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Multiple Interaction Tool Study

Introduction

A study was made of the Multiple Interaction (MI) tool for a series of global data runs taken over a wide range of luminosities near the end of Run 1A. The Multiple Interaction tool is designed to return a value of 1 through 4 to indicate whether or not an interaction is determined to be a single or multiple interaction event. The algorithm and basic usage procedure is already documented in DØ Note 1691 and will not be restated here. The tool returns a '1' to indicate the event is 'most likely' a single interaction, '2' is 'likely','3' is 'likely' multiple, and '4' is 'most likely' a multiple interaction. If the tool returns a value of '0' then there was not enough information with which to make a decision. The information used to make this determination is the Level 0 Multiple Interaction flag and Slow Z vertex position, the Central Detectors' vertex results, and the total energy seen in the calorimeter. Results are given for both the Level 0 MI flag, which is the only information available at the end of the Level 1 trigger, and the MI tool, which is available offline. With the current work being done on making the Central Detector vertex code functional in Level 2, perhaps the tool could be implemented there also at some point.

Level 0 Multiple Interaction Flag Results

Figures 1 through 4 summarize the data for just the Level 0 Multiple Interaction flag. Each plot shows the fraction of events for each run that have the flag value set to 1,2,3, and 4, respectively. Drawn on each curve is the

expected number of events that are singles (on Figures 1 and 2) and multiples (on Figures 3 and 4). Figures 5 and 6 show the fraction of events that have the MI flag equal to 1 or 2 (Figure 5) and equal to 3 or 4 (Figure 6). Figure 7 gives a MI flag=1 'efficiency' that is the number of events marked with MI flag=1 divided by the number of single interaction events predicted by theory.

It can be seen from Figures 1 and 7 that the Level 0 MI flag=1 case seems to be less efficient as the luminosity climbs. It is also apparent that the flag=2 case climbs with luminosity and thus brings more and more multiple interaction events into the combined flag=1 plus 2 sample at higher luminosities. This effect also adversely affects the MI tool as is shown later. Since there is no effective multiple interaction Monte Carlo for the Level 0, a study can not be made to determine what fraction of multiple interaction events are mis-identified as single and so the amount of multiple interaction contamination in the marked as single events is unknown. An estimate for the flag=1 situation would be less than 5%.

Multiple Interaction Tool Results

The results for the MI tool are presented in a separate set of figures. Figures 8 through 11 summarize the data for the Multiple Interaction tool. Each plot shows the fraction of events for each run that have the tool value set to 1,2,3, and 4, respectively. Drawn on each curve is the expected number of events that are singles (on Figures 8 and 9) and multiples (on Figures 10 and 11). Figures 12 and 13 show the fraction of events that have the MI tool equal to 1 or 2 (Figure 12) and equal to 3 or 4 (Figure 13). Figure 14 gives a tool=1 'efficiency' that is the number of events marked with MI tool=1 divided by the number of single interaction events predicted by theory.

The results of the MI tool show good correlation in the number of events judged single and the expected number of single interactions. The trends indicate that, as the luminosities increase above those seen at DØ in Run 1A, the number of events marked as single will exceed the expected number. This is the same trend shown by the Level 0 MI flag=1 and 2. The tool seems to be able to correct this effect at current luminosities but may not be adequate at higher luminosities ($> 8E30$).

Conclusions

The current Multiple Interaction Tool does a reasonable job at distinguishing multiple interaction events from singles. Higher luminosities will see the efficiency of selecting singles decrease for tool=1 results. The amount of contamination, ie multiples marked as singles, is unknown but for tool=1 guestimated to be less than 5%. Higher luminosities will see the contamination increase for tool=2 results if the Level 0 MI flag=2 result cannot be improved.

Further studies of the Level 0 at the beginning of Run 1B with the new geometry may help to more accurately mark single interaction events with less contamination by multiples. It is hoped that this will help the Level 0 MI flag=2 situation. Another study is being done that is attempting to use the individual channel times in more clever algorithms to see if the Level 0 can match more than just the primary Z vertex. This will allow additional confirmation of a multiple interaction.

It is highly recommended that users try out the tool on samples of Run 1A data especially at higher luminosities ($> 5E30$). Run 1B events will require intense scrutiny if the expected increase in luminosity is achieved. Familiarity with the tool and its results will be very useful.

