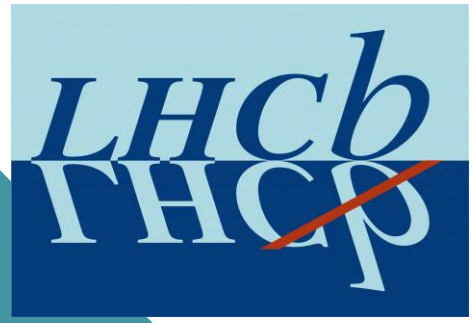

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

Automated and user-friendly Connectivity Test

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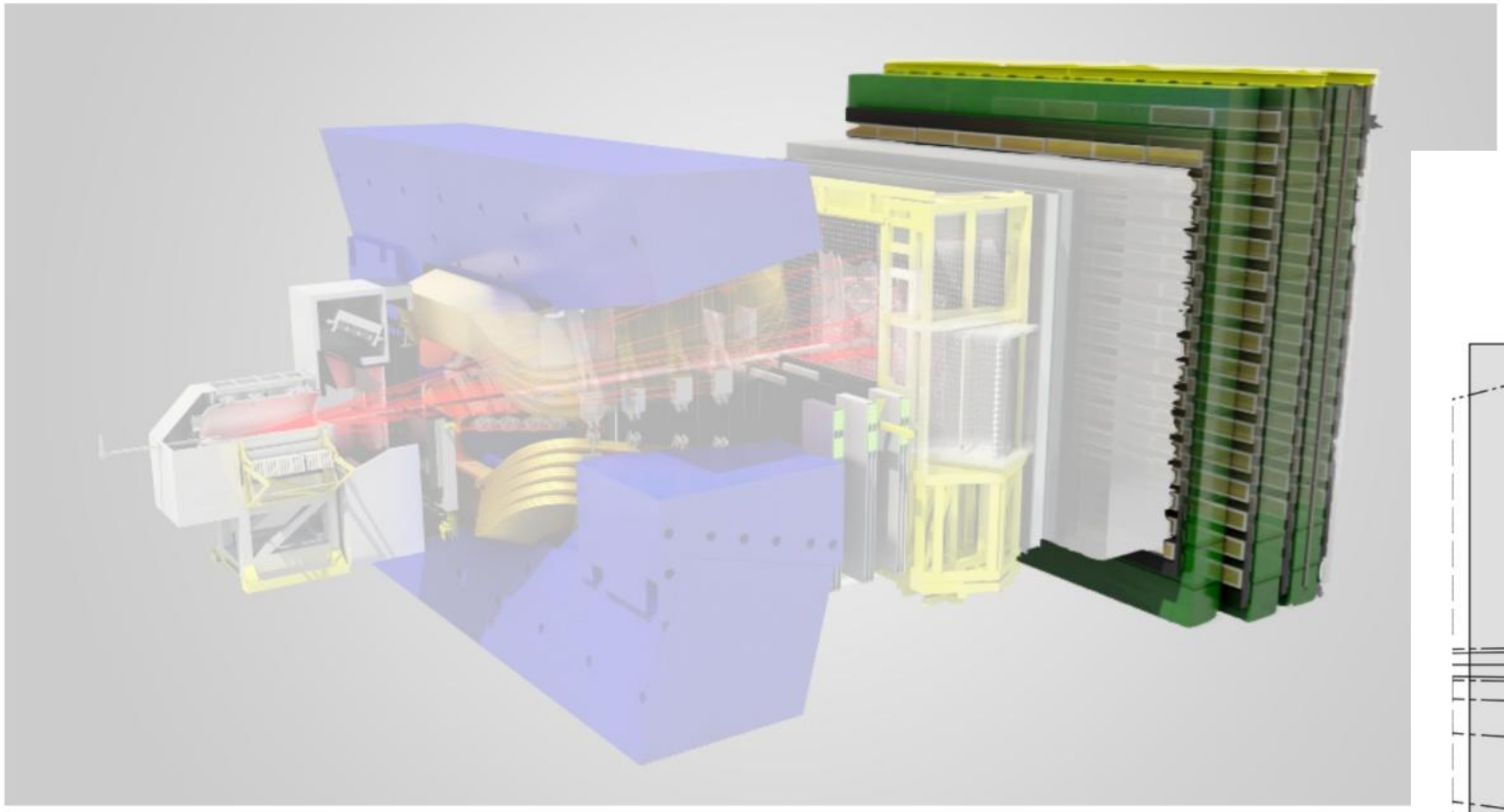
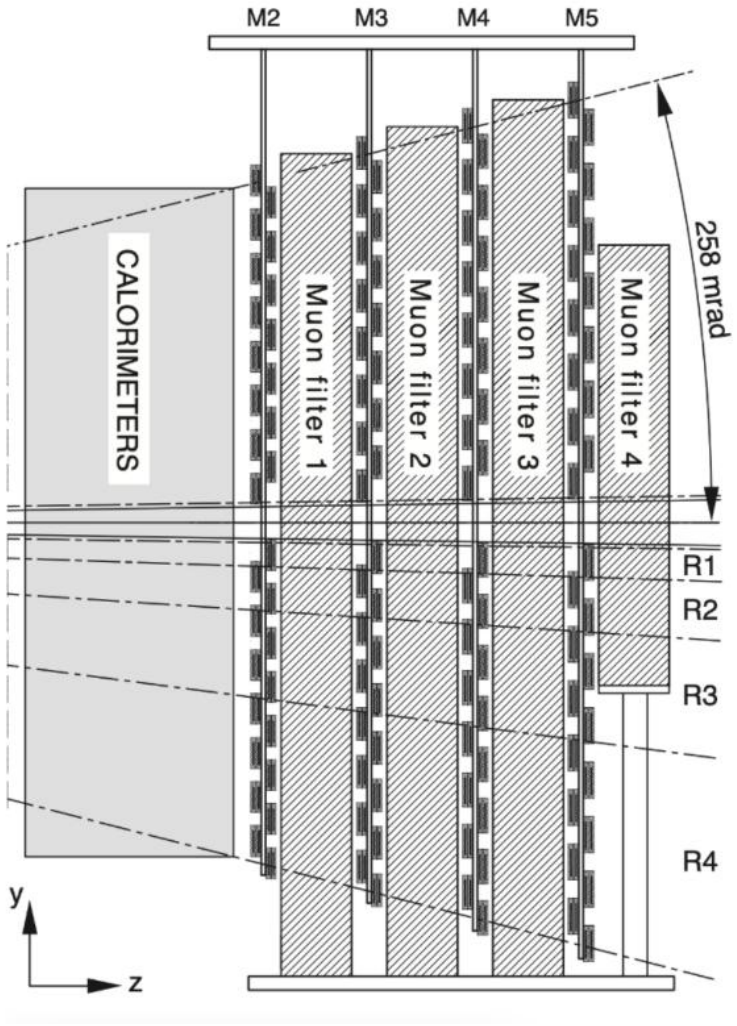
Who am I?

