Electron detector correlations

Setup

Analytical Formulation

Definitions

Let us define the time distribution of electrons hitting an e-detector "element" as

$$S(t) = R(t) + A(t) \qquad (1)$$

where R(t)=r $\lambda\, e^{-\lambda t}$ is the real distribution and A(t)=a the accidental distribution per PU protected muon. In zeroth order this corresponds also to the observed time distribution

$$S0(t) = S(t) \qquad (2)$$

In first order we have to account for possible correlations C(τ) ≠0 (for Ta<t<Tb) for the detection of an electron at time t, following an earlier electron at time t'. The correlation depends on the detector response, it can suppress electron detection at t (deadtime) or enhance it (afterpulsing).
The first order correction is

$$S1(t) = \int_{t-Tb}^{t-Ta} G(t', t)\, dt' \qquad (3)$$

with

$$G(t', t) = S(t')\, C(t-t')\, S(t) \qquad (4)$$

where T is the max time range over which correlations exist. G consists of the following terms

$$G(t', t) = R(t')\, C(t-t')\, A(t) + A(t')\, C(t-t')\, A(t) + A(t')\, C(t-t')\, R(t) \qquad (4)$$

The R C R term vanishes, because there is only one real e per muon. For S1(t) we obtain with τ = t - t'

$$S1(t) = a \int_{Ta}^{\min(Tb, t)} R(t-\tau)\, C(\tau)\, d\tau + a^2 C_T + a R(t) C_T \qquad (5)$$

with $C_T = \int_0^T C(\tau)\, d\tau$. Only the first term (RCA) is a trouble maker, as it may lead to a time dependence of the accidentals. The last term ACR is time dependent, but follows the muon decay distribution, thus does not lead to a distortion. If C=0 all the corrections vanish.

The RCA term

$$RCA(t) = a \int_{Ta}^{\min(Tb, t)} R(t-\tau)\, C(\tau)\, d\tau \qquad (6)$$

Using R(t-τ)=$\frac{R(t)}{r\lambda}$ R(-τ) we get

$$RCA(t) = a \frac{R(t)}{r\lambda} \int_{Ta}^{\min(Tb, t)} R(-\tau)\, C(\tau)\, d\tau \qquad (6)$$

Let's call the integral

$$I(t) = \int_{Ta}^{\min(Tb,t)} R(-\tau)\, C(\tau)\, d\tau \qquad (7)$$

$$Tb < t: \quad I(t) = \int_{Ta}^{Tb} R(-\tau)\, C(\tau)\, d\tau$$

$$Ta < t < Tb: \quad I(t) = \int_{Ta}^{t} R(-\tau)\, C(\tau)\, d\tau$$

RCA(t=Ta)=0, then for t<Tb the correction will build up. At t=Tb, I(t) becomes independent of t, so the correction RCA will exponentially disappear with the muon lifetime.

■ Examples

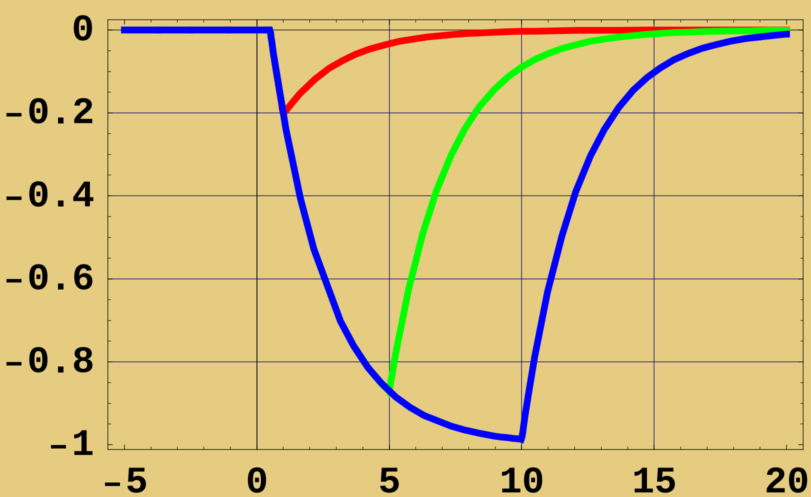
□ Example C(τ)=f for τ<T (deadtime in RCA term)

f=0 no deattime, f=1 100% deadtime

$$Tb < t: \quad I(t) = \int_{Ta}^{Tb} R(-\tau)\, f\, d\tau = r\,(e^{\lambda\, Tb} - e^{\lambda\, Ta});\; RC(t) = a\, r\, f\, e^{-\lambda\, t}\,(e^{\lambda\, Tb} - e^{\lambda\, Ta}) \qquad (8)$$

$$Ta < t < Tb: \quad I(t) = \int_{Ta}^{t} R(-\tau)\, f\, d\tau = r\,(e^{\lambda\, t} - e^{\lambda\, Ta});\; RC(t) = a\, r\, f\,(1 - e^{-\lambda\,(t-Ta)})$$

```
RC1[t_, Ta_, Tb_] := If[t < Ta, 0, If[t > Tb, -E^(-λ t) (E^(λ Tb) - E^(λ Ta)), -(1 - E^(-λ (t-Ta)))]]
R0 = 0.455; λ = R0; Plot[{RC1[t, 0.5, 1.], RC1[t, 0.5, 5], RC1[t, 0.5, 10]}, {t, -5, 20}];
```

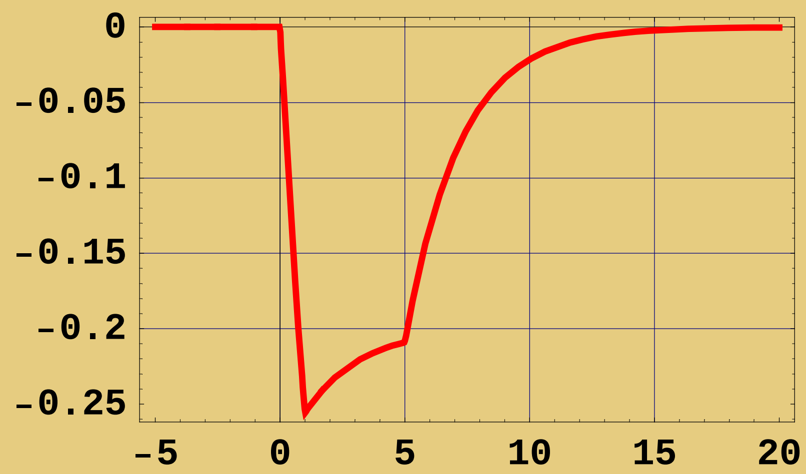


The curves have to be scaled by r f. If f=1 (=segment completely dead) than the scale is proportional to r, which is basically the solid angle of the segment.

□ Example C(τ)=f1 for 0< τ<T1 and f2 for T1<f2<T2 (deadtime in RCA term)

```
RC1[t_, Ta_, Tb_, f_] := If[t < Ta, 0, If[t > Tb, -f E^(-λ t) (E^(λ Tb) - E^(λ Ta)), -f (1 - E^(-λ (t-Ta)))]];
 RCS[T1_, T2_] := RC1[t, 0, T1, f1] + RC1[t, T1, T2, f2]; RCS[T1, T2]
f1 = .7; f2 = 0.2;
R0 = 0.455; λ = R0; Plot[RCS[1, 5], {t, -5, 20}];
```

```
If[t < 0, 0, If[t > T1, -0.7 e^(-λ t) (e^(λ T1) - e^(λ 0)), -0.7 (1 - e^(-λ (t-0)))]] +
 If[t < T1, 0, If[t > T2, -0.2 e^(-λ t) (e^(λ T2) - e^(λ T1)), -0.2 (1 - e^(-λ (t-T1)))]]
```



□ Example C(τ)=f for τ<T, but only one detected electron per PU protected muon allowed

If events with a second electron are rejected, than the first order correction consists of electrons were the second electron was lost due to correlation effects (deadtime). This class of electrons would be enhanced. The critical term in this case is ACR, namely

$$\mathrm{ACR}(t) = \int_{\max(0,t+\mathrm{Ta})}^{t+\mathrm{Tb}} a(t)\, C(t'-t)\, R(t')\, dt' = a \int_{\max(-t,\mathrm{Ta})}^{\mathrm{Tb}} R(t+\tau)\, C(\tau)\, d\tau \qquad (10)$$