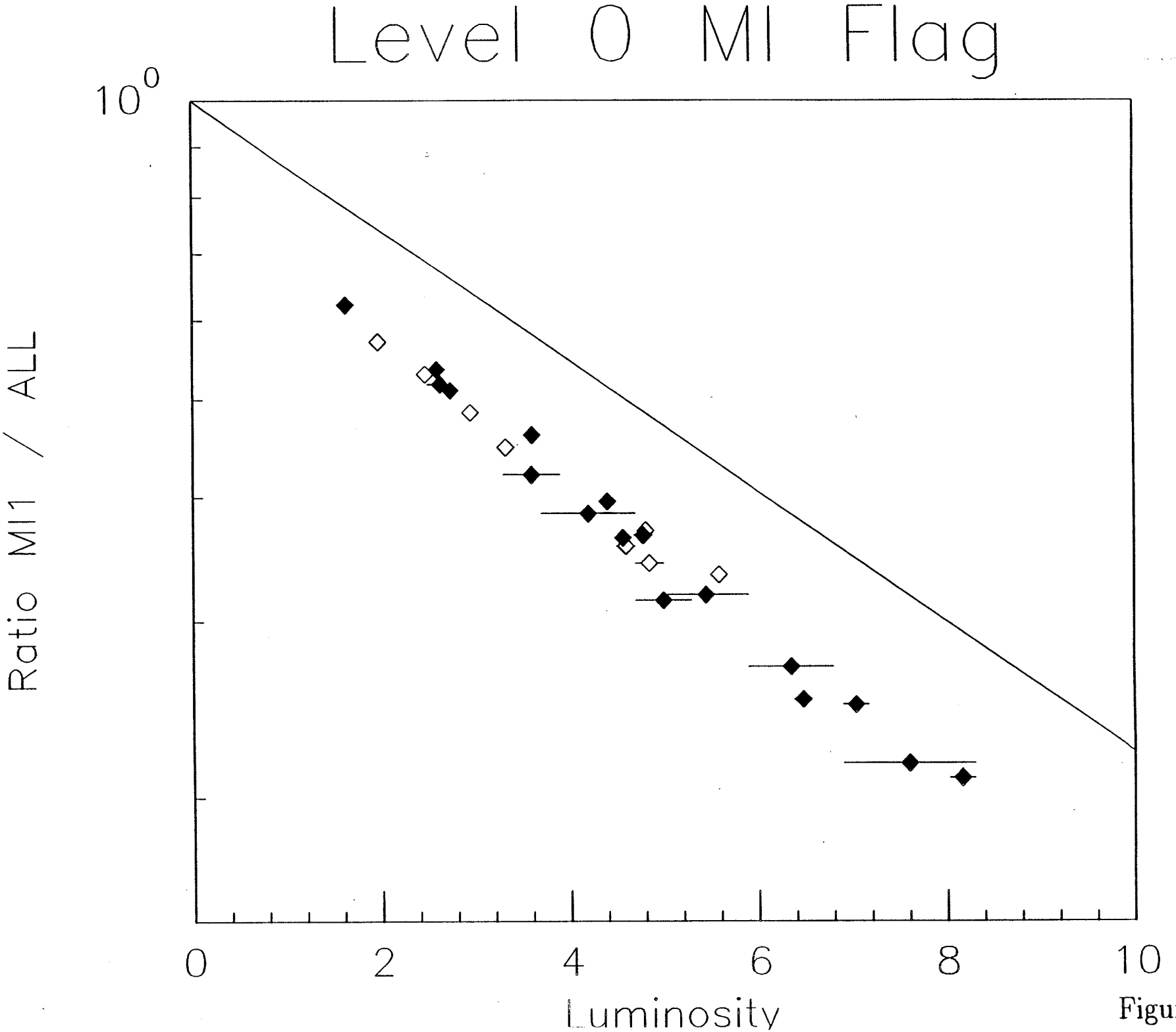

Figure 1

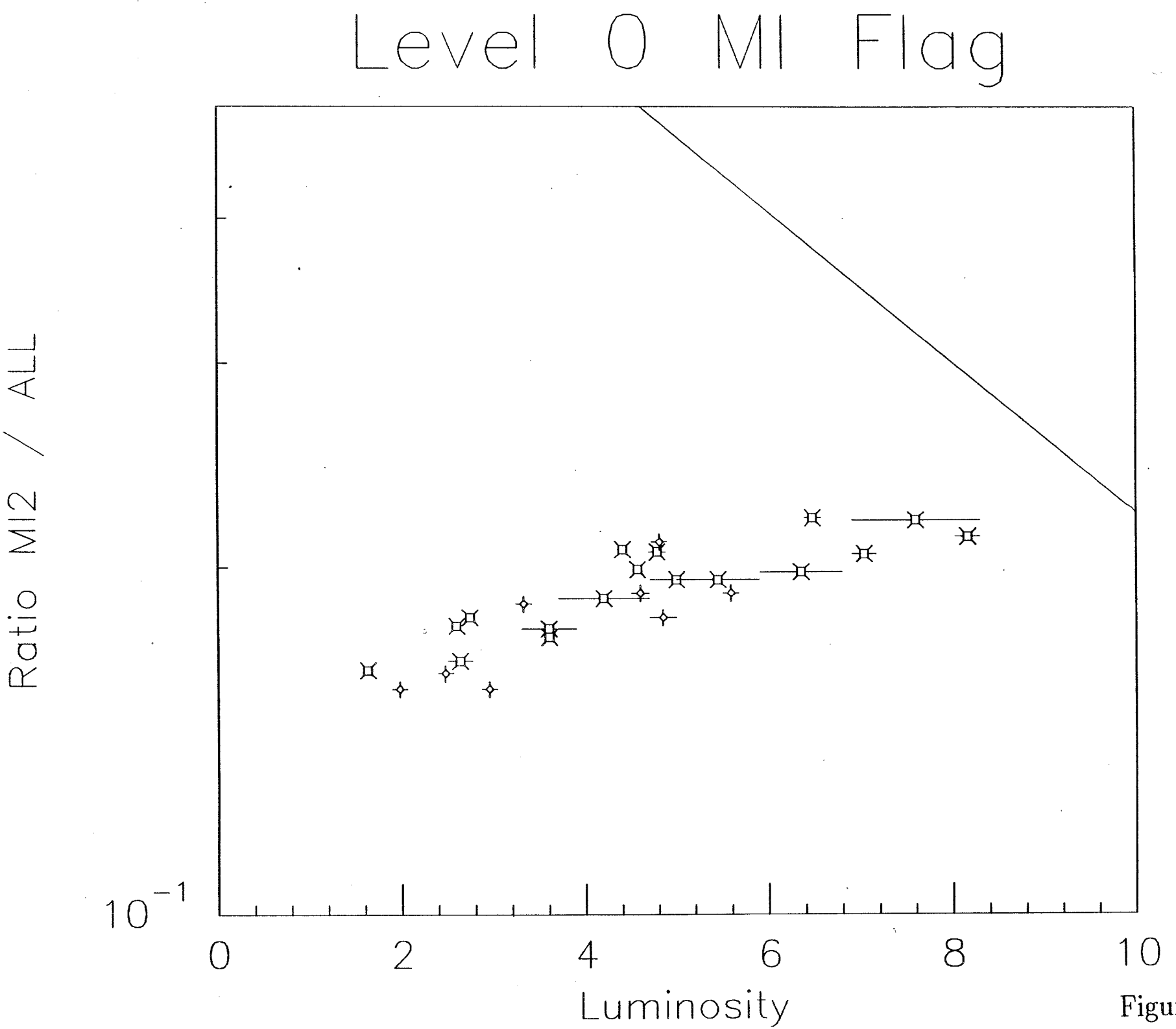

Figure 2

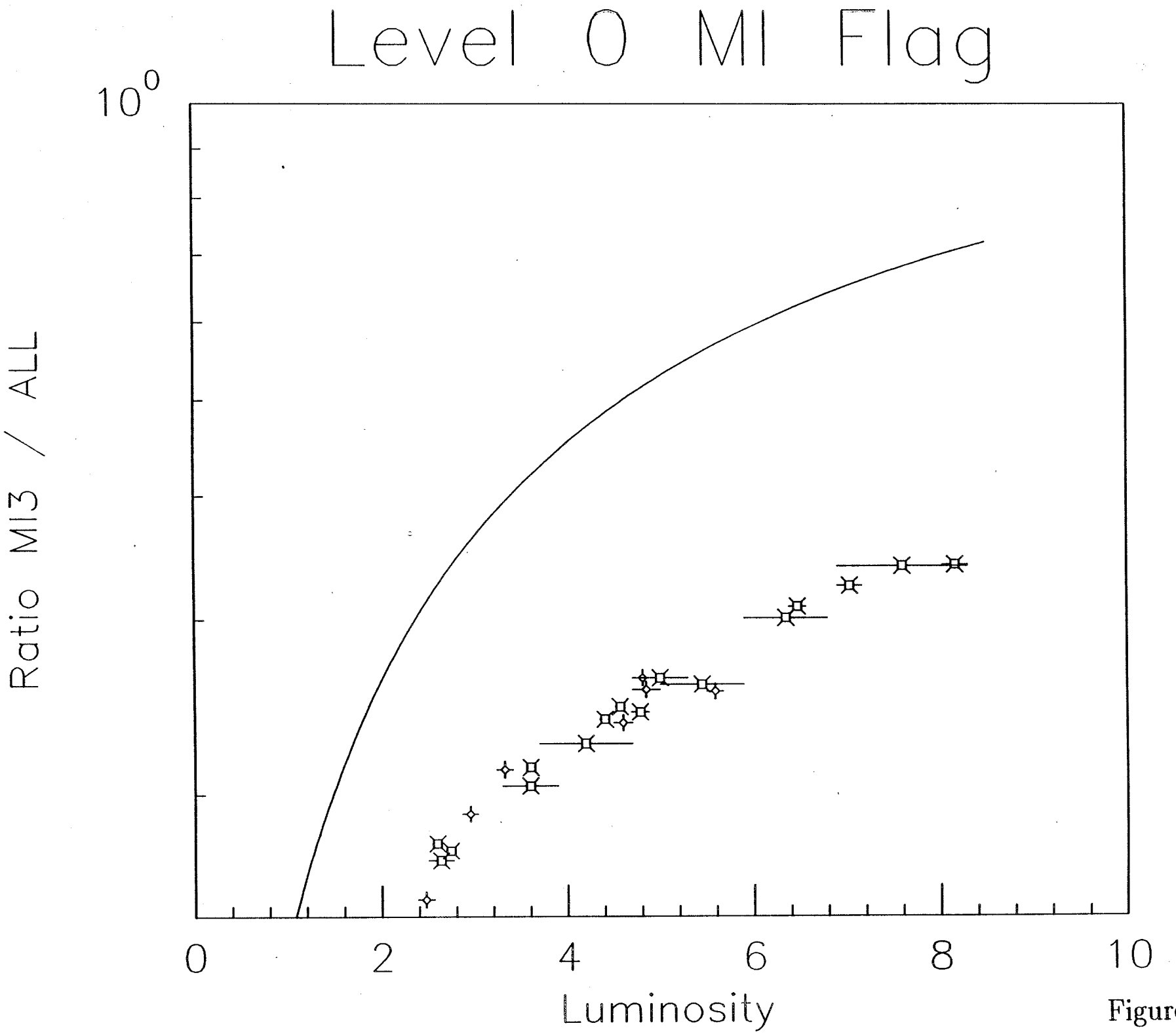

