Shorter dipoles, beam dynamics

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LIU-PSB meeting: H- injection

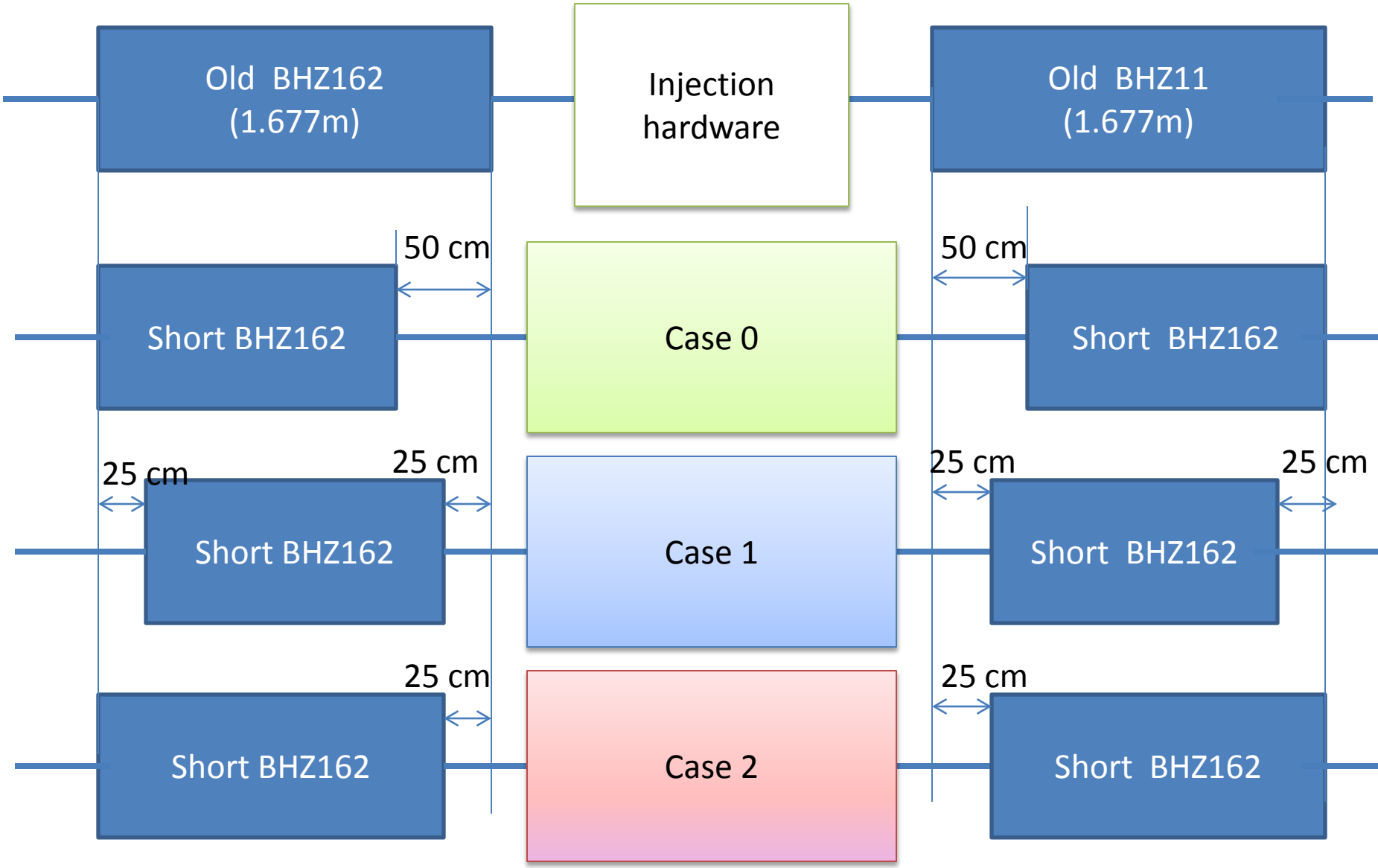
29/3/12

Outline

- Motivation: Shorter dipoles to accommodate the H- injection hardware

- Single particle dynamics:
  - Vertical β–beating (w.r.t. existing perturbations)
  - 3 options studied
  - Changes in geometry
- Multi-particle (space-charge):
  - To do

