Helium burst incident at the PROSCAN medical cyclotron facility

Peter Hottinger, Markus Kostezer, PSI, Villigen, Switzerland

Abstract:

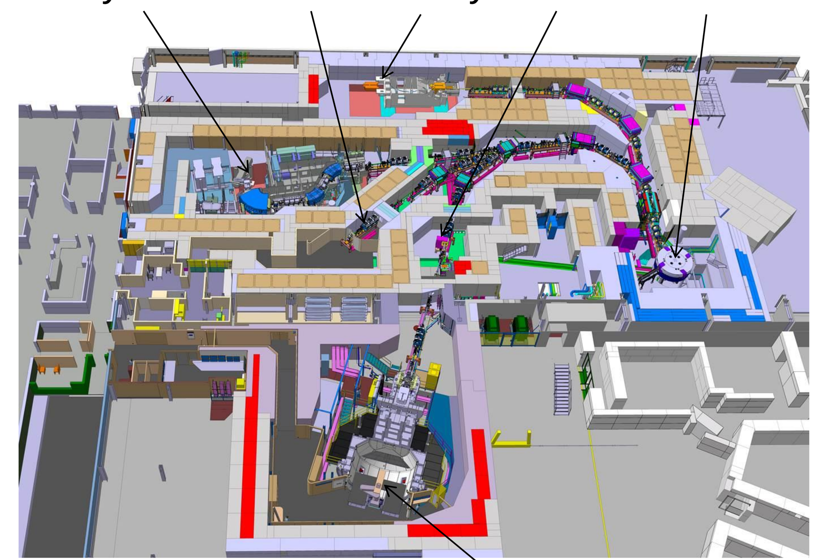
PROSCAN is a proton irradiation facility for tumor treatment at the Paul Scherrer Institute in Switzerland; it is in operation since 2007. At the heart of the facility is COMET, a compact, super-conducting 250 MeV cyclotron. The facility serves three Gantries for generic tumor treatment, OPTIS 2 for eye cancer treatment and the proton irradiation facility (PIF) for radiation resistance tests of electronics. PROSCAN is operated 52 week per year, four to five days per week for cancer treatment. The facility is operated most weekends as well for PIF. About eight long weekends a year are scheduled for maintenance.

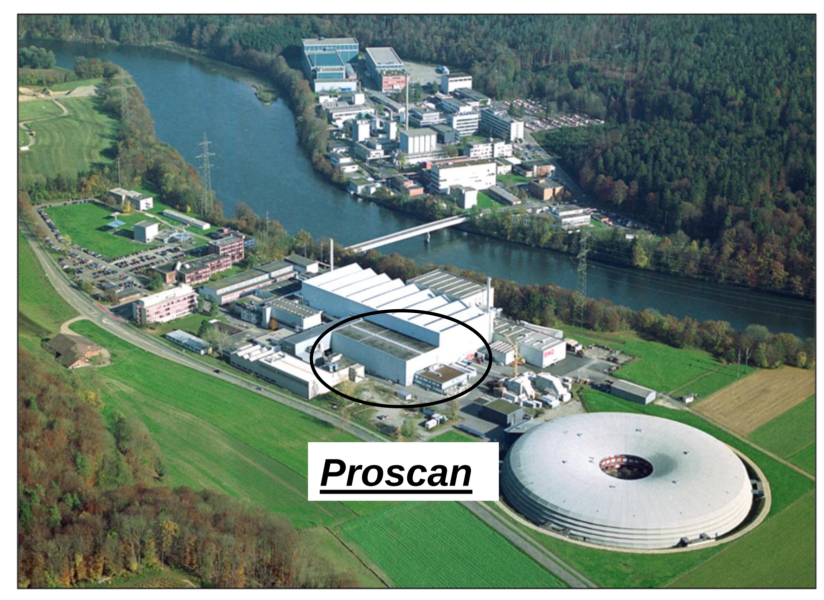
On the maintenance weekend in October 2016 a severe incident happened that caused an interruption of several days. The cryostat warmed up suddenly and the evaporating liquid Helium bursts out of the He tank. The poster will describe the sequence of events and presents the measures taken to prevent a similar event from happening again.

Tumor Treatment in the medical facility

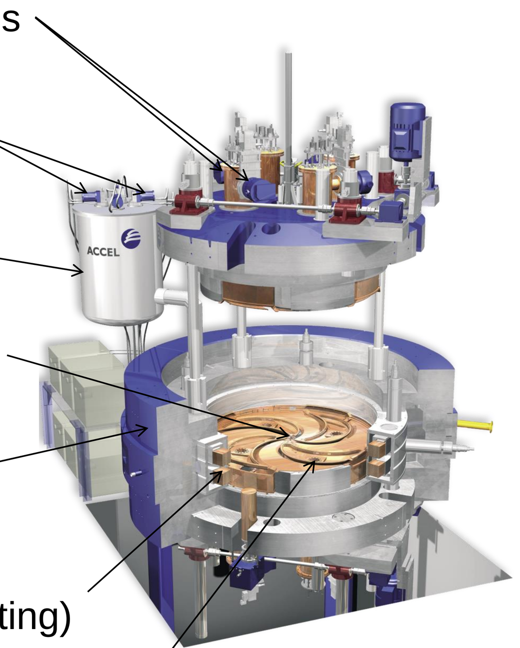
Proton treatment of eye, brain and spine tumors. In case of an unexpected incident or delay, the planning for the treatment of the patient must be immediately arranged for the earliest possible date.
This is not always easily accomplished, due to the lack of available time slots arising from advanced bookings.

