Investigation of magnetic field inside Belle II spectrometer

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What is Belle II

Operation of Belle II detector at SuperKEKB [1], e+/e- asymmetric collider, designed to study B meson decays, have started in springtime 2019. Key features of Belle II and SuperKEKB are:

1. High precision vertex detection (aimed for B decay)
2. Very high beam currents of 3A
3. Use of nano-beam technology
4. Target luminosity at end of experiment: 50 ab-1.
5. Clean collisions resulting from colliding leptons at energies tuned to desired observable

Investigation overview

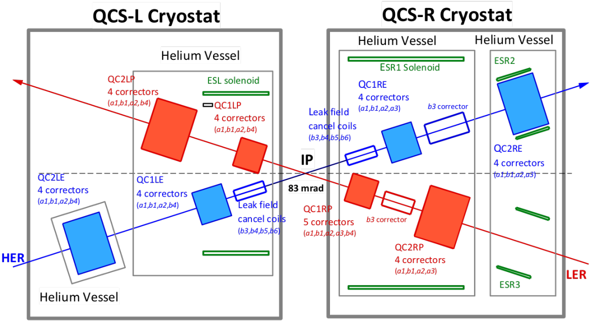
To achieve high data quality, precise field map is necessary. Aim: field map better than 0.1%.

Combination of following methods was used:

1. Initial Final Element Method simulation.
2. Mapping of whole tracking volume, in solenoid field only
3. Mapping of accessible volumes with of full magnetic system.

Magnet system of Belle II

Around Interaction Point, complex magnetic system is present [1].



1. Superconducting solenoid, 4,4 kA, 1,5 T.
2. Final focus quadruples. Both: superconducting and permanent magnets. Integral field gradients up to 22.91 T.
3. Compensating solenoids.

Initial simulation

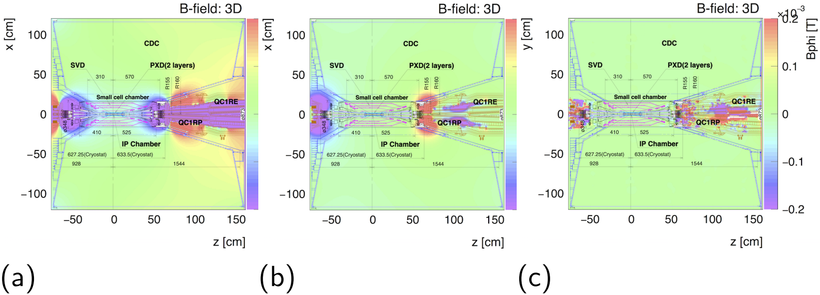


Figure: Magnetic field strength in x-z plane from simulation (model 1A): (a) Bz (b) Br (c) Bϕ components. The Belle II detector drawing is overlayed.

Initial simulation and accessible regions

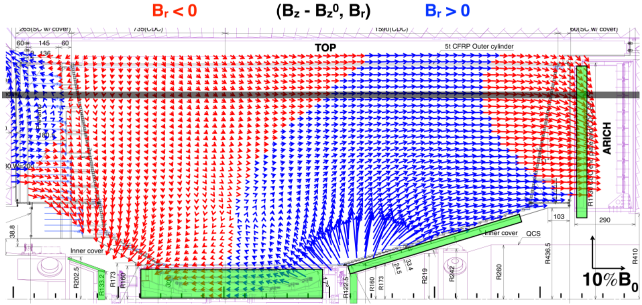
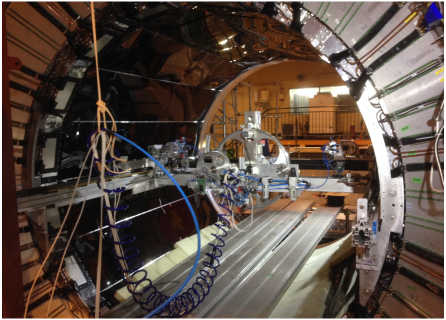


Figure: Initial estimate of field, created by accelerator development group[3], using Opera-3D (TOSCA) [2]. Green color highlights regions accessible when full magnetic system is present, black bar represents radial limit of whole volume measurement.

First measurement campaign

First measurement was of full tracking volume, but only before beam optics magnets where installed, in June 2016. Mapping robot was provided by B-field mapping & Magnet support group from CERN [5]. System consisted of linear set of 34 3D Hall probes, fixed to plate parallel to diameter of the main solenoid. Using pneumatic drive, said plate was motorized, allowing it to rotate as well as slide along axis of the solenoid.



First measurement vs initial simulation

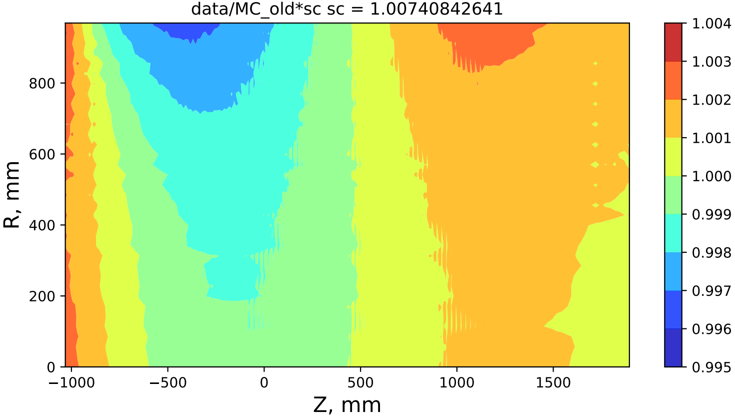
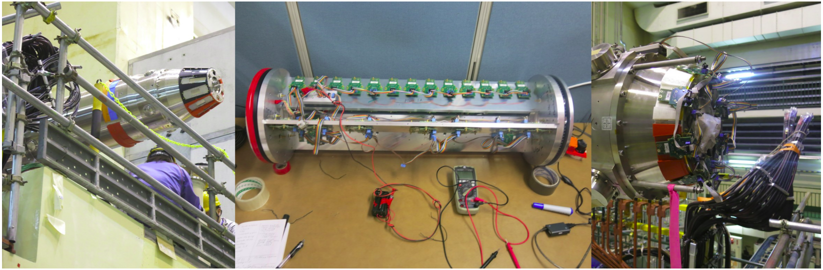


Figure: Ratio between 2016 measurement and initial simulation

Second measurement campaign



Measurement, of full set of magnets, in accessible regions, was performed in summer 2017. Robotized mapper consisted of three planes with total of 43 sensors.

Using piezoelectric motor plates where rotated around solenoid axis. Additional 46 sensors were fixed to surfaces of magnet cryostat and Central Drift Chamber using 3D printed structures.

Second measurement results

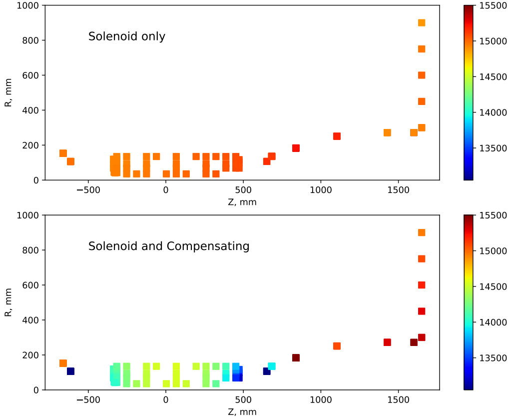


Figure: The B field generated by Belle II solenoid only and with compensating solenoids

D0 measurement quality

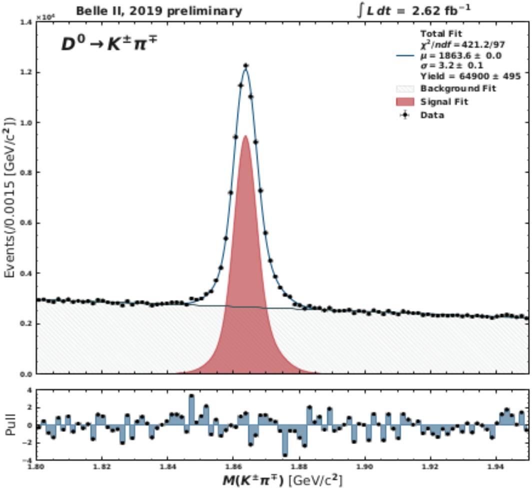


Figure: Preliminary D0 reconstruction[6].

Ongoing and future work

Current effort concentrates providing map with improved description just outside of 2016 measurement volume.

Cosmic muon track shape provide indication of map imperfections at larger radii.

Precise checks are done using secondary decays of $K_s \to PiPi$. Variation in mass distribution width is useful to investigate spatial distribution of imperfections.

References

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The End

Ackowlegements

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