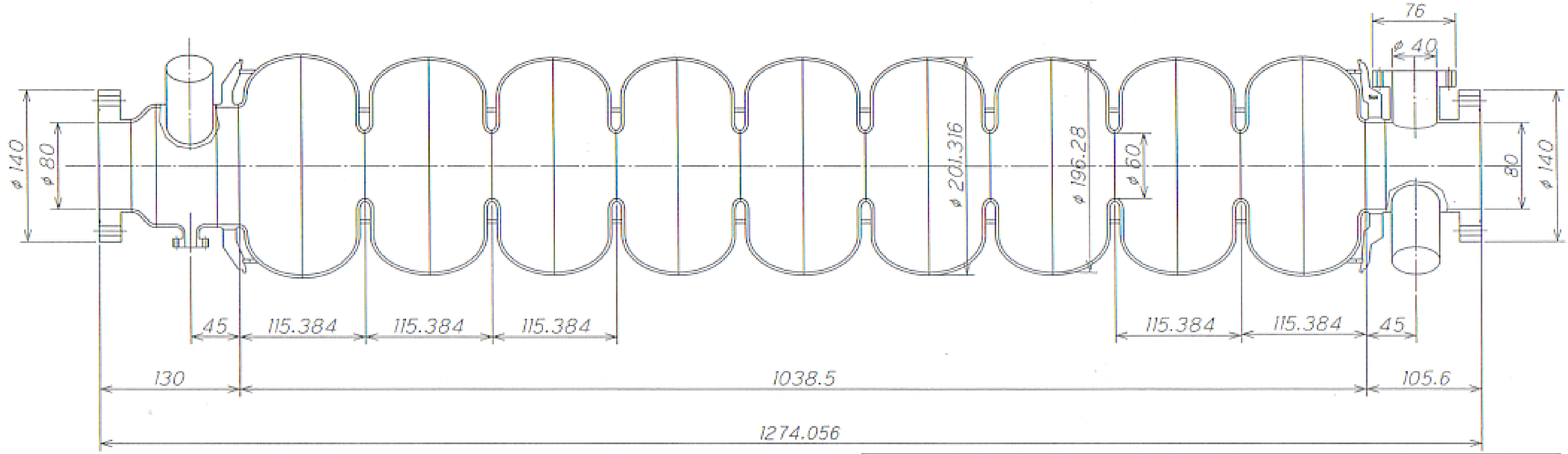
Development of ILC high gradient cavity

K.Saito : ILC WG5 convener

- **R&D status of the ILC high gradient cavity**

KEK LL shape 9-cell cavity structure

Design based on Jacek's and slightly changed on end cells by Y.Morozumi, KEK



Reachable ~ 50MV/m
19% smaller RF loss

Cavity RF parameter	KEK LL	TESLA
R/Q[Ω]	1200	1012
Γ [Ω]	285	271
Cell-to-cell coupling [%]	1.5	1.9
Ep / Eacc	2.3	2.0
Hp / Eacc [Oe/(MV/m)]	36	41.5
Expected max. Eacc [MV/m]	48.6	42.2

1) Input coupler and HOM coupler positions are the same as TESLA cavity design.
2) Helium vessel base plate will be modified from baseline cavity.

WG5: cavity

Cavity fabrication and Vertical Test
- Nb material(M.Wake)
- Cavity fabrication(H.Inoue, K.Saito, T.Saeki)
- Pre-tuning(Y.Higashi)
- Preparation(K.saito, T.Saeki)
- Vertical test(T.Saeki, T.Higo, N.Toge)
- Tuner(Y.Higashi, H.Yamaoka)
- Bonding of SUS/Nb(F.Furuta)
- Aluminum sealing(F.Furuta)
- Cavity design(Y.Morozumi)
- HOM(Y.morozumi, S.Noguchi)
- Structure analysis(H.Yamaoka)
- International collaboration(K.Saito)

— **K.Saito**

Niobium material (M.Wake) — **M.Yake**

500kW high power input coupler
- Coupler design(S.Kazakov, H.Matsumoto)
- Fabrication(S.Kazakof, H.Matsumoto)
- Brazing(N.Kudo)
- High power test(H.Matsumoto, S.Kazakov)
- Internatinal collaboration(H.Matsumoto)

— **H.Matsumoto**

45MV/m cryostat
Cryostat design (K.Tsuchiya, A.Terashima

— **K.Tsuchiya**

Nb/Cu clad seamless cavity
Forming machine design(K.Ueno, K.Enami)

— **K.Ueno**

WG5 K.Saito

International Collaboration
DESY,INFN-Milan,
INFN LNL,SLAC,FNAL,JLAB,Cornell

Asia WG5
PAL,IHEP,
Beijing uni

WG2 H.Hayano

International collaboration for LL shape 9-cell cavity

DESY	SLAC	FNAL	JLAB	KEK
J.Sekutowicz	**K.Ko**	**N.Solyak**	**P.Kneisel**	**K.Saito**
	L.Ge	**I.Gonin**		**F.Furuta**
	L.Lee	**T.Khabiboulline**		**Y.Higashi**
	Z.Li			**T.Higo**
	C.Ng			**H.Inoue**
	L.Xiao			**Y.Morozumi**
				T.Saeki
				H.Yamaoka
				K.Ueno
				K.Enami
Design	**Beam simulation**	**HOM, Lorentz detuning Multipacting**	**Cavity fabrication 5-cell**	**9-cell**

LL shape cavity has a small iris : 60D, on the other hand TESLA shape 70D
HOM, tighter alignment tolerance, multipacting, Lorentz detuning ??

3. Low Loss cavity: Higher Order Modes.

SLAC (Ωmega 3D,complex frequency), **FNAL** (2D), **DESY** (Fem2D, ABCI),

- Loss factors of inner single cell

		LL	TTF
$k_{\perp}$ (σ_z=1mm) single inner cell	[V/pC/cm^2]	0.38	0.23
$k_{\parallel}$ (σ_z=1mm) single inner cell	[V/pC]	1.72	1.46

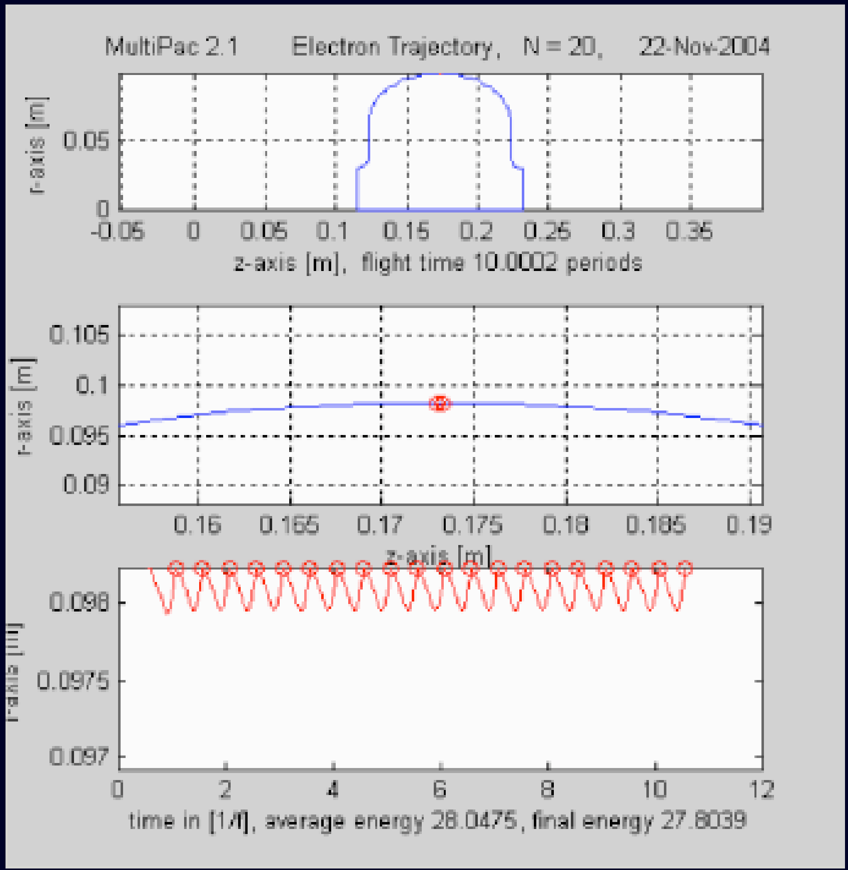
Compensation for increased $k_{\perp}$ will demand better cavity alignment

