Performance test of the tig10 to be used for ECBR measurements with TITAN

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1 Introduction

At the TITAN experiment there will be several detectors installed to observe radiation that is being emitted by ions stored inside the EBIT. Currently, a thick crystal HPGe (Ge), a thin crystal low energy Ge (LeGe) and several planar Si (PIPS) detectors are installed at the experiment. These detectors are read out by various preamplifier and thus provide different output signals and ranges (see table 1). The requirements for the data acquisition system are to provide an energy resolution comparable to analog systems and the time stamp of the event. To read out these signals we investigated the performance of a tig10

Detector	Preamp	Output polarity	Output range	Typ. range
Ge	RC	-	0-5V	0-1 V ?
LeGe	TRP	+	0-5 V	0-5 V
PIPS	2003BT	+	0-5 V	0-0.2 V
	Mesytec	(+/)-	0-±5 V	0-±0.2 V

Table 1: List of detectors and preamplifier currently installed at TITAN.

14bit sampling ADC system. Herefore, efficiency, resolution and performance were compared with an ORTEC DSPEC system, a digital waveform processing ADC. For direct comparison we installed the sources in front of the detectors and took data with both systems, DSPEC and tig10. This reduces any effects due to different source placement.

2 Performance of the DSPEC

To get energy spectra from the LeGe we used a ^{133}Ba source due to its several energy lines between 6 keV and 350 keV. In order to obtain spectra with the Ge detector we used a ^{60}Co source in combination with a ^{57}Co source. This provides lines in the regions of 120 keV and 1300 keV. The spectra were fitted with Radware, a software package for interactive graphical analysis of γ-ray data. This program is fitting a function consisting of a Gaussian peak, a step function to account for Coulomb scattered photons, a background and a skew function to account for photons that got scattered out of the crystal. The FWHM of spectra fitted with Radware agree with the results obtained with Maestro, Ortec's program to read out DSPECs. Quoted uncertainties are only uncertainties of the fit.

2.1 Ge detector resolution

The resolutions of the Ge detector for several peaks, read out with the DSPEC, are listed in table 2. Analyzed with ORTEC's program Maestro, the FWHM of the peaks were determined to be 0.99 keV @ 122 keV, 0.96 keV @ 136 keV, 1.75 keV @ 1173 keV and 1.82 keV @ 1333 keV.

Position [keV]	**PosErr [keV]**	**FWHM [keV]**	**FWHM error [keV]**
14.246	0.015	0.887	0.009
122.059	0.002	0.984	0.001
136.485	0.002	0.978	0.006
1173.285	0.002	1.706	0.004
1332.522	0.002	1.796	0.005

Table 2: FWHM of the Ge detector at different energies (^{60}Co and ^{57}Co) achieved with the DSPEC and fitted with Radware.

2.2 LeGe detector resolution

To determine the resolution of the LeGe detector a ^{133}Ba source was used. The spectrum was fitted in Origin with a Gaussian and a step function and the results are listed in table 3. The fitted resolution achieved with Radware are listed in table 4. Due to the small crystal, the number of photons scattered out of the crystal is rather small and the results of both programs agree very well.

The fitted peak positions plotted as function of gamma energies results in a straight line for both results of Origin and Radware. The specrum taken with DSPEC and LeGe detector is linear in the range between 5 keV and 400 keV (see Figure 1).

Position [keV]		FWHM [keV]	
6.700	±0.003	0.162	±0.006
14.711	±0.003	0.208	±0.006
25.359	±0.003	0.282	±0.006
35.231	±0.000	0.314	±0.001
36.098	±0.001	0.334	±0.002
53.415	±0.001	0.358	±0.002
79.860	±0.005	0.441	±0.003
81.237	±0.000	0.450	±0.001
122.294	±0.002	0.579	±0.003
136.697	±0.011	0.615	±0.016
160.826	±0.012	0.685	±0.017
276.564	±0.003	1.001	±0.006
302.984	±0.030	1.049	±0.020
356.127	±0.030	1.123	±0.020

Table 3: FWHM of the LeGe detector at different energies (^{133}Ba and ^{57}Co) achieved with the DSPEC and fitted with Origin.

RW Position [keV]		RW FWHM [keV]	
53.163	±0.001	0.347	±0.004
79.640	±0.001	0.435	±0.002
81.019	±0.001	0.441	±0.001
276.57	±0.08	0.919	±0.020
303.028	±0.011	0.983	±0.028
356.240	±0.007	1.147	±0.010

Table 4: FWHM of the LeGe detector at different energies (^{133}Ba and ^{57}Co) achieved with the DSPEC and fitted with Radware.

3 Performance of the tig10

During the tests with the tig10 several parameters were optimized to achieve the best energy resolution. Besides, we also investigated the contribution of electric noise to the spectrum. The tig10 card was set to 4 V mode.

3.1 tig10 energy resolution

Several parameters need to be set for the use of the tig10. The parameters that mainly determine the energy calculation of a sampled wave form are L and M.An ODB script was modified in order to scan through many different L and M parameters on the tig10 card. The script currently resides in the directory " /online/tig10" on titan04.