$$t < -\mathrm{Tb}:\ \mathrm{ACR}(t) = 0$$

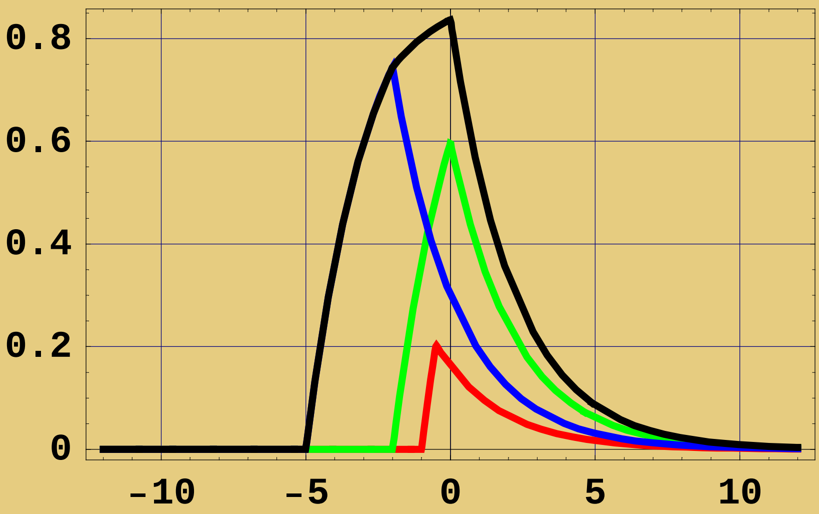
$$-\mathrm{Tb} < t:\ \mathrm{ACR}(t) = a \int_{-t}^{\mathrm{Tb}} R(t+\tau)\, C(\tau)\, d\tau = a\, r\, e^{-\lambda t}\left(e^{\lambda t} - e^{-\lambda \mathrm{Tb}}\right) = a\, r\left(1 - e^{-\lambda (t+\mathrm{Tb})}\right) \qquad (10a)$$

$$-\mathrm{Ta} < t:\ \mathrm{ACR}(t) = a \int_{\mathrm{Ta}}^{\mathrm{Tb}} R(t+\tau)\, C(\tau)\, d\tau = a \frac{R(t)}{r\lambda} \int_{\mathrm{Ta}}^{\mathrm{Tb}} R(\tau)\, C(\tau)\, d\tau \qquad (10b)$$

$$= a\, r\, e^{-\lambda t}\left(e^{-\lambda \mathrm{Ta}} - e^{-\lambda \mathrm{Tb}}\right) \qquad (10c)$$

Equ. 10b is of particular interest. For positive times the correction has the muon lifetime independent of the shape of C(τ). The shape before t=0 is also interesting as it shows the deadtime effect.

```
ACR[t_, Ta_, Tb_] := If[t < -Tb, 0., If[t < -Ta, 1 - E^(-λ (t+Tb)), E^(-λ t) (E^(-λ Ta) - E^(-λ Tb))]]
R0 = 0.455; λ = R0; Plot[{ACR[t, 0.5, 1], ACR[t, 0, 2],
  ACR[t, 2, 5], ACR[t, 2, 5] + 0.9 ACR[t, 0, 2]}, {t, -12, 12}];
```



- Example C(τ)= f δ(τ-T) (afterpulsing)

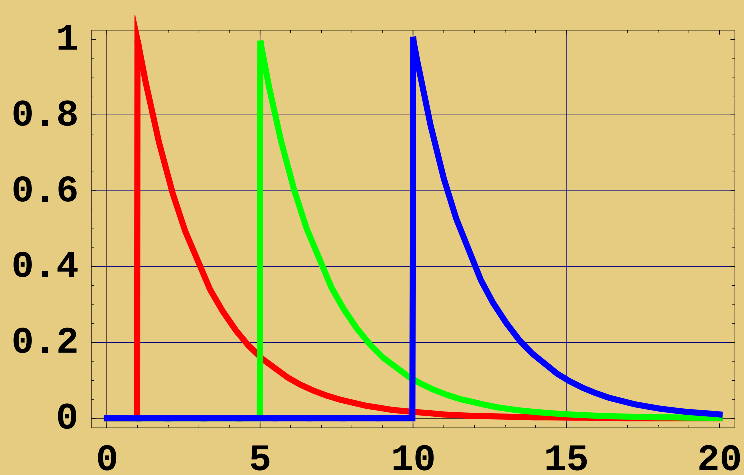
This case is not really an RCA term, rather a second R' term.

$$R'(t) = \int_{\max(t-T,0)}^{t} R(t)\, f\, \delta(\tau - T)\, d\tau = f\, r\, \lambda\, e^{\lambda(t-T)} \qquad (9)$$

$T < t$: $R'(t) = f\, r\, \lambda\, e^{\lambda(t-T)}$

otherwise $R'(t) = 0$

```
RC2[t_, T_] := If[t > T, E^(-λ t) E^(λ T), 0]
R0 = 0.455; λ = R0; Plot[{RC2[t, 1], RC2[t, 5], RC2[t, 10]}, {t, 0, 20}];
```



The curves have to be scaled by f compared to the R distribution.

Estimates

The autocorrelations are similar to S1. Assume that S(t-t') is the undisturbed time distribution after hit at time t after a hit at time t'. The autocorrelation then shows the deformation of the test function due to deadtime effects

$$\text{ACdead}(t) = \int \delta(t') C(t-t') S(t)\, dt' = C(t) S(t) \tag{11}$$

i.e. the deadtime correlation C(t-t') can be directly determined. If S(t) is truly accidental, S(t)=a. If we plot the global autocorrelation function of reconstructed tracks. ACdead/a(t)=C(t). Assume we get C(τ)=f for τ<T. From example 1 we conclude that the accidental background will be changed by

$$\begin{aligned} t > T: \quad & \text{RC}(t) = r f e^{-\lambda t} (e^{\lambda T} - 1) \\ t < T: \quad & \text{RC}(t) = r f (1 - e^{-\lambda t}) \end{aligned} \tag{12}$$

where r~0.7 for the whole detector. We can study whether that is significant.
The deadtime contribution to the autocorrelation function is reflected in the change of the test function S(t). The ACdead(t) thus is proportional due the rate of the test function (accidentals).
The second term in the autocorrelation due to afterpulses is

$$\text{ACafter}(t) = \int_{\max(t-T,0)}^{t} R(t') C(t-t')\, dt' = \int_{0}^{\min(T,t)} R(t-\tau) C(\tau)\, d\tau \tag{13}$$

$$= e^{-\lambda t} \int_{0}^{\min(T,t)} R(\tau) C(\tau)\, d\tau$$

$$T < t: \quad \text{ACafter}(t) = e^{-\lambda t} \int_{0}^{T} R(\tau) C(\tau)\, d\tau \quad \text{for } C(\tau) = f \delta(\tau - T): \; f e^{-\lambda (t-T)}$$

$$t < T: \quad \text{ACafter}(t) = e^{-\lambda t} \int_{0}^{t} R(\tau) C(\tau)\, d\tau \quad \text{for } C(\tau) = f \delta(\tau - T): 0$$

The autocorrelation term does not depend on any test function. It can be separated from the deadtime effect by keeping the test function small, e.g. by analyzing electrons in a pile-up protected region.

Fast Monte Carlo

Structure

The Fast Monte Carlo Program fmc generates and analyzes the time distribution of isolated muon "events" with accidental and decay electrons generated in a region of (T1,T2) relative to mu stop t=0. The program directory will be submitted to CVS. The event loop is

```
for(int iev=0; iev < (int)mpar.events; iev++){
   gData->fEvent= iev;
   gData->monte->ProcessEvent();
   gData->detector->ProcessEvent();
   gData->analyzer->ProcessEvent();
```

where the classes

```
 gData->monte=new TMonte;
 gData->detector=new TDetector;
 gData->analyzer=new TAnalyzer;
```

perform the event generation, detector deadtime modelling and analysis/histogramming, respectively.
The control parameters are defined in Parameter.h and are read in a tree and stored with the generated root files. Examples of Parameter information is given below. The extension _f indicates that update flag =0, i.e. a fixed deadtime of the detector is used.
1E9 events are generated in 30 CPU min, so 1E10 simulation can be performed.

- **Examples**

root[273] open("demo_f")	root[271] open("demo")	root[287] open("demo1hs_f")	root[285] open("demo1hs"))
=== === > EVENT : 0	=== === > EVENT : 0	=== === > EVENT : 0	=== === > EVENT : 0
branchlimit = 10000	branchlimit = 10000	branchlimit = 10000	branchlimit = 10000
T1 = −25	T1 = −25	T1 = −25	T1 = −25
T2 = 25	T2 = 25	T2 = 25	T2 = 25
events = 1 e + 07	events = 1 e + 07	events = 1 e + 09	events = 1 e + 09
r0 = 0.455	r0 = 0.455	r0 = 0.455	r0 = 0.455
acc_rate = 0.05	acc_rate = 0.05	acc_rate = 0.05	acc_rate = 0.05
debug = 0	debug = 0	debug = 0	debug = 0
efficiency = 0.7	efficiency = 0.7	efficiency = 0.7	efficiency = 0.7
fD = 1	fD = 1	fD = 2	fD = 2
dt = 3, 2	dt = 3, 2	dt = 5, 2	dt = 5, 2
df = 0, 0.2	df = 0, 0.2	df = 0.8, 0.2	df = 0.8, 0.2
update = 0	update = 1	update = 0	update = 1
debug = 0	debug = 0	debug = 0	debug = 0
debug = 0	debug = 0	debug = 0	debug = 0
acc = 2	acc = 2	acc = 2	acc = 2
auto_real_cut = 0, 5	auto_real_cut = 0, 5	auto_real_cut = 0, 5	auto_real_cut = 0, 5
auto_acc_cut = −20, −15	auto_acc_cut = −20, −15	auto_acc_cut = −20, −15	auto_acc_cut = −20, −15

The figures show top to bottom (time axis in μs):

i) generated electrons (green and cyan are lost electrons due to deadtime)

