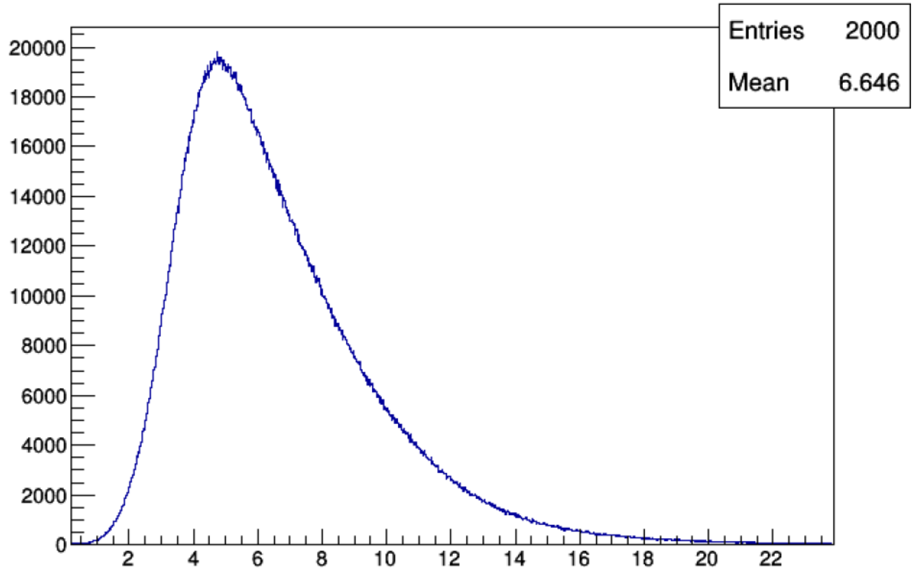
Phase scan analysis (modulated signal)

Logbook: BOA_Logbook_Sept-2018 pages 67-68 (B_0 = 125,124,123,122 uT)

Data: T231018_PhaseScanMod_0031.tof -> _0072.tof (skip 51,52)

Ramsey_phase_mod-1000003.dat -> _mod-1000007.dat (skip 5)

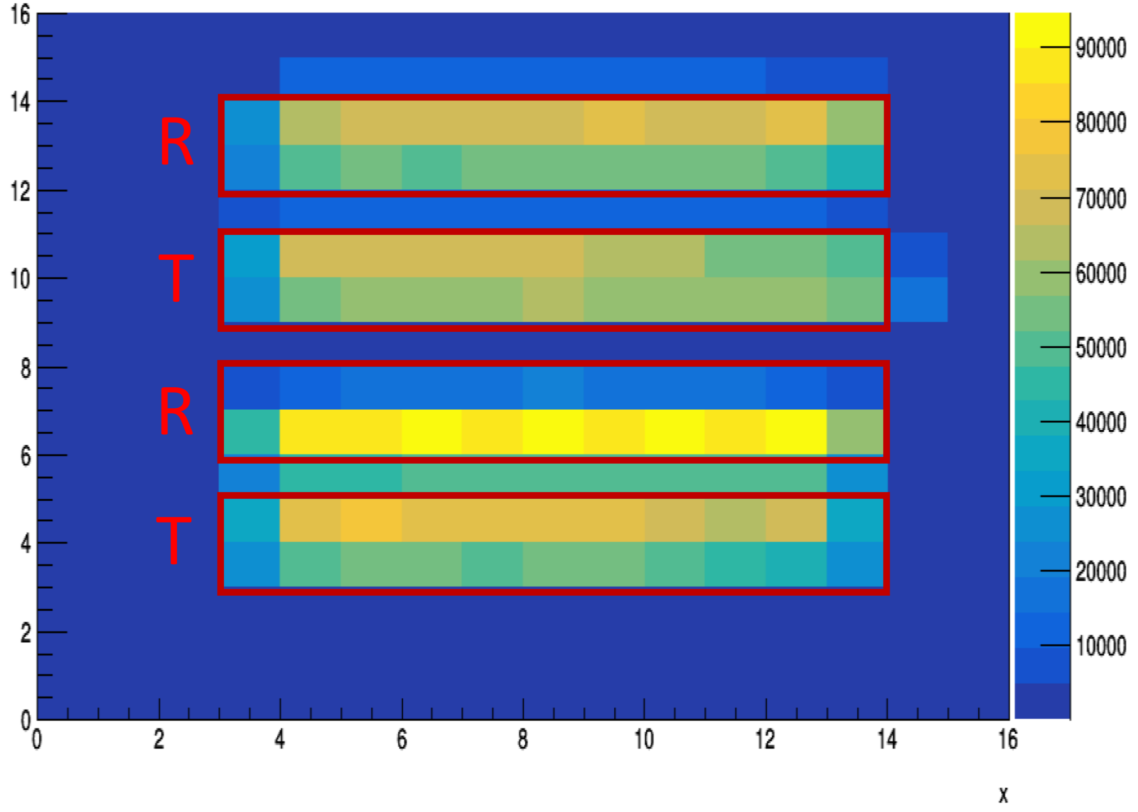


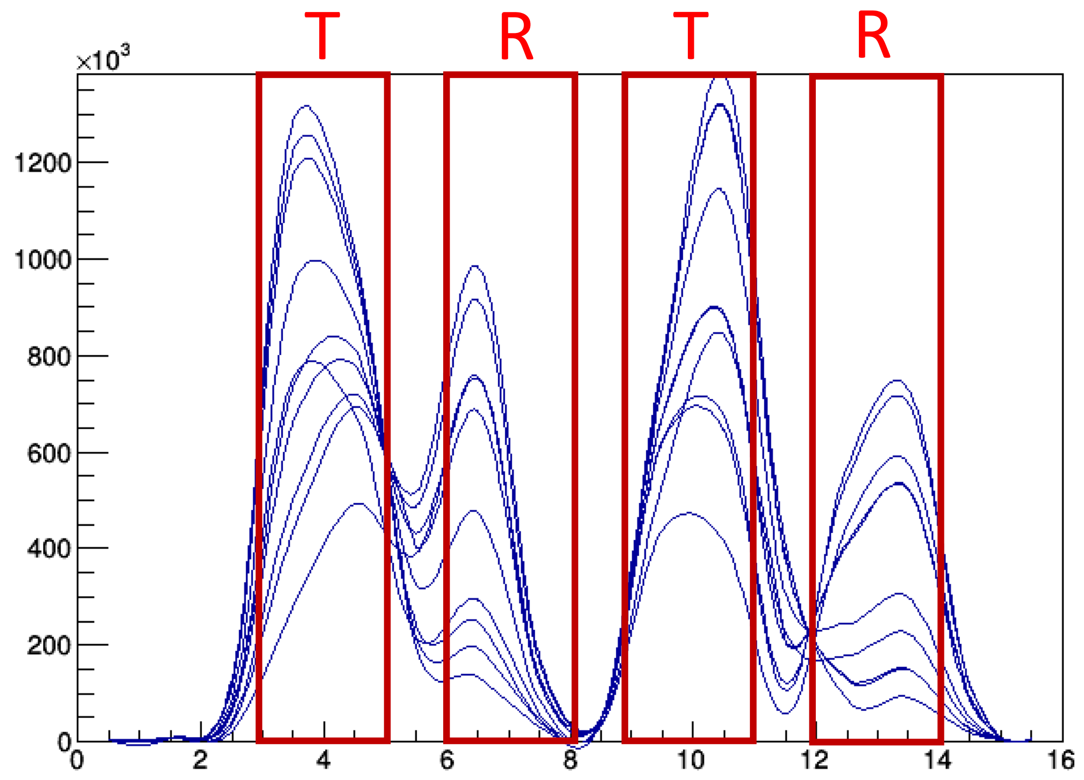
B_0 = 125 µT

	Bins X	Bins Y
UP ref	4-14	13-14
UP tra	4-14	10-11
DOWN ref	4-14	7-8
DOWN tra	4-14	4-5

$$A = \frac{R - T}{R + T}$$

2D (file 34)





$$A = \frac{R-T}{R+T}$$

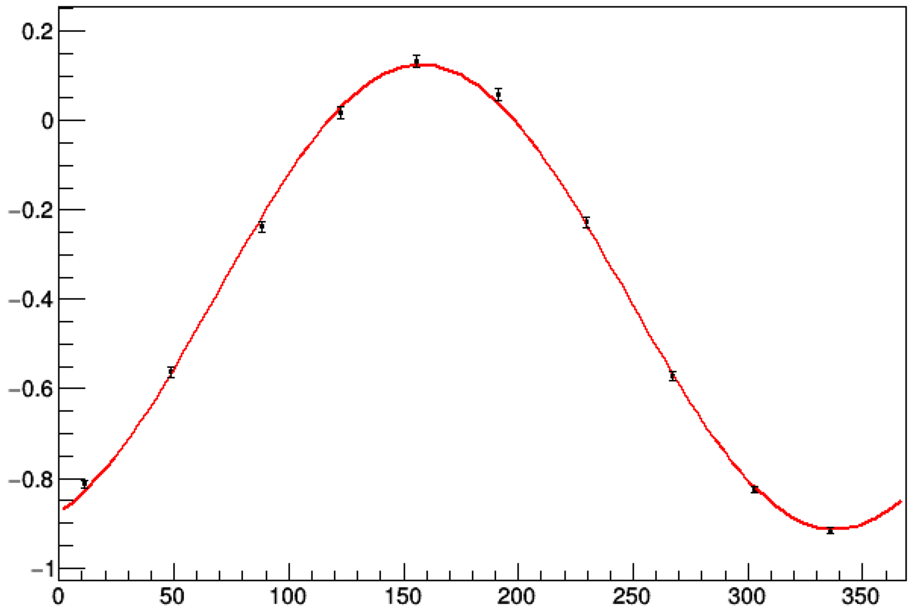
$$\sigma_A^2 = \left(\frac{\delta A}{\delta R}\right)^2 \sigma_R^2 + \left(\frac{\delta A}{\delta T}\right)^2 \sigma_T^2 + 2\,\frac{\delta A}{\delta R}\frac{\delta A}{\delta T}\sigma_{RT}$$

$$= \left(\frac{2T}{(R+T)^2}\right)^2 \sigma_R^2 + \left(-\frac{2R}{(R+T)^2}\right)^2 \sigma_T^2 + 2\,\frac{\delta A}{\delta R}\frac{\delta A}{\delta T}\sigma_{RT}$$

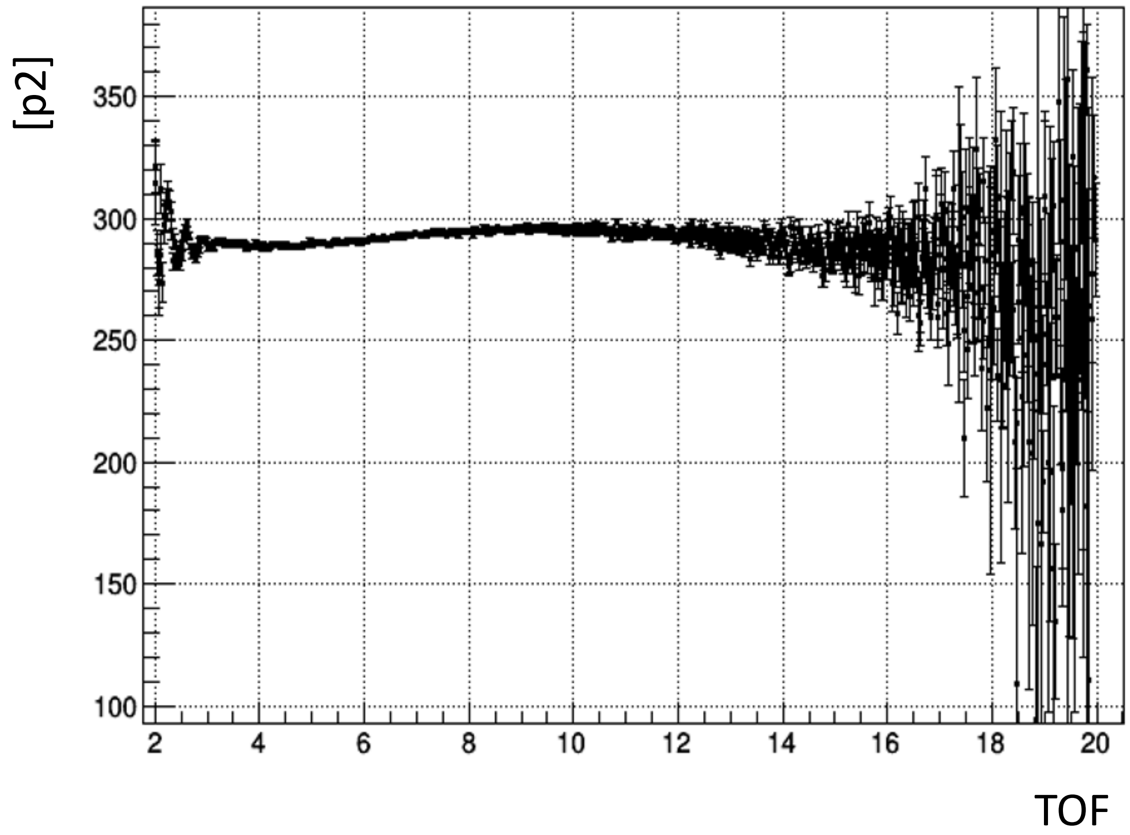
1) Assume
- Poissonian error
- No covariance

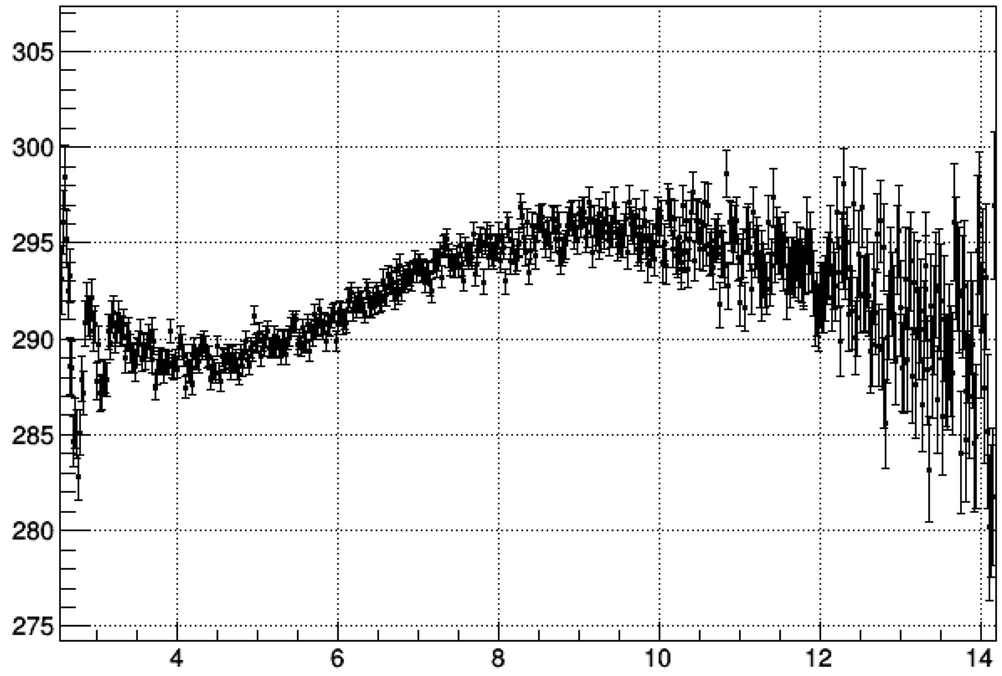
2) For each TOF bin fit asymmetry VS Φ_{SF}:
"[p0]+[p1]*sin(x*π/180.+[p2])"

3) Plot [p2]*180./ π vs TOF

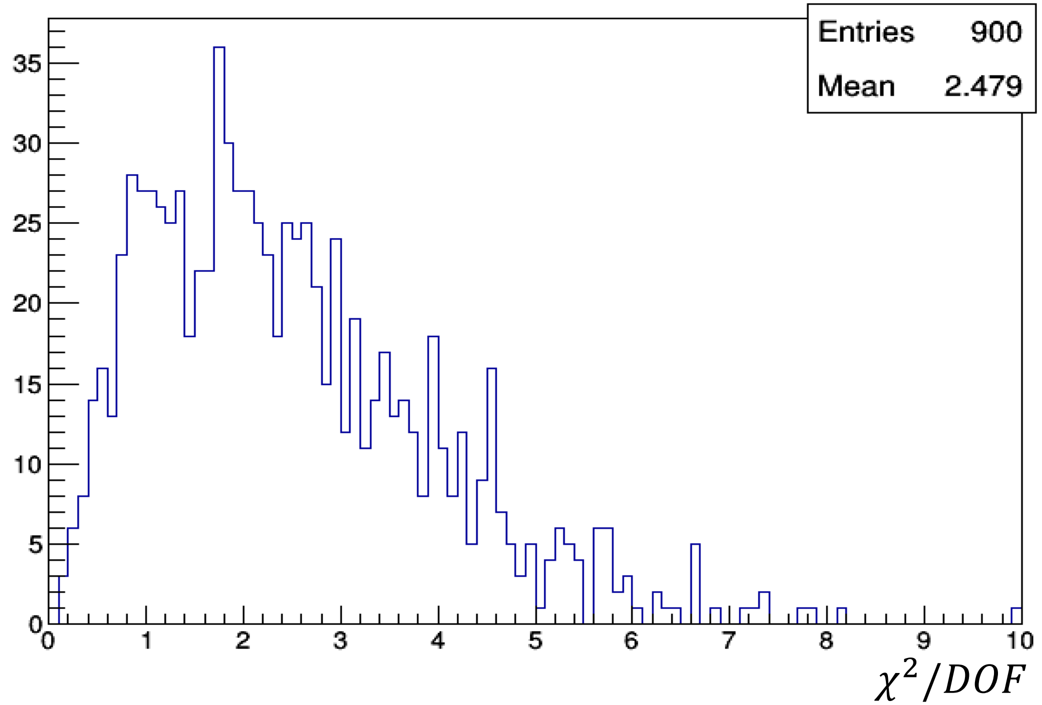


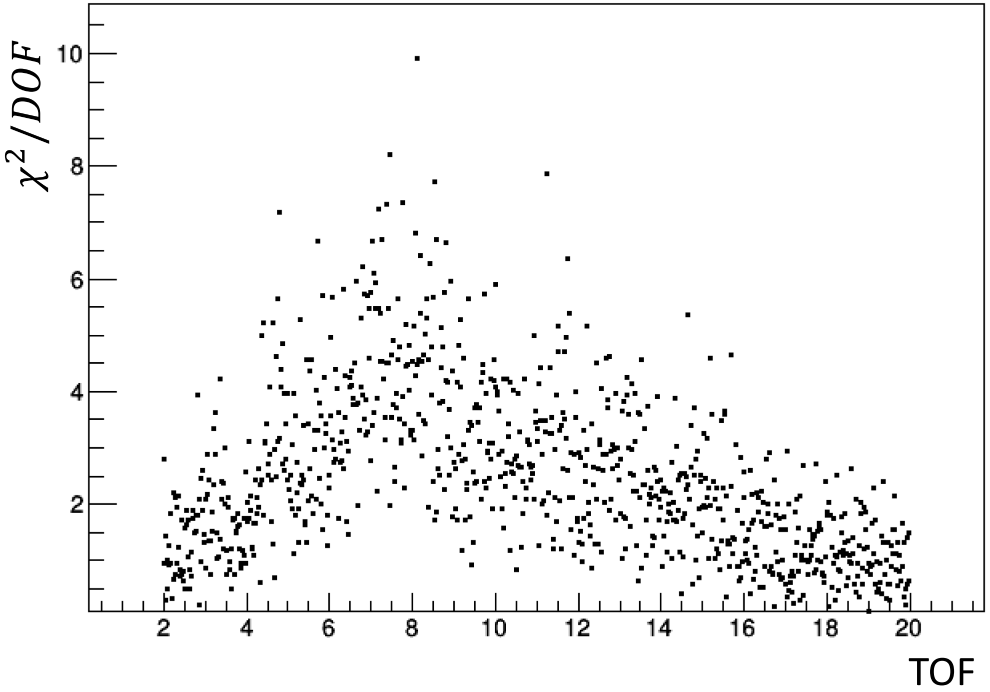
B_0 = 125 uT UP beam 900 bins (bin width is 20 um)

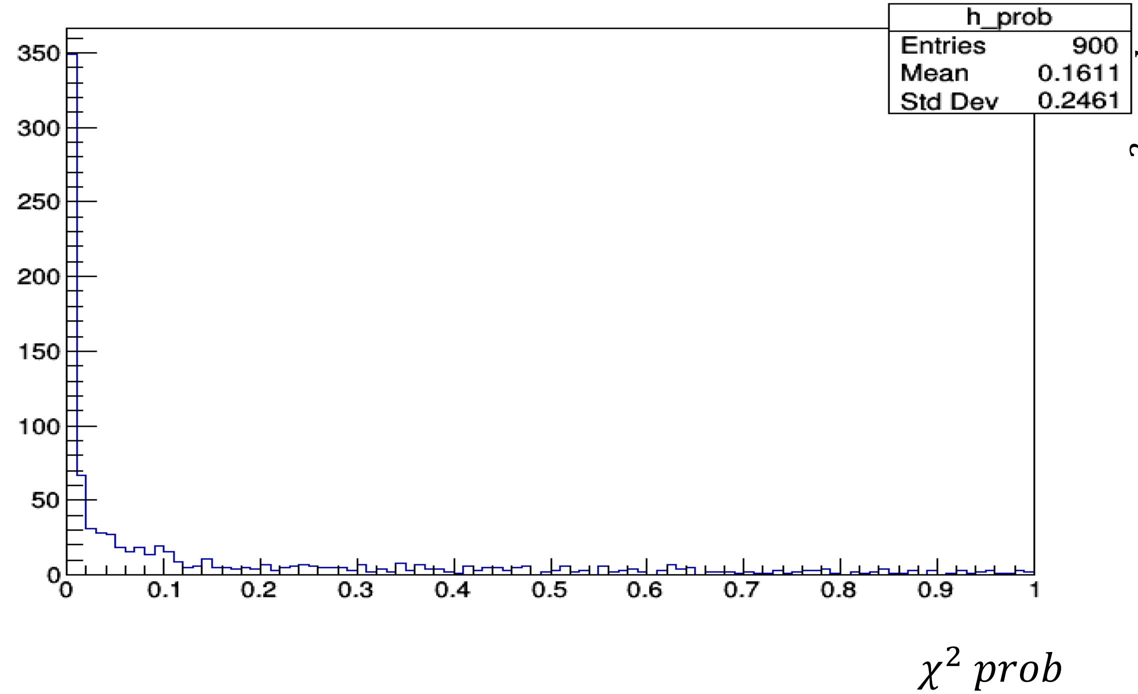


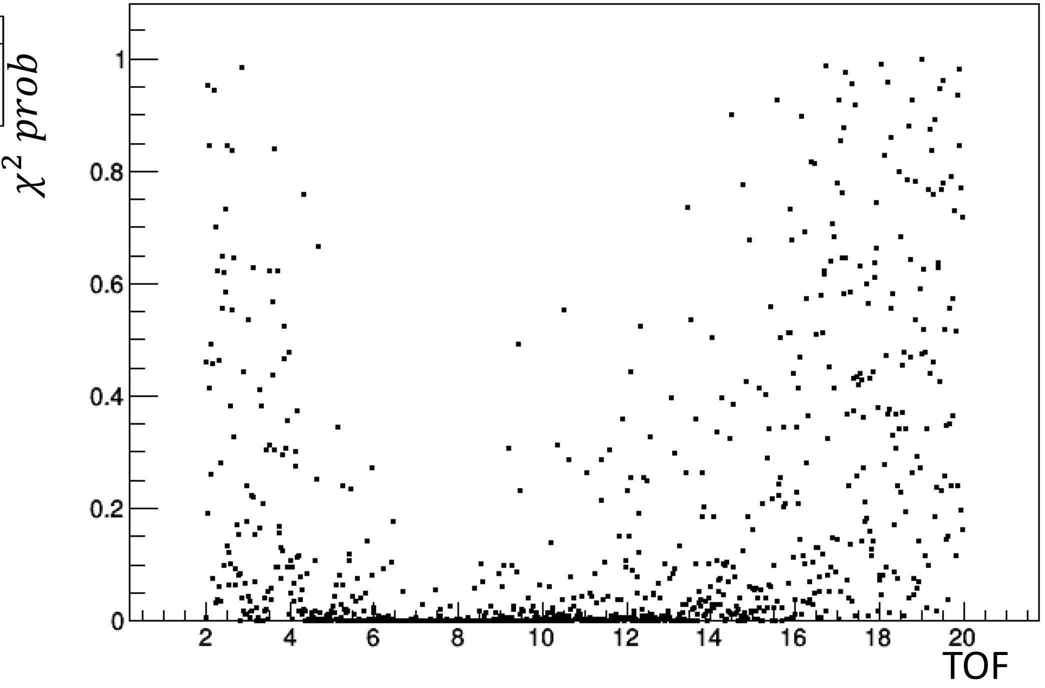


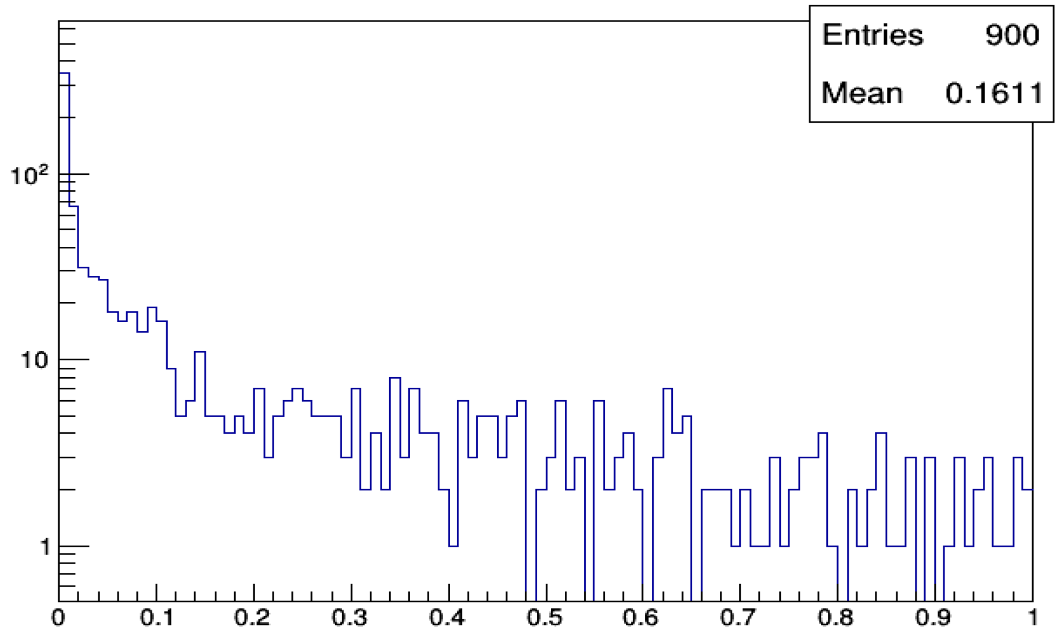
but…


Entries 900
Mean 2.479
χ^2/DOF

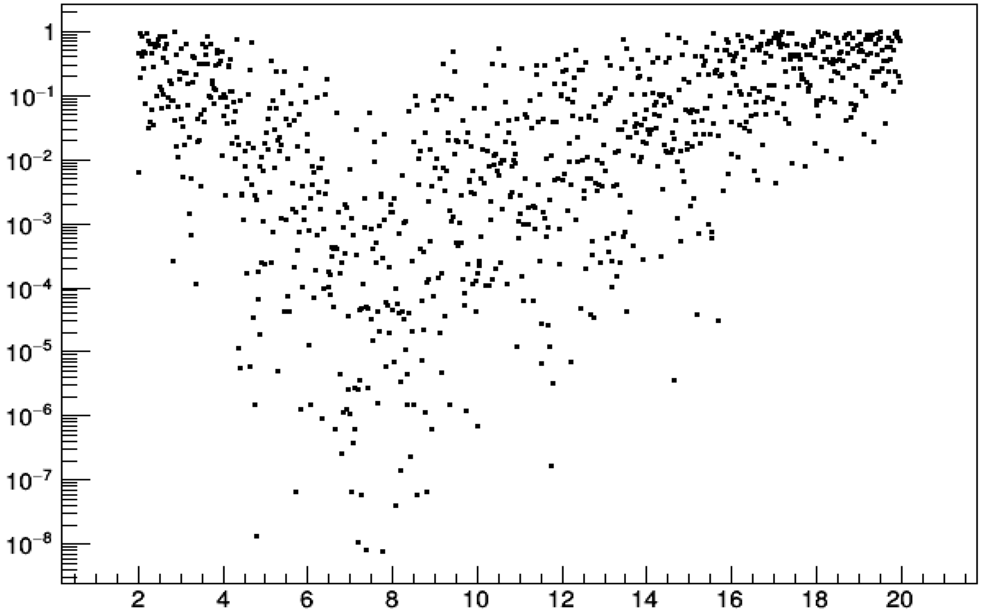

χ^2/DOF
TOF

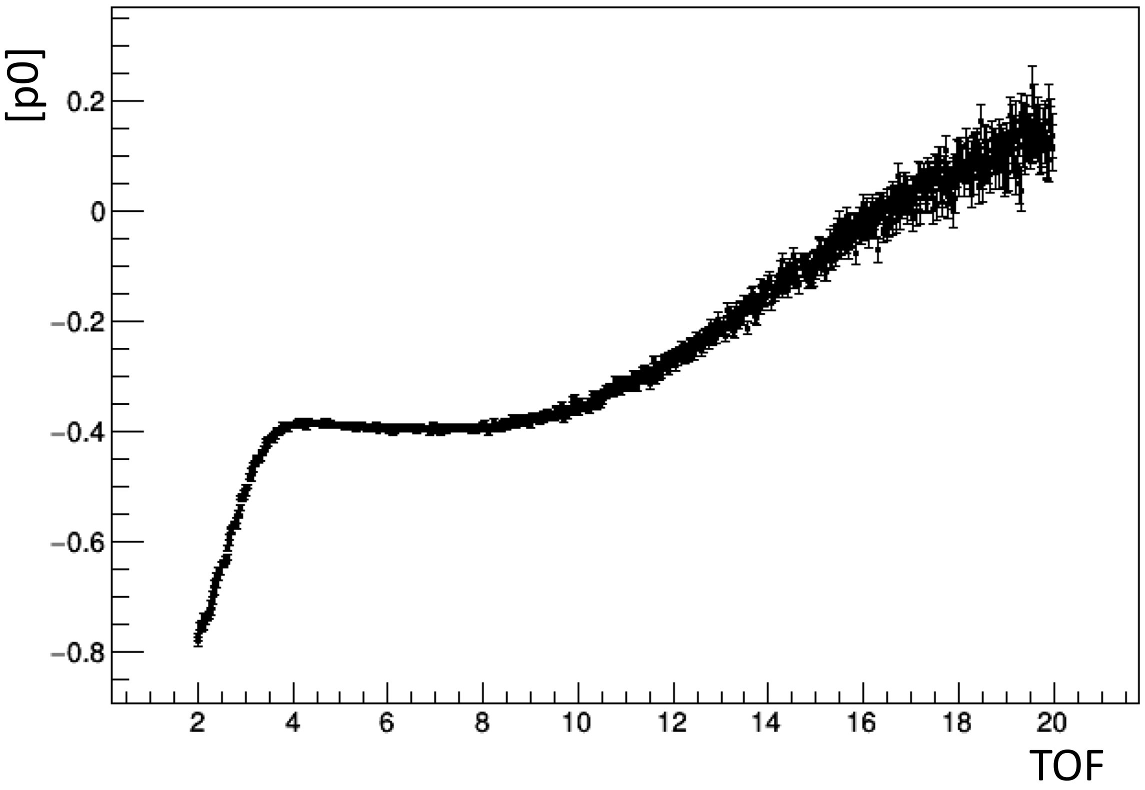

h_prob
Entries 900
Mean 0.1611
Std Dev 0.2461
χ^2 prob


χ^2 prob
TOF

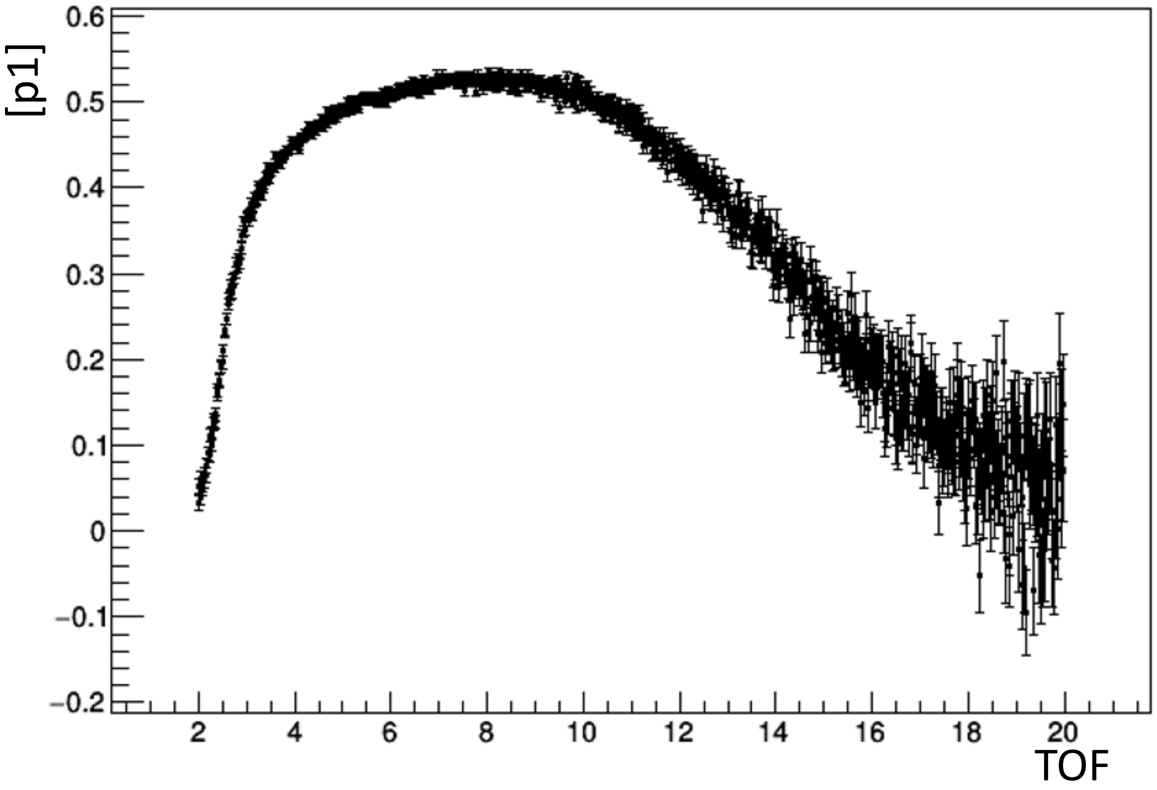


Entries 900
Mean 0.1611



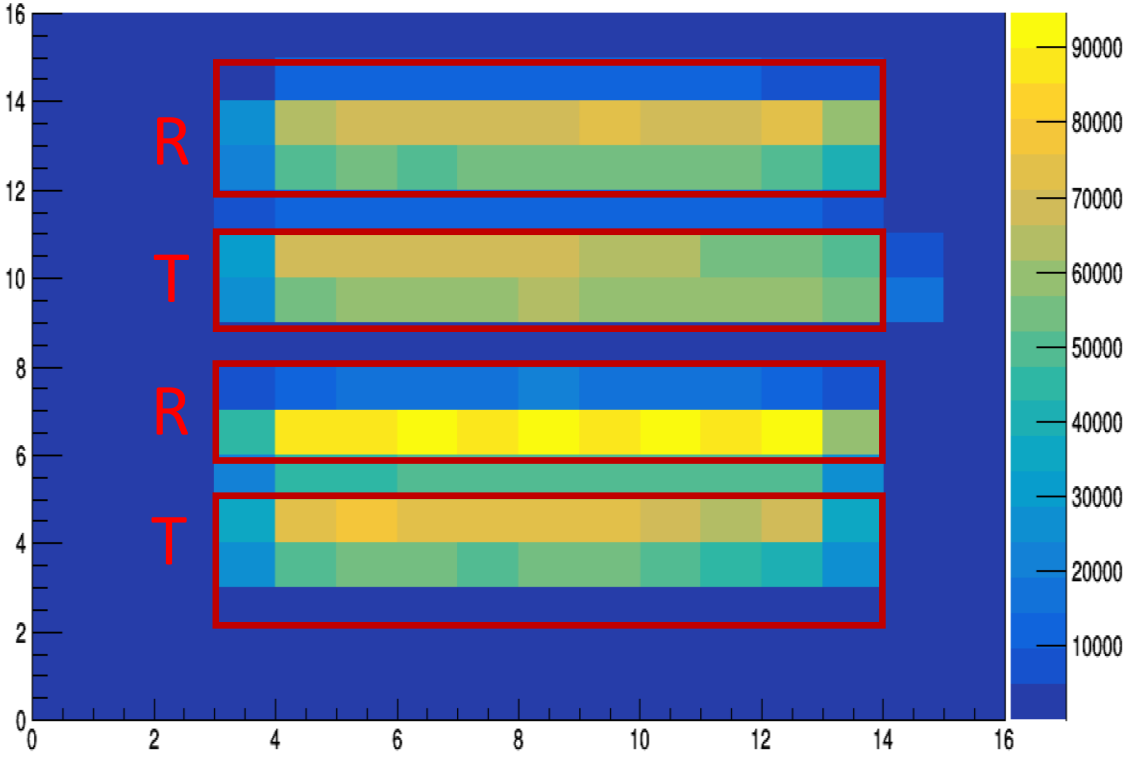


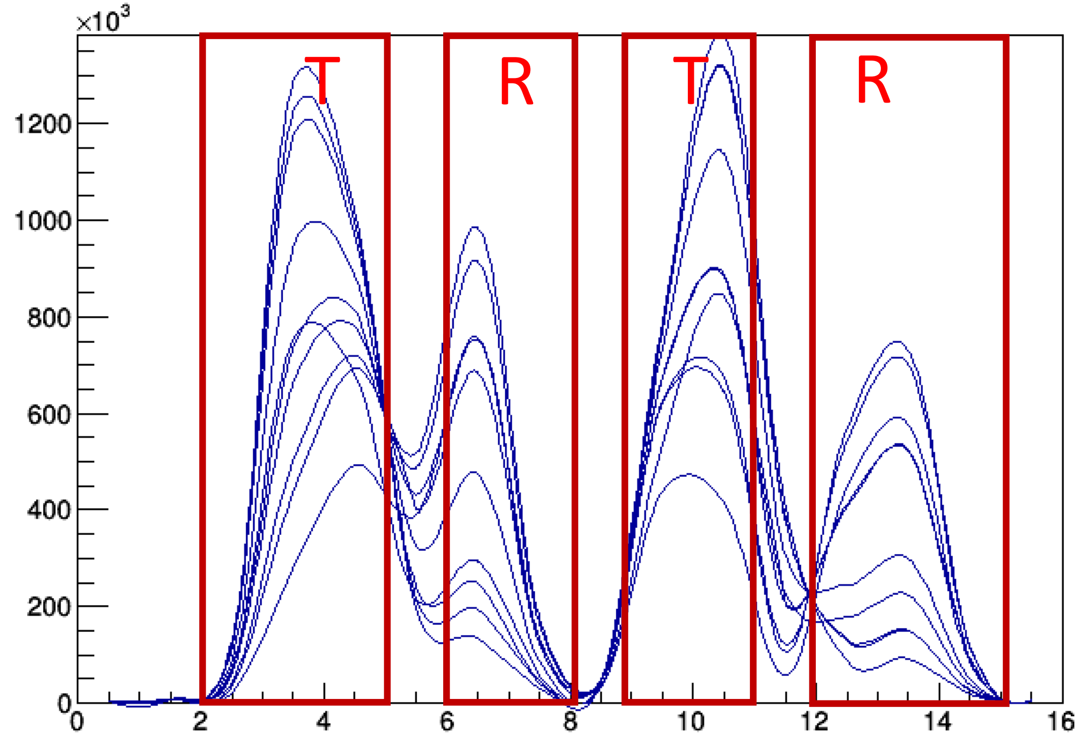
[p0]
0.2
0
−0.2
−0.4
−0.6
−0.8
2
4
6
8
10
12
14
16
18
20
TOF

