13th Beam Telescopes and Test Beams Workshop

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Book of Abstracts

Contents

Facilities / **1**

Status and plan of testbeam line at KEK

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At KEK an electron test beam facility with beam momentum up to 5.5 GeV has been established since 2022. Usually the beam is available for sensor testing for three periods (May-June, Oct-Dec and Feb-Mar) in each year in total about 5.5 months. The beam rate at 3 GeV is more than 2 kHz with beam spot size of 2 cm (1 cm) in horizontal (vertical) direction in RMS.
We have a plan to improve the focusing the electron test beam line by modifying the beam transfer magnet configuration. We will discuss the plan and recent updates on the test beam line tracking system.
Also we have started to discuss a hadron test beam line at KEK Tokai campus (J-PARC). A test measurement has been performed to verify there is enough amount of charged pion for a hadron test beam line. We will discuss result of the measurement.

Hands-on tutorials / **2**

Constellation Hands-on: Control and DAQ Framework for Test Beams and Beyond

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Constellation is a control and data acquisition framework for small-scale experiments like test beams or lab characterizations. It provides the necessary functionality for such environments like synchronous operation of several machines, unified configuration interface, logging, telemetry, data transmission and error handling. So-called satellites form the basis of Constellation, which are autonomous programs that control an instrument.

This tutorial provides a short introduction into Constellation and its core principles. The operation of multiple satellites, including configuration and monitoring, is covered as well. Finally, participants of the tutorial will implement their own satellite in Python for real hardware provided for the tutorial.

Facilities / **3**

The DESY II Test Beam Facility - Present and Future

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The DESY II Test Beam Facility is looking back at another successful year.
In this contribution, a review is given over the test beam period 2024 and the running period 2025.

This includes the current status of the facility as well as recent developments of the infrastructure, improvements for the user community, and noteworthy events.
In addition, the current developments for the future of the facility after the upgrade of the accelerator complex for the planned synchrotron light source PETRA IV are presented and discussed.

Infrastructures and software / **4**

Design of the Detector Systems in HPES Test Beam Terminals

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The High-energy Proton Experiment Station (HPES) is currently being constructed as part of the CSNS-II project. The 1.6 GeV protons are extracted from the Rapid Cycling Synchrotron of CSNS and directed to the HPES in the form of "single particle beam". Two test terminals have been designed in the HPES to facilitate the completion of beam tests. The HPES is designed to serve as an advanced detector test platform for the development of High Energy Physics in China, facilitating a high resolution proton beam telescope and a proton energy measurement device. In this presentation, an overview of the terminal detector devices and their considerations of designs will be introduced, as well as the prospects to the HPES.

Infrastructures and software / **5**

Constellation - a Flexible Control and Data Acquisition Framework for Test Beam Environments

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The qualification of new detectors in test beam environments presents a challenging setting that requires stable operation of diverse devices, often employing multiple data acquisition (DAQ) systems running on several machines. Changes to these setups are frequent, such as using different reference detectors depending on the facility. Managing this complexity necessitates a system capable of controlling the data taking, monitoring the experimental setup, facilitating seamless configuration, and easy integration of new devices.
Constellation is a flexible control and data acquisition framework developed with the requirements of laboratory and test beam environments in mind. Constellation streamlines setup integration through network discovery, enhances system stability by operating autonomously, and simplifies onboarding with comprehensive documentation.
This contribution will provide an overview of the Constellation project, showcase recent developments and report on user experience from recent test beams.

Testing and evaluation / **6**

Test Beam Results of SINTEF 3D Pixel Sensors for the ATLAS Phase II Upgrade

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The High-Luminosity upgrade of the Large Hadron Collider (HL-LHC) at CERN will require silicon pixel detectors that can withstand extreme radiation levels. To face these challenges, the ATLAS experiment will carry out its Phase II Upgrade. This includes replacing the current tracking system with the all-silicon Inner Tracker (ITk), whose innermost layer will feature radiation-hard 3D sensors. These 3D sensors must tolerate fluences over 1E16 neq/cm2 over their lifetime operation in ATLAS. In this talk, we present test beam results for a pre-production 3D pixel sensor developed by SINTEF using a single-sided fabrication process. The sensor was irradiated to a fluence of 1.7E16 neq/cm2 and measured using the EUTelescope setup at the CERN test beam facility. The analysis delivered an excellent outcome, with a hit detection efficiency of up to 98% at perpendicular beam incidence after irradiation.

Facilities / **7**

Progress of the first proton test beam in China

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The High-energy Proton Experiment Station (HPES) is currently being constructed at China Spallation Nuetron Source (CSNS) in China. A 1.6-GeV proton beam is extracted from the Rapid Cycling Synchrotron of CSNS and guided to the experimental station. The extremely weak proton beam is prepared for tests of the advanced detector or electrics, and HPES is designed to serve as an advanced platform for the R&D of detector method and technique. The facility is the first dedicated experimental station of test beam. The design and progress will be introduced in this presentation.

Testing and evaluation / 8

Silicon sensors for the AMS-L0 Upgrade: beam test setup and results

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The Alpha Magnetic Spectrometer (AMS) was installed on the International Space Station in 2011. This particle physics experiment is designed to measure the composition of cosmic rays in low Earth orbit, with the primary goal of distinguishing between antimatter and matter. AMS is equipped with a permanent magnet and multiple detectors, allowing it to analyze incoming cosmic rays with rigidities ranging from 1 GV to several TV.

To maximize the remaining data collection period before the ISS planned retirement in 2030, the AMS collaboration plans to install in 2026 an additional silicon tracking layer, on top of the existing instrument. This tracking layer, L0, consists of two planes of silicon microstrip detectors, each composed of 36 fundamental units called "ladders," with a total effective detection area of 8 m^2. This upgrade will not only increase the acceptance of multiple analysis channels by a factor of three and extend the measurable energy range of AMS, but it will also enhance the identification of incoming particles before they interact with the detector material and undergo fragmentation.

To thoroughly validate the charge identification and spatial resolution capabilities of L0 and its ladders, we conducted multiple beam tests at CERN. These tests include beams of heavy ions and muons. In this work, we will first introduce the relevant background information, with a detailed discussion of the experimental setup used in the recent L0 beam tests. Specifically, we installed two sets of beam telescopes, one upstream and one downstream with respect to the ladder to reconstruct particle trajectories. This let us estimate the particles position at the ladder location with a precision of approximately 2 μm. We also exploited a charge detector to assist in analyzing the charge resolution of the ladder in offline analysis by having a precise reference. Finally, we will present and discuss the preliminary results from these L0 beam tests.

Hands-on tutorials / 9

The Corryvreckan Test-Beam Reconstruction Framework — Hands-on

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Corryvreckan is a software framework dedicated to the analysis of test-beam data. It employs a modular concept, providing algorithms for typical analysis steps like pixel masking, clustering, tracking, alignment and for the reconstruction of commonly investigated observables like hit detection efficiency, spatial and temporal resolution, or material budget. This approach allows for a flexible configuration and adaption to a broad range of setups and devices, and explicitly includes the EUDAQ2 framework and the AIDA TLU.
This tutorial provides an introduction to the Corryvreckan framework, the use of different analysis modules and their configuration. A key point of Corryvreckan — the flexible event building mechanism — will be covered for a typical setup, making use of EUDAQ2 and the AIDA TLU. Finally, the use of Corryvreckan as a tool for online monitoring will be covered.

Facilities / 10

The current status of the Beam Test Facility at LNF-INFN

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The DAFNE Beam Test Facility (BTF) at INFN Laboratori Nazionali di Frascati (INFN-LNF) provides primary and secondary electron (positron) beams for detector development, calibration, and various fixed target experiments. The DAFNE-LINAC feeds BTF with primary electron (positron) beams whose operational energy, charge and pulse duration can be also adjusted.
Through optimized use of primary and secondary beams, the facility offers a wide range of run-time tunable beam intensities, energies, spot dimensions, and divergences to a broad community of HEP and non-HEP users, which will be reported as case studies for typical new detector development experiences.
A key strength of BTF is its flexibility, allowing beam and service equipment parameters to be easily adjusted even during data collection. The facility includes two experimental halls, BTFEH1 and BTFEH2, equipped with beam diagnostics and many essential services for experiments, along with 24/7 operations and dedicated beamline scientists.
Additionally, the latest developments in the control system and data delivery will be showcased, routinely used to provide users with real-time detailed experimental conditions.

