Quasi Traveling Wave Side Couple RF Gun for SuperKEKB

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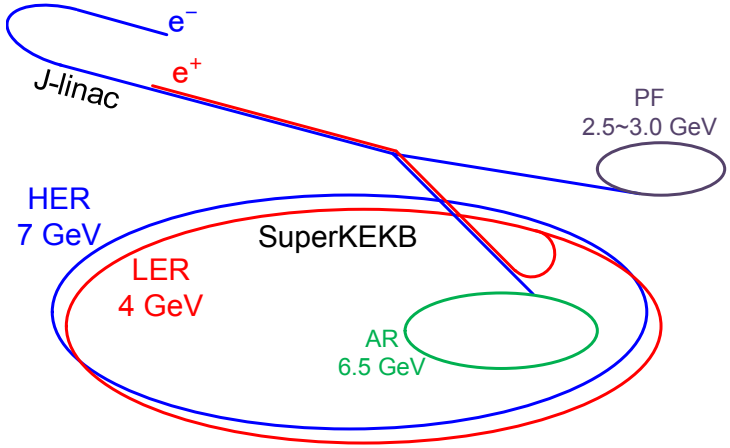
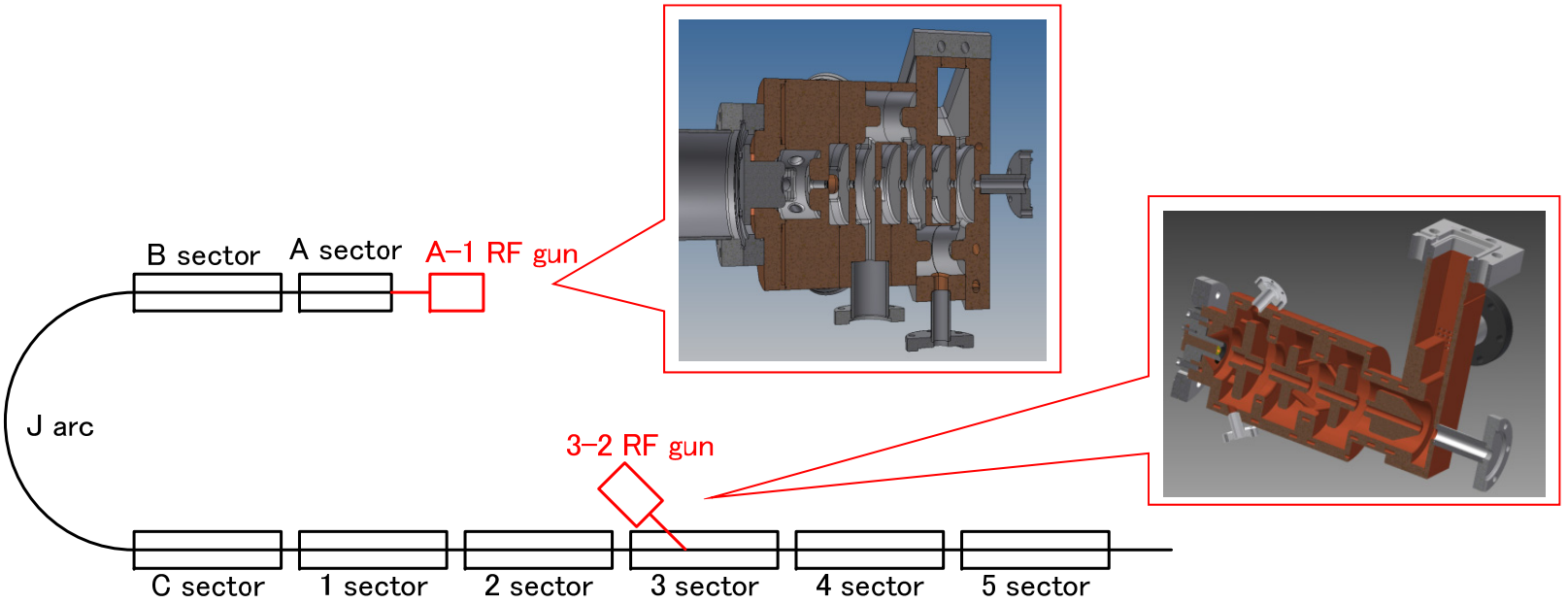
Contents

- Introduction
- Disk and Washer(DAW) type RF gun
- Quasi-traveling wave RF gun
- Cavity calculation and design of Quasi-traveling wave RF gun
- Conclusion

SuperKEKB Upgrade and RF gun development

	KEKB obtained (e+ / e-)	SuperKEKB required (e+ / e-)
Energy	**3.5 GeV / 8.0 GeV**	**4.0 GeV / 7.0 GeV**
Charge	e- → e+ / e- 10 → **1.0 nC / 1.0 nC**	e- → e+ / e- 10 → **4.0 nC / 5.0 nC**
Emittance [mm-mrad]	**2100 / 300**	**6 / 20**





