The Front-end Electronics for the 1.8-kchannel SiPM Tracking Plane in the NEW Detector

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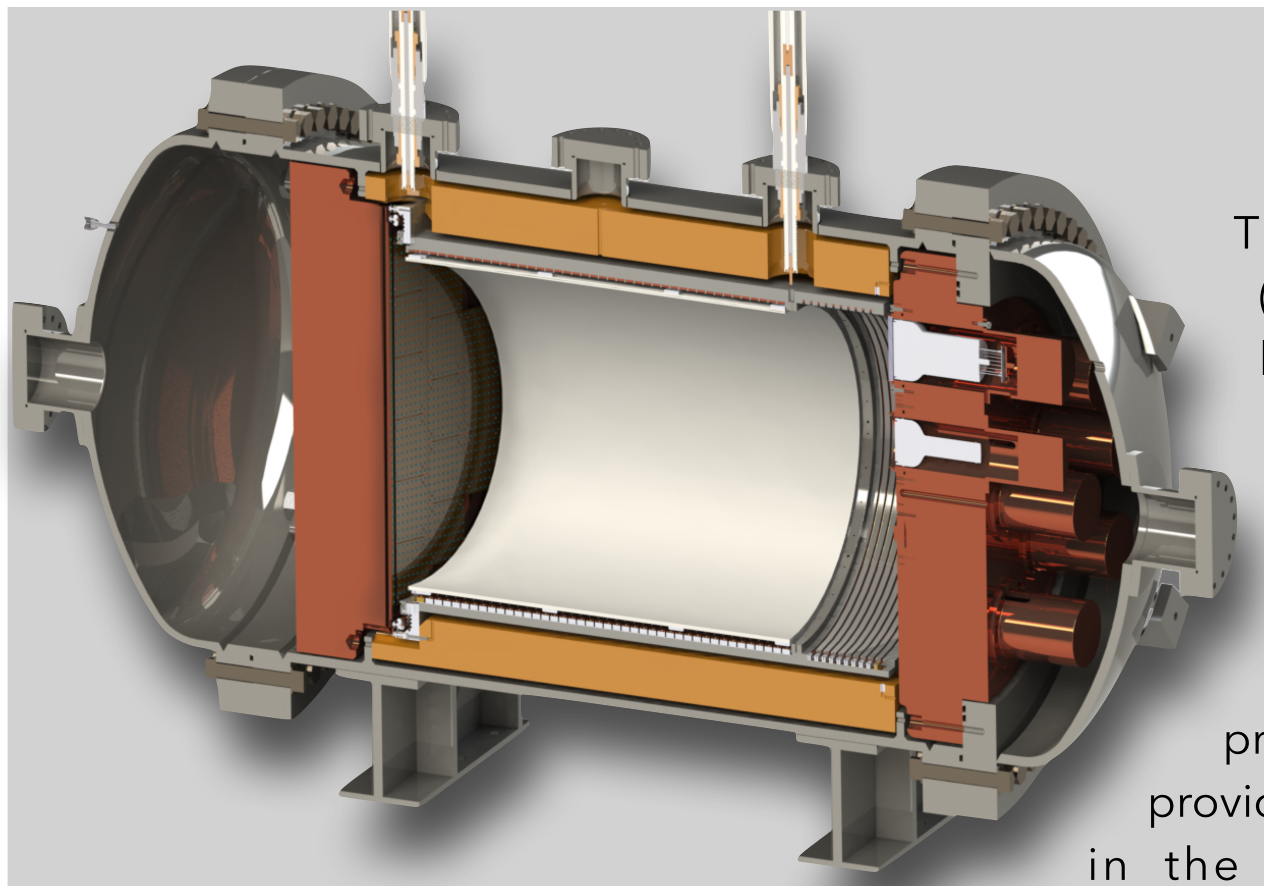
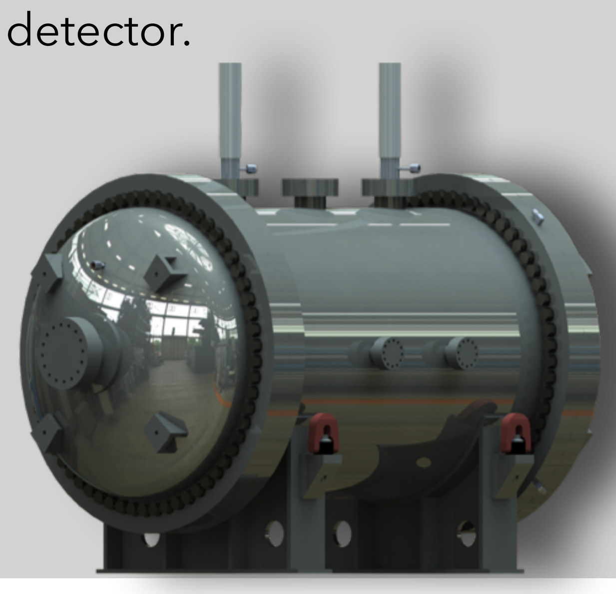
NEW Detector

