Magnetic Field Measurements Using 3D MSL Probe: Report and Analysis

Session Conducted on September 16-17, 2024, Encompassing Discharges #46271 to #46340

This report summarizes the results obtained from measurements of the magnetic fields generated (primarily) by poloidal field coils on GOLEM. The magnetic fields were measured with the MSL probe [1] and a set of four Mirnov coils.

1 Comparison of Magnetic Fields: MSL Probe vs. Mirnov Coils

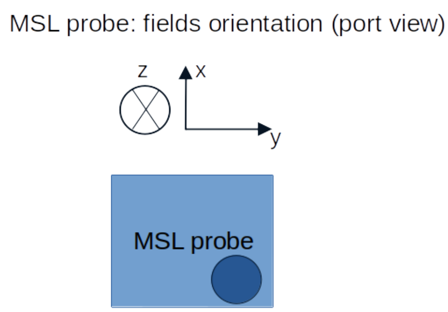


Figure 1: Orientation of the MSL probe in the chamber

1.1 Toroidal Magnetic Field Winding

The value measured by MSL was compared during experiments with the value of B_t measured with a standard diagnostic (MC coil). Since the values were comparable, we moved on to the main measurements.

Based on the known orientation of the probe in the chamber (shown in Figure 1) and the positive values of the measured signal, see Figure 2, it can be concluded that the default orientation of the toroidal magnetic field is anticlockwise (ACW).

1.2 Stray Magnetic Fields

1.2.1 Stray Field Generated by Toroidal Field Winding

Vertical component
Based on the results and suggestions outlined in the report dated April 26, 2024, a scan over U_{bt} was performed. The measured vertical stray magnetic field is shown in Figure 3.
Interestingly, the magnitude of the vertical stray field increases toward the high-field side (HFS). This observation challenges the claim that the stray field results from insufficient compensation of the toroidal field (TF)

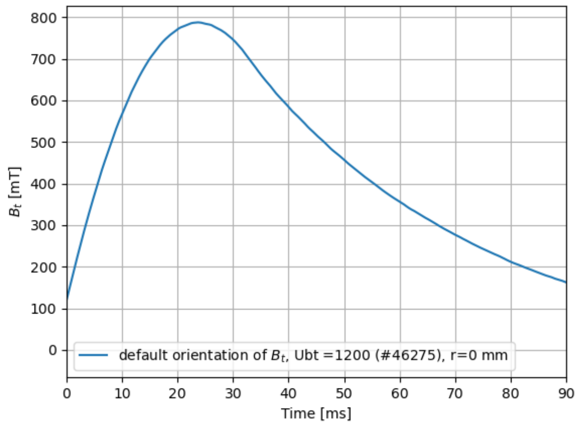
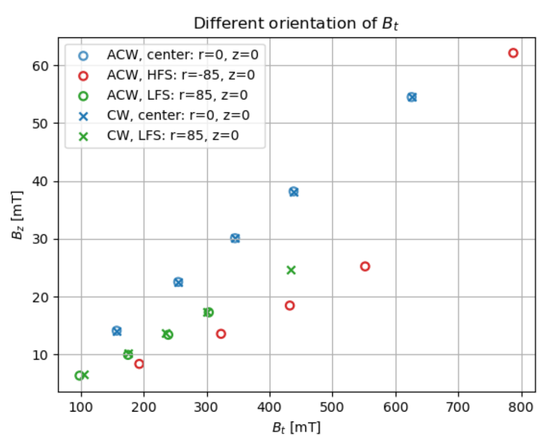


Figure 2: Measured toroidal magnetic field $B_t = B_y^{\mathrm{MSL}}$

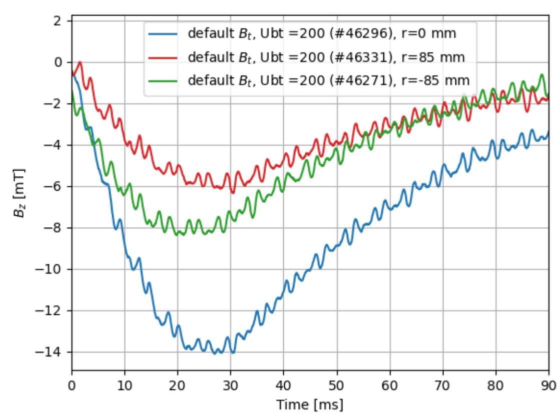
conductor. A possible explanation is that the field is enhanced by currents induced in the surrounding conducting structures.

