L-Neon Cooling Test of the Convection-Type L-H_2 Absorber

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KEK LH_2 Absorber Home Page
http://ishimotopc2.kek.jp/absorber/

Mucool/MICE Meeting at IIT, Feb 3-9, 2002

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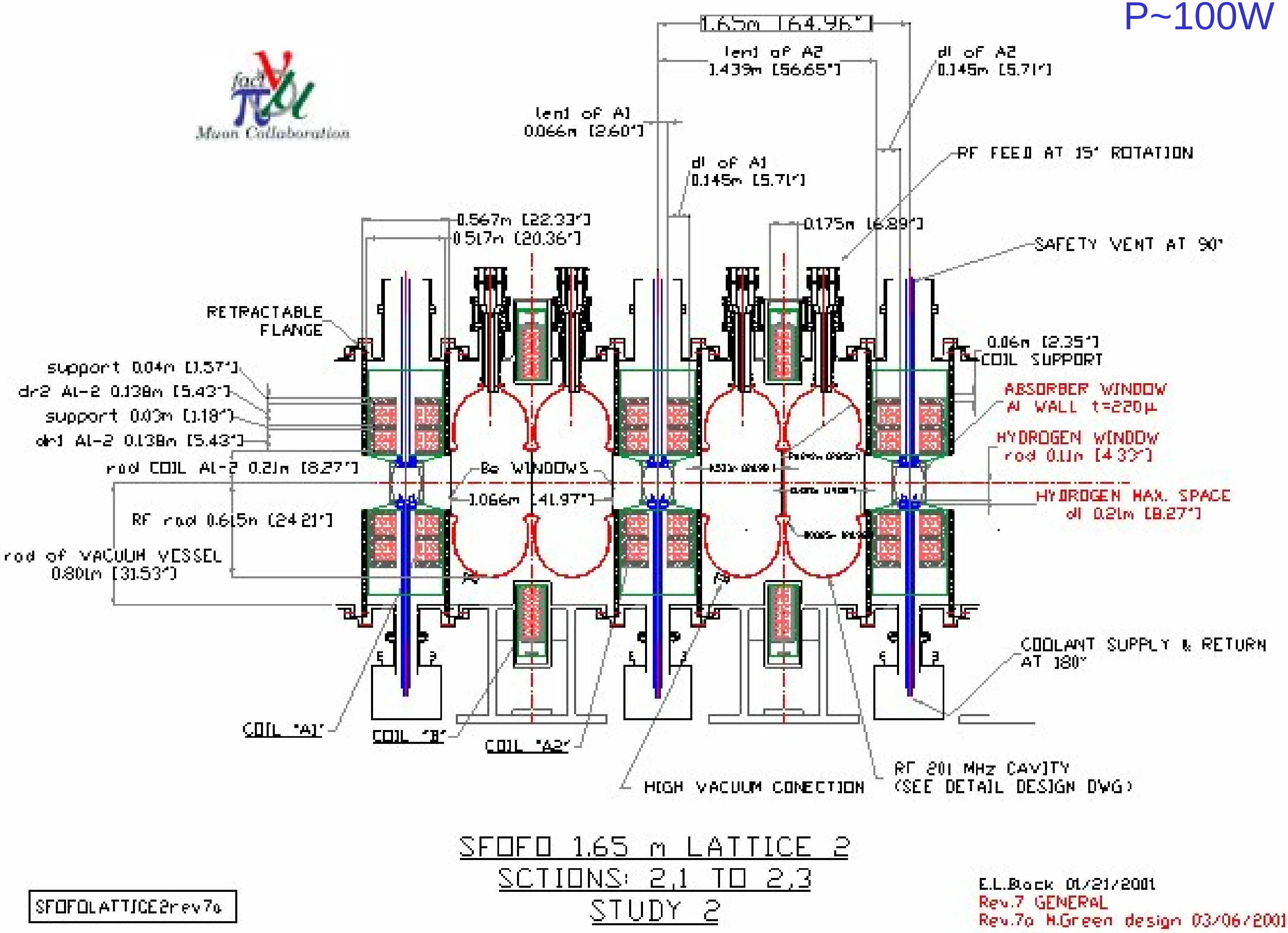
LH_2 Absorber

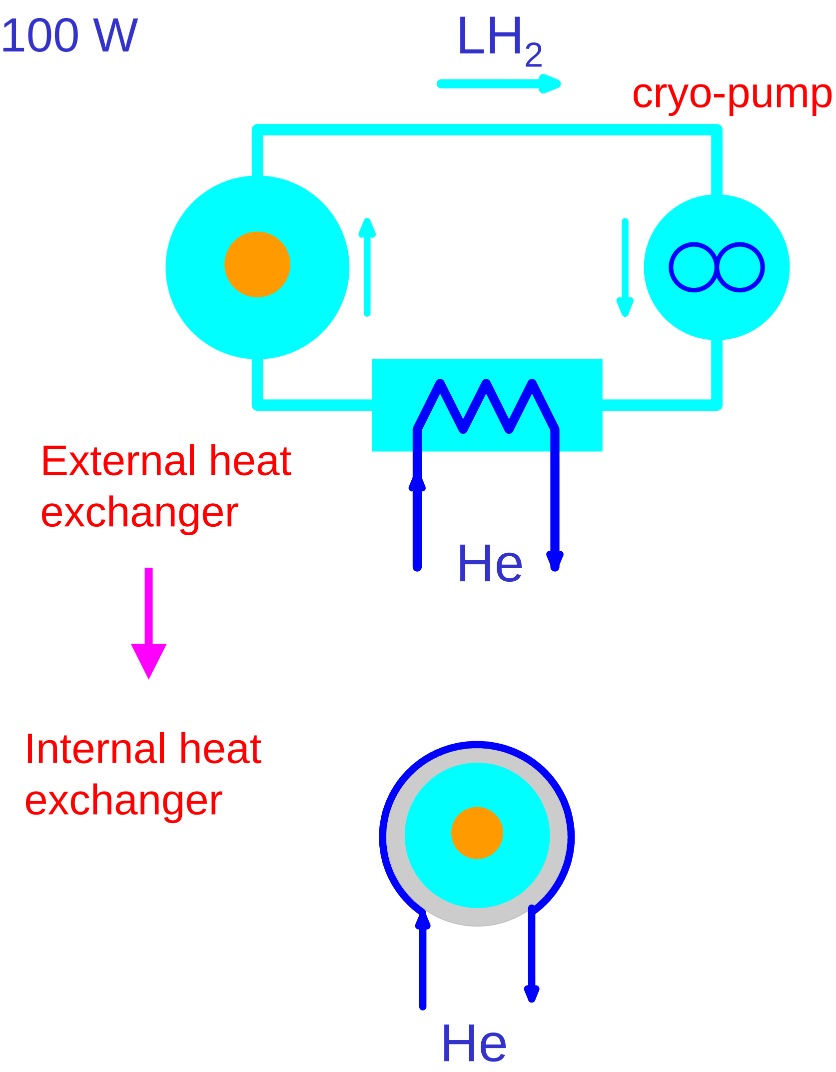
D=22cm, L=21cm

P~100W



LH_2 Absorber

Cooling power ; > 100 W



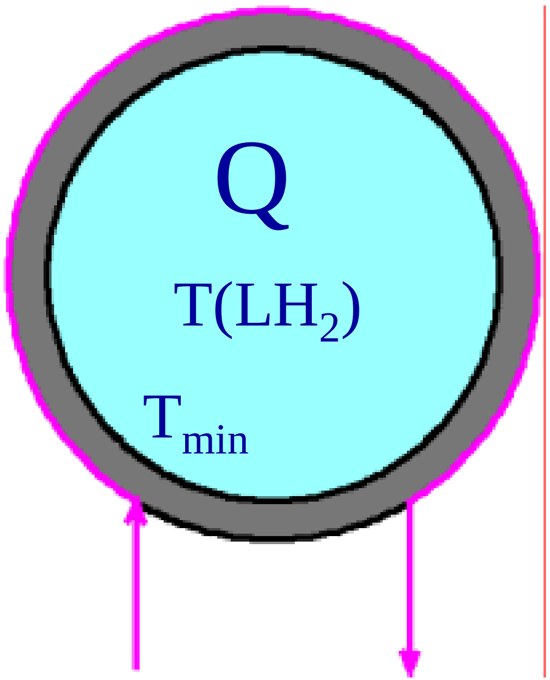
(1) **Forced Flow Cooling**

- high power; > 500 W (SLAC; LH_2T)
- external heat exchanger
- cryo-pump
- large LH_2 volume (safety problem)
- 2 atm (SLAC) → 1 atm (FNAL) ?
- cost

(2) **Convection Cooling**

- lower power ?
- internal heat exchanger
- simple
- small LH_2 volume
- low cost

Cooling Principle



Gas-He

T_{in} T_{out}

dT(K), dP~0

He Flow: n (l/s)

(1) Inlet temperature

$T_{min}(LH_2) > 13.8K$; avoid Solid-H_2

$T_{in} = 5 \sim 10K$ **<Indirect H.E.>**

(2) Max. operation temperature

$T_{max}(LH_2) < 20$ K (1 atm)

; minimize pressure to windows

$T_{out} = 15 \rightarrow 20K$ **<Boiling Effect>**

; bubble formation enhanced the convection

For example;

