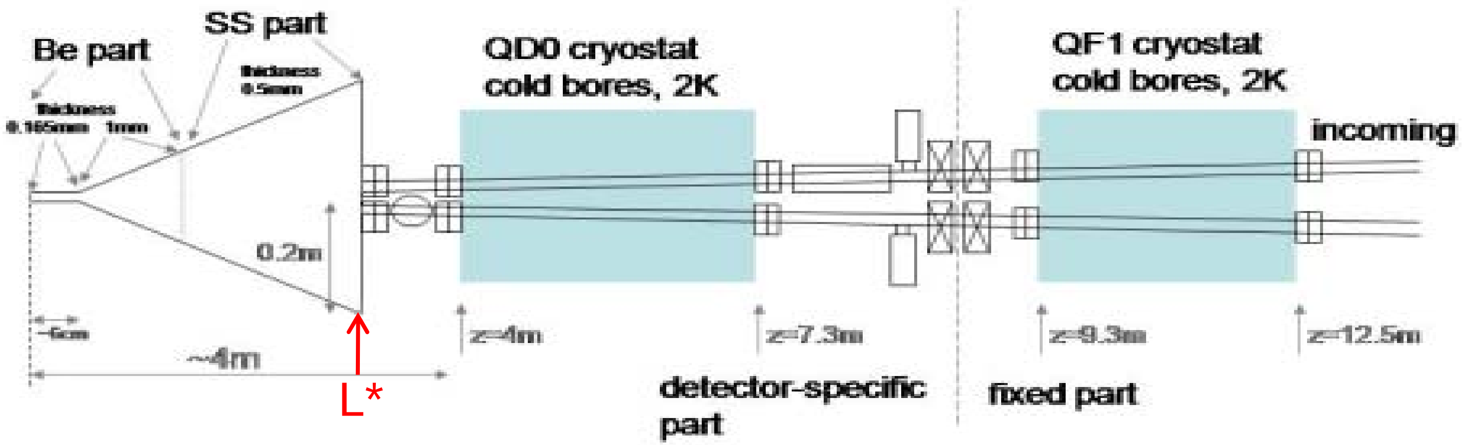
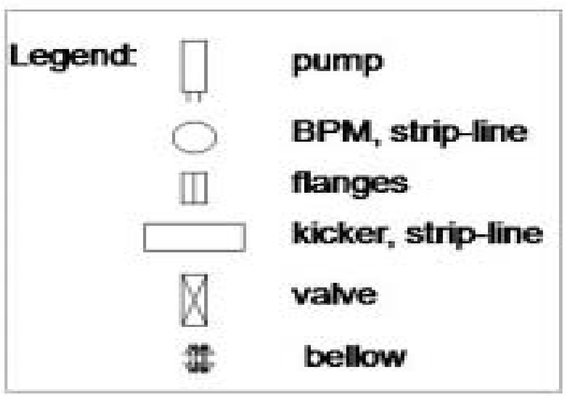
A Basic Design of IR Vacuum system

Y. Suetsugu, KEK

- Possibility of a pumping system without *in-situ* baking at z < L*

- 0-th draft of IR region (A. Seryi)
  - **Starting point**



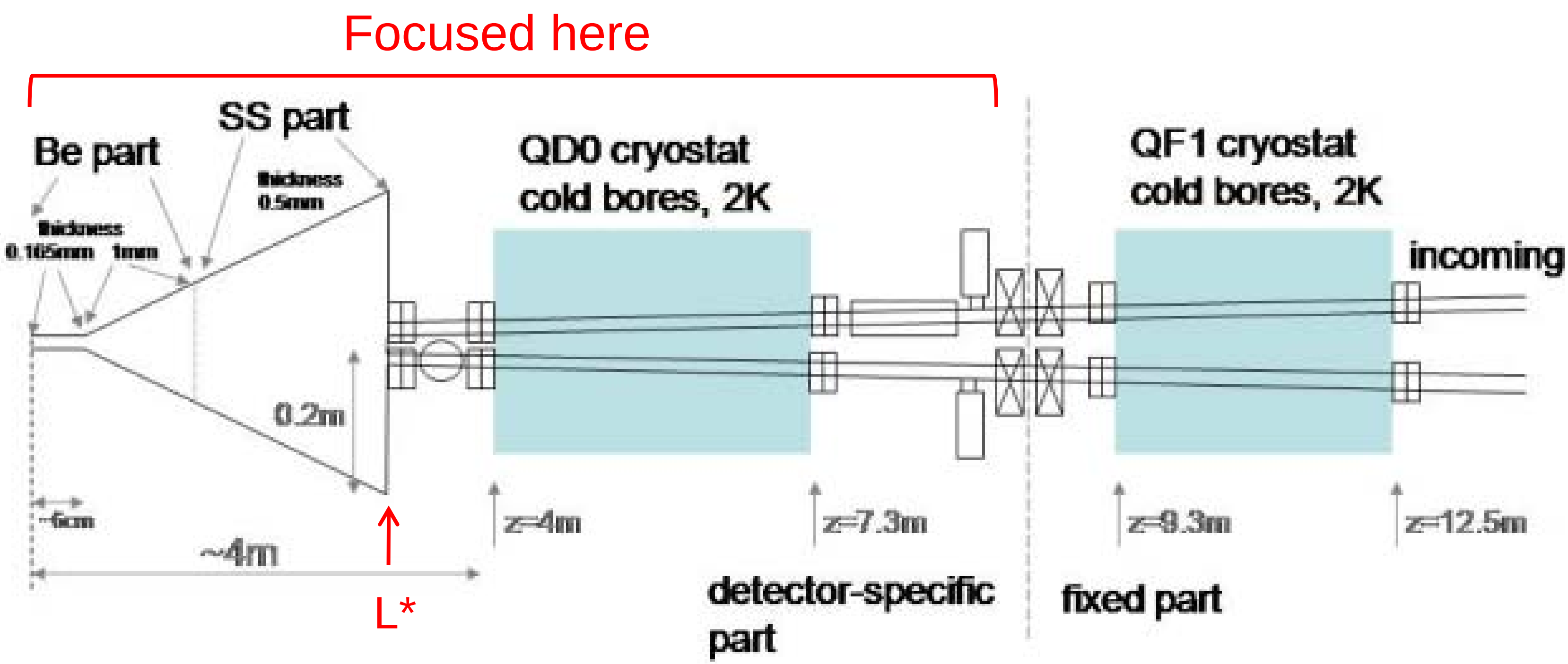


Apertures typically r=1cm in incoming beamline, and r=1.2cm+0.08cm*Z(m) in the outgoing beamline

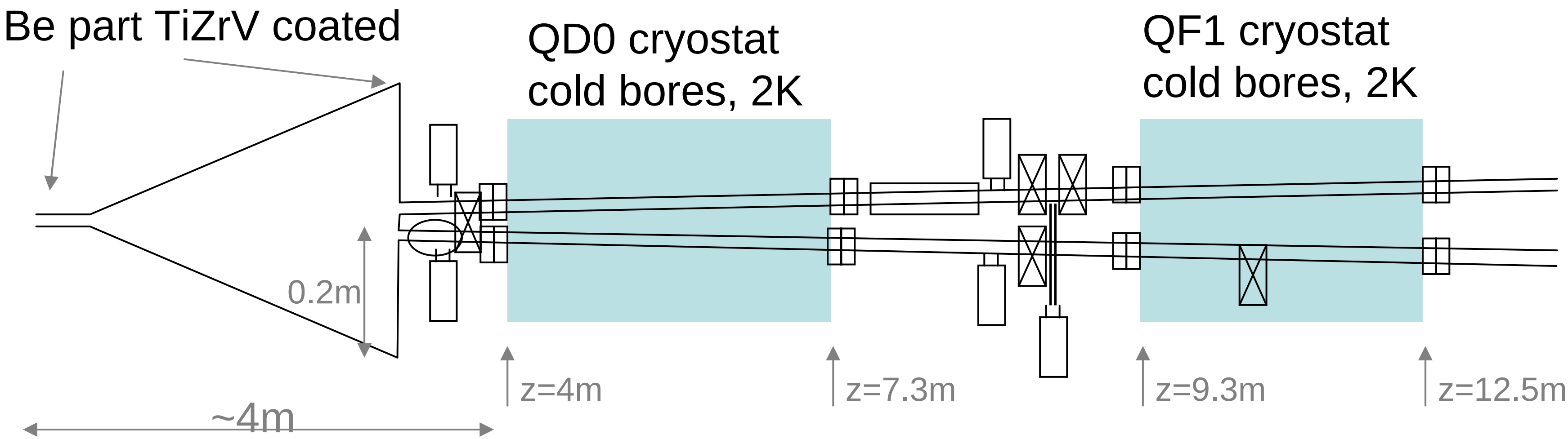
Be-SS connection is permanent

- Required pressures
  - **For z < L* : 1 ~ 10 x 10^{-7} Pa (= 1 ~ 10 nTorr)**
  - **Up to 200 m from IP: ≤1×10^{-7} Pa (= 1 nTorr)**

(by L. Keller, 15/8/2007)



- The first consideration by O. Malyshev (2007/8/16)
  - Very reasonable design.
  - NEG coating at z < L* should be effective.



