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SDC
SOLENOIDAL DETECTOR NOTES

SDC JET TRIGGER PERFORMANCE STUDIES

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Chapter 1

Introduction

The SDC trigger identifies physics objects such as electrons, photons, jets, muons, and neutrinos, and selects events based on combinations of one or more of these objects. This report discusses the techniques of triggering on jets. Jet detection is important for triggering on many physics signals, such as those for top quarks and quark compositeness. Jet identification, and good knowledge of jet p_T dependence of the cross section, are mandatory for studying Quantum Chromodynamics. Therefore, the jet p_T threshold needs to be set so that there is a 1-2 decade overlap with existing data from lower energy experiments (for example, CDF)[3].

Jet triggers require only local calorimeter information. The basic unit of calorimeter level 1 trigger information is the trigger tower. This is the sum of either the total energy in the calorimeter electromagnetic (EM) or hadronic (HAC) compartment in a $.1\eta \times .1\phi$ region. Generally, this is composed of the transverse sum of 4 $.05 \times .05$ EM towers or the longitudinal sum of two $.1 \times .1$ HAC towers digitized on an 8-bit logarithmic scale. Details on the techniques of electronics that integrate the PMT signal are found in Ref. [8]. The trigger information is sent by the calorimeter front end electronics to the level 1 trigger crates[5]. The information is received by the calorimeter summation crates[9, 1]. These sum up the energy in $.4 \times .4$ regions and transmit this information to the Jet Energy Sum/Jet Threshold Crate.

At Level 1, the trigger can identify jets by summing the digitized energies in the EM and HAC towers in a certain size $\eta \times \phi$ region to compose two overlapping grids of double this size $\eta \times \phi$ tower energies and comparing these energies with several thresholds. The trigger electronics sums up the energy over the entire calorimeter, starting with the input $.1 \times .1$ towers, in a summation tree that sums these $.1 \times .1$ into $.2 \times .2$ sums and then sums these into $.4 \times .4$ sums, and so on until the final 3.2×3.2 sums are combined into total calorimeter energy sums. Therefore, the trigger can apply a threshold against any size sum at the point where it is computed in the summation tree. If two overlapping grids of sums are desired, these are composed of the sums accumulated from the tower sums of the next smaller size. While there is the flexibility in the trigger design to select any particular tower sum size, there are consequences for the hardware that depend on which sums are used in the trigger. Therefore, it is important to understand which size is optimal for triggering.

The purpose of this document is to investigate what strategy is best for triggering given

the calorimeter information that is available. This includes calculating the effects of the digitization scale and the methods by which towers are combined and tested. In summary, the performance of jet triggers for the SDC was studied to answer the following questions:

- What size grid is optimal for finding jets?
- Should two overlapping grids or one non-overlapping grid of jet towers be used?
- How will the increase in luminosity to $10^{34} cm^{-2} sec^{-1}$ change the performance characteristics of a jet trigger?
- Is the type of integer scale used for energies a significant factor in determining resolution?

We used 19000 QCD twojet events from 20-400 GeV, and minbias events corresponding to a poisson distribution with mean of 1.6 events per crossing. In simulating the higher luminosity of $10^{34} cm^{-2} sec^{-1}$, minbias events corresponding to a poisson distribution with mean of 16 events per crossing were used. These were generated using the Monte Carlo program ISAJET. The events were integrated over three beam crossings, using a scintillator calorimeter shaping function from ZEUS [7]. The energy deposit in the calorimeter was simulated by the program SIM3, from Greg Sullivan at the University of Chicago [6]. Jets were looked for on eight size scales, with energies first converted to one of two possible integer scales. A trigger tower size of $.1 \times .1$ in η and ϕ was used for η <2, and twice that for η >2. The simulation was run on Symmetric MultiProcessor Silicon Graphics Inc. 4D/380s at the Physics Detector Simulation Facility of the SSC Laboratory.

Jets were looked for in a calorimeter covering $\eta < 3$. Energy sums were made in each square in two sorts of grids – an overlapping grid, so that the calorimeter was covered twice, and a non-overlapping grid. The sizes of grids used were single calorimeter tower, single trigger tower ($.1 \times .1$), $.2 \times .2$, $.4 \times .4$, $.8 \times .8$, 1.6×1.6, 3.2×3.2 and full calorimeter squares in $\eta \times \phi$. The simulation converted the E_T in each trigger tower to an integer scale (for transmission from the calorimeter to the trigger processing crates), then into a linear scale for adding. An "ideal" case used linear 31-bit scales for both of these. The results were compared with those obtained using an 8-bit logarithmic scale for transmission and a 12-bit linear scale for adding. This implementation is based on [1]. For the region sizes $.2 \times .2$ through 3.2×3.2, both a single array of non-overlapping sums and two overlapping arrays were used.

In order to evaluate the performance of various jet trigger techniques, we have to select the target trigger rate for the jet trigger. The design maximum Level 1 Trigger rate is 100 kHz. Uncertainties in rates to be expected at SSC as well as detector performance require demonstration that the Level 1 trigger can meet its benchmark performance with an output rate considerably below 100 kHz. In addition, some part of the Level 1 bandwidth must be devoted to the triggers necessary to understand acceptance. We have established a target total Level 1 trigger rate of 30 kHz. We expect one-half the Level 1 bandwidth to be filled by triggers involving the calorimeter system. We anticipate distributing this bandwidth among single electron, single photon, combinations of electrons and photons, neutrinos, and jets. Therefore the anticipated trigger bandwidth devoted to jet triggers should be about 3 kHz. At higher luminosity, we anticipate allowing a higher rate of about

10 kHz to be used for jet triggers. We also explore other rates to look at the effect of different bandwidths on performance.

The results from this study have important implications for the SDC calorimeter first level trigger design. The electronics for testing on a larger jet tower size is simpler, since each step in size results in a reduction by four of the final number of pieces of information which must be compared. In a sense, overlapping grids of a given size are of similar difficulty as non-overlapping grids of the next smaller size, since the information required to form two overlapping grids of $.8 \times .8$ towers is just the information required to find one non-overlapping grid of $.4 \times .4$ towers. However, a single grid involves less electronics than two grids. The number of bits required to transmit the energy of a trigger tower must be as small as possible, yet it should yield good jet resolution. The number of bits is also limited by the need to have good resolution at lower E_T values for electron identification. The 8-bit logarithmic scale allows transmission of the HAC and EM energy every 16 nsec on a 1 Gbit/sec optical fiber [5, 1]. The 8-bit logarithmic scale used here was also used to give the electron trigger efficiencies given in [2].

For each tower sum grid size chosen, to reduce the effect of background events we ignore the energy contained in a tower unless it meets some minimum threshold. For this reason a variety of such thresholds was used for each tower size in order to determine the effect of doing this. The various rate tables and curves, and efficiency tables and curves in this document show the rates/efficiencies with this "low energy cutoff" set so as to optimize efficiency in the particular case shown.

Chapter 2

Overview of Results

For simplicity, a subset of the data is presented in this section to give a broad idea of the results and implications of the study, and complete results follow in subsequent sections.

Figure 1 shows jet trigger rates at the SSC design luminosity of $10^{33} cm^{-2} sec^{-1}$, for three sizes of grids of overlapping towers. A line is drawn at 3 kHz. The required thresholds to achieve a 3 kHz rate are: 56.5 GeV with $.1 \times .1$ towers, 102.7 GeV with $.4 \times .4$ towers, and 137.6 GeV with 1.6×1.6 towers.

Figure 2 shows jet trigger rates at the increased luminosity of $10^{34} cm^{-2} sec^{-1}$, for the same three sizes of grids of overlapping towers. A line is drawn at 10 kHz. The thresholds required to achieve a 10 kHz rate are: 80.1 GeV with $.1 \times .1$ towers, 143.4 GeV with $.4 \times .4$ towers, and 183.3 GeV with 1.6×1.6 towers. In calculating results for higher luminosity, minbias events corresponding to a poisson distribution with mean of 16 events per crossing were used.

Figure 3 shows the efficiency curves for the three tower sizes, with thresholds set to achieve a 3 kHz rate. The efficiency plotted is the efficiency the trigger has in finding jets with p_T greater than the plotted amount. In other words, the efficiency for the 1.6×1.6 trigger at 200 GeV is plotted to be 96.4%, so that the 1.6×1.6 trigger finds 96.4% of jets with $p_T > 200$ GeV. The turn-on curve is steeper at 1.6×1.6 than at the smaller sizes, and full efficiency is reached much sooner.

Figure 4 shows the efficiency curves for the three tower sizes at the higher luminosity. Again the 1.6×1.6 trigger performs better than the smaller sizes. The $.1 \times .1$ trigger has not reached full efficiency by 400 GeV p_T with this 10 kHz rate.

Table 1 shows the jet p_T values at which 95% efficiency is reached in various cases. One achieves 95% efficiency for jets above 190 GeV with a 1.6×1.6 trigger; with a $.1 \times .1$ trigger, 95% efficiency is reached only for jets above 287 GeV. At the higher luminosity, 1.6×1.6 towers achieve 95% efficiency at 253 GeV; the $.1 \times .1$ towers do not achieve 95% efficiency until 387 GeV.

Figure 5 shows the effect on efficiency of using overlapping vs. non-overlapping grids of jet towers. The efficiency curves are those for 1.6×1.6 towers, with a 3 kHz rate. The overlapping grid of towers performs somewhat better. This effect is approximately the same

Type of jet trigger		3 kHz at 10^{33}	10 kHz at 10^{34}
$.1 \times .1$		287	387
$.4 \times .4$	overlapping	229	313[2]
1.6×1.6	overlapping	190	253[3]
$.4 \times .4$	non-overlapping	243[3]	336[2]
1.6×1.6	non-overlapping	211	281[3]
all have low energy cutoff at .1 GeV except as noted [2] – low energy cutoff at .2 GeV [3] – low energy cutoff at .5 GeV			

Table 2.1: Jet p_T at which 95% efficiency is achieved (GeV)

at higher luminosity and with other sizes of jet towers.

Figure 6 shows the effect of using an 8-bit logarithmic scale, rather than a "perfect" scale. There is some loss of efficiency, but it is smaller than that observed between overlapping and non-overlapping towers, and changing tower sizes. Thus we conclude that the resolution of the scales used for transmission of energies and making energy sums is a relatively unimportant factor in determining jet efficiency.

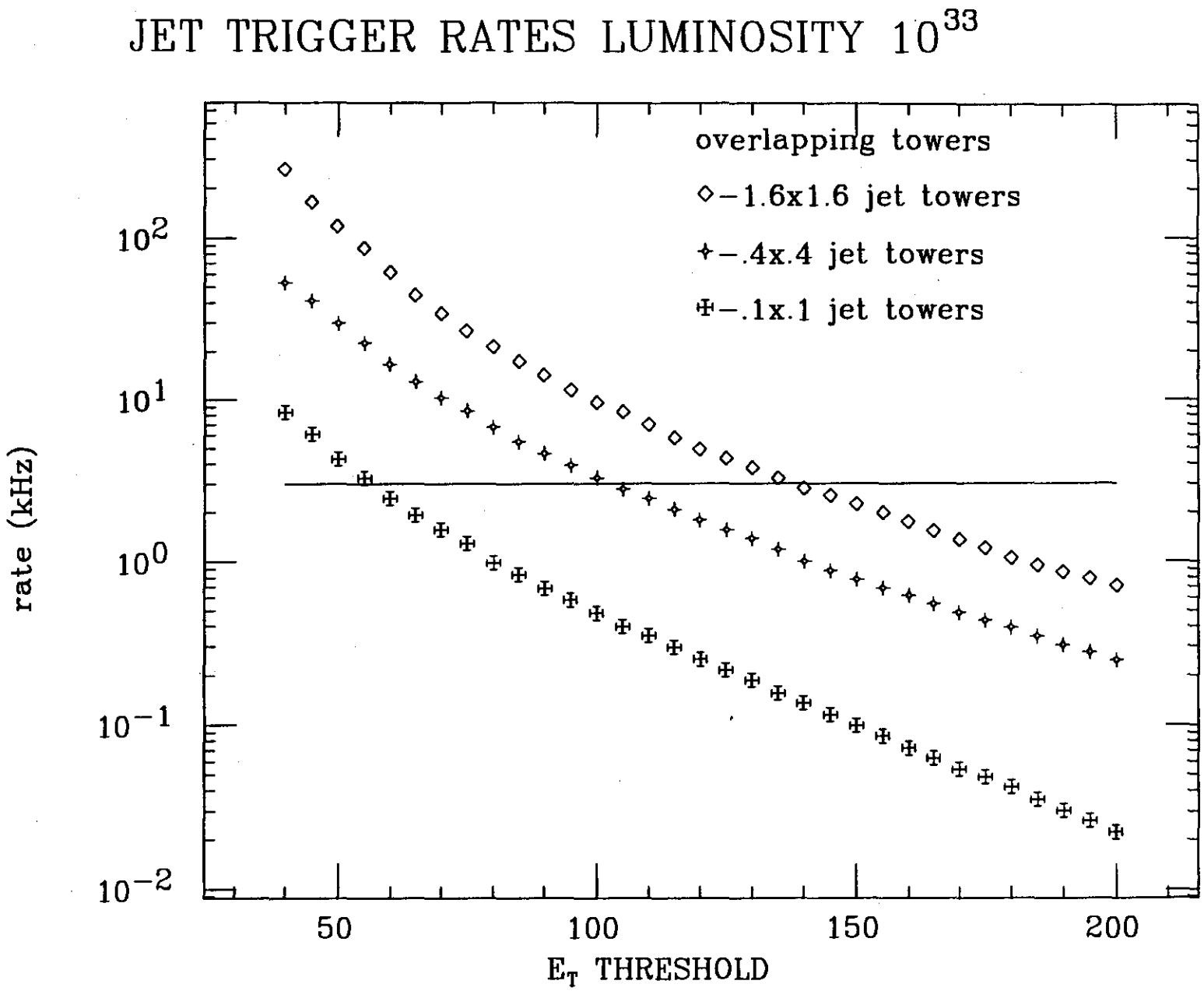
JET TRIGGER RATES LUMINOSITY 10^{33}
overlapping towers
◇–1.6x1.6 jet towers
✧–.4x.4 jet towers
✠–.1x.1 jet towers
rate (kHz)
10^2
10^1
10^0
10^{-1}
10^{-2}
50
100
150
200
E_T THRESHOLD

Figure 1

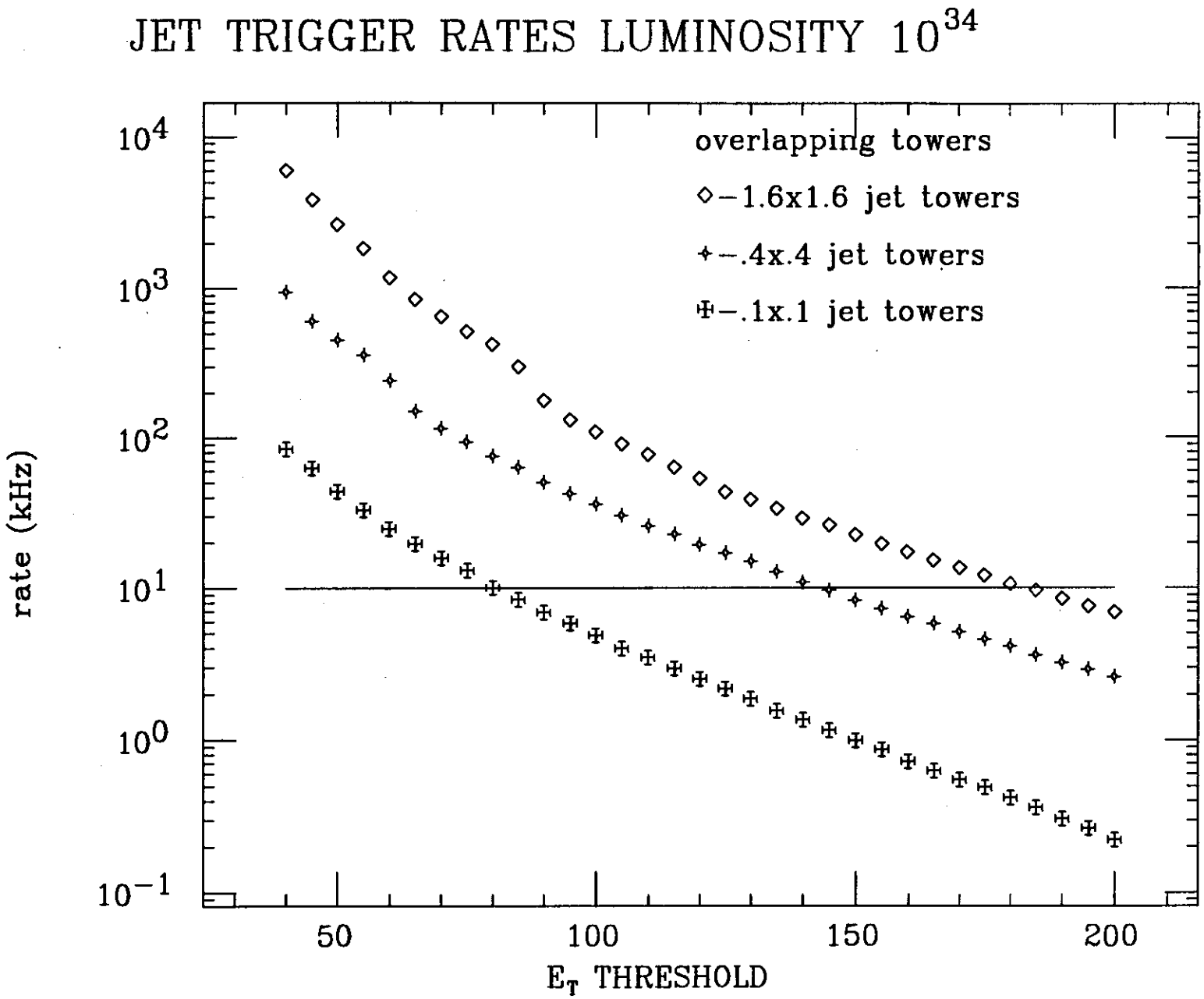
JET TRIGGER RATES LUMINOSITY 10^{34}
overlapping towers
◇–1.6x1.6 jet towers
✧–.4x.4 jet towers
✠–.1x.1 jet towers
rate (kHz)
10^4
10^3
10^2
10^1
10^0
10^{-1}
50
100
150
200
E_T THRESHOLD

