



LHC Injectors Upgrade

LIU-BWS Performance in PS

Preliminary Results Vol.1

BWS Meeting

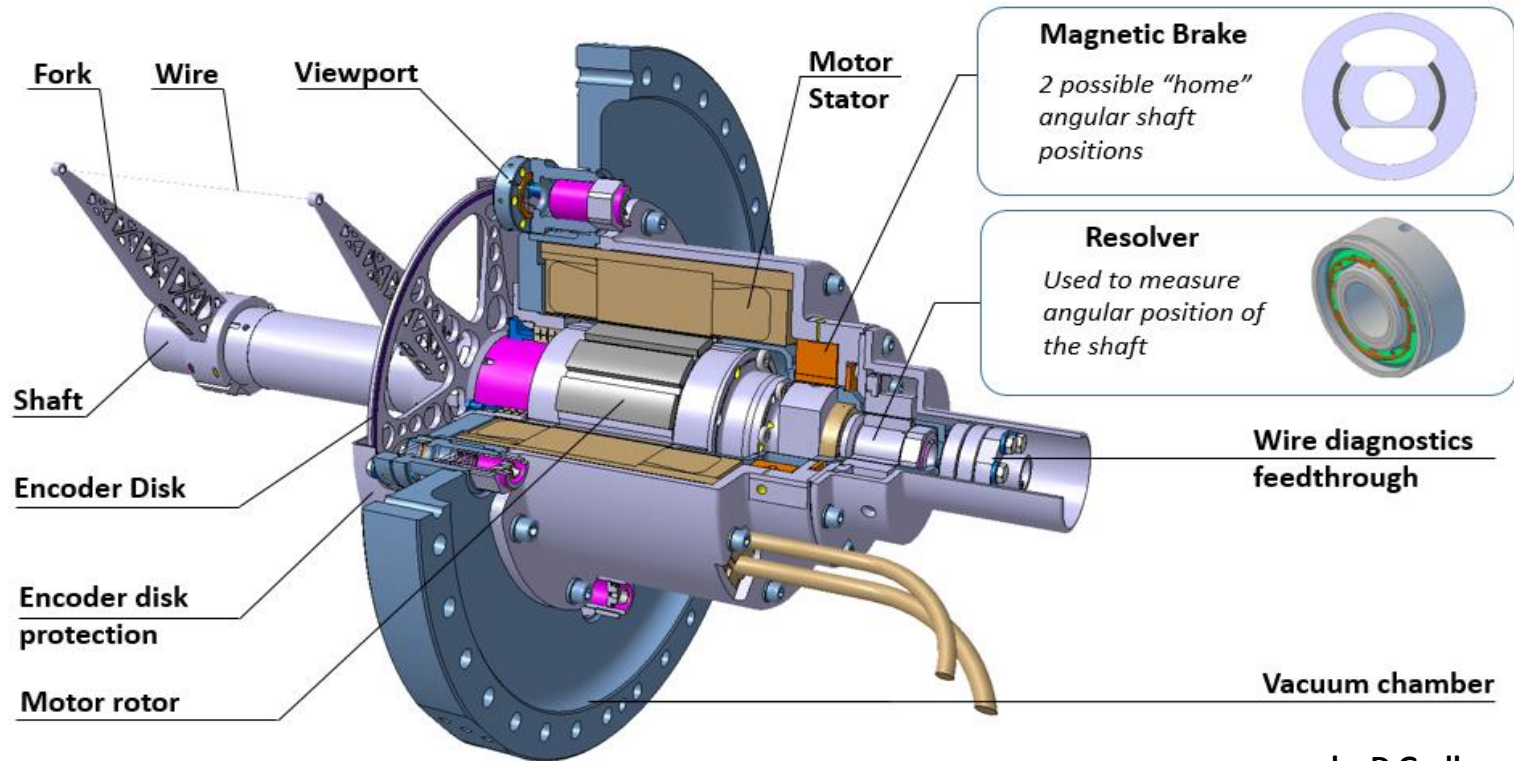
04.02.2019

J.L. Sirvent



1. LIU Beam wire scanners architecture and design

1.1 Scanner mechanical design



by D.Gudkov

Features:

- Forks** → 3D printed metal, optimized for low vibrations and deformations.
- Shaft** → Shared shaft for all mobile components (in vacuum).
- Encoder** → Al. Metallic disk with high laser engraved track (40um pitch).
- Motor** → Brushless and frameless motor with magnetic coupling.
- Brake** → Safety home-return device.



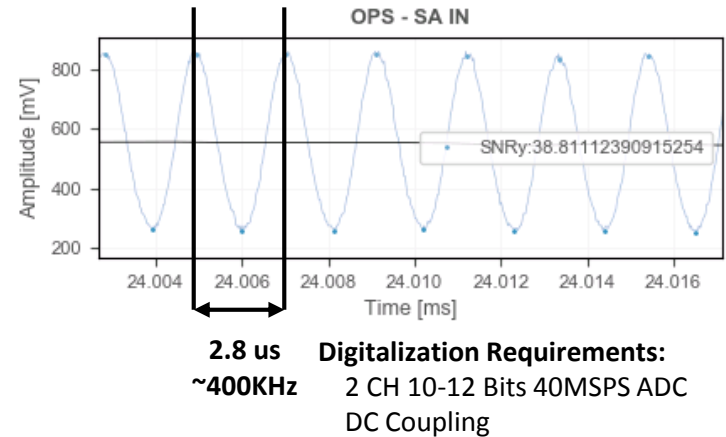
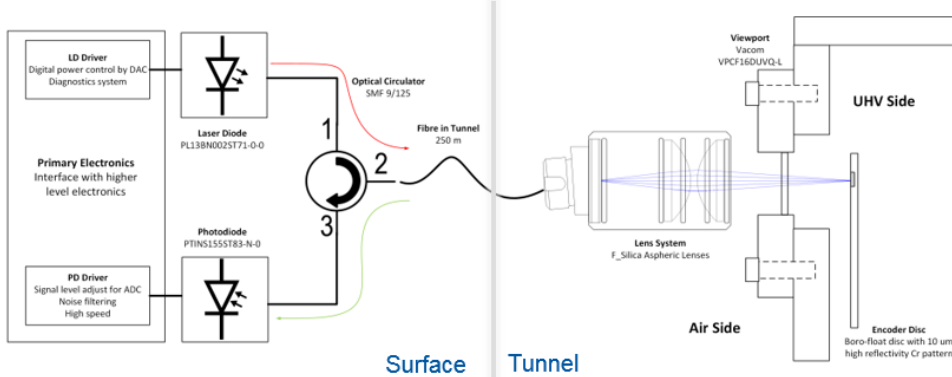


1. LIU Beam wire scanners architecture and design

1.2 Beam profile determination devices

1. Passive optical position sensor:

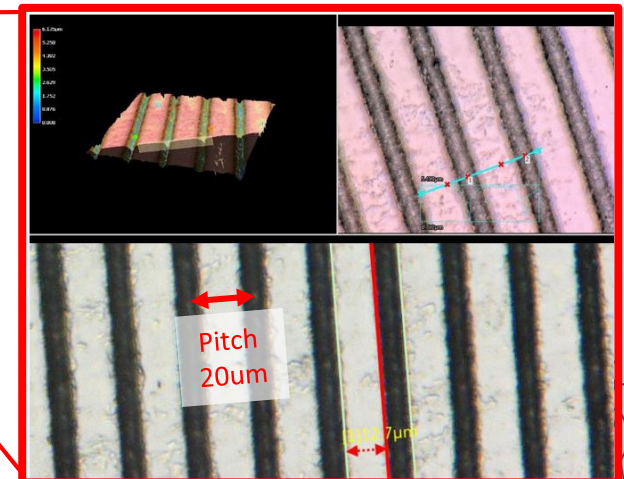
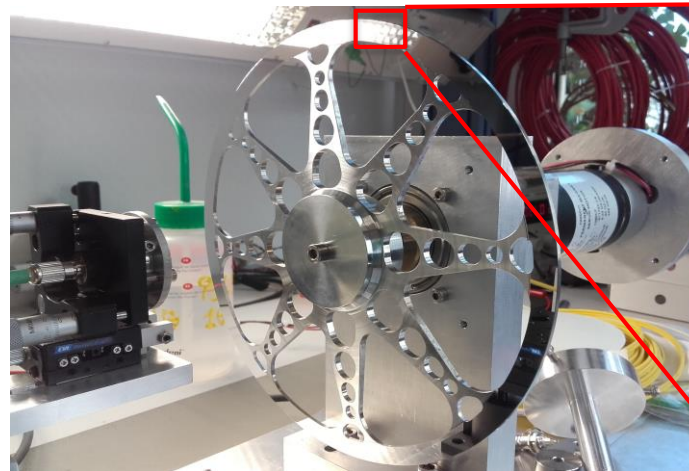
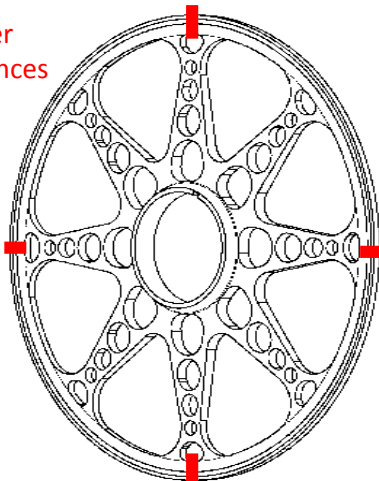
- Rad-Tol Incremental fibre optic encoder system
- Typically sinusoidal signal <1MHz



Thorough R&D program for disk production during 2017-2018:

- Aluminium type, surface treatment, slits engagement process...

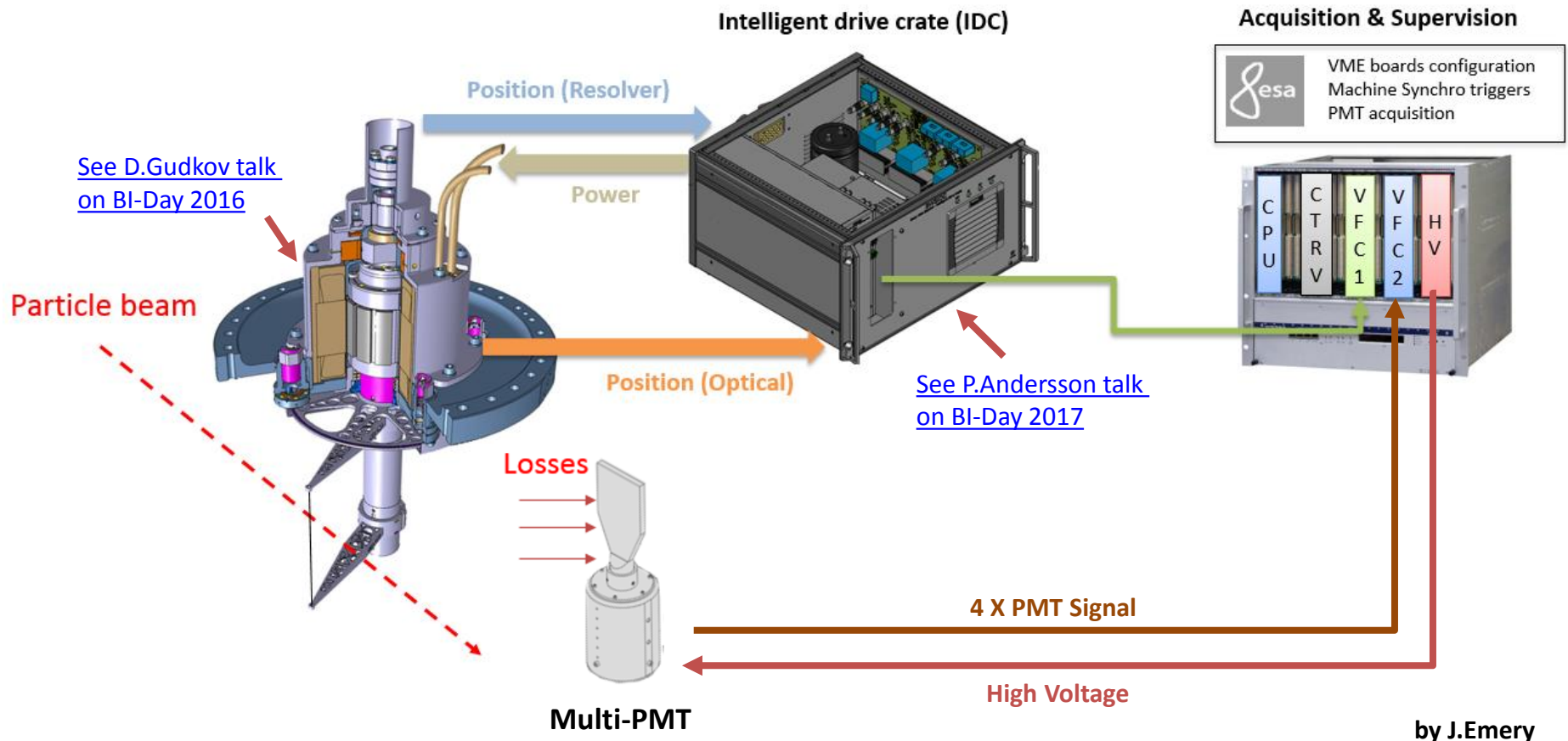
Encoder References





1. LIU Beam wire scanners architecture and design

1.3 Control and acquisition electronics



Final Configuration for all systems shown adobe:

- Current Test Configuration in PSB → Motion Control Alpha (Pre-Series), OPS+PMT Acquisition (Scope-based)
- Current Test Configuration in PS → Motion Control (IDC), OPS+PMT Acquisition (Scope-based, VME + FESA)





2. Calibration and wire position uncertainty

2.1 Procedure for LIU-BWS and performance

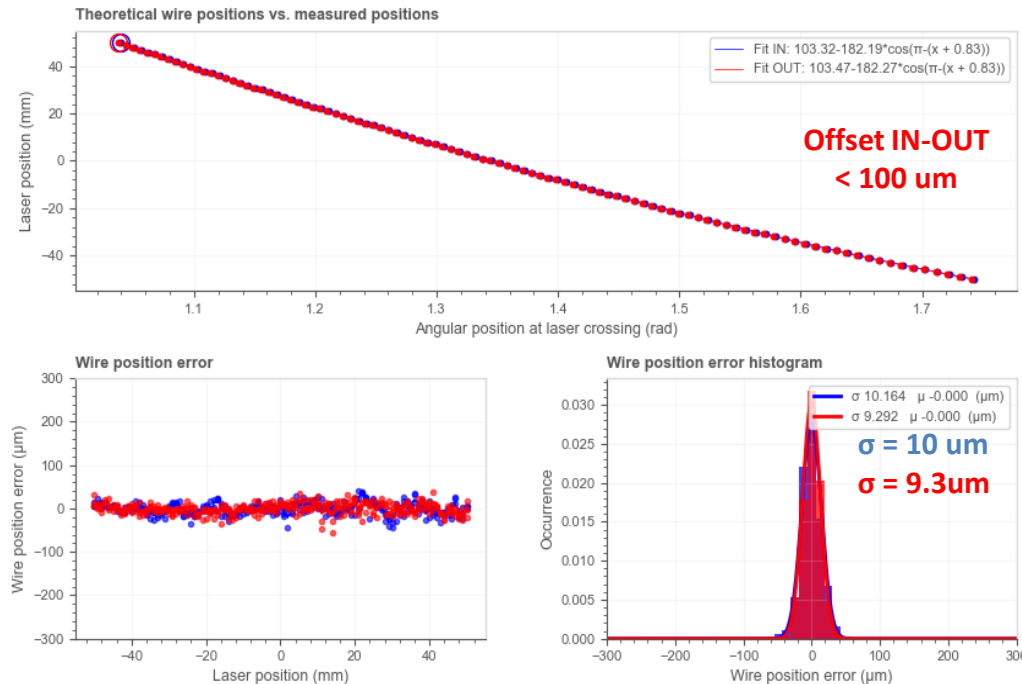
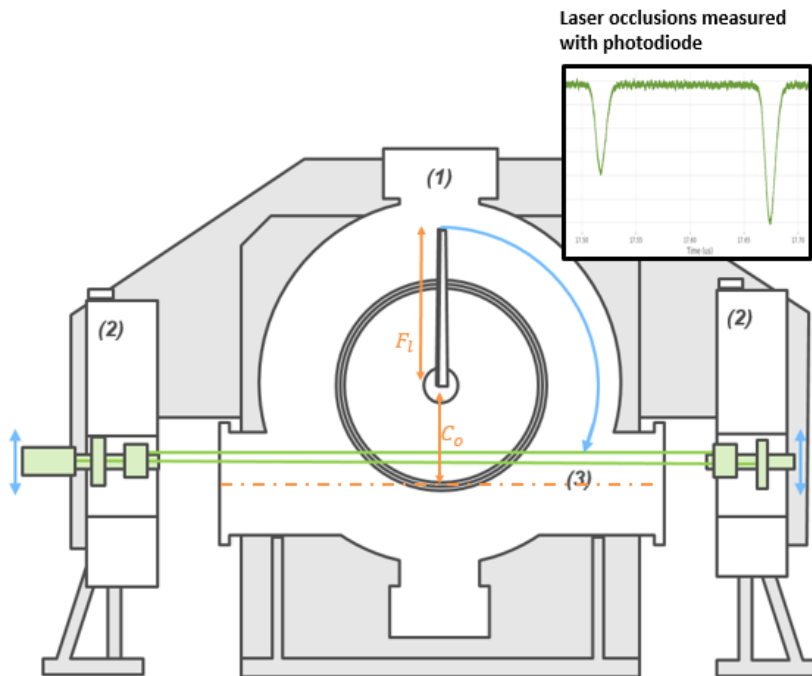
Why we calibrate the LIU-BWS?

- **Characterization** of angular-to-projected motion (compensation for BWS assembly tolerances).
- **Assessment** of wire determination uncertainty under a controlled environment.
- **Test** different motion profiles to characterize/minimize vibrations on system or wire.

Projection based on Scanner Mechanics:

$$Y = C_o - F_l \cos(\pi - \alpha_{Sensor} + \theta)$$

Three parameters fit based on equation: C_o, F_l, θ
Extracted residuals to determine: Precision & Accuracy
Accuracy: Systematic deviations, **Precision:** Random variations





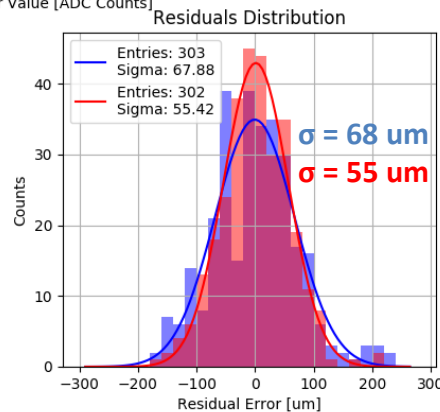
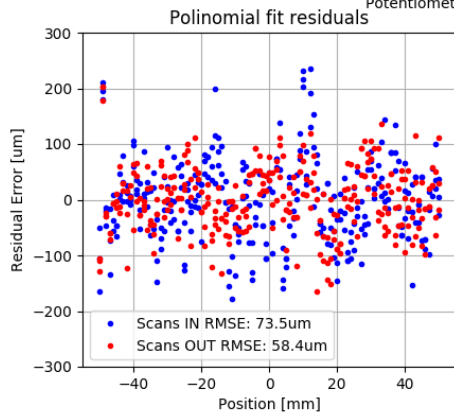
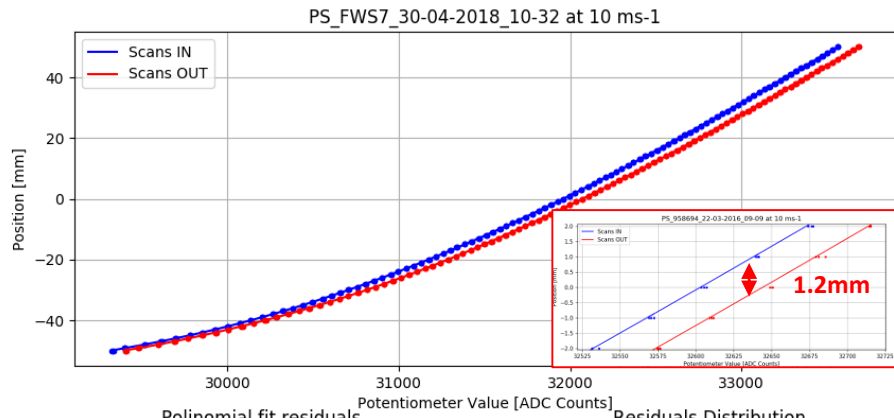
2. Calibration and wire position incertitude

2.2 Comparison with Operational Fast wire scanners

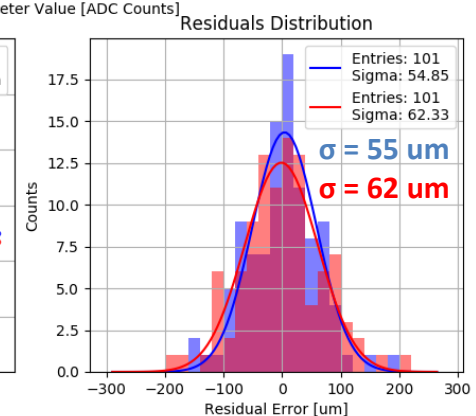
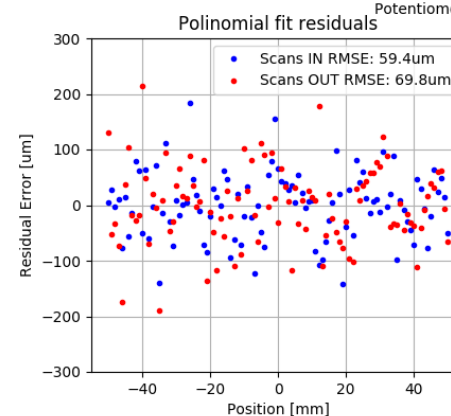
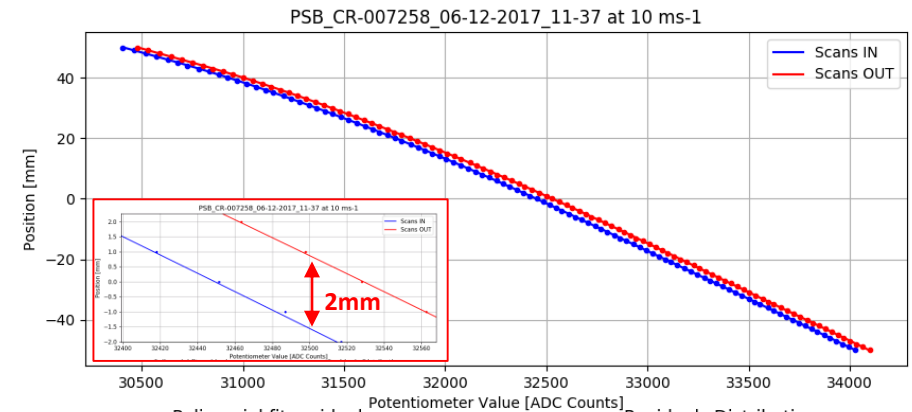
How LIU-BWS performance compares to operational CPS and PSB in calibrations?

- CPS and PSB BWS are calibrated with a similar setup
- Potentiometer Vs Position data fitted with 6-10 polynomial
- IN + OUT lookup tables generated (Mechanical play \rightarrow Curves offset)

Calibration **CPS** BWS 30/04/2018



Calibration **PSB** BWS 06/12/2017



More info: See [E.Piselli's Talk on BI-Day 2016](#)





3. Operational Tests in LHC Injectors 2018

PSB Tests during 2018 : 5 Campaigns and > 1105 Scans

DATE	SCANNER NAME	CAMPAIGN NAME	SCANS
2018_04_09	PSB_PXBWSRA005_CR000001	Test_PSB	56
2018_04_10	PSB_PXBWSRA005_CR000001	MetallicDisk	49
2018_04_11	PSB_PXBWSRA005_CR000001	MetallicDisk	112
2018_07_13	PSB_PXBWSRA005_CR000001	PSB_Tests_Metallic_Disk	141
2018_11_01	PSB_PXBWSRA005_CR000001	PSB_Brightness_With_PS	747



