Update on Tune Shifts at Injection

Electron Cloud Meeting

30/09/16

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Introduction

- The heat load is a good measure of the **total** amount of electron cloud in each sector.
- However, the heat load can not be used to determine the effect of electron cloud on the beam itself, as the heat load is dominated by the stripes that are far away from the beam position.
- By looking at the shift in tunes along the batch at injection, we can determine how much the beam is influenced by electron cloud, and therefore infer a **local** electron cloud density.
- The local electron cloud density can be used as input into simulations to determine the effect of chromaticity / octupoles / ADT.
- For example, generating the figure on the right (see E. Benedetto PhD Thesis 2006), which shows stabilising chromaticity vs e-cloud density.

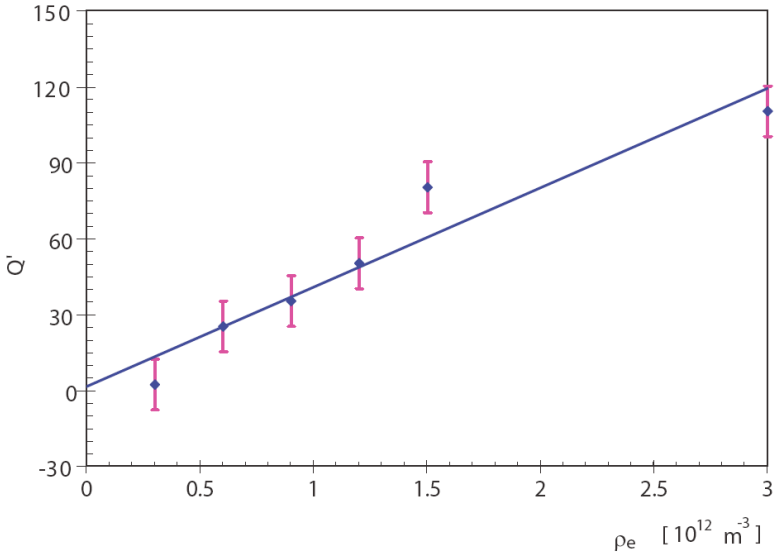
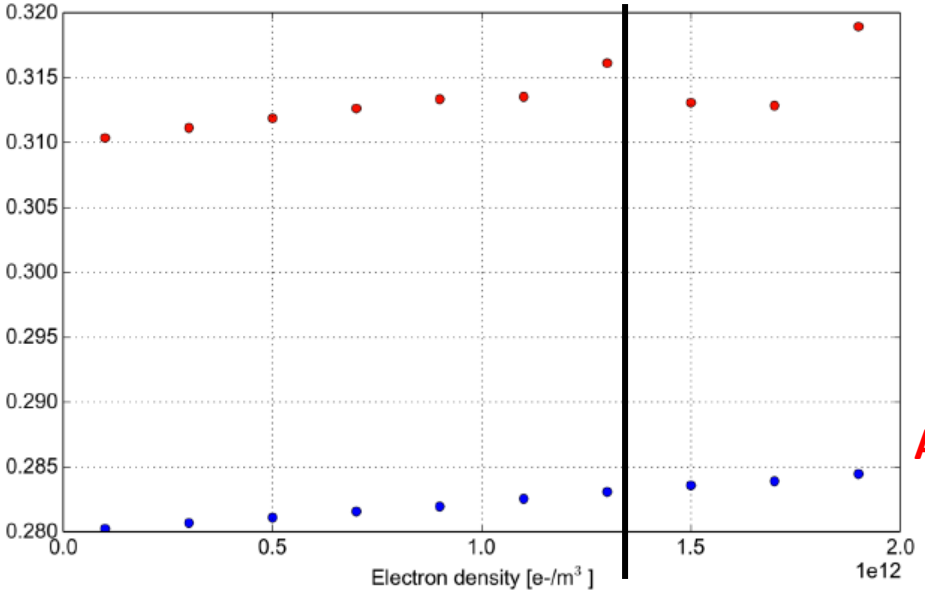


Figure 7.13. Chromaticity as a function of the electron-cloud density level at which the transition between the two regimes occurs in the simulation.