MSc Student in Particle Physics @ Sapienza University of Rome

Summer Student @ INFN Laboratori Nazionali di Frascati under the LHCb group.
During my project I mainly worked on the **renewal of WinCC panels** for the muon system, with a particular focus on the automation and user-friendliness of the Connectivity Test.

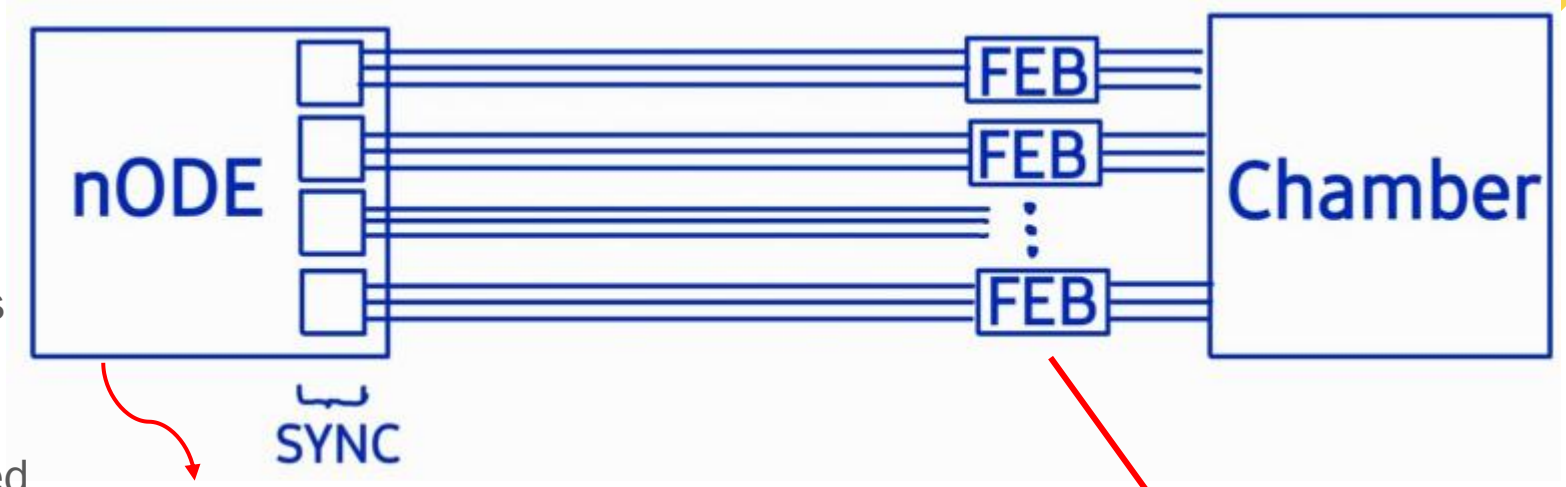
The muon system

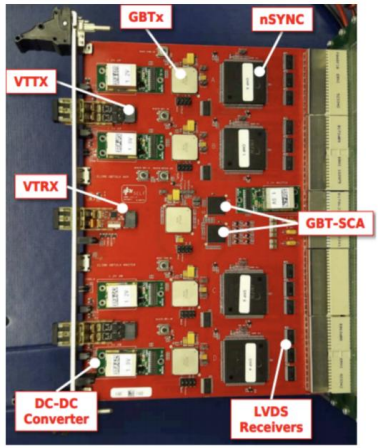


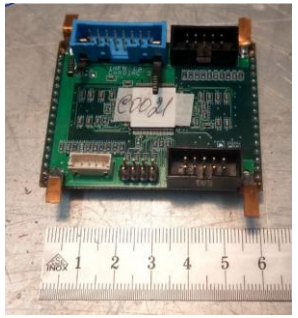


The main characters: nODEs & FEBs

Front-End Boards (FEBs) amplify, shape and filter the chamber's signal to remove noise. Each chamber can be connected to several FEBs (up to 14), which then pass the logical channels to the new Off-Detector Electronics (nODE).
The system contains 144 nODEs, each equipped with four nSYNC chips for advanced processing: bunch crossing identification, clock synchronization, buffering, measurement of hit times, and coarse alignment. Each nSYNC can manage up to 48 channels





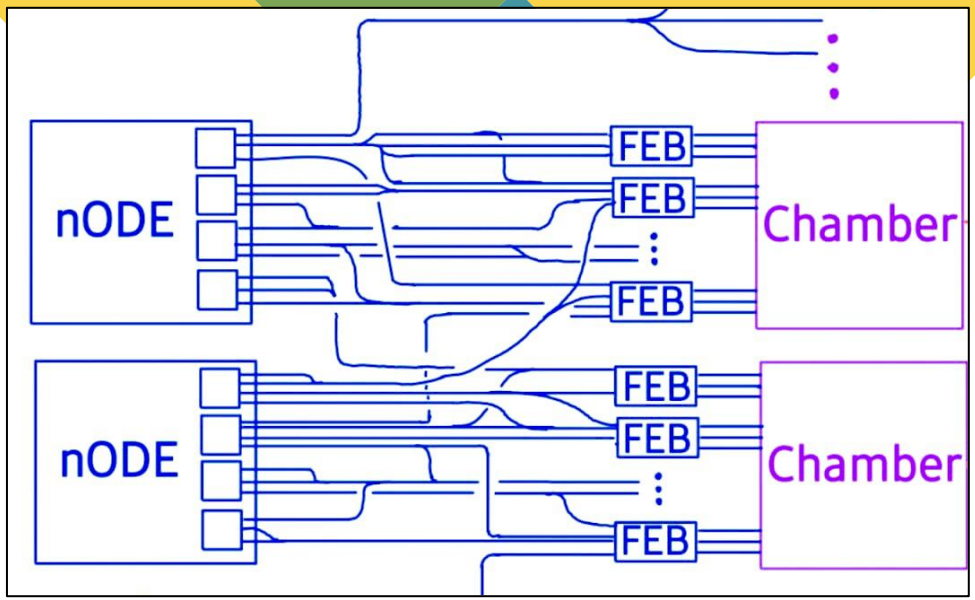


What's a Connectivity Test?

The Connectivity Test (CT) of the LHCb muon system is used to verify that **all copper cable connections** between the front-end electronics (FEBs) and the readout modules (nODEs/nSBs) are correct and working.
During the test, test pulses are sent through the system, and their arrival is checked to confirm whether:

- the **signal reaches the expected** position,
- the signal appears **noisy** or **weak**,
- it is **missing** altogether,
- or it appears in the **wrong place**.

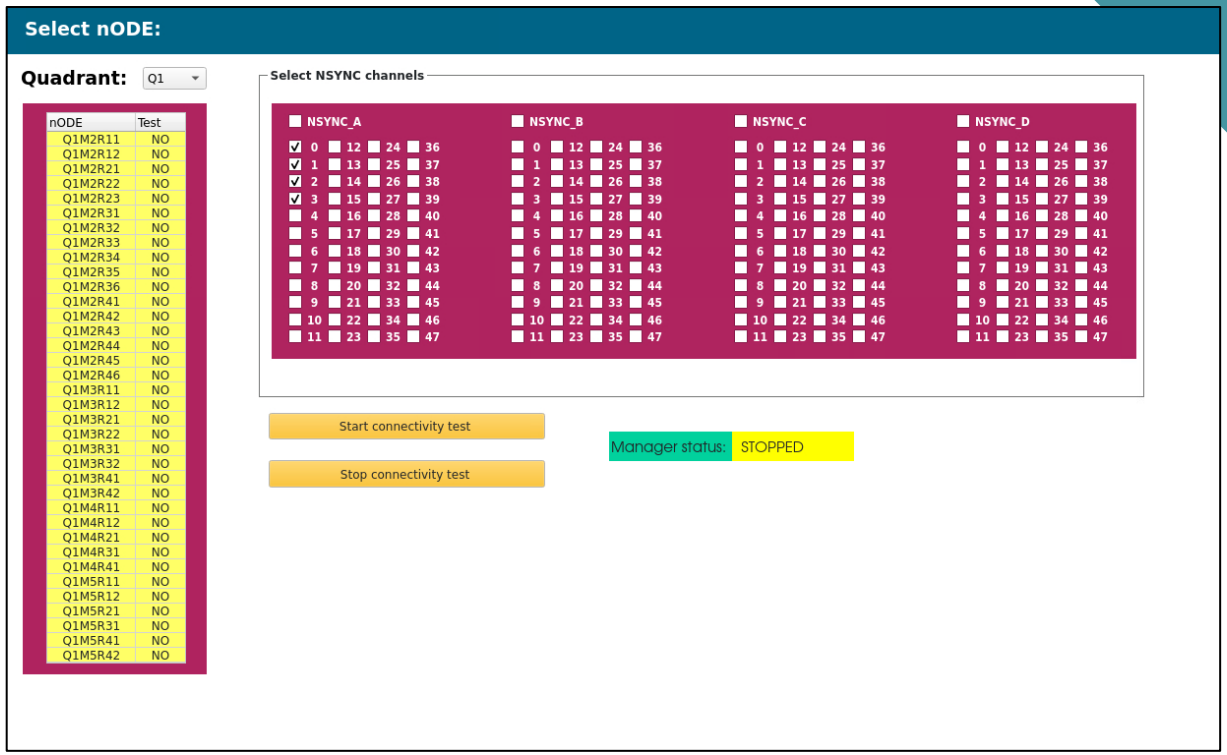
The results help identify faulty cables, wrong connections, or hardware issues, ensuring that the entire muon readout system is properly wired and ready to record data.



Main Goal: Renew the CT

The original panel designed by Sofia was powerful but mainly designed for expert users.
Our goal is to completely renew this system by:

- Automating the test so that even **non-experts** can run it correctly;
- Redesigning the interface to provide clear, **user-friendly** result visualization;
- Consolidating multiple functions into a single panel, making the entire test as simple as **pressing one button**.



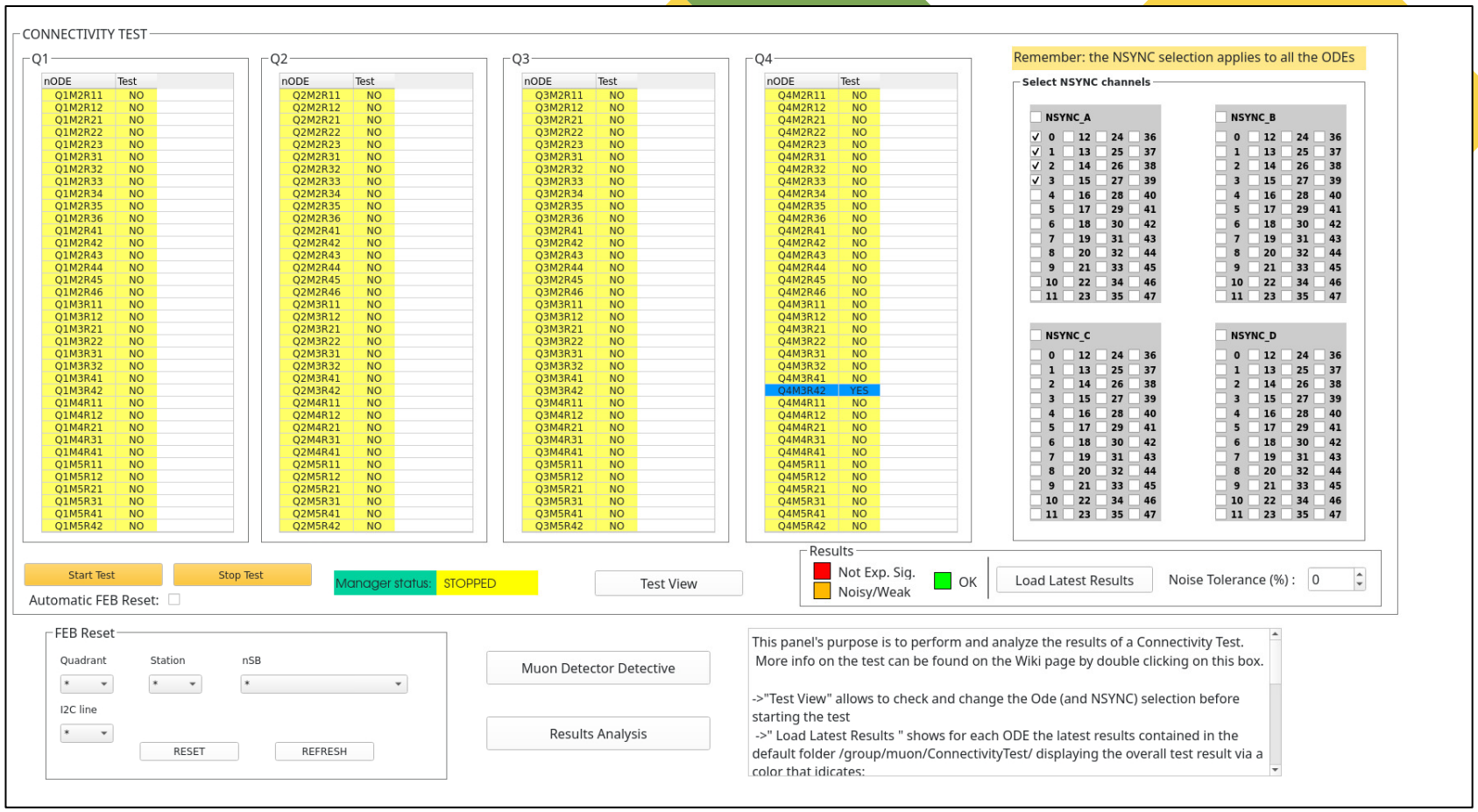
The original CT panel

The new Panel

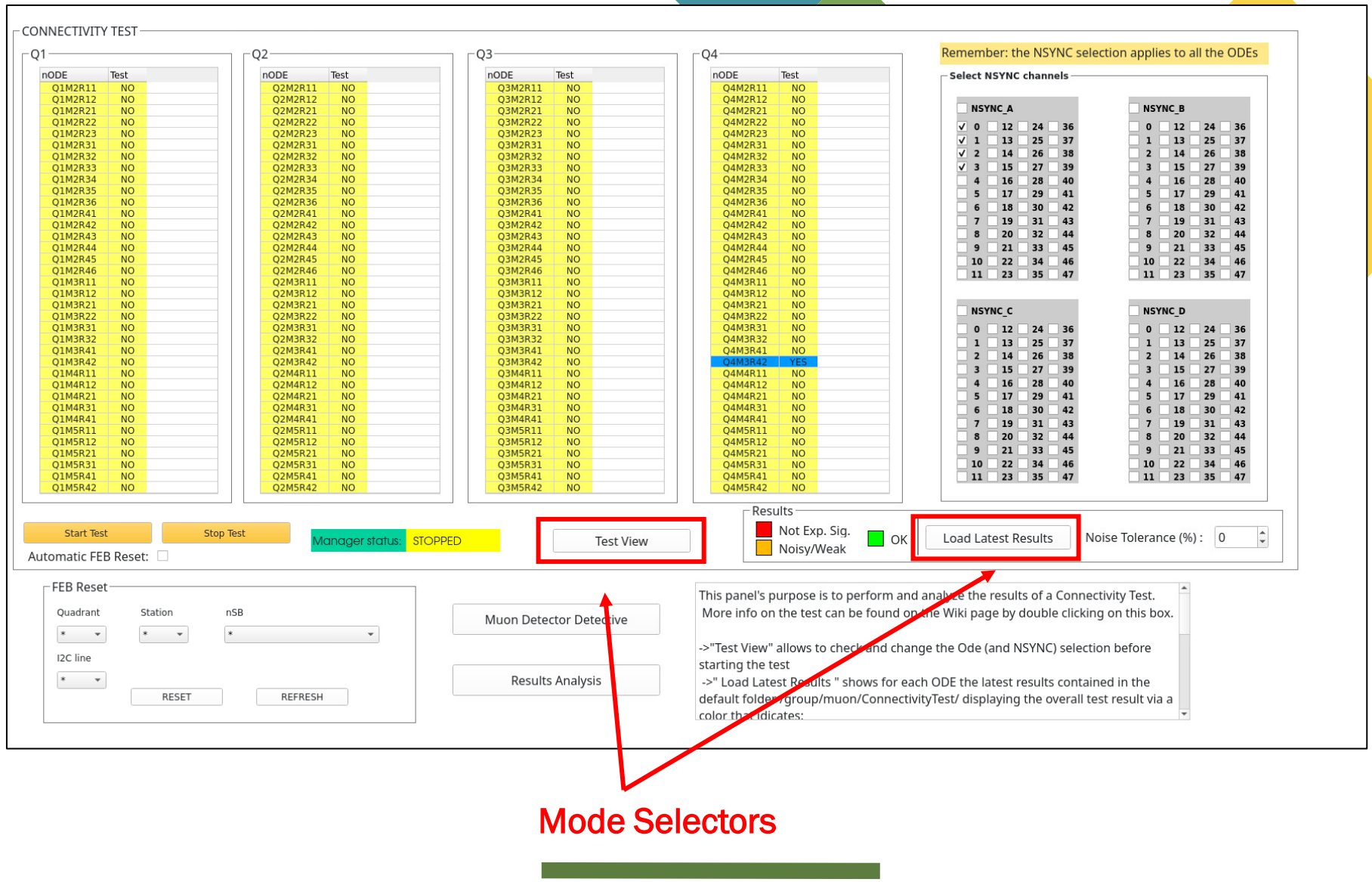
The new panel introduces a **dual-view design** (Test and Results) that integrates all essential tools in one place.
Instead of navigating through multiple panels, the user can now:

- Access all ODEs at a glance;
- Switch quickly between different modes;
- Instantly identify potential issues thanks to a color-coded overview.

This approach speeds up the workflow and reduces the chances of operator error.



The panel allows the operator to select between different modes depending on the stage of the test. These selectors give flexibility while maintaining a unified interface, ensuring that the same panel can serve both setup and result analysis purposes.



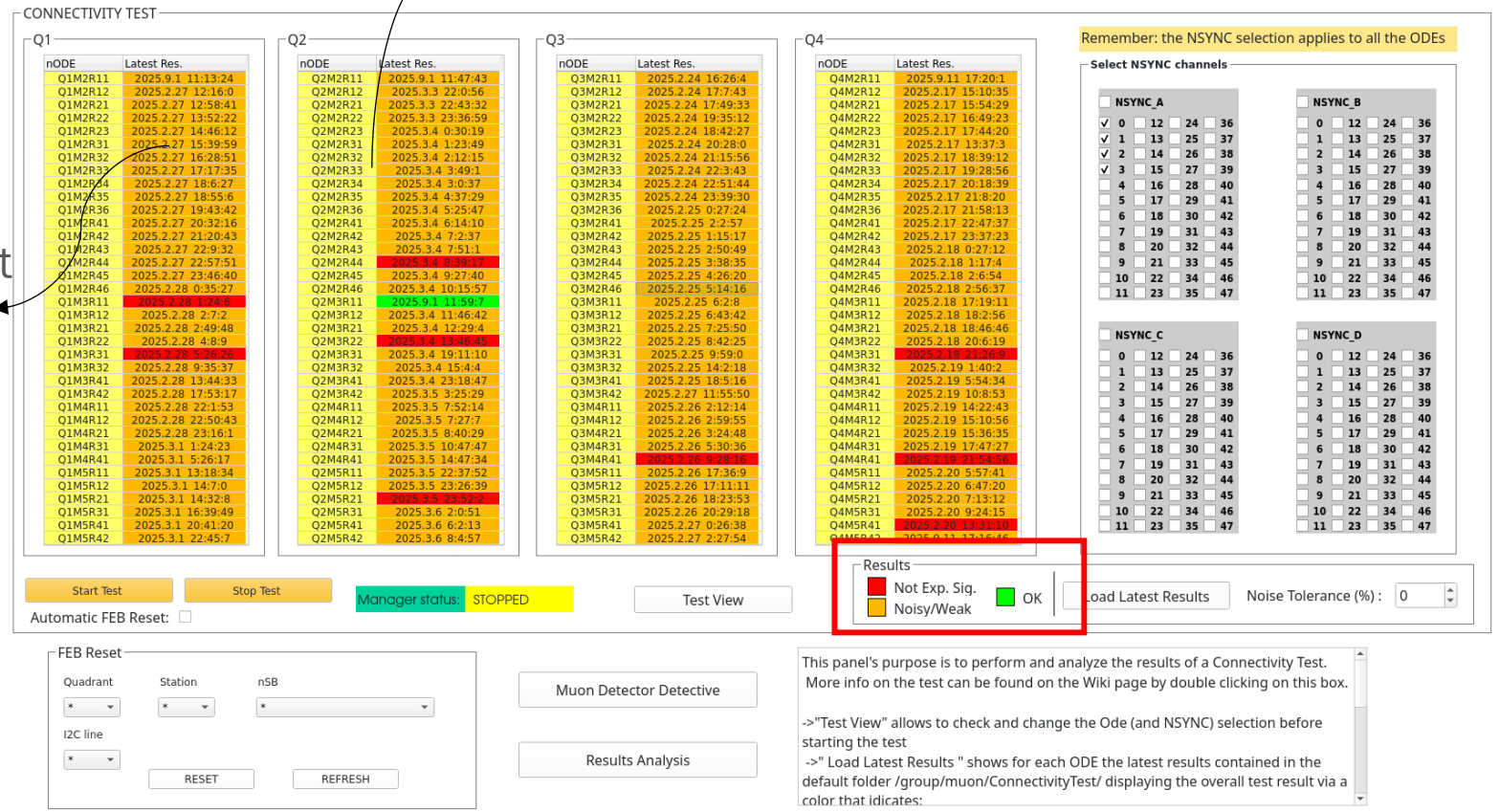
Test View

In the Test View, the user can choose which ODEs to test. This view also integrates an automatic FEB reset option (currently under development), aimed at ensuring that each board starts in a clean state before the test begins.

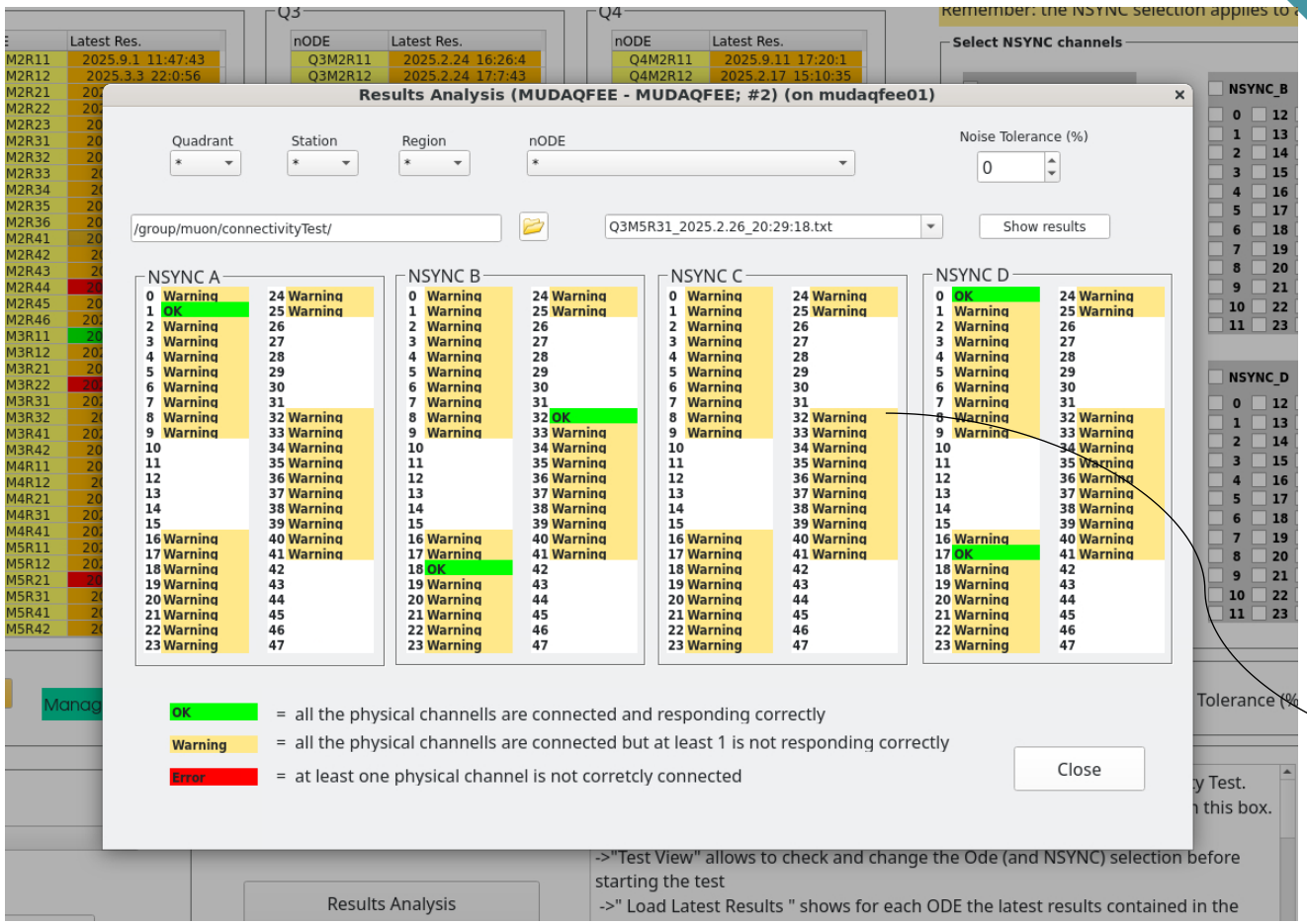
Result View

The test's results are written in a file for each ODE.
This view shows latest ODE test files.
Each ODE is color-coded according to the overall health of its channels, providing a quick, intuitive snapshot of the system status.

By clicking on any ODE result, the user can open the detailed Result Analysis panel for deeper inspection.



Previously done offline using a Python script.



Each logical channel is color-coded based on its performance, making it easy to identify problematic areas immediately.

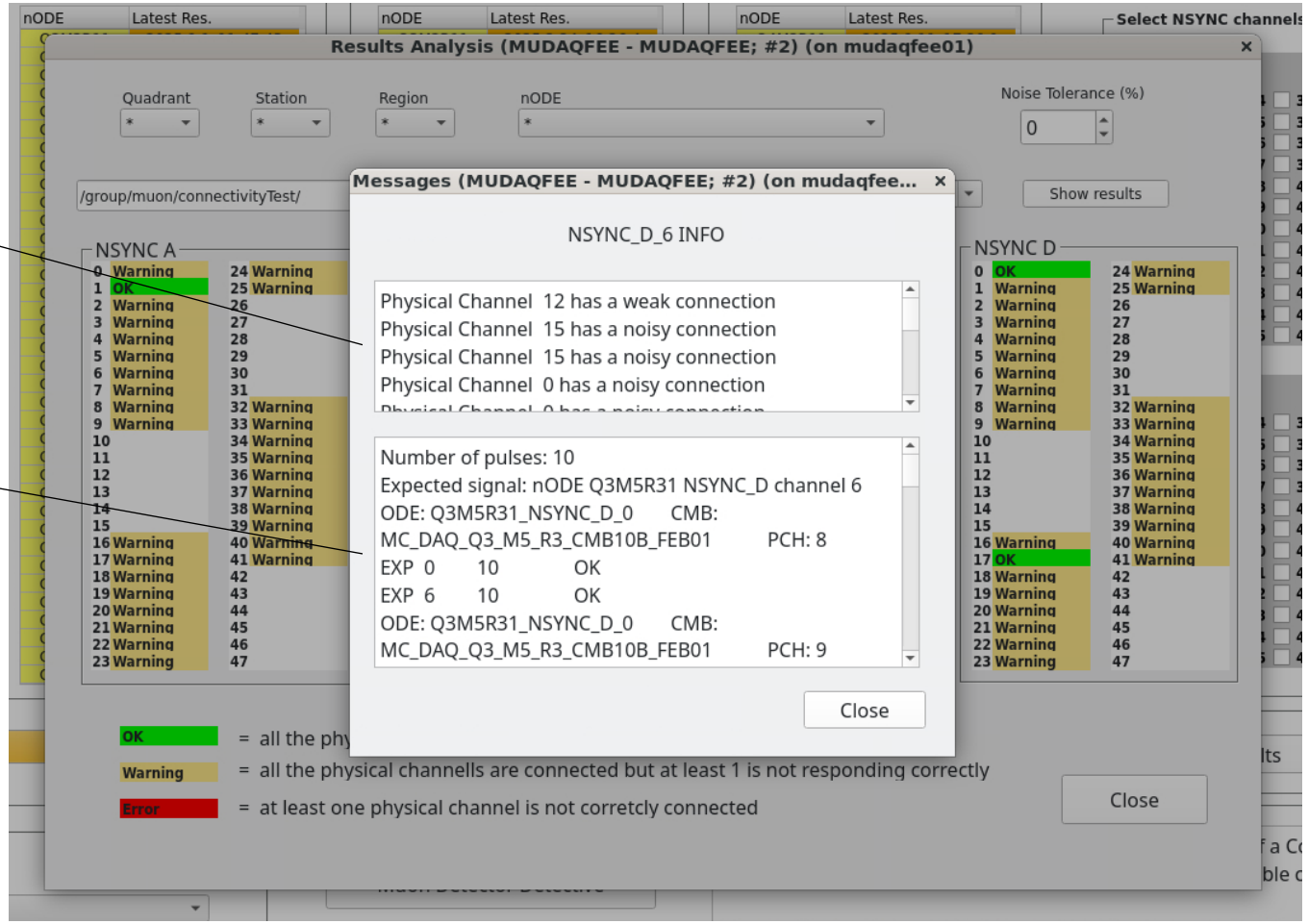
This panel (evolution of the already started “res” panel) provides a detailed visualization of the test results for a single ODE. By focusing on individual channels, the operator can precisely diagnose whether issues are due to noise, weak signals, or faulty connections.

Result Analysis Panel

Channel Analysis Panel

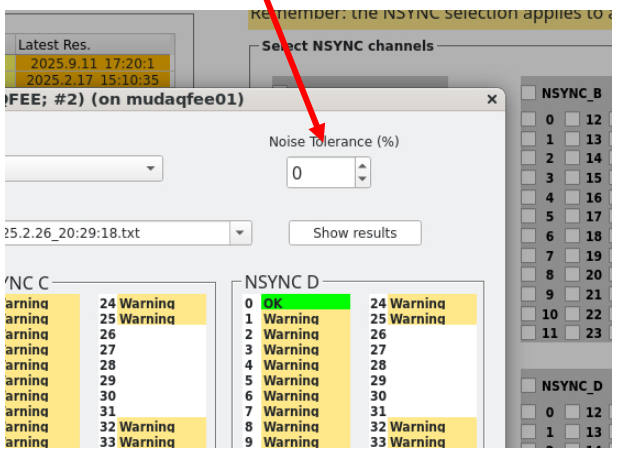
Automatic error and warning messages for each channel, helping the operator interpret the raw information quickly and accurately.

Original Test Results from the file to make troubleshooting more efficient and reduce the need for manual log-checking.



Noise Tolerance

A major challenge in the Connectivity Test is distinguishing genuine connection problems from fluctuations caused by electronic noise. To address this, we use a Noise Tolerance selector, already present in the original Python Script. This feature allows the operator to tune the sensitivity of the test, filtering out channels that are only slightly noisy or weak.



What next?

The finished panel is already available on the MUDAQFEE project and represents a starting point for future improvements.
The next steps aim at making the CT procedure even faster and more autonomous:

- Implementing a reliable automatic FEB & ODE reset before each test run;
- Parallelizing the procedure across multiple detector regions, reducing runtime by up to a factor of 8;
- Review the test to minimize false noise-related errors.

Thank you for your attention