SLHCV3.1b: optics repository for HL-LHC 150T/m triplet scenario

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Content

Introduction

SLHCV3.1b contains a realistic, nearly complete, usable optics model for an HL-LHC scenario using 150T/m triplets Based on SLHCV3.0 and ATS_V6.503. [1]
It is not final since it still depends on some working assumptions:

- interconnect lengths between magnets,
- lengths and types of triplet correctors,
- installation and relocation of several matching quadrupoles,

and misses some parts

- optics transitions,

and some optimizations

- phase advance optimization for IR2/8/4/6,
- control of Q",
- position of triplet BPMS,
- IP1-IP5 phase advance (or maybe working point).

[1] SLHC Project Report 49, 50, 53, 55, ATS Note 2011 33, 60, 132 and reference therein.

Repository: names and specs

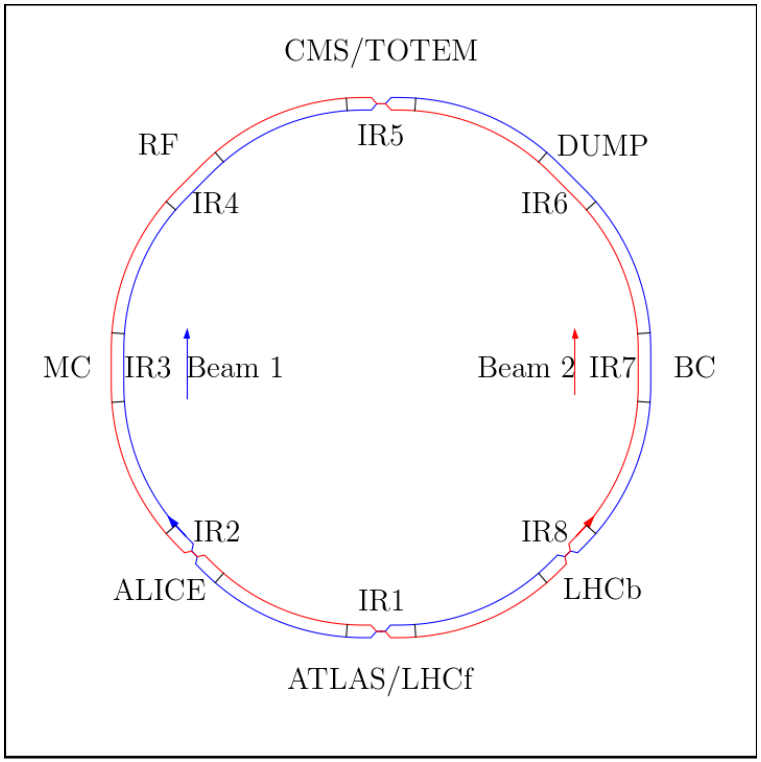
name	$\beta^*_\times$ [m]	$\beta^*_\parallel$ [m]	$\theta_\times$ [μrad]	$\parallel$ sep [mm]	$\times$ planes IP1/IP5
opt_150_11000_11000	11.0	11.0	170	2	v/h, adj.
opt_150_5500_5500	5.5	5.5	245	2	v/h, adj.
opt_150_2000_2000	2.0	2.0	80	2	v/h, adj.
opt_150_0400_0400	0.40	0.40	180	0.75	v/h, adj.
opt_150_0150_0150	0.15	0.15	295	0.75	v/h, adj.
opt_150_0100_0100	0.10	0.10	360	0.75	v/h, adj.
opt_150_0075_0300	0.30	0.75	275	0.75	v/h, fixed
opt_150_0050_0200	0.20	0.05	335	0.75	v/h, fixed
opt_150_0075_0300hv	0.30	0.75	275	0.75	h/v, fixed
opt_150_0050_0200hv	0.20	0.05	335	0.75	h/v, fixed

with their thin version.

Total of 4 IR5, 7 6, 6 IR2/8 new optics, the rest really minor changes with some very similar to SLHC3.0 or ATSV6503 or the nominal LHC.

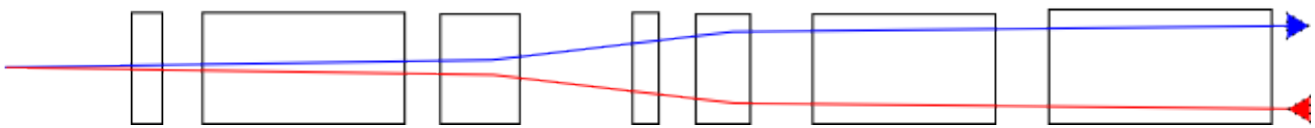
A rich toolkit and few sample jobs is provided as well derived from SLHC3.0 as well. Mask file, error assignment routines, correction filters for tracking are under preparation.

LHC IR layout



IR1 and IR5 layout:

IP TAS Q1-Q3 D1 TAN D2 Q4-Q6 Q7-Q13



Layout changes

IR1 and IR5 triplet area ($l_{\mathrm{Q1}} = l_{\mathrm{Q3}}$, $l_{\mathrm{Q2a}} = l_{\mathrm{Q2b}}$):

```
IP 23 {.46 | Q1   | .46} .36 .12 BPM .24
      {.36 | MCBXDa | .46 | Q2a     |.46 } .24 BPM .12 .36
      {.46 | Q2b    | .46 | MCBXDb |.36 } .24 BPM .12 .36
      {.46 | Q3     | .46 } .24 BPM .12 .36
      {.18 .18 |MCBXC   |.18  .20 .115|MQSX3   |.115
       .20 .075|MCOSSX3 |.075 .20 .075|MCSTX3  |.075
       .20 .075|MCDTSX3 |.075 .25}
```

D1: single sc. dipole; TAN and TCT: nominal length
D2: larger aperture 2-in-1, moved towards the IP by 15m
Crab cavities: 3 staggered modules per side per IP per beam
Q4: larger aperture 2-in-1
Q5: long MQY type moved towards the arc by 11m
Q10: added MS circuit and replaced MCBC
IR6: new long MQY type Q5

Layout parameters

```
l.MQXL      :=          7.6850000000 ;
l.MQX       :=          6.5770000000 ;
dq1q2a      :=          3.5600000000 ;
dq2aq2b     :=          1.9150000000 ;
dq2bq3      :=          3.5600000000 ;
deltaposD2  :=        -15.0000000000 ;
deltaposQ4  :=          0.0000000000 ;
deltaposQ5  :=         11.0000000000 ;
deltaposQ6  :=          0.0000000000 ;
```

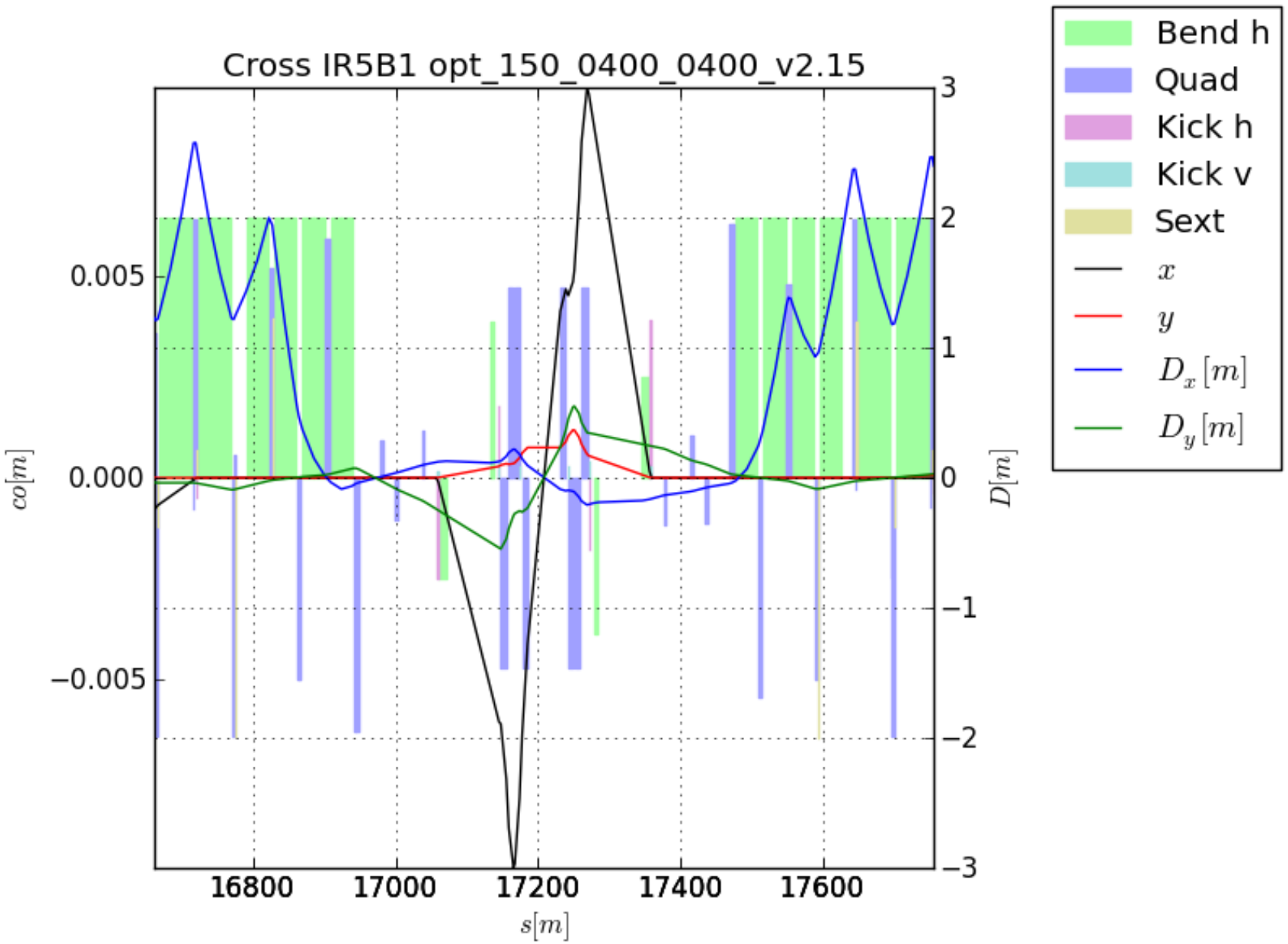
Lengths in m.

MCBX and MCBYY strengths

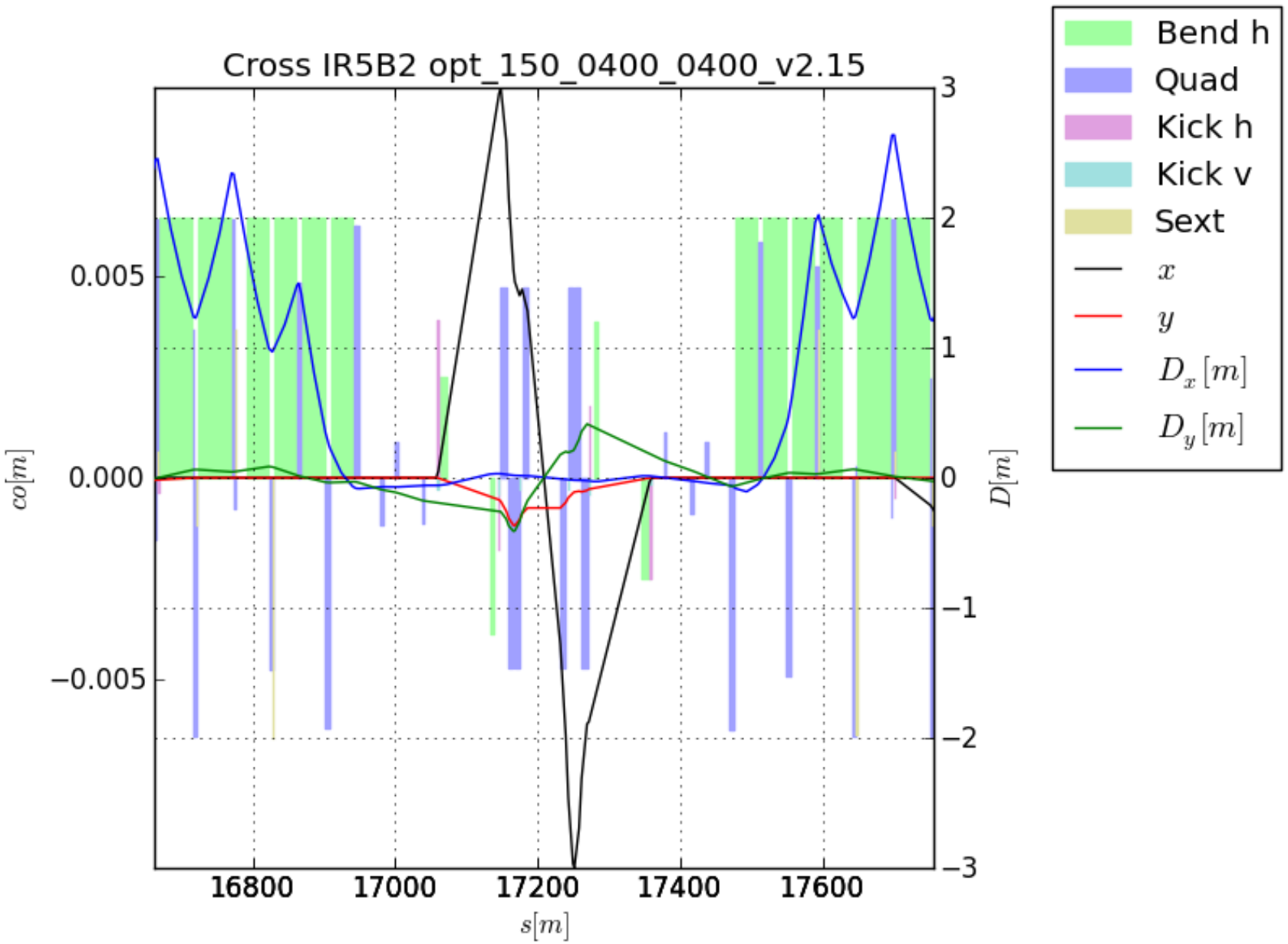
name	acbx1	acbx3	acbyy
opt_150_11000_11000	18.18	45.61	98.03
opt_150_2000_2000	5.62	21.27	47.80
opt_150_5500_5500	17.57	65.54	143.68
opt_150_0400_0400	6.62	49.73	109.97
opt_150_0150_0150	6.62	81.50	180.23
opt_150_0100_0100	6.62	99.46	219.95
opt_150_0075_0300	6.62	75.98	168.01
opt_150_0050_0200	6.62	92.55	204.67
opt_150_0075_0300hv	6.62	75.98	168.01
opt_150_0050_0200hv	6.62	92.55	204.67
max nominal values	64	64	97
reserve for orbit correction	25	25	n/a

Maximum values per family in μrad.

Crossing scheme



Crossing scheme

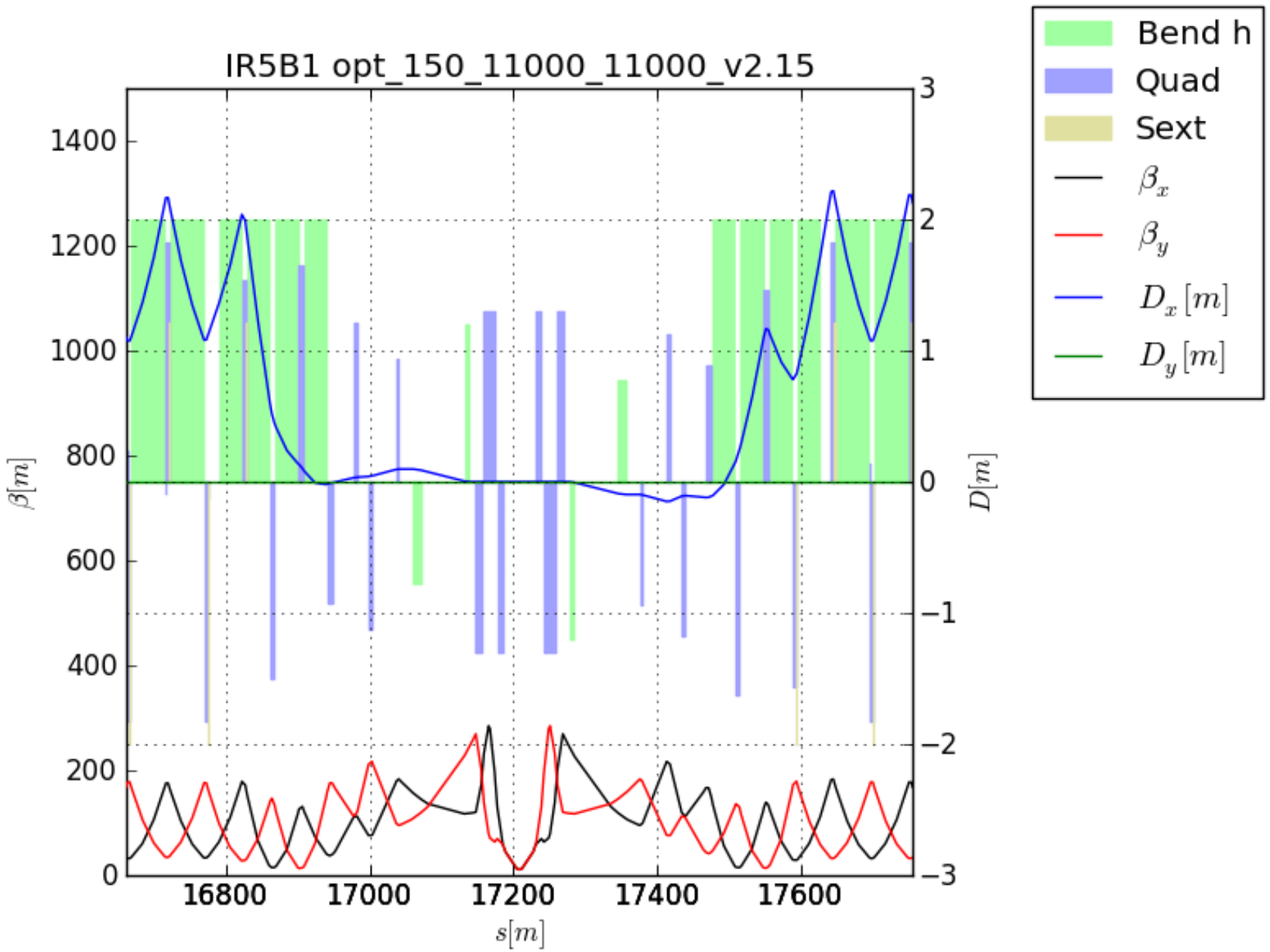


Aperture model

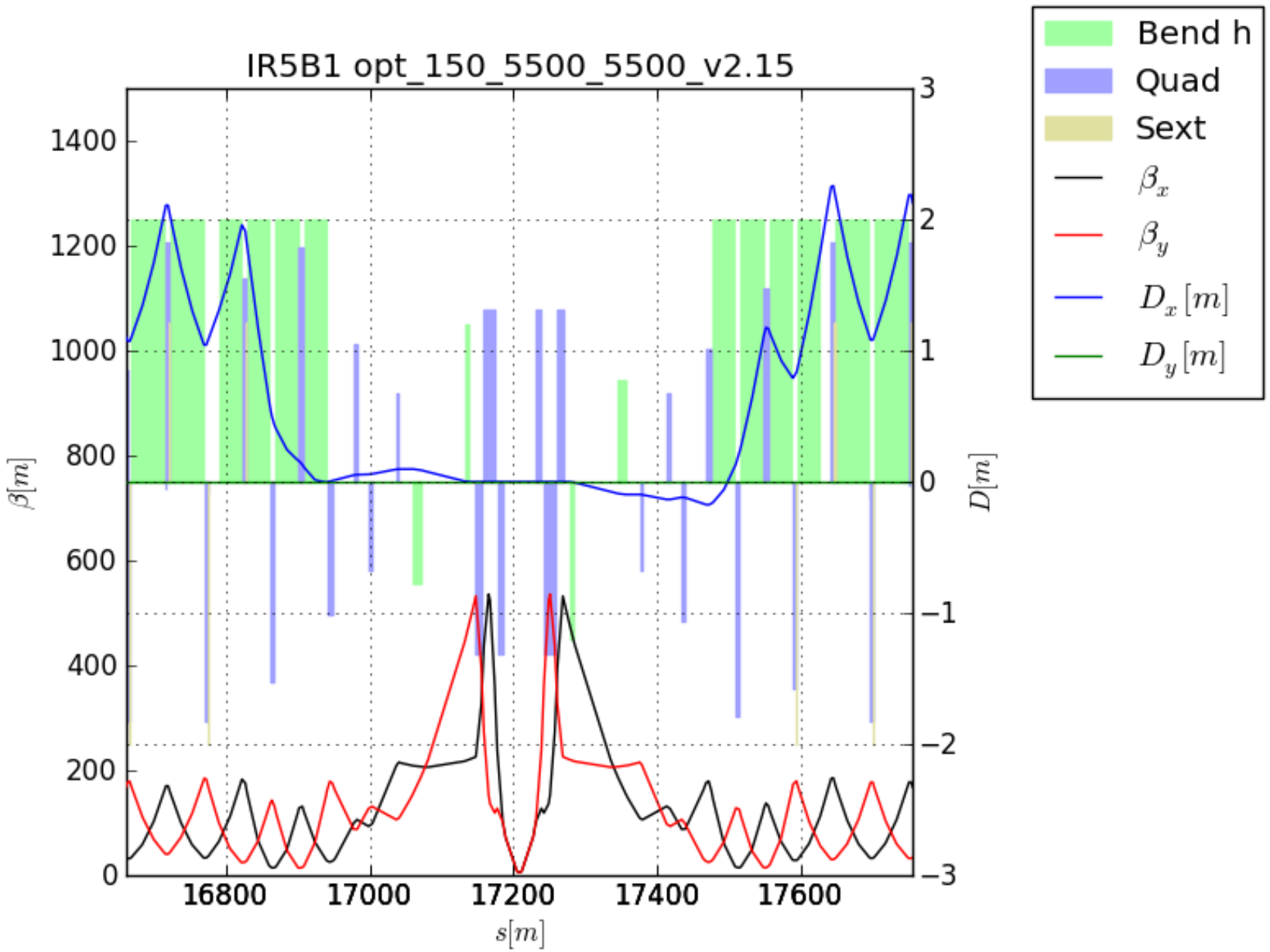
Based on Phase I.

- MQX and MC_X: octagon scaled by the triplet aperture ($a_{\mathrm{mqx}} = 140$mm)
- D1: round $r = a_{\mathrm{mqx}}/2 + 7$mm
- TAS: round $r = 30$mm
- BPMs: round $r = a_{\mathrm{mqx}}/2$
- TAN: ellipse $a, b = 41, 37$mm
- D2 and MCBYY: rectellipse $g, r = (37, 42)$mm for 106mm coil aperture
- Q4: rectellipse $g, r = (30, 35)$mm for 90mm coil aperture
- BPMs D2, Q4, Q5: round $r = 41, 37.5, 30$mm

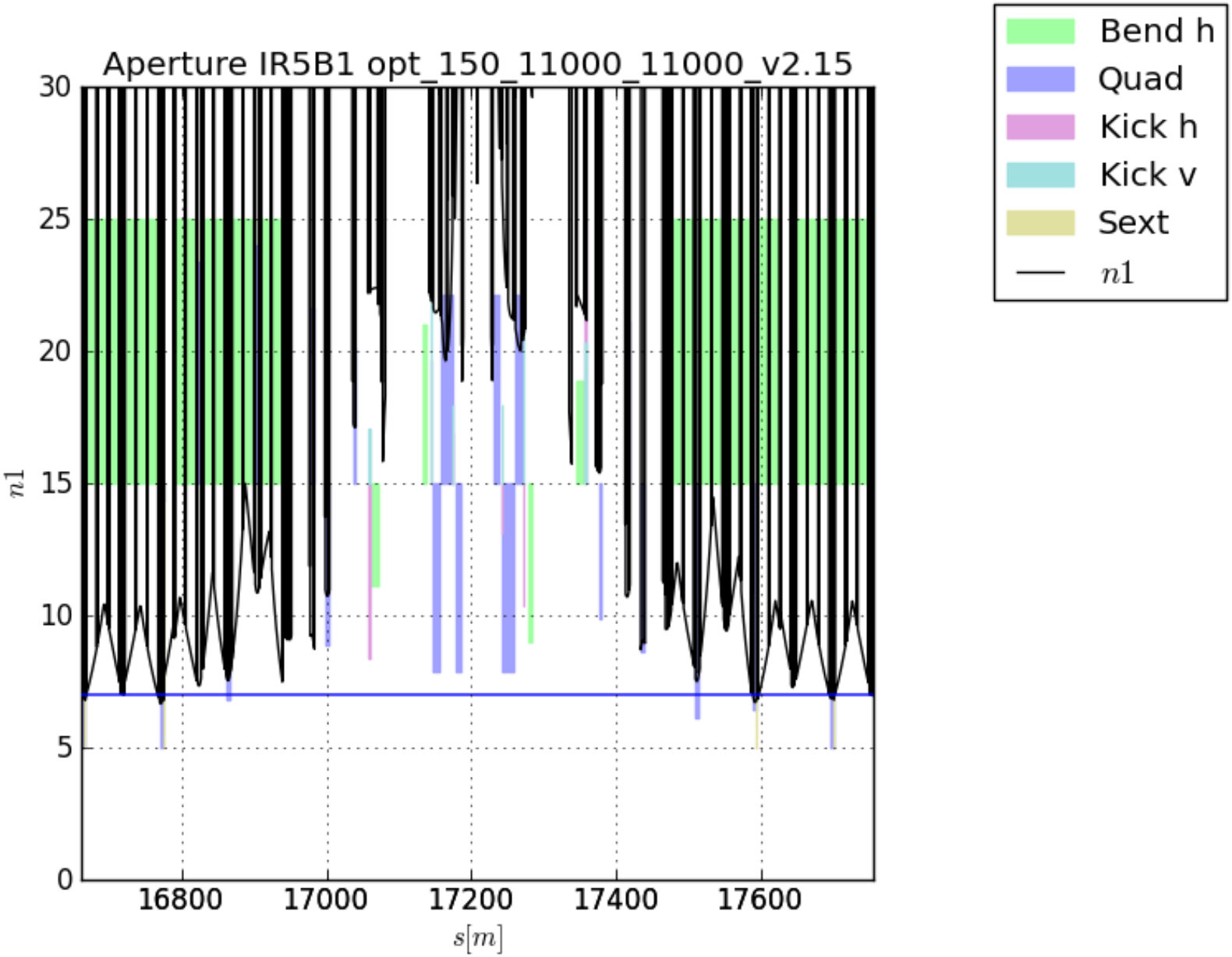
IR5 injection



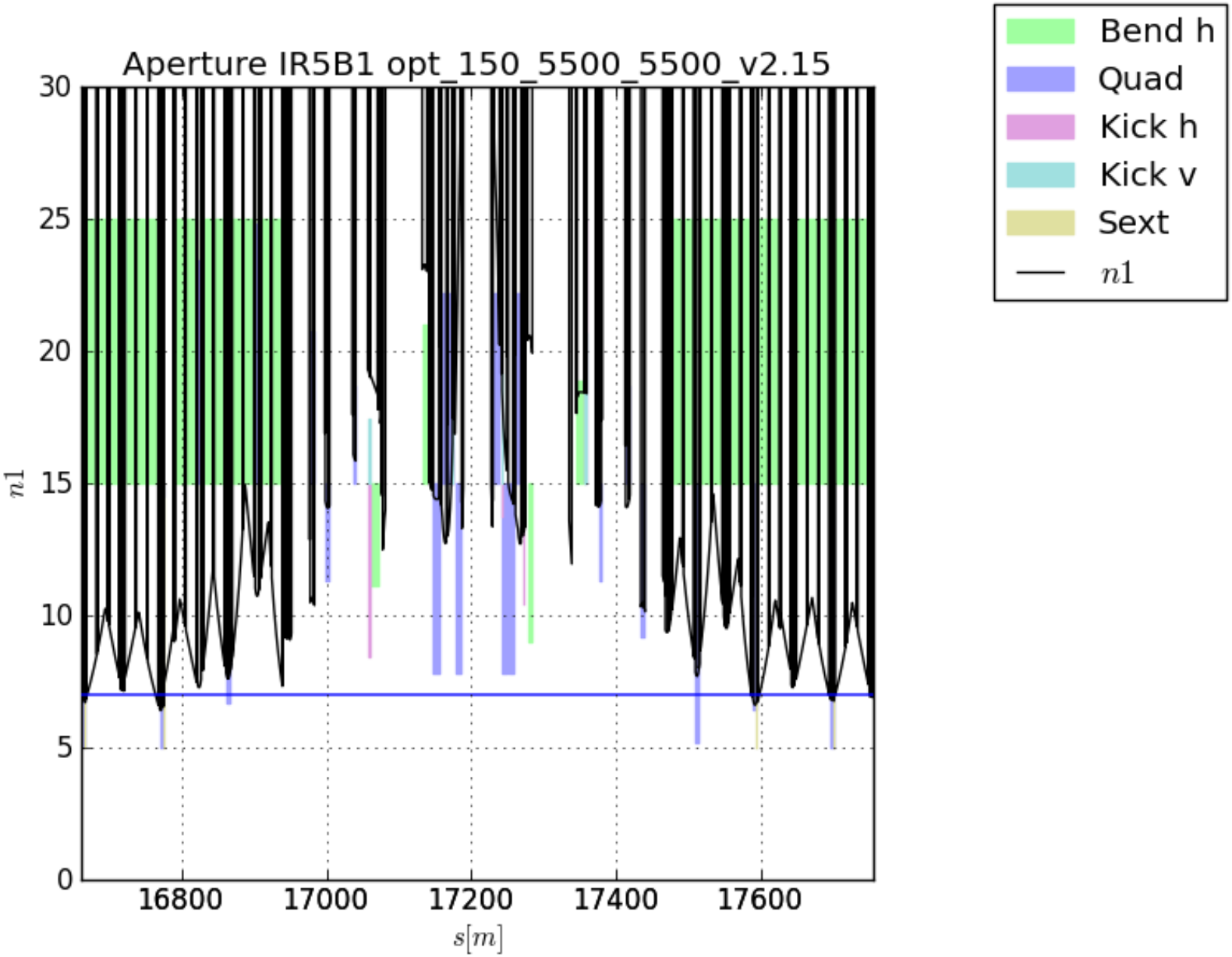
IR5 injection



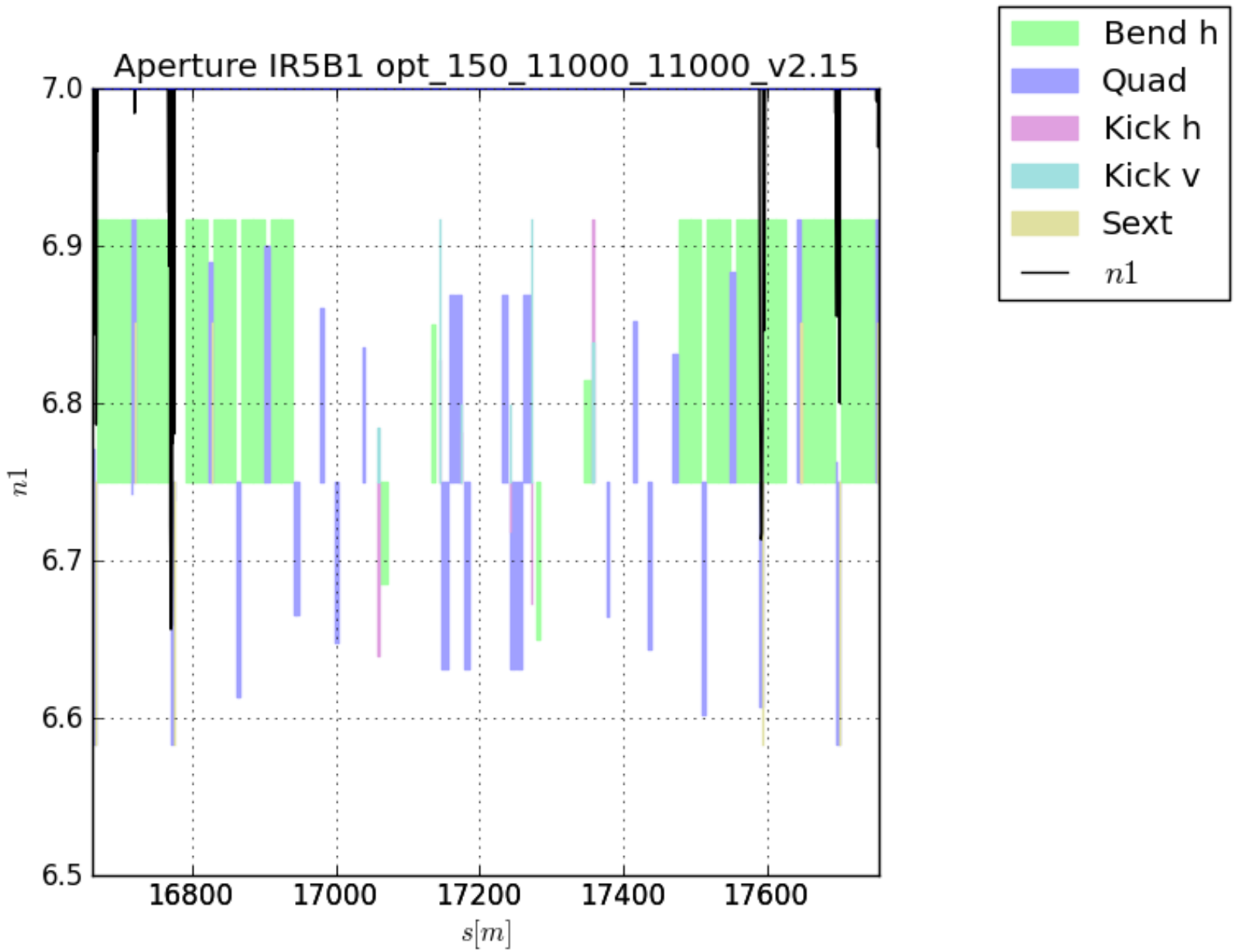
IR5 injection



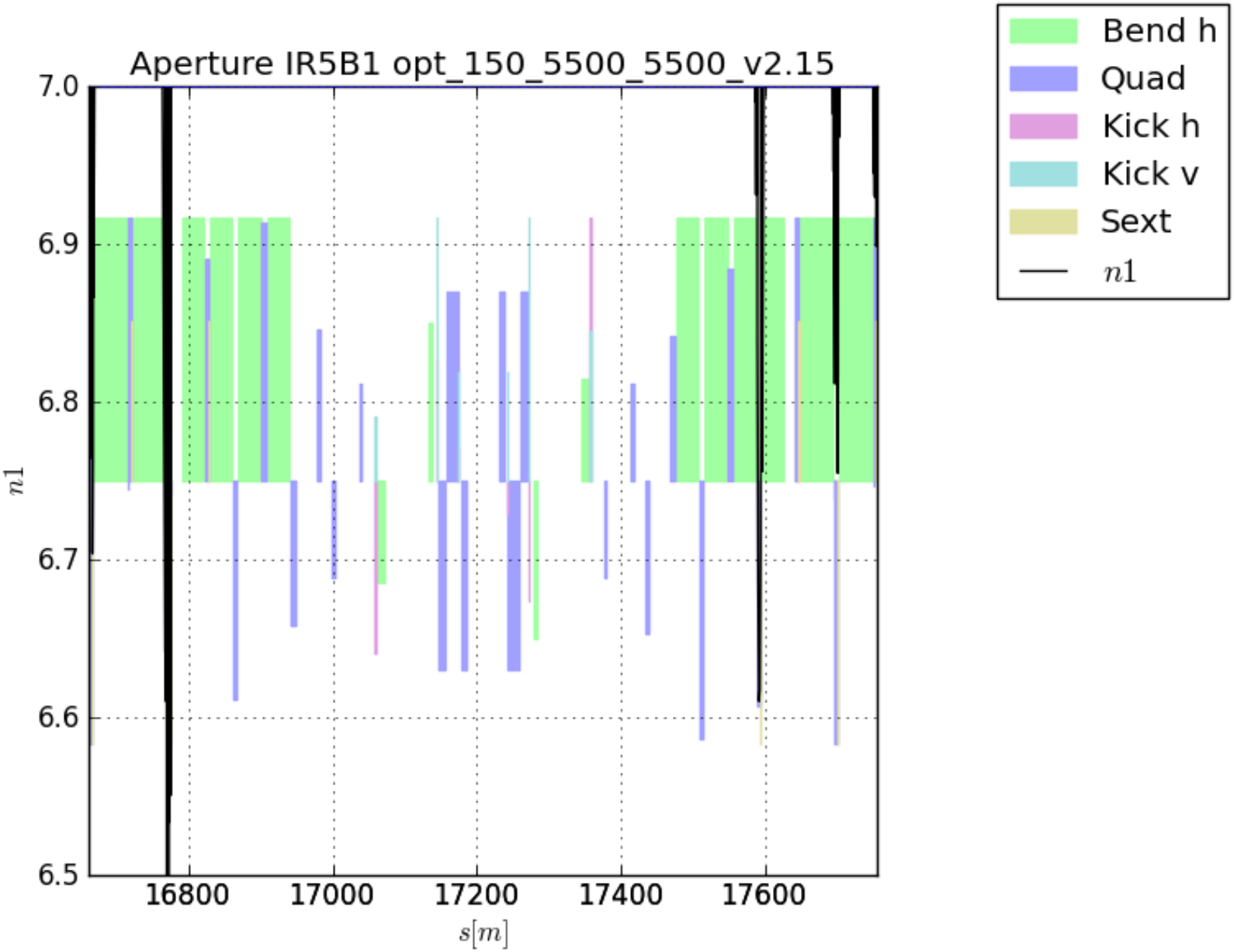
IR5 injection



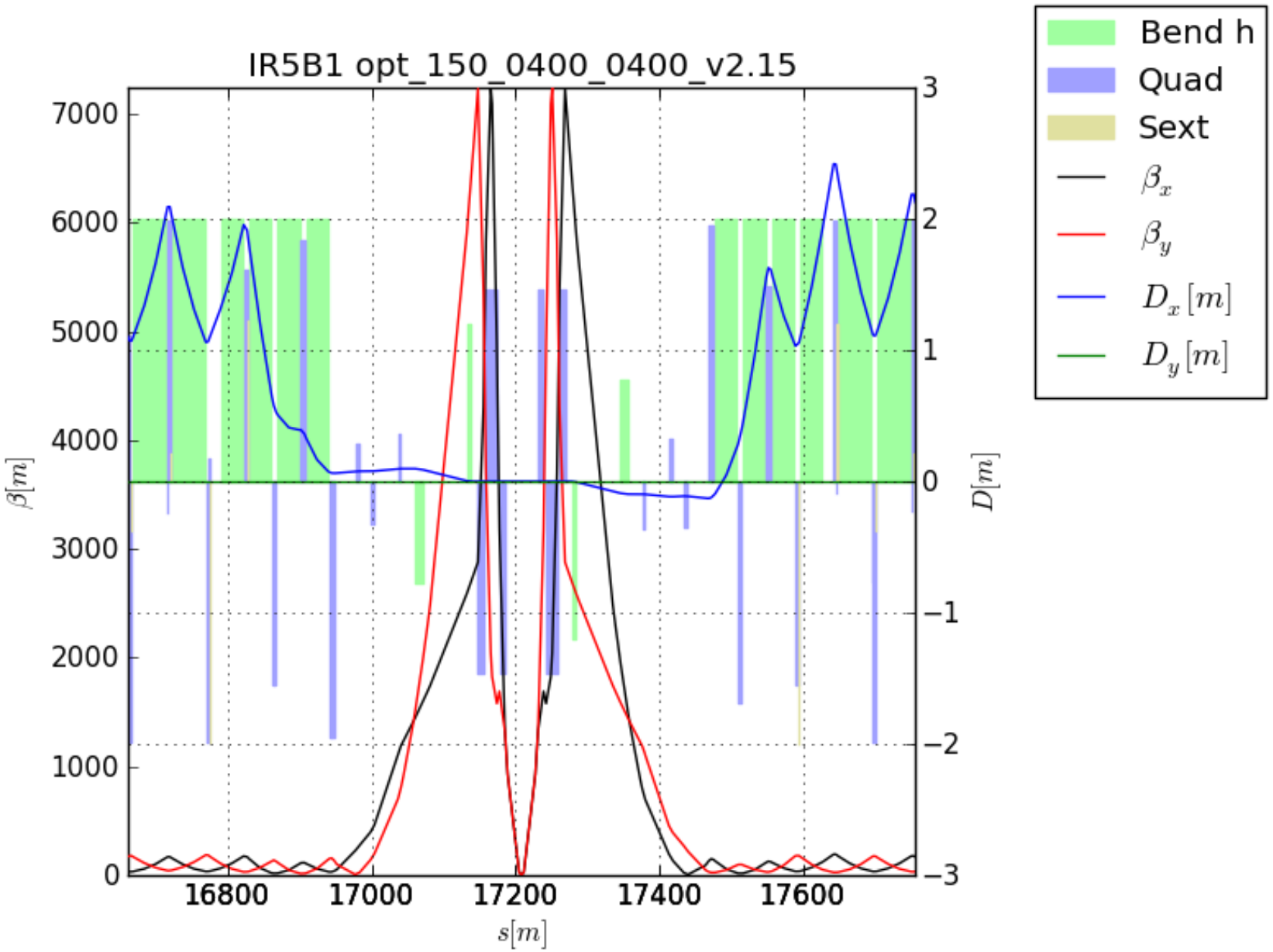
IR5 injection



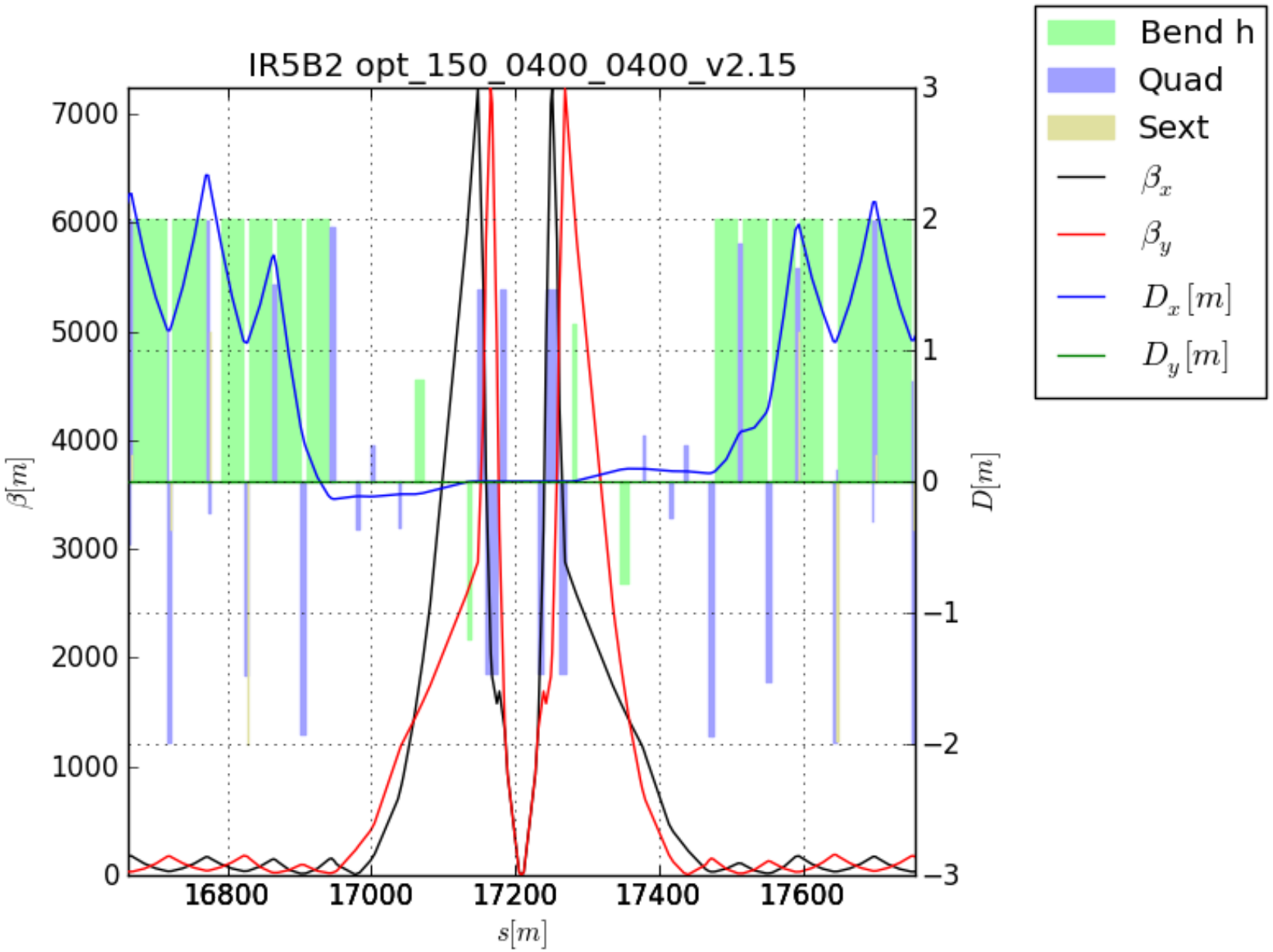
IR5 injection



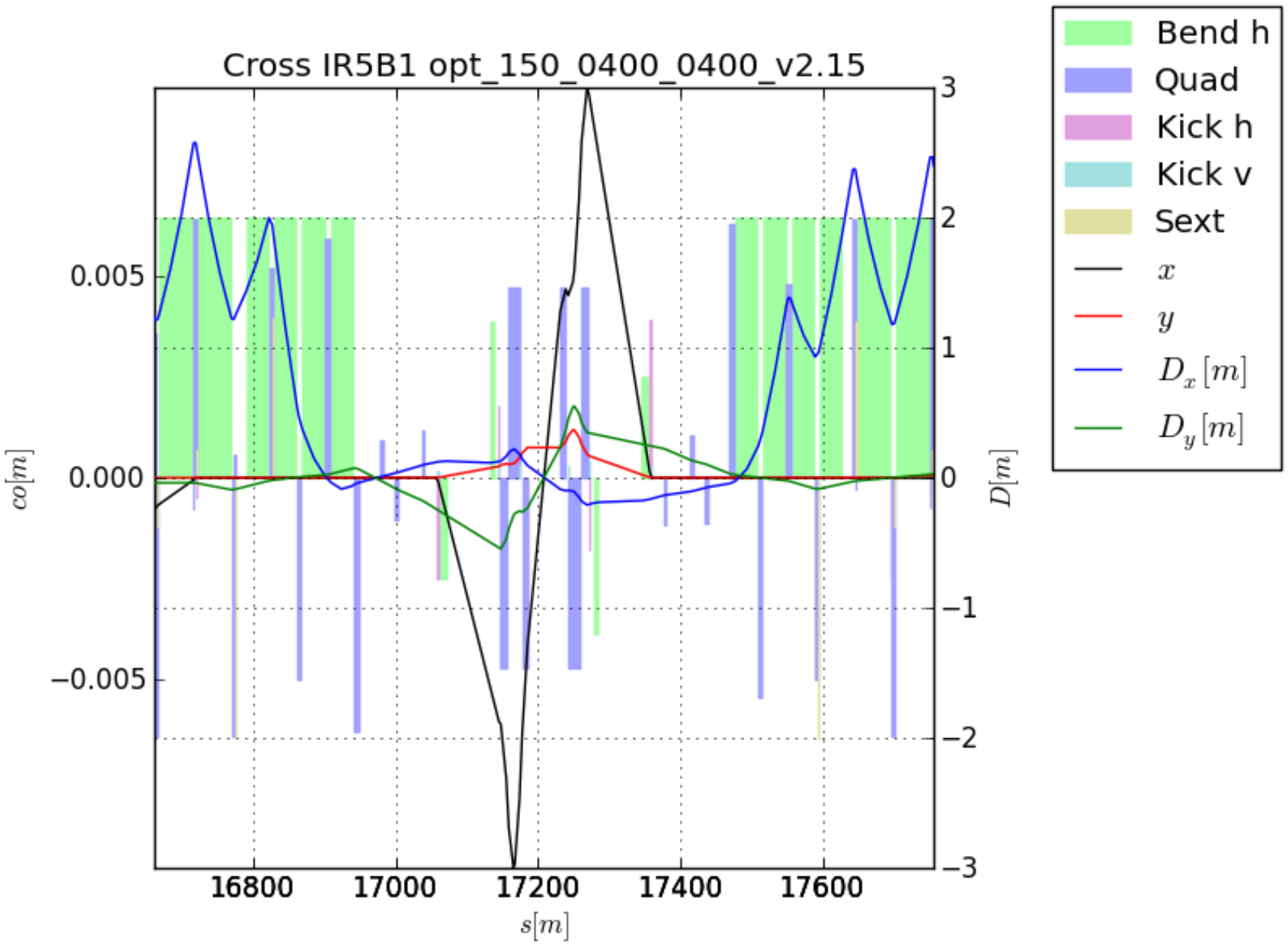
IR5 pre-squeeze



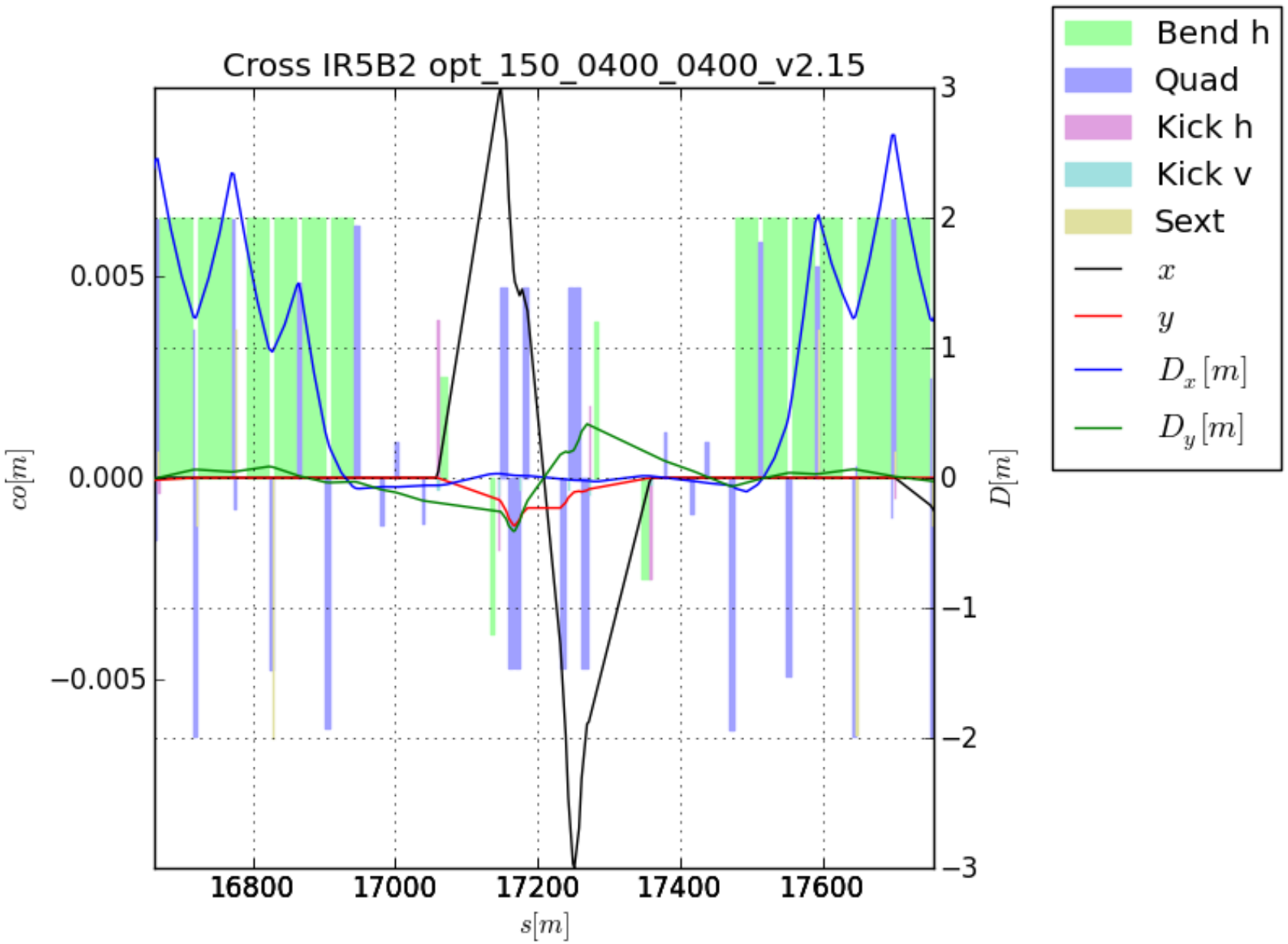
IR5 pre-squeeze



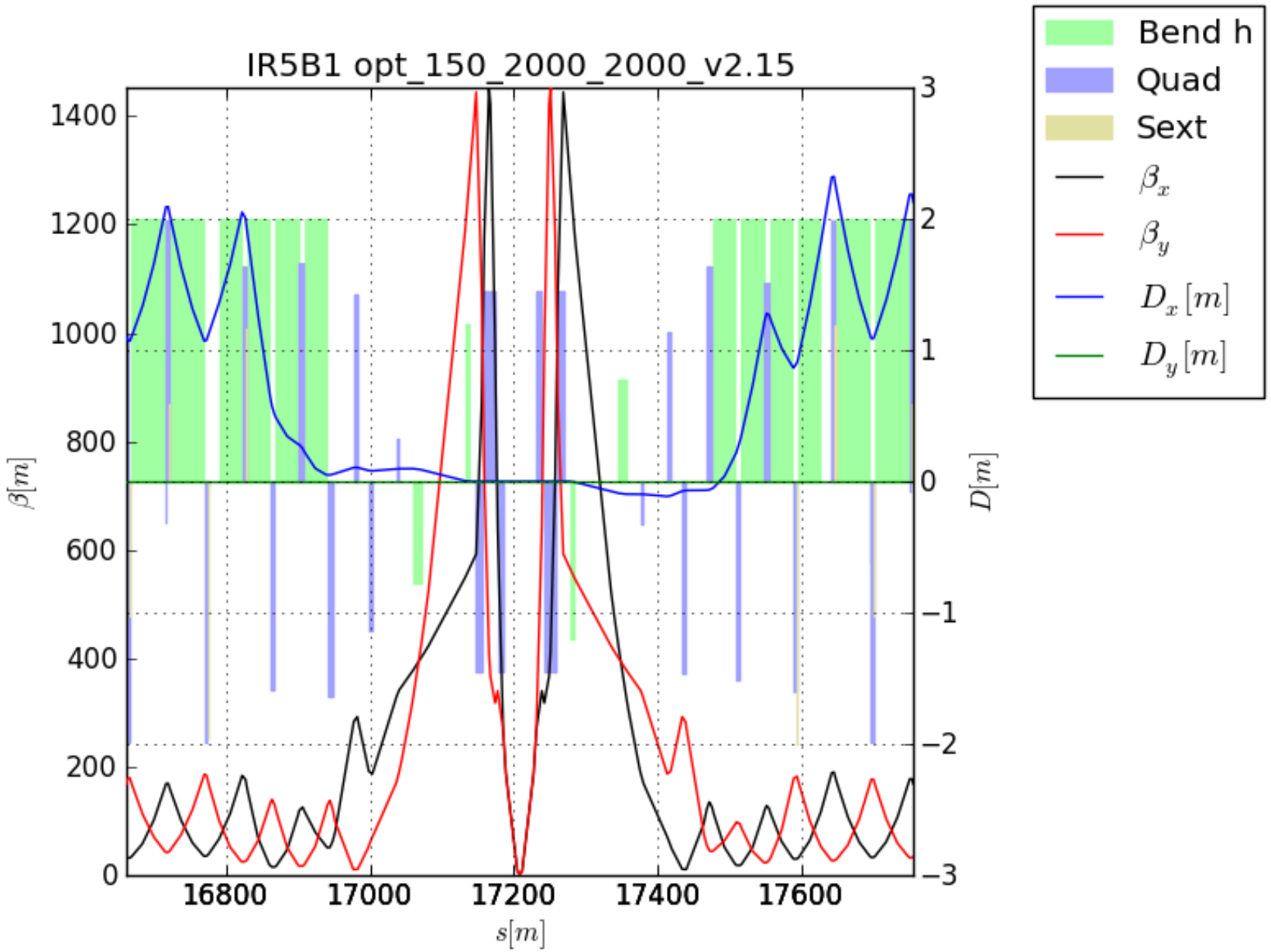
IR5 pre-squeeze



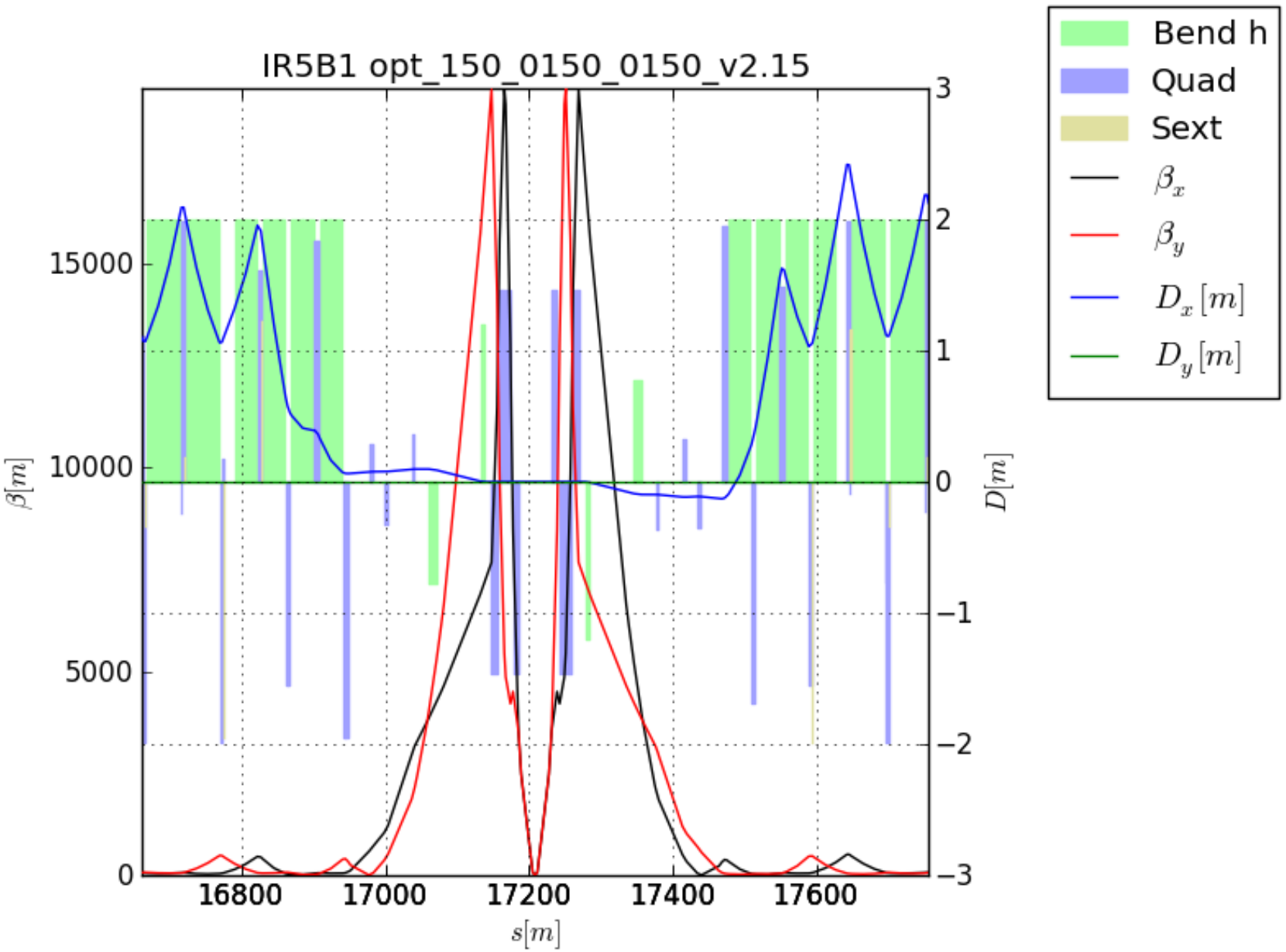
IR5 pre-squeeze



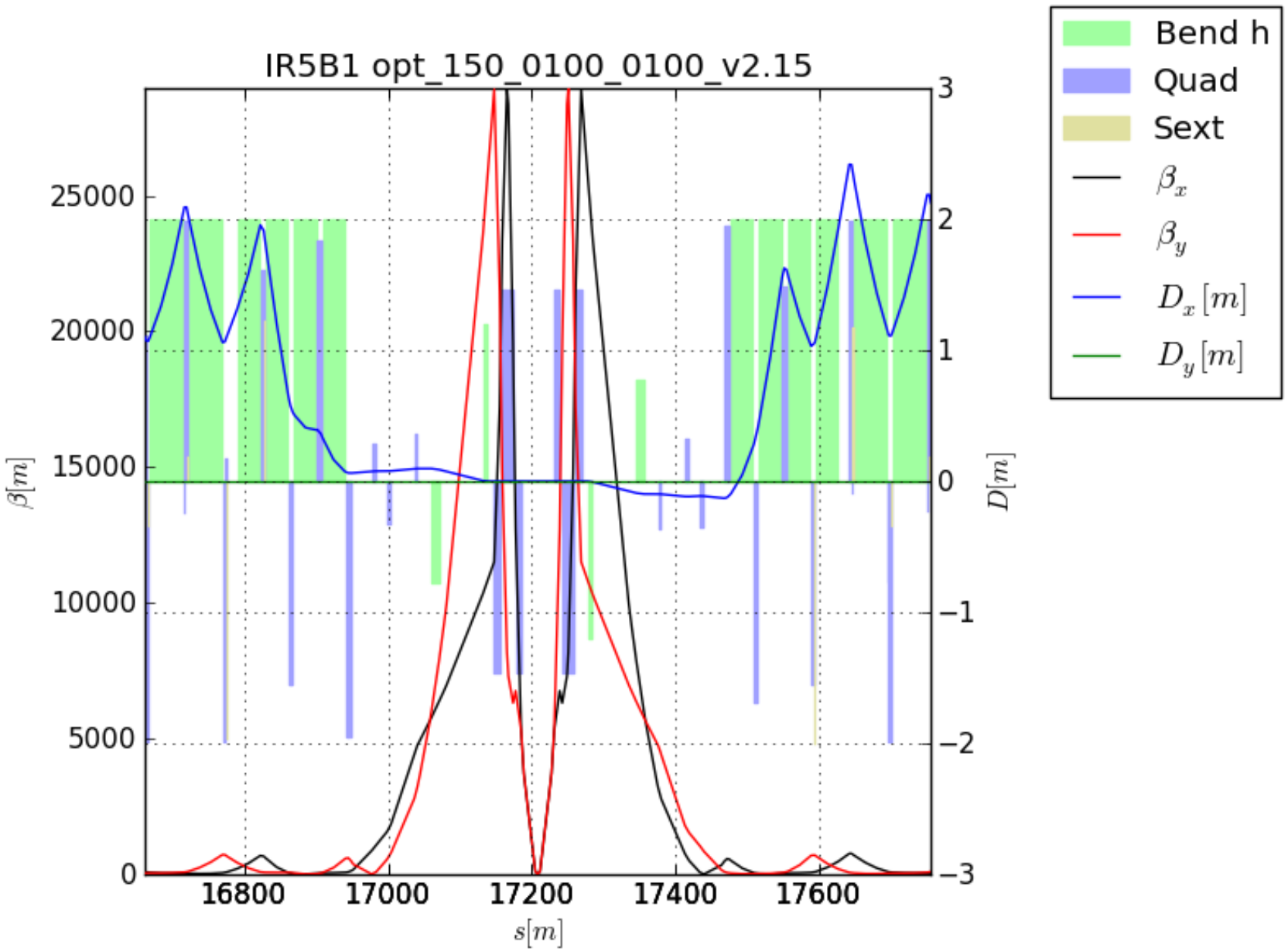
IR5 pre-squeeze



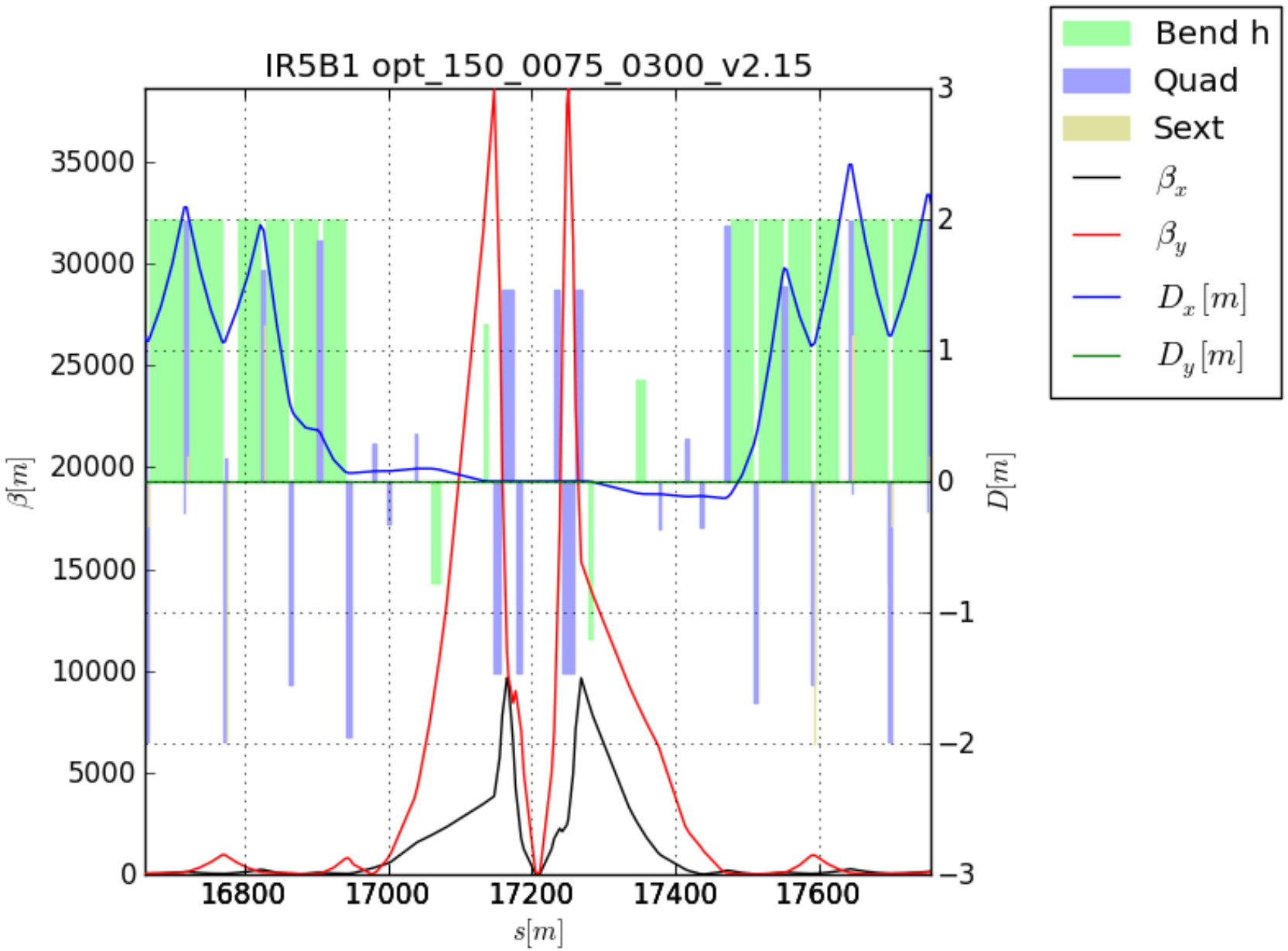
IR5 squeeze


IR5B1 opt_150_0150_0150_v2.15
Bend h
Quad
Sext
β_x
β_y
$D_x[m]$
$D_y[m]$
$\beta[m]$
$D[m]$
$s[m]$
0
5000
10000
15000
16800
17000
17200
17400
17600
3
2
1
0
−1
−2
−3