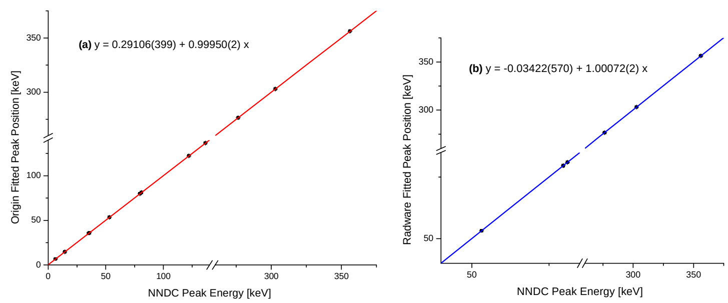
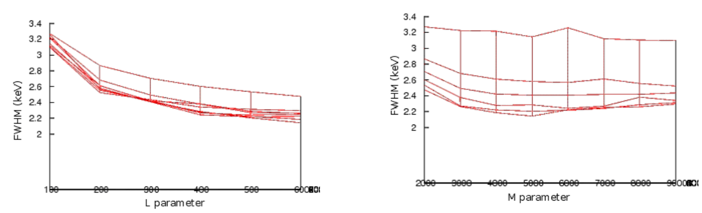


Figure 1: Fitted peak position versus gamma energy of LeGe detector and DSPEC, analyzed with Origin and Radware.

3.1.1 Ge detector energy resolution

It was found that the L parameter had the largest effect on the resolution while the M parameter had little to no effect. The lack of dependence of the resolution on the M parameter is surprising given that it is a major component in correcting for the decay of the pulse from the pre-amp.



(a) Scan for the L parameter for given M values for the 1.33 MeV peak of ^{60}Co. The best resolution obtained is 2.2-2.3 keV.

(b) Scan for the M parameter for given M values for the 1.33MeV peak of ^{60}Co. For a given L parameter there is no significant variation with M.

Figure 2: FWHM of the 1.33 MeV peak for different scans of L and M.

One of the highest energy resolutions was obtained for the parameters **L**=600 and **M**=5000. The data file containing this spectrum is called run00155.mid, the reference DSPEC file is called Ge-co60-co57.Chn. Both spectra were fitted with Radware to exclude biasing due to different fitting functions and routines. The results are shown in table 5. The values in table 5 show that the energy resolution for tig10 and DSPEC are comparable for high energy photons with the tig10 being about 20% worse. For lower energy photons the energy resolution achieved with the tig10 is about 1.5 times worse than the one obtained with the DSPEC.

To check the reliability of fit and the efficiency of the data acquisition a quotient of the different peak areas was calculated ($\frac{\text{Peak1}}{\text{Peak2}}$[tig10] and $\frac{\text{Peak1}}{\text{Peak2}}$[DSPEC]) (see

Position [keV]	**tig10 FWHM [keV]**	**DSPEC FWHM [keV]**	**FWHM ($\frac{\text{tig10}}{\text{DSPEC}}$)**
122.06	1.456	0.983	1.48
136.47	1.494	0.977	1.53
1173.2	2.039	1.704	1.20
1332.5	2.147	1.794	1.20

Table 5: FWHM of the Ge detector at different energies (^{60}Co and ^{57}Co) achieved with the tig10. Also shown is the resolution achieved with the DSPEC and the fraction fig10/DSPEC. Both spectra, tig10 and DSPEC, were fitted with Radware.

table 6). The error value arises from the uncertainty of the fit calculated by

Quotient Peak1/Peak2	**tig10**	**DSPEC**
1332/1173	0.848(8)	0.885(3)
1332/136	2.679(45)	2.850(6)
1332/122	0.332(3)	0.343(1)
136/122	0.124(2)	0.120(1)

Table 6: Quotient of Ge peak areas recorded with tig10 and DSPEC, fitted with Radware.

Radware. The quotients agree reasonably well with each other.
In an earlier test the detection efficiency of the system was investigated. Two spectra with Ge and the same source (^{57}Co) were taken with DSPEC and tig10. The spectra were normalized to the duration of the data acquisition. Afterwards, the spectra were integrated over three different regions and the peaks at 122 keV and 136 keV (see Figure 7). These integrated counts were then used to form the quotient of DSPEC and tig10 ($\frac{\text{Integral DSPEC}}{\text{Integral tig10}}$). As values in table 8 show, both systems are equally efficient, the quotient is 1. The spectra were normalized on run time. The settings for the tig 10 were **L**=280 and **M**=15000.

3.2 LeGe detector energy resolution

The same scan that was performed with Ge detector and tig10 was also done with LeGe detector and tig10. The best energy resolution was achieved for similar parameters **L** and **M** as with the Ge detector (**L**=600 and **M**=5000, run00155.mid). Both spectra were fitted with Radware to exclude influences due to different fitting functions and routines. The results are listed in table 9. If the spectra are fitted with either root or Origin, the FWHM agree within error. For lower energies the resolution of the tig10 is 1.5 to 2 times worse than that obtained with the DSPEC. But for higher energies, the resolution is comparable in both cases with the DSPEC being slightly better.

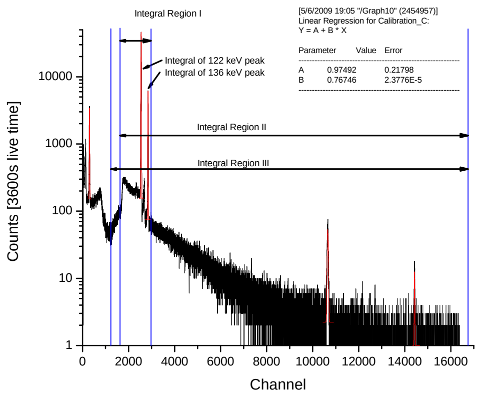


Table 7: Regions that were integrated to compare the acquisition efficiency of DSPEC and tig10.

Region or peak	**Quotient** $\frac{\text{DSPEC}}{\text{tig10}}$
122 keV	0.97(1)
136 keV	0.97(1)
I	1.00(1)
II	1.02(1)
III	1.02(1)

Table 8: Quotient of integrated regions recorded with DSPEC and tig10. The tig10 spectrum was integrated with root, the DSPEC spectrum was integrated using Origin.

