Industrielle Kühlung

11.03.2014

ZIEHL IV, Bonn

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Sumitomo Cryogenics of Europe GmbH
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Darmstadt

Inhalt

- Sumitomo Cryogenics
- Grundlagen
  - Temperaturbereich Kryotechnik
  - Thermodynamische Prozesse
  - Technische Realisierung
- Herstellung
  - Qualität/Zuverlässigkeit
  - Serienproduktion
- Anwendungen
  - Forschung
  - Medizintechnik
- Zusammenfassung

SHI Corporate: Product Portfolio

<By Segment>

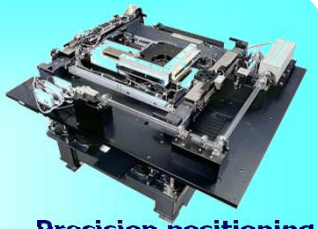
SHI Cryogenics Group

Precision Machinery

Cryogenics Equipment

Cryopump

Proton therapy system



Precision positioning Equipment

Cyclotron PET

Plastics Injection Molding Machinery

Cryocoolers for Superconductivity (MRI, R&D), Vacuum application as incorporated into Cryopumps (Semiconductor)

Machinery Equipment

Power transmission equipment

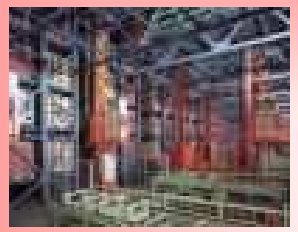
Construction Machinery

Hydraulic excavators

Ships

Ships

Industrial Machinery



Logistics & handling system

Material handling system

Automated parking system

Turbines & pumps

Forging press

Environmental Facilities & Plants

Water treatment system

Energy-related system

Cryogenics Business History

SHI Cryogenics Group

1983 — *Cryogenics business started at Tanashi for manufacturing 10K GM OEM*

1995 — *Start manufacturing 4KGM for MRI at Tanashi*

1999 — *Establish SCAI for sales and Service in the US market*

2000 — *Establish SCEG for sales and service in European market*

2002 — *Acquired IGC-APD Cryogenics and SCAI & SCEL started*

2004 — *Acquired Daikin cryogenics business and success their products and service business*

Establish SCGS & SCKL for Sales and Service in Chinese & Korean Market

2011

2012~

Start MRI application

10K GM for Cryopumps

4K GM

Chiller

Pulse Tube

SHI Tanashi JPN

SICERA

1W Pulse Tube

Pulse Tube (Remote Valve)

F-40 Comp

SCEG GER

SCAI US

SCEL UK

IGC-APD

SCGS China

SCKL Korea

DAIKIN Cryogenics

GM-JT, Cryopumps

Global Network

Basingstoke
UK

Chicago
US

Darmstadt
Germany

Suwon
Korea

Santa Clara
US

Allentown
US

Shanghai
China

Tanashi
Japan

Taiwan

Manila
Philippines

2 R&D, Applications, Mfg, Service and Sales

5 Applications, Service and Sales

2 Service And Sales

1 Mfg

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Grundlagen: Temperaturbereich

Siberia
Minimum observation temperature
(-64.6℃)

Dry Ice
(-78℃)

LN2
(-196℃)

LH2
(-253℃)

LHe
(-269℃)

℃	Kelvin	
27	300	
10		
0	273	
-20		
-40		
-70		Low temperature
-100		
-140		Cryogenics => 120K
-162		
-196	**77**	Very low temperature
-250	20.5	
-269	**4.2**	Extremely low temperature
-271	2.1	
-272	1	
Absolute zero degree -273	0	