Electron Cloud Densities

- Simulations in PyECLOUD using a single bunch, scanning the e-cloud densities.
- Only the electron cloud from the dipoles are used in the simulation (which accounts for about 65% of the total electron cloud). Simulations that include the quadrupoles are currently being run.
- This can give an approximate conversion between measured tune shift and electron density.



Horizontal
Vertical

A. Romano

unstable

Data Acquisition

- The electron cloud builds up within a few turns, so we can use the data from the injection oscillation to calculate the tune shift along the batch and infer a local e-cloud density.

- We have some miscellaneous 32k turn data from the scrubbing run. But we have been logging 4k turns for all injections since fill 5260 (29/08). So once the tools are perfected we can have a good idea on the progression of the electron cloud from this point.

- There are several different methods one can use to extract the tune from the injection oscillation data:

  Method 1: Take the FFT, find the maximum value in the range $0.1 < Q < 0.4$. Search for sidebands between Qmax +(l-0.5)*Qs and Qmax – (l+0.5)*Qs, and then manually infer the tune shift based on these points.

  Method 2: Take only the injection oscillation data and run them through SUSSIX to acquire the first N harmonics, then apply filtering.

  Method 3: Kotzian Algorithm. Take the Hilbert transform (which returns a real and imaginary part), calculate the phase and do a linear fit to the data from the injection oscillation to determine the phase advance.

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  os

All data is stored on the abpdata eos server. To access: first go to cernbox.cern.ch and perform a one time login.

Then log onto lxplus and go to **/eos/project/abpdata/lhc/injosc**

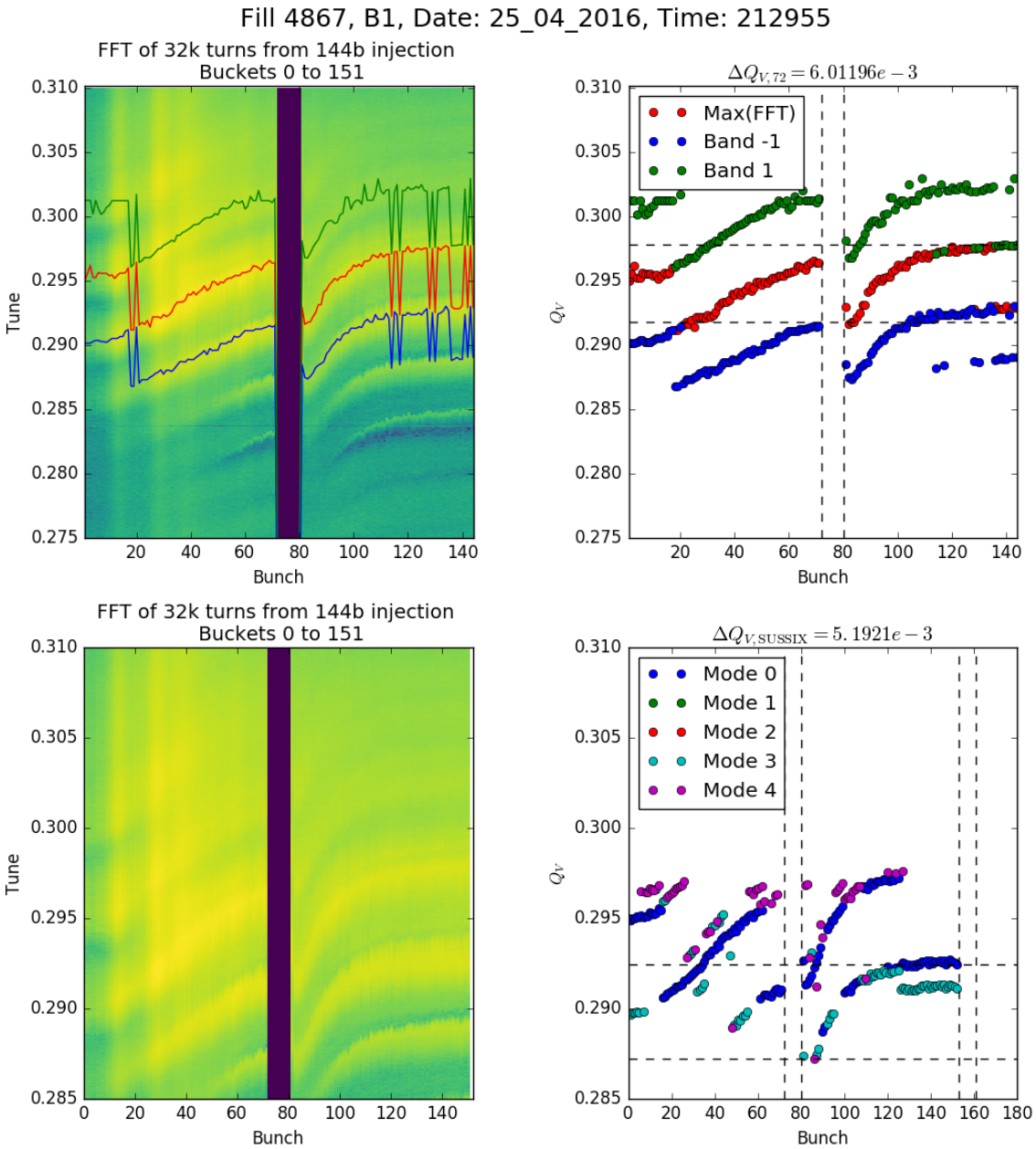
Conversely, they can be accessed by pointing a browser to