Figure 4 illustrates the time evolution of the measured vertical field generated by the default horizontal stabilization setting and the stray field produced by the toroidal field coil winding. The different orientation of the fields suggests that the generated stray field may affect the plasma position, and an additional field (generated by horizontal stabilization PF coils) is required to compensate for it.

When comparing signal magnitudes, the stray field generated by the toroidal coils exceeds the maximum value that can be produced by the stabilizing winding after the first 2 ms.



(a) Maximum absolute value of the measured vertical component vs. maximum absolute value of the measured toroidal component of the magnetic field generated by the TF coils.



(b) Comparison of measured stray field signal generated by TF coils in 3 different radial positions.

Figure 3: Vertical component of stray magnetic field generated by toroidal field coils winding.

Horizontal component

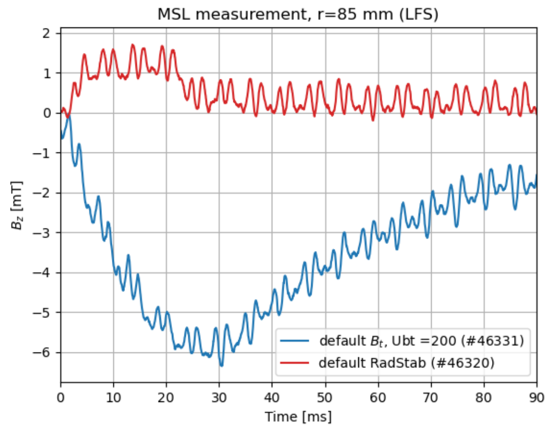


Figure 4: Comparison of the measured vertical component of the magnetic field generated by horizontal stabilization and toroidal field coils on the LFS

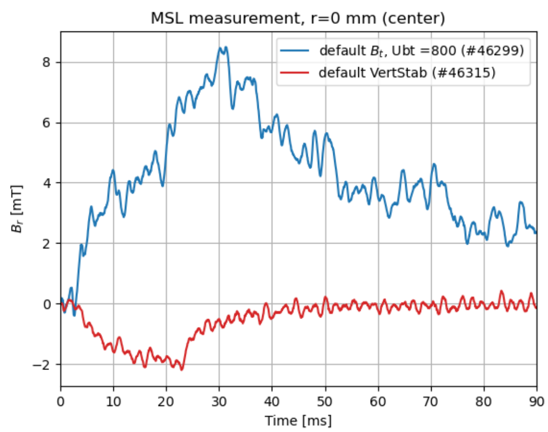


Figure 5: Comparison of the measured horizontal component of the magnetic field B_r generated by vertical stabilization and toroidal field coils at the center

2 Outlook

- It would be interesting to analyze the effect of the stray field generated by the toroidal coils on the plasma breakdown: generating the vertical field using a PFC such that the generated field compensates for the one generated by TF (in this case the magnitude of the generated field by PFC should be sufficient).
- Determine the exact origin of the vertical stray field generated when using TF coils (insufficient compensation of the field generated by the supply winding of the TF; positioning of the coils; currents induced in the surrounding conductive structures, etc.)
- Determine the effect of stray field generated by TF on plasma position (e.g. ideally by changing the direction of B_t while keeping E_t - can be difficult to breakdown)

References

[1] K. Kovařík, I. Ďuran, I. Boshakova, R. Holyaka, and V. Erashok. Measurement of safety factor using hall probes on castor tokamak. *Czechoslovak Journal of Physics*, 56:B104–B110, Oct 2006.