Instrumentation Technologies

www.i-tech.si

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Basic functionality, Interlock, Gain Setting Issues

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  - Dataflows
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- Gain Setting

Introduction,1

- **Why Workshop?**
  - **Community gathering, exchange of experience.**
  - **Clarifying principles, discussions.**
  - **Presenting different products in detail.**
  - **Practical hints.**
  - **Fostering community growth and intensity, forum.**

Introduction, 2

- **Workshop Schedule**

Day 1:

- **Libera Brilliance overview, news, Fast Feedback building options.**
- **Libera Bunch by Bunch system.**
- **Introduction of new products.**

Dinner

Day 2:

- **User presentations.**
- **Libera Brilliance 2.0 Release, discussion**

Libera Brilliance Advantages

- **Libera Brilliance is widely used, main reasons:**
  - **Excellent metric performance (RMS, BCD)**
  - **Reconfigurability**
  - **From narrowband to wideband measurements**
  - **Regular software and firmware upgrades**
  - **Advanced timing and synchronization possibilities**
  - **Direct integration into control system**

Introduction to Libera Brilliance Functionality

The data paths:

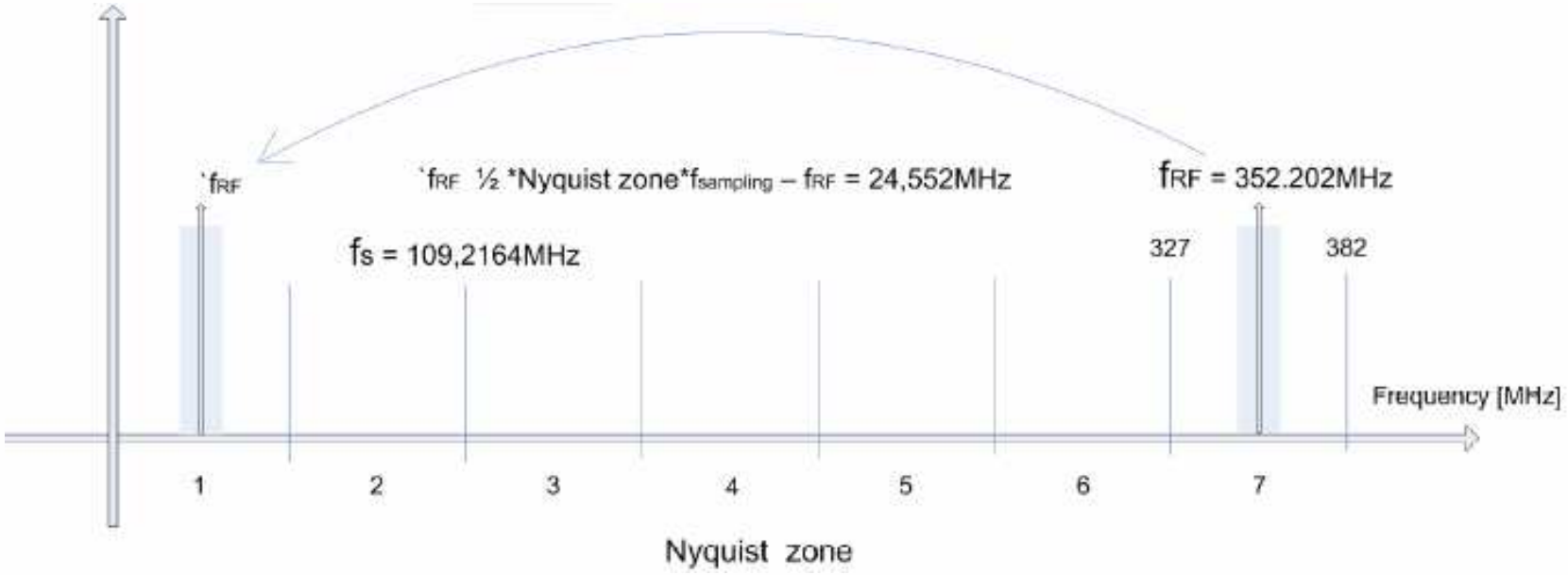
- **ADC data buffer.**
- **Turn by Turn Acquisition.**
- **Decimated Turn by Turn.**
- **Fast Acquisition.**
- **Slow Acquisition.**

Main principles:

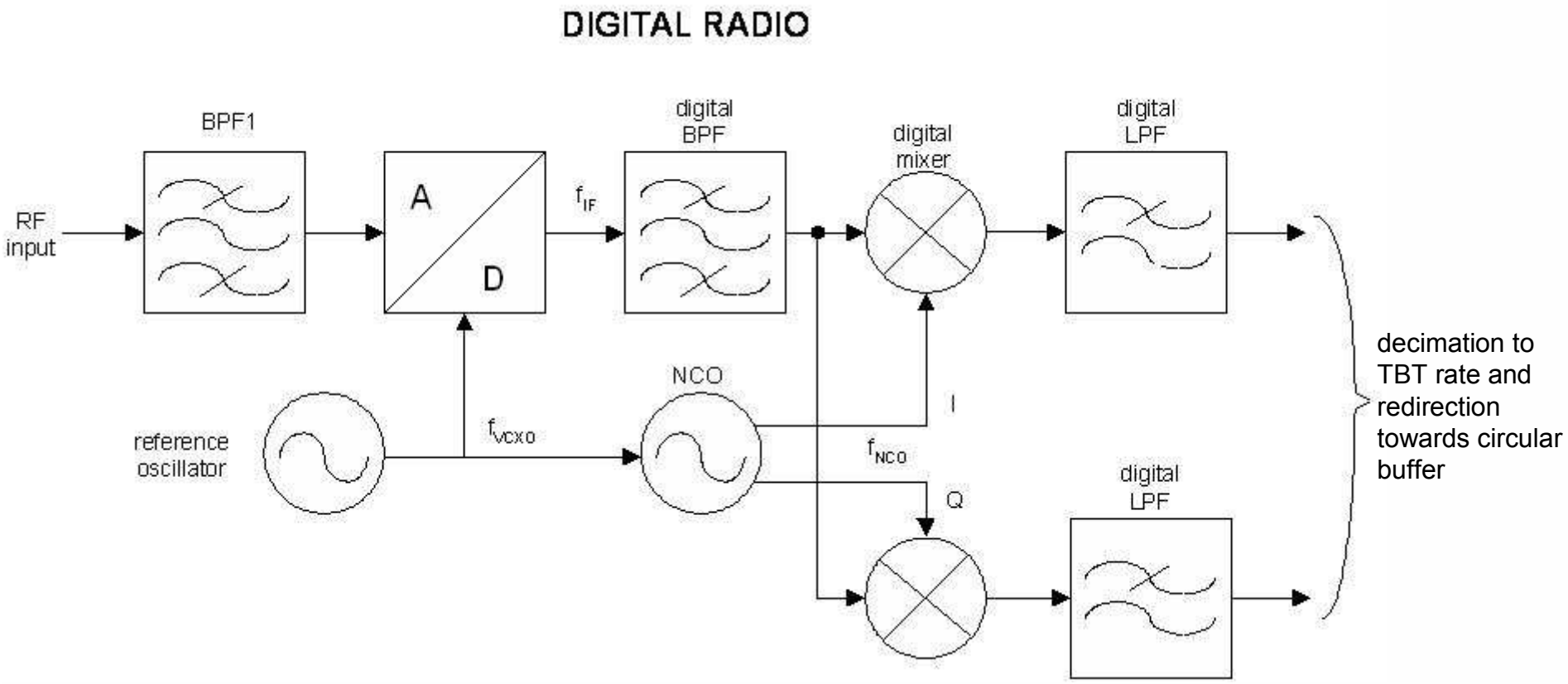
- **Switching.**
- **Digital signal Conditioning.**

Undersampling

- **Analog bandpass filters at RF**
- **Enough analog bandwidth of ADCs**
- **No need for mixing to IF in analog**

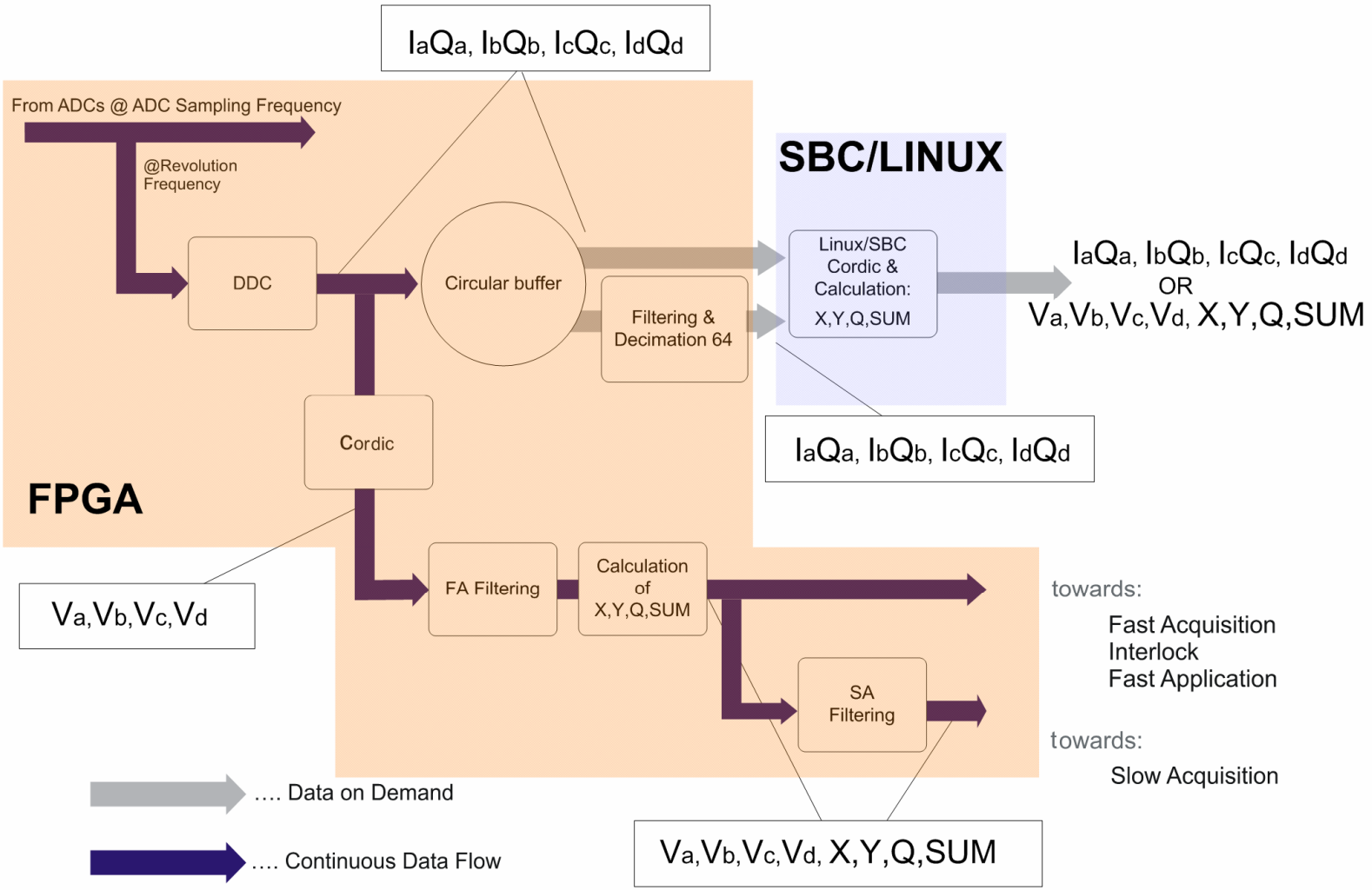


Digital Down Converter



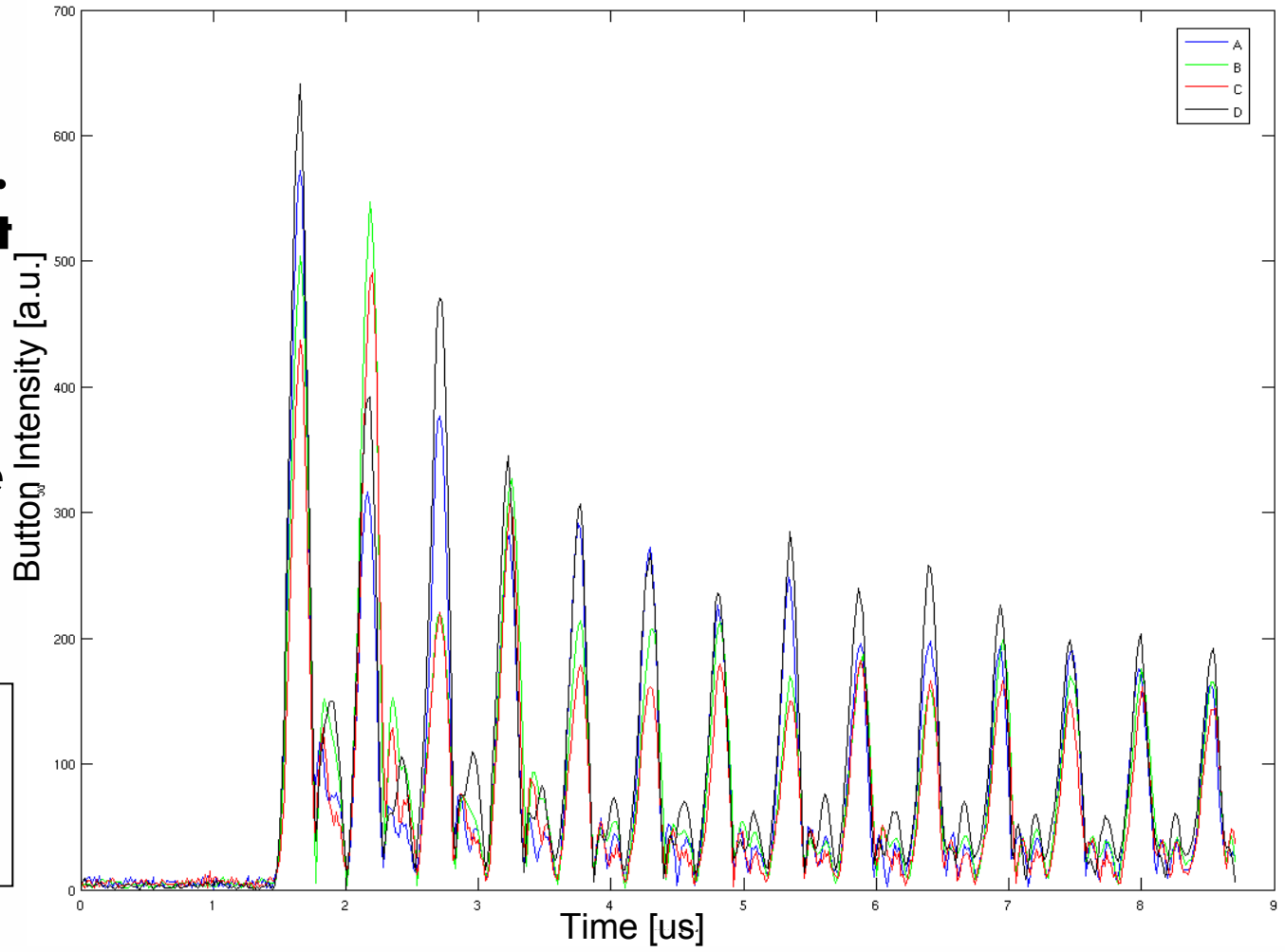
Dataflows

Data Formats on Libera



ADC Data Use Case

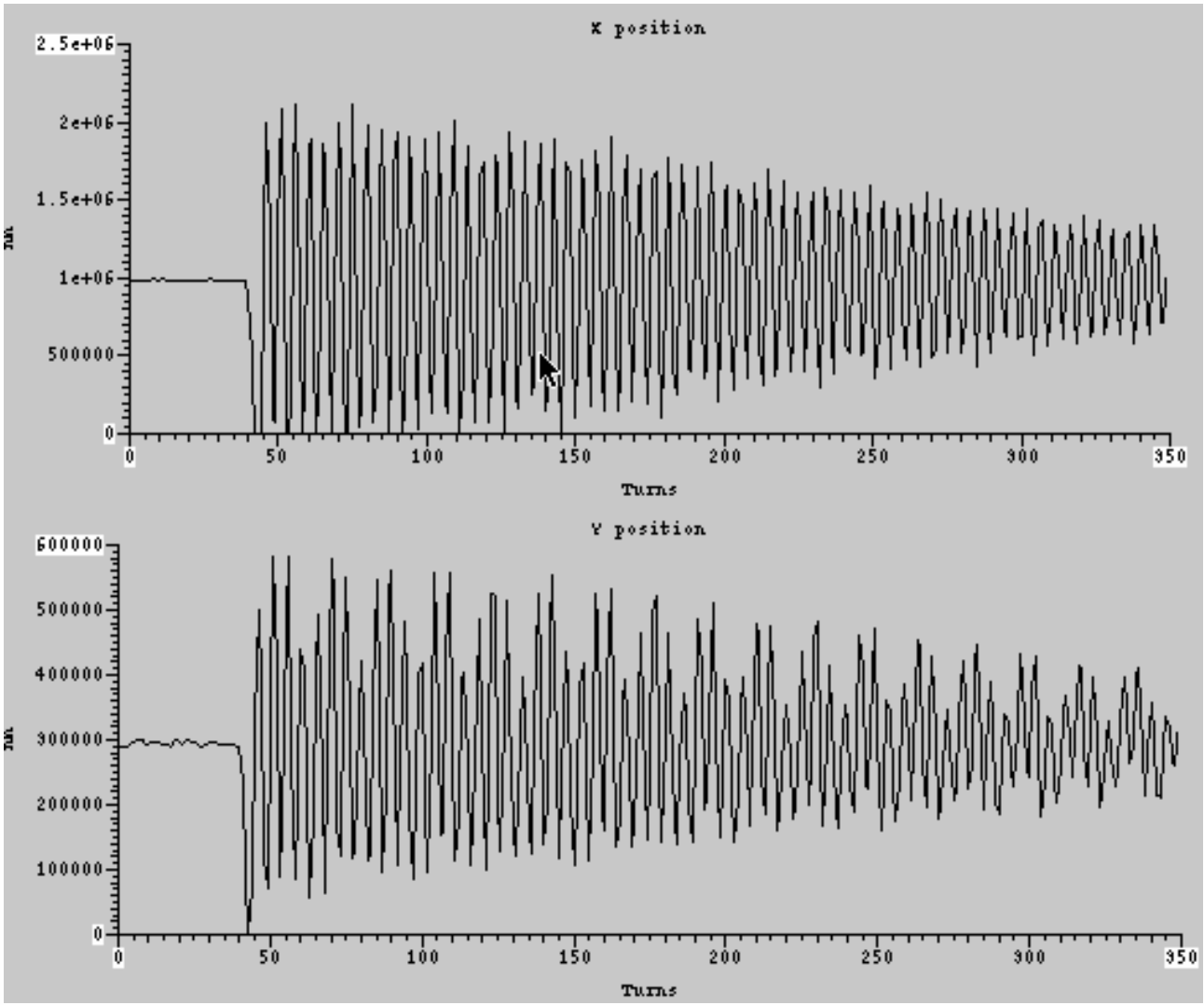
Consecutive injections into Diamond booster. Injection is not set up correctly, causing strong losses on every turn. It is possible to see booster period of 528ns.



Courtesy by Guenther Rehm, DLS

TBT Data Use Case

Classic picture of the injection, recorded at Pohang Light Source (PAL), Korea



Courtesy by Kiman Ha, PAL

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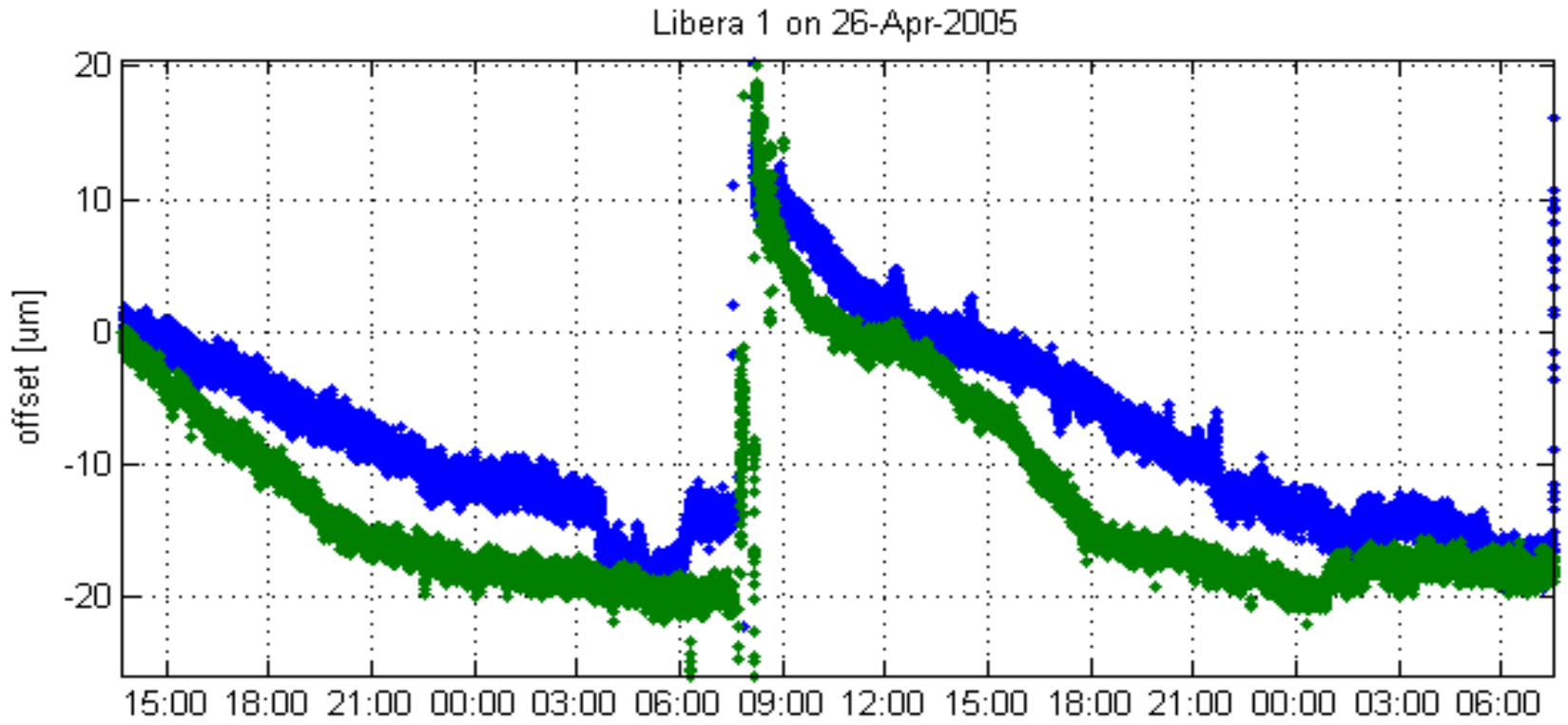
SA Data Use Case



Courtesy by Guenther Rehm, DLS

This beam decay was recorded in SRS, Daresbury, where one of first Libera Electrons was tested. Note that the X axis is in hours. The movement of the beam was confirmed as a real one.

Switching

- Crossbar switch is capable to redirect any input channel to any analog processing chain, providing inherent calibration.
- It switches through 4 switch positions, at ~13kHz.
- This means that lower Notch filter for FA data is at ~3.4kHz (lower harmonic).
- Switching artefacts diminished by:
  - DSC (amplitude and phase compensations)
  - Corrections of TBT data in time domain (Anti-spike method, new in Release 2.0)
  - Notch filter at lower harmonic in FA data chain

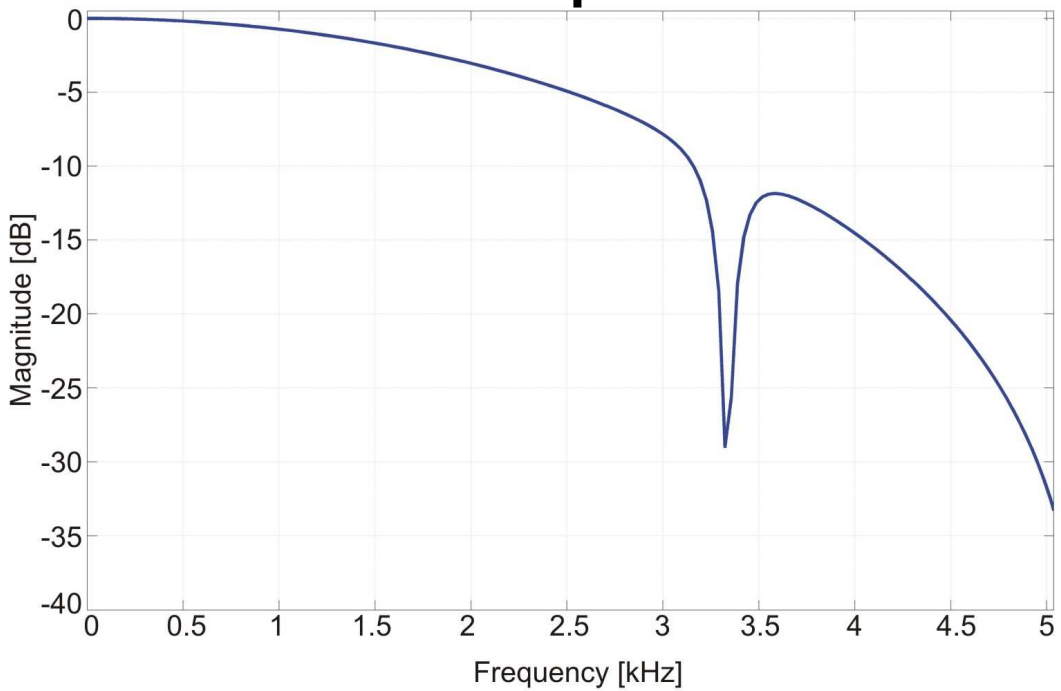
Switching

Used switch combinations

Switch position	Input			
	A	B	C	D
	Analog Channel Output			
0	C	D	A	B
1	C	A	D	B
2	D	C	A	B
3	D	A	C	B
4	C	D	B	A
5	C	B	D	A
6	D	C	B	A
7	D	B	C	A
8	B	D	A	C
9	B	A	D	C
10	B	C	A	D
11	B	A	C	D
12	A	D	B	C
13	A	B	D	C
14	A	C	B	D
15	A	B	C	D

- **Additional notch filter inserted in FA filtering chain**

Combined filter response of FA data

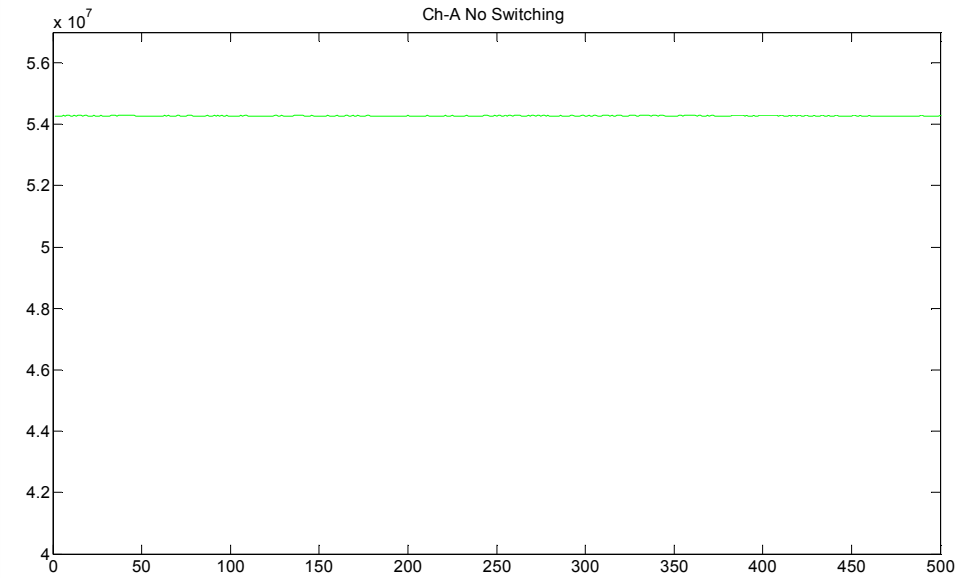


DSC Algorithm

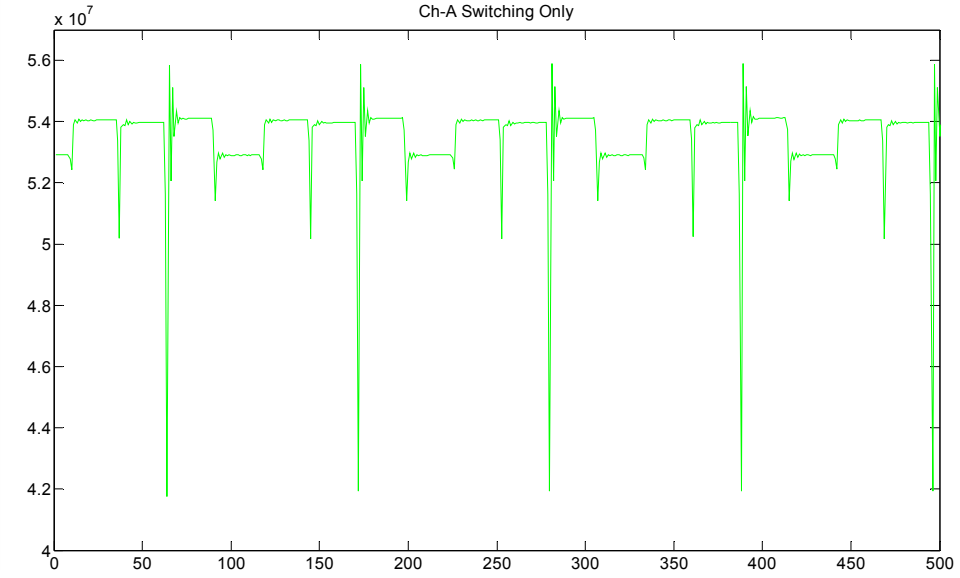
- Diminishes switching artefacts.
- Composed from two main algorithms:
  - Amplitude compensation
    - Compensates different amplifications of analog processing chains.
  - Phase compensation
    - Compensates different signal path lengths.
- The use of switching and the DSC is highly recommended for all data paths, with the exception of the ADC data.

TBT Data, Channel A

No Switching.



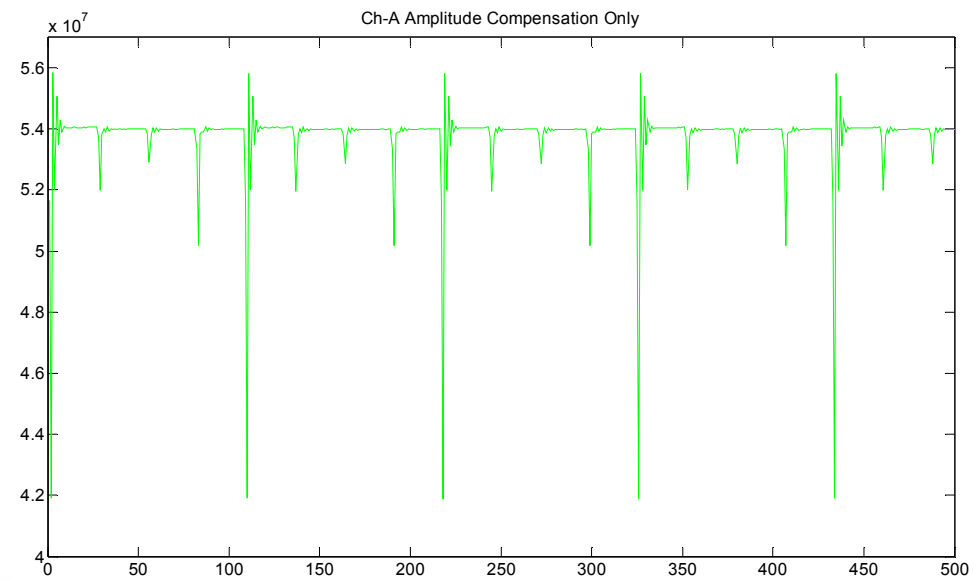
Switching on, no DSC.



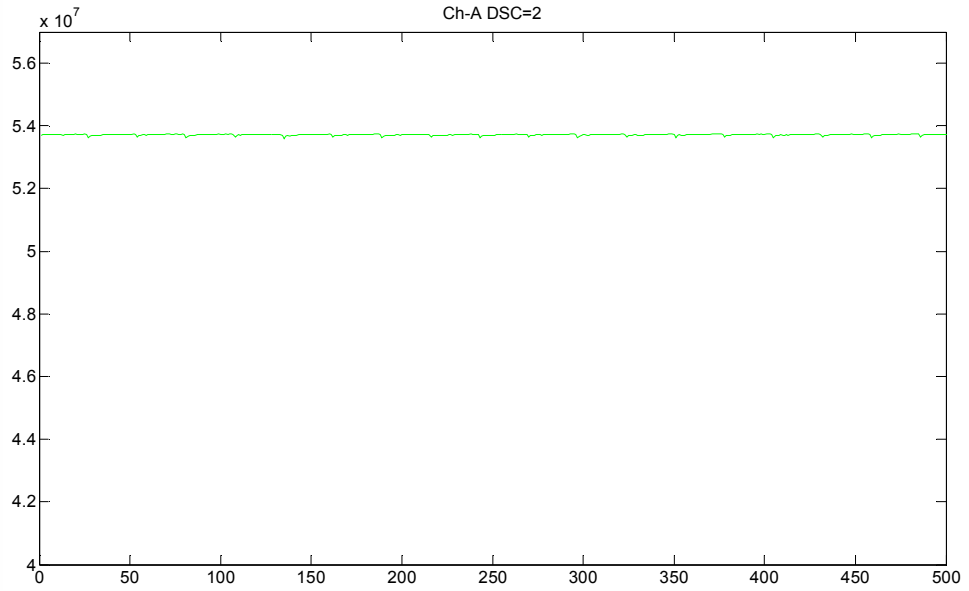
Measured in laboratory, Instrumentation Technologies

TBT Data, Channel A

Switching and amplitude compensation.

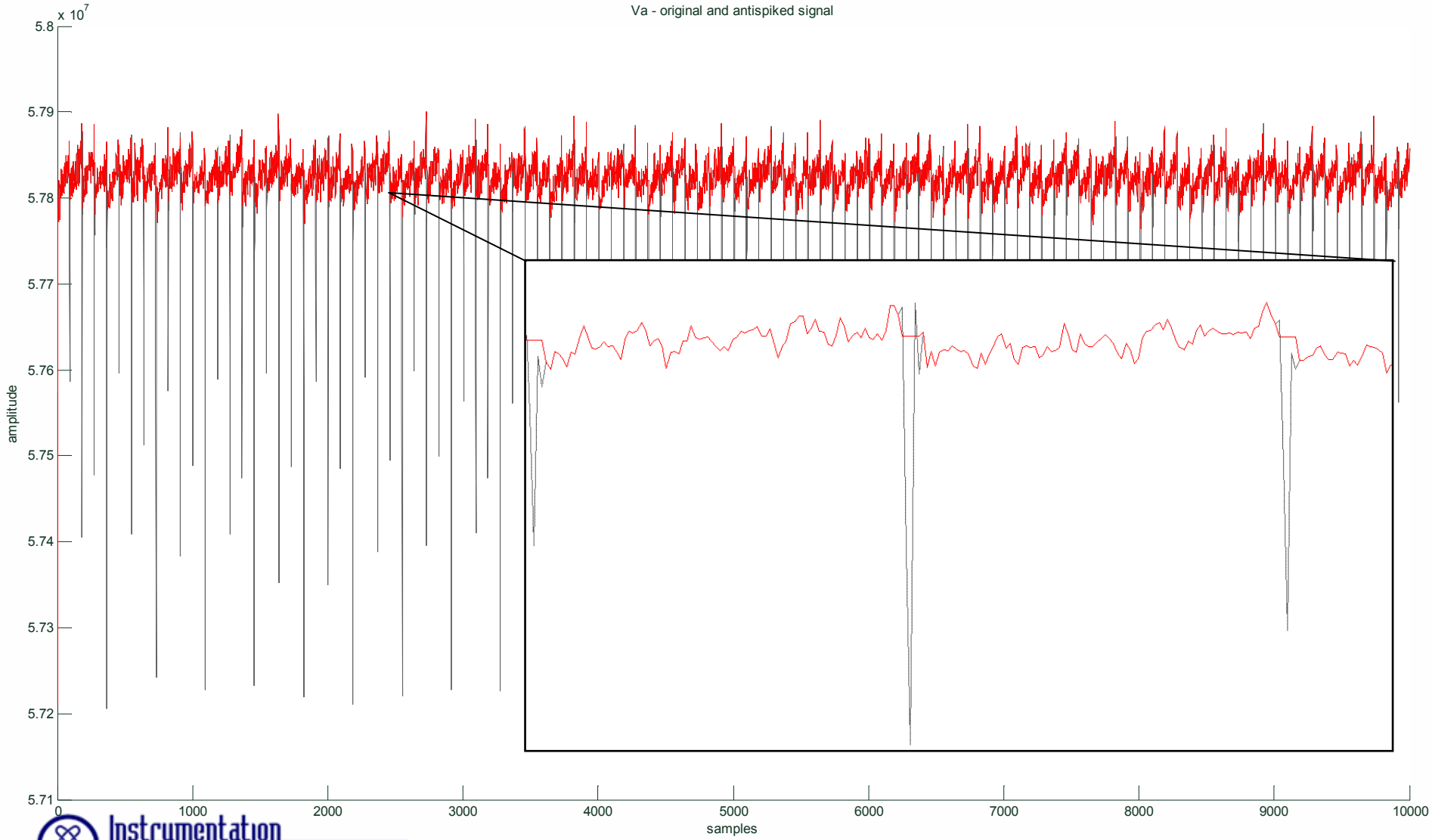


Switching and complete DSC on.



Measured in laboratory, Instrumentation Technologies

Anti-Spike in time domain

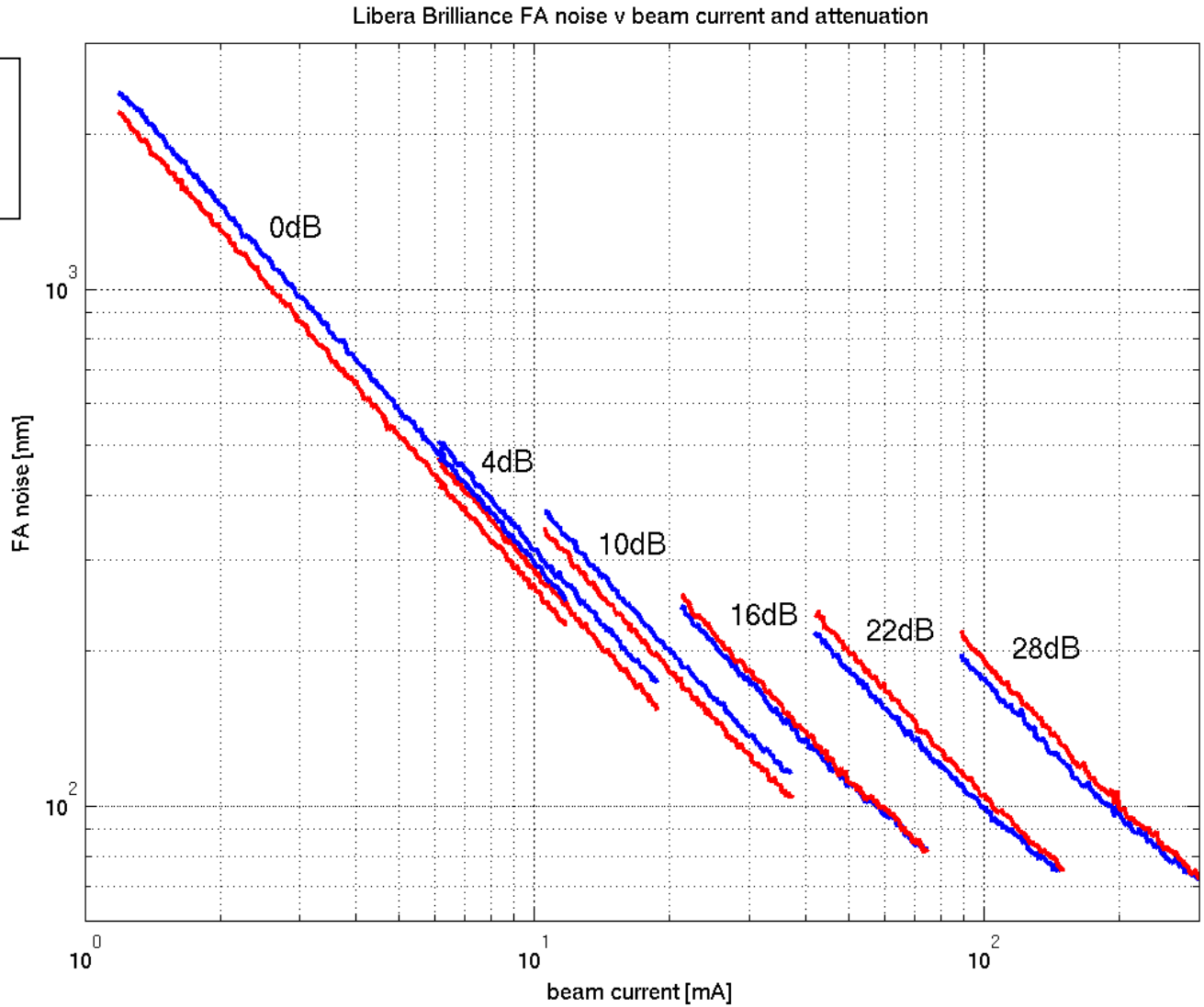


RMS on FA Data

Measured on the beam, DLS.

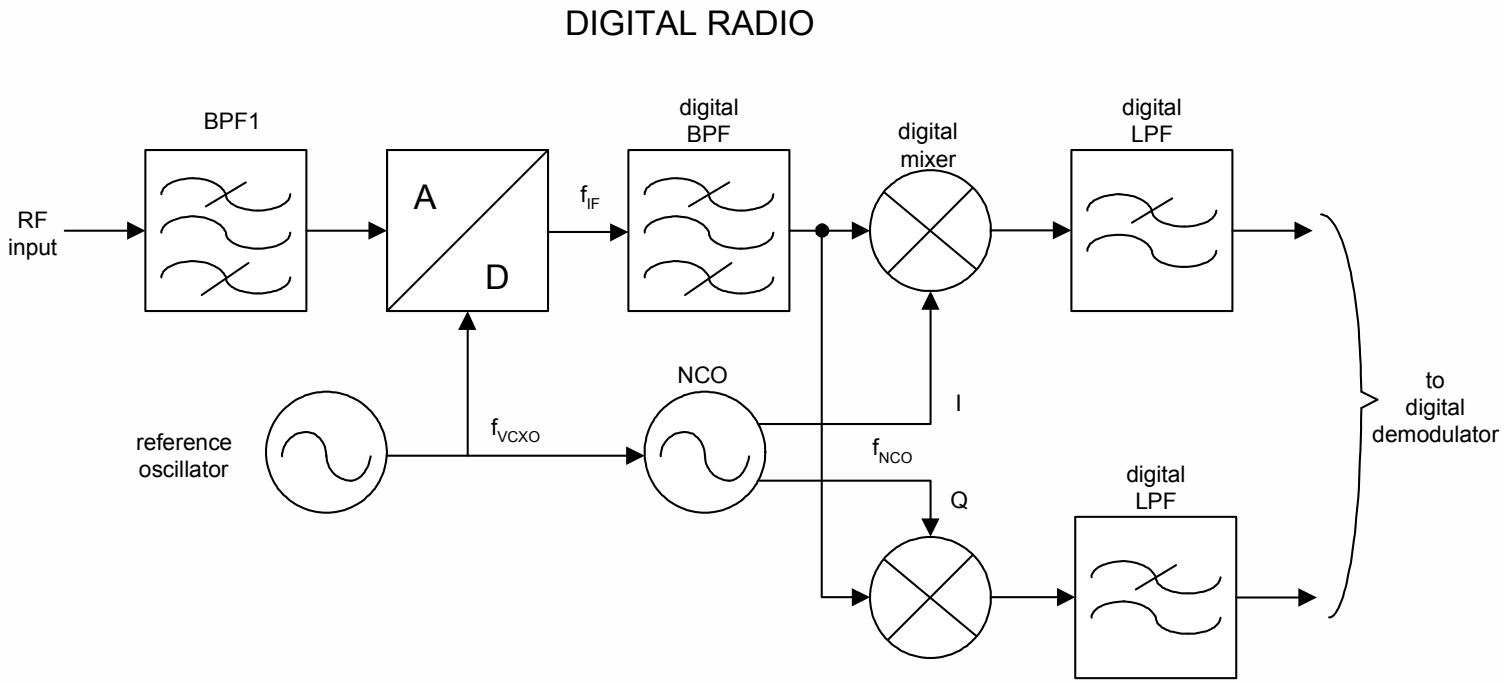
- **The RMS can be kept under 0.1μm down to 50mA.**

Courtesy by Guenther Rehm, DLS



Offset-Tuning Effect

- **Mixing of the signal with the NCO brings the signal to DC.**
- **Deviation of the sampled data from the DC is called offset-tune.**



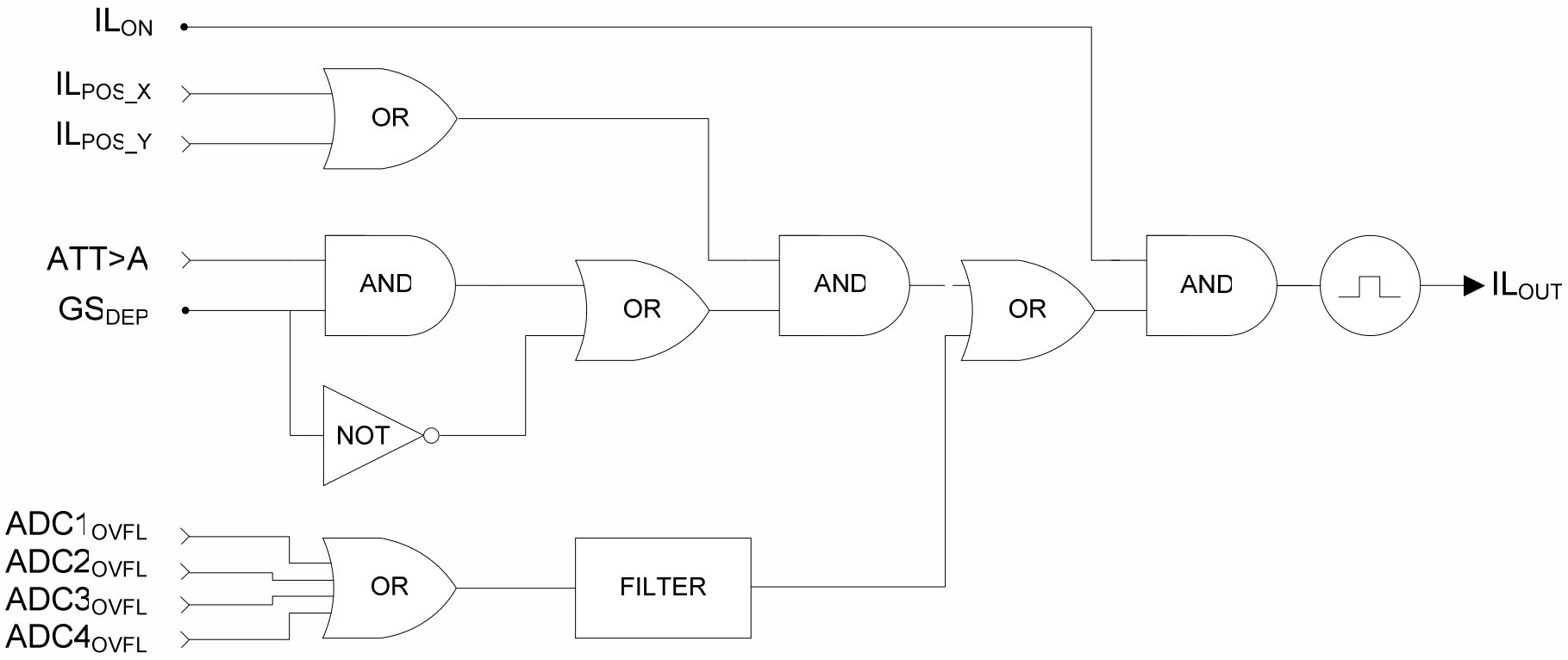
Offset-Tuning Effect

- If MC is supplied, Libera is precisely tuned and, by default, the data is precisely in the DC.
- Due to non-linearity of the ADC and digital ground bouncing, the RMS is slightly spoiled if precisely in the DC.
- The controlled offset-tune was introduced to filter out these spurs from the bandwidth of interest.
- The downside of this approach is that the timing is a bit more complicated.

Interlock Mechanism

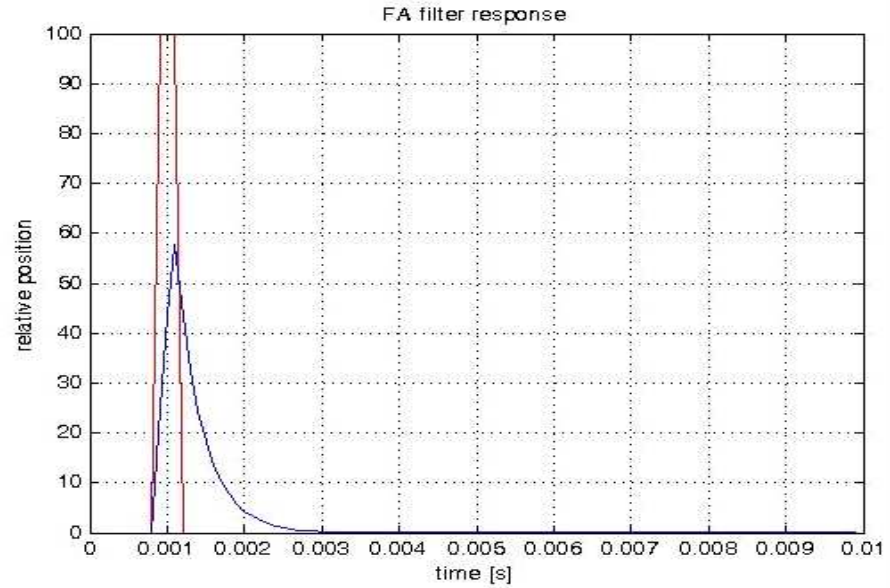
- **Interlock mechanism is directly connected to accelerator global Interlock system through Libera Interlock output. It provides continuous monitoring of the beam. It tiggers when:**
  - **The (X or Y) positions exceed predefined limits. Done on 10kSps data.**
  - **At least one ADC goes into overflow.**
- **The latency is in few *μ*s.**

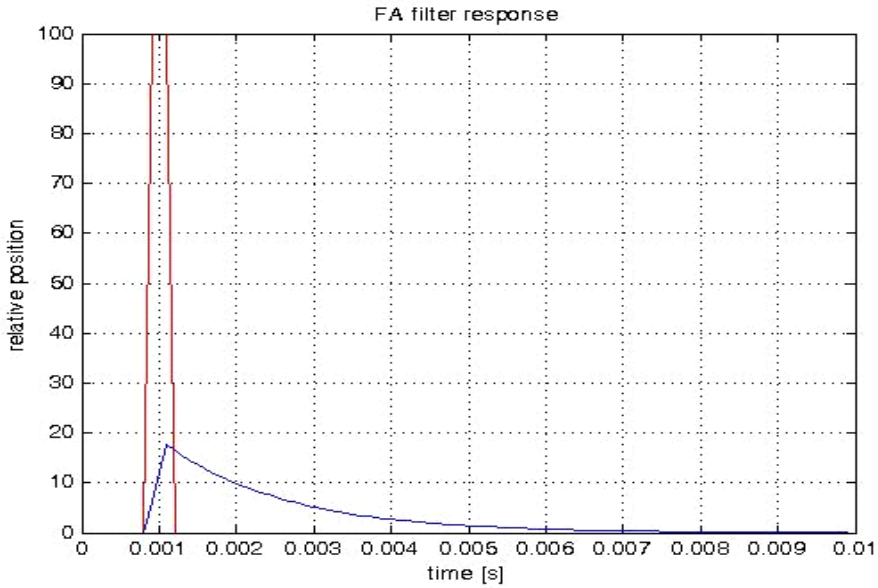
Interlock Logic



X&Y Interlock Position Filtering

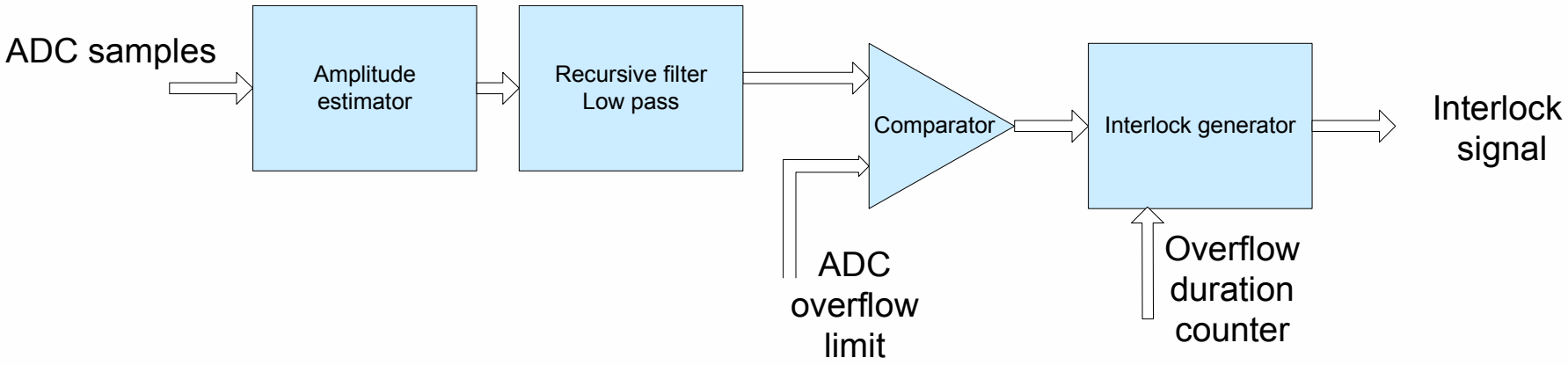
There is an optional filtering employed, to prevent erratic Interlock triggering due to spike, for exampe when gain changes. The amount of filtering can be set by the user in 255 steps. Below left a moderate filtering is shown (setting 63), while on right the filtering is substantial (setting 15).





ADC overflow Filtering

- **The ADC overflow measurement has also increased robustness through position filtering and the overflow duration control.**

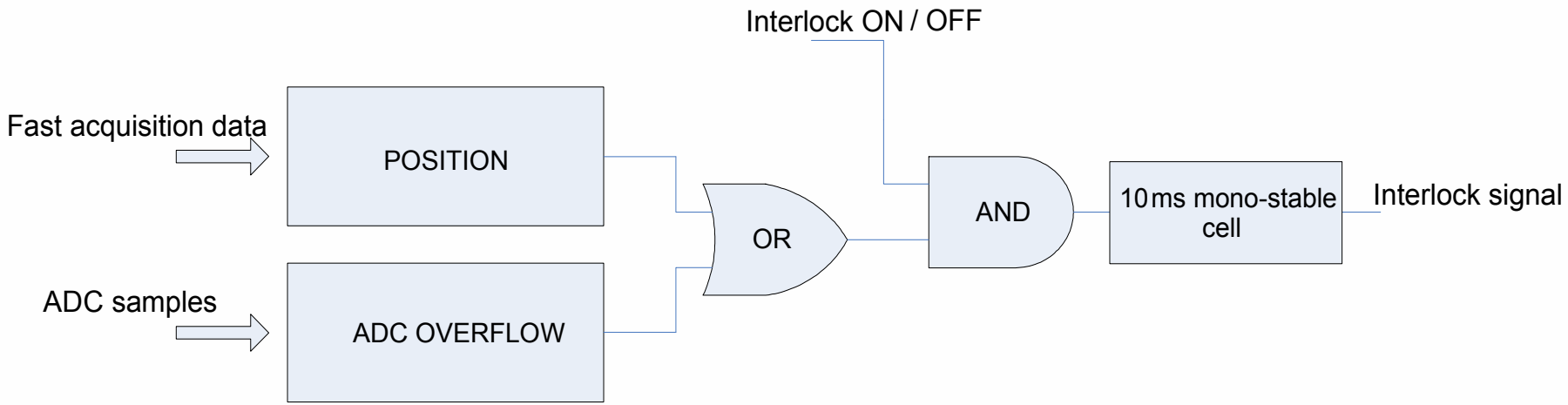


Interlock Gain Dependence

- **The input power threshold is set, above which the interlock starts monitoring the beam position. The feature is useful since:**
  - **At low stored current, the power stored in the beam is harmless.**
  - **At very low beam currents, the readings can't be accurate enough and thus the Interlock triggering is prevented.**
- **Alternative approach to control this issue is used on Diamond Light Source.**

Interlock Signal Generation

Once a position exceeds the limits, or ADC overflow occurs, the interlocks signal is activated for the whole time outside the limits and also 10 ms after the condition is cleared (mono-stable cell).



Gain Setting Issues, 1

- The beam current dynamics (if the system is not in the top-up operation mode) can reach over 60dB.
- To follow this, and to keep the resolution of the measurement under control, the gain setting of the analog signal processing must be adapted.
- The gain is changed by means of variable attenuators, in steps of 1dB.

Gain Setting Issues, 2

- The attenuation must be set having in mind working range of the analog components (linearity is important) and range of the ADCs.
- The default gain scheme (table of values of the attenuator vs input power) was proposed. It was made after lab measurements.
- The scheme can be changed by user.

Gain Setting in Big Systems

- **With many Liberas installed in the accelerator, simultaneous change of gain is wanted.**
- **The change should be somehow controlled from the control system.**

Conclusion

- **Libera Brilliance is a great and proven system, which revolutionized beam position monitoring by introducing a number of new ideas and principles.**
- **Industrial approach including technical support is a standard.**
- **New features are being added continuously, and software is mantained through Release policy.**
- **The new developments are done in close collaboration with customers.**