Understanding runaway electrons is a crucial topic for today’s tokamaks and for ITER. A new compact gamma-ray spectrometer was developed in order to optimise the measurement of Bremsstrahlung radiation emitted from these highly energetic particles. A LYSO:Ce scintillator crystal was chosen for its good light yield, high efficiency and fast decay time. The crystal was coupled to silicon photomultipliers and allows for a compact and robust design, insensitive to the magnetic field of tokamaks. A dedicated electronic board was developed for both on-line control of the diagnostic parameters and for optimal signal readout. The design of this detector allows for high-rate measurements (exceeding 1 MHz) of the energy spectra in a range up to several MeV with an energy resolution of about 8% at 1.1 MeV. Due to its compact dimensions, the instrument is well suited for implementation into array configurations, for example gamma-ray cameras. This work presents the design of the LYSO gamma ray spectrometer and the characterization of its performance in terms of energy resolution, counting rate capability and linearity.