New layouts considered



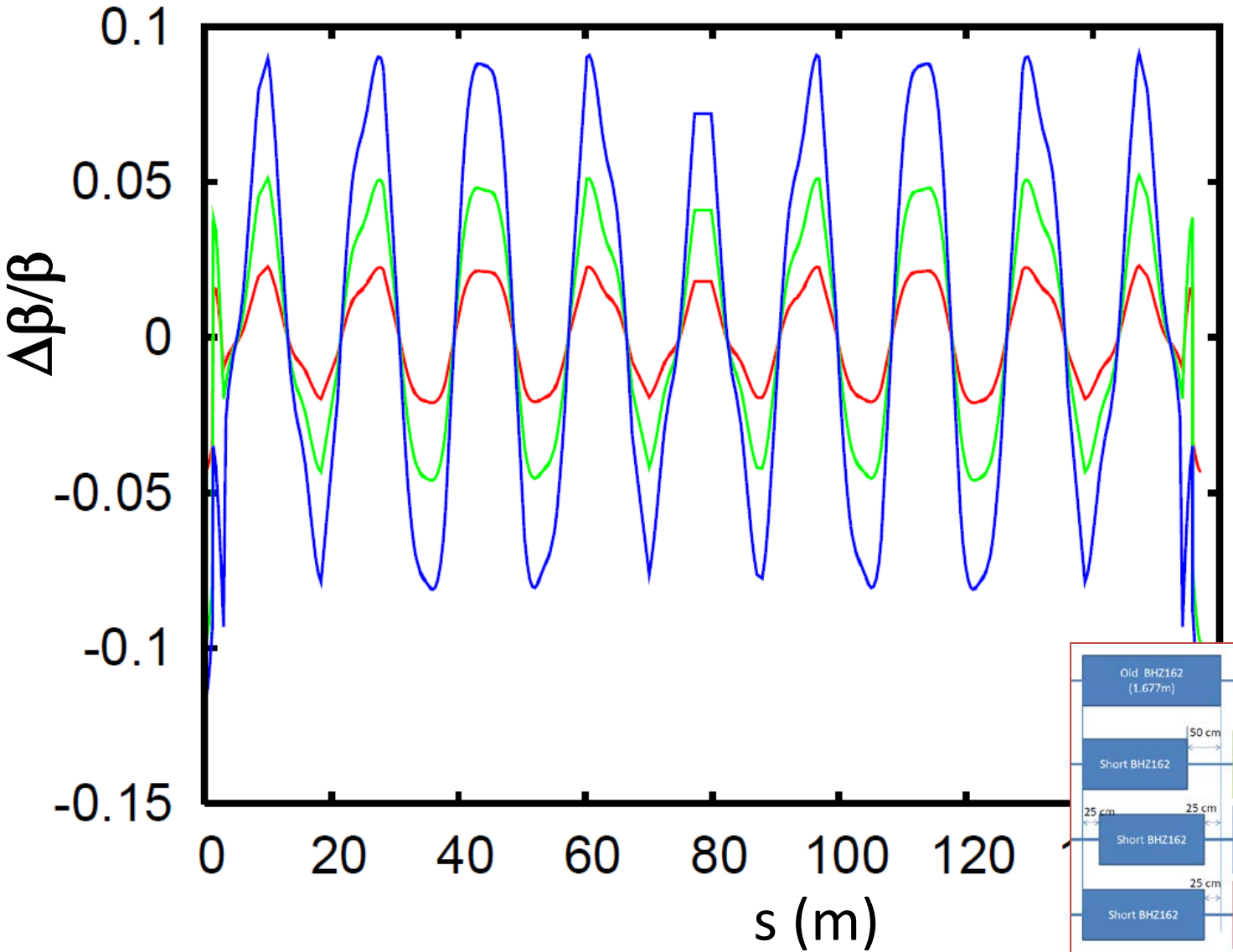
Vertical β–beating if Shorter Dipoles

- Qv close to half-integer:
  - any quadrupolar perturbation in the vertical…

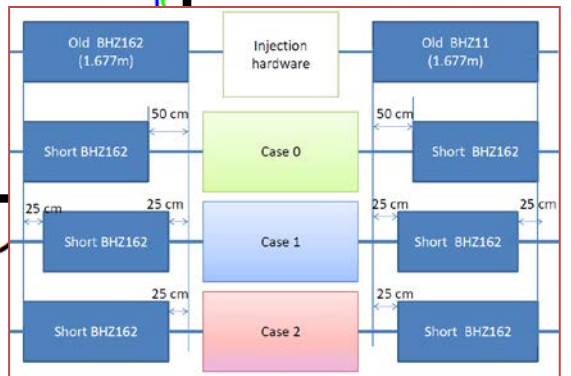
- Different edge focusing:
  - $kl = \tan(\psi/2)/\rho$ vertical focusing @ BHZ edges
  - $\rho = (L-\Delta L)/\psi$ bending radius
  - $\psi = 2\pi/32$ bending angle

- Displacement of the edges
  - focusing occurs at a different phase
  - may be cancellation effects

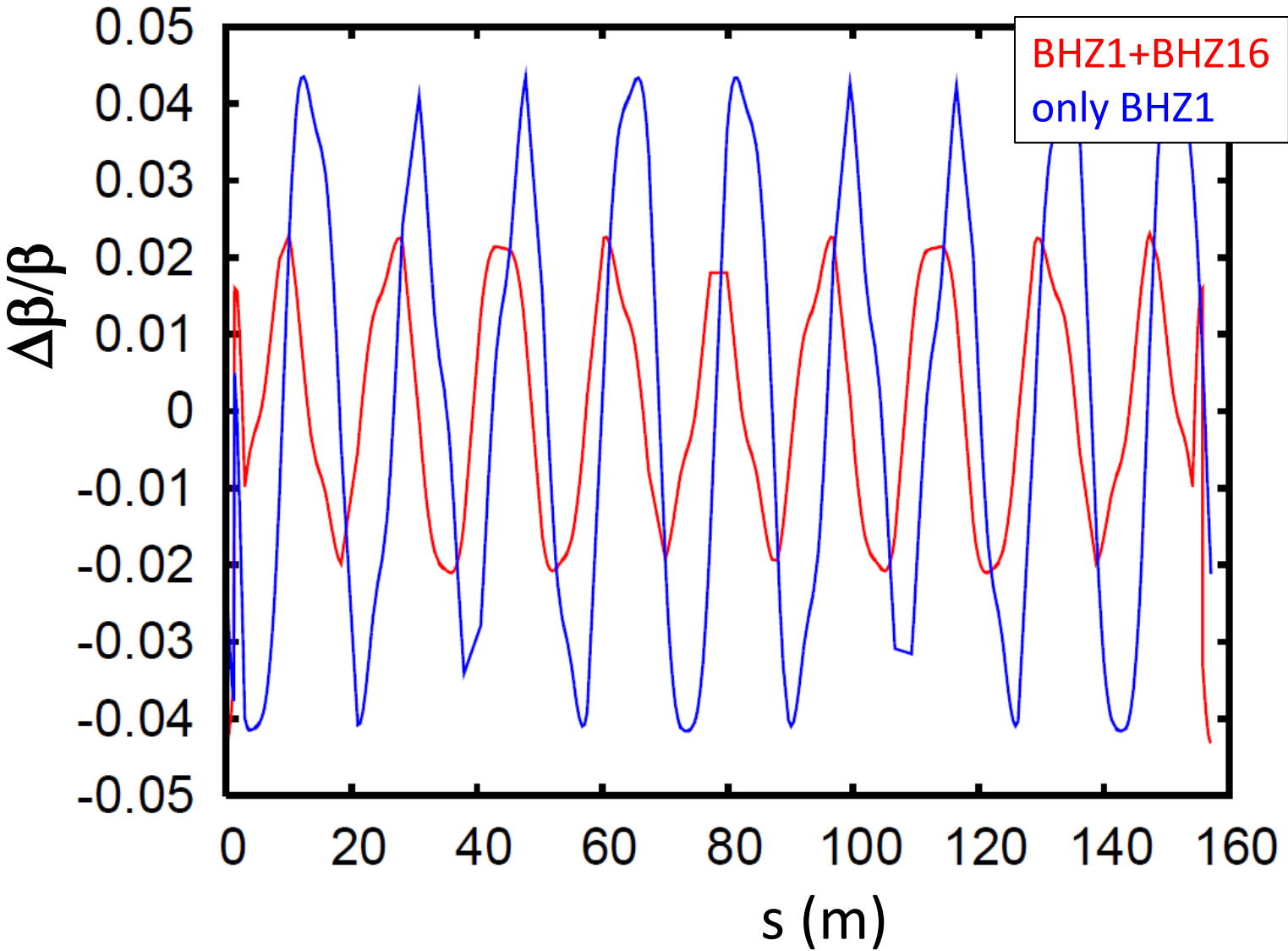
BetaBeating for the different options



The best is case 2:
- ΔL=0.25m
- center is displaced



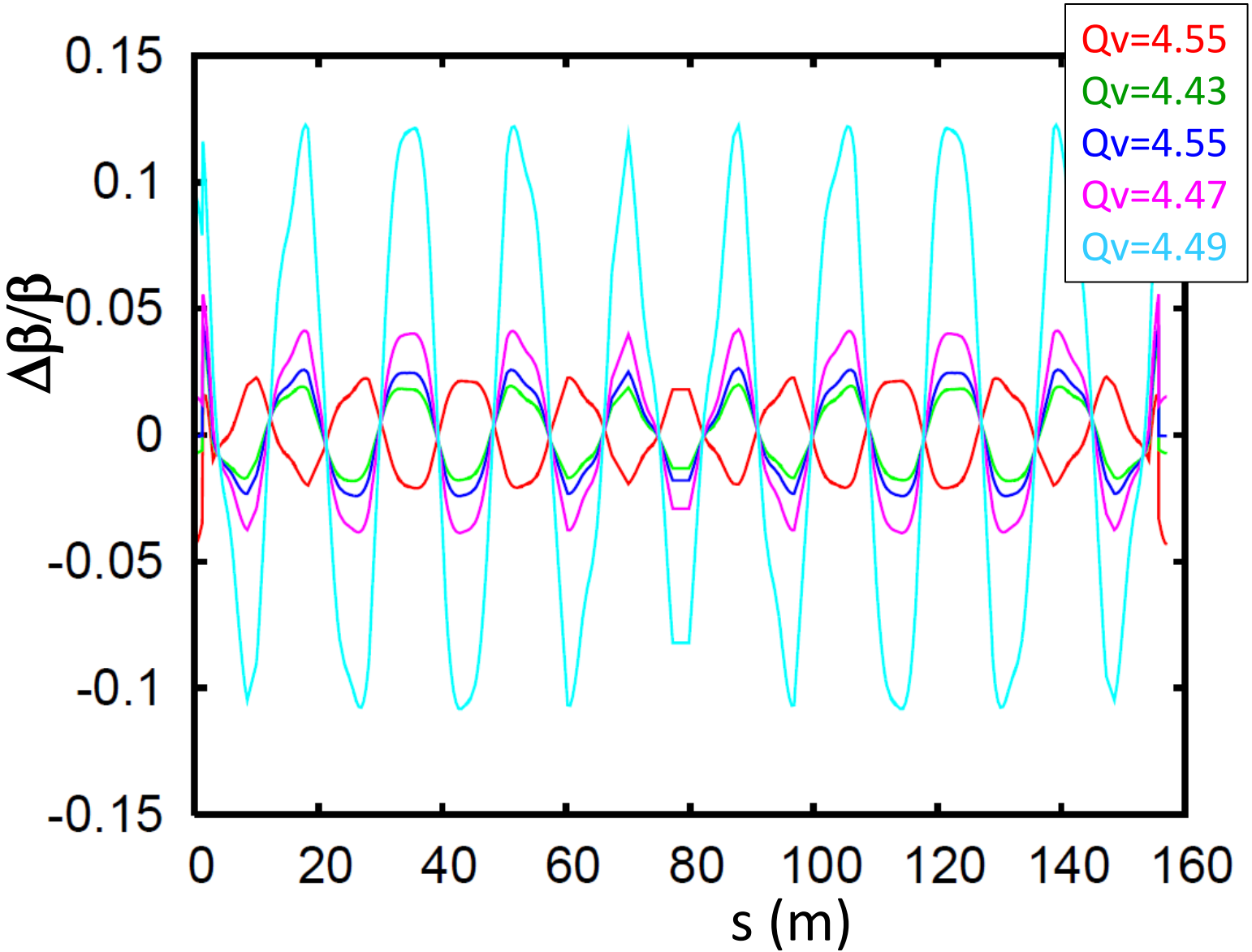
What if only BHZ1 is shorter?



if both:
- partial cancellation

case 2:
- ΔL=0.25m
- center is displaced

Change of Qv


Qv=4.55
Qv=4.43
Qv=4.55
Qv=4.47
Qv=4.49
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
Δβ/β
0
20
40
60
80
100
120
140
160
s (m)

Compare with chicane perturbation

- Tried to compensate 2Qv=9 excitation w. QDE3 & QDE14
- Used same MADX matching script as Christian's for the chicane

SHORTER DIPOLES:
kf = 0.7566 ;
kd = -0.7732 ;
dkd3 = -0.0006;

Vs.

