TUNE AND CHROMATICITY MEASUREMENT AT COSY

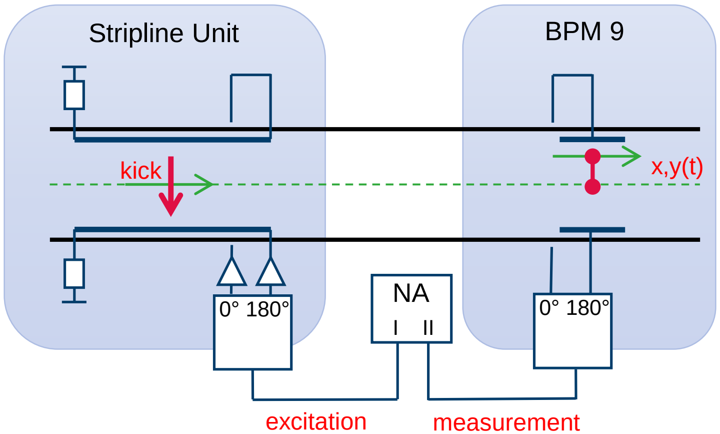
JUNE 24TH, 2020 I BERND BREITKREUTZ AND PHILIPP NIEDERMAYER

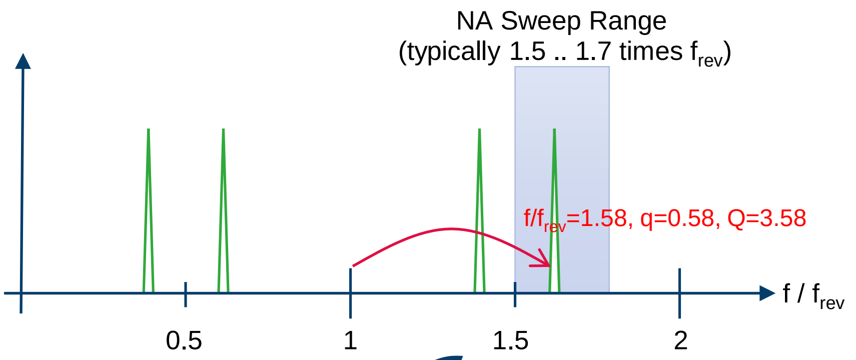
OUTLINE

- tuneSweep
- fastTune
- fastTune - Continuous tune measurement
- fastTune - Chromaticity

TUNE SWEEP SYSTEM

- New name for the well established tune measurement system at COSY
- Coasting beam (allows for higher BPM gain)
- Setup: Network analyzer excites betatron oscillations via stripline electrodes, measures beam feedback via BPM
- Typical tune: Q=3.5 .. 3.7 in both x and y
- Measure |s21| from 1.5 to 1.7 times revolution frequency
- Peaks are at $(1+q)f_{rev}$ -> Q=3+q





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TUNE SWEEP HARDWARE

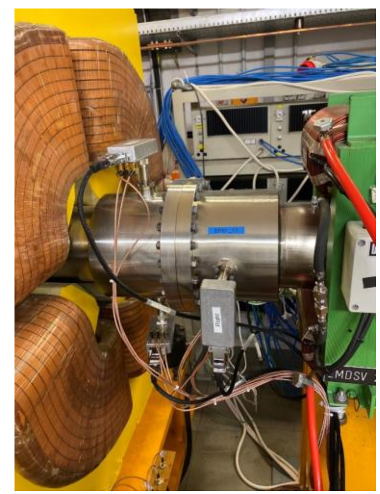
Network Analyzer: HP4396A

Excitation: “Stripline Unit”

