Tau projection, B-field estimation and automatic half-cycle rejections

Preliminary report (March 8th 2001)

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Summary

A new software is completed. It has quite a number of new features including Tau projection, experimental B-field estimation and automatic half-cycle rejections. It is worth noting however that the author was unable improve in any significant manner the baseline correction (see history below). It is believed that half-cycle asymmetries and other defects are making a more accurate baseline estimation difficult. Further research is needed.

Software summary

The library can now read directly into a THEM DAT file. A very simple yet efficient high-level API was developped (classes THEMFile and THEMFilter) to read and process THEM DAT Files. See software documentation for further information (file mhelp.chm).

Without tau projection (not recommended)

In order to make results easier to compare and understand, we start by showing results we get without tau projection (but the baseline was corrected, there was the usually stacking over 6 half-cycles and some wavelet shrinkage was also applied). The data of the Bob2.dat was used.

Figure 1. Typical off-time response without tau projection. Please note that raw data is usually presented on a larger scale (notice the values on the y axis).

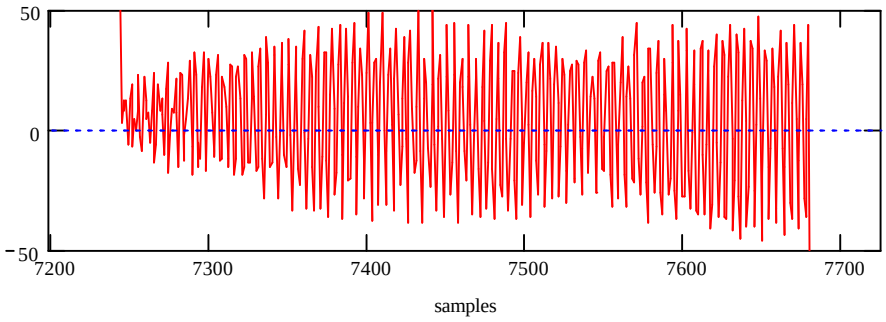
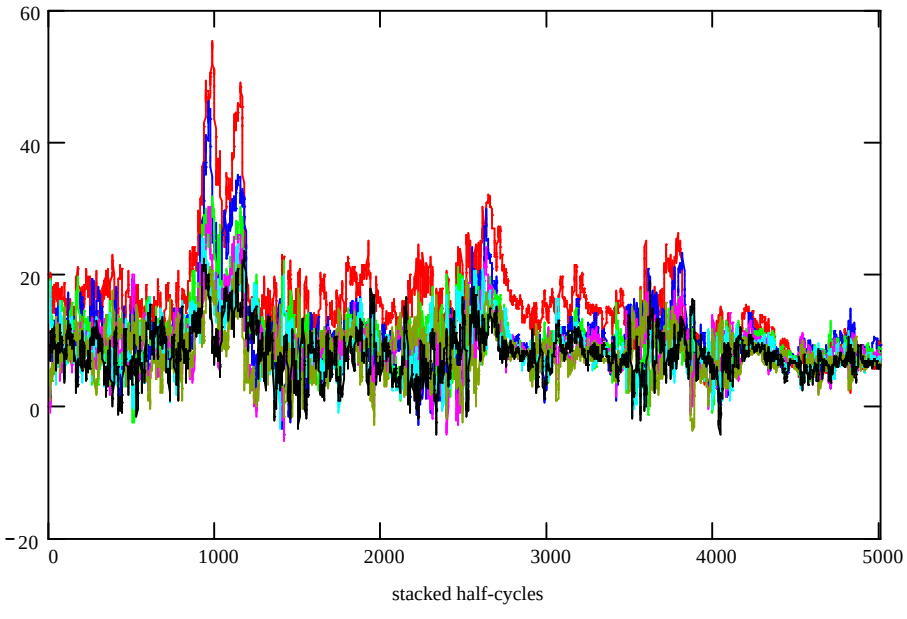


Figure 2. Channels without tau projection. As in other channels in this document, a narrow lowpass filter was used: running average over 10 samples. A more aggressive lowpass filtering would normally be recommended, but this figure should serve as a basis for comparison with what follows.



