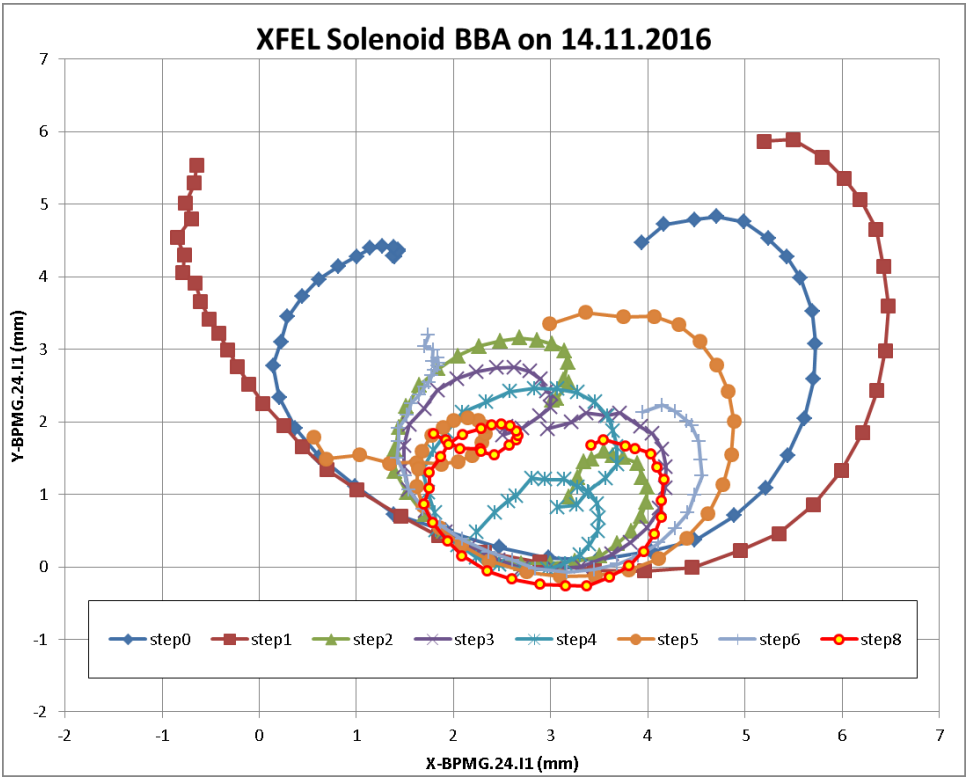
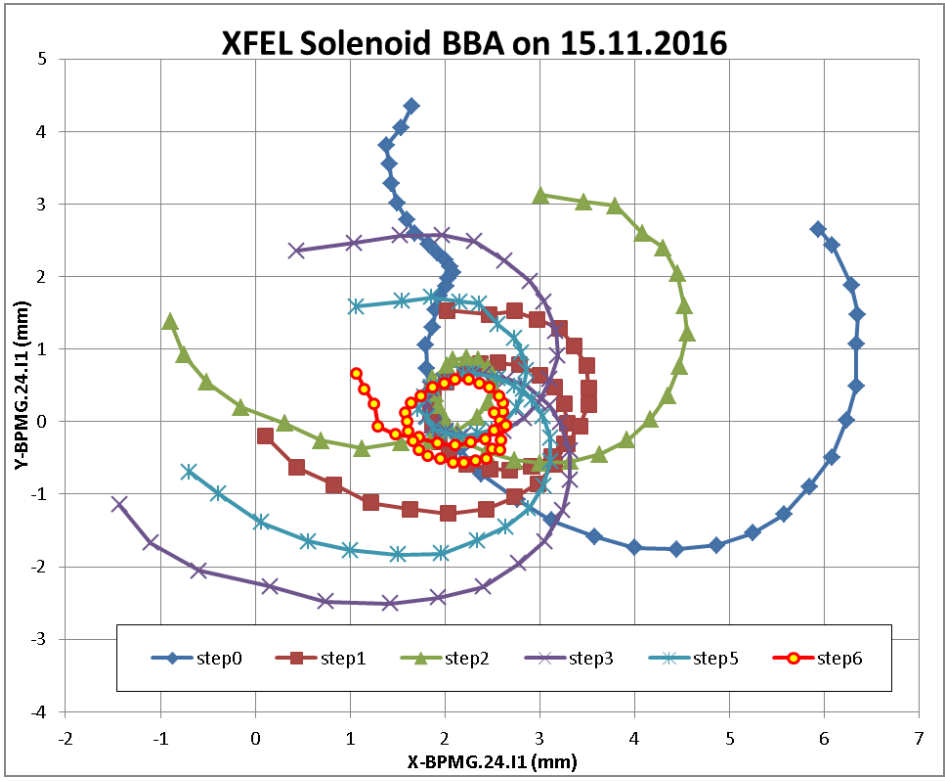
Solenoid BBA at XFEL and remarks from the XFEL recommissioning in 2016-2017

M. Krasilnikov, PPS, 10.1.2017

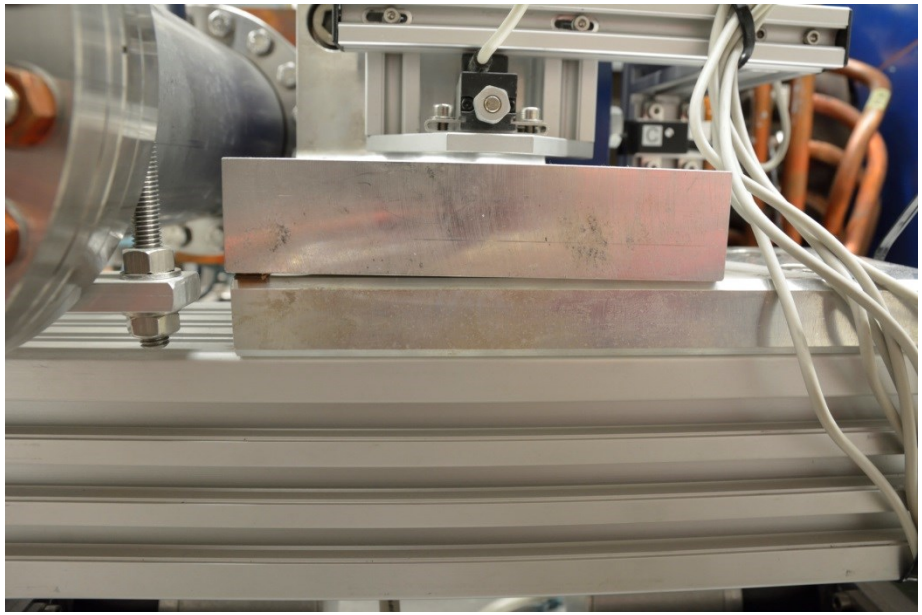
XFEL Solenoid BBA on 14-15.11.2016





Imain=-400A…step (10)20A…+400A

Mechanical “intervention” to correct the pitch angle

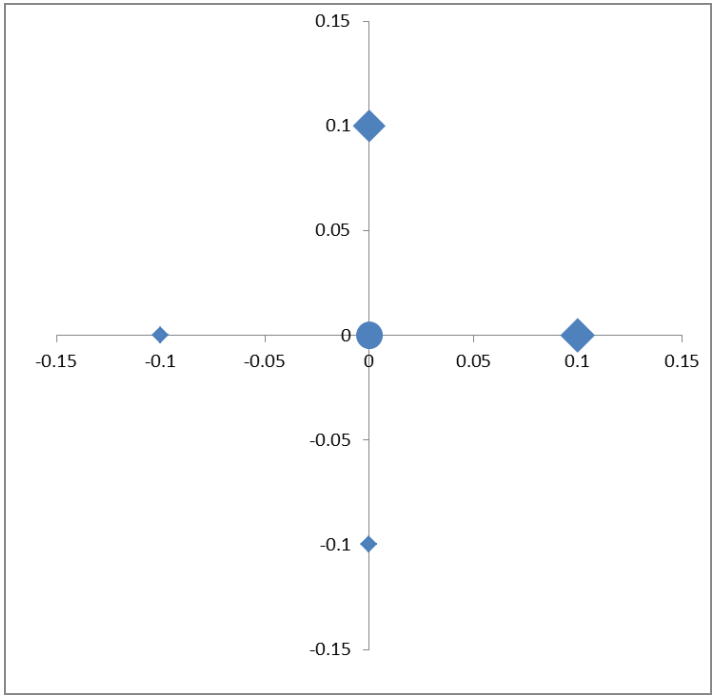


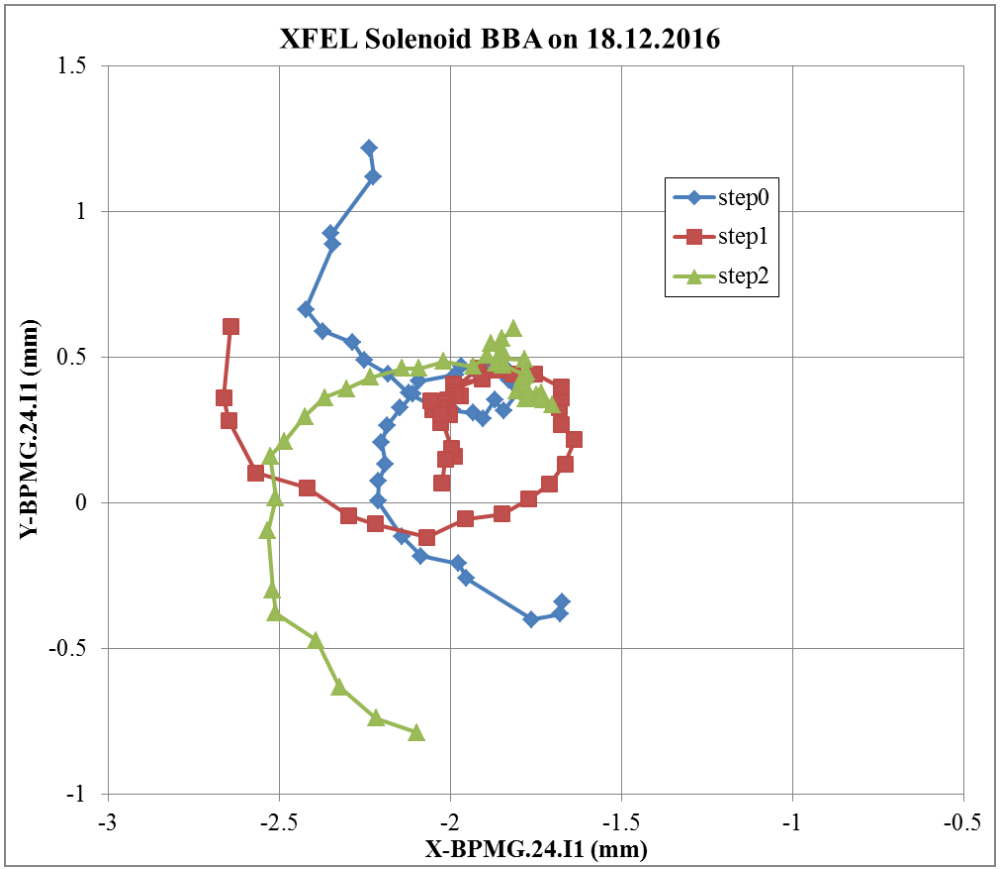
XFEL Injector solenoid BBA on 18.12.2016

M. Krasilnikov, Y. Kot

Raw data

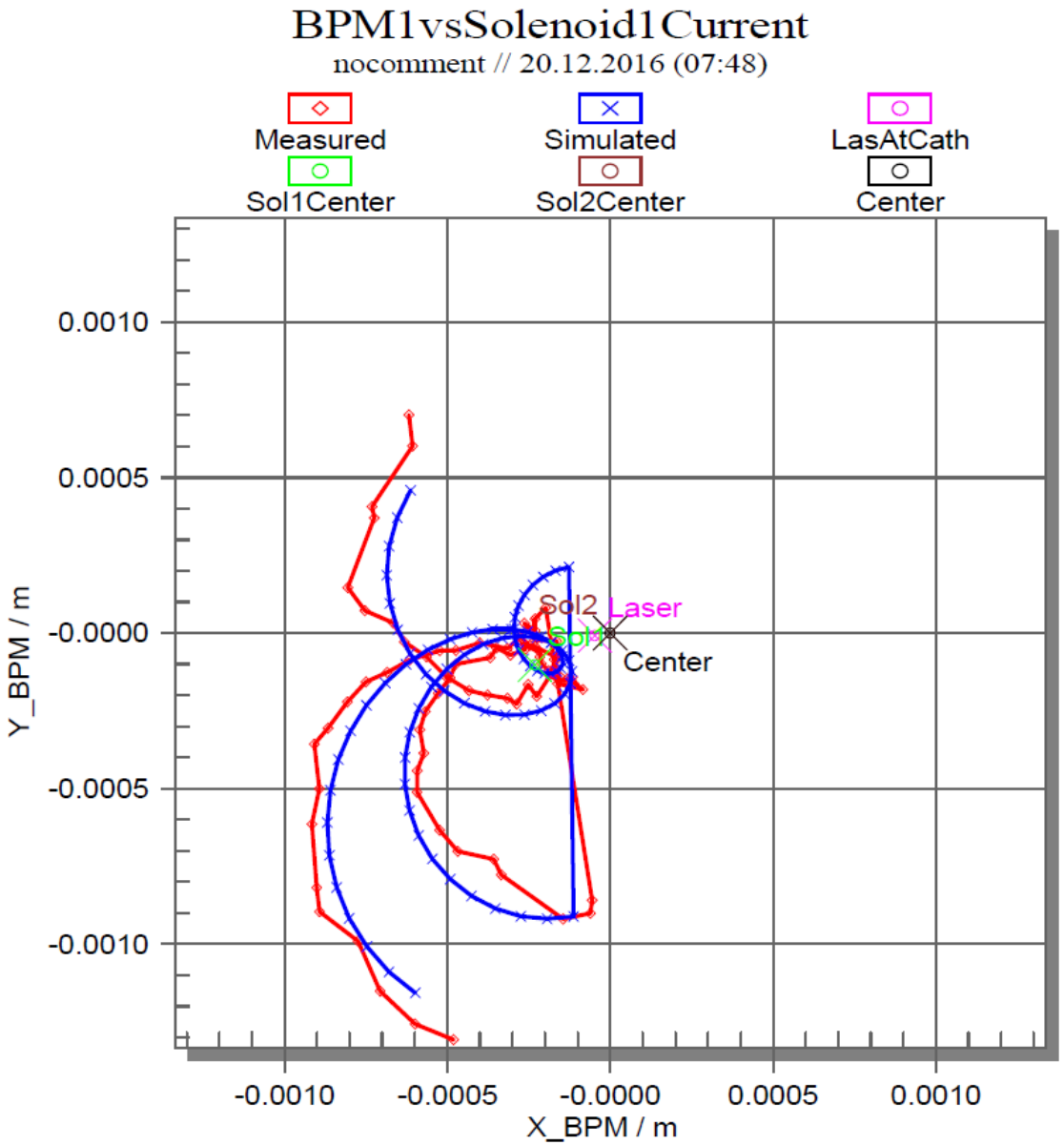
roll	0	mrad
yaw	3.4422	mrad
pitch	-1.6778	mrad
x_off	-0.7	mm
y_off	-0.1	mm





colour	roll	yaw	pitch	x	y	file	DXsol	DYsol	steps
cyan	-2	3.15	-2.1	-0.755	-0.03	2016-12-18T152436	-0.1	0	
blue	-2	3.15	-2.1	-0.655	-0.03	2016-12-18T153012	0	0	step0
green	-2	3.15	-2.1	-0.555	-0.03	2016-12-18T153605	0.1	0	step1
red	-2	3.15	-2.1	-0.655	-0.13	2016-12-18T154319	0	-0.1	
black	-2	3.15	-2.1	-0.655	0.07	2016-12-18T154914	0	0.1	step2

