BPM Studies

- Triplet residual shift studies
  - Global analysis of all fills
  - Wiggler experiments revisted
- 4 bunch fills
- Gain analysis
- Ideas for future studies

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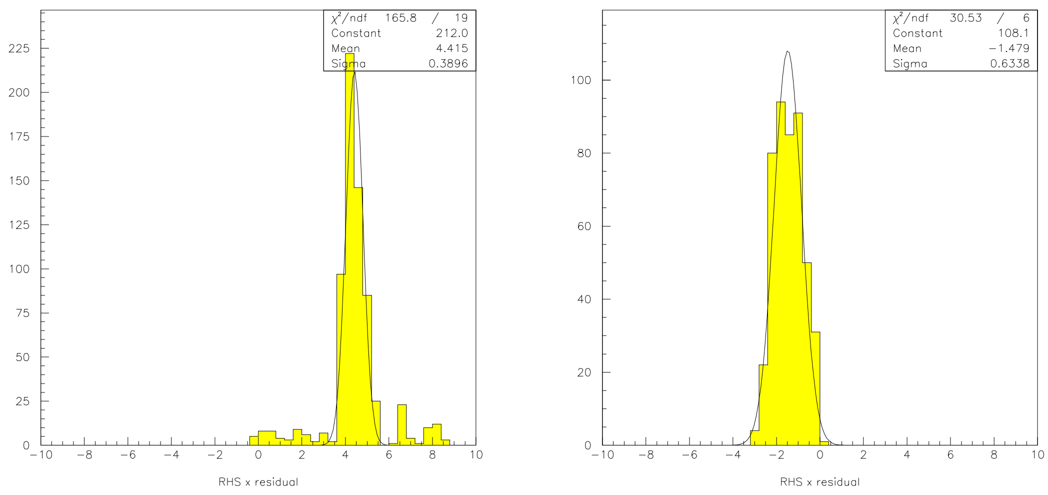
Triplet Shift Studies

- Have processed all spectrometer measurements:

  18 normal ramps, plus 2 anomalous ramps (8945, 8715)

  ~ 10 fills at fixed energy, some with control tests

- Select periods with centred beam &/or gain calibrations.
- Fit 2 relative gains in either arm, minimising triplet residuals. Try and fit all periods in fill simultaneously, although occasionally this causes problems...
- Independent fits to x and y. It seems y is more delicate, and in following I only show y data if there was an actual gain calibration in the fill
- Figure of merit is shift in triplet residual between, for example, low & high energy, eg. RHS x 41 & 93 GeV in 7251

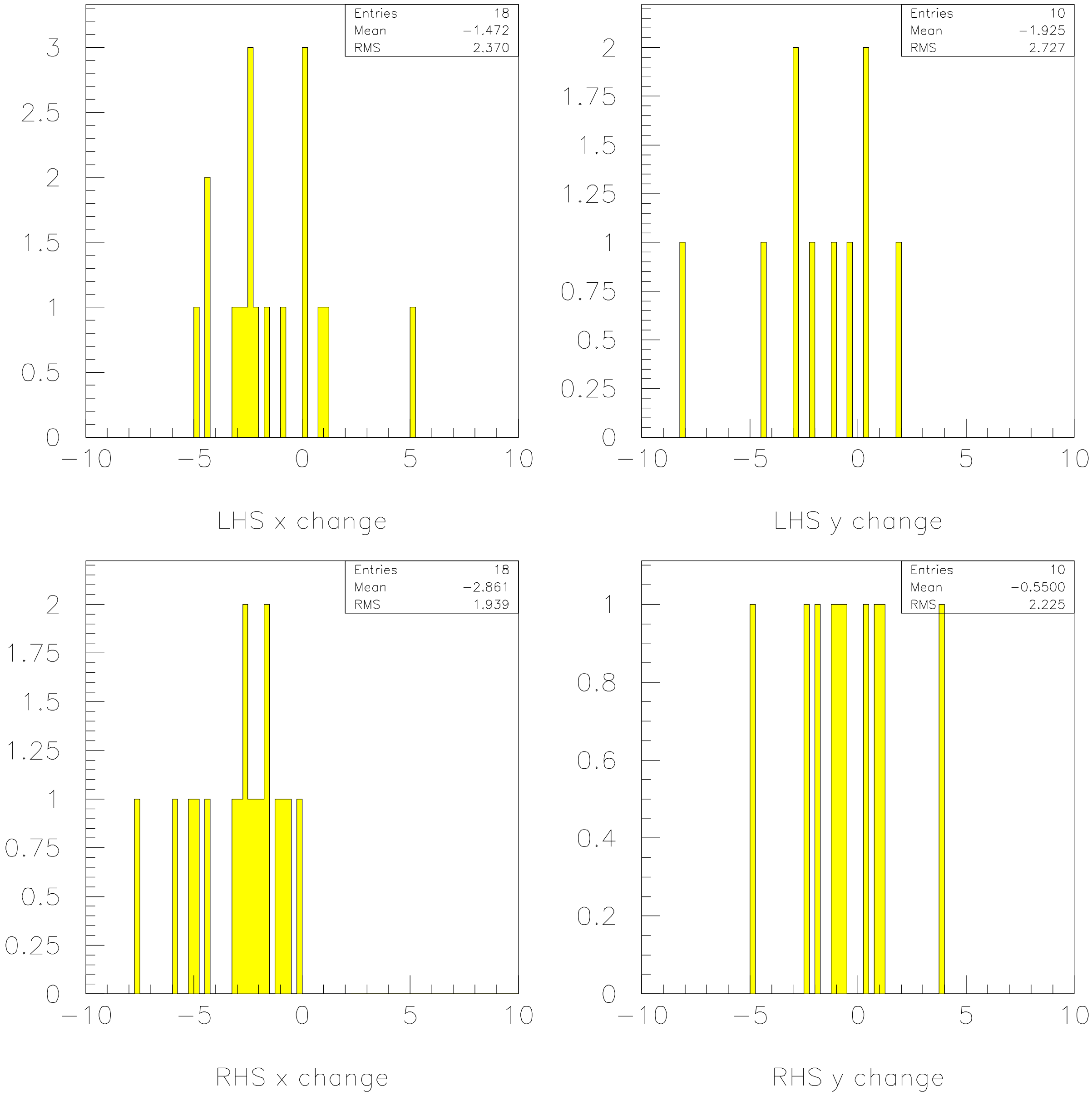


In this case a shift of -6 microns...

- When looking at energy dependence of these shifts I calculate everything relative to residual value at 50 GeV