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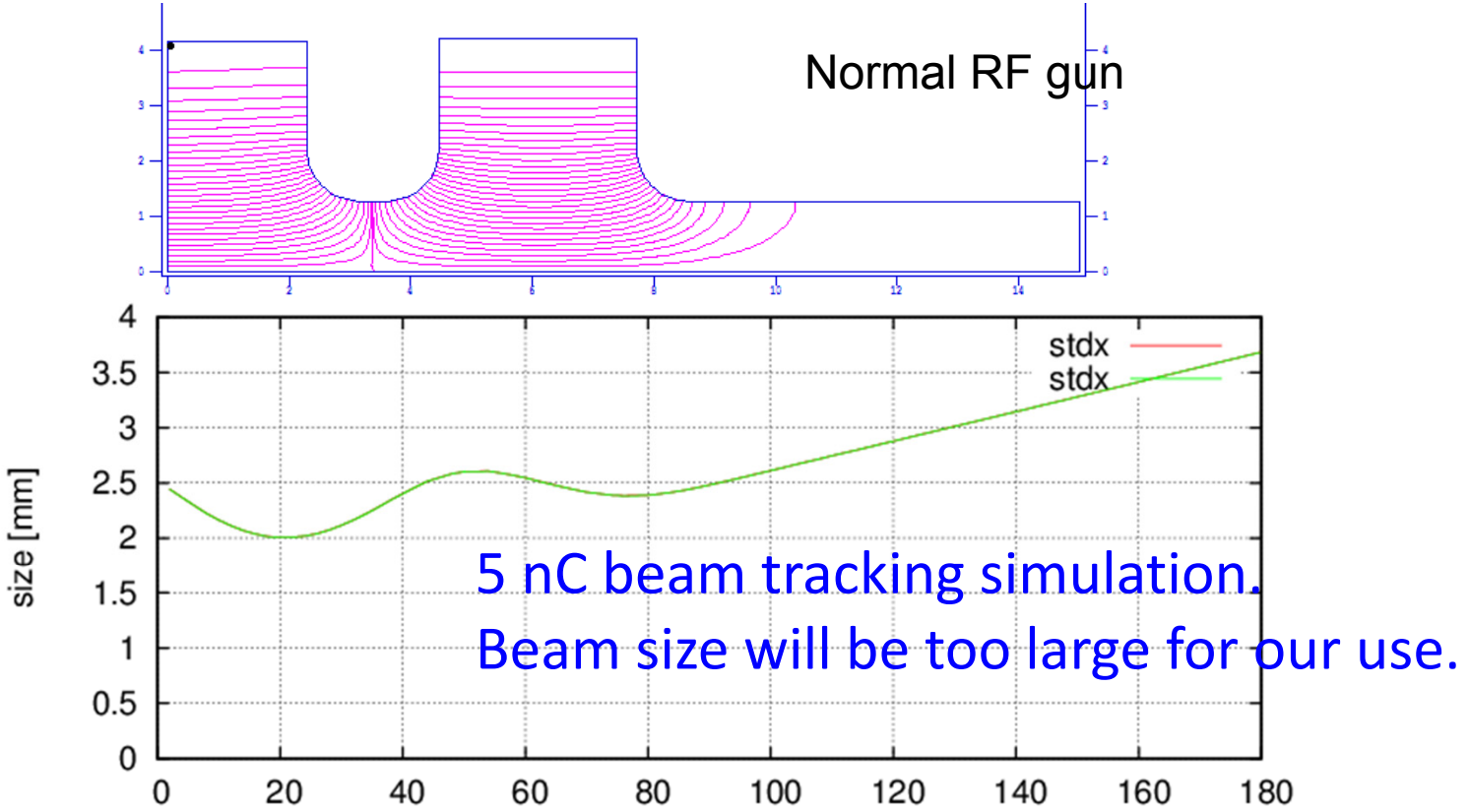
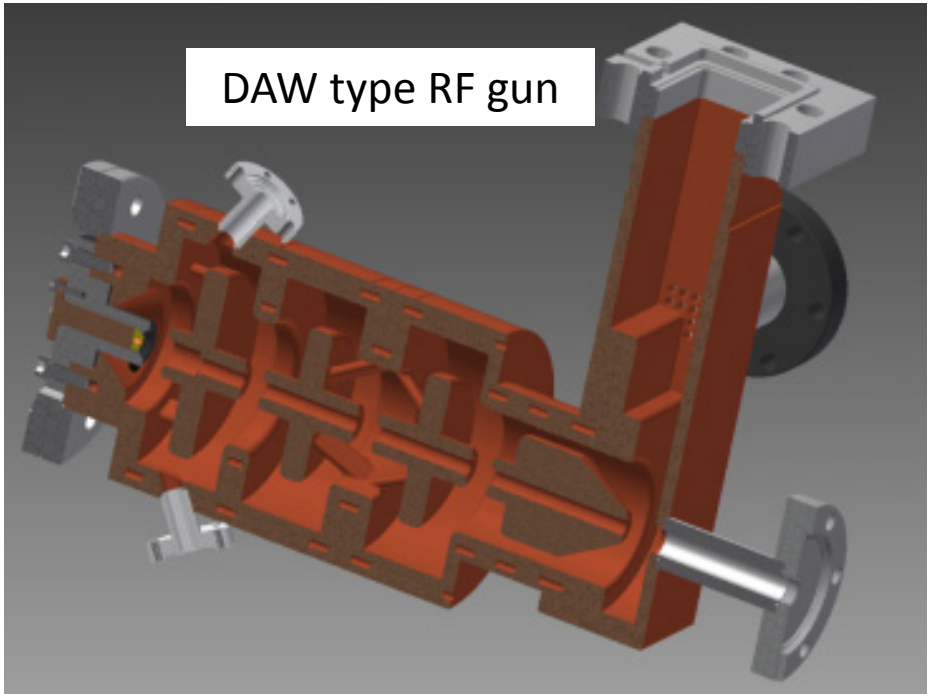
Why we need advanced RF gun?



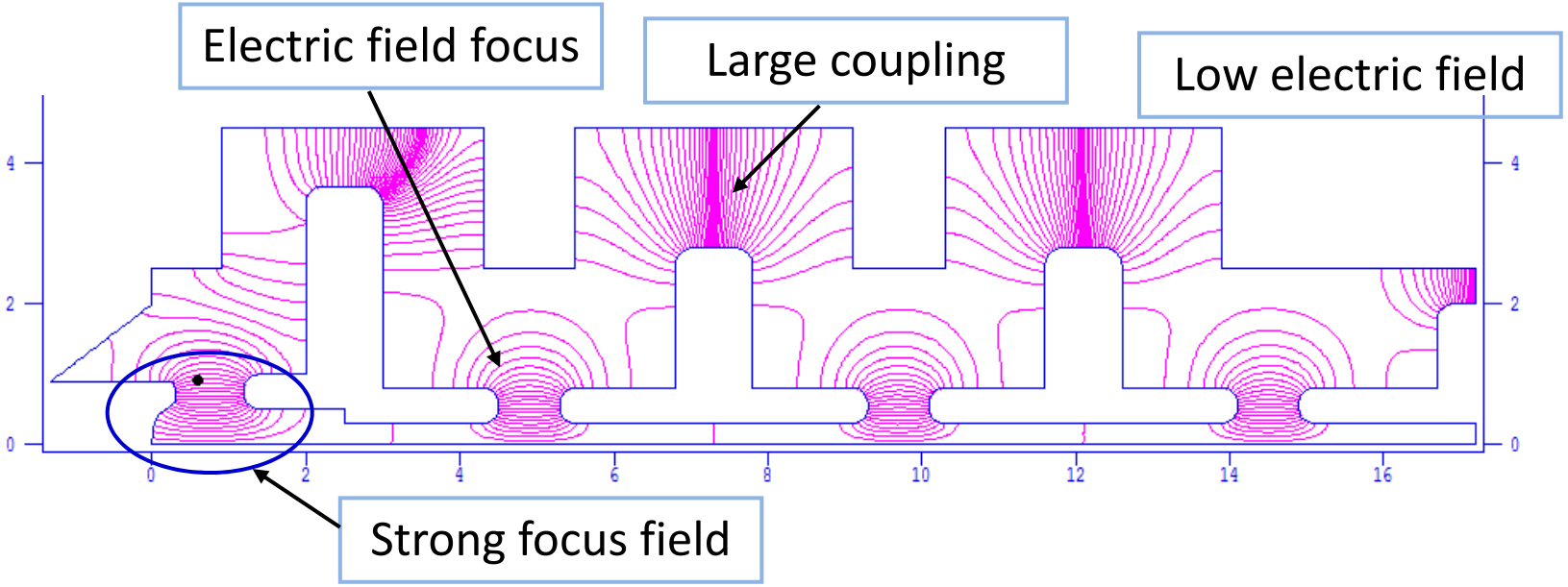
Normal RF gun does not have focusing E-field.
5 nC beam charge has much higher space charge.
We need advanced RF gun.