Q=100 W, T_{in}= 6 K, $T_{out} \sim$ 20 K, dT ~ 14K

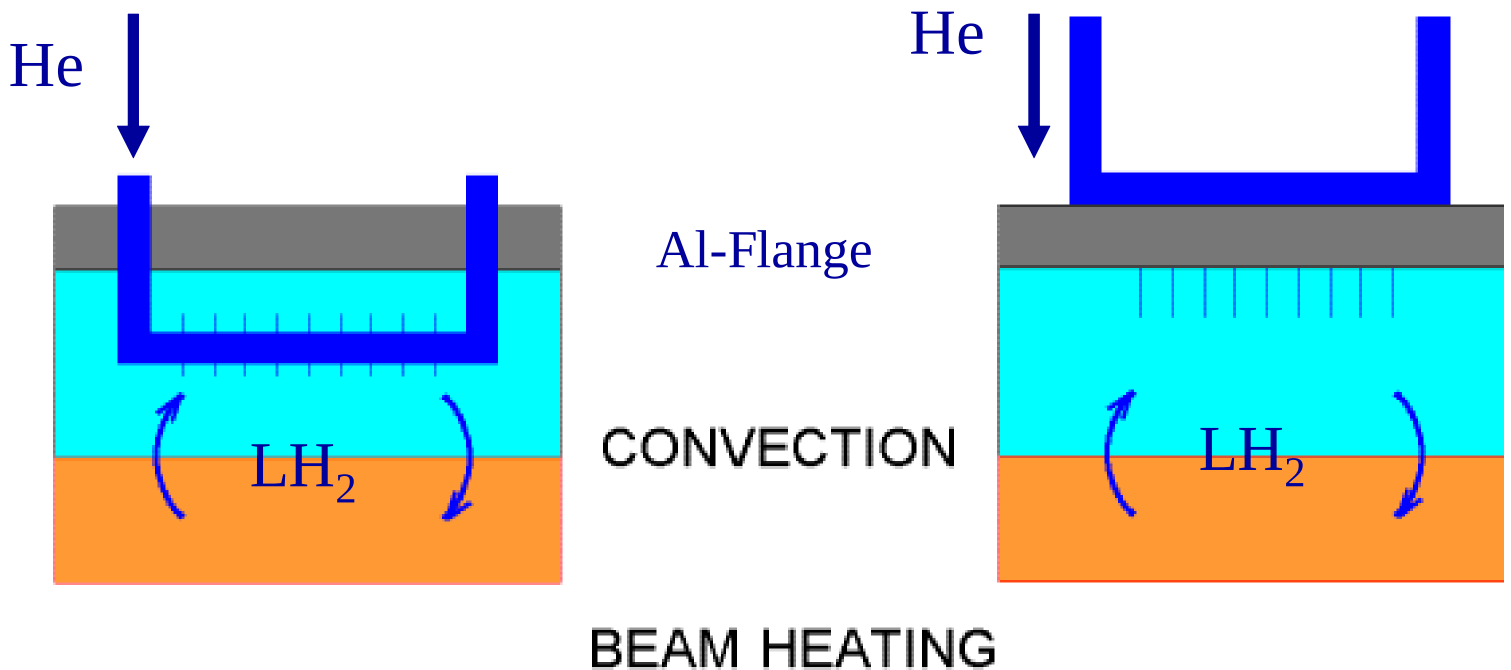
Required He flow rate: n

~ <u>**38** (l/h) : Liquid He</u>

~ <u>**7** (l/s) : Gas He</u>

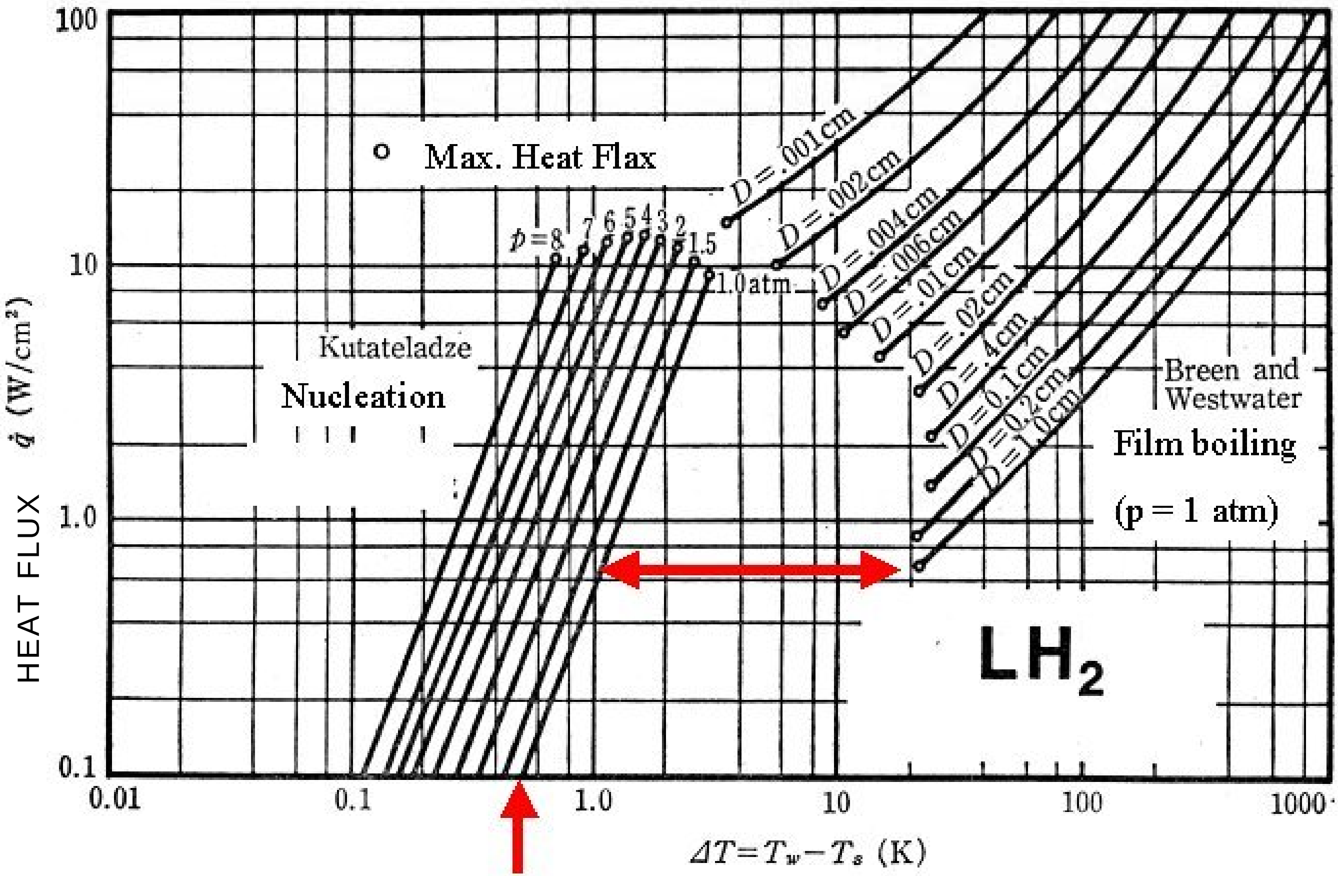
Heat Exchanger

direct heat exchanger | **indirect heat exchanger**



	direct heat exchanger	indirect heat exchanger
He inlet temperature:	14 K	5 - 10K (needs test)
Heat exchanger area:	small	large
He flow rate:	high	low (1/5 – 1/10)
flow control:	not required (T_{in} >14K)	required (over cool)