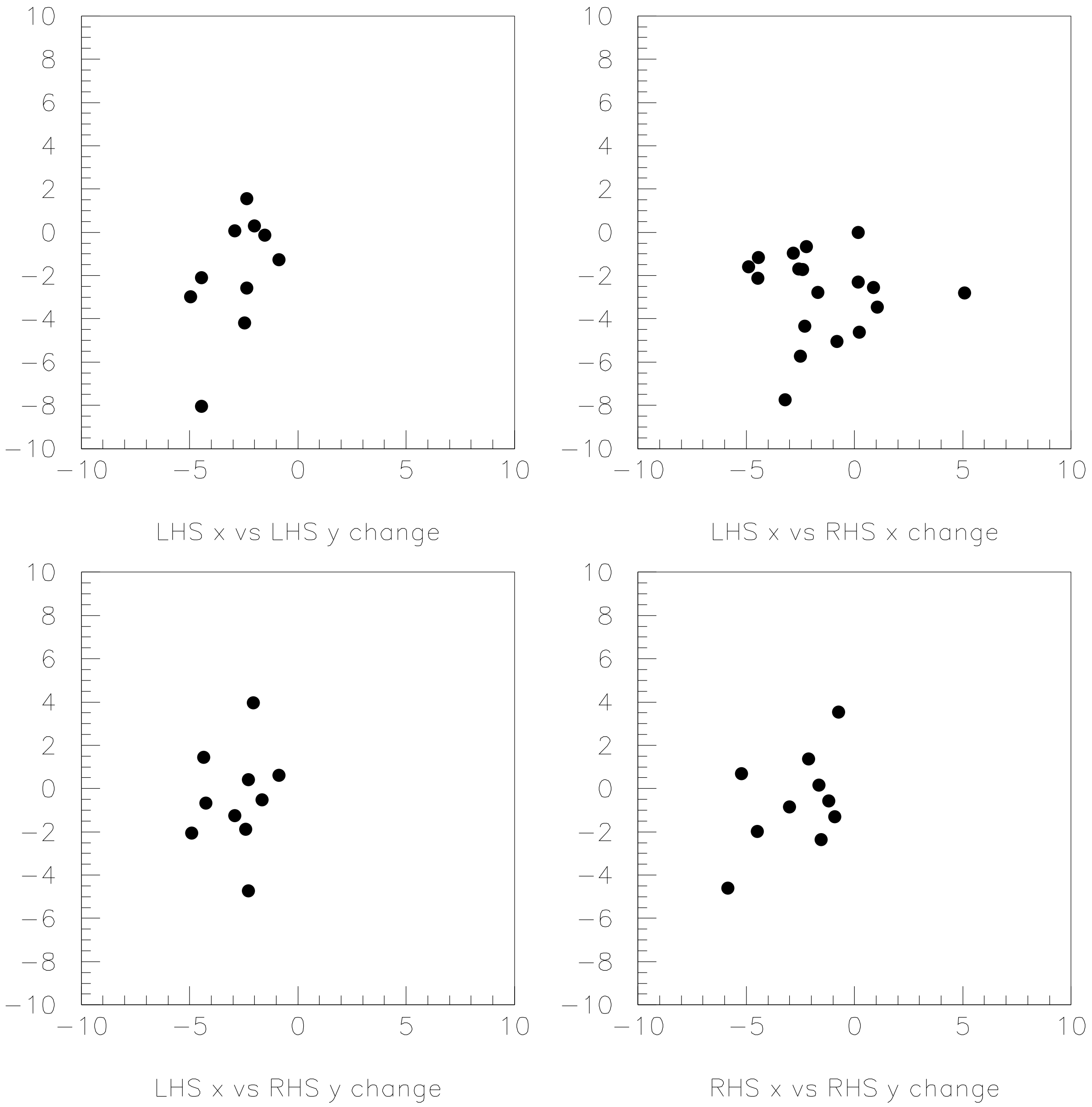
Triplet shifts 50 GeV $\rightarrow \sim 93$ GeV

(Unless stated, all scales in microns and GeV)



Very clear bias seen – strongly negative

Correlation between triplet shifts

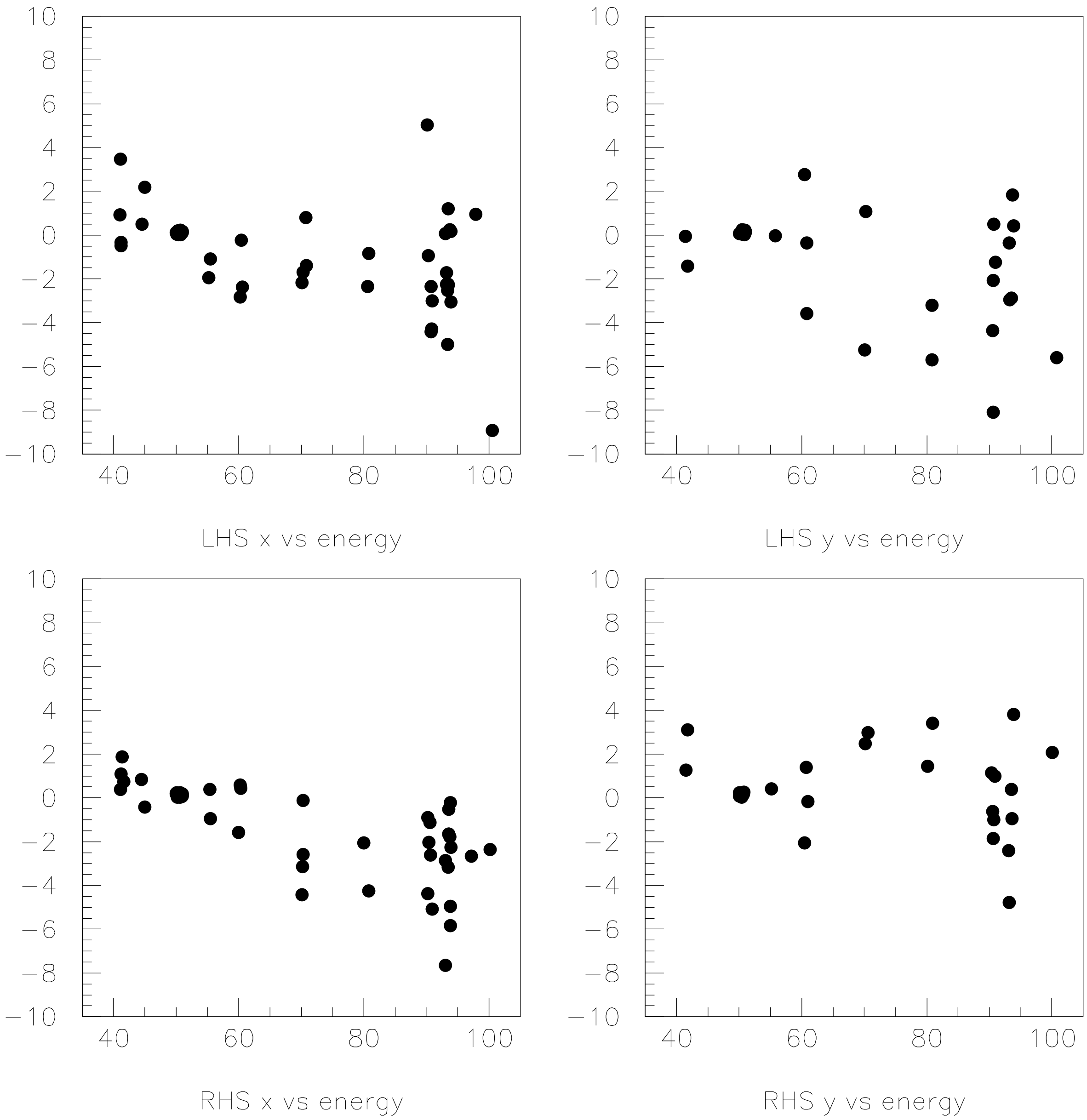


Suggestive of correlation between x and y, and between sides

(x–y correlation may become clearer when y fits cleaned up)

Triplet shifts vs energy

Now include points at low and intermediate energies



Strongly suggestive of a *linear* dependence

(Again, larger scatter in y may come from poorer fit quality)

What can this be correlated to?

Obvious issues to consider:

- Temperature
  Unlikely. Have analysed all relevant temperature information for all fills . As expected its variation with energy is non-linear (although temperature change in blocks themselves are certainly not E^4). Generally blocks rise by a few 0.1°, with difference between blocks much less than this. Also special low current fills give lower temperatures, but similar results. I will get around to making a plot...

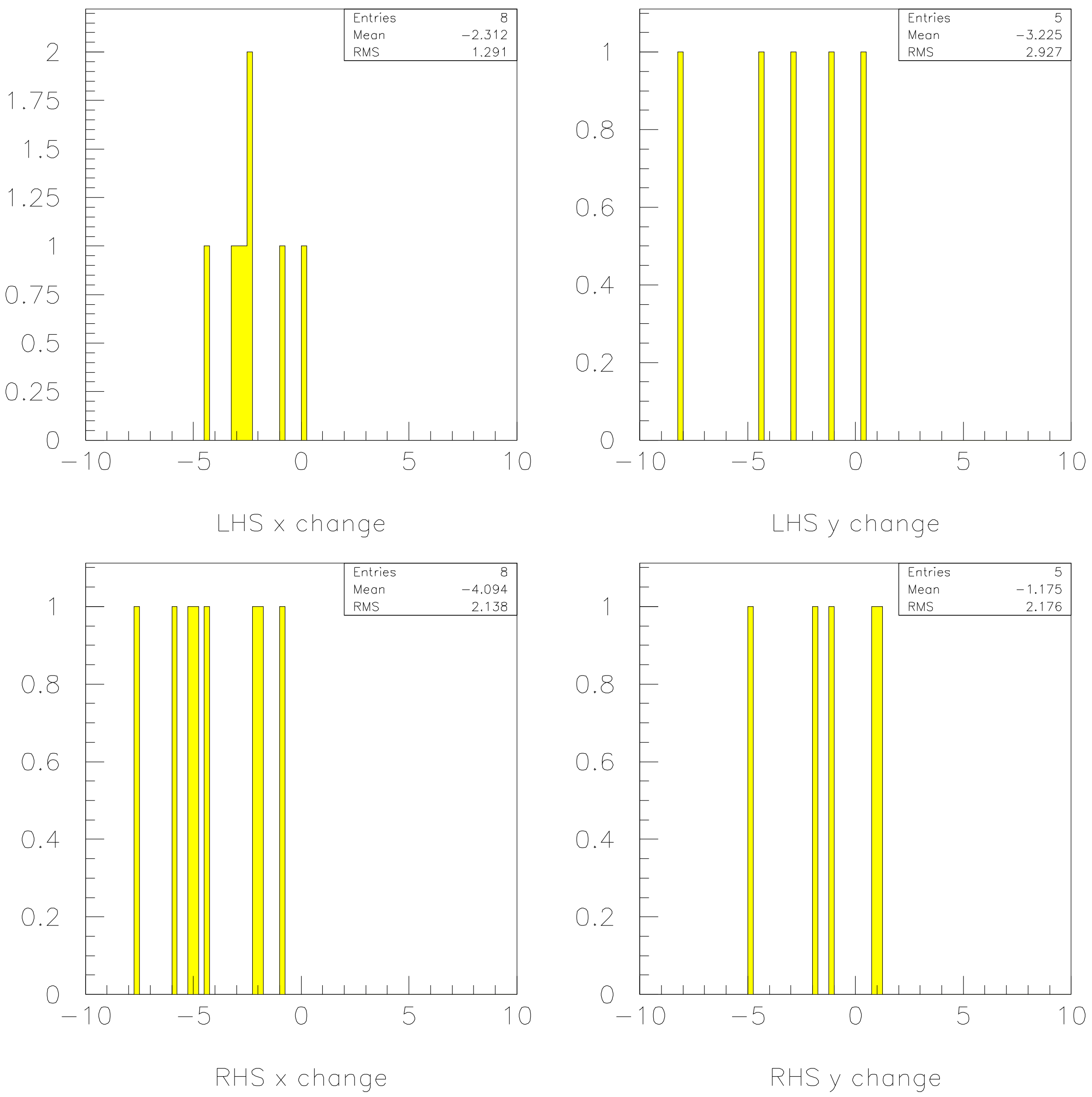
- Beam position in BPM
  No. Have checked the relative positions in x & y in the BPMs for all measurements. Re-centreing was done properly (rms $\sim 50\,\mu m$?), & I have discarded the few bad cases. No apparent bias with energy or correlation with shifts.

- Time into fill / at energy point?
  Not analysed yet. Certainly not the 1st order effect, but $drifts$ need to be understood

Not these. Only clear sign of correlation comes with optics. Remake triplet plots separately for physics and polarisation $\rightarrow$

Triplet shifts 50 GeV $\rightarrow \sim 93$ GeV

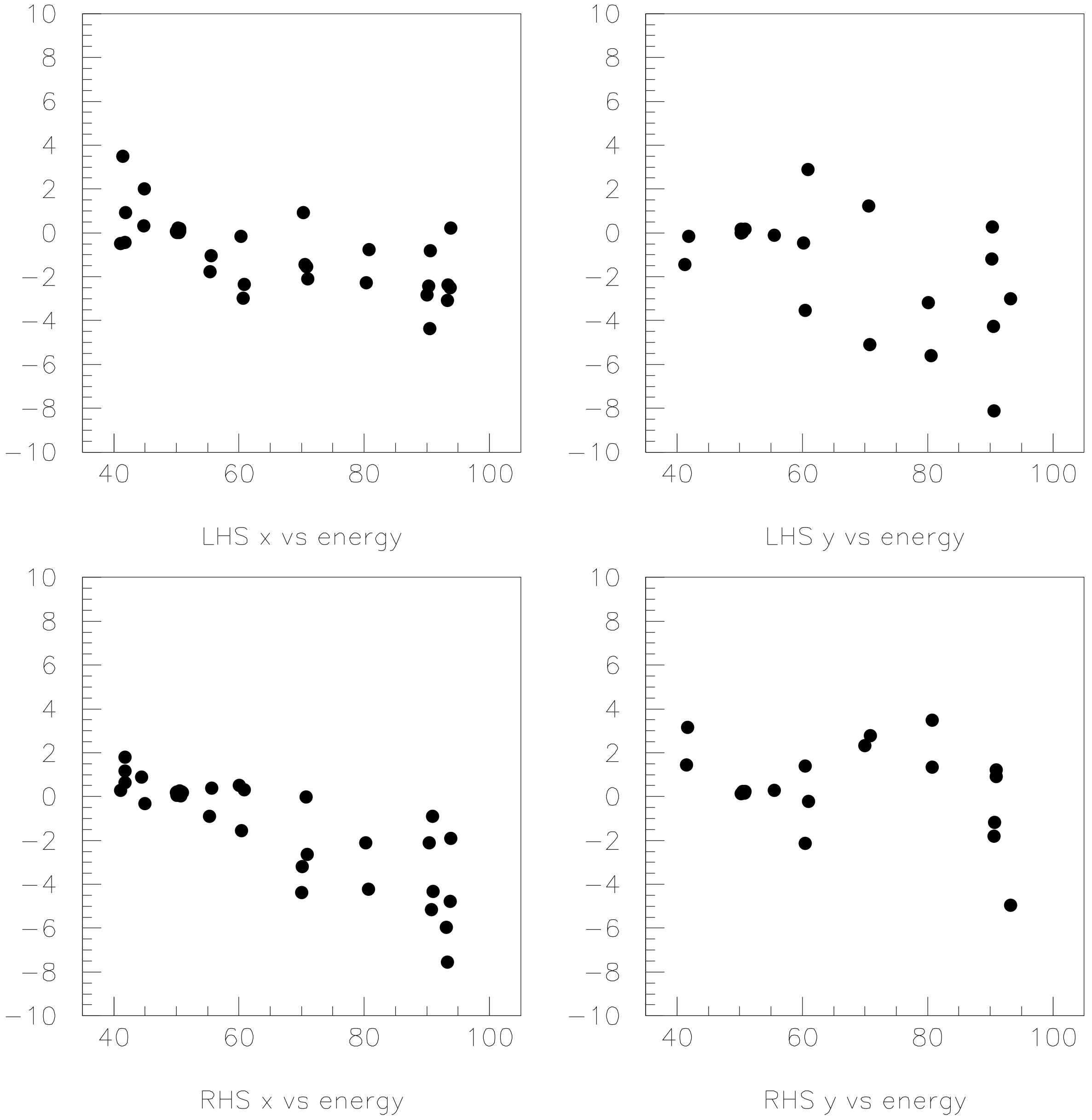
Polarisation Optics



These shifts are rather large...