Simultaneous simulations of 3 steps



Fit Parameters List

RF-GunPITZ : AngleXSolMain = -0.00558 deg

RF-GunPITZ : AngleYSolMain = -0.00516 deg

RF-GunPITZ : Laser_Beam_CenterX = -4.74e-005 m

RF-GunPITZ : Laser_Beam_CenterY = -7.6e-006 m

RF-GunPITZ : XSolMainCenter = -0.000232 m

RF-GunPITZ : YSolMainCenter = -0.000102 m

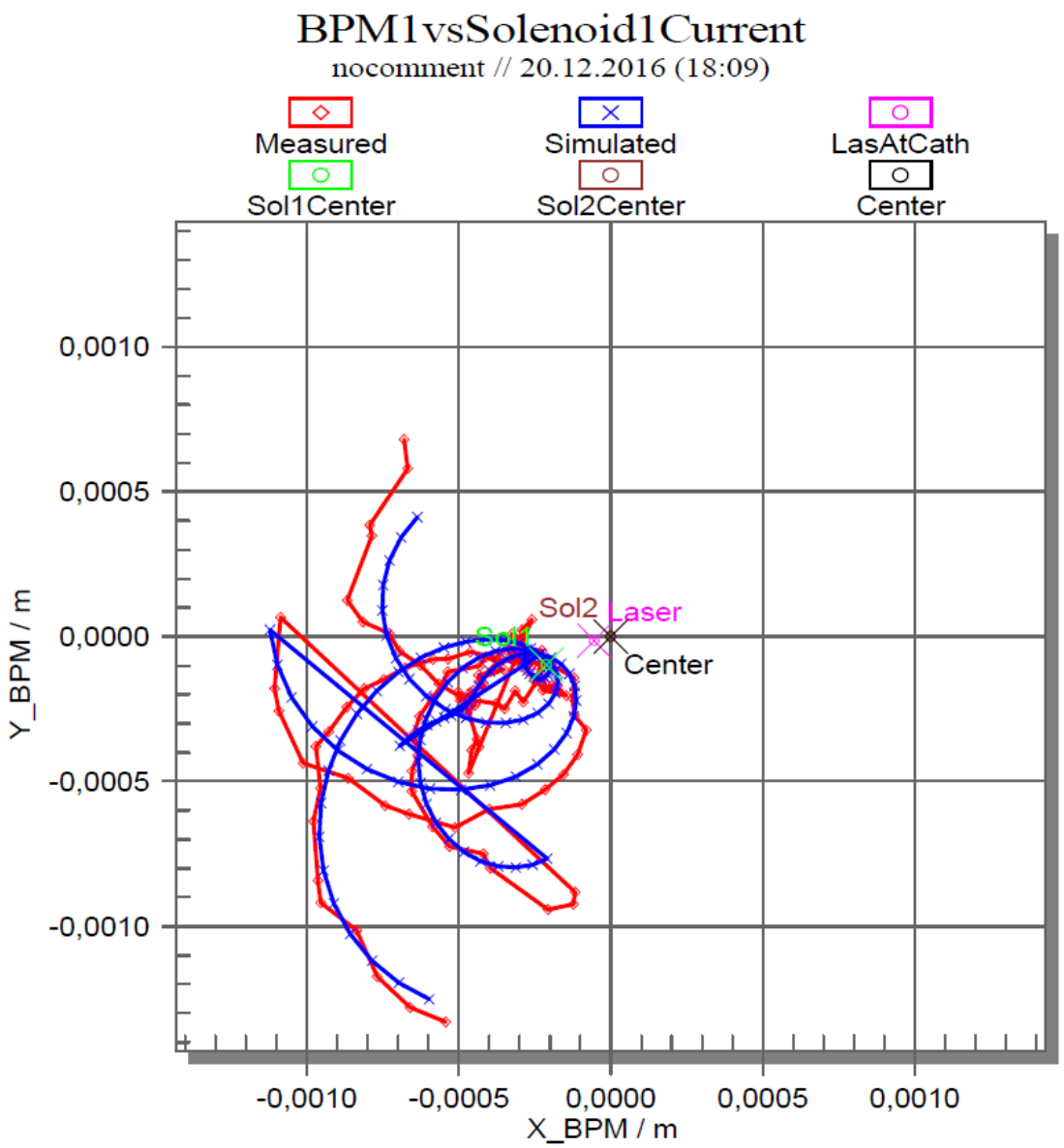
Offsets List / [m]

X_BPM = 0.000214002

Y_BPM = 6.30967e-005

Fixed (for these simulations):
Ecath=30MV/m
Phase=-153deg
→<Pz>=3.56MeV/c (?)
➔ Try to (slightly) fit them as well?

Simultaneous simulations of 3 steps (+ 2RF parameters)



Fit Parameters List

RF-GunPITZ : AngleXSolMain = -0.00667 deg
RF-GunPITZ : AngleYSolMain = -0.00527 deg
RF-GunPITZ : Ez_Field_At_Cathode = 25.5 MV/m
RF-GunPITZ : Initial_Phase = -146 degree
RF-GunPITZ : Laser_Beam_CenterX = -5.45e-005 m
RF-GunPITZ : Laser_Beam_CenterY = -1.41e-005 m
RF-GunPITZ : XSolMainCenter = -0.000212 m
RF-GunPITZ : YSolMainCenter = -9.73e-005 m

Offsets List / [m]

X_BPM = 0.000275784
Y_BPM = 8.53563e-005

→<Pz>=3.05MeV/c (?)

Current conclusions

- Based on measurements from 18.12.2016
- Obtained misalignment list:

Fit Parameters List

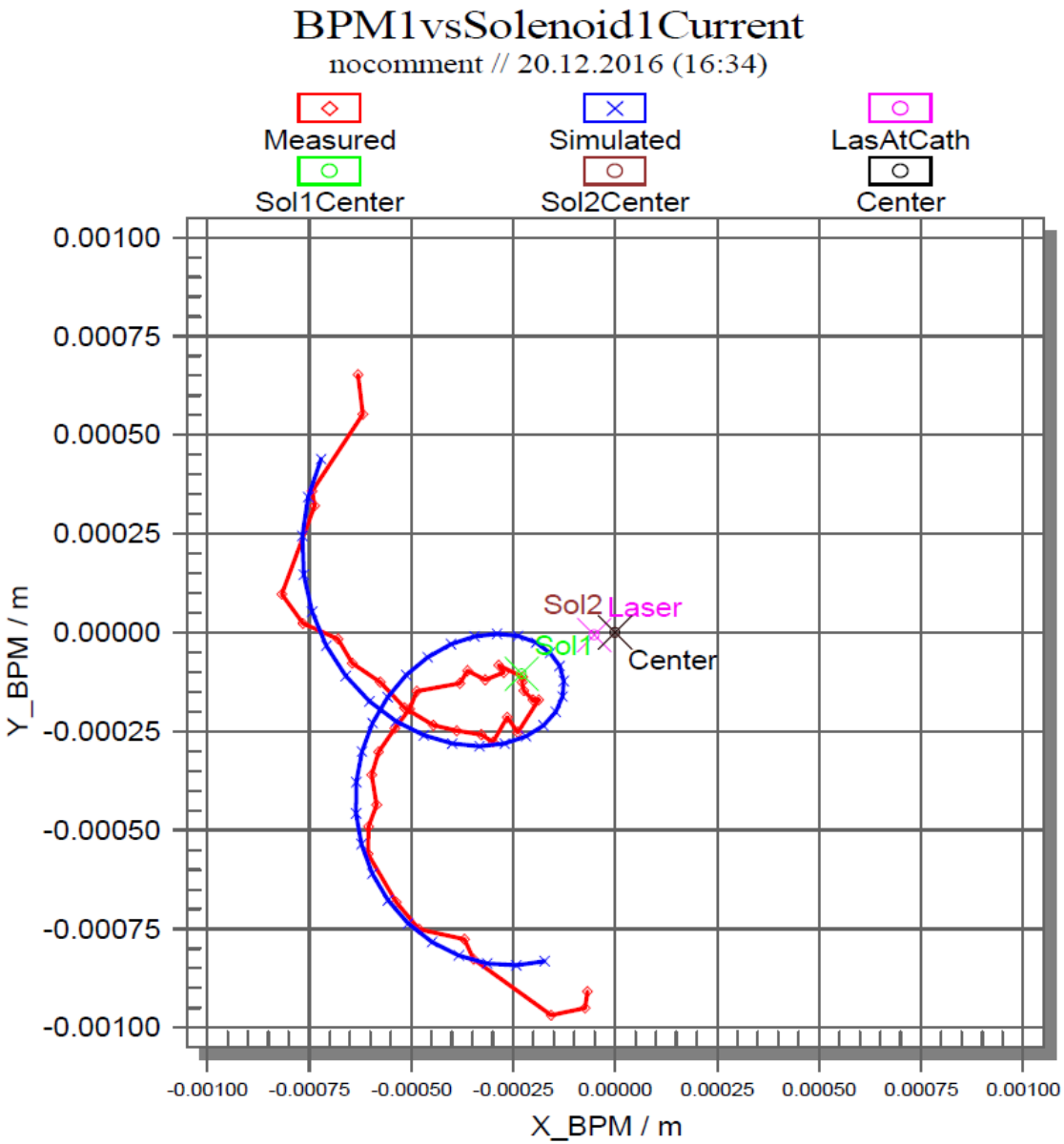
RF-GunPITZ : AngleXSolMain = -0.00558 deg
RF-GunPITZ : AngleYSolMain = -0.00516 deg
RF-GunPITZ : Laser_Beam_CenterX = -4.74e-005 m
RF-GunPITZ : Laser_Beam_CenterY = -7.6e-006 m
RF-GunPITZ : XSolMainCenter = -0.000232 m
RF-GunPITZ : YSolMainCenter = -0.000102 m

Offsets List / [m]

X_BPM = 0.000214002
Y_BPM = 6.30967e-005

- Recommendations:
  - DXsolenoid=+230um
  - DYsolenoid=+100um

Step0 only



Fit Parameters List

RF-GunPITZ : AngleXSolMain = -0.00615 deg

RF-GunPITZ : AngleYSolMain = -0.00514 deg

RF-GunPITZ : Laser_Beam_CenterX = -5.06e-005 m

RF-GunPITZ : Laser_Beam_CenterY = -6.6e-006 m

RF-GunPITZ : XSolMainCenter = -0.000229 m

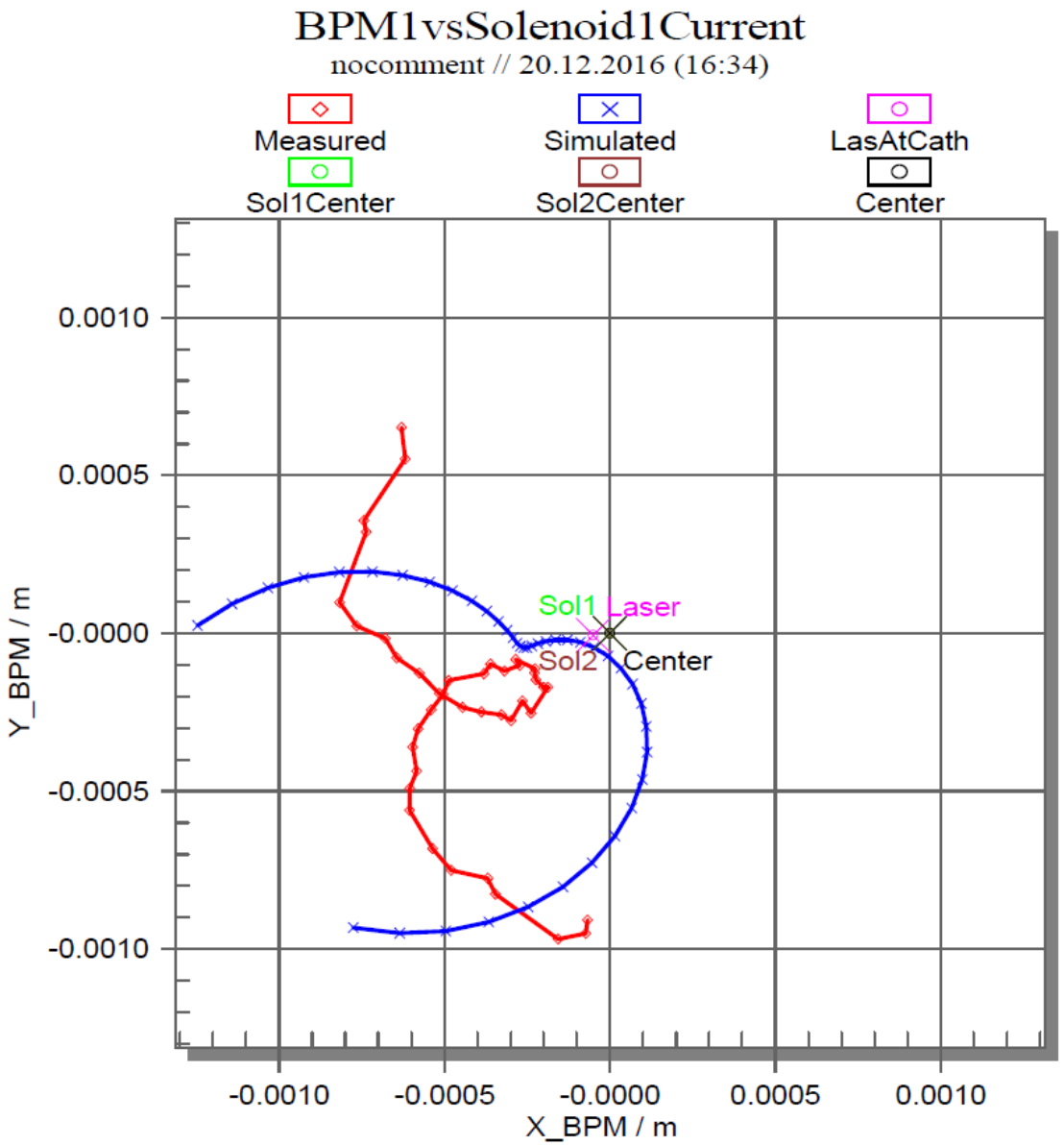
RF-GunPITZ : YSolMainCenter = -0.000105 m

Offsets List / [m]

