RTML Coupling Correction Update

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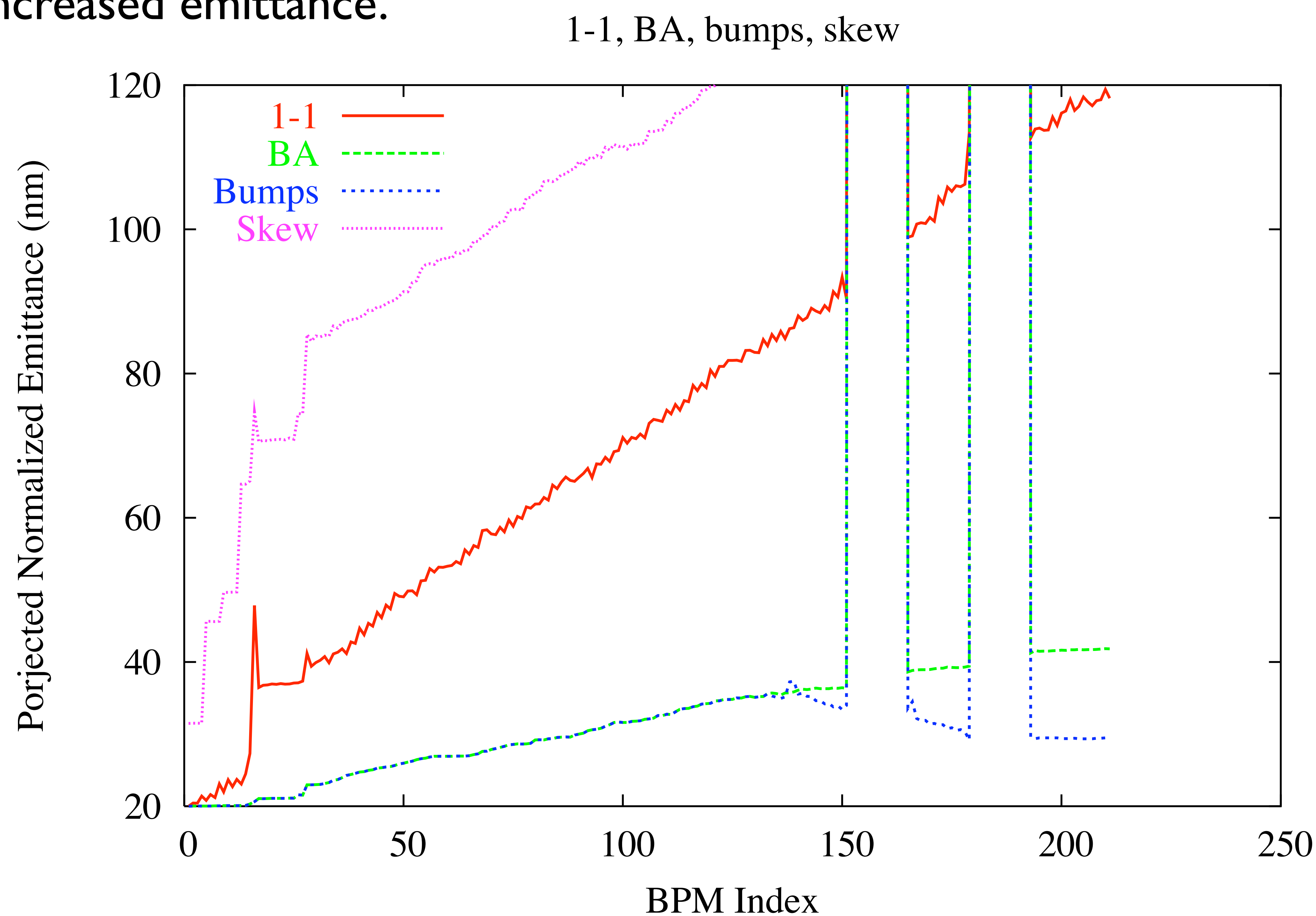
August 29th, 2006

GDE Accelerator Physics Meeting

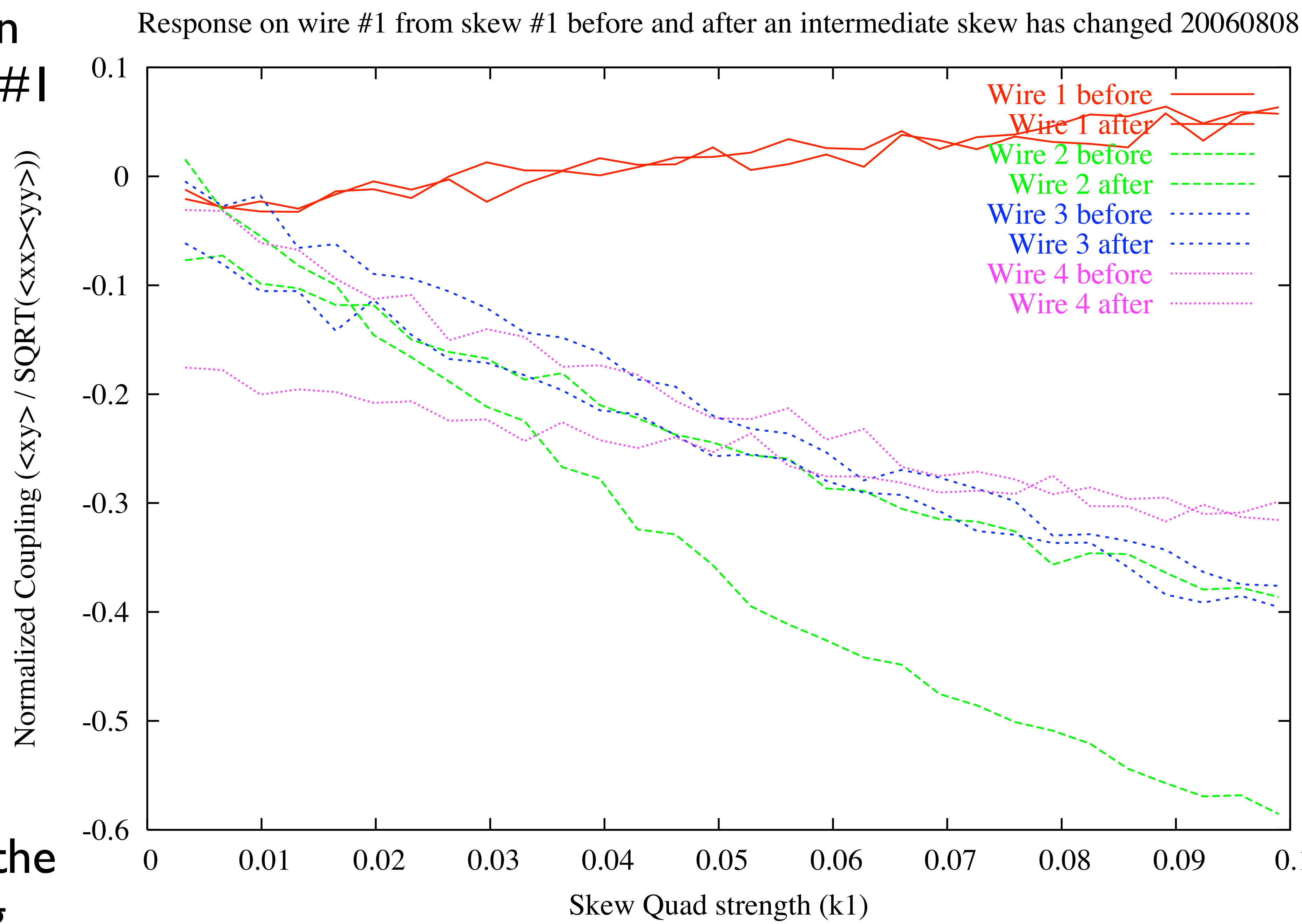
Performance back at Vancouver

- 1-1, BA then dispersion bumps worked reasonably well, but there still was an appreciable contribution (several nm) due to coupling.
- Skew correction method did not perform well in decoupling the beam and many times drastically increased emittance.



Analytical Solution

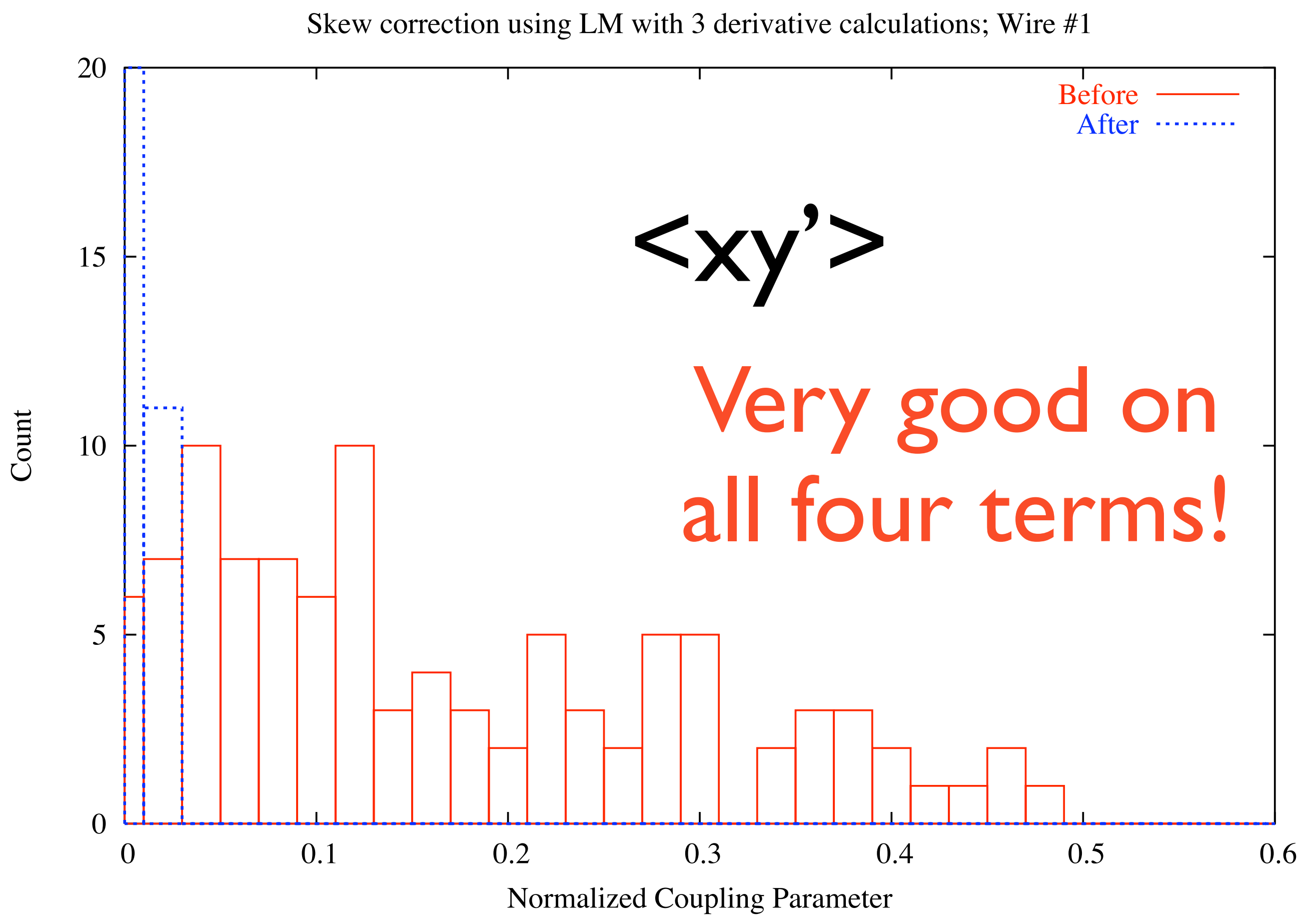
- There was a thought that a more analytical method could be found where given a set of measurements on the four wire scanners, appropriate strengths could be found on the four skew quads.
- Here, the response on wire #1 due to skew #1 is shown
- Both with perfect lattice and one tilted intermediate quadrupole
- The response on the wires is linear with the skew strength as expected.
- However, the slope is highly dependent on the intermediate coupling so, no analytical formula can be found without knowledge of the intermediate coupling. (Some kind of scanning must be performaned to find the response matrix.)

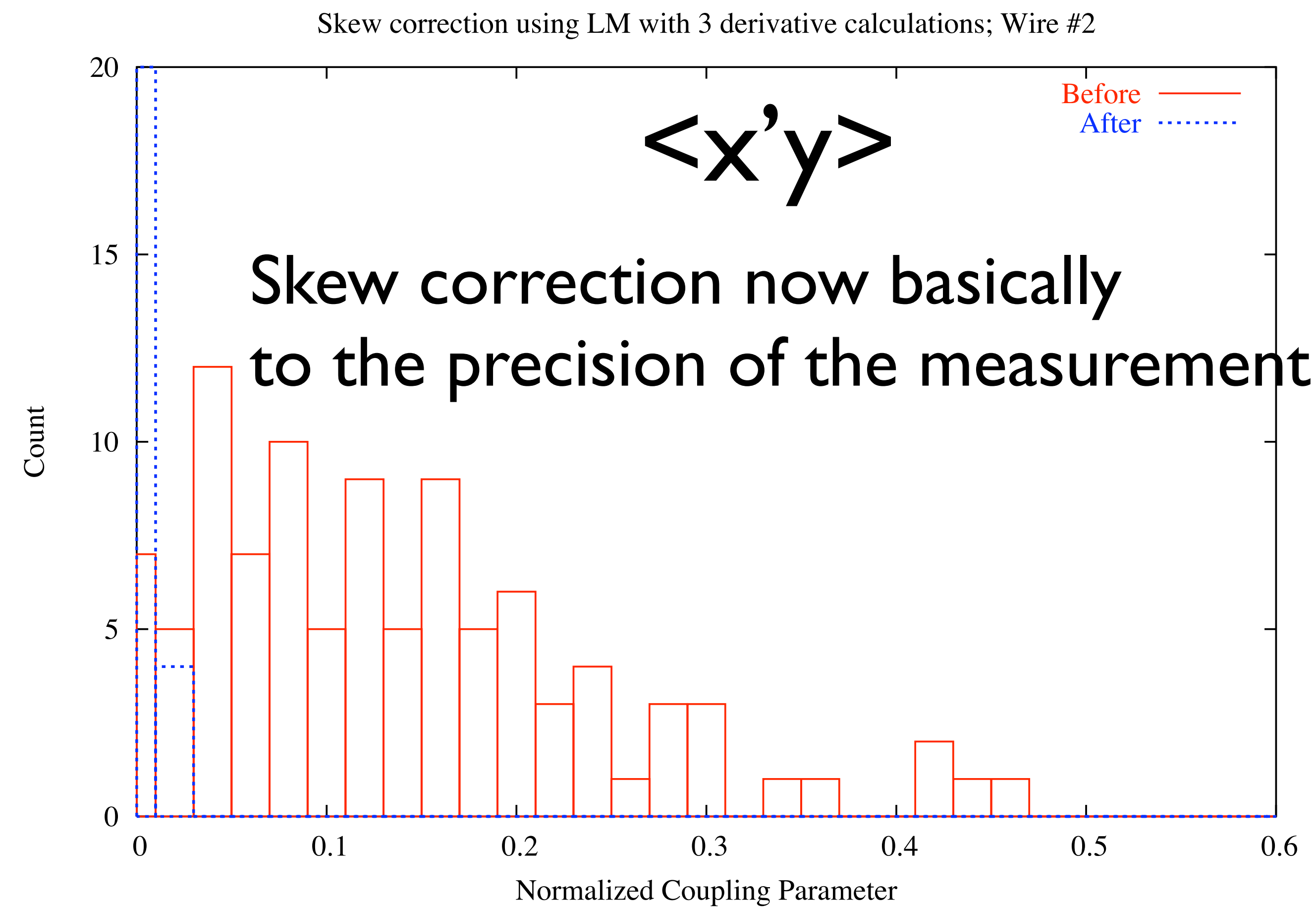


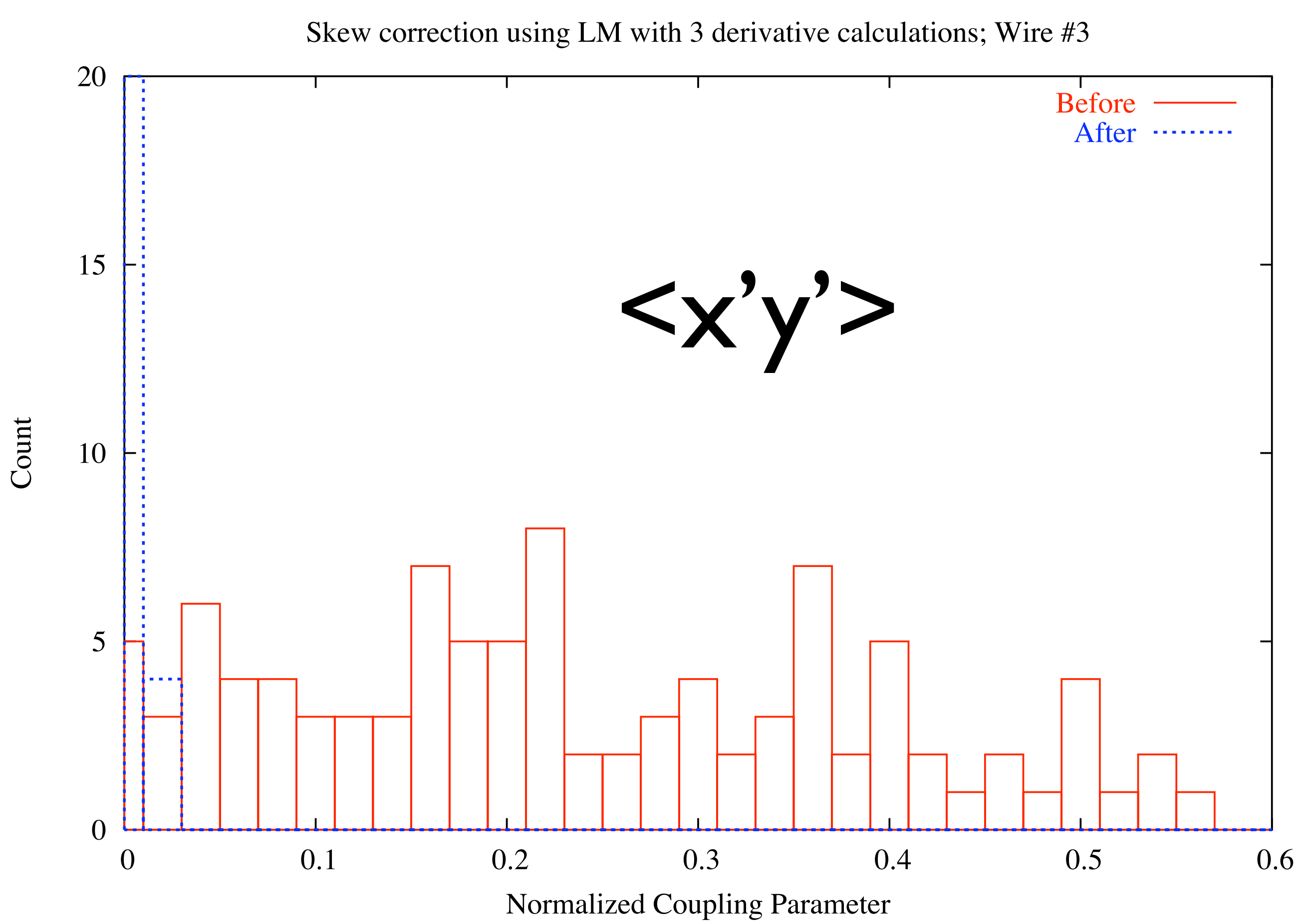
Better method found

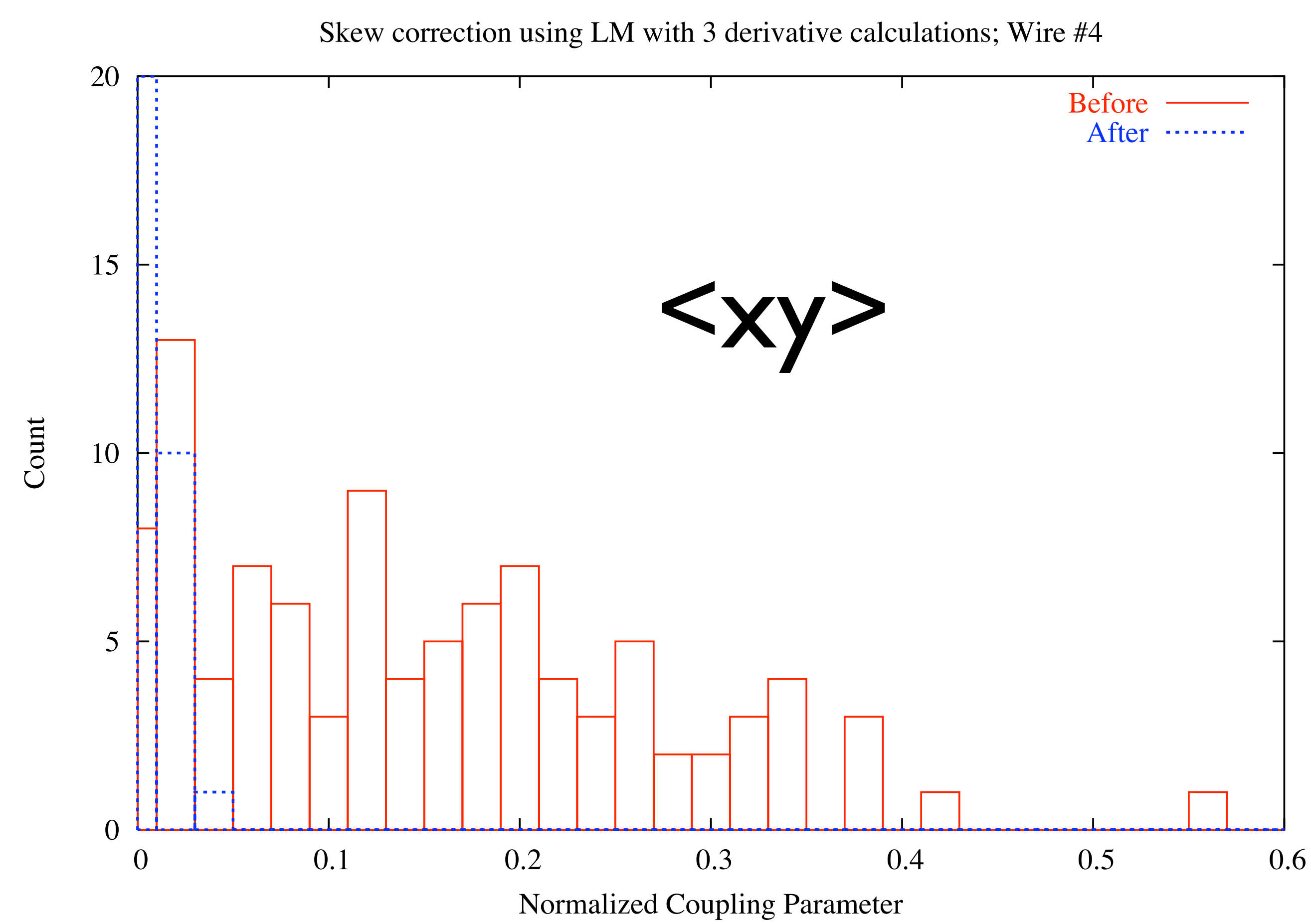
- My iterative technique was not working well:
  - Find wire with largest coupling value
  - Use skew quad that the above wire is most responsive to and zero <xy> term in wire
  - iterate until all 4 wires are zeroed
- A nonlinear optimizer, Levenberg-Marquardt or LM, was found to perform very well if the response matrix is recalculated several times during the optimization process.
- Levenberg-Marquardt is from Numerical Recipes, however, provided the response matrix is recalculated after each iteration a linear optimizer could probably also be used.

LM Skew Correction Performance

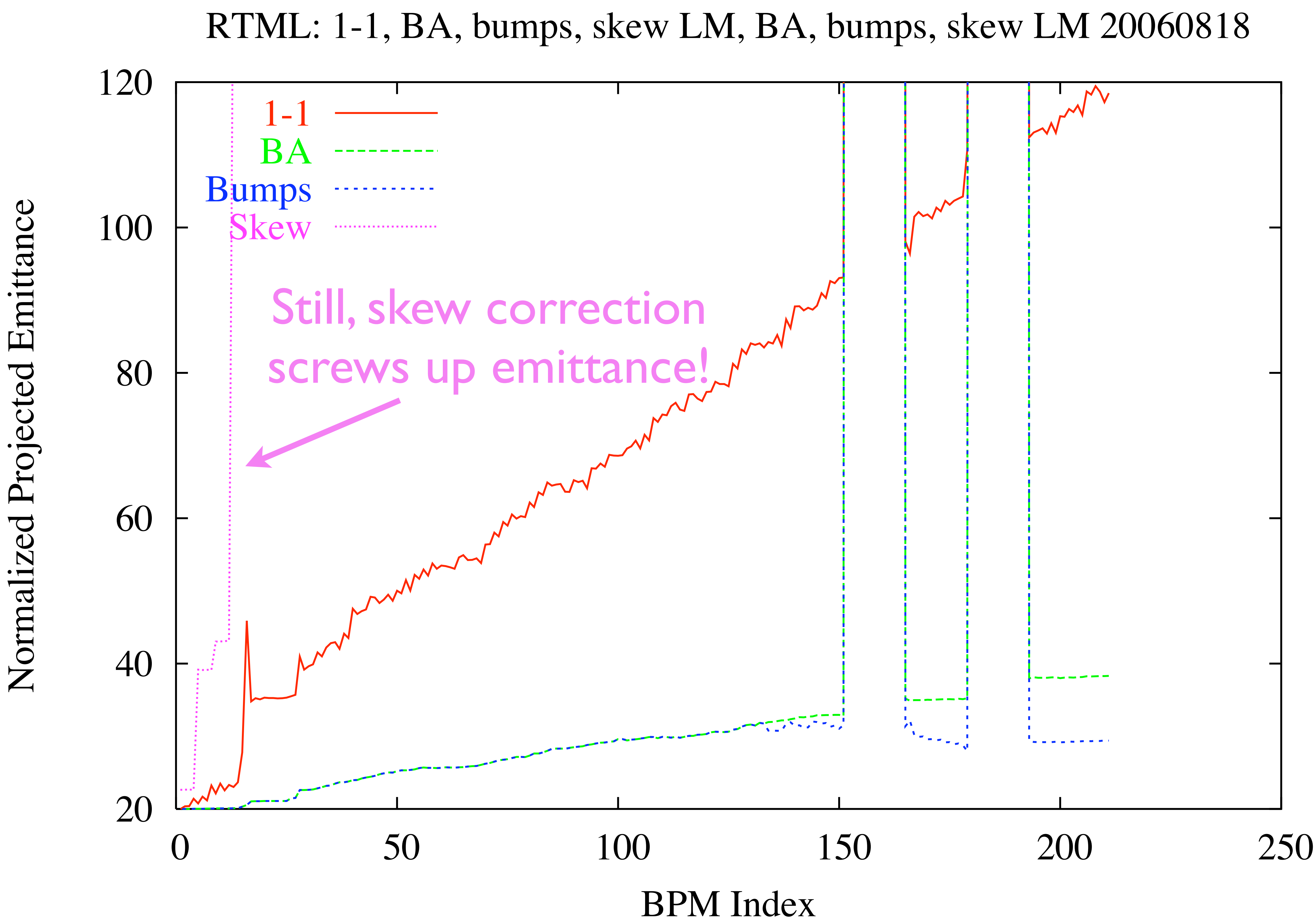








Emittance preservation with new method?



What's going on?

