T 82: Calorimeters II

Time: Thursday 16:00–18:15 Location: Tg

T 82.1 Thu 16:00 Tg

Test beam results of the Megatile prototype for the CALICE AHCAL — •Anna Rosmanitz for the CALICE-D-Collaboration — Johannes Gutenberg-Universität Mainz

The CALICE collaboration develops several highly granular calorimeter concepts for a future e^+e^- collider, that are specialised for Particle Flow Algorithms.

The current design for the AHCAL consists of small, seperately produced scintillator tiles with a size of 3x3 cm^2 read out by silicon photomultipliers (SiPM). They are separately wrapped in reflective foil and glued to the boards. In total, the AHCAL is going to have 8 million channels.

To facilitate the assembly process, the Megatile, a structured scintillator plate, was developed at the University of Mainz. Its advantage is that larger sections of 12x12 channels are produced at once with the channels separated by tilted trenches filled with reflective TiO_2.

Different prototypes of the Megatile have been tested in test beams at DESY with electrons. This talk presents the light yield and cross talk results from this analysis.

T 82.2 Thu 16:15 Tg

Test Beam Study of CALICE Scintillator Tiles — •Fabian Hummer, Frank Simon, Ivan Popov, and Lorenz Emberger for the CALICE-D-Collaboration — Max-Planck-Institut für Physik

One of the main design drivers at future energy-frontier e^+e^- colliders is the precise determination of the energy of particle jets. This is achieved with detector designs optimized for the particle flow paradigm. CALICE is an R&D collaboration focused on the development of highly granular calorimeters optimized to aid this paradigm by providing high spatial resolution. The Analogue Hadronic Calorimeter (AHCAL) is one of the detector concepts based on the SiPM-on-Tile technology, using scintillating tiles read out by Silicon Photomultipliers. A key aspect of the recently completed technological prototype is the capability for single-cell time stamping on the nanosecond level to enhance the particle separation and background rejection capability. To investigate the intrinsic time resolution of this technology, a modular test beam setup has been designed and tested at DESY in October 2020. In this setup four scintillator tiles arranged as a "beam telescope" are read out by precise digitizers, allowing detailed studies of the time structure of the detector response. We have investigated different scintillator materials and tile arrangements. In this contribution we will introduce the setup, outline the calibration procedure and report on the achievable time resolutions.

T 82.3 Thu 16:30 Tg

Easing the assembly of the CALICE high-granularity Analogue Hadronic Calorimeter: an application of the Megatile concept — •Antoine Laudrain for the CALICE-D-Collaboration — Johannes Gutenberg Universität, Mainz, Germany

The CALICE collaboration is developing a high-granularity Analogue Hadronic Calorimeter (AHCal), designed for future experiments at lepton colliders. The current design includes around 8 million scintillator tiles, individually wrapped in a reflective foil and glued on a board, and read out by silicon photomultipliers (SiPM). After the successful assembly of a 22000-channel technological prototype (tested in beams at CERN in 2018), a new mechanical design easing the assembly is being developed.

The new concept relies on Megatiles, a large plate of scintillator housing 12x12 channels. The channels are separated by optical trenches filled with a glue-TiO2 mixture, ensuring both the mechanical robustness and the optical isolation. Several prototypes have been built and continuously tested in a cosmic-ray test stand at the University of Mainz. The performances are competitive compared to the original design. The latest developments presented in this talk improve the performance of edge channels and reduce the optical cross-talk between neighbouring channels.

T 82.4 Thu 16:45 Tg

Pandora Particle Flow Algorithm Studies on CALICE AHCAL 2018 Prototype Test Beam Data — •Daniel Heuchel for the CALICE-D-Collaboration — DESY, Hamburg, Germany

The CALICE collaboration is developing highly granular calorimeters for a future e^+e^- collider, like ILC or CLIC. To achieve the desired jet energy resolution of 3-4% for jet energies between 40-500 GeV in such an experiment the Pandora Particle Flow Algorithm (PandoraPFA) can be used. The basic concept of PandoraPFA is to use the energy measurement of the sub-detector providing the best resolution for each individual particle. This means that charged particles are measured by the tracker, neutral particles by the calorimeters. For this pattern recognition framework high granularity in the calorimeter systems is crucial to correctly assign particle tracks to shower clusters and efficiently separate charged and neutral particles.
The current Analog Hadronic Calorimeter (AHCAL) technological prototype features 38 active layers with a total of 21888 channels each consisting of a 3x3cm^2 scintillating tile read-out by a Silicon Photomultiplier (SiPM). Three test beam periods at the SPS CERN have been performed in 2018 to proof the scalability to a full collider detector and to measure different particles for detailed shower analysis.
In this contribution, we will present first results of the application of PandoraPFA to AHCAL data. Focusing on the case of single particle reconstruction and the separation of a neutral hadron in the vicinity of a charged one, we are validating the simulated algorithm performance with test beam data.

T 82.5 Thu 17:00 Tg

Analysis of shower shapes recorded with the CALICE AHCAL in 2018 Test Beam Data — •Olin Pinto for the CALICE-D-Collaboration — Deutsches Elektronen-Synchrotron DESY

The analog hadron calorimeter prototype is a highly granular calorimeter based on steel absorbers and $30 \times 30 \times 3$ mm^3 scintillator tiles read out by Silicon Photomultipliers (SiPM), developed by the CALICE collaboration. It has acquired sizeable datasets with precise five-dimensional information on electromagnetic and hadronic showers in two test-beam periods at the CERN SPS beam test facility The unprecedented granularity of the detector provides detailed information about the properties of electromagnetic and hadronic showers, which helps to constrain shower models through comparisons with model calculations. Results on longitudinal and lateral shower profiles compared to GEANT4 shower models will be discussed which were measured for electrons and pions in the energy range between 10 and 200GeV. A shower parametrization is used on both longitudinal and lateral shower profiles and a comparison is performed with a variety of different hadronic shower models which can provide input for further development of these models.

T 82.6 Thu 17:15 Tg

Simulation of ALP reconstruction for the SHiP experiment — •Phi Chau, Matei Climescu, and Rainer Wanke — Johannes Gutenberg-Universität, Institut für Physik, Mainz, Germany

So-called Axion-Like Particles (ALPs) are Dark Matter candidates. Various experimental approaches are foreseen to search for evidence of its existence. At the SHiP experiment the SPS 400 GeV proton beam could produce ALPs by interaction with a target material and subsequent decays of the produced particles. These ALPs would be boosted in longitudinal direction and may decay into two photons. The photon pair would be detected by the sampling calorimeter of the experiment, which consists of 50 layers of active material, each separated via lead absorber layers. High precision layers (2-3x) are supposed to support the track reconstruction and improve the angular resolution of photon showers while the other layers, consisting of scintillators with SiPM readout, measure the deposited energy. In this contribution results of simulation studies for determination of the calorimeter design's suitability for ALPs detection and its efficiency are presented. The focus of these studies is put on an ALP mass range of 0.1-1.5 GeV. Also, the performance of the detector in terms of photon energy resolution is determined.

T 82.7 Thu 17:30 Tg

Neural network based pulse shape analysis with the Belle II electromagnetic calorimeter — •Stella Katharina Wermuth — DESY, Hamburg, Deutschland

The Belle II experiment, located at the SuperKEKB e^+e^- collider in Japan, uses pulse shape analysis techniques to distinguish electromagnetically and hadronically interacting particles within the CsI(Tl) electromagnetic calorimeter. The pulse shapes from the particle-dependent scintillation response are nominally analyzed with a multi-template offline fit to measure the fraction of scintillation emission produced by hadrons. This fitting method allows for the determination of the total deposited energy, the total scintillation emission by hadrons, and the time of energy deposit. This presentation reports on a new approach to extract the total deposited energy, and the hadronic component of the scintillation emission from the pulse shapes using machine learning techniques. For this, a neural network is trained on pulse shapes produced in crystals from calorimeter clusters from simulated photons and pions, and is employed as a multivariate regression tool. I will show the comparison between the performance of the neural network and the performance of the current fitting method. The neural network shows an improvement in the total and hadron energy resolution, and robustness towards fluctuations in photon pile-up from beam backgrounds.

T 82.8 Thu 17:45 Tg

Particle identification with the Belle II calorimeter using machine learning — •Abtin Narimani Charan for the Belle II-Collaboration — Deutsches Elektronen-Synchrotron DESY, Hamburg

The Belle II experiment, located at the asymmetric SuperKEKB e^+e^- collider in Tsukuba, Japan, performs studies of B-physics and searches for new physics at the luminosity frontier. The Belle II electromagnetic calorimeter is constructed from 8736 CsI(Tl) scintillator crystals. It is designed to measure the energy deposited by charged and neutral particles. The electromagnetic calorimeter also provides important contributions to the Belle II particle identification system. Identification of low-momentum muons and pions is crucial in the electromagnetic calorimeter if they do not reach the outer muon detector.

This talk presents an application of a convolutional neural network to separate muons and pions. The granularity of the calorimeter crystals provides 5x5 and 7x7 pixel images of calorimeter clusters which are used as inputs to the neural network. The performance of the network is investigated with data control samples of muons and pions. Finally, comparisons of the neural network approach with conventional methods and with a BDT using shower-shapes are presented.

T 82.9 Thu 18:00 Tg

First studies of pulse-shape analysis in pure CsI at Belle II. — •Munira Khan for the Belle II-Collaboration — DESY BELLE II

The Belle II electromagnetic calorimeter is the first high energy physics detector to implement pulse shape discrimination in CsI(Tl) crystals, as new method to improve particle identification. Different particles produce a different scintillation response in the crystals. By analysing these pulse shapes, electromagnetically and hadronically interacting particles can be distinguished. This technique has been demonstrated in the first data from the Belle II experiment and included in the particle identification.

Pure CsI has a faster scintillation time, is more resistant against radiation damage from high beam backgrounds, and is therefore an interesting calorimeter material for future high intensity colliders or a potential upgrade of Belle II. This talk will report on a test-bench setup for pure CsI crystals at DESY and simulation studies with GEANT. The goal of this project is to perform investigation into a pulse-shape analysis with this scintillator material and compare it to the well-characterised CsI(Tl).