Introduction_4

- The first consideration by O. Malyshev (2007/8/16)
  - **Very reasonable design.**
  - **NEG coating at z < L* should be effective.**
- However,
  - **Baking *in-situ* at 180 - 200 °C is indispensable to make use of the NEG coating.**
  - **Is it available?**
    - Dangerous to the detector circuit.
    - Mechanical strength?
  - **Is the capacity of the NEG-coating sufficient?**
- How about a system without *in-situ* baking?
  - Is it possible?

Pump system_1

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

      H_2: 2×10^{-6} Pa m^3 /s/m^2 (~ 2×10^{-9} Torr l /s/cm^2)
    - After 100 hours evaculation (after 4 days)

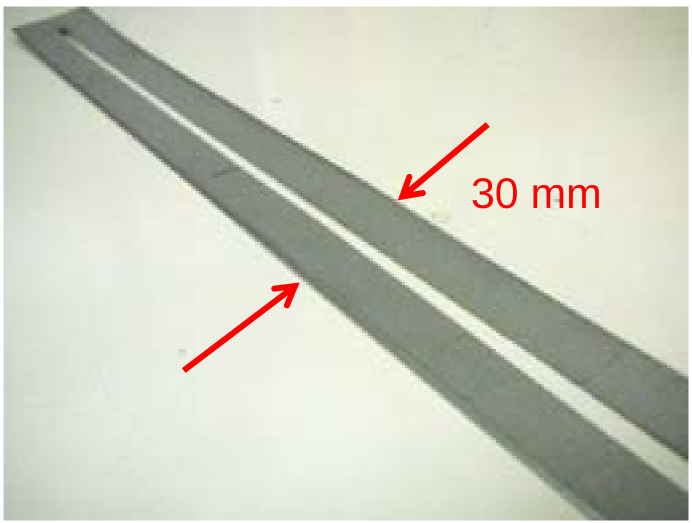
      CO: 2×10^{-8} Pa m^3 /s/m^2 (~ 2×10^{-11} Torr l /s/cm^2)

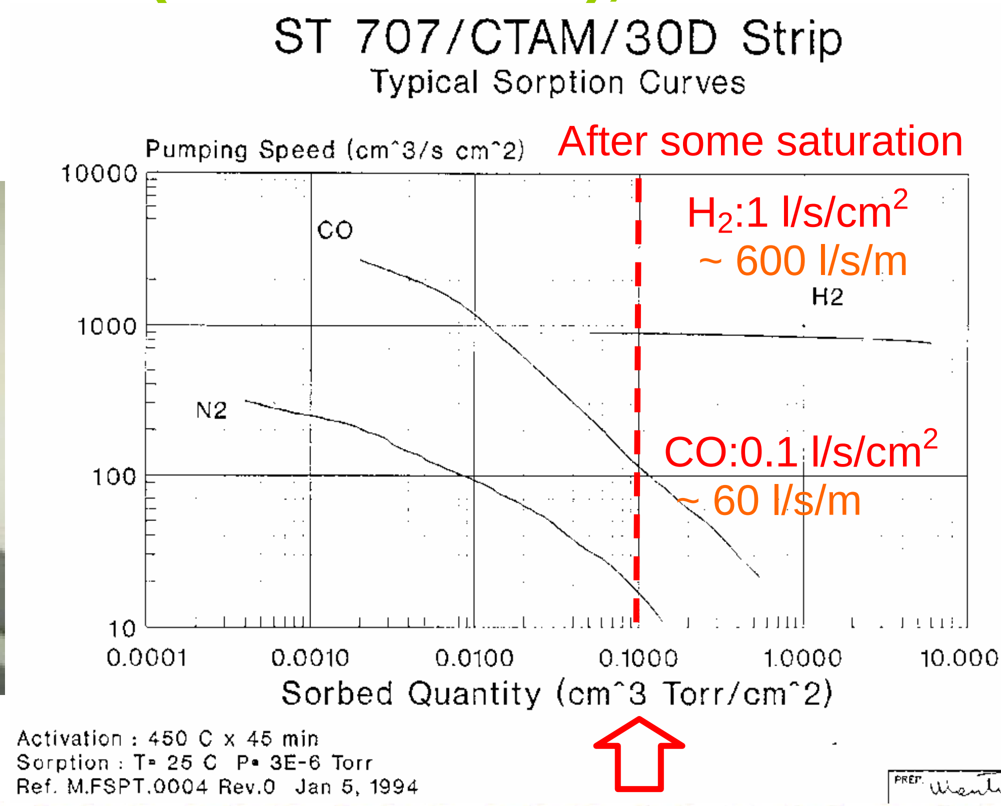
      H_2: 2×10^{-7} Pa m^3 /s/m^2 (~ 2×10^{-10} Torr l /s/cm^2)
    - About 20 times larger than those after baking (O. Malyshev)

Pump system_2

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

St707 NEG strip



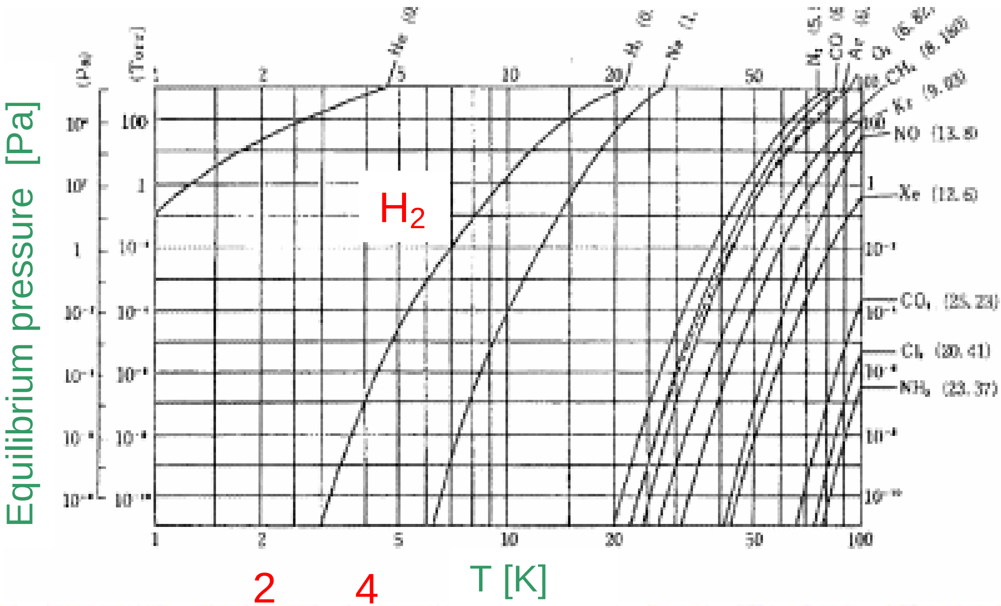


- Assumptions
  - QD0 = Cryopump (at T = 2 K[?])
  - Pumping speed

A: Area
P_{eq}: Equilibrium pressure
m: mass of gas molecule
T: Temperature
C_g: Sticking coefficient

$$S = \frac{1}{4}\bar{v}AC_g\left\{1-\frac{P_{eq}}{P}\sqrt{\frac{T}{T_s}}\right\} = \sqrt{\frac{kT}{2\pi m}}AC_g\left\{1-\frac{P_{eq}}{P}\sqrt{\frac{T}{T_s}}\right\}$$

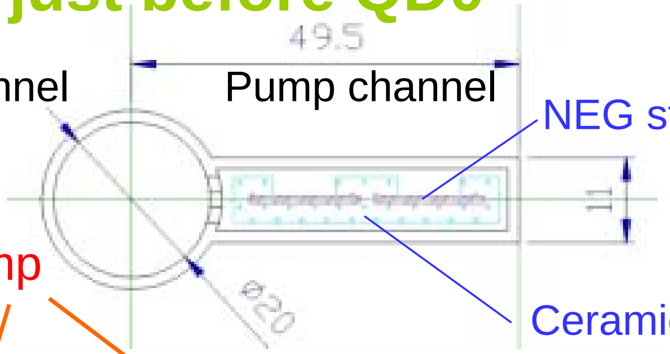
  - $P_{eq} << P$
  - $C_g = 0.1$
  - As a first approx.
  - S_{H2} = 3.6 m³/s/m² =036 *l*/s/cm²
  - If *r* = 10 mm, S_{H2} = 0.22 m³/s/m =220 *l*/s/m