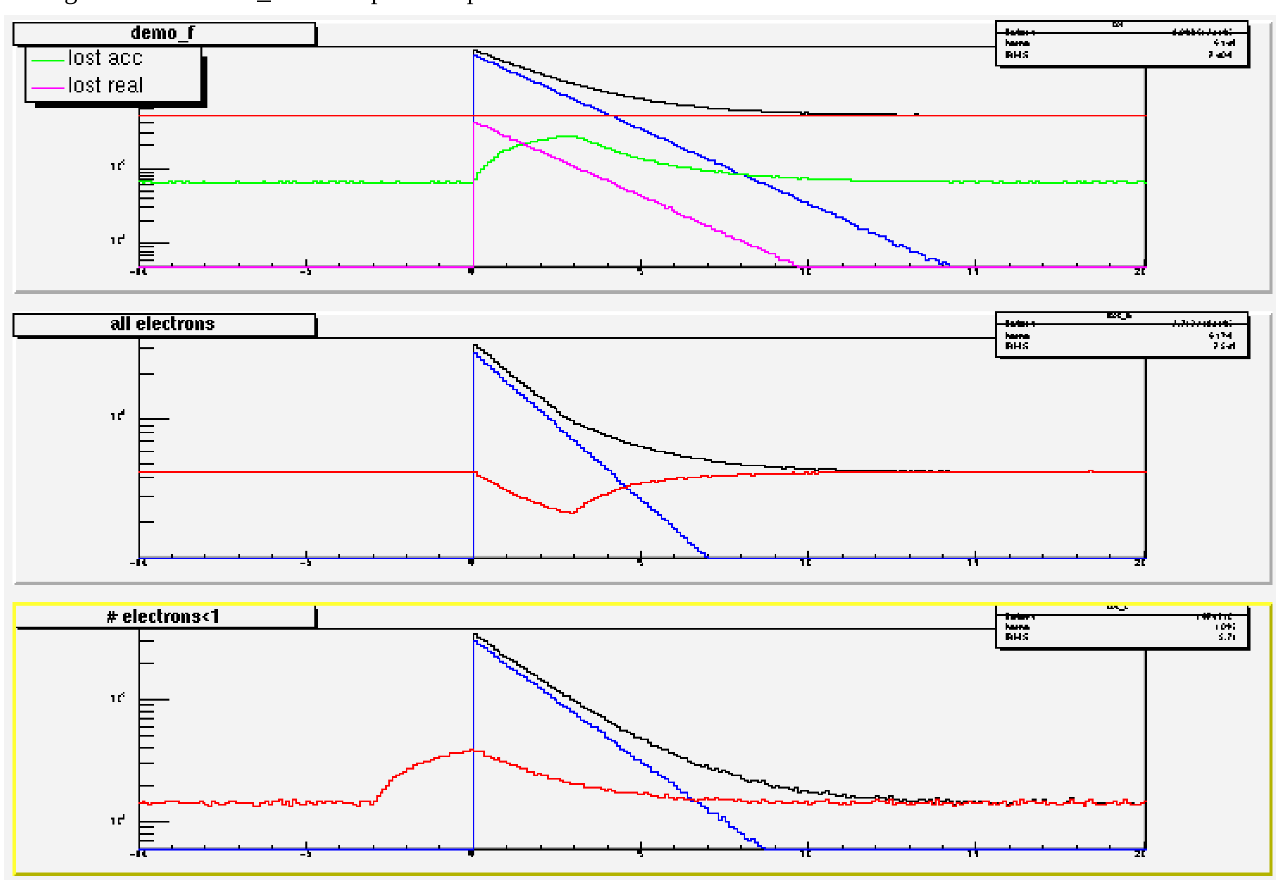
ii) all accepted electrons

iii) only events with exactly one electron

iv) autocorrelation functions for start (real or acc in indicated time range), stop all subsequent accidentals.

v) electron multiplicity for generated and accepted events.

The figure show a demo_f as a simple example.



□

The following cases were simulated:

name	condition	comment
demo	non – updating simple deadtime function	i)
demo_f	updating simple deadtime function	0
demo1hs	~~updating simple deadtime function~~ ∧	0
demo1hs_f	updating 2 component deadtime function	0

i) autocorrelation has slope, probably caused by increased accidental survival probability after fixed deadtime. This second order term was not accounted for in the analytical formalism above.

All results are displayed in data.pdf, the input parameters are given in the table above.

Fit to examples

The examples were fitted to the formulae developed in this note, using a somewhat eleborate fit framework (to be documented later).

The fitted time spectra are shown in figures demo.pdf, demo_f.pdf, demo1hs.pdf and demo1hs_f.pdf.

The main fit results are given in the table below and figure result.pdf.

		demo_t		demo_f_t		demo1hs_t		demo1hs_f_t	
acc_a		chi2=	0.963224	chi2=	1.17661	chi2=	1.077344	chi2=	1.855613
t1	0	0	0	0	0	2	0	2	0
t2	1	3	0	3	0	5	0	5	0
a	2	43034.47	11.81128	43428.83	11.68023	4493462	125.8238	4516159	124.4289
f1	3	0.69996	0.0015	0.59488	0.0014	0.54397	0.00055	0.48872	0.00054
r0	4	0.45351	0.0017	0.53313	0.00232	0.45501	0.00063	0.49481	0.00079
f2	6	0	0	0	0	0.12137	0.00026	0.1097	0.00027
real_a		chi2=	0.876388	chi2=	1.010927	chi2=	0.967676	chi2=	1.047511
a	2	-2.5181	1.25648	-2.72871	1.25654	9.70074	6.45602	10.44819	6.47778
r0	4	0.45483	0.0002	0.45478	0.0002	0.45502	0.00002	0.45501	0.00002
A	5	602916.9	246.8695	609054.4	248.111	31454805	1260.881	31621657	1264.231
tot_a		chi2=	0.928731	chi2=	1.44931	chi2=	1.057933	chi2=	3.061426
a	2	43032.98	12.2679	43466.25	12.42807	4493478	128.4905	4516856	129.428
f1	3	0.70358	0.01139	0.73603	0.01111	0.54412	0.00255	0.58856	0.00248
r0	4	0.45442	0.00132	0.43768	0.0012	0.455	0.00026	0.44717	0.00025
A	5	603410.5	1636.206	625988	1622.742	31456263	17095.7	32123191	16850.39
f2	6	0	0	0	0	0.12151	0.00076	0.11912	0.00075
tot_a1		chi2=	13.34319	chi2=	15.69817	chi2=	149.0285	chi2=	205.8566
a	2	43250.02	11.66656	43709.82	11.78707	2251729	60.11026	2264263	60.40512
r0	4	0.55141	0.00047	0.53216	0.00046	0.5115	0.00004	0.50426	0.00004
A	5	503378.9	308.4226	519659.4	315.3496	27988444	1636.519	28418687	1652.798
acc_b		chi2=	2.346985	chi2=	0.954701	chi2=	6.922074	chi2=	0.974751
a	2	1463.229	2.2131	1427.566	2.20528	138733.4	22.67555	137433.2	22.62225
f1	3	2.53566	0.01465	2.33464	0.01484	1.92594	0.00173	1.86714	0.00175
r0	4	0.48671	0.00388	0.45026	0.00385	0.46163	0.00059	0.45431	0.00061
f2	6	0	0	0	0	0.59357	0.00126	0.46708	0.00121
real_b		chi2=	1.096734	chi2=	1.14502	chi2=	0.887442	chi2=	0.919591
a	2	-0.51172	0.41659	-0.32004	0.41813	0.36238	2.06678	-0.15643	2.06098
r0	4	0.45488	0.00059	0.4554	0.0006	0.45509	0.00006	0.45508	0.00006
A	5	67612.53	82.66502	66762.41	82.14983	3228111	403.9268	3207135	402.6136
tot_b		chi2=	2.387622	chi2=	1.052714	chi2=	6.852193	chi2=	0.961667
a	2	1461.879	2.34493	1428.299	2.32034	138748.8	23.72322	137447	23.61392
f1	3	2.6649	0.01739	2.31037	0.01676	1.94531	0.00257	1.86379	0.00253
r0	4	0.4565	0.00079	0.45527	0.00079	0.45558	0.00008	0.45513	0.00008
A	5	67119.92	100.5611	66844.55	99.39452	3224282	508.0032	3207396	504.2651
f2	6	0	0	0	0	0.59739	0.00111	0.46645	0.00107
tot_b1		chi2=	77.60995	chi2=	60.34465	chi2=	3746.529	chi2=	3068.72
a	2	1541.571	2.29241	1501.826	2.26399	73329.06	11.17666	72220.44	11.09782
r0	4	0.46442	0.0008	0.46299	0.0008	0.46426	0.00008	0.4629	0.00008
A	5	72632.5	97.53197	71448.28	96.67406	3386074	471.8931	3358933	469.8248

Discussion:

- In general the model reproduces the shape of the distributions, qualitatively the expected f1=0.56 and f2=0.14 agree with the model a fits. Quantitively the numerical agreement would require further thought.
- The **a fits** (all electrons) have difficulties for the fixed deadtime, the **b fits** (single e) have difficulties for the updating deadtime. This is probably caused by the fixed/updating function not properly described in the analytical formulation as evidenced in the autocorrelations. The lifetimes cannot be fitted reliably in this cases.
- In the cases of good chi2 (a fit updating and b fit fixed deadtime) the lifetime agrees with the input.