~230 μm instead of 300 μm

HOM loss factor are higher : **$k_{\perp}$ by 65%, $k_{//}$ by 18%.**

4. Multipacting and the Lorentz force detuning (**FNAL Group**)

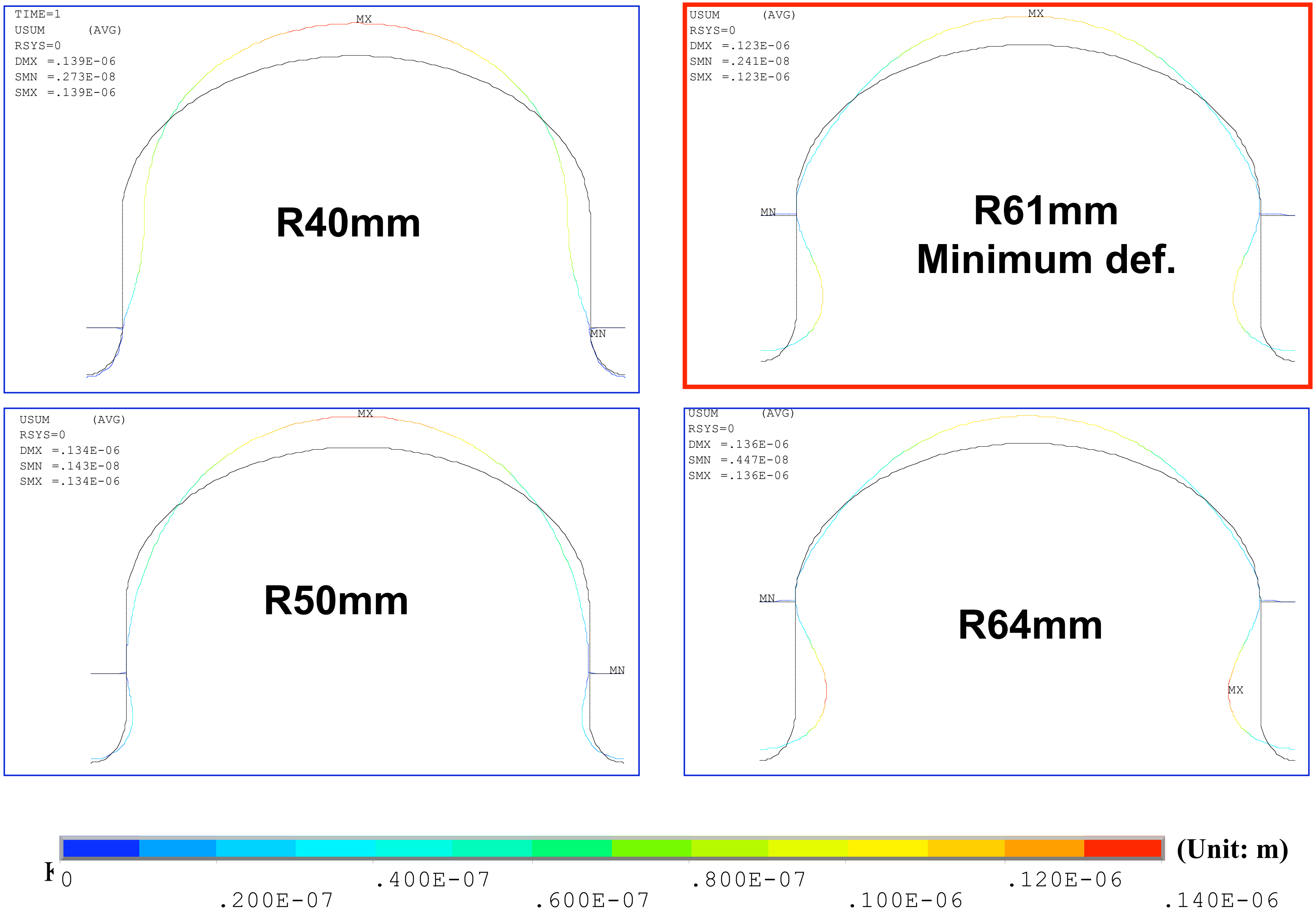
Multipacting



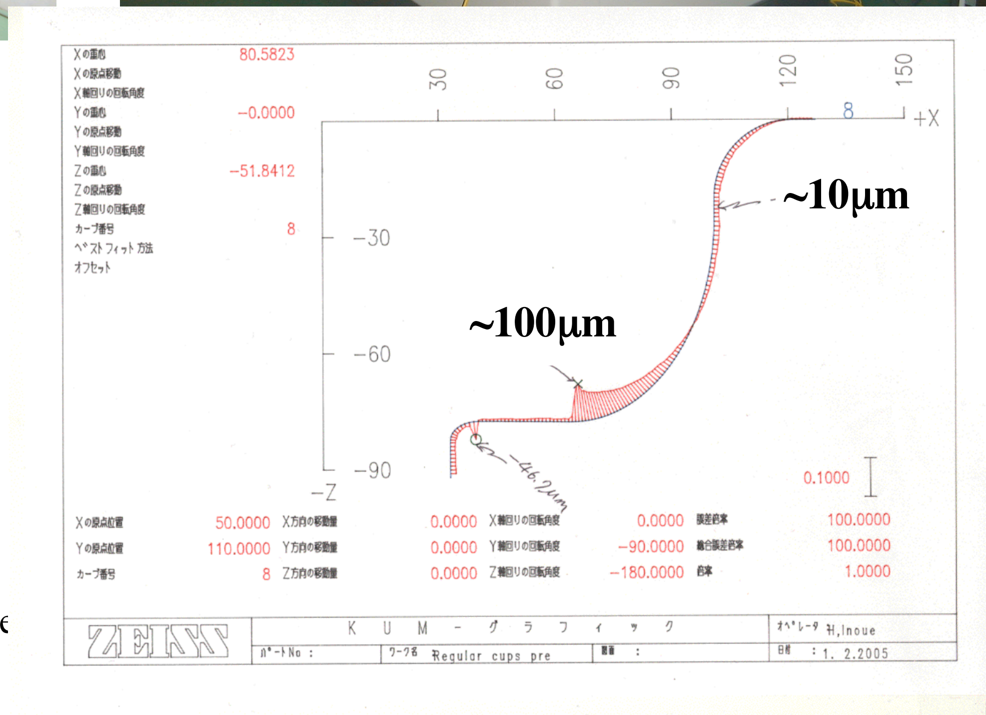
At the equator one resonance trajectory was found, but impact energy is too small, to create enough secondary electrons.

