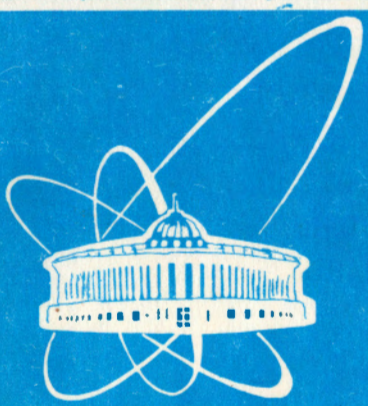

СООБЩЕНИЯ
ОБЪЕДИНЕННОГО
ИНСТИТУТА
ЯДЕРНЫХ
ИССЛЕДОВАНИЙ

Дубна

E9-97-390

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CALCULATION OF THE TileCal MAGNETIC FORCES USING 3D TOSCA MODEL

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1997

Морозов Н.А. и др. E9-97-390

Расчет пондеромоторных сил, действующих на тайл-калориметр, на основе пространственной модели в рамках программы Tosca

Целью работы является получение новой информации по распределению пондеромоторных сил, действующих на тайл-калориметр детектора ATLAS (LHC, CERN). Для оценки распределения поля вблизи различных областей, где вычислялись силы, была использована существующая пространственная модель детектора, построенная при помощи программы Tosca. Полученные подробные распределения сил вдоль различных поверхностей позволяют лучше понять механику функционирования системы.

Работа выполнена в Лаборатории ядерных проблем ОИЯИ.

Сообщение Объединенного института ядерных исследований. Дубна, 1997

Morozov N.A. et al. E9-97-390

Calculation of the TileCal Magnetic Forces Using 3D Tosca Model

The purpose of the given paper is to contribute to the new summary (taking into account the latest information) of magnetic forces, acting on various parts of the TileCal of the ATLAS detector (LHC, CERN). To get an impression of the field distribution in the vicinity of the objects under consideration of existing 3D Tosca field model of the detector was used. The detailed distribution of forces along the border of various parts of the system, derived here, is valuable for understanding the mechanics of system performance.

The investigation has been performed at the Laboratory of Nuclear Problems, JINR.

Communication of the Joint Institute for Nuclear Research. Dubna, 1997

Problem formulation

The purpose of the given paper is to contribute to the new summary (taking into account the latest information) of magnetic forces, acting on various parts of the TileCal (girder, Barrel, Extended Barrel, forward shielding disk)[1].

- *Estimation of the forces when both the solenoid and the toroid are on. It requires a truly 3D computer model of the system.*
- *Detailed distribution of forces along the border of various parts of the system.*
- *Coupling forces between the barrel and the extended barrel.*

Computer models

To get an impression of the field distribution in the vicinity of the objects under consideration the existing ***3D Tosca field model*** of the detector was used[2]. This model implies an ideal detector magnetic system (without any additional metallic objects). The information was used to calculate the field distribution at the iron-air interface surfaces for estimating the forces, acting on various parts of the TileCal.

The well known 2D POISCR program[3] and the 3D IE (constant magnetization) approach were also used[4] for the consistency cross-check of the 3D PDE (OPERA-3D) method.

Integrated forces, acting on various surfaces

The azimuthal force density values, integrated along the corresponding linear length of the surface (Z-length or R-length), are given in Figure 1. All of the coils (solenoid, BT and ECTs) are on. As was predicted in Ref. [5], the maximum force was applied to the girder surface and directed along the radius to the BT. The total radial force, acting on the girder part corresponding to the BT coil, would be about 1700 kN/coil. The value is in good agreement (for this type of calculations) with the value 1350 kN/coil indicated in Ref. [5,6].

The total coupling force between the Barrel and the Extended Barrel, pushing the finger region from the Extended Barrel side in the direction of the Barrel (along the Z-axis), is of the order of 500 kN. This force is connected with the solenoidal field to a large extent. There is an air gap of the order of 1 mm between the Barrel and the Extended Barrel.

The forces applied to the external TileCal surfaces (BT side of girder and ECT side of shielding disk) are largely defined by the fringe field of the toroids. Thus, they are close to zero when the toroids are off. Similarly, the forces applied to the internal surfaces are defined by the solenoid field and would be zero when the solenoid is off.