Position [keV]	**tig10 FWHM** [keV]	**DSPEC FWHM** [keV]	**FWHM** $(\frac{\text{tig10}}{\text{DSPEC}})$
53	0.681(1)	0.346(4)	1.97
79.6	0.787(1)	0.435(2)	1.81
81	0.790(2)	0.441(1)	1.79
276	1.023(6)	0.919(20)	1.11
303	1.121(4)	0.982(28)	1.14
356	1.108(4)	1.147(10)	0.97

Table 9: FWHM of the LeGe detector at different energies (^{133}Ba) achieved with the tig10. Also shown is the resolution achieved with the DSPEC and the fraction fig10/DSPEC. Both spectra, for tig10 and DSPEC, were fitted with Radware.

Huge deviations arise when the quotient is formed with peak intensities relative to each other. Here, the values calculated for tig10 and DSPEC vary by up to a factor 4 as shown in table 10. Assuming that the DSPEC records spectra more

Quotient **Peak1/Peak2**	**tig10**	**DSPEC**
303/276	2.020(21)	0.945(16)
81/303	180.8(11)	40.8(5)
303/53	0.110(1)	0.420(6)
81/53	19.876(50)	17.138(117)

Table 10: Quotient of LeGe peak areas recorded with tig10 and DSPEC, fitted with Radware.

reliable, looking at these values rises a question on the reliability of the read out of the LeGe detector with the tig10. One explanation might be the considerable electrical noise of the tig10 for lower channels. For the Ge the noise contribution was investigated and is presented in chapter 5.4. It was found that below 40 keV the spectrum of the Ge detector strongly depends on the trigger threshold set in the ODB. This limit of 40 keV for the Ge detector corresponds to a limit of about 300 keV for the LeGe detector and thus might explain, why the count rate with the tig10 is about four times the count rate of the DSPEC. Constant noise should not affect the peak area, so it can't be the only explanation why the quotients in table 10 vary that strongly.
Due to the transistor reset preamplifier the height of an X-ray event is in the 100 meV range. This results in a FWHM of about 3 channels for the tig10. In comparison with the DSPEC, this is a reduction of a factor six. The FWHM of the DSPEC is about 18 channels (see Figure 3).

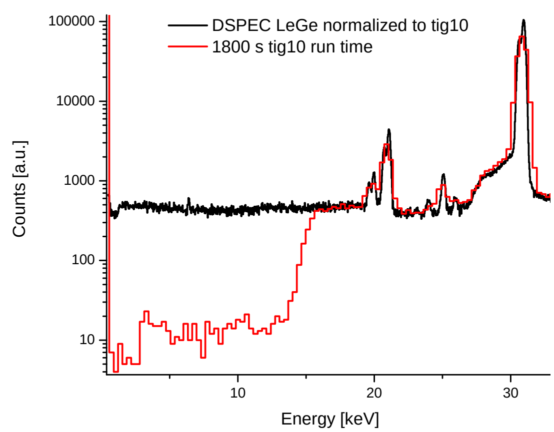


Figure 3: The difference of tig10 and DSPEC in resolution for the low energy region. The FWHM in channels of the tig10 (red line) is about a factor six less than of the DSPEC (black line). Peaks that can be resolved with the DSPEC are not resolvable by the tig10.

4 Trigger on Transistor Reset

For the low energy X-ray detector (LeGe) we are using a transistor reset preamplifier. Figure 4 displays examples for transistor resets (yellow signal) together with the inhibit signal (blue). The inhibit signal is a TTL signal of 10 μs width and starts coincidentally with the transistor reset. In some cases the transistor reset is done in steps (see Fig. 4b). The steps are separated in time by about 55 μs each of which is accompanied by the 10 μs inhibit signal. The tig10 triggers on these transistor resets: This is most likely due to the fact that in most

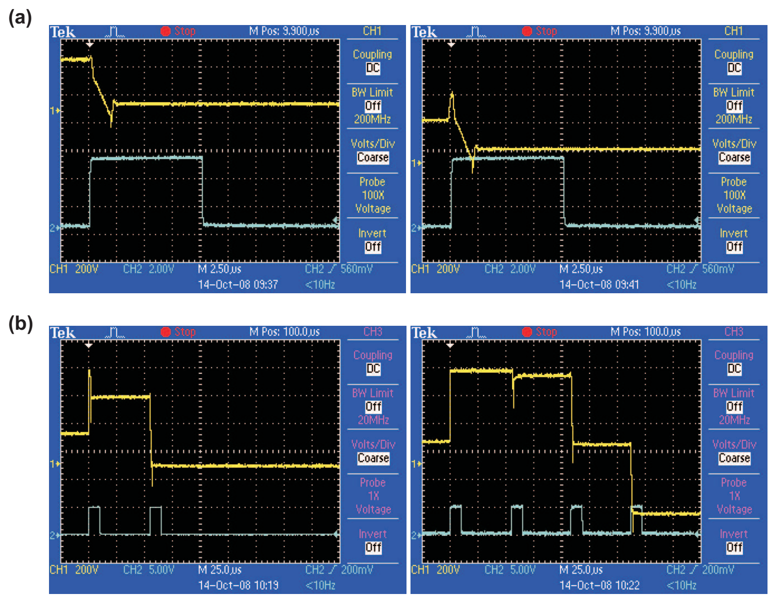


Figure 4: LeGe signal during a transistor reset (Yellow) and the inhibit signal (Blue).

cases the signal peaks before the transistor resets.

