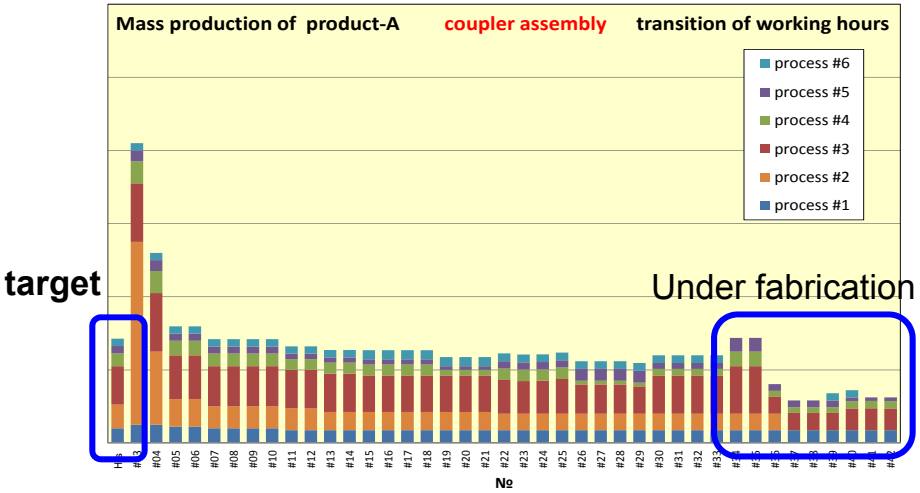


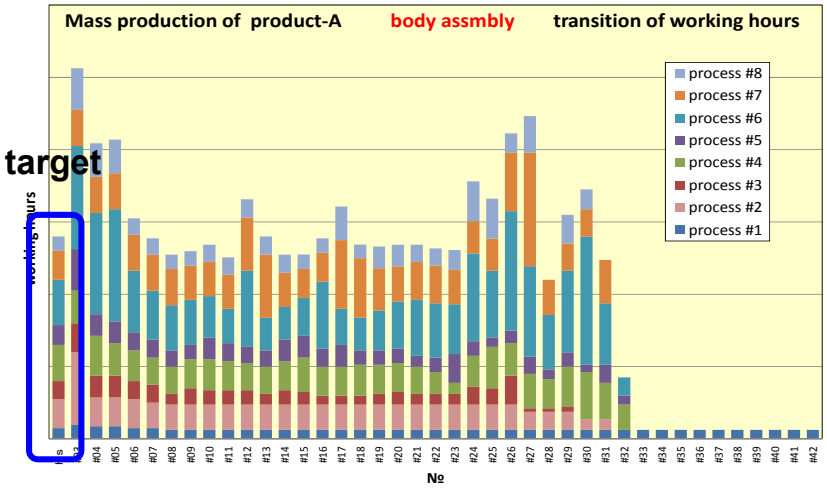
4 cavities／1 batch

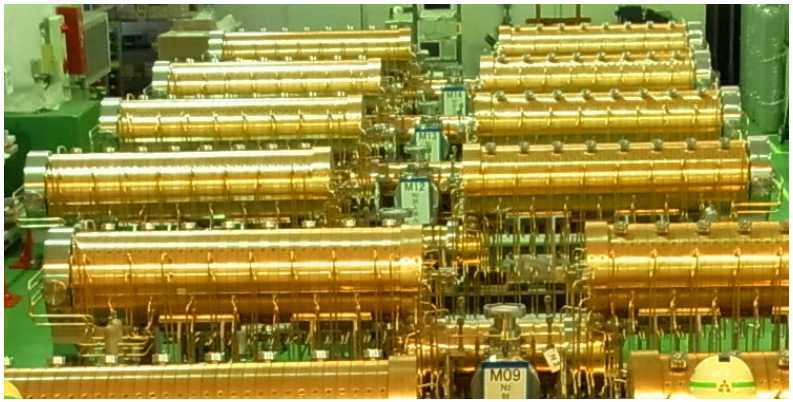
Pha	eplate lding	Cavity quantity at final welding in one batch	New Procedure or new design
	BW	1	
-	-	1	Seamless dumbbell
	BW	1	
ST 2-	BW	2	Retainer flange for monitor port
futu	BW	4	⇩

Monitoring of manufacturing time for each process lead to improve the productivity.

