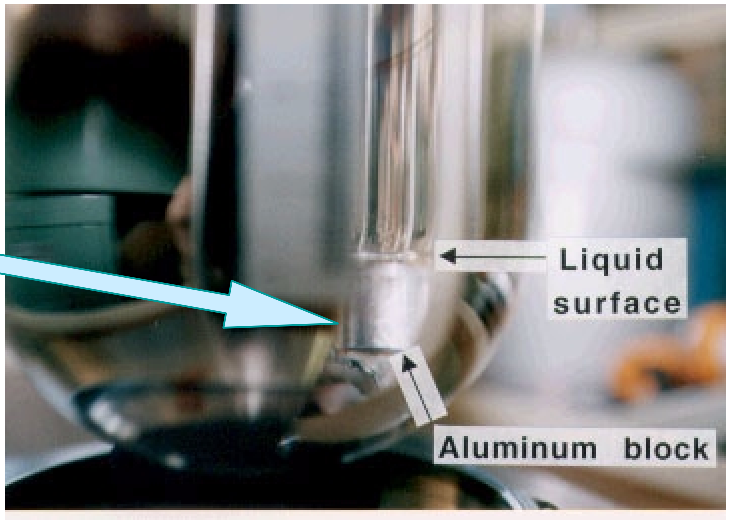
LXe PHOTON DETECTOR - CRYOGENICS

KEK

Tom HARUYAMA

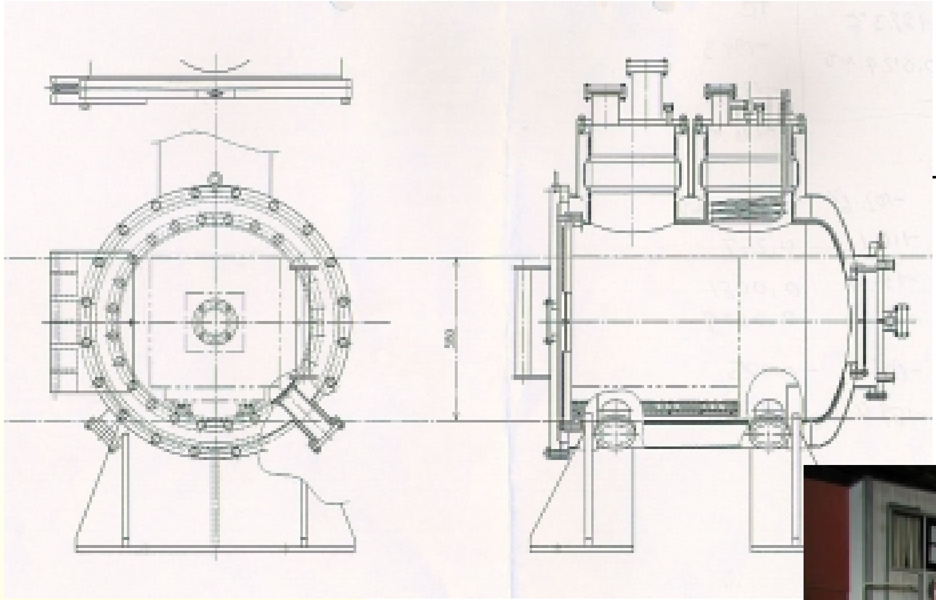
1. Cryogenic operation of 120 L large-proto detector
2. Pulse tube refrigerator development
3. Purification scheme
4. Final photon detector system

LXe is heavier than Aluminum!



2002.7.16 PSI

CRYOGENIC OPERATION FOR LARGE-PROTO DETECTOR



-LXe 120 L
-PMT 250

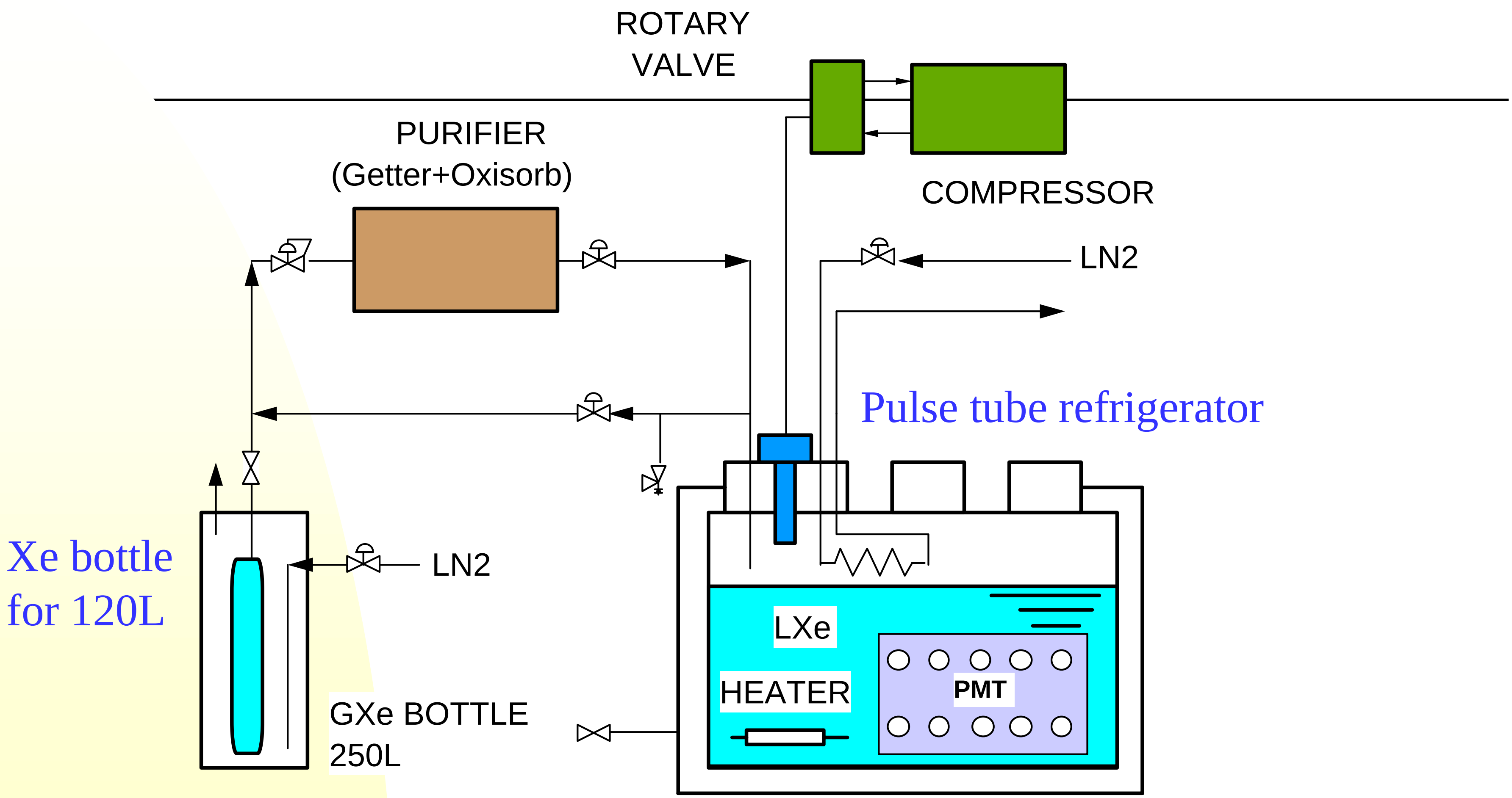
-First operation--March, 2001
-8 runs up to now