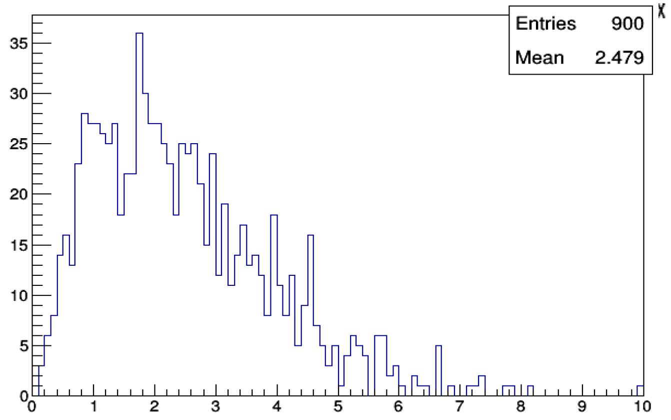


[p1]
0.6
0.5
0.4
0.3
0.2
0.1
0
−0.1
−0.2
2
4
6
8
10
12
14
16
18
20
TOF

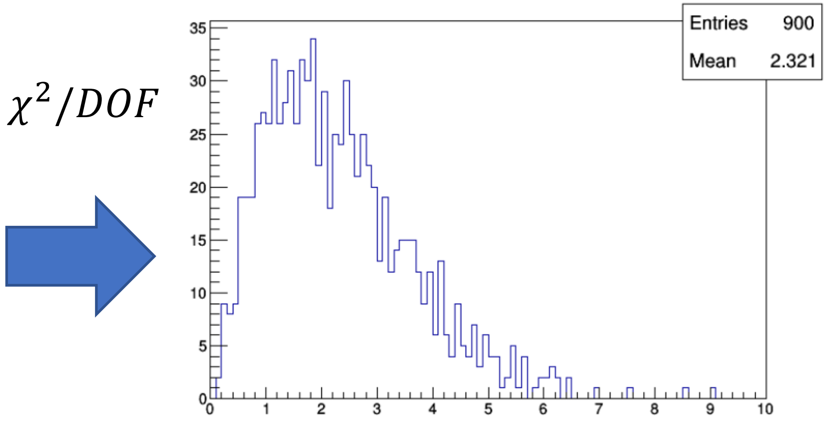
- Increase R_up and T_down area







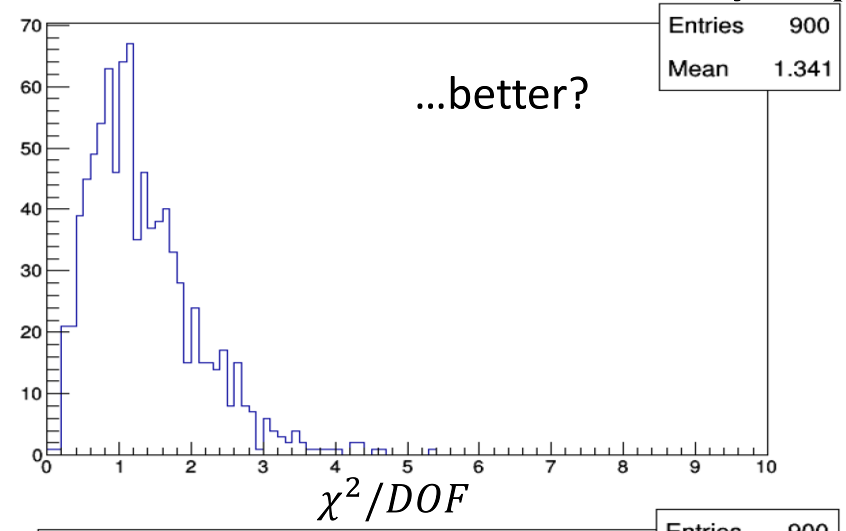
χ^2/DOF

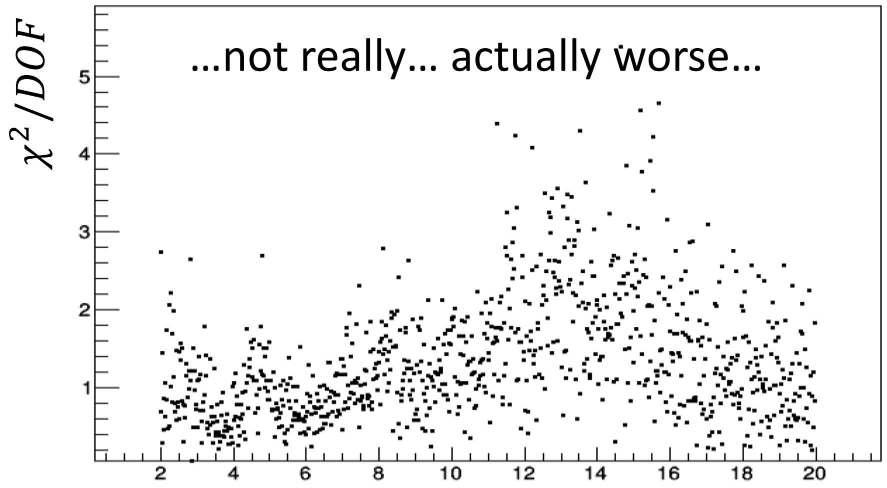


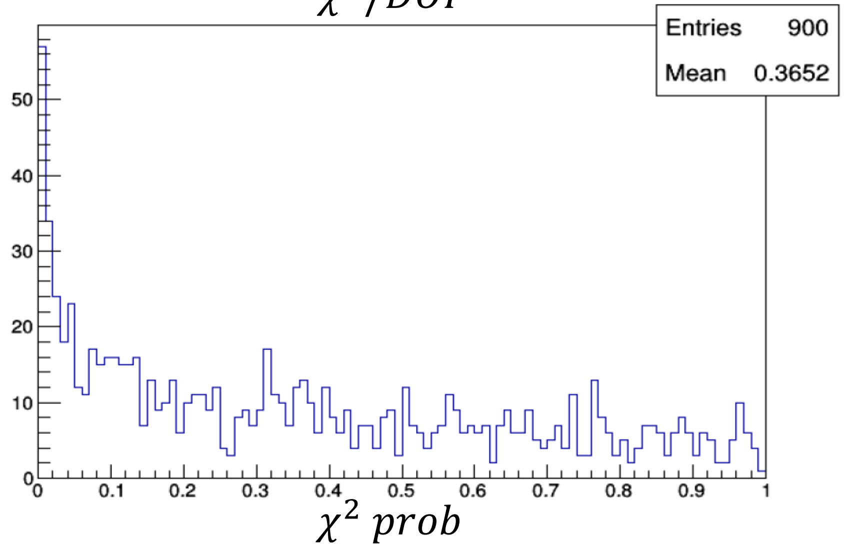
- Introduce Φ_{SF} error : $\sigma_{\Phi_{SF}}$= 0.15° (observed RMS)

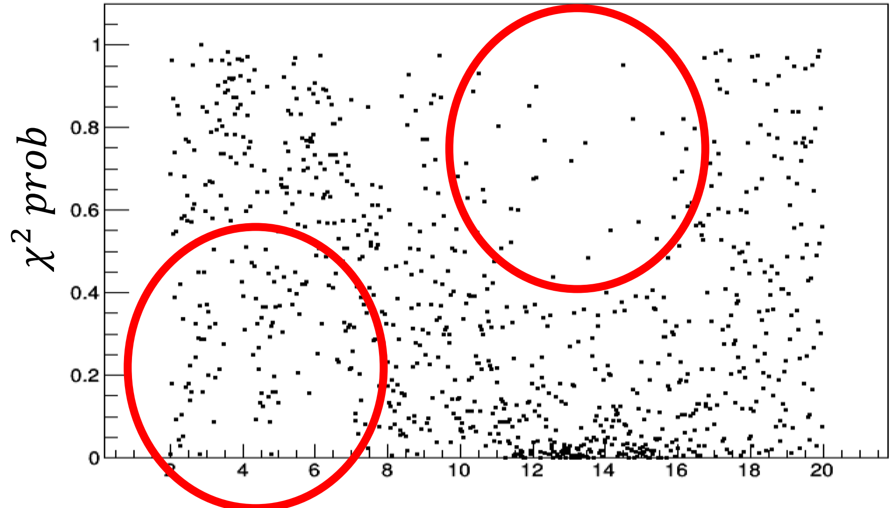
➡ no substantial changes in χ^2/DOF distribution

- What I inflate arbitrarily $\sigma_{\Phi_{SF}}$ (ex. = 3°)?

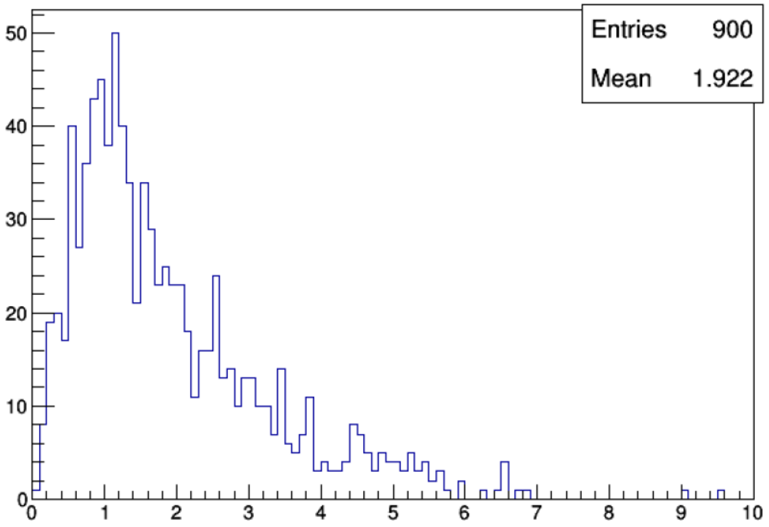


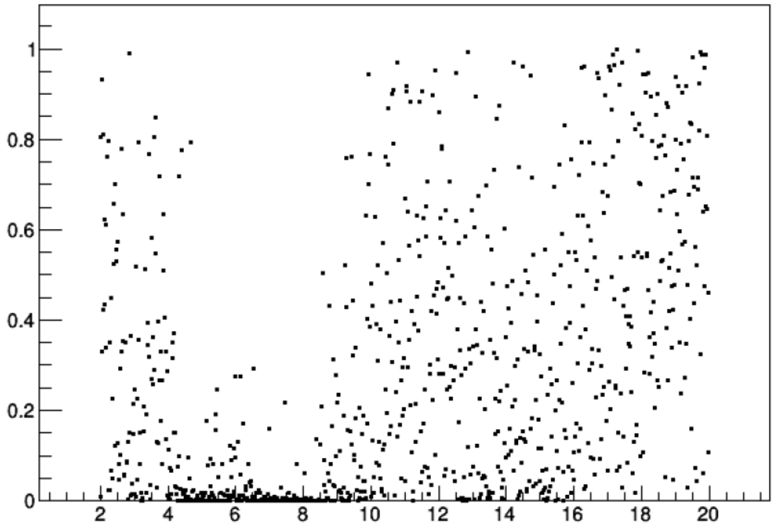


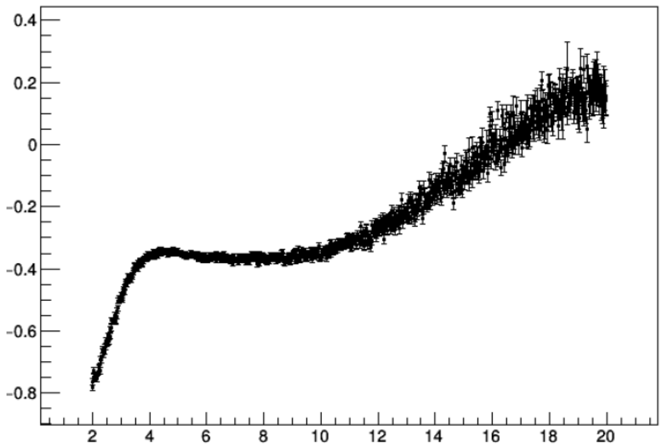


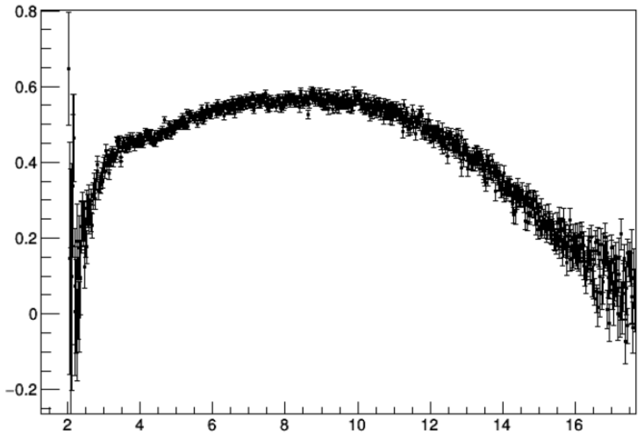


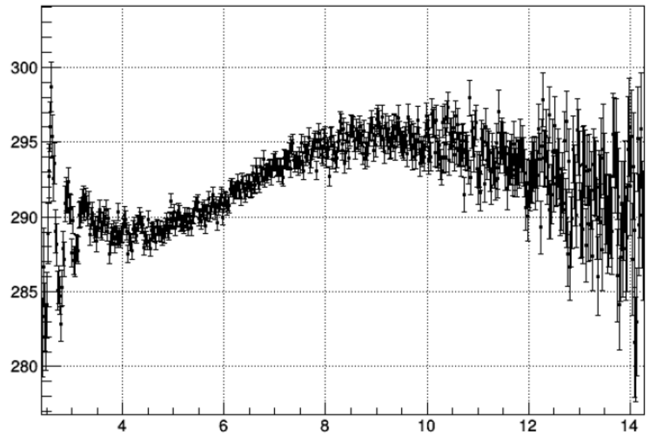
- Fit with $\dfrac{[p_0]+[p_1]\sin\left(x\cdot\frac{\pi}{180}+[p_2]\right)}{1+[p_3]\sin\left(x\cdot\frac{\pi}{180}+[p_2]\right)}$



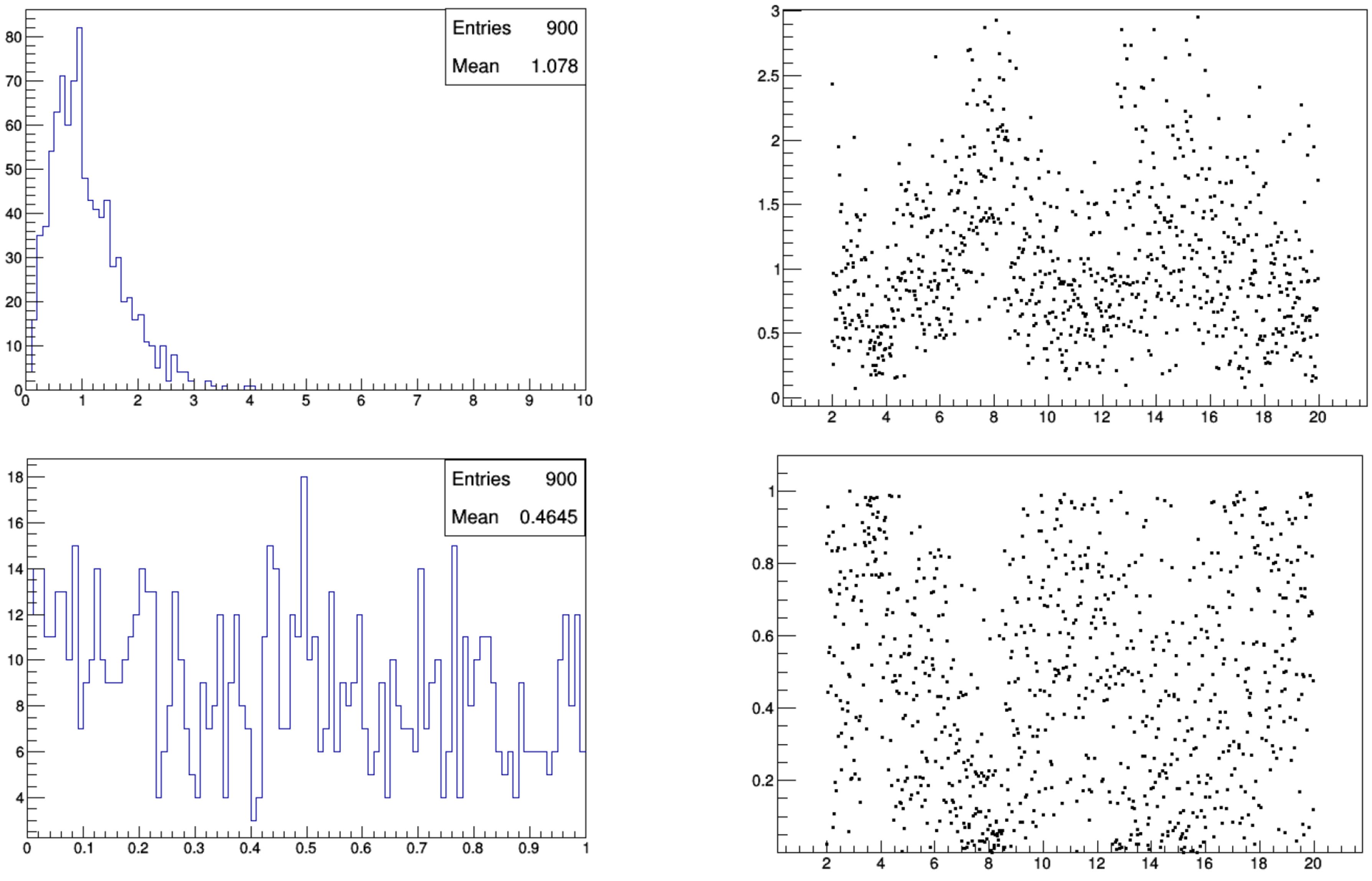




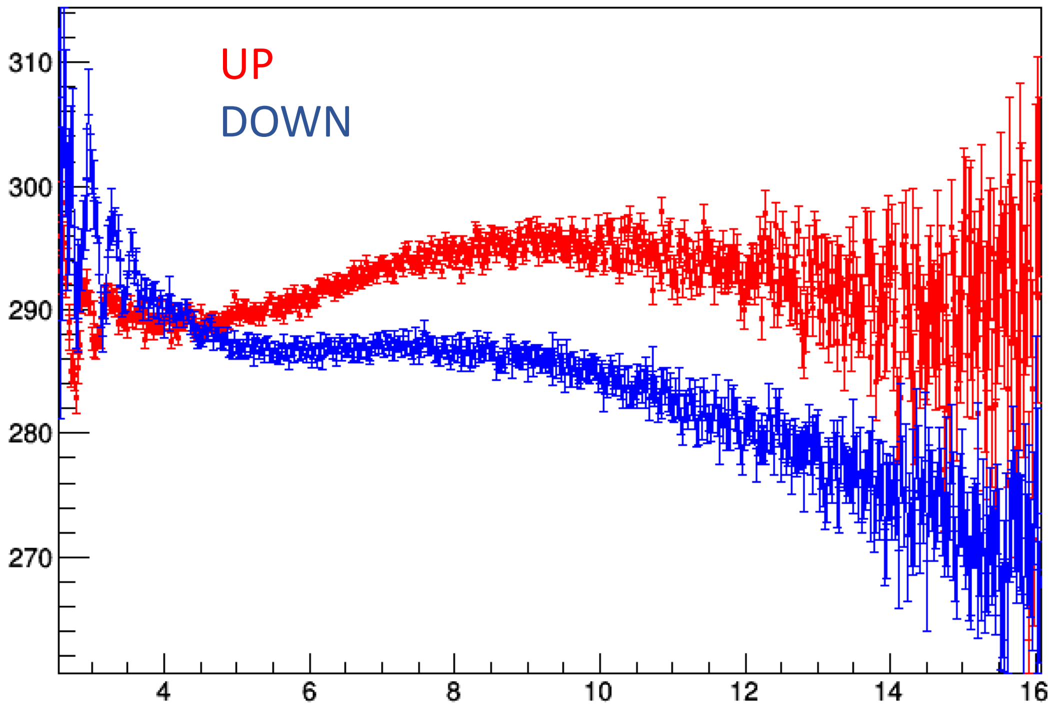


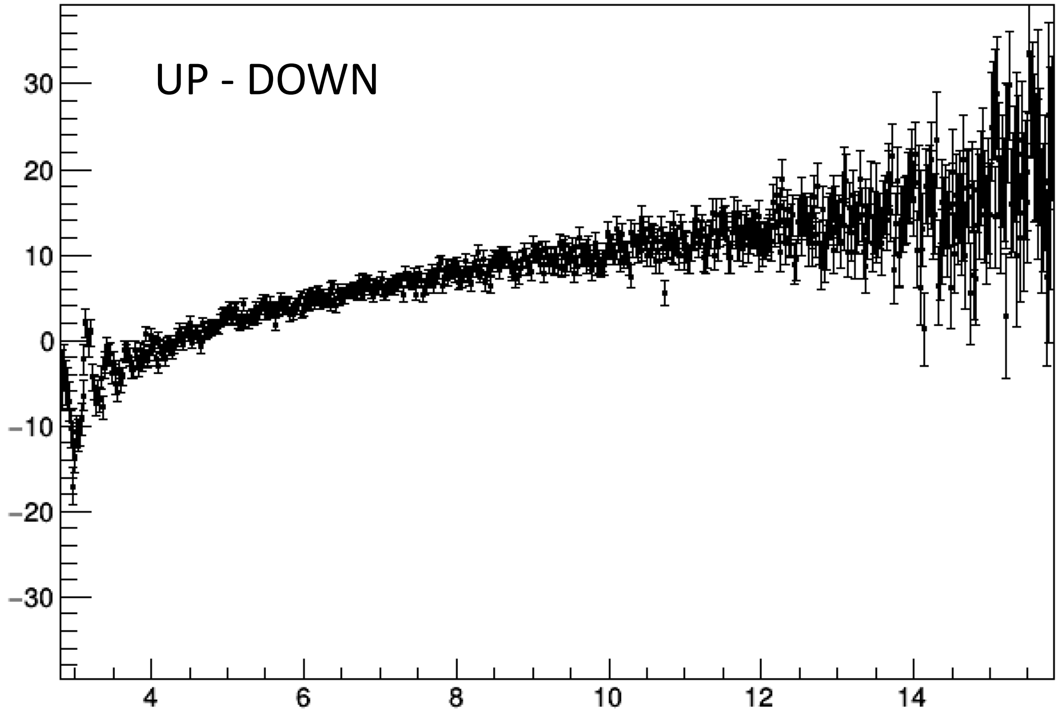


- Combine poissonian error on detector counts with a fixed 3% error

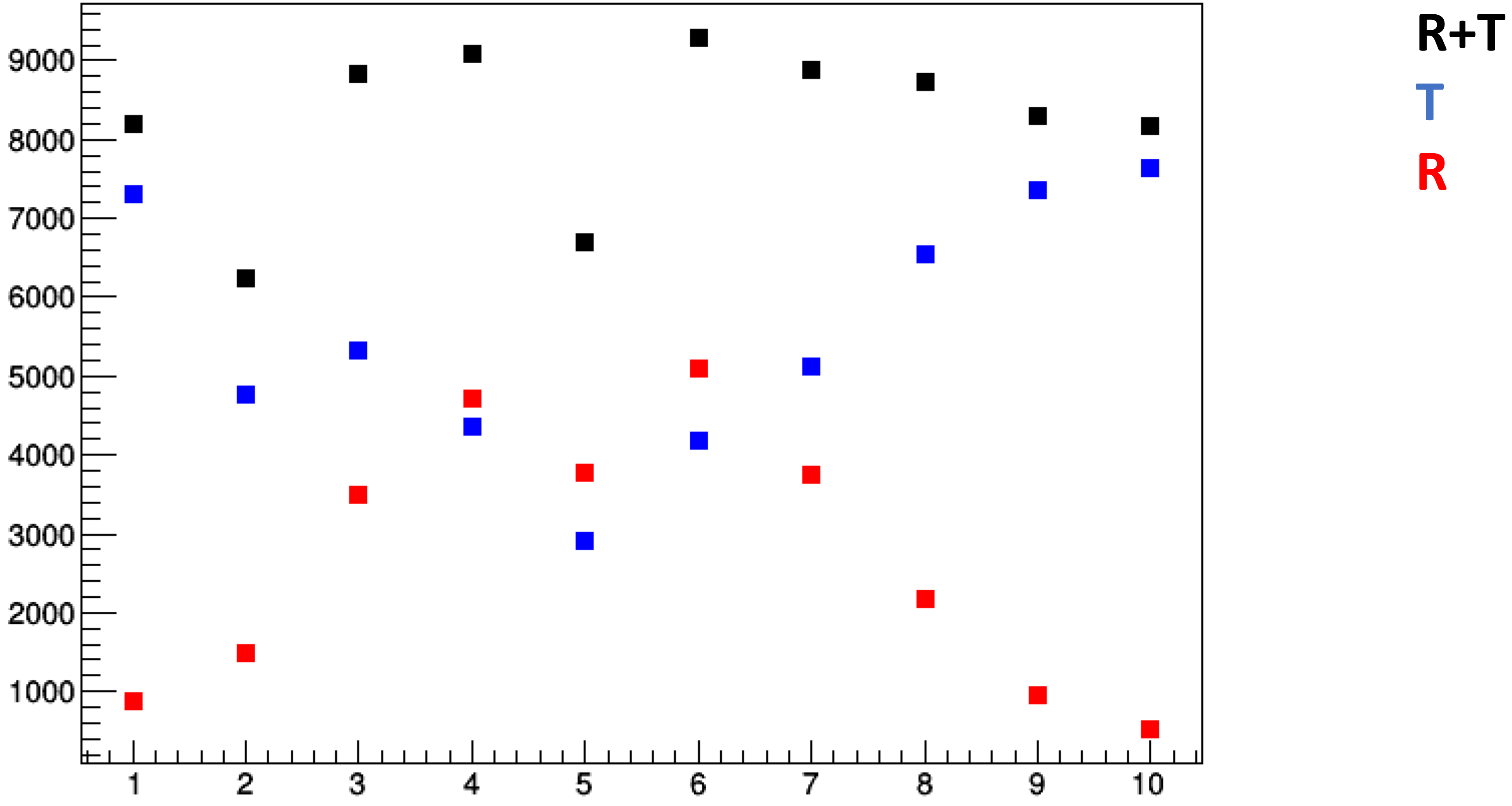


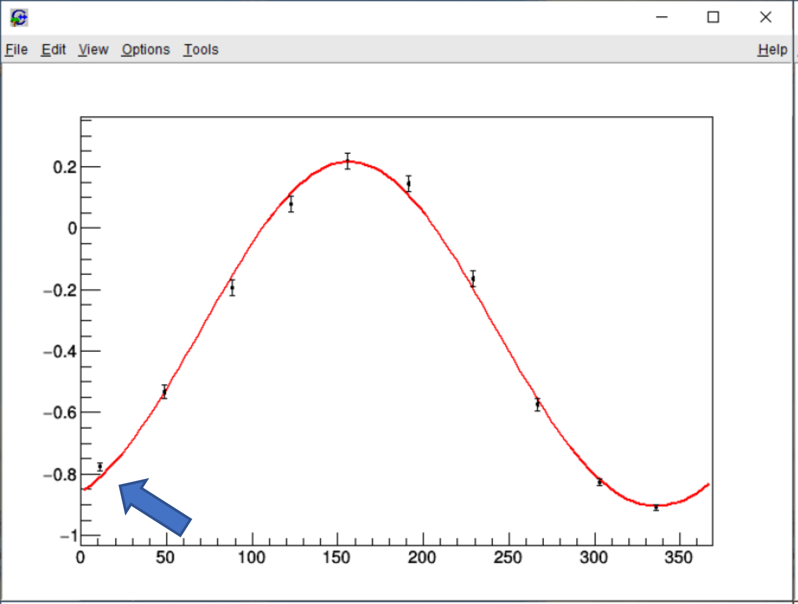
UP vs DOWN beams (125 μT)

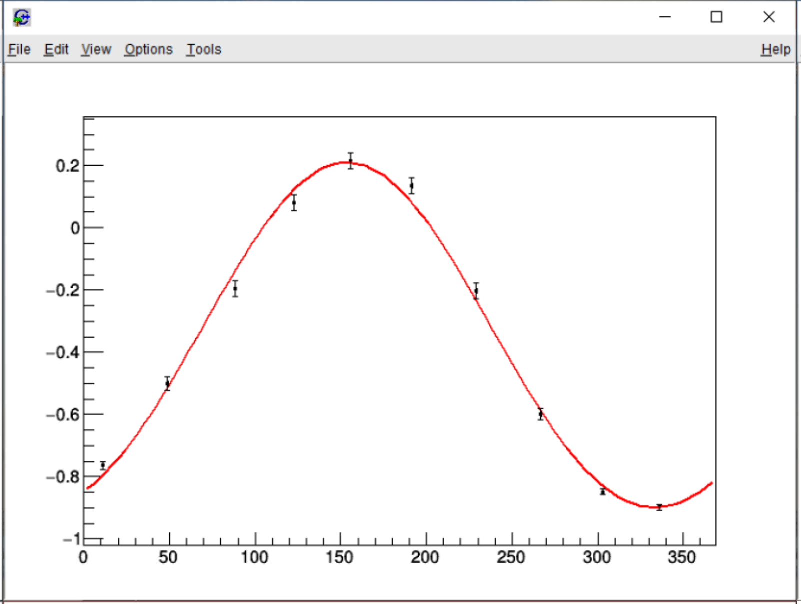


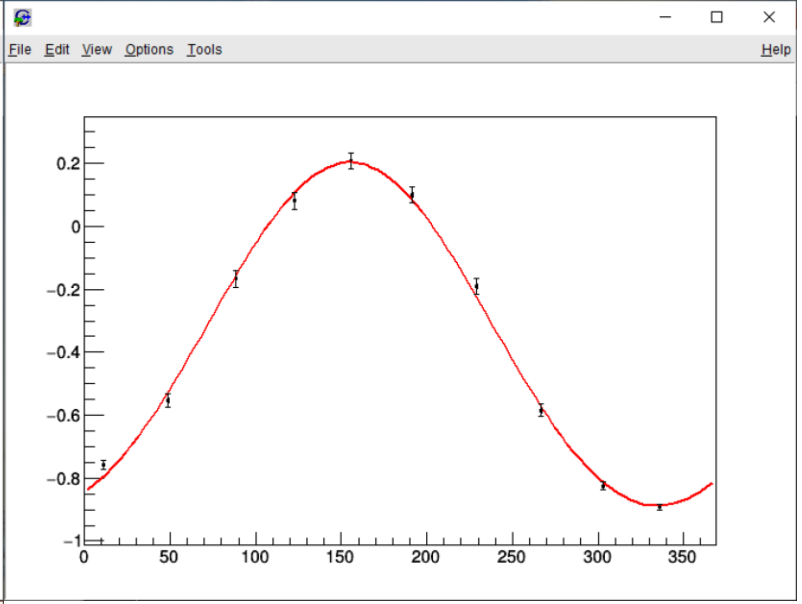


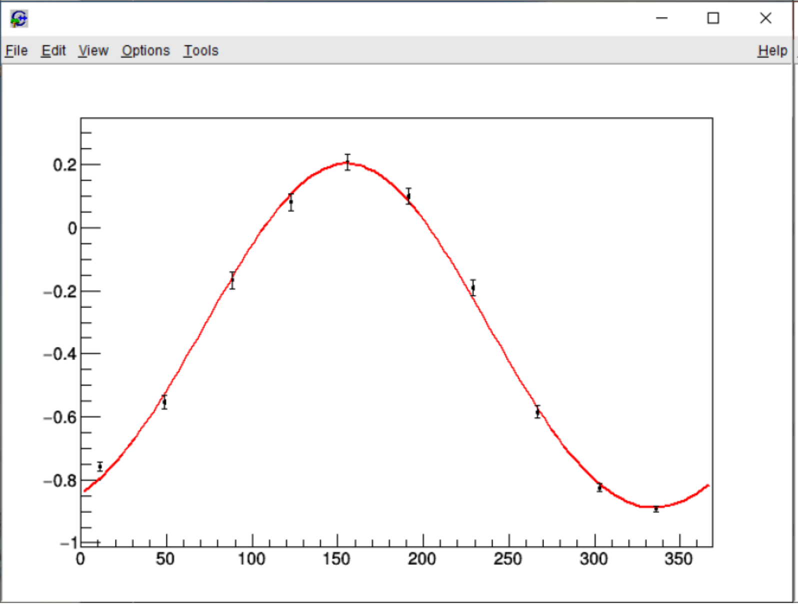
Beam intensity variations (125 uT, tof = 5 ms, up)

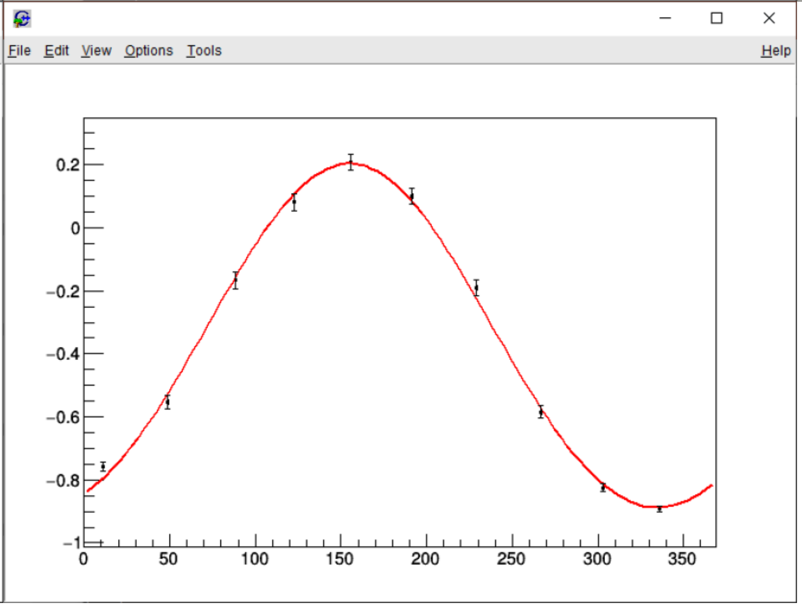










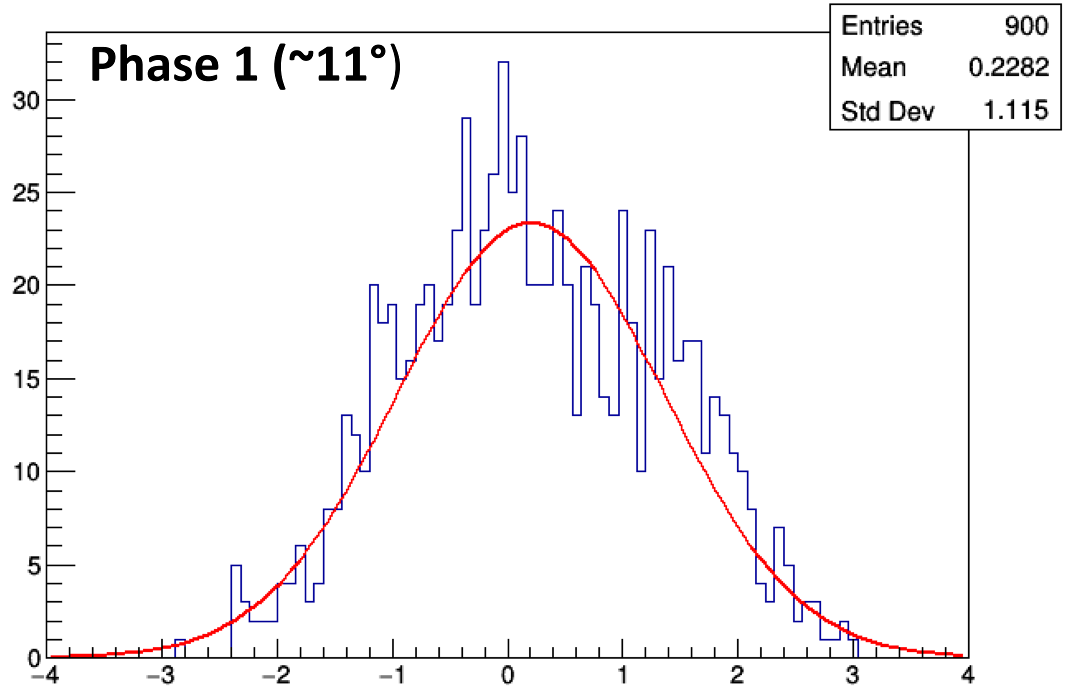


Tof = 8.08, 8.10, 8.18, 8.20, 8.54 ms

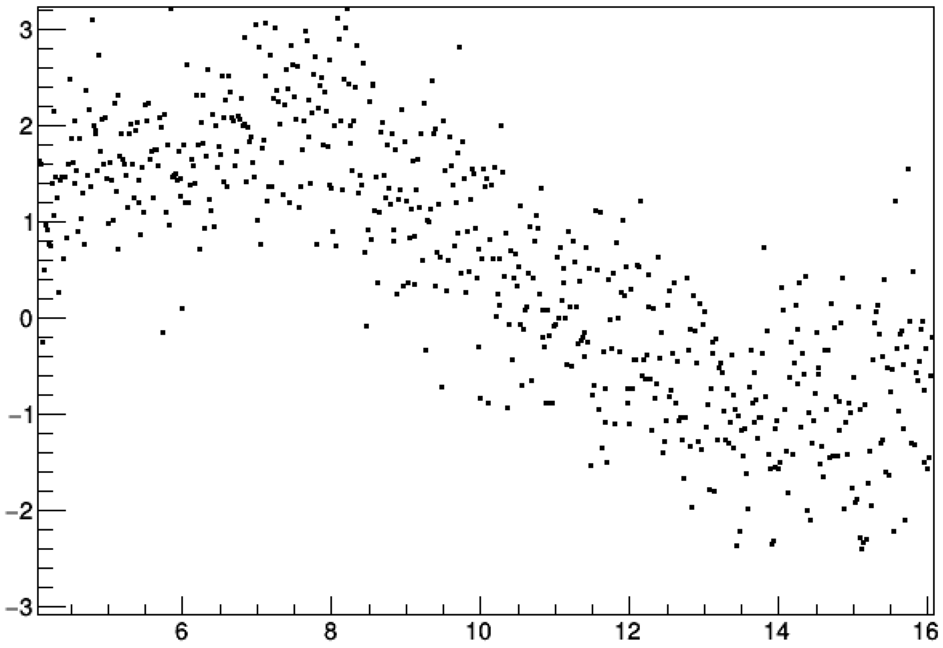
→ suspicious, check pulls

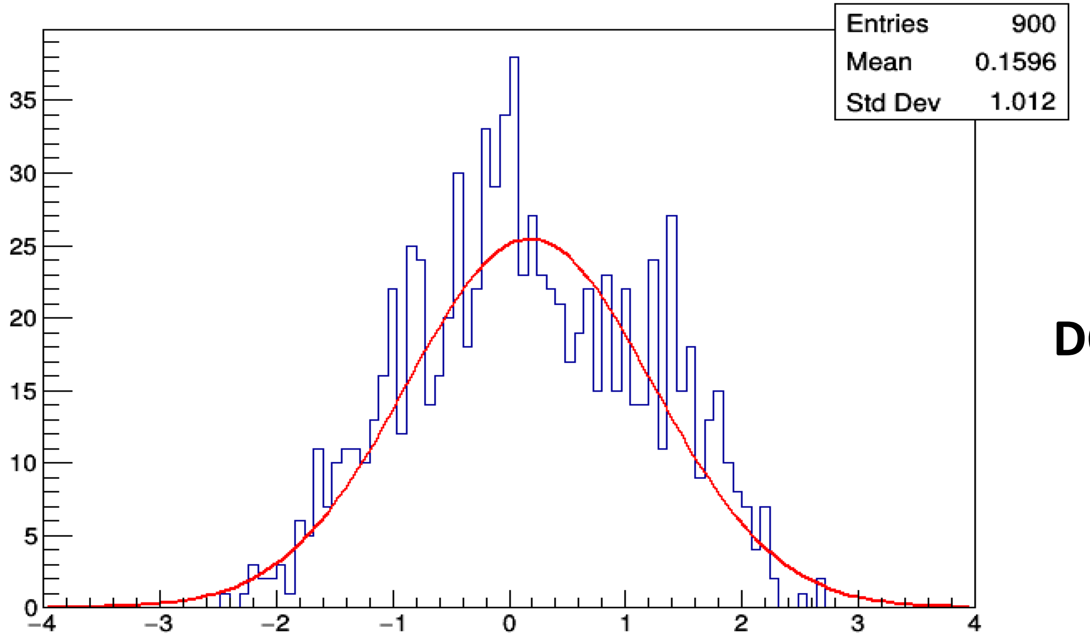
Pull distr.: $\frac{A_{obs}-A_{fit}}{\sigma_A}$ **if OK, it's a gaussian with $\mu = 0$ and $\sigma = 1$**

Phase 1 (~11°)

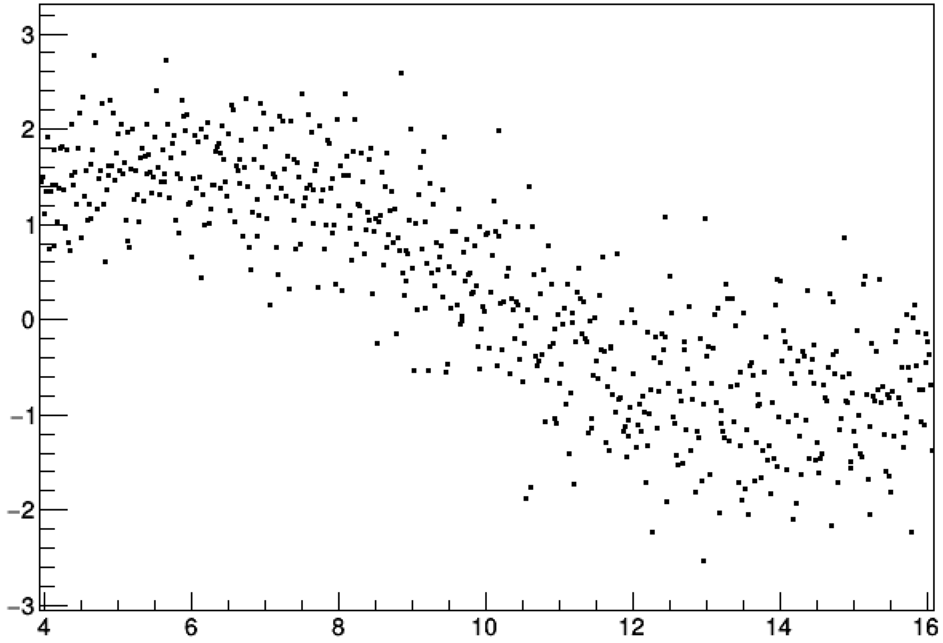


UP

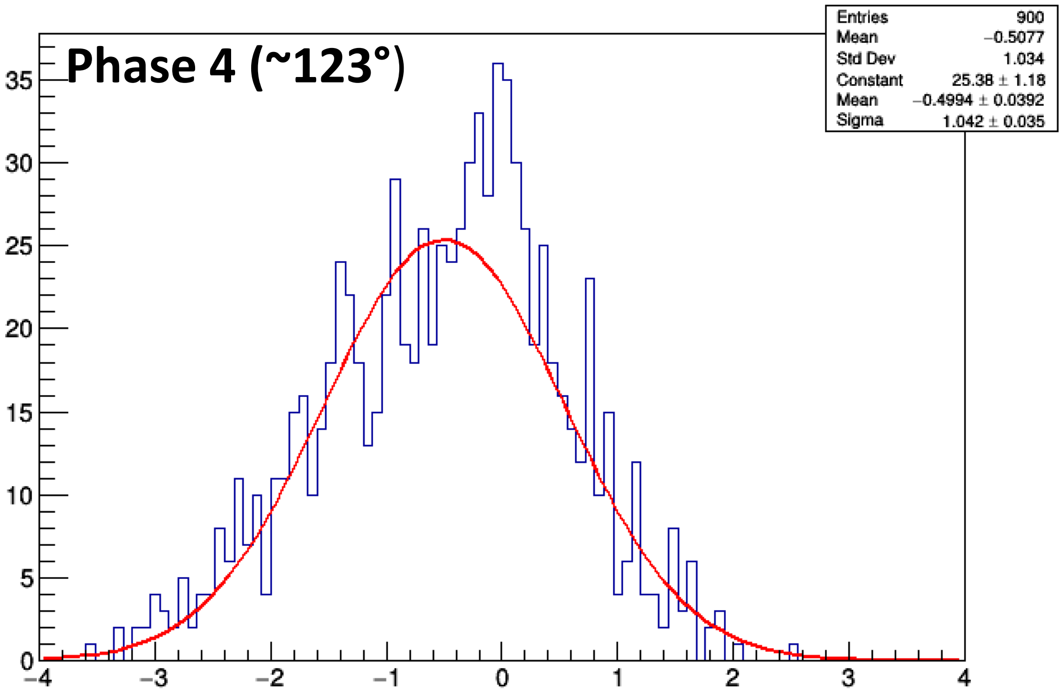




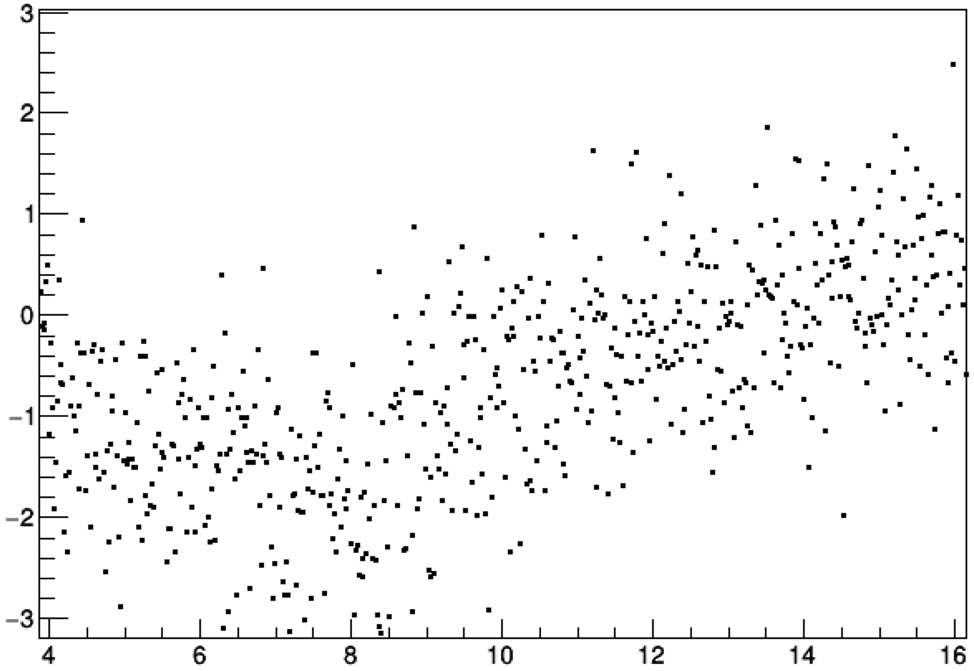
DOWN

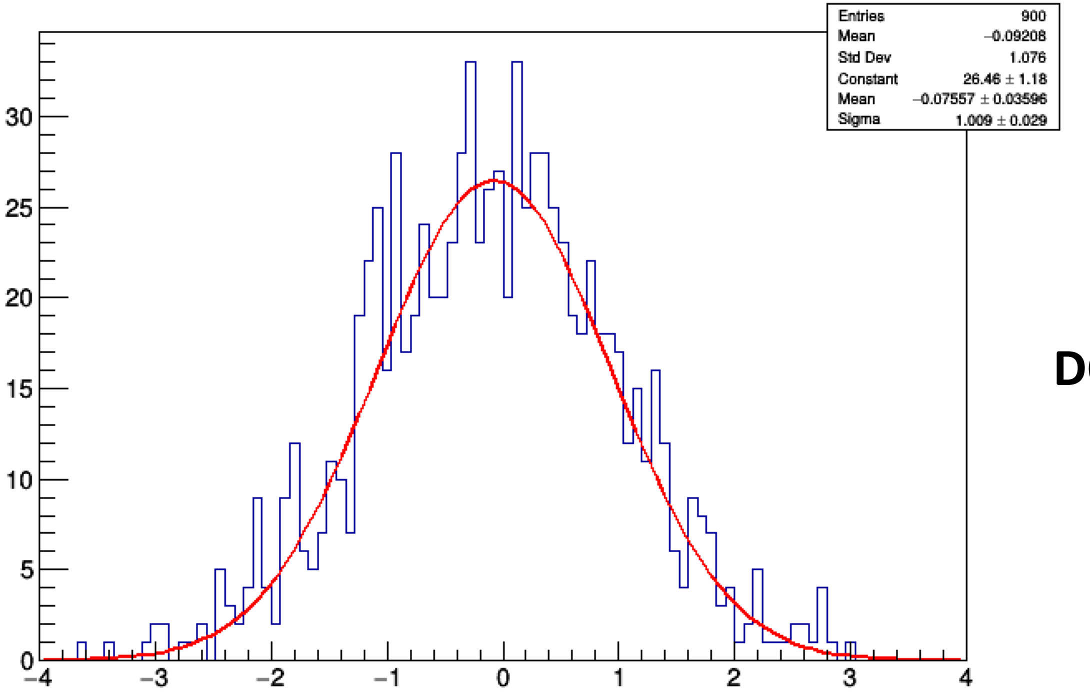


Phase 4 (~123°)

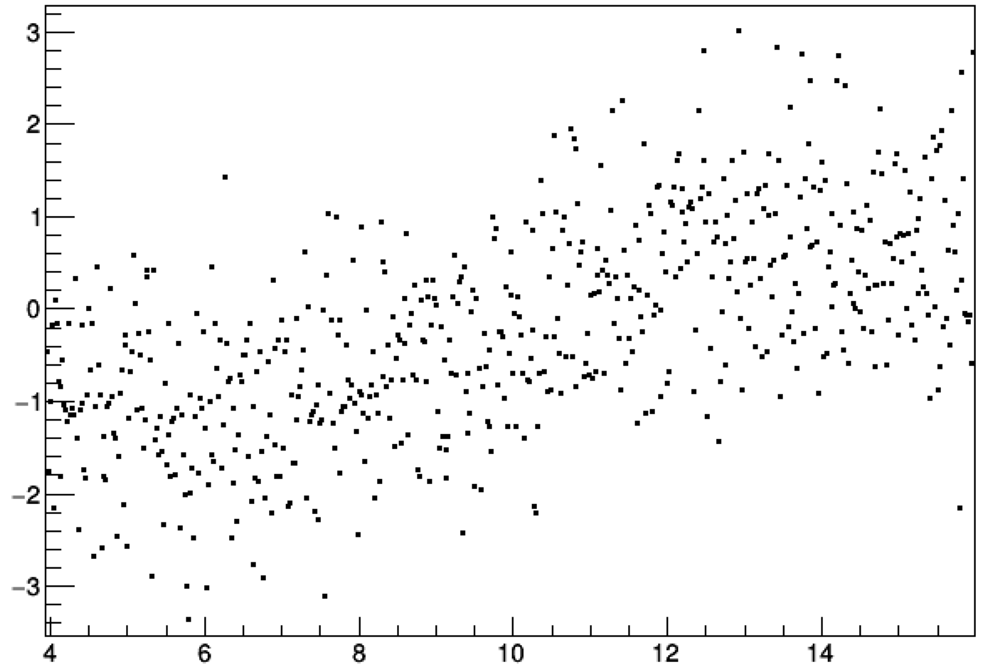


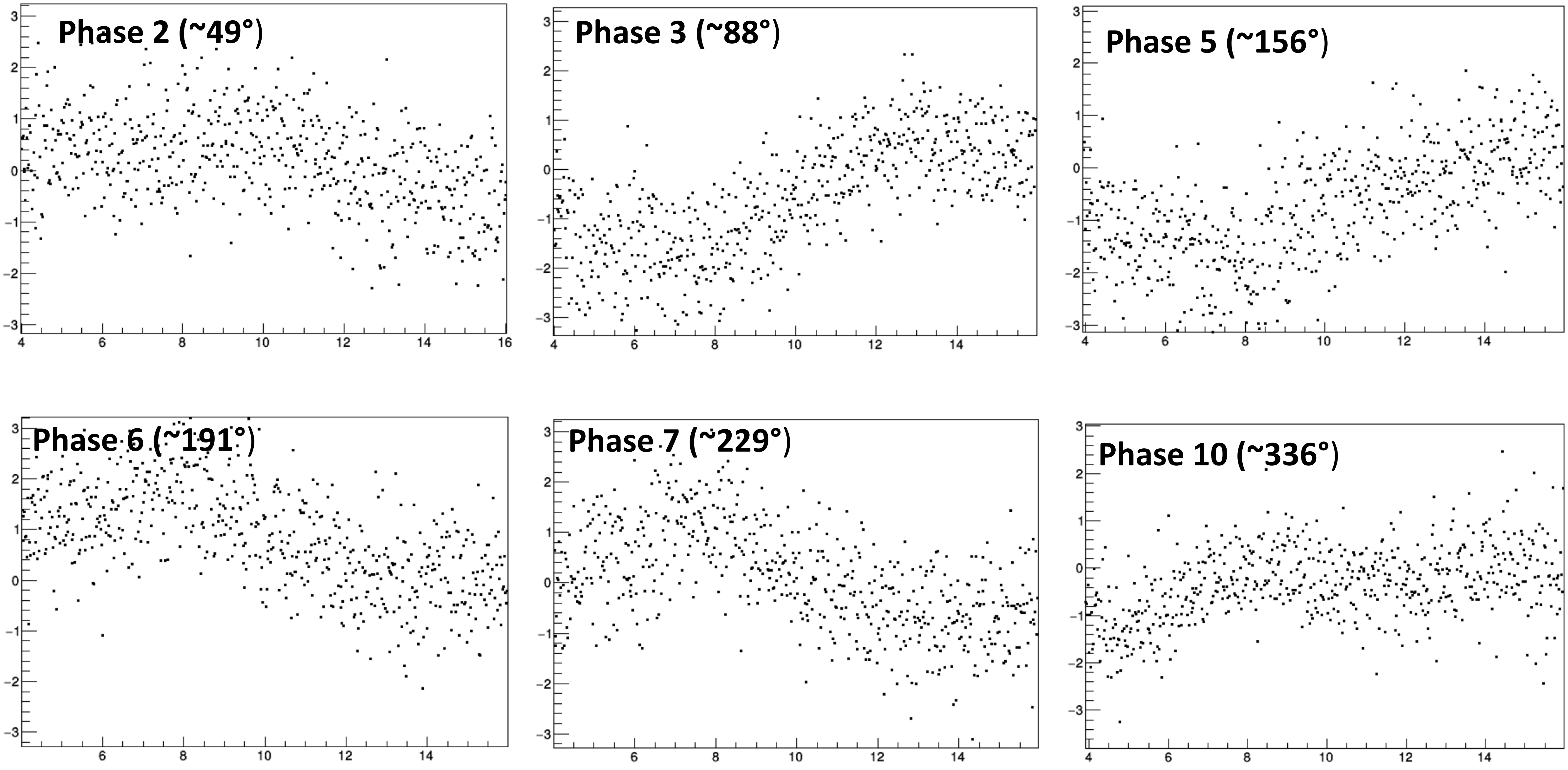
UP





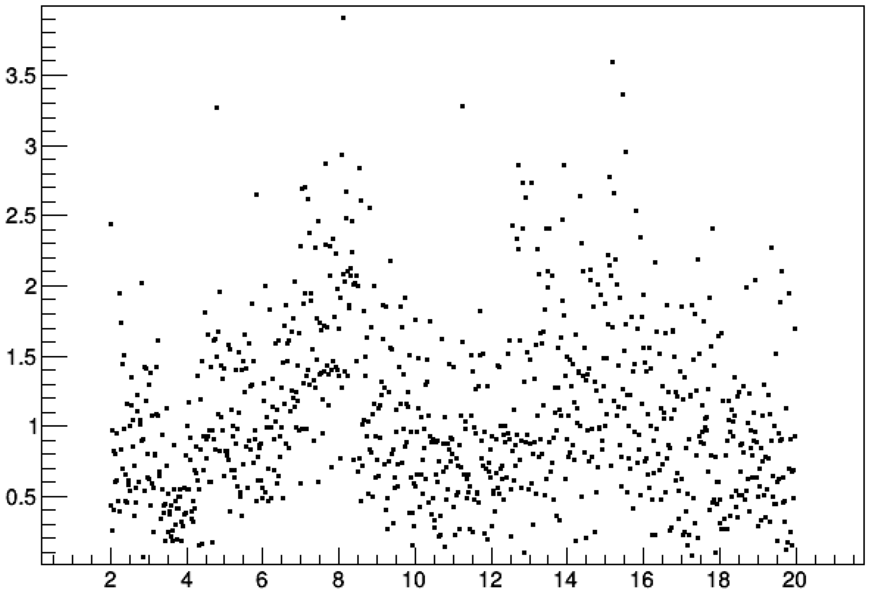
DOWN



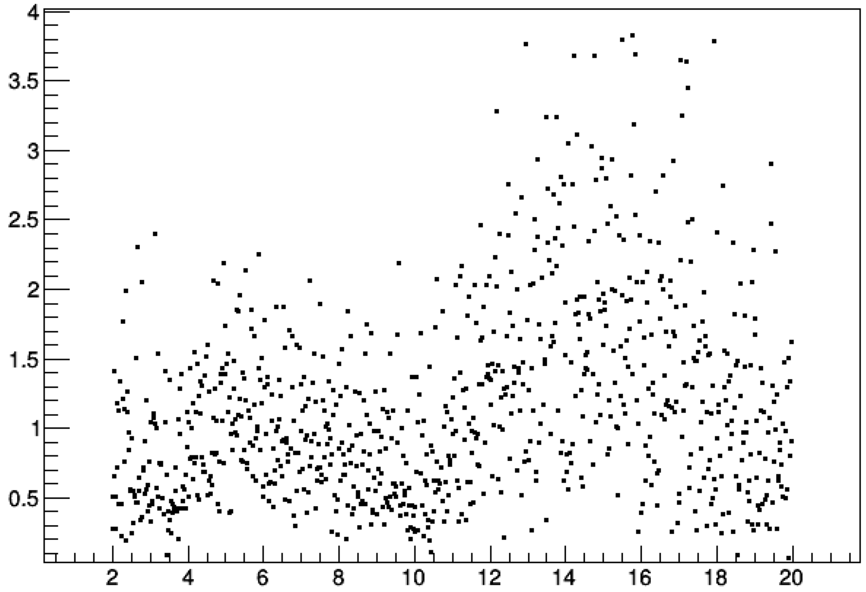


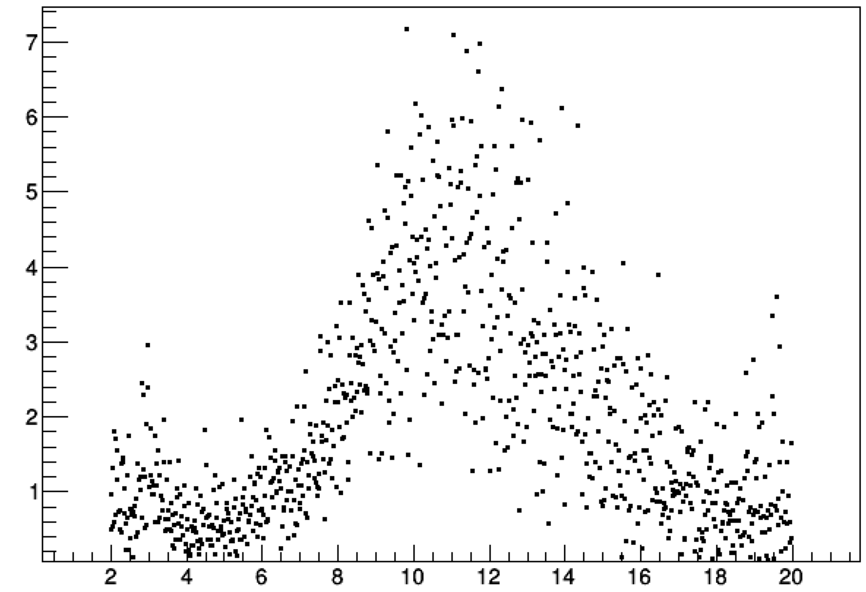
Phase 2 (~49°)
Phase 3 (~88°)
Phase 5 (~156°)
Phase 6 (~191°)
Phase 7 (~229°)
Phase 10 (~336°)

χ^2 UP vs. DOWN

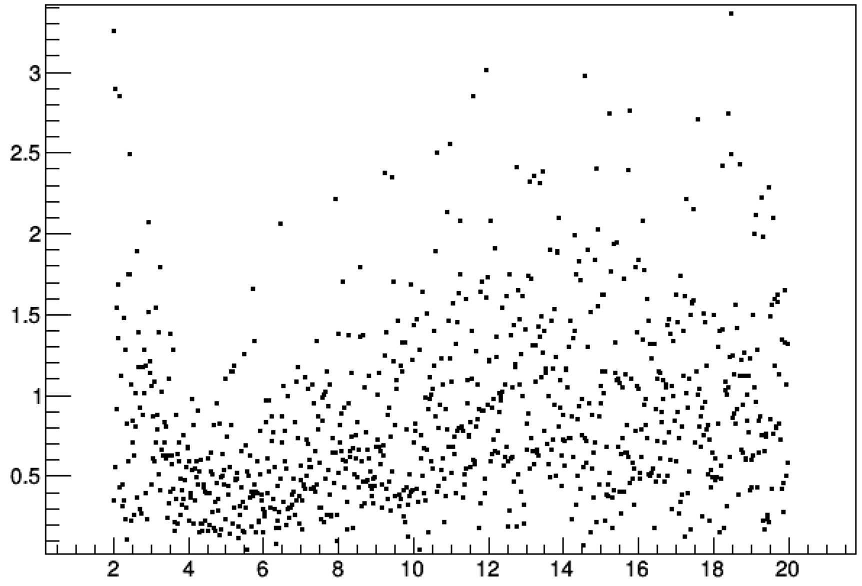


(125 µT)

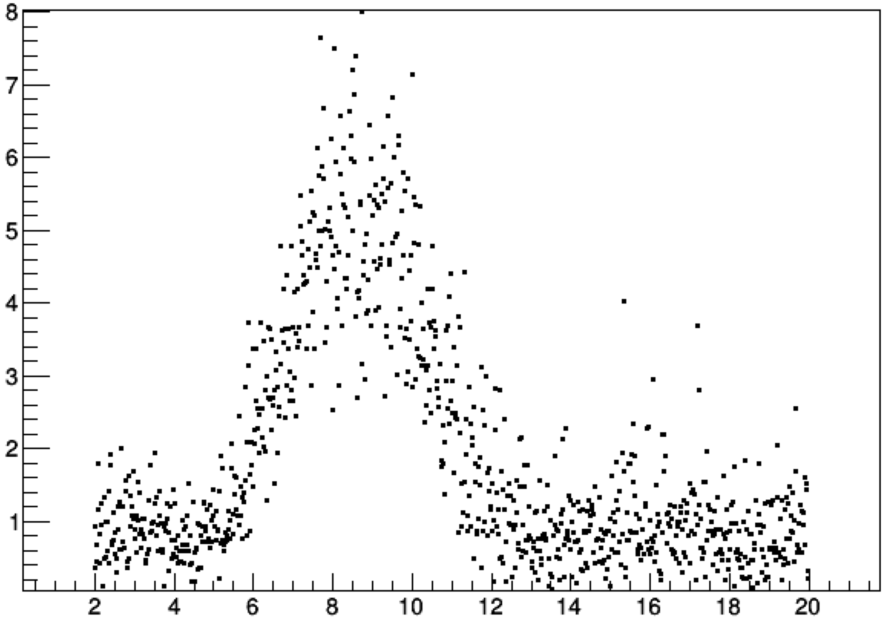




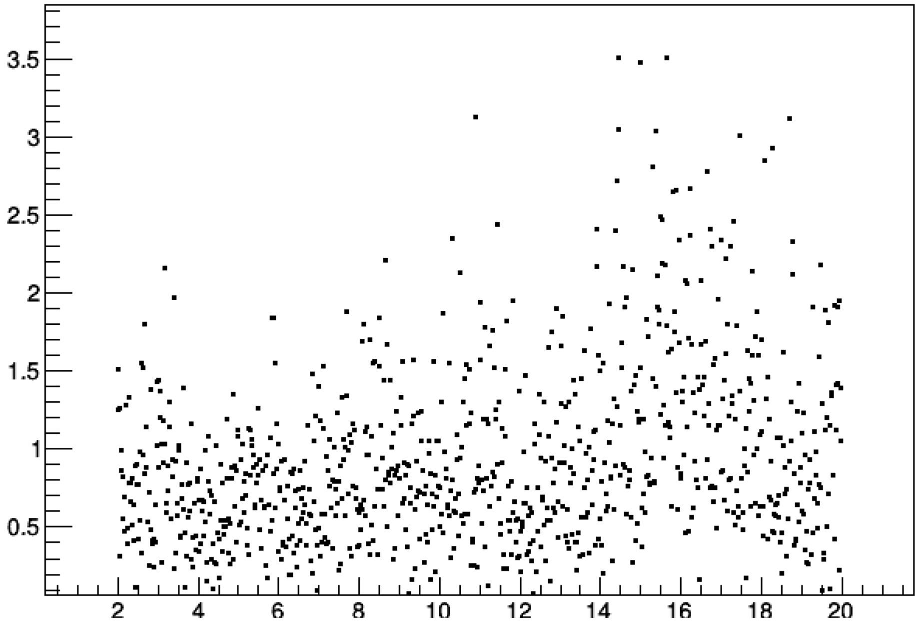
(124 µT**)**

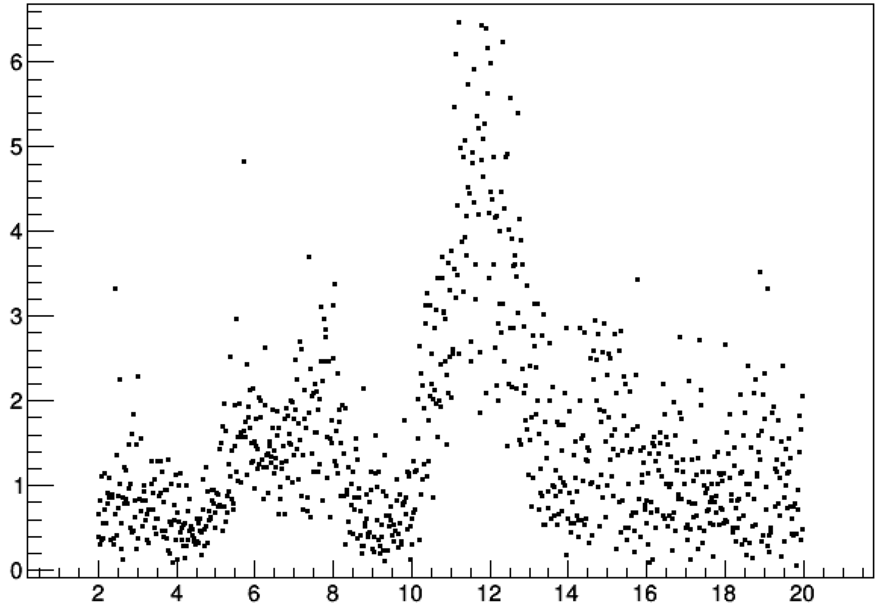


χ^2 UP vs. DOWN

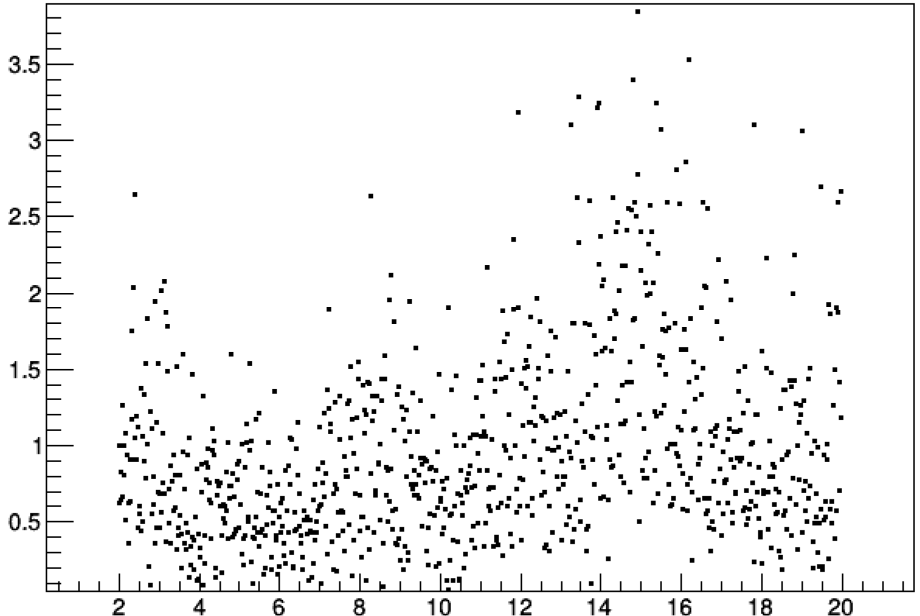


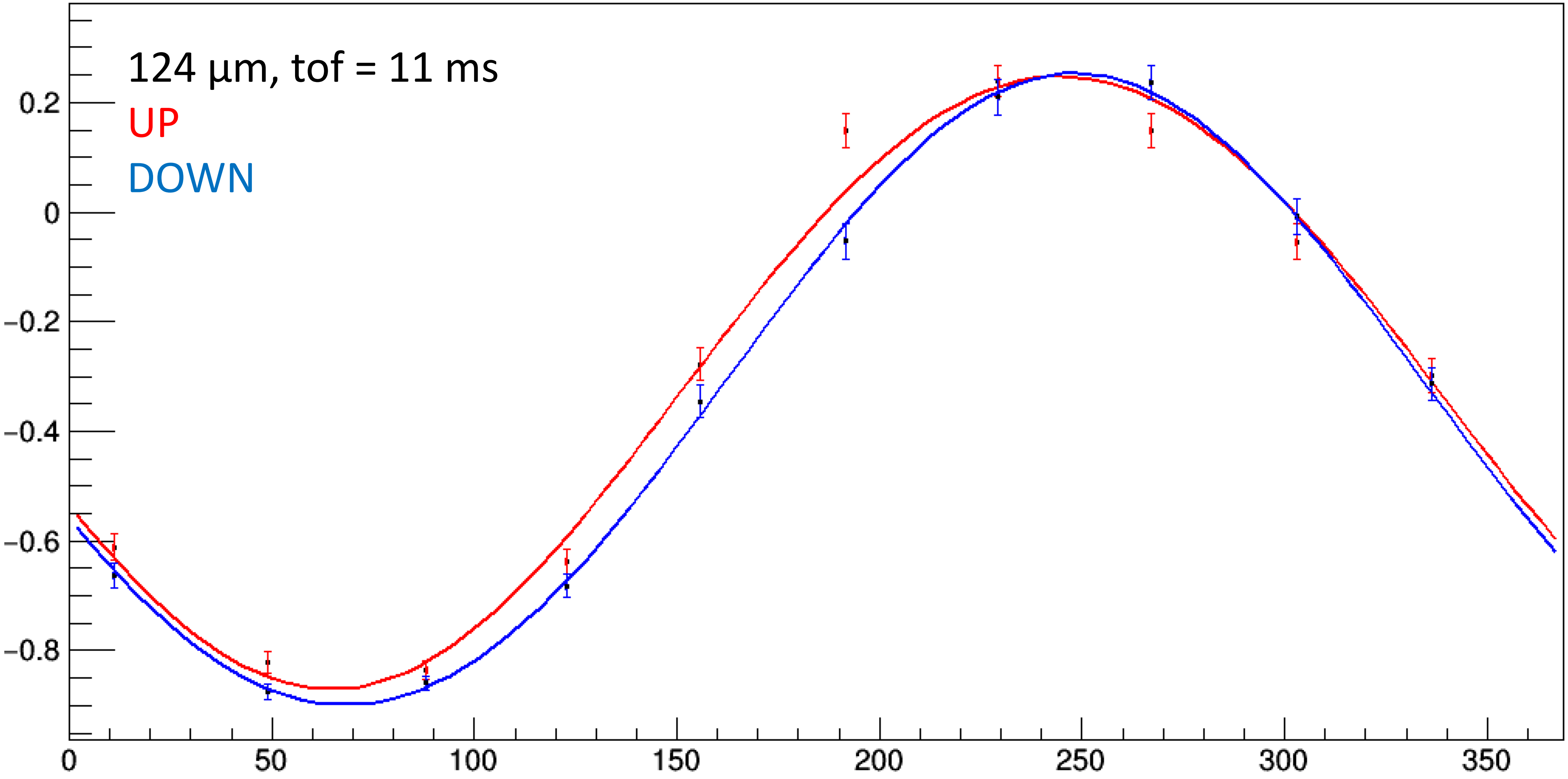
(123 μT)



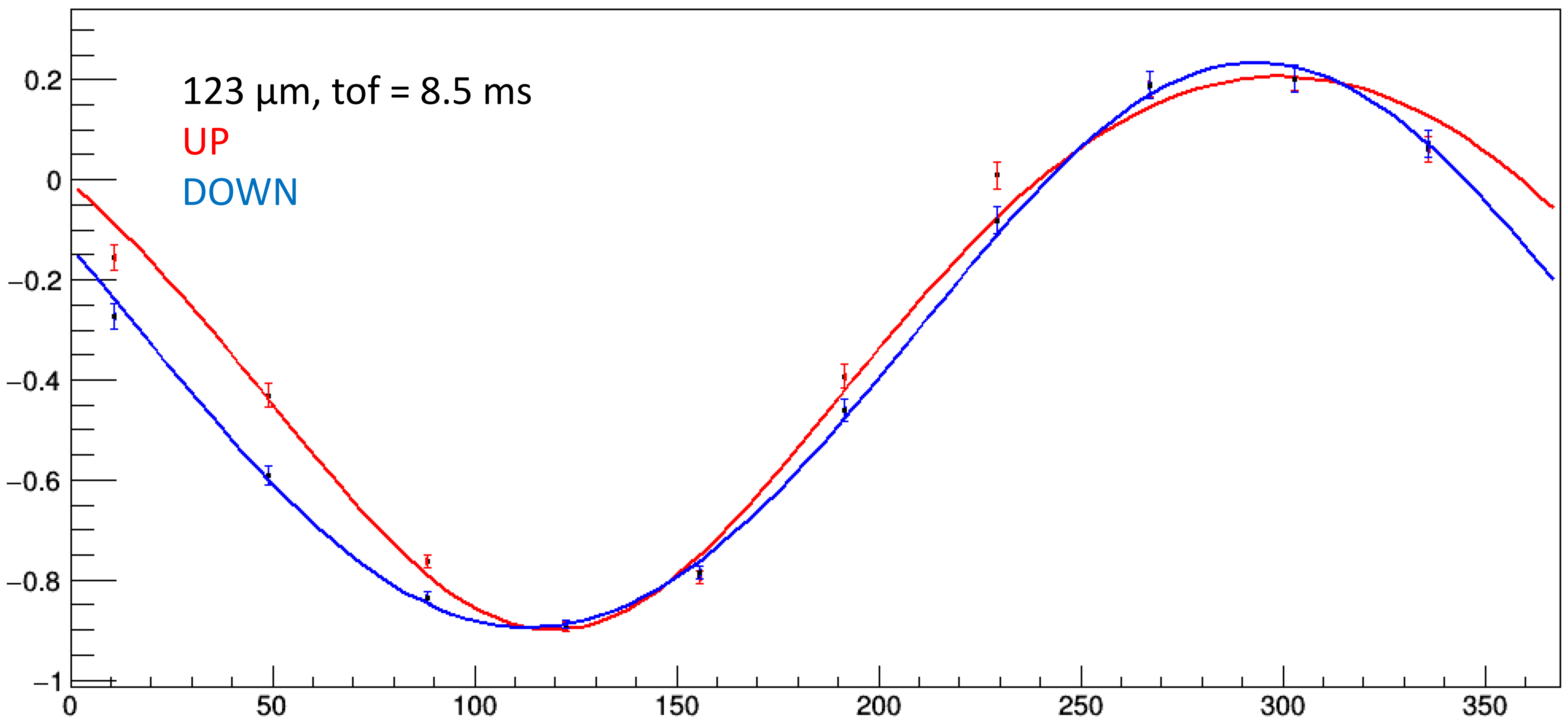


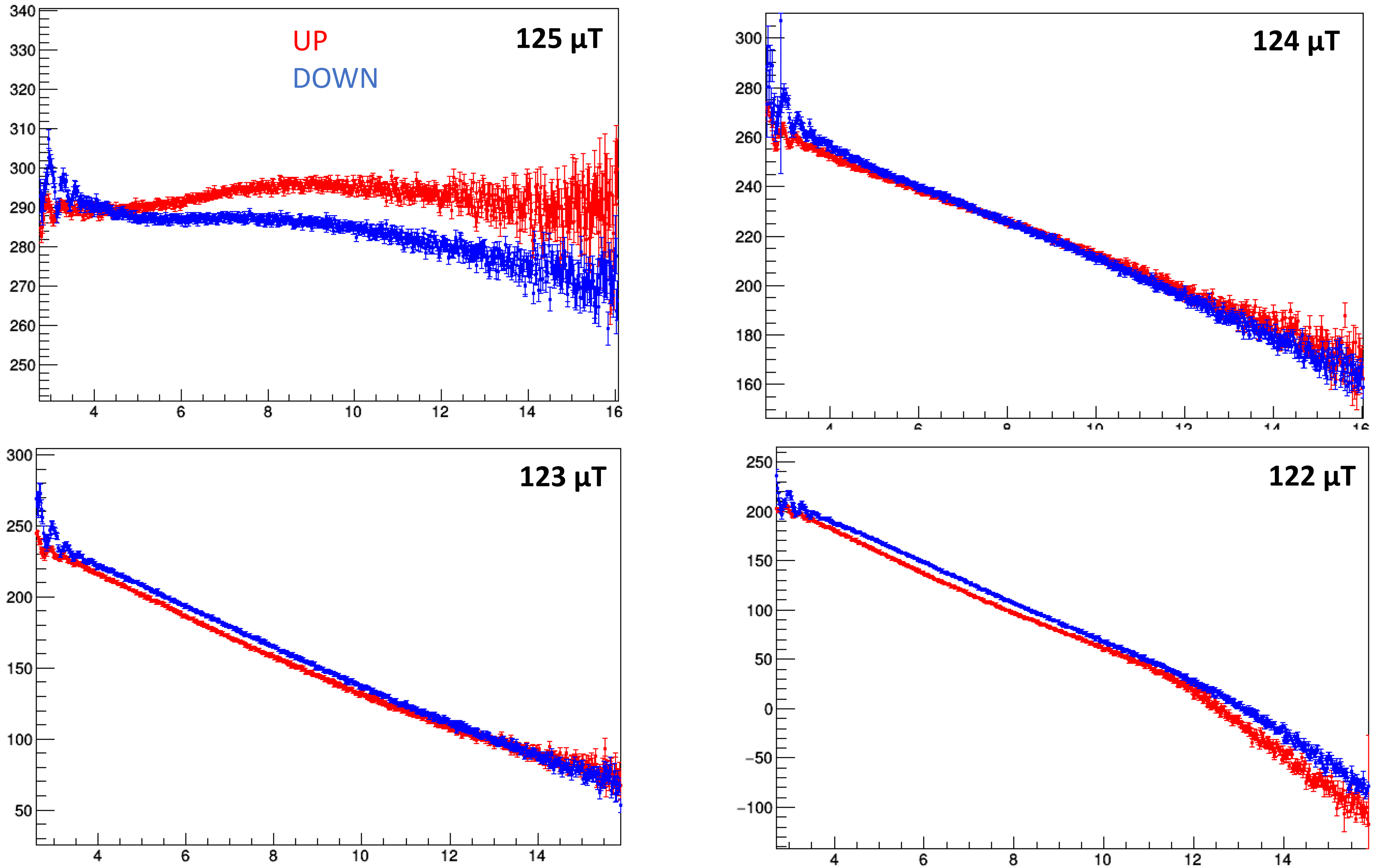
(122 μT)





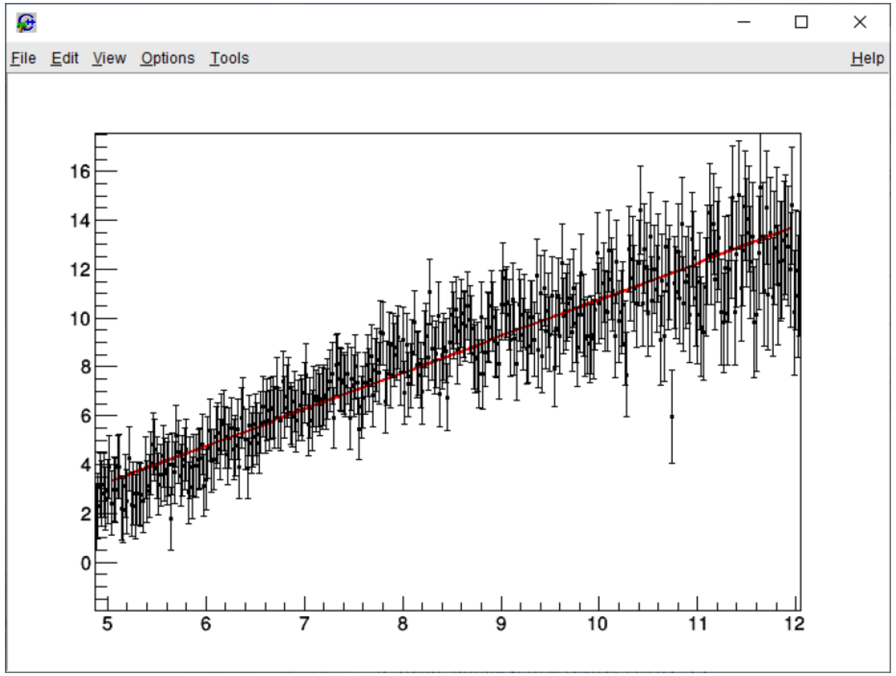
124 µm, tof = 11 ms
UP
DOWN
0.2
0
−0.2
−0.4
−0.6
−0.8
0
50
100
150
200
250
300
350

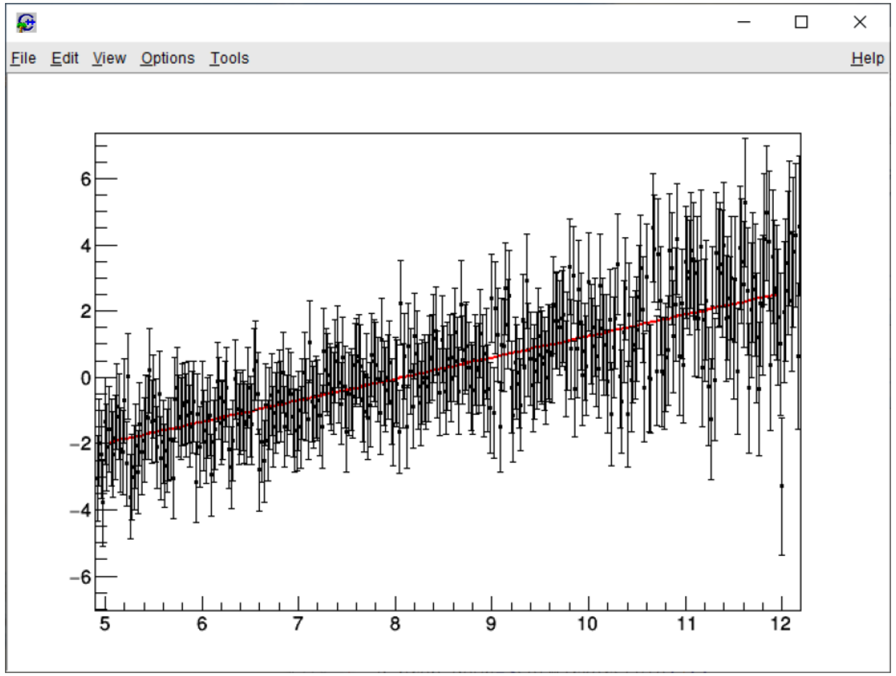

123 µm, tof = 8.5 ms
UP
DOWN
0.2
0
−0.2
−0.4
−0.6
−0.8
−1
0
50
100
150
200
250
300
350

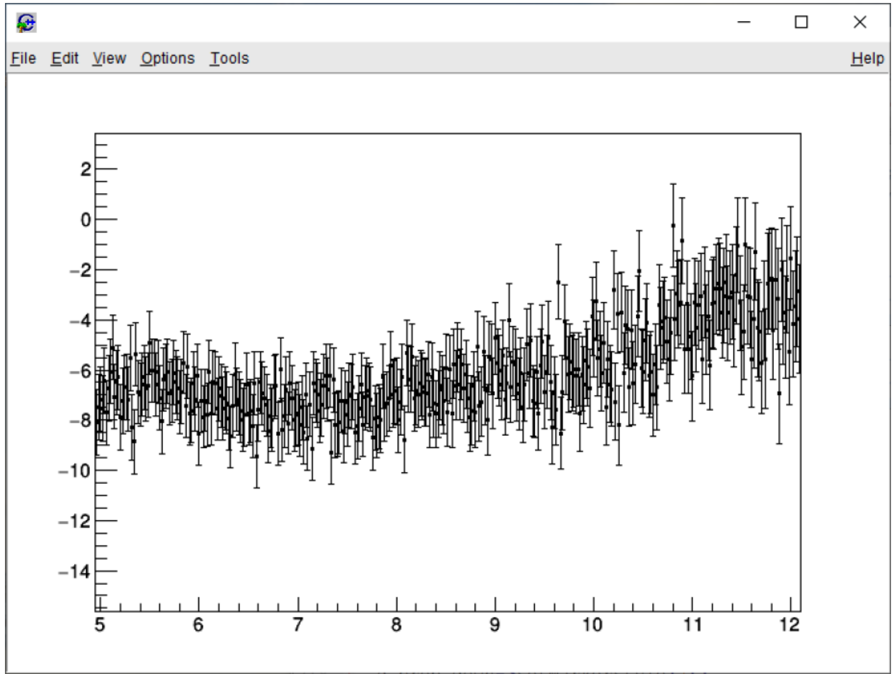


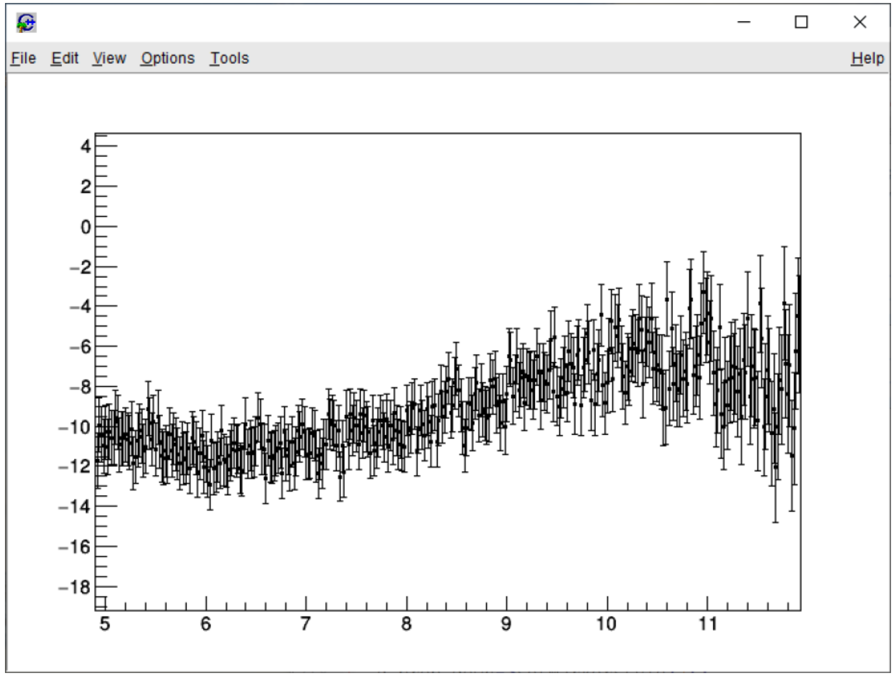
UP
DOWN
125 μT
124 μT
123 μT
122 μT

UP - DOWN


File Edit View Options Tools Help


File Edit View Options Tools Help


File Edit View Options Tools Help


File Edit View Options Tools Help

Phase scan analysis (sinusoidal signal)

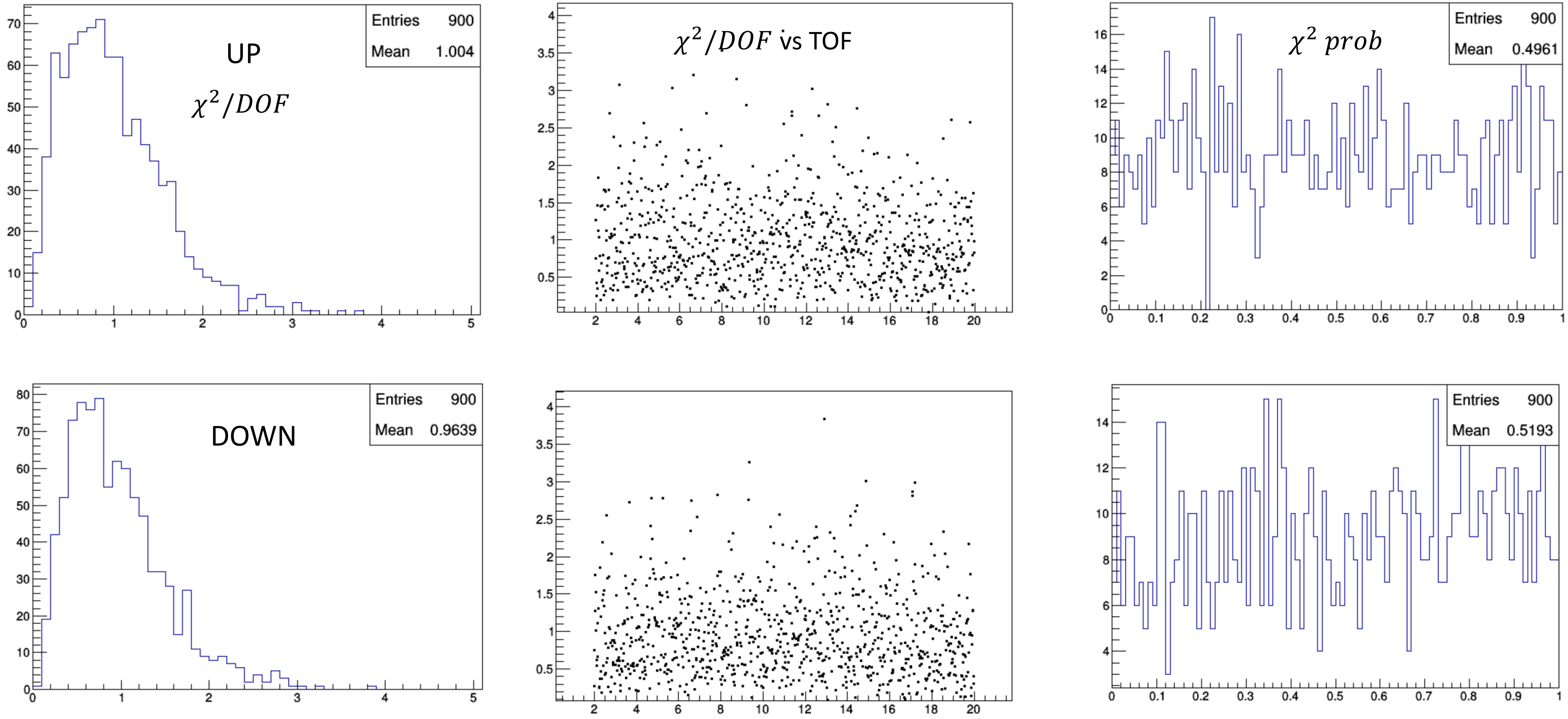
Logbook: BOA_Logbook_Sept-2018 pages 39 (B_0 = 125,124,123,126,127 uT)

Data: T151018_phramsey-tof_0009.tof -> _0058.tof

Ramsey-1000004.dat-> …8.dat

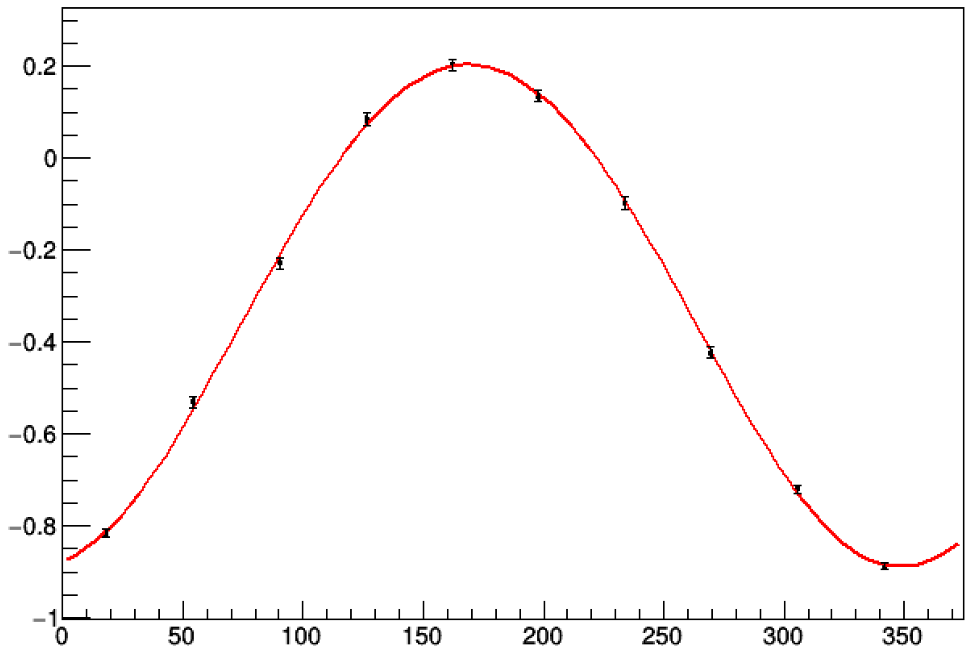
N.B: Assume detector data purely Poissonian (remove 3% correction)

125 μT

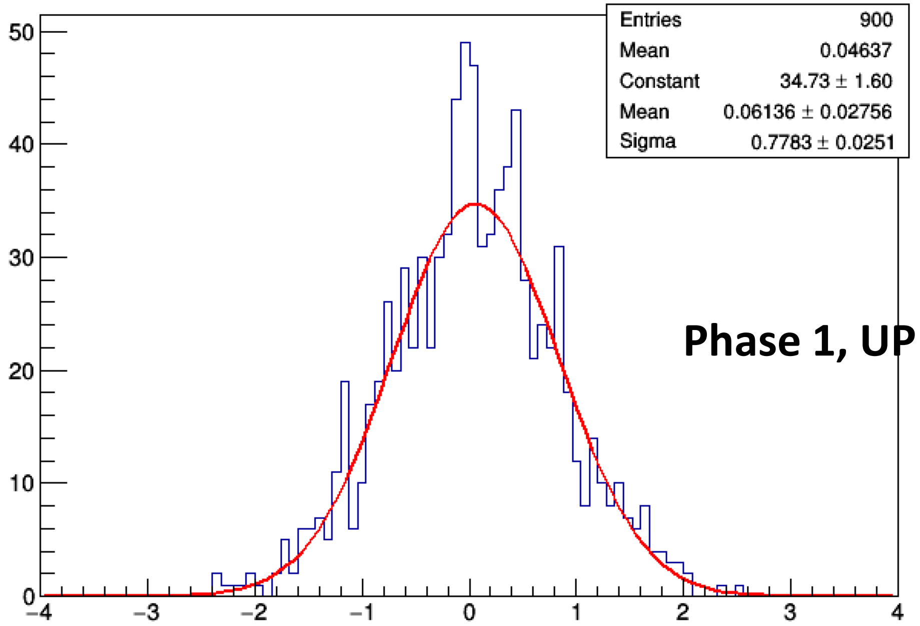


→ detector errors and fitting function OK

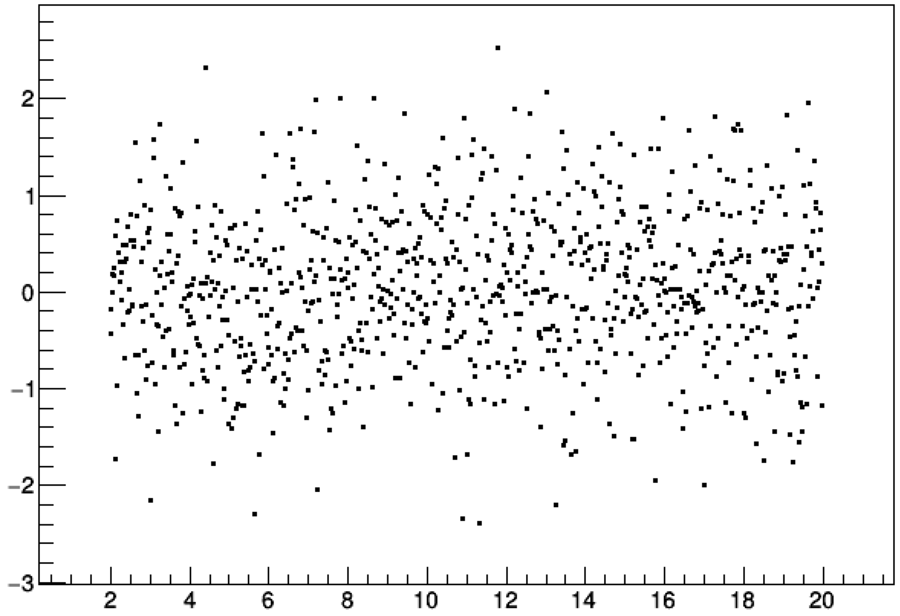
Pool distr.

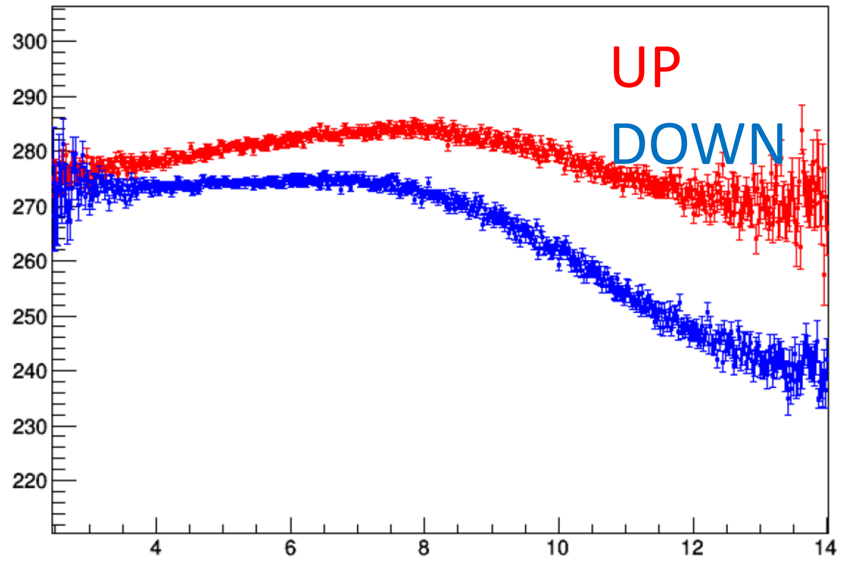


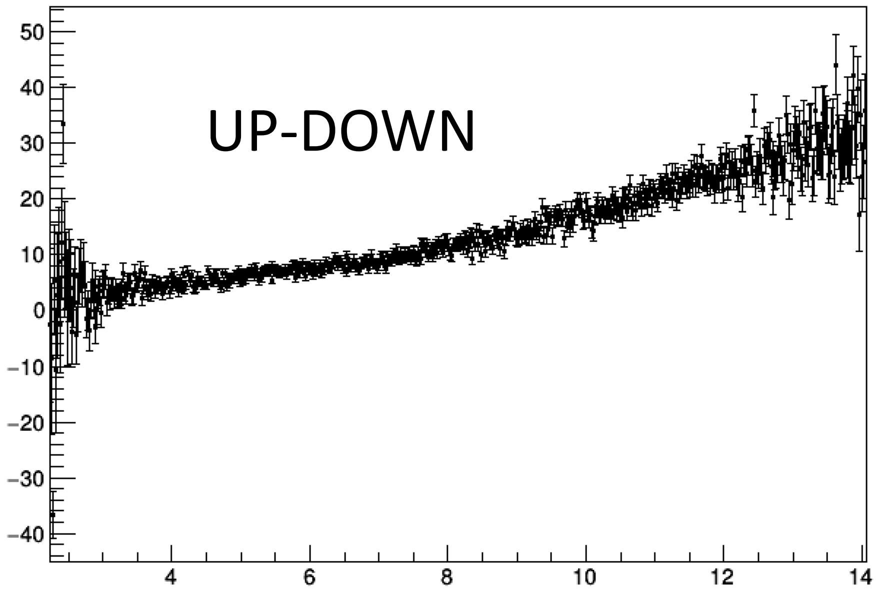
5 ms, up

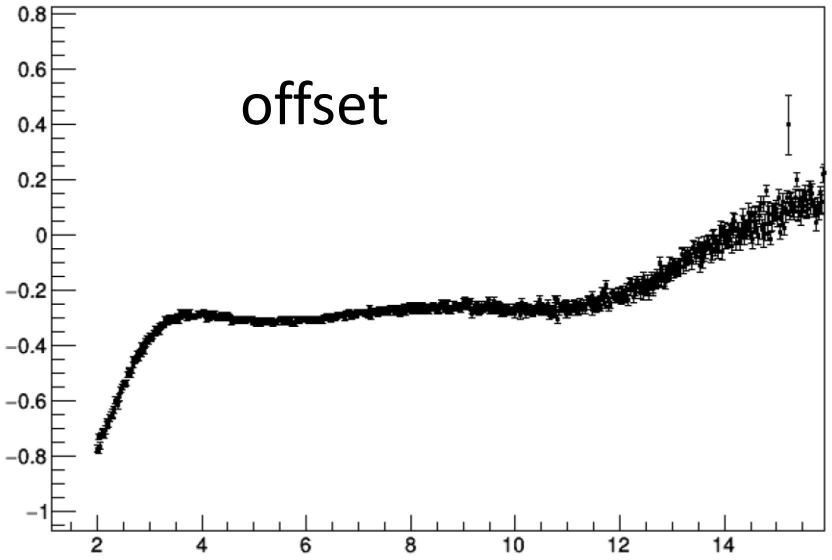


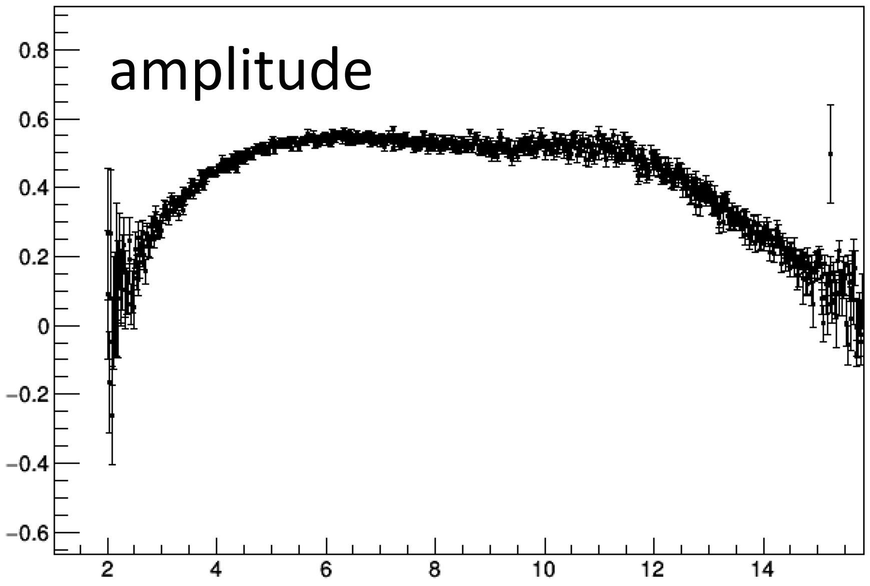
Phase 1, UP (~18°)



