

Scintillator

Model: CYBERSTAR

As the linearity of this single-photon counting detector is only kept within a limited counting rate range, we have added an **automatic attenuator control system**.

Automatic attenuator control system

Principle

The automatic attenuator control system is composed of:

- an electronics (from CAVAC) that determines the detector dead time from its analog output pulses.
- An attenuator control unit (XIA PFCU-4 control unit) that commands the insertion or extraction of absorbers
- A set of 4 absorber foils housed in a box and pneumatically-controlled. Using a binary combination of the 4 filters, one has the choice between 16 different levels of attenuation (from 0 up to 15 foils in the beam).

The CAVAC electronics acts on the PFCU-4 control unit (to insert or extract absorbers into the beam) so as to maintain the detector dead time within preset limits. The limits are to be set according to the known linearity of the detector for each energy of operation.

Practical informations

The remotely operated filters are located in the 1st hutch of BM5 in-between the Be exit window and the 3-axis diffractometer.

One filter box is presently available, the filters are made of Aluminum (Al foils, 0.5 mm thick). The box contains 4 filters that can be combined:

- absorber 1: 1 foil
- absorber 2: 2 foils
- absorber 3: 4 foils
- absorber 4: 8 foils

There are 3 ways of operating the absorber: **full manual**, **manual under SPEC**, and **automatic under SPEC**.

Note: If the maximum number of filters was not sufficient to prevent the detector from saturation, e.g. observation of the direct beam, one solution may consist of reducing the slits.

Acknowledgments:

This documentation is inspired from the one of Odile Robach (beamline ID3).

Mode (1): Fully manual mode

The filters are moved manually by choosing a combination of the 4 switches present on the front panel of the XIA NIM card.¹ Here, one has to note in the logbook the number of filters used during the measurements. This mode may be useful during an alignment procedure.

Mode (2) : Manual mode set under SPEC

- Type the command **filteroff**
- Type the command **filterset n**, where n must be an integer between 1 and 15. The macro will produce one of the 15 possible combinations of the 4 filters.
e.g. "filterset 0": no filter, "filterset 1": 1 foil, ..., "filterset 15": 15 foils (maximum attenuation).

In this mode (and in mode 3 as well), the SPEC command "ct" (count) displays a number between 0 and 15 corresponding to the number of attenuator foils present in the beam.

The counter "det_corr" provides the corrected intensity calculated as follows:

$$I_{\text{REAL}} = I_{\text{MEASURED}} \cdot (\text{atten})^n$$

- atten: attenuation factor of one foil
- n: number of attenuator foils

When in a scan mode, for every point of the scan, SPEC stores the number of attenuator foils n, the value of det_corr, and the value of Detector in the SPEC file (if created). This way, you don't need to write in the logbook the number of filters used.

Mode (3) : Automatic mode under SPEC

This mode is useful, for example, for reflectivity scans with important intensity variations from one point to the other.

In this option, available under SPEC, the electronics automatically inserts or removes filters depending on the number of counts received by the detector. The level of saturation of the detector is measured by a special electronics² that measures the dead time of the detector. Once calibrated the electronics inserts filters in the incident beam until the dead-time gets under a certain threshold.

To use this mode one must:

- follow an **initialization procedure**
- determine the **dead time thresholds and the absorber attenuation factor**

Then the automatic mode can start by typing the command **filteron**.

¹ XIA module, located in the NIM rack of the control hutch

² CAVAC module, located in the NIM rack of the control hutch

Note: Notice that a counting time of 0.1s is too small for the attenuators to follow correctly. The automatic control mode of the attenuators makes SPEC a bit slower.

Initialization procedure before using the filters under SPEC

- make sure all cables are connected properly (see **cabling description**) and that the attenuator box is under pressure (~ 3 to 6 bars).
- make sure the 4 filter switches on the XIA card are on the left, i.e. red lights OFF and filters extracted
- type **filteroff** in SPEC
- unplug the attenuator card (by extracting it 1 cm out of the rack)
- unplug the 9-pin connector then re-plug it
- re-plug the attenuator card
- close the beam shutter
- type **det_cal** in SPEC. This command should return values like :
0 0.084 4.529 0.101
- if it returns only zeros, try doing the “**det_cal**” command again and again.
- open the beam shutter
- type **ct** in SPEC (counts 1 second)

After this procedure, if you do a “**filterset 1**” in SPEC, the red LED corresponding to filter 1 should be ON on the XIA filters card, and the “**ct**” command in SPEC should return “Attenuator = 1”.

For calculating Det_corr, one then needs to enter the attenuation factor into SPEC. For the automatic insertion of filters, one needs to setup the thresholds on the dead-time for inserting or removing the filters.

