Notes on Ti sputtered sample plates used in 2007

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Abstract

The main aim of this note is to dig the problem of TF vs ZF Alpha **after the readjustment of L2** and to make a conclusion - is it useful to use Ti substrate? In addition, Ti data of 2007 is compared with standard Ag sample plates measured in 2005. Some comments are made on Ni substrate measured in 2007.

1 B_per configuration 100 G

In transverse field 100G there is no problem to fit sepparate histograms suggesting common slow relaxing signal and unique fast relaxing signals. See Fig. (1-2) for details.

/mnt/home/nemu/analysis/2007/Ti/Ti_B_per_h1324_12us.db

ABSTRACT

Separate Histos #1 #3 #2 #4 fits of 0-12 us range to one common exponent;

At low energies (<= 4keV) additional fast exponent is added to Histo #1;

Additional distortion gaussian signal is added to Histo #2;

At B 3.5G and low energies (2kev and 0.9keV) all histos are distorted

As a next step I had checked the idea of early time asymmetry which is the following [Thomas]. At small negative times muons are decaying on the fly **close (30-0 cm) to the surface of the sample** with radial position similar to the position of the muons which stop inside the sample. That is why asymmetry plot must be a smooth function close to the constant (including Larmor precession, if the field is not zero) for times around zero. This feature is illustrated in file

/mnt/home/nemu/analysis/2007/Ti/Ti_TF_slow_fast_neg_time.db

ABSTRACT

This is a crosscheck of the "early time" asymmetry fits;

Asymmetry fits;

Data are Postpileup rejected;

Backgrounds are fixed from 1-1500 channels;

Hists 1 vs 3 ”positive” times - fast and slow expo signal;

Additional asymmetry fit is made [in the form asy*cos(wt+fi), where w and fi are common with ”positive” time asymmetry fit]

for Hists 1 vs 3 for ”negative” times $-0.03- > 0.01$ us;

Alpha is common for ”negative” time and ”positive” times.

Asymmetry for the fast relaxing signal for ”positive” time is taken like ASYneg-ASYslow making total asymmetry in ”positive” time equal to the asymmetry at negative time;

Hists 2 vs 4 - only slow relaxing signal common with slow relaxing for 1 vs 3;

From the Fig. (5) one can conclude that (for the 15kV transport) the ”negative” time asymmetry is almost constant at the level 0.26-0.27. The drop down at 0.89 keV may be a consequence of the lower transport. The asymmetry of the fast relaxing signal is the difference between Asy_{neg} and Asy_{slow} in Fig. (5) with relaxation shown in Table (1):

Energy (keV)	Fast Relaxation (MHz)	Pos Eror (MHz)	Neg Eror (MHz)
0.9	4.3	3.4	1.6
2.08	37.2	46.1	22.7
3.08	21.0	22.5	22.5

Table 1: Fast relaxation seen in the Left–Right asymmetry in Ti (B_per=100 G). The look on the separate histograms shows that the fast ”relaxation” is a distortion present mainly in the histogram # 1 (Left).

2 B_per Configuration: Small and Zero Fields

For small fields and for zero field, alpha can be estimated by fitting the negative and near zero time asymmetry via constant Asy=0.27 (even for the transport 12kV). Results are summarized in Fig. (6). The fit of all the data to a constant gives Alpha=1.006(4) ChiSQ/Deg=11.7/20. The interval of Alpha is 1.00±0.03. Bearing in mind that in the first approximation

$$dP \sim 0.5 d\alpha \tag{1}$$

one can say that this interval of Alpha will be transfered to the interval

$$Asy = 0.27 \pm 0.015 \tag{2}$$

As a conclusion of this section:

1. At least down to 2keV Alpha is very close to 1.0 within tolerance better than 0.03
2. Alpah=1.0 is a good starting point for the analysis
3. For more sophisticated analysis, negative time [-0.02:0.01] μs asymmetry can be fixed to 0.27 and one can do some kind of a combine fit in positive time using common alpha

Second point is illustrated in figures Fig. (7-8). In these figures zero field data were fitted in the assumption of Alpha fixed to 1.0. One can see nice agreement between TF and ZF data. Higher asymmetry for E=0.9 keV in zero field can have two origins: one systematic (alpha is fixed to one, real alpha may be little bit smaller than one), other physical because of the possible loss of the asymmetry in TF due to backscattered muonium.

Practical hint: For such particular fits (where alpha is fixed to one) one can use histograms fit with one normalization constant N_0 (instead of two independent) for both histograms. In this approach background can be fitted.

Fig. (9-11) illustrate combine fit in positive and negative time time using common alpha.

3 B_par Configuration

In this configuration one have to set ring anodes voltages to compensate shift of the beam spot. For these particular measurements all points for $E > 1$ keV were measured at 15 kV transport and $RAL - RAR = -0.52\ kV$; for the $E = 0.86$ keV the 12 kV transport and $RAL - RAR = -0.50\ kV$ settings were used. Fig. (12 shows the energy dependence of alpha in B_par=100G for separate histograms #1 and #3 fits of $0 - 8\ \mu$s range to one exponent for the energies bigger or equal 4 keV and to two signals (fast and slow) for energy smaller or equal 3 keV.

Slow relaxation signal is shown in Fig. (13. Next picture Fig. (14) shows how slow relaxation is sensitive to the model. When fitting with one signal, relaxations at E<4 keV are systematically higher.

Slow relaxations measured at different setups and fields are compared in figures Fig. (15) and Fig. (16). Zero field relaxation is systematically low than both transverse field data. As for B_per vs B_par 100 G data, at high energies, relaxations are similar. At low energies, signal measured in B_par relaxes faster.

4 Ag sample plate: measuremants of 2005

In this section data on silver sample plate are reviewed. Fits are in

/mnt/home/nemu/analysis/2005/uSR_on_SamplePlate_Bpar/Ag_B_par_h13.db

ABSTRACT

Separate Histos #1 #3 of 0-8 us range to one common exponent;

At low energies additional fast exponent is added to Histo #1;

Additional distortion gaussian signals are added to Histos #3

and

/mnt/home/nemu/analysis/2005/uSR_on_SamplePlate/Ag_B_per_h1324.db

ABSTRACT

Separate Histos #1 #3 #2 #4 fits of 0-8 us range to one common exponent;

At low energies additional fast exponent is added to Histo #1;

Additional distortion gaussian signals are added to Histos #2 #3 #4

Fast relaxing signal is similar to Ti data and is observed in histogram #1 for energies less or equal 3 keV.

Similar to Ti and Al, simulated asymmetry is higher than experimental slow relaxing asymmetry, see Fig. (17).

B_par and B_per data are compared in Fig. (18), Fig. (19) and Fig. (20). Slow relaxation does not depend on setup and is similar in TF=50 G and zero filed.

Finally Ag is compared with Ti in Fig. (21). Note smaller relaxation in silver. **There is no need to use Ti as a sample plate, Ag sample plates are better.**

5 Ni sample plate

The idea to use Ni coated sample plate is the following: Ni is a ferromagnet with internal field of about 1500 G and must not contribute to the signal at the applied weak transverse magnetic field. This feature is illustrated in Fig. (22-25). Data were taken at T=20K, 15 kV transport and implantation energies 4.5 keV for ZF and 4 keV for TF measurements.

Ni coated sample plate was studied with small (38 mm opening) shield designed for the small sample setup. Zero field asymmetry plot is shown in Fig. (22). At $t < 40$ ns one can see fast relaxing Ni internal field signal. For $t > 40$ ns only very slow relaxing signal in ZF is observed. The amplitude of this signal is bigger than 1/3 of the initial asymmetry.