4.1 Transistor Reset inhibit signal

To tag triggers on these transistor resets we send the inhibit signal to another channel of the tig10 card. Ideally, we could then exclude those LeGe events whose timestamp are within a certain range of the timestamp of an inhibit signal.

Initially, we sent the inhibit signal straight into the tig10 channel. However, the number of events registered by the tig10 in this channel did not agree with those recorded by a separate scaler. Due to the buffer size of 16 events, the difference between the number of events of the scaler and in the tig10 midas data file should equal to +15. However, we observed more counts with the tig10 than on the scaler. We thus concluded that the tig10 cannot handle the 10 μs TTL signal properly.

The problem could be avoided by feeding the inhibit signal to a Gate and Delay Generator with a 1 μs output signal. Figure 5 shows the waveforms stored by the tig10 for the TTL inhibit signal and the LeGe signal with the transistor reset. Both channels were individually triggered. For all observed cases, the event builder correctly assigned the same event number for both channels (in the case of Fig. 5 it is event #15). Thus, in principle the LeGe events could be sorted and those events corresponding to transistor resets could be excluded. Also, for transistor resets the tig10 has so far always reported a vanishing energy and will, thus, not be considered as a regular event. But, due to the

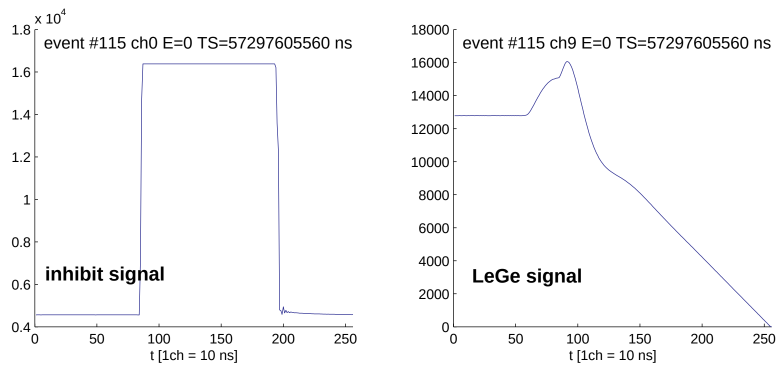


Figure 5: Tig10 waveforms of a transistor reset: TTL inhibit signal on the left and LeGe signal on the right.

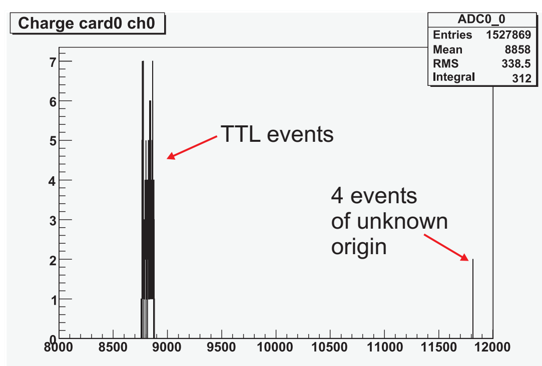


Figure 6: Tig10 charge spectrum for a channel with the TTL inhibit signal. Most TTL signals appear around 8800, however there are also four out of 312 not-understood events on the right.

problem of 'Re-triggering' (see 5), it will be essential to correctly identify events due to transistor resets in case the 'Re-triggering' problem cannot be fixed.
Note also that in Figure 5 the tig10 reports zero charge ($E = 0$) for the TTL signal. This is due to an incorrect setting of the latency parameter. With the correct settings for the latency parameter, the tig10 assigns a charge value to a 1 μs TTL signal which is different to zero. A test run of 1 hour has been performed and all TTL events were assigned about the same charge value. However, in other individual cases different charge values have been observed for a TTL signal fed into the tig10 (see Figure 6). Their origin is currently not understood.

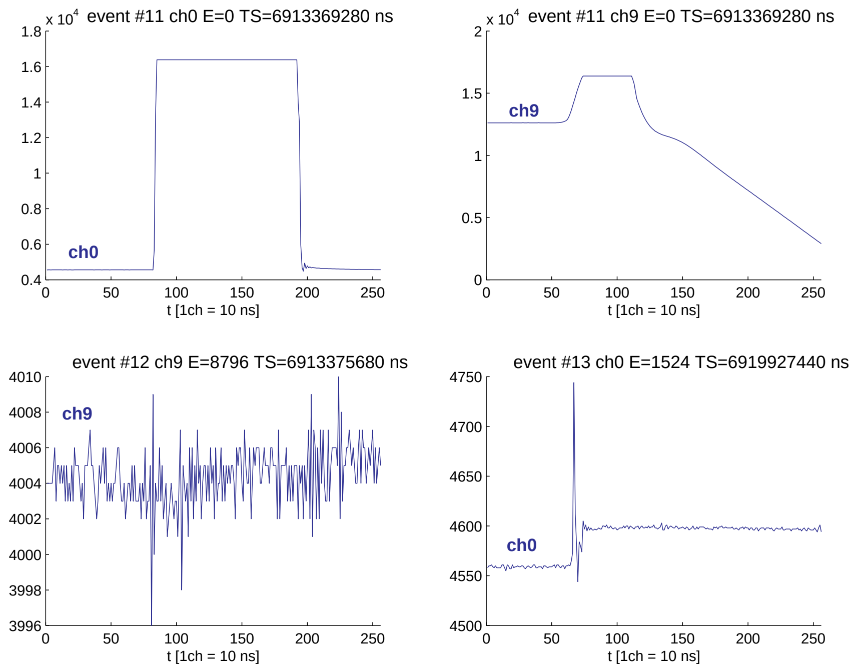


Figure 7: Example for waveforms of re-triggered events. Event #15 is the trigger on the transistor reset. Event #12 and #13 are re-triggered events.