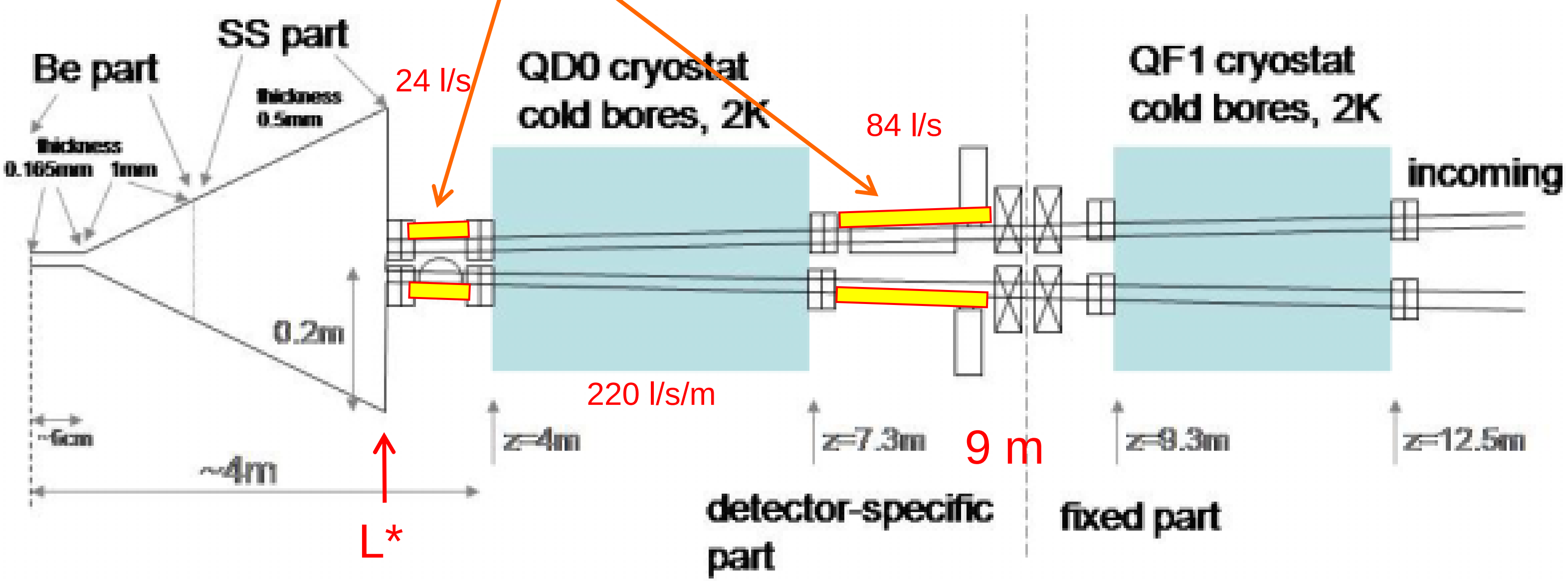
Pump system_4

- If no pump at cone region (z < L*)
  - NEG pump just before QD0

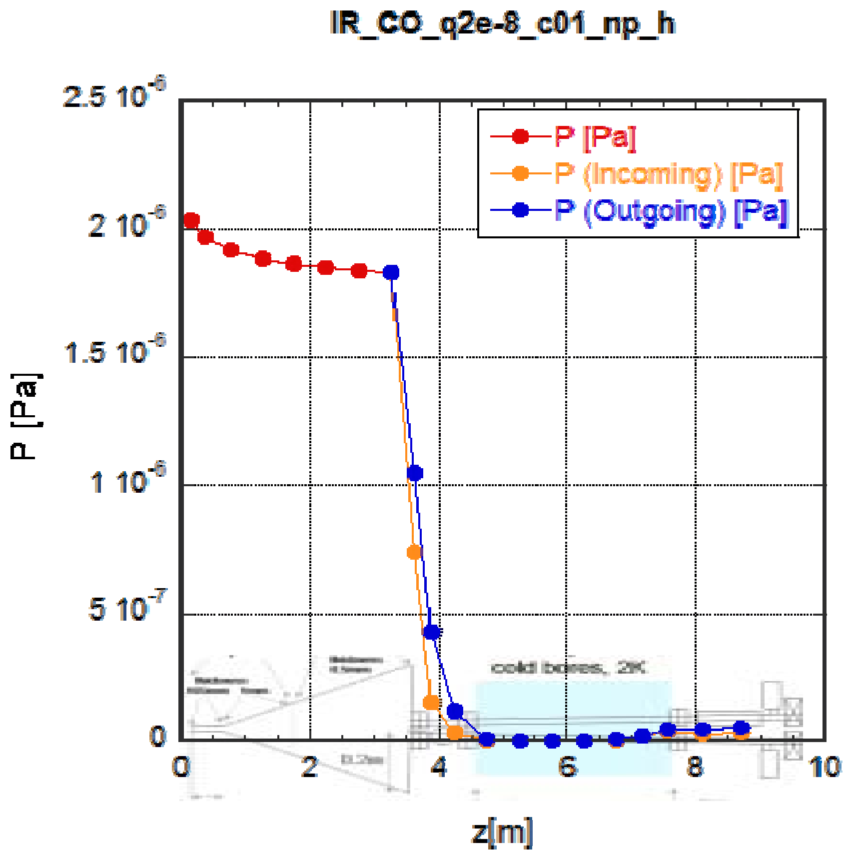
Ex.



Lumped pump may be OK



- Pressure distribution after 100 hours evacuation
- Calculated by a Monte Carlo code

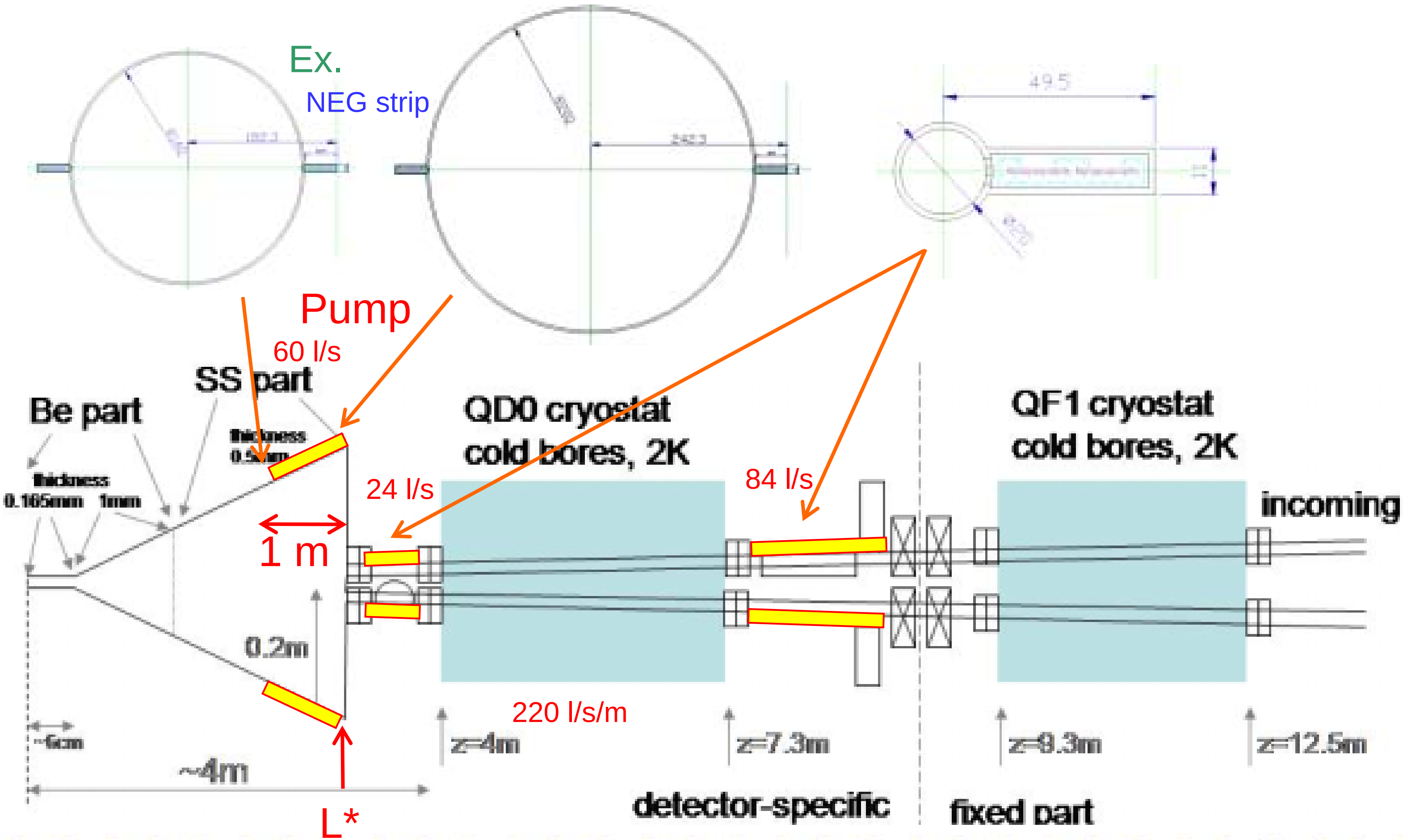


– **Q = 2×10^{-8} Pa m^3 /s /m^2 for CO**

– **P (z < L*) > 1×10^{-6} Pa!**

Some pumping are required at z < L* !