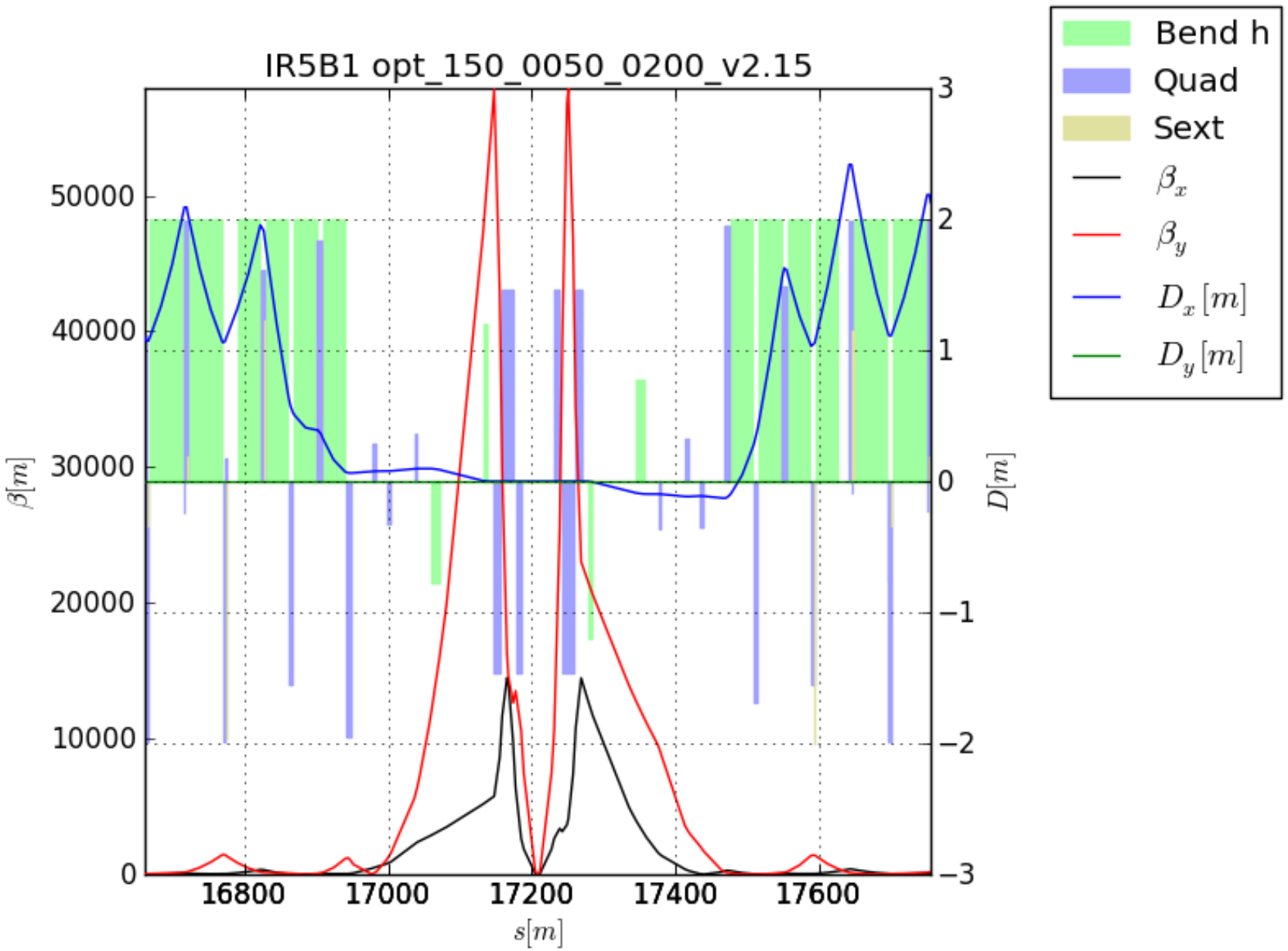
IR5 squeeze


IR5B1 opt_150_0100_0100_v2.15
Bend h
Quad
Sext
β_x
β_y
$D_x[m]$
$D_y[m]$
$\beta[m]$
$D[m]$
$s[m]$
25000
20000
15000
10000
5000
0
3
2
1
0
−1
−2
−3
16800
17000
17200
17400
17600

IR5 squeeze


IR5B1 opt_150_0075_0300_v2.15
Bend h
Quad
Sext
β_x
β_y
$D_x[m]$
$D_y[m]$
$\beta[m]$
$D[m]$
$s[m]$
35000
30000
25000
20000
15000
10000
5000
0
3
2
1
0
−1
−2
−3
16800
17000
17200
17400
17600

IR5 squeeze


IR5B1 opt_150_0050_0200_v2.15
Bend h
Quad
Sext
β_x
β_y
$D_x[m]$
$D_y[m]$
$\beta[m]$
$D[m]$
$s[m]$
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10000
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50000
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17000
17200
17400
17600
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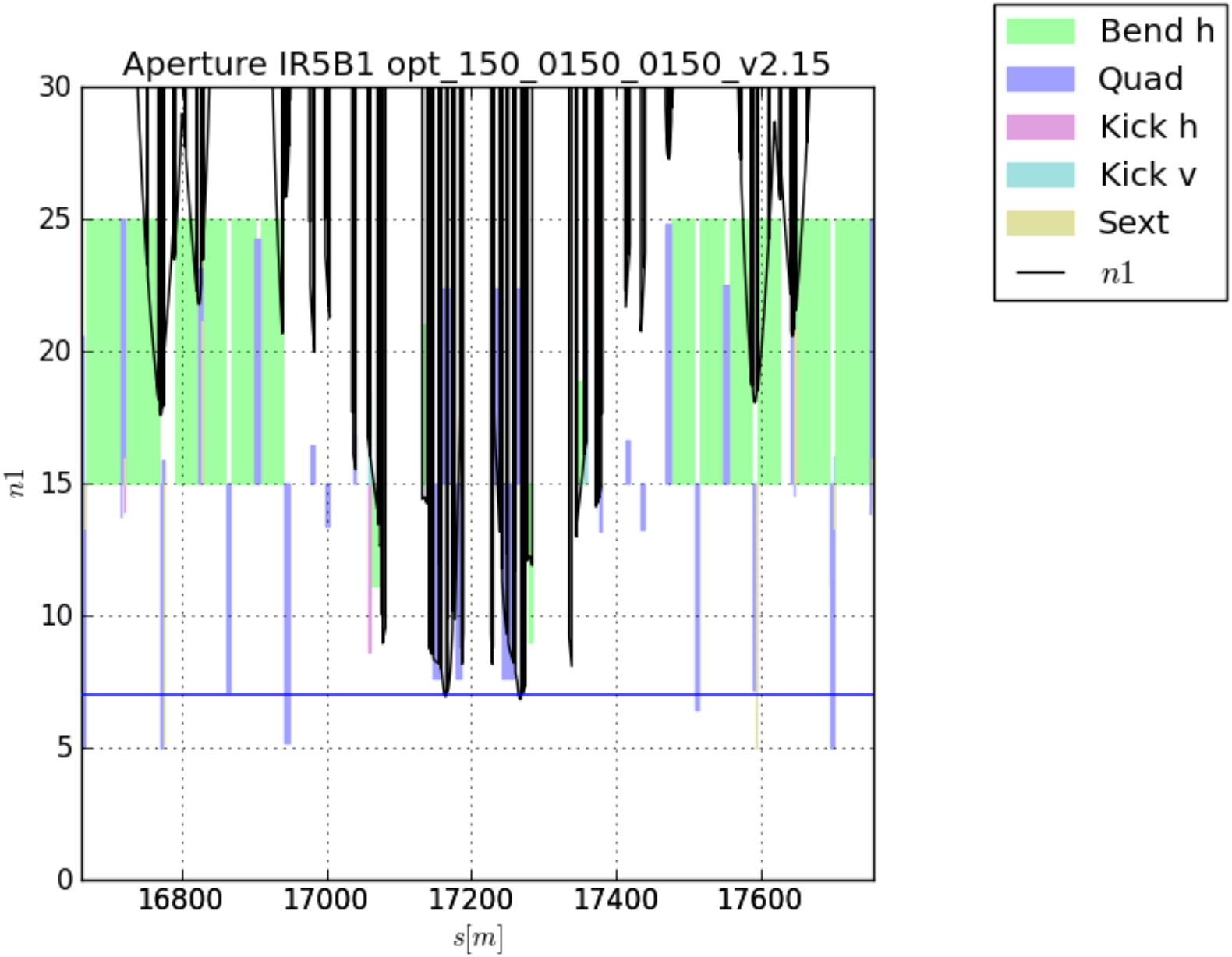
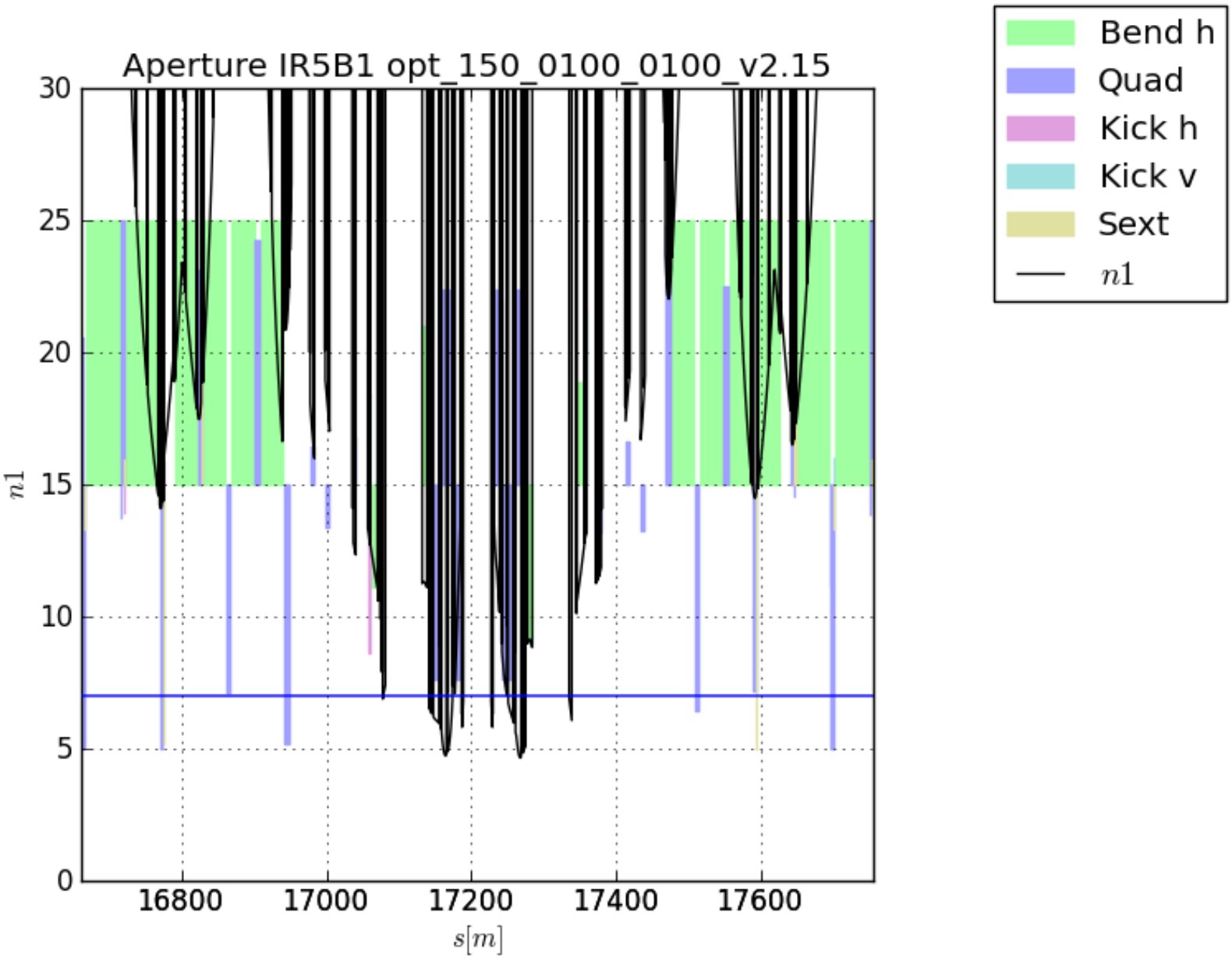
−1
−2
−3

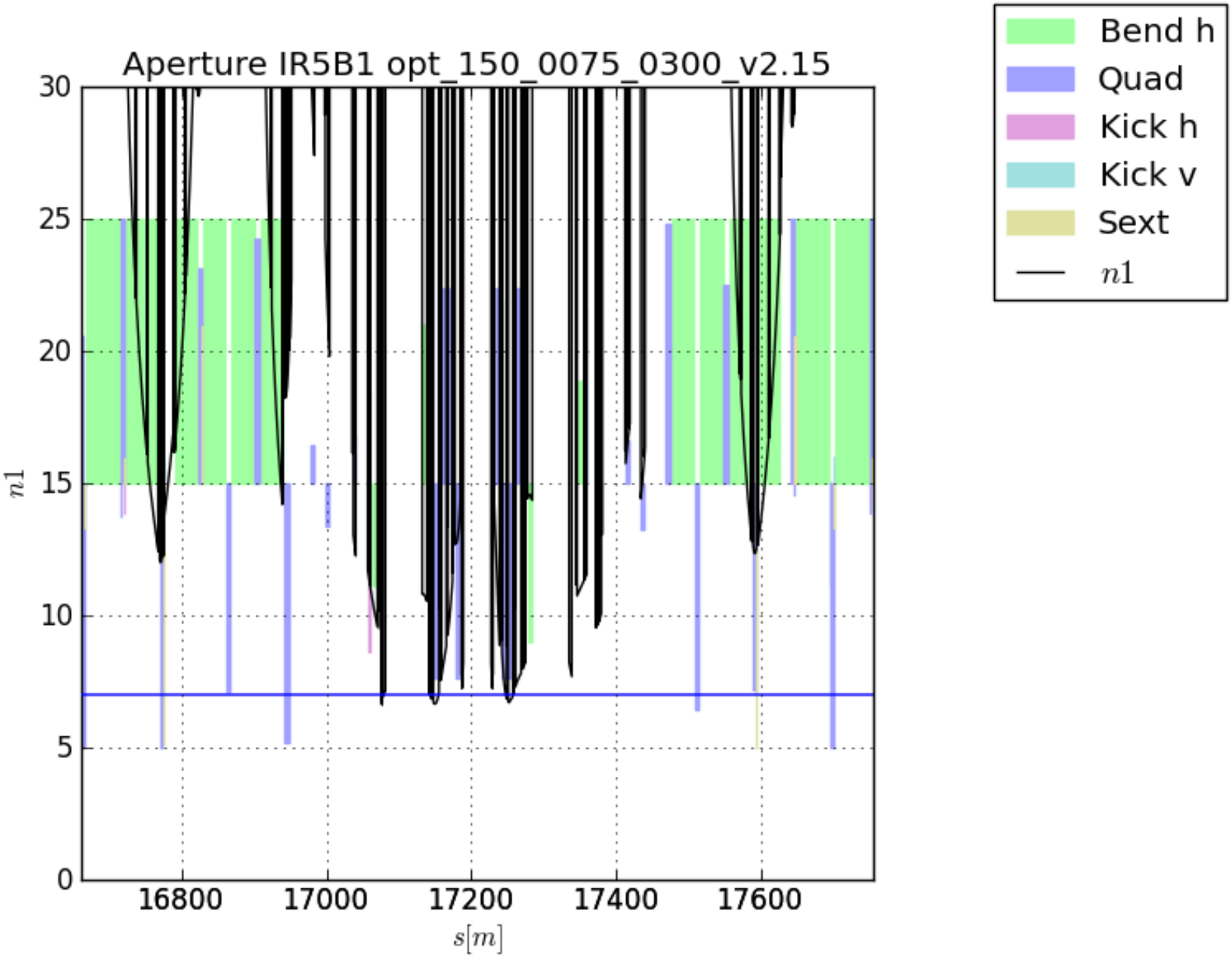
IR5 squeeze


Aperture IR5B1 opt_150_0150_0150_v2.15
Bend h
Quad
Kick h
Kick v
Sext
$n1$
30
25
20
15
10
5
0
16800
17000
17200
17400
17600
$s[m]$

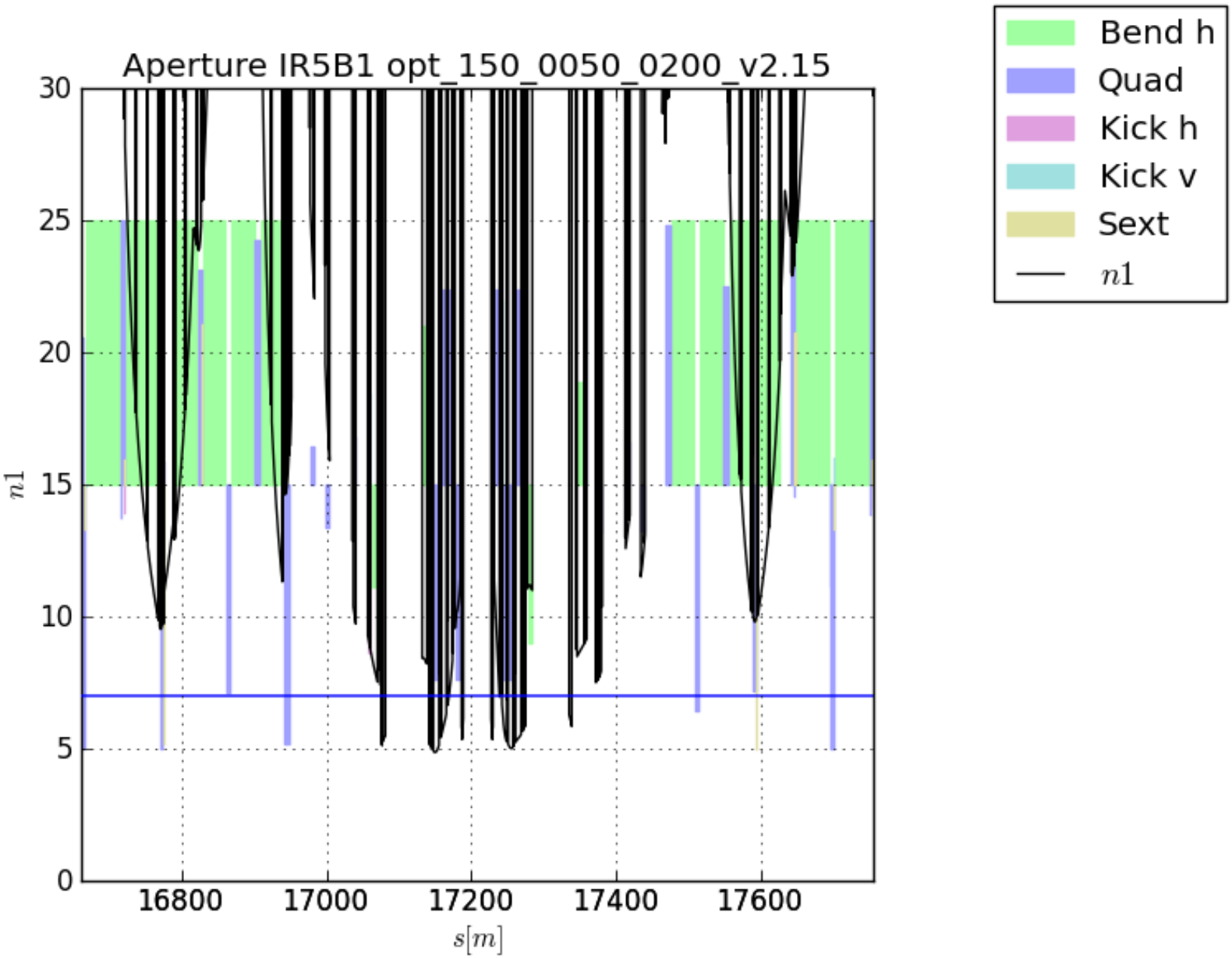
IR5 squeeze


Aperture IR5B1 opt_150_0100_0100_v2.15
Bend h
Quad
Kick h
Kick v
Sext
$n1$
30
25
20
15
10
5
0
$n1$
16800
17000
17200
17400
17600
$s[m]$

IR5 squeeze


Aperture IR5B1 opt_150_0075_0300_v2.15
Bend h
Quad
Kick h
Kick v
Sext
$n1$
30
25
20
15
10
5
0
16800
17000
17200
17400
17600
$s[m]$

