national accelerator laboratory

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MUON GROUNDSHINE

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A. INTRODUCTION

This note gives a preview of some of the work being done by R. G. Alsmiller, et al. at ORNL.

At our request, R. G. Alsmiller has modified his muon transport programs to calculate muon fluxes in a homogeneous medium due to high energy proton interactions in targets of arbitrary composition in a geometry resembling that of the neutrino beam facility.

This modification gives an estimate of the muon flux background which may be expected via groundshine around the steel backstop in the neutrino beam facility.

Although these results are truly preliminary, they may give some useful guidance in the planning of the experimental areas.

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B. ASSUMPTIONS & GEOMETRY

The pion source is given by the Trilling formula with the latest coefficients as given by J. Ranft[1]. The protons are incident along the axis of symmetry of the system.

The target is either Be or Pb for 200 GeV protons or Be in the case of 400 GeV protons.

The target is located on the axis of a void cylinder 1.0 m in radius, 600 m long. Either 100 or 163 m of soil exists between the disk and the detector plane.

The steel muon absorber is represented by a black disk of various radii. All the muons incident on this disk are absorbed. See Figure 1.

The muons reaching the detector are those muons created in a cone outside the black disk and multiple Coulomb scattering back towards the axis.

Except for the empty decay tunnel, everything else (black disk and detector plane) is buried in soil. The soil extends indefinitely in all directions.

The distances used do not represent the current thoughts about Area 1.

The muon flux is underestimated for at least two reasons. Large angle Coulomb scattering, and radiative loss contributions to muon scattering have been neglected. The large angle scattering may underestimate the flux by a factor

of about 2. See the Appendix in Reference 2.

On the other hand, the muon flux is overestimated because the black disk is infinitely thin. In the real configuration the steel would occupy part of the volume now filled with soil. This steel would remove some of the muons now reaching the detector.

The results of the present preliminary calculations are shown on Figures 2-5.

REFERENCE

1. J. Ranft and T. Borak, Improved Nucleon-Meson Cascade Calculations, NAL Report FN-193 (1969).
2. R. G. Alsmiller, M. Leimdorfer and J. Barish, High Energy Muon Transport, ORNL Report 4322 (1968).