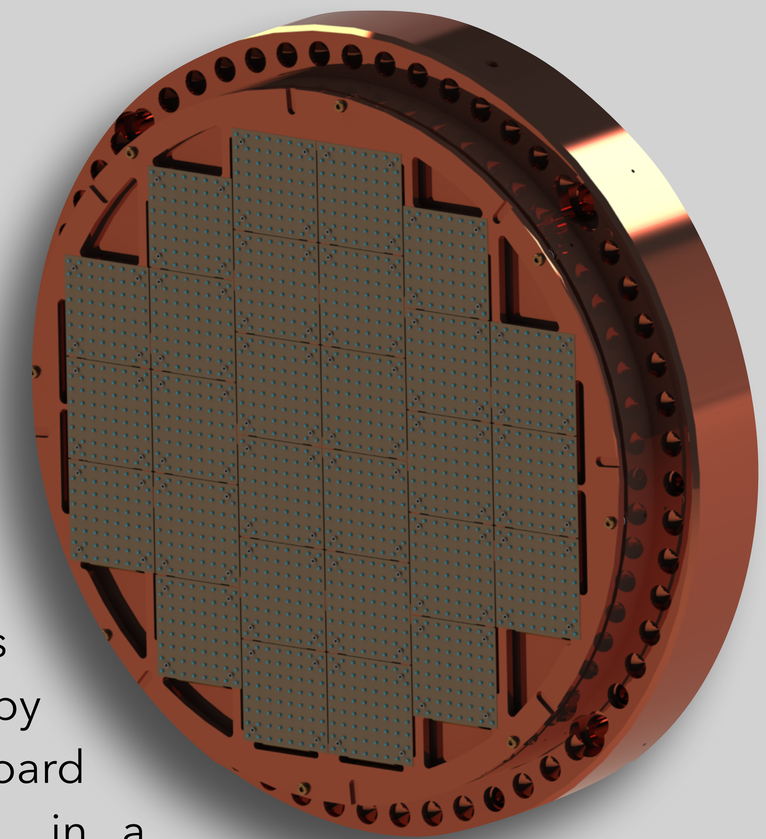


The NEXT ββ0v (neutrinoless double beta decay) experiment will use a high-pressure gas electroluminescent TPC to search for the decay of Xe-136. The primary goal of NEW is to provide an intermediate step in the construction of the NEXT-100 detector that would allow the validation of the technological solutions proposed for the NEXT experiment. NEW would permit a measurement of the energy resolution at high energy, and the characterization of the 2-electron topological signature, by measuring the ββ2v mode. Finally, NEW will permit a realistic assessment of the NEXT background model before the construction of the NEXT-100 detector.