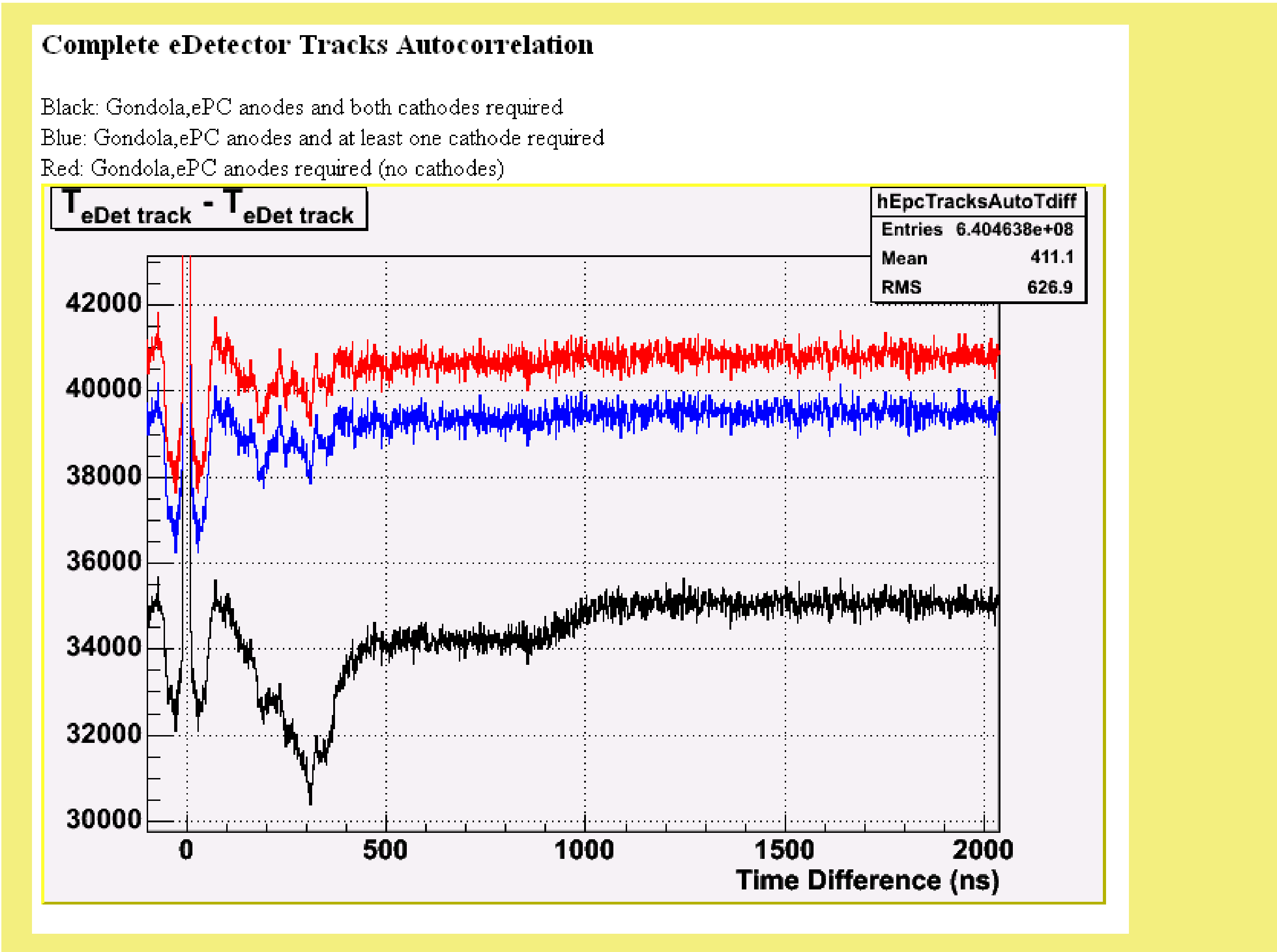
High Statistics Fits

Instead of investigating the above extreme situation (large acc background) further, we generate realistic spectra based on Steve's autocorrelation functions.

Input

Steve's experimental autocorrelation functions. I don't completley understand the fast decay before 300 ns. Are these after-pulses? For the moment I ignore the afterpulses and approximate the deadtime functions with:

condition	deadtimes	fractions
2 cath required	(0, 0.4), (0.4, 1.)	0.9, 0.97
1 ≤ cath required	(0, 0.4), (0.4, 1.)	0.097, 0.995



Study 1: deadtime

The conditions given in the table below were simulated, the generated data is shown in data1.pdf.

2 cath10	1 cath10	2 cath_f10	2 cath10a
=== === > EVENT : 0 branchlimit = 10000 T1 = -25 T2 = 25 events = 1 e + 10 r0 = 0.455 acc_rate = 0.000455 debug = 0 efficiency = 0.7 fD = 2 dt = 0.4, 1 df = 0.9, 0.97 update = 1 debug = 0 debug = 0 acc = 2 auto_real_cut = 0, 5 auto_acc_cut = -20, -15	=== === > EVENT : 0 branchlimit = 10000 T1 = -25 T2 = 25 events = 1 e + 10 r0 = 0.455 acc_rate = 0.000455 debug = 0 efficiency = 0.7 fD = 2 dt = 0.4, 1 df = 0.97, 0.995 update = 1 debug = 0 debug = 0 acc = 2 auto_real_cut = 0, 5 auto_acc_cut = -20, -15	=== === > EVENT : 0 branchlimit = 10000 T1 = -25 T2 = 25 events = 1 e + 10 r0 = 0.455 acc_rate = 0.000455 debug = 0 efficiency = 0.7 fD = 2 dt = 0.4, 1 df = 0.9, 0.97 update = 0 debug = 0 debug = 0 acc = 2 auto_real_cut = 0, 5 auto_acc_cut = -20, -15	=== === > EVENT : 0 branchlimit = 10000 T1 = -25 T2 = 25 events = 1 e + 10 r0 = 0.455 acc_rate = 0.00455 debug = 0 efficiency = 0.7 fD = 2 dt = 0.4, 1 df = 0.9, 0.97 update = 1 debug = 0 debug = 0 acc = 2 auto_real_cut = 0, 5 auto_acc_cut = -20, -15
2 cath9 === === > EVENT : 0 branchlimit = 10000 T1 = -25 T2 = 25 events = 1 e + 09 r0 = 0.455 acc_rate = 0.000455 debug = 0 efficiency = 0.7 fD = 2 dt = 0.4, 1 df = 0.9, 0.97 update = 1 debug = 0 debug = 0 acc = 2 auto_real_cut = 0, 5 auto_acc_cut = -20, -15	**1 cath9** === === > EVENT : 0 branchlimit = 10000 T1 = -25 T2 = 25 events = 1 e + 09 r0 = 0.455 acc_rate = 0.000455 debug = 0 efficiency = 0.7 fD = 2 dt = 0.4, 1 df = 0.97, 0.995 update = 1 debug = 0 debug = 0 acc = 2 auto_real_cut = 0, 5 auto_acc_cut = -20, -15	**2 cath_f9** === === > EVENT : 0 branchlimit = 10000 T1 = -25 T2 = 25 events = 1 e + 09 r0 = 0.455 acc_rate = 0.000455 debug = 0 efficiency = 0.7 fD = 2 dt = 0.4, 1 df = 0.9, 0.97 update = 0 debug = 0 debug = 0 acc = 2 auto_real_cut = 0, 5 auto_acc_cut = -20, -15	**1 cath_f9** === === > EVENT : 0 branchlimit = 10000 T1 = -25 T2 = 25 events = 1 e + 09 r0 = 0.455 acc_rate = 0.000455 debug = 0 efficiency = 0.7 fD = 2 dt = 0.4, 1 df = 0.9, 0.97 update = 0 debug = 0 debug = 0 acc = 2 auto_real_cut = 0, 5 auto_acc_cut = -20, -15

The fitted time distributions can be viewed by following the links in the table above. The results are summarized in result1.pdf.

The very, very preliminary conclusions are:

- The 1E10 statistics/ 1E3 signal to noise fits get the right lifetime, even if the BG distortions are ignored. Nearly no difference between 1 cathode and 2 cathode requirements. The fit b (one e only) gets a higher chi2 with the BG distortions ignored? The 1E2 signal to noise fit a is more sensitive, both in lifetime and chi2.