Figure 3

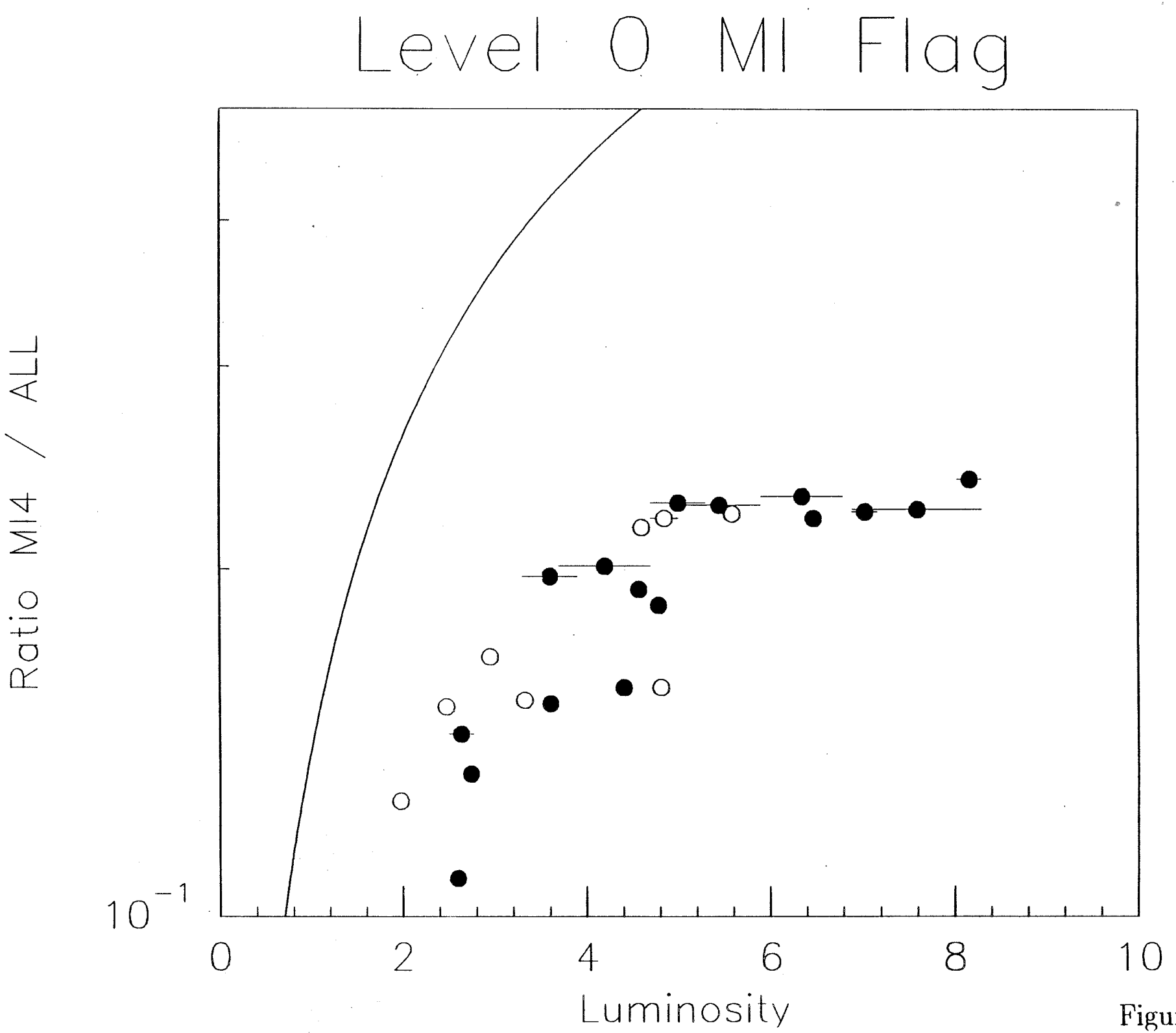

Figure 4

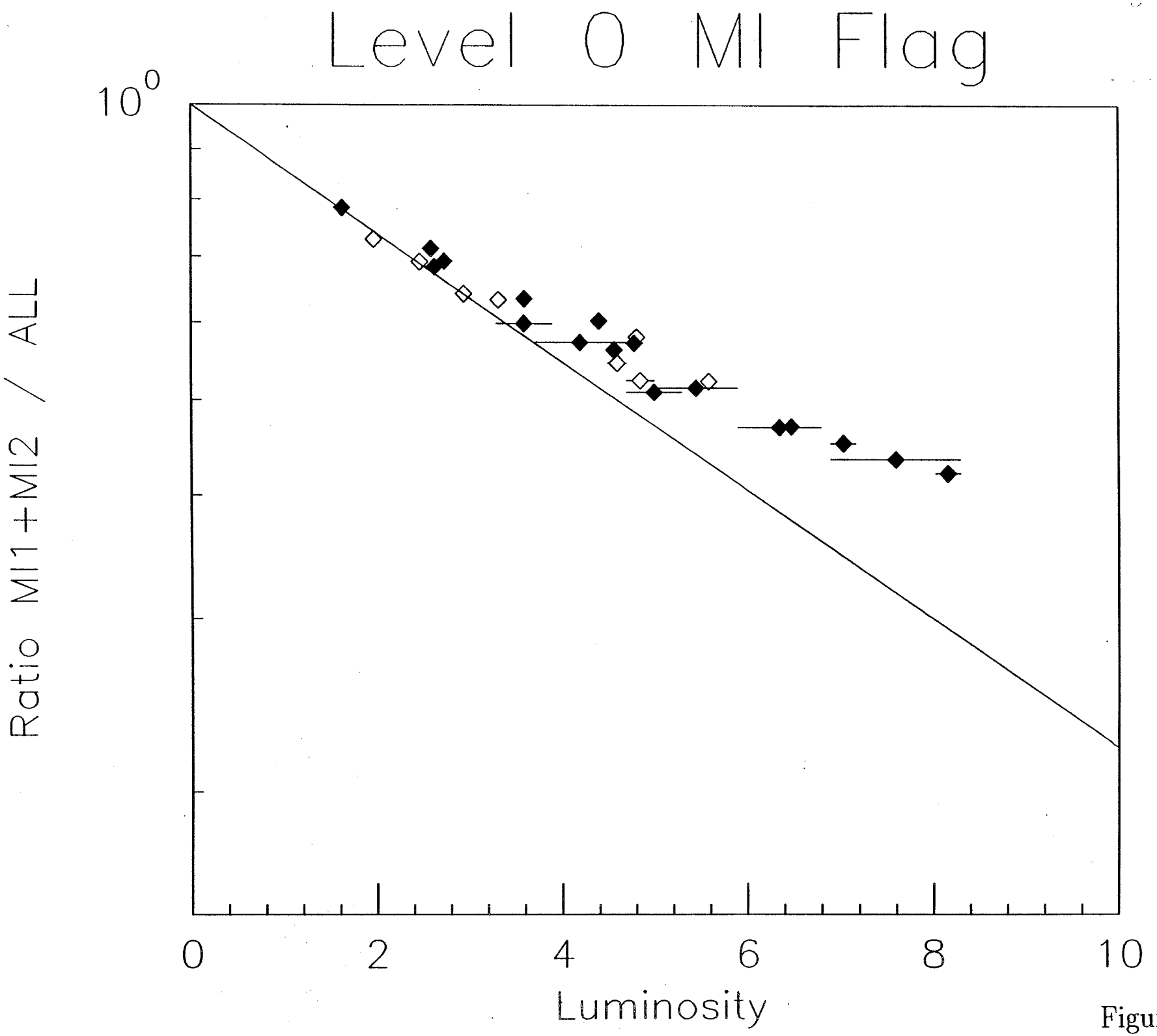

Figure 5

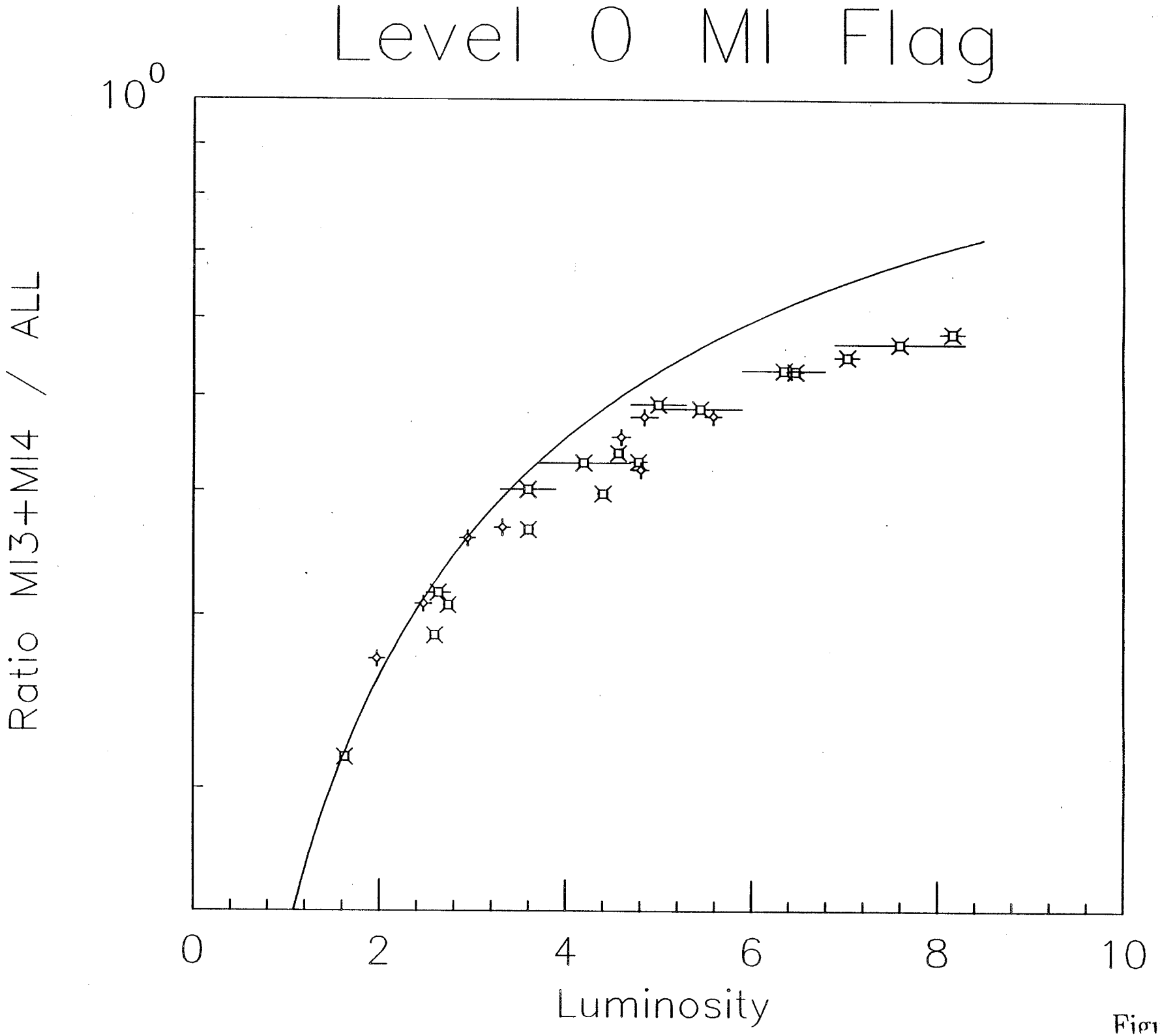