Optimization of Stiffener location

Eacc=38MV/m by Yamaoka

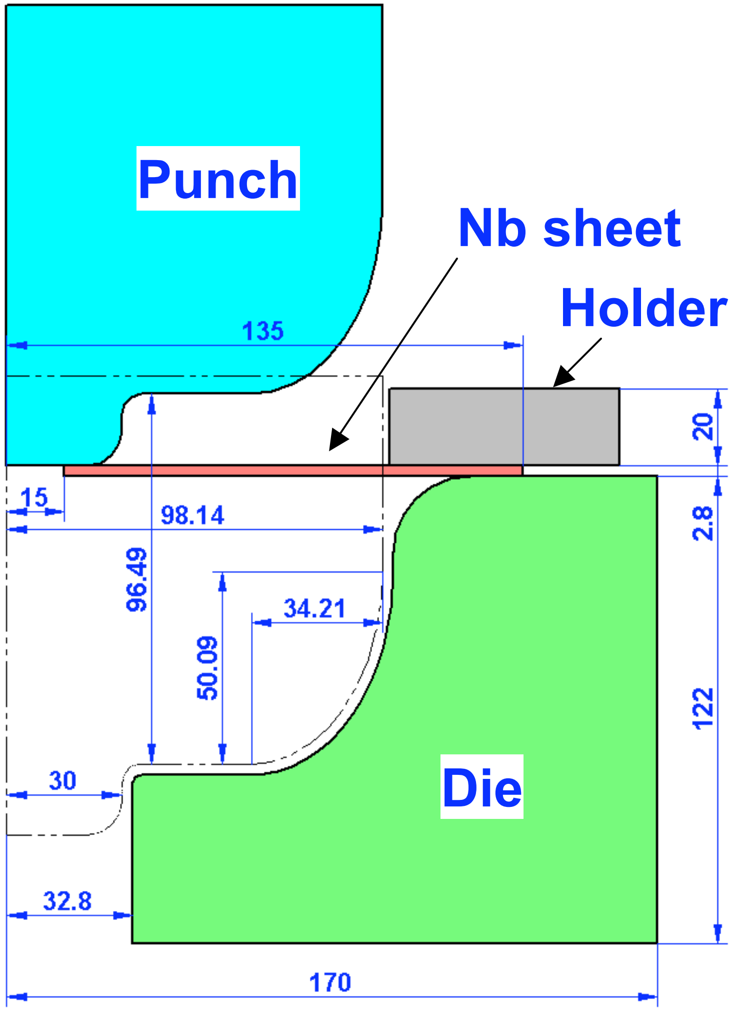


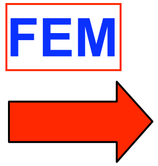
Deep drawing Die fabrication

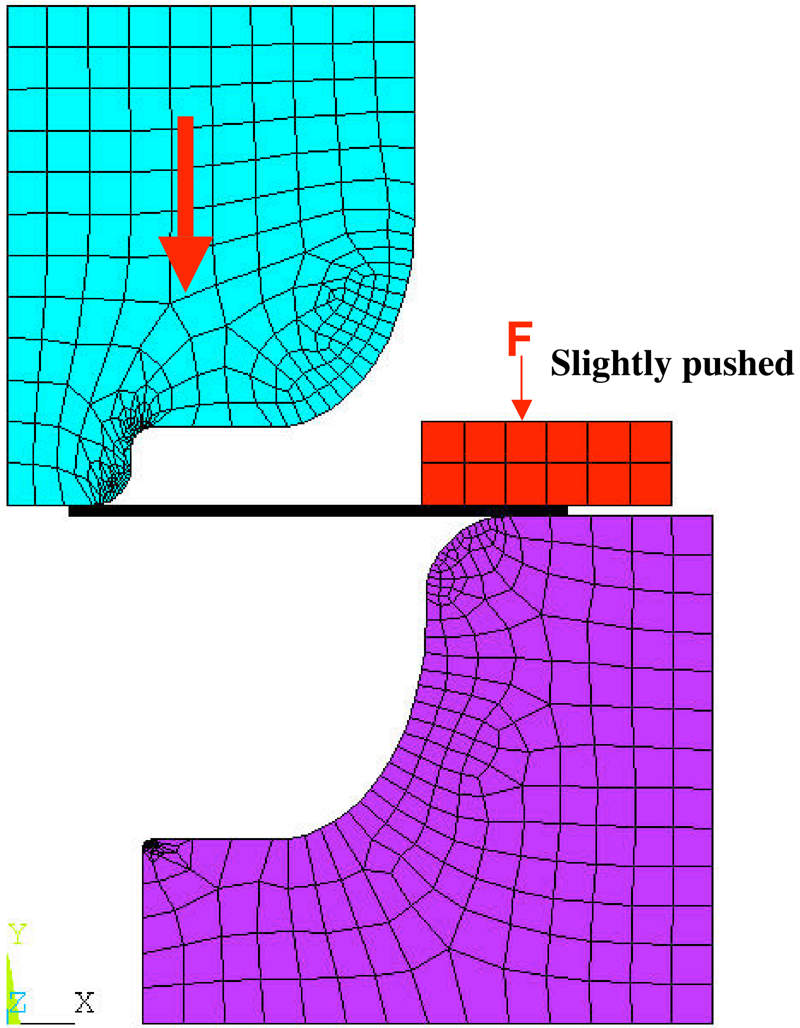


