SoNDe

Solid-State Neutron Detector

INFRADEV-1-2014/H2020

Grant Agreement Number: 654124

Deliverable Report: D2.1 2x2 Demonstrator

Project and Deliverable Information Sheet

SoNDe Project	Project Ref. No. 654124	
	Project Title: Solid-State Neutron Detector SoNDe	
	Project Website: http://www.fz-juelich.de/ics/ics-1/DE/Leistungen/ESS/SoNDe-Projekt/	
	Deliverable ID: D2.1	
	Deliverable Nature: 2x2 Hardware Demonstrator	
	Deliverable Level: PU	Contractual Date of Delivery: 30.05.2016
		Actual Date of Delivery: 16.08.2016
	EC Project Officer: Bernhard Fabianek	

Document Control Sheet

Document	Title: Solid-State Neutron Detector SoNDe	
	ID: Website-Deliverable-D2.1	
	Version: 1.0	
	Available at: Project Website	
	Software Tool: MS Word 2011	
	Files: 2x2-Demo-Deliverable-D2.1.docx	
Authorship	Written by	Sebastian Jaksch, FZJ
	Contributors	Ralf Engels, Günter Kemmerling (FZJ), Codin Gheorge (IDEAS)
	Reviewed by	Sebastian Jaksch, FZJ
	Approved	Sebastian Jaksch, FZJ

List of Abbreviations

FZJ	Forschungszentrum Jülich, Jülich Research Centre
JCNS	Jülich Centre for Neutron Science
LLB	Laboratoire Léon-Brillouin
ESS	European Spallation Source
IDEAS	Integrated Detector Electronics AS
MaPMT	Multi-anode Photomultiplier Tube
S-DAM	SoNDe Data Acquisition Module
ROSMAP	IDEAS code name for counting electronics

Table of Contents

Executive Summary

This 2x2 demonstrator of a SoNDe detector module shows a combination of four Multi-anode Photomultiplier Tube (MaPMT) with the accompanying electronics similar to the setup projected to be used in the final detector.

It both serves to show the feasibility of the approach to combine several panels of MaPMTs together as well as for testing of the technology. At this stage, a wide array of questions concerning the interoperation of several modules have to be answered, such as the mode of time synchronization between the modules and the combination of data coming from several modules. These tests are fundamental for a proper operation of the complete SoNDe detector at a later stage, however are so deeply ingrained into the construction that any design changes at a later stage will prove very costly, in time and resources. Therefore, a detailed testing of the 2x2 demonstrator is now scheduled and will be performed in the near future.

The demonstrator consists of four identical modules, each with a pixelated scintillator/carrier glass sandwich, a H8500 Hamamatsu MaPMT and a specifically designed readout system with a front-end board to connect to the MaPMT and a controller board that also houses the logic and communication part.

Introduction

One of the main goals in the first work package WP2 (2x2 Demonstrator) is to determine the scalability of the proposed technology. To do so the interconnection between the modules, the synchronicity of the data transfer and the reassembly of an image from several modules have to be tested and evaluate. Solving these issues at this stage in the project will ensure a working full-scale detector by the end of the project. This testing can only be done if appropriate hardware is available, which is why this 2x2 demonstrator was constructed.

Solutions to other issues that were identified earlier during the project, such as the separation of the single pixels in the scintillator glass, connection between readout electronics and MaPMT and reliability of the software framework can also continuously be studied using this new improved demonstrator.

The main challenges during the development phase of the 2x2 demonstrator were the high integration density of electronics, keeping the form factor of the module below 5x5 cm^2 and thus smaller than the MaPMT outer dimension. The overall power consumption of the modules, the electronic and mechanical connections of the single components, that both grants a reliable construction procedure but keeps the modularity and thus ease of maintenance after the modules have been assembled into the whole detector. The 2x2 demonstrator design is in line with all the requirements to the SoNDe detector and we are confident that further testing will prove its feasibility.

Construction of the 2x2 demonstrator

As previously described the 2x2 demonstrator consists of four pixelated scintillator/carrier glass sandwiches, H8500 Hamamatsu MaPMTs and two-stage readout electronics comprised of a controller board for the logic/communication and a frontend board to provide connections to the MaPMT. All components mounted onto a 2x2 frame for later testing and ease of handling. In the following section, we will describe the construction of the 2x2 demonstrator, which will in itself be the prototype for the later upscaling in WP3.