Force density distributions

Force distributions along the outer girder surface (averaged over azimuthal period 45°) is given in Figure 2.The magnetic field (absolute value) and the force distribution along the azimuth at the outer girder surface are given in Figure 3. In this Figure the azimuthal positions of the toroid coils (BT and ECT) are also shown schematically. As a consequence of the azimuthal variation of the force density on the outer girder surface, the maximum force applied to some of the TileCal Barrel modules (situated at ± 7.5° from the BT coils) is of the order of 180 kN. For the Extended Barrel modules it is ≈ 80 kN. In Figure 4 the total force, applied to various Barrel and Extended Barrel modules is given. The maximum axial linear density of the force acting on the module angular width can be estimated as follows:

$$3.5\ (\mathrm{MN/(rad*m)}) \times 2\pi / 64\ (\mathrm{modules}) \approx 34\ (\mathrm{kN/m}).$$

The field map at the midplane of the detector (Z=0) is given in Figure 5. The azimuthal variation of the field is quite clearly seen there.

The density of the coupling force between the Barrel and the Extended Barrel (along the Z-axis) has also azimuthal variation due to different girder magnetization from the BT side (see Figure 6).

The force distribution along the TileCal inner surface is given in Figure 7. There is no need to average the force density along the azimuth: no field variation takes place for these surfaces. The discontinuity in the curve corresponds to the TileCal crack region between the Barrel (left side of the curve) and the Extended Barrel (right side of the curve).

The force distribution along the shielding disk surfaces (averaged over azimuthal period 45°), as seen from the TileCal and ECT sides, is given in Figure 8 (part I, force density magnitude < 0.6 kN/(m×rad) and Figure 9 (part II, force density magnitude <40 kN/(m×rad).

Conclusions

- The maximum force is applied to the girder surface of the TileCal and is directed to the BT.
- As a consequence of the azimuthal variation of the force density on the outer girder surface, the maximum radial force applied to some of the TileCal modules is of order of 180 kN (barrel) and 80 kN (extended barrel).
- The forces applied to the external TileCal surfaces are defined by the fringe field of the toroids and they disappear when the toroids are off. Similarly, the solenoid defines the forces applied to the internal surfaces of the TileCal.
- The detailed distribution of forces along the border of various parts of the system, derived here, is valuable for understanding the mechanics of system performance.

Acknowledgments

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Many thanks also to our Dubna colleague O.V.Lomakina, helping us with preparing the graphical illustrations for the paper.

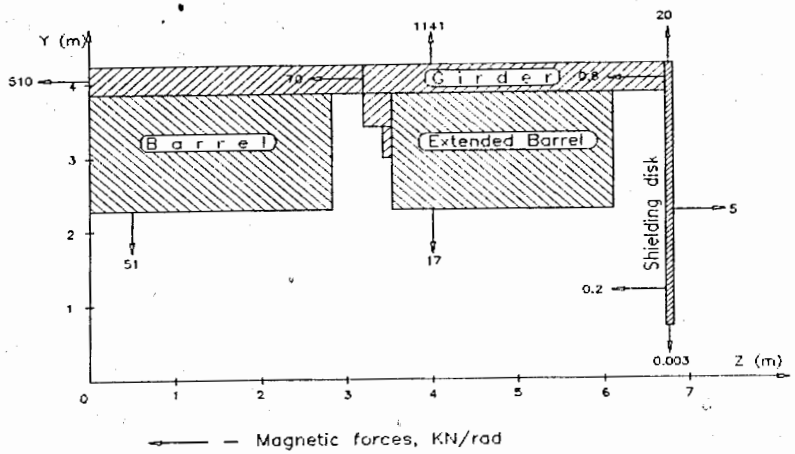

Figure 1 Magnetic force density, applied to various TileCal surfaces (averaged over azimuthal period 45°).

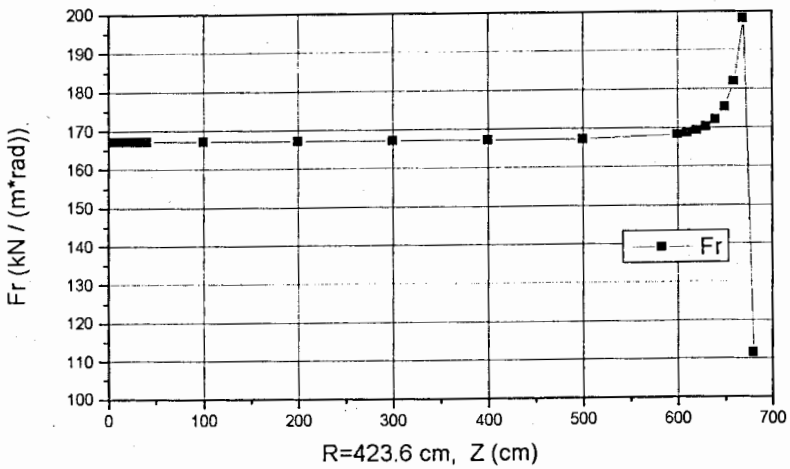

Figure 2 Radial force density distribution along the outer girder surface (averaged over azimuthal period 45°).

