The EUDET research infrastructure for detector R&D

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Abstract

EUDET is an initiative supported by the European Union to improve infrastructures for detector R&D, in particular for the International Linear Collider (ILC). The project is focused on providing support for larger scale prototype experiments as well as on facilitating collaborative efforts. It encompasses developments for vertex detectors, gaseous and silicon tracking, and highly granular electromagnetic and hadron calorimeters. In total 32 European institutes participate in the project. 27 other institutes in Europe and abroad are associated members and linked to the progress and later exploitation of the infrastructures. EUDET is closely linked to the international R&D collaborations for a future ILC detector. The R&D infrastructure program is described and some results of the R&D efforts are presented.

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1 Introduction

Over the past years several candidate technologies for vertex and tracking detectors and calorimetry were identified which meet the challenging demands for the physics at the ILC. Currently, the R&D effort enters into a phase where these technologies have to be extended to larger prototype detectors in order to verify their feasibility and to optimize the overall detector performance. The EUDET project [1] with support from the European Union provides a framework for the development and construction of larger prototypes for ILC detector technologies.

2 Project Overview

EUDET is an Integrated Infrastructure Initiative in the sixth framework program (FP6) of the European Union [2]. The project started beginning of 2006 and runs over a period of five years. The total budget amounts to 21.5 million € out of which 7 million are contributed by the European Commission. It assembles 28 contractual partners from 32 European universities and laboratories working on detector R&D for a linear collider experiment. In addition 27 associated institutes worldwide participate in the design and construction of the infrastructures as well as their subsequent exploitation. The organization is based on three activities, Network, Transnational Access and Joint Research Activities. Networking between the partner institutes is particularly important. The joint research activities (JRA) specifically focus on the design and construction of the infrastructures. Transnational access activities support European groups in the scientific use of the infrastructures. The three activities are organized in several work packages or tasks. Examples of these tasks, their status and plans, are discussed below.

3 Test Beam Infrastructure

The joint research activity (JRA) on test beam infrastructure consists of a large bore super conduction magnet and a high-precision beam telescope. The super-conducting magnet supplied by the associated partner KEK (Japan) provides a magnetic field of about 1 Tesla in a bore of 85 cm diameter. It possesses a light coil and a stand-alone Helium supply thus making it ideally suited for experimentation in a test beam, for example tracking studies in a magnetic field. The cooling and control infrastructure was constructed using EUDET funds. It has been set up at DESY in close collaboration with KEK. The magnet is available for experiments in the test beam area since summer 2007.

The second test beam infrastructure provided within EUDET is a multilayer pixel telescope with CMOS sensors with the potential of a space resolution of about 1 μm. The telescope itself consists of six layers of monolithic active pixel sensors (MAPS) as well as a versatile DAQ system. This DAQ system has well defined interfaces easily adaptable to the needs of other detectors installed inside the telescope for reference measurements (device under test). A first version of this telescope became available in summer 2007 and was tested successfully in test beams at DESY and CERN. In summer 2008 the device was intensively used by five different groups at the CERN SPS test beam. 50 million tracks were taken during that period. Its performance and first results are described in more detail in elsewhere in these proceedings [3]. Currently, a fully digital device with increased readout speed is under construction. It will be available in fall 2009.

4 Tracking Detectors

The two main technology options for the main tracker of the ILC detector, Time Projection Chambers (TPC) and silicon strip detectors (SSD), are part of the EUDET program. A large

TPC field was provided to be equipped with GEM or MicroMegas-based readout structures which have demonstrated their potential to achieve single point space resolutions of 100 µm or below in small prototypes. To this aim the field cage was equipped with a modular endplate to receive large surface area gas amplification structures. The large prototype field cage was designed, constructed, and delivered to DESY. The development of modern readout electronics adapted for micro pattern gas detectors is also part of the TPC project. The readout system for the large prototype is based on the readout electronics developed for the ALICE experiment at the LHC. The main part of this system is a fast analog-to-digital converter. This chip, called ALTRO, digitizes the TPC signals with a sampling frequency of 25 MHz. In order to adopt this chip to the specifics of the TPC readout with micro-pattern gas detectors, a new charge sensitive pre-amplifier has been developed. The so-called PCA16 chip is a programmable charge sensitive device, which integrates 16 channels into one package. It has a programmable peaking time between 30 and 120 ns, and a programmable gain in four steps between 12 and 27 mV/fC. Enough chips are available to equip the large prototype. The TPC infrastructure has been fully designed and is now available for the community. Thus test beam experiments with large surface GEM and MicroMegas amplification structures in a high field magnet are possible. Details of the development of the large prototype can be found in [4]. For the SSD community infrastructures such as a large & light mechanical structure for Silicon strip detectors or a cooling and alignment system prototype are provided within EUDET. Within the SiTPC – Infrastructure an 8-chip Timepix+GEM module is also available, and a similar module with integrated grid (Ingrid) will be available in the near future.

5 Calorimeter Infrastructure

The anticipated physics at the ILC requires calorimeters with unprecedented energy resolution, in particular for jets. Particle-flow algorithms based on highly granular electromagnetic and hadronic calorimeters are considered to be promising candidates to achieve these goals. In EUDET scalable prototypes for these main calorimeters are developed and constructed, together with developments of silicon sensors and calibration systems.

A tungsten absorber structure for an electromagnetic calorimeter, partially constructed by EUDET funds, will be the basis for important studies towards the ILC detector calorimeter. The power dissipation of the readout electronics completely embedded in the detector is among the critical design issues. The low duty cycle of the ILC (0.5%) can be exploited to power-pulse the electronics avoiding cooling systems, which would deteriorate the calorimeter performance. EUDET will allow for large-scale studies on these and other R&D issues. The active Silicon sensors to be placed in 6.8 mm high gaps within the tungsten structure are matrices of 18x18 pixels of 5x5 mm^2 obtained from 300µm thickness wafer. 30 wafers were recently delivered and characterized with I-V and C-V curves. The wafers are glued on special printed circuit boards (PCBs) of 18x18 cm^2 with minimal thickness (800 µm) to also house the readout Asics.

A similar detector architecture with embedded electronics is foreseen for the hadron calorimeter. It requires the development of frontend electronics (ASICs) on a common platform and a unified DAQ system, both for electromagnetic and hadron calorimeters. The board in the volume is subdivided into “base units” of manageable size, each carrying four front-end Asics. The footprint of the SPIROC ASIC prototype, which was produced in 2007 within the EUDET project, was incorporated, and a solution for the inter-connection of the boards was found and prototyped. Control and communication electronics for data transfer, calibration steering and power distribution are designed in this modular approach as mezzanine boards located in the accessible periphery of the layer [5].

6 Conclusion and Summary

This paper summarizes the EUDET project and discusses the significant progress achieved since its start in 2006. Examples of achievements are the commissioning of the large bore magnet and the first operational version of the beam telescope. In 2009 most of the remaining EUDET infrastructures are to be completed such that they can be fully used. The project provides additional funds for European partner institutes for ILC detector R&D and through the transnational access scheme can support other groups in their research for the ILC and beyond. Most importantly for the ongoing phase of the R&D program focusing on larger detector prototypes EUDET has played an important role in establishing and fostering collaboration in Europe and has also made major contributions to the international R&D efforts. The project is well on track with major milestones already accomplished.

Acknowledgement

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