BPM Studies

More on triplet residual shift studies

- Adding cross-talk term to gain fits
- Updated global analysis of all fills
- Wiggler experiments revisited
- Q_s and f_{RF}

1999 analysis

Summary

To Do list

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31/8/01

Reanalyse data with cross-talk terms

Repeat global triplet residual studies of previous meeting with extended gain fit:

- There is evidence of coupling between x and y (see later)
- Therefore introduce cross-talk terms:

$$\begin{aligned}\delta x_1 &= g_1\,\delta x_1^{\mathrm{raw}} + q_1\,\delta y_1^{\mathrm{raw}} \\ \delta x_3 &= g_3\,\delta x_3^{\mathrm{raw}} + q_3\,\delta y_3^{\mathrm{raw}},\end{aligned}$$

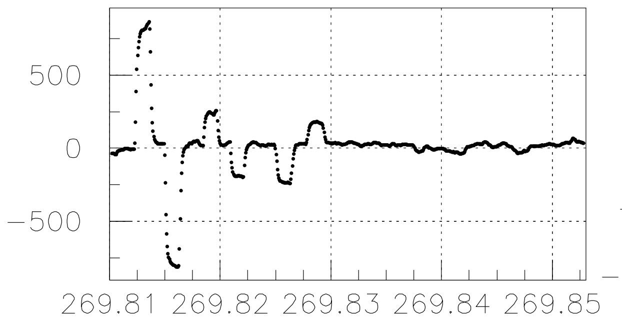
  & similarly for 4 & 6. All terms w.r.t. 2 (RHS) & 5 (LHS)

Strategy:

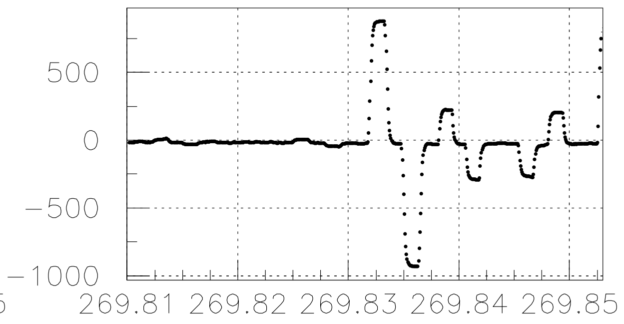
- Determine terms from fits to suitable fills. Make independent fits for x analysis and y analysis.
- Apply terms to all data
- Repeat global study of triplet residual shifts vs energy in all ramped fills
- Look again at dedicated wiggler, Q_s etc experiments

Example of calibration

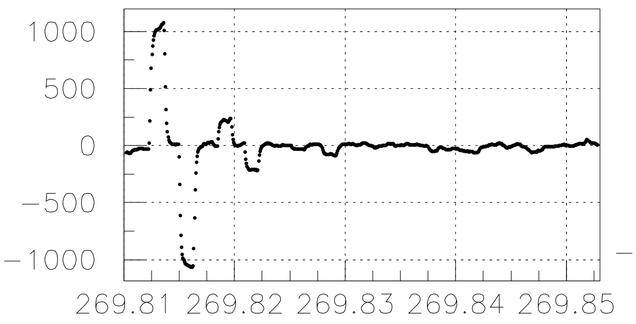
Fill 8559, high energy, RHS arm $\longrightarrow$ bumps in x then y



