Vetoing charged particles for neutrino detection at the LHC

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LHC
Scattering and Neutrino Detector at the LHC

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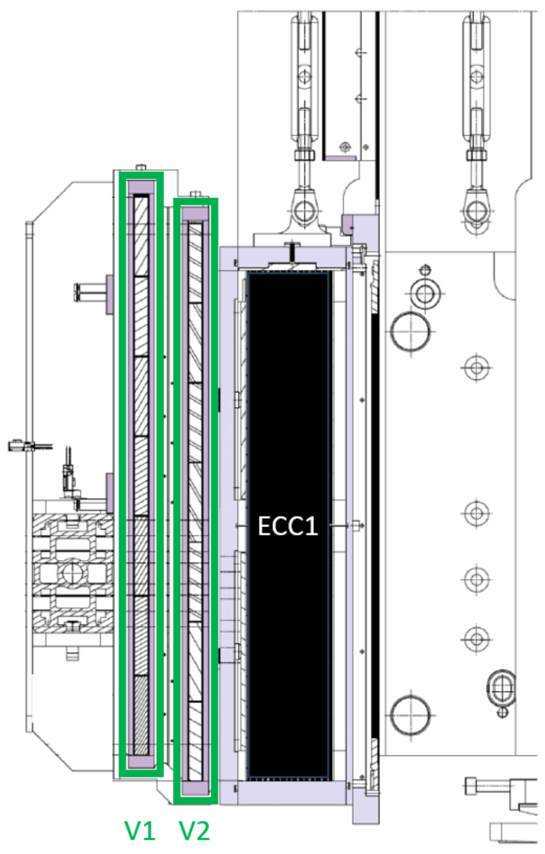
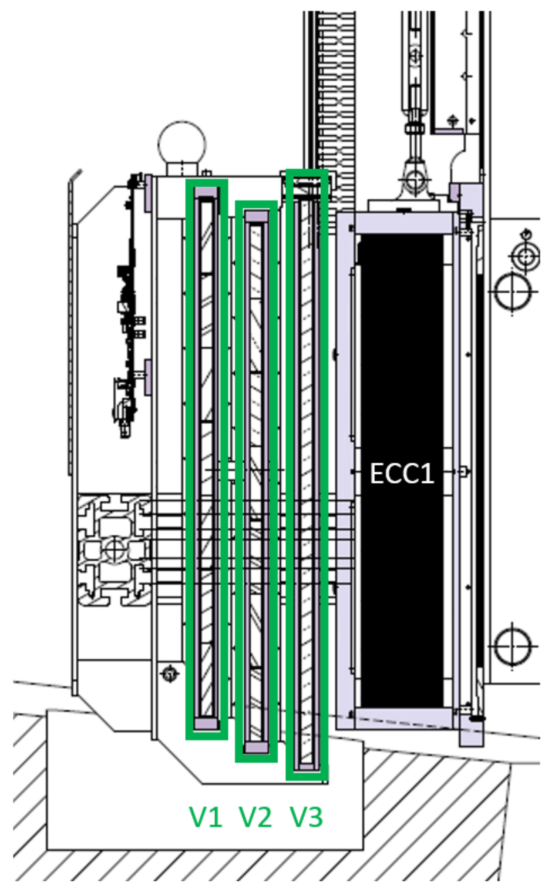
Why an additional plane?

The SND@LHC Collaboration recently **observed neutrino interactions from ν_μ** [1] at the LHC achieved with a strong selection to distinguish the rare neutrino signal from the background. Vetoing incoming charged particles is crucial to reject muons, the main background contribution.
In the current configuration, the veto system's inefficiency [2][3] was such to require the use of the first two tracker planes to reach the necessary rejection power, strongly reducing the fiducial volume.
Add a third veto plane with vertical instead of horizontal bars to
→ reach inefficiency $\sim \mathbf{10^{-10}}$
→ **better coverage** at the bottom edge of the tungsten target



