The Front-end for the new focal plane detector for the NUMEN project

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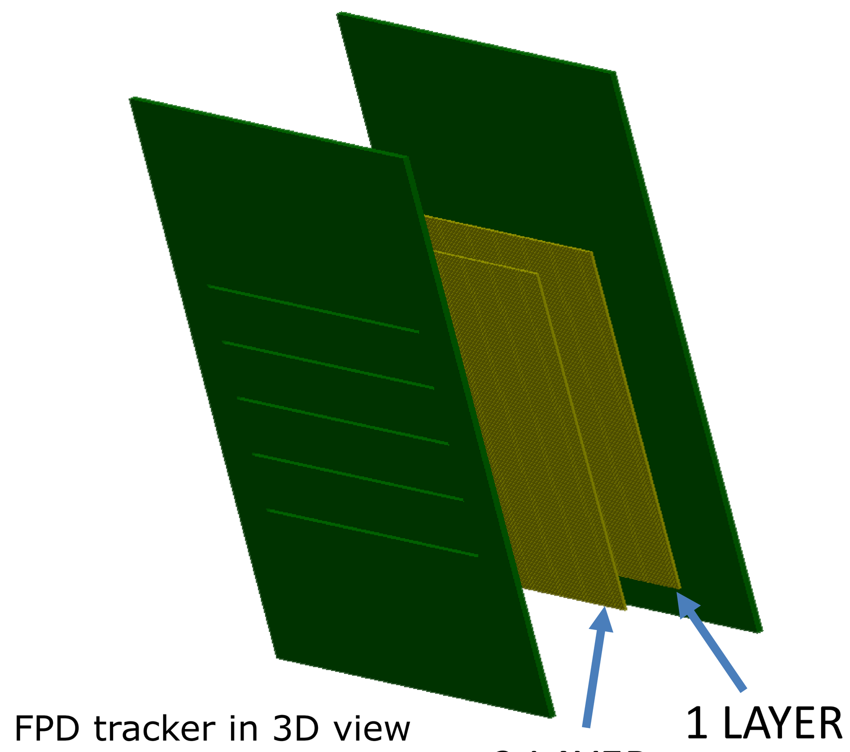
Abstract:
The design of the front-end electronics for the new tracker of the MAGNEX [1] Focal Plane Detector (FPD) for the NUMEN project is presented [2]. The front-end is based on the VMM chip[3], developed for ATLAS experiment at CERN. The architecture of the front-end (FE) electronics is designed to be modular and scalable to the final detector. The segmented anode board is designed in order to take advantage of the unique performances of the VMM chip, allowing a digital reconstruction of the track at high event rate. This anode board is connected to front-end by mean of Micro Coax Cable Assembly and does not make use of vacuum connectors. The front-end boards will be placed in air, facilitating in this way the heat dissipation and the connection to the read-out (RO) electronics. An innovative anode read-out strategy allows the reduction of the total number of channels to about 1400 and the measurement of the track at different depth in the detector with 750 micron spatial resolution.

Target specification
- Digital reconstruction of the track at high event rate.
- full-custom FE and RO electronics.
- Reduction of the total number of channel

