PART B

ATLAS Internal Note
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Study of neutron and γ backgrounds in ATLAS

Abstract

The radiation environment in the ATLAS detector has been evaluated using DTUJET for the primary pp-collision at 7×7 TeV, GEANT for the geometry and material descriptions (SLUG) as well as simulation of hadronic and electromagnetic cascades, and GCALOR for low energy neutron transport. An attempt has been made to present a coherent approach to identification and quantification all of the relevant sources of uncorrelated background for detector elements and potential radiation damage.

A preliminary estimate of neutron and γ fluxes is presented. It has been compared with calculations based on the FLUKA code. In general, results obtained with GCALOR are a factor of 2 higher than the FLUKA estimates, but for the very forward endcap chambers the γ flux is a factor of 10 higher than those using FLUKA.

Several different shielding concepts have been considered. The best results have been obtained with the GEM neutron elimination concept, which includes the forward calorimeter placed just behind the endcap calorimeter and isolating the collimators, low beta quadrupoles, and forward calorimeters with heavy concrete shielding. In this concept it is possible to reduce the neutron and γ backgrounds for the barrel chambers (neutron flux $\sim$ 5 kHz cm^{-2}) and the external muon endcap chambers ($\sim$ 10 kHz cm^{-2}) to an acceptable level. In the inner muon endcap chambers the neutron flux is 100 kHz cm^{-2}. Further reduction of this flux requires increasing the thickness of the endcap calorimeter.

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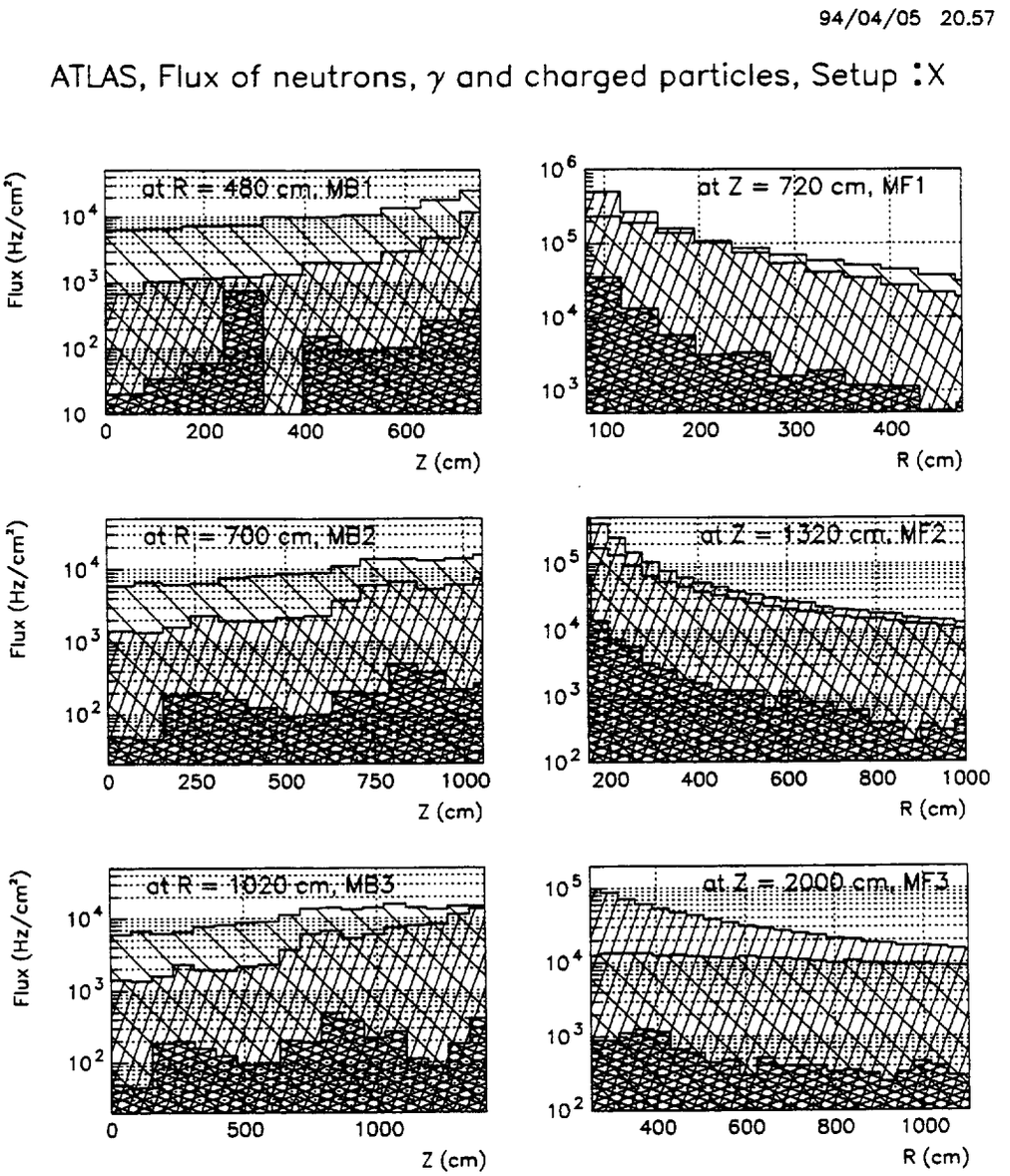


Figure 20: **Setup X**: Neutron (left hashed), γ (right hashed) and charged particles (shaded) fluxes in the barrel (MB) and endcap (MF) muon chamber positions.

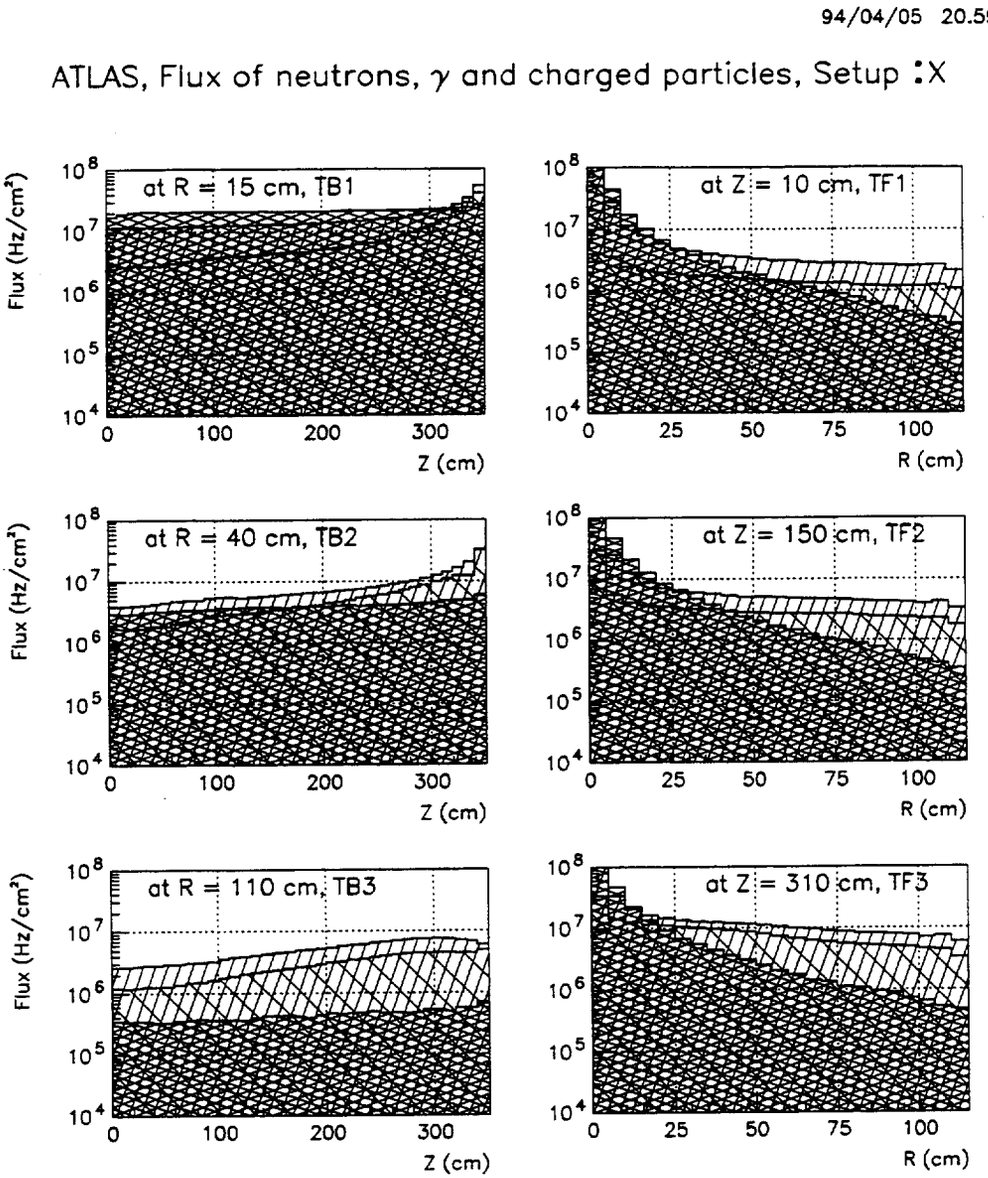


Figure 21: **Setup X**: Neutron (left hashed), γ (right hashed) and charged particles (shaded) fluxes in the tracker. "B" denotes barrel, "F" — endcap.

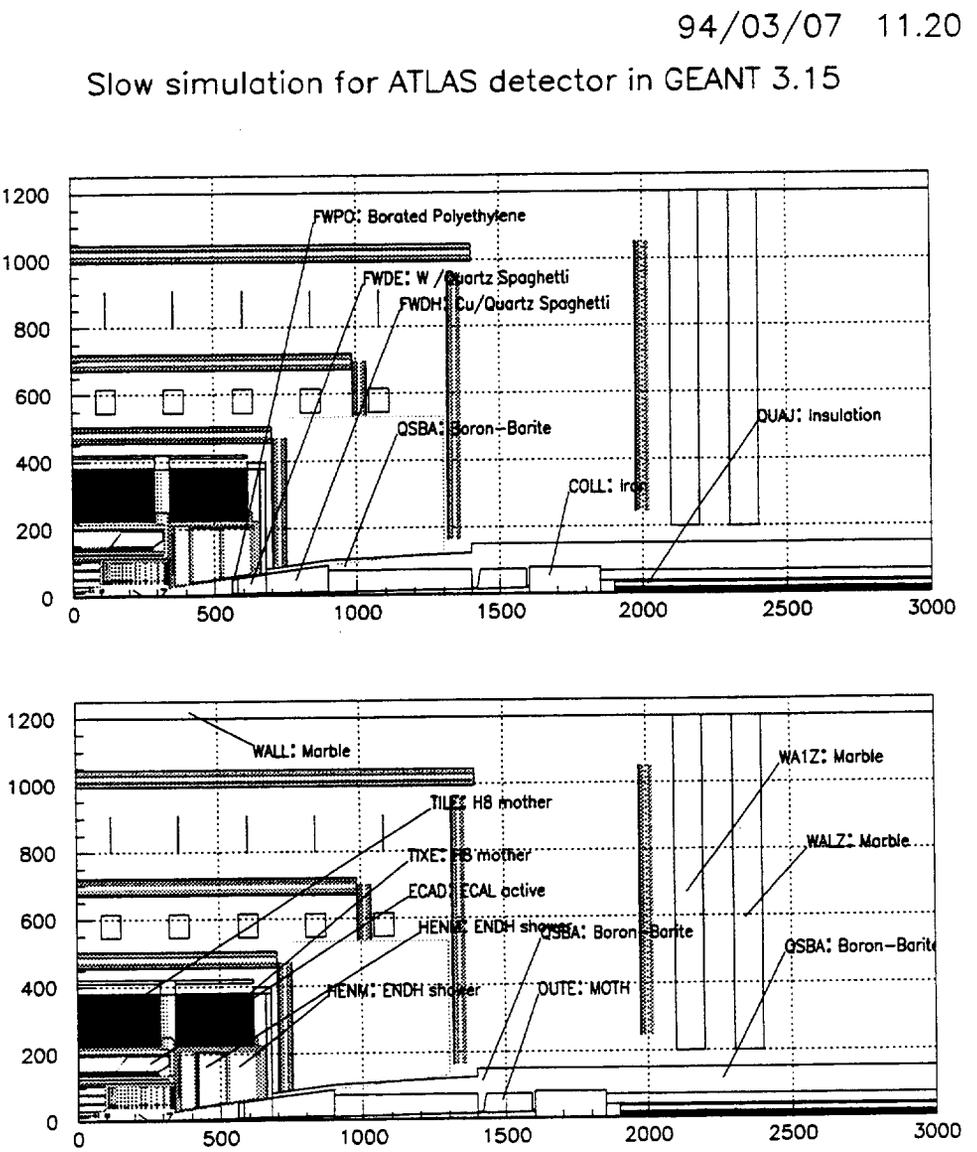


Figure 22: **Setup C**: a compact tungsten based electromagnetic calorimeter (1m long) place just behind the endcap calorimeter with copper based hadron calorimeter after it.

