Accelerating structure

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on behalf of the accelerating-structure and positron group

SuperKEKB review, March 14, 2018

Contents

- Introduction
  - S-band accelerating structures in the injector linac -
- Deterioration in accelerating voltage
- How do we tackle the problem ?
- Summary

Introduction I

Three types of S-band quasi-constant-gradient accelerating structure of 2 m in length as main accelerators

Type	Number in use
• **PF-type accelerating structures**	**134**
• **KEKB-type accelerating structures**	**80**
• **Large-aperture accelerating structures (LAS) ***	**10**

* special structure for the positron capture unit

Introduction 2

PF-type structures
fabricated about 35 years ago as the injector for the PF ring

don't work well

Mean RF parameters of five kinds of the PF-type

r_a [MΩ/m]	57.8 (57.3 - 58.3)
τ [neper]	0.335 (0.302 - 0.368)
T_f [us]	0.51 (0.462 - 0.558)
$V_a/P^{1/2}$ [MV/MW$^{1/2}$]	7.29 (7.00 - 7.58)

Introduction 3

KEKB-type structures
fabricated about 20 years ago for the KEKB injector

work well as designed

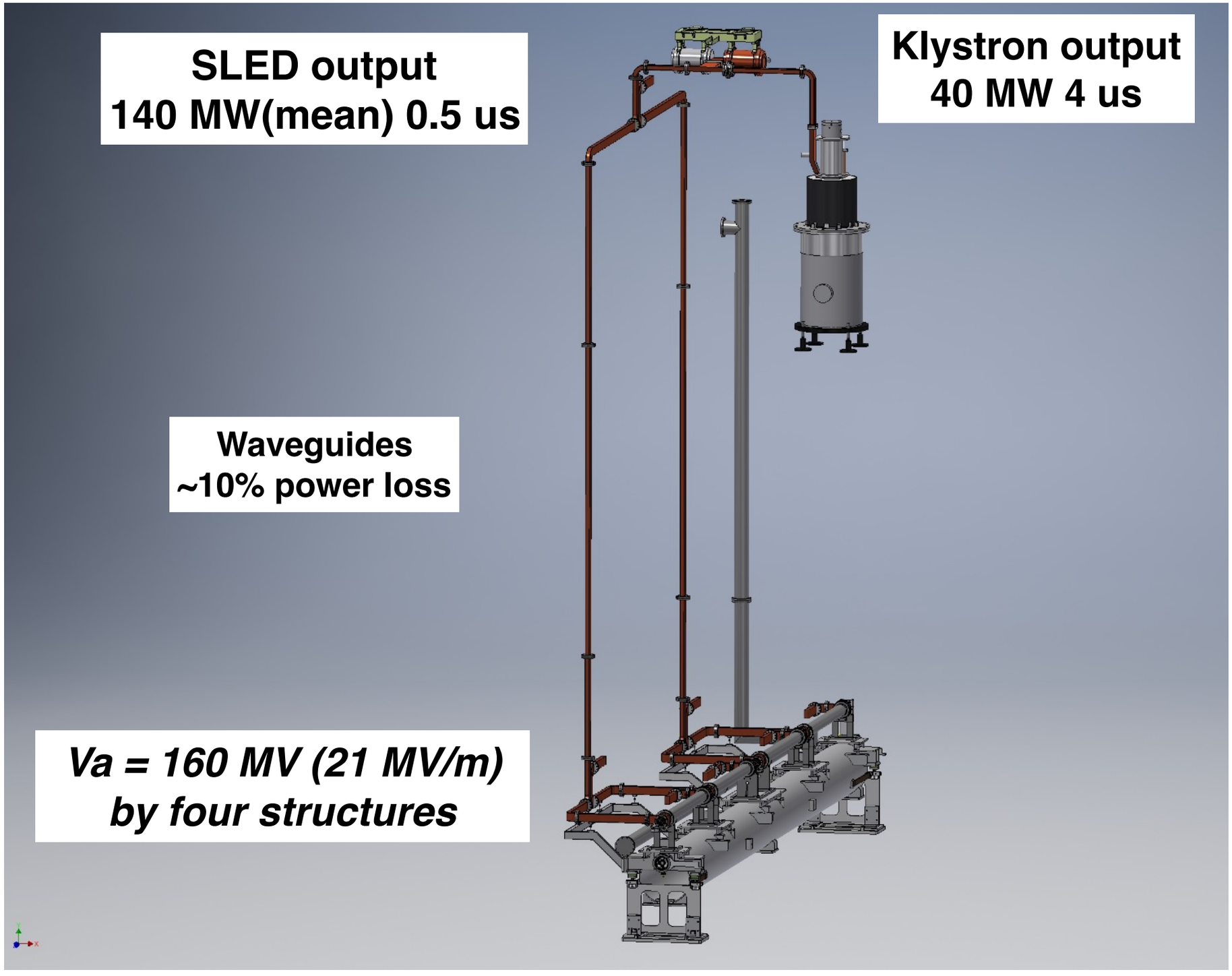
Mean RF parameters of five kinds of the KEK-type

r_a [MΩ/m]	57.8 (57.3 - 58.3)
τ [neper]	0.335 (0.302 - 0.368)
T_f [us]	0.51 (0.462 - 0.558)
$V_a/P^{1/2}$ [MV/MW$^{1/2}$]	7.29 (7.00 - 7.58)

