



# Preliminary Design Studies on LDC Vacuum Pipes

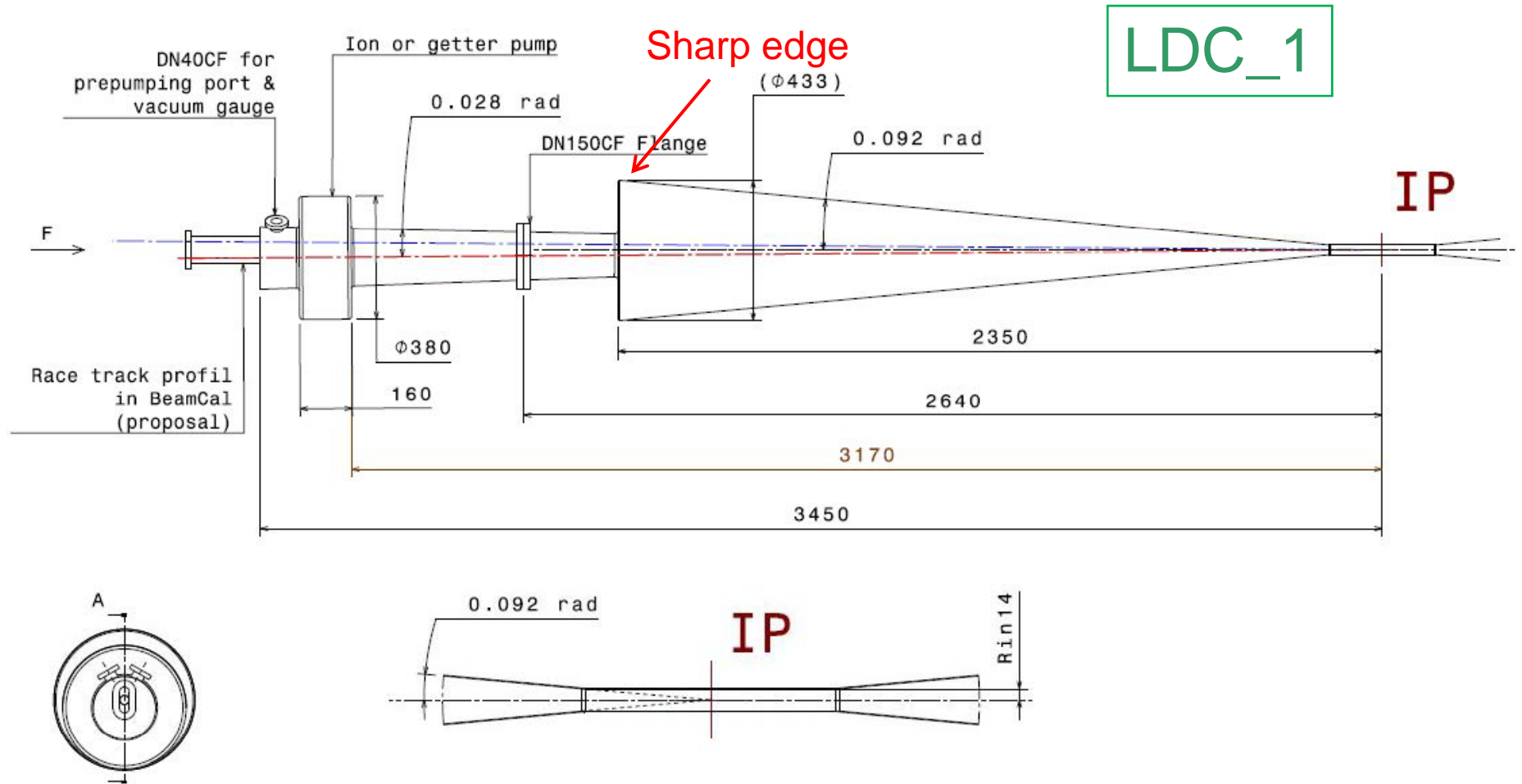
Y. Suetsugu, KEK

- Loss factor
- Structural strength
- Expected pressure profile



# Loss factor

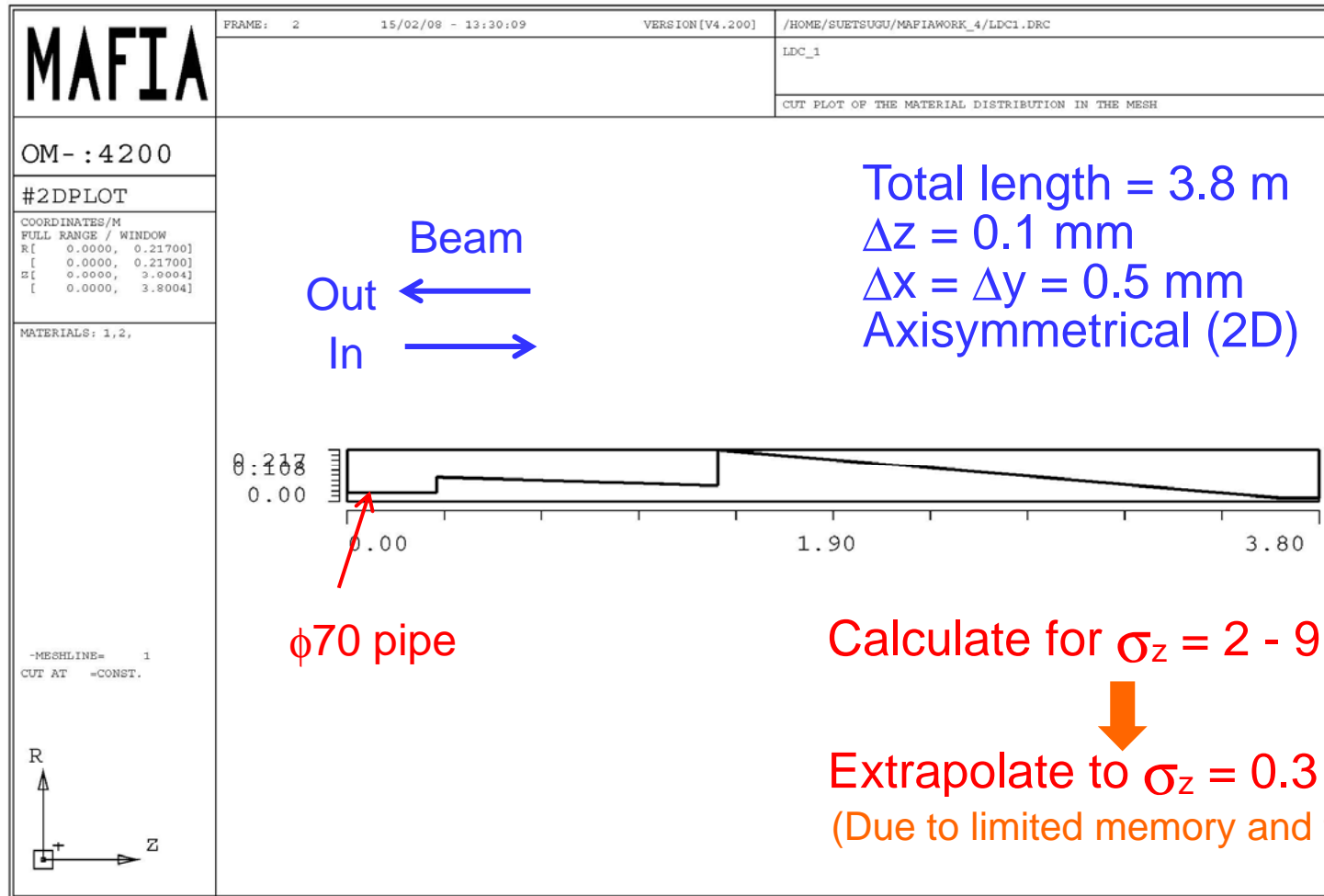
- Base Model





# Loss factor

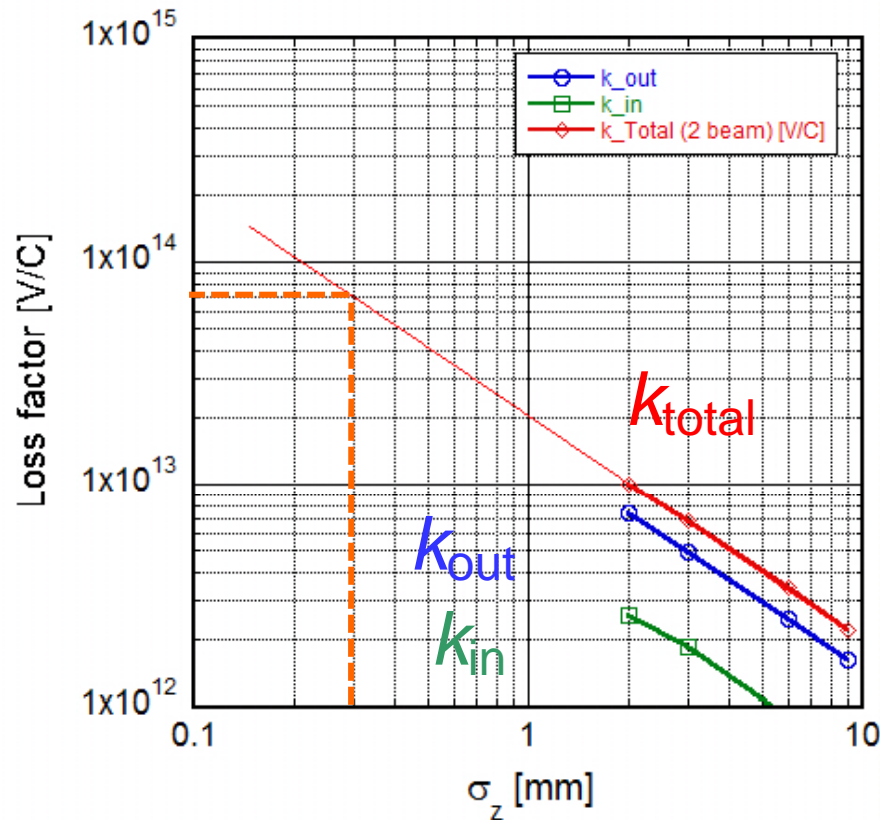
- Model for calculation





# Loss factor

- Results