5 Re-triggering

We observed that the tig10 sometimes triggers 'twice' on the same event. First it triggers on the correct event, a second trigger appears a bit later.

5.1 Re-trigger on transistor reset

Figure 7 shows an example of a trigger on a transistor reset where ch0 is sampling the waveform of the TTL inhibit signal and ch9 is recording the LeGe signal. In ch9 a second event is being recorded 6.4 μs after the correct transistor reset event, while in ch0 the second event is recorded about 6.6 ms later. Latter waveform could be a real signal of not understood origin, while the first one is white noise and should not be triggered on. Note that both re-triggered events are stored with a non-zero charge value. The charge values for re-triggered events vary from case to case and will thus add to the background unless they can be correctly identified and removed from the spectra. Re-triggered events have been observed in several scenarios which can be classified as listed in Table 11.

Type		energy signal	inhibit signal
I	re-trigger?	yes	yes
	delay	6.3-6.5 μs	6.5 ms
	charge	non-zero, no systematic	around a fixed value
	waveform	noise	as in Fig. 6
	occurrence	5 out of 826 events	
II	re-trigger?	yes	yes
	delay	6.3-6.5 μs	differs from case to case, max 6 ms
	charge	non-zero, no systematic	small values including zero
	waveform	noise	noise
	occurrence	13 out of 826 events	
III	re-trigger?	no	yes
	delay		no systematic known
	charge		same as II
	waveform		noise
	occurrence	1 out of 369 events	
IV	re-trigger?	no	yes
	delay		6.5 ms
	charge		same fixed value as in I
	waveform		as in Fig. 6
	occurrence	1 out of 369 events	
V	re-trigger?	yes	no
	delay	6.2 (once 6.7) μs	
	charge	non-zero, no systematic	
	waveform	no signal	
	occurrence	8 out of 826 events	

Table 11: Types of re-triggered events after a transistor reset

trigger threshold	ratio of events with zero charge [%]	comment
50	>0.1	
30	~2	
20	~34	
10	~75	probably includes already real noise events, too

Table 12: Trigger threshold and re-triggered events: The trigger threshold for the PIPS detector was varied. For lower thresholds the amount of re-triggered events increased. A re-triggered event is indicated by its vanishing charge. It was checked by looking on the waveforms that this is an appropriate indicator.

5.2 Re-trigger on regular events

For Germanium (LeGe and Ge) and PIPS detectors we observed re-triggered events also on regular events. The waveforms of these re-triggered events contains no information, i.e. it is noise. More detailed investigations were done for the PIPS detectors. For these detectors, the number of the re-triggered events is trigger threshold dependent. For typical settings the delay between real signal and re-trigger was 6.1 μs in every case. All observed re-triggered events were stored by the tig10 with a charge value of zero. A possible explanation could be found in the waveforms of the detectors. As shown in Fig. 8, all detectors carry some overshoot or ringing on the signal, which the tig10 might have troubles with. Together with Chris Pearson we looked on the waveform processing for individual events on the tig10 card. Ideally, the detector signal and its processed waveforms should look like as it is sketched in Fig. 9a. The width of the pulse in the 'clipped' waveform is fixed to 350 ns. However, we have observed processed waveforms as sketched in Fig. 9b. The width of the 'clipped' waveform was about 1.3 μs and the overshoot of the detector signal could potentially lead to a second trigger depending on the trigger threshold. In this case, the L parameter was set to $L = 4.8$ μs and the re-triggered event would thus identical to the 6.1 μs which we normally observe for the delay of re-triggered events in the PIPS detector.
However, this explanation failed to explain the 6.4 μs delay of the re-triggered events for the transistor reset in the LeGe detector for which the L parameter was set to 2.8 μs.
General remark: All tests including the inhibit signal and the re-triggering have been performed before a change in the tig10 frontend in October 2009. It is, thus, advisable to investigate these issues again.

5.3 Threshold limit for Ge detector

We investigated the behavior of the tig10 for different *Trigger Threshold* level. Spectra were taken for different trigger threshold values and normalized to

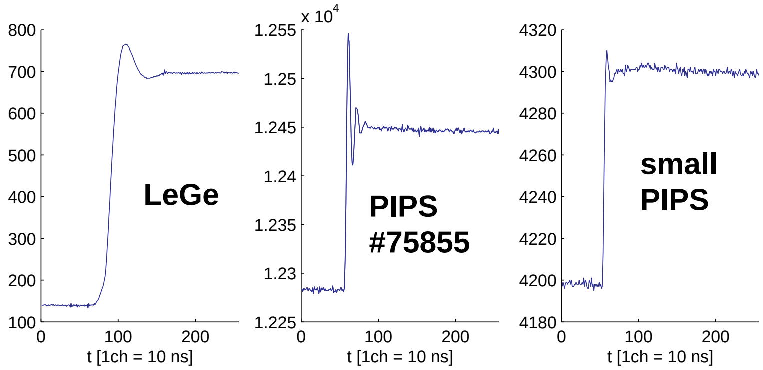


Figure 8: Examples for signals of several detectors.

