“Hazard Mitigation for SRF Accelerators and Cryogenics”

Discussions

Akira Yamamoto (Convener)

TTC-IBS-2024: Hot Topics Session,
Daejeon, April 10, 2025

TTC-IBS-2024: Hot Topics Session:

“Hazard Mitigation for SRF Accelerators and Cryogenics”

Introduction for "Hazard Mitigation for SRF Accelerators and Cryogenics" *Akira Yamamoto (KEK & CERN)*

Auditorium, Science Culture Center (2F) 16:00 - 16:05

Consequences of big earth quake resulting in damages in accelerators and associated systems including cryogenics
Yasuhiro Kondo (JAEA/J-PARC), Yasuhiro Makida (KEK/J-PAR…

Helium management during emergency events for the LCLS superconducting linac at SLAC
Sebastian Aderhold (SLAC), Eric Fauve (SLAC)

Hazard mitigation and Helium conservation for future large-scale SRF-based Accelerator Cryogenics
Kota Nakanishi (KEK), Boyan-Kaloyanov Naydenov (CERN)

Discussion and Summary *Akira Yamamoto (KEK & CERN)*

Auditorium, Science Culture Center (2F) 17:20 - 17:30

→ **Discussions, Lessons learned and Preparation for the Future**

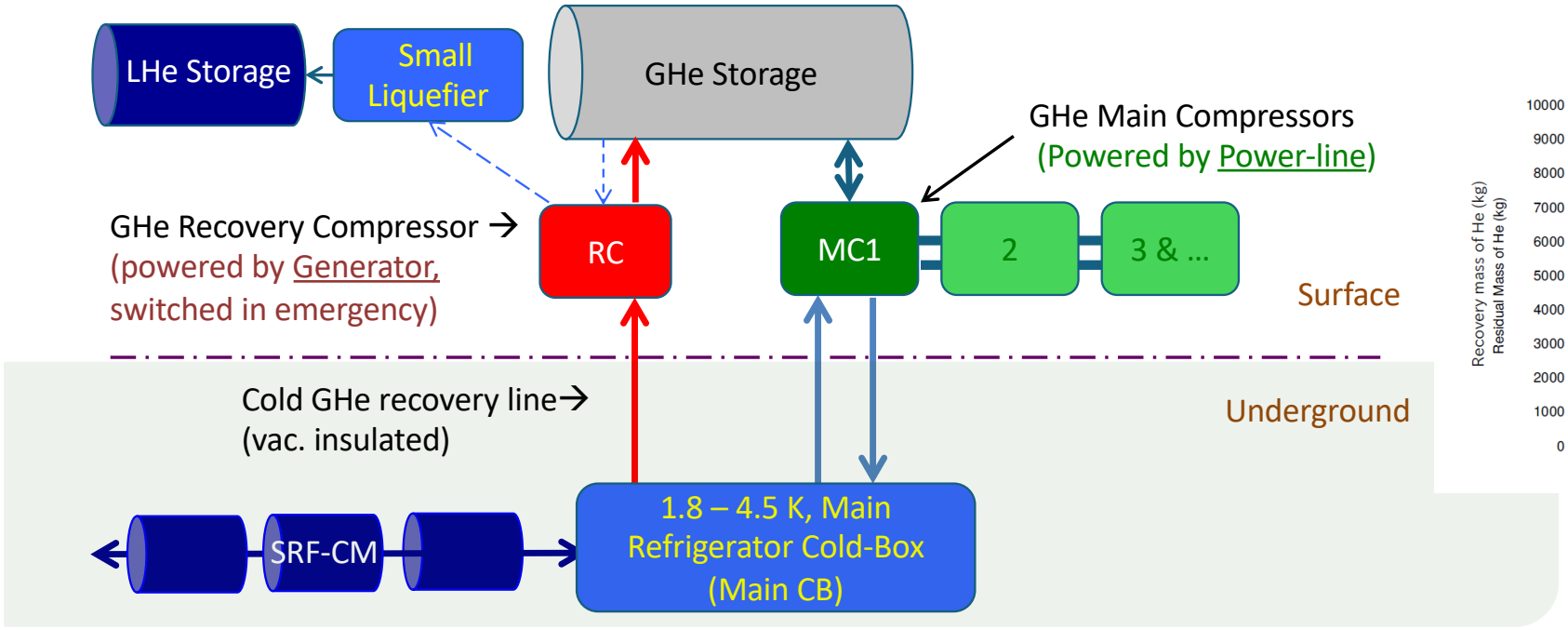
Lessons learned & Future Actions required

