Adiabaticity study - update

D. Kelliher 23/01/2020

Aim of Study

- Study the effect of varying the longitudinal parameters on the longitudinal distribution.
- We expect that if the transition is adiabatic the longitudinal emittance should be preserved.
- If the adiabaticity parameter, ε, is sufficiently low (~0.1), a distribution which is initially at equilibrium will remain in equilibrium.
- Questions to address
    - is the onset of emittance growth a threshold effect?
    - Can we establish an equation for emittance growth as a function of adiabaticity?

$$\epsilon = \frac{1}{\omega_s^2}\left|\frac{d\omega_s}{dt}\right|$$

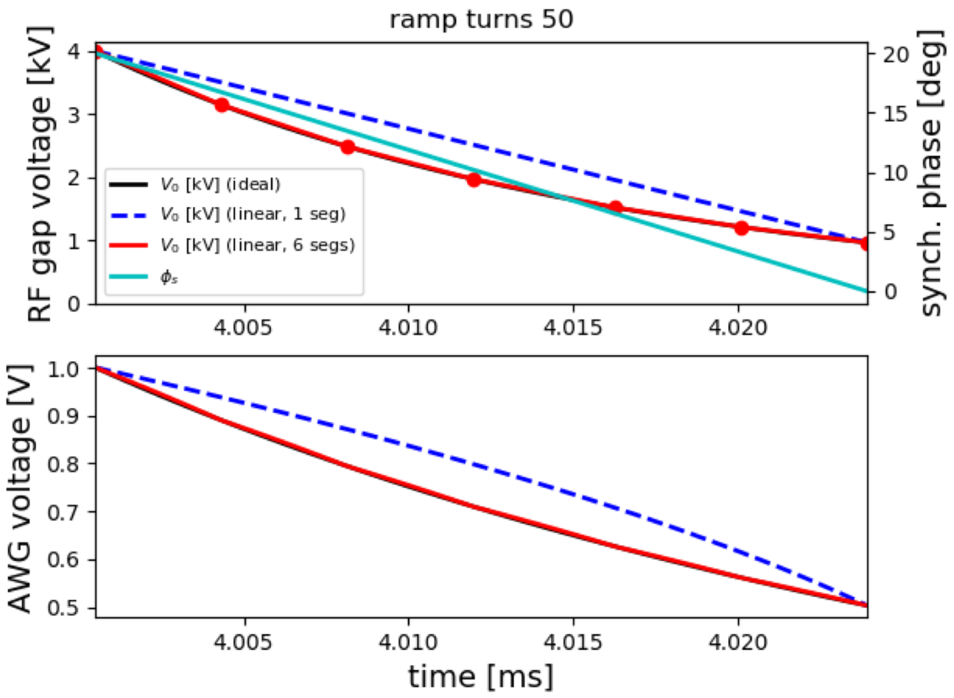
Proposed Experiment
(adapted from 15/10/2019)

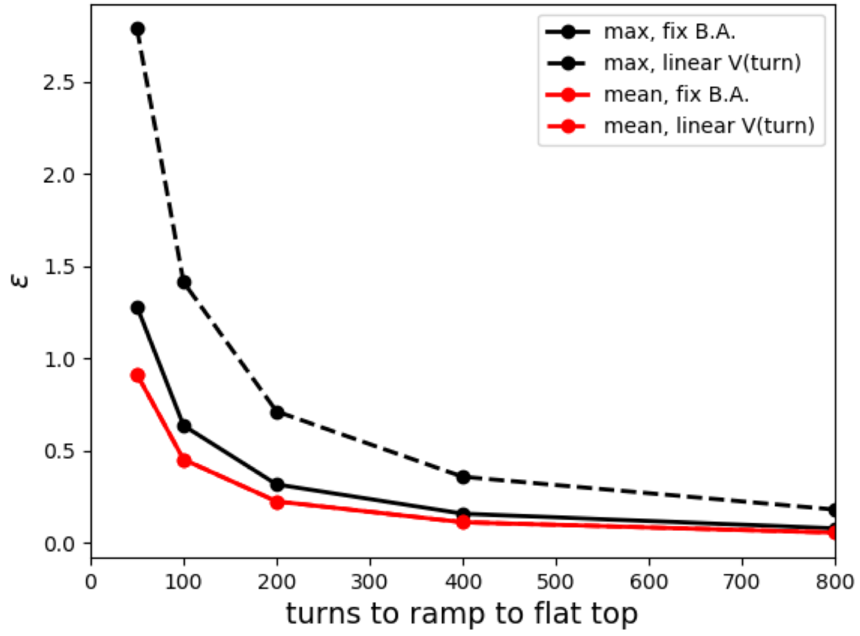
Aim: Experimentally measure the dependence of longitudinal emittance growth on the adiabatic parameter.

- Accelerate with usual settings until some point where beam has escaped foil and the emittance has reached an equilibrium.
- Ramp to zero phi_s over a range of turns. At the same time, ramp the voltage to preserve the bucket area. Note: the flat top energy varies with number of turns.
- Maintain flattop for many synchrotron oscillations.
- Use raw bunch monitor data or tomography to measure emittance blow up if any.

Specifying transition settings

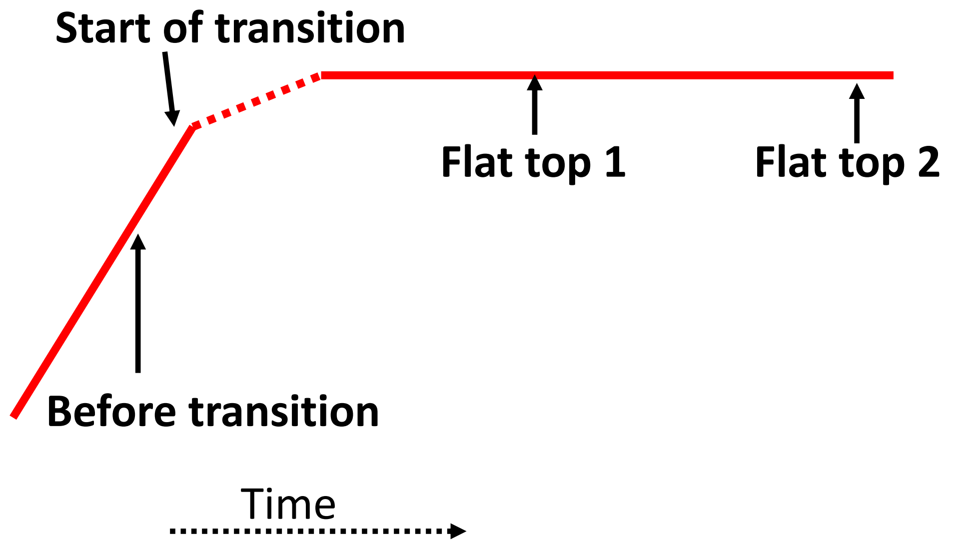
- Ramp phi_s from 20 deg to 0 in varying number of turns while adjusting the voltage to keep the bucket area constant.





