FLASH-RT program

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Comparison of HEDA2 to Switchyard beamline

Betatron motion Dispersion Dispersion

$$x = R_{11}x_0 + R_{12}x_0' + R_{16}\delta$$

$$\sigma_x^2 = \sigma_{\mathrm{scr}}^2 + \frac{\beta_x \varepsilon_x}{\beta\gamma} + \left(D\frac{\sigma_P}{P}\right)^2 \rightarrow \left(D\frac{\sigma_P}{P}\right)^2$$

Screen resolution far from the dipole exit

$\boldsymbol{R_{16}}$ at the **exit window after the switchyard** is **twice** as R_{16} at the screen station of HEDA2

→ the horizontal beam size will be **doubled at the exit window;**

→ maybe also more difficult to focus the beam to the same size vertically

Another difference is the **edge-(de)focusing** at the pole faces of the switchyard dipole → focusing in the deflection plane and de-focusing in the non-deflection plane

Optics of the beamlines

	HEDA2	Switchyard
ρ (m)	0.6	0.3
θ (degrees)	60	60
$L_{\mathrm{exit}\rightarrow\mathrm{scr/win}}$ (m)	0.7	1.87
R_{16} (m)	**−0.906**	**−2.31**
R_{26} (rad)	−0.866	−1.155

	HEDA2	Switchyard
Q_{-1}	PST.QT5 2.392 m	HIGH2.Q5 2.573 m ← Distance from dipole entrance
Q_{-2}	PST.QM3 4.292 m	HIGH2.Q4 4.333 m
Q_{-3}	HIGH1.Q10 6.752 m	HIGH2.Q3 6.543 m
Q_{-4}	HIGH1.Q7 8.96 m	HIGH2.Q2 9.058 m

Quadrupoles to be used

0. Preparation

- Machine parameters:
  - Laser: BSA 2 mm 1 nC (<1 mm 1pC)
  - Gun: MMMG, 6.3 MeV/c
  - Booster: MMMG+15, 22.5 MeV/c, booster power < 3.5 MW

  - Degauss all quadrupoles if not
  - Gun quads optimization at High1.Scr1 with Imain=500->370A

1. Beam transport from High1 to High2

1. Beam transport in High1 (High1.Q4, HIGH1.Q6, HIGH1.Q7)
    1. Make quadrupoles steering free
    2. Round beam transport with **High1.Scr4** and **PST.Scr1Btm** (see Appendix 1)

2. Beam transport in PST (HIGH1.Q10, PST.QM3, PST.QT5)
    1. Make quadrupoles steering free
    2. Round beam transport with **PST.Scr5** and **High2.Scr2** (see Appendix 1)

3. HEDA2 phase scan → minimize the momentum spread
    1. Focus the beam horizontally at High2.Scr2 with High2.Q1 and Q2
    2. Grab the momentum spectrum at the current setting: <P>=P0
    3. Phase scan for minimal momentum spread → C**ompensate the momentum (P0)** by tuning the booster SP, if booster power <=3.5 MW
    4. Degauss High2.Q1 and High2.Q2

- If momentum is not compensated, then re-tune the transports for the current beam momentum (step 1-2)

2. Focusing the beam at Disp3.Scr1

- Tune quadrupoles (HIGH1.Q10, PST.QM3, PST.QT5 and other High1 quads) to maximize the peak pixel at Disp3.Scr1 (or minimize XYrms)
  - Grab the beam images with 20 statistics
  - Run optimization script (fminsearch or bayesopt, goal function?) and at the best setting grab the beam images with 20 statistics

- Tune the quads (PST quads and High2.Q1-Q2) to to maximize the peak pixel at Disp3.Scr1 (or minimize XYrms)
  - Grab the beam images with 20 statistics
  - Run optimization script (fminsearch or bayesopt, goal function?) and at the best setting grab the beam images with 20 statistics

- Repeat all the prev. steps at different charges (1 pC, sub-pC)

Appendix 1. Three quads focusing for round beam transport

Quads: q1, q2, q3; two screen stations afterwards: scr1, scr2

1. Degauss and make quads steering free if possible
2. Set q1 to a current I_1(e.g., 1A), and q2 to $-0.5I_1$, q3 to $+0.5I_1$
3. Observe beam at scr1 after q3, tune q2 (usually increase in amp.) such that beam becomes round at scr1
4. Go to scr2 after scr1, tune q3 (usually increase in amp.) such that beam becomes round at scr2
5. Repeat 2 and 3 three to four times, until in step 2, beam is also found round at scr1; stops at least after two iterations
6. Note: The starting point in step 1 should also be a free parameter, overall, don't over-focus the beam

- **Always save beam images (better stop polling in video client) after each tuning:**
- \Development\ScreenStudy\SaveImages.m
- (not work for High1.Scr5 and new screen stations, for them please insert screen, connect to TV system and then run this script once for each screen; in case it breaks due to communication problem, just restart)