-Refrigeration only mode
-Safety operation

LARGE-PROTO DETECTOR
-Operation history-

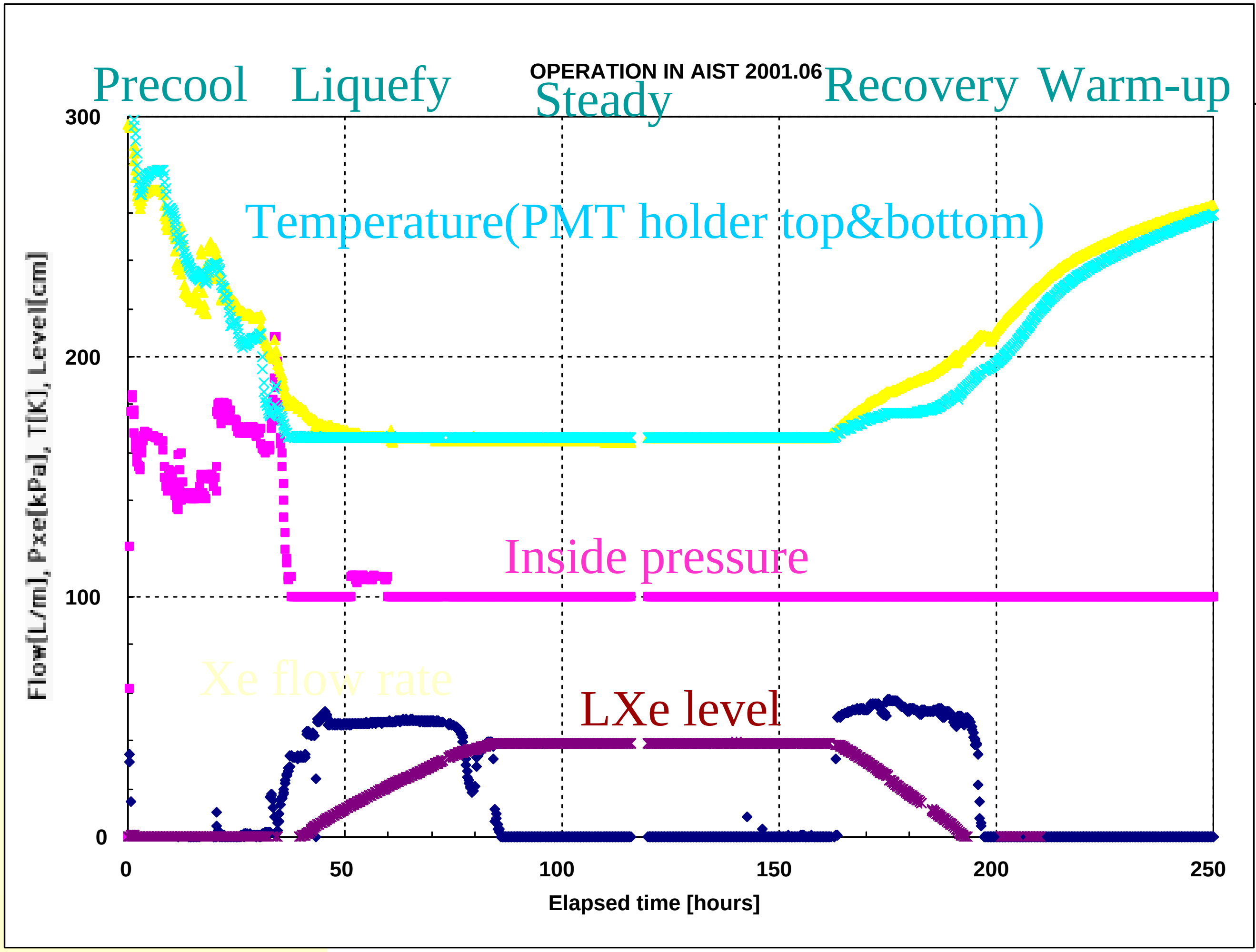
RUN	DATE(DAYS)	LXe	TEST	REFRIG. OPERATION	SITE
1	3/1-3/5, 2001 (5)	10 L	INITIAL	2.5 days	KEK
2	4/27-5/9, 2001(13)	96 L	INITIAL	2.5 days	KEK
3	6/8-6/19, 2001(12)	106 L	γ-beam	3 days	AIST
4	8/16-9/9, 2001(25)	96 L	Cosmic ray	18 days	KEK
5	11/5-12/2, 2001(28)	120 L	Cosmic ray	16 days	KEK
6	2/15-3/7, 2002(21)	120 L	Cosmic ray	11 days	KEK
7	3/25-4/10, 2002(17)	120 L	γ-beam	7 days	AIST
8	5/8-7/10, 2002(63)	120 L	Cosmic ray Purify	(50 days)	KEK

LARGE PROTO DETECTOR
-System flow diagram (without circulation purification)-



CRYOGENIC OPERATION FOR LARGE-PROTO DETECTOR

-Operation Overview-



LARGE-PROTO DETECTOR
-Typical operation mode for 120 L of LXe-

Operation mode	Time (days)	Liq/rec. rate	LN2* (Total)
Pre-cooling	24-36 H (1-1.5)	--	15-20 L/H (400-700 L)
Liquefy	48-72 H (2-3)	2.2-2.5 L/H	15 L/H (800-1000 L)
Steady	-	--	0
Recovery	36 H (1.5)	2.5-2.9 L/H	~30 L/H (1000 L)
Warm-up	72 H (3)	--	--

***~15m long foam-insulated cooling pipe**

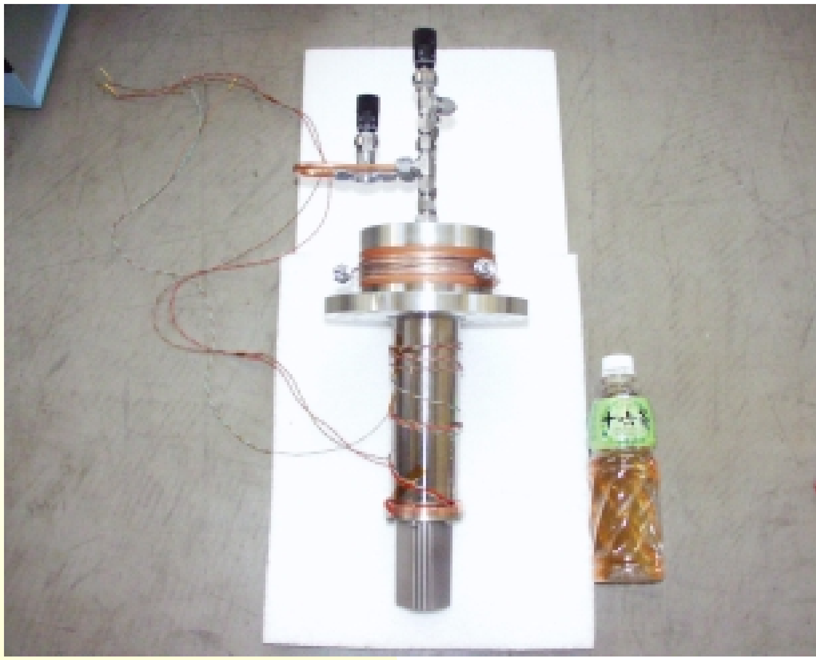
CRYOGENIC OPERATION FOR LARGE-PROTO DETECTOR
-Heat Load-