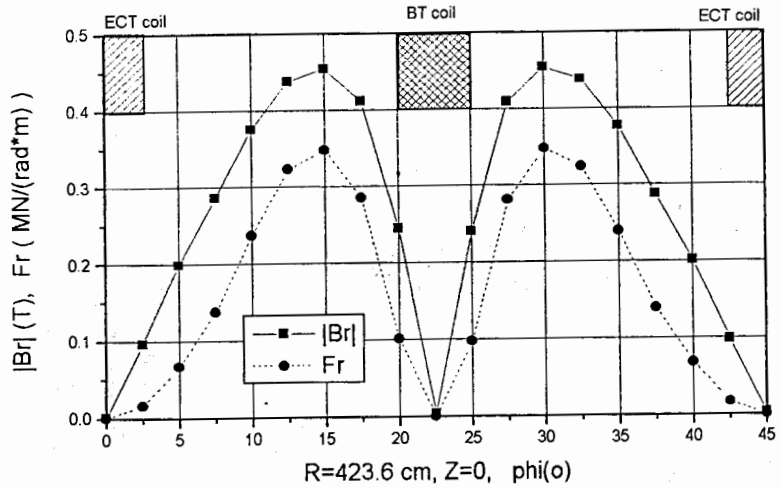

Figure 3 Magnetic field and radial force density distribution along the azimuth at the outer girder surface.

