Energy Measurements with Resonant Spin Depolarization 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:

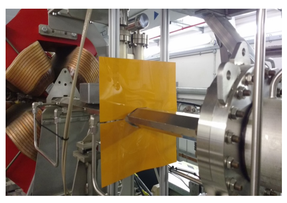
$$R_{norm} = \frac{1}{I(t)^2}\frac{dN}{dt} \propto f_1 + f_2 P(t)^2$$

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.

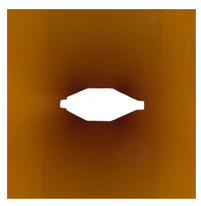
Beam loss monitors Design

A radiochromic film was used to measure the radiation footprint in the location where the detectors would be installed.

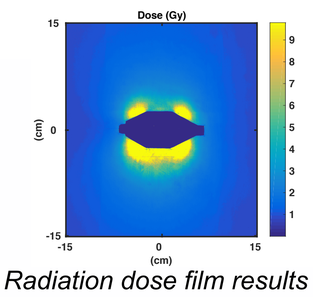
This information was used for the design of the detectors that are dedicated for the energy measurements. With this geometry, the highest fraction of the lost particles can be captured, and small fluctuations of the beam losses can be detected.



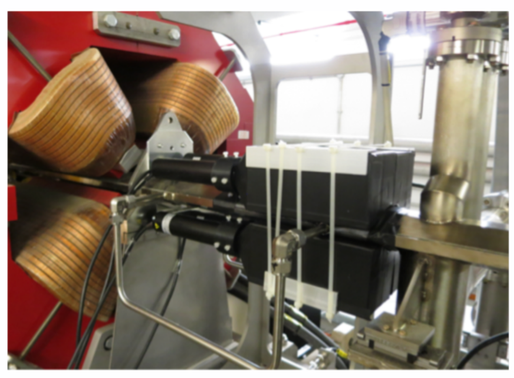
Radiochromic film in the storage ring.



Radiochromic film results.



Radiation dose film results in Grays (Gy).



Four scintillator detectors installed in the storage ring of DLS.

Four scintillator detectors were installed around the beam pipe and attached to photomultipliers.

The detectors were covered with 1.3 mm lead for protection from x-rays.

Signal acquisition and data analysis

The monitors are connected with a Libera acquisition system with two hardware interfaces:

- SMA for signal output.
- RJ-25 pinout for power supply and gain control voltage.

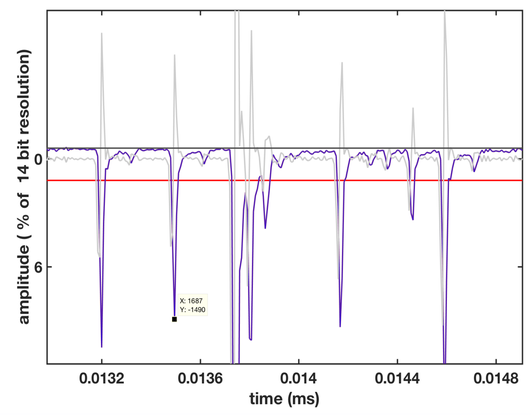
Other characteristics:

- Impedance input of 50 Ω for short individual pulses.
- The input is digitised with 125 MHz.

Hardware interfaces of the Libera instrument.

<u>Signal processing: Counting</u>

When the ADC signal exceeds the threshold increments the counter by 1.
However, pile up events prevent to count all the occurring events.
Differential counting was used instead of normal counting to counteract this problem.

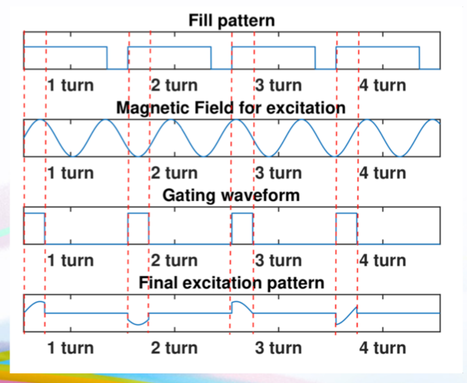


Continuous Measurements

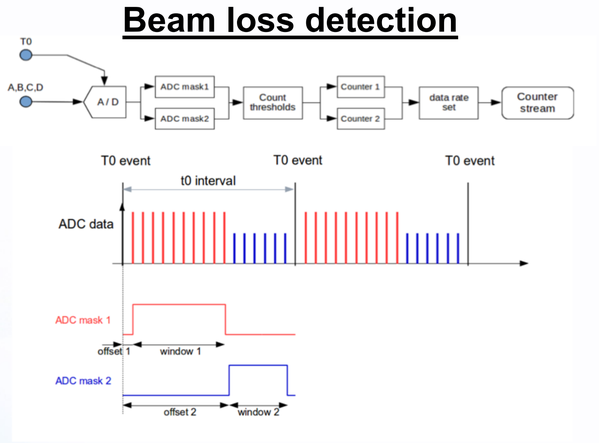
The goal of this project is to conduct energy measurements continuously, during user operation. However, beam losses from external factors could disturb the measurement.

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

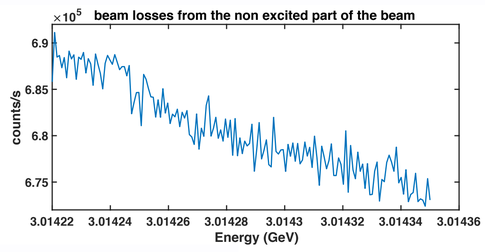


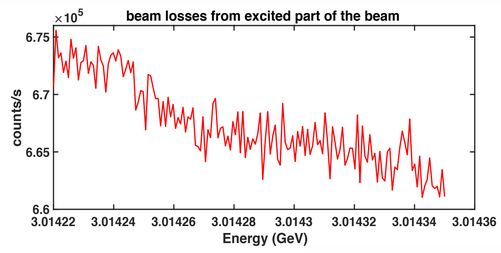
Beam loss detection

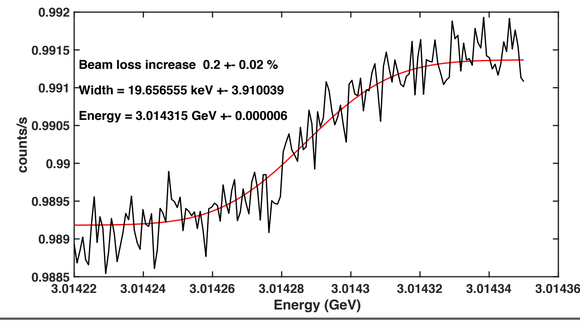


Results

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.







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