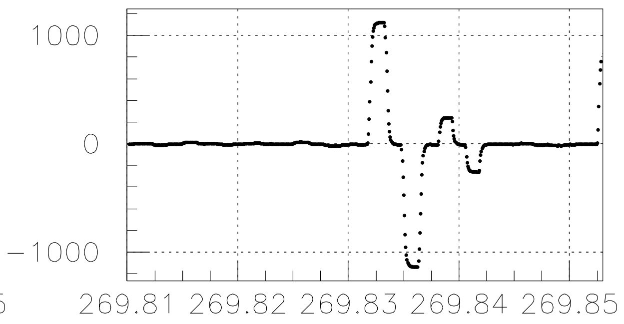
Scatter in BPM X 1 vs time



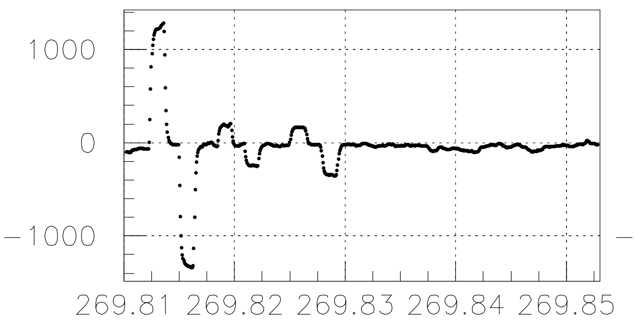
Scatter in BPM Y 1 vs time



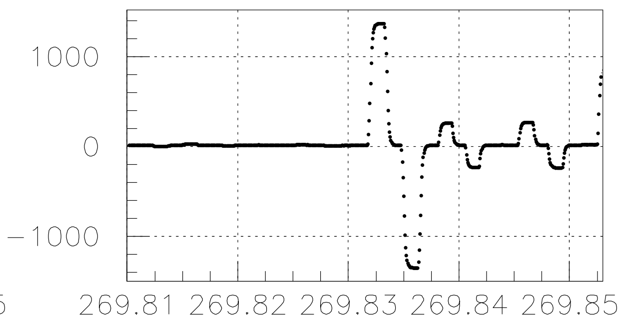
Scatter in BPM X 2 vs time



Scatter in BPM Y 2 vs time



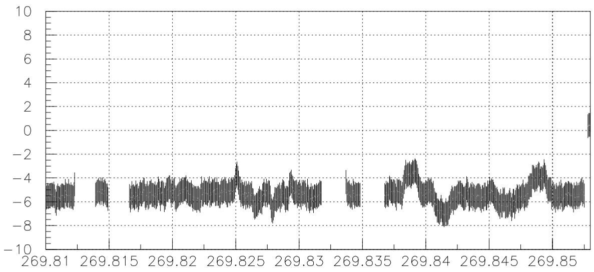
Scatter in BPM X 3 vs time



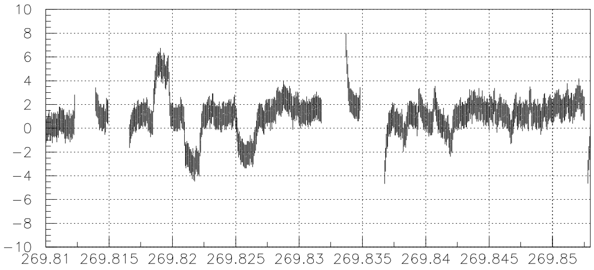
Scatter in BPM Y 3 vs time

Residuals

x and y residuals without cross-talk gain term included...

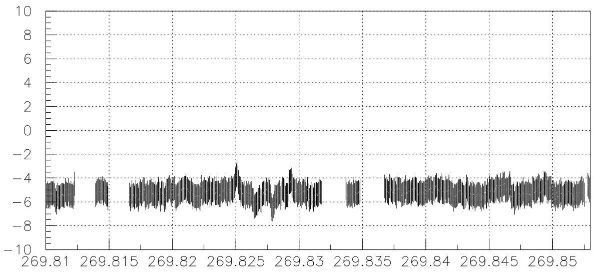


RHS x residual vs time

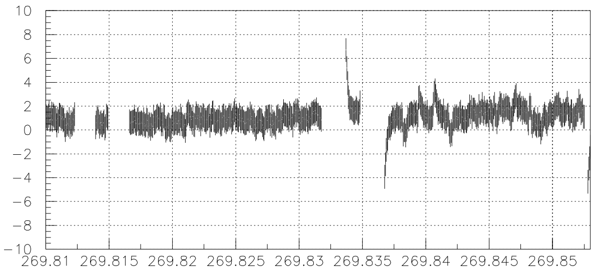


RHS y residual vs time

...and with cross-talk gain term included:



RHS x residual vs time



RHS y residual vs time

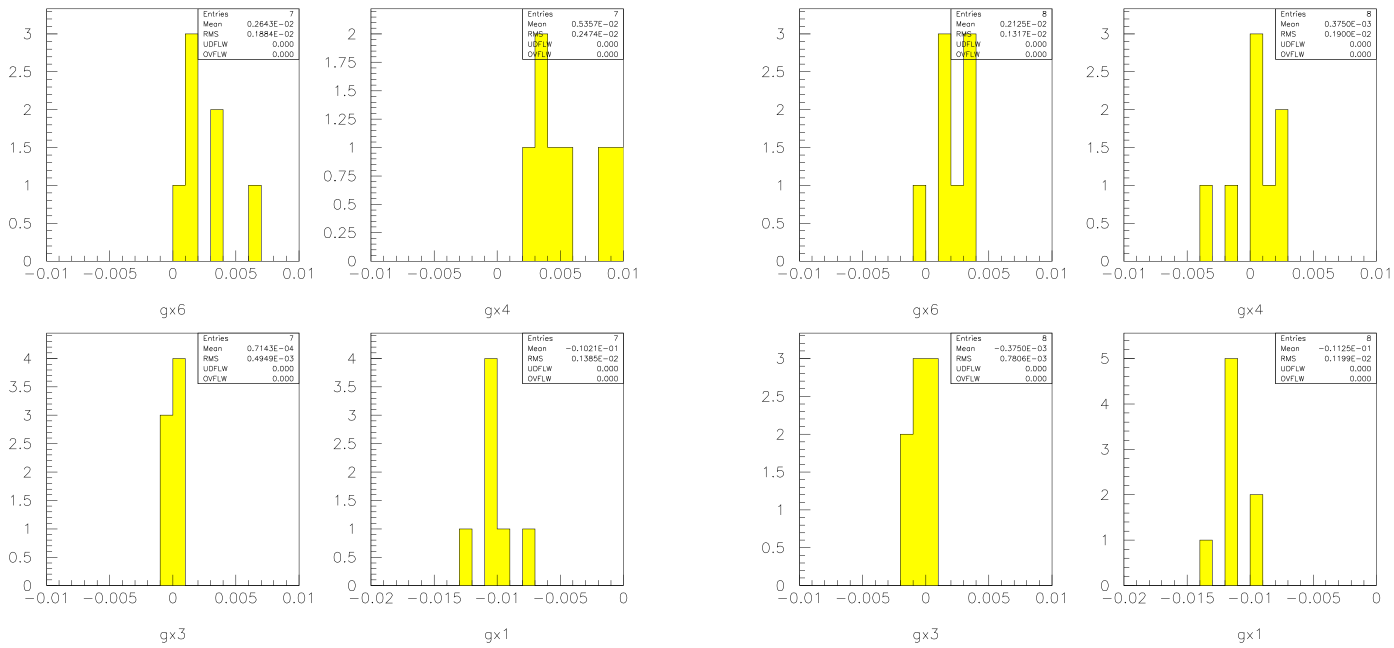
Improves resolution (particularly in y) and can lead to shifts

