The Orange Cryostat: from Wet to Dry

NEUTRONS FOR SCIENCE

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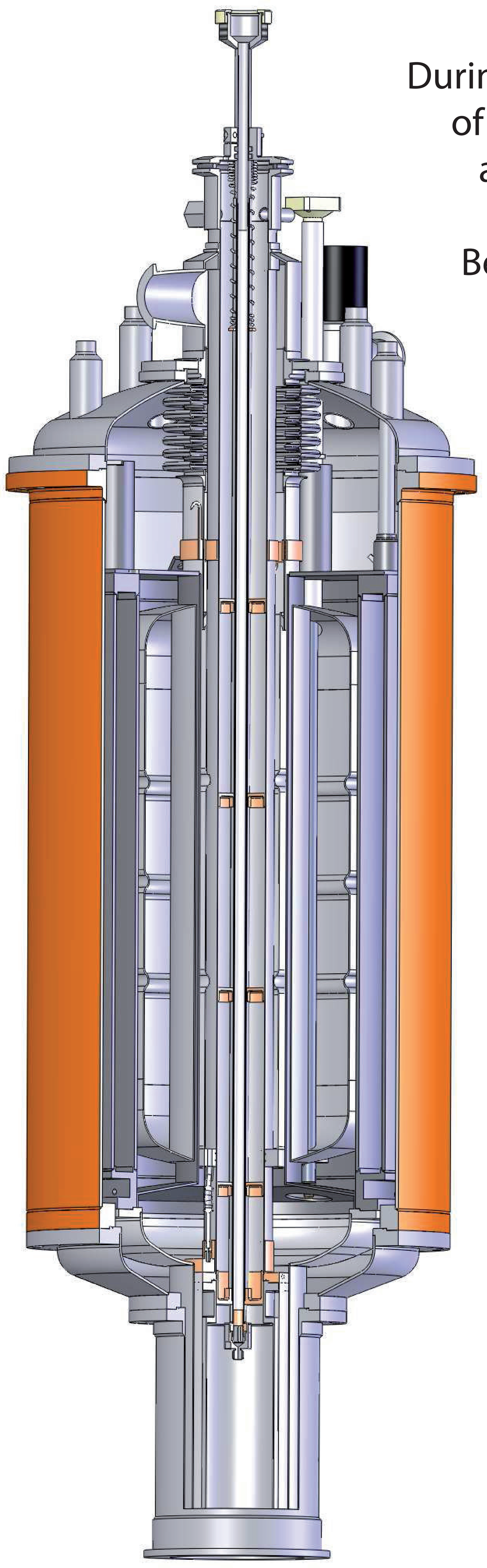


During the last decade, the performances of the cold heads have made big progress while the cost of the helium gas has continued to increase. The investment cost of an Orange cryostat is still attractive but a dry cryostat is much easier to use and roughly 3 times cheaper to operate.

Because ILL owns many Orange cryostats in which we can use ^{3}He and dilution refrigerators, we have decided to design and build a dry version of the Orange cryostat that is fast and very easy to operate, i.e. without Joule-Thomson stage reaching temperatures below 3 K.

As the cryogenic performances calculated for a Ø49 mm and a Ø70 mm sample bore are very similar, a Ø70 version featuring a Ø49 heating insert has been considered so as to cover a wider temperature range.

Top-loading Wet Orange Cryostat

Specifications

1.5 - 320 K - cryostat
1.5 - 550 K - cryofurnace
Ø70 sample bore, Ø330 cryostat

Investment

cryostat ≈ 40 k€
manpower ≈ 1.2 k€
electronics ≈ 10 k€
dewars ≈ 20 k€
pump ≈7 k€
total: ≈ 78 k€

Operation (200 days)