Lectures / 11

Particle tracking and identification with Timepix-series detector setups in LHC experiments and space science

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In high energy physics experiments, hybrid pixel detectors are an integral part of the tracking systems closest to the interaction points, where their good spatial resolution and high radiation resilience allow for particle tracking by connection of "dots"registered in different layers of an onion-like detector. Another approach to particle detection and tracking relies on a complex analysis of the imprints seen in the pixel matrices (tracks), which provide a rich set of features. These allow for identification of impinging particles, particle trajectory or reaction kinematics reconstruction. The latter is particularly valuable for applications with limited resources, for example in space experiments, but it also enables fundamental-science-reach measurements with simple table-top experiments.
In this contribution, I will discuss how test beam data enhances data analysis methodologies, clarifies the limitations of various approaches, and ultimately leads to optimized detection setups. I will present the latest results from Timepix-type detectors used within LHC experiments or as a space radiation monitors in low Earth orbit and will discuss their application within a GeV-range particle spectrometer for measurement for galactic-cosmic-ray properties.

Infrastructures and software / 12

babyMOSS Telescope for ALICE ITS3 Pixel Sensor Characterization

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The current ALICE Inner Tracking System (ITS2) is based on Monolithic Active Pixel Sensors (MAPS) called ALPIDE. During LHC Long Shutdown 3, its three innermost layers will be replaced by the ITS3 detector. It will based on wafer-scale silicon sensors of up to 26 cm $\times$ 10 cm, thinned to about 50 μm and curved into truly cylindrical detector layers. The first prototype of the sensor - MOnolithic Stitched Sensor (MOSS) - was produced in 2023. It consists of ten Repeated Sensor Units (RSU) stitched together. Each RSU consists of two half-units (HU) labeled top and bottom, with a pixel pitch of 22.5 μm and 18 μm, respectively. Each HU contains four matrices, also referred to as regions, with a pixel count of 256 $\times$ 256 and 320 $\times$ 320, respectively. To facilitate in-beam and irradiation studies, a single-RSU sensor with an area of about 30 $\times$ 14 mm^2, the so-called babyMOSS, was produced.

To increase the scope of the ITS3 sensor qualification, a new dedicated beam telescope was built. In contrast to the standard ITS3 telescope, which uses ALPIDE sensors, this telescope is based on babyMOSS sensors assembled in six reference planes and a device under test (DUT) plane in the middle, spaced 2.5 cm apart. This arrangement provides a tracking resolution of about 2 μm. All planes are read and controlled by ALPIDE DAQ boards adapted for use with babyMOSS using custom-designed interface boards. The trigger system consists of two scintillators of the same size as the babyMOSS, placed before and after the reference planes. With careful alignment, a trigger efficiency of about 12 % per region is achieved. Data acquisition is managed via the EUDAQ2 framework.

The babyMOSS telescope has been commissioned in the lab with cosmics. It was used in three consecutive test beams at CERN PS in 2024 with a 10 GeV pion beam and in a test beam at ELSA in Bonn in 2025 with a 2.9 GeV electron beam. A total of five DUTs were characterized in terms

of detection efficiency, spatial resolution and cluster size. The results show that the current sensor prototype achieves a detection efficiency of $> 99\%$ with a fake-hit rate below the ITS3 requirement of 10^{-6} hits/pixel/trigger.

This contribution presents the design, implementation, and results of the babyMOSS telescope, highlighting its role in qualifying the ITS3 pixel sensors in several test beam campaigns.

Facilities / 13

Status of the Fermilab Test Beam Facility and Irradiation Test Area

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Fermilab plays host to the Fermilab Test Beam Facility(FTBF) and the Irradiation Test Area (ITA). The FTBF is one of the highest energy proton facilities in the world which is dedicated to helping experimenters develop, test, and calibrate particle detectors. The Fermilab accelerator complex delivers a 120 GeV primary proton beam and secondary/tertiary beams of varying momenta and particle content. The ITA provides access to high intensity (up to 2.7e15/hr) 400 MeV protons directly from the FNAL linac. FTBF and ITA provide beamline instrumentation, sources, ancillary equipment, and technical support needed to run successful experiments. This talk will cover the current status of the FTBF and ITA facilities and give updates on beam instrumentation infrastructure.

Testing and evaluation / 14

Testbeam results on 3D silicon sensor with the Timepix4 telescope

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The upcoming HL-LHC will pose significant challenges to particle detectors which will have to cope with many quasi simultaneous collisions. To disentangle different collisions and to restore the efficiency of reconstruction algorithms, the next-generation of silicon pixel detectors must provide a per hit time measurement with a resolution on the order of 50 ps enabling 4D tracking. 3D silicon sensors, with their vertical electrode configuration penetrating into the substrate, can offer a promising solution for such applications due to their intrinsic radiation hardness and fast charge collection properties.

This work presents a timing performance study of an existing 3D silicon sensor read out by a Timepix4 ASIC, based on data collected from a recent testbeam campaign, using the Timepix4 beam telescope. A comprehensive timing analysis was conducted, incorporating corrections for the time-walk effect and for variations in the Voltage Controlled Oscillator clocks used in the Time-to-Digital converters. To achieve the best timing resolution, correction parameters must be determined and applied for each pixel. The sensor response was examined under both perpendicular and grazing angle incidence of the tracks, with the latter providing insight into the timing behavior at different depths within the sensor. After applying these corrections, a currently best timing resolution of order of 150 ps was achieved for the pixel area between the electrodes. Various studies of the 3D sensor as function of bias voltage and threshold setting will be presented, and the limitations of the tested 3D sensor will be discussed.

These results provide valuable input for the developments for the future LHCb VELO upgrade, where 3D sensors are a prominent candidate for achieving precise timing in such a dense collision environment.

Testing and evaluation / 15

OCTOPUS Project - Optimized CMOS Technology fOr Precision in Ultra-thin Silicon

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Monolithic Active Pixel Sensors (MAPS) fabricated using advanced CMOS imaging processes represent the ideal candidate for vertex detectors and trackers in future lepton colliders, offering high circuit densities, low material and power budgets.

The OCTOPUS project, developed within the DRD3 collaboration, aims to simulate, develop, and evaluate fine-pixel monolithic sensors based on the 65 nm TPSCo process. In line with the requirements of vertex detectors for major lepton collider proposals, the main objective is to realize a vertex sensor demonstrator with a spatial resolution of 3 µm, a temporal resolution below 10 ns, a total material budget of 50 µm silicon, and an average power consumption below 50 mW/cm². The project timeline features a gradual approach that allows sensor performance to be adapted to future developments of the European Strategy for Particle Physics (ECFA). As an intermediate step, the project involves the development of a new generation high-resolution sensors for beam telescopes at DESY and CERN.

The contribution will present the objectives, structure, and preliminary results of the OCTOPUS project. The outcomes of simulations conducted within the project and connections with previous studies will be discussed.

Infrastructures and software / 16

A Python-based Control Software for the AIDA-2020 Trigger Logic Unit and Tests in High-Rate Test Beam Environments

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The AIDA-2020 Trigger Logic Unit (TLU) synchronizes different detector systems in test beams such as beam telescopes, time reference planes, and devices under test to identify tracks and accurately reconstruct particle trajectories.

The hardware offers a large set of features and provides flexible support for different test beam setups, including different trigger modes (legacy EUDET and AIDA mode) for communication with various detector DAQ systems.
It enables advanced trigger logic configurations and offers fine time stamping capabilities.
The AIDA-2020 TLU is integrated in the EUDAQ2 framework for slow control and data acquisition.

This contribution presents a new stand-alone Python-based control software, designed to simplify the configuration and provides a streamlined user-friendly workflow from configuration to data interpretation.
The TLU is configured with comprehensive configuration options and boolean expressions for the trigger logic.
Data from each trigger is stored in a human-readable and compressed HDF5 data format.
Improvements of the software regarding event and data handling enable operation at higher trigger rates compared to the existing EUDAQ2 implementation.

The newly-developed control software was tested in multiple test beam campaigns at the DESY test beam facility and trigger rate studies up to 90 kHz were conducted at the ELSA accelerator at the University of Bonn.