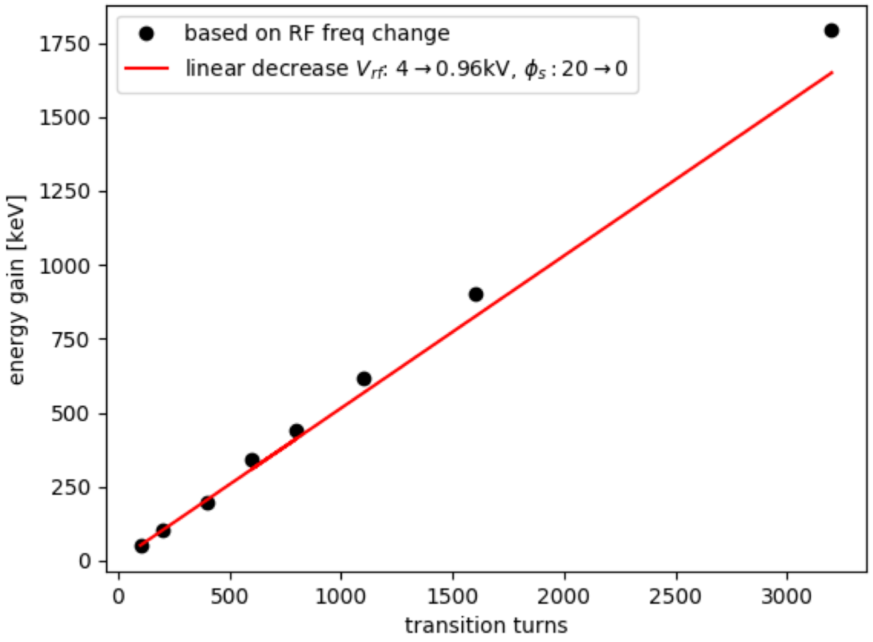
Data summary

Case	Ramp turns	Peak ε	Dates
~~0~~	~~50~~	~~1.29~~	–
1	100	0.70	9/12, 12/12
2	200	0.35	9/12, 12/12
3	400	0.178	9/12, 12/12
4	800	0.09	9/12, 12/12
5	600	0.119	12/12
6	1100	0.066	12/12
7	1600	0.045	12/12
8	3200	0.023	12/12



- Data taken before transition and at two later times in the flat top (about 50 and 100 synchrotron oscillations later).
- Triggers times of data acquisition: 6.162ms, 6.842ms, 9.542ms, 12.242ms
- 1 sets of data taken per condition taken on 9/12, 3 sets of 12/12.

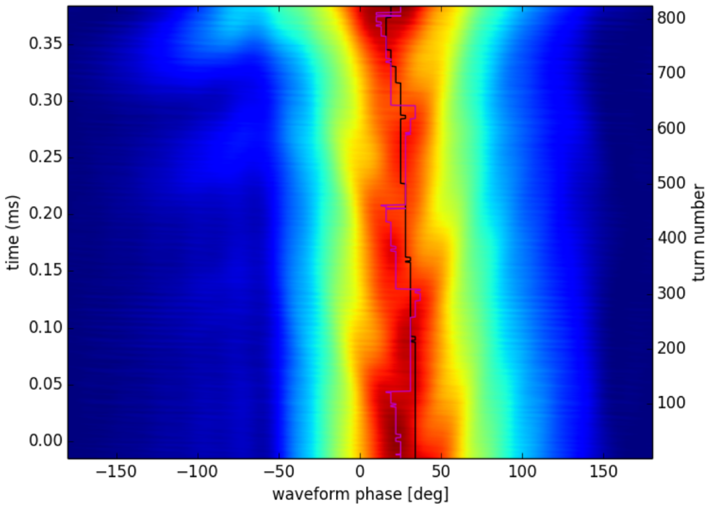
Energy calculation



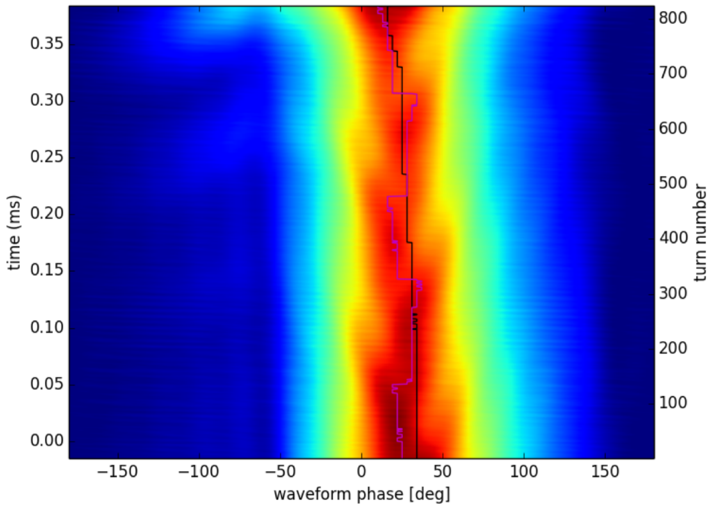
- Calculate frequency of RF waveform at the start of transition and during flat top.
- Use table (svk20.dat) to convert to kinetic energy.
- Energy increase from start to end of transition roughly consistent with expected value.

Before transition
(filter applied, 9/12)