the same as those of the PF-type

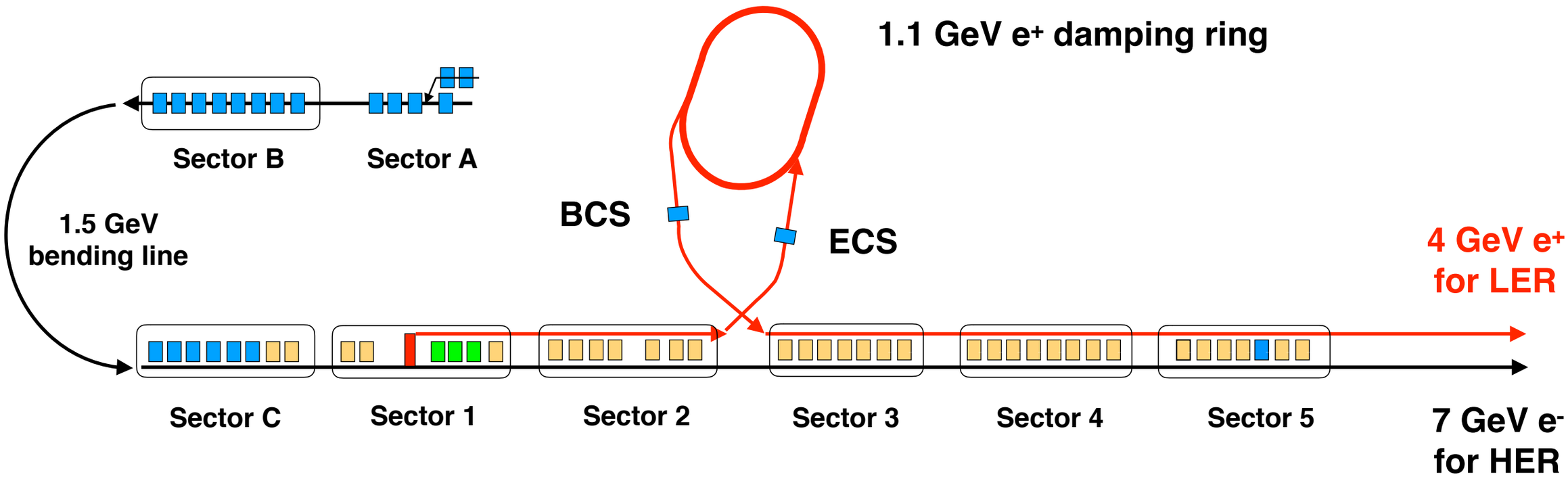
Introduction 4

Designed performance of the accelerating unit



Introduction 5

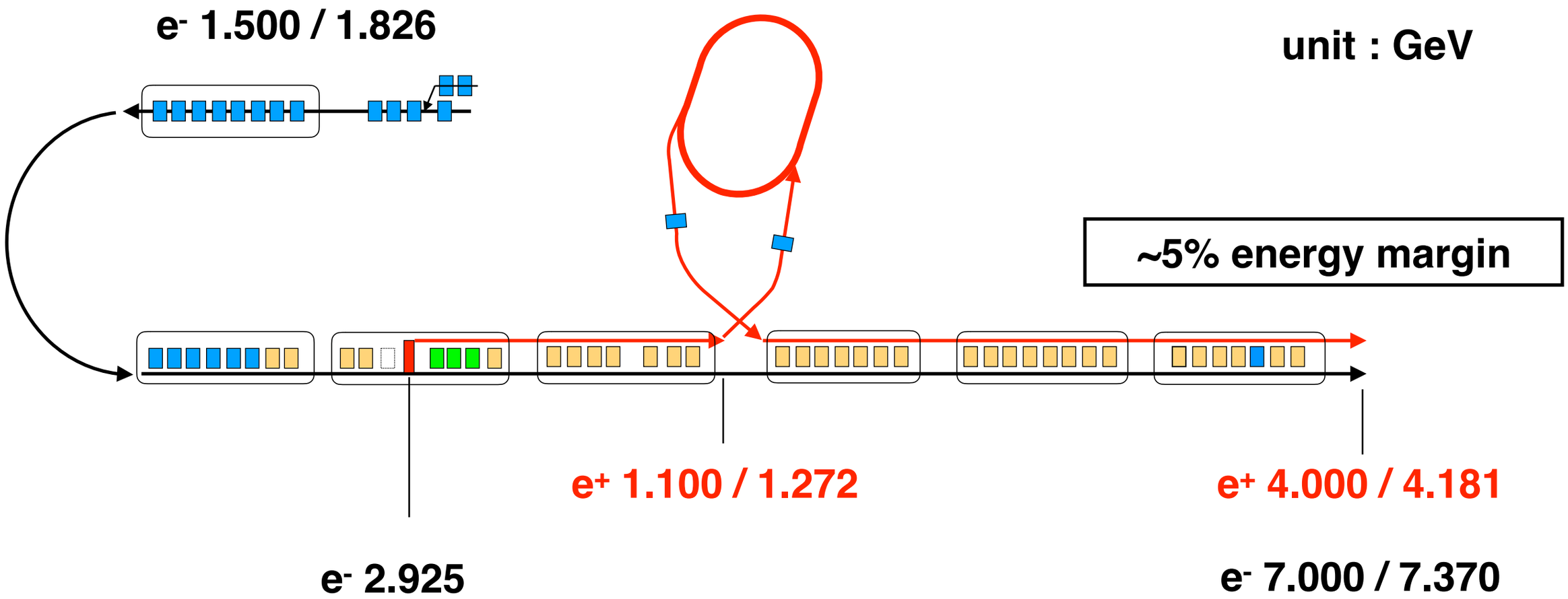
Arrangement of 54 S-band accelerating units in the injector linac



- PF-type structure unit
- KEKB-type structure unit
- LAS unit
- e^+ generator needful of 3 GeV primary e^-

Introduction 6

Required energy and available maximum energy at important points



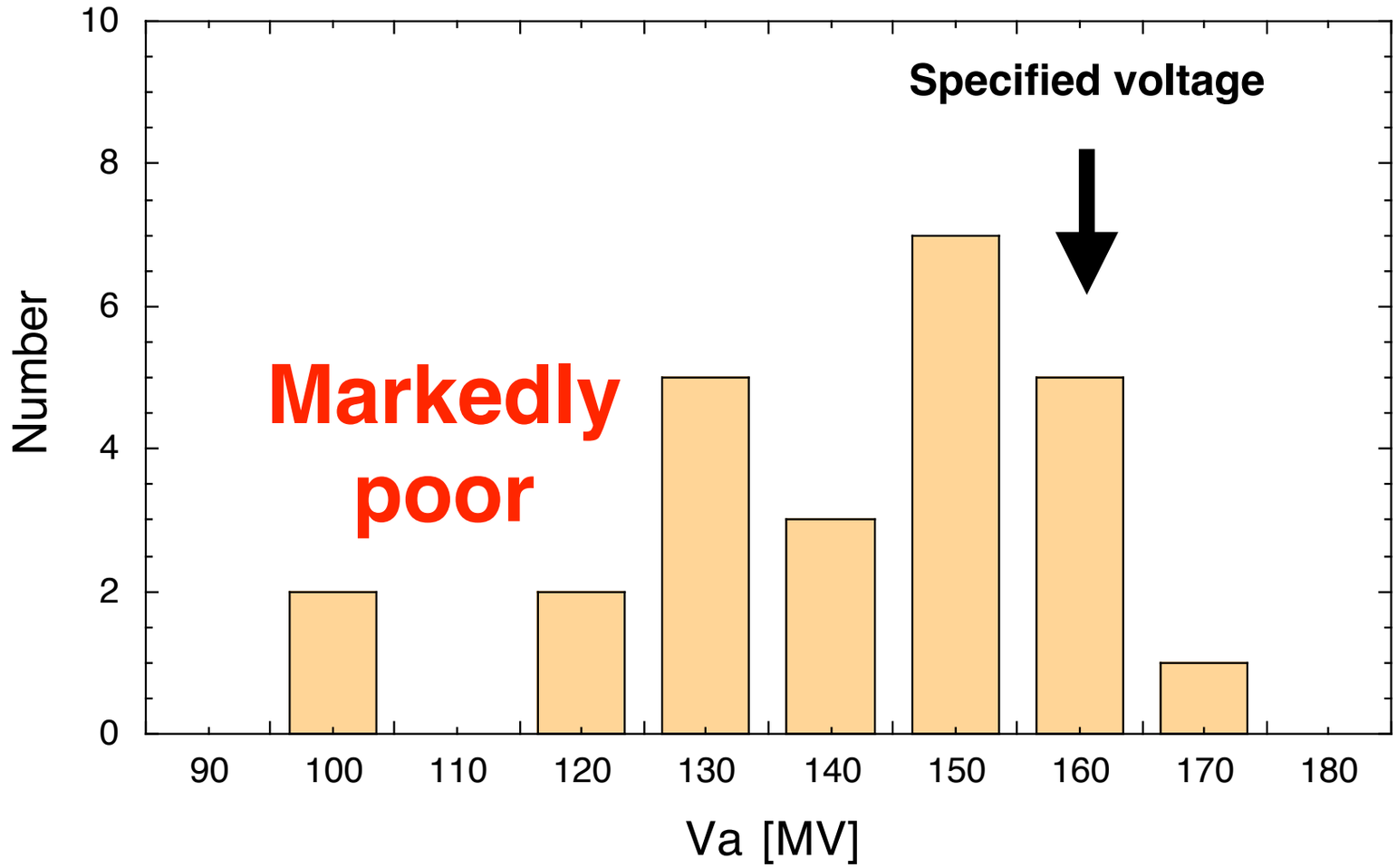
No energy margin for the 6S operation at

