Vacuum conditioning, cooling, biasing and test of the CLUSTER detector

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1. General

The major difference between the CLUSTER detectors and the other type HPGe detectors is that the CLUSTER detectors are built by encapsulated HPGe crystals with their own vacuum space. Other important peculiarities are: composite assembly comprising 7 Capsules, compactness – the space between the components and especially between the cold and warm structures of the cryostat, is very limited, relatively large size of the whole construction, many vacuum sealed components and AC coupled input of the preamplifier by miniature ceramic capacitor. This requires more careful attitude toward the conditioning and biasing the detector.

2. Vacuum conditioning

The vacuum conditioning should be done only by oil free vacuum units. The use of oil-based prepumps causes a back-flow of oil vapors which pollute the inner space surfaces thus causing instabilities of the HV lines and saturation of the absorber which is to maintain the vacuum of the cryostat.

The pump system should have enough power and at least 200 l/min capacity is required. Two CLUSTER detectors can be conditioned simultaneously.

The conditioning procedure begins with air evacuation which has to be done by weak prepump in order to avoid the pressure shock of the initial phase. If not available two things may be done – either to use the detector vacuum valve by slow opening or another ventilation valve, which is initially kept open and after the start of the prepump is to be closed. The first option may cause the valve cork to fall into the adapter tube (despite the constructive means to retain it on the adapter shaft) which lately will prevent closing the valve and even may cause valve damage. One has to be very careful applying it. The second option requites ventilation valve with large opening, otherwise the pressure wave is still considerable.

After reaching a vacuum of $5\text{-}8.10^{-1}$ the turbopump can be started. The TPS unit starts the turbopump at the very beginning and reaches full speed when the vacuum improves reasonably.

The vacuum conditioning requires heating the inner cold structure. It has an effect of degasing of the surfaces (releasing of the absorbed gases) and improving the vacuum absorber capacity. The temperature to be reached is 50 – 55 ºC and to be kept at least 60 h if the cryostat has not been kept long time open and/or at humid air. If the cryostat has been ventilated by air with humidity more than 50% or has been kept open (even at dry air) more than 4 h, the heating the inner structure has to be extended with 48 h. If the cryostat has not been opened the heating may be reduced down to 12-48 h depending of the case (12 h – only for cooling down after short cycling, 24 h after accidental warming up if the previous conditioning has been carried out soon).

N.B. The ventilation of the cryostat is preferably to be done by nitrogen and is obligatory if the humidity is high.

The vacuum to be reached is $2\text{-}5.10^{-6}$ at 50 ºC and after switching off the power and reaching room temperature has to drop down to $2\text{-}5.10^{-7}$. The total conditioning time has to be no less than 96 h. The power supply has to be able to provide up to 12 V and 2 Amps. The connector is the DB9 connector on the valve adapter box. The polarity is not important. The temperature control is done by Pt100 sensor installed at the cold frame and the corresponding connector is attached on the Ch.B connector panel, LEMO 302 female connector. Use of Pt-104 data logger is recommended.

N.B. It is also recommended to use PT-104 data logger for permanent temperature control *during the operational of the CLUSTER detector, however the cable – 4 wires shielded ones, has to have shield connected to the LEMO male connector case in order to facilitate good screening of the Pt100 wires. The connection to the male LEMO pins is made according 4-wire circuitry. If elevated noise is observed and is proved that the Pt100 readout is responsible one can try various shielding manners (isolated from the side of the PT-104 etc.) or even to give up temperature control at all.*

3. Cooling

After the conditioning is done, the vacuum valve has to be closed carefully. It has to be done slowly maintaining good vacuum, the deterioration should not be more than factor 5. If needed short stops in order to improve the vacuum have to be done. After closing the CLUSTER has to be cooled reportedly. It is recommended to use the cooling bayonets (with phase separator tips), however is any doubt exist that the cooling fails, one has to switch to manual cooling by small dewar vessel and funnel. *Never let the detector to begin warming up during the cooling, i.e. leaving the dewar without LN2. It causes short cycling and than the detector must shortly conditioned again. Short cycling is partial warming up followed by cooling. In this case the gases released from the absorber during the warming up are condensed and adsorbed at the crystal (capsule) and associated electronics surfaces causing HV instability, leak current and HV break down.*

4. Biasing

The biasing can start when the detector has reached a stable low temperature. Usually it happens for 12 h, overnight cooling is recommended. If any doubt exist that the detector is not cold enough the biasing should start lately.