Simulation of deep drawing

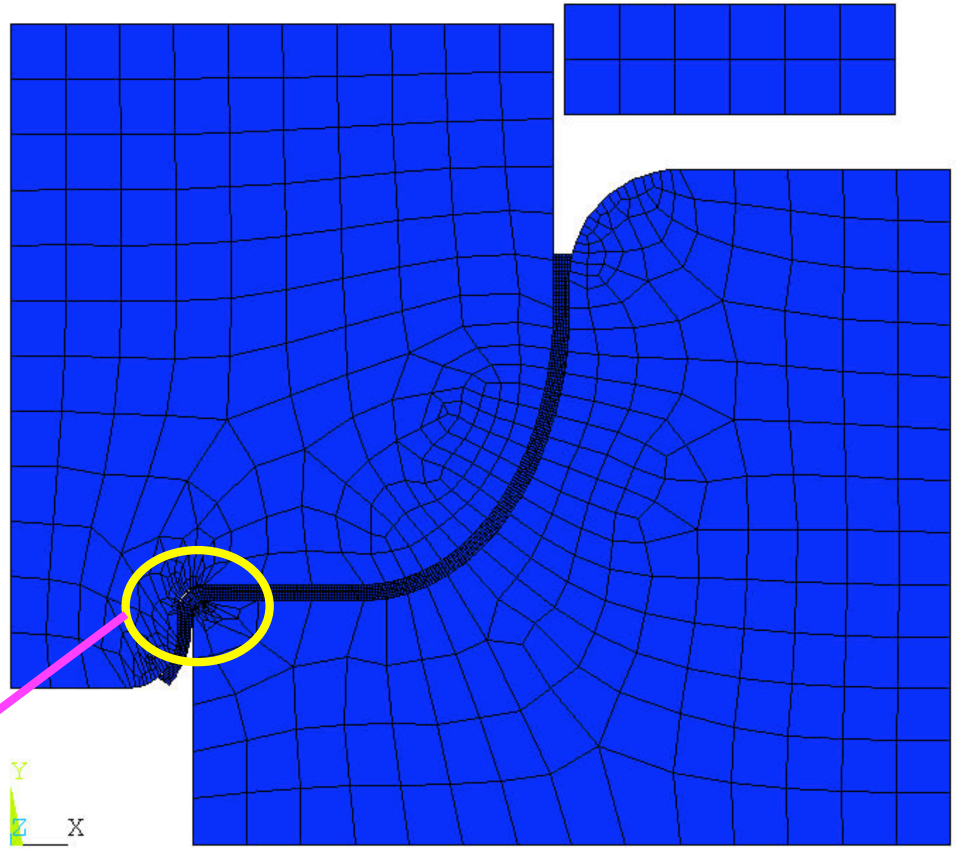
By H.Yamaoka

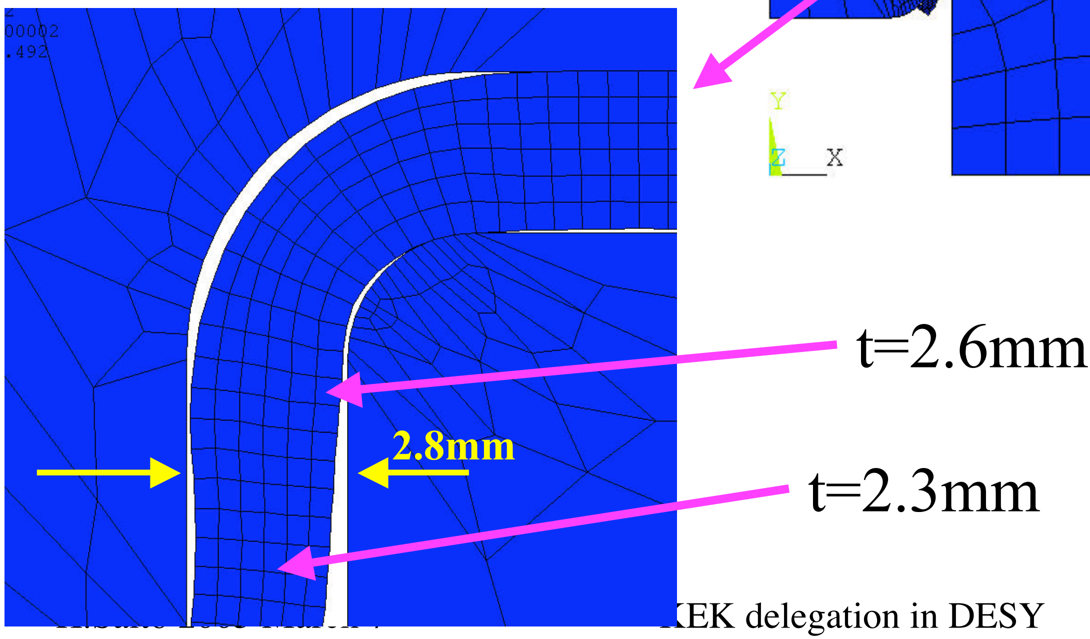






Needs corning





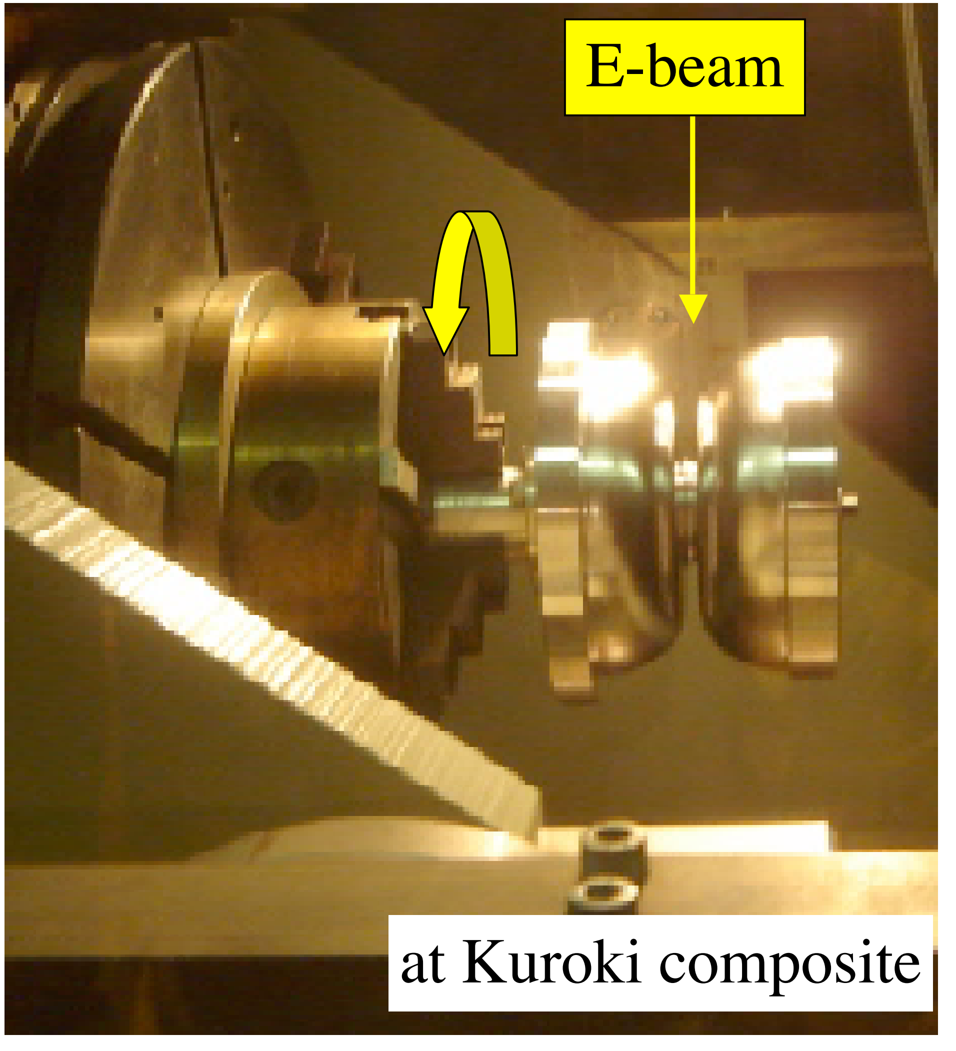
Niobium material delivered from Tokyo Denkai