Next picture Fig. (23) shows B_par 260 G asymmetry plot. This spectrum was measured with big enough statistics to see internal field. Note component at 222 G. Bearing in mind narrow opening, this signal could be attributed to the muons stopped in the shield.

Last figures Fig. (24) and Fig. (25) show asymmetry plots for small silver sample 10×10 mm^2 mounted on the Ni coated sample plate. The shield was changed to the usual one with 60 mm opening. In spite of rather high implantation energy (4 keV) where for both Ag and Ti sample plates there is no fast relaxing signal, one can see very fast relaxing internal field signal from the Ni sample plate, slow relaxing signal at applied field (which comes from Ag square) **and semi-fast signal at frequency close to precession in applied field**.

That is why I would recommend to use Ni sample plate for special tasks (small samples) and only when slow relaxing signal from the sample (with relaxation less than 2 MHz) is expected.

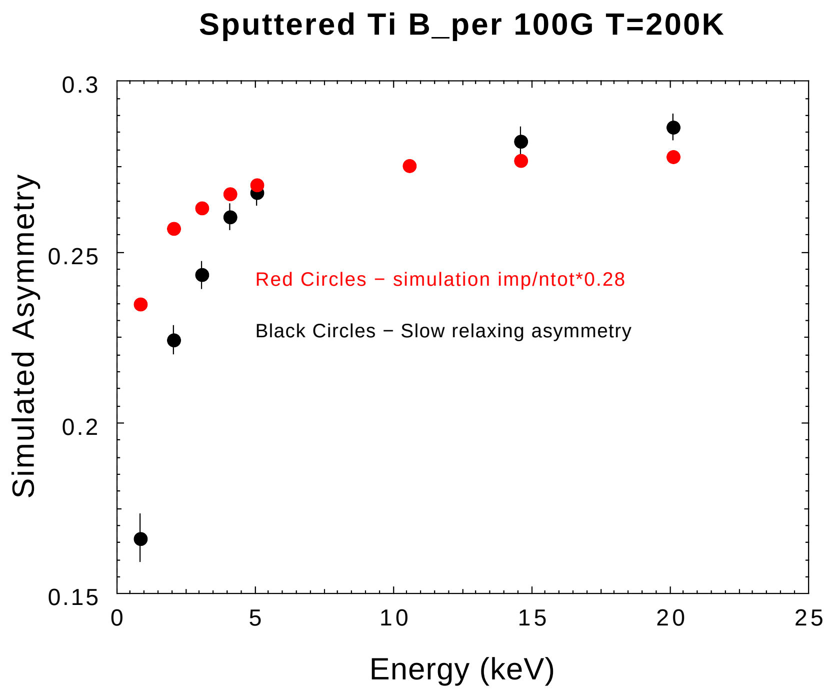

Figure 1: Energy dependence of the slow relaxing asymmetry (15kV transport except the lowest energy at 12kV transport)

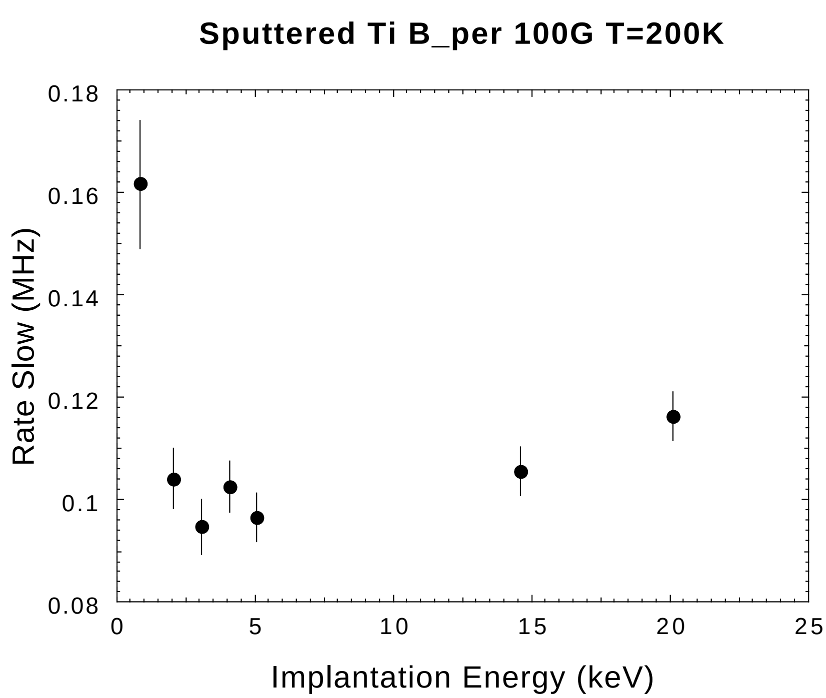

Figure 2: Energy dependence of the slow relaxation (15kV transport except the lowest energy at 12kV transport)

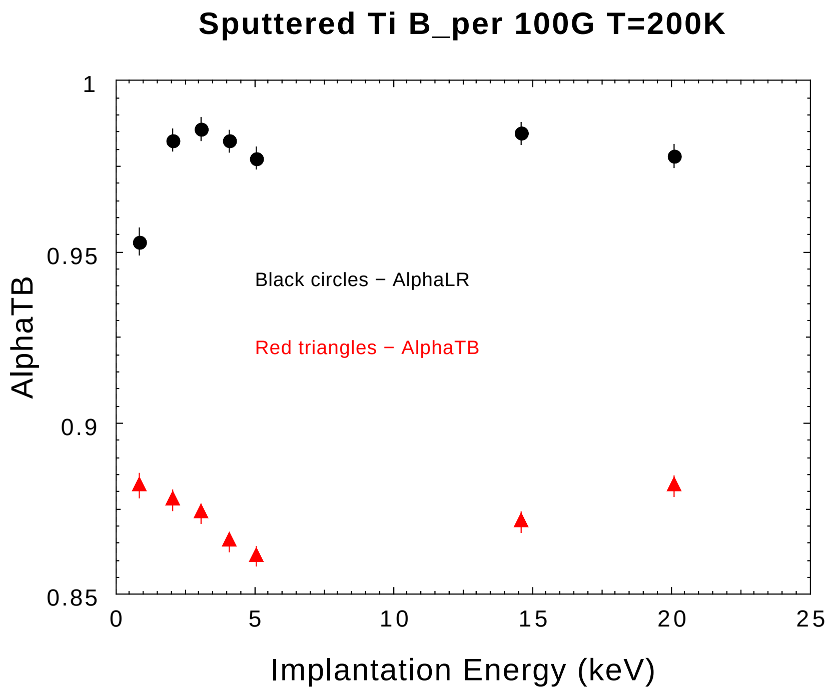

Figure 3: Energy dependence of Alpha (15kV transport except the lowest energy at 12kV transport)

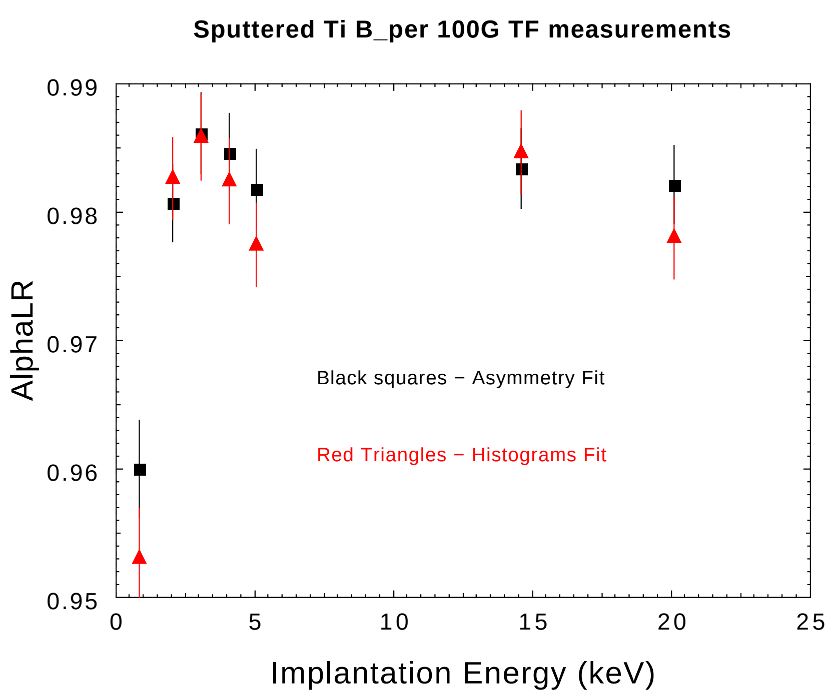

Figure 4: Energy dependence of AlphaLR (15kV transport except the lowest energy at 12kV transport). Histograms vs Asymmetry fits