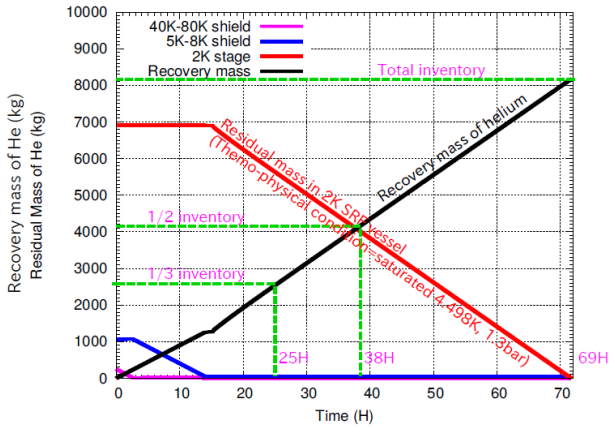
Lesson learned:

- The current SRF accelerator systems not ready to conserve He inventory in case of major hazard causing total power failures.
  - SRF system with low pressure (2 bar max.) will face difficulty to conserve He inv.
  - (It is much different from SCM system (20 bars max.)
- He resource cost is getting significantly high (> a factor 5) and the current emergency action concept may not work in future.

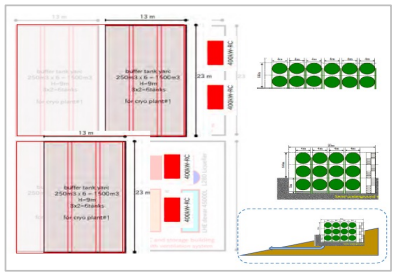
- **Future Actions:**
- He resource conservation (i.e. 100 % recovery) will become a critical requirement large SRF accelerator system in the future, in response to He cost extraordinary expensive. TH **full He recovery will become inevitable in** future large SRF acc. system.

