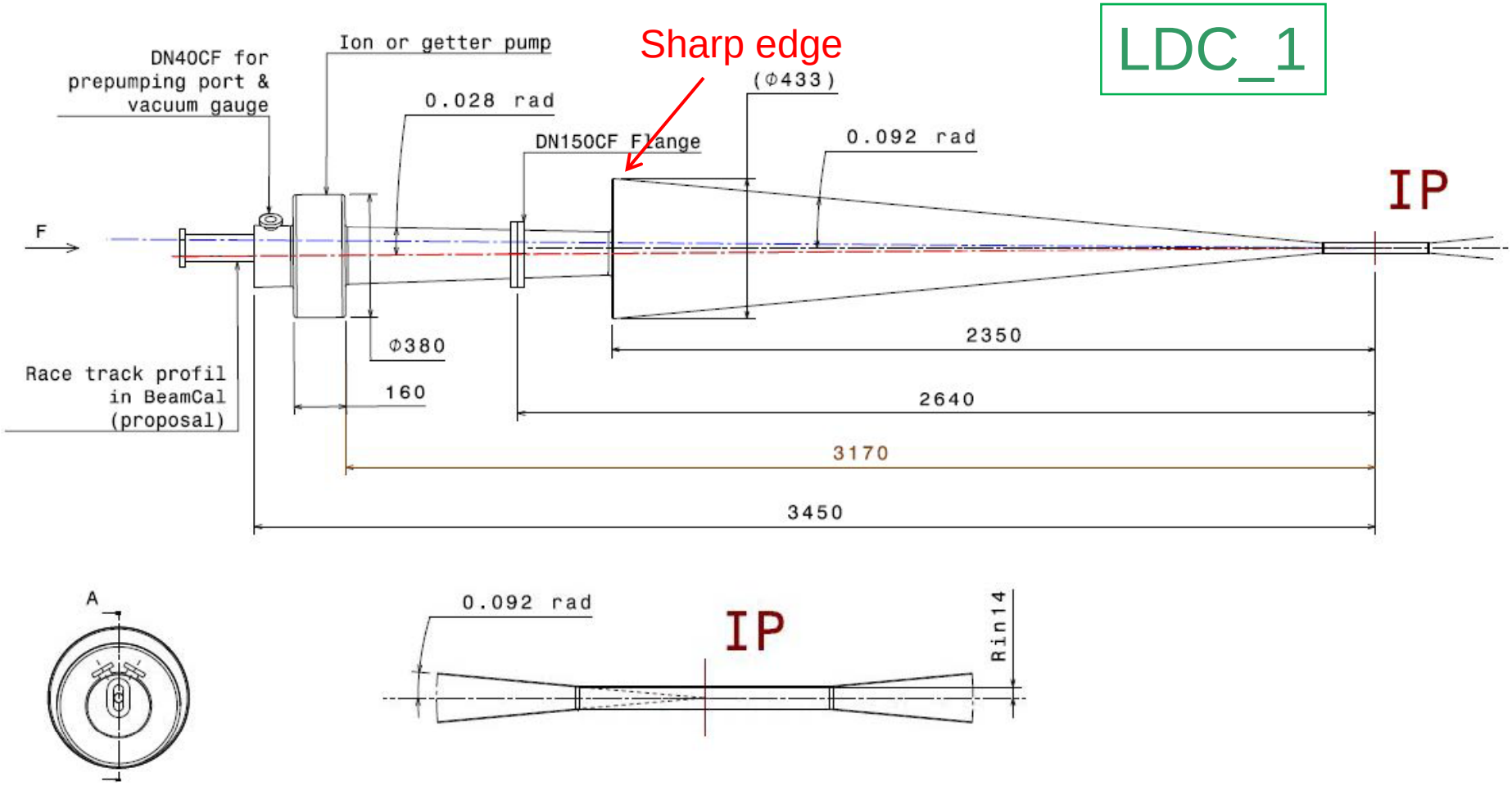
Preliminary Design Studies on LDC Vacuum Pipes

