EUDET-Memo-2007-21

JRA1 - Next Steps Towards the Final Telescope

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November 19, 2007

Abstract

During the EUDET Annual Meeting in Paris October 2007 the status and first results of the JRA1 Demonstrator telescope was presented and discussed [1, 2]. By the end of December the first phase of this project will be completed. In a second phase during 2008 a final telescope with digital readout will be developed. This document shortly describes the milestones and status of JRA1 as of October 2007.

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1 Introduction

Within EUDET JRA1 a test beam telescope will be developed. It will provide a high precision of better than 3 μm, even at the lower energies available at the DESY test beam facility. In addition to high precision, a high readout speed and easy handling is of importance.
The project is divided into two phases. During the first phase a first test facility with analogue readout and a much lower readout speed is being build (Demonstrator). This two-phase approach gives the opportunity to check the design and to have a first telescope quickly available for the groups working on detector R&D. The use of an established pixel technology with analogue readout and no data reduction gave the possibility to have such a telescope ready on a very short time scale. Detailed descriptions of all building blocks for the Demonstrator telescope are given in [1]-[9]. In a second phase of this project the final telescope will be developed. Pixel sensors with fully digital readout, integrated Correlated Double Sampling (CDS), and data sparsification will be used. The final telescope is foreseen for the end of 2008 to be exploited by users at the DESY test beam in 2009.
Table 1 summarises all milestones of the JRA1 project. In the following document the status of the not yet completed milestones is shortly described.

Milestone	**Description**	**Date**	**Task**	**Status**
JRA1-1	SDC Prototype 1 ready	9	C	completed
JRA1-2	Magnet available	12	A	completed
JRA1-3	SDC Prototype 2 ready	18 →24	C	soon available
JRA1-4	Field map available	18 →24	A	soon available
JRA1-5	Analog Telescope integration in beam	18	B	completed
JRA1-6	Readout for prototype available	18	D	completed
JRA1-7	IDC prototype ready	27	C	
JRA1-8	Final pixel telescope integrated in beam	36	B	
JRA1-9	TC ready	36	C	
JRA1-10	Final readout ready	36	D	
JRA1-11	Tracking software available	36	D	
JRA1-12	Test report analog telescope available	36	E	
JRA1-13	Final project reports	48	A,B,C D,E	

Table 1: List of milestones within JRA1. The date is given in months after the start of EUDET (Jan 1st 2006).

2 JRA1-3: SDC Prototype 2 ready

The SDC prototype 2 chip is the first chip with integrated zero suppression and output memories. No active pixel sensor elements are included in this design. Details to this

chip can be found in [5]. The submission of the chips was done in July 2007 and returned from the foundry in September 2007. At the time of the annual meeting the tests were under preparation. This milestone is delayed by 6 month but this delay was approved by the steering committee earlier on.

3 JRA1-4: Field Map available

A superconducting magnet originally constructed as a spare for a balloon experiment [10] could be obtained on loan from the KEK Laboratory in Tsukuba, Japan. In 2006 the magnet was transported from Japan to Hamburg and successfully commissioned [11]. In order to fulfil the milestone "Magnet available" a complete field map needs to be available for the future infrastructure users. A team from CERN-PH performed the field map measurements in summer 2007 with specially developed hardware. The accuracy of measurement was in the range of $10^{-}4$. The analysis of the 100.000 points taken at a field strength of 1 Tesla is under way. As this milestone is not on the critical path for the EUDET project, the deadline for this milestone was postponed from summer 2007 to the end of 2007. Detailed reports on the work will ready in December 2007.

4 JRA1-7: Intermediate Digital Chip Prototype ready

The IDC prototype is the intermediated digital chip Mimosa 22 based on the Mimosa16 chip. Compared to the Mimosa16 it has a larger surface, smaller pitch, an optimised pixel, JTAG programming, and more testability [5]. At the time of the annual meeting the design of the chip was close to completion.

5 JRA1-9: Telescope Chip ready

As final sensor for the EUDET Telescope the Mimosa22+ is foreseen. This is the Mimosa22 chip complemented with a digital readout, implemented by the Suze01 chip [5]. This is in preparation and is planned to be available at the end of 2008.

6 JRA1-10: Final Readout ready

The heart of the DAQ system is a general purpose acquisition board called EUDRB (EUDET Data Reduction Board) [6]. This is featuring two I/O buses: the VME64x for high throughput data transfer and synchronous operation with other devices and the USB 2.0 for standalone and bench top testing. To maximise its flexibility a mother- / daughter- board scheme has been followed, in order to have all the computing and memory elements common to all possible configurations on the motherboard, while the sensor specific requirements have been implemented on removable and interchangeable daughter cards.

