"Fast" Relaxation in Low Energy Muons Experiments

D.G. Eshchenko

Abstract

The analysis is based on the year-2003 data (Cu, Stainless steel and Ni), where all 4 histograms were collected. Fits were done by WKM program using a "separate histograms" grouping. This approach enables to follow the muon spin precession/evolution in details and to distinguish between "physical" and "systematic" fast relaxation. Some practical methods to measure "physical" fast relaxation are summarized.

1 Conclusions based on Cu experiments

There is no fast relaxation in the bulk Cu. That is why the fast relaxing signal in Cu is supposed to be "systematic".

Due to the pronounced relaxation in zero field (at T=20) it is possible to do fits with the single histograms grouping both for TF and ZF fields.

Experiments were done both with "guards on" and "guards off" regimes which makes it possible to compare different deacceleration regimes.

There is no fast relaxation down to 4keV in any regime (see Figures 1,2 for example).

At lower energies and "guards on", there is a "distortion" in *all histograms* looking like *an increase* of counts at early times. Note that for "a physical" process (muon is inside the sample or at/close to the sample's surface) the increase of the counts in the histogram number 1(2) should be accompanied with similar decrease of the counts in the histogram number 3(4).

In the "guards off" regime these distortions go down and **there is no fast relaxation/distortion for this regime in the histogram number 3.** See graphs 3,4,5,6 for the refference.

Conclusions:

- Always use "guards of" regime for energies less than 4 keV.
- Always use the histogram type of fits instead of the asymmetry grouping to check is the "fast" relaxation physical or not.

Some useful fits for the "physical" signal are shown in Fig 7, 8.

2 Conclusions based on Stainless Steel experiments

There is a mixture of physical and systematic fast relaxation in Stainless Steel.

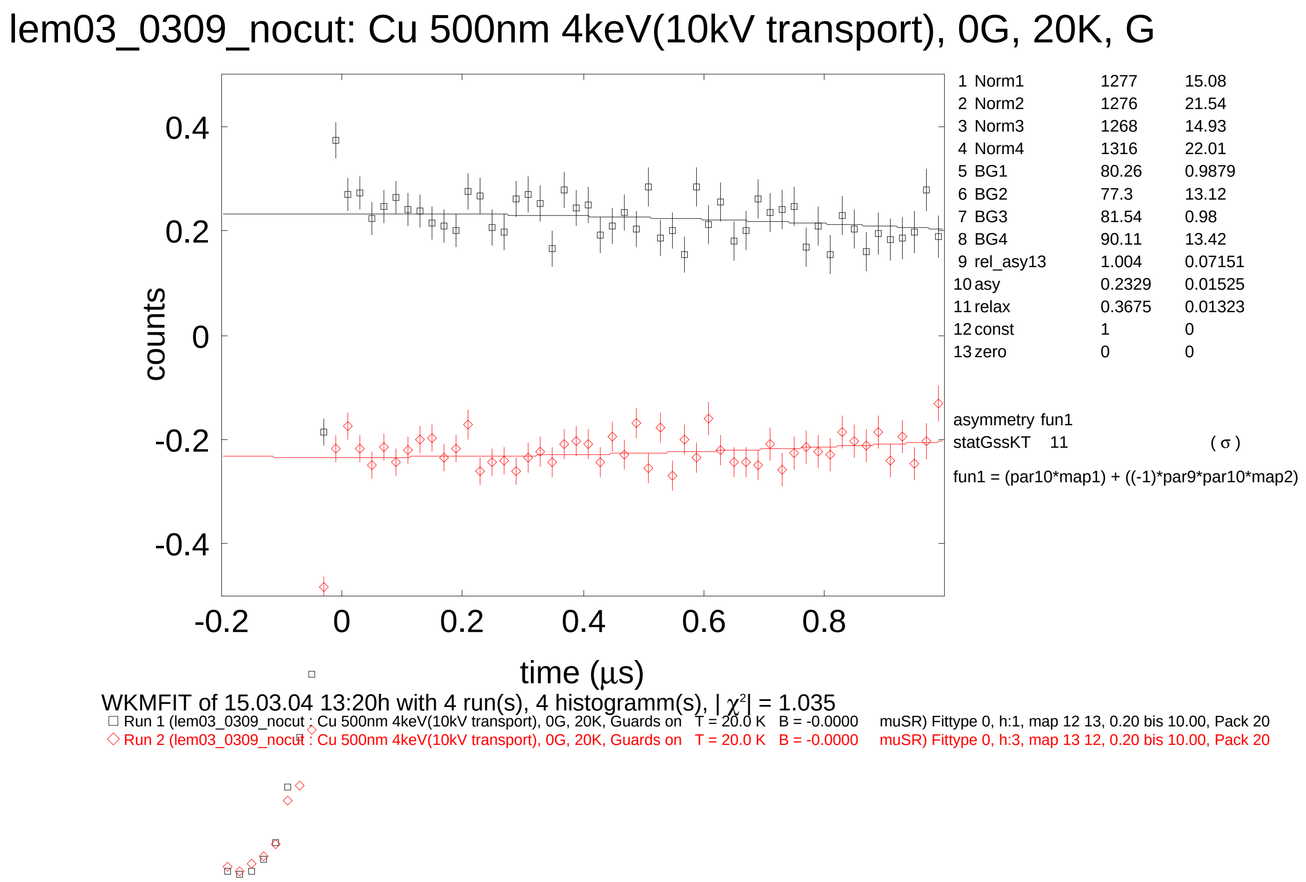
In the bulk (at T=20K), there is a very fast physical relaxation. Analysis shows that histogram number 2 is bad - there is no physical fast relaxation in this histogram. *One have to exclude early times of this histogram from the fit (see graphs 9,10 for details).* This finding is confirmed by Ni data (see Fig. 11)

In Stainless Steel, near the surface the slow relaxing signal amplitude increases. This is compliment to the Cu signal (see Fig 12)

Slow relaxing signal in Stainless Steel is temperature dependent (see graph 13).

Conclusions:

- In the year-2003 data fits skip first 20 ns in the histogram #2.
- Due to the very fast depolarization at low temperatures, the stainless still foil can be used as a substrate for the small samples at $T < 40$ K and down to 1.3k eV muon energy (until the "physical" relaxation in the sample is less than 50 MHz).



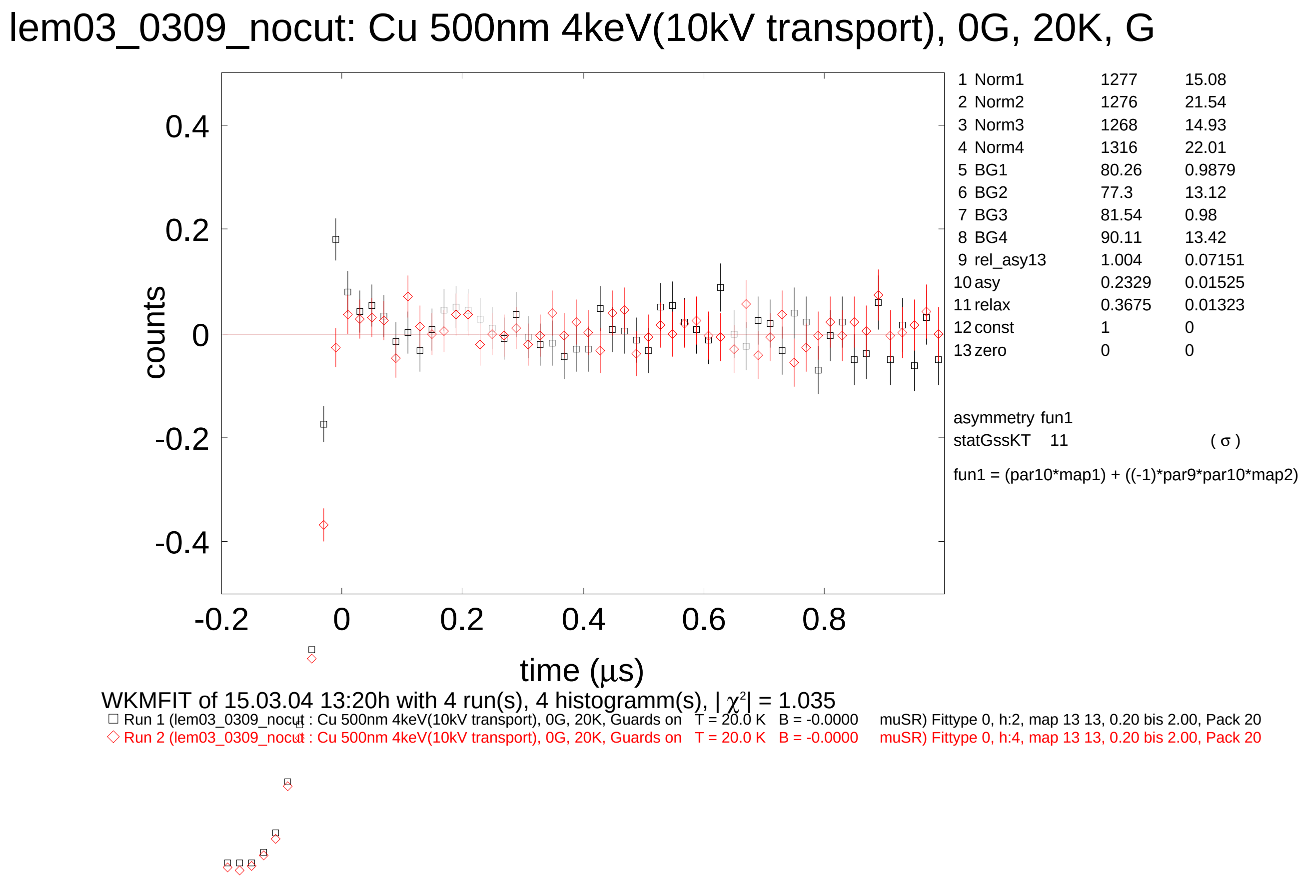
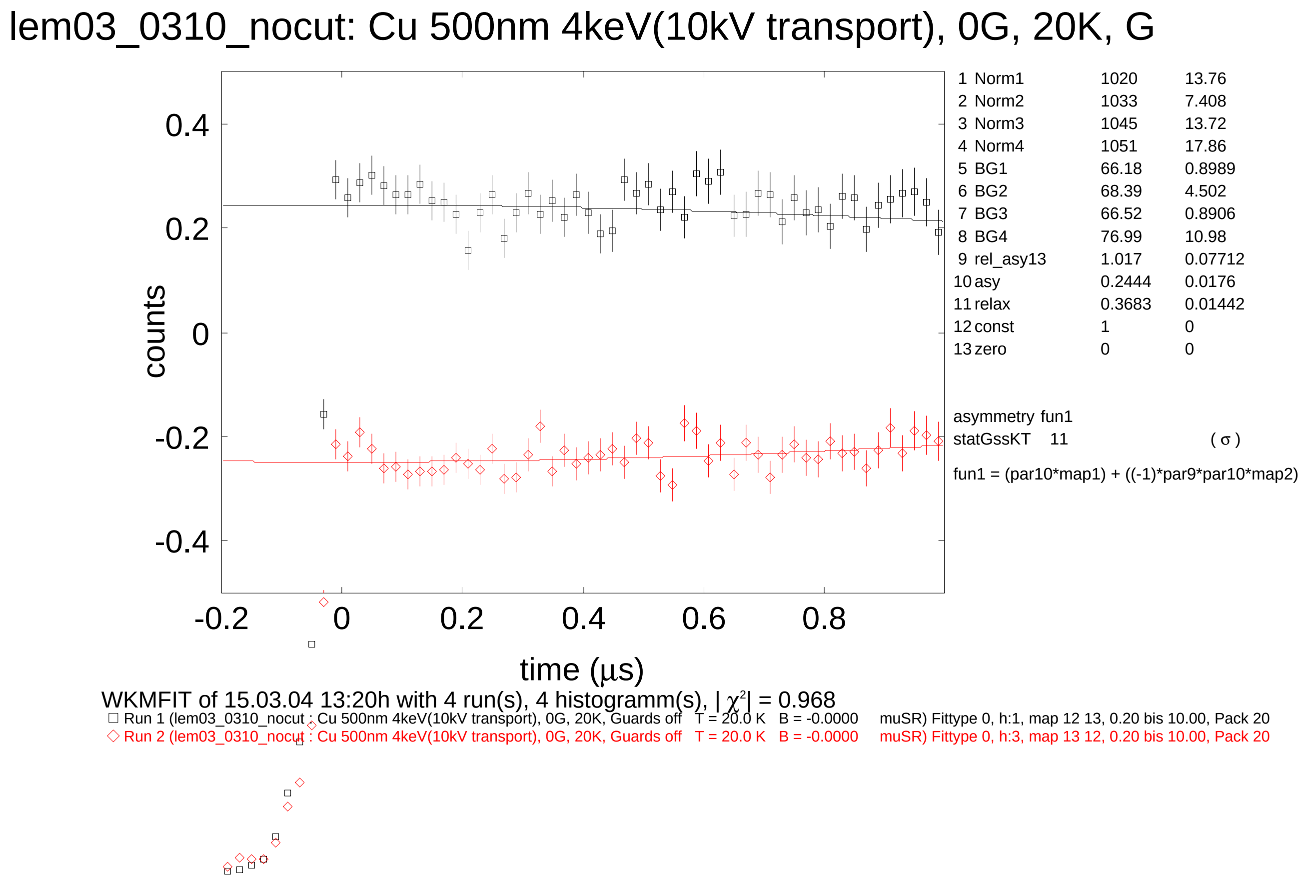