Phase	LXe (L)	PMT	Heat Load W@165K			Total (W)
			Static	PMT	Cable	
L.Proto	120	250	24	16	10	50
Final	800	800	20	52	50	122

*Static heat load depends on manufacturers design
*PMT power dissipation 65mW/PMT
*Due to number and length of cables

PULSE TUBE REFRIGERATOR DEVELOPMENT
-KEK in-house pulse tube refrigerator-

2002.7.16 PSI

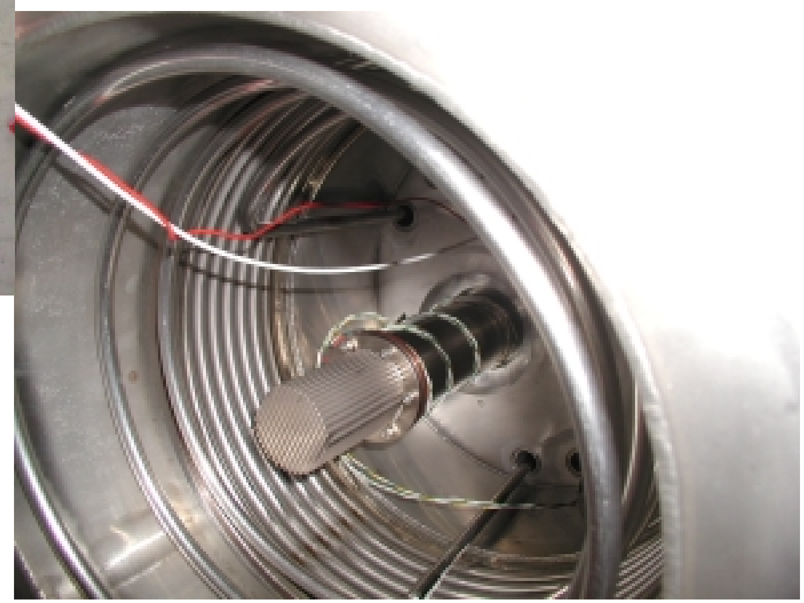


Features of pulse tube refrigerator

- -No vibration
- -Effective direct re-condensing
- -Possibly long life
- -Easy maintenance
- -Eco-friendly