Triplet shifts vs energy

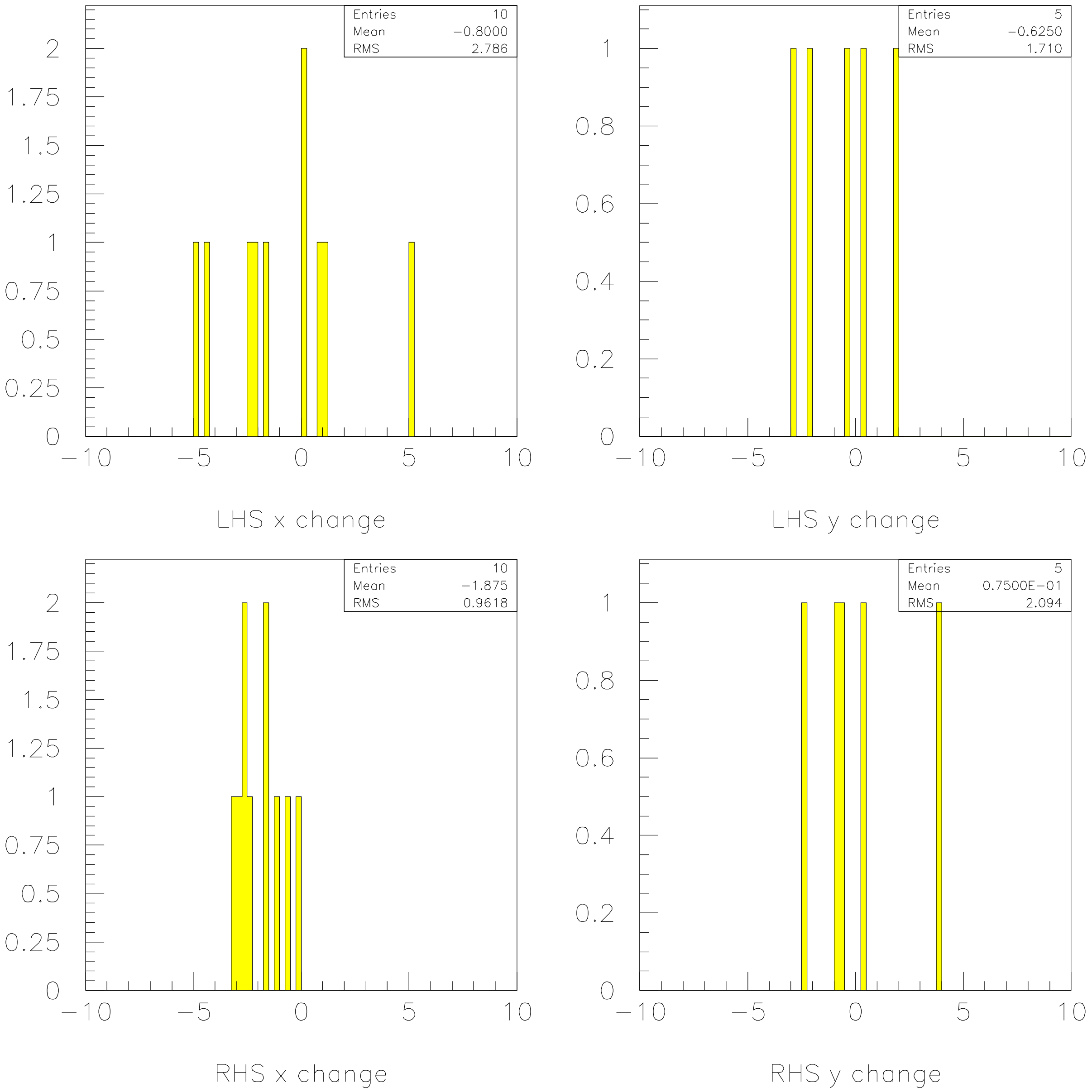
Polarisation Optics



Clearer and steeper slopes seen than in the optics blind plot

Triplet shifts 50 GeV $\to \sim 93$ GeV

Physics Optics



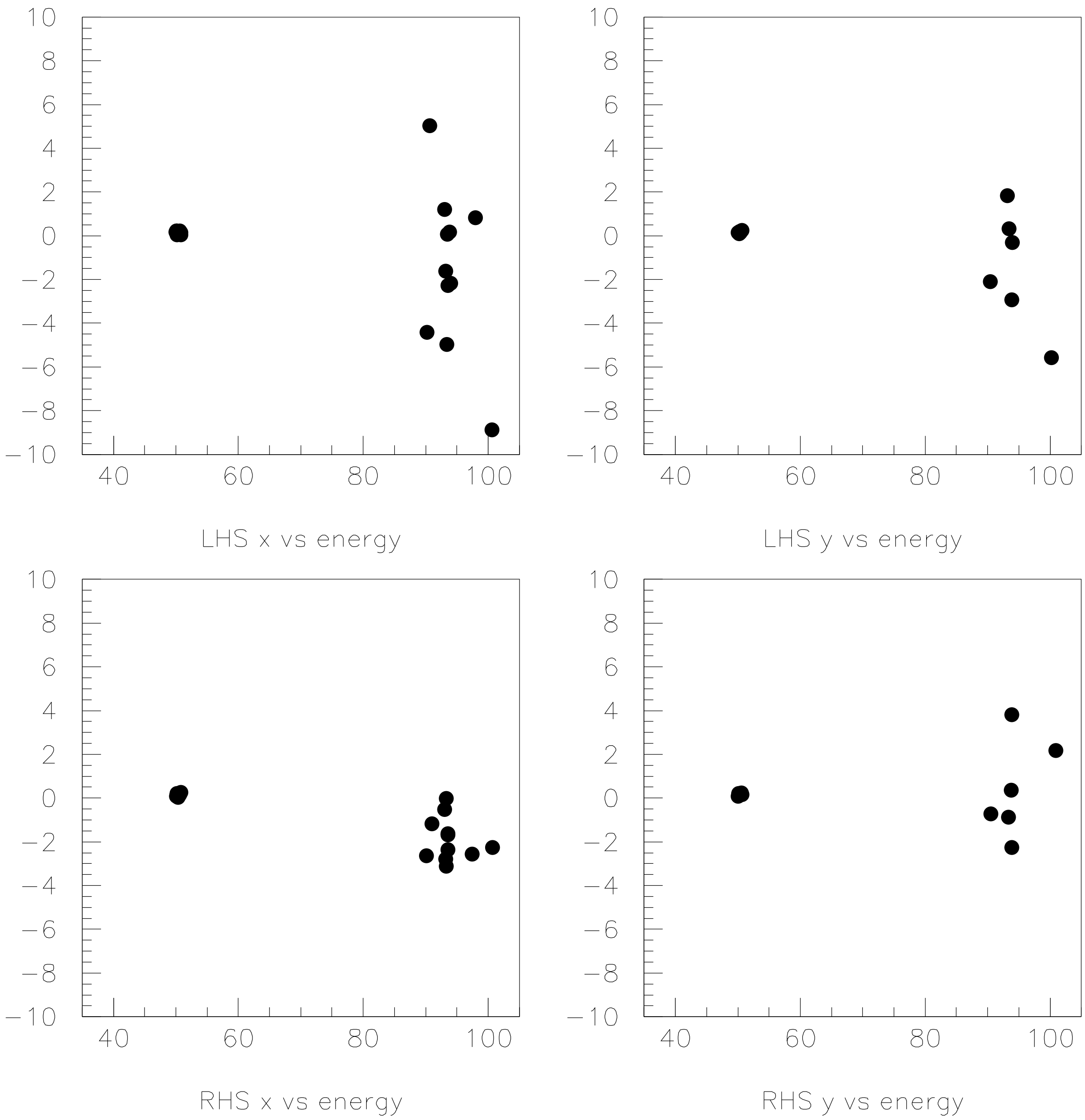
These shifts are significantly smaller than in polarisation case

(NB this analysis is not corrected for the the ambient field effect. Including this will dampen the bias in x by 0.62 (0.48) microns at 93 GeV for the polarisation (physics) optics...

Eric estimate from meeting 200, 6/10/2000)

Triplet shifts vs energy

Physics Optics



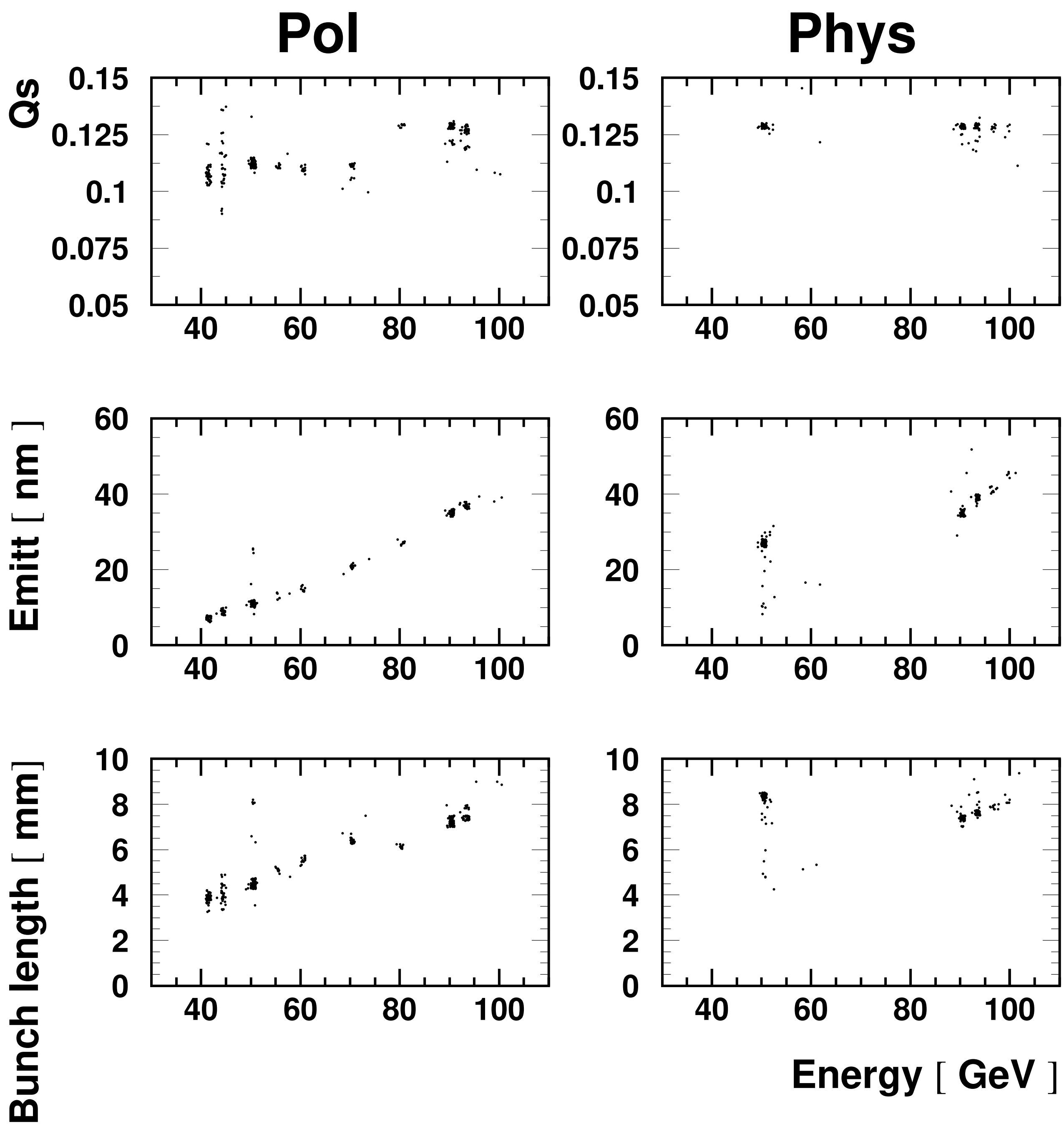
Clean but (very) shallow slope, esp after B field correction

Intermediate conclusions:

- Significant bias, linear with energy, in polarisation optics!
- Any such effect much smaller for physics optics
- Additional e^-/e^+ dependence? Hard to say

Variables with Optics dependence

Joerg's sawtooth model allows us to look at various variables' dependence on energy & optics for spectrometer fills



Bunch length and emittance certainly have a correlation with triplet shift behaviour. Can find out more by looking at wiggler shift experiments (responsible for outliers around 50 GeV)

Wiggler Experiments

In three fills the E/D wigglers were manipulated to change the bunch length (and emittance). Have analysed these, using log books and logging DB to check wiggler settings, and taking care to analyse periods where beams were centred and stable

The fills were (with my time windows in brackets):

- Fill 7519, e^-, pol
  Wigglers off (173.87–173.917), wigglers on (173.926–173.938) and wigglers off (173.947–173.955), all at 50 GeV
- Fill 7667 e^+, phys
  Wigglers on (187.552–187.60), wigglers off (187.63725–187.645) at 50 GeV
- Fill 7667 e^+, phys
  Wigglers on (188.66–188.720), wigglers off (188.7325–188.735) at 50 GeV

When wigglers are on, the bunch length is $\sim \times 2$ longer

And there was another fill, where Pol3 wiggler was manipulated

- Fill 7719 e^-, pol
  Wiggler off (191.935–191.972), wiggler on (191.981–191.998) at 50 GeV

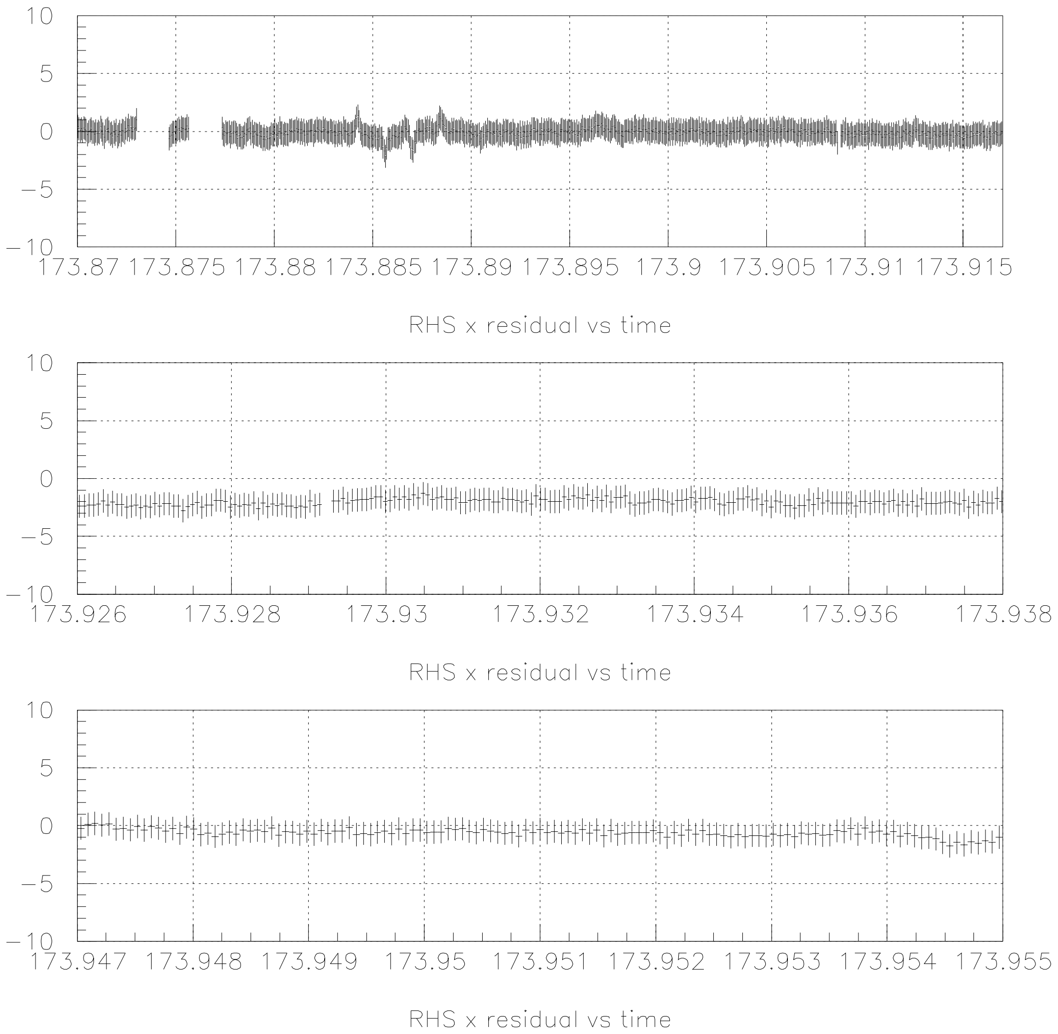
Note this was a synchrotron light experiment, and the manipulation is not expected to change the bunch length

Wiggler experiment fill 7519

Shifts in residuals (omitting RHS y which has bad fit):

Wigglers	LHS x	LHS y	RHS x	RHS y
Off (ref)	0	0	0	/
On	0.0	-2.0	-2.1	/
Off	-1.6	0.0	-0.5	/

Example for RHS x (off, on, off):



