Chromaticity Modeling

W. Chou, March 20, 2003

1. Main contributors to the chromaticity:

$$\xi(\text{total}) = \xi(\text{lattice}) + \xi(\text{dogleg}) + \xi(\text{body sext}) + \xi(\text{chrom sext})$$

Lattice: $\xi = -1/4\pi \times \sum \beta_i (qL)_i$ $\quad qL = B'L / B\rho$
96 magnets, distributed around the ring

Dogleg: $\xi = -1/4\pi \times \sum \beta_i (qL)_i$ $\quad qL = B'L / B\rho$
2 sets: Dog-3 and Dog-13

Body sextupole: $\xi = -1/4\pi \times \sum \beta_i D_i (sL)_i$ $\quad sL = B''L / B\rho$
96 magnets, distributed around the ring

Chrom sextupole: $\xi = -1/4\pi \times \sum \beta_i D_i (sL)_i$ $\quad sL = B''L / B\rho$
SEXTS: 12, one at each Short-odd
SEXTL: 9, three at each L4, L8, L18 $\Leftarrow$!

2. How the doglegs affect the chromaticity:

- The doglegs' direct contribution $\xi(\text{dogleg})$ is small:
  $\sum qL$ (Dog-3 & Dog-13) $= 0.1152\ m^{-1}$
  qL (one F magnet) $= 0.1567\ m^{-1}$
  So $\xi(\text{dogleg}) \approx 1\%\ \xi(\text{lattice})$
- Their impact on $\xi(\text{lattice})$ and $\xi(\text{body sext})$ is also small. This is because the changes of β-function and D-function due to the doglegs are averaged out around the ring.
- The main impact is on $\xi(\text{chrom sext})$, because these sextupoles are localized, especially SEXTL. The local perturbations of β and D due to the doglegs are large. Furthermore, this perturbation is time dependent.

	$\xi(x)$	$\xi(y)$
(1) Bare lattice (Lat)	-9.16679	-7.03638
(2) Lat + 2 Doglegs	-9.57427	-7.01265
(3) Lat + 1/4 Dogleg	-9.13578	-7.19977
(4) Lat + body sext	-23.55770	11.65977
(5) Lat + body sext + Dog03	-23.65678	11.40421
(6) Lat + body sext + Dog13	-23.64934	11.38948
(7) Lat + body sext + 2 Doglegs	-23.40371	11.00271
(8) Lat + body sext + chrom sext + 2 Doglegs	0.04399	-0.18496
(9) Lat + body sext + chrom sext (no Dogleg)	3.67119	-11.11968

3. Method of chromaticity modeling - two steps:

- Step 1 - Getting body sextupole values throughout the cycle:
  - At each moment of the cycle (e.g., every millisecond), measure ξ(total) for given SEXTS and SEXTL current.
  - Use MAD to calculate ξ(lattice), ξ(dogleg), ξ(chrom sext).
  - The difference is ξ(body sext), from which one can calculate the body sextupole strength ssf and ssd at this moment.
  - The body sextupole values have time dependence because of the remnant field.

- Step 2 - Writing an Excel spreadsheet:
  - With ssf and ssd known, for any given SEXTS and SEXTL (in ampere) one can calculate ξ(total).
  - Or vice versa, for any given ξ(total), one can calculate SEXTS and SEXTL (in ampere). - This is the spreadsheet that Francois is working on.

We are still in Step 1 now.

4. Successes and problems:

- A successful "blind check" on body sextupole at injection:
  - One team at the MCR measured the DC chromaticity at 9 different settings of SEXTS and SEXTL and got the values of ssf and ssd.
  - Another team at the E4R measured the field and got the values of ssf and ssd.
  - The two teams did not talk to each other before they reported their results (a blind check).
  - The results agree with each other very well.