Nucleation Heat Transfer



Nucleation Heat Transfer; q = 0.1 W/cm^2 at 1 atm, dT = 0.55 K

Boiling Effect of LH_2 absorber

Nuclear boiling heat transfer ; hot wall

LH_2 ; $q = 0.1\ W/cm^2$ at 1 atm, $dT = T_w - T_L = 0.55\ K$

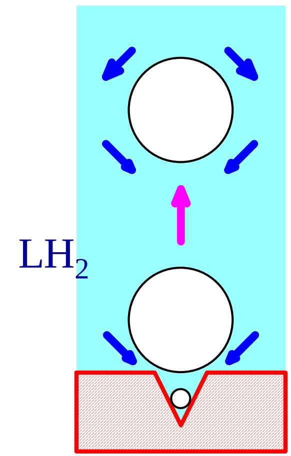
Then, Q = 200W when A = 0.2 m^2

(1) bubble formation and takeoff

- Enhance surface heat transfer by nucleation

(2) upward movement

- Enhance heat conductivity in LH_2



Boiling by beam ; cold wall

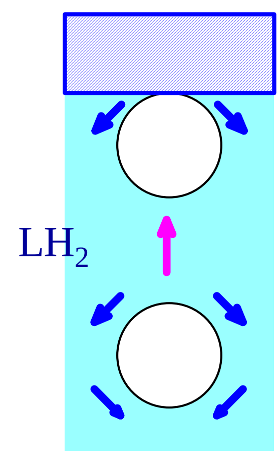
< needs beam test>

(1) bubble formation and upward movement

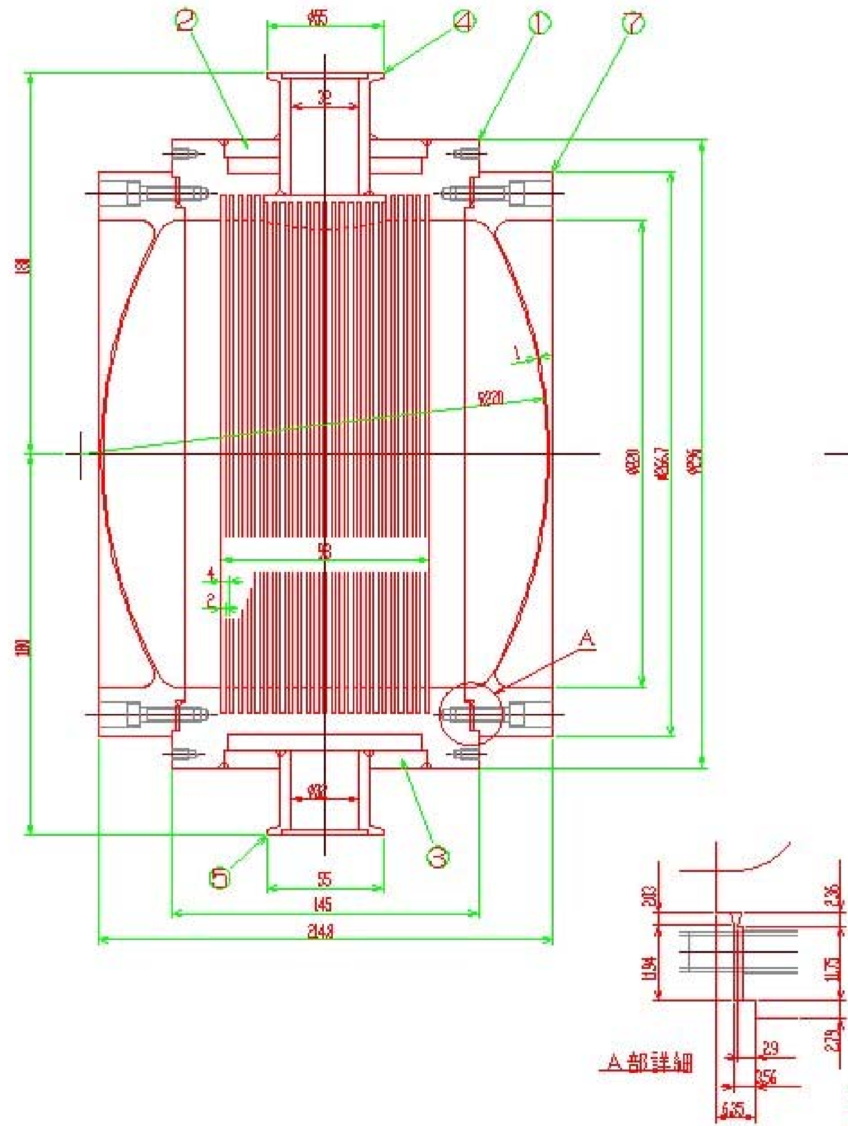
- Enhance heat conductivity in LH_2

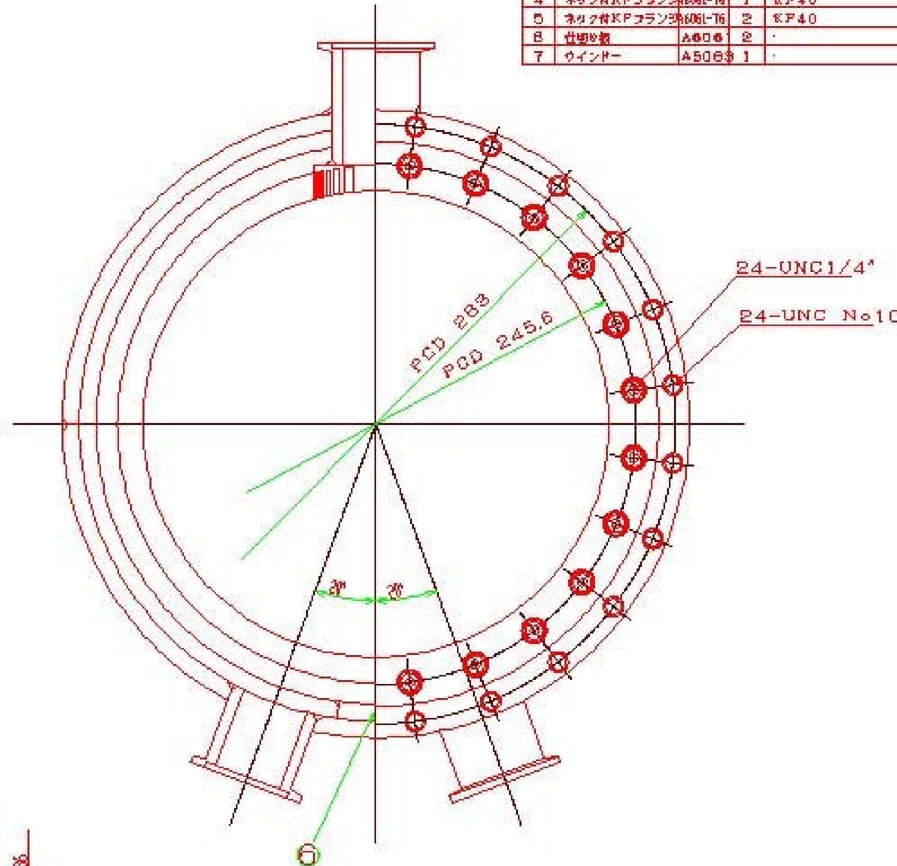
(2) bubble touch the wall

- Enhance surface heat transfer by touching the wall ?



品番	名称	材質	数量	備考
1	ボディ	A5083	1	・
2	カバー	A5052	1	・
3	カバー	A5052	1	・
4	ネック付KFフランジ	A6061-T6	1	KF40
5	ネック付KFフランジ	A6061-T6	2	KF40
6	仕切り板	A6061	2	・
7	ウインドー	A5083	1	・





△				
△				
△				
改訂	年月日	記事	担当	承認

客先名		名称	LH2 ABSORBER
客先図		図番	
承認 / 審査 / 設計	尺度 M	平成13年08月1日	

MPC 株式会社ミラプロ

D=22cm, L=21cm

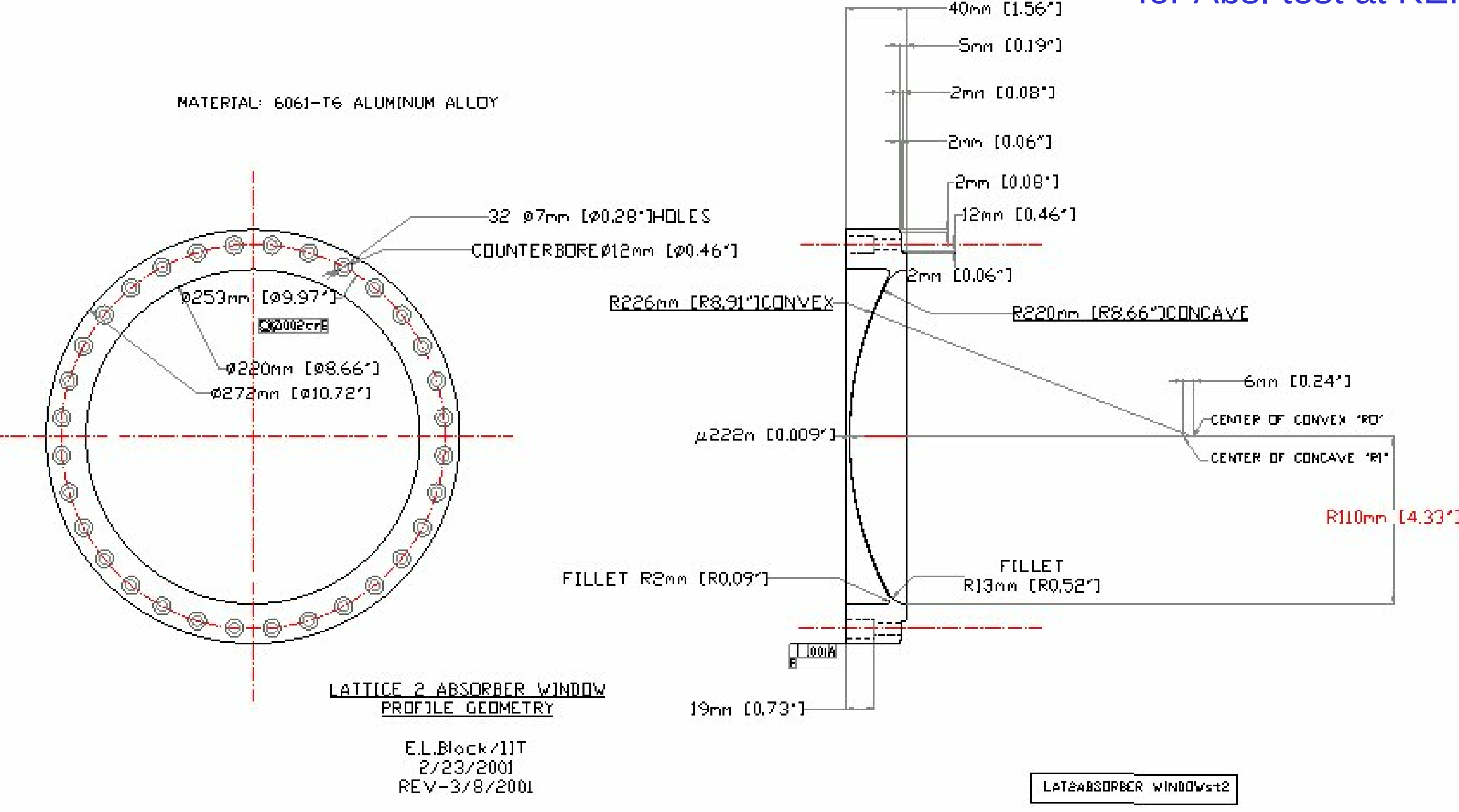
LH_2 Absorber Window for LATTICE 2

(IIT design)

t = 0.222 mm

t =1 mm

for Abs. test at KEK



組図

品番	名称	材質	数量	備考
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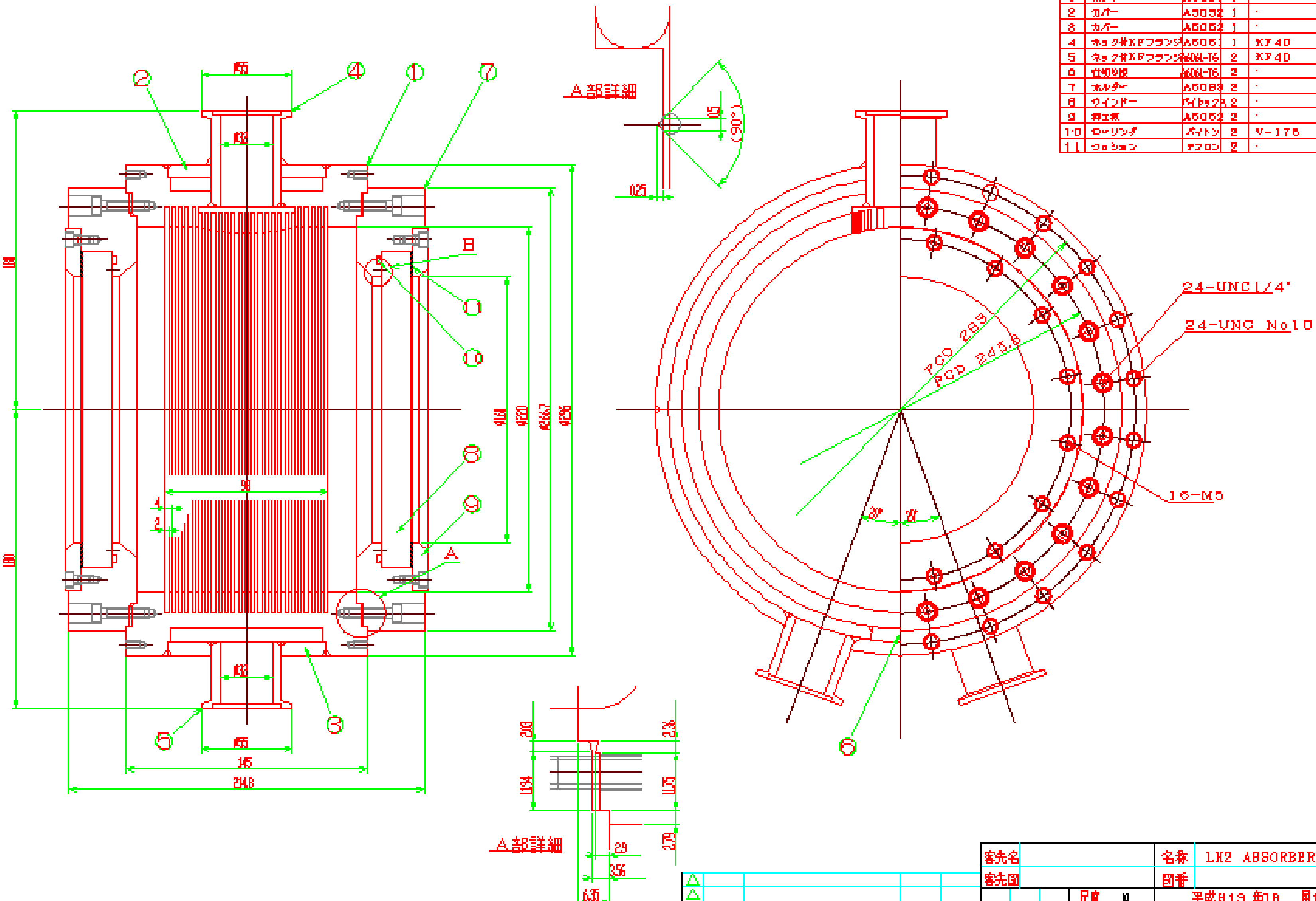
6	仕切り板	A6061-T6	2	・
7	ホルダー	A5083	2	・
8	ウインドー	パイレックス	2	・
9	押エ板	A5052	2	・
10	Oーリング	バイトン	2	V-170
11	クッション	テフロン	2	・