Testing and evaluation / 17

Results of test-beam characterization of babyMOSS for the ALICE ITS3 upgrade

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During the LHC Long Shutdown 3, the ALICE experiment will replace the three innermost layers of the current Inner Tracking System with three truly-cylindrical, ultra-light layers constituted by bent wafer-scale Monolithic Active Pixel Sensors (MAPS) realized in 65 nm CMOS technology through stitching technique.
The first ITS3 sensor prototypes were produced in the Engineering Run 1 in 2023. The babyMOSS chip is one single Repeated Sensor Unit (RSU), i.e. the base modular unit repeated by stitching in the MOnolithic Stitched Sensor (MOSS) prototype, manufactured for characterization and irradiation studies.
The babyMOSS chip has an area of about 30×14 mm^2 and the pixel array is divided into two independent Half Units (HUs) with different pixel pitches: 22.5 μm for the top HU and 18 μm for the bottom HU. Both HUs consist of four regions that implement different front-end electronics flavours.

This poster shows the results from the test beam on babyMOSS chips performed in September 2024 at the CERN PS with a telescope composed of six babyMOSS tracking planes. In this experiment, three babyMOSS chips were tested: one non-irradiated and two irradiated to 10^{13} 1 MeV n_{eq}/cm^2, which is above the expected ITS3 radiation load.
The analysis is carried out using the Corryvreckan software, a CERN standard tool for test beam data analysis. A detailed description of the analysis workflow is provided, highlighting how geometry definition, alignment, and track reconstruction are performed to get to residual distribution and efficiency evaluation.
The results for the three Devices Under Test are presented, focusing on the performance in terms of efficiency, spatial resolution, and fake hit rate. For both non-irradiated and irradiated DUTs, there is a valid operating range in terms of threshold that satisfy the ITS3 requirements for efficiency and fake hit rate, i.e. above 99% and below 10^{-6} hits/pixel/event respectively.

Lectures / 19

40 Years of DESY II - A Review

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On March 22nd, 1985 the first beam was accelerated which marked the beginning of 40 years of highly reliable operations. Since then, it plays an important role in the particle physics landscape. While no experiment was performed at DESY II, it served as a pre-accelerator for the DORIS storage ring, the PETRA storage ring and thus the one-of-its kind proton-electron collider HERA.

While usually no one pays too much attention the pre-accelerators, DESY II is world-wide renowned for its Test Beam facility. Three individual beam lines offer user-selectable, high-energy electron or positron beam with weekly availabilities with unmatched reliability. With these pre-requisites, DESY II is a landmark in the particle physics community and one of the four routinely operated multi-GeV test beams around the globe.

In this contribution, we will present the history of our DESY II synchrotron and Test Beam Facility along its 40 years of operation.

Testing and evaluation / **20**

Performance Measurements of Irradiated HV-MAPS for LHCb Upgrade II

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Detectors operated within high radiation environments such as at the HL-LHC will face unprecedented challenges in particle rates and radiation induced damage. Thus, a deep understanding of radiation induced damage in the detector is crucial to ensure the performance requirements are met over the lifetime of the detector. In semiconductor based detectors the radiation induced damage can be categorized into surface and bulk damage. Bulk damage mostly affects the sensor diode itself and surface damage show significant effects on the electronics part of the sensor. Especially in high voltage monolithic sensors active pixel sensors (HV-MAPS) these effects are important to understand, as the sensor diode and readout electronics are integrated in a single substrate. This leads to the necessity of systematic studies of radiation induced damages in HV-MAPS.

Motivating the systematic study of HV-MAPS are the performance and radiation tolerance requirements of Upgrade II of the LHCb experiment. For Upgrade II the central region of the downstream tracking system - Mighty-Tracker - will be equipped with HV-MAPS - called MightyPix. Doses of up to $3 \cdot 10^{14}\ 1{-}\mathrm{MeVn_{eq}/cm^2}$ and 40 MRad are expected in the central region of the detector at the end of Run 5. Hence, it is crucial to understand the radiation tolerance of HV-MAPS for a long term success of the Mighty-Tracker.

This work presents performance characterization measurements of irradiated HV-MAPS. The performed irradiation campaigns were done using a proton beam at the Bonn cyclotron and photons using an X-ray tube.
The sensor used for the studies is the TelePix2, as the analog part is similar to the MightyPix.
Its performance is characterized by a testbeam campaign at the DESY II testbeam facility and laboratory measurements.

The presented measurements include studies of non-irradiated sensors, a $1 \cdot 10^{14}\ 1 - \mathrm{MeVn_{eq}/cm^2}$ proton irradiated sensor and a sensor irradiated up to 40 MRad using photons.

Testing and evaluation / **21**

Beam Tests of the SiPM-on-Tile front-end for the CMS High Granularity Calorimeter

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For the upcoming high-luminosity LHC, the endcap calorimeters of the CMS experiment will be replaced by the high-granularity calorimeter (HGCAL). HGCAL is a sampling calorimeter using both silicon and scintillator as active materials in different regions depending on the radiation dose. The scintillator-based front-end of HGCAL has been tested in Summer 2024 in a test beam campaign at CERN's north area facility. For the first time, the full pre-series readout chain of HGCAL's scintillator modules has been tested in a particle beam. Initial results demonstrate stable operation in a 3T magnetic field, synchronization of two scintillator tile modules, as well as a good understanding of the relation between trigger and DAQ readout data with properly calibrated modules. As a next step, a stainless steel absorber stack instrumented with eight scintillator tile modules has recently been exposed to electrons with up to 6 GeV at the DESY II test beam facility, with the goal to study the calorimetric and timing performance. This contribution will give an overview of the measurement campaigns in the past year and showcase the quality of the recorded data.

Testing and evaluation / **22**

Testbeam studies on Cold Noise and Cracking in ITk Strips modules.

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The High Luminosity-Large Hadron Collider (HL-LHC) will reach an approximate pile-up of 200 collisions per bunch crossing, three times more than the current Large Hadron Collider. Beginning operation at the end of the decade, it will accumulate up to 4000 fbˆ-1, increasing the chances of observing new processes and allowing measurement of rare processes with higher precision. Moreover, the pile-up increase means more particle production, causing higher radiation damage and detector occupancy conditions. Therefore, the current tracking system in the ATLAS detector will be replaced by the new Inner Tracker (ITk), consisting of pixel and strip sub-systems. The ITk is based on silicon detectors called modules, composed of individual sensors and readout electronics. For the last two years, the ITk strip testbeam group has performed studies on two problems that have threatened the performance or operability of the detector: cold noise and cracking. Cold Noise is a phenomenon observed in certain types of modules that increases the noise read when the module is cooled down. Detailed studies of modules exhibiting cold noise have been performed at the DESY-II testbeam facility, providing insight into the potential impact on detector performance. Cracking is an issue that affects the module's sensor when the modules are glued onto the local structures, producing stress fractures on the sensors. The main solution for cracking is adding an extra kapton layer, known as interposer, between the sensor and the module's hybrids. Various types of interposed modules have been tested at the DESY-II and CERN SPS testbeam facilities, calculating the range of operational thresholds, and comparing the interposed modules' performance with non-interposed modules.

Facilities / **23**

CERN Beamlines

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The CERN secondary beamlines of the North and the East Area deliver beams of secondary and tertiary particles, as well as attenuated primary protons and ions. These beams are driven by the SPS and PS accelerators, and used for fixed target experiments and beam tests. Protons with 24 GeV/c at the PS and with 400 GeV/c at the SPS produce typically hadrons, electrons, and muons within a wide range of momenta between 0.1 GeV/c and 360 GeV/c at fluxes from several 100s up to 10^9 particles per spill that serve several experimental areas throughout the complex. The CERN irradiation facilities will also be discussed, specifically GIF++, IRRAD and CHARM. IRRAD and CHARM are driven by the PS primary proton beam at 24 GeV/c with up to 8×10^{11} protons per spill.

This talk will present the features of the different beam lines and beams serving the various fixed target experiments and test beam areas, including beam properties, available infrastructure for tests and beam instrumentation, e.g. the installed beam telescopes. Measurements of the beam performance are shown following the recent extensive consolidation activities and beamline improvements

throughout. Future plans are also presented including beam control software upgrades during LS3 as well as planned upgrades for the beamlines.

Testing and evaluation / 24

Automated Tests of the Tileboards for the High Granularity Calorimeter upgrade of the CMS experiment

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The CMS experiment will be upgrading its detectors in lieu of higher luminosities and collision rates during the High-Luminosity era of the LHC (HL-LHC). One key upgrade of the CMS detector will be its end-cap calorimeters, which will be fitted with the new High Granularity Calorimeter (HGCAL). The Hadronic calorimeter is split into two sections using different technologies owing to the amount of radiation damage. The SiPM-on-Tile technology consists of small scintillator tiles that are read out by SiPMs (Silicon Photo-multiplier) on the PCB. The PCB without any scintillators on it is known as a tileboard. A tileboard will house 1 or 2 readout ASICs (called HGCROCs), and each HGCROC can read out 72 channels. To test and certify the 4000 boards and the functionality of the HGCROCs, a robust and highly automated quality control procedure is needed. The QC procedure also acts as the initial tuning of operating parameters. In March of 2025, a first set of 8 boards were tuned and assembled into a stainless steel absorber stack and tested with electrons of energy up to 6 GeV in the DESY II testbeam facilities for the first time. The test setup, procedure and results from the tuning will be reproted, and a first look into the analysis of the calorimetric performance will be presented.