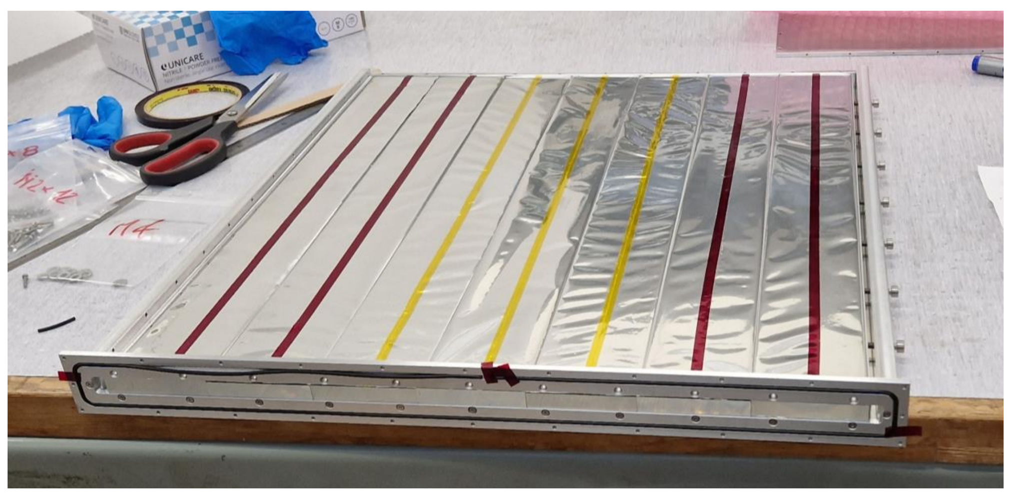
Previous veto system configuration



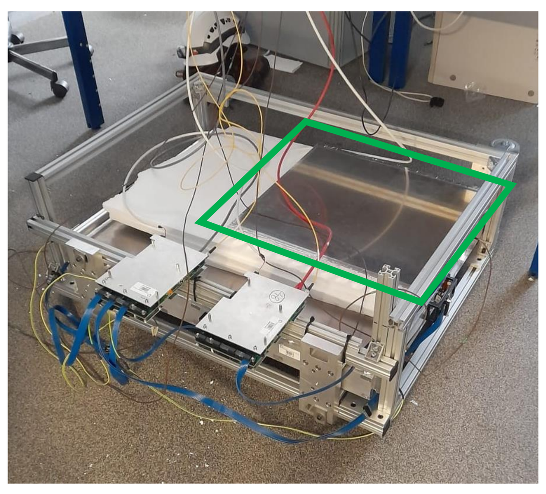
New veto system configuration

Assembly

The new veto plane (V3) consist of seven bars 6 cm wide, 1 cm thick, and 46 mm, long **extending** by 2 cm above and below the veto 1 (V1) and 2 (V2). Each bar is wrapped in aluminized mylar foils to enhance reflection and reduce cross talk between bars.
Signals are read-out only from the top by 56 SiPMs carefully aligned to be centered on bar edges, so that each bar is uniquely read out by 8 SiPMs. The vertical bars **minimize readout dead time** due to the passage of a second muon in an already hit bar in V1 or V2.



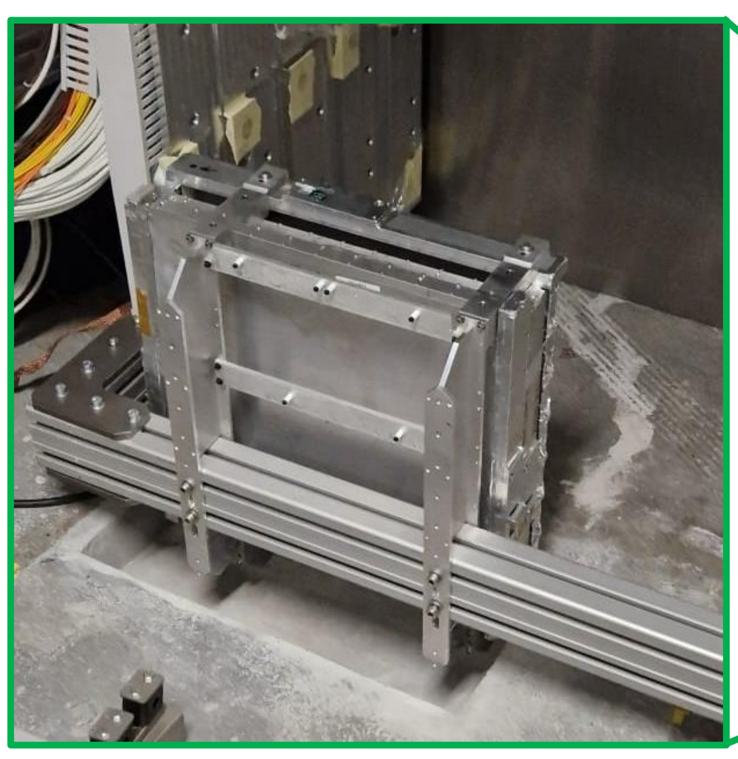
V3 bars, wrapped in mylar, aligned in the aluminium case