Figure 2

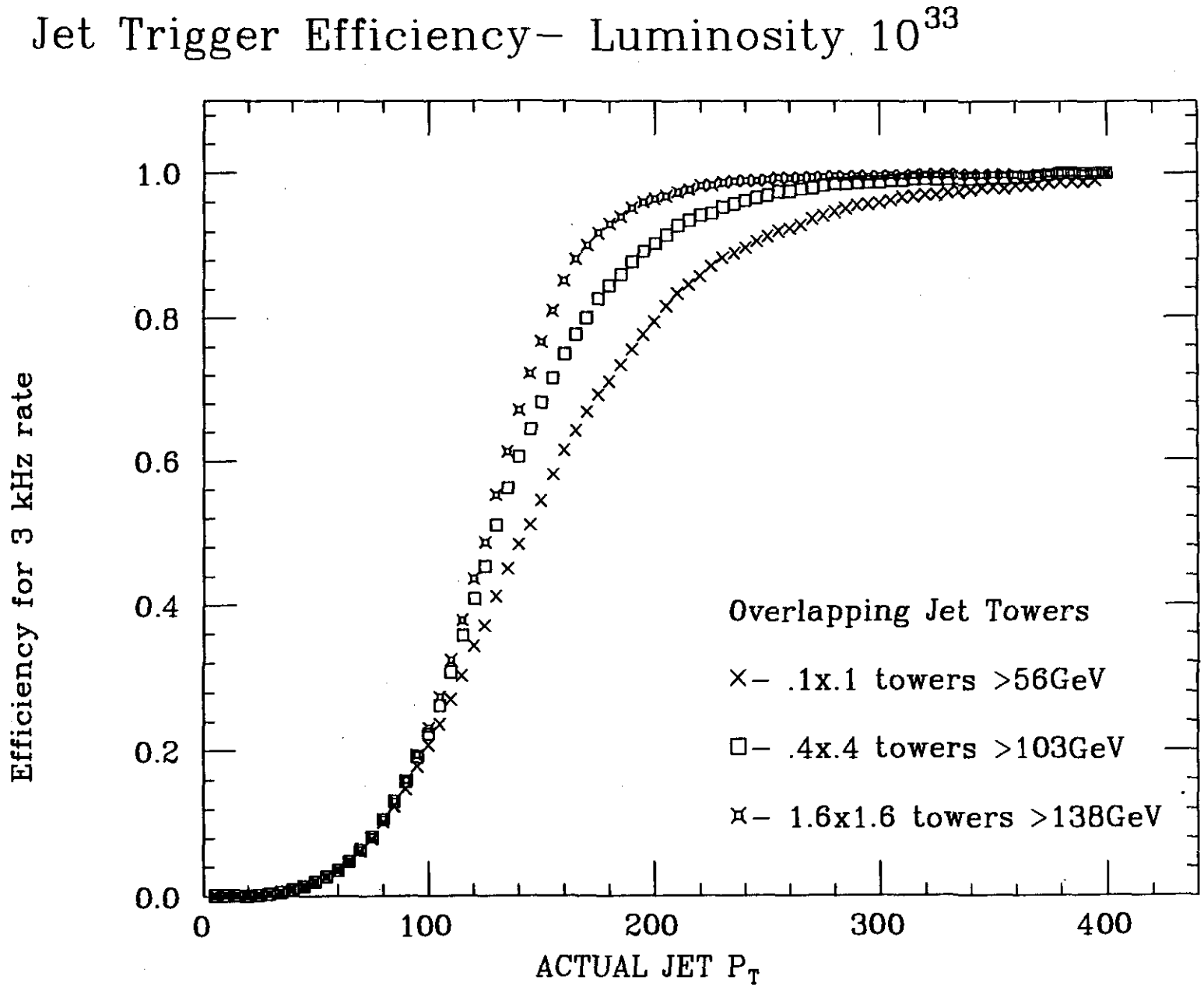
Jet Trigger Efficiency– Luminosity 10^{33}
Efficiency for 3 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
Overlapping Jet Towers
×– .1x.1 towers >56GeV
□– .4x.4 towers >103GeV
¤– 1.6x1.6 towers >138GeV

Figure 3

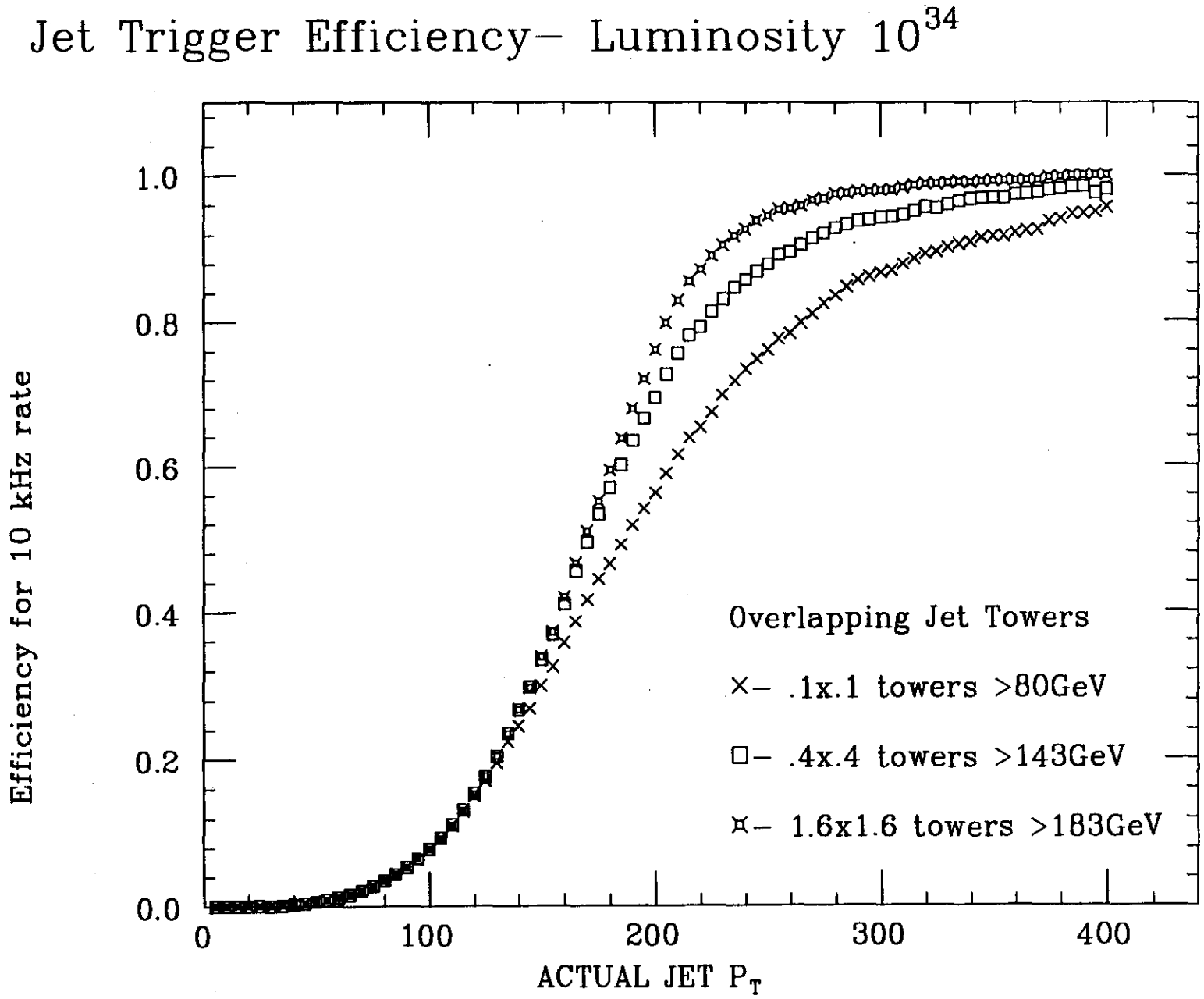
Jet Trigger Efficiency– Luminosity 10^{34}
Efficiency for 10 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
Overlapping Jet Towers
×– .1x.1 towers >80GeV
□– .4x.4 towers >143GeV
¤– 1.6x1.6 towers >183GeV

Figure 4

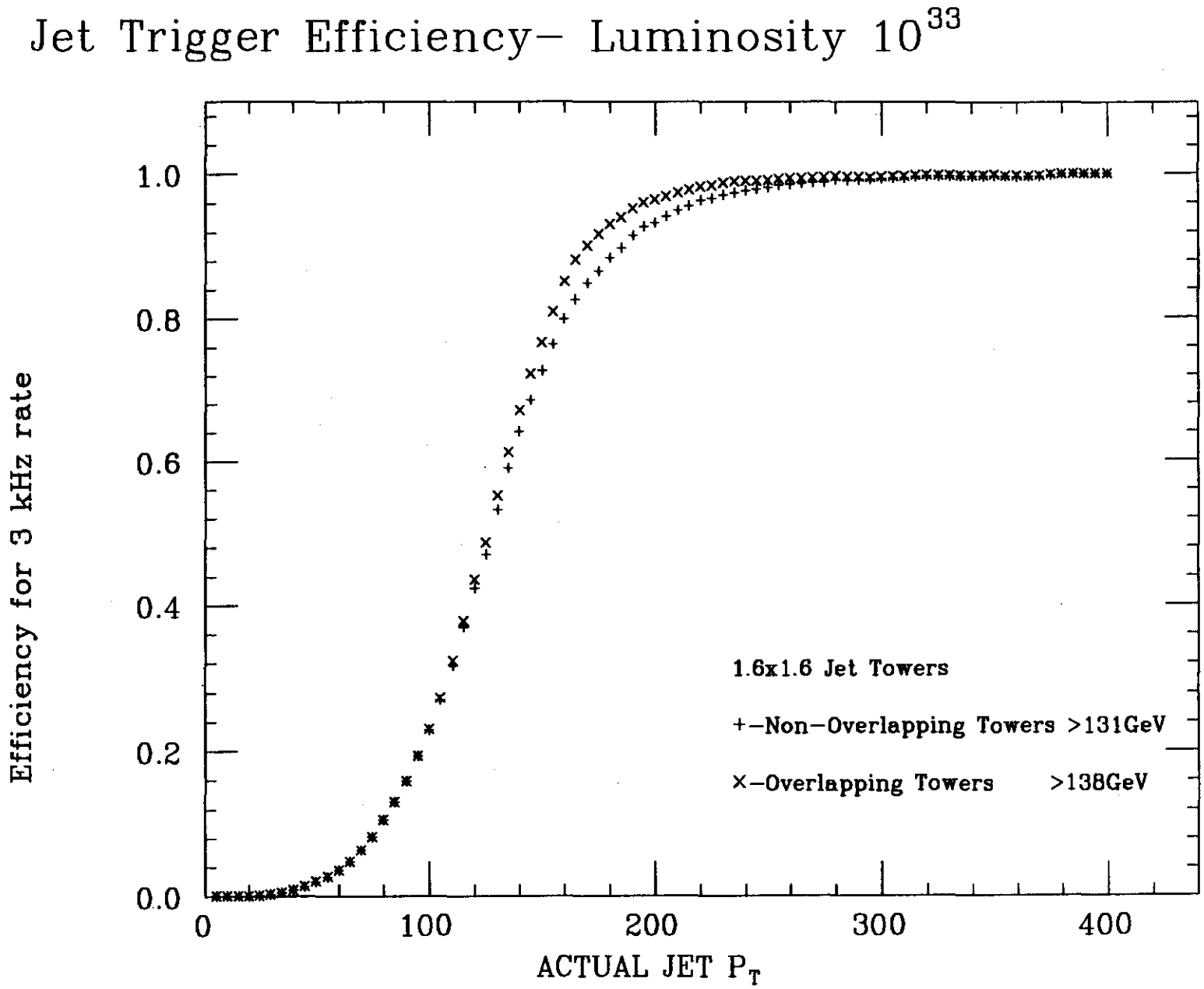
Jet Trigger Efficiency– Luminosity 10^{33}
Efficiency for 3 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
1.6x1.6 Jet Towers
+–Non–Overlapping Towers >131GeV
×–Overlapping Towers >138GeV

Figure 5

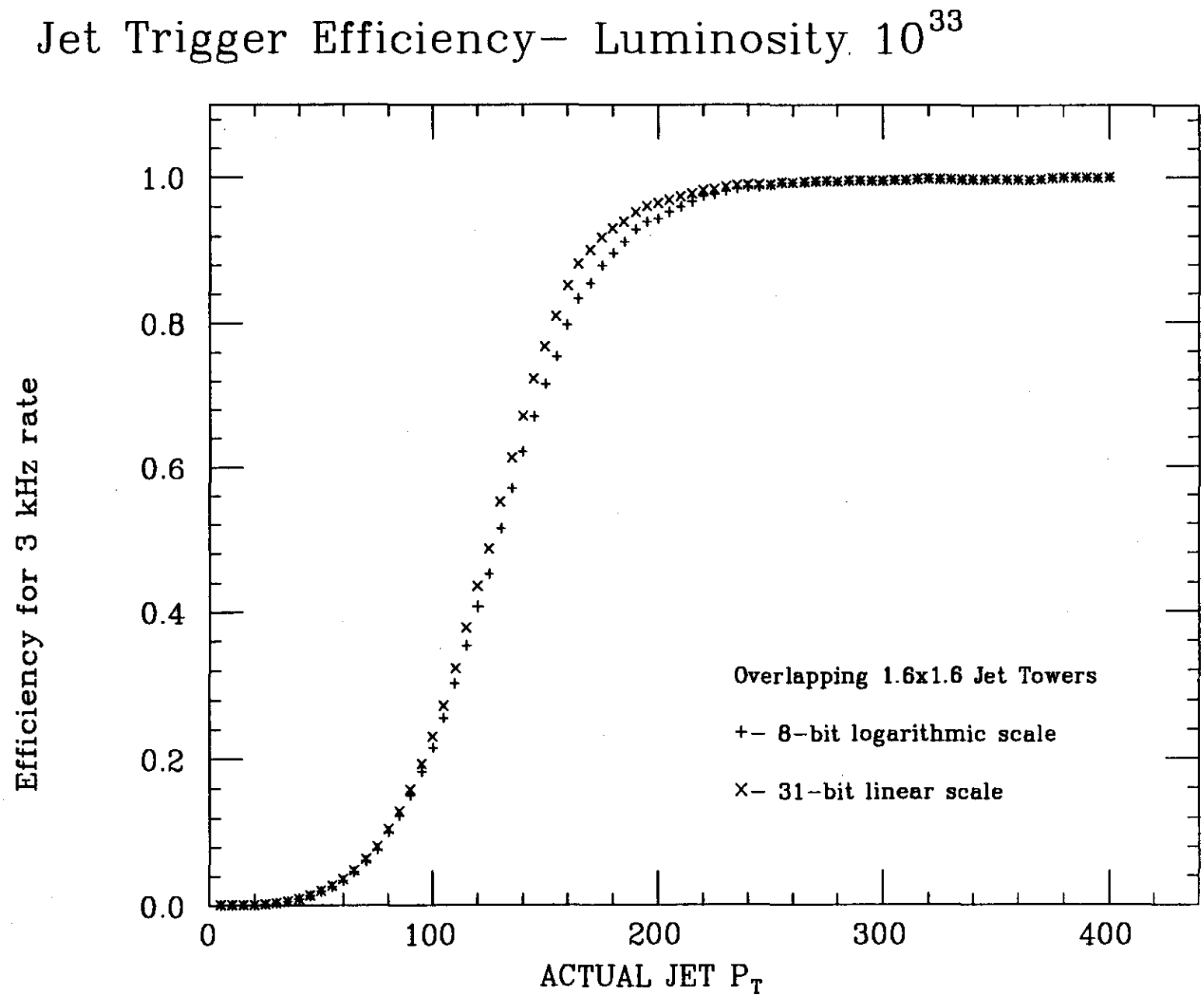
Jet Trigger Efficiency– Luminosity 10^{33}
Efficiency for 3 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
Overlapping 1.6x1.6 Jet Towers
+– 8–bit logarithmic scale
×– 31–bit linear scale

Figure 6

Chapter 3

Conclusions

Jet trigger performance is a strong function of tower size. The best performance was found with an overlapping grid of 1.6×1.6 towers or an overlapping grid of 3.2×3.2 towers. The choice between these is not obvious. At luminosity of $10^{33} cm^{-2} sec^{-1}$, 95% efficiency is reached by the overlapping grid of 3.2×3.2 towers at 186 GeV, assuming a 3 kHz rate. When the luminosity increases to $10^{34} cm^{-2} sec^{-1}$, 95% efficiency is not reached until 330 GeV with a 3 kHz rate. Because of this, we consider a rate of 10 kHz at $10^{34} cm^{-2} sec^{-1}$ luminosity to be standard. At 10 kHz, an overlapping grid of 3.2×3.2 towers reaches 95% efficiency at 251 GeV.

At the luminosity of $10^{34} cm^{-2} sec^{-1}$, small size jet triggers do not reach full efficiency at 400 GeV unless a rate in excess of 10 kHz is taken. A single trigger tower jet trigger, for instance, requires 30 kHz rate to reach 95% efficiency at 284 GeV. For comparison, a 3.2×3.2 jet trigger reaches 95% efficiency at 251 GeV with a 10 kHz rate; i.e., with a rate a factor of three smaller, it displays better efficiency.

The disparity in performance between these two extremes is present at $10^{33} cm^{-2} sec^{-1}$ as well. For instance, a single trigger tower at 3 kHz reaches 95% efficiency at 287 GeV. A 3.2×3.2 tower at 1 kHz reaches 95% efficiency at 243 GeV; thus again, despite having a rate three times smaller, the 3.2×3.2 size has better efficiency.

With the tower size of 3.2×3.2, there is less of a difference between using overlapping and non-overlapping towers than with smaller sizes. This may indicate that almost all jets are contained in a 1.6×1.6 region of the calorimeter.

The choice of an integer scale does not seem to be an important consideration in determining the performance of a jet trigger.

With the increase in luminosity at the SSC the job of jet triggering will become proportionately more difficult, but a jet trigger which performs best at higher luminosity seems to be the same jet trigger which performs best at the design luminosity.

Further studies are ongoing, in particular to determine the best method for multiple jet triggering and to identify the role jet triggering will play in detecting interesting physics events.

Chapter 4

Jet Rates

4.1 Luminosity of $10^{33} cm^{-2} sec^{-1}$

All rates here are shown in kHz, where a 1 mb jet cross section corresponds to 1 MHz at the SSC design luminosity of $10^{33} cm^{-2} sec^{-1}$. An average of 1.6 minbias events per crossing were used in addition to the QCD twojet events. This represents a minbias cross section of 96 mb. Table 2 shows the E_T thresholds necessary to achieve trigger rates of 1, 3, and 10 kHz. For instance, if one wanted to have a background rate of 3 kHz using an overlapping grid of 3.2×3.2 jet towers, the required E_T threshold would be 146.2 GeV, using a low energy cutoff of .5 GeV. Figures 7-9 show the rates plotted against E_T threshold for overlapping and non-overlapping grids of all sizes.