Testing and evaluation / 25

Results of long-term ageing tests on Eco-Friendly Resistive Plate Chamber detectors

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Resistive Plate Chambers (RPCs) are particle detectors extensively used in several domains of Physics. In High Energy Physics, they are typically operated in avalanche mode with a high-performance gas mixture based on tetrafluoroethane (C2H2F4), a fluorinated high Global Warming Potential greenhouse gas.
The RPC EcoGas@GIF++ Collaboration has pursued an intensive R&D activity to search for new gas mixtures with low environmental impact, fulfilling the performance expected for the LHC operations and for future applications.
In this talk, results obtained with new eco-friendly gas mixtures based on tetrafluoropropene and carbon dioxide even under high-irradiation conditions will be presented. Long term ageing tests carried out at the CERN Gamma Irradiation Facility will be discussed together with their possible limits and future perspectives.

Testing and evaluation / 26

Test beam characterization of H2M: a MAPS produced in a 65 nm CMOS imaging process

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The high energy physics community recently gained access to a 65 nm CMOS
imaging process, which enables a higher density of in-pixel logic in monolithic active pixel sensors (MAPS). To explore this novel technology, the H2M (Hybrid-to-Monolithic) test chip has been designed and manufactured. The design followed a digital-on-top design workflow and ports a hybrid pixel-detector architecture, with digital pulse processing in each pixel, into a monolithic chip. The chip matrix consists of 64×16 square pixels with a size of 35×35 um^2, and a total active area of ~1.25 mm^2.
This contribution will introduce the H2M chip and cover its characterization in the test beam. A hit-detection efficiency above 99 % has been measured, unaffected by thinning samples down to 21 um.

Additionally, a measured non-uniformity of the in-pixel response related to the size and location of the n-wells in the analog circuitry will be discussed, as well as its impact on time resolution.
Testing the chip revealed several peculiarities, rooted in the depth of the DAQ framework, configuration of the chip, reference systems, or analysis software. It is part of a successful testing campaign to find and solve this kind of issues and the lessons learned will be summarized as the final part of this contribution.

Testing and evaluation / **27**

Simulation and Test Beam Measurements in MAPS in a 65 nm CMOS Imaging Technology

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The TANGERINE group is advancing Monolithic Active Pixel Sensors (MAPS) based on 65 nm CMOS technology for future lepton colliders and beam telescopes. This work provides a comprehensive overview of the research and development of these sensors, covering the design, simulation, and testing phases. It includes the characterization of chip prototypes such as DESY CHIP V2 (also known as DESY ER1) and sensor behavior simulations using a genetic algorithm approach.

Preliminary characterization results from laboratory measurements and test beam campaigns of the four-pixel analog test structure of DESY CHIP V2 are presented. Key performance metrics, including efficiency, are discussed, along with initial findings on in-pixel rise-time variation.

On the simulation side, this study examines both conventional square/rectangular pixel layouts and hexagonal pixel arrangements. The simulation strategy integrates Monte Carlo methods with electrostatic field simulations using Technology Computer-Aided Design (TCAD). A comparative analysis of efficiency, cluster size, and spatial resolution was performed to assess the potential advantages of hexagonal pixels over traditional layouts.

Facilities / **28**

CERN PS/SPS Physics Coordination - Outlook for the coming years

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CERN provides a wide range of testbeam opportunities to an ever increasing user base, with its 4 multi-user beamlines on the SPS North Area (H2,H4,H6,H8), 3 multi-user beam lines on the PS East Area (T9,T10,T11), 3 complimentary irradiation facilities (GIF++, IRRAD, CHARM) and several fixed target beamlines dedicated to specific long term experiments. While the technical description of the CERN beam lines is covered by another talk, we will in this talk show the developments in the test beam usage over the last years, present the beam schedule until the end of the current run (Q3 of 2026) and present an outlook for the test beam opportunities after the Long Shutdown (LS) 3, including the challenges that a high intensity beam program to the future SHIP experiment in the North Area EHN2 will entail.

Testing and evaluation / 29

Test beam setup of the ATLAS Tile Calorimeter with Phase II Upgrade Readout Electronics

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The Phase II upgrade of the Large Hadron Collider (LHC) aims to significantly increase the accelerator's instantaneous luminosity. To meet the trigger requirements and withstand the higher radiation levels and ageing of electronics, a new readout system for the ATLAS Tile Calorimeter (TileCal) is being developed. The performance of the new TileCal electronics has been evaluated in multiple test beam campaigns at CERN Super Proton Synchrotron. Key results with data collected between 2021 and 2024 using muon, electron, and hadron beams at various energies and incident angles will be discussed. An overview of these beam test campaigns, detailing the upgrades to the calorimeter electronics, trigger system, and particle identification will be presented.

Testing and evaluation / 30

Muon Response in Projective Geometry Configurations of the ATLAS Tile Calorimeter Test Beam

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The Tile Calorimeter, the central hadronic calorimeter of the ATLAS experiment, is in the process of being upgraded for the upcoming High Luminosity –Large Hadron Collider (HL-LHC). The Tile Calorimeter test beam set-up in the North Experiment Area at CERN Super Proton Synchrotron is used to test electronics and software for the HL-LHC upgrade of the calorimeter. This study aims to show, quantitatively, the muon tagging capability of the upgraded calorimeter. This information will be used in the first level trigger. Comparisons with the legacy readout will be shown. In addition, energy loss per path length (dE/dx) distributions have been measured using beams of muons. The analysis has been performed with the different photomultiplier gains for each radial layer of the calorimeter. Finally, the setup has been simulated using Geant 4 Monte-Carlo, and comparisons of data and Monte-Carlo simulations will be presented.

Testing and evaluation / 31

Performance measurements of the ME0 station for the CMS muon system at the HL-LHC

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The High-Luminosity LHC (HL-LHC) will deliver proton-proton collisions at 5 to 7.5 times the nominal LHC luminosity, with an expected number of 140 to 200 pp-interactions per bunch crossing. To maintain the performance of muon triggering and reconstruction under high background, the forward part of the muon spectrometer of the CMS experiment will be upgraded with Gas Electron Multipliers (GEM) and improved Resistive Plate Chambers (iRPC) detectors. A 6-layer Triple-GEM detector (ME0 station), covering about 60m2, will extend the pseudo-rapidity coverage of the muon system from |n|<2.4 to |n| <2.8 and will be installed behind the new high-granularity calorimeter (HGCAL) during the third Long Shutdown (LS3, 2026–2029). ME0 will be exposed to a background rate up to 150 kHz/cm2 and it required several design modifications. The design and performance under test with beams and irradiation at the GIF++ facility of a prototype 6-layer stack is discussed, and demonstrates that the prototype can operate in the challenging conditions of HL-LHC. Testbeam activities to test these chambers have started in 2021 and have continued up to 2024 and consisted both of tests at SPS with muons and at GIF++ under intense gamma irradiation. I will summarize the design changes the ME0 detectors underwent in the past years, together with all lessons learned from the continuous testing of the detectors, to finalize with a presentation of the measurement of their performance.

Infrastructures and software / 32

Advancements and future expansions of the Caribou DAQ system

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Caribou is a versatile data acquisition system used in multiple collaborative frameworks (CERN EP R&D, DRD3, AIDAinnova, Tangerine) for laboratory and test-beam qualification of novel silicon pixel detector prototypes. The system is built around a common hardware, firmware and software stack shared accross different projects, thereby drastically reducing the development effort and cost. It consists of a custom Control and Readout (CaR) board and a commercial Xilinx Zynq System-on-Chip (SoC) platform. The SoC platform runs a full Yocto distribution integrating the custom software framework (Peary) and a custom FPGA firmware built within a common firmware infrastructure (Boreal). The CaR board provides a hardware environment featuring various services such as powering, slow-control, and high-speed data links for the target detector prototype. Boreal and Peary, in turn, offer firmware and software environments that enable seamless integration of control and readout

for new devices. While the first version of the system used a SoC platform based on the ZC706 evaluation board, migration to a Zynq UltraScale+ architecture is progressing with the finalized support of the ZCU102 board and the ultimate objective of integrating the SoC functionality directly into the CaR board, eliminating the need for separate evaluation boards. This talk describes the Caribou system, focusing on the latest project developments and showcasing progress and future plans across its hardware, firmware, and software components.