e^+ 4.166 and e^- 7.291

Deterioration in accelerating voltage I

Most of the PF-type structures don't work well

suffering from power reflection and/or excessive field emission

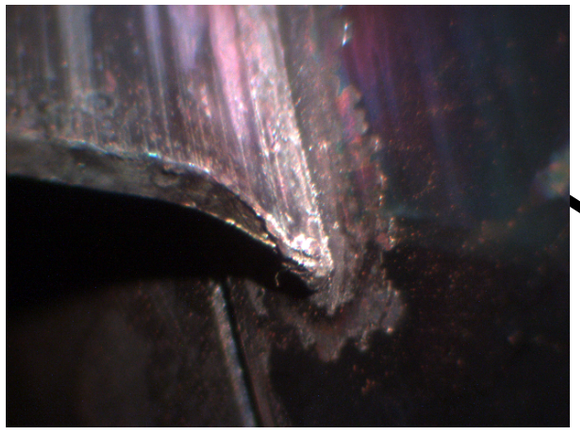


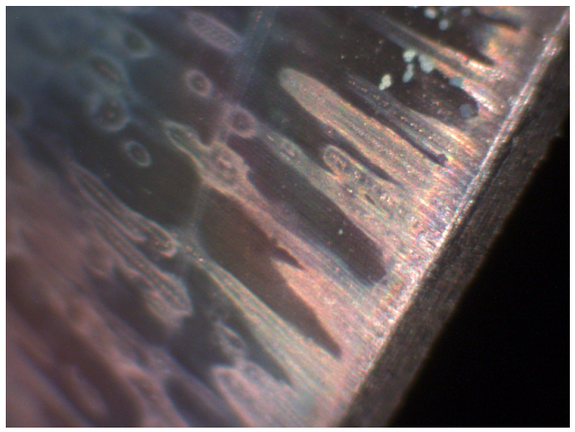
Average voltage of 33 units = 145 MV < 160MV design

What's wrong with the structures?

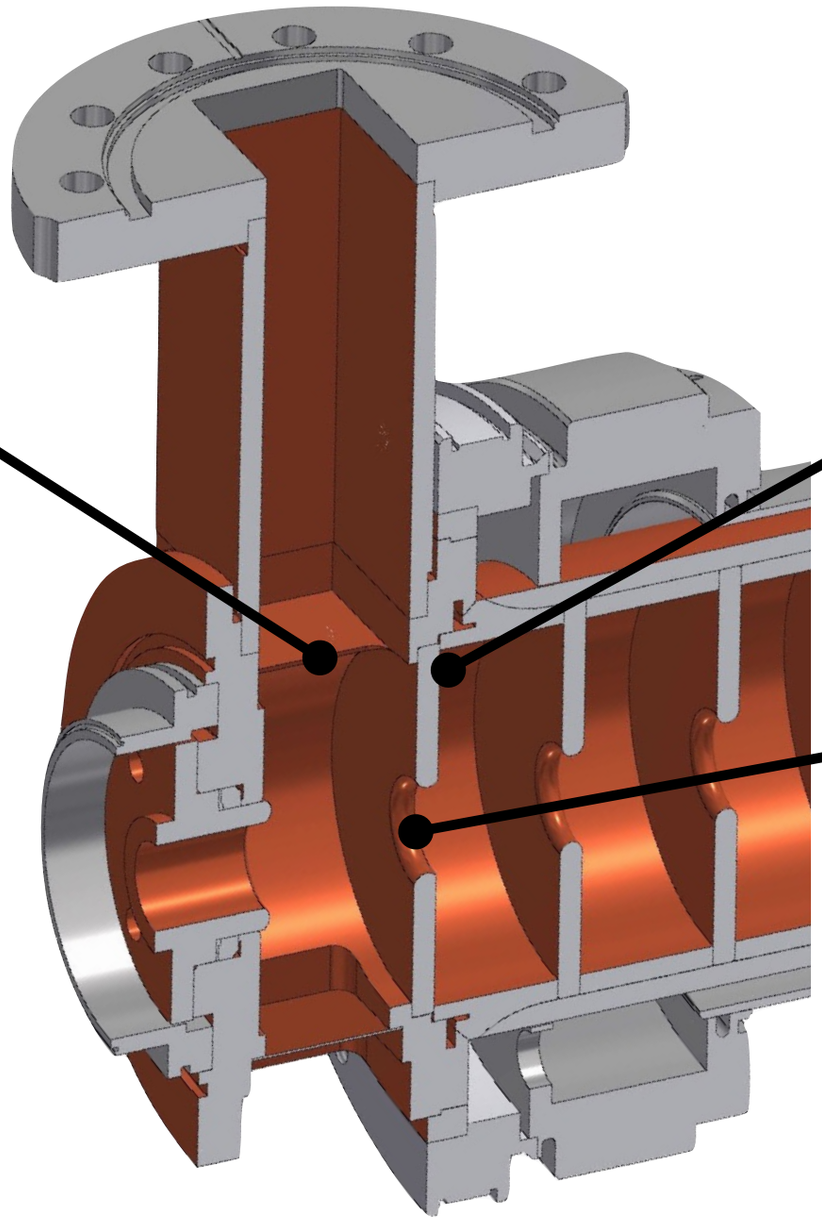
Deterioration in accelerating voltage 2

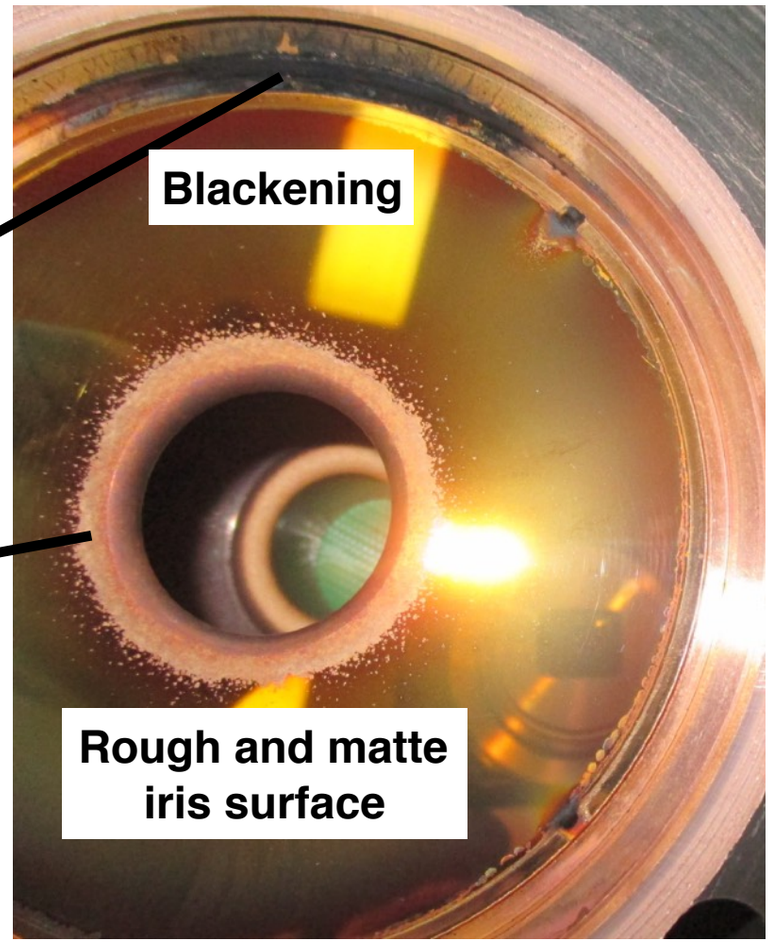
The couplers have been severely damaged !