Type of jet trigger		10 kHz	3 kHz	1 kHz
calorimeter tower		31.4	47.4	64.9
trigger tower		37.6	56.5	80.0
$.2 \times .2$	non-overlapping	51.0	76.7	106.5[2]
$.2 \times .2$	overlapping	53.6[4]	83.5	115.4[3]
$.4 \times .4$	non-overlapping	64.3	91.1[3]	130.7
$.4 \times .4$	overlapping	69.8[2]	102.7	140.2
$.8 \times .8$	non-overlapping	77.6	110.9	141.7[3]
$.8 \times .8$	overlapping	84.4	119.6	161.6
1.6×1.6	non-overlapping	88.9[2]	131.0	175.6
1.6×1.6	overlapping	93.9[2]	137.6	182.9
3.2×3.2	non-overlapping	96.7[3]	139.0[3]	164.7[4]
3.2×3.2	overlapping	102.4[3]	146.2[3]	197.8[3]
entire calorimeter		139.5[4]	212.0[4]	301.5[4]
all have low energy cutoff at .1 GeV except as noted [2] – low energy cutoff at .2 GeV [3] – low energy cutoff at .5 GeV [4] – low energy cutoff at 1 GeV				

Luminosity of $10^{33} cm^{-2} sec^{-1}$

Table 4.1: Jet E_T threshold needed to achieve given rates (GeV)

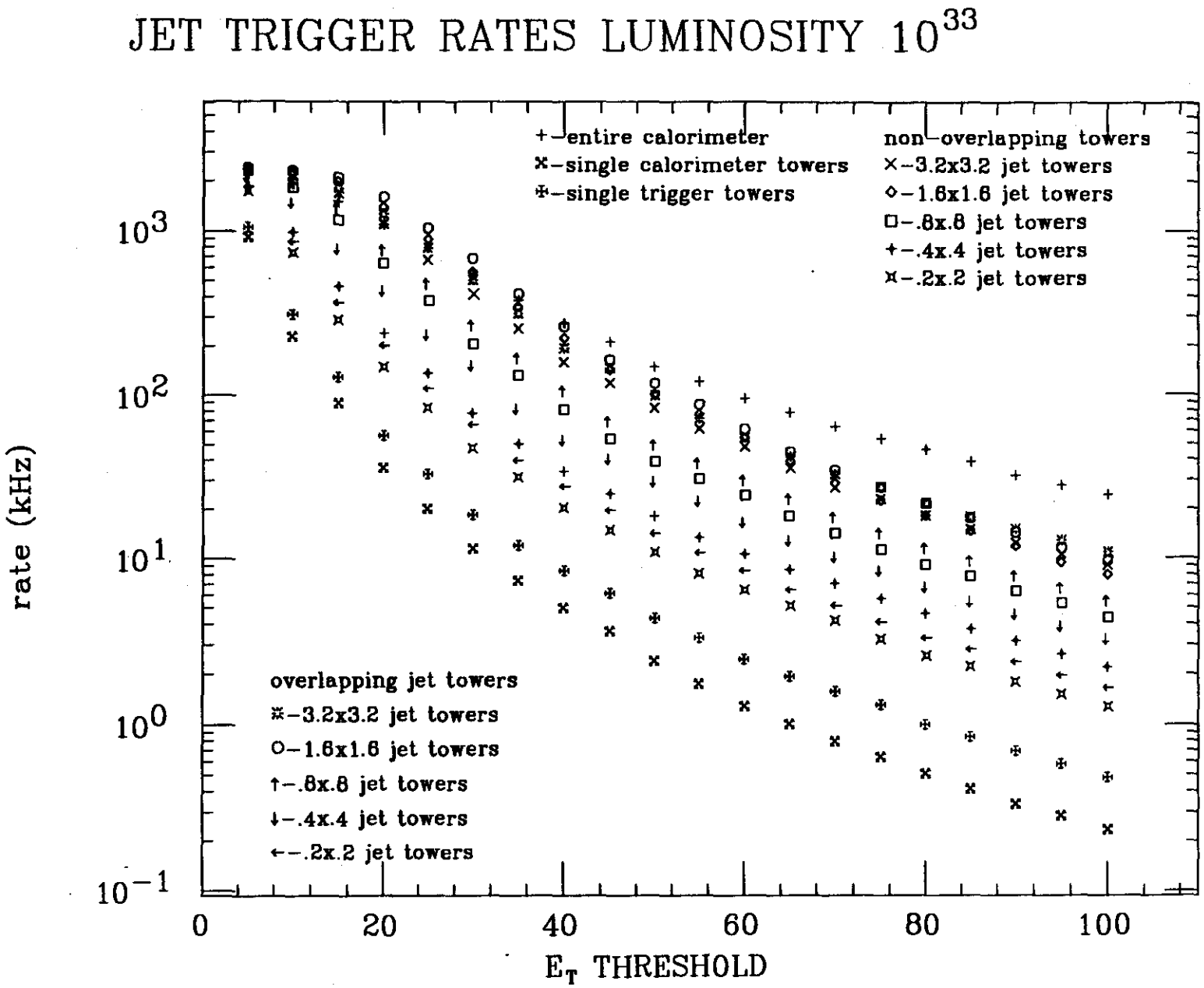
JET TRIGGER RATES LUMINOSITY 10^{33}
+–entire calorimeter
×–single calorimeter towers
✠–single trigger towers
non–overlapping towers
×–3.2x3.2 jet towers
◇–1.6x1.6 jet towers
□–.8x.8 jet towers
+–.4x.4 jet towers
¤–.2x.2 jet towers
overlapping jet towers
✠–3.2x3.2 jet towers
○–1.6x1.6 jet towers
↑–.8x.8 jet towers
↓–.4x.4 jet towers
←–.2x.2 jet towers
rate (kHz)
10^3
10^2
10^1
10^0
10^{-1}
0
20
40
60
80
100
E_T THRESHOLD

Figure 7

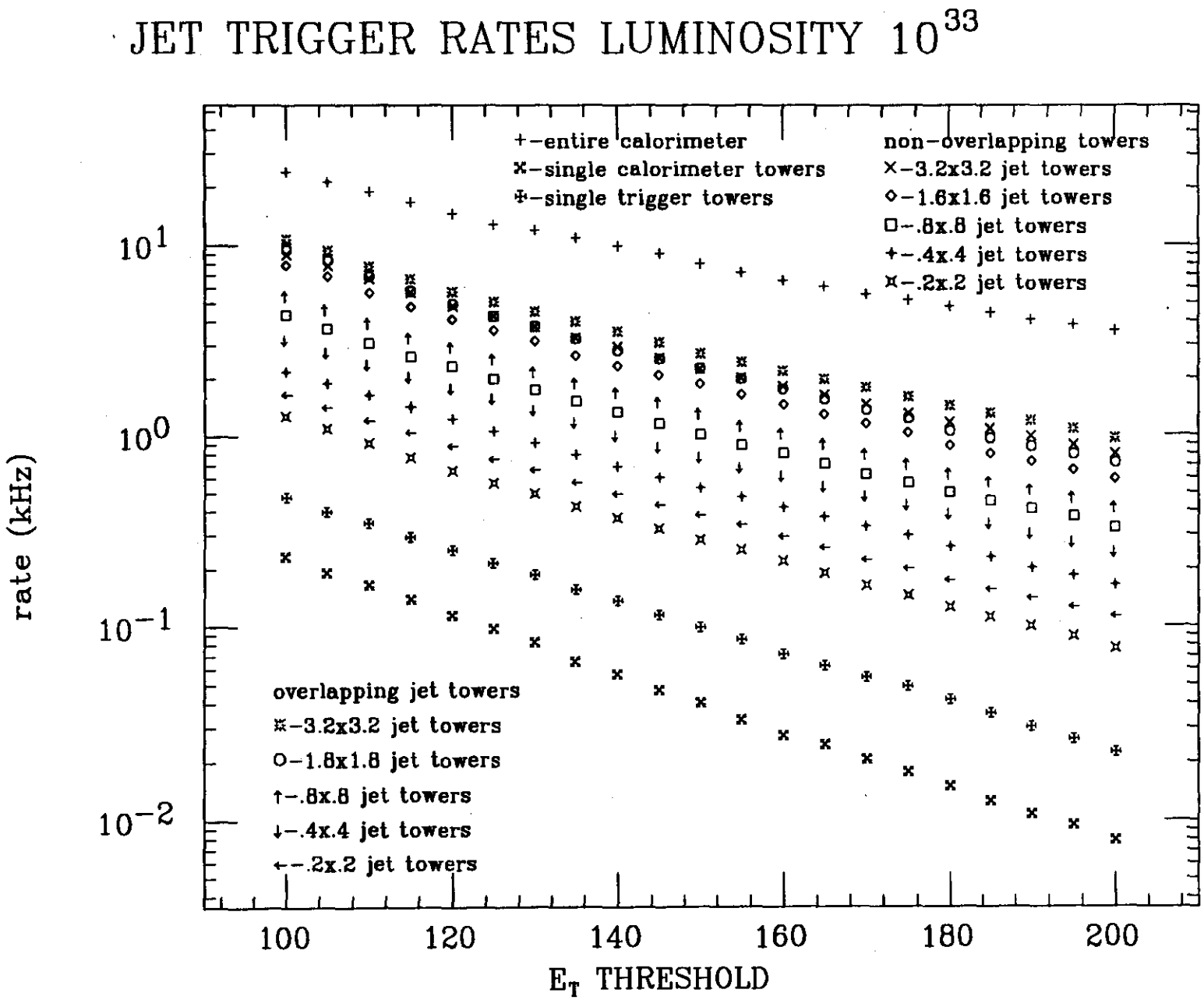
JET TRIGGER RATES LUMINOSITY 10^{33}
+−entire calorimeter
×−single calorimeter towers
Φ−single trigger towers
non−overlapping towers
×−3.2x3.2 jet towers
◇−1.6x1.6 jet towers
□−.8x.8 jet towers
+−.4x.4 jet towers
¤−.2x.2 jet towers
overlapping jet towers
⌘−3.2x3.2 jet towers
O−1.8x1.8 jet towers
↑−.8x.8 jet towers
↓−.4x.4 jet towers
←−.2x.2 jet towers
rate (kHz)
10^1
10^0
10^{-1}
10^{-2}
100
120
140
160
180
200
E_T THRESHOLD

Figure 8

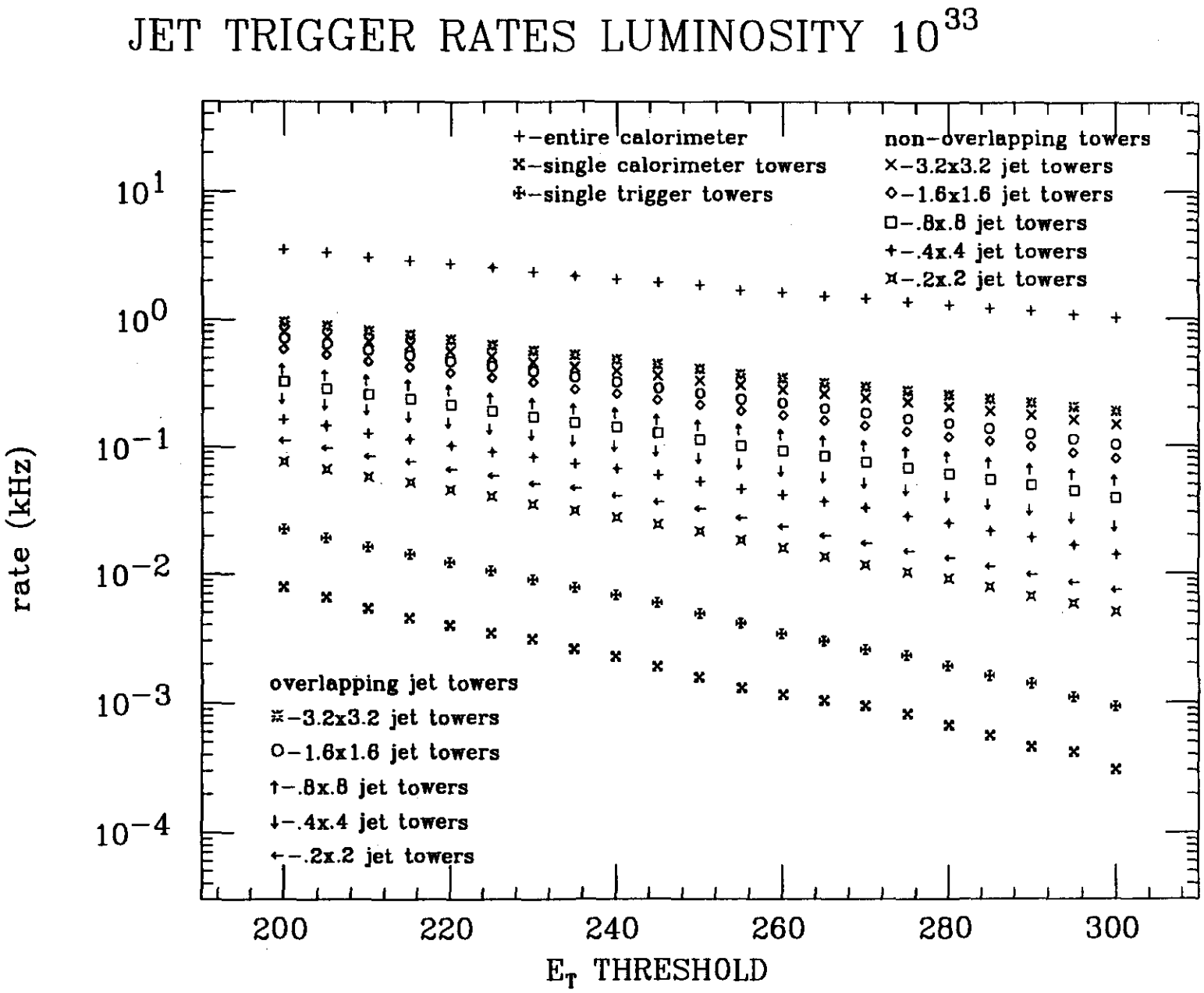
JET TRIGGER RATES LUMINOSITY 10^{33}
+–entire calorimeter
×–single calorimeter towers
✠–single trigger towers
non–overlapping towers
×–3.2x3.2 jet towers
◇–1.6x1.6 jet towers
□–.8x.8 jet towers
+–.4x.4 jet towers
¤–.2x.2 jet towers
overlapping jet towers
⋇–3.2x3.2 jet towers
○–1.6x1.6 jet towers
↑–.8x.8 jet towers
↓–.4x.4 jet towers
←–.2x.2 jet towers
rate (kHz)
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
200
220
240
260
280
300
E_T THRESHOLD

Figure 9

Type of jet trigger		30 kHz	10 kHz	3 kHz
calorimeter tower		47.5	65.1	93.3
trigger tower		56.8	80.1	115.0
$.2 \times .2$	non-overlapping	77.4	107.1[2]	147.1[3]
$.2 \times .2$	overlapping	84.2	116.1[3]	160.4[2]
$.4 \times .4$	non-overlapping	97.4	132.3[2]	170.9[4]
$.4 \times .4$	overlapping	105.4	143.4	188.4[3]
$.8 \times .8$	non-overlapping	108.2[3]	147.2[3]	199.3[3]
$.8 \times .8$	overlapping	131.4	173.1	228.1
1.6×1.6	non-overlapping	110.0[4]	152.1[4]	207.2[4]
1.6×1.6	overlapping	139.0[3]	183.3[3]	240.3[3]
3.2×3.2	non-overlapping	137.2[4]	186.9[4]	249.1[4]
3.2×3.2	overlapping	144.1[4]	194.1[4]	260.2[4]
entire calorimeter		184.8[5]	266.1[5]	379.0[5]
all have low energy cutoff at .1 GeV except as noted [2] – low energy cutoff at .2 GeV [3] – low energy cutoff at .5 GeV [4] – low energy cutoff at 1 GeV [5] – low energy cutoff at 2 GeV				

Luminosity of $10^{34} cm^{-2} sec^{-1}$

Table 4.2: Jet E_T threshold needed to achieve given rates (GeV)

4.2 Luminosity of $10^{34} cm^{-2} sec^{-1}$

All rates here are shown in kHz, where a 1 mb jet cross section corresponds to 10 MHz at the maximum SSC luminosity of $10^{34} cm^{-2} sec^{-1}$. An average of 16 minbias events per crossing were used in addition to the QCD twojet events. This represents a minbias cross section of 96 mb. Table 3 shows the E_T thresholds necessary to achieve trigger rates of 3, 10 and 30 kHz. For instance, if one wanted to have a background rate of 3 kHz using a overlapping grid of 3.2×3.2 jet towers, the required E_T threshold would be 194.1 GeV, using a low energy cutoff of 1 GeV. Figures 10-12 show the rates plotted against E_T threshold for overlapping and non-overlapping grids of all sizes.

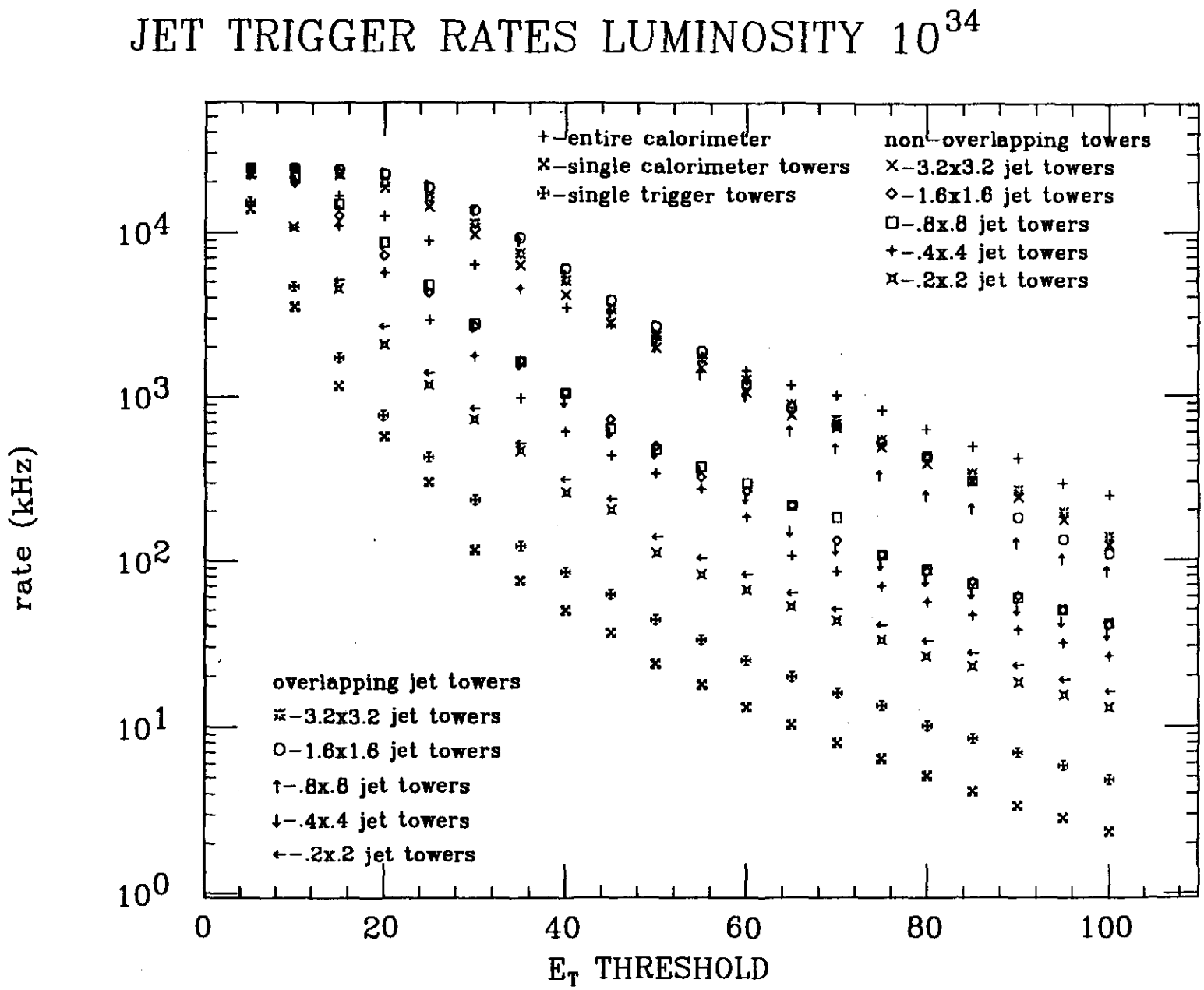
JET TRIGGER RATES LUMINOSITY 10^{34}
+–entire calorimeter
×–single calorimeter towers
✠–single trigger towers
non–overlapping towers
×–3.2x3.2 jet towers
◇–1.6x1.6 jet towers
□–.8x.8 jet towers
+–.4x.4 jet towers
×–.2x.2 jet towers
overlapping jet towers
×–3.2x3.2 jet towers
○–1.6x1.6 jet towers
↑–.8x.8 jet towers
↓–.4x.4 jet towers
←–.2x.2 jet towers
rate (kHz)
10^4
10^3
10^2
10^1
10^0
0
20
40
60
80
100
E_T THRESHOLD