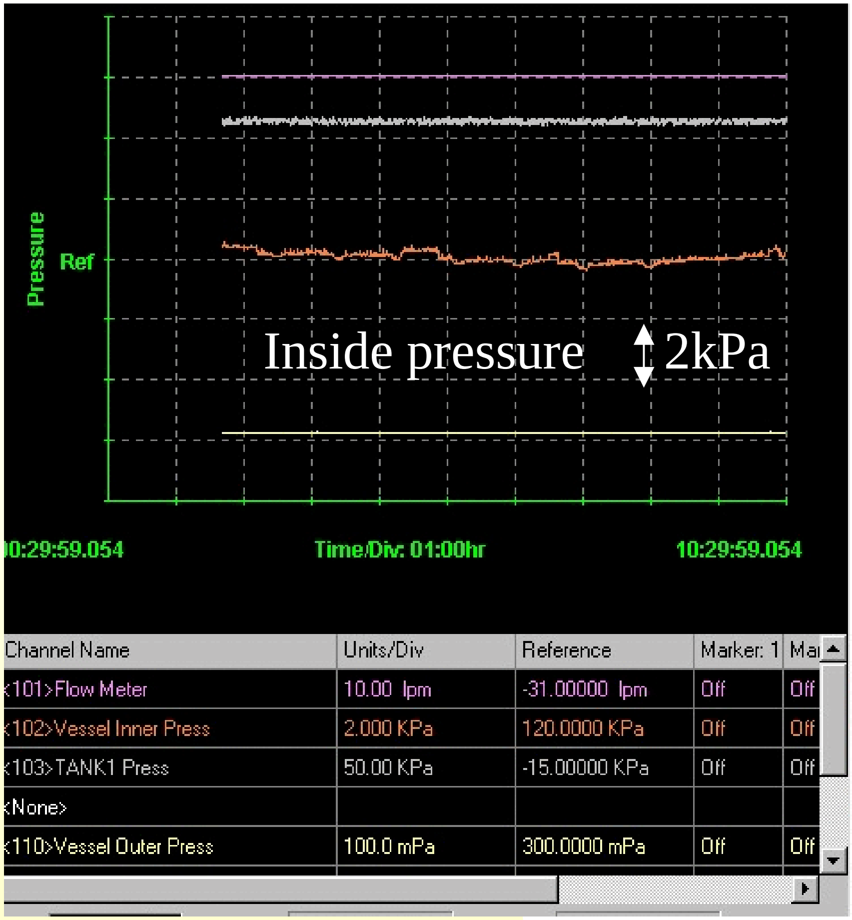
Achieved Cooling Power

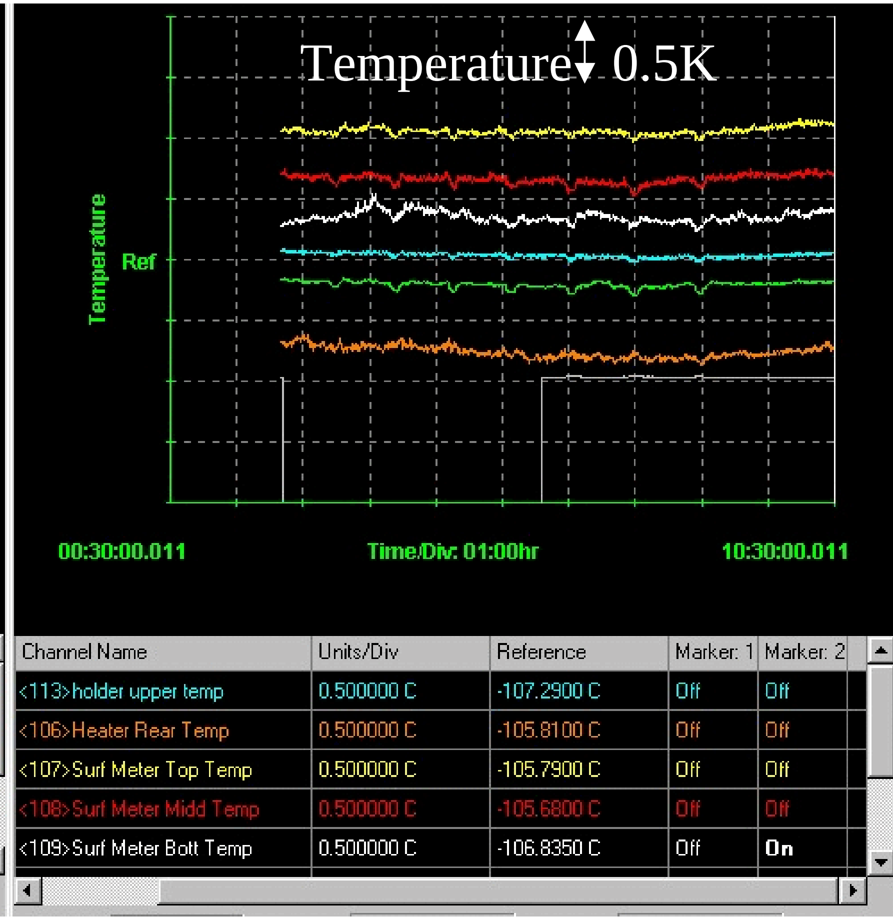
- -70 W @165K
- -2.2 kW compressor
- -2.2 Hz operation
- -Coefficient Of Performance ~3%



