Temperature Stabilization of the BOREXINO Detector for the CNO Quest

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Borexino and CNO

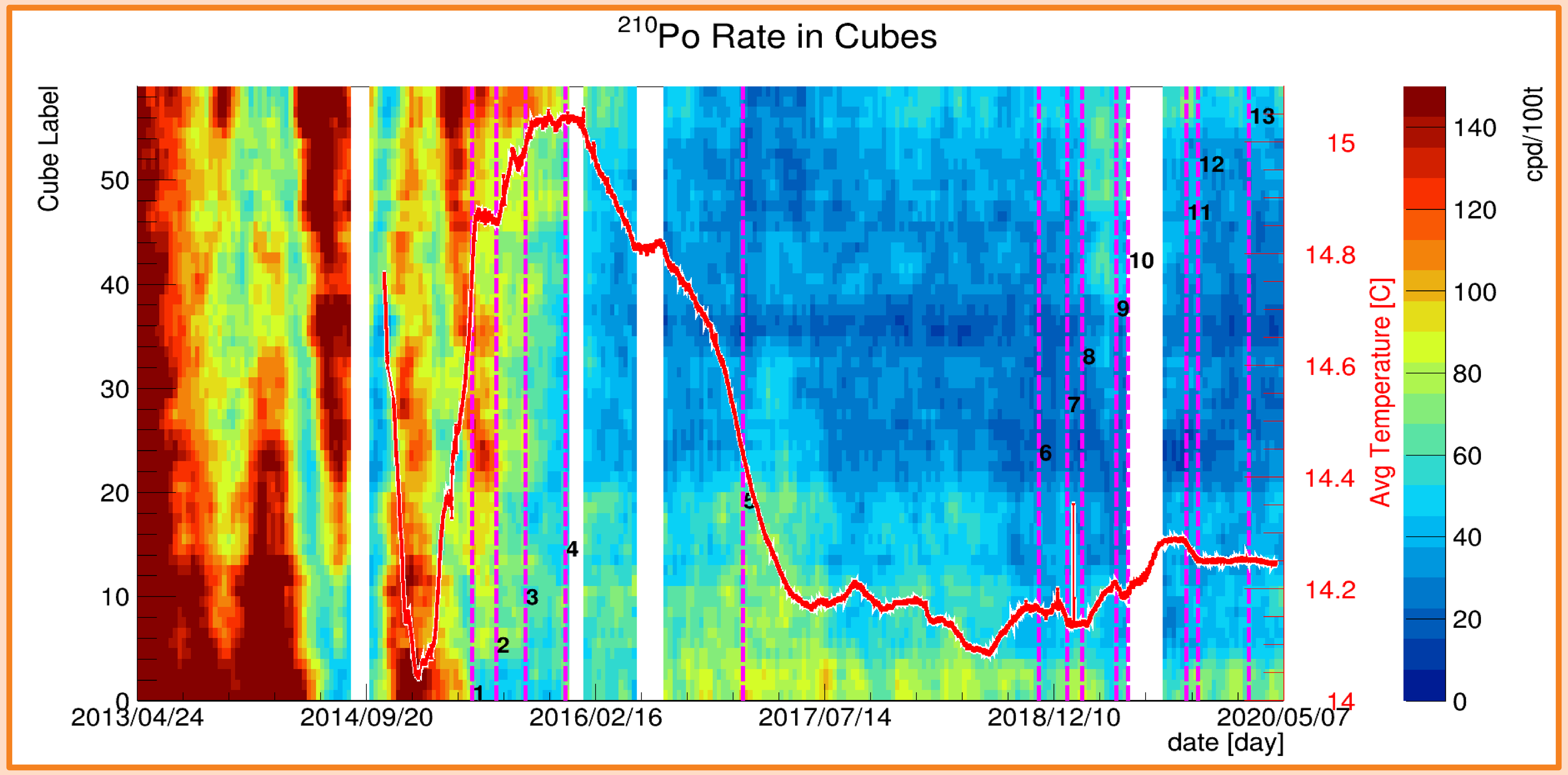
Borexino is a liquid scintillator detector optimized for sub-Mev solar neutrinos detection. CNO **Neutrino detection is currently based on independently constraining the ^{210}Bi background, inferred from ^{210}Po trough the A=210 chain.**

Thermal Insulation

Detector thermal stability is necessary for avoiding background variations due to mixing induced by temperature changes (human activities and seasonal effects).

From May 2015 and January 2016 [1][3][4], the detector surface (900 m^2) was covered with two layers of insulation material: outer layer, 10 cm of mineral wool Ultimate Tech Roll 2.0 with thermal conductivity at 10°C equal to 0.033 W/m/K; inner layer, 10 cm mineral wool Ultimate Protect wired Mat 4.0 reinforced with Al foil 65 g/cm^{2,} with glass grid on one side with thermal conductivity at 10°C equal to 0.030 W/mK.