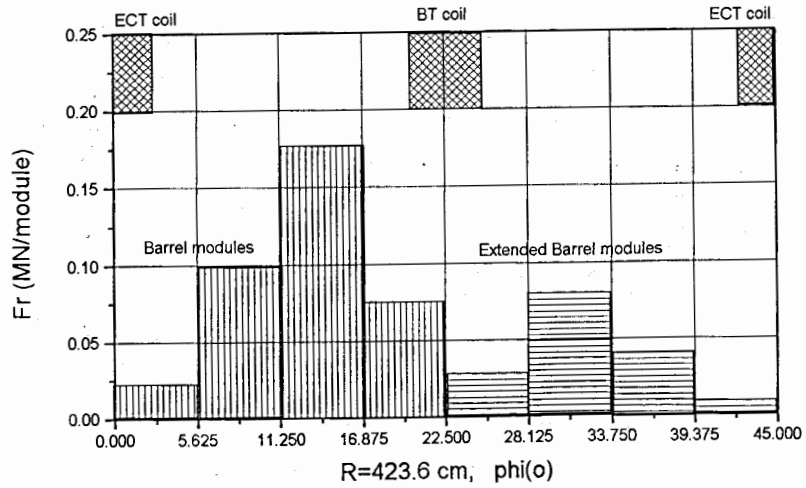

Figure 4 Radial force acting on various TileCal modules

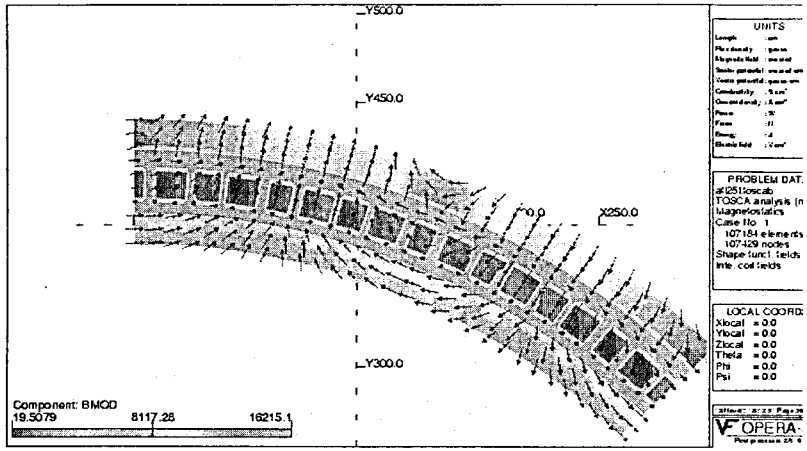

Figure 5 Field map in the girder region for Z=0

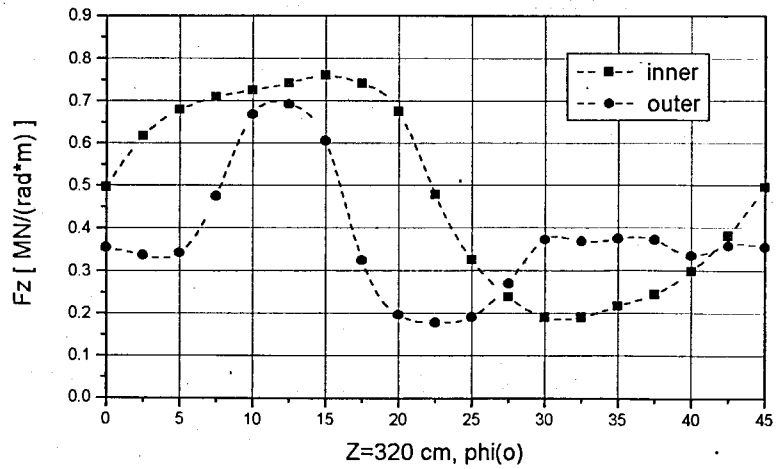

Figure 6 Axial force density distribution in the inner (R=390 cm) and outer R=418 cm) girder shells at the finger position (Z=320 cm).

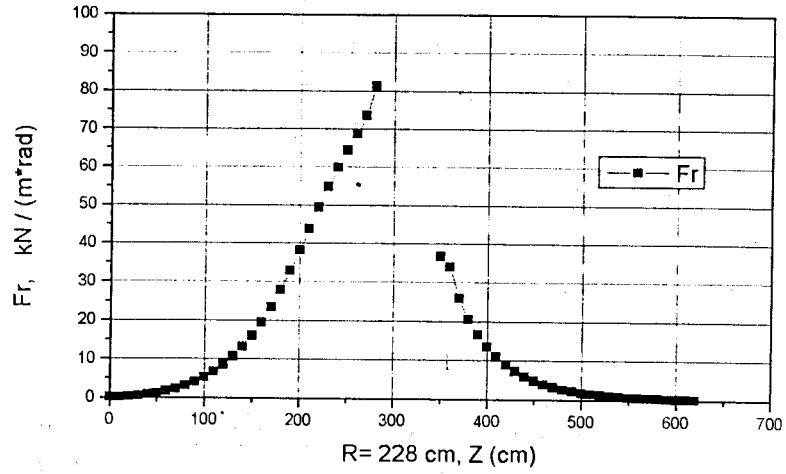

Figure 7 Radial force density distribution along the TileCal inner surface

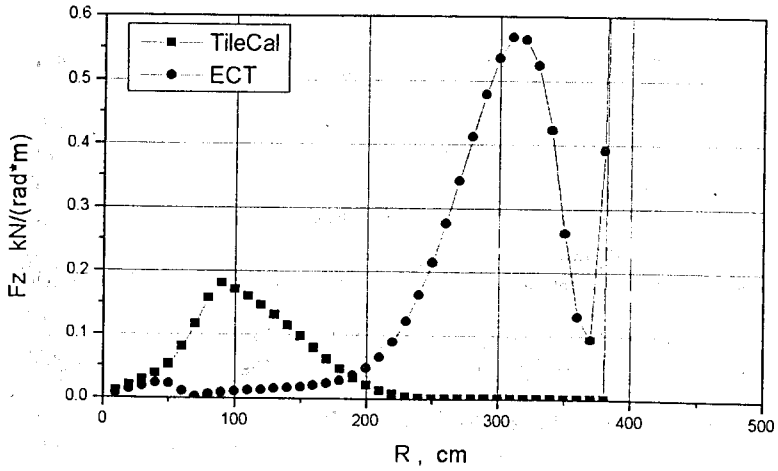

Figure 8 Axial force density distribution along the shielding disk surfaces (averaged over azimuthal period 45°), part-I.

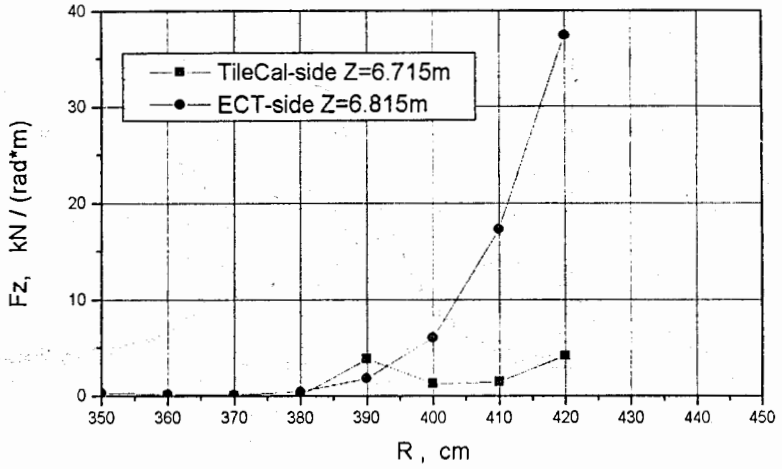

Figure 9 Axial force density distribution along the shielding disk surfaces (averaged over azimuthal period 45°), part-II.

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