Testing and evaluation / 33

Test beam results of 65 nm CMOS monolithic sensors with Operational Amplifier output buffer for the ALICE ITS3 upgrade

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During the 3^{rd} LHC Long Shutdown (LS3) that will take place in the years 2026-2030 the three innermost layers of the ALICE Inner Tracking System (ITS) will be replaced by a truly cylindrical tracker (ITS3) consisting of Monolithic Active Pixel Silicon (MAPS) sensors in a 65 nm technology.

A thickness reduction to 50 µm will allow the bending of silicon sensors to realize a semi-cylindrical self-sustaining half layer. Therefore, a very low material budget (0.07 X/X_0 per layer) will be achieved thus improving the tracking capability and efficiency at low transverse momentum (p_T < 0.1 GeV/c) by a factor of two.

An Analog Pixel Test Structure (APTS) has been developed by the ALICE and CERN R&D in the context of the Multi-Layer Reticle 1 submission to validate the candidate technology. It consists of a 6 x 6 pixel matrix with 10, 15, 20 and 25 µm pitch characterized by a low dose n-implant in the epitaxial layer near the collection diode. Two different output buffers have been developed: one based on a high-speed individual operational amplifier (APTS-OA) that allows to explore timing performance, and a classical one based on source-follower stage (APTS-SF).

Test beam campaigns have been performed at the CERN-SPS facility (120 GeV/c particles) to investigate the APTS-OA using ALPIDEs as tracking planes and an APTS-SF as trigger plane.

In this contribution, timing measurements indicating 63 ps time resolution, a detection efficiency exceeding 99%, together with the ongoing activities will be presented to demonstrate the suitability of the technology to the ITS upgrade requirements.

Moreover, due to the different characteristics of the telescope planes a particular focus on the integration readout systems will be shown.

Testing and evaluation / 34

Data acquisition and analysis of test beam studies for the ATLAS High-Granularity Timing Detector

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The installations of detector upgrades for the High-Luminosity Large Hadron Collider (HL-LHC) will begin in late 2026. The luminosity is expected to increase by a factor of 7.5, reaching a total integrated luminosity of 4000 fb^{-1}. The number of collisions per Bunch Crossing (BX) will be between 140 and 200 with 1.5 vertex/mm. This poses important challenges for the tracking performance in the ATLAS experiment. The inner tracker will be replaced entirely to improve the tracking performance up to $|\eta| = 4$. However, its performance deteriorates in the forward regions of the detector. The High-Granularity Timing Detector (HGTD) is introduced to add timing information which, combined with the ITk spatial information, will allow it to recover its performance in the forward region where the ITk impact parameter resolution is degraded.

HGTD will comprise 8032 modules with a total of about 3.6 M channels. The modules consist of two hybrids each composed of a Low-Gain Avalanche Detector (LGAD) sensor bump-bonded to a Front-End readout ASIC, the ALTIROC.

This talk will discuss the HGTD test beam studies of test PCBs (single hybrid) and modules performed to obtain their time resolution and efficiency measurements at different operational points, i.e. different sensor bias voltages and ASIC thresholds. It will have a particular focus on the readout system for ALTIROC used in the test beam studies, called AlVin, and on the Corryvreckan module developed for the timing analysis and the evaluation and development of corrections for it, called Ullals.

Testing and evaluation / 35

The ATLAS High-Granularity Timing Detector: Results from hybrids in test beam and test bench studies

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The expected luminosity increase at the High-Luminosity phase of the LHC (HL-LHC), with instantaneous luminosities up $7.5 \times 10^{34}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$, will be a challenge to the
performance of the ATLAS detector. The pile-up is expected to increase to up to 200 interactions per bunch crossing, resulting in degraded performance of the currently used reconstruction and trigger algorithms in the endcap and forward regions of the detector. To mitigate these pile-up effects, the High-Granularity Timing Detector (HGTD) will be integrated into the endcap regions, between the new Inner Tracker (ITk) and the calorimeter cryostat, covering the pseudorapidity range of $2.4 < |\eta| < 4.0$. HGTD aims for a single-track time resolution for minimum-ionizing particles of 30 ps at the beginning of the lifetime, up to 50 ps after the maximum fluence of 2.5×10^{15} $\mathrm{n_{eq}/cm^2}$. The high-precision timing information improves the capability to correctly assign tracks to vertex.

HGTD consists of 8032 modules, each 2×4 cm^2 composed of two silicon sensors bump-bonded to the ASICs and glued to a PCB. The HGTD sensors are based on the Low-Gain Avalanche Detector (LGAD) technology. Each sensor is a 15×15 array of 1.3×1.3 mm^2 LGAD pads, adding up to 3.6 million read-out channels in total.
Several test beam campaigns have been carried out at the CERN SPS and at DESY to study the performance of the sensors, hybrids and modules. Moreover, a Sr-90 timing testing set-up for hybrids and modules has been deployed at CERN, enabling continuous measurements, complementary to test beam campaigns. This contribution will focus on the latest test beam and Sr-90 results for hybrids.

Testing and evaluation / 36

Status and beam test results of the ePIC-dRICH detector at EIC

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The dual-radiator Ring Imaging Cherenkov (dRICH) detector is a crucial component of the ePIC experiment at the Electron-Ion Collider (EIC), designed for charged hadron identification in the forward region across a momentum range of ˜3 to ˜50 GeV/c. It will utilize aerogel and gas (C_2F_6) radiators to produce Cherenkov light, detected by a total of ˜3 m2 of Silicon Photomultipliers (SiPMs) with 3x3 mm² pixels.
A prototype dRICH detector, featuring a readout plane consisting in 2048 sensors was tested at CERN-PS beam facilities in October 2023 and May 2024. The SiPMs sensors are arranged in so-called Photo Detection Units (PDUs). The PDU represents a novelty and integrates up to 256 3x3 mm² sensors, along with cooling and front-end electronics based on the ALCOR ASIC chip. The modular design demonstrated successful detection of Cherenkov photon rings at different beam momenta, validating the detector's performance and its readiness for integration into the ePIC experiment. Results from the beam tests will be showed in this talk.

Testing and evaluation / **37**

Test beam of a cell prototype for a dual readout-calorimeter proposal at the Future Circular Collider FCC-ee

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The IDEA apparatus, a proposed experiment for the future FCC-ee accelerator, recently incorporated a novel electromagnetic calorimeter into its baseline design. This calorimeter aims to improve the energy reconstruction for neutral particles to 3 % at 1 GeV, while simultaneously enabling particle-flow algorithms through fine segmentation.

Designed to fit inside the magnet coil, the crystal calorimeter will be composed of two scintillating crystal layers with approximate thicknesses of 6 X_0 and 18 X_0. The required transverse cell size of 1-1.5 cm, requires a readout based on Silicon Photomultipliers. One the central features of such apparatus will be a simultaneous measurement of the Cherenkov and scintillation light fractions (dual-readout) in the shower for the back layer. This calorimeter will complement the sampling hadronic one located outside the magnet, and that is also designed for dual-readout.

INFN, in collaboration with the Calvision consortium in the USA, is actively involved in the proof of principle of such crystal calorimeter with the sections of Milano Bicocca, Napoli, and Perugia.

This contribution will presents results from a test beam conducted in 2024 at the CERN North Area H6 beamline. For this test, PWO, BGO, and BSO crystals were exposed to a 10-100 GeV electron beam. The primary objective was to demonstrate the double readout technique using Silicon Photomultipliers, crucial for a compact design of the apparatus and an overall versatility for the design of future applications.

The single crystal under test was mounted on a rotation stage to exploit the directionality of the Cherenkov photons; we explored both optical and waveform template techniques for the identification, finally proving we can separate such photons from the scintillation ones.

A larger prototype, capable of shower containment is currently under development within the MAXICC prin project as part of the DRD6 collaboration and will be tested on beam in the fall 2025.