cern.ch/abpdata/lhc/injosc

Method 3: Kotzian Algorithm. Take the Hilbert transform (which returns a real and imaginary part), calculate the phase and do a linear fit to the data from the injection oscillation to determine the phase advance.

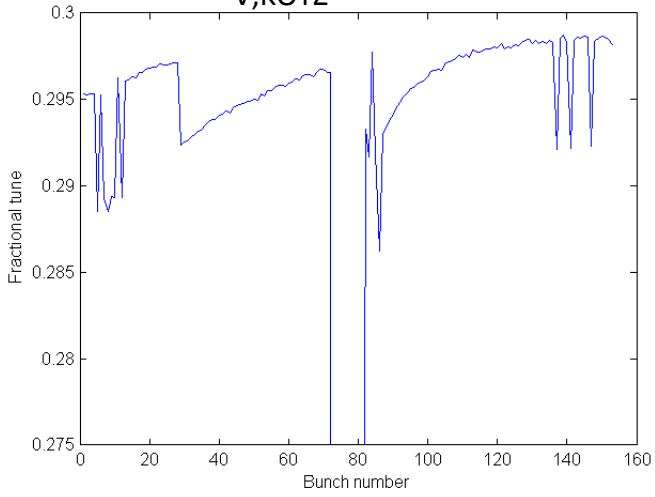
