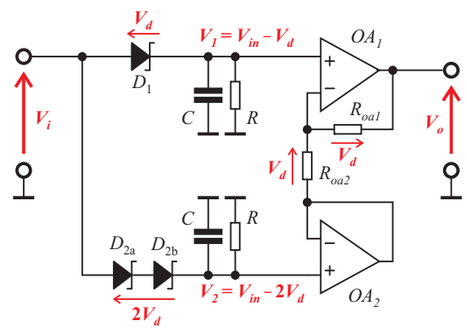
A high-resolution diode-based orbit measurement system – prototype results from the LHC

Marek Gasior, Jakub Olexa, Ralph Steinhagen, CERN

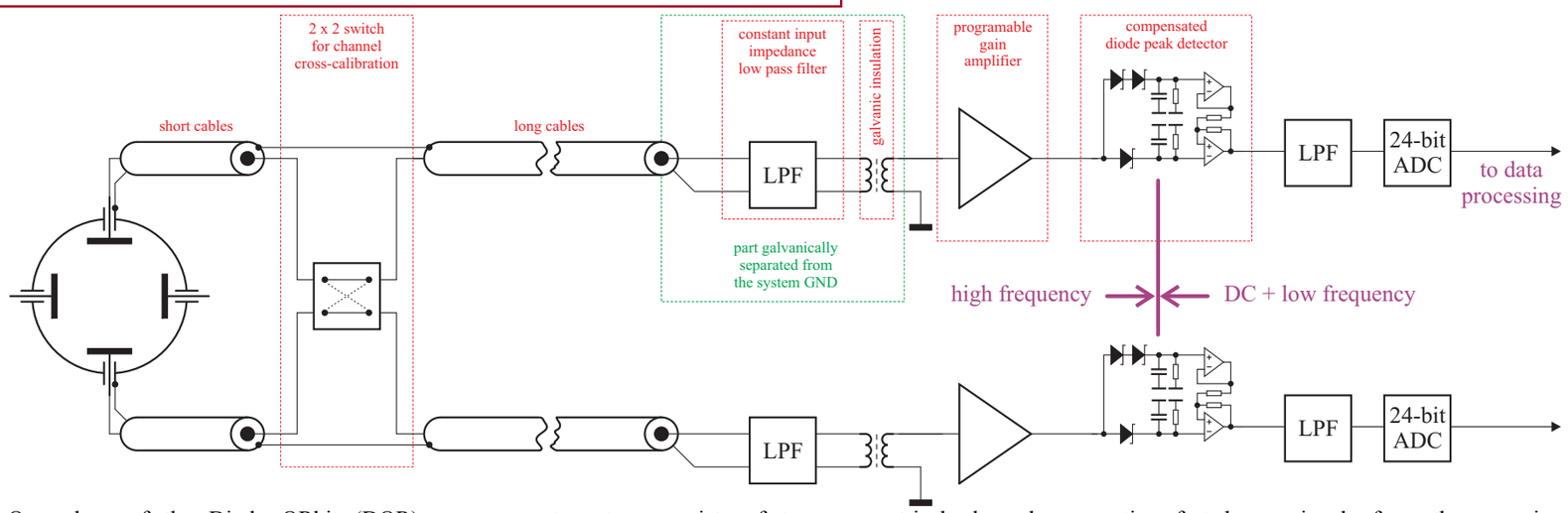
Abstract. The prototype of a high resolution beam position monitor (BPM) electronics based on diode peak detectors was tested with LHC beams. In this technique developed at CERN the short beam pulses from each BPM electrode are converted into slowly varying signals by compensated diode peak detectors. The slow signals can be digitised with a laboratory voltmeter or high resolution ADC. As presented in the paper, this technique allows resolutions in the order of 1 ppm of the BPM aperture to be achieved with a measurement rate in the Hz range. Ongoing developments and future prospects for the technique are also discussed.

Architecture



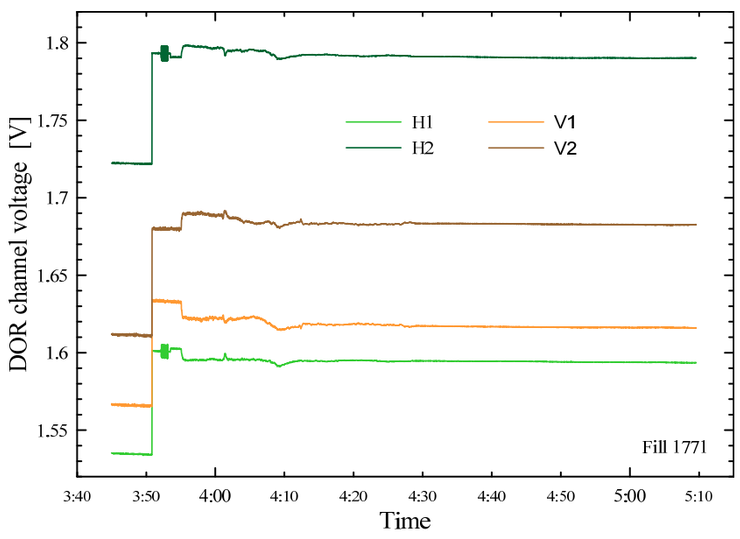
Functional diagram of the compensated diode peak detector.

The compensated diode peak detector consists of two peak detectors, one with single, and second with double fast Schottky diode, integrated into one package for good symmetry of the forward voltages and thermal coupling. The difference of the output voltages from both peak detectors is equal to one diode forward voltage V_d. This voltage is converted into current V_d/R_{oa2}, which in turn is converted back into V_d with $R_{oa1}=R_{oa2}$. In this way $2V_d$ is added to the output of OA_2, compensating $2V_d$ drop on the two diodes D_{2a}, D_{2b} and the output voltage V_o is equal to the input voltage V_i.

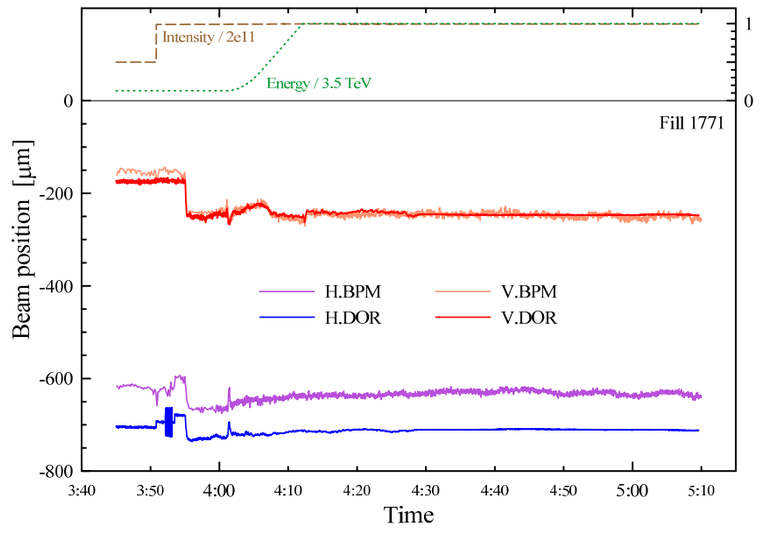


One plane of the Diode ORbit (DOR) measurement system consists of two symmetrical channels converting fast beam signals from the opposing electrodes of a position pick-up into slowly varying DC signals. The multiplexer is foreseen for cross-calibration of each channel pair.

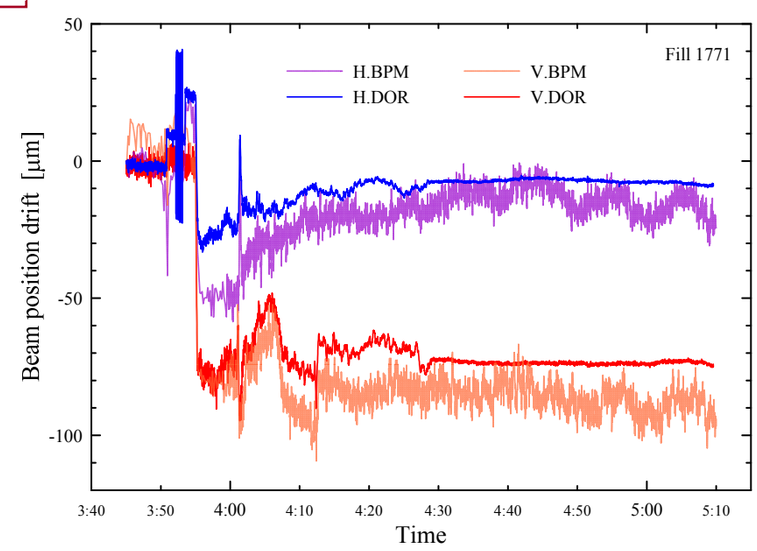
Measurements with the LHC beam



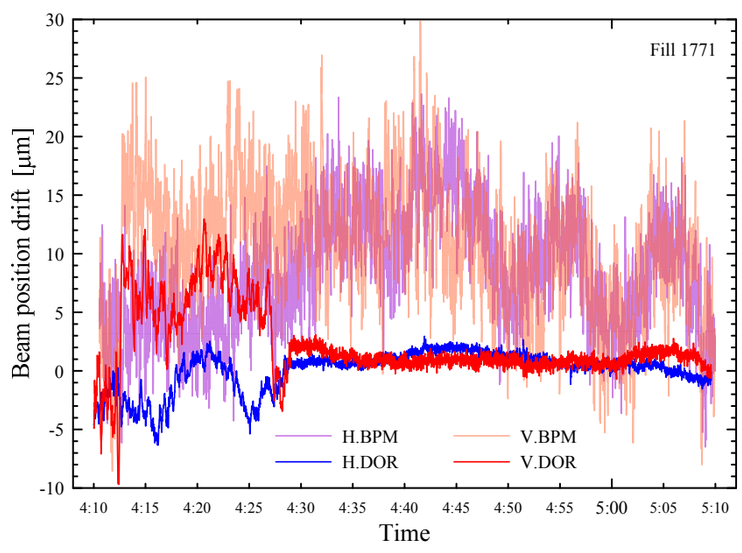
An example of Diode ORbit (DOR) signals acquired with a 6.5-digit laboratory voltmeter at 1 Hz. The DOR front-end was connected to an LHC short-circuited 150 mm stripline BPM of diameter 49 mm. 4 DOR channels were multiplexed with a mechanical relay switch.



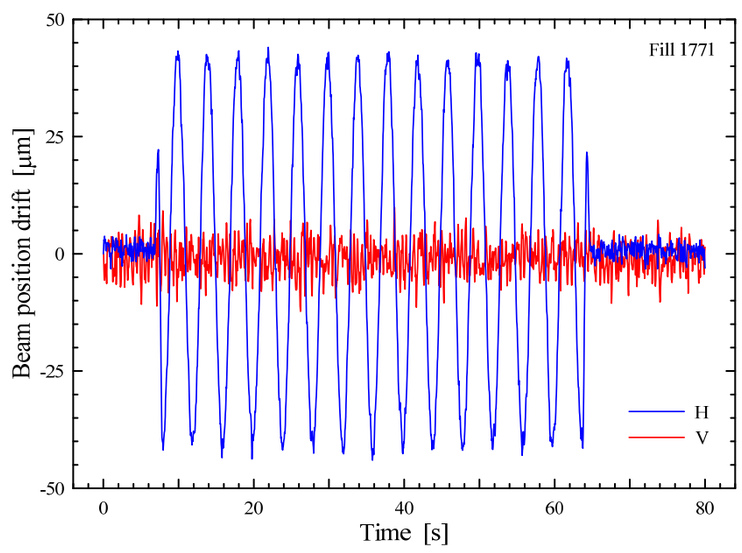
A comparison of beam position calculated from the shown raw DOR signals (theoretical stripline formula) to a standard LHC BPM. Pick-ups of both systems are physically next each other. The presented results are without any prior system calibration.



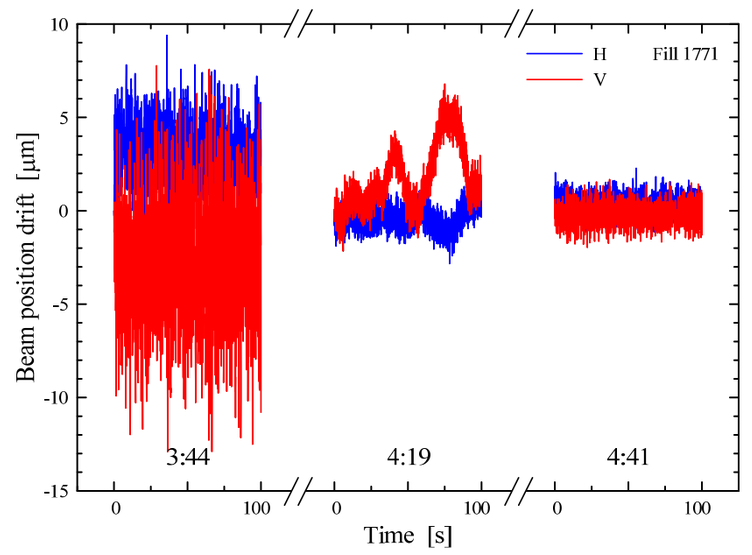
Beam positions as on the plot to the left, but with beam offsets removed at the beginning of the measurement. Around 4:29 the orbit feed-back (OFB) system was turned off.



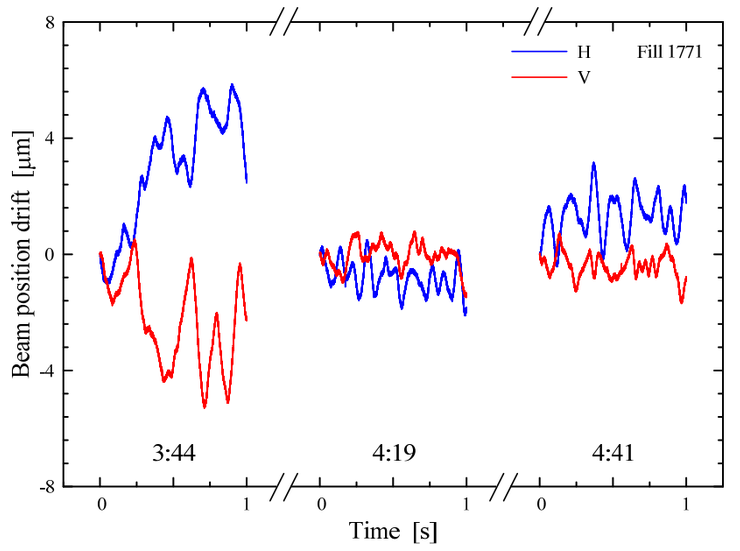
Last hour of measurements presented on the previous plot with beam offsets forced to zero at the end.



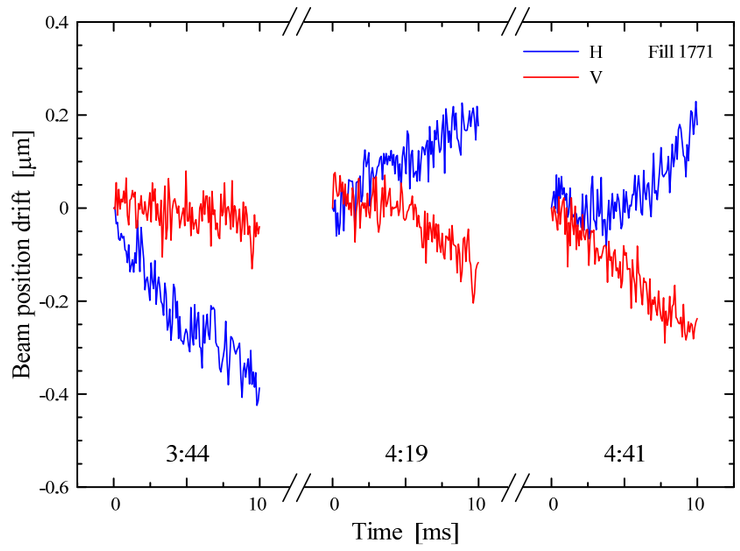
Zoom on beam positions during radial modulation ($\Delta p/p = 2\times10^{-4}$ at 0.25 Hz) seen also on the previous plots around 3:52. The DOR signals were acquired simultaneously (in parallel to the voltmeter acquisition) with 24-bit ADCs at 11.7 kHz.



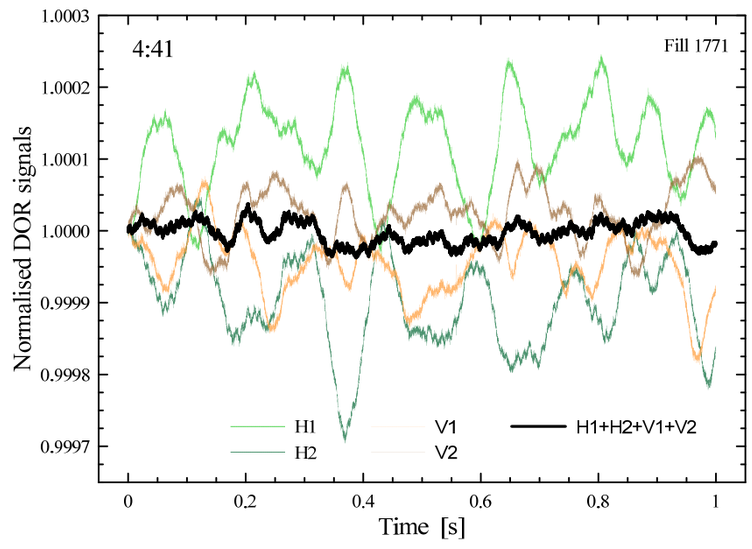
Zoom on 100-second DOR signal records around 3:44 – LHC beam at 450 GeV and OFB on, around 4:19 – beam at 3.5 TeV and OFB on, as well as around 4:41 – beam at 3.5 TeV and OFB off; ADC acquisition.



Zoom on the first second of the records from the previous plot. 3:44 – LHC beam at 450 GeV and OFB on, around 4:19 – beam at 3.5 TeV and OFB on, 4:41 – beam at 3.5 TeV and OFB off; ADC acquisition.



Zoom on first 10 ms (some 112 LHC revolutions) of the records from the previous plot. 3:44 – LHC beam at 450 GeV and OFB on, around 4:19 – beam at 3.5 TeV and OFB on, 4:41 – beam at 3.5 TeV and OFB off; ADC acquisition.



Zoom on the first second of raw DOR signals and their sum, record of 4:41, OFB off, ADC acquisition at 11.7 kHz.

ID: MOPD24, contact: marek.gasior@cern.ch