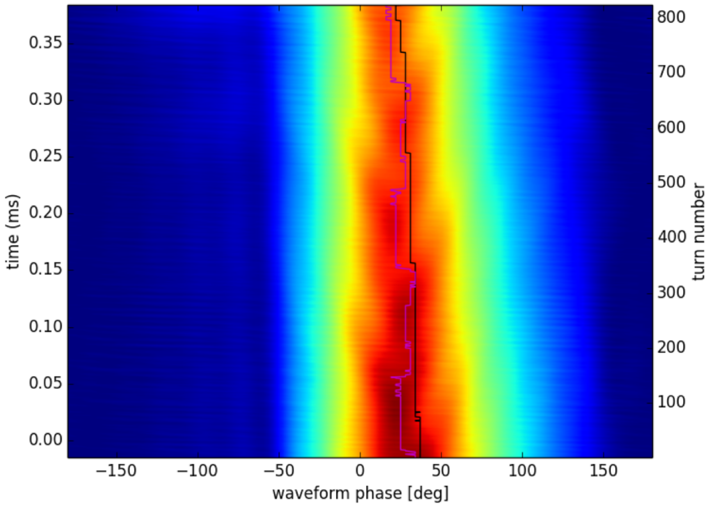
Case 1



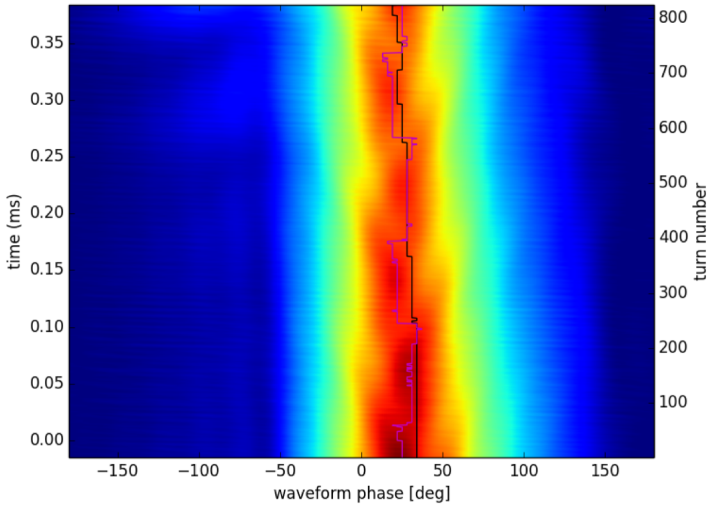
Case 2



Case 4



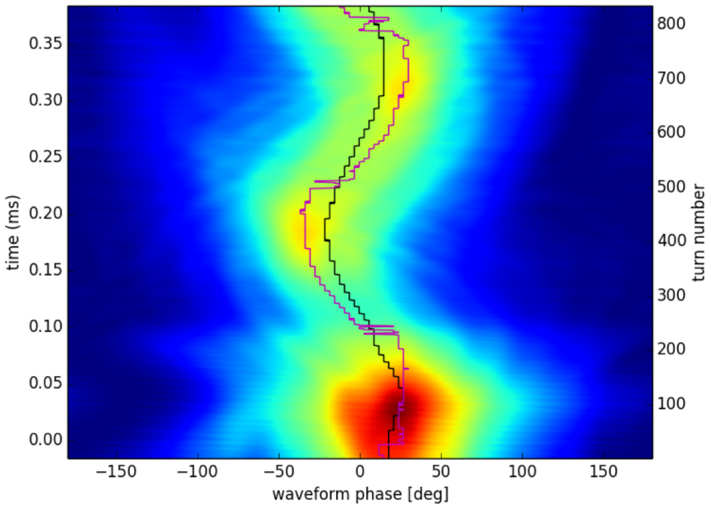
Case 3



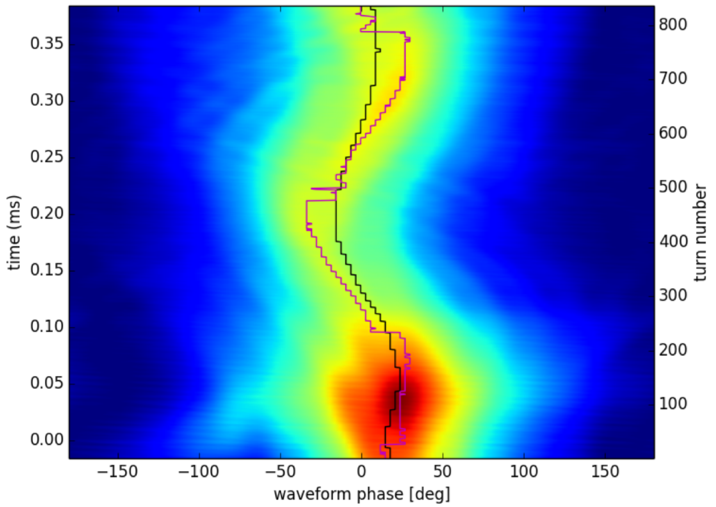
Transition

(filter applied, 9/12)

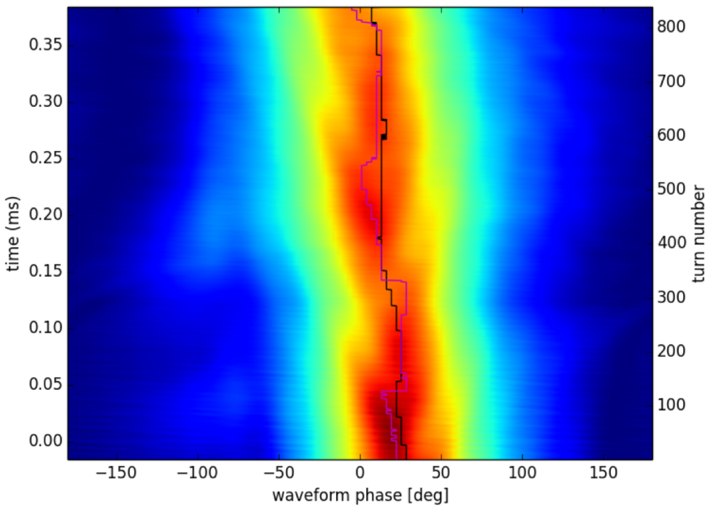
Case 1



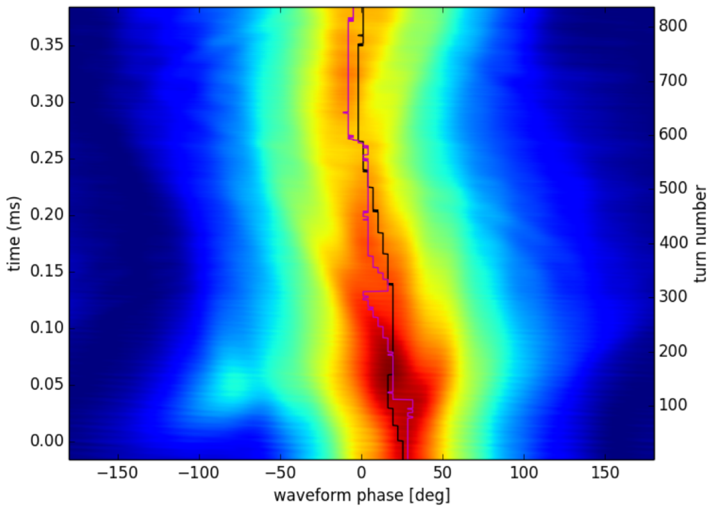
Case 2



Case 4



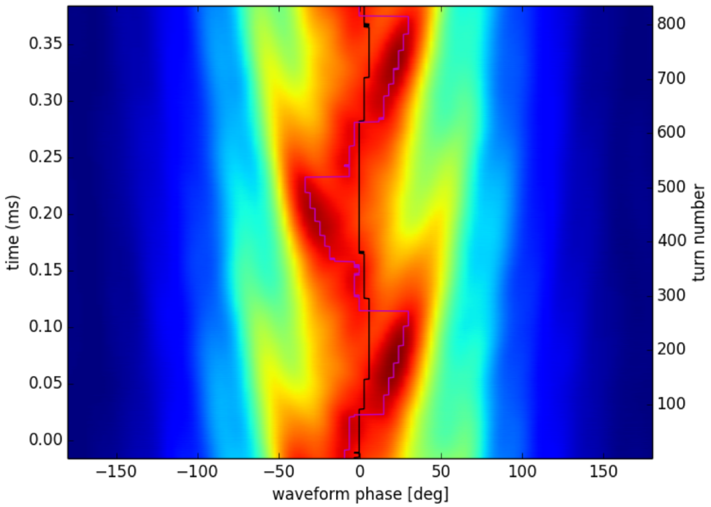
Case 3



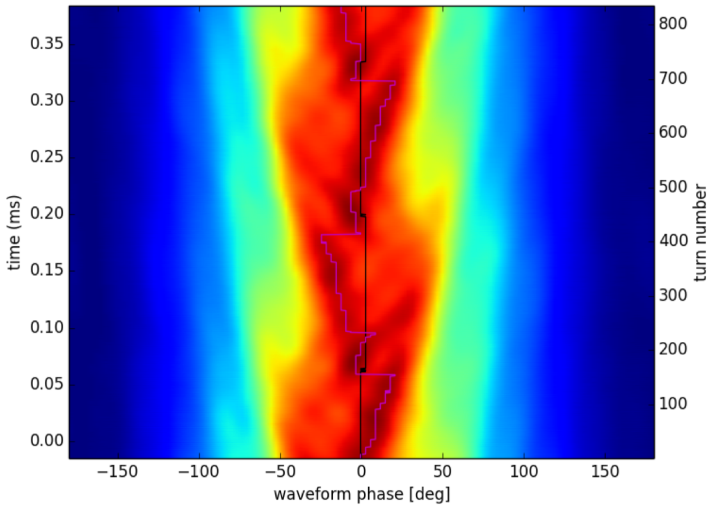
50 synchrotron oscillations later

(filter applied, 9/12)