100 LHe/week ≈ 11 k€
140 LN2/week ≈ 0.5 k€
4 800 kWh ≈ 0.3 €
total: ≈ 12 k€/year

Top-loading Dry Orange Cryostat

Specifications

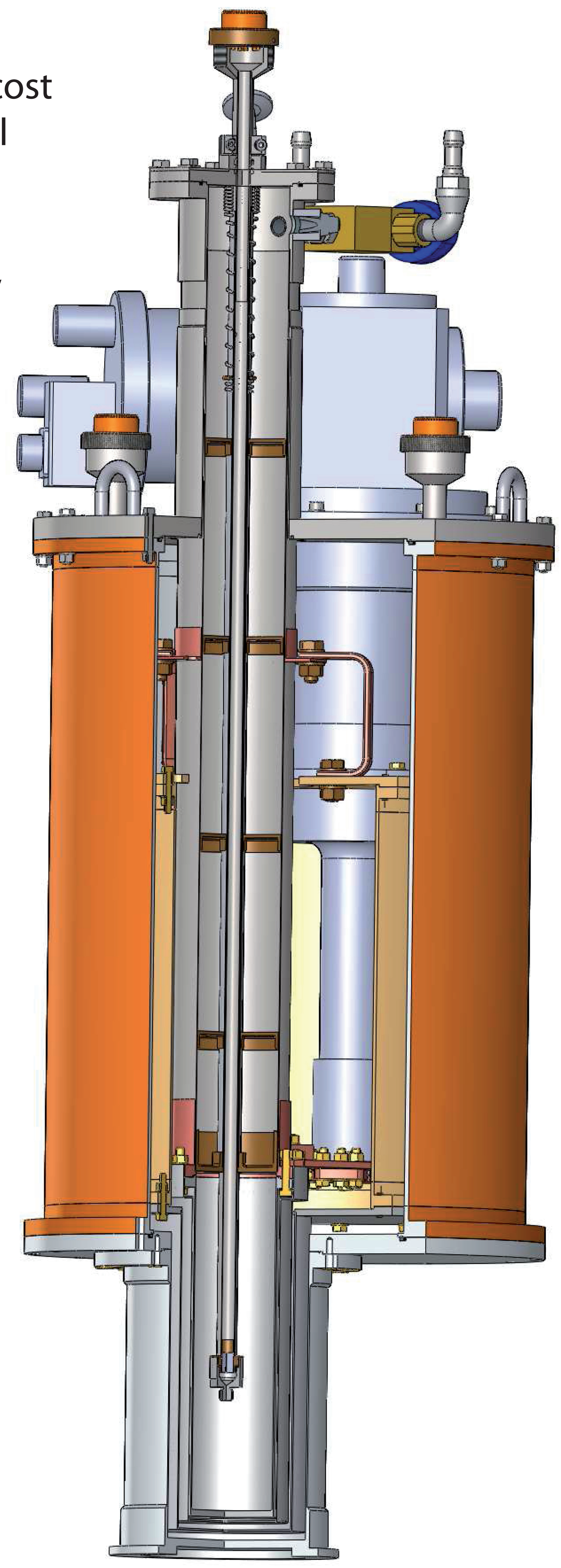
3 - 320 K - Ø70 sample bore
3 - 620 K - Ø49 sample bore
Ø420 cryostat