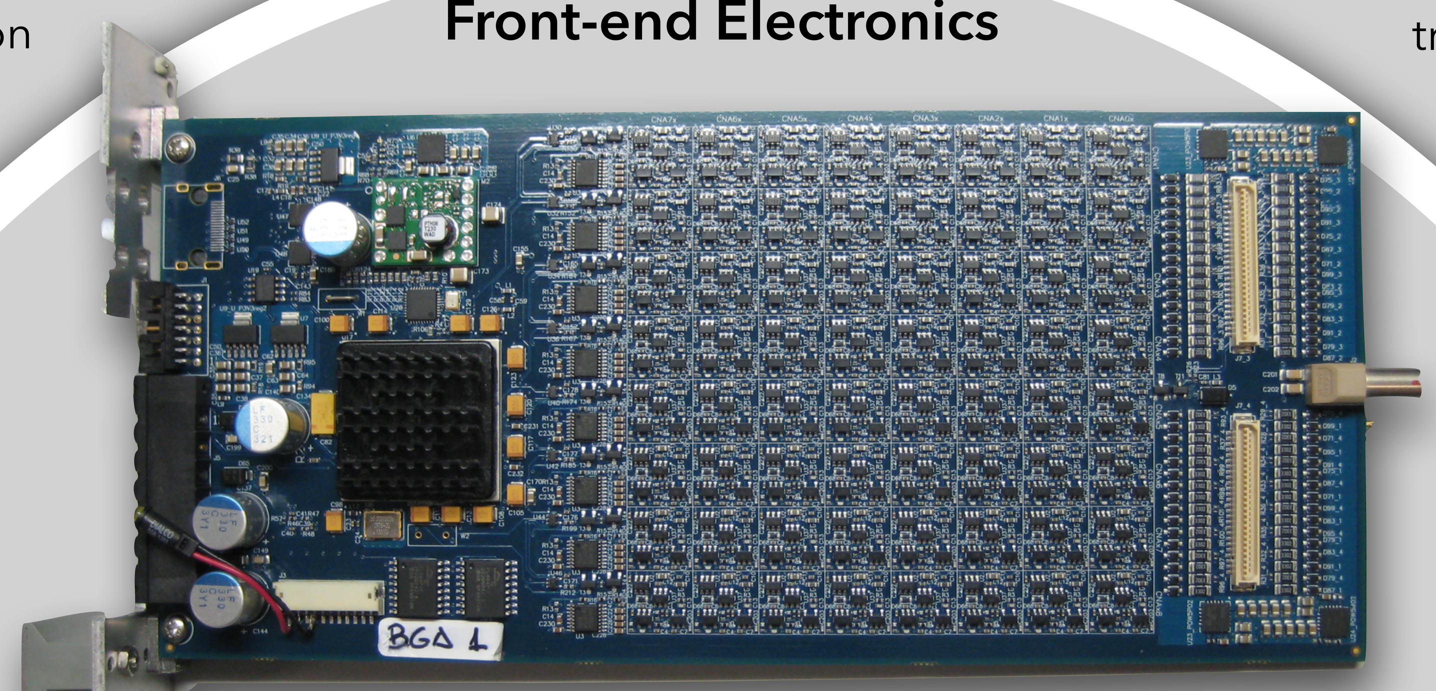


Tracking Plane

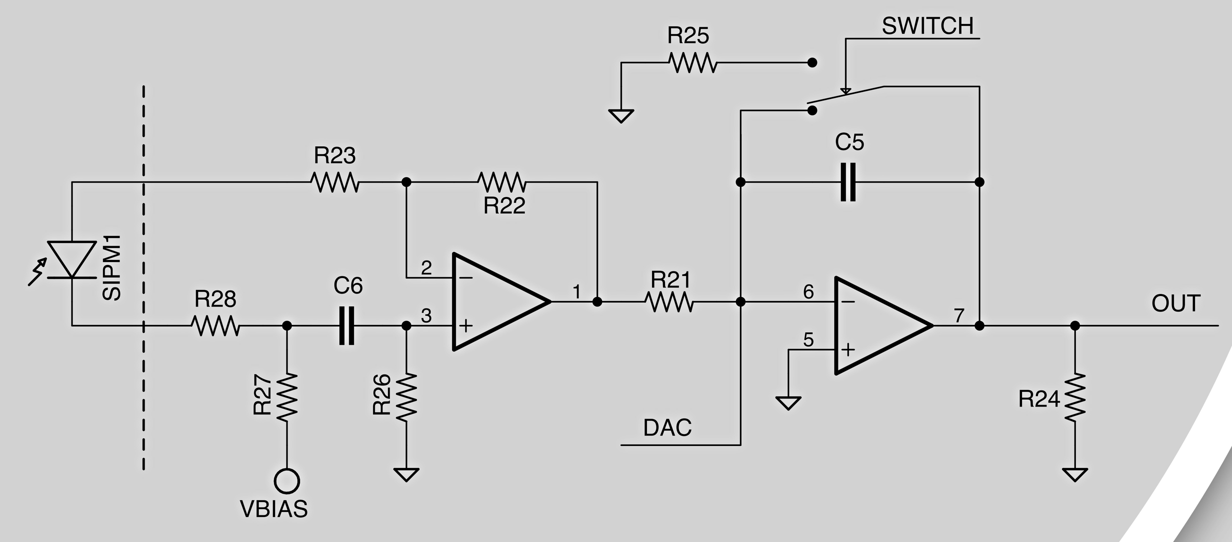
The NEW tracking plane is made of 28 Kapton DICE-Boards (KDB). Each KDB has an 8x8 SiPM array placed with 10 mm pitch, a NTC temperature sensor and 4 LEDs for calibration. The KDBs over-cover the fiducial region with ~1800 SiPMs total, ensuring that there are no dead regions. The connector is located at the end of a long tail, and is screened from the gas, in the fiducial volume, by a 120 mm thick copper shield. The DICE-Board operates with a differential signal output in a broadside coupled traces scheme. That achieves a better reduction of the noise during signal acquisition, which is essential due to the 5 meter signal transmission. Just in front of the tracking plane there is a 5 mm fused silica plate, coated with a wavelength shifter (TPB) in order to shift the xenon VUV light (170 nm) to the SiPM response peak (420 nm).