X_BPM = 0.000226217

Y_BPM = 0.000112075

Expected: Step0→+solenoid offsets=0



Fit Parameters List

RF-GunPITZ : AngleXSolMain = -0.00615 deg

RF-GunPITZ : AngleYSolMain = -0.00514 deg

RF-GunPITZ : Laser_Beam_CenterX = -5.06e-005 m

RF-GunPITZ : Laser_Beam_CenterY = -6.6e-006 m

RF-GunPITZ : XSolMainCenter = 0 m

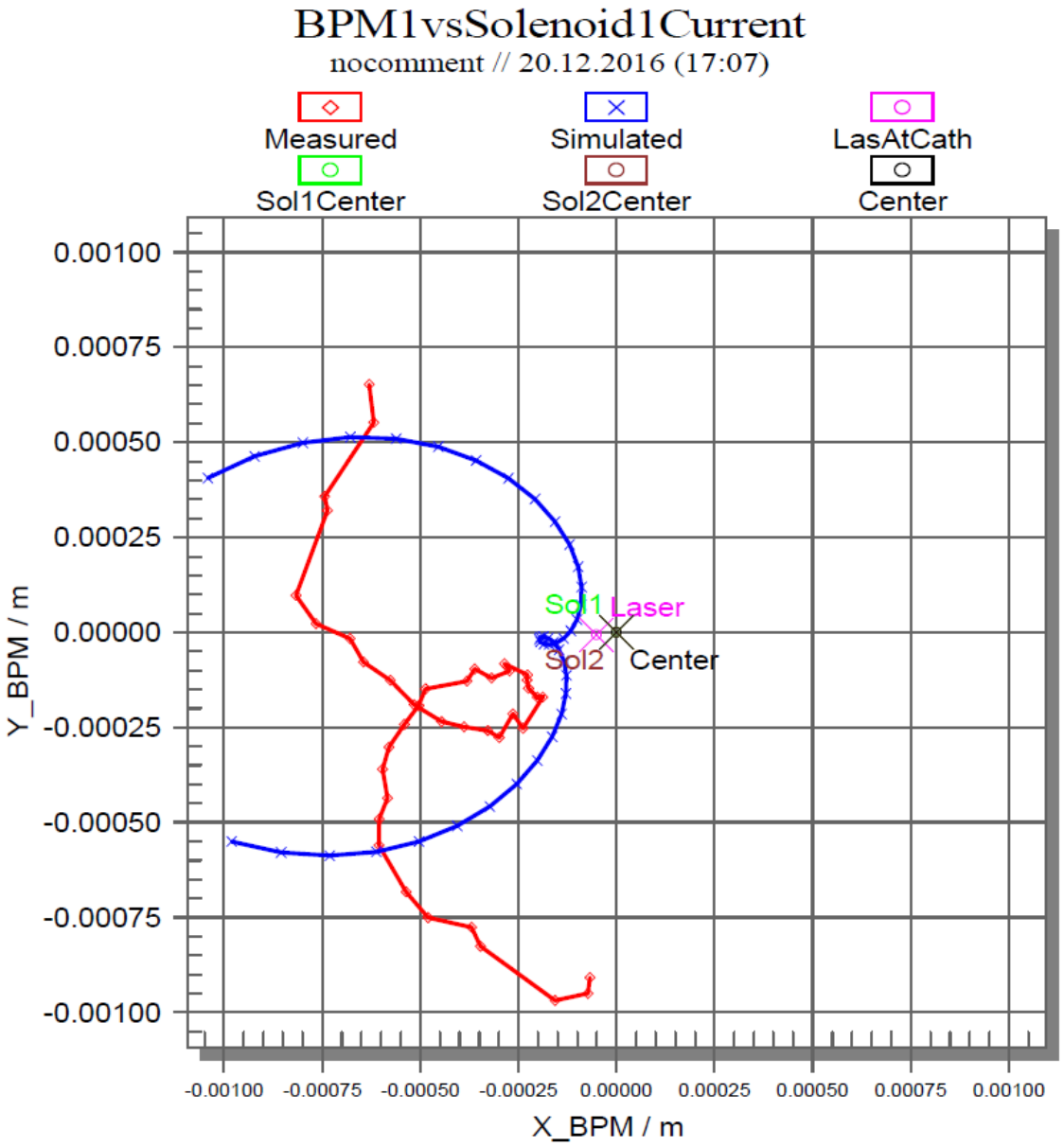
RF-GunPITZ : YSolMainCenter = 0 m

Offsets List / [m]

X_BPM = 0.000226217

Y_BPM = 0.000112075

Expected: …+Pitch→0



Fit Parameters List

RF-GunPITZ : AngleXSolMain = -0.00615 deg

RF-GunPITZ : AngleYSolMain = 0 deg

RF-GunPITZ : Laser_Beam_CenterX = -5.06e-005 m

RF-GunPITZ : Laser_Beam_CenterY = -6.6e-006 m

RF-GunPITZ : XSolMainCenter = 0 m

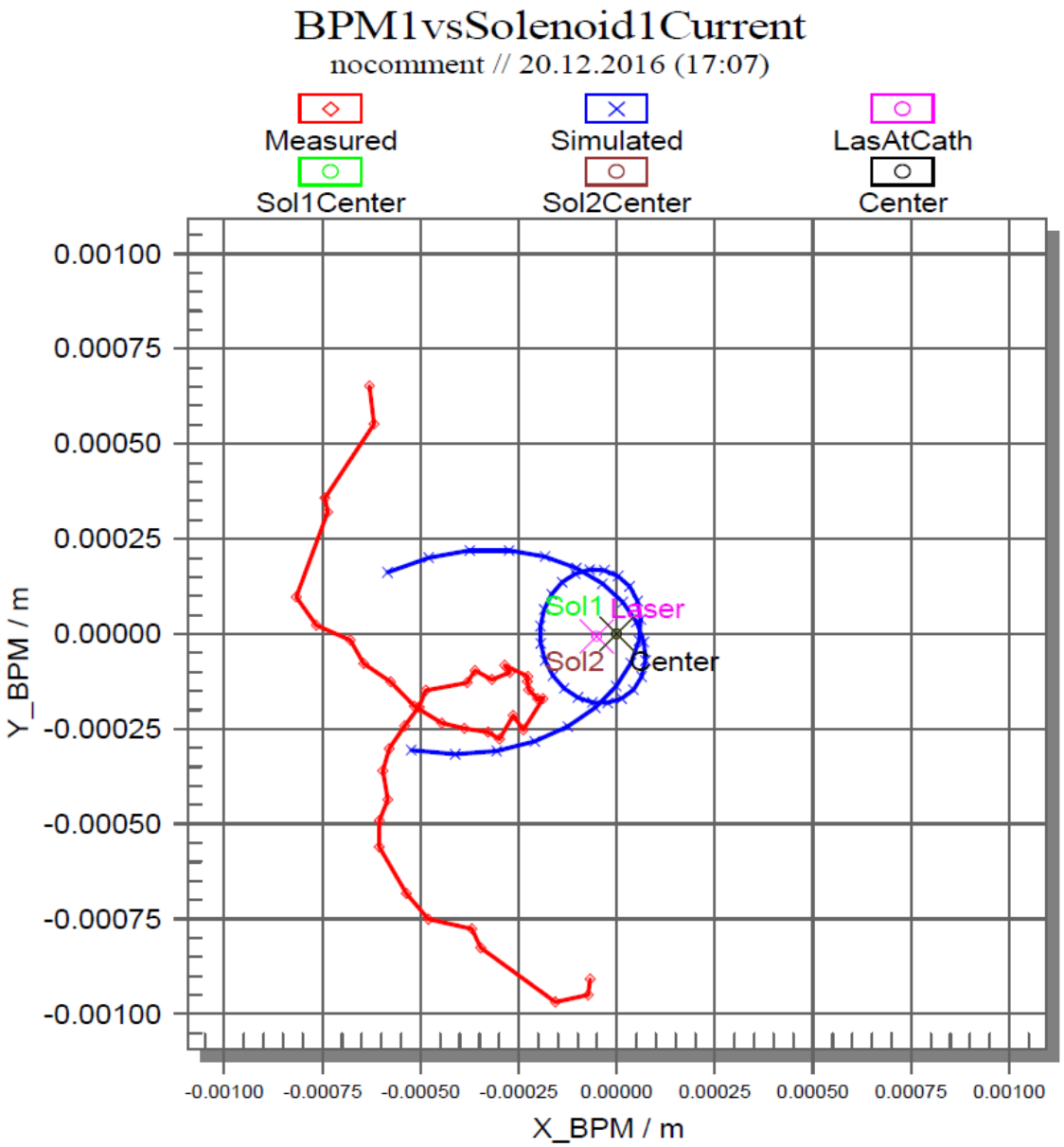
RF-GunPITZ : YSolMainCenter = 0 m

Offsets List / [m]

X_BPM = 0.000226217

Y_BPM = 0.000112075

Expected: …+Yaw→0



Fit Parameters List

RF-GunPITZ : AngleXSolMain = 0 deg

RF-GunPITZ : AngleYSolMain = 0 deg

RF-GunPITZ : Laser_Beam_CenterX = -5.06e-005 m

RF-GunPITZ : Laser_Beam_CenterY = -6.6e-006 m

RF-GunPITZ : XSolMainCenter = 0 m

RF-GunPITZ : YSolMainCenter = 0 m

Offsets List / [m]

X_BPM = 0.000226217

Y_BPM = 0.000112075

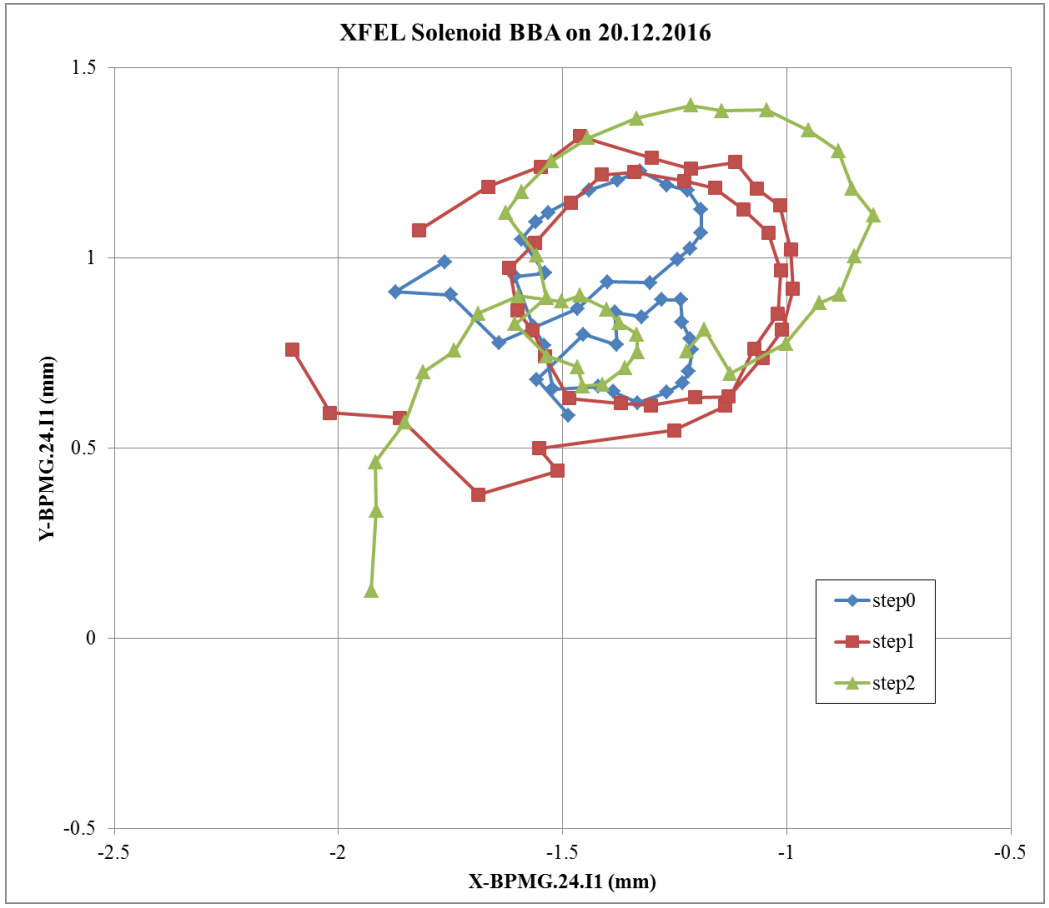
NB: Only laser misaligned

XFEL PI Solenoid BBA: next iteration on 21-22.12.2016

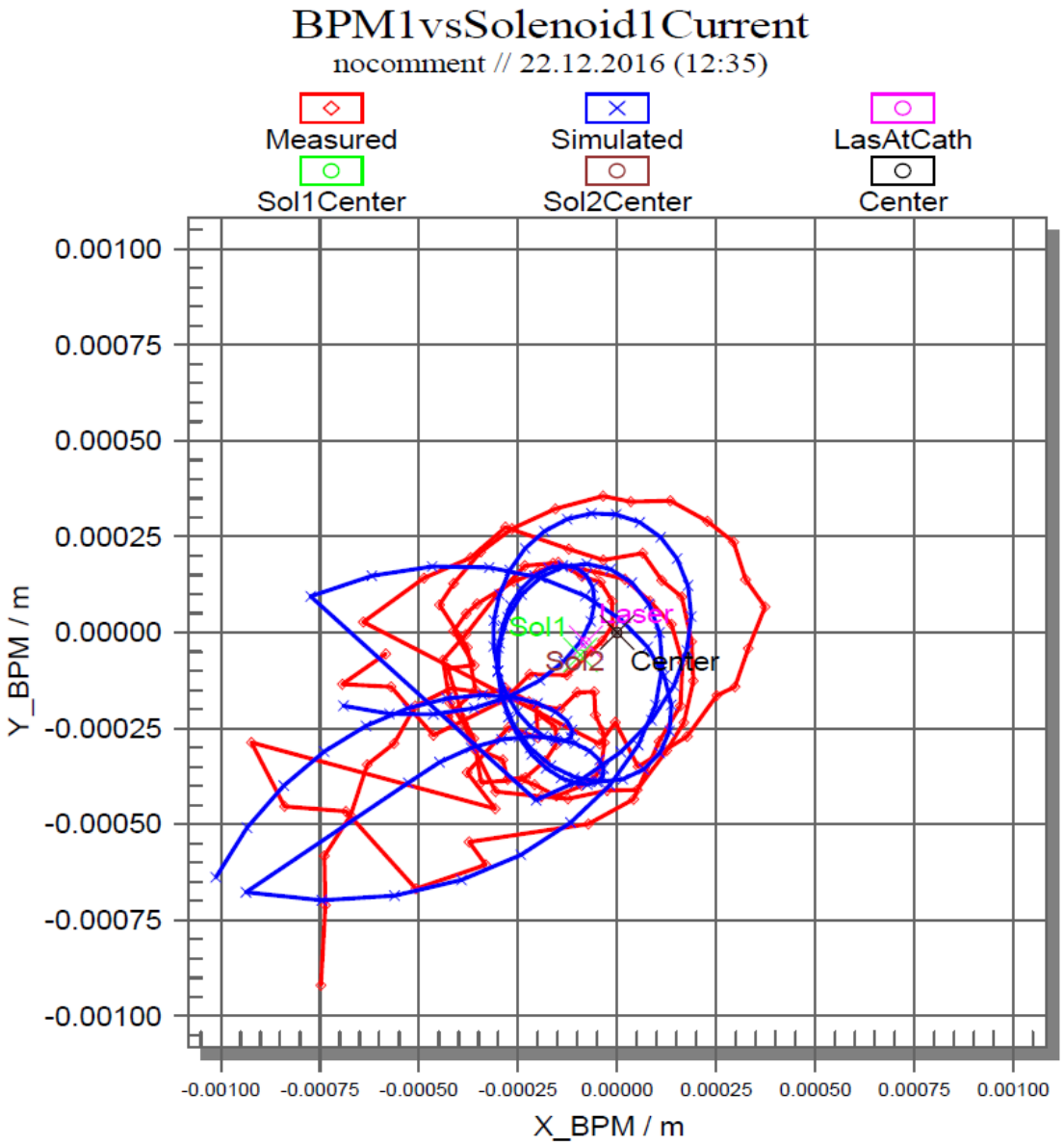
M, Krasilnikov, Y. Kot

Measurements 21.12.2016N

roll	yaw	pitch	x	y	file	DXsol	DYsol	steps
-2	2.1	-2.95	-0.27	0.22	2016-12-22T042904	0	0	step0
-2	2.1	-2.95	-0.17	0.22	2016-12-22T051855	0.1	0	step1
-2	2.1	-2.95	-0.27	0.32	2016-12-22T054553	0	0.1	step2