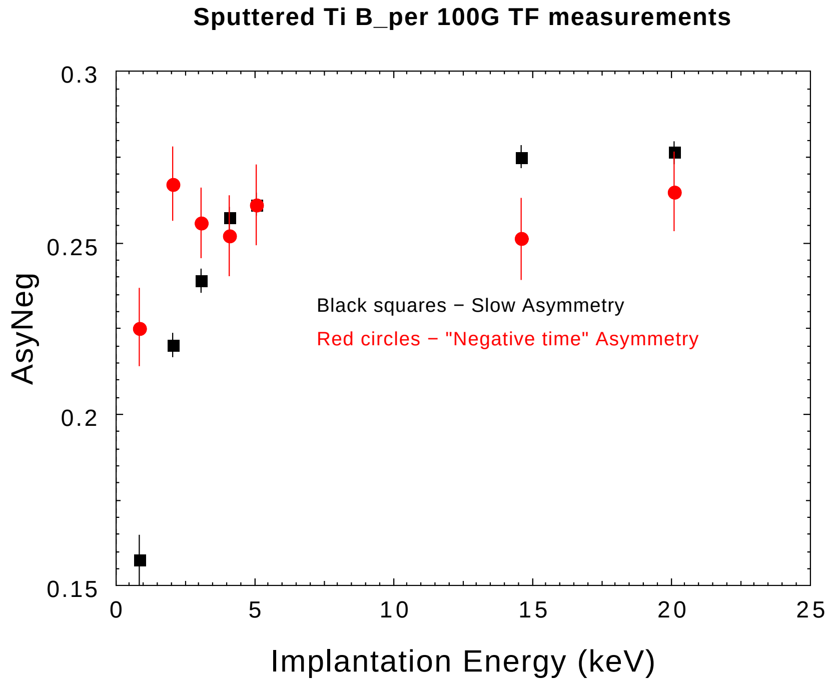

Figure 5: Energy dependence of the slow relaxing asymmetry and ”negative” time asymmetry (15kV transport except the lowest energy at 12kV transport)

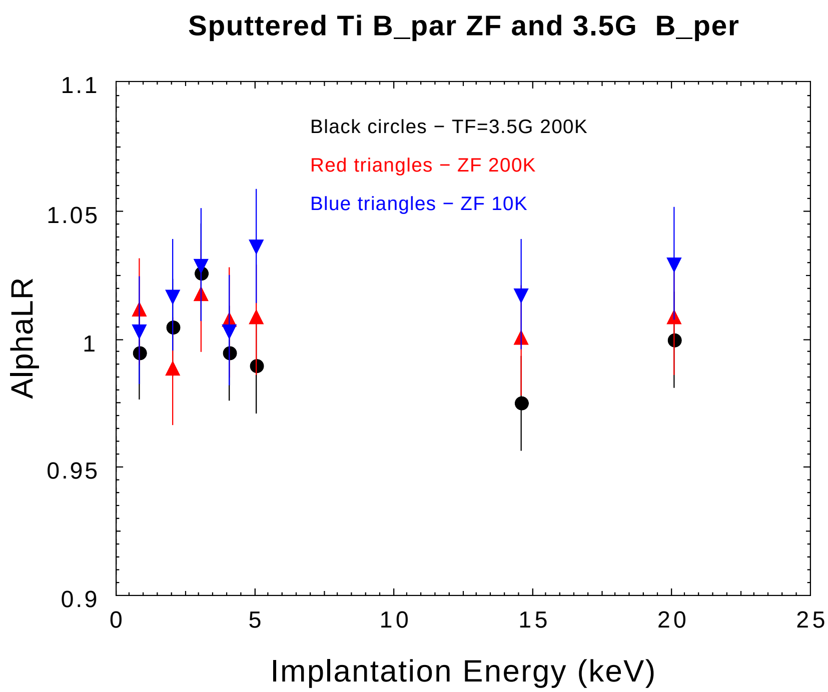

Figure 6: Energy dependence of the low field alpha (15kV transport except the lowest energy at 12kV transport). Negative time asymmetry is fixed to 0.27

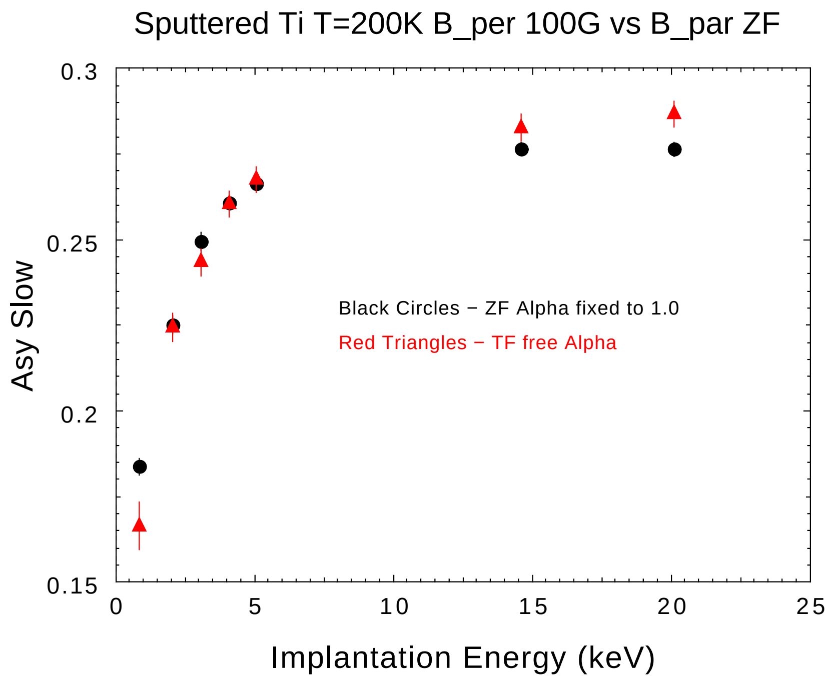

Figure 7: Energy dependence of the slow relaxing asymmetry measured in B_per=100 G and in zero field. Bigger zero field asymmetry at 0.87 keV may be the result of 12 kV transport.