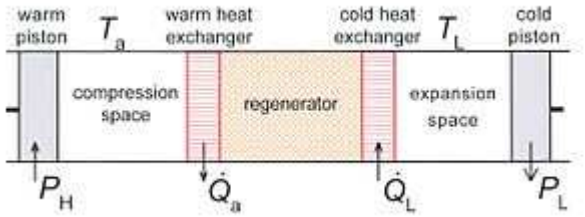
Temperature range

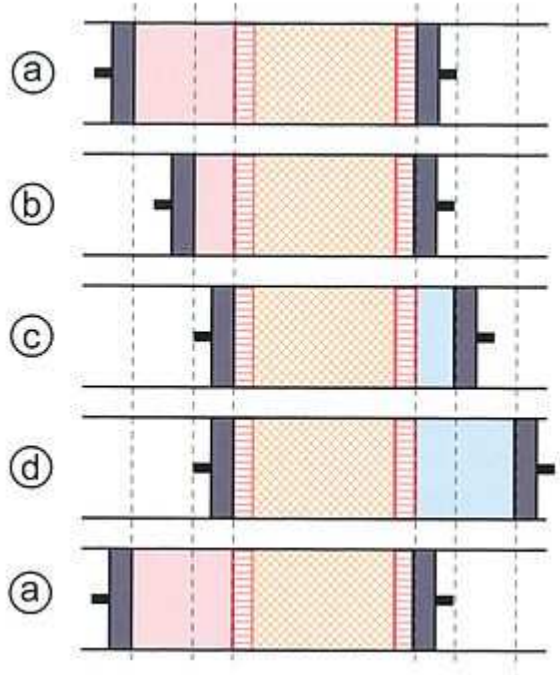
of Cryocooler products

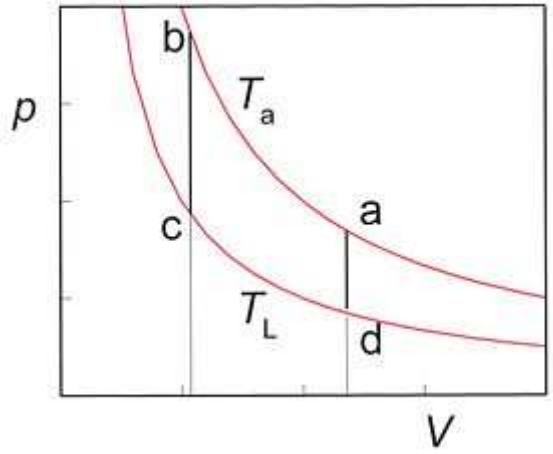
Thermodynamischer Kreisprozess mit Helium als Kältemittel

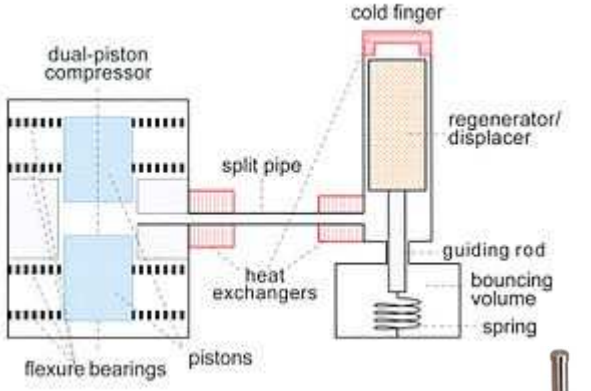
- Brayton
  - George Brayton, USA, 1830 – 1892
  - Kühlung => „reverse Brayton“ => Bell Coleman cycle
- Claude
  - George Claude, Frankreich, 1870 – 1960
  - Luftverflüssiger in 1902
  - Mitbegründer von L'Air Liquide S.A.,
- Stirling
  - Robert Stirling, GB, 1790 – 1878
  - Philips(ab 1940 erste Produkte)
- Gifford-McMahon
  - W. Gifford & R. C. Longsworth, 1963

Grundlagen: Stirling









The cooling cycle is split in 4 steps as depicted in Fig. left.
The cycle starts when the two pistons are in their most left positions:

From a to b. The warm piston moves to the right while the cold piston is fixed. The compression at the hot end is isothermal (by definition), so heat Qa is given off to the surroundings at ambient temperature Ta.

From b to c. The two pistons move to the right. The volume between the two pistons is kept constant. The hot gas enters the regenerator with temperature Ta and leaves it with temperature TL. The gas gives off heat to the regenerator material.