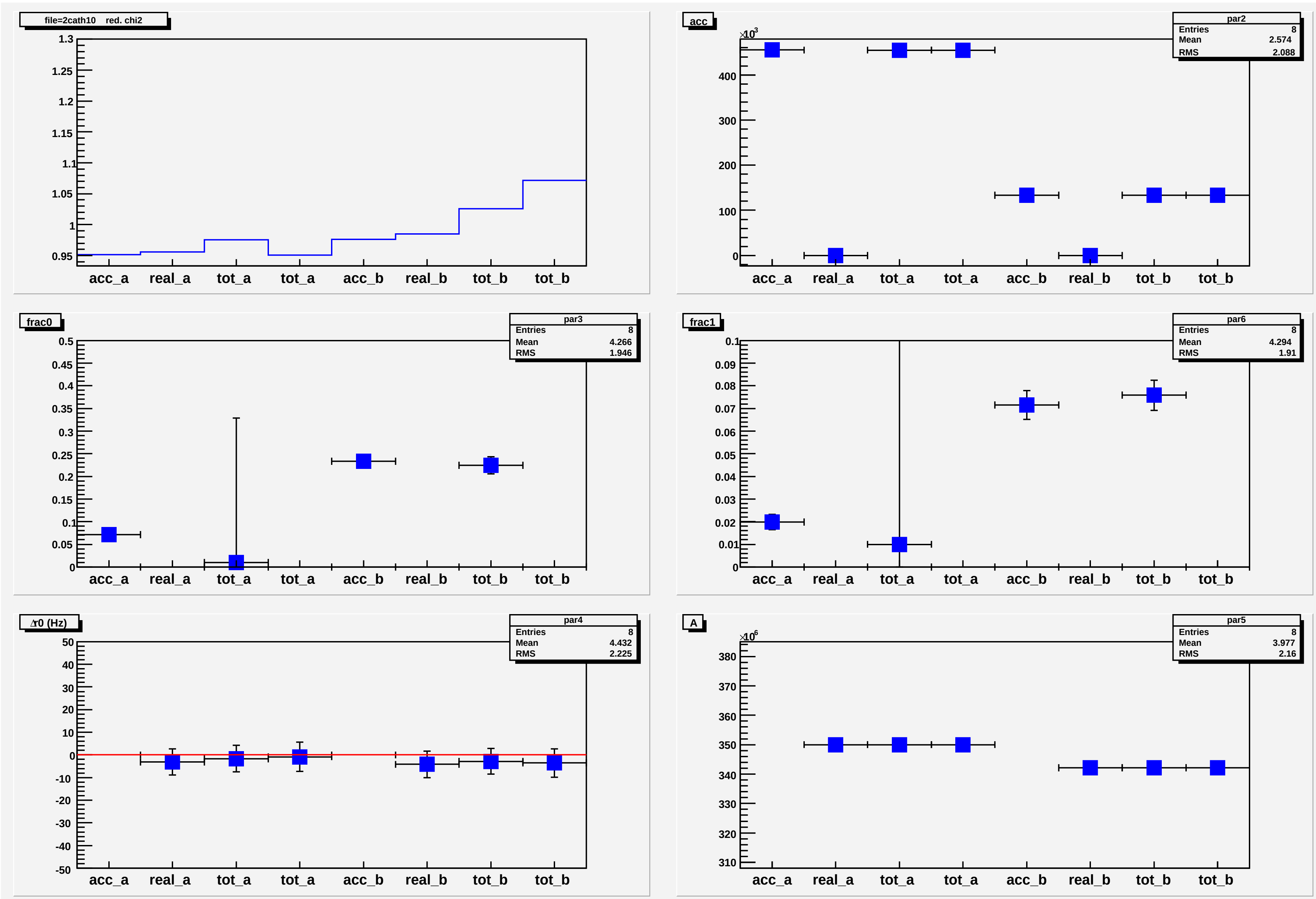
- The 1E9 fits a have more problems both with chi2 and lifetime.

- ### Study 2: after pulses

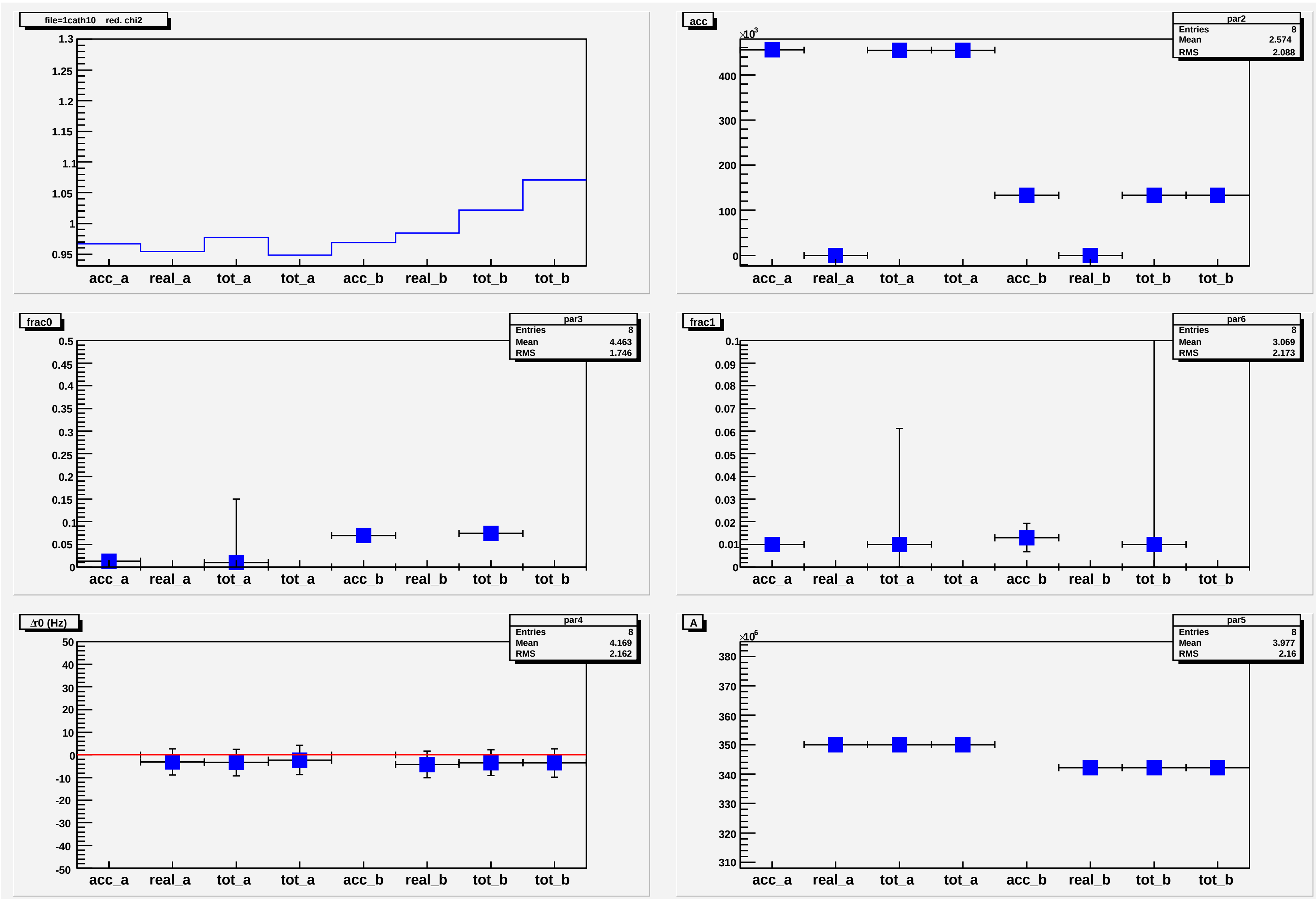
Deadtime effects were turned off and afterpulses were generated after real edet hit. The time distribution of the correlated afterpulses was 1-x/0.3 on the interval 0.1-0.3 μs. I.e. the correlation function disappears at 0.3us. The afterpulse fraction was 0.05 according to Steve's plot of eDet autocorrelation. The origin of the high value of 5% for these auto-correlations is ununderstood, they should be much smaller because the gondola's are much cleaner than that (order 1E-6)??
Such autocorrelations severely distort the fit (1E9) statistics, if the fit is started at t=0.01 μs (after05a.pdf, after05ar.pdf). If the fit is started at t=0.03 μs, once gets the correct results (after05b.pdf, after05br.pdf). If the afterpulse fraction is reduced to 1E-3, the t=0.01 μs starts to become acceptable (after001ar.pdf).