Simulations (Ez=30MV/m, Phi=-153deg →fixed)



Fit Parameters List

RF-GunPITZ : AngleXSolMain = 0.000312 deg

RF-GunPITZ : AngleYSolMain = -0.00196 deg

RF-GunPITZ : Laser_Beam_CenterX = -7.87e-005 m

RF-GunPITZ : Laser_Beam_CenterY = -2.64e-005 m

RF-GunPITZ : XSolMainCenter = -9.29e-005 m

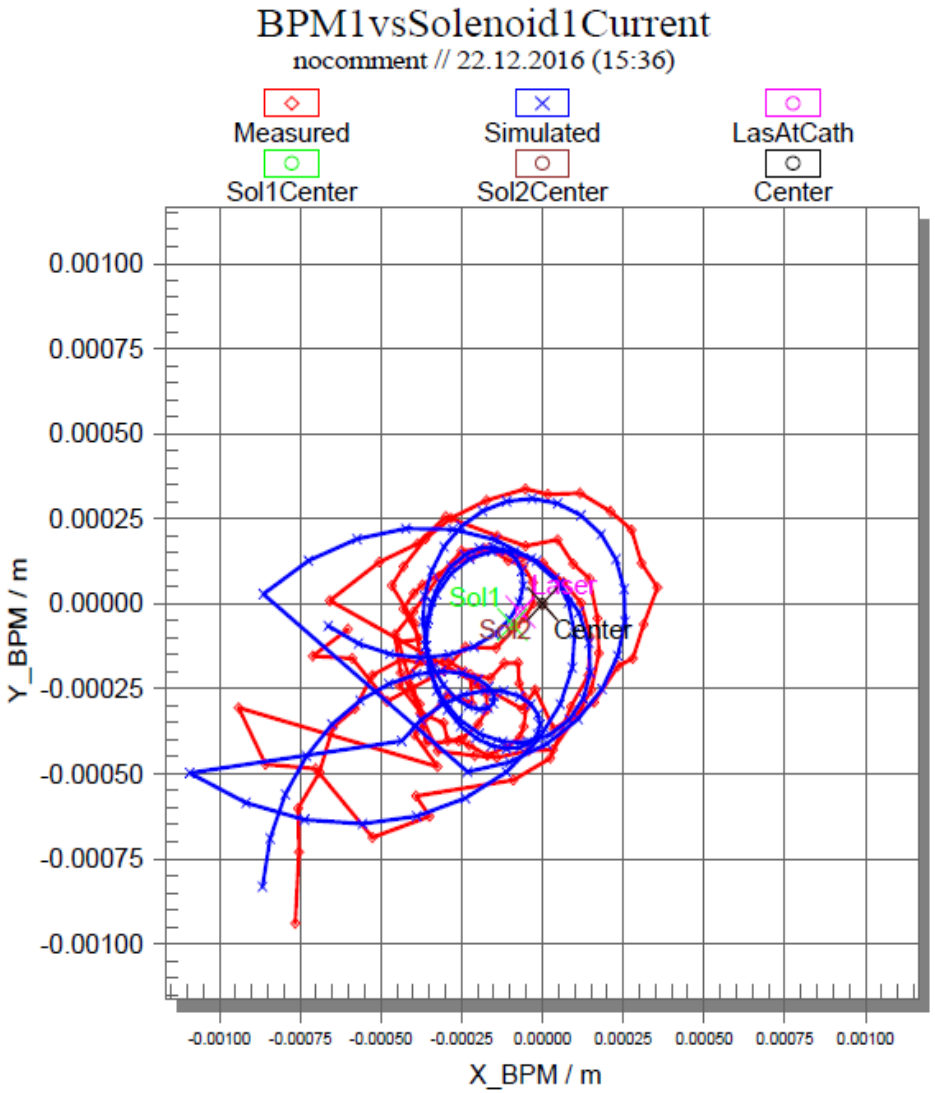
RF-GunPITZ : YSolMainCenter = -5.92e-005 m

Offsets List / [m]

X_BPM = 0.000653181

Y_BPM = 0.000590166

Simulations (Ez, Phi →tuned)



Fit Parameters List

RF-GunPITZ : AngleXSolMain = 0.00107 deg

RF-GunPITZ : AngleYSolMain = -0.00176 deg

RF-GunPITZ : Ez_Field_At_Cathode = 30 MV/m

RF-GunPITZ : Initial_Phase = -117 degree

RF-GunPITZ : Laser_Beam_CenterX = -6.77e-005 m

RF-GunPITZ : Laser_Beam_CenterY = -2.34e-005 m

RF-GunPITZ : XSolMainCenter = -9.33e-005 m

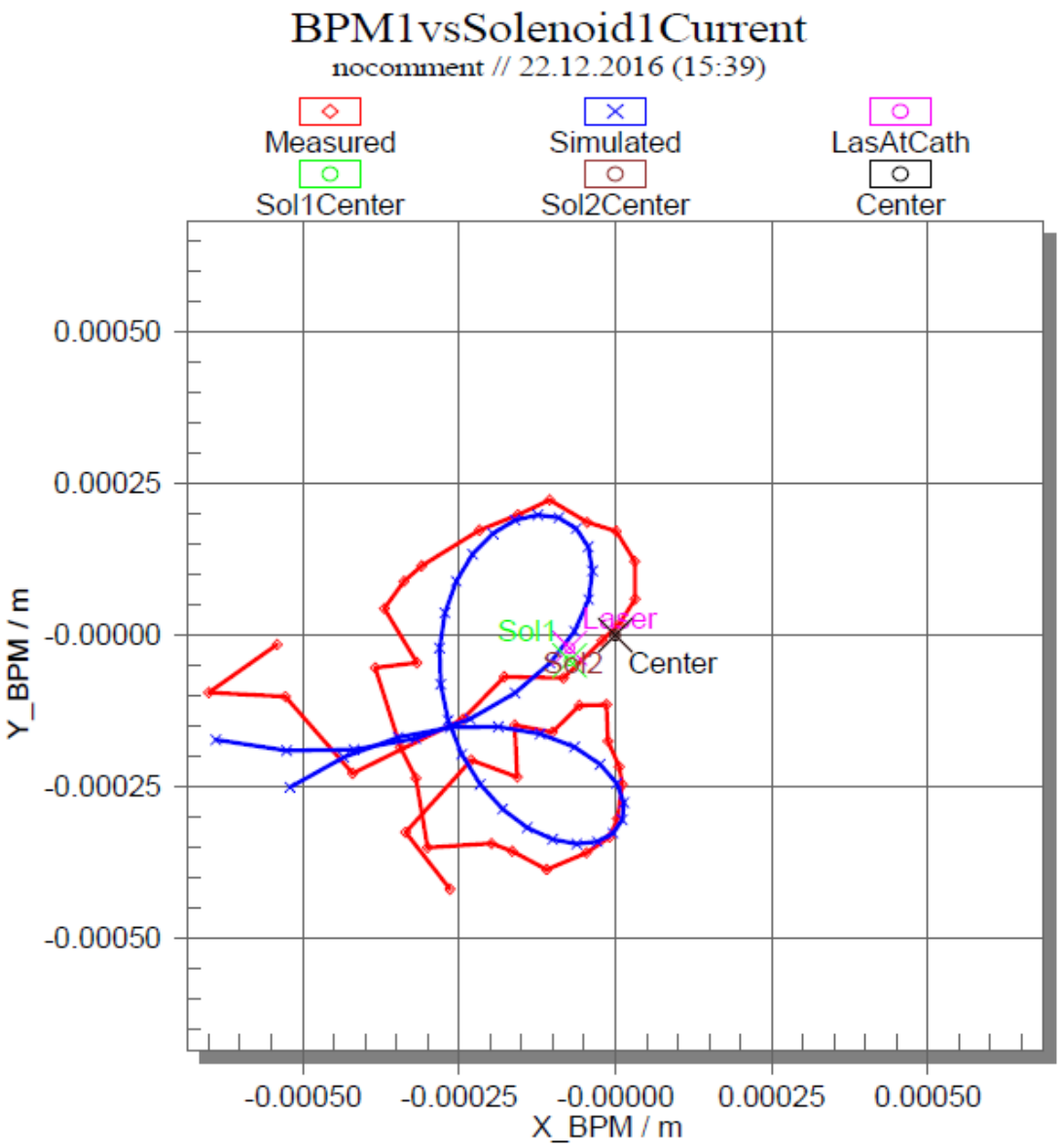
RF-GunPITZ : YSolMainCenter = -6.11e-005 m

Offsets List / [m]

X_BPM = 0.000670787

Y_BPM = 0.000609132

Simulations: step 0 only (“best”)



Fit Parameters List

RF-GunPITZ : AngleXSolMain = 0.000524 deg

RF-GunPITZ : AngleYSolMain = -0.00112 deg

RF-GunPITZ : Laser_Beam_CenterX = -7.36e-005 m

RF-GunPITZ : Laser_Beam_CenterY = -2.12e-005 m

RF-GunPITZ : XSolMainCenter = -7.28e-005 m

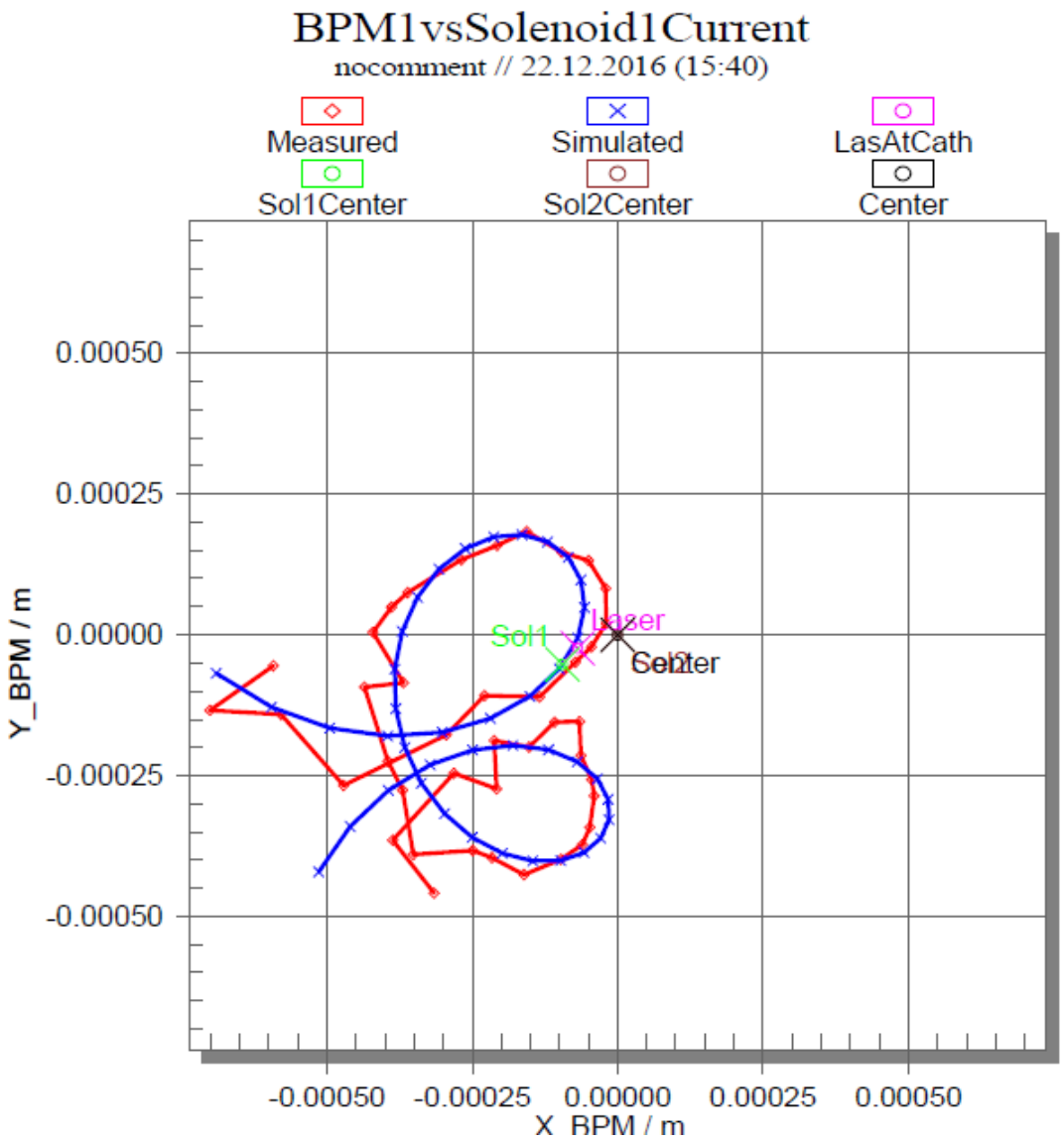
RF-GunPITZ : YSolMainCenter = -4.16e-005 m

Offsets List / [m]

X_BPM = 0.000609963

Y_BPM = 0.000549828

Simulations: step 0 only (“best”, Ez,Phi tuned)



Fit Parameters List

RF-GunPITZ : AngleXSolMain = 0.000959 deg

RF-GunPITZ : AngleYSolMain = -0.00141 deg

RF-GunPITZ : Ez_Field_At_Cathode = 31.9 MV/m

RF-GunPITZ : Initial_Phase = -106 degree

RF-GunPITZ : Laser_Beam_CenterX = -6.91e-005 m

RF-GunPITZ : Laser_Beam_CenterY = -2.36e-005 m

RF-GunPITZ : XSolMainCenter = -9.5e-005 m

RF-GunPITZ : YSolMainCenter = -5.23e-005 m

Offsets List / [m]