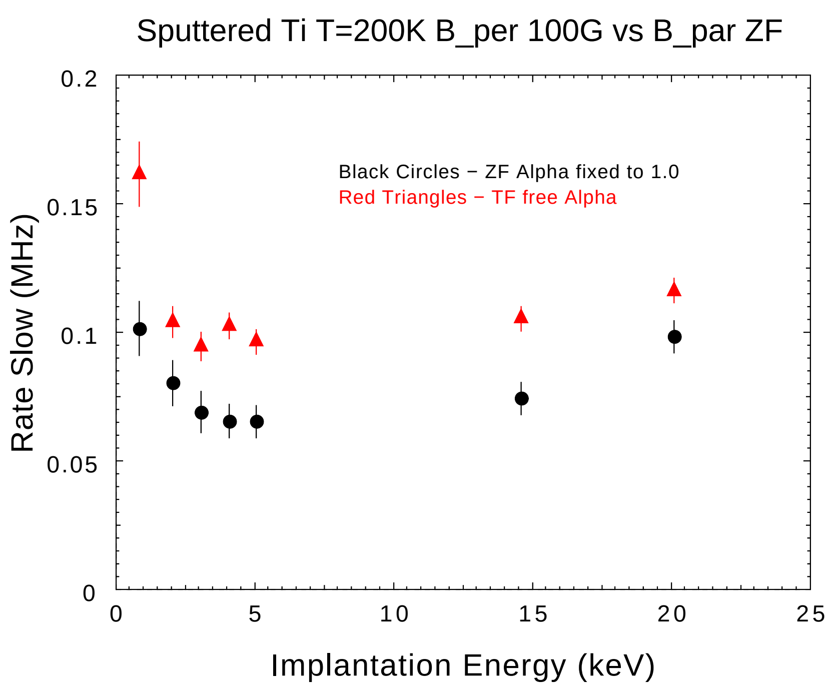

Figure 8: Energy dependence of the exponential relaxation for B_per=100 G and ZF measurements. In zero field relaxation is smaller.

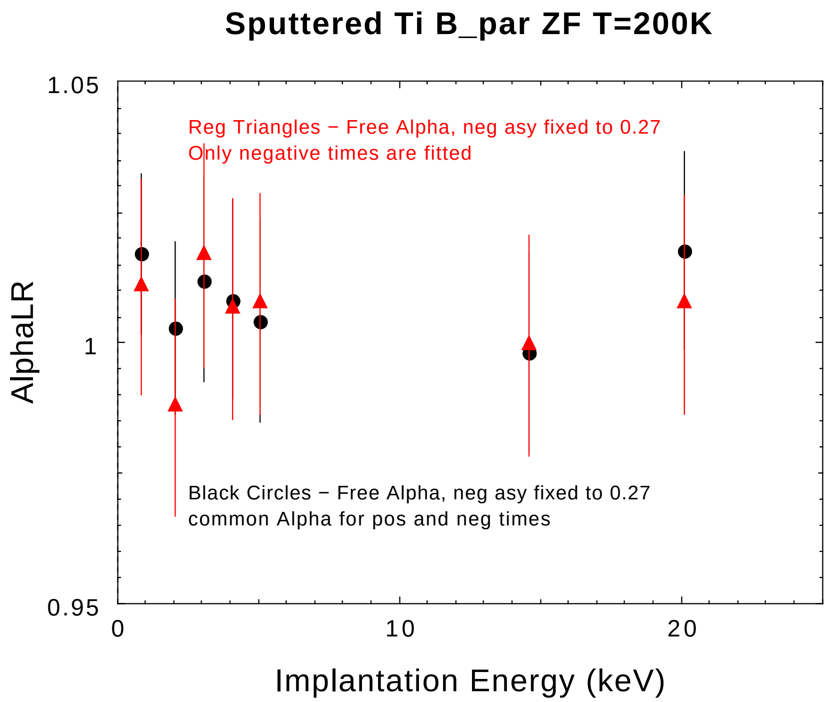

Figure 9: Negative time asymmetry is fixed to 0.27. One can see that the inclusion of positive times does not change alpha. In the case of fitting the positive times without negative, asymmetry presentation fits are unstable (either alpha or asymmetry is changed until the limits without significant change of Chi Square. On the other words, additional condition like forcing negative time asymmetry to be 0.27 solves the problem of extremely high cross-correlation between asymmetry and alpha for positive times. This approach is almost equivalent to the fixing of the "initial" asymmetry to 0.27. The main difference is that in negative time approach we do not care about relaxation of this initial asymmetry and **use more channels or more statistics** for fit. We postulate that negative time asymmetry is constant (well, multiplied by precession term in the case of TF). Separate histograms fit with free normalization constants does converge but gives alpha of order 0.9 which is not acceptable.

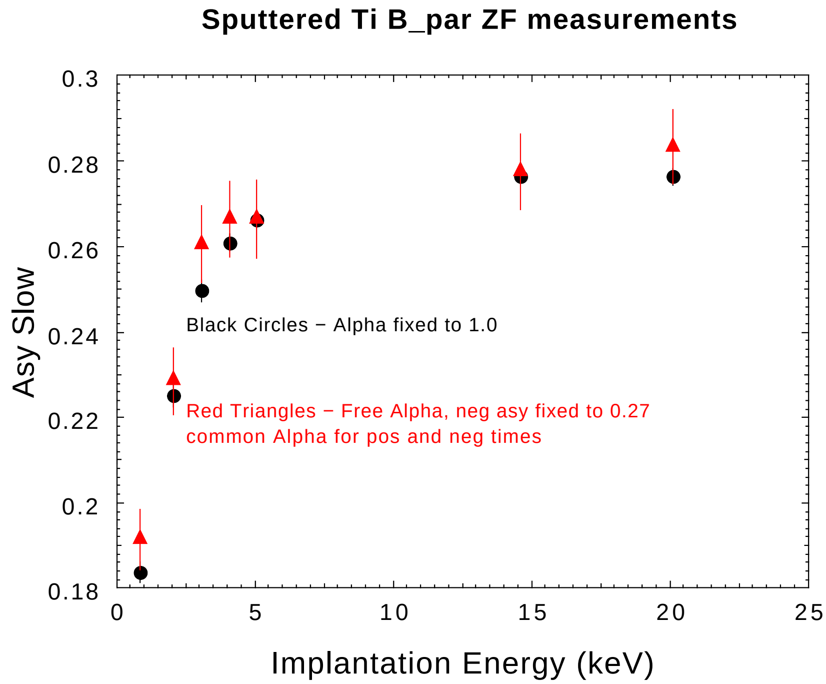

Figure 10: Energy dependence of the slow relaxing asymmetry for Alpha=1.0 and for fitted Alpha. Without the trick (fitting together negative and positive times with negative time asymmetry fixed to 0.27), it is impossible to get reliable asymmetry fits.

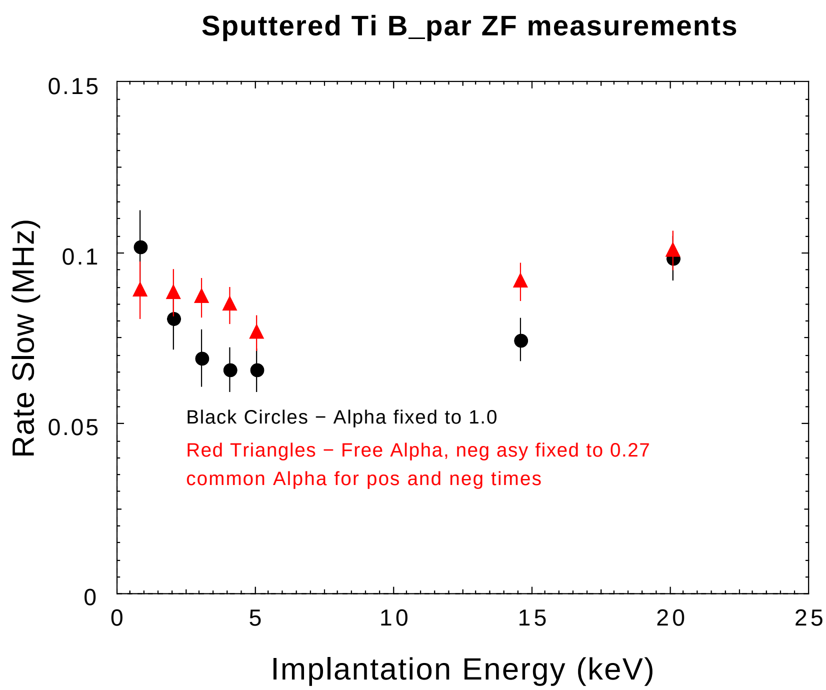

Figure 11: Energy dependence of the exponential relaxation for Alpha=1.0 and for fitted Alpha.