DAW (Disk and Washer) RF gun development

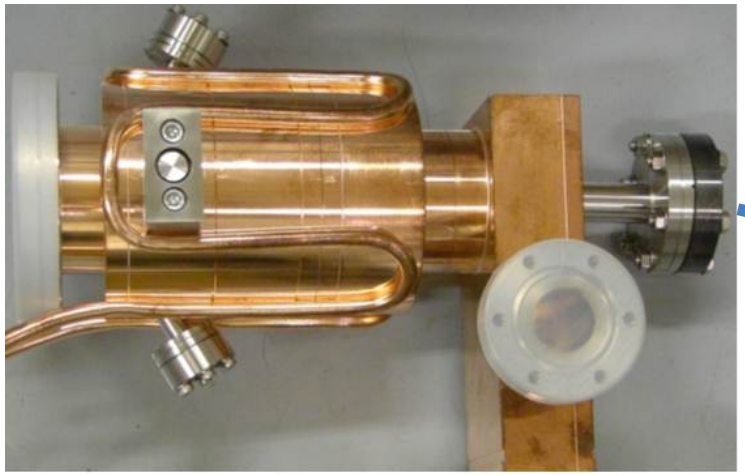


Beam tracking simulation result

Emittance	6 mm-mrad
Size (σ)	1.2 mm
Bunch length	8 psec
Energy	3.2 MeV



DAW (Disk and Washer) RF gun

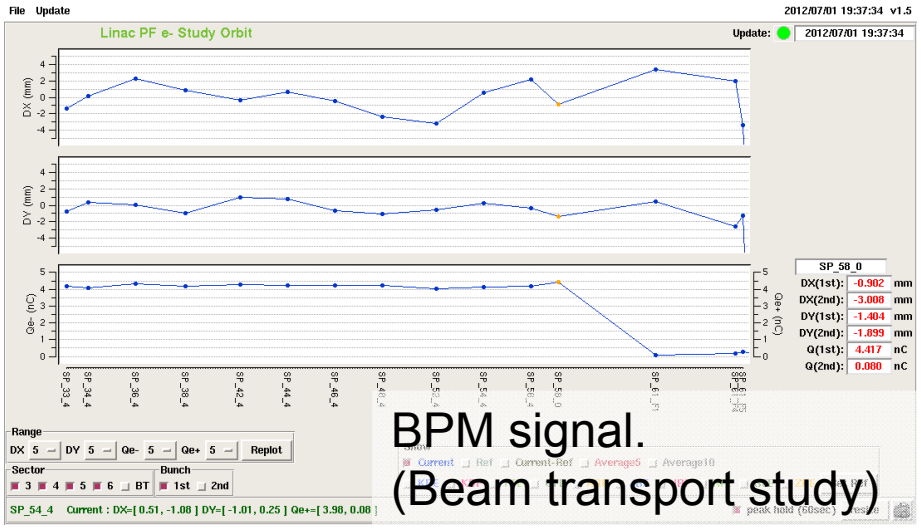


RF gun

RF gun beam line

We already installed RF gun into KEK linac beam line and tested.

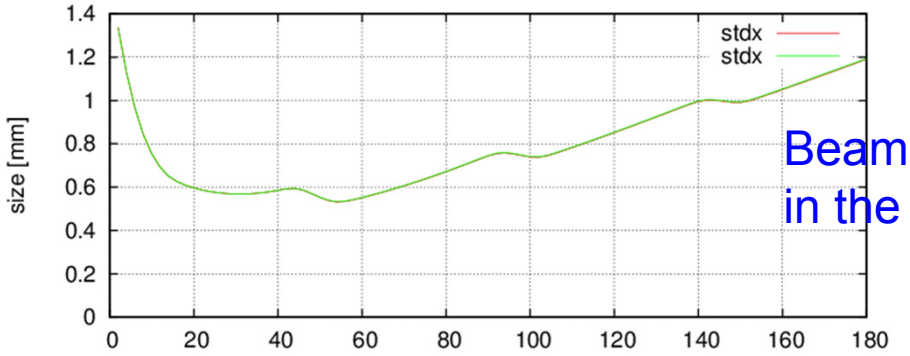
DAW type RF gun beam study result



BPM signal.
(Beam transport study)

4.8 nC beam generation

4.4 nC beam transport to linac end.



Beam has divergence angle
in the gun. (calculation)

Focusing field is NOT enough. Low beam energy: 3 MeV

This gun has no margin (5 nC is maximum output.).

We need a new advanced RF gun

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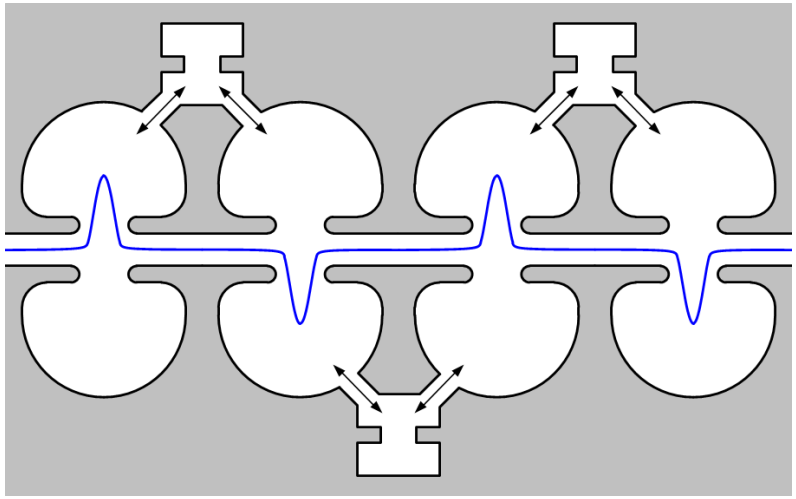
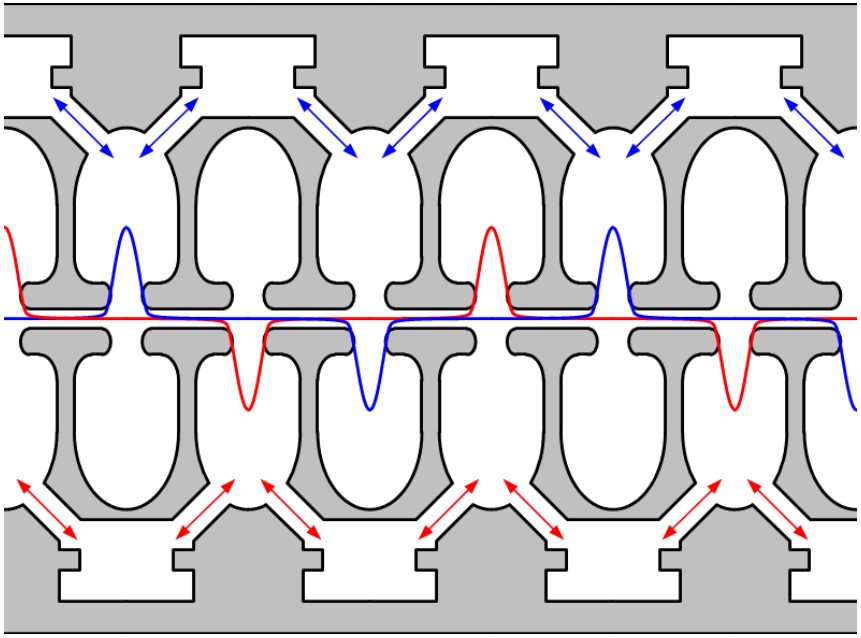
Structure of the quasi traveling wave cavity



