The CHarged ANTIcounter for the NA62 experiment at CERN

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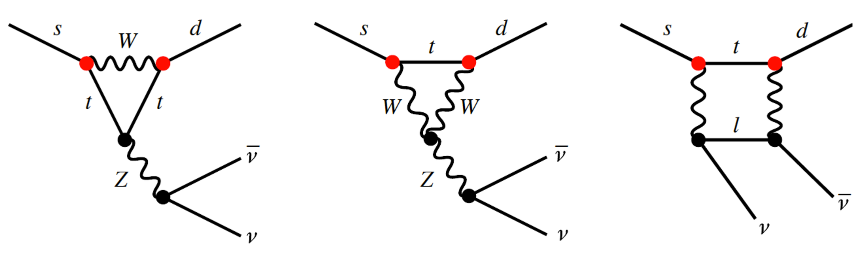
Why study $K^+ \rightarrow \pi^+\nu\bar{\nu}$?



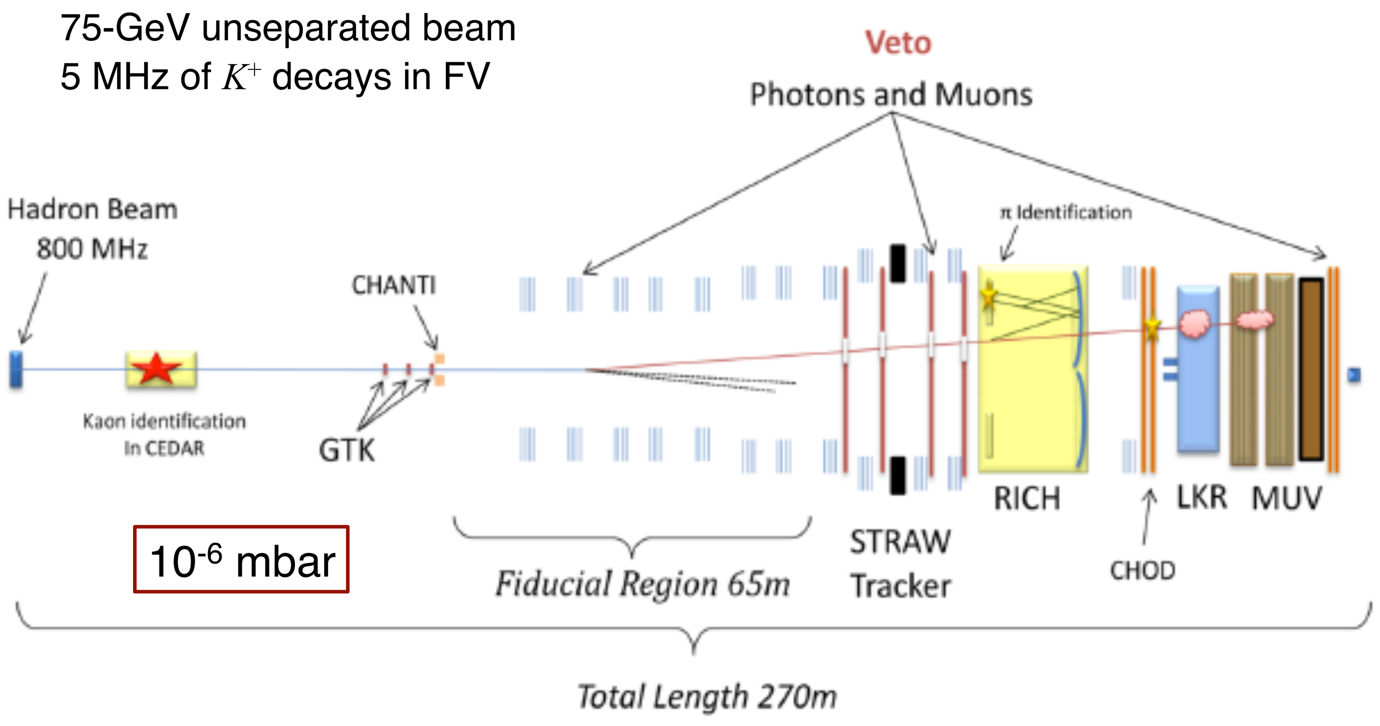
FCNC processes with loops dominated by top
No long-distance contributions from intermediate γs
Hadronic matrix element from BR(K_{e3})