IR5 squeeze


Aperture IR5B1 opt_150_0050_0200_v2.15
Bend h
Quad
Kick h
Kick v
Sext
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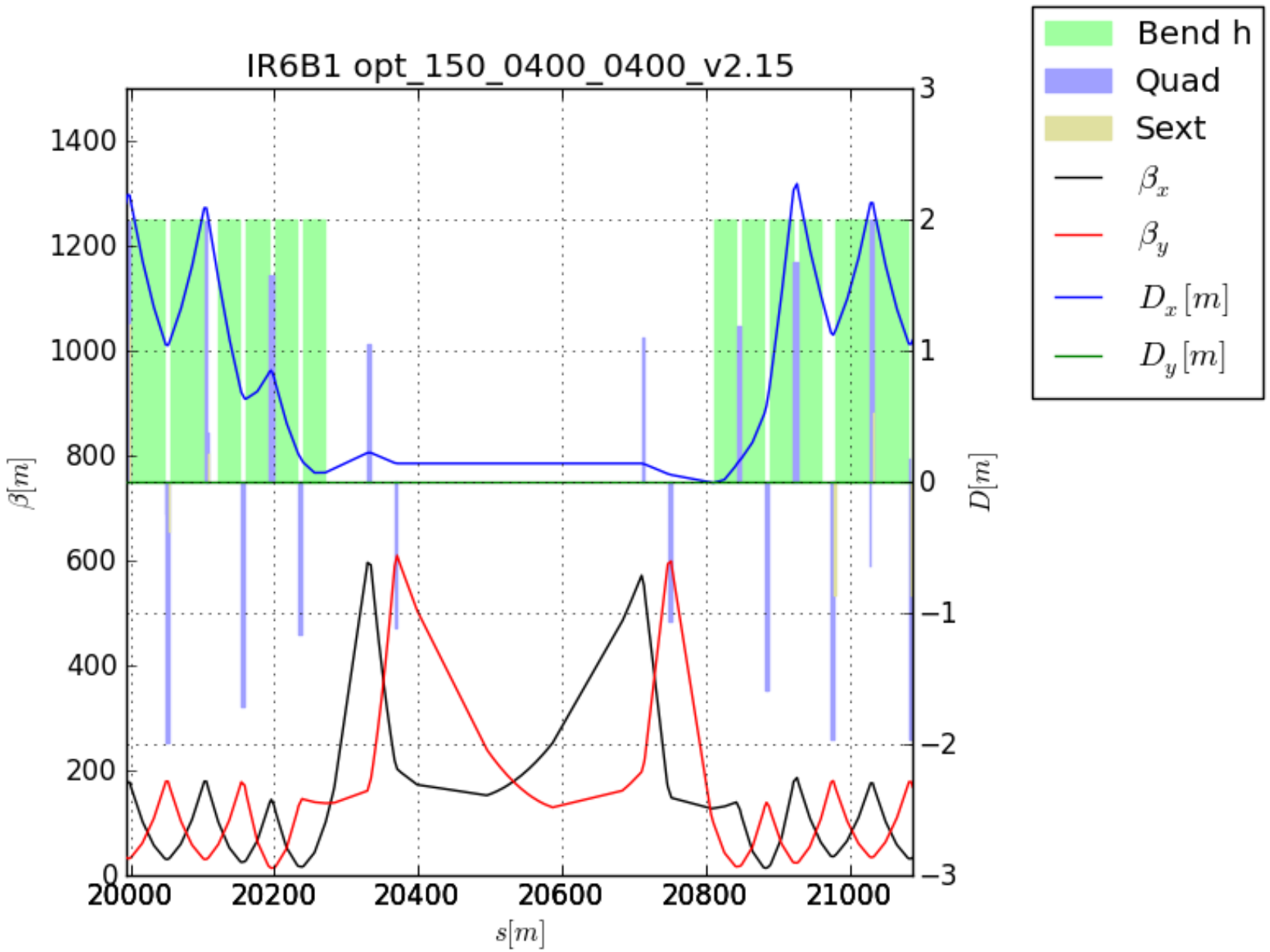
25
20
15
10
5
0
16800
17000
17200
17400
17600
$s[m]$

IR6


IR6B1 opt_150_0400_0400_v2.15
Bend h
Quad
Sext
β_x
β_y
$D_x[m]$
$D_y[m]$
$\beta[m]$
$D[m]$
$s[m]$
0
200
400
600
800
1000
1200
1400
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20200
20400
20600
20800
21000
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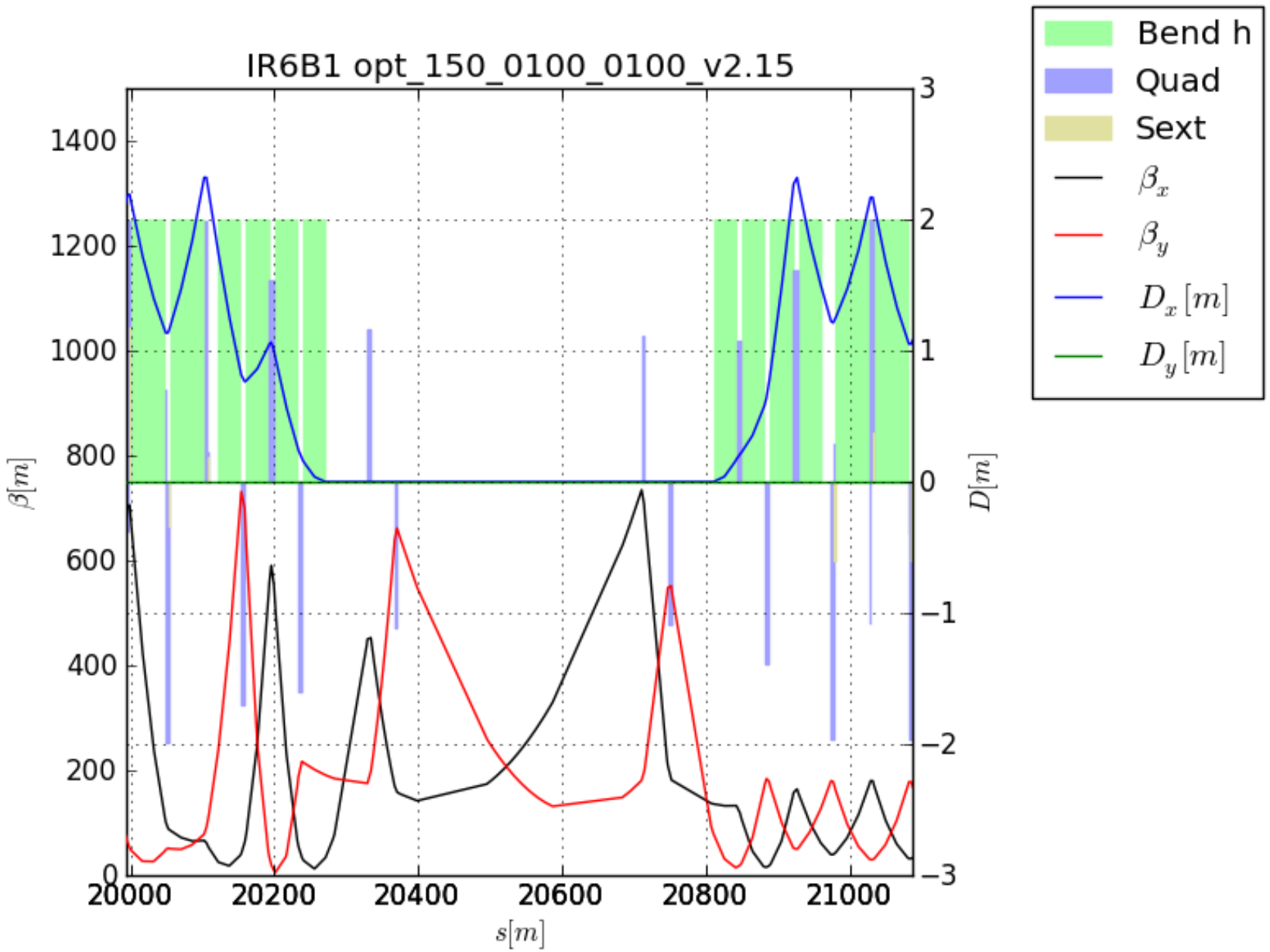
−2
−1
0
1
2
3

IR6


IR6B1 opt_150_0100_0100_v2.15
Bend h
Quad
Sext
β_x
β_y
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$D_y[m]$
$\beta[m]$
$D[m]$
$s[m]$
0
200
400
600
800
1000
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1400
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20400
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20800
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−1
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1
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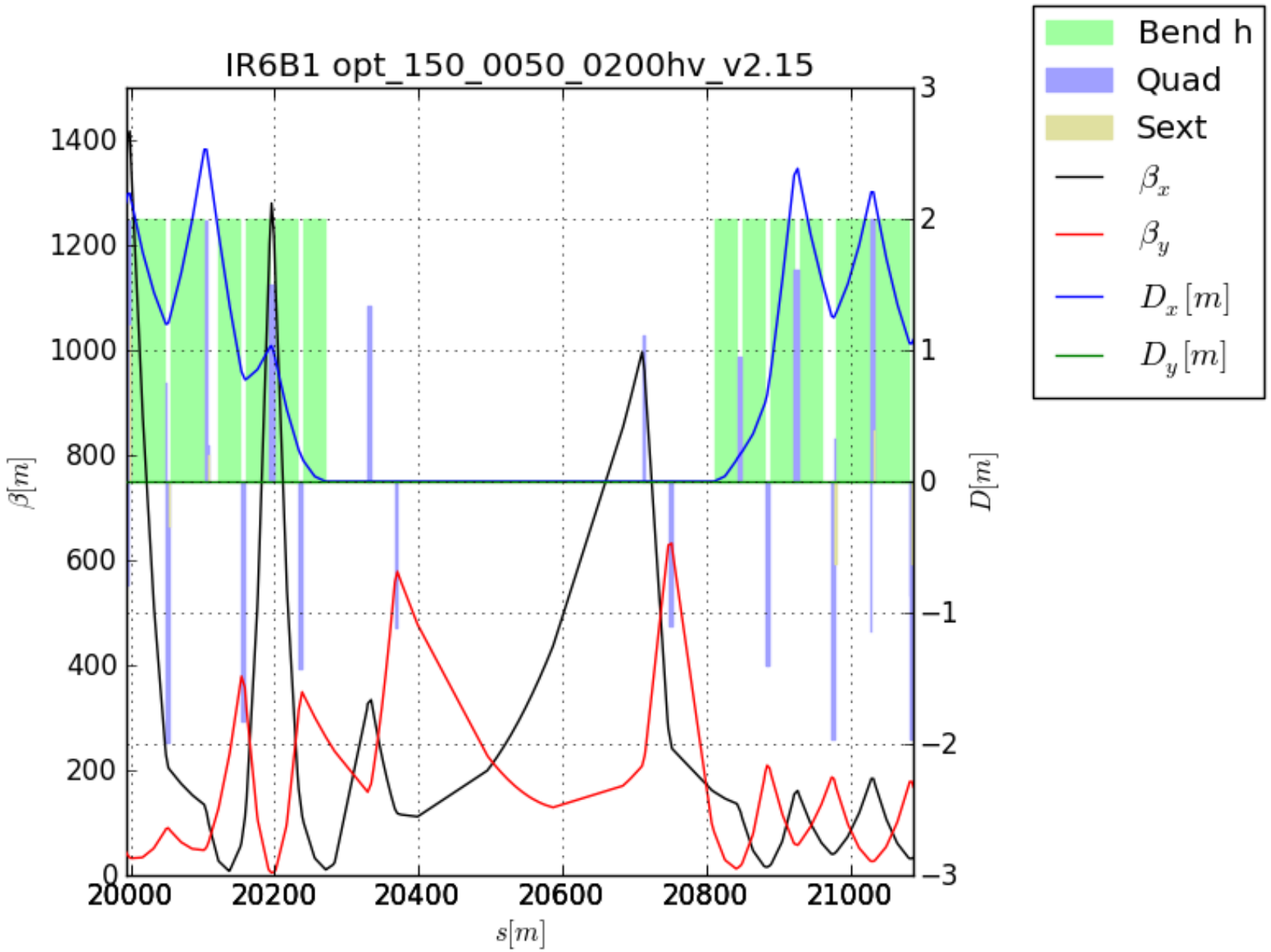
3

IR6


IR6B1 opt_150_0050_0200hv_v2.15
Bend h
Quad
Sext
β_x
β_y
$D_x[m]$
$D_y[m]$
$\beta[m]$
$D[m]$
$s[m]$
0
200
400
600
800
1000
1200
1400
20000
20200
20400
20600
20800
21000
−3
−2
−1
0
1
2
3

IR6 dump system features

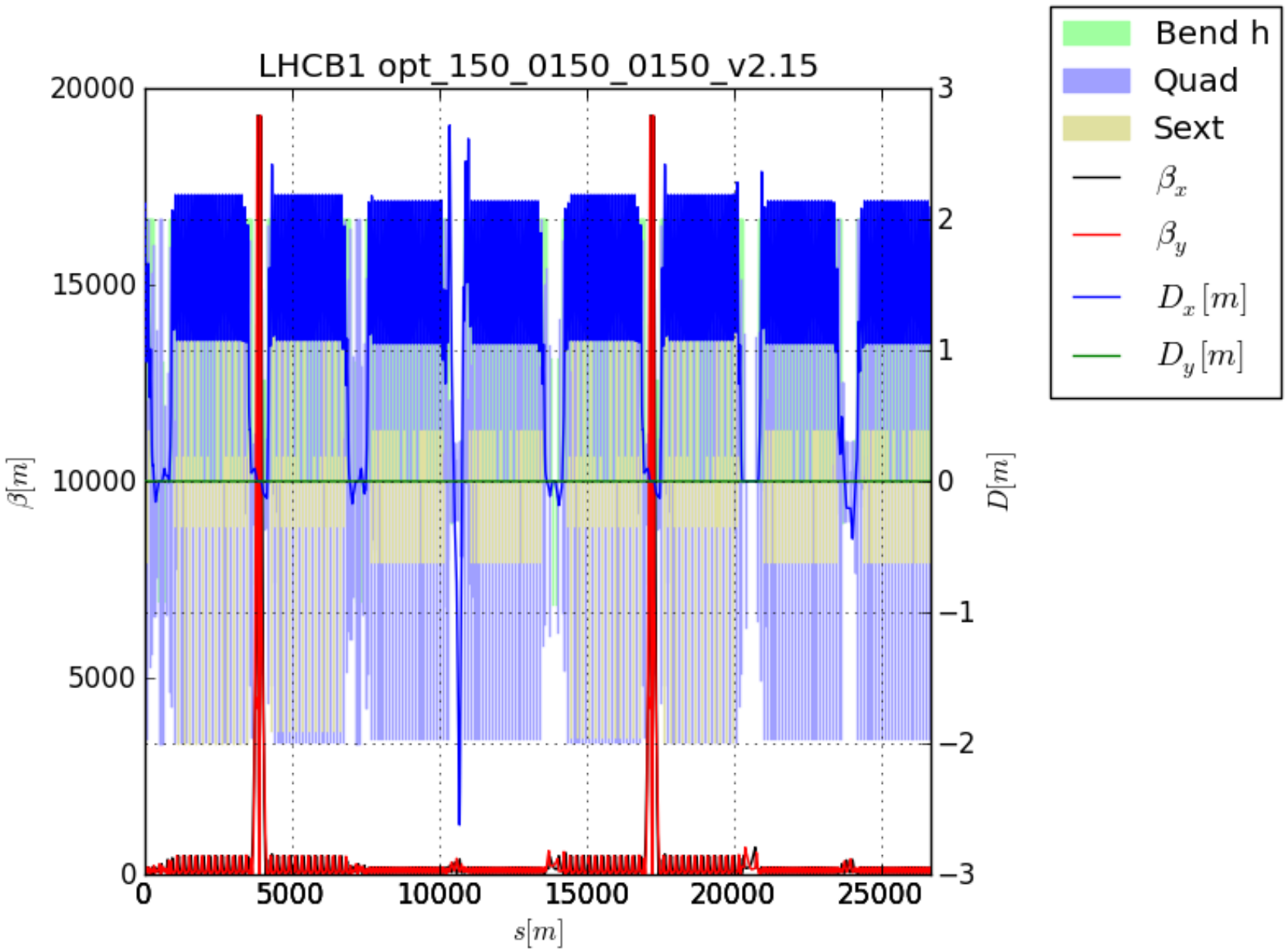
name	dpxb1	dpxb2	dxb1	dxb2	bxb1 dump	bxb2 dump	byb1 dump	byb2 dump	dmuxb1 kick	dmuxb2 kick
	murad	murad	m	m	m	m	m	m	2pi	2pi
inj	0	-256	0.14	0.186	5012	5052	3955	3698	0.2631	0.2633
1111	0	-256	0.14	0.186	5012	5052	3955	3698	0.2631	0.2633
3333	0	0	0	0	5455	5867	4241	3699	0.25	0.25
4444	0	0	0	0	5743	6134	3955	3698	0.25	0.25
8228	0	0	0	0	5581	5820	6115	3698	0.25	0.25
5115	0	0	0	0	5012	5052	4063	3699	0.25	0.25
2882	0	0	0	0	7456	6818	3955	3698	0.25	0.25
1551	0	0	0	0	7244	6758	3974	3828	0.25	0.25

Without injection constraints optics can be optimized for the dump system.
It is possible to attempt to improve inj and 1111.

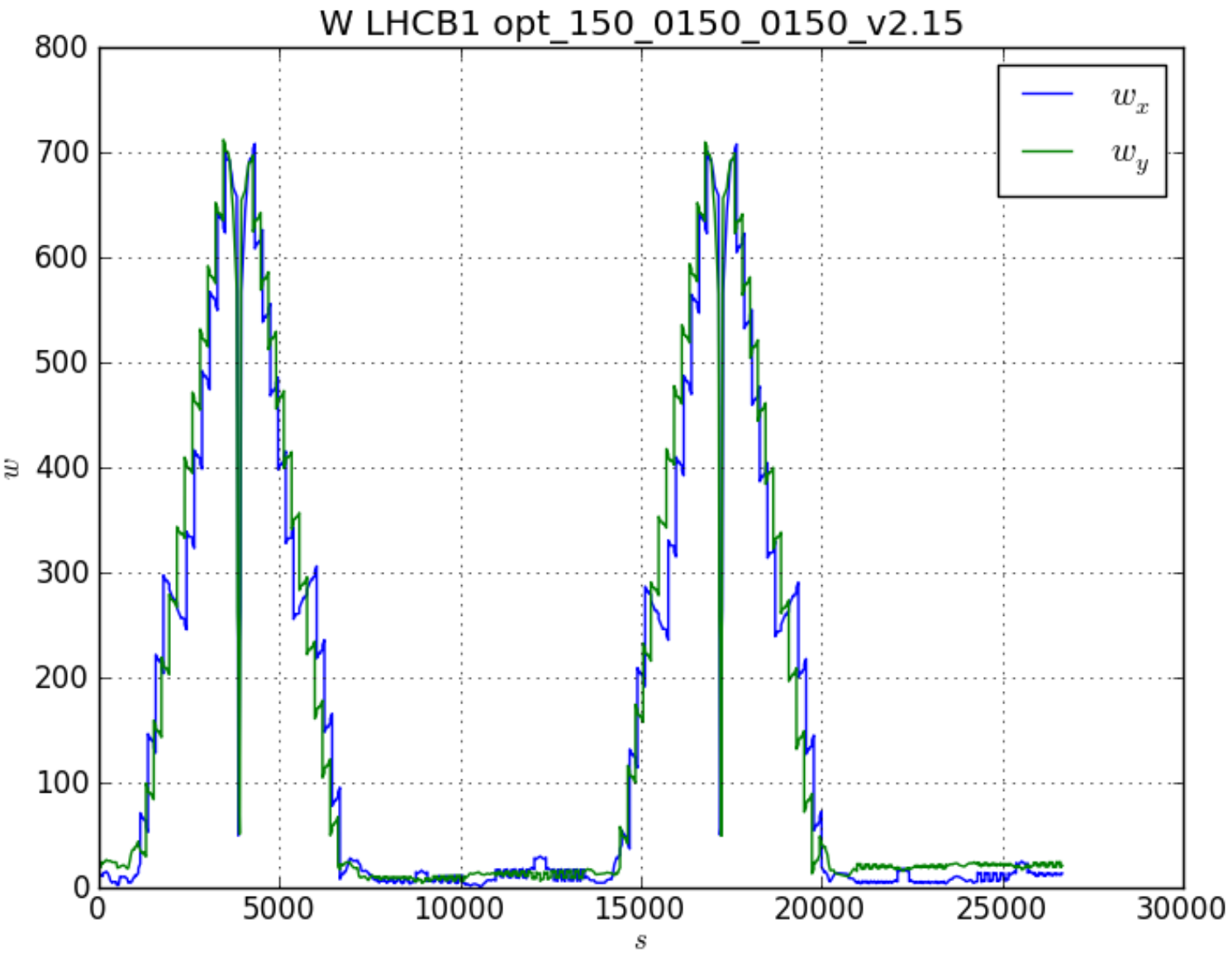
Other insertions

- Similar to SLHCV3.0
- Effort to keep beta function unnecessarily large, magnet strengths not too close to lower limit, minimum changes with respect to nominal.
- For IR2 and IR8 phase advances probably not yet optimal.
- For IR4 Beta at the IP preserved as much as possible, to be checked for the damper and other instruments.
- IR3 and IR7 identical just rematched for the new arcs.

W functions: $W\delta = |\Delta\beta/\beta_0 + i(\Delta\alpha_0 - \alpha\Delta\beta_0/\beta_0)|$



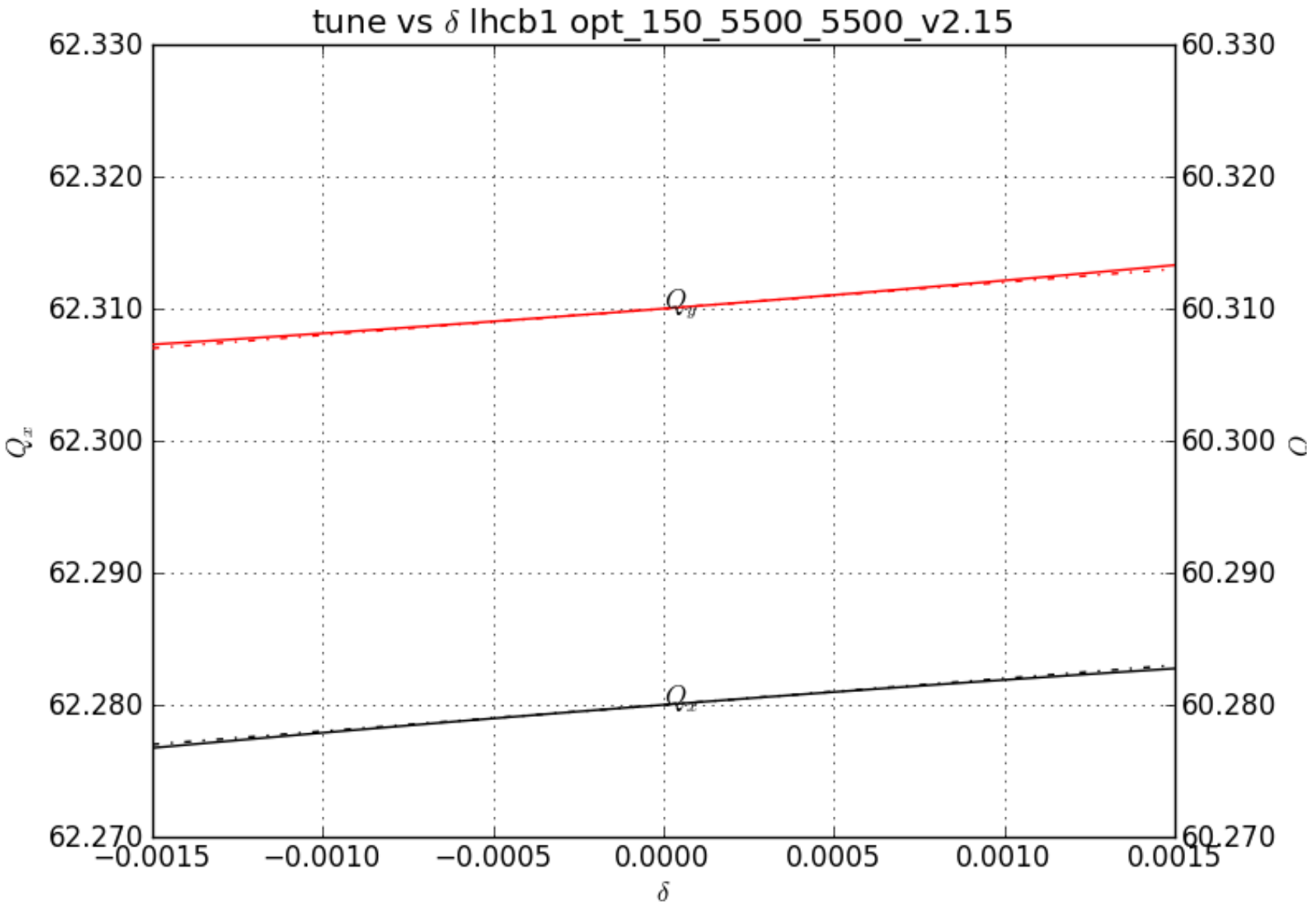
W functions: $W\delta = |\Delta\beta/\beta_0 + i(\Delta\alpha_0 - \alpha\Delta\beta_0/\beta_0)|$



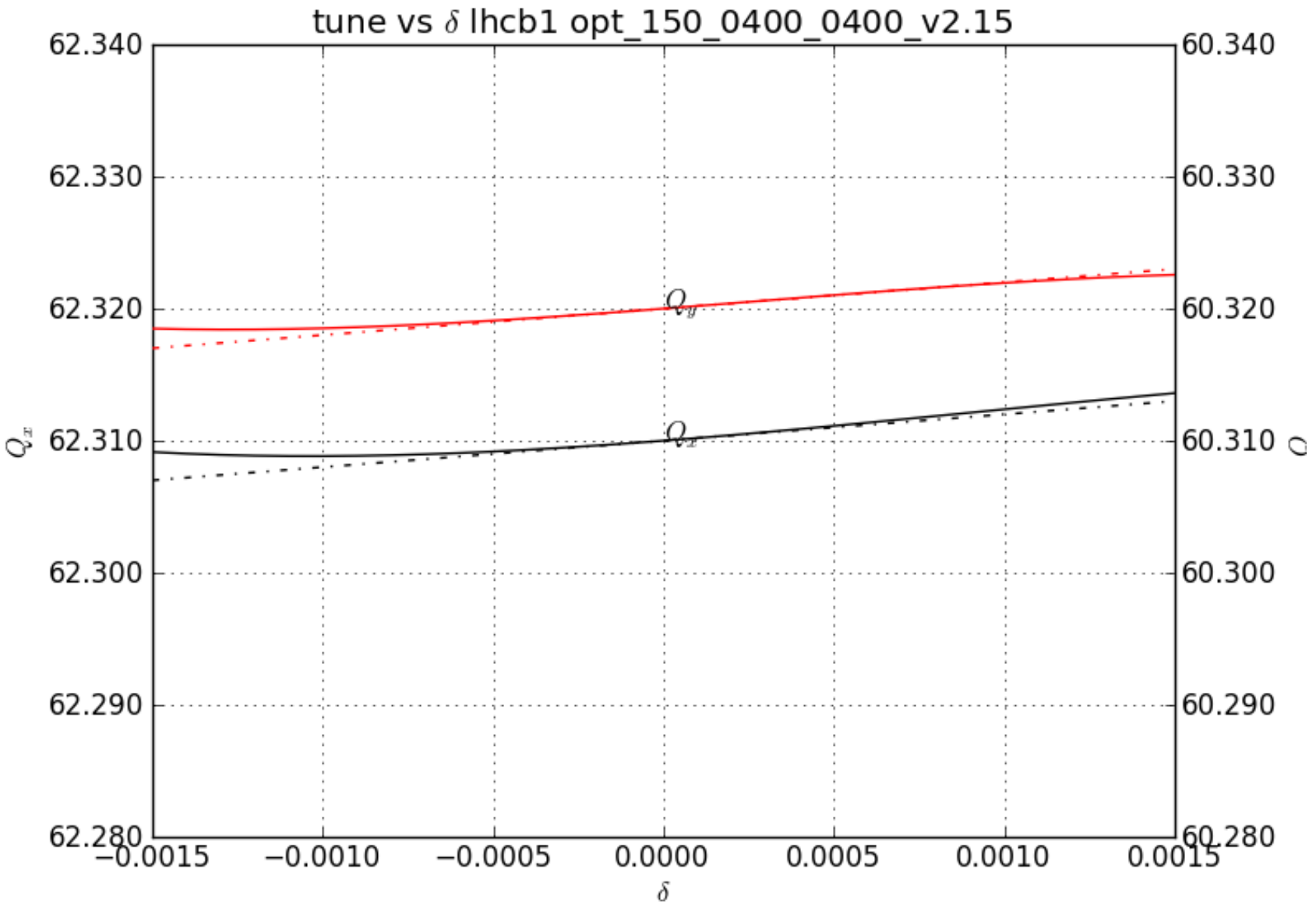
W functions: table

name		wx1	wy1	wx5	wy5	wx3	wy3	wx7	wy7
opt_150_11000_11000	b1	24	23	23	21	19	17	29	26
opt_150_11000_11000	b2	13	11	33	29	23	27	32	30
opt_150_5500_5500	b1	28	38	27	31	30	26	37	47
opt_150_5500_5500	b2	17	35	39	37	25	40	47	41
opt_150_2000_2000	b1	19	6	25	11	14	14	25	10
opt_150_2000_2000	b2	15	19	39	11	23	13	27	18
opt_150_0400_0400	b1	44	23	49	35	13	15	25	11
opt_150_0400_0400	b2	33	38	66	33	25	14	28	25
opt_150_0150_0150	b1	79	87	78	82	1	14	9	21
opt_150_0150_0150	b2	83	92	75	86	18	11	5	14
opt_150_0100_0100	b1	120	121	120	121	6	16	7	19
opt_150_0100_0100	b2	122	132	120	137	18	6	5	7
opt_150_0075_0300	b1	160	41	42	160	3	3	12	20
opt_150_0075_0300	b2	160	42	45	161	19	9	8	18
opt_150_0050_0200	b1	239	61	61	239	2	3	7	24
opt_150_0050_0200	b2	239	58	62	245	16	5	5	17
opt_150_0075_0300hv	b1	45	160	159	40	10	2	16	8
opt_150_0075_0300hv	b2	44	161	161	45	25	5	14	31
opt_150_0050_0200hv	b1	60	241	238	59	6	4	16	9
opt_150_0050_0200hv	b2	65	247	232	66	25	3	11	25

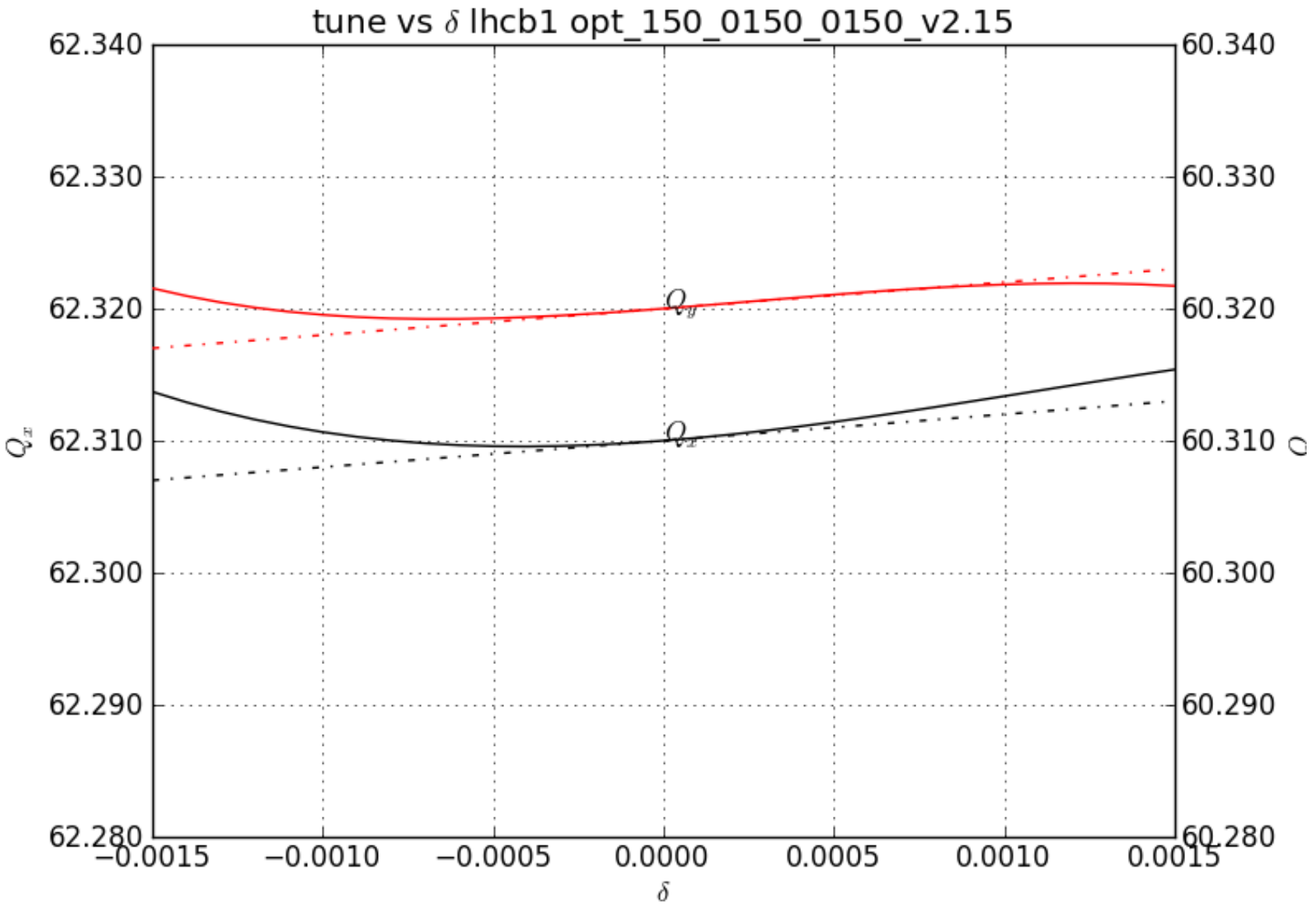
Tune vs delta



Tune vs delta



Tune vs delta



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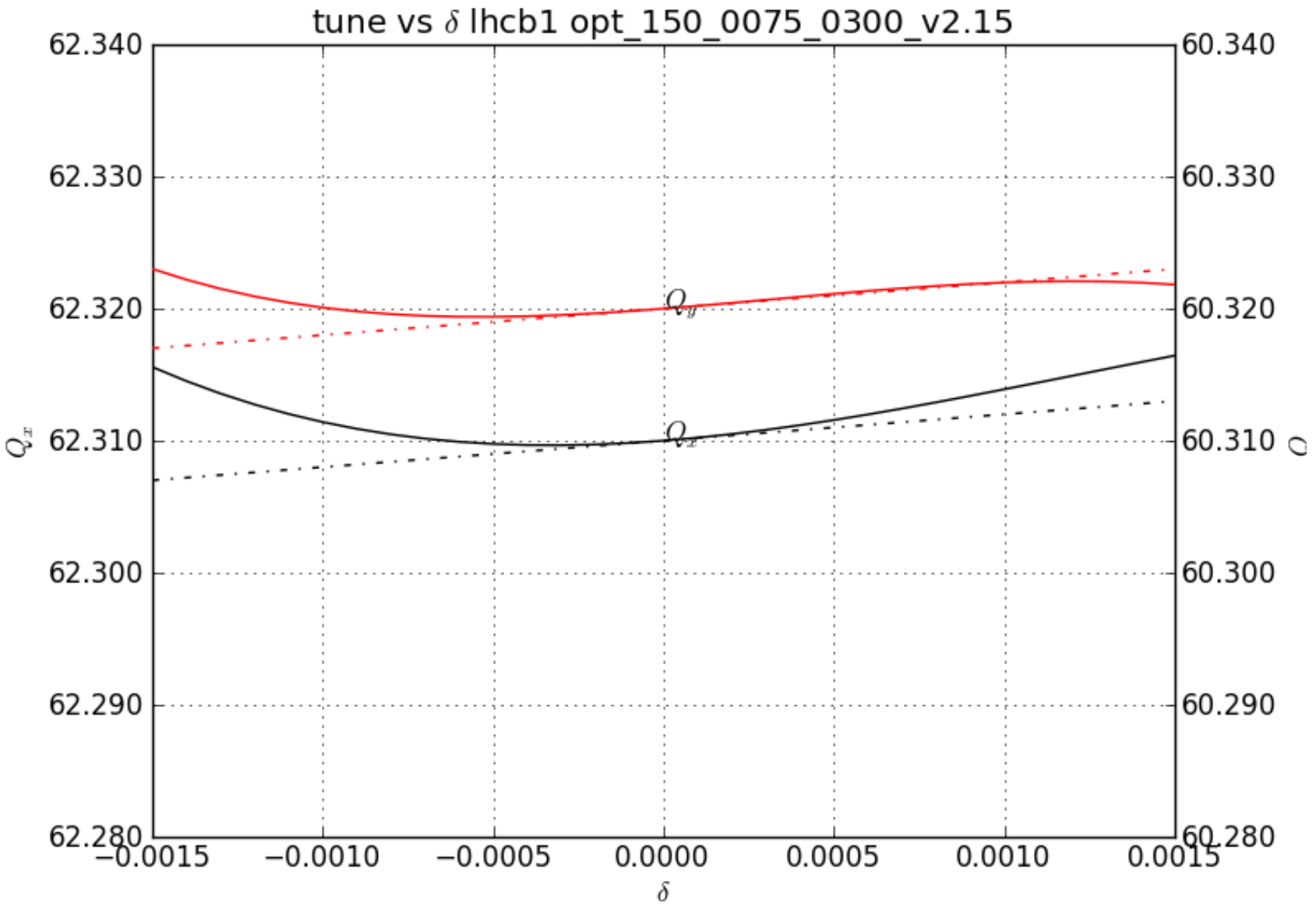
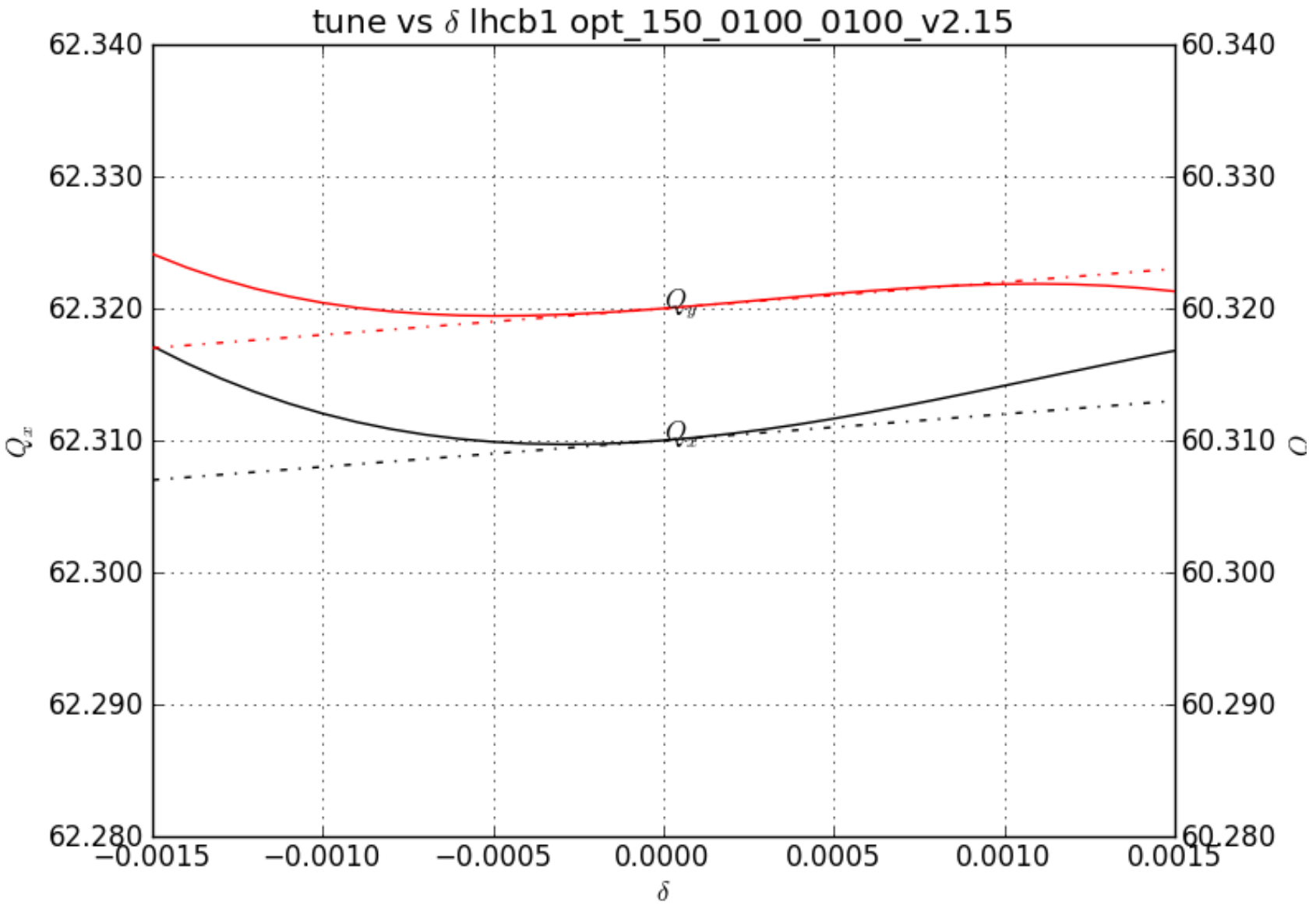
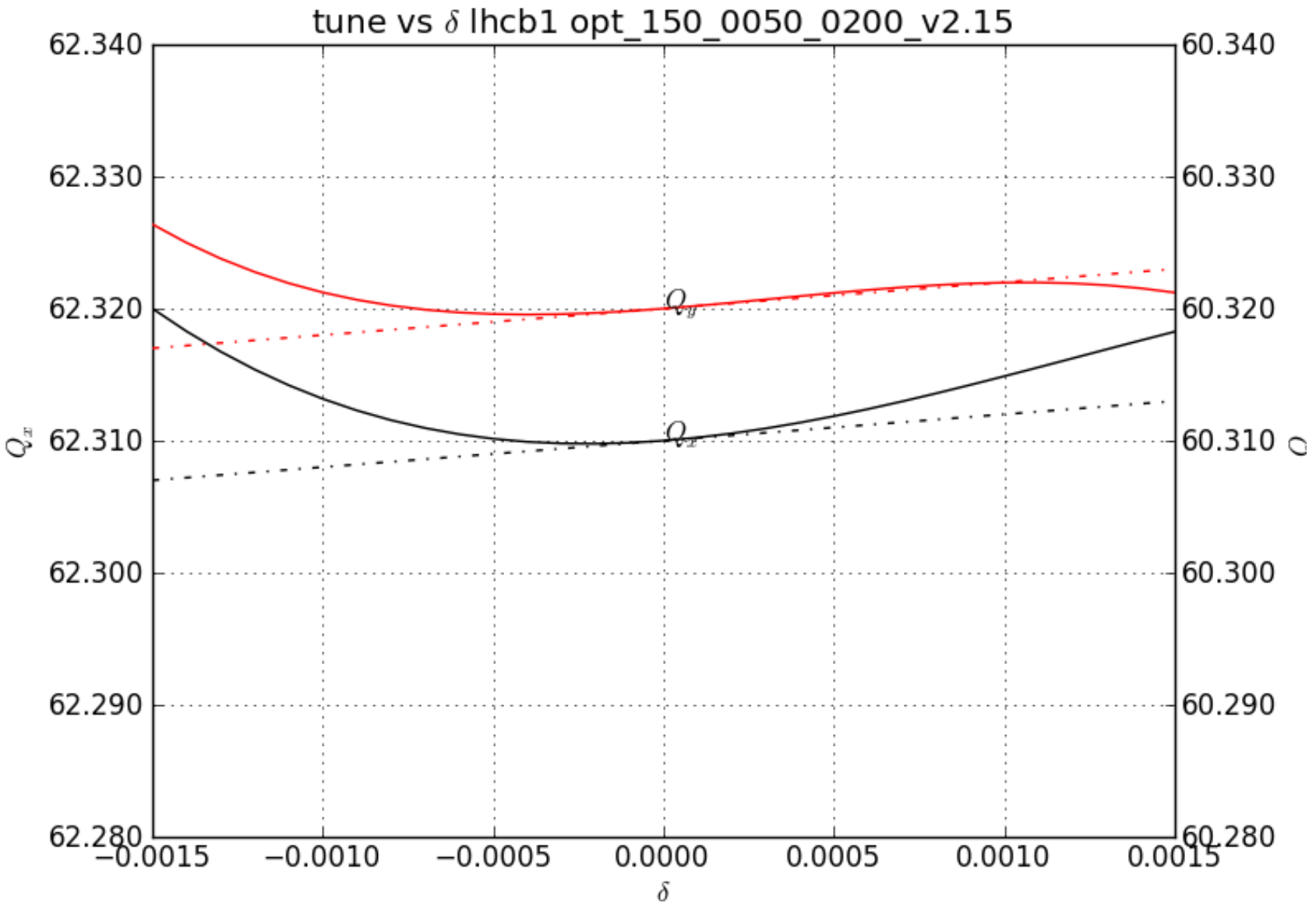