Front-end Electronics

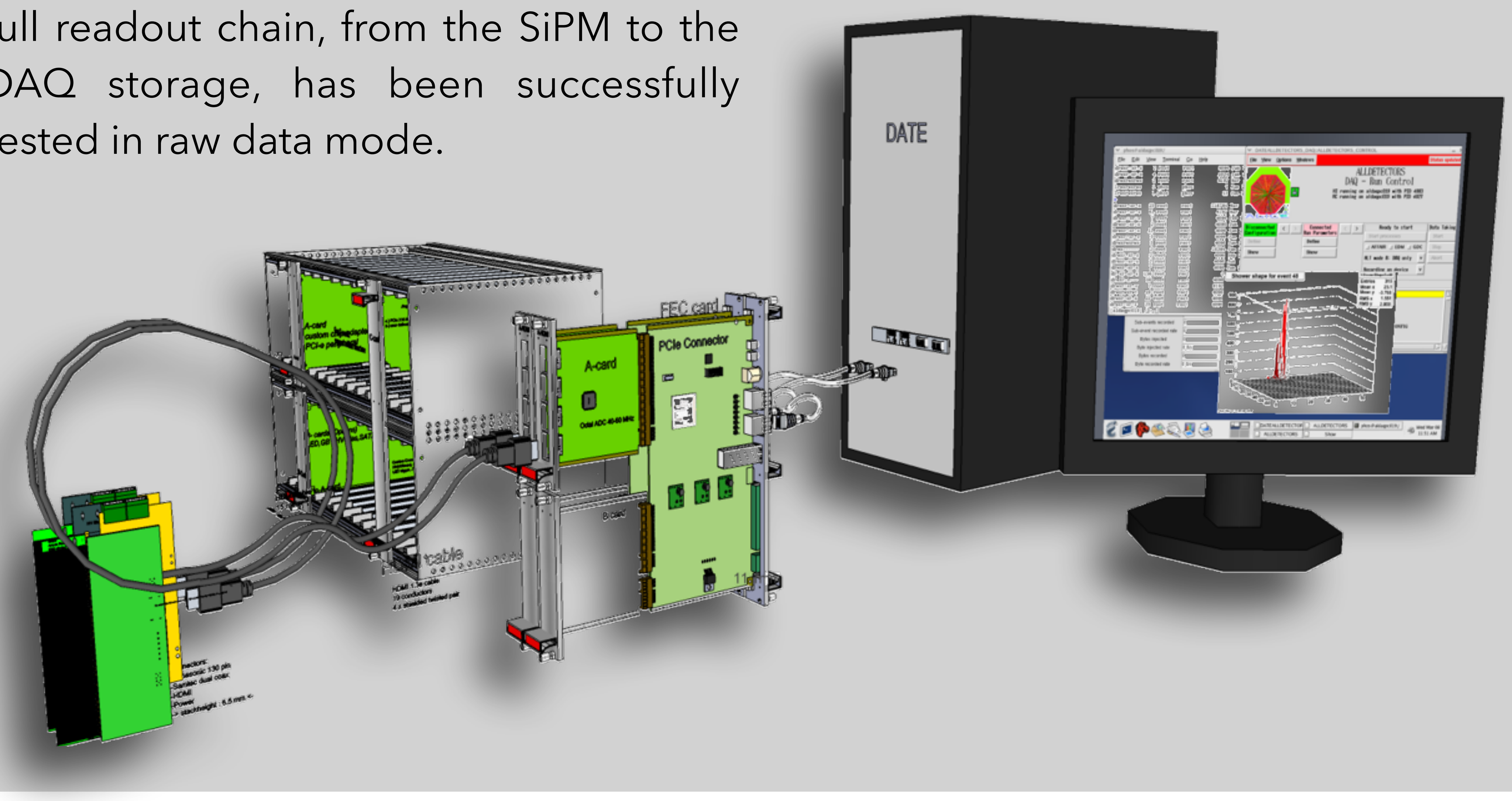


A leap forward from the previous NEXT-DEMO[1] front-end board, the gated-integrator-based design has been modified to read out 64 channels (a 4x increase), reduce power consumption per channel in a factor of 3.5 and cost in a factor of 3, remove one amplifier stage and add automatic (FPGA-based) offset voltage compensation. Also, the new differential input stage reduces the noise coupled into the long 5 meter interconnection, which made it impossible to obtain the photon spectrum with enough resolution for the tracking plane calibration. The front-end splits the external SiPM bias voltage into individual lines to decouple them completely. We found that an on-board buck regulator was generating too much 300 kHz noise, which explains the poor photon spectrum in the results section. An additional filter was added to the board design revision.



