# T2K-WAGASCI: MIDAS-based DAQ software and online monitor for the readout of a large number of MPPCs

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**Abstract.** The WAGASCI project aims to perform a study of neutrino-nucleus interactions at the J-PARC accelerator in Japan with a new fine-grained neutrino detector (WAGASCI module) coupled with muon range detectors (WallMRD and BabyMIND).

The WAGASCI module main target for neutrinos is purified water. A hollow cuboid lattice made of scintillators bars is used to detect charged particles coming out of the neutrino interaction points. Measurements in wide phase space become possible by the combination of the WAGASCI modules, side and downstream muon range detectors. The downstream-MRD, the so-called BabyMIND detector, also works as a magnet and provides charge identification capability as well as magnetic momentum measurement for high energy muons.

The DAQ of the WAGASCI experiment is a modern DAQ that takes the object oriented paradigm to a new level of sofistication. Not only objects are exensively used, but the very architecture of the DAQ itself is modular, composed of many blocks indipendent from each other and with a clear external API. This makes adding new functionality quite easy and maintaing the software less time consuming.

Our DAQ is an hybrid made up of multiple packages, most notably MIDAS (a DAQ framework developed at TRIUMF and PSI), Pyrame (a frontend software developed at LLR) and the well-known ROOT (developed at CERN). It is the first attempt to merge MIDAS and Pyrame, in a hopefully armonic and organical way. This is because the official T2K DAQ software is MIDAS-based while the WAGASCI frontend electronics is supported by Pyrame only.

## 1. The WAGASCI experiment

WAter Grid And SCIntillator (WAGASCI[1]) is a new measurement for neutrino cross-section experiment located in Japan at the J-PARC facility. It is exposed to the very same neutrino beam as the T2K experiment but at a different off-axis angle of 1.5 deg. It is located in the same pit as the off-axis T2K Near Detector (ND280) and at the same distance of 280m from the beam target.

Its short-term aim is to measure with high precision the neutrino-H2O and neutrino-CH cross-sections and their ratio. Its strong points are:

- the neutrino passive target (WAGASCI detector) is mostly water (Water:CH $\sim$ 80:20), same as the T2K far detector SuperKamiokande;

- it has good sensitivity to side-going muons thanks to the two Side Muon Range Detectors (WallMRD in figure 2);
- it has a fine-grained grid-like structure that gives a good 3D track reconstruction efficiency (figure 1);
- Use the Baby Magnetised Iron Neutrino Detector (BabyMIND[2]) to discriminate the charge of the forward going muons.

Among its longer-term aims are:

- use this cross-section measurement to decrease the T2K systematic error;
- improve the understanding of the neutrino-nucleon cross-section and final state interaction models;
- use the different neutrino beam peak energy with respect to ND280 enables to develop and test new analysis techniques to narrow down the neutrino initial energy by comparing the results of the two experiments;
- improve, test and benchmark the SPIROC2D chip (WAGASCI) and FEB board (BabyMIND) and the surrounding electronics;
- develop and test a new data acquisition software framework (based on the MIDAS and Pyrame programs);

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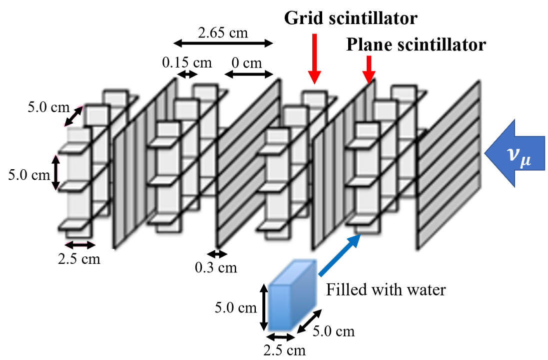


Figure 1: WAGASCI module inner structure (water ∼ 80%, hydrocarbon ∼ 20%)

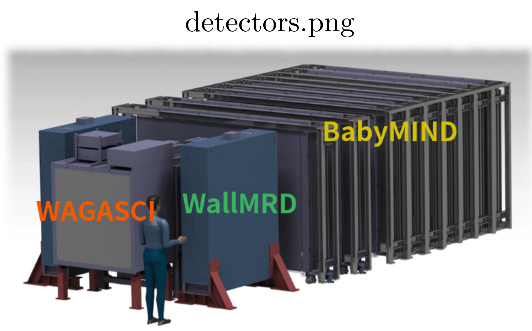


Figure 2: Detectors relative location.

