Comparing BBQ, 21.4MHz and 1.7GHz Schottkys

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Tune Tracker Workshop

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Thanks to the following people

- M. Gasior for building the hardware.
- P. Cameron, M. Gasior and F. Caspers for discussions.
- Tevatron group for BBQ support.

Goals

- Install the BBQ in the Tevatron.
- Compare the BBQ with the existing tune measurement systems in the Tevatron.

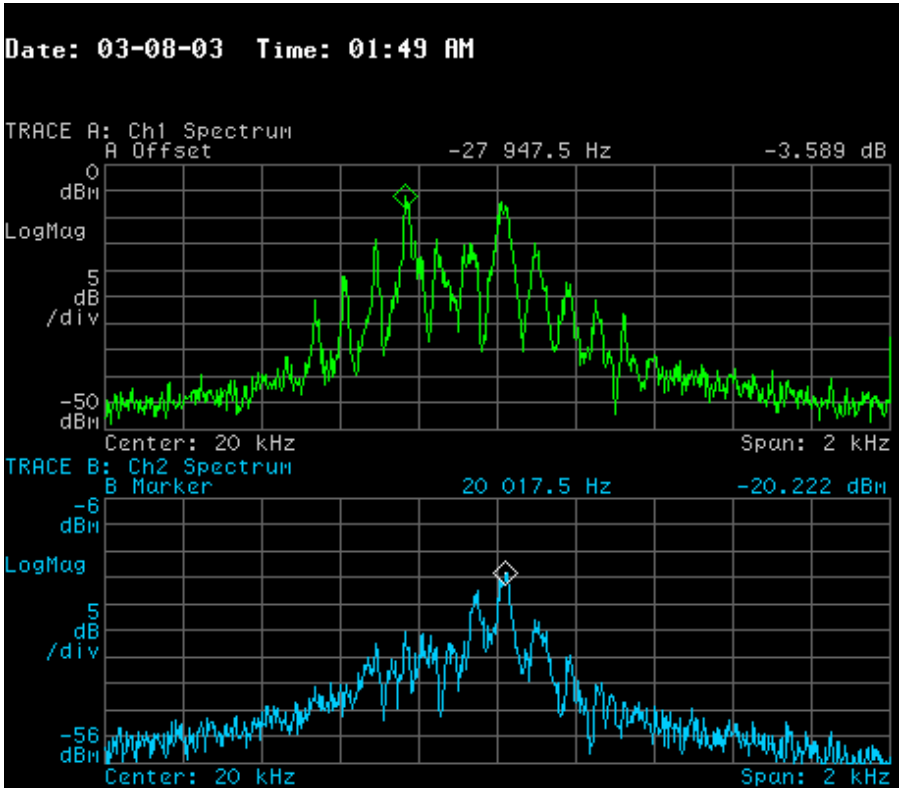
Different Bunch Types

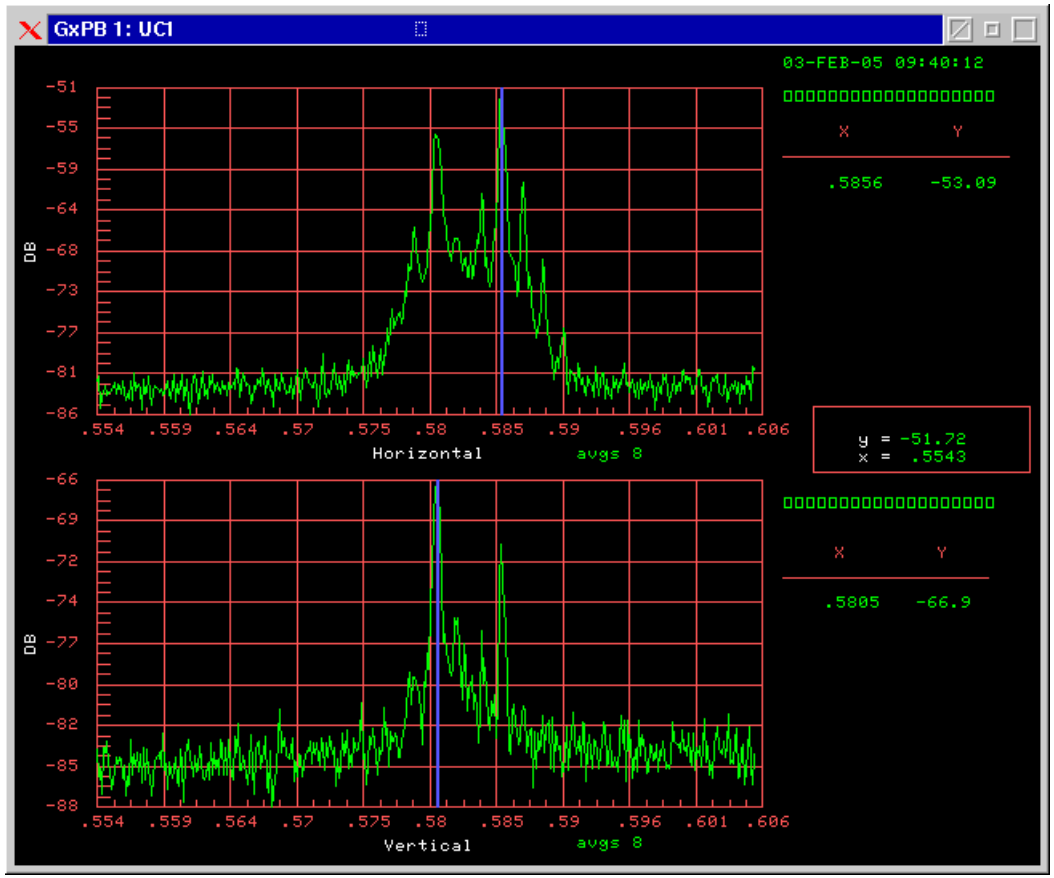
- There are 2 different bunch types in the Tevatron
  - Uncoalesced bunch. Approx 200e9 protons spread out in 30 adjacent buckets. Mainly used for tuning in the Tevatron.
  - Coalesced bunch. Can range from 150e9 to 280e9 of protons in one bucket. Used for HEP. At HEP there are 36 bunches of protons and 36 bunches of pbars in 3 trains of 12 bunches separated by 21 buckets.

Comparison Experiments

- Comparison experiments between the BBQ and 21.4 Mhz Schottky.
  - 150GeV with uncoalesced beam. VTICK on/off.
    - VTICK is a vertical kicker connected to a noise source. Centre is around tune frequency bw is 5kHz, power 5W.
  - 980GeV with 4x0 coalesced bunches.
  - 980GeV with 36x36 during HEP.
- Note BBQ measures tunes BELOW ½ integer while 21.4MHz measures tunes above ½ integer.

Uncoalesced Beam (VTICK on) 150GeV





BBQ Qh = 0.5855
BBQ Qv = 0.5804

Schottky Qh = 0.5856
Schottky Qv = 0.5805

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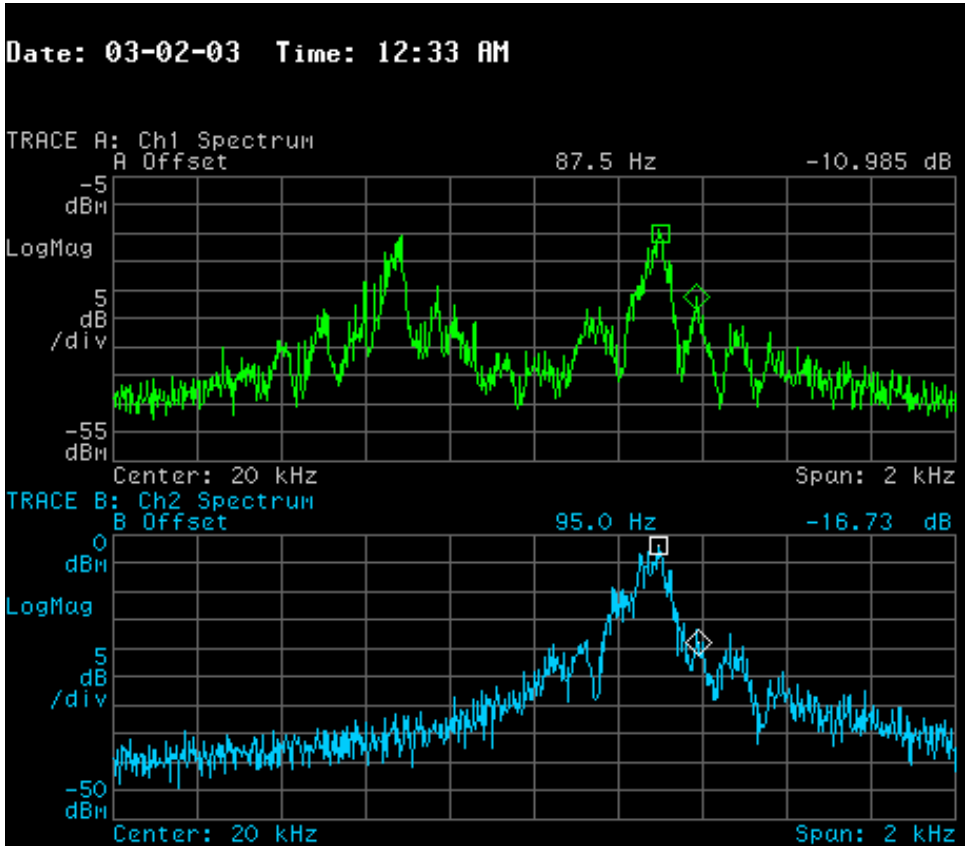
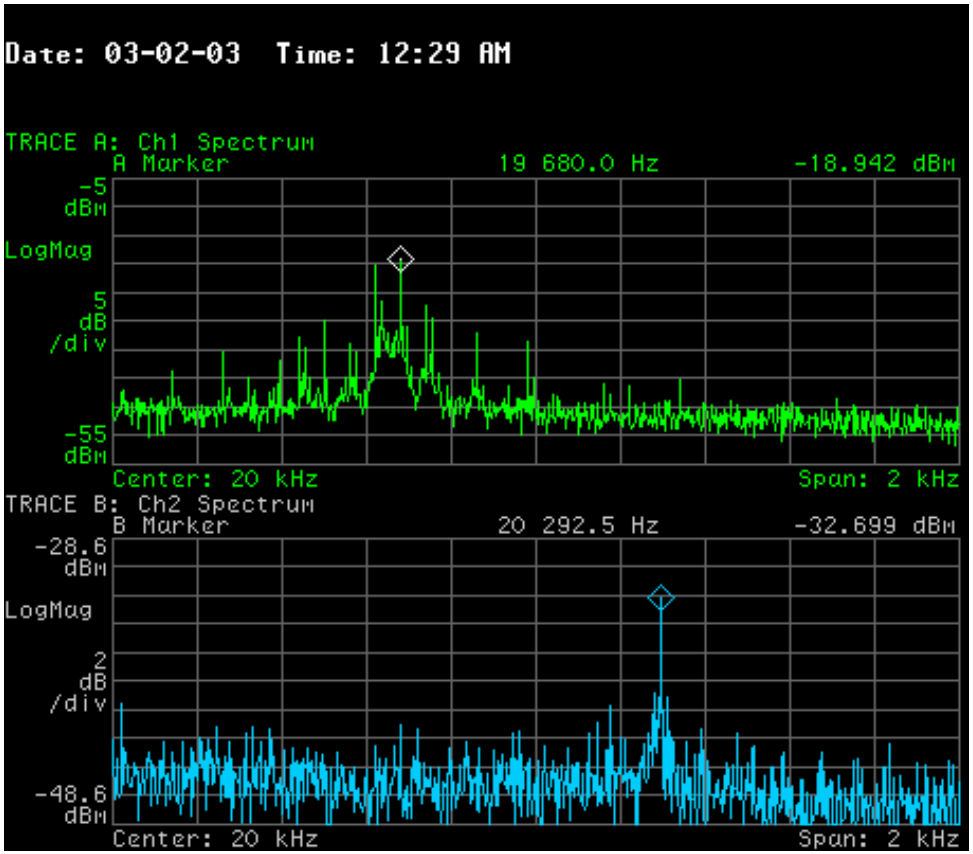
Uncoalesced Beam with BBQ (28 Jan 2005)