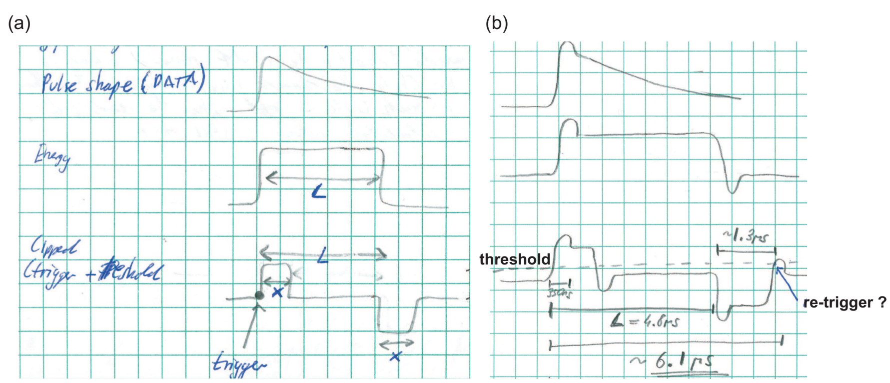


Figure 9: tig10 waveform processing: The 'clipped' waveform leads to an event trigger. Its height is proportional to the detector's signal height.
(a) ideal settings
(b) observed for small PIPS detector

their exact runtime afterwards. Above 40 keV, the spectra are identical, but below 40 keV, the spectra vary strongly depending on the threshold chosen. Depending on the threshold, the intensity of the 14 keV peak of ^{57}Co changes significant. This suggests that the trigger threshold is not well defined but smeared out. The problem is that it is impossible to reduce the threshold further because the card would trigger on too many noise events. It becomes impossible to determine the peak area of any peak below 40 keV, because the spectrum is depending on the parameters set for the tig10 (see Figure 10).

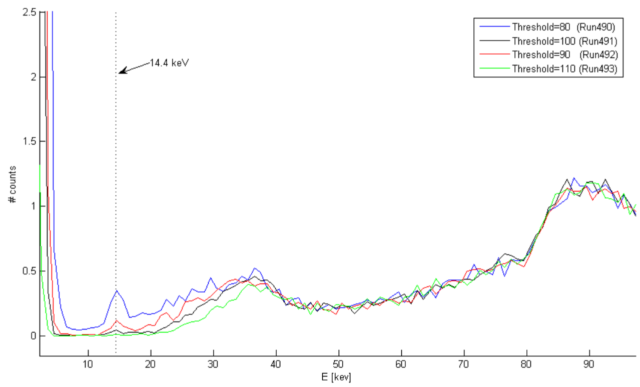


Figure 10: Dependency of the spectrum for different thresholds. The thresholds used for these spectra were 80, 90, 100 and 110.

To confirm that this behavior is tig10 related and not an issue of the detector or the positioning of the source, a comparison spectrum with the DSPEC was taken. This spectrum clearly resolves the 14 keV line and results in an energy resolution, that is better by a factor of two. In Figure 11 the spectra of tig10 and DSPEC are presented together with the DSPEC spectrum plotted as dashed black line, whereas the tig10 spectra are plotted similar to Figure 10. More details on the settings of tig10 and DSPEC are listed in the EBIT elog, Message ID 101. All these tests were performed with a firmware of the tig10 that uses only one sampled value to trigger. During these tests the tig10 was shielded against electro-magnetic noise by copper sheets.

5.4 Noise

In order to determine the electric noise of the tig10, the pre trigger value was changed to 600 in order to start sampling 6 μs before the actual rise of the signal (see Figure 12). Each event was inspected visually to make sure that in the region of interest there is indeed only noise. Then, the noise channels of each event were Fourier transformed individually and the results added up. During these tests we had some issues with the tig10. For wave forms larger than 600 the tig10 would become unstable. Sometimes non-consistent behavior

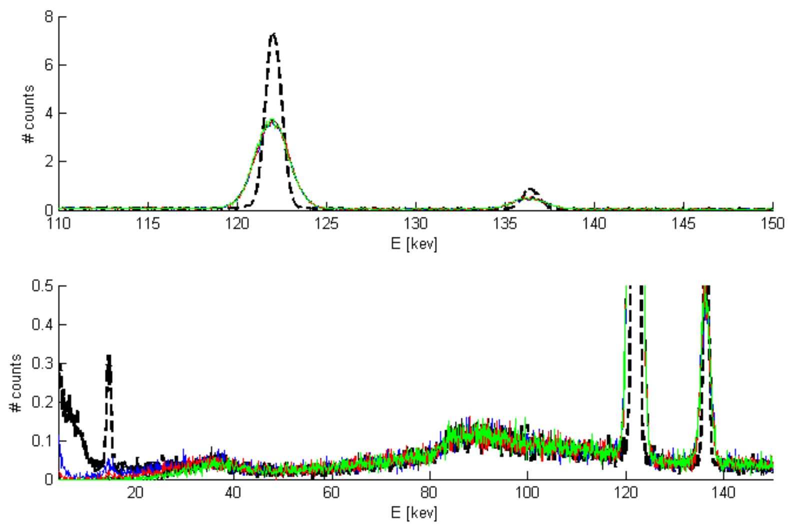


Figure 11: Comparing threshold of tig10 and DSPEC. The DSPEC has a better defined trigger level and the peak at 14 keV can clearly be resolved. The tig10 has a soft trigger Threshold and doesn't resolve the 14 keV in a reasonable way. The spectra are normalized by their run time.

