BESSY VSR

HZB Helmholtz Zentrum Berlin

Characterisation of the Second Stable Orbit Generated by Transverse Resonance Island Buckets (TRIBs)

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4th MT student retreat
Berlin
11th of June 2018

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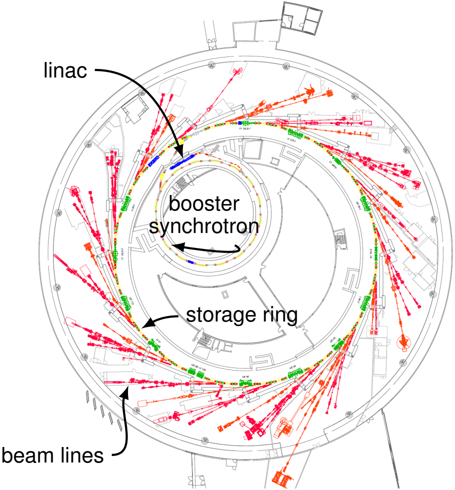
Introduction: BESSY II

Overview BESSY II [1]



Storage ring

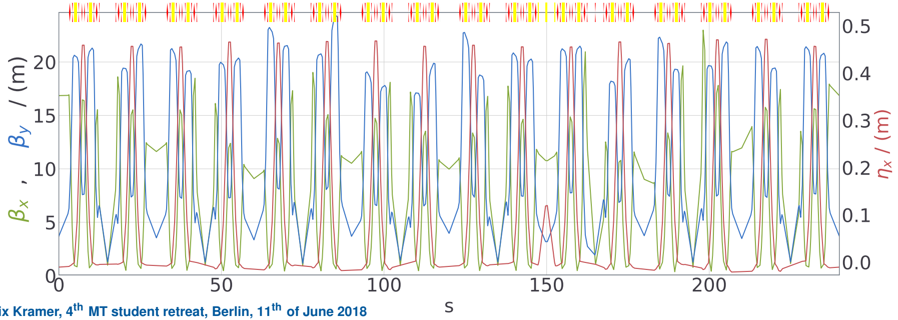
Circumference	240m
RF-frequency	500MHz
Revolutiontime	800ns
Tunes Q_x/Q_y	17.8/6.6
Damping times $\tau_x/\tau_y/\tau_s$	7.8/7.7/3.9ms
Beamlines	$\approx$ 50
Users per year	$>$ 2000

- ⋆ static structures: diffraction, scattering, spectroscopy, microscopy experiments
  - ⇒ high average brilliance
- ⋆ dynamic structures: pump-probe, time-of-flight experiments
  - ⇒ special time structure

Dedicated operation modes:

$\Rightarrow$ special optics

BESSY II standard optics ($\alpha_p = 7e-4$, $\sigma_t = 15\,\text{ps}$)[2,3]

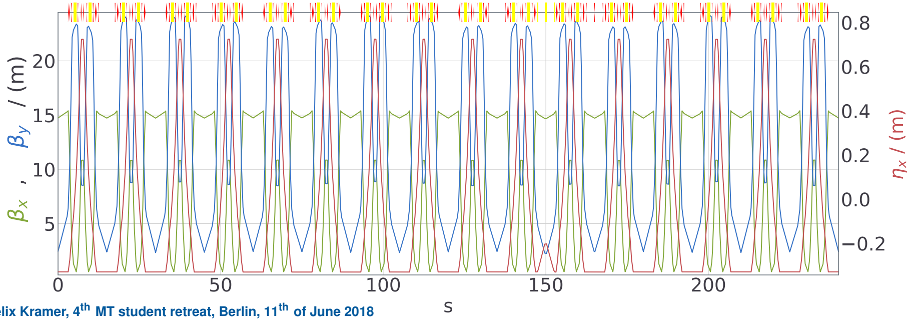


Introduction: Motivation for TRIBs

Dedicated operation modes:

$\Rightarrow$ special optics

BESSY II low-α optics ($\alpha_p = 7e-4$, $\sigma_t = 3\,\text{ps}$)[2,3]

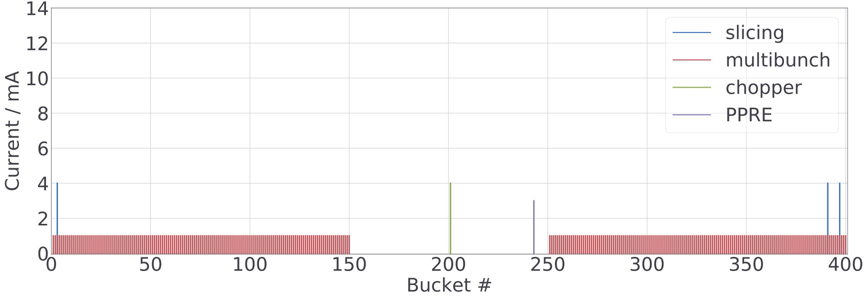


Dedicated operation modes:

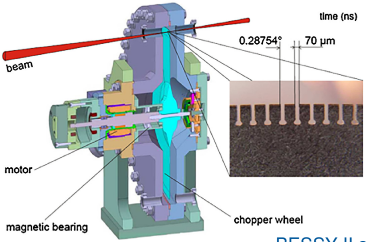
$\Rightarrow$ special optics

$\Rightarrow$ special bunches

BESSY II standard fill ($\sigma_t = 15\,\text{ps}$) [2]



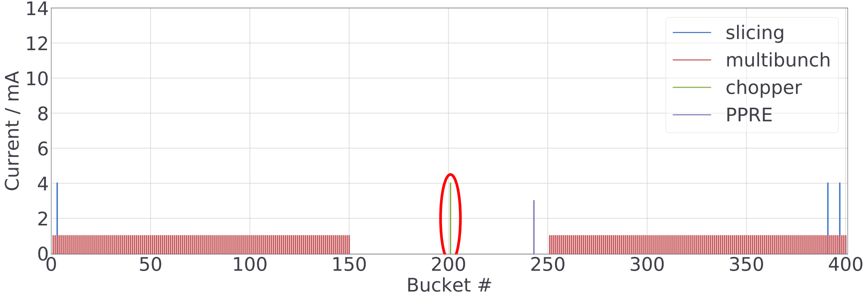
Chopper [4]



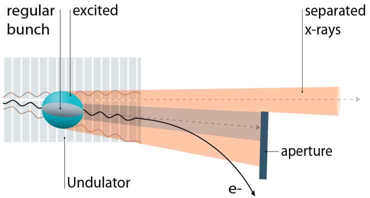
Bunch seperation schemes:

$\Rightarrow$ mechanical chopper (200 ns dark gap)

BESSY II standard fill ($\sigma_t = 15$ ps) [2]



PPRE [5]

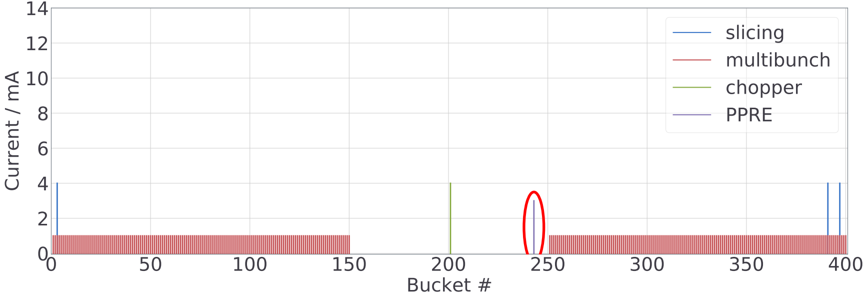


Bunch seperation schemes:

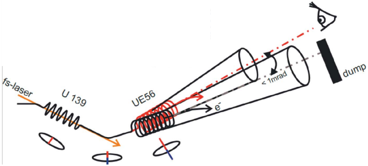
⇒ mechanical chopper (200 ns dark gap)

⇒ pulse picking by resonant excitation (PPRE)

BESSY II standard fill ($\sigma_t = 15\,\text{ps}$) [2]



Slicing [6]



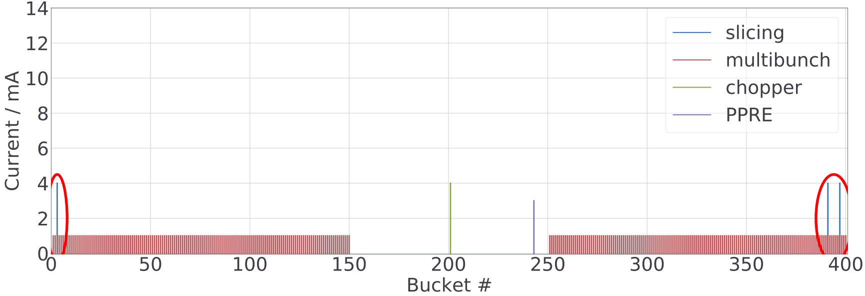
Bunch seperation schemes:

⇒ mechanical chopper (200 ns dark gap)

⇒ pulse picking by resonant excitation (PPRE)

⇒ slicing

BESSY II standard fill ($\sigma_t = 15\,\text{ps}$) [2]



Dedicated operation modes:

⇒ special optics

⇒ special bunches

⇒ special fill pattern

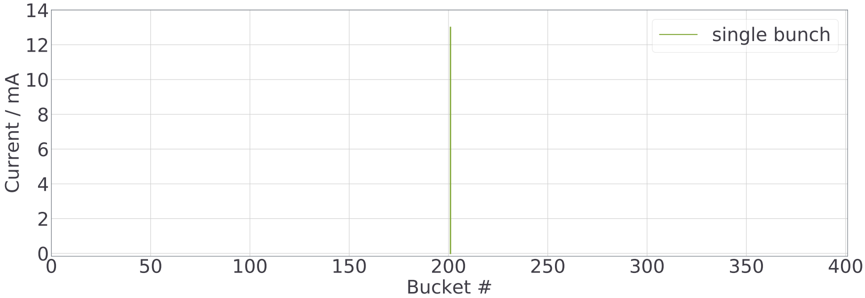
Bunch seperation schemes:

⇒ mechanical chopper (200 ns dark gap)

⇒ pulse picking by resonant excitation (PPRE)

⇒ slicing

BESSY II single bunch mode [2]



Dedicated operation modes:

⇒ special optics

⇒ special bunches

⇒ special fill pattern

⇒ BESSY VSR

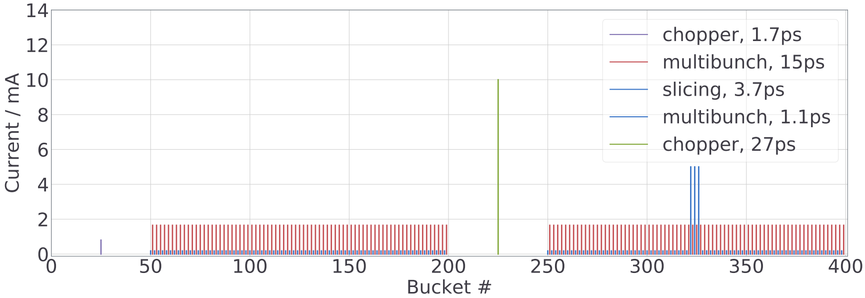
Bunch seperation schemes:

⇒ mechanical chopper (200 ns dark gap)

⇒ pulse picking by resonant excitation (PPRE)

⇒ slicing

BESSY VSR Possible fill [2]



why not use seperate orbits offering multiple operation modes simultaneously?

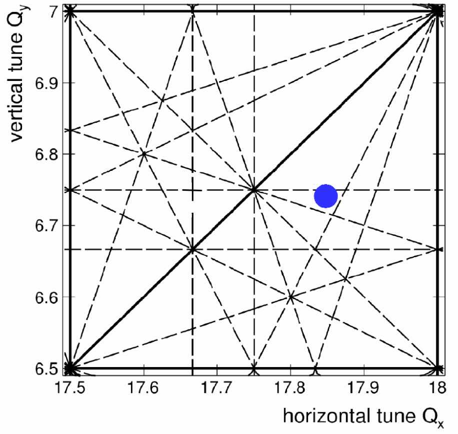
$\Rightarrow$ bunch separation by beamline adjustment

$\Rightarrow$ bunch separation by chopper, PPRE, slicing obsolete

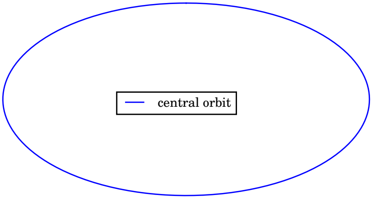
$\Rightarrow$ fill pattern induced tune transients and following stress for cavitys, feedbacks is reduced

Transverse Resonant Islands (TRIBs): Principle

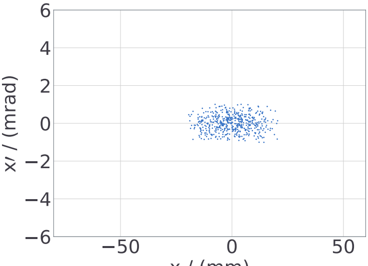
Tune diagram [7]



Course of the second orbit [2]

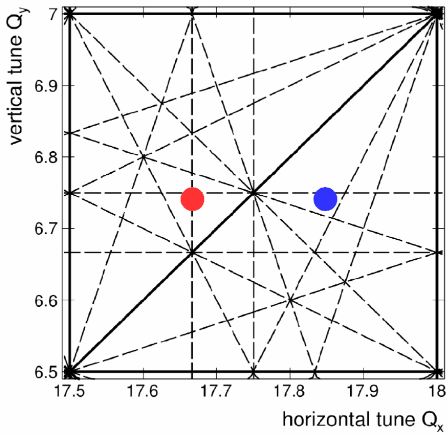


Tracking results: 0 Turns [2,3]



Transverse Resonant Islands (TRIBs): Principle

Tune diagram [7]



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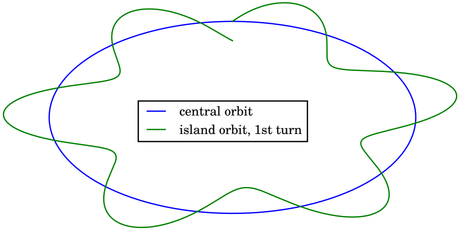
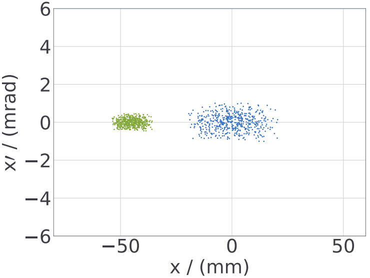
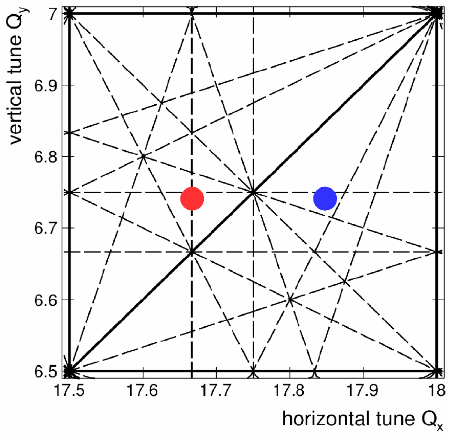


Tracking results: 0 Turns [2,3]

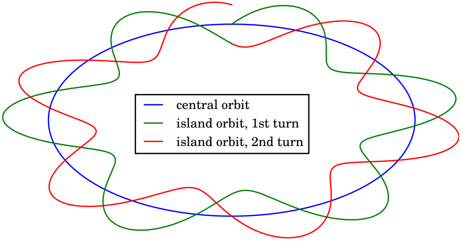


Transverse Resonant Islands (TRIBs): Principle

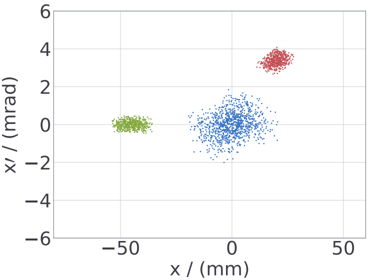
Tune diagram [7]



Course of the second orbit [2]



Tracking results: 1 Turn [2,3]



Transverse Resonant Islands (TRIBs): Principle

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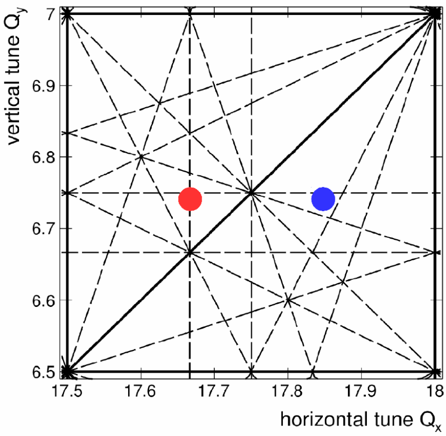
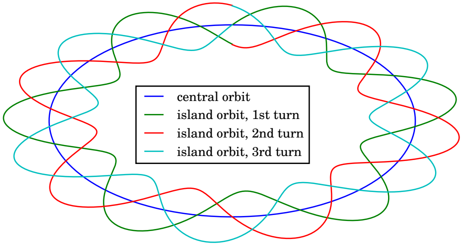
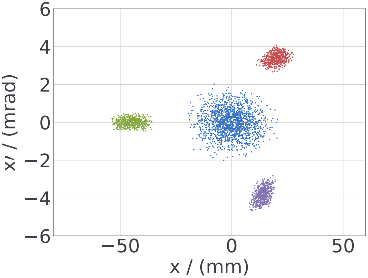


Course of the second orbit [2]

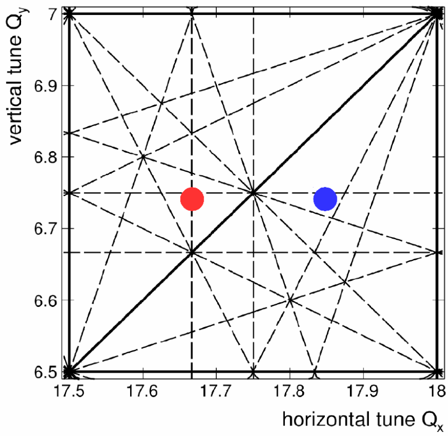


Tracking results: 2 Turns [2,3]

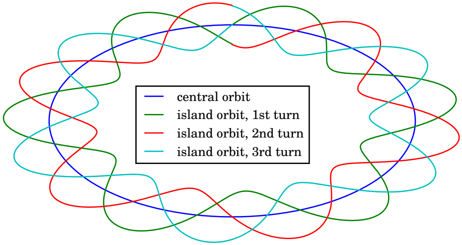


Transverse Resonant Islands (TRIBs): Principle

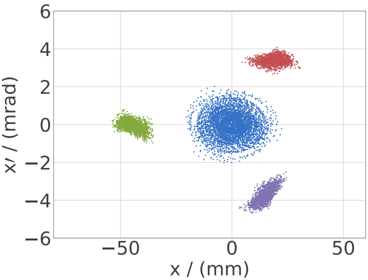
Tune diagram [7]



Course of the second orbit [2]



Tracking results: 9 Turns [2,3]



Transverse Resonant Islands (TRIBs): Principle

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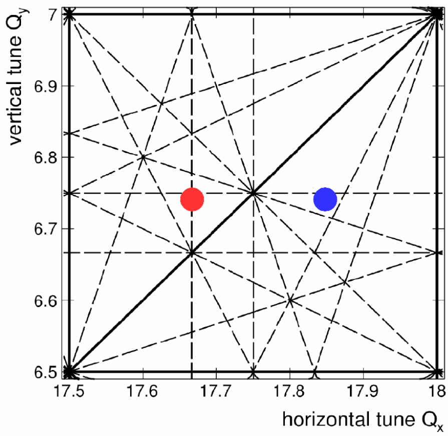
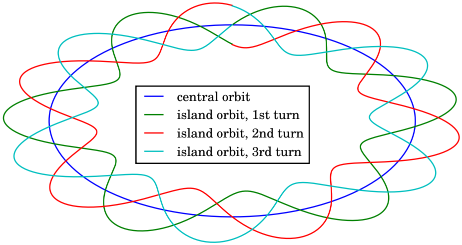
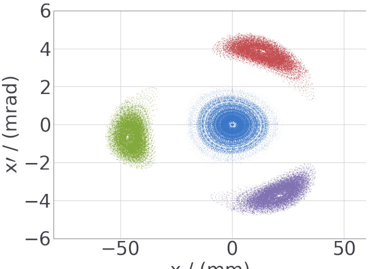


Course of the second orbit [2]

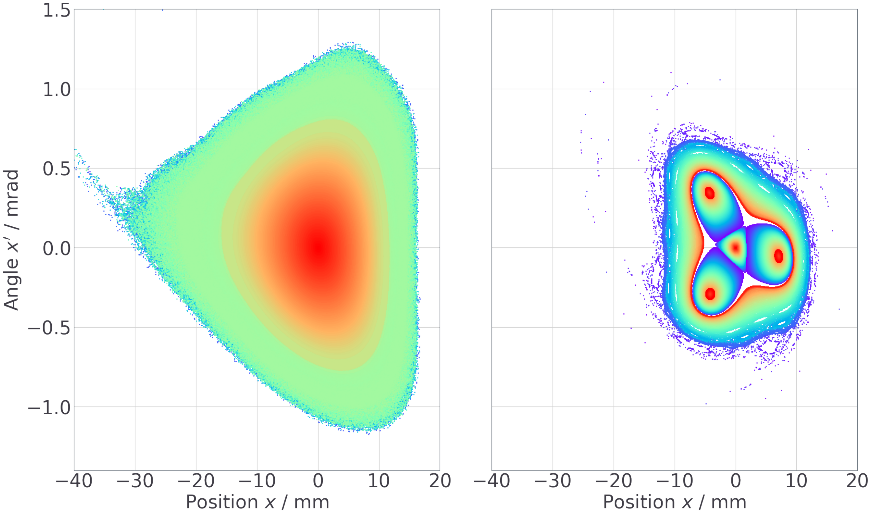


Tracking results: 100 Turns [2,3]



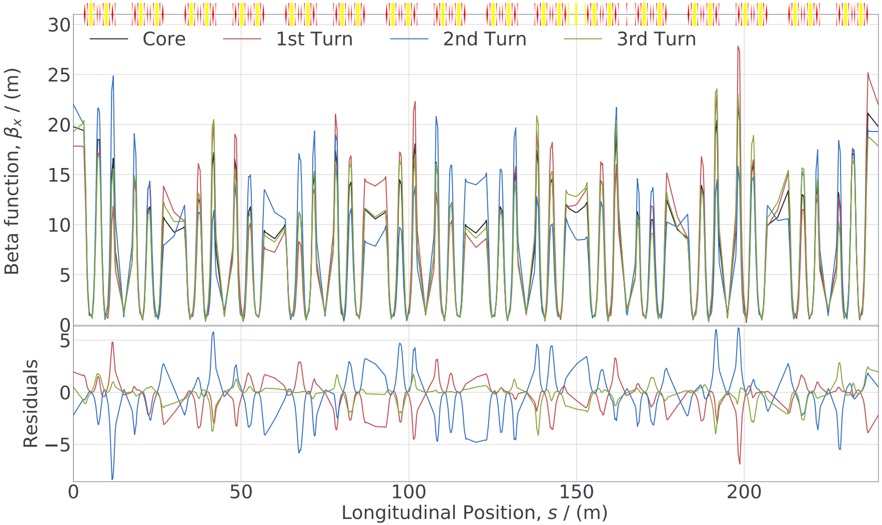
Transverse Resonant Islands (TRIBs): Principle

BESSY II - Standard and TRIBs Optics Phase Space @ Injection [2,3,8]

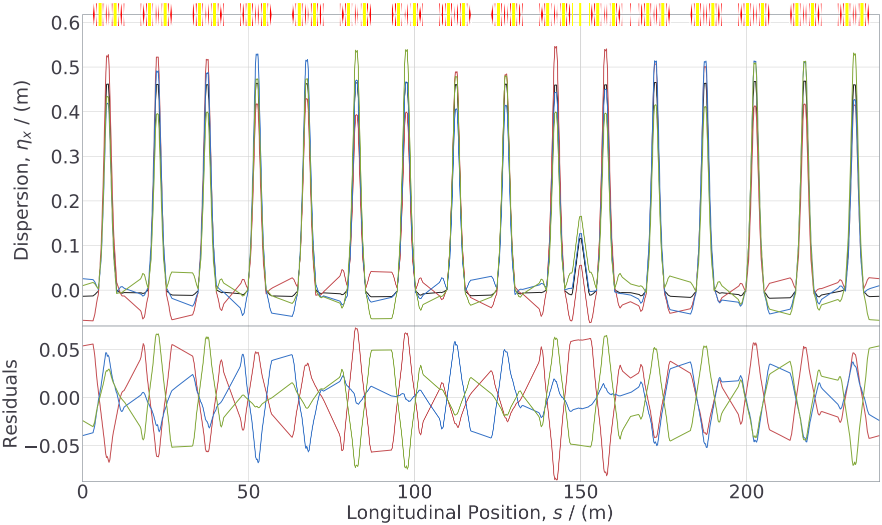


TRIBs at BESSY II: Optics Simulation

Betafunction of Core and Island Beam [2,3,8]

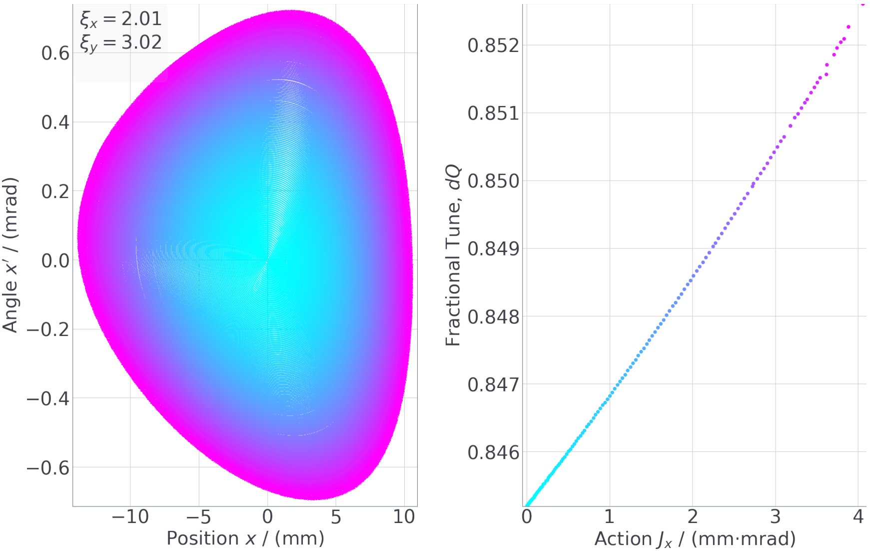


Dispersion of Core and Island Beam [2,3,8]



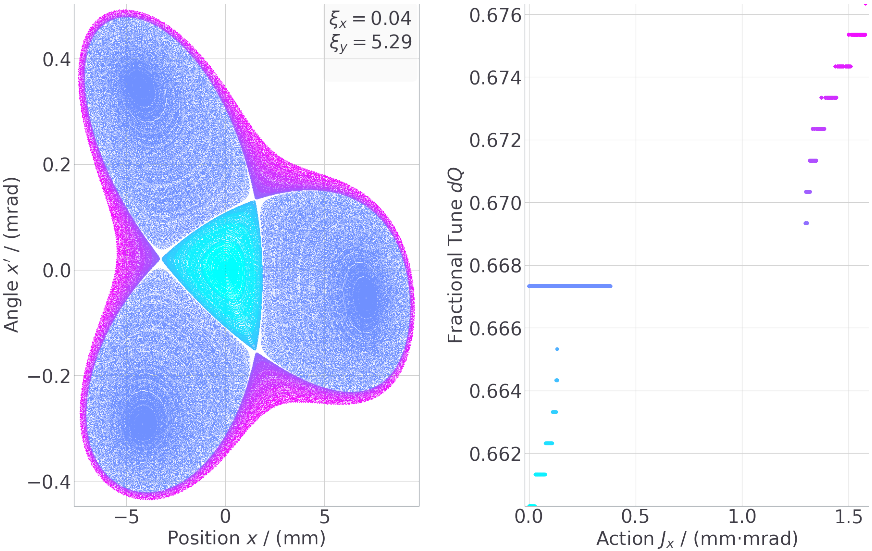
TRIBs at BESSY II: Optics Simulation

Tuneshift with Action for BESSY II Standard Optics: 2.2 kHz mm^{-1} mrad^{-1} [2,3,8]



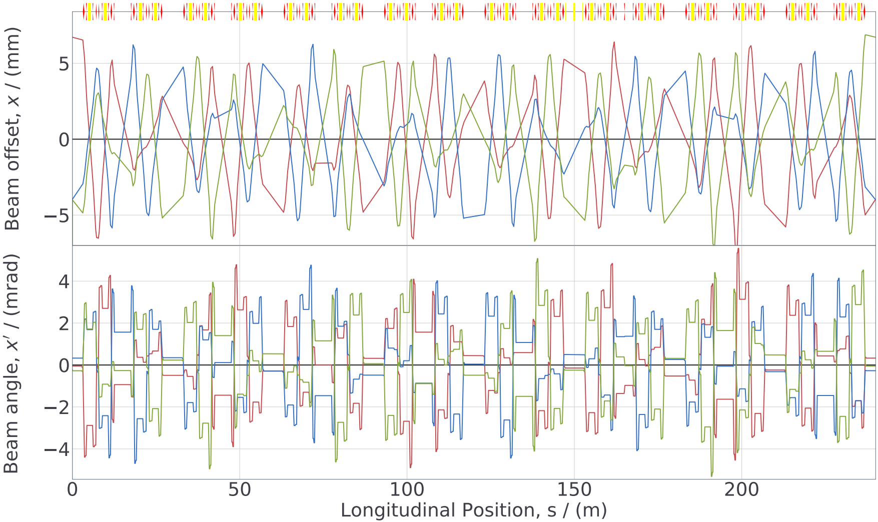
TRIBs at BESSY II: Optics Simulation

Tuneshift with Action for BESSY II TRIBs Optics: 10.6 kHz mm^{-1} $mrad^{-1}$ [2,3,8]



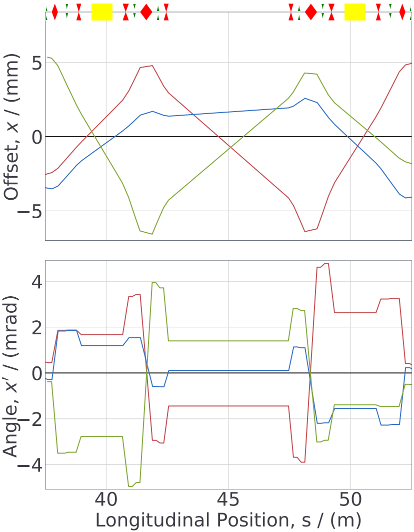
Characterisation of the Second Orbit: Separation

Position and Angle Separation of Core and Island Beam [2,3,8]

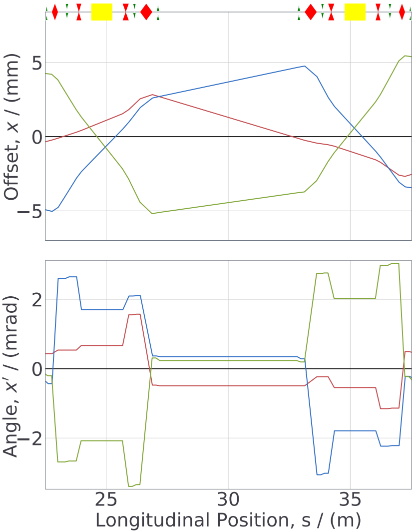


Characterisation of the Second Orbit: Separation

Triplet Straight T2 [2,3,8]



Duplet Straight D2 [2,3,8]



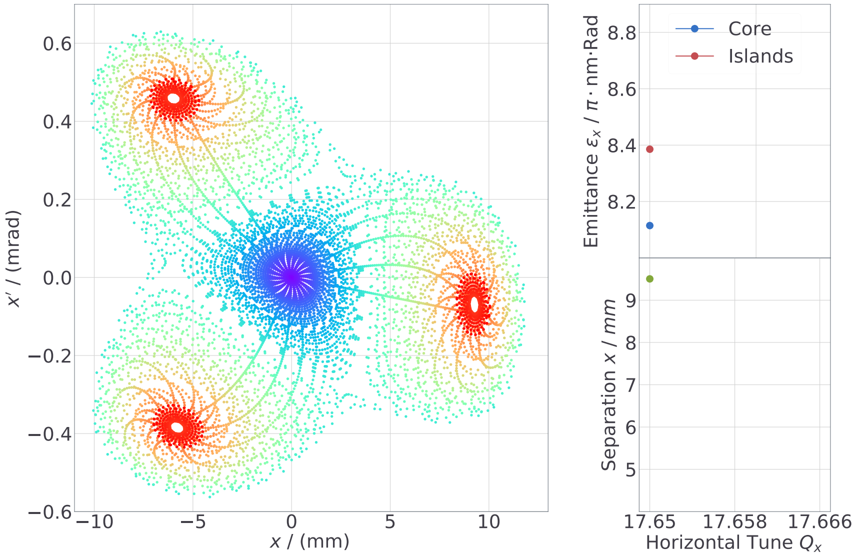
Characterisation of the Second Orbit: Separation

Overview of the Island Position/Angle in the Insertion Devices [3,8]

Section	ID	Displacement / mm			Angle / mRad		
		1st Turn	2nd Turn	3rd Turn	1st Turn	2nd Turn	3rd Turn
D1	Injection BUMP	6.7174	-3.9578	-3.9932	-0.05376	0.32808	-0.27485
T1	BAM WLS 7T	1.3152	0.11078	-1.5561	-0.93677	1.5655	-0.26765
D2	U125ID2R	1.2981	3.6842	-4.4469	-0.49464	0.34677	0.2342
T2	HMI WIGGLER - MPW 7T	-0.58177	1.6588	-0.85216	-1.4422	0.11404	1.3989
D3	UE56ID3R	-3.8811	4.1013	0.56769	-0.2945	-0.2847	0.5317
T3	U41IT3R	-1.5728	0.49419	1.1399	0.0043903	-1.4628	1.1512
D4	U49ID4R	-3.8081	-1.5582	4.9714	0.3163	-0.48362	0.061571
T4	UE49IT4R	-0.34921	-1.3378	1.3285	1.5663	-0.86625	-0.88968
D5	UE52ID5R	2.4581	-5.0744	1.4682	0.44419	0.039474	-0.48759
T5	UE46IT5R	1.4979	-1.2096	-0.67239	0.58948	1.073	-1.4958
D6	U139ID6R (Modulator) + UE56ID6R (Radiator)	4.8264	-0.77336	-4.5489	-0.1445	0.48775	-0.24696
T6	Collimator + UE48IT6R (EMIL)	1.5547	0.10857	-1.7177	-1.1195	1.3533	0.1174
D7	UE112ID7R	1.6858	3.686	-4.5171	-0.52521	0.26038	0.31483
T7	PSF WLS 7T	-0.72157	1.4625	-0.49279	-1.6324	-0.058378	1.6416
D8	U49ID8R	-5.0178	3.3645	2.2969	-0.23718	-0.31924	0.47859
T8	4 x .54m 360kV CAVITIES (scraper at center)	-1.6938	0.15858	1.5113	0.43334	-1.4549	0.65292

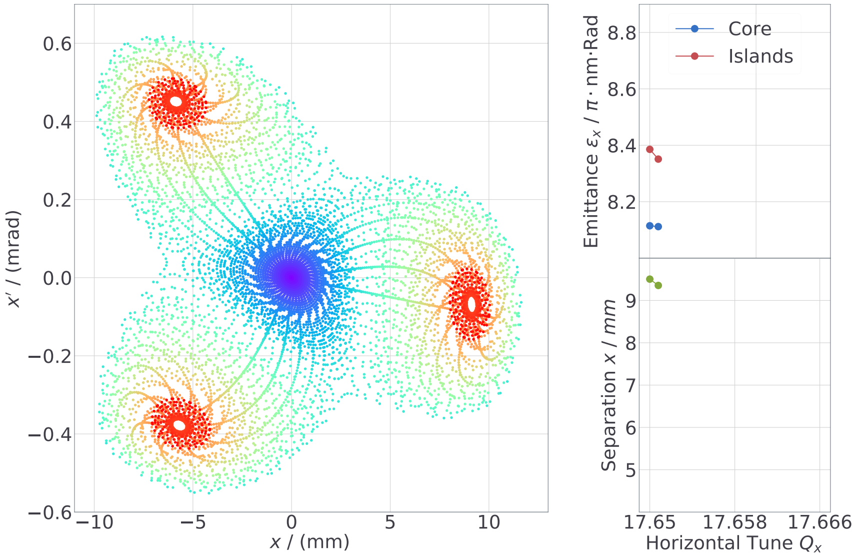
Characterisation of the Second Orbit: Tune vs Emittance (100 Particles, 100 Turns)

Separation vs Core Tune $Q_x = 17.65$ [2,3,8]



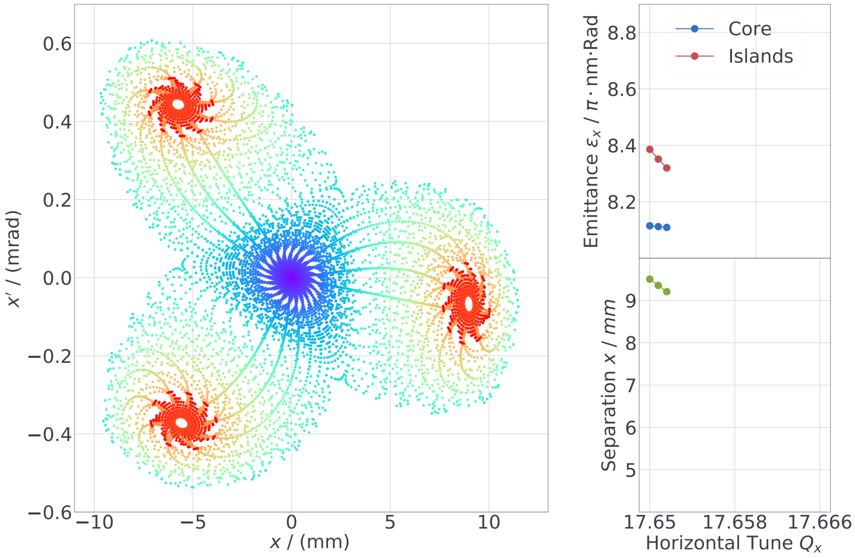
Characterisation of the Second Orbit: Tune vs Emittance (100 Particles, 100 Turns)

Separation vs Core Tune $Q_x = 17.6508$ [2,3,8]



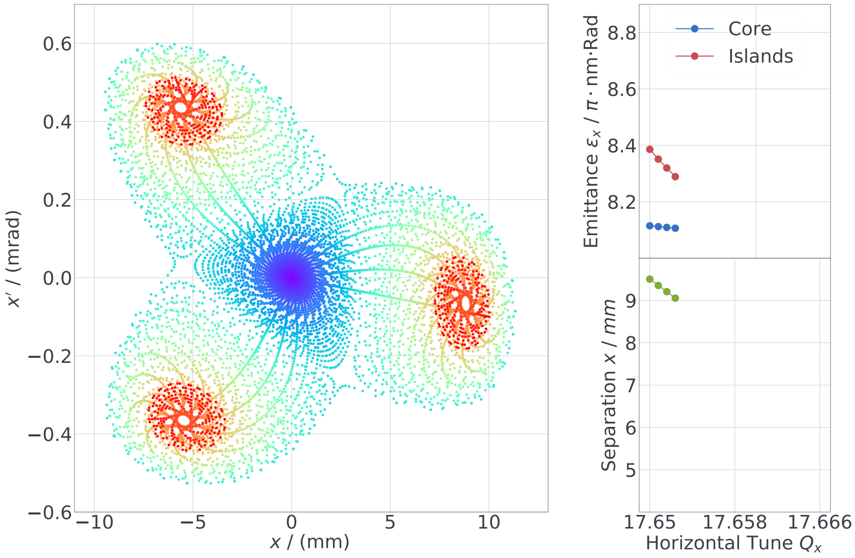
Characterisation of the Second Orbit: Tune vs Emittance (100 Particles, 100 Turns)

Separation vs Core Tune $Q_x = 17.6516$ [2,3,8]



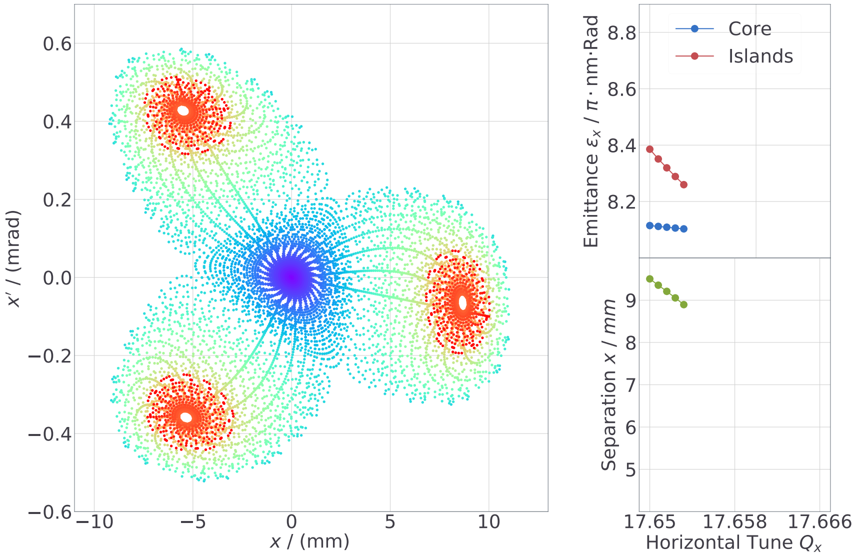
Characterisation of the Second Orbit: Tune vs Emittance (100 Particles, 100 Turns)

Separation vs Core Tune $Q_x = 17.6524$ [2,3,8]



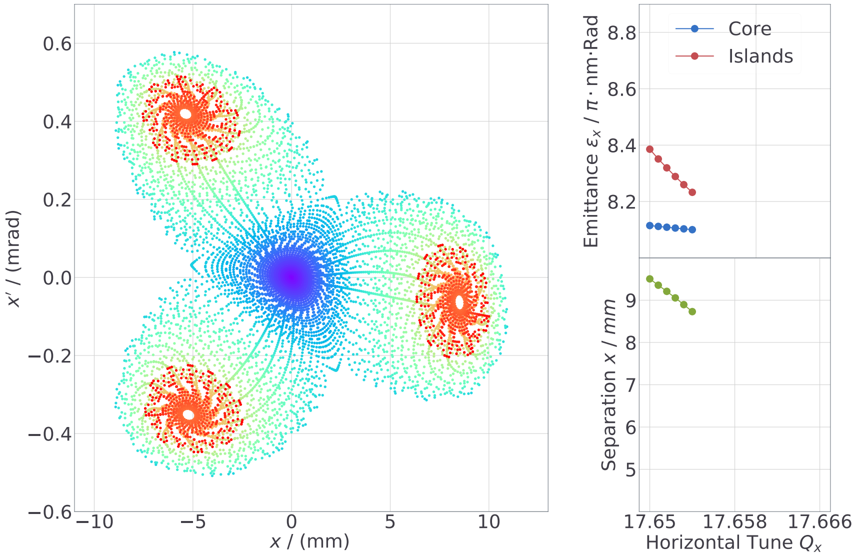
Characterisation of the Second Orbit: Tune vs Emittance (100 Particles, 100 Turns)

Separation vs Core Tune $Q_x = 17.6532$ [2,3,8]



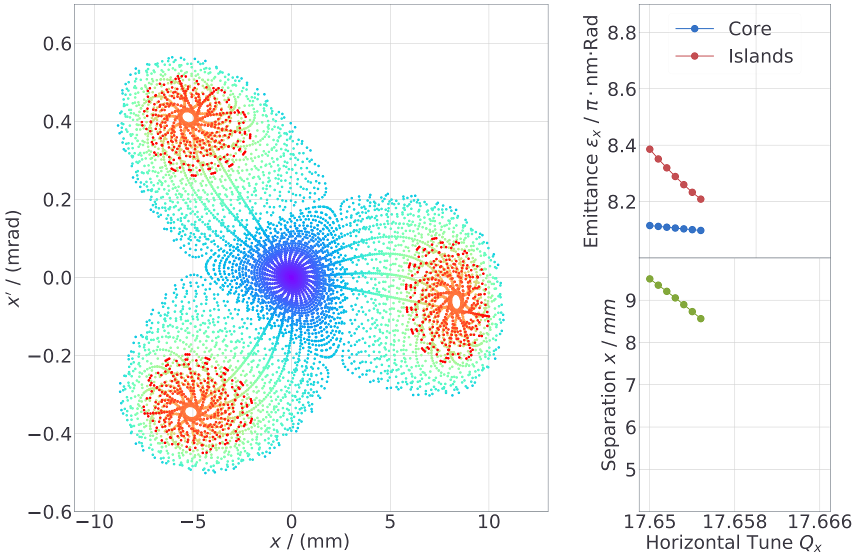
Characterisation of the Second Orbit: Tune vs Emittance (100 Particles, 100 Turns)

Separation vs Core Tune $Q_x = 17.654$ [2,3,8]



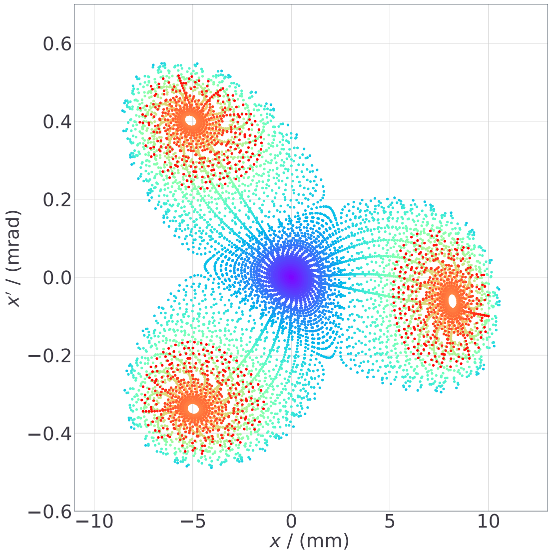
Characterisation of the Second Orbit: Tune vs Emittance (100 Particles, 100 Turns)

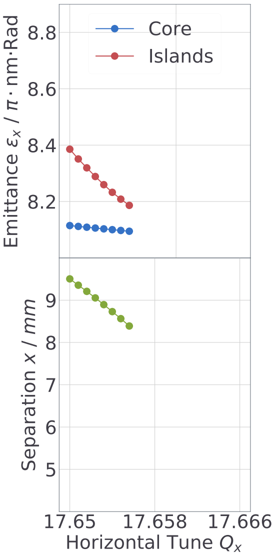
Separation vs Core Tune $Q_x = 17.6548$ [2,3,8]



Characterisation of the Second Orbit: Tune vs Emittance (100 Particles, 100 Turns)

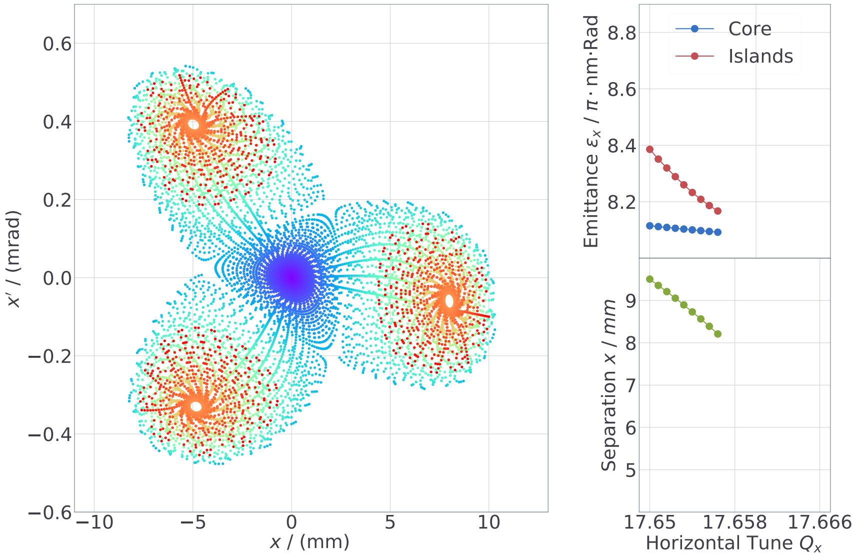
Separation vs Core Tune $Q_x = 17.6556$ [2,3,8]





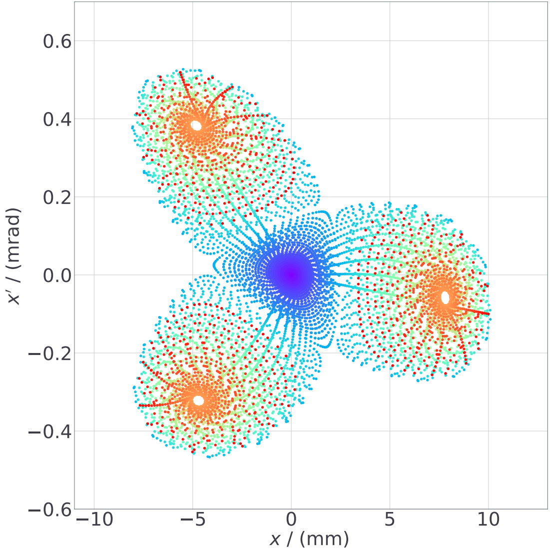
Characterisation of the Second Orbit: Tune vs Emittance (100 Particles, 100 Turns)

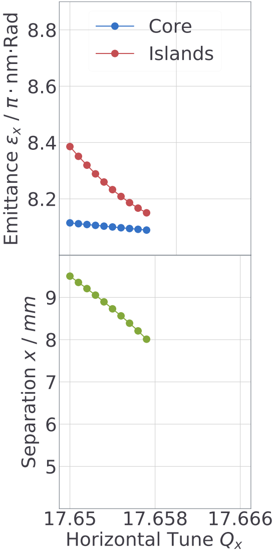
Separation vs Core Tune $Q_x = 17.6564$ [2,3,8]



Characterisation of the Second Orbit: Tune vs Emittance (100 Particles, 100 Turns)

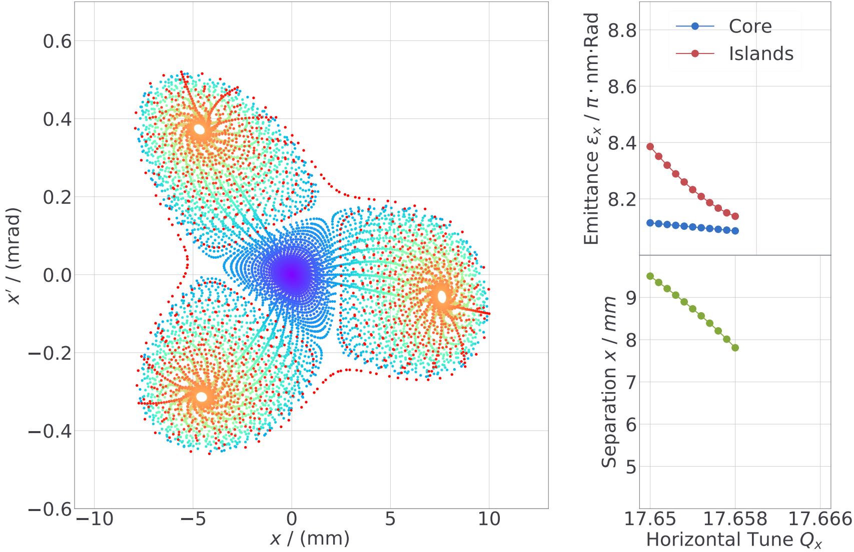
Separation vs Core Tune $Q_x = 17.6572$ [2,3,8]





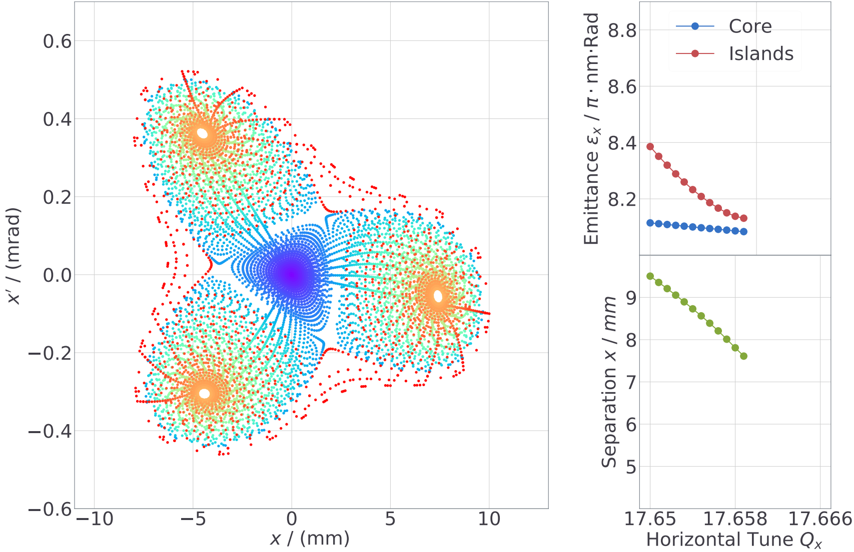
Characterisation of the Second Orbit: Tune vs Emittance (100 Particles, 100 Turns)

Separation vs Core Tune $Q_x = 17.658$ [2,3,8]



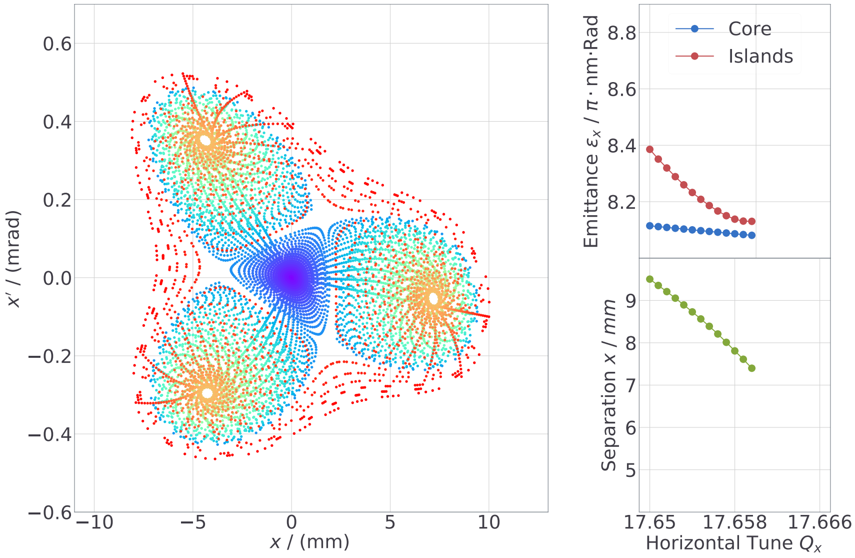
Characterisation of the Second Orbit: Tune vs Emittance (100 Particles, 100 Turns)

Separation vs Core Tune $Q_x = 17.6588$ [2,3,8]



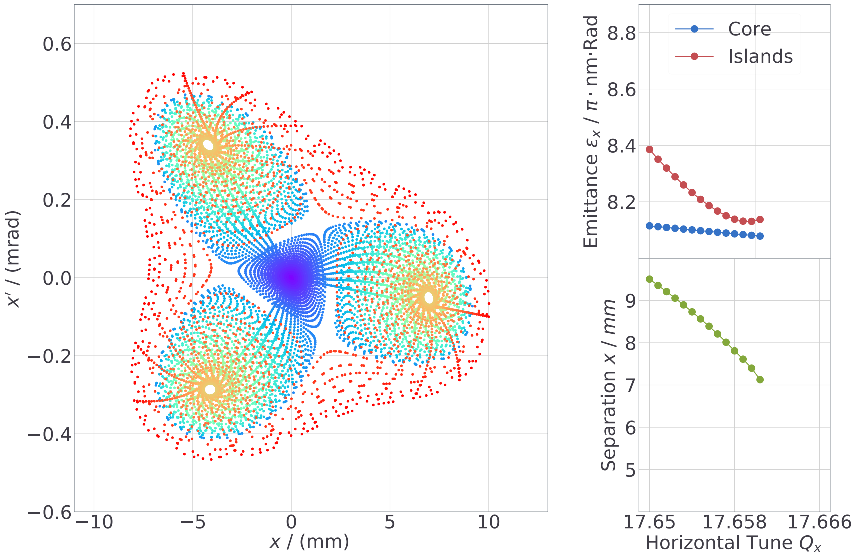
Characterisation of the Second Orbit: Tune vs Emittance (100 Particles, 100 Turns)

Separation vs Core Tune $Q_x = 17.6596$ [2,3,8]



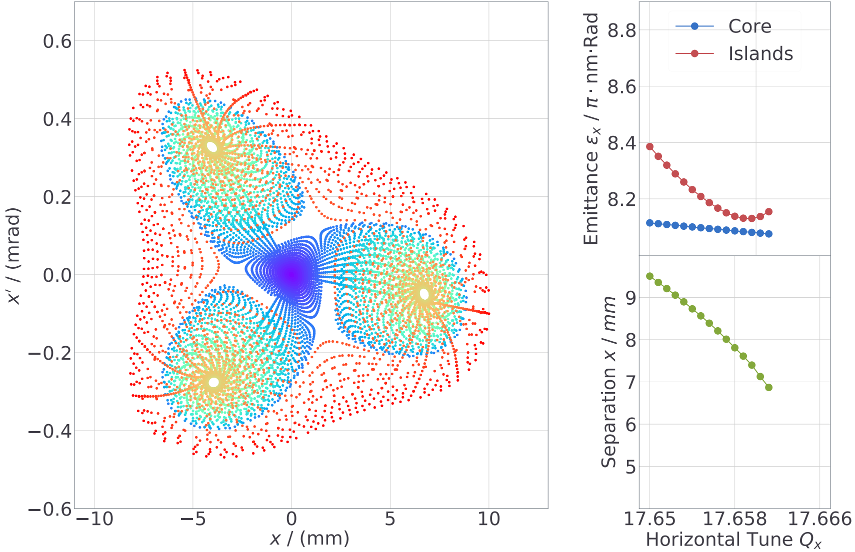
Characterisation of the Second Orbit: Tune vs Emittance (100 Particles, 100 Turns)

Separation vs Core Tune $Q_x = 17.6604$ [2,3,8]



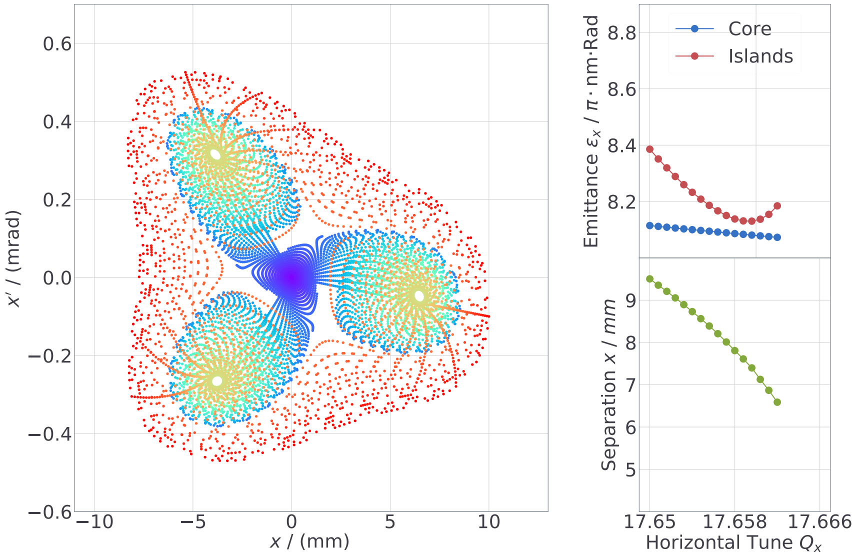
Characterisation of the Second Orbit: Tune vs Emittance (100 Particles, 100 Turns)

Separation vs Core Tune $Q_x = 17.6612$ [2,3,8]



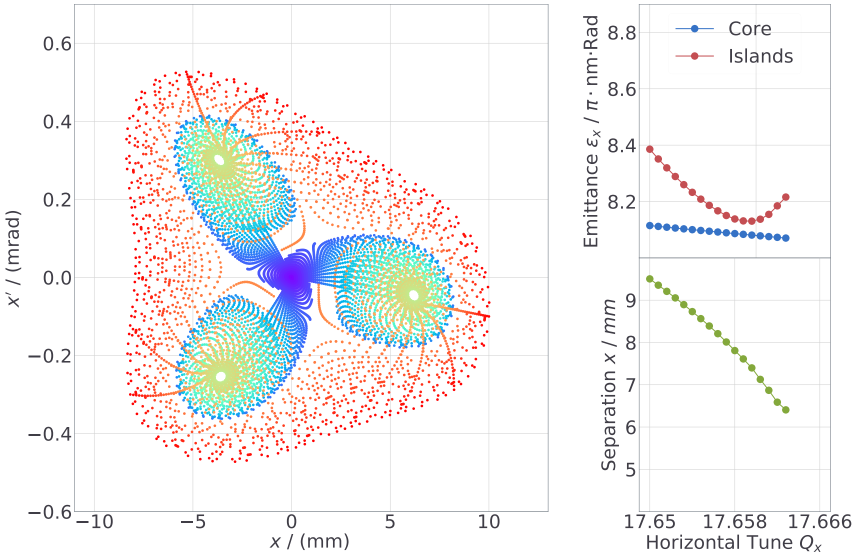
Characterisation of the Second Orbit: Tune vs Emittance (100 Particles, 100 Turns)

Separation vs Core Tune $Q_x = 17.662$ [2,3,8]



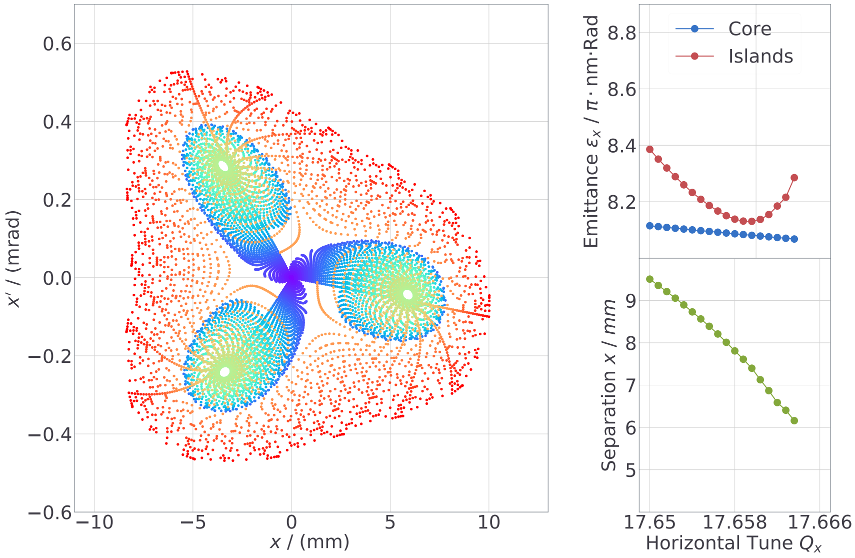
Characterisation of the Second Orbit: Tune vs Emittance (100 Particles, 100 Turns)

Separation vs Core Tune $Q_x = 17.6628$ [2,3,8]



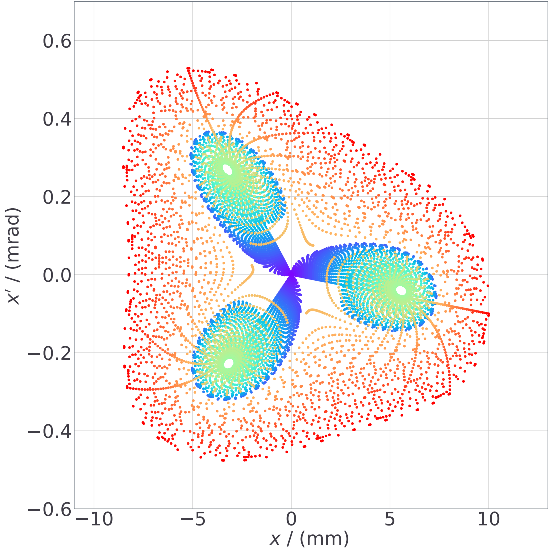
Characterisation of the Second Orbit: Tune vs Emittance (100 Particles, 100 Turns)

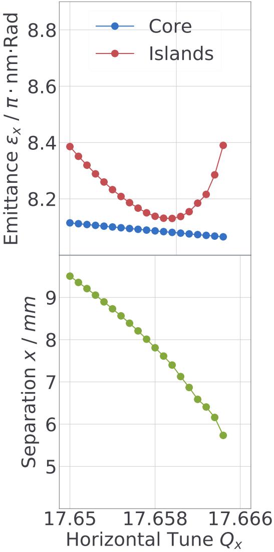
Separation vs Core Tune $Q_x = 17.6636$ [2,3,8]



Characterisation of the Second Orbit: Tune vs Emittance (100 Particles, 100 Turns)

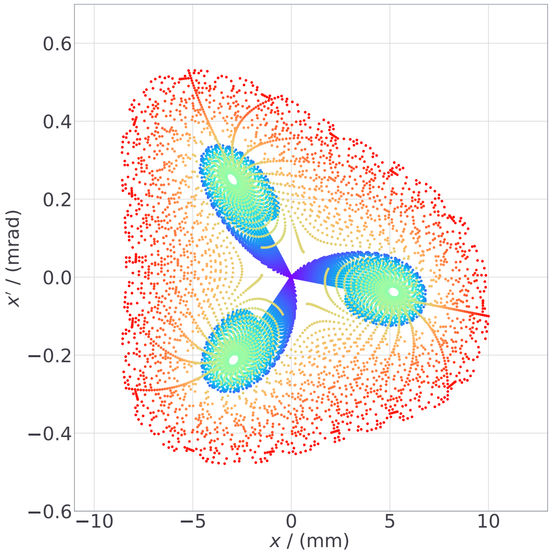
Separation vs Core Tune $Q_x = 17.6644$ [2,3,8]

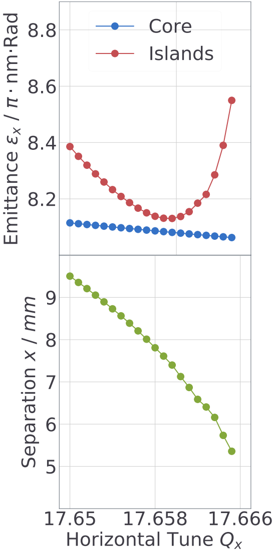




Characterisation of the Second Orbit: Tune vs Emittance (100 Particles, 100 Turns)

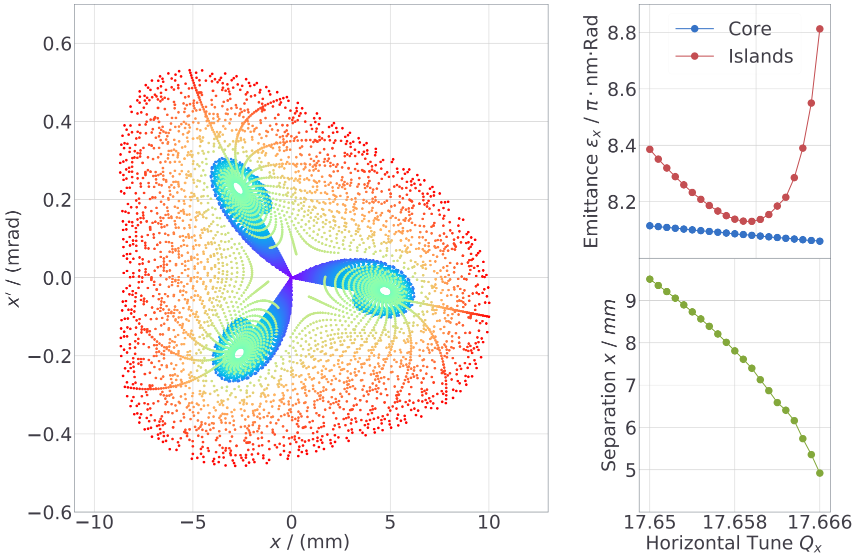
Separation vs Core Tune $Q_x = 17.6652$ [2,3,8]





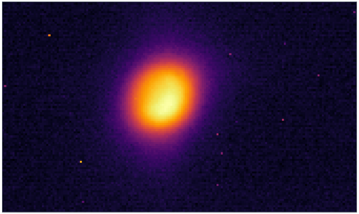
Characterisation of the Second Orbit: Tune vs Emittance (100 Particles, 100 Turns)

Separation vs Core Tune $Q_x = 17.666$ [2,3,8]

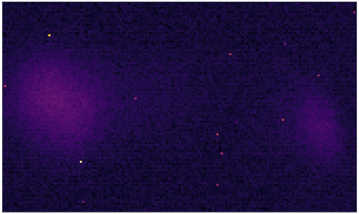


Friendly User Test Week: Overview

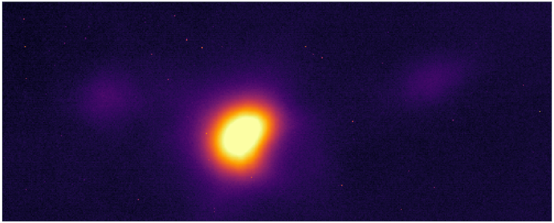
All Current On Core Orbit [2]



Only Single Bunch on Island Orbit [2]



Single Bunch on Island Orbit, Multibunch on Core [2]



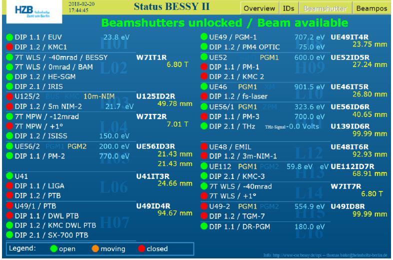
- one entire week (KW 8, 2018) for friendly user experiments
- more external feedback

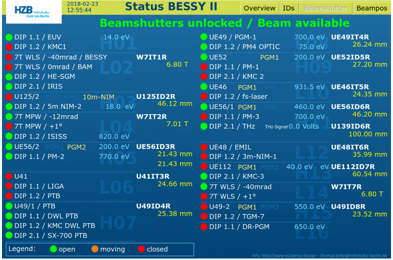
Requirements:

Injection efficiency	$> 90\,\%$
Lifetime	$> 5\,\mathrm{h}$

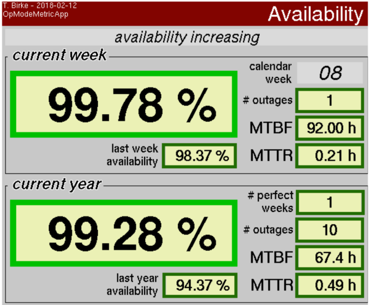
Friendly User Test Week: Overview

Open Beamshutters, Tuesday/Friday [9]



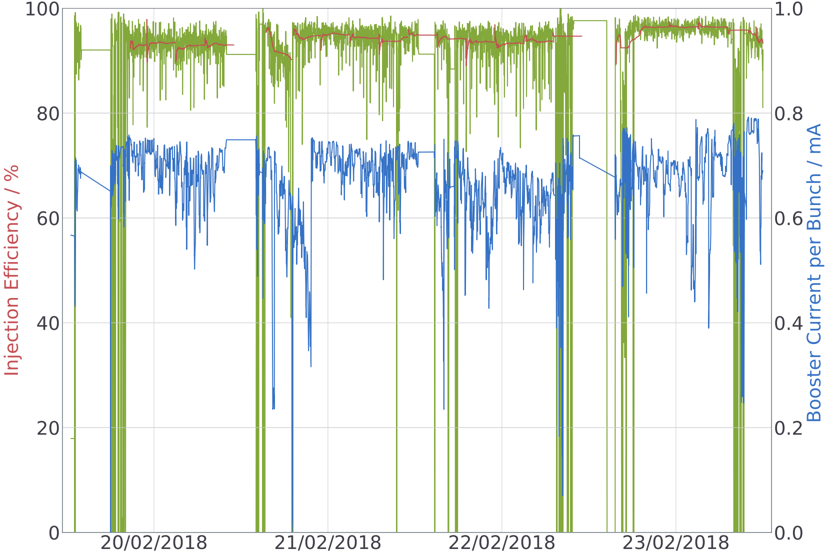


Total Availability [9]

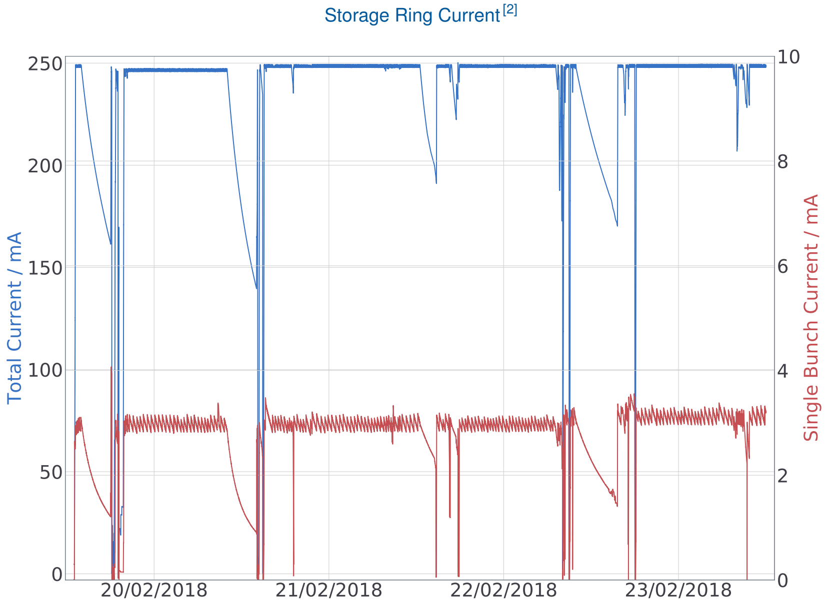


Friendly User Test Week: Stability

Injection Efficiency [2]

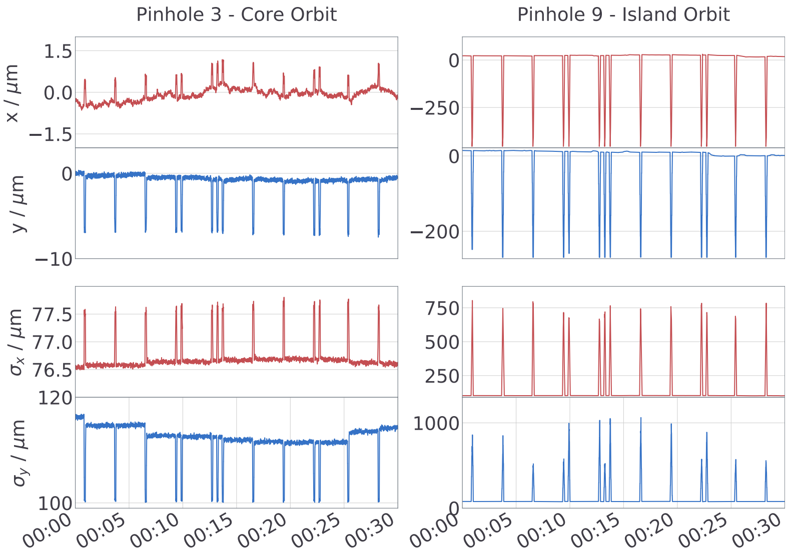


Friendly User Test Week: Stability



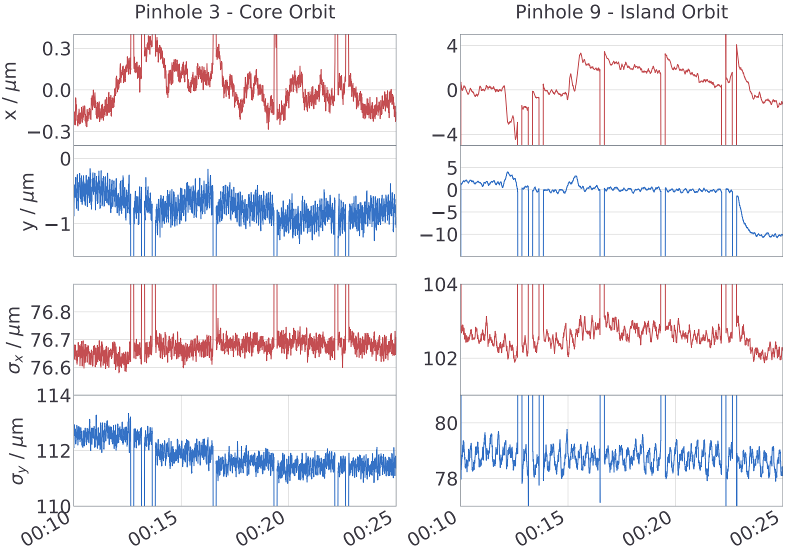
Friendly User Test Week: Stability

Beam Stability, Friday 23rd [2]



Friendly User Test Week: Stability

Beam Stability, Friday 23rd [2]



Friendly User Test Week: Feedback

General Tone

- No major unsolvable problems observed
- Roughly same quality for experiments
- UE52: very positive, seperation possible without bump
- UE56-2: Easy to switch
- Gregor: Easy separation, No problems with gas phase target as not dependant on beam pos/sigma
- signal cleaner than chopper, much smaller leftover signal

Main Problem: Injection Scheme

- Standard Top Up: 100ms pre and 50 posttrigger
- TRIBs Top Up: 8s widened beam with intensity drop
- Different beam conditions which not all users can compensate
- Big problem for spectroscopy and microscopy
- Feedback loops steer away in this time
- Strong kick at Island Collapse

$\Rightarrow$ Provide Additional Pre- and Posttrigger for sensitive users

$\Rightarrow$ Reduce excitation to $<$500 ms (disregard 1 image from on the fly scan)

Epilogue: Conclusion and outlook

Summary

- Resonant islands as bunch seperation scheme provides seems very promising
- LOCO in combination with nonlinear optics from conversion factors not bad
- Chromaticity, TSWA, Separation and Tune dependany provide good observables to verify optics
- Tuneshift with amplitude (TSWA) is measurable with the bbfb system
- TSWA simulation with elegant gives results in order of measurement

Outlook

Nonlinear optics are the key for optimization of TRIBs optics

$\Rightarrow$ Characterize the nonlinear lattice of BESSY II

- $\rightarrow$ chromaticity
  - $\rightarrow$ chromatic sextupoles
- $\rightarrow$ tune shift with amplitude
  - $\rightarrow$ harmonic sextupoles

$\Rightarrow$ Master control of resonance islands

- $\rightarrow$ numerical optimization of trusted nonlinear lattice
- $\rightarrow$ phase space of one-turn map from the general hamiltonian

Thank you for your attention!

AKNOWLEDGEMENT AND PARTNERS

Federal Ministry
of Education
and Research

HZB Helmholtz
Zentrum Berlin

BESSY VSR

HUMBOLDT-UNIVERSITÄT · ZU BERLIN ·

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