The biasing has to be done in steps of 500 to 1000 V at ramp up speed of 1-10 V/s. If manually done the potentiometer has to be turned very slowly. The change of the bias applied has to be done if the preamplifier is powered. Relative long awaiting time (stop points), 1-4 h, have to be applied in order to stabilize the HV - performance. Due to the unknown vacuum status of the capsule and some peculiarities of the HV filter fast biasing is not recommended. It may cause the channel to fail (blown FET). Monitor the baseline of the preamplifier signal, if any instability or other unusual behavior is found immediately stop the ramping and wait some time until it stabilizes. If needed ramp down to some lower voltage is also recommended.

5. Test

The test is to be done at two voltages – the operational $\mathbf{U_{op}}$ and the sub operational $\mathbf{U_{op}}$ **-500 V.** The goal is to determine the status of the detector – radiation damages, leak current etc. and the feasibility to operate high bias crystals et lower ones.

*N.B. The bias voltages marked with * are only the maximal. The recommended bias is usually 500 V less. However, if incomplete charge collection is observed then higher bias is needed.*

Before the spectroscopy test to start one has to adjust the PZ of the channel preamplifier and the signal offset. This is done by 2 the potentiometers of the 3-potentiometers group. The middle ones is for the offset and the potentiometer close to the connector panel is for the PZ.

The potentiometer toward the inner compartment, where the cables are coming from and where are located the HV and signal feedthrough, is for the drain voltage and it must be always +5 V. The other single potentiometer at the other side of the preamplifier board is for the drain current and this current has to be approx. 10 mA. The both settings, the drain voltage and current are preset and do not have to be changed. Any adjustment of the drain current has negligible effect and eventually may only destroy the performance of the preamplifier.

Observe the pulses at reasonable oscilloscope scale, both in voltage and time, for example 10 mV and 2 ms, DC input, 50 Ohm. Use always plastic adjustment screwdriver.

The spectroscopy test as to be carried out always at the same conditions, e.g. 6 μs shaping time and such a gain that the 1332 keV line of ^{60}Co to come around ch. Nr. 6000-6500 by 8000 ch. Spectrum. Typically gain 50x1.24 (standard for GSI) gives good results. If due to production tolerances of the feedback capacitor (which dominates the conversion factor of the preamplifier) or other reason the gain is too high, go lower, e.g. 50x0.84 (also standard for GSI), lately the line position can be scaled up. Too high gain speaks for high conversion factor and is an early sign that the feedback capacitor may have already damaged contacts (due to thermal stress). Use ^{60}Co for the test, ^{57}Co (in combination with ^{241}Am for calibration purposes) is also needed for the low energy region, however it may be skipped if not important. One has to determine not only the FWHM but also the ration FWTM/FWHM which gives information about the radiation damages status of the crystal (if the statistic is good enough). Acquisition time should be sufficient in order to have good statistics, e.g. 4000 counts at the top of the peak. The dead time does not have to exceed 1%, usually 0.7% corresponds to 1000 cps required by IEEE standard for detector test. Record also the position of the 1332 keV line.

The operational temperature has to be recorded as well, however only at running preamplifier (power supply on, at least few hours). Don't be stressed if see it considerably higher than -196 ºC, the correct temperature measurement depends on many factors and essentially not all of them are fulfilled. Typical operational temperature is -160-170 ºC.

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