Fit for the 15 fills where there are both x and y calibrations

Results for 'y talking to x'

Following previous experience of gain fits, split into e^- & e^+

Electrons **Positrons**



(Note the different choice of plot window for each BPM)

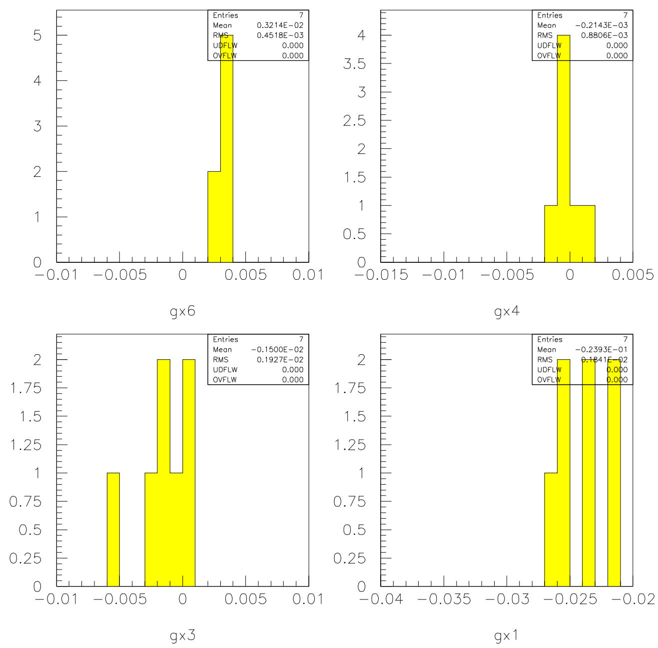
Observations:

- Reproducible results
- Most significant for BPM 1 (both particles) and BPM 4 (electrons)
- No difference for fills 8368 & 8443, with swapped cards in BPM 1 & 3. However recall that terms are relative to BPM 2 (RHS) and 5 (LHS)...

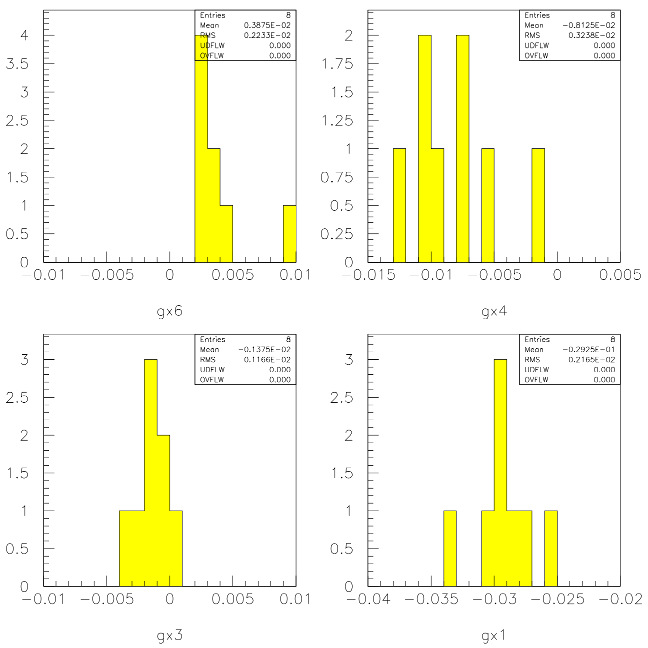
Results for ‘x talking to y’