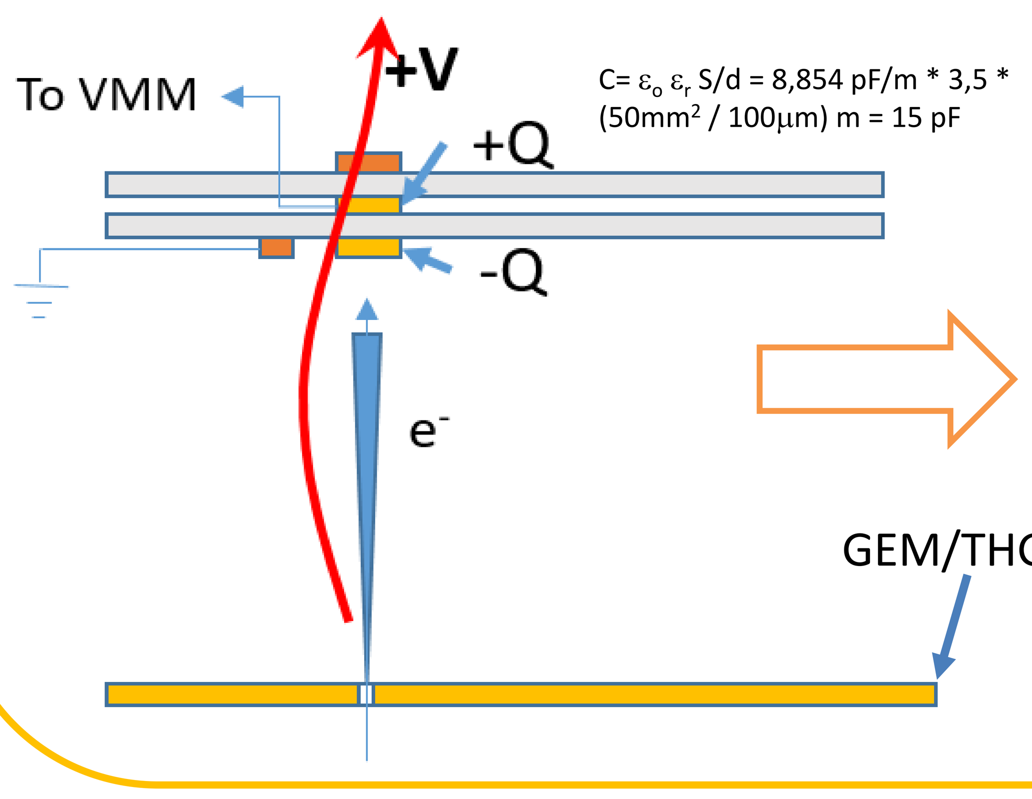
Main Features
- modular
- scalable
- radiation hard architecture
- high event rate
- easy maintenance
- precise synchronization