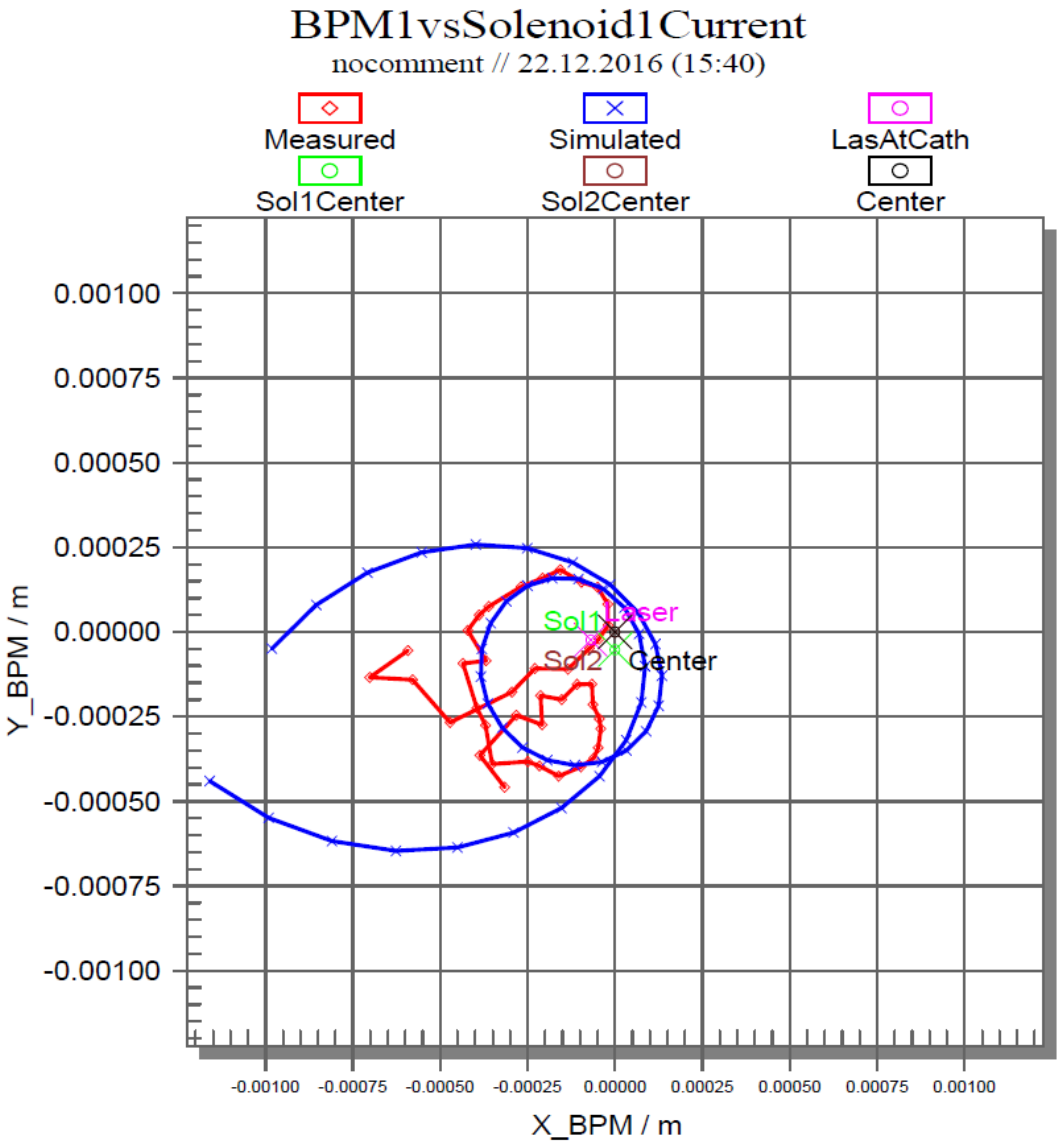
X_BPM = 0.000661434

Y_BPM = 0.00058932

Next Steps (?)

- We are probably coming to systematic limit of the procedure (measurements + solenoid positioning)
- Angles ~0.001 and smaller, offsets <100um
- Improve stability/reliability of BPM measurements (curves should be smoother). ?Increase BSA to 1-1.2mm?
- ?try 2D (Xsol,Ysol), step 50 um scan w.r.t. the actual position?

Simulations: step 0 only:
Xsol→0



Fit Parameters List

RF-GunPITZ : AngleXSolMain = 0.000959 deg

RF-GunPITZ : AngleYSolMain = -0.00141 deg

RF-GunPITZ : Ez_Field_At_Cathode = 31.9 MV/m

RF-GunPITZ : Initial_Phase = -106 degree

RF-GunPITZ : Laser_Beam_CenterX = -6.91e-005 m

RF-GunPITZ : Laser_Beam_CenterY = -2.36e-005 m

RF-GunPITZ : XSolMainCenter = 0 m

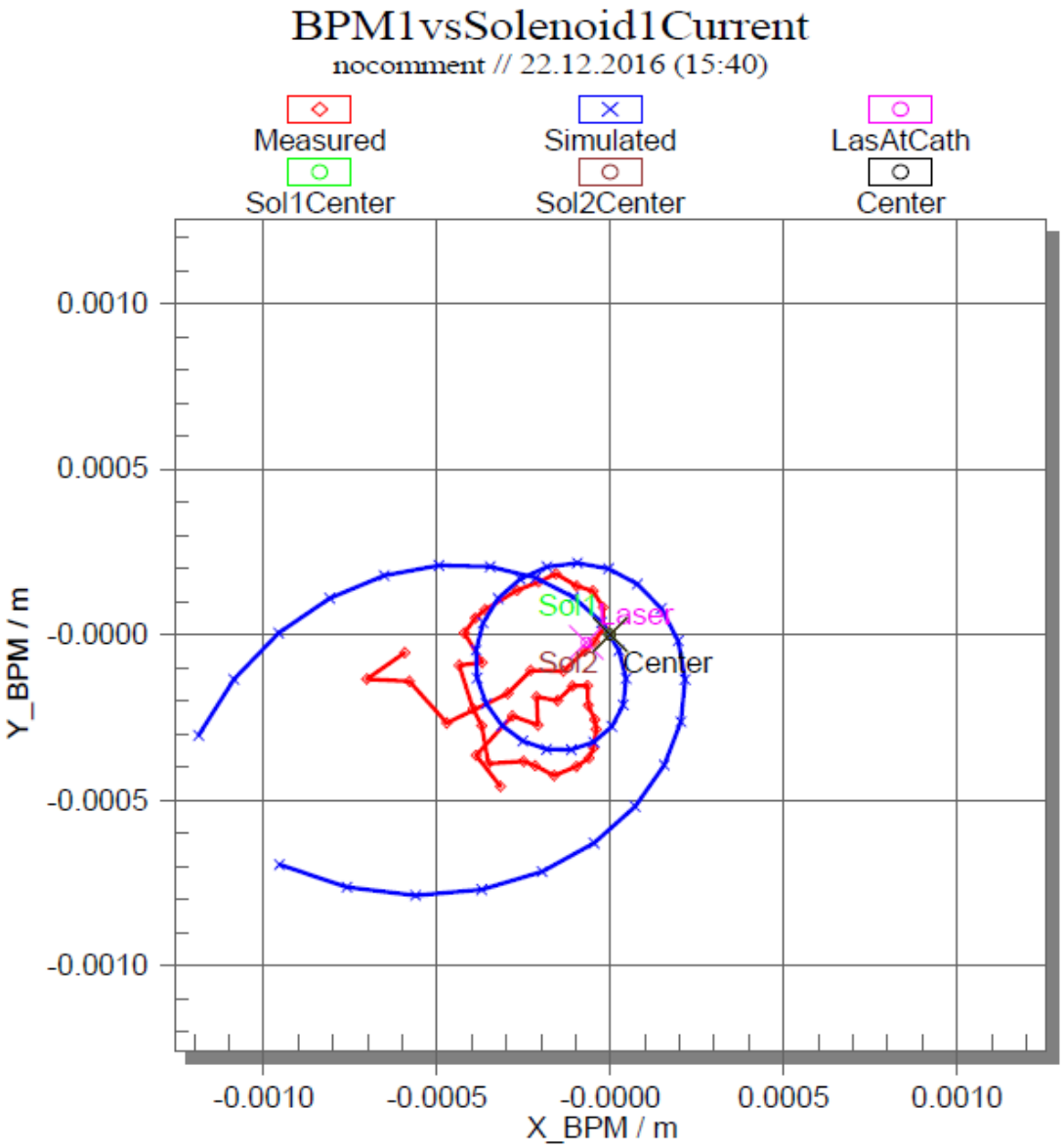
RF-GunPITZ : YSolMainCenter = -5.23e-005 m

Offsets List / [m]

X_BPM = 0.000661434

Y_BPM = 0.00058932

Simulations: step 0 only:
Xsol→0; Ysol→0



Fit Parameters List

RF-GunPITZ : AngleXSolMain = 0.000959 deg

RF-GunPITZ : AngleYSolMain = -0.00141 deg

RF-GunPITZ : Ez_Field_At_Cathode = 31.9 MV/m

RF-GunPITZ : Initial_Phase = -106 degree

RF-GunPITZ : Laser_Beam_CenterX = -6.91e-005 m

RF-GunPITZ : Laser_Beam_CenterY = -2.36e-005 m

RF-GunPITZ : XSolMainCenter = 0 m

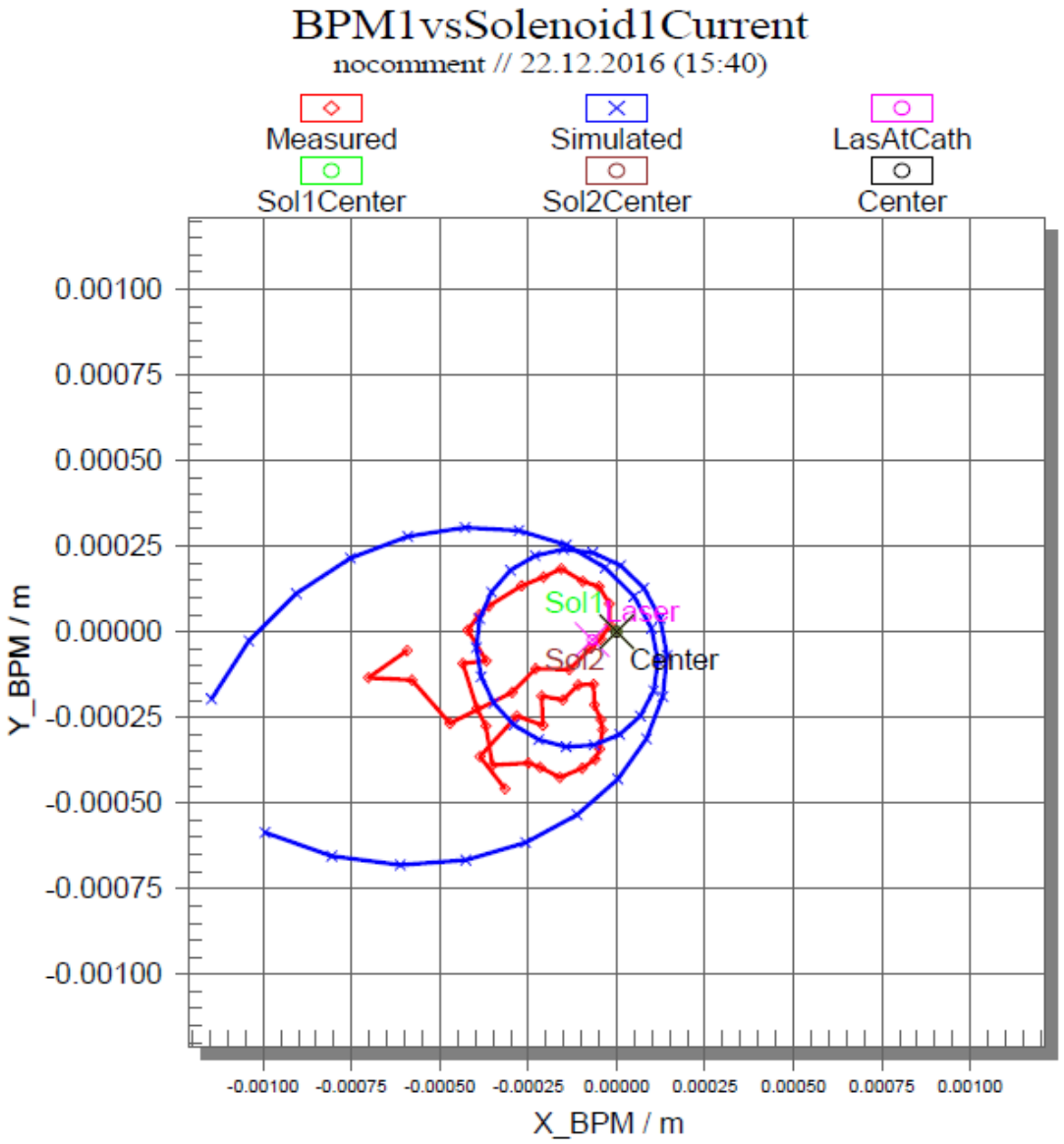
RF-GunPITZ : YSolMainCenter = 0 m

Offsets List / [m]

X_BPM = 0.000661434

Y_BPM = 0.00058932

Simulations: step 0 only:
Xsol→0; Ysol→0; Y-angle→0



Fit Parameters List

RF-GunPITZ : AngleXSolMain = 0.000959 deg

RF-GunPITZ : AngleYSolMain = 0 deg

RF-GunPITZ : Ez_Field_At_Cathode = 31.9 MV/m

RF-GunPITZ : Initial_Phase = -106 degree

RF-GunPITZ : Laser_Beam_CenterX = -6.91e-005 m

RF-GunPITZ : Laser_Beam_CenterY = -2.36e-005 m

RF-GunPITZ : XSolMainCenter = 0 m

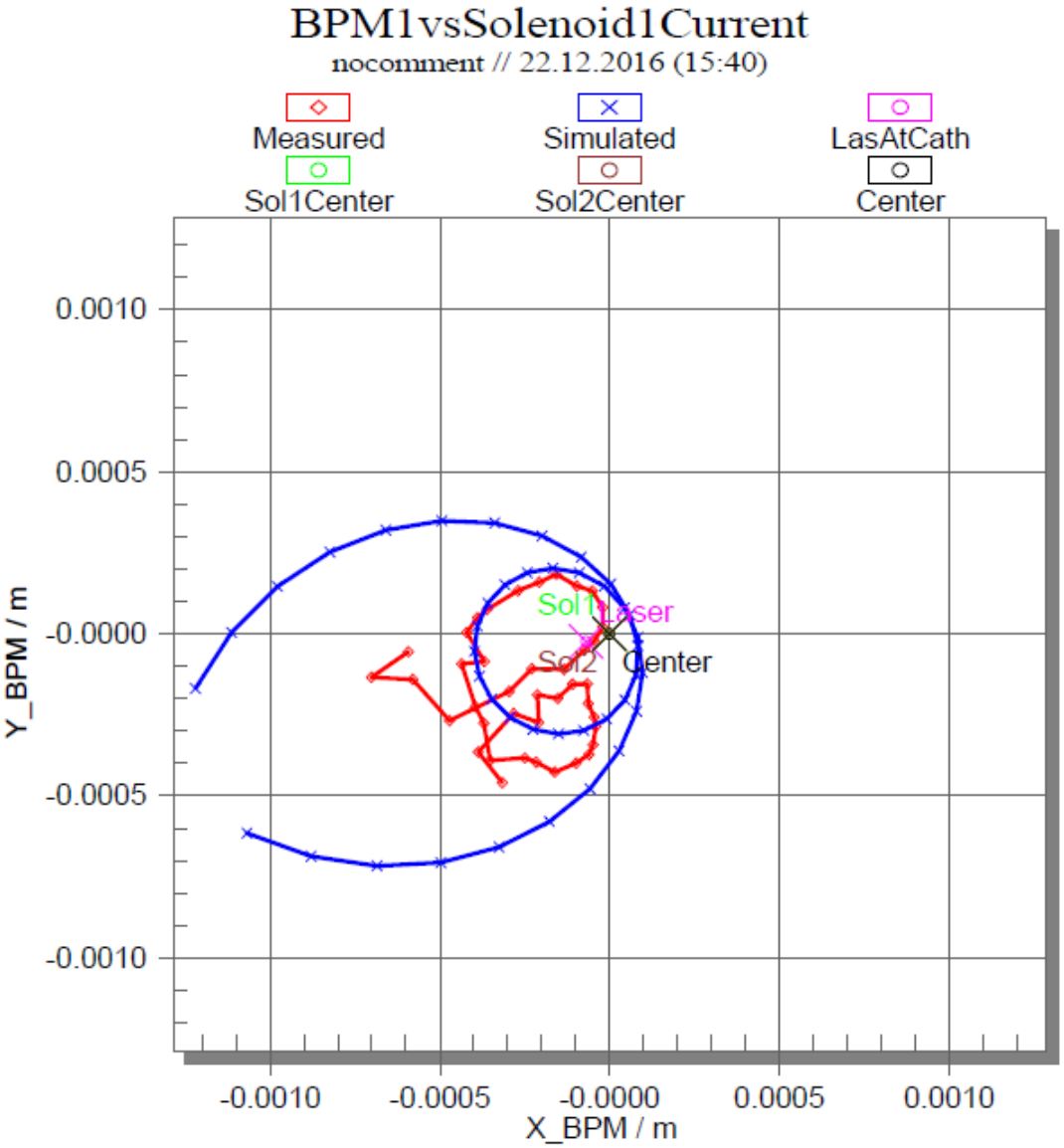
RF-GunPITZ : YSolMainCenter = 0 m

Offsets List / [m]