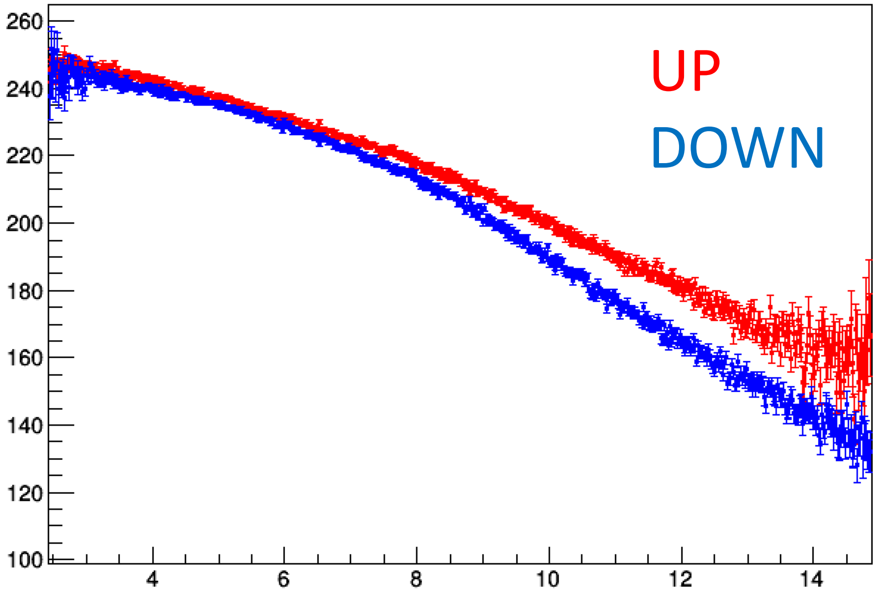

UP
DOWN
300
290
280
270
260
250
240
230
220
4
6
8
10
12
14

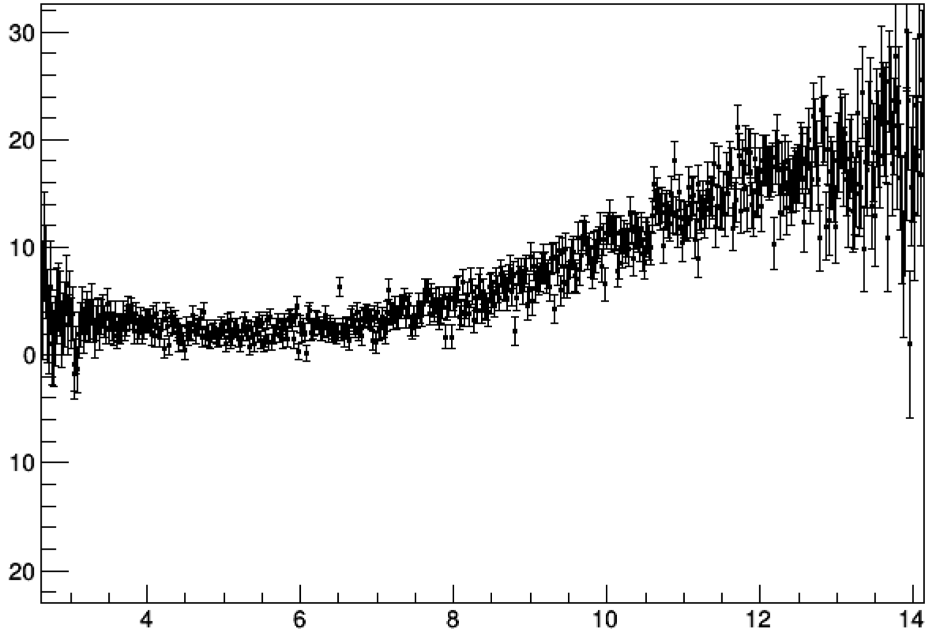

UP-DOWN
50
40
30
20
10
0
−10
−20
−30
−40
4
6
8
10
12
14


offset
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1
2
4
6
8
10
12
14

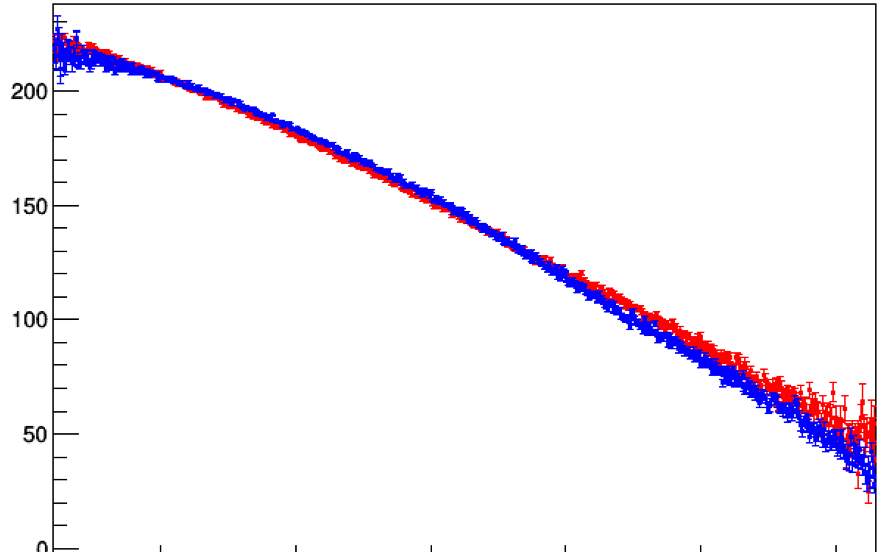

amplitude
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
2
4
6
8
10
12
14

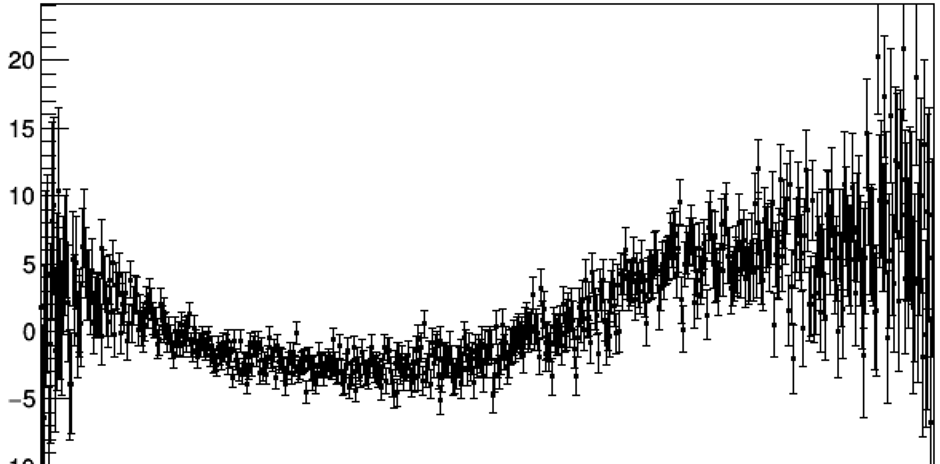
124 uT

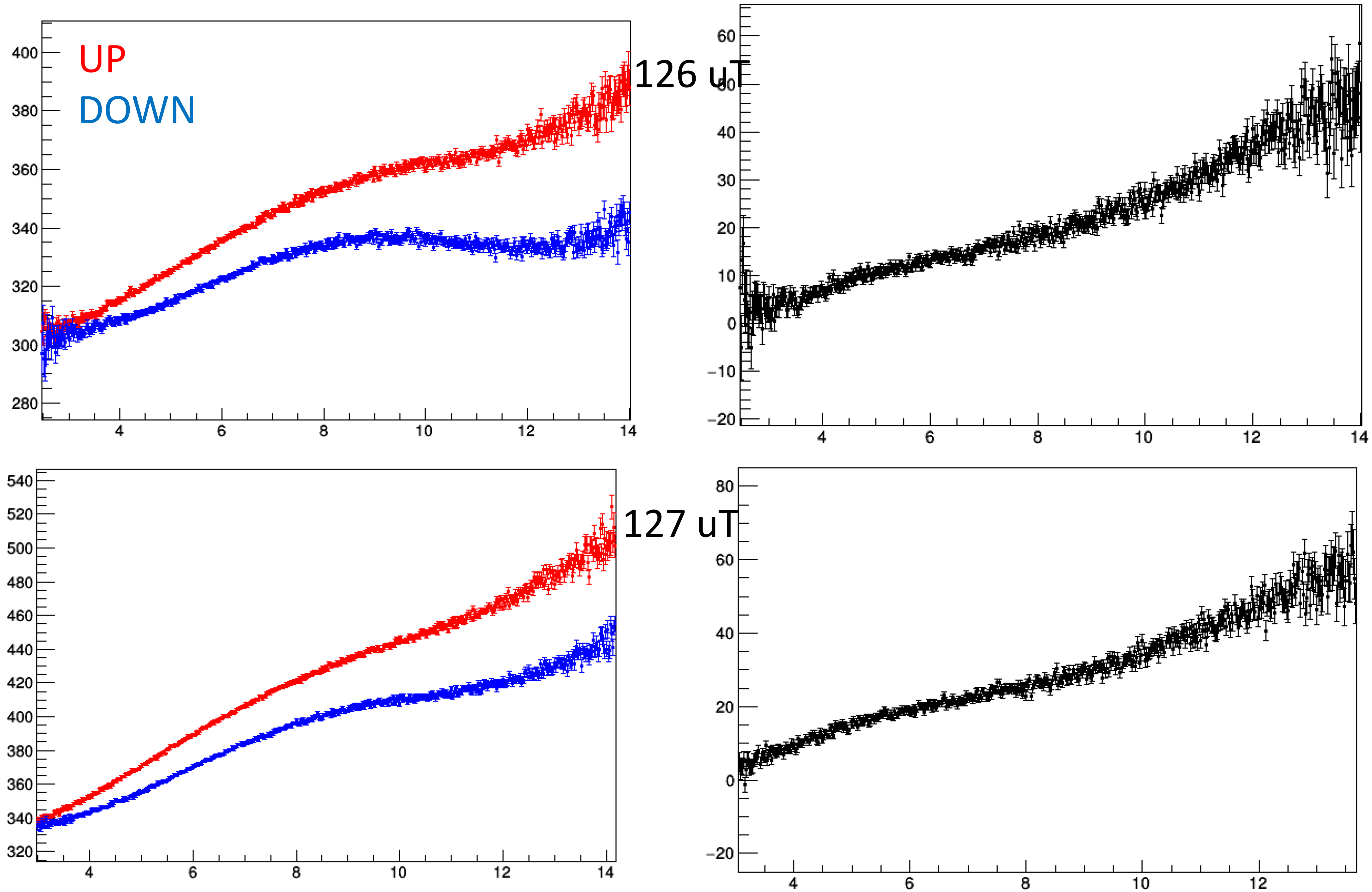

UP
DOWN
260
240
220
200
180
160
140
120
100
4
6
8
10
12
14


30
20
10
0
10
20
4
6
8
10
12
14

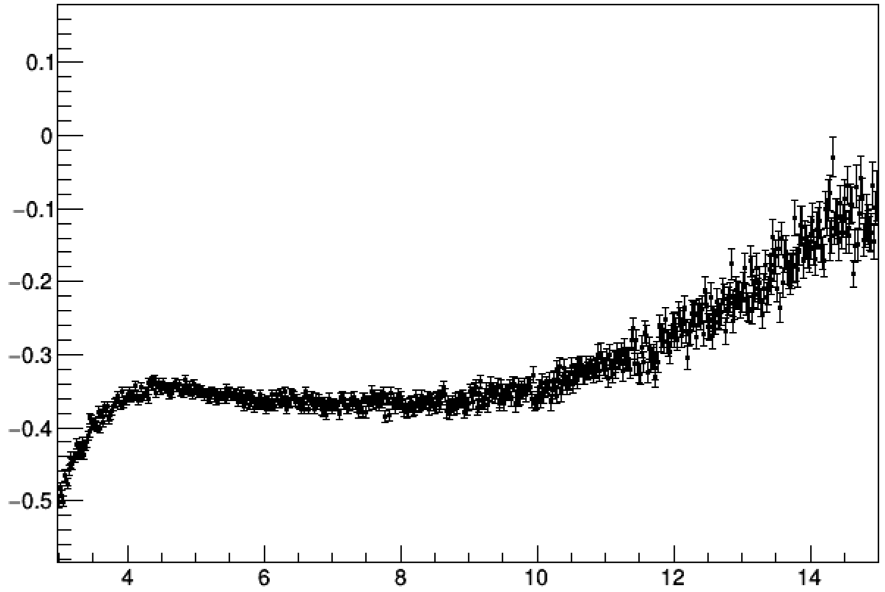
123 uT


200
150
100
50
0

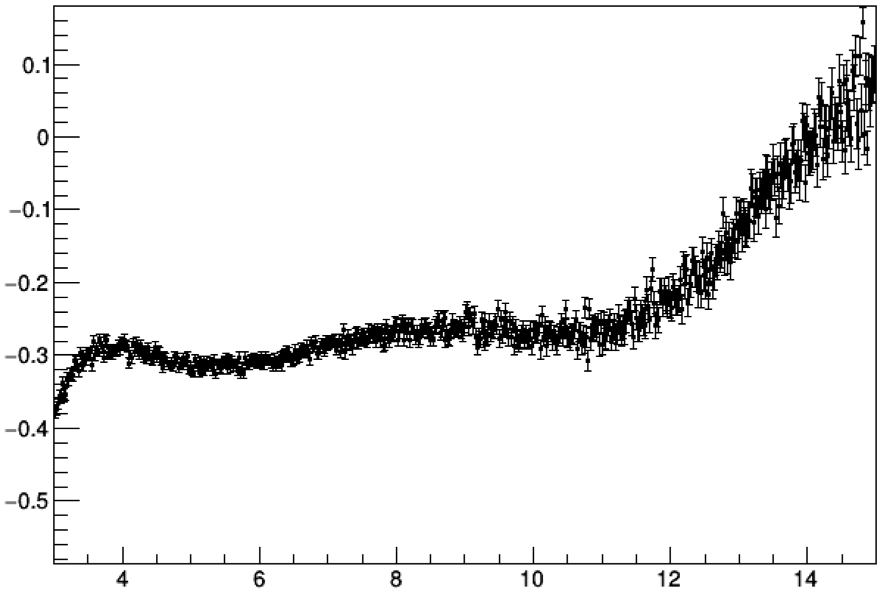

20
15
10
5
0
−5

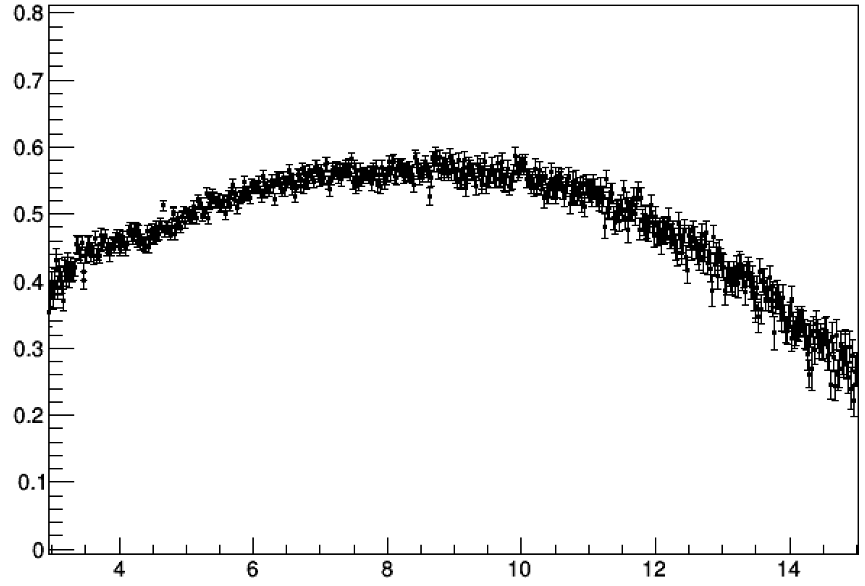

UP
DOWN
126 uT
127 uT

Modulated VS non modulated

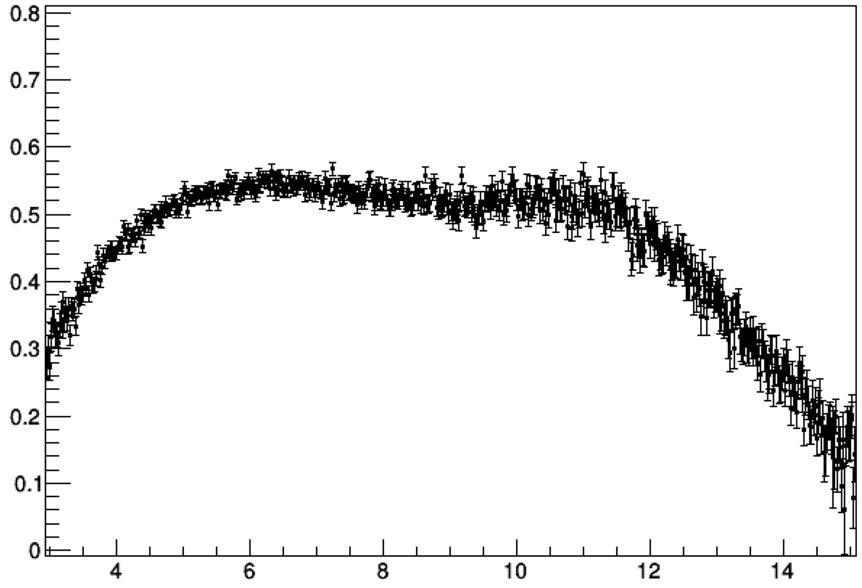


offset

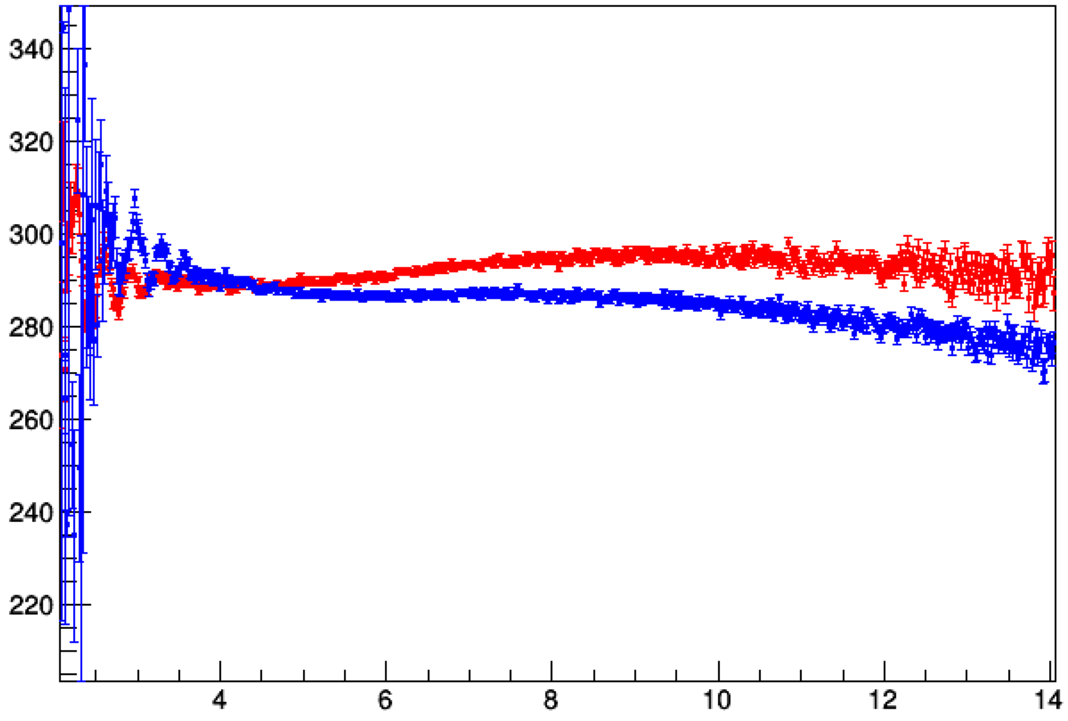


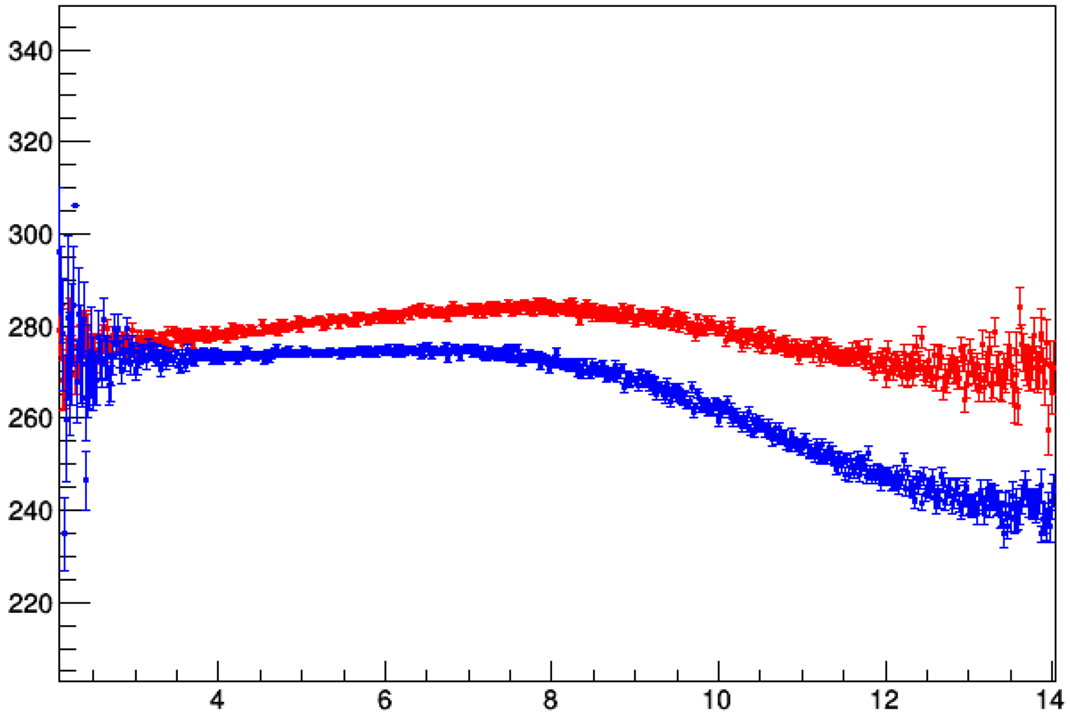


amplitude

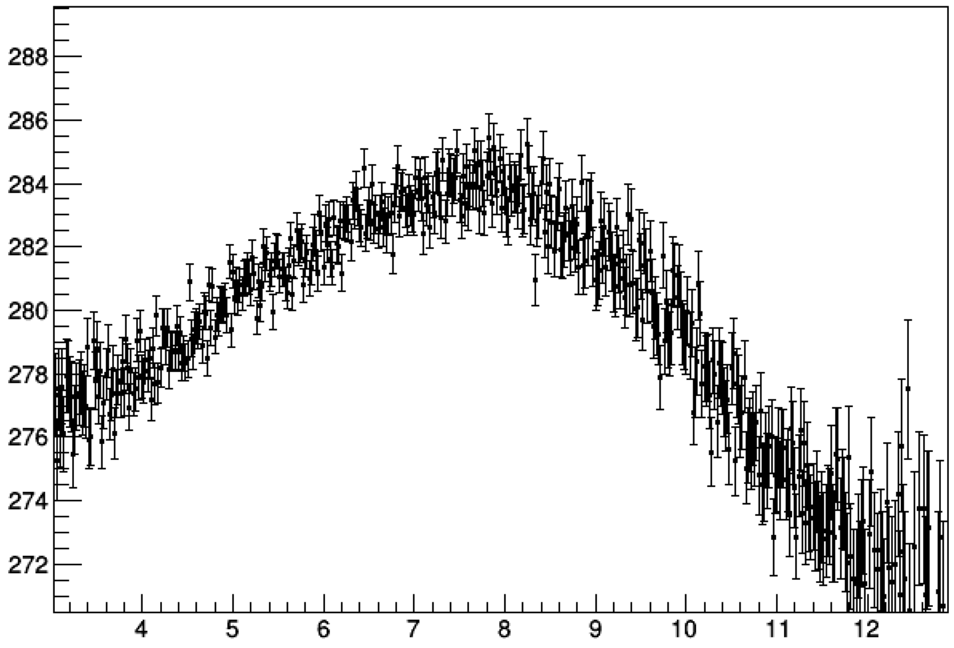


Modulated VS non modulated

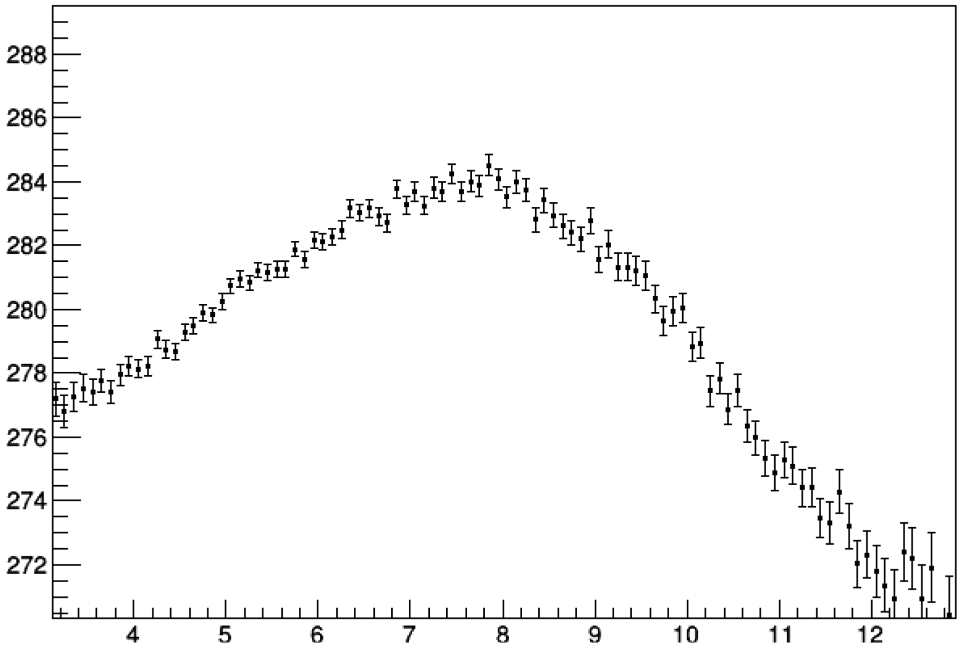




Investigate binning effects (125 uT, non mod., up)



Time bin = 20 μs



Time bin = 100 μs

→ no difference

Simulation (as from: Piegsa - NIM A 589 (2008) 318)

B0 (1) = 158 μT $\left(-\frac{\gamma B_0}{2\pi} = 4608\ Hz\right)$

B0 (2) = variable

B0 (3) = 110 μT $\left(-\frac{\gamma B_0}{2\pi} = 3208\ Hz\right)$

B1 (1) = B1 (3) = 25 μT

ω = variable

$B0\ (1) = 158\ \mu T \quad (-\frac{\gamma B_0}{2\pi} = 4608\ Hz)$

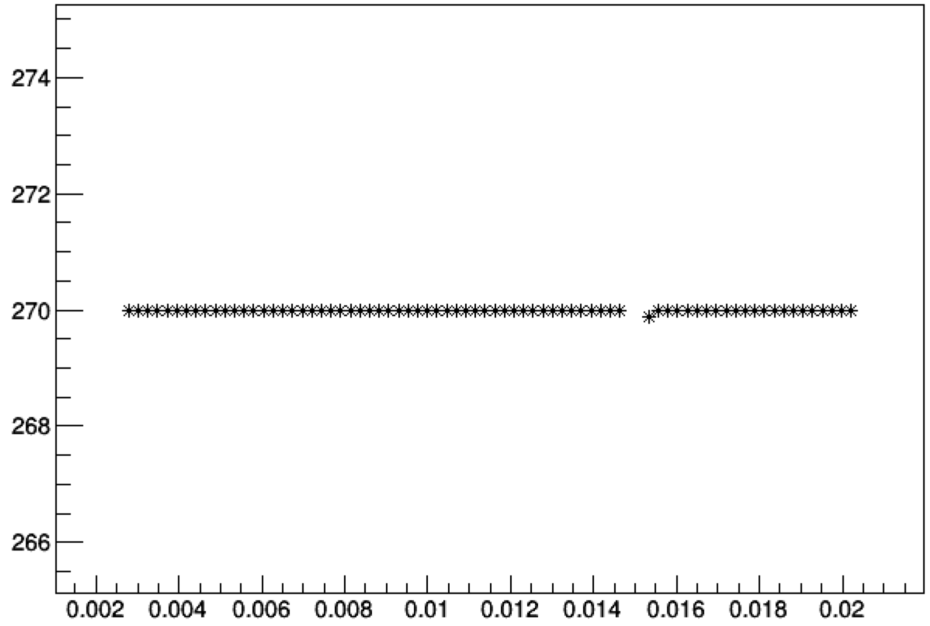
$B0\ (2) = 134\ \mu T \quad (-\frac{\gamma B_0}{2\pi} = 3908\ Hz)$

$B0\ (3) = 110\ \mu T \quad (-\frac{\gamma B_0}{2\pi} = 3208\ Hz)$

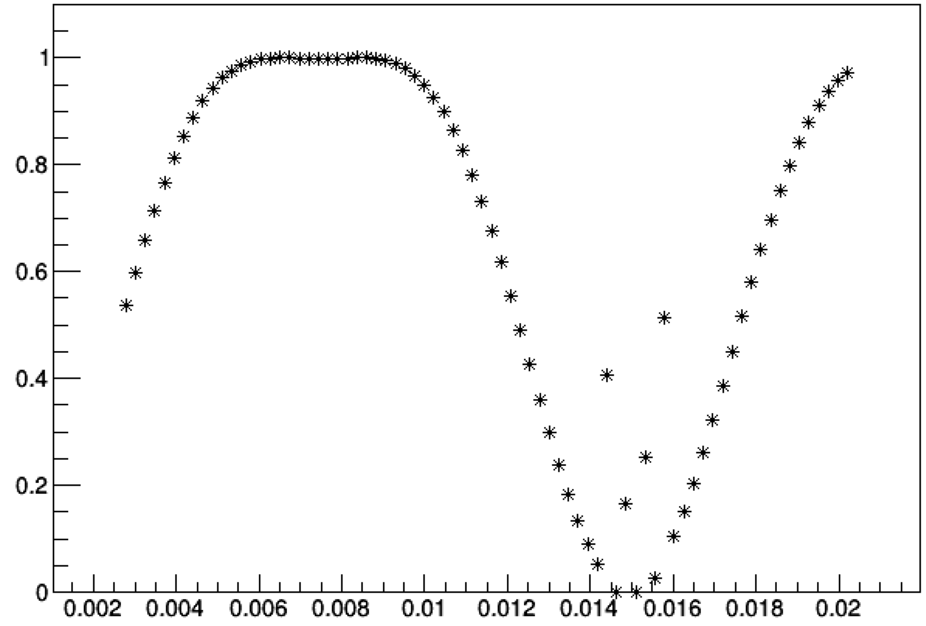
$B1\ (1) = B1\ (3) = 25\ \mu T$

$\omega = 3908 * 2\pi$

phase



amplitude



B0 (1) = 158 μT $\left(-\frac{\gamma B_0}{2\pi} = 4608\ Hz\right)$

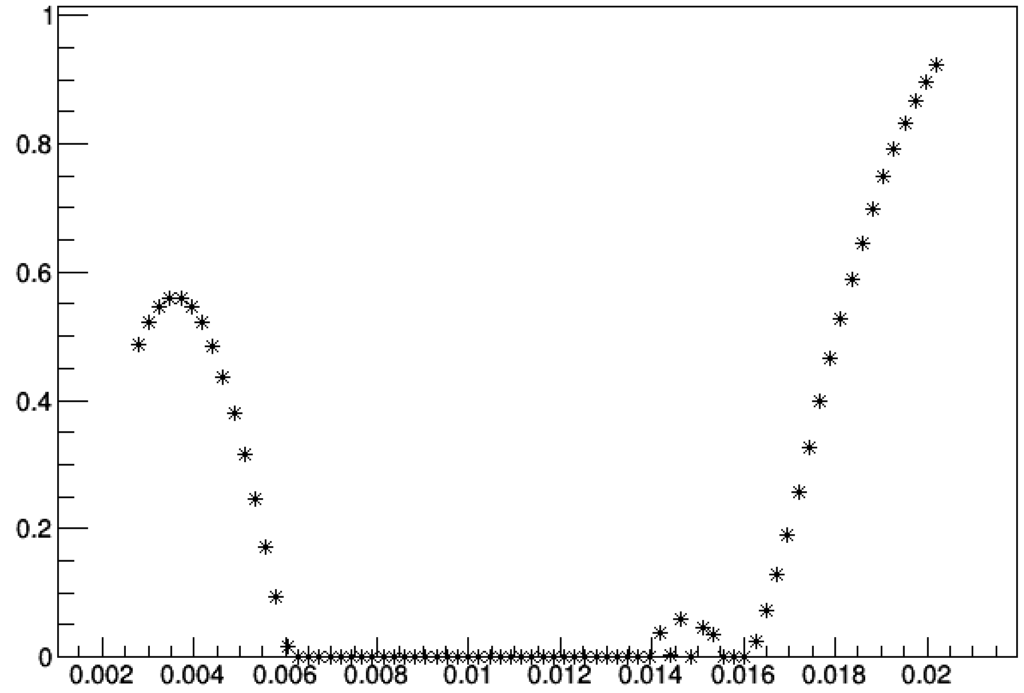
B0 (2) = 134 μT $\left(-\frac{\gamma B_0}{2\pi} = 3908\ Hz\right)$

B0 (3) = 110 μT $\left(-\frac{\gamma B_0}{2\pi} = 3208\ Hz\right)$

B1 (1) = B1 (3) = 25 μT

$\omega = 3800 * 2\pi$

amplitude



B0 (1) = 158 µT $\left(-\frac{\gamma B_0}{2\pi} = 4608\ Hz\right)$

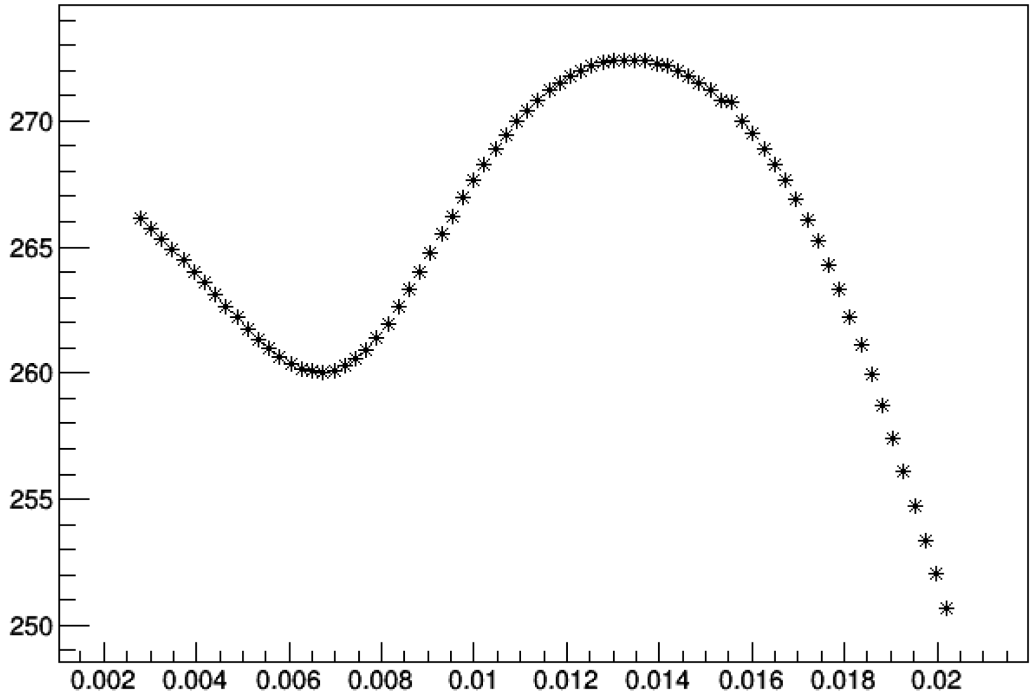
B0 (2) = 130 µT $\left(-\frac{\gamma B_0}{2\pi} = 3791\ Hz\right)$

B0 (3) = 110 µT $\left(-\frac{\gamma B_0}{2\pi} = 3208\ Hz\right)$

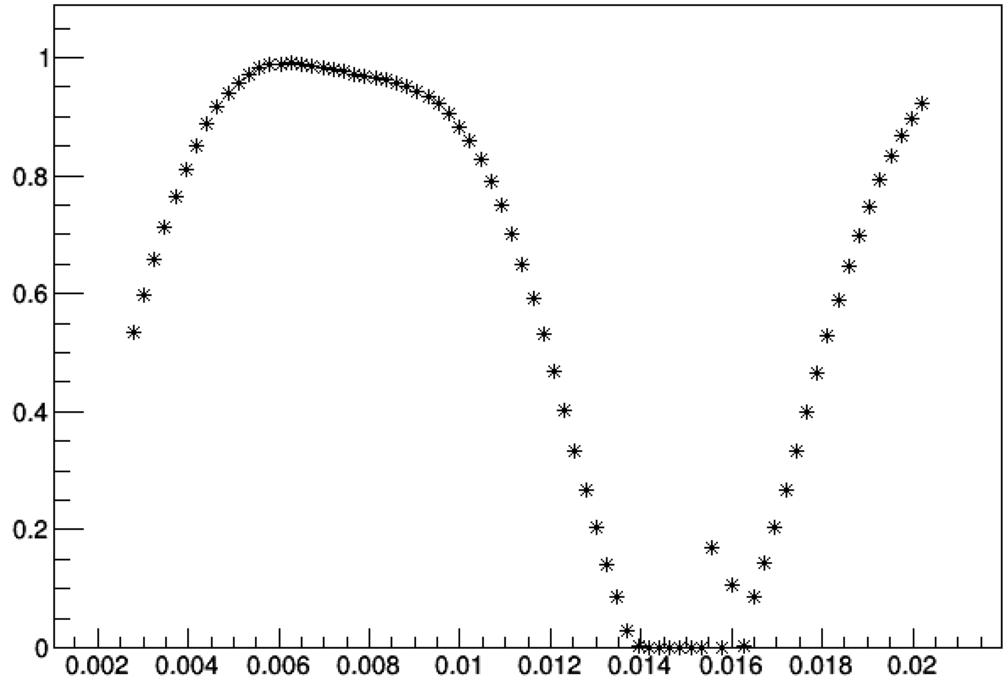
B1 (1) = B1 (3) = 25 µT

$\omega = 3800 * 2\pi$

phase



amplitude



B0 (1) = 157 μT $\left(-\frac{\gamma B_0}{2\pi} = 4579\ Hz\right)$

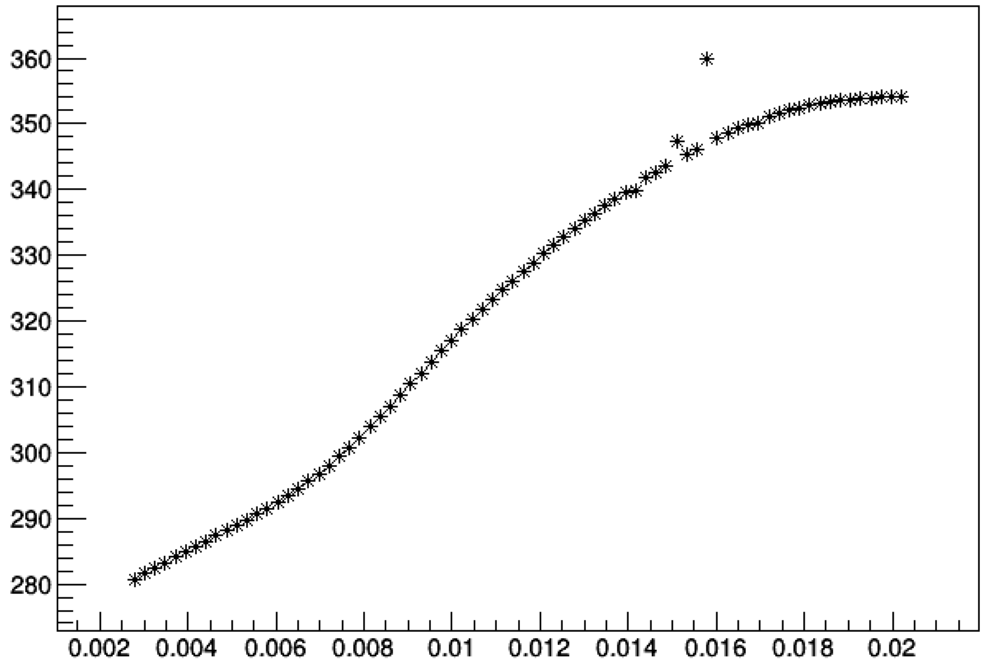
B0 (2) = 129 μT $\left(-\frac{\gamma B_0}{2\pi} = 3762\ Hz\right)$

B0 (3) = 109 μT $\left(-\frac{\gamma B_0}{2\pi} = 3179\ Hz\right)$

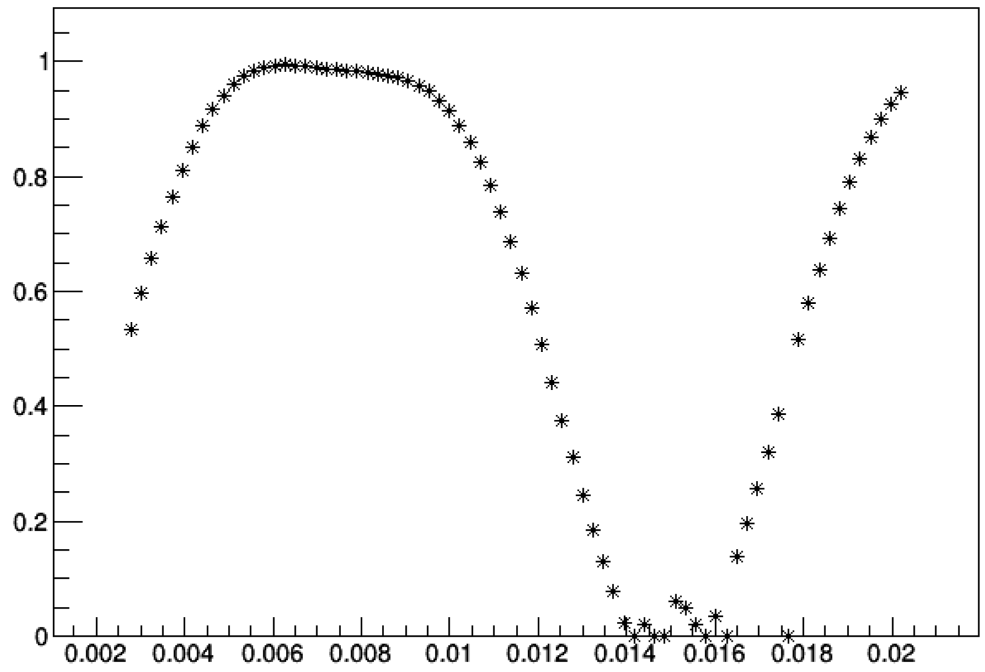
B1 (1) = B1 (3) = 25 μT

$\omega = 3800 * 2\pi$

phase



amplitude



B0 (1) = 130.1 μT $\left(-\frac{\gamma B_0}{2\pi} = 3794\ Hz\right)$

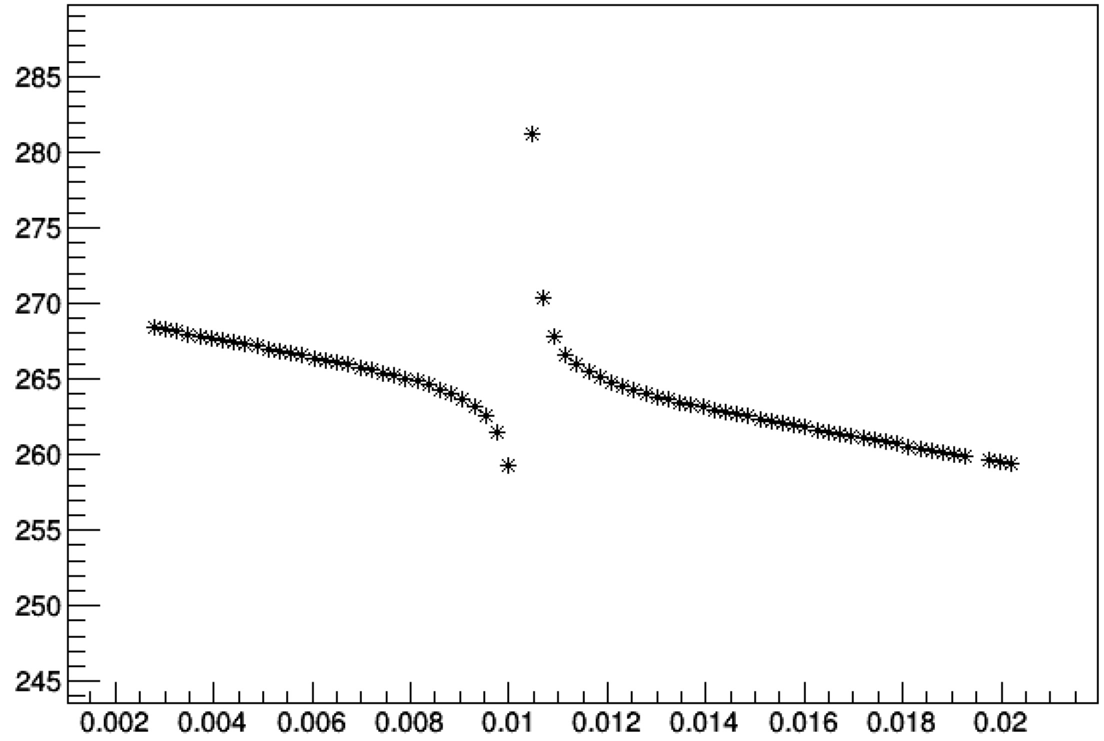
B0 (2) = 130 μT $\left(-\frac{\gamma B_0}{2\pi} = 3791\ Hz\right)$

B0 (3) = 129.8 μT $\left(-\frac{\gamma B_0}{2\pi} = 3786\ Hz\right)$

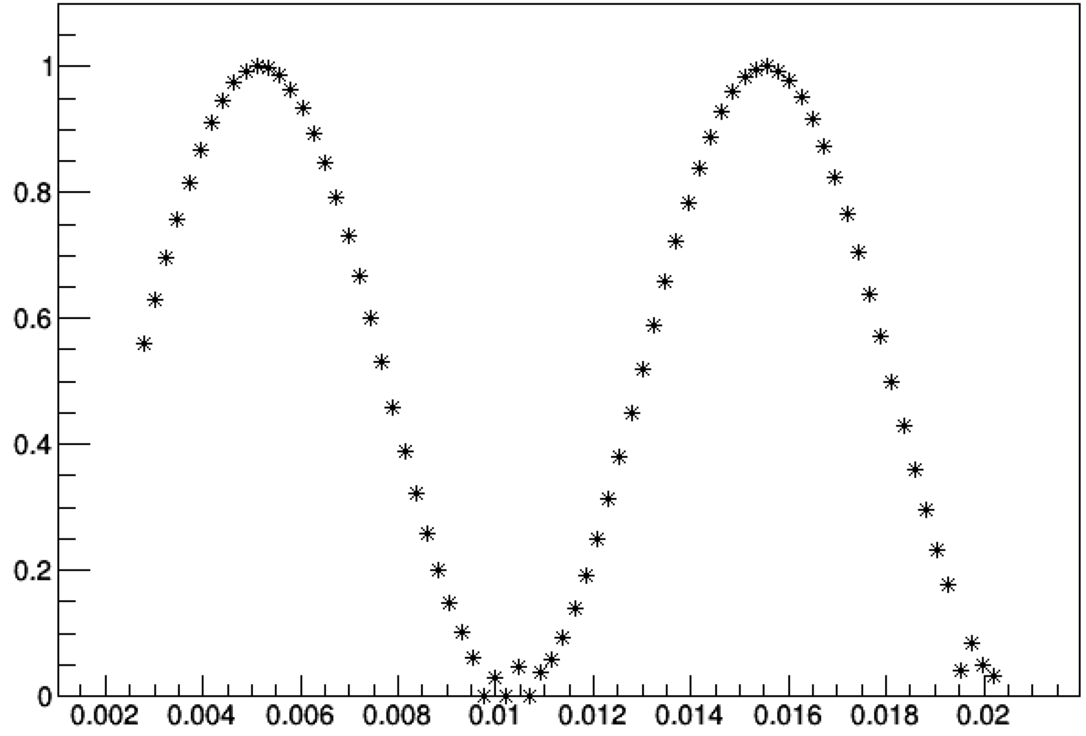
B1 (1) = B1 (3) = 25 μT

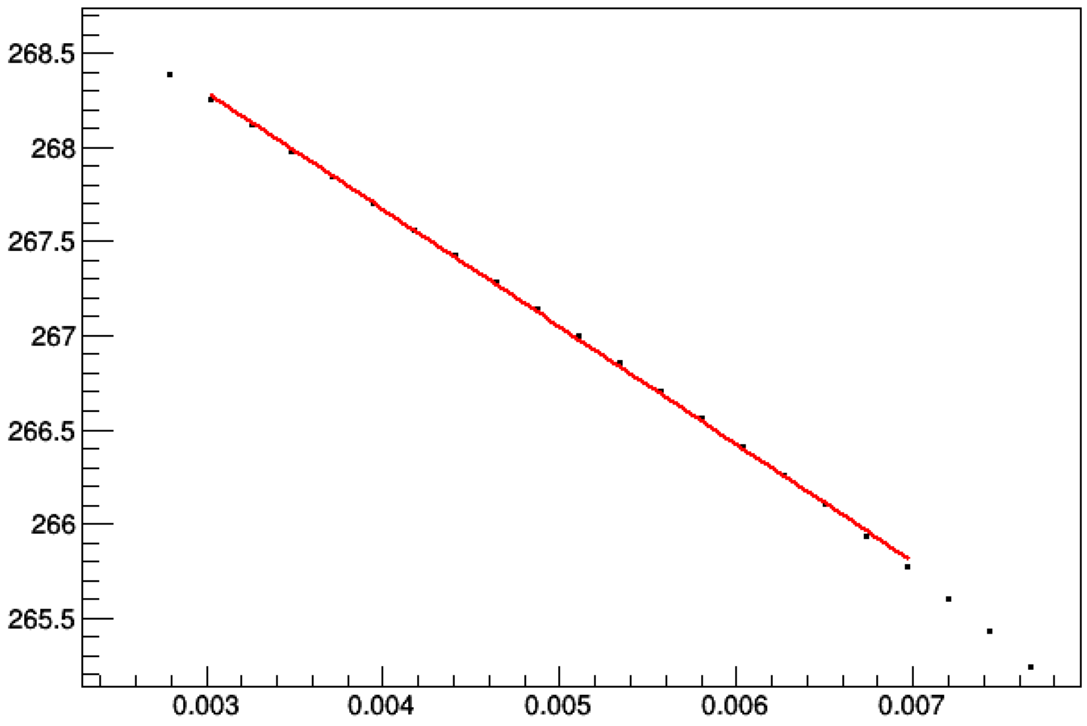
$\omega = 3788 * 2\pi$

phase

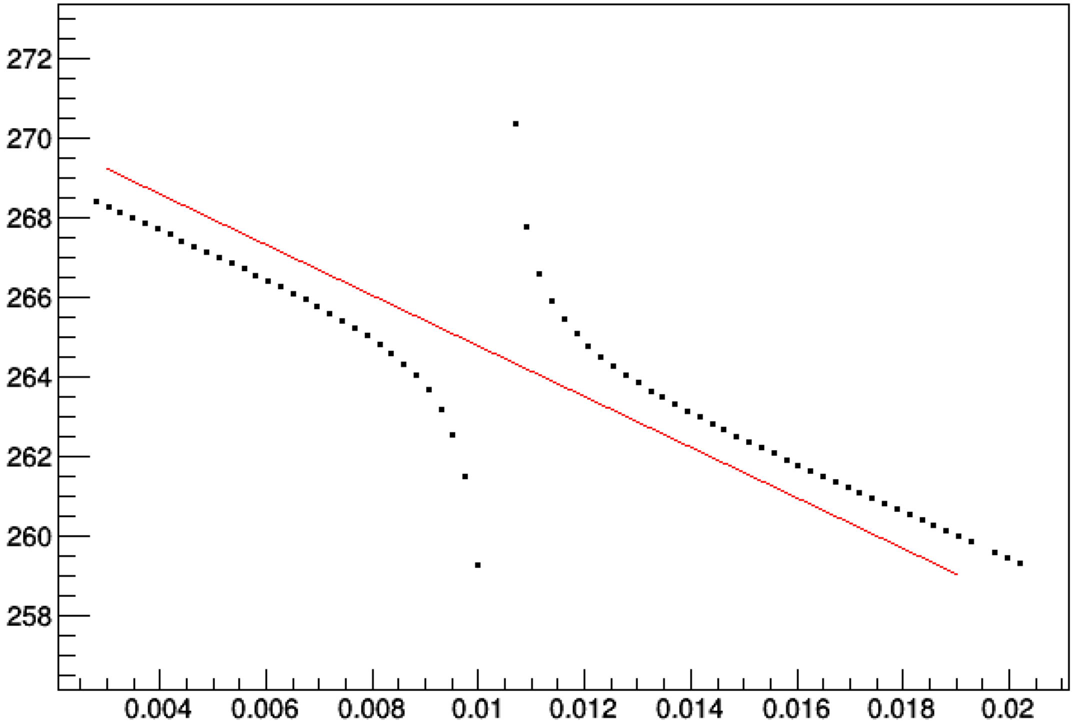


amplitude

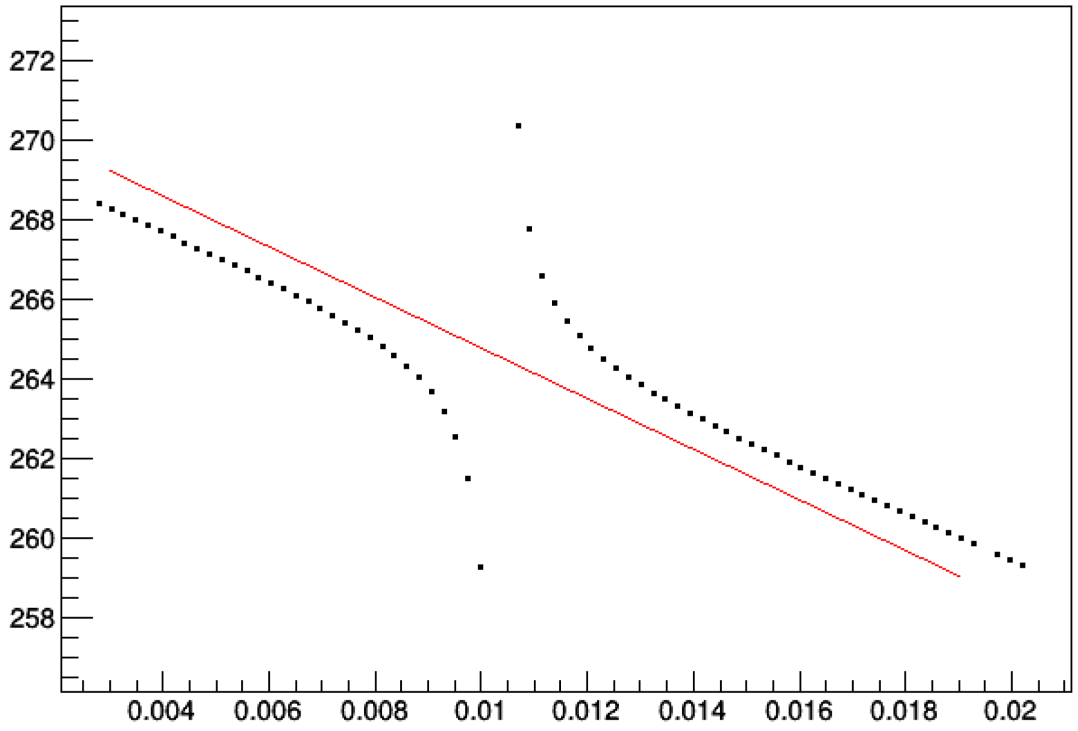


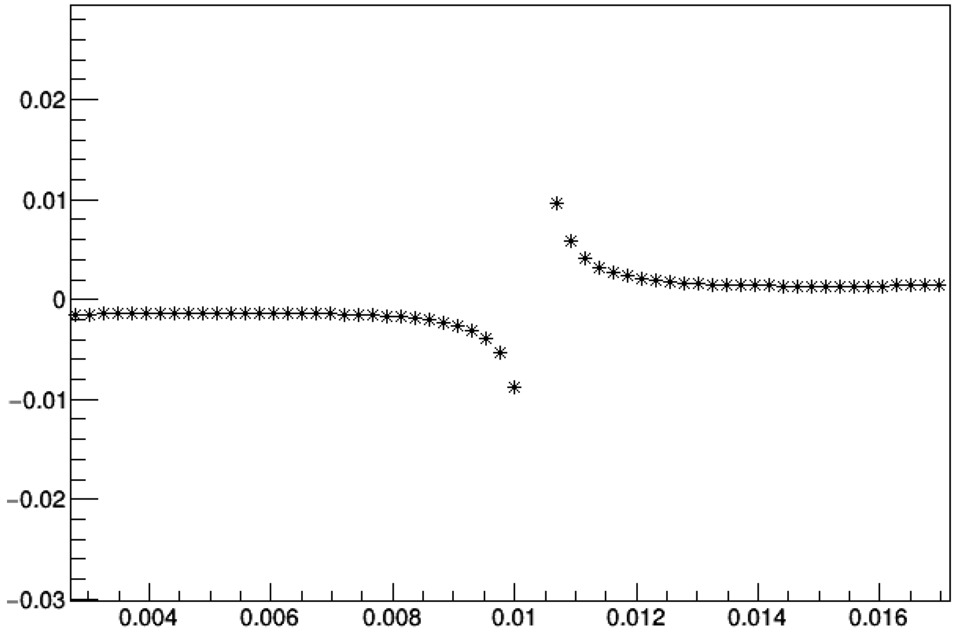


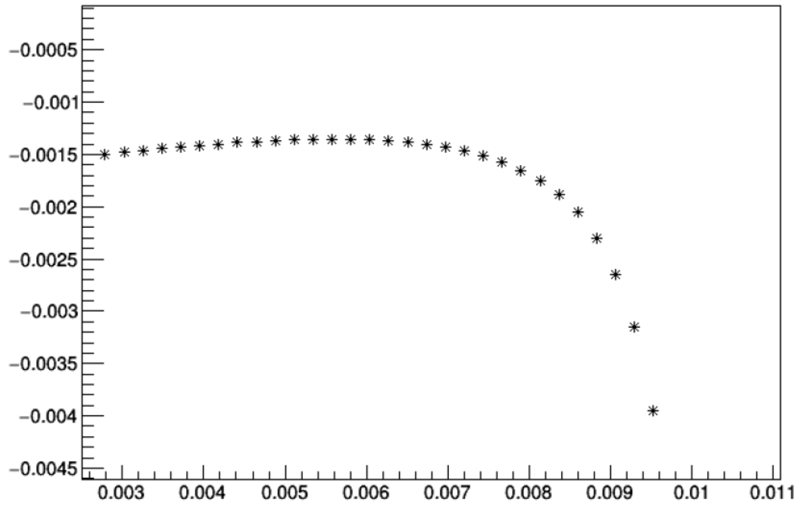
Oscillation still there!



Real or artefact of the simulation?
Rotating frame approx. still valid?