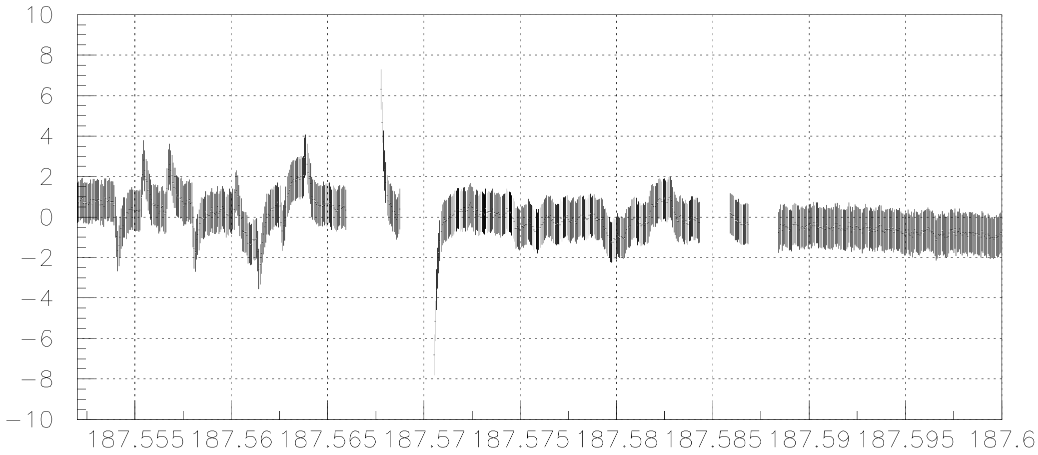
Here fit quality and beam stability very good

Wiggler experiment fill 7667

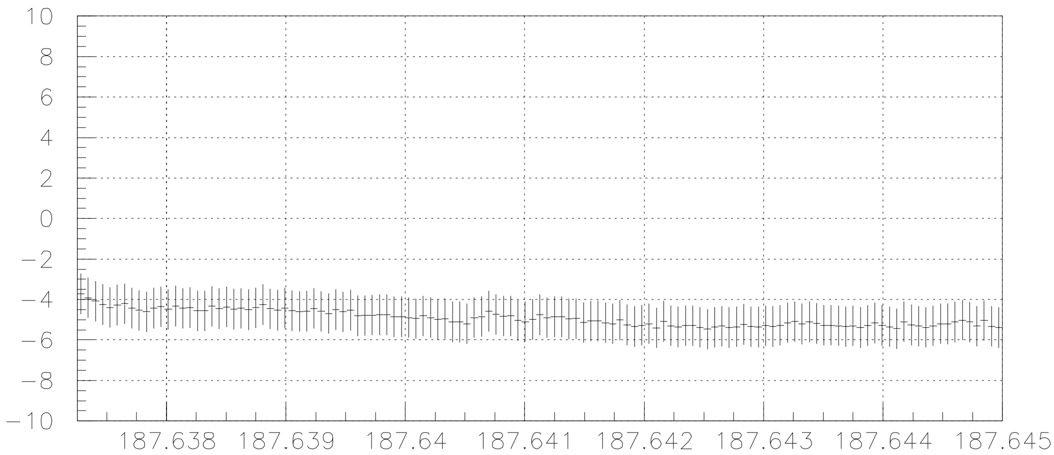
Shifts in residuals:

Wigglers	LHS x	LHS y	RHS x	RHS y
On (ref)	0	0	0	0
Off	-5.3	-1.0	2.0	-2.3

Example for LHS x (on, off):



LHS x residual vs time



LHS x residual vs time

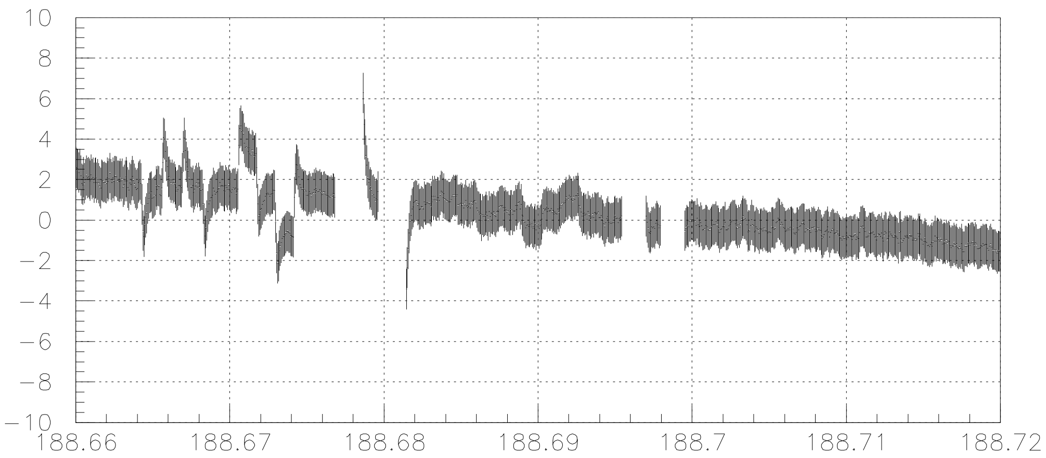
Some drift, but cant explain huge LHS x shift. Drifts and poor repositioning mean that RHS results not yet solid.

Wiggler experiment fill 7676

Shifts in residuals:

Wigglers	LHS x	LHS y	RHS x	RHS y
On (ref)	0	0	0	0
Off	-4.5	-0.2	0.5	2.3

Example for LHS x (on, off):



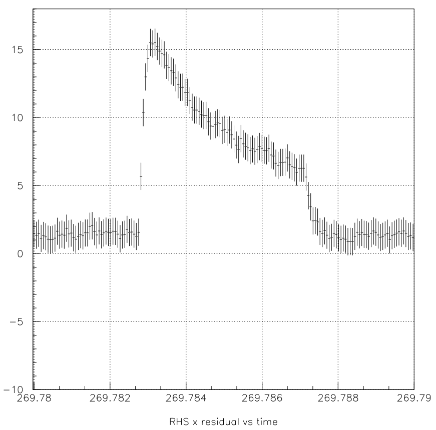
LHS x residual vs time

LHS x residual vs time

Unfortunately drifting beam in ‘on’ period and significant drift in residuals. However many fit variations tried, and best quality results also give largest effect...

Wiggler Conclusions

- For each wiggler experiment it seems that at least one triplet residual shows a significant shift. We see effects both when the wigglers go up and down.
- Results can perhaps be firmed up with more sophisticated analysis, eg. introducting x/y cross-terms in fit and looking at wire data
- In previous analyses we did see hint of something in first fill (Eric and John), but analysis of latter fills maybe did not select data carefully enough, plus confused issues by including the Pol3 experiment (7719). Here I see no evidence of a significant change.
- Conclusion: bunch length still a very plausible candidate!
- However, importance to look at Q_s experiments (8552,8556,8559) and corrector/synchrotron light experiment (7520) in similar detail. I suspect these wont show up anything much, but I have already seen the following in 8559 correlated with a Q_s ramp:

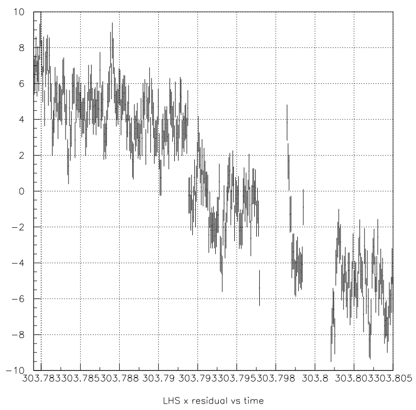


Very odd, but 'smells' different from our main problem

4 bunch / 2 beam – the horror, the horror

During are only 2 beam experiment (fill 8945) it was noticed online that something horrible was happening to the residuals, even at fixed energy. I have had another look at this:

- Residuals on LHS are indeed horrible even at stable energy and fixed timing, eg. LHS x at 90 GeV, e^- timing:



- Furthermore a huge (45 μm) triplet shift is seen for the LHS when ramping from 50 $\rightarrow$ 90 GeV with fixed timing – completely anomalous!
- However RHS behaves as in any other fill

Single beam experiment, 8715, shows identical behaviour!

There two fills are the only 4 bunch spectrometer MDs!