RRR~300
270 ϕ, 2.8 ^{t} sheet for cell material

Deep drawing of center cell cups

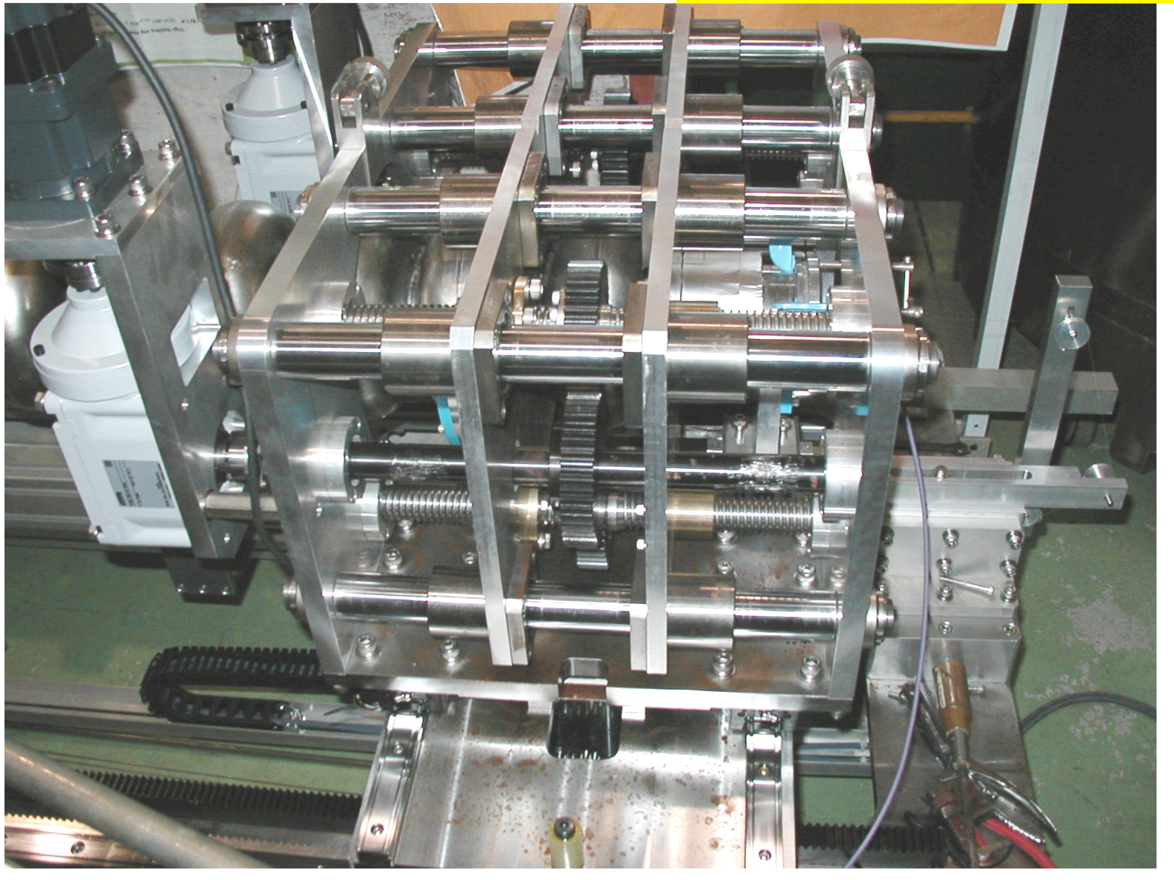
at Kikuchi Seisakusho

Nb Dumbbell successful EBW test on 23 Feb. 2005



Pre-tuning system for 1300MHz 9-cell cavity

KEK: by Y.Higashi and T.Higo



Pre-tuning is ready.

High power input coupler(500kW) for 45MV/m operation

Hiroshi Matsumoto, Sergey Kazakov

Input Coupler for ILC 45 MV/m

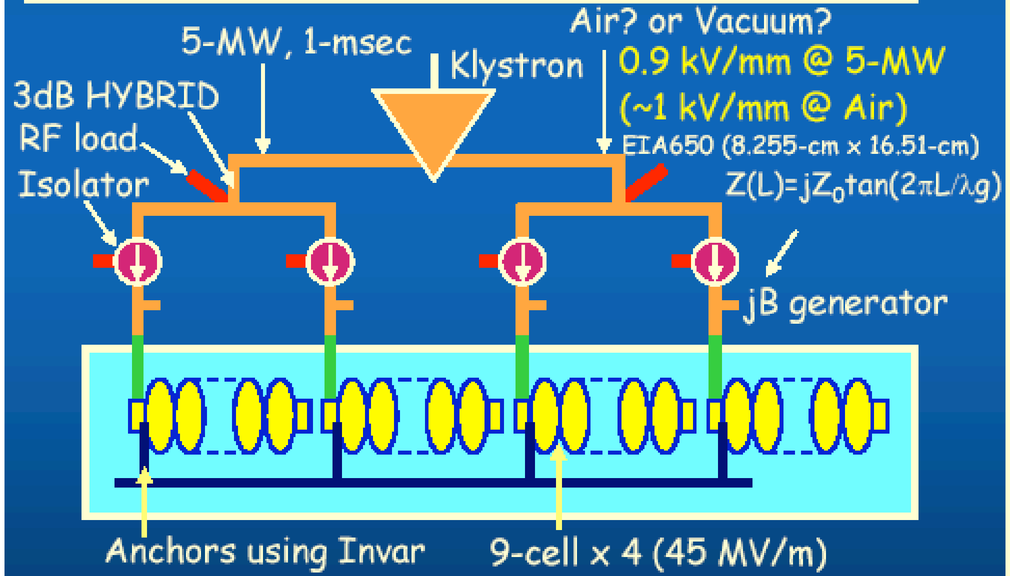
Basic Technologies:

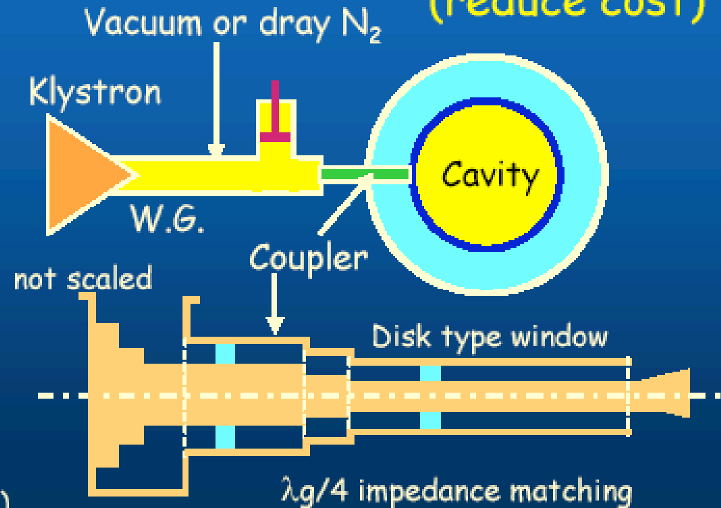
- -low electric field gradient at air side → < 1 kV/mm
- high purity ceramic → >99.7%
- use new brazing material Ag:Cu → Au:Cu (:Ti, option)
- surface coating → TiN, and or diamond-like carbon

H. Matsumoto, S. Kazakov

USE NEW RF FEED SYSTEM.

- separate coupling adjustment from coupler adopted the jB generator. (system simple)
- no tapering part at rf window to reduce multipactoring. (improve reliability)
- try to omit an rf window for room temperature side. (reduce cost)



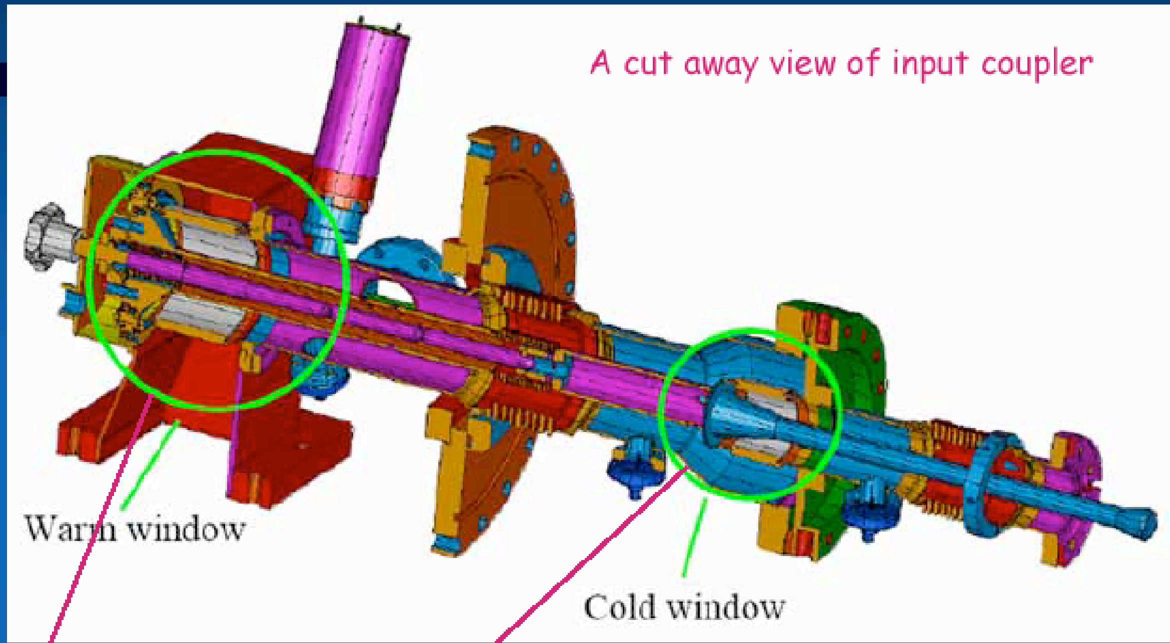


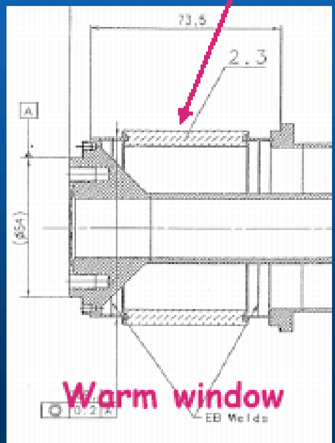
* Electric field gradient in the waveguide (kV/mm) @ 5-MW

