

CRYSTAL DETECTORS

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Convener's report.

1 Introduction

Scintillating crystals are the first class choice for homogeneous calorimeters. They provide excellent energy resolution over a wide range, with high detection efficiency for low energy electrons and photons. For optimal performances, crystals must fulfill some basic requirements as uniformity of the material, mechanical robustness and easy machining. In the last years, to cope with the requirements of new high-energy and high-luminosity experiments, new heavy materials were introduced and optimized. The benefits of these developments are nowadays largely used in a wide range of environments, from medical applications to space experiments. The session reviewed some of these applications: the large scale CMS PWO calorimeter, now in the construction phase (papers presented by I. Dafinei and P.P. Rebecchi); the use of YAP crystals for gamma cameras (paper presented by N. Belcari); the CsI calorimeter designed for the GLAST experiment (paper presented by G. Bogaert); the Mainz Leadfluoride calorimeter (paper presented by F. Maas). R. Novotny presented a comparison of different crystals for medium energy applications. A new kind of crystal application where the scintillation light is used as charge-particle anticoincidence in the search for phonon signals associated with WIMP interaction was presented by T. Frank.

2 High energy and space experiments

CMS Collaboration, which will operate at LHC from year 2005, is building a calorimeter made of 77000 PWO crystals. The goal of CMS experiment is to get the best electromagnetic resolution for energies in the range from GeV to TeV. A fast response is needed to resolve the 25 ns bunch-crossing rate. A fine lateral

granularity is mandatory to reduce the intense pile-up associated with the unprecedented event rate (10^9 events/s) expected at LHC. This led to the choice of PWO, extremely compact, reasonably fast but with poor LY and high refraction index. In the recent years, an enormous effort was put to increase the light signal (without losing the fast response) and to insure the radiation resistance of the material.

The R & D necessary to guarantee the production of PbWO_4 crystals able to satisfy such challenging constraints was presented in the I. Dafinei's paper. The performance of the pre-production crystal batches (about 6000 barrel crystals) is consistent with the very strict quality parameters defined by the ECAL Collaboration. The procedures of quality control as well as the main characteristics of these crystals are discussed. Recent developments in the PbWO_4 crystals growth technology may speedup the crystal supplying for the ECAL construction.

To study the radiation resistance of the CMS PWO production crystals, a special set-up is under test at GIF, a CERN irradiation facility with a strong $\text{Cs}137$ γ source: the set-up allows to monitor both the transmission and the scintillation of the crystals. Different light sources are used: an LED of 440 nm, a Xenon lamp with different wavelengths, an UV laser of 337 nm and electrons from SPS-X5 beam. The goal is to find a relation between the irradiation degradation of the electron (or the UV laser) signal and the degradation of the monitor (LED) signal and to measure the variation of such relation from crystal to crystal. The paper presented by P.P. Rebecchi describes the GIF-ECAL setup and the latest results obtained in 2001.

The R&D activity developed for CMS led to a wide use on PWO crystals in other experiments at high and medium energies (see next paragraph).

A CsI(Tl) hodoscopic calorimeter is designed for the Gamma-ray Large Area Space Telescope (GLAST), the next-generation observatory for 20 MeV to 300 GeV gamma rays, to be launched in 2005. The paper presented by G. Bogaert discusses the design and the development of this space-based calorimeter, with special focus on the treatment of the CsI(Tl) crystals, including issues of surface treatment, wrapping or coating for maximal light yield, radiation damage, and PIN diode bonding for robustness against the rigors of launch and of the space environment.

3 Medium energy experiments

Clean and efficient photon detection in the energy regime below 1 GeV requires fast and compact inorganic scintillators. A comparative study of large BaF_2 , CeF_3 and PbWO_4 crystals, performed within the TAPS physics program, has been presented by R. Novotny. The response have been investigated using

monoenergetic photons up to 850 MeV energy provided by the tagged photon facility at MAMI, Mainz. For CeF₃ and PbWO₄, respectively, excellent resolutions have been obtained, and are compared to the performance of the BaF₂-calorimeter TAPS. In addition, proton beams between 85 MeV and 2 GeV have been used recently, to determine the quenching factors of the scintillation light of CeF₃ and PbWO₄. The applicability in hadronic and photonuclear reaction studies and the individual advantages of the three investigated scintillator materials are discussed. The concept of the Photon Ball, proposed as an upgrade of the ANKE magnetic spectrometer at COSY is also illustrated. The use of PbWO₄ will allow installing a very compact photon detector with high granularity read-out with fast fine-mesh photomultiplier tubes to allow high count-rate capabilities even in a high magnetic strayfield.

The paper presented by F. Maas illustrates the first use of Lead Fluoride as a pure Cherenkov radiator, providing a fast (20ns) crystal calorimeter with good energy resolution (3.2% at 1 GeV). The performance concerning radiation damage, calibration and energy resolution for the first 511 channels is presented.

4 Medical applications

C.W.E. van Eijk presented a review on the use of scintillating crystals for medical applications in the parallel session on Radiotherapy and Medical Imaging.

The paper presented by N. Belcari investigates the possibility to readout a matrix of scintillator crystals, with more than 400 pixels, by means of wavelength shifting (WLS) fibers. The small light yield leads to a low signal/noise ratio, especially for events with small energy deposition. To increase the collection of photons produced in a YAP:Ce matrix the possibility of shaping the surface of each finger crystal was investigated and the results of the Monte Carlo simulations for the proposed coupling geometry is presented. The surface can be shaped by a "V" cut on both sides of the crystal. An alternative solution easier to be implemented is represented by a "half pipe" cut. This solution permits a simpler coupling with a standard 2 mm diameter round WLS fiber. A test 5 x 5 "half pipe" crystal matrix has been produced by Crytur. Some preliminary measurements of the performance of the proposed system are also presented.

5 Crystals for WIMP searches

The sensitivity for WIMP search via the detection of the phonons produced by the nuclear recoil can be highly improved by the ability to discriminate the gamma

and beta backgrounds. The paper presented by T. Frank reports on the project of CRESST phase II to achieve this discrimination by means of simultaneous measurement of phonons and scintillation light. A 300 g detector module consisting of two separate calorimeters fitted with tungsten phase transition thermometers was developed. A 300 g CaWO₄ crystal serves as the target material. A thermometer on the CaWO₄ crystal detects phonons. A second smaller detector in close proximity detects the scintillation light. Measurements with this setup are presented.