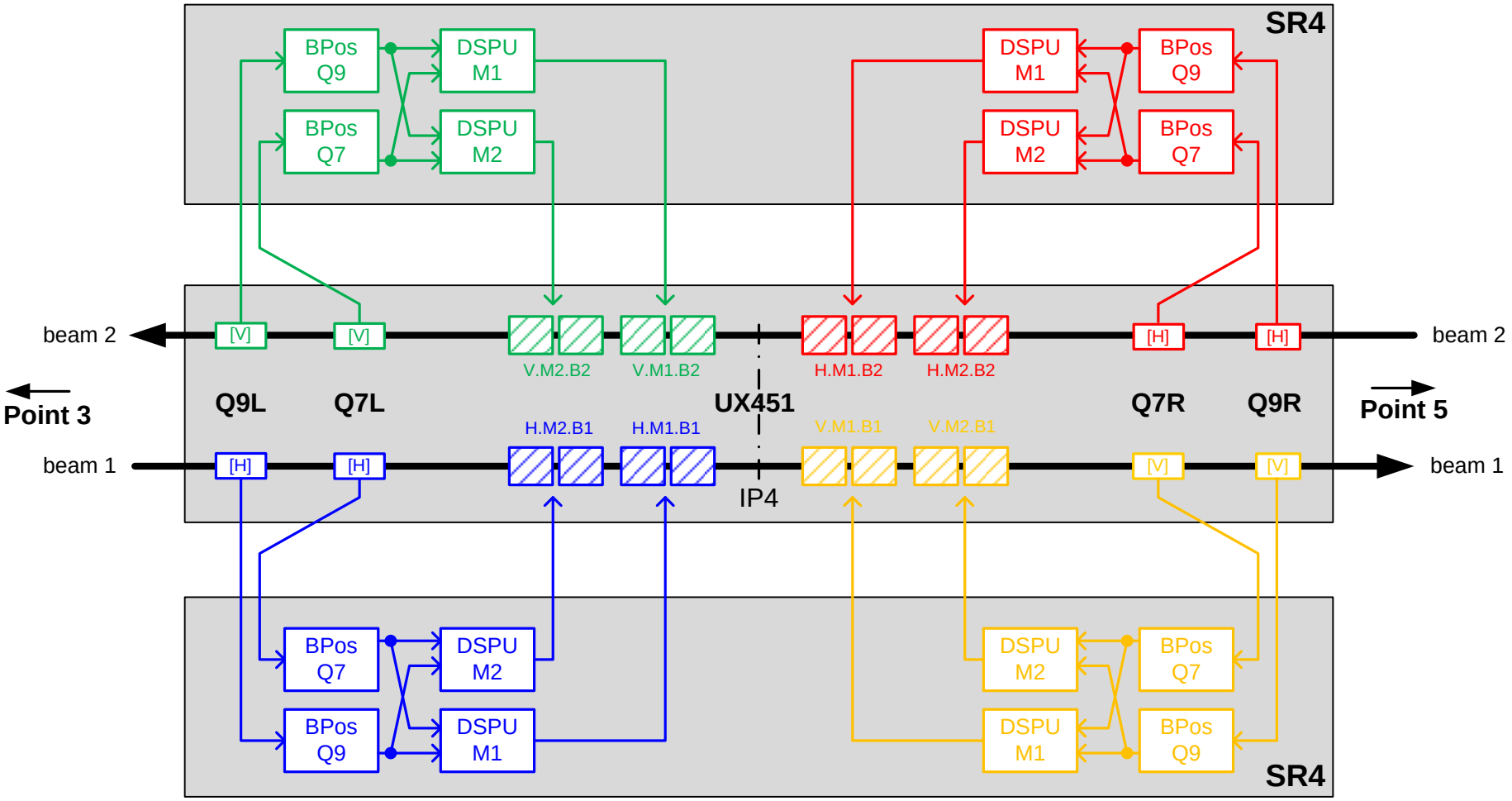
Compatibility of beta functions during the squeeze in IR4 with ADT