Figure 10

JET TRIGGER RATES LUMINOSITY 10^{34}

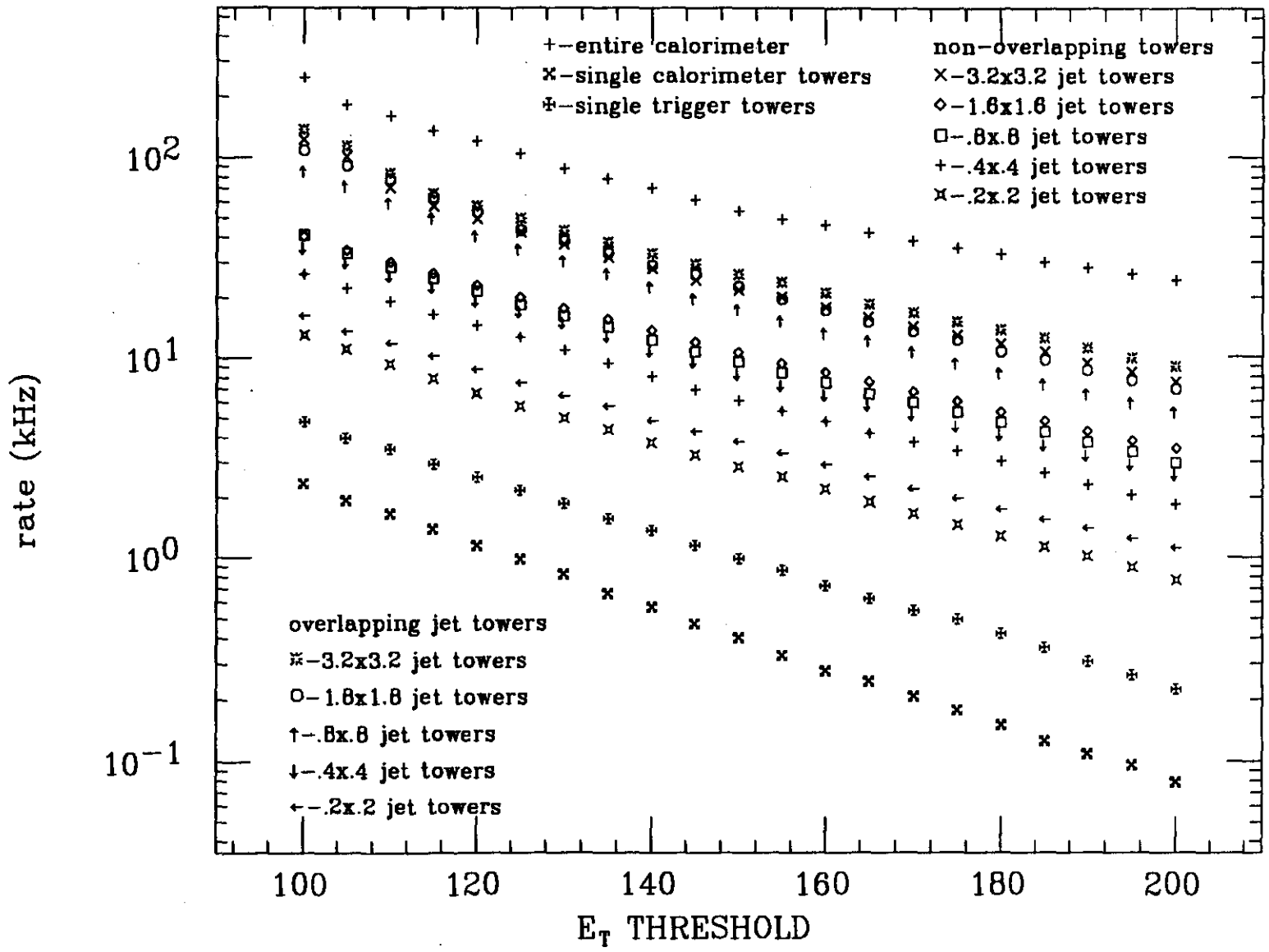

Figure 11

JET TRIGGER RATES LUMINOSITY 10^{34}

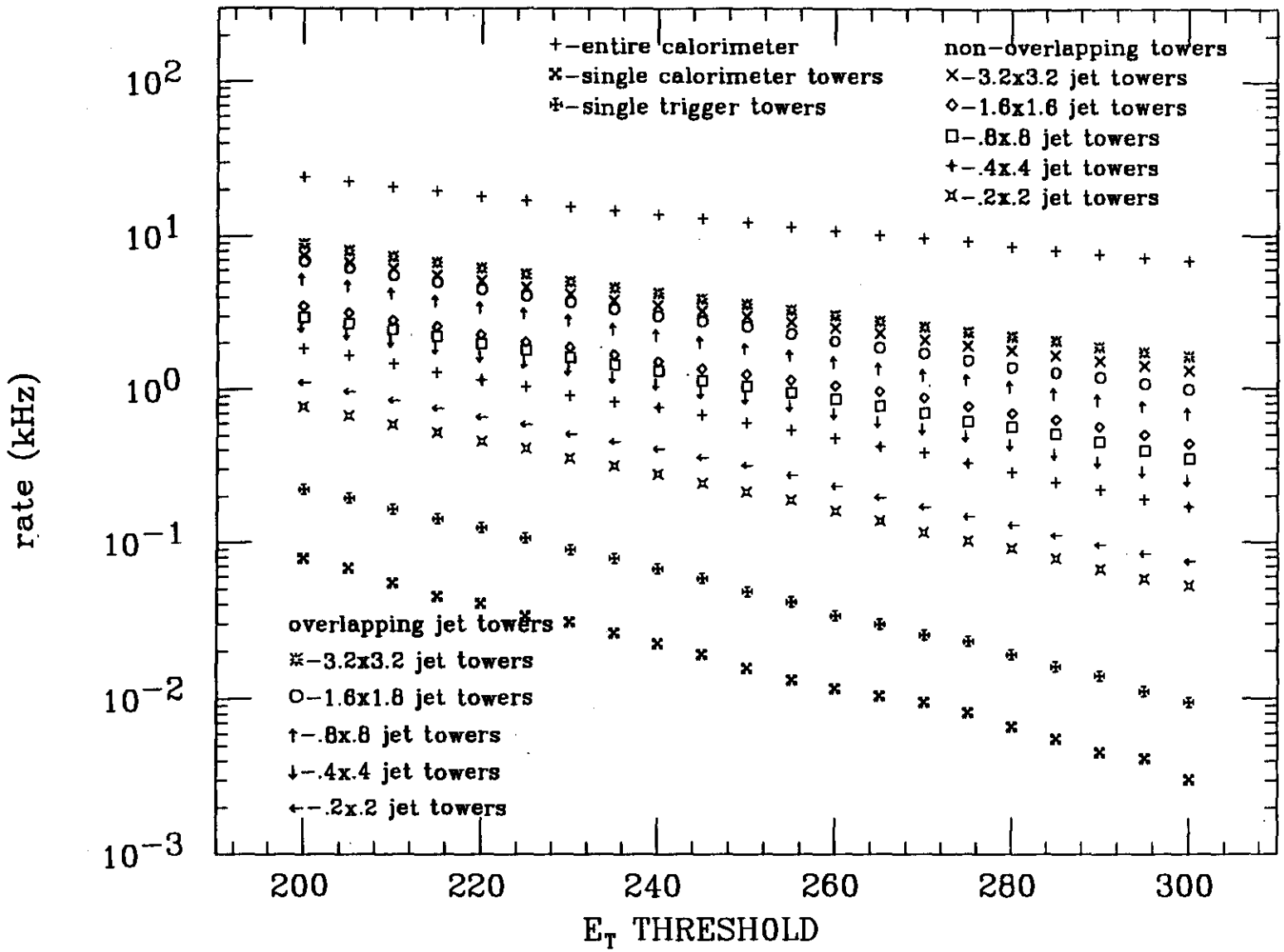

Figure 12

Chapter 5

Jet Trigger Efficiencies

5.1 Luminosity of $10^{33} cm^{-2} sec^{-1}$

Table 4 shows the actual jet p_T at which 70% efficiency for jets is reached with the various jet triggers considered. The thresholds are set to achieve a 1 kHz, 3 kHz, and 10 kHz rate. To reach 70% efficiency as soon as possible with a 3 kHz rate, therefore, one would use an overlapping grid of 1.6×1.6 towers, and reach 70% efficiency at an actual jet p_T of 144 GeV.

Table 5 shows the actual jet p_T at which 80% efficiency for jets is reached with the various jet triggers considered. The thresholds are set to achieve a 1 kHz, 3 kHz, and 10 kHz rate. To reach 80% efficiency quickly at a rate of 3 kHz, a grid of 1.6×1.6 towers performs best, reaching 80% efficiency at 154 GeV p_T.

Table 6 shows the actual jet p_T at which 90% efficiency for jets is reached with the various jet triggers considered. The thresholds are set to achieve a 1 kHz, 3 kHz, and 10 kHz rate. For a 3 kHz rate, an overlapping grid of 1.6×1.6 towers reaches 90% efficiency soonest, at 170 GeV p_T.

Table 7 shows the actual jet p_T at which 95% efficiency for jets is reached with the various jet triggers considered. The thresholds are set to achieve a 1 kHz, 3 kHz, and 10 kHz rate. For a 3 kHz rate, an overlapping grid of 3.2×3.2 towers reaches 95% efficiency soonest, at 186 GeV p_T.

Type of jet trigger		10 kHz	3 kHz	1 kHz
calorimeter tower		145	197	254
trigger tower		129	178	232
$.2 \times .2$	non-overlapping	122	167	221[2]
$.2 \times .2$	overlapping	119[4]	159	210[3]
$.4 \times .4$	non-overlapping	116[3]	160[3]	208
$.4 \times .4$	overlapping	113[2]	153	201[2]
$.8 \times .8$	non-overlapping	111	153	200
$.8 \times .8$	overlapping	109	148	195
1.6×1.6	non-overlapping	108[2]	147	195[3]
1.6×1.6	overlapping	106	144	190
3.2×3.2	non-overlapping	108[3]	148[3]	193[4]
3.2×3.2	overlapping	107[4]	148[3]	193[3]
entire calorimeter		111[4]	149[4]	196[4]
all have low energy cutoff at .1 GeV except as noted [2] – low energy cutoff at .2 GeV [3] – low energy cutoff at .5 GeV [4] – low energy cutoff at 1 GeV				

Luminosity of $10^{33} cm^{-2} sec^{-1}$

Table 5.1: Jet p_T at which 70% efficiency is achieved (GeV)

Type of jet trigger		10 kHz	3 kHz	1 kHz
calorimeter tower		164	225	295
trigger tower		149	201	267
$.2 \times .2$	non-overlapping	137	189	253[2]
$.2 \times .2$	overlapping	134[4]	180	237[3]
$.4 \times .4$	non-overlapping	130	180[3]	236
$.4 \times .4$	overlapping	126[2]	171	223
$.8 \times .8$	non-overlapping	124	169	223[3]
$.8 \times .8$	overlapping	120	161	211
1.6×1.6	non-overlapping	120[2]	161	212
1.6×1.6	overlapping	114[2]	154	201
3.2×3.2	non-overlapping	117[3]	159[3]	207[4]
3.2×3.2	overlapping	116[3]	158[3]	207[3]
entire calorimeter		122[4]	163[4]	213[4]
all have low energy cutoff at .1 GeV except as noted [2] – low energy cutoff at .2 GeV [3] – low energy cutoff at .5 GeV [4] – low energy cutoff at 1 GeV				

Luminosity of $10^{33} cm^{-2} sec^{-1}$

Table 5.2: Jet p_T at which 80% efficiency is achieved (GeV)

Type of jet trigger		10 kHz	3 kHz	1 kHz
calorimeter tower		202	273	377
trigger tower		180	242	332
$.2 \times .2$	non-overlapping	165	225	310[2]
$.2 \times .2$	overlapping	160[4]	211[3]	288
$.4 \times .4$	non-overlapping	156	212[3]	281
$.4 \times .4$	overlapping	149[2]	199	262
$.8 \times .8$	non-overlapping	146	197	261[3]
$.8 \times .8$	overlapping	137	185	243
1.6×1.6	non-overlapping	136[2]	186	245[2]
1.6×1.6	overlapping	128	170	222
3.2×3.2	non-overlapping	130[3]	176[3]	229[3]
3.2×3.2	overlapping	128[3]	172[3]	225[3]
entire calorimeter		146[5]	191[4]	251[5]
all have low energy cutoff at .1 GeV except as noted [2] – low energy cutoff at .2 GeV [3] – low energy cutoff at .5 GeV [4] – low energy cutoff at 1 GeV [5] – low energy cutoff at 2 GeV				

Luminosity of $10^{33} cm^{-2} sec^{-1}$

Table 5.3: Jet p_T at which 90% efficiency is achieved (GeV)

Type of jet trigger		10 kHz	3 kHz	1 kHz
calorimeter tower		236	335	398
trigger tower		207	287	397
$.2 \times .2$	non-overlapping	190[2]	265[2]	377[3]
$.2 \times .2$	overlapping	187[4]	249[2]	340[4]
$.4 \times .4$	non-overlapping	180[2]	243[3]	336[2]
$.4 \times .4$	overlapping	169[2]	229	312
$.8 \times .8$	non-overlapping	170	226[2]	307[3]
$.8 \times .8$	overlapping	160[2]	213	277
1.6×1.6	non-overlapping	159[2]	211	280[2]
1.6×1.6	overlapping	141	190	247
3.2×3.2	non-overlapping	146[2]	191[3]	252[3]
3.2×3.2	overlapping	140[3]	186[3]	243[3]
entire calorimeter		162[5]	226[5]	292[5]
all have low energy cutoff at .1 GeV except as noted [2] – low energy cutoff at .2 GeV [3] – low energy cutoff at .5 GeV [4] – low energy cutoff at 1 GeV [5] – low energy cutoff at 2 GeV				

Luminosity of $10^{33} cm^{-2} sec^{-1}$

Table 5.4: Jet p_T at which 95% efficiency is achieved (GeV)

5.1.1 Overlapping vs. Non-Overlapping Grids

In all of the efficiency curves shown, the efficiency plotted for a particular jet p_T value is the efficiency of the trigger in finding jets with p_T above the value.

First the effect of using a two overlapping grids rather than one non-overlapping grid was determined. Figure 13 shows the efficiency curve for $.2 \times .2$ jet towers, plotted against the p_T of the highest p_T jet in the event, for both non-overlapping and overlapping jet towers. The threshold here was set to achieve a 1 kHz rate: for overlapping grids of towers, the required threshold was 115 GeV, with a low energy cutoff of .5 GeV. For a non-overlapping grid the threshold was 106 GeV, with a low energy cutoff of .2 GeV. We see that the lower jet threshold used by the non-overlapping jet trigger only results in higher efficiency for lower p_T jets – this is due to the steeply falling distribution of jet energies. Figure 14 shows the efficiency curve for $.2 \times .2$ jet towers, plotted with the threshold set to achieve a 3 kHz rate: for overlapping grids of towers, the required threshold was 83 GeV, with a low energy cutoff of .1 GeV. For a non-overlapping grid the threshold was 77 GeV, with a low energy cutoff of .1 GeV. Again the overlapping grid shows a clear improvement. Figure 15 shows the efficiency curve for $.2 \times .2$ jet towers, plotted with the threshold set to achieve a 10 kHz rate: for overlapping grids of towers, the required threshold was 54 GeV, with a low energy cutoff of 1 GeV. For a non-overlapping grid the threshold was 51 GeV, with a low energy cutoff of .1 GeV. At this rate the advantage of the overlapping grid is less marked.

Figure 16 shows the efficiency curve for $.4 \times .4$ jet towers, plotted against the p_T of the highest p_T jet in the event, for both non-overlapping and overlapping jet towers. The threshold here was set to achieve a 1 kHz rate; for overlapping grids of towers, the required threshold was 140 GeV, with a low energy cutoff of .1 GeV. For a non-overlapping grid the threshold was 131 GeV, with a low energy cutoff of .1 GeV. Figure 17 shows the efficiency curve for $.4 \times .4$ jet towers, plotted with the threshold set to achieve a 3 kHz rate: for overlapping grids of towers, the required threshold was 103 GeV, with a low energy cutoff of .1 GeV. For a non-overlapping grid the threshold was 91 GeV, with a low energy cutoff of .5 GeV. Figure 18 shows the efficiency curve for $.4 \times .4$ jet towers, plotted with the threshold set to achieve a 10 kHz rate: for overlapping grids of towers, the required threshold was 70 GeV, with a low energy cutoff of .2 GeV. For a non-overlapping grid the threshold was 64 GeV, with a low energy cutoff of .1 GeV. Qualitatively, then, the $.4 \times .4$ case behaves very much like the $.2 \times .2$ case – the overlapping grid always performs better, but as the rate increases, its advantage decreases.

Figure 19 shows the efficiency curve for $.8 \times .8$ jet towers, plotted against the p_T of the highest p_T jet in the event, for both non-overlapping and overlapping jet towers. The threshold here was set to achieve a 1 kHz rate; for overlapping grids of towers, the required threshold was 162 GeV, with a low energy cutoff of .1 GeV. For a non-overlapping grid the threshold was 142 GeV, with a low energy cutoff of .5 GeV. Figure 20 shows the efficiency curve for $.8 \times .8$ jet towers, plotted with the threshold set to achieve a 3 kHz rate: for overlapping grids of towers, the required threshold was 120 GeV, with a low energy cutoff of .1 GeV. For a non-overlapping grid the threshold was 111 GeV. with a low energy cutoff of .1 GeV. Figure 21 shows the efficiency curve for $.8 \times .8$ jet towers, plotted with the threshold set to achieve a 10 kHz rate: for overlapping grids of towers, the required threshold was 84 GeV, with a low energy cutoff of .1 GeV. For a non-overlapping grid the threshold was 78

GeV, with a low energy cutoff of .1 GeV. Again in the $.8 \times .8$ case, we see that overlapping towers perform better, and that the advantage of using them decreases as the rate increases.

Figure 22 shows the efficiency curve for 1.6×1.6 jet towers, plotted against the p_T of the highest p_T jet in the event, for both non-overlapping and overlapping jet towers. The threshold here was set to achieve a 1 kHz rate; for overlapping grids of towers, the required threshold was 183 GeV, with a low energy cutoff of .1 GeV. For a non-overlapping grid the threshold was 176 GeV, with a low energy cutoff of .1 GeV. Figure 23 shows the efficiency curve for 1.6×1.6 jet towers, plotted with the threshold set to achieve a 3 kHz rate: for overlapping grids of towers, the required threshold was 138 GeV, with a low energy cutoff of .1 GeV. For a non-overlapping grid the threshold was 131 GeV, with a low energy cutoff of .1 GeV. Figure 24 shows the efficiency curve for 1.6×1.6 jet towers, plotted with the threshold set to achieve a 10 kHz rate: for overlapping grids of towers, the required threshold was 94 GeV, with a low energy cutoff of .2 GeV. For a non-overlapping grid the threshold was 89 GeV, with a low energy cutoff of .2 GeV. In the 1.6×1.6 case, overlapping grids again outperform non-overlapping grids, and the advantage decreases with increasing rate.