He Flow Lines in Emergency to Recovery



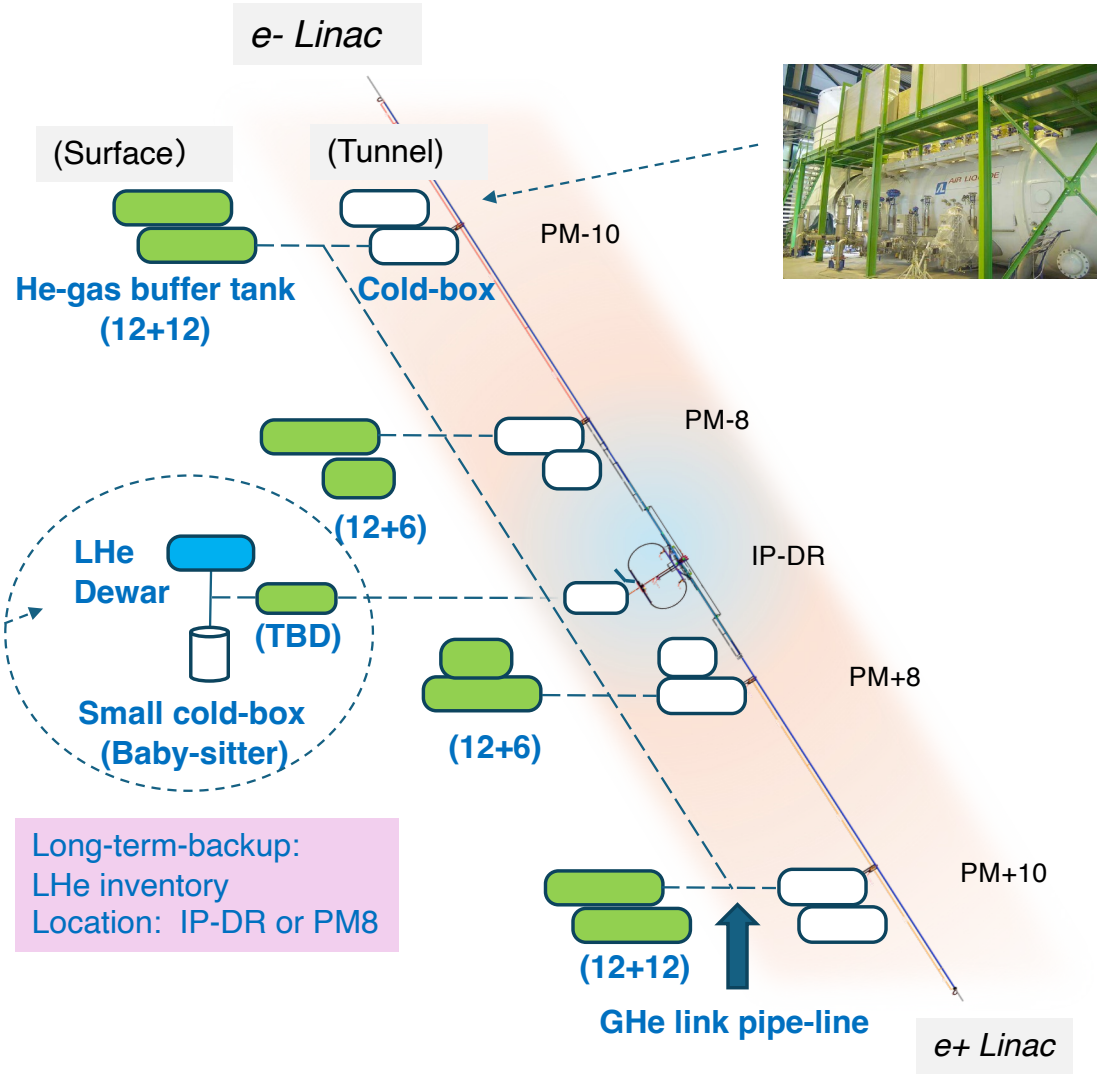


3 days



250m3 buffer tank
Weight = 70t
H=4.3m (including base)
W=4m, L=23m

- Volume : 43000 L (at 6 buffer tank $(250 \times 6\ \mathrm{m}^3)$
- Size : ~ L=12m, W=2.5m, H=2.6m
- Spec : $0.2 \sim 0.5$ %/day