Tune Shifts at Injection - Scrubbing

25th April – 144b Injection in B1

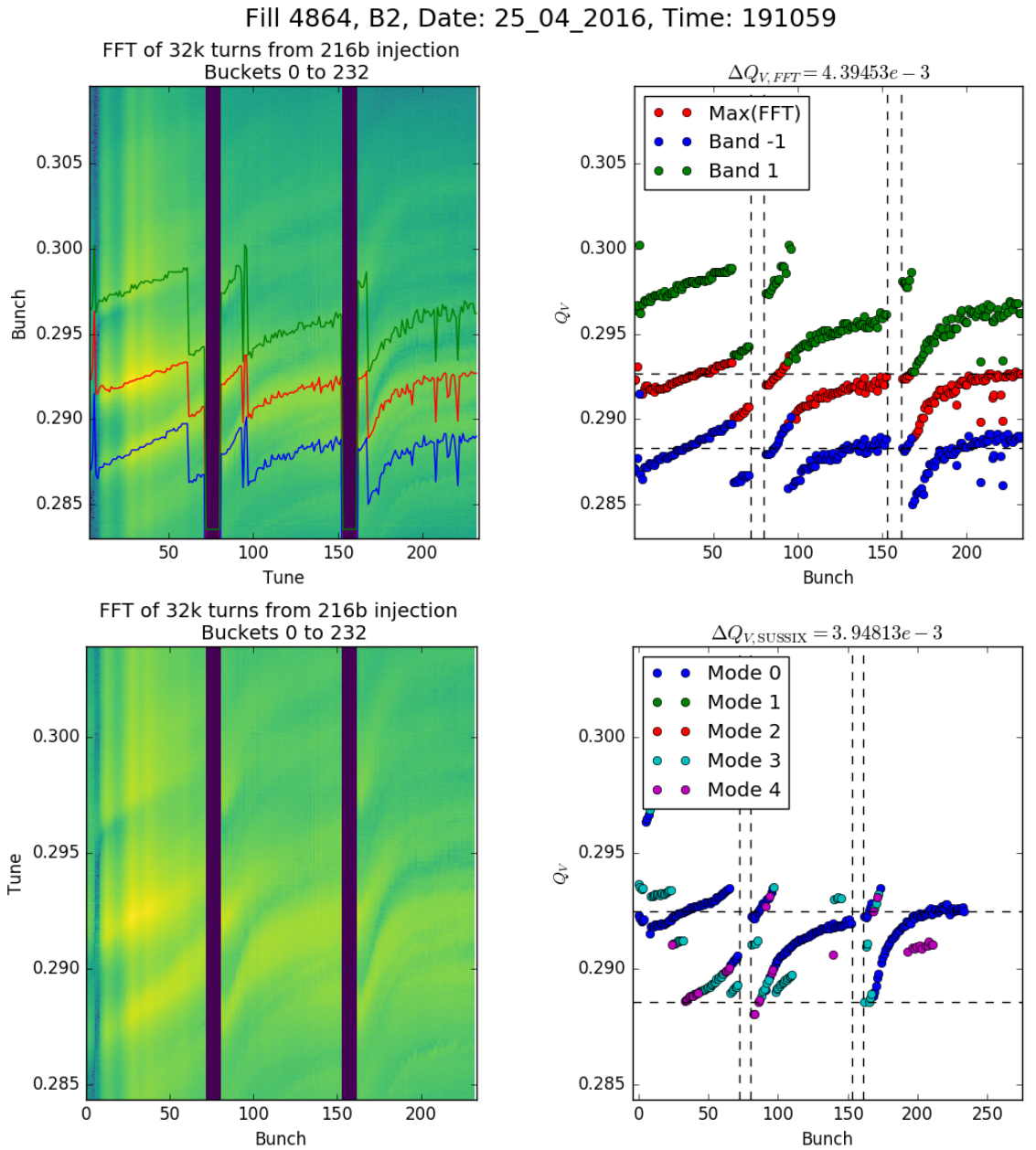


- Scrubbing acquisition for 144b injection.
- Tune shift for batch 2 in 144b injection is ~5.0e-3 to 6.0e-3.
- Corresponds to approximately 1.35e12 e-/ m^3