Figure 25 shows the efficiency curve for 3.2×3.2 jet towers, plotted against the p_T of the highest p_T jet in the event, for both non-overlapping and overlapping jet towers. The threshold here was set to achieve a 1 kHz rate; for overlapping grids of towers, the required threshold was 198 GeV, with a low energy cutoff of .5 GeV. For a non-overlapping grid the threshold was 165 GeV, with a low energy cutoff of 1 GeV. Figure 26 shows the efficiency curve for 3.2×3.2 jet towers, plotted with the threshold set to achieve a 3 kHz rate: for overlapping grids of towers, the required threshold was 146 GeV, with a low energy cutoff of .5 GeV. For a non-overlapping grid the threshold was 139 GeV, with a low energy cutoff of .5 GeV. Figure 27 shows the efficiency curve for 3.2×3.2 jet towers, plotted with the threshold set to achieve a 10 kHz rate: for overlapping grids of towers, the required threshold was 102 GeV, with a low energy cutoff of .5 GeV. For a non-overlapping grid the threshold was 97 GeV, with a low energy cutoff of .5 GeV. We see that in the 3.2×3.2 case, the advantage of using overlapping grids of towers is not nearly so large as in all the smaller tower sizes. This suggests that containment of jets within 1.6×1.6 regions of the calorimeter is fairly good.

Jet Trigger Efficiency– Luminosity 10^{33}

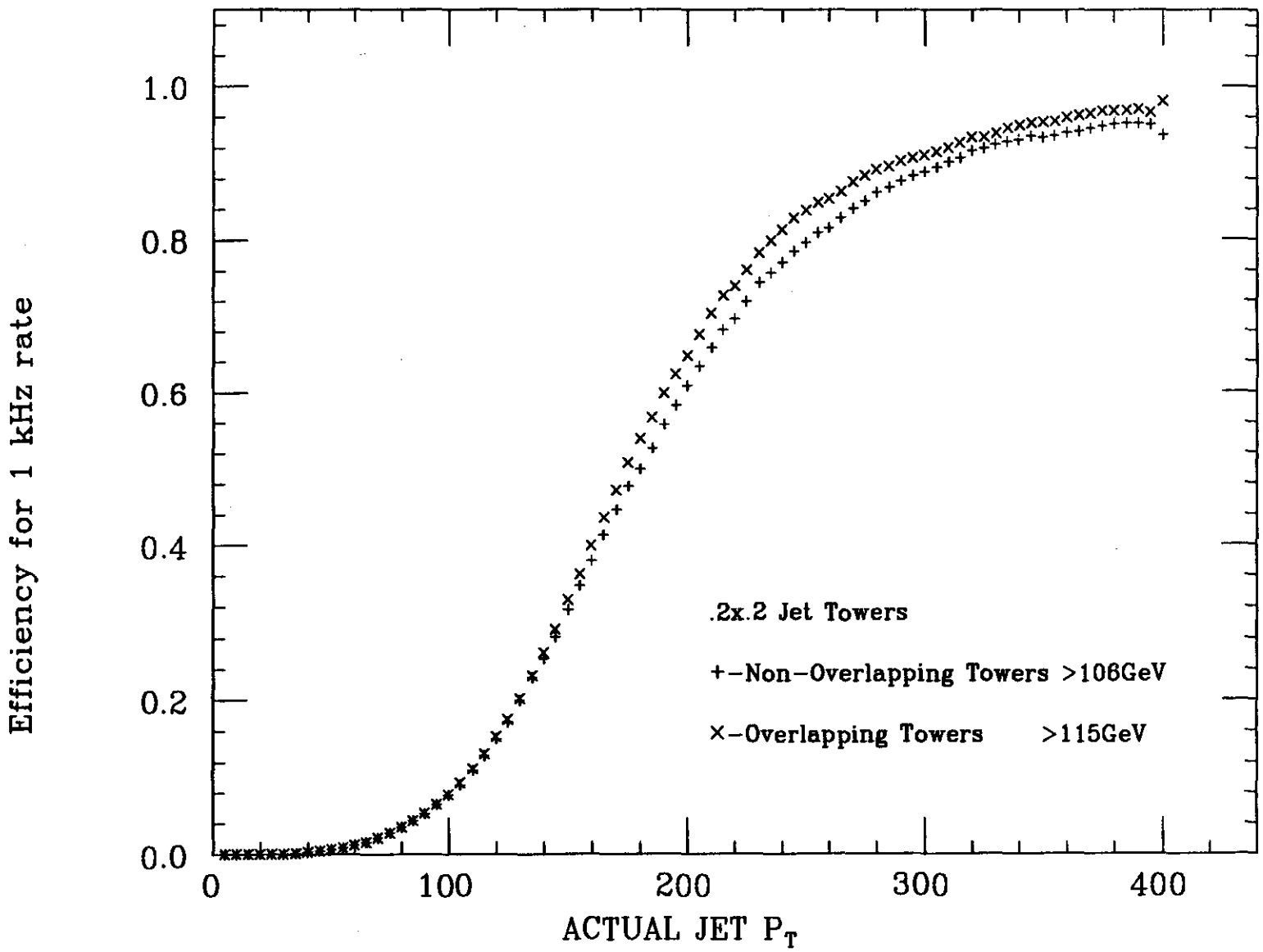

Figure 13

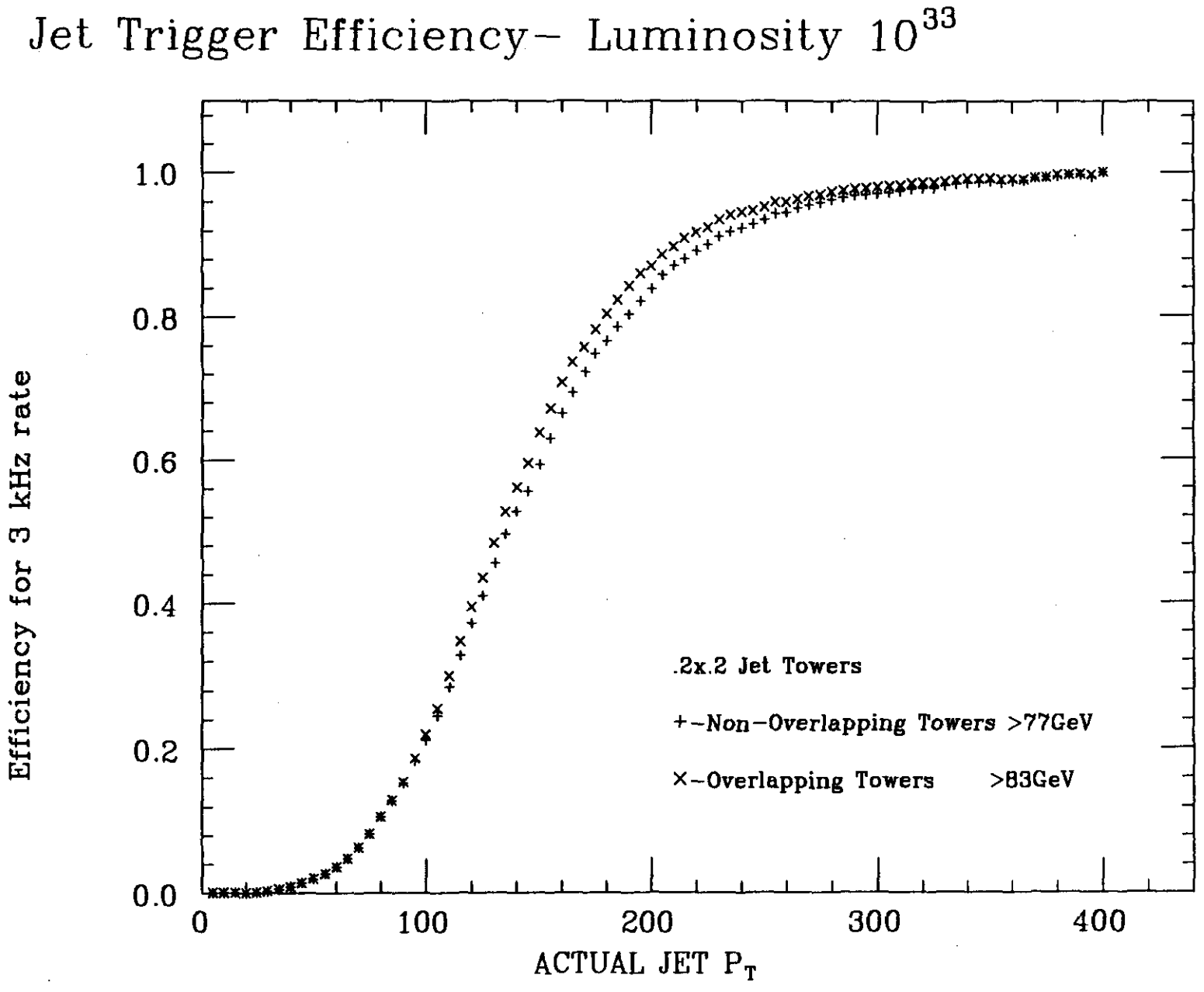
Jet Trigger Efficiency– Luminosity 10^{33}
Efficiency for 3 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
.2x.2 Jet Towers
+–Non–Overlapping Towers >77GeV
×–Overlapping Towers >83GeV

Figure 14

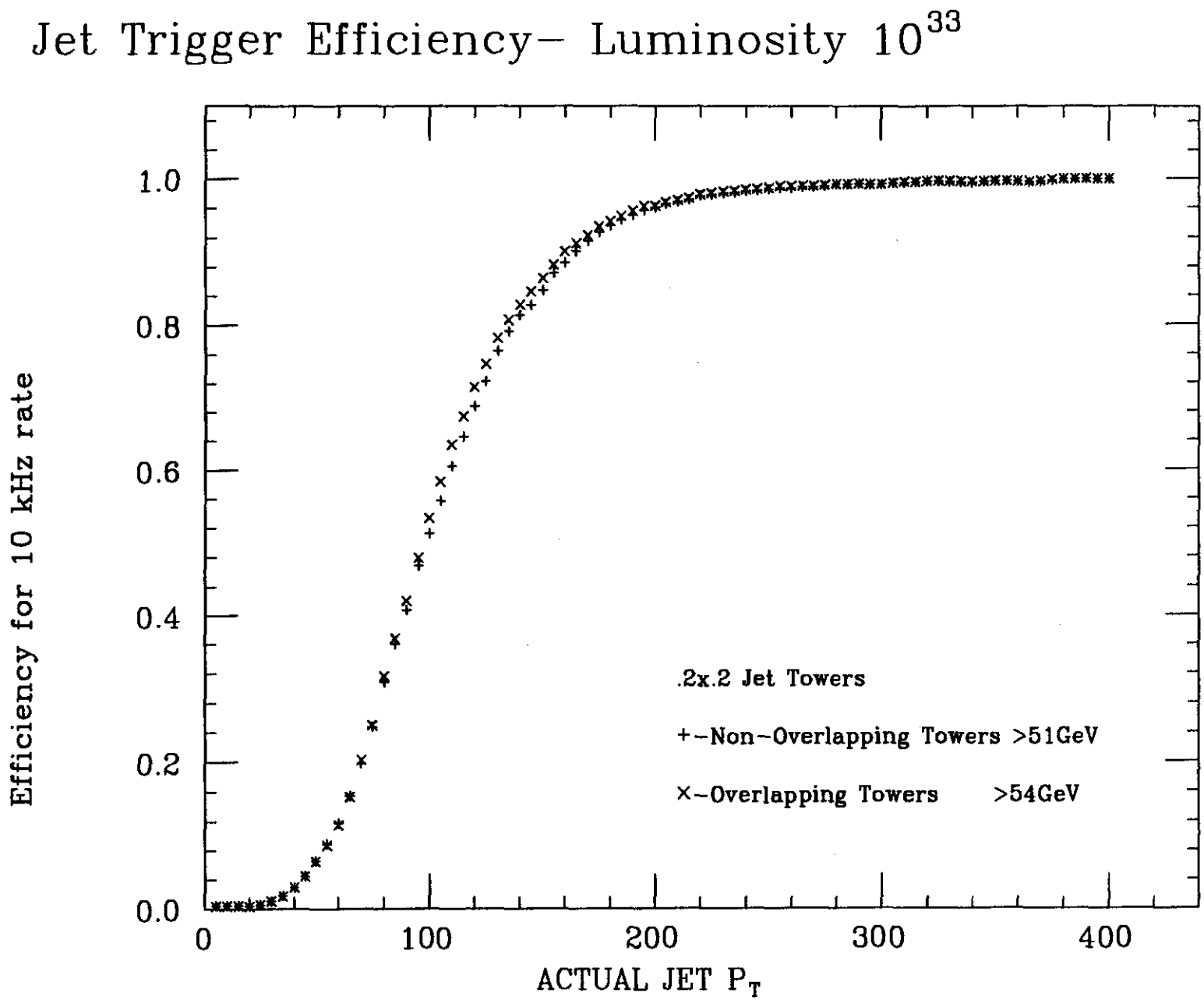
Jet Trigger Efficiency– Luminosity 10^{33}
Efficiency for 10 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
.2x.2 Jet Towers
+–Non–Overlapping Towers >51GeV
×–Overlapping Towers >54GeV

Figure 15

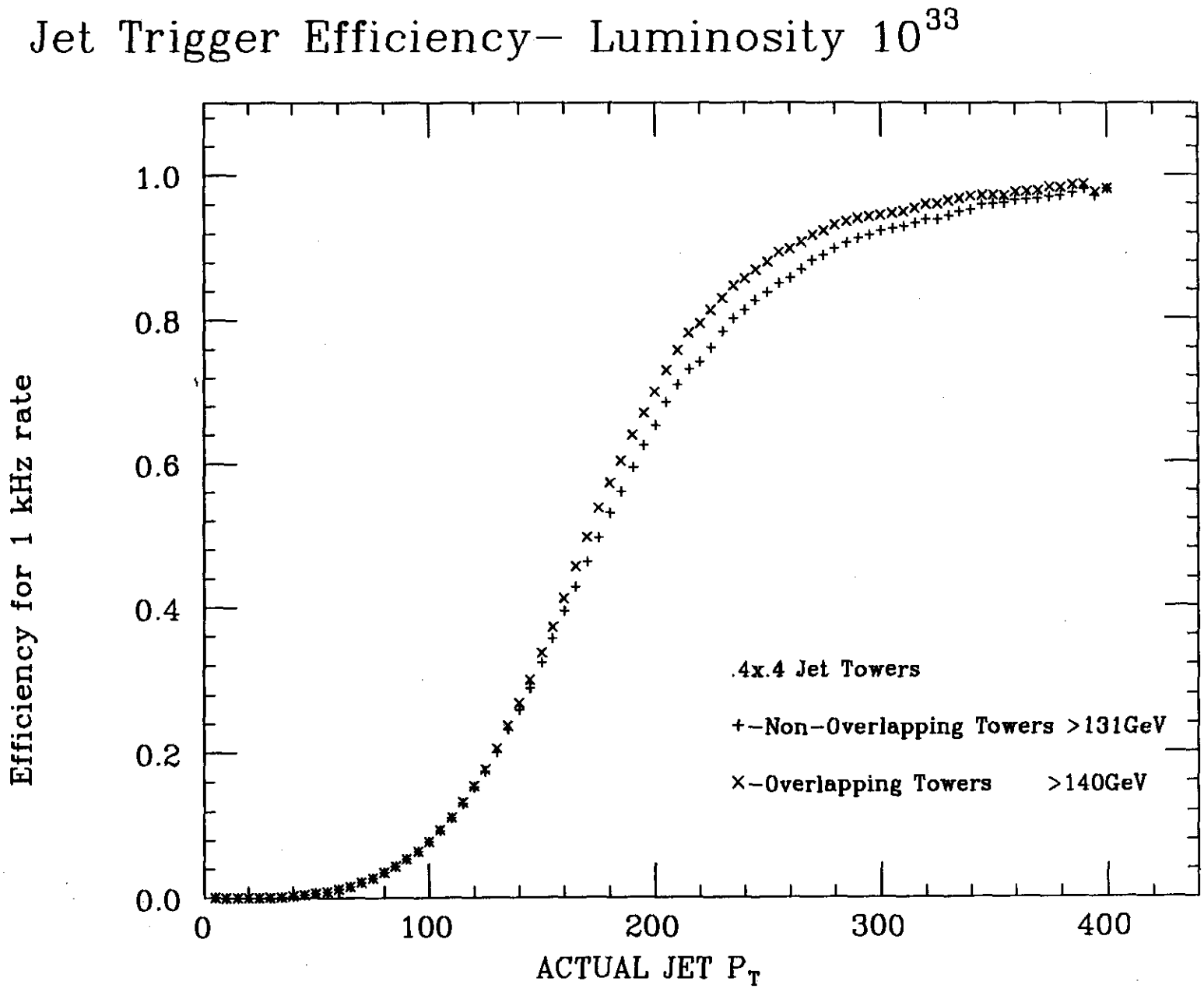
Jet Trigger Efficiency– Luminosity 10^{33}
Efficiency for 1 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
.4x.4 Jet Towers
+–Non–Overlapping Towers >131GeV
×–Overlapping Towers >140GeV

Figure 16

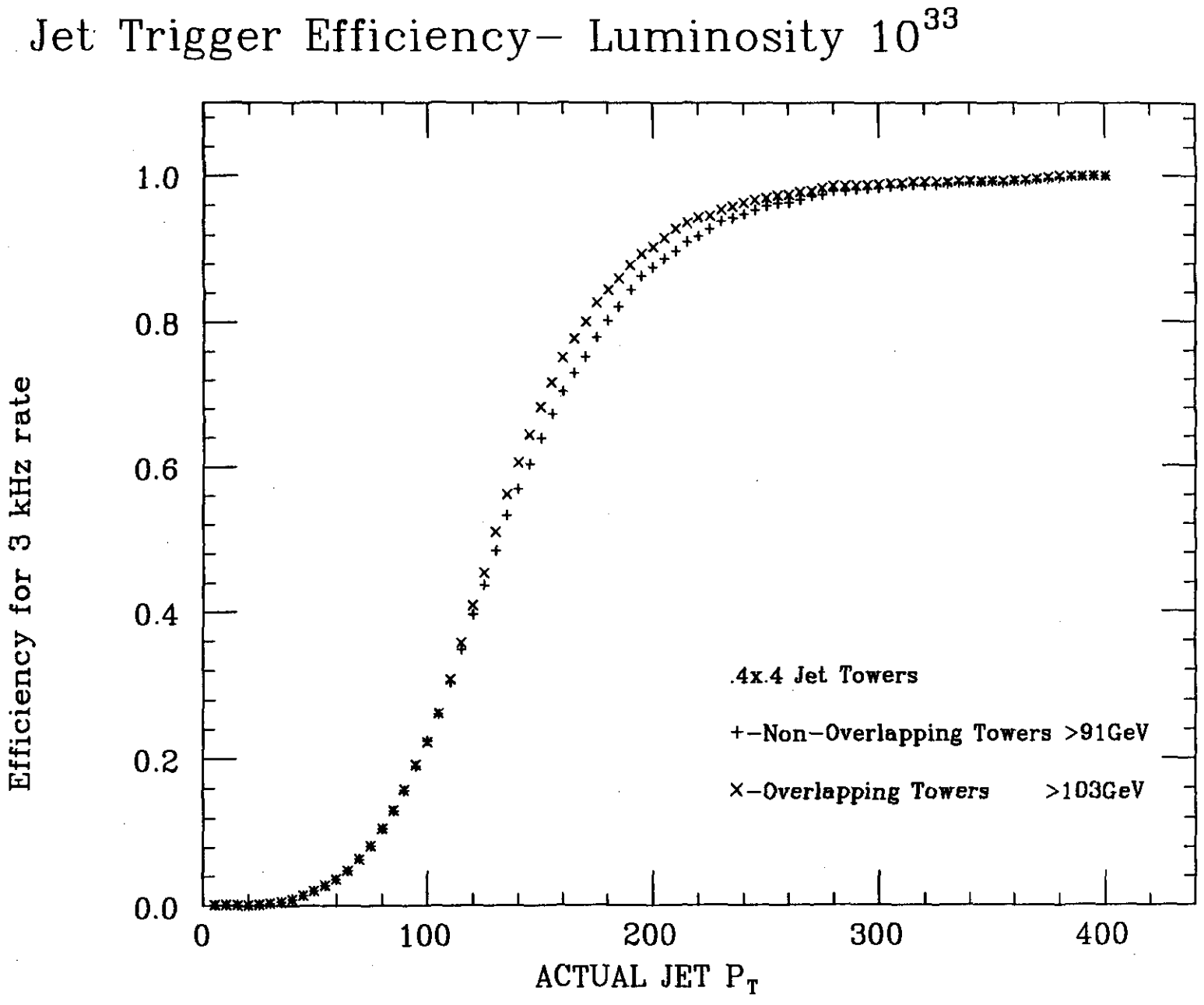
Jet Trigger Efficiency– Luminosity 10^{33}
Efficiency for 3 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
.4x.4 Jet Towers
+–Non–Overlapping Towers >91GeV
×–Overlapping Towers >103GeV

Figure 17

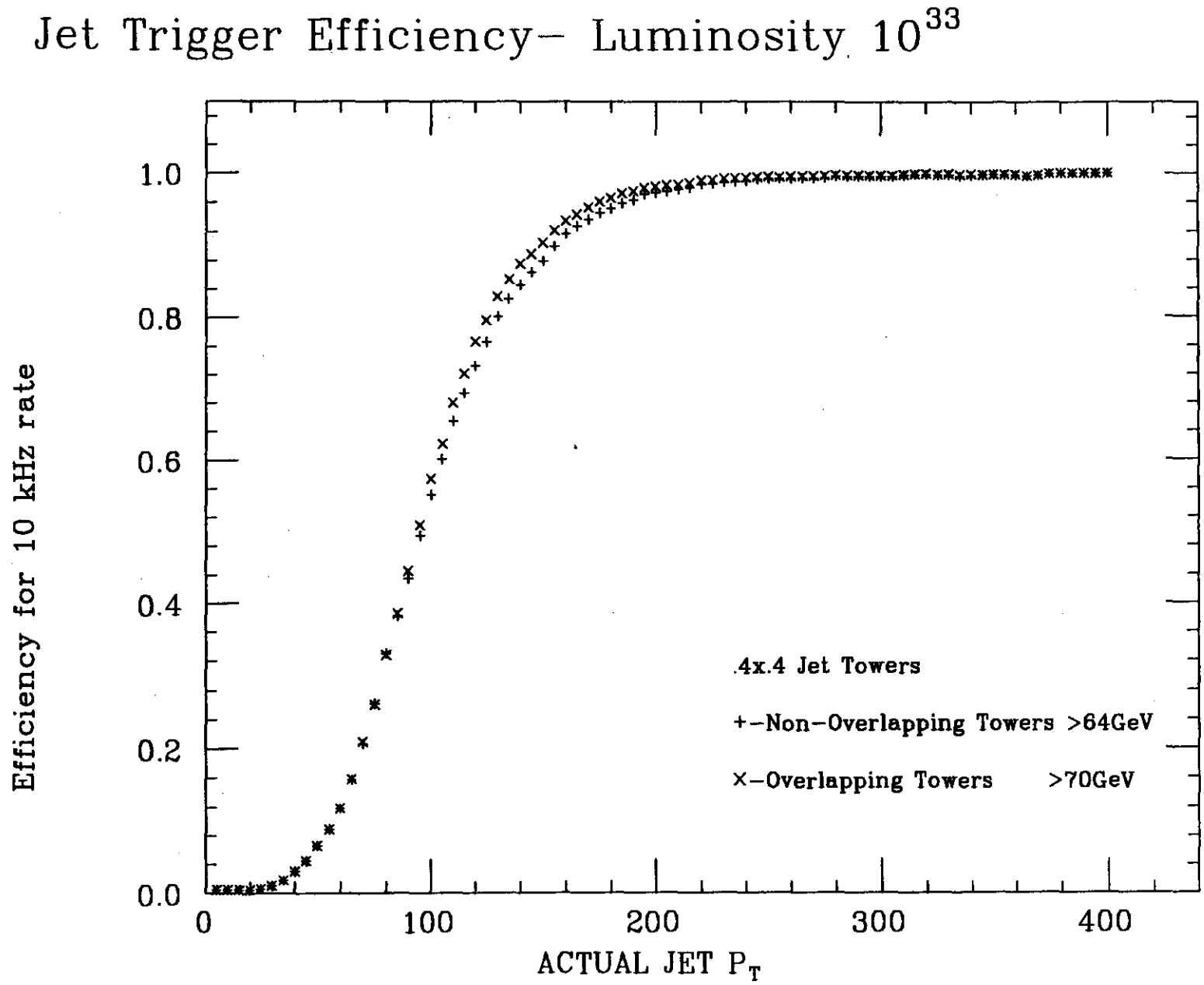
Jet Trigger Efficiency– Luminosity 10^{33}
Efficiency for 10 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
.4x.4 Jet Towers
+–Non–Overlapping Towers >64GeV
×–Overlapping Towers >70GeV

Figure 18

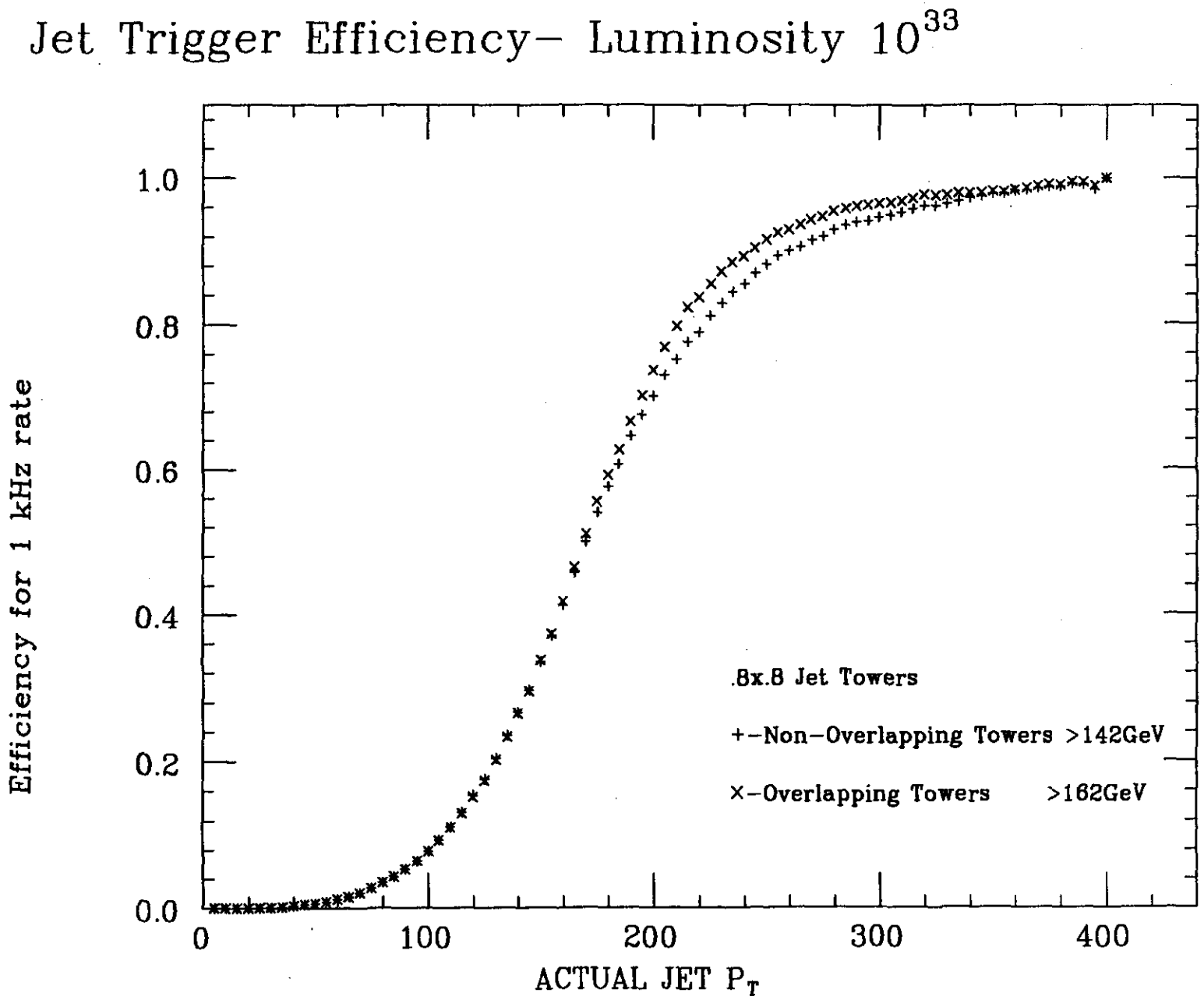
Jet Trigger Efficiency– Luminosity 10^{33}
Efficiency for 1 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
.8x.8 Jet Towers
+–Non–Overlapping Towers >142GeV
×–Overlapping Towers >162GeV

Figure 19

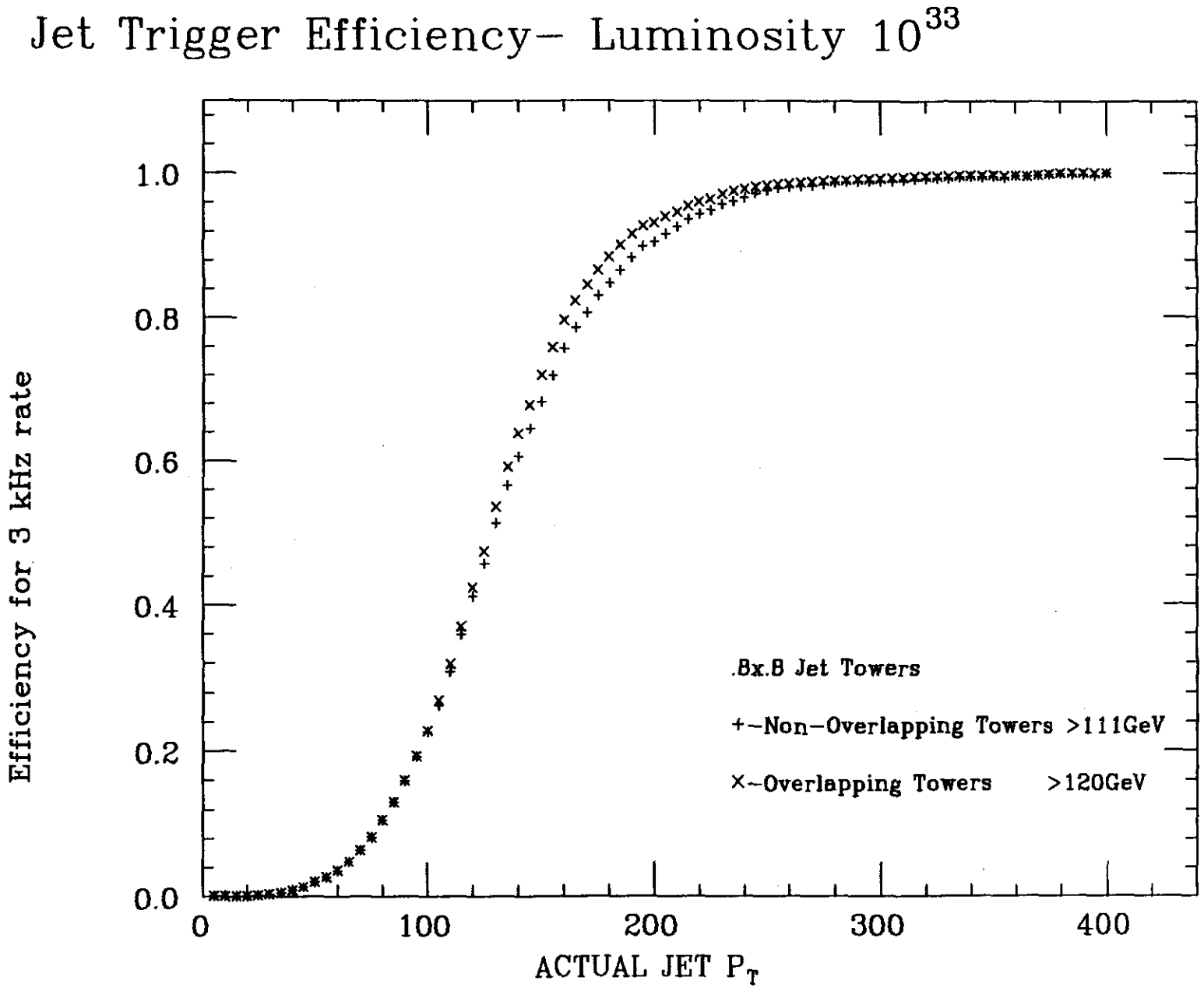
Jet Trigger Efficiency– Luminosity 10^{33}
Efficiency for 3 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
.8x.8 Jet Towers
+–Non–Overlapping Towers >111GeV
×–Overlapping Towers >120GeV

Figure 20

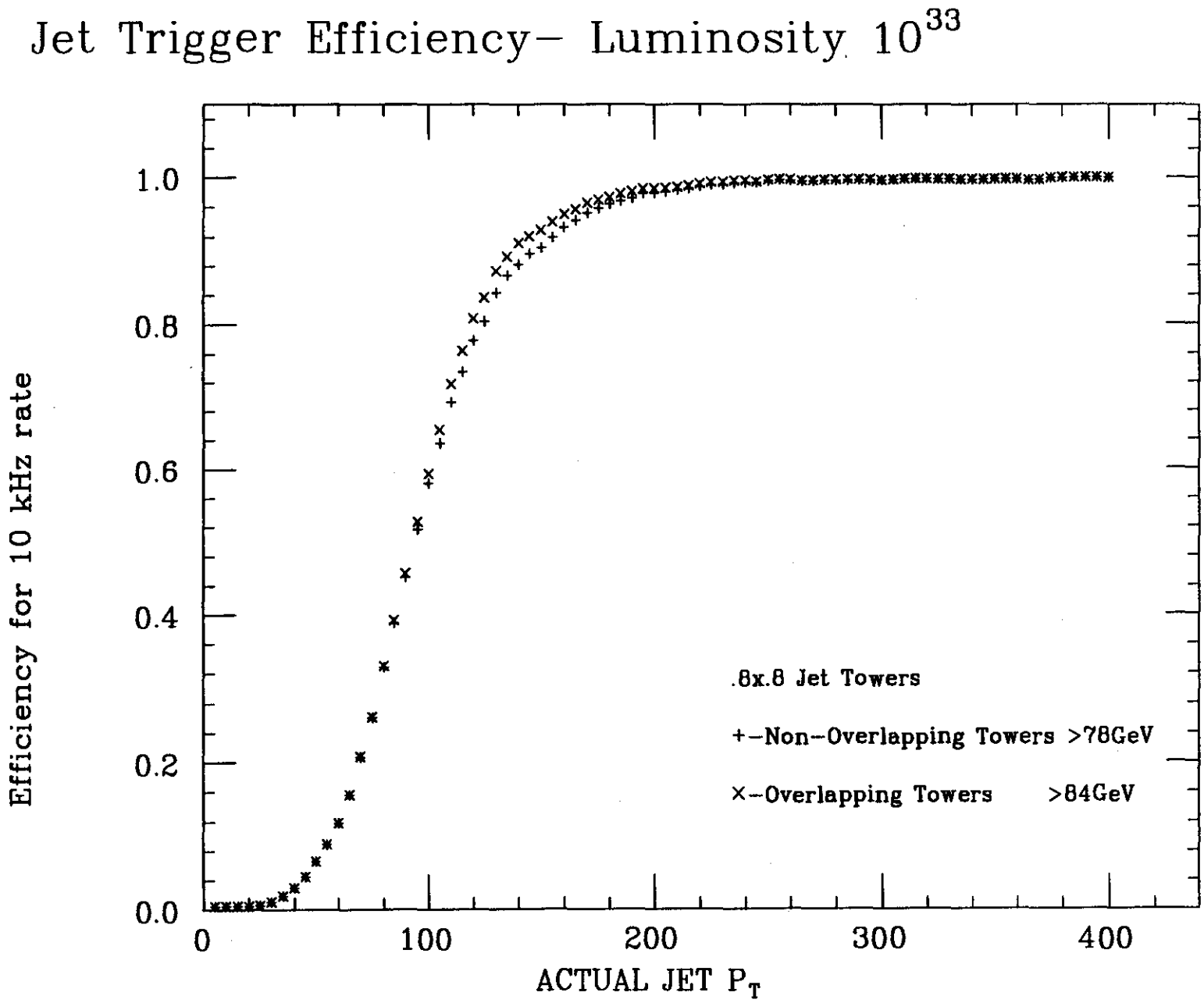
Jet Trigger Efficiency– Luminosity 10^{33}
Efficiency for 10 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
.8x.8 Jet Towers
+–Non–Overlapping Towers >78GeV
×–Overlapping Towers >84GeV

Figure 21

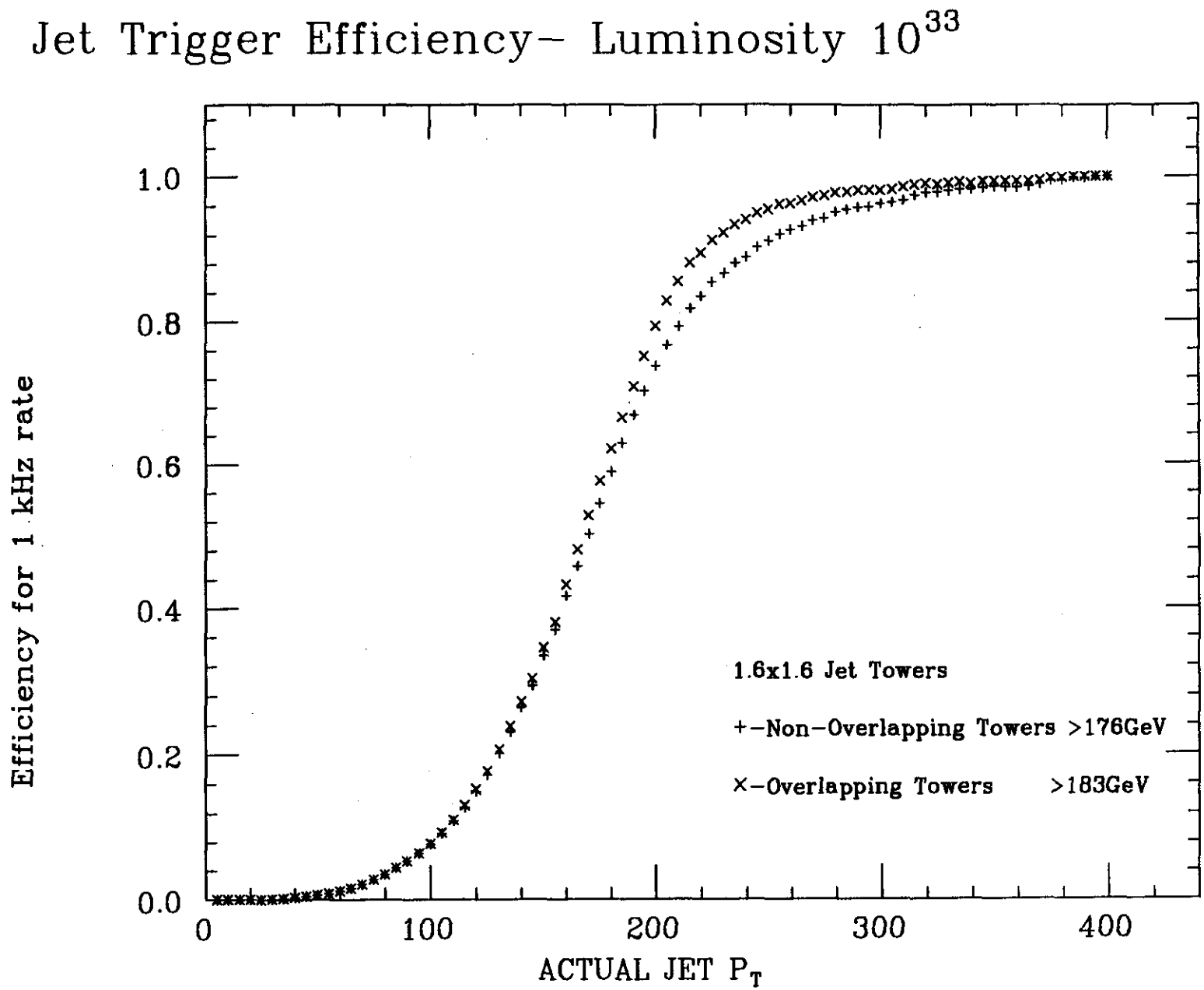
Jet Trigger Efficiency- Luminosity 10^{33}
Efficiency for 1 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
1.6x1.6 Jet Towers
+-Non-Overlapping Towers >176GeV
×-Overlapping Towers >183GeV

Figure 22

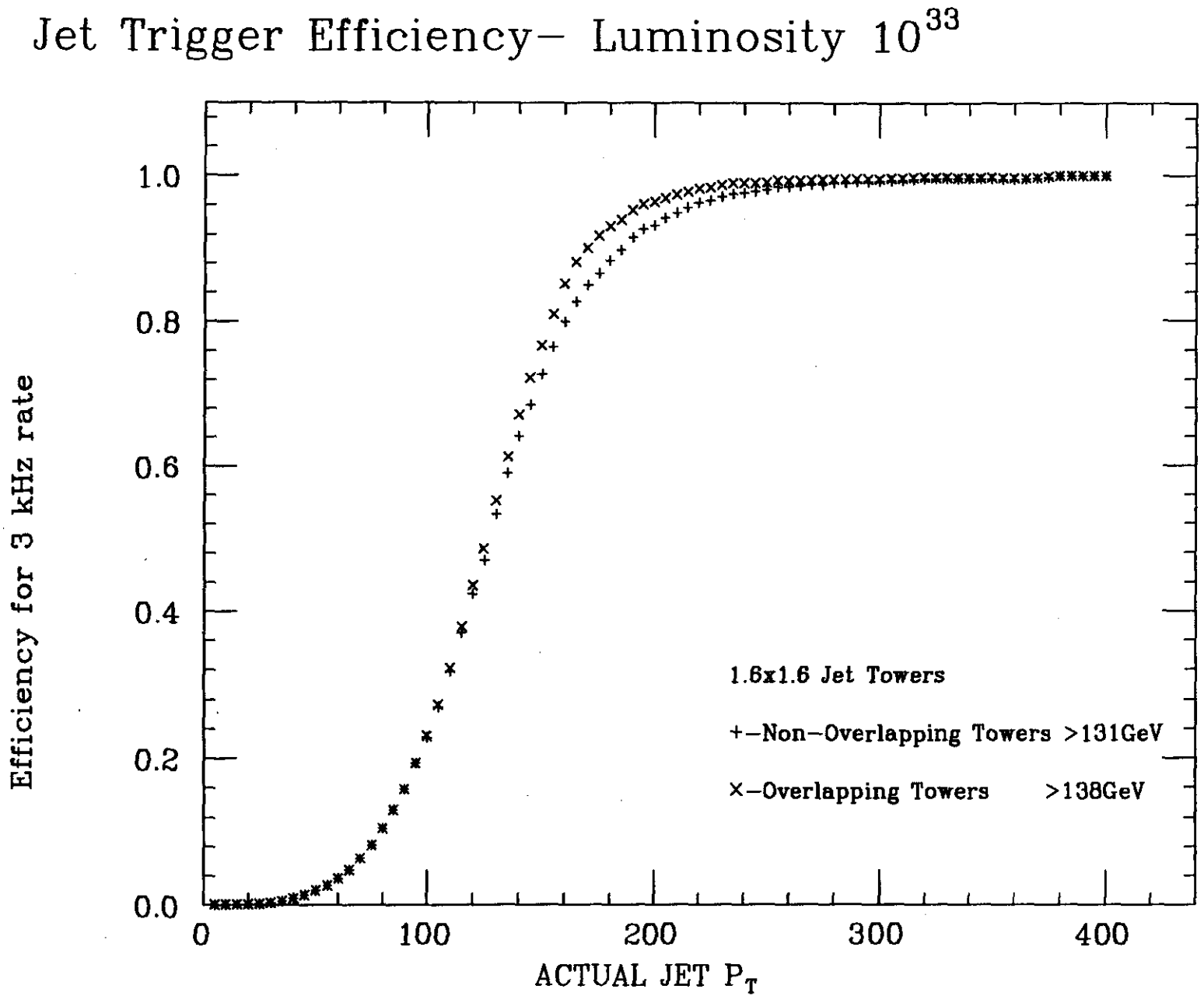
Jet Trigger Efficiency– Luminosity 10^{33}
Efficiency for 3 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
1.6x1.6 Jet Towers
+–Non–Overlapping Towers >131GeV
×–Overlapping Towers >138GeV

Figure 23

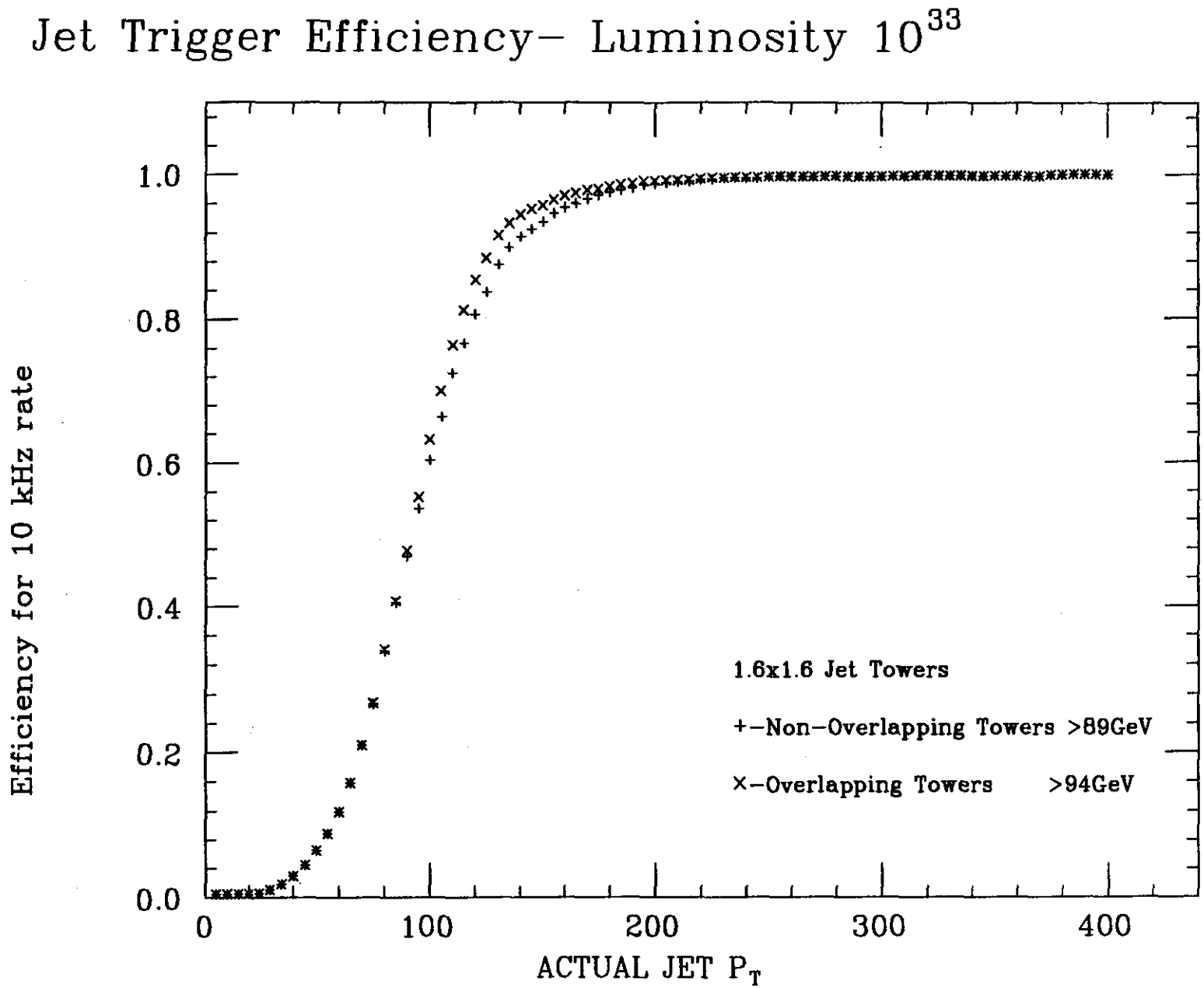
Jet Trigger Efficiency– Luminosity 10^{33}
Efficiency for 10 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
1.6x1.6 Jet Towers
+–Non–Overlapping Towers >89GeV
×–Overlapping Towers >94GeV

Figure 24

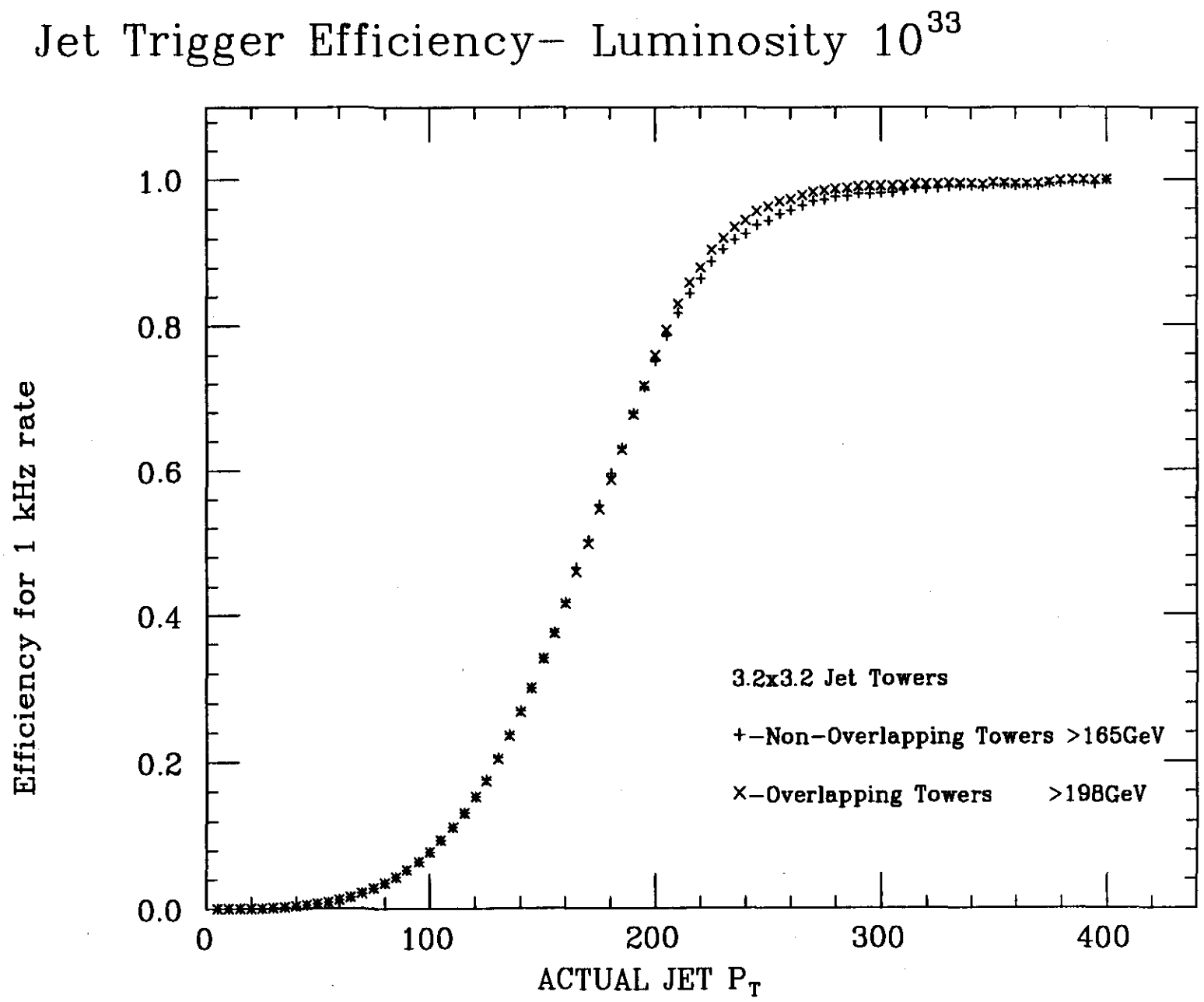
Jet Trigger Efficiency– Luminosity 10^{33}
Efficiency for 1 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
3.2x3.2 Jet Towers
+–Non–Overlapping Towers >165GeV
×–Overlapping Towers >198GeV

Figure 25

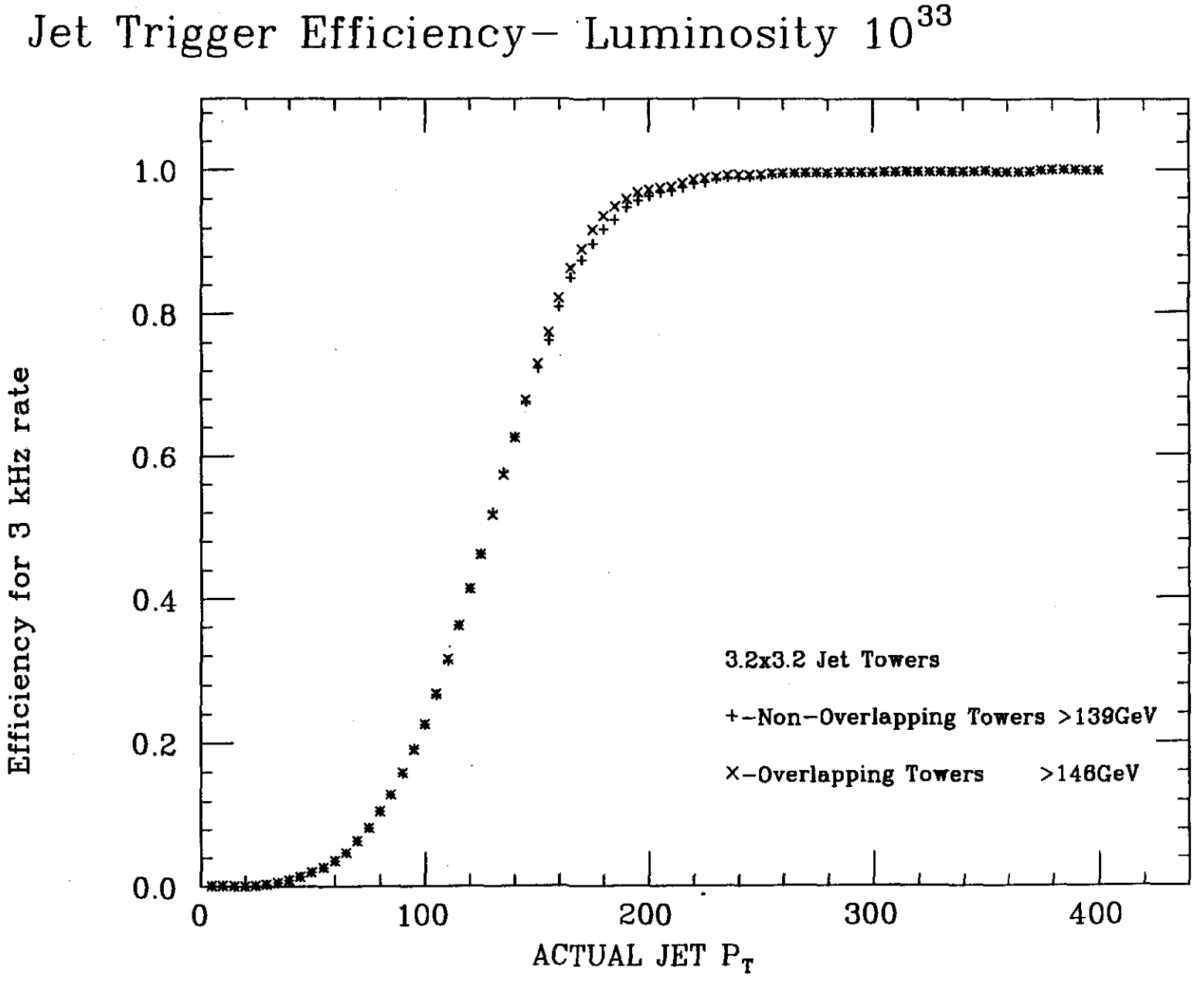
Jet Trigger Efficiency– Luminosity 10^{33}
Efficiency for 3 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
3.2x3.2 Jet Towers
+–Non–Overlapping Towers >139GeV
×–Overlapping Towers >146GeV

Figure 26

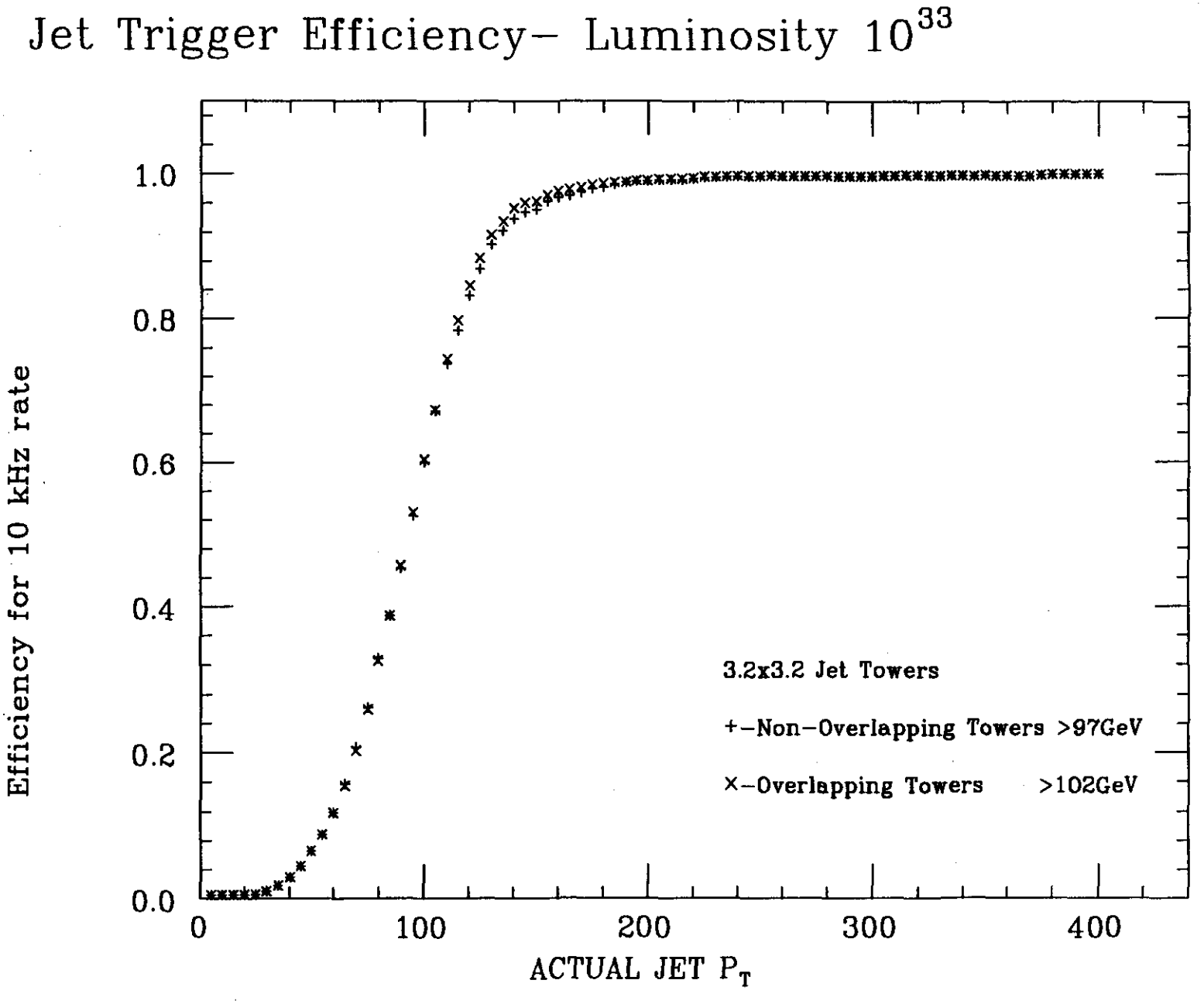
Jet Trigger Efficiency– Luminosity 10^{33}
Efficiency for 10 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
3.2x3.2 Jet Towers
+–Non–Overlapping Towers >97GeV
×–Overlapping Towers >102GeV

Figure 27

5.1.2 Effects of Changing Jet Tower Size

In all of the efficiency curves shown, the efficiency plotted for a particular jet p_T value is the efficiency of the trigger in finding jets with p_T above the value.