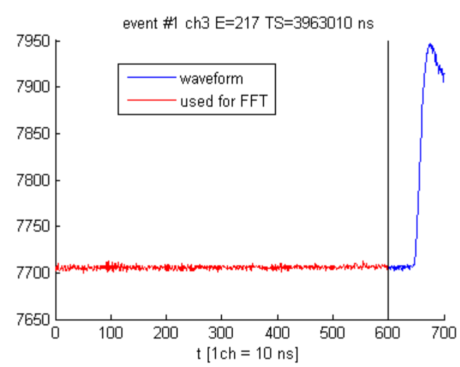


Figure 12: Sampled waveform of a triggered event. The first 600 channel were used for a fast furrier transformation.

in the count rate was observable. Occasionally, the count rate without a source was higher than with a source. Additionally, we could find several triggered events, that were just triggered by noise, i.e. without an energy signal. In order to reduce the noise shielding was added to the tig10. On both sides of the card copper sheets were installed inside the VXI crate. The front of the crate was completely closed with copper sheets and the top of the crate was covered with a aluminum grid. The grid was chosen to allow air flow through the crate for cooling. All the sheets were screwed together and connected with a grounding copper cable. This grounding cable was then connected to the ground of the rack. The FFT frequency spectra are shown in Figure 13 and Figure 14. Especially for frequencies higher than 40 MHz, shielding with copper

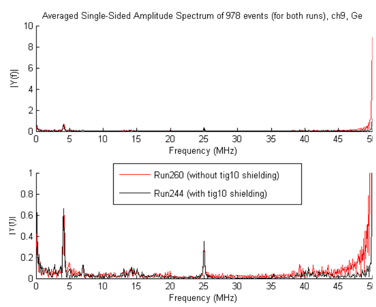


Figure 13: FFT frequency spectrum of the Ge detector BGND signal.

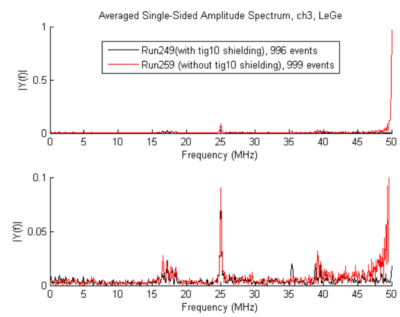


Figure 14: FFT frequency spectrum of the Ge detector BGND signal.

plates resulted in good noise reduction. For lower frequencies noise reduction due to shielding is very limited. Significant is the peak at 25 MHz that is present in all the spectra. According to Jean Pierre Martin, this peak originates from the sampling process. It should vanish if the K parameter is set to a multiple of 4. For these runs the K value was set to 200, so the noise at this frequency has to be of different origin. The full report of these tests is listed in the EBIT elog at message ID 94 and 95.

5.5 Coincidence test

Since the time stamp of an event is recorded, it was possible to create coincidences. This feature wasn't investigated in detail during the tests described above. So far, only coincidences of the same trigger event were used. During TITAN's ECBR run with ^{124,126}Cs it could be demonstrated that the coincidence condition works. Figure 15 shows the spectra of Ge detector on the left and Si (beta) detector on the right. The first row shows spectra without coincidence condition, while the second row exhibits the cleaned spectra with coincidence condition. In the last row the spectrum of the time difference between β^+ and γ event is illustrated.

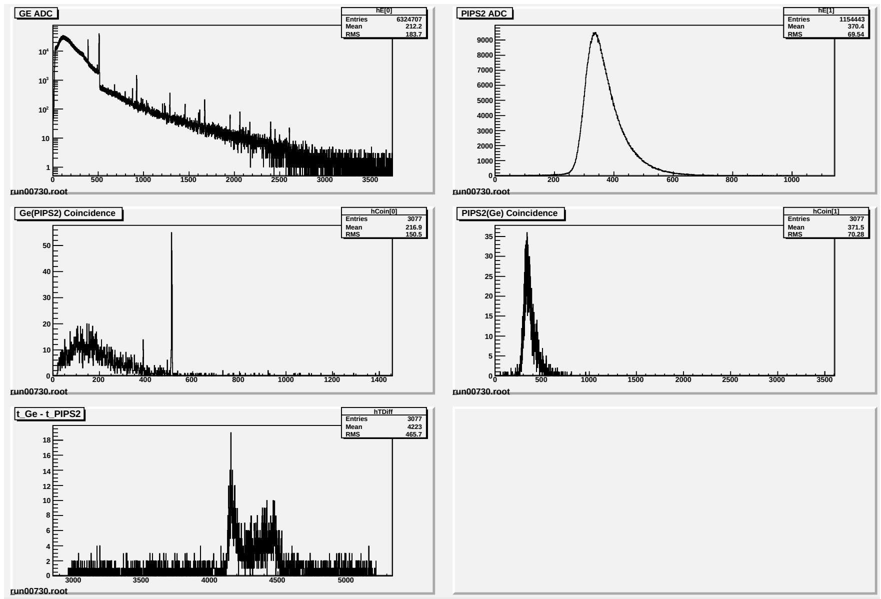


Figure 15: Coincidence spectra taken during the ^{126}Cs beam time. Gamma spectra of the Ge detector are plotted on the left, while beta spectra are plotted on the right. The first row shows the complete spectrum while the second row consists of spectra cleaned under the coincidence condition. The timing spectrum in the last row illustrated the timing between beta and gamma event.

6 PIPS detectors

Before the PIPS detectors[1] were installed in the EBIT, their performance was tested with an analog system and with the tig10. Due to a noisy environment (caused by the vibrations of the vacuum pumps) the tests were performed in the TIGRESS detector lab. An unsealed ^{207}Bi source (with an activity of 37 kBq measured on Sep. 15, 2004) was placed about 2.5 cm above a PIPS detector and β^+ and conversion electron spectra were taken. The vacuum in the chamber was around 20 mTorr. The analog system consisted of a Canberra Amplifier 2026 with a shaping time of $4\,\mu$s (coarse gain 10, fine gain 213) and a MCA. Figure 16 shows a spectrum taken with the analog system. Afterwards, a spectrum was taken with the tig10 ($K = 400$, $L = 480$). Table 13 compares the energy resolution achieved with both systems. The tig10's resolution is almost 50 % worse than the one of the analog system.

