‘Phase Trombone’ for HAPPEX

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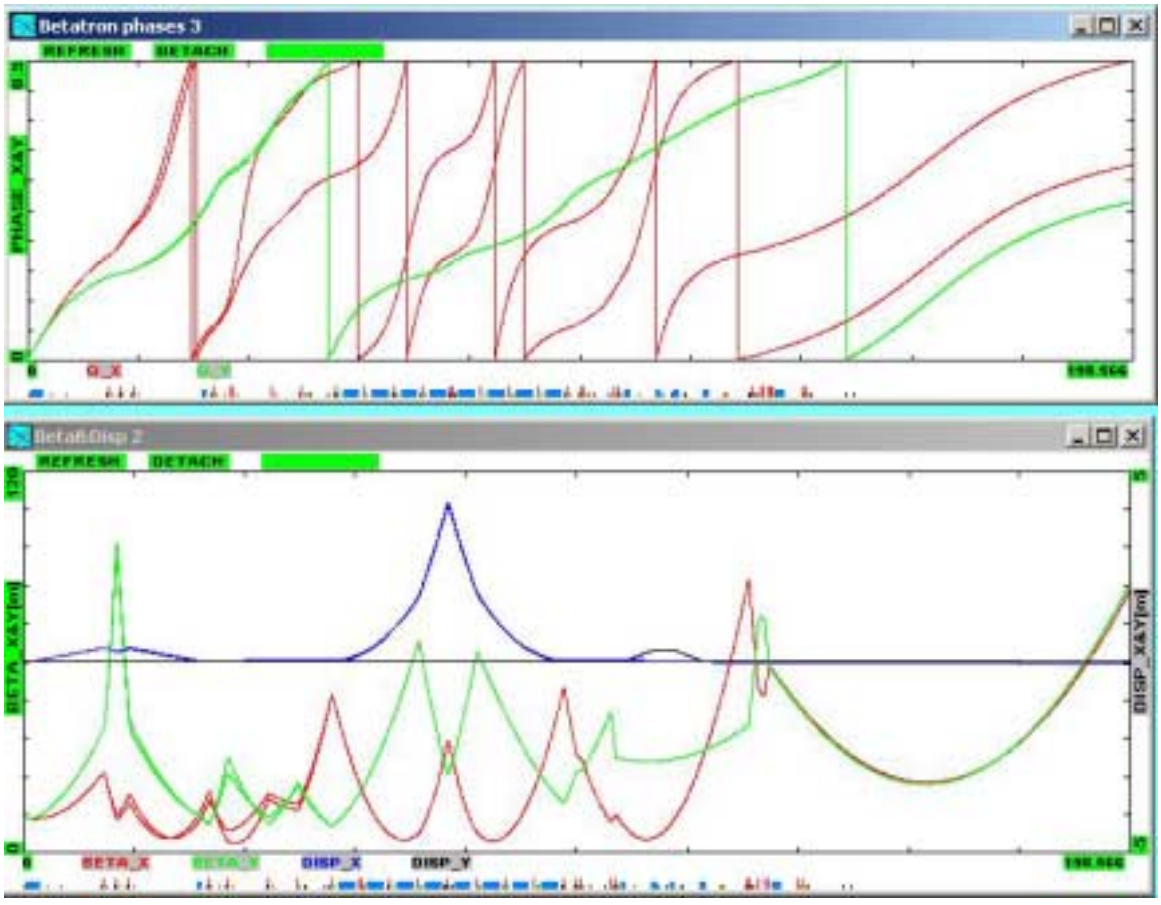
- Suppression of betatron motion driven helicity asymmetries
  - betatron phase ‘sweep’ to average out helicity asymmetries
- ‘Phase Trombone’ in Hall A
  - ‘closed beta bump’ insert before the Hall A arc (1C01-1C08)
  - independent control in the horizontal and vertical betatron phases (±60 deg.)
- Hall A Optics implementation with eight quads (2 x 2 +2+ 2 = 8)
- ‘Multi knob’ control software (Michele Joyce)

- Phase Trombone Optics ($\Delta\phi_x$=60 deg)
  - top plot – betatron phase (hor/red, ver/green in units of 2π, mod π); hor. phase advances by 60 deg while the vertical phase stays fixed.
  - bottom plot – beta functions (hor/red, ver/green); optics altered before the arc to accommodate the phase shifts is matched to the design at the beginning of the arc



- ‘Multi knob’ algorithm – cubic spline parameterization for 8 quads

MQA1C01

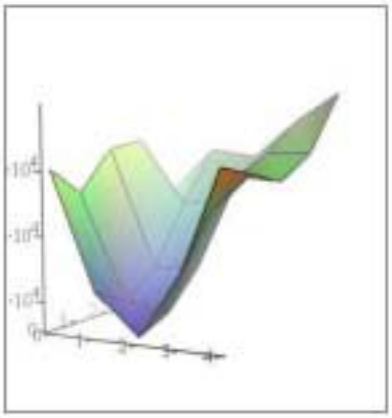
Computed spline coefficients:

$$S1 := cspline(Mxy, M1)$$

Fitting function for surface:

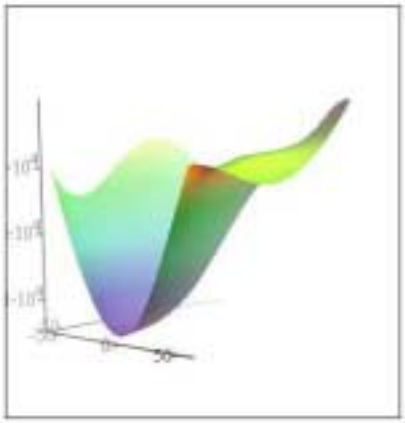
$$F1(x, y) := interp\left[S1, Mxy, M1, \begin{pmatrix} x \\ y \end{pmatrix}\right]$$

Original Surface



M1

Fitted Surface



F1

S1 =

	0
0	0
1	3
2	2
3	0.421
4	1.333
5	2.245
6	0.739
7	-0.768
8	0.576
9	1.629
10	2.681
11	-1.014
12	-4.71
13	1.707
14	1.992
15	2.278
16	-1.657
17	-5.591
18	1.229
19	1.124
20	1.019
21	-0.796
22	-2.611
23	-3.045
24	-0.848
25	1.349
26	-0.136
27	-1.62
28	

- PZT measured helicity asymmetries for various settings of Phase Trombone ($\Delta\phi_x$, $\Delta\phi_y$) – as measured by Kent Paschke (May 26, 2004)

PT set	Dx(+/-0.3 μm)	Dy(+/-0.3μm)	Dx'(+/-0.01μrad)	Dy'(+/-0.02 μrad)
(0, 0)	2.0 μm	2.9 μm	-0.19μrad	-0.08 μrad
(30, 0)	1.2 μm	2.7 μm	-0.22μrad	-0.07 μrad
(-30,0)	3.2 μm	2.8 μm	-0.16μrad	-0.0.7 μrad
(30,30)	1.0 μm	1.2 μm	-0.21μrad	-0.12 μrad

- Excellent orthogonality of two independent planes for standard level of betatron match of the Hall A line (done through 8T matching quads).
- Easy to use software interface GUI (Michele Joyce)