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客先名		名称	LH2 ABSORBER
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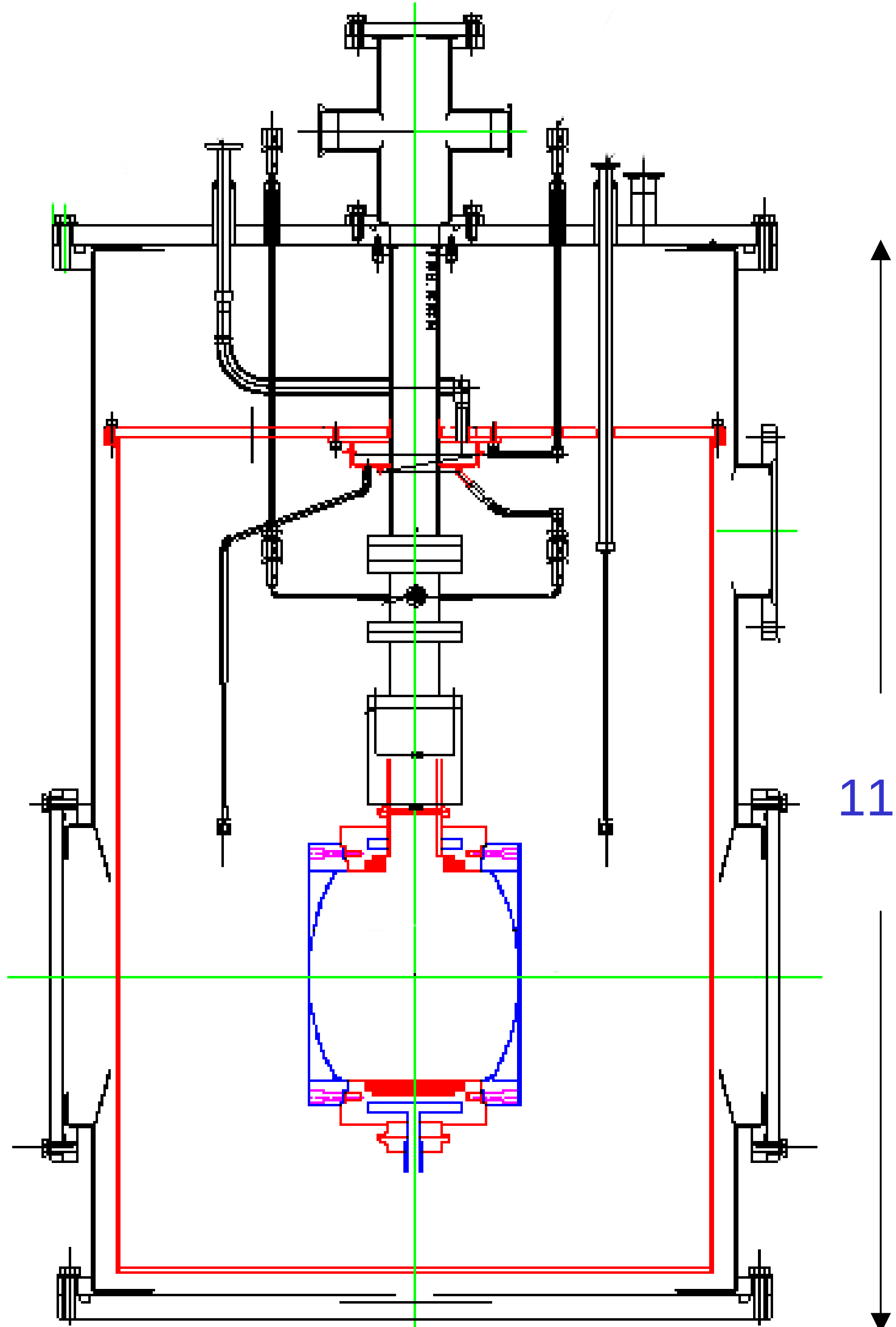
承認 審査 設計	尺度 1/1	平成H13 年10 月1 日	

MPC 株式会社ミラプロ

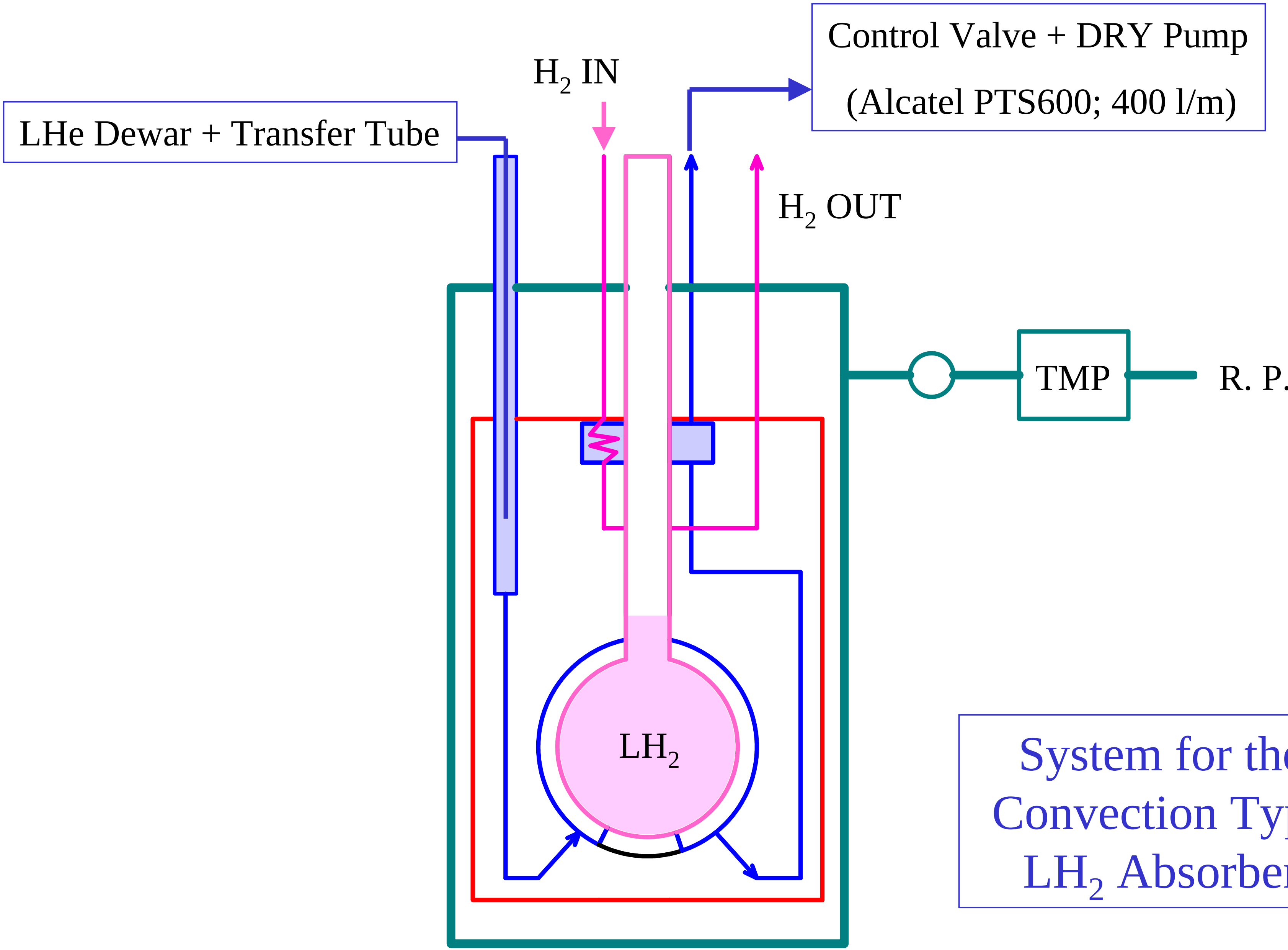
Test Cryostat for LH_2 Absorber at KEK



110 cm

D=22cm, L=21cm

System for the Convection Type LH_2 Absorber



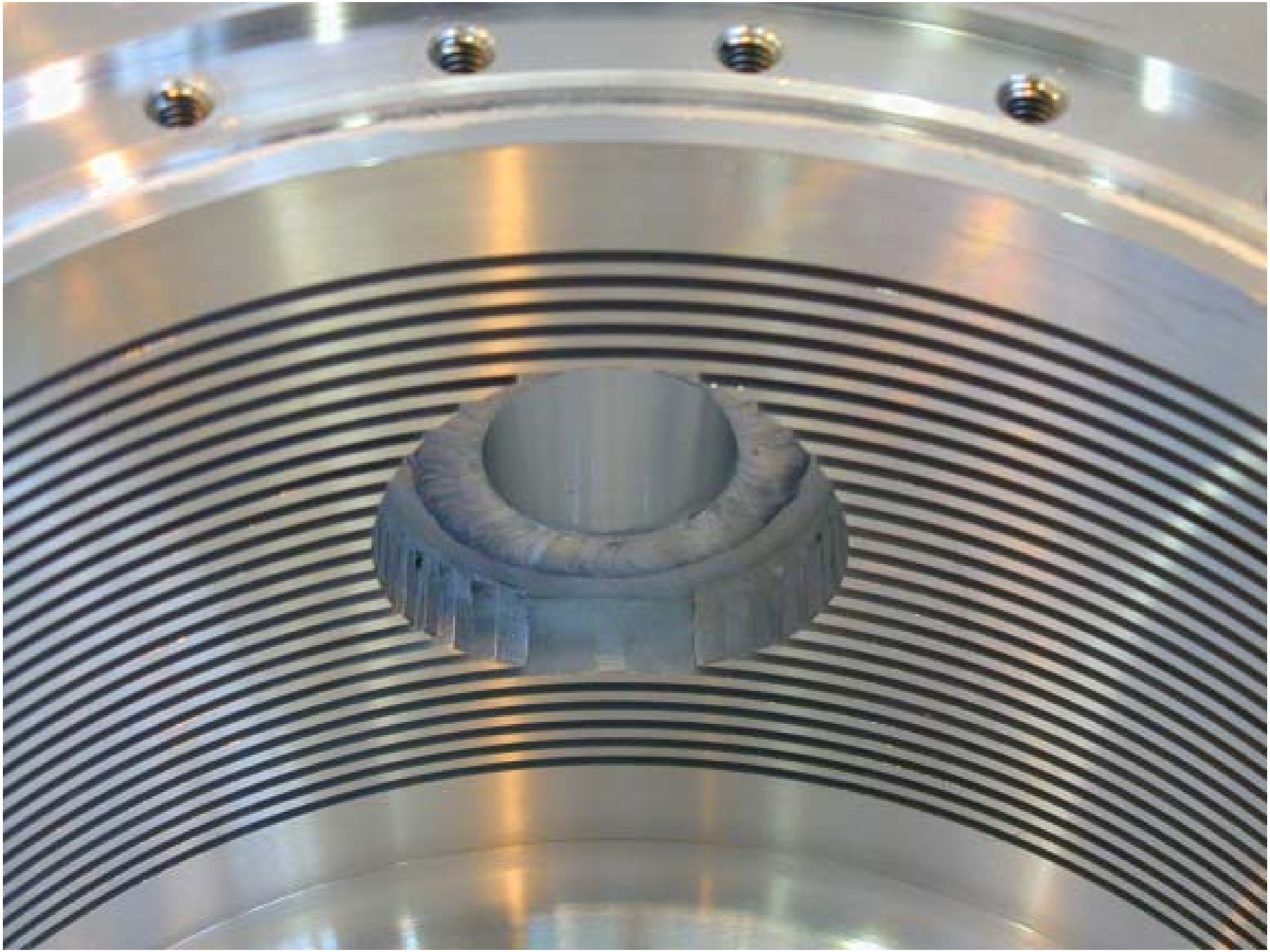
LH_2 and LNe and GHe

	LH_2	LNe	GHe (4.2K,1 atm gas)
molecular weight: g/mol	2	20	4
boiling point (1atm) : K	20.4	27.1	--
triple point: K(Torr)	13.96 (54.0)	24.56 (324.8)	--
density(b.p.): g/cm^3	0.0708	1.204	0.0172
specific heat: J/gK	9.28	1.84	5.23
viscosity: 10^{-7} kg/ms	124	1240	13.0
thermal conductance: 10^{-3} W/mK	119	113	9.0

Test at KEK; GHe & LNe

Test at FNAL; LH_2

D=22cm, L=21cm, V= 8 litter



24 Fins, Pitch = 2 mm, Depth= 12 mm

Test Window Al t = 1mm

Glass Window

…. leaked at 80-300 K

Heater

Stainless Steel Wire

d = 0.34mm

Resistance;

= 7.5 Ohm/m at R.T.