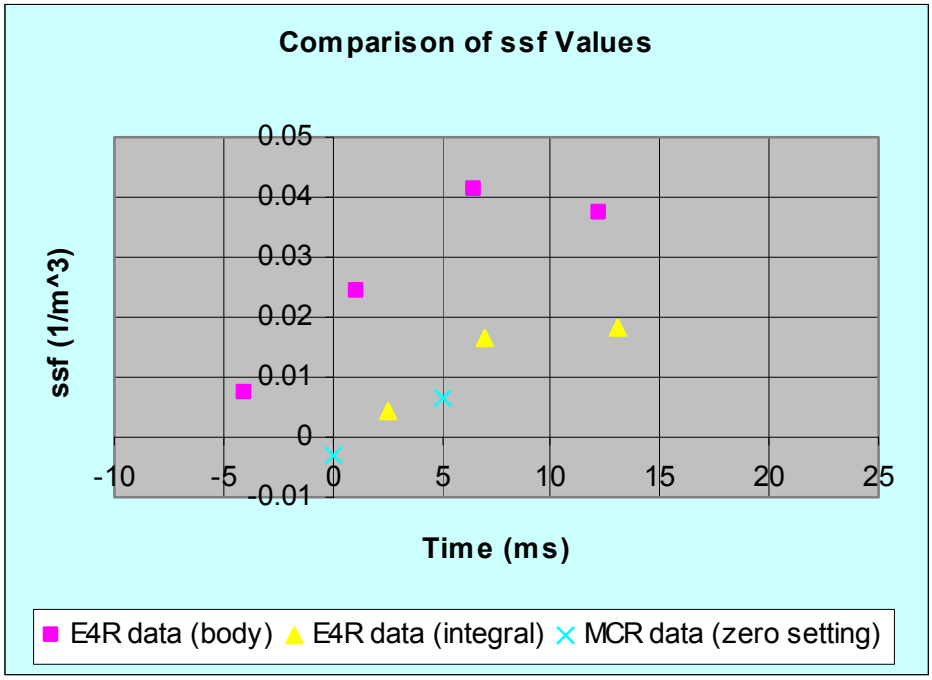
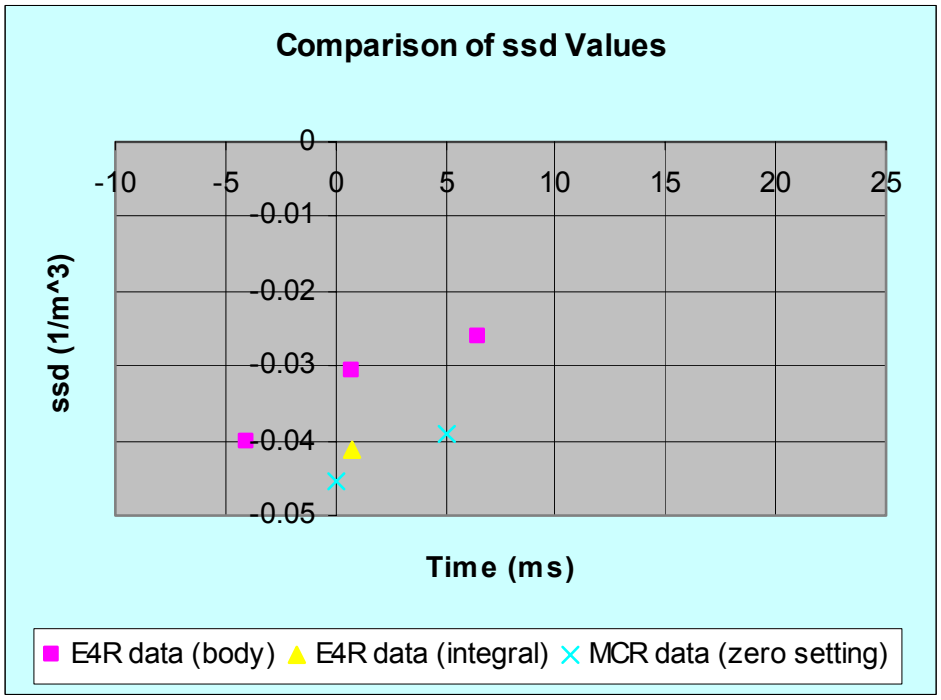
- But we are less successful in the rest of the cycle:
  - We have 4 measured chromaticity data sets:
    1) DC chromaticity at 9 different chrom sext current settings (Jan 30, 2003)
    2) AC chromaticity at zero chrom sext current (first 13 ms, Ray, Jan 10, 2002)
    3) AC chromaticity at zero chrom sext current (first 13 ms, FN-620, 1994)
    4) AC chromaticity at normal chrom sext current setting (whole cycle, Jan 28, 2003)
  - The first three data sets agree with each other fairly well.
  - But the last one shows significant discrepancy.
  - Moreover, the fitted values of ssf and ssd from 4) do not meet the expected remnant field character. In particular, the ssd variation looks weird.

5. Need more measurements:

- More field measurement: (Joe, Phil)
  - DC: Every 100 A up to 1000 A.
  - AC: An improved stretched wire method for better resolution.

- More chromaticity measurement: (Ray and the clique)
  - Zero chrom sext current: Re-measure it for better accuracy.
  - Actual setting of chrom sext current: Pick several moments during the cycle and measure it manually instead of using the automated procedure.

F magnet



D magnet