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

$k_{total}$  (two beams)  $\sim 7 \times 10^{13}$  V/C  
@  $\sigma_z = 0.3$  mm

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

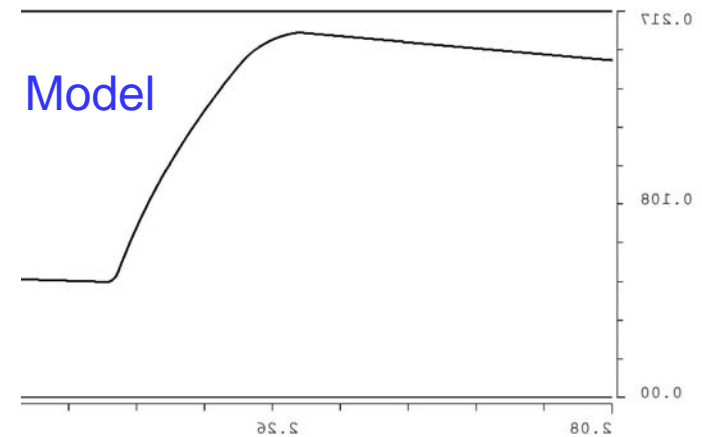
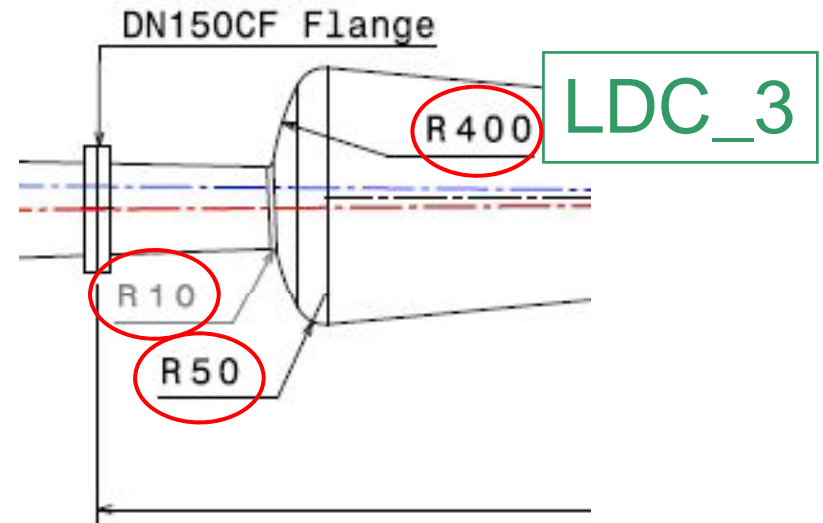
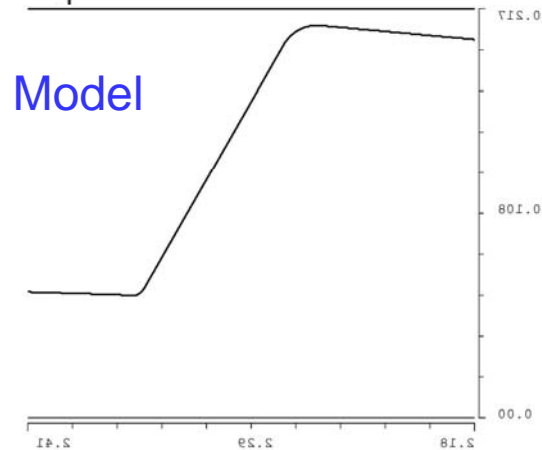
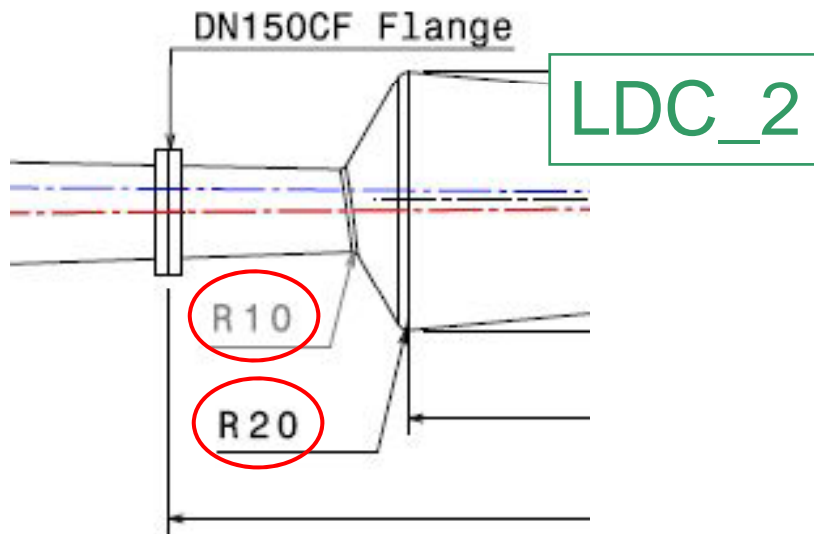
$\therefore P = kql = \sim 20$  W (one side)