Y. Suetsugu, KEK

- Loss factor
- Structural strength
- Expected pressure profile

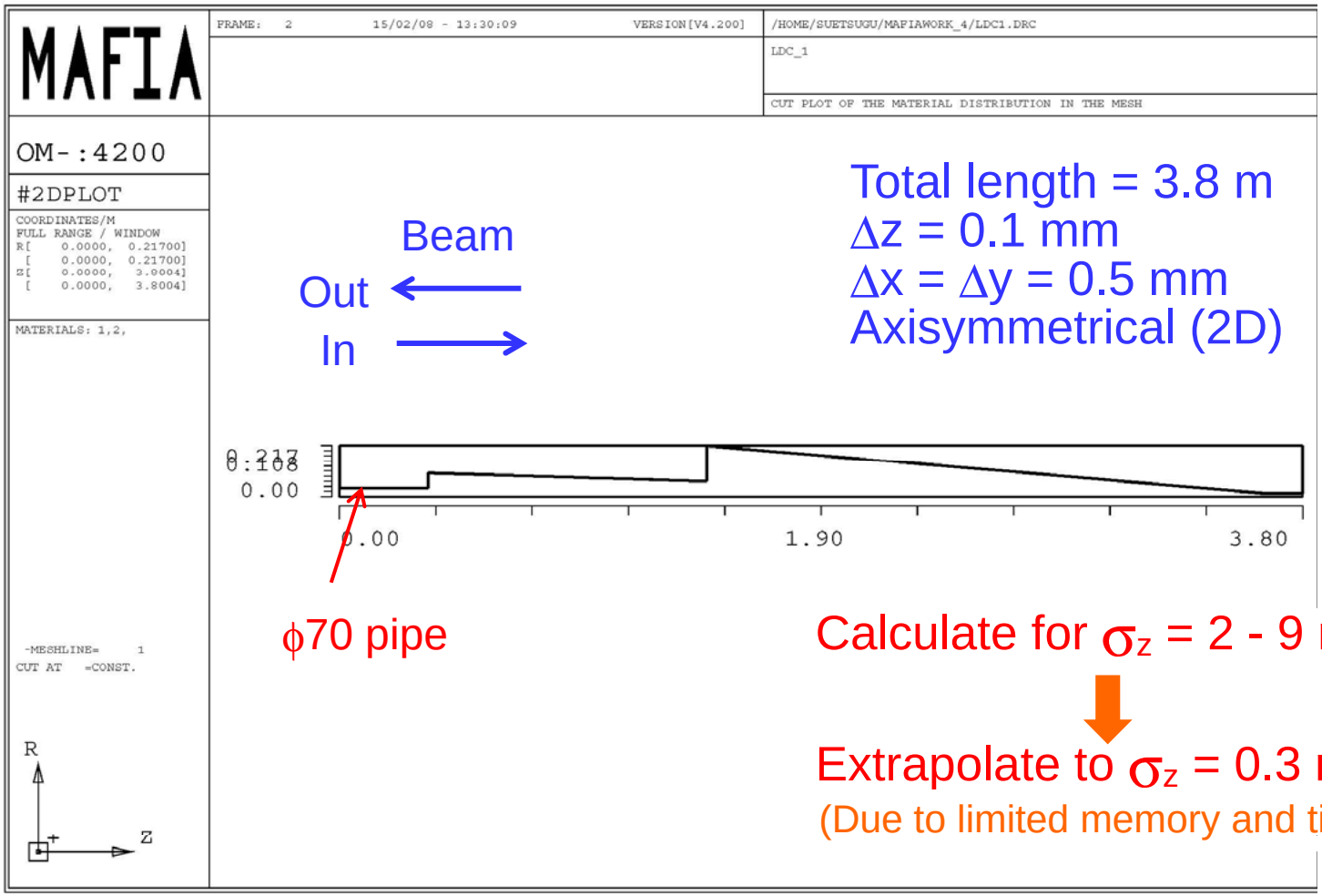
Loss factor

- Base Model



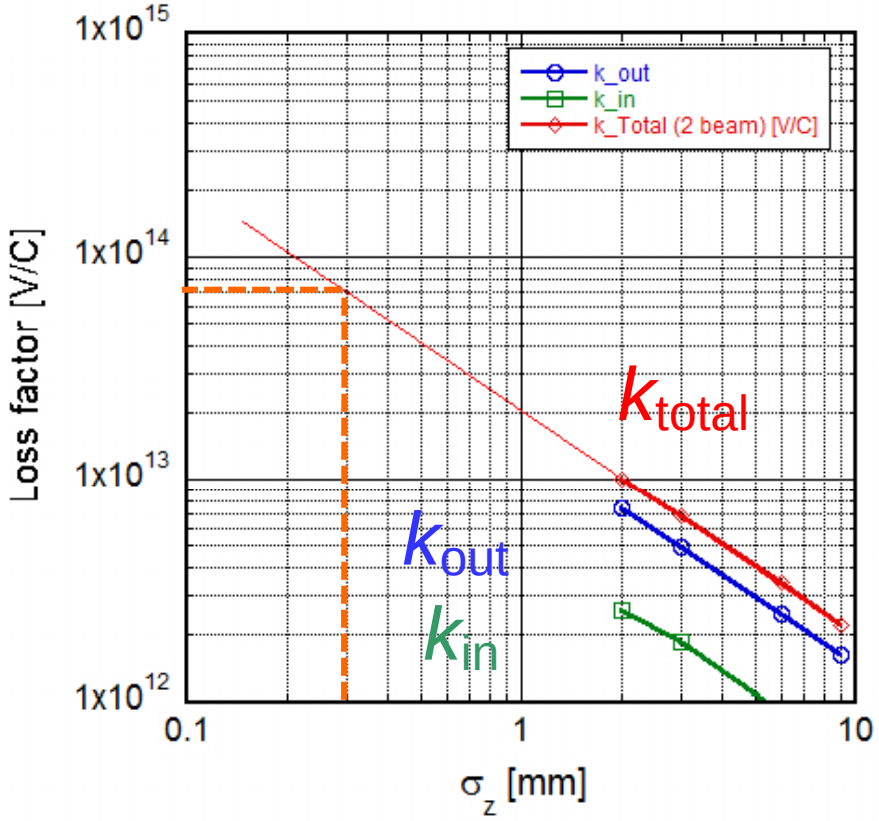
Loss factor

- Model for calculation



Loss factor

- Results



k_{in} and k_{out} is different, since the apertures at both ends are different.

k_{total} (two beams) ~7×10^{13} V/C @ σ_z = 0.3 mm

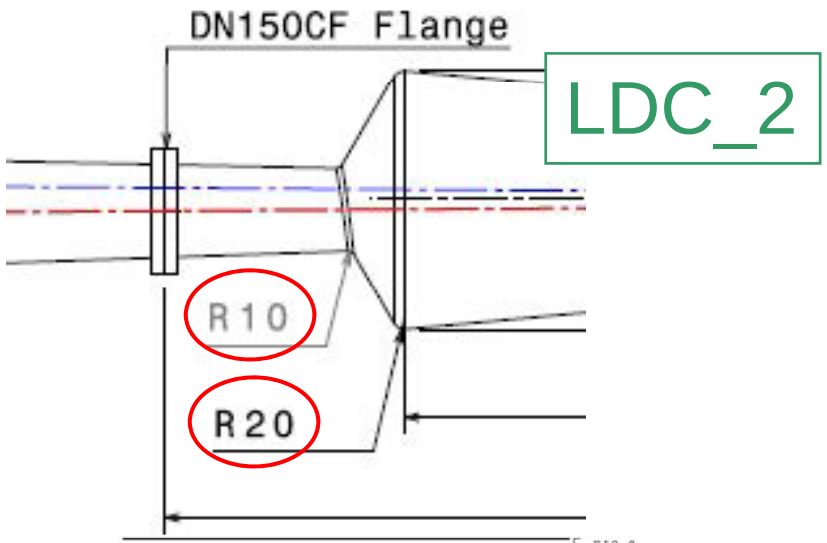
If q = 3.2 nC, N_b = 5400 bunch, and f_r = 5Hz : I = 8.6×10^{-5} A

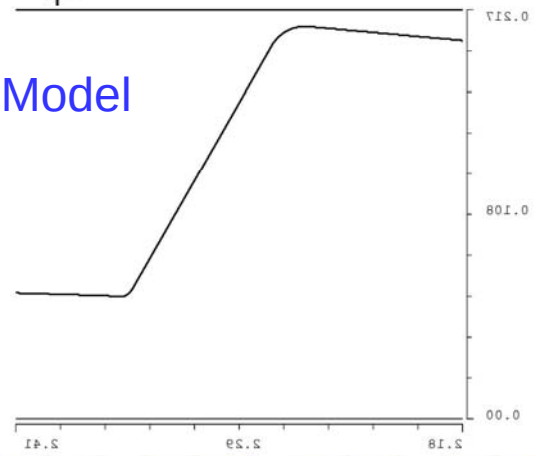
$\therefore P = kqI$ = ~20 W (one side)