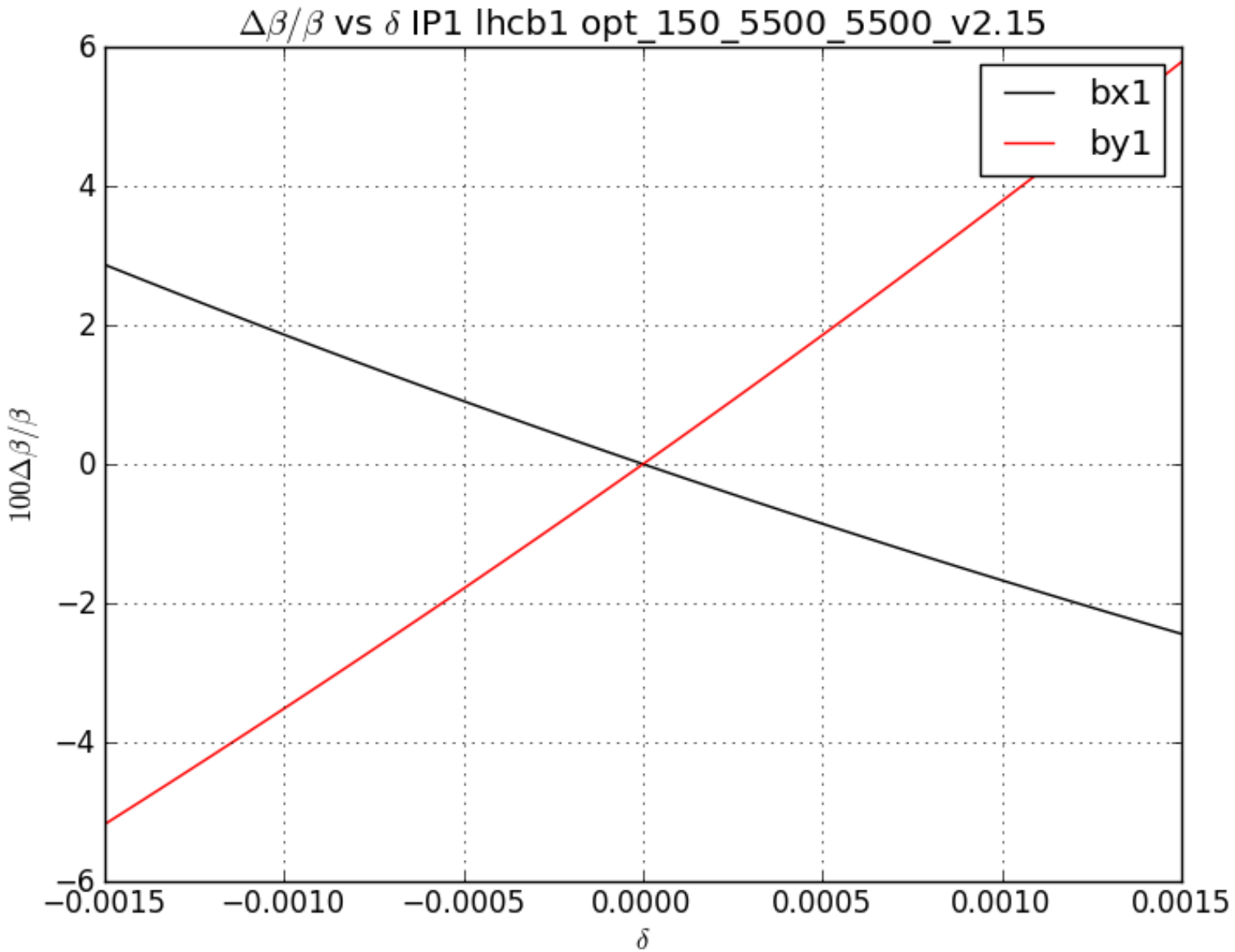
Tune vs delta



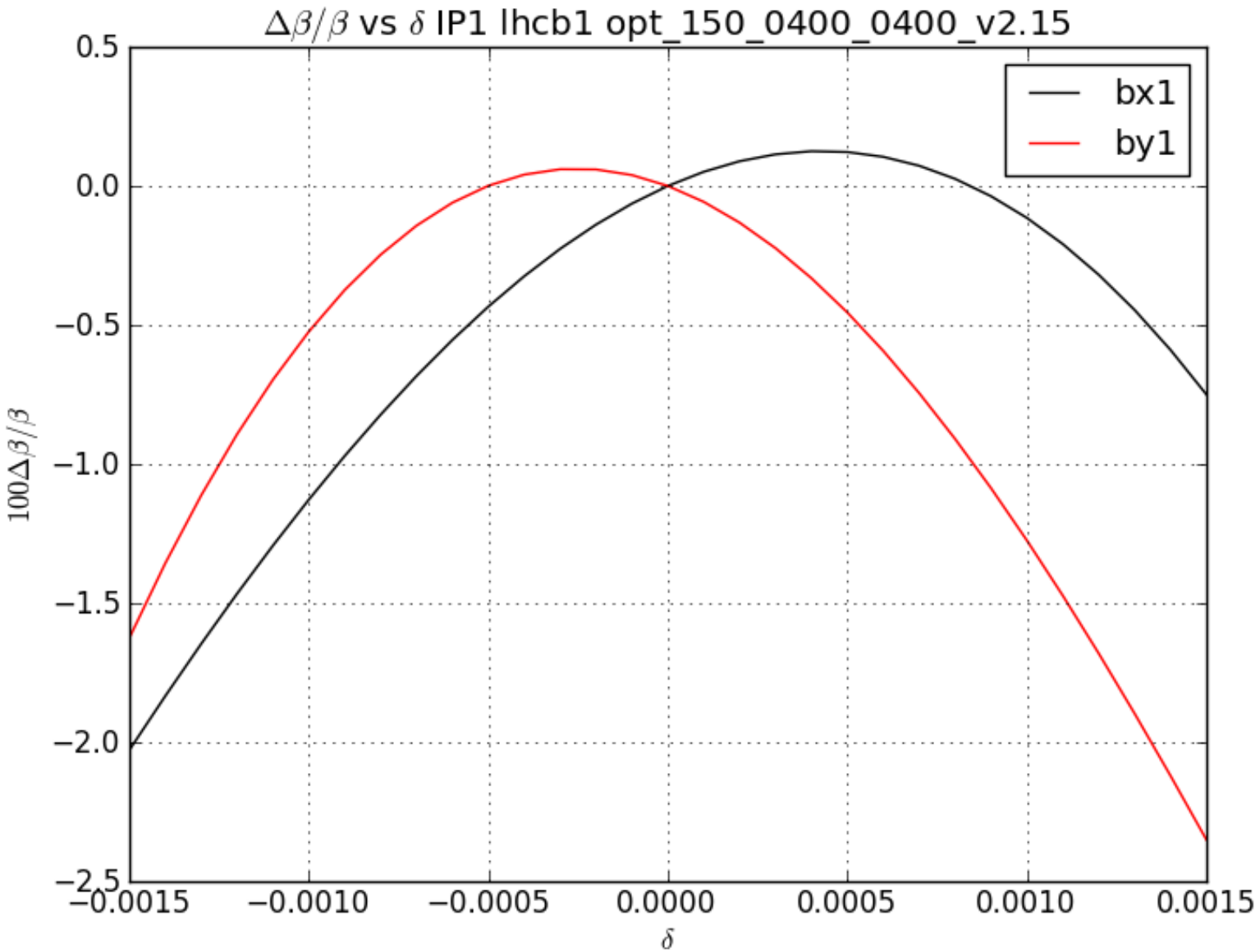
Tune vs delta



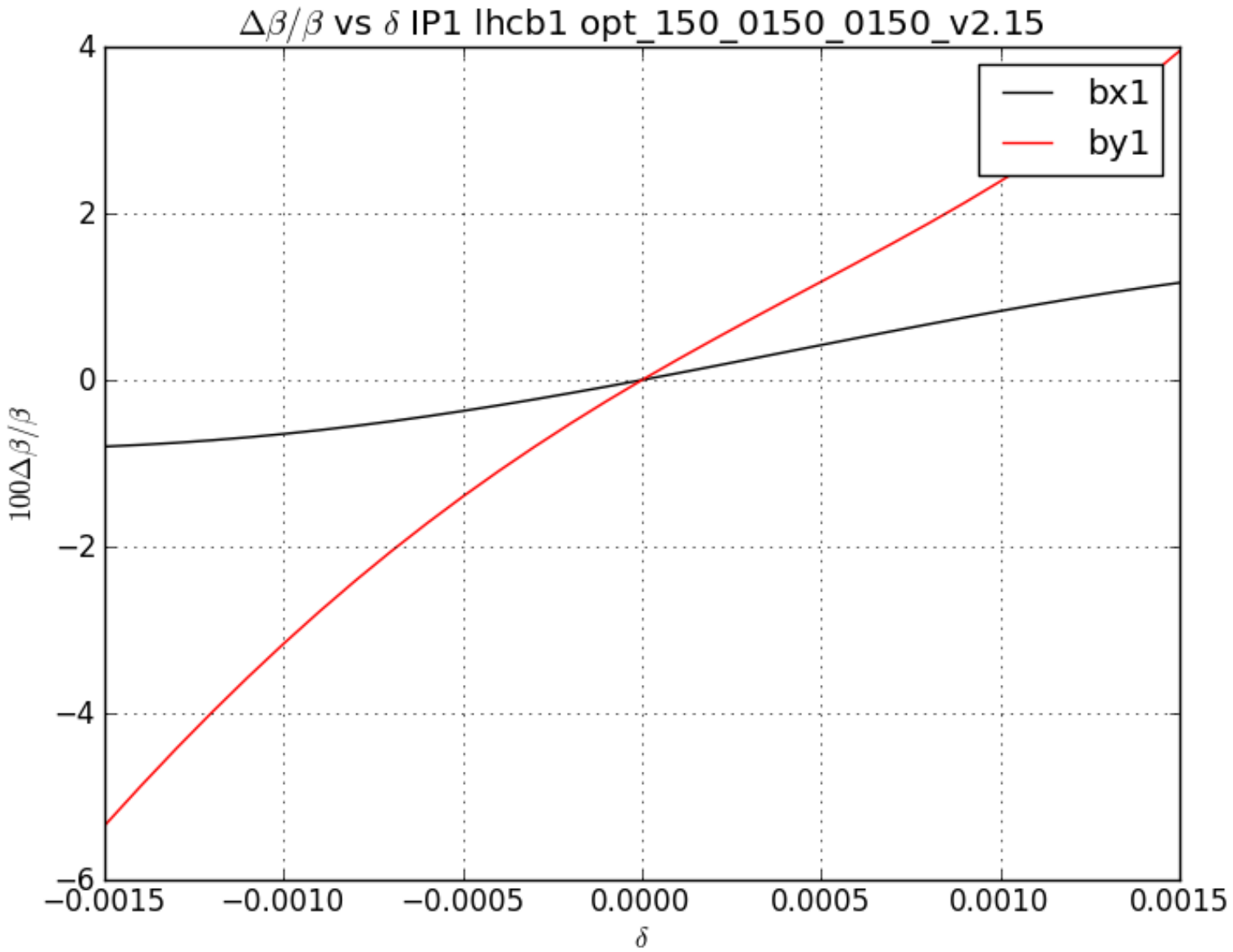
Non linear beta beating



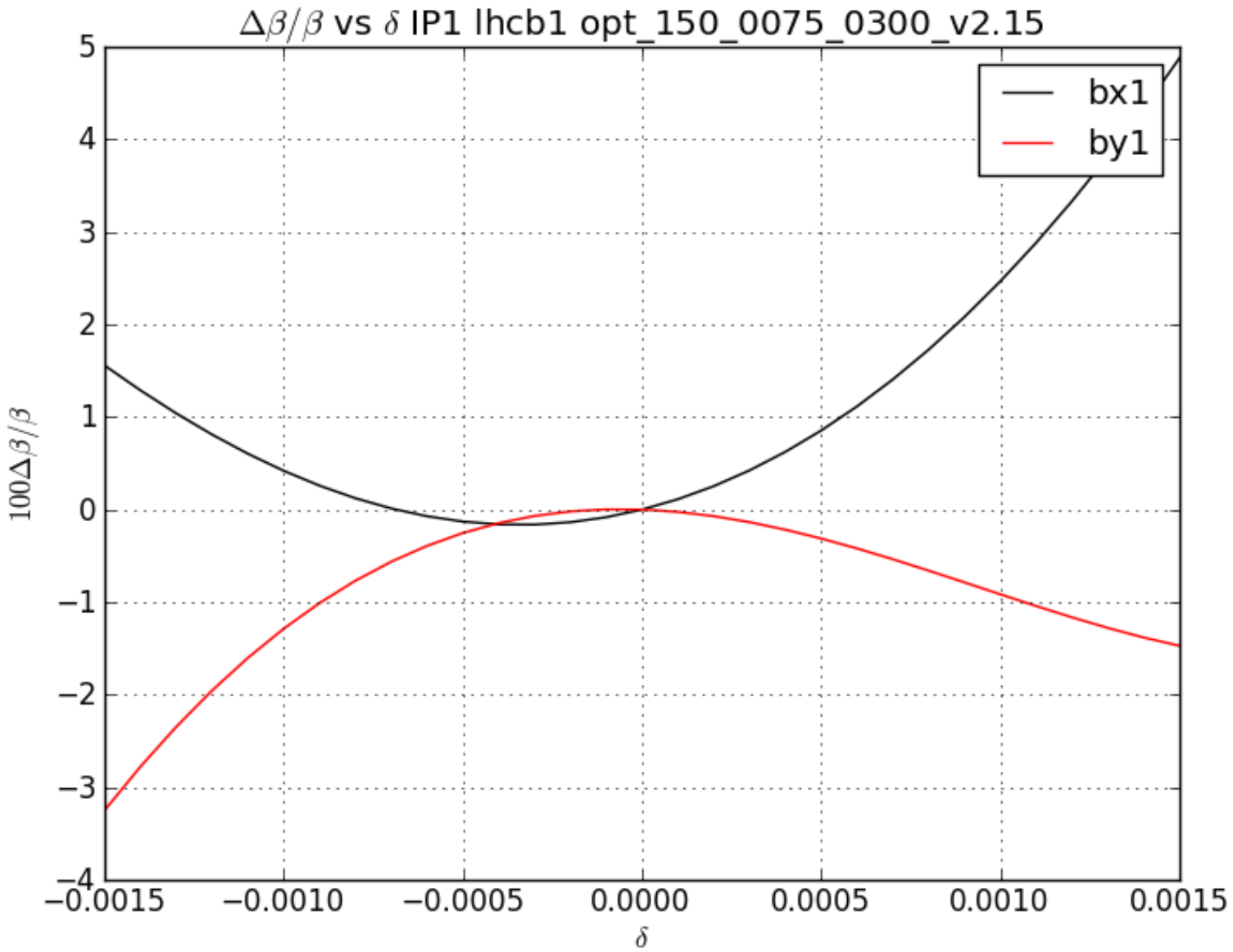
Non linear beta beating



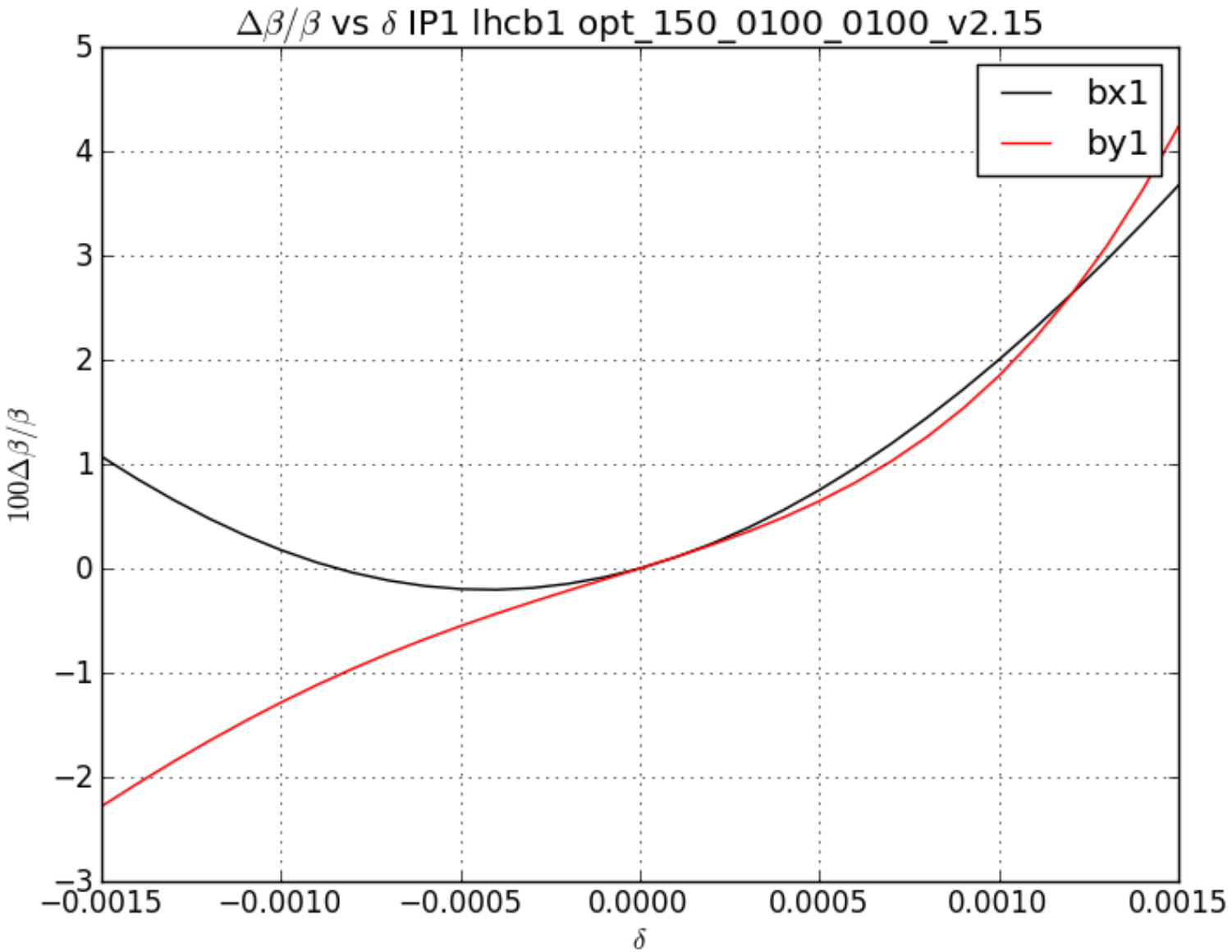
Non linear beta beating



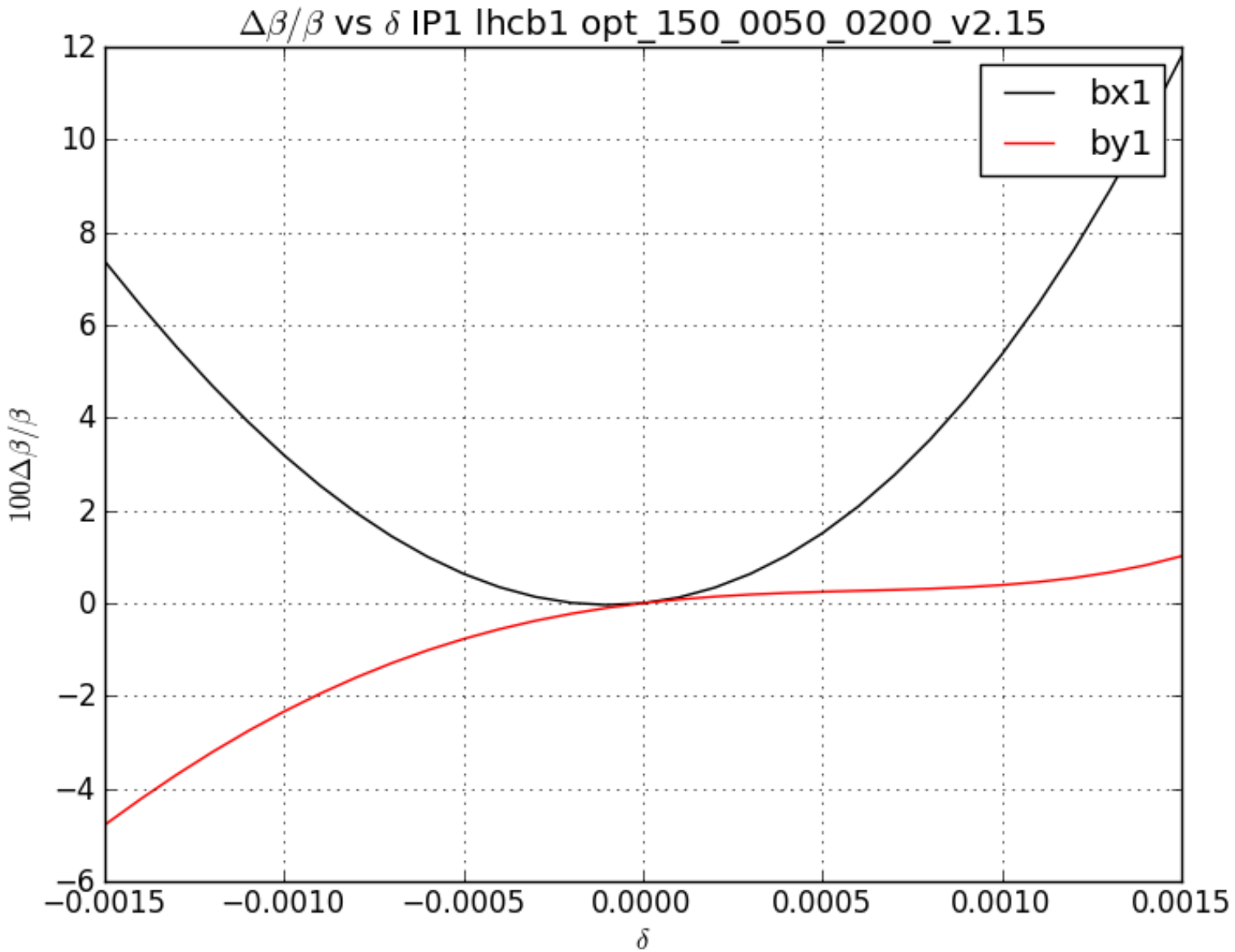
Non linear beta beating



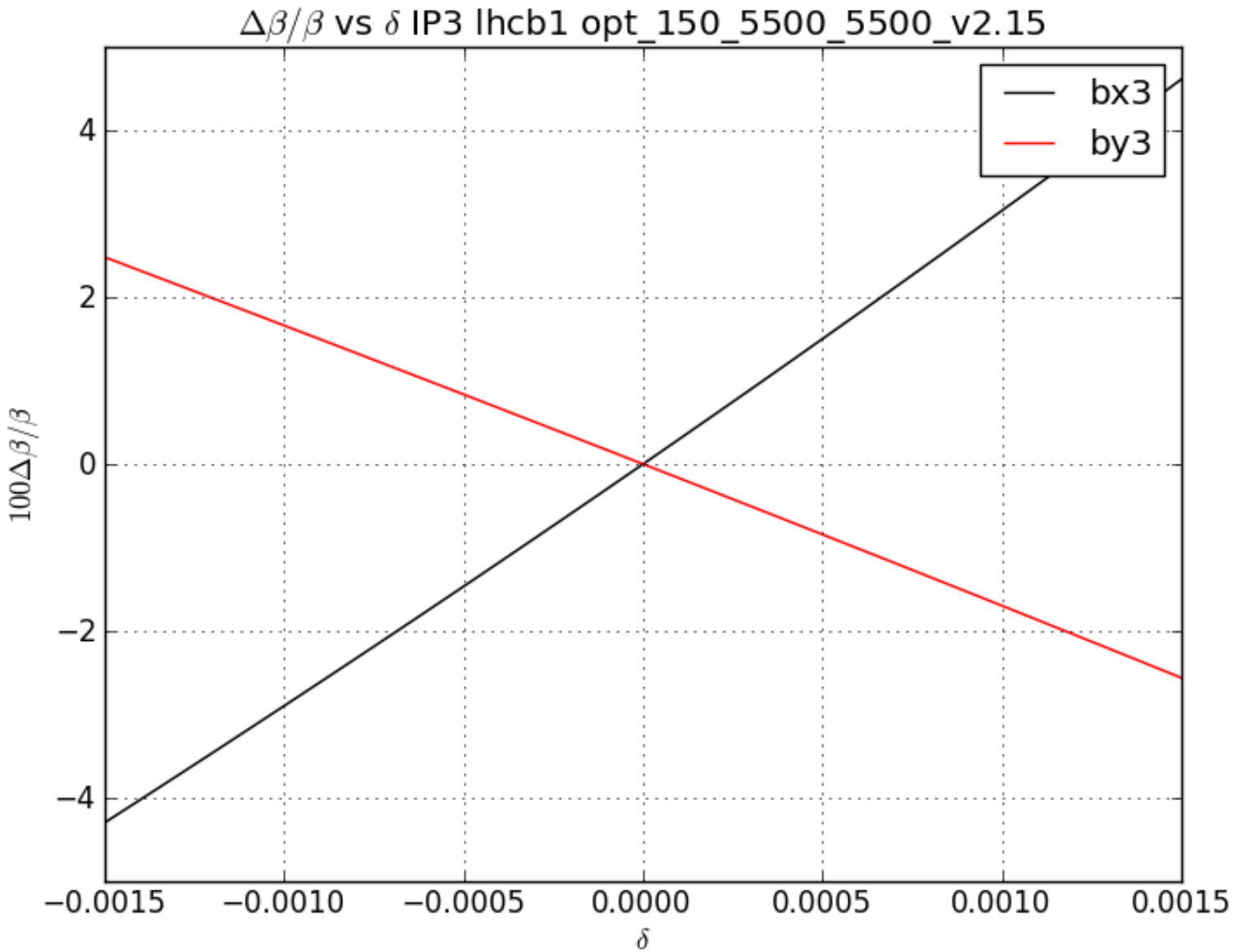
Non linear beta beating



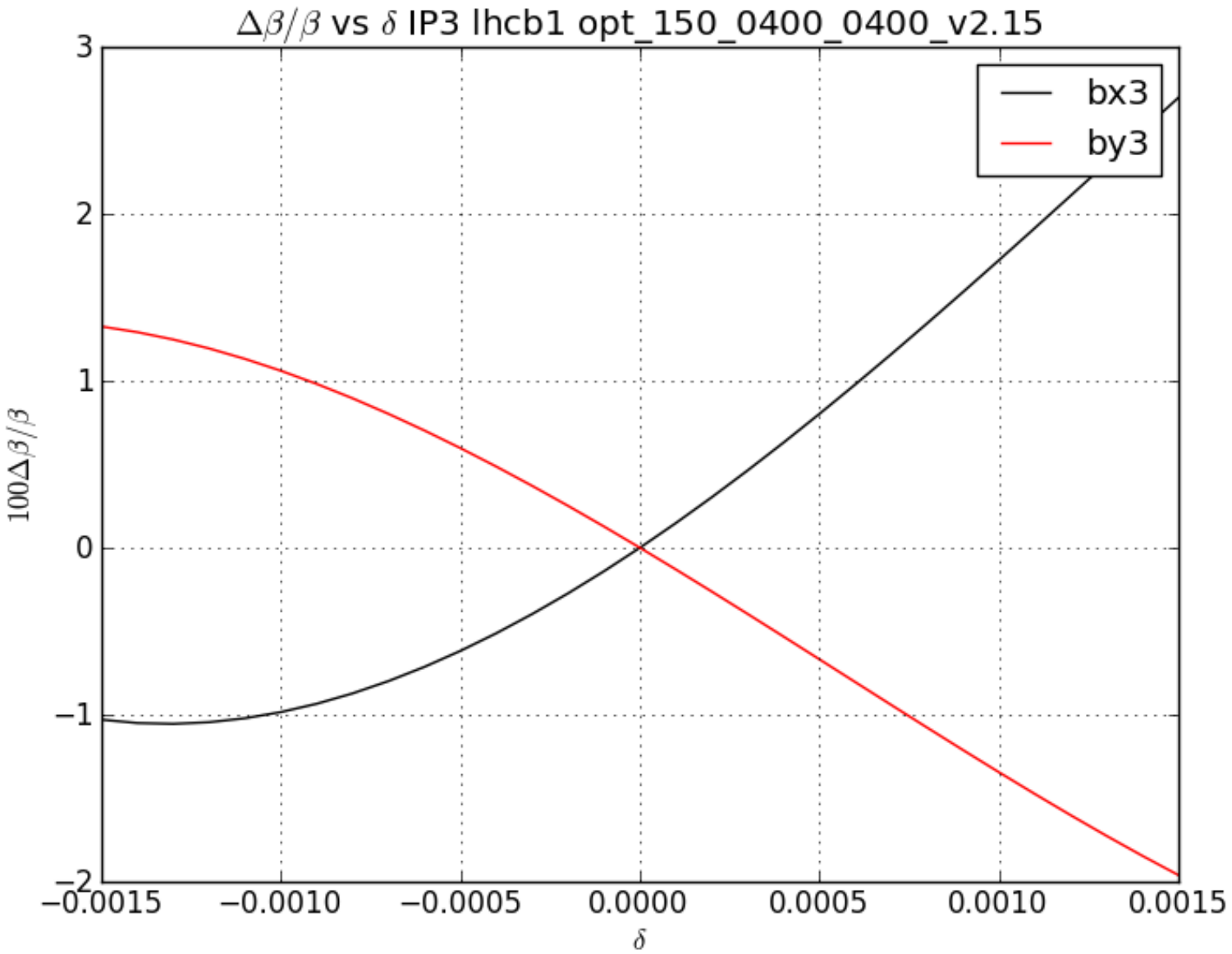
Non linear beta beating



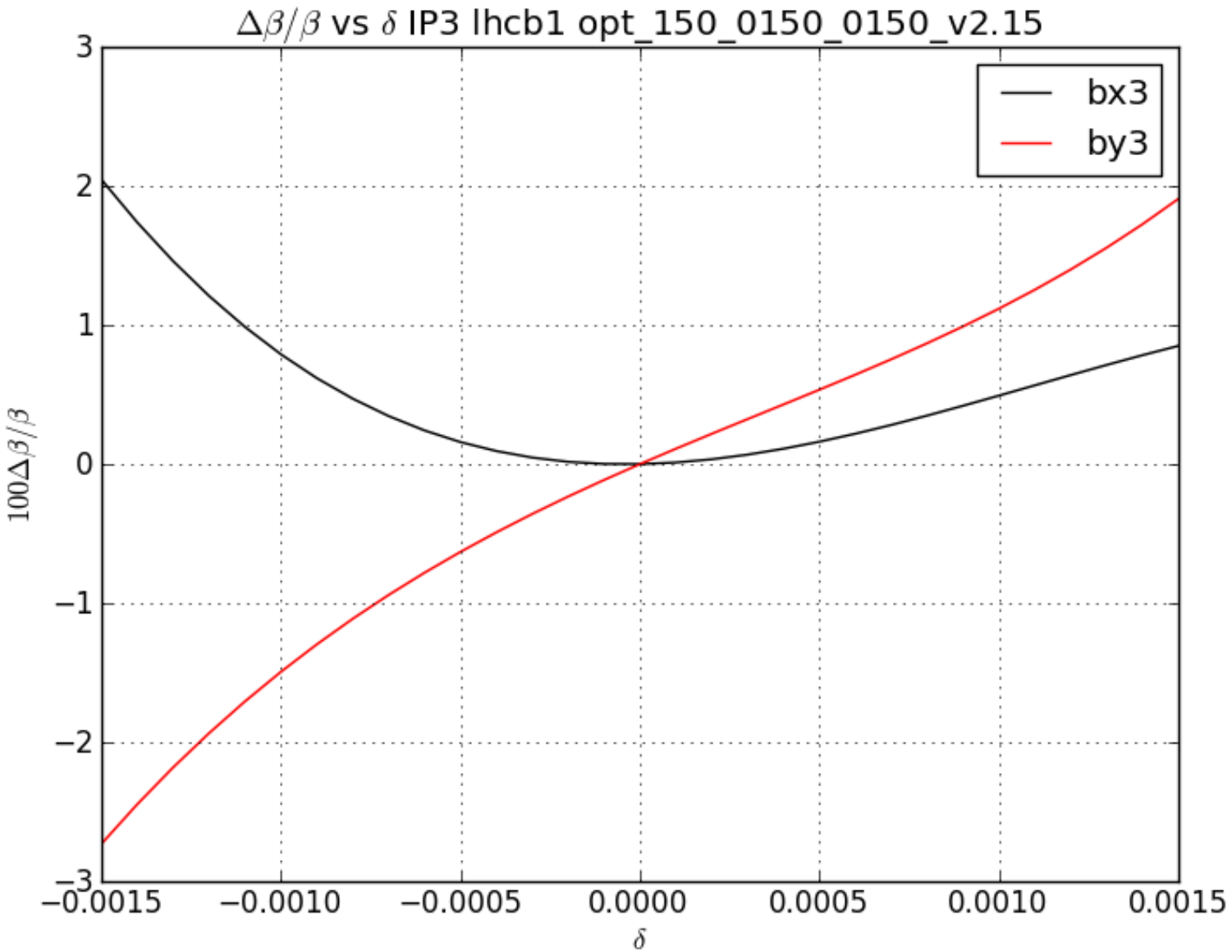
Non linear beta beating



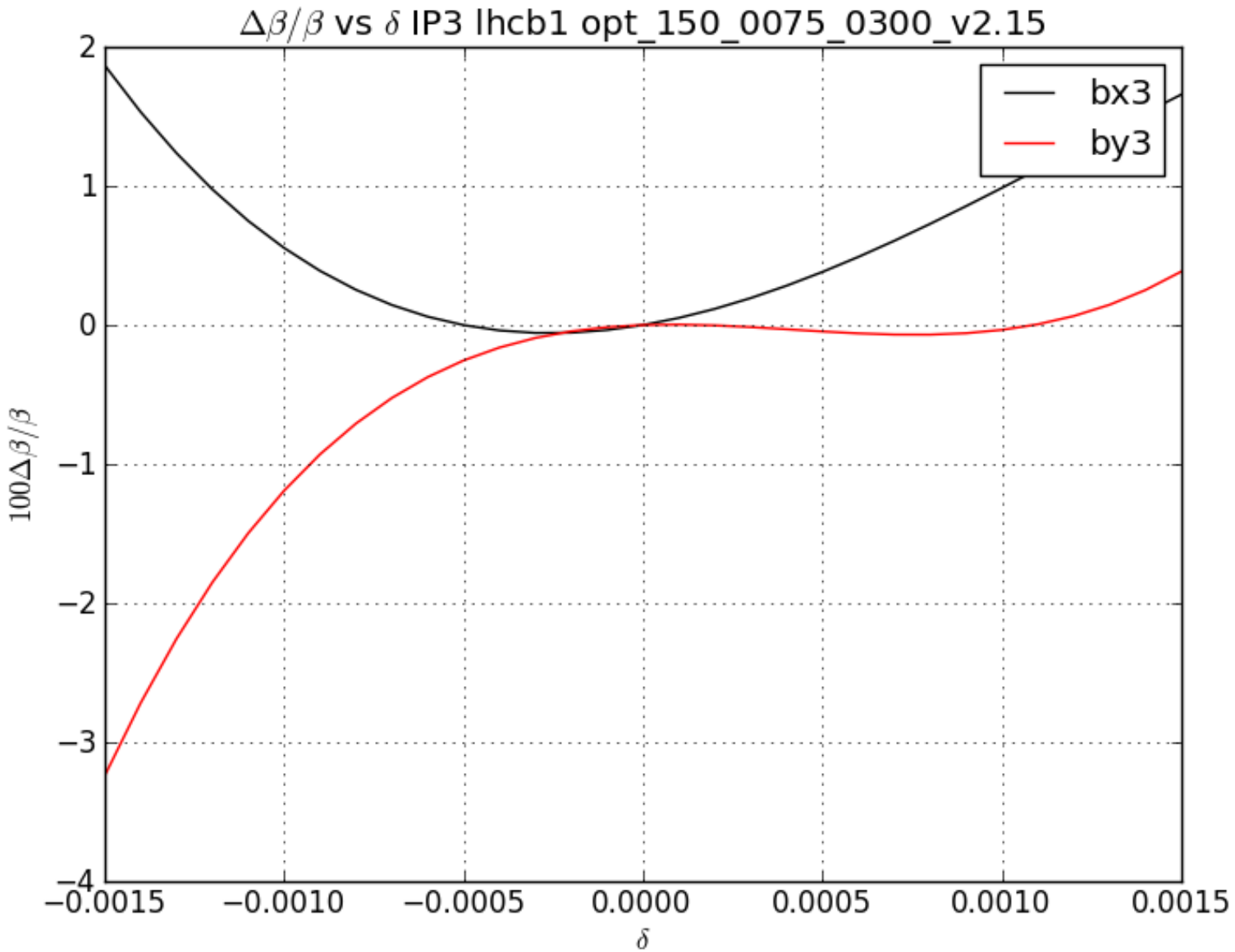
Non linear beta beating



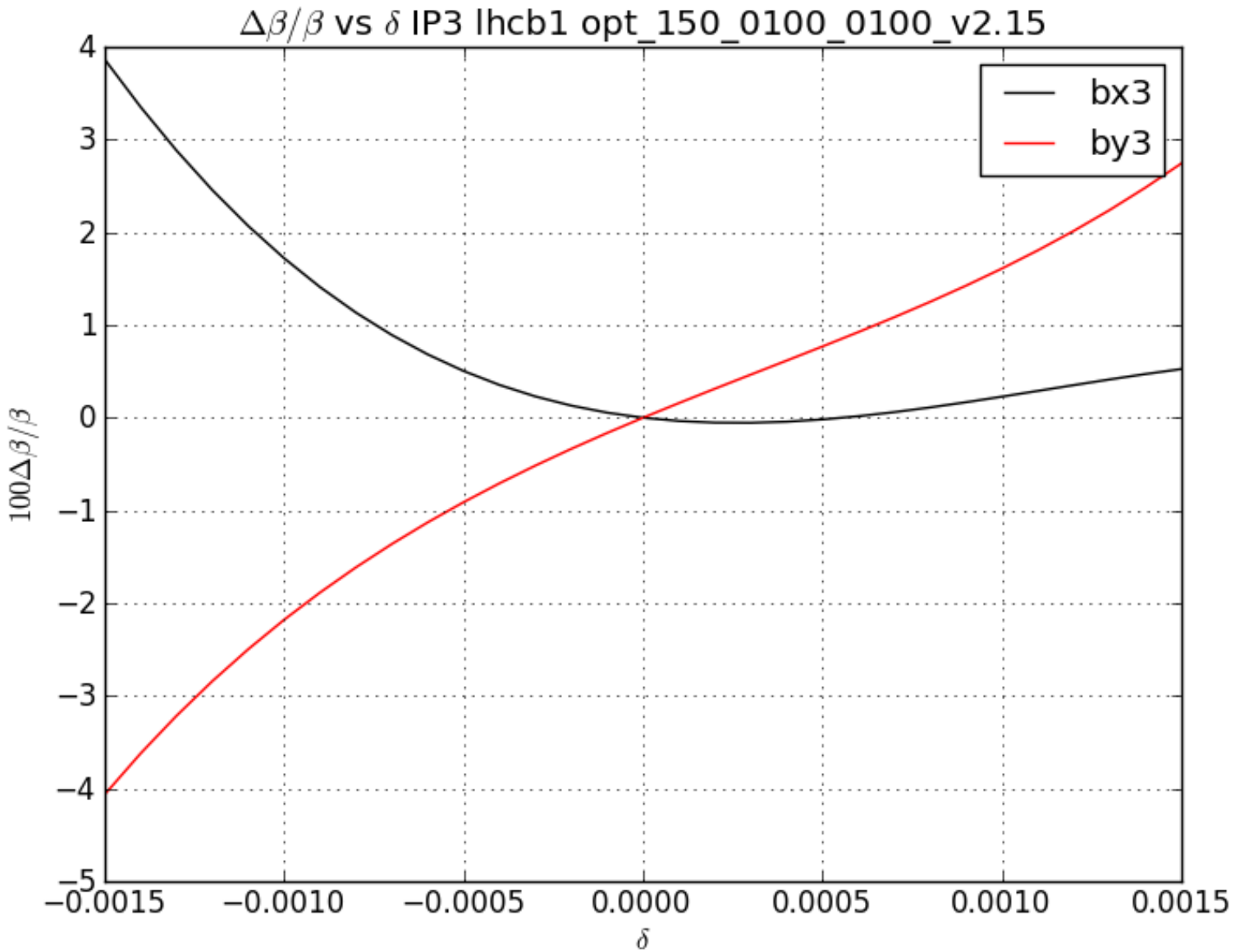
Non linear beta beating



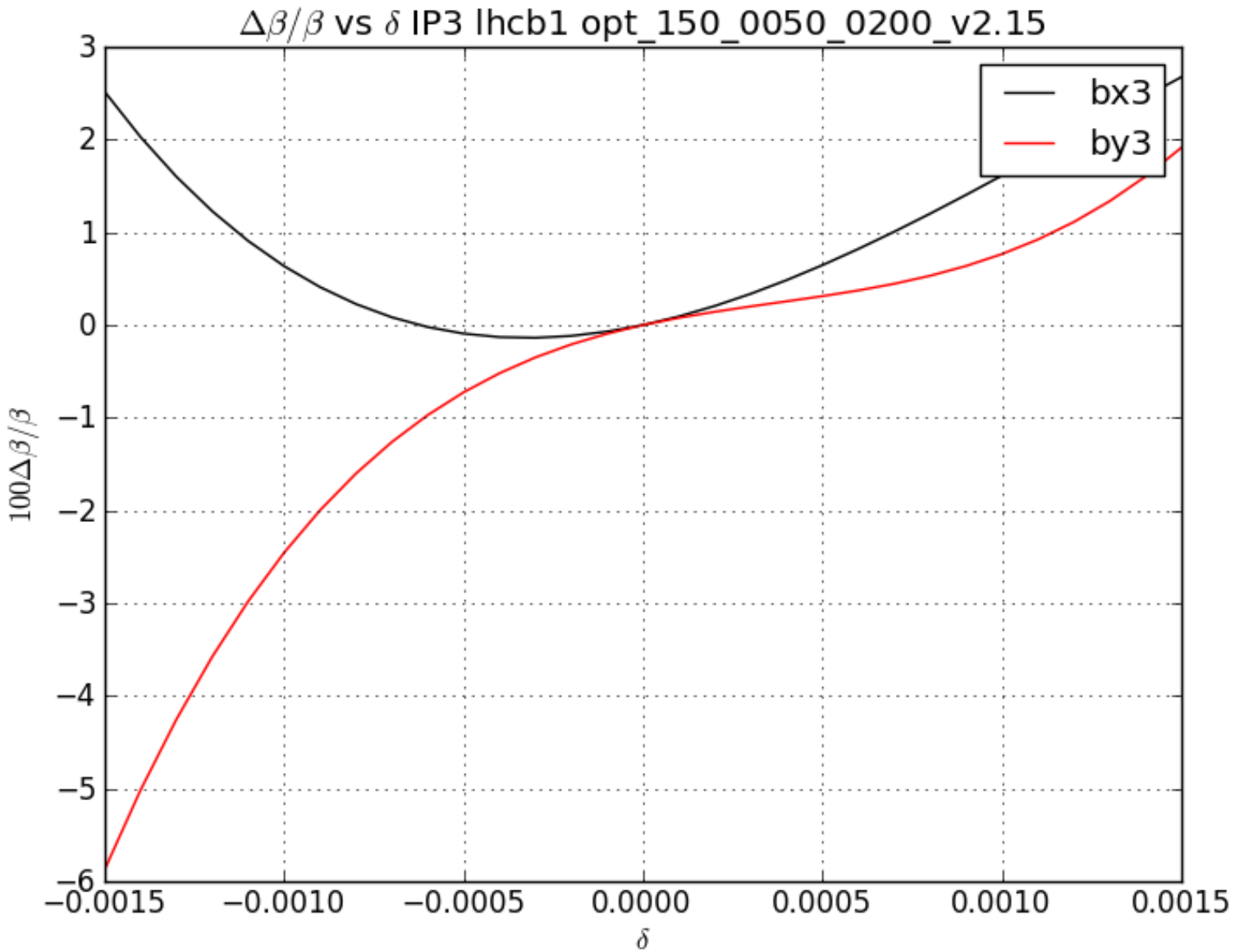
Non linear beta beating



Non linear beta beating



Non linear beta beating



Thin version for tracking

Target: generate sequence and optics using only thin elements (for symplectic tracking) as close as possible to the thick optics.
Invariants:

- phase advances of arcs and IR
- twiss parameters at all IPs (including IR3 and IR7)
- selected quadrupole strengths for squeeze and injection.

Knobs:

- insertions quads
- KQF/D
- KSF,KSD
- orbit corrector (but not MCBX)

Directory listing

/afs/cern.ch/eng/lhc/optics/SLHCV3.1b

aperture
beambeam
errors
toolkit
iroptics
tables
readme
slhc_sequence.madx
slhc_removeinstall.madx
crab_install.madx
job_sample.madx
job_makeoptics.madx
job_makethin.madx

opt_150_11000_11000.madx
opt_150_5500_5500.madx
opt_150_2000_2000.madx
opt_150_0400_0400.madx
opt_150_0150_0150.madx
opt_150_0100_0100.madx
opt_150_0075_0300.madx
opt_150_0050_0200.madx
opt_150_0075_0300hv.madx
opt_150_0050_0200hv.madx
opt_150_11000_11000thin.madx
opt_150_5500_5500thin.madx
opt_150_2000_2000thin.madx
opt_150_0400_0400thin.madx
opt_150_0150_0150thin.madx
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opt_150_0075_0300hvthin.madx