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
  - $\sigma_z = 3$  mm
  - Two beams

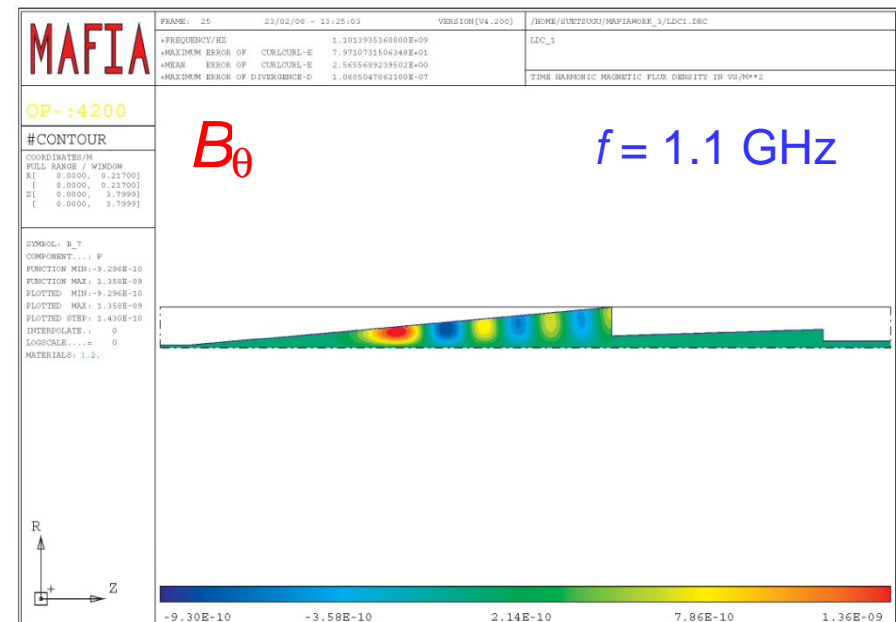
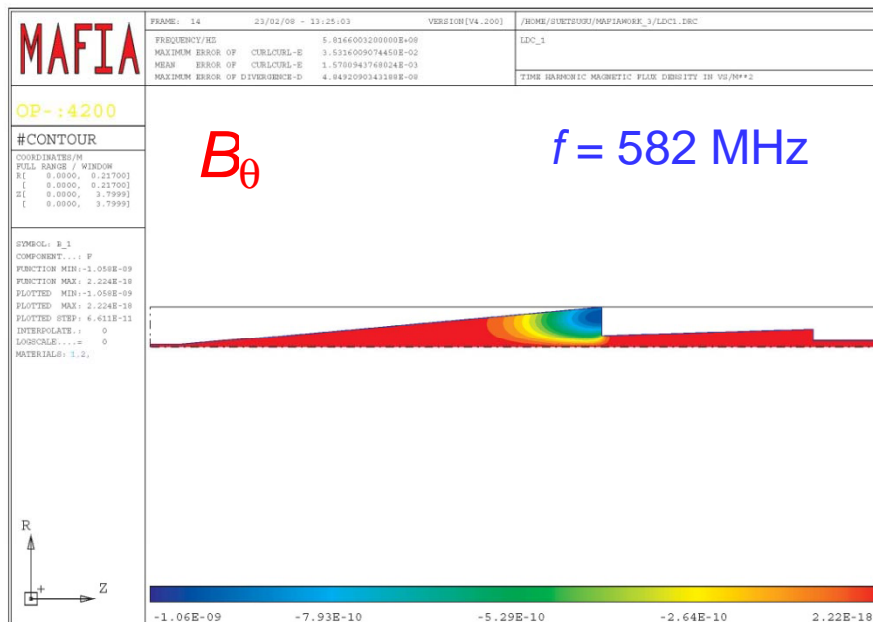
| Type  | Loss factor ( $k_{\text{total}}$ ) | Ratio |
|-------|------------------------------------|-------|
| LDC-1 | $6.81731 \times 10^{12}$           | 100%  |
| LDC-2 | $6.71416 \times 10^{12}$           | 98.5% |
| LDC-3 | $6.68828 \times 10^{12}$           | 98.1% |

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.

