



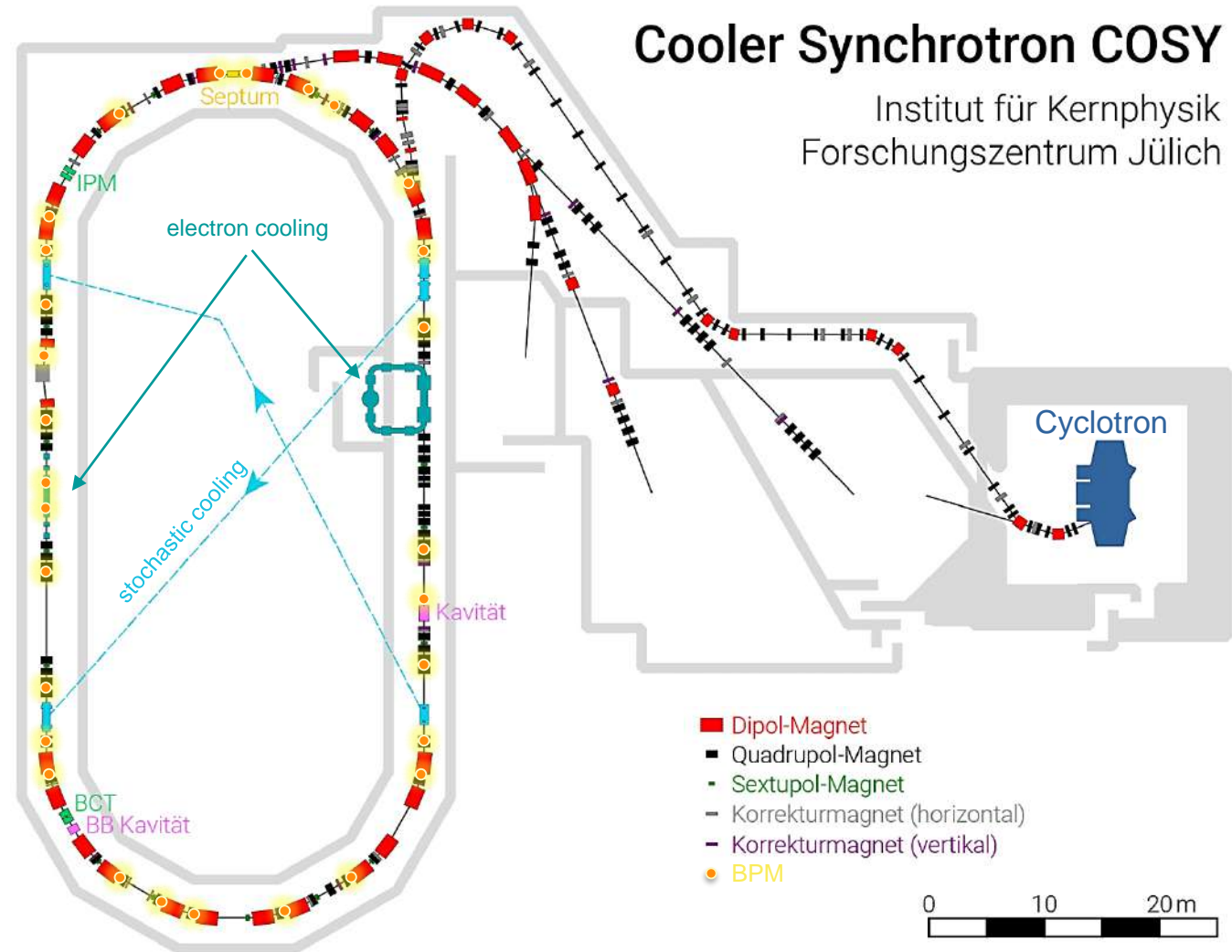
LIBERA HADRON APPLICATIONS AND OPERATIONAL EXPERIENCE AT COSY

10.6.2021 | LIBERA WORKSHOP 2021

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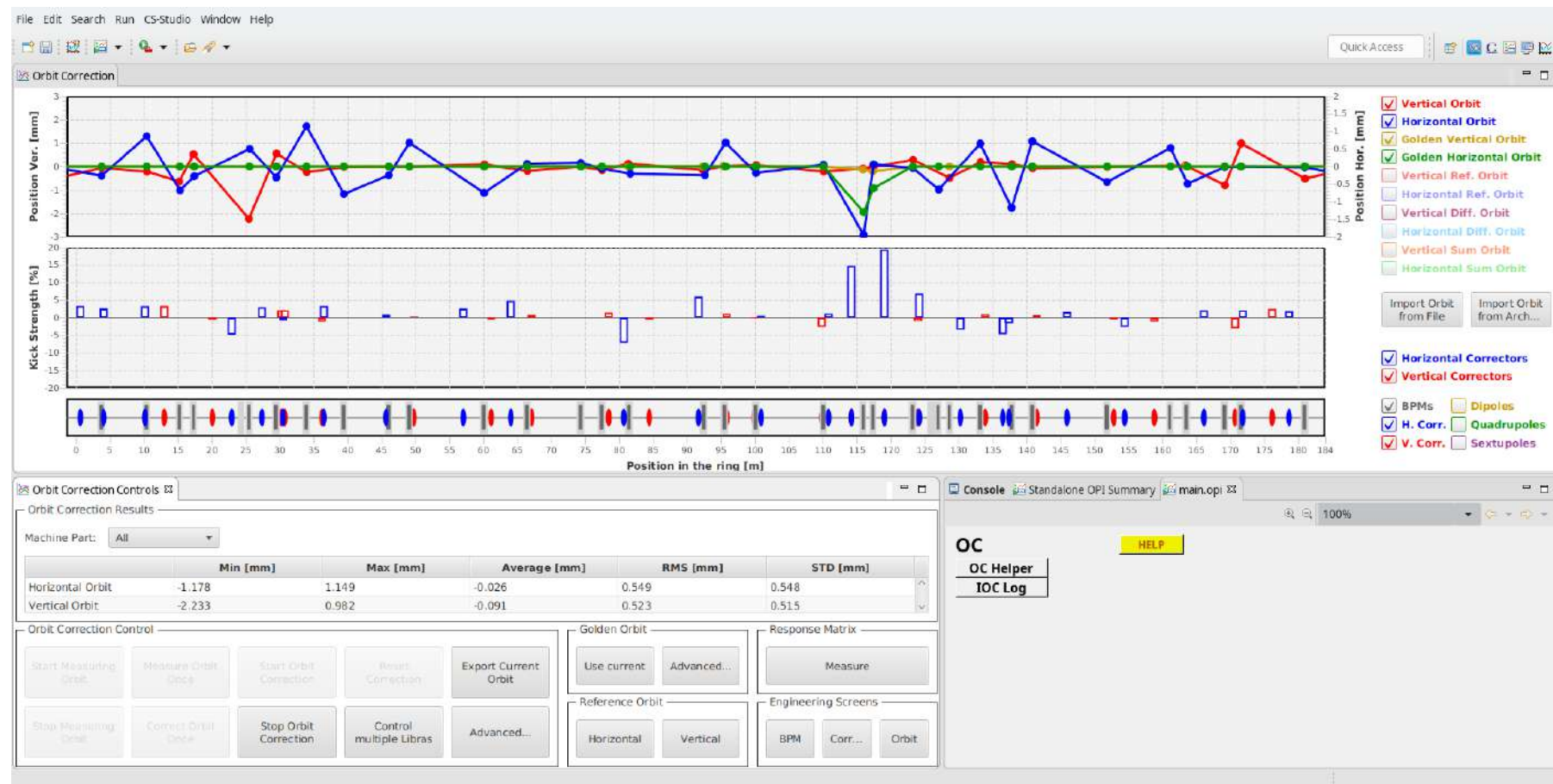
COOLER SYNCHROTRON COSY

- Cosy 184 m circumference
- Internal experiments and 3+2 external beam-lines
- Polarised and unpolarised protons and deuterons
- Momentum: 0.3 – 3.7 GeV/c
- 29 BPMs -> 8 Libera Hadron
- Cooling: 2 electron cooler, stochastic cooling
- Cyclotron initial operation 1967
- COSY construction start 1988, initial operation 1992



REGULAR OPERATION - ORBIT CORRECTION

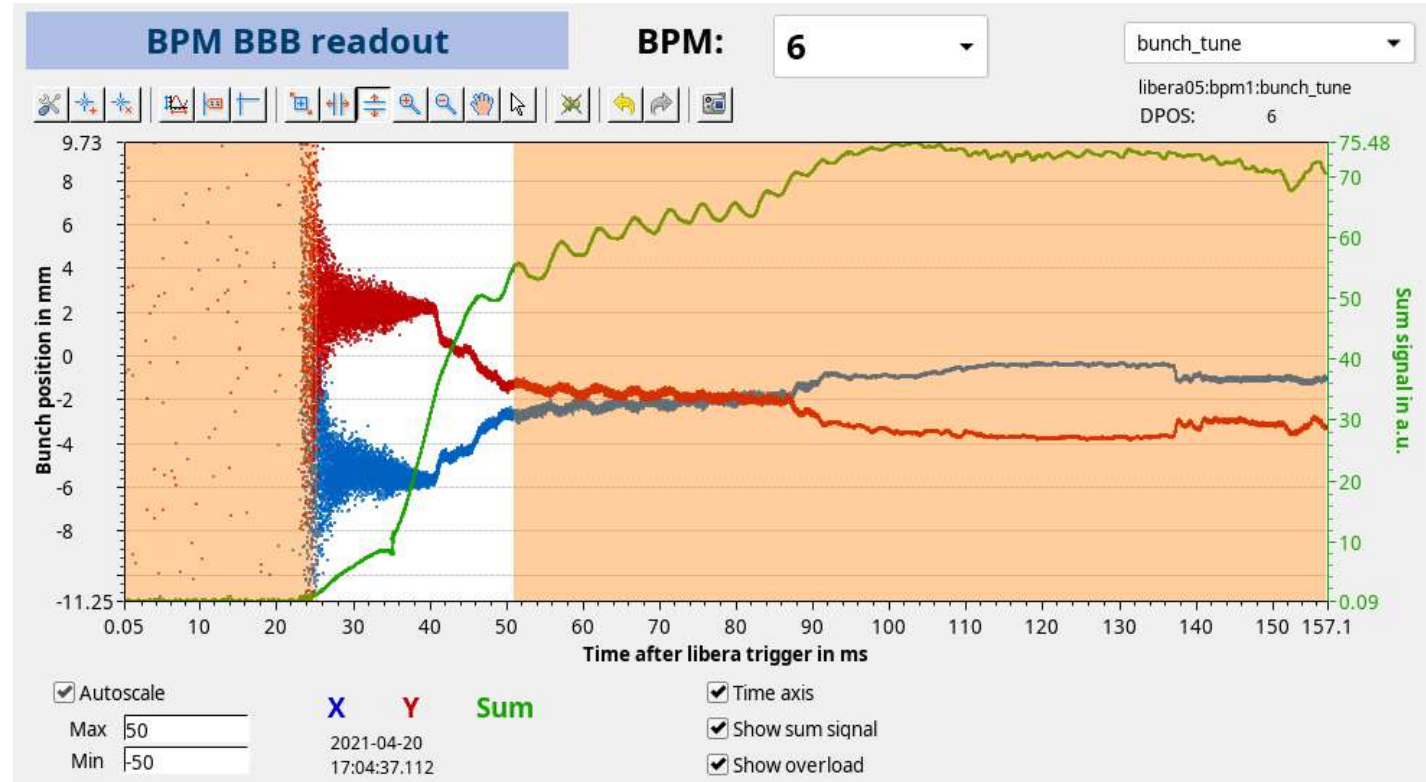
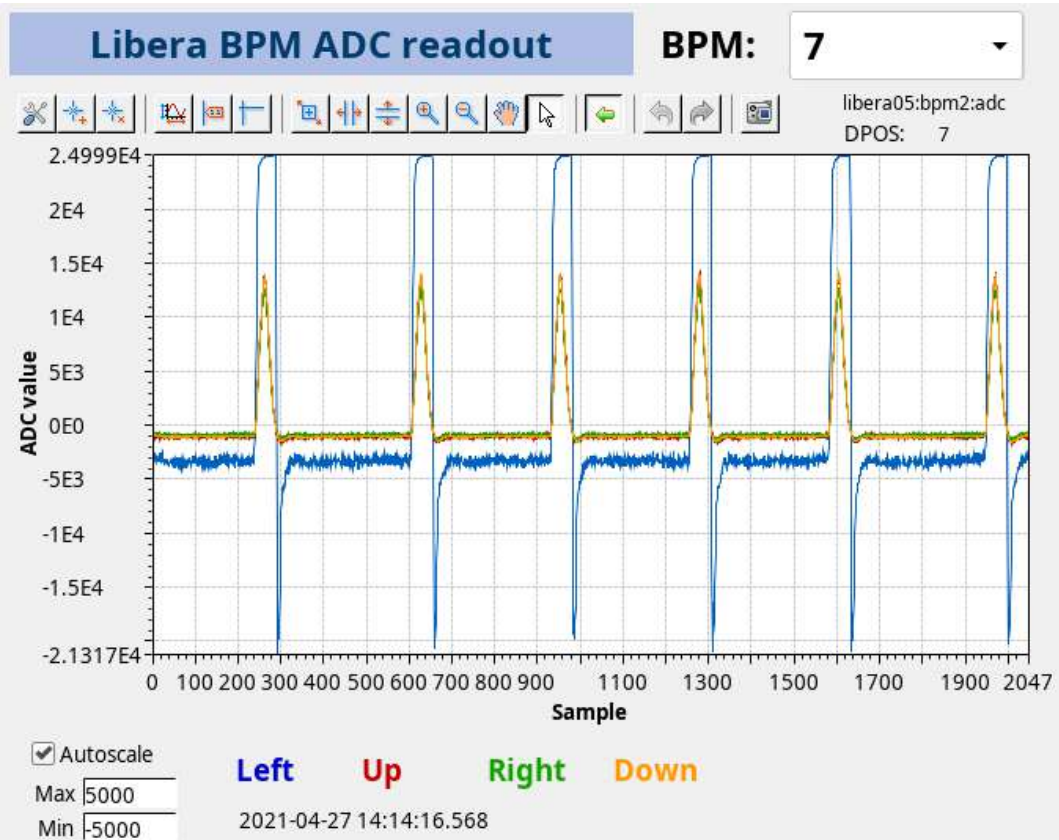
- Mostly using 10 Hz .sa-data
- Iteration time 1 s
- Magnet controllers legacy from early '90s, therefore slow
- Iterative process, magnet correction set to parts of calculated value
- Convergent in about 45 s.



Picture: K. Grigoryev, J. Hetzel

REGULAR OPERATION

- Using ADC data visualisation to find errors fast. Here, one cable had bad contact



Displaying the bunch position and sum information during injection, bunching and acceleration. Orange background indicating overload or underload status.

LIBERA PROBLEMS

- IOC stability
 - When used heavily we managed to get the IOC unstable quite easy
 - Advanced logging / alarming would help resolve issues faster
 - Failing IOC has impact on other software functions like SSH access or libera-ireg function
- Hardware
 - 10 units running (8 production + 2 test) with 35 ADC cards since 2018
 - One unit had to be send back for repair (firmware issue)
 - One ADC card was replaced, but then working fine in test unit (since mid March '21)
 - New order of Hardware came with new firmware
 - > upgrade of old units seamless

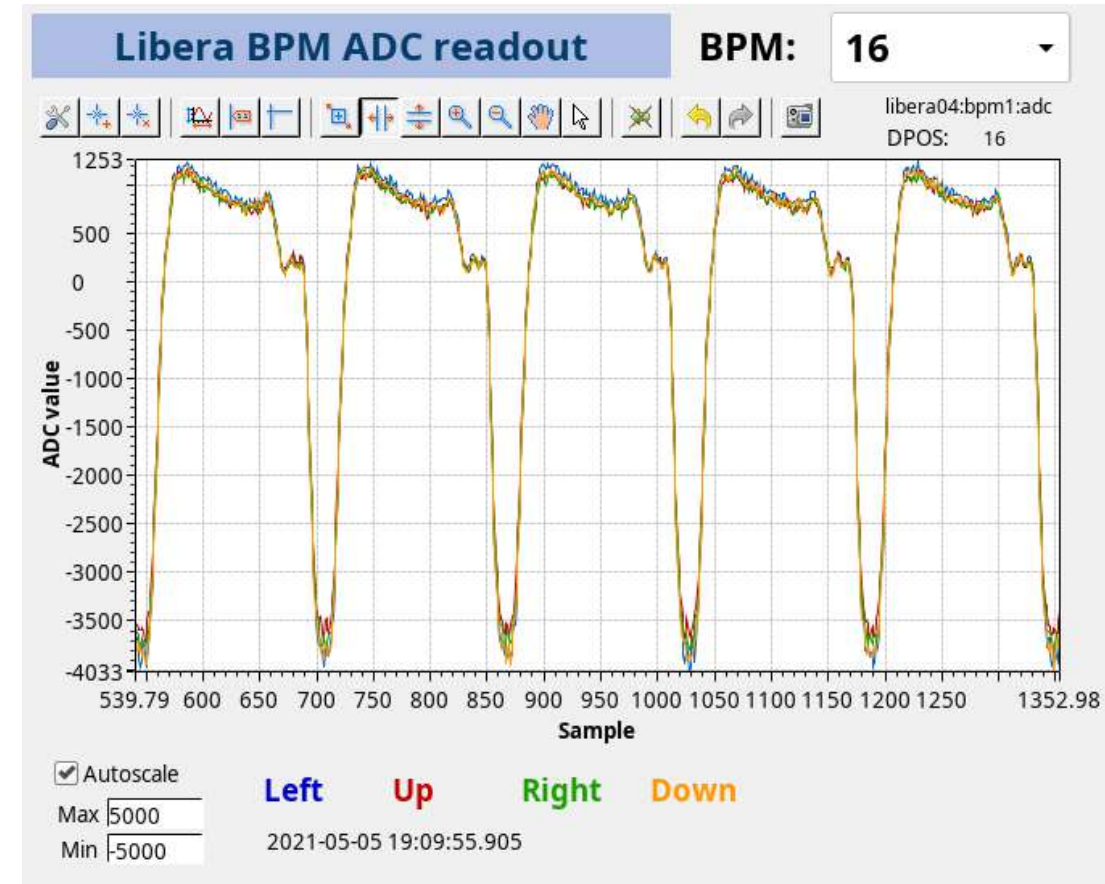
```
dbScan warning from '10 second' scan thread:  
Scan processing averages 62.00 seconds (60.79 .. 63.41).  
Over-runs have now happened 96 times in a row.  
To fix this, move some records to a slower scan rate.
```

```
CA.Client.Exception.....  
Warning: "Virtual circuit disconnect"  
Context: "op=0, channel=libera04:evrx:events:t2:timestamp,  
type=DBR_TIME_STRING, count=1, ctx="libera04.cc.kfa-juelich.de:5064"  
Source File: ../getCopy.cpp line 92  
Current Time: Wed Feb 17 2021 11:28:37.843214410
```



LIBERA PROBLEMS

- Barrier Bucket operation
 - Hard edges of a bunch due to RF settings
- Bunch recognition system is likely to not detect a position
 - BBB algorithm has problems recognising the bunches
 - Has worked in recent beam time, but in previous not reliably
 - NBA algorithm as well
 - Only few tries to get it to work by now



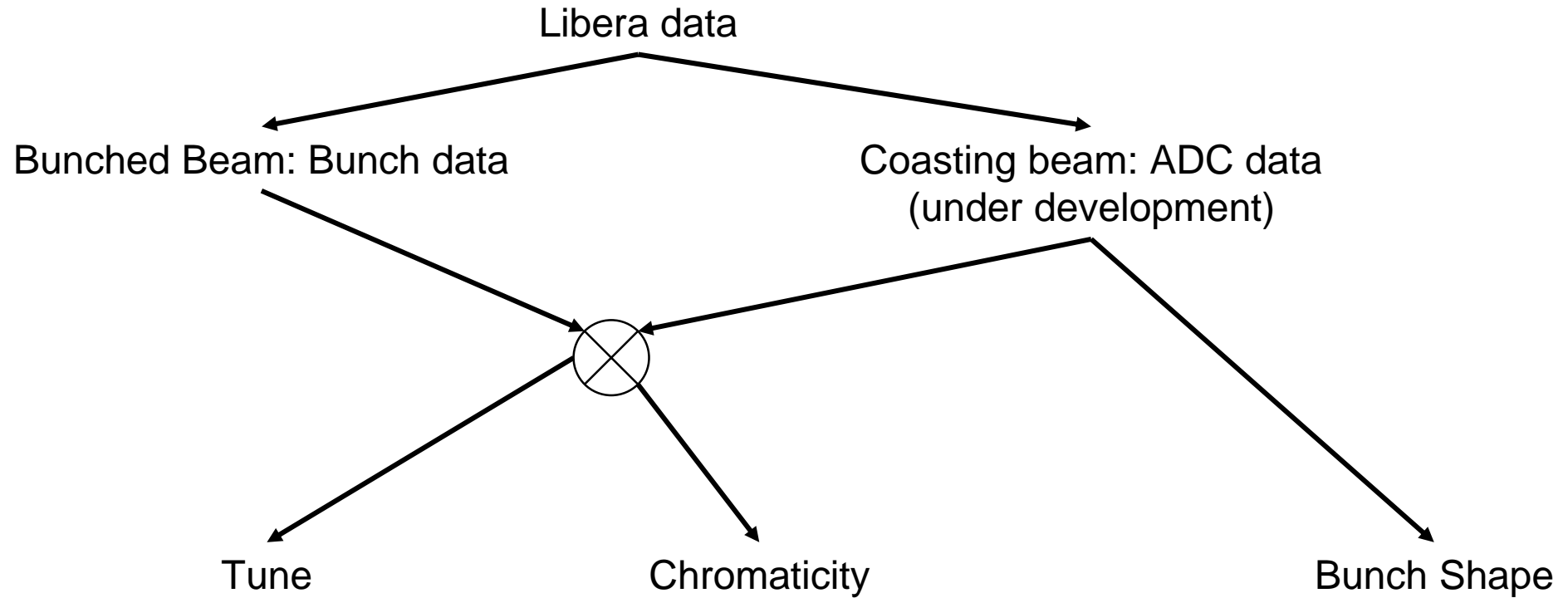
Picture: V. Kamerzhiev

USER APPLICATIONS BASED ON LIBERA DATA

- Not running on Libera hardware but standalone/external
- Done within the master thesis of Philipp Niedermayer:
 - Presented on IPAC 2021: MOPAB319
 - Thesis soon to be available:
 - „Development of a fast betatron tune and chromaticity measurement system using bunch-by-bunch position monitoring“, Philipp Niedermayer, Master thesis in physics at the RWTH Aachen University
- Chromaticity measurements
- Tune measurements
- Bunch Shape Monitor

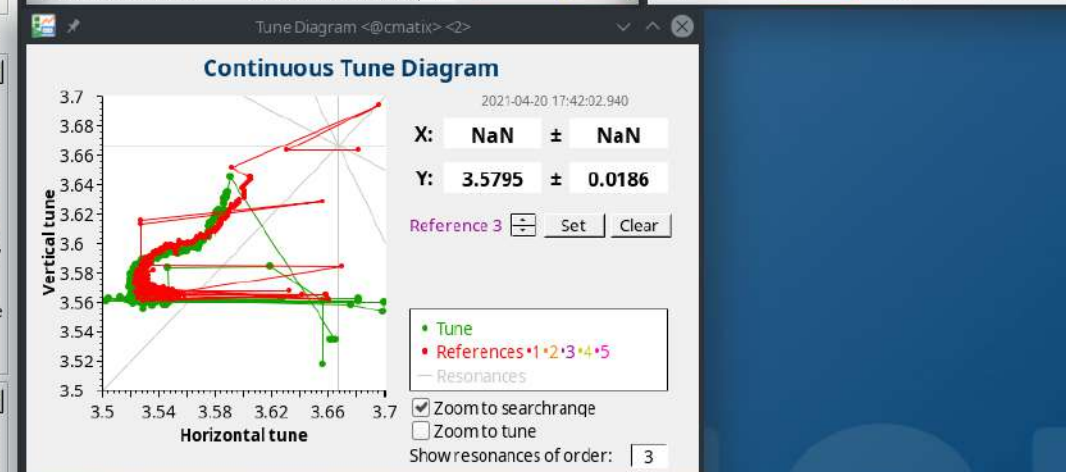
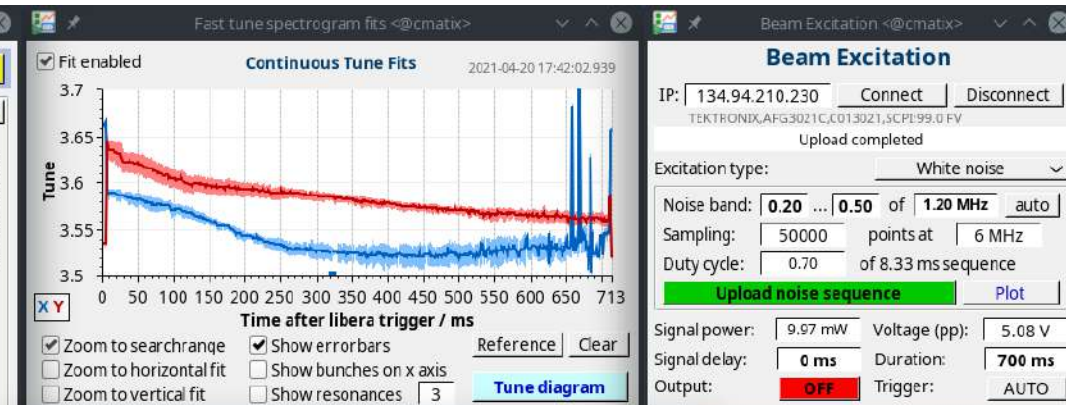
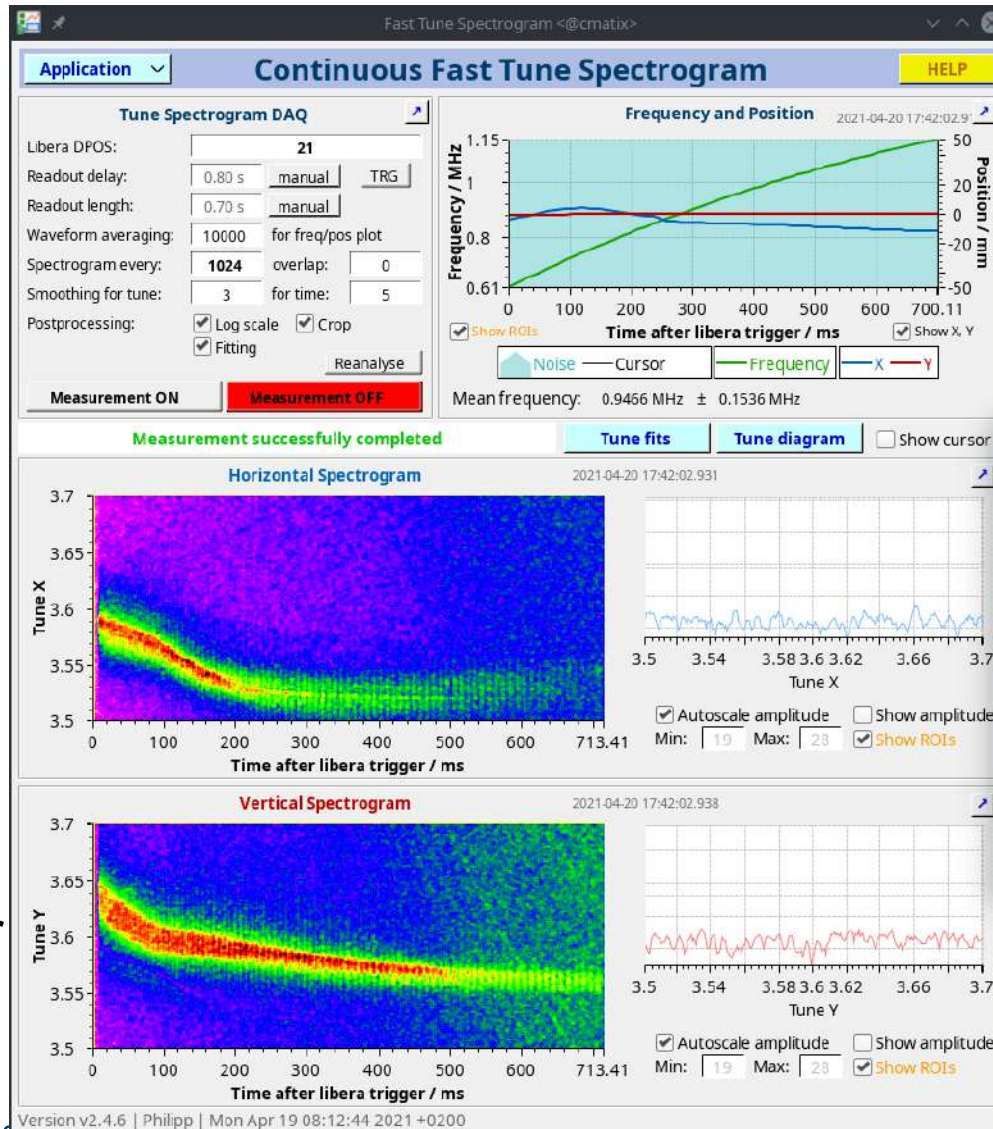
USER APPLICATIONS BASED ON LIBERA DATA

Data structure



FAST TUNE

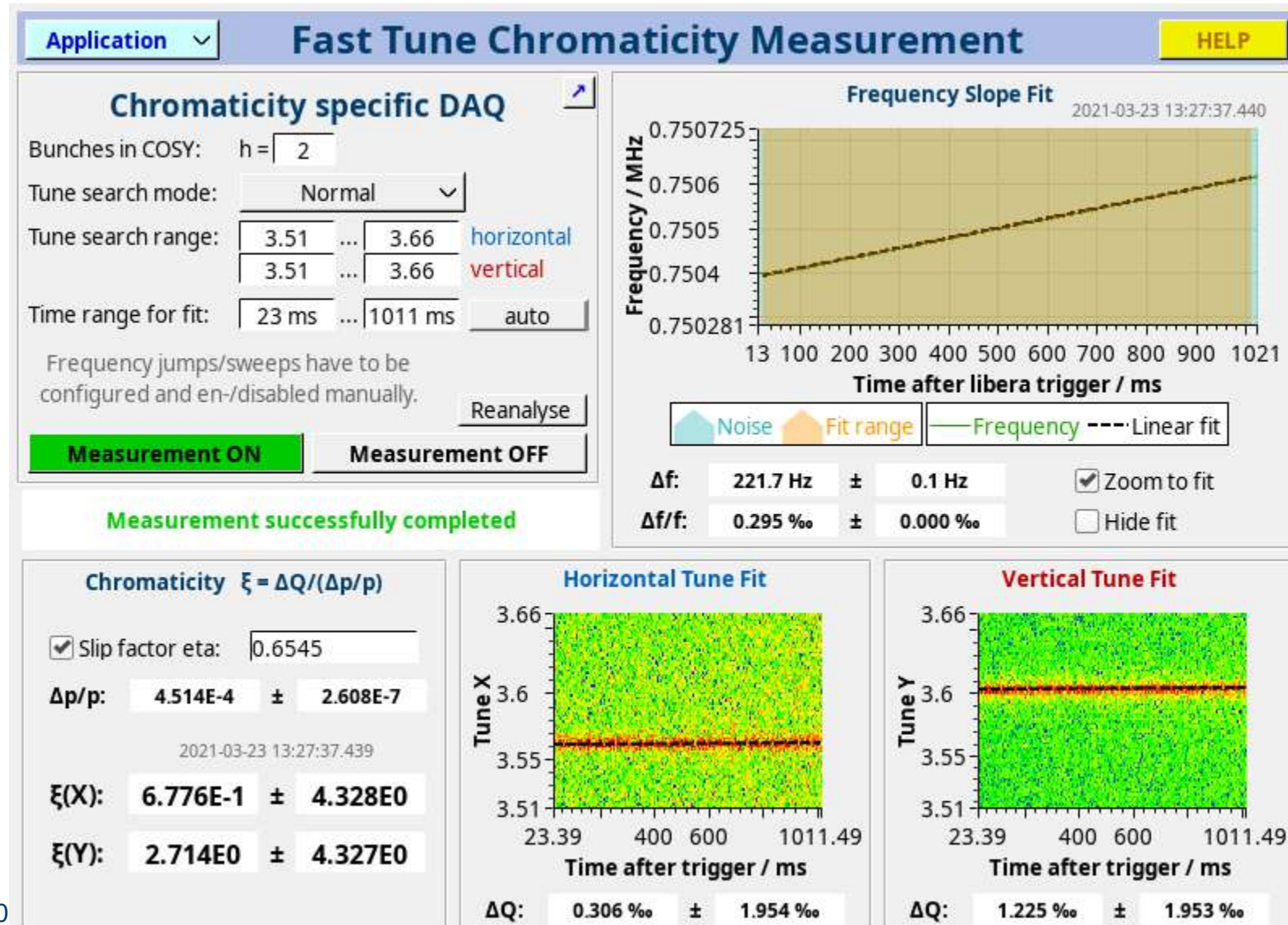
- Operation modes: Single or continuous measurement
- On single measurement, typically 8192 bunches are used for FFT
- Optional background measurement for noise reduction



CHROMATICITY MEASUREMENT

Picture: Y. Valdau

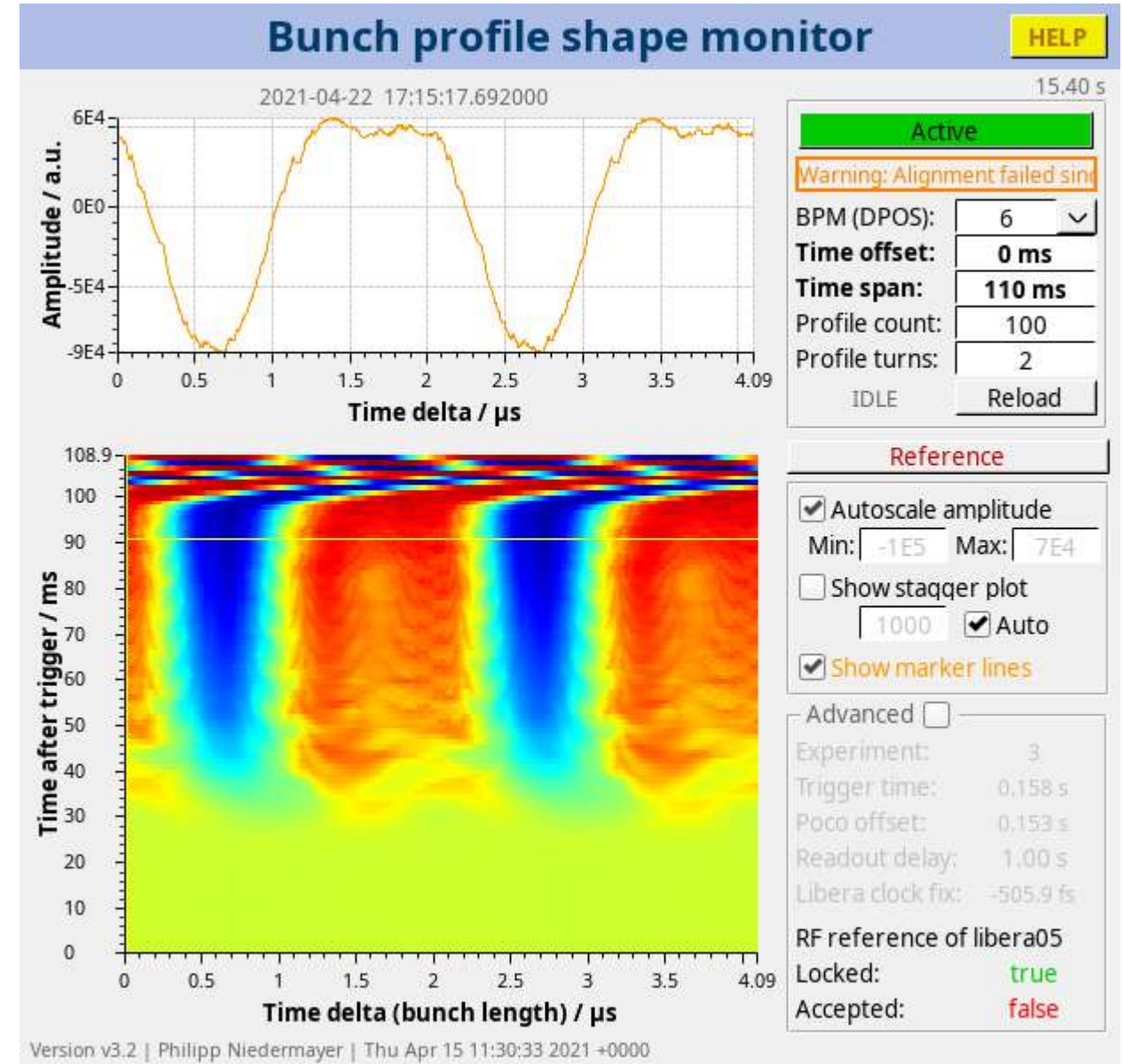
- Chromaticity is measured by measuring the tune change during an induced momentum change
- The revolution frequency is slightly changed while the magnetic field stays constant
- The tune change is observed (with continuous tune measurement method) and the chromaticity calculated



BUNCH SHAPE EVOLUTION

- Tool under development
- Usage of ADC data
- Visualisation of bunch shape over time
- Usable with online data or archived data
- Prospectively data source for Phase Space Tomography

Acceleration ↑
Bunching ↑
Injection (no bunches) ↑

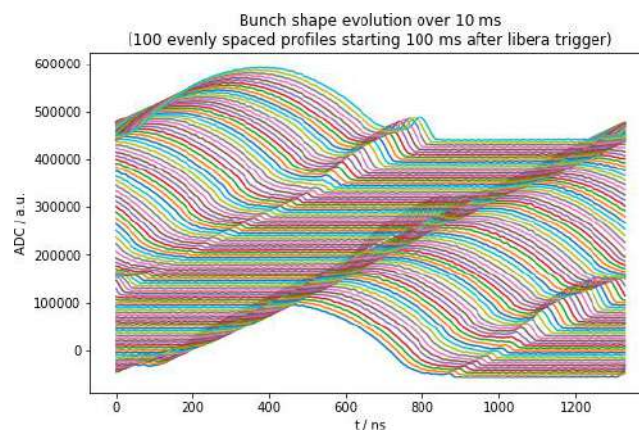


LIBERA PROBLEMS

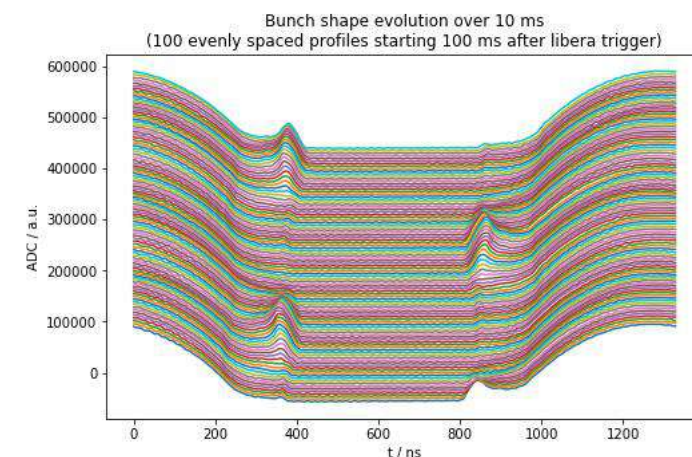
- Download of large chunks of Libera data
 - Using libera-ireg binary mode
 - i-tech tests 20 s for filled ADC buffer
 - Our tests ~4 min for filled ADC buffer
- ADC clock
 - All Liberias are coupled to a central 10 MHz distribution (GPS reference)
 - 250 MHz seems not consistent over all devices

LIBERA	CLOCK
libera01	4 ns - 506.0 fs
libera02	4 ns - 512.5 fs
libera04	4 ns - 507.7 fs
libera05	4 ns - 507.8 fs
libera06	4 ns - 528.5 fs
libera07	4 ns - 510.8 fs
libera09	4 ns - 509.7 fs
libera10	4 ns - 506.3 fs
mean deviation from 4 ns:	
-511 fs \pm 7 fs	

No time correction



With time correction



CONCLUSION

- The Libera offers a wide range of information of beam properties.
 - These can be used for calculating vital machine parameters.
- Downloading a huge amount of data fast with the EPICS version is a problem.
 - For un-bunched beam raw ADC-data has to be processed.
- The EPICS-IOC performance could be better, as failing IOC is the main problem we face.
 - Many parameters are offered as PV, then of cause many want to get these information. Therefore a lot of PVs are active.
 - The failing IOC also influences the overall function (libera-ireg and/or SSH failing).
- What we would like to have improved:
 - New firmware versions available for old units.
 - Documentation could be better in some parts (e.g. FFT usage, polarity of input signal).