- New skew correction method decouples beam very well. Why does emittance blow up?
- The reason is that the skew correction alters the vertical dispersion along the machine by altering the beam's x-y coupling and there's large dispersion in the horizontal.
- So, if the vertical dispersive emittance growth is minimized before the skew correction, it won't be after the skew quads have modified the intermediate coupling terms.
- Ultimately, by separating the skews from the wire scanners, emittance tuning and coupling correction become irreparably intertwined.

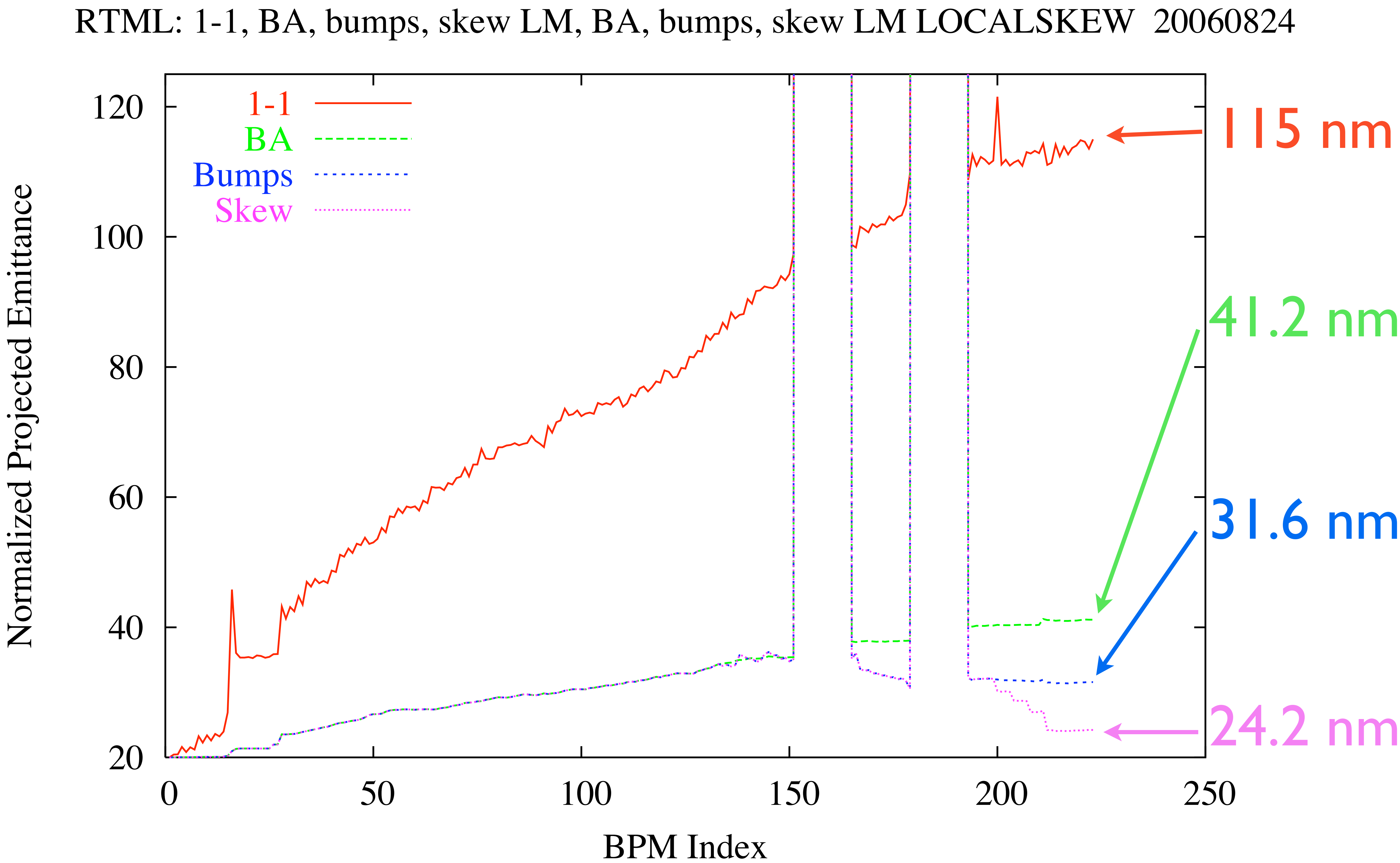
Solutions...

- Tried performing skew correction first.
  - Didn't work, emittance tuning (by changing beam orbit) changes coupling terms so after emittance tuning beam is recoupled
- Tried Iterating
  1. Emittance tuning
  2. Skew Correction
  3. repeat
  - Didn't improve performance
- Emittance tuning and skew correction should be "decoupled" in order to easily perform tuning...

The Solution:

- Move skew correction to immediately upstream of wire scanners.
- This way, varying the skew strength will have minimal effect on vertical dispersion in RTML
- Results on next page...

It Worked!