Rough and discolored surface





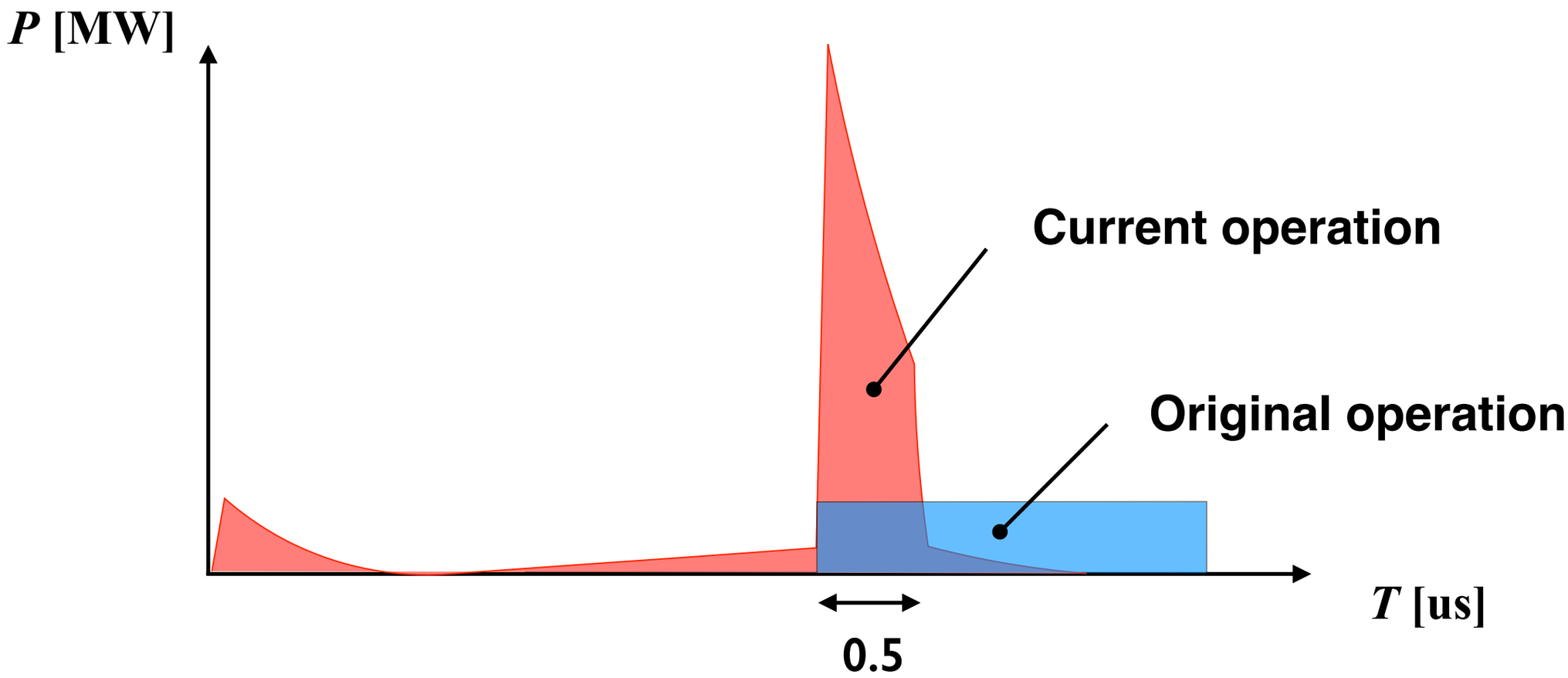
Some couplers and their neighboring cells to pieces and under investigation

Deterioration in accelerating voltage 3

Higher power operation for KEKB

8.3 MV/m (original) → 21 MV/m in operation with SLED

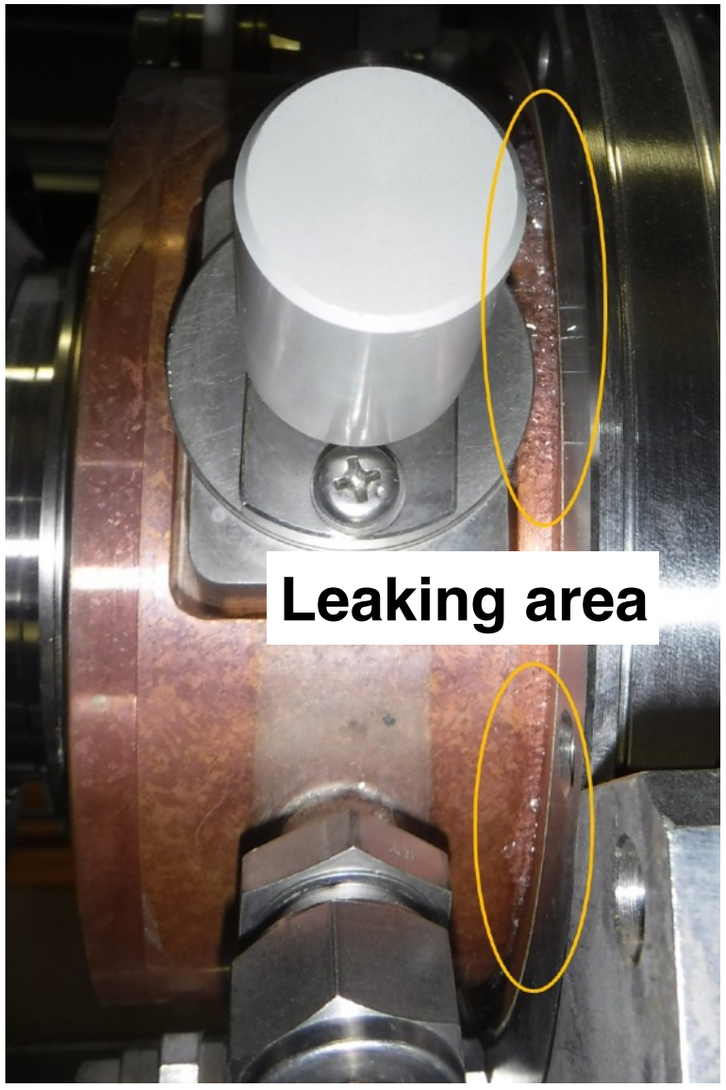
Peak power 8 times higher than that in original operation

