Libera Beam Loss Monitors used for Energy Measurements in Diamond Light Source

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Outline

- Resonant Spin Depolarisation
- Libera beam loss monitor
- Results

Resonant Spin Depolarisation

- High precision energy measurements technique.

- <u>Sokolov - Ternov effect:</u> spins of beam particles are oriented in the same way under the influence of synchrotron radiation when they circulate in storage rings for a long time

- Precession frequency of the electron spin depends only on the beam energy:

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

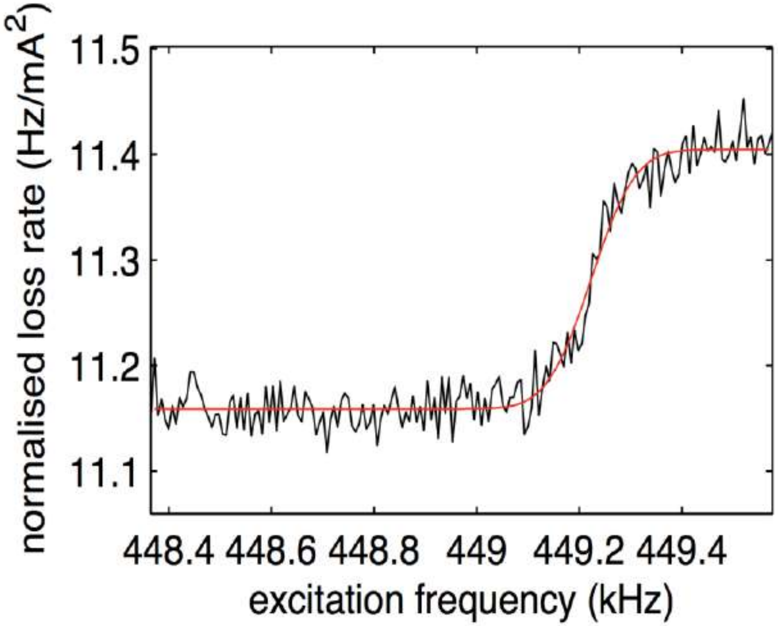
Resonant Spin Depolarisation

- The beam is excited by a horizontal magnetic field produced by a vertically oriented stripline
- The frequency is set to any harmonic to the spin tune and the polarization can be coherently rotated away from its equilibrium orientation.

- Depolarization -> Touschek scattering -> beam losses.

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

- Need for a sensitive beam loss monitor to capture the largest fraction of the radiation footprint resulting from beam losses.



Touschek scattering

- Loss mechanism driven by large angle Coulomb collisions in the electron bunch.
- Transfer momentum from transverse -> longitudinal motion.
- Electron can exceed the longitudinal acceptance limit.
- Touschek scattering occur in pairs ->coincidence signal from two beam loss monitors.

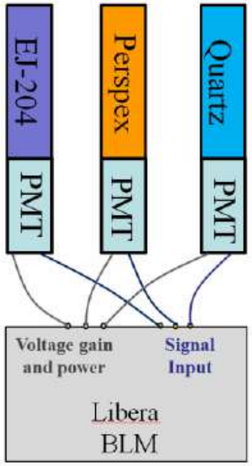
Setup

Beam loss detector -> Light production from charged particles + Light collection

Three beam loss detectors were built and studied.

- Rod 15 cm long 3 cm diameter attached to a photomultiplier.
- Three types of material tested:
  - EJ-204 plastic scintillator
  - Perspex
  - Quartz fused glass (Cherenkov radiator)

Detectors are covered with a lead layer of 1.3 mm thick to protect the detectors from X-rays.