PULSE TUBE REFRIGERATOR DEVELOPMENT
-Stable temperature control -

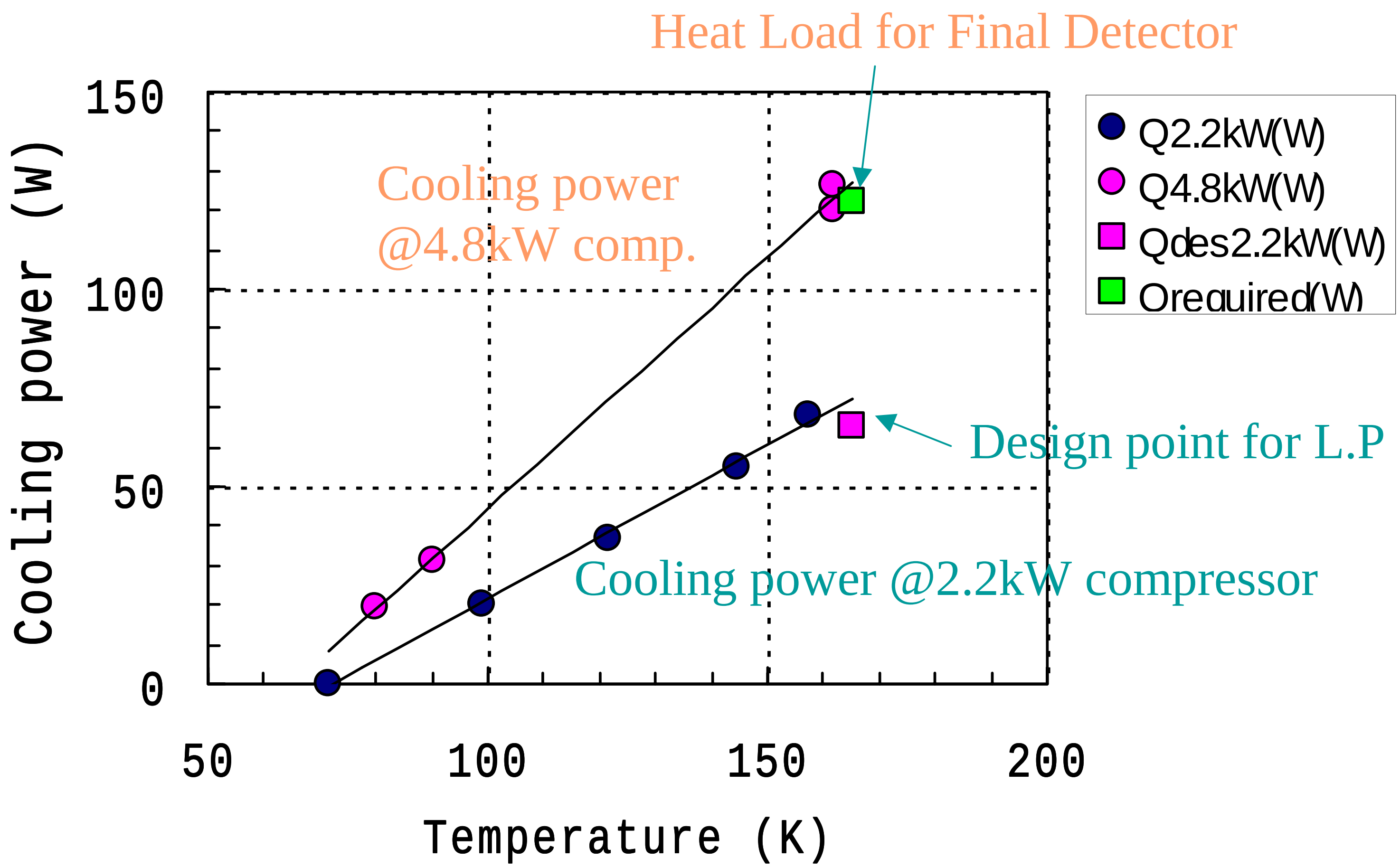
2002.7.16 PSI



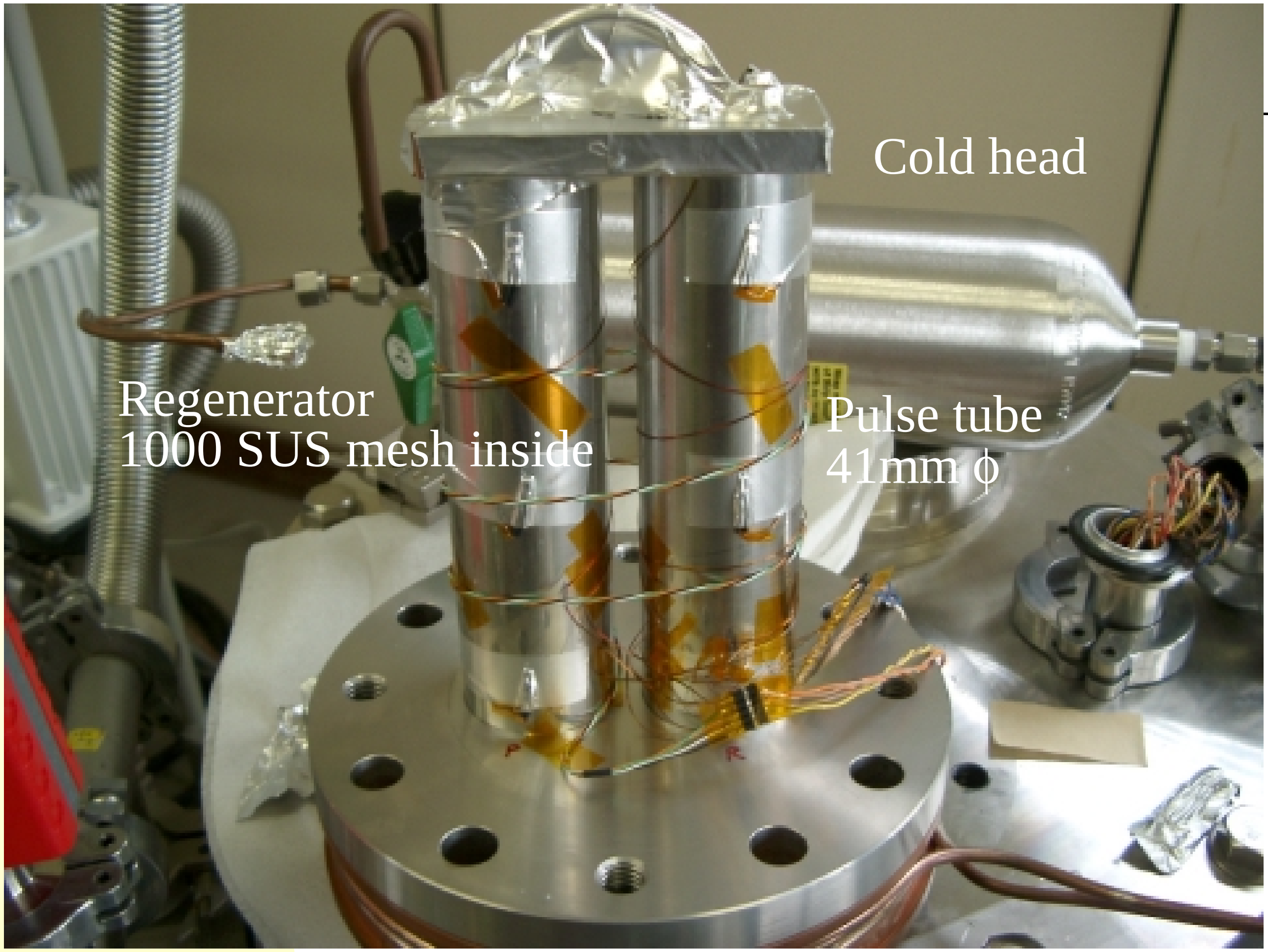


-Very quiet environment is achieved!
-No ON-OFF, no excess cooling

PULSE TUBE REFRIGERATOR DEVELOPMENT
-KEK in-house coaxial pulse tube refrigerator-

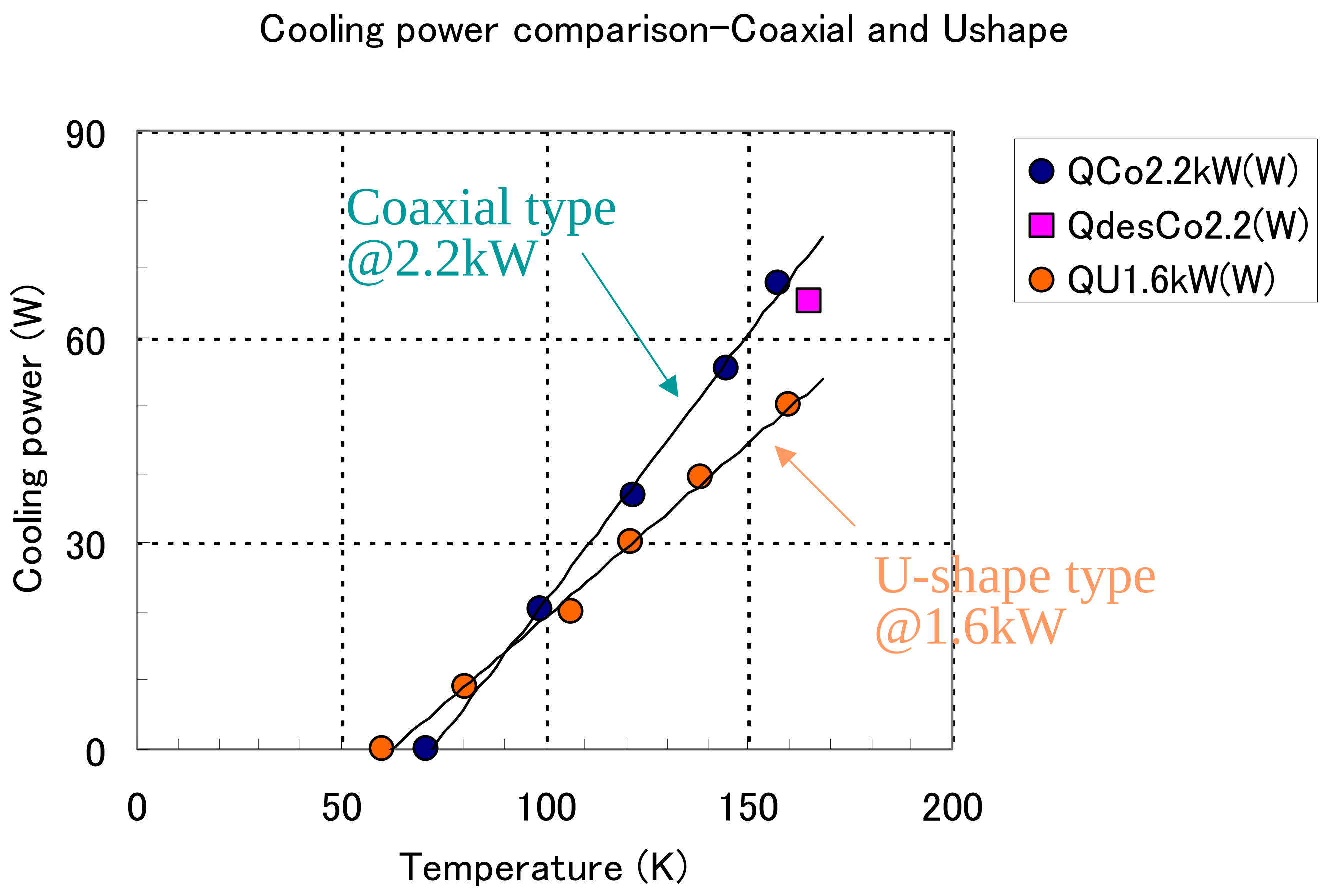


PULSE TUBE REFRIGERATOR DEVELOPMENT
-KEK in-house U-shape pulse tube refrigerator-



