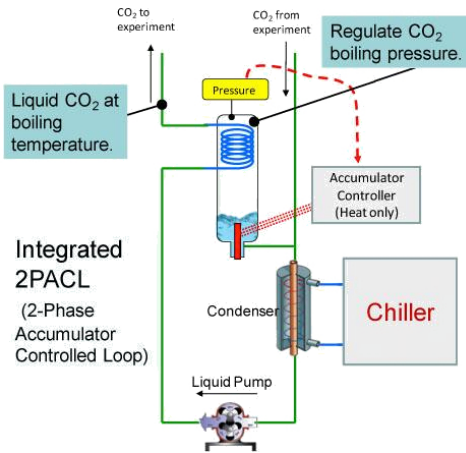


# INTEGRATED CO<sub>2</sub> COOLING SYSTEM

*Integrated accumulator and heat exchanger to simplify use and control.*

*CERN's detectors contain millions of silicon pixels used to record the tracks of particles created during collisions at interaction points in the Large Hadron Collider (LHC). Radiation damage has a significant impact on the lifetime of these silicon sensors. Lowering the temperature of the sensors to below 0°C reduces the negative effects of radiation. CO<sub>2</sub> as coolant is an excellent option for this application as it can withstand a large amount of radiation while providing stable, high-efficiency cooling over long distances. Furthermore, it has the advantage of being a non-toxic, non-flammable, non-ozone-depleting refrigerant.*



## AREA OF EXPERTISE

- Cooling instrumentation
- Electronics

The 2PACL system make use of evaporative CO<sub>2</sub> cooling – whereby the change in phase from liquid to gaseous CO<sub>2</sub> results in a cooling effect.

A 2PACL cooling plant contains a vessel (called the accumulator), a liquid pump, condensers (heat exchangers), and a chiller. The accumulator stores a liquid/vapour mixture of CO<sub>2</sub>, and regulates the pressure inside the system. This liquid/vapour mixture is liquefied further in a condenser, which is cooled by the chiller. The liquid is then pumped through small tubes to the detector where it evaporates before returning to the cooling plant.

## CONTACT

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Find out more at:

[kt.cern](http://kt.cern)

I-2PACL is a simplified version of the 2PACL design, in which the accumulator is integrated with the internal condenser. This makes the system cheaper and easier to control, however, the cooling capacity of the system is reduced as a consequence.

In both systems, use of CO<sub>2</sub> in long cooling tubes enables the process to be controlled from the cooling plant, which can be located at a relatively large distance from the area to be cooled. In addition, CO<sub>2</sub> is substantially cheaper than fluorocarbon refrigerants and has a much lower negative impact on the environment.

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## ADVANTAGES & APPLICATIONS

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- High-efficiency cooling – due to the high heat transfer coefficient of CO<sub>2</sub>.
- High thermal control – better than +/- 0.2°C stability.
- Distance cooling – CO<sub>2</sub> can be transferred through small cooling tubes (e.g. stainless steel welded piping) and retains its cooling capacity over long distances (>50m).
- Distributed cooling – small pipes can reach difficult to access areas that are hidden or embedded, providing distributed cooling throughout the entire system.
- Reduced risk of damage to expensive equipment – CO<sub>2</sub> is gaseous at room temperature, so will not damage equipment if a leak occurs in the system.
- Natural refrigerant - CO<sub>2</sub> is non-toxic, non-flammable, non-ozone-depleting and cheaper than other refrigerants.
- Low vibration levels - compared to other cooling fluids.
- Temperature range - -45°C to +25°C
- Easy operation – in the case of the I-2PACL cooling system, which uses a simple heater control in the accumulator.

## LIMITATIONS

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- High-pressure system – requires appropriate hydraulic circuit design to be in place (specific safety procedures may apply).
- High-tech system – not appropriate for applications with more basic cooling needs, such as food refrigeration, where cheaper CO<sub>2</sub> cooling systems already exist.

## IP STATUS

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- The I-2PACL system has been jointly patented by CERN and the Dutch National Institute for Subatomic Physics (Nikhef). The patent has been granted in Japan (6087359) and is pending in Europe (2753887).
- The 2PACL system, originally developed at Nikhef, has been widely published and therefore the principle is not protected. However, certain methods, designs and/or results generated from continued research and development may not be available in the public domain, and therefore constitute proprietary CERN know-how.