Long-term-backup:
LHe inventory
Location: IP-DR or PM8

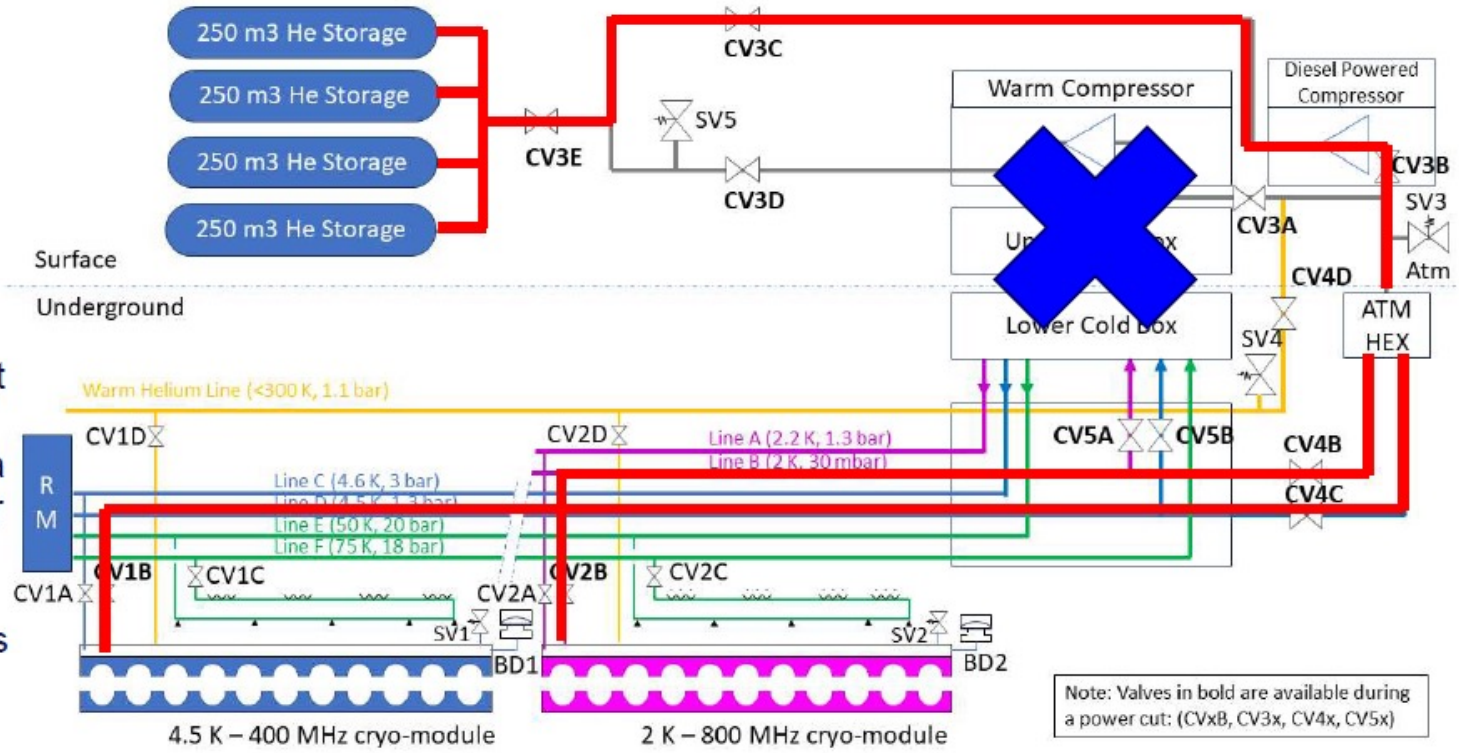
Focus: Scenario S2

FCC-ee

Conceptual design!

S2 compliance – Loss of full sector cooling capacity

- Cause: lack of refrigeration capacity that could appear due to:
  1. A problem in the compression station.
  2. A problem with the cold box.
  3. A full power cut.
- Mitigation measures:
  - UPS-powered critical valves.
  - Installation of an atmospheric heat exchanger / evaporator.
  - Installation of a diesel generator, a supply of diesel and a compressor that is powered by this generator.
- Strategy: it is awaited until cryomodules reach 1.5 bar before starting the recovery (~30 min for 4.5 K CM, and ~ 100 min for 2 K CM).



Allows for a small operational margin.

Helium Recovery System study outcome

FCC-ee

Preliminarily concept sizing:

Separate compressor, or reusing part of the stage compressors?

	Point H	Point L
Mass flow rate	530 g/s	315 g/s
Isothermal compression power	1 MW	600 kW
Electrical Power needs	2 MW	1.2 MW
Diesel generator rating	2.5 MW	1.4 MW
Autonomy	24 h	13 h
Diesel tank	15000 L	4900 L
Cooling water needs	~100 m3/h	~60-100 m3/h
Atmospheric heat exchanger	810 kW	500 kW
Cavern volume needs	16 m2 x 8 m	10 m2 x 8 m

Source: Linde

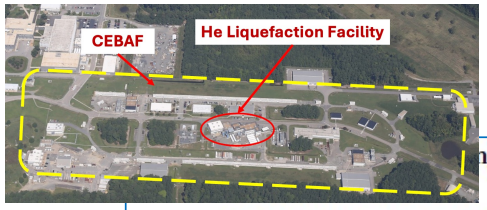
All the helium storage is provided by the usual He gas tanks installed at each point.