Repeat to find terms relevant for understanding y behaviour:

Electrons



Positrons



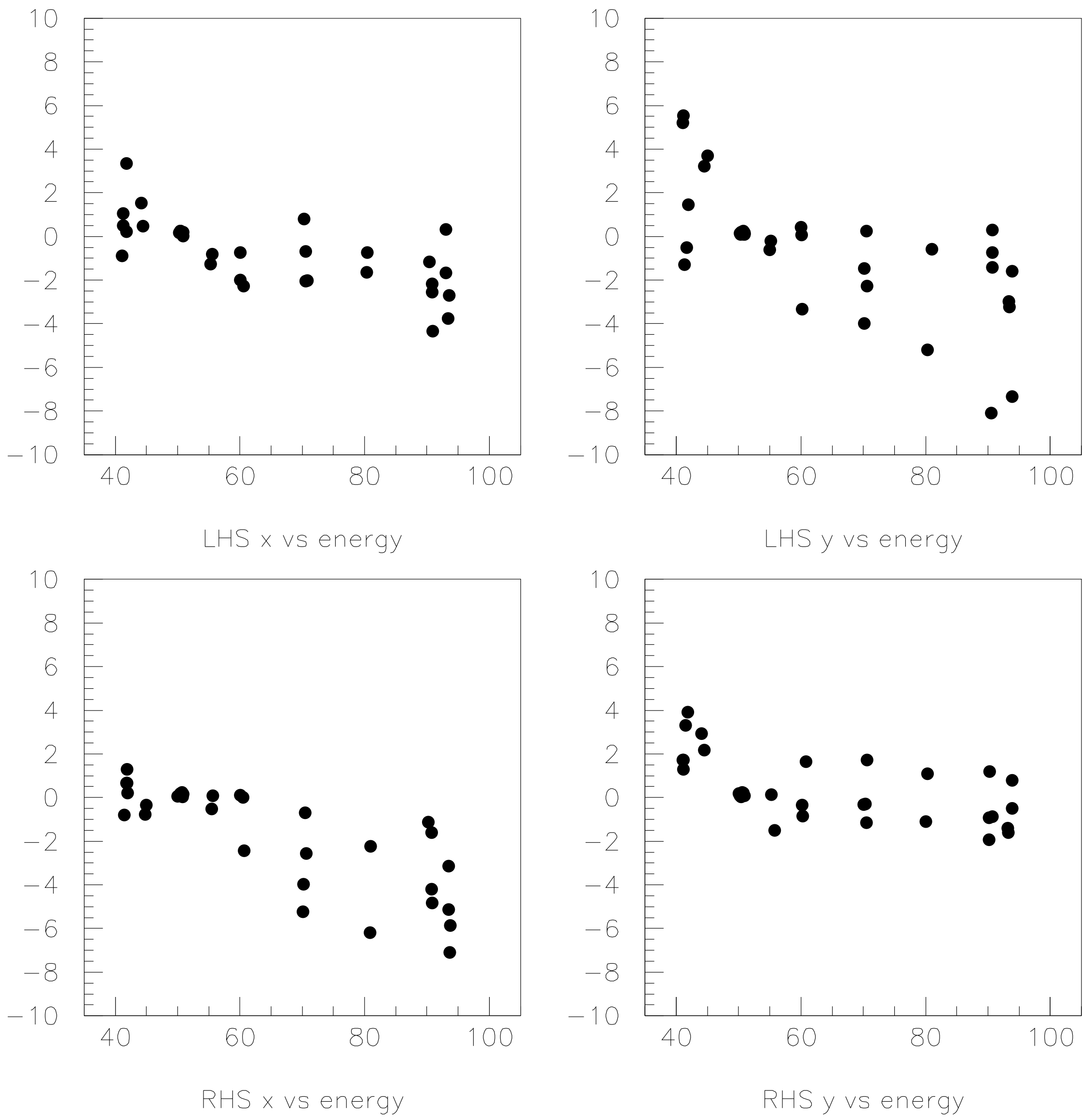
(Note the different choice of plot window for each BPM)

Observations:

- Terms, where significant, have same sign to those in x-fits, indicating cross-talk as main origin of x–y coupling, rather than geometrical rotation...
- Similar strength to terms in x-fits, although a little larger...
- Reproducibility and particle dependence, as for x-fits

