TESTING AND CERTIFICATION OF FRONT-END ELECTRONICS FOR PARTICLE DETECTORS

INCDTIM CETATEA

PIM 2021 International Conference Processes in Isotopes and Molecules

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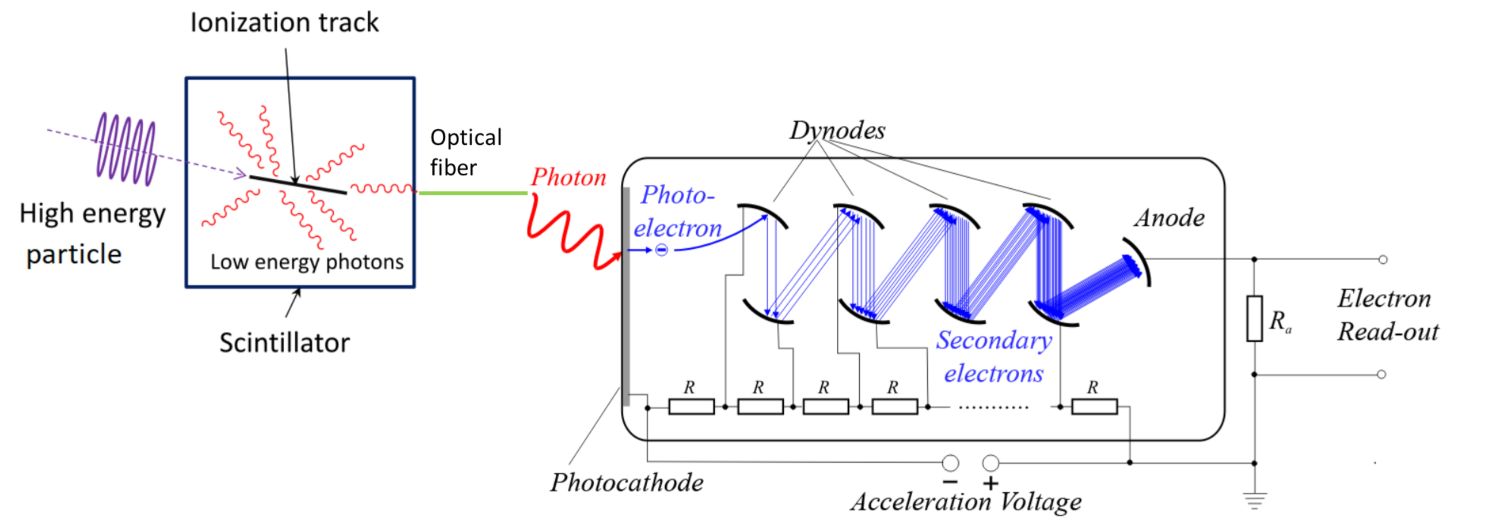
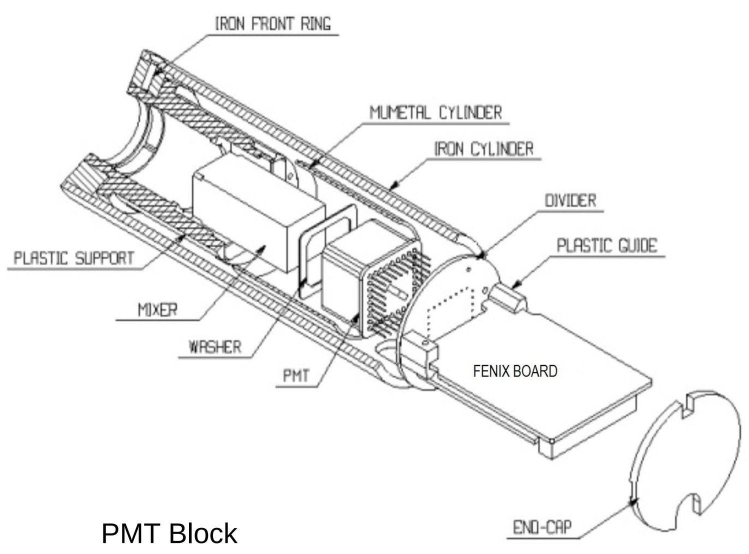
Abstract: The front-end electronics of particle detectors are working in radiation environments, for long periods without the possibility of maintenance. That's why must be intensively tested in harsh operating conditions to guarantee the reliability and linearity on long-term. The paper presents the test methods for the certification of active the dividers for photomultiplier tubes, produced by INCDTIM, as collaborating institute, for the Phase II Upgrade of Tile calorimeter of ATLAS Experiment at CERN LHC. Are described the burn-in set-up for annealing of the active dividers, the automated test bench for functional tests of ten active dividers simultaneously, and the test results for pre-production lot dividers.