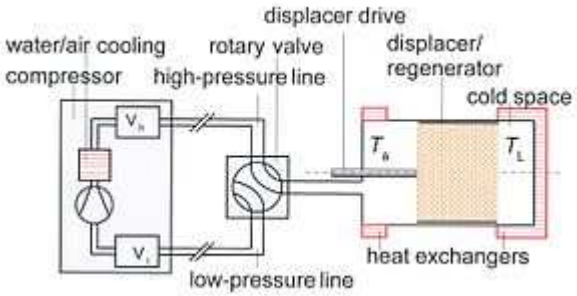
From c to d. The cold piston moves to the right while the warm piston is fixed. The expansion is isothermal and heat QL is taken up. This is the useful cooling power.

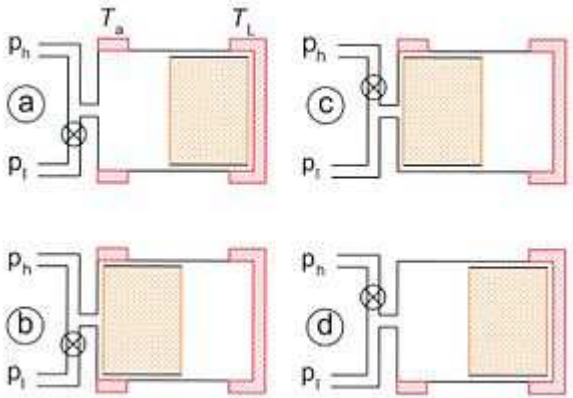
From d to a. The two pistons move to the left while the total volume remains constant. The gas enters the regenerator with low temperature TL and leaves it with high temperature Ta so heat is taken up from the regenerator material.

At the end of this step the state of the cooler is the same as in the beginning.

Source: Wikipedia, Article Cryocoolers

Grundlagen: Gifford-McMahon





The cycle starts with the low-pressure (lp) valve closed, the high-pressure (hp) valve open, and the displacer all the way to the right (so in the cold region). All the gas is at room temperature.

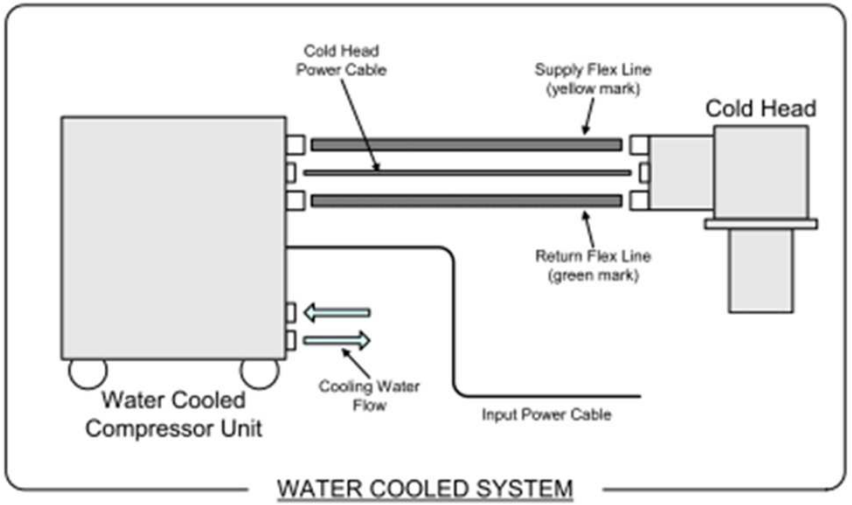
From a to b. The displacer moves to the left while the cold head is connected to the hp side of the compressor. The gas passes the regenerator entering the regenerator at ambient temperature Ta and leaving it with temperature TL. Heat is released by the gas to the regenerator material.

From b to c. The hp valve is closed and the lp valve opened with fixed position of the displacer. Part of the gas flows through the regenerator to the lp side of the compressor. The gas expands. The expansion is isothermal so heat is taken up from the application. This is where the useful cooling power is produced.

From c to d. The displacer moves to the right with the cold head connected to the lp side of the compressor forcing the cold gas to pass the regenerator, while taking up heat from the regenerator. From d to a. The lp valve is closed and the hp valve opened with fixed position of the displacer. The gas, now in the hot end of the cold head, is compressed and heat is released to the surroundings. In the end of this step we are back in position a.