Theory: BR = $(8.22 \pm 0.69_{par} \pm 0.29_{th}) \times 10^{-11}$
10% measurement offers NP sensitivity

Experiment: BR = $(17.3^{+11.5}_{-10.5}) \times 10^{-11}$
BNL 787/949 – Stopped K^+, 7 candidates

The NA62 experiment at the CERN SPS

75-GeV unseparated beam
5 MHz of K^+ decays in FV

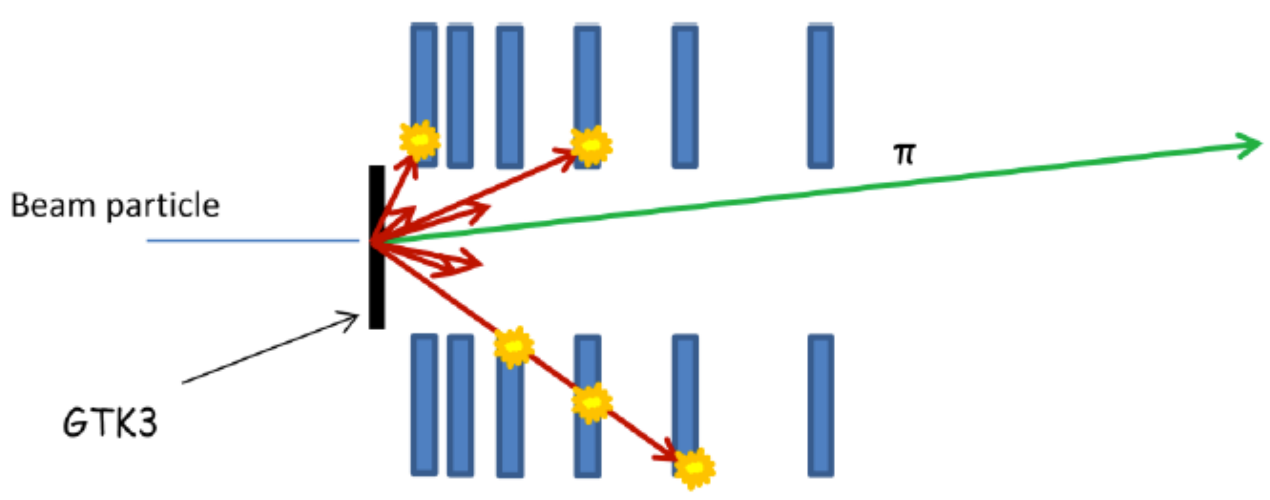


NA62 goal: ~100 $K^+ \rightarrow \pi^+\nu\nu$ decays w/ S/B ~ 10
Need 10^{-12} rejection for abundant channels:

$K^+ \rightarrow \pi^+\pi^0$, $K^+ \rightarrow \mu\nu$

K beam definition	**CEDAR** (diff. Cerenkov)
Beam tracking	**Gigatracker** (Si pixel)
Inelastic rejection	**CHANTI**, LAV
Decay tracking	Magnetic spectrometer **4 straw chambers** in vacuum
Decay PID	**RICH**, **MUV** (μ veto)
Photon vetoes	**LAV** (**ANTI**) – large angle **LKr** calorimeter **IRC+SAC** – small angle