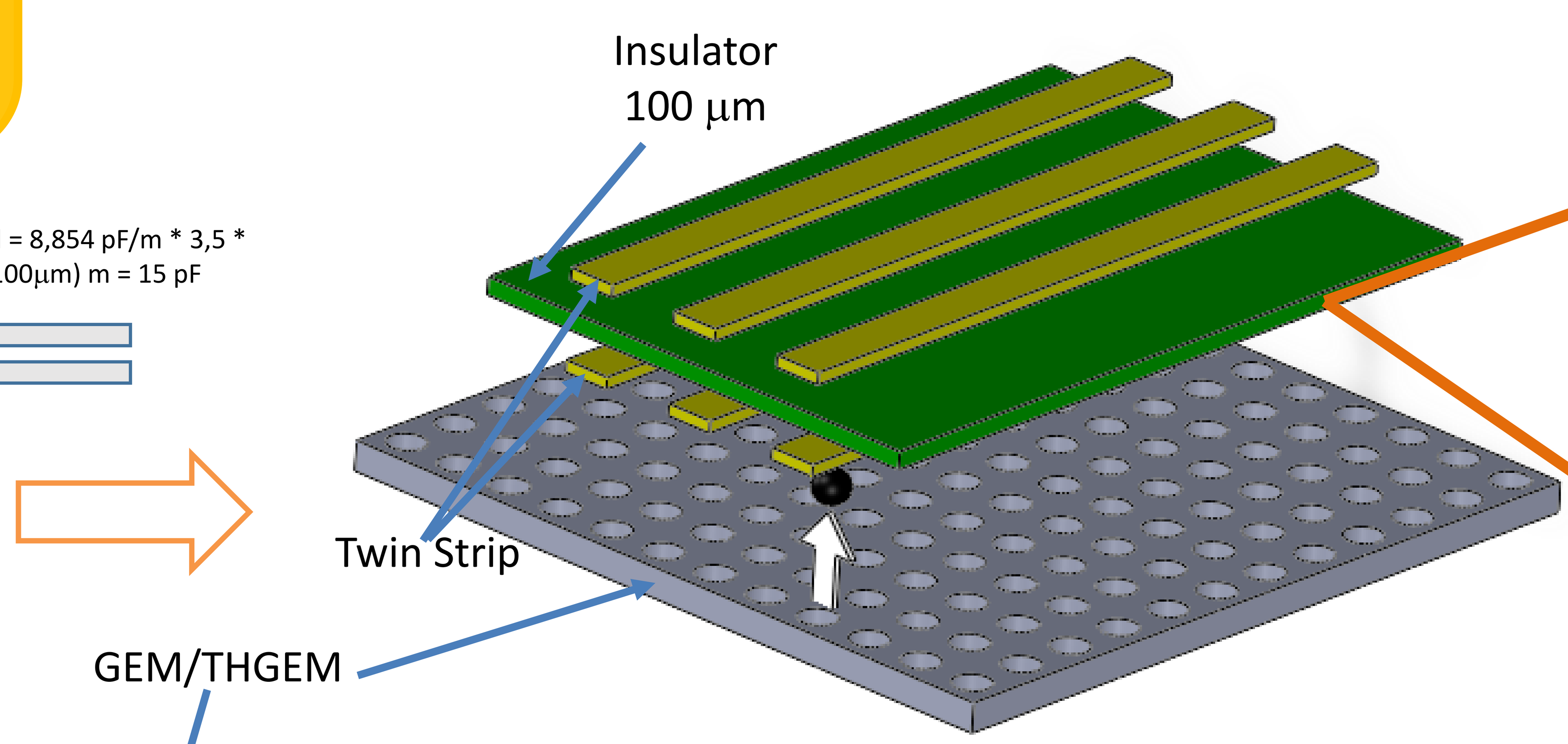
The New Focal Plane Detector

A new concept for the tracker was developed. The starting point was to extract, for each track, the position of the ions at different depth in the tracker in a fully digital way. The ionization charge is driven by the electric field in the gas towards a multiplying stage, a triple GEM. Electrons are, then, directed towards a first layer of 750 μm pitch strips.
Each strip of this layer is capacitive coupled to a twin strip in a second layer. The charge pulse inducted in the twin strip is then integrated by the FE and shaped. The value of the capacitance for each channel of the tracker is optimized in reference to the selected FE ASIC performances. The drift time is also measured by the FE at sub-ns resolution.