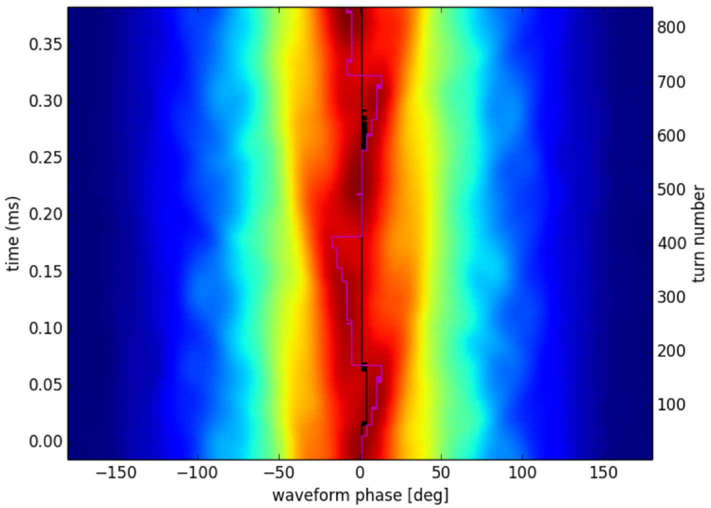
Case 1



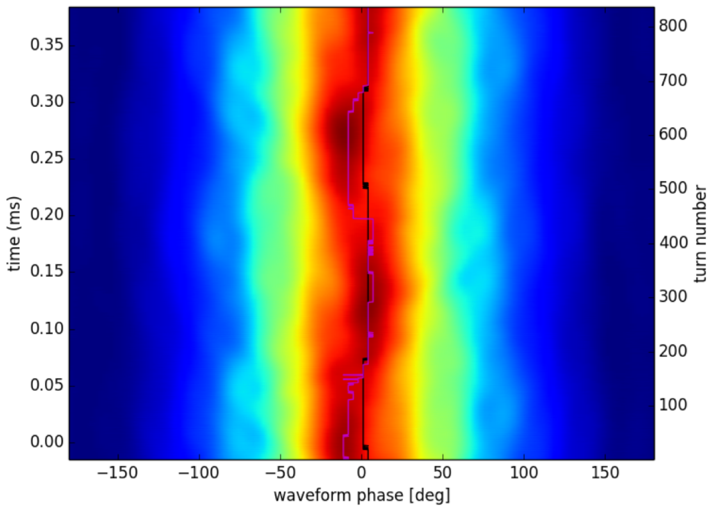
Case 2



Case 4

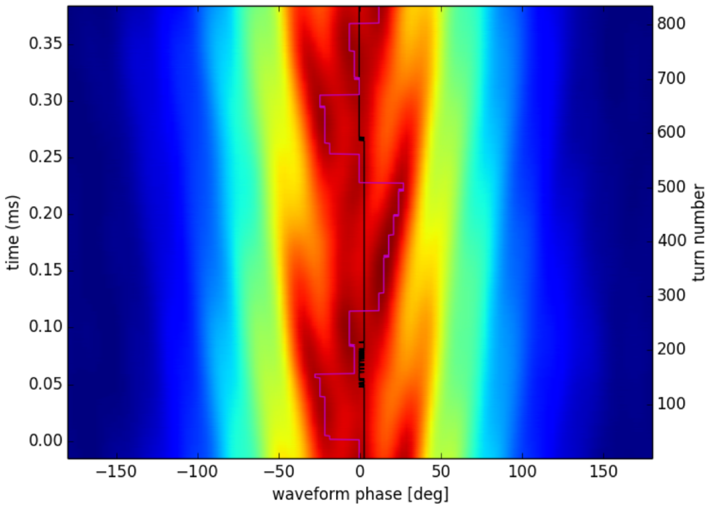


Case 3

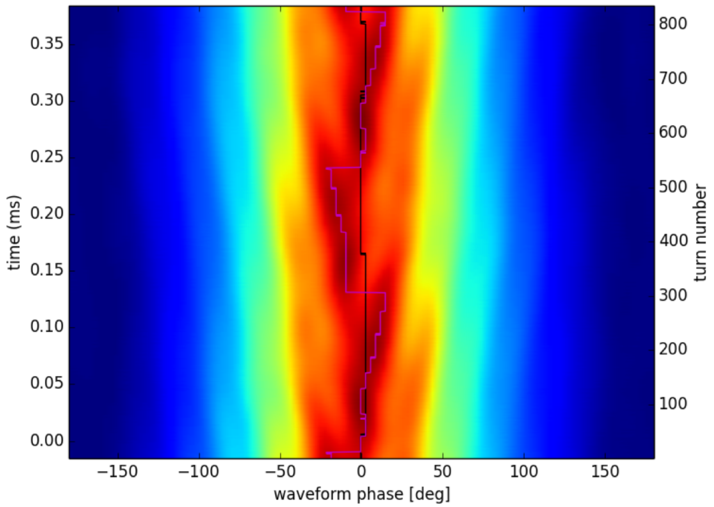


100 synchrotron oscillations later
(filter applied, 9/12)

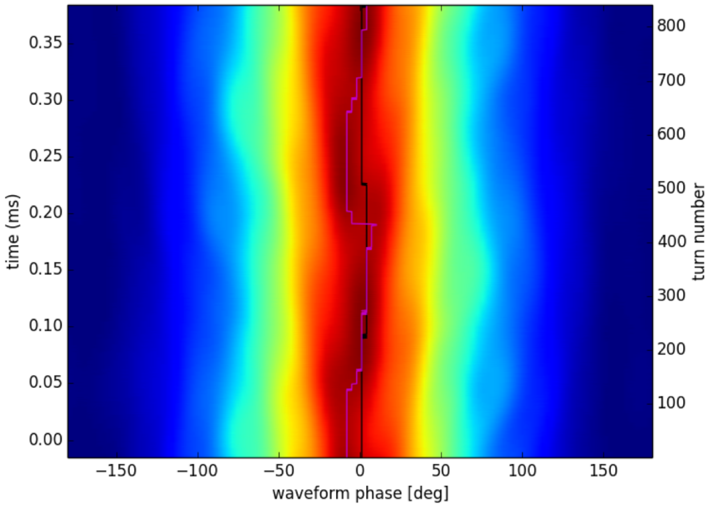
Case 1



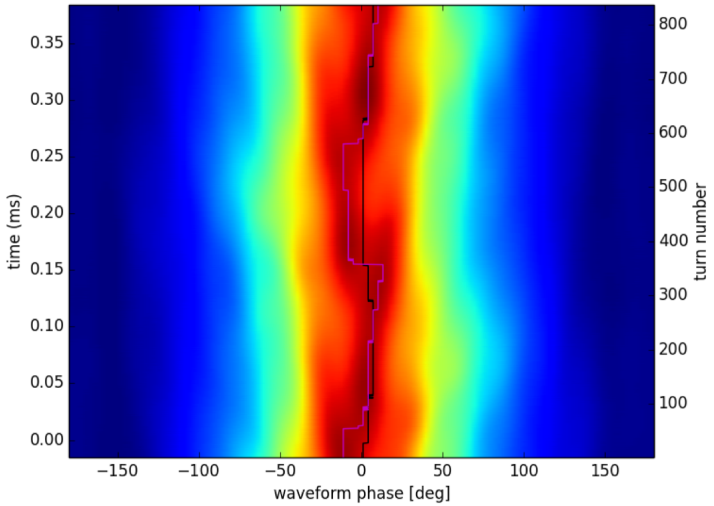
Case 2



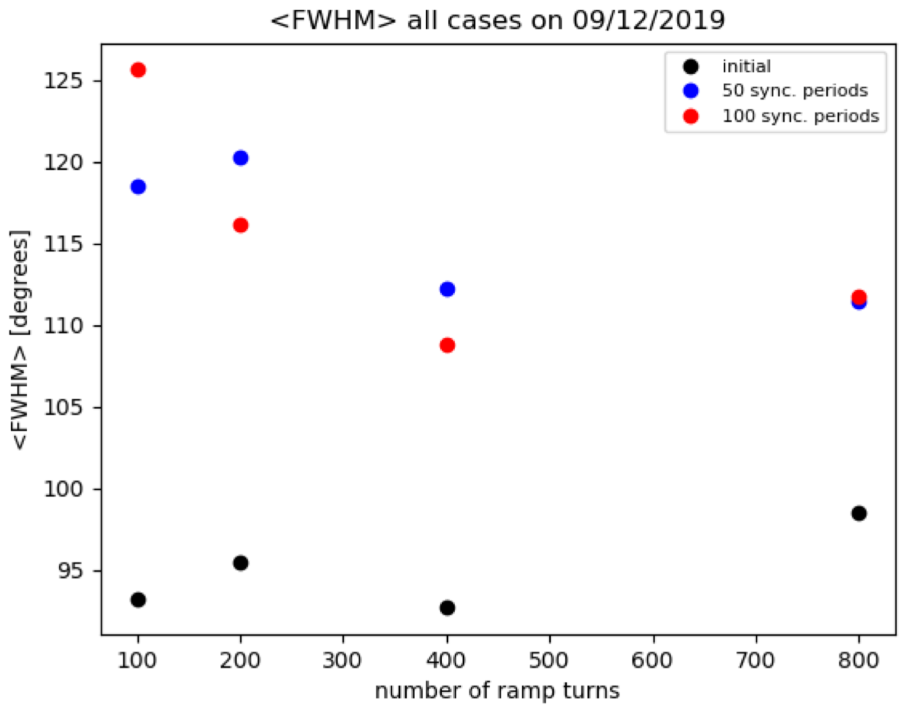
Case 4

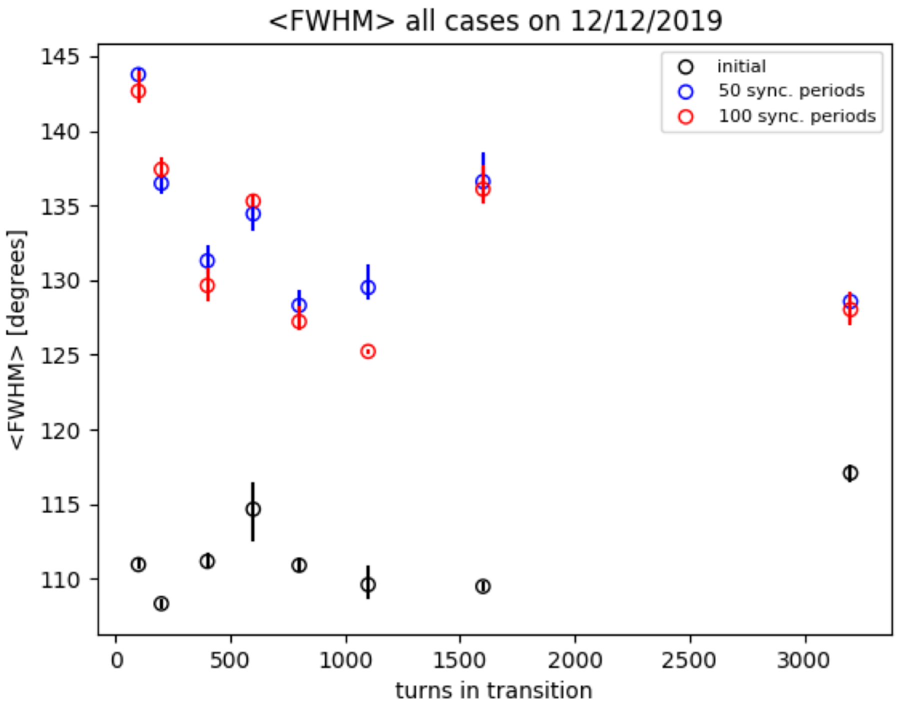


Case 3

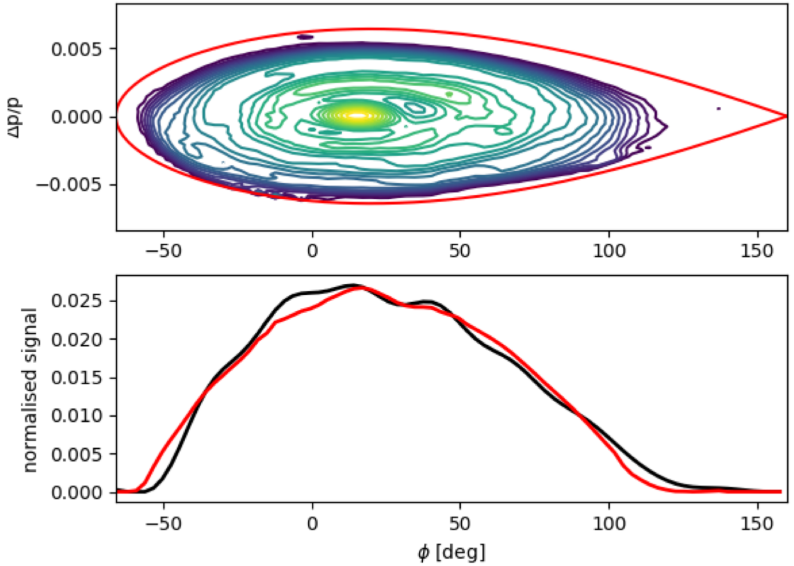


Mean FWHM

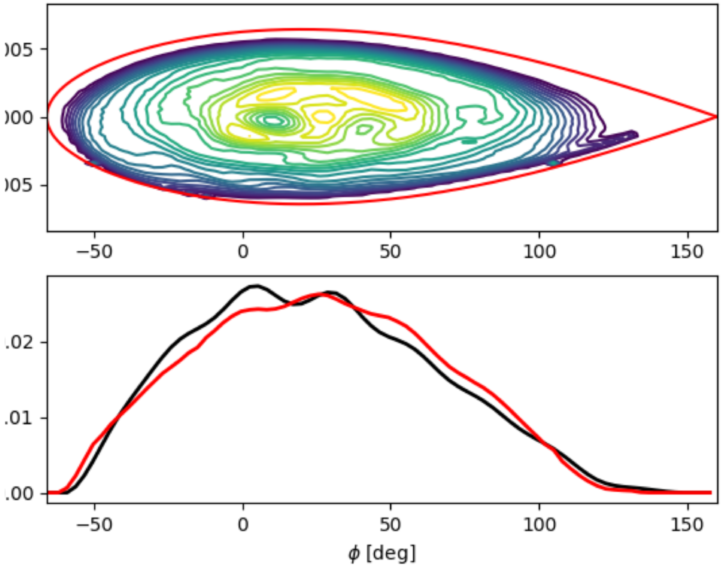

<FWHM> all cases on 09/12/2019
initial
50 sync. periods
100 sync. periods
<FWHM> [degrees]
number of ramp turns
125
120
115
110
105
100
95
100
200
300
400
500
600
700
800


<FWHM> all cases on 12/12/2019
initial
50 sync. periods
100 sync. periods
<FWHM> [degrees]
turns in transition
145
140
135
130
125
120
115
110
0
500
1000
1500
2000
2500
3000