Tau projection (recommended)

While we can still see some residual lowpass problems in the off-time response, the tau projection works well and allows us to get clean channels with little effort. The only drawback seems to be that such an algorithm requires a fair amount of CPU cycles. From a research point of view, the tau projection allows us to see easily what is going on in the signal itself without having to worry about excessive high frequency noise. It should provide us with a very good foundation for future work. At the processing level, it is hard to imagine a better way to clean the signal.

Figure 3. Typical off-time responses after applying the tau projection (and stacking over 6 half-cycles). The signal is always rounded off to the nearest integer so that apparent small discontinuities in the signal should be ignored.

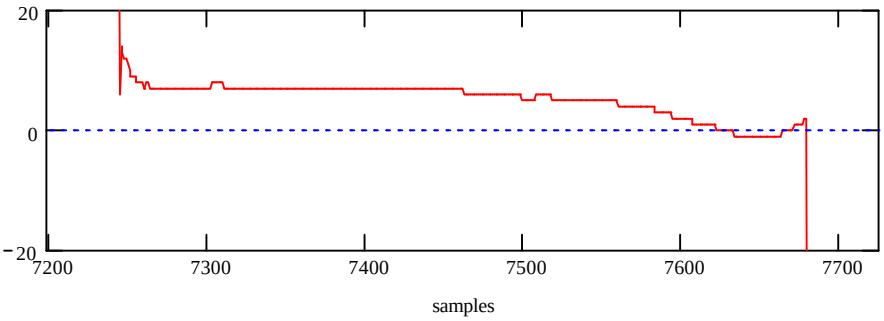
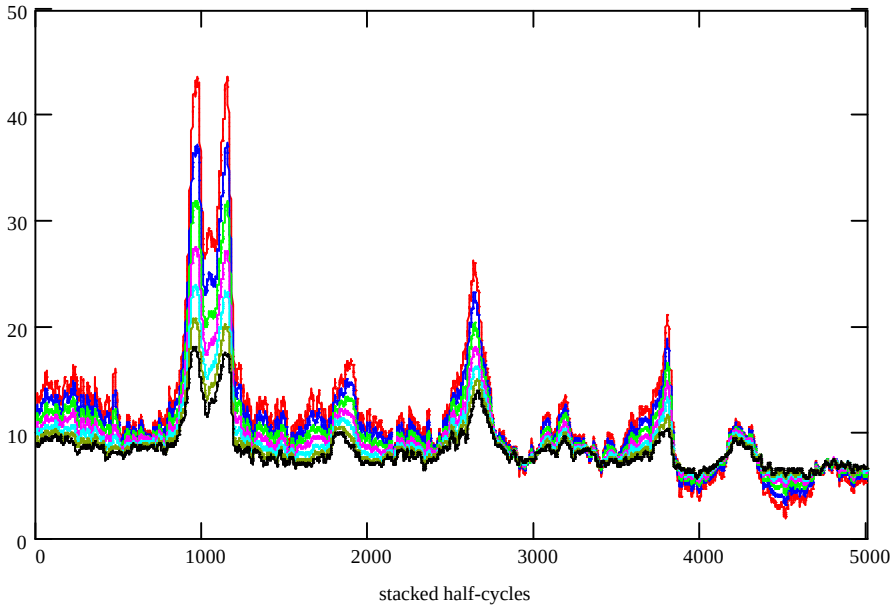


Figure 4. Some channels from the Tau projection (a running average with a window of 10 stacked half-cycles or 60 raw half-cycles is also applied).



B-field estimation

Still very much experimental, we achieve what seems to be an accurate estimation of the B-field: looking at the channels show that the anomalies are still visible (compare Fig. 4 with Fig. 6). Unfortunately, the results are not entirely convincing when looking at the channels only (anomalies are difficult to see), but the typical off-time response (see Fig. 5) is certainly very nice.

Figure 5. Typical off-time response after processing (stacked over 6 half-cycles). Notice how monotonic the response is and how little noise is present. The amplitude of the off-time response is higher in the B-field estimation.

