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^{55}Fe Tests and Measurement of Dark Pulse Rate

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To ensure the functionality of the final Outer Tracker modules we propose the following two tests for every straw channel:

- measurement of the ^{55}Fe pulse height for every channel
- determination of the dark-pulse rate at nominal HV

Before testing, the modules should undergo a commissioning.

Module commissioning

The modules should be flushed with counting gas for at least 12 hours. The gas flow must not be smaller than 1 Vol/h. After the flushing, the modules should undergo a "HV training" during which the modules are kept under nominal voltage (1520 V for Ar/CO_2) for 12 to 24 h (gas flow of 1 Vol/h). The training currents should be logged.

Test conditions (after flushing and training)

Gas type	Ar/CO_2 (70/30)
Flow	1 Vol/h (flushed before)
HV setting	1480 V
Amplifier	Heidelberg VV50
Threshold	to be defined

The choosen HV value is about 40 V lower than the envisaged operating voltage of the modules in LHCb. The reason for the lower HV value is the limited dynamic range of the VV-50 amplifier.

Determination of the dark-pulse rate

To determine the rate of dark-pulses the VV-50 outputs are fed to an discriminator[1]. Fig. **??** shows the rates of the dark-pulses for different threshold voltages of the discriminator. Two data sets are shown: a "zero" measurement of a channel without HV, a threshold scan for a channel with HV where the anode currents are small (O(1 nA)). Thus for good channels the measured rate at nominal HV setting is low (¡2 HZ) also for small values of the threshold voltage.
Channels with a high rate of HV related dark-pulses (to be defined) should be therefore recorded and possibly also disconnected to avoid cross-talk to neighbouring channels.

^{55}Fe pulse height measurement

With the above conditions the signal heights for ^{55}Fe pulses (activity of used Fe source: 700 MBq) are taken for every wire. The Lemo outputs of the VV-50 are connected directly to an oscilloscope (50 Ω input impedance) and the avarage pulse height is determined. A typical pulse is shown in Fig. 2.
Fig. 3 shows the pulse height values (arbitrary units) for 4×64 channels of a 1 m prototype module. The pulse-heights are measured at a distance of about 10 cm from the modules ends. The observed maximum variation is 13% (RMS: 6%).
Beside measuring the signal height for all straws the signal shape should be compared to a reference signal. Channels for which the test reveals a significantly lower amplitude (to be defined) or channel which show a different signal shape must be recorded.

Future test-setup

To simplify the dark-pulse and the ^{55}Fe measurement we foresee to provide a test-board. The board is based on the VV-50 amplifier and comprises also the HV decoupling capacitors for 64 channels. Without any additional interface the test board can directly be plugged to a module. The board will allow multiplexing of the Fe signals and together with a comparator will also allow the measurement of the dark-pulse rate.

Open questions

[1] In the measurements presented here, a standard 50 Ω NIM discriminator is used. For the tests of the serial production we foresee to provide a setup where the VV-50 is combined with a comparator and a counter.

While we believe that both measurements described here are meaningful qualitative tests of the module properties it is hard to give today quantitative criteria for a channel qualification.
We also do not know wheter it is useful to store the pulse-height and dark-current information in the module data-base. Mostlikely it is sufficient to store only the up-normal cases.
The last open issue is whether one really wants to disconnect "hot" channels and how this could be achieved technically.