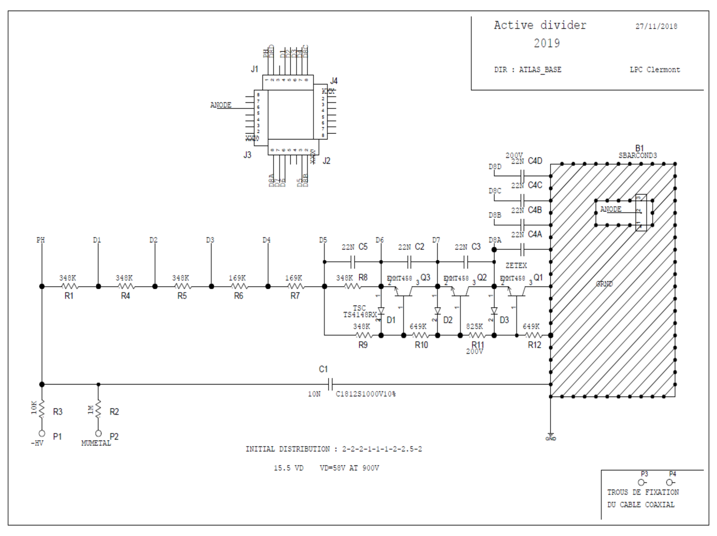
The principle of particle detection in Tile Calorimeter– see right

The high energy particles, resulting from collisions of protons or heavy ions, hit the scintillating tiles, producing low energy photons. This photons are collected and transmitted, via optical fiber, to photomultiplier tube (PMT) photocathode. Photon bombarded photocathode generates photo-electrons or primary electrons which are accelerated by high voltage and multiplied in avalanche to secondary electrons, generating an anodic current proportional with number of detected particles.

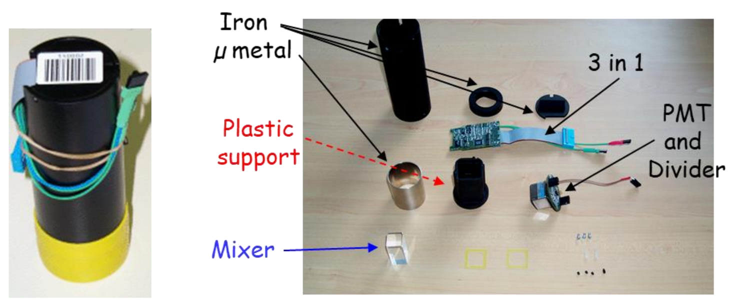


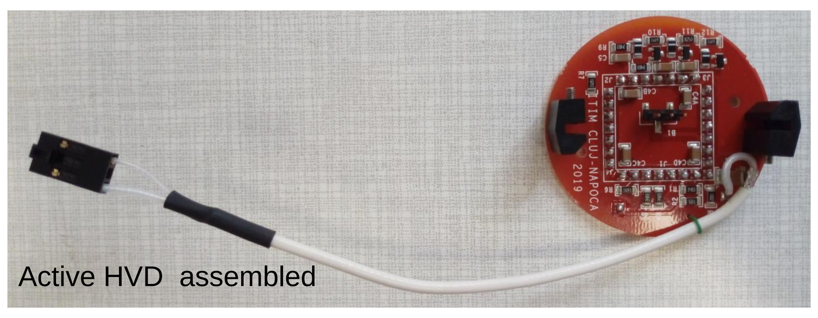


PMT Block



Active HVD schematic





Active HVD assembled

HV active Divider (HVD) – part of PMT Block– see left

In the Tile Calorimeter of ATLAS experiment at CERN, the photomultiplier tubes are assembled together with light mixer, HV divider and front end electronic board in so called PMT Block. In Phase II Upgrade of Tile calorimeter part of PMT tubes and all passive dividers and "3in1" front end boards will be change with improved versions; HV active dividers and FENICS boards.

