Flat beam experiment
Proposed "plan of action" for 2004 up to energy upgrade

December 14, 2003

Main goals:
1. get enough data for graduating Yin-e Sun,
2. achieve an emittance ratio above 100 and get a refereed paper out of this results.

Physics goals:
1. understand and develop some procedure to properly setup the round-to-flat beam transform,
2. do some thorough parametric studies of the round-to-flat beam transform,
3. work toward achieving an emittance ratio of about 100 (with reasonable largest transverse emittance),
4. if time allows, investigate the bunch compression of flat beams.

Prerequisites:
we must have a clear understanding of:
1. energy evolution in the accelerator,
2. round beam parameter evolution along the beam-line.
3. the transverse emittance diagnostics.

Experimental details:
The flat beam experiment could be divided in four phases each being summarized hereafter:

A diagnostics and lattice tests:
1. test emittance measurement using the slits and quadrupole, quadrupole scans,
2. make sure the skew quadrupole are performing accordingly to their setting (take some set of difference orbit)

B study of the round-to flat-beam transform:
1. **Study of kinetic angular momentum vs B-field on the cathode:**
   Already some data have been taken for Yin-e Sun's PAC2003 paper, but we should retake some of these data to generate a better set than those presented in Fig.4 of this paper. The idea is to vary the magnetic field on the cathode (given a laser spot size) and record the rotation of slits image on different viewers.
2. **Learning how to set-up the round-to-flat beam transformer (see Fig. 1):**
   - a) from X3 slit image observation on X4/X5 (with skew quadrupoles off), determine beam initial conditions, estimate the correlation matrix and with the help of numerical model setup the skew quadrupole to generate flat beam,
   - b) study the evolution of the kinetic angular momentum along the round-to-flat beam adapter (there is a viewer downstream of each skew quadrupole in the adapter so that on can study the evolution of the X3 slit image)

-c) an interesting results would be to see how the smallest of the flat beam emittance compared to the value $\varepsilon_{th}^2/(2L)$ thus we need to try to measure this "thermal" emittance of a magnetized beam.

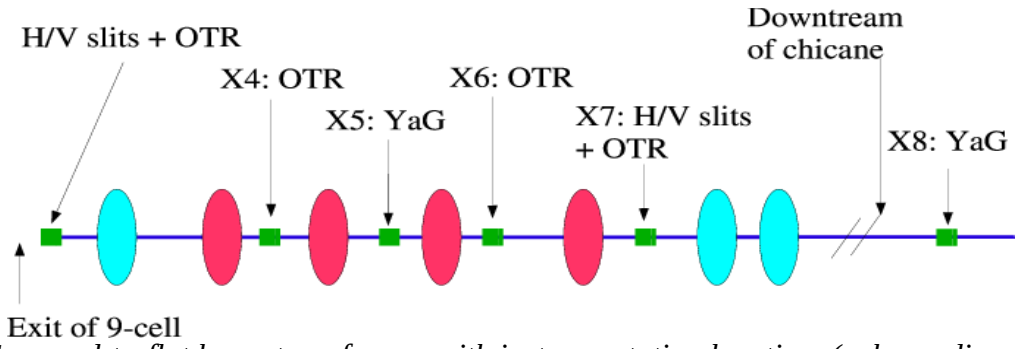

Fig.1: round-to-flat beam transformer with instrumentation location. (color coding: red: skew quadrupoles, cyan: normal quadrupoles)

C parametric study of flat beam properties dependence :

Take data on flat beam data for comparison with theoretical and numerical models.

1. **Dependence on magnetostatic field on the photo-cathode surface and radius of laser spot:**
   - a) For given laser spot radius on the cathode and measure the dependence of emittances (measure both at X7 and X11 if possible) on magnetostatic field.
   - b) Iterate step (a) for various laser spot radii on the photo-cathode
   - c) Find the best emittances and emittance ratio
2. **Dependence on laser pulse shape (short vs elongated pulses)**
   Previous Item 1 should be done both for the short (3ps Gaussian) and long (stacked Gaussian pulses) photo-cathode drive-laser configuration
3. **Dependence on bunch charge**
   For the "long" photo-cathode drive-laser setup, we should measure the dependence of the best flat beam measured in Item 1 versus the bunch charge
4. **Dependence on incoming total energy spread (chromatic effect studies)**
   For the best flat beam obtained in Item 1, we should measure the dependence of emittance, emittance ratio versus incoming momentum spread by varying the phase of the 9-cell cavity.

D Compression of flat beams (if time allows)

1. Study the variation of flat beam properties upon compression with the magnetic bunch compressor.
2. Compare both the case of vertical and horizontal flat beam setup and see what are the difference in obtained parameters after compression.

E Required time (in unit of ''A0-days'')

Phase A:
Can be done in parallel with round beam study in January 2004.

A1	3 days
A2	2 days

Phase B:
From previous measurement experience:

B1	2 days
B2a	3 days
B2b	3 days
B2c	5 days

Phase C:
we should have the machine available for two weeks without interruption
10 days

Phase D:
time estimate not yet done.

Total number of days needed 28 days

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rounded to 30 days dedicated to flat beam related studies