Rejection of K+ inelastic decays: CHarged ANTI

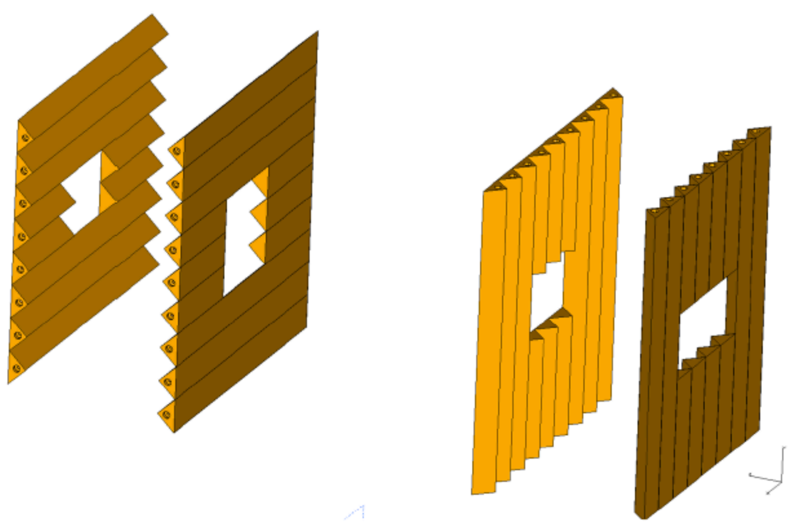


The CHarged ANTI is required in order to reduce the critical background induced by inelastic interaction of the beam with the collimator and the Gigatracker (GTK) stations. The most critical events are the ones in which the inelastic interaction takes place in the last GTK station (GTK-3). In such cases pions, or other particles produced in the interaction, if emitter at low angle, can reach the straw tracker and mimic a K decay in the fiducial region. If no other track is detected, these events can appear like a signal event, one single π^+ in the final state.
A GEANT 4 simulation has shown that kaon inelastic interactions with GTK-3 happens in about 5/10⁴ cases. So the combined rejection factor of the analysis cuts and the CHANTI veto must lead to a remaining inefficiency of 2×10^{-10}.
CHANTI detector is composed by 6 stations which are hermetic to charged particles produced by GTK-3 between 49 mrad and 1.31 rad.
The expected rate is about 2 MHz, more than 1 MHz due to muon halo. CHANTI is also required in order to tag beam halo background immediately close to the beam. Even if it is not intended as a trigger veto at L0. time resolution required is smaller than 2 ns to keep the random veto rate at an acceptable level.

CHANTI components choice and characterization

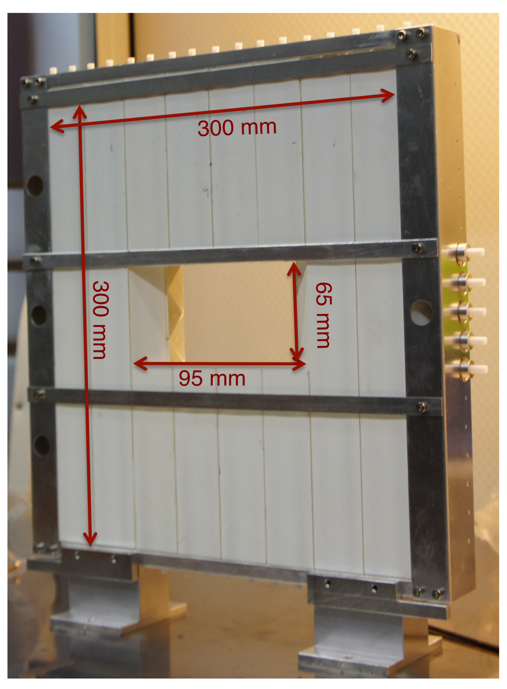
Scintillator Bar

Each station is made up of two layers, X Y.
Y (X) layer is composed of 22 (24) scintillator bars arranged parallel to X (Y) direction. Each bar is triangularly shaped with a 1.7 mm diameter hole. The triangular shape allows a gap-free assembly. The amount of light shared between two adjacent bars depends on the impact point of the particle.