For each sensor in the telescope there is a corresponding EUDRB board in the DAQ system and the two are linked via three connections named as follows:

- **Analog link**. This is the analog line connecting the pixel chip to the readout board. It is made by a CAT-5e Ethernet cable with one pair of conductors for each sub-array.
- **Digital link**. This line is dedicated to the chip steering and synchronisation. Again it is made using a network cable.
- **JTAG link**. This line is used to send to and receive from the chip its configuration. The EUDRB board is generating the JTAG pattern in single–ended mode and a level adapter is needed to enter the MimoTel chip that is accepting differential signals.

The EUDRB is named after one of its most important feature, in fact along with a standard fully transparent readout mode in which all pixel signals are transferred to the equipment computer, also a more advanced modality called ZS (zero suppressed) can be used, in which the DAQ board is performing online the Correlated Double Sampling and transferring to the computer only the signal and the address of pixels above a certain user–defined threshold.
Another important element of the DAQ system is the Trigger Logic Unit; this can be considered as the replacement of a NIM crate with all the most commonly used modules [7].
During the annual meeting it was shown that a reasonable usable DAQ system, is available. But a few remaining issues have to be solved until the milestone end of 2008:

- Improve speed and stability
- Run Control: GUI for configuration
- Data Collector: abbreviate processing steps
- Documentation

7 JRA1-11: Tracking software available

One important milestone for the Final Telescope is the availability of the tracking software. The status of a preliminary software version was presented at the Annual Meeting in Paris [9]. From this presentation one can conclude that the tracking software *EUTelescope* is in good shape. The results obtained from the three data taking periods at DESY and CERN are proving that it is well behaving. The goal to have the final software ready at the end of 2008 can be easily reached. The main steps for the near future are the following:

- Include the ILC LCIO format in the DAQ software to avoid the conversion step and speed up the data processing.

- Improve the alignment processor: use Millipede and therefore include it into MarlinUtil
- Improve the integration with the DUT user: A good exercise will be the integration of the DEPFET sensor and will start with the next month.
- Improve the currently available event display.

8 JRA1-8: Final pixel telescope integrated in beam

As described in the previous sections, all electrical building blocks necessary for the final telescope are on track. As soon new software or hardware is available in will be incorporated in the existing telescope and tested in a real environment. For the time while DESY test beams are not available from January to August 2008 the telescope will be tested in the laboratory or in summer 2008 at CERN SPS. With this continuous testing we try to ensure the goal of having the final telescope ready at the end of 2008. The mechanics of the existing Demonstrator telescope is described in [8]. A very similar support system will be used for the final telescope. All necessary improvements are identified and a new design was under development at the time of the annual meeting.

Acknowledgement

This work is supported by the Commission of the European Communities under the 6^{th} Framework Programme "Structuring the European Research Area", contract number RII3-026126.

References

[1] E. Corrin, I.M. Gregor, "Status of the JRA1 Demonstrator", EUDET-Memo-2007-19

[2] A. Bulgheroni, "First Test Beam Results from the EUDET Pixel Telescope", EUDET-Report-2007-06, Proc. of the IEEE NSS 2007 in Honolulu, USA

[3] J. Alozy, F. Bergsma, F. Formenti, P.A. Giudici, C. Grefe, A. Kehrli, L. Linssen, M. Losasso," First Version of the PCMAG Field Map" EUDET-Memo-2007-51

[4] I.M. Gregor, T. Haas,"Milestone Report: Analogue Telescope integrated in Beam", EUDET-Memo-2007-16

[5] A. Himmi, G. Dozire, Ch. Hu-Guo, M. Winter "JRA1 Milestone: SDC Prototype 2 ready", EUDET-Memo-2007-55

[6] A. Cotta Ramusino, C. Bozzi "The EUDET Data Reduction Board (EUDRB)", EUDET-Memo-2007-36

[7] D. Cussans "Description of the JRA1 Trigger Logic Unit (TLU)", EUDET-Memo-2007-02

[8] I.M. Gregor, C. Muhl "Mechanics, Cooling and Infrastructure for the JRA1 Telescope" EUDET-Memo-2007-26

[9] A. Bulgheroni, Ph. Roloff, A.F. Zarnecki, "Status of the Analysis Software", EUDET-Memo-2007-20

[10] BESS Collaboration, Y. Ajima et al., "A superconducting solenoidal spectrometer for a balloon borne experiment", Nucl.Instrum.Meth.A443:71-100,2000.

[11] T. Haas, "Status of JRA1", EUDET Annual Report 2006, EUDET-Memo-2006-11