In case of normal conducting S-band accelerator at MHI

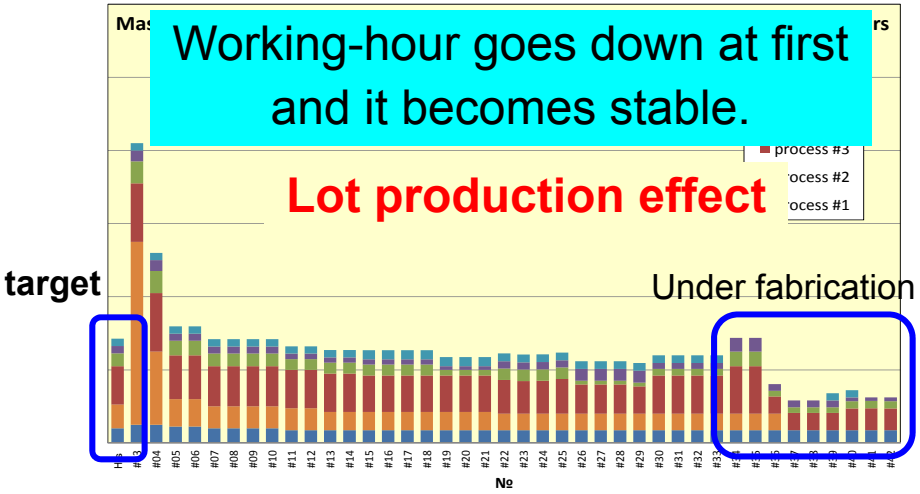


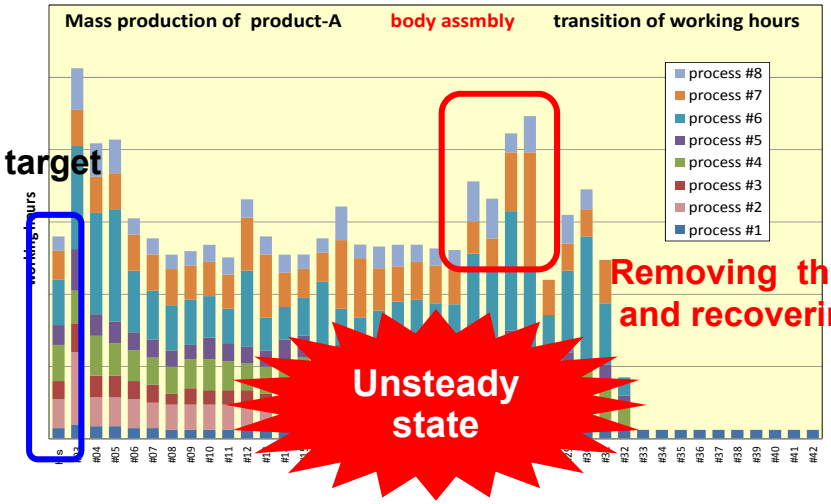


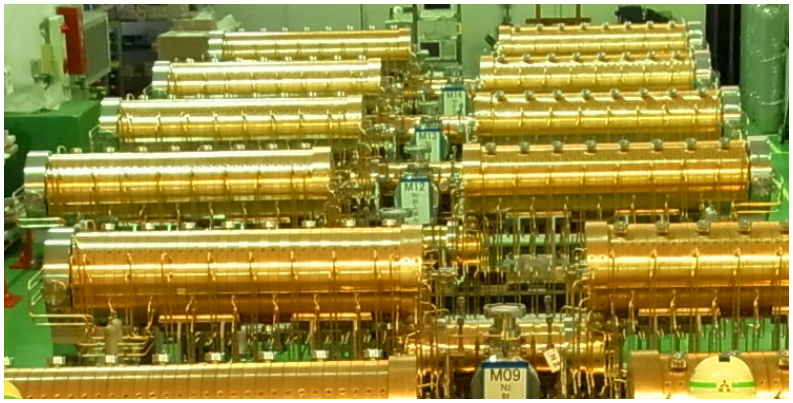


Monitoring of manufacturing time for each process lead to improve the productivity.

In case of normal conducting S-band accelerator at MHI







3-1 Cost analysis

Cost ratio of cavity with LHe jacket for more than 3,000 cavities without Nb, NbTi (*) and management cost

(%)

	Material	HP-code	Mechanical Machining	Welding & Assembly	Inspection	Surface process	Sub-total
Cavity	3* [only Ti]	1	12	15	5	23	59
LHe Jacket	13	1	6	5	3	0	28
Jigs & Factory investment	0	0	2	2	2	9	13
Sub- total	16	2	20	22	10	32	100

This estimation was done by MHI.

3-2 Cost analysis

The ratio of material for LHe jacket is much higher by spec of own rigidity, accuracy and frequency tuner type

- Need to review of titanium thickness
- Need to review of the structure

The ratio of surface process for cavity is much higher

- Need to develop low-cost procedure for EP
- Need to develop new surface process

⇒Laboratory and industry should solve this problem with each best efforts

General principles about cost reduction for mass-production:

1.Reducing number of parts
- Seamless dumbbell
- **Combination of pick up port and flange**

2.Automation or outsourcing
- Pre-tuning
- Visual inspection by Kyoto-KEK camera

3.Batch process
- Welding 9 seams of 4 cavities in one batch

4.Reducing process time
- Change of fabrication procedure ⇐Change EBW to LBW
- Using special jig and machine ⇐**Vacuum chucking for turning**
- Optimization of machine time and factory layout

3-2 Cost reduction

General principles about cost reduction for mass-production:

1.Reducing number of parts

- Seamless dumbbell
- **Combination of pick up port and flange**

2.Automation or outsourcing

- Pre-tuning
- Vis

3.Ba

- We

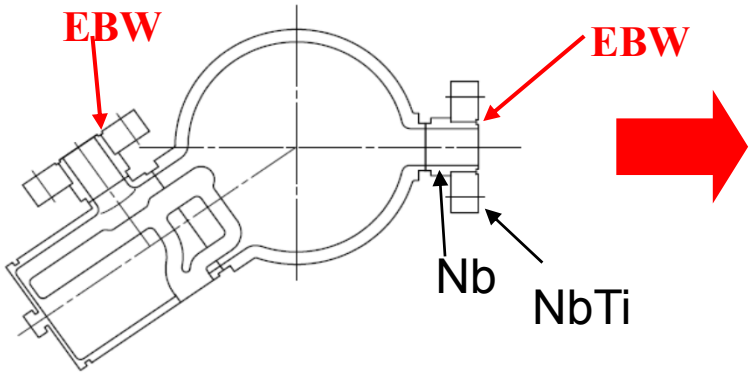
4.Re

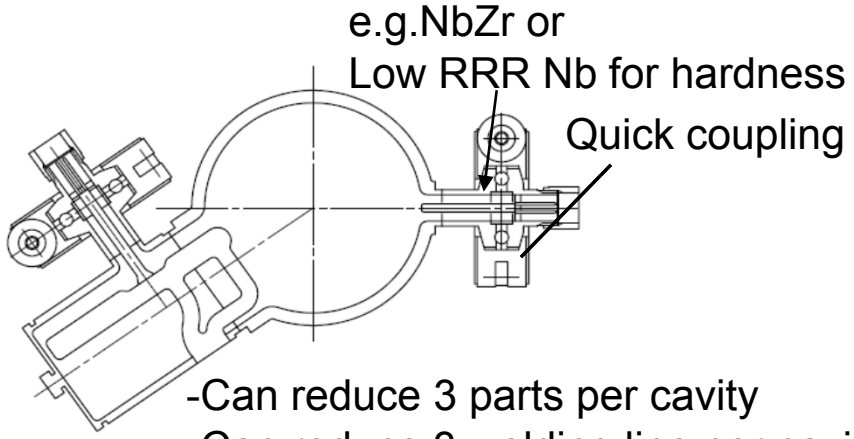
- Change of fabrication procedure ⇐Change EBW to LBW
- Using special jig and machine ⇐**Vacuum chucking for turning**
- Optimization of machine time and factory layout

Can reduce ▲10 to 15% cost by these method while keeping the Quality

Some test and verification need for more cost reduction

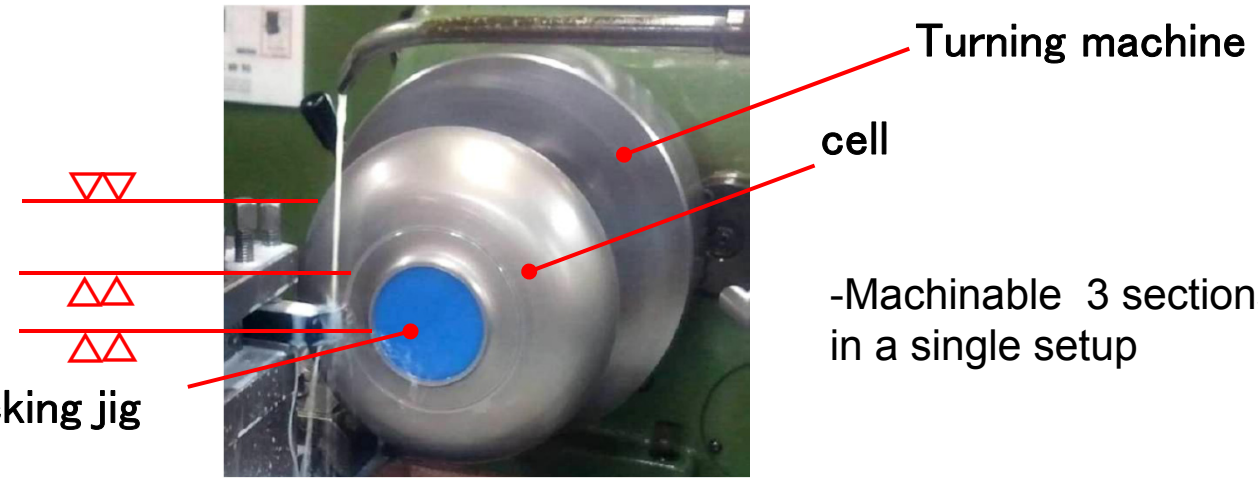
- Combination of pick up port and flange





-Can reduce 3 parts per cavity
-Can reduce 3 welding line per cavity
-Need to test for the influence of EP

- Vacuum chucking for turning



-Machinable 3 sections
in a single setup

4 Summary

- **QCD** are important things for Industrialization. Industry need to know target price for making efforts to the target.
- We have improved the quality of cavity step by step and almost achieved the ILC spec. We have to maintain the level of quality by various inspection. The criteria of inspection are important for management.
- We have reduced the cost and shorten the delivery time by changing the design and improving the productivity step by step. Improving the productivity is realized by monitoring each process at production site.
- As the material of LHe jacket and surface process of the cavity are much expensive, some improvements are needed from the view point of cost reduction.
- We keep to propose and verify various improvements steadily in according with general principle of cost reduction for realizing ILC as a industry.

Special thanks

Special thanks to

E. Kako, K. Watanabe , S. Noguchi,

T. Shishido and Y. Yamamoto at KEK

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