CHICANE:
kf = 0.7563 ;
kd = -0.7718 ;
dkd3 = -0.00691 ;

Conclusion: Factor 10 lower than chicane perturbation

Compare with existing errors

- Compare beta-beating with what we have now in the machine
  - i.e. that we correct with **QNO correctors**

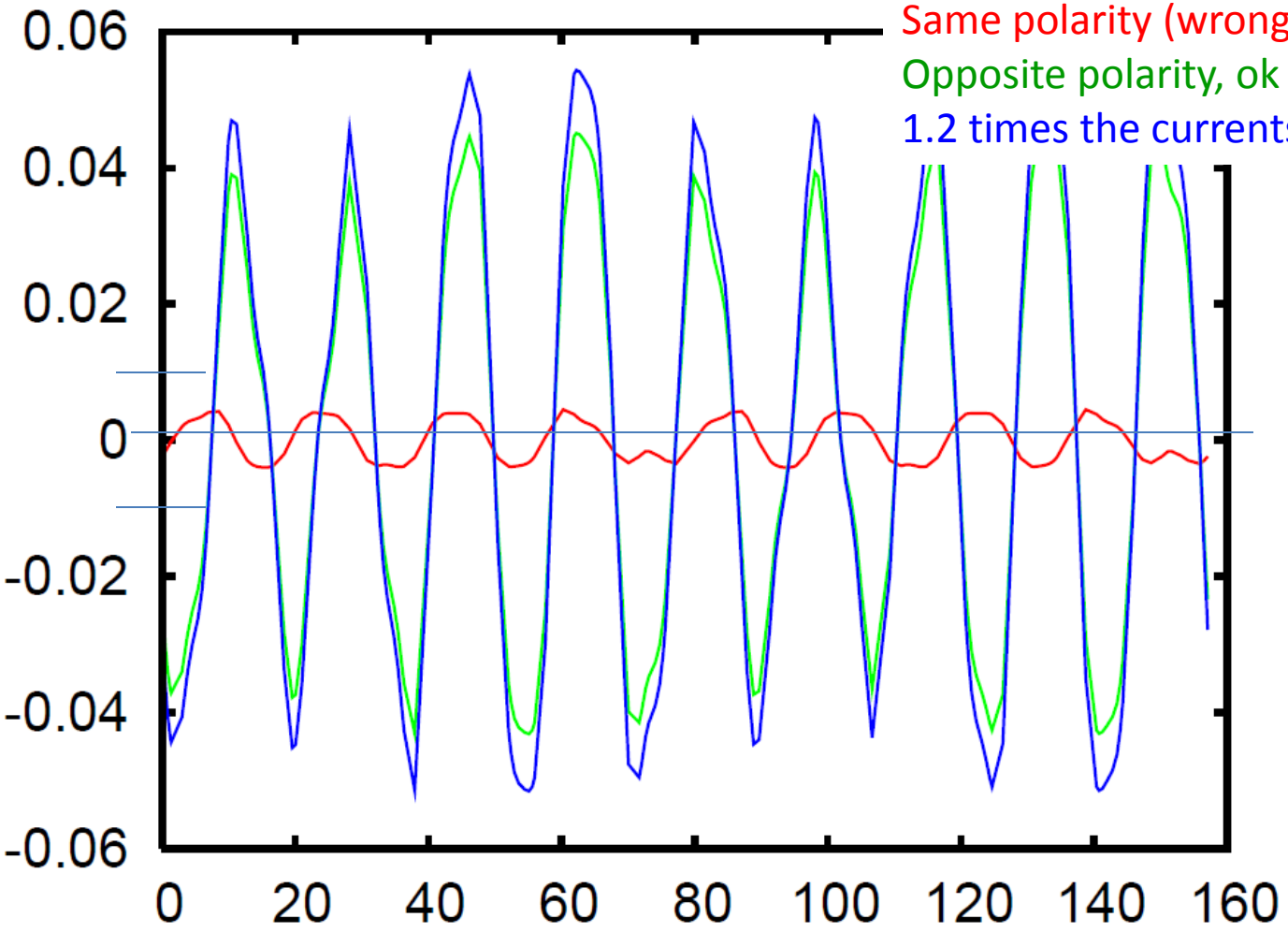
- I QNO412L3 = -0.94 A;
- I QNO816L3 = -1.77 A;

(klqno412L3 = 1.0/Brho(**50MeV**)*0.05/85.0*Iqno412L3)

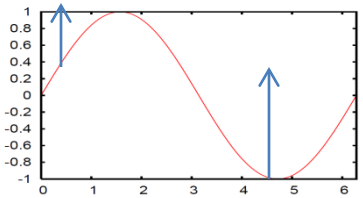
- klqno412l3 = -0.00029 = **klqno4= -klqn12**
- klqno816l3 = -0.00055 = **klqno8= -klqn16**

- Conclusions: same ~order of existing errors in the machine (see next slide)