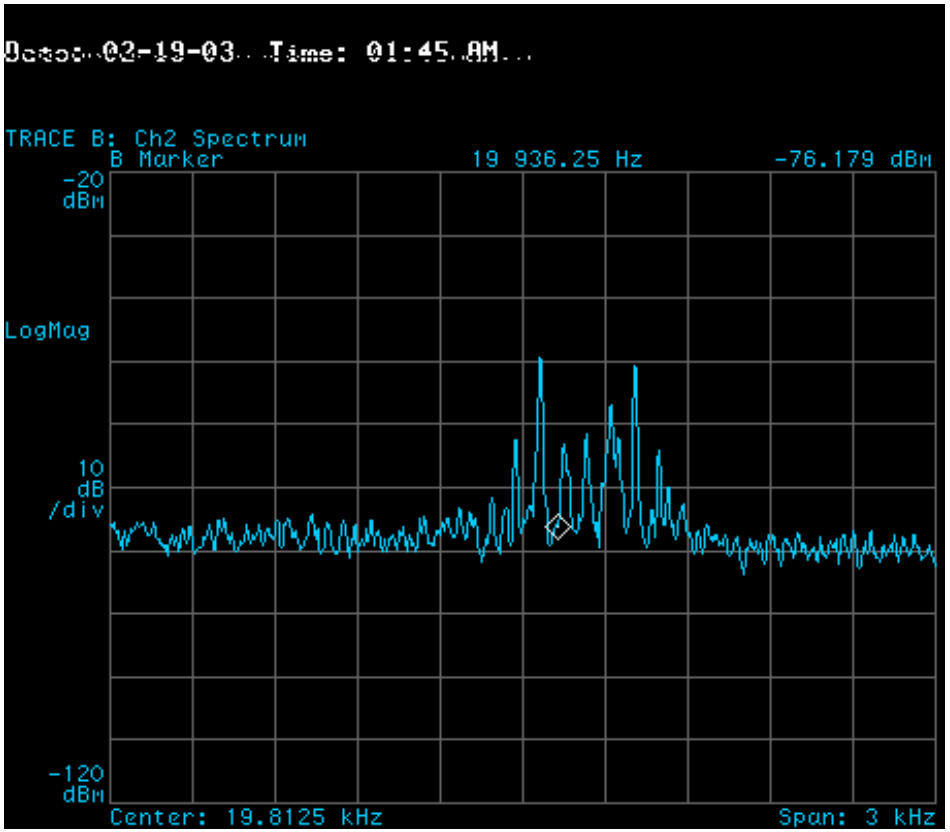


VTICK on

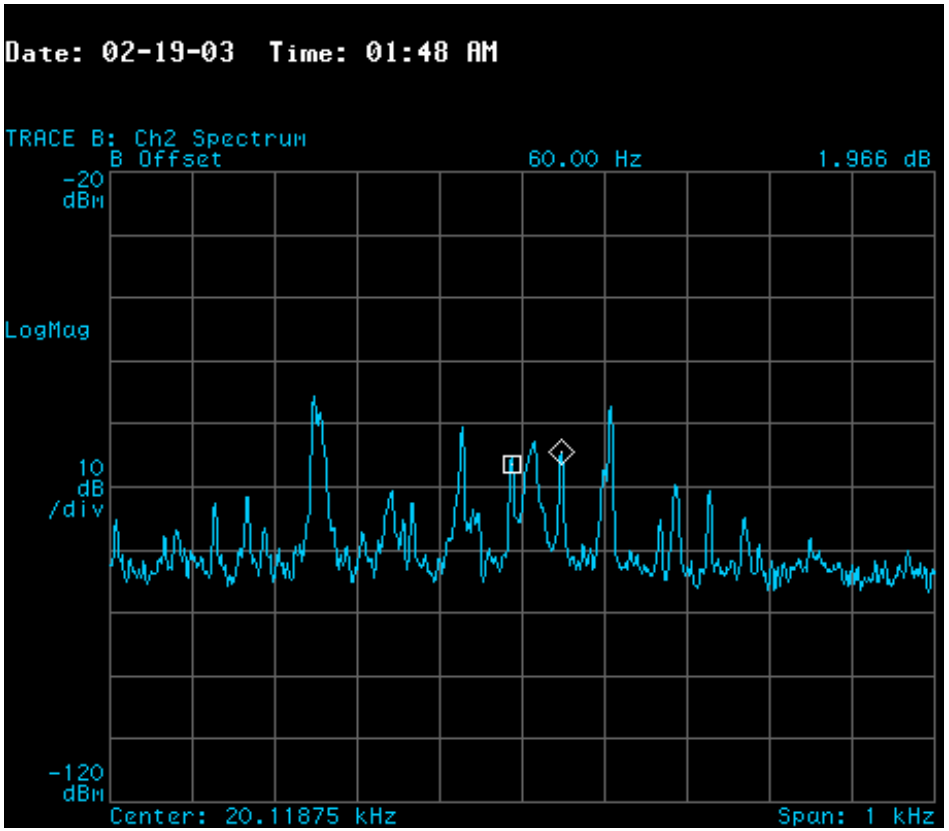


VTICK off

Uncoalesced VTICK off (17 Jan 2005)

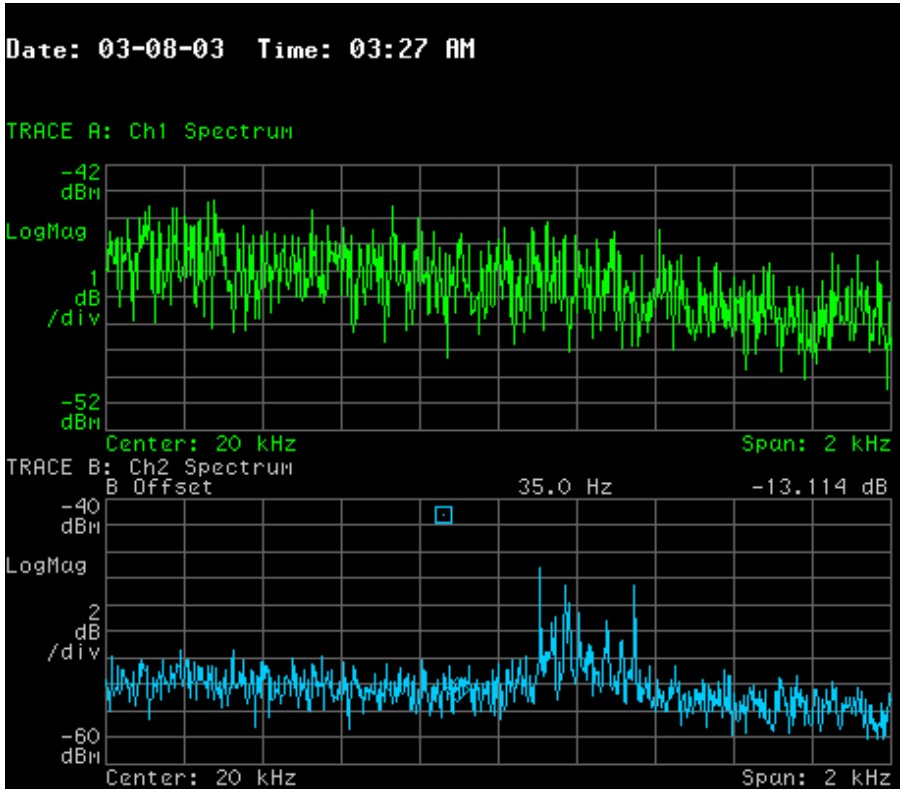


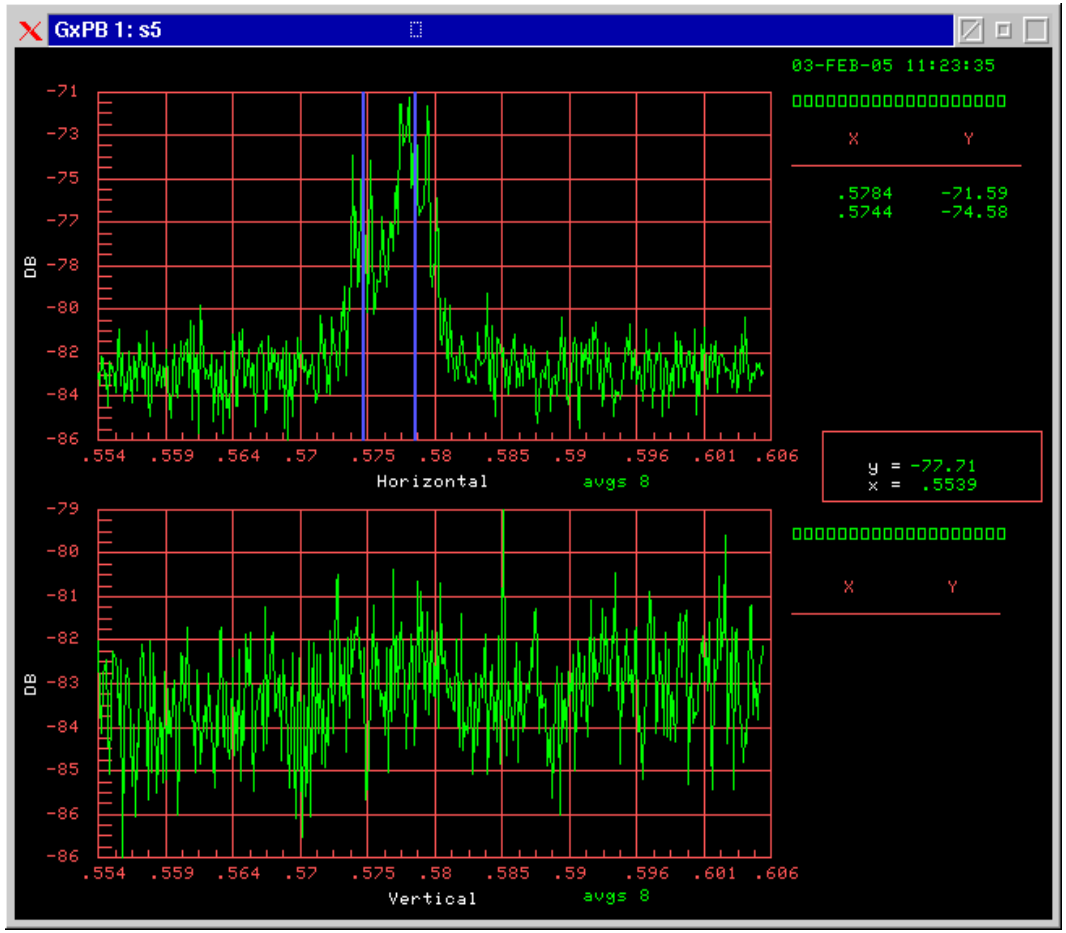
Horz channel. Note absence of large 60Hz lines.



Zoomed in to see 60Hz.

At low beta 4x0 (VTICK off)





No signal from BBQ horz and Schottky vert. For BBQ, adding 70MHz LPF will probably show signal

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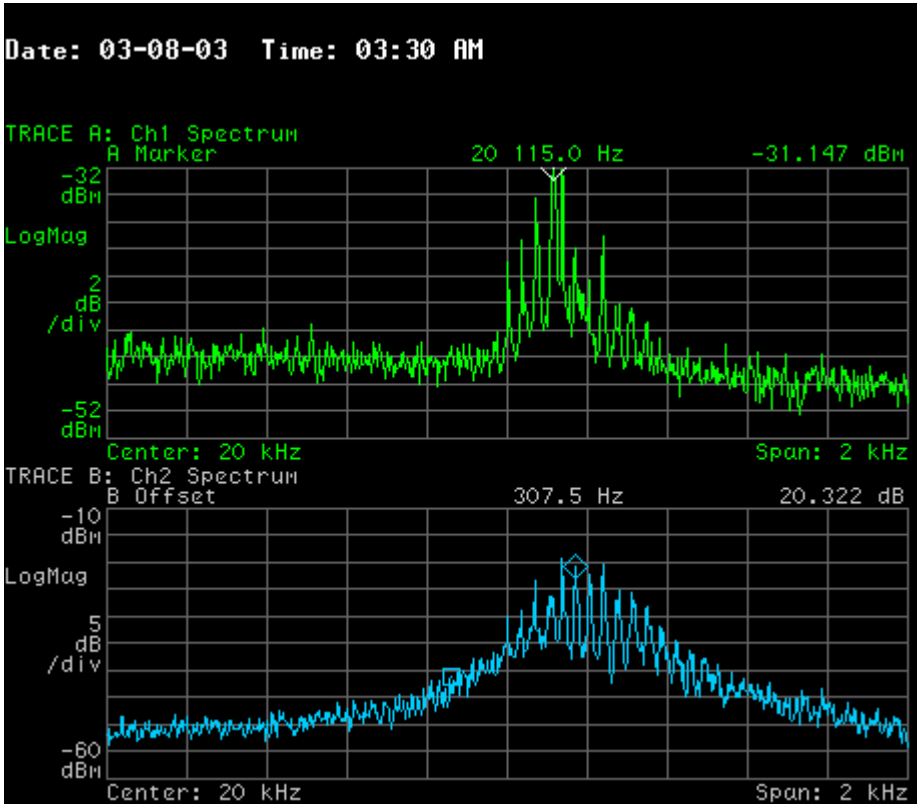
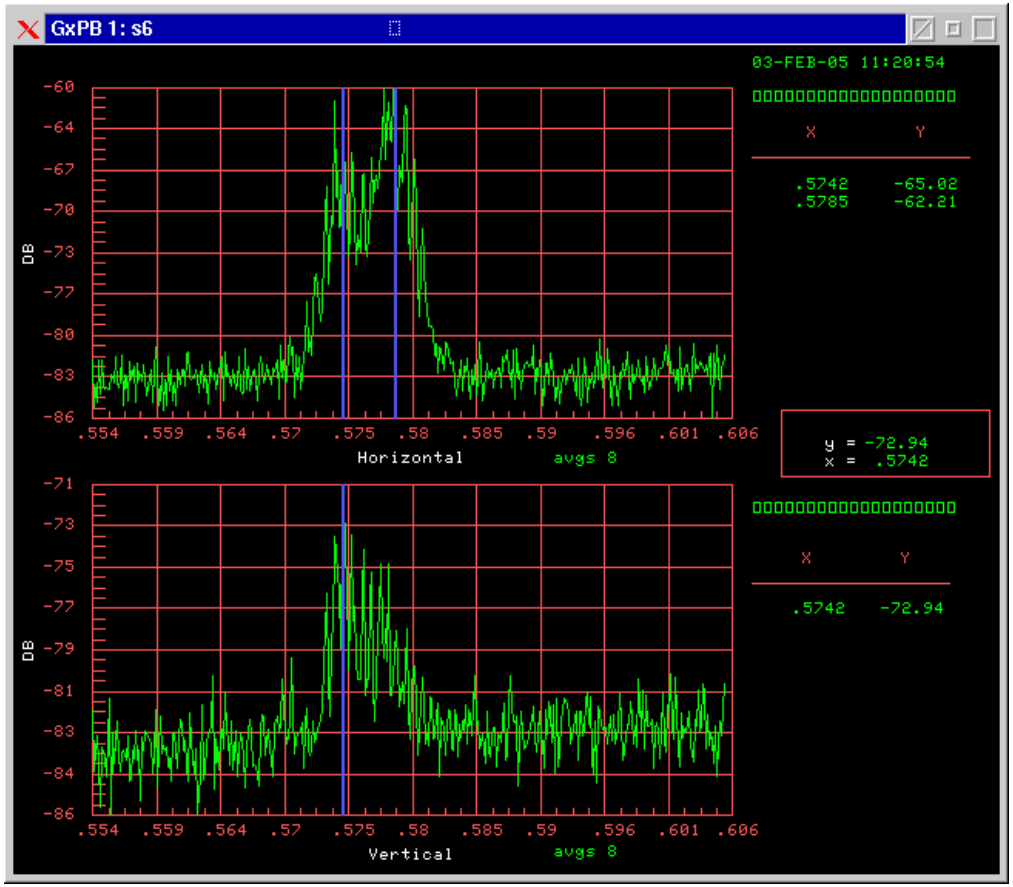
4x0 low beta (VTICK on)





BBQ Qv=0.5784

Note differences in shape.

