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MIT-GEM-EM-17

Electromagnetic Forces on the SSC GEM Detector Coil and Vacuum Vessel in the Absense of the Forward Field Shaper

May 7, 1993

Abstract:

This document and all reports and memoranda in this series are intended as a record of work in progress. They are for use in informal discussions of design and fabrication alternatives. This material is subject to change and should not, therefore, be published or referred to in the open literature. Conclusions are preliminary and distribution should be strictly limited.

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R.L. Myatt

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MIT GEM DETECTOR Memoranda
Approval Sheet

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1.0 Abstract

SSC personnel have expressed an interest in knowing the electromagnetic forces acting on the GEM Detector cold mass in the absence of the Forward Field Shaper (FFS) and associated support structure. This is achieved with a 2-D axisymmetric ANSYS [1] model of the detector coil and vacuum vessel. The finite element model and a similar analysis are documented in an earlier report[2], and the interested reader is referred there for additional details. This analysis simply modifies the existing finite element model by assigning an air-like permeability to the iron FFS and its structural elements. Results in the form of tables and figures are presented.

2.0 Conclusions

The 2-D analysis calculates loads on the axisymmetric vacuum vessel and coil assuming that the FFS is not present. Results are presented in Table 3.0-1 and Figs 3.0-1 to 3.0-3, which show traction force vectors on the carbon steel vacuum vessel and detector magnet coil. The analysis indicates that operating the coil without the FFS increases the axial load on the coil by about 8 MN (16%), but has little effect on the carbon steel vacuum vessel force summation.

3.0 Results

The objective of the analysis is met by calculating electromagnetic forces on the detector coil and carbon steel vacuum vessel. These net axial and radial forces are shown in Table 3.0-1. Results from the previous analysis (baseline configuration, FFS present) are shown in Table 3.0-2 for comparison purposes. To help illustrate the force distribution over the surface of the body, vector plots are included for the coil and the vacuum vessel. Figure 3.0-1 shows the **I x B** body forces in the coil, while Fig. 3.0-2 shows the so-called traction forces acting on the vacuum vessel. Loads are proportional to the vector length (2.54 cm maximum) and have units of N. To help clarify these results, Figs 3.0-3a and 3.0-3b are included to show the same information for vacuum vessel elements inside and outside the winding inner radius (9.466 m), respectively.

4.0 References

1. ANSYS 5.0, Swanson Analysis Systems, Inc., Houston, PA

2. R.L. Myatt, MIT-GEM-EM-11, "Electromagnetic Forces on Major Iron Components of the SSC GEM Detector," January 15, 1993, MIT Plasma Fusion Center, Cambridge, MA.

Table 3.0-1 Axial and Radial Forces on the GEM Detector Coil and Vacuum Vessel In the Absence of the FFS

Component	Net Axial Electro-magnetic Force [MN]	Total of Positive & Negative Axial Forces [MN] (2)	Net Radial Electro-magnetic Force [MN/rad]
Coil (**I x B**)	-57.5	19.0/-76.5	37.0
Vacuum Vessel VV Inside R_c (1) VV Outside R_c (1)	0.81 0.66 0.15	90.4/-89.6 74.3/-73.7 15.8/-15.7	-0.96 -0.92 -0.04

Table 3.0-2 Axial and Radial Forces on the Baseline GEM Detector Coil and Vacuum Vessel (3)

Component	Net Axial Electro-magnetic Force [MN]	Total of Positive & Negative Axial Forces [MN] (2)	Net Radial Electro-magnetic Force [MN/rad]
Coil (**I x B**)	-49.7	18.7/-68.4	36.2
Vacuum Vessel VV Inside R_c (1) VV Outside R_c (1)	0.9 0.8 0.1	82.6/-81.7 66.7/-65.9 15.8/-15.7	 -0.9 0

Notes:

1. R_c is the inside radius of the winding (9.466 m).

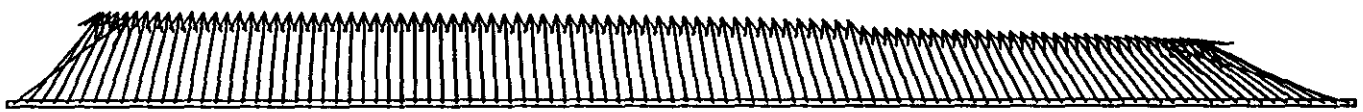
2. The third column is included here to show the potential for error in the axial force calculation. The net axial load on the vacuum vessel is a small difference between two large numbers.

