

RTML Coupling Correction Update

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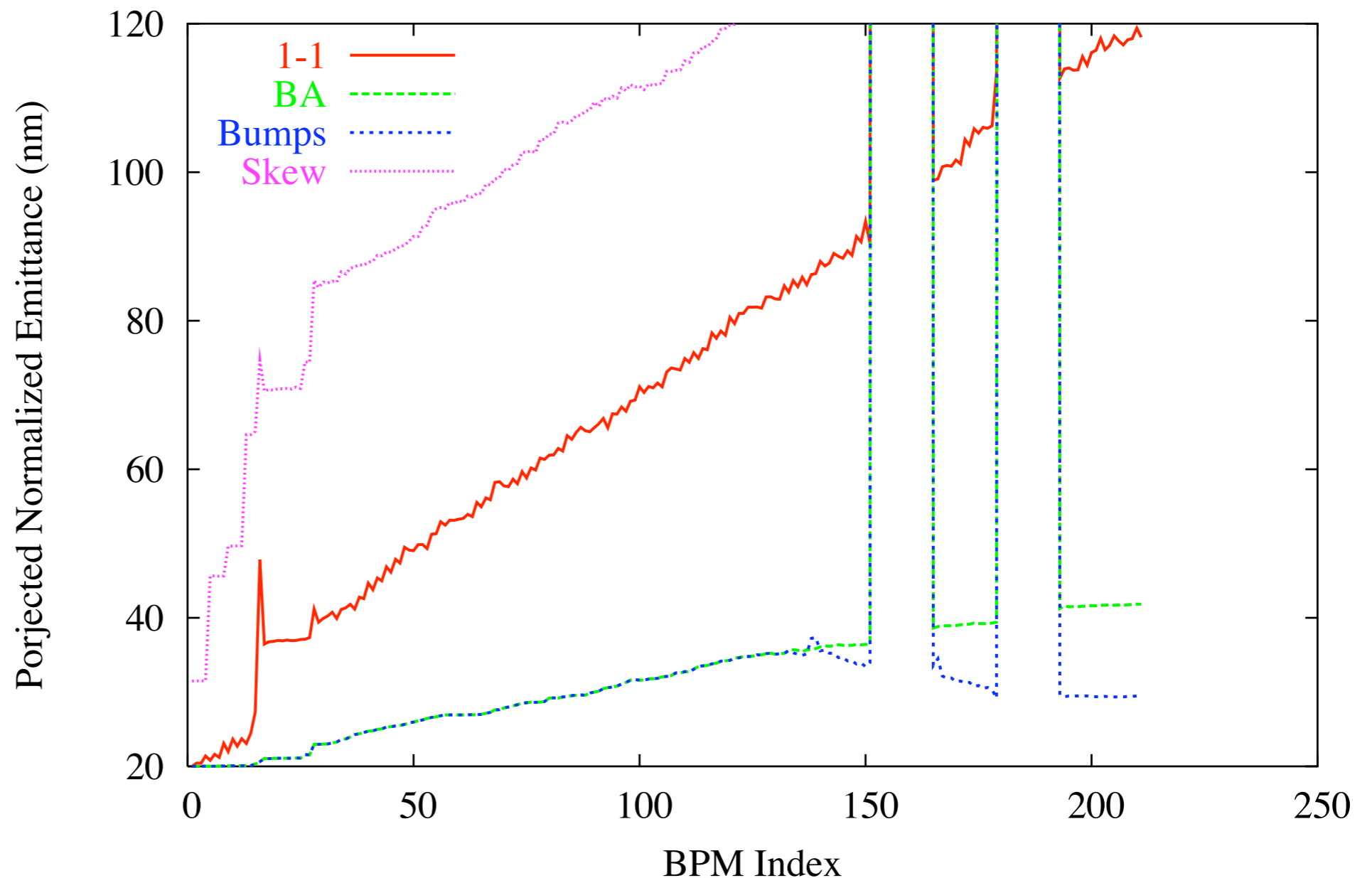
August 29th, 2006

GDE Accelerator Physics Meeting

Performance back at Vancouver

- I-I, 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.

1-1, BA, bumps, skew



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.