- For example, NEG pumps at the last 1 m of cone

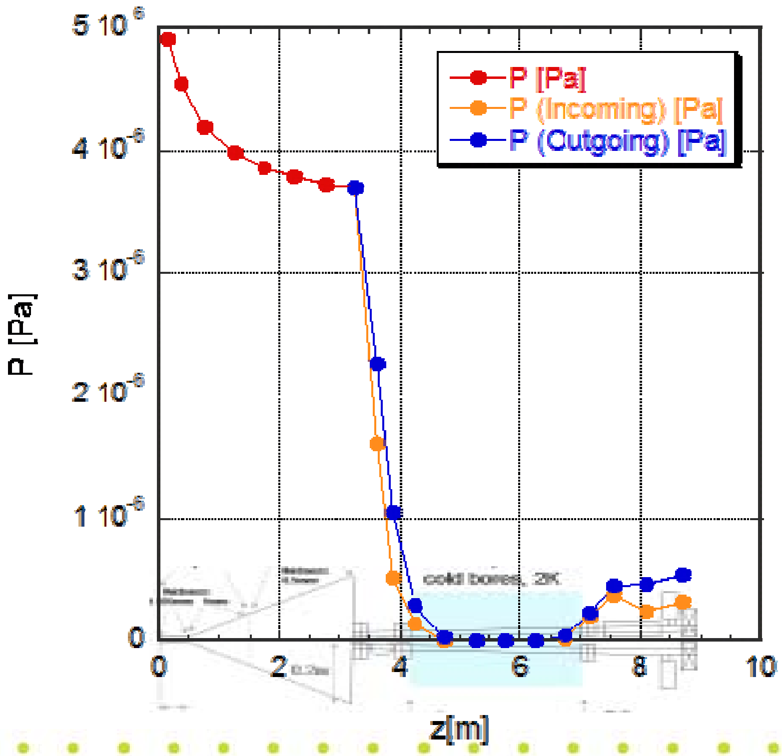


Pump system_7

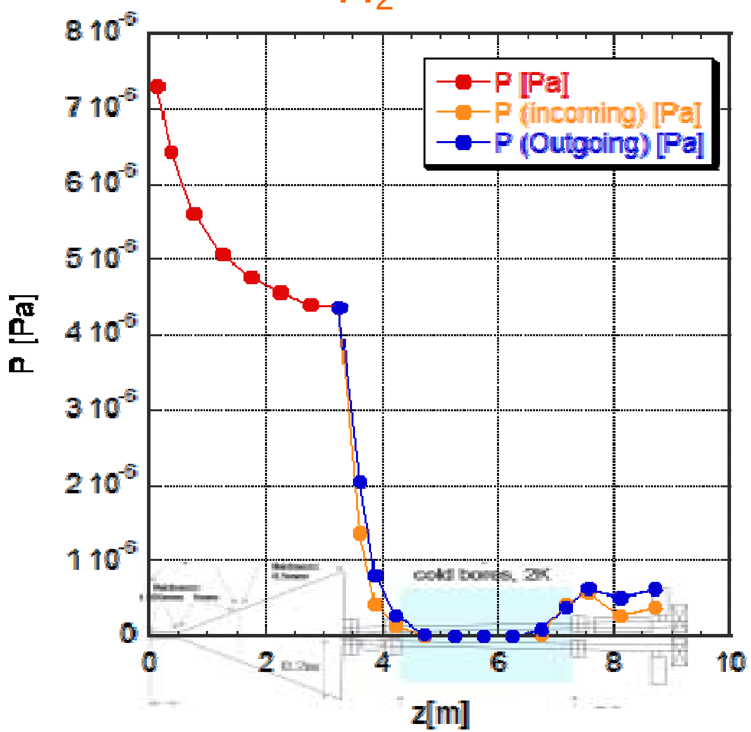
- Pressure distribution after 10 hours evacuation
  - ***Q* = 2x10^{-7} Pa m^3 /s /m^2 for CO**
  - ***Q* = 2x10^{-6} Pa m^3 /s /m^2 for H$_2$**

P > 1 x10^{-6} Pa

CO



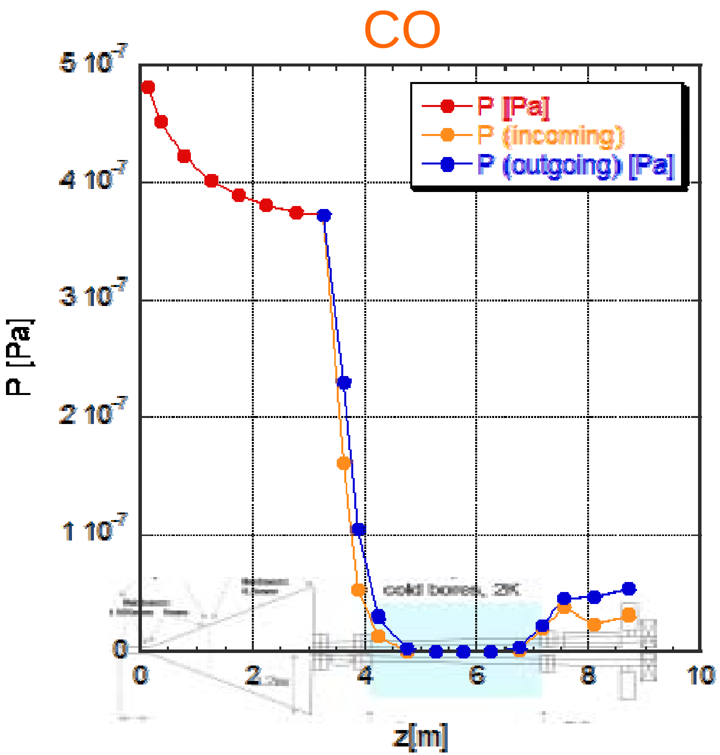
H$_2$

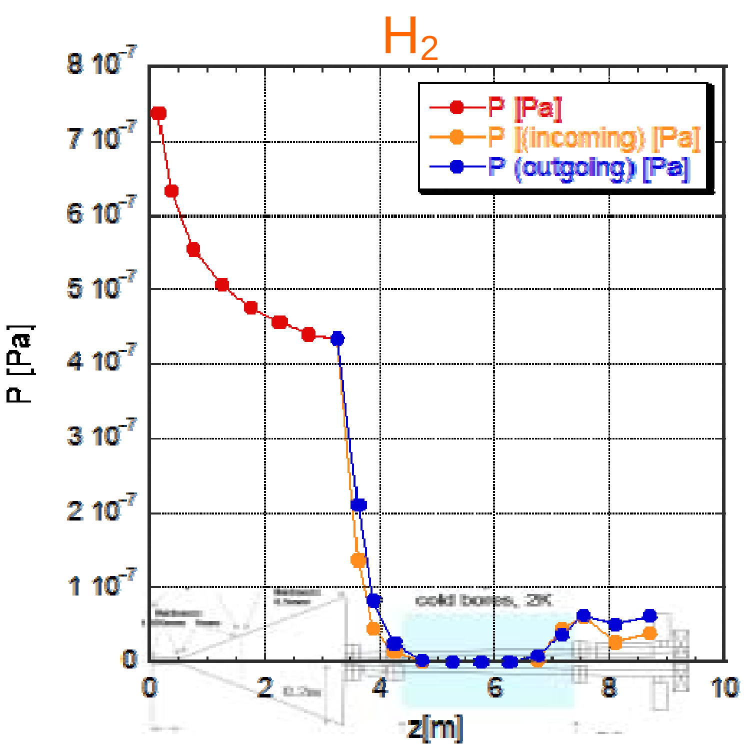


Pump system_8

- Pressure distribution after 100 hours evacuation
  - $Q = 2 \times 10^{-8}$ Pa m^3 /s /m^2 for CO
  - $Q = 2 \times 10^{-7}$ Pa m^3 /s /m^2 for H_2