Figure 6

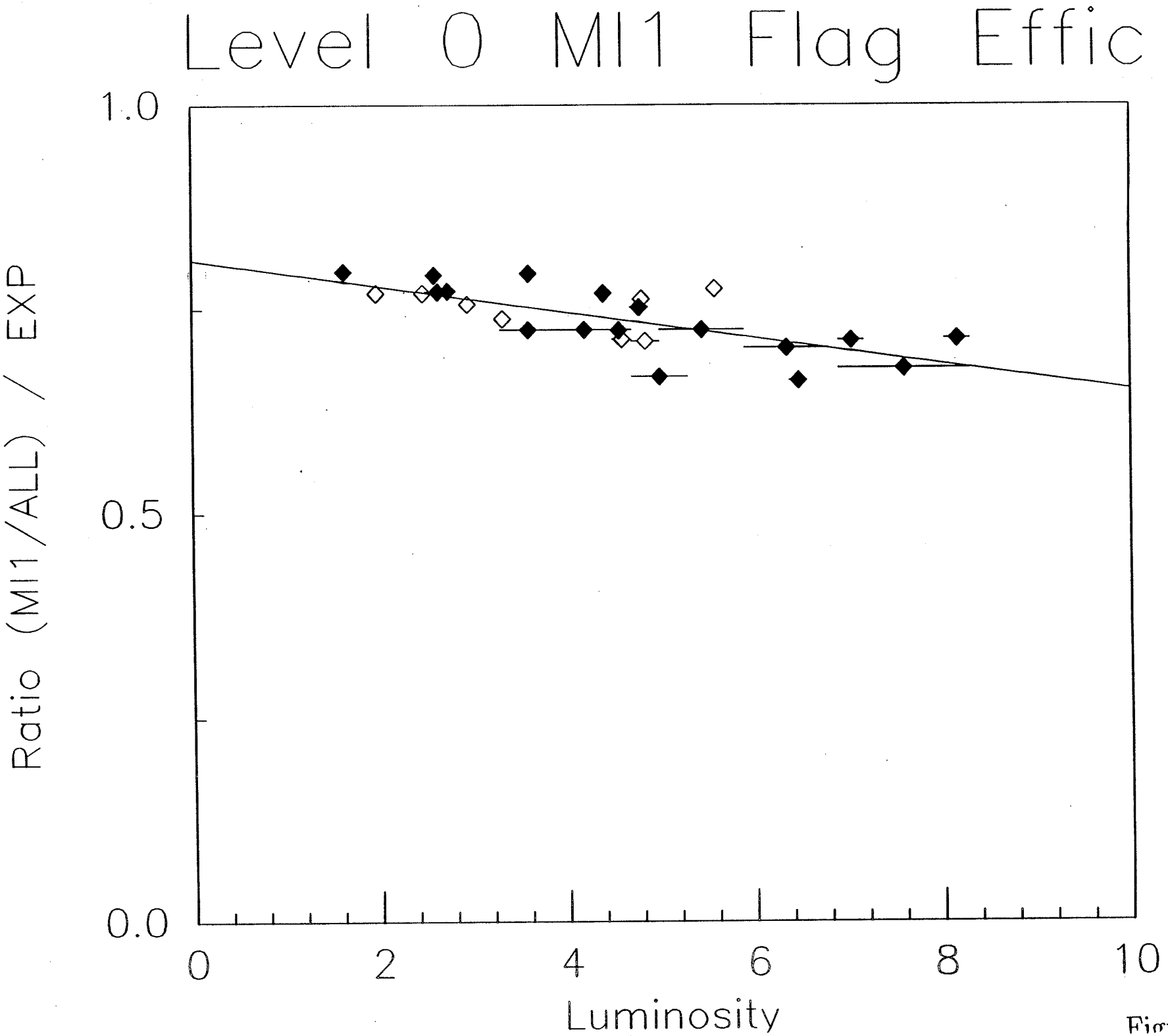
Level 0 MI1 Flag Effic
1.0
0.5
0.0
Ratio (MI1/ALL) / EXP
0
2
4
6
8
10
Luminosity