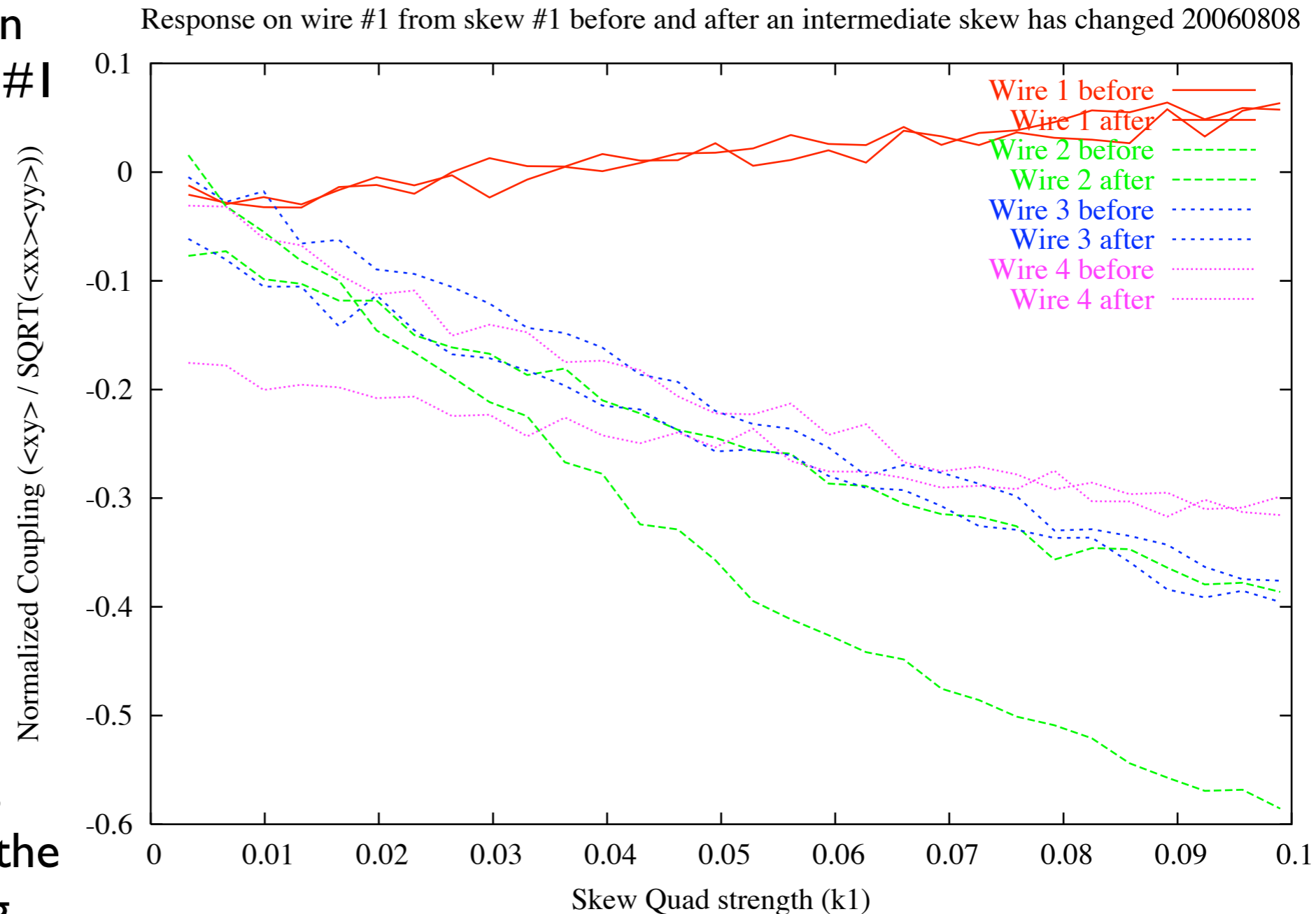
- Here, the response on wire #1 due to skew #1 is shown

- 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 performed to find the response matrix.)