The light from each scintillator bar is collected by a wave-length shifting fiber and read out by a Hamamatsu MPPC (S13660 for the WAGASCI module). The low dark noise and crosstalk rates of this MPPC model enable to take data with a low-ish threshold of 1.5 or 2.5 photo equivalent units and continuously calibrate the detector using the dark noise hits between the beam spills. The total number of channels is 2880.

## 2. DAQ

The WAGASCI DAQ is called ANPAN (Acquisition Networked Program for Accelerated Neutrinos). It uses MIDAS as a user interface while Pyrame as a frontend software for both the DAQ and slow control.

Pyrame[3] is a fast prototyping framework for online systems developed at the (Laboratoire Leprince-Ringuet: LLR). It provides basic blocks (called modules) for slow control or data acquisition. These blocks can be assembled together to quickly obtain complete systems for testbenches and small scale experiments. The framework is very flexible and provides lots of options.

On the other hand MIDAS[4] is a data acquisition system developed at PSI and TRIUMF. MIDAS is written in C, JavaScript and some C++. Its strenghts are the highly customizable web-based GUI and the online database (ODB), where each and every configuration parameter is stored.

Pyrame is great as a frontend program but has got only a very rudimental GUI. The database capabilities are quite limited too. That is where MIDAS really shines. I tried to combine Pyrame and MIDAS to get the best out of the two of them. They communicate through the exchange of TCP packets.

To give a concrete example of how all of this works together, below I am describing the WAGASCI slow monitor and control architecture (temperature sensors, water level sensors, high voltage and magnet power supply). The WAGASCI slow control software is organized in many layers, like an onion. The inner layers directly interface with the hardware and implement very simple functions, such as "set voltage", "read temperature", and so on. The intermediate layers are responsible for storing and processing the data. The outer layers present the data to the user in the form of a web-based graphical user interface (GUI shown in figure 3). The inner layers are managed by Pyrame, the intermediate layers by the MIDAS frontend and the outer layers by the MIDAS web server (HTML/Javascript/JSON-RPC). All the code is brand new: until now there was no support in Pyrame nor in MIDAS for any of the devices in use. The architecture and GUI of the other modules is similar to the one described above (figure 4).

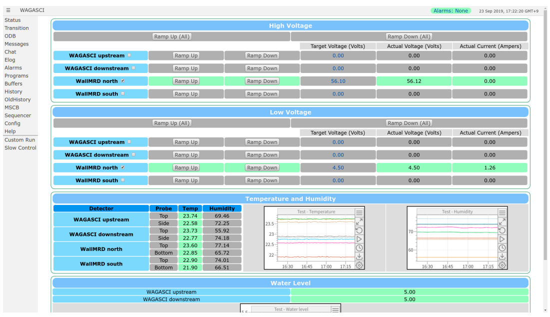


Figure 3: ANPAN slow monitor and control GUI

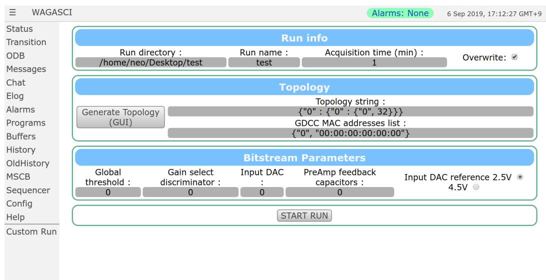


Figure 4: ANPAN custom run start page

## 3. Future prospects

Because the BabyMIND electronics will be the base on top of which the new ND280 upgrade electronics is going to be developed, and the WAGASCI and ND280 DAQ software bear many similarities, the knowledge acquired while building and operating our detectors would prove useful for the ND280 upgrade endeavor as well.

## References

[1] Koga T *et al.* 2015 *Water/CH Neutrino Cross Section Measurement at J-PARC (WAGASCI Experiment)* (JPS Conf. Proc.) chap 3

[2] Antonova M *et al.* 2017 *Proceedings, Prospects in Neutrino Physics (NuPhys2016): London, UK, December 12-14, 2016* (*Preprint* 1704.08079) URL `http://lss.fnal.gov/archive/2017/conf/fermilab-conf-17-270-apc.pdf`

[3] Magniette F, Rubio-Roy M and Thiant F 2015 *Journal of Physics: Conference Series* **664** 082028 URL `http://stacks.iop.org/1742-6596/664/i=8/a=082028`

[4] Khaw K *et al.* 2019 *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment* **945** 162558 ISSN 0168-9002 URL `http://www.sciencedirect.com/science/article/pii/S0168900219310824`