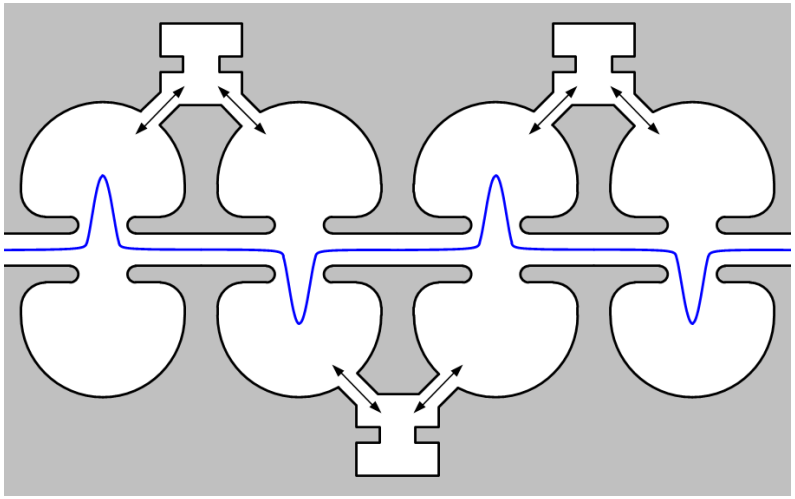
Normal side coupled cavities



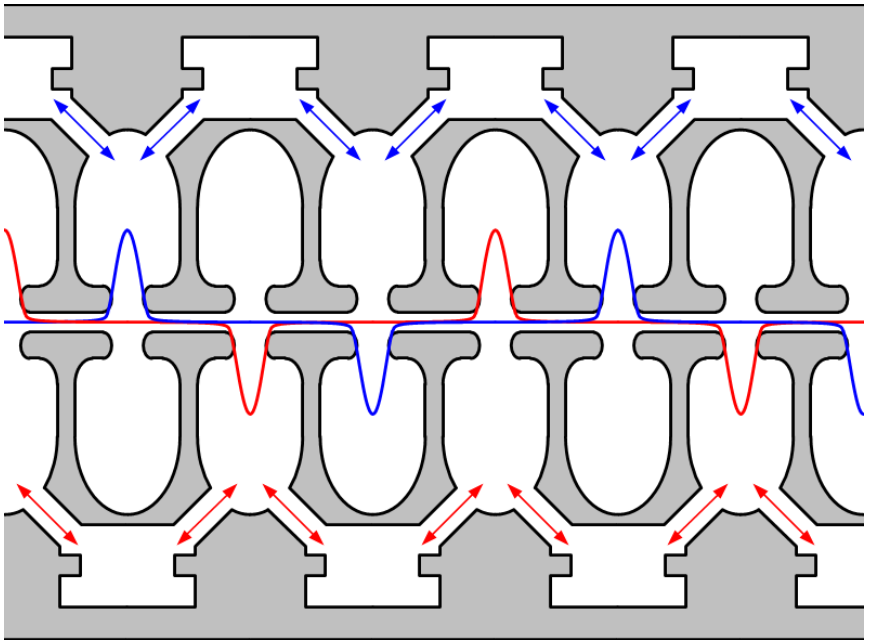
Quasi traveling wave side coupled cavities

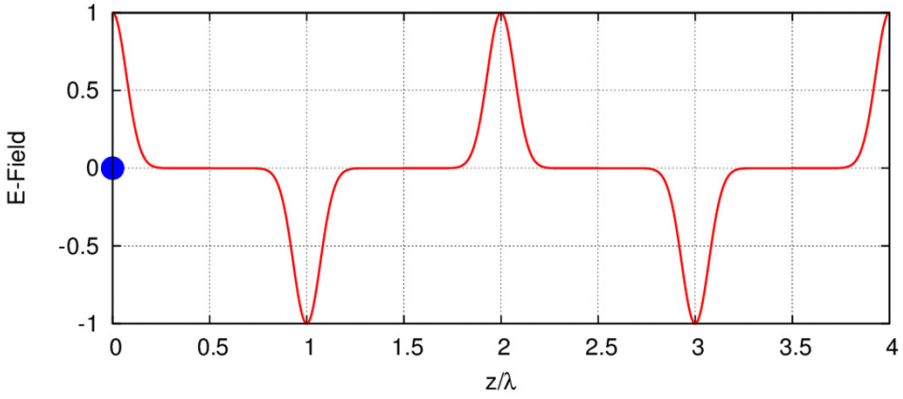
The close nose makes focus field. Our DAW RF gun is using this focus field. Side coupled cavity also can be made the close nose. But, long drift space is problem. One solution is to use tow standing wave cavity.

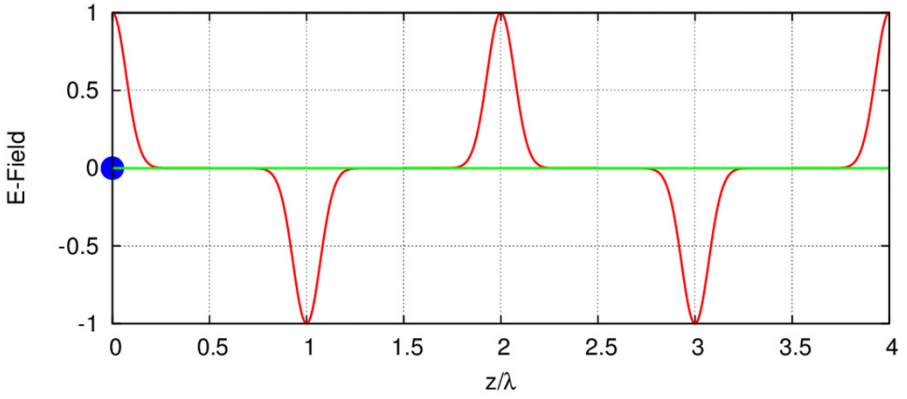
Normal side coupled cavities



Quasi traveling wave side coupled cavities





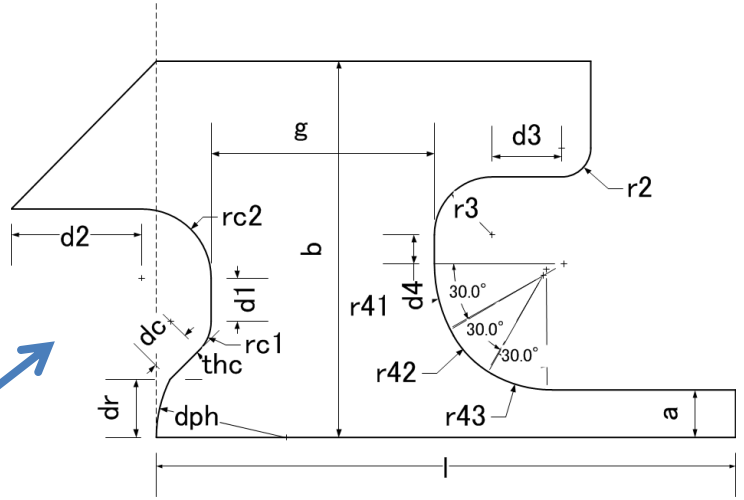


1st Cavity Design (cathode cell)

We need strong focus field.

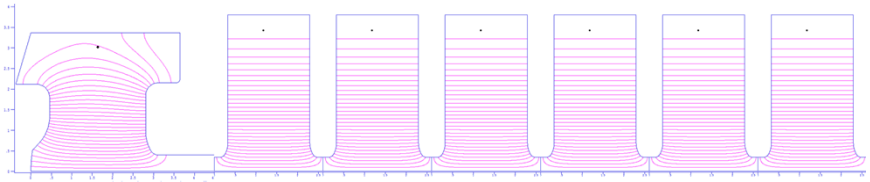
But strong focus field may cause emittance growth.
We must avoid the electric field concentration.

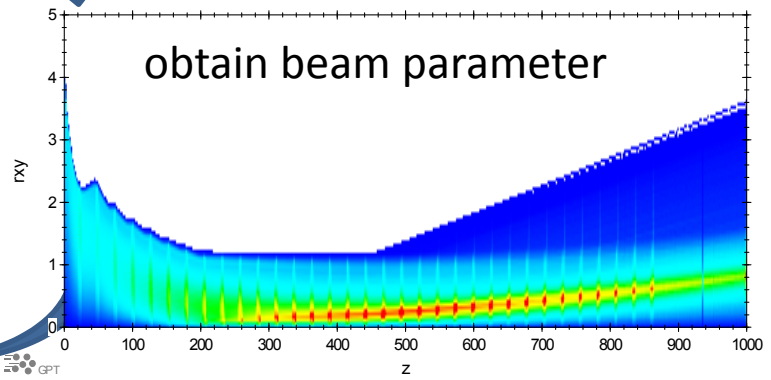
To avoid beam defocussing, emittance growth and field concentration,
a lot of parameters were searched for design.