X_BPM = 0.000661434

Y_BPM = 0.00058932

Simulations: step 0 only:
Xsol→0; Ysol→0; Y-angle→0 ; X-angle→0



Fit Parameters List

RF-GunPITZ : AngleXSolMain = 0 deg

RF-GunPITZ : AngleYSolMain = 0 deg

RF-GunPITZ : Ez_Field_At_Cathode = 31.9 MV/m

RF-GunPITZ : Initial_Phase = -106 degree

RF-GunPITZ : Laser_Beam_CenterX = -6.91e-005 m

RF-GunPITZ : Laser_Beam_CenterY = -2.36e-005 m

RF-GunPITZ : XSolMainCenter = 0 m

RF-GunPITZ : YSolMainCenter = 0 m

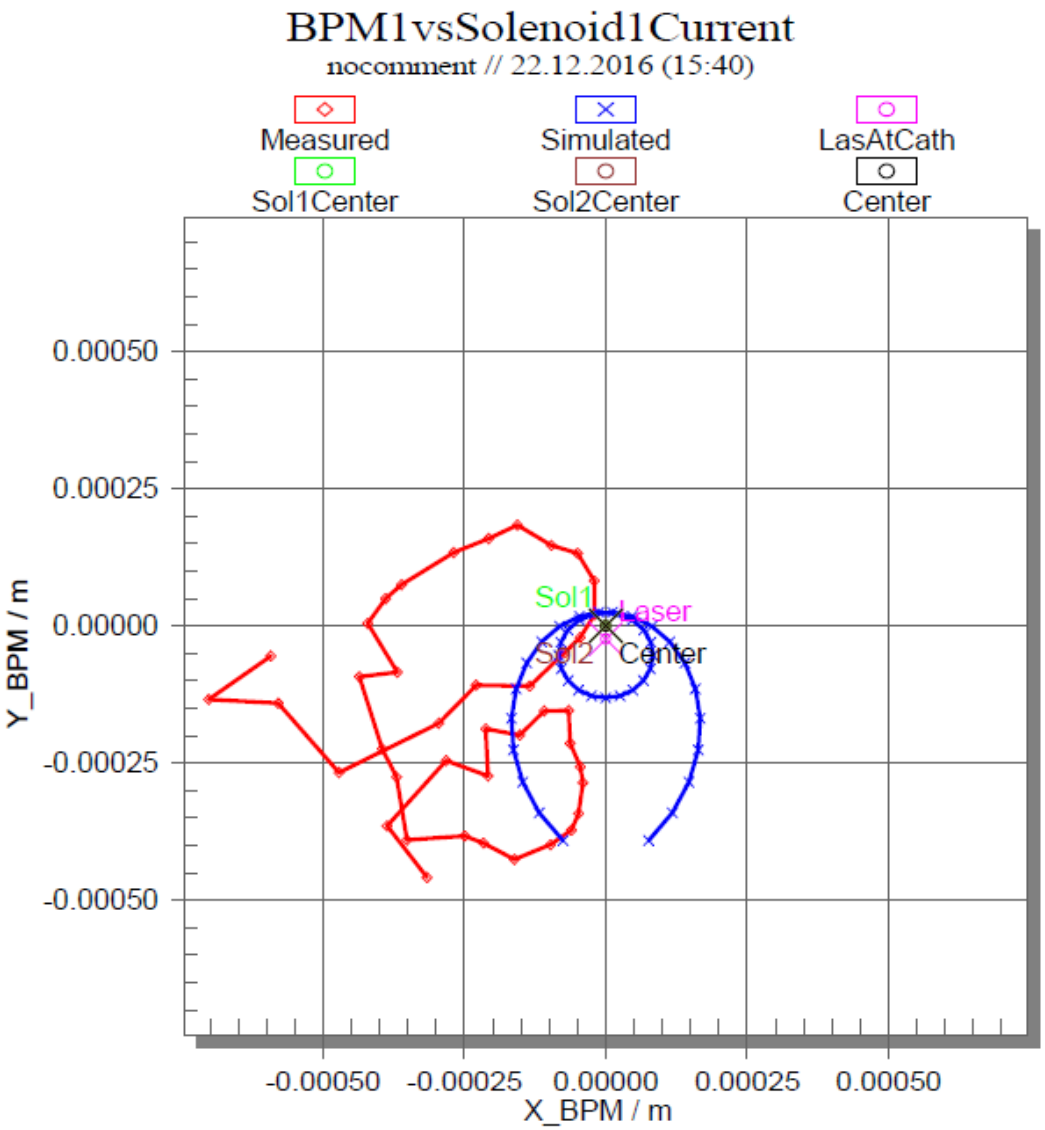
Offsets List / [m]

X_BPM = 0.000661434

Y_BPM = 0.00058932

Simulations: step 0 only:

Xsol→0; Ysol→0; Y-angle→0 ; X-angle→0 ; Y-angle→0; Xlas→0



Fit Parameters List

RF-GunPITZ : AngleXSolMain = 0 deg

RF-GunPITZ : AngleYSolMain = 0 deg

RF-GunPITZ : Ez_Field_At_Cathode = 31.9 MV/m

RF-GunPITZ : Initial_Phase = -106 degree

RF-GunPITZ : Laser_Beam_CenterX = 0 m

RF-GunPITZ : Laser_Beam_CenterY = -2.36e-005 m

RF-GunPITZ : XSolMainCenter = 0 m

RF-GunPITZ : YSolMainCenter = 0 m

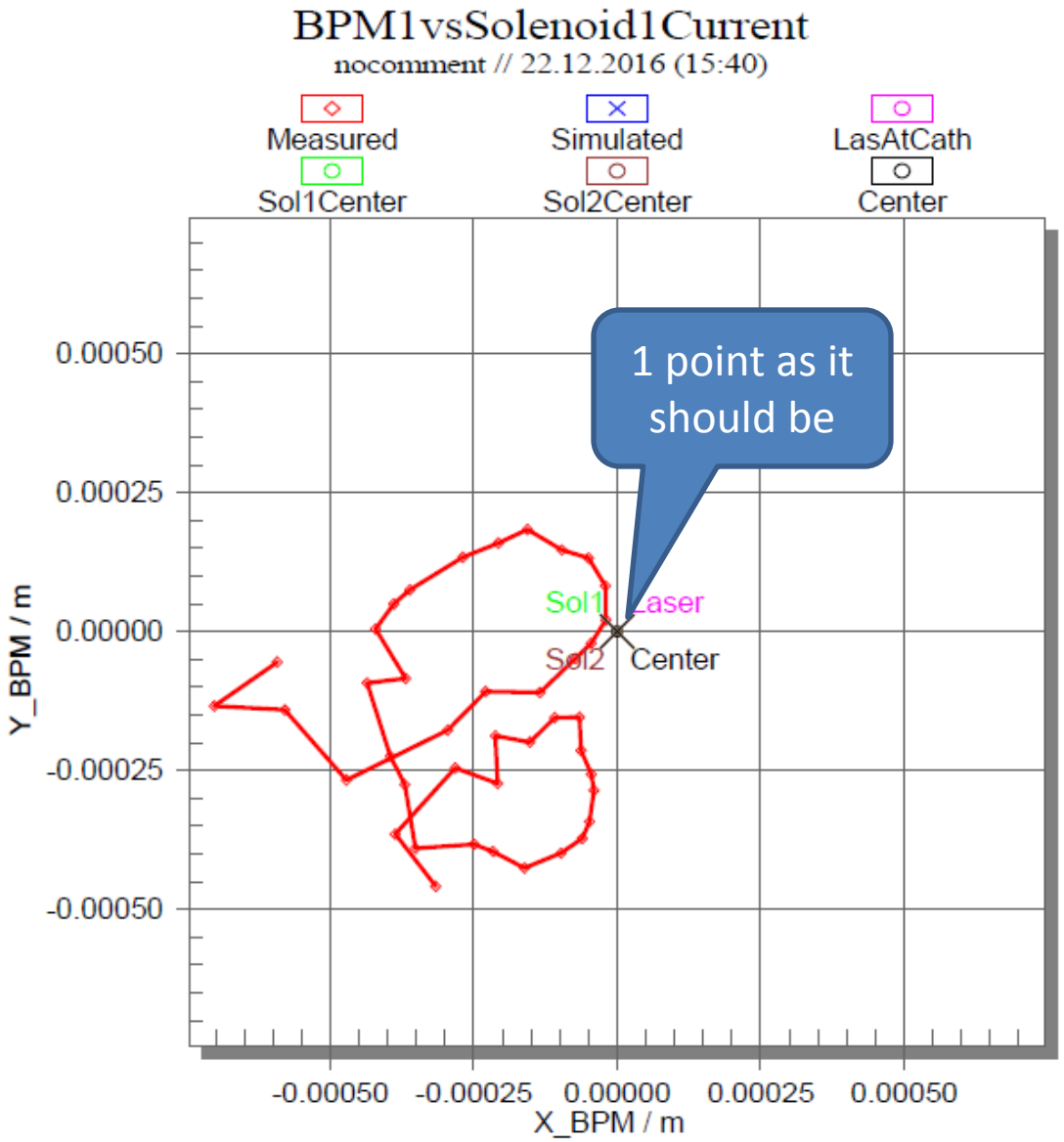
Offsets List / [m]

X_BPM = 0.000661434

Y_BPM = 0.00058932

Simulations: step 0 only:

Xsol→0; Ysol→0; Y-angle→0 ; X-angle→0 ; Y-angle→0; Xlas→0; Ylas→0



Fit Parameters List

RF-GunPITZ : AngleXSolMain = 0 deg

RF-GunPITZ : AngleYSolMain = 0 deg

RF-GunPITZ : Ez_Field_At_Cathode = 31.9 MV/m

RF-GunPITZ : Initial_Phase = -106 degree

RF-GunPITZ : Laser_Beam_CenterX = 0 m

RF-GunPITZ : Laser_Beam_CenterY = 0 m

RF-GunPITZ : XSolMainCenter = 0 m

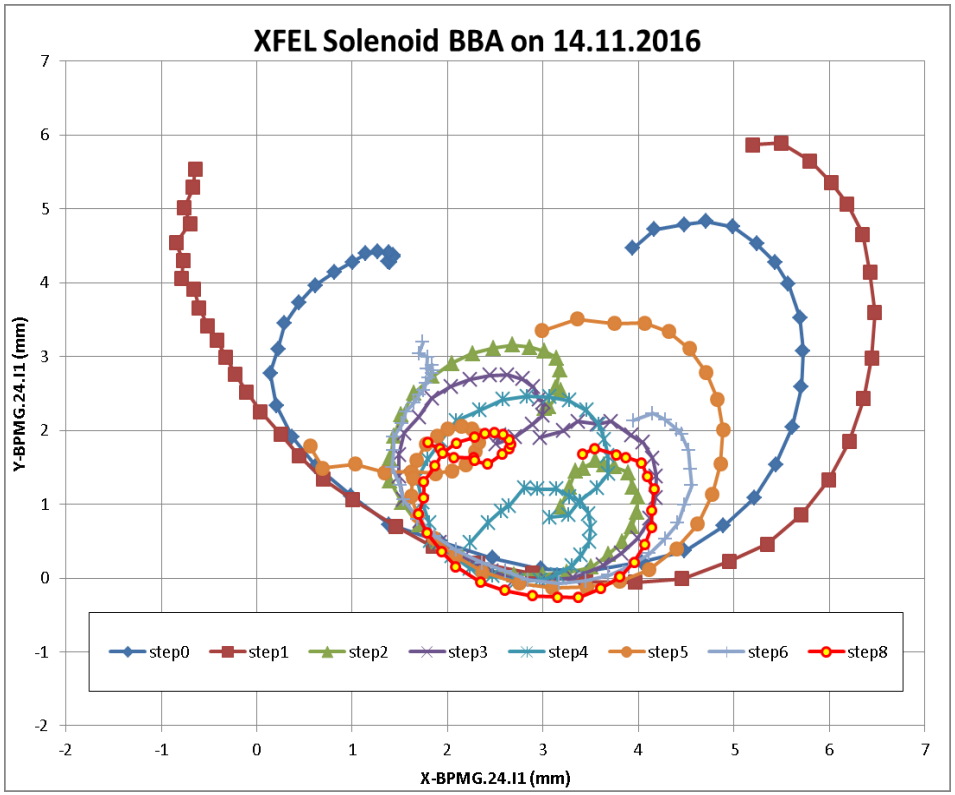
RF-GunPITZ : YSolMainCenter = 0 m

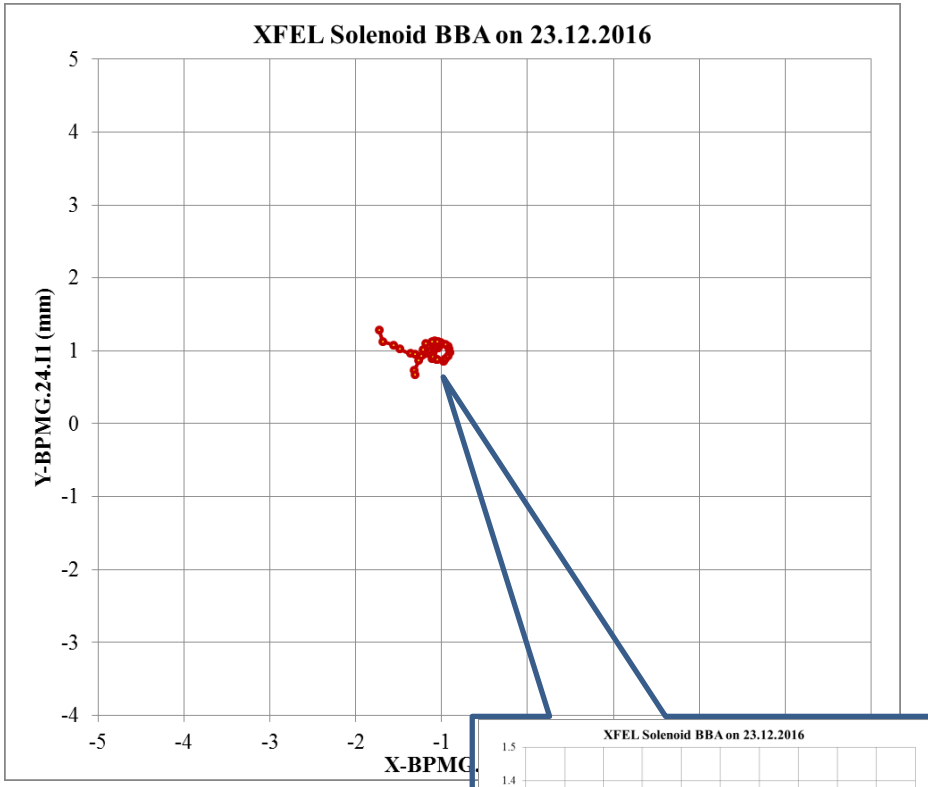
Offsets List / [m]

