SINGLE PASS COLLIDER MEMO CN-354

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TITLE: PROPOSAL FOR MONITORING THE OFF-ENERGY FUNCTION IN THE ARCS*

I. What to Measure.

For each of two energies, E_1 and E_2 - - determined from measurements in the launch spectrometer - - measure the corresponding $x-$ and $y-$ positions at all corresponding BPM's. Let the X-BPM's in each Achromat be labeled n (from 0 to 9) and the Y-BPM's be labeled m (also from 0 to 9).

For X-BPM number n, define

$$\eta_{xn} = E_1 (\frac{\Delta x}{\Delta E})_n;$$

and for Y-BPM number m,

$$\eta_{ym} = E_1 (\frac{\Delta y}{\Delta E})_m$$

II. What to Calculate for Each Achromat.

Let me label Achromats by "ℓ" ($\ell = 1, 2, \ldots 23$).

For <u>each Achromat</u> calculate, using formulas below,

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$\eta_{xM}(\ell)$ = average of η_{xn}

$\eta_{xA}(\ell)$ = cosine component (at ν_o) of η_{xn}

$\eta_{xB}(\ell)$ = sine component (at ν_o) of η_{xn}

and correspondingly for y.

The formulas for these quantities depend on the "Achromat type." I define three types of Achromats: F, D and S.

An F-type achromat begins with a focussing magnet,

A D-type begins with a defocussing type,

An S-type Achromat is anomalous and is to be given special treatment.

It will also be useful to group Achromats into "Achromat Blocks" each containing about three Achromats. I identify them by a block number b (b = 1, 2, ... 8).

Let's also define two "Sectors" in each Arc: Sector A is the part of the Arc before the "reverse" bend and Sector B the part after.

The arrangements of BPM's and Achromats in the Arcs is given in Table I.

The Achromat type is given for each Achromat in Table II.

III. The Formulas.

Let me define an "average" quantity for any function in any one Achromat by

$$\langle f_n \rangle = \frac{1}{10} \sum_{o}^{9} f_n$$

The quantities desired for each Achromat are:

$$\eta_{xM} = \langle \eta_{xn} \rangle$$

$$\eta_{xA} = \langle \eta_{rn} \cos \phi_n \rangle$$

$$\eta_{xB} = \langle \eta_{xn} \sin \phi_n \rangle$$

and same for y.

The phases ϕ_n are determined from

$$\phi_n = \phi_{o\ell} + n\,\Delta\phi,$$

where

$$\Delta\phi = 108^o(always),$$

and $\phi_{o\ell}$ is a constant which depends on the Achromat type and is different for x and y. Specifically,

For x : $\phi_{o\ell} = 0$ in an F-Achromat, 85^o in a D-Achromat.

For y : $\phi_{o\ell} = 85^o$ in an F-Achromat, 0 in a D-Achromat.

These do not apply to the S-Type Achromats. (They will be discussed in a separate note.)

IV. The Display.

It would be useful to have a bar-graph display of the six eta quantities as a function of Achromat number.

The nominal value of η_{xM} is 35 mm, and of η_{yM} is zero. The nominal values of η_{xA} and η_{xA} are zero, while the nominal values of η_{yA} and η_{yB} are variable, ranging from zero to about 20 mm. Table III gives my estimates of the expected value for each Achromat. (Someone should do an accurate calculation of them.)

The measured values may be expected to differ from the nominal values by perhaps 5 to 25 mm. A resolution of the display of about a few mm would be useful.

It would also be useful if the difference between measured and nominal values could be displayed (perhaps only on request). At least for those quantities whose nominal value is not uniformly zero.

A luxury would be to be able to exchange the η_A and η_B displays for the corresponding magnitude and phase displays. (η_A and η_B are the components of a phasor.)

In addition to the displays for each Achromat, it would also be useful to display (for each coordinate) the average of each quantity for each Block, displayed against Block Number. This will, presumably, give less "noise" in the measurements and will be less sensitive to small local perturbations unless they accumulate.

Finally, it would be quite useful to have available Sector averages. The Sector average of η_M will indicate any energy mismatch of the Linac to the Arcs. Non-zero Sector averages of η_A and η_B will show any eta-mismatch at the entrance to the Sector.

V. Rationale.

Eta errors may arise from local anomalies or from accumulating contributions from earlier anomalies. The two quantities η_{xM} and η_{yM} are sensitive only to local disturbances. Propagating η-distrubances travel as a free betatron oscillation, whose amplitude and phase are revealed by $\eta_{xA}, \eta_{xB}, \eta_{yA}$, and η_{yB}. These quantities will therefore show the growth of eta-errors through the Arcs.

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TABLE I: Identification and Grouping of Achromats
(Same for North and South Arcs, except where noted)

Sector	Block No.	Achromat Number	BPM No.
	b	ℓ	n
A	1	1	0 to 9
		2	0 to 9
		3	0 to 9 (North only*)
	2	4	0 to 9
		5	0 to 9
		6	0 to 9
		7	0 to 9
	3	8	Special (omit)
B	4	9	0 to 9
		10	0 to 9
		11	0 to 9
	5	12	0 to 9
		13	0 to 9
		14	0 to 9
	6	15	0 to 9
		16	0 to 9
		17	0 to 9
	7	18	0 to 9
		19	0 to 9
		20	0 to 9
	8	21	0 to 9
		22	0 to 9
		23	0 to 9

*Achromat 3 is missing in the South Arc.

TABLE II: Achromat Type List

Achromat No.	Type	
ℓ	North Arc	South Arc
1 to 2	F	D
3	F	(non-existant)
4-7	F	D
8	S	S
9-23	D	F

TABLE III: Nominal Values of η_{yA} and η_{yB}*

Block No.	Achromat No.	North	Arc	South	Arc
b	ℓ	η_{yA}	η_{yB}	η_{yA}	η_{yB}
1	1	-16	0	0	-20
	2	-14	0	0	-20
	3	0	0	-	-
2	4	0	0	0	-12
	5	0	0	0	0
	6	0	0	0	0
	7	+10	0	0	+12
3	8	-	-	-	-
4	9	+4	0	0	+12
	10	0	0	0	0
	11	0	0	0	-18
5	12	-10	0	0	-22
	13	0	0	0	-22
	14	+14	0	0	-8
6	15	+16	0	0	0
	16	+12	0	0	+22
	17	+18	0	0	+20
7	18	+14	0	0	0
	19	+18	0	0	-22
	20	+18	0	0	+22
8	21	-18	0	0	0
	22	-18	0	0	-18
	23	-18	0	0	-18

*All values in millimeters.