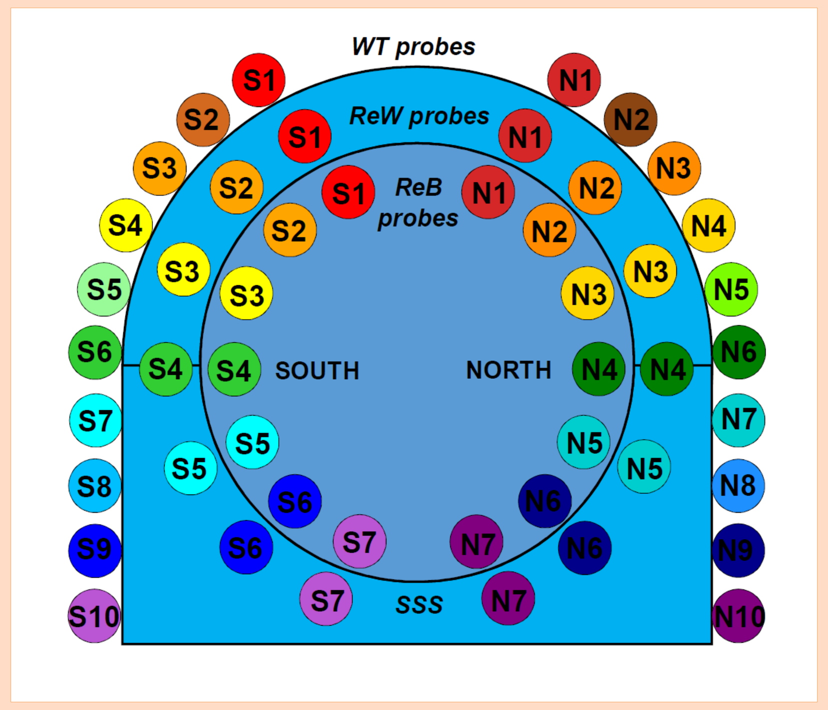
^{210}Po evolution in the liquid scintillator in 59 cubes (3 ton each) in the sphere r < 3m

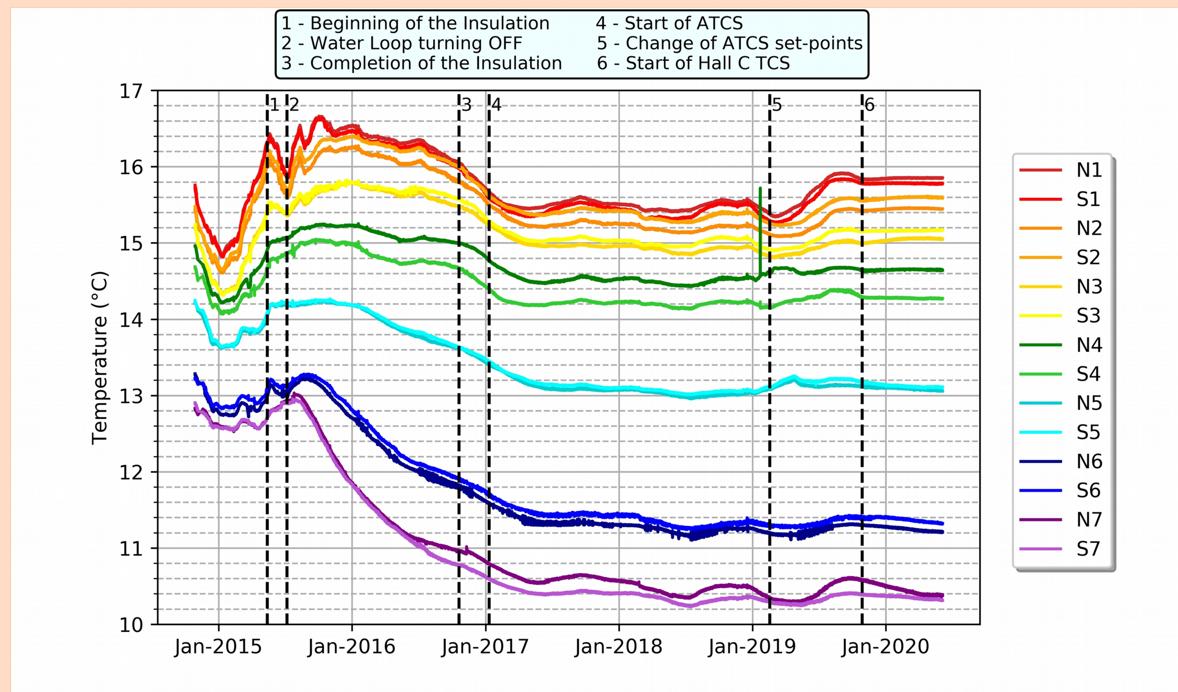


Effect of the thermal stabilization program on the ^{210}Po evolution

- Summary of the operations-

[1] Start of the temperature stabilization program. [2] Stop of the water re-circulation system. [3] The insulation of the whole detector is completed. [4] Insulation of all possible conductive connections. [5] Start of the top active temperature control system. [6] Installation of other two active temperature control systems on the Water Tank. [7] Commissioning of the new control systems [8] Change of the top control system set-point. [9] Interruption of the new control systems [10] Adjustment of the top active control set-point. DAQ break. [11] Installation and commissioning of the Hall C temperature control system. [12] Setting of the final configuration of the Hall C system. [13] End of the CNO analysis period.





Borexino Temperature Sensors

There are 67 temperature sensors in different positions inside and outside the detector in operation since 2014. From this monitoring system we can determine the average natural vertical gradient (~0.5°C/m). **Keeping this gradient constant is the key to damp convective currents inside the liquid scintillator.**

Temperature Control System

In order to compensate for the heat loss due to the thermal insulation (247 W) and to damp the residual seasonal variations from the Laboratory Hall environment, different active TCS's were designed, installed and commissioned [5][6][7][8][9] from 2016 to 2019. The stability passed from 0.2°C to <0.1°C with the commissioning of the temperature control system of the Laboratory Hall [11][12].

Fluid dynamics simulation

The complex dynamics of the ^{210}Po and ^{210}Bi during the most important phases of the thermal insulation program has been continuously interpreted using fluid dynamics numerical simulation with FLUENT.

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