$\Delta Q_{V,KOTZ} \approx 6e-3$



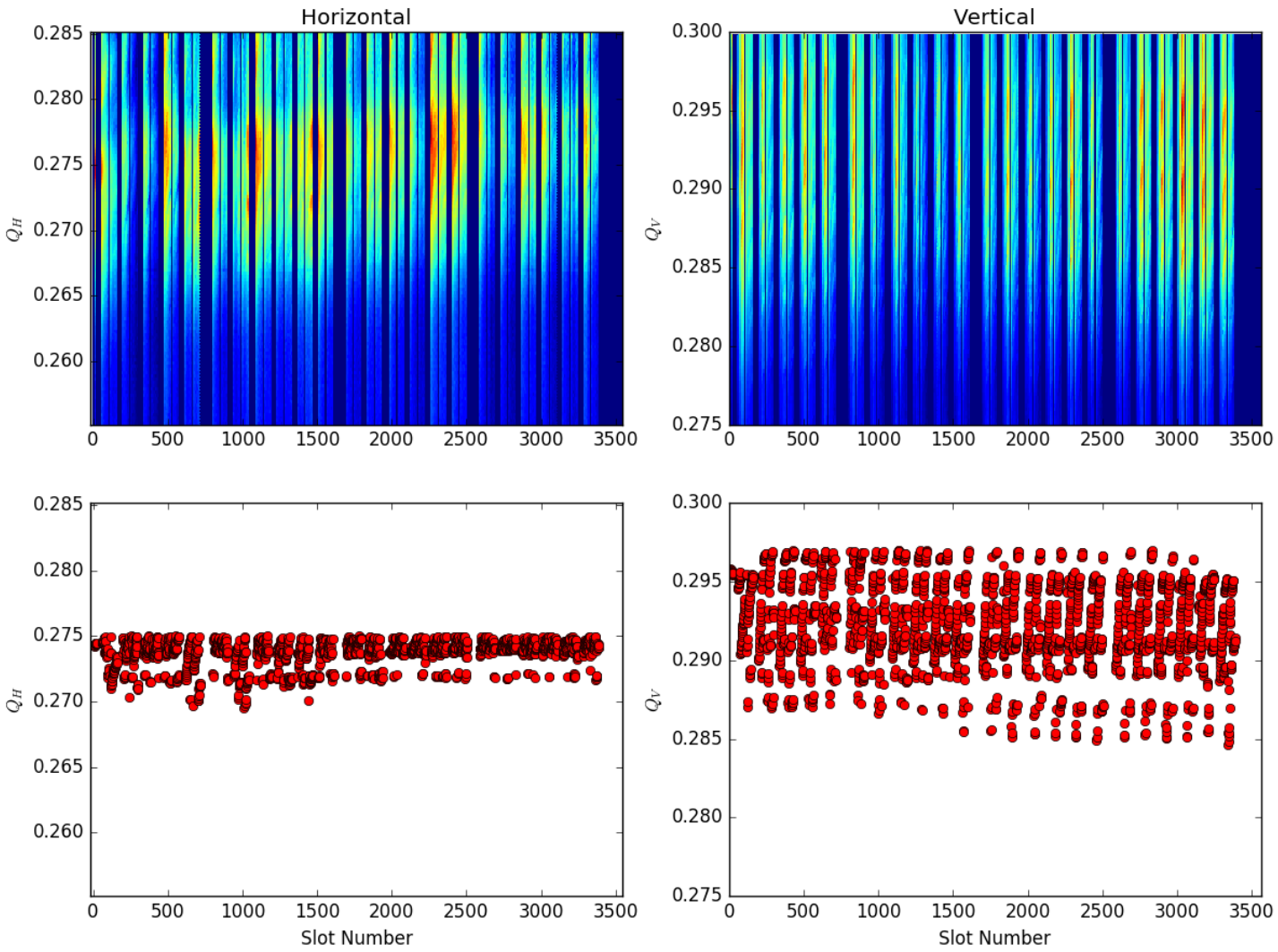
25th April – 216b Injection in B2



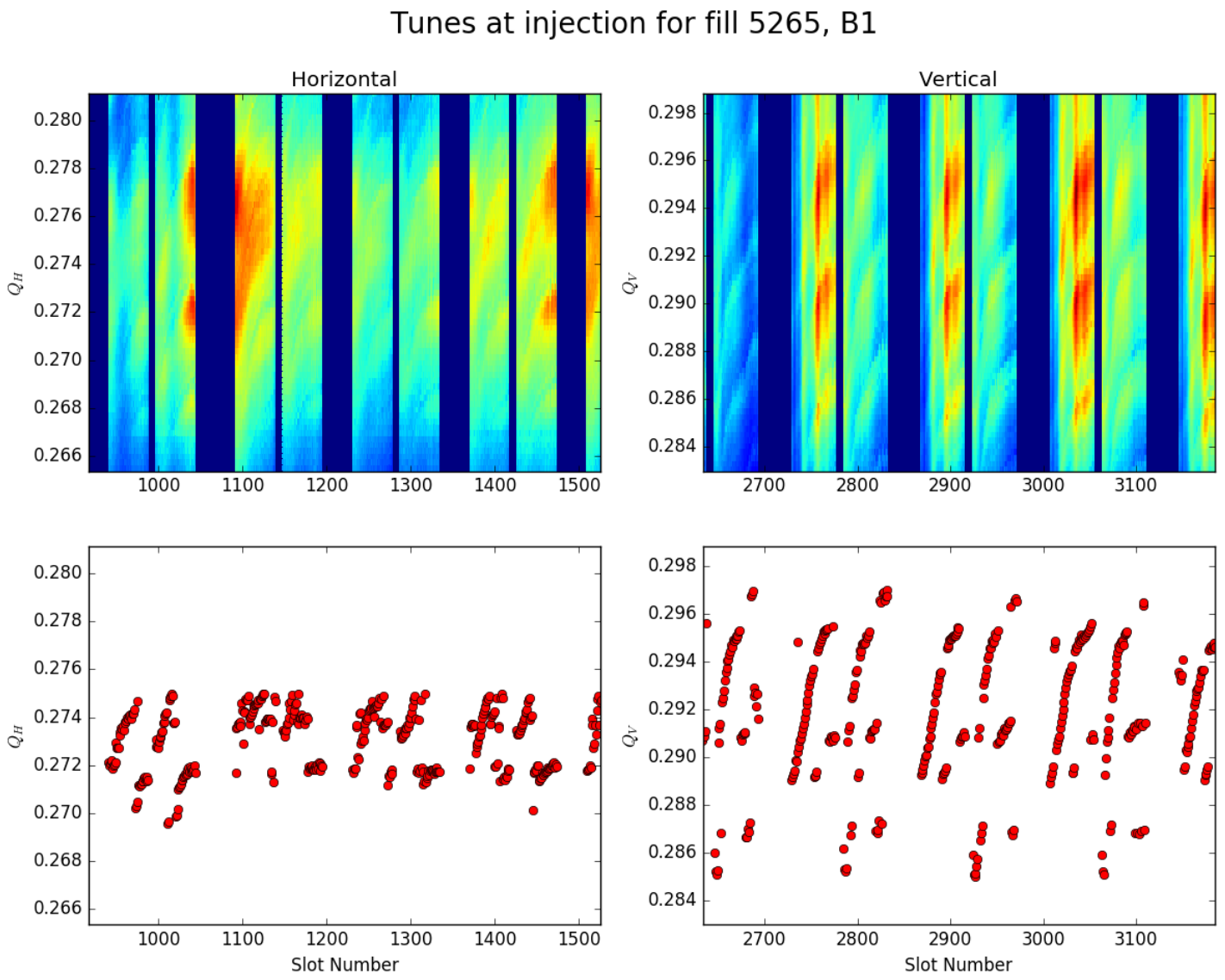
- Scrubbing acquisition for 216b Injection in B2.
- Tune shift for batch 2 and batch 3 in 216b injection is ~3.9e-3 to 4.4e-3.
- Corresponds to around 0.9e12 e-/m^3.