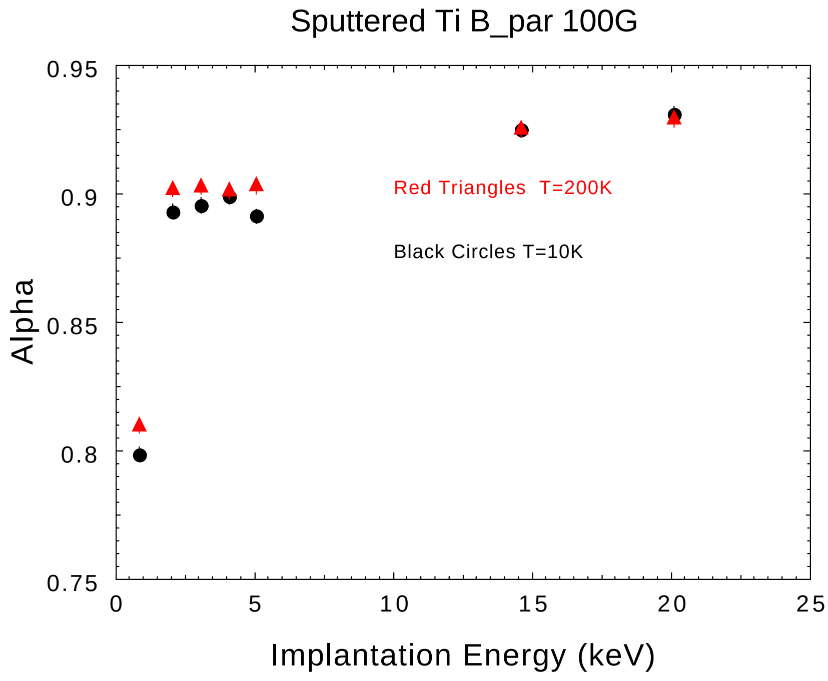

Figure 12: Ti 2007: Energy dependence of Alpha in B_par=100 G. Point at $E = 0.86$ keV is at different transport (12kV) and ring anodes settings.

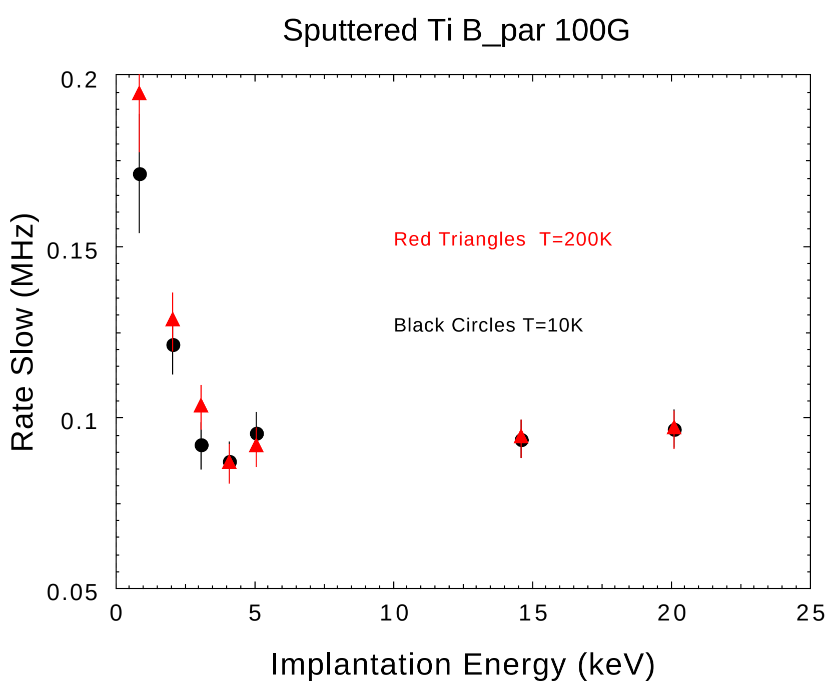

Figure 13: Ti 2007: Energy dependence of slow relaxation in B_par=100 G. Point at $E = 0.86$ keV is at different transport ($12\ kV$) and ring anodes settings.

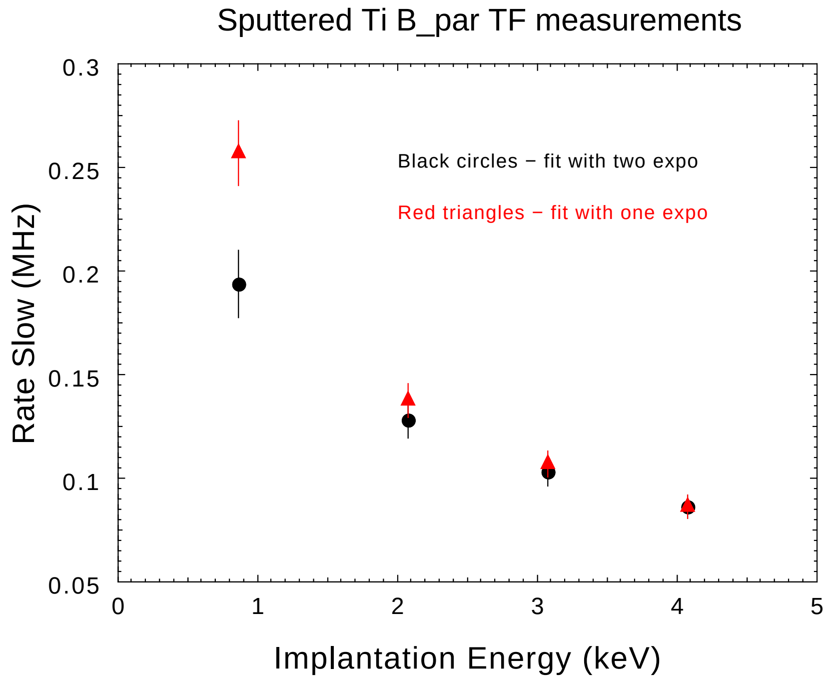

Figure 14: Ti 2007: Energy dependence of slow relaxation in B_par=100 G. Point at $E = 0.86$ keV is at different transport (12 kV) and ring anodes settings.

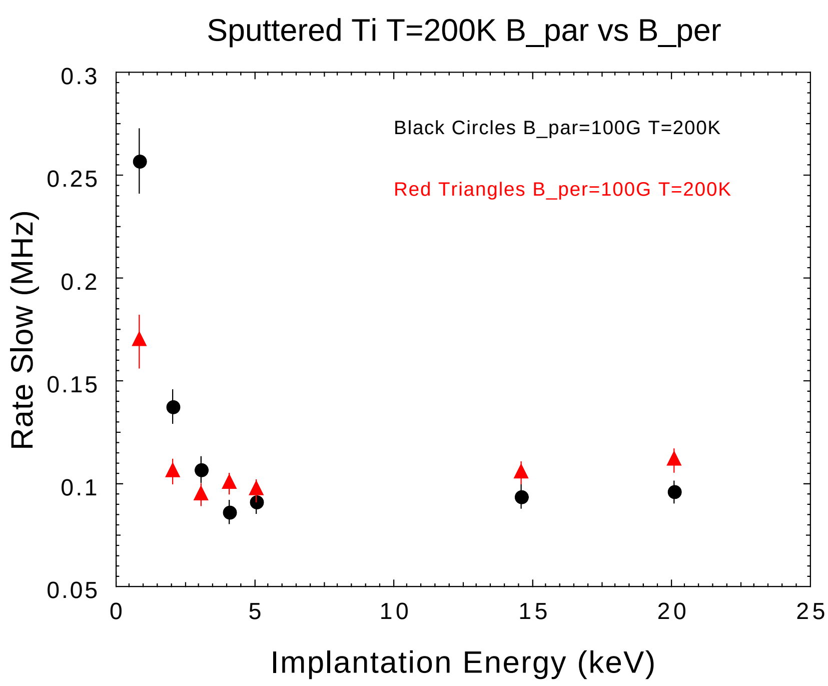

Figure 15: Ti 2007: Energy dependence of slow relaxation measured in B_par and B_per setups. Fits are to one exponential relaxation signal.