Global triplet residual shifts: polarisation optics

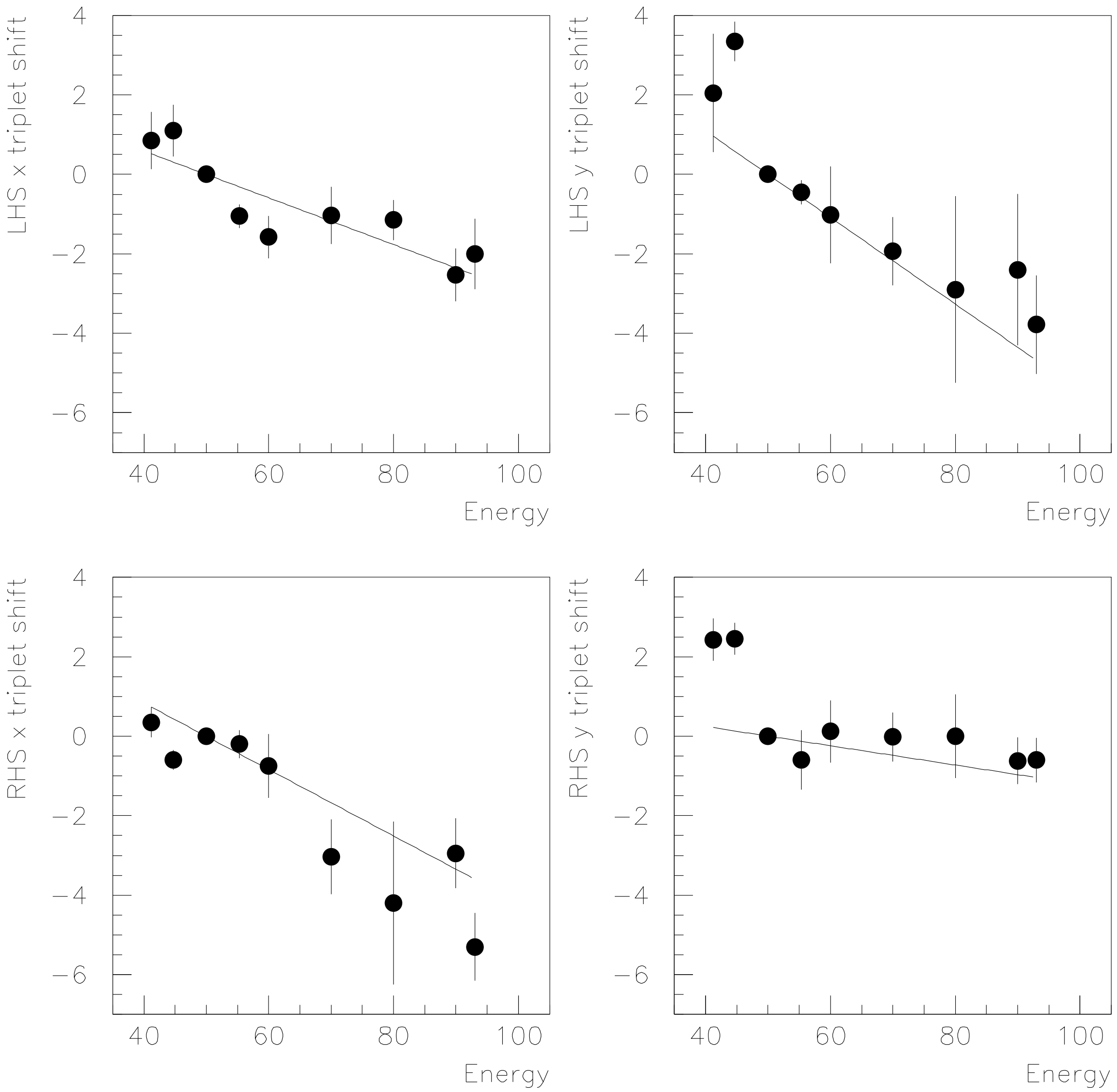
Triplet residual shifts vs energy, normalised to 50 GeV



- As remarked last time, rather linear in energy
- Now sure that the scatter is genuine, rather than due to imperfections in analysis $\longrightarrow$ mean behaviour is clean, but fill to fill there is variation (reminiscent of TGV effect!)