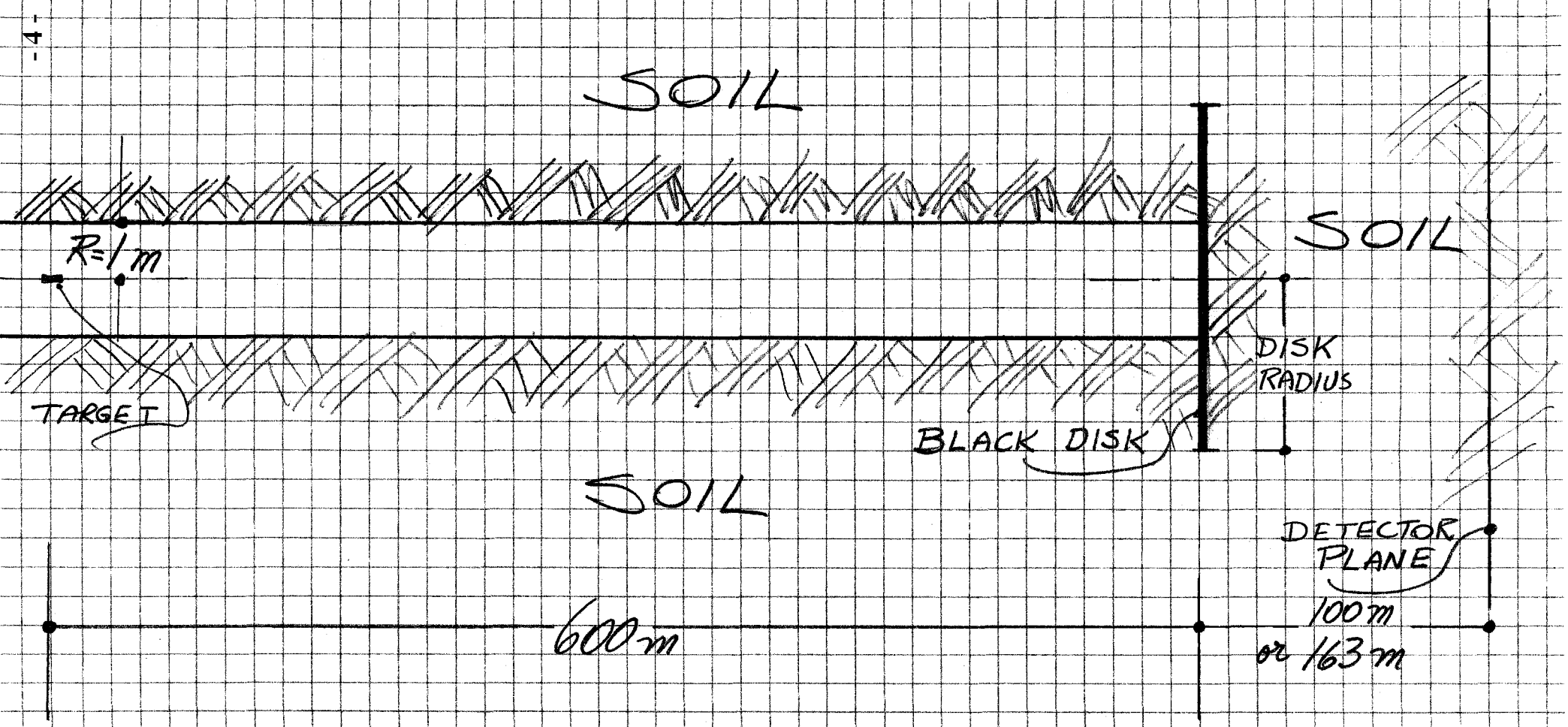

FIG 1. GEOMETRY USED FOR MUON GROUNDSHINE CALCULATIONS.

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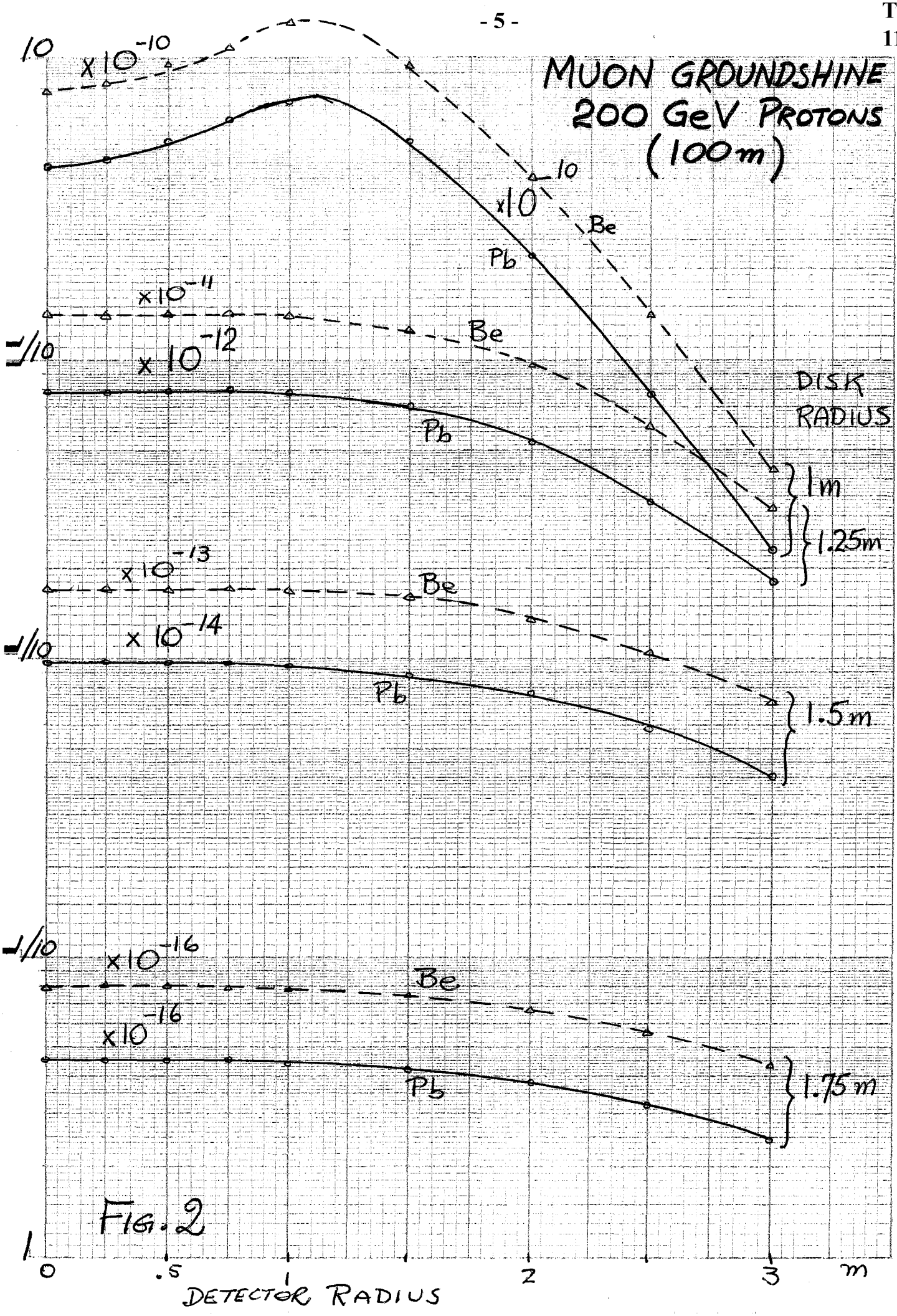
MUON GROUNDSHINE
200 GeV PROTONS
(100m)
10
x10^-10
10
x10
Be
Pb
x10^-11
Be
1/10
x10^-12
Pb
DISK
RADIUS
1m
1.25m
x10^-13
Be
1/10
x10^-14
Pb
1.5m
1/10
x10^-16
Be
x10^-16
Pb
1.75m
1
0
.5
1
2
3
m
DETECTOR RADIUS