Procedure to determine the thresholds (and also the attenuation factor):

(needs only to be done once)

- put the diffractometer to a position where the detector intensity is between 20000 count/s and 40000 count/s, so that the detector is not saturated but the dead-time is large enough.
- **filterset 0**
- **ct** (e.g: detector: 31000 count/s, dead-time = 0.0037)
- **filterset 1**
- **ct** (e.g.: detector: 14900 count/s, dead-time = 0.00156)
- **filtersetup**
- answer the questions:
- **Threshold to insert filters (...)?**
- Here, you put a value slightly higher than the dead-time measured with zero filters (for example 0.004).
- **Threshold to extract filters (...)?**
- Here you put a value slightly smaller than the dead-time measured with one filter (for example 0.001)
- **Attenuation factor (...)?**
- Here you put the ratio between the counts measured with zero filter and with one filter (e.g. here $2.08 = 31000 / 14900$)
- **Serial line number in config (...)?**
- Leave it as it is

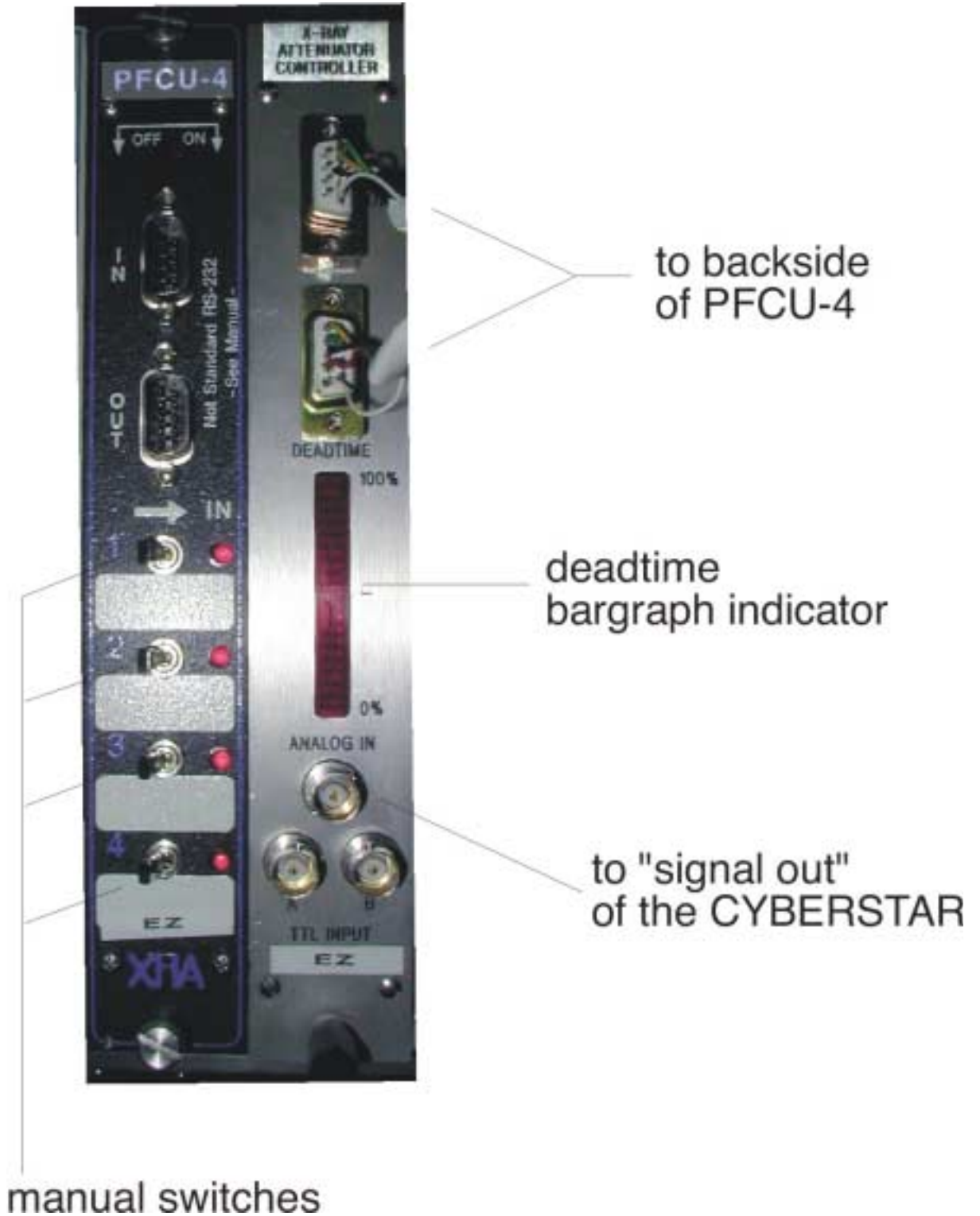
Note: A constant dead time value after a series of **ct** is an indication that the settings are satisfactory: typing the command **ctu** (ct update) to perform a series of **ct**.

