

Observation of 50Hz lines in the LHC BBQ system.

R. De Maria

Thanks to M. Gasior, R. Steinhagen, G. Arduini.

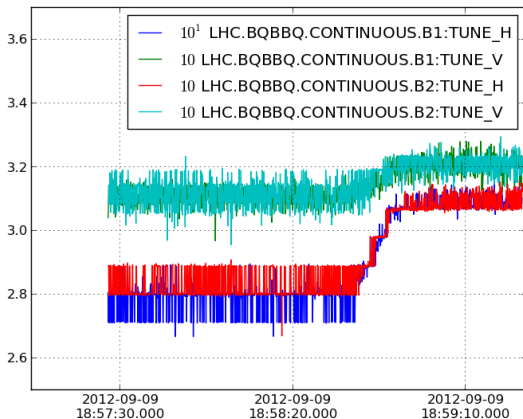
CERN, Geneva

LBOC, 2012/10/16

Introduction

The presence of 50Hz noise line in particular in the horizontal plane:

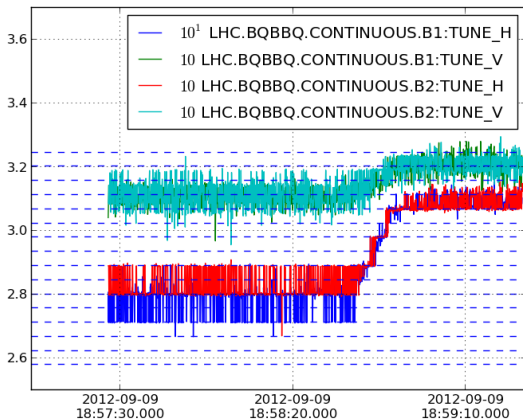
- makes tune tracking difficult
- might be a source of emittance growth if coupled with the beam



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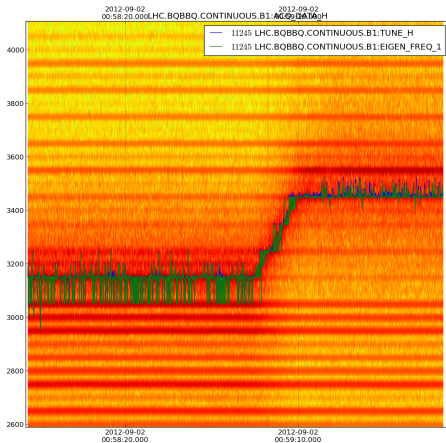
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Introduction

The presence of 50Hz noise line in particular in the horizontal plane:

- makes tune tracking difficult
- might be a source of emittance growth if coupled with the beam



RHIC experience ¹

Extensive campaign to identify the sources:

- vertical lines change with coupling
- change of the phase of main power supplies changes the pattern
- lines width much less than Hz
- few parts of 10^7 in the MB may explain the RHIC data

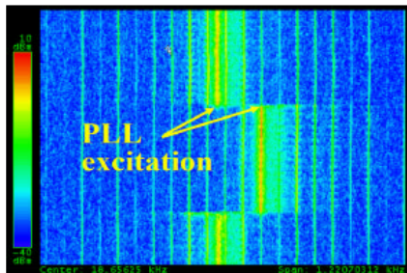
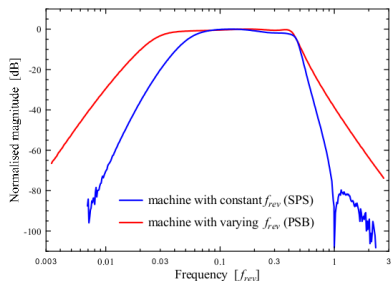


Figure 1: Spectrum with BBQ excitation and 60Hz lines

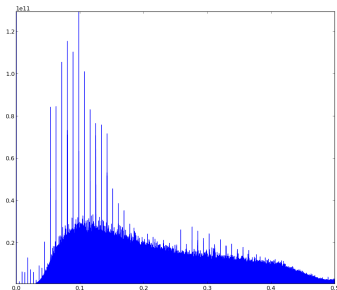
¹Peter Cameron, BNL; Marek Gasior, Rhodri Jones, CERN Cheng-Yang Tan, FNAL ; Observations of Direct Excitation of the Betatron Spectrum by Mains Harmonics in RHIC, October 2006, AP Note 253.

LHC BBQ no beam

BBQ Frev suppression filter



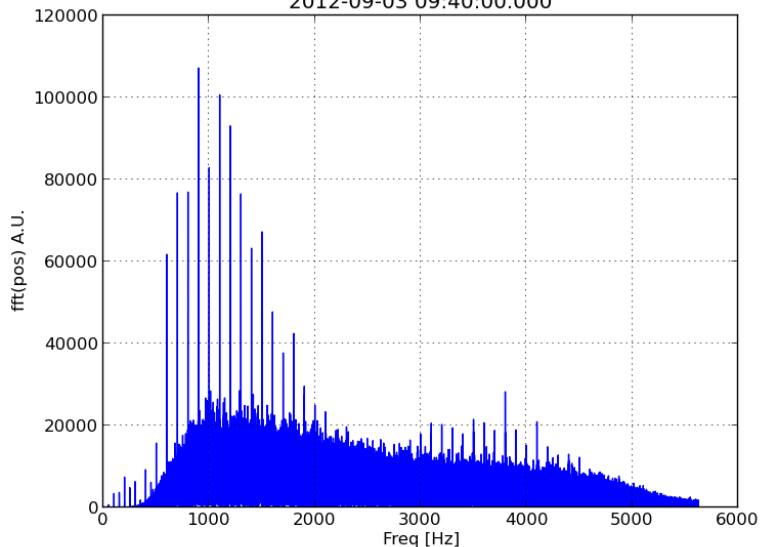
Noise no beam on 2012-06-18



M. Gasior, FARADAY CUP AWARD: High Sensitivity Tune Measurement using Direct Diode Detection, CERN-ATS-2012-246.

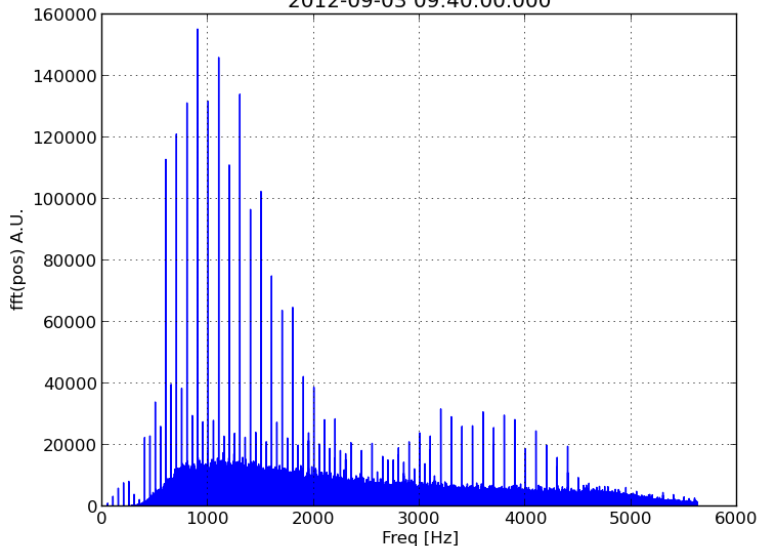
LHC BBQ spectra no beam

LHC.BQBBQ.CONTINUOUS.B1:ACQ_DATA_H
2012-09-03 09:40:00.000



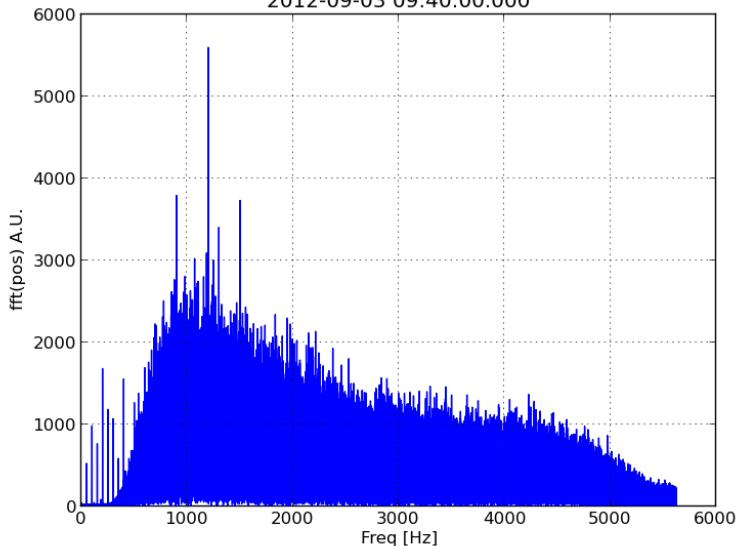
LHC BBQ spectra no beam

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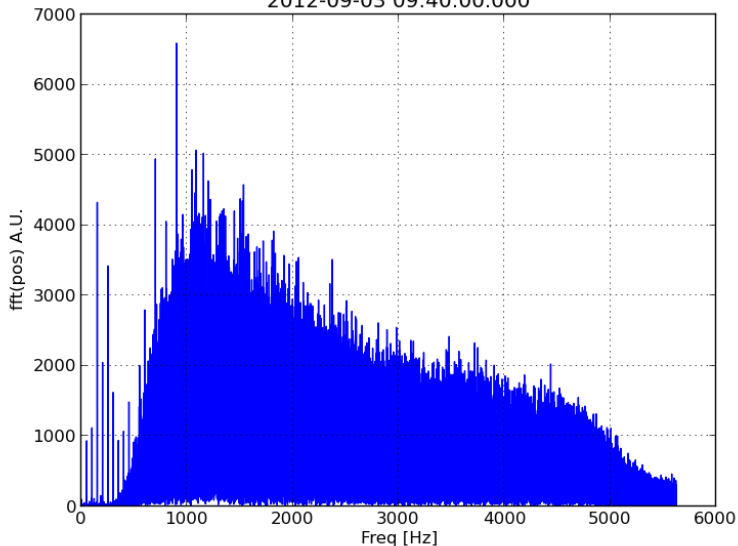
LHC BBQ spectra no beam

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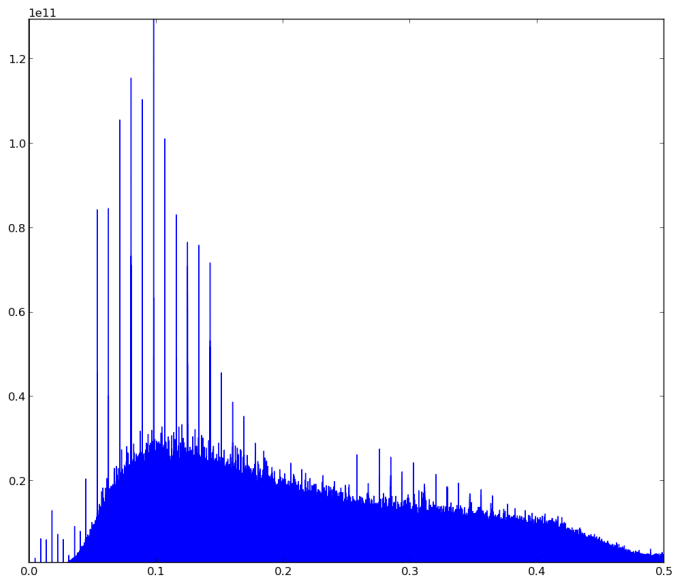


LHC BBQ spectra no beam

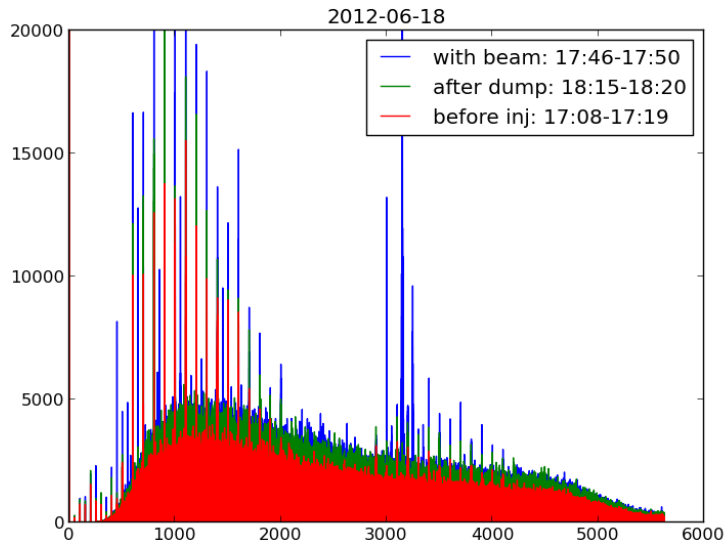
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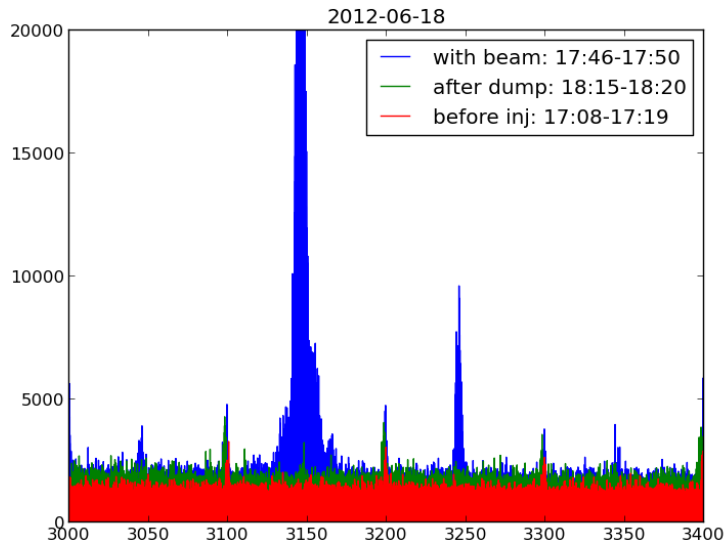
LHC BBQ spectra with and without beam



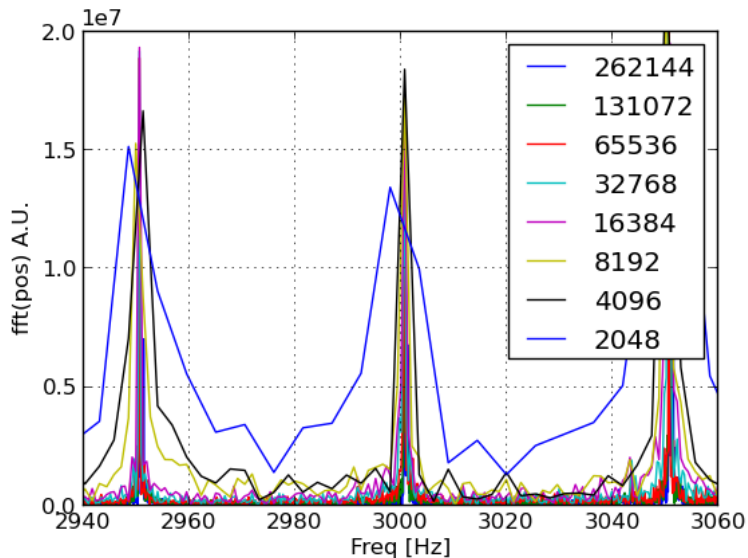
LHC BBQ spectra with and without beam



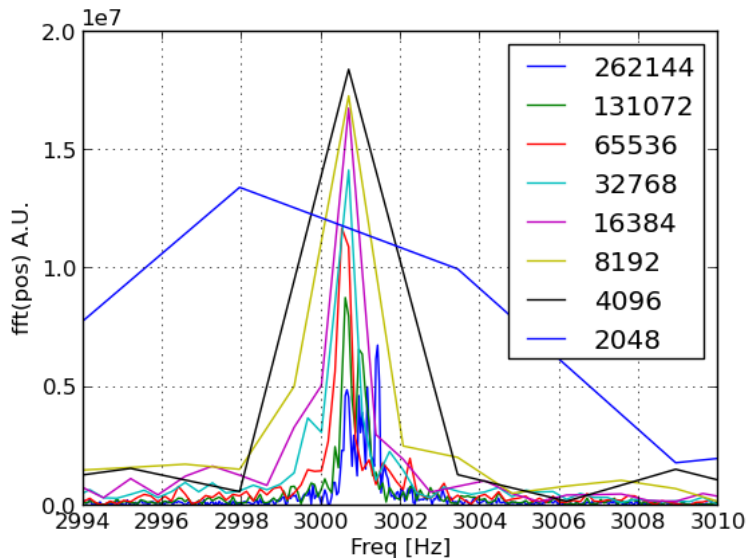
LHC BBQ spectra with and without beam



Line width

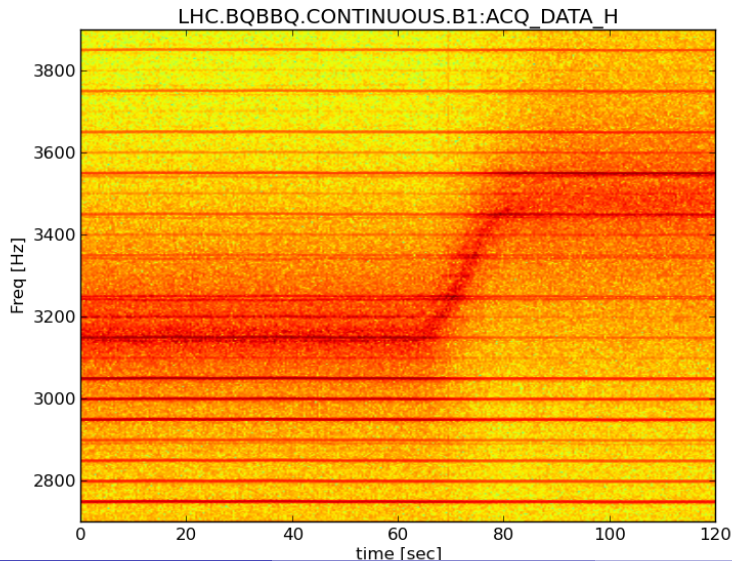


Line width



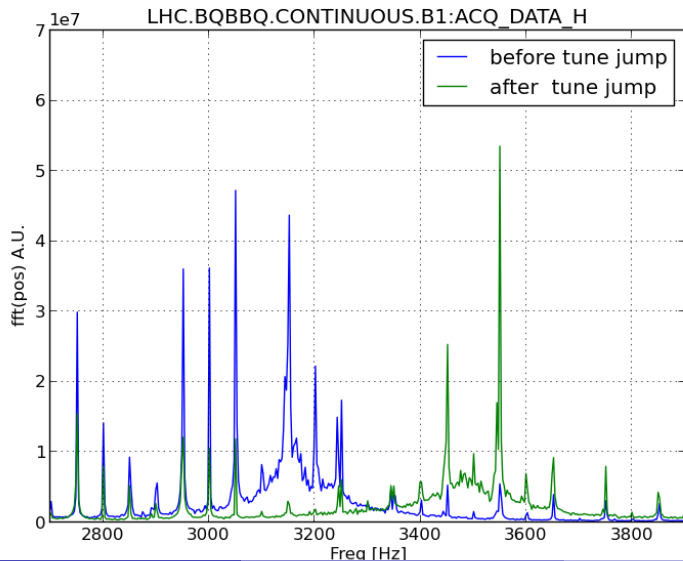
LHC BBQ during tune jump:

2012-09-02 00-58-51



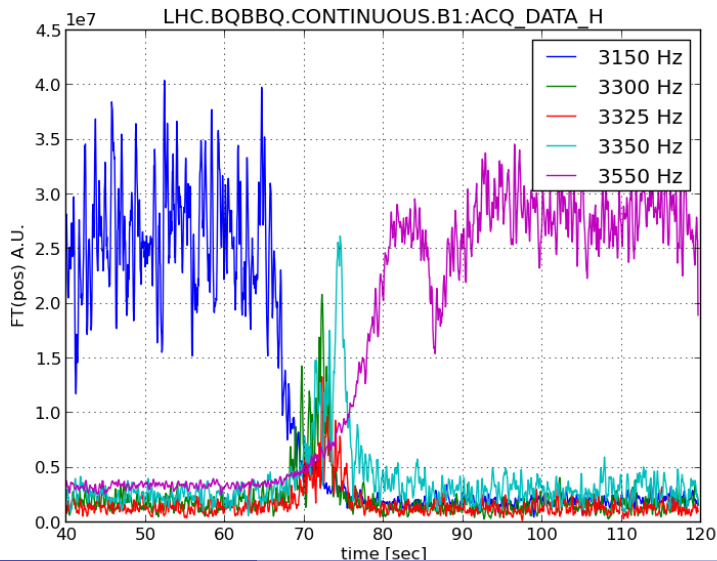
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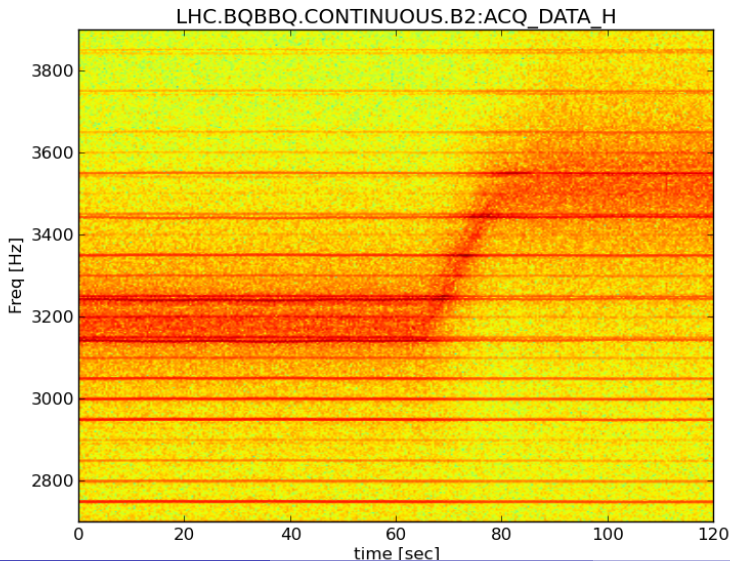
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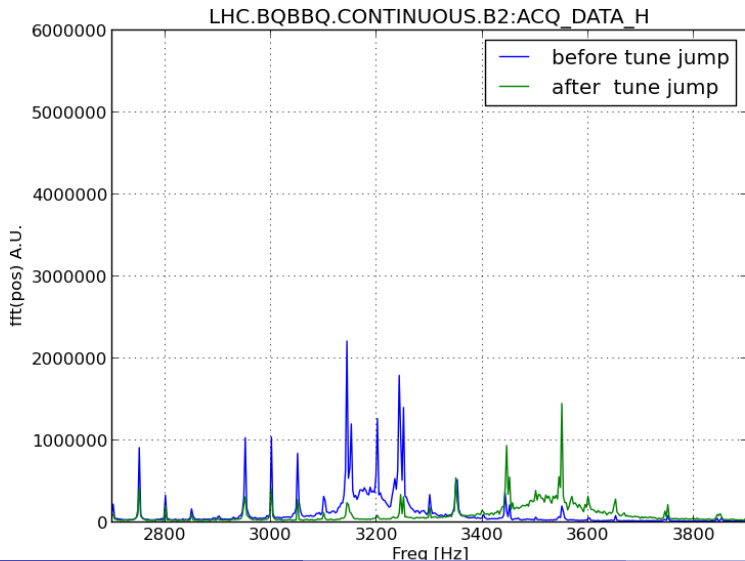
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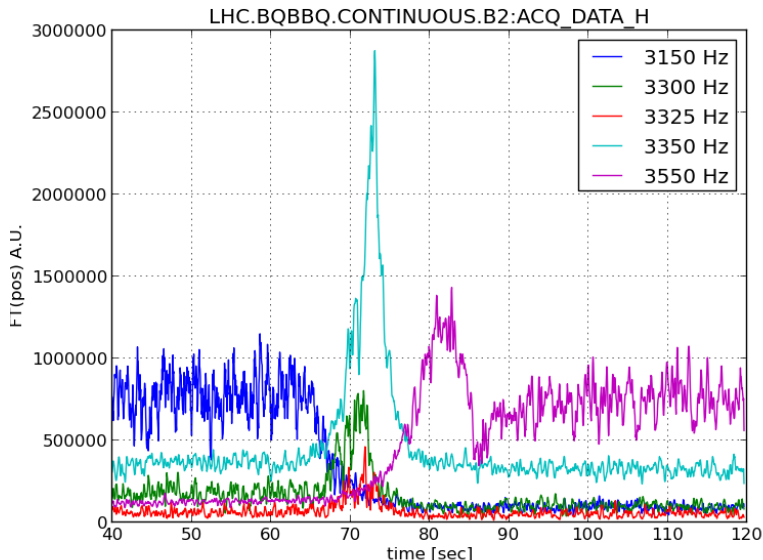
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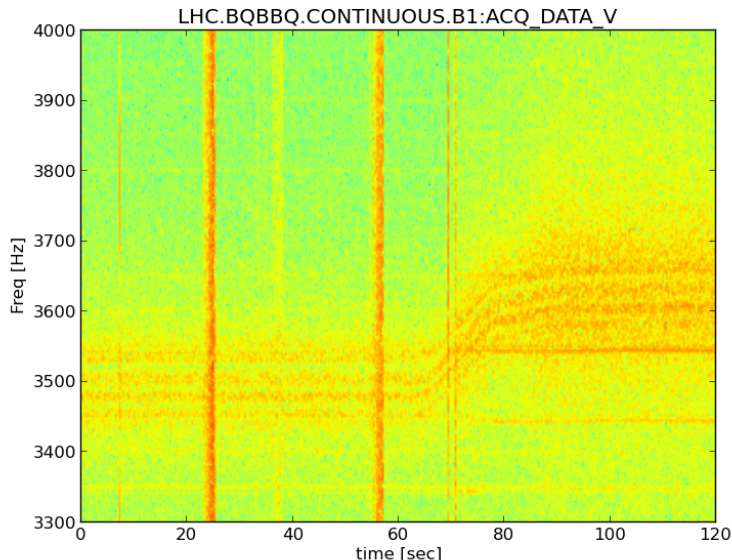
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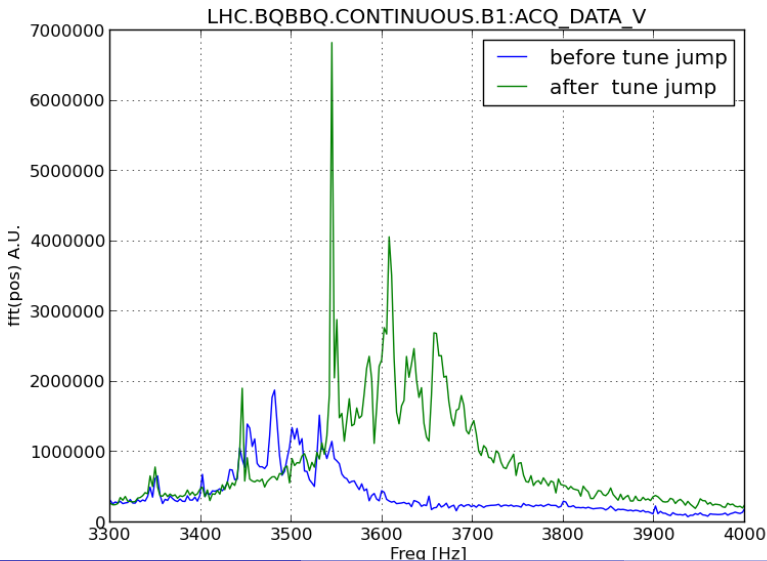
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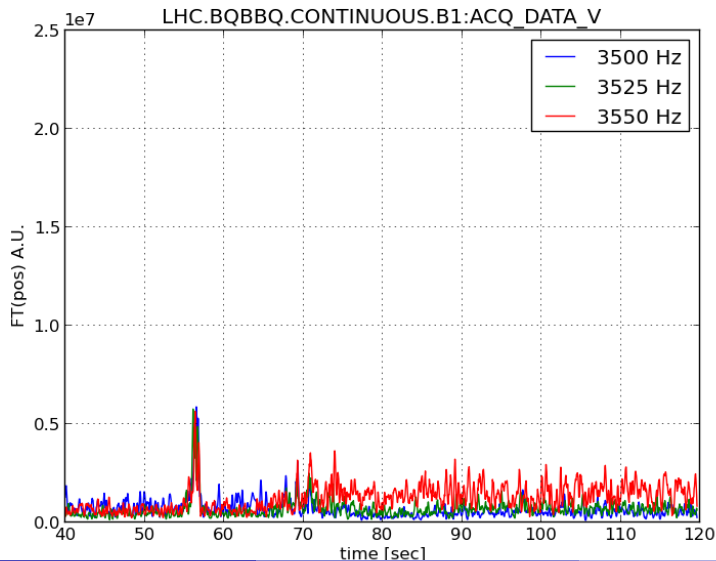
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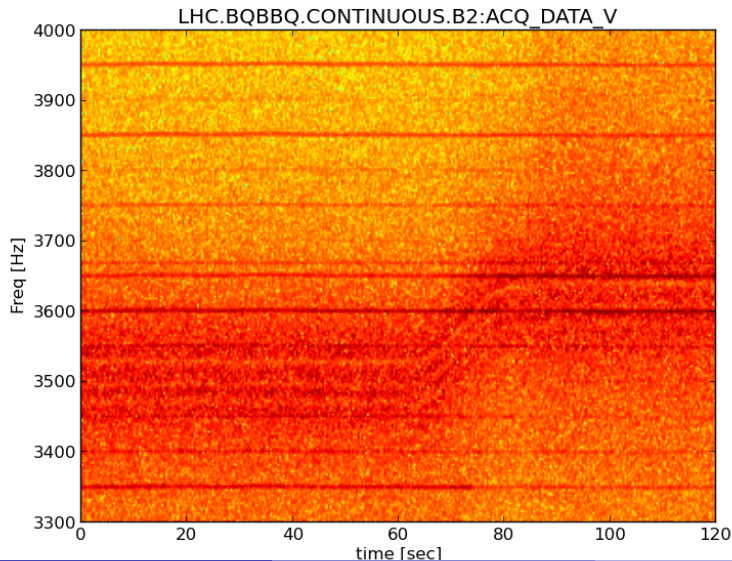
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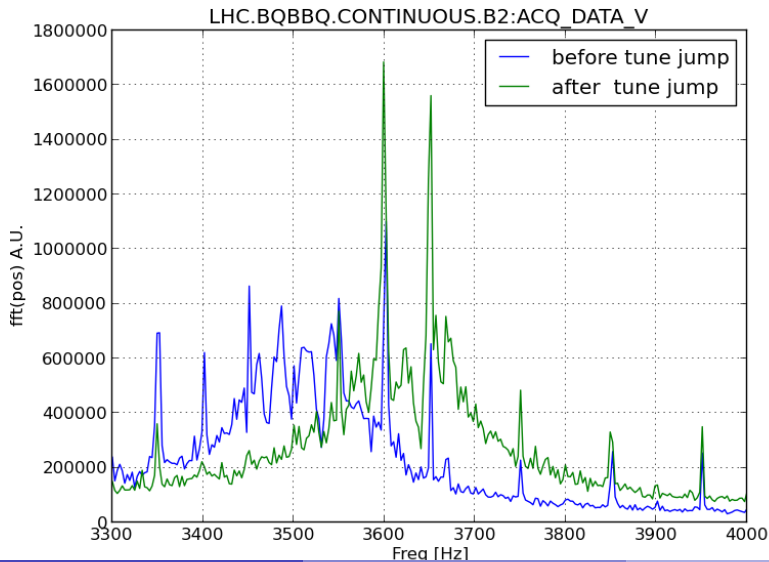
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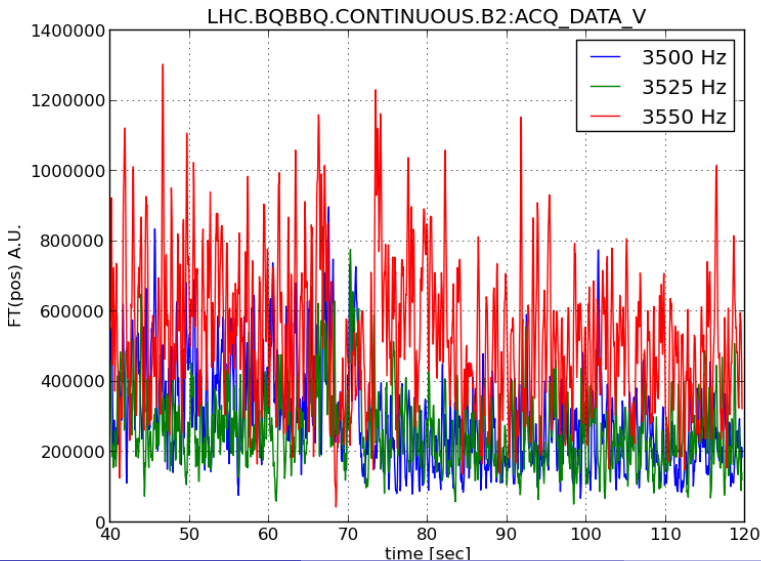
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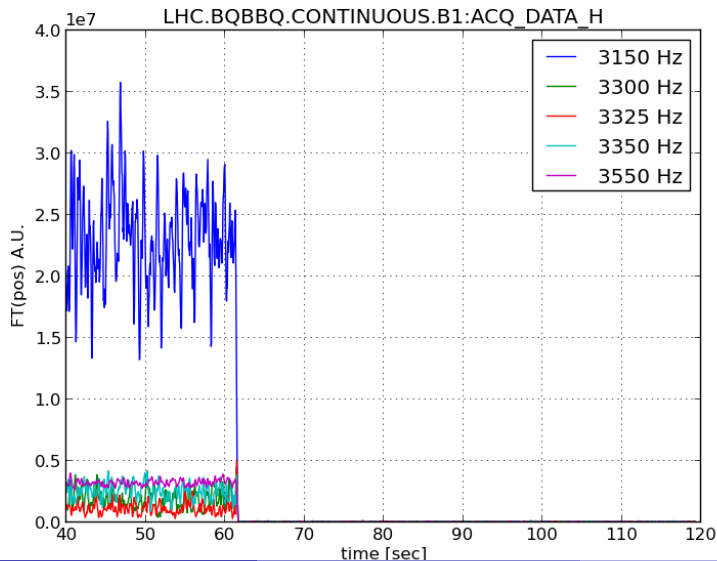
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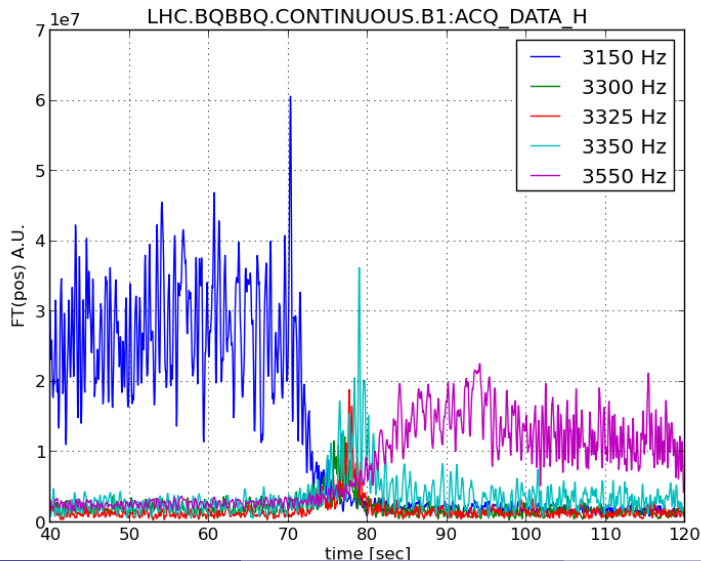
LHC BBQ during tune jump:

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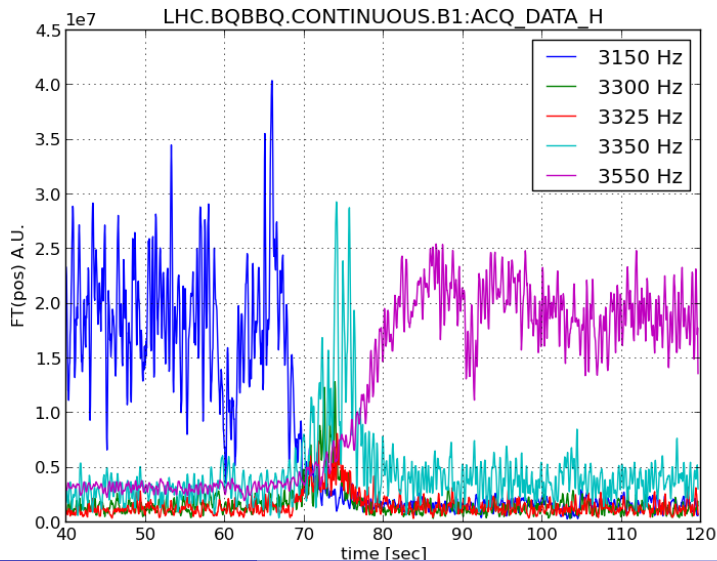
LHC BBQ during tune jump:

2012-09-03 03-02-58



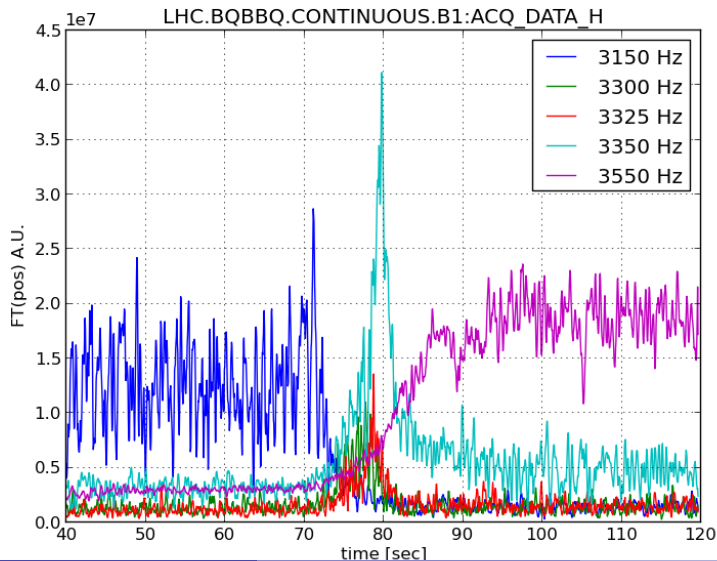
LHC BBQ during tune jump:

2012-09-03 20-05-13



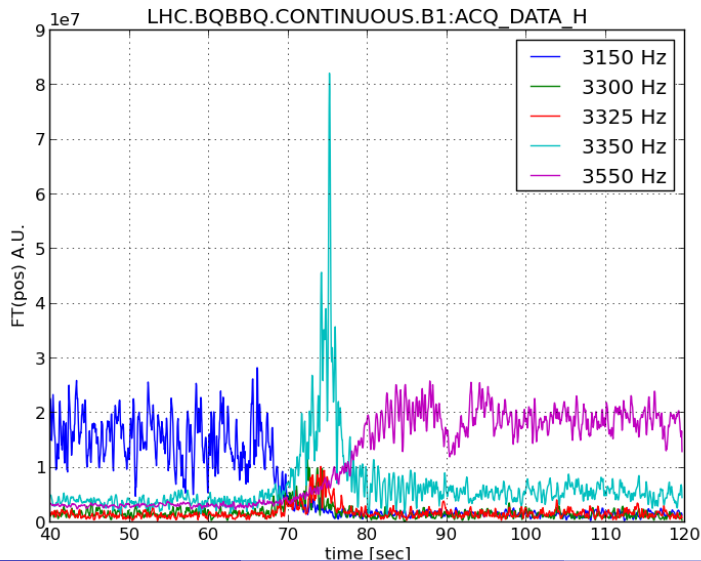
LHC BBQ during tune jump:

2012-09-04 10-40-02



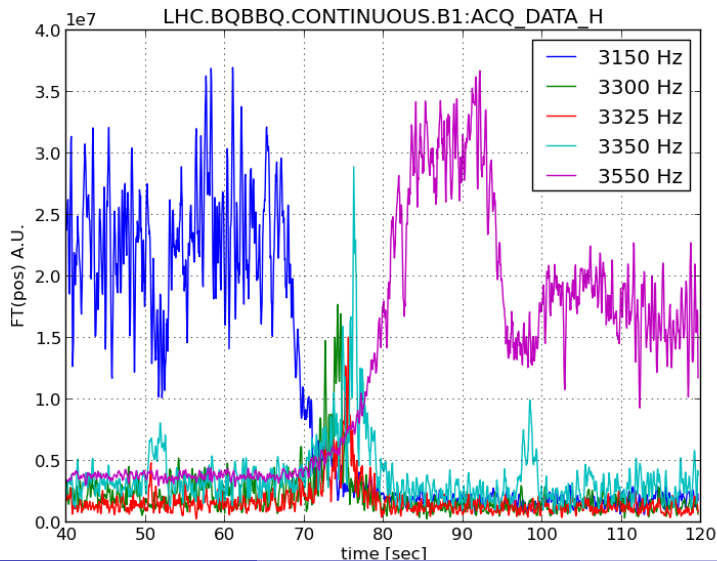
LHC BBQ during tune jump:

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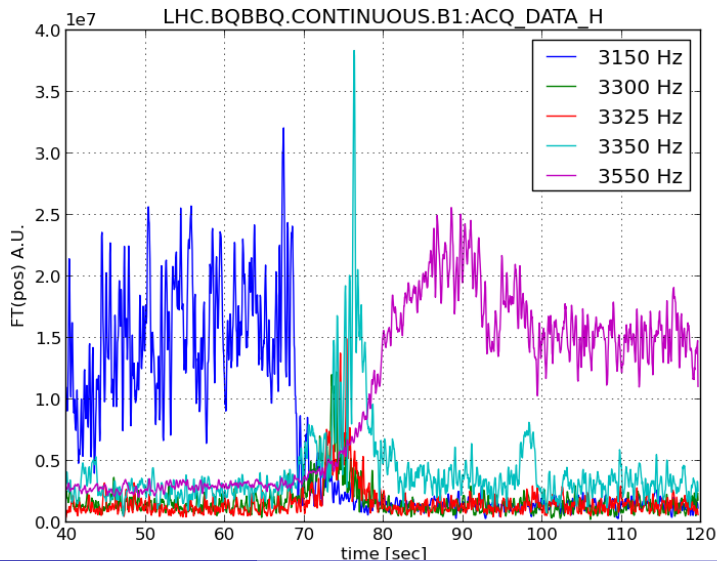
LHC BBQ during tune jump:

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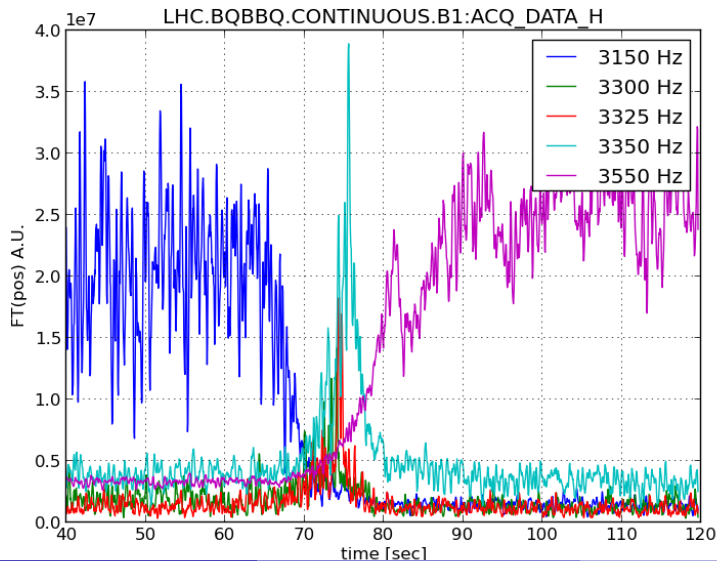
LHC BBQ during tune jump:

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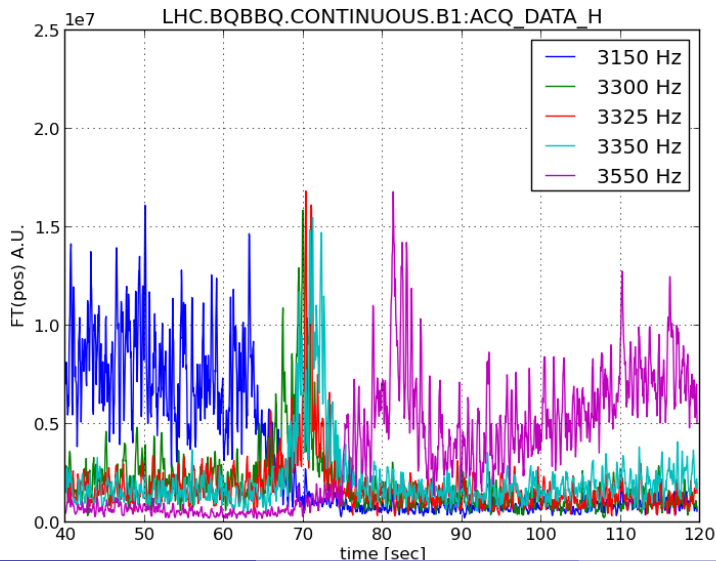
LHC BBQ during tune jump:

2012-09-06 10-49-07



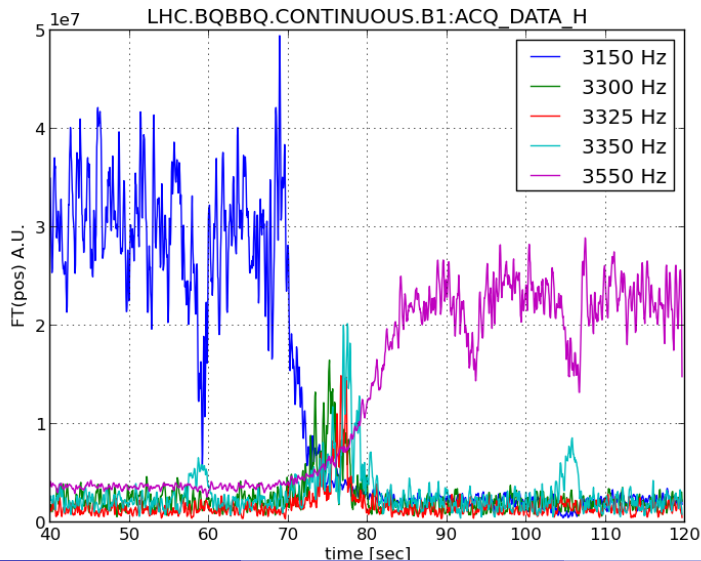
LHC BBQ during tune jump:

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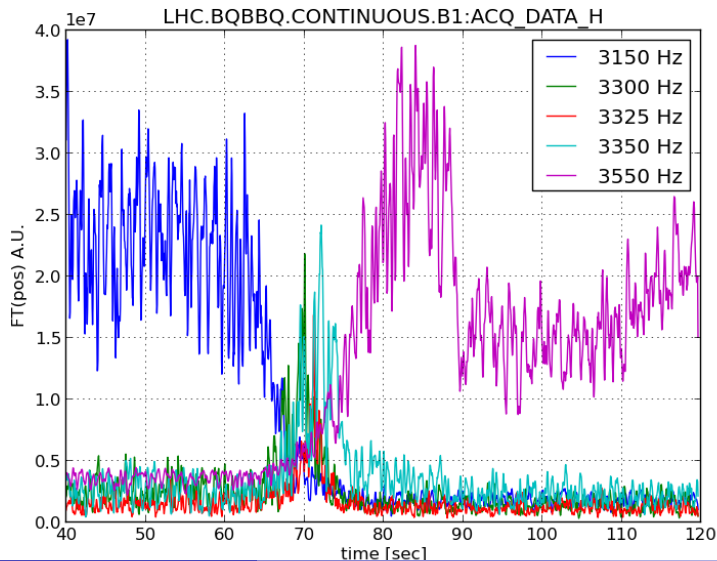
LHC BBQ during tune jump:

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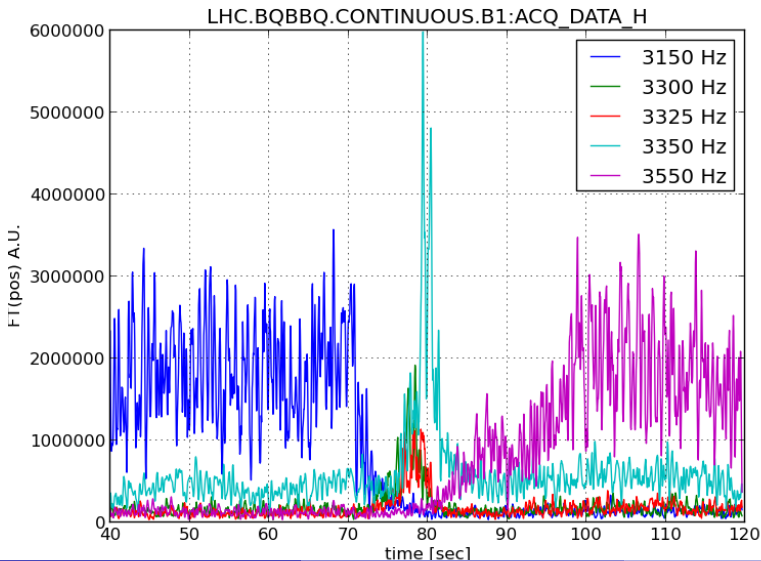
LHC BBQ during tune jump:

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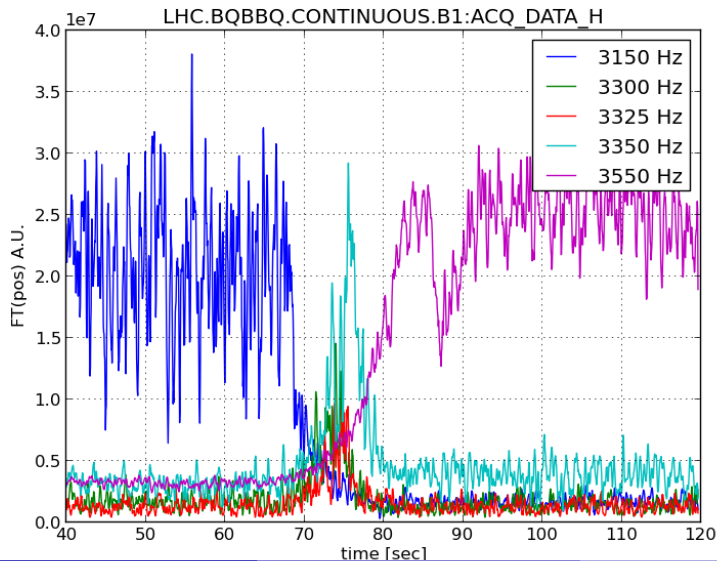
LHC BBQ during tune jump:

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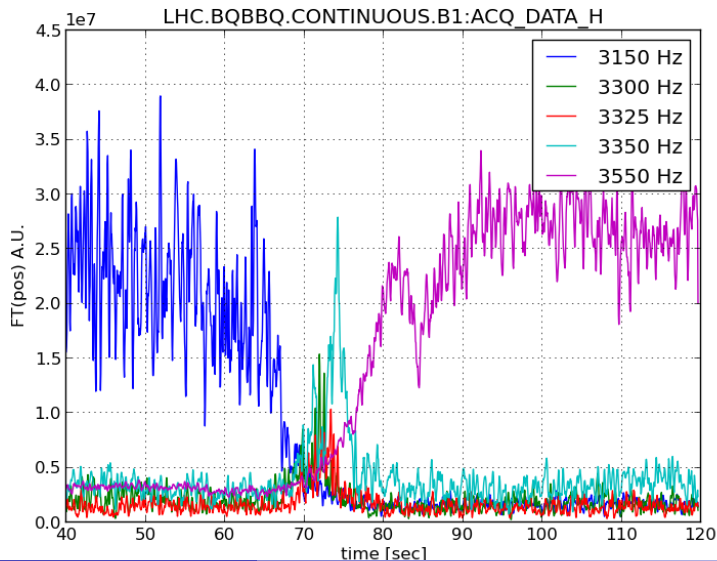
LHC BBQ during tune jump:

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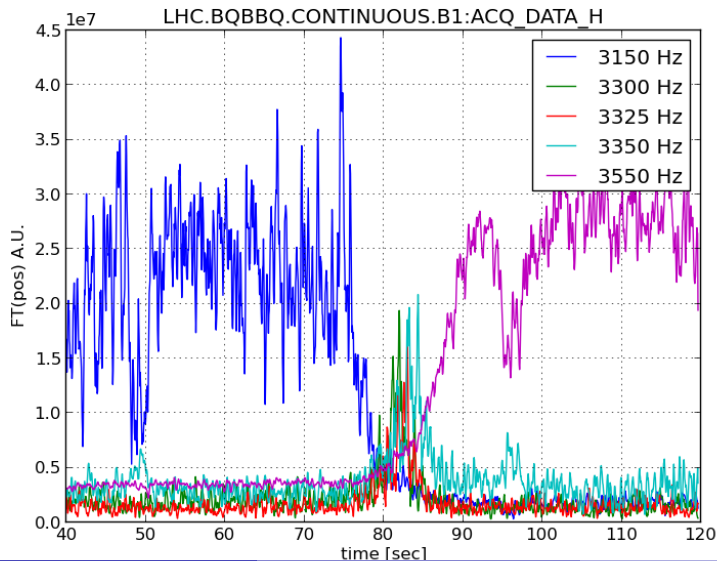
LHC BBQ during tune jump:

2012-09-08 05-02-46



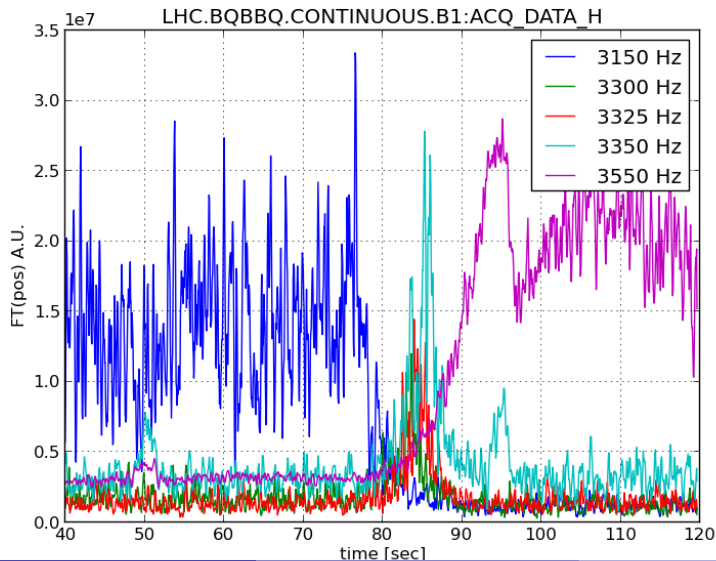
LHC BBQ during tune jump:

2012-09-08 18-50-29



LHC BBQ during tune jump:

2012-09-08 21-51-39



Conclusion

The Direct Diode Detection used in the LHC BBQ is very sensitive!
Similar effects observed and studied extensively in RHIC.

In the LHC BBQ 50 Hz lines are visible without beam.

The relative intensity differences with and without overlapping tunes suggests the beam couple with the noise source.

An experiment to show the impact of the active filter did not show an impact on a pilot bunch spectra (but low SNR) nor on the baseline noise.

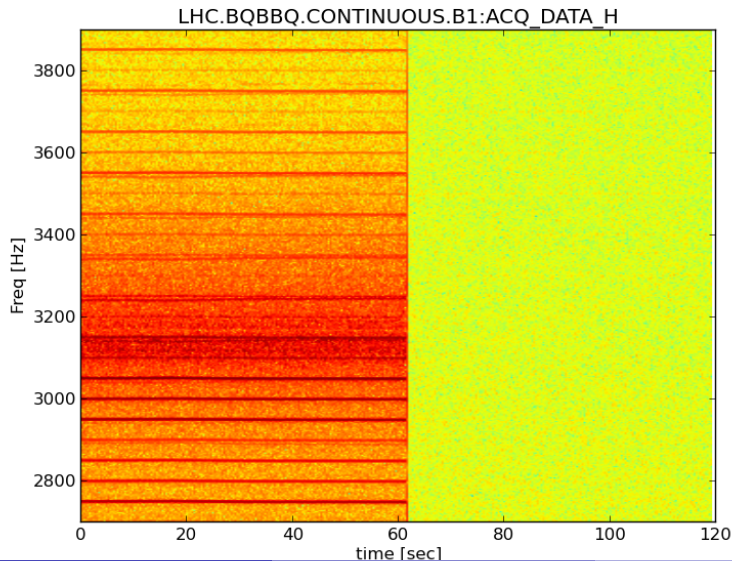
One could look at the noise lines while varying the coupling to identify if one plane is dominant.

Depending on the power converter technology, one could try to reproduce the RHIC experiment by perturbing the main 50 Hz phase.

Backup

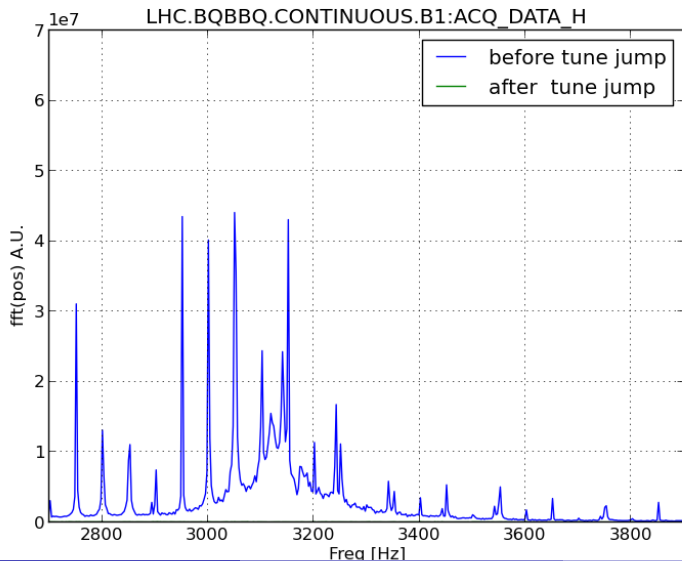
LHC BBQ during tune jump:

2012-09-03 00-58-05



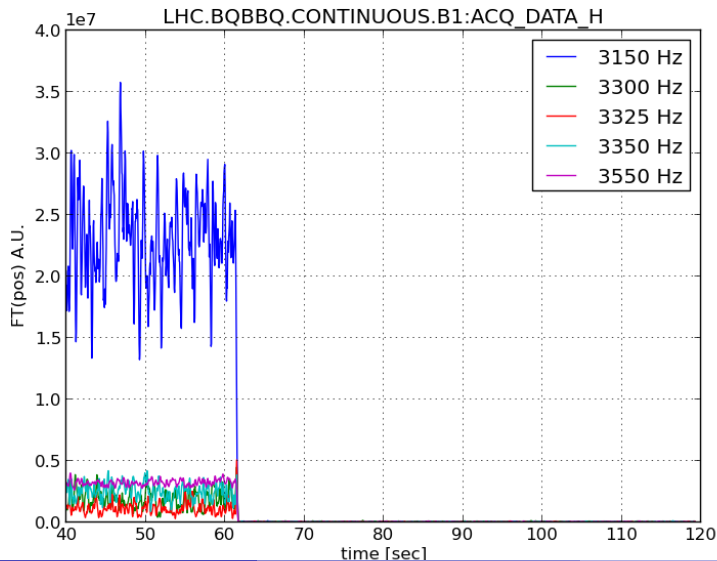
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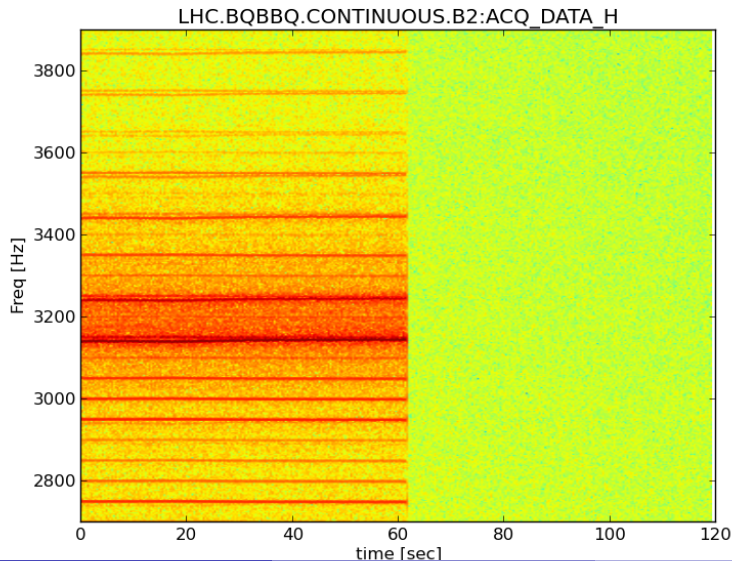
LHC BBQ during tune jump:

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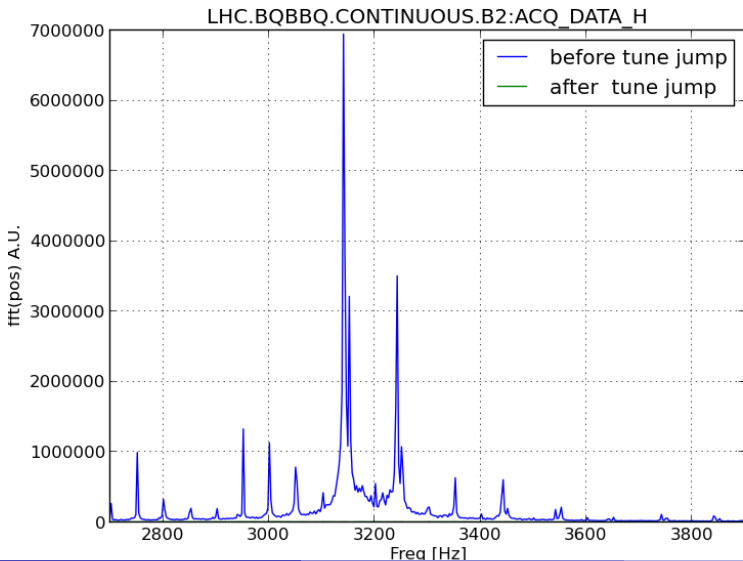
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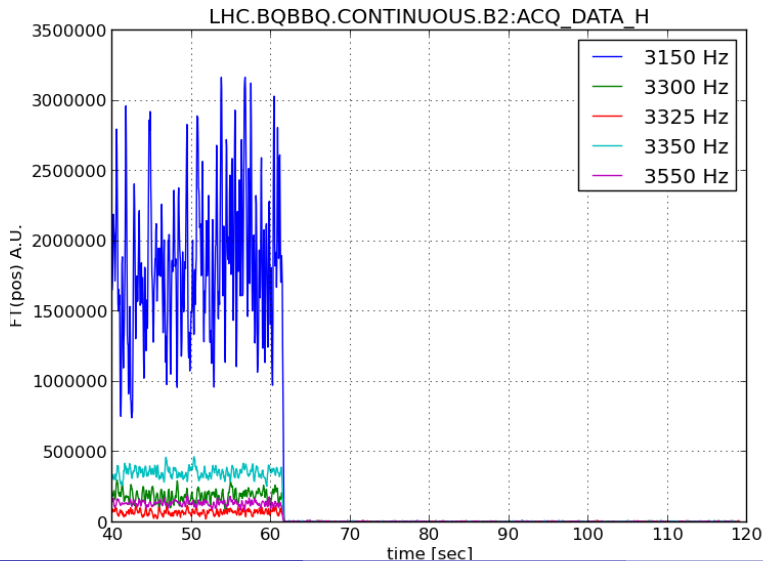
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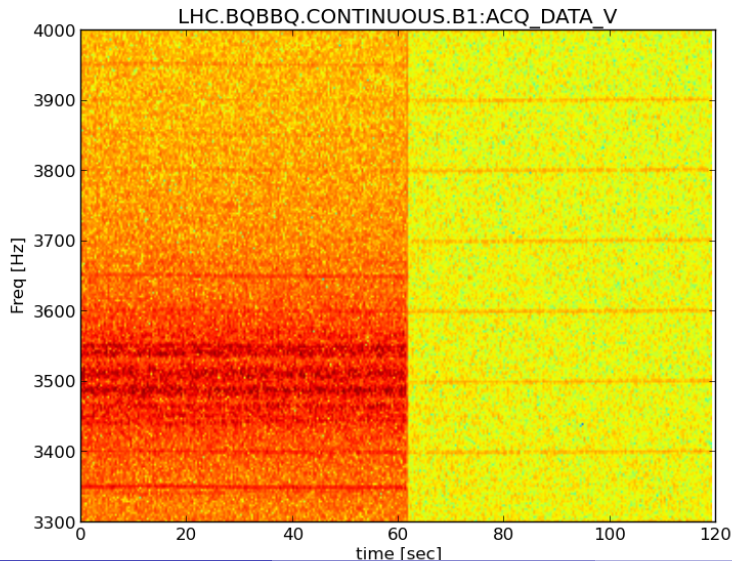
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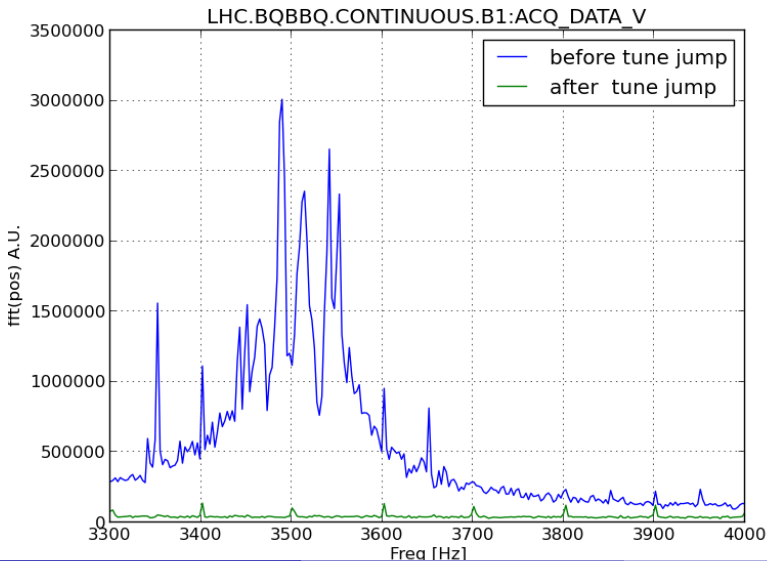
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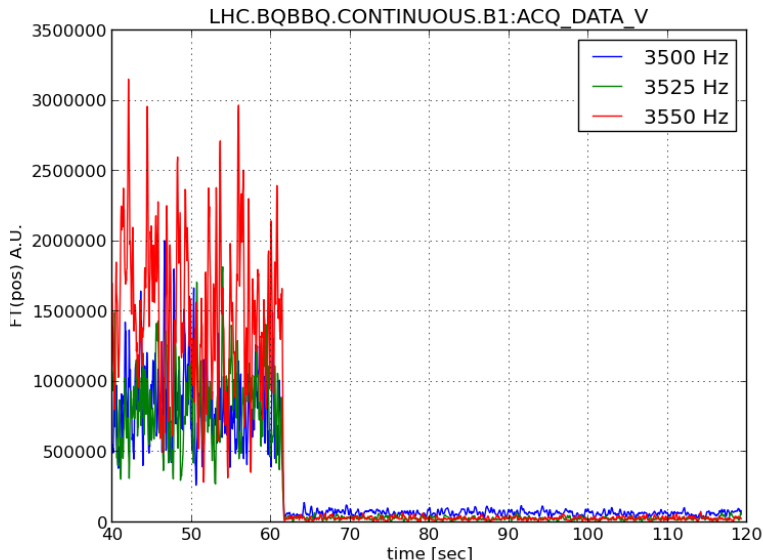
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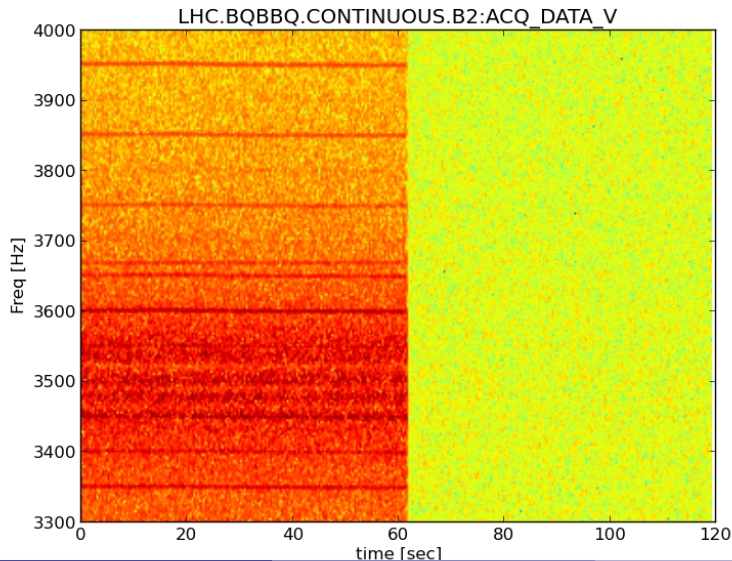
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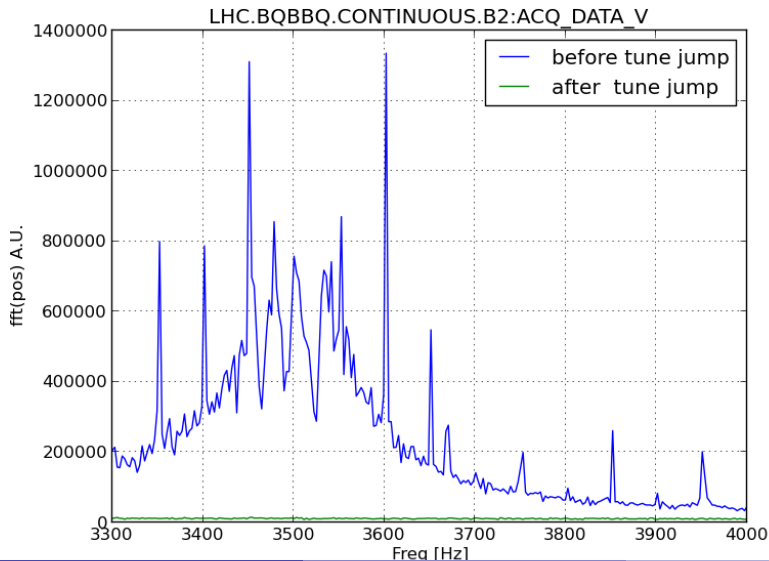
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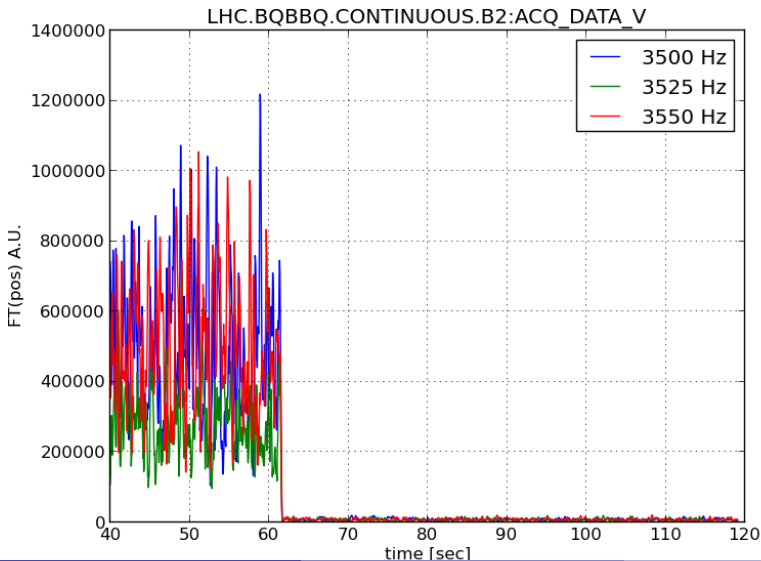
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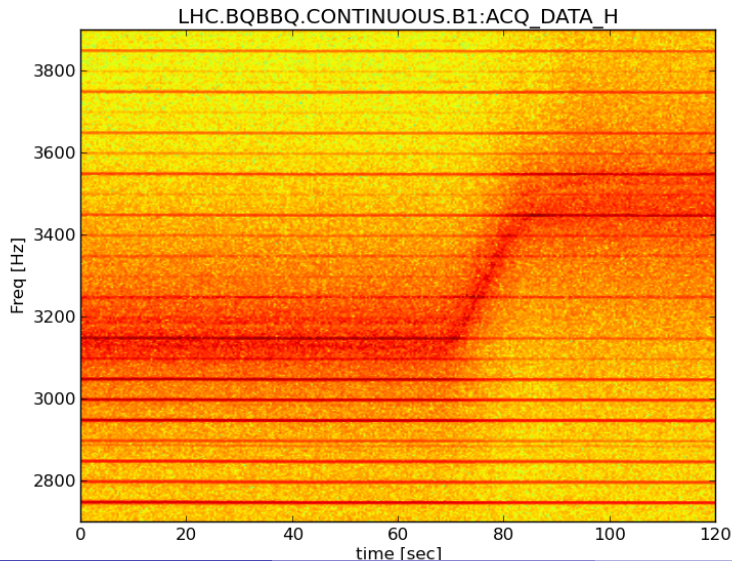
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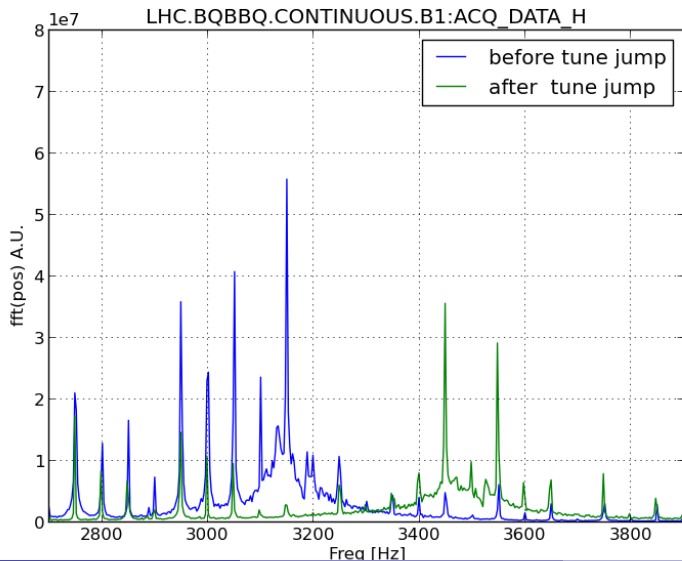
LHC BBQ during tune jump:

2012-09-03 03-02-58



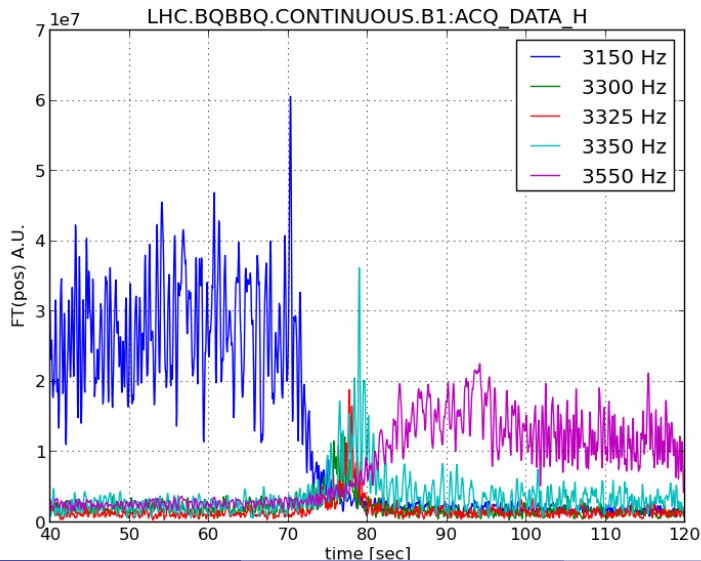
LHC BBQ during tune jump:

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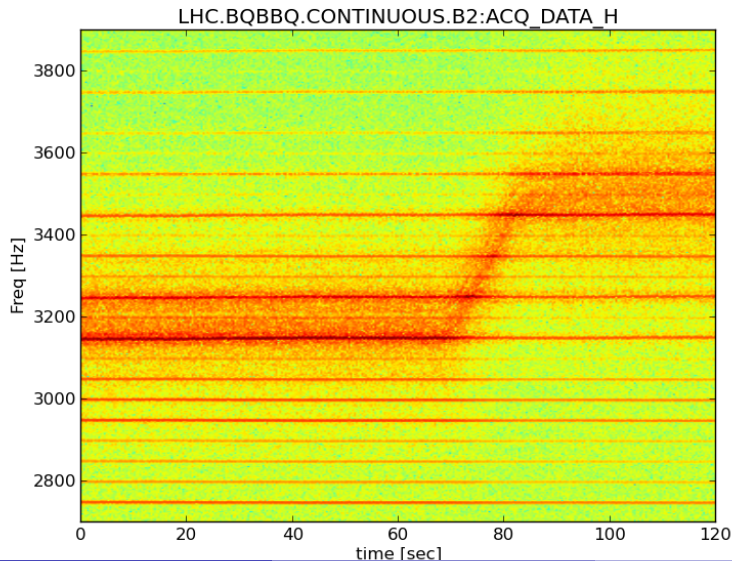
LHC BBQ during tune jump:

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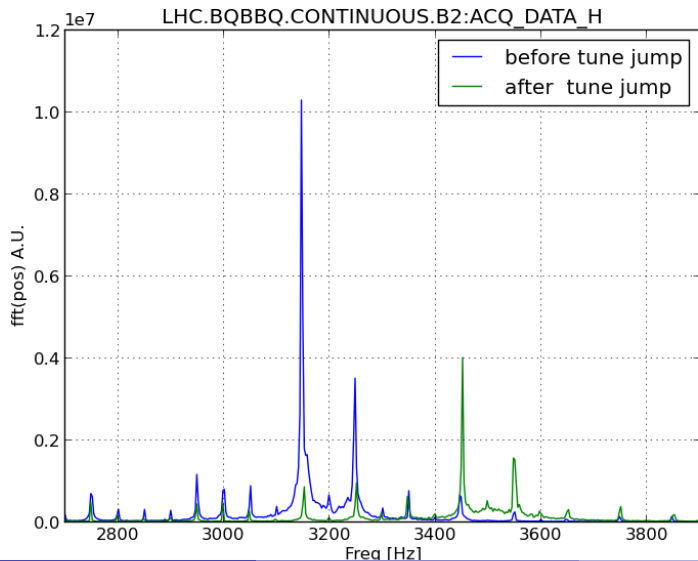
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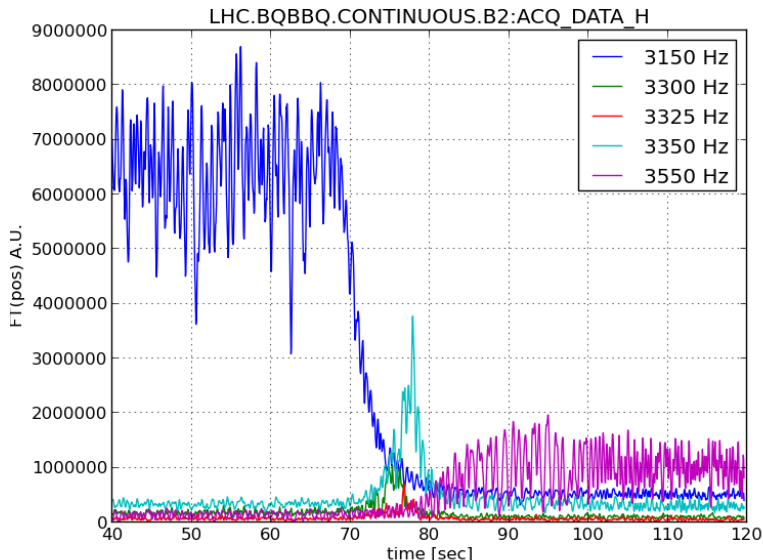
LHC BBQ during tune jump:

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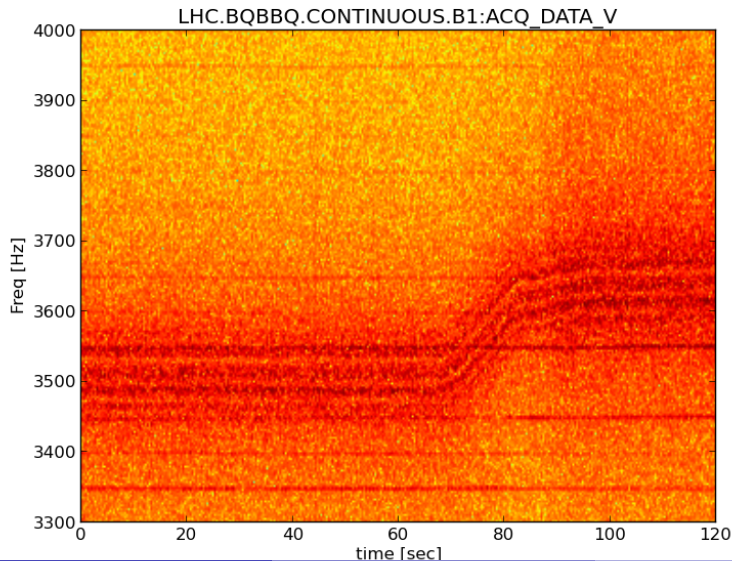
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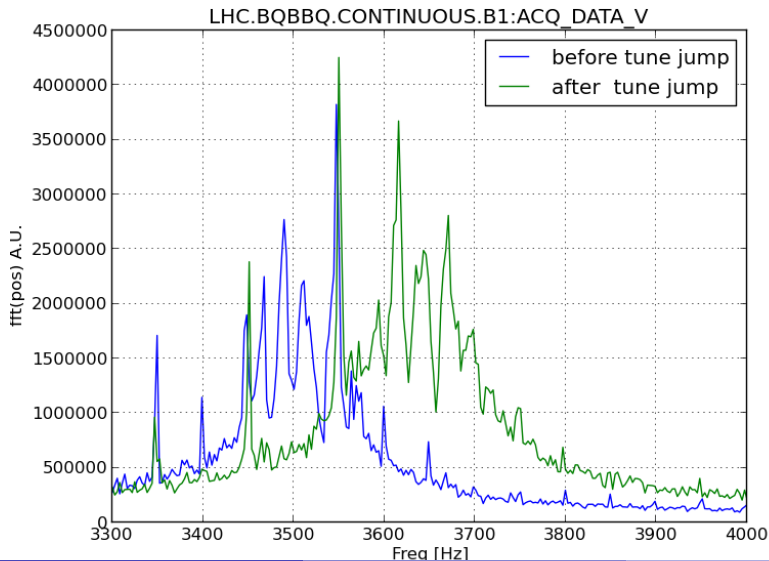
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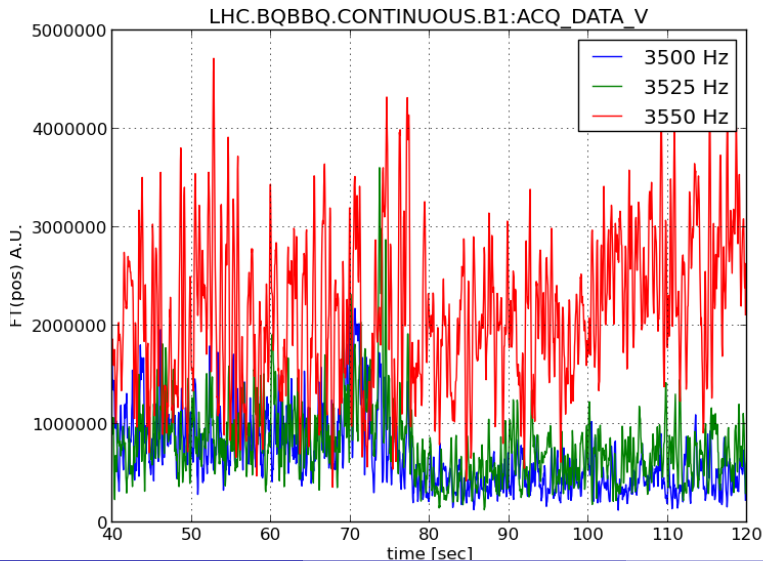
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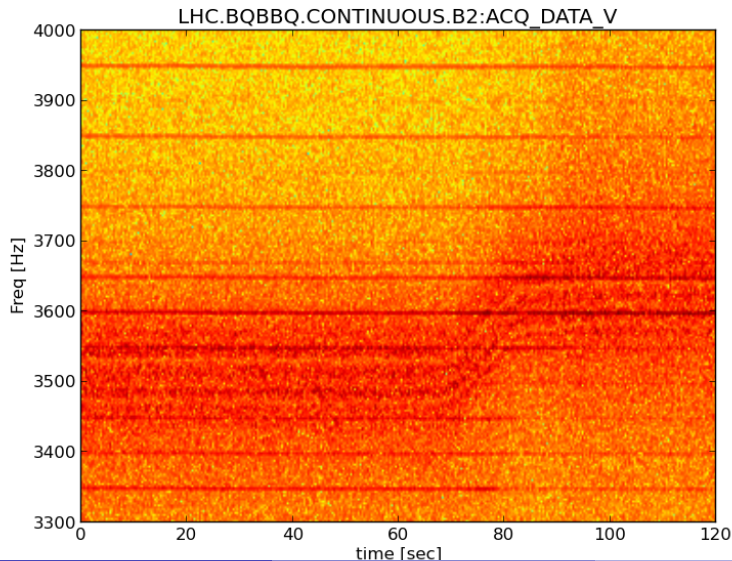
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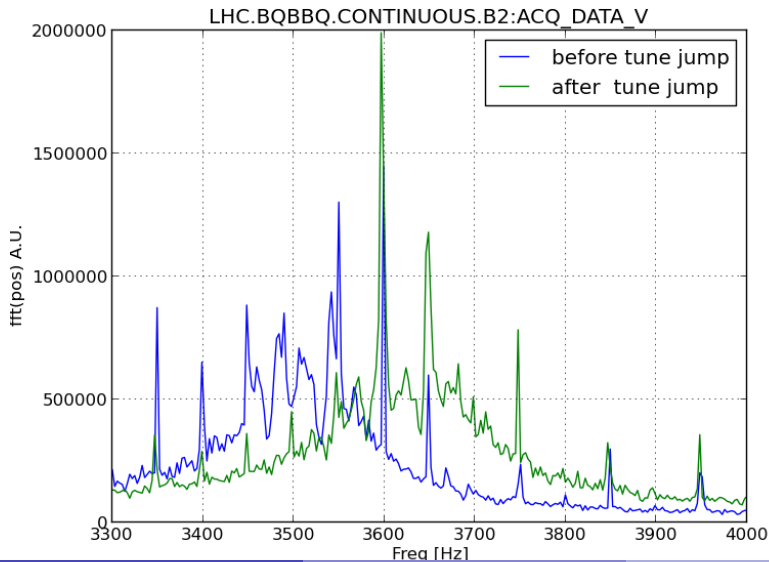
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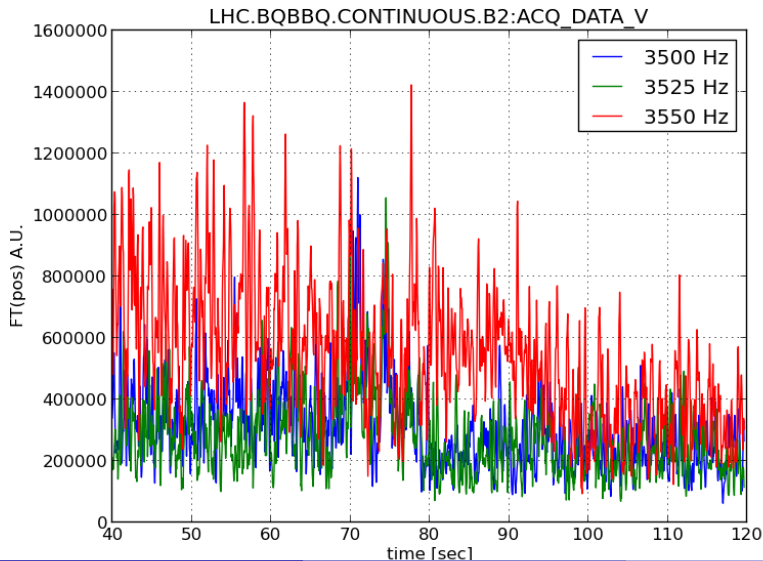
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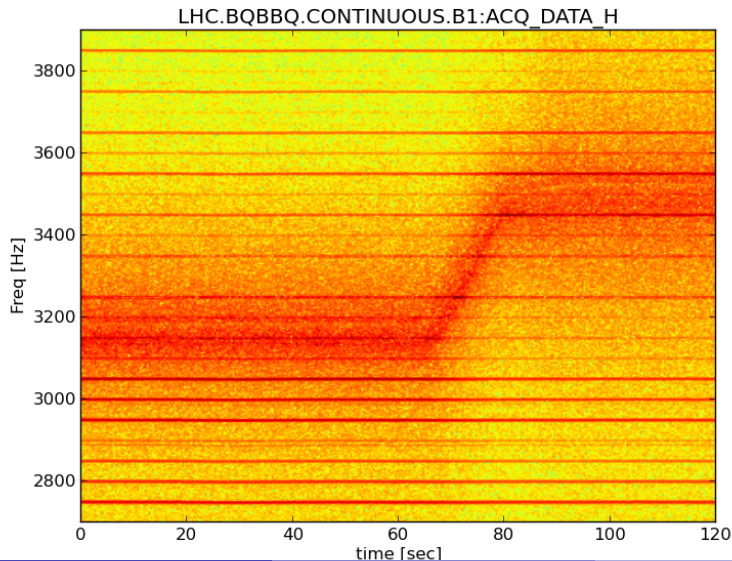
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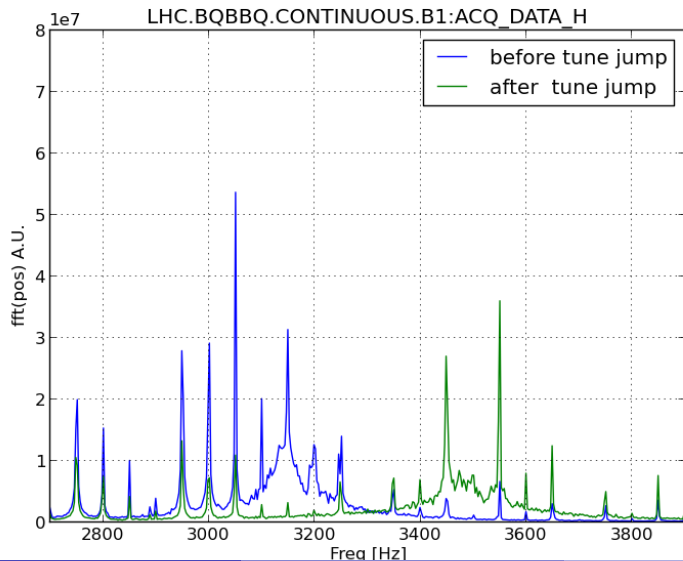
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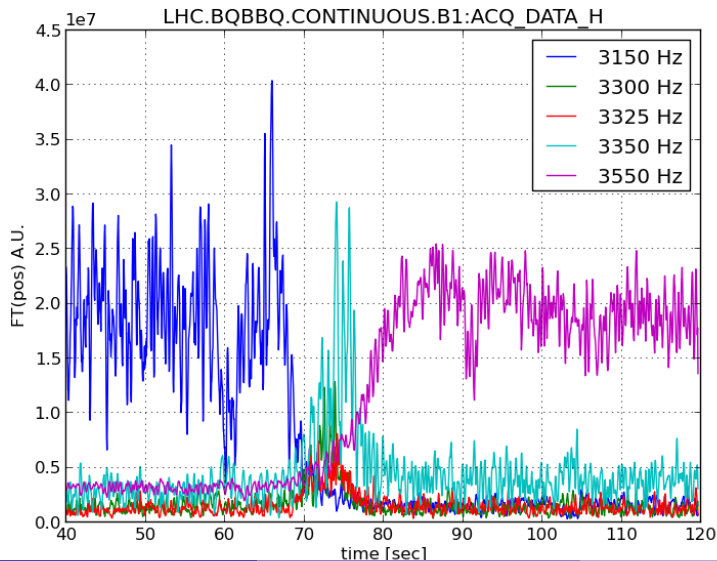
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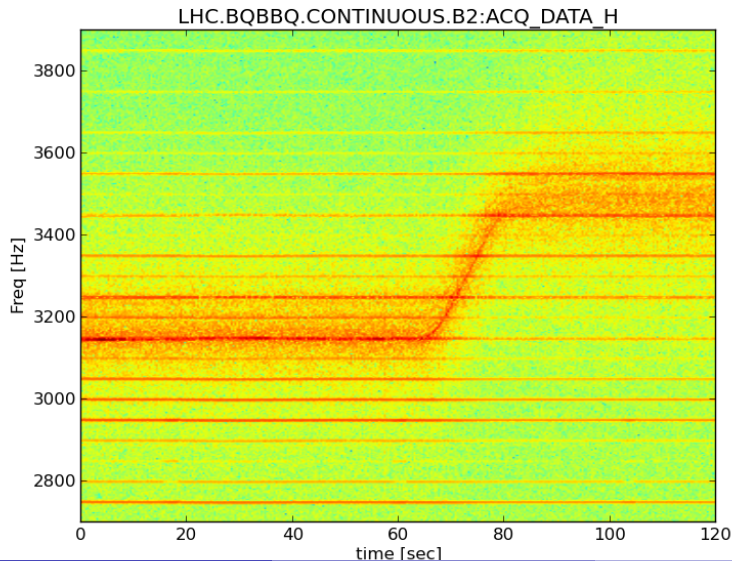
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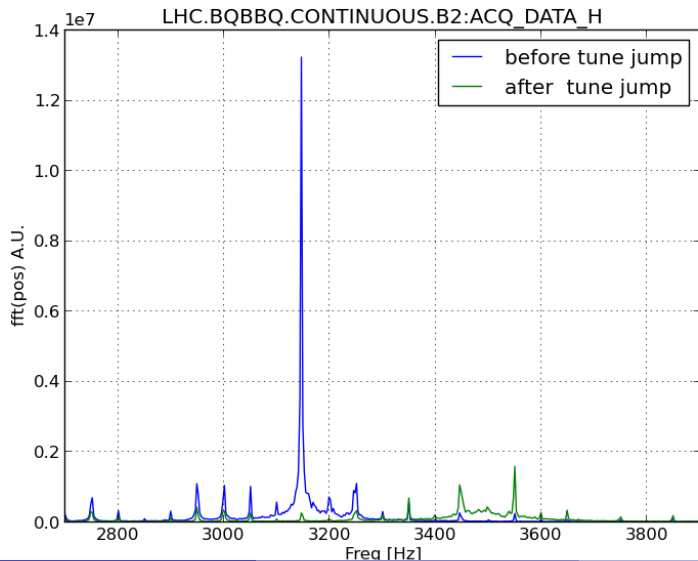
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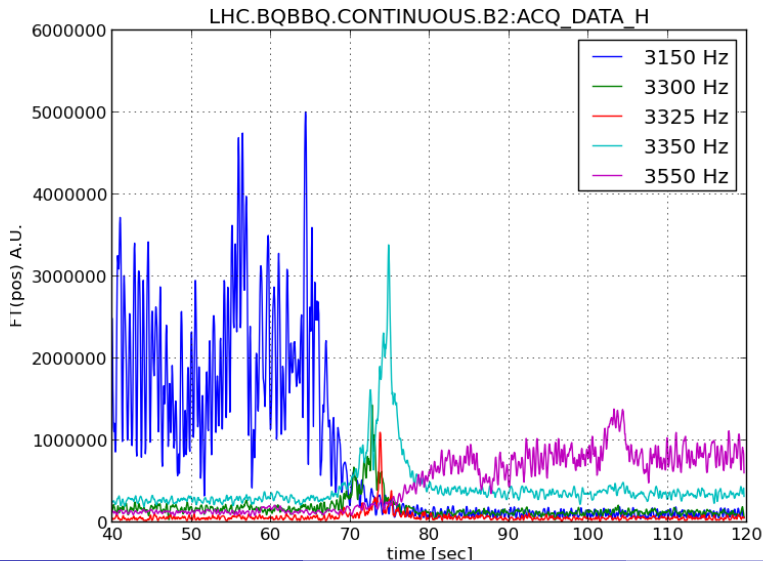
LHC BBQ during tune jump:

2012-09-03 20-05-13



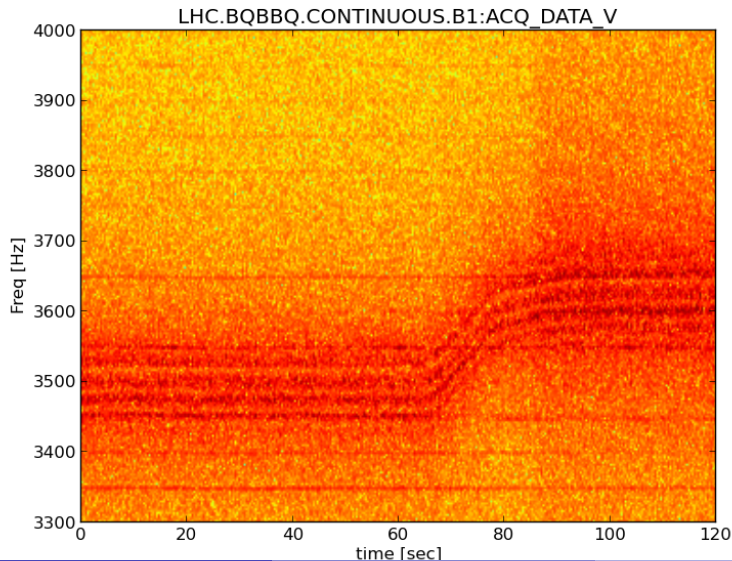
LHC BBQ during tune jump:

2012-09-03 20-05-13



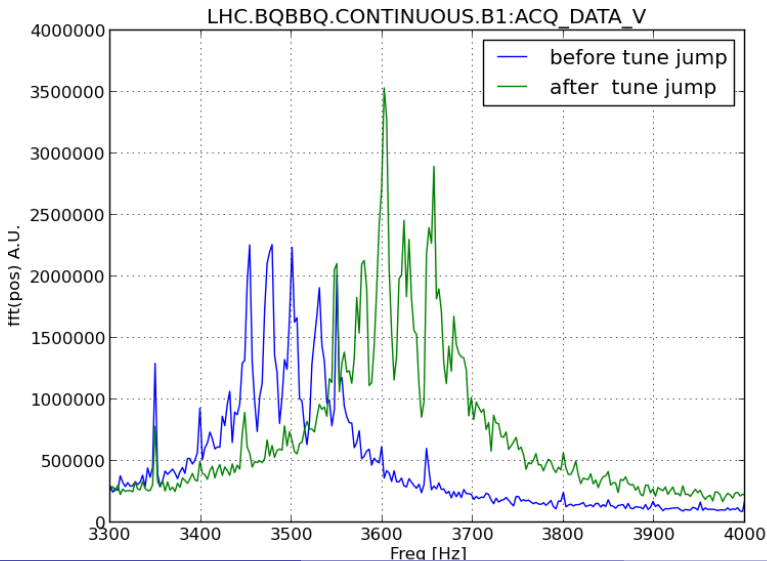
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2012-09-03 20-05-13



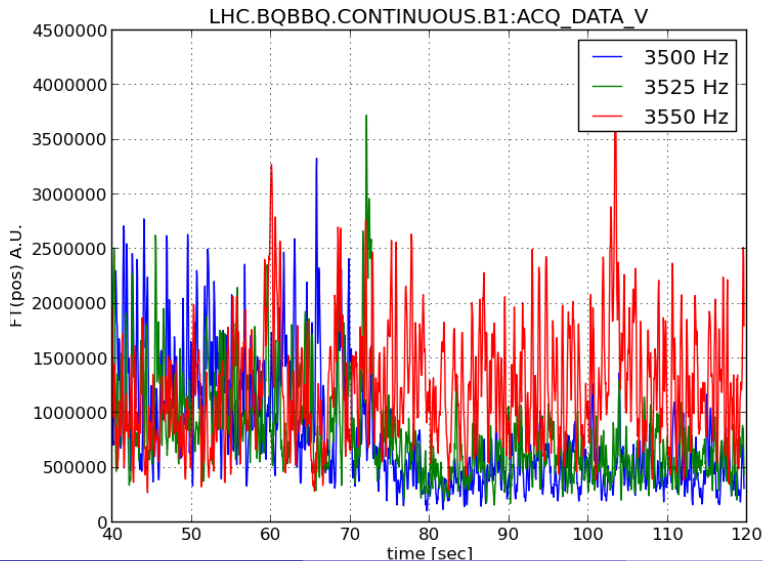
LHC BBQ during tune jump:

2012-09-03 20-05-13



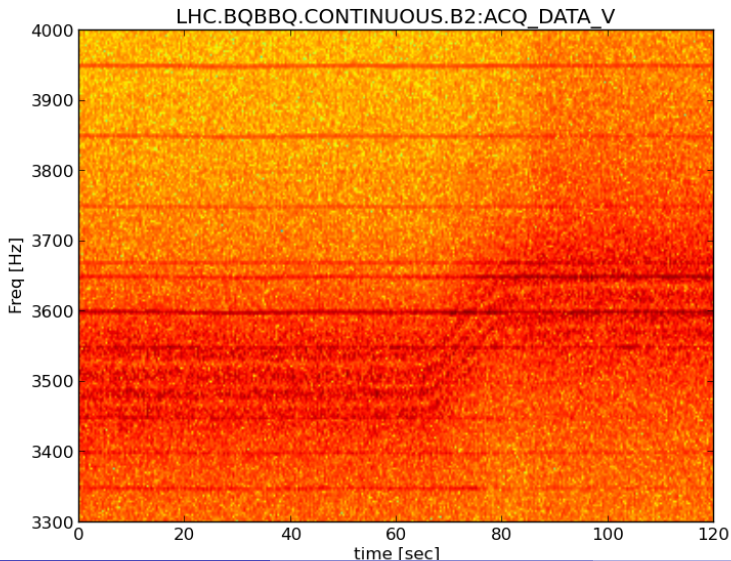
LHC BBQ during tune jump:

2012-09-03 20-05-13



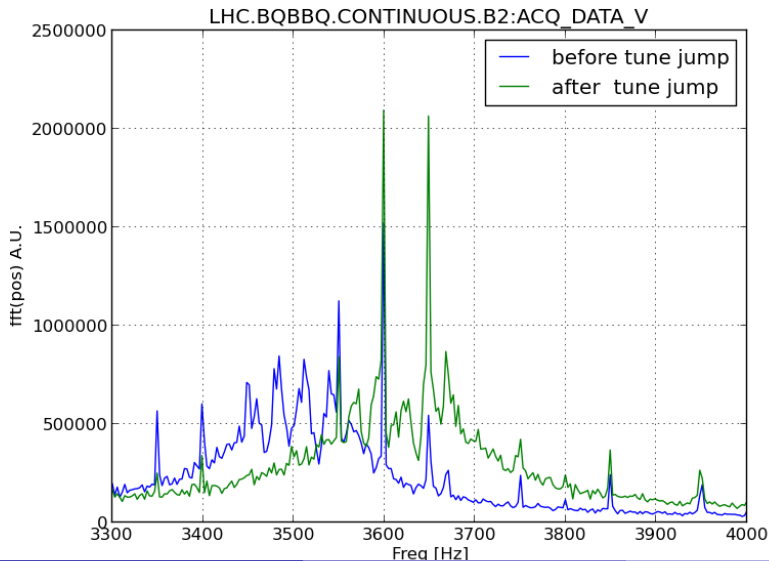
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2012-09-03 20-05-13



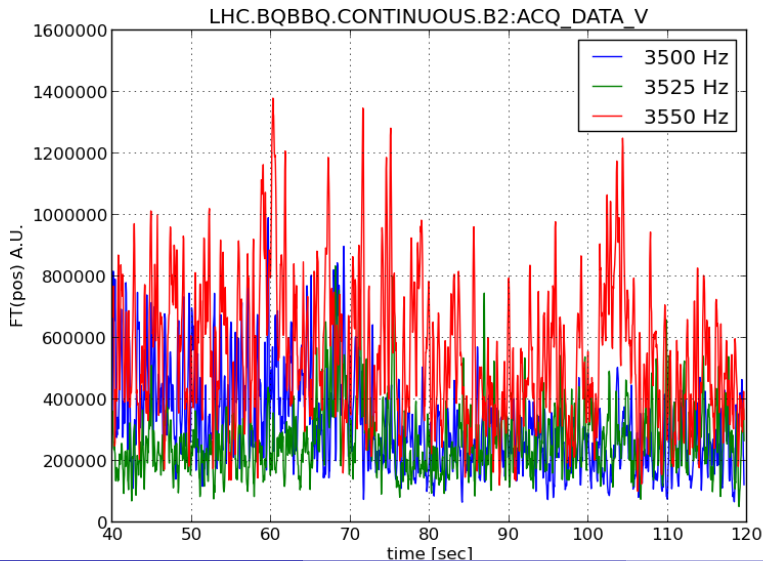
LHC BBQ during tune jump:

2012-09-03 20-05-13



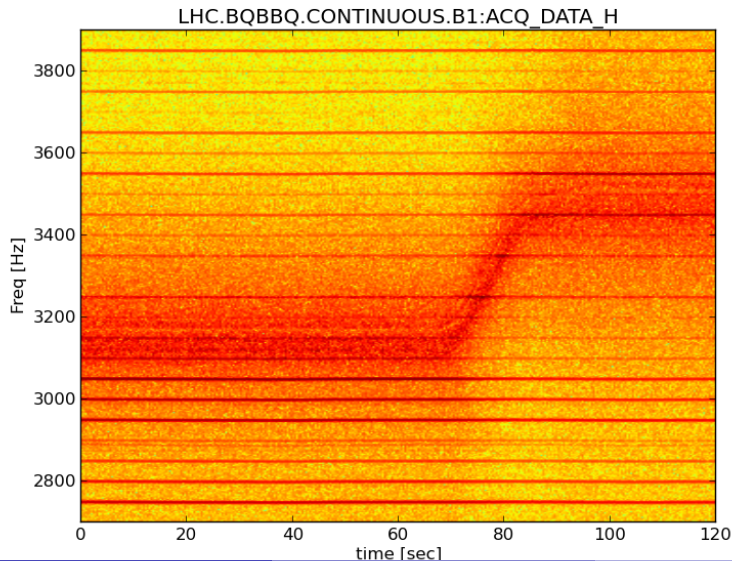
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2012-09-03 20-05-13



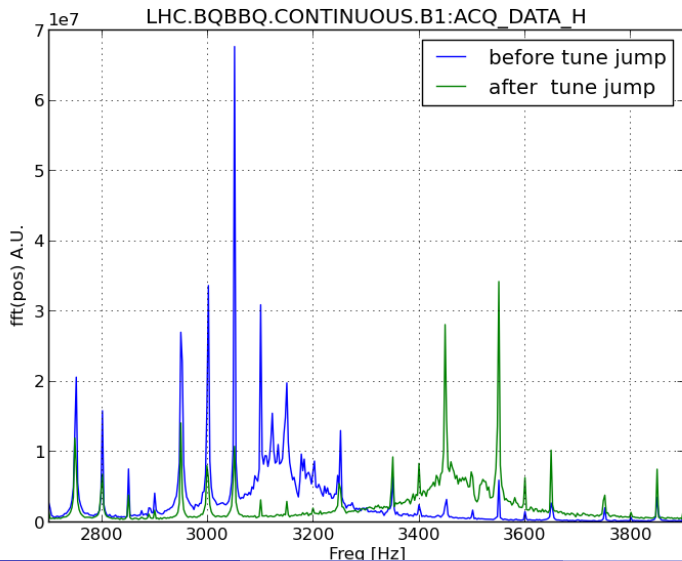
LHC BBQ during tune jump:

2012-09-04 10-40-02



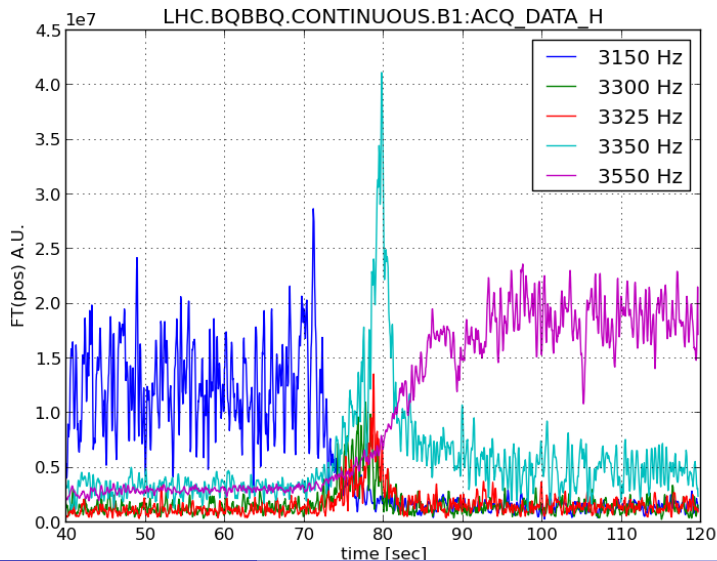
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2012-09-04 10:40-02

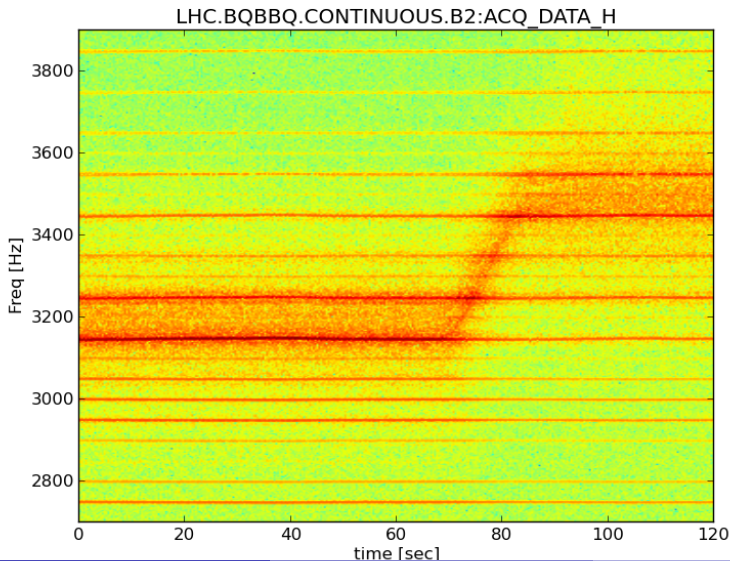


LHC BBQ during tune jump:

2012-09-04 10-40-02

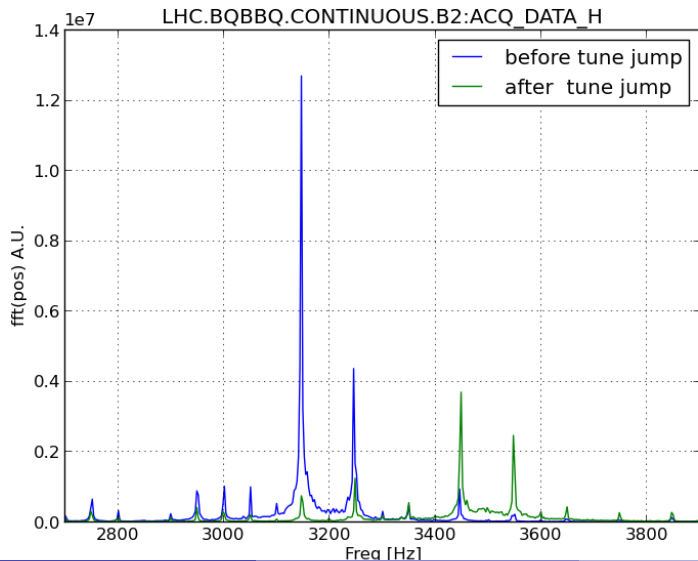


LHC BBQ during tune jump: 2012-09-04 10-40-02



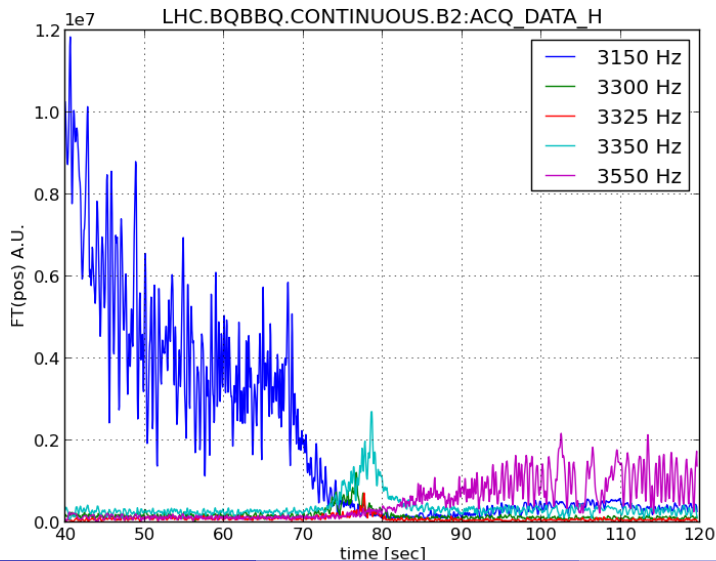
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2012-09-04 10-40-02



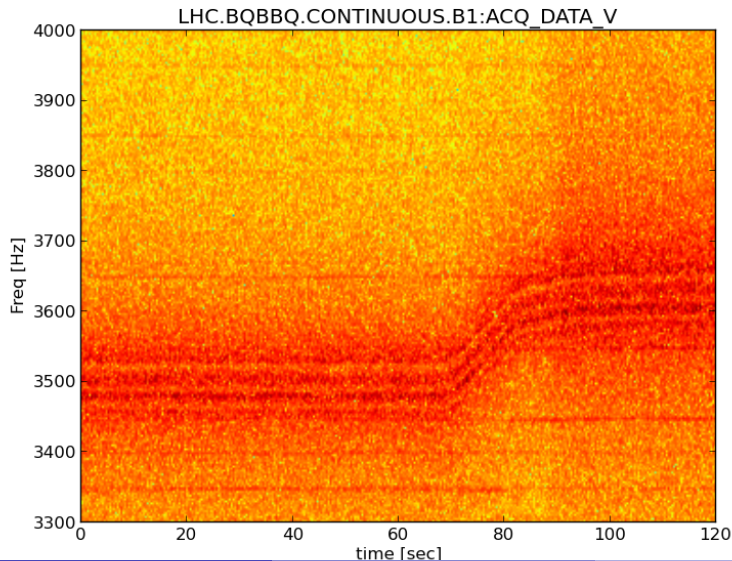
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2012-09-04 10-40-02



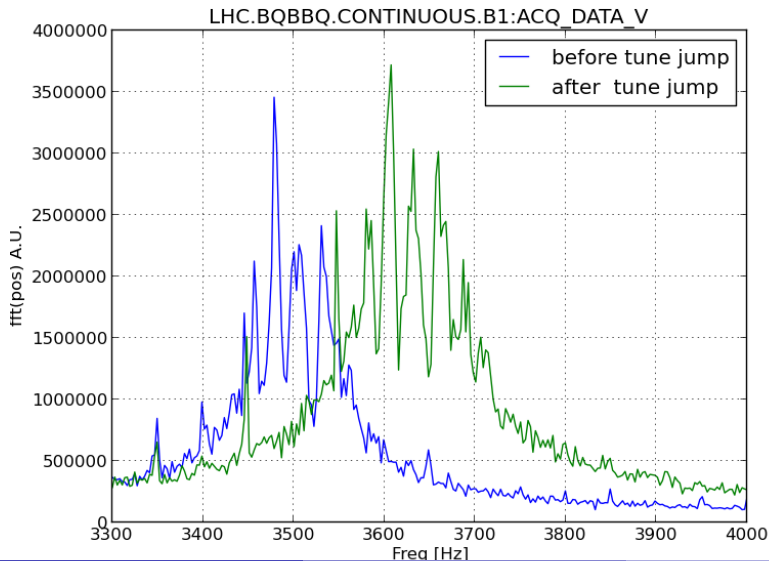
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2012-09-04 10-40-02



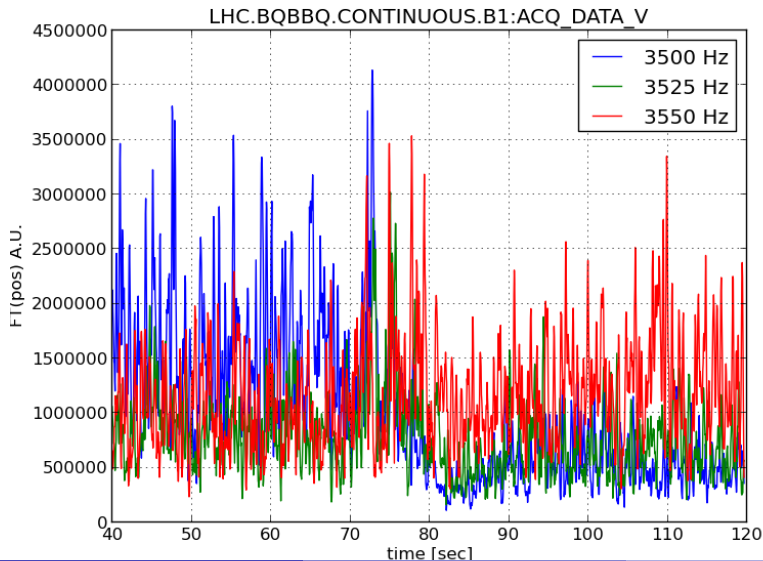
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2012-09-04 10:40:02



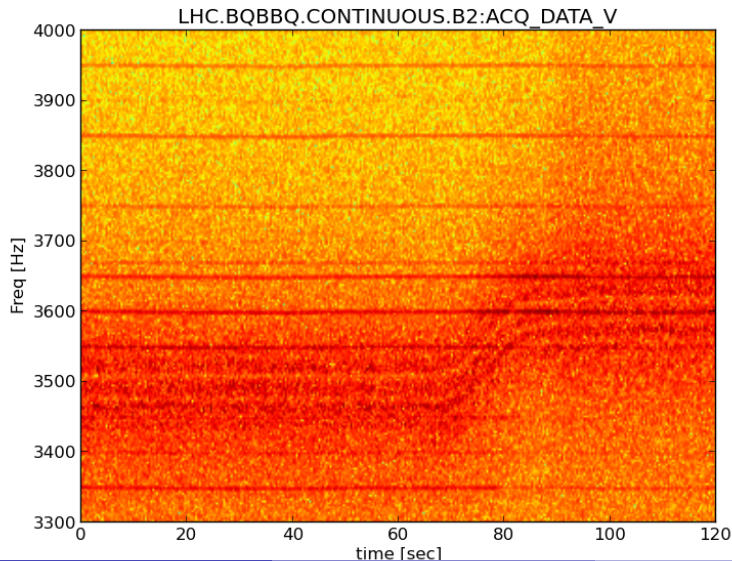
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2012-09-04 10-40-02



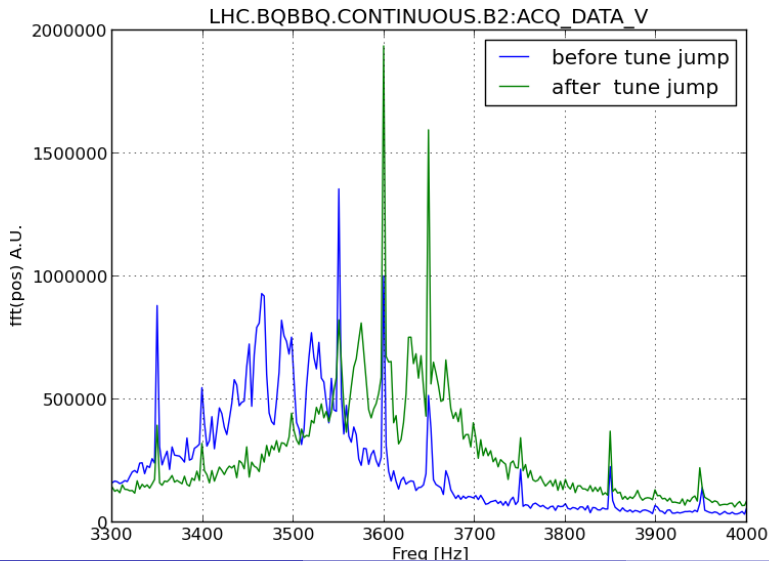
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2012-09-04 10-40-02



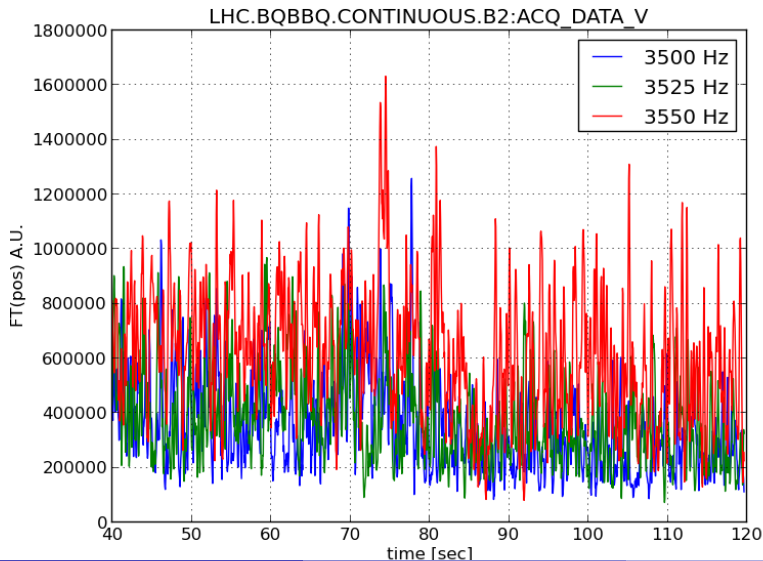
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2012-09-04 10-40-02