Tune Shifts at Injection – From August

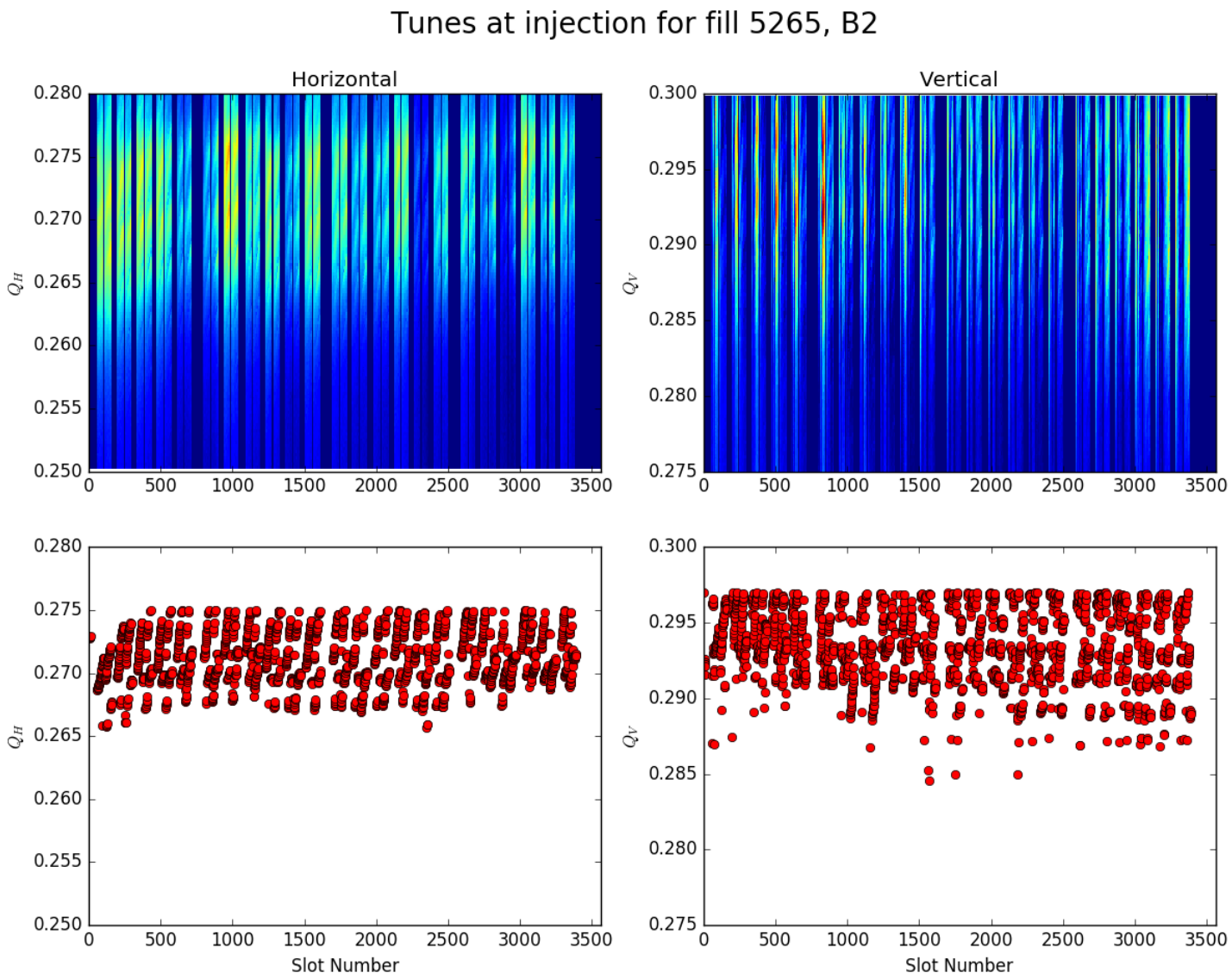
31st August – Fill 5265



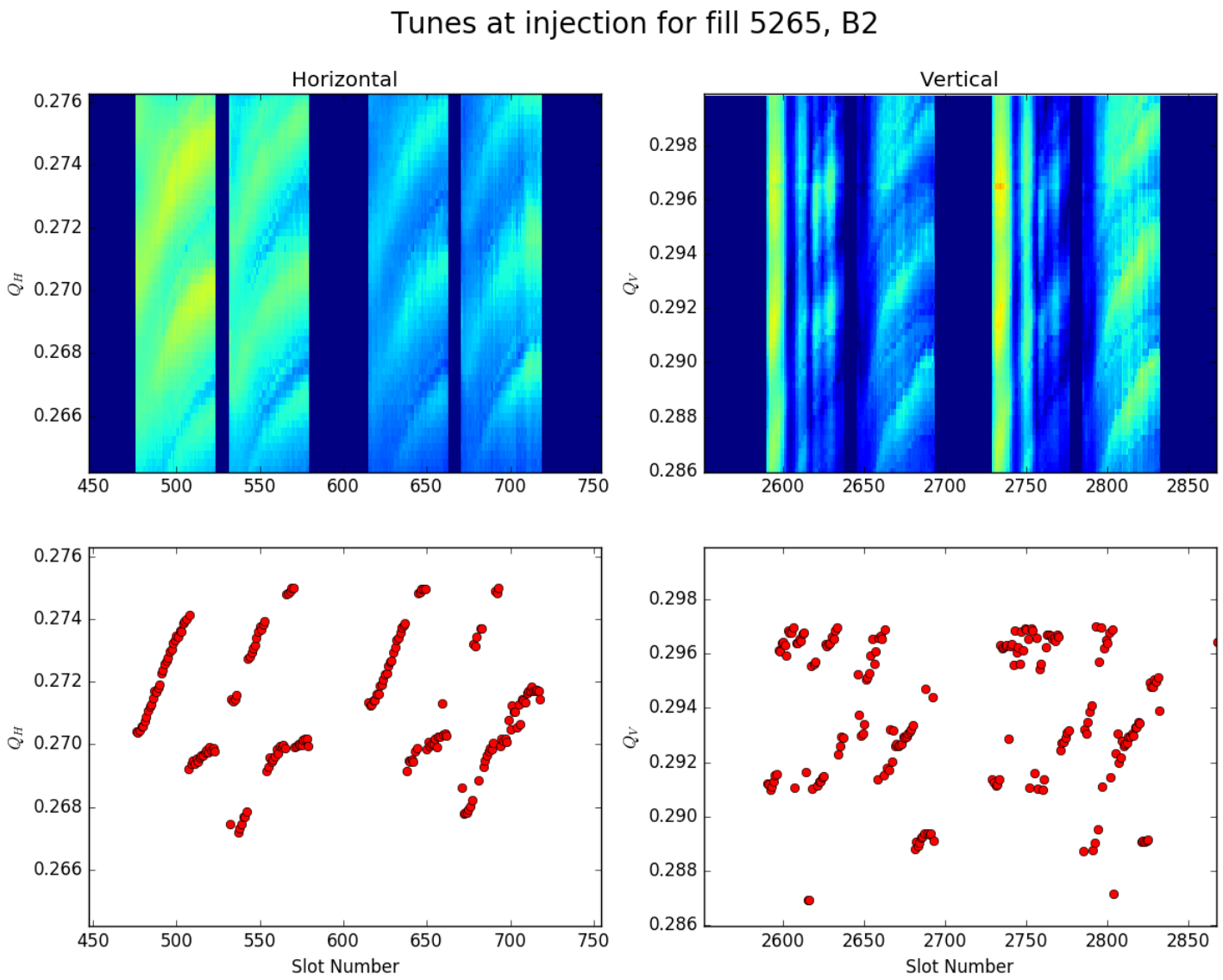
31st August – Fill 5265



31st August – Fill 5265



31st August – Fill 5265



Conclusions

- 4k turns is being saved for all injections and has been since the end of August.
- Currently developing the tools to robustly calculate the tune shift for each injected bunch.
- The information from the tune shift is valuable input into simulations in order to accurately model the current state of the machine.
- In the future, we will be able provide an accurate tracking of the tune shift and get a clearer idea of the level of scrubbing throughout the year.