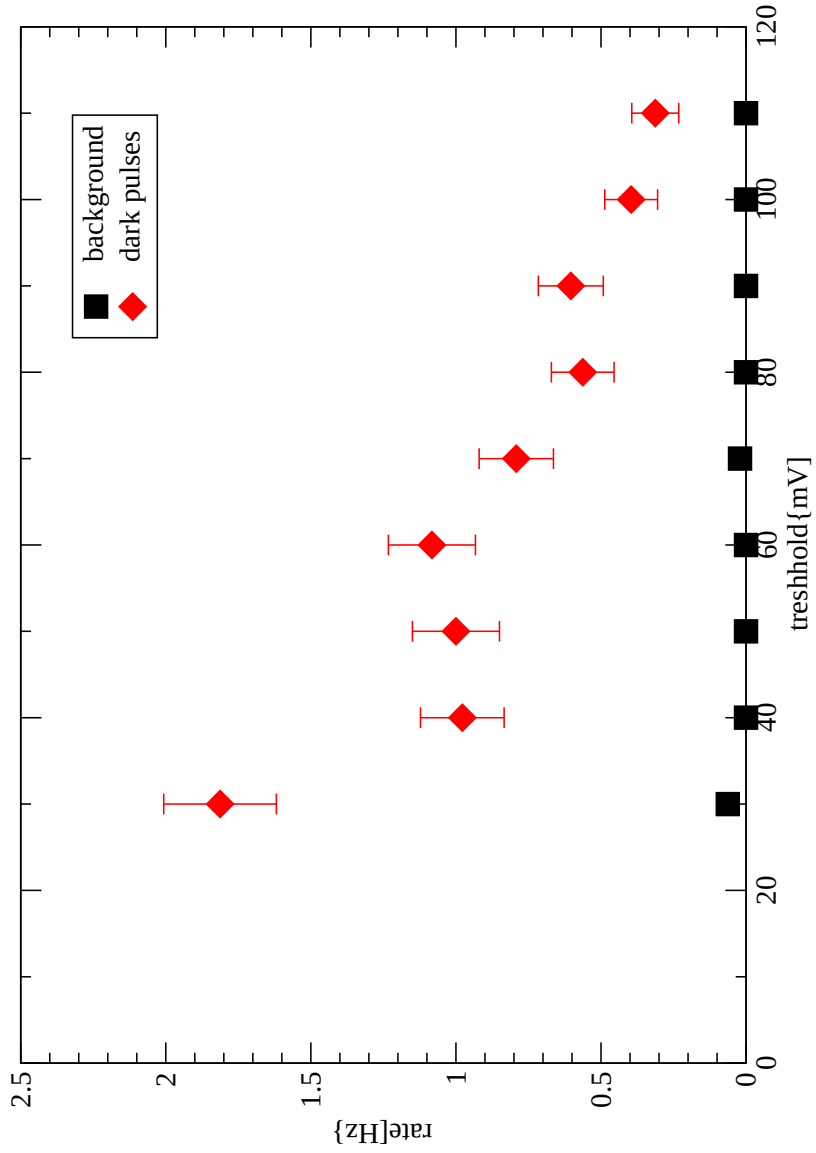

Figure 1: Rate of dark-pulses for different threshold voltages for the same channel at nominal HV (red) and at 0 V (black). The rate at large threshold voltages for the nominal HV setting is compatible with cosmics.