Todo

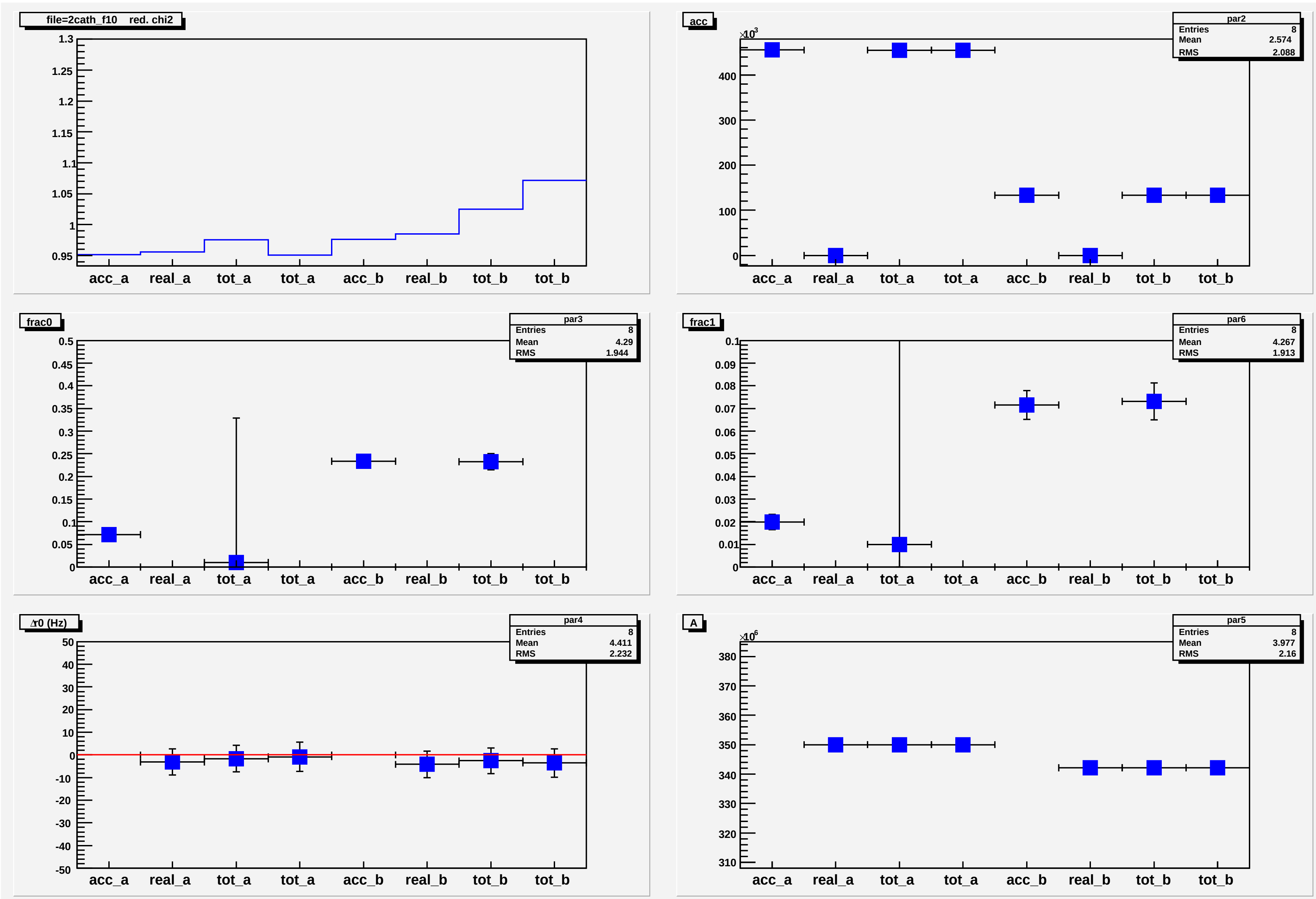
More careful conclusions study 1. Perhaps simulate larger deadtime effect. Redo some fits with different initial seeds.Try to find better minimum for poor ch2.



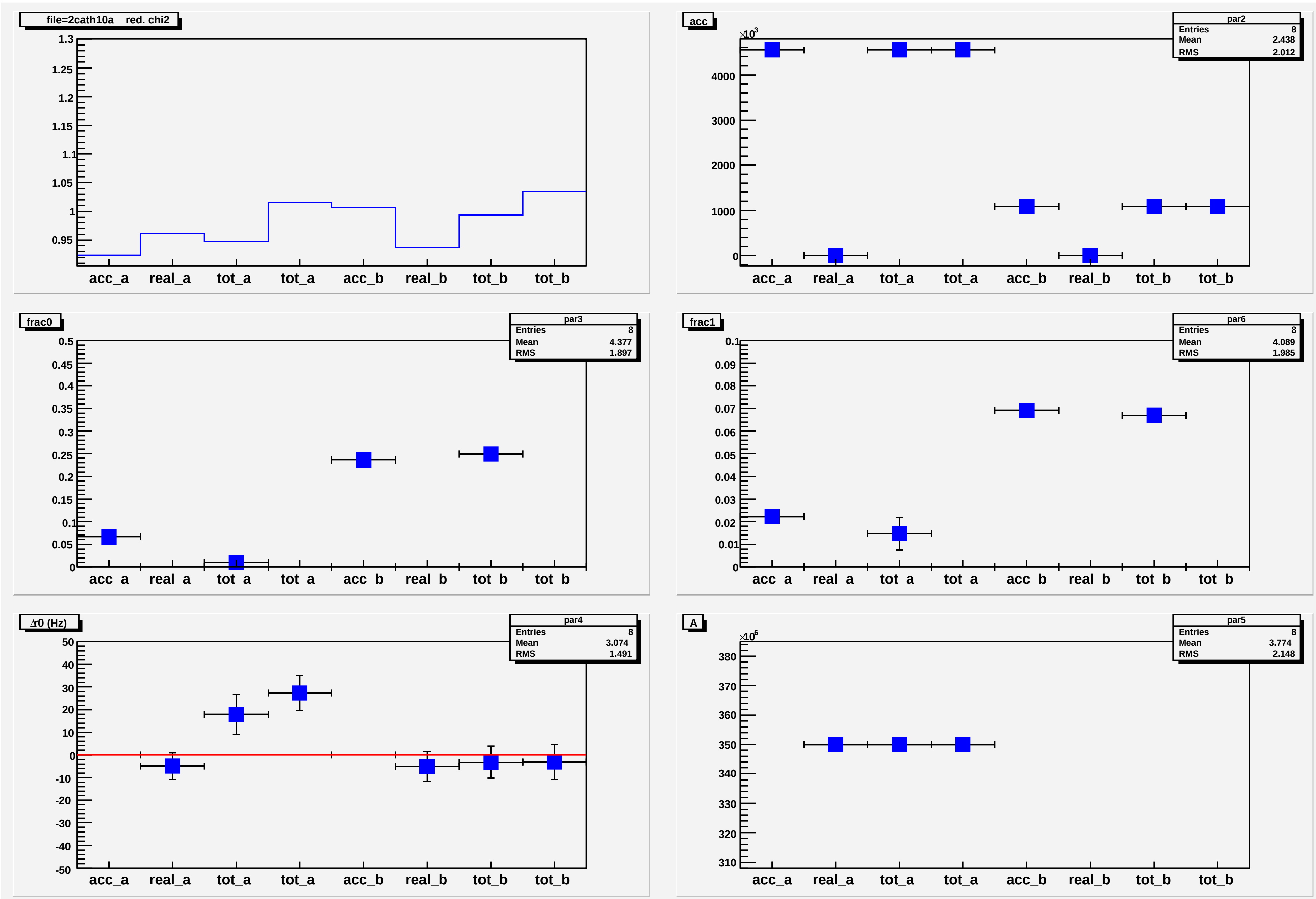
file=2cath10 red. chi2
1.3
1.25
1.2
1.15
1.1
1.05
1
0.95
acc_a real_a tot_a tot_a acc_b real_b tot_b tot_b
acc
par2
Entries 8
Mean 2.574
RMS 2.088
×10^3
400
300
200
100
0
acc_a real_a tot_a tot_a acc_b real_b tot_b tot_b
frac0
par3
Entries 8
Mean 4.266
RMS 1.946
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
acc_a real_a tot_a tot_a acc_b real_b tot_b tot_b
frac1
par6
Entries 8
Mean 4.294
RMS 1.91
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
acc_a real_a tot_a tot_a acc_b real_b tot_b tot_b
Δr0 (Hz)
par4
Entries 8
Mean 4.432
RMS 2.225
50
40
30
20
10
0
-10
-20
-30
-40
-50
acc_a real_a tot_a tot_a acc_b real_b tot_b tot_b
A
par5
Entries 8
Mean 3.977
RMS 2.16
×10^6
380
370
360
350
340
330
320
310
acc_a real_a tot_a tot_a acc_b real_b tot_b tot_b