Wolfgang Hofle

Some material taken from presentations for Run 1 and initial Run 2 situation:
W. Höfle, D. Valuch: LMC 05. Feb. 2014
G. Kotzian, W. Höfle, D. Valuch: LBOC 15. Apr. 2014
D. Valuch: LBOC 24. May 2016
W. Höfle: HL-TCC, 20 Aug. 2020

Run 1 ADT System



Bpos – Beam Position Module
DSPU – Digital Signal Processing Unit

pick-ups are dedicated BPMCS integrated with cryostats of quadrupoles

Original Specifications (ADT)

- Pick-ups
  - two pick-ups per plane per beam (8 in total)
  - coupler type pick-ups BPMC provided by BI group
  - The modulated signal at 400 MHz is used
  - integrated with Q7 and Q9 cryostats left and right of point 4
  - *minimum β functions of 100 m*
  - low dispersion preferable (Q7LHB1 and Q7RHB1 very good)
  - *higher than specified β functions allowed for better performance*
- Kickers
  - Four kickers per beam and plane (16 in total)
  - *minimum β functions 100 m*
  - *higher than specified values allowed for better than planned performance and allowed additional functionalities without upgrades*

Pickups for ADT after LS1 (optics 6.5xx)

make available four Q8 PU (LBOC 15.04.2014)

B1 horizontal	Q10L	Q9L	Q7L	Q8R	Q9R	Q10R
	β = 32 m	β = 111 m	β = 106 m	β = 133 m	β = 19 m	β = 153 m
		run 1	run 1	new run 2		new run 2

B1 vertical	Q10L	Q9L	Q8L	Q7R	Q9R	Q10R
	β = 175 m	β = 54 m	β = 155 m	β = 161 m	β = 142 m	β = 46 m
	new run 2		new run 2	run 1	run 1	

B2 horizontal	Q10L	Q9L	Q8L	Q7R	Q9R	Q10R
	β = 158 m	β = 22 m	β = 96 m	β = 150 m	β = 101 m	β = 29 m
	new run 2		new run 2	run 1	run 1	

B2 vertical	Q10L	Q9L	Q7L	Q8R	Q9R	Q10R
	β = 44 m	β = 160 m	β = 167 m	β = 151 m	β = 56 m	β = 180 m
		run 1	run 1	new run 2		new run 2

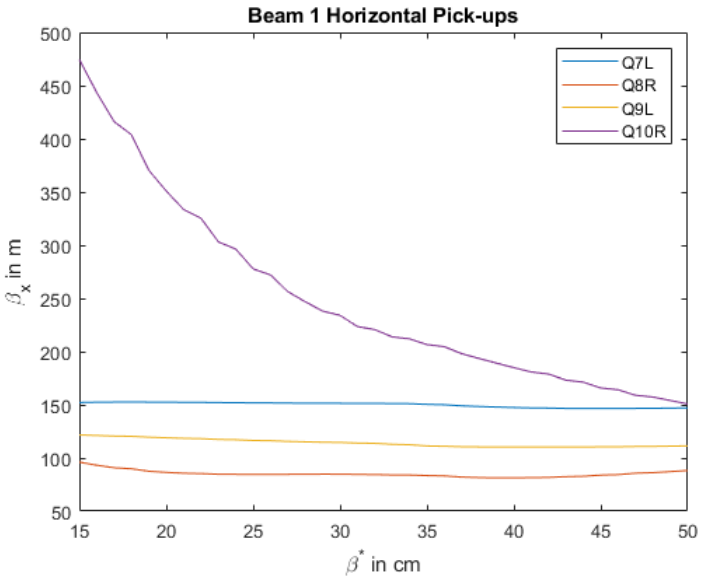
All PUs are couplers (BPMCS type) that already exist, high beta preferable