Figure 7

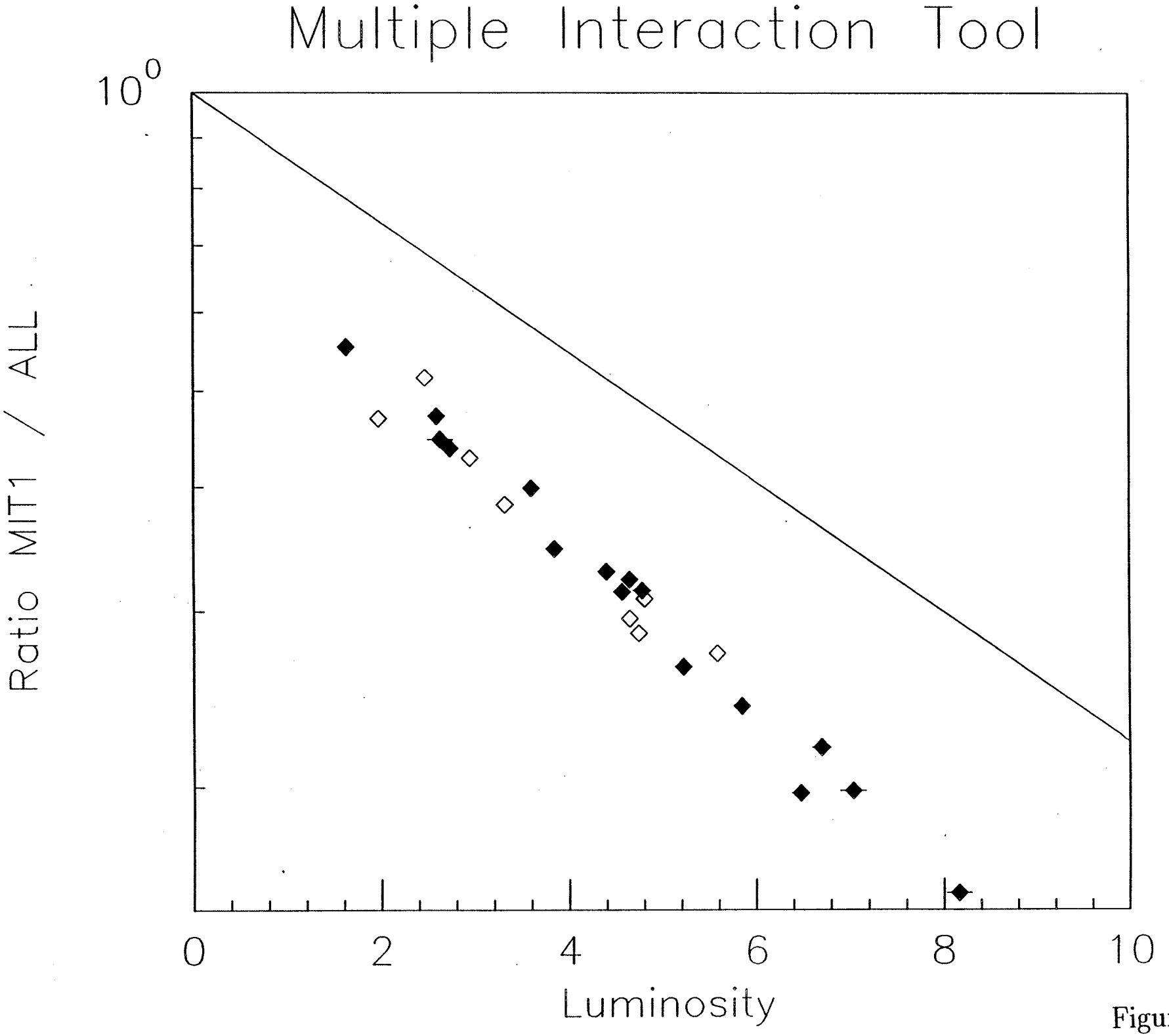
Multiple Interaction Tool
10^0
Ratio MIT1 / ALL
0
2
4
6
8
10
Luminosity