3. Results taken from Ref. 2.

1

Total Axial Force: -57.5 MN

Total Radial Force: 37.0 MN/rad



Force Vector Scale: 2.54 cm = 5.24 MN

Axis of Symmetry

ANSYS 5.0
APR 21 1993
10:57:38
PLOT NO. 2
VECTOR
STEP=2
SUB =1
TIME=2
FMAG
ELEM=8131
MIN=.223E+07 [N]
MAX=.524E+07

.223E+07
.261E+07
.298E+07
.336E+07
.373E+07
.411E+07
.449E+07
.486E+07
.524E+07

Fig 3.0-1 I x B Body Force Vectors in Coil Elements

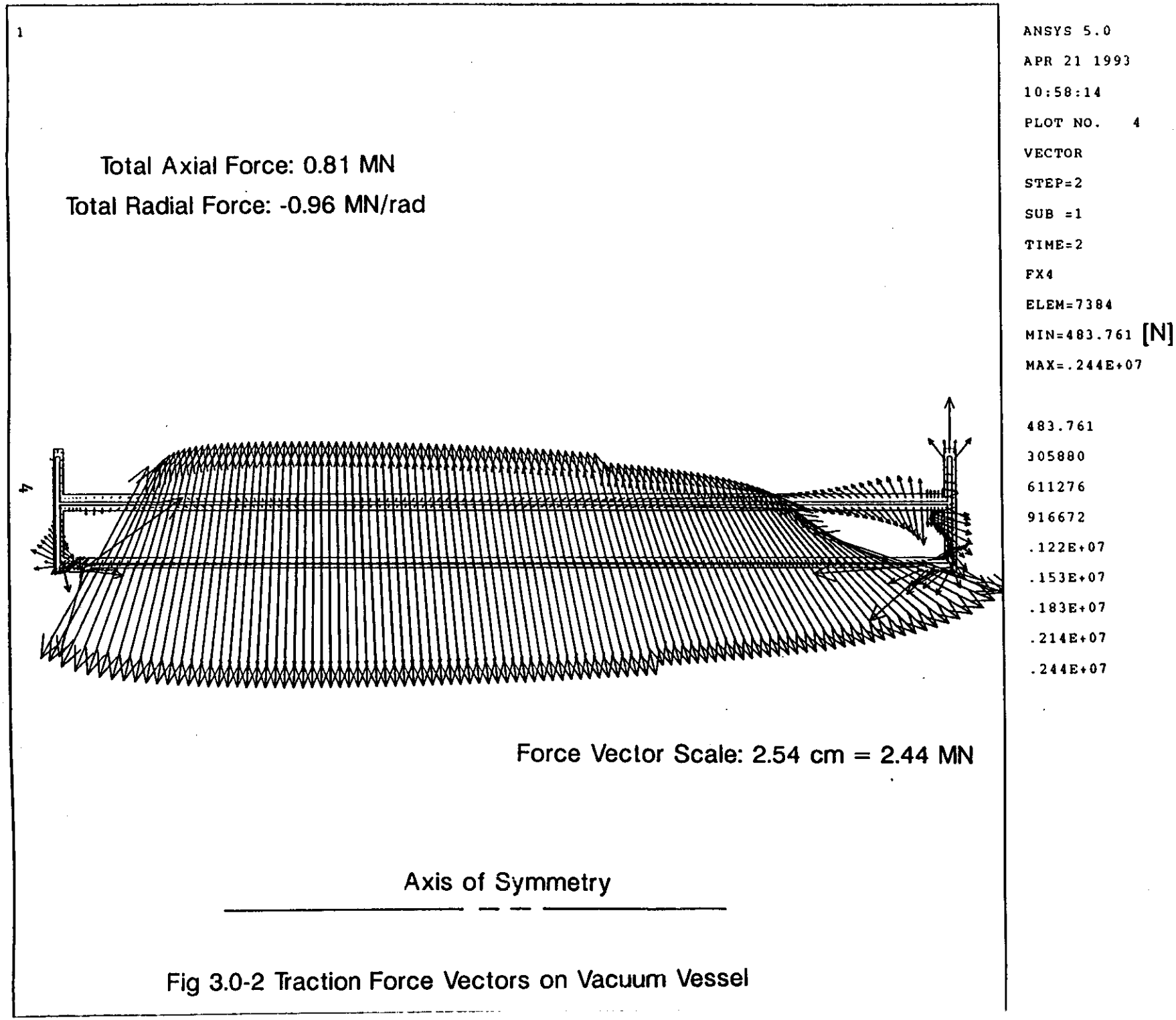


Fig 3.0-2 Traction Force Vectors on Vacuum Vessel

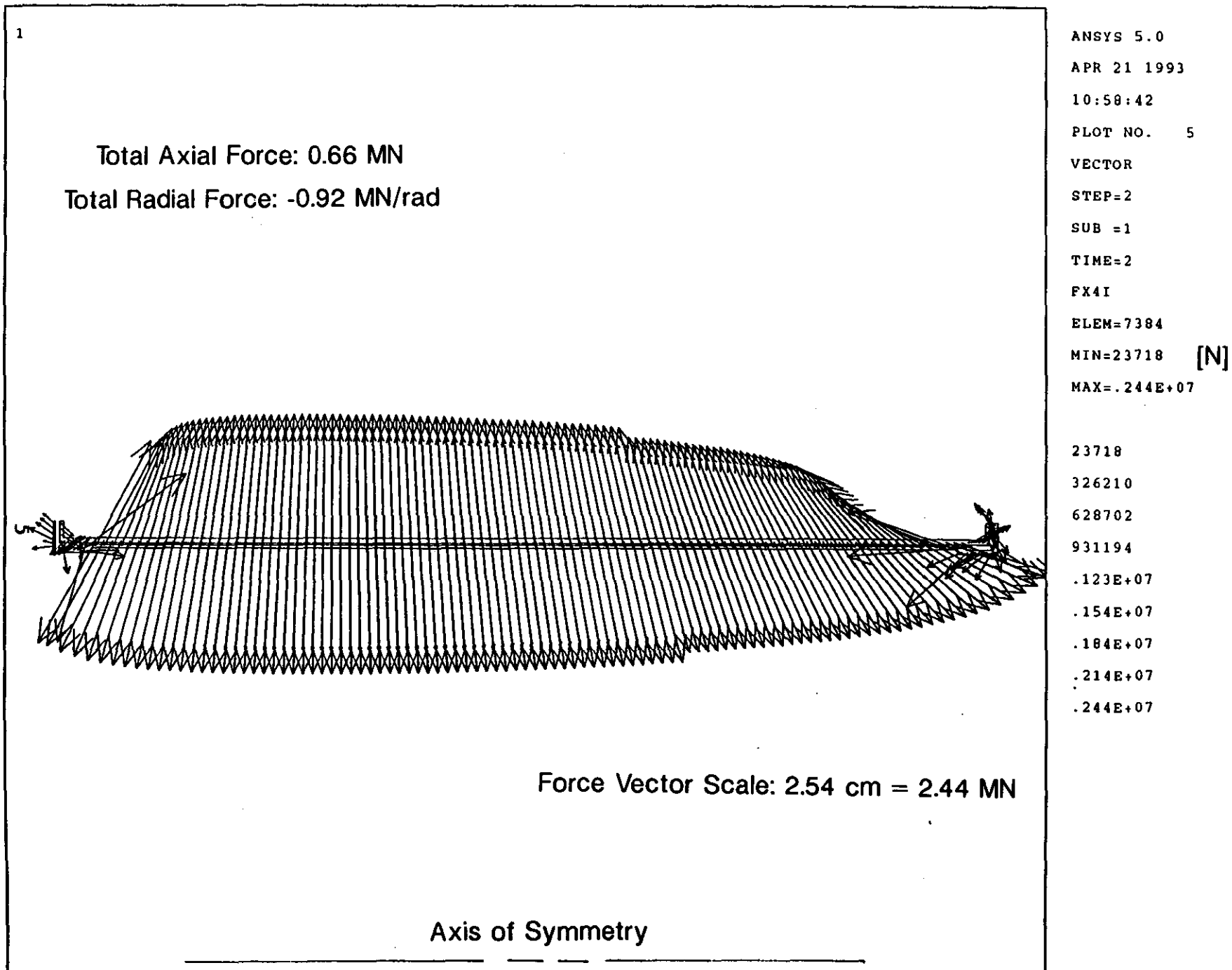


Fig 3.0-3a Traction Force Vectors on VV Elements Inside a 9.466 m Radius

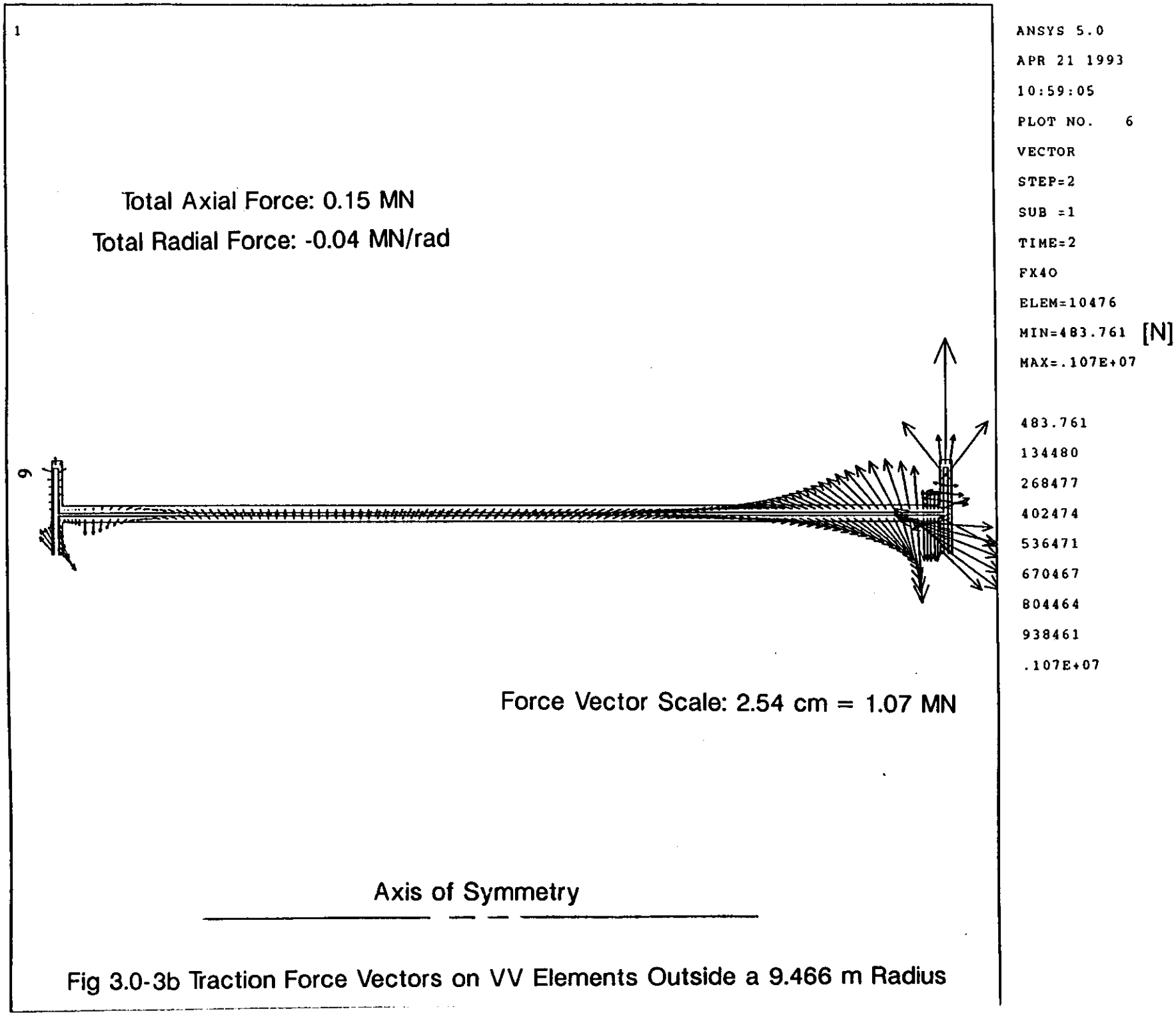


Fig 3.0-3b Traction Force Vectors on VV Elements Outside a 9.466 m Radius