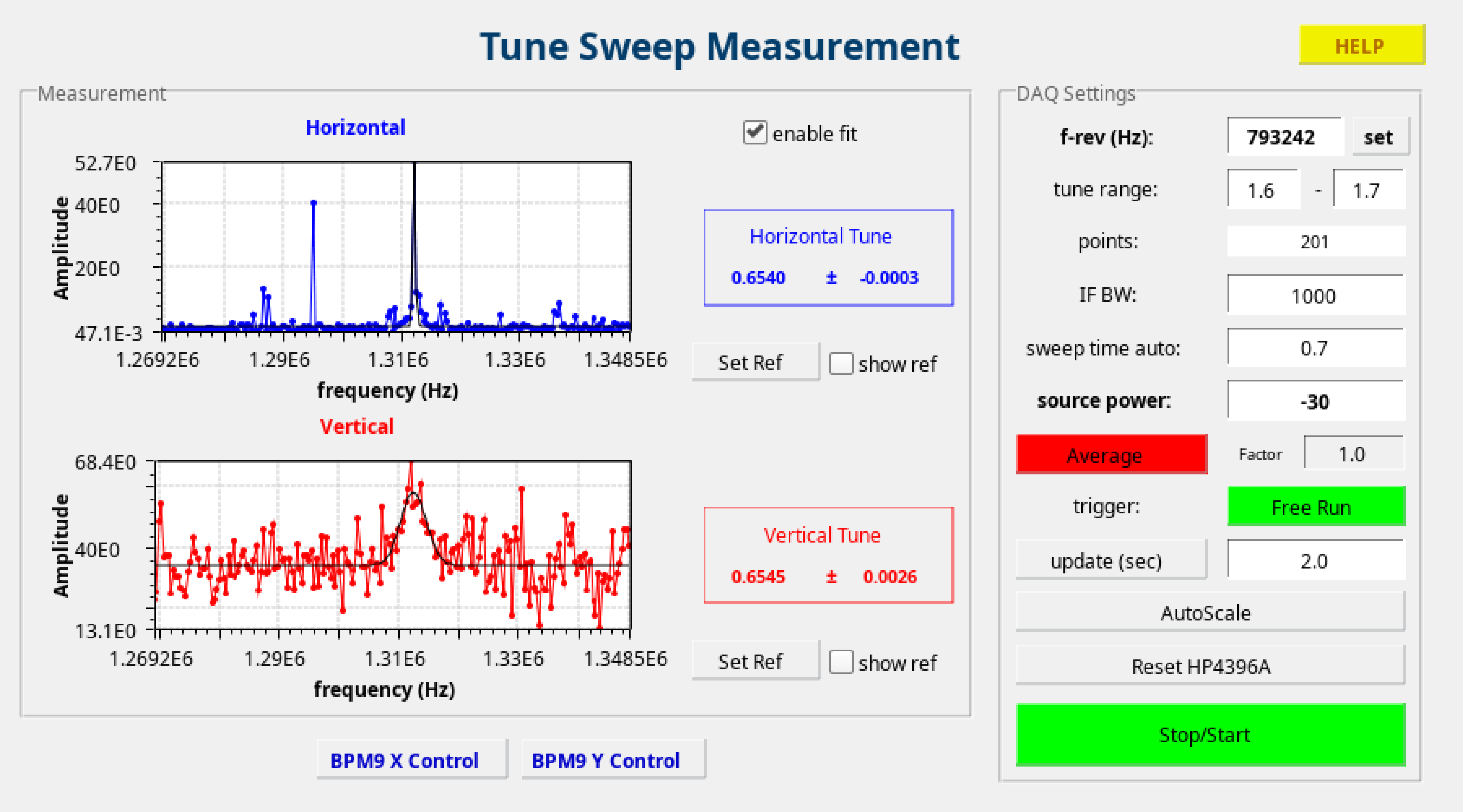
Control, Power Amplifiers

Electrodes (inside magnet)