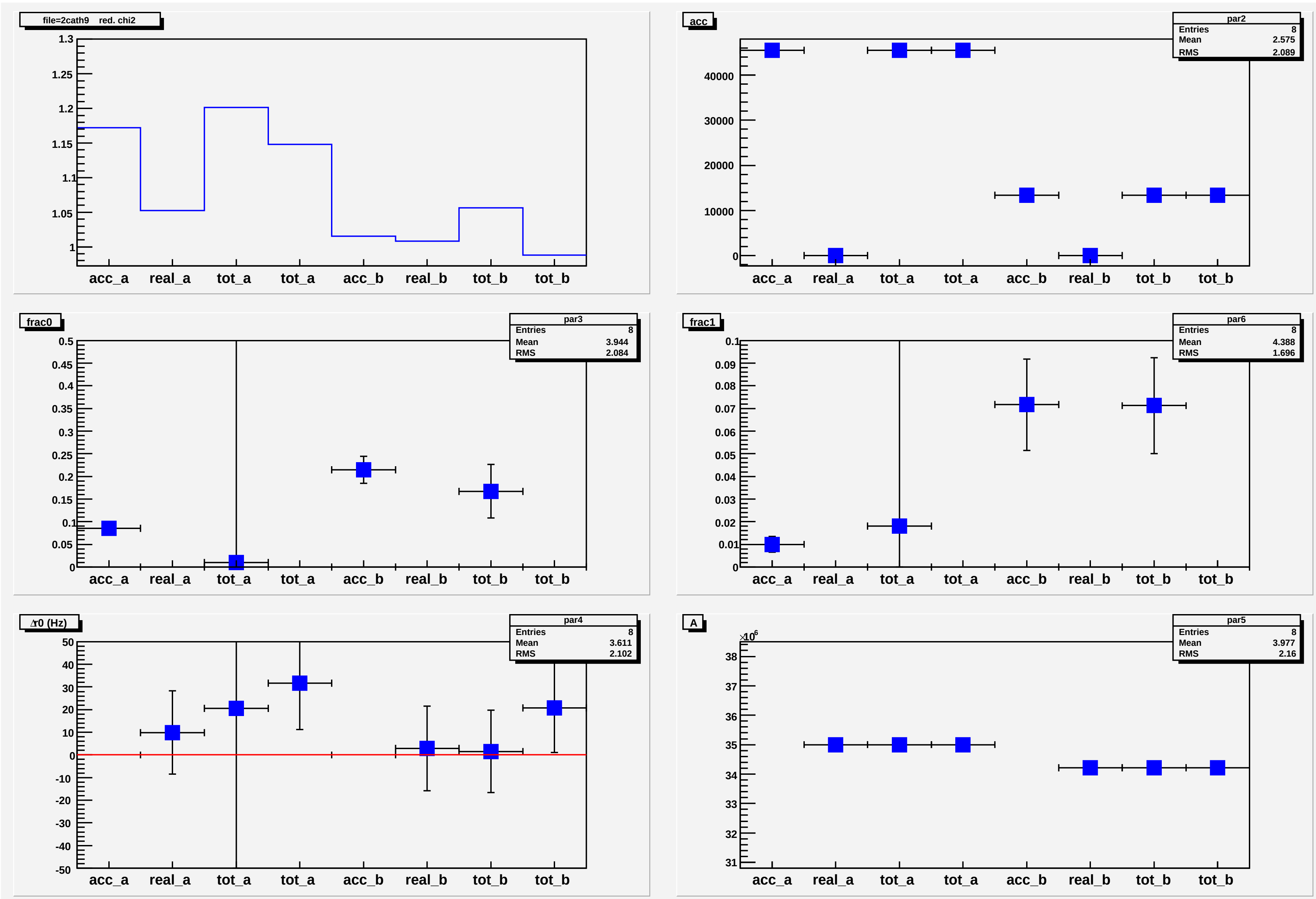


file=1cath10 red. chi2
1.3
1.25
1.2
1.15
1.1
1.05
1
0.95
acc_a real_a tot_a tot_a acc_b real_b tot_b tot_b
acc
par2
Entries 8
Mean 2.574
RMS 2.088
×10^3
400
300
200
100
0
acc_a real_a tot_a tot_a acc_b real_b tot_b tot_b
frac0
par3
Entries 8
Mean 4.463
RMS 1.746
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
acc_a real_a tot_a tot_a acc_b real_b tot_b tot_b
frac1
par6
Entries 8
Mean 3.069
RMS 2.173
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
acc_a real_a tot_a tot_a acc_b real_b tot_b tot_b
Δr0 (Hz)
par4
Entries 8
Mean 4.169
RMS 2.162
50
40
30
20
10
0
-10
-20
-30
-40
-50
acc_a real_a tot_a tot_a acc_b real_b tot_b tot_b
A
par5
Entries 8
Mean 3.977
RMS 2.16
×10^6
380
370
360
350
340
330
320
310
acc_a real_a tot_a tot_a acc_b real_b tot_b tot_b

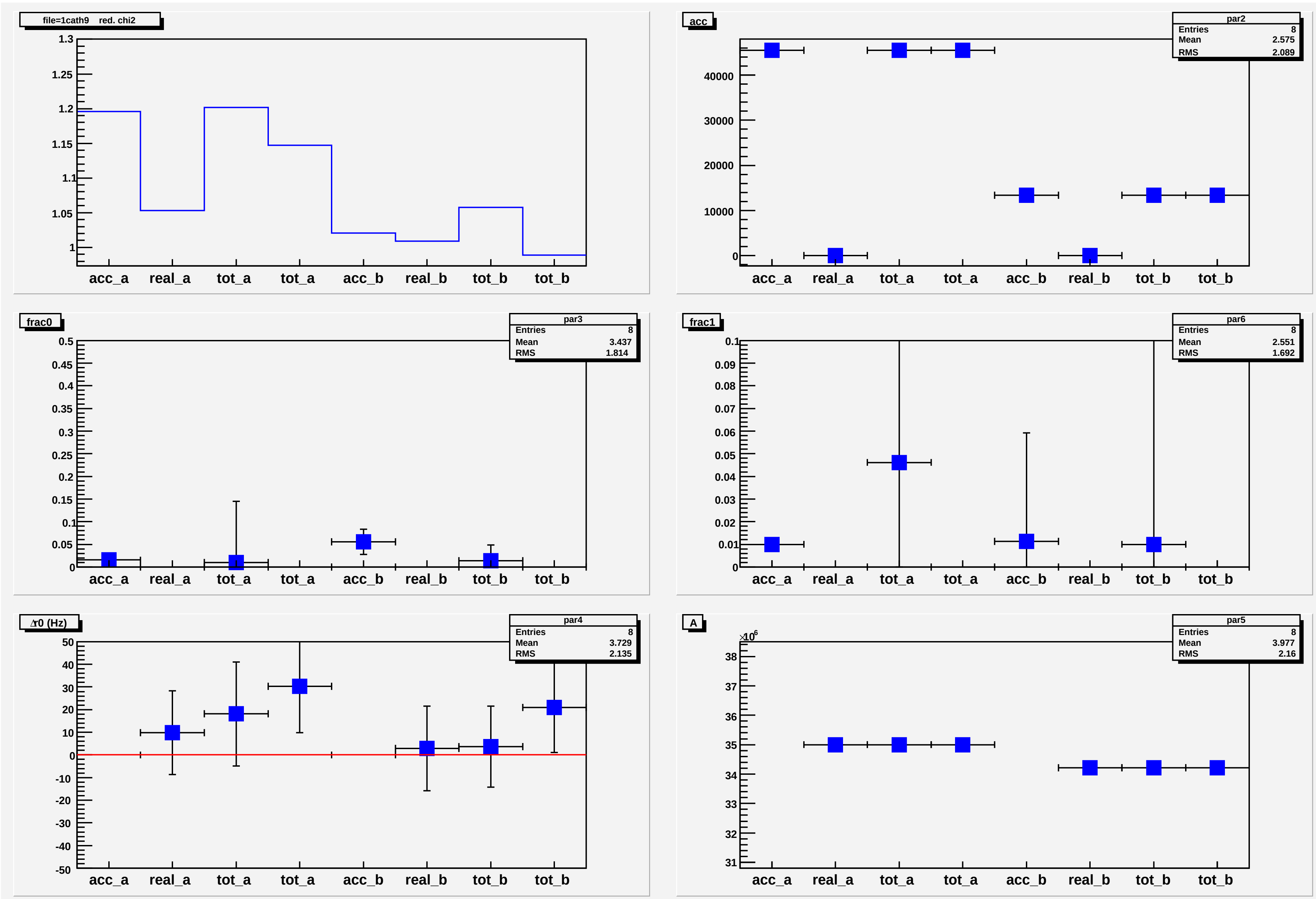


file=2cath_f10 red. chi2
acc
par2
Entries 8
Mean 2.574
RMS 2.088
×10³
frac0
par3
Entries 8
Mean 4.29
RMS 1.944
frac1
par6
Entries 8
Mean 4.267
RMS 1.913
Δr0 (Hz)
par4
Entries 8
Mean 4.411
RMS 2.232
A
par5
Entries 8
Mean 3.977
RMS 2.16
×10⁶
acc_a real_a tot_a tot_a acc_b real_b tot_b tot_b