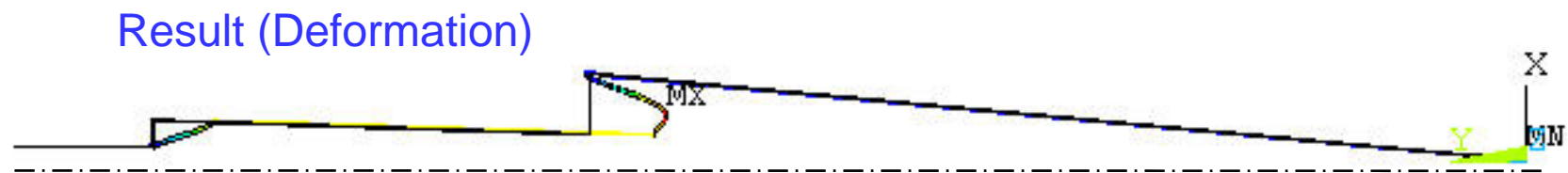


# Structural strength

- Deformation and stress

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

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







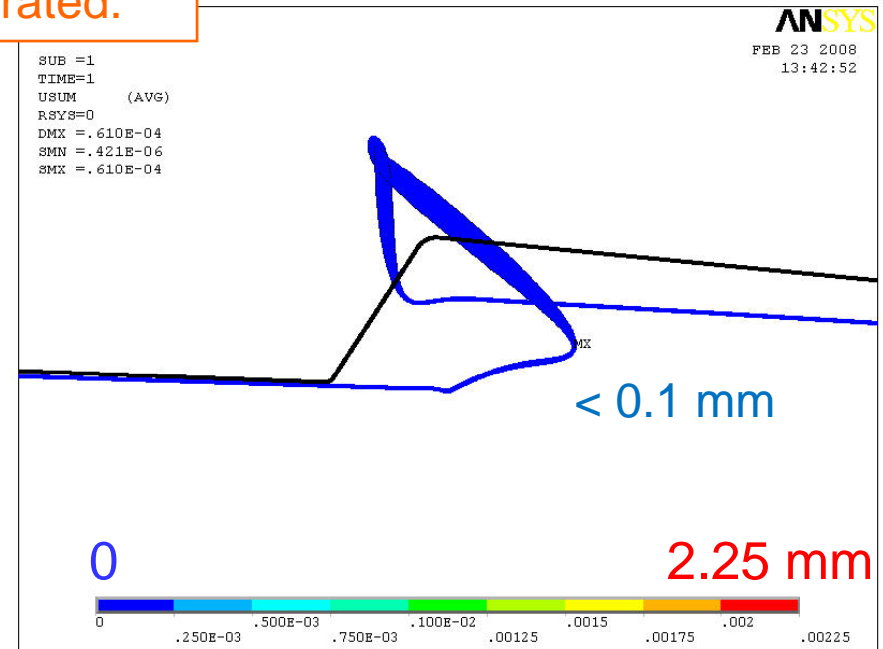
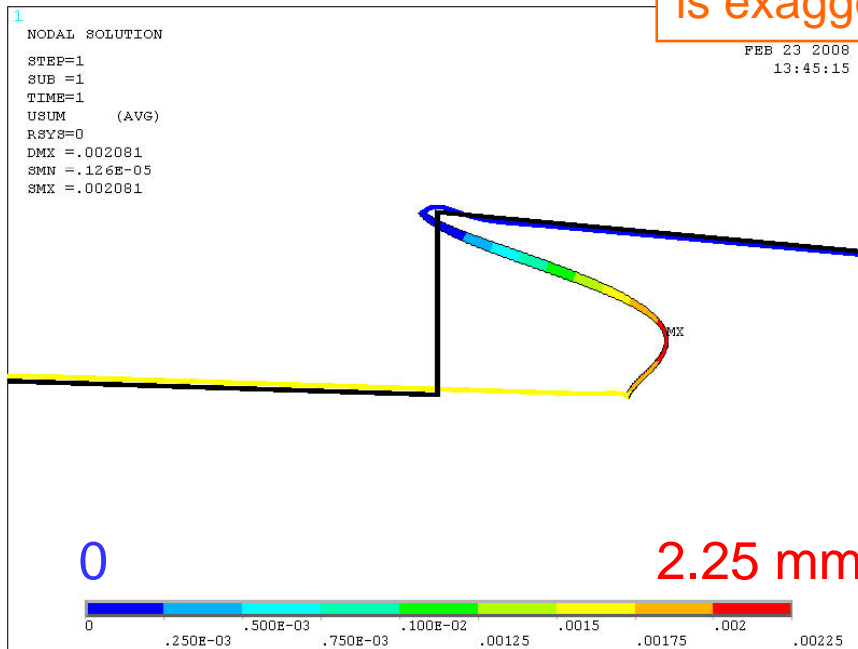
# Structural strength

- Result: Deformation

LDC\_1

Deformed shape is exaggerated.

LDC\_2



Deformation is much decreased by the round edges.



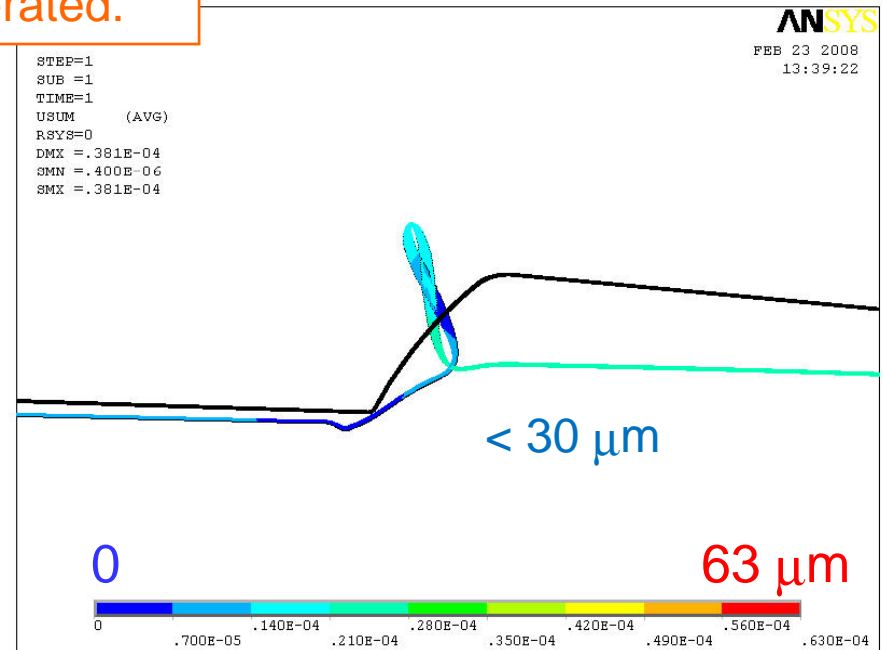
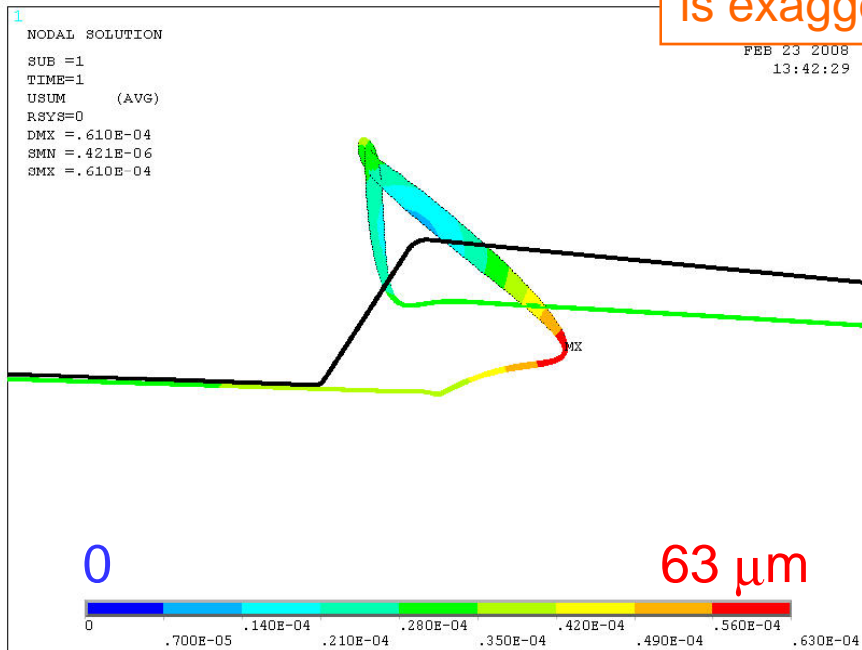
# Structural strength

- Result: Deformation

LDC\_2

Deformed shape is exaggerated.