3. Operational Tests in LHC Injectors 2018

PS Tests during 2018 : 18 Campaigns and > 3236 Scans

DATE	SCANNER NAME	CAMPAIGN NAME	SCANS
2018_06_07	PS_PXBWSRB011_CR000001	Acquisition_Tests_Without_Beam	177
2018_06_08	PS_PXBWSRB011_CR000001	Acquisition_Tests_With_Beam_LHCINDIV	206
2018_06_11	PS_PXBWSRB011_CR000001	Acquisition_Tests_With_Beam_LHCINDIV_LHCPROBE_TOF	251
2018_06_13	PS_PXBWSRB011_CR000001	Acquisition_Tests_With_Beam_LHC25_BCMS	52
2018_08_23	PS_PXBWSRB011_CR000001	Acquisition_Tests_Sistematic_INOUT	82
2018_10_02	PS_PXBWSRB011_CR000001	MotionTests_NewControlElectronics_Eugenio	30
2018_10_05	PS_PXBWSRB011_CR000001	ScopeTracesWithHV	7
2018_10_05	PS_PXBWSRB011_CR000001	QPMT_Tests	57
2018_10_09	PS_PXBWSRB011_CR000001	MDWithEugenio	134
2018_10_11	PS_PXBWSRB011_CR000001	MD_BCMS12	155
2018_10_15	PS_PXBWSRB011_CR000001	MD_BCMS_Bumps	256
2018_10_17	PS_PXBWSRB011_CR000001	MD_TOF	114
2018_10_19	PS_PXBWSRB011_CR000001	MD_SFTPRO	125
2018_10_24	PS_PXBWSRB011_CR000001	MD_BCMS_Brightness	330
2018_10_25	PS_PXBWSRB011_CR000001	MD_BCMS_VFC_FESA_EmitBlowUp	212
2018_10_30	PS_PXBWSRB011_CR000001	MD_BCMS_Systematics_INOUT	245
2018_11_01	PS_PXBWSRB011_CR000001	MD_Brightness with PSB	717
2018_11_06	PS_PXBWSRB011_CR000001	MD_With_BGI	56



3. Operational Tests in LHC Injectors 2018

SPS Tests during 2018 : 2 Campaigns and > 728 Scans

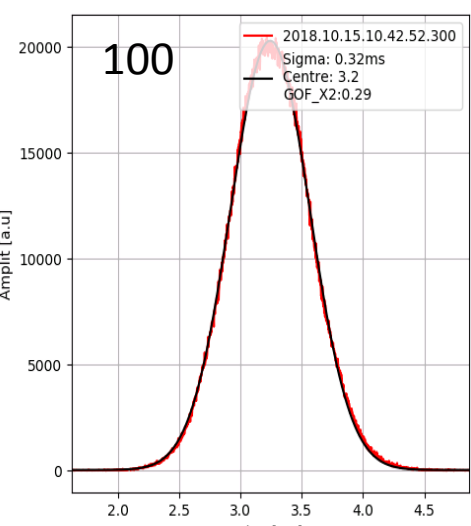
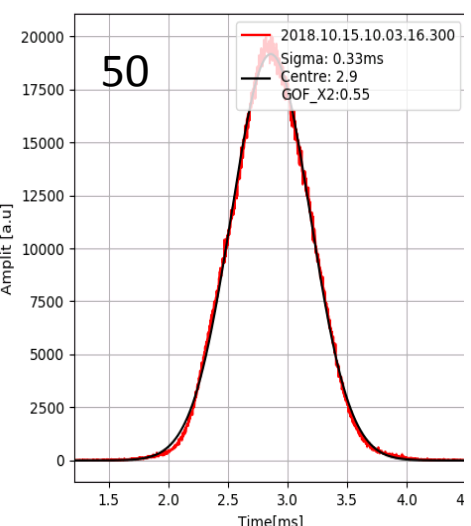
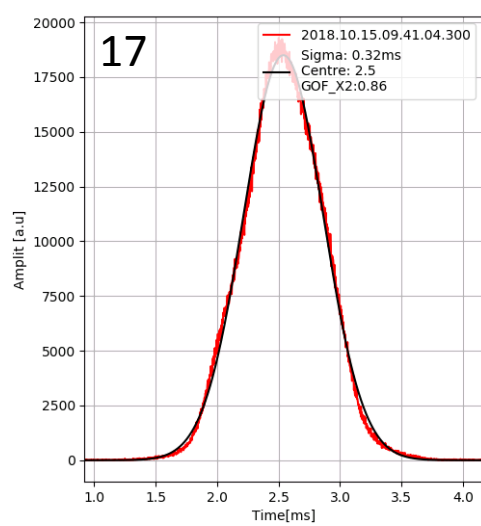
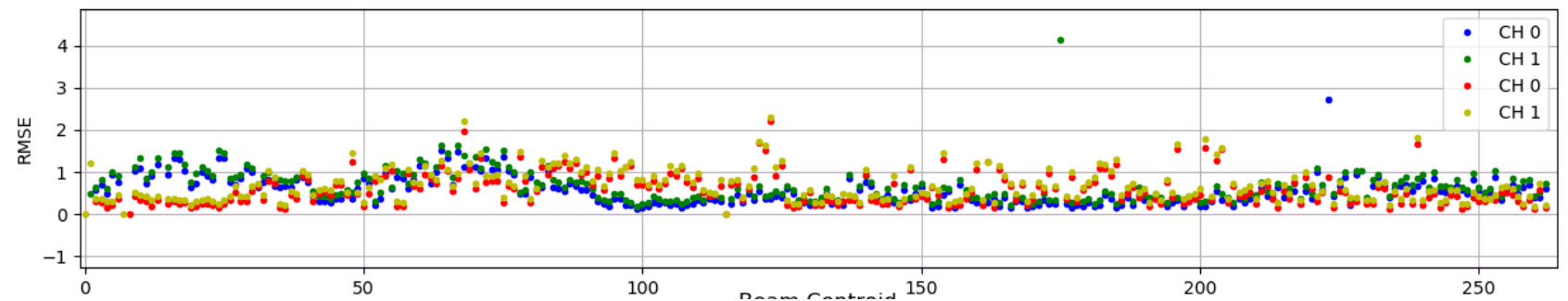
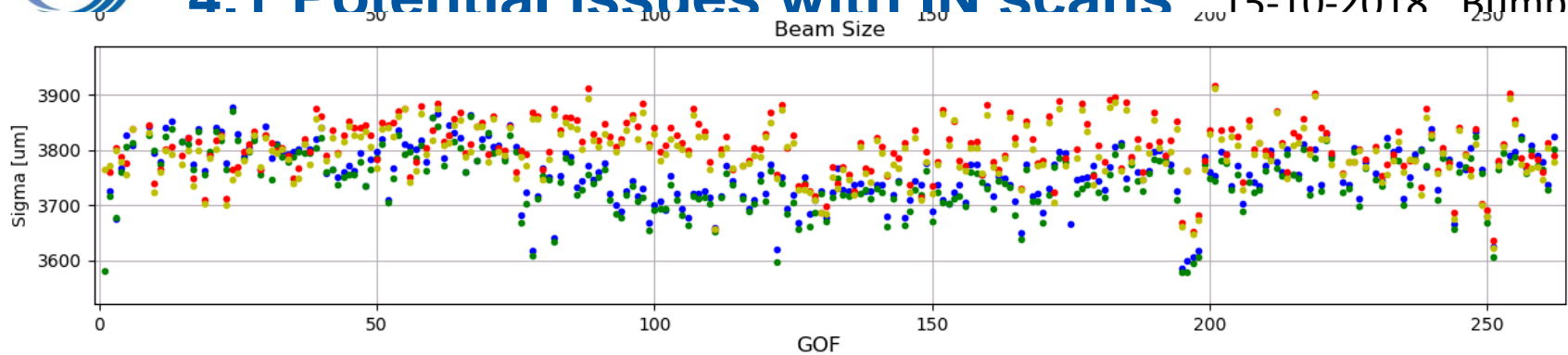
DATE	SCANNER NAME	CAMPAIGN NAME	SCANS
2018_11_08	LIU-BWS_SPS_V0	SPS_Test_MPMT_BCMS4x48Bunches_FlatBottom	141
2018_11_09	LIU-BWS_SPS_V0	SPS_Test_MPMT_SeveralBeams_and_Energies	587



4. Results from test with Beam

4.1 Potential issues with IN scans

15-10-2018 Bjmn Study



IN Scans

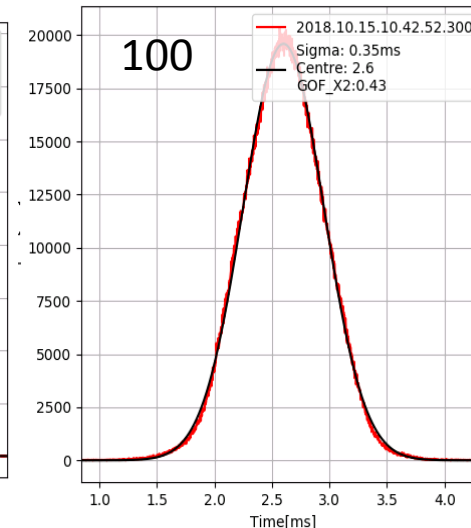
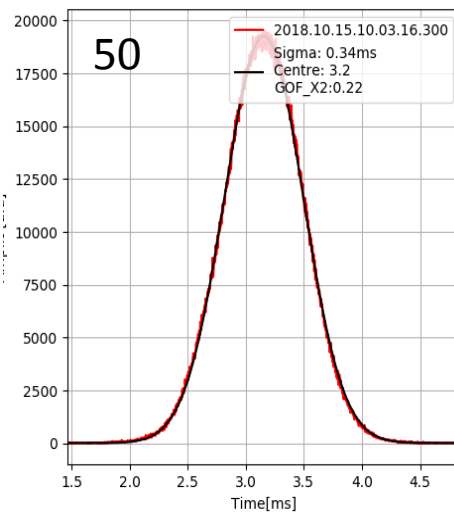
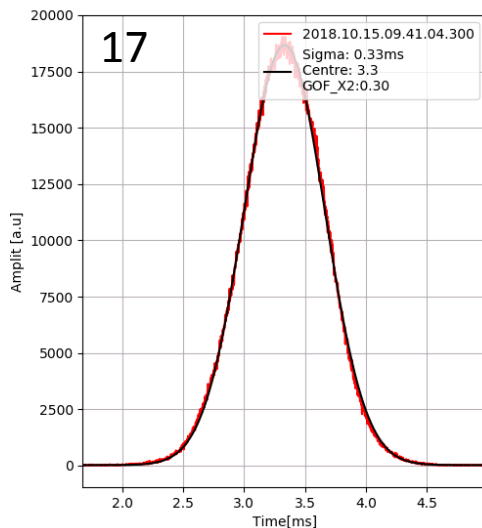
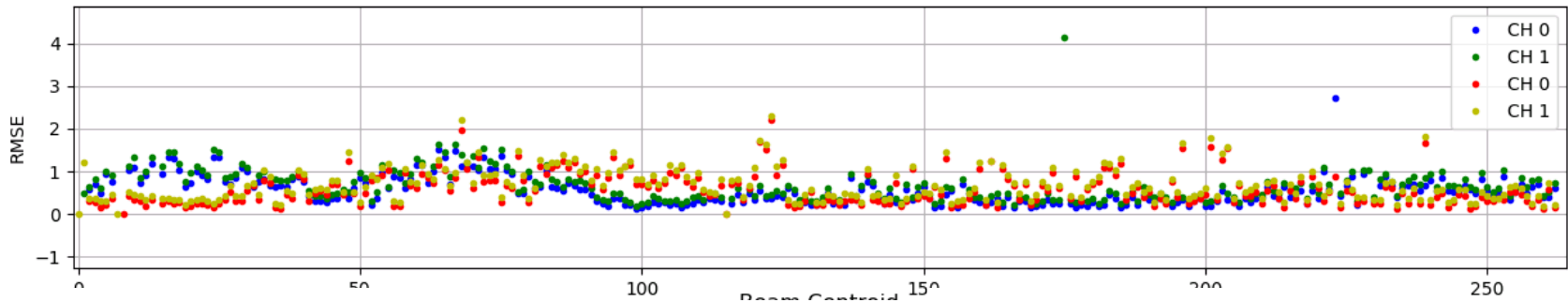
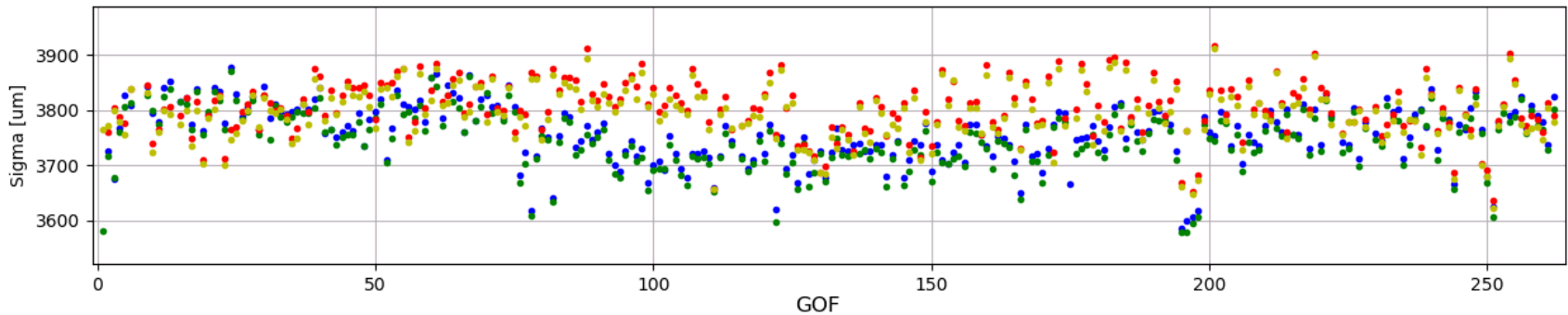




4. Results from test with Beam

4.1 Potential issues with IN scans

15-10-2018_Bumps Study



OUT Scans

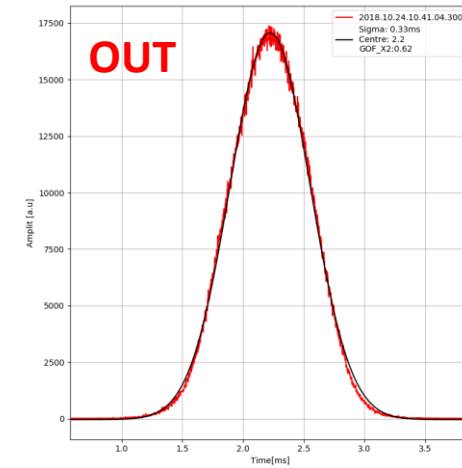
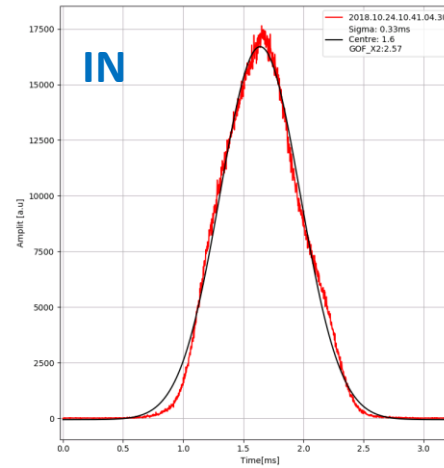
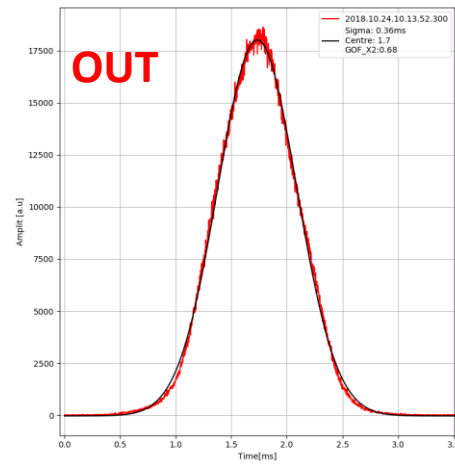
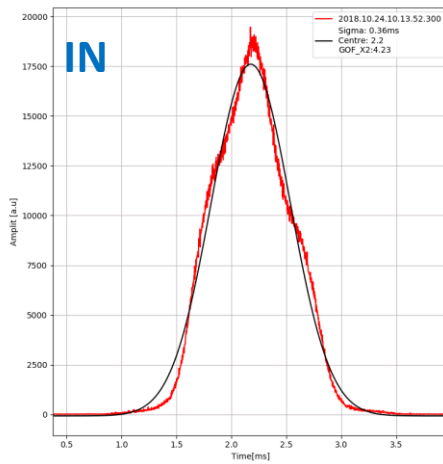
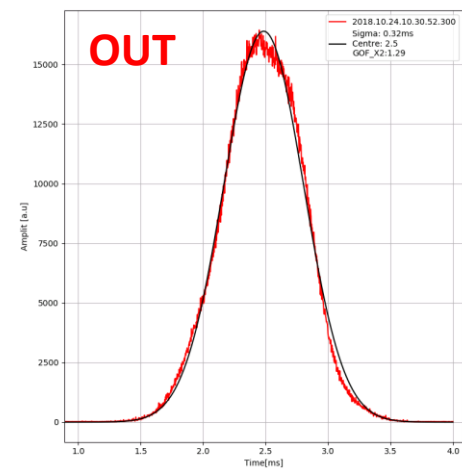
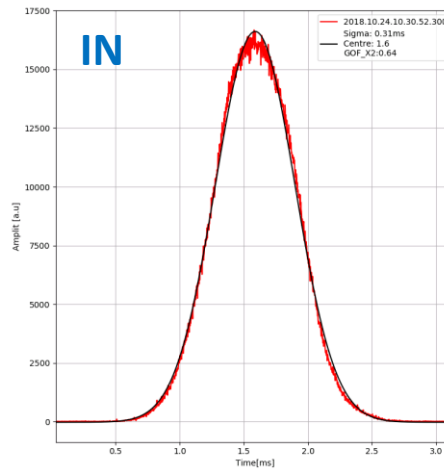
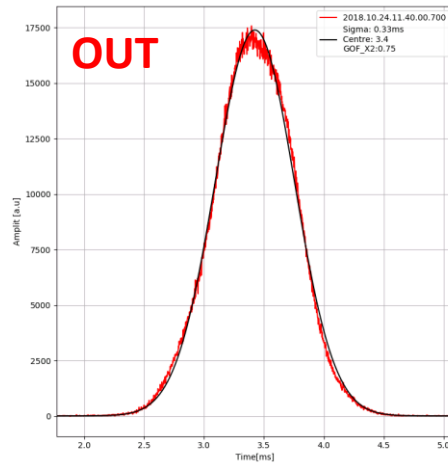
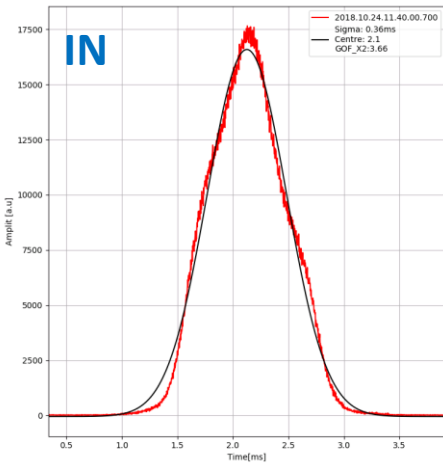




4. Results from test with Beam

4.1 Potential issues with IN scans

24-10-2018_Brightness

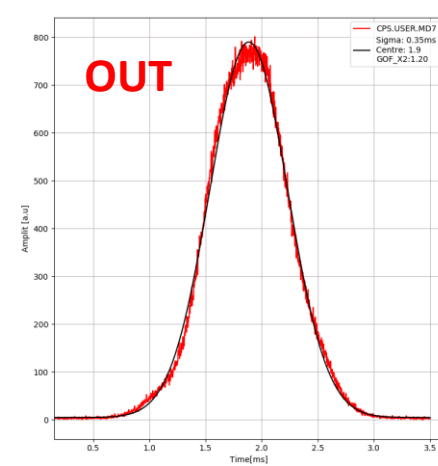
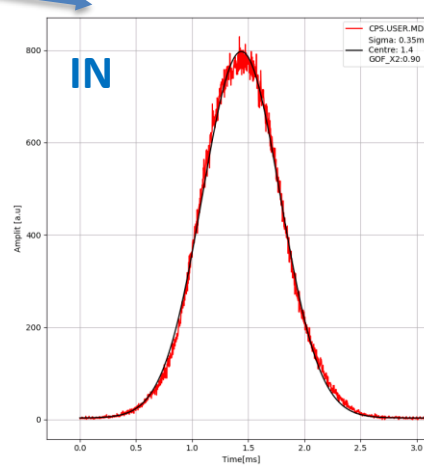
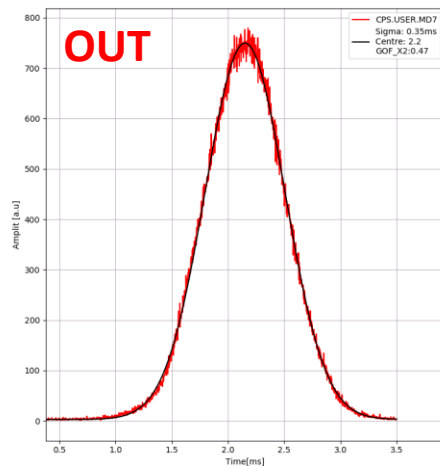
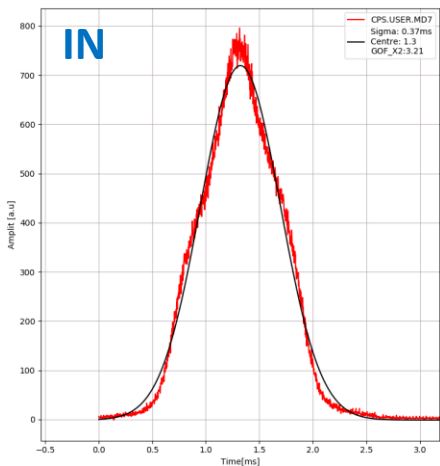
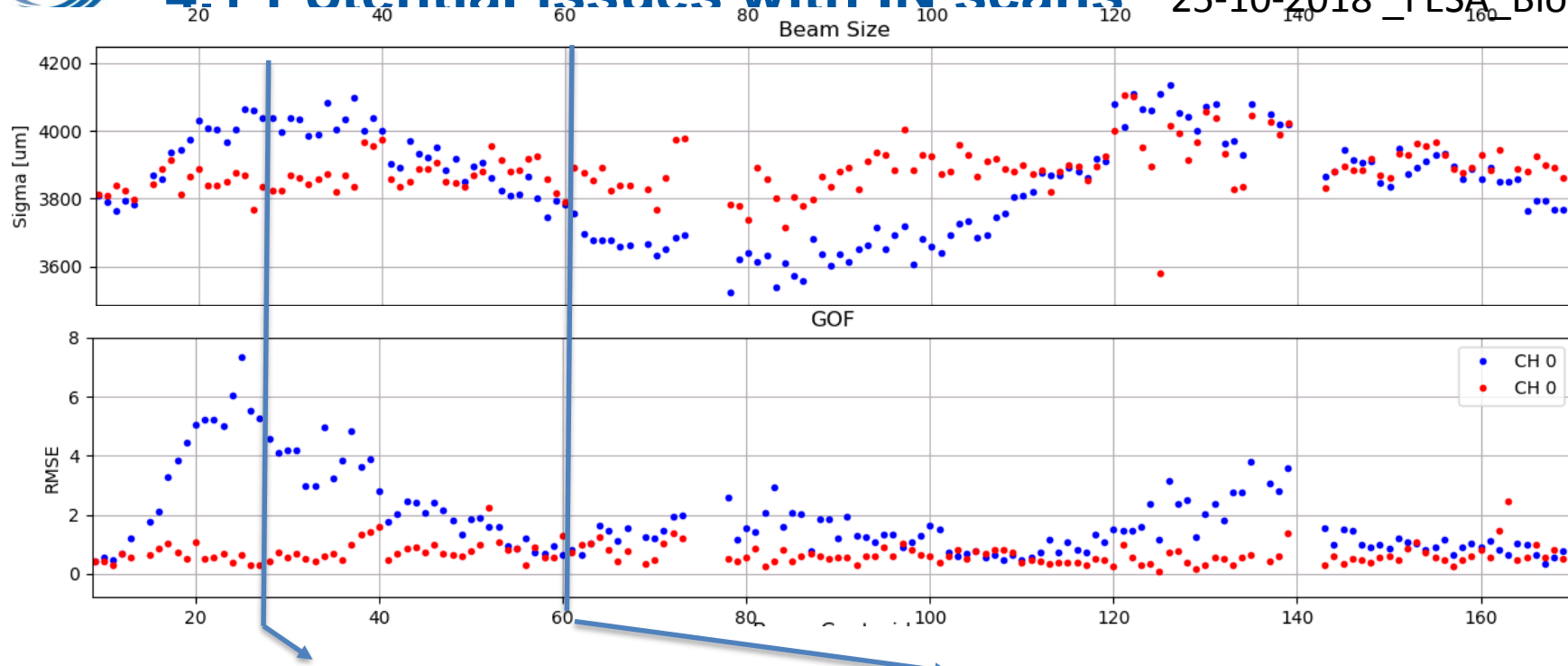




4. Results from test with Beam

4.1 Potential issues with IN scans

25-10-2018 _FESA_ Blowup

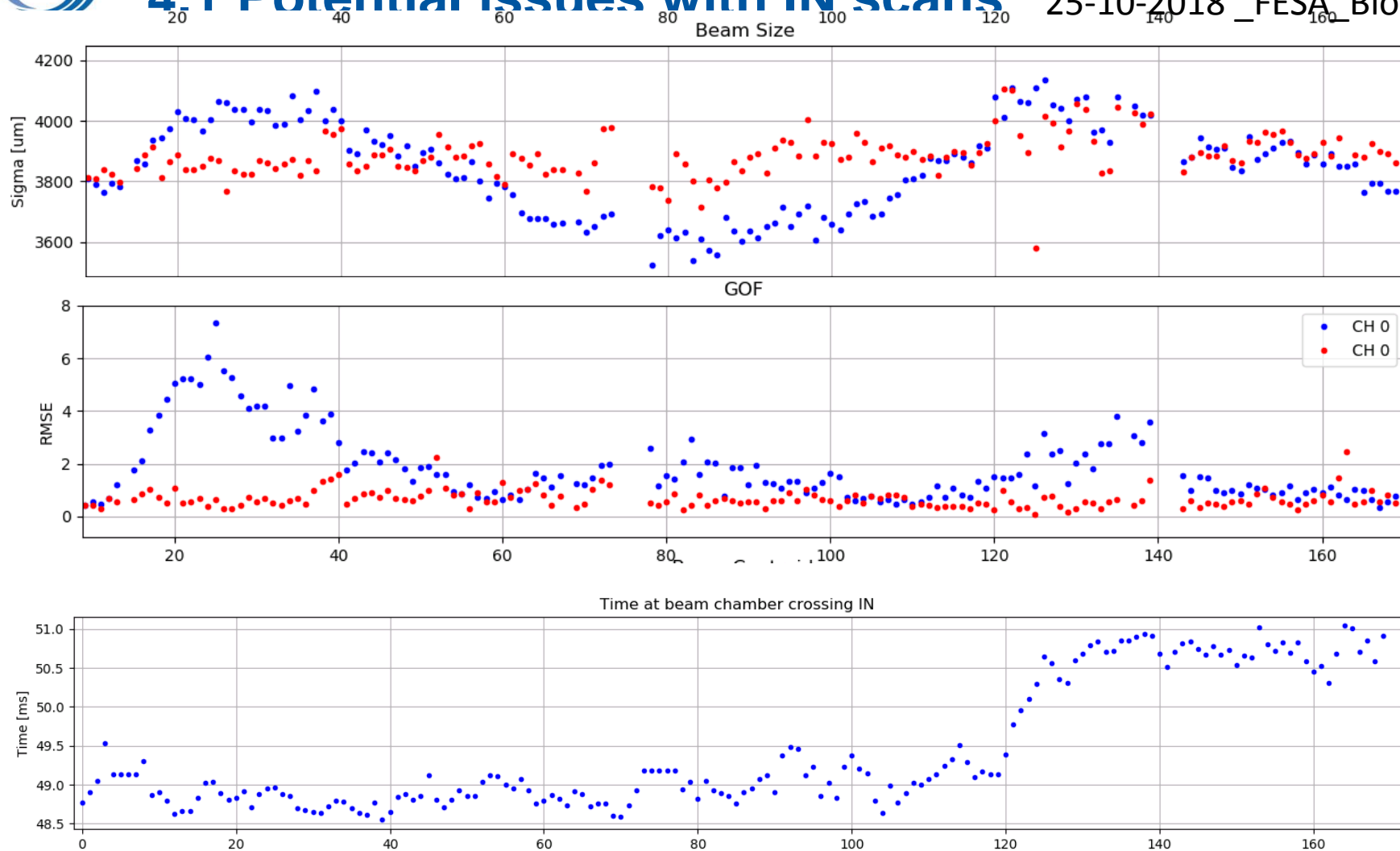




4. Results from test with Beam

4.1 Potential issues with IN scans

25-10-2018 _FESA_Blowup



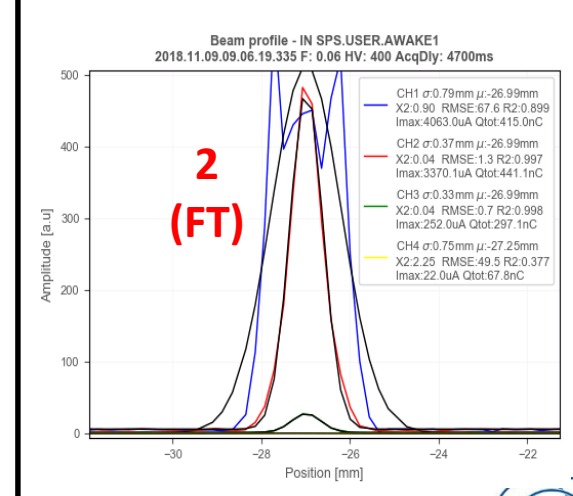
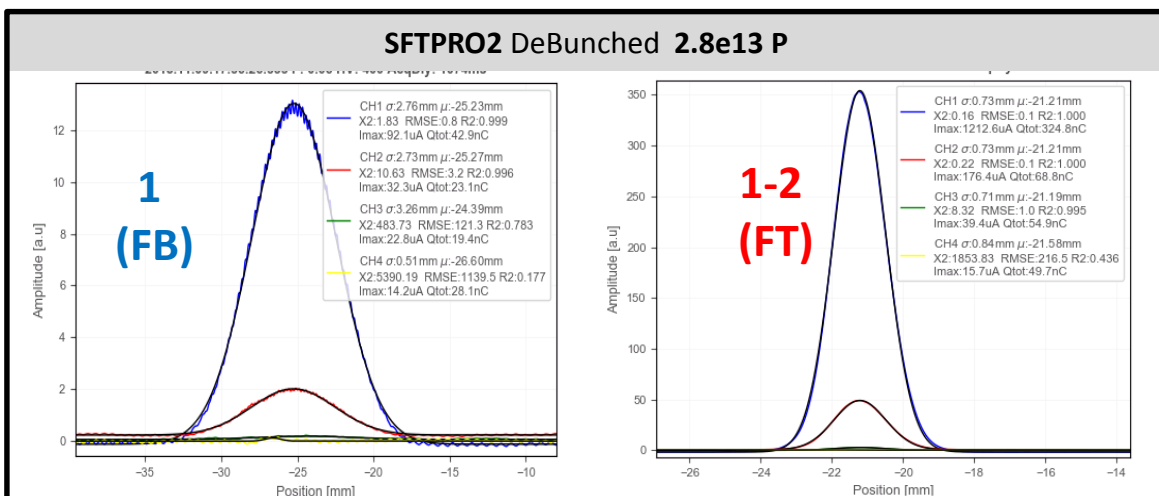
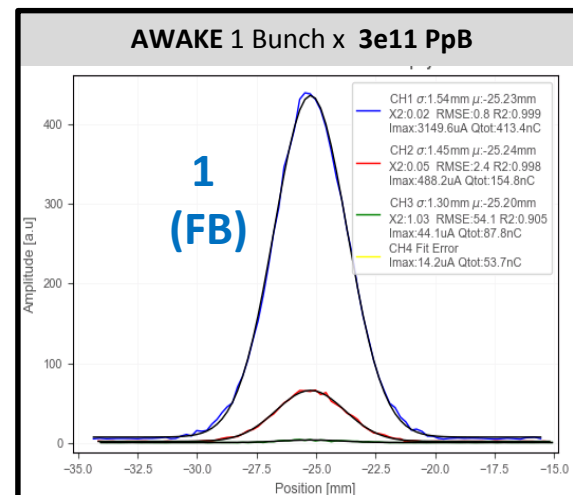
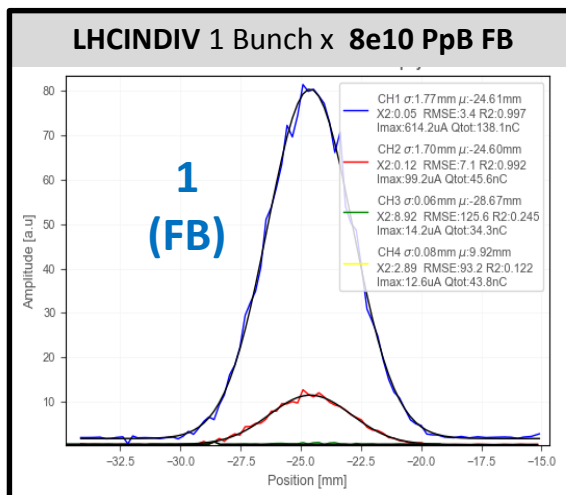
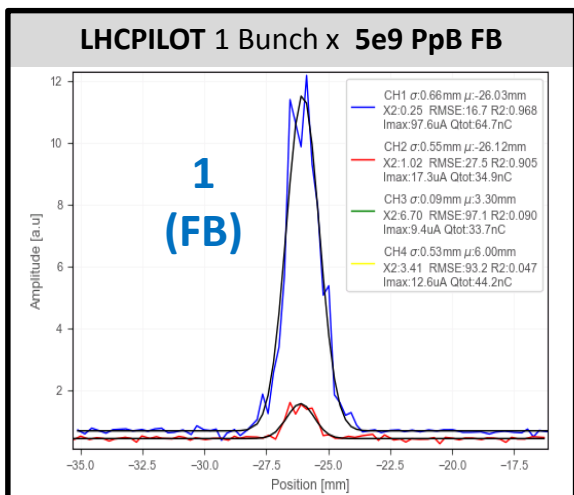


4. Results from tests with beam

4.1 Coverage of Injectors dynamics: SPS



Super Proton Synchrotron (SPS): Single working point at all measurements HV @ 400V



To fully profit Dyn. Range in SPS recomended to push HV @ 500-550V





4. Results from tests with beam

4.1 Coverage of Injectors dynamics: PS

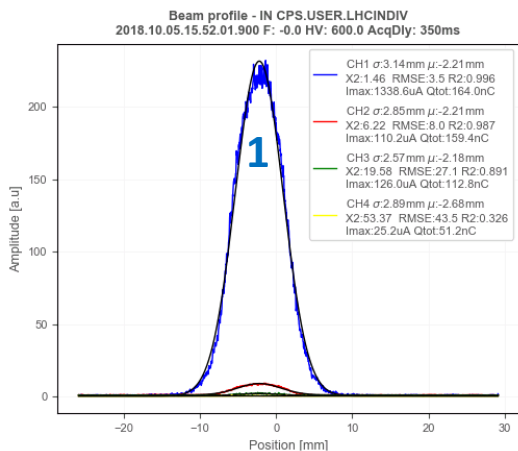


Proton Synchrotron: Single working point at all measurements HV @ 600V

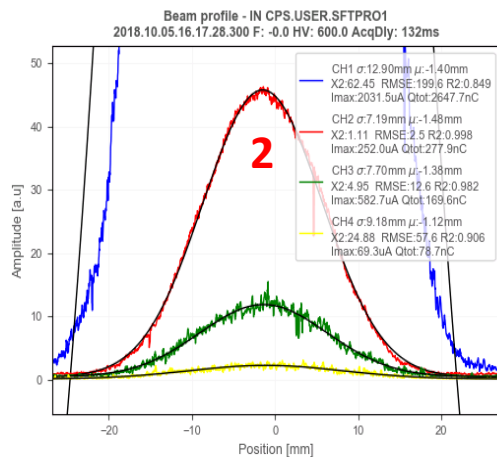
Flat_Bottom

Flat_Top

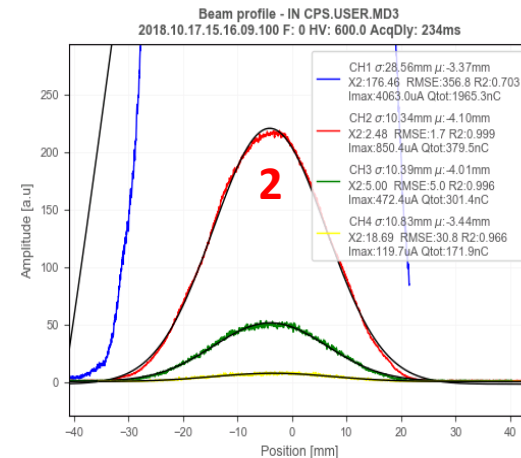
LHCINDIV 1 Bunch x 4e10 PpB



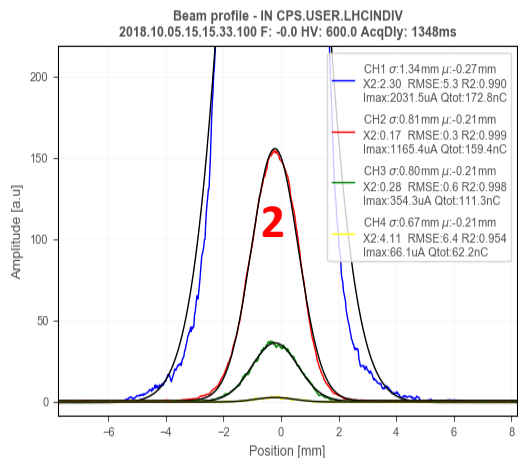
SFTPRO1 8 Bunch x 200e10 PpB



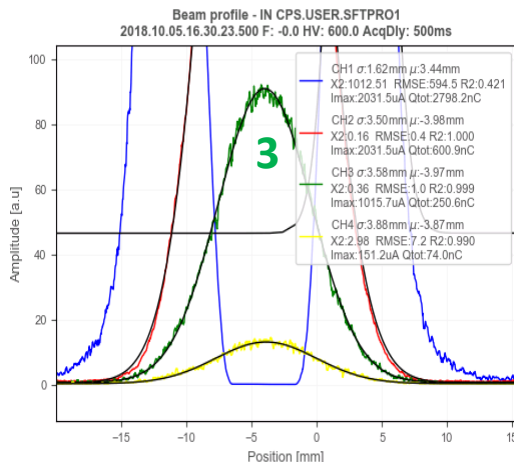
TOF 1 Bunch x 810e10 PpB



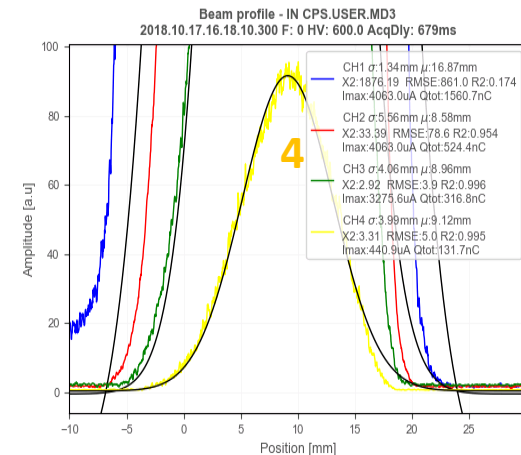
LHCINDIV 1 Bunch x 4e10 PpB



SFTPRO1 8 Bunch x 200e10 PpB



TOF 1 Bunch x 810e10 PpB





4. Results from tests with beam

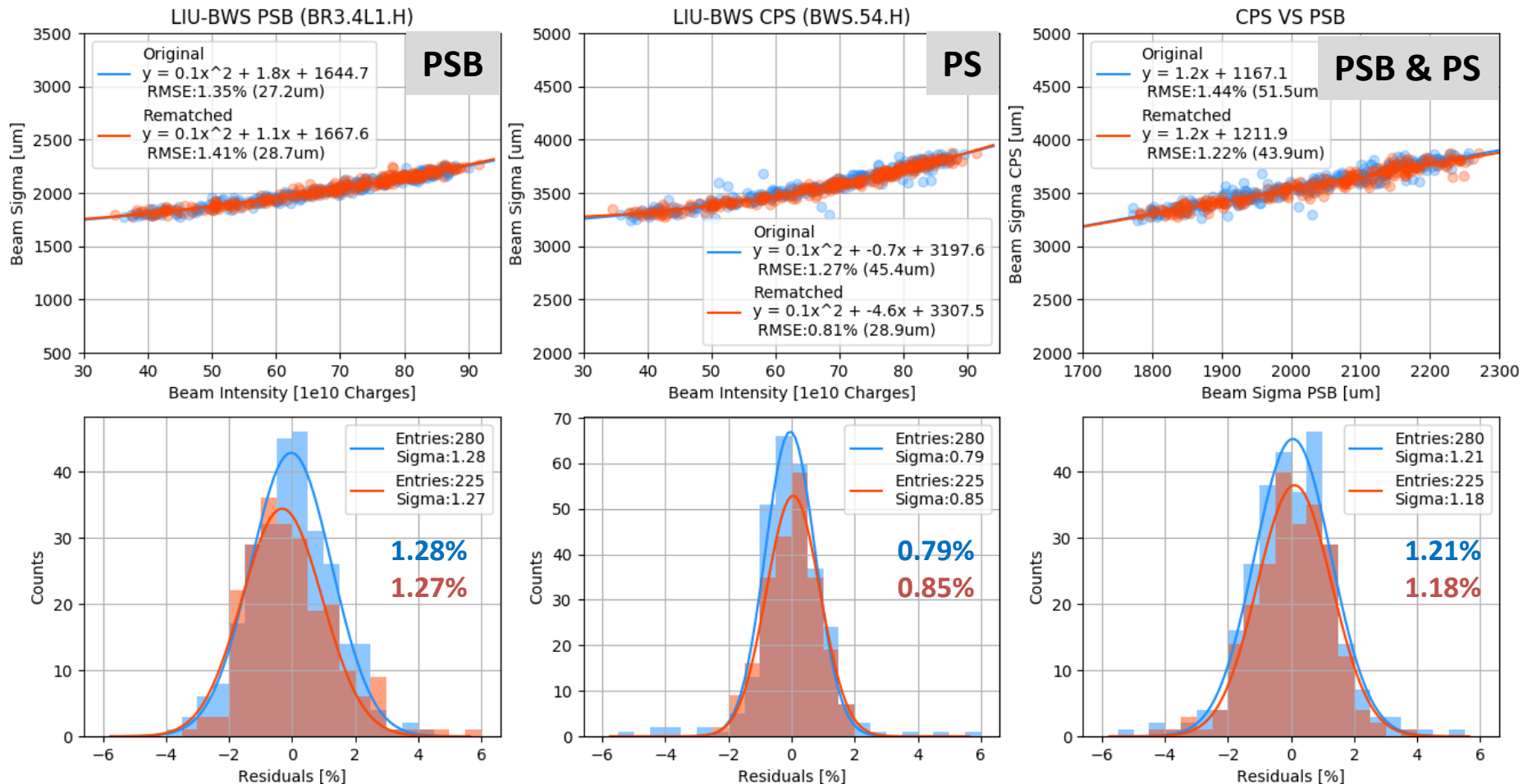
4.2 Precision in beam profile determination: PSB & PS

Date: 01/11/2018

Beam: BCMS Beam single bunch 30-90e10 PpB scans at Flat Bottom

Brightness studies operating **PSB** and **PS** LIU-BWS to check blow-up in PS with diff. transfer optics.

Precision in beam profile determination through polynomial fit with Intensity (Residuals dispersion)





4. Results from tests with beam

4.2 Precision in beam profile determination: PSB & PS

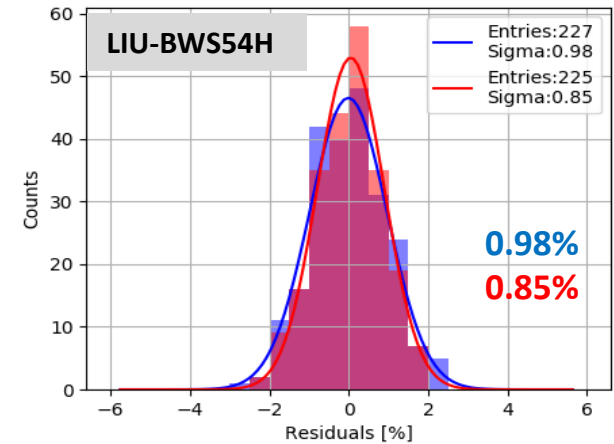
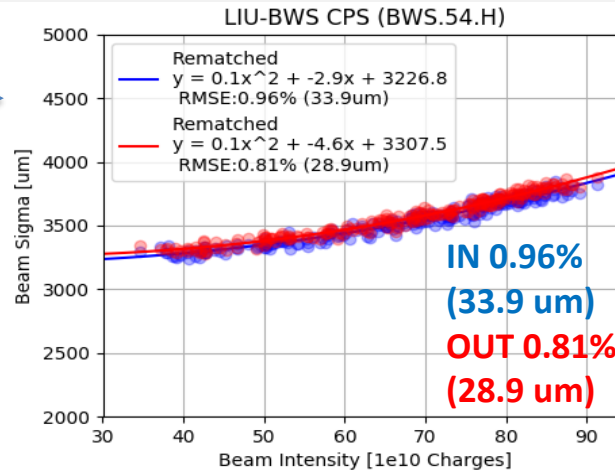
Date: 01/11/2018

Beam: BCMS Beam single bunch 30-90e10 PpB scans at Flat Bottom

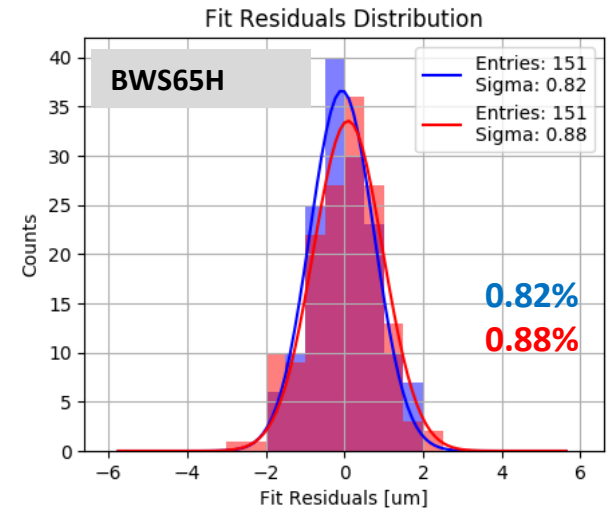
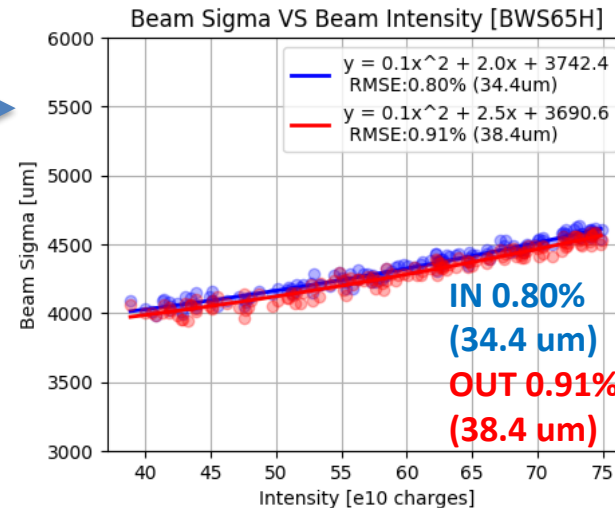
Brightness studies operating **PSB** and **PS** LIU-BWS to check blow-up in PS with transfer optics.

Precision in beam profile determination trough polynomial fit with Intensity (Residuals dispersion)

Data from LIU-BWS54H
from previous slide
(01/11/2018)

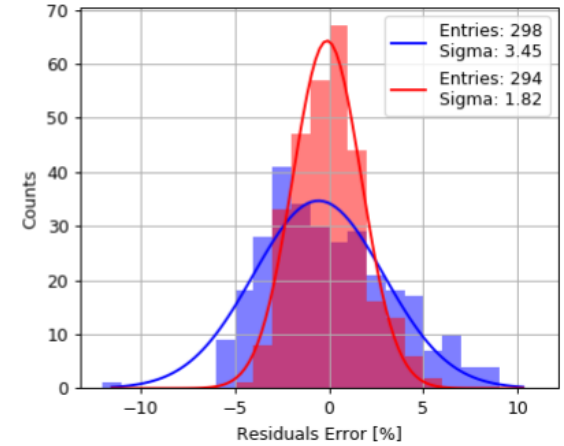
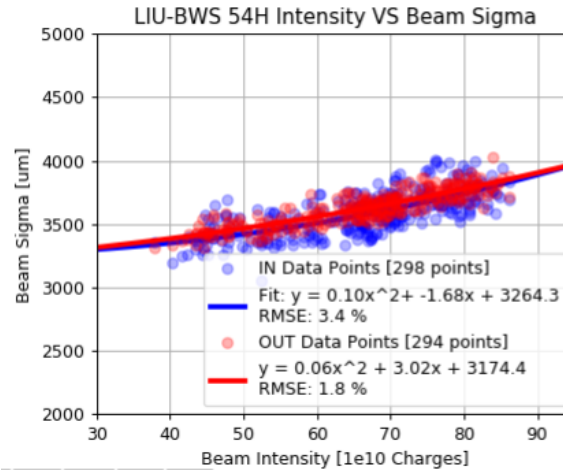


Comparison with data from
BWS65H brightness tests
E.Senes (12/10/2018)

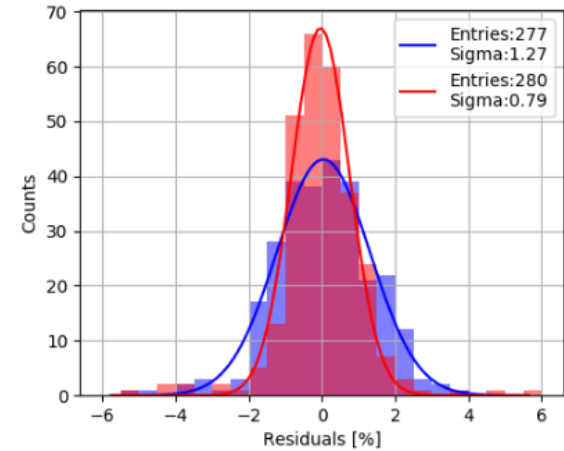
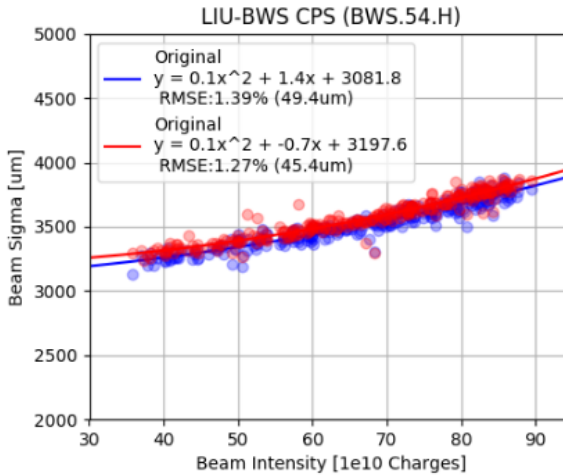




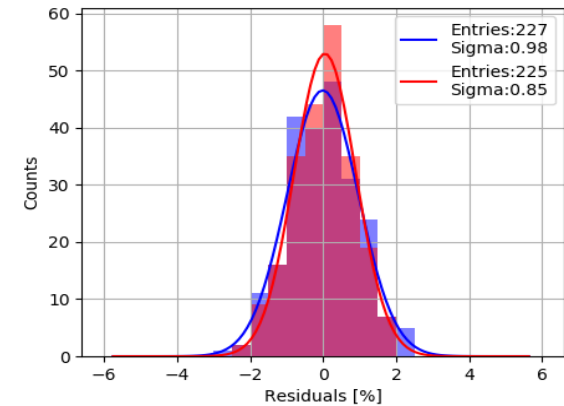
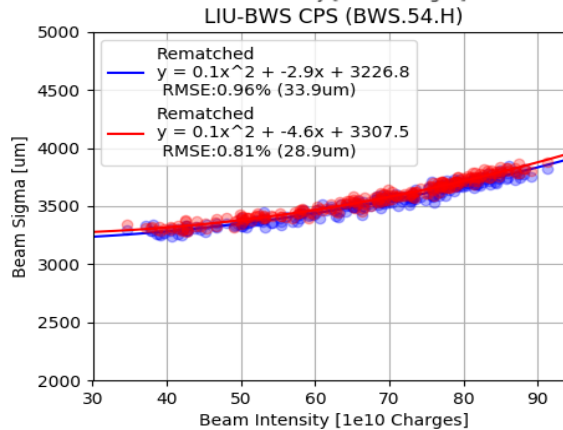
24/10/2018
CPS LIU-BWS Alone
IN - OUT
3.45% - 1.82%



01/11/2018
Operating
PSB BWS
Orig. Optics
IN - OUT
1.27% - 0.79%



01/11/2018
Operating
PSB BWS
Rem. Optics
IN - OUT
0.98% - 0.85%





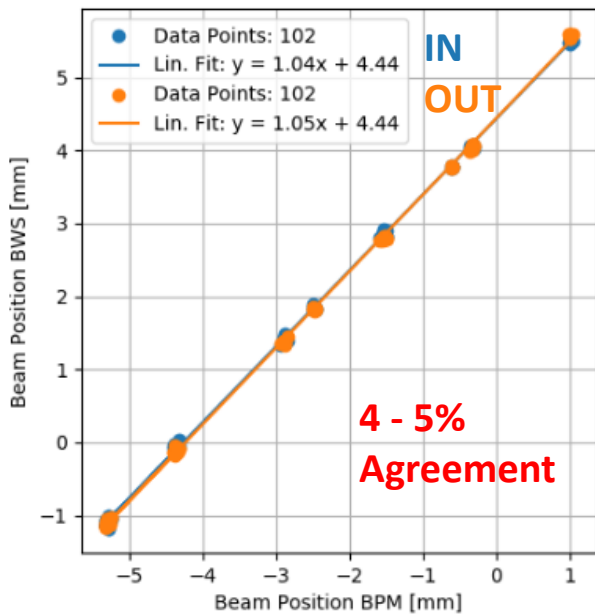
Date: 15/10/2018

Beam: Measurements at flat bottom single bunch 83.29e10

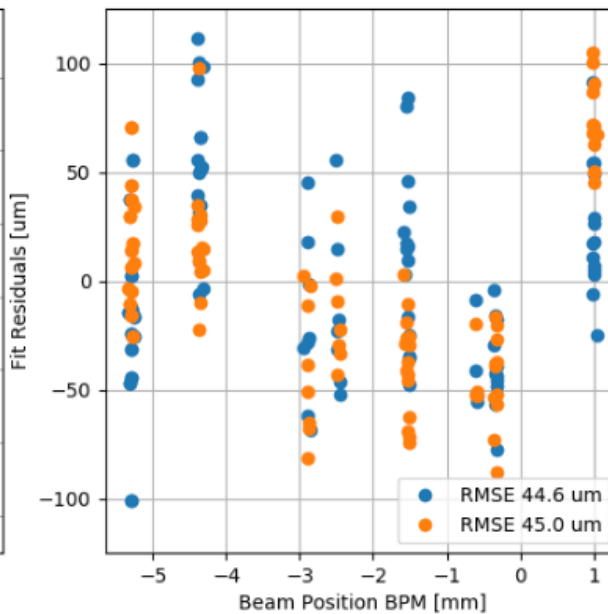
Bumps Measurements MD4603 (Morning) MD4404 (Afternoon)

Beam profile measurements with bumps (beam displacement), comparisons later with BPMs.

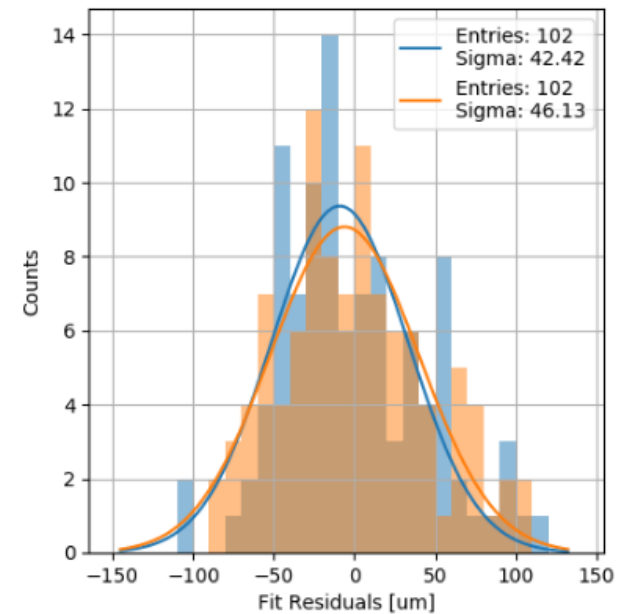
Beam Position
LIU-BWS54H Vs BPM54H



Fit Residuals



Residuals Distribution





4. Results from tests with beam

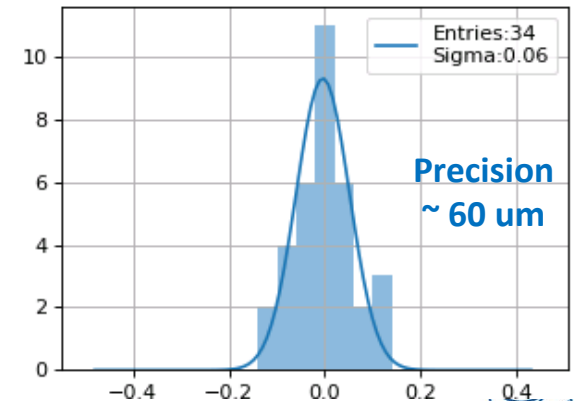
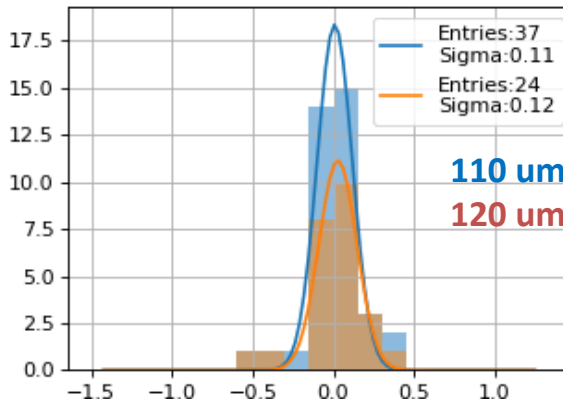
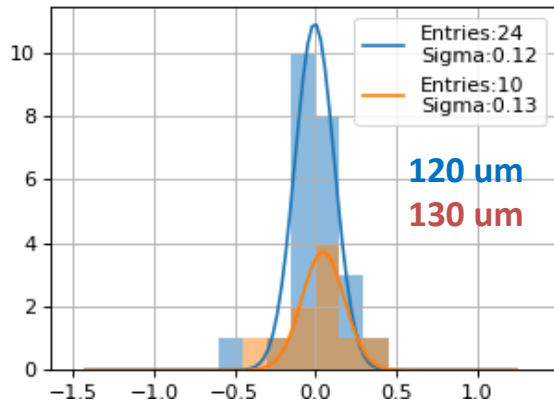
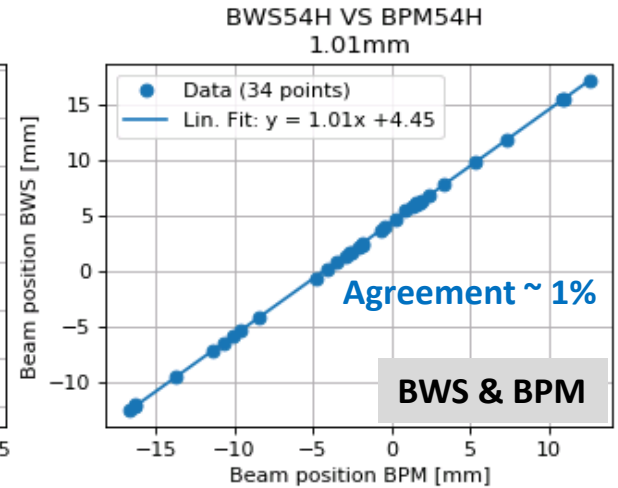
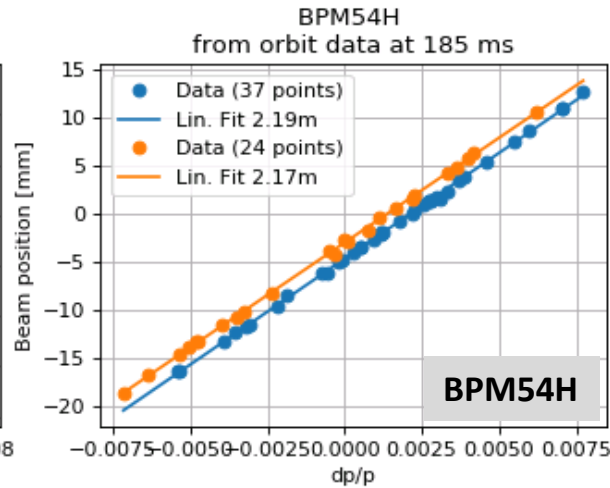
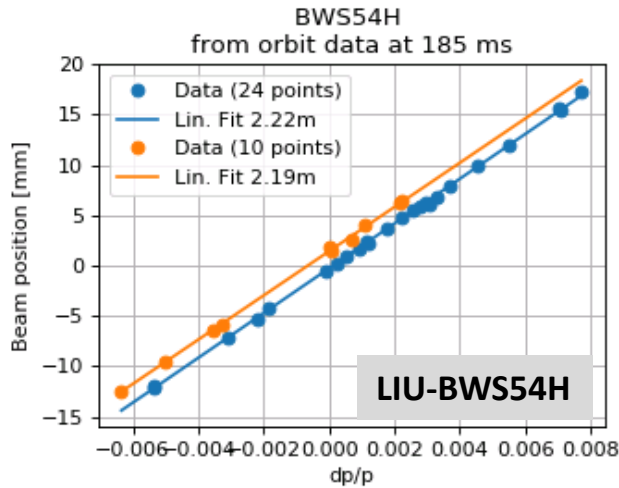
4.2 Precision in beam profile determination: Beam Pos. PS

Date: 01/11/2018

Beam: BCMS Beam single bunch 30-90e10 PpB scans at Flat Bottom

Beam energy dispersion in H. plane --> Beam centroid position

Beam centroid measured with BPM and LIU-BWS (Check slope and agreement)



Date: 15/10/2018

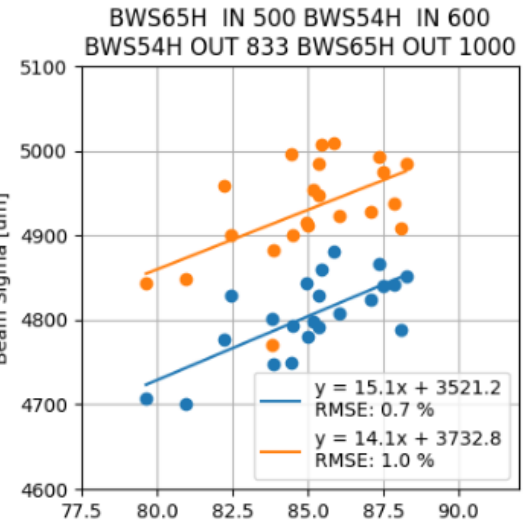
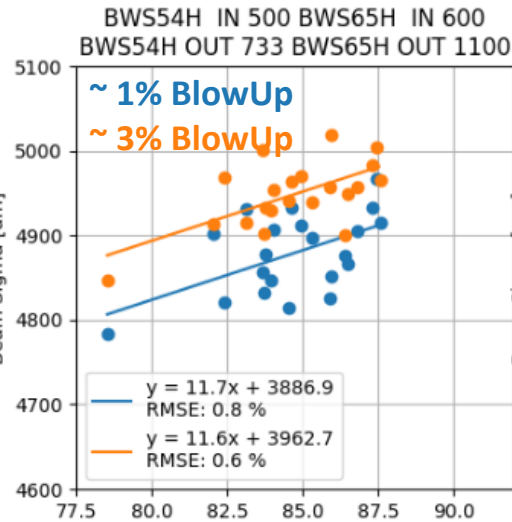
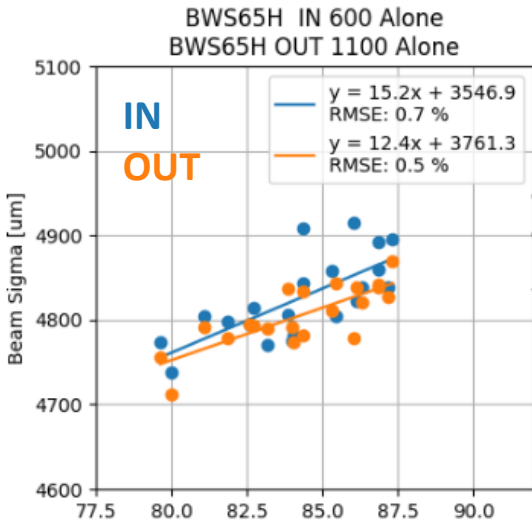
Beam: Measurements at flat bottom single bunch BCMS 83.29e10
MD4603 (Morning) MD4404 (Afternoon)

Checking Emittance Blow-Up in BWS65H produced by BWS54H

Mean Sigma In 4825.5 um
Mean Sigma Out 4804.9 um

Mean Sigma In 4878.7 um
Mean Sigma Out 4948.1 um

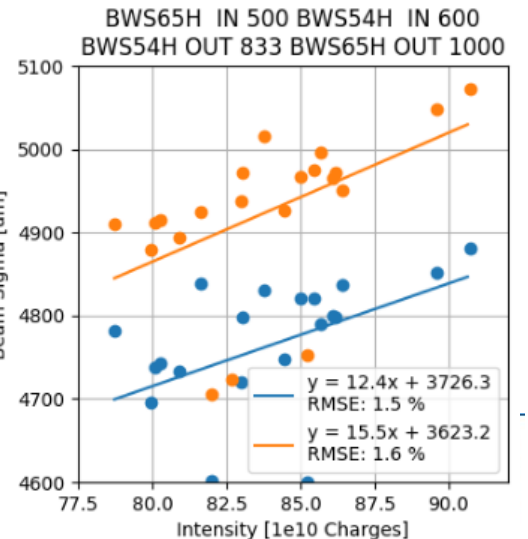
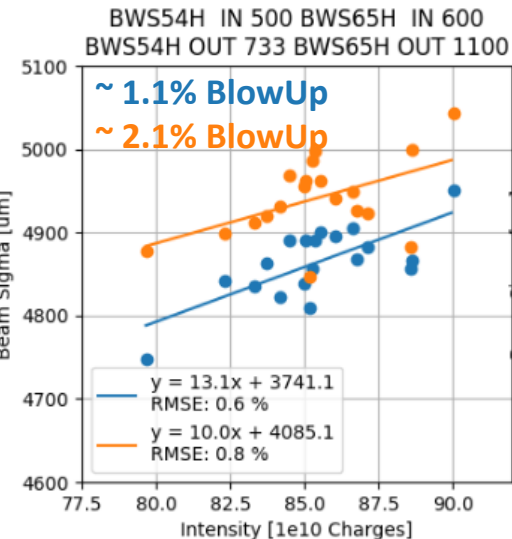
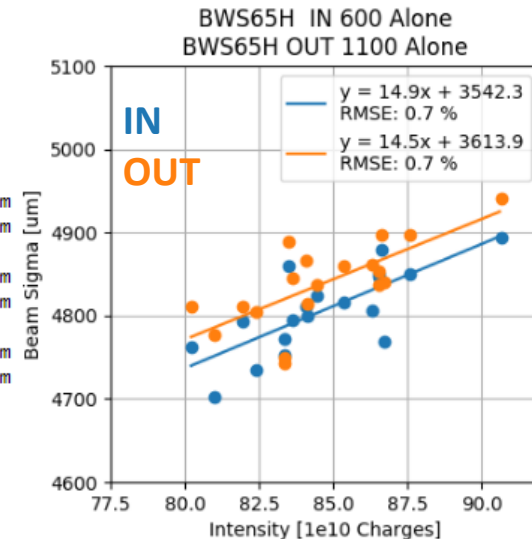
Mean Sigma In 4805.0 um
Mean Sigma Out 4930.8 um



Mean Sigma In 4806.2 um
Mean Sigma Out 4838.7 um

Mean Sigma In 4863.7 um
Mean Sigma Out 4941.1 um

Mean Sigma In 4762.7 um
Mean Sigma Out 4924.4 um



Date: 15/10/2018

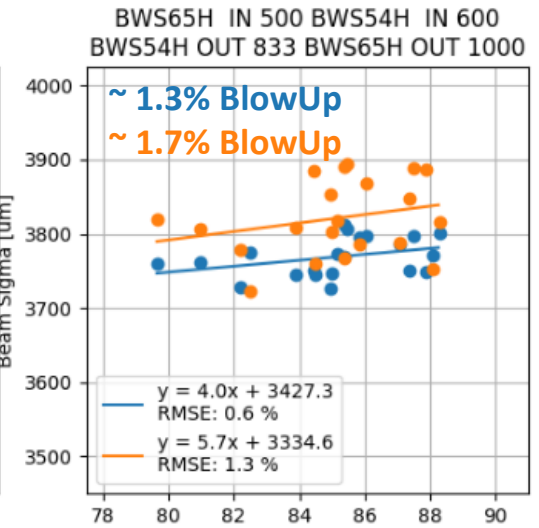
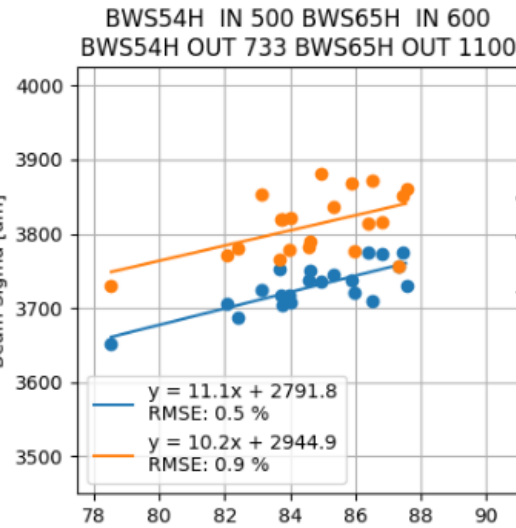
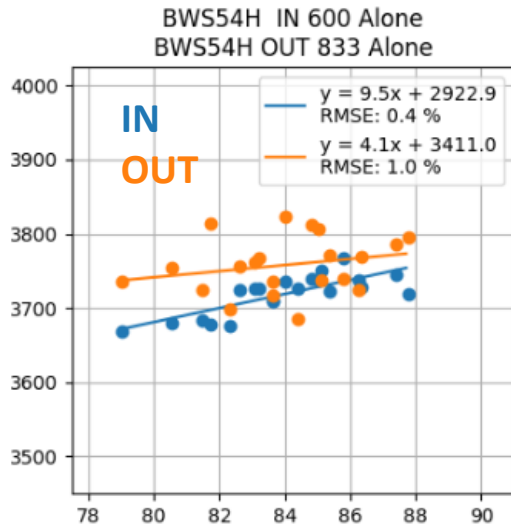
Beam: Measurements at flat bottom single bunch BCMS 83.29e10
MD4603 (Morning) MD4404 (Afternoon)

Checking Emittance Blow-Up in BWS54H produced by BWS65H

Mean Sigma In 3718.6 um
Mean Sigma Out 3757.8 um

Mean Sigma In 3729.1 um
Mean Sigma Out 3811.7 um

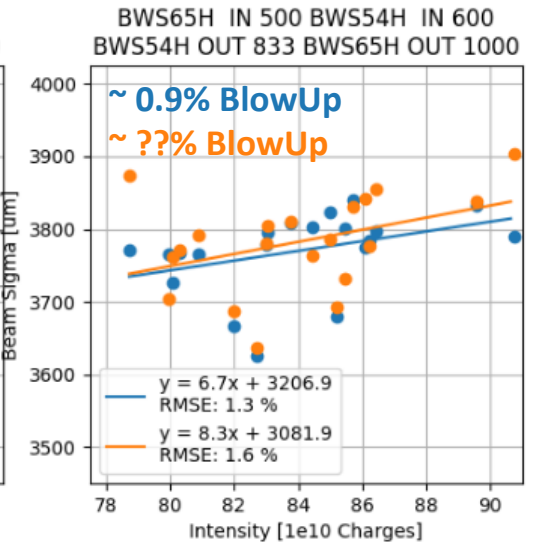
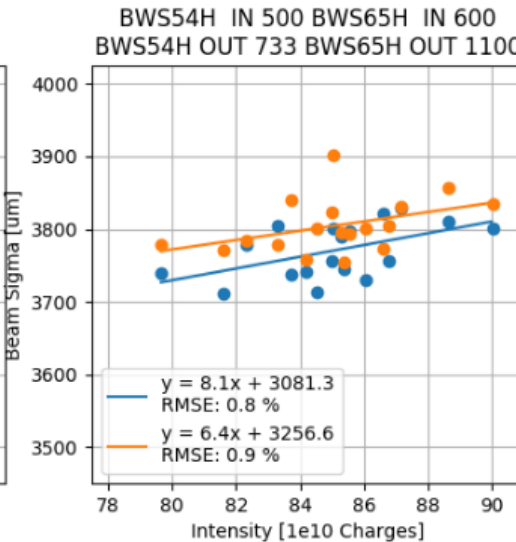
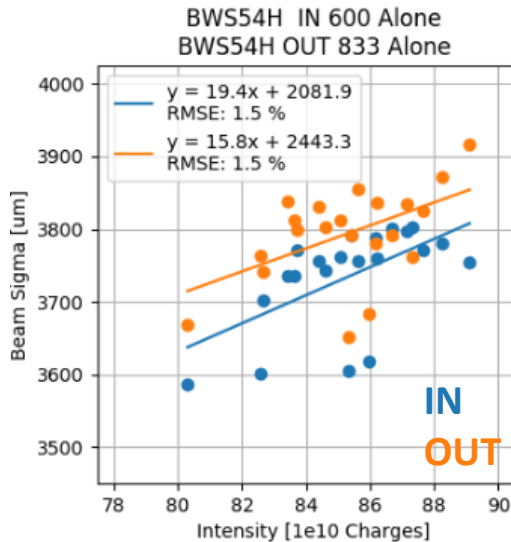
Mean Sigma In 3768.8 um
Mean Sigma Out 3821.0 um



Mean Sigma In 3734.1 um
Mean Sigma Out 3793.9 um

Mean Sigma In 3770.4 um
Mean Sigma Out 3804.5 um

Mean Sigma In 3769.8 um
Mean Sigma Out 3782.1 um







4. Results from tests with beam

4.2 Precision in beam profile determination: SPS

Date: 10/05/2017

Beam: COAST of AWAKE beam @ 270GeV 1 bunch 0.23e11PpB

Benchmarking LIU-BWS against operational Linear BWS @ 1ms-1

Determination of beam profile precision for both devices with a COAST beam by fitting emittance growth.