-U-shape:expected higher cooling power

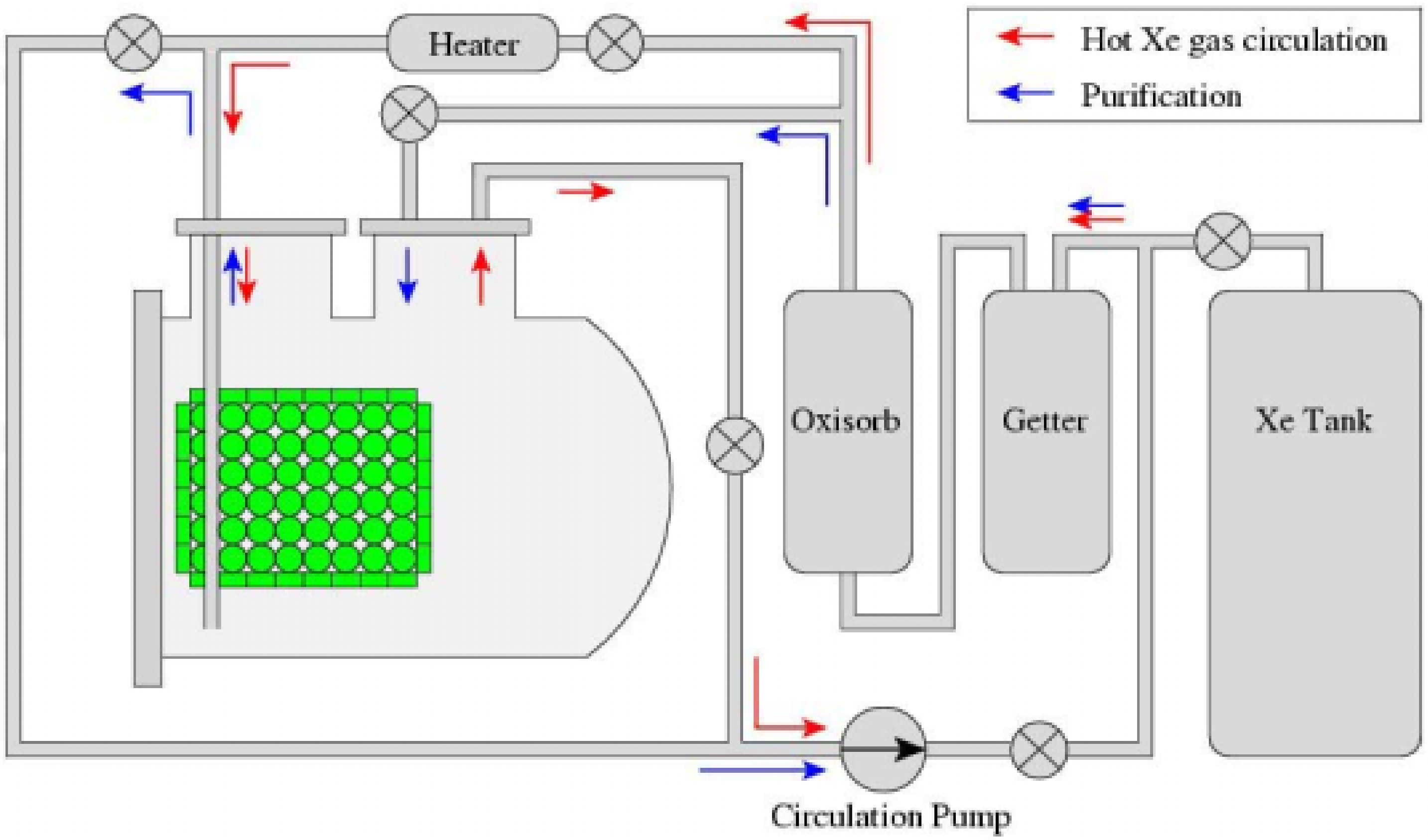
PULSE TUBE REFRIGERATOR DEVELOPMENT
-KEK in-house U-shape pulse tube refrigerator-



-COP~3%
-Remaking regenerator better performance

PURIFICATION SHEME -Large Proto experience-

2002.7.16 PSI



Effective purification method is found…

→good result, but…

Additional Heat Load

-5L/min Xe gas(300K) → 50-60W@165K

-25L/min →250-300W@165K!

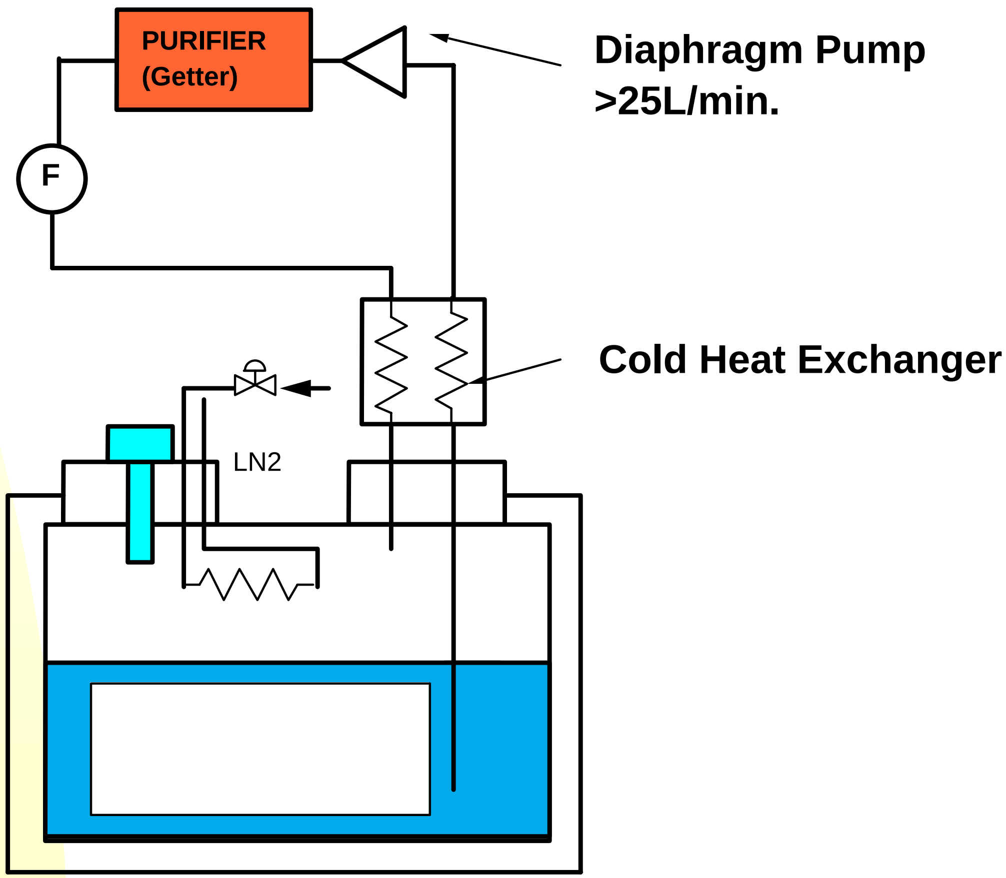
-Heavy load for refrigerator

-LN consumption increase~10-40L/hour

↓

Can be solved by: Cold heat exchanger

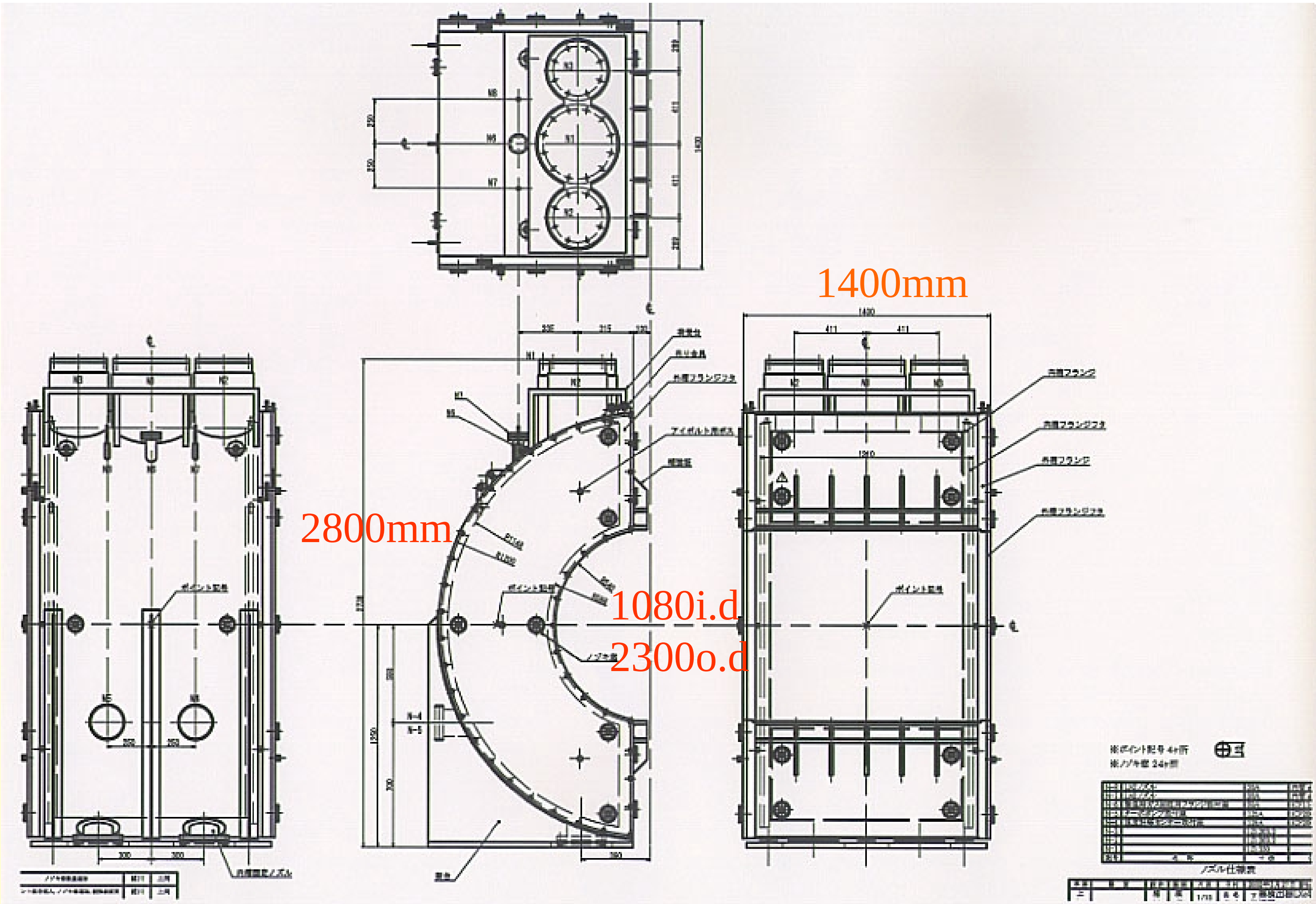
Possible circulating purification scheme…



DESIGN STUDY FOR FINAL CALORIMETER CRYOSTAT

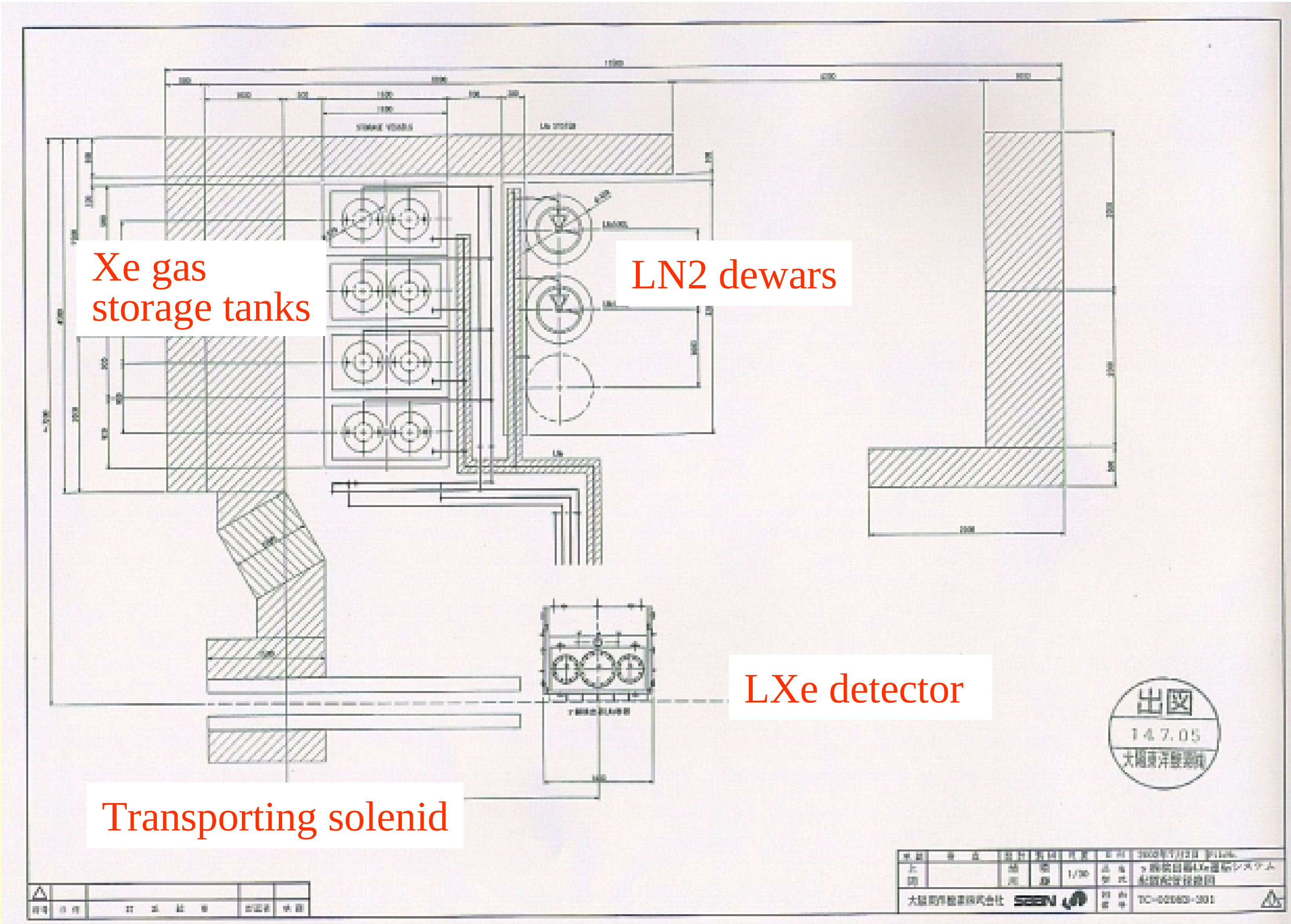
2002.7.16 PSI

-General view-



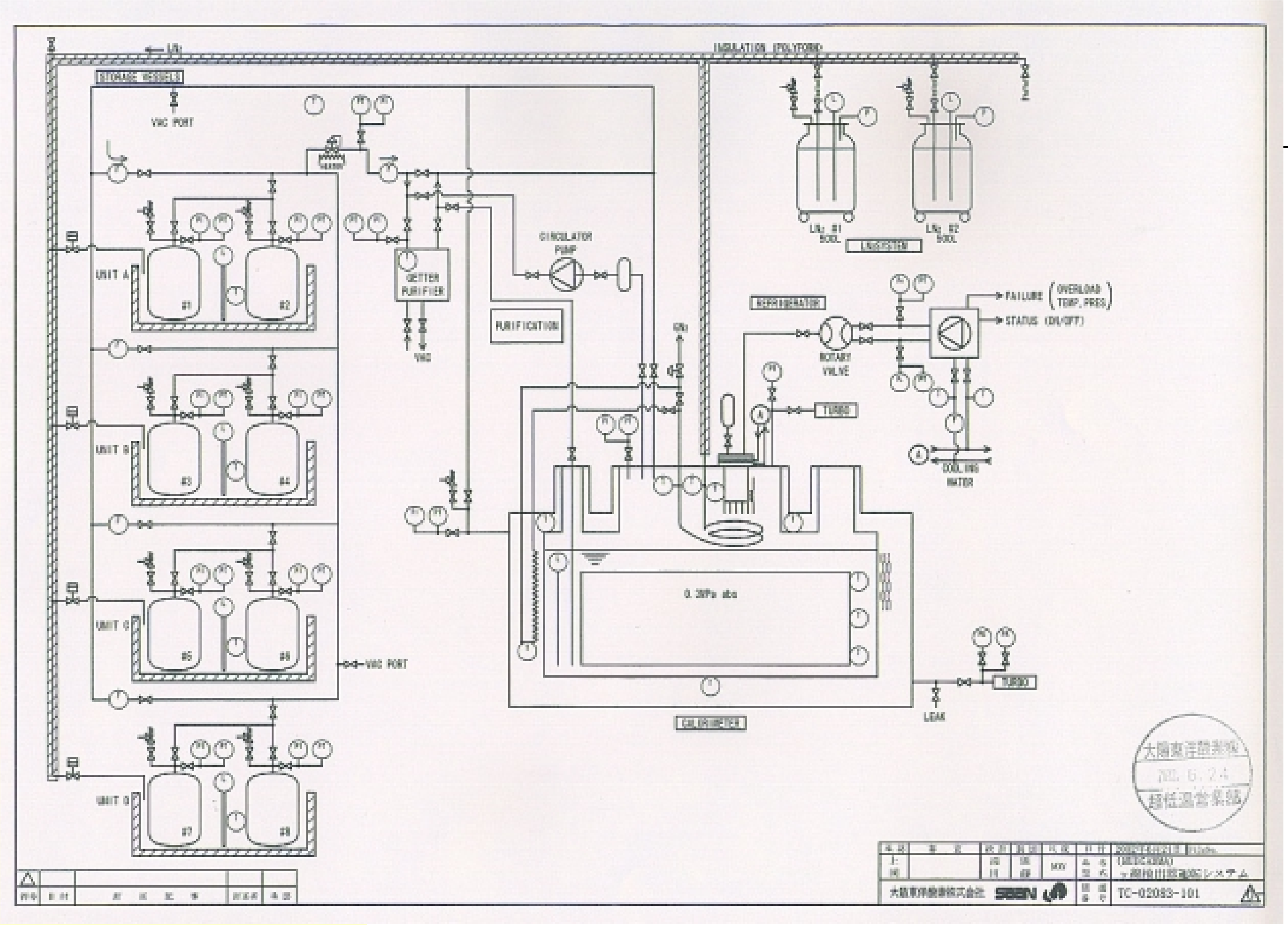
DESIGN STUDY FOR FINAL CALORIMETER CRYOSTAT 2002.7.16 PSI

-Layout-



DESIGN STUDY FOR FINAL CALORIMETER CRYOSTAT
-Flow scheme-

2002.7.16 PSI



DESIGN STUDY FOR FINAL CALORIMETER CRYOSTAT
-Operation scheme-

2002.7.16 PSI

DAY	STEP	MAN/ AUTO	ACTION	EMERGENCY
-	PUMPING/ GAS CHARGE	MAN	-OUTER VACUUM PUMPING -INNER VESSEL PUMPING -COLD TRAP ACTIVE	-POWER SHUT
3	BAKING	MAN	-HOT GAS TEMP. CONTROL	-POWER SHUT
4	PRECOOL	AUTO	-VESSEL PRESSURE CONTROL (LN2)	-POWER SHUT -LN2 EMPTY
7	LIQUEFY	AUTO	-VESSEL PRESSURE CONTROL (LN2) -TANK VALVE CHANGE CONTROL -PURIFIER ACTIVE	-POWER SHUT -LN2 EMPTY -VACUUM
7	CIRCULATION	AUTO	- PURIFICATION BY LIQUID PUMP OUT -	-POWER SHUT -LN2 EMPTY -VACUUM
-	STEADY	AUTO	- VESSEL PRESSURE CONTROL (REFRIG.+LN2 BACK-UP)	-POWER SHUT -REF. SHUT -LN2 EMPTY -VACUUM
7	RECOVERY	SEMI	-TANK UNIT COOLING -LN2 LEVELCONTROL -XE FLOW CONTROL TO TANKS	-LN2 EMPTY
5	WARM UP	SEMI	-HEATER CONTROL -VACUUM BREAK	

SUMMARY
of photon detector cryogenics

1. Cryogenic operation mode is understood through large-proto detector experiments
2. Pulse tube refrigerator development is on-going for the final detector
3. Effective purification scheme can be established
4. Final photon detector is now under detailed designing

Design study for final calorimeter cryostat

Gas for effective bake-out

-large heat capacity
-good thermal conductivity

Gas	N_2	Xe	Ar	Ne	H_2
C_p(kJ/kgK)	1.04	0.16	0.52	1.03	14.2
λ(W/cmK)	2.4	0.3	1.6	4.6	16.8

@300K, 0.1 MPa