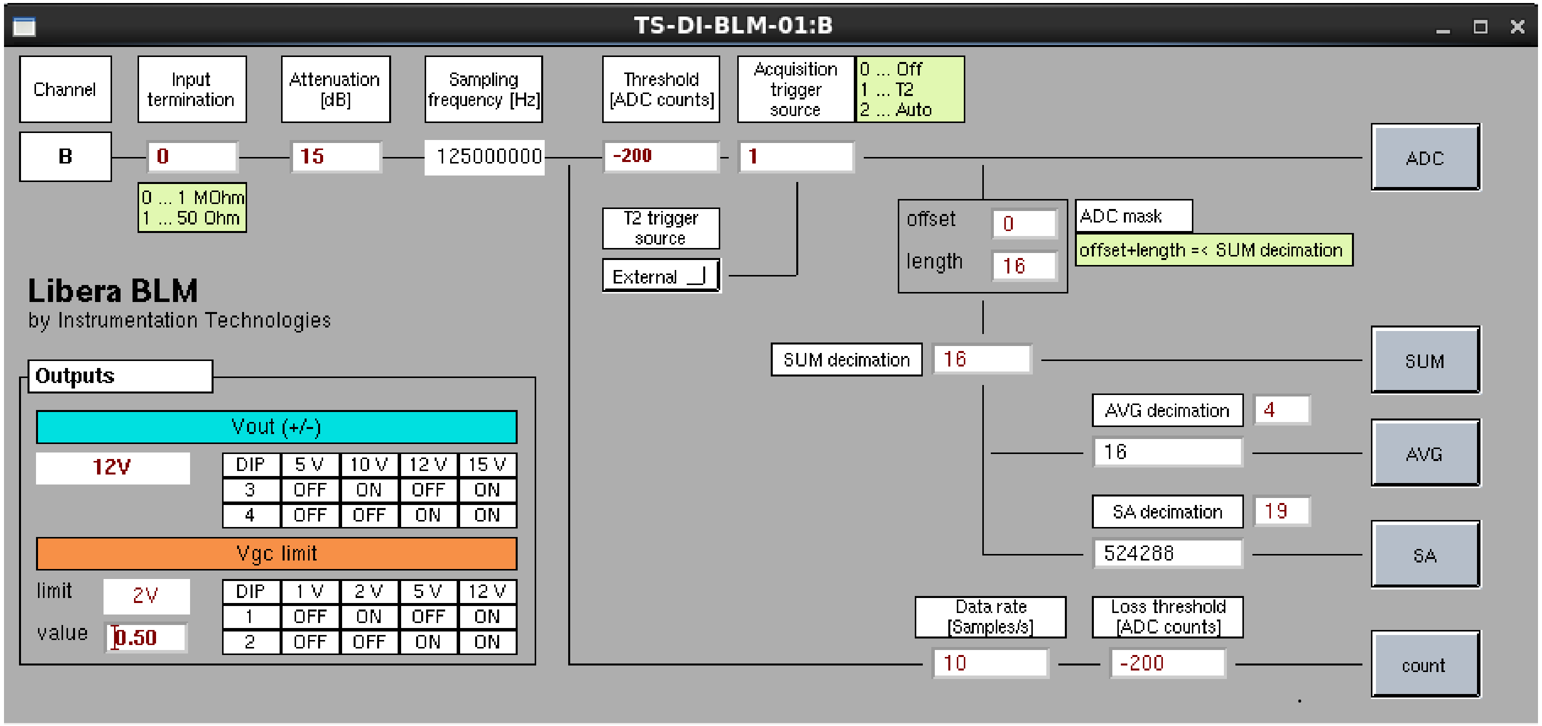


Signal acquisition

The detectors are connected with a Libera BLM instrument with two hardware interfaces:

- 4 SMA coaxial connectors for signal output.
- External triggering.
- 4 RJ-25 connectors for:
  - power supply
  - gain control voltage

Software Interface

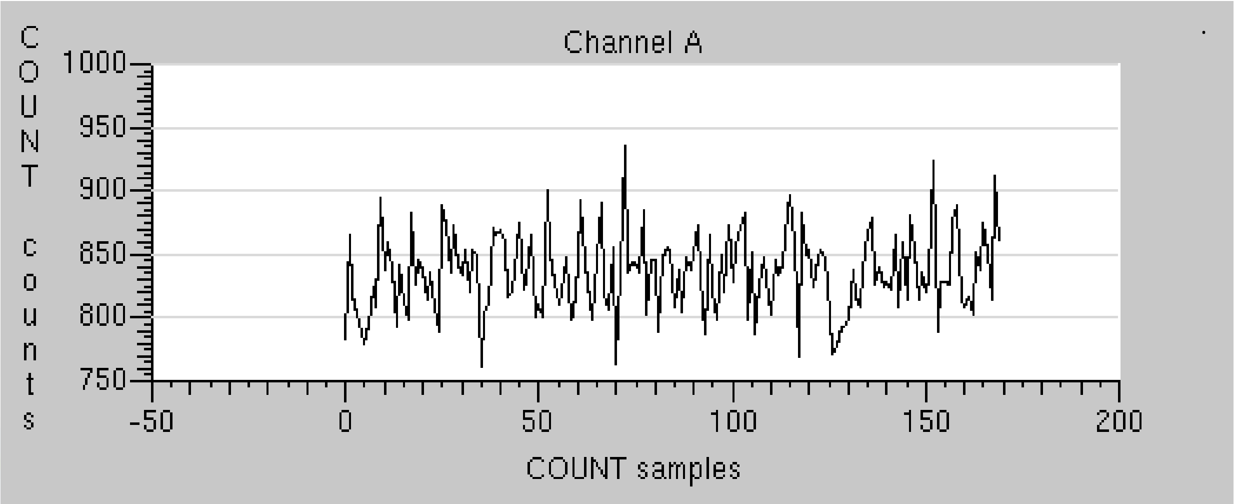


<u>Parameters that can be set:</u>

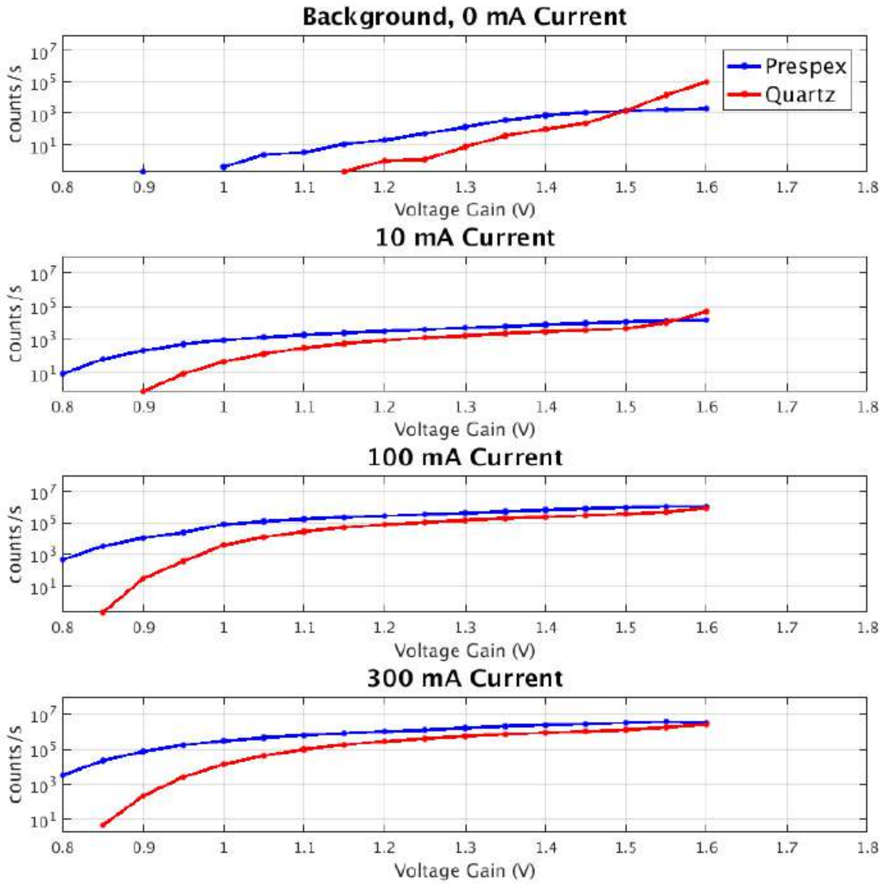
- Input impedance for fast or low losses
- Attenuation
- Sampling frequency
- Threshold and output data rate in count mode
- Triggering
- Gain of the Photomultiplier

Count samples

- The ADC data is continuously monitored for the negative peak value in each input channel.
- Every ADC sample that exceeds the threshold value increments the counter by 1.
- Data rate = 10 samples/s



First comparison results



The three detectors were tested.

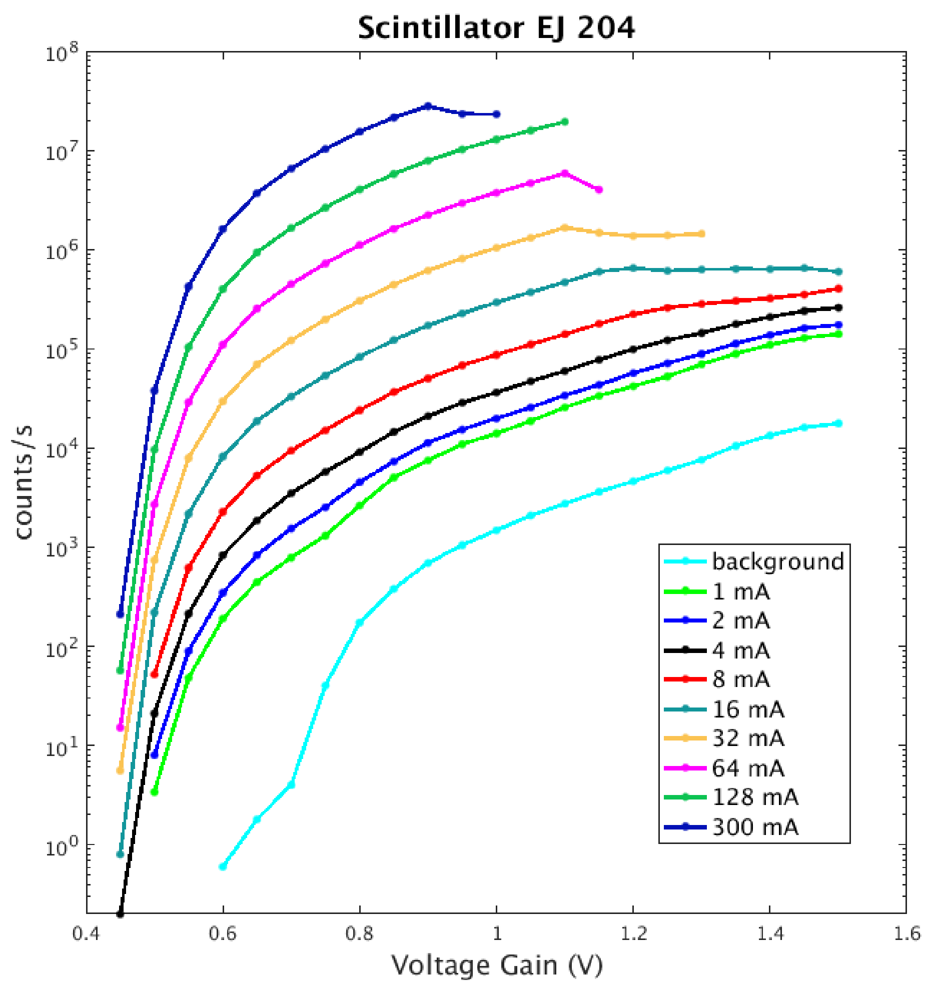
Perspex and Quartz are compared.

Perspex gives higher count rates than Quartz.

Scintillator EJ -204 revealed a problem for nominal operation current of the machine.

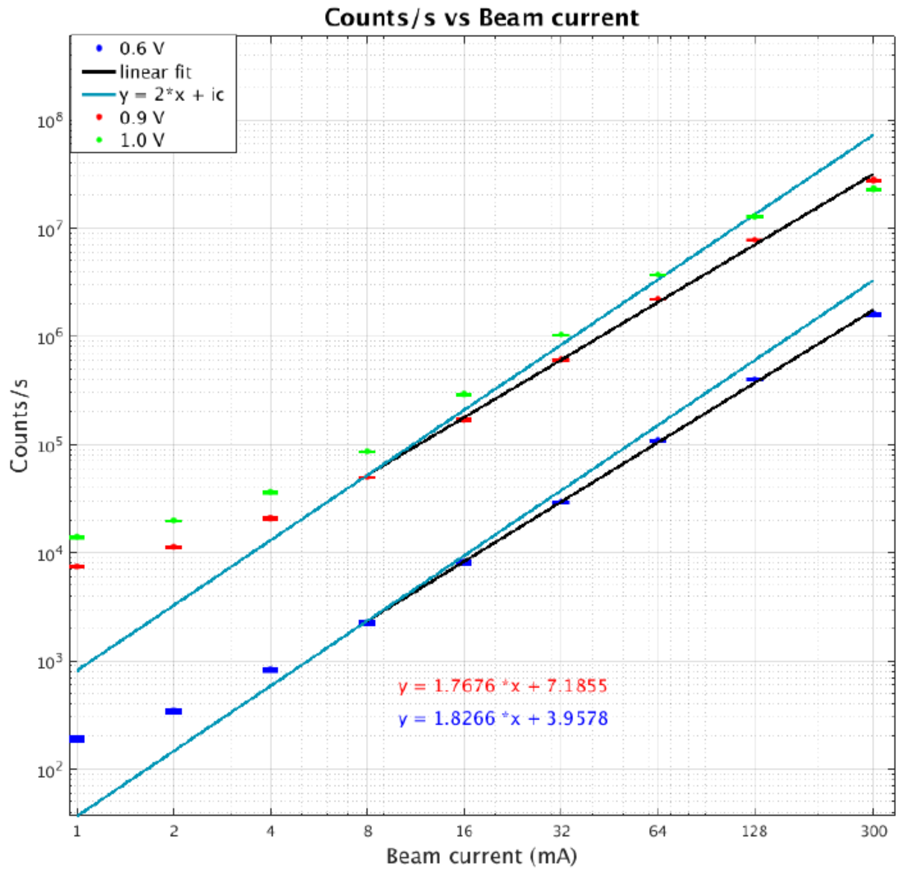
Further investigation needed.

Scintillator EJ-204 performance



- Counts/s rate was measured for various beam currents in the machine.
- The voltage gain is scanned and the mean value of 50 measurements is plotted.
- The photomultiplier connected to the detector is saturated for high values of voltage gain.
- As the beam current is increased the saturation is more intense.
- Evidence that scintillator produces high amount of light that the PMT cannot handle it.

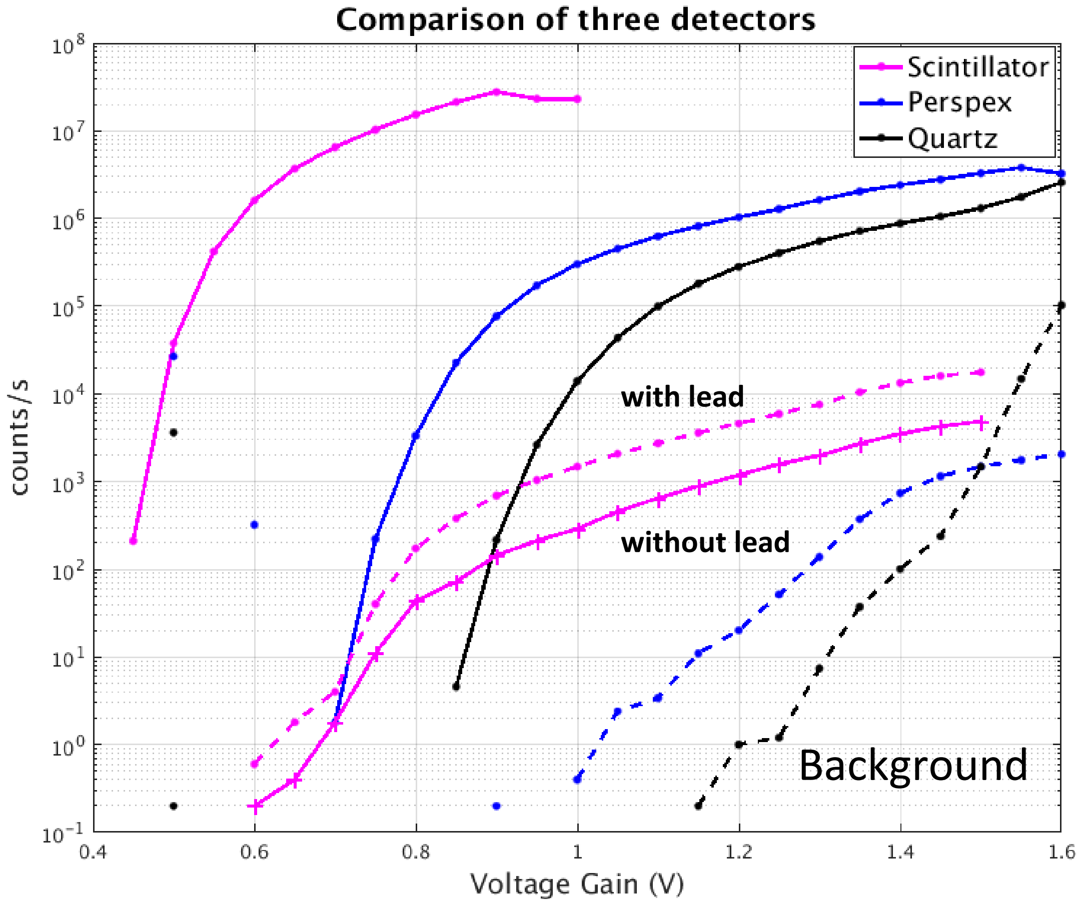
Choice of PMT gain voltage



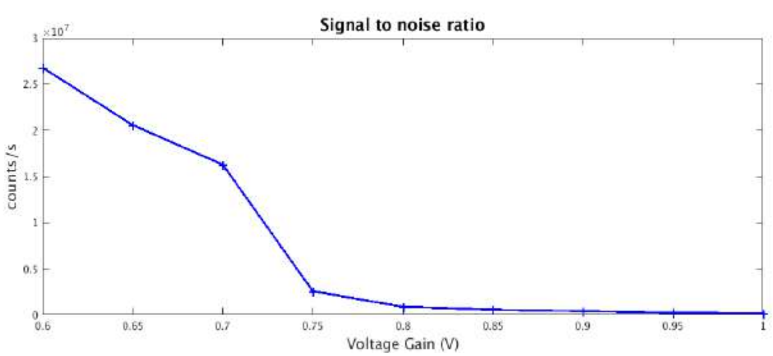
- Beam losses increase with the beam current.
- Data were taken for various voltage gains in the photomultiplier.
- Counts/s rate is proportional to the square of beam current (linear regions).
- For 300 mA nominal beam current in the storage ring low voltage gains in the PMT are chosen.

Final results

300 mA beam current



- Two different data sets were combined for the comparison of the detectors performance.
- Background events (dashed lines) are included.
- Scintillator maximum count rate is 7 times higher than perspex count rate.
- Without lead the background is reduced.
- No need for high voltage gain.
- Scintillator best performance confirmed.



Conclusion

- Beam loss detectors were tested.
- Libera beam loss monitor was used for data acquisition.
- Linear region of our photomultiplier was investigated.
- Scintillator EJ-204 is the most sensitive and brightest detector of our test.
- The detector material of the beam loss monitors for our project was addressed.