Beam tracking

Field calculation



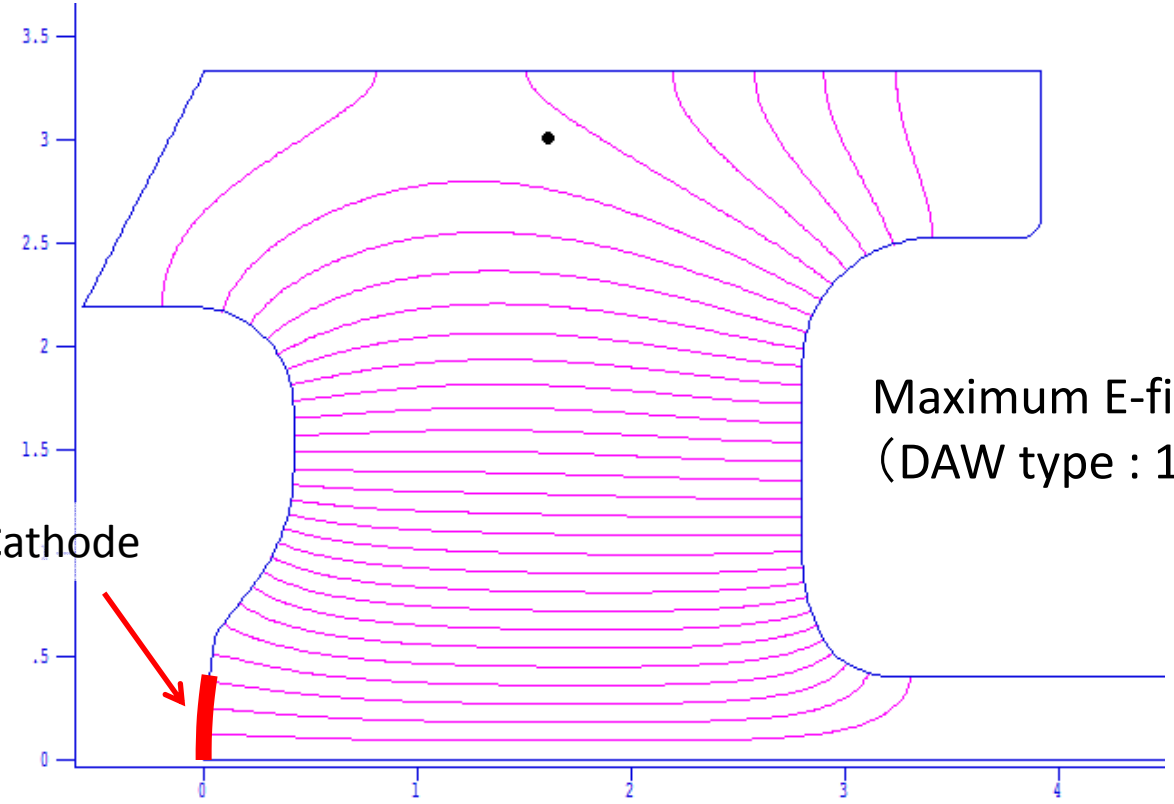


Feedback to cavity parameters

Automatic optimization by using downhill simplex method

1st Cavity Design (cathode cell)

Finally, we gat optimum cavity shape.

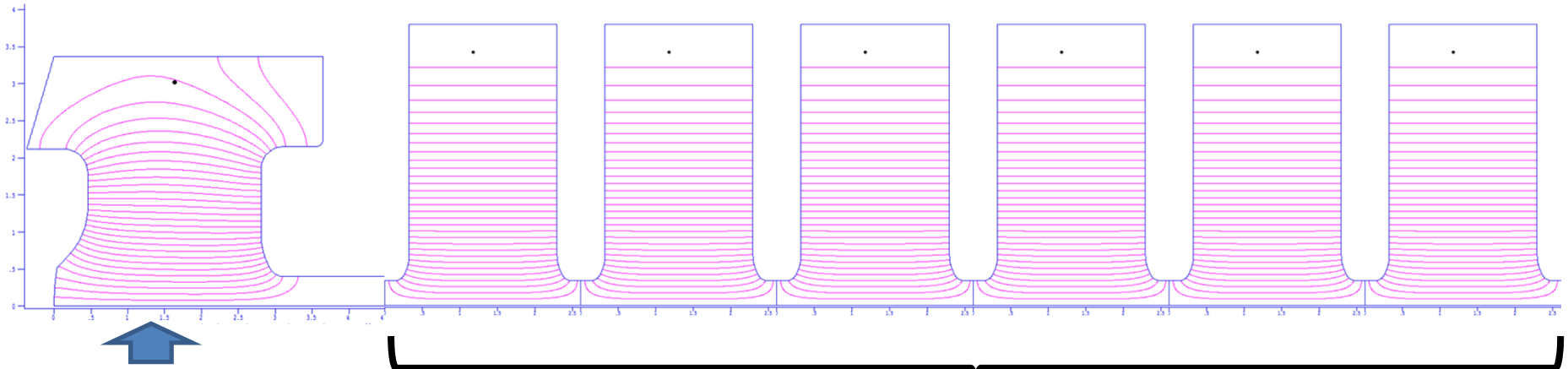


Cathode

Maximum E-field at surface: 120 MV/m
（DAW type : 150 MV/m）

Whole cavities design

This RF gun has total of seven acceleration cavities. These are divided into two standing wave structure of 3 and 4 side coupled cavities respectively.



