Helium Group Meetingについて

○ ICNS2009において、中性子散乱施設長の会合がありHe3不足問題が議論され、Heグループを組織して代替検出器を検討するように委託した。

<u>主なメンバー</u>

Ron Cooper (SNS), Graham Smith (BNL), Bruno Guerard (ILL), Nigel Rhodes (ISIS),
Kazuhiko Soyama (J-PARC), Günter Kemmerling (FZ Jülich) and Thomas Wilpert (HMI Berlin),
Karl Zeitelhack (FRM-II) ほか

<u>これまでの会合</u>

Helium Group Meeting, Munich, July 7-8, 2009
Helium Group Meeting, Oxford, September 15, 2009
Helium Group Meeting, Orland, October 30, 2009

<u>検討内容</u>

・中性子散乱分野で必要なHe量の調査。
・少ないHe3をどうシェアできるか、そして代替検出器は何か。
・代替検出器の開発に関する国際協力の検討。

^{3}Heの需要と供給

今後の供給（この数年間）

10,000 ℓ/y　US　（半分はHomeland, 半分はscienceへ？）*

10,000 ℓ/y　Russia

＊USAのファンドに関係するもの
代替の効かないものを優先する
と米国政府が発言している。

今後の需要

100,000 ℓ　（next 5years）　Homeland Security
100,000 ℓ　（next 5years）中性子散乱全体
（16,000 ℓ　（ next 5years）　J-PARC/MLF）
→ 40,000 ℓ/y

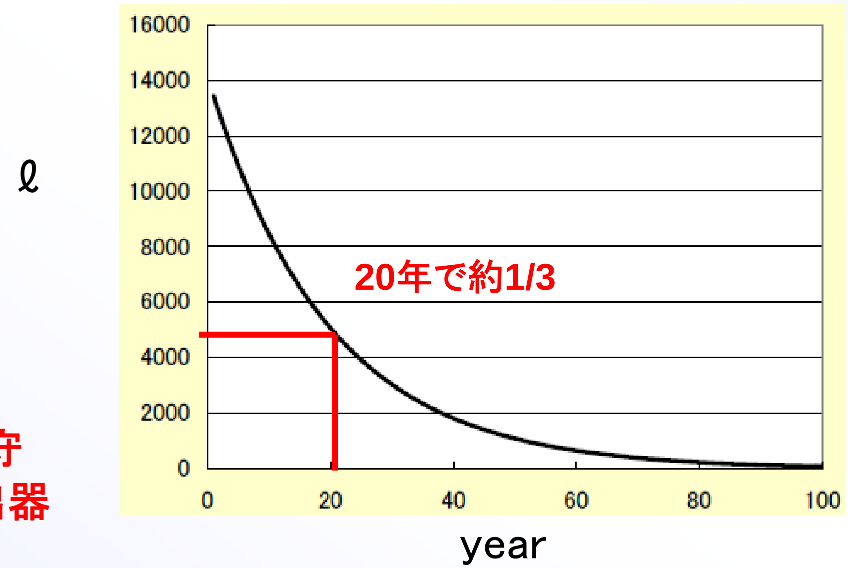
1インチ　1m　10気圧の検出器のHe-3ガス・・・・　5ℓ必要

今後の供給量が
中性子全体で最低2,500ℓ/年
最低約170ℓ/施設　程度
とも予想されているが。。

2500 – 4500 ℓ/y 低温物理
MRI imaging
Neutron polarizing filter
→ 代替品の無いもの

今後の供給予測

US tritium stock is 36 kg
decay at a rate of 5.5% per year
an annual 3He production of just 1.98 kg
（IEEEの論文から）



＊小面積のHe3検出器や既存のHe3検出器の保守
には供給可能と思われるが、大面積のHe3検出器
の代替検出器の開発は不可欠である。

Shortage of ^{3}He – An Overview

^{3}Helium is a by-product of Tritium production for nuclear weapons. Tritium decays via ß-decay into ^{3}He with a half life of 12,3 years. The only suppliers commercially are the US and Russia. With the end of the cold war tritium production has been reduced significantly. The current supply is a result of tritium production many years ago. The stock pile of ^{3}He is rapidly running out and will be gone within a year or two.

In 2009 the US government will release 40000 l for security programs only, none of the US supplied gas will be available for industrial / scientific needs. Russia is estimated to release no gas until late in the year supplying less than 10000 l. Starting in 2010 the US will not release more than 10000 l per year, which is supposed to be mainly dedicated to security programs. Russia is believed to deliver about the same annual quantity starting in 2010. The ^{3}He in the US is owned by the DOE. An interagency committee has been setup to decide where the ^{3}He goes.

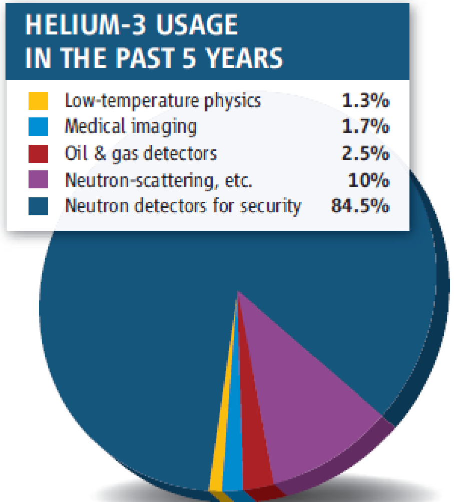
Canada with its CANDU reactors could be an additional future supplier of ^{3}He. There seem to be discussions, but the situation is not clear.