Measurement: BPM 9



TUNE SWEEP GUI



https://gitlab.cce.kfa-juelich.de/BCC/Tune/tuneSweep/HP-GUI

NEW BPM READOUT: THE LIBERA HADRON

- ADCs
  - 250MHz sampling frequency
  - 16bit
- Built-in EPICS IOC

From: https://www.i-tech.si/products/libera-hadron/

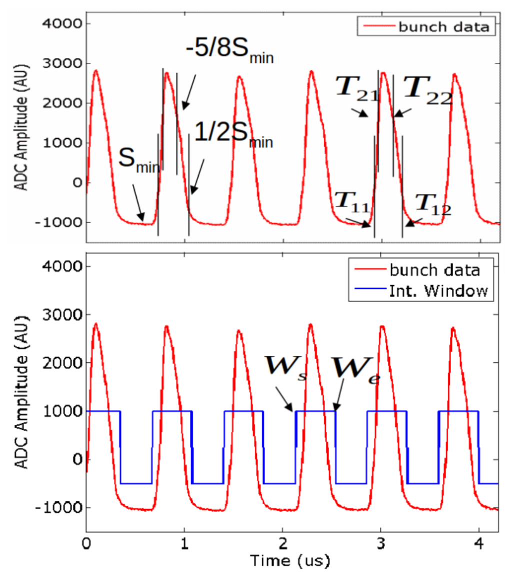
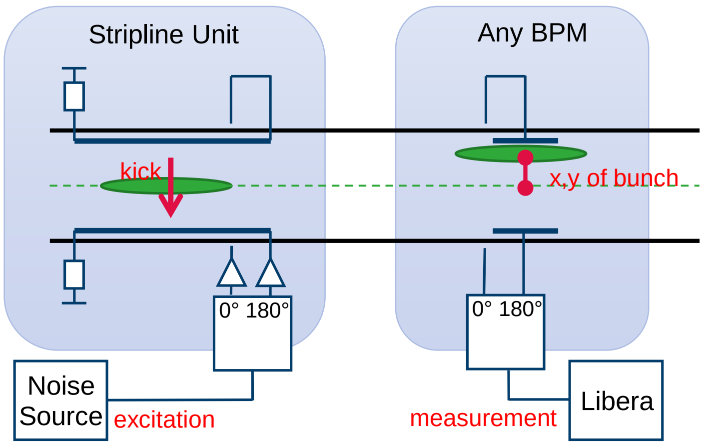


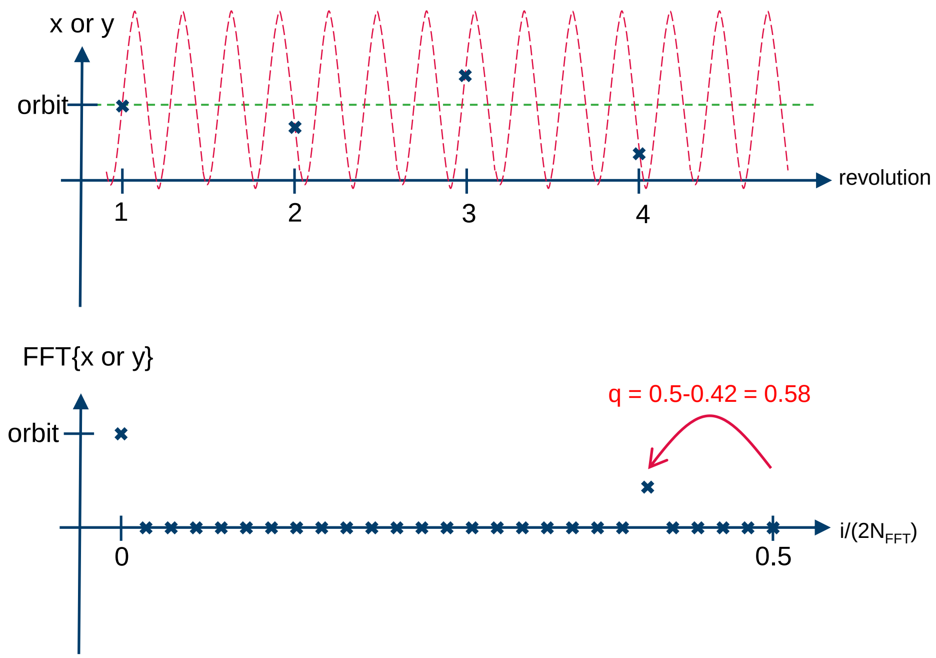
Figure 3: Bunch detection

From: Libera Hadron User Manual

- Bunch detection
  - one (x,y) per revolution ("Bunch-by-Bunch"-data")
  - Slow BbB-data (10Hz, averaged) for Orbit measurement
  - All BbB-data since last trigger are written to 2GB memory (roughly 67M values, or 90 seconds at 750kHz)