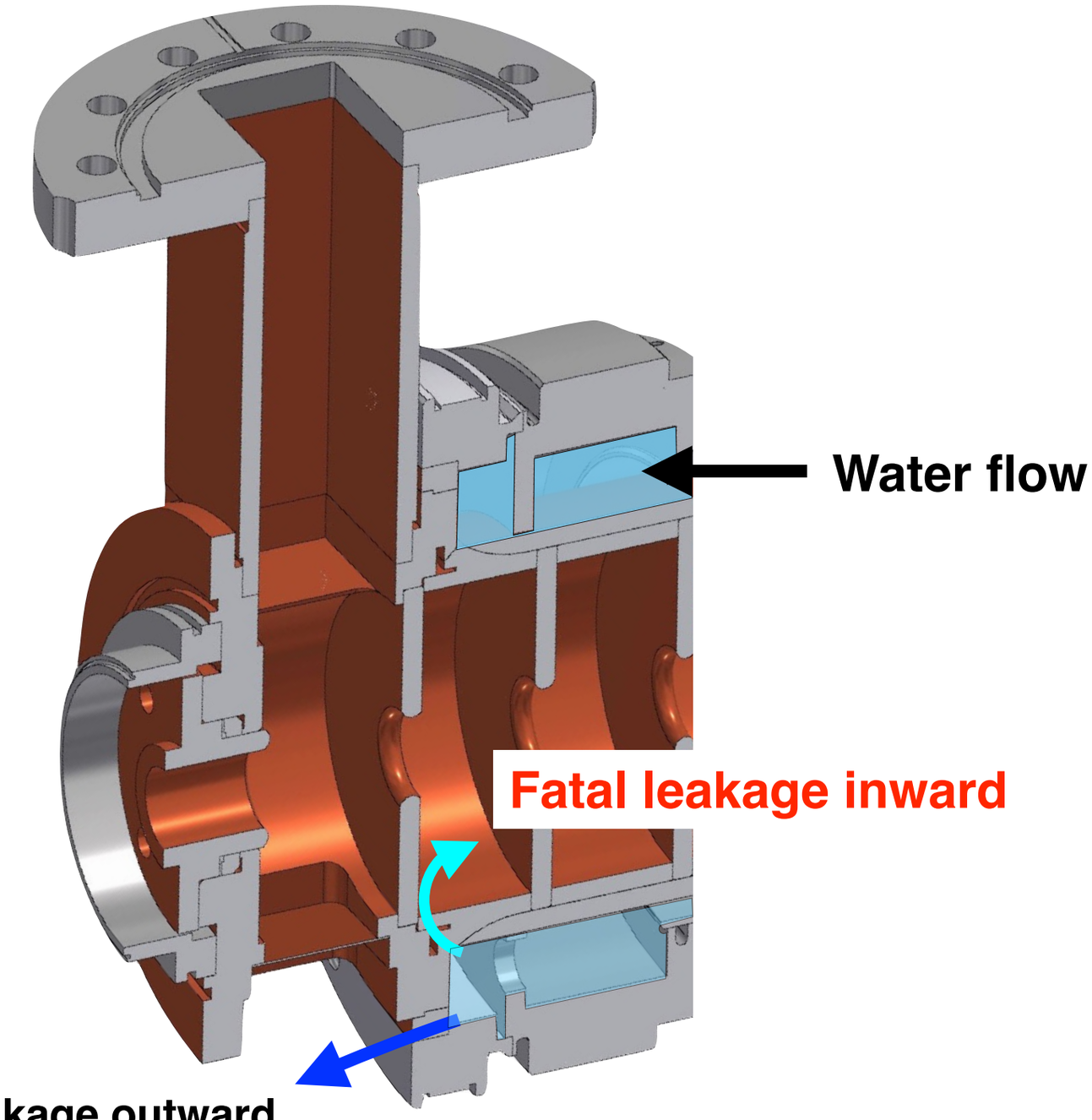


Deterioration in accelerating voltage 4

Water leakage

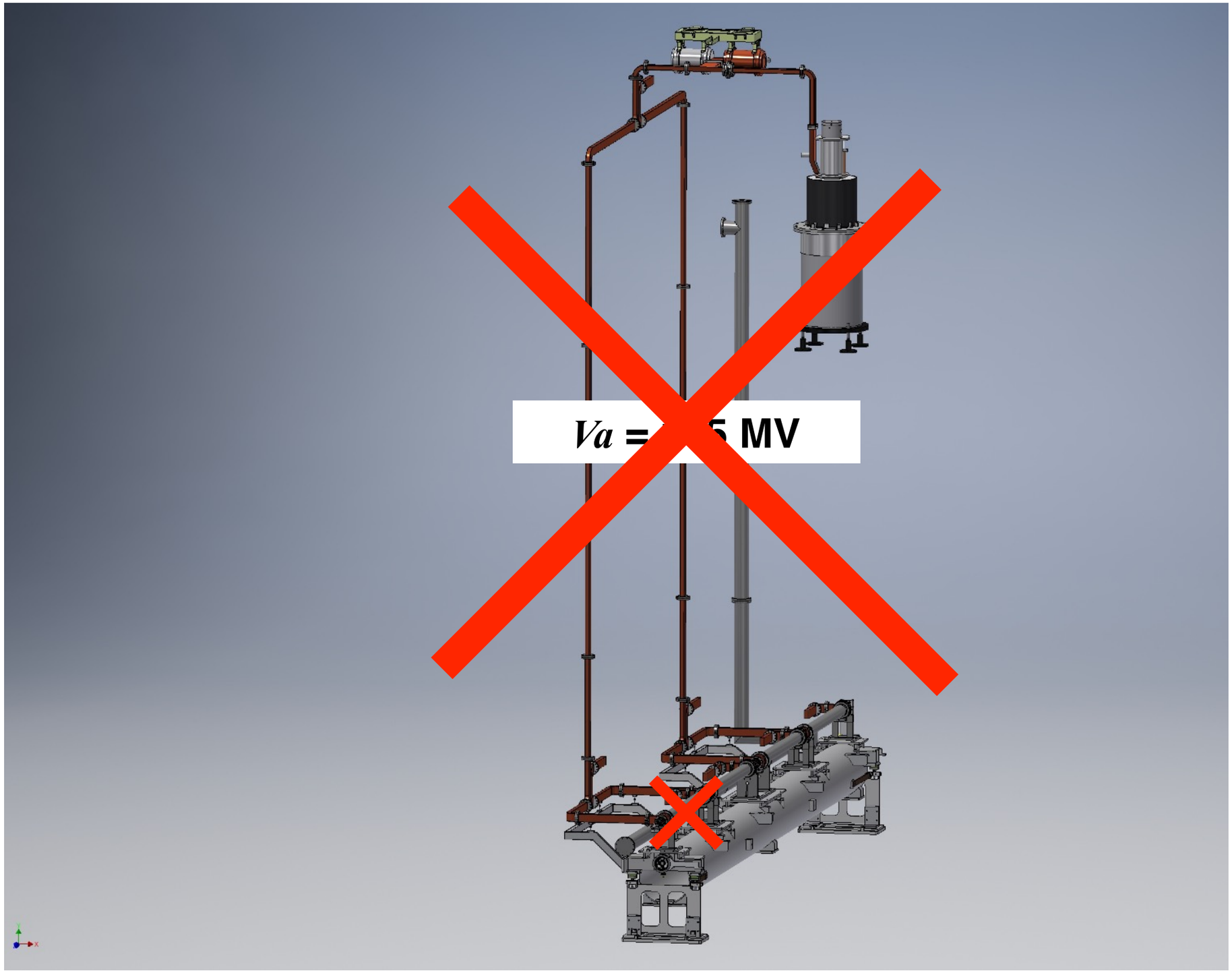
Erosion and corrosion at complex welding junctions facing water channels