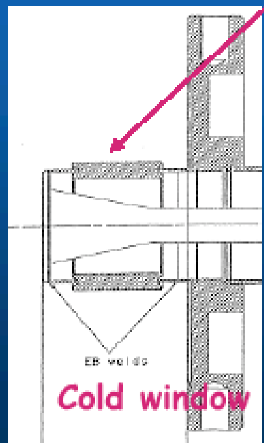
L-band (8.255-cm x 16.51-cm): 0.9 -> seems not enough margin in air

S-band (3.404-cm x 7.21-cm) : 2.2 -> no good in air, good in SF6 (but no good at 10-MW)

The present TESLA Coupler



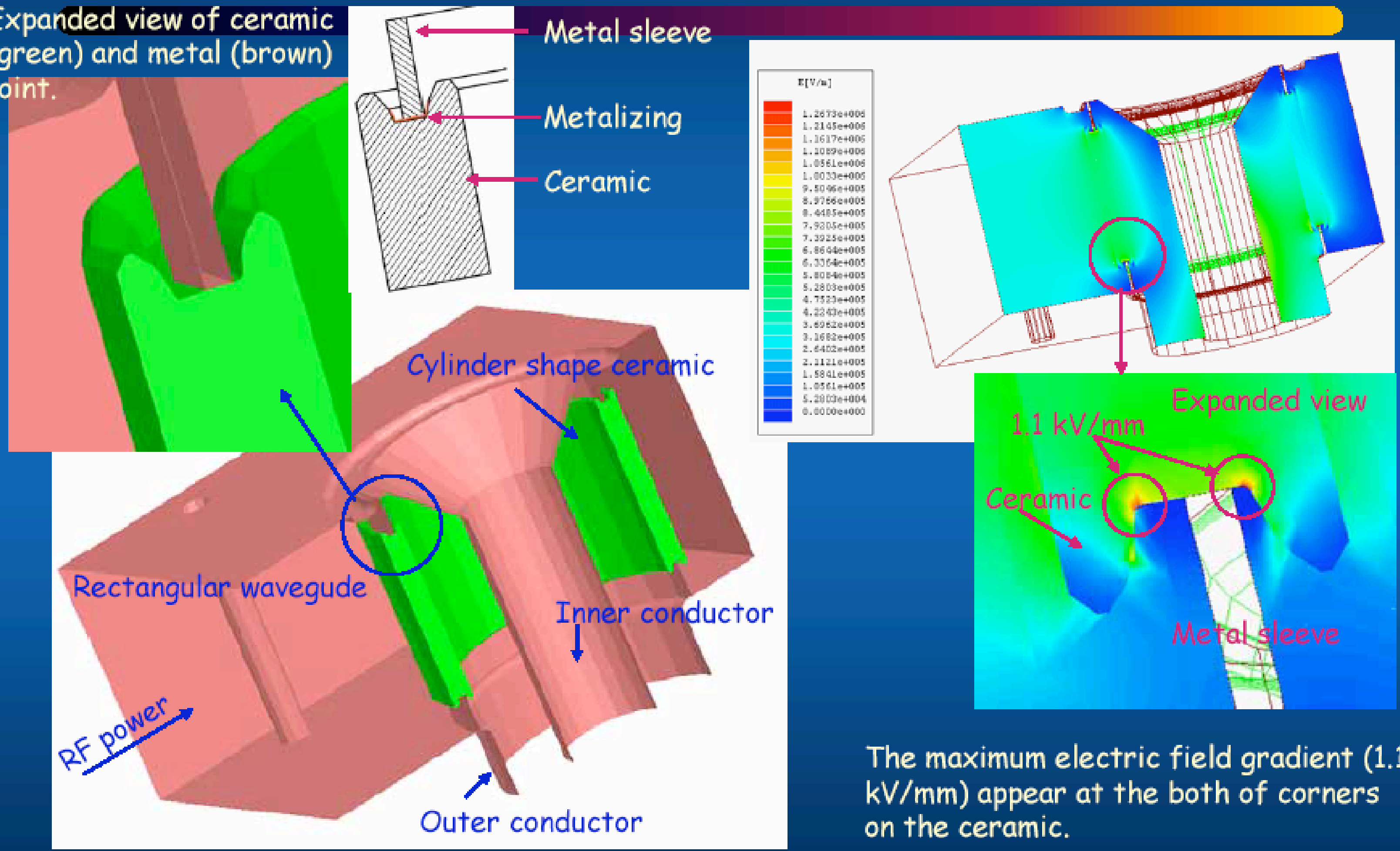




Coupler comprises of two windows, warm and cold. The present TESLA coupler is **one of the most expensive and not enough reliable component**, because of **complicated structure**. The goal of our activity is to realize the structure **simple** and the **low cost**.

We stared from window simulation to find the maximum fields at the ceramic and estimate losses. Also, we studies to fix the window material and brazing method.