The diesel could be supplied a-posteriori thanks to the operational margin of >30 min.

Is the concept compatible with CV and HSE constraints in the cavern?

Further study needed to assess if ATM HEX can be located on the surface/shaft instead.

Reserved:



An experience at JLab, 2003

ngs of 2005 Particle Accelerator Conference, Knoxville, Tennessee

SRF PERFORMANCE OF CEBAF AFTER THERMAL CYCLE TO AMBIENT TEMPERATURE *

R. A. Rimmer, J. Benesch, J. Preble, C. Reece, JLab, Newport News, VA 23606, USA

Abstract

In September 2003, in the wake of Hurricane Isabel, JLab was without power for four days after a tree fell on the main power lines feeding the site. This was long enough to lose insulating vacuum in the cryomodules and cryogenic systems resulting in the whole accelerator warming up and the total loss of the liquid helium inventory. This thermal cycle stressed many of the cryomodule components causing several cavities to become inoperable due to helium to vacuum leaks. At the same time the thermal cycle released years of adsorbed gas from the cold surfaces. Over the next days and weeks this gas was pumped away, the insulating vacuum was restored and the machine was cooled back down and re-commissioned. In a testament to the robustness of SRF technology, only a small loss in energy capability was apparent, although individual cavities had quite different field-emission characteristics compared to before the event. In Summer 2004 a section of the machine was again cycled to room temperature during the long maintenance shutdown. We report on the overall SRF performance of the machine after these major disturbances and on efforts to characterize and optimize the new behavior for high-energy running.

INTRODUCTION

GeV in 2002 for physics running with a test run achieving 6.0 GeV for a short period. When Hurricane Isabel blew through in September 2003 and the resulting power outage resulted in the warm up of all the cavities the arc rate models had to be re-established from scratch and in many cases were quite different from those developed previously.

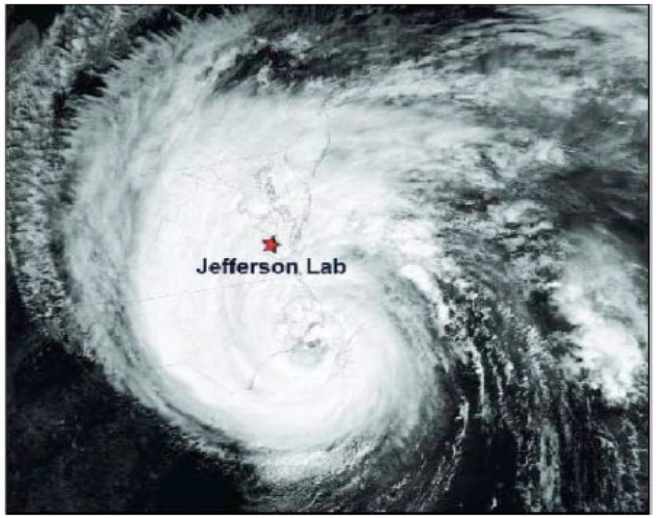


Figure 1: Hurricane Isabel, September 2003.

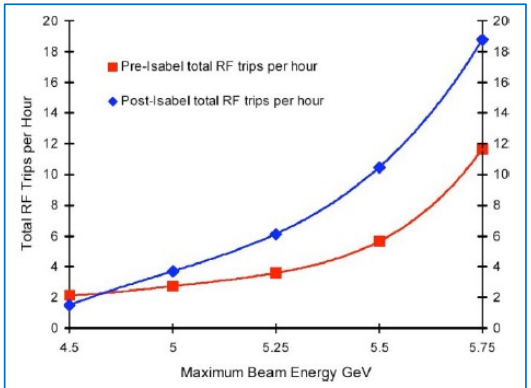


Figure 2. Trip rates before and after hurricane Isabel.