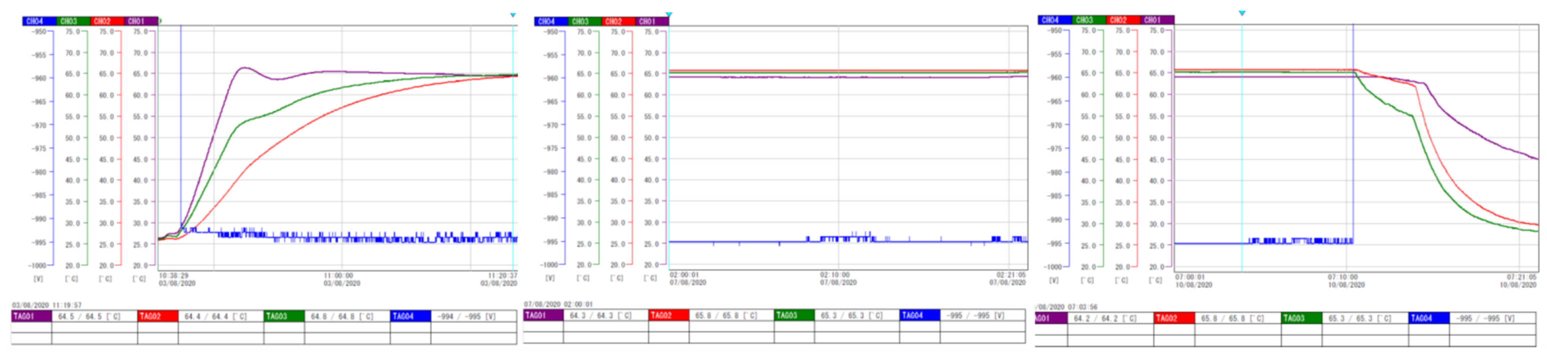
The primary purpose of the HVD is to partition the high voltage between the dynodes of the PMT. The HVD board also serves as a socket allowing connection of the PMT to the front-end electronics without any interconnecting wires. Transistors on the last 3 stages improved the linearity at anodic high currents.

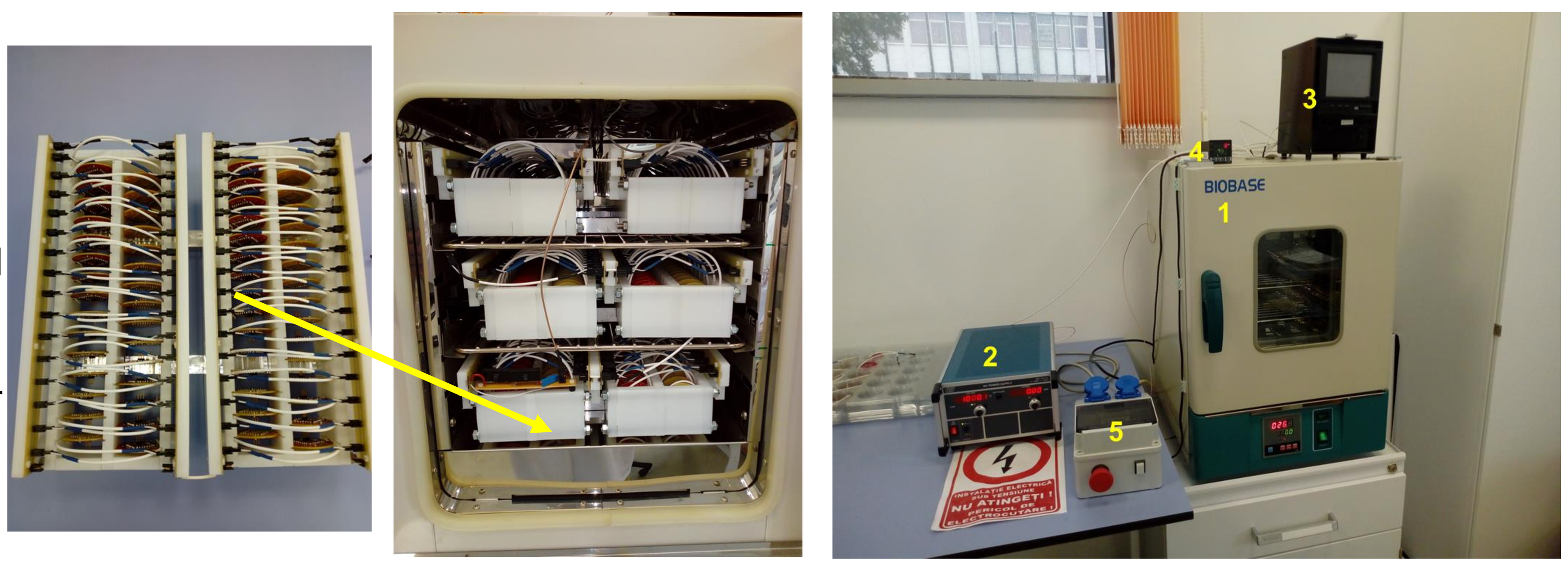
INCDTIM, as collaborating institute, for the Phase II Upgrade of Tile calorimeter of ATLAS Experiment at CERN LHC, is responsible for the production, testing and quality certification of 11000 HV active dividers needed for detector upgrade. Further are presented the test methods for the certification of the active dividers for photomultiplier tubes. Are described the burn-in set-up for annealing of the active dividers, the automated test bench for functional tests of ten active dividers simultaneously, and the test results for pre-production lot dividers.