Schottky Qv=0.5785

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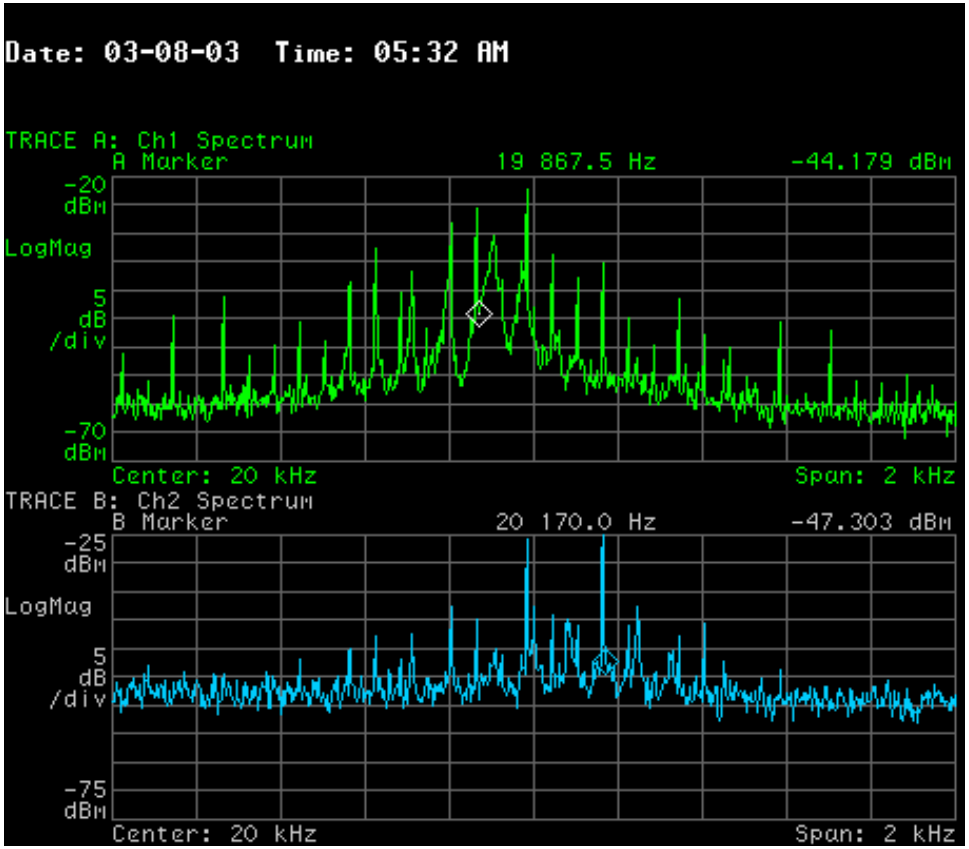
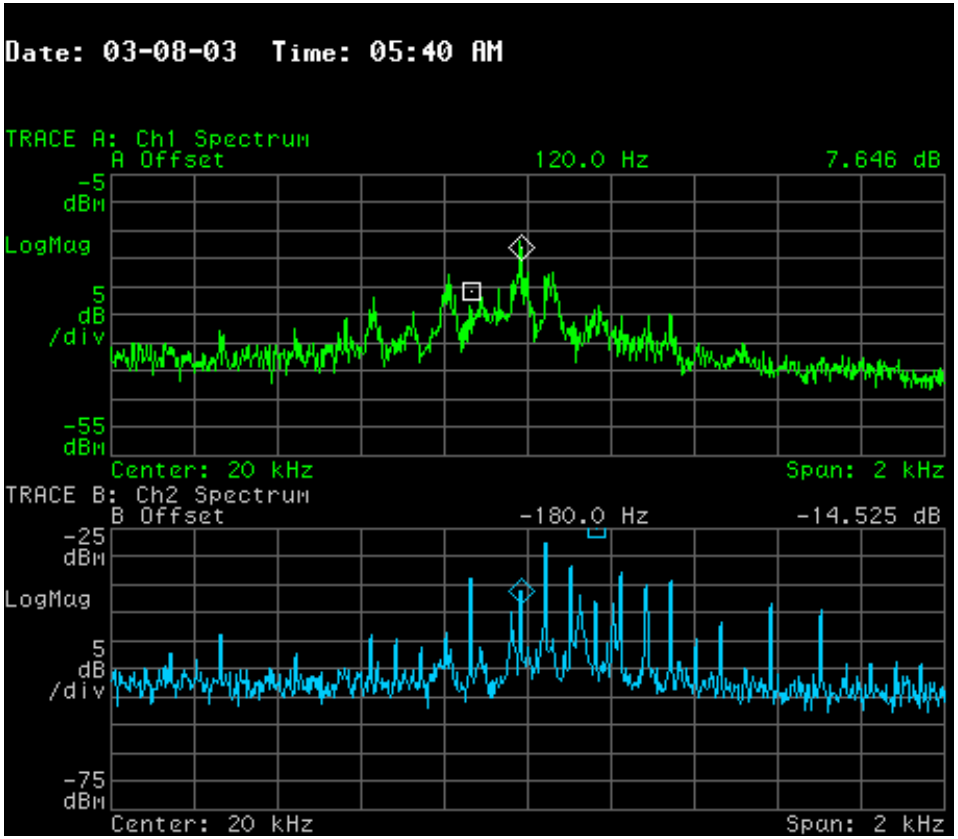
36x0 at 150GeV (VTICK off)





Helix off

Helix on

Note: 60Hz lines disappears on helix for horz but not vert. Vert pos changes by approx -4mm and horz by +3mm.Electronics?

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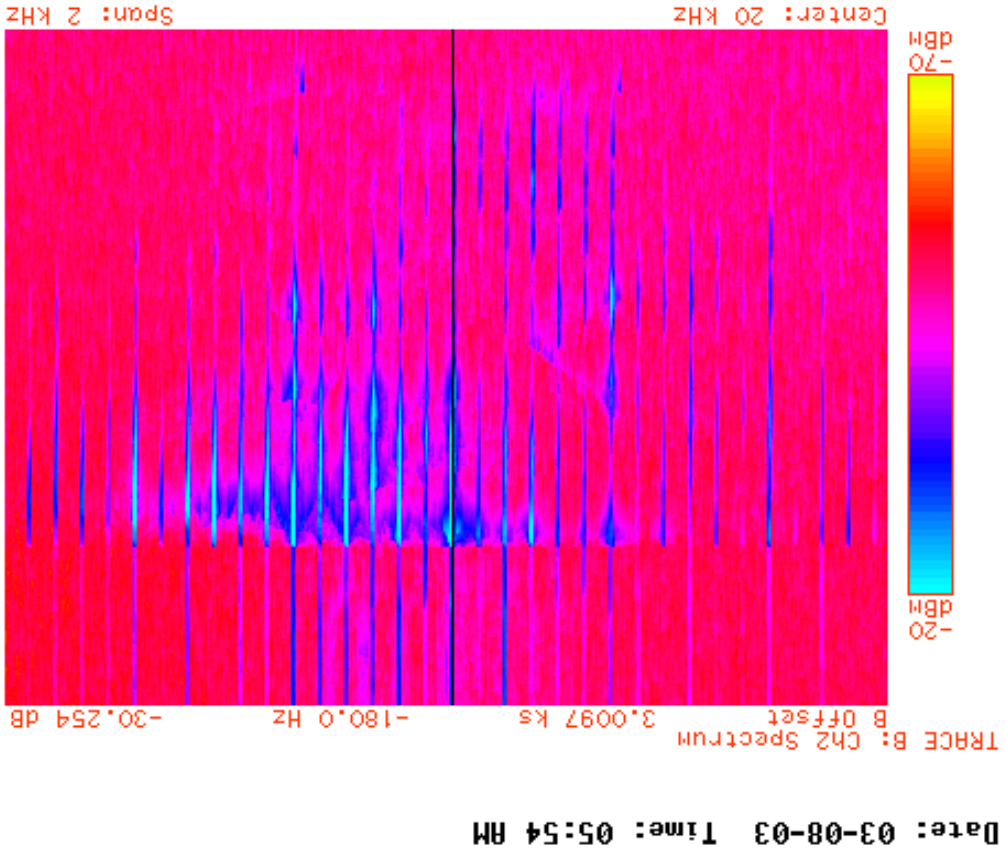
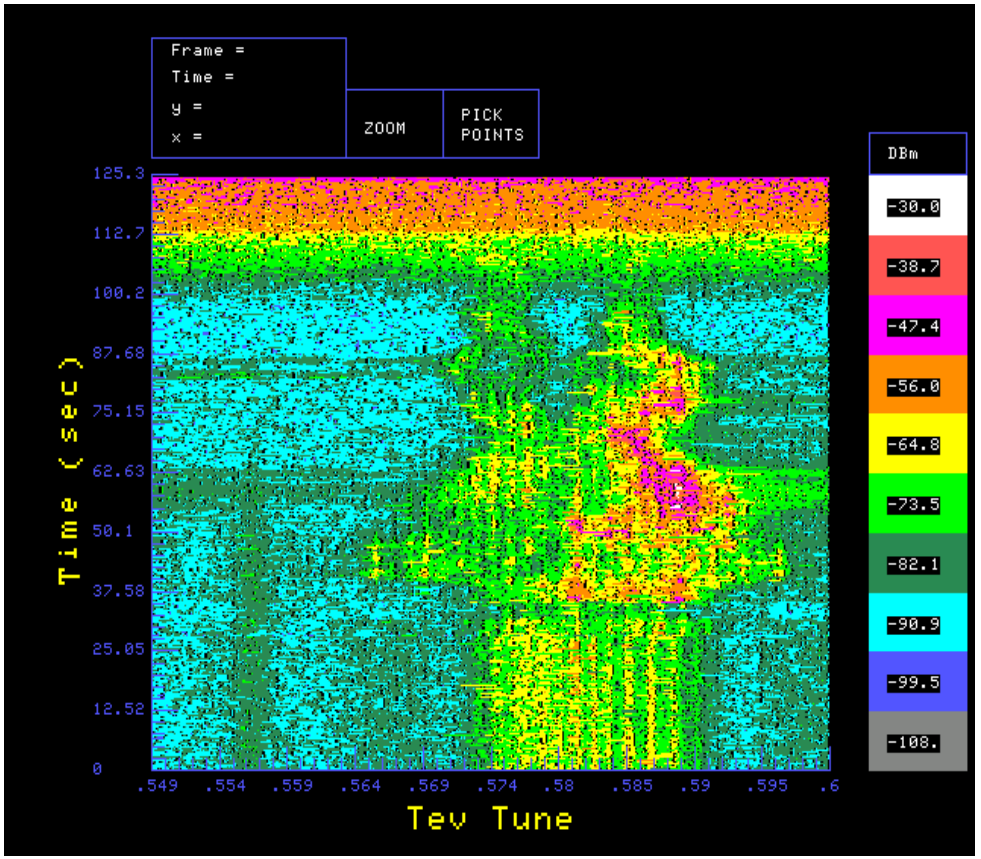
36x36 going up the ramp





Going up the ramp, BBQ dominated by 60Hz lines

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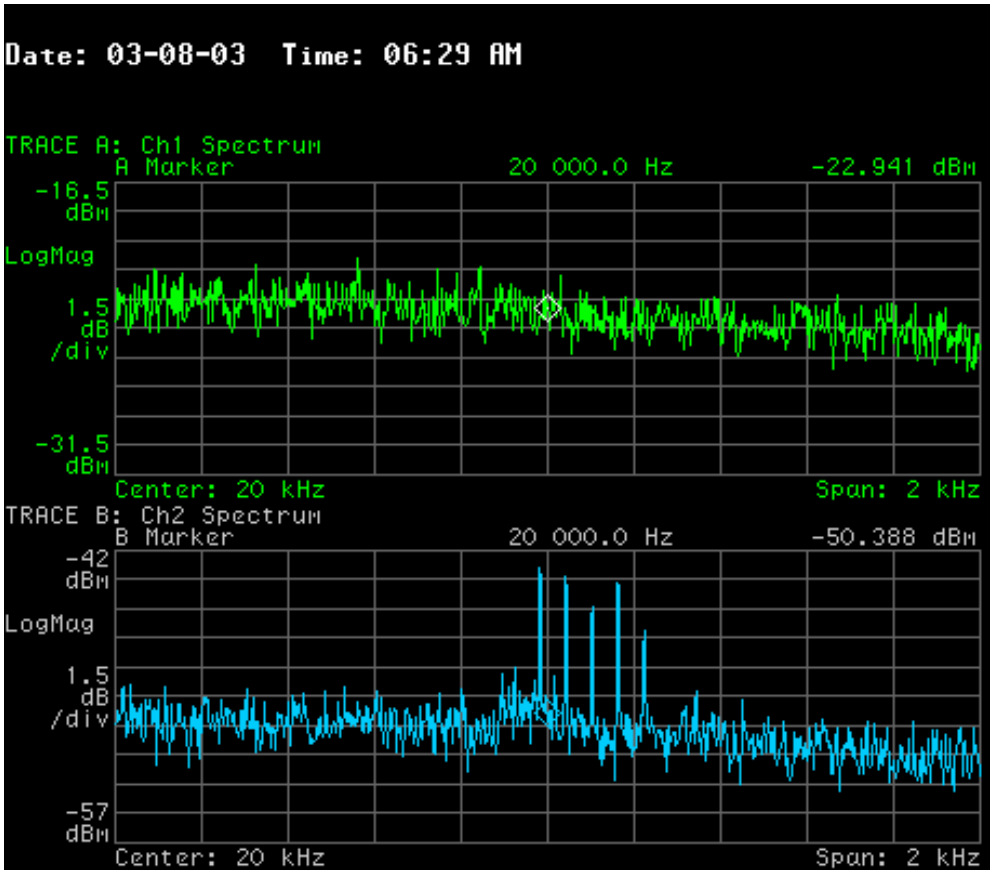
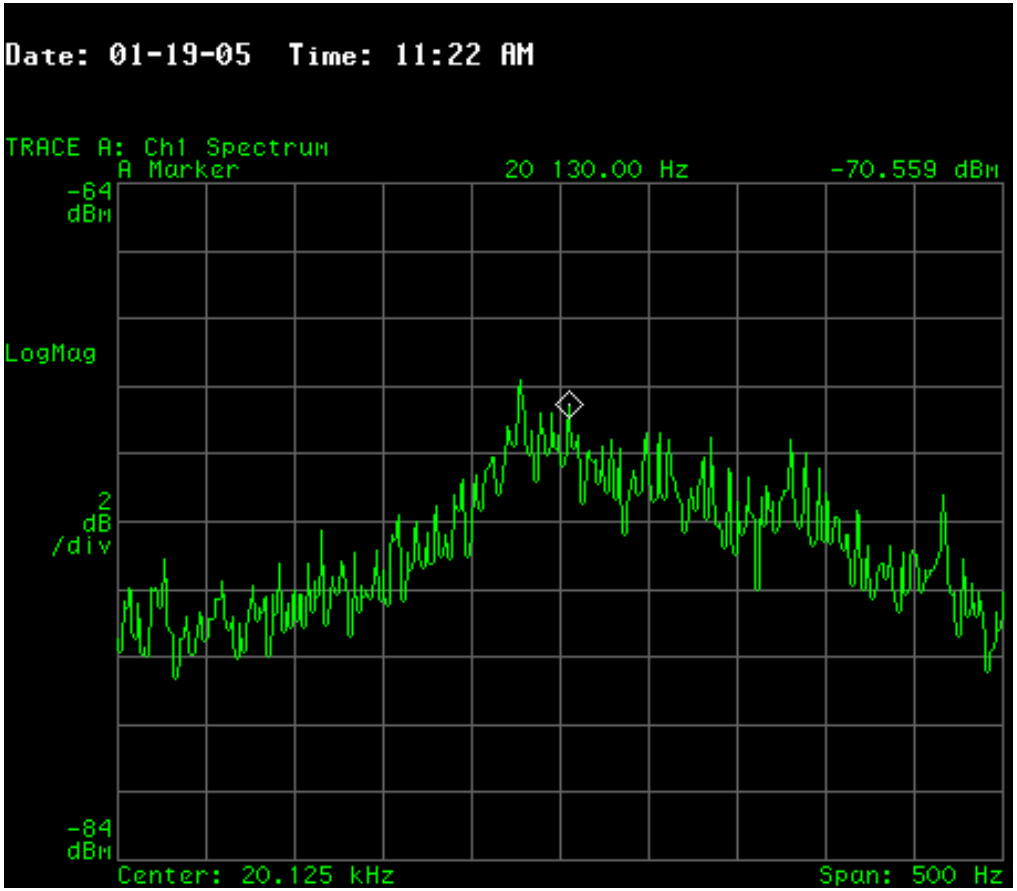
36x36 low beta





Strong 60Hz lines at the start of store.