Source: Wikipedia, Article Cryocoolers

Technische Realisierung GM



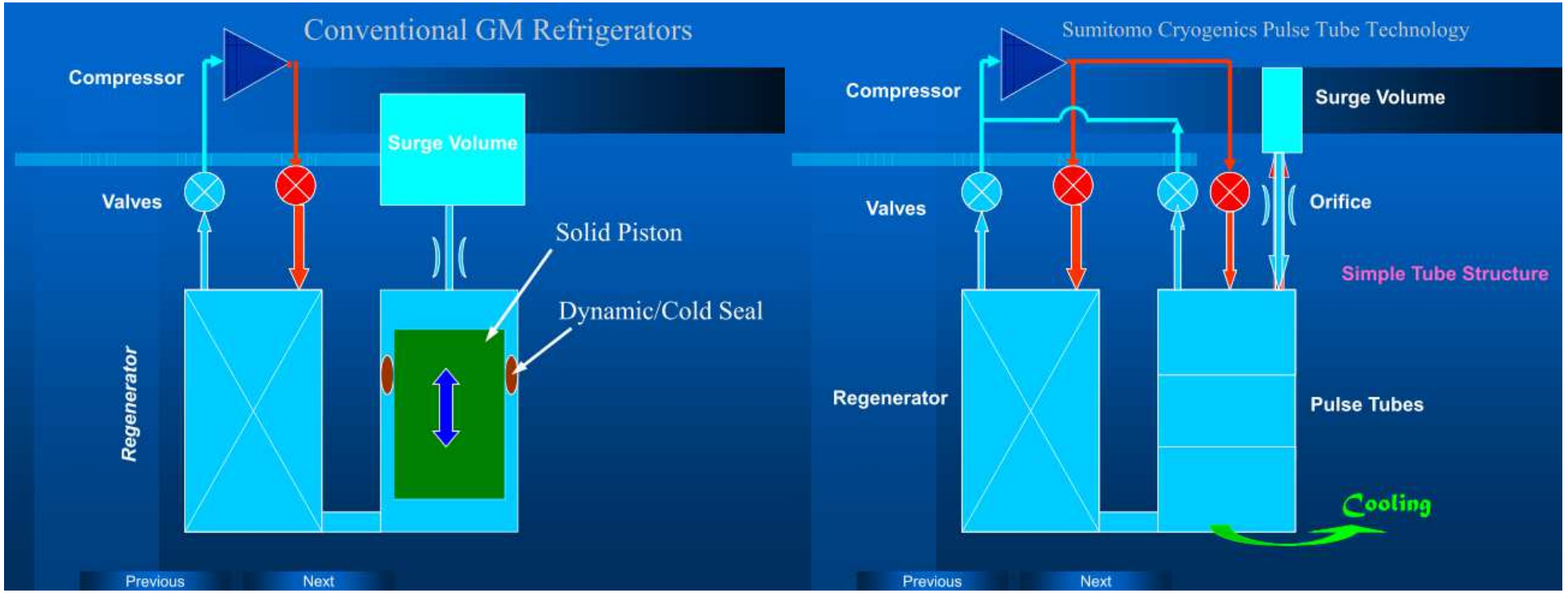
SYSTEM CONFIGURATION

Cryocooler	CH-110
Cooling Capacity (50/60Hz)	170/180W@70K 180/205W@80K
Power consumption (50/60Hz)	6.8/7.8kW

F-70LP Compressor
(443W x 588D x 532H, 120kg)

CH-110 Coldhead
(13.7kg)