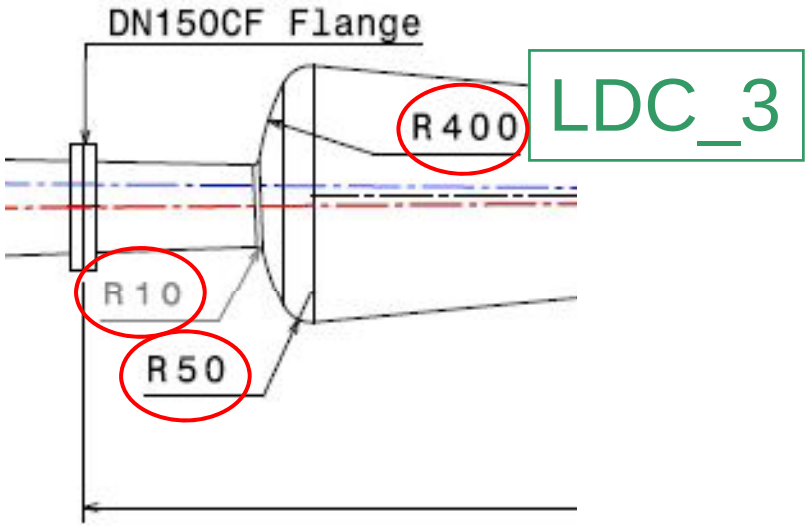
For reference;
at ERING08, for two beams,
Suetsugu: $k = 8 \times 10^{14}$ V/C Too big.
Yamamoto-san:
$k = 1.6 \times 10^{14}$ V/C
Novokhatski-san:
$k = 5.5 \times 10^{13}$ V/C

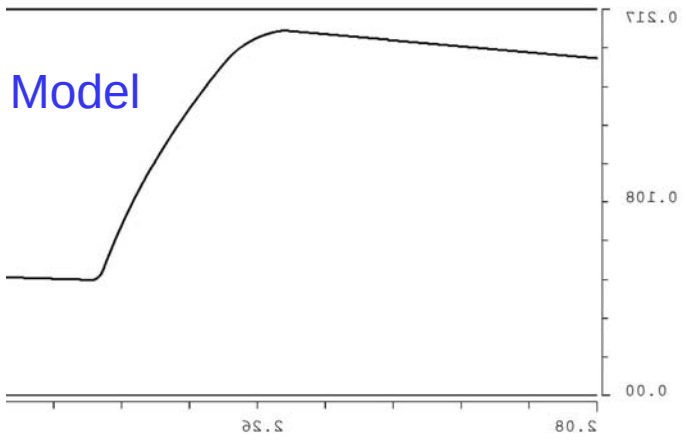
Loss factor

- Effect of round edges at cone section









Loss factor

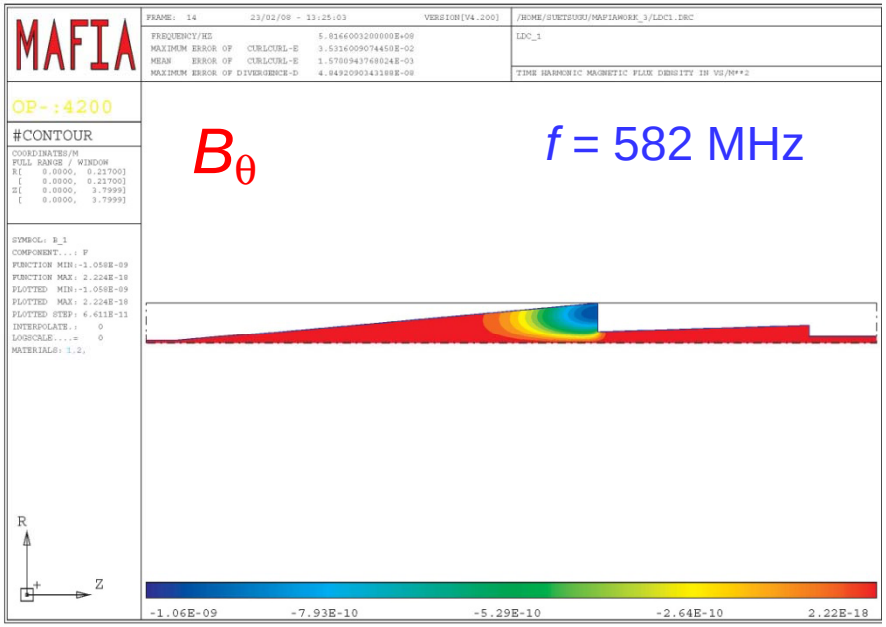
- Effect of round edges
  - σ_z = 3 mm
  - Two beams

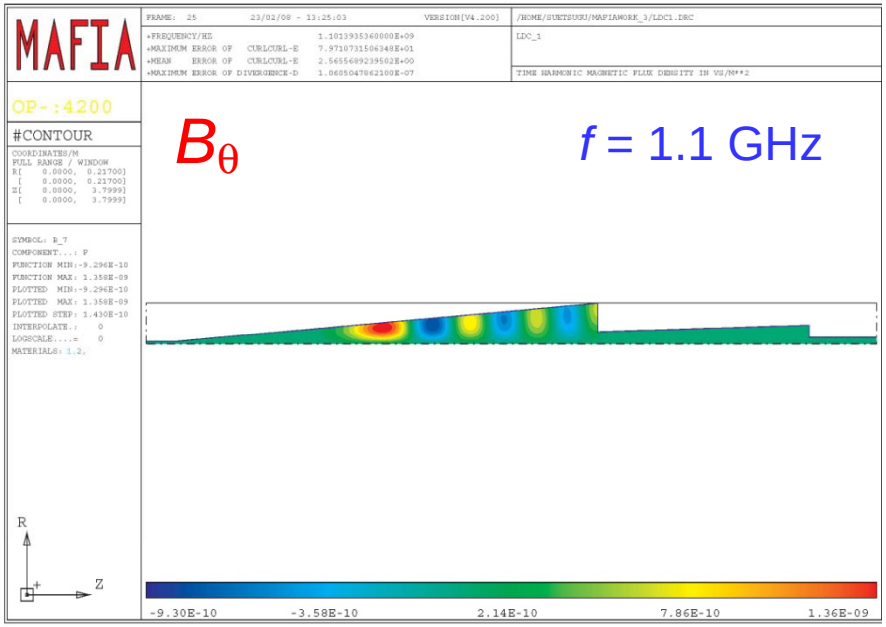
Type	Loss factor (k_{total})	Ratio
LDC-1	6.81731×10^{12}	100%
LDC-2	6.71416×10^{12}	98.5%
LDC-3	6.68828×10^{12}	98.1%

Almost no effect on the loss factors.

Loss factor

- Dissipation of power
  - **Examples of lower modes in the structure**





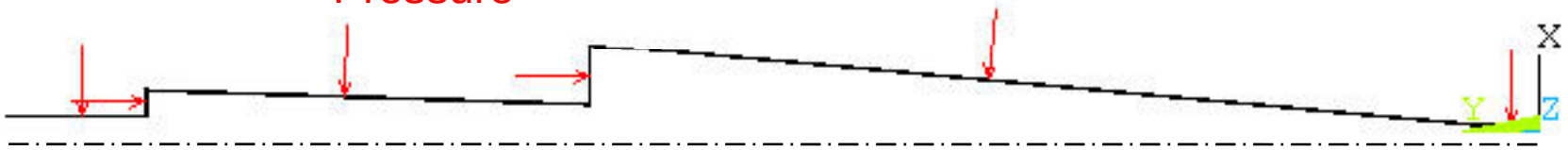
Most of power will be dissipated at the cone section.

Structural strength

- Deformation and stress
  - **Material: Al alloy (Al5052, H34), with a thickness of 3 mm.**
  - **Load: Atmospheric pressure (1.013×10^5 Pa)**
  - **By ANSYS**

Total length = 3.8 m
$E = 7.056 \times 10^{10}$ N/m^2
$\nu = 0.3$
Axisymmetrical (2D)

Model Pressure



Result (Deformation)

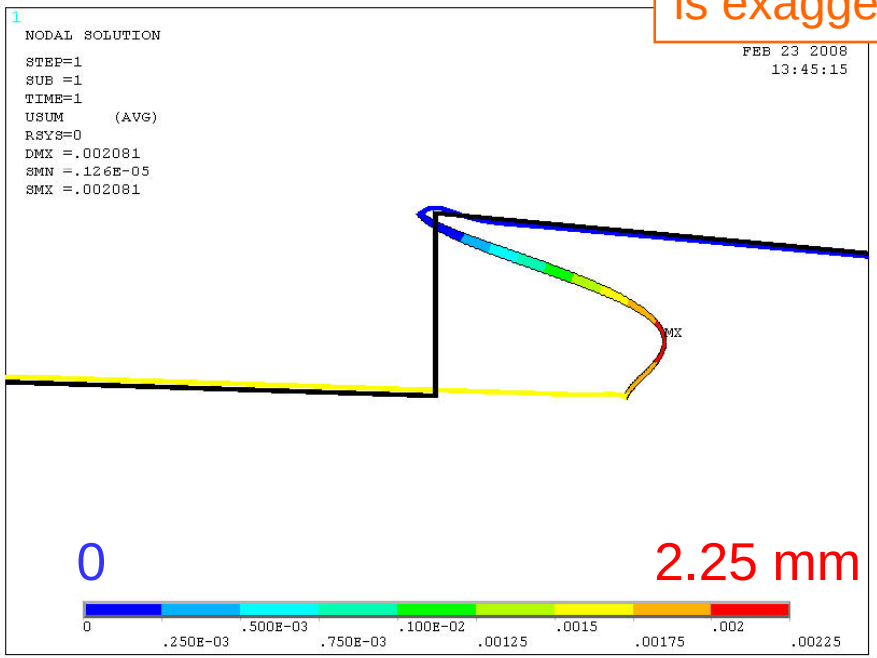
Structural strength

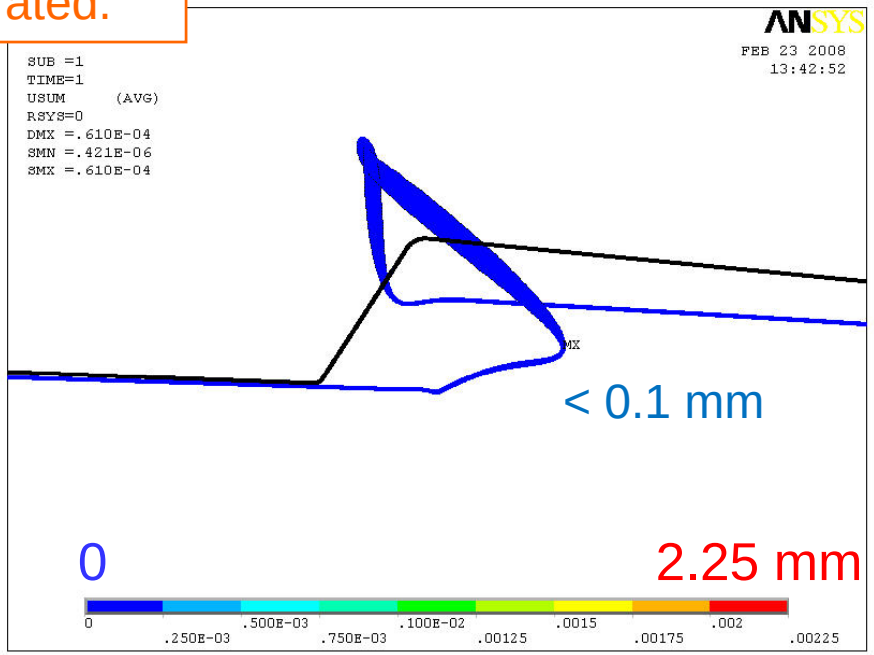
- Result: Deformation

LDC_1

Deformed shape is exaggerated.

LDC_2





Deformation is much decreased by the round edges.