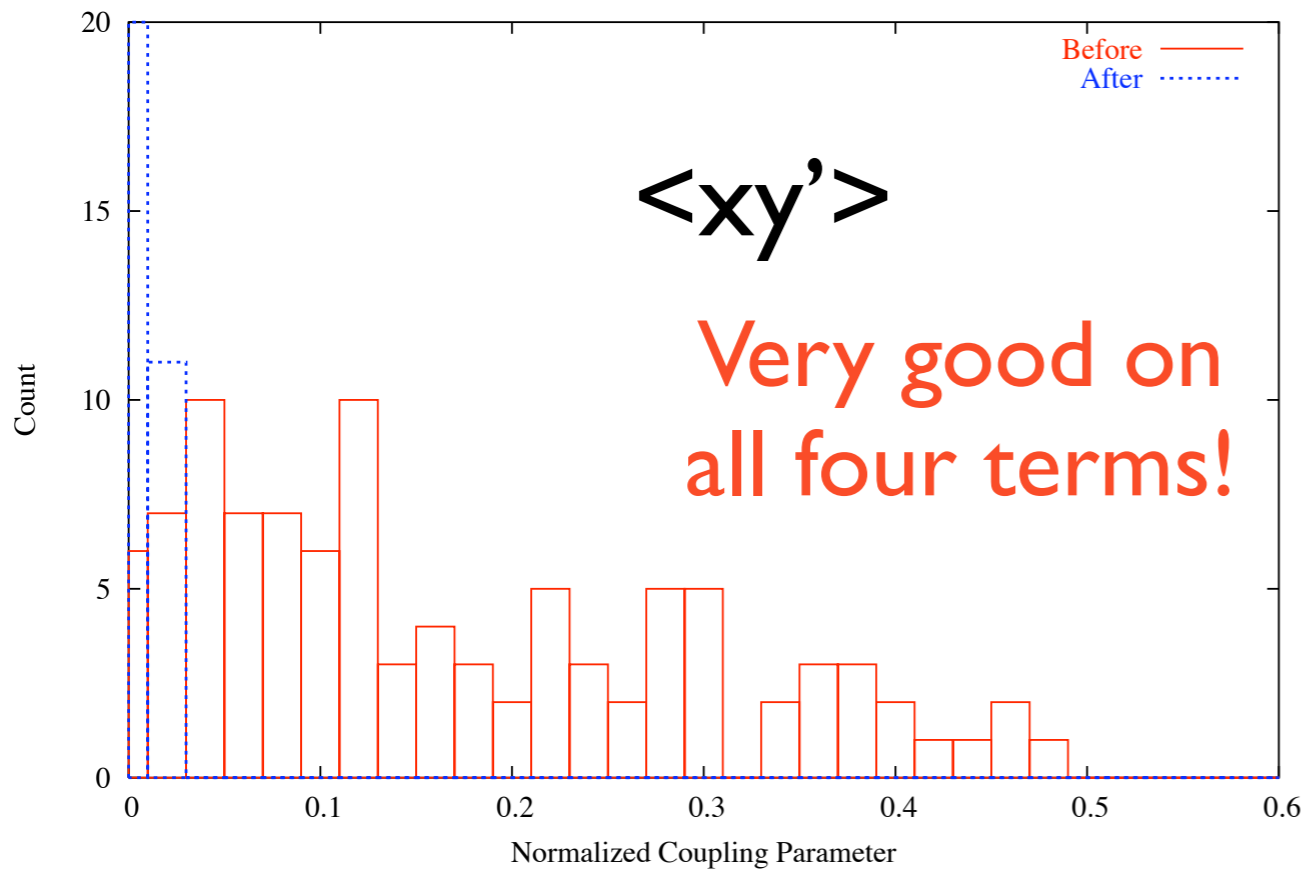


Better method found

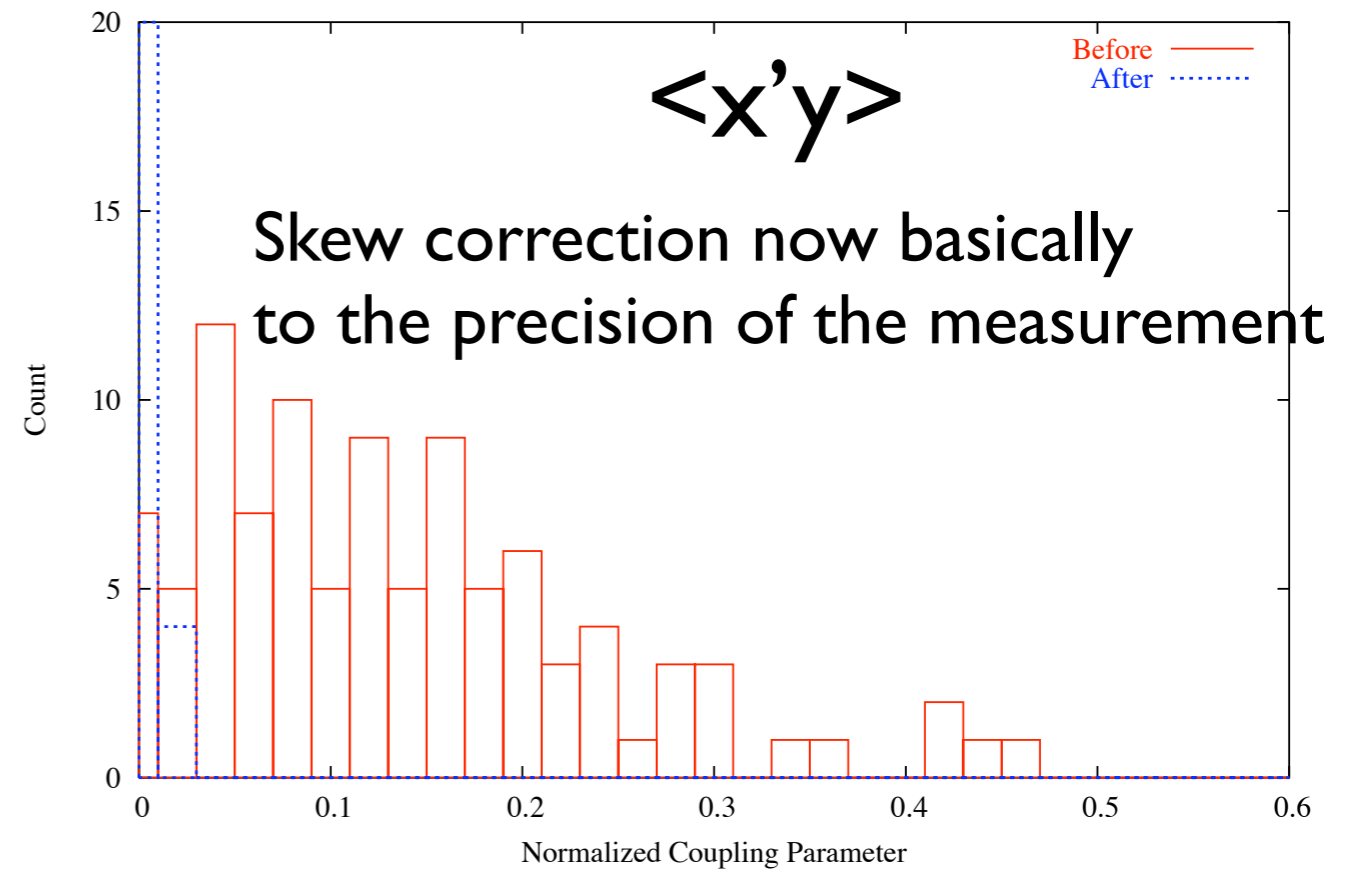
- My iterative technique was not working well:
 - Find wire with largest coupling value
 - Use skew quad that the above wire is most responsive to and zero $\langle xy \rangle$ term in wire
 - iterate until all 4 wires are zeroed
- A nonlinear optimizer, Levenberg-Marquardt or LM, was found to perform 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

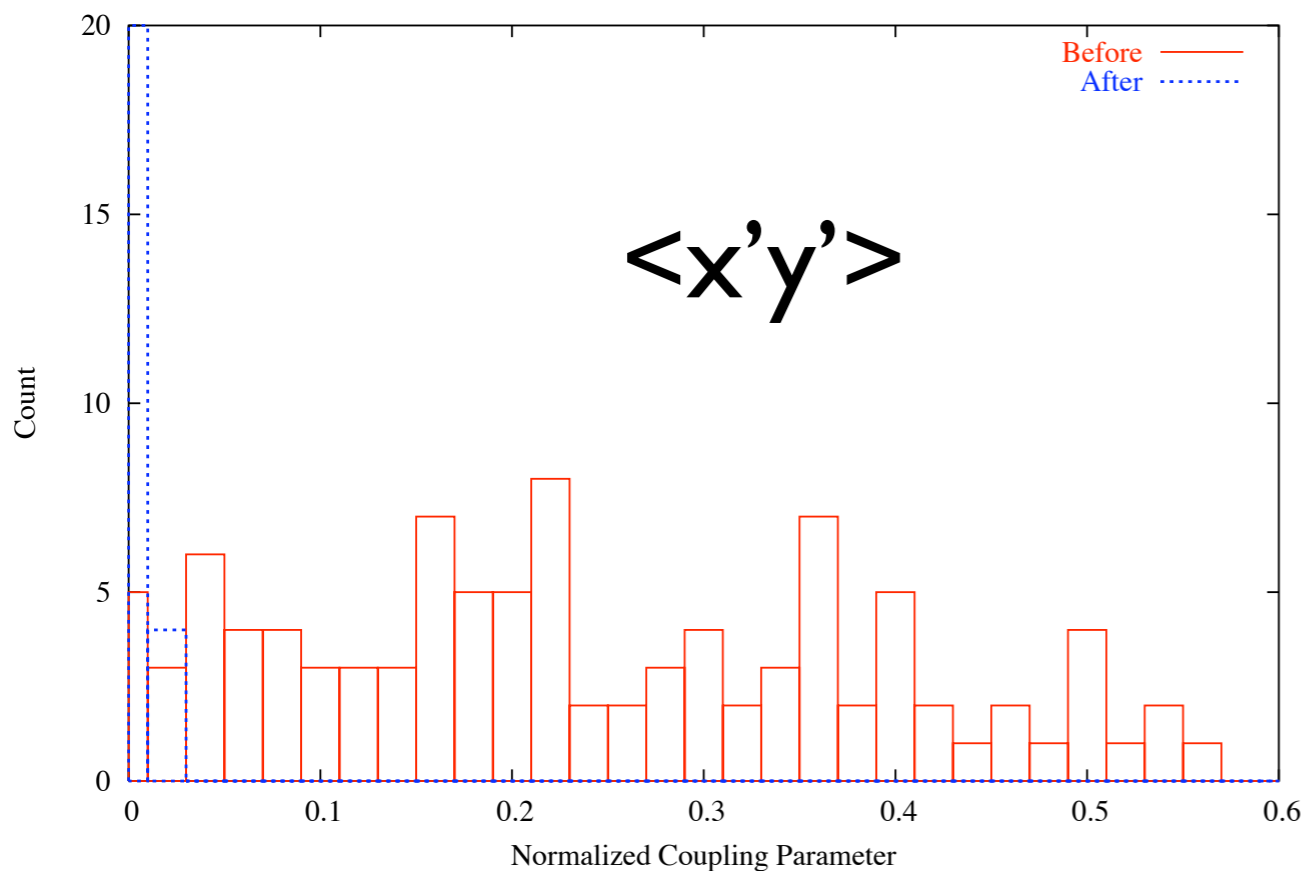
Skew correction using LM with 3 derivative calculations; Wire #1



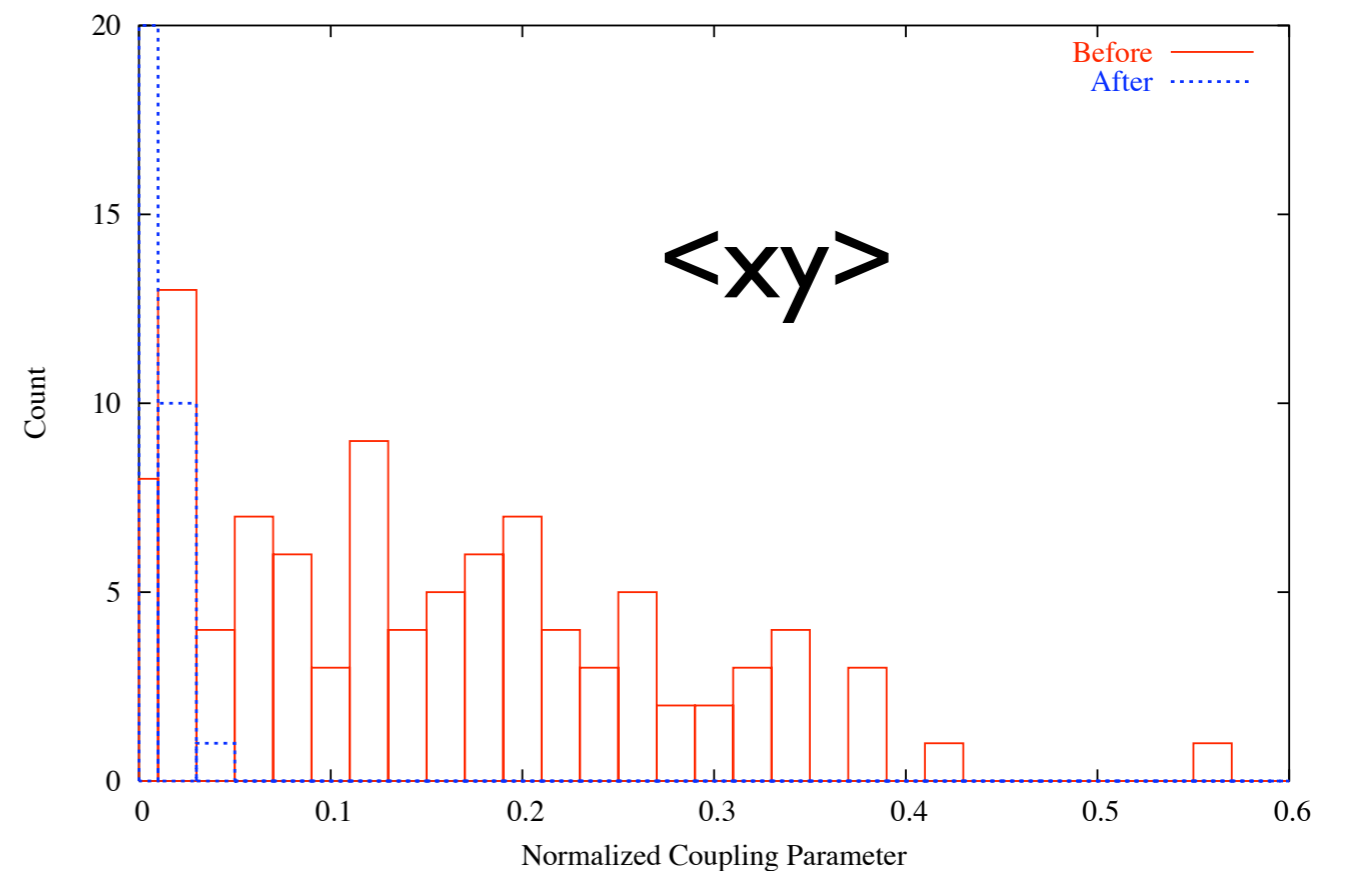
Skew correction using LM with 3 derivative calculations; Wire #2