Grundlagen: Pulsrohkühler



- Keine bewegten Teile
- Geringerer Verschleiß
- Längere Wartungszyklen

Technische Realisierung PTR

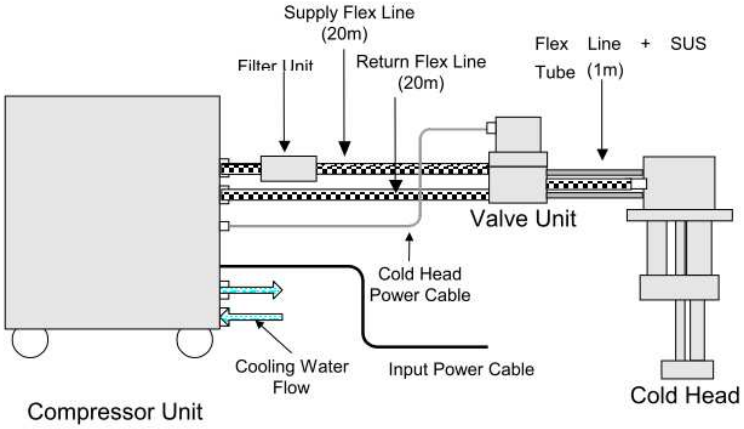


Figure 1.1 SRP-082B2S (VU Separate Type) CRYOCOOLER SYSTEM

RP-082B2S Coldhead
(13.7kg)

F-70LP Compressor
(443W x 588D x 532H, 120kg)

Cryocooler	SRP-082B2S
Cooling Capacity (50Hz)	1st: 35W@45K 2nd: 0.9W@4.2K
Power consumption (50Hz)	6.8kW

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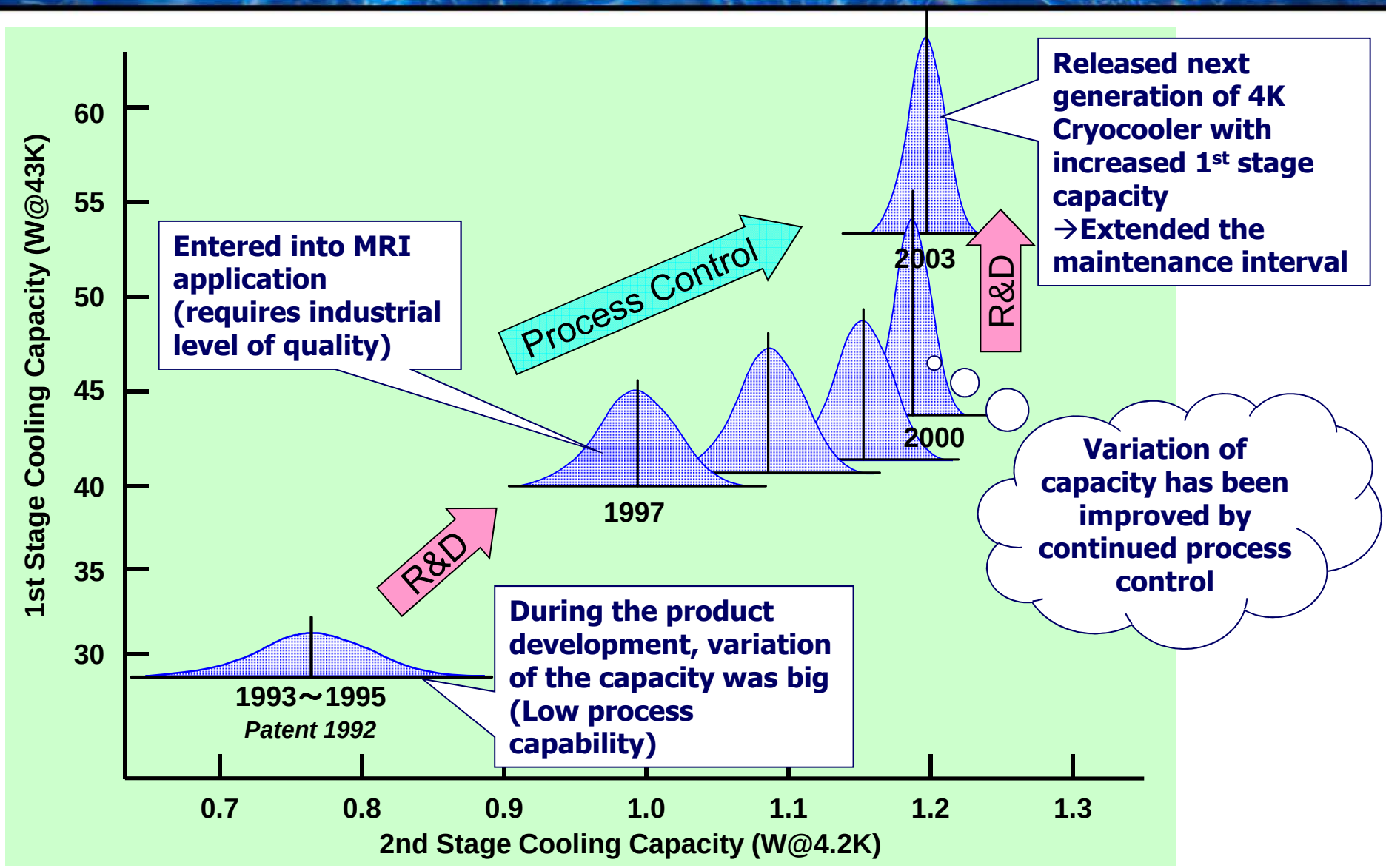
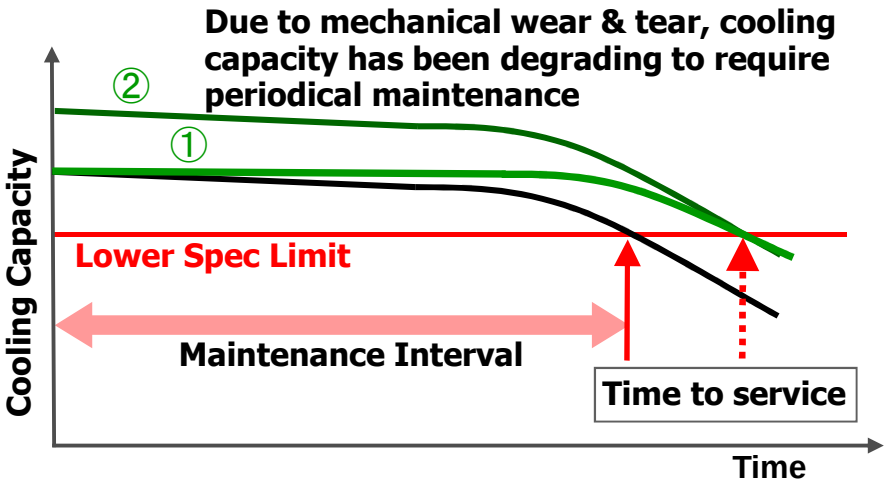
History of Process Capability Improvement