FIG. 2

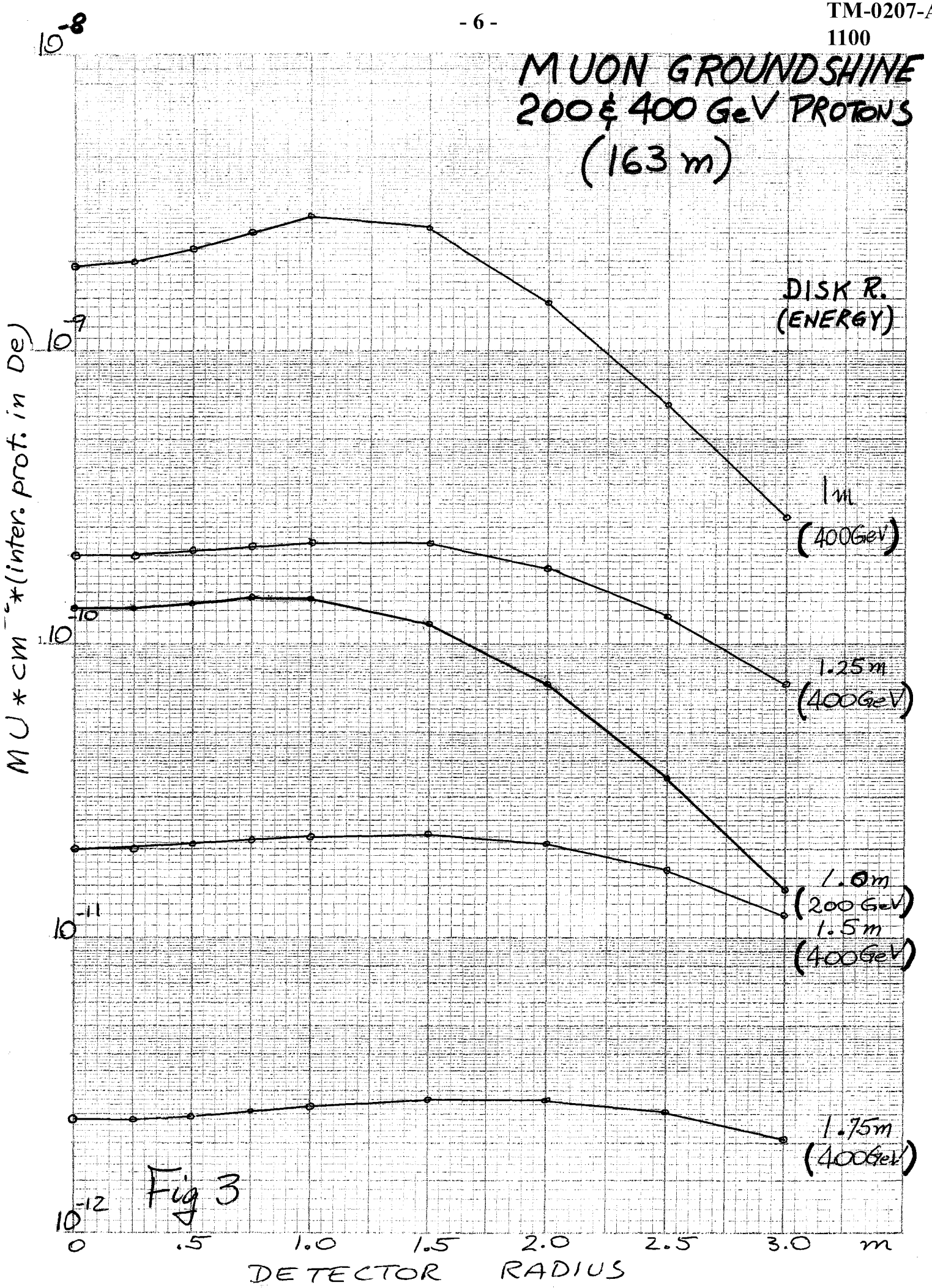
MUON GROUNDSHINE
200 & 400 GeV PROTONS
(163 m)
DISK R.
(ENERGY)
1m
(400GeV)
1.25m
(400GeV)
1.0m
(200 GeV)
1.5m
(400GeV)
1.75m
(400GeV)
MU * cm⁻² * (inter. prot. in De)
10⁻⁸
10⁻⁹
1.10⁻¹⁰
10⁻¹¹
10⁻¹²
0
.5
1.0
1.5
2.0
2.5
3.0
m
DETECTOR RADIUS

Fig 3

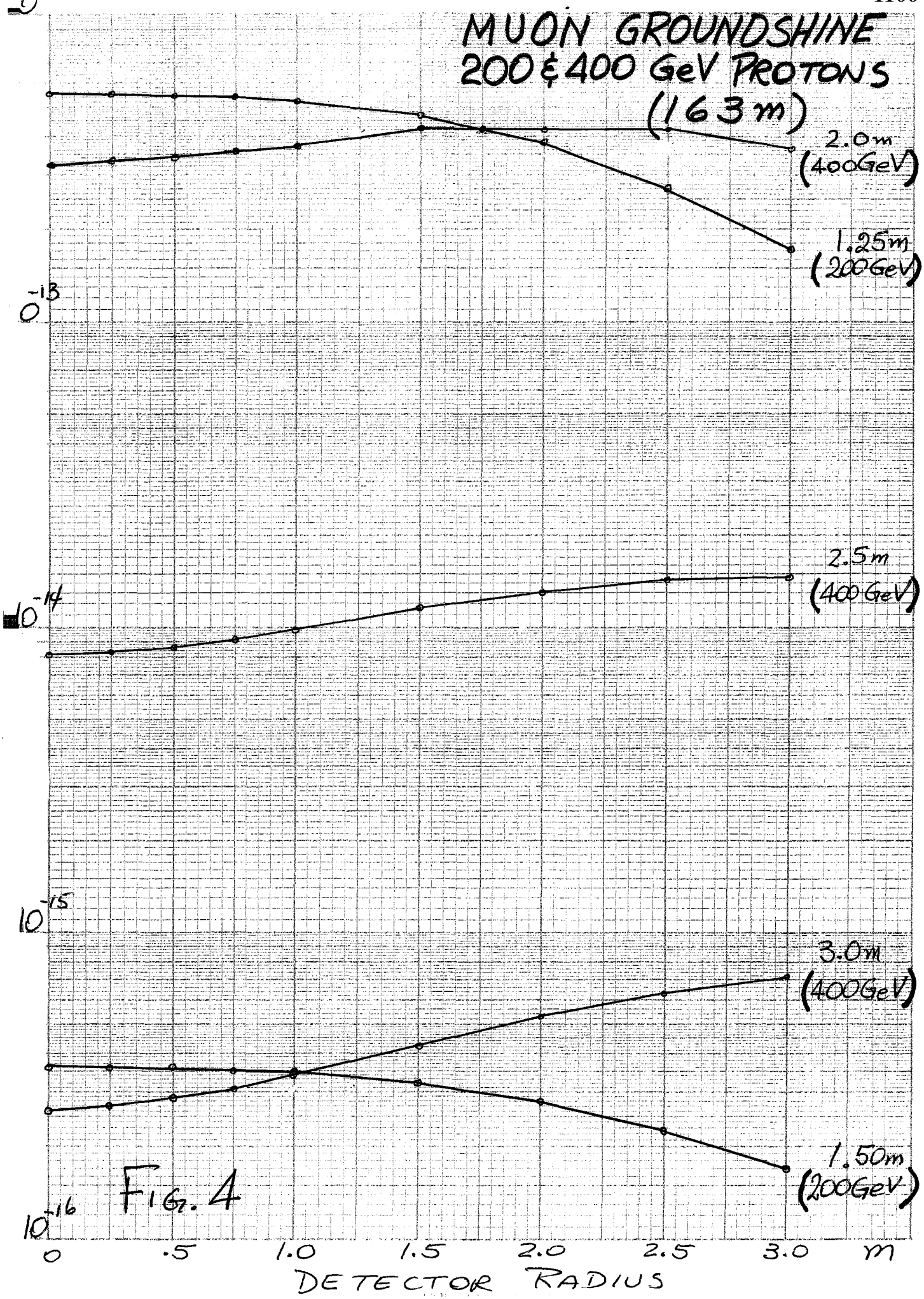
MUON GROUNDSHINE
200 & 400 GeV PROTONS
(163 m)
2.0m
(400GeV)
1.25m
(200GeV)
2.5m
(400 GeV)
3.0m
(400GeV)
1.50m
(200GeV)
10^{-12}
10^{-13}
10^{-14}
10^{-15}
10^{-16}
0
.5
1.0
1.5
2.0
2.5
3.0
m
DETECTOR RADIUS

FIG. 4

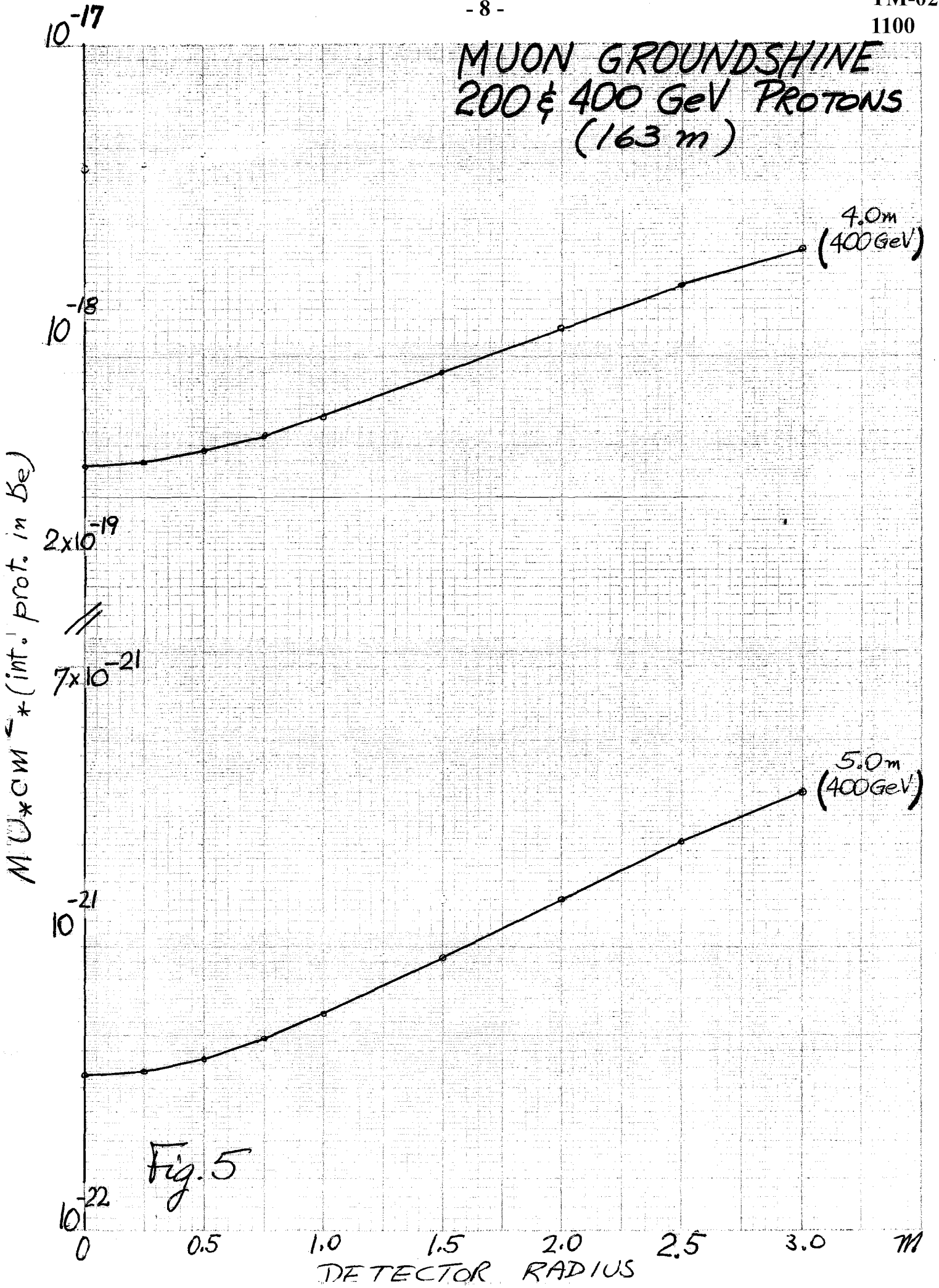
MUON GROUNDSHINE
200 & 400 GeV PROTONS
(163 m)
4.0m
(400 GeV)
5.0m
(400 GeV)
10^{-17}
10^{-18}
2×10^{-19}
7×10^{-21}
10^{-21}
10^{-22}
MU*cm²*(int. prot. in Be)
0
0.5
1.0
1.5
2.0
2.5
3.0
m
DETECTOR RADIUS

Fig. 5