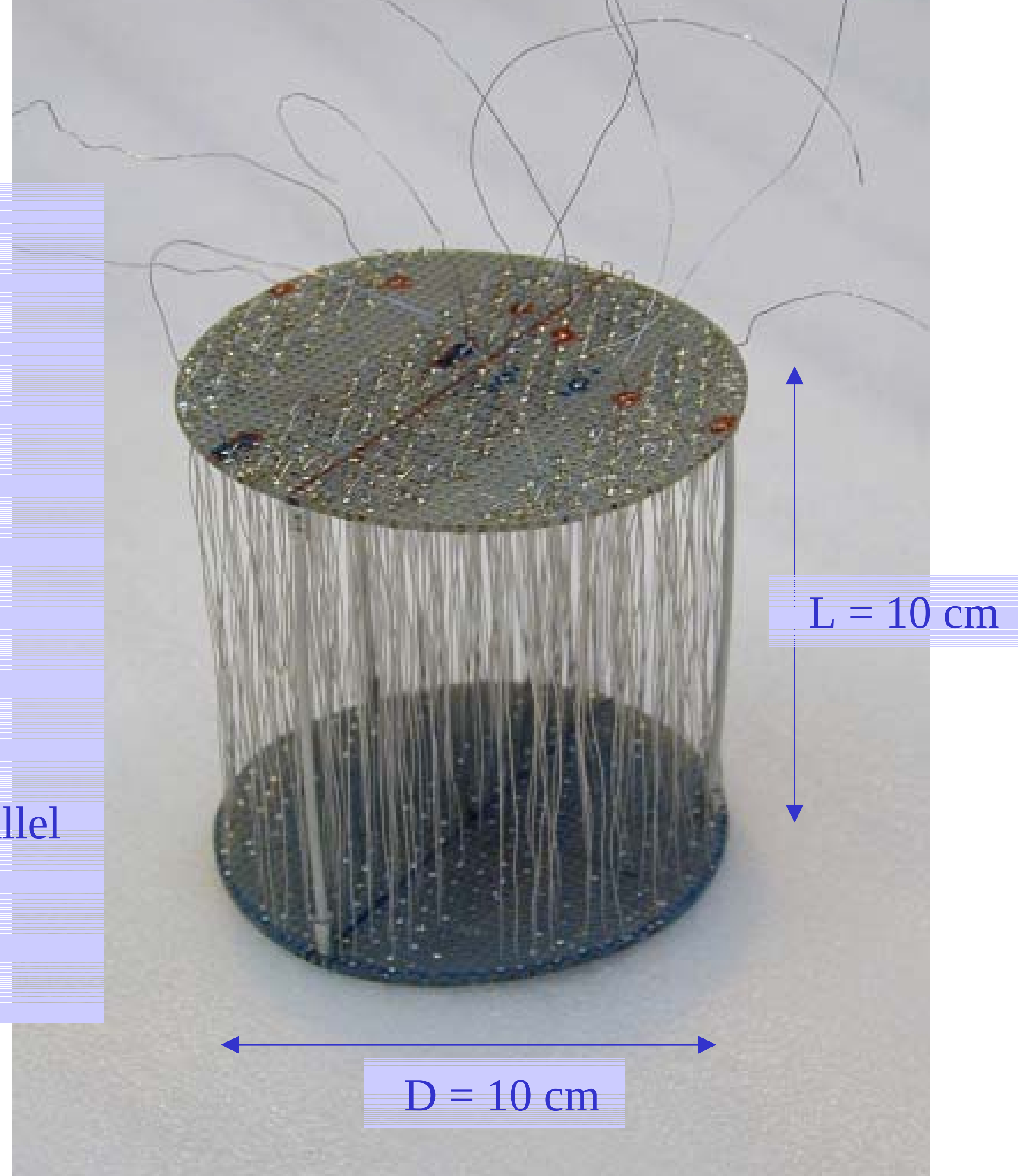
~ 6 Ohm/m at 27K

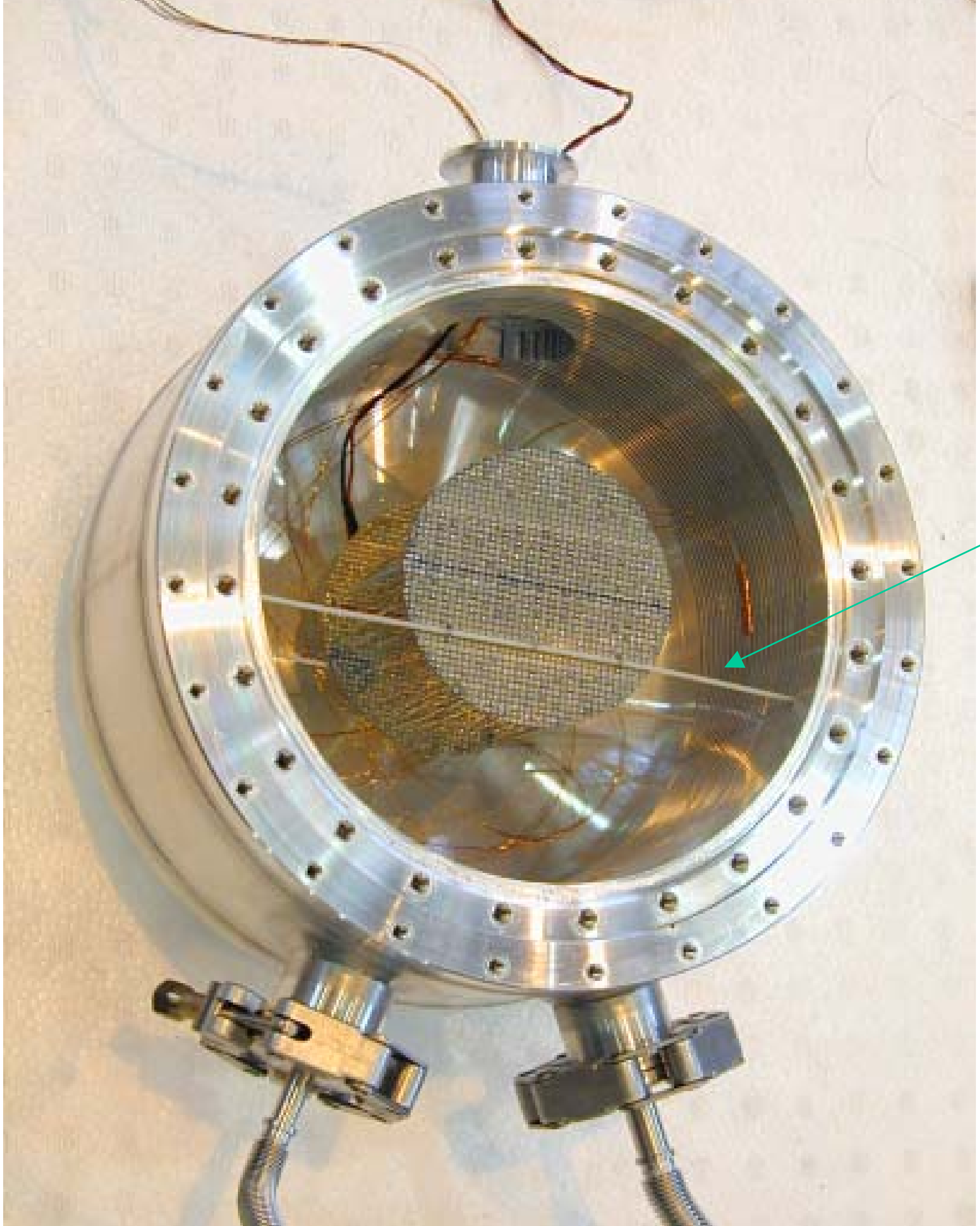
Total;

5 wires of 6 m length parallel

~ 9 Ohm at R.T.