[1]Note that PIPS2 is NOT the small PIPS!

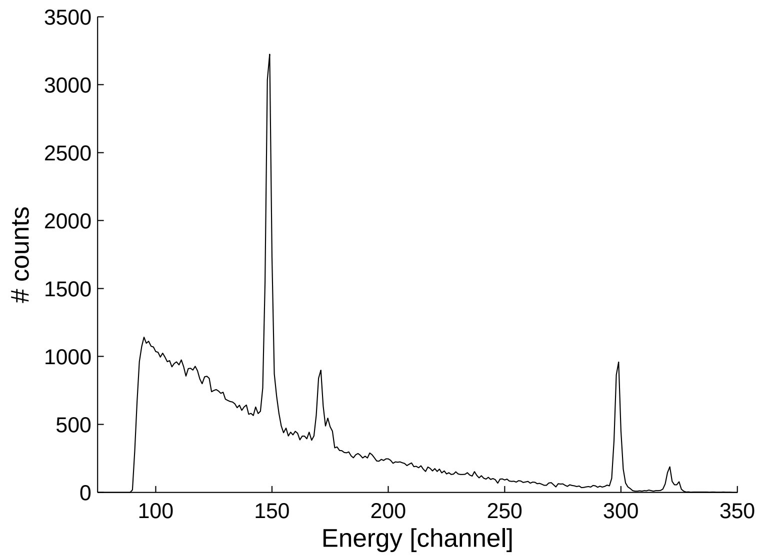


Figure 16: ^{207}Bi spectrum taken with the PIPS detector and analog electronics.

PIPS 1 (#75855)		
energy [keV]	FWHM analog [keV]	FWHM tig10 [keV]
481.69	11.0	14.7
975.65	10.6	14.6
PIPS 2		
energy [keV]	FWHM analog [keV]	FWHM tig10 [keV]
481.69	10.8	14.7
975.65	10.0	14.7

Table 13: Energy resolution of PIPS detectors for ^{207}Bi internal conversion electrons.

7 Conclusion

For TITAN's coaxial Ge detector the energy resolution of the tig10 for photons of more than 1 MeV is about 20 % worse than those of the DSPEC. In the energy region of 120 keV the resolution of the tig10 is about twice the resolution achieved with the DSPEC. Using a script to take spectra with the tig10 for different parameters resulted in optimized parameters to take gamma spectra. The quotients of peak areas were similar for tig10 and DSPEC. This gives confidence to determine branching ratios with Ge detector and tig10 for photon energies above 40 keV.
For photons with less than 40 keV the spectrum is dependent of the trigger threshold. This is an issue for applications at TITAN, since it prohibits one from observing X-ray spectra in the region between 15 keV and 30 keV. Copper shielding that got installed, reduced the high frequency noise but didn't improve the situation with the soft trigger issue below 40 keV.
The digitalization of a LeGe detector signal of a transistor reset preamplifier with the tig10 didn't perform well. The energy resolution of the tig10 in the region of $\sim$50 keV is twice the resolution of the DSPEC. For higher energies the resolution becomes comparable with the DSPEC being about 10% more precise. Comparing the quotients of different peak areas didn't result in any reasonable values. This might be due to electrical noise.

During the tests it became clear that the important points for TITAN's future spectroscopic DAQ are:

- Resolution of Ge and LeGe detector
- Performance of the DAQ with the coaxial Ge detector in the low energy range. Are peak heights between 5 and 40 keV dependent of the trigger threshold, e.g. is there a soft trigger threshold?
- What happens during the reset pulse of the LeGe's preamplifier? Is it possible, to also record the reset inhibit pulse on another channel and clean up the spectrum afterwards?
- Can we record the signal of betas hitting a PIPS (Si surface barrier) detector? Can we create a coincidence between betas and gammas?

A lot of people spent time and energy on these tests. First we would like to thank the TIGRESS group for borrowing us tig10 card and VXI crate. Thanks a lot also to Pierre Amaudruz, Scott Williams and Chris Pearson, who spent many hours trying to adopt the tig10 to our needs. Thank as well to Aaron and Stephan, who spent days in analyzing spectra and trying to figure out what's happening with the detector signals inside the tig10.

A tig10 parameter scan

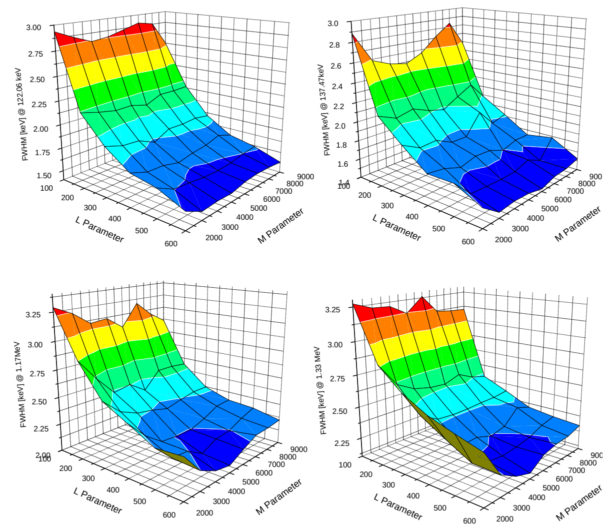


Figure 17: K-L-parameter scans for different photon energies taken with tig10 and Ge detector.