FAST TUNE SYSTEM

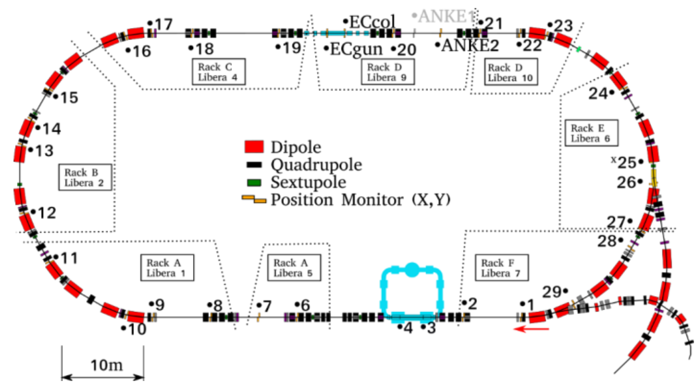


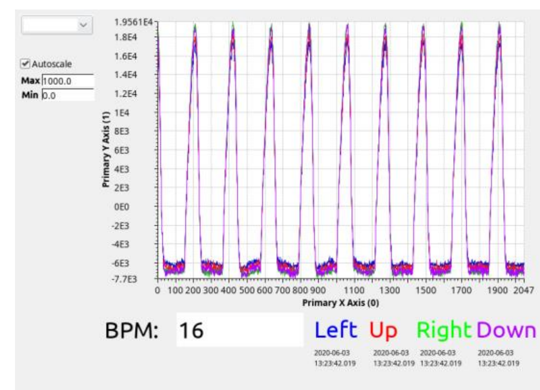


FAST TUNE HARDWARE

Excitation:
AFG3021C
Function Generator

Measurement:
All BPMs, Liberas





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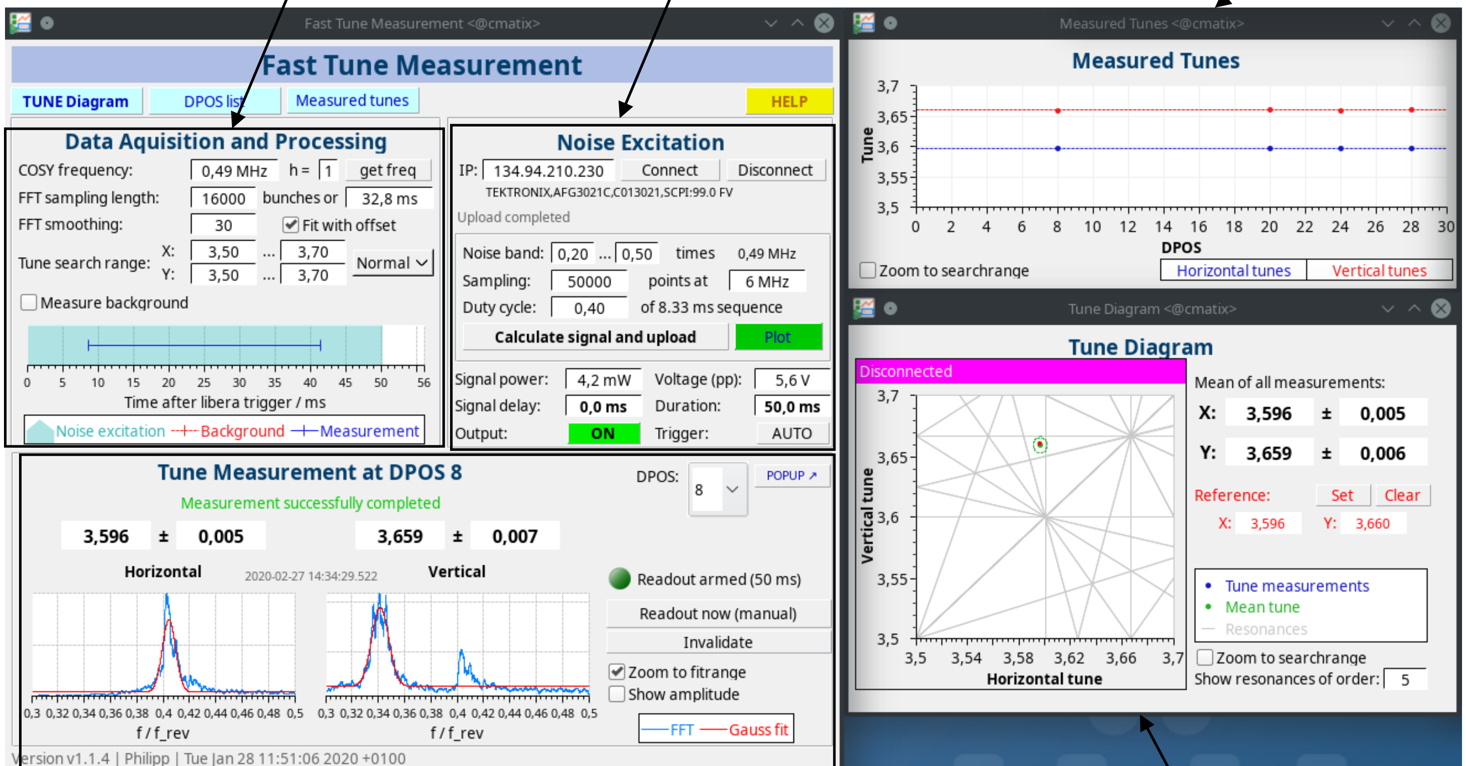
FAST TUNE GUI