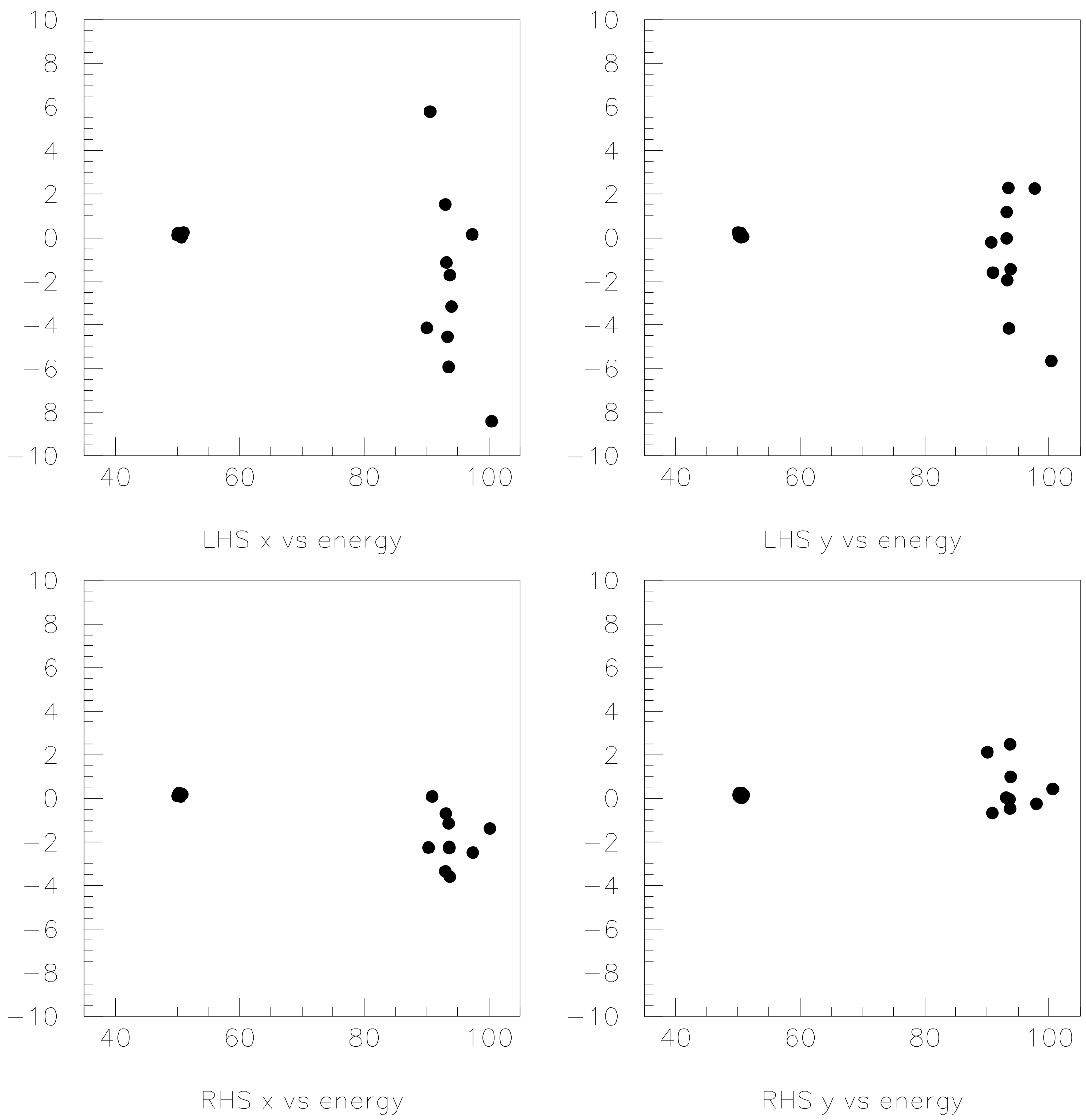
Global triplet residual shifts: polarisation optics