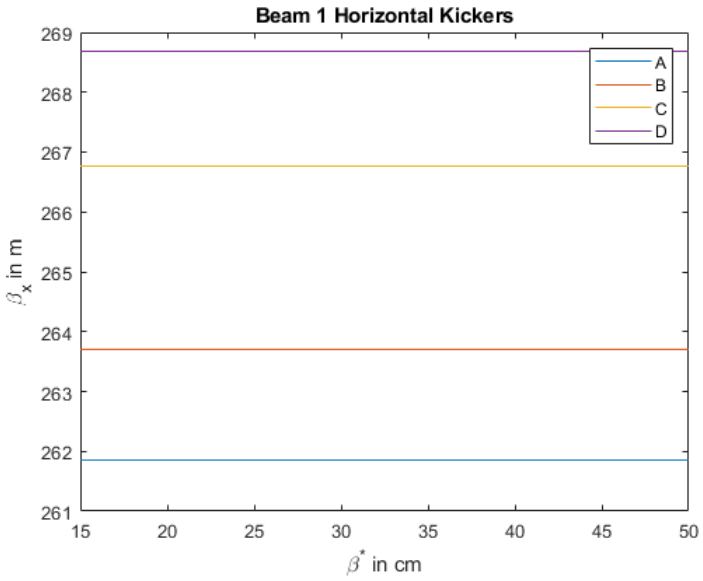
Agreement in 2014 with BI on the usage of the Q8's

HL squeeze – ADT

Squeeze from 50 cm to 15 cm, 36 twiss files from R. de Maria
script for extraction by D. Valuch