Skew correction using LM with 3 derivative calculations; Wire #3

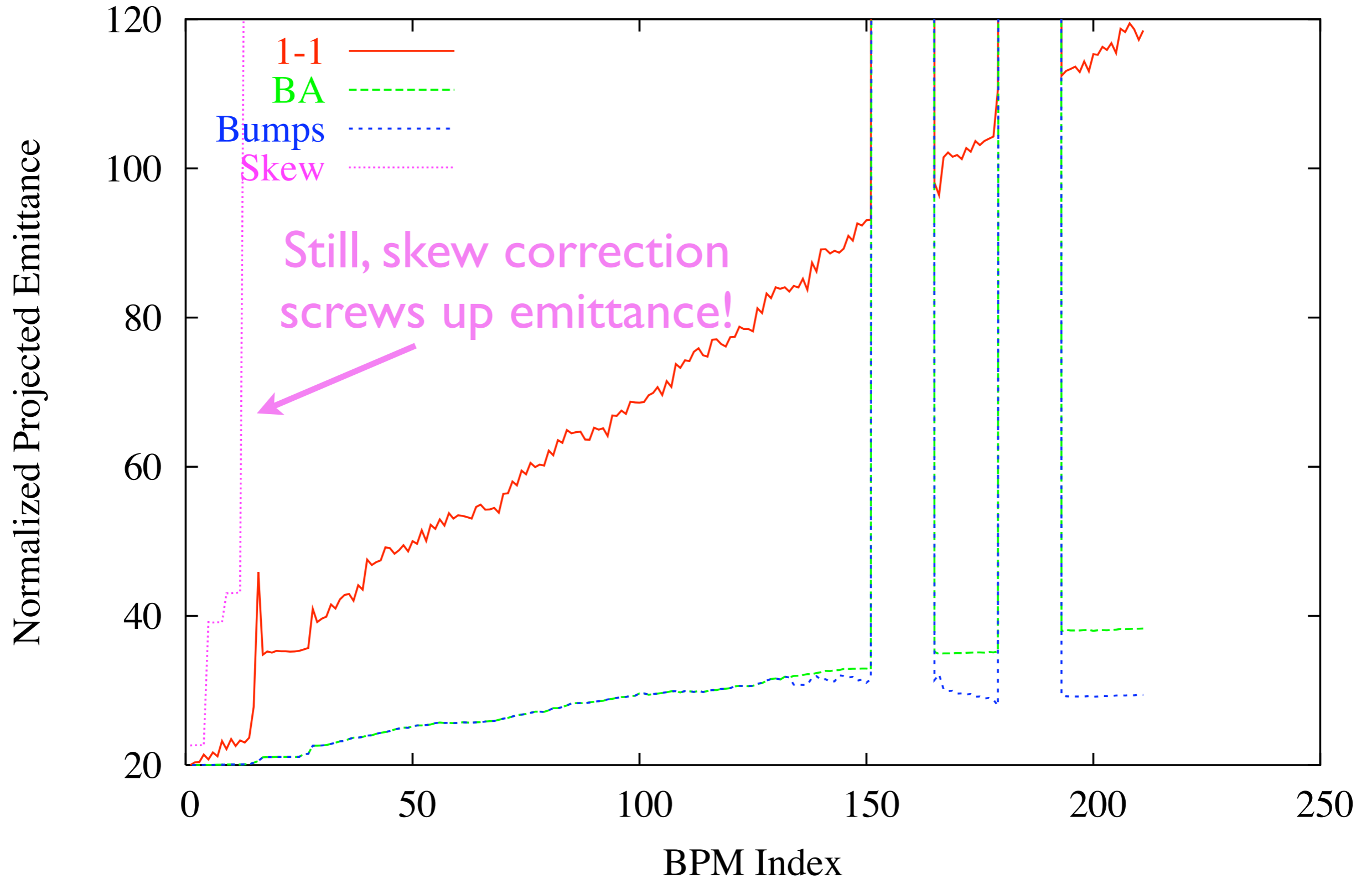


Skew correction using LM with 3 derivative calculations; Wire #4



Emittance preservation with new method?