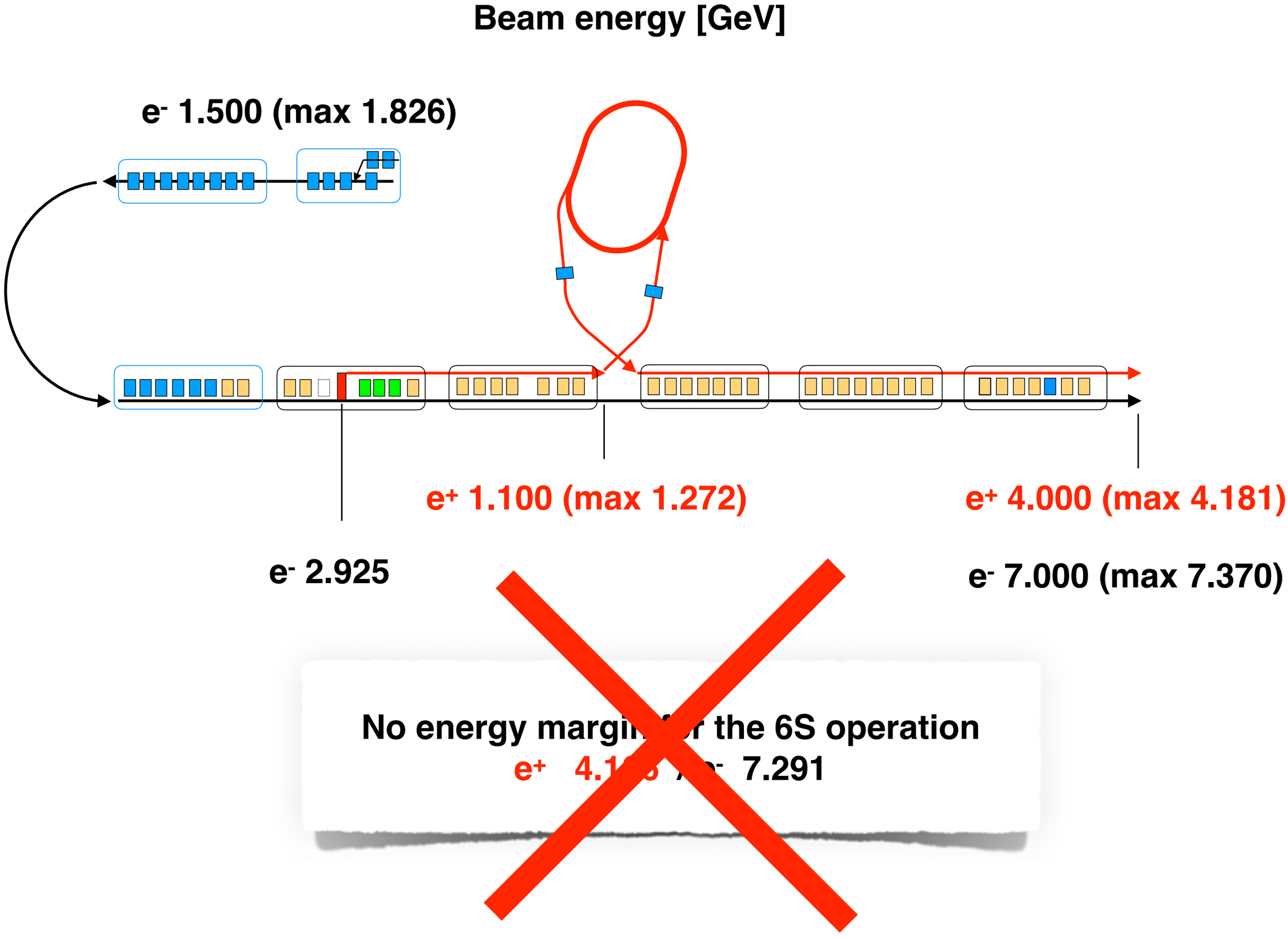


Deterioration in accelerating voltage 5

We have to stop the unit and loose the unit voltage of 145 MV when the fatally damage happens to one of the structures.



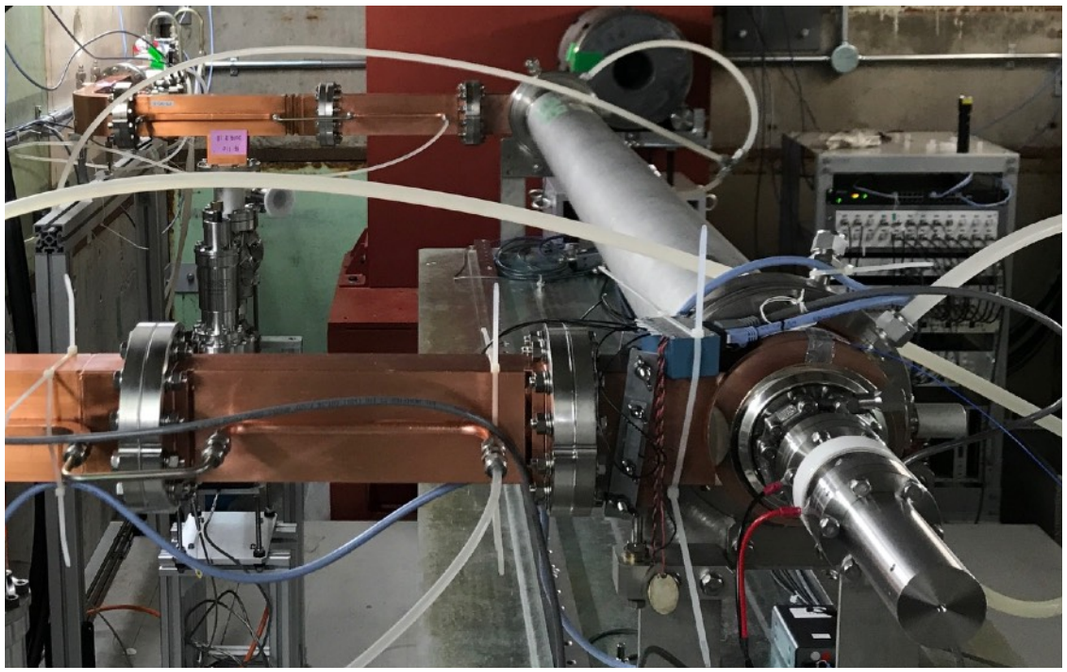
Deterioration in accelerating voltage 6



How do we tackle the problem ?

Reuse the spare PF-type structures

taken away at reconstruction of the linac injector:
having damaged couplers:
available for temporary operation



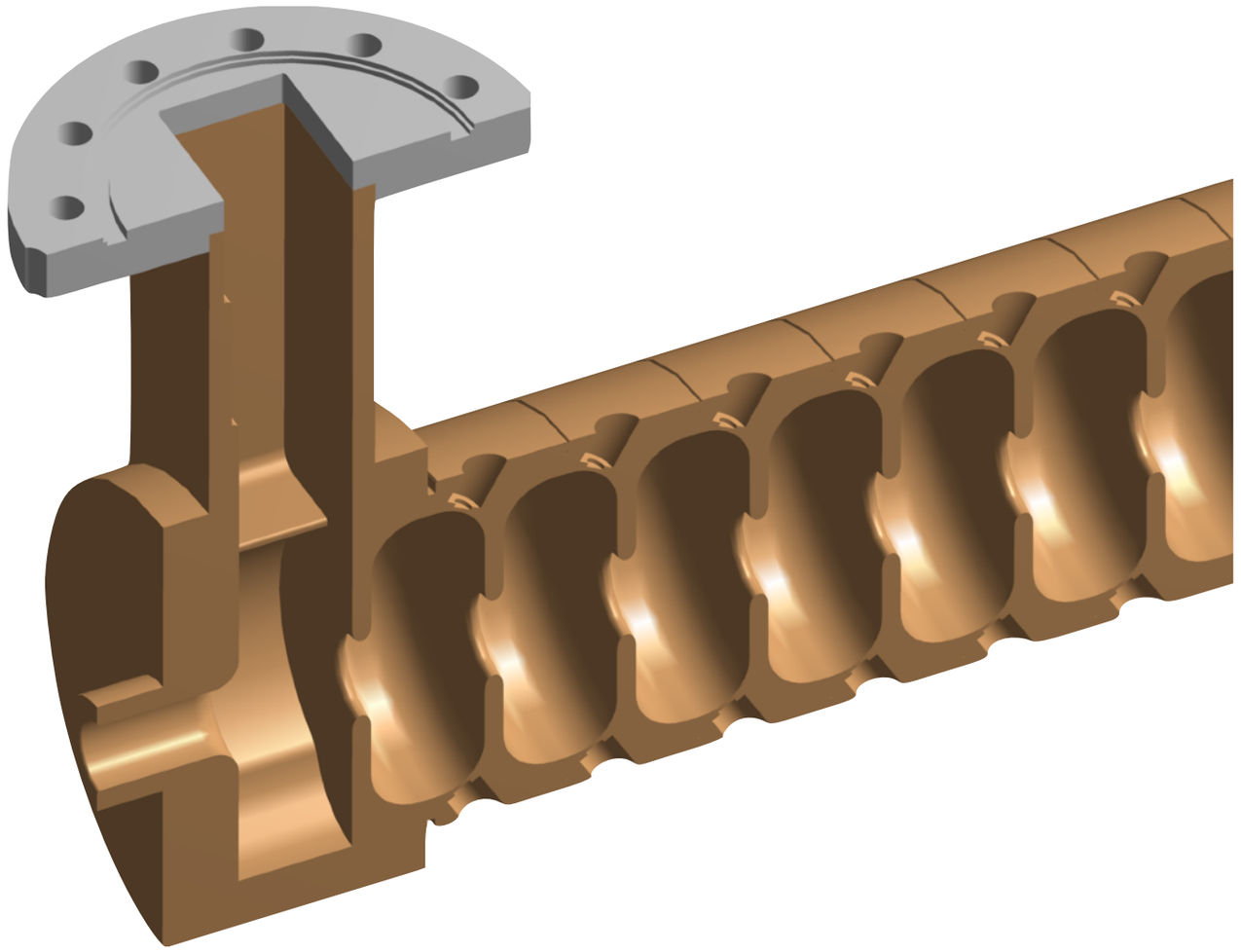
Spare structure under high-power check in our shield room

Almost all suffer from power reflection and excessive field emission

How do we tackle the problem ?