Figure 1: Cu ZF 20K E=4keV 10kV transport, guards on.



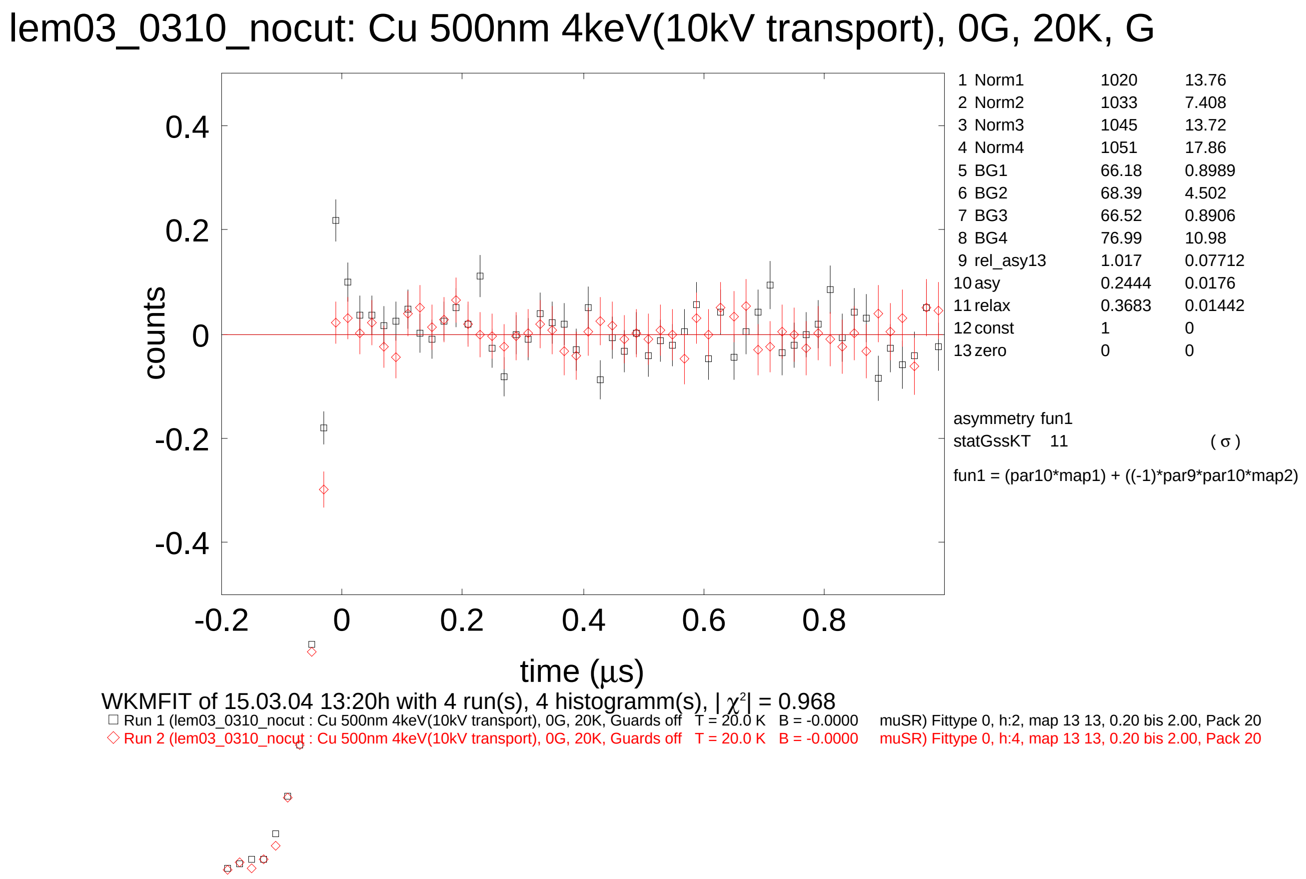
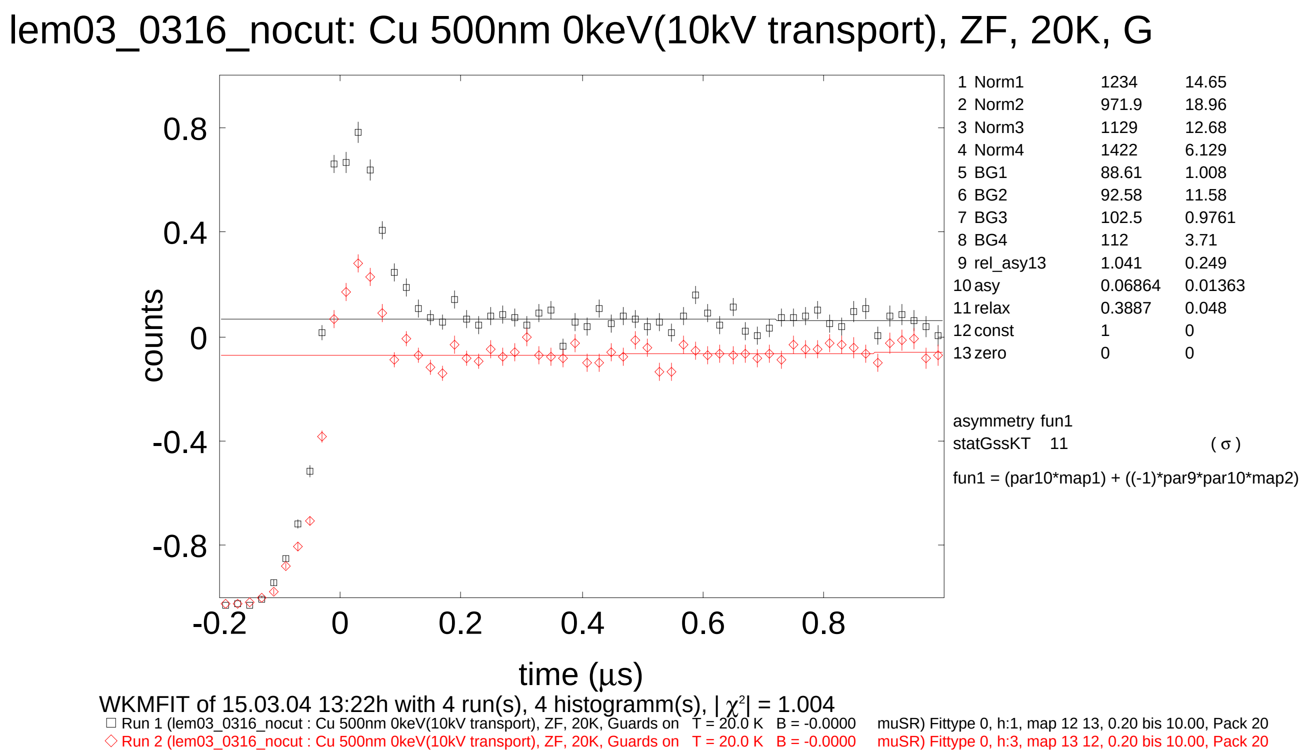


Figure 2: Cu ZF 20K E=4keV 10kV transport, guards off.