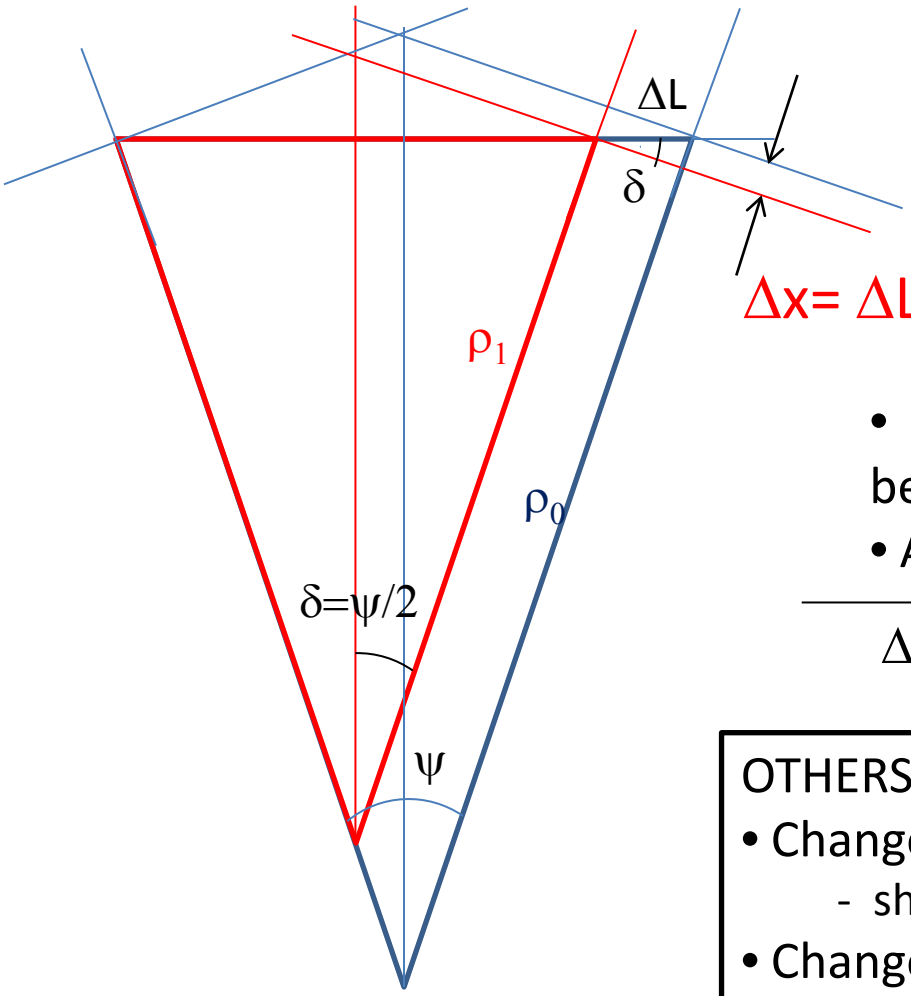
Existing errors: cured w. QNOs



- The 2 pairs are orthogonal, so they add-up
- The different polarity assure that the correction is not canceled-out, as phase advance between the two is almost 2.25 pi



Change in geometry



$\Delta x = \Delta L \sin(\delta) = 24.5\text{mm}$

- Trajectory @ exit of short BHZ16 will be $\Delta x = -24.5$mm offset
- Add $\Delta x = -10$mm offset w.r.t. Linac2

$\Delta x_{tot} = -34.5\text{mm}$

OTHERS:

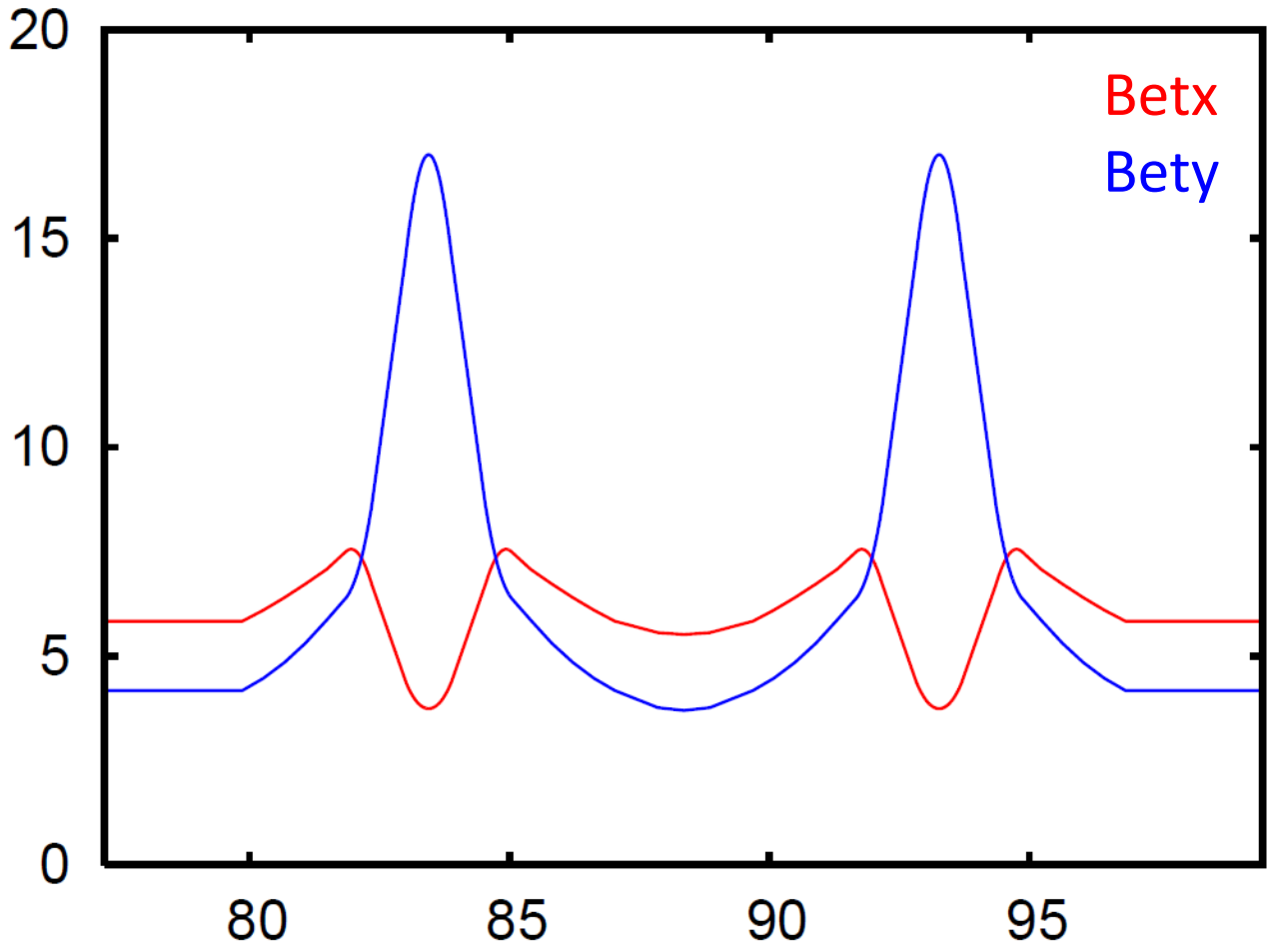
- Change of Twiss param & Disp. in inj. region:
  - should be taken into account
- Change in circumference length:
  - to be estimated for completeness
  - should be ~negligible w.r.t. extraction bump

Summary & Outlook

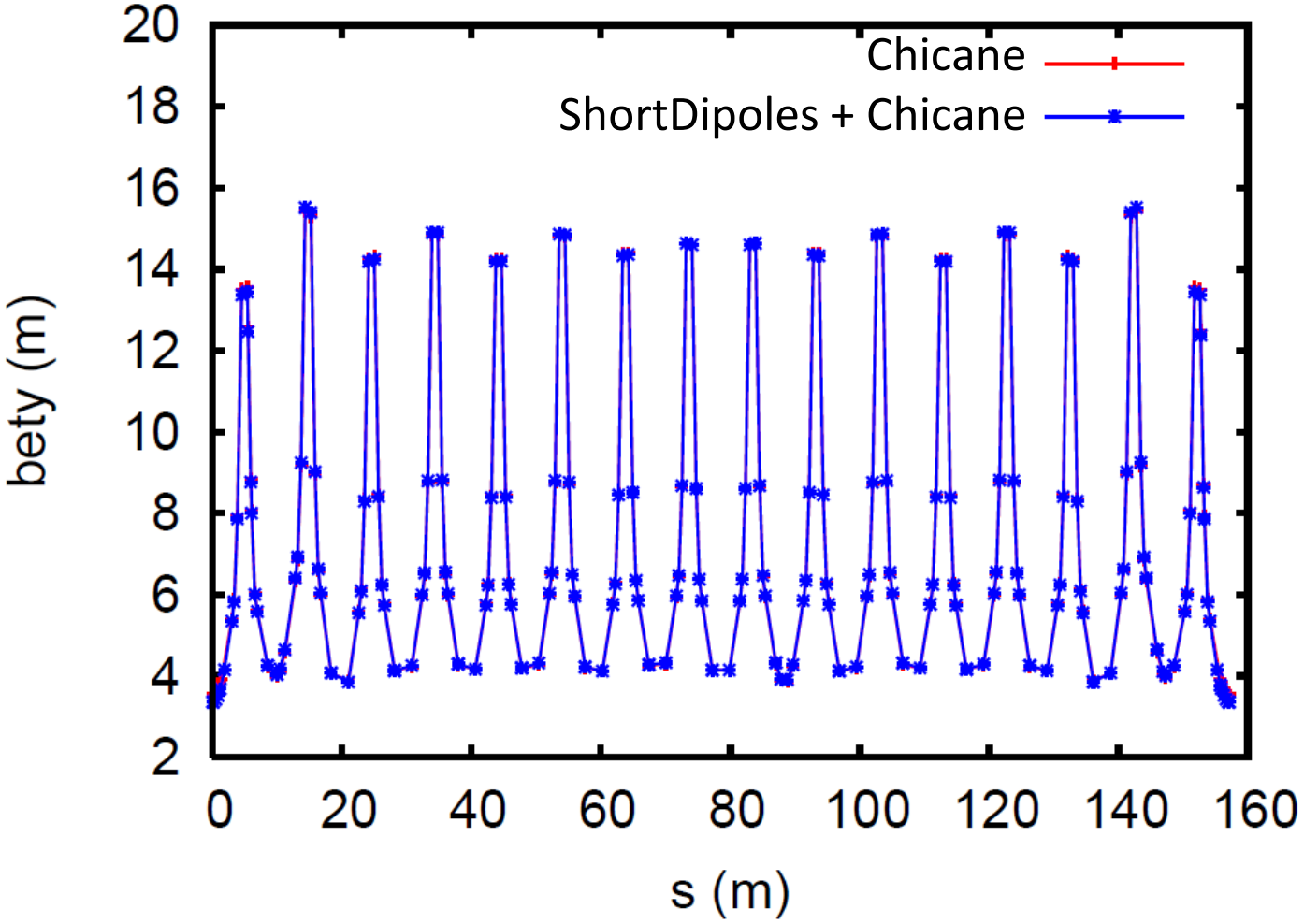
- Shorter dipoles option looks feasible for single particle dynamics:
  - Perturbation (vert. βbeating) ~same order as existing errors
  - (partial cancellation of additional focusing)
- Preferred option:
  - ΔL=25 cm shorter + displaced (case 2), both BHZ1 & BHZ162
- Change in geometry:
  - Δx=~25 (+10) mm offset inward w.r.t. Linac2 injection
  - Geometry of injection line & region to be revised

- Space charge & break of 16-fold periodicity:
  - All resonances become systematic
  - May reduce space-charge limit (but perturbation is “small”…)
  - **Thorough simulations not feasible on short time scale**

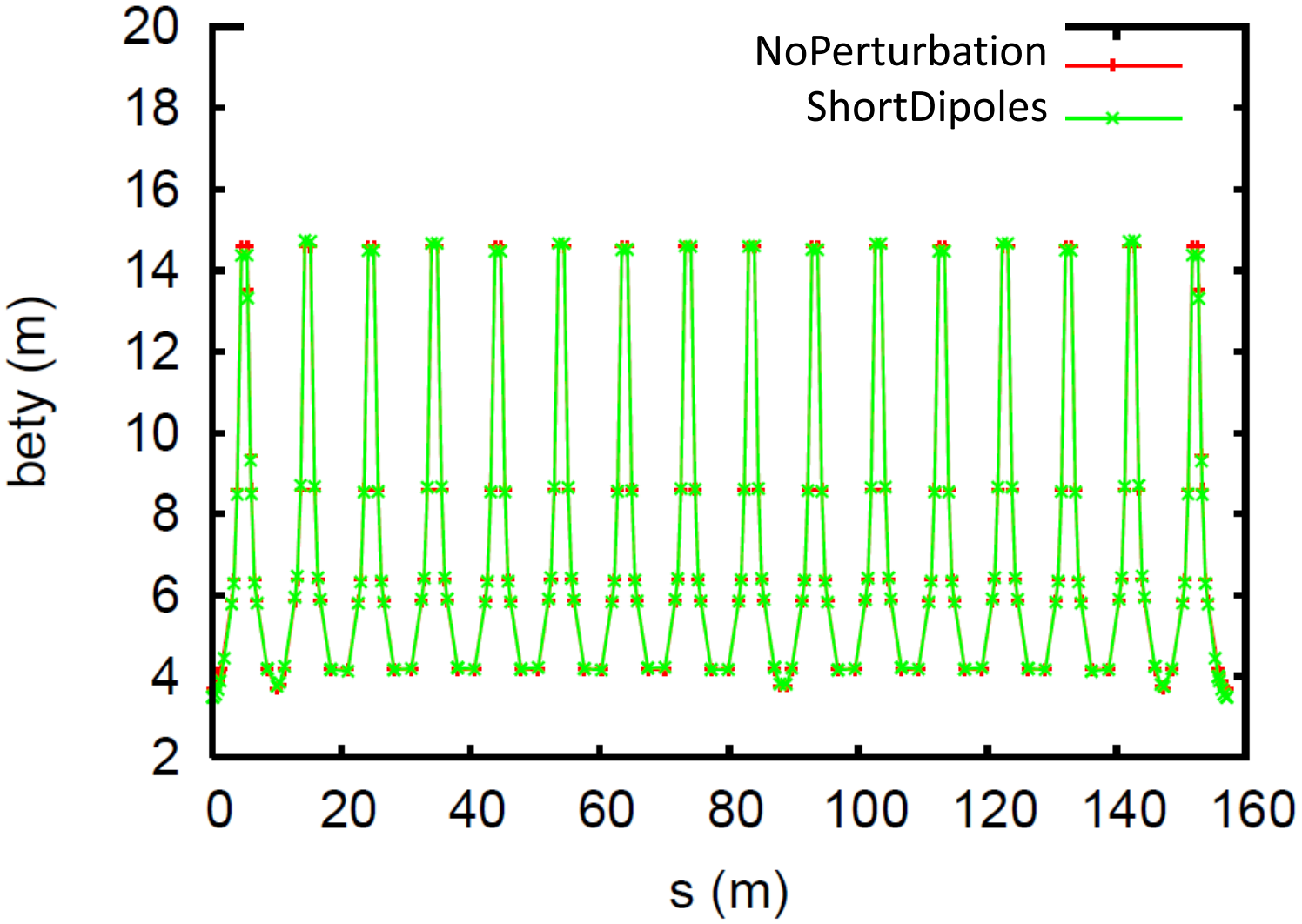
Back-up slides


20
15
10
5
0
80
85
90
95
Betx
Bety

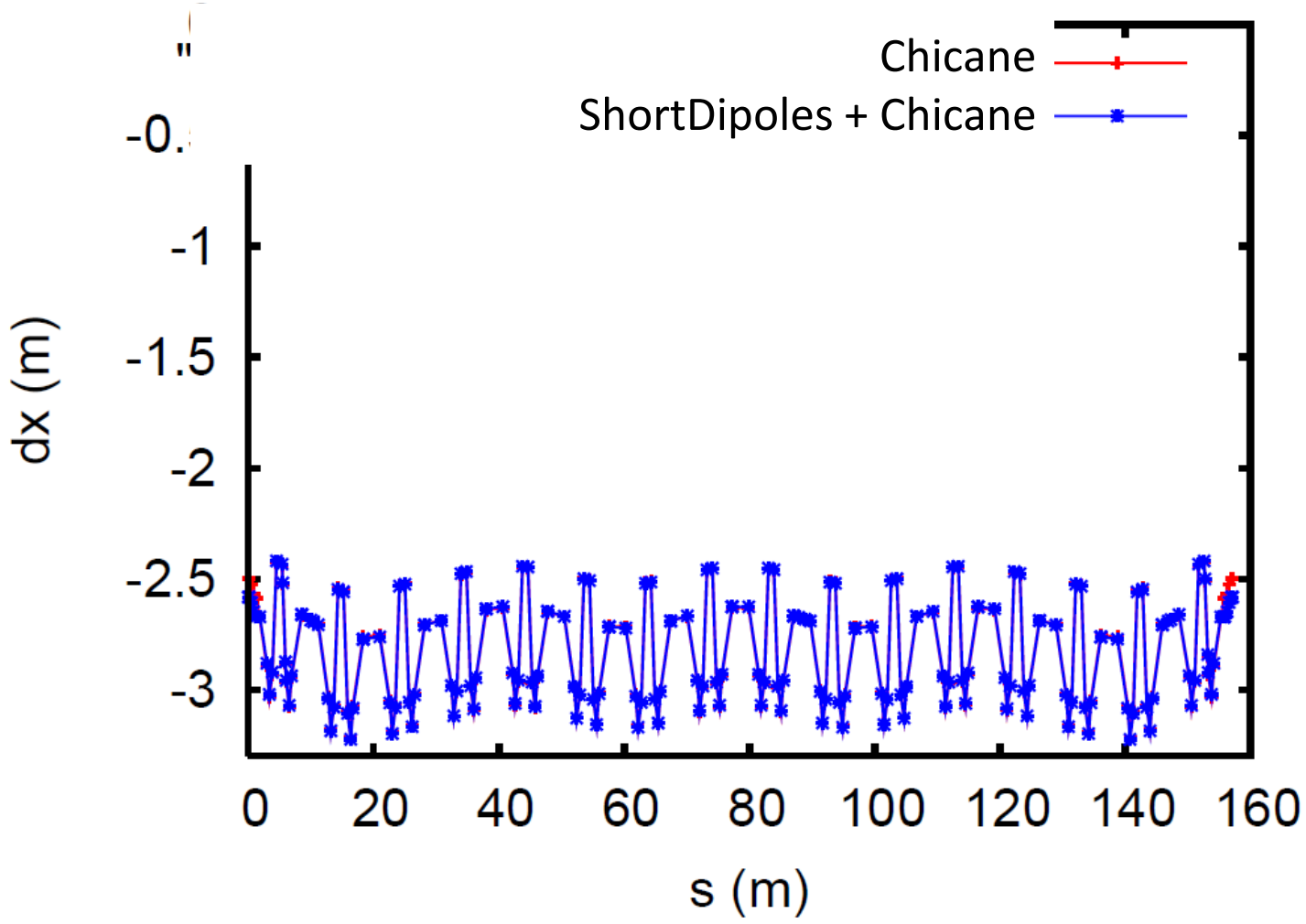
Beta_v


Chicane
ShortDipoles + Chicane
bety (m)
s (m)
20
18
16
14
12
10
8
6
4
2
0
20
40
60
80
100
120
140
160

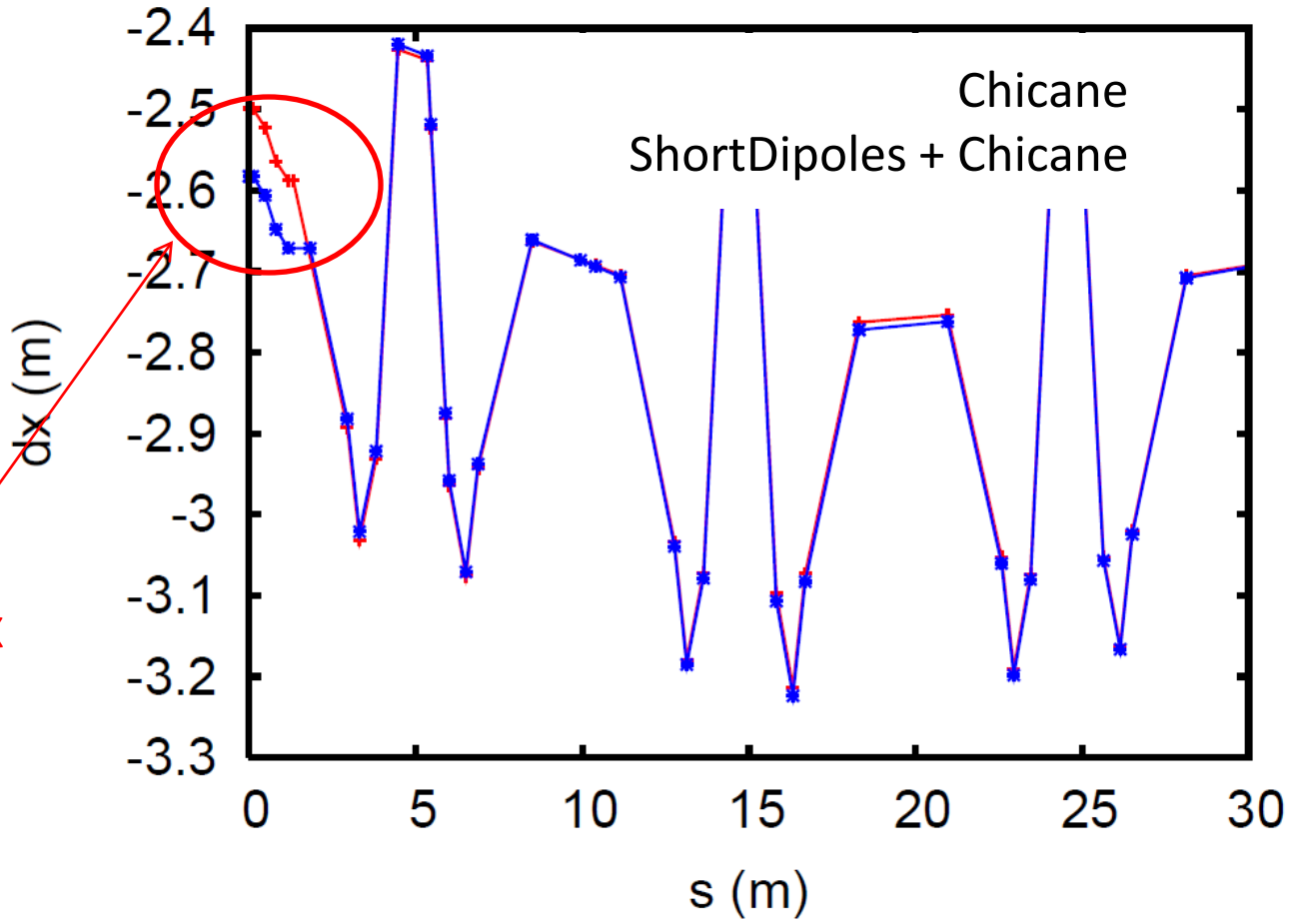
Beta_v without chicane



Dispersion


Chicane
ShortDipoles + Chicane
dx (m)
-0.
-1
-1.5
-2
-2.5
-3
0
20
40
60
80
100
120
140
160
s (m)

Zoom of previous…



Larger Dx
@ foil

Dispersion without chicane