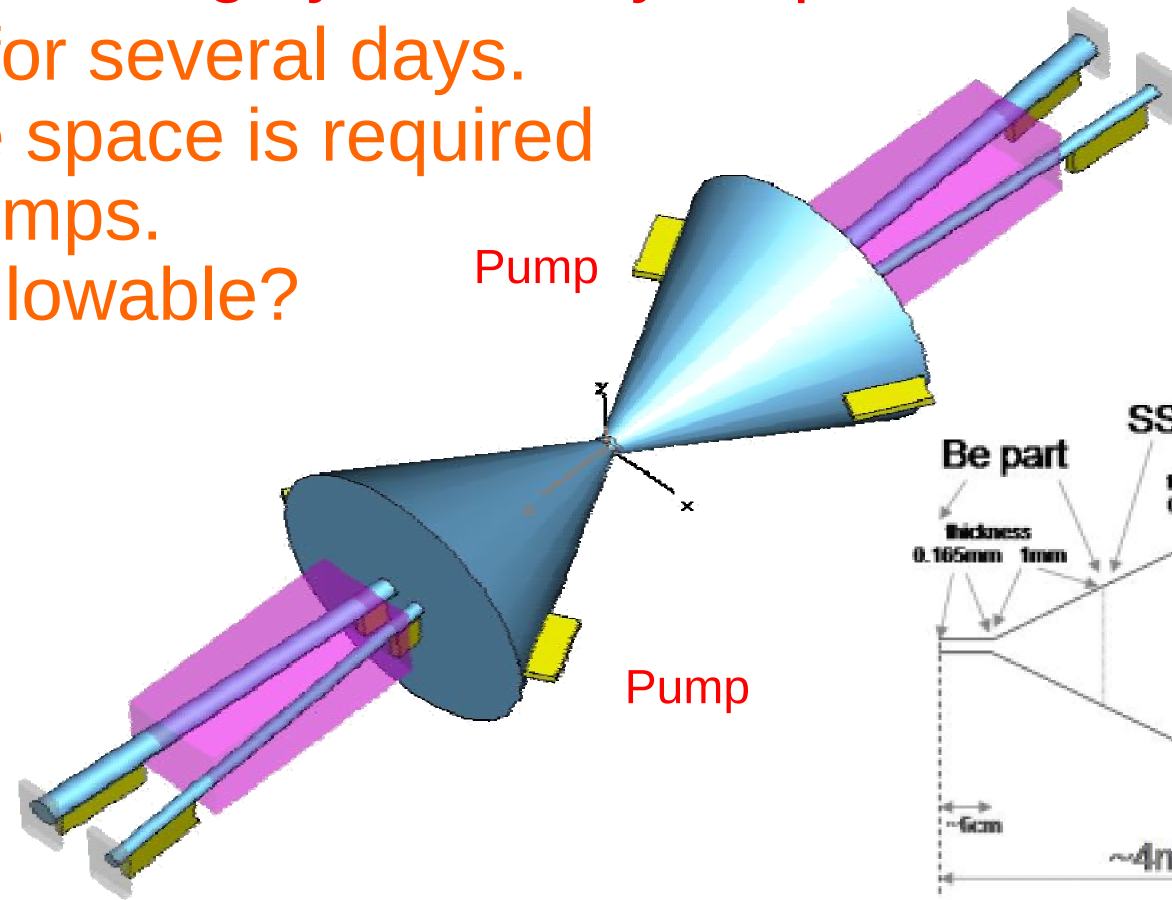
P < 1 x10^{-6} Pa !



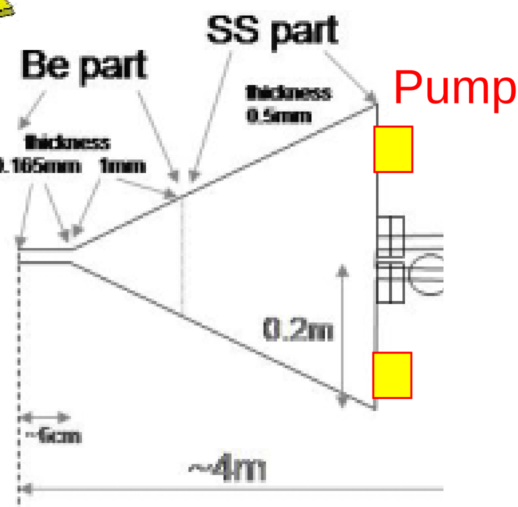


Pump system_9

- If some pumps (~120 *l*/s) is prepared at cone, no *in-situ* baking system may be possible.
- Wait for several days.
- Some space is required for pumps.
- Is it allowable?

