IBIC 2022 International Beam Instrumentation Conference

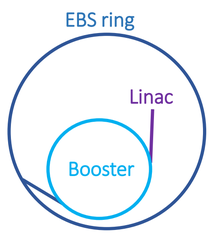
MOP35

NEW MEASUREMENTS USING LIBERA-SPARK ELECTRONICS AT ESRF: THE HIGH-QUALITY PHASE-MONITOR AND THE SINGLE-ELECTRON

E. Buratin, P. Borowiec, G. Denat, N. Benoist, J. Jacob, K. Scheidt, F. Taoutaou
European Synchrotron Light Facility, 38000 Grenoble, France

The ESRF complex

EBS parameters in **User-mode:**
- Circumference = 844 m
- Beam energy = 6 GeV
- Beam current = 200 mA
- Typical lifetime = 20h
- $3.5 \cdot 10^{12}$ electrons
- Revolution time = 2.816 µs

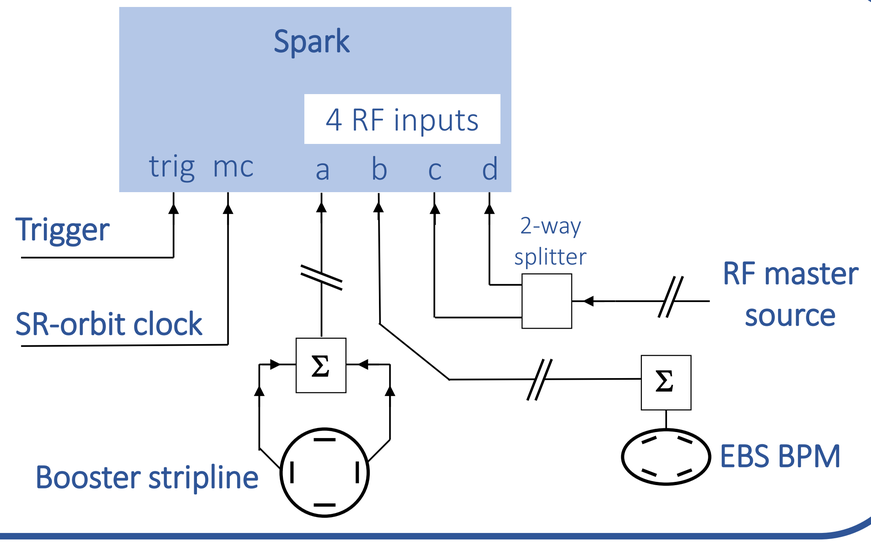


At injection:
- 0.5 mA/shot
- 60-80% injection efficiency

The high-quality phase-monitor

In TZ01 the **new phase-monitor** has been installed, based on Libera Spark Beam Position Monitor (BPM) electronics:
- Trigger
- A SR-orbit clock 355 kHz
- 4 RF inputs:
  - A Booster stripline
  - EBS BPM buttons
  - Master Source signals

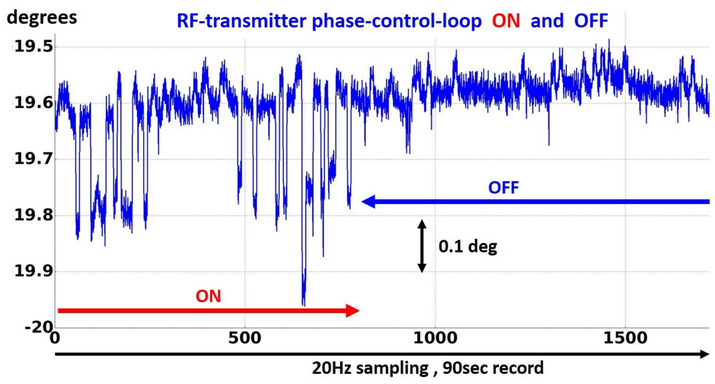
The **wobbly Phase-Locked Loop (PLL)** affects all 4 RF inputs at the same way.



EBS phase measurements during operation

Phase between a EBS BPM and the RF master source

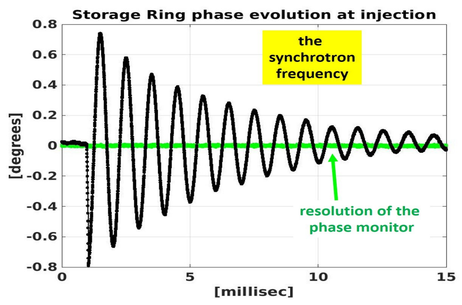
RF transmitter **ON** and **OFF**

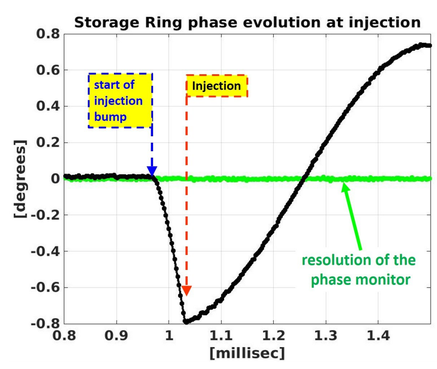


EBS phase measurements at injection

Time-resolved evolution:

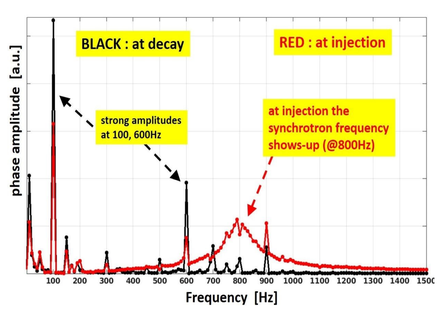
damped oscillation



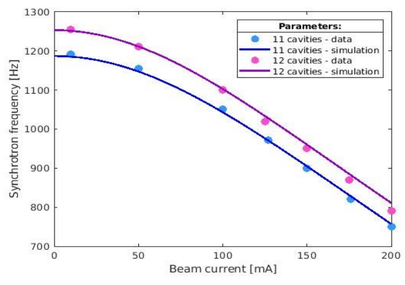


Frequency-domain:

Synchrotron radiation frequency ~ 1 kHz



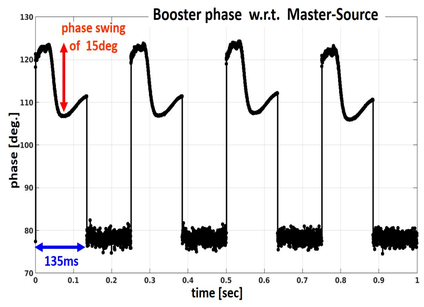
EBS synchrotron frequency as a function of beam current



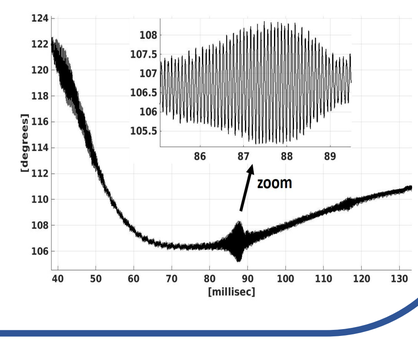
Booster phase measurements

Time-resolved evolution:

4 cycles of 250 ms



Additional fluctuations



The single-electron experiment

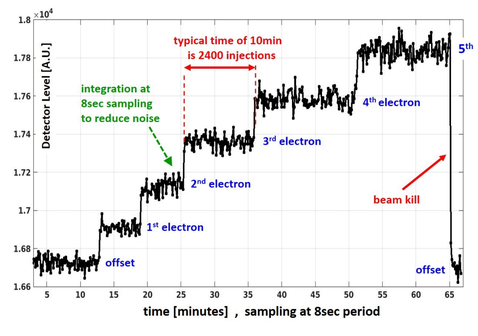
Single-electron injection and control:
- All injection elements on (**continuous injection**), but **Linac gun off**
- Electrons generated at the Linac accelerating structures (2*100 MeV), called "**dark current**", that has no time structure, can fill any of 352 Booster buckets, around 100 electrons
- We reduce the dark-current flux by the insertion of 4 **screens** in the **Transfer Line 2 (TL2)**

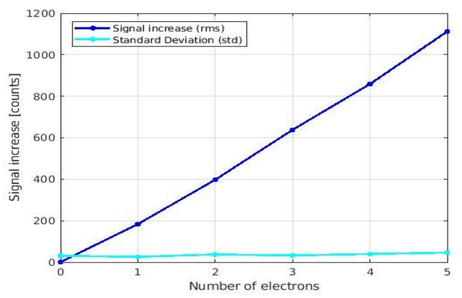
The visible-light set-up:
- Cell 5 is equipped with an in-vacuum water-cooled **Visible Light Mirror** (VLM) to extract visible light for beam measurements
- Light source: 0.62 T **bending magnet** (BM)
- Additional optical elements are used (periscope, mirrors, 3-m achromat)
- A **Photo-Multiplier Tube** (PMT) and a **Beam-Loss Monitor** (BLM) electronics are used to acquire the signals

The single-electron measurement:

- PMT: at 1 MΩ impedance, 0.7 V gain, integrated mode, integrating time = 8 s
- Continuous injection
- One step visible every 10 minutes (~2400 injections)
- 1-2-3-4-5 electrons were recorded in about 1h, then killed with the scraper

- Signal-to-Noise ratio > 6
- Around 200 counts per electron with this configuration

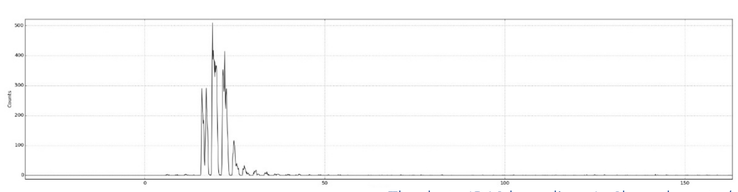




The impurity measurement:

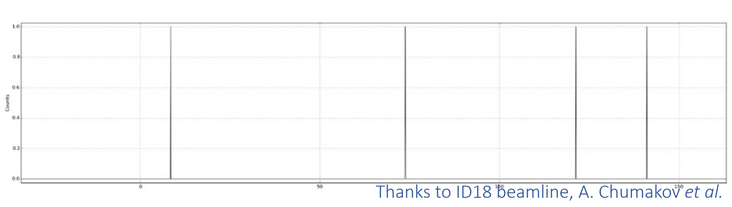
Machine Development Time (MDT) with ID18 users to verify the bunch purity

Before optimization with the single-electron device:
➔ **bunch impurities**



Thanks to ID18 beamline, A. Chumakov *et al.*

After optimization:
➔ **no impurities**, but few peaks linked to cosmic-ray pollution



Thanks to ID18 beamline, A. Chumakov *et al.*

Conclusions

The **phase-monitor** can be used to follow-up the EBS phase, the Booster phase during each cycle, the evolution of synchrotron frequency with beam parameters and the cabling length variation with operation. It is useful during the User-mode operation, to identify issues from the frequency domain, and during the MDT studies, to cross-check the physics behaviour and to optimize the machine.

Secondly, the visible-light system has been exploited successfully for **single-electron measurements**. For the moment, the system is limited to low light levels, but the goal is to extend the S/N range by a better PMT and to implement a time-correlated-photon-counting system, to be able to determine also the position of these electrons. Afterwards, we want to improve the dynamic range of purity measurements with photon-to-pulse converters, with the aim of measuring the impurities also during USM operation.