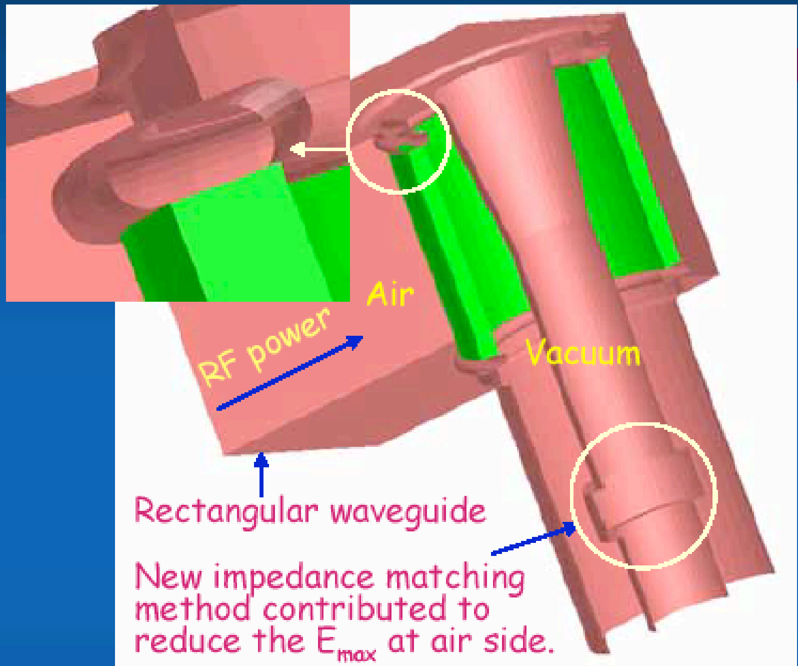
Simulation of Original Warm Window

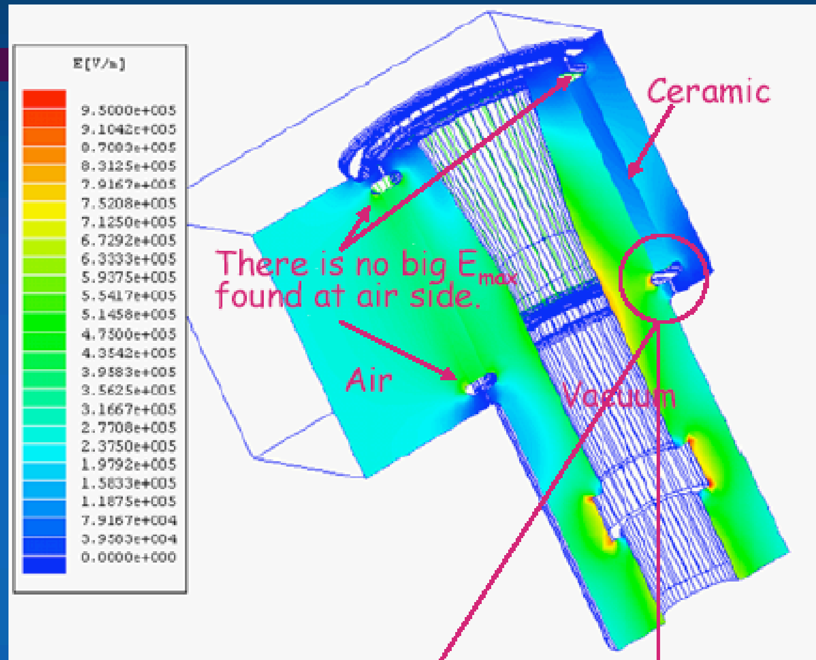


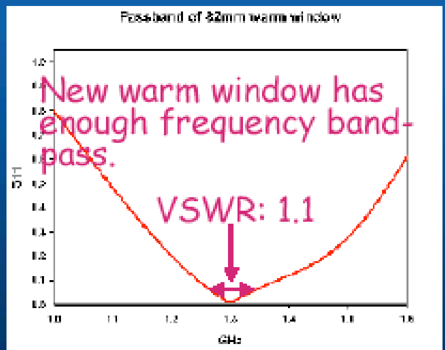
The maximum electric field gradient (1.1 kV/mm) appear at the both of corners on the ceramic.

A cut away view of original window (warm side) for input coupler.

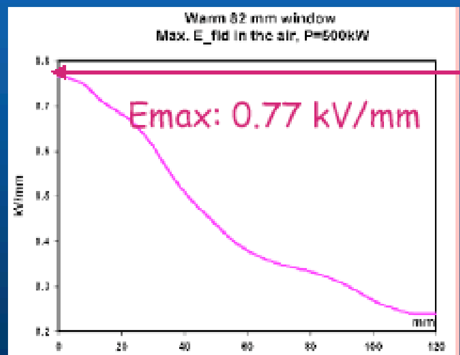
Simulation of New Warm Window Type I



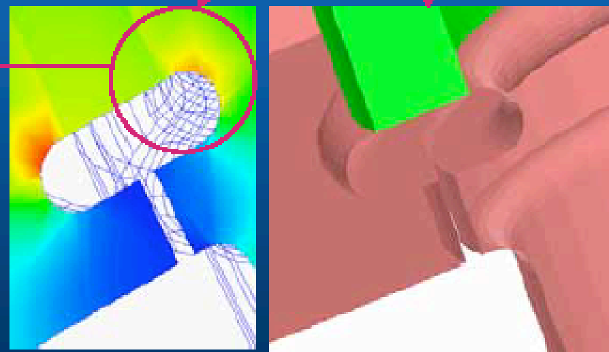




Frequency response curve.

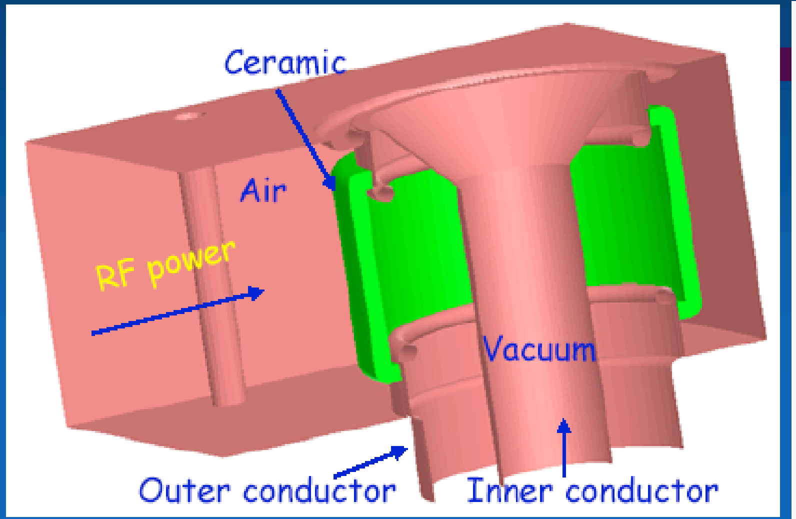


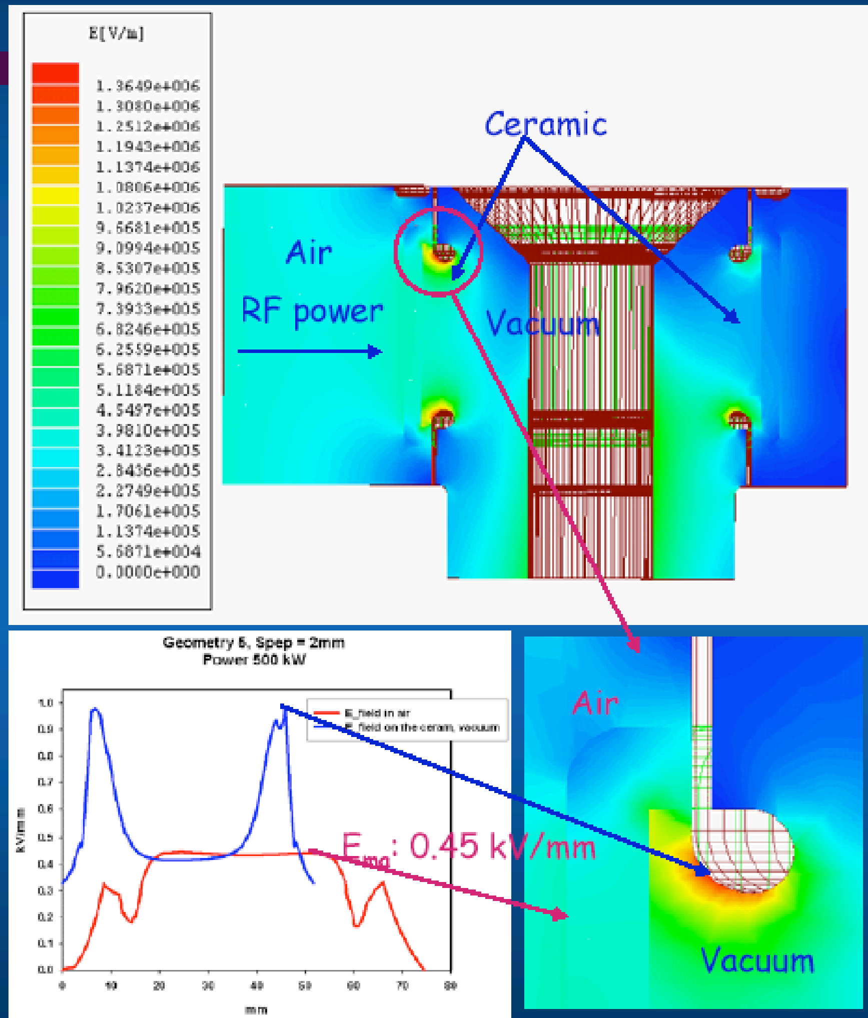
A E_{max} in air along the junction between ceramic and metal ring.



Expanded view of ceramic and metal ring.