272
270
268
266
264
262
260
258
0.004 0.006 0.008 0.01 0.012 0.014 0.016 0.018 0.02


0.02
0.01
0
−0.01
−0.02
−0.03
0.004 0.006 0.008 0.01 0.012 0.014 0.016


−0.0005
−0.001
−0.0015
−0.002
−0.0025
−0.003
−0.0035
−0.004
−0.0045
0.003 0.004 0.005 0.006 0.007 0.008 0.009 0.01 0.011

B0 (1) = 130 µT $\left(-\frac{\gamma B_0}{2\pi} = 3791\ Hz\right)$

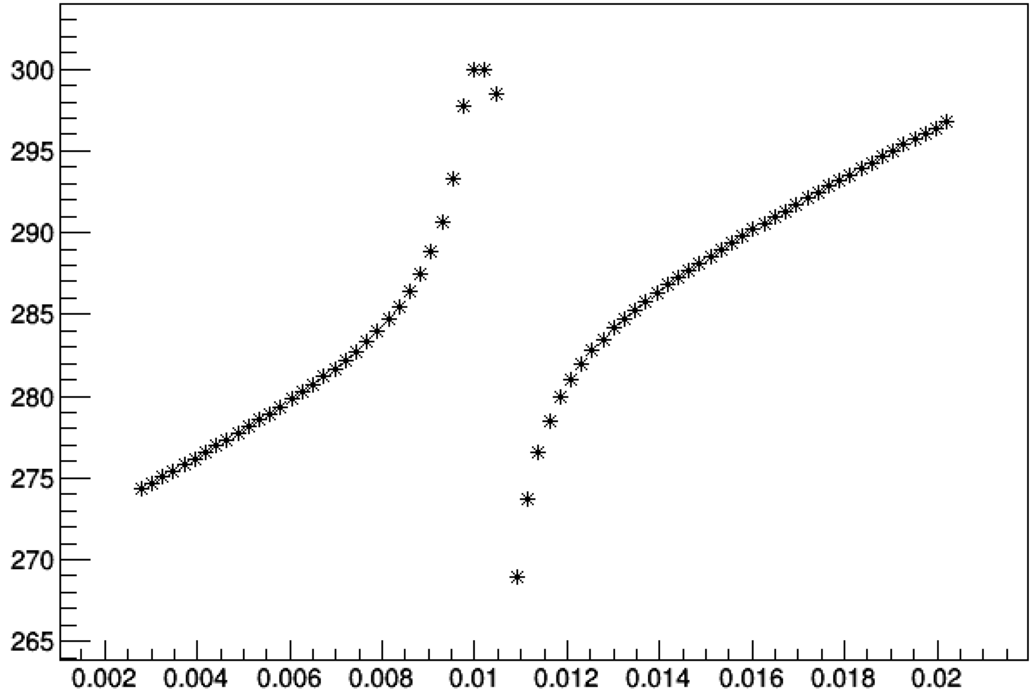
B0 (2) = 130 µT $\left(-\frac{\gamma B_0}{2\pi} = 3791\ Hz\right)$

B0 (3) = 130 µT $\left(-\frac{\gamma B_0}{2\pi} = 3791\ Hz\right)$

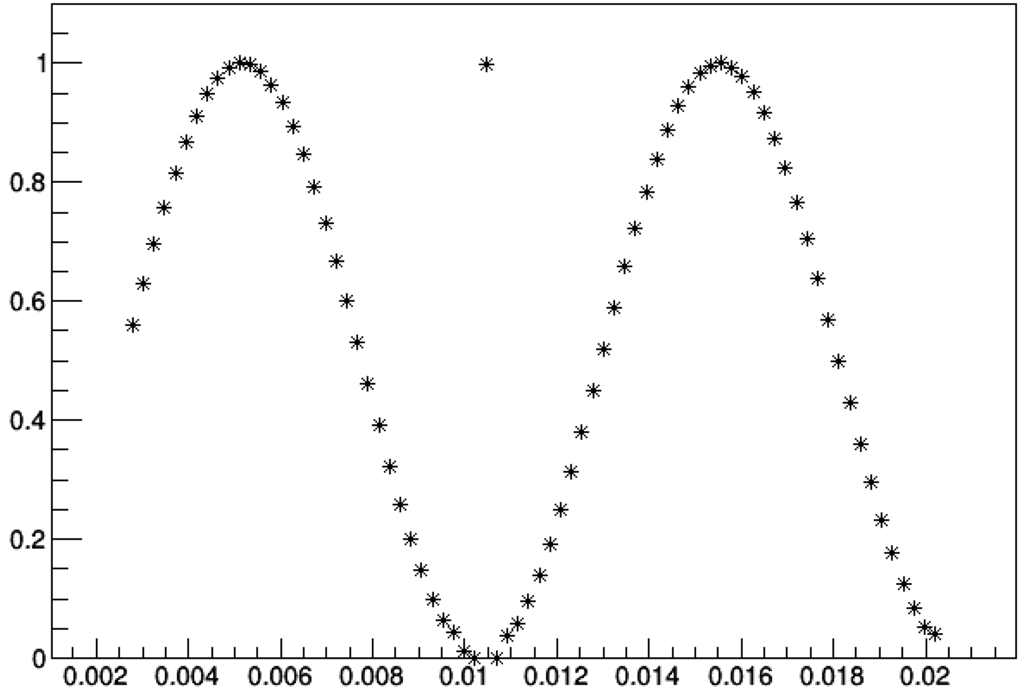
B1 (1) = B1 (3) = 25 µT

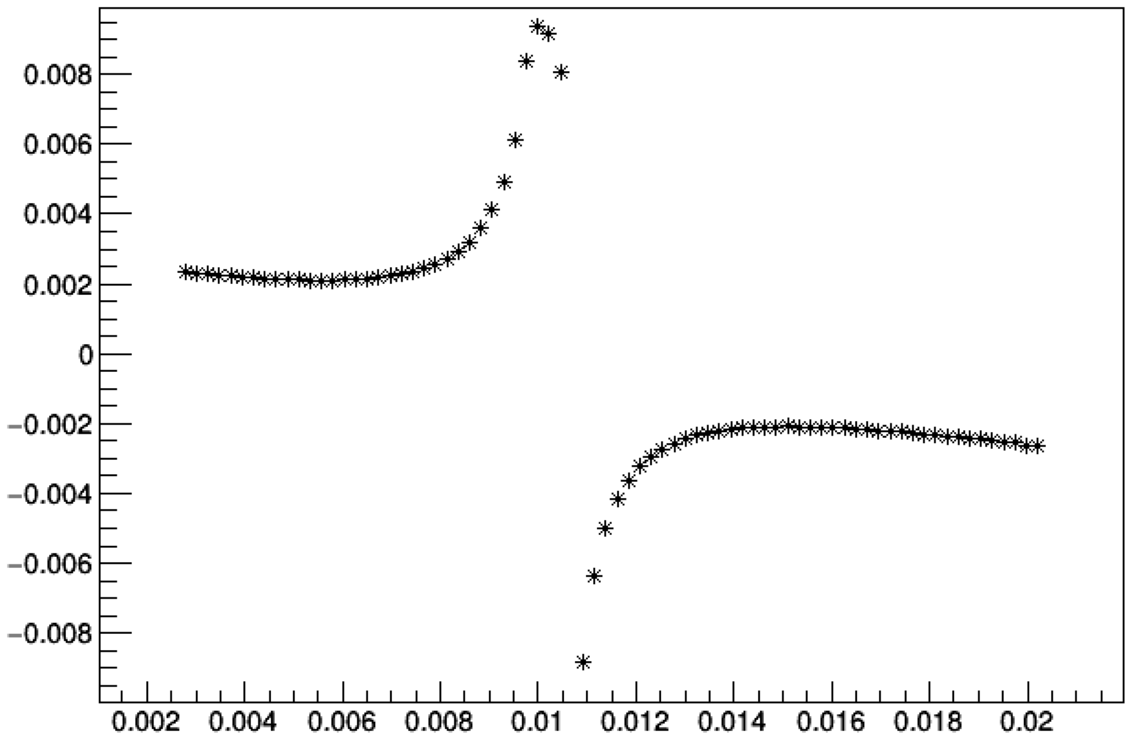
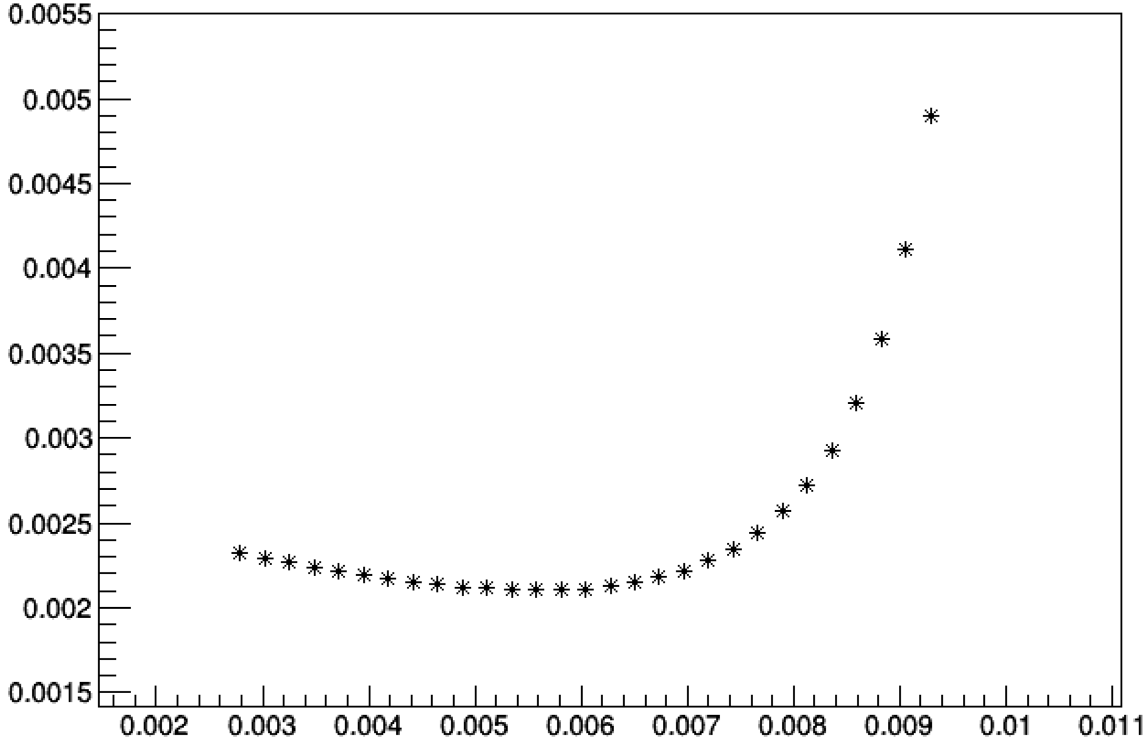
$\omega = 3800 * 2\pi$

phase



amplitude




0.008
0.006
0.004
0.002
0
−0.002
−0.004
−0.006
−0.008
0.002
0.004
0.006
0.008
0.01
0.012
0.014
0.016
0.018
0.02

0.0055
0.005
0.0045
0.004
0.0035
0.003
0.0025
0.002
0.0015
0.002
0.003
0.004
0.005
0.006
0.007
0.008
0.009
0.01
0.011

B0 (1) = 1300 μT $\left(-\frac{\gamma B_0}{2\pi} = 37914\ Hz\right)$

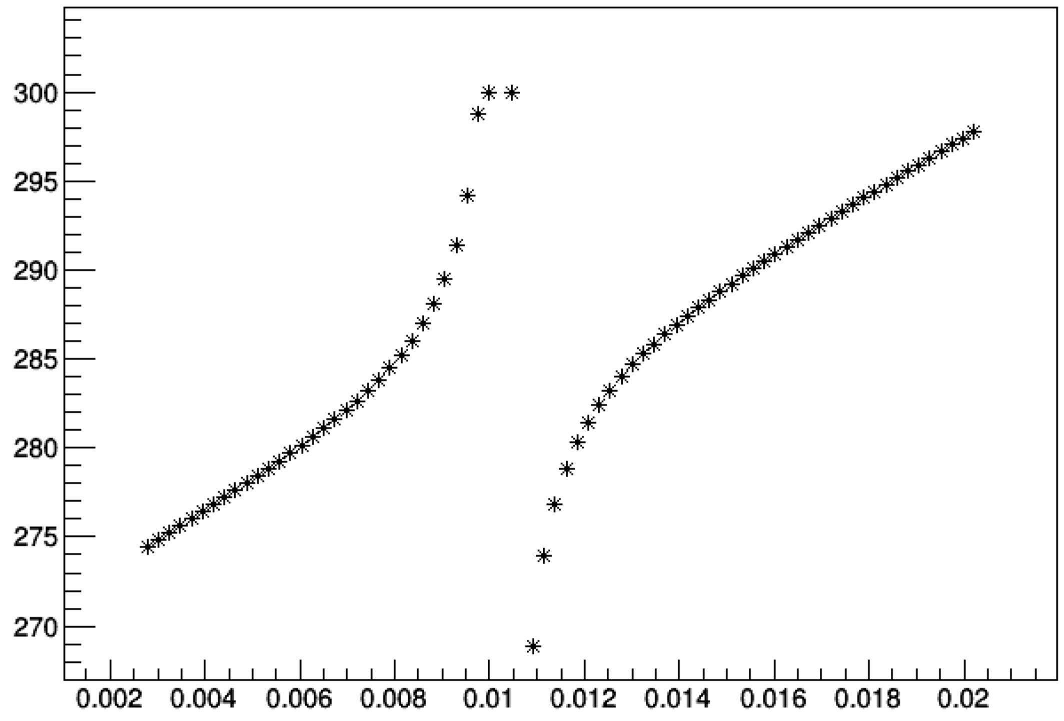
B0 (2) = 1300 μT $\left(-\frac{\gamma B_0}{2\pi} = 37914\ Hz\right)$

B0 (3) = 1300 μT $\left(-\frac{\gamma B_0}{2\pi} = 37914\ Hz\right)$

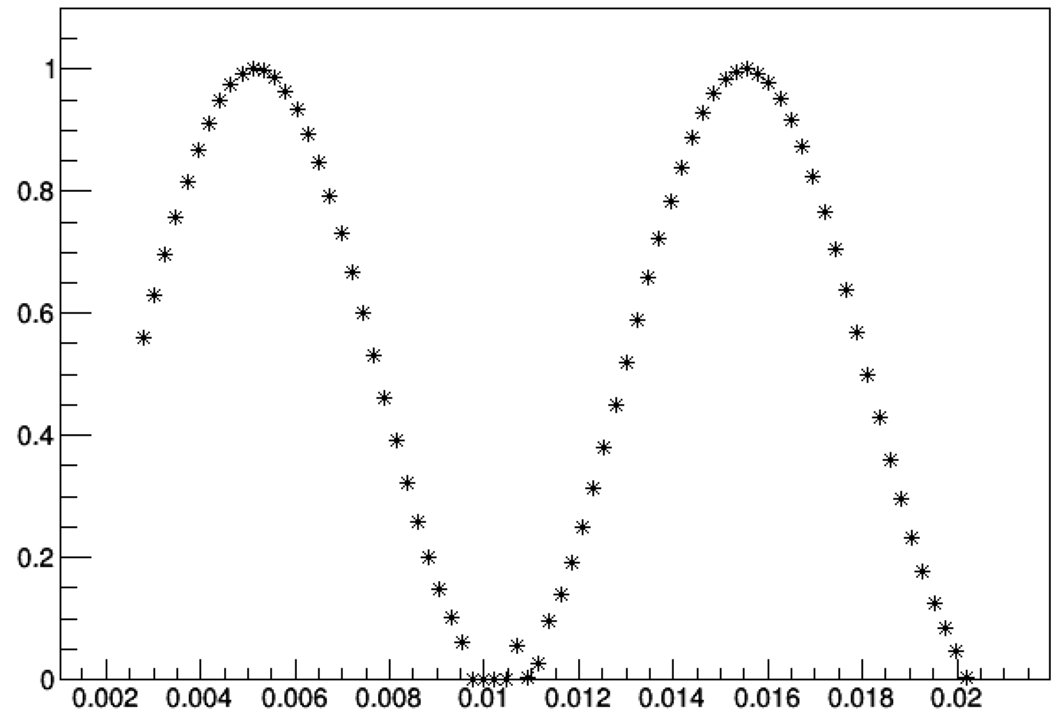
B1 (1) = B1 (3) = 25 μT

$\omega = 37920 * 2\pi$ (same $\omega - \omega_0(2)$)

phase



amplitude



B0 (1) = 1300.1 μT $(-\frac{\gamma B_0}{2\pi} = 37917\ Hz)$ (same $\omega_0(1) - \omega_0(2)$)

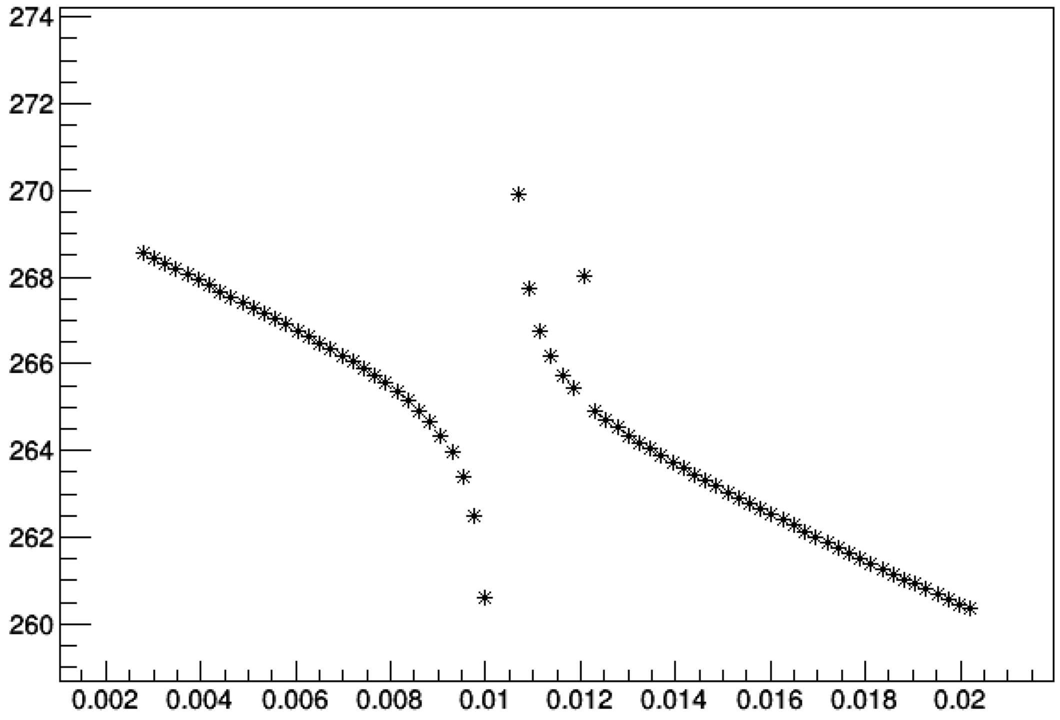
B0 (2) = 1300.0 μT $(-\frac{\gamma B_0}{2\pi} = 37914\ Hz)$

B0 (3) = 1299.8 μT $(-\frac{\gamma B_0}{2\pi} = 37908\ Hz)$ (same $\omega_0(3) - \omega_0(2)$)

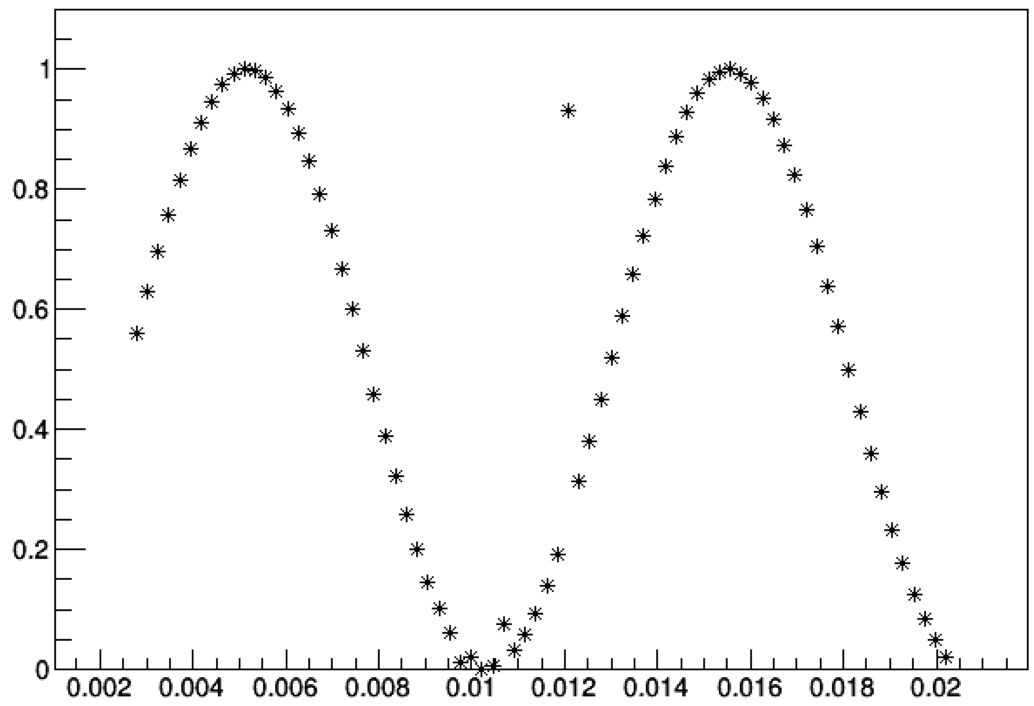
B1 (1) = B1 (3) = 25 μT

$\omega = 37911 * 2\pi$ (same $\omega - \omega_0(2)$)

phase



amplitude



B0 (1) = 1300.1 μT $\left(-\frac{\gamma B_0}{2\pi} = 37917\ Hz\right)$ (same $\omega_0(1) - \omega_0(2)$)

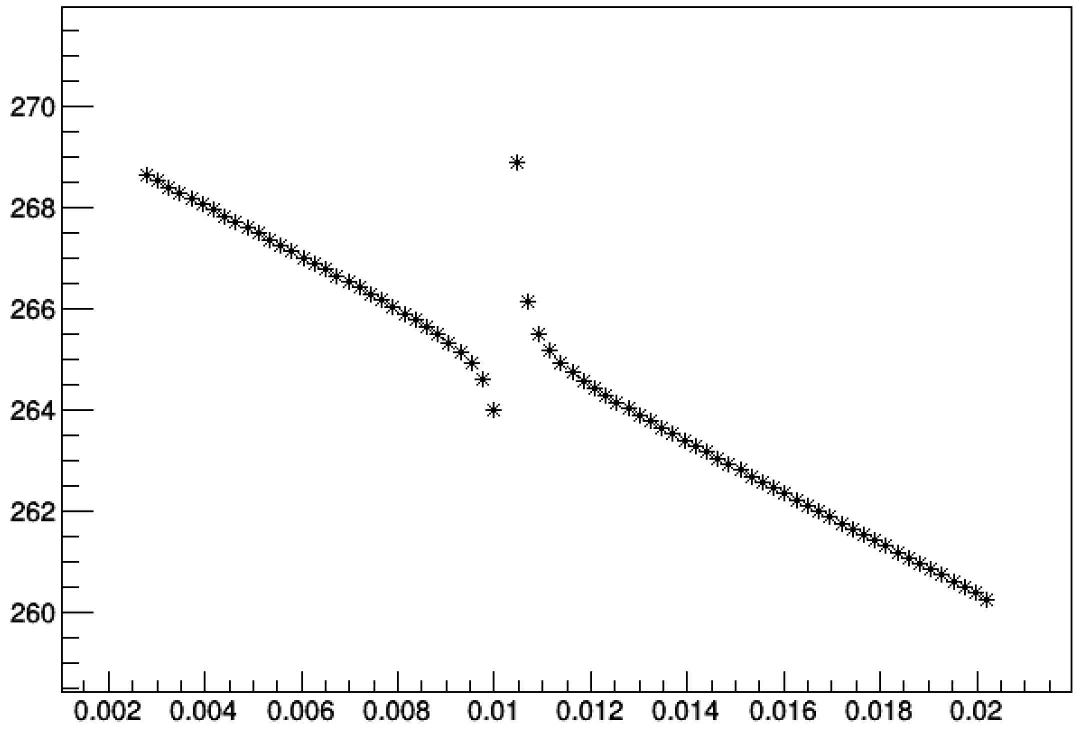
B0 (2) = 1300.0 μT $\left(-\frac{\gamma B_0}{2\pi} = 37914\ Hz\right)$

B0 (3) = 1299.8 μT $\left(-\frac{\gamma B_0}{2\pi} = 37908\ Hz\right)$ (same $\omega_0(3) - \omega_0(2)$)

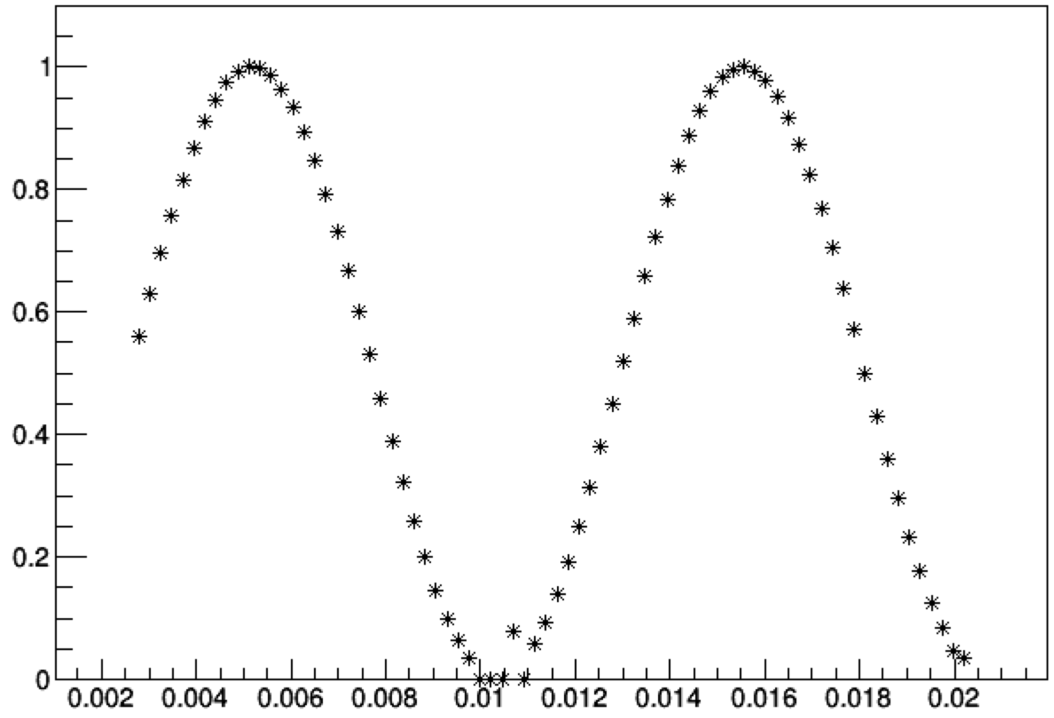
B1 (1) = B1 (3) = 100 μT and SF length = 10 cm (instead of 40)

$\omega = 37911 * 2\pi$ (same $\omega - \omega_0(2)$)

phase



amplitude



B0 (1) = 1300.1 μT $\left(-\frac{\gamma B_0}{2\pi} = 37917\ Hz\right)$

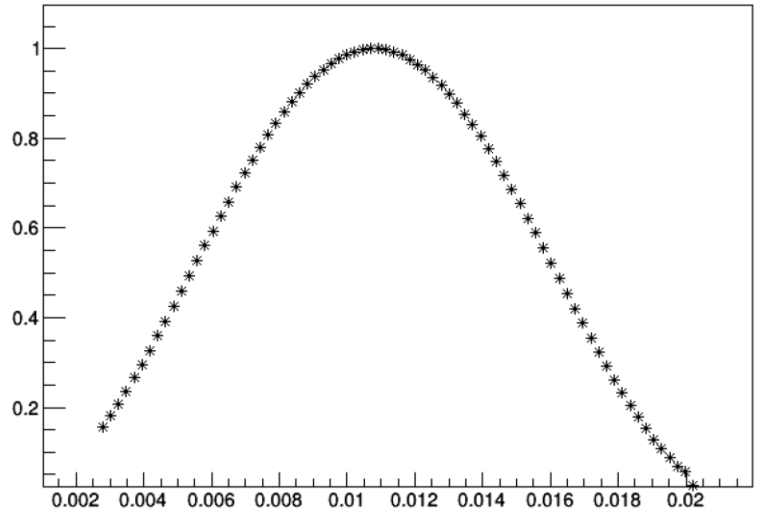
B0 (2) = 1300.0 μT $\left(-\frac{\gamma B_0}{2\pi} = 37914\ Hz\right)$

B0 (3) = 1299.8 μT $\left(-\frac{\gamma B_0}{2\pi} = 37908\ Hz\right)$

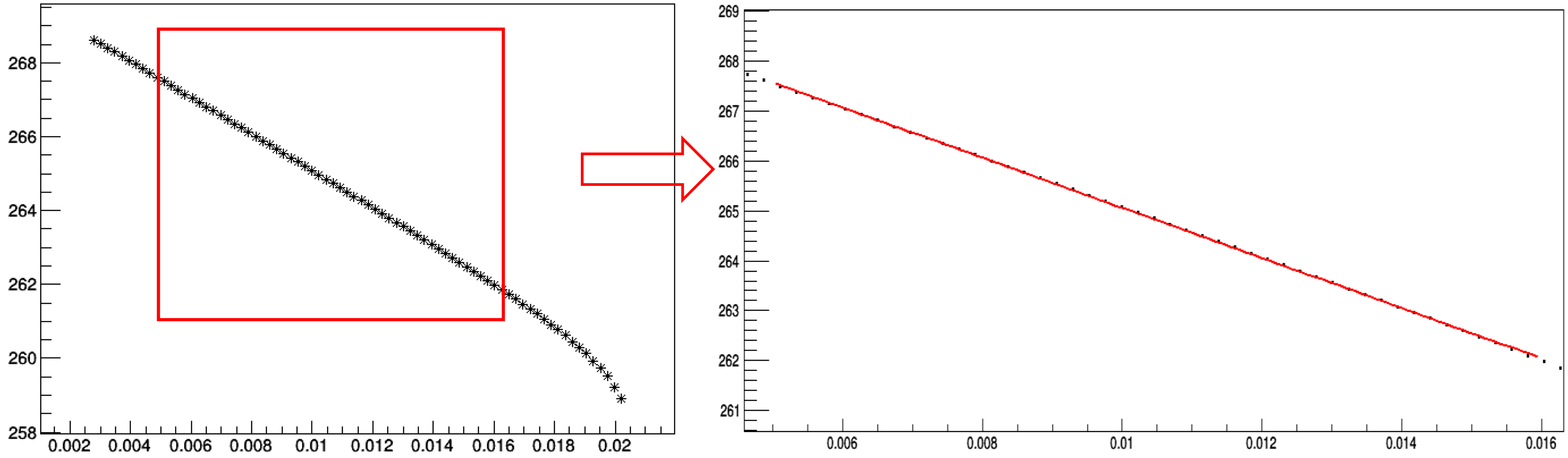
B1 (1) = B1 (3) = 48 μT and SF length = 10 cm

$\omega = 37911 * 2\pi$

amplitude



phase



Simulation status:

1) Rotating frame

- Analytical tool (constant fields, as from NIM A 589 (2008) 318–329)
- “Multi-matrices tool” (time dependent intensity NIM A 786 (2015) 71–77)

2) Abs. system with multi-matrices approach (any B(t) field)
(under test, Rabi scan seems ok)

Rabi scan (abs. sys.)

$B_x = 2B_1\cos(\omega t + \varphi)$

(phase-averaged results)

spin flipper length = 40 cm
neutron velocity = 700 m/s (5.65 A)
spin flipper crossing time = 571 µs
B0 = 130 µT ($\omega_0 = -\gamma B_0 = 23822$)
B1 = $-\pi/(\tau * \gamma)$ = 30 µT ($\omega_1 = -\gamma B_1 = 5498$)

Rabi formula with $\Delta = \omega - \omega_0'$

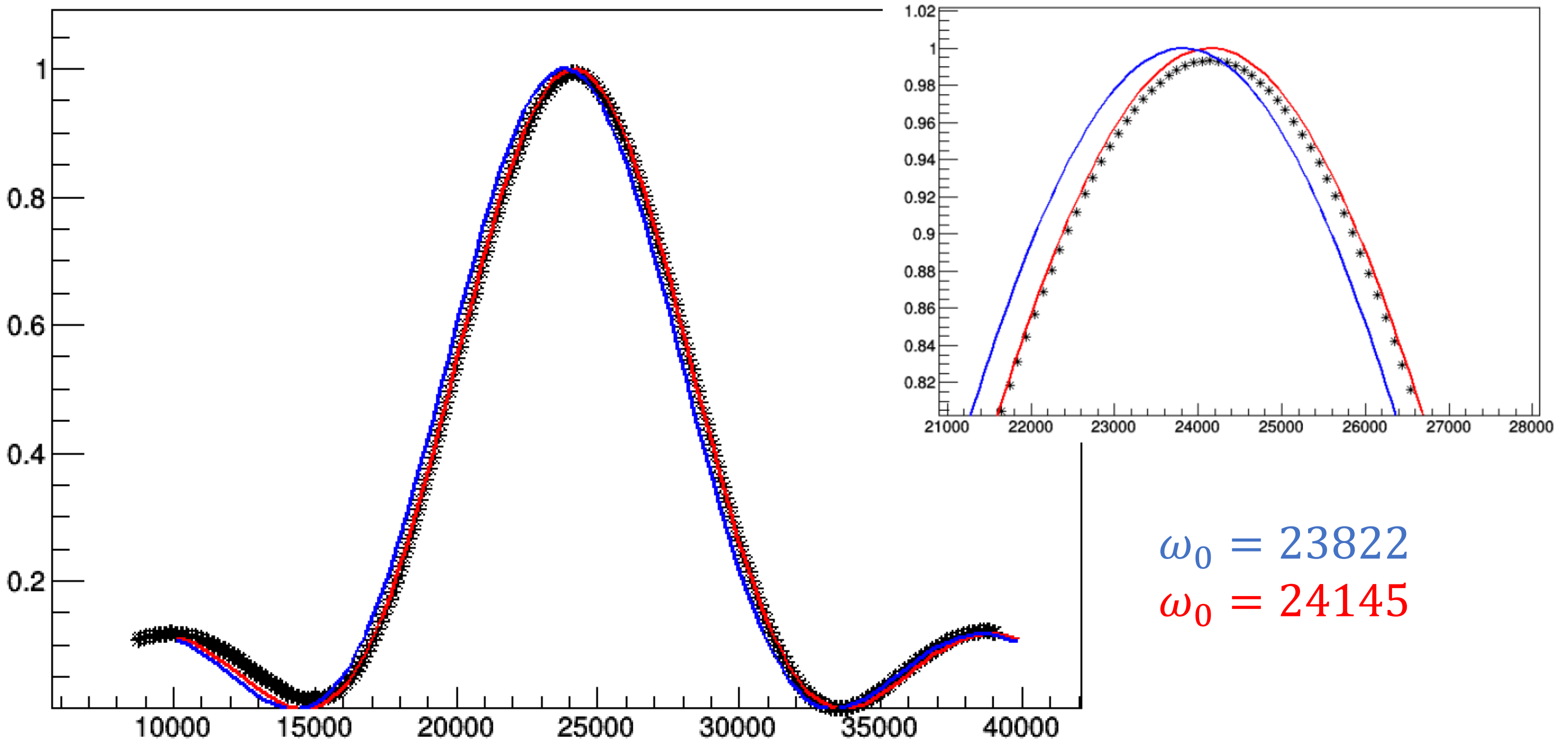
$$\mathcal{P}_{\text{Rabi}}(\Delta) = \frac{\omega_1^2}{\Delta^2 + \omega_1^2} \sin^2\left(\frac{\tau}{2} \cdot \sqrt{\Delta^2 + \omega_1^2}\right)$$

Bloch-Siegert frequency shift

$$\omega_0' = \omega_0 + \delta_{\text{BS}} = \omega_0 \cdot \left(1 + \frac{1}{4}\left(\frac{\omega_1}{\omega_0}\right)^2\right)$$

Theoritical ω_0' value = 24139
Observed ω_0' value = 24145

Max = 0.9935



Ramsey phase scan (abs. sys.)

(phase-averaged results)

B0 (1) = 130 μT $\left(-\frac{\gamma B_0}{2\pi} = 3791\ Hz\right)$

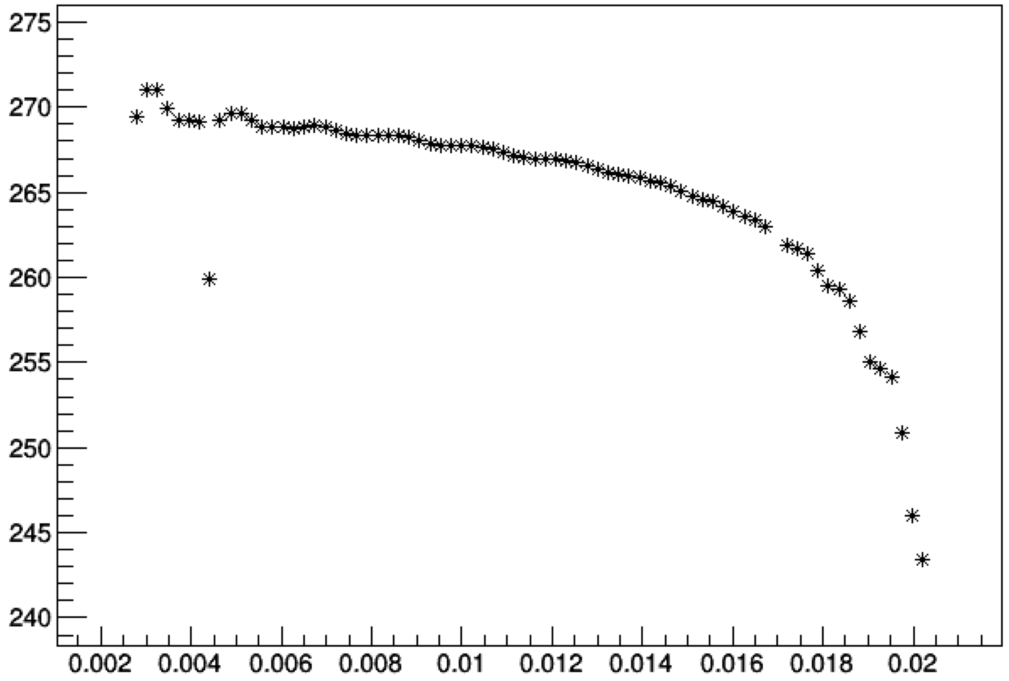
B0 (2) = 130 μT $\left(-\frac{\gamma B_0}{2\pi} = 3791\ Hz\right)$

B0 (3) = 130 μT $\left(-\frac{\gamma B_0}{2\pi} = 3791\ Hz\right)$

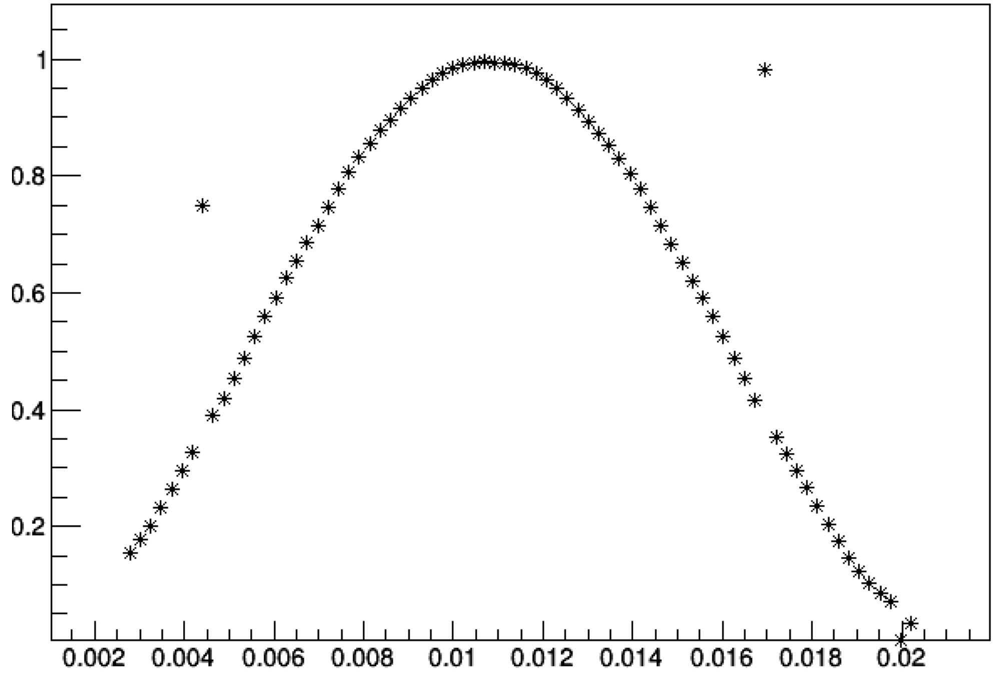
B1 (1) = B1 (3) = 12 μT

$\omega = -\gamma B_0(2)$

phase



amplitude



Ramsey phase scan (abs. sys.)