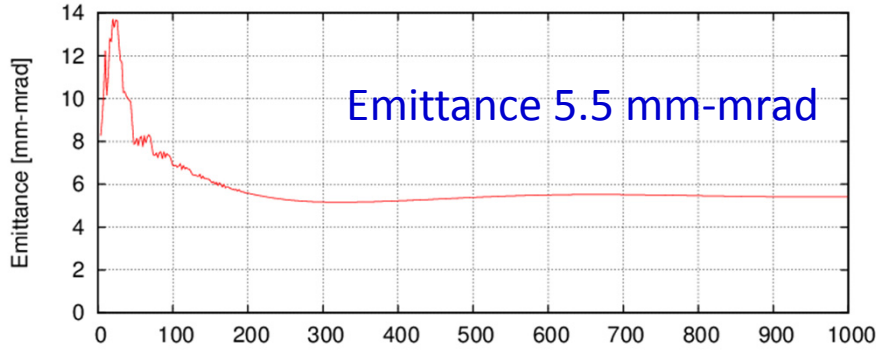
Maximum E-field at surface: 120 MV/m

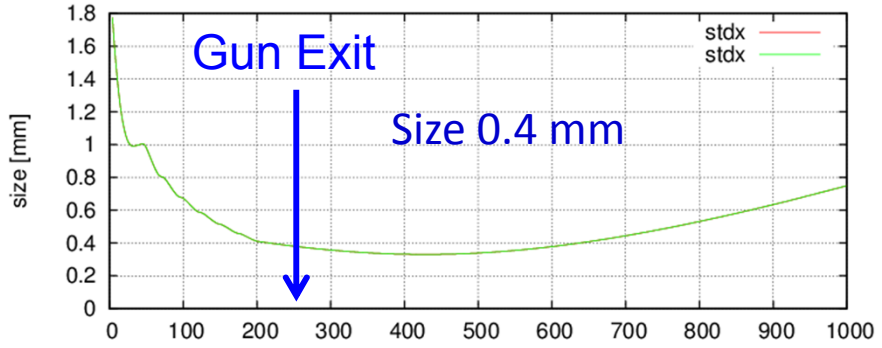
Maximum E-field at surface: 100 MV/m

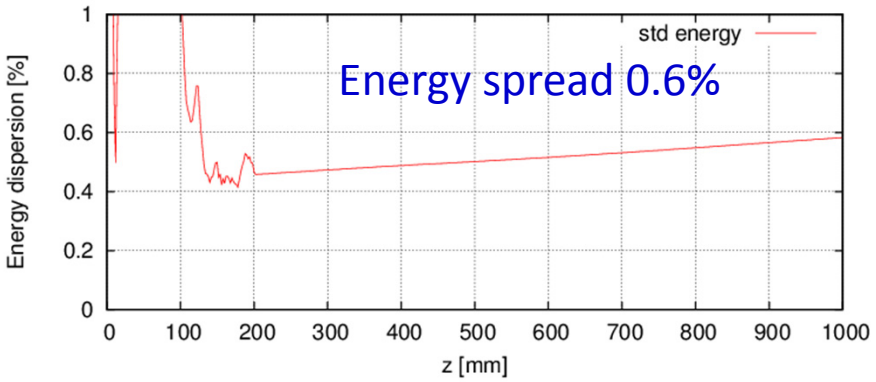
Emittance: 5.5 mm-mrad @ 5 nC

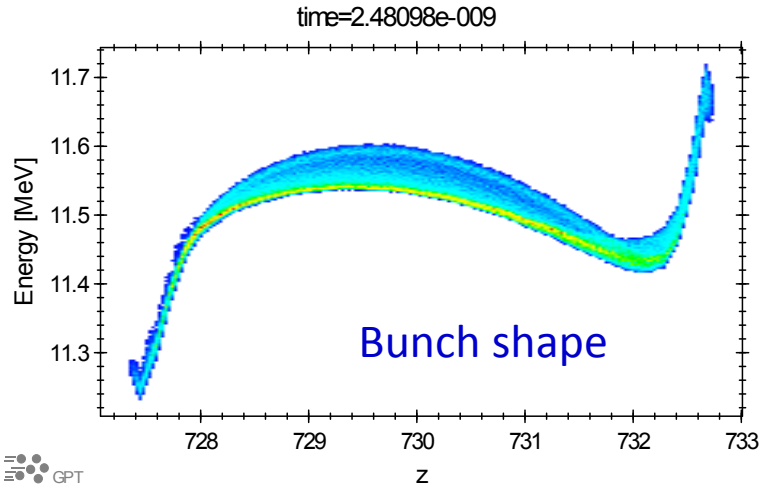
This RF gun can generate 10 nC beam

Beam tracking simulation result（5 nC）



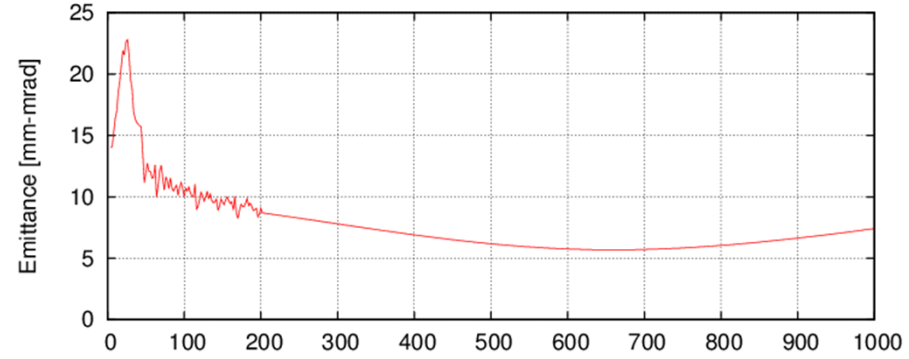


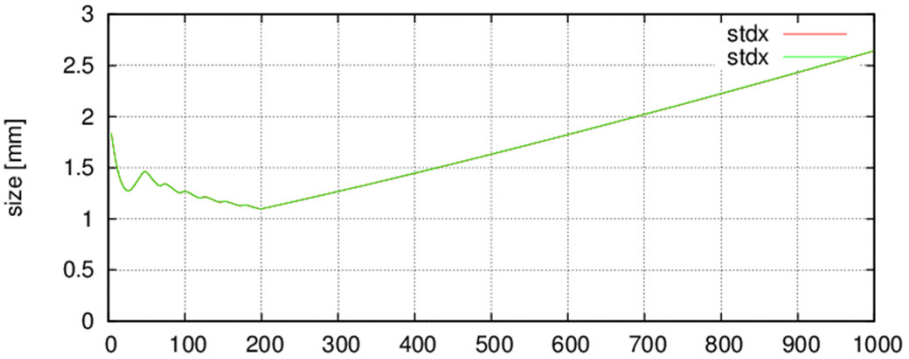


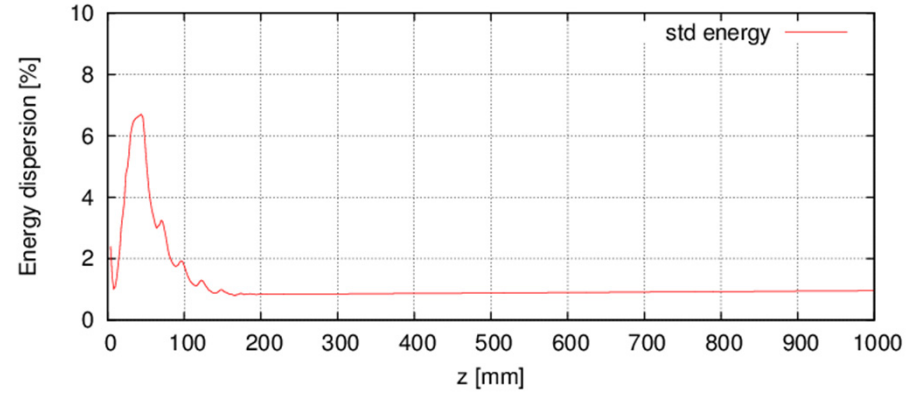


5 nC 11.5 MeV parallel beam

Beam tracking simulation result（10 nC）







This RF gun can generate 10 nC beam.