LDC\_3



Deformation further reduces to a half.



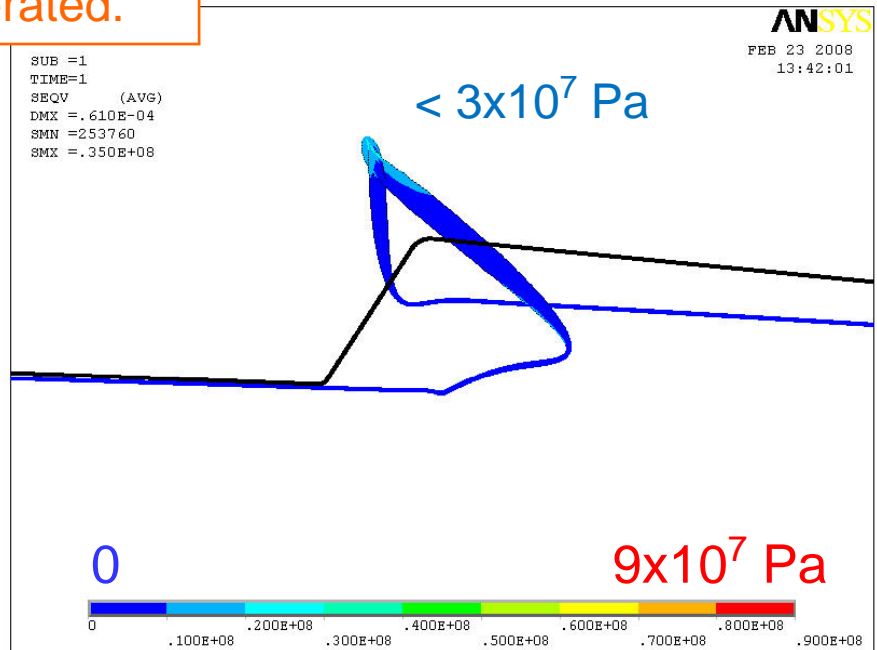
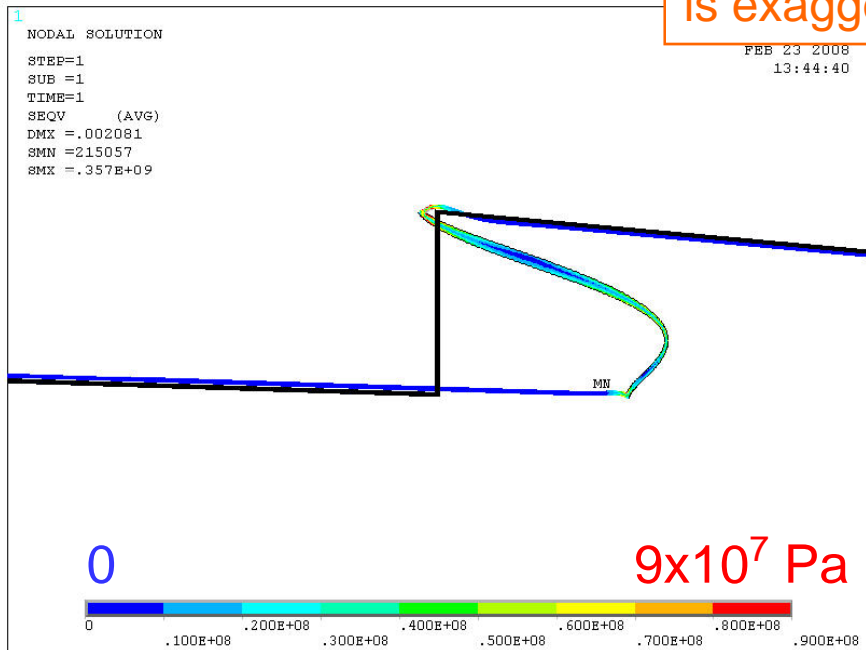
# Structural strength

- Result: Stress (Von Mises stress)

LDC\_1

Deformed shape is exaggerated.

LDC\_2



Stress is also much reduced by the round edges.



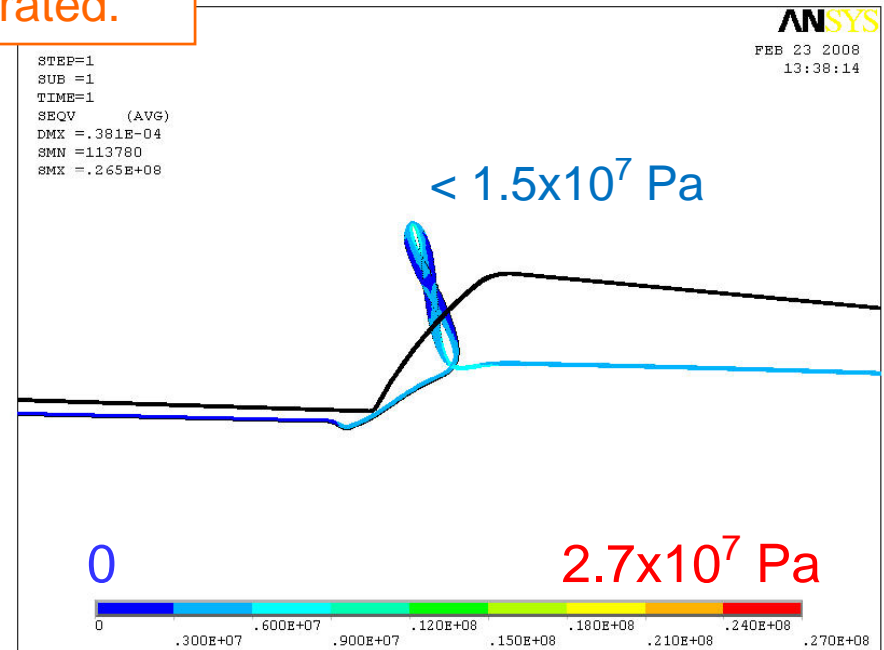
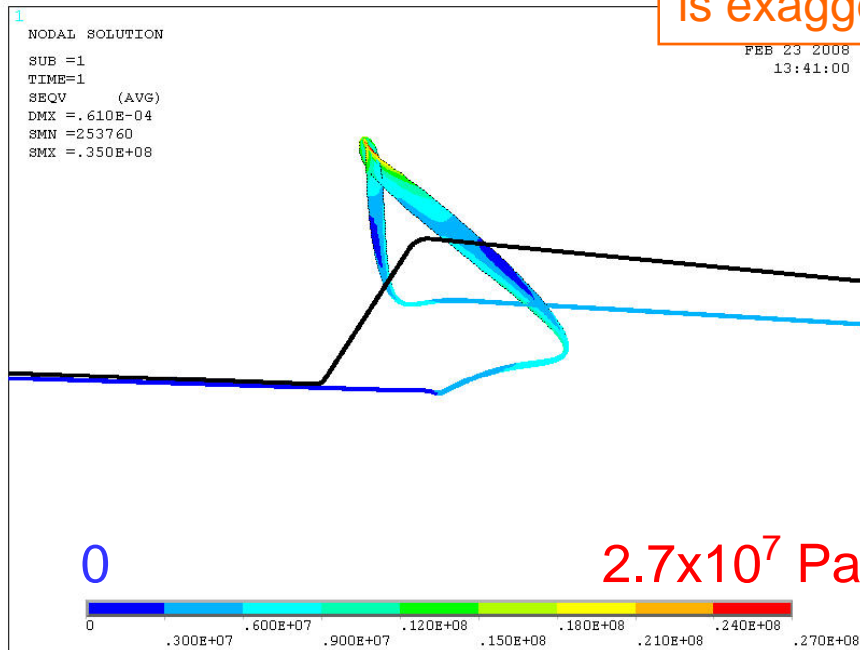
# Structural strength

- Result: Stress (Von Mises stress)

LDC\_2

Deformed shape  
is exaggerated.