Not seen on 21.4MHz Schottky. Note: 8000e9 protons

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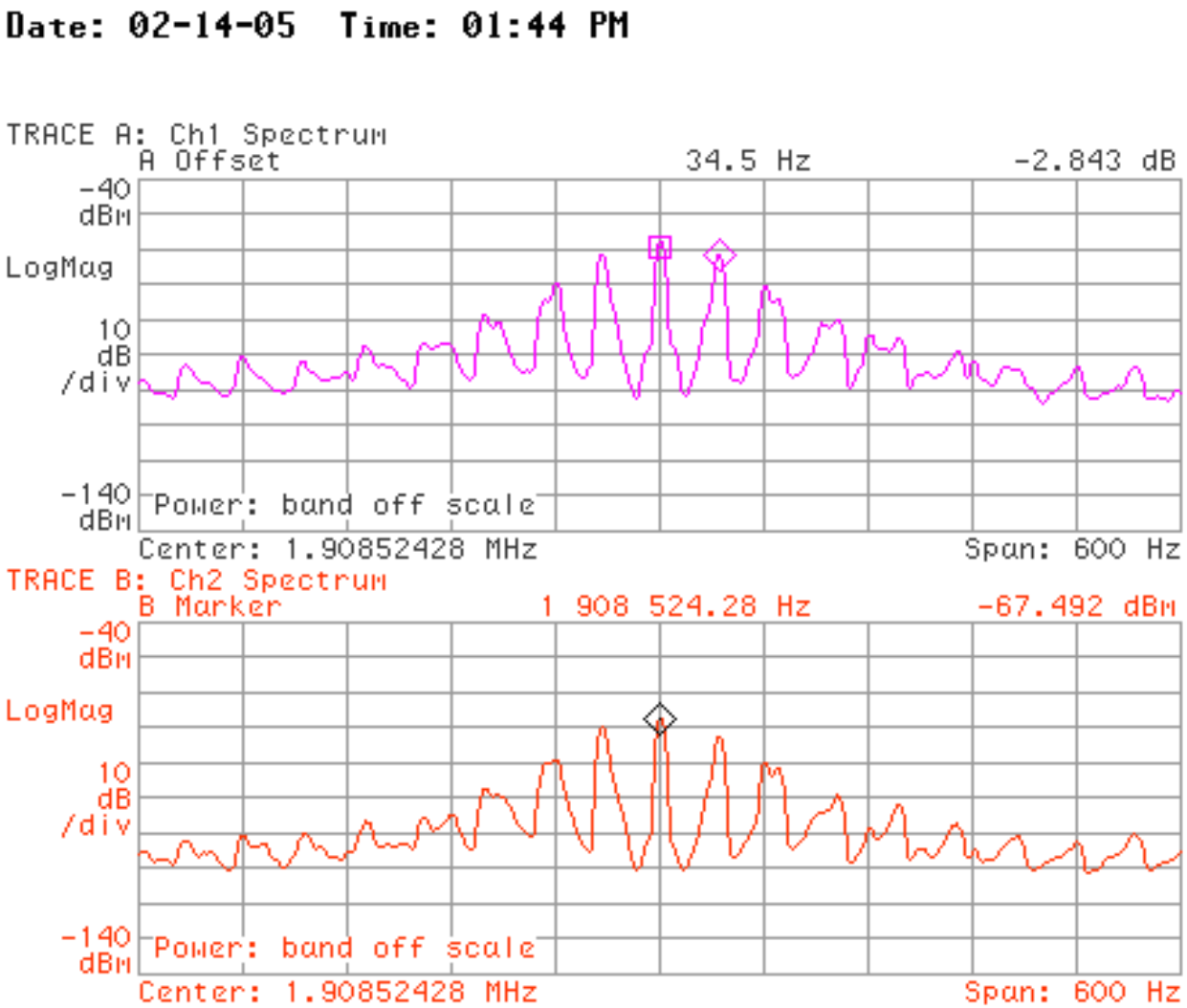
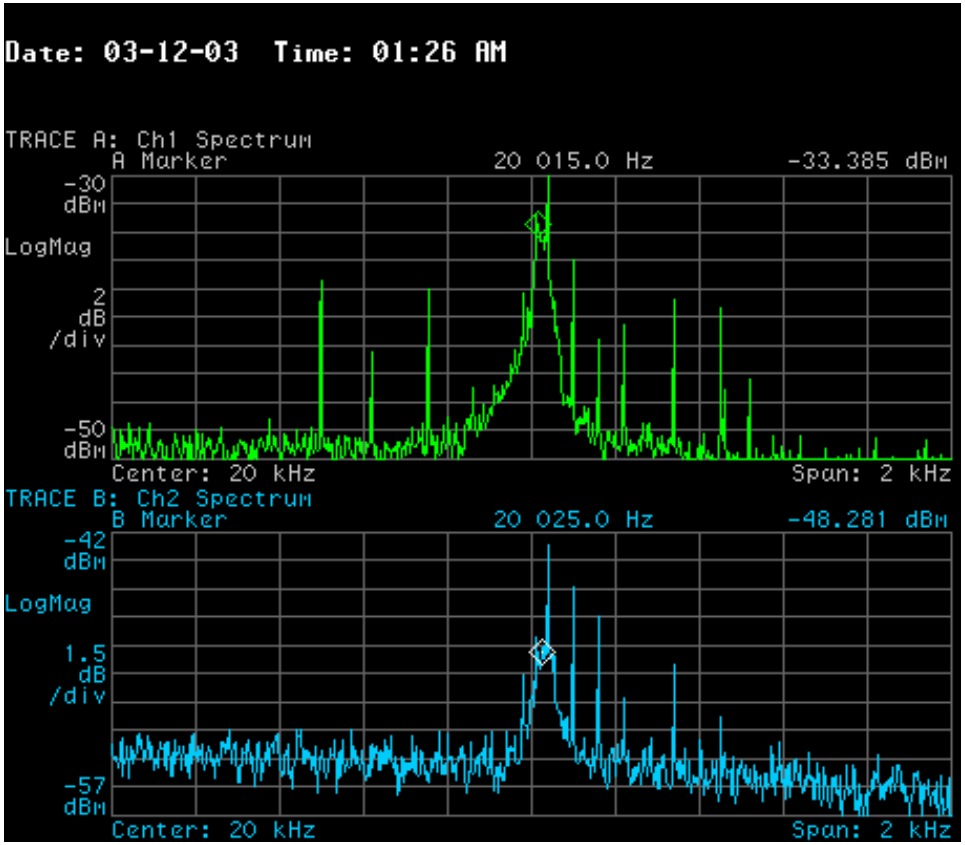
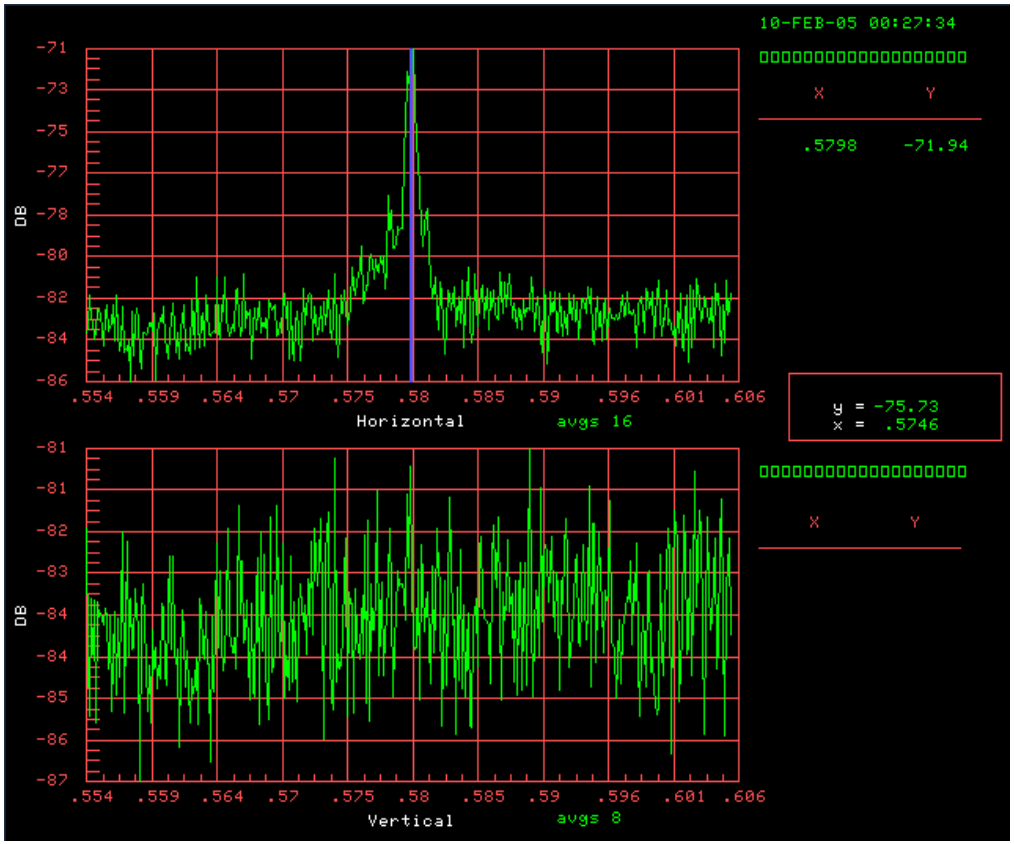
Looking at 1.7GHz (BW 100MHz)



60Hz comparable in size to synchrotron tune (each box is 60Hz)

36x36 low currents (EOS)





But with low currents 6300e9 protons, Qh and Qv seens clearly. BBQ electronics saturation for higher beam currents? 70MHz LPF cures this.
Note shape of tune and 60Hz lines (some lines got 1.5dB smaller). Noise Floor became better by about 3 to 4.5dB