Scintillator bar characteristics:

- Good LY
- Radiation hardness (5% degradation observed after 1Mrad γ irradiation)
- Low cost
- Fast response (τ few ns)



WLS fiber

Light is collected by means of one Bicron BCF92 WLS fiber placed inside each bar.
The fiber is read only at one side, on the other side it is mirrored

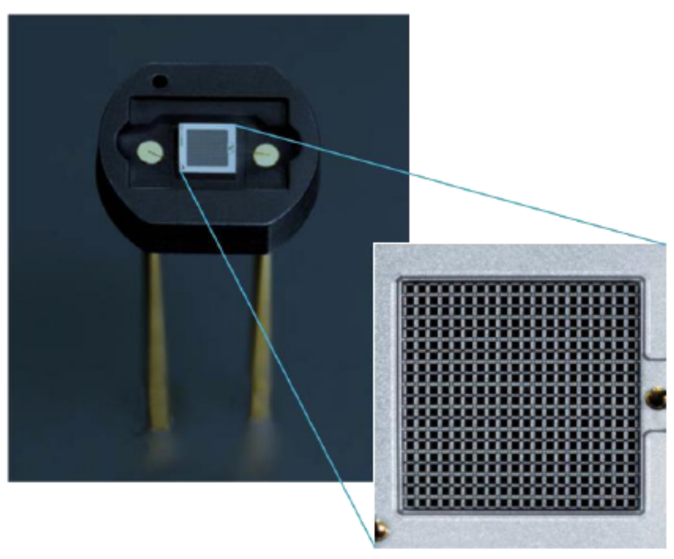
Bicron BCF92 characteristics:

- ***At***tenuation length 3.7 m
- Decay time 2.7 ns
- Emission peak 492 nm

Photon detection: SiPM

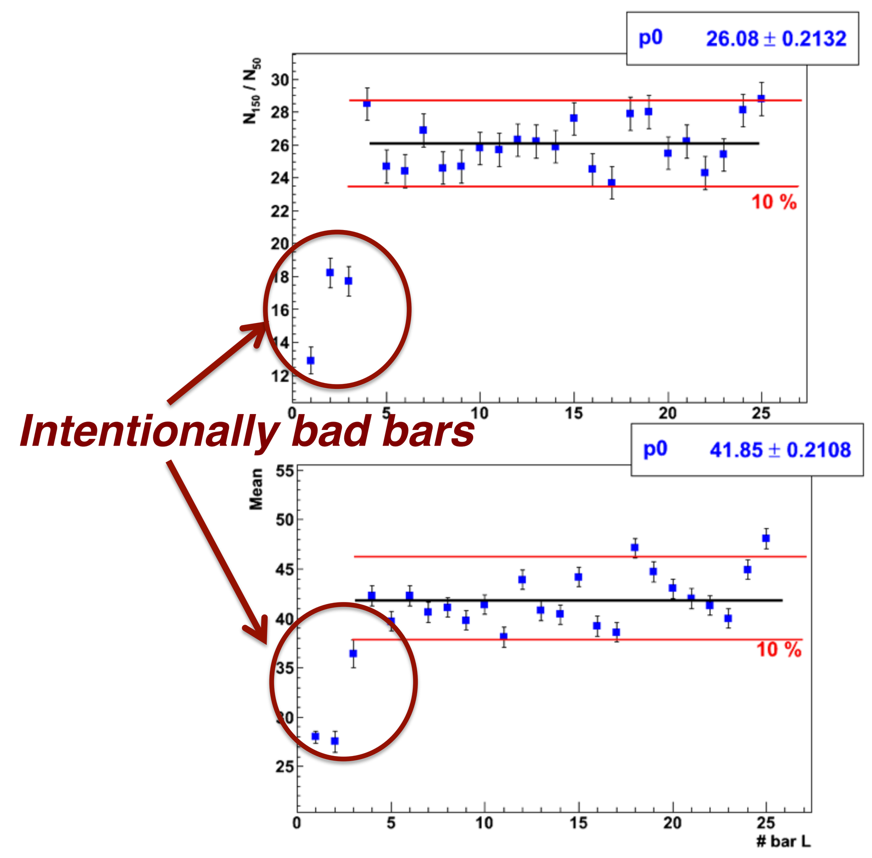
Each fiber is red by a Hamamatsu SiPM, series 13-50