Figure 8

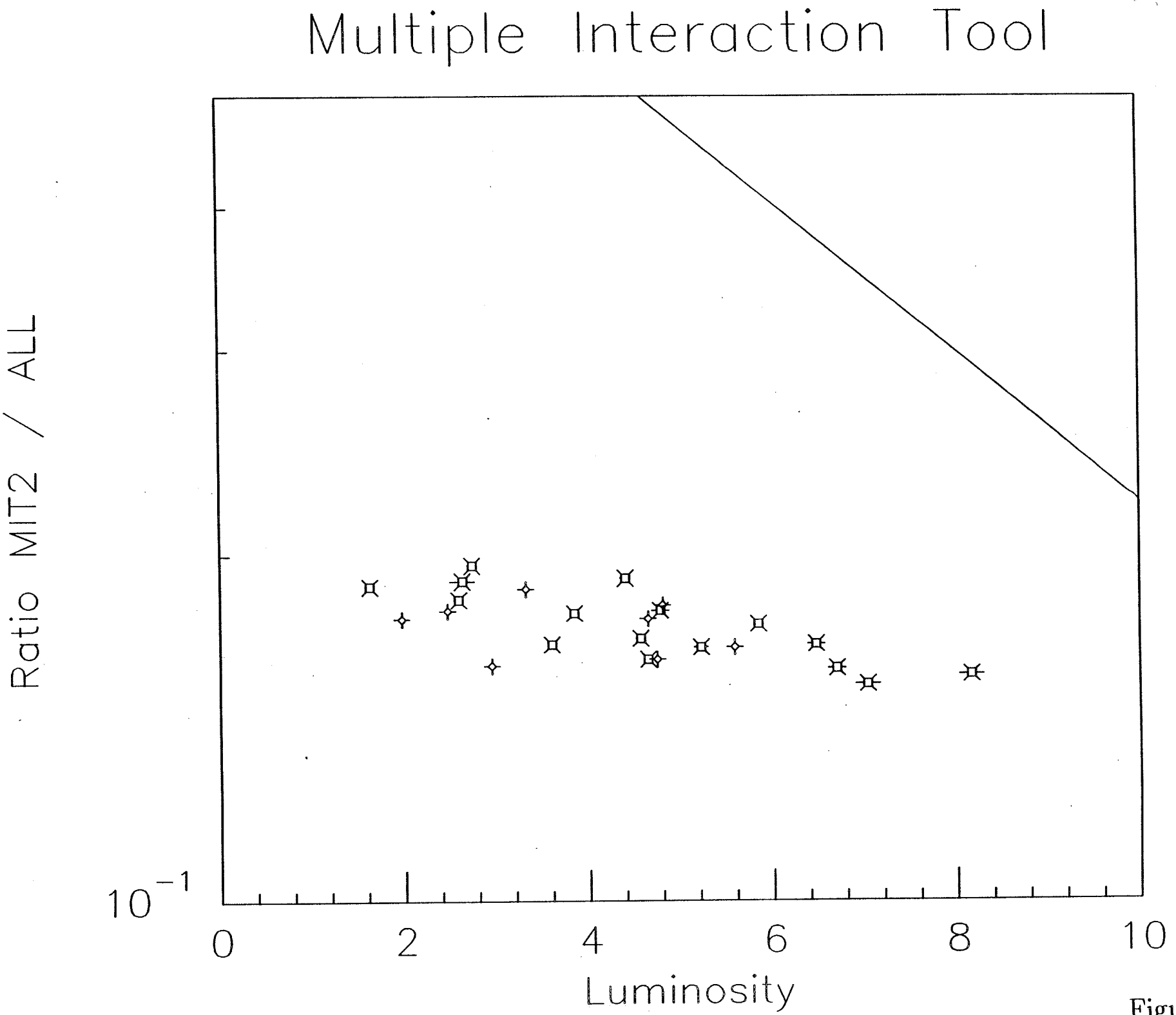
Multiple Interaction Tool
Ratio MIT2 / ALL
10^{-1}
0
2
4
6
8
10
Luminosity

Figure 9

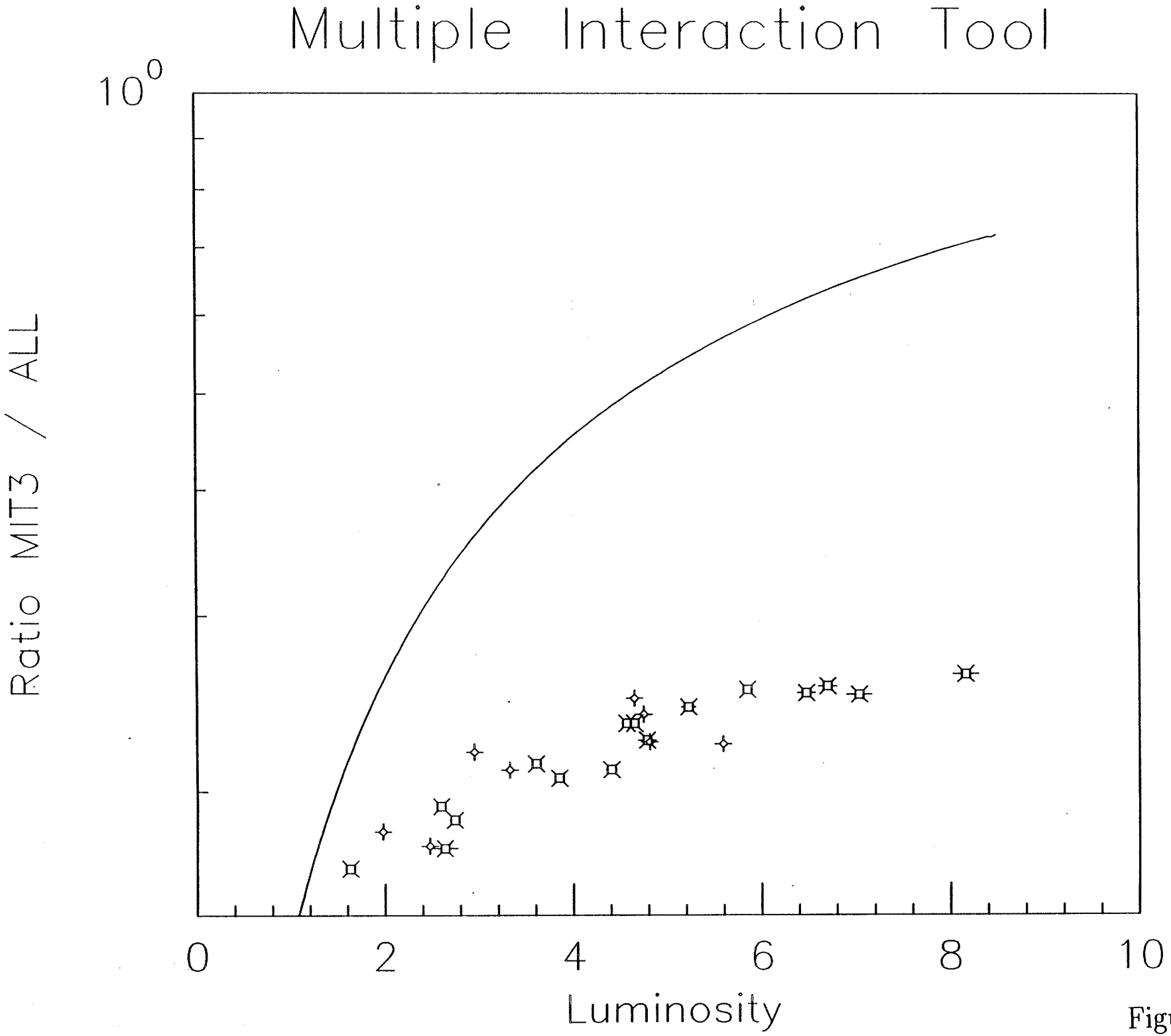
Multiple Interaction Tool
10^0
Ratio MIT3 / ALL
0
2
4
6
8
10
Luminosity