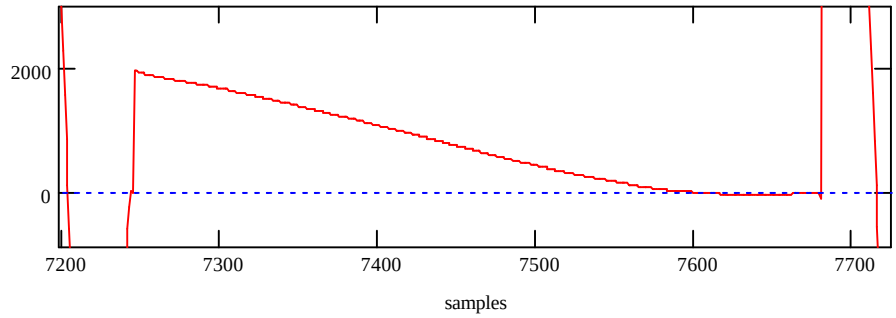
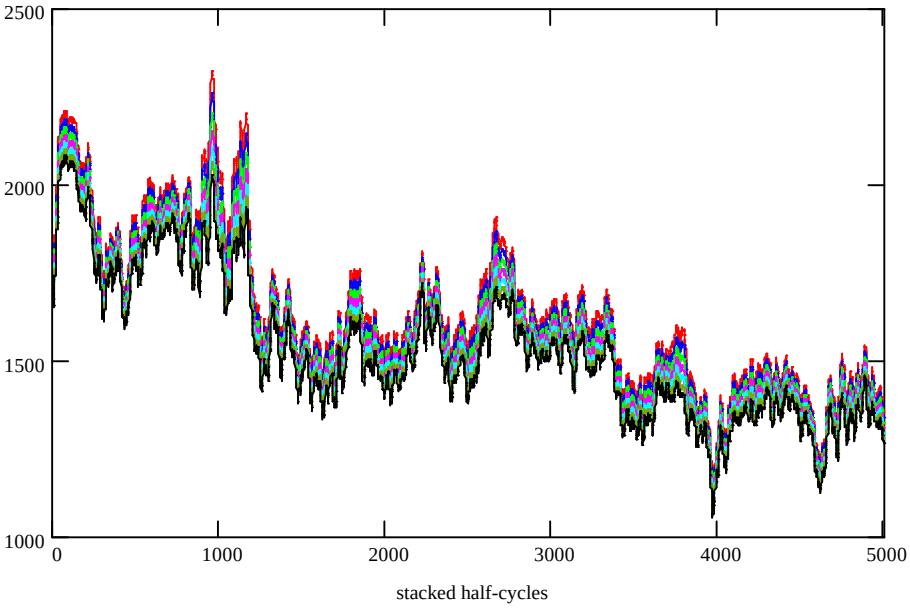


Figure 6. Some early channels for B-field estimation of stacked half-cycles (each channel amounts to 2 samples of stacked half-cycles). Interpretation seems difficult at this point. Further research is needed.



History

March 8th 2001

Some prototypical B-field is not in place and tested (class IntegratedTauProjection). While it clearly works and provide stunning results, interpretation of the channels doesn't seem obvious at this point.

It should be noted that IntegratedTauProjection, just like TauProjection are expensive procedures and while the algorithms are robust and fast, it just takes a long time to do all the computations. Memory usage should be extremely low (please use the THEMFilter and THEM File classes as examples!).

March 5th 2001

Added ExtendedSIMn which derived from SIMn. Should provide a better baseline eventually? Worked during simulations, but doesn't work with real data most certainly because of the half-cycles asymetries which weren't taken into account in the modelling.

February 15 th 2001

I've added the GMRES algorithm and a few matrices and vectors to the lot. This allows us to proceed with the TauProjection class which should prove interesting. I hope to finish the BiSIMn algorithm which would correct the baseline over a full cycle (I'm hoping the result will be a notch above what we have right now).

I'm also improving the stacking by using the median to stack (instead of the average). This provide automatic rejection of bad half-cycles.

January 18th 2001

Corrected a stupid bug in the computation of the median (see SpecialMath class).

January 17th 2001

Added a Downsampling class and also modified slightly the SIMn class.

We can now import the data directly through DAT files. The library can now serve as an extractor!

January 12th 2001

- Checked the Wavelet Shrinkage for bugs.
- Changed all the memmove to memcpy (where do these memmove come from?)

January 11th 2001

- Converted all of the headers to the new namespace headers.
- Reading and writing binary files has been optimised (wewere actually reading and writing one sample at a time which is pretty stupid).

January 10th 2001

Changed memory allocation to handle failures more efficiently. (Replaced new by new(std::nothrow) wherever it was applicable and caught exceptions elsewhere.)

January 9th 2001

Changed name of precompiled headers class from StdAfx to PrecompHeader.