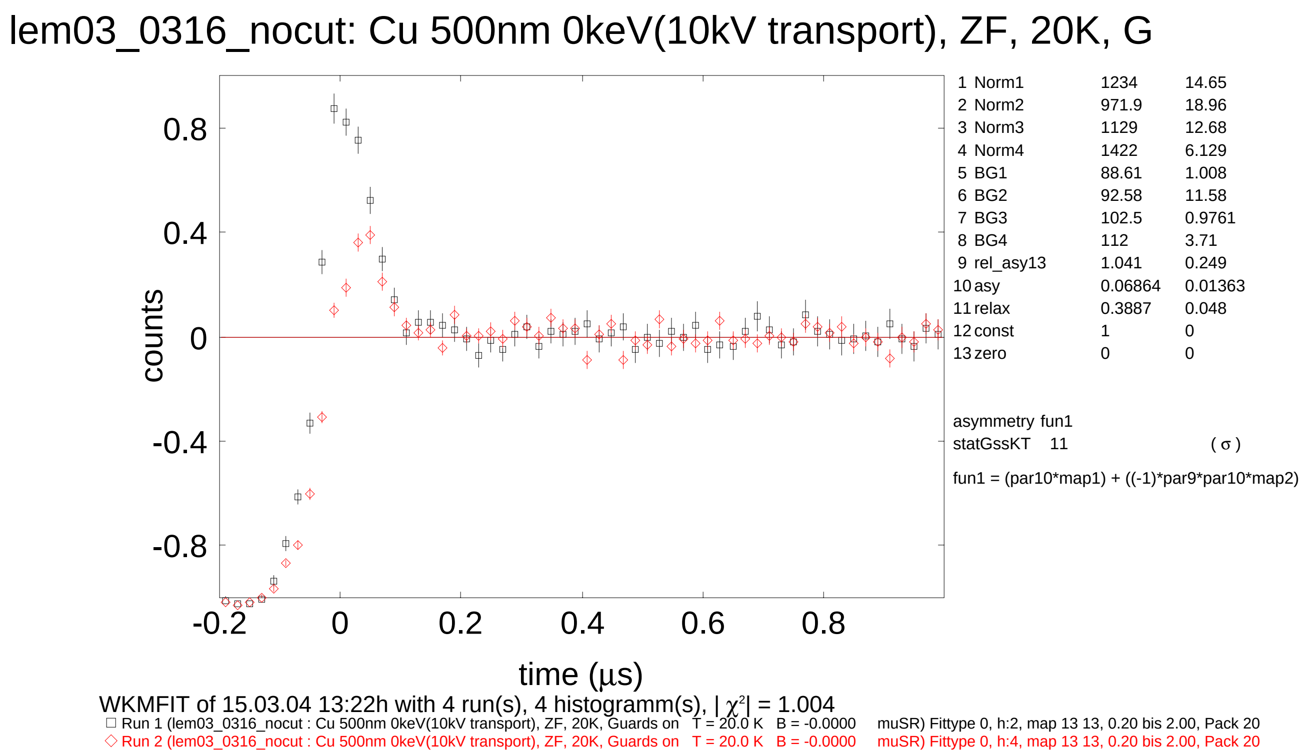
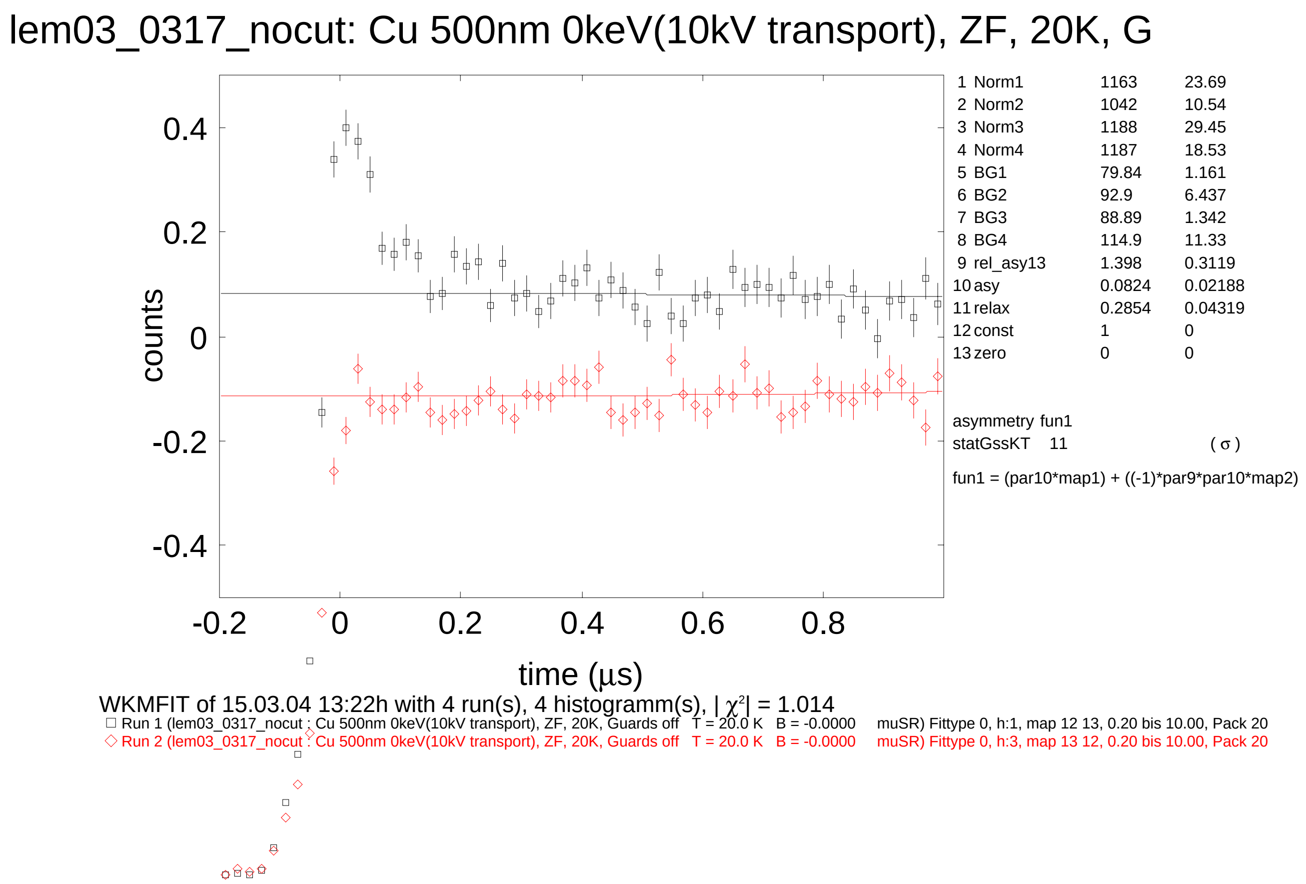


Figure 3: Cu ZF 20K E=0keV 10kV transport, guards on.



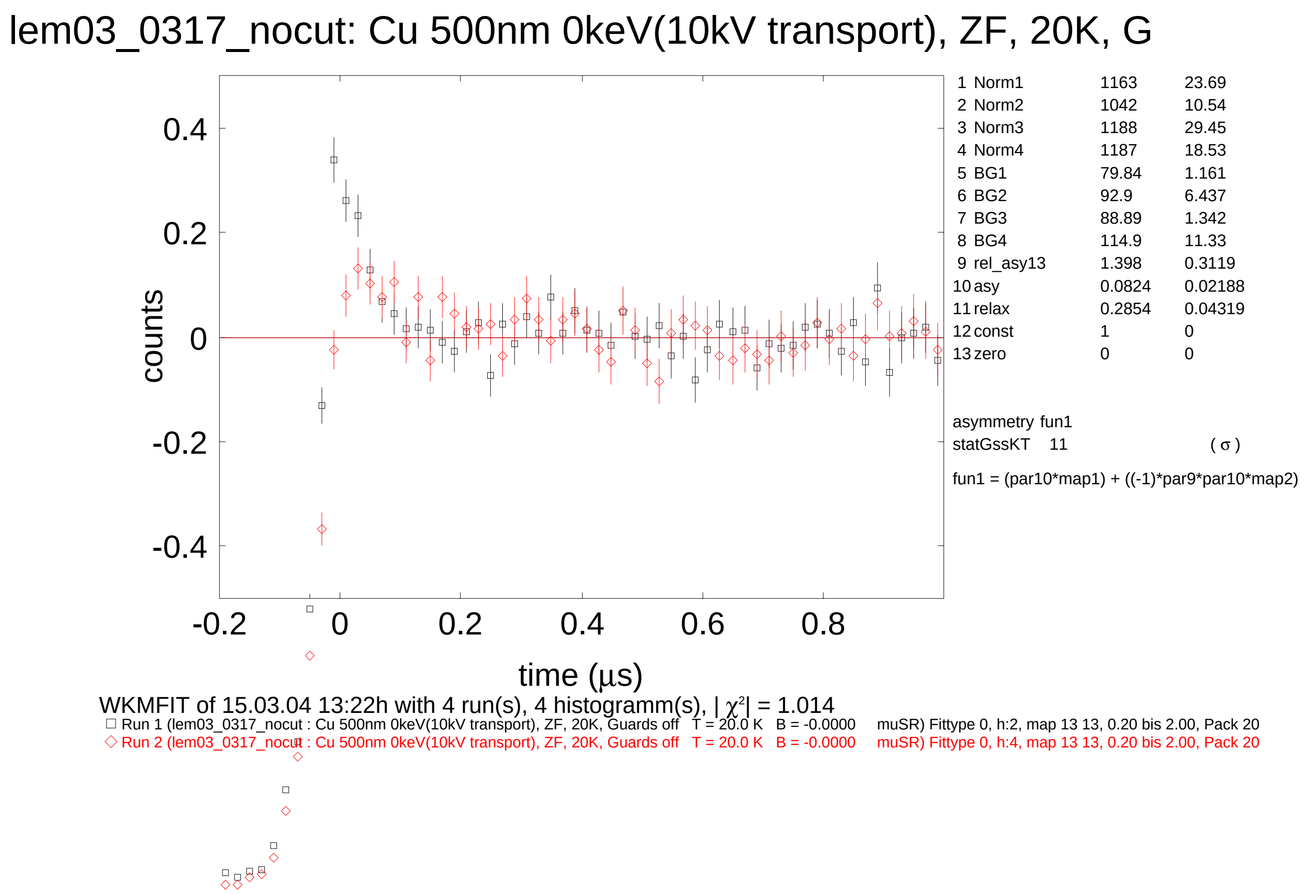
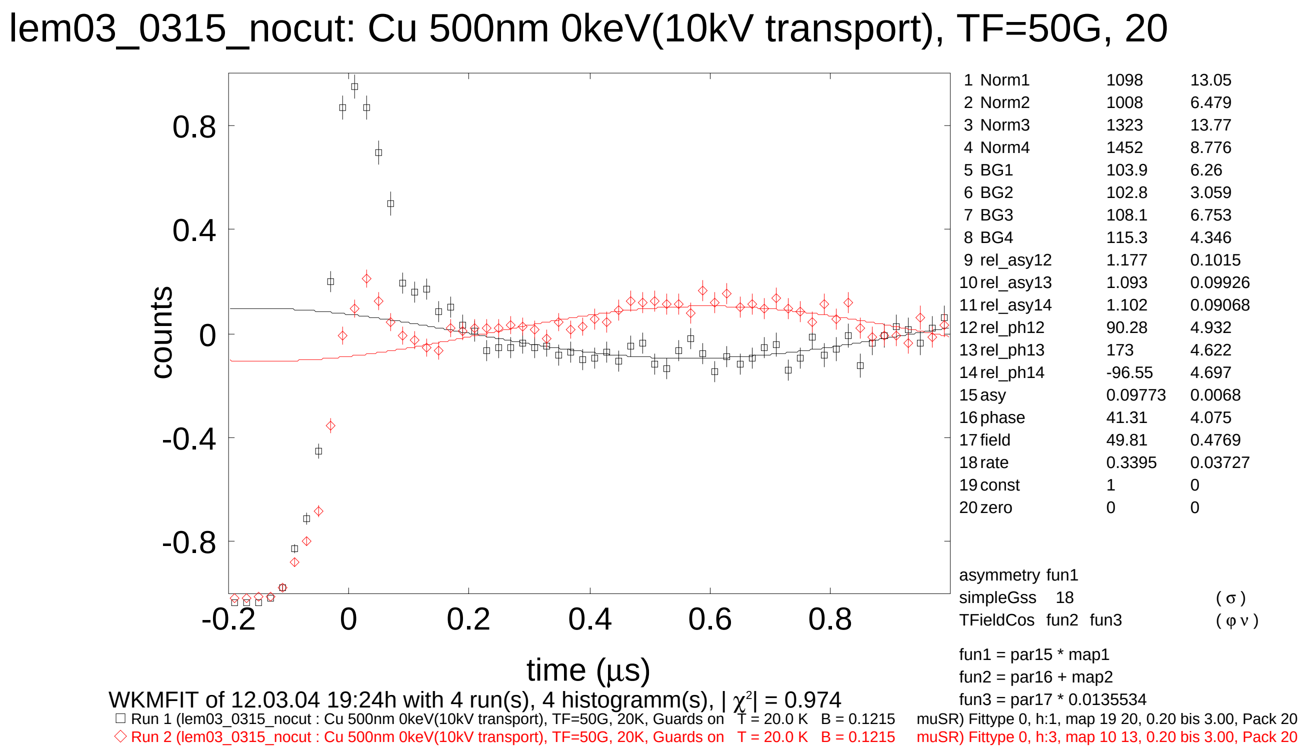


Figure 4: Cu ZF 20K E=0keV 10kV transport, guards off.