Figure 10

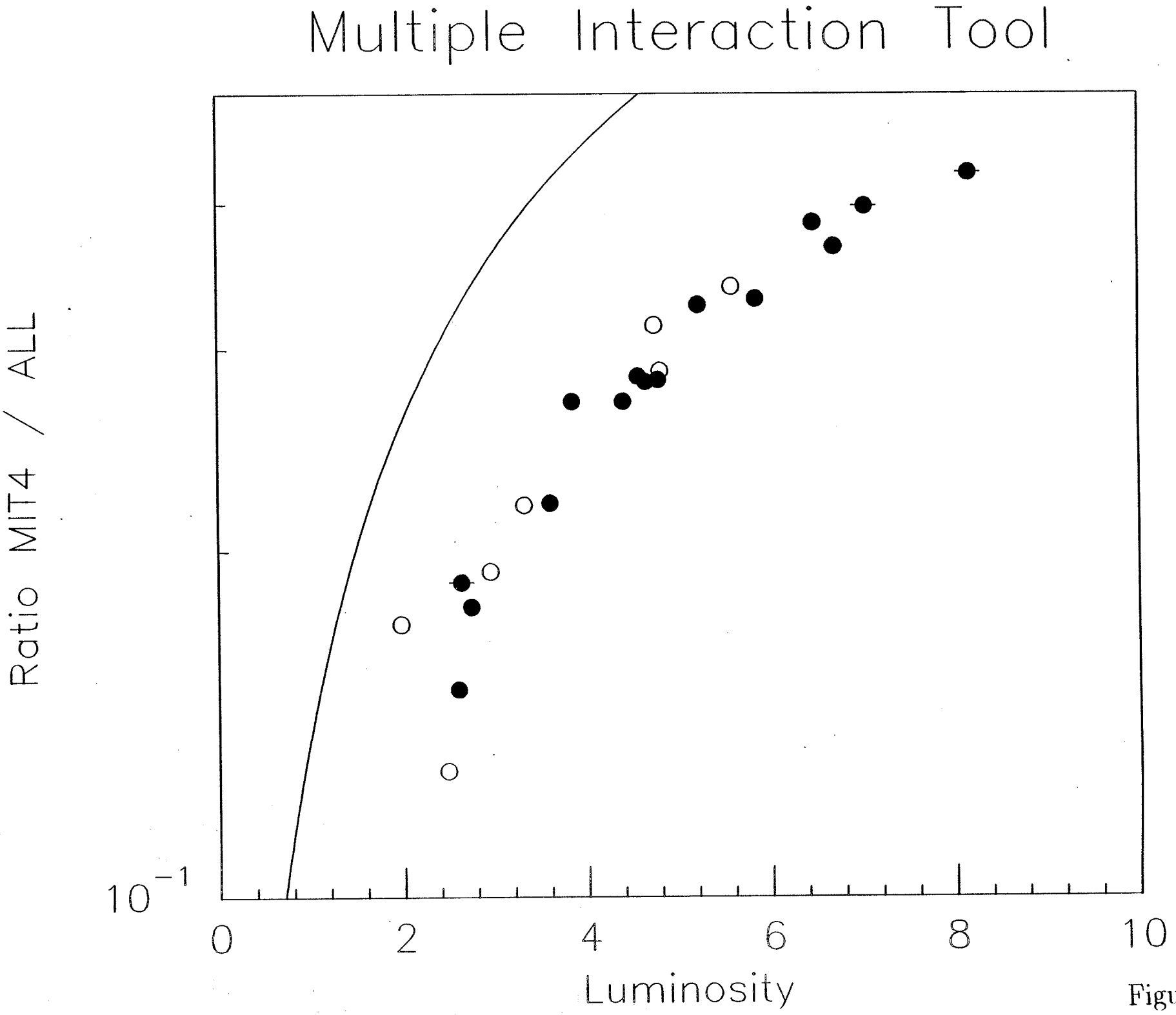
Multiple Interaction Tool
Ratio MIT4 / ALL
10^{-1}
0
2
4
6
8
10
Luminosity

Figure 11

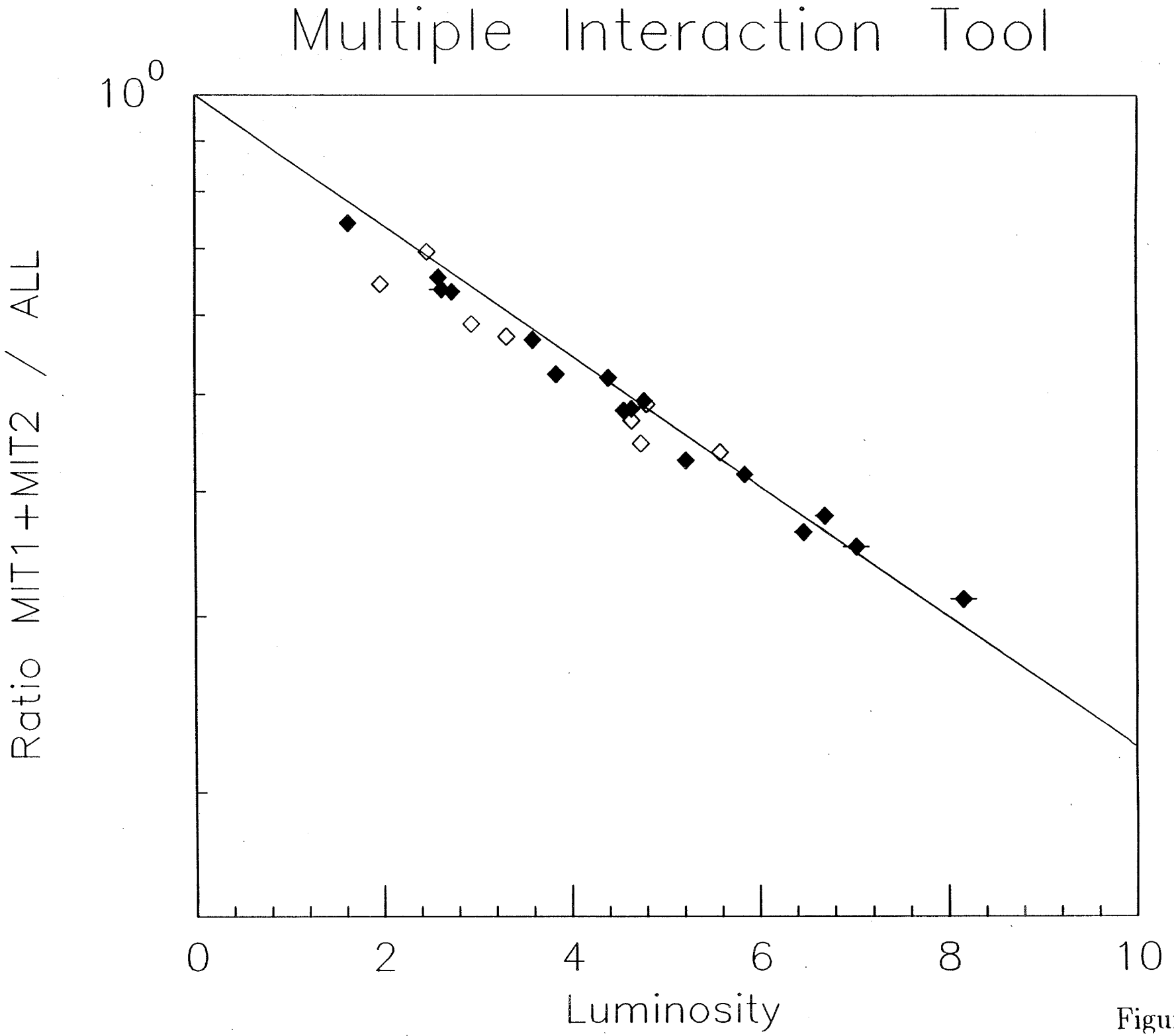
Multiple Interaction Tool
10^0
Ratio MIT1+MIT2 / ALL
0
2
4
6
8
10
Luminosity