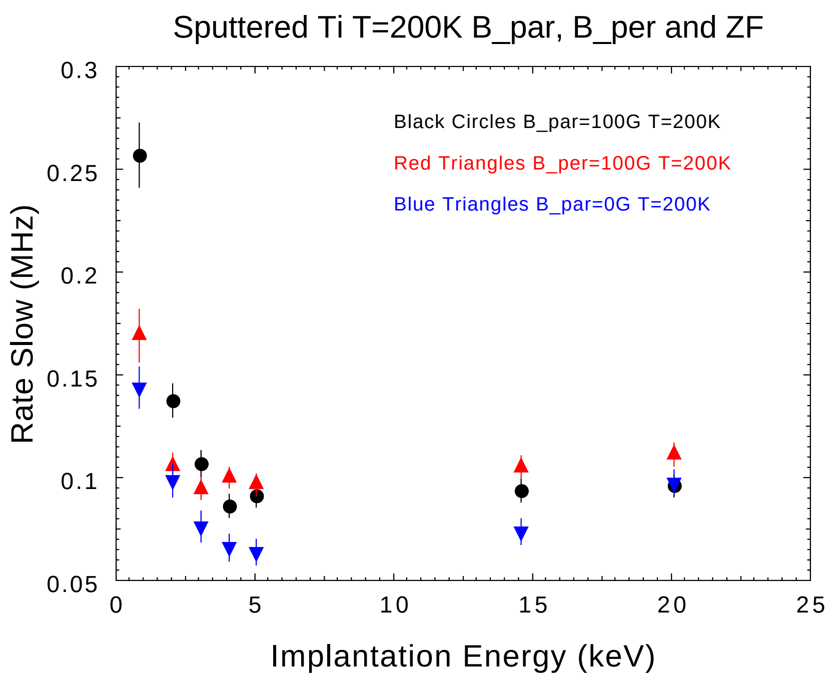

Figure 16: Ti 2007: Energy dependence of slow relaxation measured in B_par, B_per and ZF. Fits are to one exponential relaxation signal. One can see that ZF points are lower than both TF data.

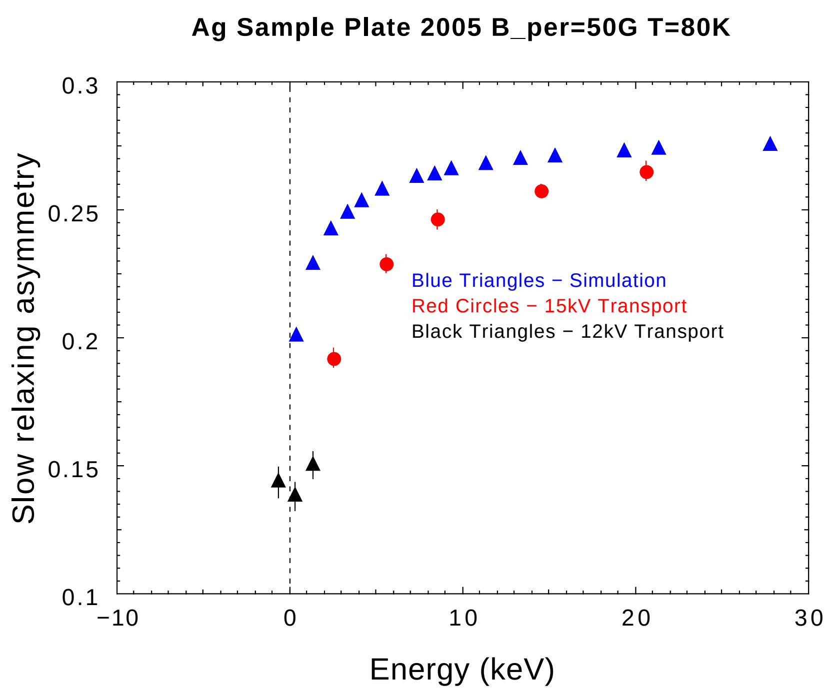

Figure 17: Ag 2005: B_per=50 G

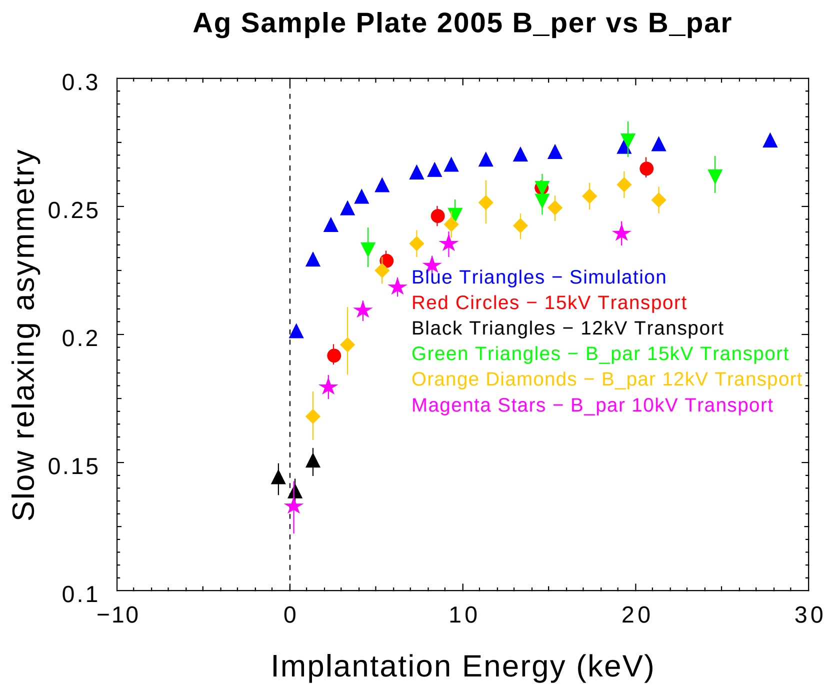

Figure 18: Ag 2005:

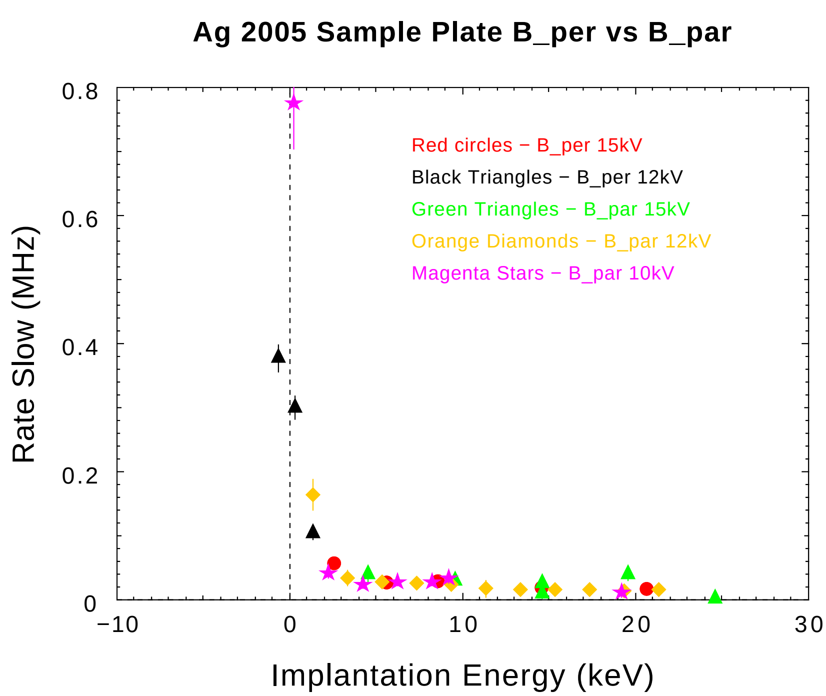

Figure 19: Ag 2005:

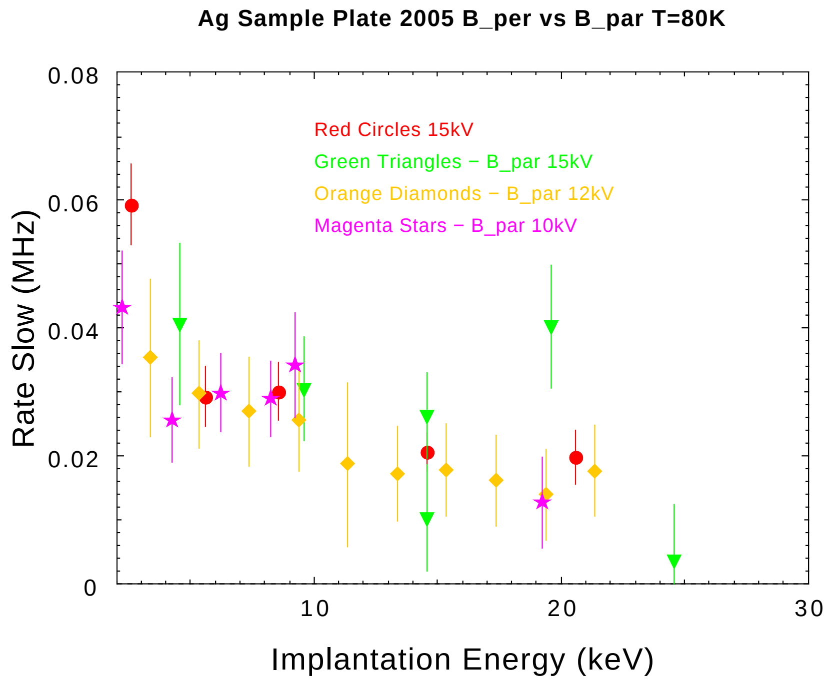

Figure 20: Ag 2005:

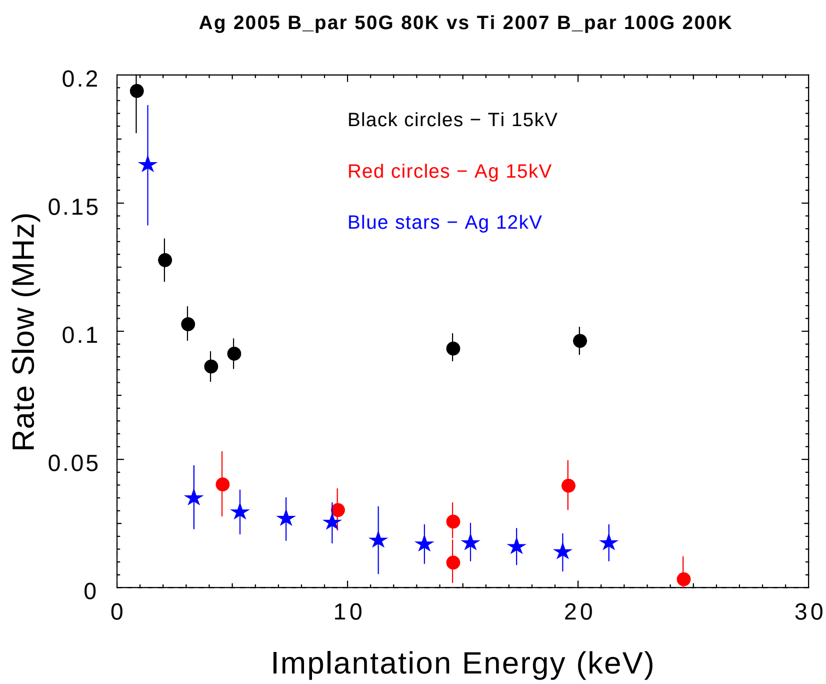

Figure 21: Ag 2005 vs Ti 2007:

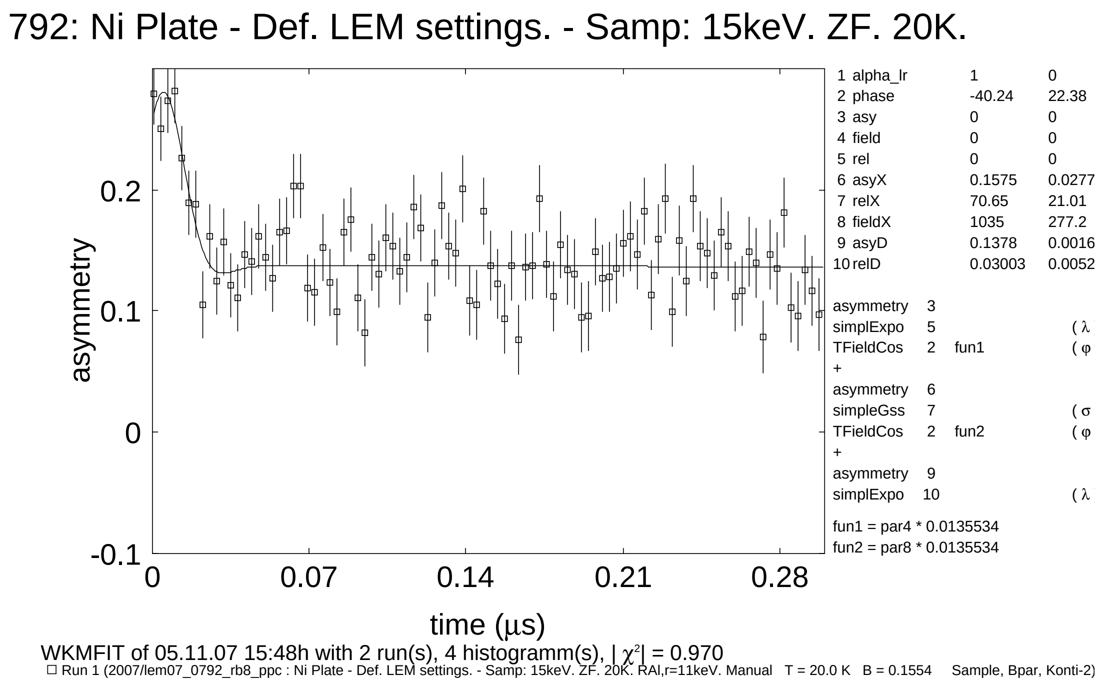

Figure 22: Ni samle plate. Small shield 38mm. T=20K ZF:

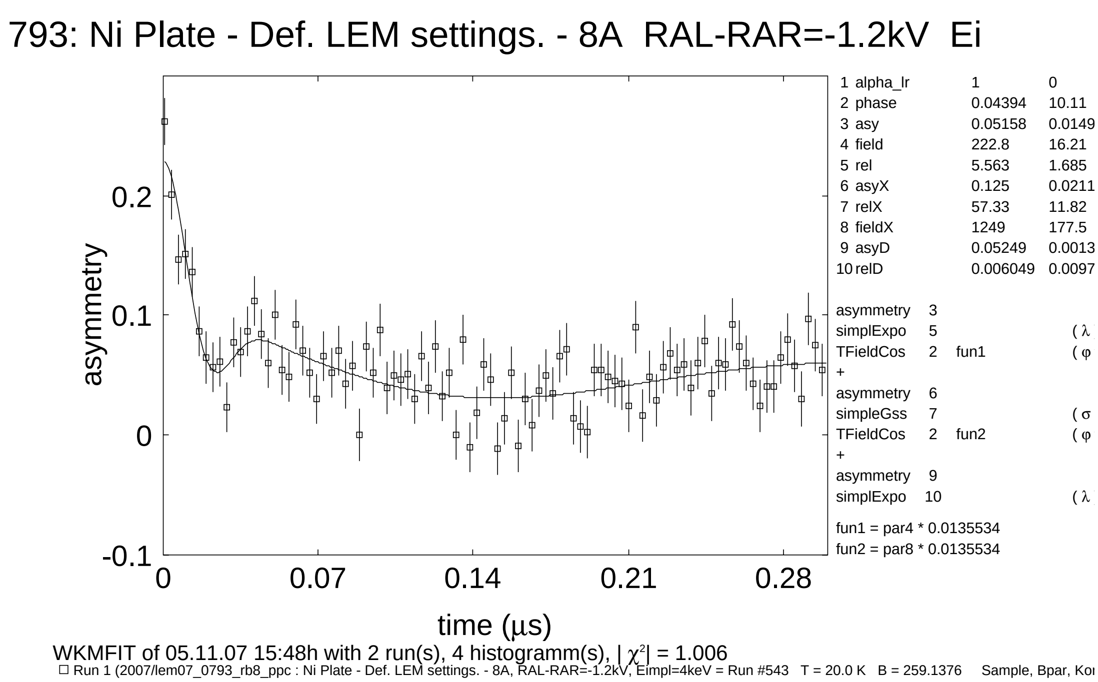

Figure 23: Ni sample plate. Small shield 38 mm covered by Ni. T=20 K B_par setup TF=260 Oe:

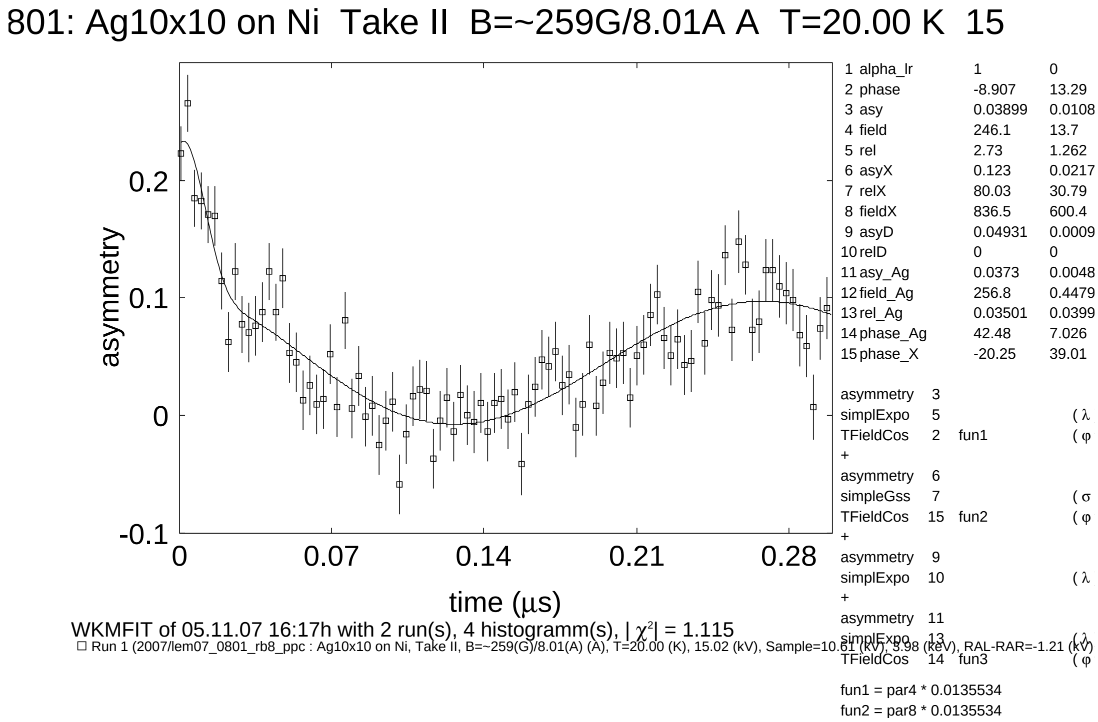

Figure 24: Ni sample plate with 10×10 mm^2 Ag. Normal shield 60 mm. T=20K B_par setup TF=260 Oe:

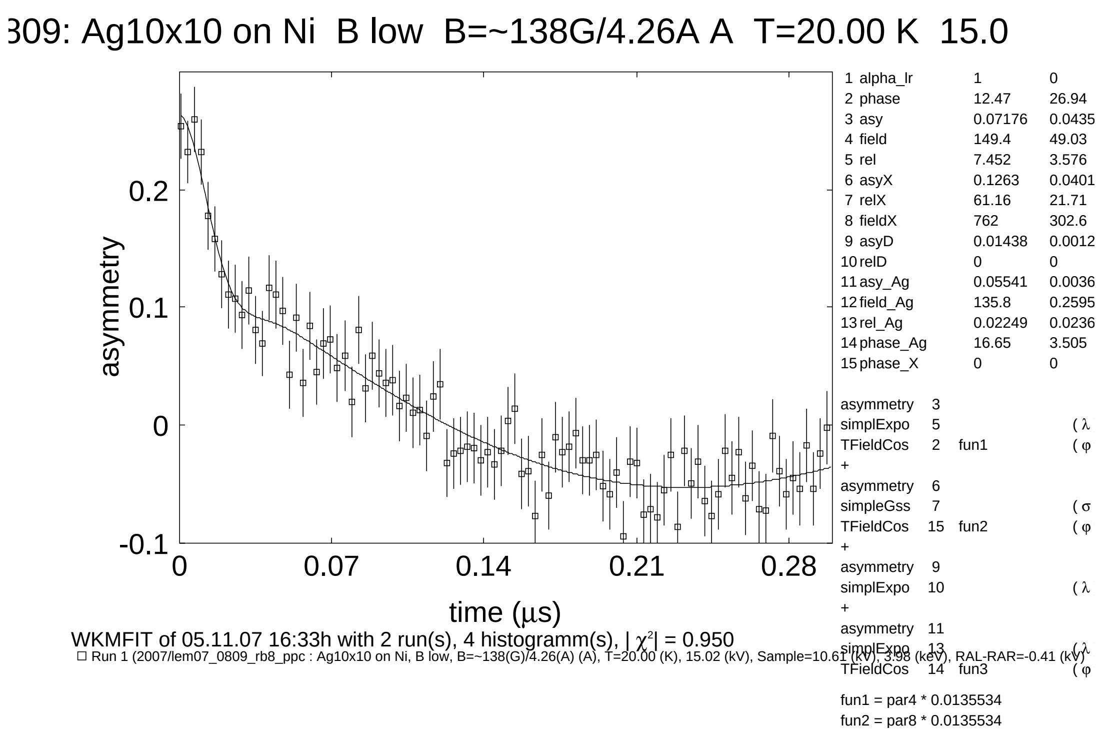

Figure 25: Ni sample plate with 10×10 mm^2 Ag. Normal shield 60 mm. T=20K B_par setup TF=138 Oe: