Continuous Beam Energy Measurements in Diamond Light Source

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Resonant Spin Depolarization

Resonant Spin Depolarization is a high precision energy measurement technique which is based on the natural spin polarization due to the emission of spin-flip radiation.

The spin of the electrons is polarized antiparallel with the main guide field of the bending magnets.

The precession frequency of the electron spin without significant solenoid magnetic fields nor electric fields depends on the energy:

$$\Omega_z = \omega_0(1+\alpha\gamma)$$

where, ω_0 is the revolution frequency, α the gyromagnetic anomaly of the electron and $\alpha\gamma$ the spin tune.

The beam is excited by a horizontal magnetic field produced by a vertically oriented stripline. The magnetic field oscillates at frequencies that match the fractional part of the spin tune and when a resonance occurs the spin starts to tilt away from the vertical axis, resulting to beam depolarization. Beam losses dN/dt due to Touschek scattering depend on the polarization of the beam:

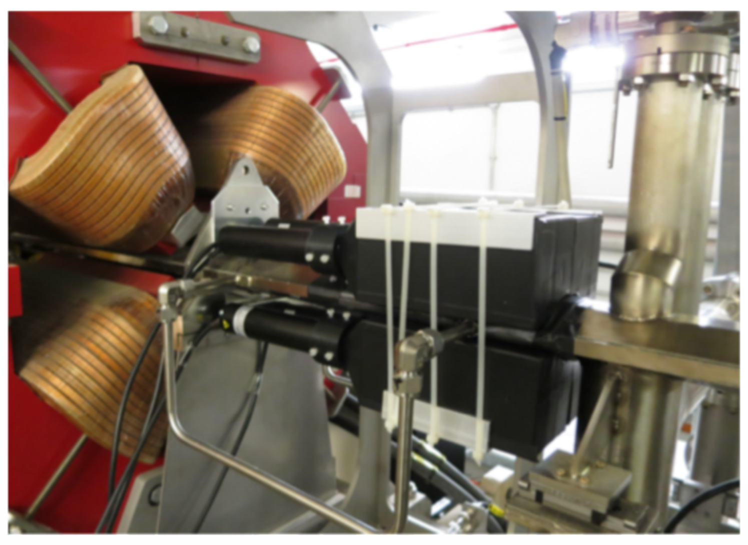
$$R_{norm} = \frac{1}{I(t)^2}\frac{dN}{dt} \propto f_1 + f_2 P(t)^2$$

where, $I(t)$ is the stored beam current and the functions f_1 , f_2 can be treated as constants for a given measurement.
Thus, a sensitive beam loss monitor is essential for detecting a rise in the beam losses due to spin depolarization.

Beam Loss Monitors Setup

Four blocks of scintillator EJ204 are attached with a photomultiplier and covered with 1.3 mm lead for protection from x-rays.

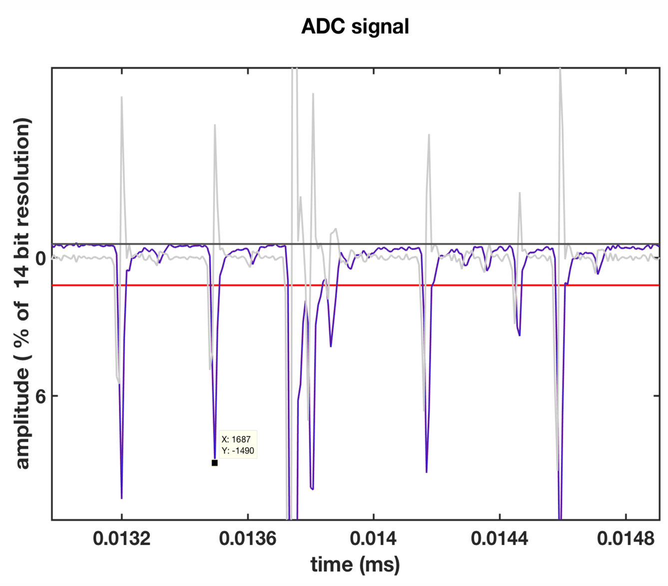
The detectors are connected with a Libera acquisition system with two hardware interface for signal output and for power supply and gain control voltage.



Four scintillator detectors installed in the storage ring of DLS.

Other characteristics:

- Impedance input of 50 Ω for short individual pulses.
- The inputs is digitised with 125 MHz sampling frequency.
- Signal processing: Differential counting.
- Gating using the revolution clock.

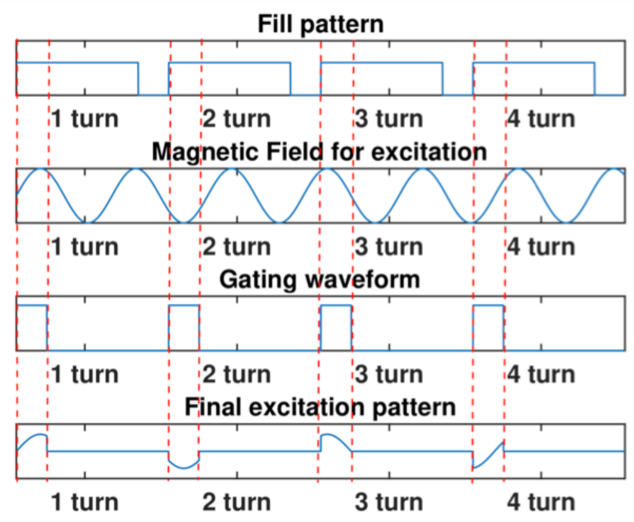


Continuous Measurements

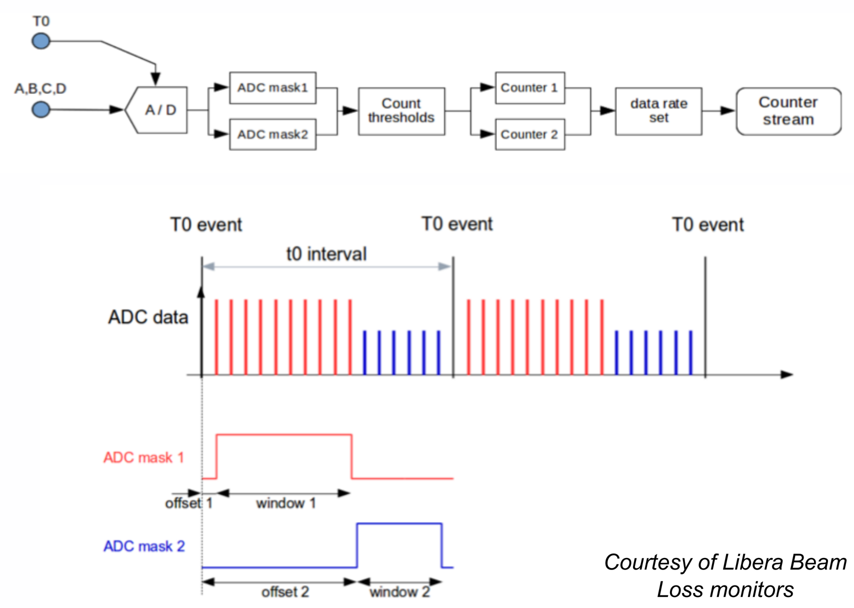
The goal of this project is to conduct energy measurements continuously, during user operation. However, beam losses from external factors could disturb the measurement.

The new approach introduces a gating in the excitation pattern and the acquisition system. The excitation is gated to half of the stored bunches and the acquisition system counts losses in both halves independently.

Excitation



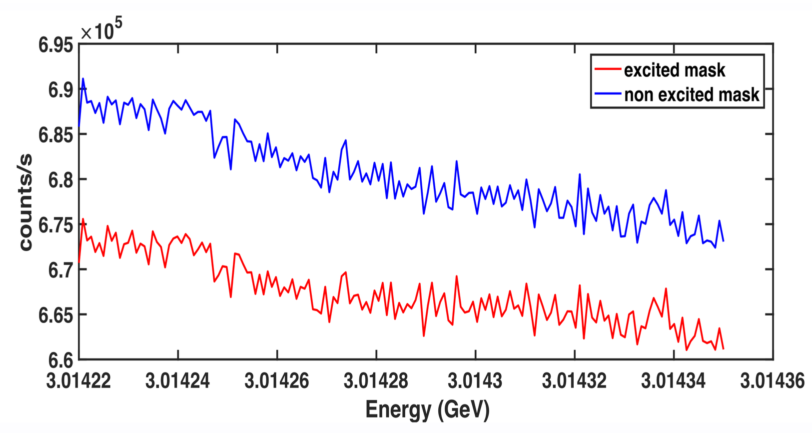
Beam loss detection

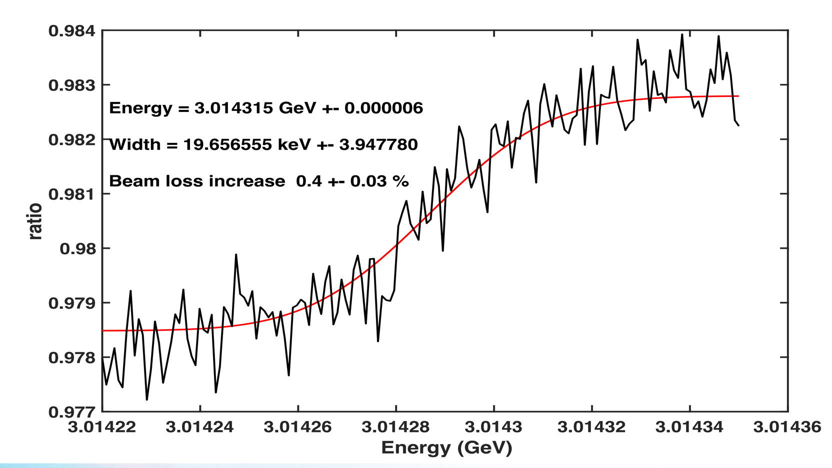


Courtesy of Libera Beam Loss monitors

Results

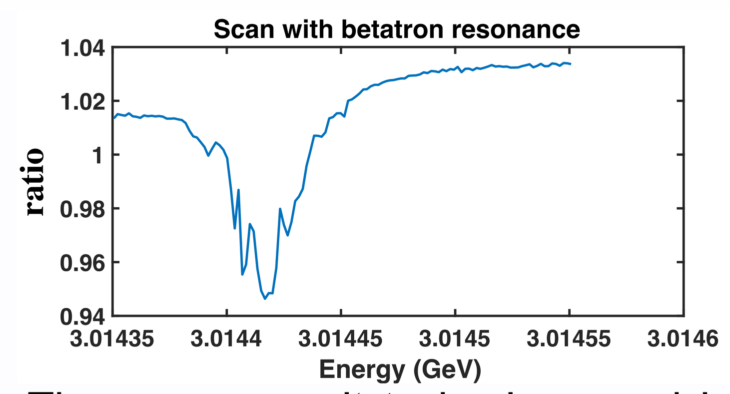
The masks have been set in order to record same amount of losses. The beam losses from the excited and non excited part of the beam are illustrated. The ratio between the two measurements, suppresses external factors that modify the loss rate and shows the depolarization of the beam.

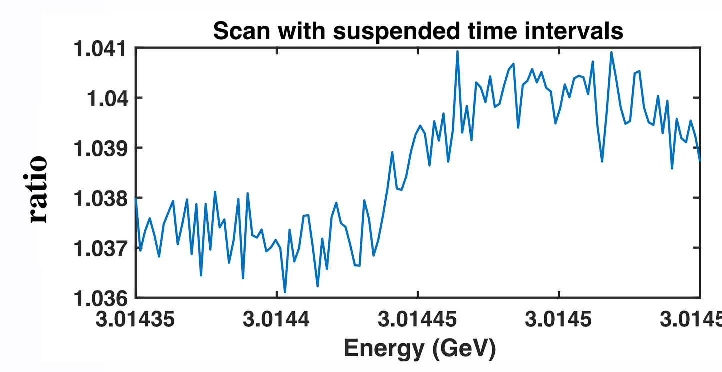




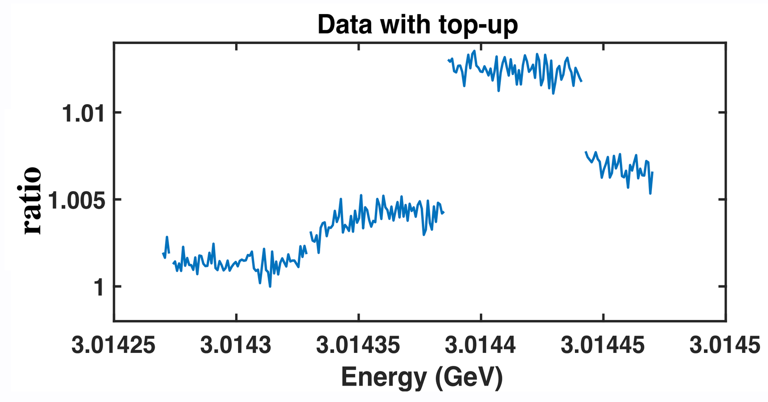
Method Optimization

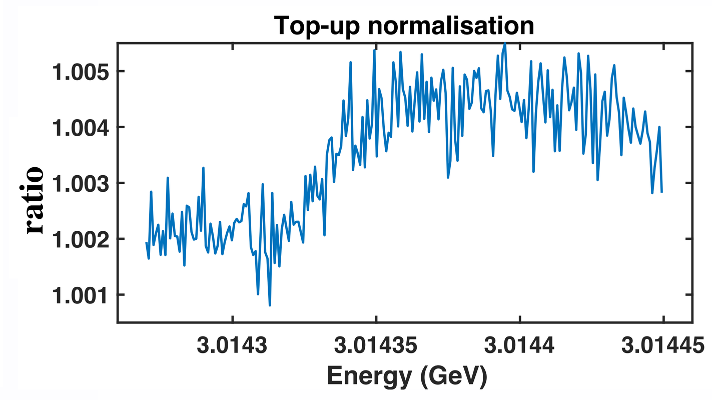
- During the excitation some higher order betatron coupling resonances create losses that disturb the reading of the losses due to depolarisation. For this reason, after every excitation in each frequency, the scan is suspended for one minute, the beam losses due to betatron resonances fade and only the losses due to depolarisation remain.





- The scans result to be long and last more than ten minutes that is the time interval of each top-up. Normalization due to charge inequalities in the two masks is shown.





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