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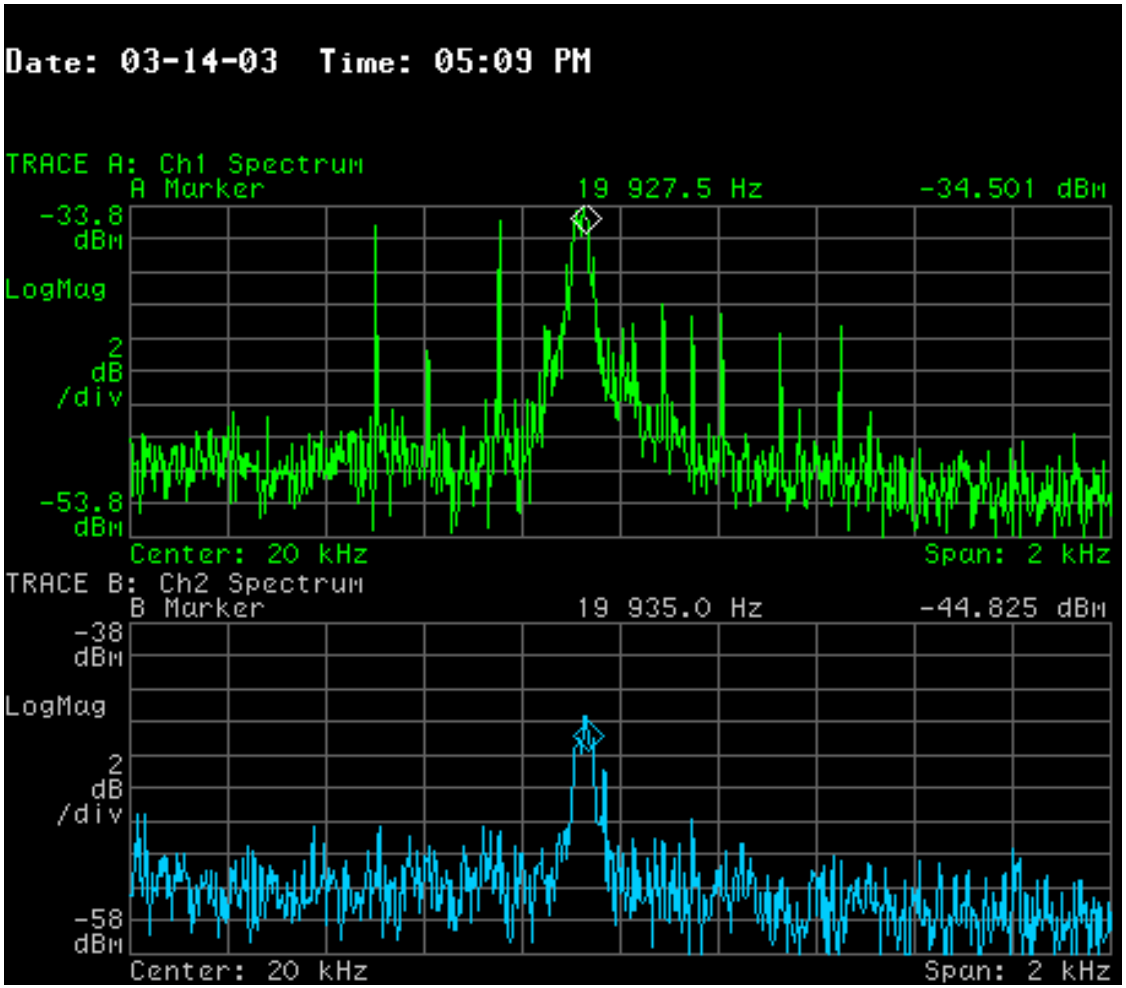
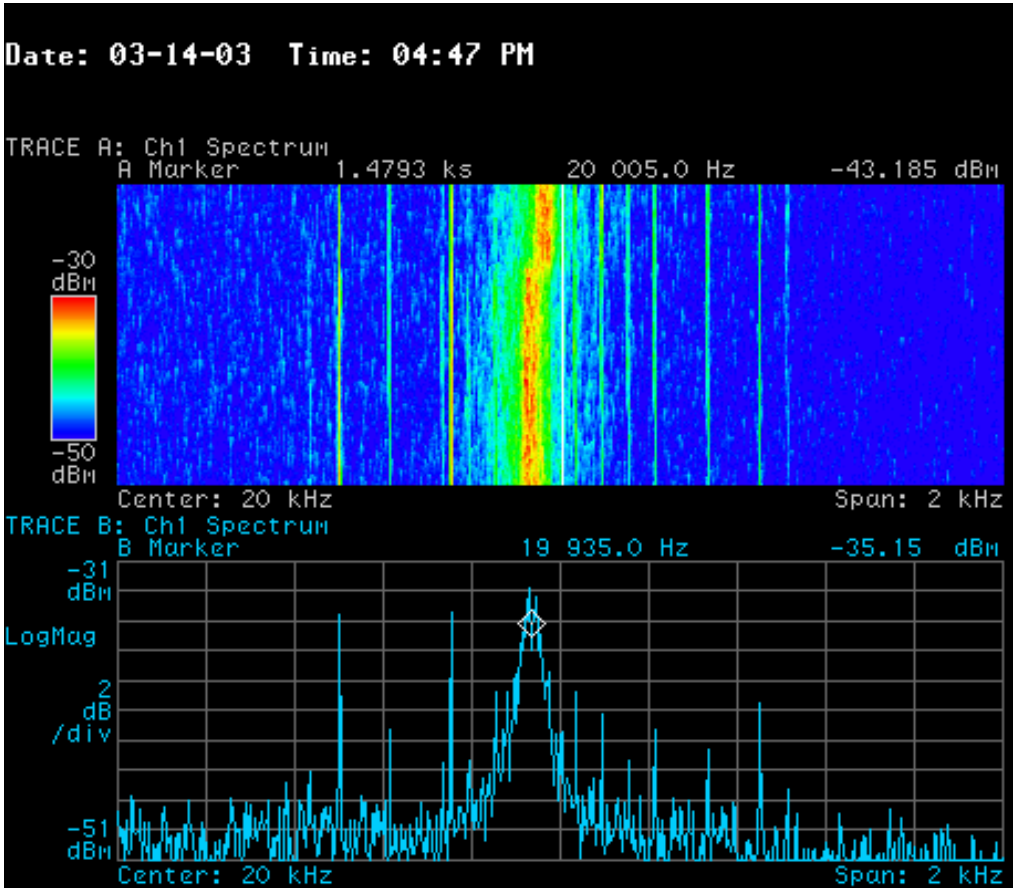
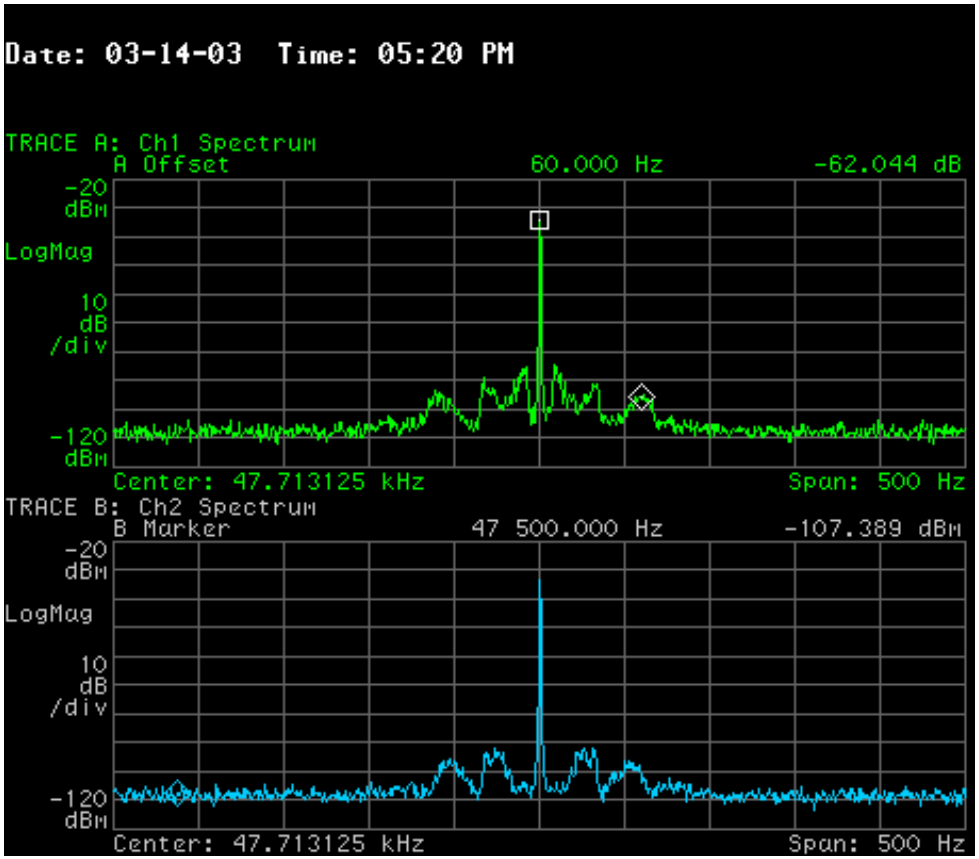
60Hz and tune position



Note disappearance of 60Hz in vert!

60Hz Characteristics





60Hz does not move when the tune moves.

No 60Hz around revoltution harmonics

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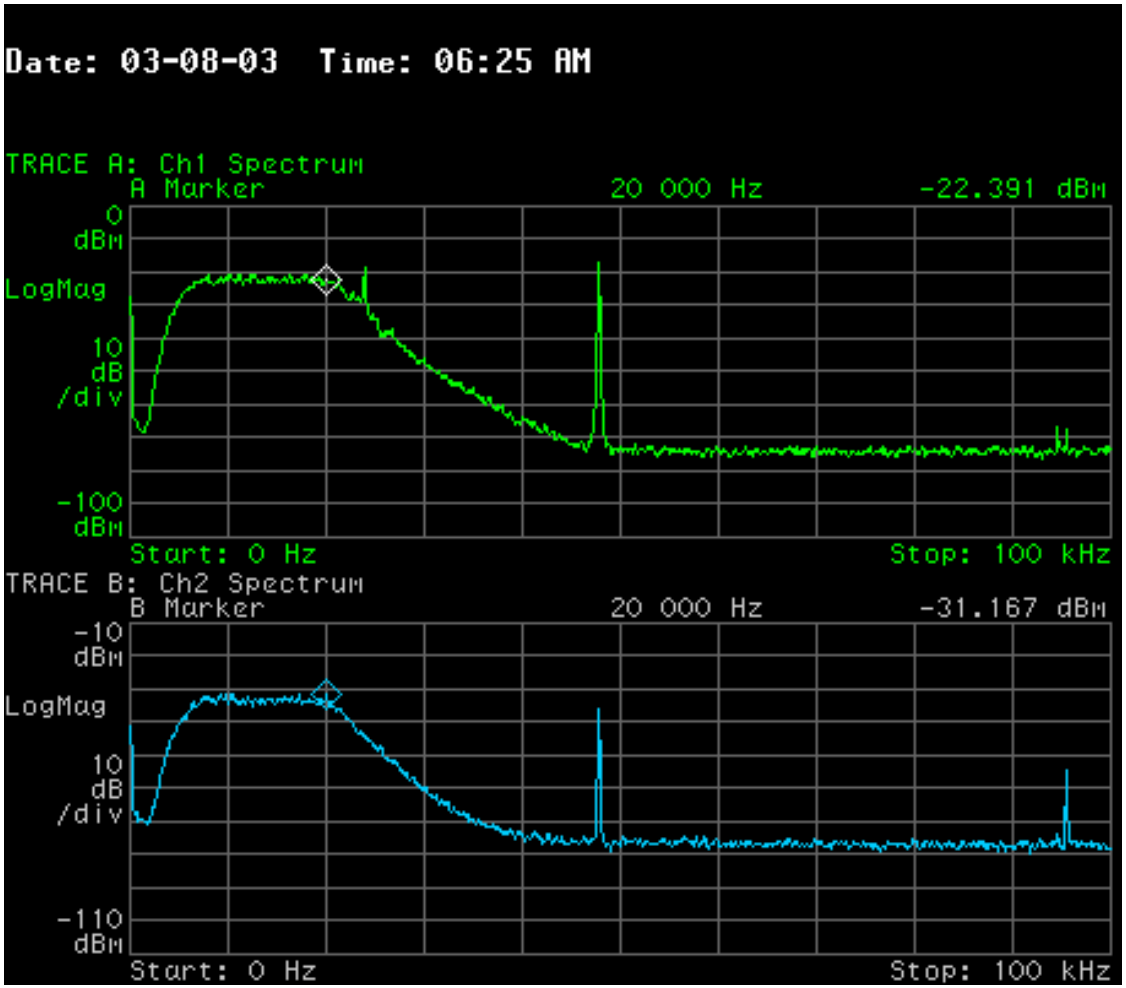
½ frev (how?)

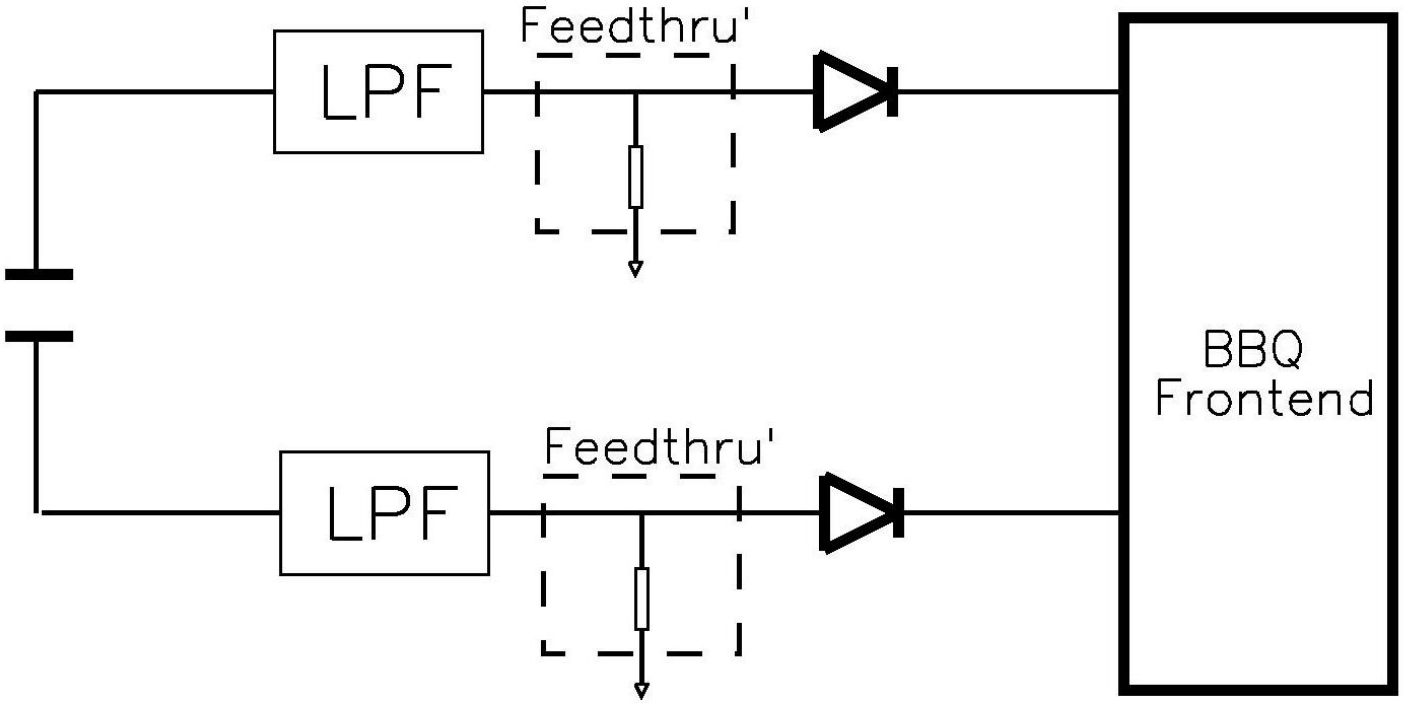


Indications of nonlinearity or saturation

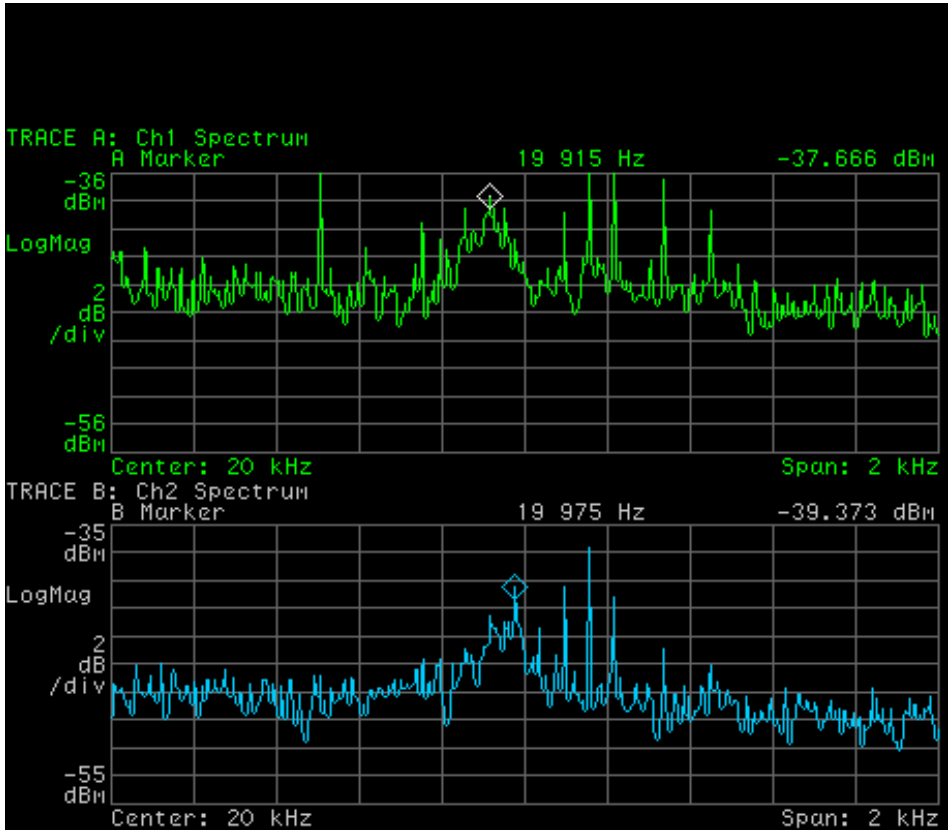
Inserting Filters

- Motivation came from:
  - Building Dampers. Too much bandwidth caused the transverse dampers to saturate. Fixed with 70MHz LPF.
  - Arguments from ½ cell hypothesis or 60Hz from baseband could possibly be eliminated by insertion of 25MHz HPF.