LDC\_3

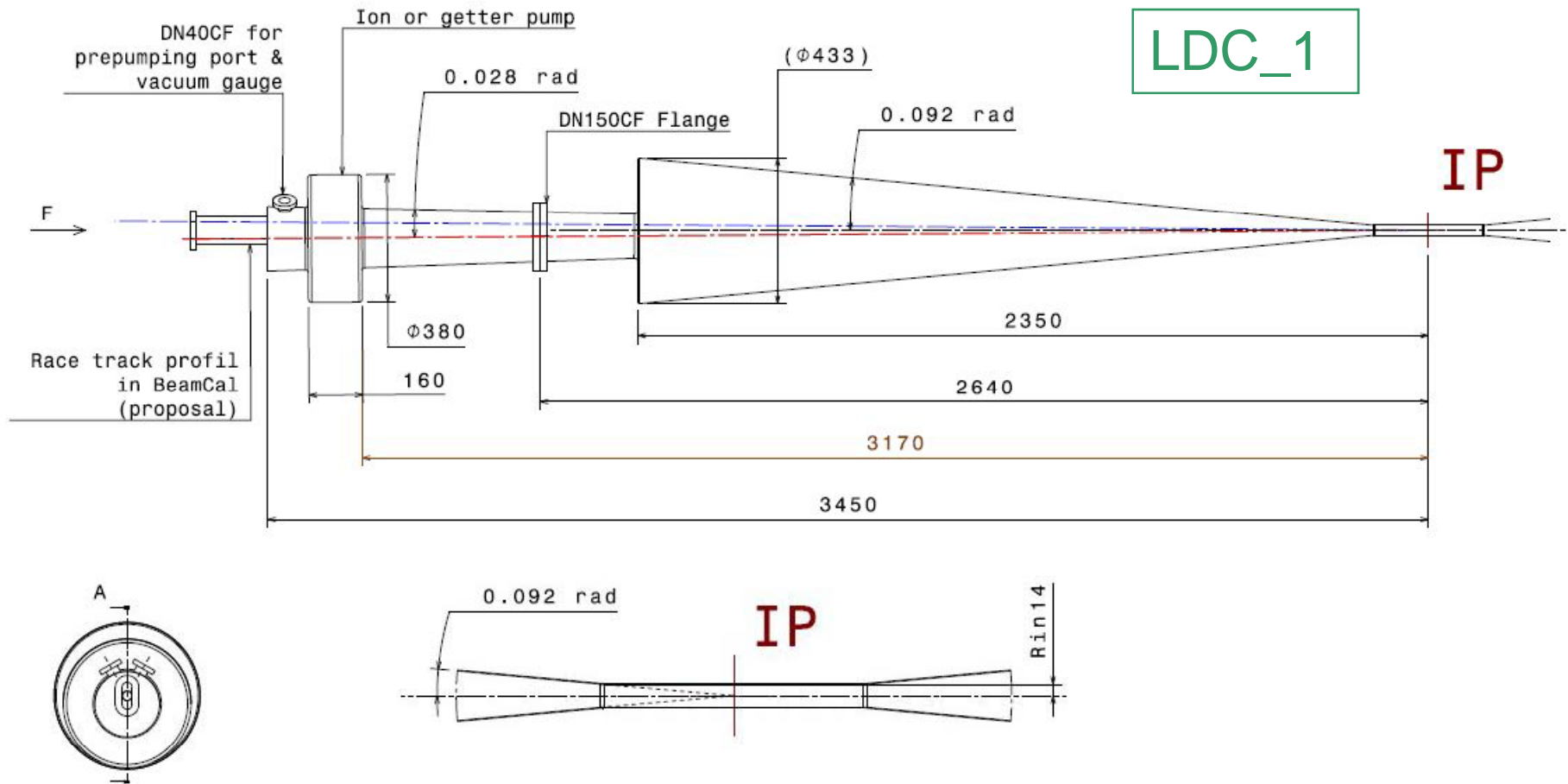


Stress further reduces to a half.  
(Yield strength of aluminum alloy is  $2.2 \times 10^8$  Pa)



# Pressure profile

- Base Model





# 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:  $2 \times 10^{-7} \text{ Pa m}^3 / \text{s/m}^2$  ( $\sim 2 \times 10^{-10} \text{ Torr l/s/cm}^2$ )  
H<sub>2</sub>:  $2 \times 10^{-6} \text{ Pa m}^3 / \text{s/m}^2$  ( $\sim 2 \times 10^{-9} \text{ Torr l/s/cm}^2$ )
    - After **100 hours** evacuation (after 4 days)  
CO:  $2 \times 10^{-8} \text{ Pa m}^3 / \text{s/m}^2$  ( $\sim 2 \times 10^{-11} \text{ Torr l/s/cm}^2$ )  
H<sub>2</sub>:  $2 \times 10^{-7} \text{ Pa m}^3 / \text{s/m}^2$  ( $\sim 2 \times 10^{-10} \text{ Torr l/s/cm}^2$ )
    - About **20 times larger than those after baking** (O. Malyshev)