Contribution to Life Cycle Cost

SHI Cryogenics Group

Maintenance cycle of Cryocooler



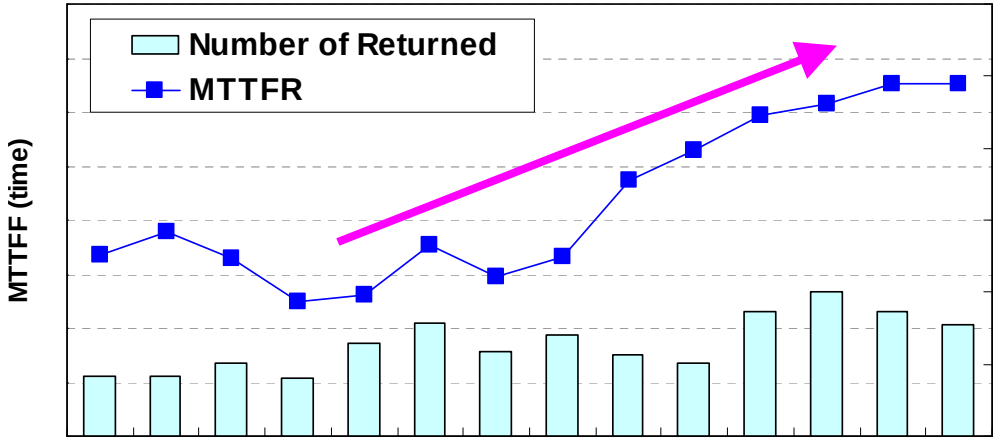
The way to extend the maintenance interval

①Increase the robustness of the parts (reduce wear rate, etc.)

②Shift the cooling capacity to upper side

R&D work and Production Improvement (process control) are required to achieve.

Image of Mean time to the first repair (MTTFR)



MTTFR = Maintenance Interval has been extended over the years, due to the continued improvement activities.