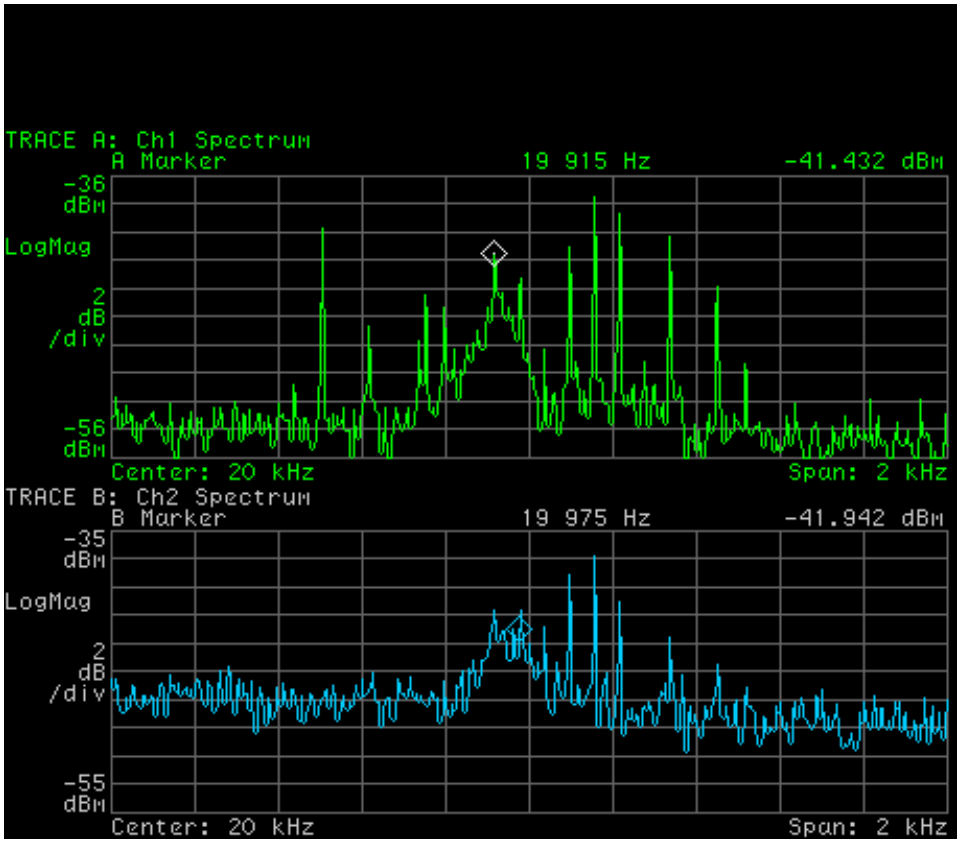
Adding 70MHz LPF improves S/N



Results of Adding 70MHz filter

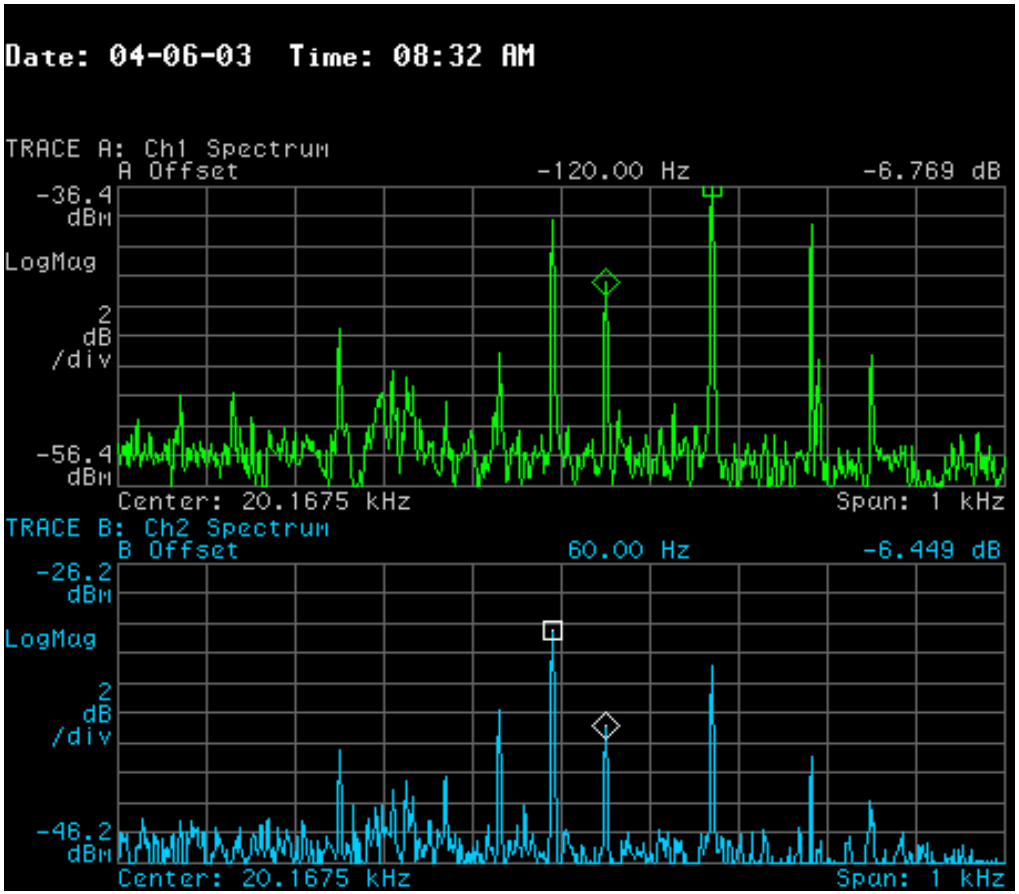


No filter

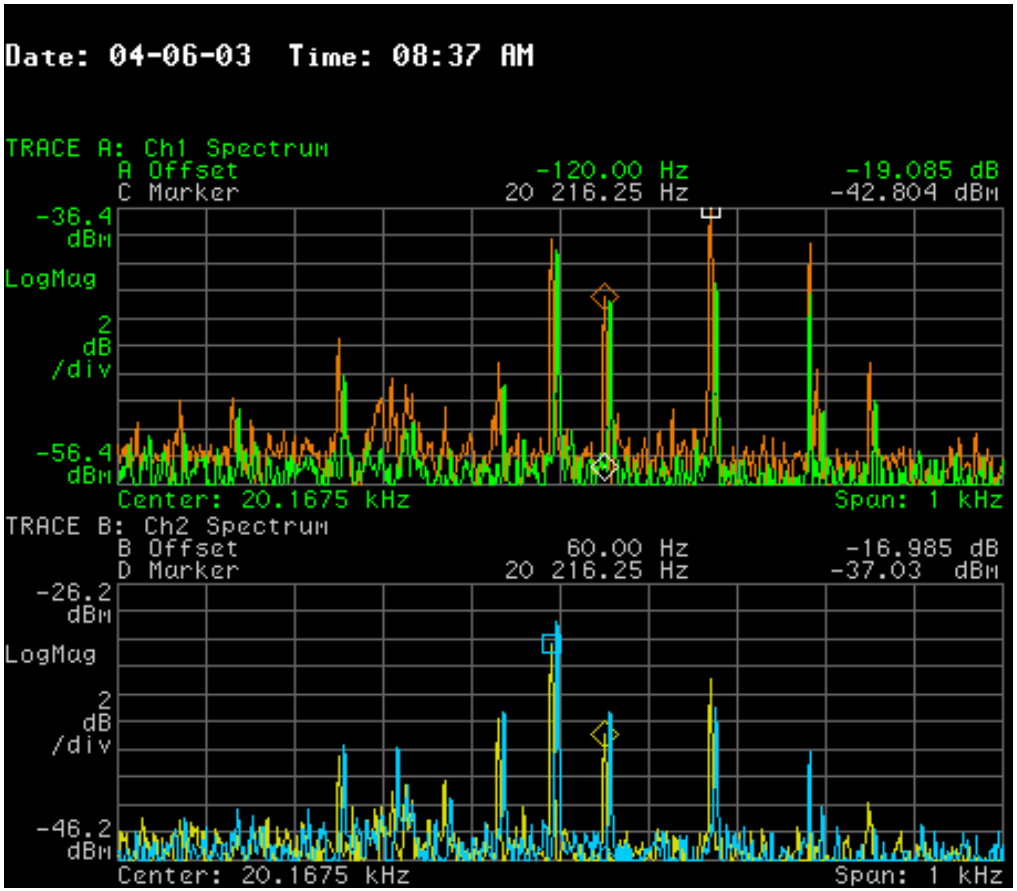


70MHz LPF

Inserting 25MHz HPF (another store)



No filter



25 Mhz HPF

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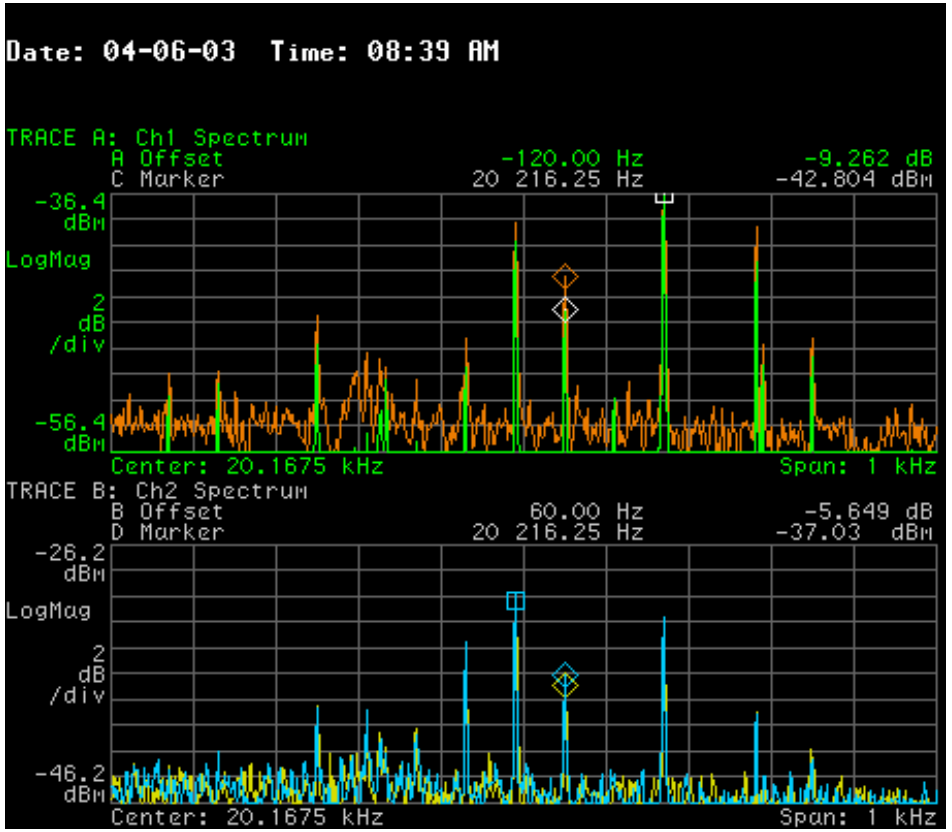
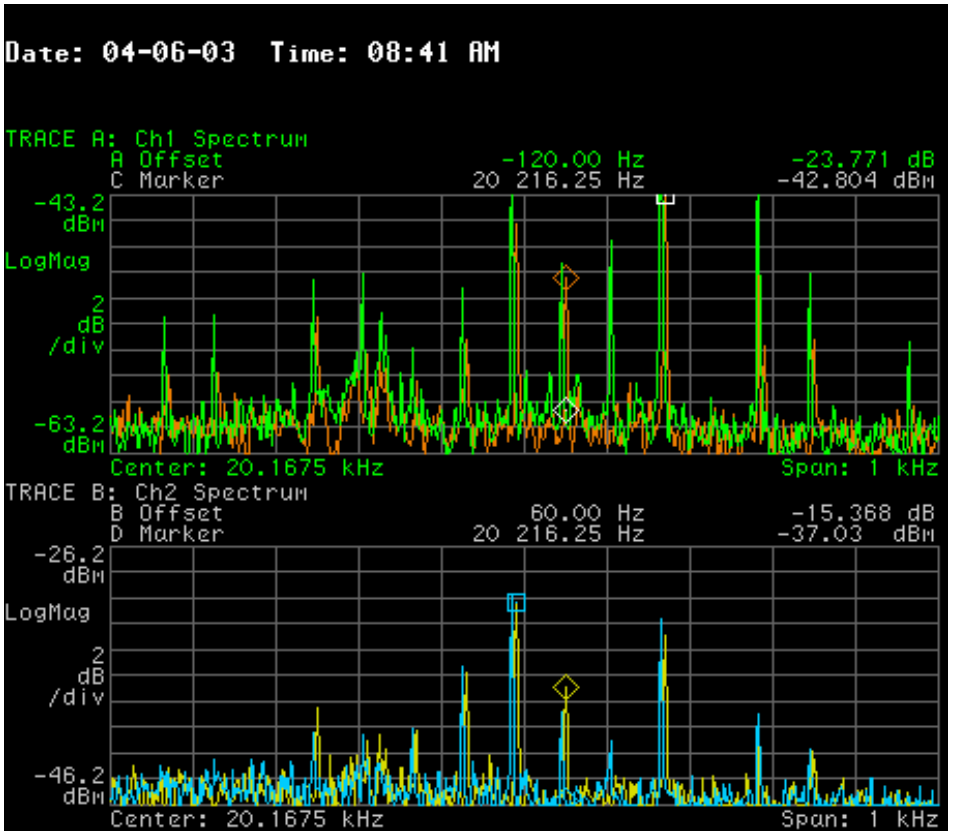
25MHz HPF and 75MHz LPF