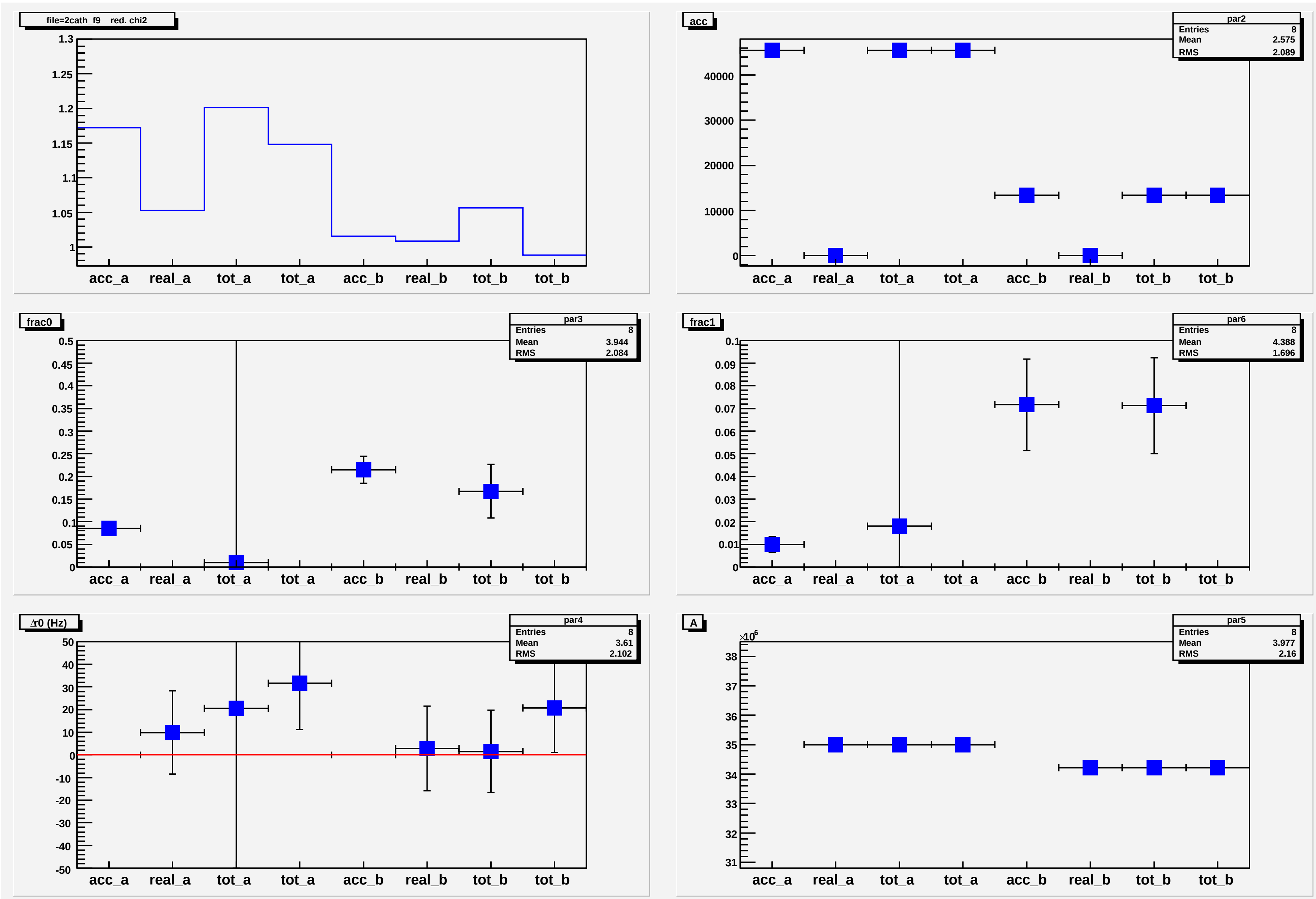

file=2cath10a red. chi2
acc
par2
Entries 8
Mean 2.438
RMS 2.012
×10^3
frac0
par3
Entries 8
Mean 4.377
RMS 1.897
frac1
par6
Entries 8
Mean 4.089
RMS 1.985
Δr0 (Hz)
par4
Entries 8
Mean 3.074
RMS 1.491
A
par5
Entries 8
Mean 3.774
RMS 2.148
×10^6
acc_a
real_a
tot_a
tot_a
acc_b
real_b
tot_b
tot_b

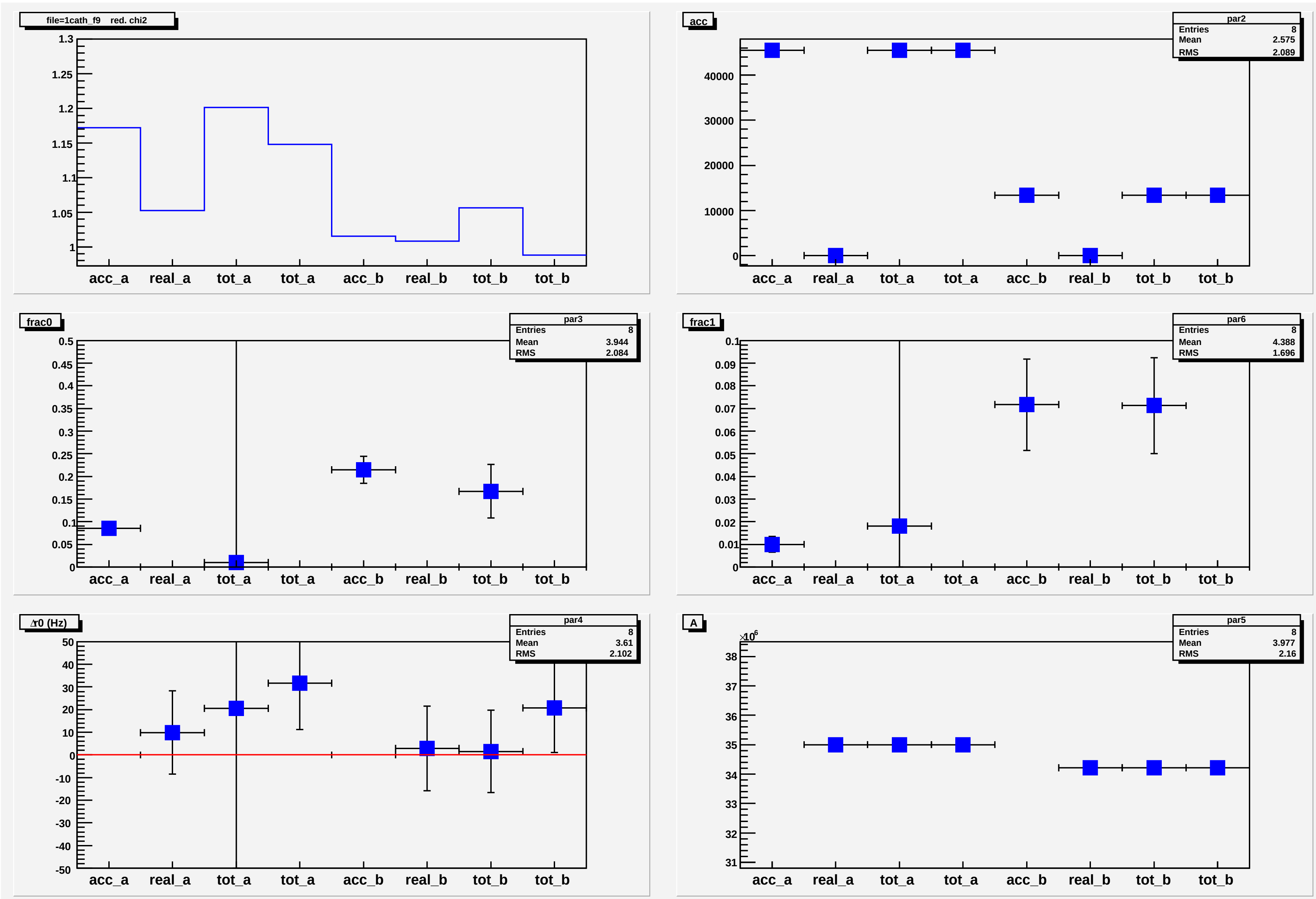


file=2cath9 red. chi2
acc
par2
Entries 8
Mean 2.575
RMS 2.089
frac0
par3
Entries 8
Mean 3.944
RMS 2.084
frac1
par6
Entries 8
Mean 4.388
RMS 1.696
Δr0 (Hz)
par4
Entries 8
Mean 3.611
RMS 2.102
A
par5
Entries 8
Mean 3.977
RMS 2.16
acc_a
real_a
tot_a
tot_a
acc_b
real_b
tot_b
tot_b



file=1cath9 red. chi2
acc
par2
Entries 8
Mean 2.575
RMS 2.089
frac0
par3
Entries 8
Mean 3.437
RMS 1.814
frac1
par6
Entries 8
Mean 2.551
RMS 1.692
Δr0 (Hz)
par4
Entries 8
Mean 3.729
RMS 2.135
A
par5
Entries 8
Mean 3.977
RMS 2.16
acc_a real_a tot_a tot_a acc_b real_b tot_b tot_b


file=2cath_f9 red. chi2
1.3
1.25
1.2
1.15
1.1
1.05
1
acc_a
real_a
tot_a
tot_a
acc_b
real_b
tot_b
tot_b
acc
par2
Entries 8
Mean 2.575
RMS 2.089
40000
30000
20000
10000
0
frac0
par3
Entries 8
Mean 3.944
RMS 2.084
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
frac1
par6
Entries 8
Mean 4.388
RMS 1.696
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Δr0 (Hz)
par4
Entries 8
Mean 3.61
RMS 2.102
50
40
30
20
10
0
-10
-20
-30
-40
-50
A
par5
Entries 8
Mean 3.977
RMS 2.16
×10^6
38
37
36
35
34
33
32
31



file=1cath_f9 red. chi2
1.3
1.25
1.2
1.15
1.1
1.05
1
acc_a
real_a
tot_a
tot_a
acc_b
real_b
tot_b
tot_b
acc
par2
Entries 8
Mean 2.575
RMS 2.089
40000
30000
20000
10000
0
frac0
par3
Entries 8
Mean 3.944
RMS 2.084
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
frac1
par6
Entries 8
Mean 4.388
RMS 1.696
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Δr0 (Hz)
par4
Entries 8
Mean 3.61
RMS 2.102
50
40
30
20
10
0
-10
-20
-30
-40
-50
A
par5
Entries 8
Mean 3.977
RMS 2.16
×10^6
38
37
36
35
34
33
32
31