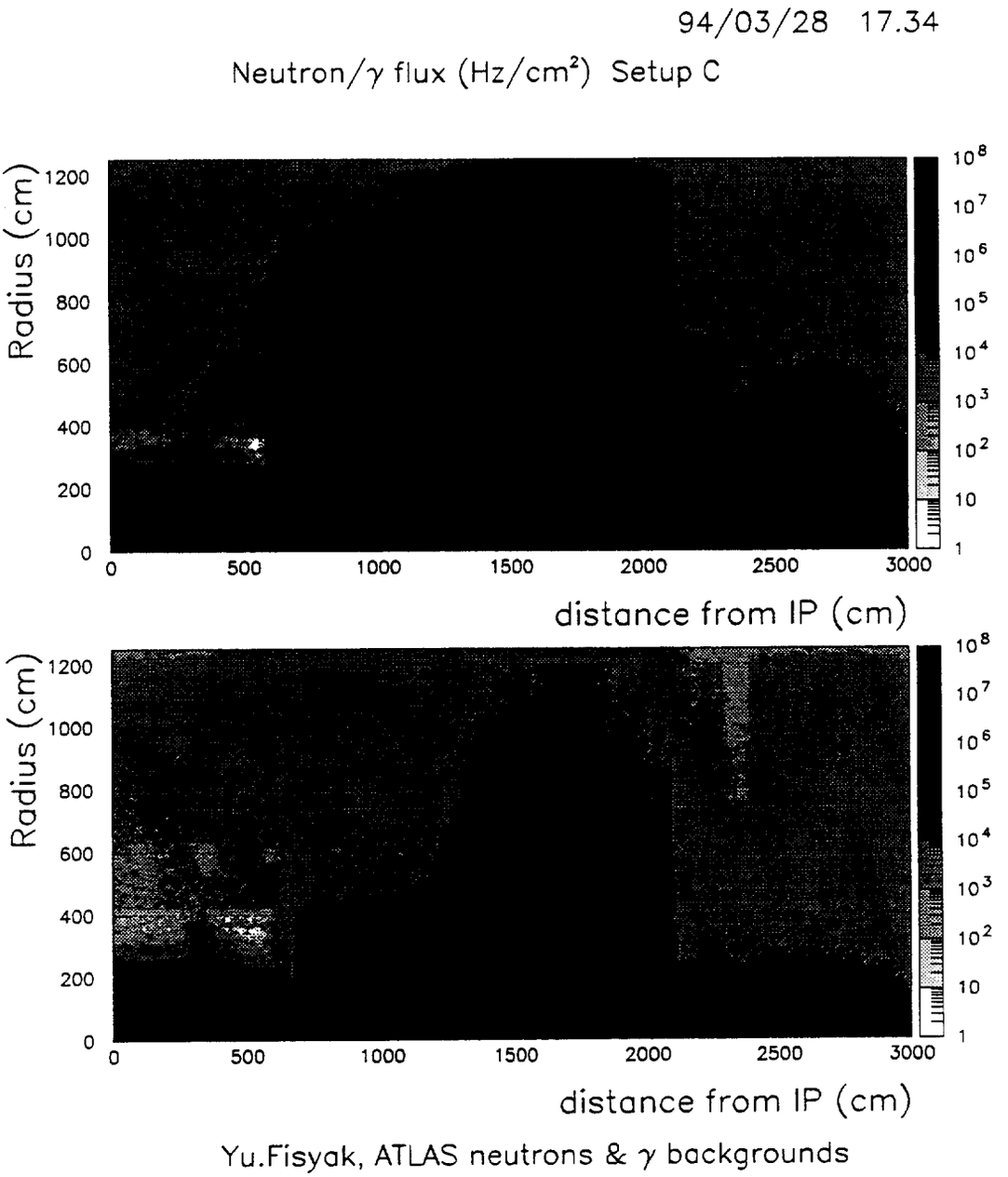


Figure 23: **Setup C**: Neutron and γ fluxes versus distance from the interaction point and radius.

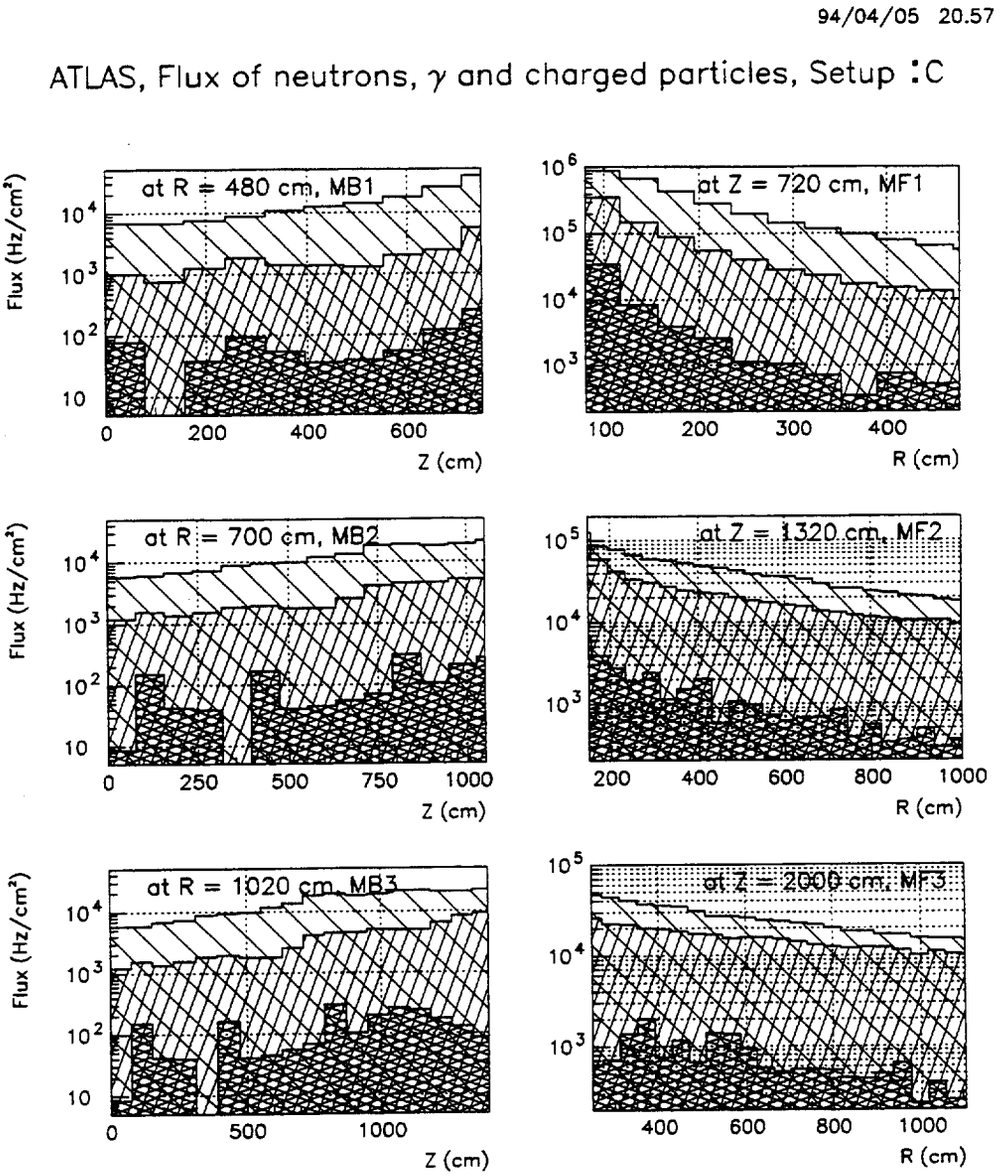


Figure 24: **Setup C**: Neutron (left hashed), γ (right hashed) and charged particles (shaded) fluxes in the barrel (MB) and endcap (MF) muon chamber positions.

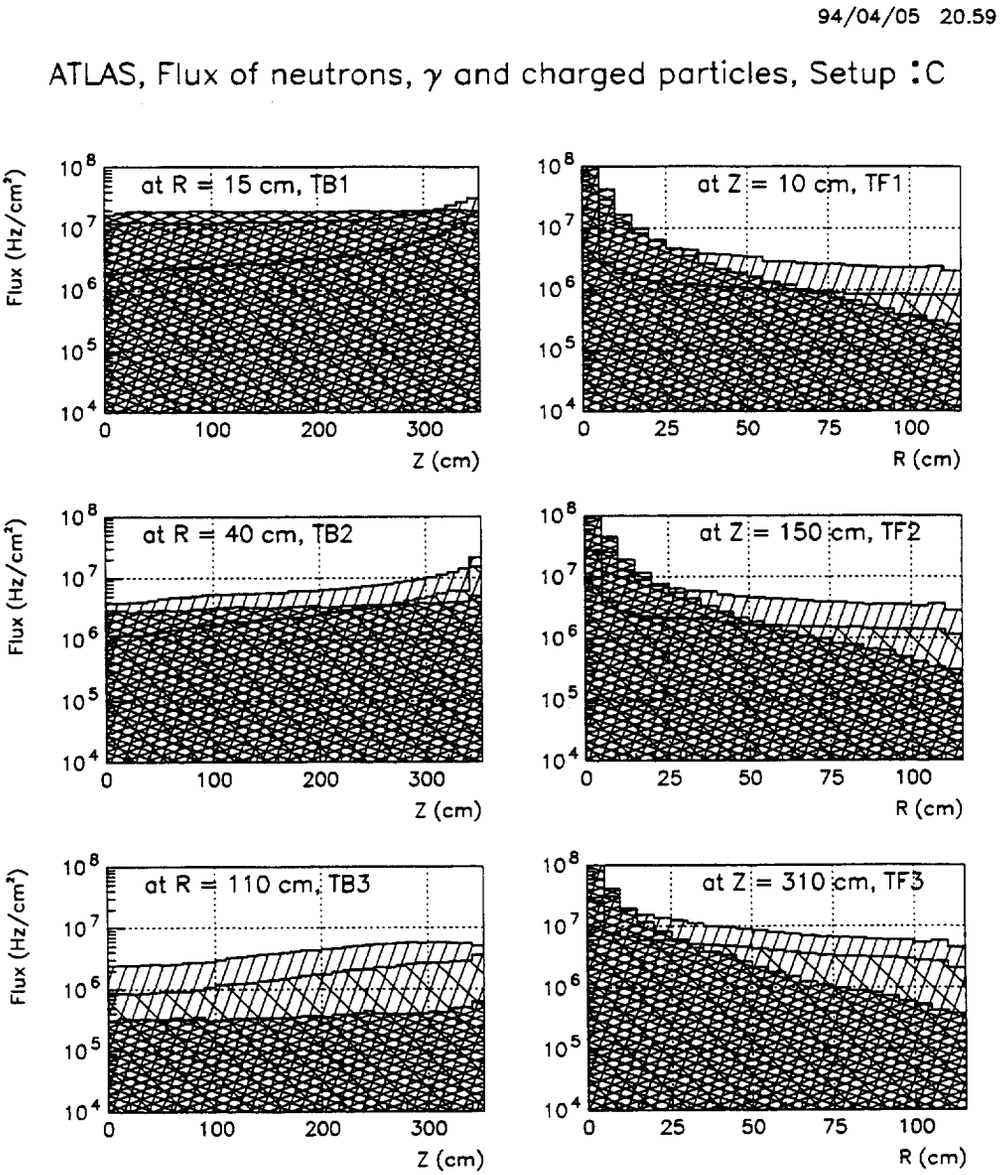


Figure 25: **Setup C**: Neutron (left hashed), γ (right hashed) and charged particles (shaded) fluxes in the tracker. "B" denotes barrel, "F" — endcap.

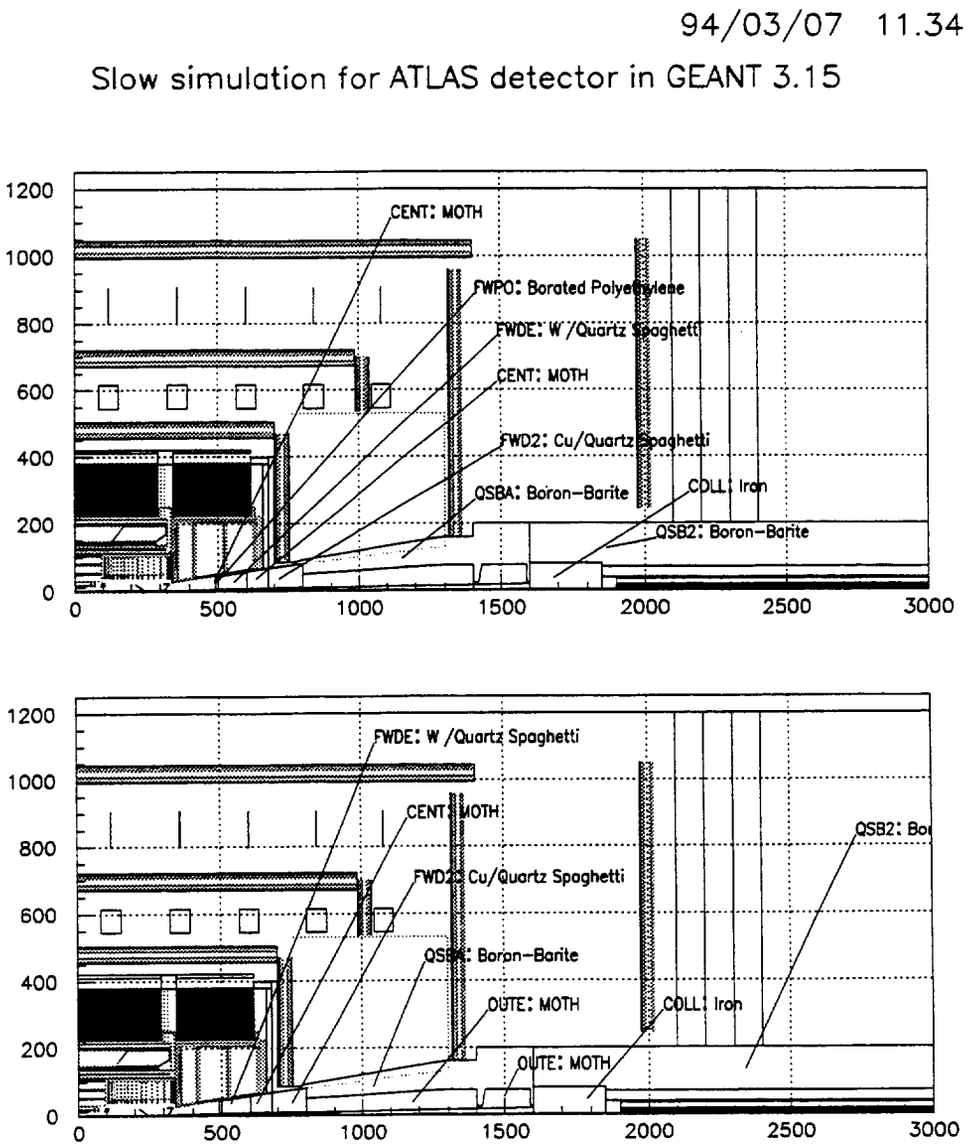


Figure 26: **Setup D**: the same as **setup C** but with reinforced shielding. The forward calorimeter is started at Z = 5m.

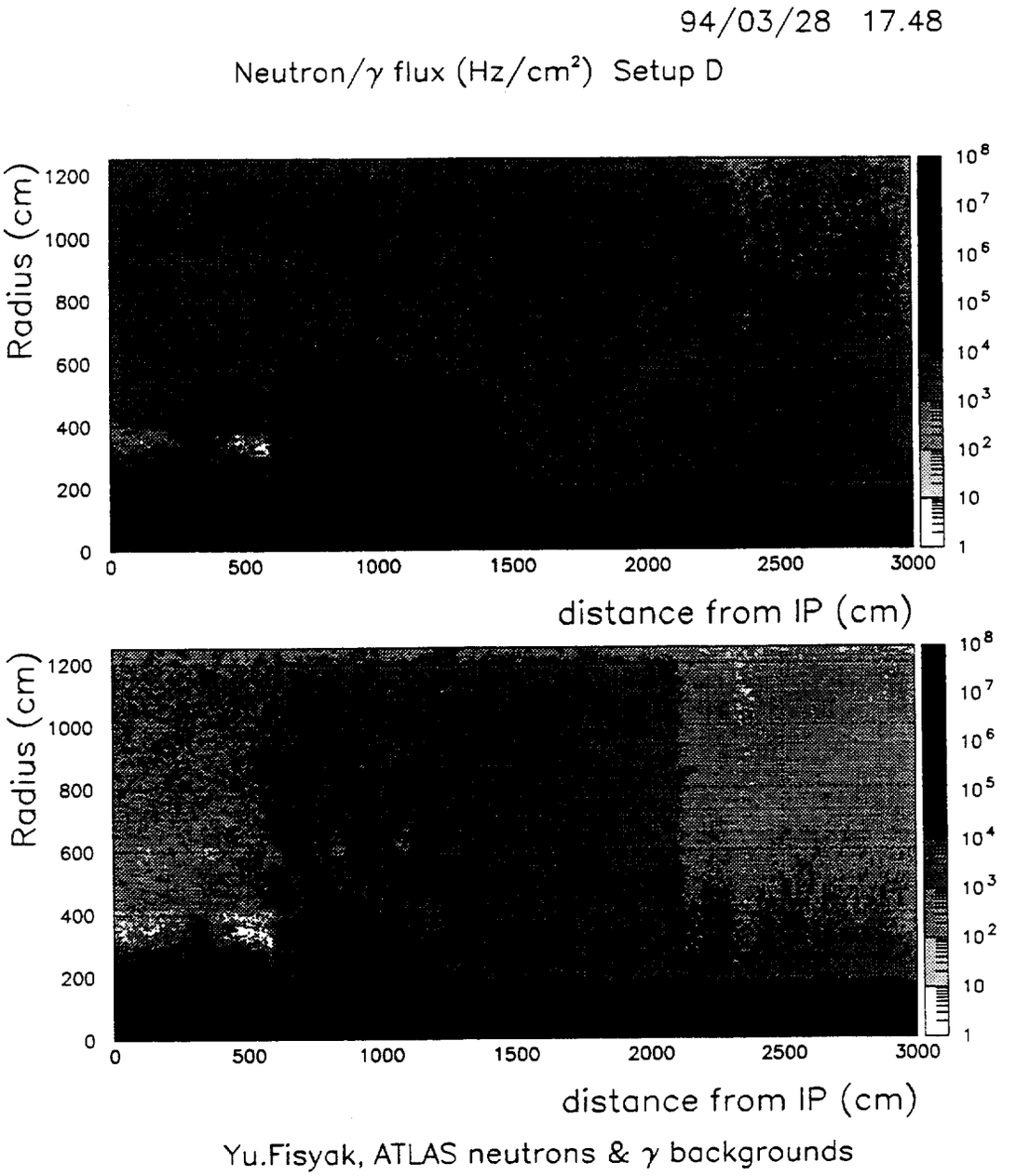


Figure 27: **Setup D**: Neutron and γ fluxes versus distance from the interaction point and radius.

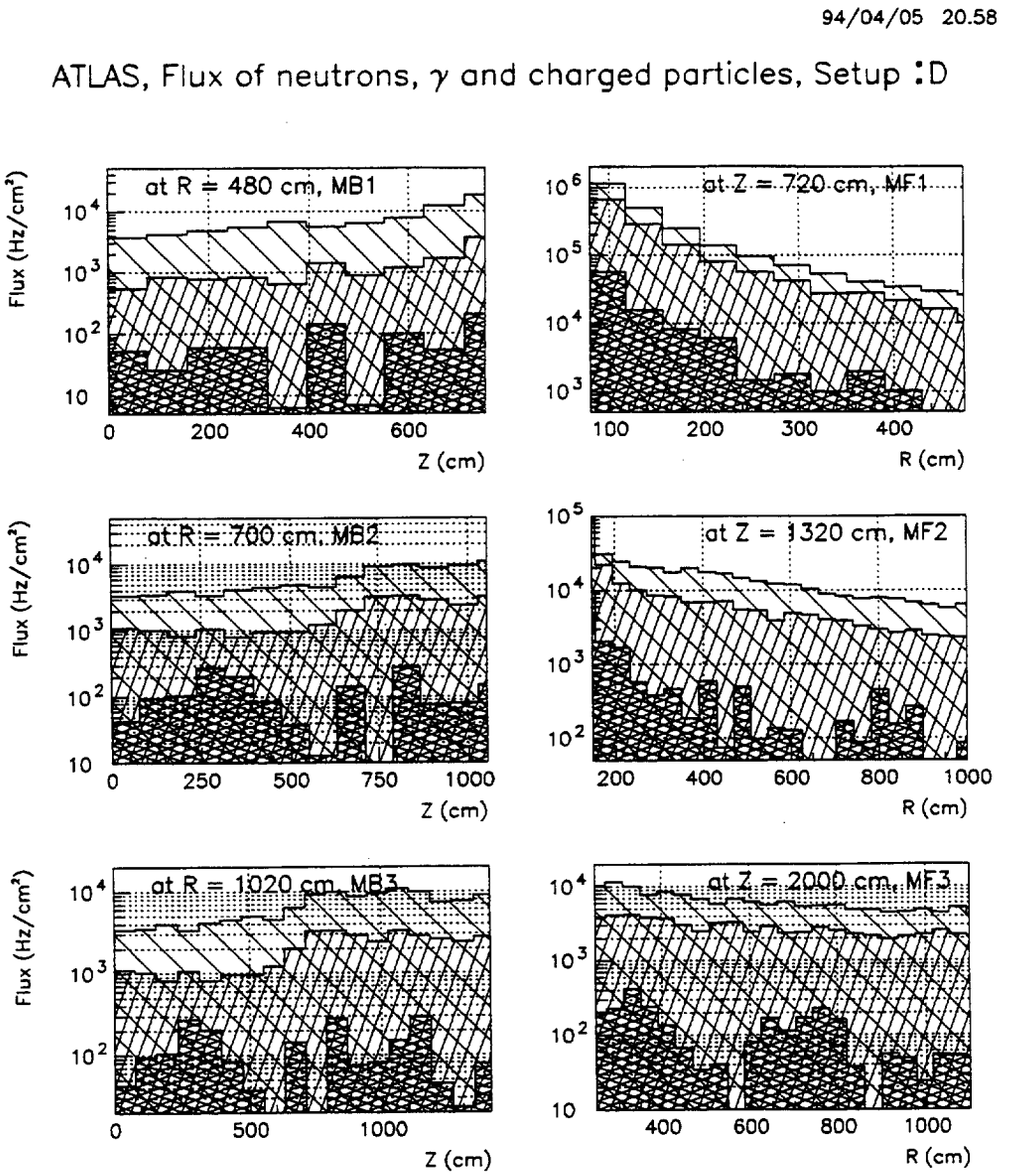


Figure 28: **Setup D**: Neutron (left hashed), γ (right hashed) and charged particles (shaded) fluxes in the barrel (MB) and endcap (MF) muon chamber positions.

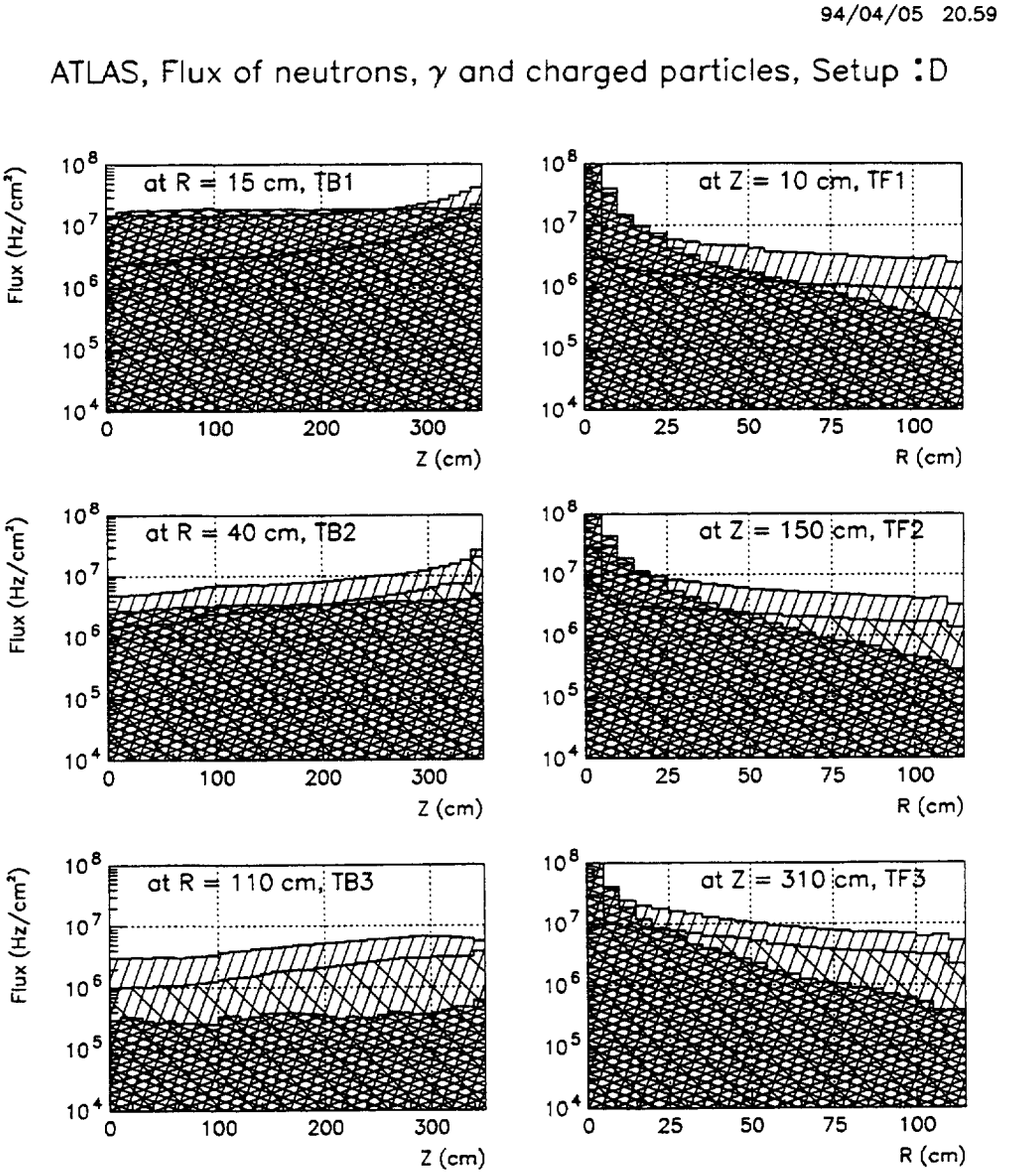


Figure 29: **Setup D**: Neutron (left hashed), γ (right hashed) and charged particles (shaded) fluxes in the tracker. "B" denotes barrel, "F" — endcap.

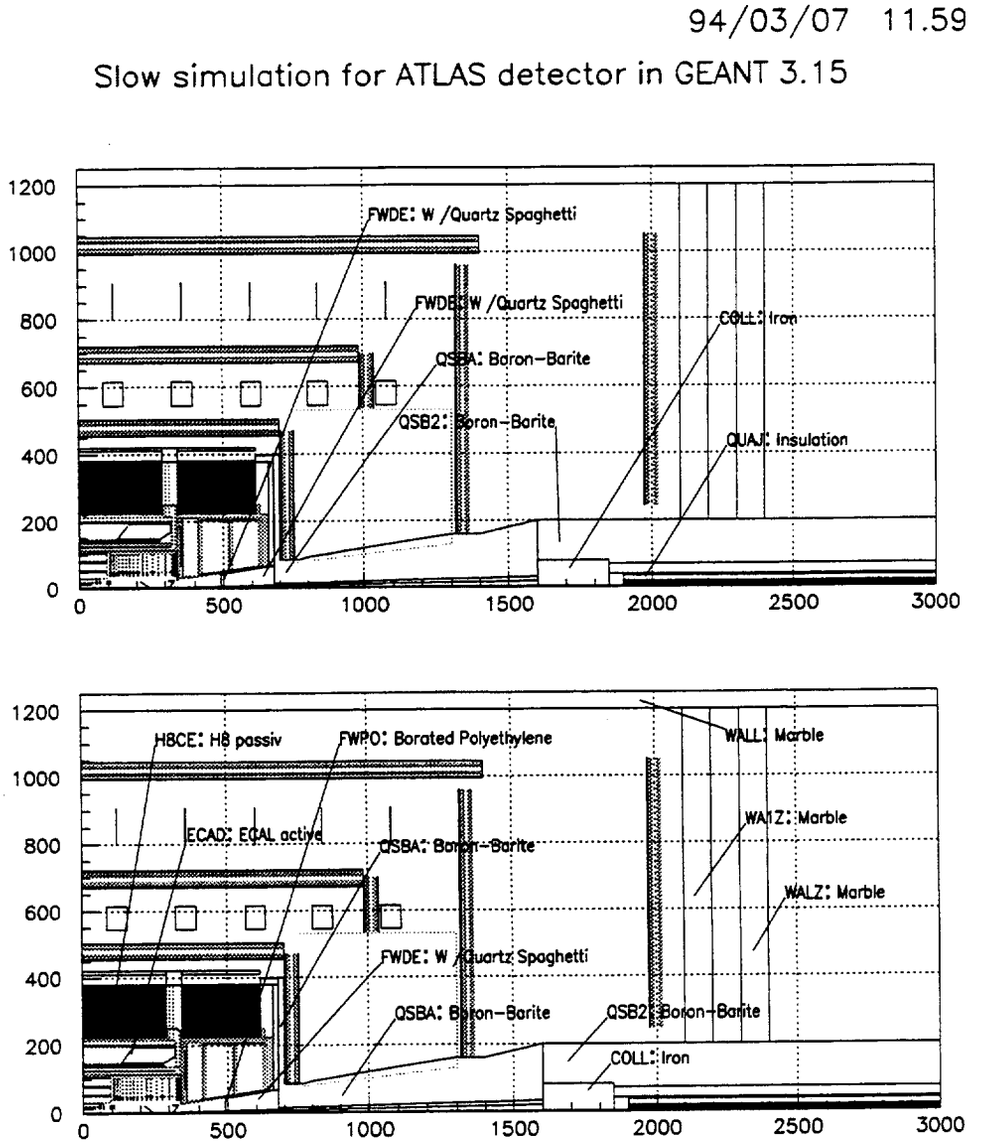
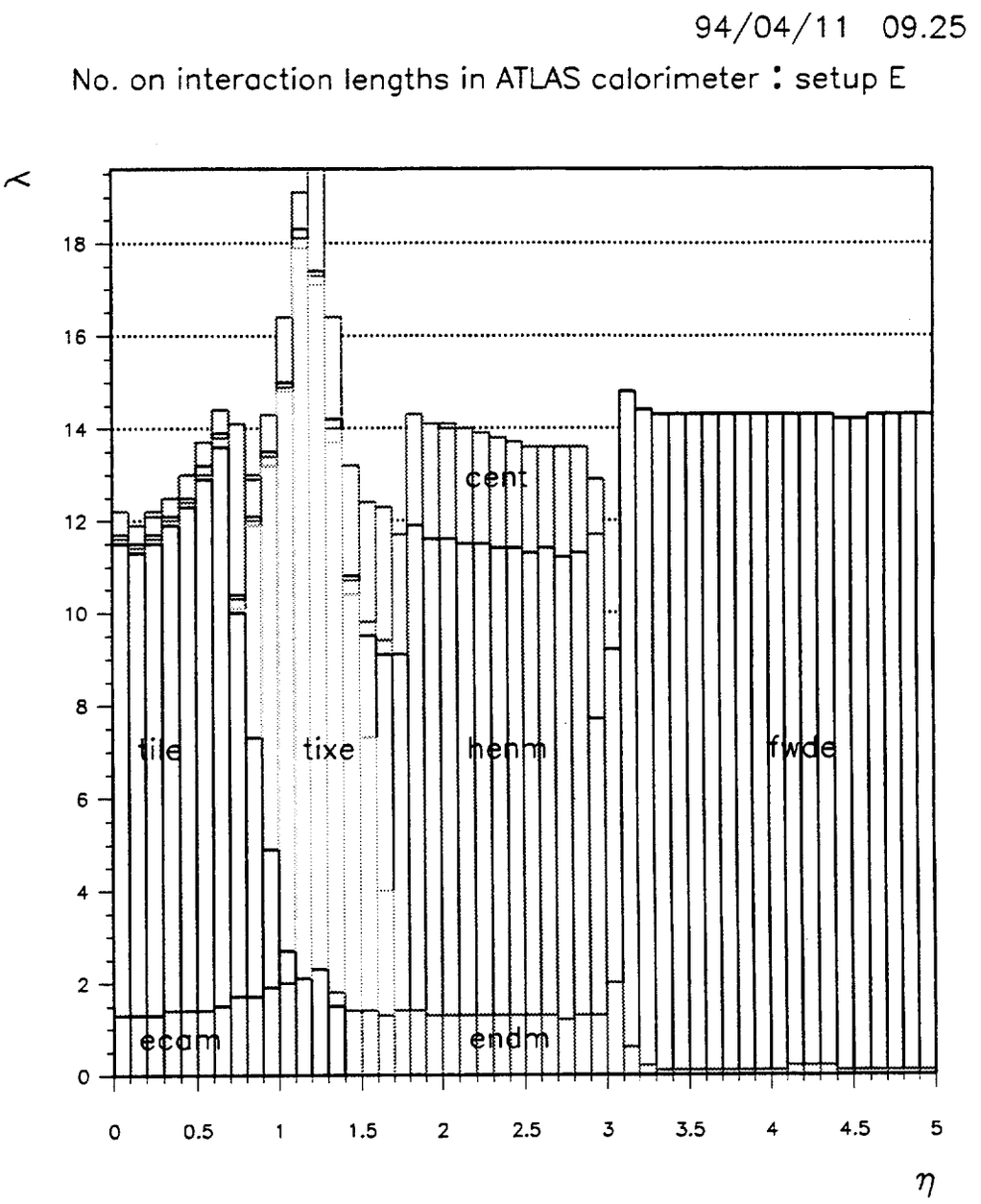


Figure 30: **Setup E**: Tungsten based forward calorimeter with reinforced shielding which includes also a concrete wall between the endcap calorimeter and the first endcap muon station.



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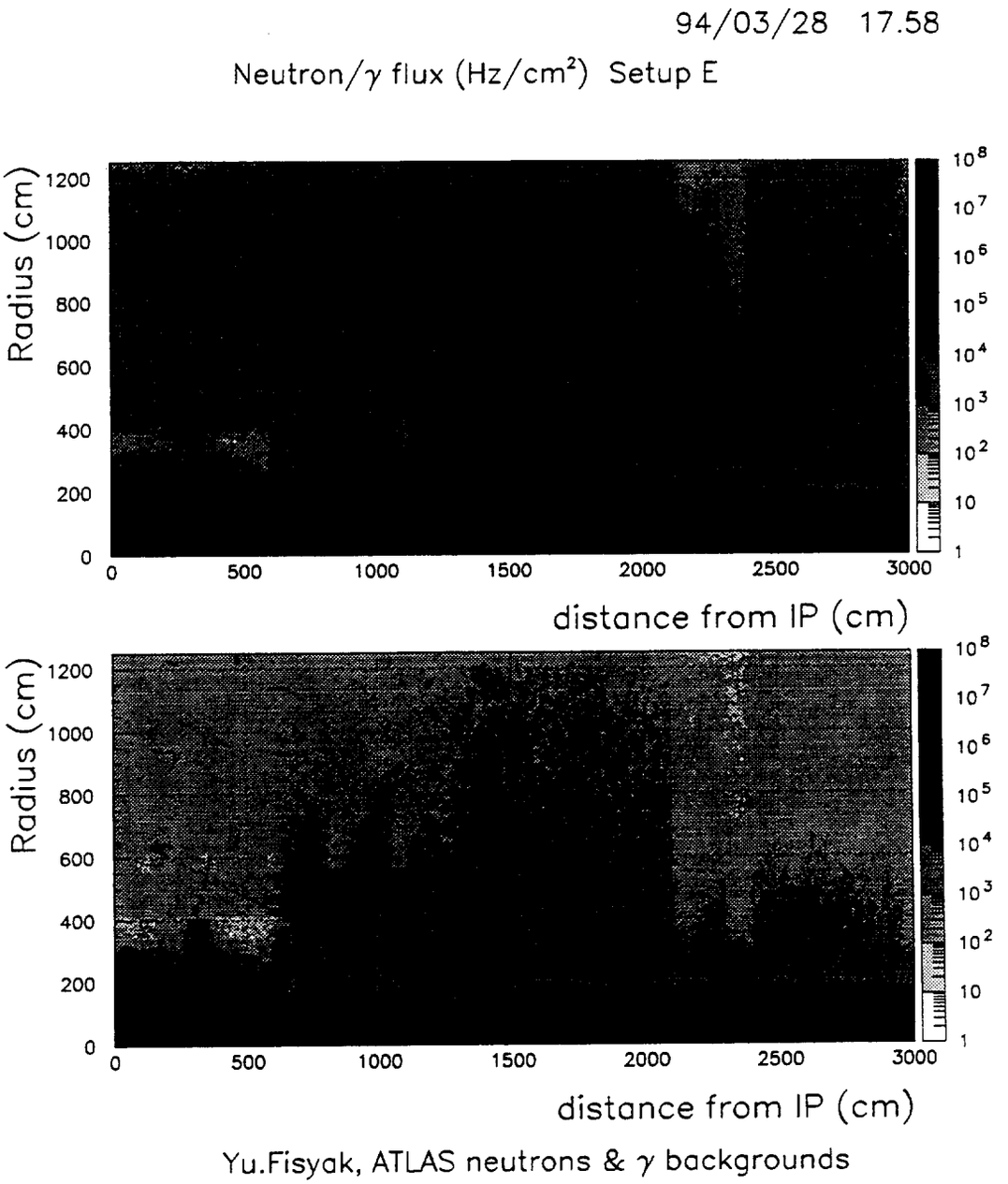
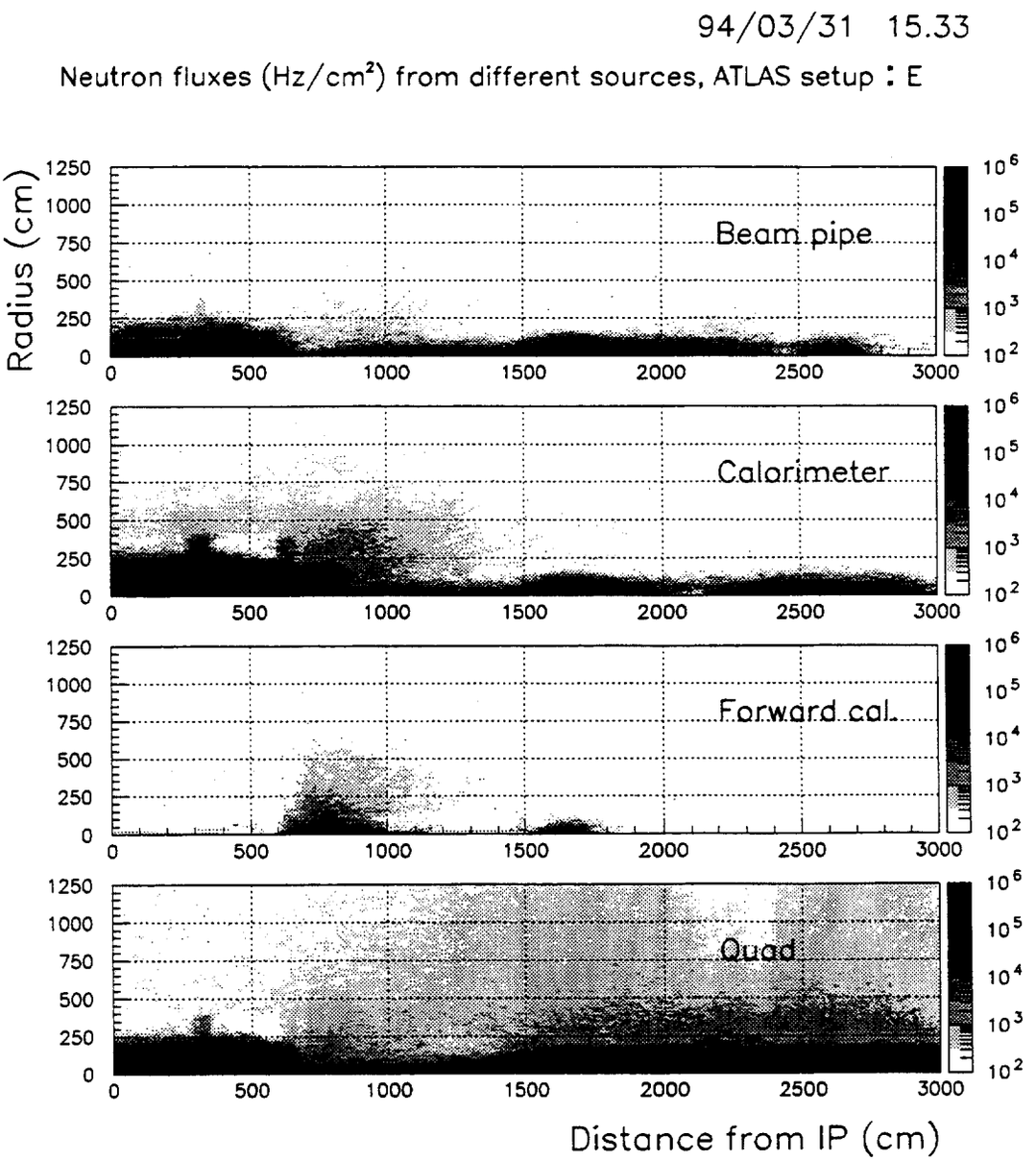


Figure 32: **Setup E**: Neutron and γ fluxes versus distance from the interaction point and radius.



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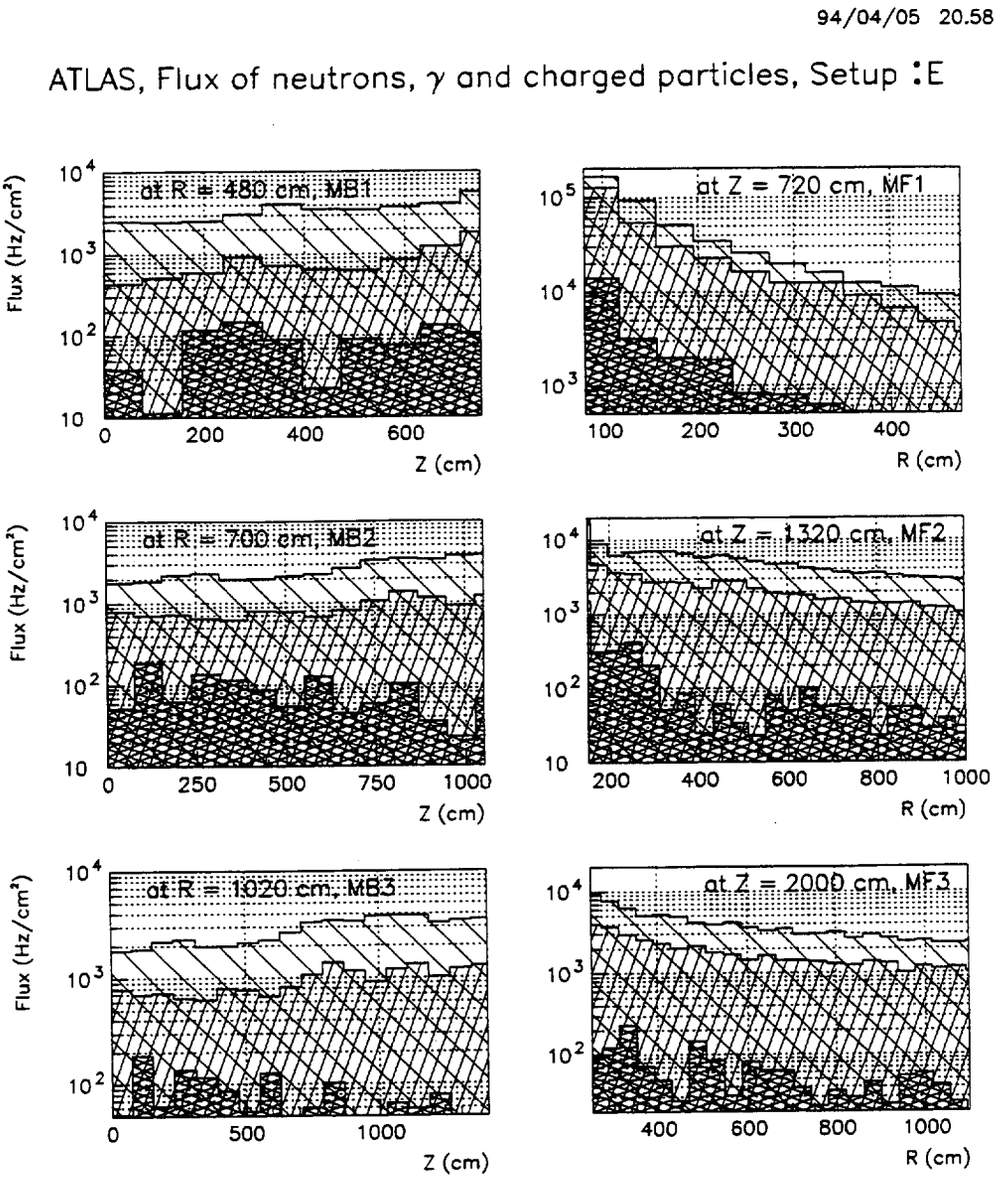


Figure 34: **Setup E**: Neutron (left hashed), γ (right hashed) and charged particles (shaded) fluxes in the barrel (MB) and endcap (MF) muon chamber positions.

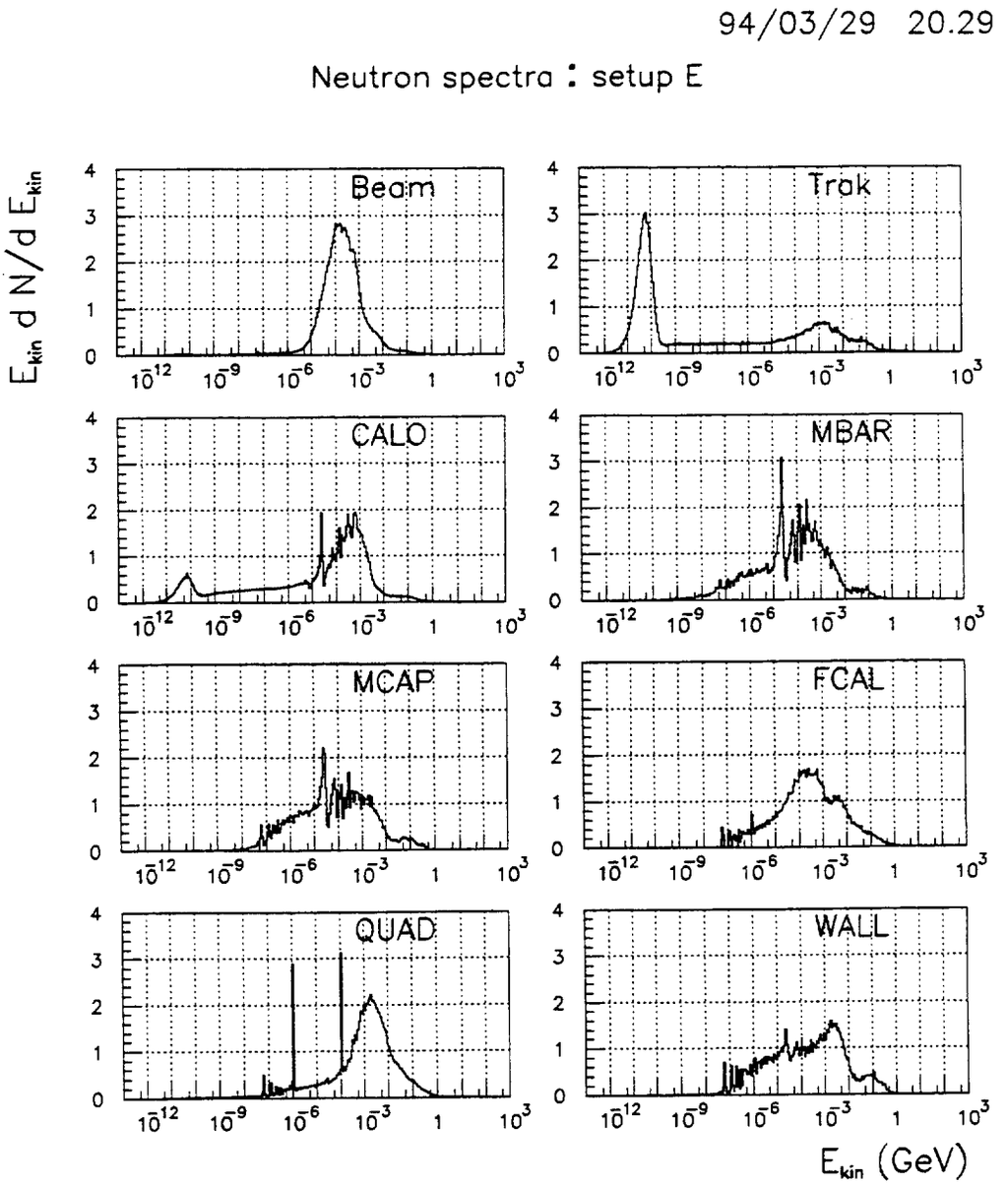
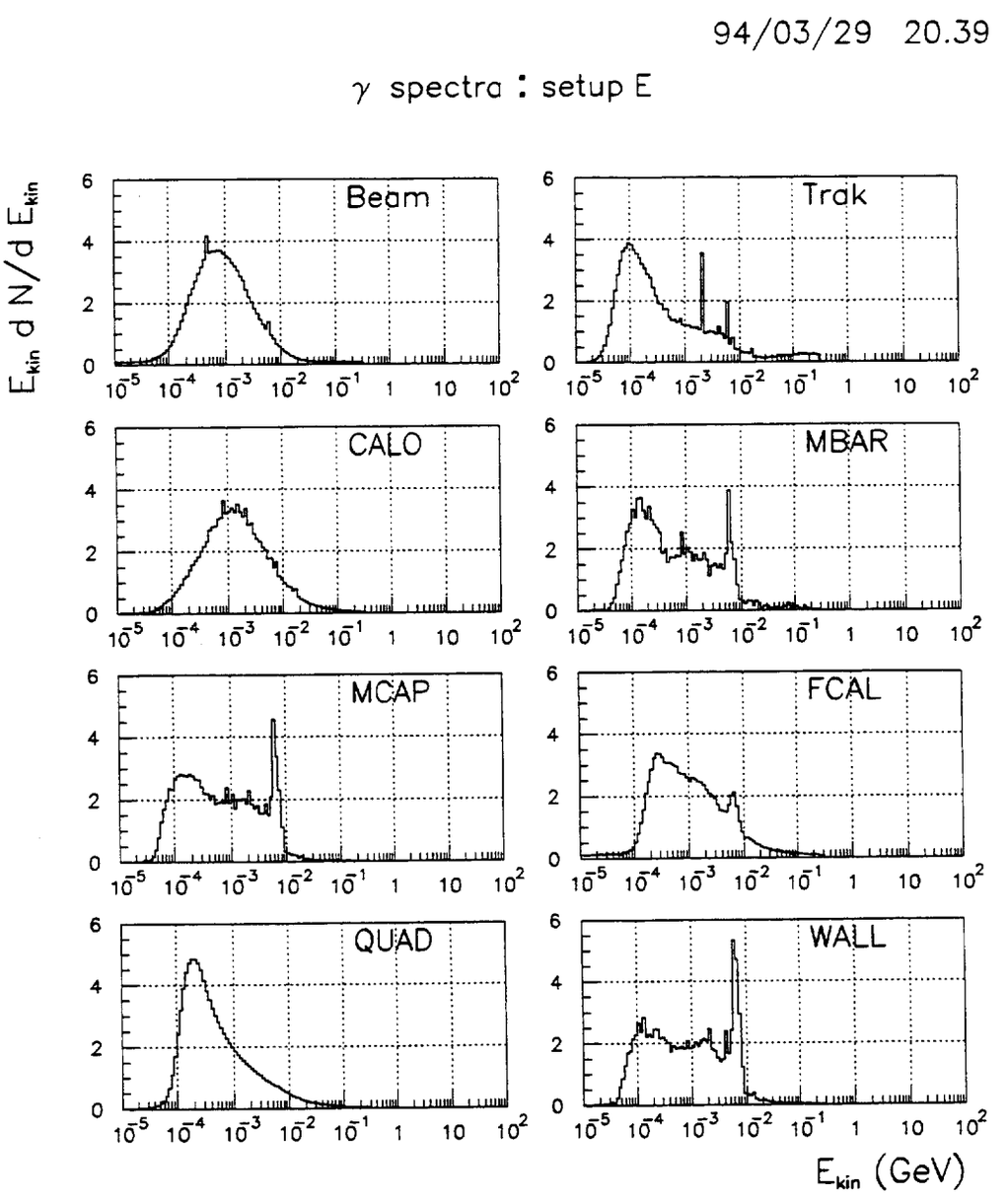


Figure 35: **Setup E**: Kinetic energy spectra of neutrons in the different parts of the detector ("Beam" denotes the beam pipe, "Trak" — the central tracker, "CALO" — the barrel and endcap calorimeter, "MBAR" — the barrel muon chambers, "MCAP" — the endcap muon chambers, "FCAL" — the forward calorimeter, "QUAD" — LBQ and its collimator, "WALL" — the experimental hall walls).



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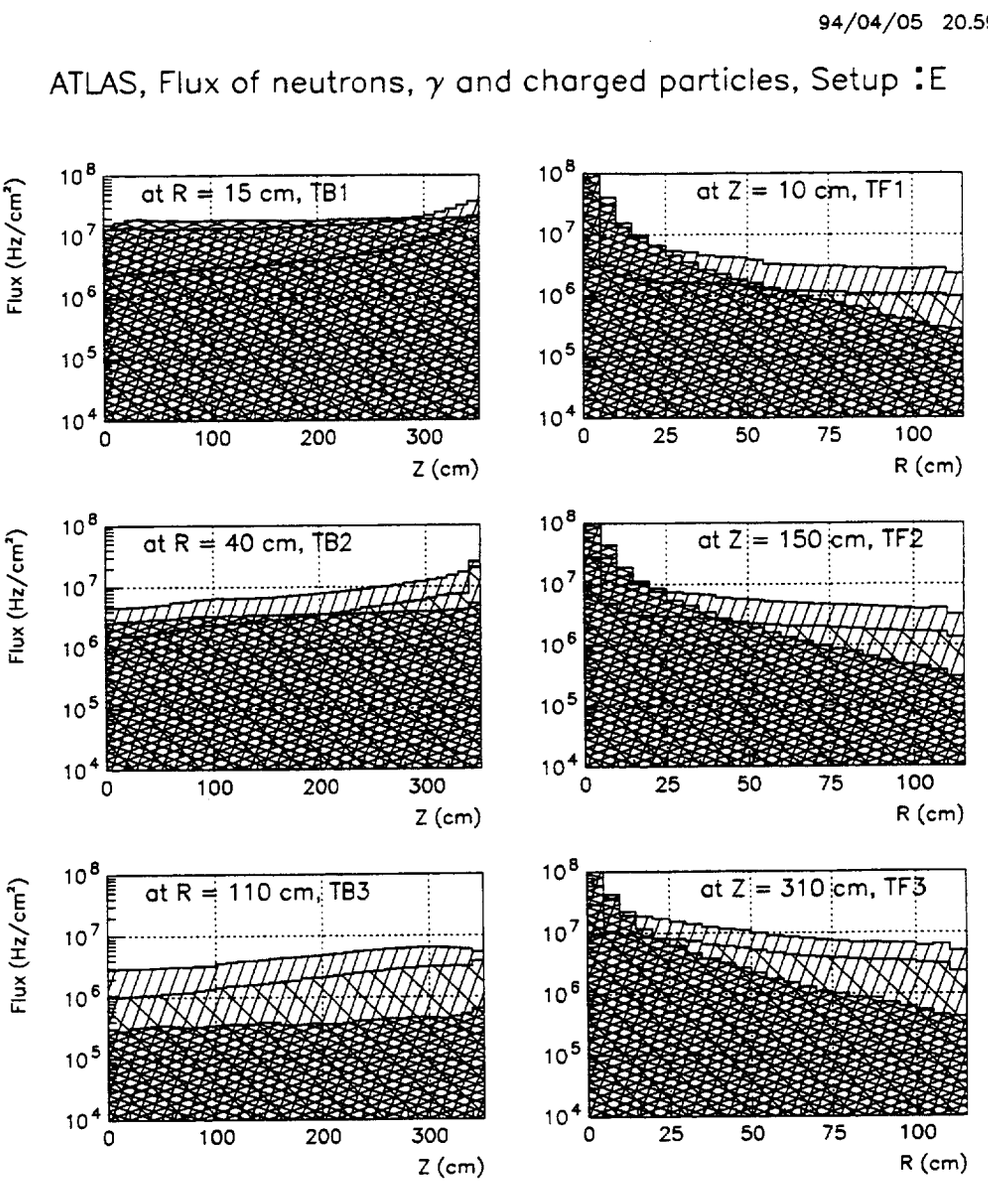


Figure 37: **Setup E**: Neutron (left hashed), γ (right hashed) and charged particles (shaded) fluxes in the tracker. "B" denotes barrel, "F" — endcap.

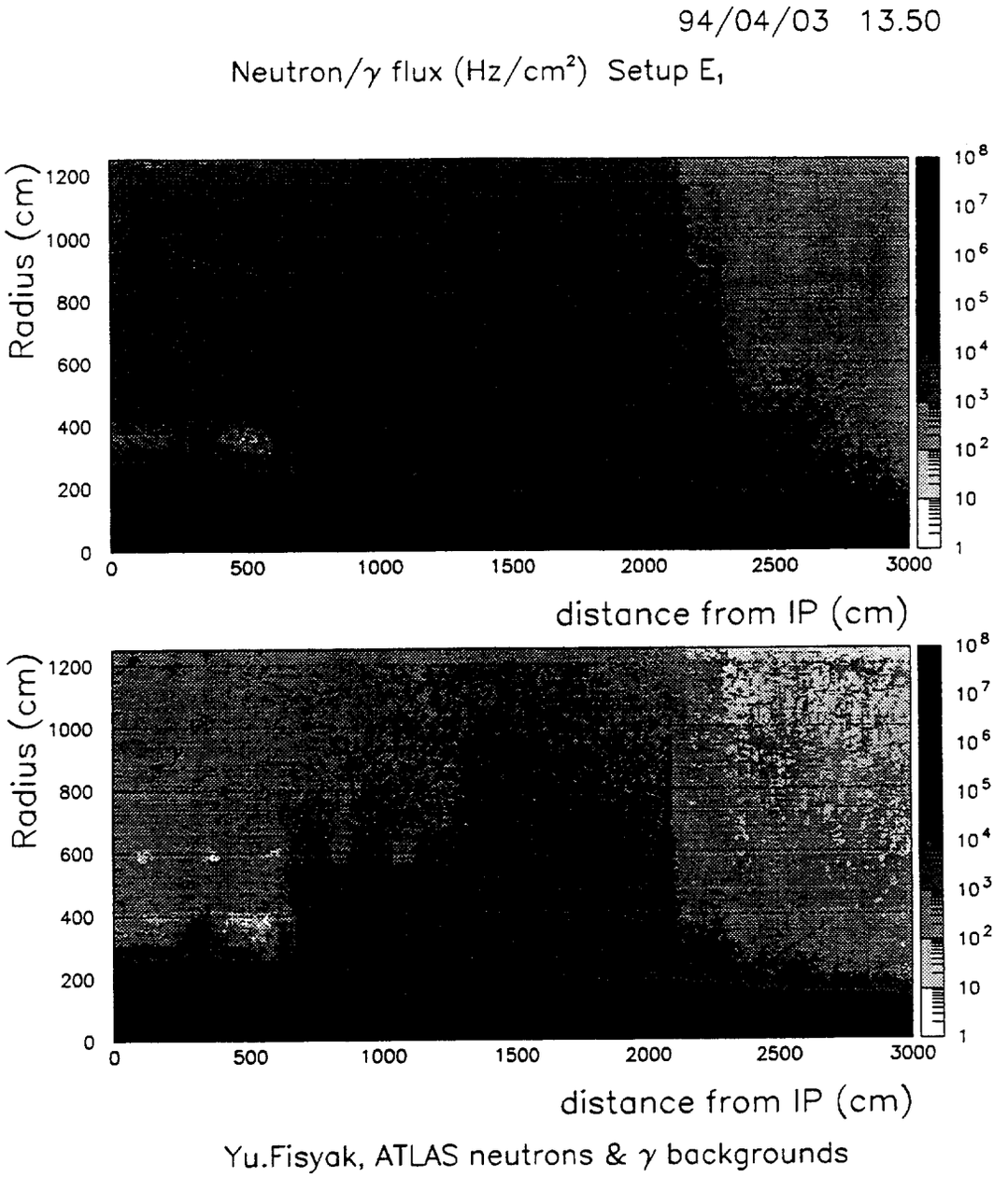
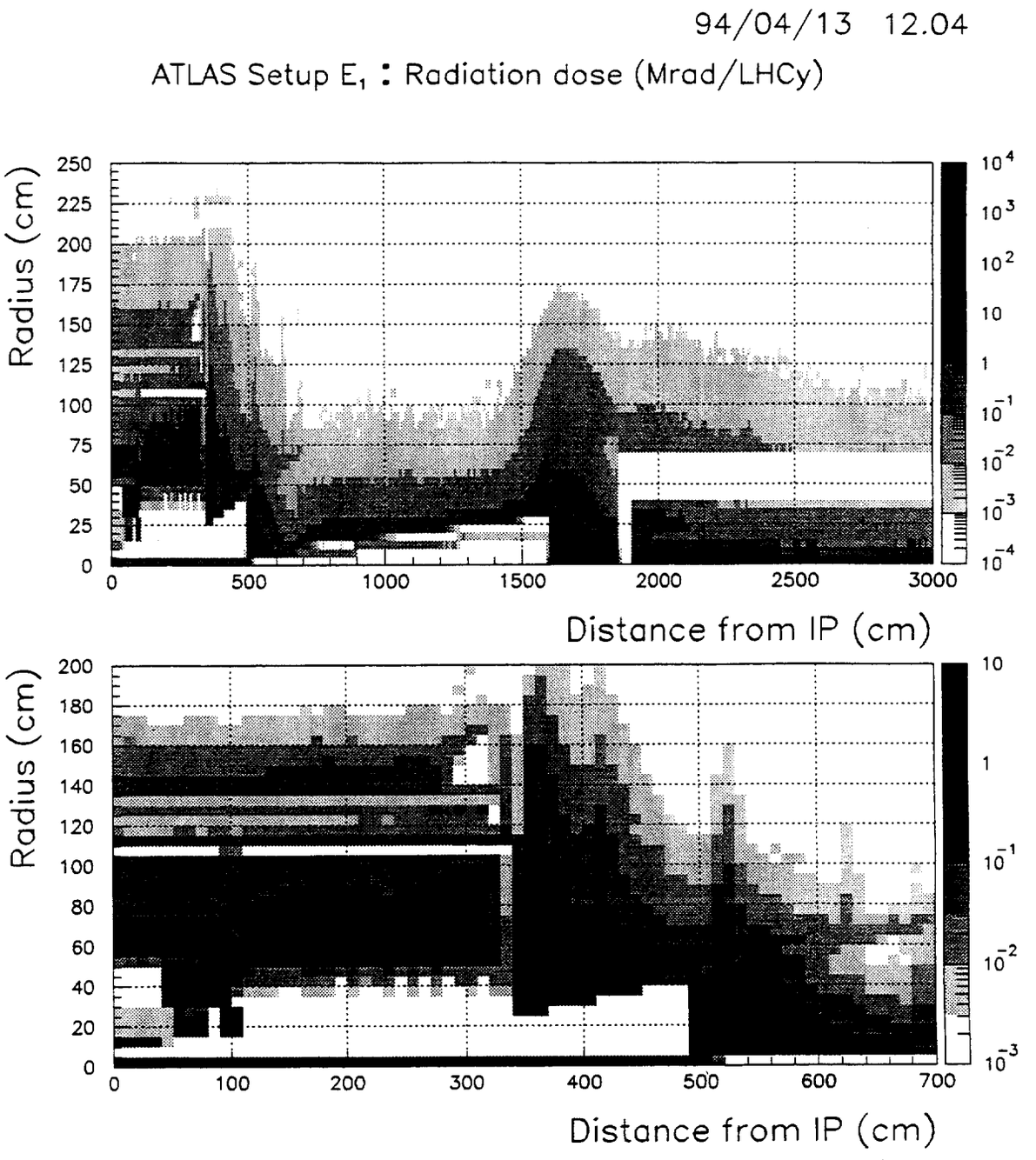


Figure 38: **Setup $\mathbf{E_1}$**: Neutron and γ fluxes versus distance from the interaction point and radius.