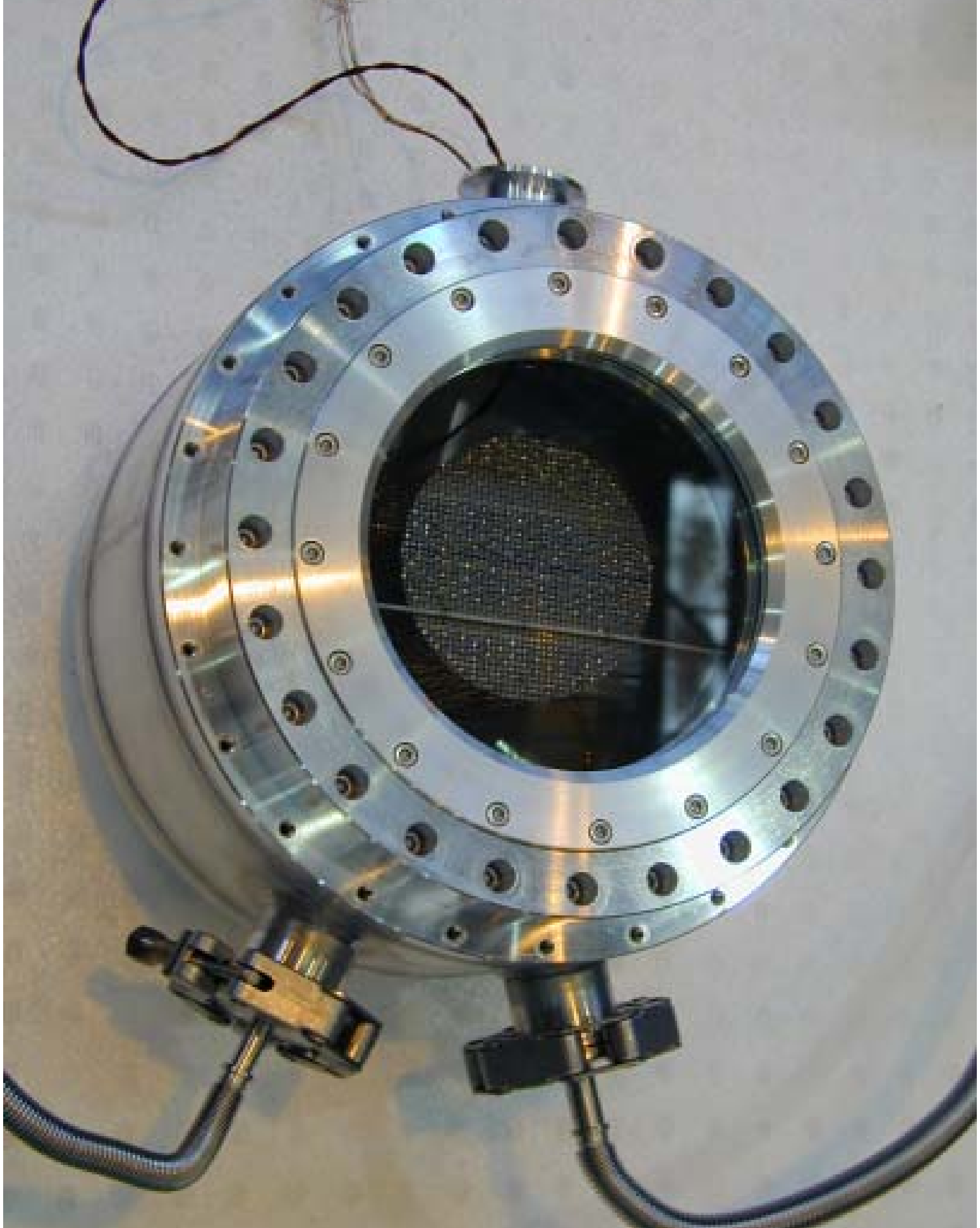
~ 7.4 Ohm at 27K





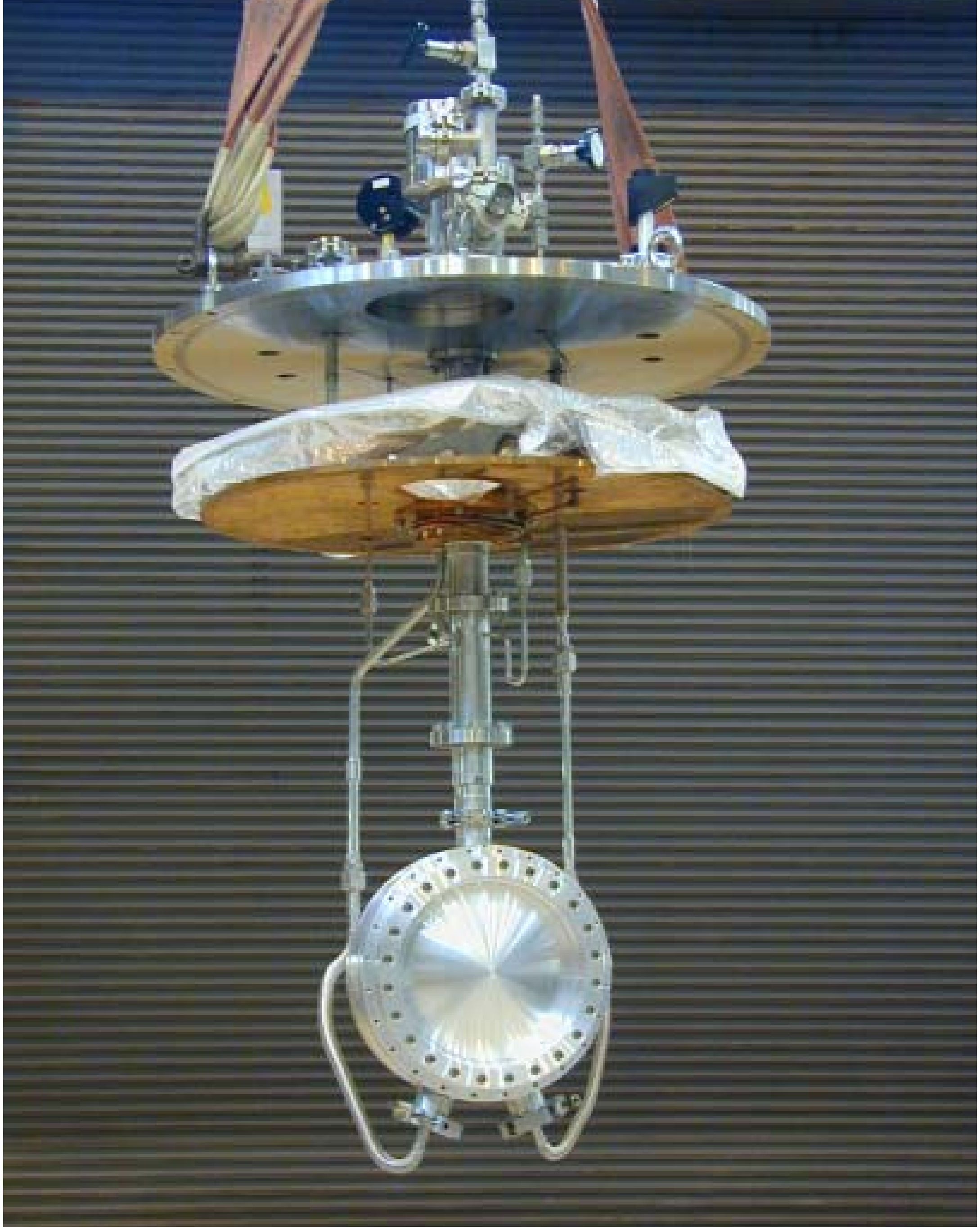
2 GFRP Rods

d = 2 mm



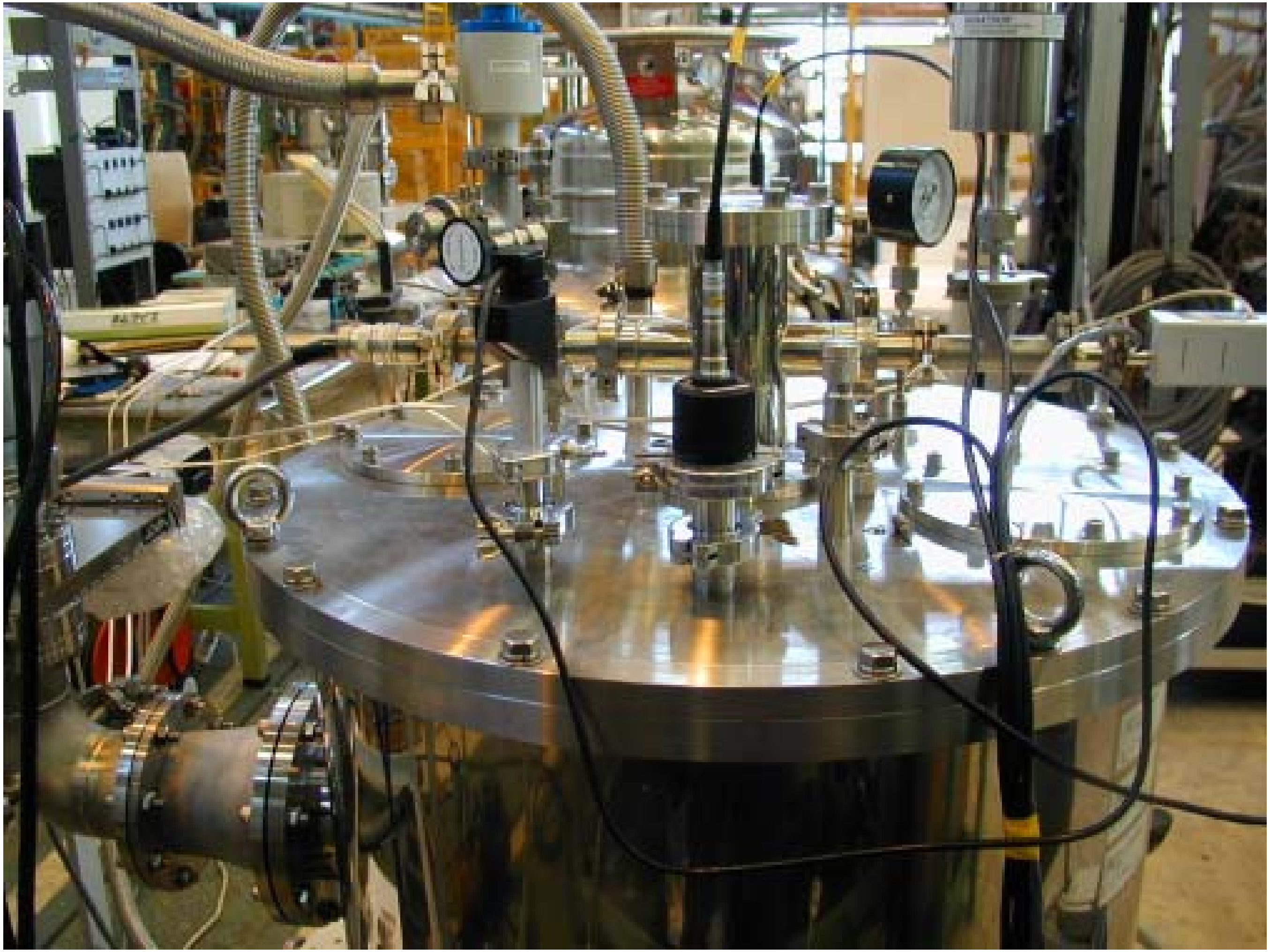
Glass Window Assemble

not used for this test



Test Cryostat for LH_2 Absorber

Top Flange of Cryostat



Cryostat and Dewar (250 l)

Pressure & Vacuum Measurements

P.S. for T.M.P.

Data logging by Keithley 2700 D.M.M.