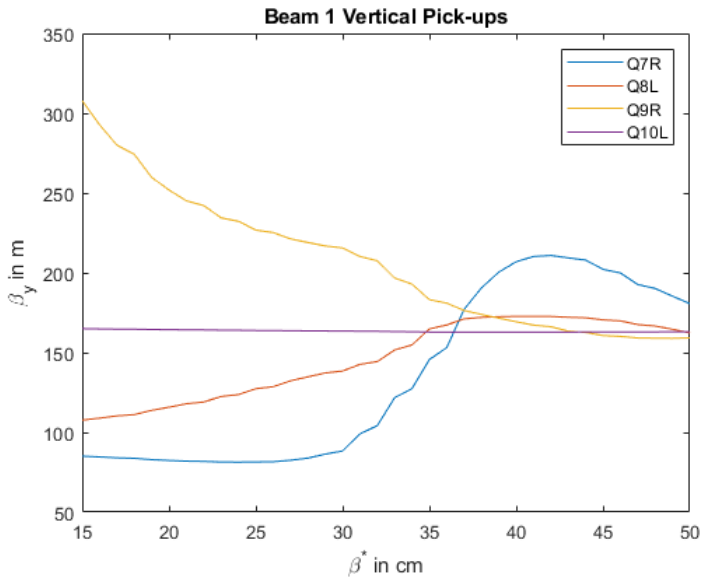
Horizontal Beam 1

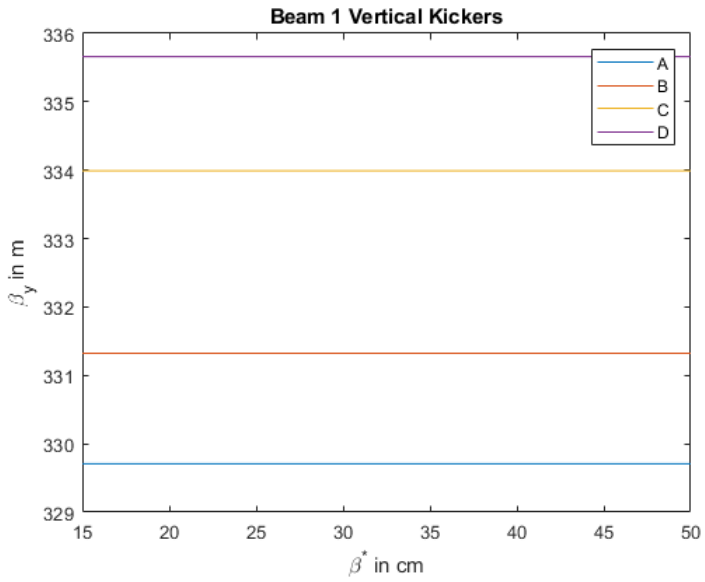




large increase of β_x for Q10R → 15 cm
kickers: only small change

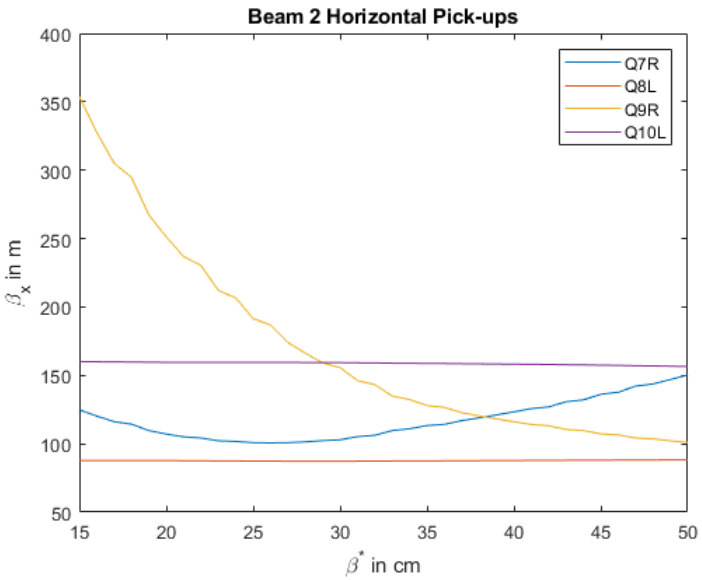
Vertical Beam 1

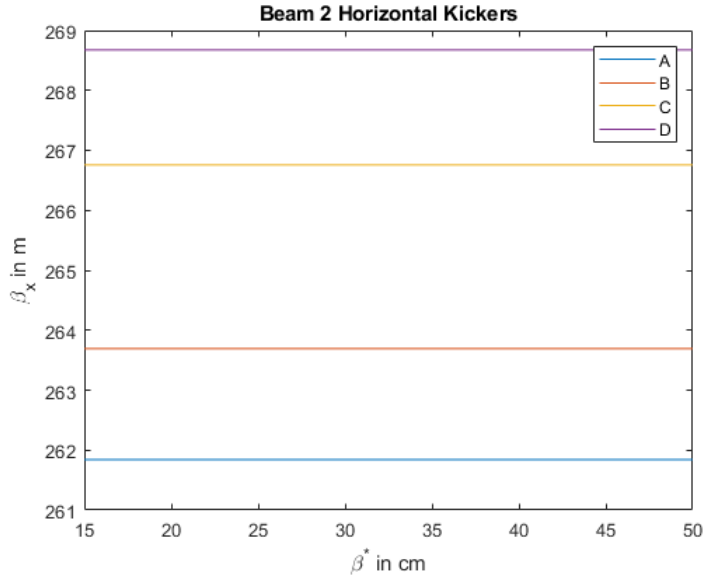




- significant increase of β_y for Q9R → 15 cm
- decreasing β_y for Q7R and Q8L
- kickers: significant increase, making B1 and B2 more equal

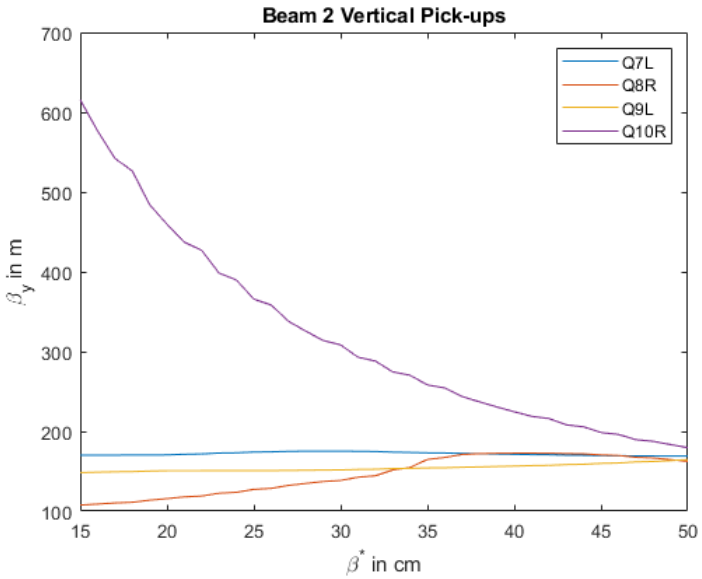
Horizontal Beam 2

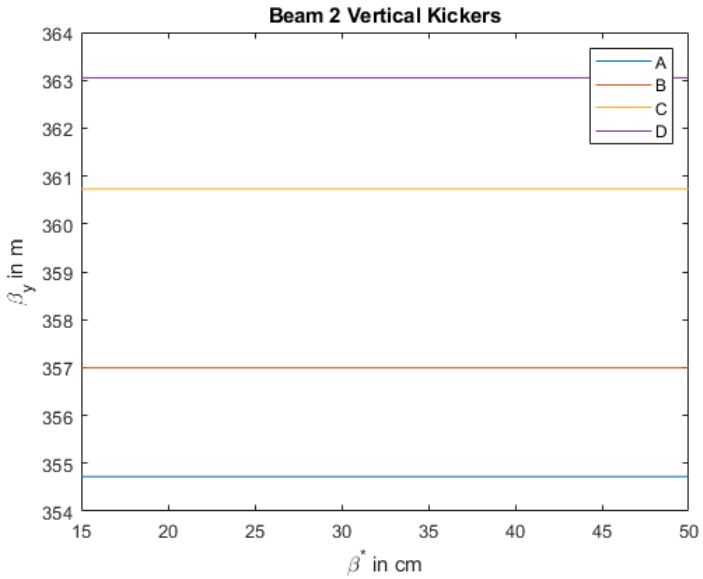




- significant increase of β_x for Q9R → 15 cm
- decreasing β_x for Q7R
- kickers: only small change

Vertical Beam 2





- significant increase of β_y for Q10R → 15 cm
- decreasing β_y for Q8R
- kickers: only small change

ADT kickers run 1, initial run2 and HL-squeeze

- Kickers: improvement proportional to $\beta^{1/2}$

Damper	Run 1: β	Run 2: β (initial)	HL-squeeze	Improvement Factor cf run 1
H.B1 (L4)	253 m	271 m	265 m	1.02
V.B1 (R4	160 m	268 m	332 m	1.44
H.B2 (R4)	204 m	263 m	265 m	1.02
V.B2 (L4)	306 m	336 m	359 m	1.08

- design peak kick strength 7.5 kV is 2 μrad (450 GeV/c); assumed β=100 m
- Run1 impact on beam is factor 1.6 higher for H.B1, V.B1, H.B2, and 1.8 higher for V.B2 (because β's much higher than 100 m)
- cf. to run 1 optics, the initial optics brought improvement for all beams and planes
- we need higher than 100 m values to keep the performance of all additional features invented and implemented along runs 1 and 2 (about gap cleaning, loss maps, excitations for measurement purposes and quench tests)

Reminder - Figure of merit for pick-ups

- motivated by S/N improvement for multiple pick-up usage compared to the reference case of a single pick-up @ β =100 m

$$\frac{S}{N} = 20\text{dB} \times \log_{10} \frac{\sum_{n=1}^{N} \sqrt{\beta_n / 100\text{m}}}{\sqrt{N}}$$