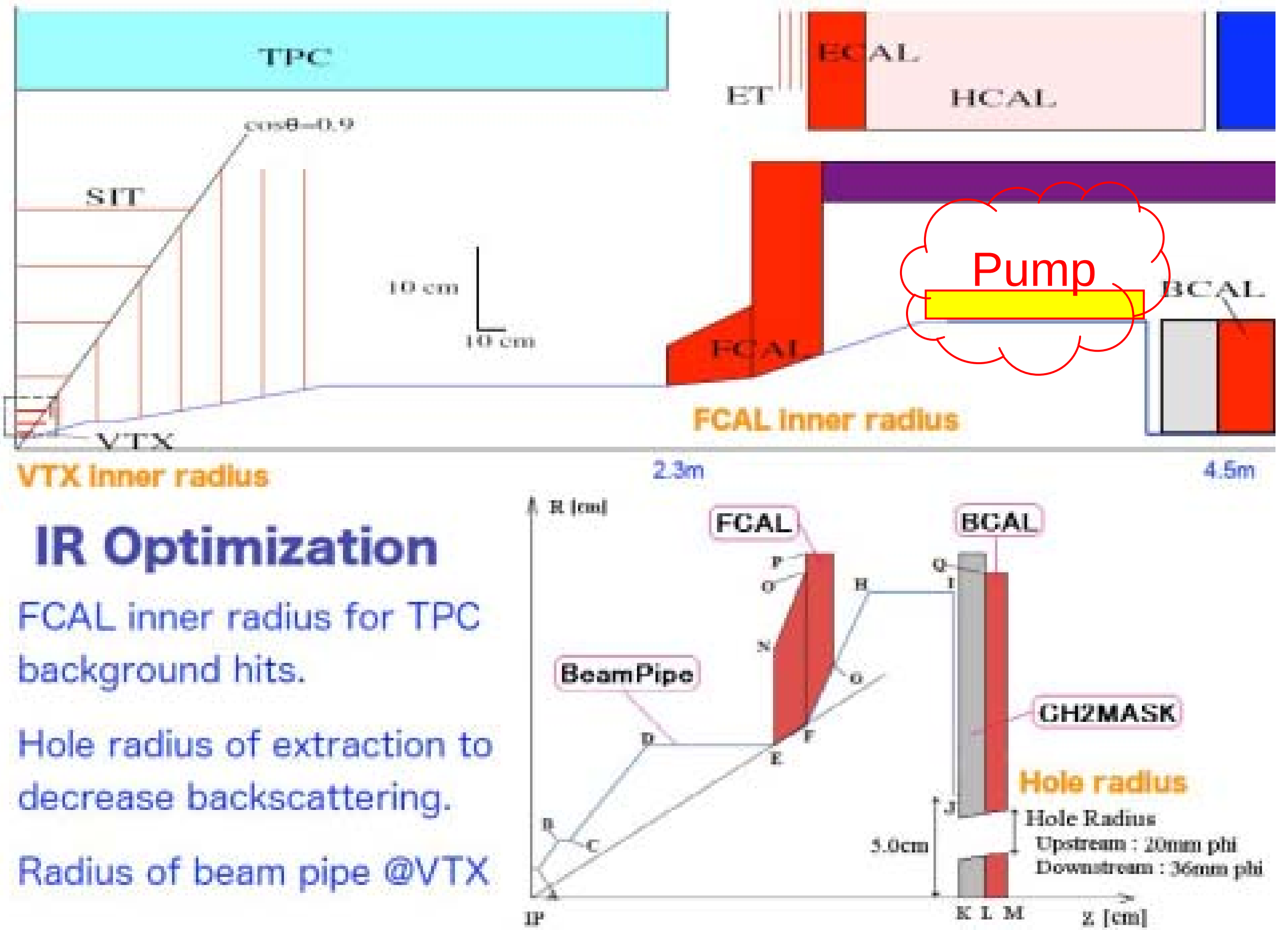


OR

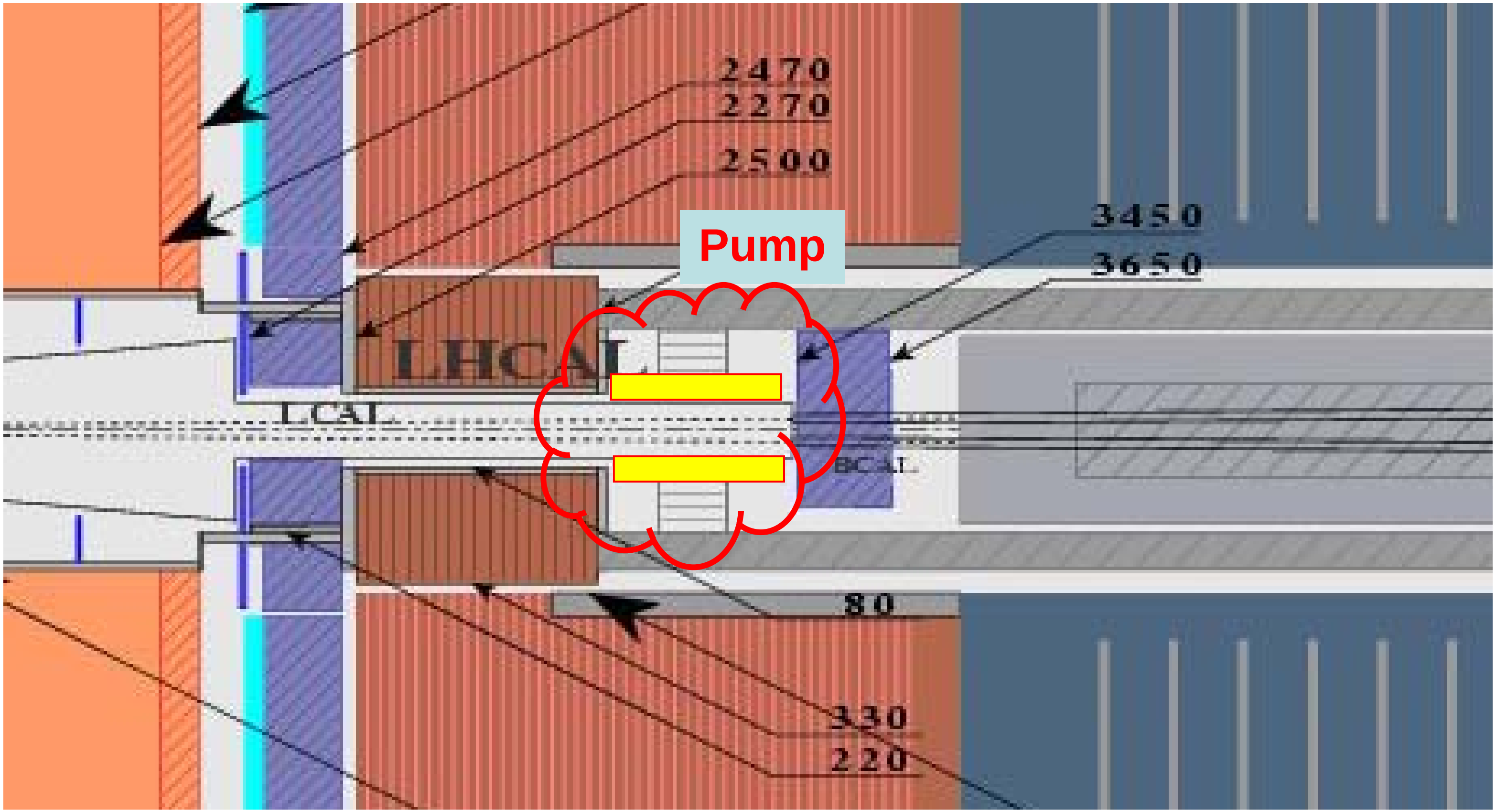


Pump system_10

- Possible for GLD

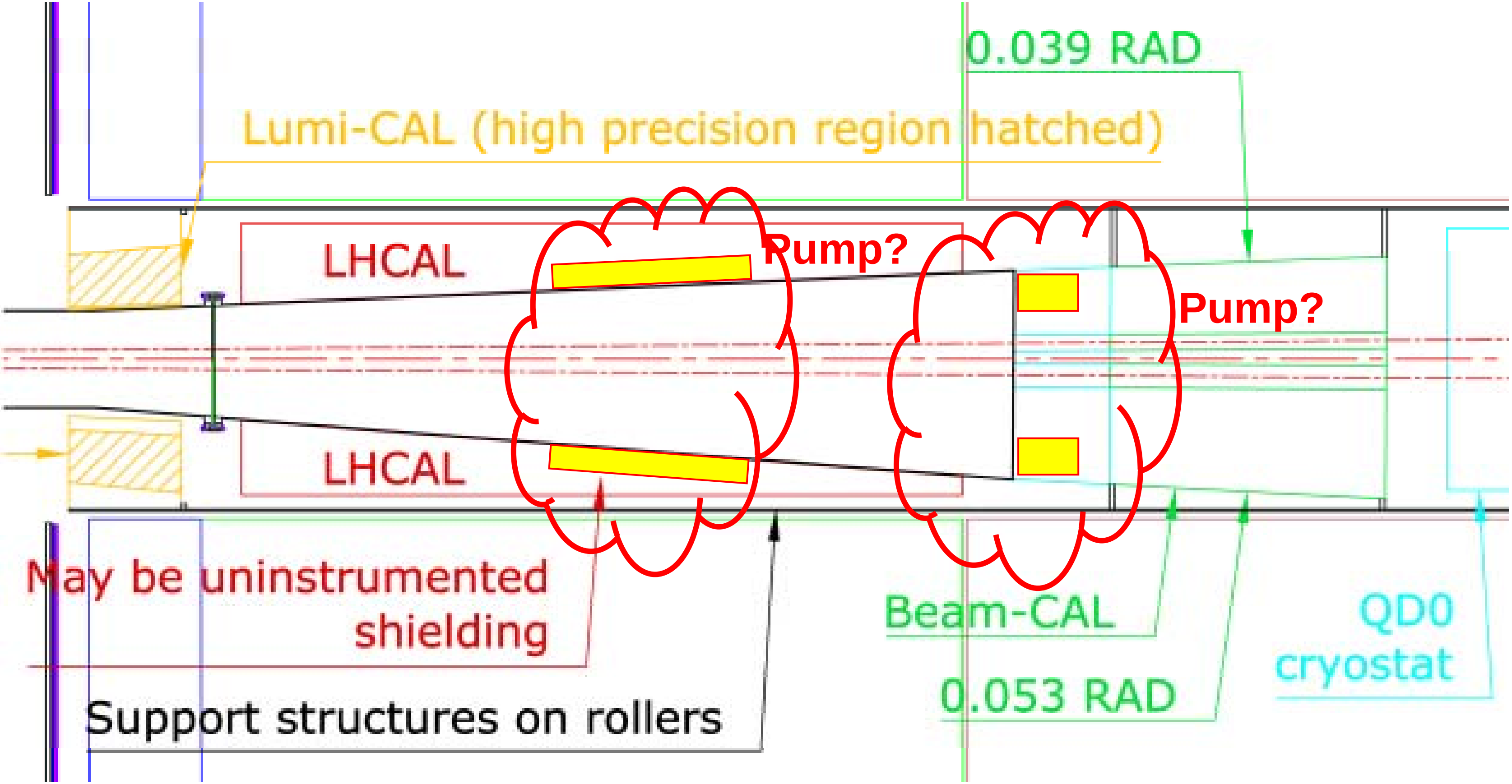


- for LDC



(by N. Meyners

- for SiD



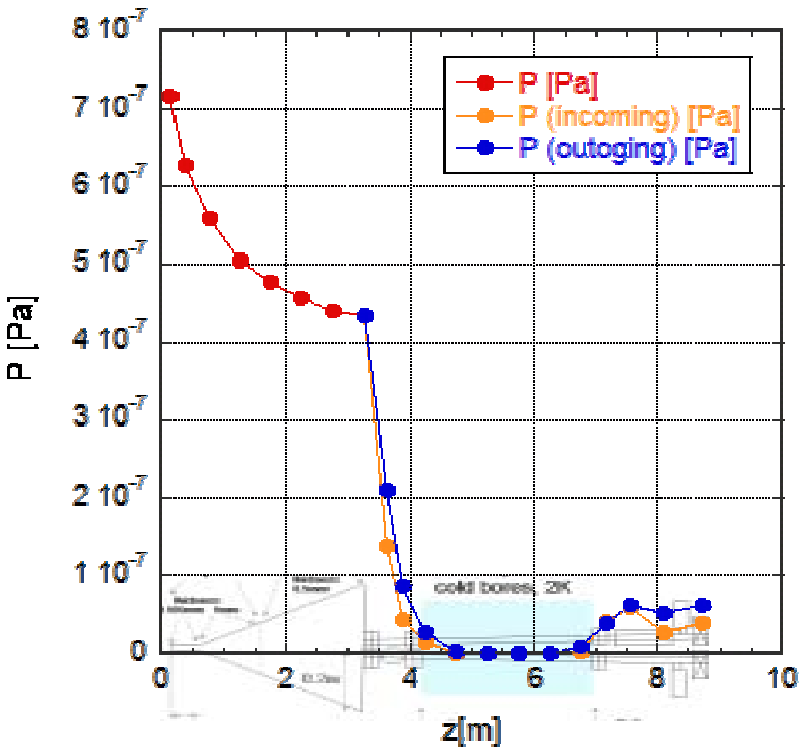
(by B. Cooper)

- Gas desorption by SR
    - Problem as Malyshev-san said
  - **Information from T. Maruyama-san (8/2/2007)**
    - SR from beam halo (halo rate ~ 10^{-3})
    - At extraction line, average photon energy = 7 MeV, power = 60 mW, from 3.5 m to 6.5 m
    - Photon density is about 2×10^{10} photons/s/m
    - If 1×10^{11} photons/s/m and $\eta = 0.1$ are assumed,
    - $Q_{photon} = 4\times10^{-11}$ Pa m^3/s/m @ 293 K ~1×10^{-10} Pa m^3/s/m
      ~1×10^{-9} Pa m^3/s/m^2
    - Still below the thermal gas desorption.
    - Similar order of gas desorption by e^-/e^+.