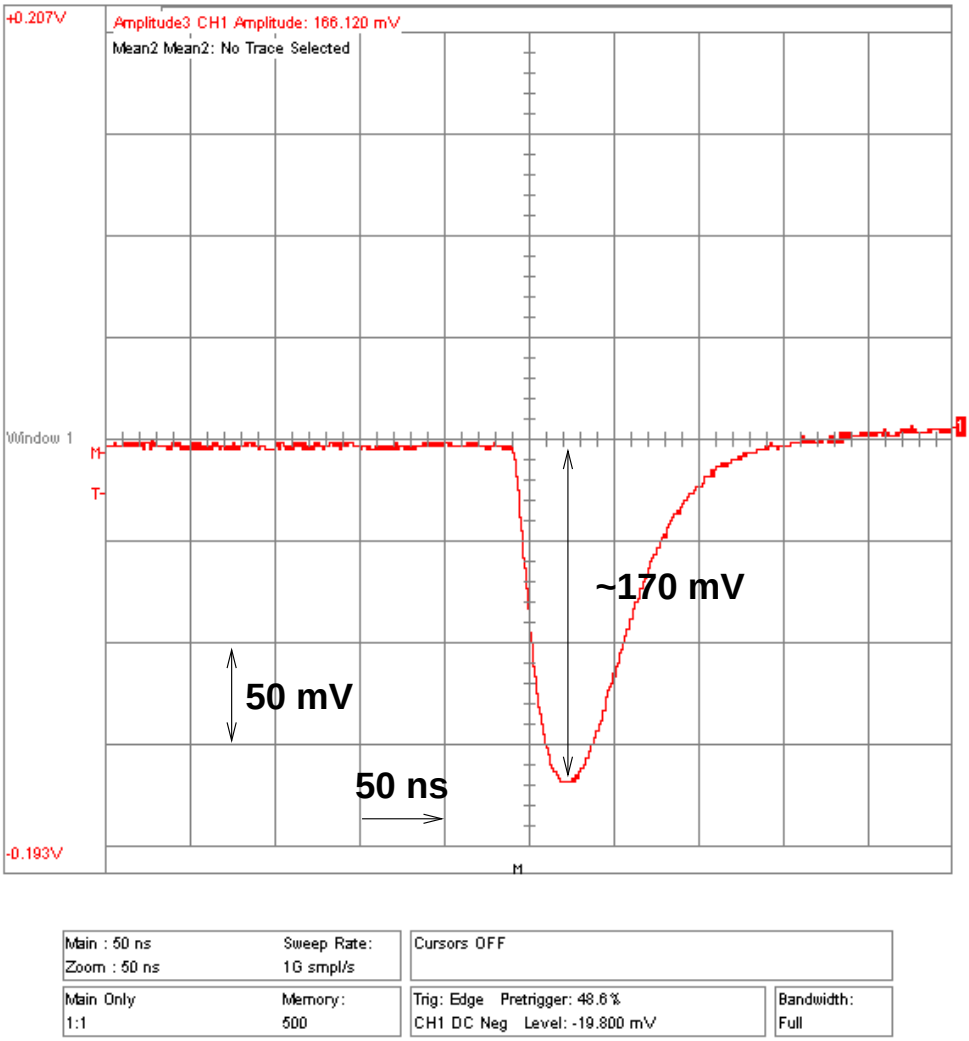

Figure 2: ^{55}Fe pulse after the VV-50 amplifier.

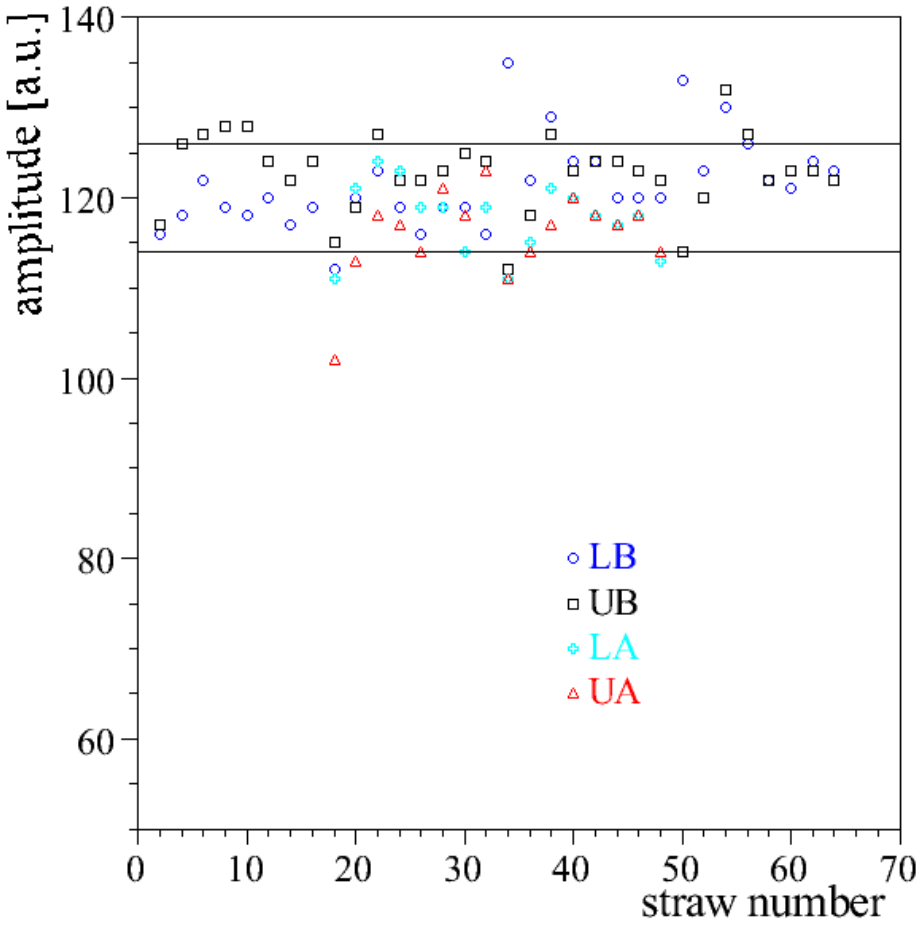

Figure 3: ^{55}Fe pulse heights for the 4×64 straws of a 1 m prototype module: L (U) denotes the lower (upper) section of the two panels A (B). The pulse height is given in arbitrary units.