Setup measurement

Setup excitation

Fit results of all BPMs

(Identify suited BPMs, deactivate others)



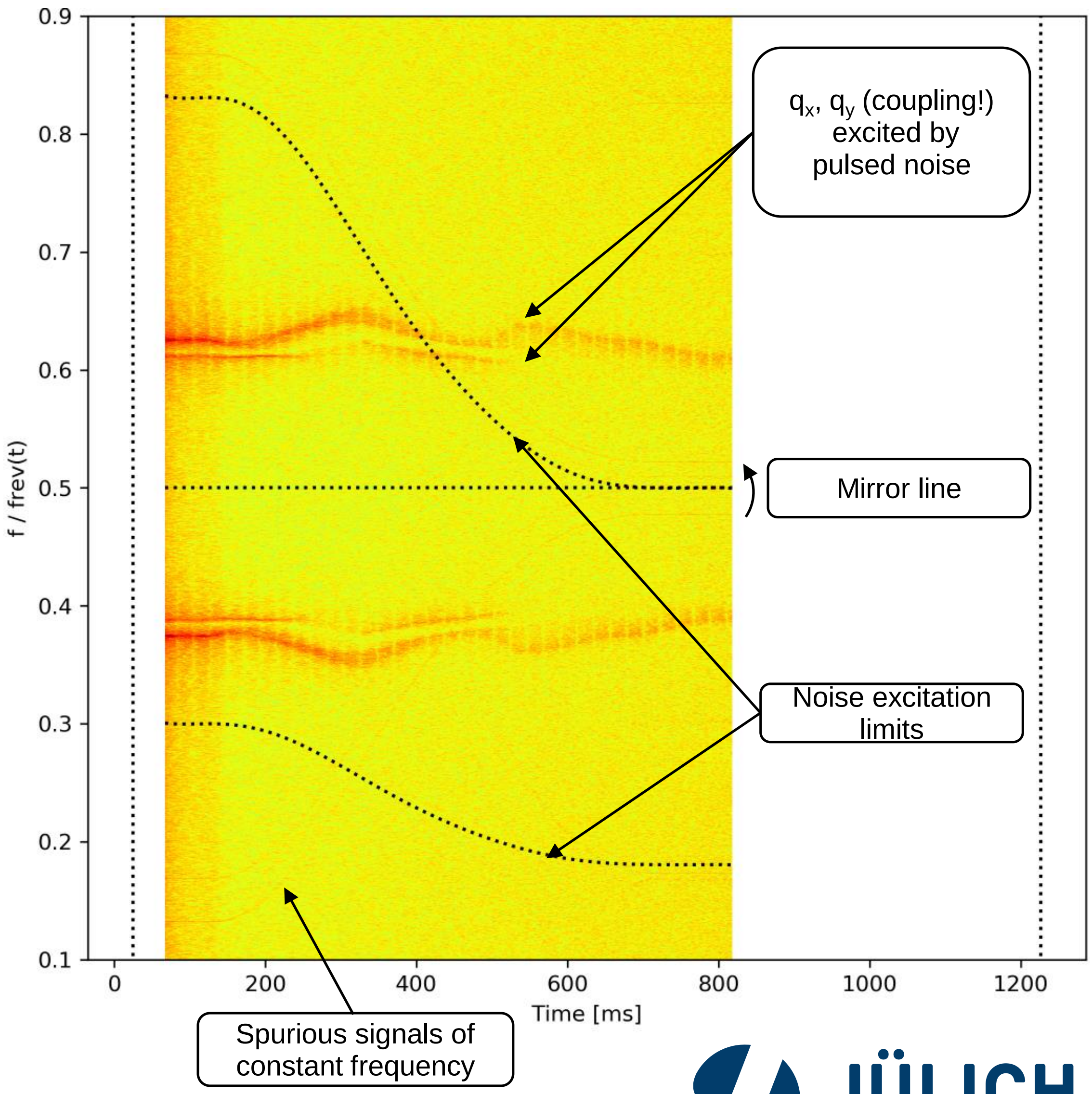
Results of one BPM (here DPOS 8)

Tune diagram of all active BPMs and their mean values

https://gitlab.cce.kfa-juelich.de/BCC/Tune/fastTune/fasttune-gui

CONTINUOUS TUNE MEASUREMENT

- Track tune during acceleration
- Straight forward with fastTune, since no need to log a PLL on or to normalize by $f_{rev}(t)$
- Challenges:
  - Rigidity increases
  - Revolution frequency changes, sidebands may leave noise band limits
  - Many data, longer readout times