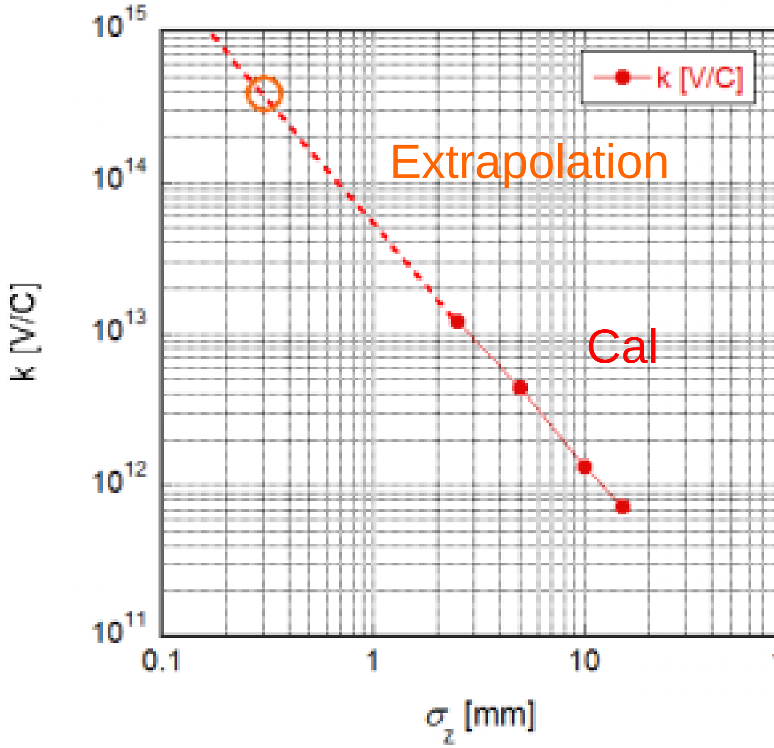
Pump system_14

- $Q_{photon} = 1x10^{-9}$ Pam^3/s/m^2 for QD0 (2 K)

H_2, $Q_{photon} = 1x10^{-9}$ Pam^3/s/m^2

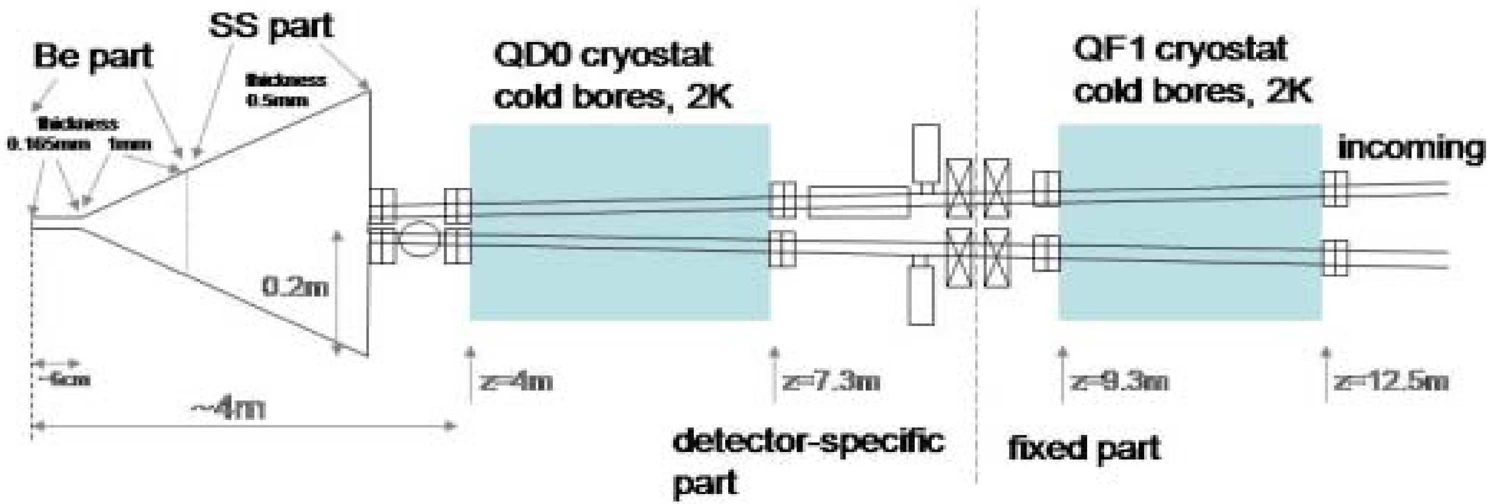


- Heating by HOM
  - **Loss factor, *k*, of a simple cone**
  - **~4×10^{14} V/C @σ_z = 0.3 mm**
  - **q = 3.2 nC, 5400 bunch, 5Hz : $I = 8.6 \times 10^{-5}$ A**
  - **$P = kqI$ x2 = 220 W**
  - **Other components?**
    - SR crotch?

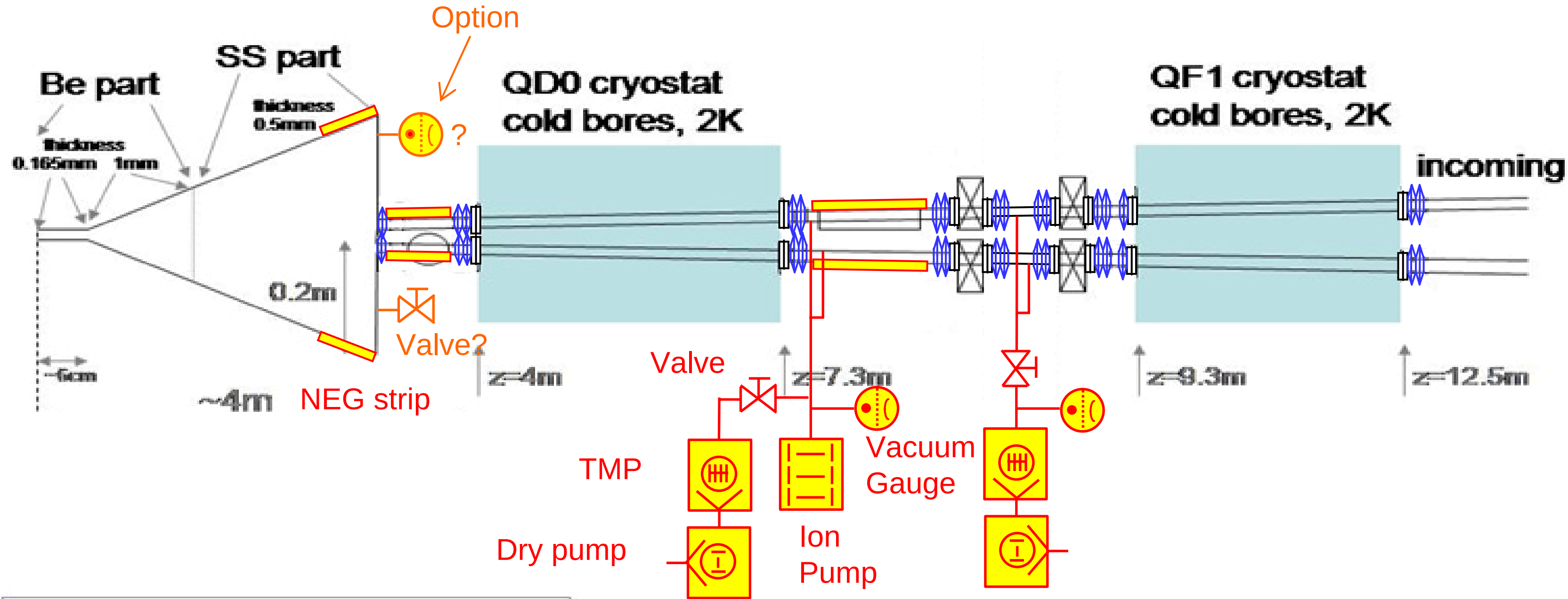


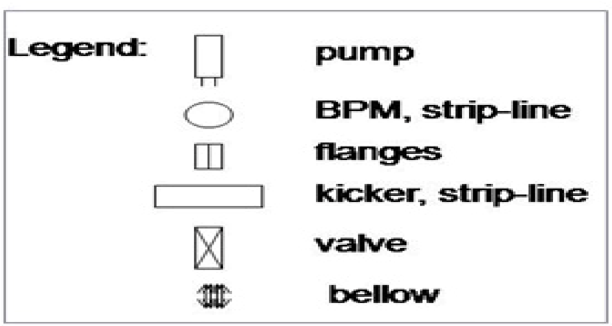
Air cooling ?
Water cooling may be safe.