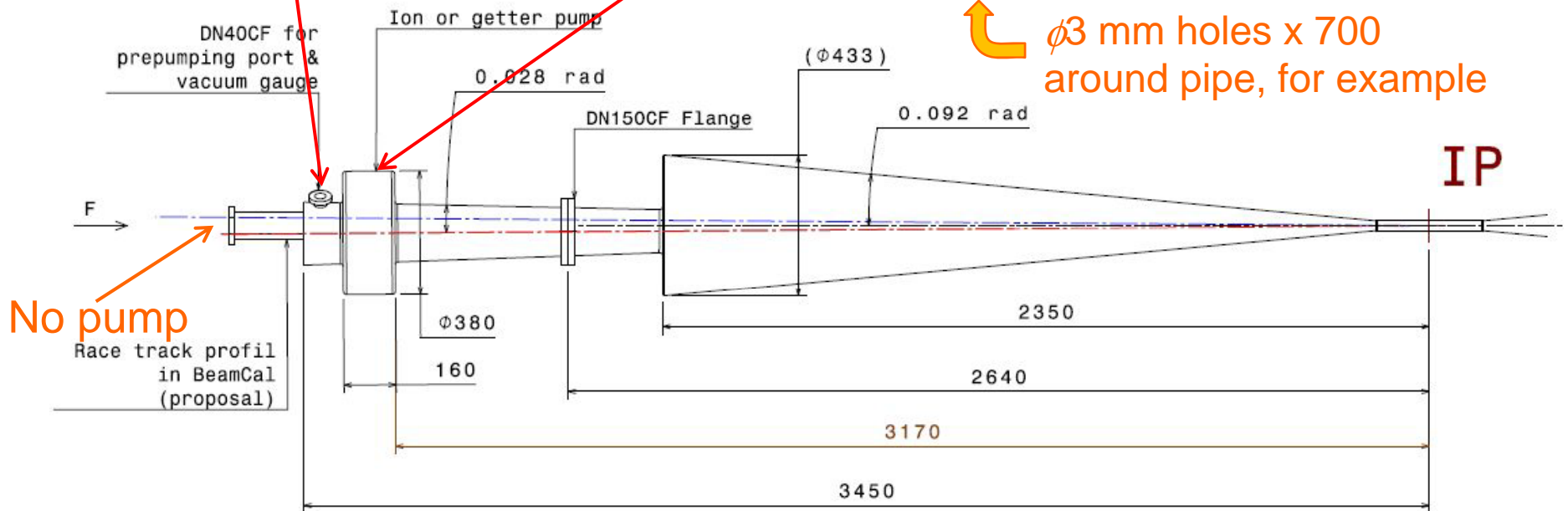
- Pumps

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

To a small ion pump  
(and rough pumps)

4m NEG strip in total  $S_{\text{eff}} =$   
 CO:  $0.2 \text{ m}^3/\text{s}$ ,  $C = 0.3 \text{ m}^3/\text{s} \rightarrow 0.12 \text{ m}^3/\text{s}$   
 $\text{H}_2$ :  $2 \text{ m}^3/\text{s}$ ,  $C = 1.1 \text{ m}^3/\text{s} \rightarrow 0.72 \text{ m}^3/\text{s}$

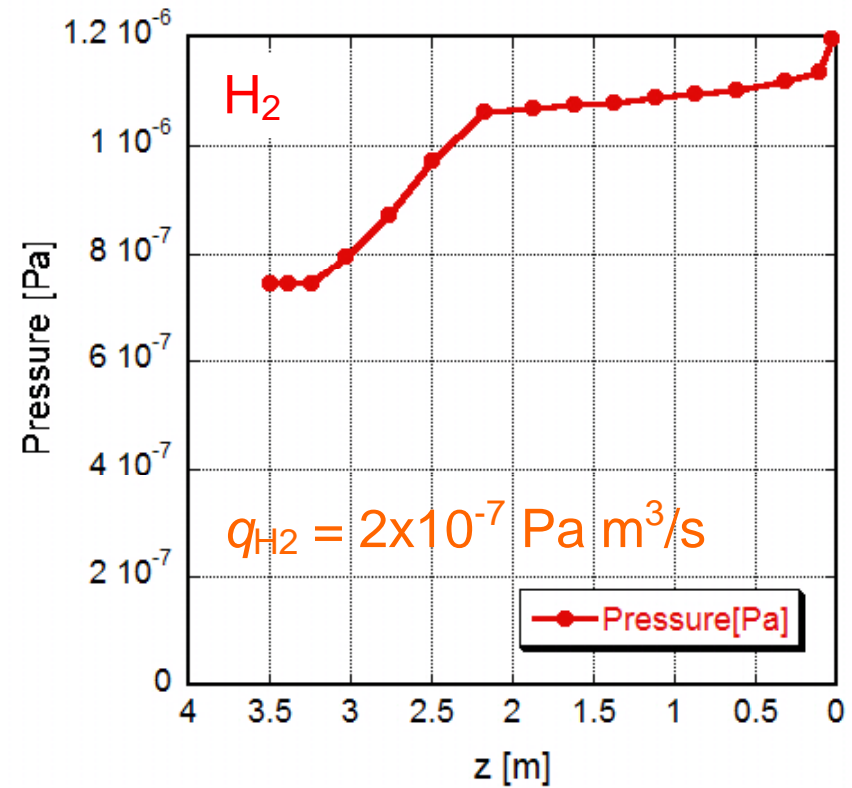
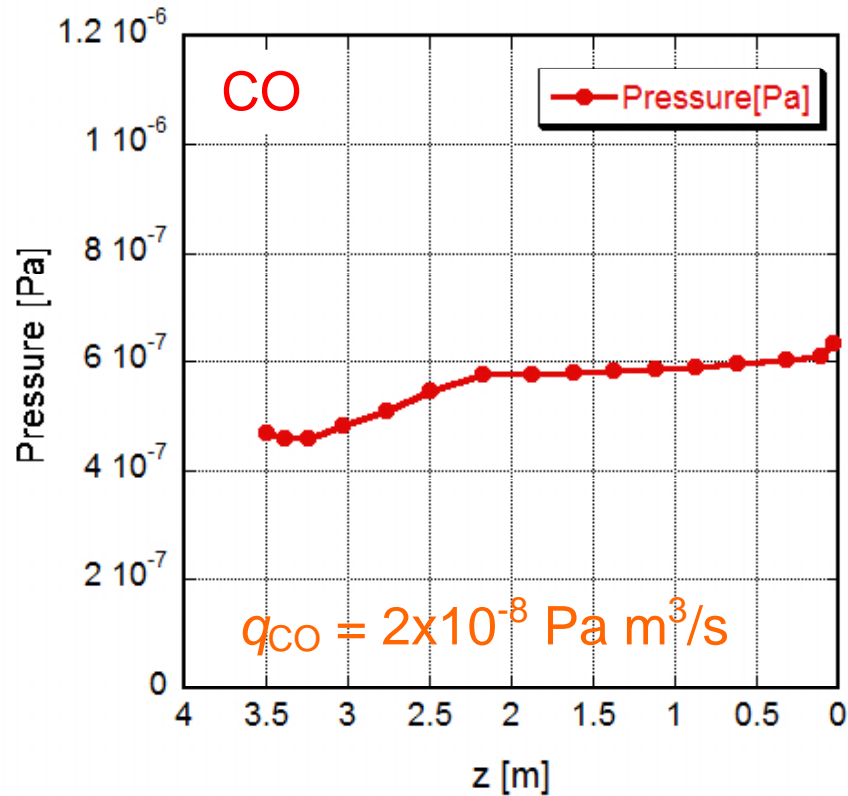
$\phi 3 \text{ mm}$  holes x 700  
around pipe, for example





# Pressure profile

- Results



$P \sim 1 \times 10^{-6} \text{ Pa}$  for H<sub>2</sub>.

The assumed pumping speed is the minimum.



Some vacuum properties of LDC beam pipe was studied.