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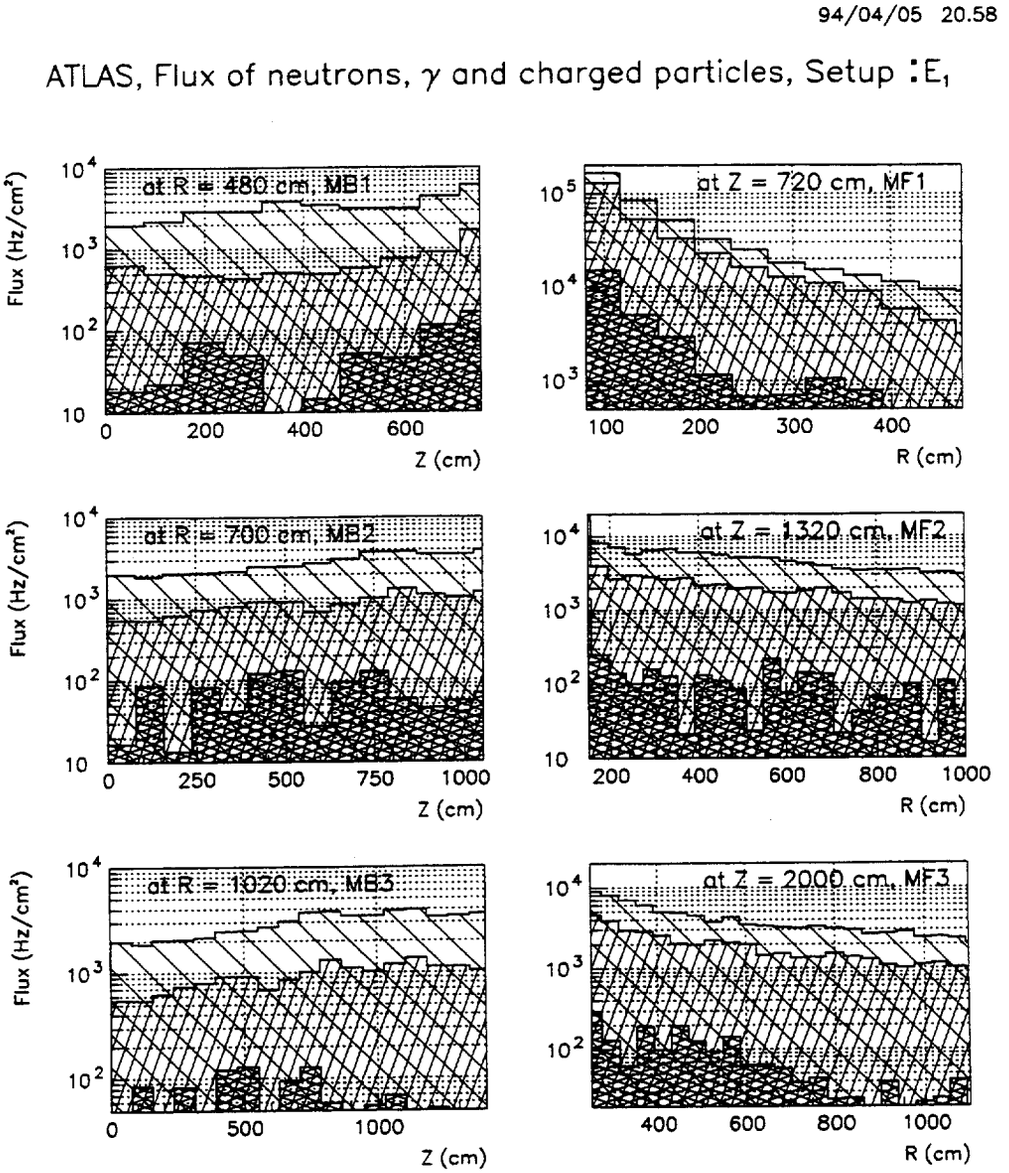

Figure 40: **Setup $\mathbf{E_1}$**: Neutron (left hashed), γ (right hashed) and charged particles (shaded) fluxes in the barrel (MB) and endcap (MF) muon chamber positions.

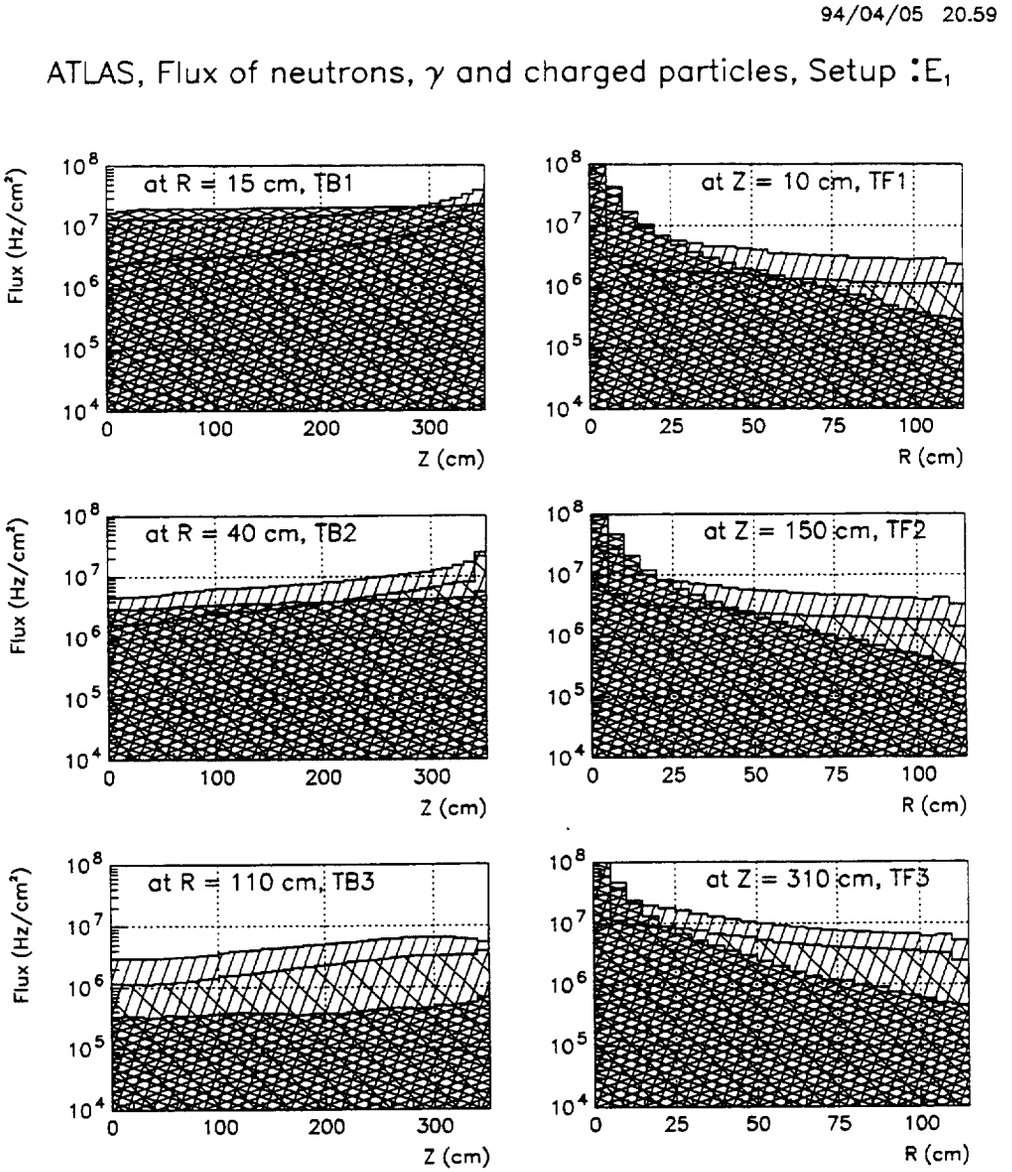

Figure 41: **Setup $\mathbf{E_1}$**: Neutron (left hashed), γ (right hashed) and charged particles (shaded) fluxes in the tracker. "B" denotes barrel, "F" — endcap.

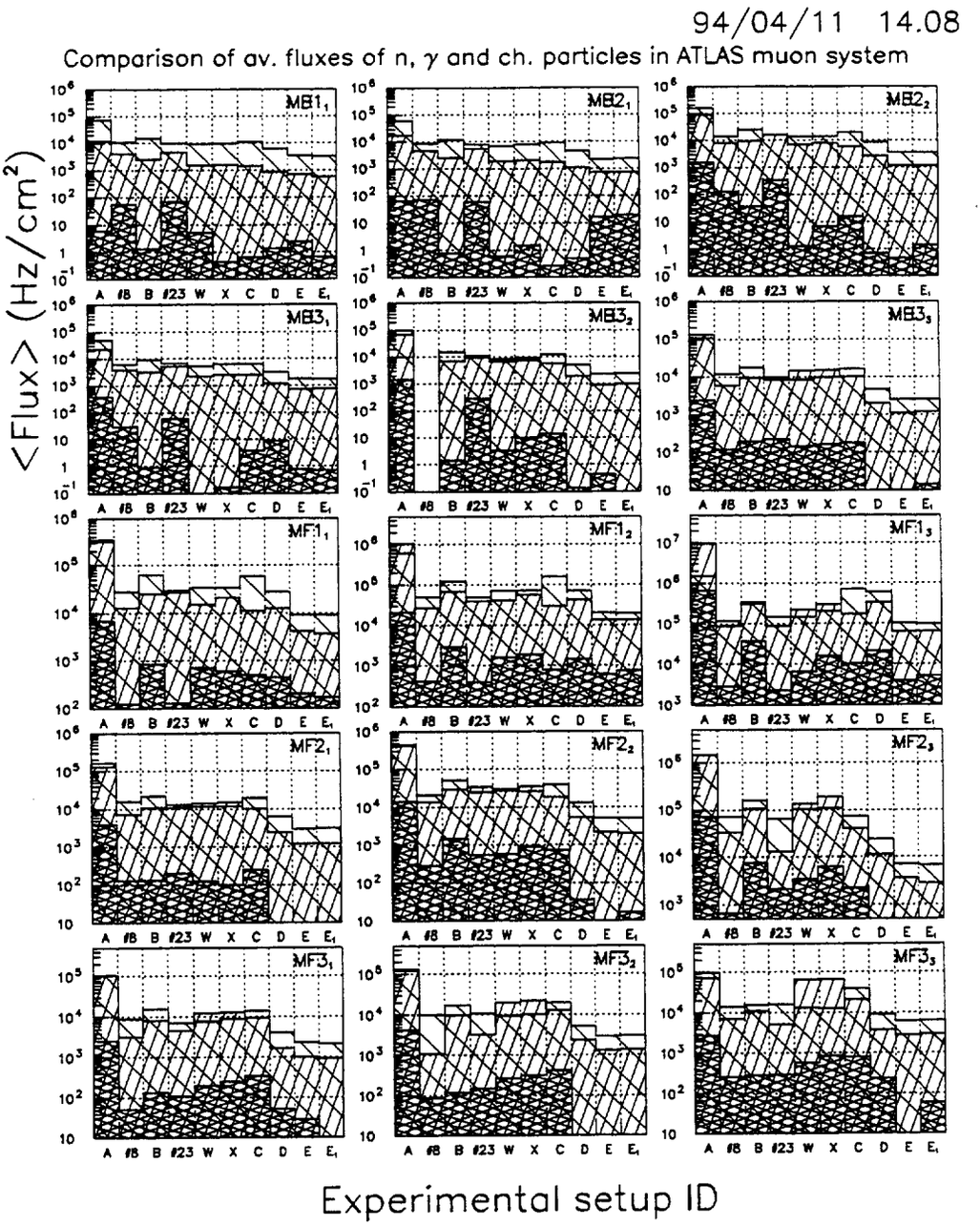

Figure 42: The comparison the average fluxes of neutrons, γ's and charged particles for the muon system in the considered setups. $MB1_1$ denotes the fluxes averaged over the first muon barrel station, $MB2_1$ — the second muon barrel station over $|Z| < 740$ cm, $MB2_2$ — over 740cm $< |Z| <$ 1300cm, $MB3_1$ for the third barrel muon station averaged over $|Z| < 740$ cm, $MB3_2$ — over 740cm $< |Z| <$ 1300cm, M $B3_3$ — over 1300cm $< |Z| <$ 1500cm, respectively $MF1_{1-3}$, $MF2_{1-3}$ and $MF3_{1-3}$ for the first, second and third endcap muon stations averaged over $\eta <$ 1.44 (subscribed by 1), $1.44 < \eta < 2.3$ (subscribed by 2) and $2.3 < \eta < 2.9$ (subscribed by 3). Neutron fluxes are left hashed, γ's are right hashed and charged particles are shaded.

