# $E_b$ with the Spectrometer

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# Introduction & analysis procedure

15 ramps to 90/93 GeV (8 $e^-$, 7 $e^+$), with similar behaviour:

- Negative triplet shifts in LHS &/or RHS
- Of 9 possible ways to construct energy, *always* 'inners' (5 & 4, 1 & 2) give ∼ highest value, and 'outers' (6 & 5, 2 & 3) ∼ lowest value. 'Span' (6 & 4, 1 & 3) lies in middle.
- 7 of these fills also have low energy points

(1–2 fills with significant positive shifts not used; other fills with badly recentred beams/other problems discarded.)

Criteria for deciding which combination (if any) is best estimator of energy, and which BPMs are driving triplet shift:

1. Agreement with $E_{\mathrm{pol}}$ over 40–60 GeV
2. Stability of result on value of triplet residual shift – unbiased combination will have no dependence, whereas a combination involving affected BPMs will have slope

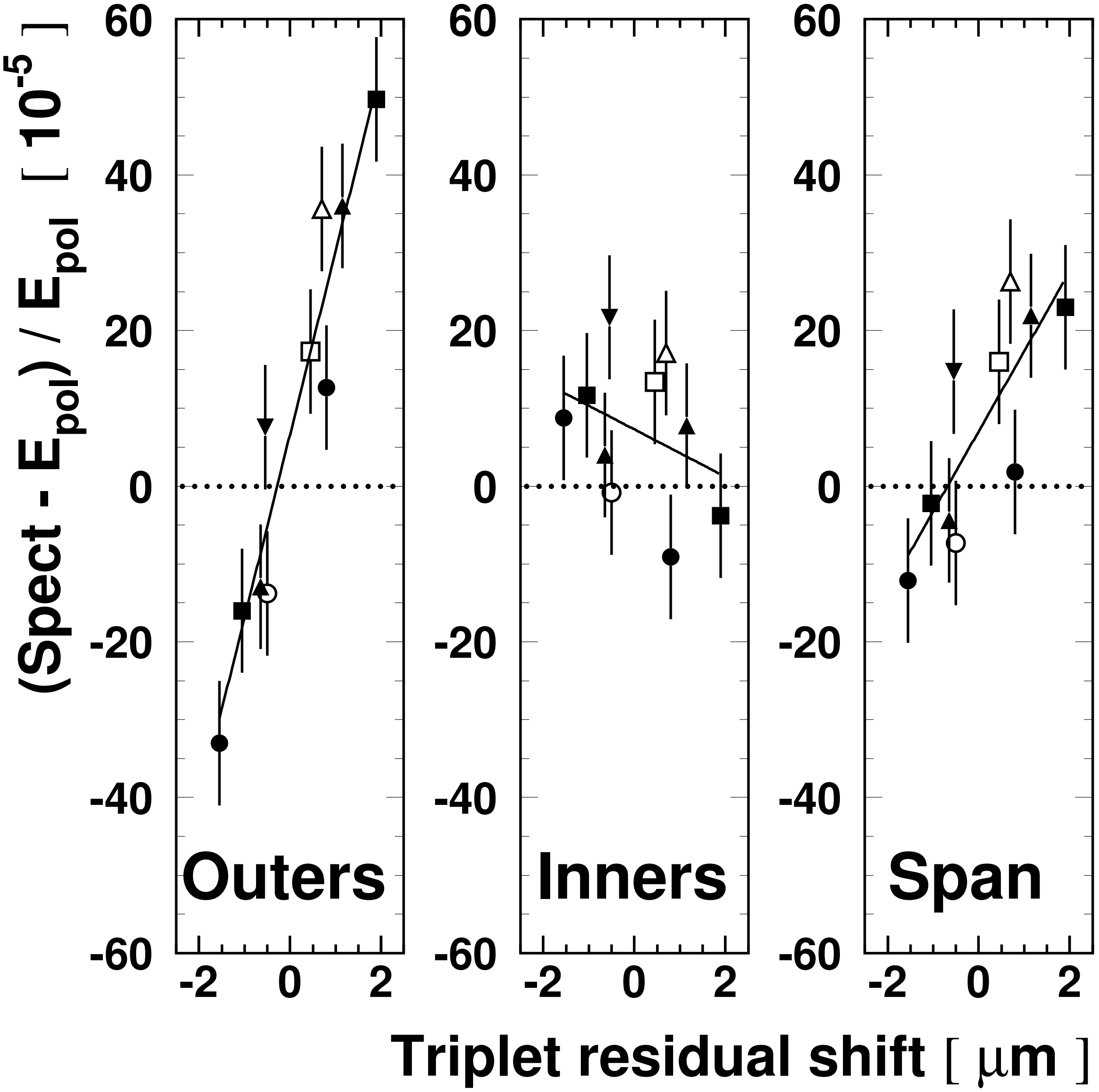
   Look both at low energy and high energy results
3. Internal consistency of BPMs to 'magnet bend centre' constrained fit – compare observed residuals to hypotheses