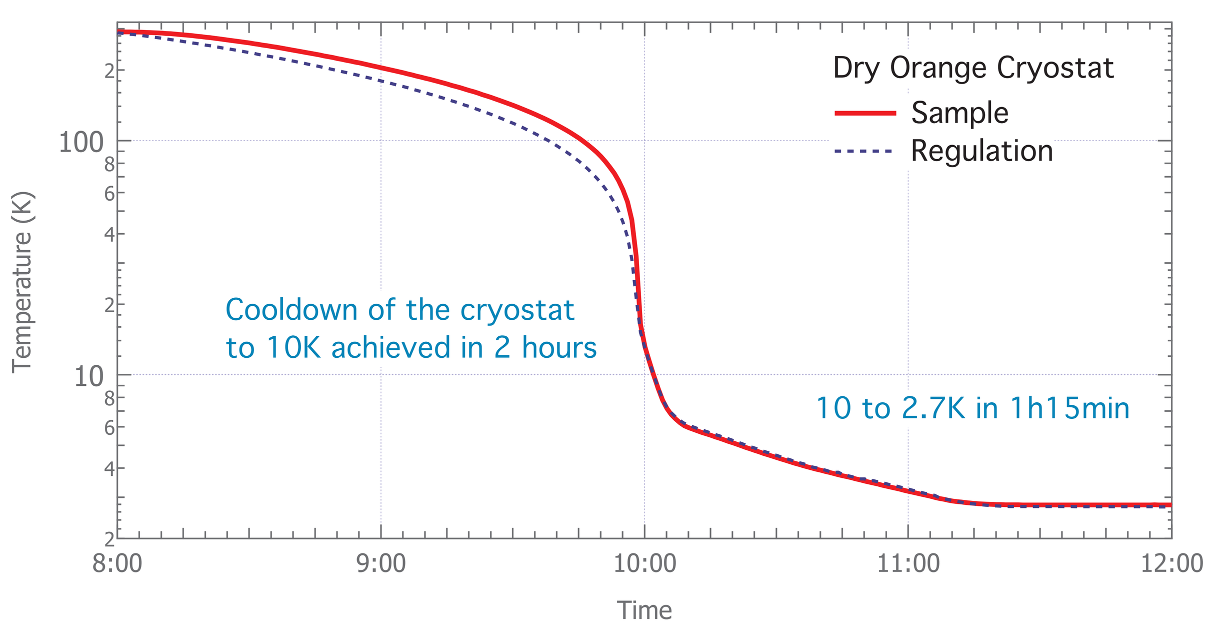
Investment

cold head ≈ 35 k€
manpower ≈ 1.2 k€
electronics ≈ 6 k€
mechanics ≈ 30 k€
total: ≈ 72 k€
i.e. same cost

Operation (200 days)

cold-head ≈ 2.5 k€
31 200 kWh ≈ 1.5 k€
total: ≈ 4 k€/year
i.e. x3 cheaper

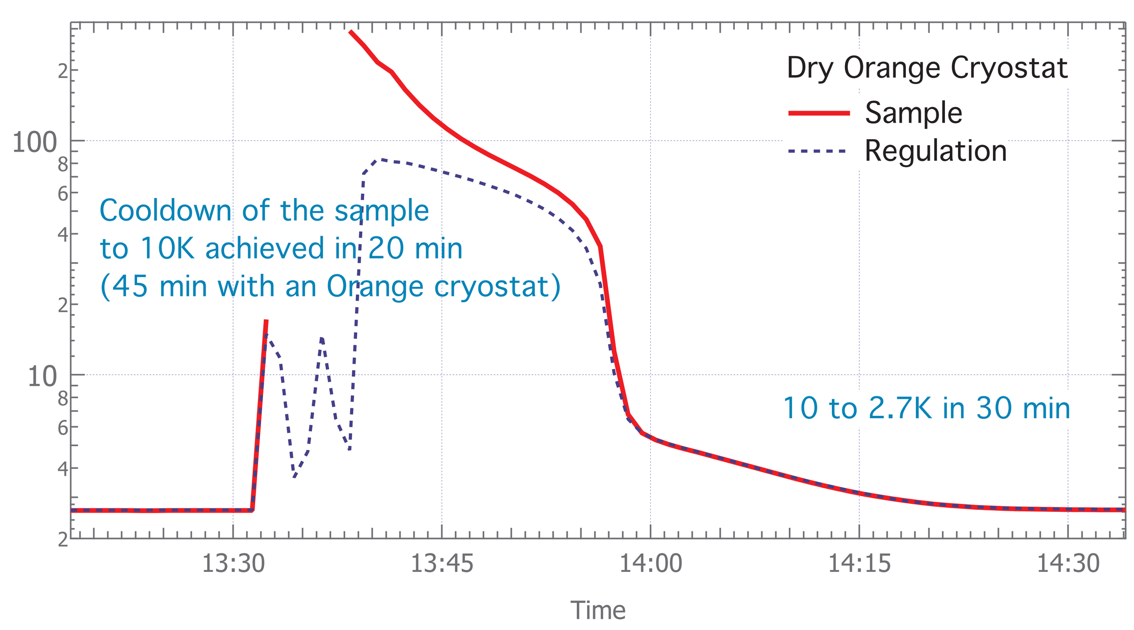




Once the compressor of the cold-head has started, it takes about 2 hours to reach 10 K at the sample.