PROSCAN Facility





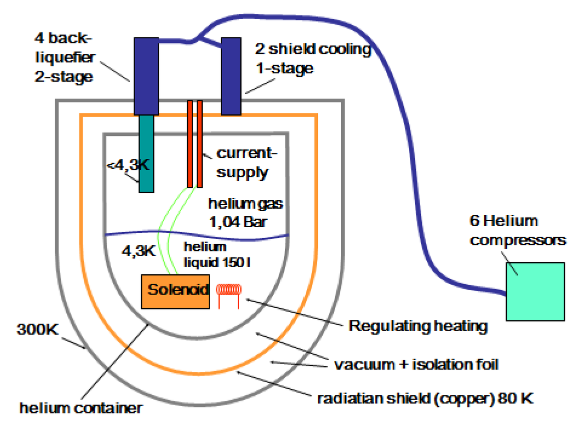
Main components of Cyclotron COMET



Cryogenics system

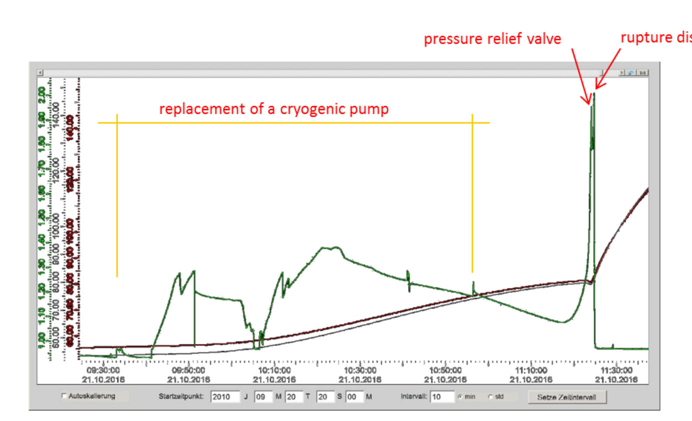
During the maintenance weekend, started 2016-10-23, a cryogenic pump (cold head) was replaced at the supply cryostat. This routine work, which has to be done annually, could be successfully completed at about 10:50 am. In order to realize the exchange, the cryogenic system has to be opened, the pressure in the tank is controlled in a controlled manner in order to minimize the loss of liquid helium.

Cryogenics schematic



the pressure is again normalized to 1.04 bar after the work by the cryogenic pumps and is kept constant (controlled) with a counter-heating. A short time later at around 11:16 o'clock a sudden pressure increase in the supply tank (L He) occurred.
The pressure increase in the supply cryostat (L He), which resulted in the burst breakage, lead to a large volume of liquid helium to be spilled.
An immediate repair had to be planned in order to minimize the disruption to patients.

Pressure and temperature curve

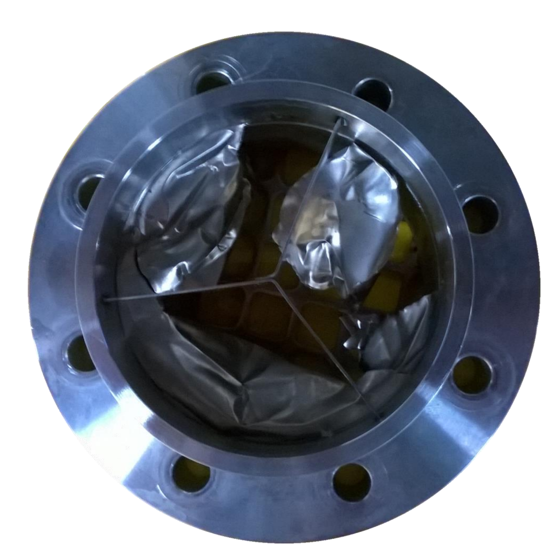


- green: he pressure in the supply cryostat
- red: temperature 80 K shield near to the supply cryostat, (shield 1)
- gray: temperature 80 K shield far to the supply cryostat, (shield 2)

At about 1.95 bar, the pressure relief valve was released for the first time to lower the pressure, but this was not enough due to the rapid rise, which led to the breaking of the bursting disc.

The broken burst disc

The broken burst disc after crash. The cryostat warmed up suddenly and the evaporating liquid Helium bursts out of the He tank.



The bursting disc with a small hole in the centre

A first inspection revealed that all cryogenic pumps (cold heads and the two shield coolers) were in operation and functioning. In order to stop the liquid helium loss, the bursting disc was replaced immediately , but leading to a pressure increase in the support cryostat. The excess pressure was manually released. Although the pressure increase remained within the safety limits, the thin film was still damaged and a small hole was created. Further investigations showed a bad isolating vacuum and the ion getter pump was taken out of service. It took about 3 days to order a replacement for this burst disk to the supplier. After the incident the ion getter pump was replaced by the turbo pump. The liquid helium had to be refilled to a certain limit, this took 1-2 days and the damaged bursting disc was replaced. Patient operation could be resumed after 4 days.

OUTLOOK

In a scheduled shutdown in 2017 of about 8 weeks, some maintenance work had to be carried out in order to prevent and minimize risk. For this purpose, the cryogenic system was completely regenerated and defrosted to clean the isolation vacuum.
In the warm state, new vacuum valves were installed, all seals were replaced and additionally a turbo pump was installed for future maintenance and replacement of the cold heads. The turbo pump, which replaced the ion getter pump in 2016, actively pumps at the isolation vacuum. This is to prevent the isolation vacuum from filling up with diffuse gases in liquid or solid form over time. In addition, the turbo pump is to be used to stabilize the pressure in the system.