Extended interval has contributed the life cycle cost of MRI system.

Serienfertigung

SHI Cryogenics Group

Manila, Philippines

Tanashi, Japan

Allentown, USA

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Application Cryostat

SHI Cryogenics Group

HE-3-SSV-CCR
(first generation)

SHI-950

SHI-4-5

4K GM Application Astronomy

SHI Cryogenics Group

RAL & ESO
ALMA (Chile)

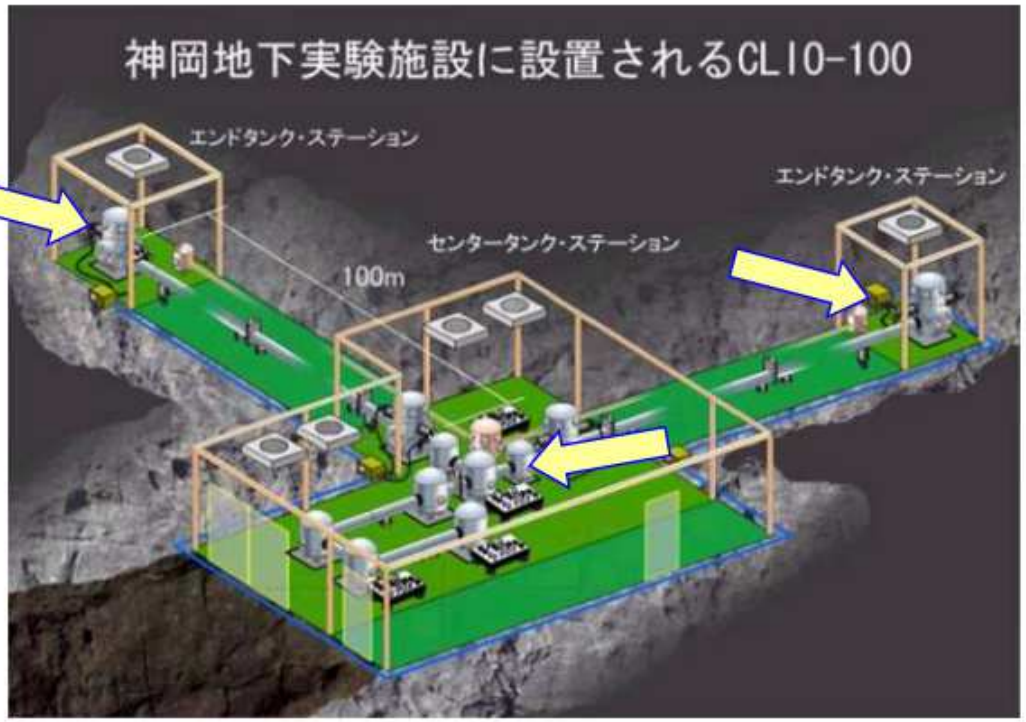
SUBARU Telescope –
NAOJ
Mauna Kea, HAWAII
(Optical IR Telescope)

Courtesy by NAOJ

Large Research Facilities

SHI Cryogenics Group

Pulsetube Cryocooler



Gravitational Wave Telescope
(Kamiokande)