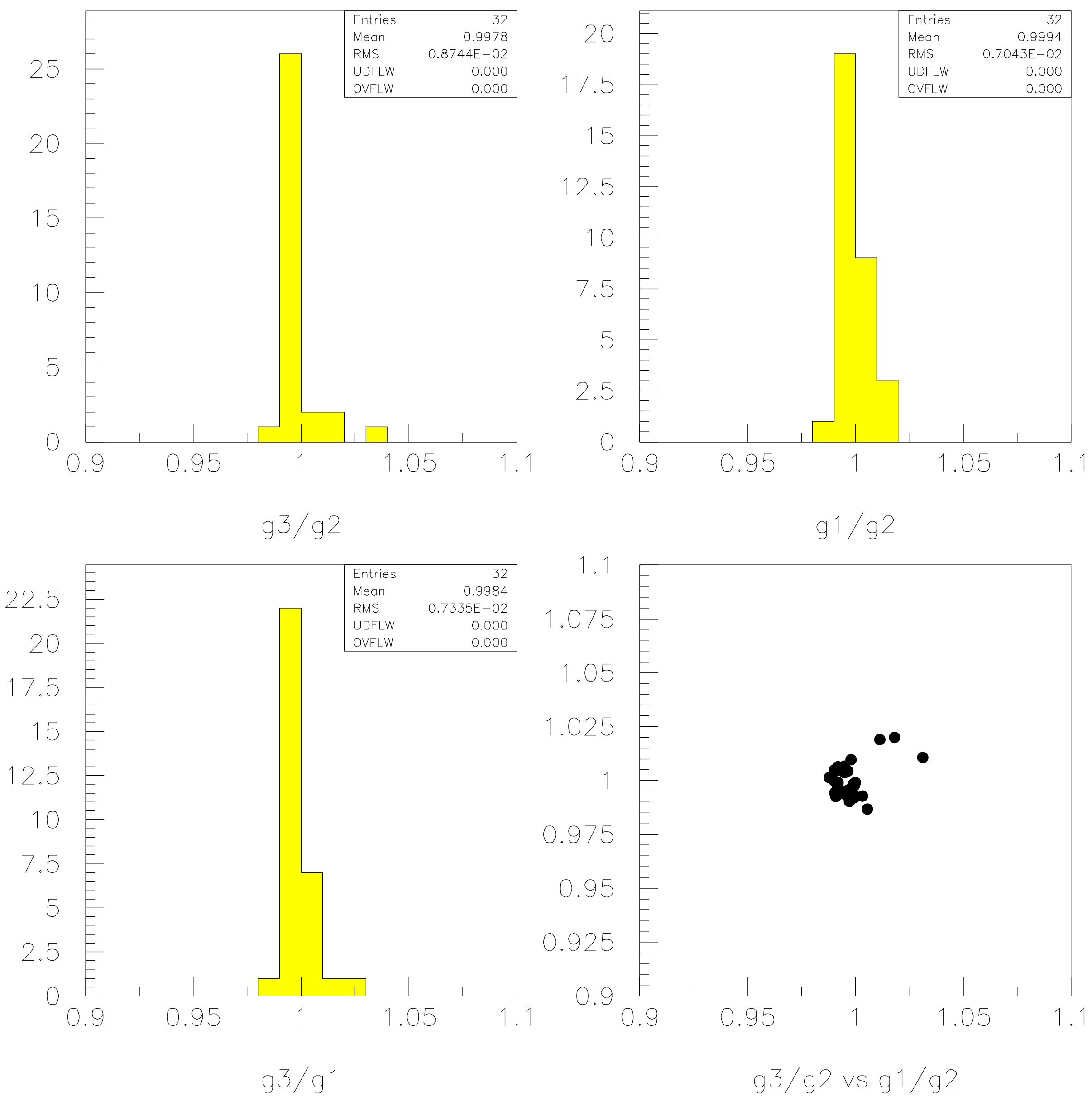
(8715 also has very sick LHS AGC signal. Fine for 8945)

Soon after another fill was taken, 8970, with 8 bunches and single beam. 'Normal', apart from very large LHS triplet drift

Follow up task: should look at some physics data (4 bunches)

Gain analysis

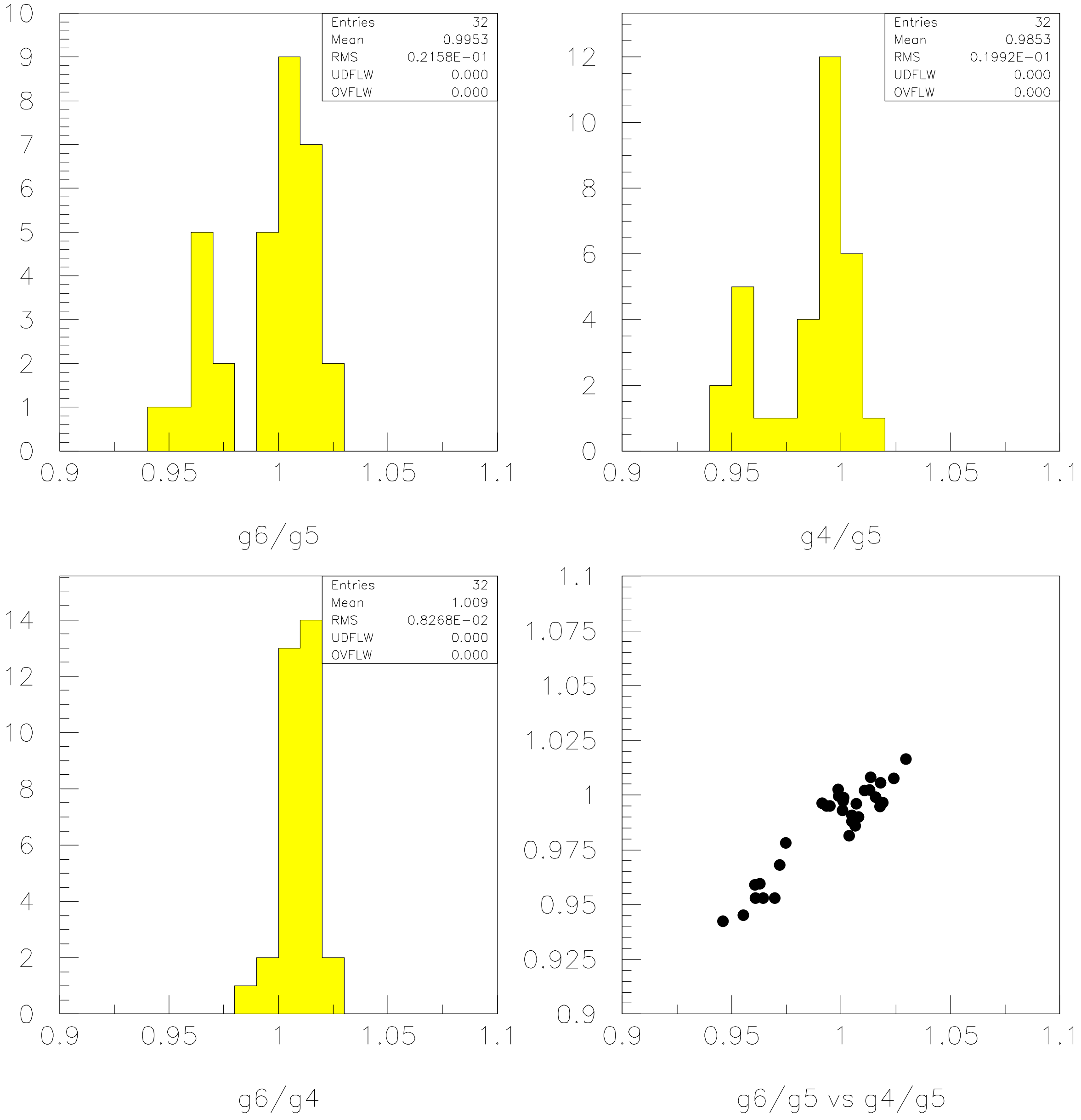
Have looked at variation in x-gains from calibrations at 50 GeV and high energy. Nothing interesting seen on RHS:



Gain analysis, LHS

But LHS has interesting sub-class of calibrations:

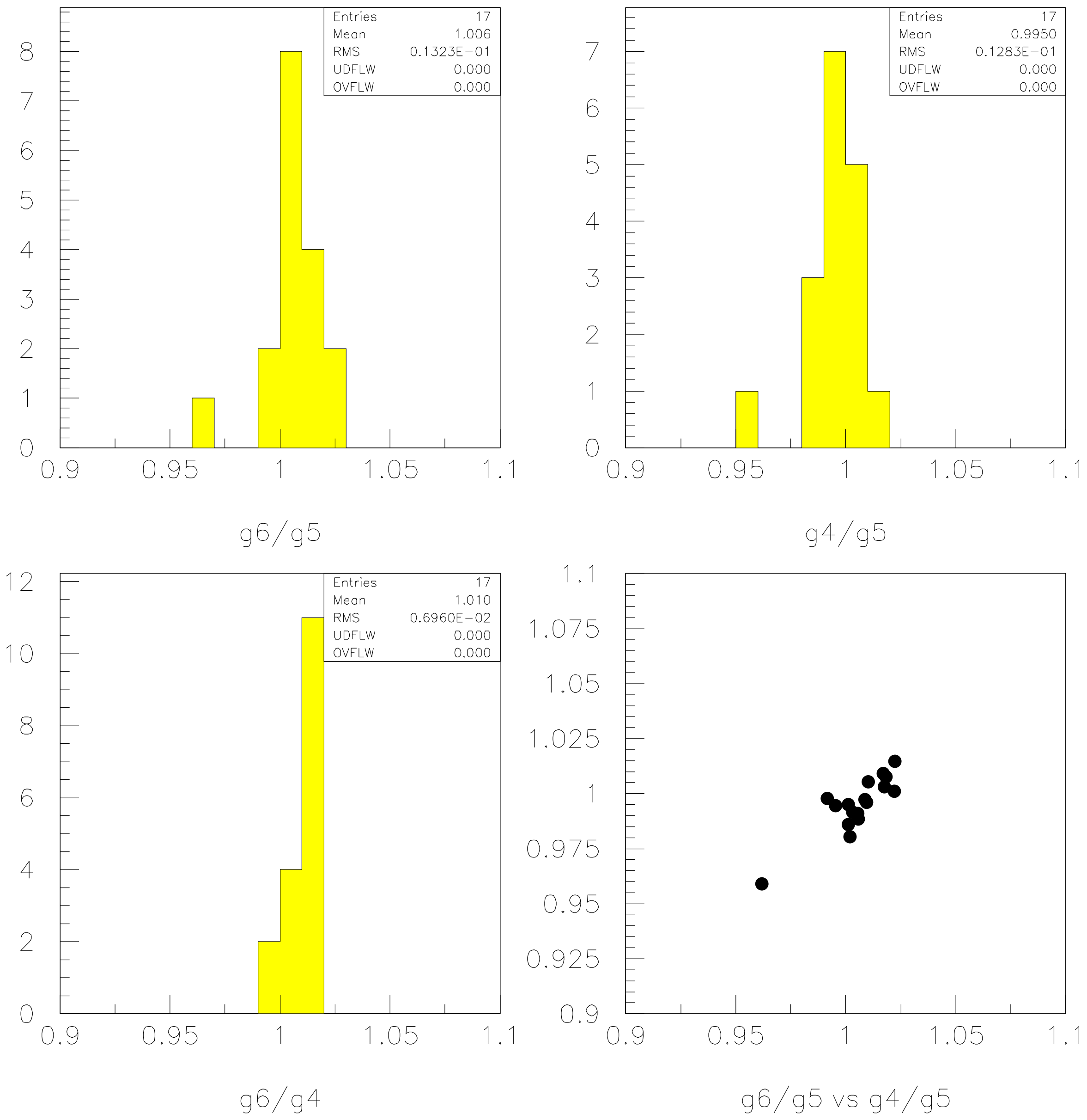
$\longrightarrow$ low relative gains of ~ 0.96 for 6 and 4



These low relative gains appear not to be correlated to optics, energy, current, time or size of triplet shift in fill...

LHS gains, electrons

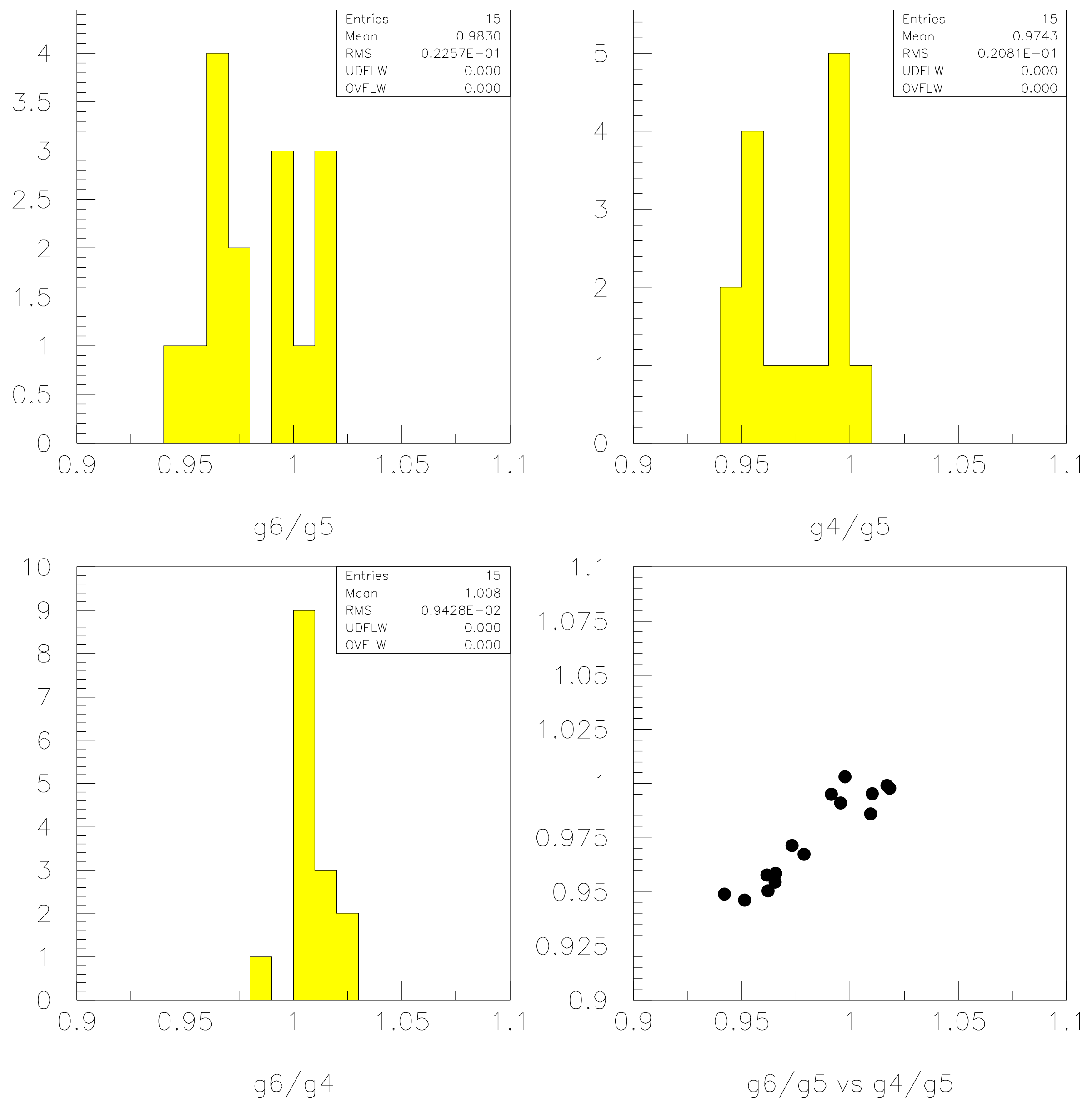
Rather they seem to be associated with particle type:



Virtually all electron fills give gains of ~ 1

LHS gains, positrons

But positron fills very often (but not always) give low values:



It would be nice to understand this (lab test?). An important task is a detailed gain cross-check vs the f_{RF} ladders.

But maybe isnt telling us anything relevant for the triplet shifts (further fact: no significant energy dependence)

Ideas for future studies

As well as tasks mentioned in the proceeding pages, the following seem promising lines of enquiry:

- 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.
- Improve fit to give cleaner y behaviour. Knowing horizontal field component from re-mapping (hopefully!) can compare expected and observed BPM-y behaviour.
- Repeat analyses with different BPM button combinations
- Detailed study of occasions when drifts with time are seen
- Detailed study of 'funnies' (timing changes, card swaps etc)

In addition to this is it possible to plan for further lab tests of the BPMs to look at issues such as bunch length dependence?

Lots to do!