- HV of the order of 70 V
- Low power consumption
- Low heat production in vacuum
- Leakage current of the order of few nA
- Radiation hard devices
- Very high rate (O 10MHz)
- With 3.5 pe threshold dark noise of about 100 Hz/channel



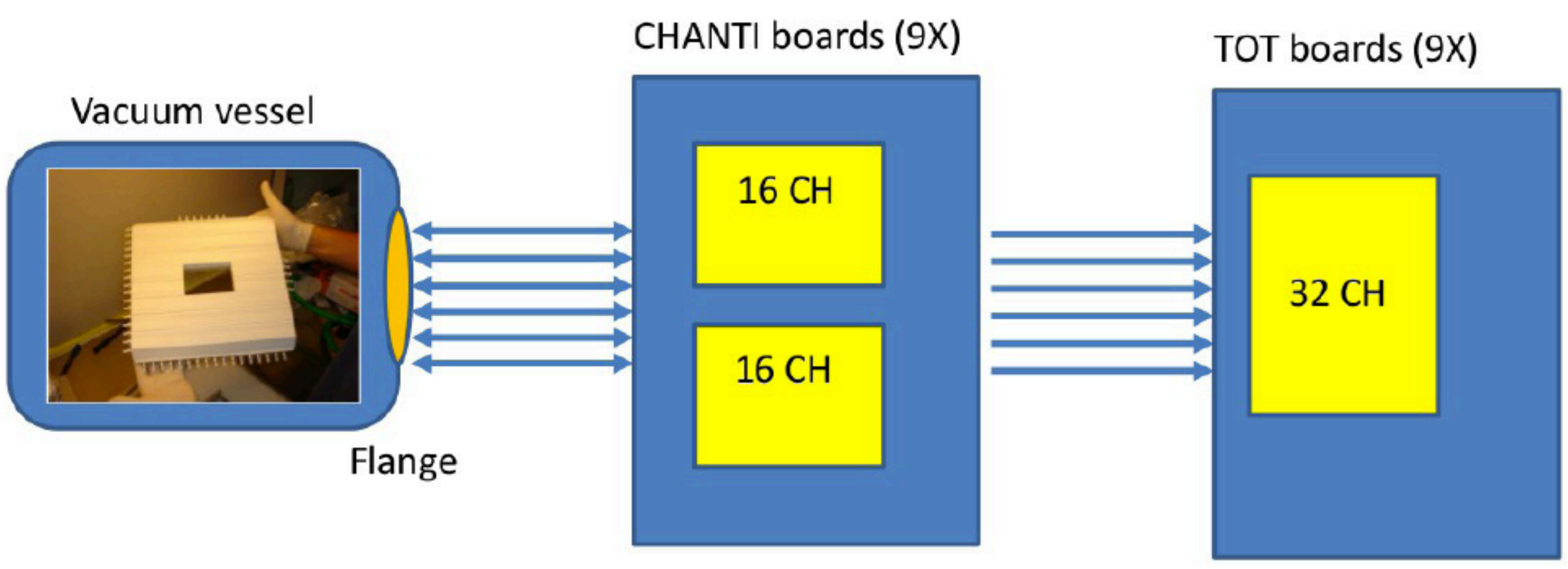
Bars test

Before the construction, after bar fiber gluing, each bar has been tested Two different tests have been developed: ***self-trigger test*** and ***cosmic rate test.***
First case: 2h data taking in self-trigger with relatively high threshold (50 mv) counting the number of events with signal greater than 150 mV (global bar performance test but no MIP response).
Second case: 12h data taking using the coincidence of two scintillator palettes as trigger and counting the mean number of pe (MIP response but local test)