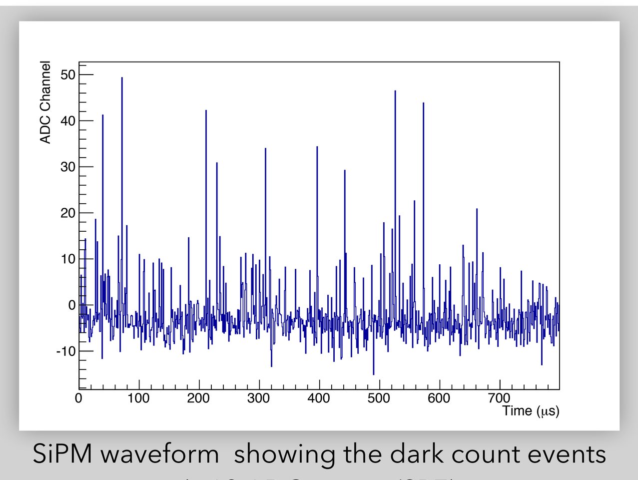
Data acquisition

The on-board FPGA reads out data from 64 1-MHz ADCs, formats data and stores them in a dual-event buffer to avoid dead time. When a trigger is received, zero-suppressed data are sent to the Scalable Readout System's (SRS) DAQ interface modules (tested on FECv3 and FECv6)[3] according to the SRS' DTCC link specification over copper (data, trigger, clock and slow controls flows on the same RJ-45 or HDMI connector). ALICE's DATE is used as DAQ software environment. As a result, the front-end electronics are fully compatible with CERN RD-51's SRS electronics. The full readout chain, from the SiPM to the DAQ storage, has been successfully tested in raw data mode.

