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NaI(Tl) Spectrometry

Scintillation spectrometers employing NaI(Tl) or $LaBr_3$(Ce) detectors basically consist of:

Detector ➔ Electronics ➔ Multichannel Analyzer ➔ Software(s) and in most applications for low-level measurements a ➔ Lead Castle

NaI(Tl) detector:

There is a range of standard detector sizes which is offered by any producer of NaI-detectors on the market. Most frequently found, and basically the reference workhorse in scintillation spectrometry, is the 3”x3” detector. Each detector unit is made of a singleTl-doped NaI crystal (or transparent poly-crystal) of 3” diameter (76.2 mm) and 3” thickness. Other popular geometries are 1”x1”, 2”x2” or 5”x4” size. The crystal is attached to the photo-sensitive cathode of a photo-electron multiplier tube (PMT), either directly or via optical coupling through a quartz glass duct. Loss-free light transfer from the crystal to the PMT cathode must be ensured. On the other surfaces not connecting to the PMT cathode the crystal is surrounded by a white medium with very high reflecting power (albedo) which serves to reflect light until it finally reaches the PMT cathode. The electrons produced by light flashes in the PMT cathode are multiplied in several stages (often 10 stages) finally yielding a pulse of electrons that is de-coupled through a capacitor and suitable for further amplification.

The whole set-up consisting of crystal, light guide and PMT is hermetically sealed in a metal encapsulation in order to protect the hygroscopic crystal from moisture and melting. A µ-metal shield all around the PMT tube helps to reduce the influence of the earth magnetic field on amplification. A set of electrical contacts that connects cathode, anode and the various stages of the PMT to accelerating power stands out of the detector unit. It is manufactured so that one cannot connect it wrong to the voltage divider or other plug-on unit. A 3”x3” detector unit together with voltage divider is shown in the picture.

The accelerating high voltage (HV) between cathode and anode is typically between 500V and 1200V and it is supplied via a voltage divider unit which is plugged onto the detector. The voltage divider splits the HV into voltage intervals that are connected to the amplifying stages of the PMT tube. An active preamplifier can be built into the voltage divider.

Electronics:

Individual units in “nuclear instrumentation module” (NIM) format were used for decades to operate scintillation spectrometers. The high voltage supply unit should provide up to 1200 Volts at currents of 150 µA for each detector. Reproducible voltage regulation and stability is an issue in scintillation spectrometry as the PMT gain is critically dependent on the HV.

The linear amplifier should at least provide amplification from *10 up to *500 and shaping times from 0.5 µs up to 3 µs. There is no need to employ a very expensive high-end spectroscopy amplifier for scintillation spectrometry.

The workhorse Analog-to-Digital-Converter (ADC) for gamma-ray spectrometry is definitively the 100 MHz Wilkinson ADC which is the cheapest and most stable unit on the market. There are, however, applications with very high counting rates which therefore require very fast successive approximation (=fixed deadtime) ADC or digital systems. We will support you in finding the best suitable and most cost-effective solutions for your applications. The conversion gain, i.e. the length of the measured spectrum in channels, in scintillation spectrometry will normally not exceed 1024 channels (1k). 2k or even 4k spectrum length is only needed when prompt gamma-ray spectra are measured where gamma-ray energies reach over 10 MeV. However, due to the complexity of prompt gamma-ray spectra one will use scintillation spectrometry only in special cases for this application.

Any multi-channel analyzer (MCA) is suitable for scintillation spectrometry as long as it can measure spectra with 1024 or more channels. There are very versatile units available in NIM format which link into the control- and analysis-PC via USB or network connection and even provide built-in ADC. Emulator software is normally used to operate the MCA, provide live spectrum display during measurement and handle spectrum administration and storage. Simple analysis functions may well be part of the emulator software.

For quantitative analysis of NaI(Tl) spectra one should use specialized software such as the SODIGAM program for high-precision analysis of scintillator spectra. The program provides all features needed by the spectrometrist for data analysis.

Plug-on MCA:

There are now electronic units on the market which are as small as the voltage divider shown above and contain all nuclear electronics needed for scintillation spectrometry, i.e. high voltage power supply, voltage divider, preamplifier, linear amplifier, ADC and MCA. The unit is powered by the USB or Ethernet connection to the PC and it plugs directly onto the detector unit. Such plug-on spectrometers are also available as fully digital spectrometers.

Lead Castle:

The lead shield for scintillation spectrometry normally provides a 5 cm thick shielding with low-activity lead all around the detector and 2 cm around the PMT. The shield may sit on a table for very easy access for the user and it should have an easy-going turning or sliding door. The geometry of the example shown in the picture is built for measurement of 1-liter Marinelli beakers and 1-liter Kautex bottles. Various versions for measurements in other optimized geometries are available.

In every case of questions about our statements and descriptions, please do not hesitate to contact us – we'll explain in every detail, and support you as best we can.