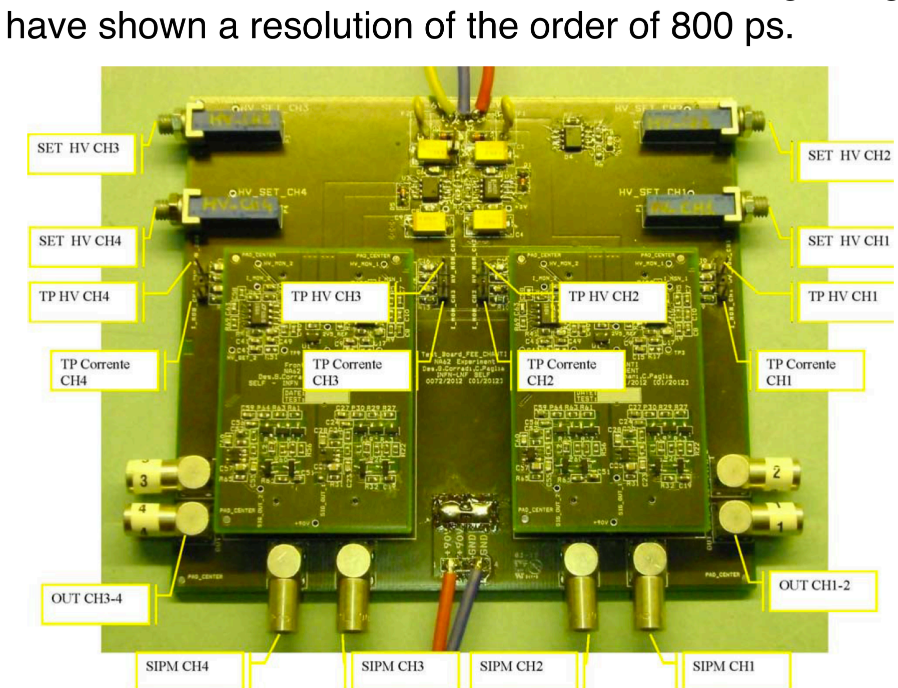


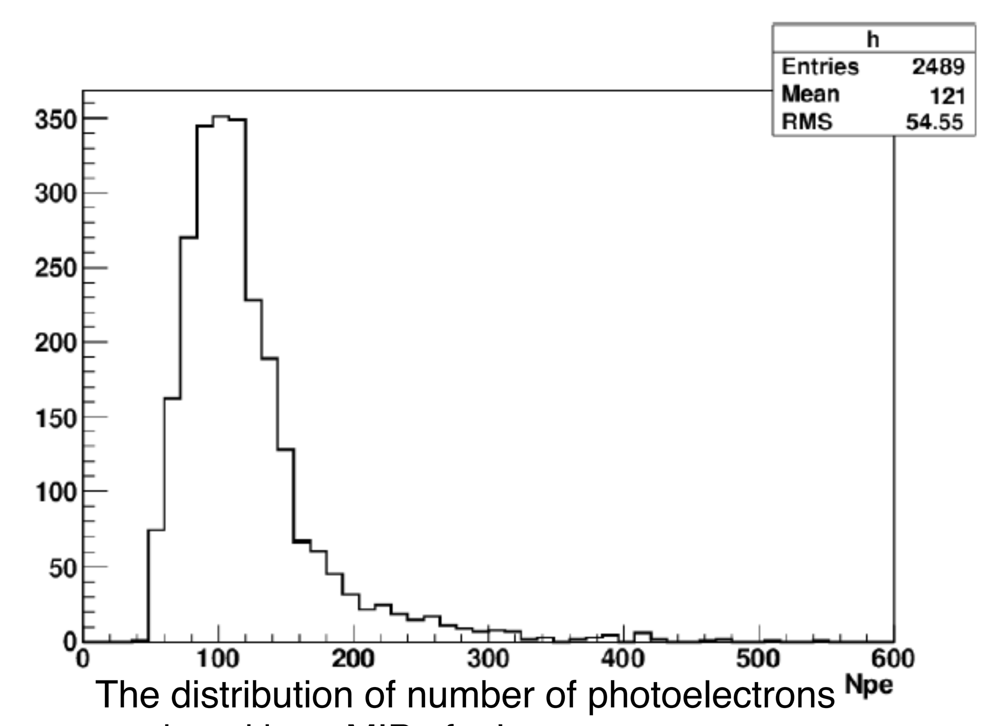
CHANTI Front-End Electronics and preliminary tests