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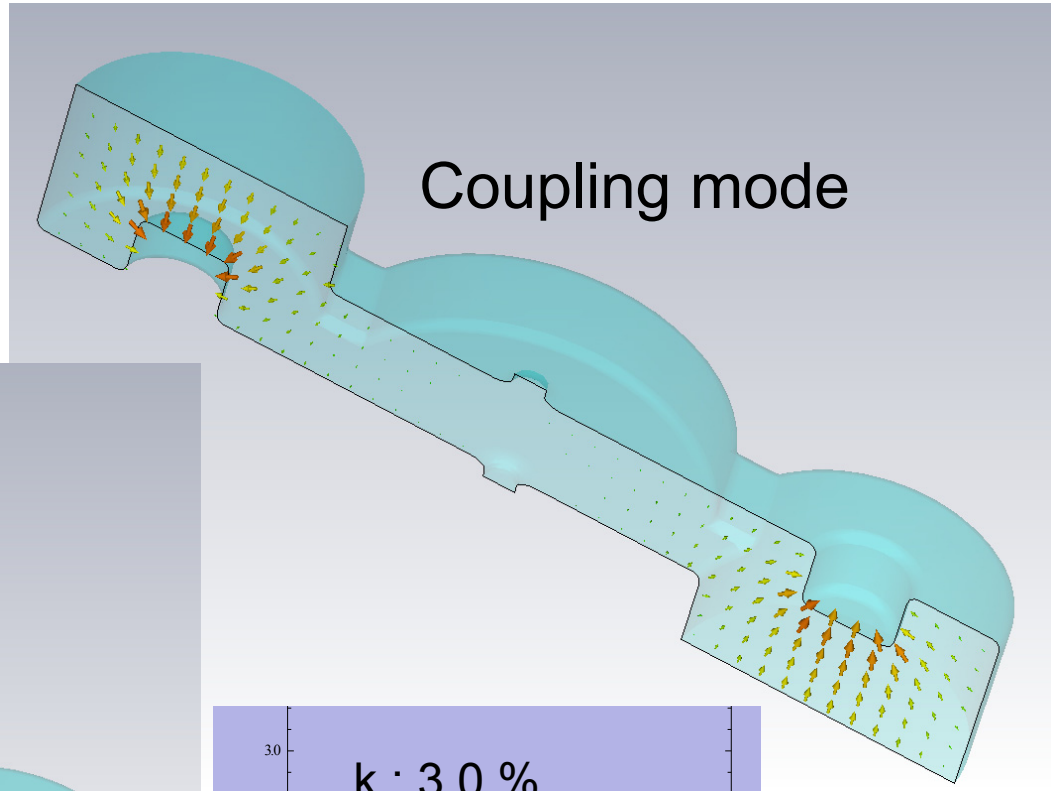
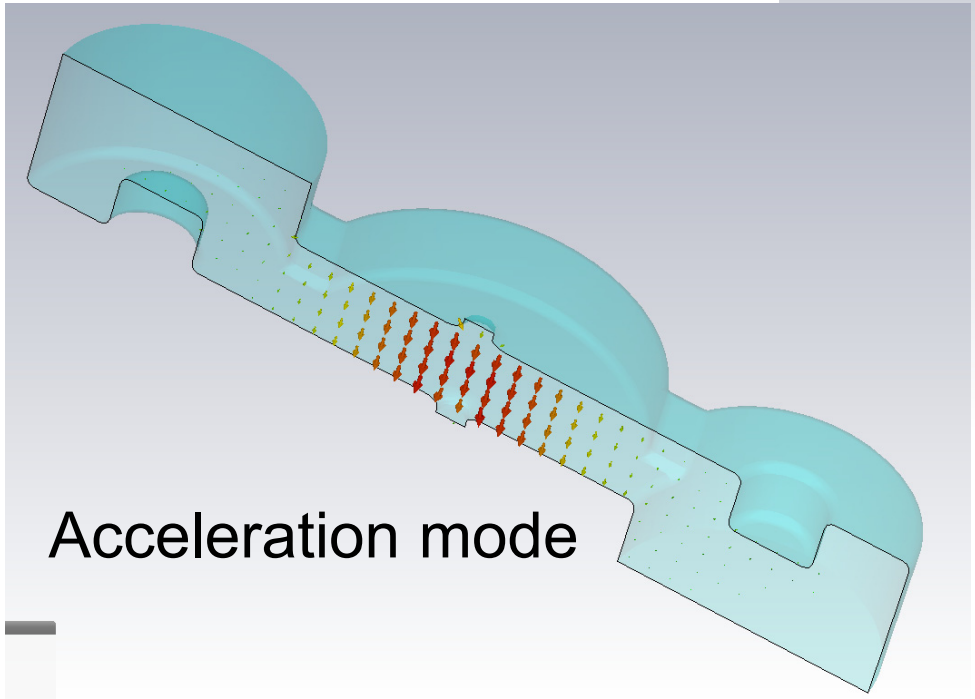
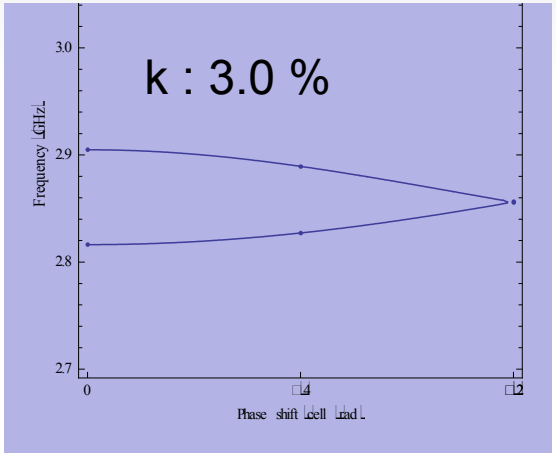
3D cavity calculation