Improvements on Pixelated Scintillator/Carrier glass sandwich

In our former deliverable, we were putting forth the approach to separate the single pixels using a wafer saw and physically cutting the scintillation glass that is itself glued to a carrier glass. Further examination of the issue has shown several other approaches, that will allow mounting on an aluminum sheet, which improves mechanical stability considerably. These improvements will be tested using the 2x2 demonstrator setup.

H8500 Hamamatsu MaPMT

The H8500 MaPMT was purchased from Hamamatsu. No further modifications were made. The glass sandwich positioned at the front of the MaPMT, by means of a mechanical frame. Compared to the solution of gluing or using optical gels facilitates the disassembly for repair as well as improves the testing capabilities when choosing a different diameter of the air gap between scintillator and the MaPMT.

Table 1. Selected requirements for the S-DAM consisting of frontend and controler board.

S-DAM Requirements	
Component/Description	**Requirement**
Connectivity Interface	Ethernet
Power Input	Single voltage connector to controller board
Dimensions	50x50 mm^2, stackable
Time resolution	> 50 ns on each channel
Data output upstream	Each detected event with timestamp and channel number in standard mode. Energy value with timestamp and channel number for each channel in calibration mode.
Data output bandwidth	50.000 detected events per second per module. S-DAM is capable to transfer all detected events.

Dedicated counting electronics

The dedicated electronics consist of a frontend module that houses the ASICs connected to the MaPMT and the control module. The control module houses the logic and performs pulse discrimination and processing. , It has the connections to the network and power supply. A selected list of the specific requirements can be found in Table 1.

It is important to note that this design can later transferred to a larger system for the upscaling process, where the control module not only supplies one frontend board but several without major modifications. This is one of the approaches to keep the power consumption low.

Another aspect that covers the commercial applicability of these modules is the possibility to supply the single modules with power over Ethernet. This way, encapsulated modules can be used independently for neutron or gamma investigations, in rough areas with a minimum of cables needed.

Conclusion

A working 2x2 demonstrator was presented (see Fig. 1). This demonstrator will later used for further testing under working conditions in neutron scattering environments. These tests will help to prepare the upscaling of the SoNDe technology to a full size detector both in terms of interoperability of the modules as well as the know-how about handling the incoming data,adapted firm- and software.

The 2x2 demonstrator enables us to show the feasibility of all components of the SoNDe detector technology, such as modularity, interconnectivity and synchronicity between the single modules. Thus, it is a major step towards a full-scale detector following the same concept.

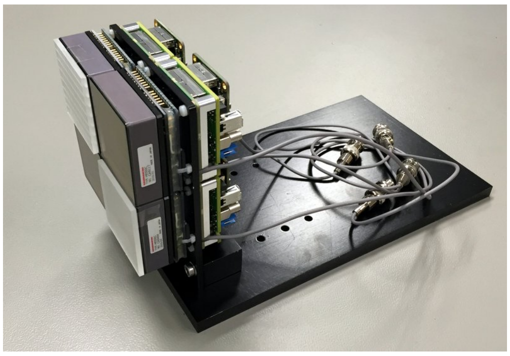
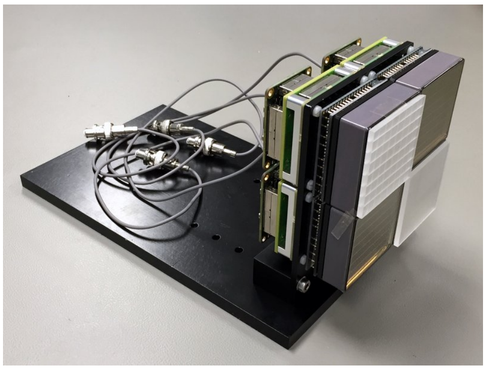

Fig. 2. Images of a mounted 2x2 demonstrator module. Different scintillator glasses are mounted for testing and comparison. The controller board has all connectors to the backend for data and electricity. The cables shown are for the high voltage supply of the MaPMTs.