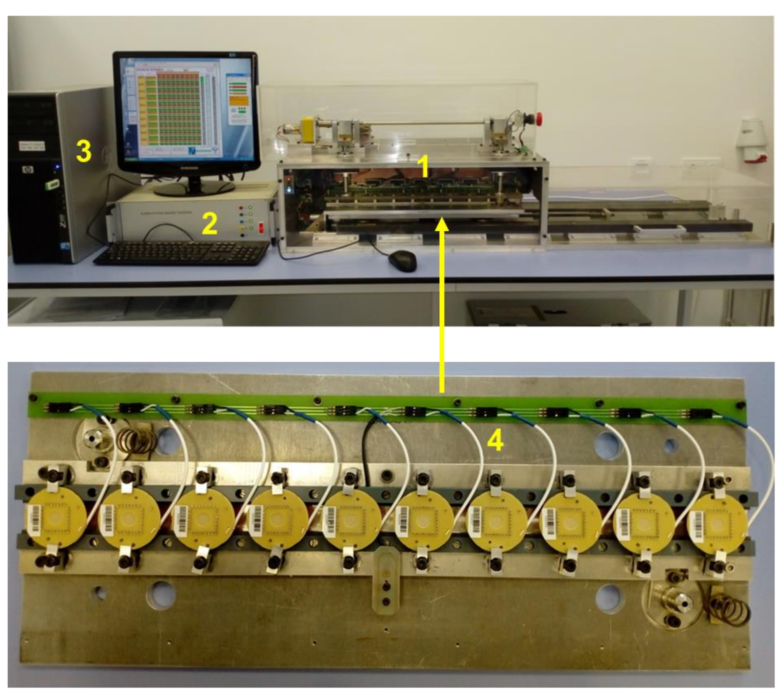
Burn-in method and set-up for annealing of HV active dividers – see right

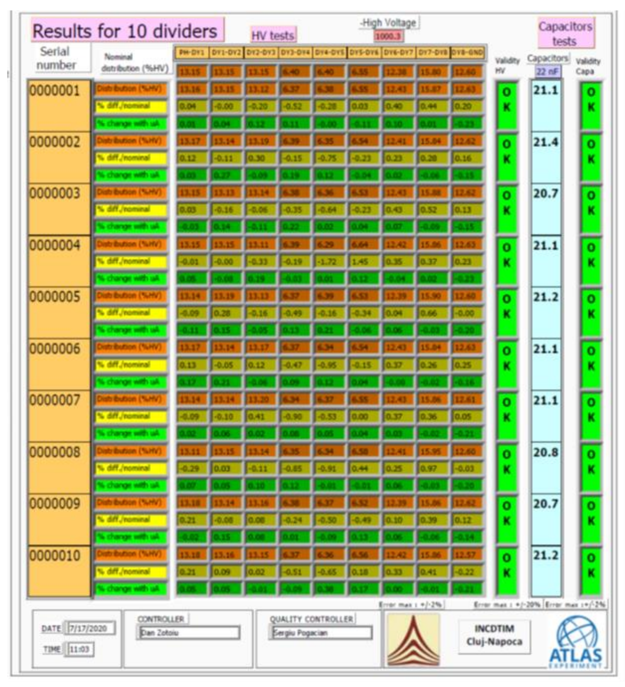
- Each HVD was kept in controlled temperature oven at 65º C for 7 days, polarized at 1000 Vdc.
- Preproduction HVD's (300pcs.) were tested on test bench before and after burn-in and results compared.
- First 60 HVD's of preproduction batch were burned-in three times (3x7days cycles), tested on test bench before and after each burn-in and results compared
- We have designed 60 HVD's capacity support, with connectors for HV supply
- The oven holds 3 supports = 180 HVD's/week
- **The burn-in set-up containing:**

1. Temperature controlled oven between Tamb+10º to 300ºC set at 65º C
2. HV power supply 200 – 1200 Vdc/100 mA set to 1000V
3. Data recorder + Pt 100 sensors & resistive divider; record temperature on three level inside the oven and HV value
4. External temperature controller for overheating extra safety
5. Protection unit; cut of power of oven and HV power supply in case of overheating, door opening or emergency button press









