Radiation Sensor with integrated electronics

R2D-CsI(Na)-Advantage-2

High-resolution CsI(Na) detector. Includes high voltage power supply and embedded multi-channel analyzer. Operated and powered through the USB port.

Highlights

- **Very good energy resolution:**
  5.6% fwhm (typ.) resolution at 662 keV
- **2-inch Ø, 3-inch tall, CsI(Na) crystal**
- **No internal radioactivity**
  Compatible with low-rate and low-background counting
- **Best for count rates, up to 5,000 cps**
- **Very linear photomultiplier**
- **Very gain stable photomultiplier**
- **Low-power embedded high voltage supply**
- **Low-power embedded MCA**
- **Digital temperature sensor**
- **Effective magnetic shield: 0.5 mm mu-metal housing with mounting flange**
- **Built-in connectors for sensor-to-sensor communication**
- **eMorpho-HPR-50-1212 embedded MCA**
- **NP10 embedded power base**
- **Entire unit is USB-controlled and USB-powered**

Features

- This radiation sensor uses a selected CsI(Na) crystal and achieves its outstanding performance through optimized analog and digital signal processing in the included MCA.
- The PMT type has been selected to provide excellent spectroscopy with good energy resolution, high linearity and excellent gain stability.
- The embedded high-voltage supply is powered and controlled through the embedded MCA.
- The high-voltage supply employs a transistorized voltage divider for best linearity at the lowest power consumption.
- The embedded MCA provides a 4K x 32-bit histogram and accurate count rate measurements.
- The entire unit is hermetically enclosed in a 0.5 mm thick stainless steel magnetic shield (mu-metal)
- Other sensors in this product line include 2-inch systems and NaI(Tl) systems for higher count rates.

Specifications

Parameter	***Symbol***	***Min***	***Typ.***	***Max***	***Comment***
Performance					
Energy resolution at 661.66 keV			5.6%	6.0%	@ 2kcps, Cs-137
Power					
Supply voltage	Vss	4.35V	5.0 V	5.5V	USB-powered
Supply current,	Iss		220 mA		HV = 1000V MCA + HV
Photomultiplier					
Anode pulse current for MCA full scale			0.60 mA		
Anode charge for MCA full scale			0.70 nC		
HV-subsystem					
HV range	HV_out	500V		1700V	
Max. HV output current	I_{HV}		100µA		
MCA					
Histogram			4096 x 32-bit		
Waveform capture			1024 samples		
ADC sampling rate			20 MSPS		
Environmental					
Operating temperature		5ºC		60ºC	
Magnetic field				10 mT	Gain drift < 1%
Entrance window		0.5 mm steel + 0.8mm Al + 2mm teflon			

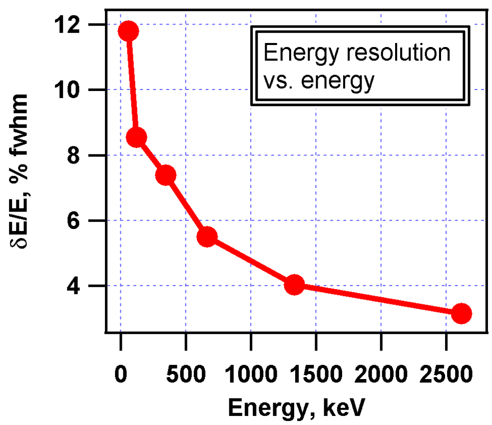


Figure 1: Energy resolution as a function of energy.

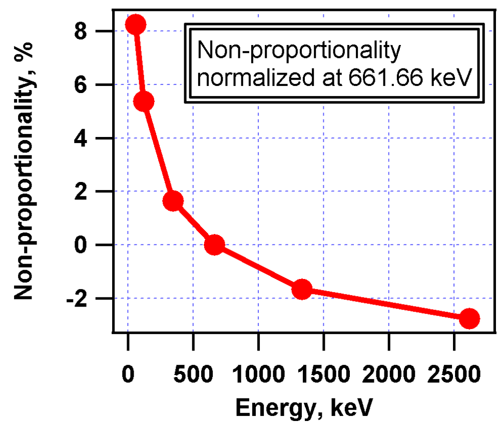


Figure 2: Deviation from proportionality as a function of energy.

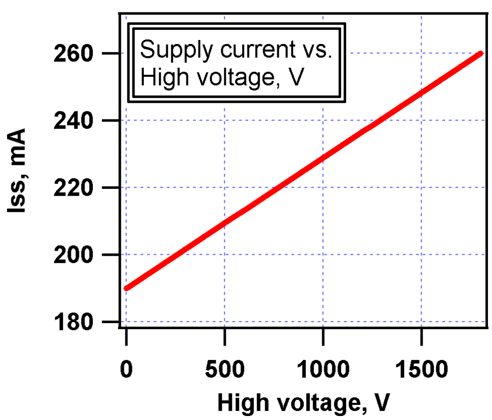


Figure 3: Supply current to the detector at zero PMT anode current.

Change of brightness as a function of energy (non-proportionality)

E / keV	*Dev. %*	*E / keV*	*Dev. %*
59.54	8.25	661.66	0.00
121.78	5.37	1332.50	-1.66
344.28	1.65	2614.53	-2.76

Table 1: Measured non-proportionality values.