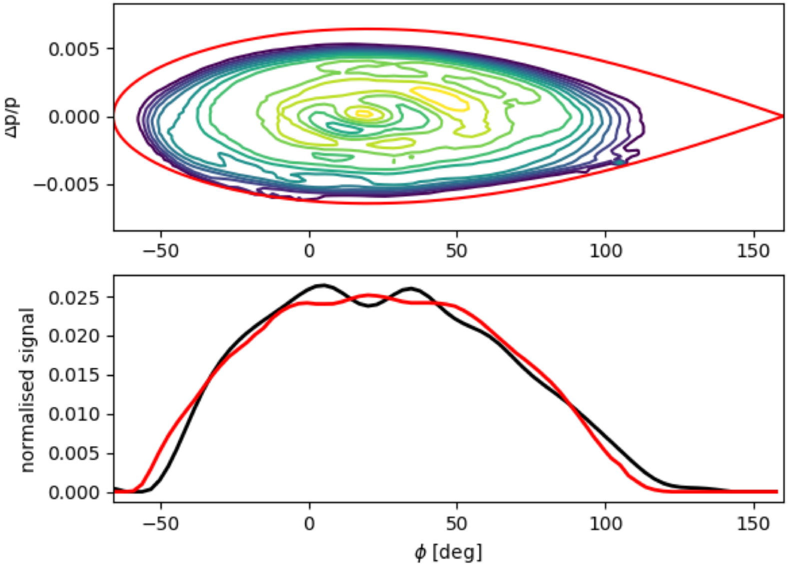
Tomography reconstruction – before transition



ramp turns = 100



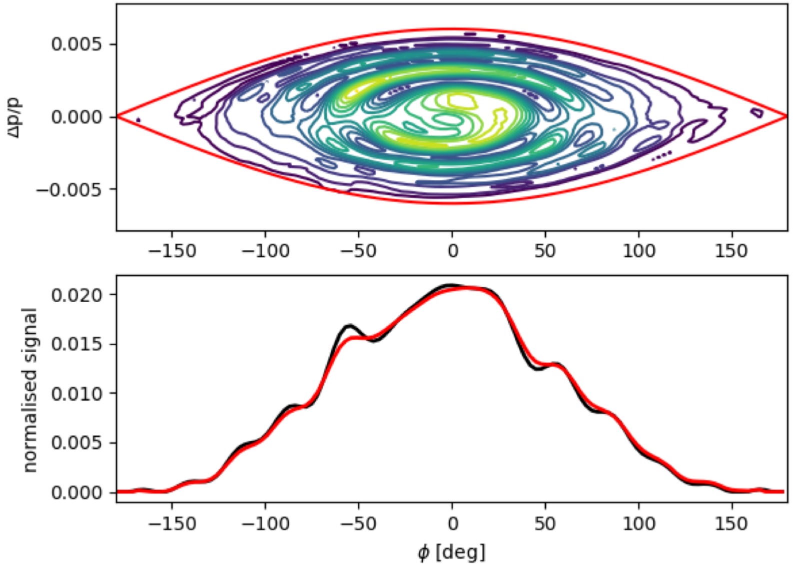
ramp turns = 800



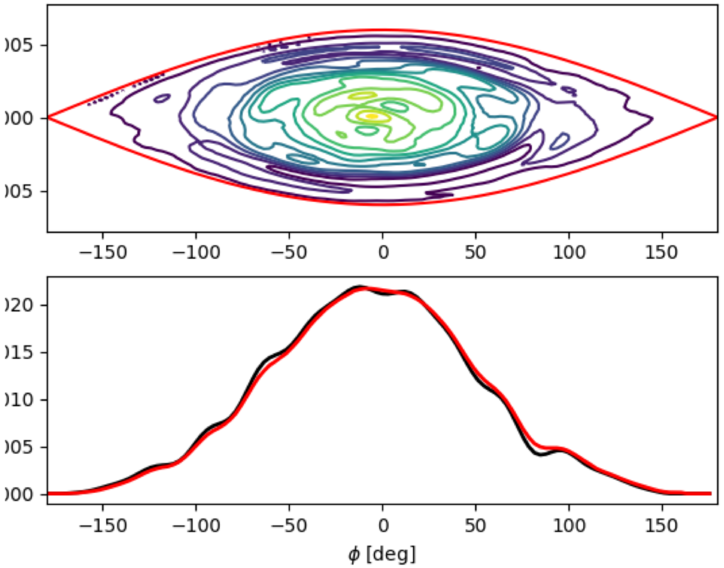
ramp turns = 3200

phi_s = 20 deg, V_rf = 4kV

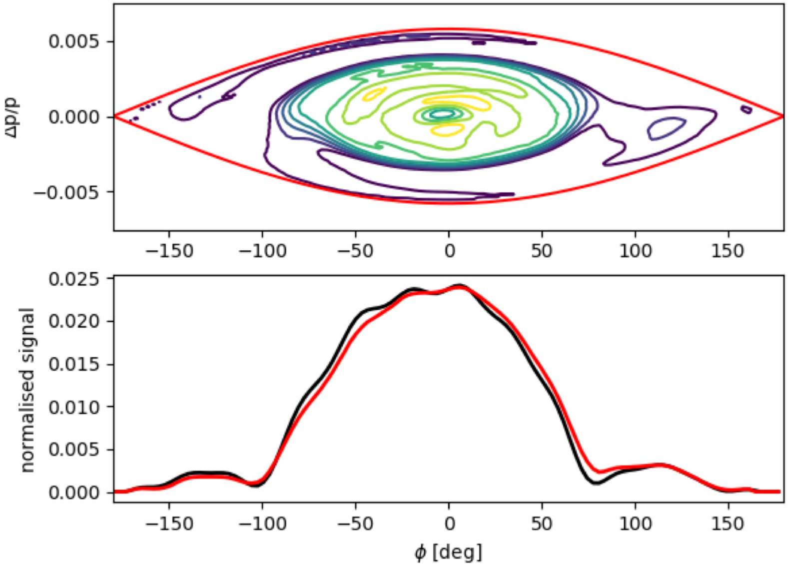
Tomography reconstruction – flat top 1



ramp turns = 100



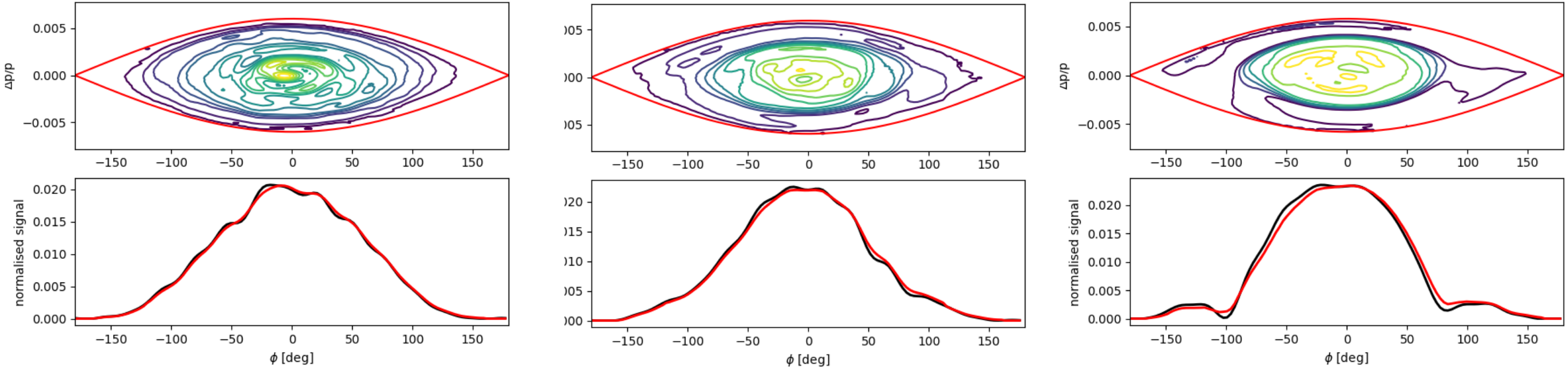
ramp turns = 800



ramp turns = 3200

phi_s = 20 deg, V_rf = 2kV (based on gap voltage monitor)

Tomography reconstruction – flat top 2



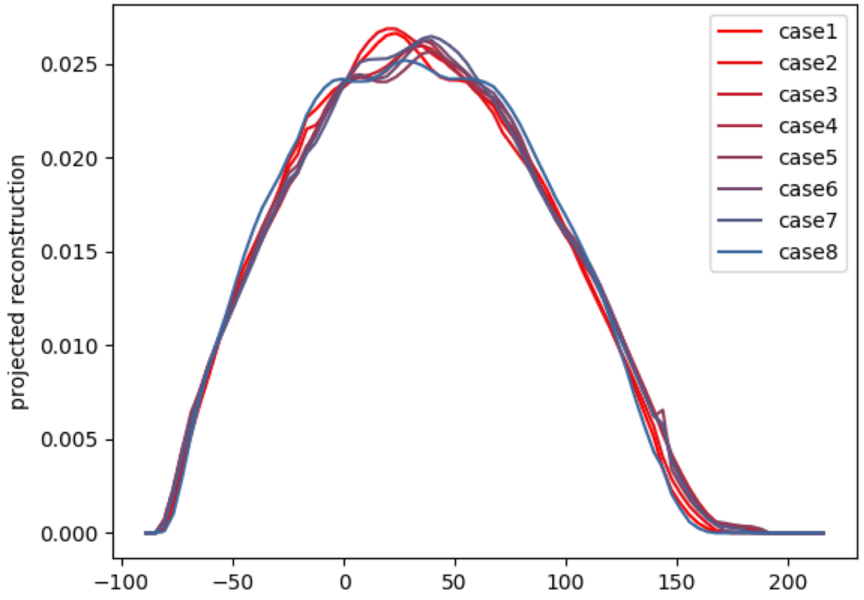
ramp turns = 100

ramp turns = 800

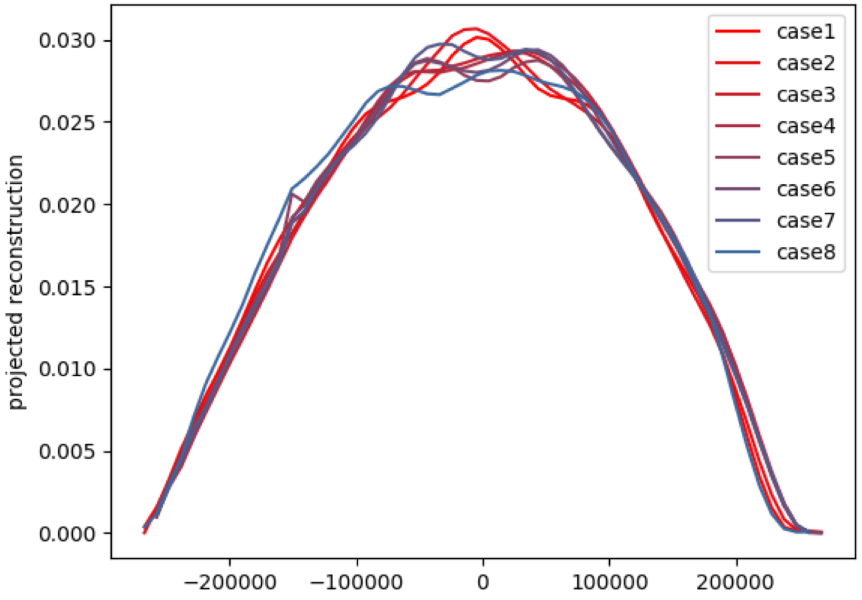
ramp turns = 3200

phi_s = 20 deg, V_rf = 2kV (based on gap voltage monitor)