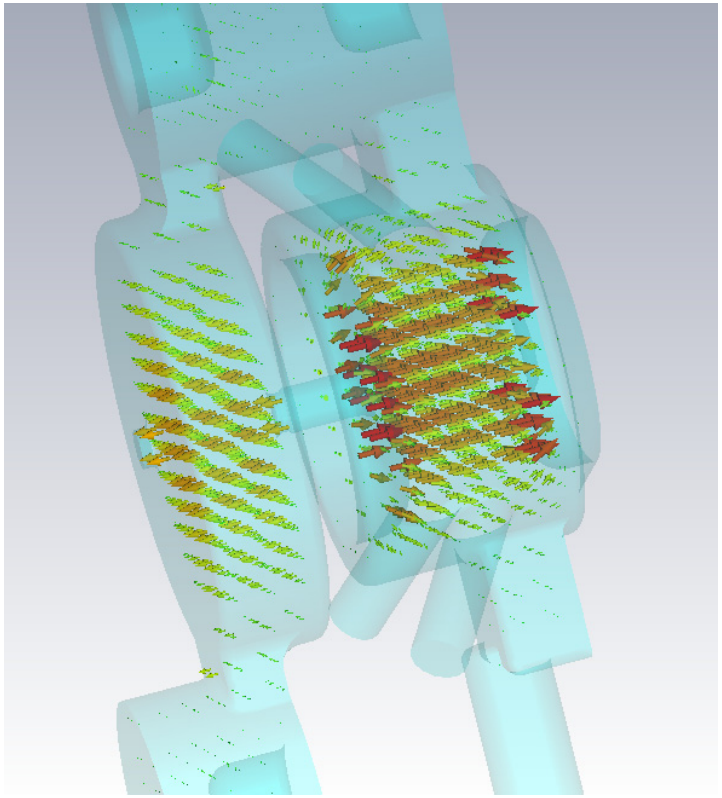
Regular cell



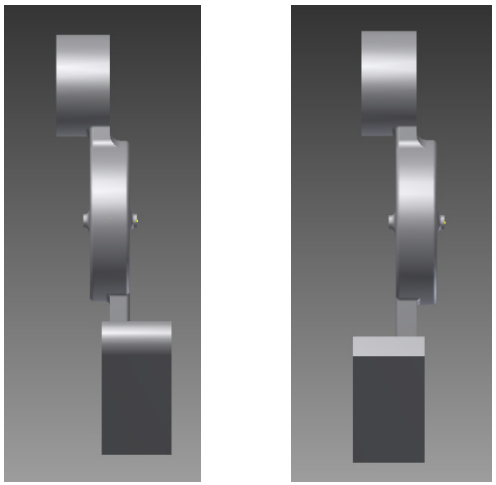




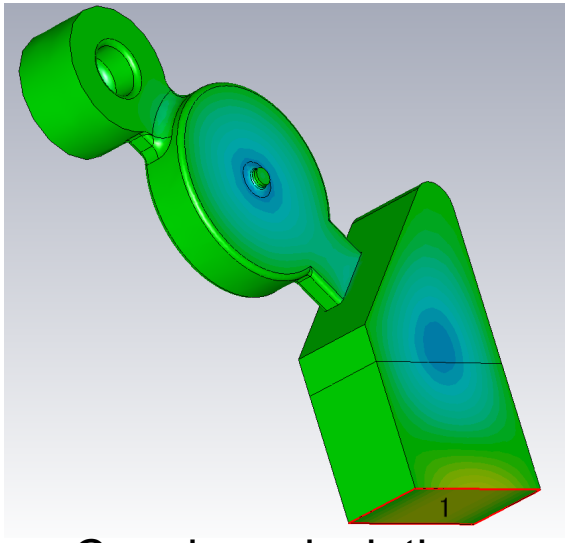
3D cavity calculation



1st cavity calculation

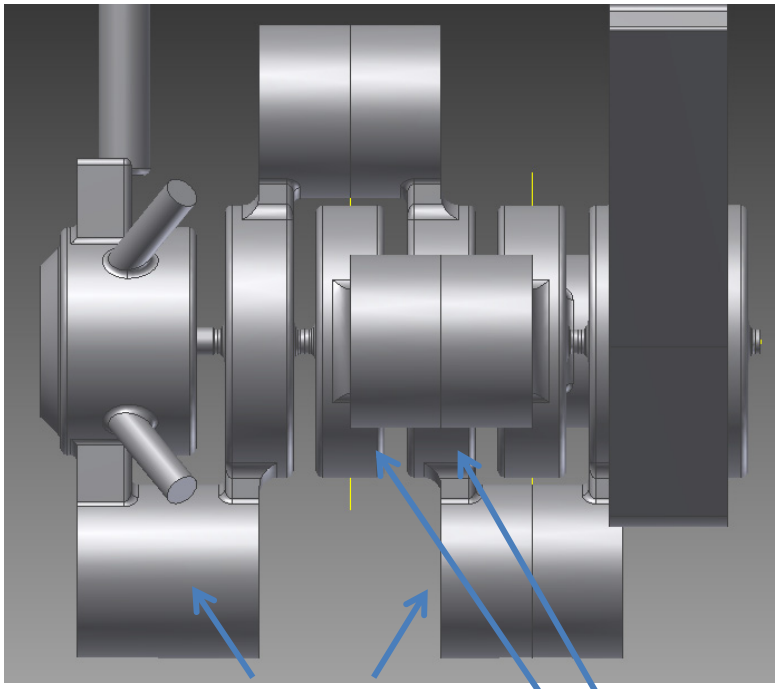


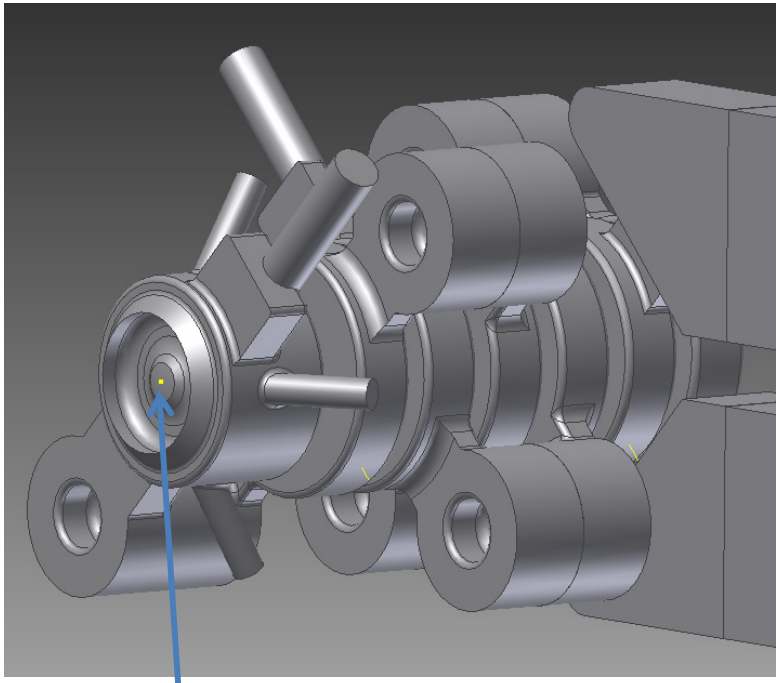
2 types coupler



Coupler calculation

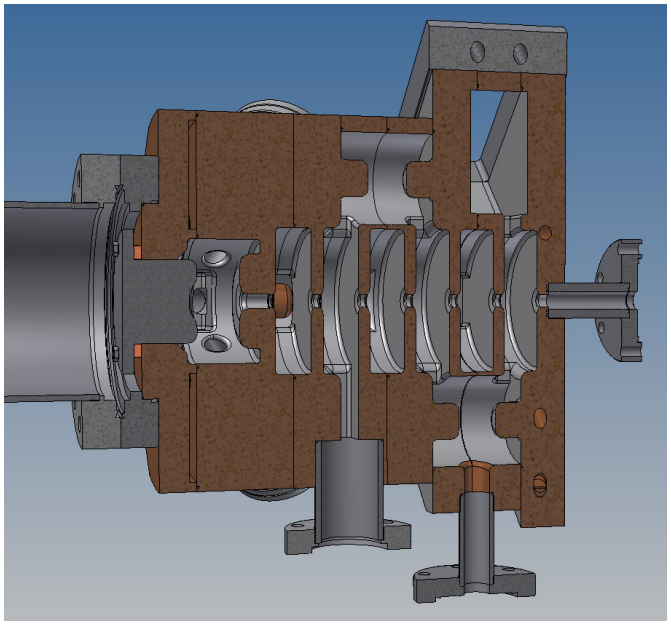
Whole cavity shape

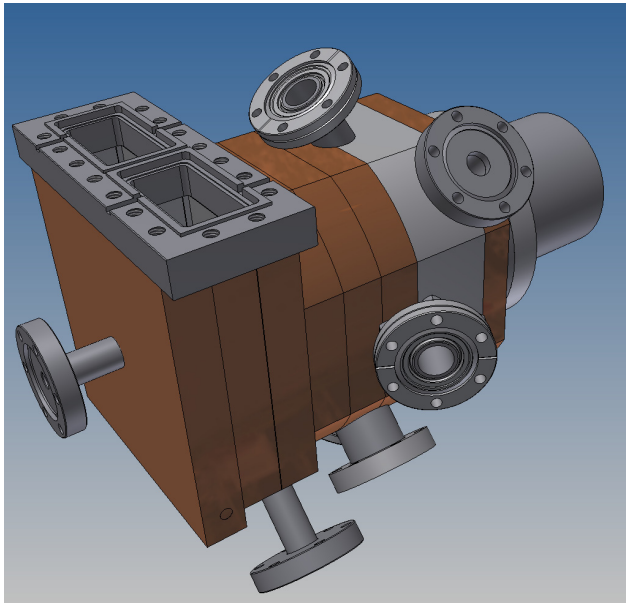


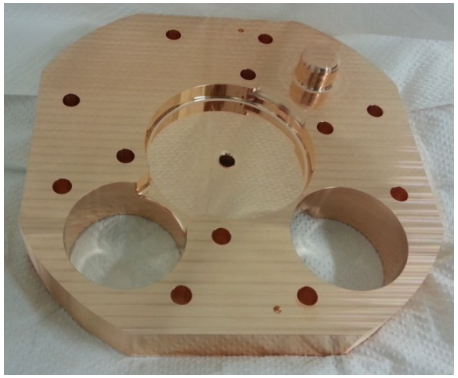


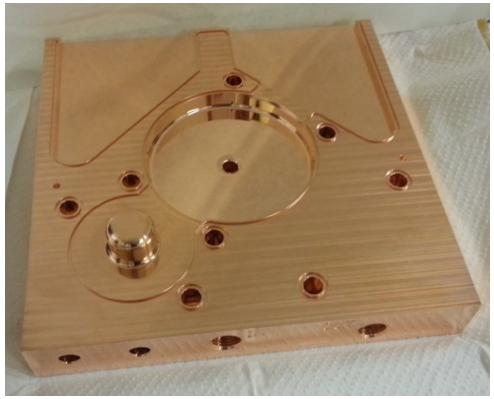
Cavity shape

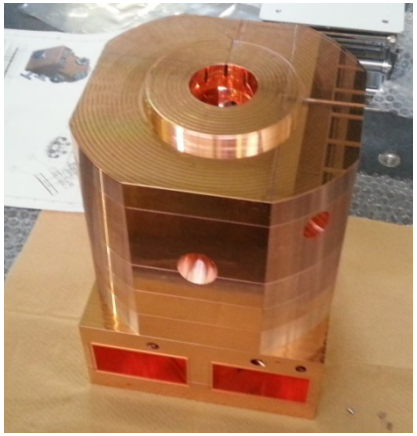
Mechanical design and manufacturing











Conclusion

- We are developing a photo cathode S-band RF gun for SuperKEKB.
- DAW type RF gun generated 4.8 nC. We confirmed electric field focus in the cavities.
- However DAW type RF gun is not enough to our SuperKEKB operation.
- A new quasi-traveling wave RF gun have developed. It is suitable for the high charge low emittance beam generation.
- The quasi-traveling wave RF gun will be tested soon.