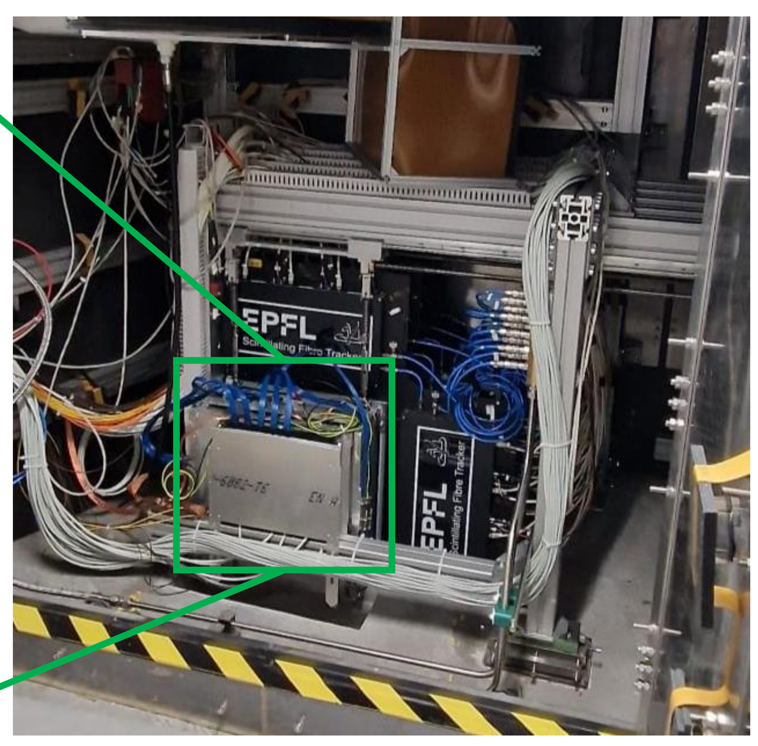
V3 in the preliminary test setup at ground level

Integration in SND@LHC

During this year end technical stop, the new veto plane was integrated in the detector.