HVD functional tests on the automated test bench – see left

After burn-in, all active dividers are tested, 10 pcs. at a time (4), on automatic test bench (1). Based on a LabView application installed on PC (3) together with external power supplies (2), the test bench allows:

- Read out of the bar codes of the 10 Dividers when entering in the test box.
- HV check and 1 KV applied to the 10 Dividers.
- Individual measurement of voltage applied between PMT tube electrodes

On QC screen are displayed

- % HV nominal input (reference value saved after calibration)
- % HV measured (average value)
- % difference/nominal reference value - maximum deviation allowed ± 2% =>OK or BAD
- % difference by applying DC current - maximum deviation allowed ± 2% =>OK or BAD

- Capacitors test, comparison to the reference values ± 20% =>OK or BAD
- All results are recorded with the information on the dates/times, and Operator + Supervisor.

Results analysis – see right

Divider counts are determined eq.(1) with respect to the difference between the reference and measured values for each Dy_i :

$$Dy_i - Dy_{ref} \text{ in \% HV} \qquad (1)$$

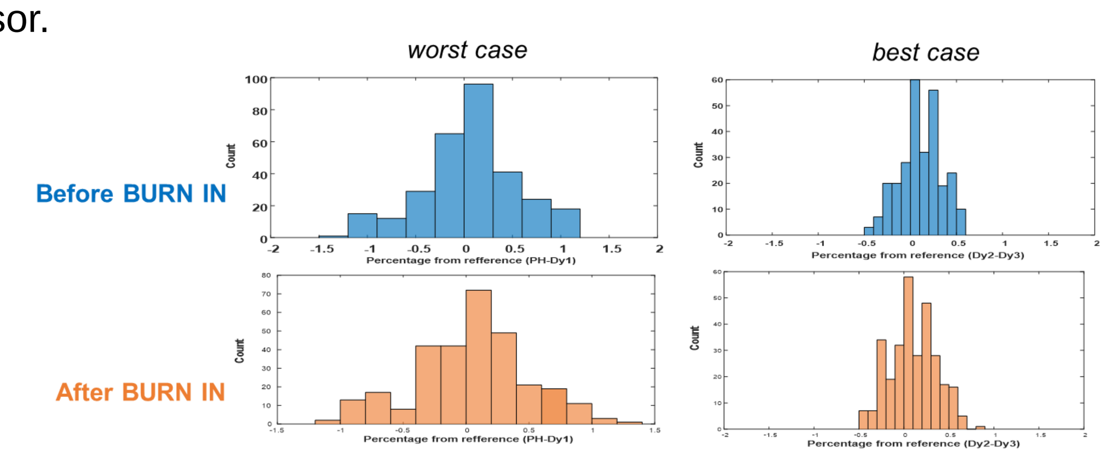
Worst case and best case are presented (right up) before and after the burn in process (the abscissa limits are between -2 and 2 % set as acceptable in the measurement software)

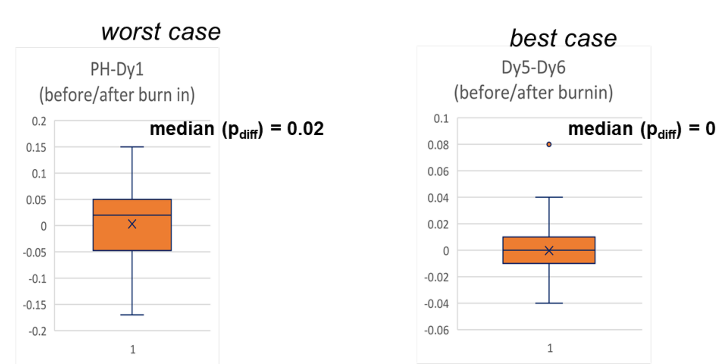
All the after burn-in measured values are between -1.5% and +1.5% In conclusion all 300 dividers passed the test.

In order to show the burn in effects HV percentage deviated from the reference value is measured before (p_{before}) and after (p_{after}) burn in tests for all dynodes

$$p_{diff} = p_{before}(Dy_i\text{-}Dy_j) - p_{after}(Dy_i\text{-}Dy_j)$$

Worst case and best case are presented (right below) using box plots representations . The median value is *0*, whereas 75% of the measurements were found between -0.05 and 0.05 (worst case).





Acknowledgments: This research was financially supported from the MCID, Nucleu-Program, project nr.PN19350101