If consistent picture emerges, decide on central value and error (even if we still don't yet know what causes the BPM shifts!)

# Comparison with true energy 40–60 GeV and dependence on triplet residual shift

For each fill with low energy data, take a reference energy (usually 50 GeV) and look at results for energies with biggest positive and negative residual shifts (averaged over both arms). Compare with true energy (ie. one or two points / fill)

Take care to account for ambient field + '$E_{\rm pol}$ – NMR' banana




(Error bars of $\pm 8 \times 10^{-5}$ chosen to give acceptable $\chi^2$)

## Comparison with true energy 40–60 GeV and dependence on triplet residual shift

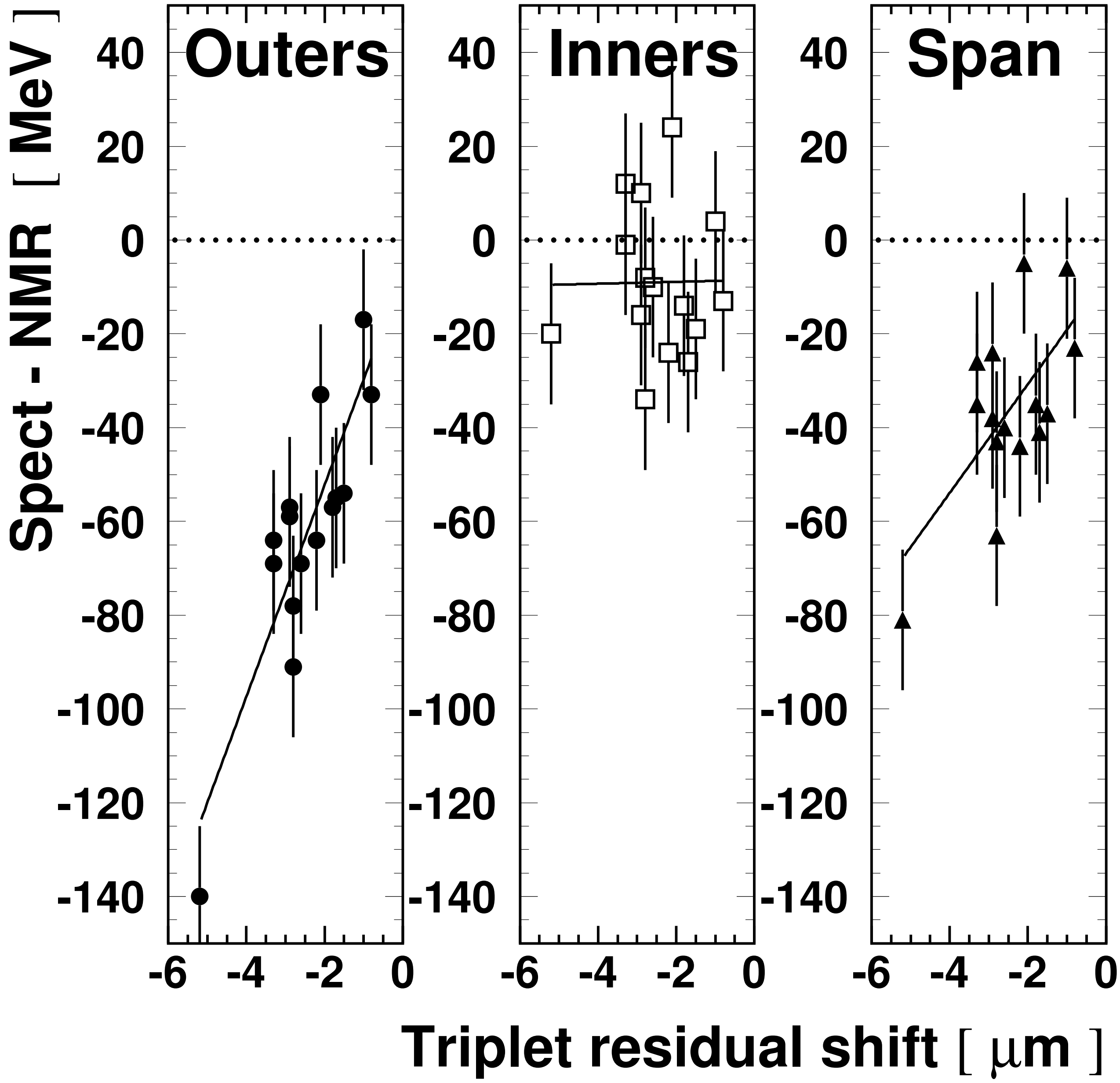
Results of linear fits (in units of $10^{-5}$):