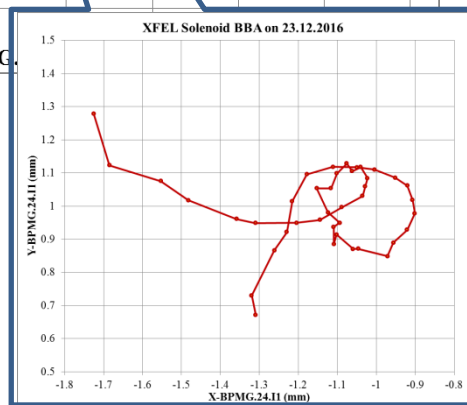
X_BPM = 0.000661434

Y_BPM = 0.00058932

Final measurements on 23.12.2016

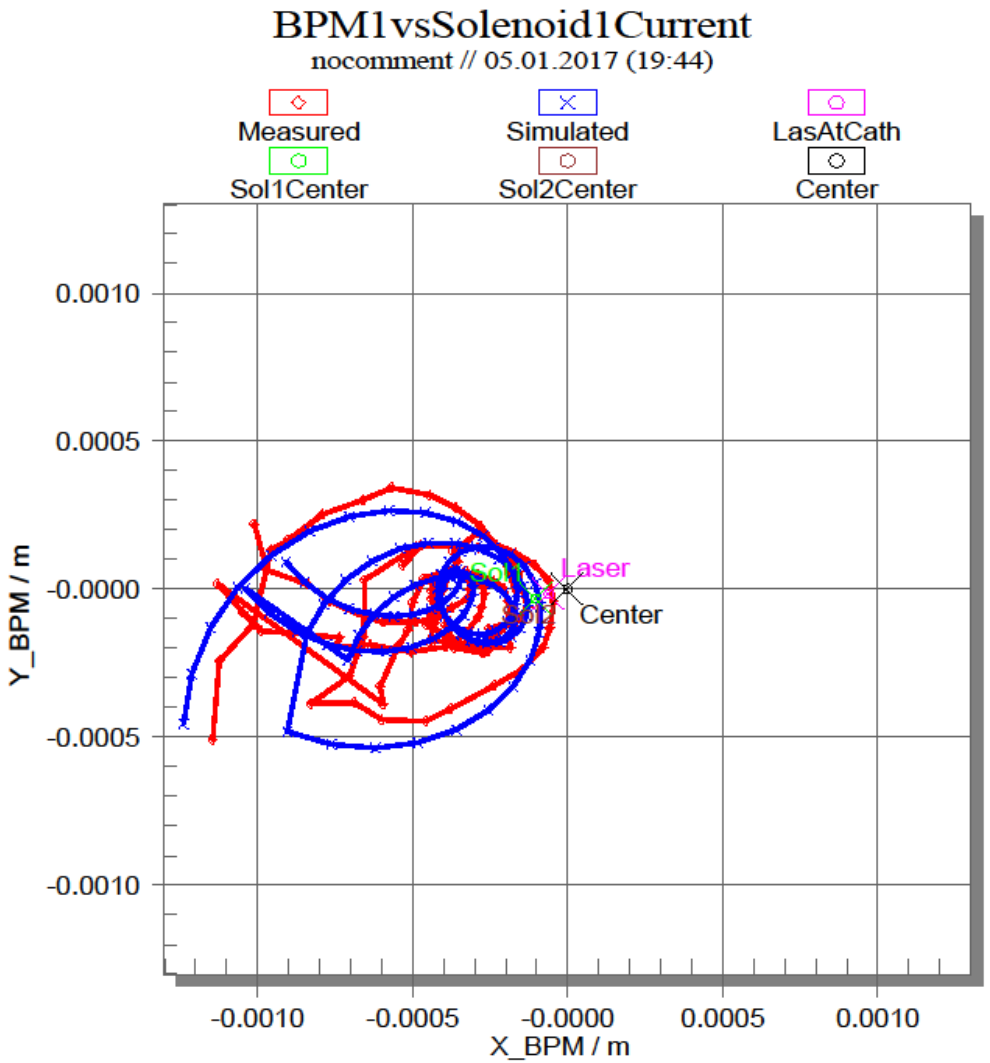






Imain=-400A…step 20A…+400A

New implementation: Static homogeneous magnetic field



Fit Parameters List

RF-GunPITZ : AngleXSolMain = -0.00309 deg

RF-GunPITZ : AngleYSolMain = 0.000477 deg

RF-GunPITZ : Ez_Field_At_Cathode = 30.4 MV/m

RF-GunPITZ : HxEarth = 0.000848 T

RF-GunPITZ : HyEarth = -0.0105 T

RF-GunPITZ : HzEarth = 0 T

RF-GunPITZ : Initial_Phase = -108 degree

RF-GunPITZ : Laser_Beam_CenterX = -6.07e-005 m

RF-GunPITZ : Laser_Beam_CenterY = -1.57e-005 m

RF-GunPITZ : XSolMainCenter = -0.000102 m

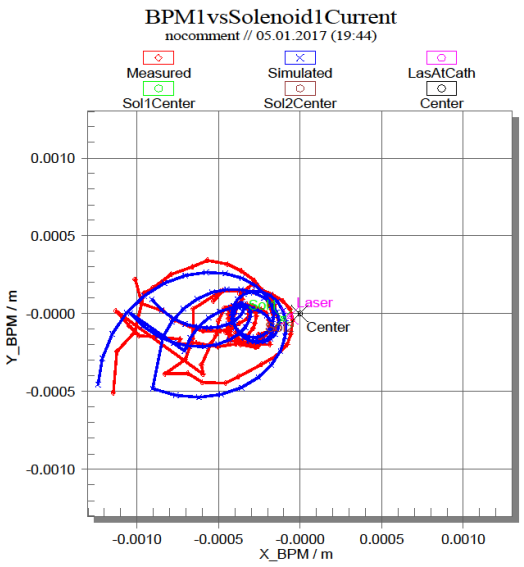
RF-GunPITZ : YSolMainCenter = -3.23e-005 m

Offsets List / [m]

X_BPM = 0.00111726

Y_BPM = 0.000603668

But: To be combined with BPM offsets

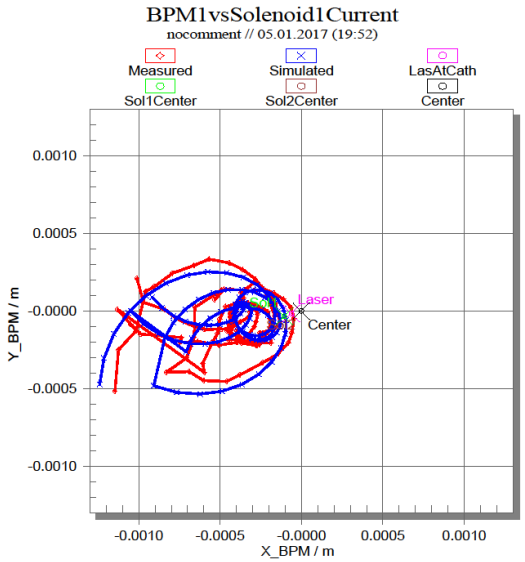


Fit Parameters List

RF-GunPITZ : AngleXSolMain = -0.00309 deg
RF-GunPITZ : AngleYSolMain = 0.000477 deg
RF-GunPITZ : Ez_Field_At_Cathode = 30.4 MV/m
RF-GunPITZ : HxEarth = 0.000848 T
RF-GunPITZ : HyEarth = -0.0105 T
RF-GunPITZ : HzEarth = 0 T
RF-GunPITZ : Initial_Phase = -108 degree
RF-GunPITZ : Laser_Beam_CenterX = -6.07e-005 m
RF-GunPITZ : Laser_Beam_CenterY = -1.57e-005 m
RF-GunPITZ : XSolMainCenter = -0.000102 m
RF-GunPITZ : YSolMainCenter = -3.23e-005 m

Offsets List / [m]

X_BPM = 0.00111726
Y_BPM = 0.000603668



Fit Parameters List

RF-GunPITZ : AngleXSolMain = -0.00317 deg
RF-GunPITZ : AngleYSolMain = 0.000401 deg
RF-GunPITZ : Ez_Field_At_Cathode = 29.9 MV/m
RF-GunPITZ : HxEarth = 0.00167 T
RF-GunPITZ : HyEarth = -0.00959 T
RF-GunPITZ : HzEarth = 0 T
RF-GunPITZ : Initial_Phase = -110 degree
RF-GunPITZ : Laser_Beam_CenterX = -6.16e-005 m
RF-GunPITZ : Laser_Beam_CenterY = -1.61e-005 m
RF-GunPITZ : XSolMainCenter = -0.000105 m
RF-GunPITZ : YSolMainCenter = -3.41e-005 m

Offsets List / [m]

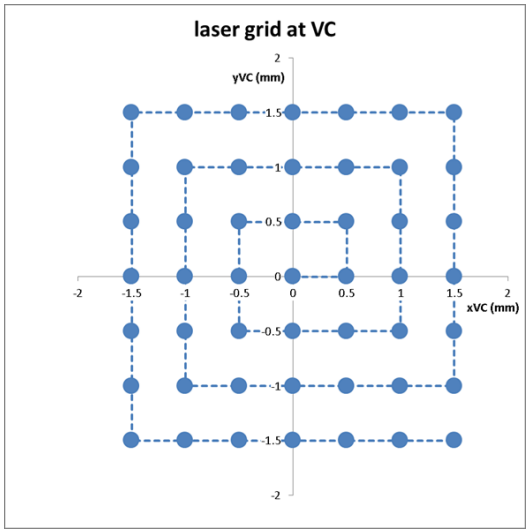
X_BPM = -0.000713545
Y_BPM = 0.00106762

(HxEarth, HyEarth, HzEarth) ←→ X_BPM, Y_BPM offsets

Proposals to measure RF-gun coupler kick at EXFEL

M. Krasilnikov (12.12.2016)

1. Power in the gun: 1.5 MW (~like for the laser and solenoid BBA), FB=On (if possible)
2. Solenoids and steerers are off, solenoid degaussed
3. Cathode laser: BSA=0.5mm (or smaller)
4. Laser BBA is (roughly) done → record the laser position (image) at the VC camera
5. Bunch charge ~ 50pC(?) – 1st BPM should deliver reliable measurements (position and bunch charge)
6. Gun phase scan in the low energy dispersive arm → Pz vs. SP Phase → MMMG phase
7. Basic measurement: beam position and bunch charge (1st BPM) vs. gun SP Phase
8. Scan cathode with 0.5 mm step (XY-grid)
    1. Record laser beam at the VC camera
    2. Gun phase scan: beam position and bunch charge (1st BPM) vs. gun SP Phase
9. (If time) Repeat 1-8 with 5 MW in the gun (nominal).



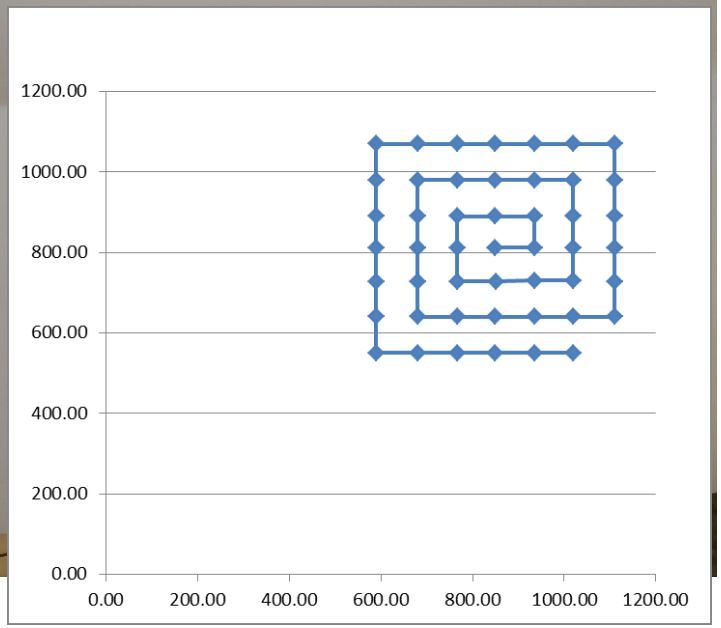
RF-gun coupler kick measurements at EXFEL