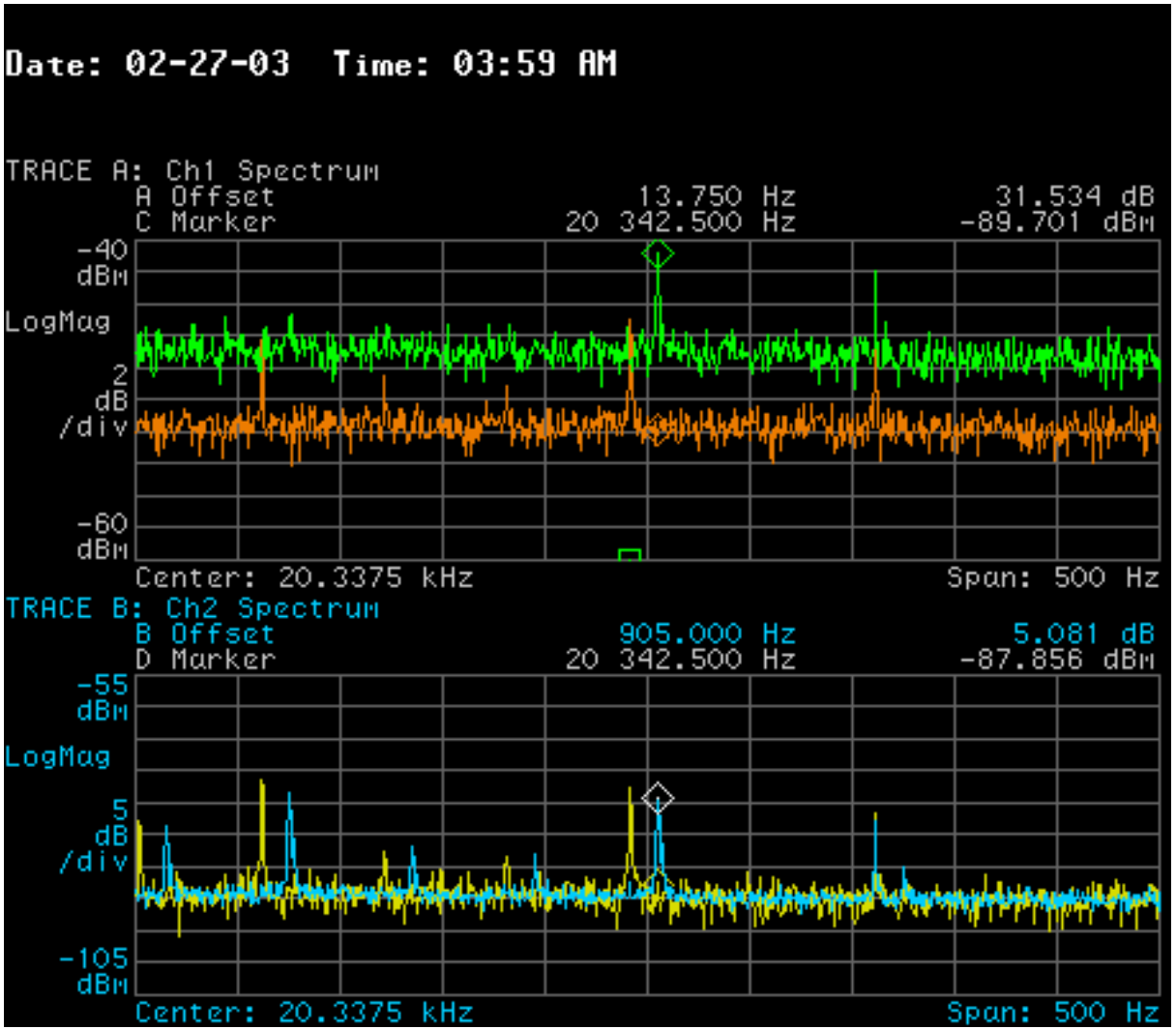




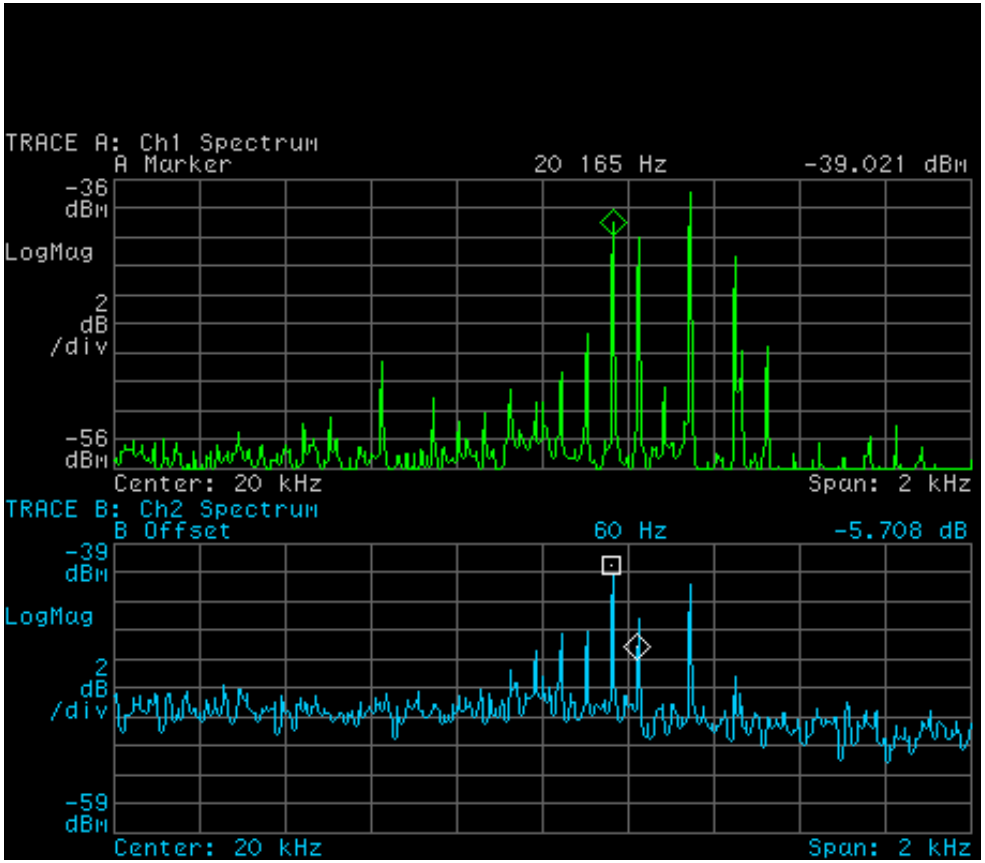
Some 60Hz characteristics

- It breathes.
- It is not in the BBQ frontend electronics power supply.
- There are other lines which are much stronger than 60Hz in the beam.