Each scintillator bar is coupled individually to a SiPM. The bias voltage, settled with a precision of few mV, is brought to the SiPM inside and the signal are carried out from the vacuum tube using appropriate vacuum tight flanges.
The CHANTI board provides fast amplification, 20 gain. The FEE also provide temperature and dark current, with nA resolution, monitor for slow adjustment of the bias voltage.
The signal is digitized as Time Over Threshold (TOT) as for the LAV.

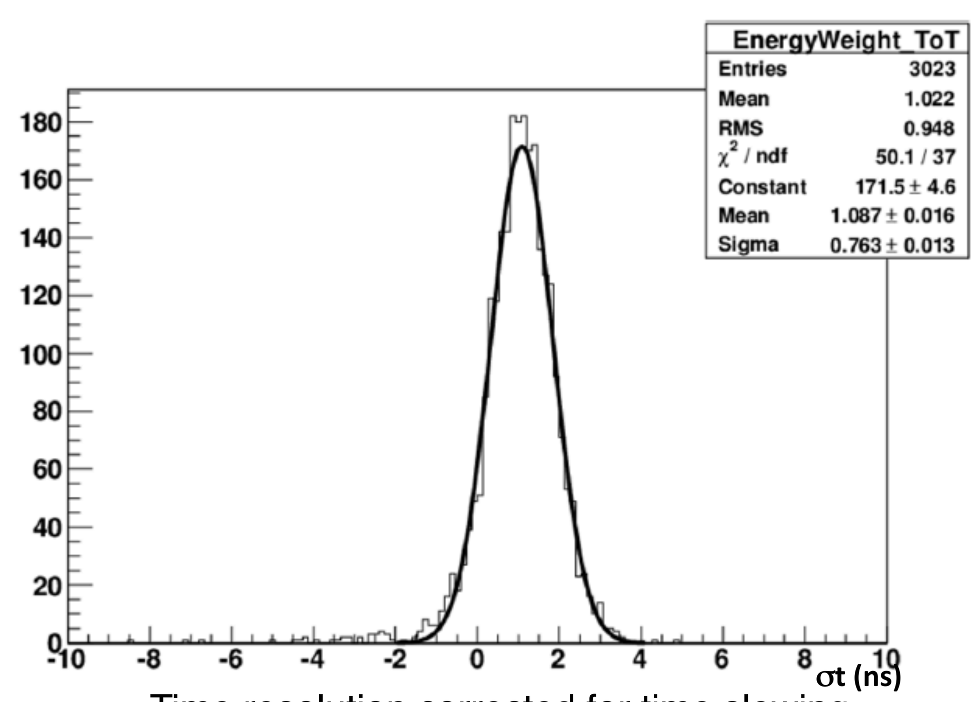


Preliminary tests have been done with cosmic rays using the first prototype station and a the FEE prototype board. External trigger has been used. About 120 photoelectrons have been collected for each layer. Time measurements, corrected for time slewing using TOT measurement, have shown a resolution of the order of 800 ps.





The distribution of number of photoelectrons produced by a MIP of a layer



Time resolution corrected for time slewing