Simulation of New Warm Window Type II





Comparison of original and new (Type I, II) window at 500 kW

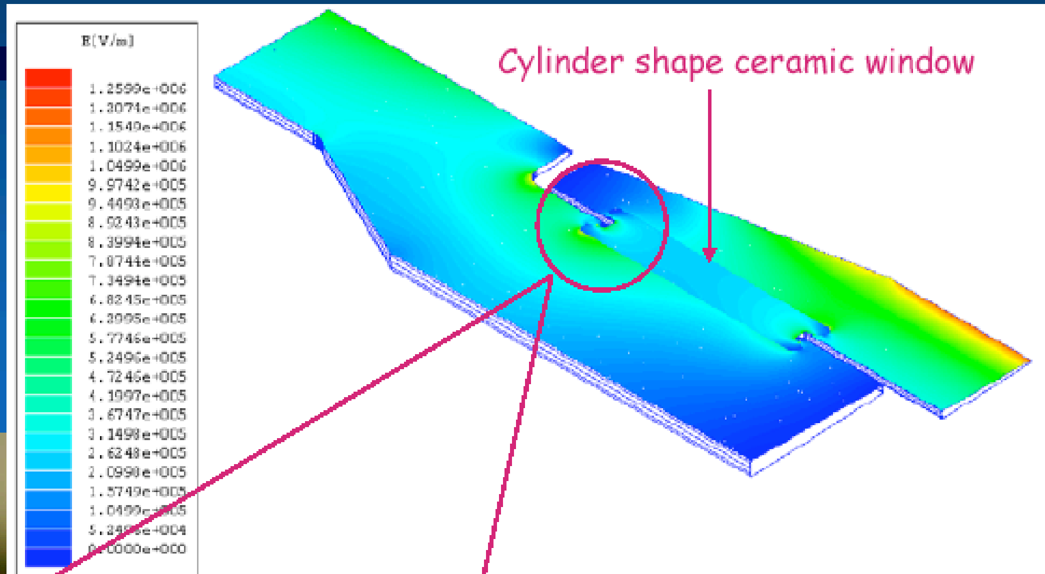
Items	Original	Type I	Type II
E_{max} in air (kV/mm)	1.1	0.77	0.45
E_{max} in vacuum (kV/mm)	1.1	0.55	0.98
Structure junction of ceramic and metal	Complicate	Simple	Acceptable (note 1)

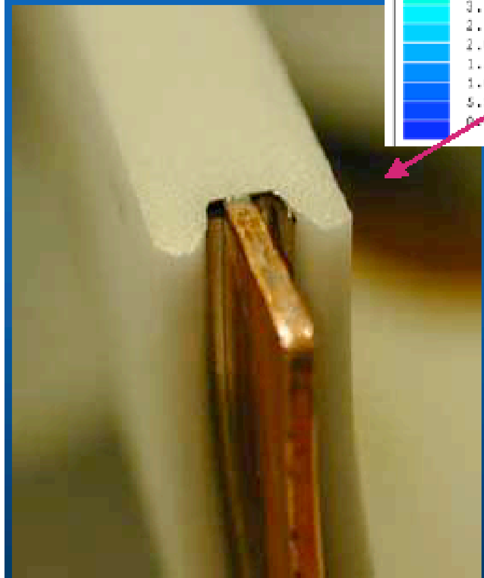
NOTE: need R&D for brazing.

E_{max} along the ceramic and metal ring. There is no large E_{max} found in air side.

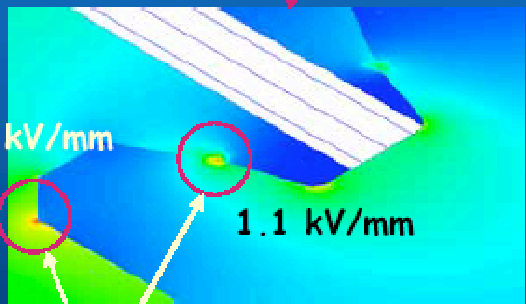
Hiroshi Matsumoto, Sergey Kazakov

Simulation of Cold Window for Original Coupler





Expanded view of brazing part



The maximum field gradient appears at the metallized surface and the sharp edge of ceramic.

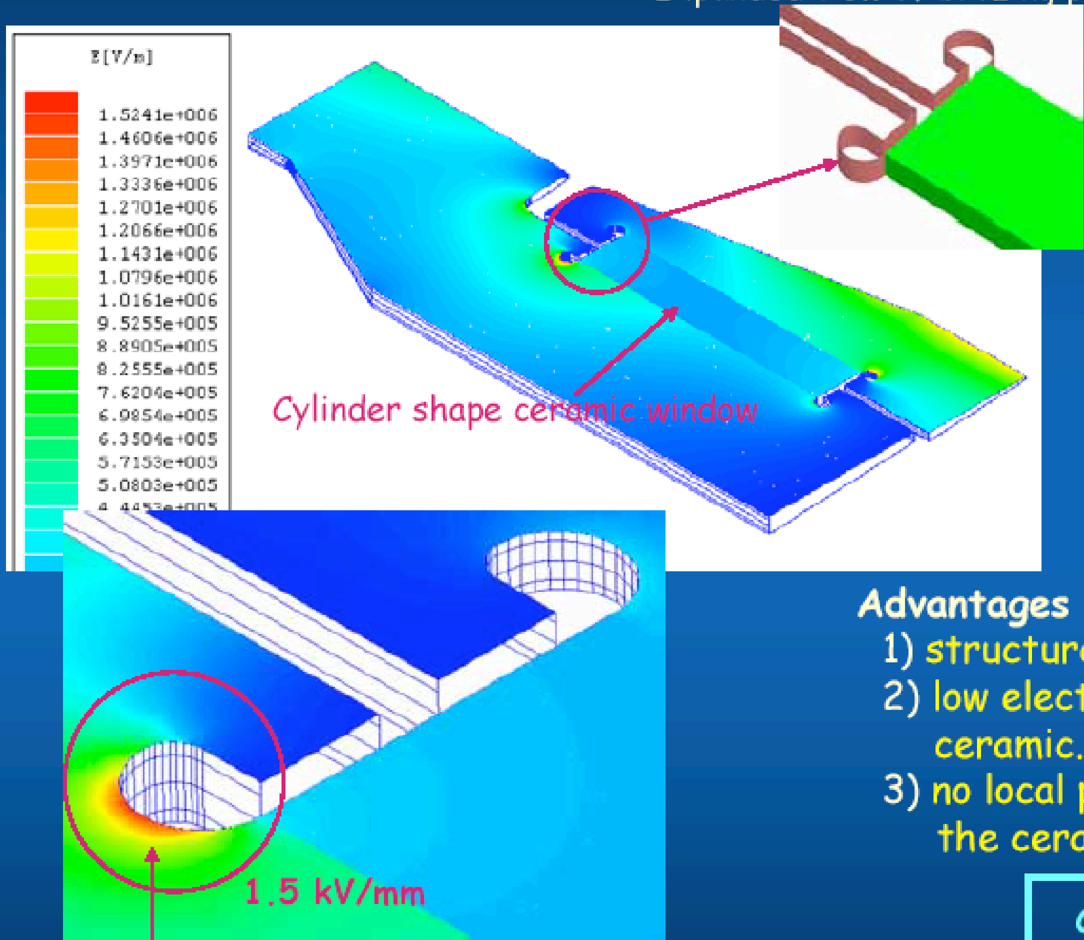
Disadvantages are;

1) difficult to make complicate shape for brazing part.
2) can be occurs the micro-cracks on the machined surface.
3) high electric-field appear at the malallization edges.

Hiroshi Matsumoto, Sergey Kazakov

Simulation of New Geometry for Cold Window

Expanded view of brazing part



The maximum field gradient only appear at surface of the copper sleeve, not on the metalizing part. Thus, there is no problem for the breakdown.

Comparison of original and new window at 500 kW

Items	Original	New
Max. E-field on the ceramic (kV/mm)	1.2	0.6
Max. E-field on the metal (kV/mm)	> 1.1	1.5
Structure junction of ceramic and metal	Complicate	Simple

Advantages of new shape are;

1) structure simple.
2) low electric field gradient on the ceramic.
3) no local peak electric field appear on the ceramic.

CONCLUSION

We have found more simple ceramic geometries with lower electric field gradient on the surface and in air.