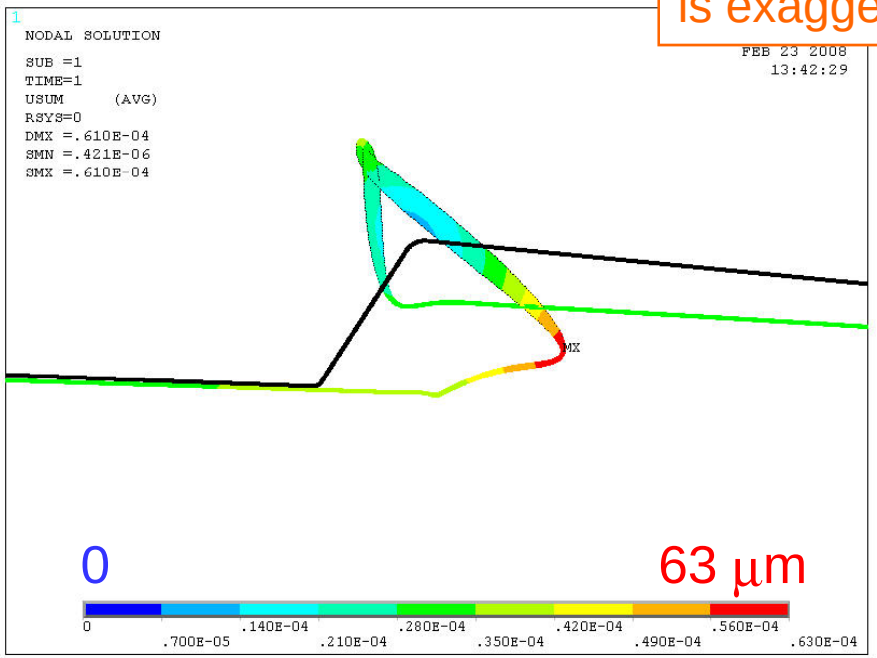
Structural strength

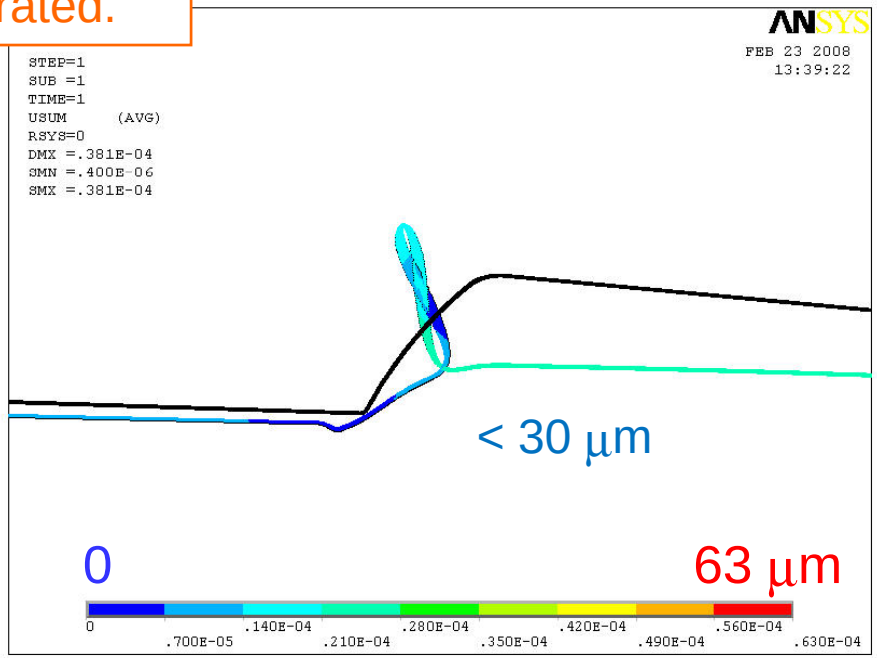
- Result: Deformation

LDC_2

Deformed shape is exaggerated.

LDC_3





Deformation further reduces to a half.

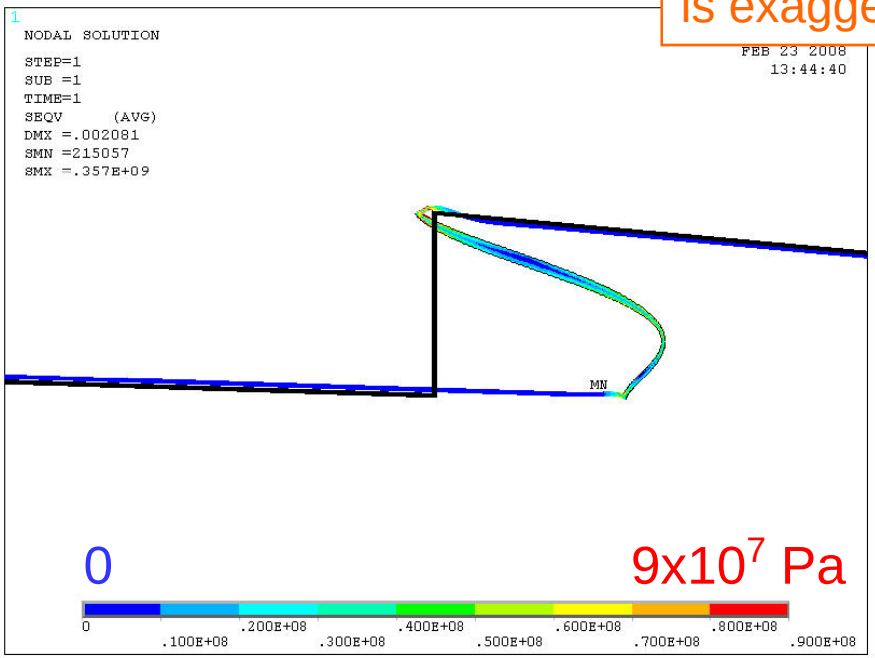
Structural strength

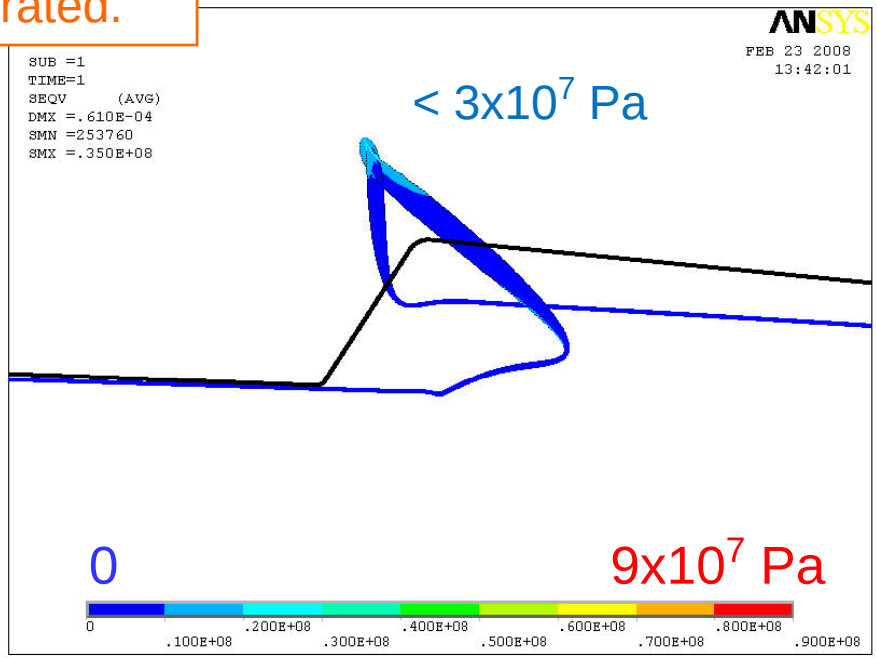
- Result: Stress (Von Mises stress)

LDC_1

Deformed shape is exaggerated.

LDC_2





Stress is also much reduced by the round edges.

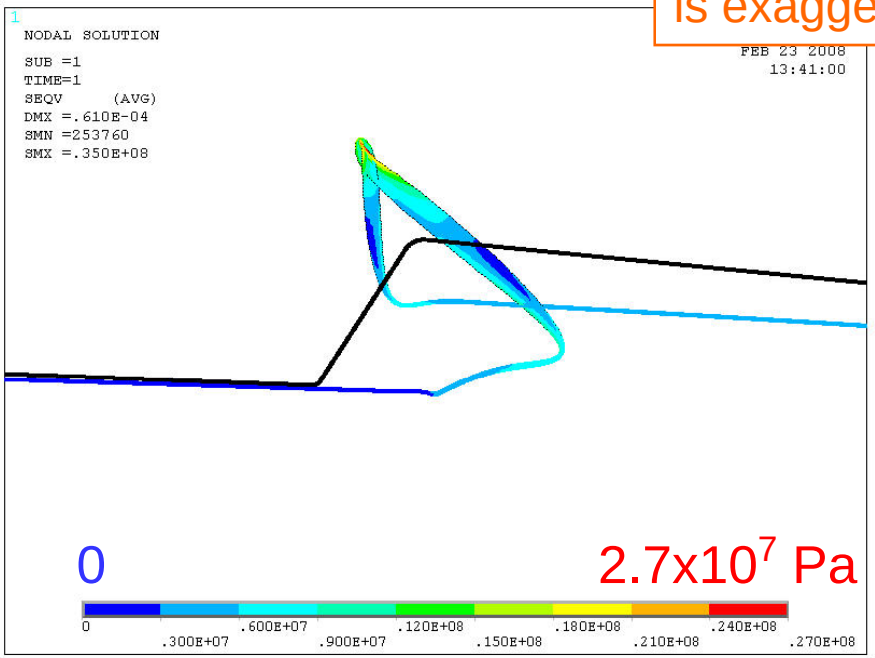
Structural strength

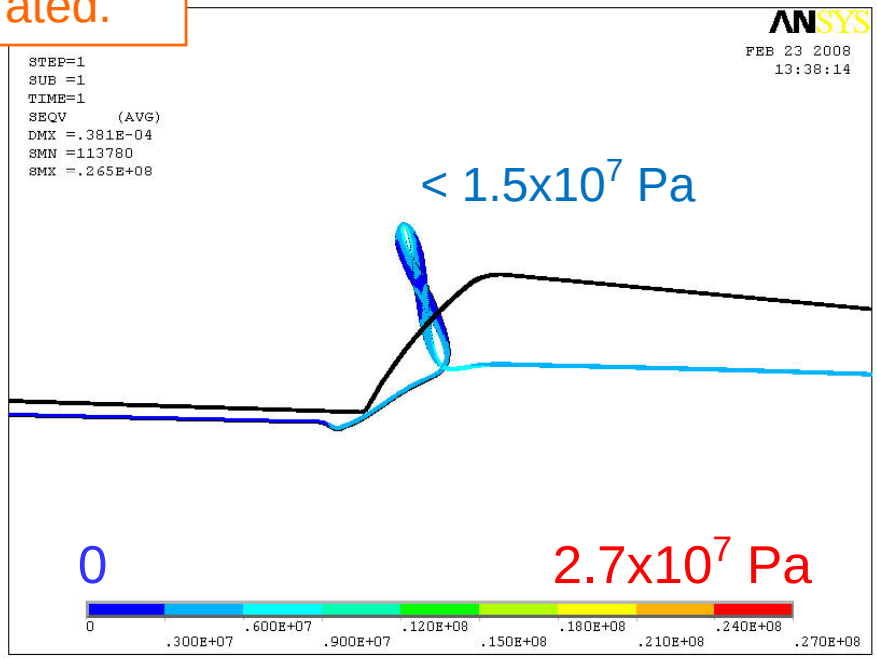
- Result: Stress (Von Mises stress)

LDC_2

Deformed shape is exaggerated.

LDC_3



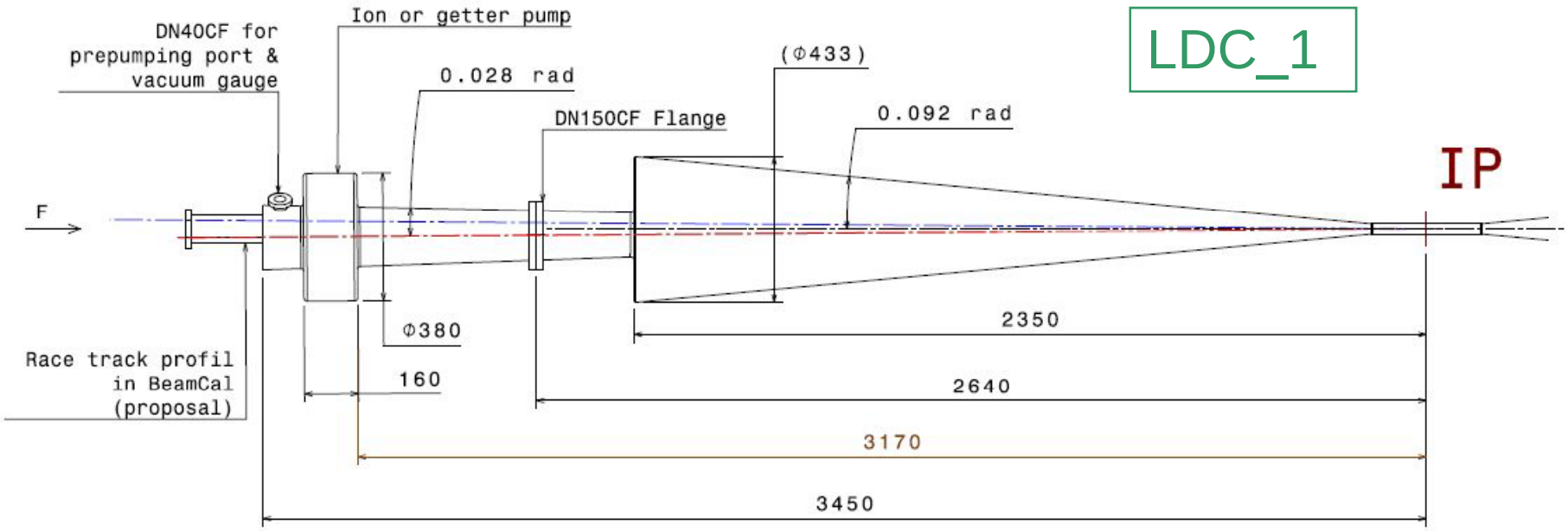


Stress further reduces to a half.

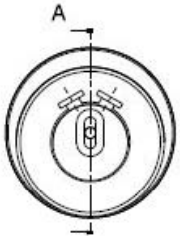
(Yield strength of aluminum alloy is 2.2×10^8 Pa)

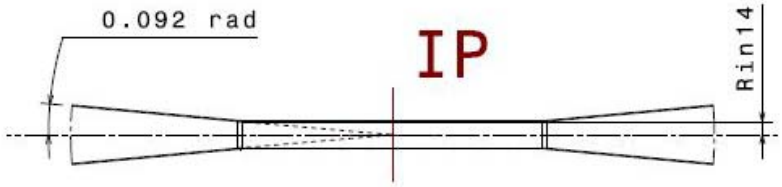
Pressure profile

- Base Model



LDC_1





Pressure profile

- Gas desorption
  - **Pre-baking before assembling should be done.**
  - **The chambers should be treated carefully after the pre-baking to avoid any contamination.**
  - **Water should be kept away as much as possible.**
  - **Thermal gas desorption rate without baking:**
    - After 10 hours evacuation:

      CO: 2 x10^{-7} Pa m^3 /s/m^2 (~ 2 x10^{-10} Torr *l* /s/cm^2)

      H_2: 2 x10^{-6} Pa m^3 /s/m^2 (~ 2 x10^{-9} Torr *l* /s/cm^2)
    - After 100 hours evaculation (after 4 days)

      CO: 2 x10^{-8} Pa m^3 /s/m^2 (~ 2 x10^{-11} Torr *l* /s/cm^2)

      H_2: 2 x10^{-7} Pa m^3 /s/m^2 (~ 2 x10^{-10} Torr *l* /s/cm^2)
    - About 20 times larger than those after baking (O. Malyshev)

Pressure profile

- Pumps
  - **NEG strip : ST707 (SAES Getters), for ex.**
  - **Aligned at the circumference of pipe**

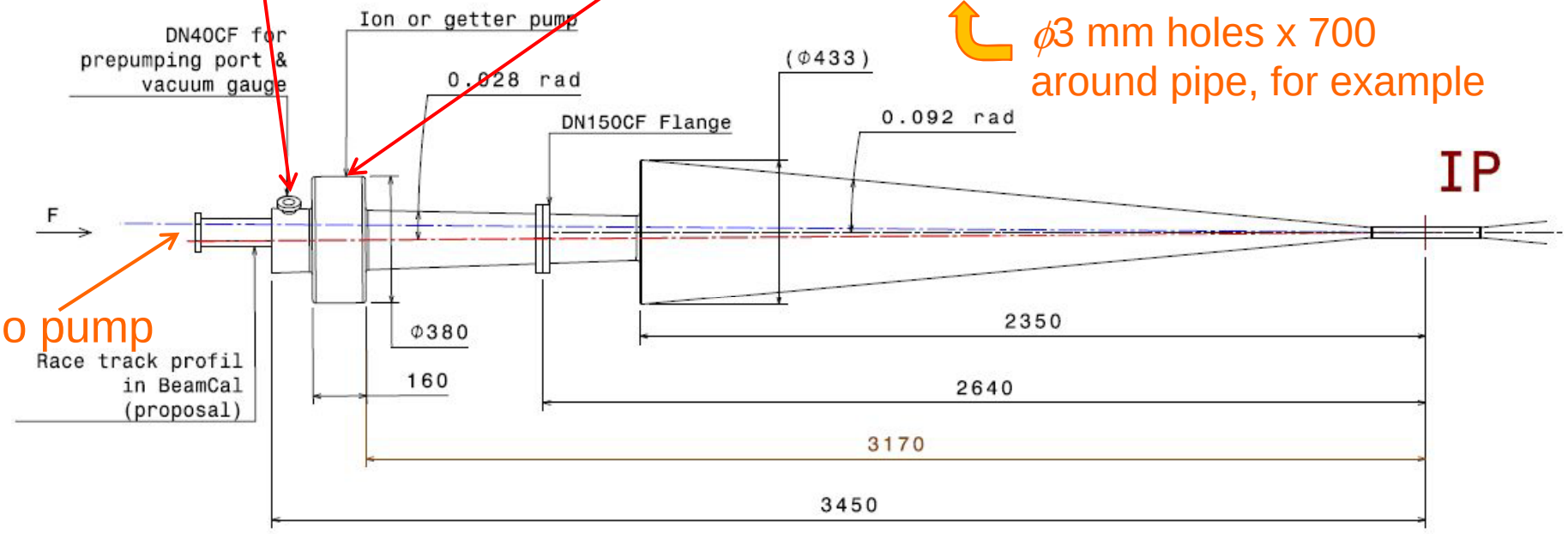
4m NEG strip in total S_{eff} =

CO: 0.2 m^3/s, C = 0.3 m^3/s → 0.12 m^3/s

H_2: 2 m^3/s, C = 1.1 m^3/s → 0.72 m^3/s

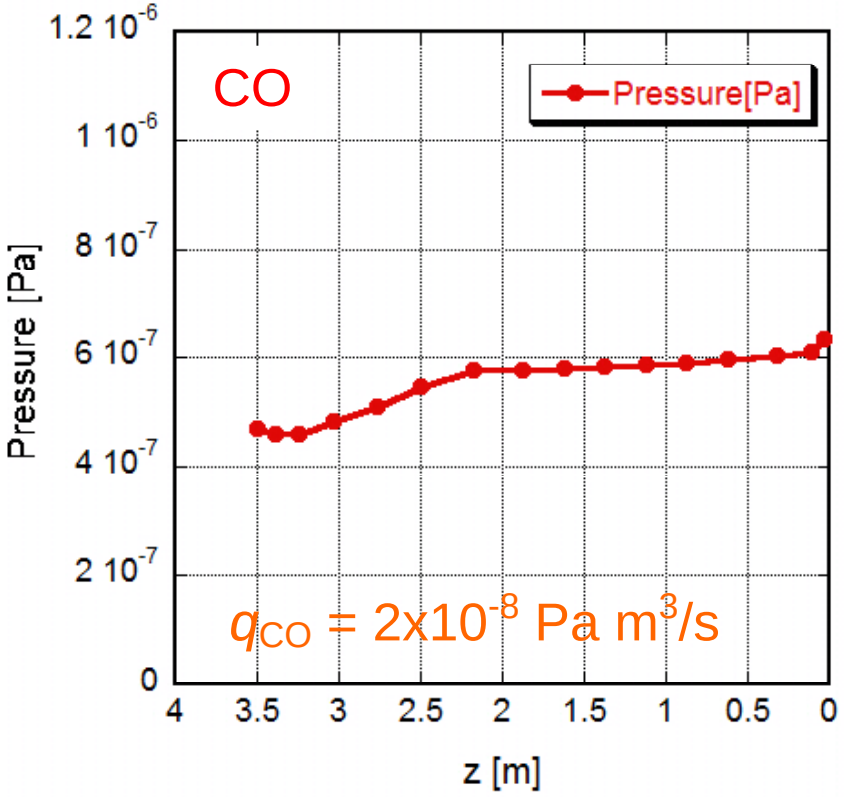
ϕ3 mm holes x 700 around pipe, for example

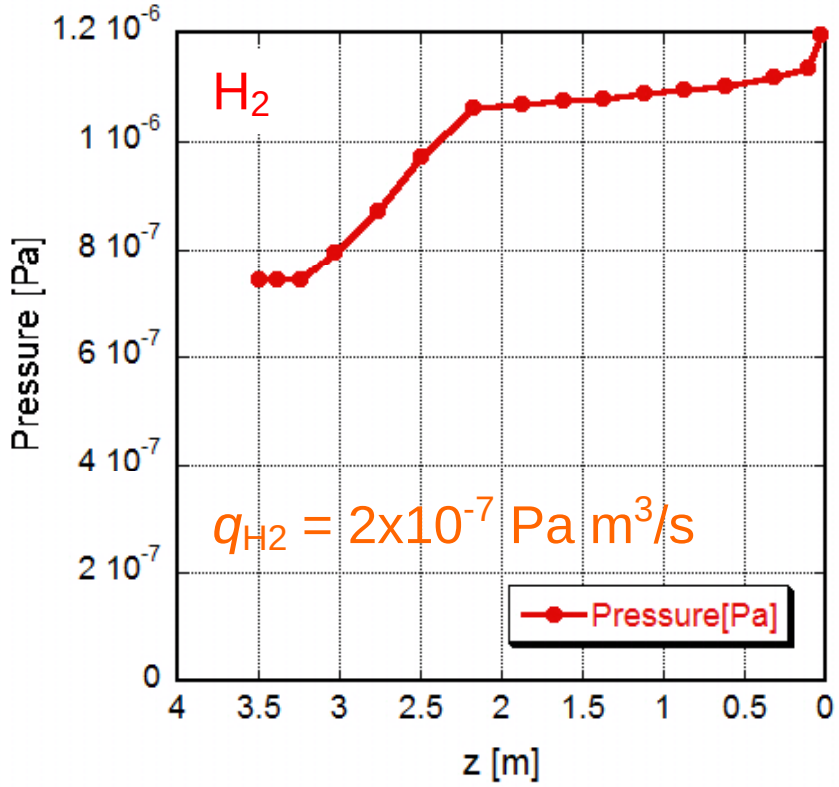
To a small ion pump (and rough pumps)



Pressure profile

- Results





P ~ 1x10^{-6} Pa for H_2.

The assumed pumping speed is the minimum.

Summary

Some vacuum properties of LDC beam pipe was studied.

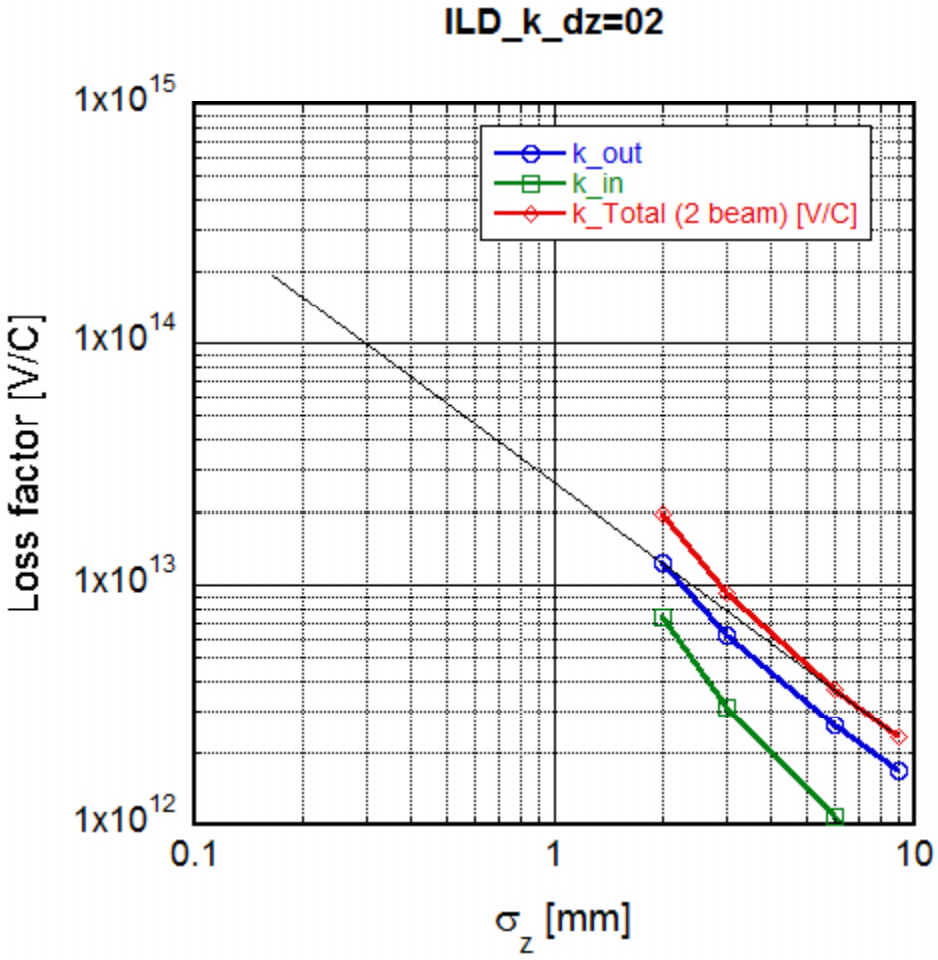
(1) Loss factor of one side for two beams is about 7×10^{13} V/C, and the dissipated power will be about 20 W.
- **Round edges of cone sections has little effect.**

(2) Structural strength is much improved by introducing round edges at cone section.
- **The stress is much lower than the yield strength of a typical aluminum alloy.**

(3) Vacuum pressure almost less than 1×10^{-6} Pa will be obtained without baking.
- **Effective pumping speed of about 0.7 m^3/s is required at least for H_2.**

Data

- Reference



Data

- Assumptions
  - **Distributed pumping to effectively evacuate these conductance-limited beam pipes**
  - **Use NEG strip : ST707 (SAES Getters), for ex.**

St707 NEG strip