DC-P.S. for Pt-Co Thermometer $I_m = 1$ mA

DC-P.S. for

Absorber Heater

I_{max} = 2 A

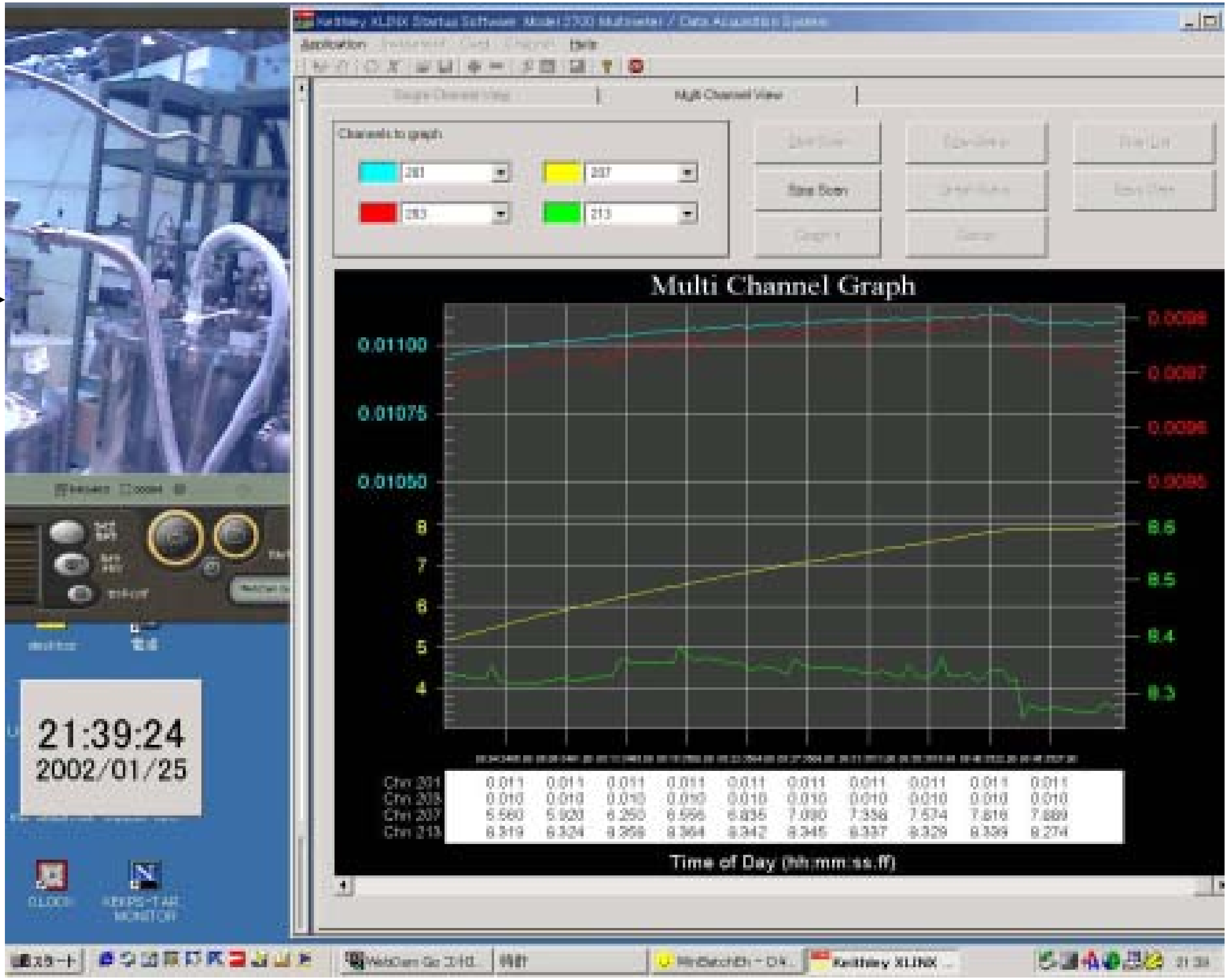
V_{max} = 100 V

PC Monitoring of Keithley 2700

Display Capture and Monitoring by the Internet every 1-5 min

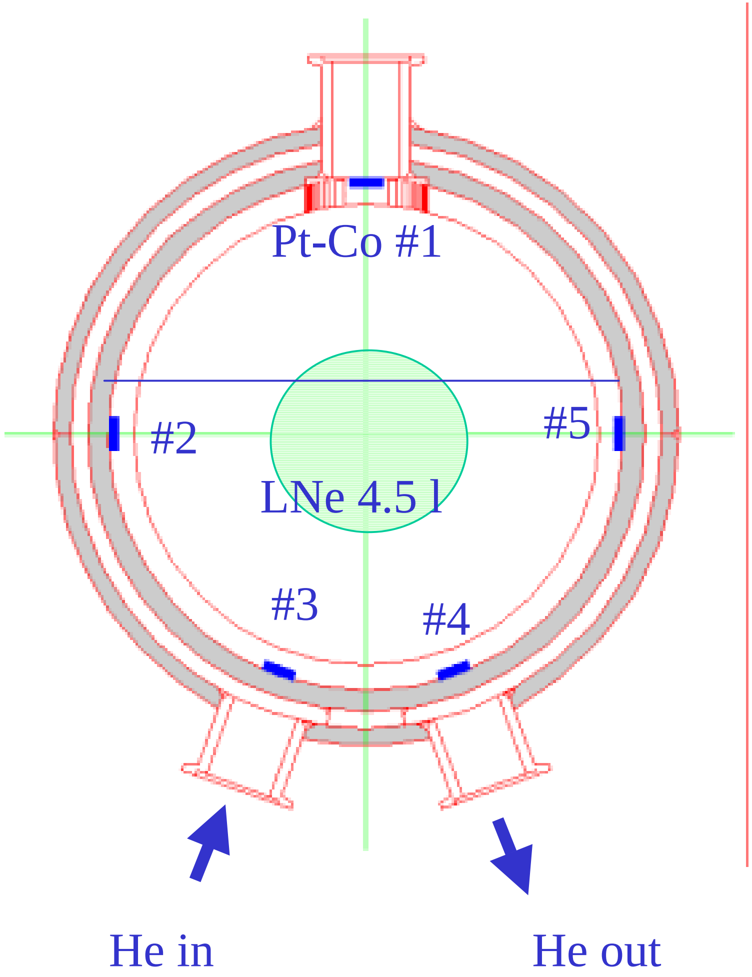
http://benkeipc.kek.jp/webcap.jpg

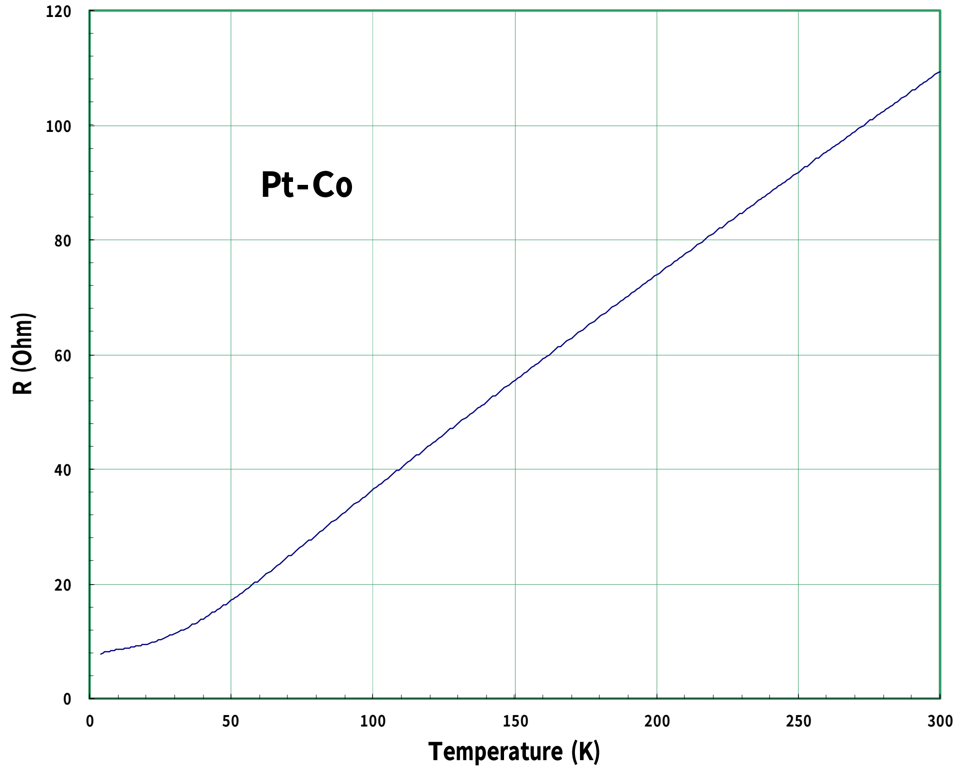
PC Live Camera



Monitor of Keithley 2700

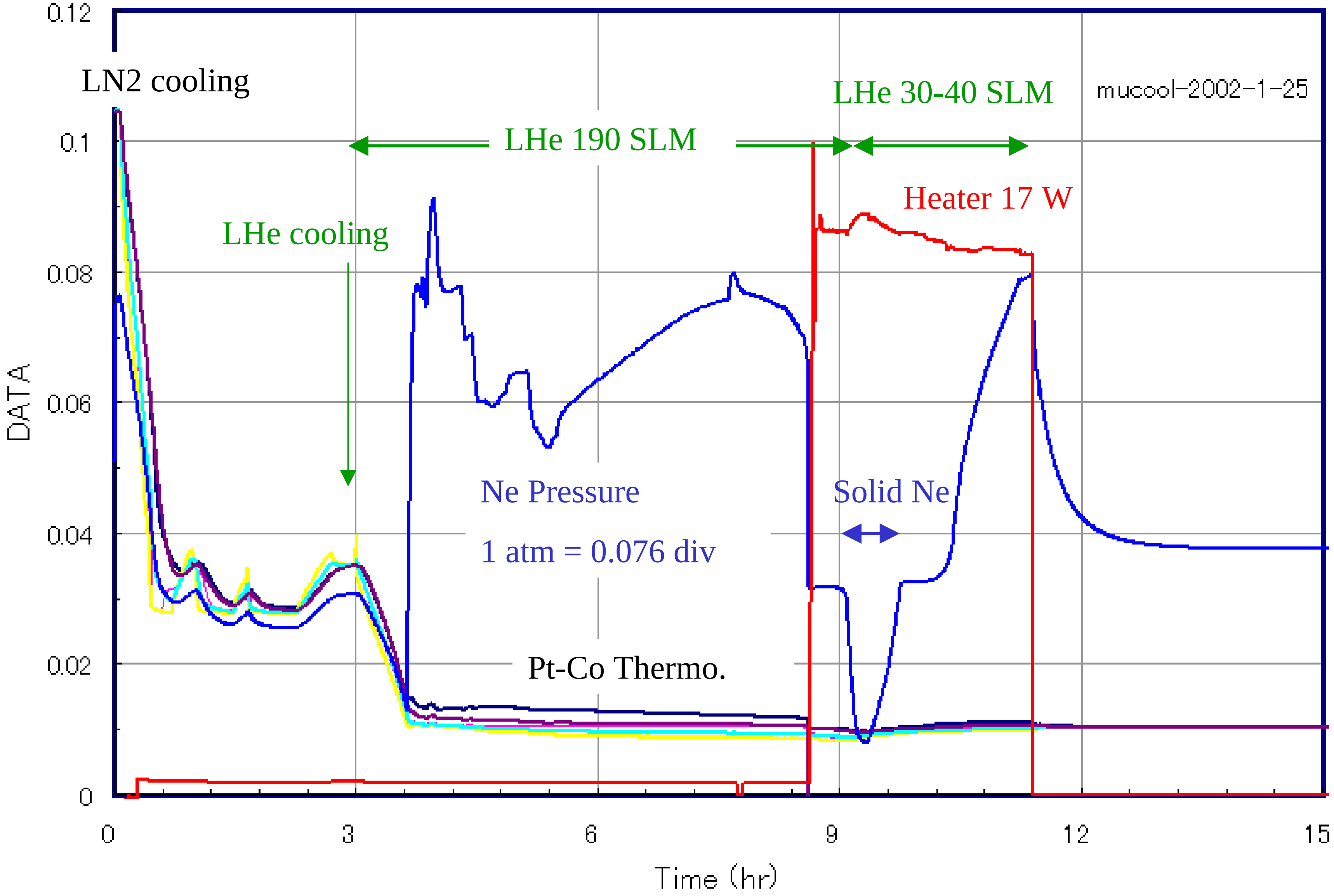
Temperature Measurement



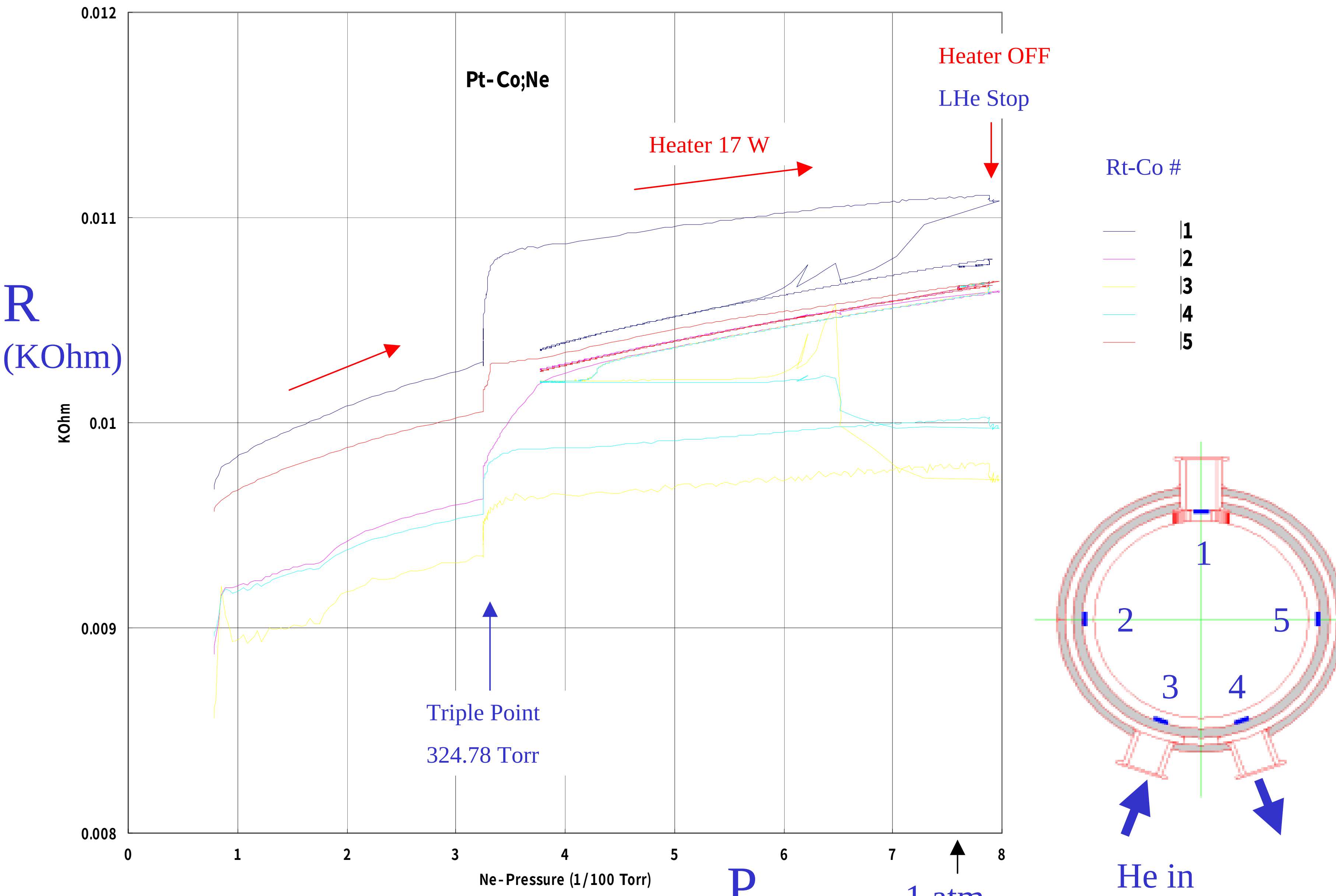


Pt-Co Thermometer

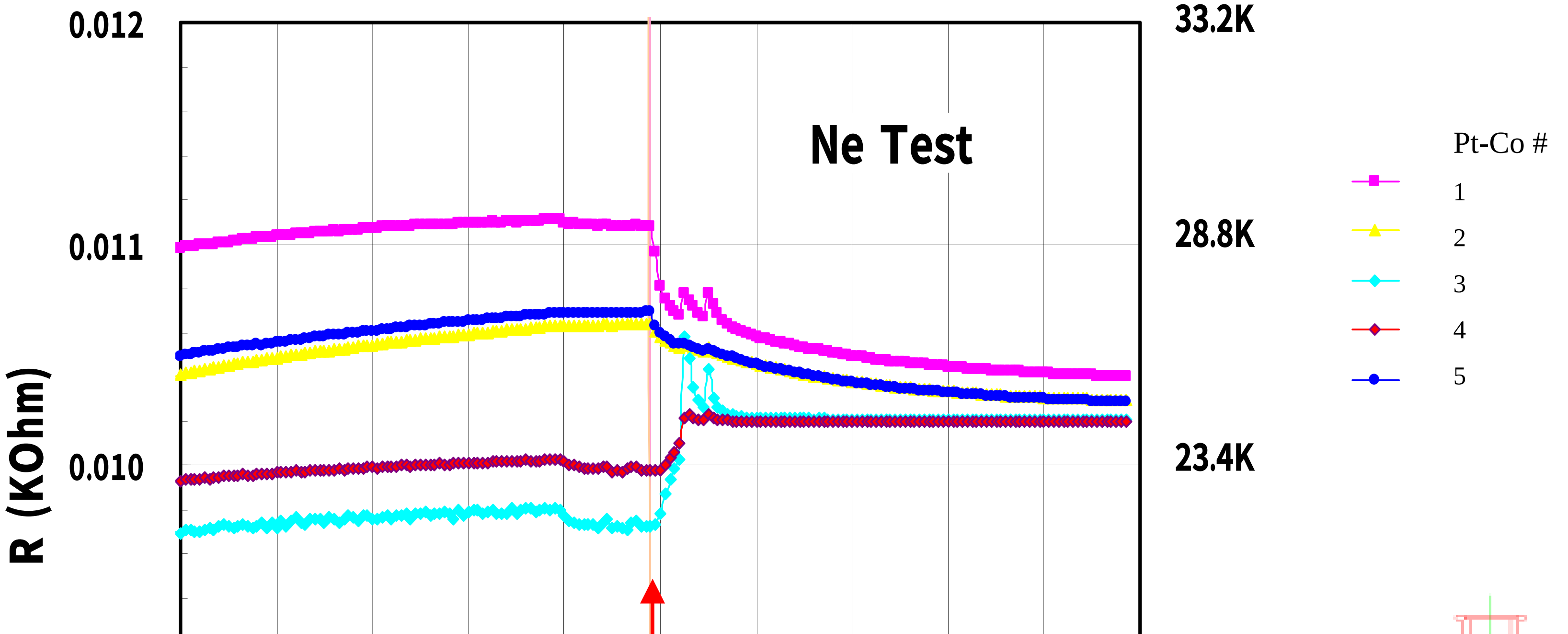
Data Record of LNe Test

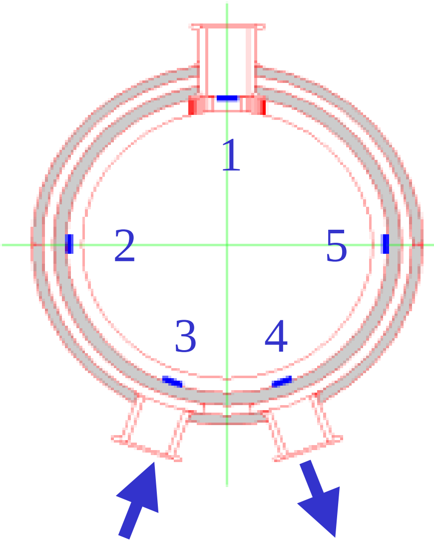


Correlation of Ne Pressure and Thermometer



Detail Data of Thermometer with/without Heater

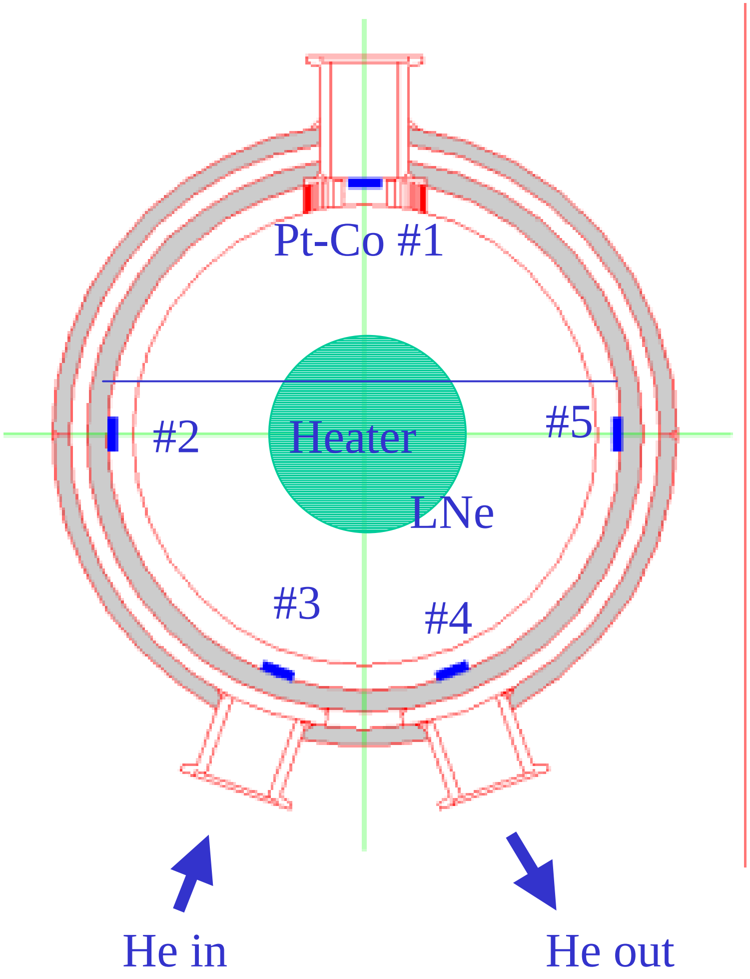




He in

Temperature Distribution of LNe cooling

$Q_H = 17\ W$



Pt-Co No.	R (Ohm)	Temp. (K)
#1	11.07	29.2
#2	10.63	27.0
#3	9.71	21.3
#4	9.97	23.3
#5	10.68	27.1

Conclusion

(1) We have succeed to operate the absorber with LNe at T=27K and Q_H=17W. The LHe consumption was 3.4 l/hr.

(2) Heater power limit was due to the DC power supply < 2 A.

(3) Max. LHe flow was 17 l/hr, when Ne was condensed.

→ Q_H = 85 W …. if it is linear. Not yet reached the LHe flow limit.

(4) The glass window was leaked at low temperature,

it needs a modification of In seal.

(5) Test plan; - continue cooling power measurements by LNe

- LNe operation with new glass window

- observation of bubble and convection

(6) Preparation for LH_2 test at FNAL 2002 ~ 2003