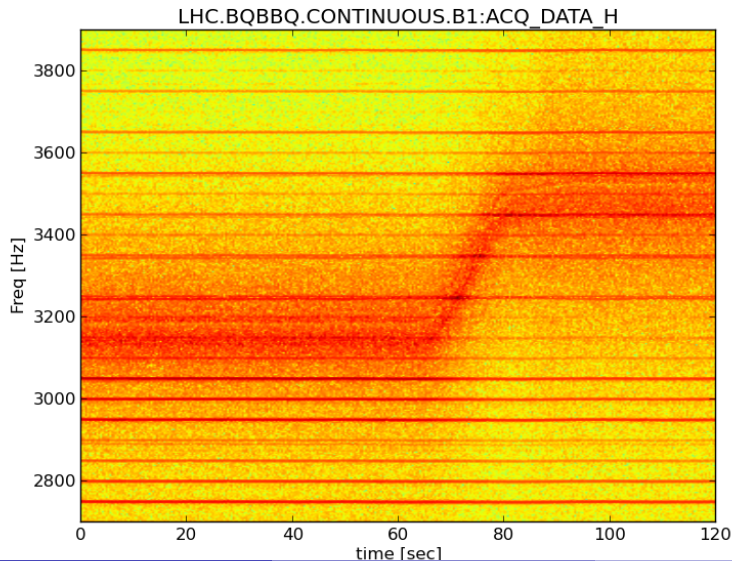
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2012-09-04 10-40-02



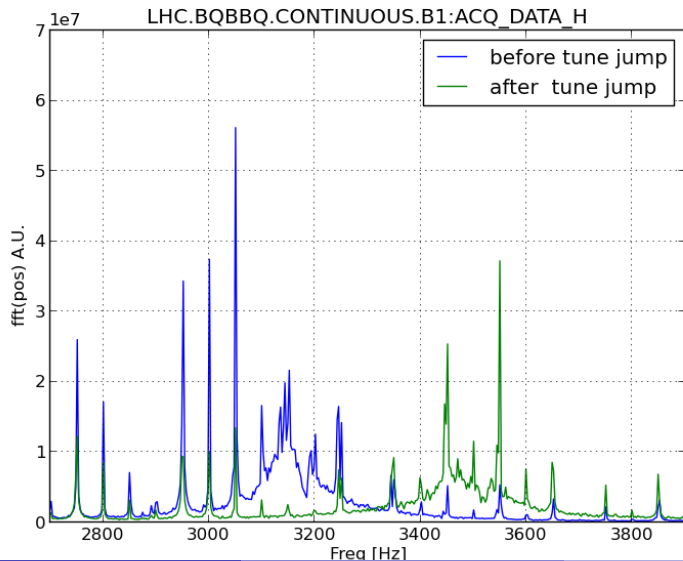
LHC BBQ during tune jump:

2012-09-04 13-50-28



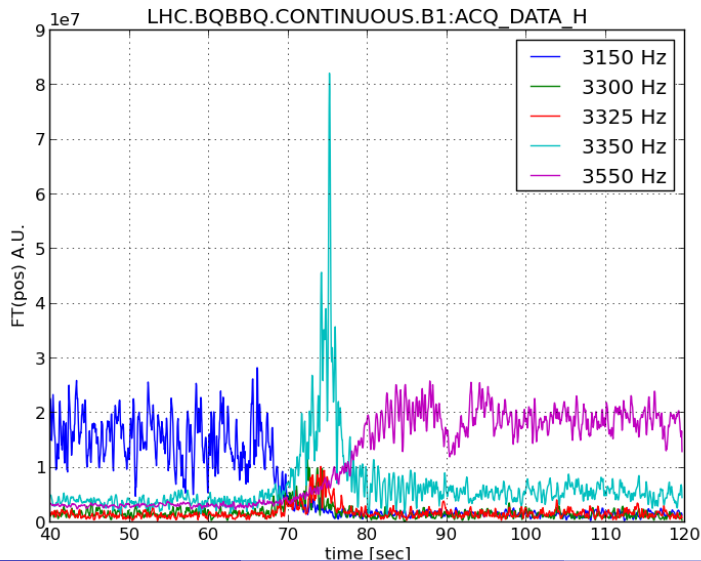
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2012-09-04 13-50-28



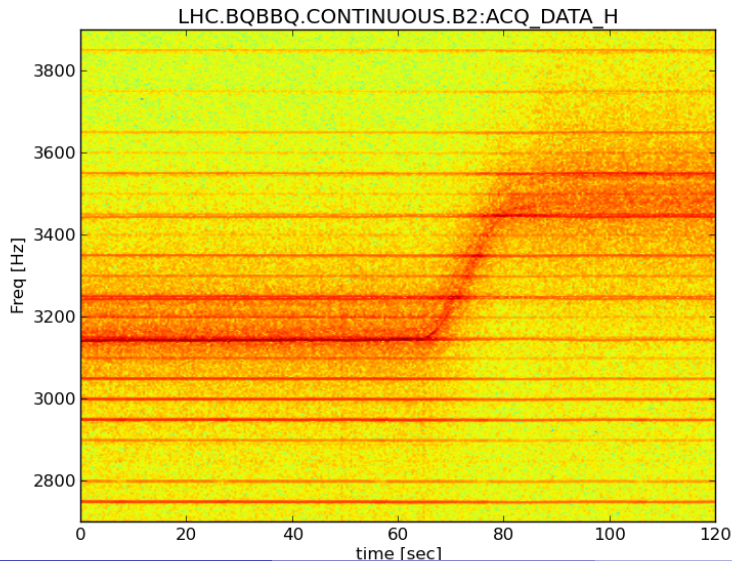
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2012-09-04 13-50-28



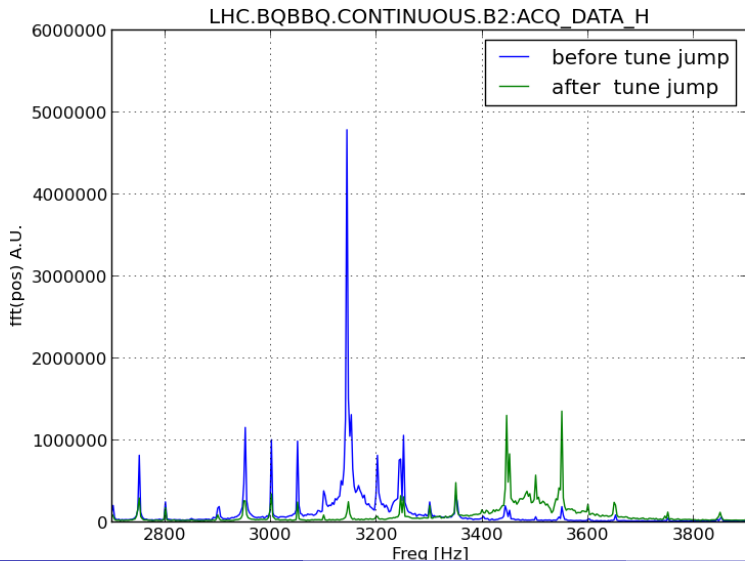
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2012-09-04 13-50-28



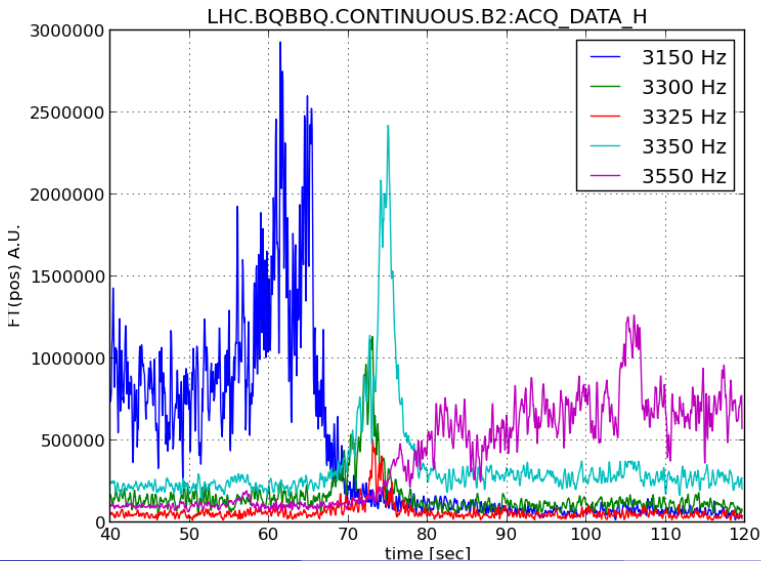
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2012-09-04 13-50-28



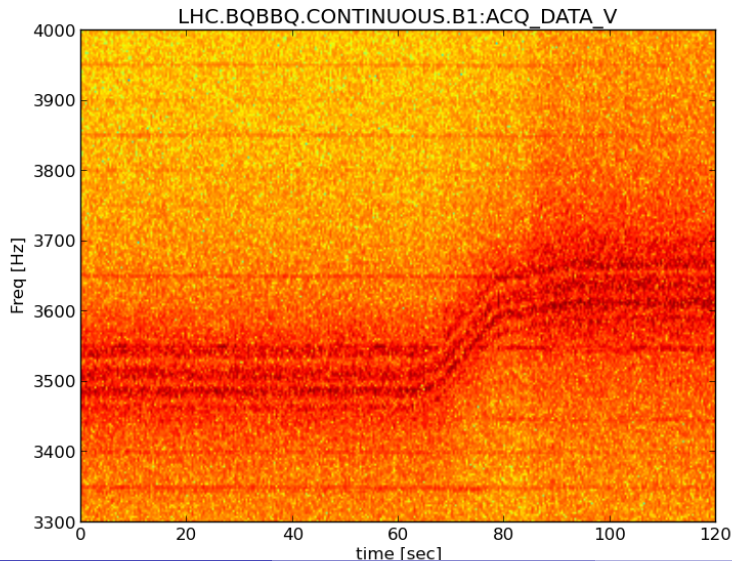
LHC BBQ during tune jump:

2012-09-04 13-50-28



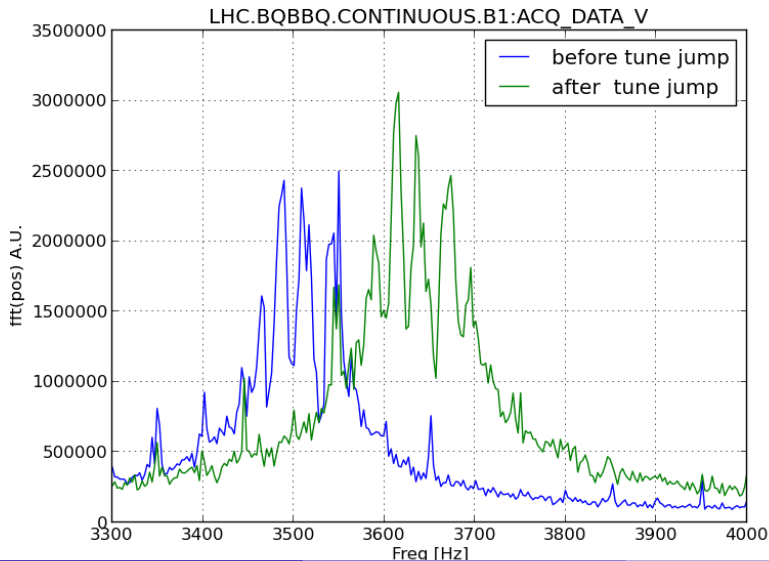
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2012-09-04 13:50-28



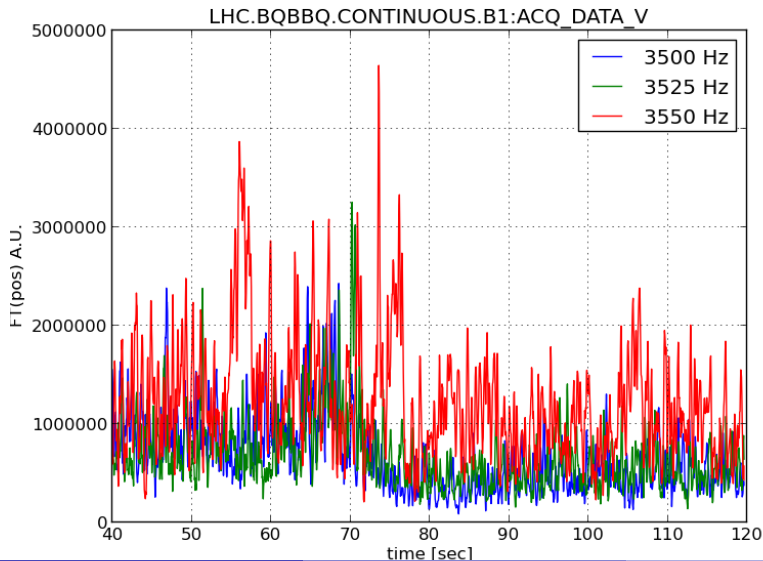
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2012-09-04 13-50-28



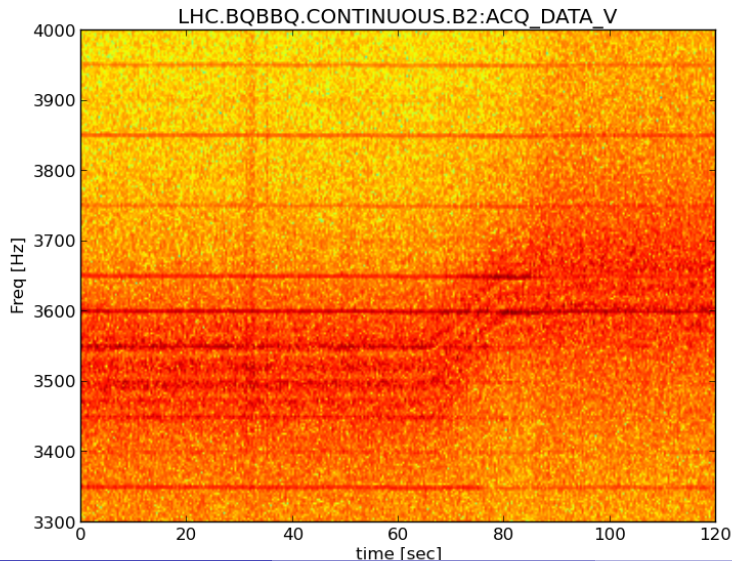
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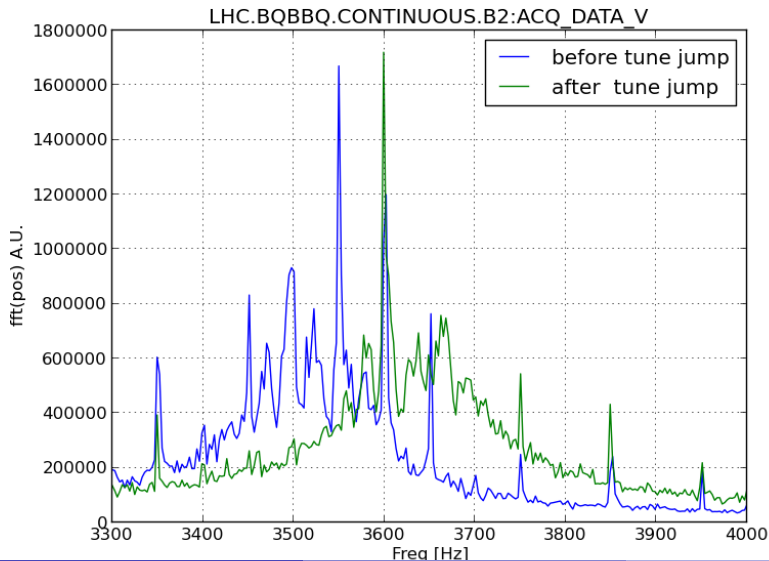
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2012-09-04 13-50-28



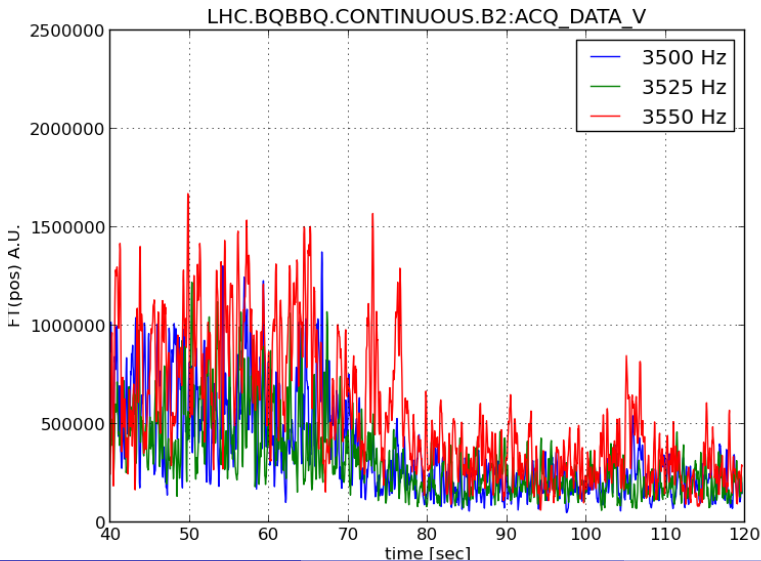
LHC BBQ during tune jump:

2012-09-04 13-50-28



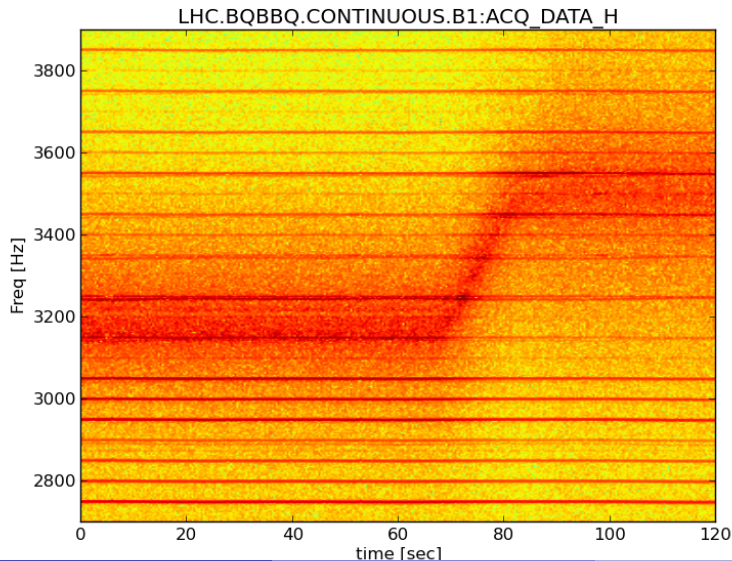
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2012-09-04 13-50-28



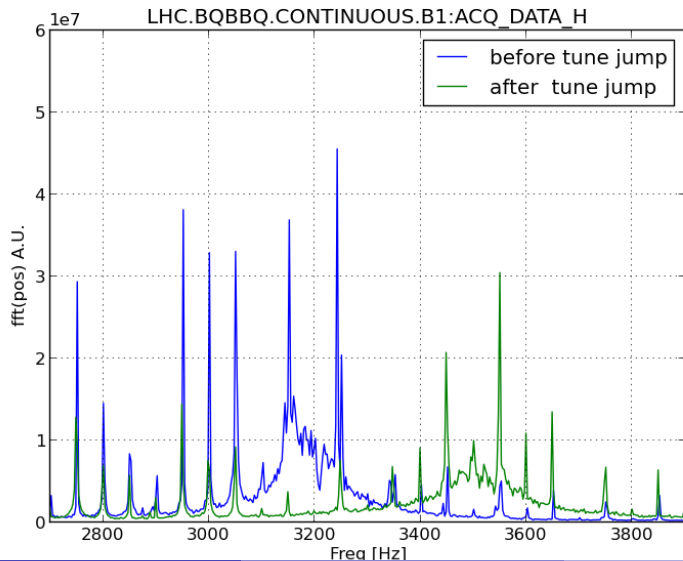
LHC BBQ during tune jump:

2012-09-04 23-24-13



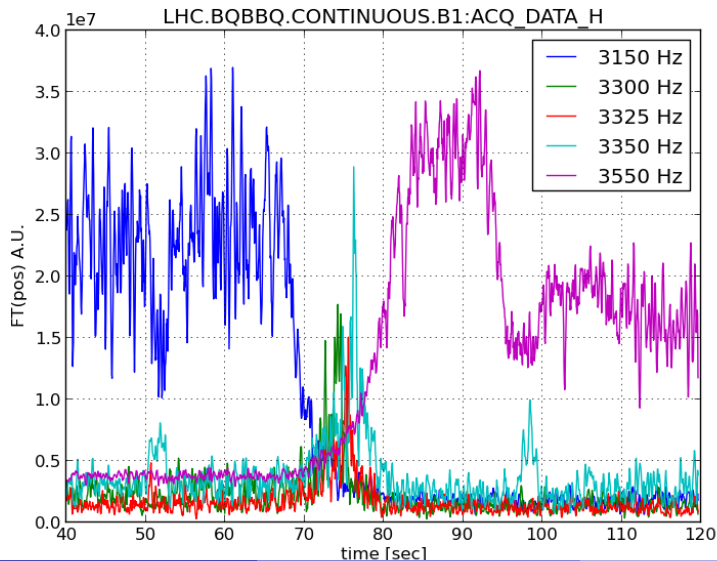
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2012-09-04 23-24-13

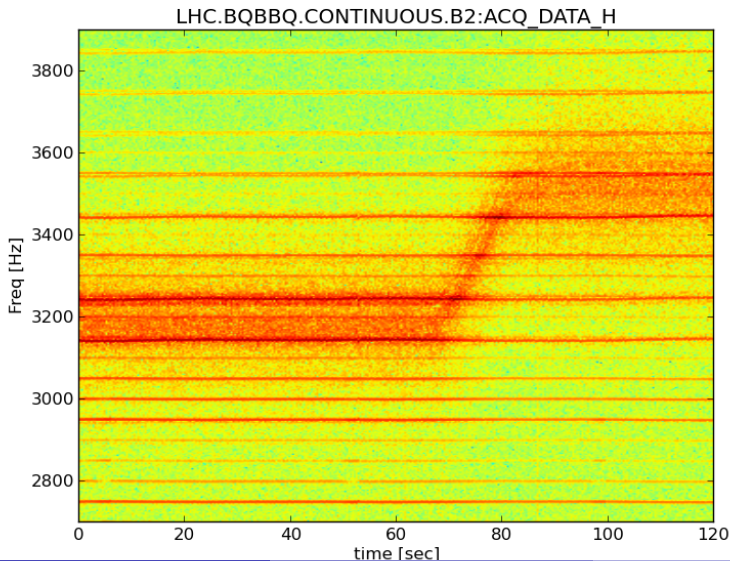


LHC BBQ during tune jump:

2012-09-04 23-24-13

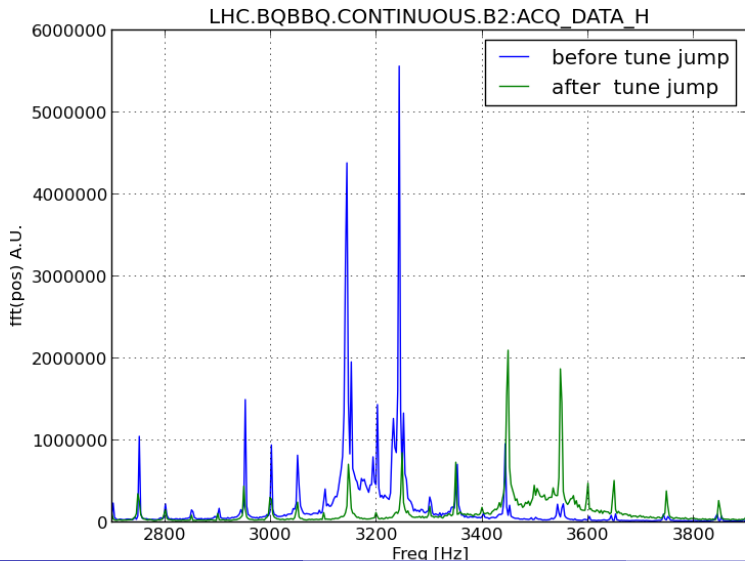


LHC BBQ during tune jump: 2012-09-04 23-24-13



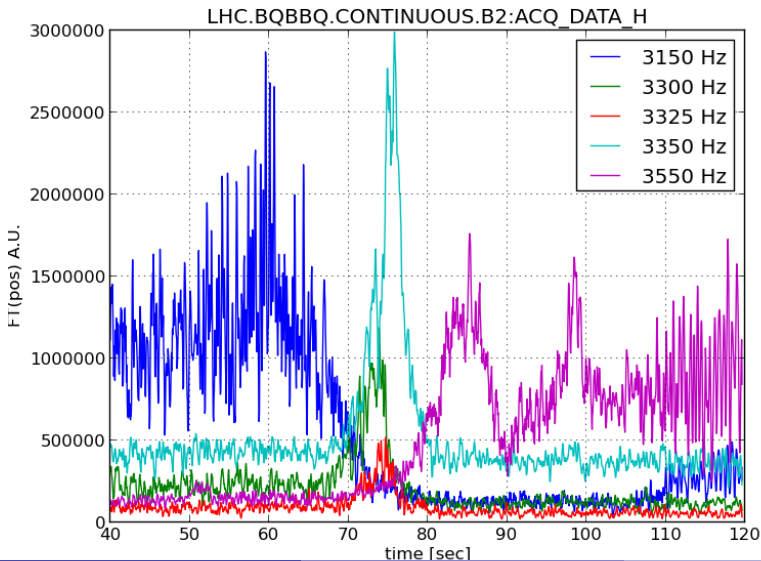
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2012-09-04 23-24-13

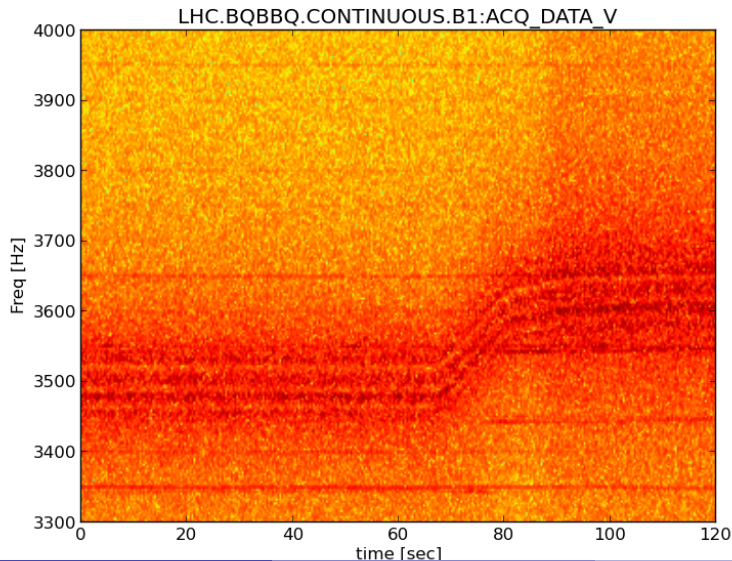


LHC BBQ during tune jump:

2012-09-04 23-24-13

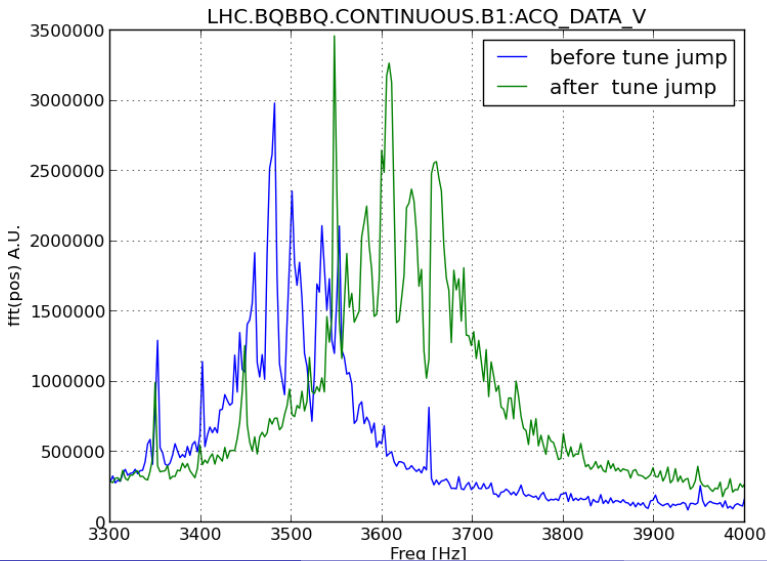


LHC BBQ during tune jump: 2012-09-04 23-24-13



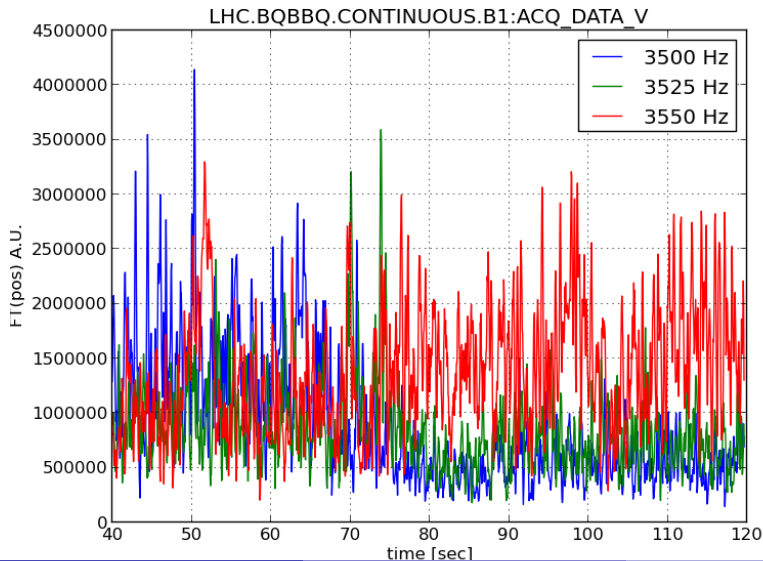
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2012-09-04 23-24-13

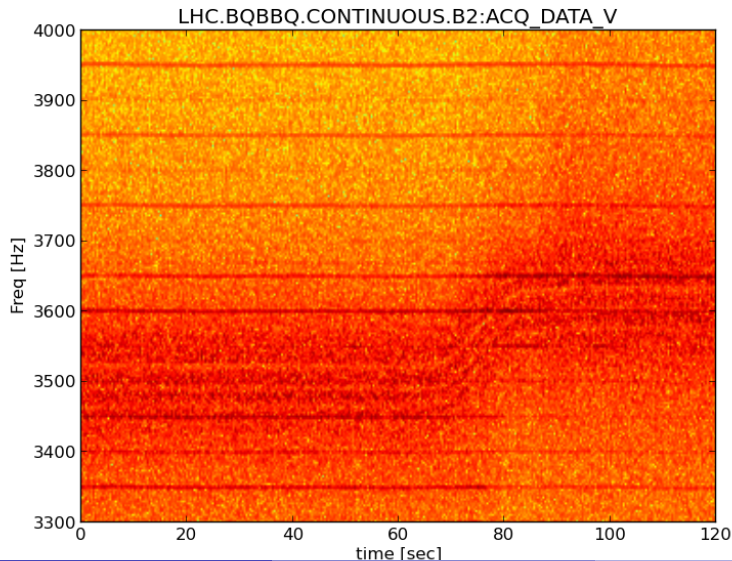


LHC BBQ during tune jump:

2012-09-04 23-24-13

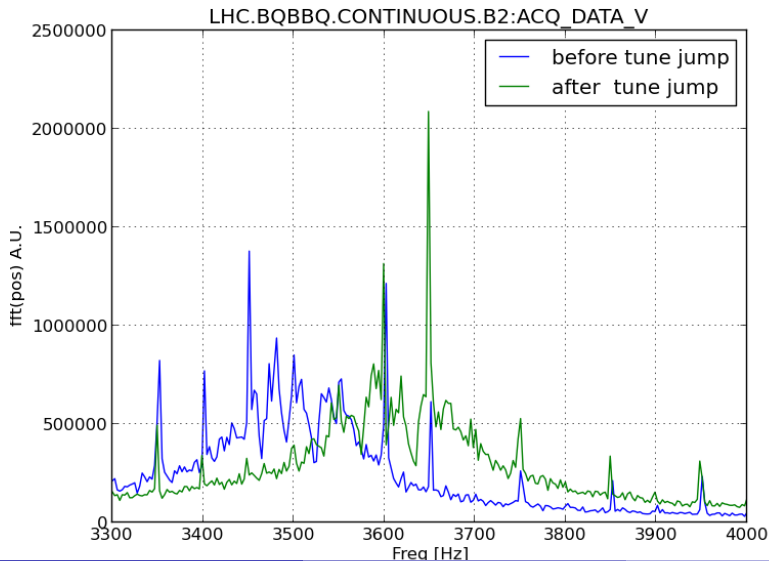


LHC BBQ during tune jump: 2012-09-04 23-24-13

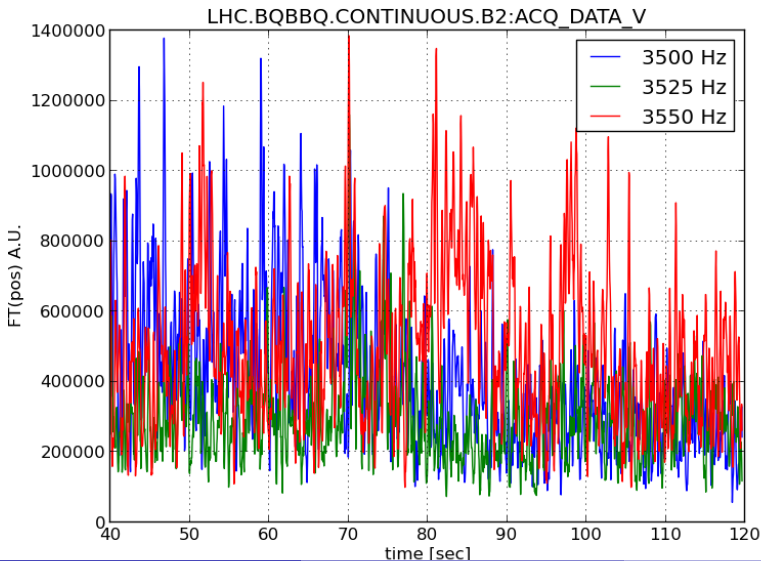


LHC BBQ during tune jump:

2012-09-04 23-24-13

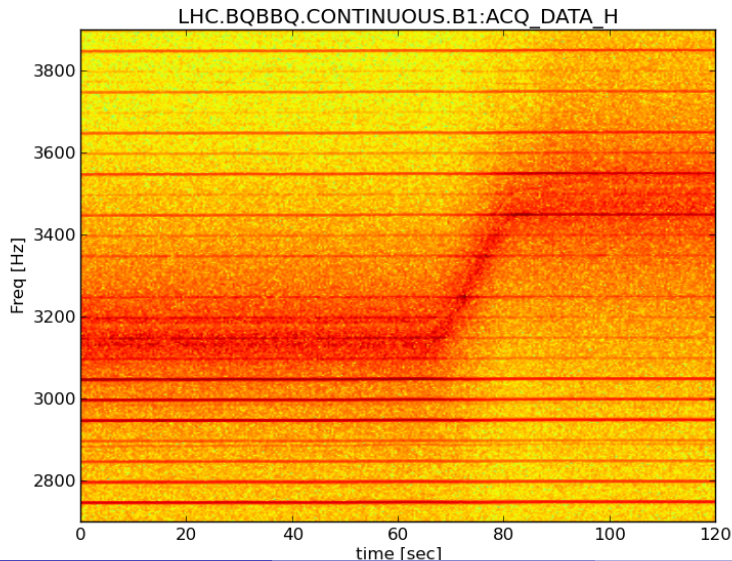


LHC BBQ during tune jump: 2012-09-04 23-24-13



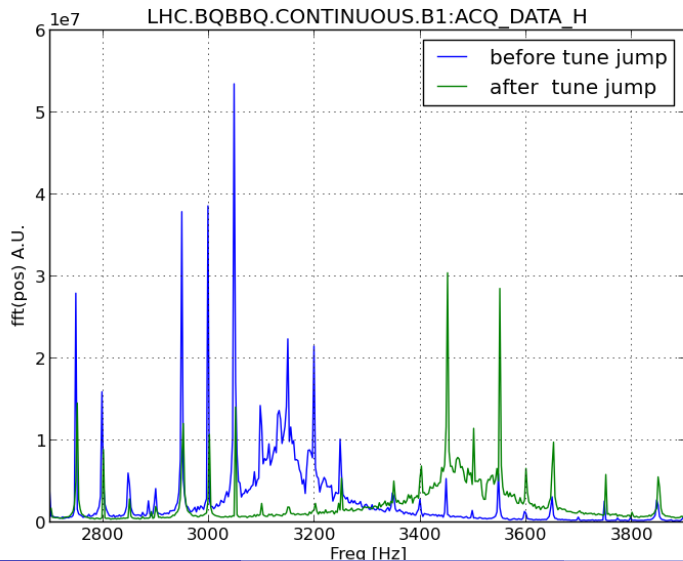
LHC BBQ during tune jump:

2012-09-05 15-31-37



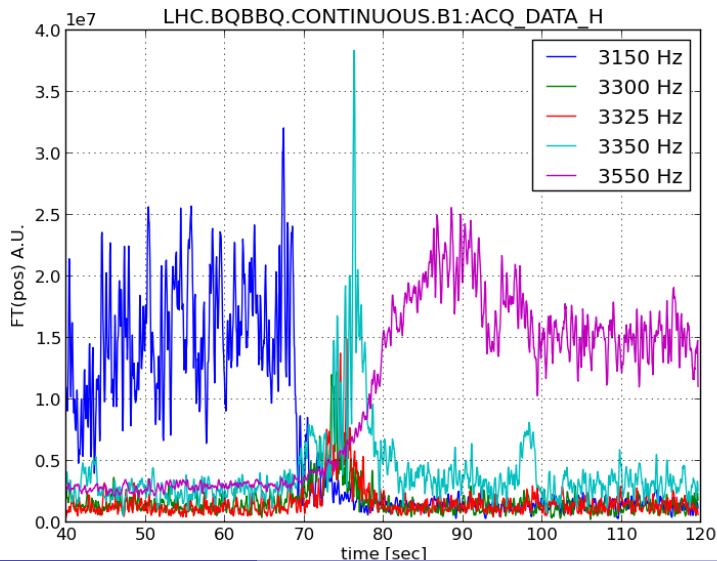
LHC BBQ during tune jump:

2012-09-05 15-31-37



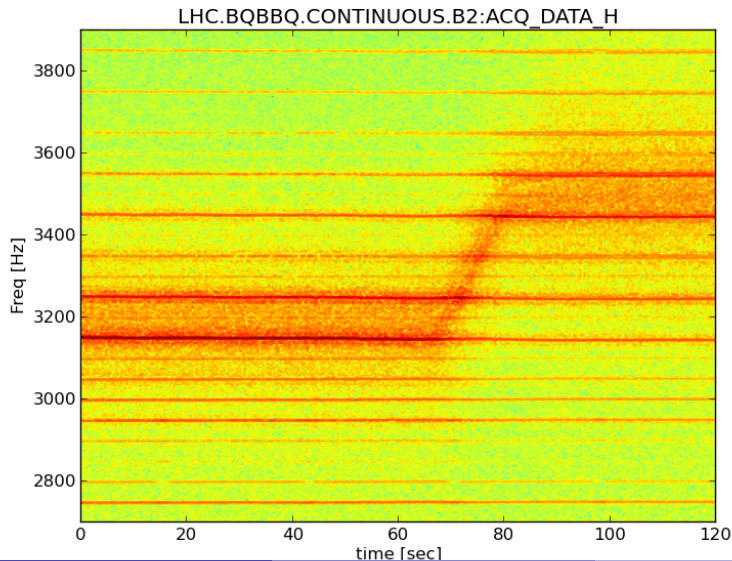
LHC BBQ during tune jump:

2012-09-05 15-31-37



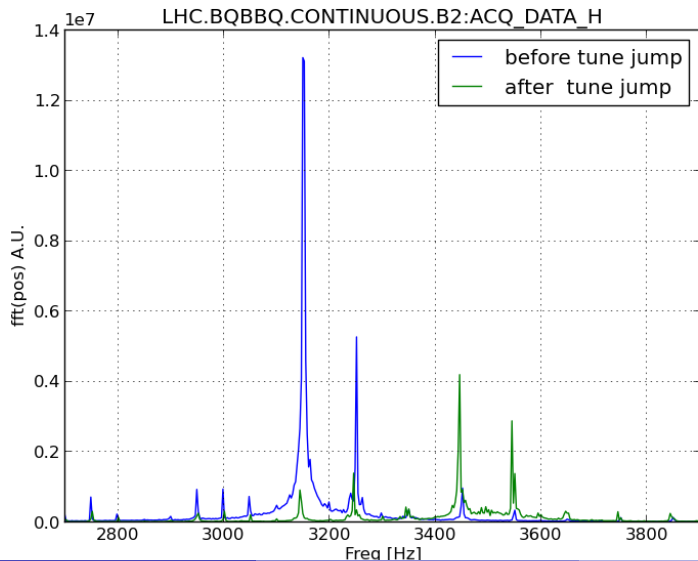
LHC BBQ during tune jump:

2012-09-05 15-31-37



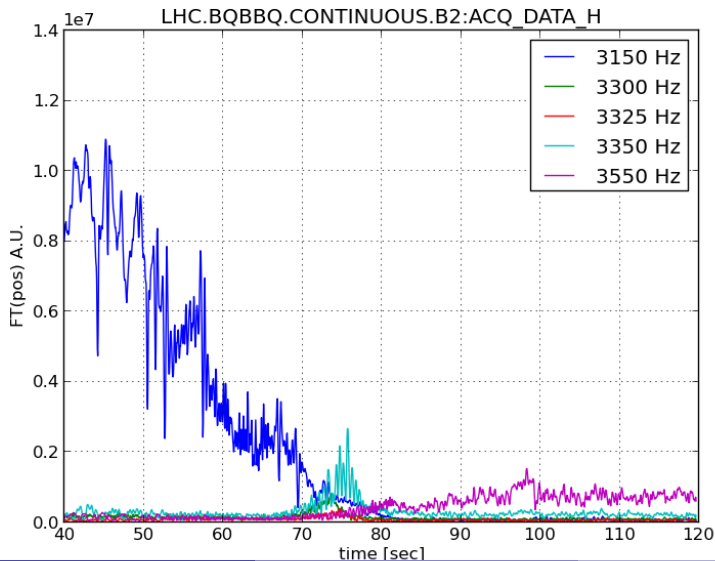
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2012-09-05 15-31-37



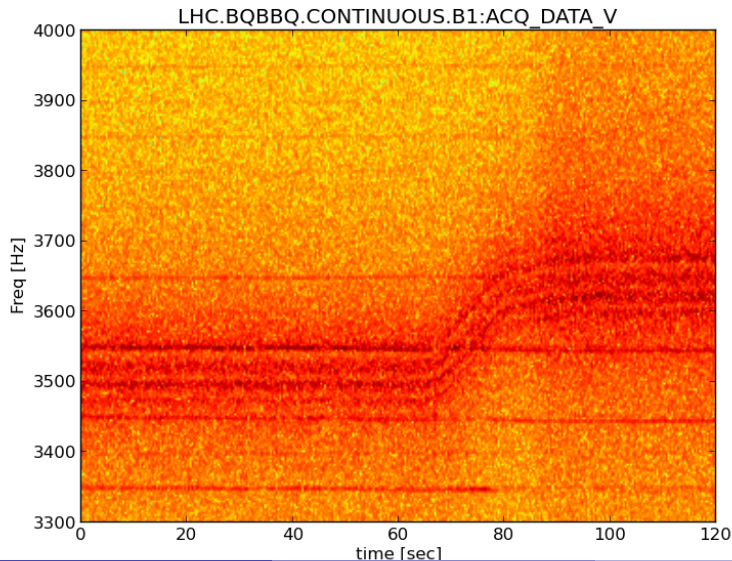
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2012-09-05 15-31-37



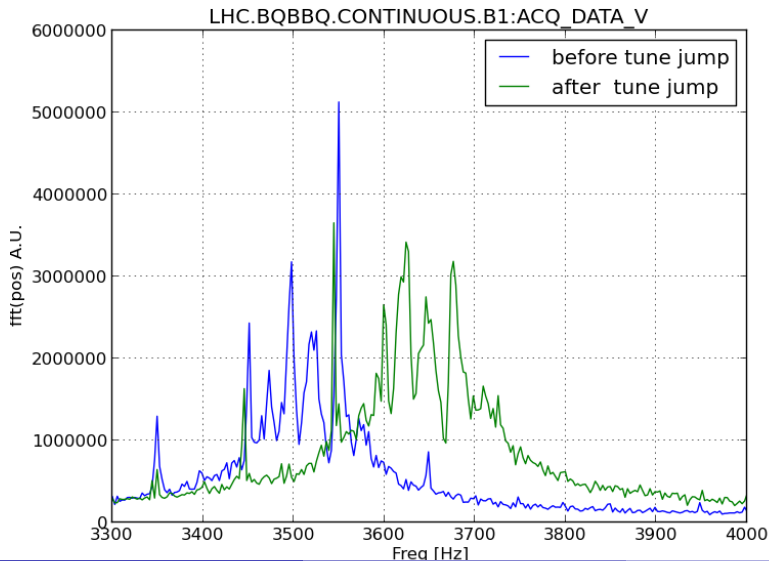
LHC BBQ during tune jump:

2012-09-05 15-31-37



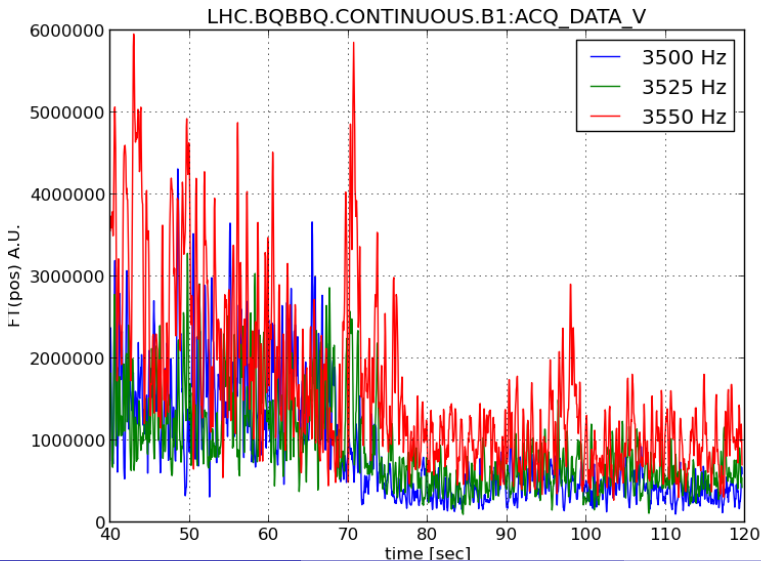
LHC BBQ during tune jump:

2012-09-05 15-31-37



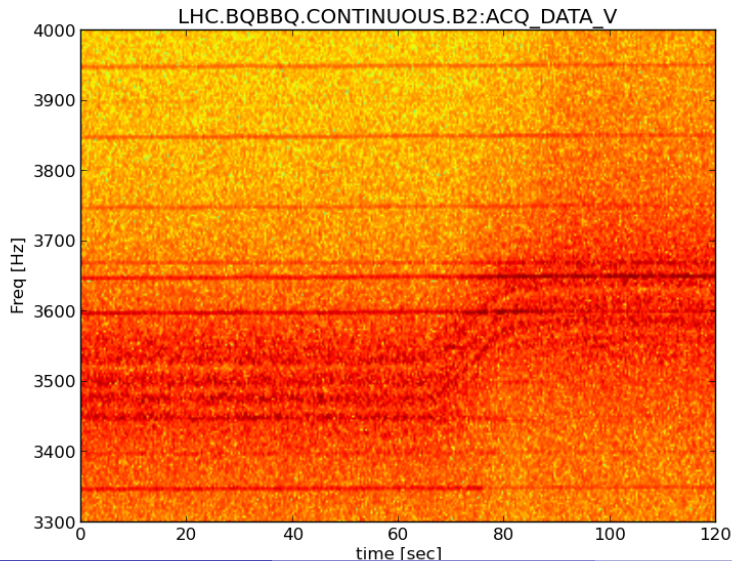
LHC BBQ during tune jump:

2012-09-05 15-31-37



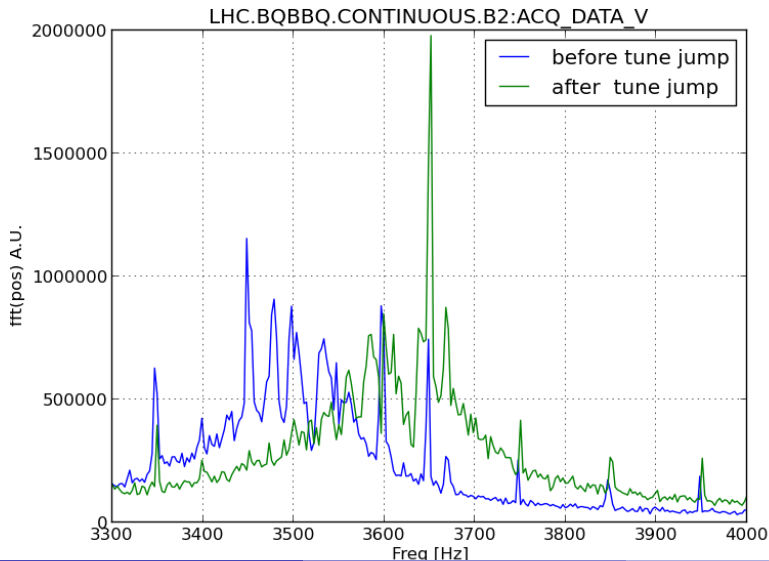
LHC BBQ during tune jump:

2012-09-05 15-31-37



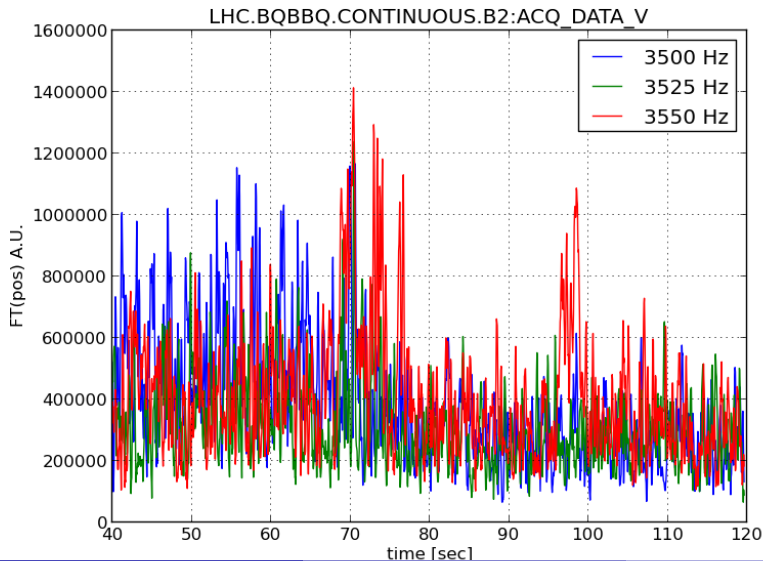
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2012-09-05 15-31-37



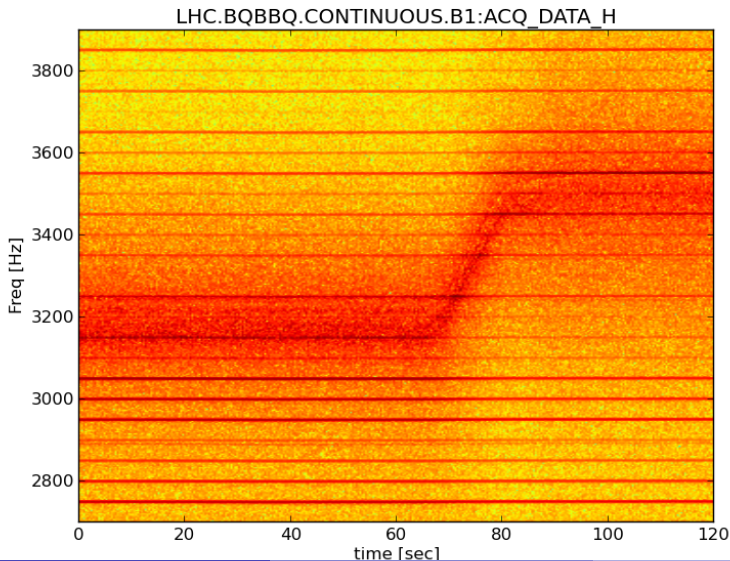
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2012-09-05 15-31-37



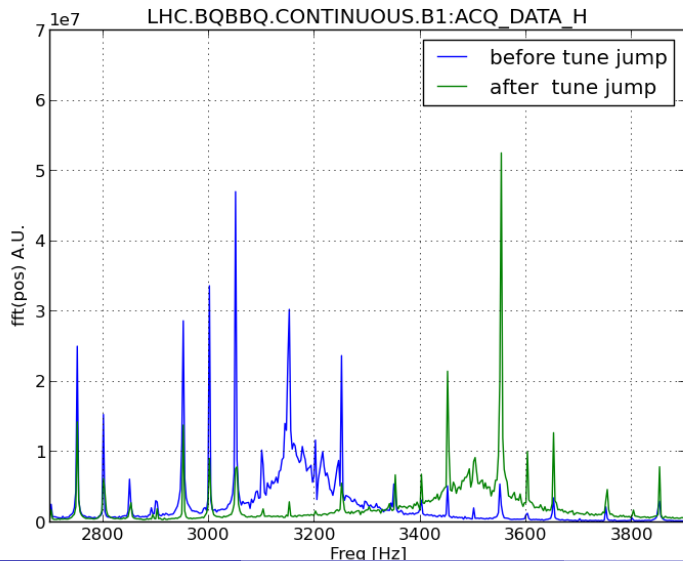
LHC BBQ during tune jump:

2012-09-06 10-49-07



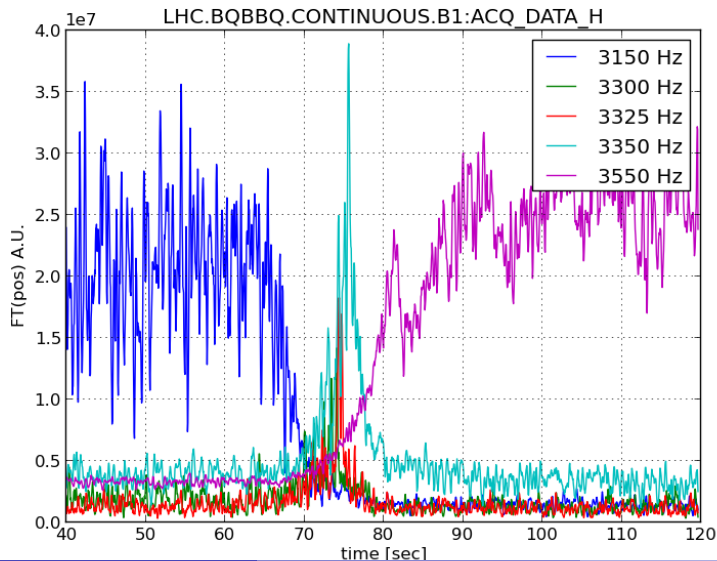
LHC BBQ during tune jump:

2012-09-06 10:49:07



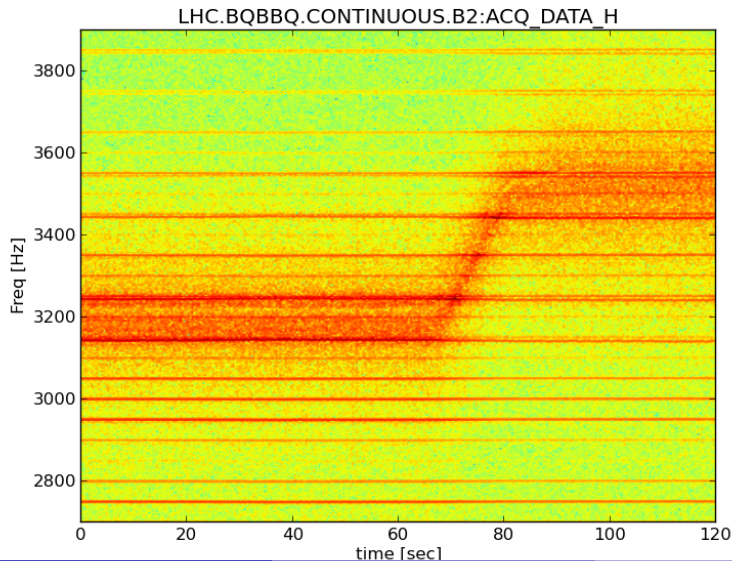
LHC BBQ during tune jump:

2012-09-06 10-49-07



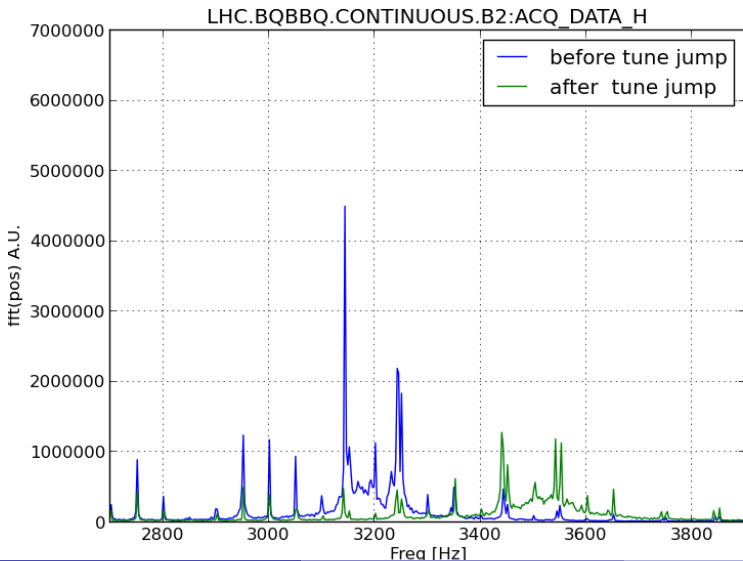
LHC BBQ during tune jump:

2012-09-06 10-49-07



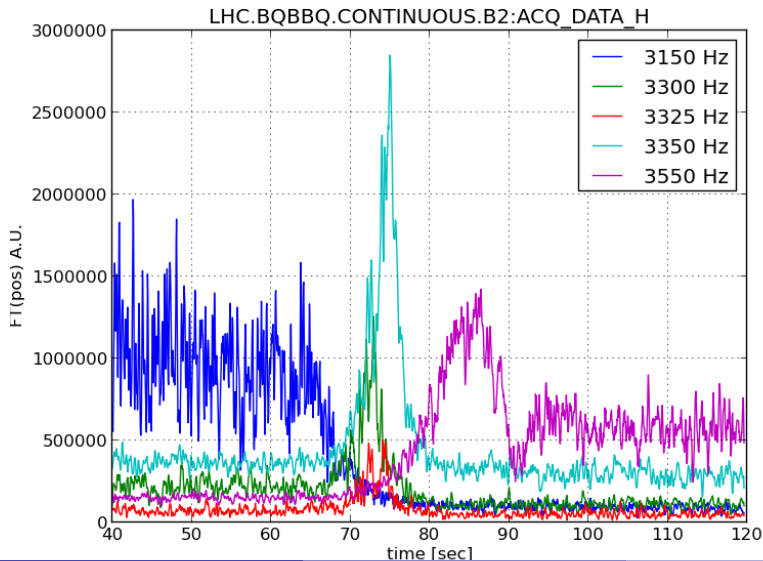
LHC BBQ during tune jump:

2012-09-06 10-49-07



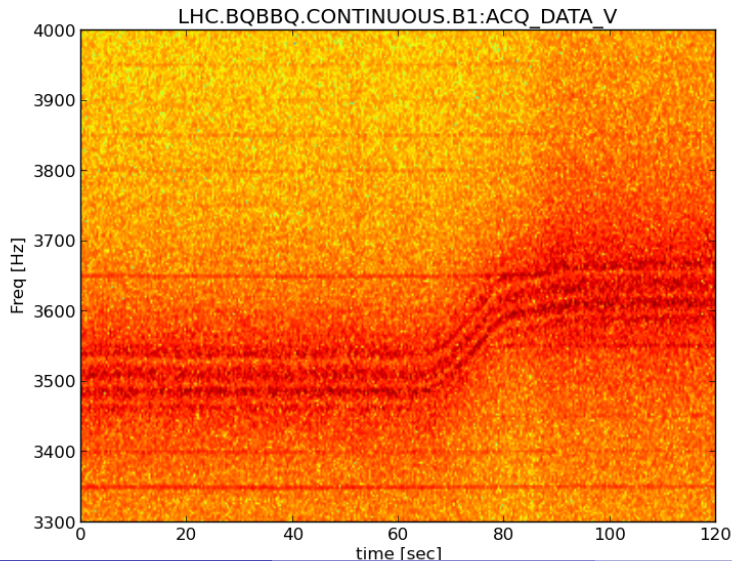
LHC BBQ during tune jump:

2012-09-06 10-49-07



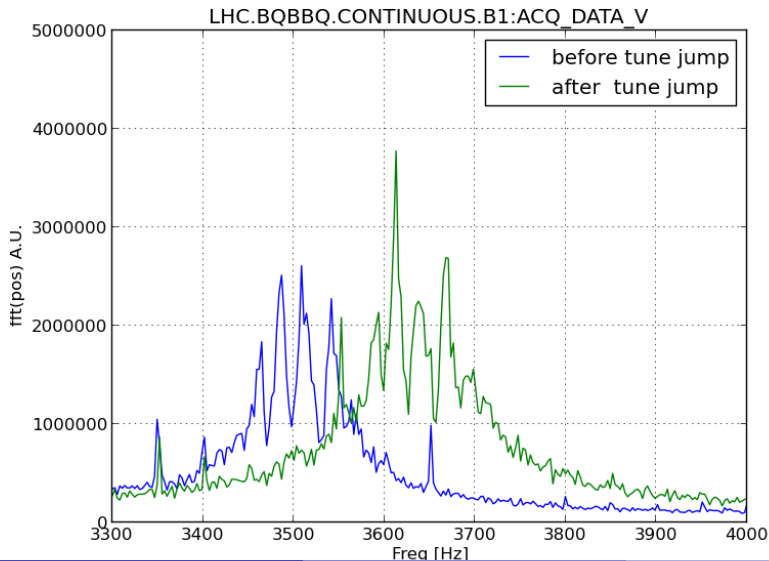
LHC BBQ during tune jump:

2012-09-06 10-49-07



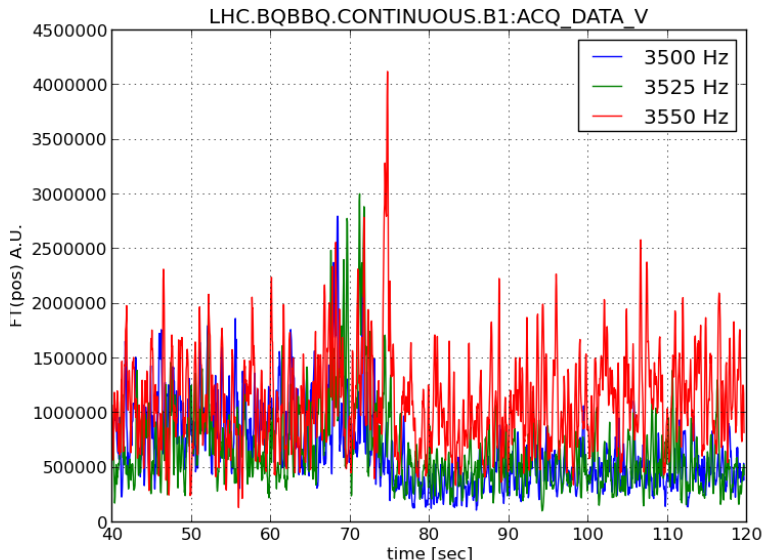
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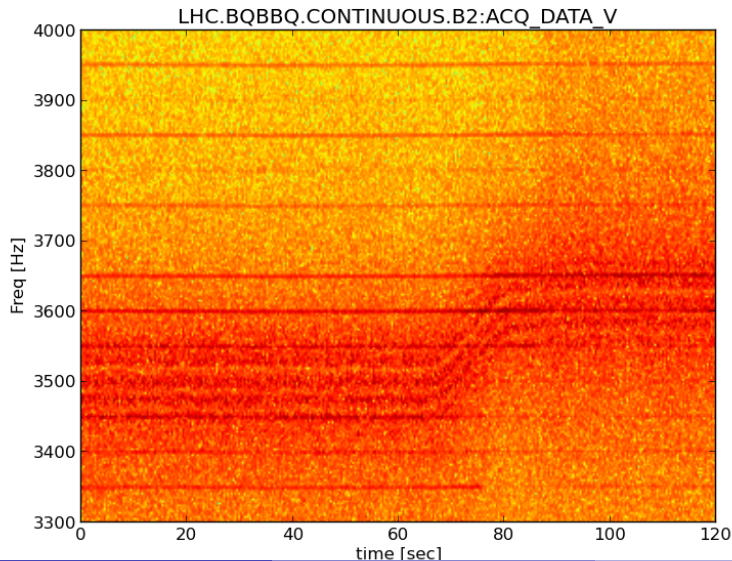
LHC BBQ during tune jump:

2012-09-06 10-49-07



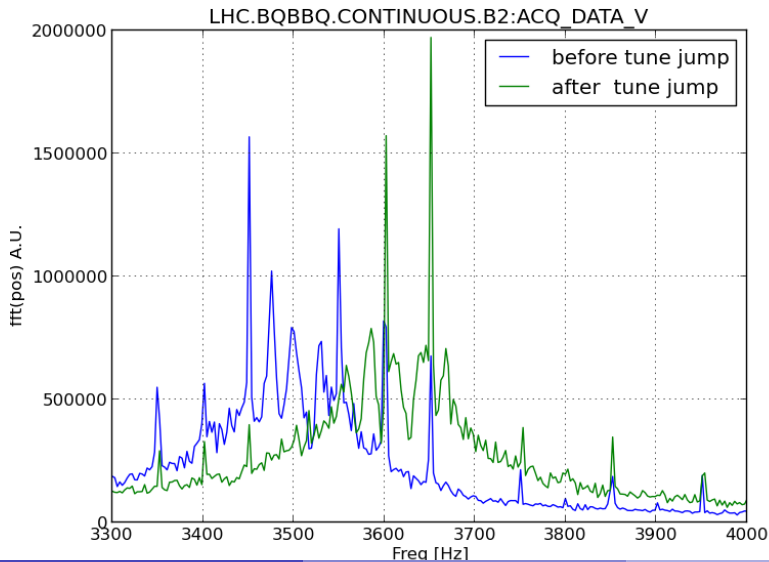
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2012-09-06 10-49-07



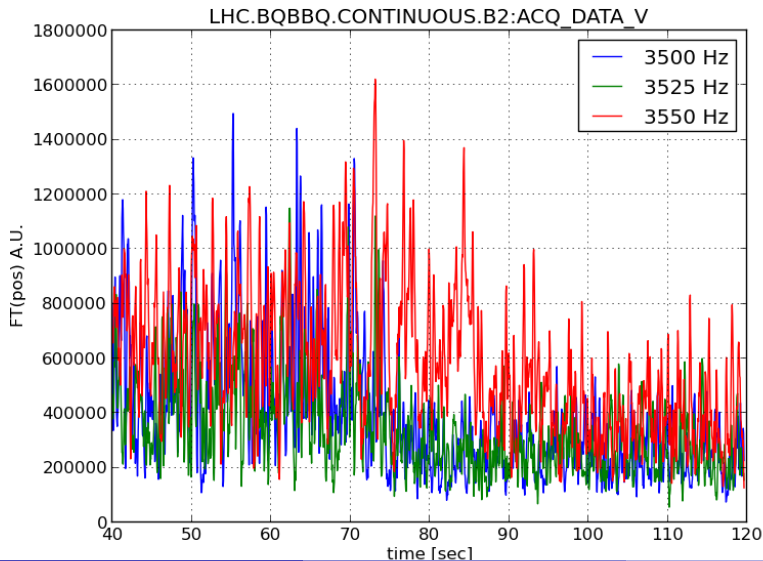
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2012-09-06 10-49-07



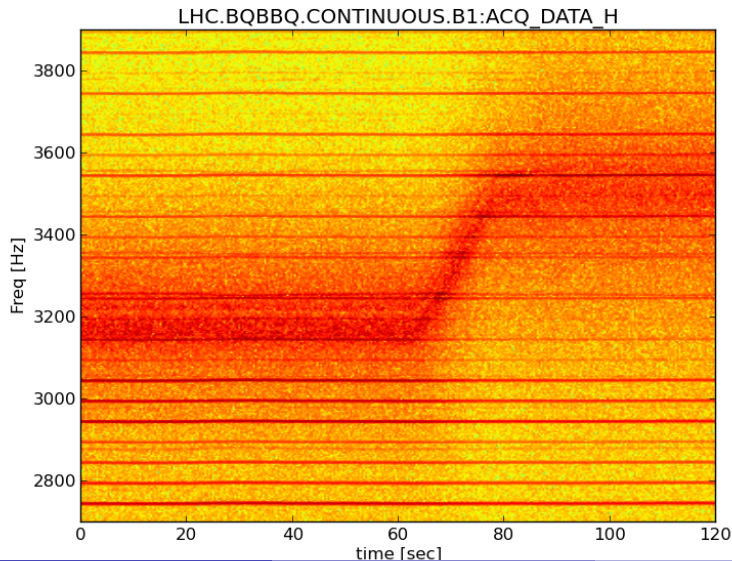
LHC BBQ during tune jump:

2012-09-06 10-49-07



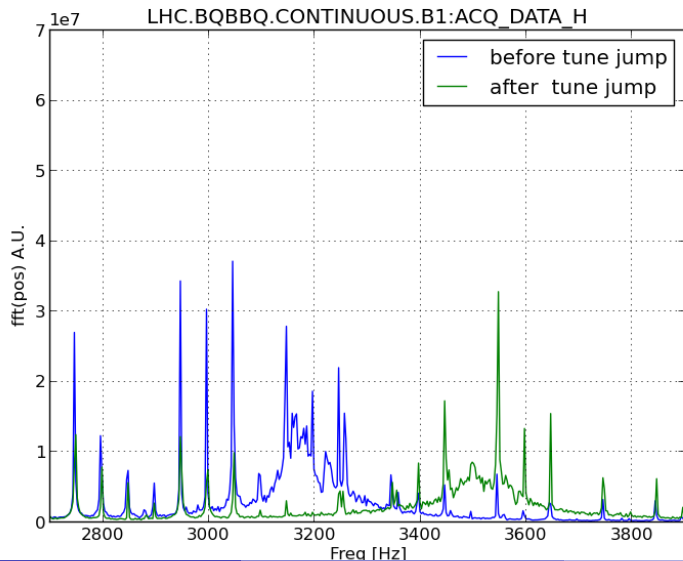
LHC BBQ during tune jump:

2012-09-06 23-05-43



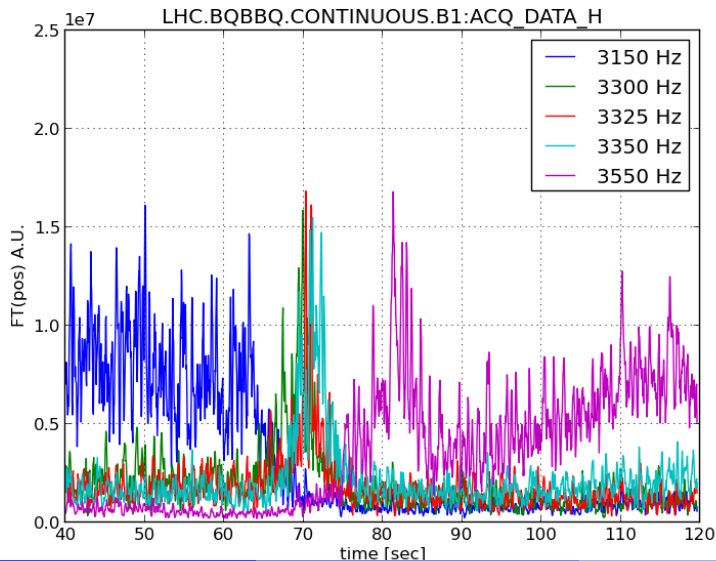
LHC BBQ during tune jump:

2012-09-06 23-05-43



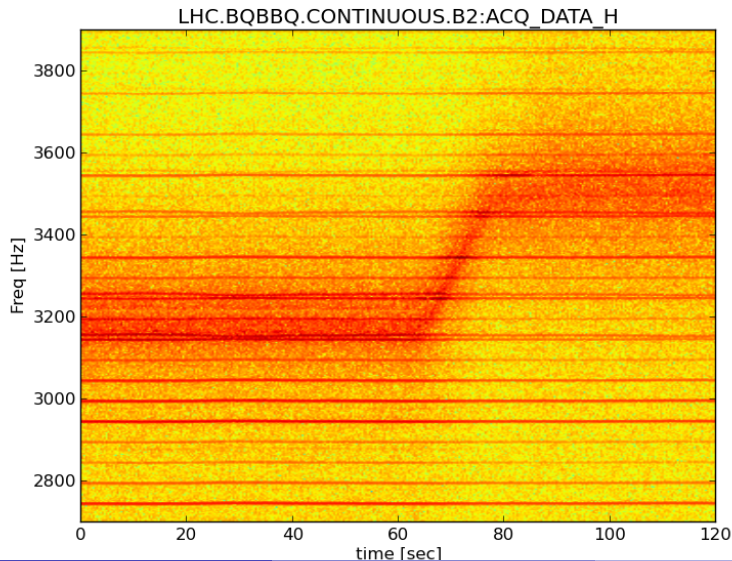
LHC BBQ during tune jump:

2012-09-06 23-05-43



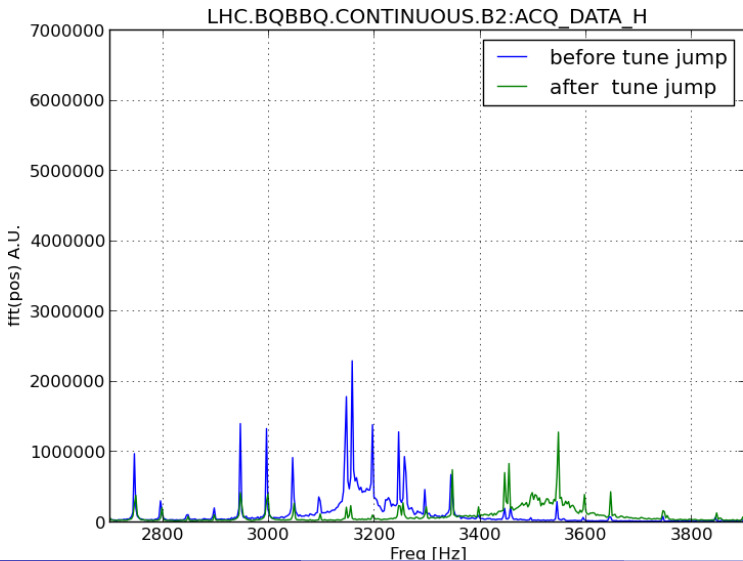
LHC BBQ during tune jump:

2012-09-06 23-05-43



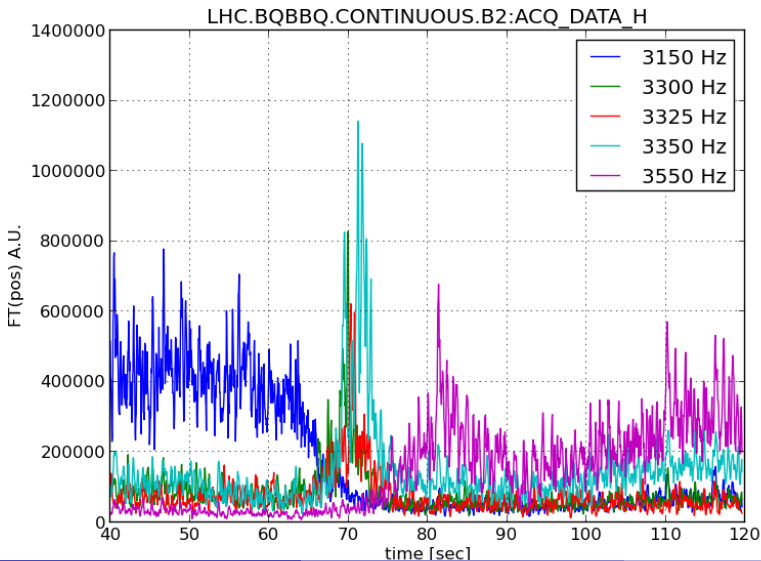
LHC BBQ during tune jump:

2012-09-06 23-05-43



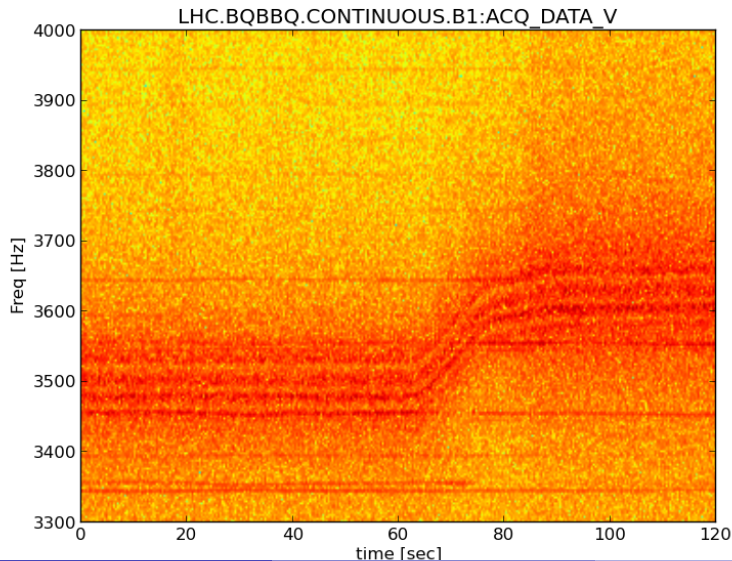
LHC BBQ during tune jump:

2012-09-06 23-05-43



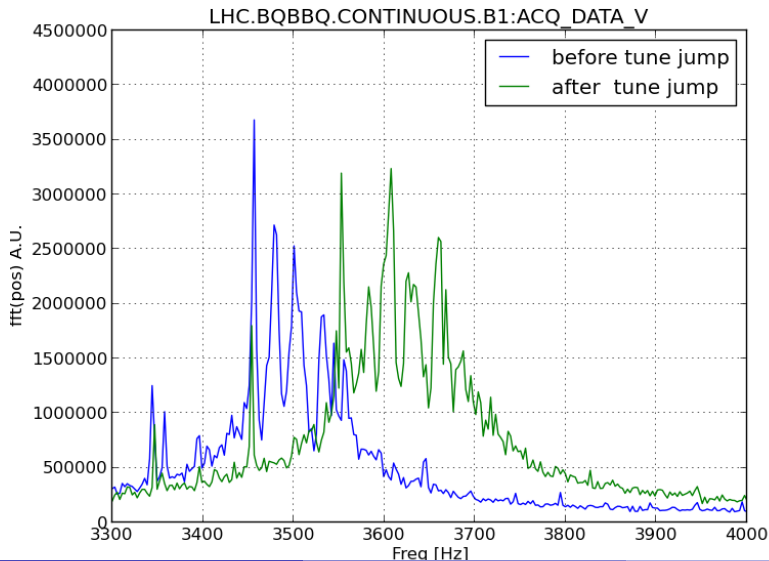
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2012-09-06 23-05-43



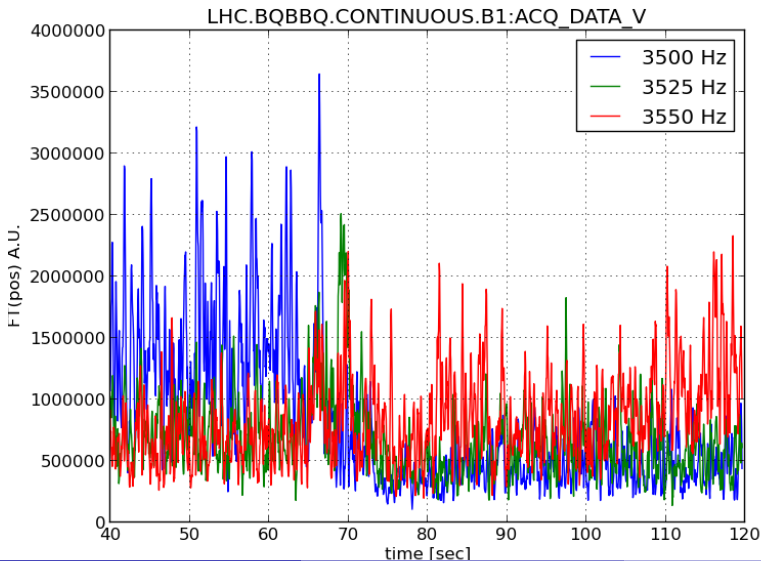
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2012-09-06 23-05-43



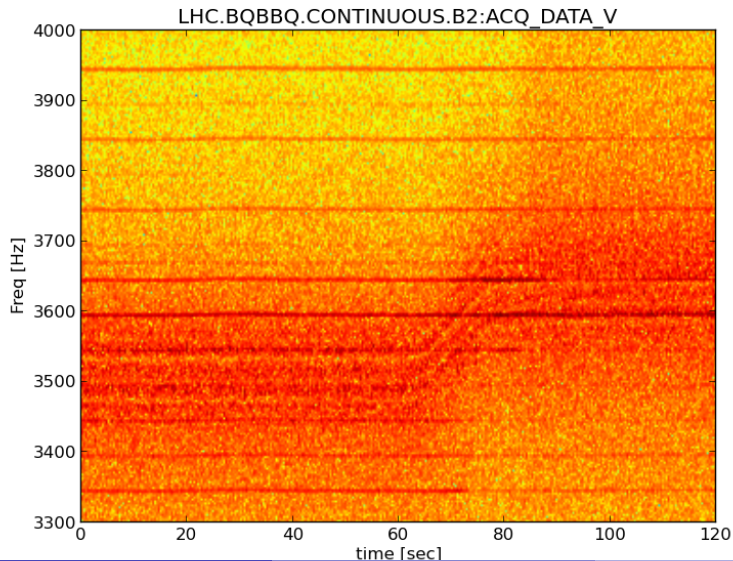
LHC BBQ during tune jump:

2012-09-06 23-05-43



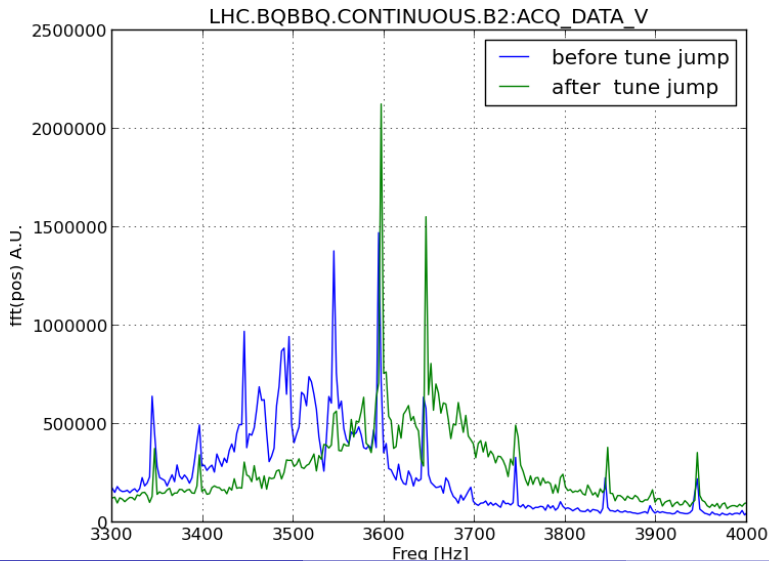
LHC BBQ during tune jump:

2012-09-06 23-05-43



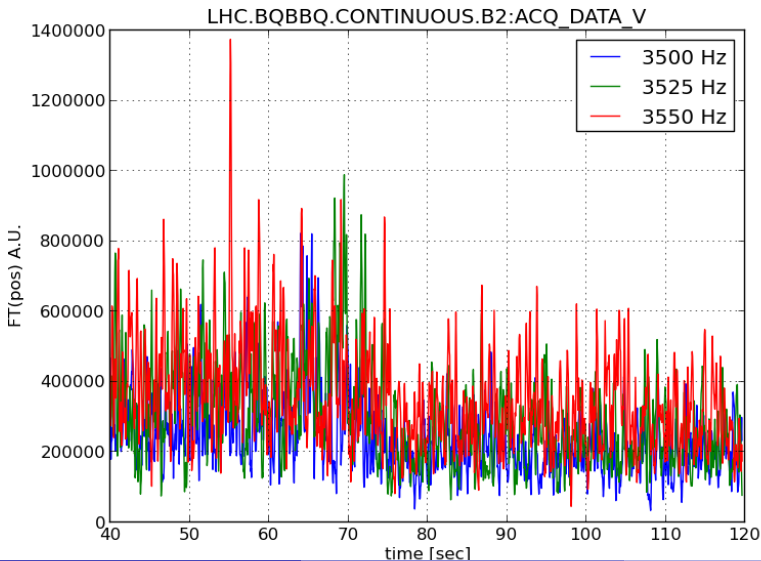
LHC BBQ during tune jump:

2012-09-06 23-05-43



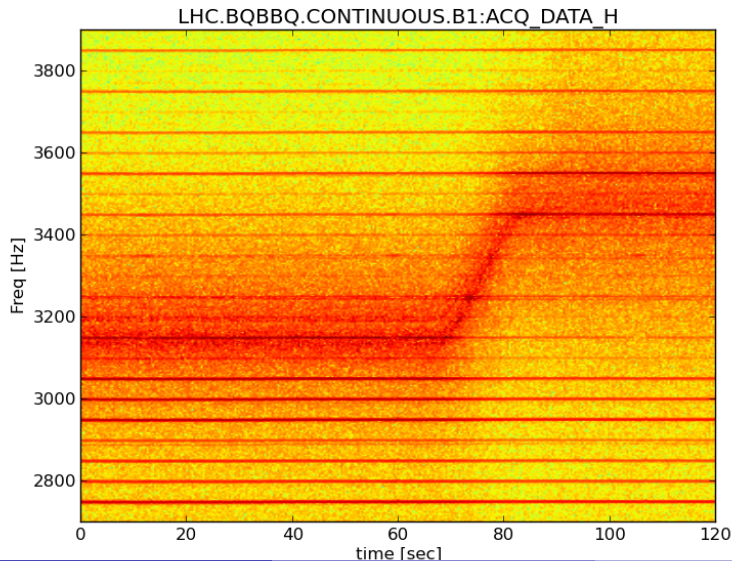
LHC BBQ during tune jump:

2012-09-06 23-05-43



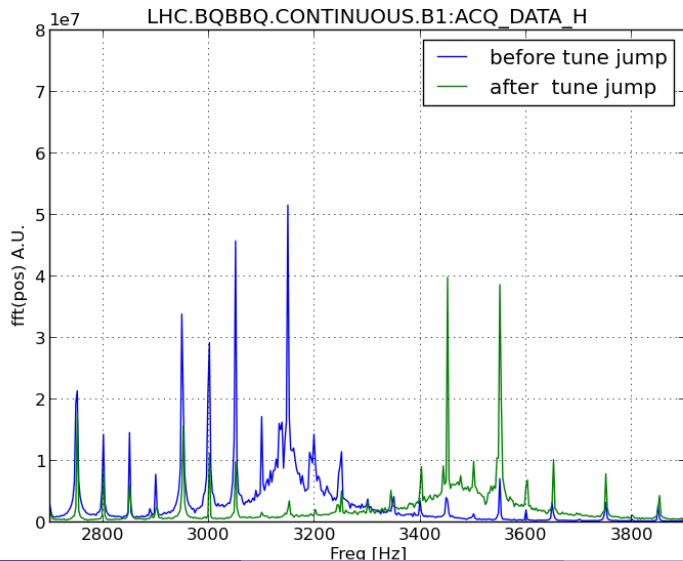
LHC BBQ during tune jump:

2012-09-07 03-22-09



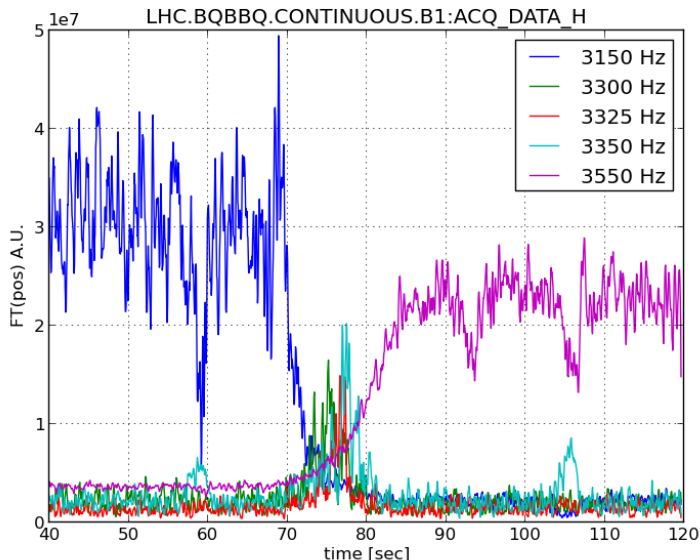
LHC BBQ during tune jump:

2012-09-07 03-22-09



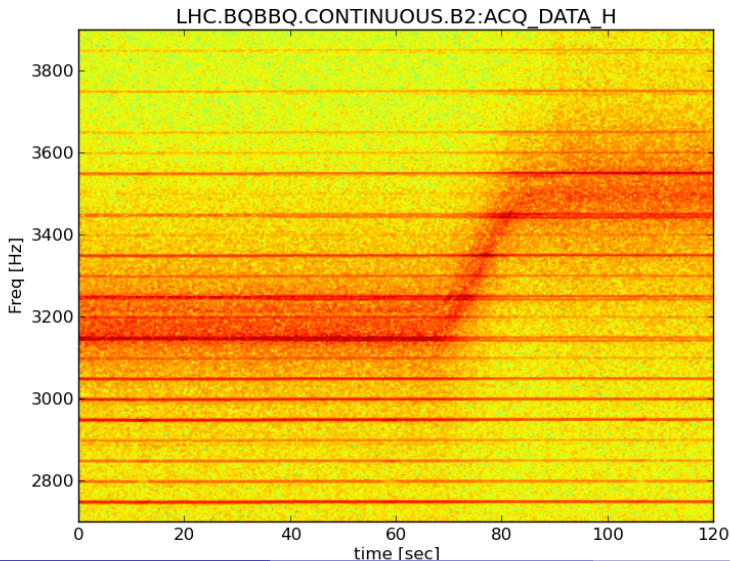
LHC BBQ during tune jump:

2012-09-07 03-22-09



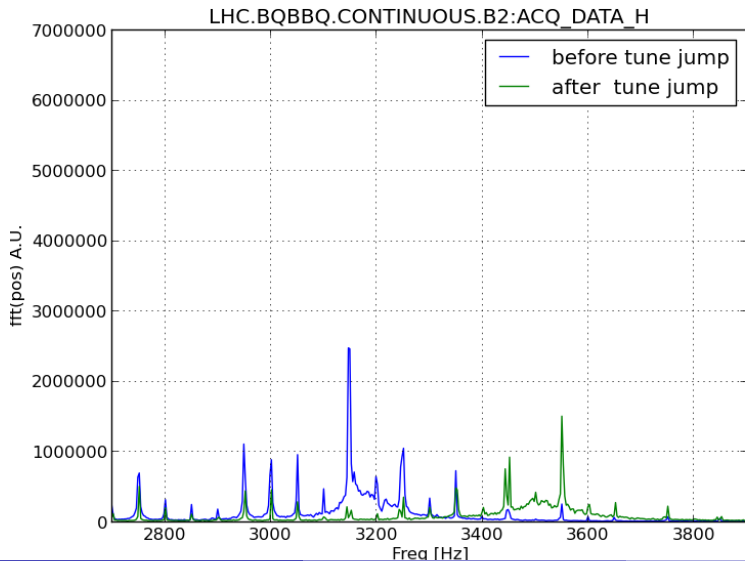
LHC BBQ during tune jump:

2012-09-07 03-22-09



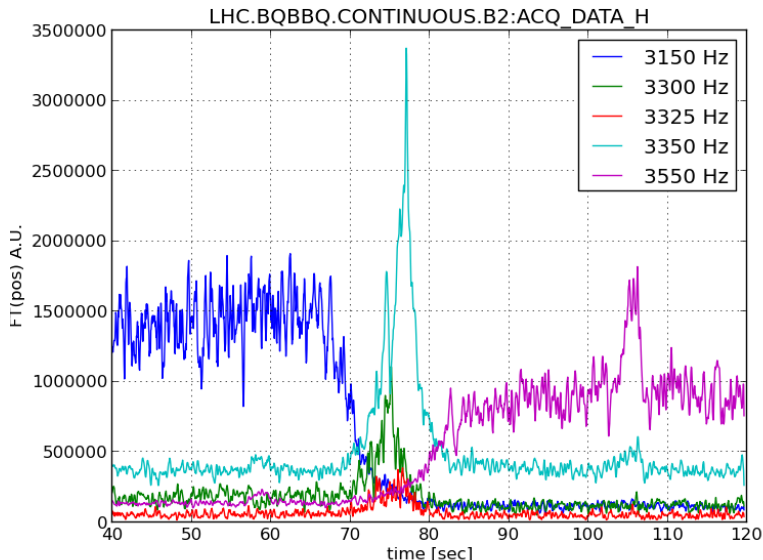
LHC BBQ during tune jump:

2012-09-07 03-22-09



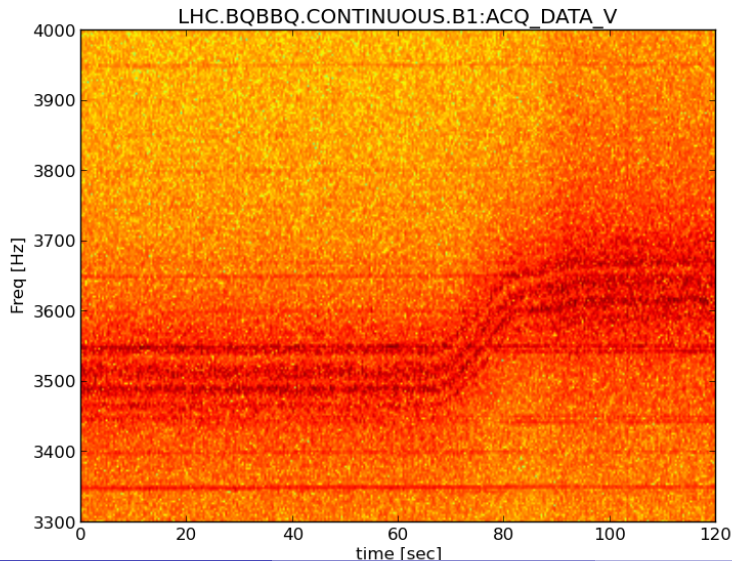
LHC BBQ during tune jump:

2012-09-07 03-22-09



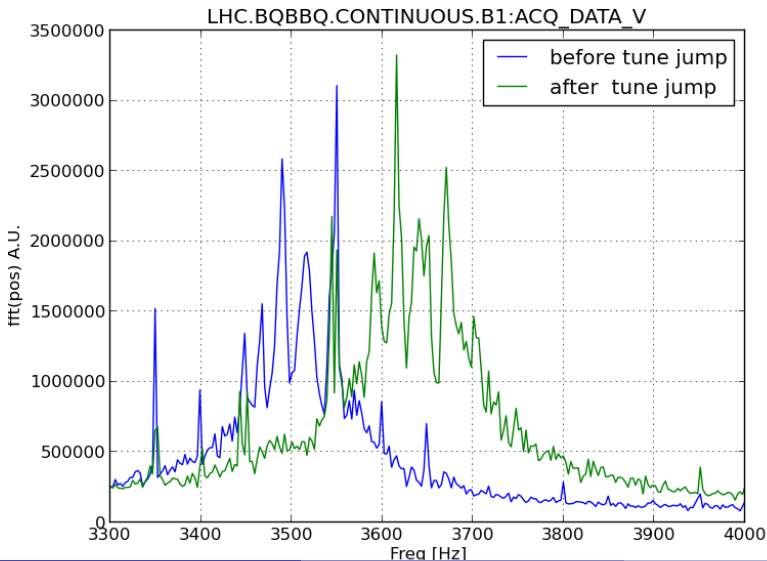
LHC BBQ during tune jump:

2012-09-07 03-22-09



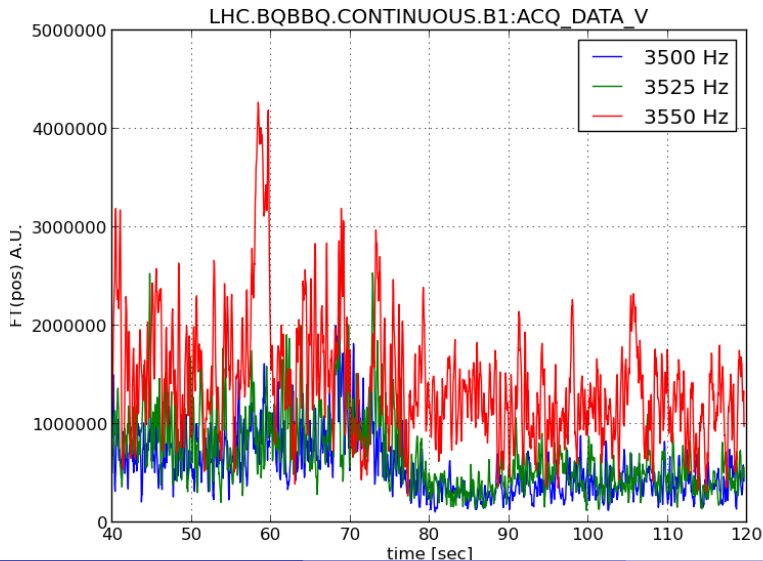
LHC BBQ during tune jump:

2012-09-07 03-22-09



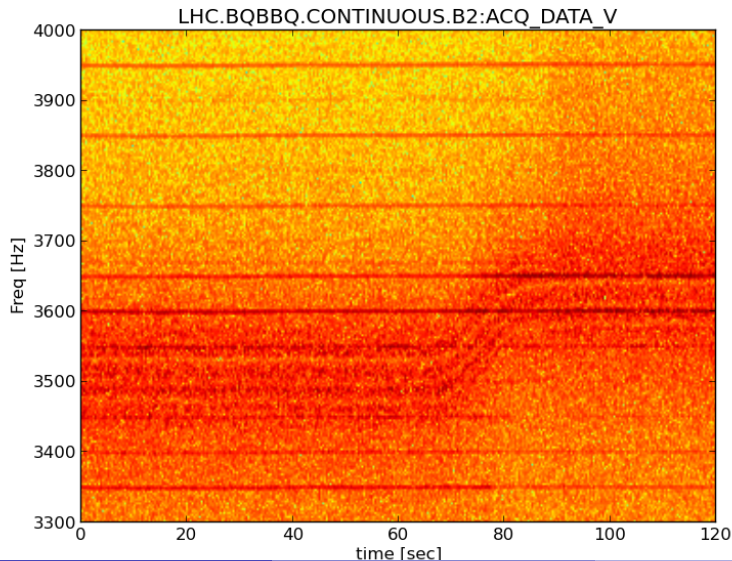
LHC BBQ during tune jump:

2012-09-07 03-22-09



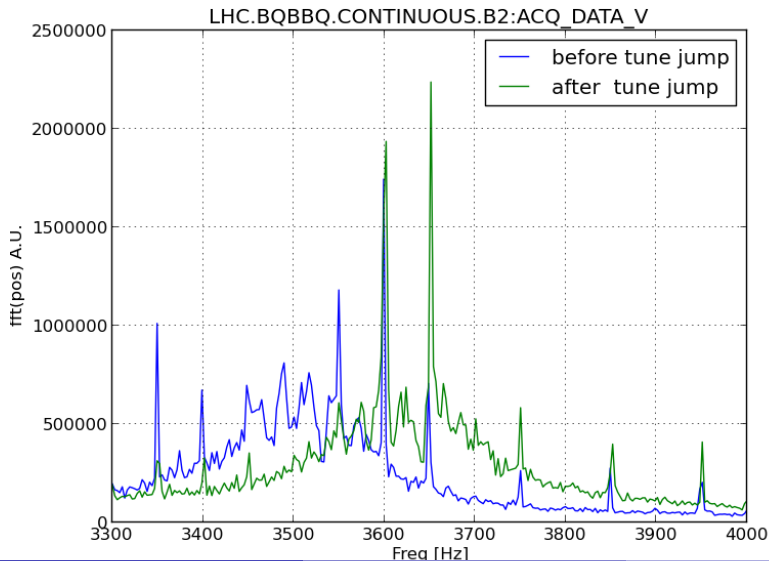
LHC BBQ during tune jump:

2012-09-07 03-22-09



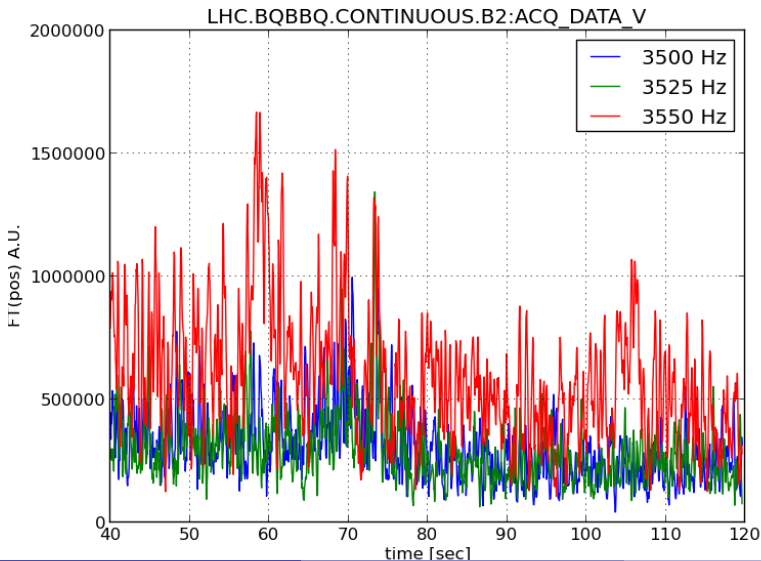
LHC BBQ during tune jump:

2012-09-07 03-22-09



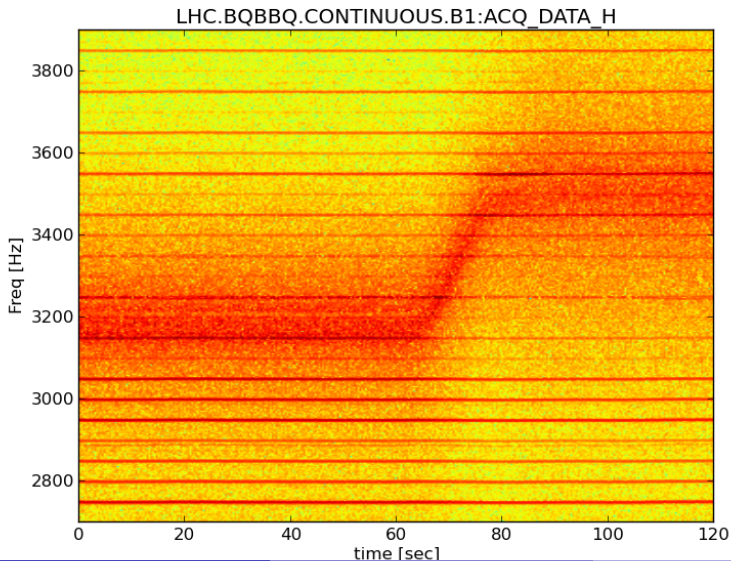
LHC BBQ during tune jump:

2012-09-07 03-22-09



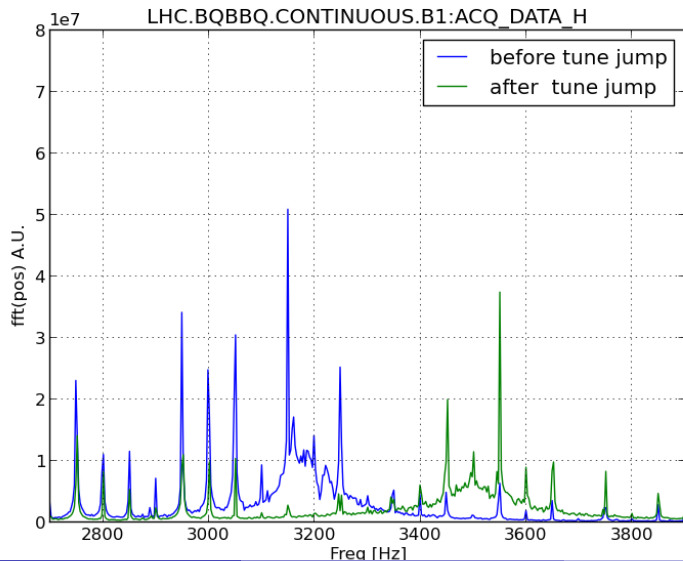
LHC BBQ during tune jump:

2012-09-07 05-38-01



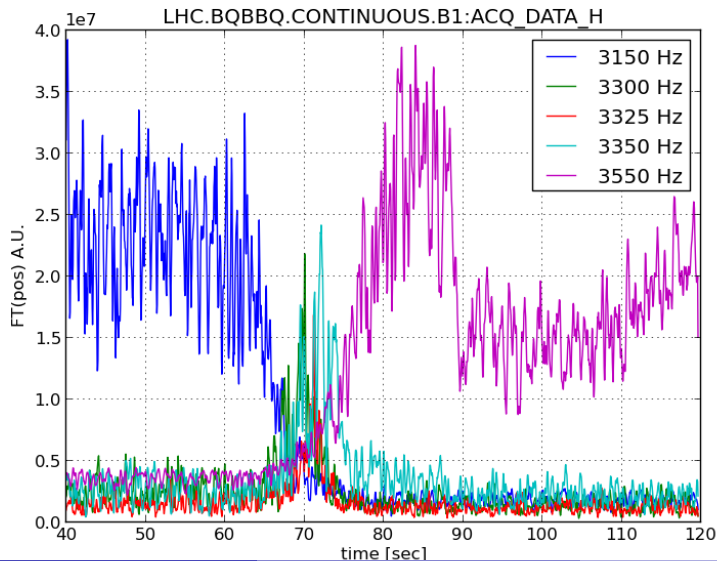
LHC BBQ during tune jump:

2012-09-07 05-38-01



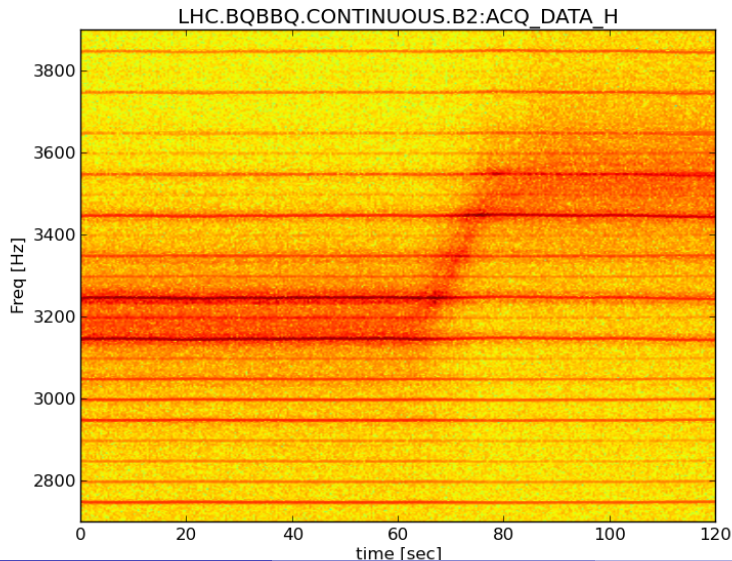
LHC BBQ during tune jump:

2012-09-07 05-38-01



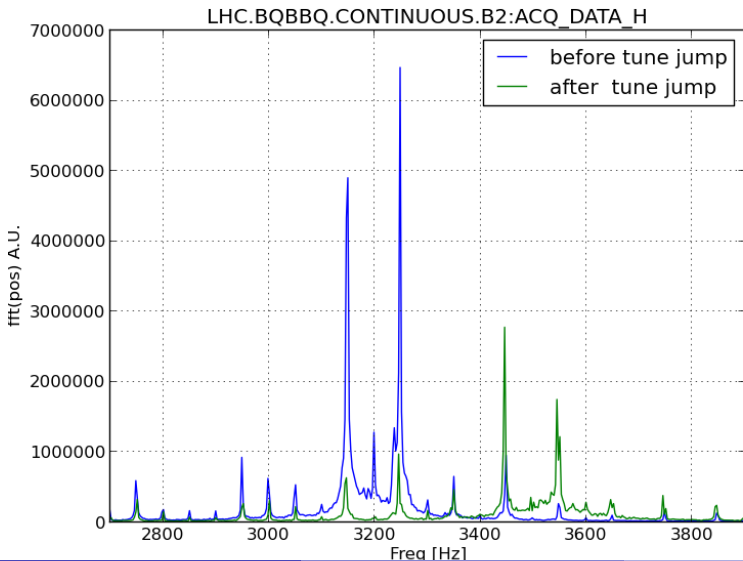
LHC BBQ during tune jump:

2012-09-07 05-38-01



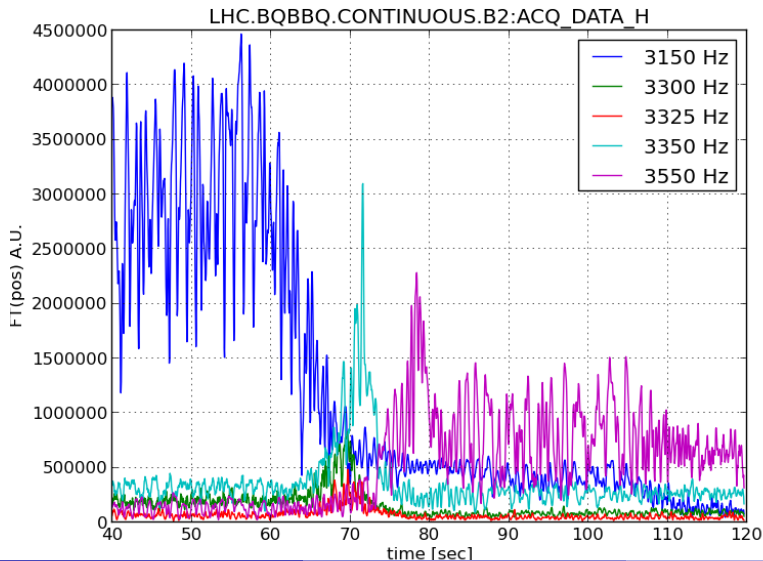
LHC BBQ during tune jump:

2012-09-07 05-38-01



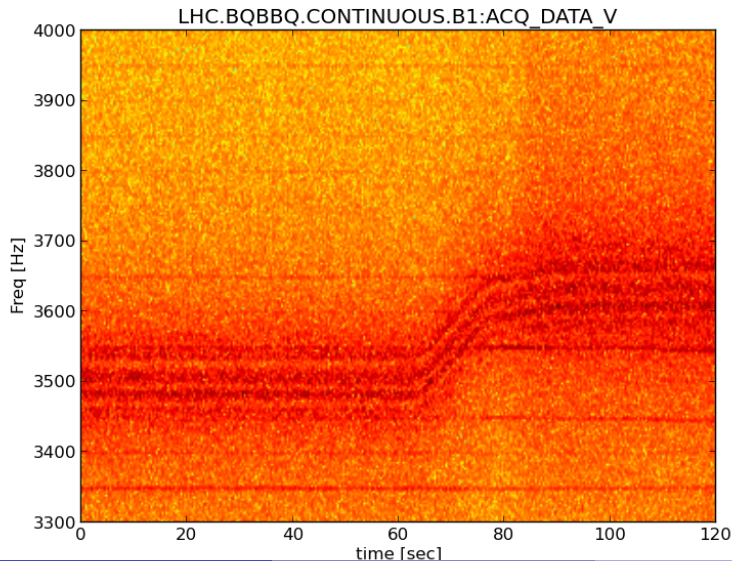
LHC BBQ during tune jump:

2012-09-07 05-38-01



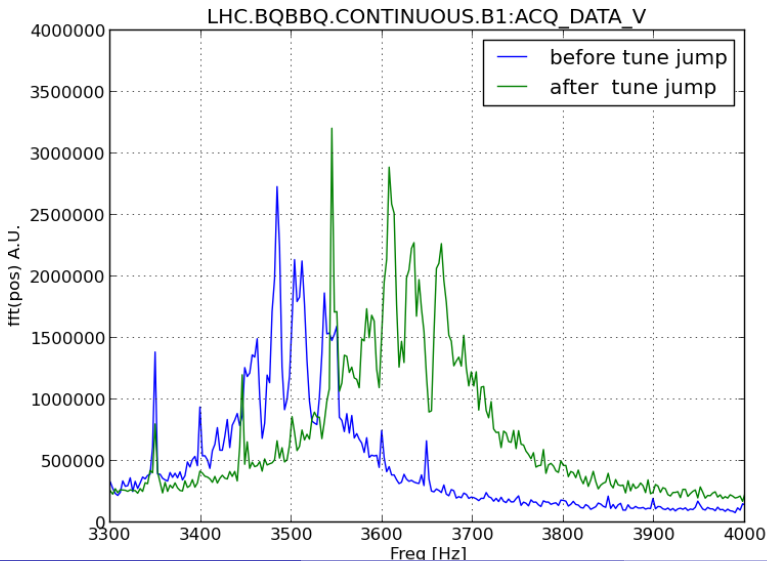
LHC BBQ during tune jump:

2012-09-07 05-38-01



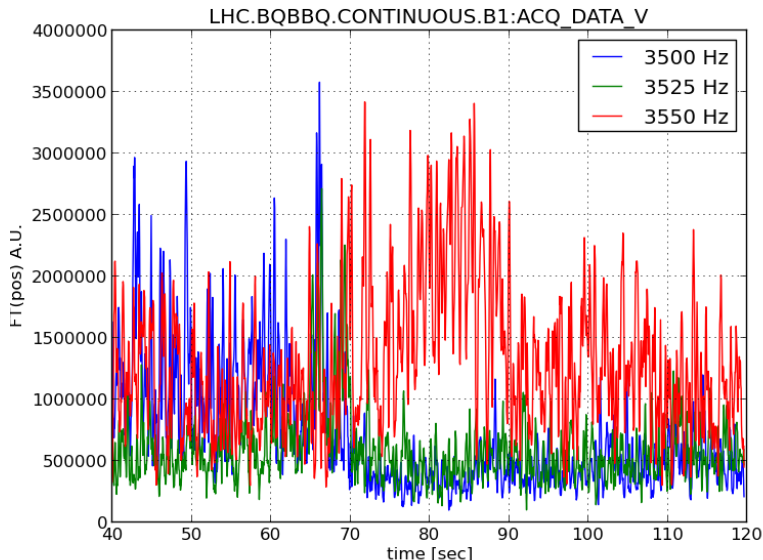
LHC BBQ during tune jump:

2012-09-07 05-38-01



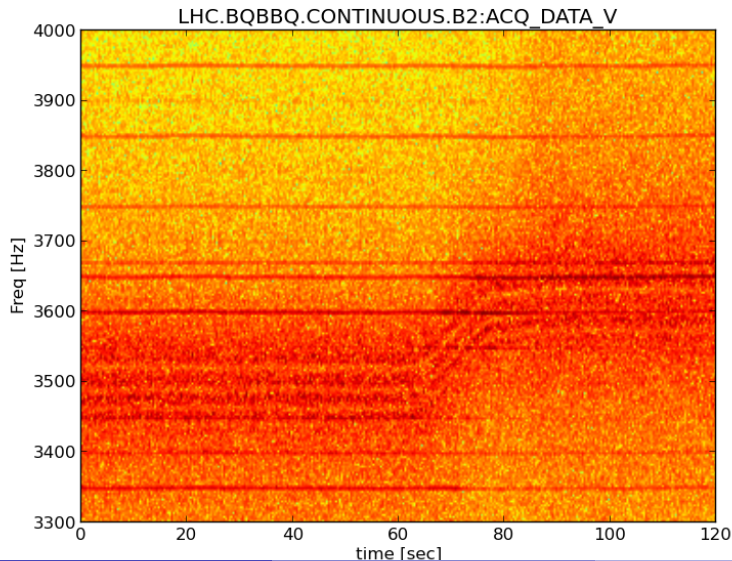
LHC BBQ during tune jump:

2012-09-07 05-38-01



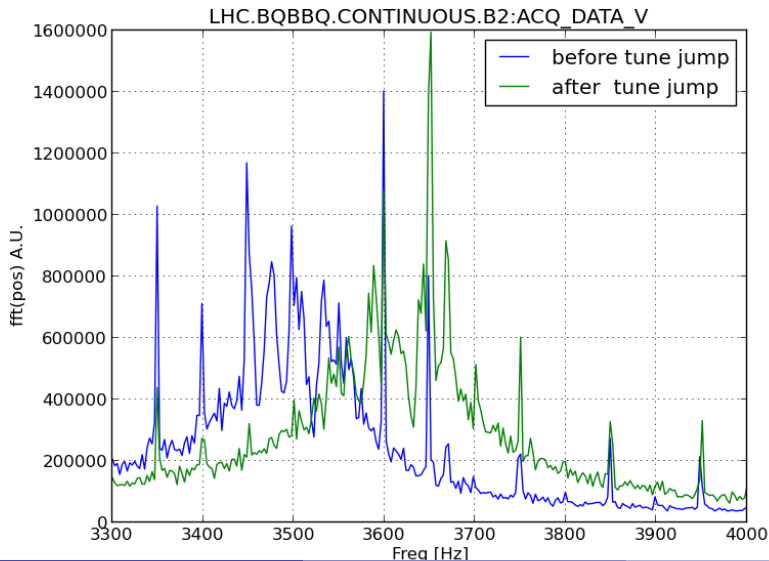
LHC BBQ during tune jump:

2012-09-07 05-38-01



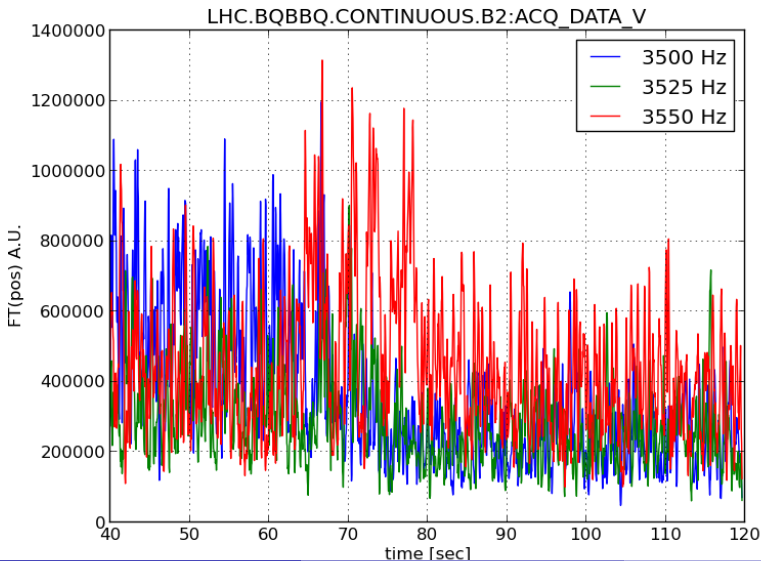
LHC BBQ during tune jump:

2012-09-07 05-38-01



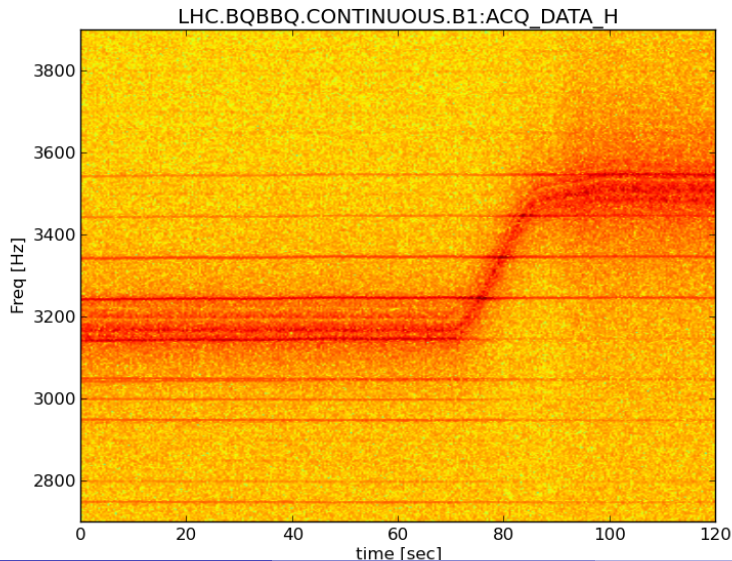
LHC BBQ during tune jump:

2012-09-07 05-38-01



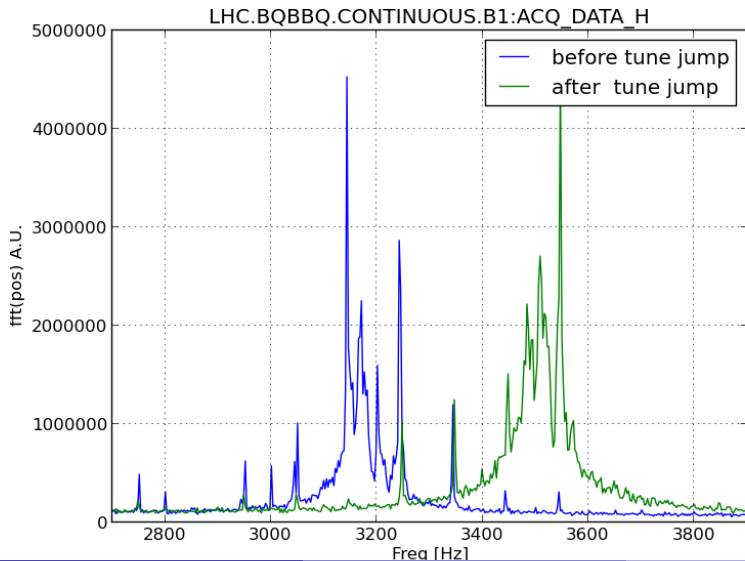
LHC BBQ during tune jump:

2012-09-07 17-20-42



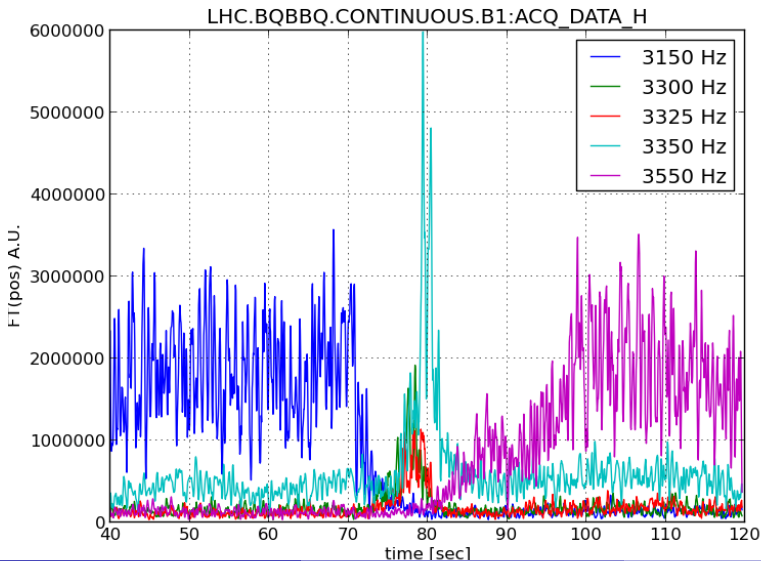
LHC BBQ during tune jump:

2012-09-07 17-20-42



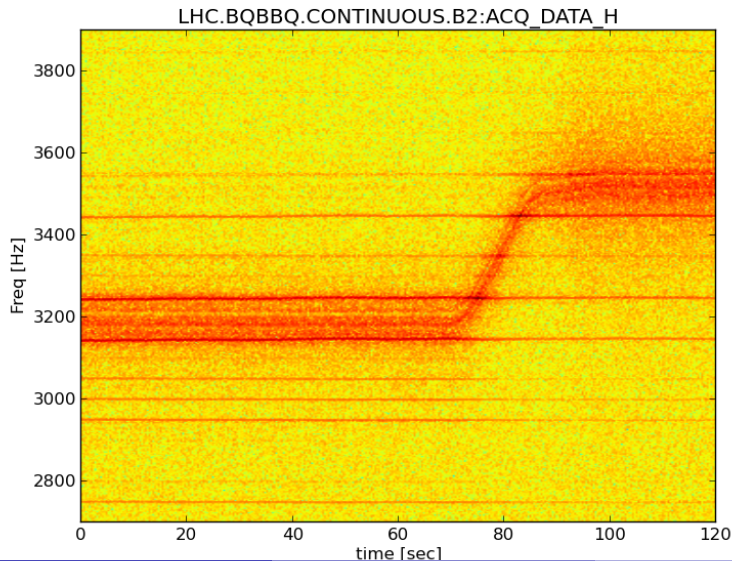
LHC BBQ during tune jump:

2012-09-07 17-20-42



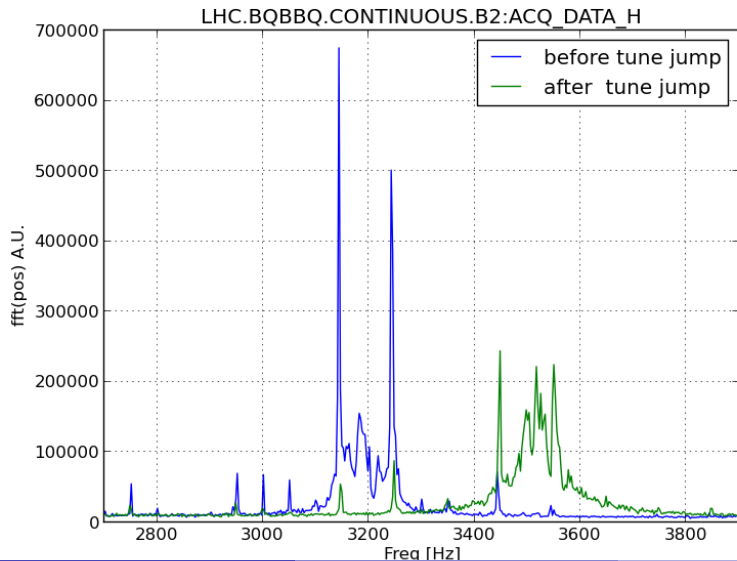
LHC BBQ during tune jump:

2012-09-07 17-20-42



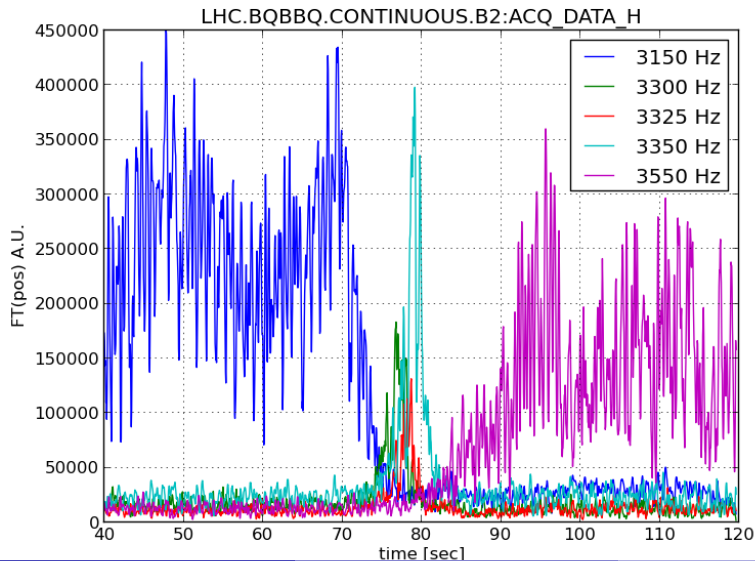
LHC BBQ during tune jump:

2012-09-07 17-20-42



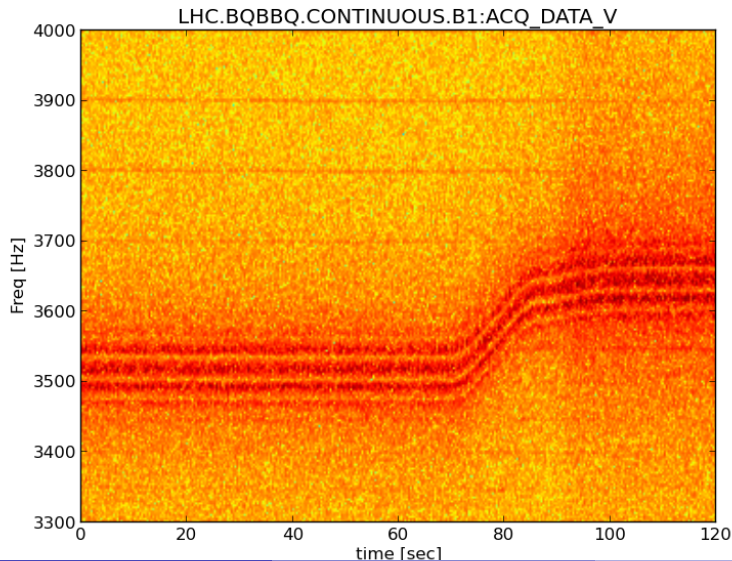
LHC BBQ during tune jump:

2012-09-07 17-20-42



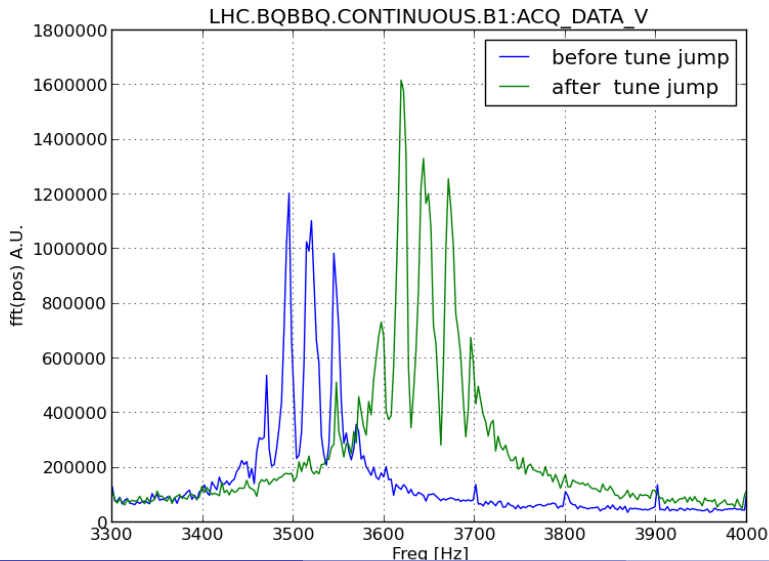
LHC BBQ during tune jump:

2012-09-07 17-20-42



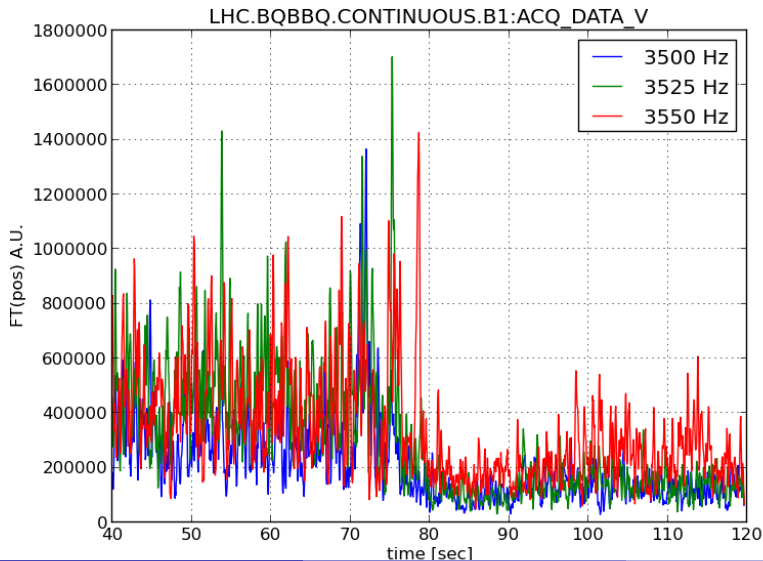
LHC BBQ during tune jump:

2012-09-07 17-20-42



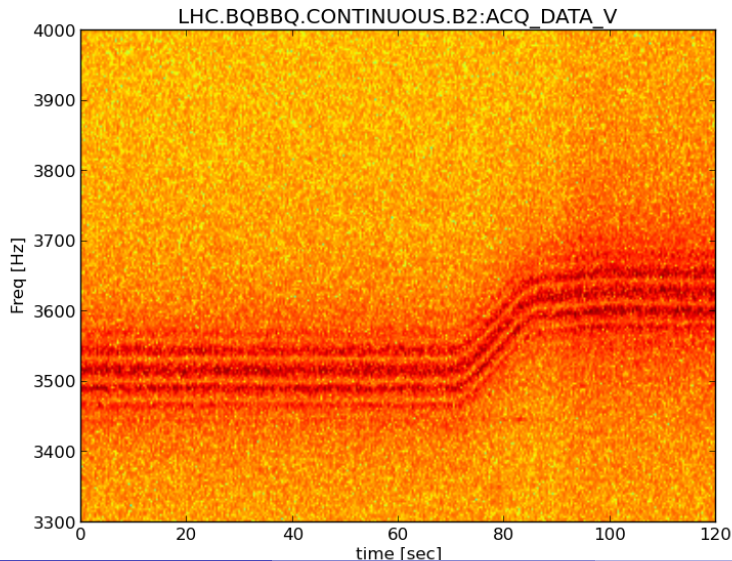
LHC BBQ during tune jump:

2012-09-07 17-20-42



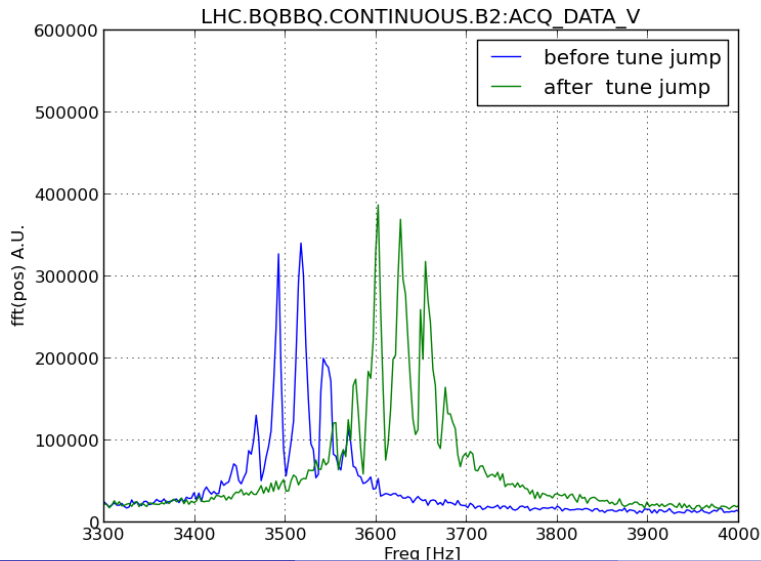
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2012-09-07 17-20-42



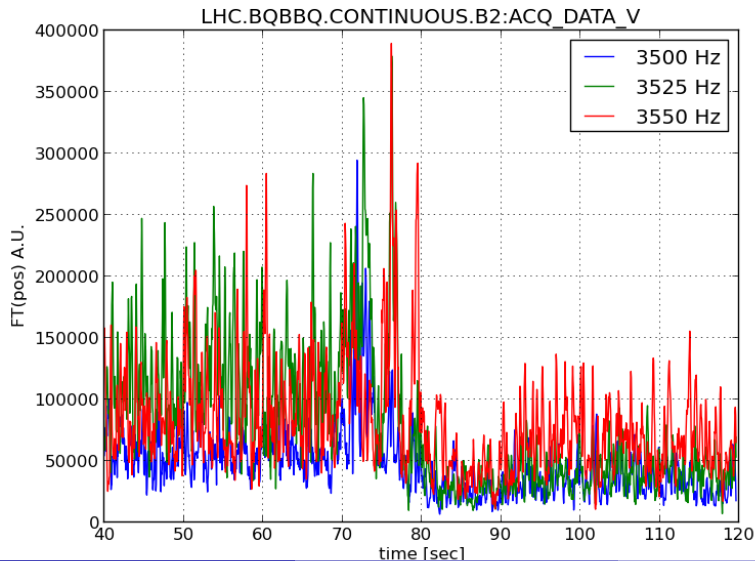
LHC BBQ during tune jump:

2012-09-07 17-20-42



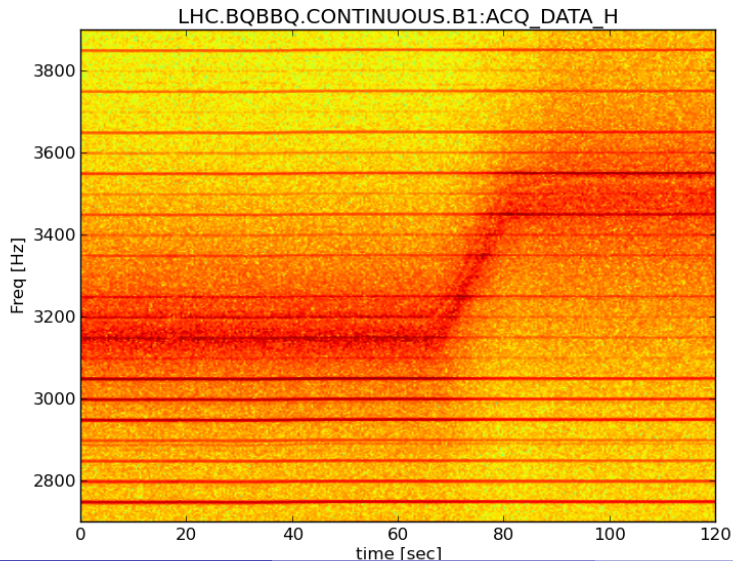
LHC BBQ during tune jump:

2012-09-07 17-20-42



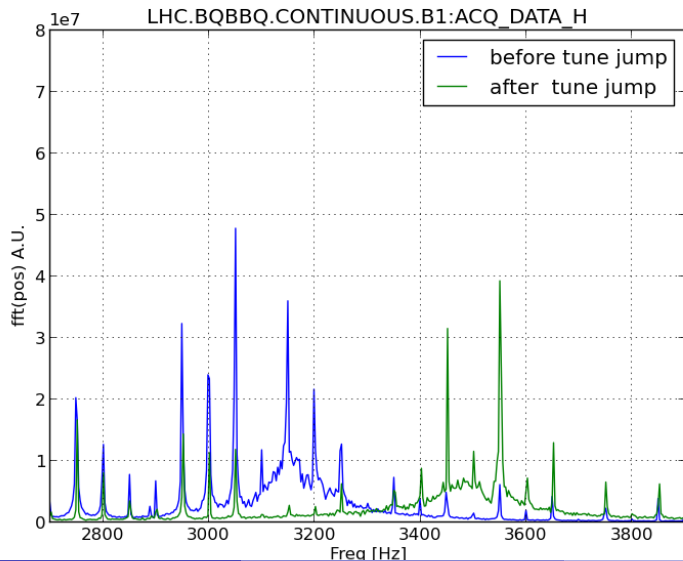
LHC BBQ during tune jump:

2012-09-07 23-26-17



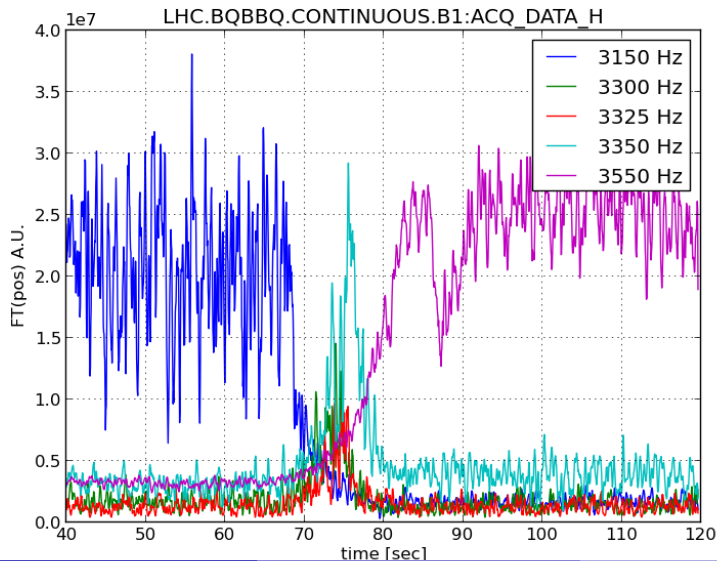
LHC BBQ during tune jump:

2012-09-07 23-26-17

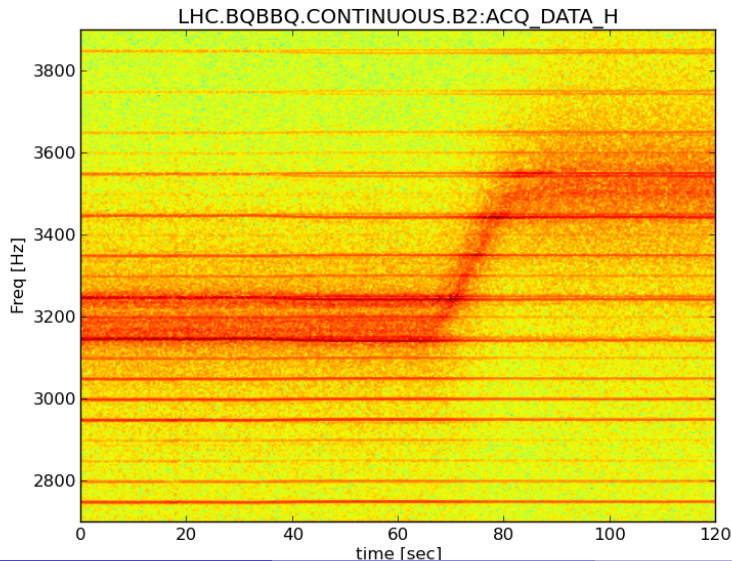


LHC BBQ during tune jump:

2012-09-07 23-26-17

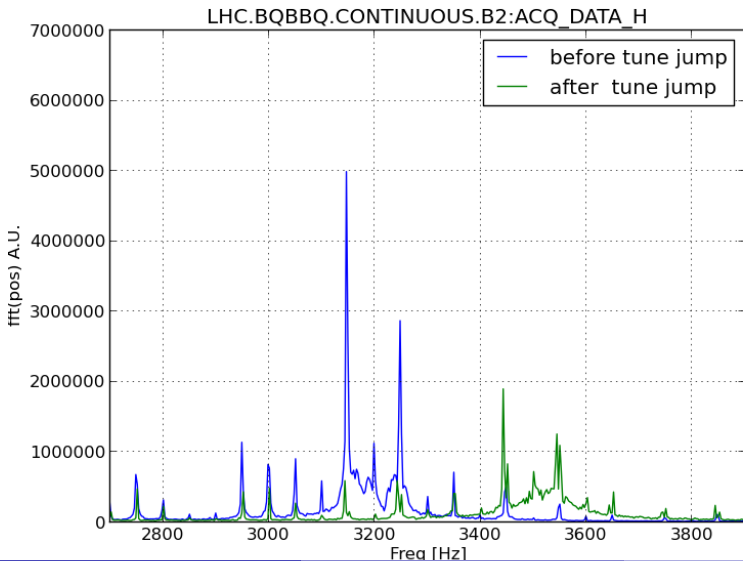


LHC BBQ during tune jump: 2012-09-07 23-26-17



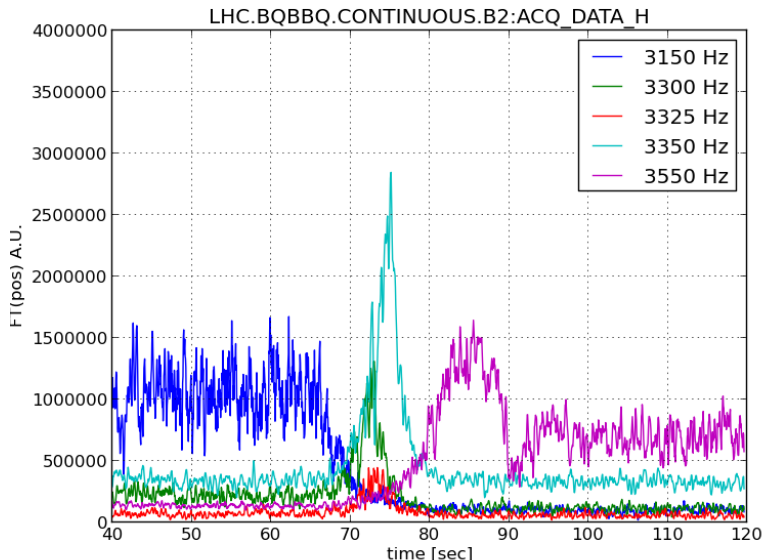
LHC BBQ during tune jump:

2012-09-07 23-26-17



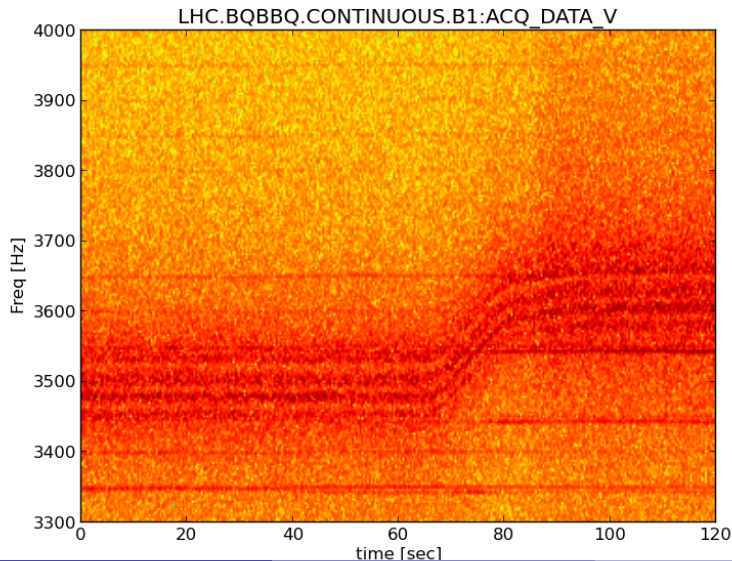
LHC BBQ during tune jump:

2012-09-07 23-26-17



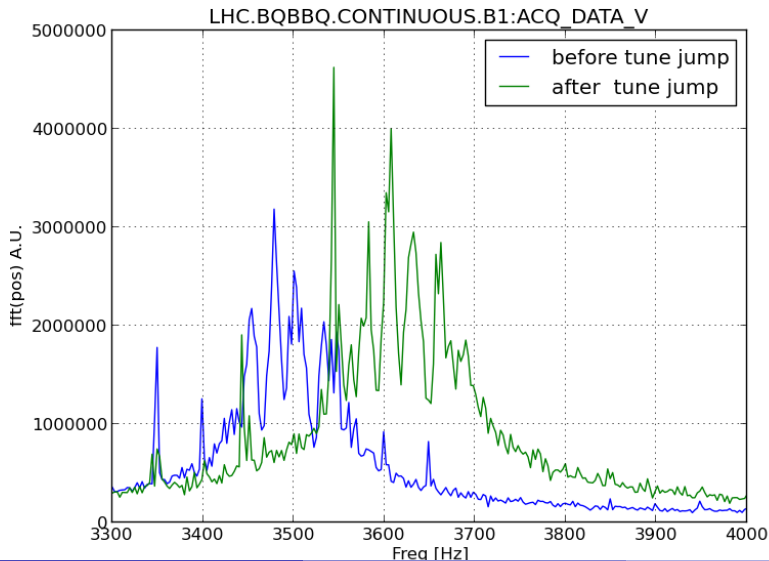
LHC BBQ during tune jump:

2012-09-07 23-26-17



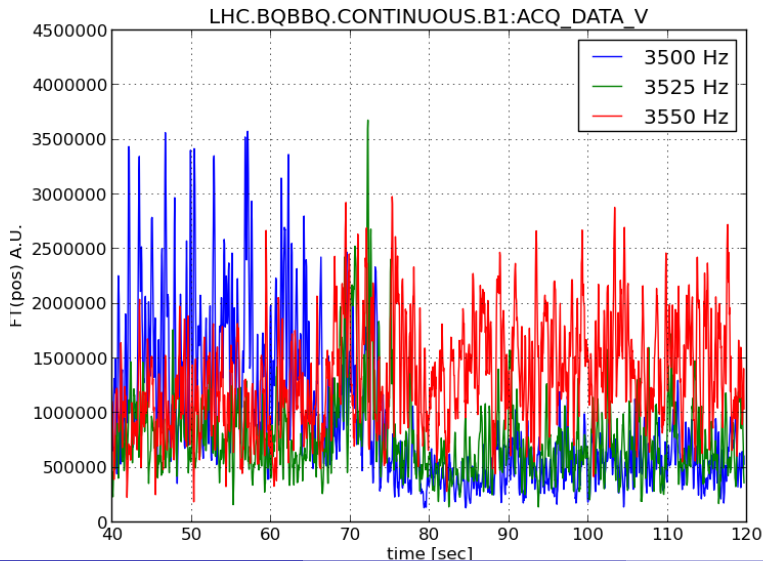
LHC BBQ during tune jump:

2012-09-07 23-26-17



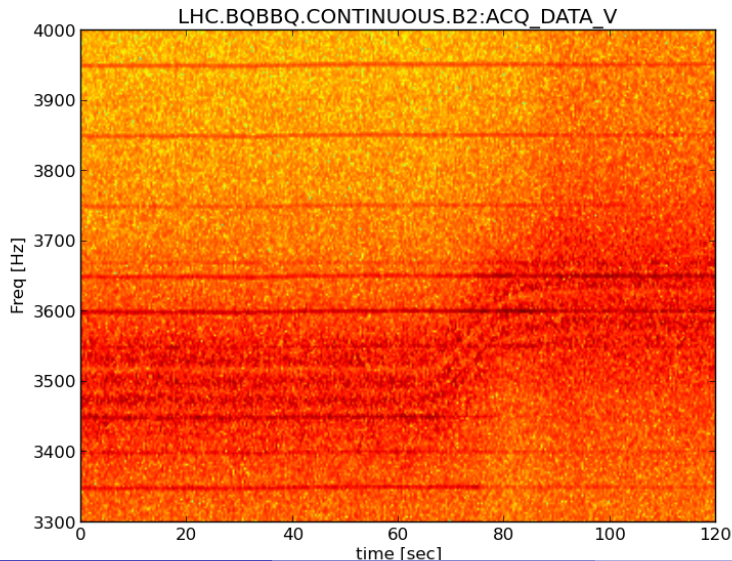
LHC BBQ during tune jump:

2012-09-07 23-26-17



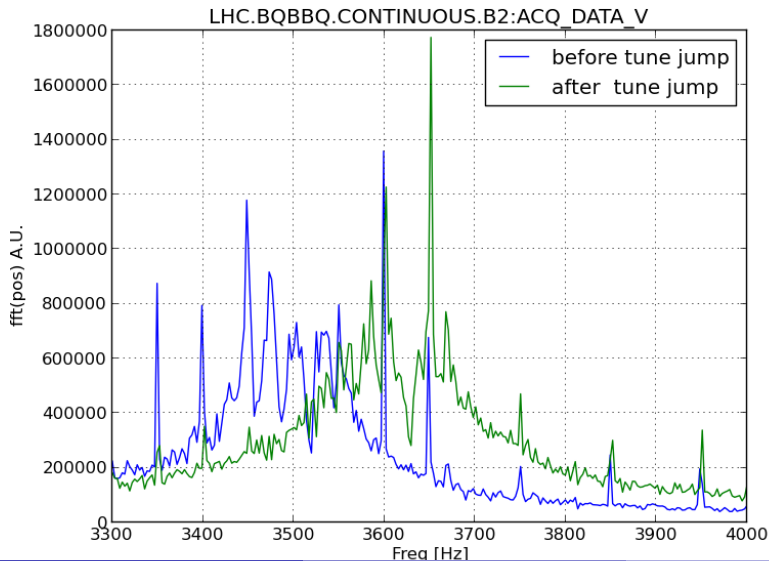
LHC BBQ during tune jump:

2012-09-07 23-26-17



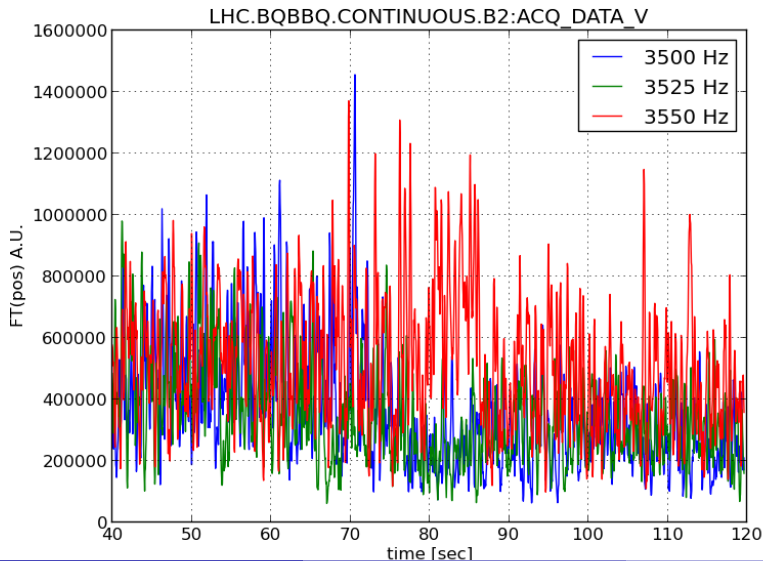
LHC BBQ during tune jump:

2012-09-07 23-26-17



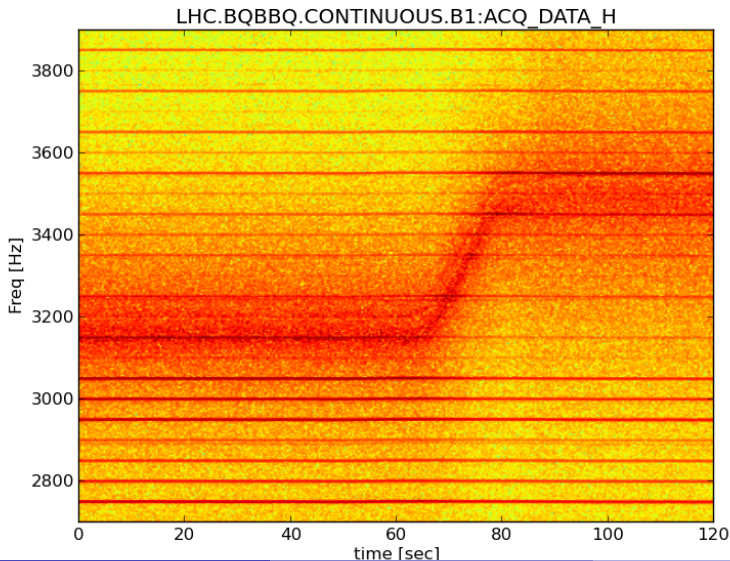
LHC BBQ during tune jump:

2012-09-07 23-26-17



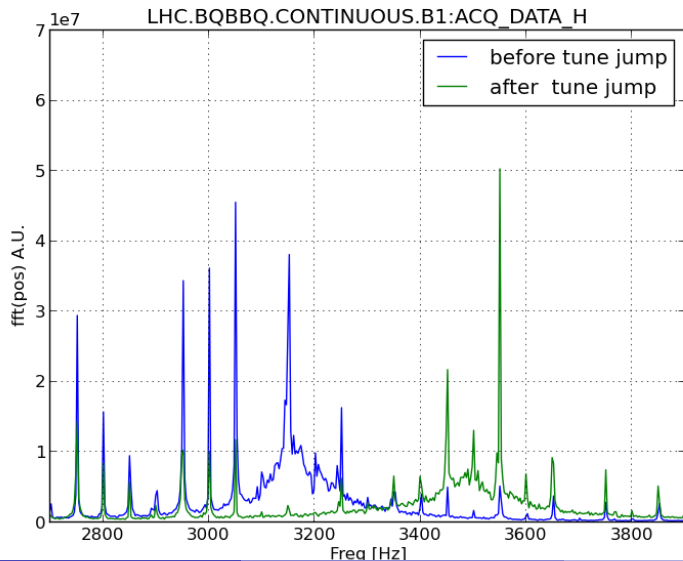
LHC BBQ during tune jump:

2012-09-08 05-02-46



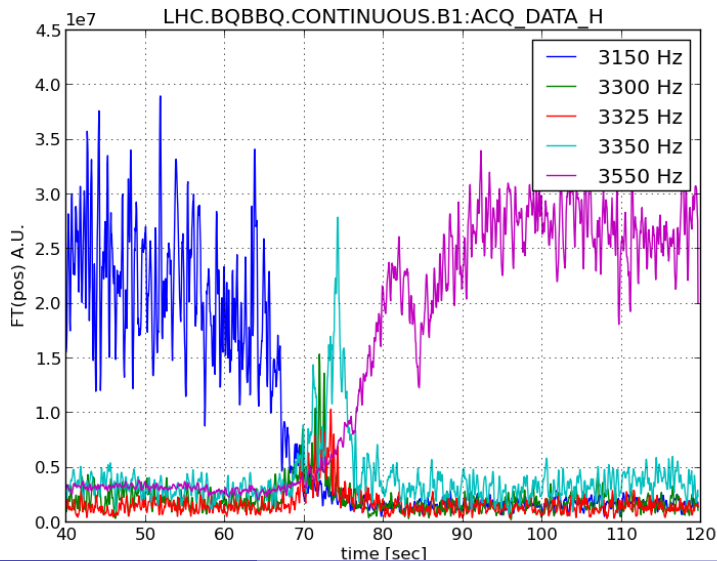
LHC BBQ during tune jump:

2012-09-08 05-02-46



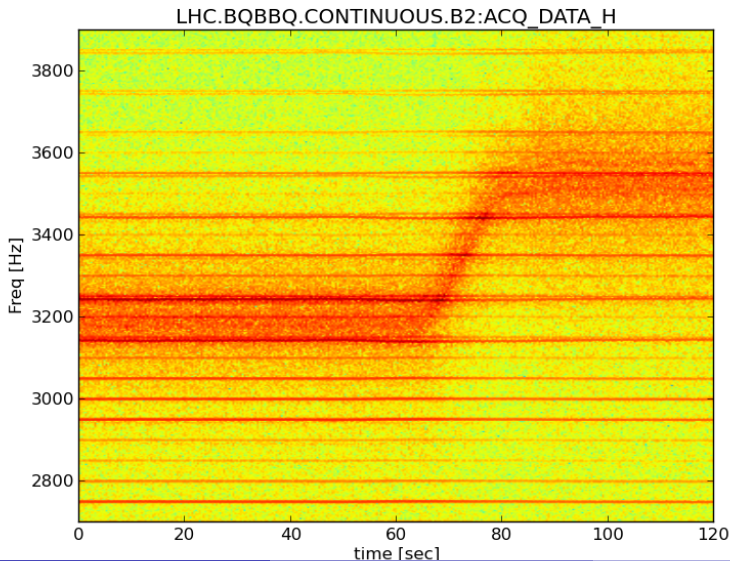
LHC BBQ during tune jump:

2012-09-08 05-02-46



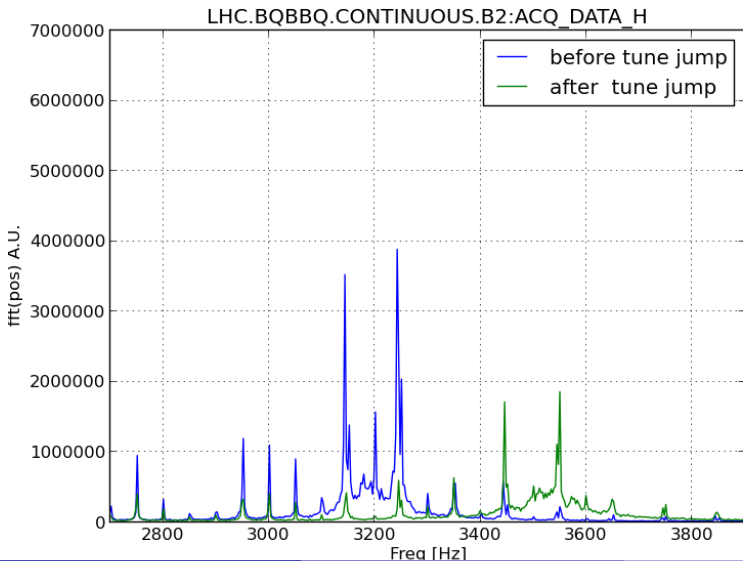
LHC BBQ during tune jump:

2012-09-08 05-02-46



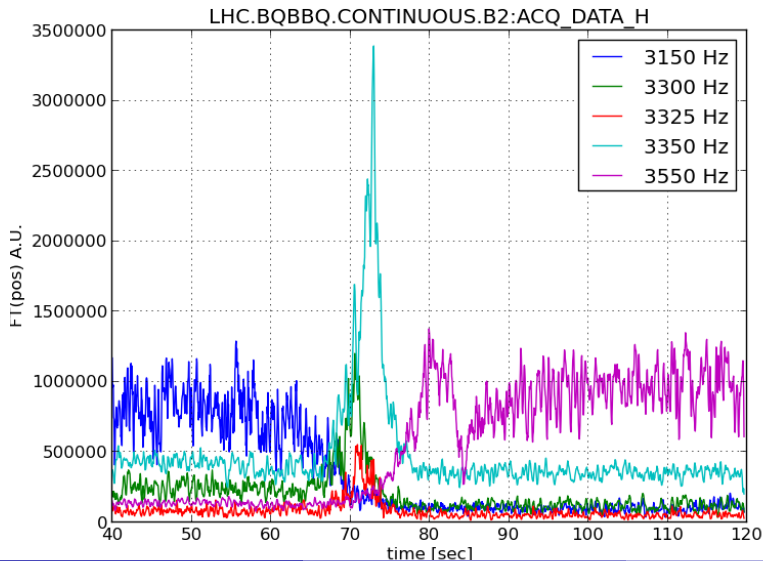
LHC BBQ during tune jump:

2012-09-08 05-02-46



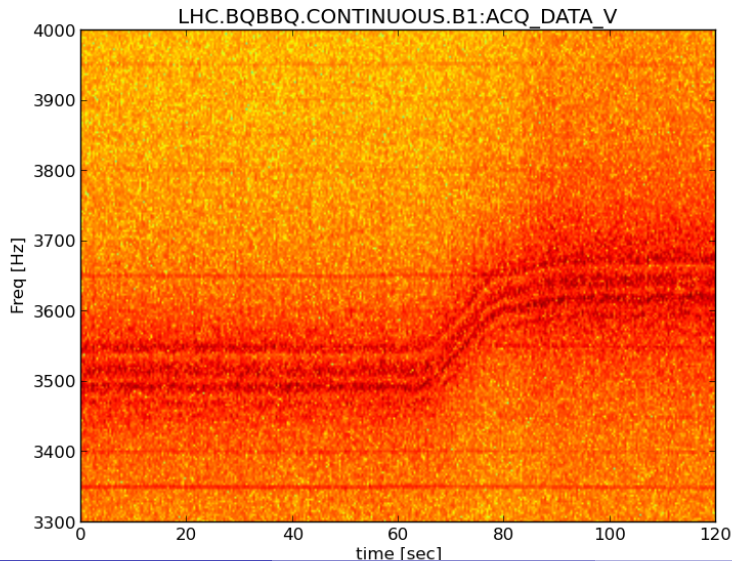
LHC BBQ during tune jump:

2012-09-08 05-02-46



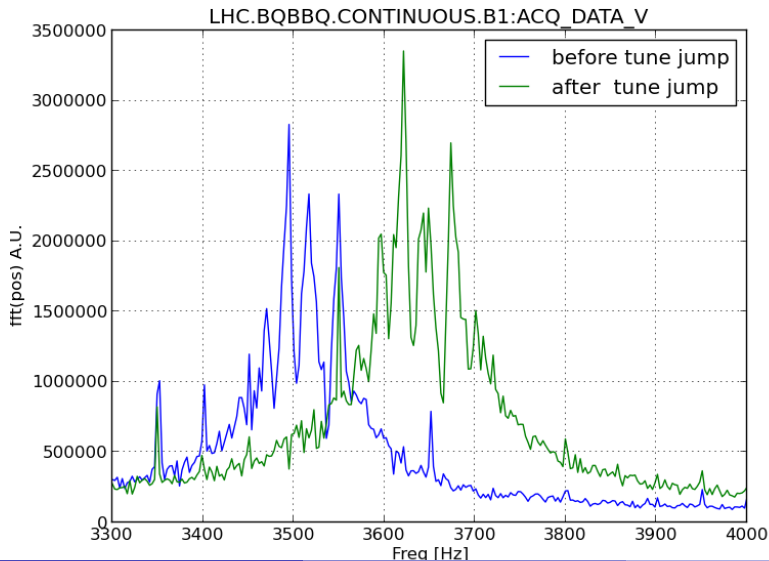
LHC BBQ during tune jump:

2012-09-08 05-02-46



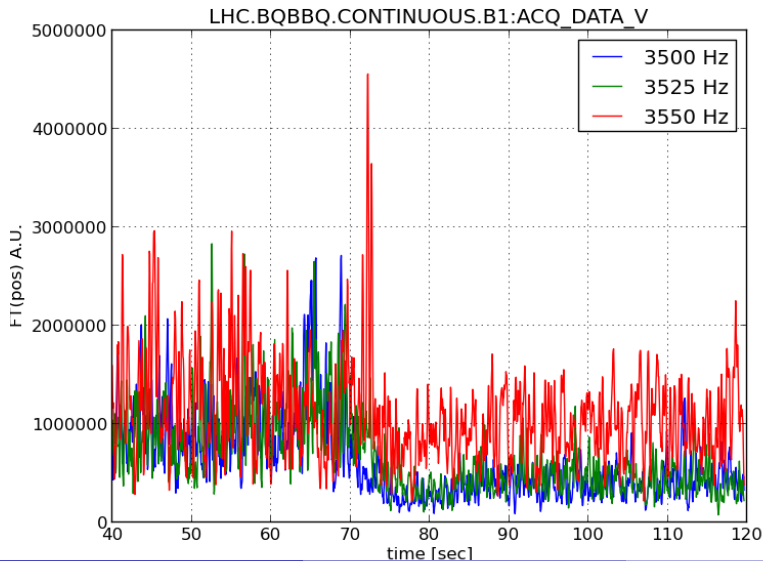
LHC BBQ during tune jump:

2012-09-08 05-02-46



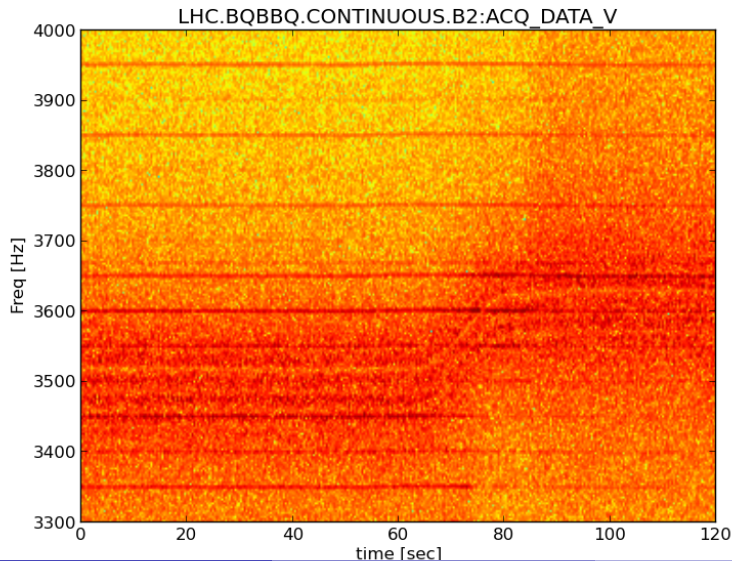
LHC BBQ during tune jump:

2012-09-08 05-02-46



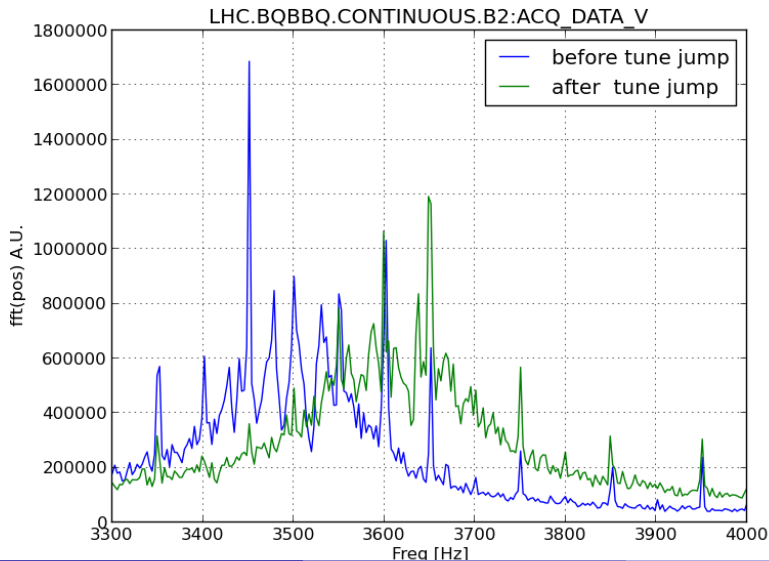
LHC BBQ during tune jump:

2012-09-08 05-02-46



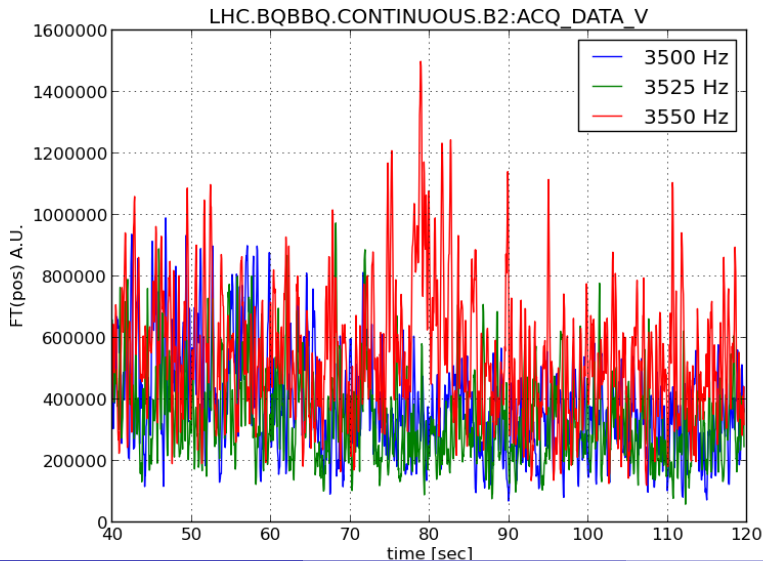
LHC BBQ during tune jump:

2012-09-08 05-02-46



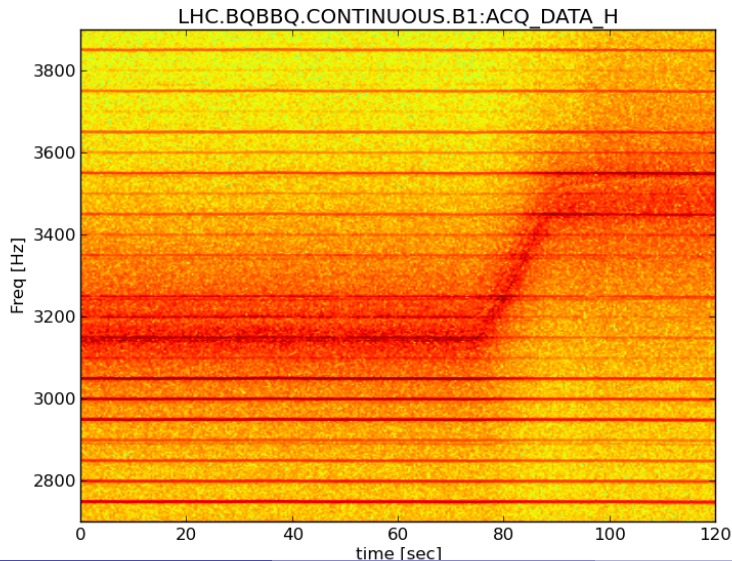
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2012-09-08 05-02-46



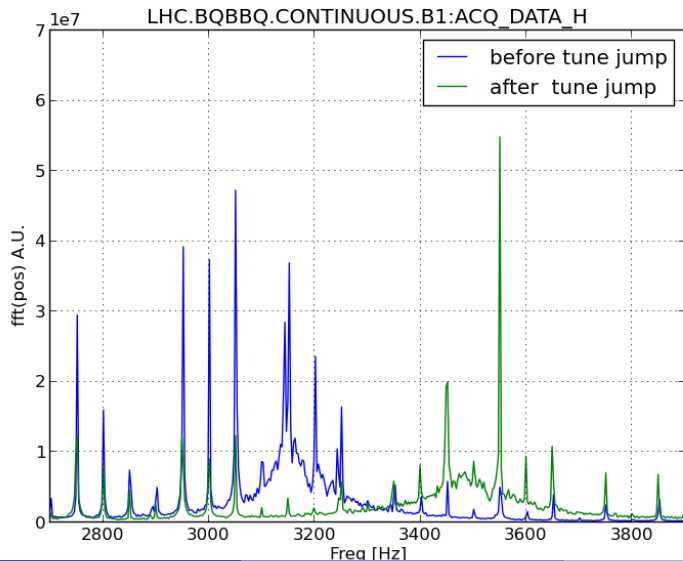
LHC BBQ during tune jump:

2012-09-08 18-50-29



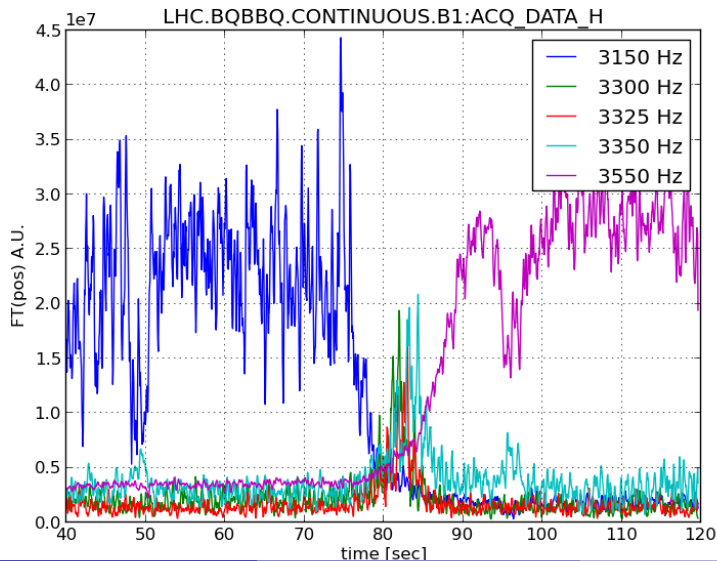
LHC BBQ during tune jump:

2012-09-08 18-50-29



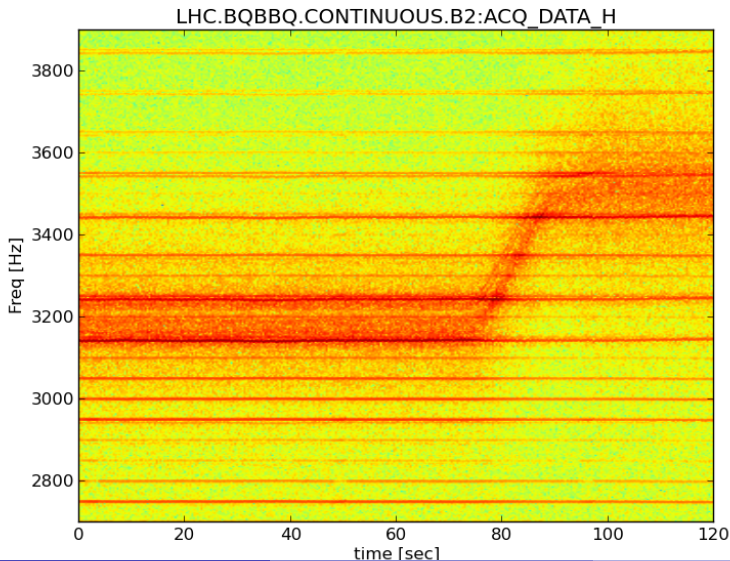
LHC BBQ during tune jump:

2012-09-08 18-50-29



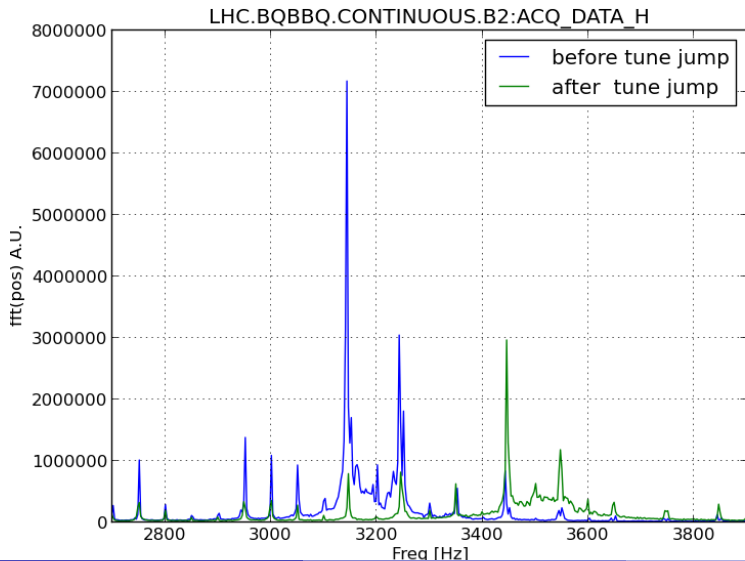
LHC BBQ during tune jump:

2012-09-08 18-50-29



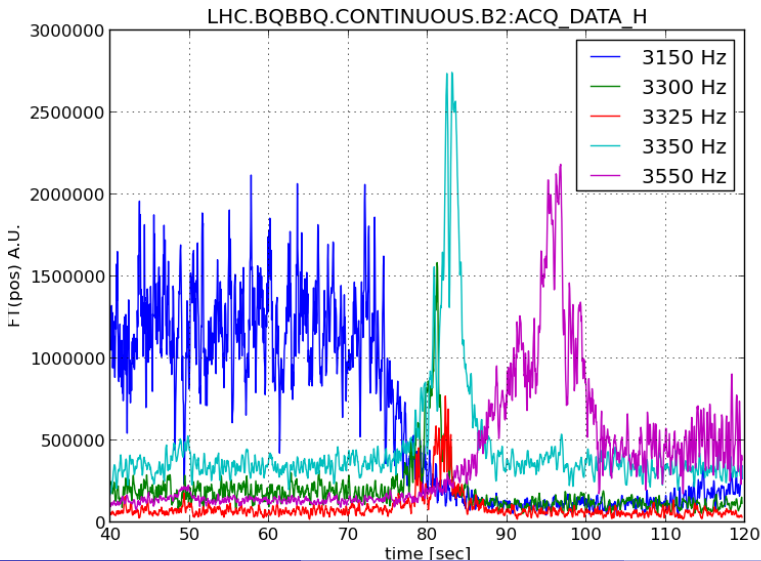
LHC BBQ during tune jump:

2012-09-08 18-50-29



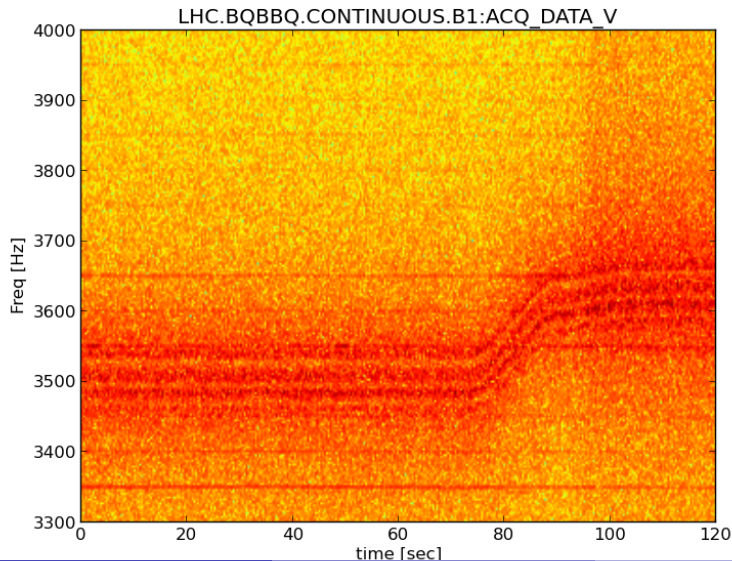
LHC BBQ during tune jump:

2012-09-08 18-50-29



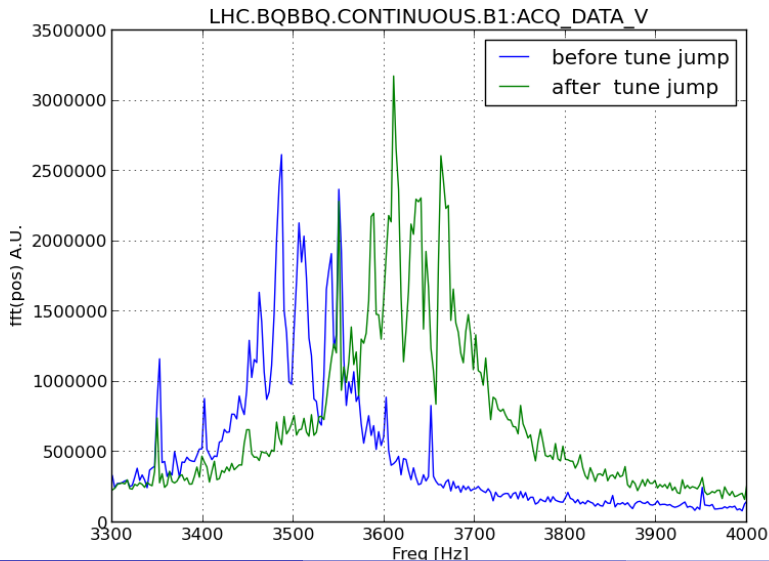
LHC BBQ during tune jump:

2012-09-08 18-50-29



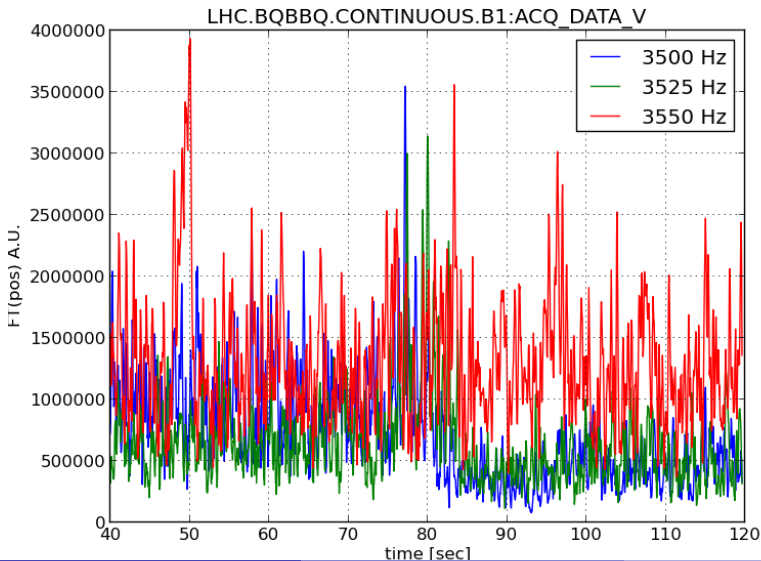
LHC BBQ during tune jump:

2012-09-08 18-50-29



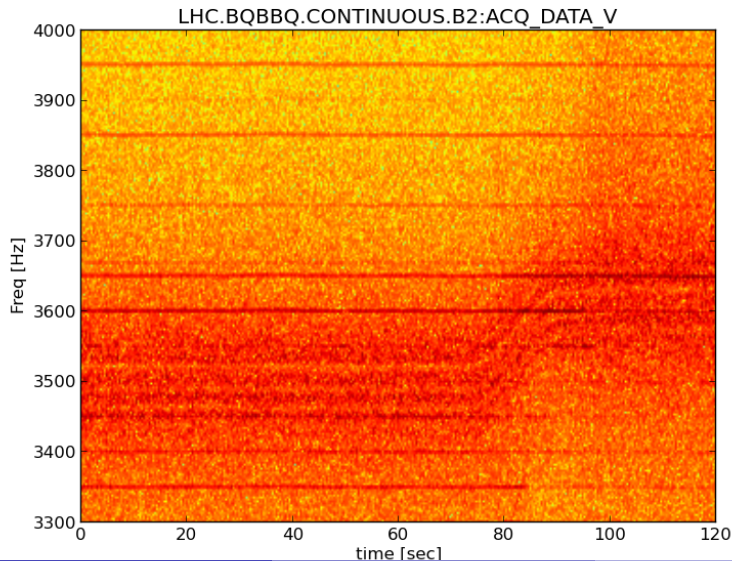
LHC BBQ during tune jump:

2012-09-08 18-50-29



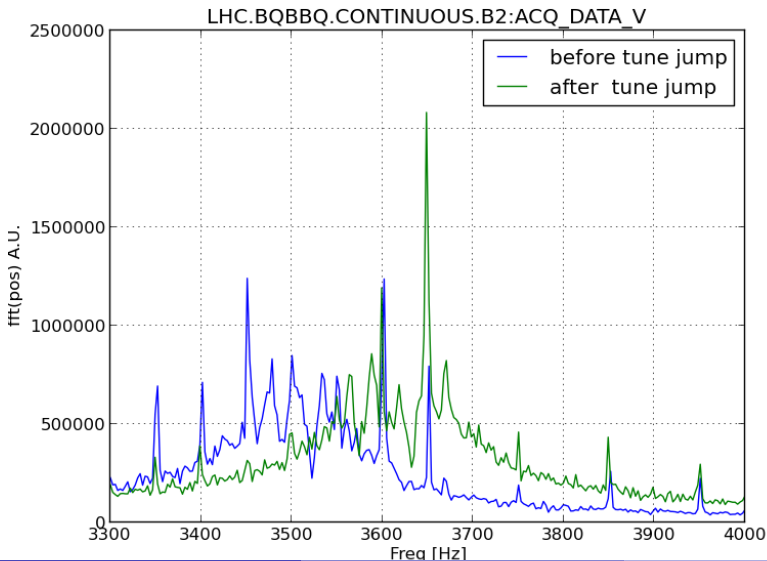
LHC BBQ during tune jump:

2012-09-08 18-50-29



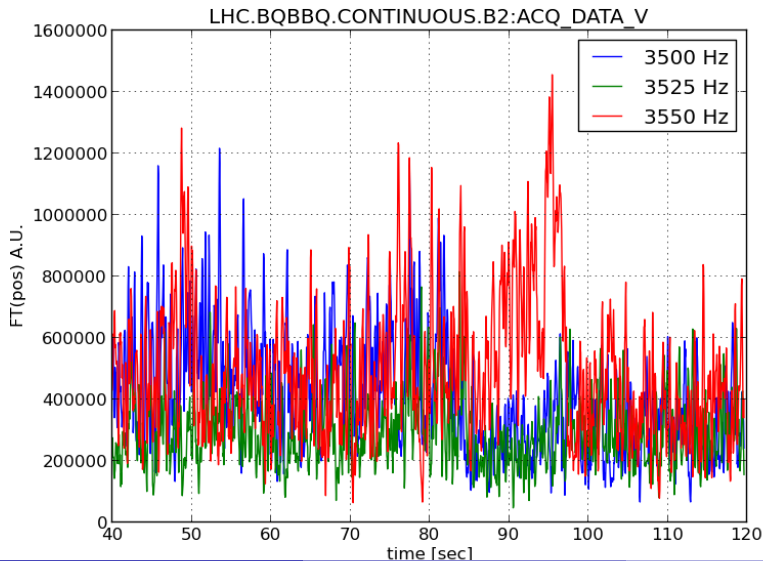
LHC BBQ during tune jump:

2012-09-08 18-50-29



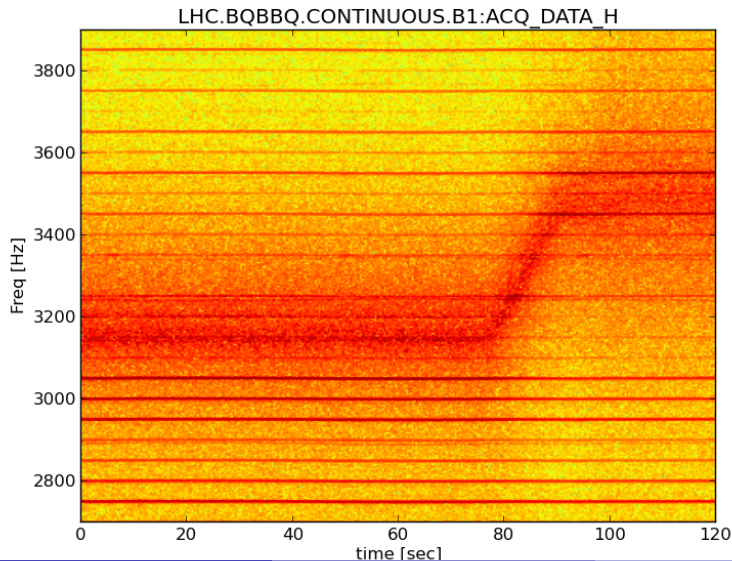
LHC BBQ during tune jump:

2012-09-08 18-50-29



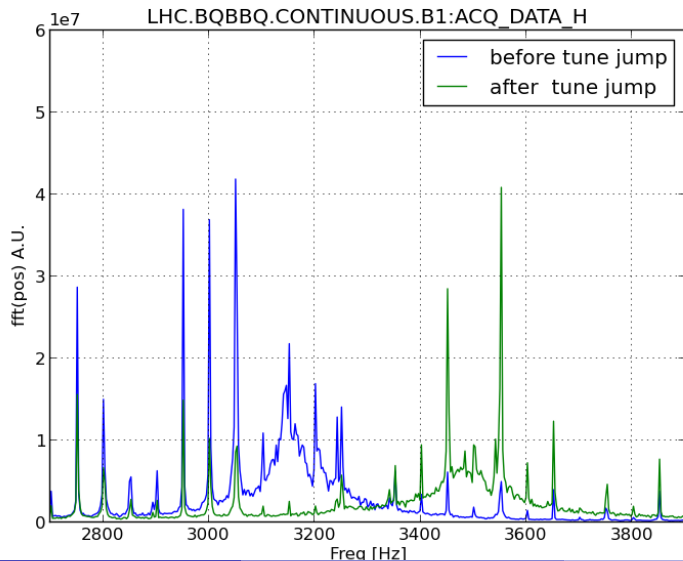
LHC BBQ during tune jump:

2012-09-08 21-51-39



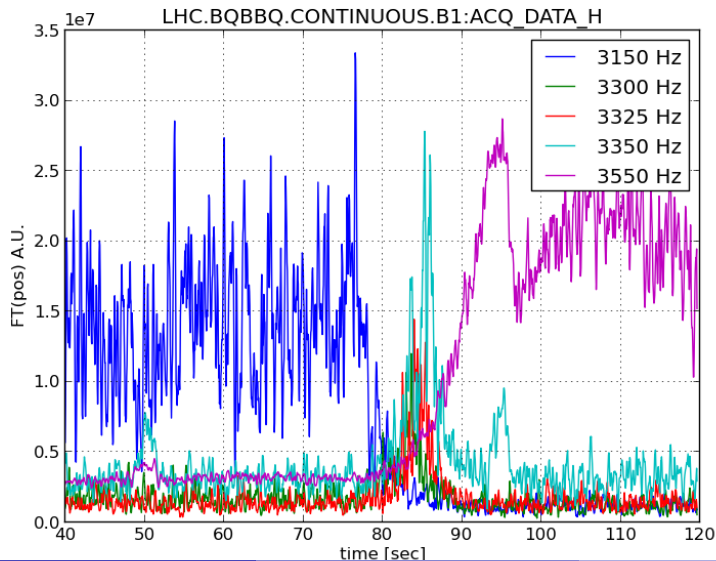
LHC BBQ during tune jump:

2012-09-08 21-51-39



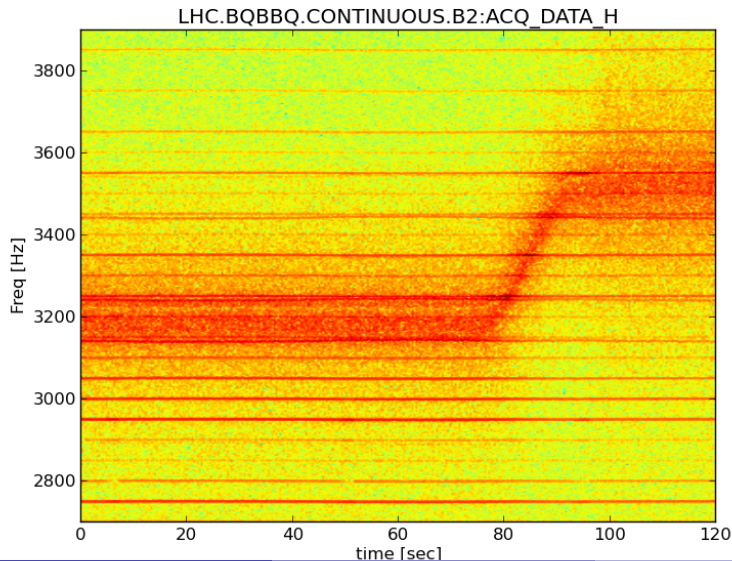
LHC BBQ during tune jump:

2012-09-08 21-51-39



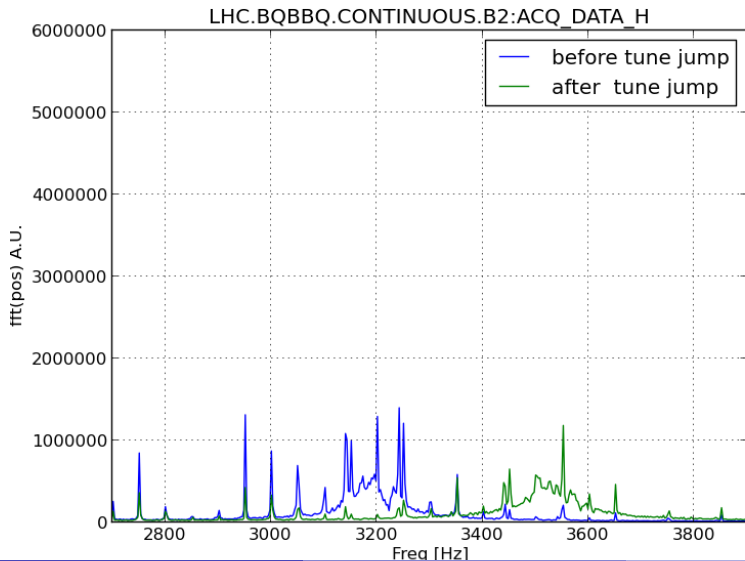
LHC BBQ during tune jump:

2012-09-08 21-51-39



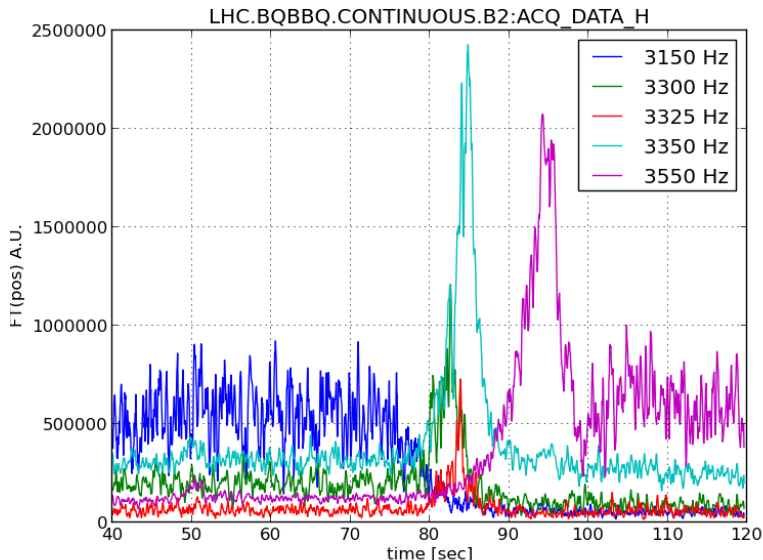
LHC BBQ during tune jump:

2012-09-08 21-51-39



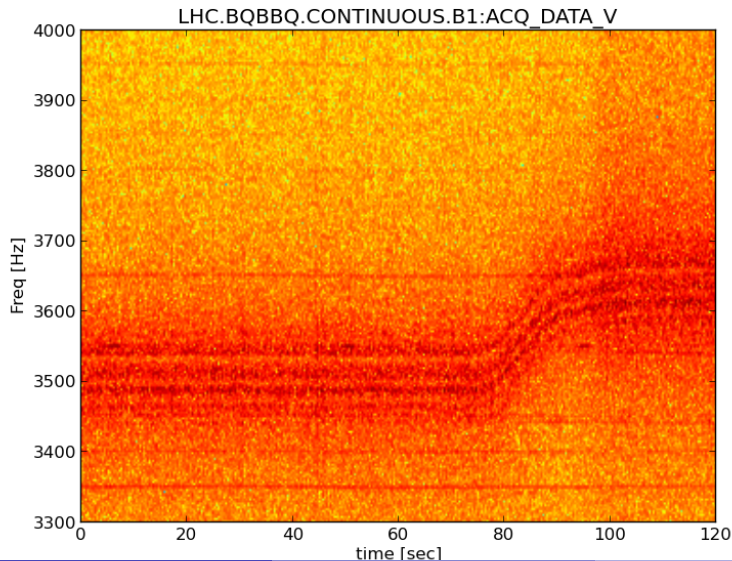
LHC BBQ during tune jump:

2012-09-08 21-51-39



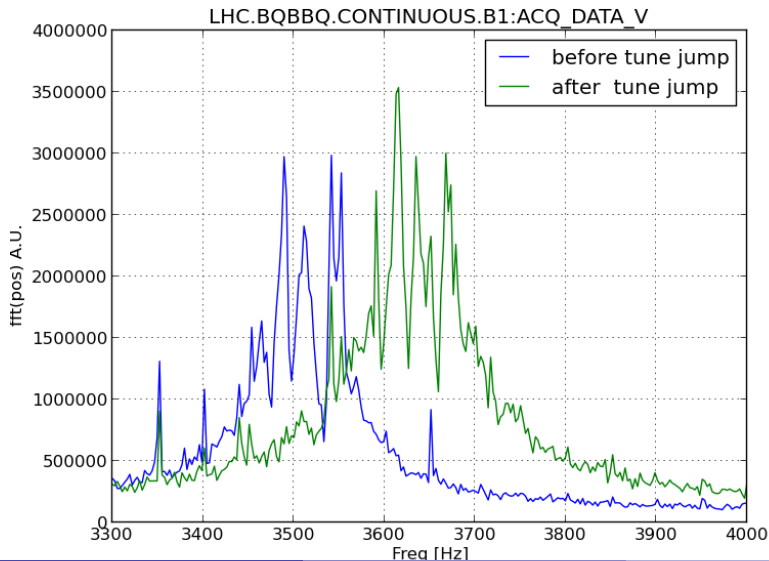
LHC BBQ during tune jump:

2012-09-08 21-51-39



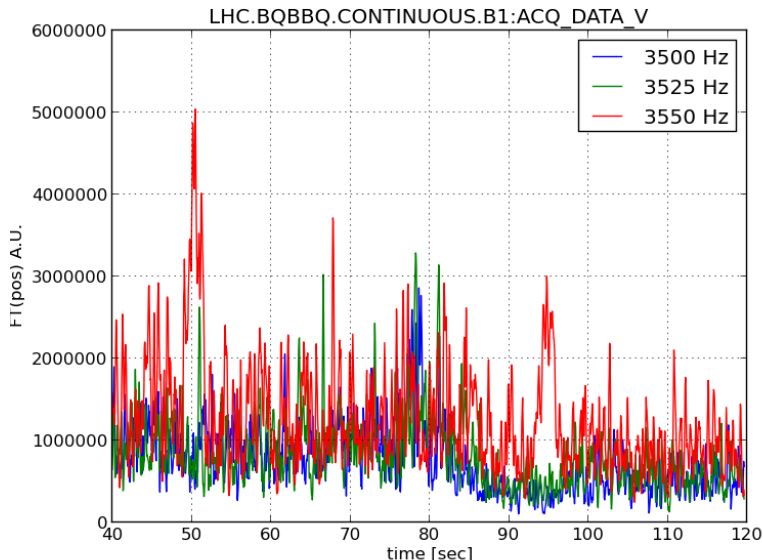
LHC BBQ during tune jump:

2012-09-08 21-51-39



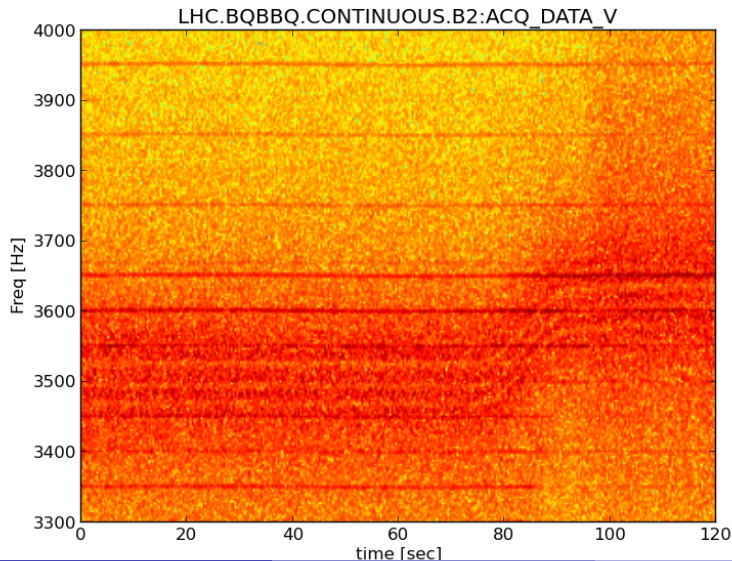
LHC BBQ during tune jump:

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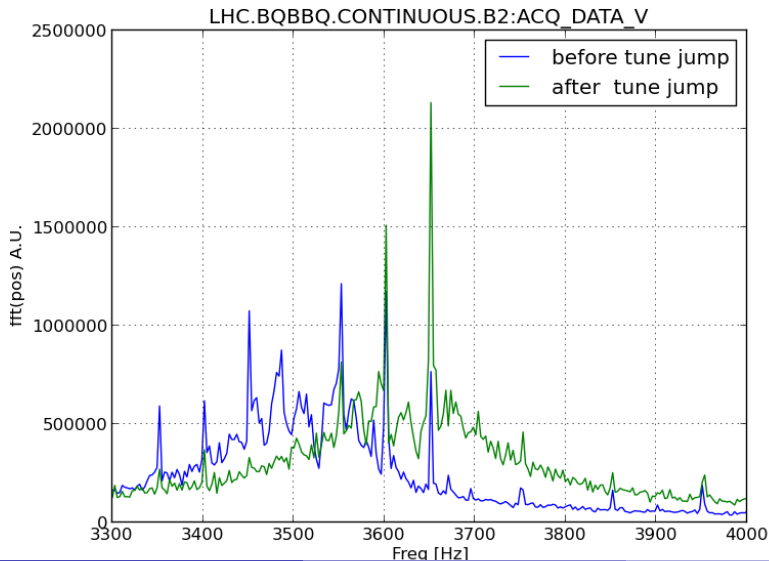
LHC BBQ during tune jump:

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