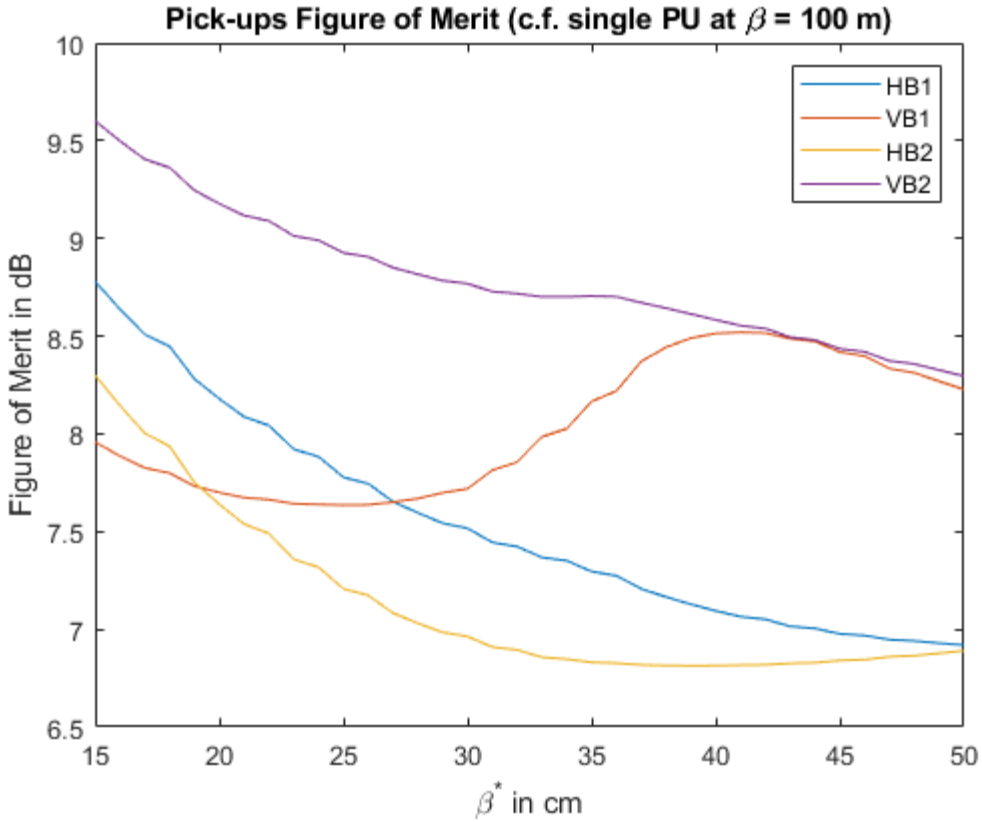
potential of 4 PUs

	Run 1 (2 PU) Q7,Q9	Run 2 (4 PU) Q7,Q9,Q10	Run 2 Q7,Q8,Q9,Q10	Improvement with BI swap
H.B1	3.8 dB	5.6 dB	7.0 dB	1.4 dB
V.B1	4.2 dB	7.4 dB	8.0 dB	0.6 dB
H.B2	4.4 dB	5.9 dB	8.0 dB	2.1 dB
V.B2	4.9 dB	6.6 dB	8.2 dB	1.6 dB