(phase-averaged results)

B0 (1) = 129.75 μT $\left(-\frac{\gamma B_0}{2\pi} = 3784\ Hz\right)$

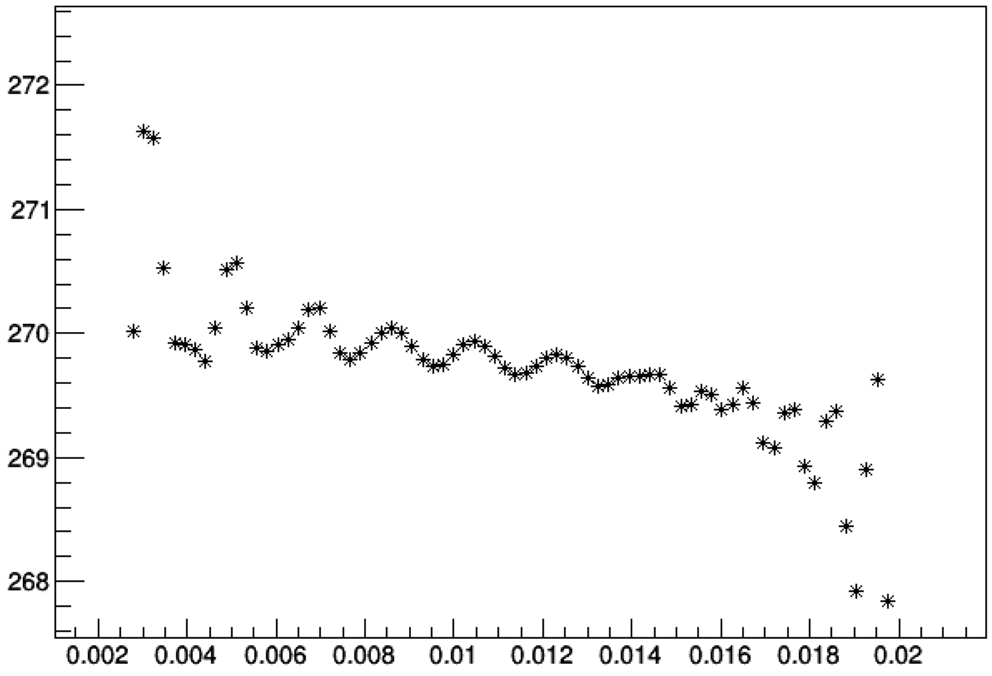
B0 (2) = 130 μT $\left(-\frac{\gamma B_0}{2\pi} = 3791\ Hz\right)$

B0 (3) = 129.75 μT $\left(-\frac{\gamma B_0}{2\pi} = 3784\ Hz\right)$

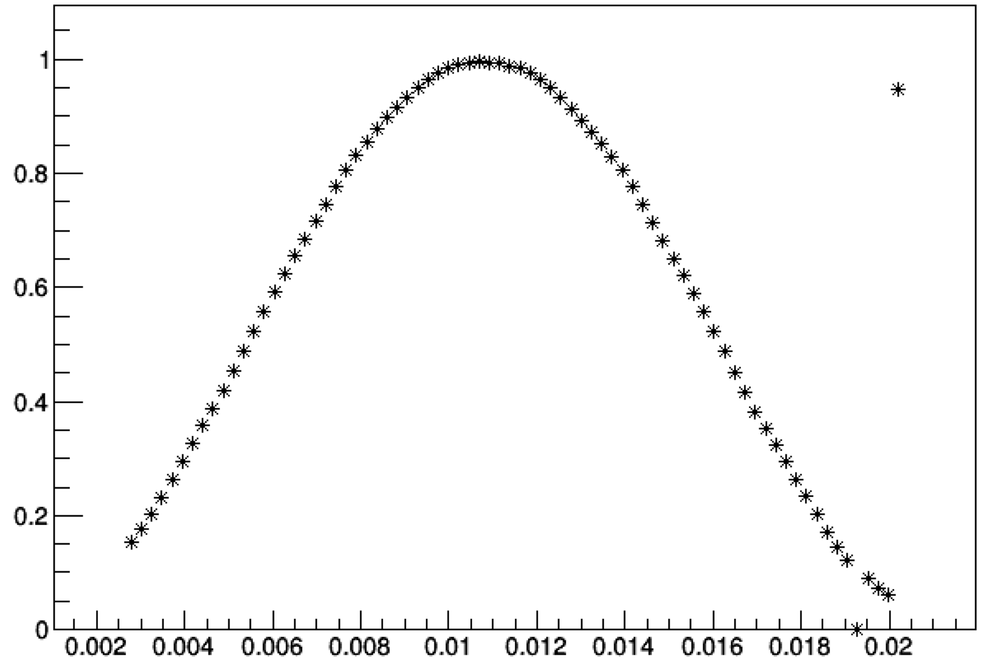
B1 (1) = B1 (3) = 12 μT

$\omega = -\gamma B_0(2)$

phase



amplitude



Ramsey phase scan (abs. sys.)

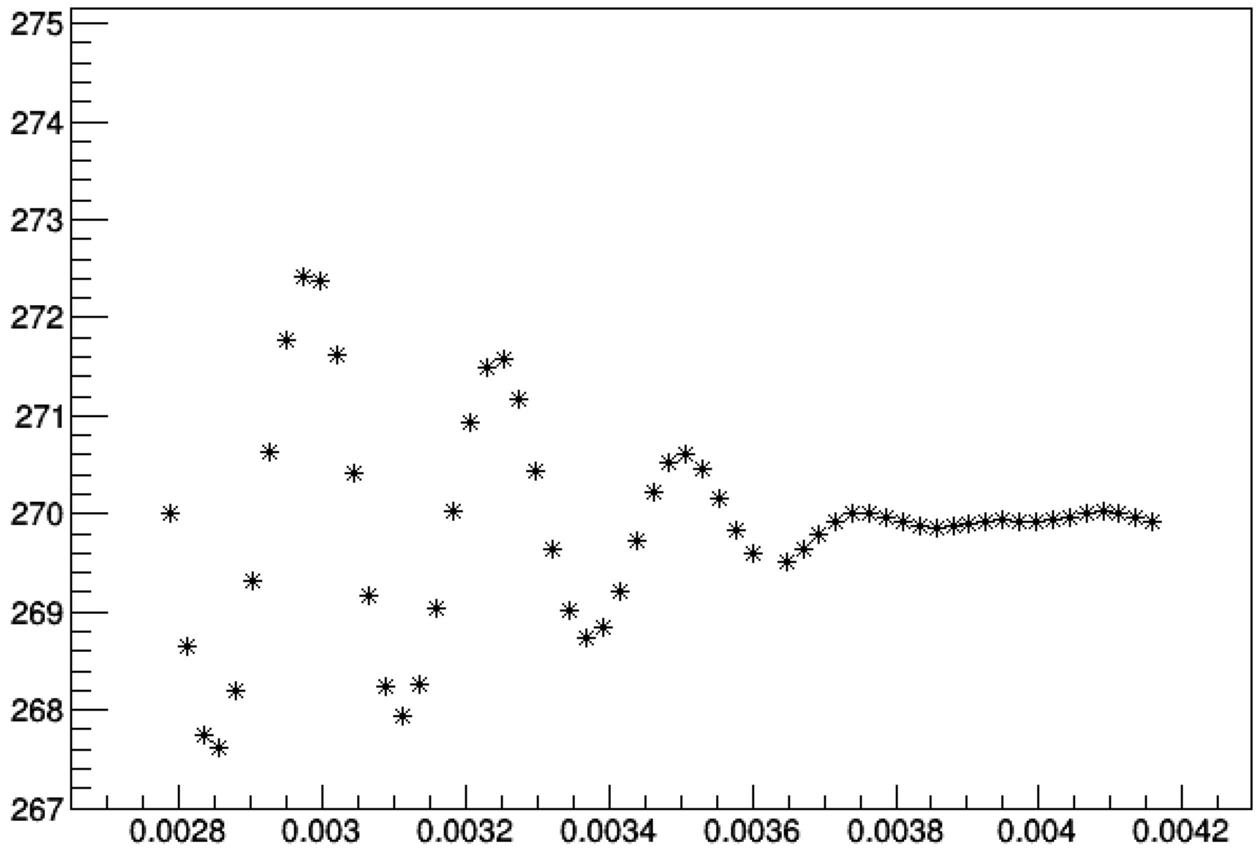
B0 (1) = 129.75 μT $(-\frac{\gamma B_0}{2\pi} = 3784\ Hz)$

B0 (2) = 130 μT $(-\frac{\gamma B_0}{2\pi} = 3791\ Hz)$

B0 (3) = 129.75 μT $(-\frac{\gamma B_0}{2\pi} = 3784\ Hz)$

B1 (1) = B1 (3) = 12 μT

$\omega = -\gamma B_0(2)$



Comparison rot.frame VS abs.sys

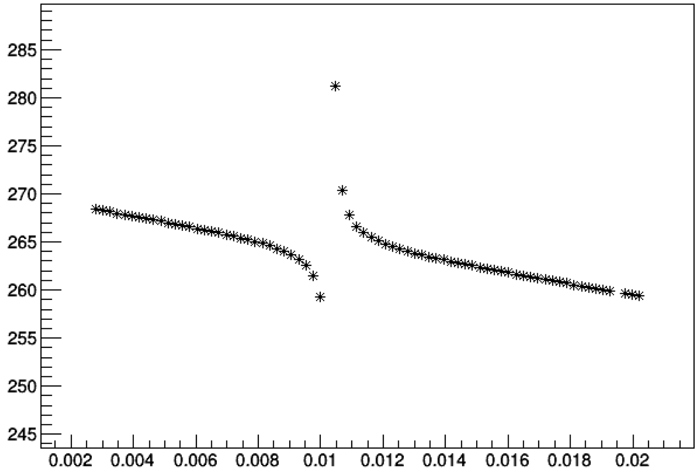
B0 (1) = 130.1 μT $\left(-\frac{\gamma B_0}{2\pi} = 3794\ Hz\right)$

B0 (2) = 130 μT $\left(-\frac{\gamma B_0}{2\pi} = 3791\ Hz\right)$

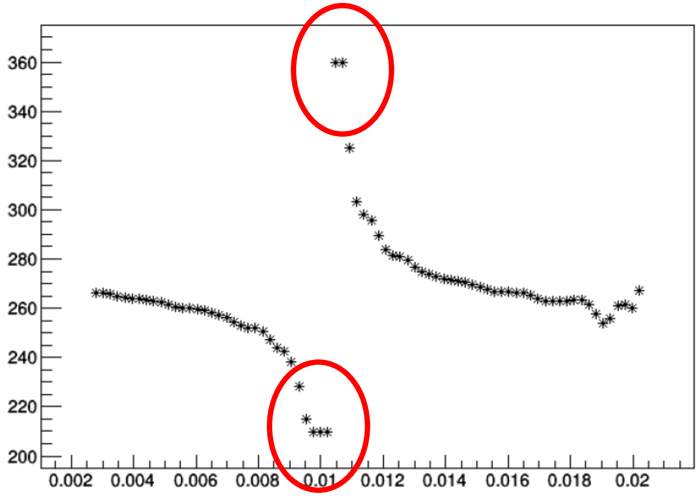
B0 (3) = 129.8 μT $\left(-\frac{\gamma B_0}{2\pi} = 3786\ Hz\right)$

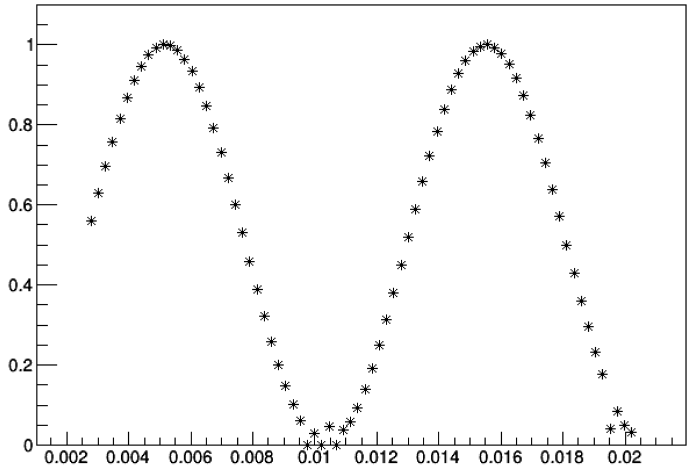
B1 (1) = B1 (3) = 25 μT

$\omega = 3788 * 2\pi$

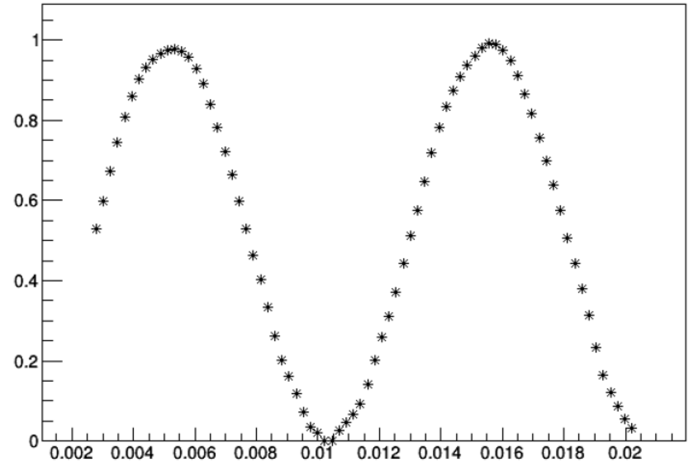


phase



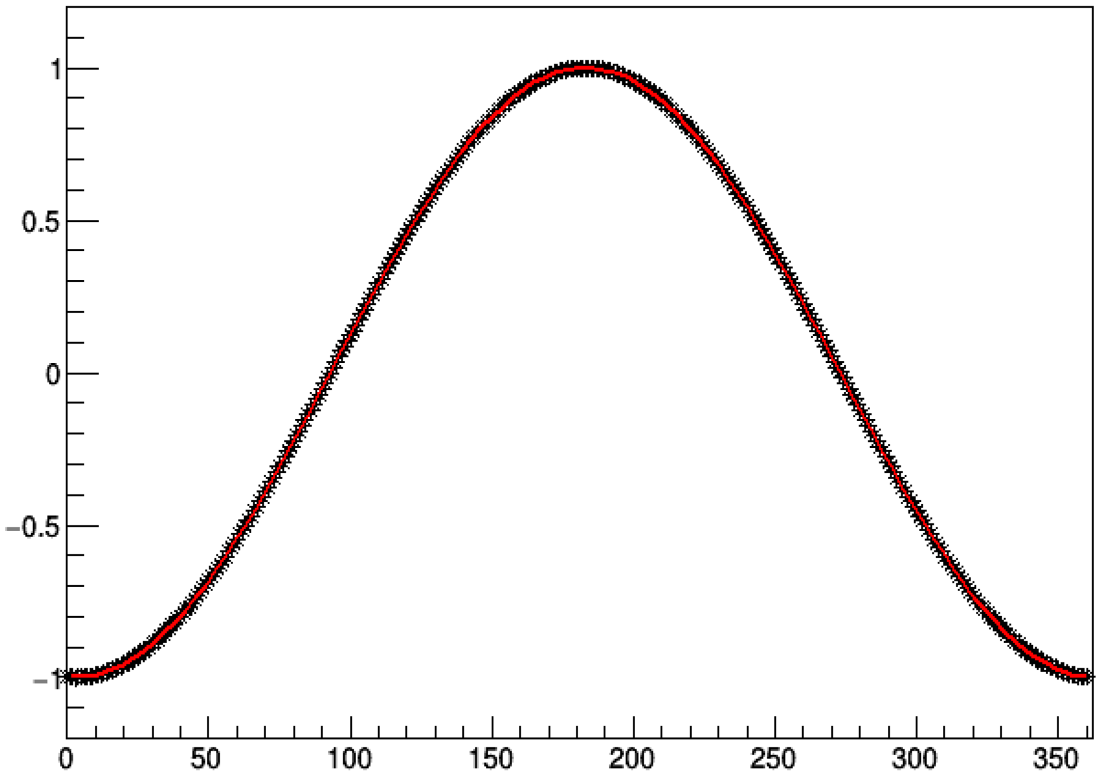


amplitude

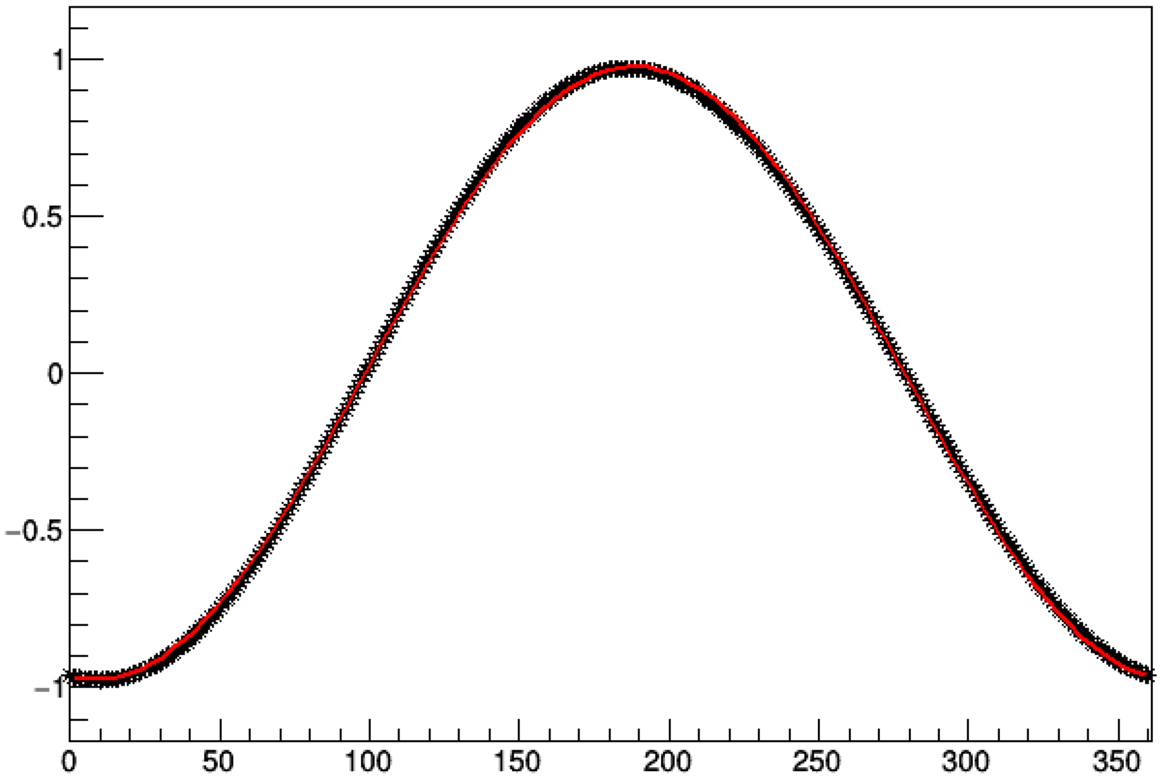


Comparison rot.frame VS abs.sys.
T (free prec. time) = 2.2 ms
$\sim\pi/2$ flip

rot.frame



abs. sys.

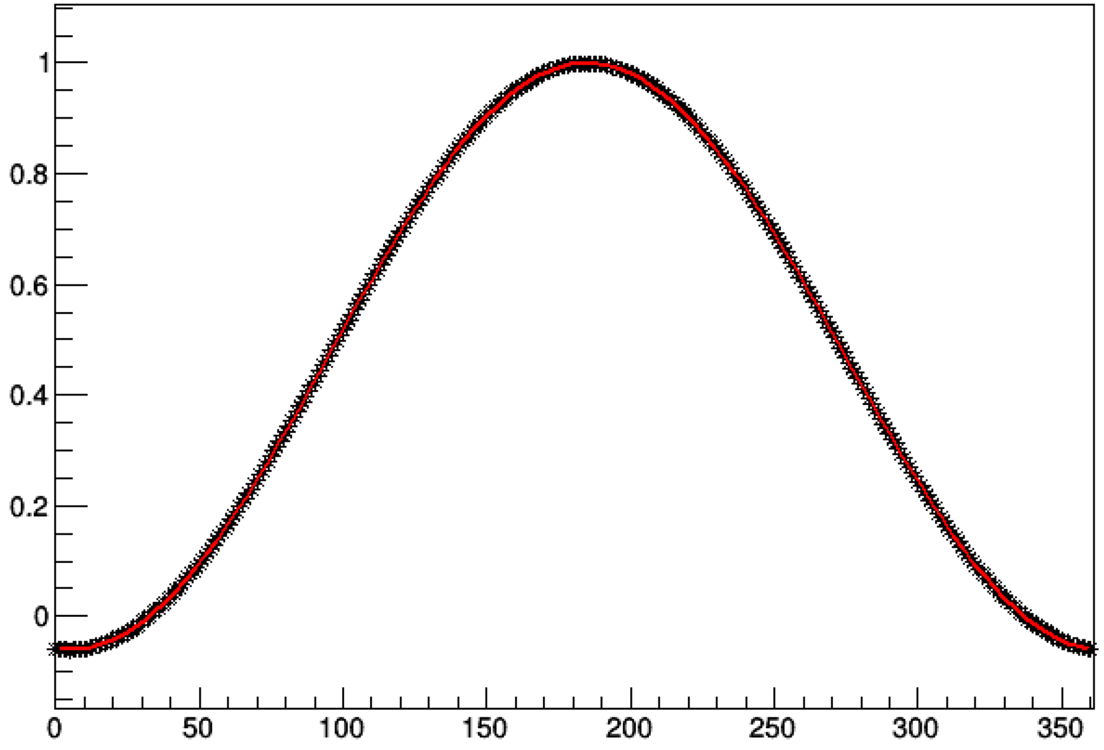


Comparison rot.frame VS abs.sys

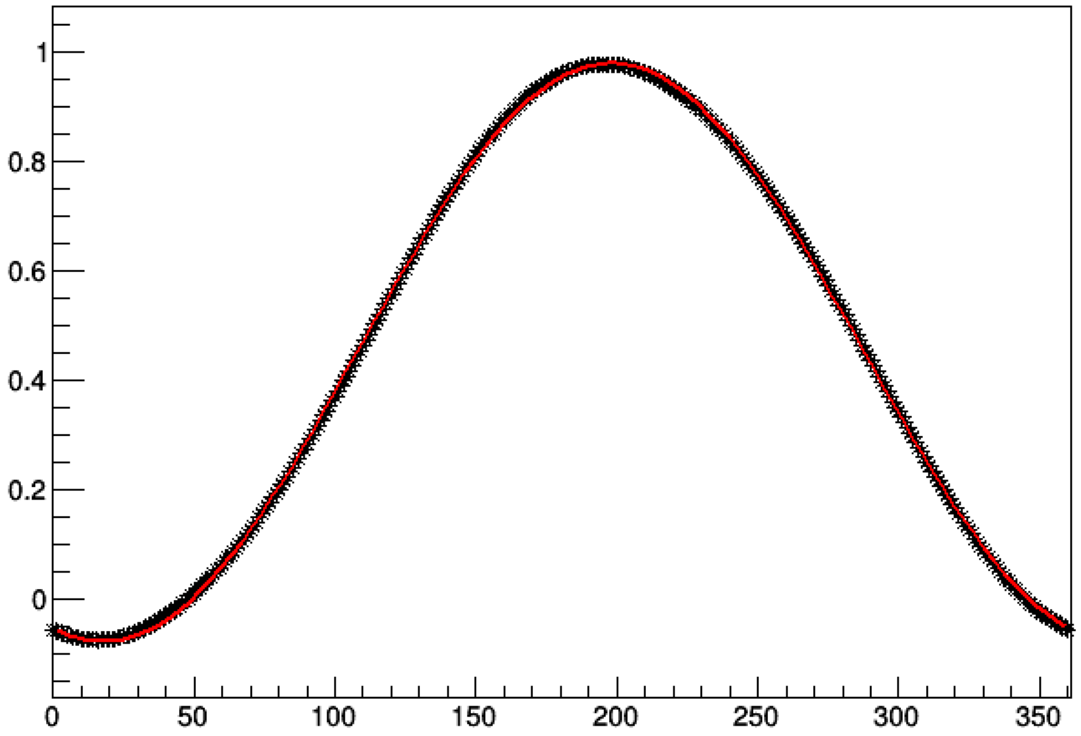
T (free prec. time) = 3.3 ms

$\sim(3/4)\pi$ flip

rot.frame



abs. sys.

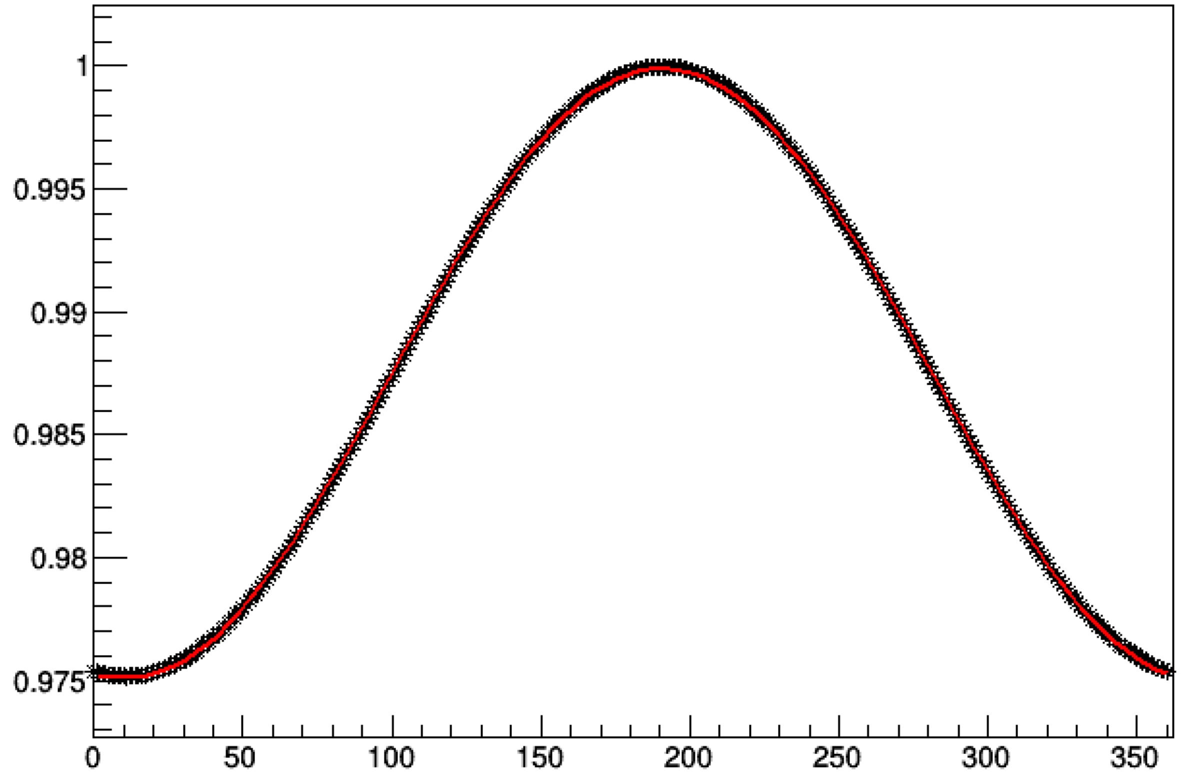


Comparison rot.frame VS abs.sys

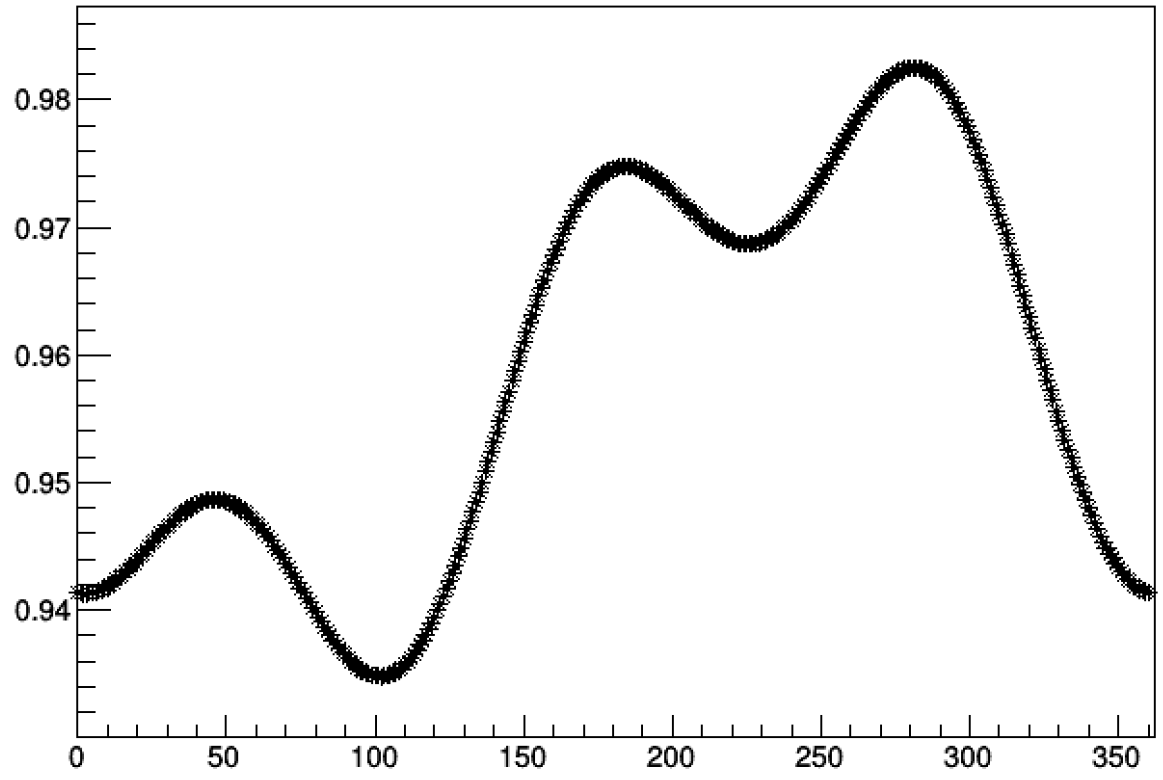
T (free prec. time) = 4.3 ms

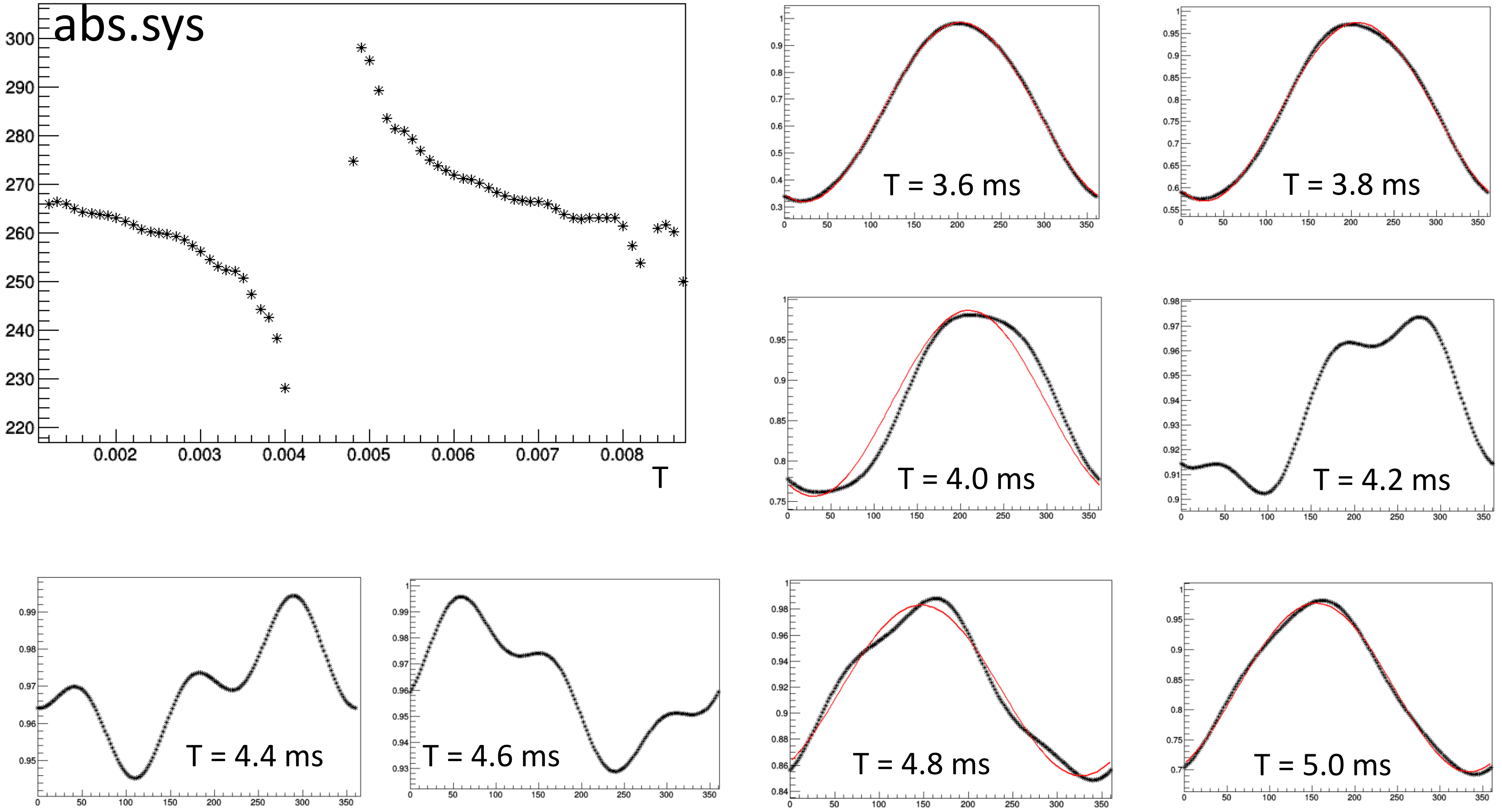
<≈ π flip

rot.frame



abs. sys.




abs.sys
300
290
280
270
260
250
240
230
220
0.002
0.003
0.004
0.005
0.006
0.007
0.008
T
T = 3.6 ms
T = 3.8 ms
T = 4.0 ms
T = 4.2 ms
T = 4.4 ms
T = 4.6 ms
T = 4.8 ms
T = 5.0 ms

(phase-averaged results)

l = 0.4; //spin flipper length
L = 2.6; //distance between spin flippers

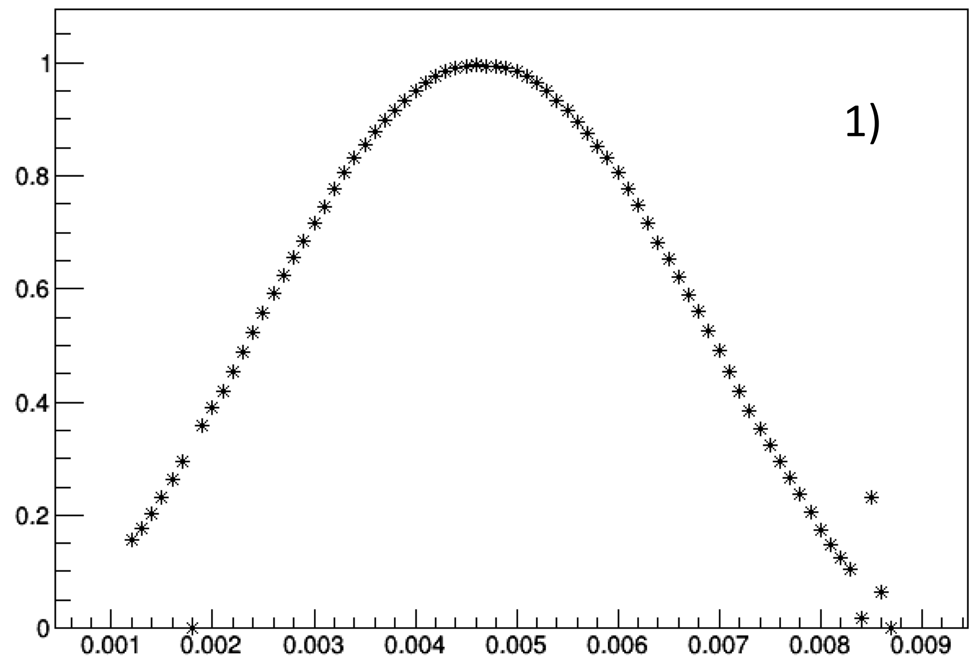
B0_1 = 130.0e-6;
B0_2 = 130.0e-6;
B0_3 = 130.0e-6;

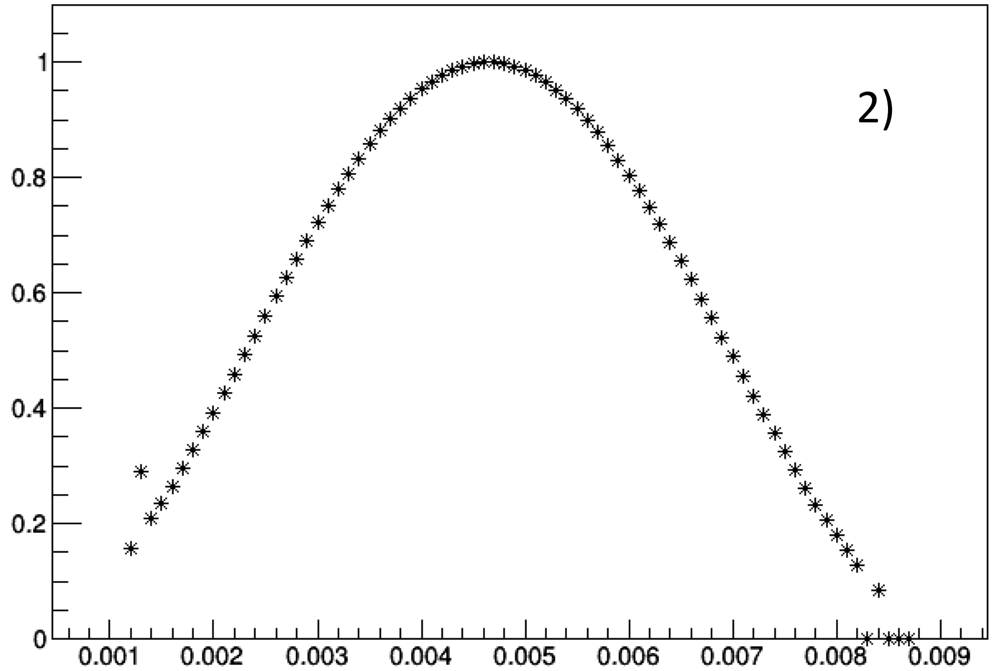
B1_1 = 12.e-6;
B1_3 = 12.e-6;;

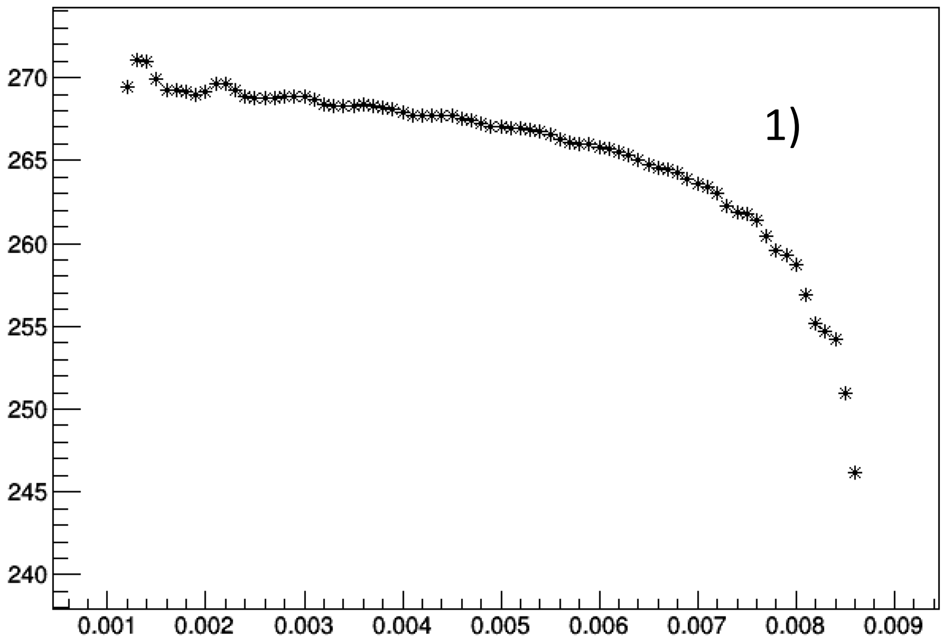
omega = -γ B0_2 (on resonance);

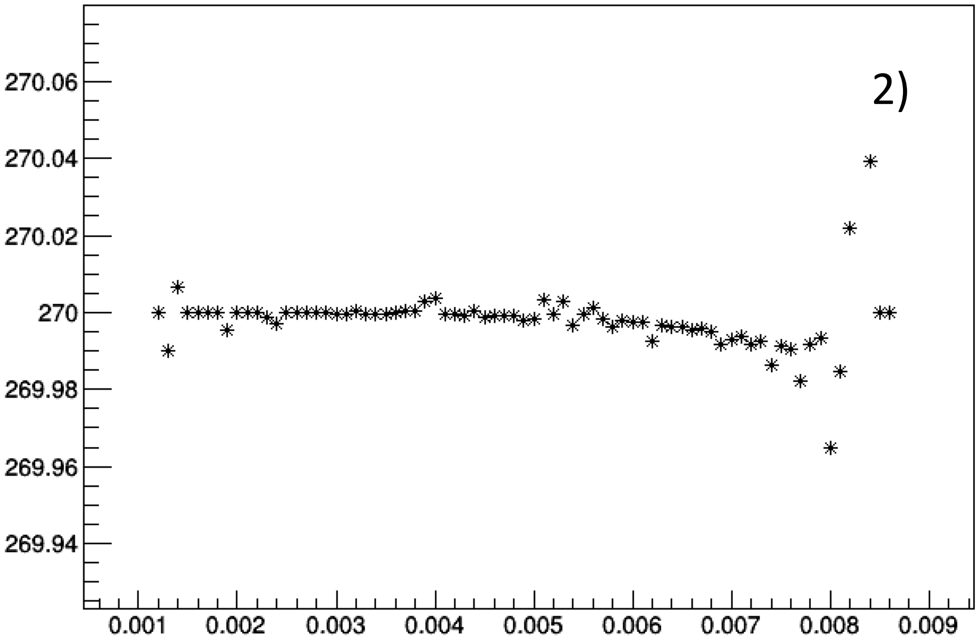
1)
$$B_x = 2B_1 cos(\omega t)$$
$$B_y = 0$$
$$B_z = B_0$$