Testing and evaluation / **38**

Beam tests of a novel optoelectronic chain with 150 ps time resolution for the LHCb RICH detector

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Charged hadron particle identification (PID) is essential for a successful flavour physics experiment. The Ring-Imaging Cherenkov (RICH) system in LHCb has provided excellent performance to date, and maintaining this level of PID performance is central to the Upgrade II physics programme. The key challenge posed by the high-luminosity LHC is an increase in pile-up at LHCb to ˜40 due to an instantaneous luminosity of $1.5 \times 10^{34}\ \mathrm{cm}^{-2}\ \mathrm{s}^{-1}$, requiring improvements in both spatial and time resolution. In particular, new photon detector technology will be required as part of the LHCb Upgrade II—in Long Shutdown 4 (LS4)—while the development of the fast readout is being anticipated as part of the RICH LS3 Enhancement. During LS3 the entire RICH readout chain will be replaced and the current photon detectors, Multi-anode Photomultiplier Tubes (MAPMTs), will be read out by a custom ASIC, the FastRICH.

In this talk I will present preliminary results from a 2024 beam test campaign at the CERN SPS, with a prototype electronic chain consisting of the FastIC, picoTDC and lpGPT/VTRX+ optical link. The functionality of the FastIC and picoTDC ASICs will be combined in the recently submitted FastRICH; therefore it serves as a pathfinder for the LS3 programme. I will present timing analysis results for this electronic chain coupled to MAPMTs, showing compatibility with the expected transit-time-spread of 150ps. These beam test measurements are validated through laboratory studies with a picosecond pulsed laser setup, in which scans of the operational thresholds of the FastIC characterise the response of the opto-electronic chain to photon signals.

This work provides deep insight into novel fast-timing techniques through detailed demonstration of a prototype RICH detector module with O(100 ps) time resolution, offering key input for upgrades to the LHCb experiment.

Testing and evaluation / **39**

Beam Tests for the Belle II VTX upgrade at High Temperatures with a Peltier-based heating and cooling device

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Beam Tests for the Belle II VTX upgrade at High Temperatures with a Peltier-based heating and cooling device

The Belle II experiment currently records data at the SuperKEKB e+e−collider, which holds the world luminosity record of $5.1 \times 10^{34} cm^{-2} s^{-1}$ and plans to push up to $6 \times 10^{35} cm^{-2} s^{-1}$. In such a luminosity range for $\mathrm{e}^{+}\mathrm{e}^{-}$−collisions, the inner detection layers should both cope with a hit rate dominated by beam-induced parasitic particles and provide minute tracking precision.
An extensive R&D program foresees a pixelated vertex detector employing depleted MAPS detectors (VTX) as a replacement for the existing vertex detector (VXD).
The OBELIX sensor is derived from TJ-Monopix2, originally developed for the ATLAS experiment, which is studied in lab experiments and beam tests to establish its performance and provide valuable inputs for the design of OBELIX.

This contribution presents a beam test setup, consisting of an EUDET-type beam telescope, a TelePix time reference plane and TJ-Monopix2 as devices under test (DUT) previously irradiated to fluences between $10^{14} n_{\text{eq}}\, cm^{-2}$ and $5 \times 10^{14} n_{\text{eq}}\, cm^{-2}$.
The event synchronization of the DUT to the telescope setup has been updated from a trigger number based (EUDET-mode) to a time stamp based system (AIDA-mode).
These DUTs are tested at temperatures between 5 ℃ and 50 ℃ to investigate cooling requirements for larger detector systems. A dedicated temperature control system utilizing a Peltier element has been installed to achieve stable temperatures during measurements across a large temperature range. The presentation provides insights into the heating and cooling device and its performance during the beam test campaign.

Testing and evaluation / 40

Characterisation of CMOS Strip Sensors

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In high-energy physics, there is a need to investigate silicon sensor concepts that offer large-area coverage and cost-efficiency for particle tracking detectors. Sensors based on CMOS imaging technology present a promising alternative silicon sensor concept.
As this technology follows a standardised industry process, it can provide lower sensor production costs and enable fast and large-scale production from various vendors.

The CMOS Strips project is investigating passive CMOS strip sensors fabricated by LFoundry in a 150 nm technology.
The stitching technique was employed to develop two different strip sensor formats.
The strip implant layout varies in doping concentration and width, allowing the study of various electric field configurations.

The performance of irradiated and unirradiated samples was evaluated based on several test beam campaigns conducted at the DESY II test beam facility. The detector response was also simulated using Monte Carlo methods combined with TCAD Device simulations.

This contribution summarises the test beam performance of the CMOS strip prototype concerning the cluster size, hit detection efficiency and spatial resolution.
In particular, the detector response simulated with Allpix^2 is presented and compared to test beam data.
Furthermore, an outlook on the next sensor submission for the CMOS Strips project, which will include an active front-end stage, is presented.

Facilities / **41**

CERN North Area Consolidation and Beamline Upgrades

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The CERN secondary beamlines of the North and the East Area deliver a huge variety of secondary and tertiary beams, as well as attenuated primary proton and ion beams. The East Area was recently renovated with work finishing in 2021. The North Area will undergo a significant renovation in two phases with the first starting in the upcoming Long Shutdown 3.

This talk will present an overview of activities in the North-Area Consolidation (NA-CONS) project and their impact on beam delivery to the North Area. The project includes general improvements to the beamlines, infrastructure, and test beam facilities, ensuring enhanced capabilities for a broad user community. A particular focus is placed on continuous efforts to improve the purity and availability of electron beams. Additional upgrades, such as a new final focus for the H6 beamline, will also be presented.

Testing and evaluation / 42

Test-beam campaign for the characterization of innovative photodetectors for Ring-Imaging Cherenkov applications

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A novel hybrid photodetector has been developed and produced as part of the 4DPHOTON ERC-funded project. This device is based on a vacuum tube containing a transmission photocathode, a microchannel plate, and a Timepix4 ASIC used as pixelated anode. It is designed to image single-photon at rates of up to 1 billion photons per second over an area of approximately $7cm^2$, achieving excellent spatial (5-10 μm) and temporal (50-100 ps) resolutions simultaneously.

A test beam has been performed at the CERN SPS H8 beam-line in order to characterize the performance of the first detector prototypes in a Ring-Imaging Cherenkov configuration.
The setup consists of a tracking telescope composed of two Timepix4 ASICs bump-bonded to semiconductor-based pixel detectors, a solid radiator for Cherenkov photon generation, and an optical system that focuses the emitted photons into a ring on the photodetectors under study.

This contribution will present the results obtained from the analysis of the data. In particular, the performance in terms of tracking resolution, Cherenkov angle resolution and the photon timing resolution will be presented, as well as the comparison between the experimental and the Geant4 simulation results.

Hands-on tutorials / 43

Hands-On: Making the most of your ten minutes of fame! Some guidelines on making engaging presentations

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Presentations in working meetings and conferences are the culmination of weeks or months of work and are one of our most important communication methods to our peers. Yet the 10-15 minutes they take are often seen as tedious and boring, both by the audience and even the presenter! We will identify, as a group, some simple but effective methods of improving presentations and posters with hands-on activities to reinforce concepts.

Testing and evaluation / 44

A hadronic calorimeter based on resistive micropattern gaseous detectors for future colliders

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The experimental results at CERN's LHC confirmed the Standard Model with high precision. However, several questions are still open and successors for the High-Luminosity LHCs are proposed to explore the Standard Model with unprecedented precision. Future colliders, like the FCC-ee and Muon Collider, aim to measure Higgs Yukawa couplings and self-interactions with unprecedented accuracy, requiring precise jet energy measurements and advanced calorimetry with Particle Flow algorithms.

This contribution presents the studies for the development of a hadronic calorimeter using resistive Micro Pattern Gaseous Detectors (MPGD). This MPGD-based calorimeter is ideal for PFA, thanks to the high-granular readout capabilities (O(cm2)), and particularly suitable for the Muon Collider background conditions, thanks to its radiation-hard technology and high rate capabilities (up to 10 MHz/cm2). Furthermore, resistive MPGDs, such as resistive Micromegas and μ-RWELL, offer excellent spatial resolution, operational stability (discharge quenching), and uniformity, making them well-suited for calorimetry.

This work presents the results on efficiency, response uniformity, as well as spatial and temporal resolution, obtained using a muon beam at CERN SPS for three MPGD technologies: resistive MicroMegas, μ-RWELL, and RPWELL. Additionally, it includes findings from tests on an hadronic calorimeter cell prototype, composed of eight alternating layers (~1 λ_I) of stainless steel and MPGD detectors, using pion beams with energies up to 10 GeV.