13-14.12.2016

13.12.2016

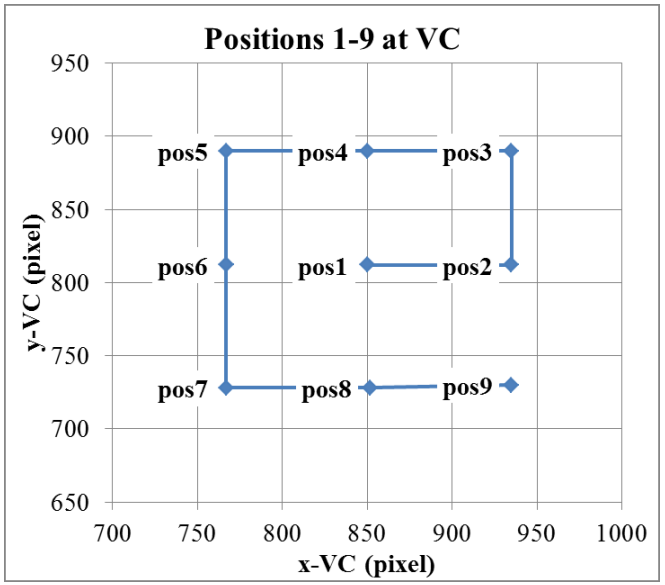
#	xVC goal	yVC goal	xVC measured	yVC measured	xBPM1 (MMMG)	yBPM1 (MMMG)	Phase scan file	commer
1	0	0	850	812	-2,50	0,06	2016-12-12T155411	14T13K0
2	0.5	0	935	812	-2,60	1,65	2016-12-12T171430	14T13
3	0.5	0.5	932	890	-1,04	1,81	2016-12-13T103800	
4	0	0.5	850	890	-1,08	0,22	2016-12-13T104649	
5	-0.5	0.5	767	890	-1,00	-1,39	2016-12-13T105550	
6	-0.5	0	767	810	-2,48	-1,41	2016-12-13T110237	
7	-0.5	-0.5	767	728	-3,92	-1,55	2016-12-13T121720	
8	0	-0.5	852	728	-3,97	0,09	2016-12-13T 122518	
9	0.5	-0.5	935	730	-3,99	1,72	2016-12-13T123311	
10	1	-0.5	1020	731	-4,02	3,81	2016-12-13T123949	
11	1	0	1020	810	-2,74	3,10	2016-12-13T124649	
12	1	0.5	1022	890	-1,29	3,22	2016-12-13T125421	
13	1	1	1021	980	0,89	3,21	2016-12-13T130602	
14	0.5	1	935	980	0,88	1,91	2016-12-13T131811	
15	0	1	850	980	0,91	0,33	2016-12-13T132500	
16	-0.5	1	767	980	0,92	-1,46	2016-12-13T133327	
17	-1	1	680	980	0,93	-3,15	2016-12-13T134019	
18	-1	0.5	680	890	-0,74	-3,14	2016-12-13T134705	
19	-1	0	680	810	-2,47	-3,11	2016-12-13T135642	
20	-1	-0.5	680	728	-3,85	-3,02	2016-12-13T140302	
21	-1	-1	680	680	-5,26	-2,89	2016-12-13T140959	
22	-0.5	-1	767	640	-5,14	-1,62	2016-12-13T141702	
23	0	-1	850	640	-5,16	-0,03	2016-12-13T142352	
24	0.5	-1	935	640	-5,22	1,56	2016-12-13T143009	
25	1	-1	1020	640	-5,21	2,89	2016-12-13T143659	
26	1.5	-1	1110	640	-4,82	3,77	2016-12-13T144314	
27	1.5	-0.5	1110	729	-4,10	4,00	2016-12-13T144932	
28	1.5	0	1110	812	-2,75	4,06	2016-12-13T153244	
29	1.5	0.5	1110	890	-1,34	3,91	2016-12-13T153856	
30	1.5	1	1110	980	0,56	4,06	2016-12-13T154529	
31	1.5	1.5	1110	1070	2,46	4,21	2016-12-13T155143	
32	1	1.5	1020	1070	2,50	3,24	2016-12-13T155923	
33	0.5	1.5	935	1070	2,71	1,85	2016-12-13T160724	
34	0	1.5	850	1070	2,89	0,13	2016-12-13T161550	
35	-0.5	1.5	767	1070	3,01	-1,49	2016-12-13T162248	
36	-1	1.5	680	1070	3,07	-3,03	2016-12-13T163045	
37	-1.5	1.5	590	1070	3,11	-4,50	2016-12-13T163809	
38	-1.5	1	590	980	1,46	-4,54	2016-12-13T164453	
39	-1.5	0.5	590	890	-0,57	-4,55	2016-12-13T165257	
40	-1.5	0	590	812	-2,33	-4,58	2016-12-13T165955	

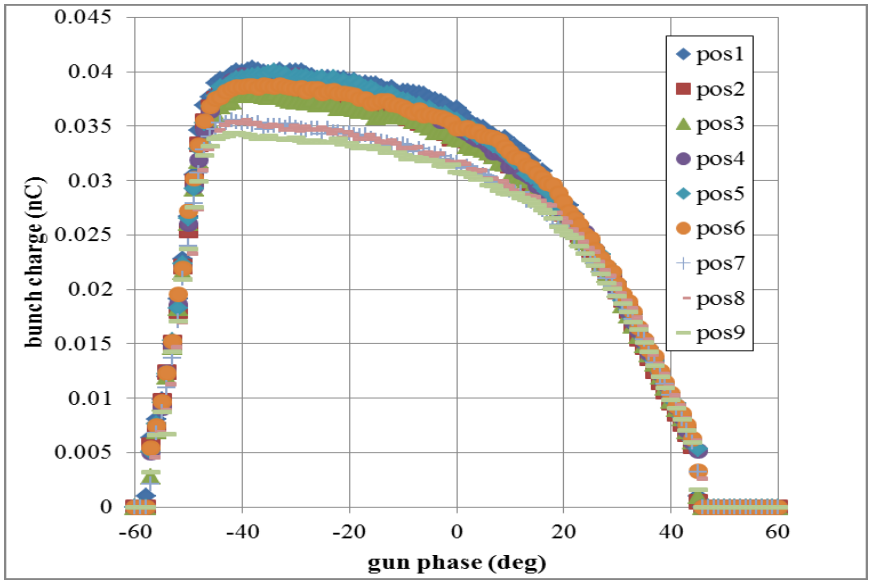
	xVC goal	yVC goal	xVC meas	yVC meas	xBPM1 (MMMG)	yBPM1 (MMMG)	Phase scan file
41	-1.5	-0.5	590	728	-3,80	-4,58	2016-12-13T170314
42	-1.5	-1	590	640	-4,65	-4,36	2016-12-14T133650
43	-1.5	-1.5	590	550	-5,13	-4,11	2016-12-14T134505
44	-1	-1.5	680	550	-5,38	-3,04	2016-12-14T135243
45	-0.5	-1.5	767	550	-5,52	-1,52	2016-12-14T135948
46	0	-1.5	850	550	-5,87	-0,16	2016-12-14T140628
47	0.5	-1.5	935	550	-5,97	1,40	2016-12-14T141312
48	1	-1.5	1020	550	-6,12	2,64	2016-12-14T141956
49	1.5	-1.5	1110	550			

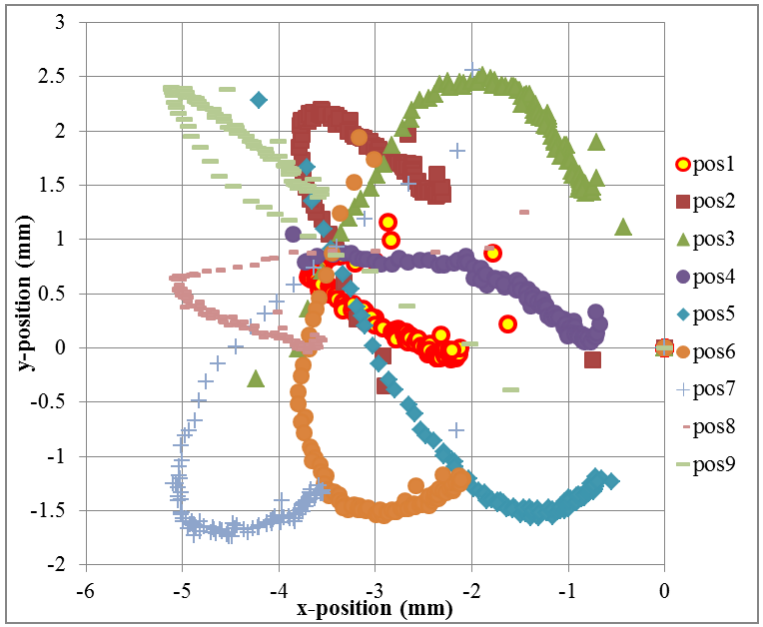


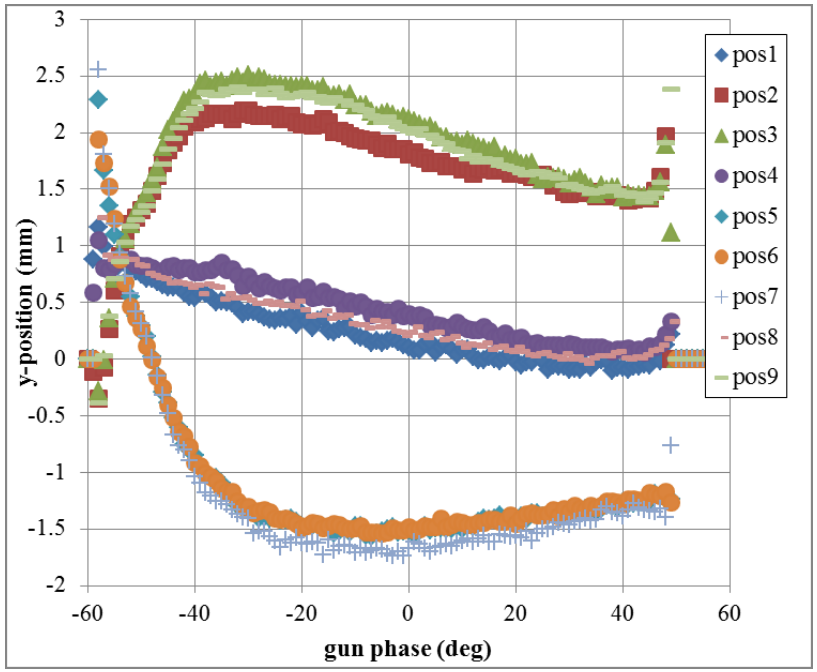
RF-gun coupler kick measurements at EXFEL

13-14.12.2016



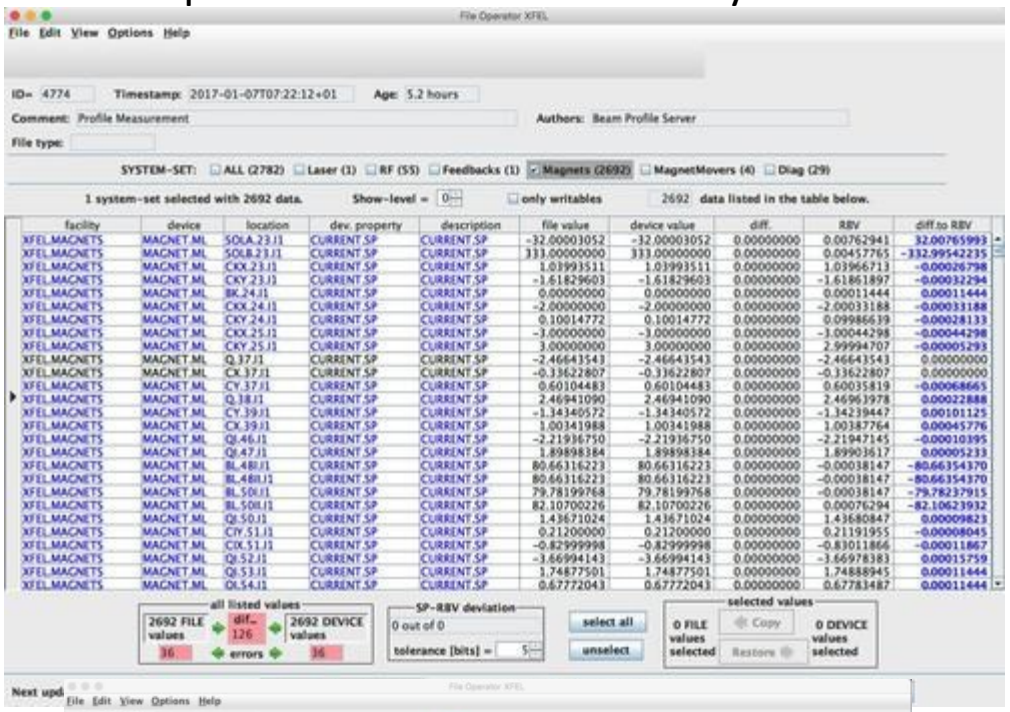


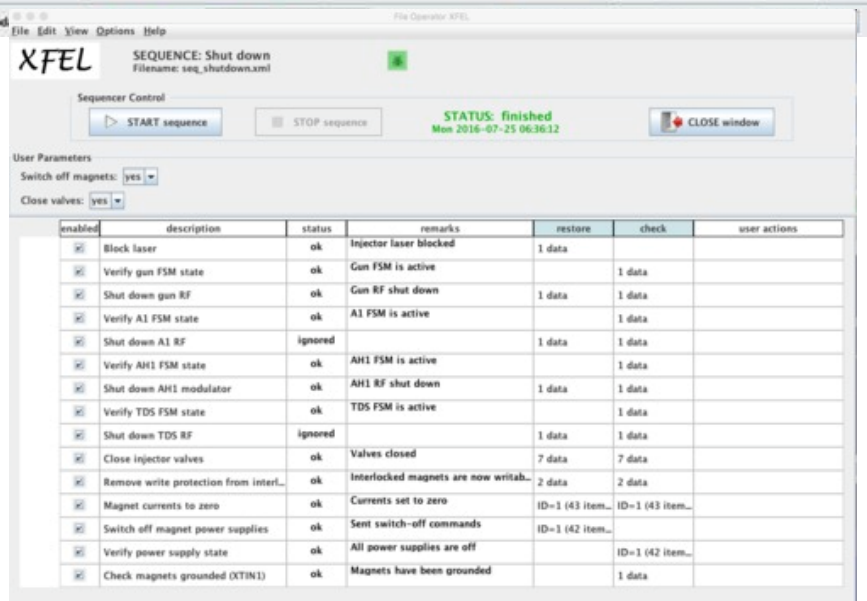


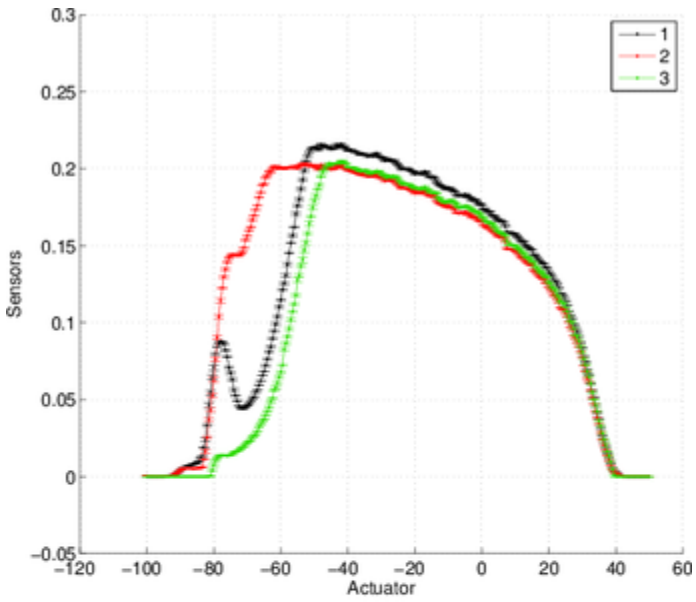


Remarks from the XFEL recommissioning (MK, week1/2017)

- Sequencer and scanner are very useful!







solenoid changed from 347A to 400A

File:	/home/xfeloper/data/scantool/2017-01-03T174522.mat
Duration:	2017-01-03 17:45:35 – 17:53:03
Samples/point:	10
Scan from:	Scan Tool version 2016-05-25
Actuator:	XFEL.RF/LLRF.CONTROLLER/CTRL.GUN.I1/SP.PHASE
Sensor 1:	XFEL.DIAG/TOROID/TORA.25.I1/CHARGE.SA1
Sensor 2:	XFEL.DIAG/BPM/BPMG.24.I1/CHARGE.SA1
Sensor 3:	XFEL.DIAG/CHARGE.ML/BPMG.25I.I1/CHARGE.SA1

Remarks from the XFEL recommissioning (MK, week1/2017)

- LH energy server → +cross checked with vector sums of gun,A1, AH1

Remarks from the XFEL recommissioning (MK, week1/2017)

- TV system is strongly integrated into DOOCS (ML → fast filtering + mean and rms values)
- Off-axis screens + kickers → very helpful for the fast matching
- Experts are highly motivated and very cooperative
- …