RTML: 1-1, BA, bumps, skew LM, BA, bumps, skew LM LOCALSKEW 20060824
1-1
BA
Bumps
Skew
Normalized Projected Emittance
BPM Index
120
100
80
60
40
20
0
50
100
150
200
250
115 nm
41.2 nm
31.6 nm
24.2 nm

So...

- Skew correction should be as close as possible to wire scanners to make skew correction and emittance tuning robust.
- Perhaps they should even be on top of each other?
  - The 4 skews and the 4 wires have the same phase, so why not just place each skew directly in front of its corresponding wire scanner?

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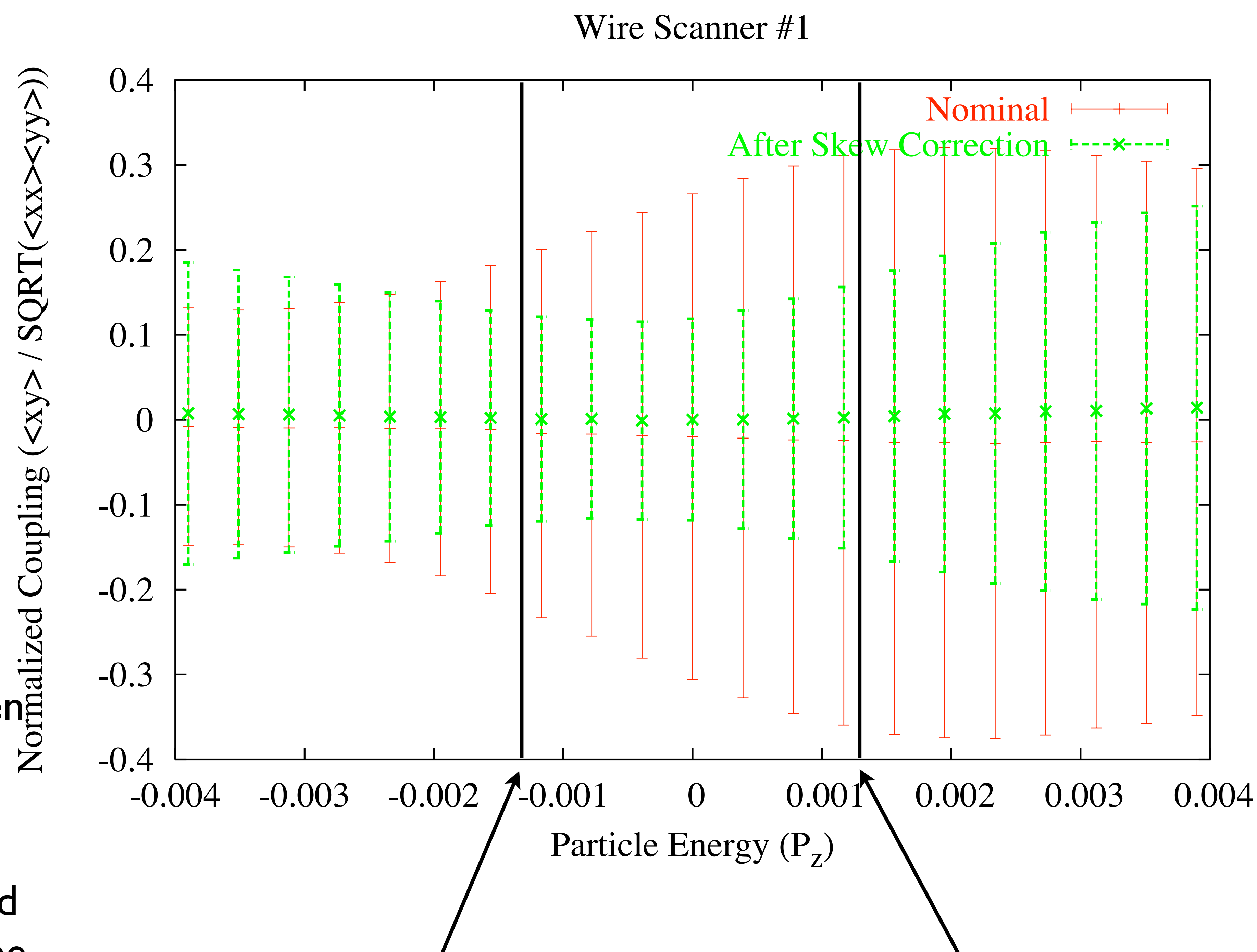
Not due to Energy Spread

- Here, Quads where tilted by 1e-3 mrad rms and energy spread zeroed.
- Coupling measured on wire scanner #1 both before and after skew correction
- Do 100 seeds, standard deviation plotted at right
- The beam energy was then adjusted and process repeated
- So, although energy spread has some effect, it's not the dominant factor



Nominal RMS energy spread: 0.0013