GM & PT, Application LAB

SHI Cryogenics Group

Application

NMR/EPR, Optical Spectroscopy

Optical Microscopy, Resistivity

X-Ray Diffraction, Large Samples

Ultra High Vacuum, Magnetic Susceptibility

UHV Manipulators, Mossbauer

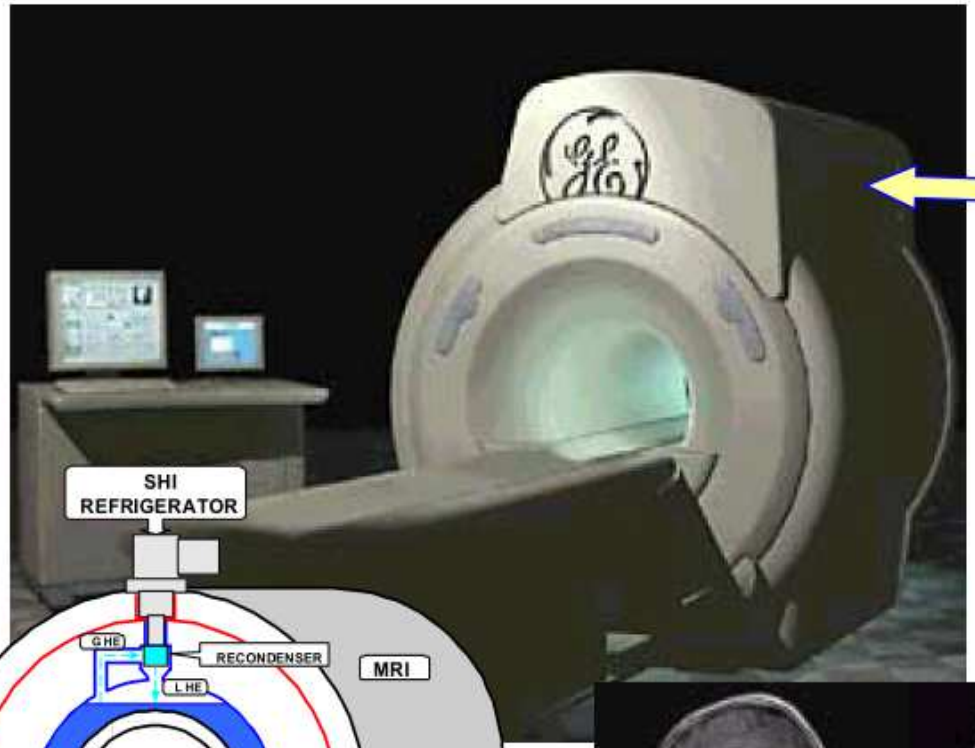
CryoProbe™500-600

Courtesy by Bruker Japan

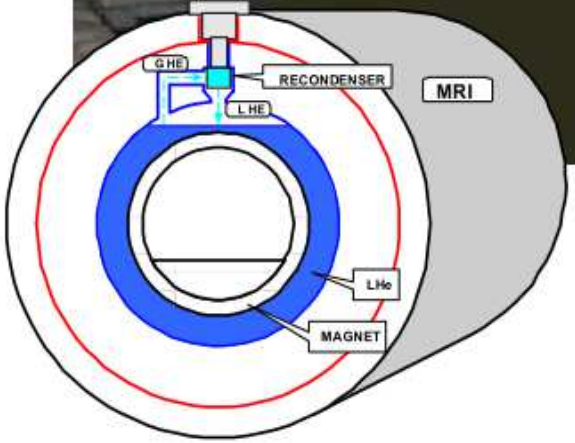
900 MHz TXI CryoProbe™

4K GM Application MRI

SHI Cryogenics Group



4KGM
cryocooler



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Breites Spektrum an Produkten und Anwendungen in der Industriellen Kühltechnik

SHI Cryogenics Group

Low — Temperature (Kelvin) — High

4.0 | 10 | 20 | 77

GM+JT Cryocooler

- Largest cooling capacity at 4K (only one manufacturer)
- Low vibration
- Low power consumption

Superconducting

- Single crystal silicon grower for wafer production
- SMES

GM/Pulse Tube Cryocooler

- Compact 4K Cryocooler
- Stable performance
- Orientation-free
- High quality, reliability
- Quite performance
- Selection of 4K lineup

Superconducting

- **MRI application**
- Other superconducting application (industrial & research)

Cryopump

- Energy saving (multiple operation)
- Stable performance
- Shorten down time (large pumping capacity)

Vacuum

- Sputtering Equipment
- Ion Implanting Equipment (for semiconductor production)

Single-stage Cryocooler

- Large cooling capacity at 20K and 77K
- Stable performance

Superconducting / Pre-cooling

- Generator
- Motor
- Fault Current Limiter (FCL)

Stirling Cryocooler

- Small, compact (integrated)
- Low power consumption

Cooling

- Dew point meter
- Infrared Camera

Vielen Dank für Ihre Aufmerksamkeit

SHI Cryogenics Group

Committed to providing the best in Cryogenic Products and Services …. The World`s Leading Supplier of Cryogenic Cooling and Cryogenically Cooled Solutions