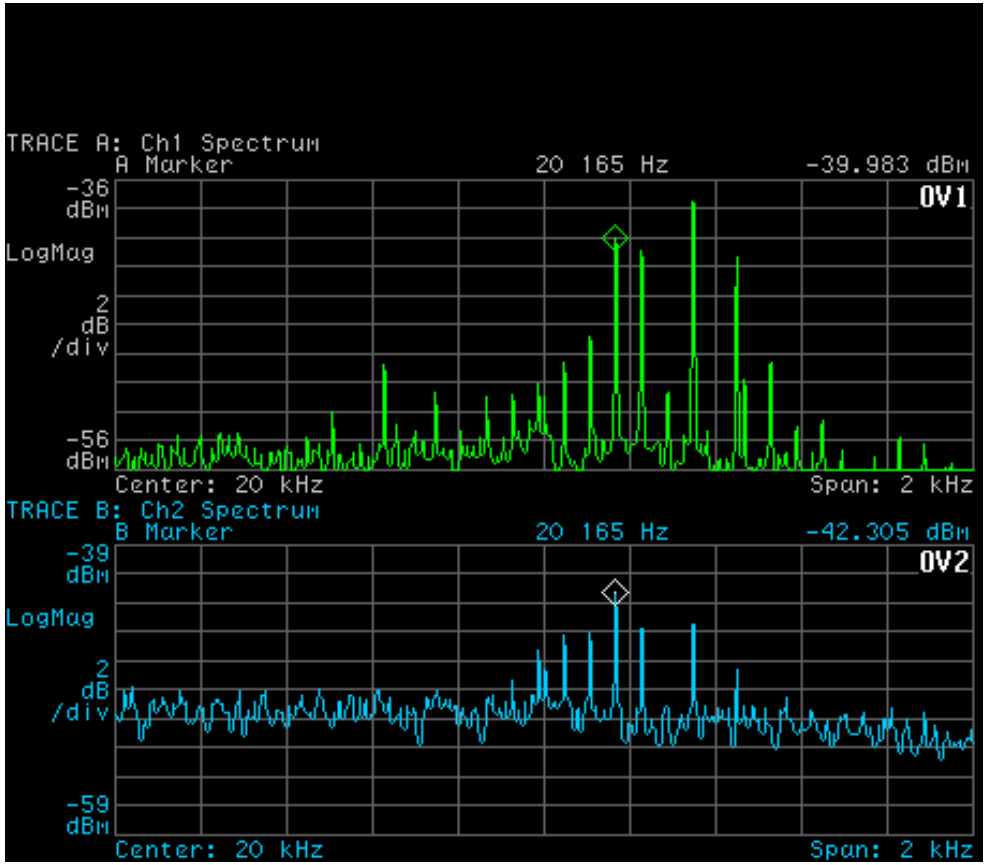
Breathing 60Hz



Checking that 60Hz is not from the BBQ Frontend



Mains supply

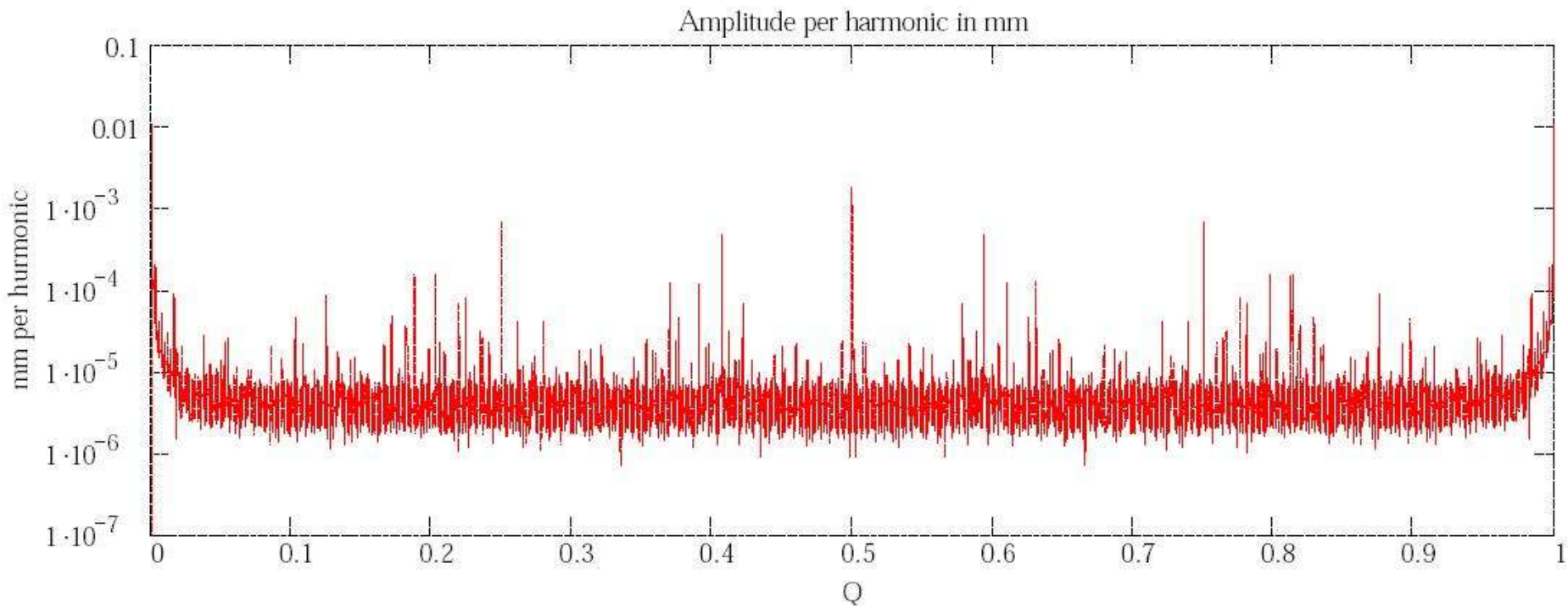


Batteries supply

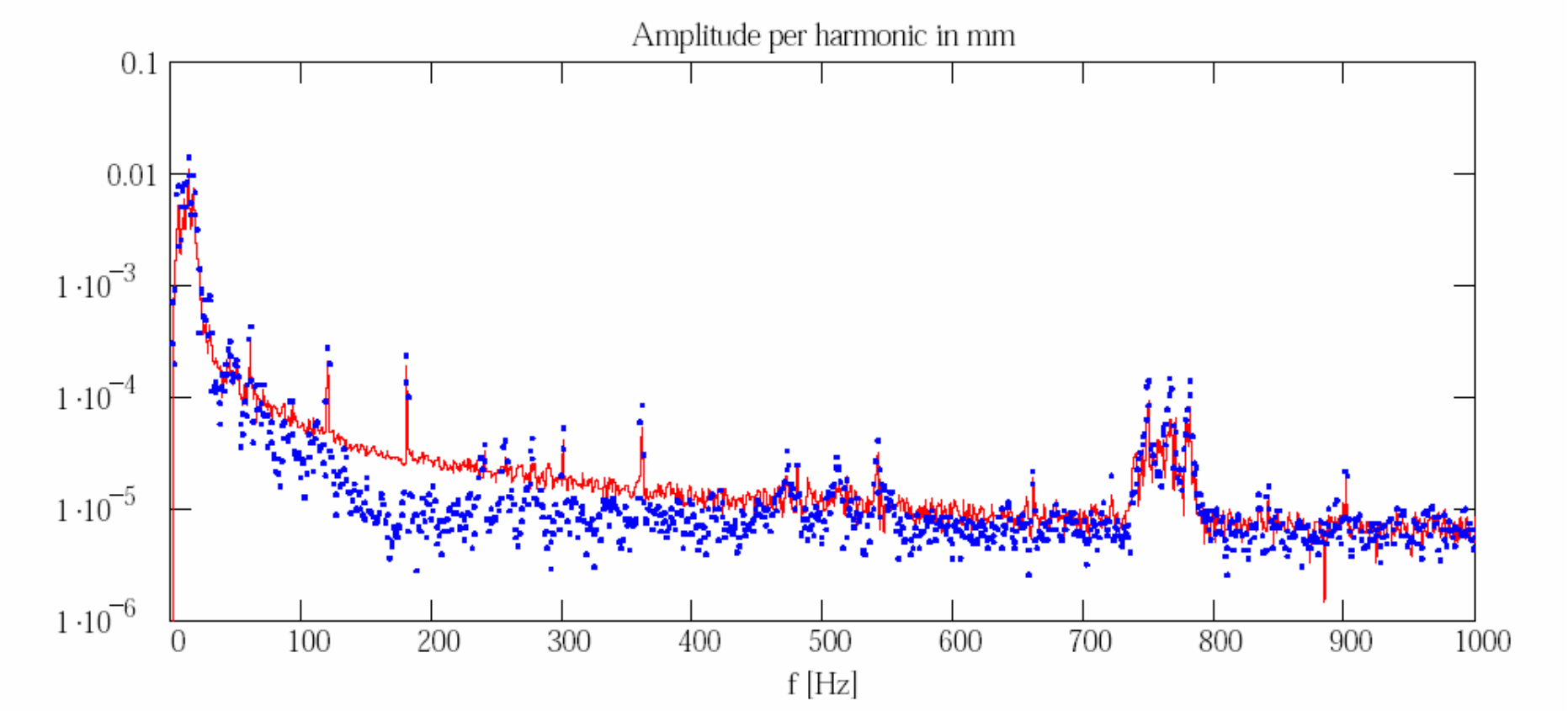
Measuring Beam Motion Spectrum

- Experiment performed by V. Lebedev, V. Scarpine and V. Ranjbar.
- BPM signal directly sampled using a digital storage scope.
  - 48192 points
  - Sampling frequency is revolution frequency: 47.712kHz
  - About 1 second worth of data. Resolution is approx 1 Hz.

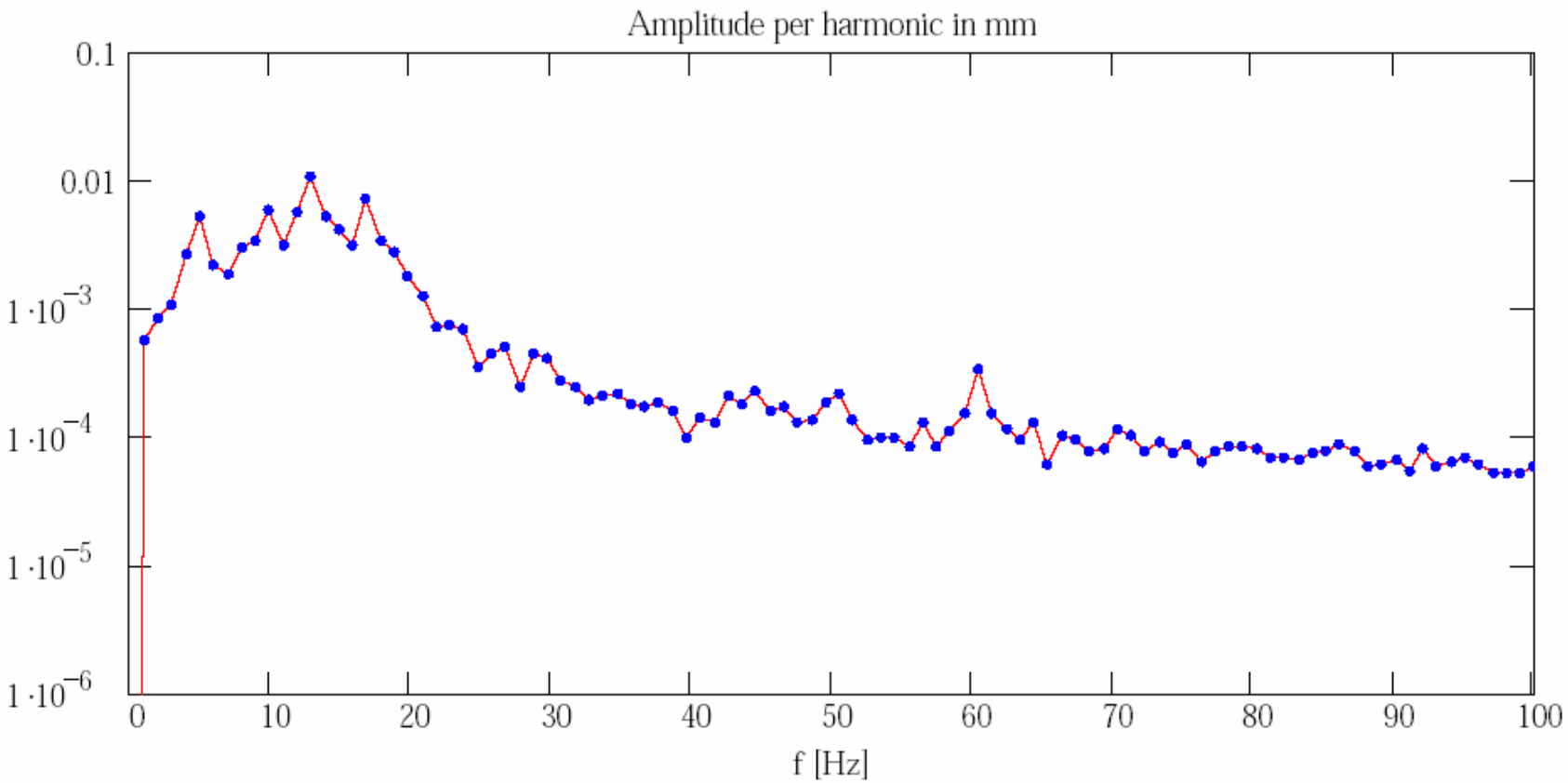
Full Spectrum



Position Spectrum (V. Lebedev, V. Scarpine, V. Ranjbar)

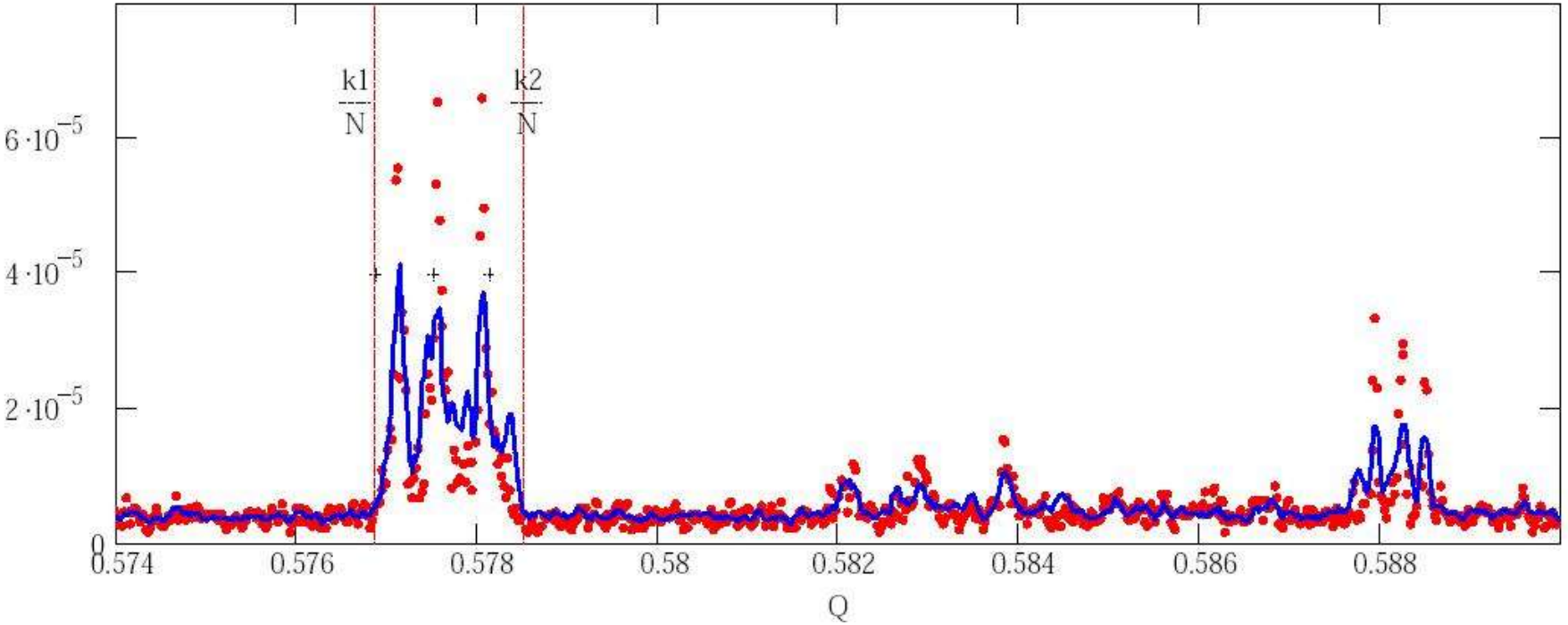


Position Spectrum (V. Lebedev, V. Scarpine, V. Ranjbar)

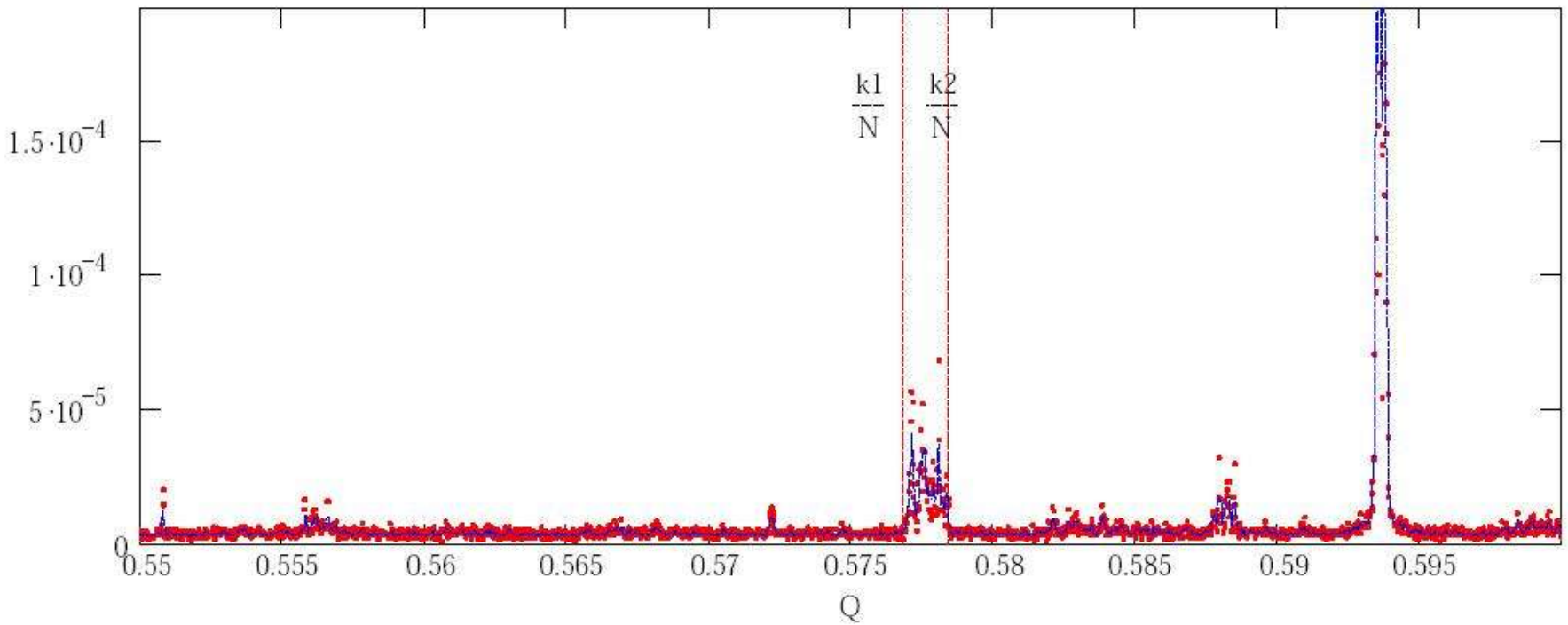


60 Hz amplitude ~1um

Tune?


k1
N
k2
N
6·10^−5
4·10^−5
2·10^−5
0
0.574
0.576
0.578
0.58
0.582
0.584
0.586
0.588
Q

Zoomed out


k1/N
k2/N
1.5·10^-4
1·10^-4
5·10^-5
0
0.55
0.555
0.56
0.565
0.57
0.575
0.58
0.585
0.59
0.595
Q

Conclusion

- BBQ does measure tune
- 60Hz is troublesome and must be understood.