Detector components

The CsI-Advantage detector employs a select quality CsI(Na) crystal, canned in an aluminum housing. The crystal is glued to a linear-focus 2-inch photomultiplier. The photomultiplier type has been selected to ensure good linearity (as required for spectroscopy) and very low gain drift (typically less than 3% in the first 24 hours after power on).

The detector is housed in a stainless steel magnetic shield made of 0.5 mm thick µ-metal. Unlike in "integral" detectors, this shield provides complete immunity to Earth's magnetic field and other weak magnetic fields of up to 10 mT (100 Gauss).

The photomultiplier is powered by a TwinBase, which is a combination of a well-matched high-voltage generator and a transistorized (active) high voltage divider.

The high voltage is controlled through the eMorpho, which is the MCA of the R2D sensor. The eMorpho receives the photomultiplier anode signal and measures the electric charge of the anode pulses. This quantity is proportional to the energy deposited in the scintillator crystal, and is used to construct energy histograms.

The entire unit is powered and controlled through its USB interface.

Operation

The CsI-advantage detector comes with all necessary software. A graphical user interface provides

The instrument gain is determined by the high voltage applied to the photomultiplier.

Theory of operation – Linearity

A number of factors have to be evaluated when discussing linearity. First of all, NaI(Tl) like other inorganic scintillators is a non-linear material. The amount of scintillation light it produces is not strictly proportional to the energy deposited by a gamma-ray, but there is a deviation from linearity, cf figures 3 and .

Beyond the intrinsic non-linearity of the scintillator, the linearity of the photomultiplier can be affected if the anode peak pulse current or the average anode current become too large.

The anode peak pulse current can be determined from the pulse charge corresponding to a particular region in the energy histogram. Divide the pulse charge by the 1.0 µs pulse shape time constant of CsI(Na) to determine the anode peak pulse current:

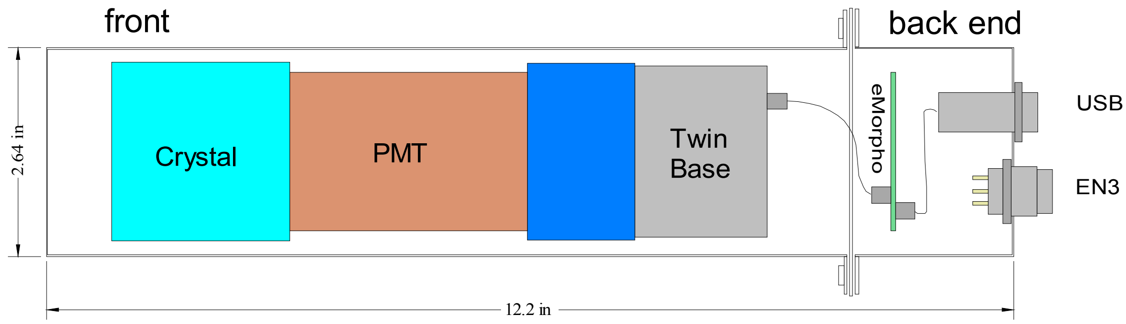
$$I_P = \frac{Q}{\tau}$$

For instance, at 100 pC the peak pulse current is 500 pC / 1.0 µs = 0.5 mA

Theory of operation – Temperature sensor

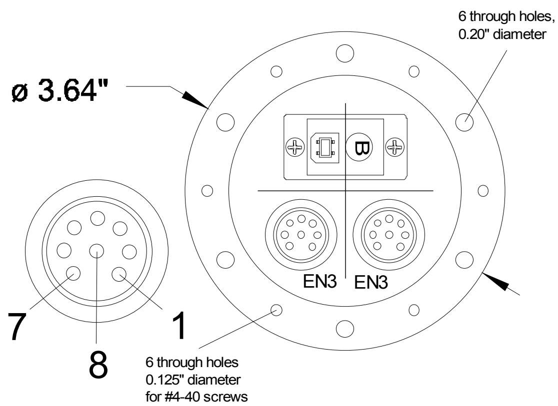
The R2D sensor includes a digital temperature sensor, which measure the internal temperature once per second with a resolution of 0.0625ºK and an accuracy of 1K. This information can be used for temperature-related gain corrections or data-quality alerts, as well as to determine and enforce safe operating conditions for the unit.

Outline drawing



Drawing 1: Outline drawing of the R2D sensor using a 3-inch diameter scintillator crystal. The outer can is made of 0.5 mm thick mu-metal, which is a type of stainless steel that strongly attenuates magnetic fields. The main can houses the crystal, PMT (with Jedec B14 socket) and a TwinBase. The embedded eMorpho MCA, together with the connectors, is mounted in the back end lid.

There are 3 connectors in the back. J1 is a USB type B jack. J2 and J3 are Switchcraft EN3 mini weather tight connectors (plugs) with 8 pins each. Pinout and pin numbering are indicated below.



Drawing 2: Back end view of the R2D-2.

J2		*J3*	
1	VXP (3.3V)	1	CL_O
2	GND	2	GND
3	X_CL	3	S5
4	S0	4	S6
5	S1	5	S7
6	S2	6	S8
7	S3	7	S9
8	S4	8	S10

Table 2: Connector pin-out.

Revision history:

P0	Feb. 2007	Initial document
R1	May 2007	Production release, update ADC-speed
R2	Jan. 2009	Update address