2)
$$B_x = B_1 cos(\omega t)$$
$$B_y = B_1 sin(\omega t)$$
$$B_z = B_0$$


1)
0
0.2
0.4
0.6
0.8
1
0.001 0.002 0.003 0.004 0.005 0.006 0.007 0.008 0.009


2)
0
0.2
0.4
0.6
0.8
1
0.001 0.002 0.003 0.004 0.005 0.006 0.007 0.008 0.009


1)
240
245
250
255
260
265
270
0.001 0.002 0.003 0.004 0.005 0.006 0.007 0.008 0.009


2)
269.94
269.96
269.98
270
270.02
270.04
270.06
0.001 0.002 0.003 0.004 0.005 0.006 0.007 0.008 0.009

(phase-averaged results)

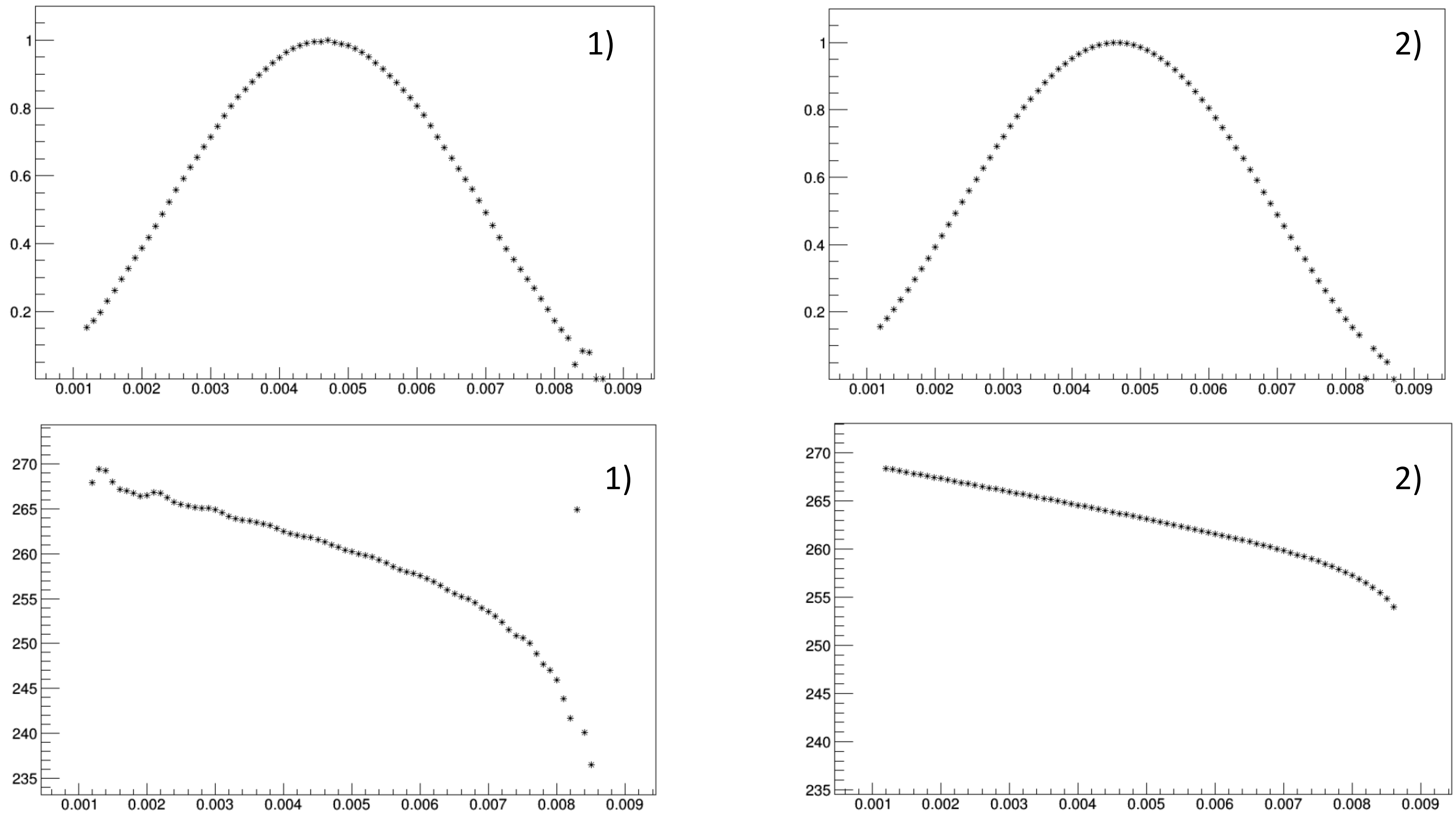
```
l = 0.4; //spin flipper length
L = 2.6; //distance between spin flippers

B0_1 =  130.1e-6;
B0_2 =  130.0e-6;
B0_3 =  129.8e-6;

B1_1 = 12.e-6;
B1_3 = 12.e-6;;

omega = 3788.*2.*pi;
```

1)

$$B_x = 2B_1 cos(\omega t)$$
$$B_y = 0$$
$$B_z = B_0$$

2)

$$B_x = B_1 cos(\omega t)$$
$$B_y = B_1 sin(\omega t)$$
$$B_z = B_0$$


1)
2)
1)
2)
1
0.8
0.6
0.4
0.2
270
265
260
255
250
245
240
235
0.001
0.002
0.003
0.004
0.005
0.006
0.007
0.008
0.009

Try to eliminate the Bloch-Siegert frequency shift

B0_1 = 130.0e-6;
B0_2 = 130.0e-6;
B0_3 = 130.0e-6;

B1_1 = 12.e-6;
B1_3 = 12.e-6;;

ω = -γ B0_2;

1) φ_{RDM1} and φ_{RDM2} are random between 0 and 2π (300exp)

$$B_x(SF1) = 2B_1 cos(\omega t + \varphi_{RDM1}) + 2B_1 cos\left(\sqrt{\mathbf{5}}\boldsymbol{\omega} t + \varphi_{RDM2}\right)$$

$$B_y(SF1\&2) = 0$$

$$B_z(SF1\&2) = B_0$$

$$B_x(SF2) = 2B_1 cos(\omega t + \varphi_{RDM1} + \varphi_{SF}) + 2B_1 cos\left(\sqrt{\mathbf{5}}\boldsymbol{\omega} t + \varphi_{RDM2} + \varphi_{SF}\right)$$

2) φ_{RDM} is random between 0 and 2π (300exp)

$$B_x(SF1) = 2B_1 cos(\omega t + \varphi_{RDM}) + 2 * \sqrt{\frac{\mathbf{3}}{\mathbf{4}}} B_1 \; cos(\mathbf{2}\boldsymbol{\omega} t + \mathbf{2}\boldsymbol{\varphi}_{\boldsymbol{RDM}})$$

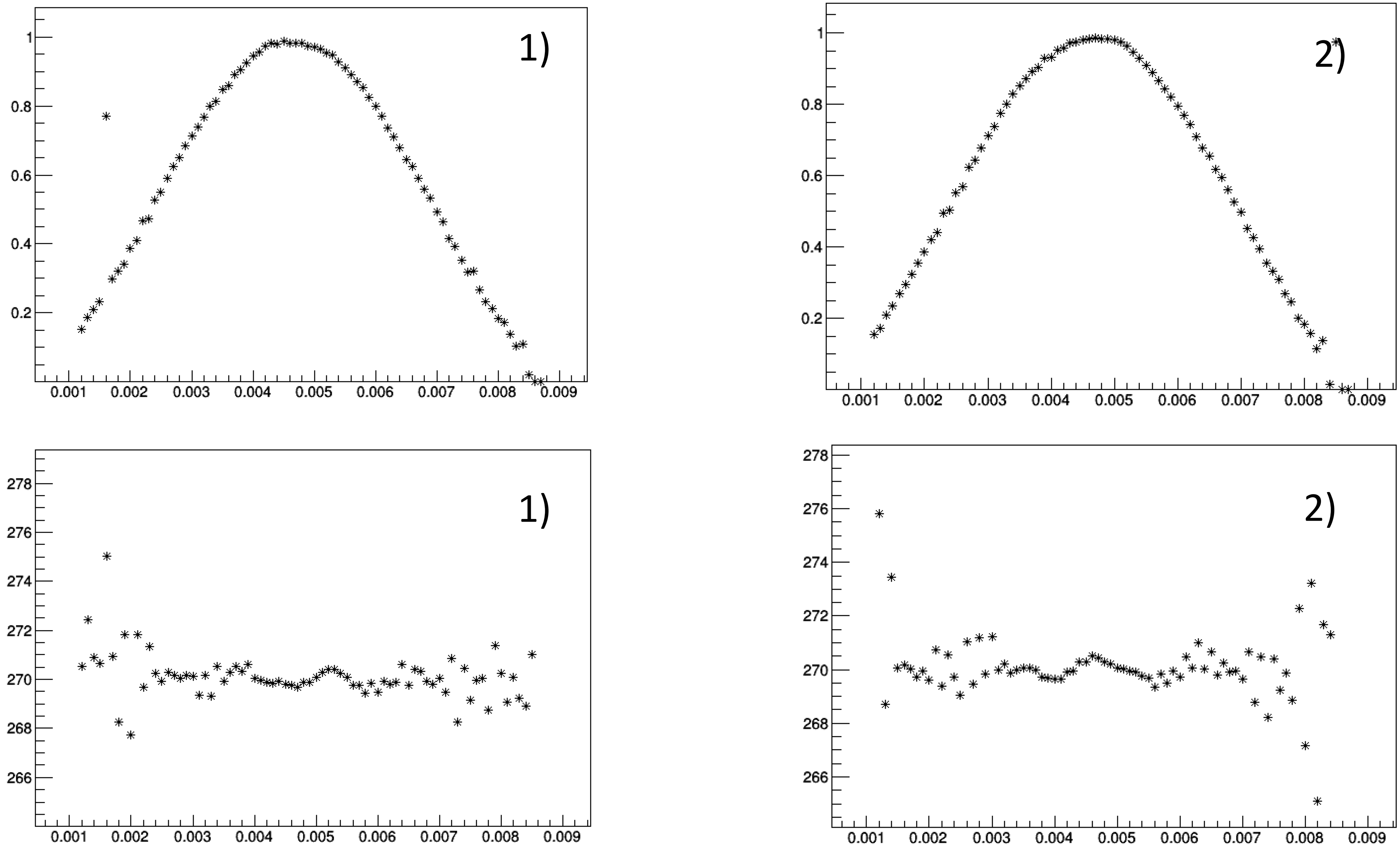
$$B_y(SF1\&2) = 0$$

$$B_z(SF1\&2) = B_0$$

$$B_x(SF2) = 2B_1 cos(\omega t + \varphi_{RDM} + \varphi_{SF}) + 2 * \sqrt{\frac{\mathbf{3}}{\mathbf{4}}} B_1 cos(\mathbf{2}\boldsymbol{\omega} t + \mathbf{2}\boldsymbol{\varphi}_{\boldsymbol{RDM}} + \varphi_{SF})$$

NB:

$$\omega_{BS} = \frac{(\gamma B_1)^2}{2(\omega_{RF} + \omega_{B0})}$$


1)
2)
1)
2)
0.2
0.4
0.6
0.8
1
266
268
270
272
274
276
278
0.001
0.002
0.003
0.004
0.005
0.006
0.007
0.008
0.009

Modulated signal in abs. sys.

D = 1.784; //distance chopper SF1
l = 0.4;   //spin flipper length
L = 2.6;   //distance between spin flippers

B0_1 = 130.1e-6;
B0_2 = 130.0e-6;
B0_3 = 129.8e-6;

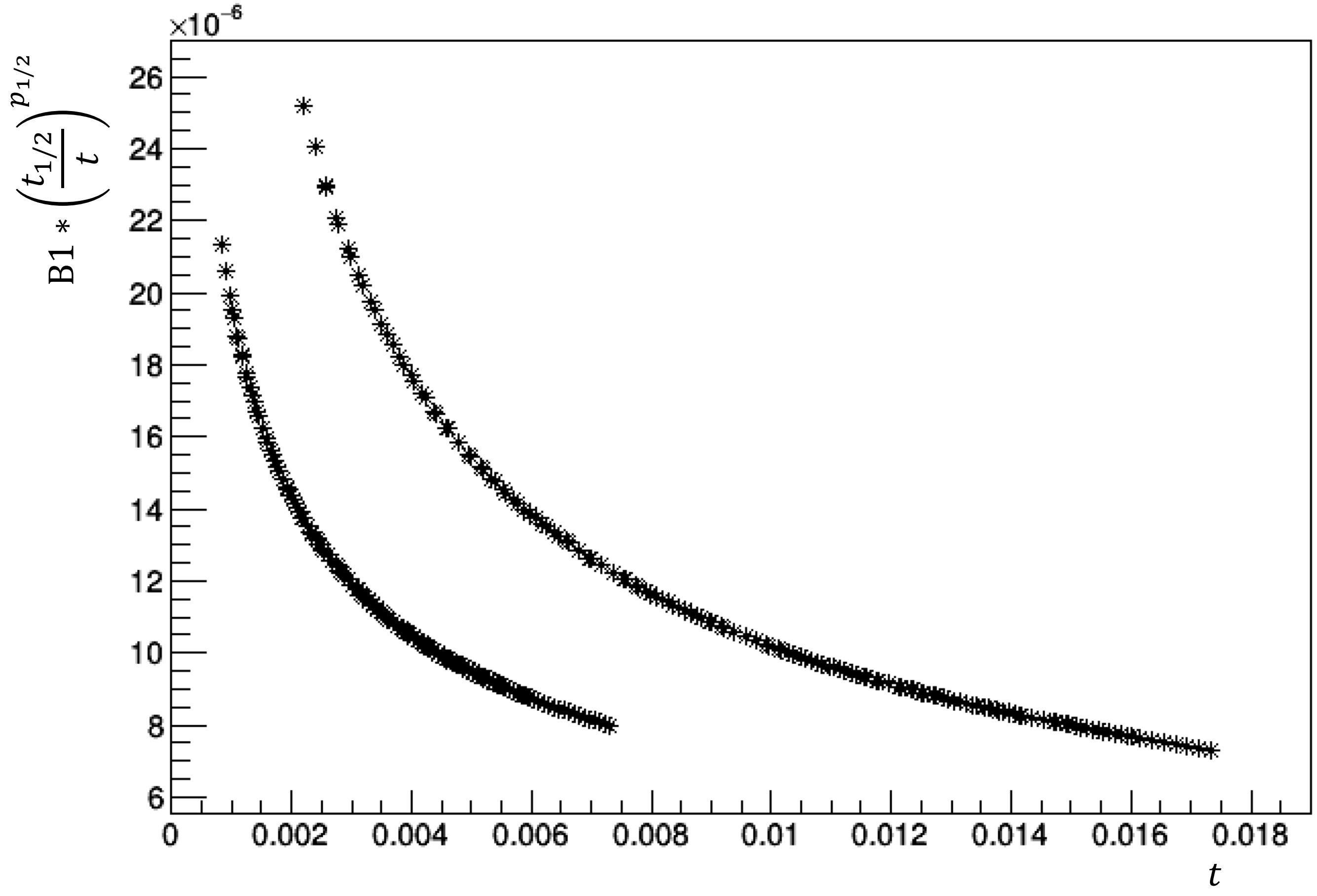
B1 = 25.e-6;
omega = 3788.*2.*pi;

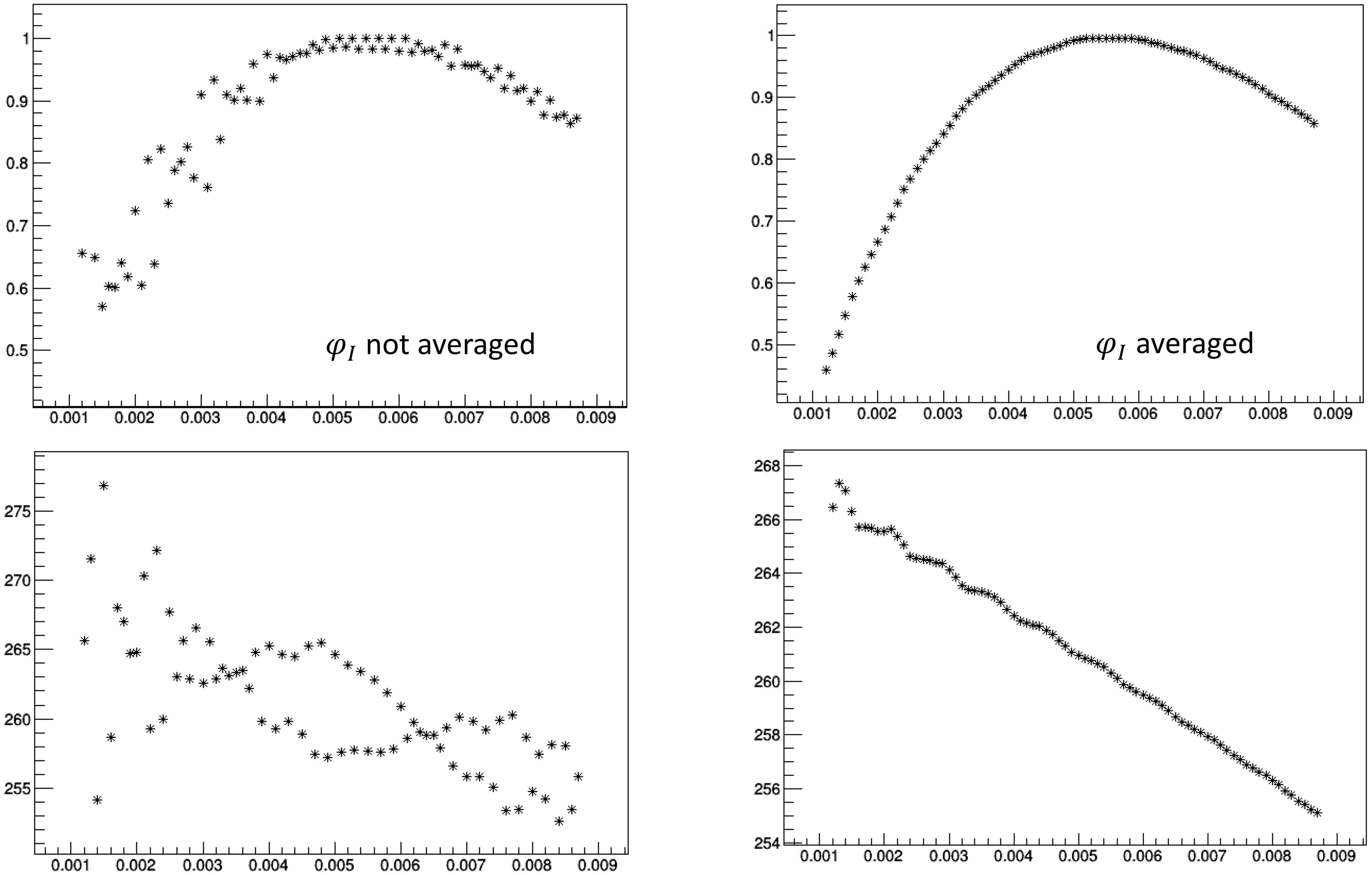
$$B_x(SF_1) = -\gamma * 2 * \mathrm{B1} * \left(\frac{t_1}{t}\right)^{p_1} \cos(\omega t)$$

$$B_x(SF_2) = -\gamma * 2 * \mathrm{B1} * \left(\frac{t_2}{t}\right)^{p_2} \cos(\omega t + \varphi_{SF})$$

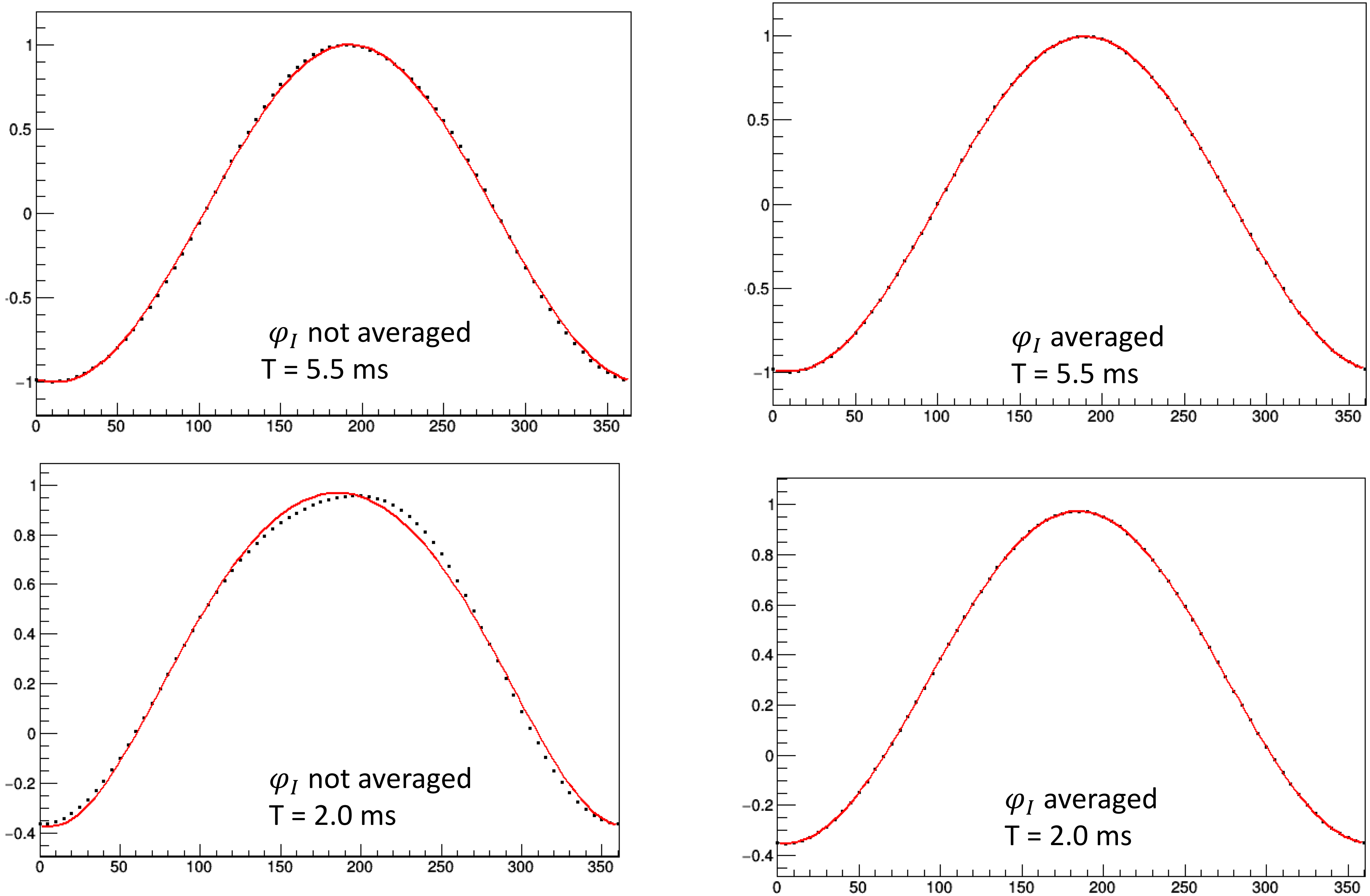
with $t_1 = 0.58\, ms$ $\quad p_1 = 0.45$

$t_2 = 2.24\, ms$ $\quad p_2 = 0.6$





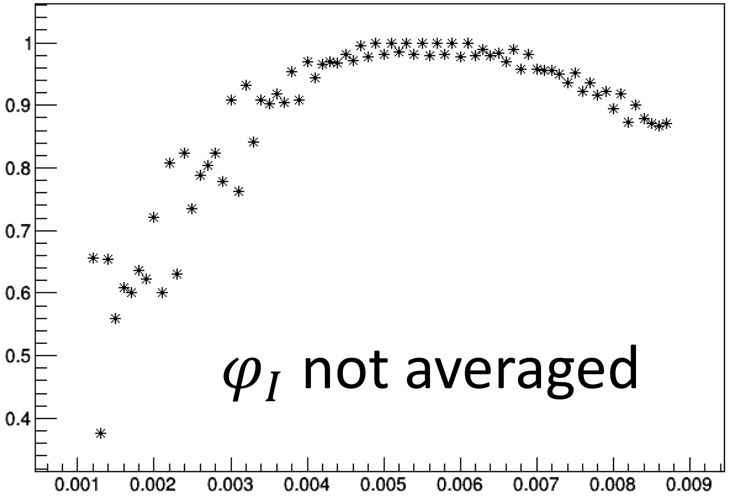
φ_I not averaged
φ_I averaged
0.5
0.6
0.7
0.8
0.9
1
0.001
0.002
0.003
0.004
0.005
0.006
0.007
0.008
0.009
255
260
265
270
275
254
256
258
260
262
264
266
268

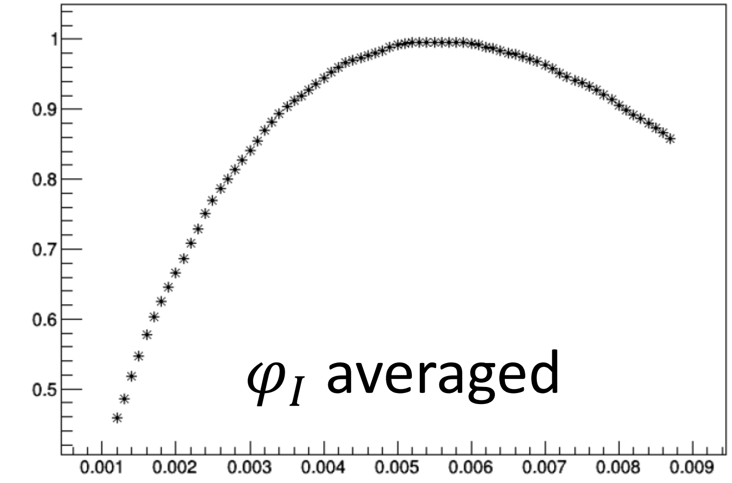


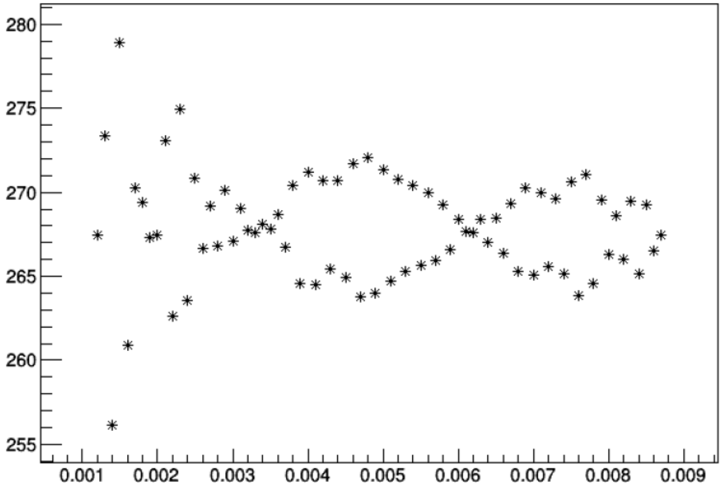
φ_I not averaged
T = 5.5 ms
φ_I averaged
T = 5.5 ms
φ_I not averaged
T = 2.0 ms
φ_I averaged
T = 2.0 ms

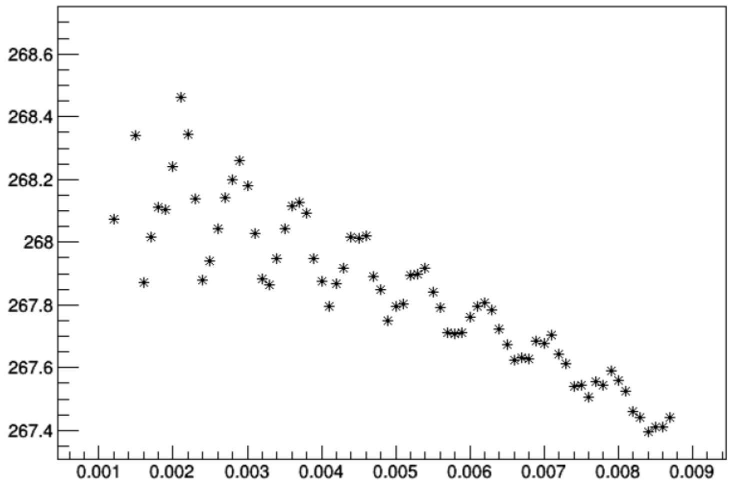
B0_1 = 130.0e-6;
B0_2 = 130.0e-6;
B0_3 = 130.0e-6;

B1 = 25.e-6;
omega = -γ B0_2;

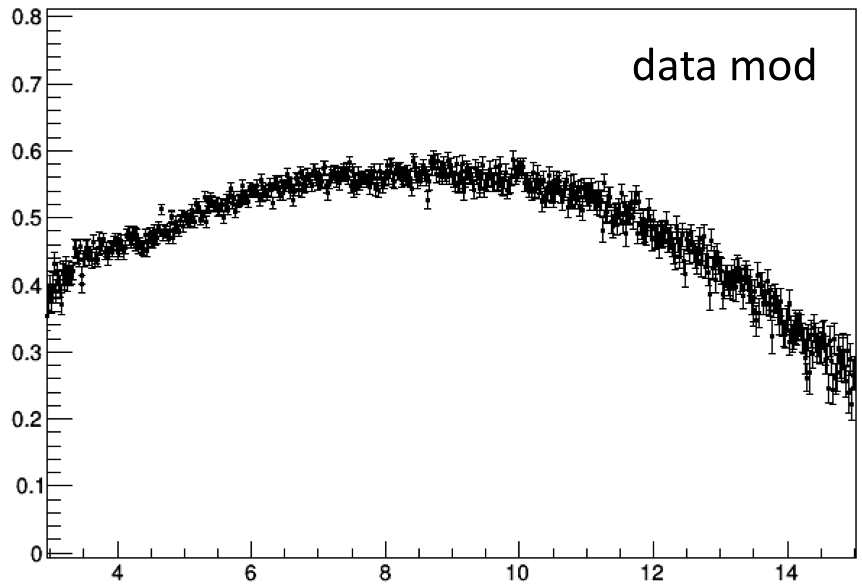


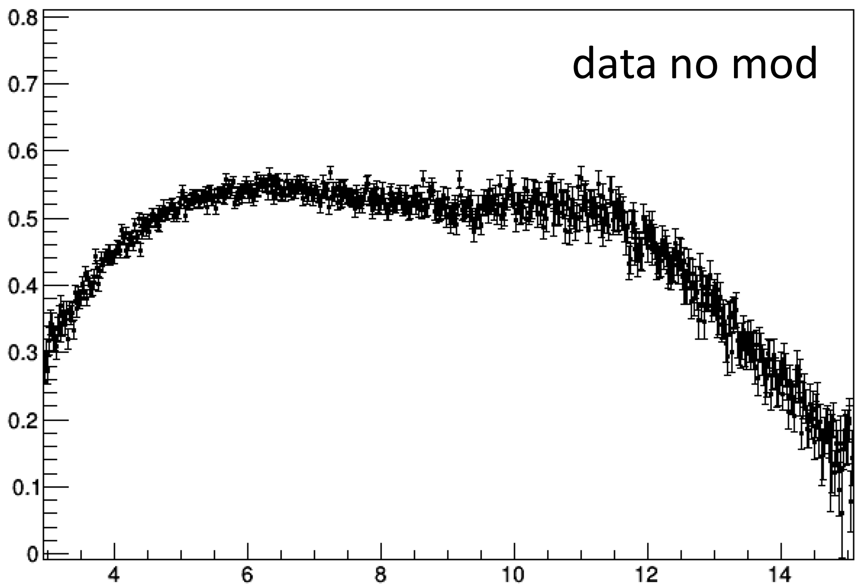


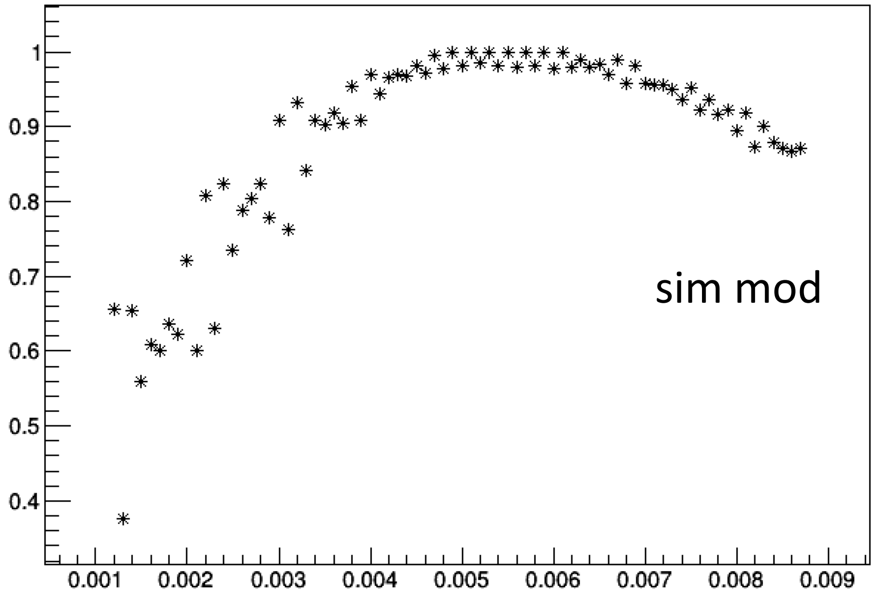


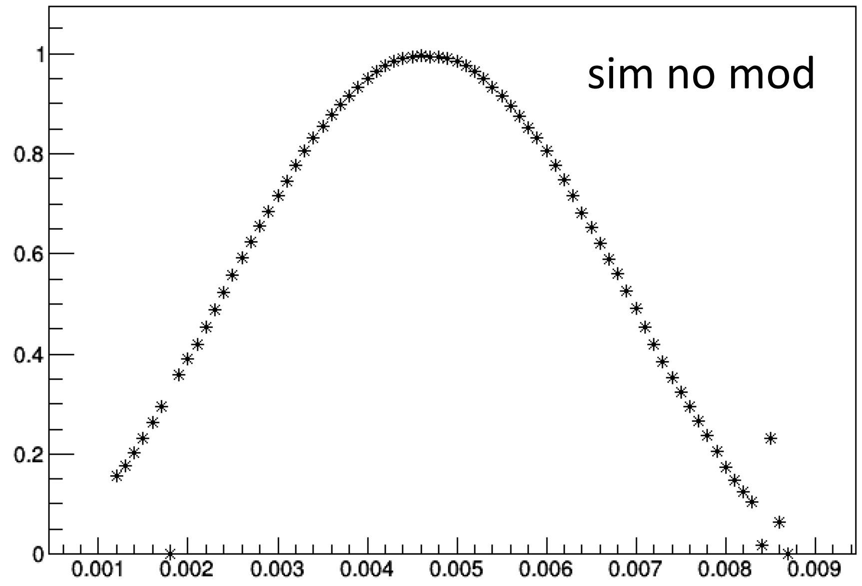


Amplitude comparison

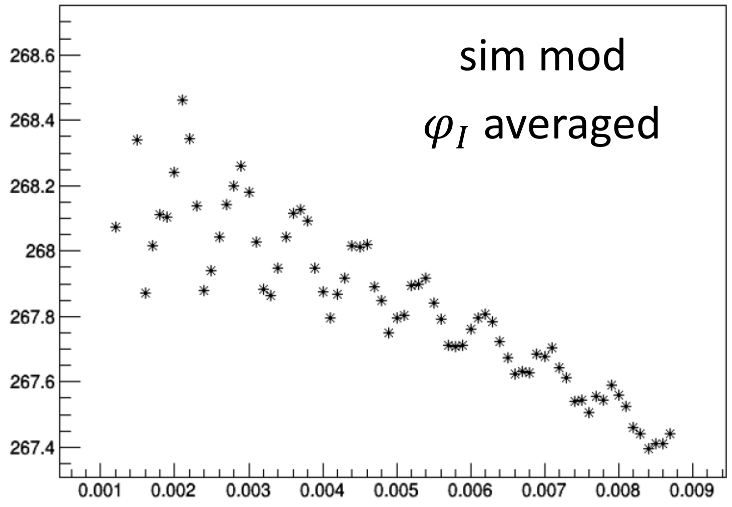


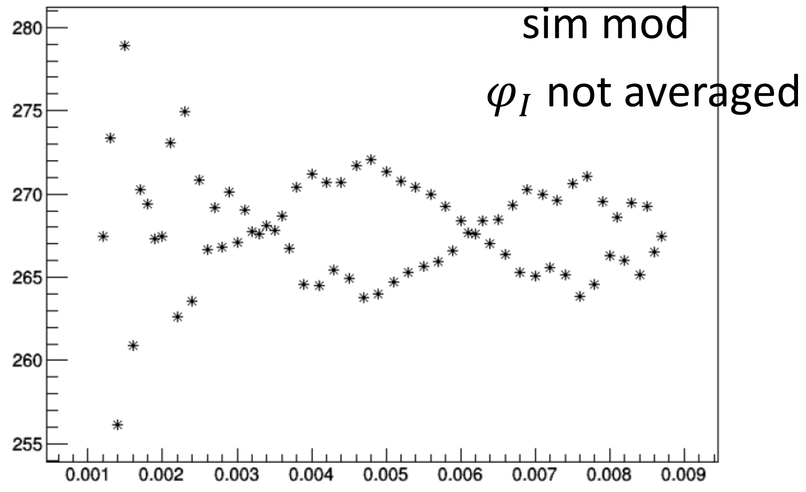


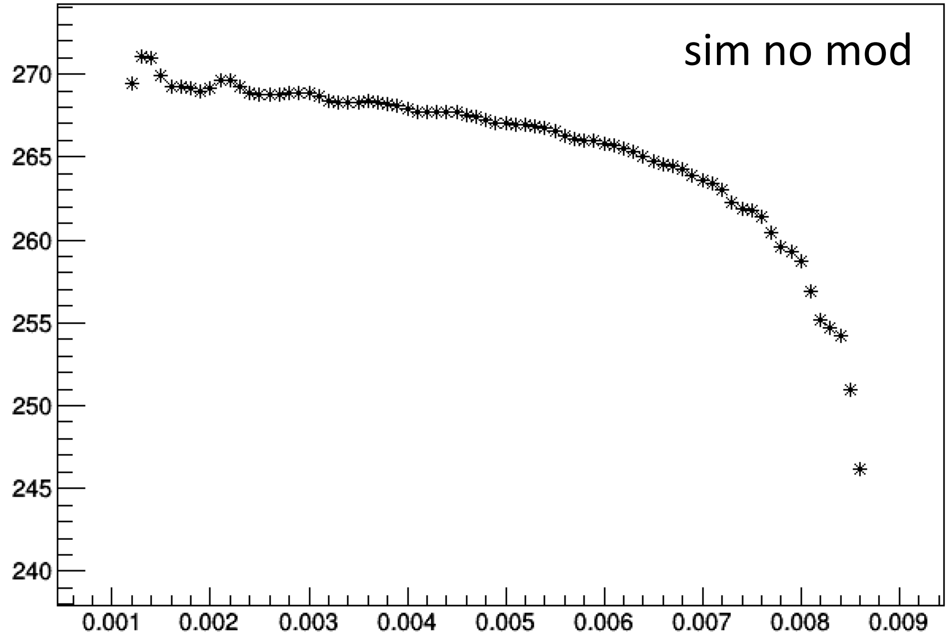




Phase comparison (on resonance)







Summary

- “tangent effect” -> in the regions where amplitude is small (close to $\pi+\pi$ flip) the asymmetry vs phase shift plot is altered (phase evaluation not easy). The effect is not described in the rotating frame approx.

- Chi2 alterations for the mod. signal seems due to non-random initial phase

- Bloch-Siegert effect can be an issue (there are ways to reduce/eliminate it)

- Pros and contra in the mod VS no mod comparison. To be tested against real data when a more homogeneous B field will be available

Plans

- Validate the tool with real data if available (ex. invetigate BS shift with Ivo’s setup)
- (make it more realistic: TOF smearing)
- (add systematics)

Hint from Zach: is it really random the initial phase?

Ex.: SF frequency = 3800 Hz, Chopper frequency = 15 Hz, ratio is 253.333 → initial phase may assume only 3 values!

B0_1 = 130.0e-6;
B0_2 = 130.0e-6;
B0_3 = 130.0e-6;

B1_1 = 12.e-6;
B1_3 = 12.e-6;;

ω = -γ B0_2;
$B_x = 2B_1 cos(\omega t)$