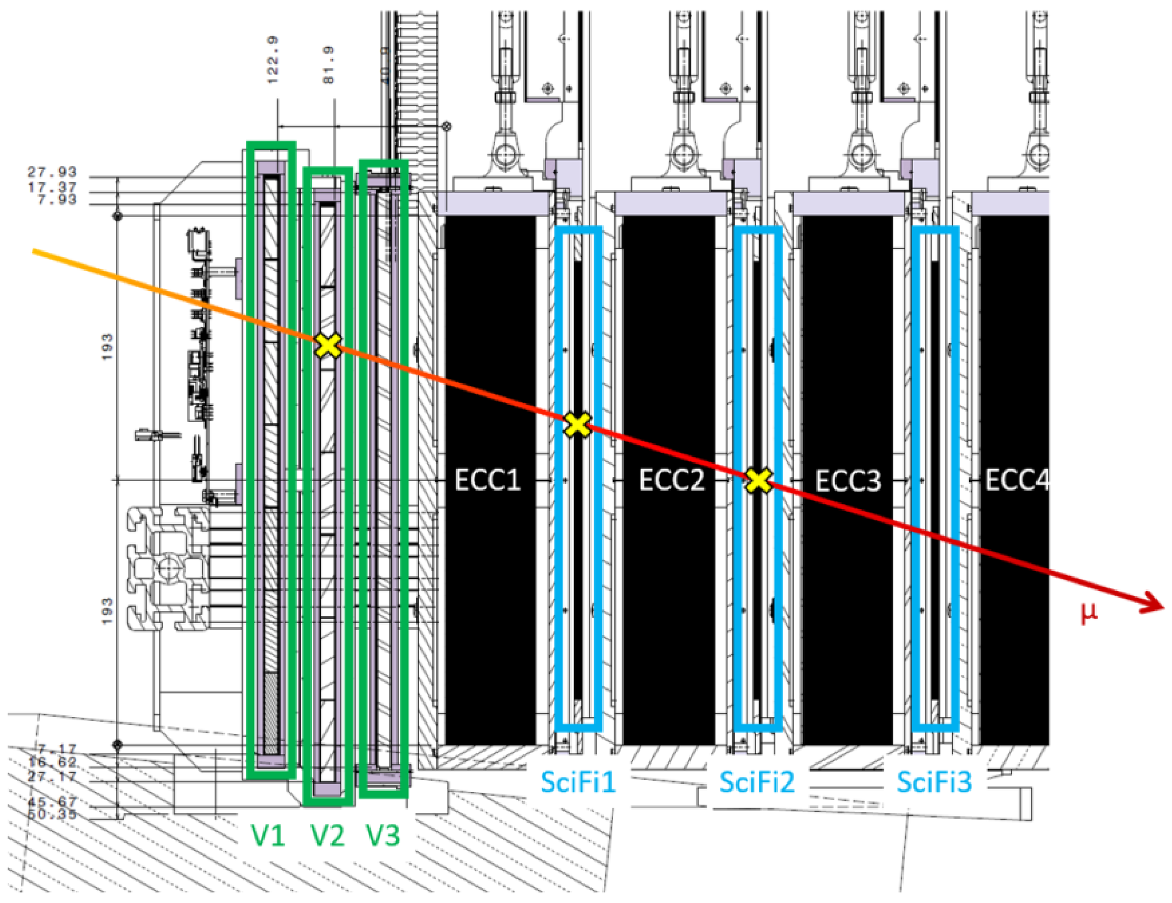
Veto system in the new configuration



Final configuration in TI18

Selected signals

To compute the efficiency of the third veto plane, events in which the incoming particle was crossing the plane needed to be selected. These events are chosen by requiring:
→ signals in the second veto plane
→ signals in the first two Scintillating Fiber (SciFi) modules
These events select both cosmic rays and events from proton-proton collisions, after the restart of LHC operations.