Figure 12

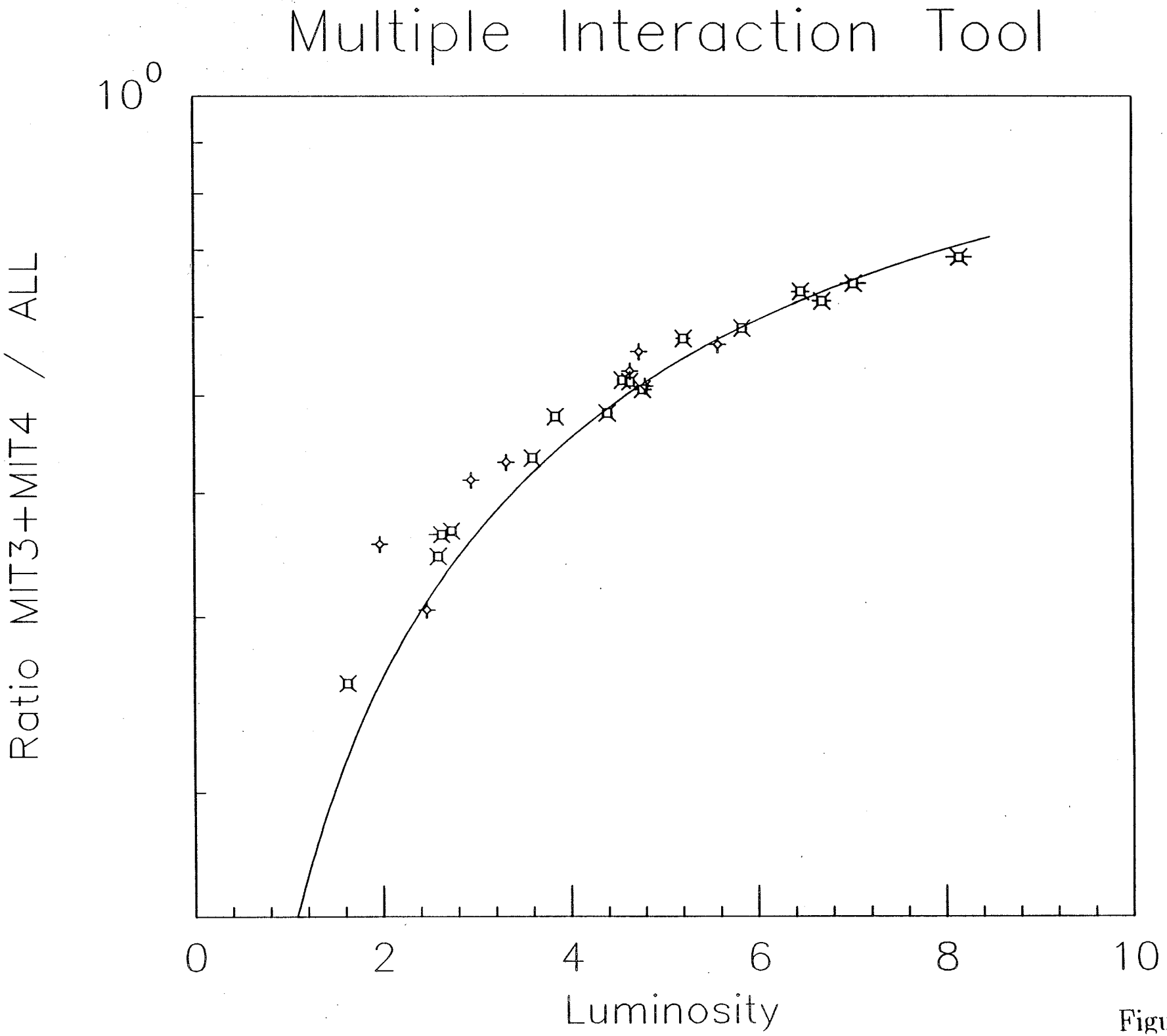
Multiple Interaction Tool
10^0
Ratio MIT3+MIT4 / ALL
0
2
4
6
8
10
Luminosity

Figure 13

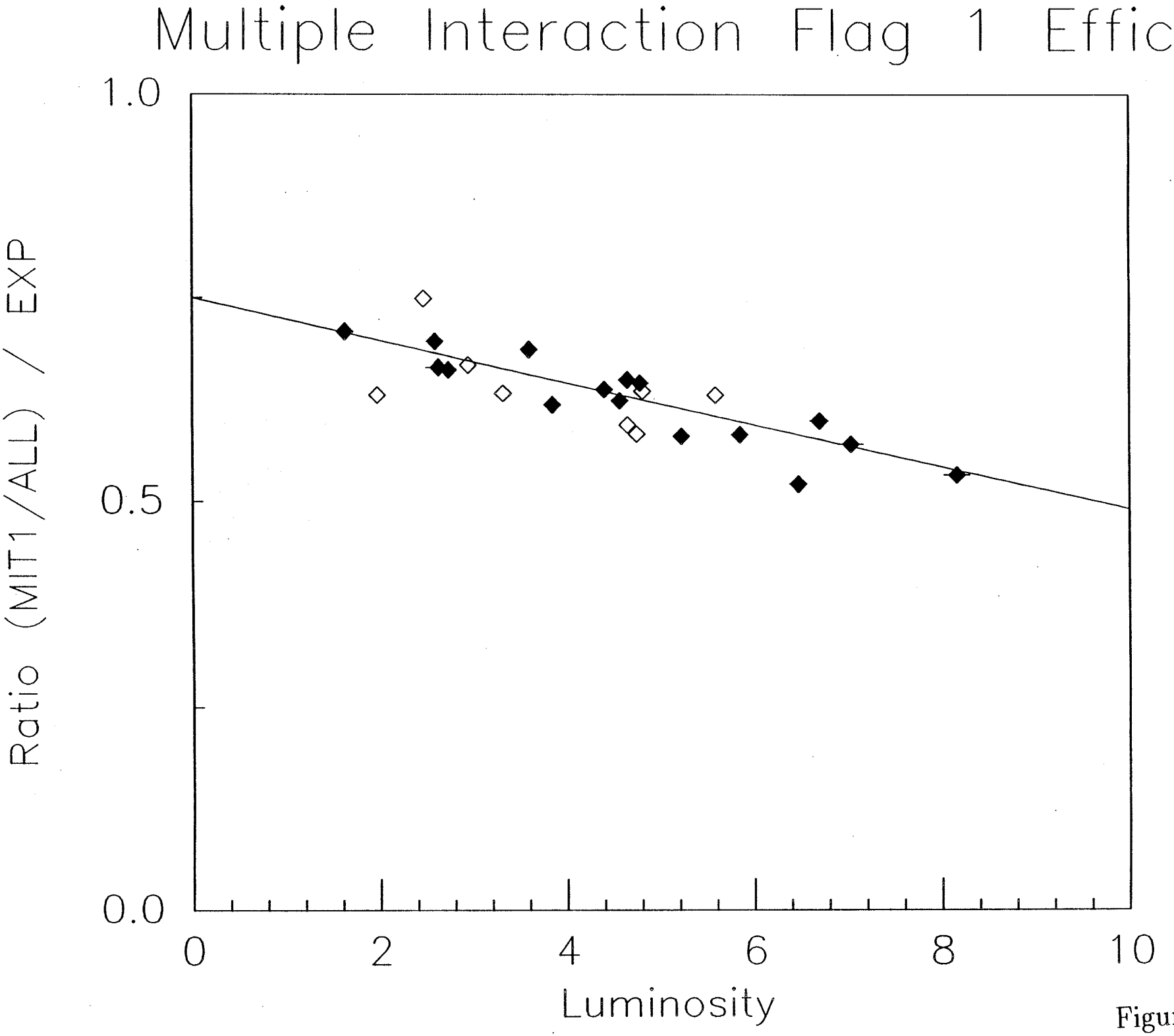
Multiple Interaction Flag 1 Effic
1.0
0.5
0.0
Ratio (MIT1/ALL) / EXP
0
2
4
6
8
10
Luminosity

Figure 14