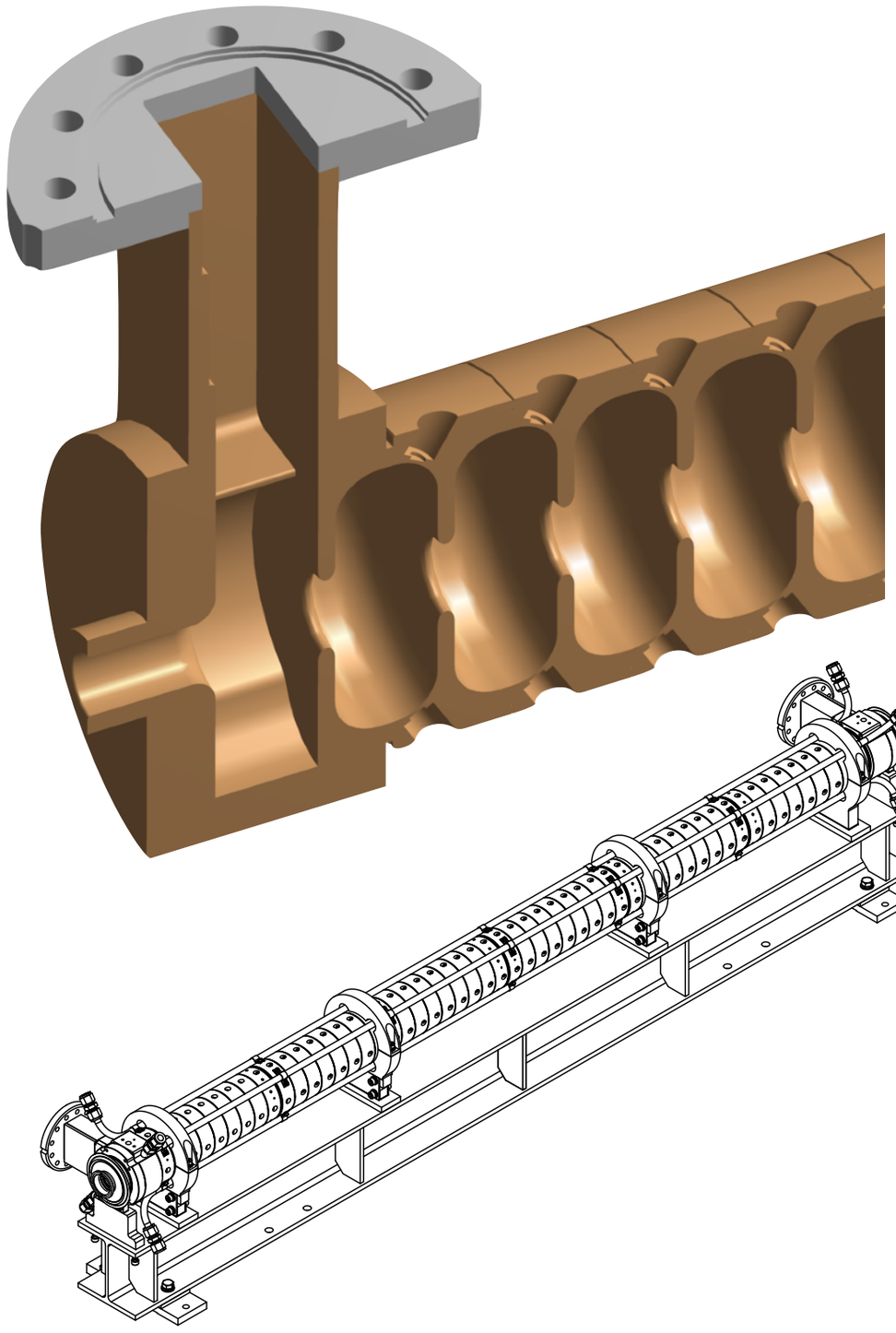
Develop new S-band structures

designed in-house and curing our problem perfectly



Prototype under fabrication and coming in this summer

How do we tackle the problem ?



Features

Ovally filleted iris
decreasing the strength of surface electric fields
approximately 15%

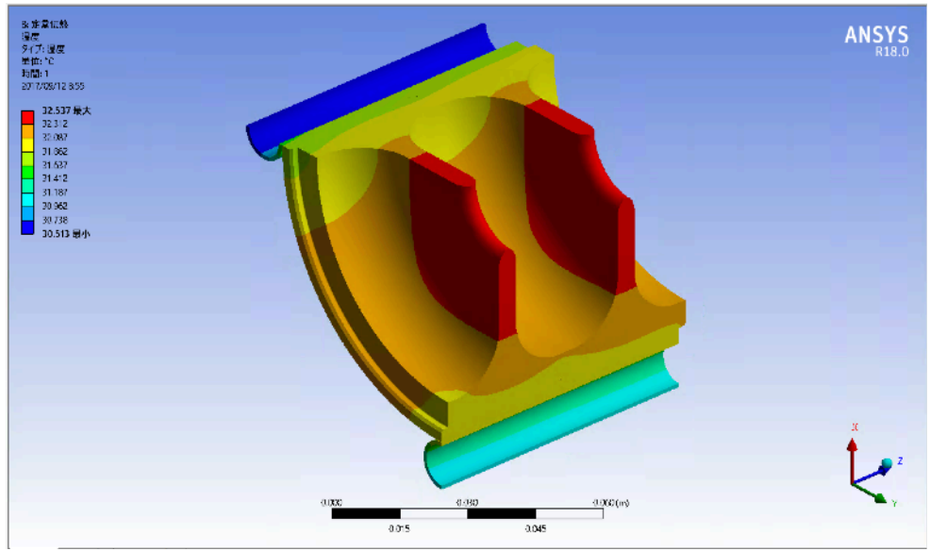
8% higher accelerating voltage

Coupler with a smooth inner surface
lowering surface electric fields

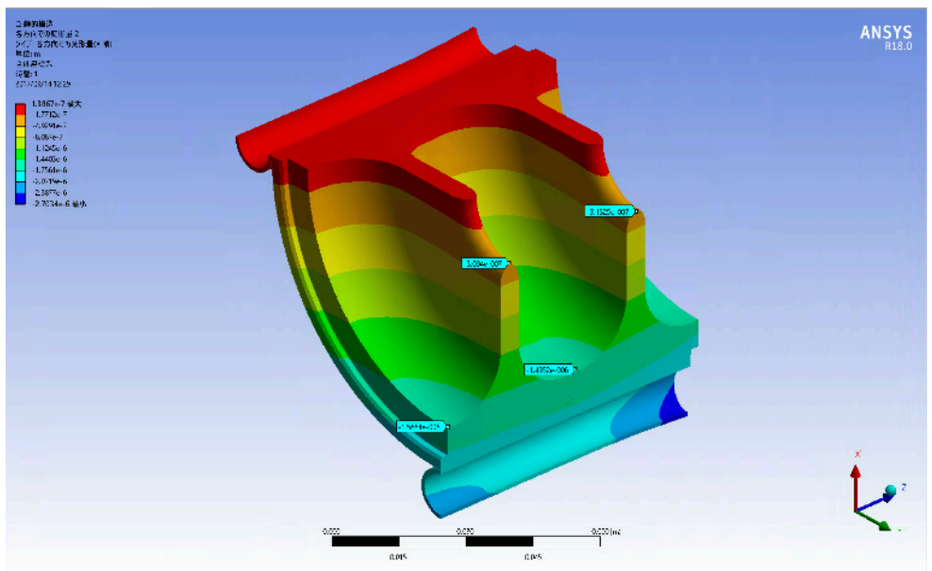
No welding junction facing the water channel

How do we tackle the problem ?