with initial run 2 initial optics

From LBOC 15.04.2014

PU Figure of Merit HL-squeeze



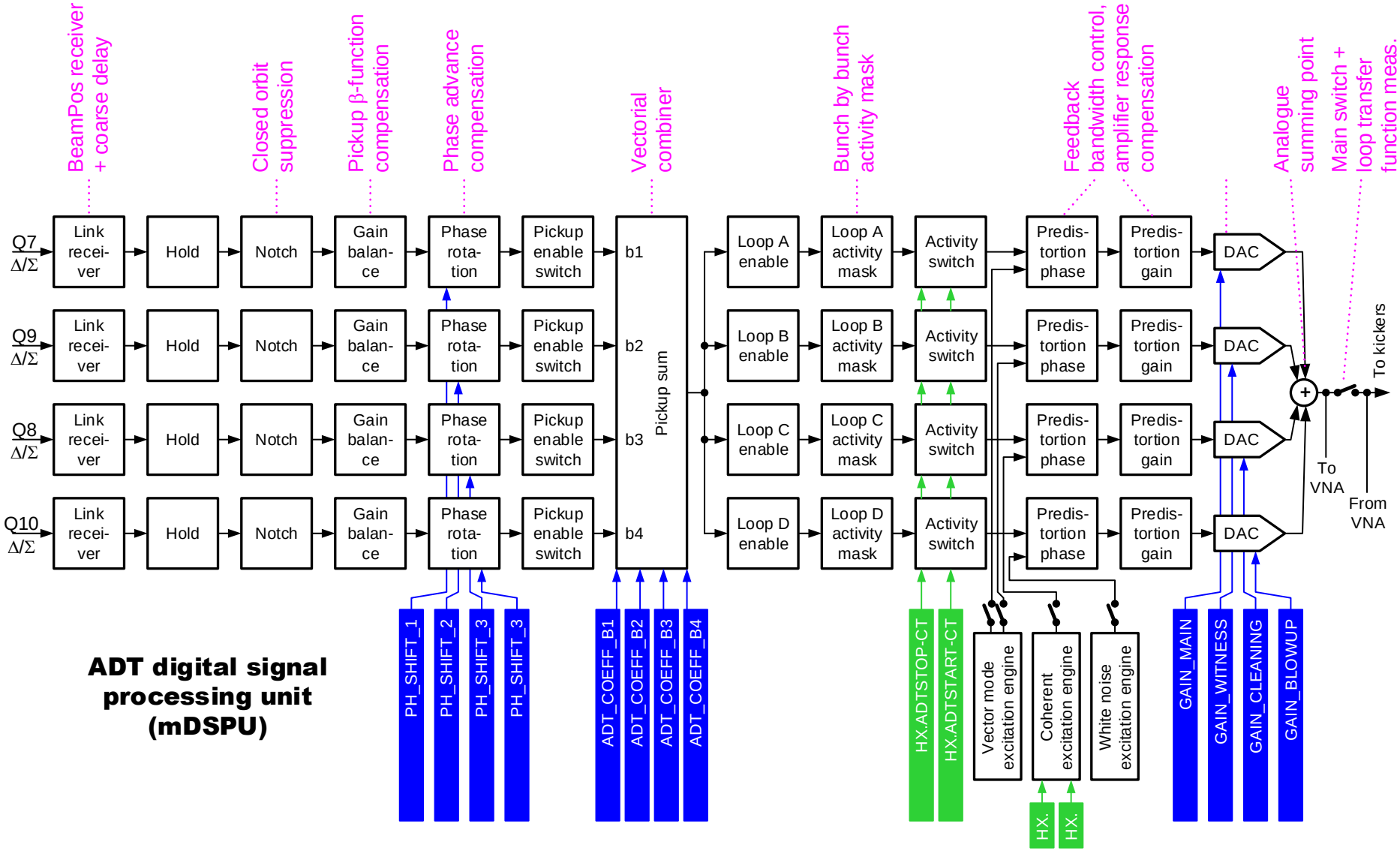
- general improvement during squeeze → 15 cm, except V.B1
- similar starting value at β=50 cm as in initial run 2 optics except for HB2 which slightly worse
- V-plane β's better than H-plane at β=50 for both beams

Preliminary Summary

- higher β at V.B1 kickers welcome
- PU figure of merit for combined set of pick-ups seems OK, however
  - achieved by large increase of β-functions at Q9R and Q10R
  - possibility to leverage on this large increase must be checked by ADT team experts

Spare

2016: ADT Digital Signal Processing Unit (mDSPU)



ADT digital signal processing unit (mDSPU)

not implemented

Pickups for ADT after LS1

v.6.503

proposal as presented at LMC: 5th Feb 2014

B1 horizontal	Q10L	Q9L	Q7L	Q7R	Q9R	Q10R
	β = 28 m	β = 127 m	β = 112 m	β = 78 m	β = 16 m	β = 158 m
		run 1	run 1	considered		new

B1 vertical	Q10L	Q9L	Q7L	Q7R	Q9R	Q10R
	β = 172 m	β = 25 m	β = 52 m	β = 127 m	β = 138 m	β = 38 m
	new		new	run 1	run1	

B2 horizontal	Q10L	Q9L	Q7L	Q7R	Q9R	Q10R
	β = 164 m	β = 17 m	β = 60 m	β = 173 m	β = 106 m	β = 30 m
	new		new	run 1	run 1	

B2 vertical	Q10L	Q9L	Q7L	Q7R	Q9R	Q10R
	β = 36 m	β = 140 m	β = 169 m	β = 23 m	β = 34 m	β = 181 m
		run 1	run 1	new		new

All PUs are couplers (BPMC type) that already exist, high beta preferable