Tomography – projections of initial distribution

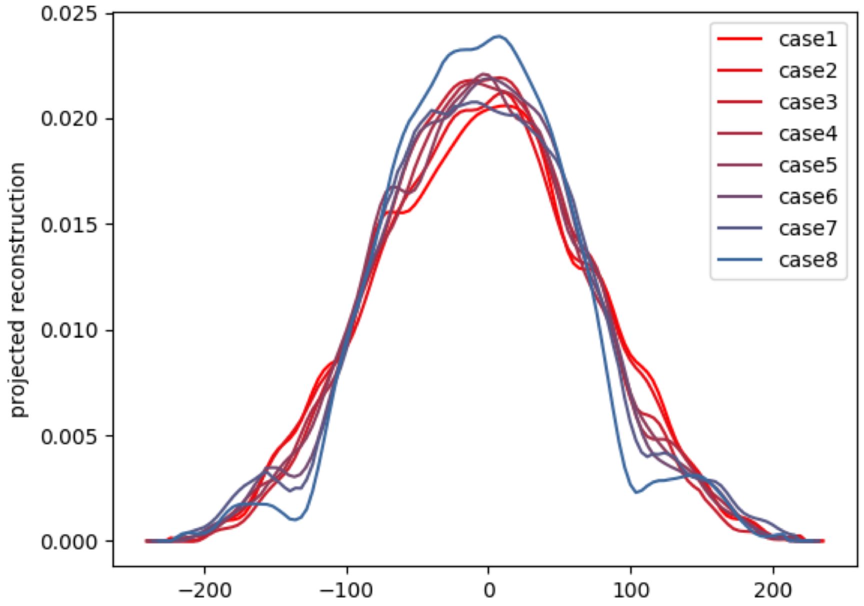


Flat top 1

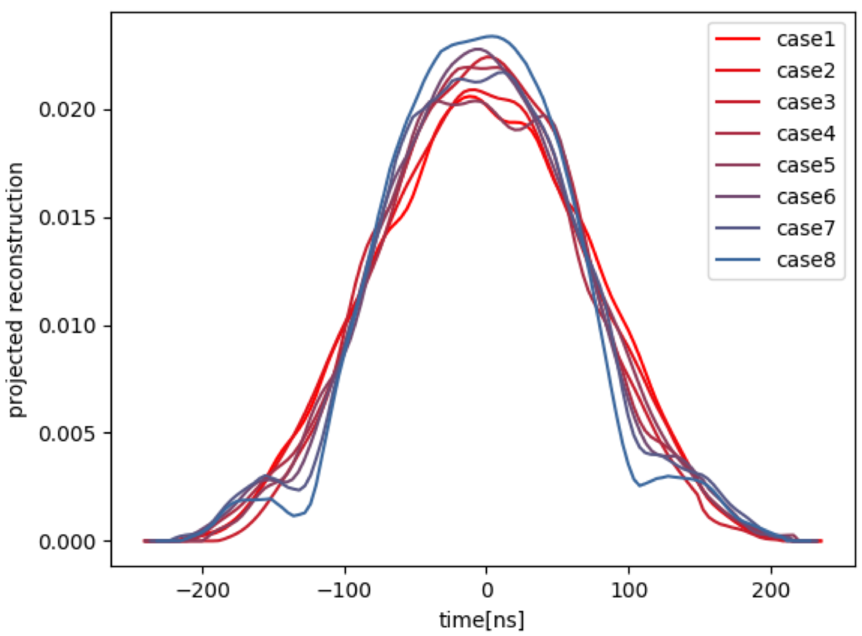


Flat top 2

Tomography – time projections in flat top

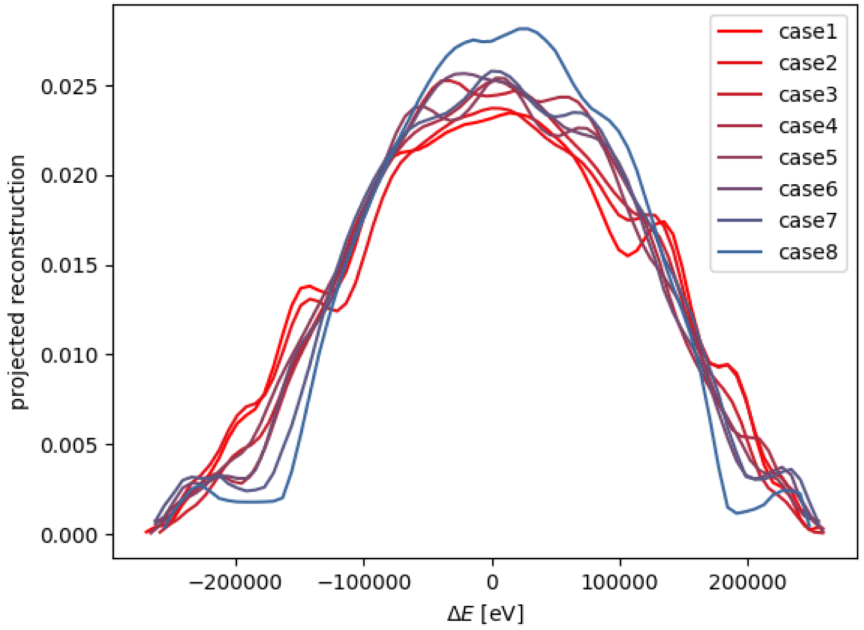


Flat top 1

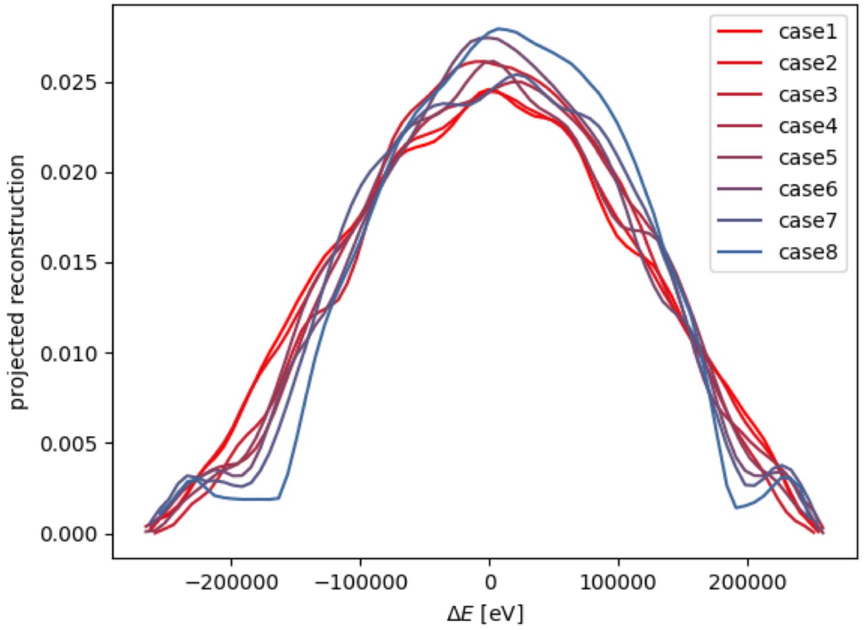


Flat top 2

Tomography – ΔE projections in flat top

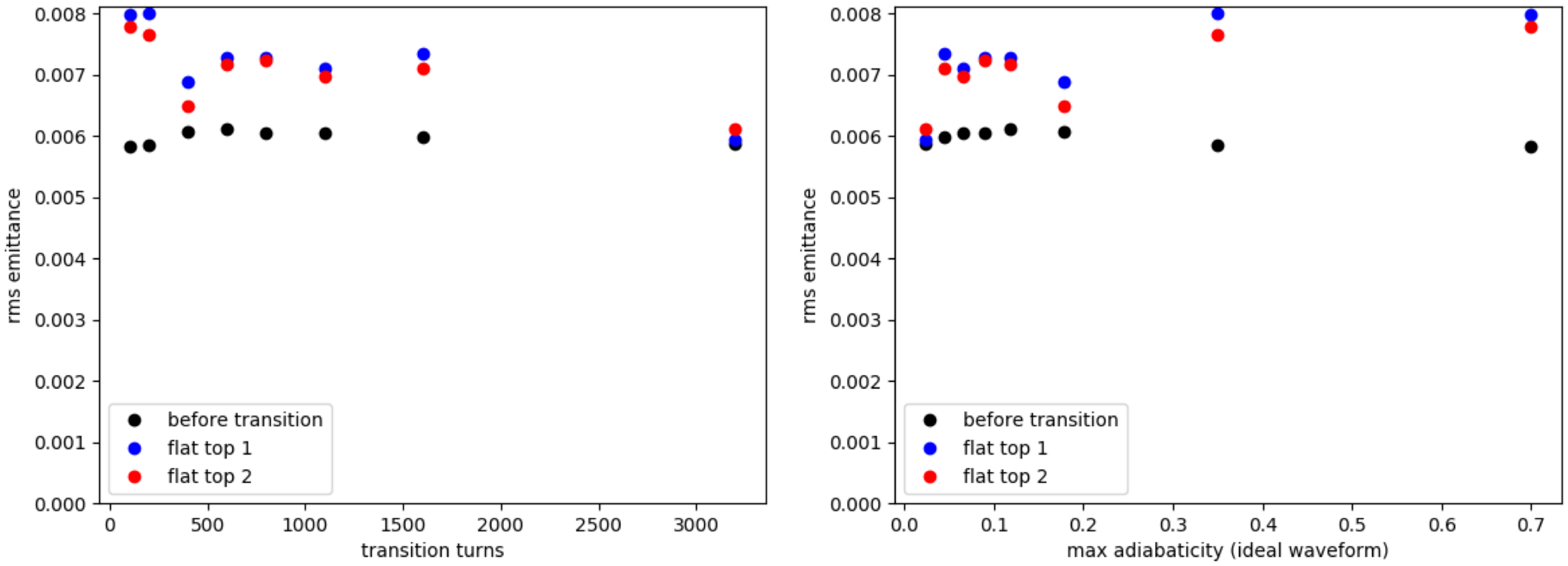


Flat top 1

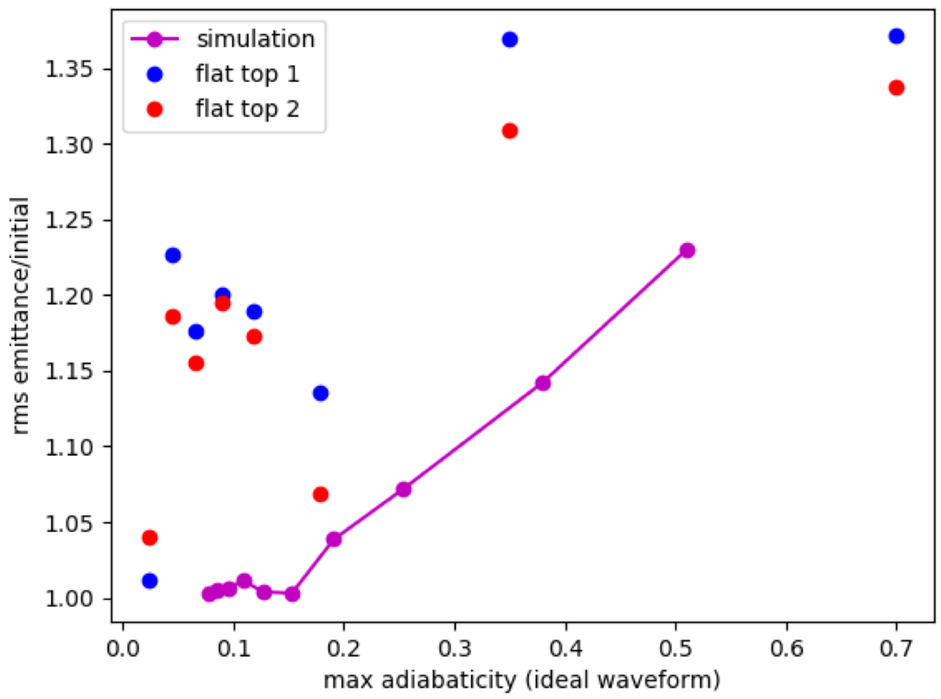


Flat top 2

Tomography – rms emittance



Comparison with simulation



- Simulation used PyHEADTAIL. Start with equilibrium distribution in with approximately same bunch length as measured distribution.