RTML: 1-1, BA, bumps, skew LM, BA, bumps, skew LM 20060818



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...

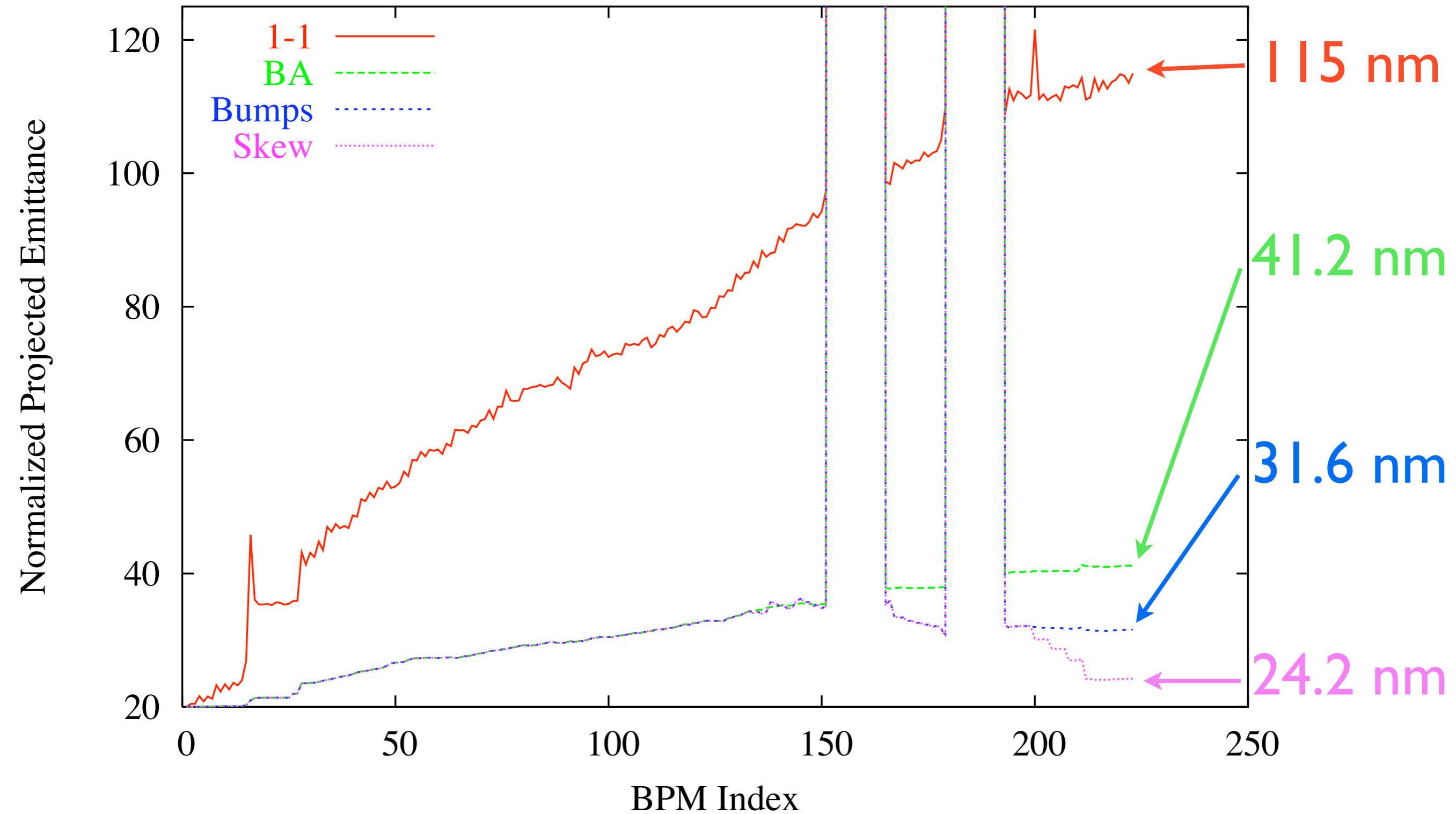
- Tried performing skew correction first.
 - Didn't work, emittance tuning (by changing beam orbit) changes coupling terms so after emittance tuning beam is recoupled
- Tried Iterating
 1. Emittance tuning
 2. Skew Correction
 3. repeat
 - Didn't improve performance
- Emittance tuning and skew correction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



So...

- Skew correction should be as close as possible to wire scanners to ensure skew correction and emittance tuning do not interfere with each other.

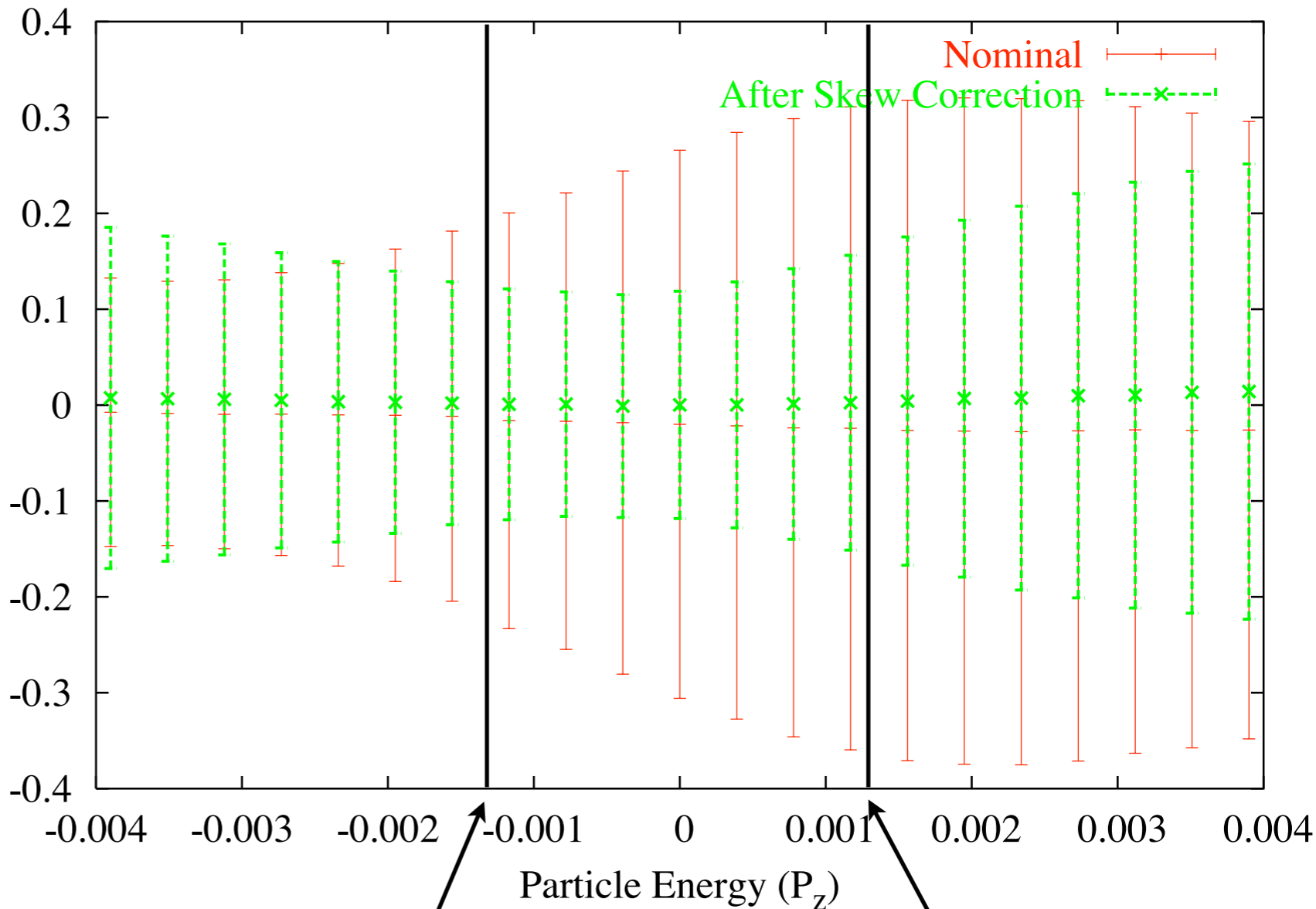
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Not due to Energy Spread

Wire Scanner #1

- Here, Quads were 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

Normalized Coupling ($\langle xy \rangle / \text{SQRT}(\langle xx \rangle \langle yy \rangle)$)



Nominal RMS energy spread: 0.0013