Infrastructures and software / 45

Beam Telescopes at the DESY II Test Beam

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A large part of the global test beam community relies on EUDET-type beam telescopes, which are provided as common infrastructure at the DESY II Test Beam and other major facilities. Considering their age, outdated components, and the increasing performance requirements for detector development, it is clear that an upgrade will become necessary soon. Among the distinguishing features of the EUDET-type beam telescopes are their ease of use and the possibility to integrate a large variety of user devices. The latter is enabled by the use of the AIDA2020 Trigger Logic Unit on the hardware side and the integration in the EUDAQ2 software framework. Both are to be continued with an upgraded telescope version, enabling a seamless switchover for existing device under test integrations. Another crucial aspect is a low material budget for excellent spatial resolution at lower beam energies of O(1GeV), which necessitates the use of thinned monolithic pixel sensors. Here, the best available production-grade option is ALPIDE, which also provides a high detection efficiency, low fake hit rate, and readout times that are an order of magnitude shorter than those of the previously used MIMSOSA26 sensor. A first prototype of a new ALPIDE-based beam telescope (Adenium) has been in continuous user operation at the DESY II Test Beam since summer 2022. The production prototype, which is based on a reworked data acquisition system that puts more emphasis on long-term maintainability, has been successfully commissioned.
This presentation will give an overview of the beam telescopes that are currently in user operation at the DESY II Test Beam and discuss the first test results obtained with the new production prototype.

Testing and evaluation / **46**

Timewalk correcting Timepix4 data for beam contamination estimation

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We present an evaluation of the timewalk effect in the new Timepix4.2 pixel detector ASIC, bump-bonded to a 300 μm planar silicon sensor. We show a comparison between three different methods – using test-pulse data, photon data, and charged-particle data, and discuss the scope of the application of each.

Charged-particle data was obtained at the PSI PiM1 beam line using coincidence with a MALTA-based beam telescope. The positron beam was used to study the fractional radiation length of test detector modules. The time of flight of scattered particles was measured by the Timepix4 with respect to a beam clock, thus separating in time the positron component of the beam from muon and pion contamination. After applying a timewalk correction based on test-pulses and the charged beam data, the FWHM of the positron peak decreases from ~ 4 ns to ~ 2 ns, limited by the trigger system of the telescope.

Additional photon data was taken with an IR laser. The timewalk extracted from this is compared to the above and the characteristics of the output signal are discussed.

Testing and evaluation / **47**

Performance Studies of an HV-MAPS for the LHCb Mighty Tracker

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In the LHC Run 5, the instantaneous luminosity of LHCb will increase by more than a factor of 5. This necessitates an upgrade of the main tracking systems to cope with the increased occupancy and radiation damage. As a part of the proposed Upgrade II, the current scintillating fibre (SciFi) tracker will be replaced by the so-called Mighty Tracker, featuring a scintillating fibre part in the outer regions, whereas the innermost part will be instrumented with silicon pixel sensors.

For this upgrade it is foreseen to utilize a High-Voltage Monolithic Active Pixel Sensor (HV-MAPS), the MightyPix. It allows for the amplifier and comparator to be embedded in the pixel's deep n-well. Due to a foundry change, future MightyPix designs are expected to transition from CMOS to NMOS comparators. To ensure the performance of the NMOS comparator with regard to the LHCb specifications, the Run2020v1 chip is evaluated.
Specifically, the time resolution and efficiency are studied, utilizing a 4 GeV electron beam provided by the DESY II Testbeam facility. The results are compared to the TelePix1, which features a comparable pixel design but a CMOS comparator.

Testing and evaluation / 48

Results from an HV-MAPS-Based Detector Prototype for Position-Resolved μSR Measurements

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Muon Spin Rotation (μSR) is a well-established technique in material science for probing magnetic properties at the atomic scale. Traditional scintillator-based μSR detectors are fundamentally limited in spatial resolution and event rate, restricting measurement precision. The utilization of ultra-thin silicon pixel sensors enables precise particle tracking, potentially revolutionizing μSR measurements.

To overcome these limitations, a pixel-based μSR spectrometer was developed and tested at the πE3 beamline at the Paul Scherrer Institute (PSI). The setup features a four-layer hodoscope with MuPix11 sensor modules, allowing for precise tracking of both incoming muons and outgoing decay positrons. The Corryvreckan framework is employed for full μSR event reconstruction, integrating advanced track selection algorithms to distinguish muons from positrons, accurately determine decay vertices, and perform high-resolution spin precession measurements.

The results demonstrate a significant improvement in the accepted event rate, enabling operation at beam rates up to 100 times higher than conventional μSR detectors, while achieving sub-millimeter spatial resolution for precise sample reconstruction and multi-sample applications.

Testing and evaluation / 49

Performance and Radiation Tolerance Measurements of TelePix2

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High-Voltage Monolithic Active Pixel Sensors (HV-MAPS) offer $\mathcal{O}$(ns) timing in combination with a low material budget making them ideal for tracking detectors in high energy physics. With future experiments aiming for higher luminosities, the HV-MAPS technology has to satisfy strict requirements on time resolution and radiation tolerance. One of such experiments is the proposed LHCb Upgrade II with a potential use of HV-MAPS in the main tracking system.

The TelePix2 is a full-size HV-MAPS developed for and used as region-of-interest trigger and timing layer for the beam telescopes at DESY test beam. Its excellent performance makes TelePix2 an ideal candidate to study its tolerance against non-ionising radiation damage. For that, TelePix2 sensors have been irradiated to fluences between 1×10^{13} and 1×10^{15} 1-MeV $\mathrm{n_{eq}/cm^2}$ at the TRIGA reactor facilities at Jožef Stefan Institute Ljubljana and at the Johannes Gutenberg University Mainz. The performance of the irradiated sensors was studied at the DESY test beam facility using a MuPix11 beam telescope as reference. These test beam measurements yield a hit efficiency of $\epsilon_{\mathrm{hit}} > 99\%$ and a time resolution of $\sigma_t < 2.4$ ns at a fluence of 1×10^{15} 1-MeV $\mathrm{n_{eq}/cm^2}$. Thus, it demonstrates a tolerance against non-ionising radiation damages. With such tolerance the HV-MAPS technology is suitable for the application in HL-LHC experiments like the LHCb Upgrade II.

The application of TelePix2 as region-of-interest trigger and timing layer is highlighted in this talk. Furthermore, it will focus on the effects of radiation damage on the performance in terms of hit efficiency and time resolution.

Infrastructures and software / 50

A silicon strip detector based beam telescope system for charge and position measurement of ions

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The Alpha Magnetic Spectrometer(AMS-02) is a particle detector that operates on the International Space Station(ISS), which aims to search for antimatter, and dark matter while performing precision measurements of cosmic rays composition and flux. To improve cosmic ray acceptance and heavy ions resolution, a new layer(L0) of silicon strip tracker will be installed on top of AMS-02. Multiple test beam activities were performed to study the L0 silicon tracker performance. A telescope system based on silicon microstrip detectors is developed for the beam test studies.

This talk will introduce the design of this telescope system. This telescope consists of multiple single-SSD modules with a readout electronics system similar to that of the L0 detector. A hybrid machine learning algorithm was introduced to address the challenges of charge reconstruction with multi-strips. This telescope's performance for heavy ion particle identification and position measurement will be presented.

Infrastructures and software / 51

TDAnalyser - A Practical Framework and Its Applications in Test Beam Timing Analysis

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We present a novel framework for the processing of test beam data, and in particular timing DUTs. Based on a modular C++ architecture, it aims to normalise workflows for the analysis of timing detectors performances through the definition of standard and user-defined analyses, e.g. from time discrimination algorithms to a full estimation of time resolution, through the extraction of inter-channel correlations. Thanks to its geometry management system, it also allows the visual monitoring of channel occupancy, or the interfacing to external tracking algorithms to produce high-level information from simple waveforms or user-specific collections. A modular extension platform provides, e.g. the definition of unpacking algorithms for specific oscilloscope output formats, the combination of multiple sources into a global event content, or the extraction of calibration parameters from a fraction of the dataset.

Beamlines for Schools / 53

The Beamline for Schools Competition (BL4S)

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Beamline for Schools (BL4S) is a physics competition for high school students from all around the world organised at CERN, the European Laboratory for Particle Physics, in Geneva, Switzerland, and DESY, the German Electron Synchrotron, in Hamburg, Germany. Teams of high school students can propose an experiment that they want to perform at a beamline, that is, a part of a particle accelerator. The teams that submit the three best proposals win a trip to CERN or DESY to perform their experiments at a fully-equipped beamline.

Here, we will introduce the competition as held in 2024 and set the stage for the teams' presentations in the following.