- Other components
  - **Auxiliary pumps**
    - Ion pumps (for noble gases), rough pumps
  - **Vacuum gauges**
  - **Bellows**



- Layout





Apertures typically r=1cm in incoming beamline, and r=1.2cm+0.08cm*Z(m) in the outgoing beamline

Be-SS connection is permanent

Summary

- Pumping system without *in-situ* baking
  - **If any pumps are available at z < L*, and waiting for several days is allowable, it may be possible.**
  - **Water cooling may be safe.**
    - Mild baking using the cooling channel may be helpful.
- Issues to be discussed
  - **Design of beam pipe inside of cryogenic system.**
    - Transition from 2 K to room temperature
  - **Detailed consideration about gas desorption by SR, ions**
    - Experience in LEP, LHC
  - **Connection of beam pipes**
    - Quick clump?
  - **RF-shielding of bellows, flanges (?)**
  - **……….**

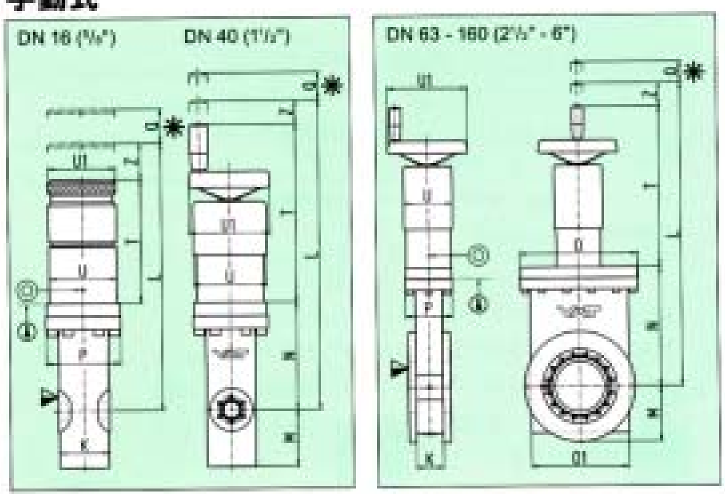
References

- Dimension of gate valve
  - **From VAT catalogue**

- Ex

オールメタルゲートバルブ

手動式



▼ valve seat side ✱ required for dismantling Ⓛ leak detection hole Ⓑ bake-out a

フランジ寸法は75頁参照

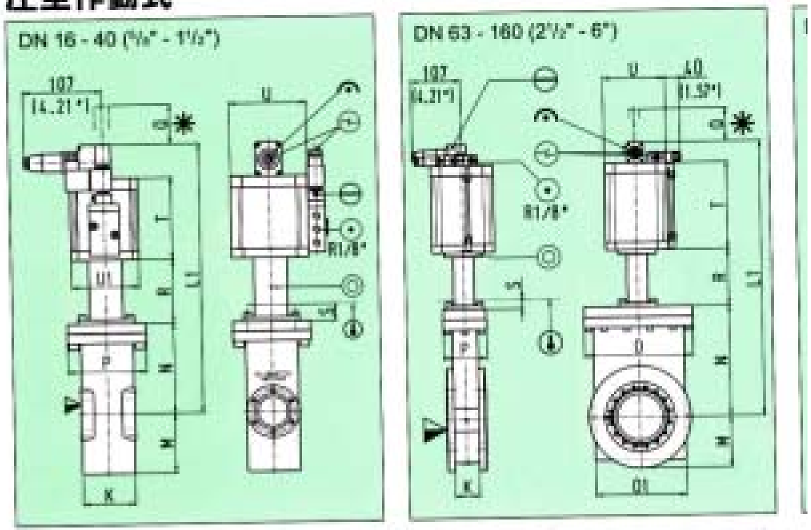
DN	mm	16	40	63	100
	inch	5/8	1 ½	2 ½	4
K	mm	48.5	70	46	54
	inch	1.91	2.76	1.81	2.13
L	mm	261	414	564	678
	inch	10.28	16.3	17.13	26.69
M	mm	56	80	90	111
	inch	2.2	3.15	3.54	4.37
N	mm	106	132	209	240
	inch	4.17	5.2	8.23	9.45
O	mm	–	–	189	237
	inch			7.44	9.33
O1	mm	–	–	156	197
	inch			6.14	7.76
P	mm	73	105	77	94
	inch	2.87	4.13	3.03	3.7
Q	mm	150	200	280	320
	inch	5.9	7.87	11.02	12.6
T	mm	122	230	266	324
	inch	4.8	9.06	8.9	12.76
U	mm	66	90	97	97
	inch	2.6	3.54	3.81	3.81
U1	mm	66	100	100	160
	inch	2.6	3.7	3.94	6.3
V	mm	–	–	–	–
	inch				
W	mm	–	–	–	–
	inch				
X	mm	–	–	–	–
	inch				
Y	mm	–	–	–	–
	inch				
Z	mm	33	52	79	114
	inch	1.3	2.05	3.11	4.45

74

- Ex

オールメタルゲートバルブ

圧空作動式



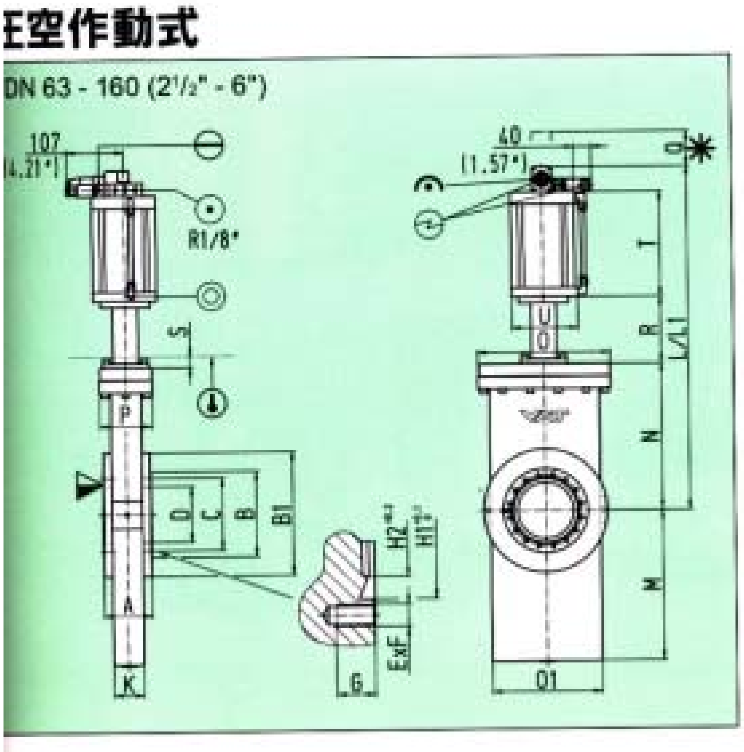
▼ valve seat side
⊖ emergency operation
mechanical position indication
✱ required for dismantling
⊙ compressed air connection
⊜ electrical connection

フランジ寸法は77頁参照、L1 及び R は延長型アクチュエータの寸法

DN	mm inch	16 5/8	40 1 1/2	63 2 1/2	100 4	160 6
K	mm inch	48.5 1.91	70 2.76	46 1.81	54 2.13	58 2.28
L	mm inch	–	–	403 15.87	473 18.62	616 24.25
L1	mm inch	312 12.28	372 14.65	527 20.75	597 23.5	740 29.13
M	mm inch	56 2.2	80 3.15	90 3.54	111 4.37	144 5.67
N	mm inch	106 4.17	132 5.2	209 8.23	240 9.45	329 12.95
O	mm inch	–	–	189 7.44	237 9.33	287 11.3
O1	mm inch	–	–	156 6.14	197 7.76	253 9.96
P	mm inch	73 2.87	105 4.13	77 3.03	94 3.7	93 3.66
Q	mm inch	150 5.9	200 7.87	280 11.02	320 12.6	450 17.72
R	mm inch	64 2.52	86 3.39	124 4.88	124 4.88	124 4.88
S	mm inch	15 0.59	20 0.79	20 0.79	20 0.79	20 0.79
T	mm inch	90 3.54	109 4.29	149 5.87	188 7.4	242 9.53
U	mm inch	83 3.27	103 4.06	98 3.86	135 5.31	190 5.91
U1	mm inch	70 2.76	90 3.54	–	–	–
V	mm inch	–	–	–	–	–
W	mm inch	–	–	–	–	–
X x Y	mm inch	–	–	–	–	–

76

- Ex



L1及びRは延長アクチュエータ用

DN	mm	63	88	100	160	200
	inch	2½	3½	4	6	8
K	mm	46	54	54	75	78
	inch	1.81	2.13	2.13	2.95	3.07
L	mm	459	537	537	702	851
	inch	18.07	21.14	21.14	27.64	33.5
L1	mm	583	661	661	826	975
	inch	22.95	26.02	26.02	32.52	38.39
M	mm	215	272	272	356	460
	inch	8.46	10.7	10.7	14.02	18.11
N	mm	231	264	264	370	443
	inch	9.09	10.39	10.39	14.57	17.44
O	mm	189	237	237	287	372
	inch	7.44	9.33	9.33	11.3	14.65
O1	mm	156	197	197	253	336
	inch	6.14	7.76	7.76	9.96	13.23
P	mm	77	94	94	93	114
	inch	3.03	3.7	3.7	3.66	4.49
Q	mm	420	520	520	700	880
	inch	16.54	20.47	20.47	27.56	34.65
R	mm	124	124	124	124	124
	inch	4.88	4.88	4.88	4.88	4.88
S	mm	20	20	20	20	20
	inch	0.79	0.79	0.79	0.79	0.79
T	mm	183	228	228	287	363
	inch	7.2	8.98	8.98	11.3	14.29
U	mm	98	135	135	190	230
	inch	3.86	5.31	5.31	7.48	9.06
V	mm					346
	inch					10.24
W	mm					302
	inch					14.89
X	mm					40
	inch					1.57
Y	mm					40
	inch					1.57