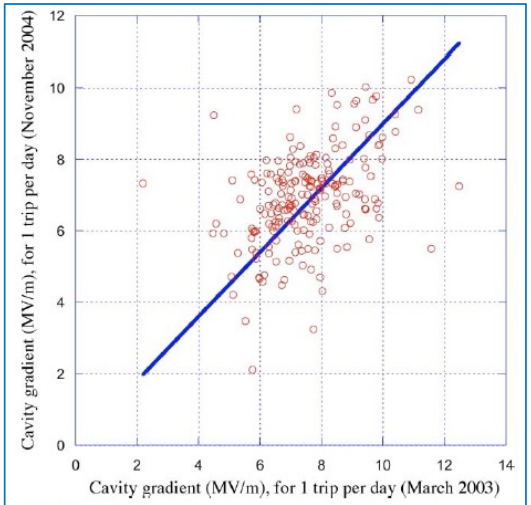


Figure 3. Comparison of pre- and post- hurricane gradients. Blue line: y = 0.9x (zero intercept forced).

An experience at JLab, 2003

Communication with JLab (c/o B. Rimmer), for introduction

RR **Robert Rimmer <rarimmer@jlab.org>**
Re: [EXTERNAL] Fwd: Time to be corrected, Re: The meeting proposal to be shifted ! Re: New publication: ozone cleaning to enhance FE onset
宛先: Akira Yamamoto <akira.yamamoto@kek.jp>,
CC: Roger Ruber <ruber@jlab.org>

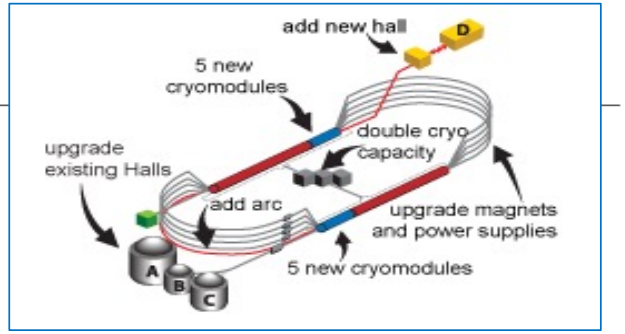
受信 - iCloud 昨日 23:05
非表示

Hi Akira,
I am sorry I will not be able to attend IPAC this year, this sounds like an interesting discussion. I will search for the original files for these papers. The main impact for CEBAF from this event was loss of site power for about 4 days. Because much of the cryogenic insulation relied on active pumping this led to a a loss of insulation vacuum and rapid loss of the 65,000l inventory of liquid helium, followed by an uncontrolled warm up of all the cryomodules. This stressed all of the indium seals leading to fears of helium to beamline vacuum leaks (this risk is unique to the old CEBAF CM design I think), however in the end I think only one CM was not recoverable. The thermal cycle did however randomize the field emission performance of the cavitites with some improving and some degrading. The net result was a slight degradation overall. This was partly the motivation for starting the cryomodule rework program which continues even today. Every cavity had to be recommissioned and it's new trip rate established when the machine was restored. Major improvements and lessons learned included:

Increased back-up power (generators) to keep vital vacuum and control systems operational in case of site power outage.
Dual site power feeds from two different substations to provide redundancy.
Redundant Cryoplants with valving so that so that either can keep the machine cold (but not operating) in case of major failure
New cryomodule designs (C100) eliminating helium to beamline indium seals.
More automated cavity and cryomodule recovery procedures.
It would be nice to have enough gas storage and back-up compressor capacity to retain the helium inventory in case of uncontrolled warm up but this is not practical for large machines (for planned warm ups e.g. 12 GeV upgrade we negotiated to send our helium back to the supplier).

Happy to discuss on Zoom, please let me know when is a convenient time for you.

Best regards,
Bob.



From: Akira Yamamoto <akira.yamamoto@kek.jp>
Sent: Thursday, March 20, 2025 10:00 PM
To: Robert Rimmer <rarimmer@jlab.org>
Cc: Akira Yamamoto <akira.yamamoto@kek.jp>
Subject: [EXTERNAL] Fwd: Time to be corrected, Re: The meeting proposal to be shifted ! Re: New publication: ozone cleaning to enhance FE onset

Dear Bob

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at the coming TTC meeting in Korea, and

we will discussion on "Hazard mitigation for SRF accelerators and Cryogenics.

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