Note: Thresholds and attenuation factor are x-ray energy dependent. They also depend on the filter material and the type of detector.

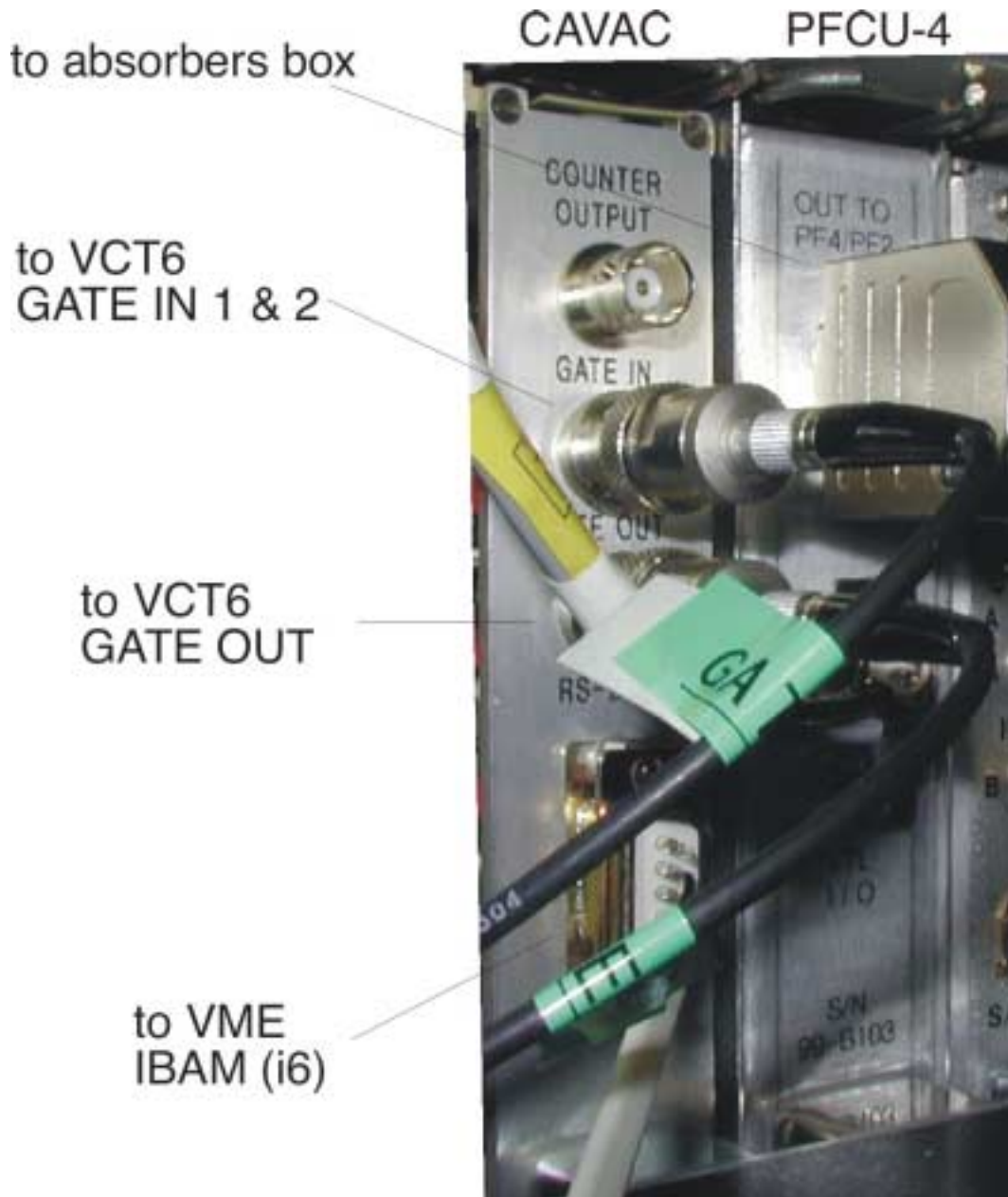
- Type **filteron** and go to an intense peak: SPEC should start inserting filters automatically as soon as the intensity gets larger than about 25000 count/s.
- To go back to the manual mode you have to type **filteroff**

Cabling description :

Below is a schematic drawing of the filter control electronics (2 NIM cards) as it looks in the rack in the control room (front panel view).



- the “ANALOG IN” input in front of the “x-ray attenuator controller” card (NIM rack in the control room) must be connected to the “SIGNAL OUT” output of the detector electronics (CYBERSTAR card in the NIM rack of the experimental hutch
- the connection on the rear side of the “x-ray attenuator controller” card and of the PFCU-4 card are shown below:



Additional information

To access the options when operating the filters through SPEC, one has to load the filters macro into SPEC using the command :

qdo /users/specadm/jmacros/detcor.mac (or simply: **jdo detcor.mac**)