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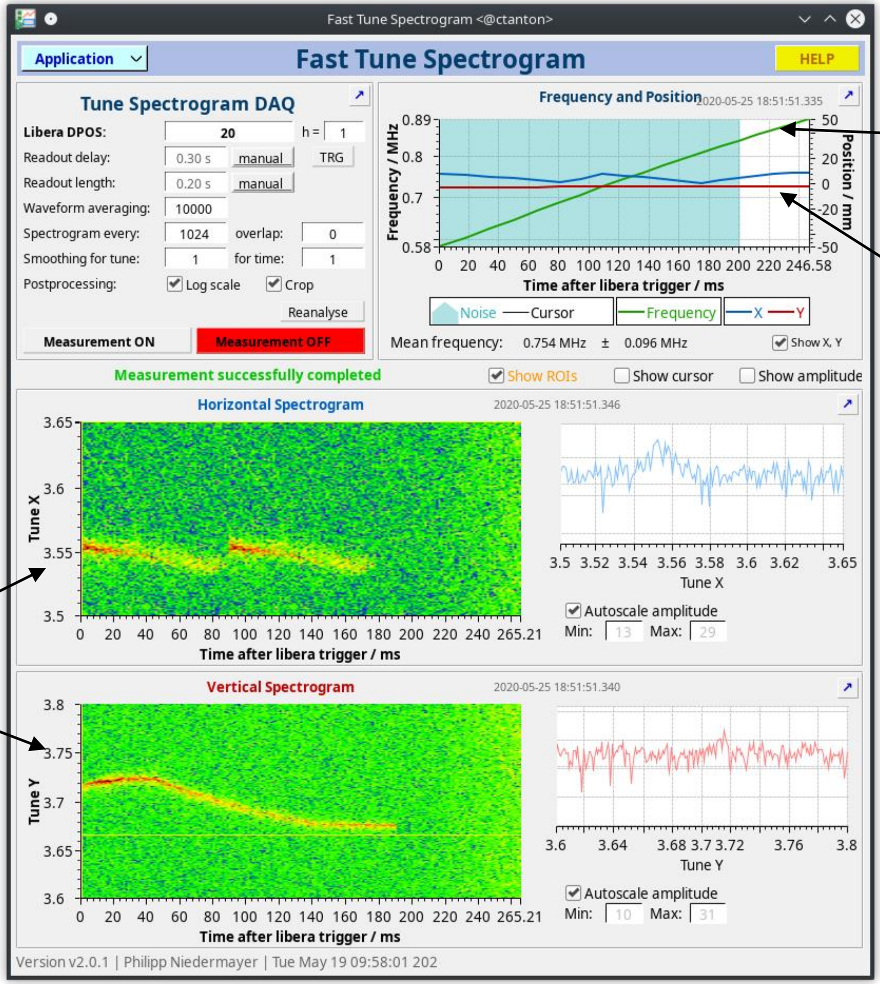
FAST TUNE SPECTROGRAM GUI



Instantaneous Frequency, as derived from BbB-timestamps

Orbit during tune measurement

Tune spectograms

CHROMATICITY WITH FAST TUNE

Idea

- Use fastTune for automated chromaticity measurements
- This should allow for multiple chromaticity measurements in longer cycles