| | Offset [MeV] | Slope $[\mu\mathrm{m}^{-1}]$ |
|---|---|---|
| Outers | $6.7 \pm 2.5$ | $23.6 \pm 2.4$ |
| Inners | $7.3 \pm 1.9$ | $-3.0 \pm 2.3$ |
| Span | $7.1 \pm 2.5$ | $10.3 \pm 2.4$ |

- Significant slope with outers in particular, & span, whereas inners rather flat $\rightarrow$ shift dominated by BPMs 6 & 1
- Residual bias of $7 \times 10^{-5}$ – genuine or feature of fills ?

# Dependence of high energy results on residual shift

Plot energy estimate at 90/93 GeV against triplet residual shift for all fills. Include $e^-$ and $e^+$ together after removing sawtooth splitting...




(Error bars of $\pm 15$ MeV chosen to give acceptable $\chi^2$)

...Striking slope seen in results from outers!

## Dependence of high energy results on residual shift

Results of fit:

| | Offset [MeV] | Slope $[\mathrm{MeV}/\mu\mathrm{m}]$ |
|---|---|---|
| Outers | $-7.1 \pm 8.4$ | $22.6 \pm 2.6$ |
| Inners | $-8.5 \pm 8.3$ | $0.2 \pm 3.1$ |
| Span | $-7.6 \pm 6.8$ | $11.6 \pm 2.6$ |

- This behaviour exactly what is expected if all shift in BPMs 6 & 3. Simulation then predicts slopes of 25.0, 0 and 12.5 MeV / $\mu m$ in the outers, inners and span respectively.
- To compare these slopes with those in low energy table, must divide by 0.93 – they are very consistent
- In the limit of 0 systematic, all three estimators agree, ie. the offsets are extremely similar
- It can be seen one fill (7129) has large weight in result. If this is excluded from fit, offset changes to -15 MeV and slope change a little. All looks OK.

If we correct for the residual offset in the low energy plot:

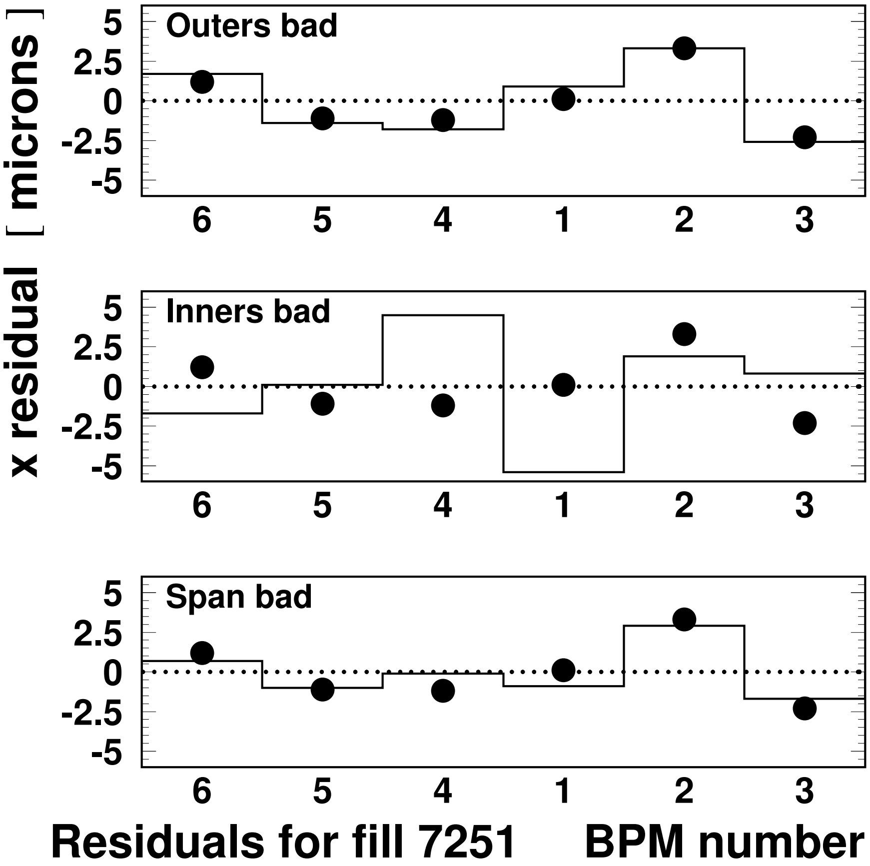
Spect - NMR at 93 GeV = -15 MeV

Plots suggest $\pm 15$ MeV error is reasonable. To be discussed.

(This made using ISR magnet model. New Prevessin fit seems to barely affect result – Federico investigating.)

# BPM residuals with magnet centre constrained fit

Making fit through all BPMs, assuming bend in centre of magnet (now measured to be good to 1.7 mm by Federico) look at fit residuals after ramp and attempt to identify bad BPMs. Write simulation to help understand/verify behaviour.



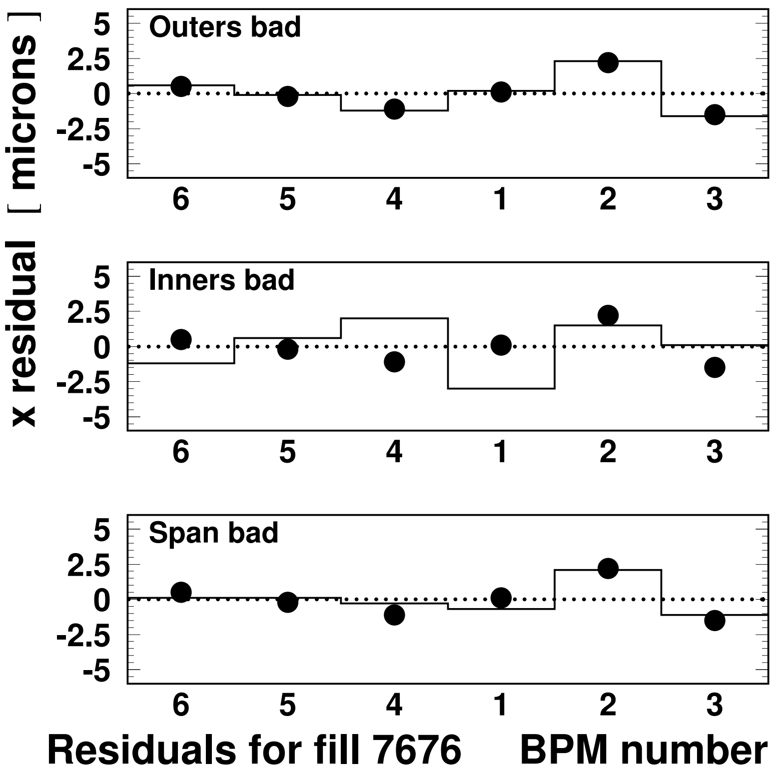

Difficulties in using this to identify bad BPMs:

- Only sensitive in case when systematic is significantly different between arms.
- For given shift in a BPM, expected change in fit residual is different across spectrometer, with bigger effects expected in inner BPMs than outer BPMs.

Thus method has limited sensitivity. Nonetheless in fills with most significant shifts the comparison with simulation suggests that the inner pairs remain stable, & BPMs 6 & 3 move.

# BPM residuals with magnet centre constrained fit

## Another example:




## and another one: