

**Libera**  
**Brilliance**

# Electron Beam Position Processor





## Many instruments. Many people. Working together.

Stability means knowing your machine has innovative solutions. For users, stability means a machine achieving its full potential, enabling them to do more science. For us, stability means synchronized, connected, dynamic state-of-the-art instrumentation, working together as one system.

Because we know that the machine is more than just the sum of its parts.

*Libera Brilliance enables beam signal processing and fast global orbit feedback building.*



## Benefits

### Cutting-edge performance

- accurate electron beam position measurements at various data rates and bandwidths, simultaneously
- excellent beam current dependence characteristics
- sub-micron position measurement resolution
- low crosstalk between channels

### Essential tool for commissioning and machine physics studies

- first turns position measurement at revolution frequency
- detailed position measurement of first turns at ADC frequency
- measurement of injection efficiency

### Built on proven technology

- platform architecture and reliability of Libera Brilliance proved at several accelerators around the world
- experience and support from the Libera community

### Easy to integrate in the control system

- well documented and maintained high-level software library (CSPI API)
- various integration principles: EPICS, Tango or other user specific applications

### Building fast global orbit feedback

- fully synchronized and formatted data from all units in the loop
- data rate at 10 kHz
- excellent position resolution
- fully compatible with photon beam position monitor

## References

**Fully equipped machines:** Australian Synchrotron (Australia), CELLS - ALBA (Spain), DESY - PETRA III (Germany), DIAMOND Light Source (United Kingdom), ESRF (France), Sincrotron Trieste - Elettra (Italy), SSRF (China), Synchrotron SOLEIL (France), Taiwan Light Source (Taiwan). **Other Libera users:** ANL-APS (United States), BNL (United States), CLS (Canada), DELTA (Germany), FZK-ANKA (Germany), IHEP-BEPC II (China), INFN LNF - Dafne (Italy), ISSP (Japan), KEK (Japan), LBNL - ALS (United States), LNLS (Brasil), NSRL (China), PAL-PLS (Korea), SLAC (United States), PSI - SLS (Switzerland), Spring-8 (Japan).

## Role in the Accelerator

Libera Brilliance features high precision position measurement of the electron beam in the booster or storage ring. Digital signal processing inside Libera Brilliance supports programmable bandwidth and can facilitate all required position measurements: pulsed, first turns, turn-by-turn and regular closed orbit.

Acquisitions can be done simultaneously on all data paths: from raw ADC acquisition, turn-by-turn acquisition, slow acquisition to fast acquisition. Fast acquisition data is provided through deterministic fast ports (SFP) at 10 kHz data rate and is the input data for fast global orbit feedback.

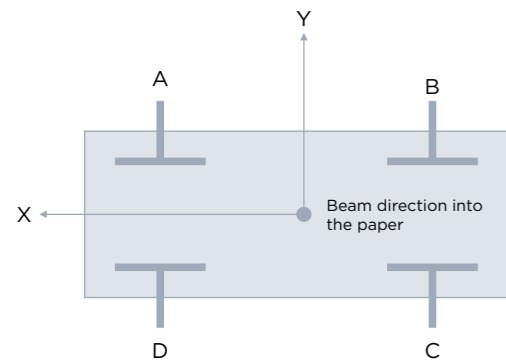
Libera Brilliance is fully customizable and can also be programmed to control the control units for corrector magnets. This can be done by using the FPGA development kit and is left to users.

## How Does It Work?

Libera Brilliance is optimized to work with input signals from button BPMs. Variable attenuators on four parallel analog chains are used to adapt the input signal to proper level. The signal processing chain on Libera Brilliance is composed of analog signal processing, digitalization on fast ADCs and digital signal processing. Each channel consists of a digital downconverter (DDC) which is followed by parallel processing in wideband and narrowband paths.

### Patented solution

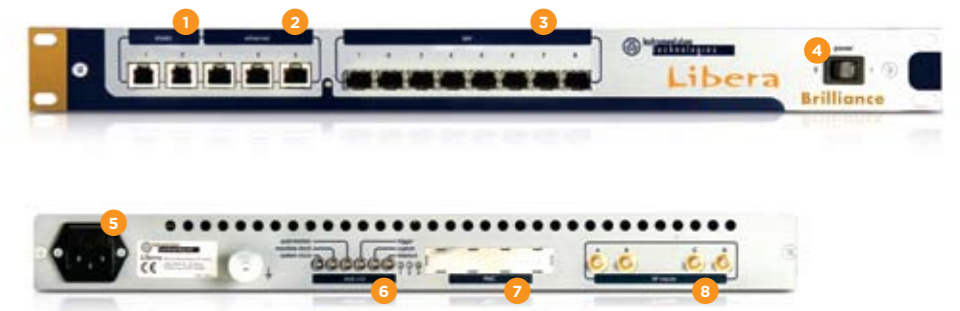
Libera as an all-in-one instrument successfully combines the advantages of the multiplexing and the four channels worlds. The innovative architecture of the RF quasi-crossbar switch and the digital crossbar switch combined with the digital signal processing enables improved reproducibility of the beam position measurement. The described solution is patented.



## Performance Specifications

Parameter	Range	Guaranteed performance, k=10mm	
		TBT=1.15 MHz	TBT=131 kHz
Resolution (turn-by-turn)	→ -28 dBm → -44 dBm	3 μm 15 μm	1 μm 5 μm
Beam Current Dependence	0 → -24 dBm 0 → -32 dBm 0 → -50 dBm		1 μm 1,5 μm 2 μm
Fill Pattern Dependence	100%-20% duty cycle		1 μm
FA Resolution	0 → -20 dBm		0,25 μm
Crosstalk		-45 dB to -70 dB	

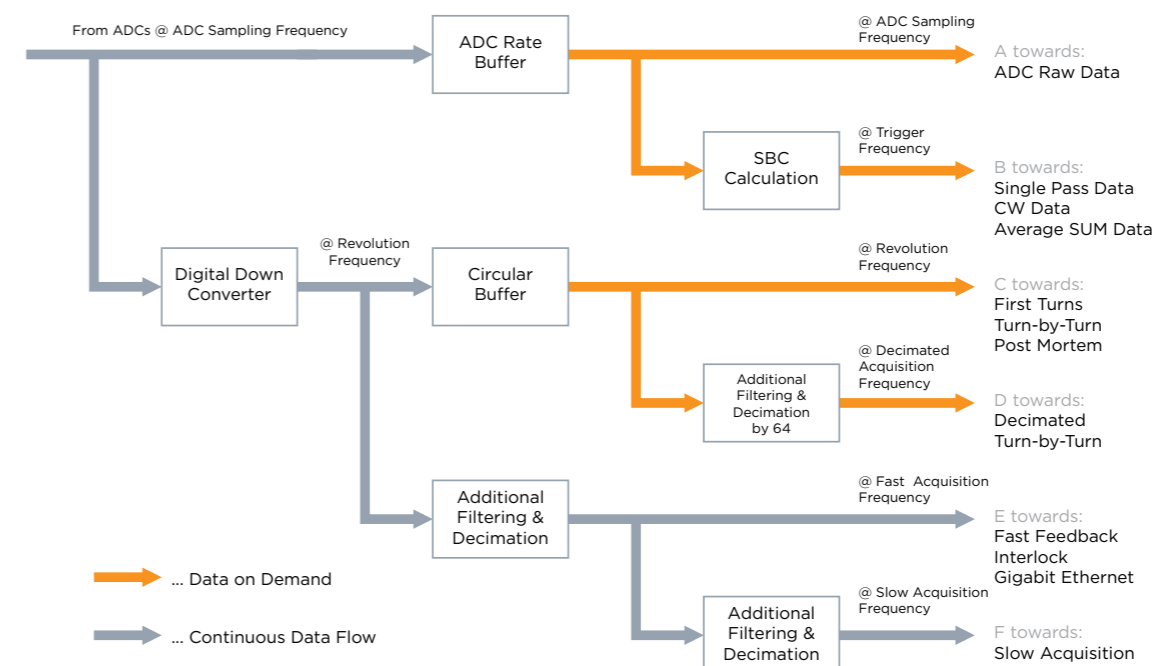
## Hardware Interfaces



- Front panel**
- 1 RS485 ports. Up to RS485 channels.
  - 2 10/100 Mb Ethernet ports used for communication and integration with accelerator control system. Control and measurement data are exchanged at lower rates. Port 3 is standard for use. Ports 1 and 2 are intended for future use.
  - 3 SFP slots. Used for fast serial communication. Libera Gigabit Ethernet Interface is available. Multiple other standards are supported.
  - 4 ON/OFF switch
- Back panel**
- 5 110 V/230 V AC mains power supply, 50-60 Hz
  - 6 Fast signal interfaces. Used for triggering and synchronization purposes. (Timing, Trigger, Interlock, Postmortem, custom)
  - 7 PMC slot. Supports standard PMC boards. Due to direct FPGA connection, the interface can be PCI - or user - defined.
  - 8 RF inputs. Connect to position pickups.

Libera Brilliance provides six data paths at different sampling rates with different bandwidth and resolution. Acquisitions can be done simultaneously on all four major data paths (ADC raw data, turn-by-turn data, fast acquisition and slow acquisition data). Fast acquisition data is available over SFP slots using Gigabit Ethernet Protocol.

## Data Paths



## High-level Software Architecture

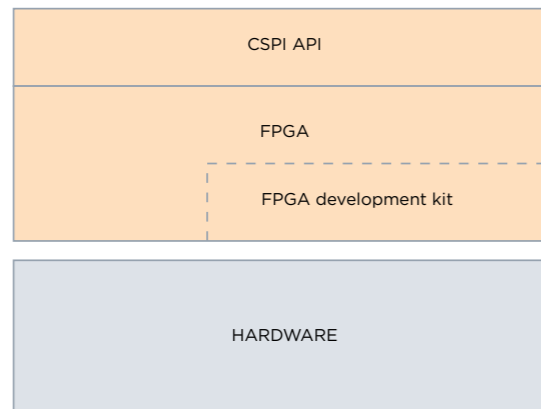
With regard to the hardware architecture that consists of single board computer (SBC) and digital board with Xilinx FPGA device, software architecture is composed of CSPI API (running on SBC) and FPGA software.

CSPI API is a high-level C interface which allows users to implement a range of applications for Libera family. It supports remote access and provides:

- configuration
- data streams
- health monitoring
- event monitoring

The CSPI API is provided to users with GNU GPL license and source code.

FPGA software can be additionally developed to meet specific users' needs. The in-house developed FPGA development kit (FDK) can be provided on request (free of charge) and allows users to adapt Libera Brilliance for their specific applications. These can be e.g. driving control units for corrector magnets.



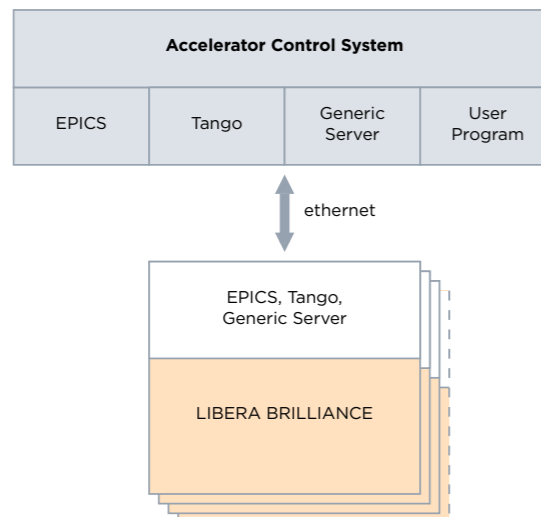
## Integration into Control System

There are various possibilities for integration of Libera Brilliance units into the accelerator control system. Units can run EPICS, Tango or Generic servers. Data flow consists of:

- data acquisitions
- event delivery
- health monitoring

Integration into control system can be done using the following principles:

- EPICS driver for Libera Brilliance is available:
  - lightweight version, based on CSPI API
  - Diamond Light Source version with extra functionalities, not based on CSPI API
- Tango and Generic server:
  - all necessary source code available from Instrumentation Technologies
  - easy implementation based on the "libera utility" example



## Fast Global Orbit Feedback

Libera Brilliance provides a fast acquisition data stream, which is essential for fast global orbit feedback building. The gathered data from Libera Brilliance units are sent through fast ports (SFP) at approximately 10 kHz data rate. To gather the basic fast acquisition data, only commercial hardware is needed.

There are 3 principles for fast global orbit feedback building:

- Libera Gigabit Ethernet Interface
- Libera Grouping
- Communication Controller (developed by Diamond Light Source)

The main difference between them is the topology which is used for connecting the Liberases and collecting the data.

Key properties and features:

- fully synchronized data to accelerator revolution frequency
- fast data at approximately 10 kHz data rate and 2 kHz bandwidth
- positions X and Y, and SUM value are provided
- the same feedback loop can include Libera Brilliance and Libera Photon (photon beam position monitor)

Data from Libera Gigabit Ethernet Interface or Libera Grouping can be easily acquired using simple receiver software with Linux or Windows PC with a Gigabit Ethernet port.

Data from Communication Controller can be collected using external hardware receiver FPGA board (commercially available).

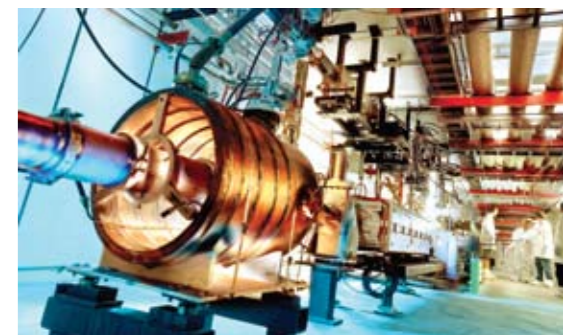
## Libera Tryout Want to Try Libera Brilliance Functionalities Prior to Purchase?

Request "Libera Brilliance Tryout" and you will evaluate the following functionalities for free:

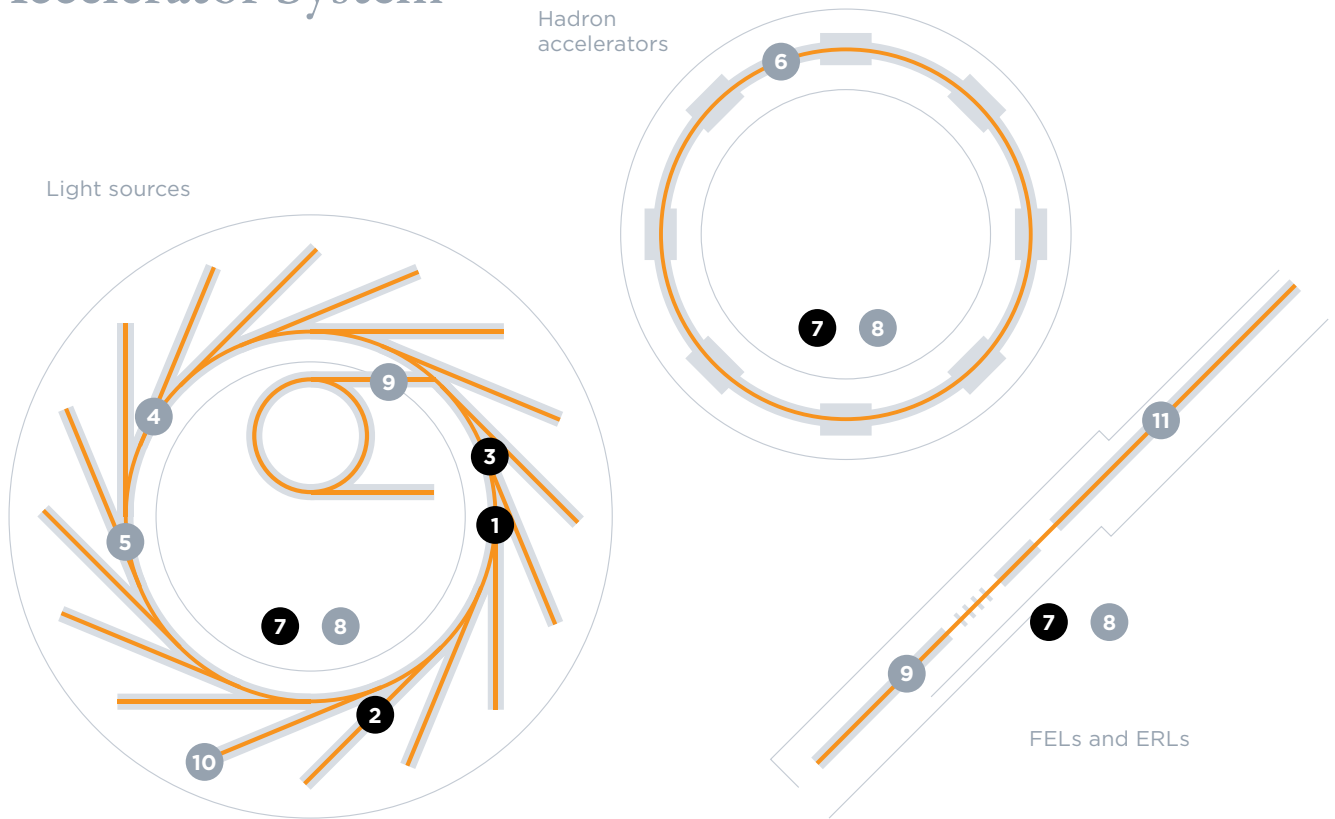
- fast acquisition
- slow acquisition
- data on demand acquisition
- complete timing
- ADC rate buffer

Benefits:

- get the Libera tryout completely customized to your machine
- evaluate the product before purchase
- get the technical support needed
- get the complete Libera Brilliance technical documentation



# Related Products in the Accelerator System



- 1 Libera Brilliance**  
*Electron beam position processor*
- 2 Libera Photon**  
*Photon beam position processor*
- 3 Libera Clock Splitter**  
*Clock and trigger signals distributor*
- 7 Libera LLRF**  
*Digital RF stabilization system*
- +** *See the cover spread for the whole product range*

→ Solution	Building Block
Synchrotron light source closed orbit feedback	Libera Brilliance + Libera Photon + Libera Clock Splitter
Beam dump for injection efficiency studies	Libera Brilliance + Libera LLRF
Turn-by-turn beam studies	Libera Brilliance + Libera LLRF

## More at [www.i-tech.si](http://www.i-tech.si)

Visit our website to read more about Libera products, download conference papers on the use of Libera at different accelerators around the world, subscribe to the I-Tech Newsletter and learn about the next gathering of the community at the Libera Workshop.

## Technical Support

Prompt and reliable. You can ask for on-site support or we can assist you remotely. You are also welcome to join us at the Libera Workshop training sessions to get the most out of Libera products.



When your users demand stability.