Can average data at each energy and make linear fit

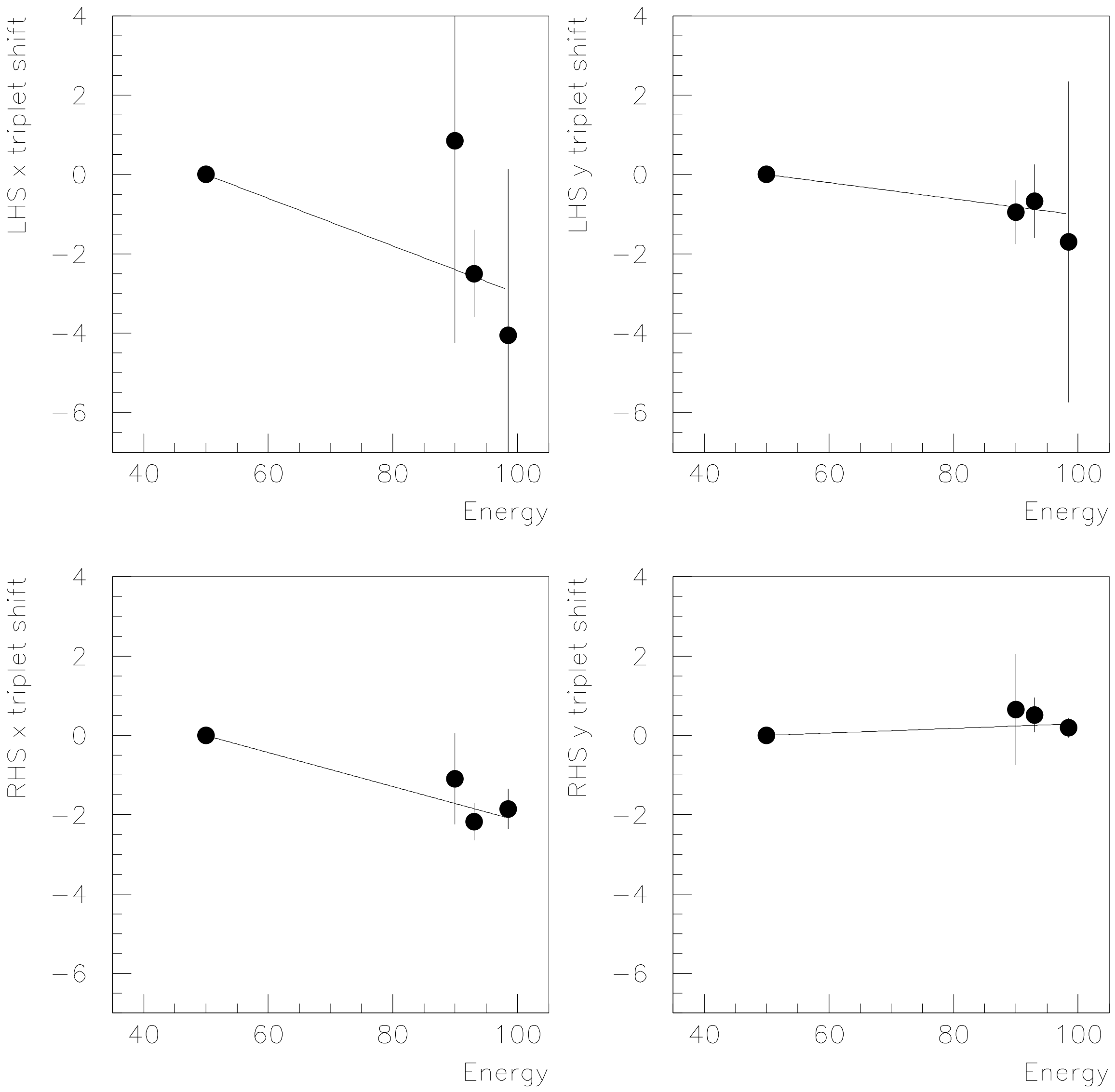


An alternative analysis might fit fill-by-fill and then average

Global triplet residual shifts: physics optics



Global triplet residual shifts: physics optics



Last time it was remarked that slopes more severe for polarisation optics ($\rightarrow$ bunch length hypothesis). In this analysis this is no longer obviously so for LHS x, but here the physics fills have alot of scatter... Shame we have no intermediate energies for physics fills...

Wiggler experiments revisited

Refit E/D wiggler experiments with cross-talk terms:

Fill 7519 (pol)

Wigglers	σ_z	H emitt	LHS x	LHS y	RHS x	RHS y
off	4.4 mm	11 nm	0	0	0	0
on	8 mm	24 nm	+0.27	-2.62	-1.93	-0.79
off	4.4 mm	11 nm	-1.02	-1.60	-0.69	-0.89

Fill 7667 (phys)

Wigglers	σ_z	H emitt	LHS x	LHS y	RHS x	RHS y
on	8.4 mm	27.5 nm	0	0	0	0
off	4.7 mm	10 nm	-4.76	-1.18	2.32	0.46

Fill 7676 (phys)

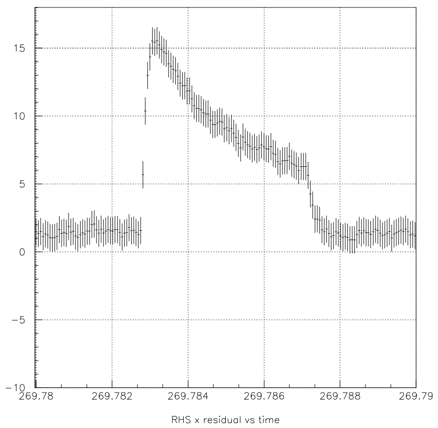
Wigglers	σ_z	H emitt	LHS x	LHS y	RHS x	RHS y
on	8.4 mm	27 nm	0	0	0	0
off	4.7 mm	11 nm	-4.43	-0.11	1.04	2.15

- All numbers reliable to $\sim 0.5\,\mu\mathrm{m}$.
- Cross-talk terms improve the fits in 7667 & 7676 w.r.t. previous analysis and dampen the drifts which had been seen $\longrightarrow$ significance of results increases
- Behaviour of fills 7667 & 7676 rather similar
- Interesting to compare bunch shortening step in fill 7519 with that in 7667 & 7676 (not entirely consistent). Also changes in 7519 are not 100 % reversible.
- Fill 7719 has pol wiggler manipulation, but stable bunch length & emittance. Residuals rather stable.

Q_s experiments and f_{RF}

Joerg remarked that Q_s manipulations change σ_z also (but not emittance). Is anything seen in the Q_s experiments?

- Difficult to analyse, because beam generally not well centred after Q_s change, and also bunch length changes less than in wiggler experiments. Cannot saying anything conclusive about changes in fills 8552 & 8556...
- ...fill 8559 however shows something dramatic as Q_s varied & bunch length changed from 4.4 $\longrightarrow$ 3.7 $\longrightarrow$ 4.4 mm

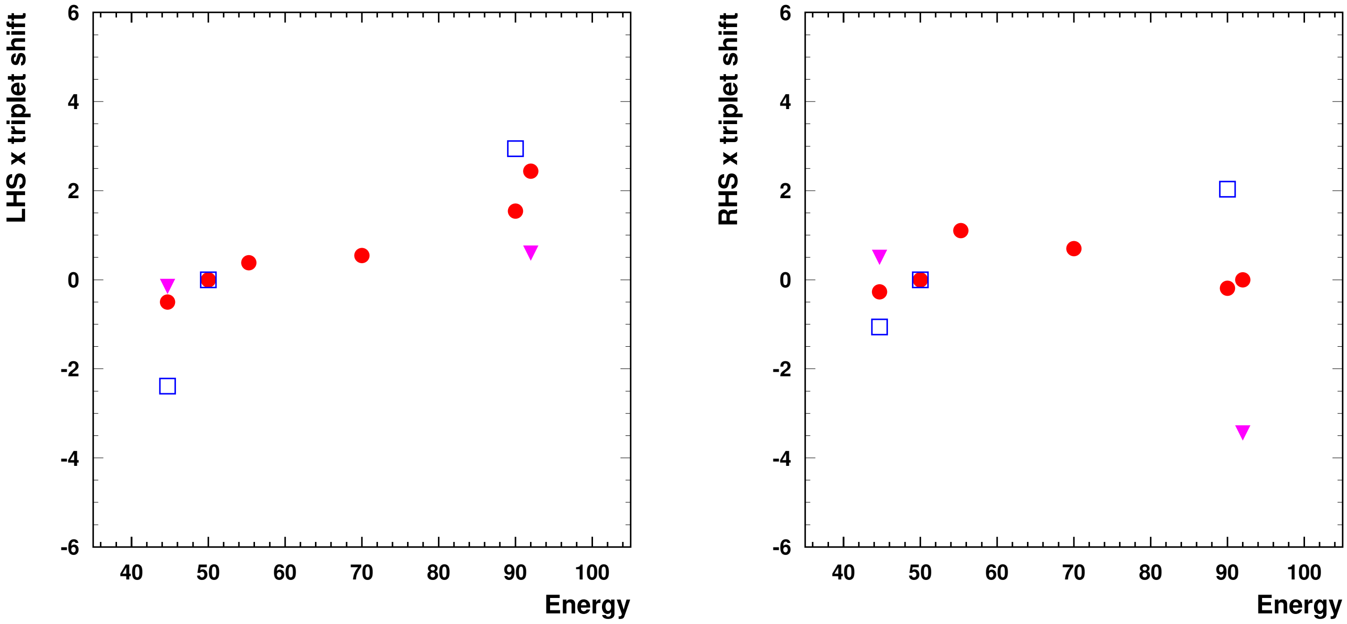


Finally, f_{RF} shifts also change bunch length. However again, effect is less dramatic than wigglers $(+100Hz \longrightarrow +15\%)$. Biggest f_{RF} changes occured during BFS calibrations:

- Fills 7931 & 8566: plausible to claim significant residual shifts as beams are lengthened, but there are problems with poor recentreing (8566) or lack of calibration (7931) which mean results arent gold plated
- Fill 8715: very big LHS residual shifts at f_{RF} change. But fill is 4 bunches, & all data are weird (see last meeting).

1999 revisited

Fills 6397, 6432 (pol optics) & 6627 (phys optics – but without wigglers, therefore same bunch properties as other fills).
Looking at x triplet residuals vs energy for these three fills:



Observations:

- The triplet residuals were not stable in 1999 either!
- Intriguingly the LHS residuals have opposite slope to 2000! What has changed?
- No clear picture on RHS

Summary

Better fitting has cleaned up data. Picture remains stable:

- Systematic effect growing linearly with energy, & seems to be more severe for pol optics $\longrightarrow$ bunch length related?
- Wiggler manipulations also lead to significant triplet shifts
- Q_s and f_{RF} experiments are less clean, but hint in same direction

1999 data have similar problems, but intriguing differences

To Do list

- Study fills with measured triplet shifts in $41 - 60$ GeV range and compare expected BPM-x behaviour with that constrained by known energy. May even be illustrative, if morally dangerous, to repeat exercise at high energy using NMR model as input.
- Similar studies in y using measured horizontal B field
- Repeat analyses with different BPM button combinations
- Detailed study of occasions when drifts with time are seen
- Detailed study of f_{RF} ladders (Eric)
- Further investigation of opposite sign slope in '99
- Follow up the 4 bunch problem (see last meeting) by looking at physics fills
- Look at BPM data *during* ramps...?
- Plan lab tests of BPMs to study gains, bunch length dependence etc