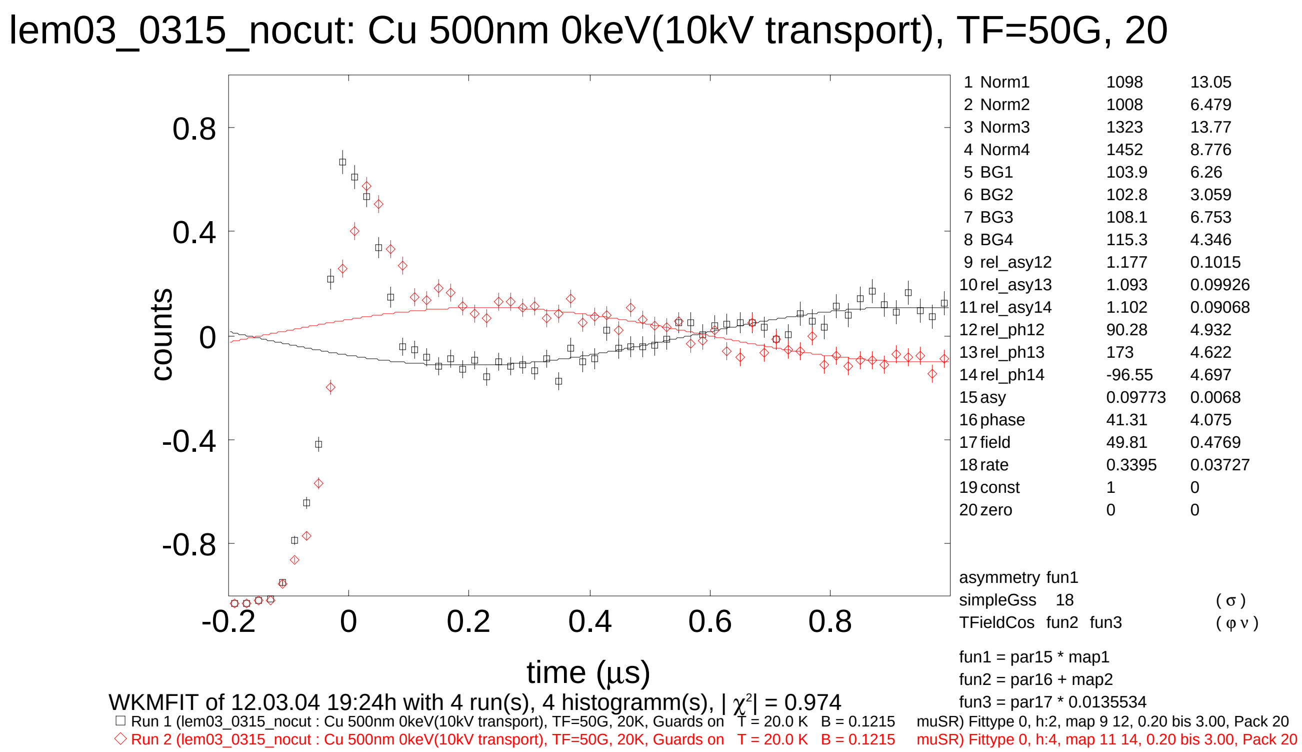
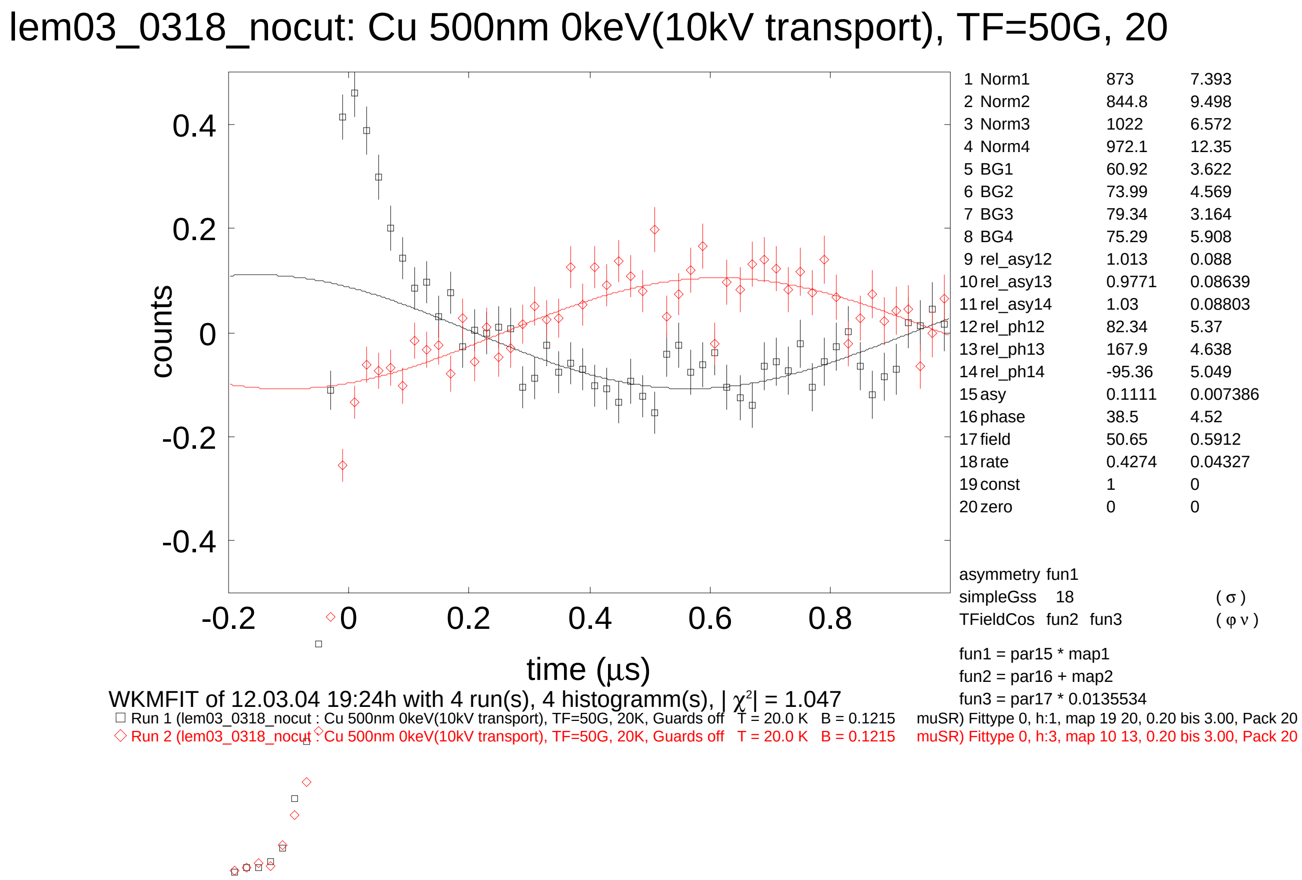


Figure 5: Cu TF=50G 20K E=0keV 10kV transport, guards on.



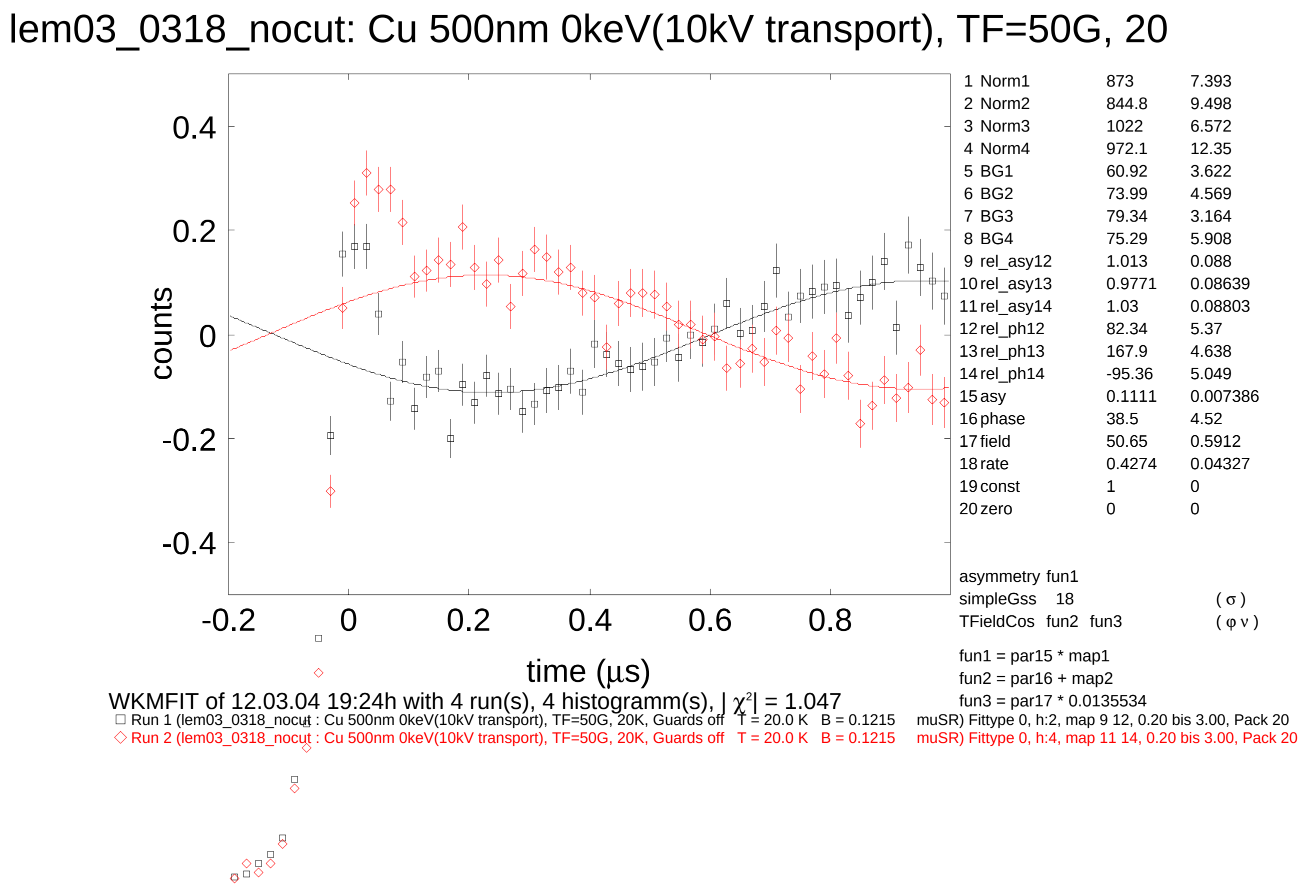
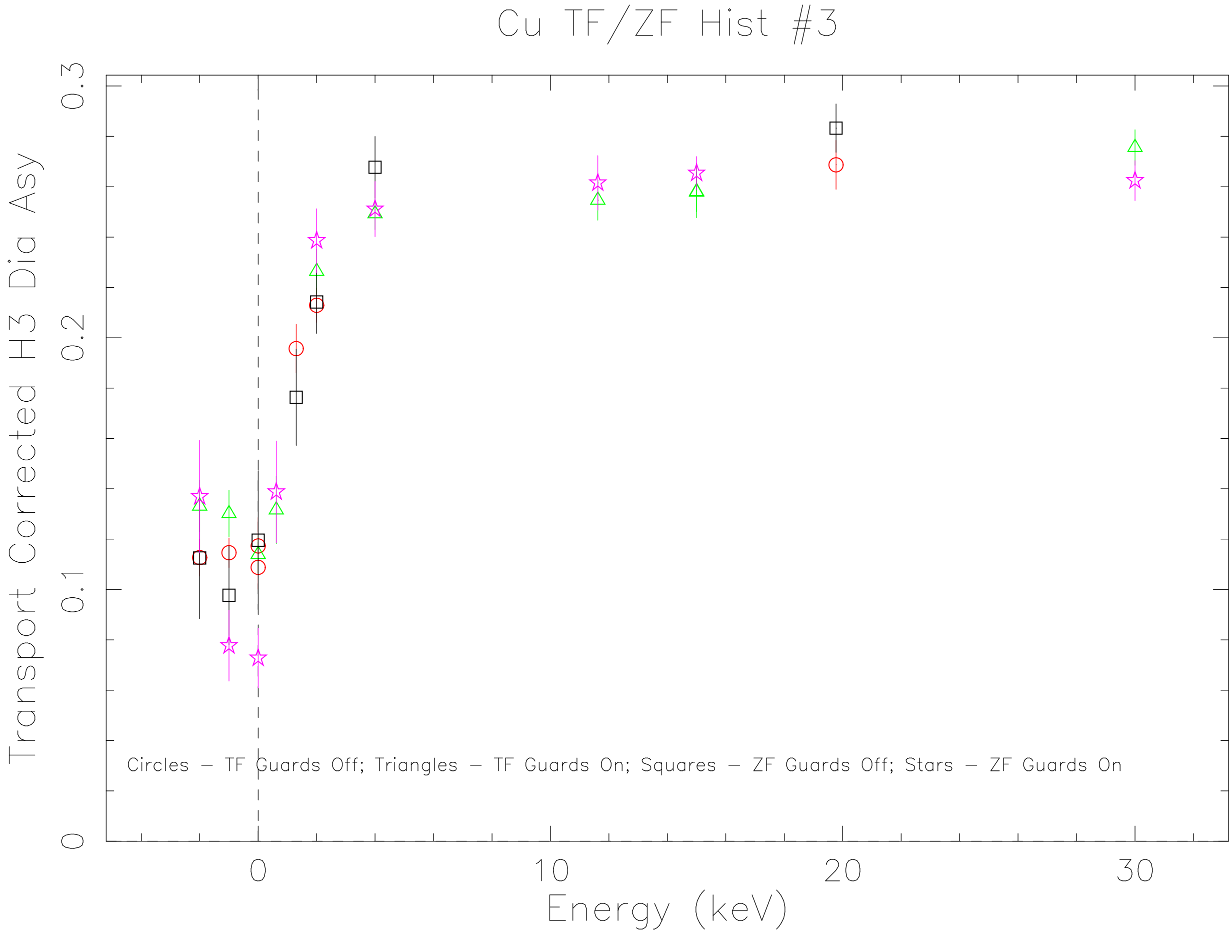


Figure 6: Cu TF=50G 20K E=0keV 10kV transport, guards off.



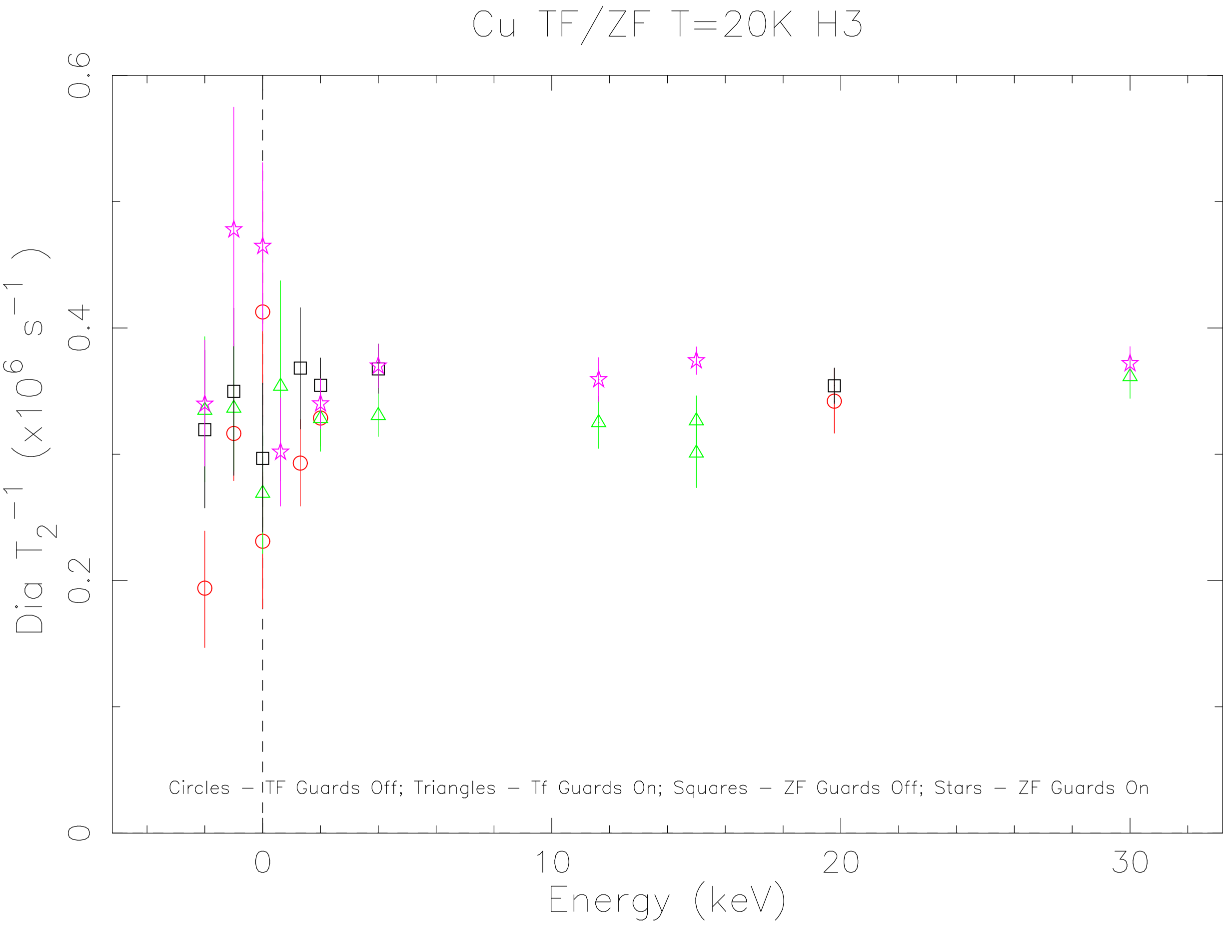
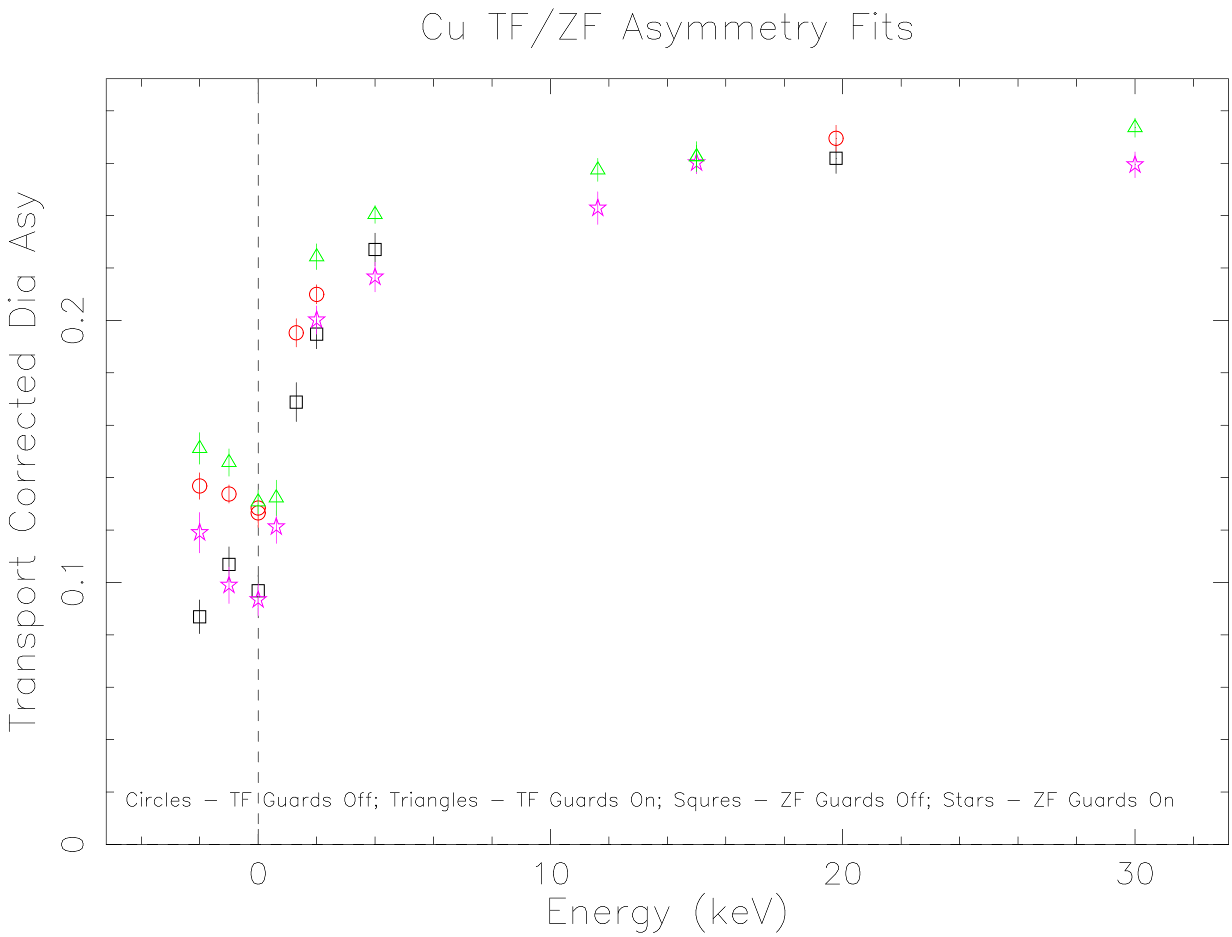


Figure 7: Cu TF=50G and ZF H3 fits. One can see no difference between TF and ZF data.



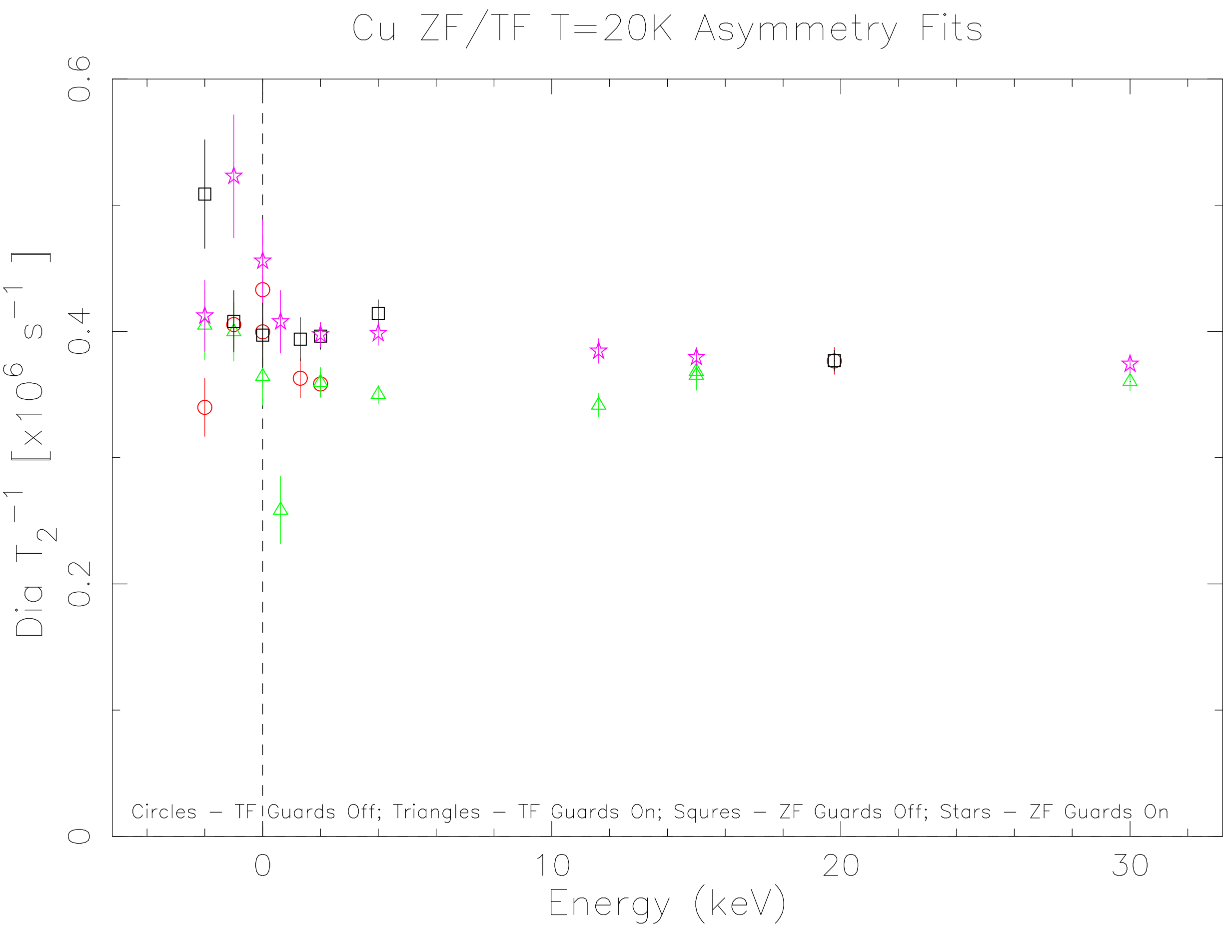
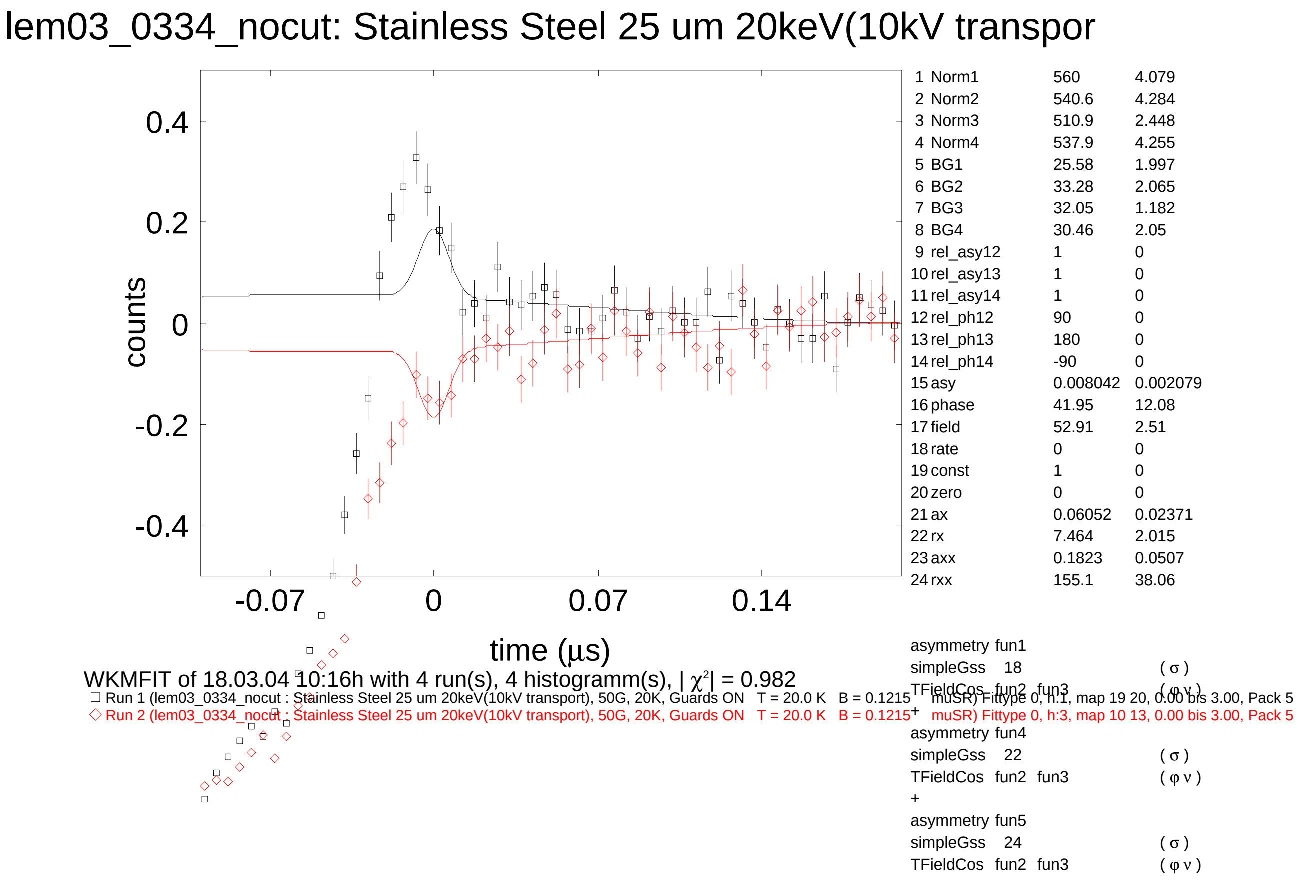


Figure 8: Cu TF=50G and ZF 1324 asymmetry fits. One can see that TF and ZF data are very close.



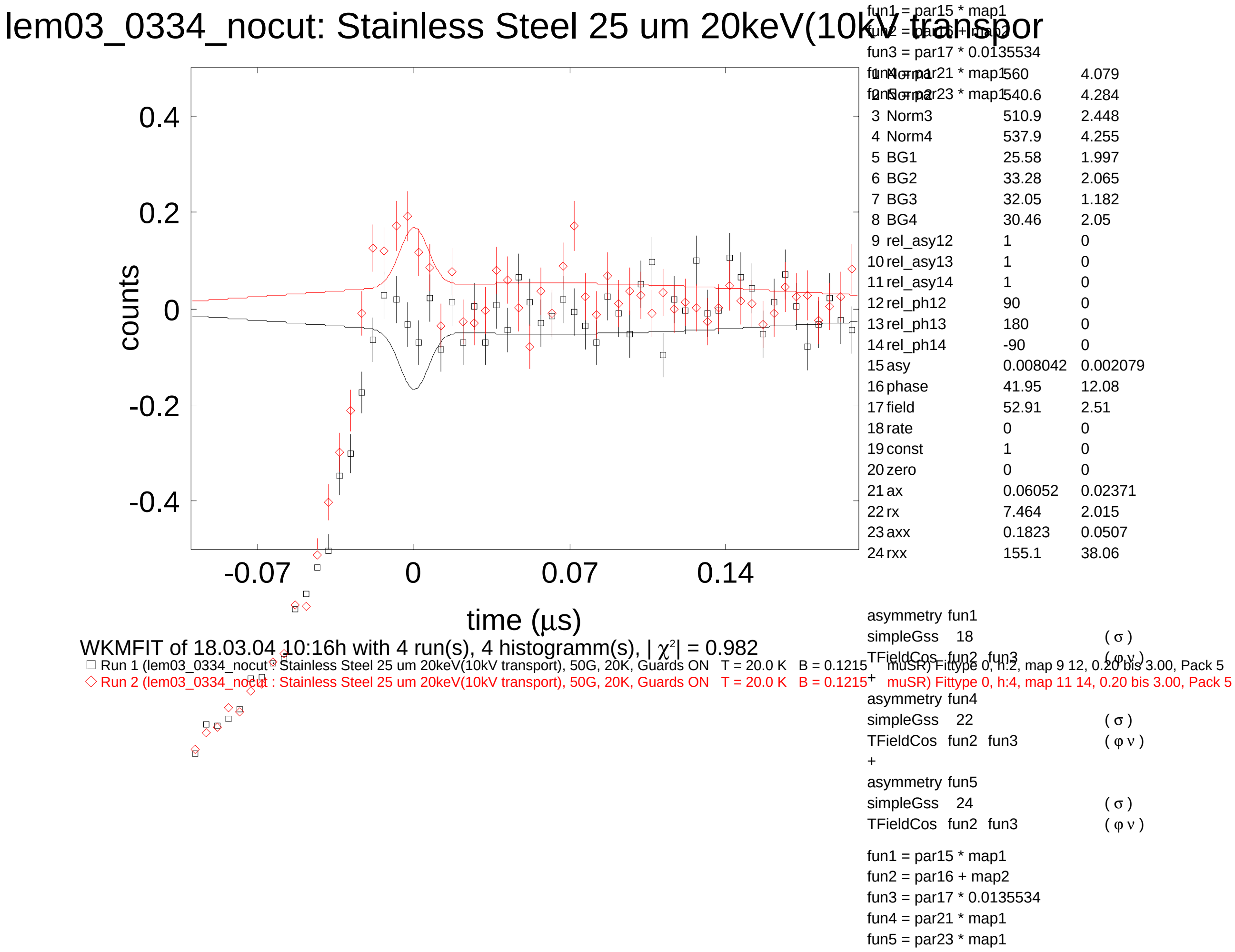


Figure 9: Up: histograms #1 and #3 are fitted with common fast relaxation. Down: this fast signal is ploted (not fitted) for histograms #2 and #4. One can see mismatch between the plotted theory and data for the histogram #2.

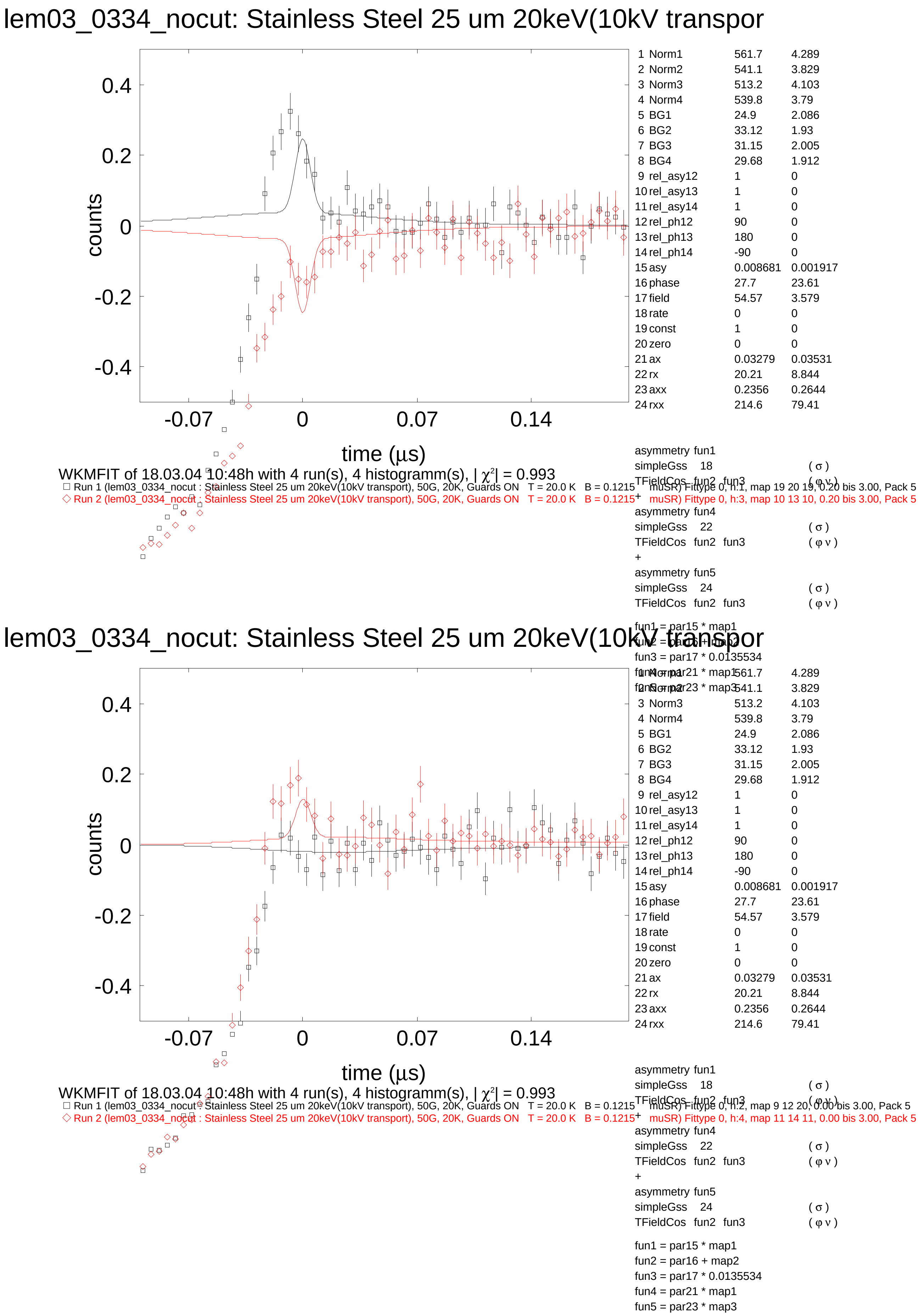
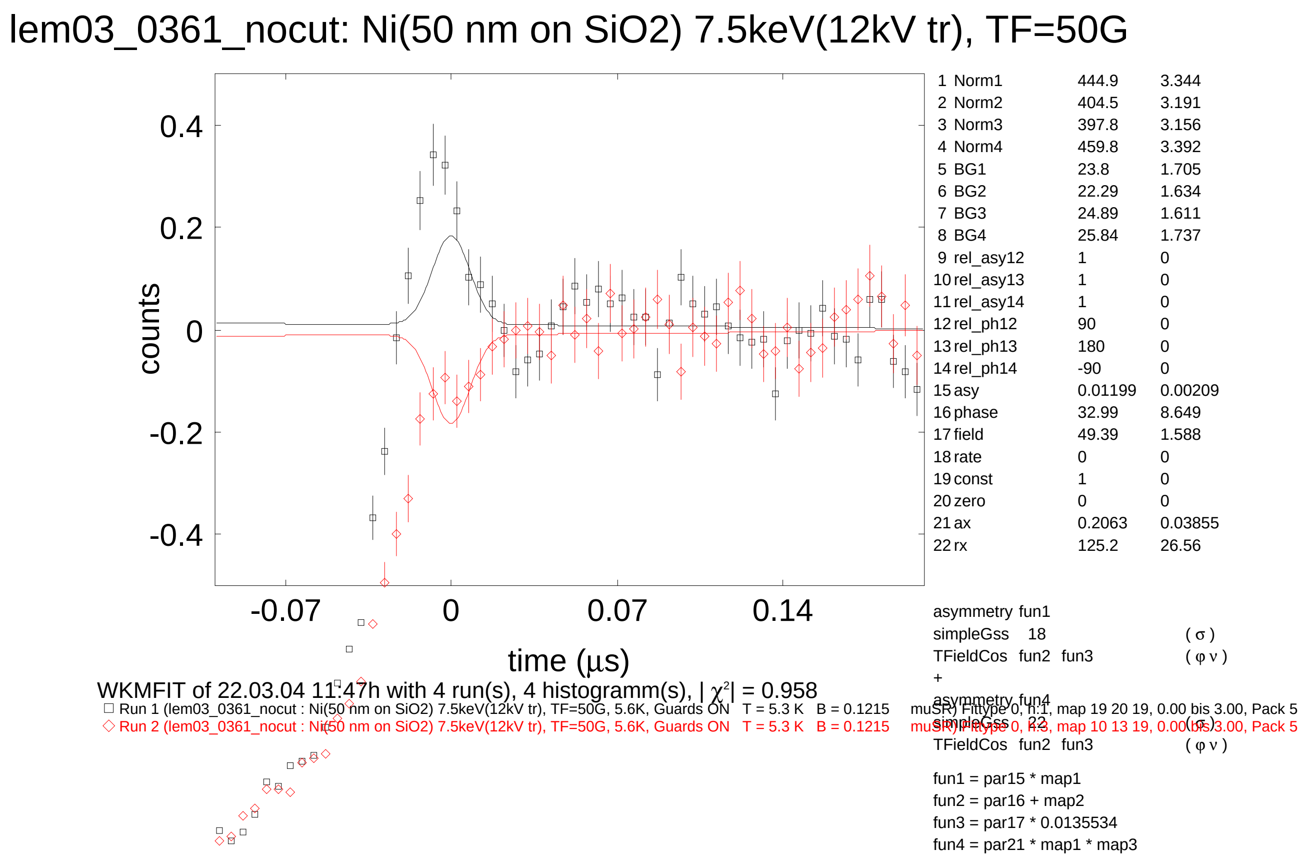


Figure 10: Down: histograms #4 is fitted with fast relaxation while the signal in histogram #2 is forced to be slow relaxing; Up: fast relaxing signal from histogram #4 is plotted for histograms #1 and #3 in a good agreement with experimental data.



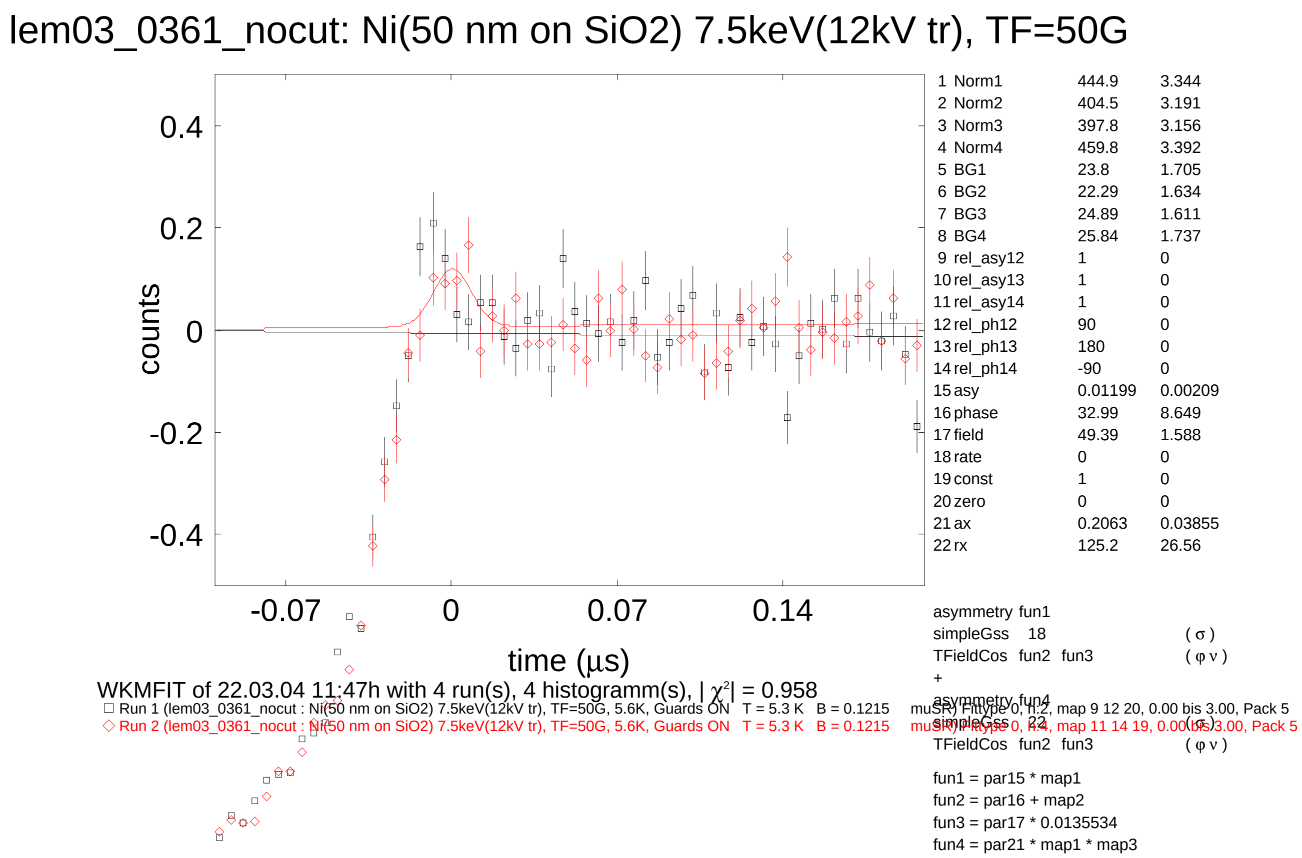


Figure 11: Ni at 5.6 K. Down: histograms #4 is fitted with fast relaxation while the signal in histogram #2 is forced to be slow relaxing; Up: fast relaxing signal from histogram #4 is plotted for histograms #1 and #3 in a good agreement with experimental data.

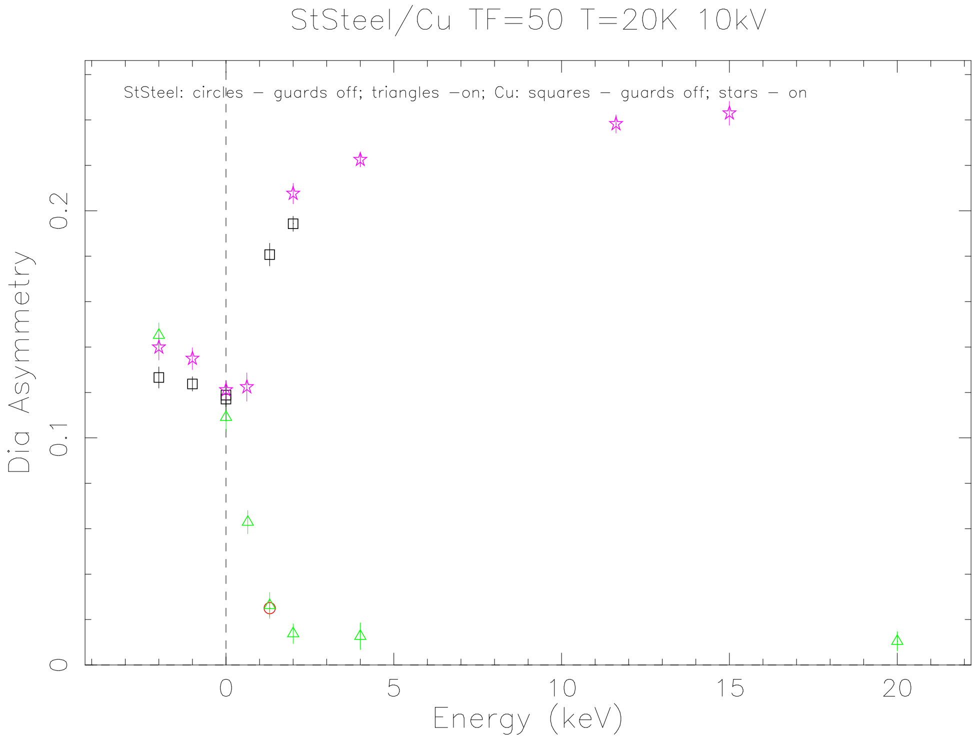


Figure 12: Energy dependences of the slow relaxing diamagnetic asymmetry in Stainless Steel and Cu measured at T=20K in TF=50G.

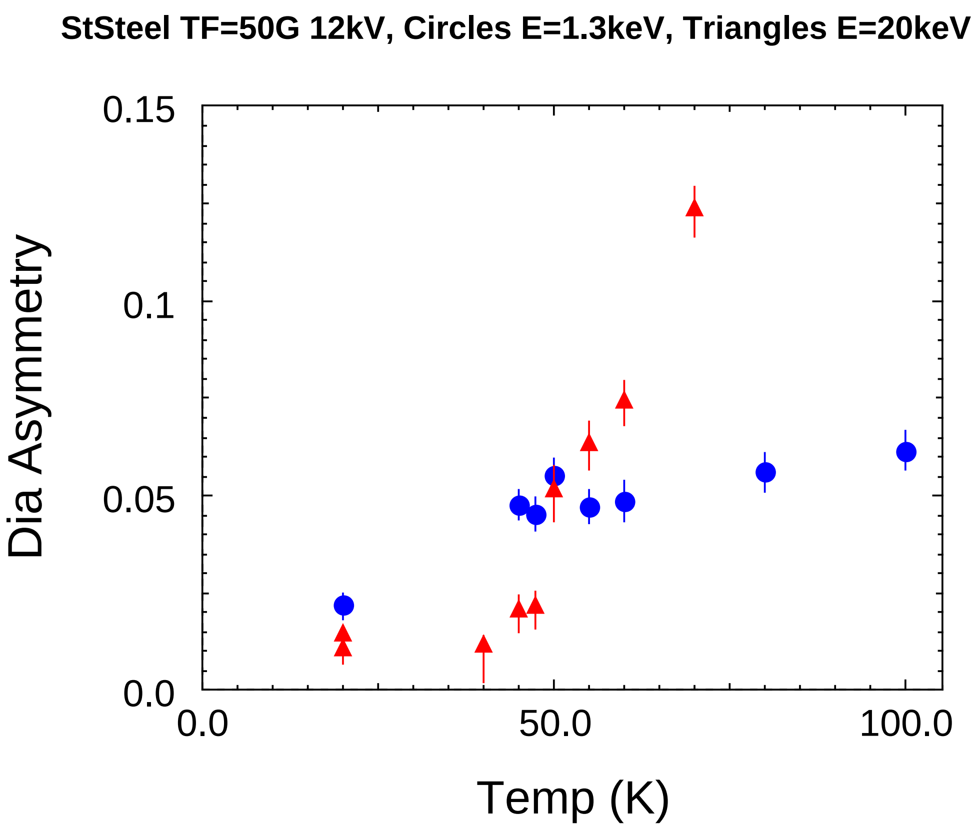


Figure 13: Temperature dependences of the slow relaxing diamagnetic asymmetry in the Stainless Steel foil.

```
278      600.6k 11.62keV Cu 50G rings on
279      605.9k 11.62keV  H=0G  rings on
280      634.6k Cu 500nm 0.62keV  H=0G 20K, sample rings are on
283      239.4k Cu 500nm 0.62keV(10kV transport)  H=50G 20K, sample rings are on
298      503.9k Cu 500nm 19.77keV(20kV transport)  H=50G 20K, Guards off
299      536.4k Cu 500nm 19.77keV(20kV transport), ZF, 20K    Guards off
300      752.9k Cu 500nm 30keV(20kV transport), ZF, 20K, beamline tests Guards on
301      701.5k Cu 500nm 30keV(20kV transport), 50G, 20K, Ne14_2 now Guards On
303      502.7k Cu 500nm 15keV(20kV transport), 50G, 20K, Ne14_2, continue Gua On
304     1041.8k Cu 500nm 15keV(20kV transport), ZF, 20K, Guards on
306      117.4k Cu 500nm 15keV(10kV transport), 50G, 20K, Guards on
307      408.5k Cu 500nm 15keV(10kV transport), 50G, 20K, Guards on
308     1135.1k Cu 500nm 4keV(10kV transport), 50G, 20K, Guards on
309      787.3k Cu 500nm 4keV(10kV transport), 0G, 20K, Guards on
310      639.3k Cu 500nm 4keV(10kV transport), 0G, 20K, Guards off
311      576.8k Cu 500nm 2keV(10kV transport), 50G, 20K, Guards on
312      897.4k Cu 500nm 2keV(10kV transport), 0G, 20K, Guards on
313      826.1k Cu 500nm 2keV(10kV transport), 0G, 20K, Guards off
314     1048.5k Cu 500nm 2keV(10kV transport), TF=50G, 20K, Guards off
315      826.6k Cu 500nm 0keV(10kV transport), TF=50G, 20K, Guards on
316      798.9k Cu 500nm 0keV(10kV transport), ZF, 20K, Guards on
317      737.5k Cu 500nm 0keV(10kV transport), ZF, 20K, Guards off
318      598.9k Cu 500nm 0keV(10kV transport), TF=50G, 20K, Guards off
319     1405.7k Cu 500nm −1keV(10kV transport), TF=50G, 20K, Guards off
320      600.8k Cu 500nm −1keV(10kV transport), TF=50G, 20K, Guards ON
321      612.8k Cu 500nm −1keV(10kV transport), ZF, 20K, Guards ON
322      606.8k Cu 500nm −1keV(10kV transport), ZF, 20K, Guards OFF
323      667.2k Cu 500nm −2keV(10kV transport), ZF, 20K, Guards OFF
324      604.1k Cu 500nm −2keV(10kV transport), 50G, 20K, Guards OFF
325      501.4k Cu 500nm −2keV(10kV transport), 50G, 20K, Guards ON
326      501.5k Cu 500nm −2keV(10kV transport), ZF, 20K, Guards ON
327      500.9k Cu 500nm 1.3keV(10kV transport), 50G, 20K, Guards OFF
328      503.1k Cu 500nm 1.3keV(10kV transport), ZF, 20K, Guards OFF
329      512.4k Cu 500nm 0keV(10kV transport), −50G, 20K, Guards OFF

334     1263.2k Stainless Steel 25 um 20keV(10kV transport), 50G, 20K, Guards ON
335      992.9k StSteel 25um 4keV(10kV tr), 50G, 20K, Guards ON
336      934.7k StSteel 25um 1.3keV(10kV tr), 50G, 20K, Guards ON
337     1242.4k StSteel 25um 1.3keV(10kV tr), 50G, 20K, Guards OFF
338     1210.6k StSteel 25um 1.3keV(10kV tr), ZF, 20K, Guards ON
339      925.4k StSteel 25um 20keV(10kV tr), ZF, 20K, Guards ON
340     1122.0k StSteel 25um −2keV(10kV tr), TF=50G, 20K, Guards ON
341      769.3k StSteel 25um −2keV(10kV tr), ZF, 20K, Guards ON
342      663.6k StSteel 25um 0keV(10kV tr), TF=50G, 20K, Guards ON
343      915.5k StSteel 25um 0.65keV(10kV tr), TF=50G, 20K, Guards ON
344     1012.2k StSteel 25um 2keV(10kV tr), TF=50G, 20K, Guards ON
346      604.4k StSteel 25um 20keV(12kV tr), TF=50G, 40K, Guards ON
347      643.2k StSteel 25um 20keV(12kV tr), TF=50G, 60K, Guards ON
348      615.4k StSteel 25um 20keV(12kV tr), TF=50G, 70K, Guards ON
349      607.4k StSteel 25um 20keV(12kV tr), TF=50G, 50K, Guards ON
350      692.7k StSteel 25um 20keV(12kV tr), TF=50G, 45K, Guards ON
351      602.3k StSteel 25um 20keV(12kV tr), TF=50G, 47.5K, Guards ON
352      602.7k StSteel 25um 20keV(12kV tr), TF=50G, 55K, Guards ON
353      602.0k StSteel 25um 1.3keV(12kV tr), TF=50G, 55K, Guards ON
354      602.5k StSteel 25um 1.3keV(12kV tr), TF=50G, 50K, Guards ON
355      623.2k StSteel 25um 1.3keV(12kV tr), TF=50G, 47.5K, Guards ON
356      781.5k StSteel 25um 1.3keV(12kV tr), TF=50G, 45K, Guards ON
357      417.6k StSteel 25um 1.3keV(12kV tr), TF=50G, 60K, Guards ON
358      461.3k StSteel 25um 1.3keV(12kV tr), TF=50G, 80K, Guards ON
359      456.1k StSteel 25um 1.3keV(12kV tr), TF=50G, 100K, Guards ON

360     2384.1k Ni(50 nm on SiO2) 7.5keV(12kV tr), ZF, 5.6K, Guards ON
361     1011.1k Ni(50 nm on SiO2) 7.5keV(12kV tr), TF=50G, 5.6K, Guards ON
362     1010.6k Ni(50 nm on SiO2) 3.5keV(12kV tr), TF=50G, 5.3K, Guards ON
363     1133.3k Ni(50 nm on SiO2) 10keV(12kV tr), TF=50G, 5.2K, Guards ON
```

Figure 14: List of runs under consideration. See *.DB and *.ps files in nemu@pc3159: /analysis/WKM/2003/Cu or nemu@pc3159: /analysis/WKM/2003/StSteel nemu@pc3159: /analysis/WKM/2003/Ni directories.