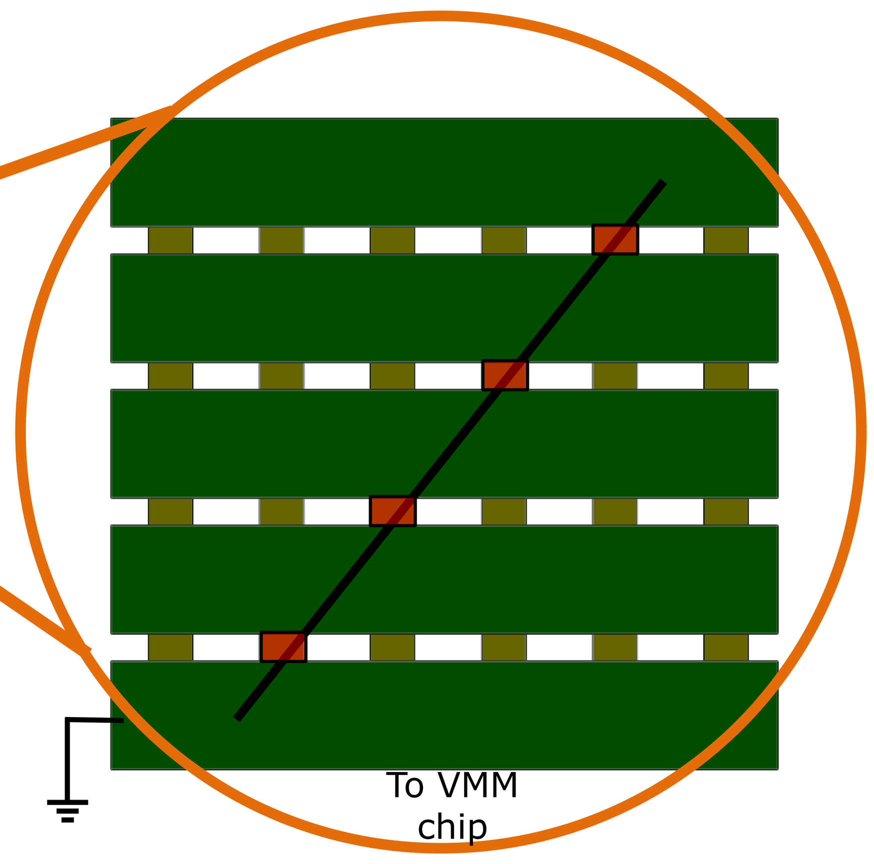


FPD tracker in 3D view





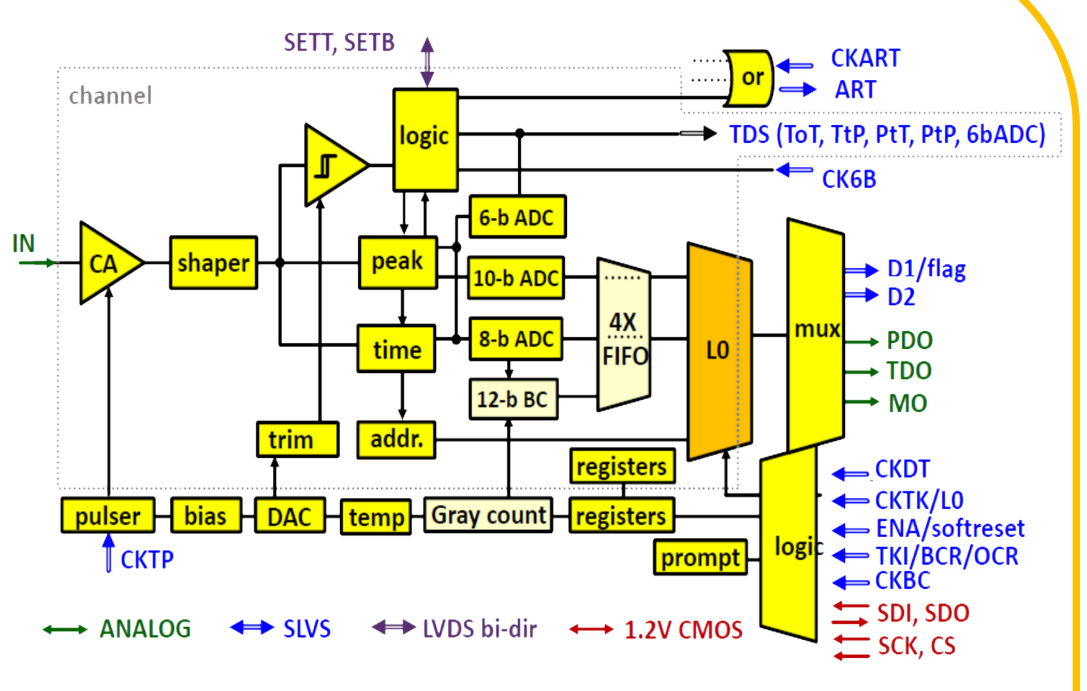
View internal of the FPD tracker



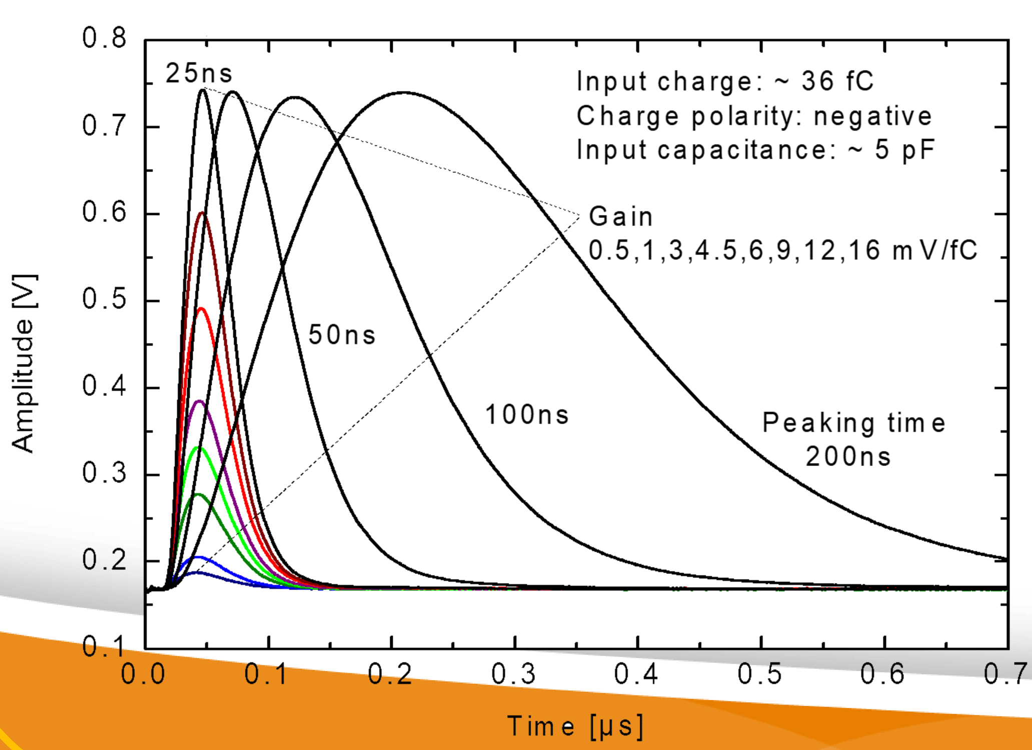
Bottom view, tracker reconstruction

The Front-end

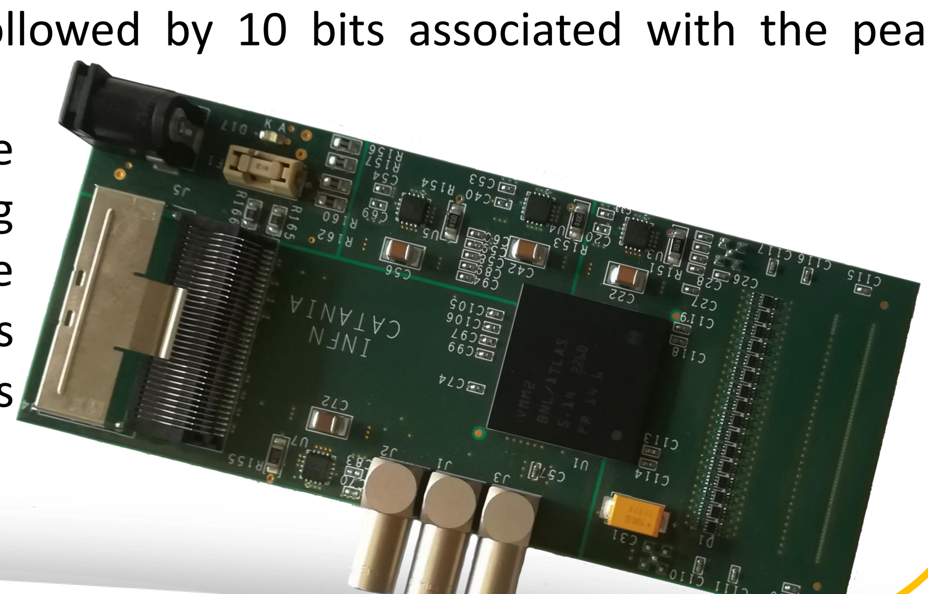
The design of front-end (FE) electronics is based on the VMM3 chip.
This chip provide 64 channels, each one of them provides the peak amplitude and time with respect to the bunch crossing clock or other trigger signal in a data driven mode.
Each channel is equipped with a fast comparator with an individually adjustable threshold. When a signal crosses a set threshold a peak detection circuit is enabled. Neighbour-enable logic allows setting the threshold relatively high and yet recording very small amplitudes. At the peak a time-to-amplitude converter is started and stopped by the trigger signal. The two amplitudes are digitized and stored in a de-randomizing buffer and readout serially with a smart token passing scheme that only reads out the amplitude, timing, and addresses of the channels with information, thus dramatically reducing the data bandwidth required and resulting in a very simple readout architecture.



Architecture VMM3



A total of 38 bits are generated in continuous (digital) mode for each event in the VMM3. The first bit is used as a readout flag, the second is the threshold crossing indicator (allows discrimination between above-threshold and neighbour events). Next is a 6 bits word for the channel address, followed by 10 bits associated with the peak amplitude, and 20 bits associated with the timing.
The 38-bit word is stored in a 4-events deep de-randomizing FIFO (there is one such FIFO per channel) and it is read out using a token-passing scheme where the token is passed first-come first-serve only among those FIFOs that contain valid events. The first token is internally generated as needed and advanced with the token clock. The data in the FIFOs is thus sequentially multiplexed to the two digital outputs data0 and data1.



REFERENCES
[1] F. Cappuzzello, et al., The MAGNEX spectrometer: Results and perspectives, Eur. Phys. J. A 52 (6) 167 (2016), DOI: 10.1140/epja/i2016-16167-1.
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