Below 10 K, the low cooling power of the 2nd stage leads to a further delay of 1h 15min to reach 3 K.

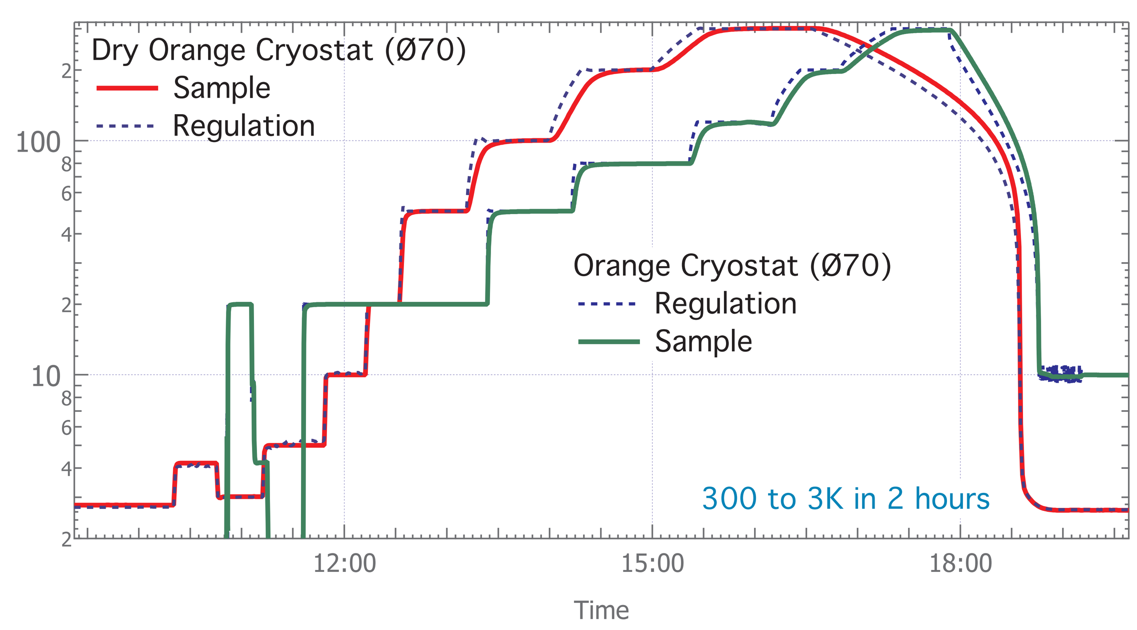
With a Ø70 wet system, the cryostat and the sample are cooled down to 1.5 K in less than 2 hours (for the same calorimeter size).



When the calorimeter is already at base temperature, 20 minutes suffice to cool down a sample to 10 K.

A further delay of 30 min is required to reach the base temperature, leading to a total time of 50 min.

With a Ø70 wet cryostat, the introduced sample is cooled down to 1.5 K in about 1h 30 min, i.e. about 2 times more time.



When carrying out an experiment, the performances of the dry cryostat are optimum if the user cool down the sample once and warm it up afterwards.

If the calorimeter is warm when starting the experiment and/or there is a need to cool down the sample several times, the wet cryostat remains clearly faster.

Remarks

The impossibility to regulate the cooling power of a cold-head leads to a huge gradient of temperature in the calorimeter if the heat exchanger is not properly designed.
A bottom-loading cryostat is not faster. The dismounting, remounting, pumping and cool-down of the cryostat are painful and time consuming.
The sample temperature cannot be known with precision in the absence of a calorimeter.

Perspectives

Several instruments have seen a flux increase of several orders of magnitude leading to a new quality of experiments. We need much faster cryostats and automatic sample changers.
We are developing a solution to shorten the cool-down time of a wet cryostat by a factor 3. Several solutions are going to be investigated for dry cryostats. The design of a cold sample-changer is also going to start within the framework of the NMI3/FP7-2 project.

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