(1) Loss factor of one side for two beams is about  $7 \times 10^{13}$  V/C, and the dissipated power will be about 20 W.

– **Round edges of cone sections has little effect.**

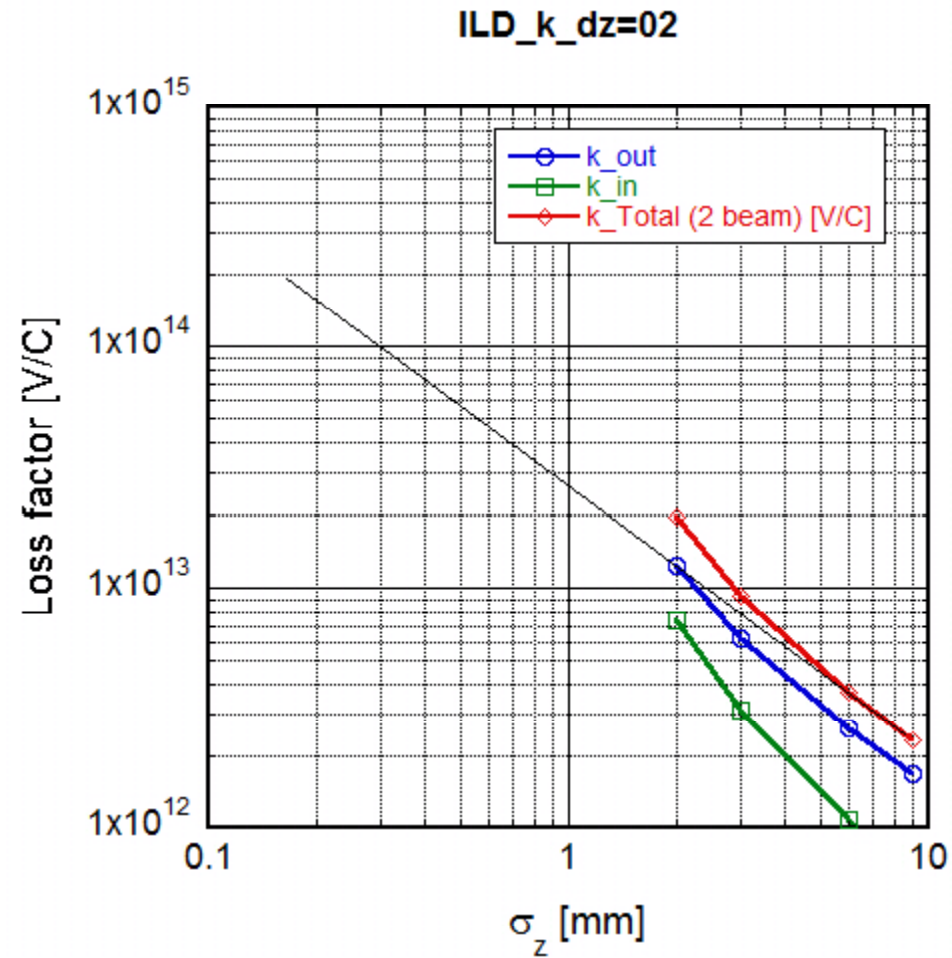
(2) Structural strength is much improved by introducing round edges at cone section.

– **The stress is much lower than the yield strength of a typical aluminum alloy.**

(3) Vacuum pressure almost less than  $1 \times 10^{-6}$  Pa will be obtained without baking.

– **Effective pumping speed of about  $0.7 \text{ m}^3/\text{s}$  is required at least for  $\text{H}_2$ .**

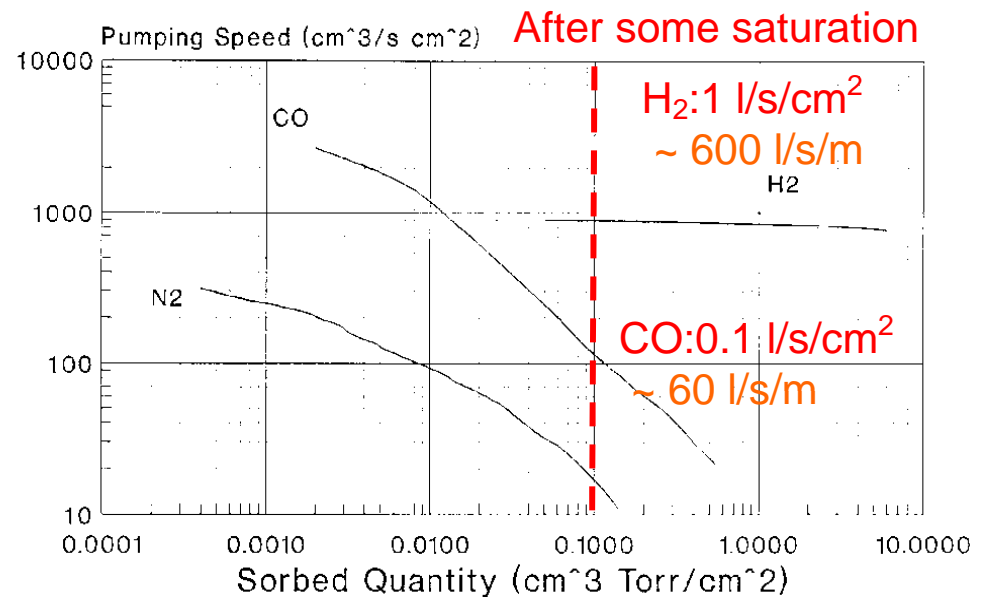
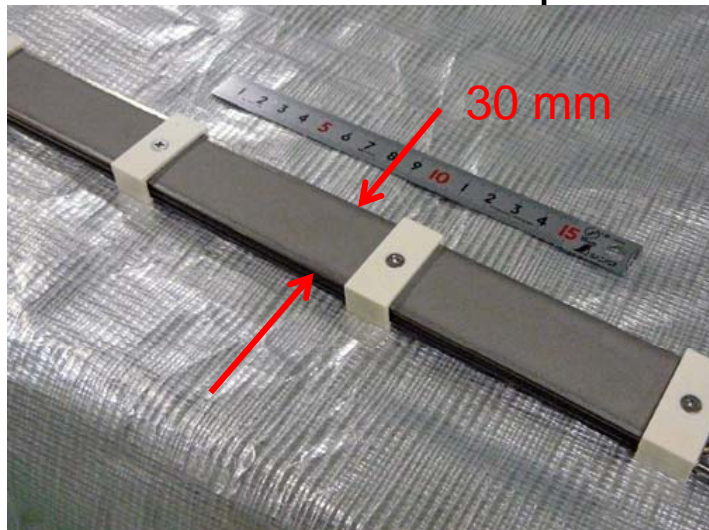
- Reference



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

ST 707/CTAM/30D Strip  
Typical Sorption Curves

St707 NEG strip



Activation : 450 C x 45 min  
Sorption : T= 25 C P= 3E-6 Torr  
Ref. M.FSPT.0004 Rev.0 Jan 5, 1994

PREP: *Wentzel*