Thermal and structural analysis

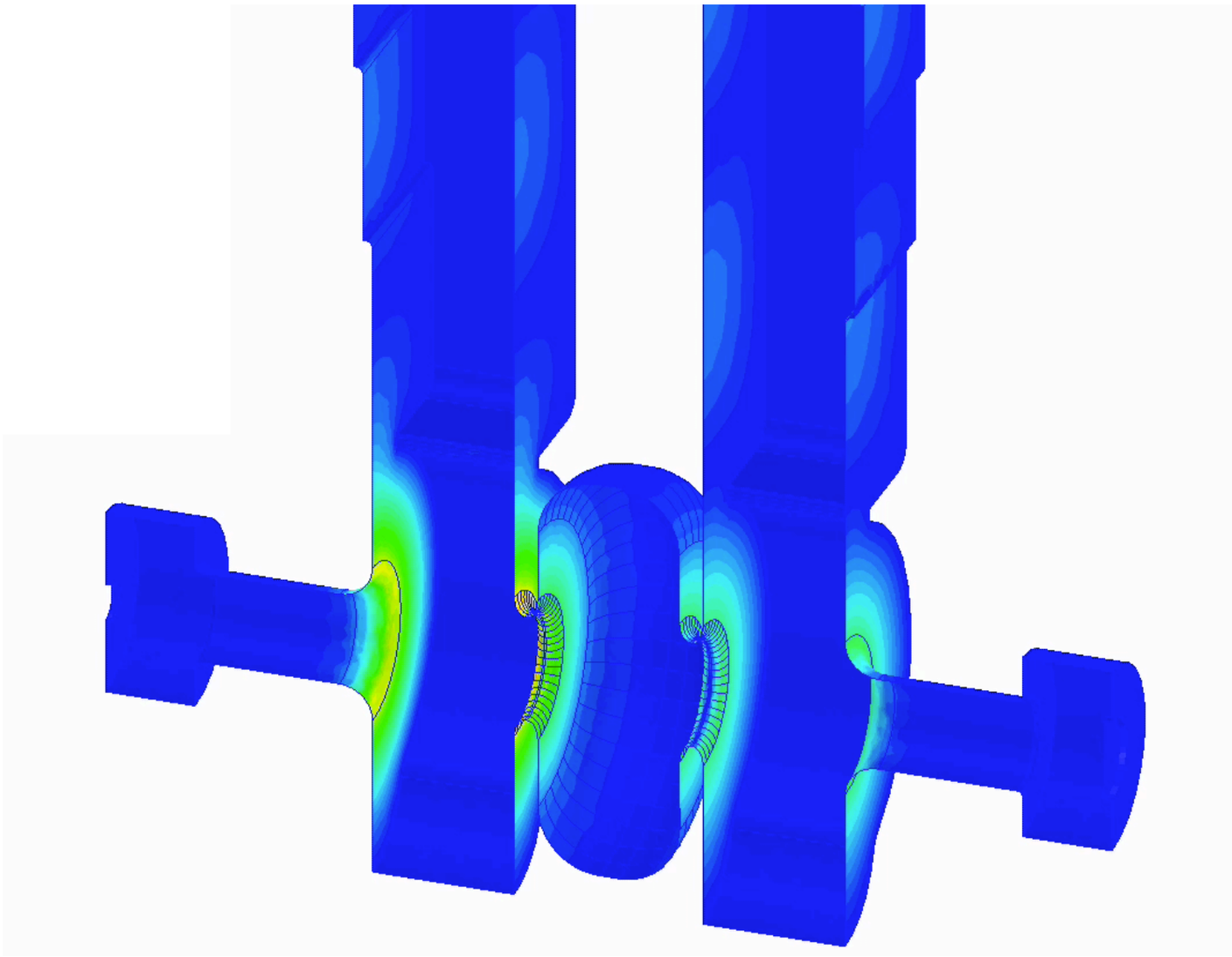


Temperature distributions



Deformation

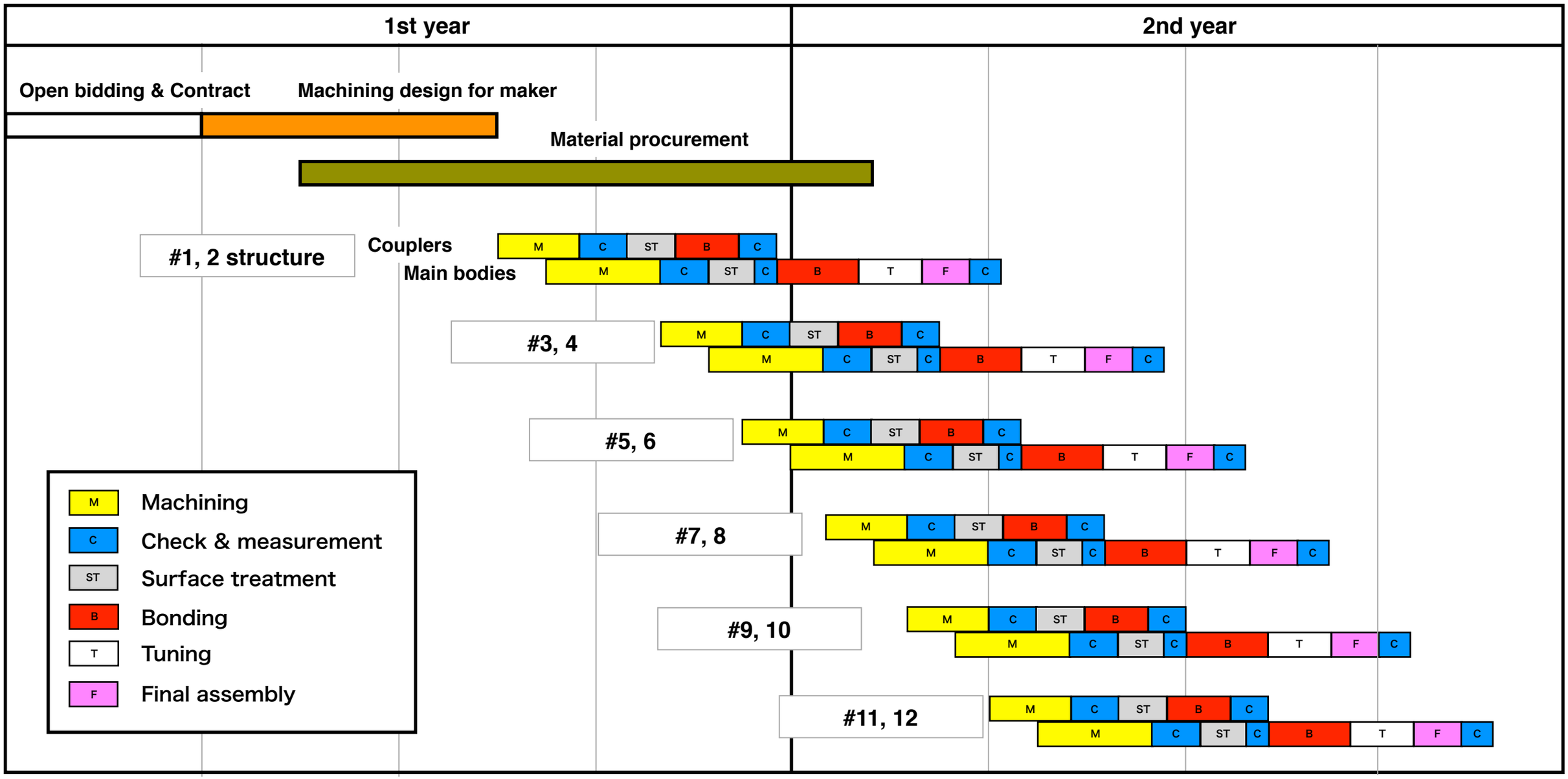
RF analysis of the coupler



Surface electric fields

How do we tackle the problem ?

Plan for fabricating 12 structures



Fabrication cost

240M yen for fabrication of 12 structures.
On the other hand, 40M yen for fabrication of only one structure.

Summary

- Markedly deterioration of PF-type S-band accelerating structures, especially at the input coupler

- Irreparable and fatal damage by water leakage

- Makeshift countermeasures by using spare structures suffering the light disease of power reflection and field emission

- New improved S-band structure indispensable for stable and sustainable operation of SuperKEKB