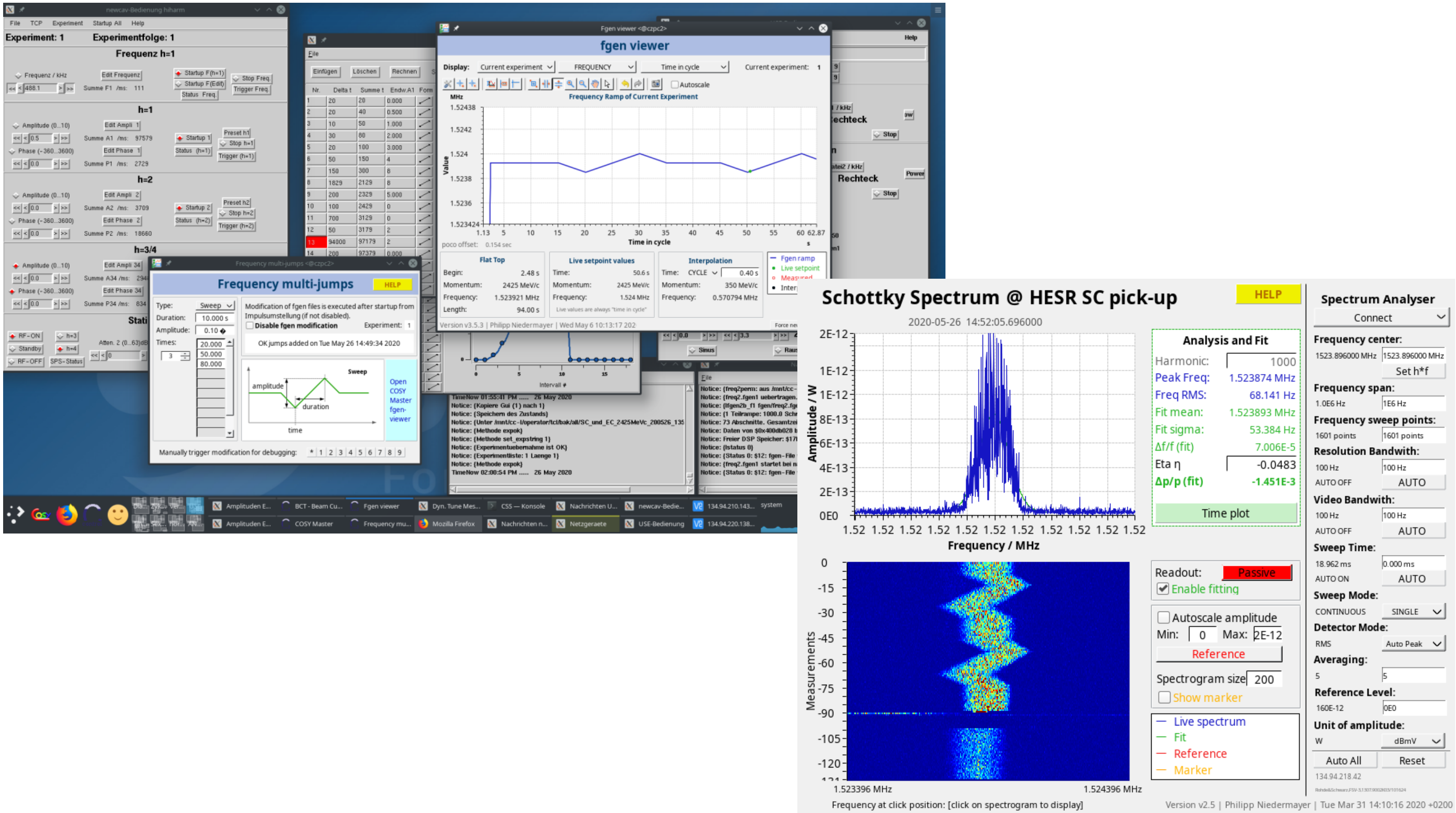
Method

- Measure tune during frequency sweeps
- Calculate tune change with respect to frequency change
- Result: Chromaticity, divided by frequency slip factor

Status

- New frequency sweep method implemented
- Analysis software written and tested (to some extend)
- No successful (reproducible) chromaticity measurement yet
- Tests under JEDI conditions (970MeV/c deuterons, cooled beam, OC) planned for engineering run in calendar week 33 (from Monday, 2020/08/10)

