ESRF | The European Synchrotron

BEAM PHASE MONITOR

USING A SINGLE LIBERA BRILLANCE

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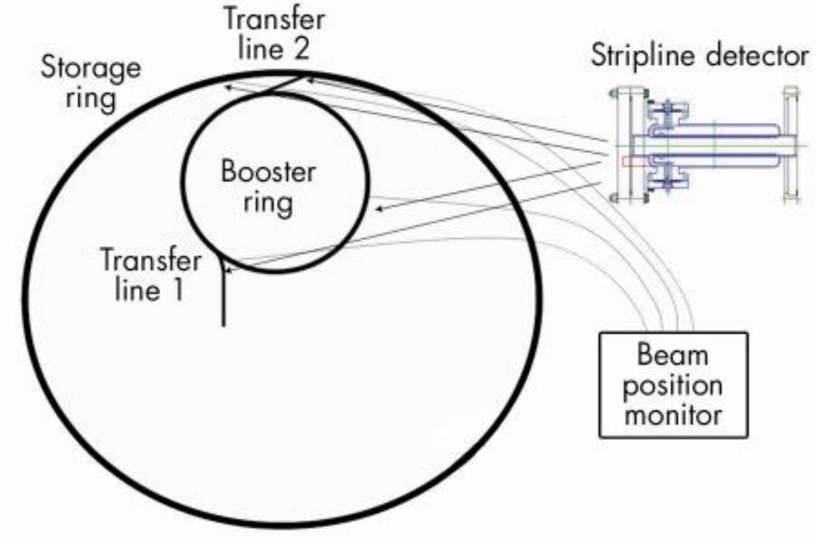
INTRODUCTION

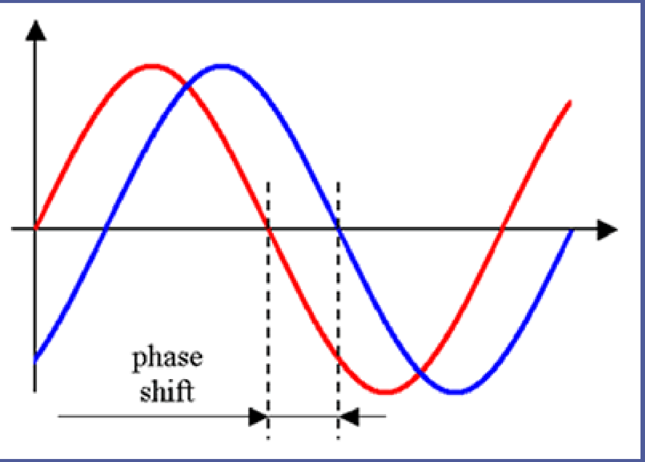
The European Synchrotron Radiation Facility has several BPM and Stripline detectors around the injection / extraction zones (TL1 and TL2).



These detectors can be used with the Libera to monitor the phase relation between the Storage Ring and the Booster Synchrotron ring.

PHASE SHIFT

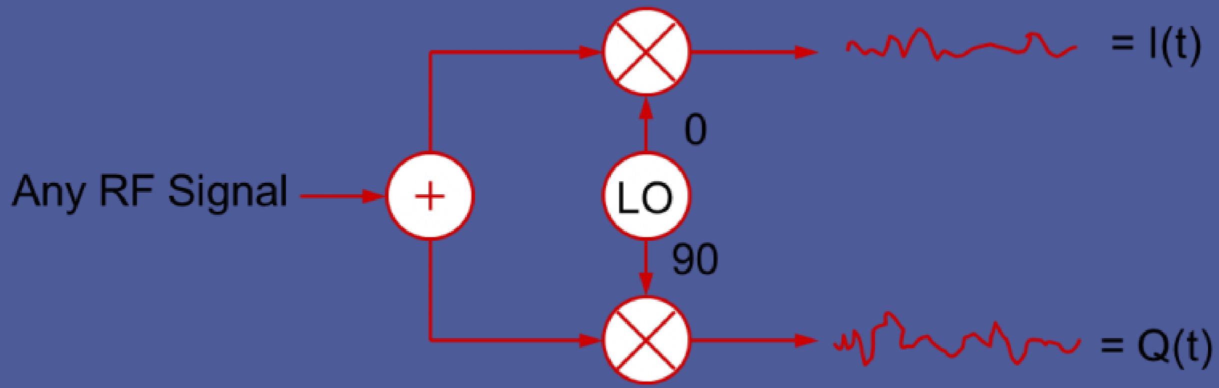
The phase measurement is a relative (ratio) measurement and not an absolute measurement. The difference in phase between two signals is known as phase shift.



In our case the phase shift is the phase relation between the beam in the Storage Ring and the beam circulating in the Booster Synchrotron ring.

QUADRATURE DEMODULATION

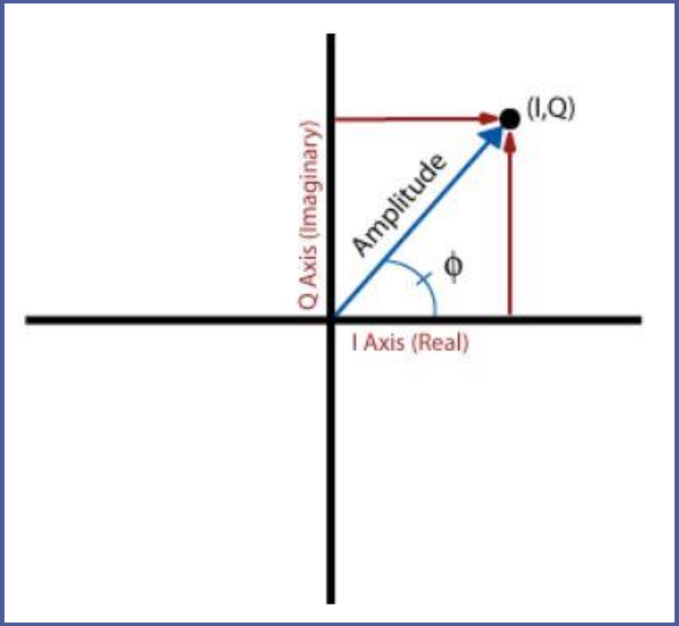
I(t) and Q(t) baseband signals can be created by mixing an RF signal with Local Oscillator signals in quadrature.



The quadrature demodulation done in the Libera and the availability of the I and Q components make the measurement of the relative phase relation easy and straight forward.

RETRIEVING THE PHASE

From the I & Q values, the complex I+Qi data and therefore the angles are calculated.



2π phase jumps are smoothed and 2π integers removed so that the phase value is always expressed in a value between 0 and 360º.

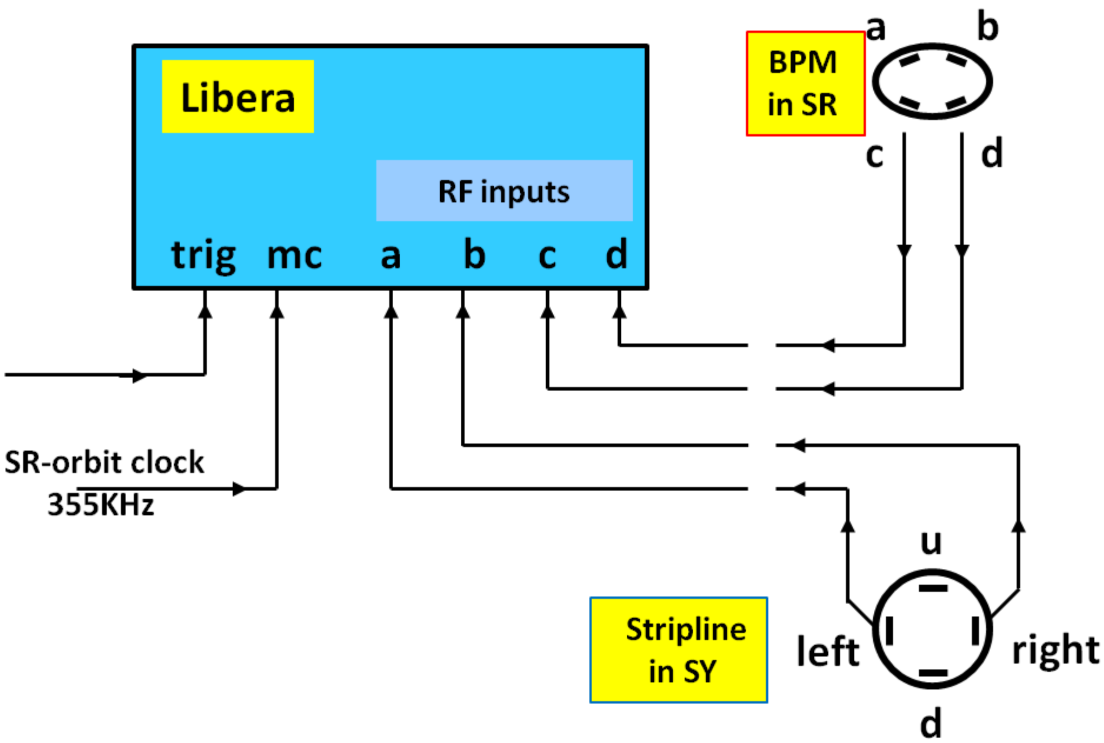
HOW DOES IT WORK?

This Libera-based phase monitor operates with Matlab routines that read the I/Q data from a Tango device server.

→ TANGO Connecting things together → MATLAB

The phase information between the four input signals is retrieved after some calculations on the I & Q values.

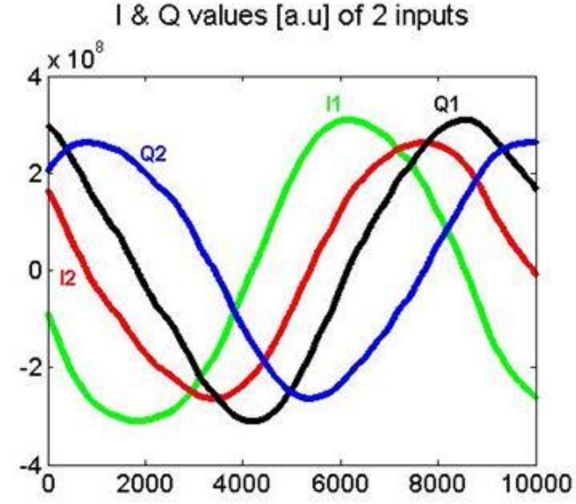
HARDWARE SETUP 1 – SR BEAM / SY BEAM

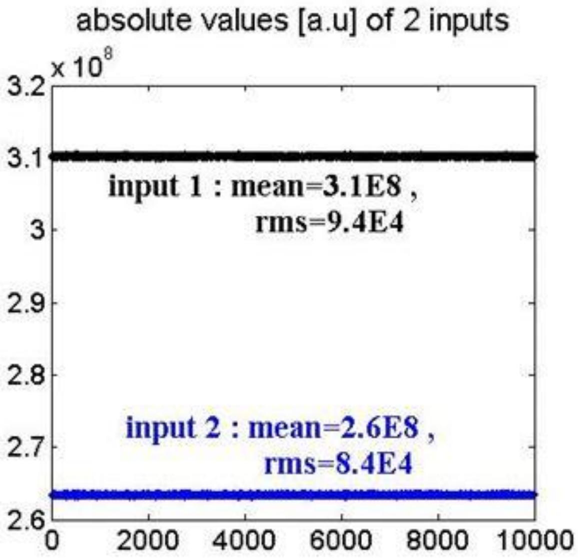


The RF signals of the Storage Ring come from two BPM buttons while those of the Booster come from two Stripline outputs.

→ no internal drift of relative phase between the four input channels

DUPLICATED INPUTS

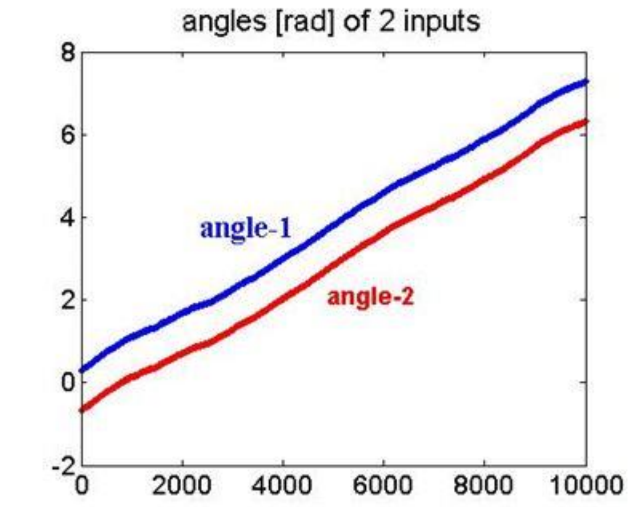




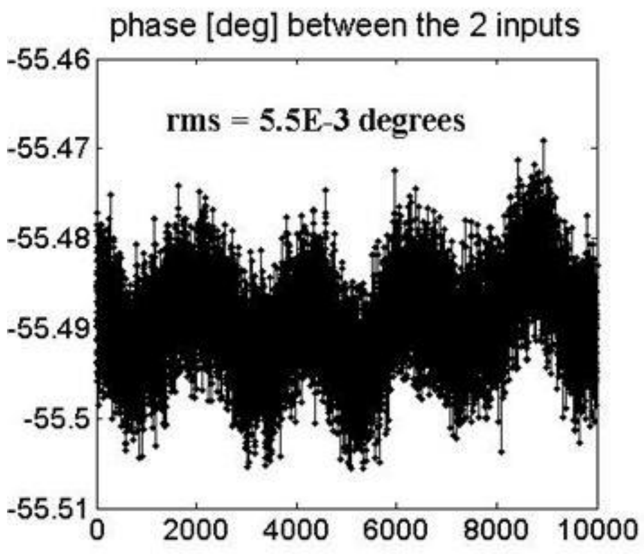
When looking at two Libera inputs with strictly identical RF signals, we observe huge fluctuations of the I/Q values.

On the other hand the stability of the two RF signals (absolute of I/Q) is very high.

DUPLICATED INPUTS

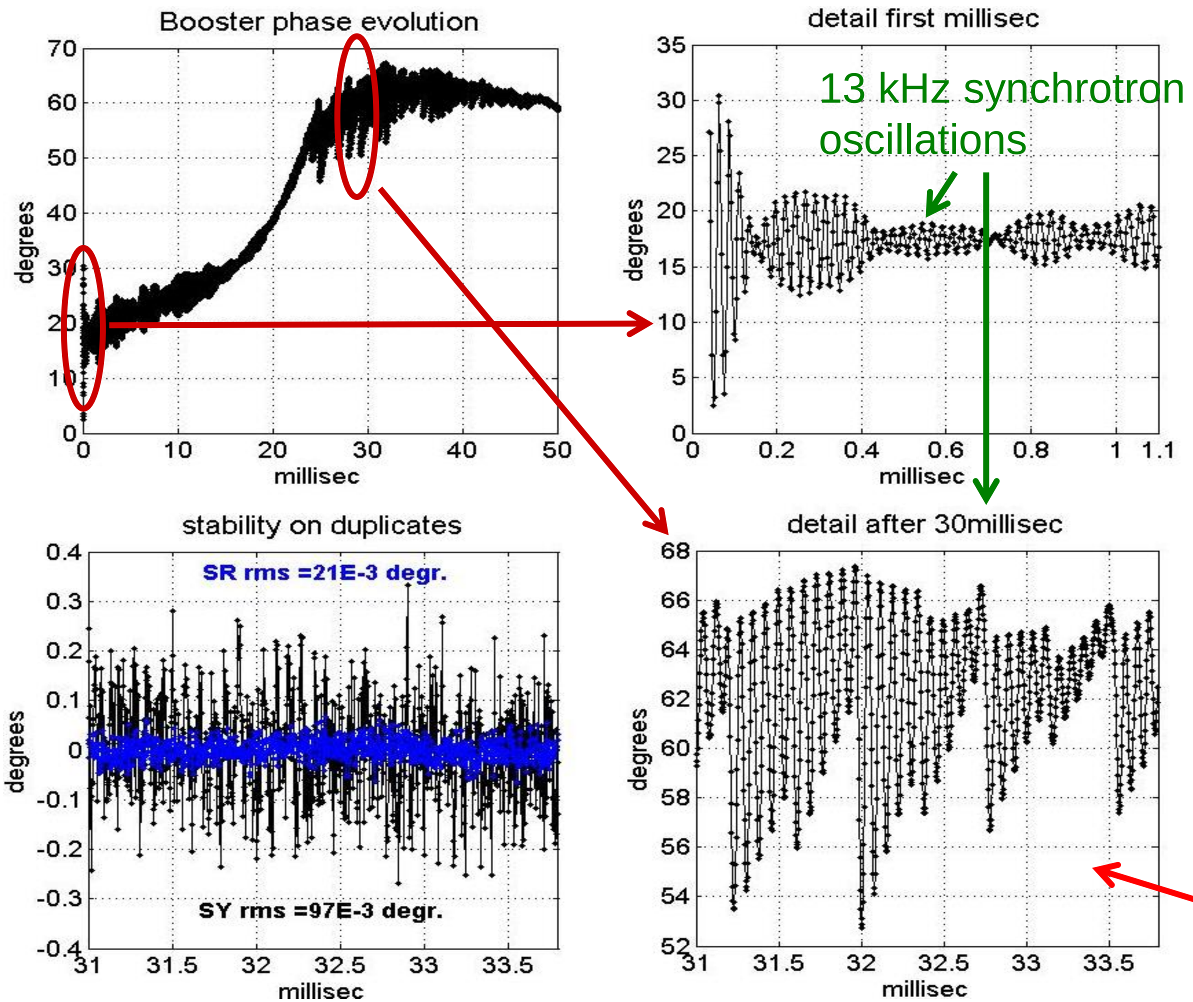


Calculated angles on the I/Q values of these two RF signals show a huge drift of about ~7 rad!



But the difference between these, now in degrees, shows a precise and stable differential phase measurement with an rms of $5.5 \cdot 10^{-3}$ degrees.

BOOSTER PHASE EVOLUTION



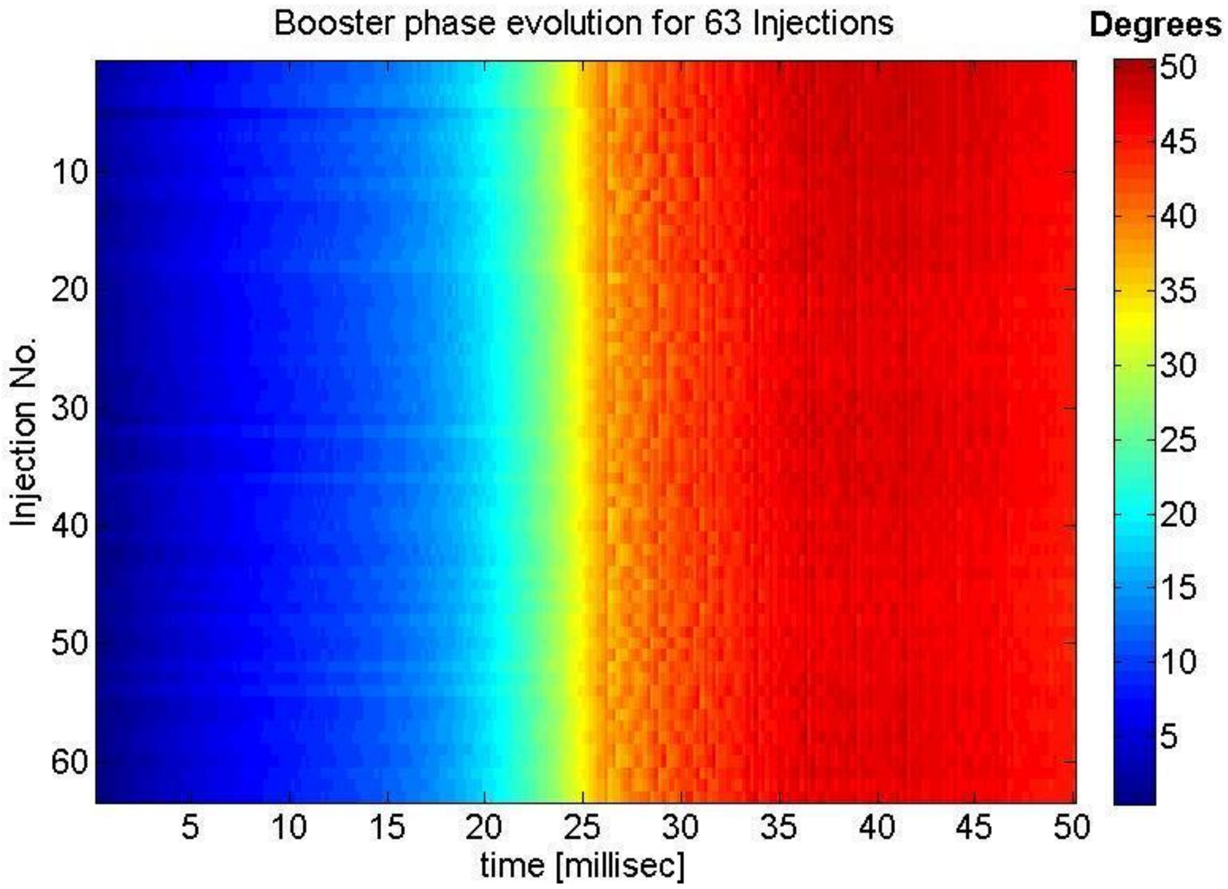
→ The SY beam phase is expressed with respect to the SR beam phase.

Reference phase is the storage ring

Global phase evolution of ~45° between injection and extraction from booster

1.1 kHz sawtooth oscillation (phaseloop feedback of booster cavity control)

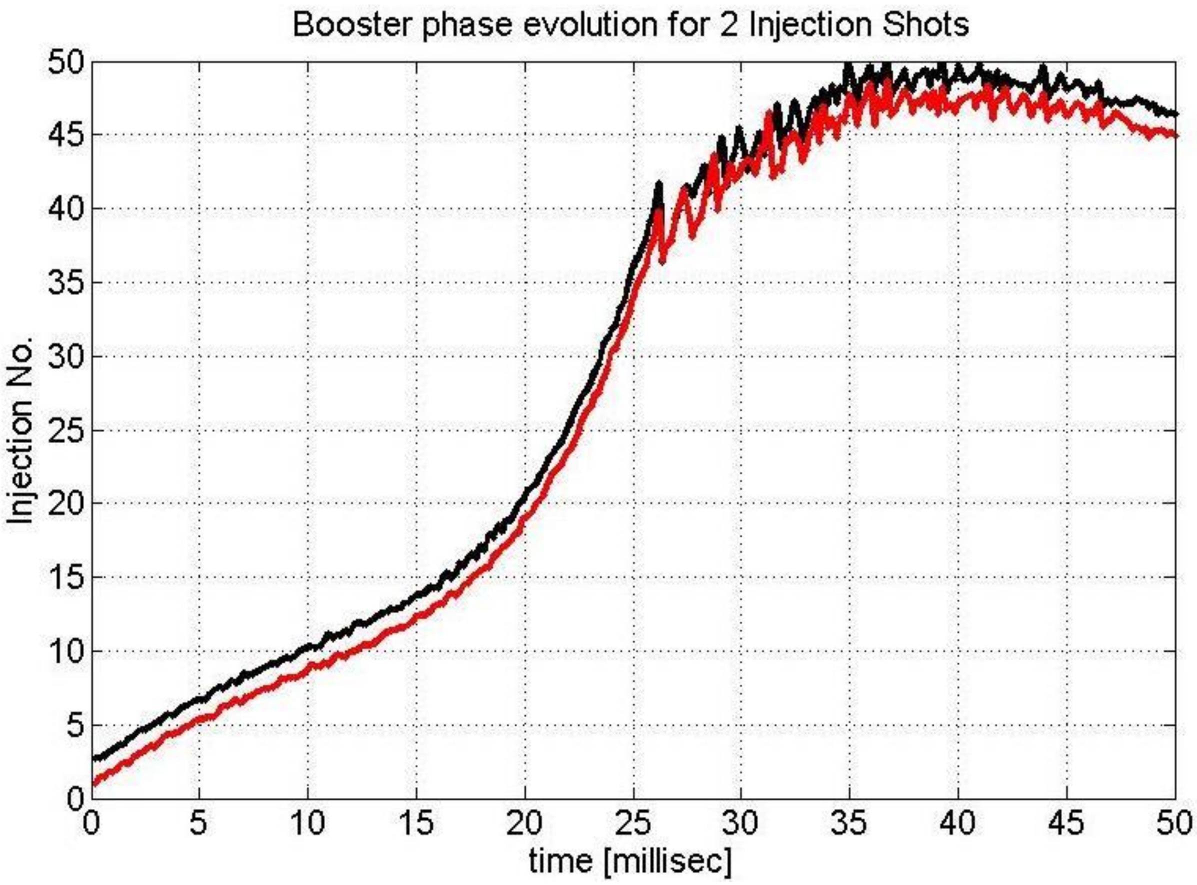
BOOSTER PHASE STABILITY



Phase variation is reproducible for many injections

Phase at extraction is constant

BOOSTER PHASE STABILITY



SY phase evolution during the acceleration cycle between the first (black) and the last (red) injection of a refill.

MOTIVATIONS

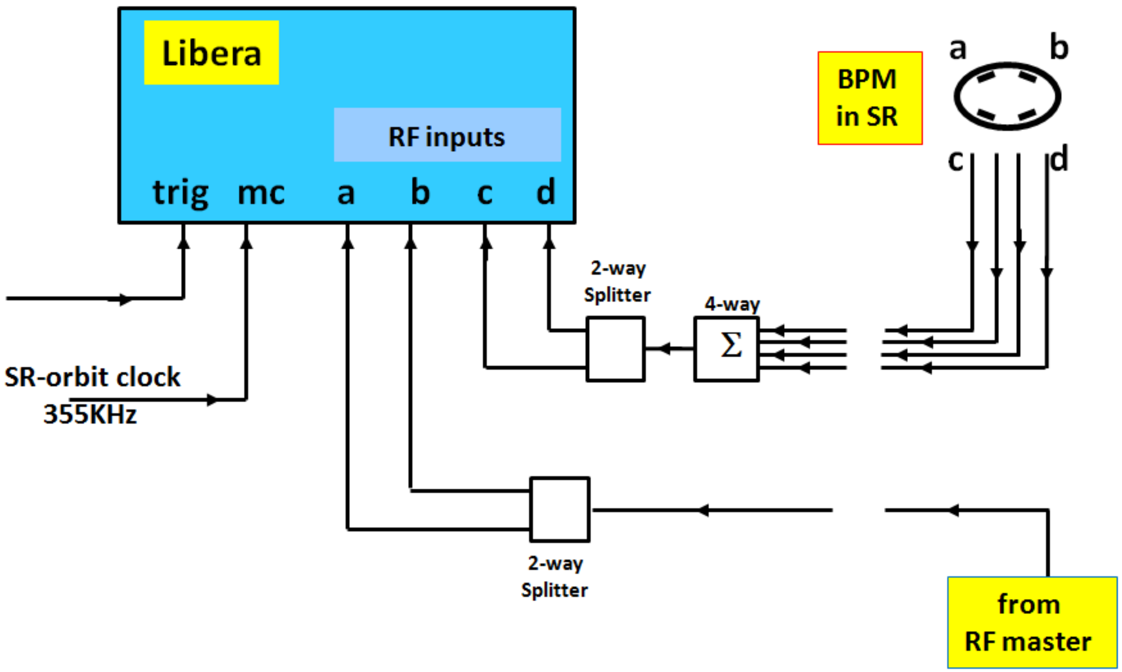
Why do we want to measure this phase?

→ Bunch arrival time at injection relative to RF bunch phase in the SR is important for injection efficiency.

It should stay constant in order to have an efficient injection in the SR.

→ It is also used for slow measurements of any phase drifts or phase evolutions (RF phase).

HARDWARE SETUP 2 – SR BEAM / SR RF



An identical system has also been added for phase measurements between the storage ring beam and the RF cavity signal.

→ The two units do not apply the so-called RF-crossbar-multiplexing calibration (essential for stable BPM measurements), nor any digital signal conditioning for amplitude and phase compensations. So each unit operates simply as a four-channel digitizer for RF signals of 352.2MHz.

ACKNOWLEDGEMENTS

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THANK YOU !