Beamlines for Schools / 54

BL4S: Calibration of a SiPM-on-Tile muon calorimeter for high-altitude ballooning applications

Authors: August Jakobson[None]; Mihkel Rannut[None]; Ralf Robert Paabo[None]; Saskia Põldmaa[None]; Violeta Jürgens[None]

This presentation explores the feasibility of muon calorimetry using scintillation detectors based on experiments conducted in September 2024 at CERN's T10 beamline. As one of the winning teams of the 2024 Beamline for Schools competition, we investigated how organic scintillators of varying thicknesses and different readout configurations respond to muons of various energies. Our setup also included a lead-glass calorimeter for comparison. To estimate the momentum of incoming muons, we employed a novel method involving threshold Cherenkov detectors for momentum bracketing. Our results indicate minimal dependence of the signal peak or spread on muon energy, suggesting significant limitations in energy resolution. Additionally, we observed the influence of temperature variations on SiPM performance and identified notable contamination in the muon beam. These findings contribute to understanding the challenges of muon calorimetry using compact, school-accessible detector setups.

Beamlines for Schools / 55

BL4S: Team SPEEDers

Authors: Daniel Lin[None]; Hari Palaniyappan[None]; Jaiden Li[None]; Niranjan Nair[None]; Richard Chen[None]; Robert Zhu[None]; Samyak Jain[None]; Theo Buckridge[None]

Smith-Purcell radiation (SPR) is a type of radiation emitted by electrons passing closely parallel to a conductive periodic surface, with potential applications in non-invasive longitudinal beam diagnostics. Selected as part of the 2025 Beamline For Schools competition, our team conducted an experiment at the DESY-II test beam facility to measure SPR in the near IR to visible electromagnetic spectrum using a 1-6 GeV electron beam. Blazed gratings with groove densities of 1200, 1800, 2400, and 3600 g/mm were tested for the production of SPR. Micron-level alignment between the beam and the grating is achieved through electron tomography of the grating with the beam telescopes. For optimal single-photon detection, our detector consists of silicon photomultiplier detectors (SiPMs) cooled with dry ice. Data was analyzed to temporally align events between the telescopes and SiPMs, isolate events with high signal-to-noise ratios, and determine their statistical significance.

Beamlines for Schools / 56

BL4S: Team Sakura Particles

Author: Team Sakura Particles[None]

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Lectures / 57

Track Based Alignment

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Track reconstruction is a key ingredient to extract the properties of the Devices Under Test.
The precision of the reconstructed tracks and their extrapolation to the Devices Under Test depends on the intrinsic resolution of the reference devices and how precise it is known their positioning and orientation in the system. A track based alignment can help to accurately determine the geometry of the tracking system.

Lectures / 58

Medical application research in the IRIS group at IFIC

Authors: Ana Ros Garcia[1]; FERNANDO HUESO GONZALEZ[None]; Gabriela Llosa Llacer[2]

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Nuclear medicine is a branch of medicine that uses radiation to diagnose and treat diseases, one of the most representative being cancer. Although scanners for medical imaging are used daily,

there is still room for improvement in terms of energy, spatial and timing resolutions. At the same time, regarding cancer treatment, in the last years hadrontherapy is becoming a key technique in radiation oncology due to the characteristics of its energy deposition compared with photons. The drawback of this technique is the difficulty of dose deposition monitoring, because the radiation used for treatment does not exit the patient's body, unlike photons.

In this contribution, we will present a short overview of nuclear medicine techniques and the different research lines in the IRIS group, including PET, protontherapy monitoring, and imaging of targeted alphatherapy.

Hands-on tutorials / 60

Hands-On: Making the most of your ten minutes of fame! Some guidelines on making engaging presentations

Author: David Barney[1]

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Presentations in working meetings and conferences are the culmination of weeks or months of work and are one of our most important communication methods to our peers. Yet the 10-15 minutes they take are often seen as tedious and boring, both by the audience and even the presenter! We will identify, as a group, some simple but effective methods of improving presentations and posters with hands-on activities to reinforce concepts.

Testing and evaluation / 61

Development and Integration of the Forward Spectator Detector for the CBM Experiment at FAIR

Authors: Otari Javakhishvili[None]; Petr Chaloupka[None]

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The Compressed Baryonic Matter (CBM) experiment at the Facility for Antiproton and Ion Research (FAIR) in Darmstadt, Germany, is designed to explore the phase diagram of strongly interacting matter under extreme conditions such as temperature and baryon density. With high interaction rates of up to approximately ten million collisions per second with heavy-ion beams, CBM requires sophisticated detector infrastructure and a special triggerless (free-streaming) real-time data acquisition system to manage the high data flow. In this environment, a major challenge is determining the centrality (the geometric overlap of the colliding nuclei) and the reaction plane (the orientation of the collision) on an event-by-event basis. These parameters can be determined by measuring forward spectator fragments—the nucleons and fragments that do not take part in the main interaction and thus continue near the beam trajectory. Accurate measurements of these fragments are therefore crucial for comprehensive collision characterization, motivating the development of the dedicated Forward Spectator Detector (FSD).

Currently in its development and prototype testing phase at the Czech Technical University in Prague, the FSD is positioned at very small angles close to the beam line. When a spectator fragment passes through a scintillator tile, light is generated and detected by the attached fast photomultiplier tubes (PMTs). To optimize performance across different regions, the FSD employs modules in various sizes, ensuring adequate granularity. The signals are processed using the Time Over Threshold

(TOT) method, and the DIRICH system handles data readout, providing accurate and efficient measurement of signal parameters. Several FSD prototype modules have been produced and tested in the mCBM setup at the GSI facility.

This presentation will discuss the challenges in designing the FSD, share recent prototype testing results, and outline the integration of the FSD into the broader CBM experimental framework. By combining modular detectors with differential granularity and advanced readout techniques, the FSD promises to enhance event reconstruction and make significant contributions to the study of dense baryonic matter.

Testing and evaluation / 62

Testbeams for DRD6 on calorimetry

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The DRD-on-calorimeter collaboration has attracted the ongoing developments of future experiment calorimeters. Several activities are ongoing in building and testing new prototypes capable of demonstrating the feasibility of different techniques. In this respect, already many results have been produced by the different projects in the community. Moreover, the collaboration is working on coordinating the testing activity to create a common infrastructure beneficial to the whole community both in terms of hardware and software, but also as coordinating effort and contact with all the major beam test or irradiation facilities.
In the talk plans for the testing coordinated effort as well as preliminary test beam results will be given.

Hands-on tutorials / 63

Hands-On: Making the most of your ten minutes of fame! Some guidelines on making engaging presentations (continuation)

Author: David Barney[1]

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Hands-on tutorials / 64

Constellation Hands-on: Control and DAQ Framework for Test Beams and Beyond

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Constellation is a control and data acquisition framework for small-scale experiments like test beams or lab characterizations. It provides the necessary functionality for such environments like synchronous operation of several machines, unified configuration interface, logging, telemetry, data transmission and error handling. So-called satellites form the basis of Constellation, which are autonomous programs that control an instrument.

This tutorial provides a short introduction into Constellation and its core principles. The operation of multiple satellites, including configuration and monitoring, is covered as well. Finally, participants of the tutorial will implement their own satellite in Python for real hardware provided for the tutorial.

Hands-on tutorials / 65

Tutorial: Silicon Detector Monte Carlo Simulations with Allpix Squared

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This interactive workshop will introduce participants to the fundamental functionalities of the Allpix Squared simulation framework, guiding them through key steps in sensor simulation and data analysis. Attendees will learn how to configure simulations, define detector geometries, and extract relevant quantities through histograms. Additionally, the participants will be able to learn how to integrate TCAD simulation results to enhance detector modeling.

The workshop will be hands-on, with step-by-step instructions provided. A Q&A session will allow for discussions on specific topics and troubleshooting.

Preparations:
Participants are encouraged to follow along on their own computers. Please install the latest release version of Allpix Squared on your computer, or ensure you can access a working version online before the tutorial. A virtual machine can be provided for those unable to install the software.

Detailed instructions for installation can be found in the manual or on the website (https://allpix-squared.docs.cern.ch/) and GitLab (https://gitlab.cern.ch/allpix-squared/allpix-squared)

Hands-on tutorials / 66

Hands-On: Making the most of your ten minutes of fame! Some guidelines on making engaging presentations (continuation)

Author: David Barney[1]

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Hands-on tutorials / 67

Global test beam facilities coordination meeting

68

Global test beam facilities coordination meeting