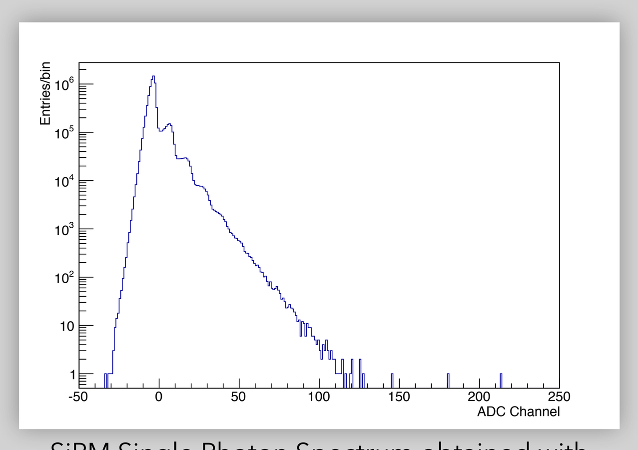


Results

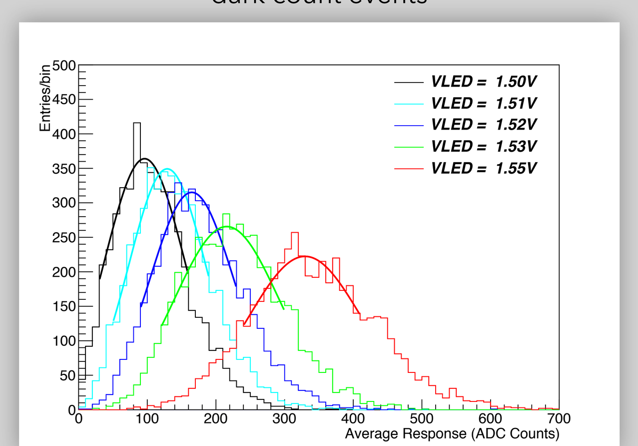
The full system has been tested in a small setup using the 64 SiPMs mounted on a DICE-Board. Signals corresponding to dark count events have been analyzed and their Single Photon Spectrum (SPS) obtained. This spectrum indicates good photon counting capability of the system, allowing the absolute calibration of the sensors. However, the utilization of noise filtering software, will improve the resolution of the system. In addition, the linearity of the system has been studied using the Photon Transfer Curve (PTC) method with a LED source, demonstrating to be linear in the range of low intensities (<40 pes), ~15% of dynamic range.



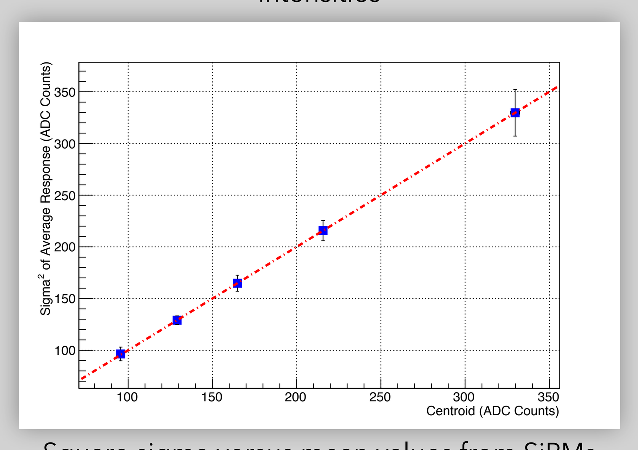
SiPM waveform showing the dark count events (~12 ADC counts/SPE)



SiPM Single Photon Spectrum obtained with dark count events



SiPM response distribution at different LED intensities



Square sigma versus mean values from SiPMs distributions

References: [1] V.Herrero et al., "Readout electronics for the SiPM tracking plane in the NEXT-1 prototype," NIMA (695) 2012, DOI: 10.1016/j.nima.2011.12.057 [2] R Esteve et al., "The trigger system in the NEXT-DEMO detector" 2012 JINST 7 C12001 doi:10.1088/1748-0221/7/12/C12001 [3] J Toledo et al., "The Front-End Concentrator card for the RD51 Scalable Readout System" 2011 JINST 6 C11028 doi:10.1088/1748-0221/6/11/C11028

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