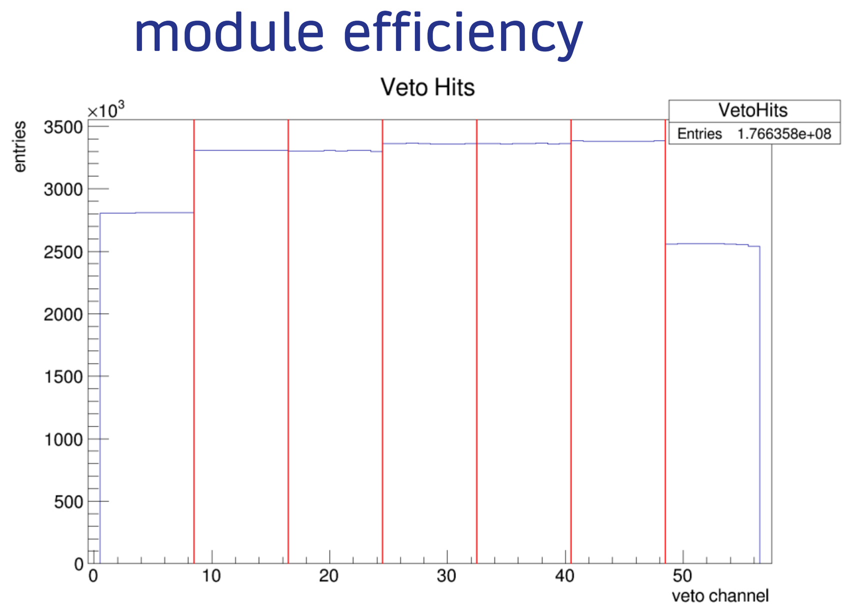


Schematic representation of selected events

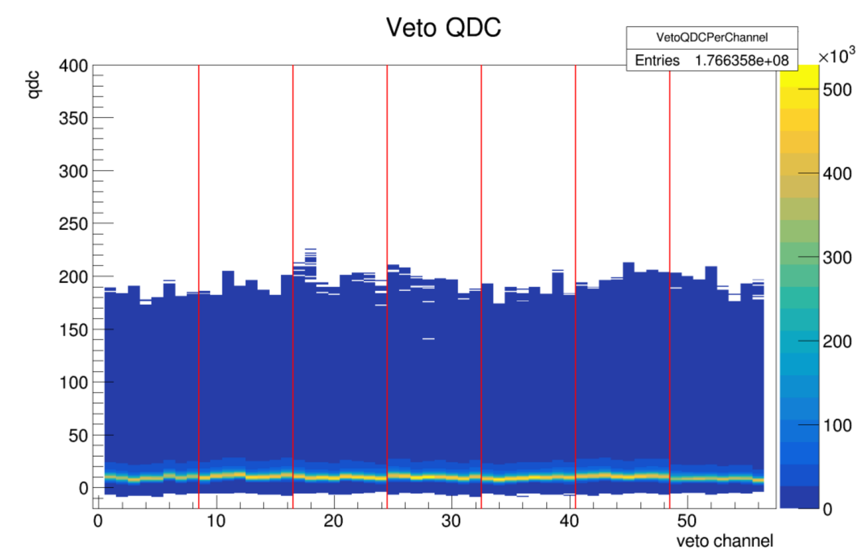
Performance

As part of the commissioning and performance study:

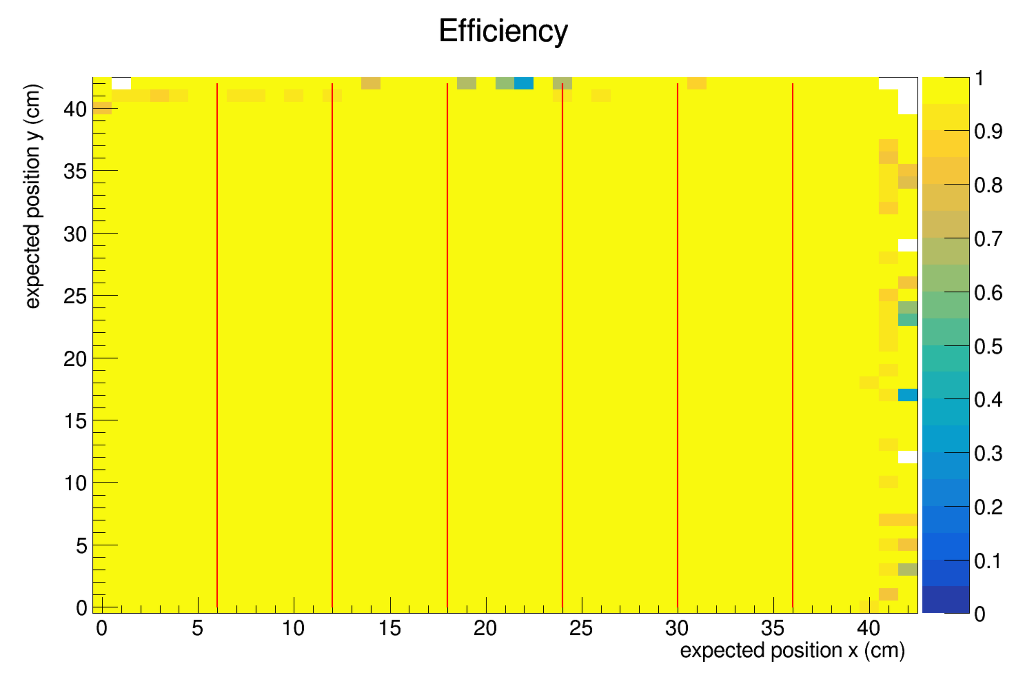
1. confirm the veto plane's integrity after transport and installation by checking each channel's data acquisition
2. validate the calibration constant checking that there is no saturation in the value of charge integrated (QDC) measured
3. **estimate the spatial efficiency**, using the expect hit position computed with the tracker module information
4. verify that **the single-side readout does not affect** the module efficiency



V3 hit distribution in selected events in TI18, red lines delimit the scintillator bars



V3 QDC distribution in selected events in TI18, red lines delimit the scintillator bars



Third veto plane efficiency in the TI18 configuration, red lines delimit the scintillator bars

The efficiency computed is **uniform and close to 1** in the entire active area. The **ratio** of the efficiency **farther** from the SiPM with respect to the area **closer** is **1.00000±0.00002**.

Citations

[1] The SND@LHC collaboration, Observation of collider muon neutrinos with the SND@LHC experiment. Phys. Rev. Lett.
[2] T. Ruf. Estimate of the Veto System Inefficiency 2022.
[3] T. Ruf. Estimate of the Veto System Inefficiency 2023.