FREQUENCY MULTI-JUMPS



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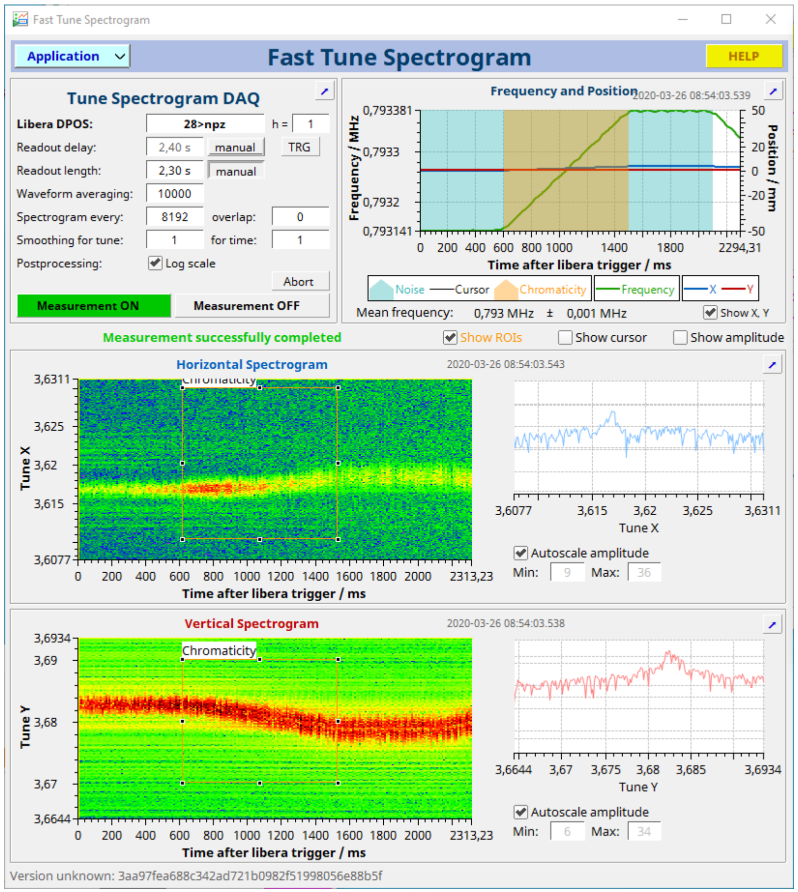
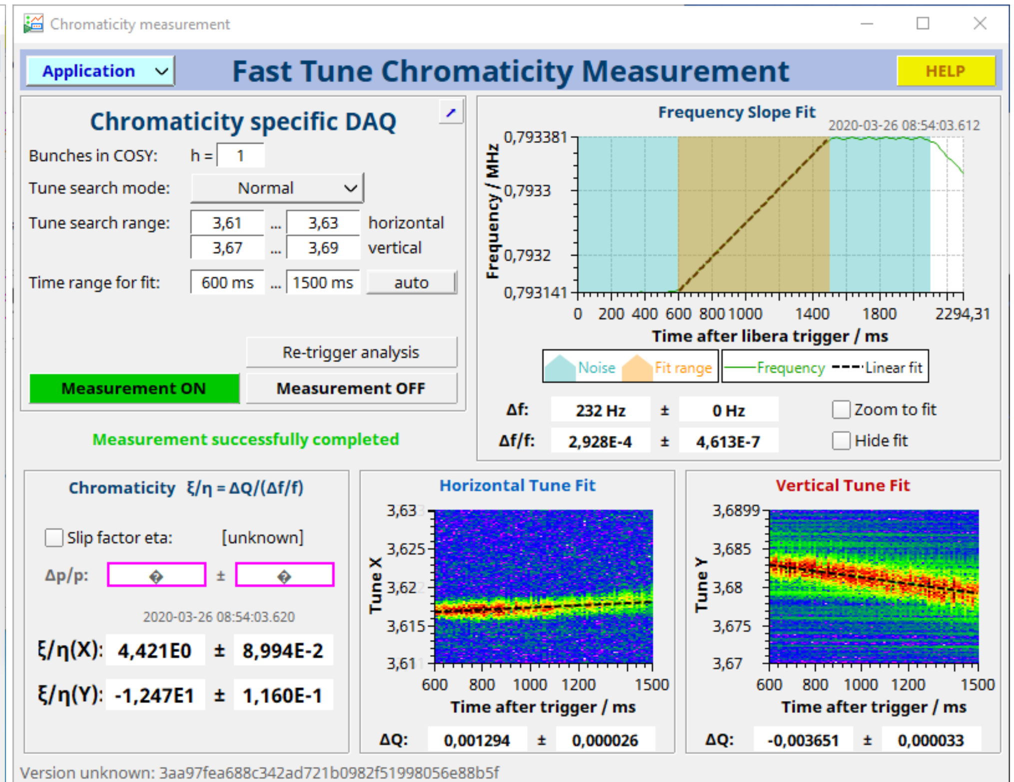
FAST TUNE CHROMATICITY MEASUREMENT GUI





COMPARISON

Tune Sweep

- Well established system
- Tune of unbunched beam (higher BPM gain)
- High spectral power density, thus good signals at high energies / uncooled beam
- Slower system
- Measurement at one single BPM. Spurious signal distinction sometimes hard

Fast Tune

- Tune of bunched beams
- No need to measure revolution frequency
- Allows for fast, multiple and continuous measurements (thus tune in ramps, chromaticity)
- Spectral power density smeared over broader band, thus less suited for uncooled beams at higher energies
- Simultaneous measurement at all available BPMs increases confidence in results