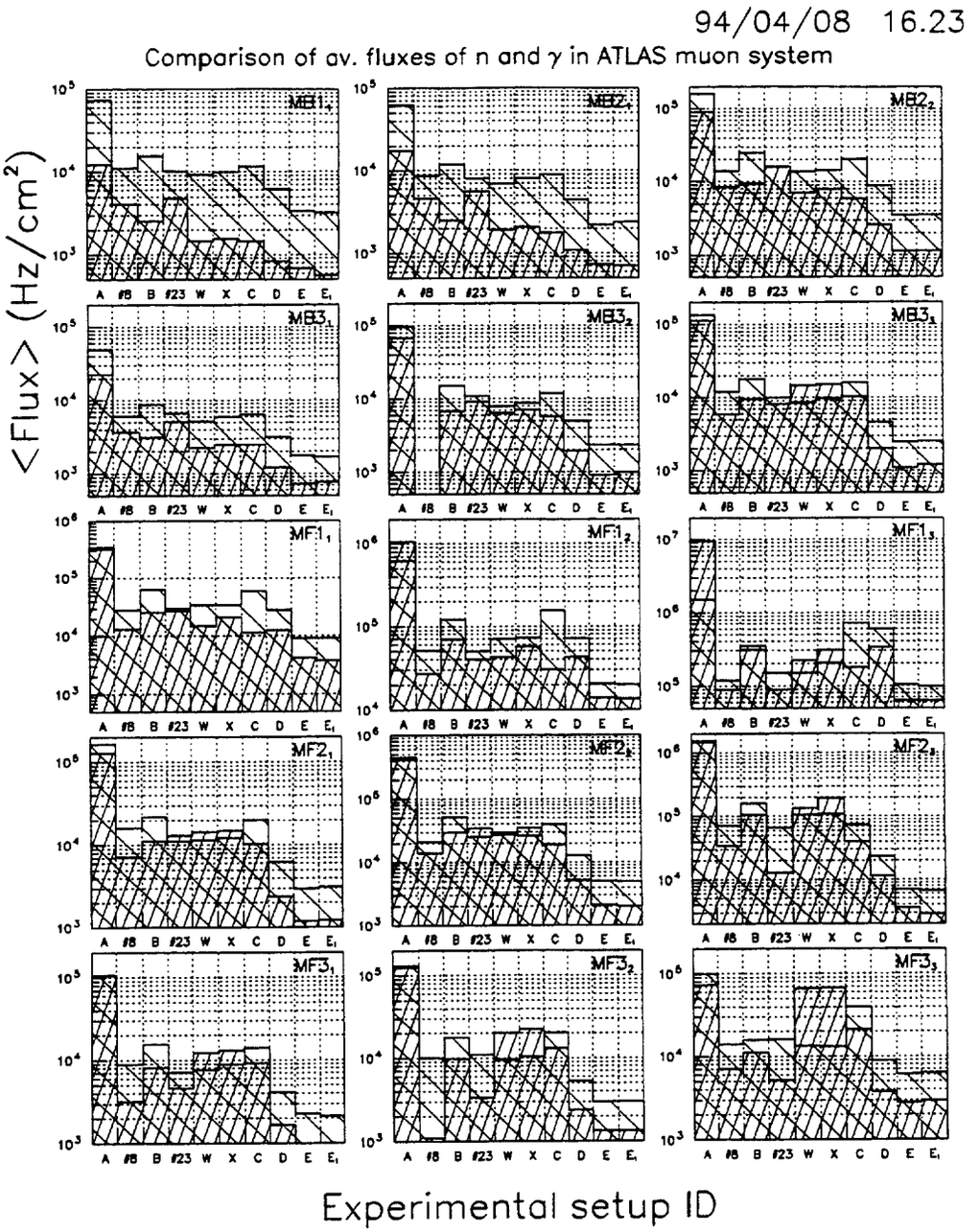

Figure 43: The comparison the average fluxes of neutrons and γ's for the muon system in the considered setups. $MB1_1$ denotes the fluxes averaged over the first muon barrel station, $MB2_1$ — the second muon barrel station over $|Z| < 740$ cm, $MB2_2$ — over 740cm $< |Z| <$ 1300cm, $MB3_1$ for the third barrel muon station averaged over $|Z| < 740$ cm, $MB3_2$ — over 740cm $< |Z| <$ 1300cm, M $B3_3$ — over 1300cm $< |Z| <$ 1500cm, respectively $MF1_{1-3}$, $MF2_{1-3}$ and $MF3_{1-3}$ for the first, second and third endcap muon stations averaged over $\eta < 1.44$ (subscribed by 1), $1.44 < \eta < 2.3$ (subscribed by 2) and $2.3 < \eta < 2.9$ (subscribed by 3). Neutrons are left hashed and γ's are right hashed.

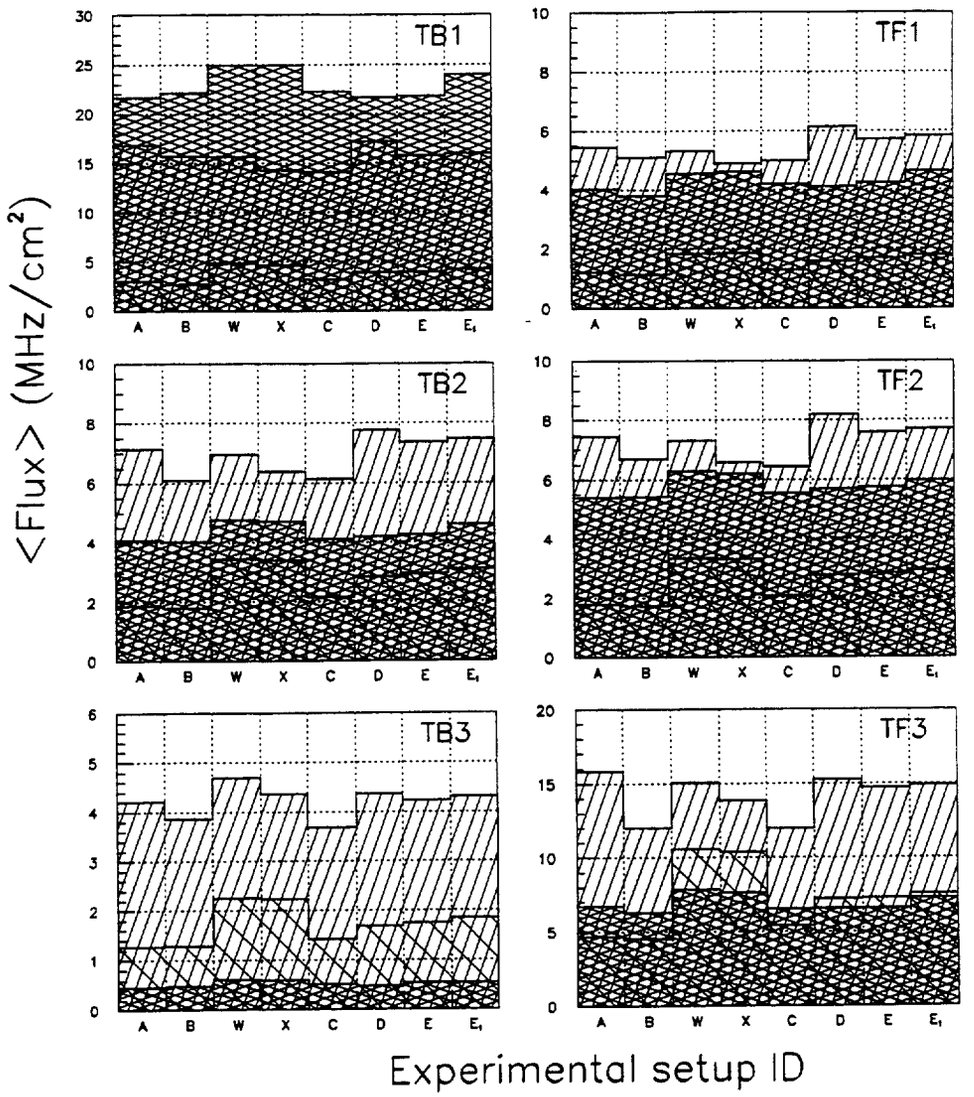

Figure 44: The comparison the average fluxes of neutrons, γ's and charged particles for the different central tracker regions (TB1-3 denote the fluxes averaged over the $|Z| < 345$ cm at R = 10-15 cm, R = 40-45 cm, R = 110-115 cm, respectively, TF1-3 — the fluxes averaged over R=10-100 cm) in the considered setups. Neutrons are left hashed, γ's are right hashed and charged particles are shaded.

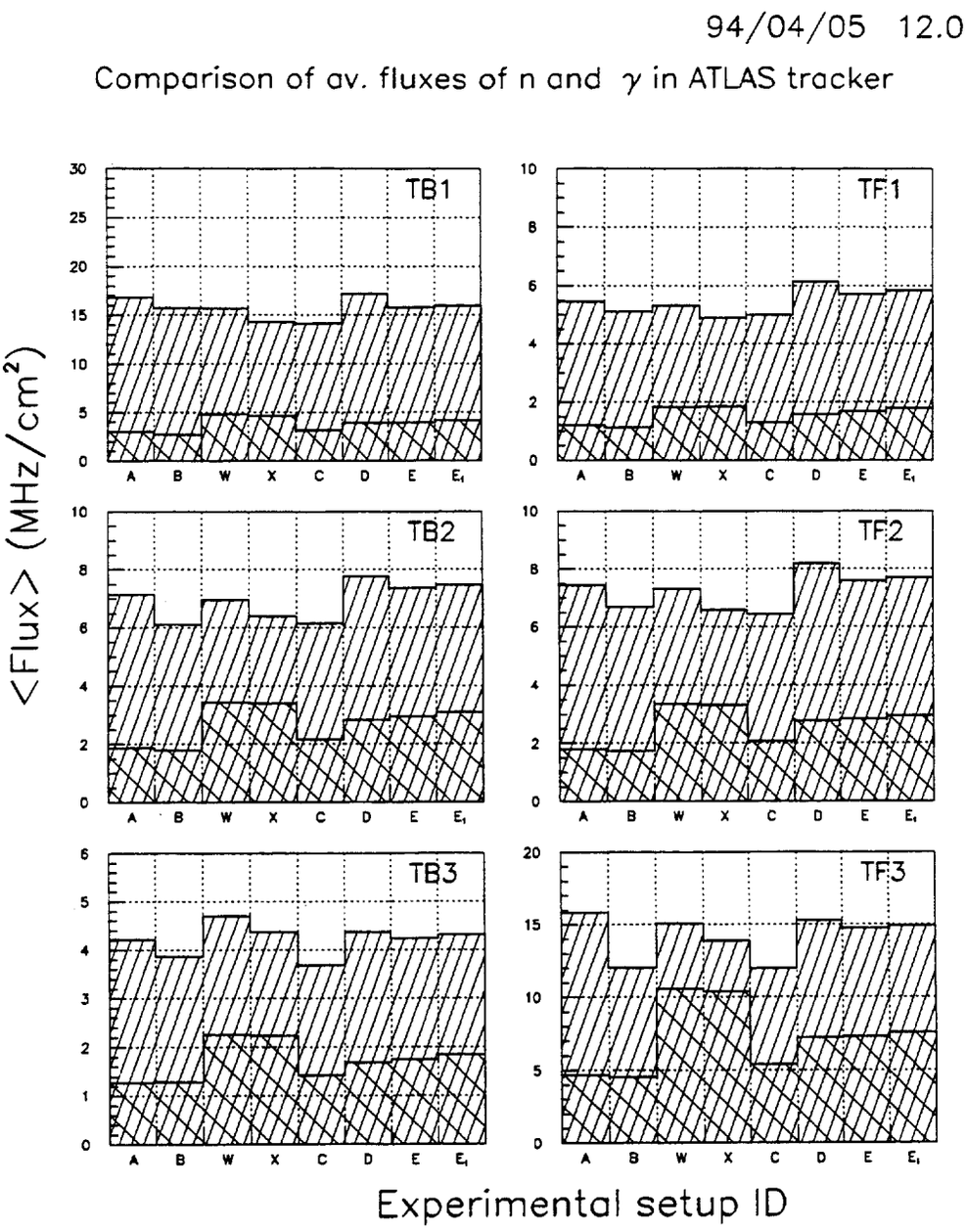

Figure 45: The comparison the average fluxes of neutrons and γ's for the different central tracker regions (TB1-3 denote the fluxes averaged over the $|Z| < 345$ cm at R = 10-15 cm, R = 40-45 cm, R = 110-115 cm, respectively, TF1-3 — the fluxes averaged over R=10-100 cm) in the considered setups. Neutrons are left hashed, γ's are right hashed.