The ^{3}He consumption over the past several years is about 50000 l/year. This is before the increase in demand for Homeland security. This additional demand is estimated to 40000l this year. Currently the two largest consumers are Security programs in the US and worldwide and neutron scattering.

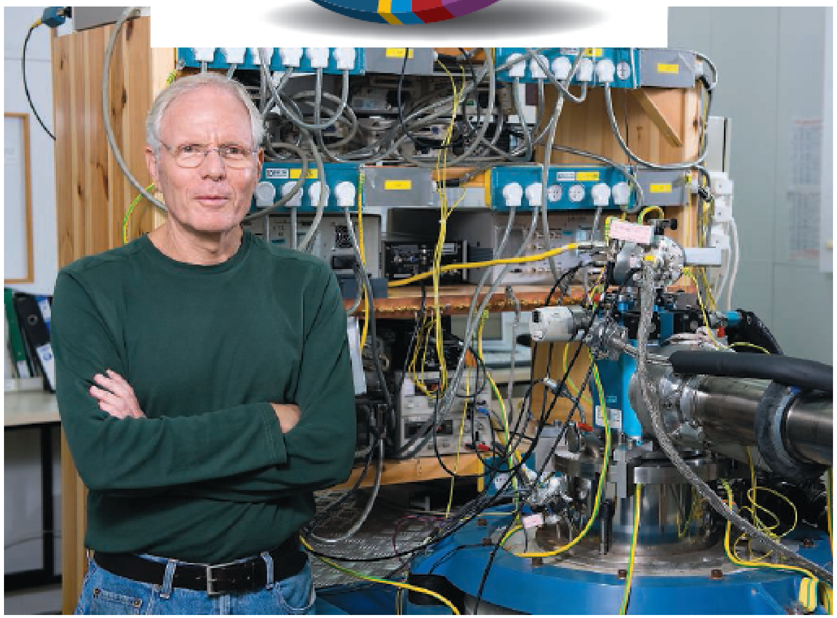
Helium-3 Shortage Could Put Freeze On Low-Temperature Research

The weird effects of quantum mechanics often emerge at extremely low temperatures. So 3 years ago, Moty Heiblum, a physicist at the Weizmann Institute of Science in Rehovot, Israel, ordered a large "dilution refrigerator," which uses frigid liquid helium as a coolant and can chill tiny electronic devices to within a thousandth of a degree of absolute zero, or 1 millikelvin. But now the manufacturer, Leiden Cryogenics B.V. in the Netherlands, cannot deliver the completed fridge: It cannot get enough helium-3—100 liters of room-temperature gas, as it's sold on the market—to fill the rig.

Heiblum has fallen victim to a severe shortage of helium-3, the lighter isotope of the most inert element. Two weeks ago, he also lost about 15 liters of helium-3 from an existing fridge when an electronic valve failed. When Heiblum tried to buy more, a supplier in the United States turned him away and a European company wanted an unaffordable €1300 per liter, up from €100 just 2 years ago. "If this continues, then low-temperature physics will just dis-



SOURCE: DOE



which we spent $1.5 billion for construction."

Low-temperature physicists say they need between 2500 and 4500 liters of helium-3 per year, primarily to fill new dilution refrigerators. Helium is the only substance that remains liquid at absolute zero, and only by pumping the vapor off a liquefied mixture of helium-3 and heavier helium-4 can physicists achieve steady temperatures below 0.8 kelvin, says William Halperin, a physicist at Northwestern University in Evanston, Illinois. "If we lose our helium-3 [supply], we're totally screwed," says Halperin, who notes that work on quantum computing and nanoscience often requires extremely low temperatures.

Helium-3 also serves a role in medical imaging. When inhaled by a patient, it allows researchers to image the lungs with an MRI.

The helium-3 supply likely won't return to its former levels. Rare in nature, the gas comes mainly from the radioactive decay of tritium generated in nuclear reactors. Pure tritium is an ingredient in hydrogen bombs, so for decades the United States and the Soviet Union kept large reserves of it and sold the helium-3 skimmed from it. But after the Cold War ended, the United States and Russia reduced their tritium reserves. Prior to 2009, DOE released 60,000 liters of helium-3 annually. In fiscal year

Published by AAAS

Heグループによる大面積He検出器の代替案の検討

- **BF3ガス検出器**：He3検出器に代わられる以前は中性子散乱に用いられていた。検出効率はHe3検出器の約1/5で非常に限られた装置（冷中性子に特化）に使用できる可能性がある。（例：検出効率75%、波長10Å、1インチ、1-2atm、$^{10}BF_3$）現在BF3ガス検出器を販売しているのは2社のみ、今後改善を目指して開発が行われているが、低検出効率、ガスの毒性、長期安定性が課題。
- **B10比例計数管**：B10を計数管の内壁に塗った検出器で中性子散乱に使用するには検出効率が低い。ストロー型検出器（多重にして高効率化）等が開発中。
- **Li6-ZnS、B2O3-ZnSシンチレータ検出器**：J-PARC、SNSで建設が行われている波長変換ファイバ読み出し型検出器が代替候補である。J-PARCではB2O3-ZnSシンチレータの開発で効率が増加。今後高性能シンチレータの開発が重要。
- **Li6、B10コンバータガス検出器**：Li6 metal foil を用いたプロトタイプ検出器が開発されている。検出効率は熱中性子で～16%で、反応性が高いので取扱いが難しい、また近い将来では大型化が困難である。
- ハイデルベルグ大学などが開発中の**GEM検出器**がある、2次元高計数率が特徴であるが、大面積化、検出効率向上、コスト低減が課題である。