Next the effect of changing jet tower size was considered. First we consider it with non-overlapping grids of jet towers. Figure 28 shows the efficiency curves for a single calorimeter tower jet trigger, a single trigger tower jet trigger, a $.2 \times .2$ non-overlapping jet trigger, and a $.4 \times .4$ non-overlapping jet trigger. The thresholds are set for a 1 kHz rate; for a single calorimeter tower jet trigger a threshold of 65 GeV E_T is required. The single trigger tower trigger requires a threshold of 80 GeV E_T. The $.2 \times .2$ non-overlapping jet trigger requires a threshold of 106 GeV E_T, with a low energy cutoff of .2 GeV. The $.4 \times .4$ non-overlapping jet trigger has a threshold of 131 GeV E_T, with a low energy cutoff of .1 GeV. As the tower size increases from a single calorimeter tower to a $.4 \times .4$ tower, the efficiency improves dramatically. Full efficiency is not reached by any of these cases at 400 GeV. Figure 29 shows these efficiency curves for a 3 kHz rate; for a single calorimeter tower jet trigger a threshold of 47 GeV E_T is required. The single trigger tower trigger requires a threshold of 56 GeV E_T. The $.2 \times .2$ non-overlapping jet trigger requires a threshold of 77 GeV E_T, with a low energy cutoff of .1 GeV. The $.4 \times .4$ non-overlapping jet trigger has a threshold of 91 GeV E_T, with a low energy cutoff of .5 GeV. Again we see that efficiency improves with increasing tower size – here full efficiency is nearly reached by 400 GeV. Figure 30 shows these efficiency curves for a 10 kHz rate; for a single calorimeter tower jet trigger a threshold of 31 GeV E_T is required. The single trigger tower trigger requires a threshold of 38 GeV E_T. The $.2 \times .2$ non-overlapping jet trigger requires a threshold of 51 GeV E_T, with a low energy cutoff of .1 GeV. The $.4 \times .4$ non-overlapping jet trigger has a threshold of 64 GeV E_T, with a low energy cutoff of .1 GeV. At the 10 kHz rate, efficiency improves as the tower size increases from a single calorimeter tower to a $.4 \times .4$ tower, and full efficiency is reached below 400 GeV in each case.

Figure 31 shows the efficiency curves for a $.2 \times .2$ non-overlapping jet trigger, a $.4 \times .4$ non-overlapping jet trigger, a $.8 \times .8$ non-overlapping jet trigger, and a 1.6×1.6 non-overlapping jet trigger. The thresholds are set for a 1 kHz rate; for a $.2 \times .2$ non-overlapping jet trigger a threshold of 106 GeV E_T is required, with a low energy cutoff of .2 GeV. The $.4 \times .4$ non-overlapping trigger requires a threshold of 131 GeV E_T, with a low energy cutoff of .1 GeV. The $.8 \times .8$ non-overlapping jet trigger requires a threshold of 142 GeV E_T, with a low energy cutoff of .5 GeV. The 1.6×1.6 non-overlapping jet trigger has a threshold of 176 GeV E_T, with a low energy cutoff of .1 GeV. As the tower size increases from $.2 \times .2$ to 1.6×1.6 the efficiency also improves; at 1 kHz a non-overlapping grid of 1.6×1.6 or $.8 \times .8$ towers nears full efficiency by 400 GeV; such is not the case for any smaller tower size. Figure 32 shows these efficiency curves for a 3 kHz rate; for a $.2 \times .2$ non-overlapping jet trigger a threshold of 77 GeV E_T is required, with a low energy cutoff of .1 GeV. The $.4 \times .4$ non-overlapping trigger requires a threshold of 91 GeV E_T, with a low energy cutoff of .5 GeV. The $.8 \times .8$ non-overlapping jet trigger requires a threshold of 111 GeV E_T, with a low energy cutoff of .1 GeV. The 1.6×1.6 non-overlapping jet trigger has a threshold of 131 GeV E_T, with a low energy cutoff of .1 GeV. The 1.6×1.6 non-overlapping grid of towers performs better than any smaller size; one could say that it and the $.8 \times .8$ grid have reached full efficiency well before 400 GeV. Figure 33 shows these efficiency curves for a 10 kHz rate; for a $.2 \times .2$ non-overlapping jet trigger a threshold of 51 GeV E_T is required, with

a low energy cutoff of .1 GeV. The $.4 \times .4$ non-overlapping trigger requires a threshold of 64 GeV E_T, with a low energy cutoff of .1 GeV. The $.8 \times .8$ non-overlapping jet trigger requires a threshold of 78 GeV E_T, with a low energy cutoff of .1 GeV. The 1.6×1.6 non-overlapping jet trigger has a threshold of 89 GeV E_T, with a low energy cutoff of .2 GeV. At the 10 kHz rate, the 1.6×1.6 tower size continues to perform better than smaller sizes.

Figure 34 shows the efficiency curves for a $.8 \times .8$ non-overlapping jet trigger, a 1.6×1.6 non-overlapping jet trigger, a 3.2×3.2 non-overlapping jet trigger, and a full calorimeter jet trigger. The thresholds are set for a 1 kHz rate; for a $.8 \times .8$ non-overlapping jet trigger a threshold of 142 GeV E_T is required, with a low energy cutoff of .5 GeV. The 1.6×1.6 non-overlapping trigger requires a threshold of 176 GeV E_T, with a low energy cutoff of .1 GeV. The 3.2×3.2 non-overlapping jet trigger requires a threshold of 165 GeV E_T, with a low energy cutoff of 1 GeV. The full calorimeter jet trigger has a threshold of 302 GeV E_T, with a low energy cutoff of 1 GeV. Here the 3.2×3.2 tower size performs best, reaching full efficiency well before any other case. The entire calorimeter size efficiency is worse than the 1.6×1.6 tower size. Figure 35 shows these efficiency curves for a 3 kHz rate; for a $.8 \times .8$ non-overlapping jet trigger a threshold of 111 GeV E_T is required, with a low energy cutoff of .1 GeV. The 1.6×1.6 non-overlapping trigger requires a threshold of 131 GeV E_T, with a low energy cutoff of .1 GeV. The 3.2×3.2 non-overlapping jet trigger requires a threshold of 139 GeV E_T, with a low energy cutoff of .5 GeV. The full calorimeter jet trigger has a threshold of 212 GeV E_T, with a low energy cutoff of 1 GeV. At 3 kHz the 3.2×3.2 towers are the best, with both larger and smaller tower sizes performing worse, and 3.2×3.2 towers reaching full efficiency sooner than any other case. Figure 36 shows these efficiency curves for a 10 kHz rate; for a $.8 \times .8$ non-overlapping jet trigger a threshold of 78 GeV E_T is required, with a low energy cutoff of .1 GeV. The 1.6×1.6 non-overlapping trigger requires a threshold of 89 GeV E_T, with a low energy cutoff of .2 GeV. The 3.2×3.2 non-overlapping jet trigger requires a threshold of 97 GeV E_T, with a low energy cutoff of .5 GeV. The full calorimeter jet trigger has a threshold of 140 GeV E_T, with a low energy cutoff of 1 GeV. Again the 3.2×3.2 tower size appears best. It seems reasonable to conclude that if one decided to use a non-overlapping grid of towers, the 3.2×3.2 size would be best.

Now we consider the effect of changing jet tower size using overlapping grids of jet towers. Figure 37 shows the efficiency curves for a single calorimeter tower jet trigger, a single trigger tower jet trigger, a $.2 \times .2$ overlapping jet trigger, and a $.4 \times .4$ overlapping jet trigger. The thresholds are set for a 1 kHz rate; for a single calorimeter tower jet trigger a threshold of 65 GeV E_T is required. The single trigger tower trigger requires a threshold of 80 GeV E_T. The $.2 \times .2$ overlapping jet trigger requires a threshold of 115 GeV E_T, with a low energy cutoff of .5 GeV. The $.4 \times .4$ overlapping jet trigger has a threshold of 140 GeV E_T, with a low energy cutoff of .1 GeV. The efficiency here improves with tower size from the single calorimeter tower size to the $.2 \times .2$ grid. In none of these cases has full efficiency been reached by 400 GeV p_T. Figure 38 shows these efficiency curves for a 3 kHz rate; for a single calorimeter tower jet trigger a threshold of 47 GeV E_T is required. The single trigger tower trigger requires a threshold of 56 GeV E_T. The $.2 \times .2$ overlapping jet trigger requires a threshold of 83 GeV E_T, with a low energy cutoff of .1 GeV. The $.4 \times .4$ overlapping jet trigger has a threshold of 103 GeV E_T, with a low energy cutoff of .1 GeV. Again the efficiency improves with tower size, at least up to $.4 \times .4$ grids of overlapping towers. Here perhaps the $.4 \times .4$ grid has reached full efficiency by 400 GeV p_T. Figure 39 shows these efficiency curves for a 10 kHz rate; for a single calorimeter tower jet trigger a threshold of

31 GeV E_T is required. The single trigger tower trigger requires a threshold of 38 GeV E_T. The $.2 \times .2$ overlapping jet trigger requires a threshold of 54 GeV E_T, with a low energy cutoff of 1 GeV. The $.4 \times .4$ overlapping jet trigger has a threshold of 70 GeV E_T, with a low energy cutoff of .2 GeV. The improvement in efficiency with tower size remains.

Figure 40 shows the efficiency curves for a $.2 \times .2$ overlapping jet trigger, a $.4 \times .4$ overlapping jet trigger, a $.8 \times .8$ overlapping jet trigger, and a 1.6×1.6 overlapping jet trigger. The thresholds are set for a 1 kHz rate; for a $.2 \times .2$ overlapping jet trigger a threshold of 115 GeV E_T is required, with a low energy cutoff of .5 GeV. The $.4 \times .4$ overlapping trigger requires a threshold of 140 GeV E_T, with a low energy cutoff of .1 GeV. The $.8 \times .8$ overlapping jet trigger requires a threshold of 162 GeV E_T, with a low energy cutoff of .1 GeV. The 1.6×1.6 overlapping jet trigger has a threshold of 183 GeV E_T, with a low energy cutoff of .1 GeV. 1.6×1.6 grids of overlapping towers show a significant advantage over any smaller grid size. Figure 41 shows these efficiency curves for a 3 kHz rate; for a $.2 \times .2$ overlapping jet trigger a threshold of 83 GeV E_T is required, with a low energy cutoff of .1 GeV. The $.4 \times .4$ overlapping trigger requires a threshold of 103 GeV E_T, with a low energy cutoff of .1 GeV. The $.8 \times .8$ overlapping jet trigger requires a threshold of 120 GeV E_T, with a low energy cutoff of .1 GeV. The 1.6×1.6 overlapping jet trigger has a threshold of 138 GeV E_T, with a low energy cutoff of .1 GeV. 1.6×1.6 overlapping towers again outperform all smaller sizes. Figure 42 shows these efficiency curves for a 10 kHz rate; for a $.2 \times .2$ overlapping jet trigger a threshold of 54 GeV E_T is required, with a low energy cutoff of 1 GeV. The $.4 \times .4$ overlapping trigger requires a threshold of 70 GeV E_T, with a low energy cutoff of .2 GeV. The $.8 \times .8$ overlapping jet trigger requires a threshold of 84 GeV E_T, with a low energy cutoff of .1 GeV. The 1.6×1.6 overlapping jet trigger has a threshold of 94 GeV E_T, with a low energy cutoff of .2 GeV. At 10 kHz the advantage of 1.6×1.6 towers remains unimpaired.

Figure 43 shows the efficiency curves for a $.8 \times .8$ overlapping jet trigger, a 1.6×1.6 overlapping jet trigger, a 3.2×3.2 overlapping jet trigger, and a full calorimeter jet trigger. The thresholds are set for a 1 kHz rate; for a $.8 \times .8$ overlapping jet trigger a threshold of 162 GeV E_T is required, with a low energy cutoff of .1 GeV. The 1.6×1.6 overlapping trigger requires a threshold of 183 GeV E_T, with a low energy cutoff of .1 GeV. The 3.2×3.2 overlapping jet trigger requires a threshold of 198 GeV E_T, with a low energy cutoff of .5 GeV. The full calorimeter jet trigger has a threshold of 302 GeV E_T, with a low energy cutoff of 1 GeV. Here there is not so much to choose between 1.6×1.6 overlapping and 3.2×3.2 overlapping towers; while in the non-overlapping case 3.2×3.2 towers showed a marked advantage, the difference with overlapping towers is much smaller. Figure 44 shows these efficiency curves for a 3 kHz rate; for a $.8 \times .8$ overlapping jet trigger a threshold of 120 GeV E_T is required, with a low energy cutoff of .1 GeV. The 1.6×1.6 overlapping trigger requires a threshold of 138 GeV E_T, with a low energy cutoff of .1 GeV. The 3.2×3.2 overlapping jet trigger requires a threshold of 146 GeV E_T, with a low energy cutoff of .5 GeV. The full calorimeter jet trigger has a threshold of 212 GeV E_T, with a low energy cutoff of 1 GeV. At a 3 kHz rate 1.6×1.6 and 3.2×3.2 overlapping towers perform much better than other sizes. Figure 45 shows these efficiency curves for a 10 kHz rate; for a $.8 \times .8$ overlapping jet trigger a threshold of 84 GeV E_T is required, with a low energy cutoff of .1 GeV. The 1.6×1.6 overlapping trigger requires a threshold of 94 GeV E_T, with a low energy cutoff of .2 GeV. The 3.2×3.2 overlapping jet trigger requires a threshold of 102 GeV E_T, with a low energy cutoff of .5 GeV. The full calorimeter jet trigger has a threshold

of 140 GeV E_T, with a low energy cutoff of 1 GeV. In conclusion, one could use either a 3.2×3.2 overlapping grid or a 1.6×1.6 overlapping grid of towers for best performance; if good perfomance with a non-overlapping grid was desired, a 3.2×3.2 grid would be best.

Jet Trigger Efficiency– Luminosity 10^{33}

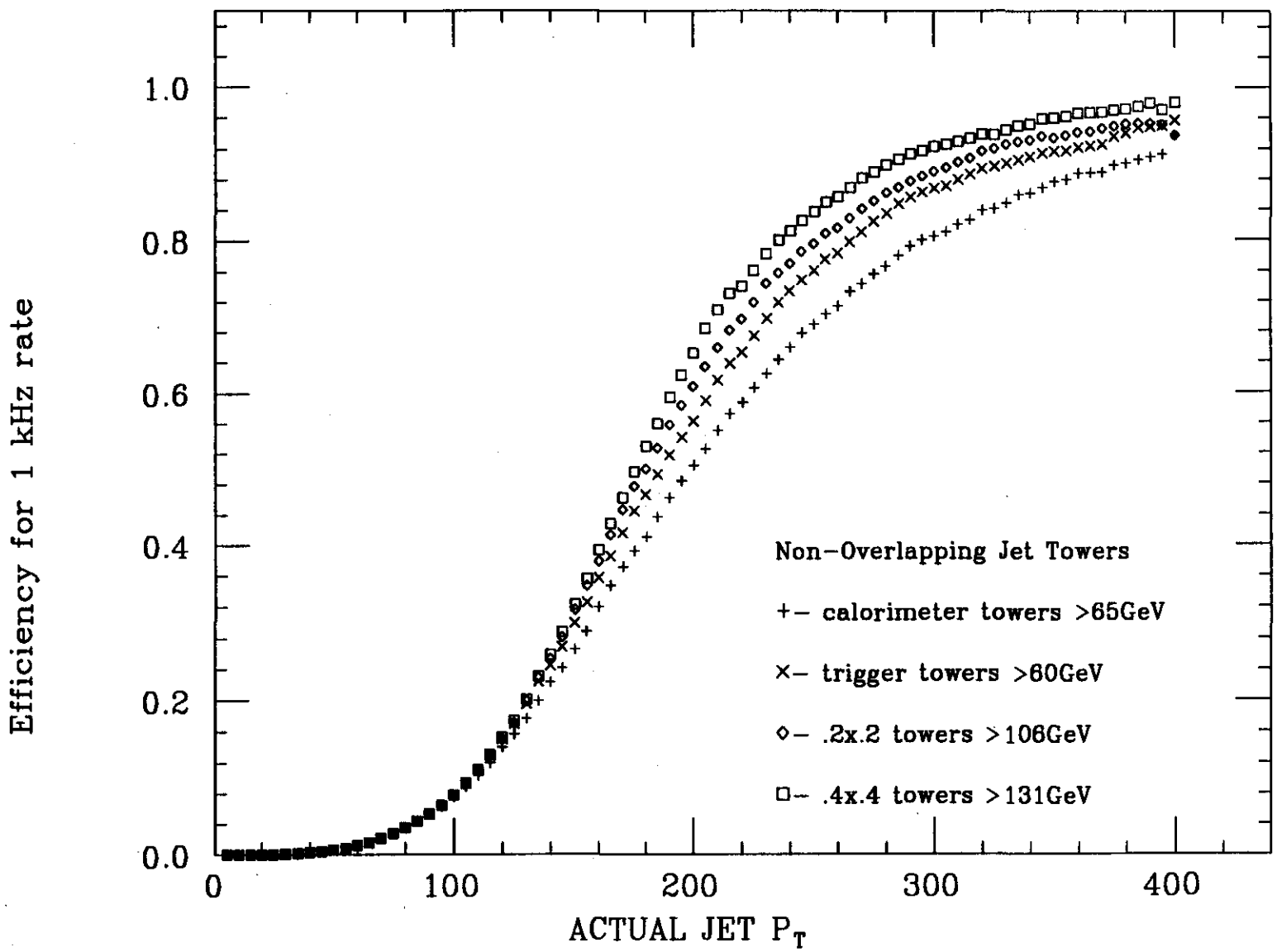

Figure 28

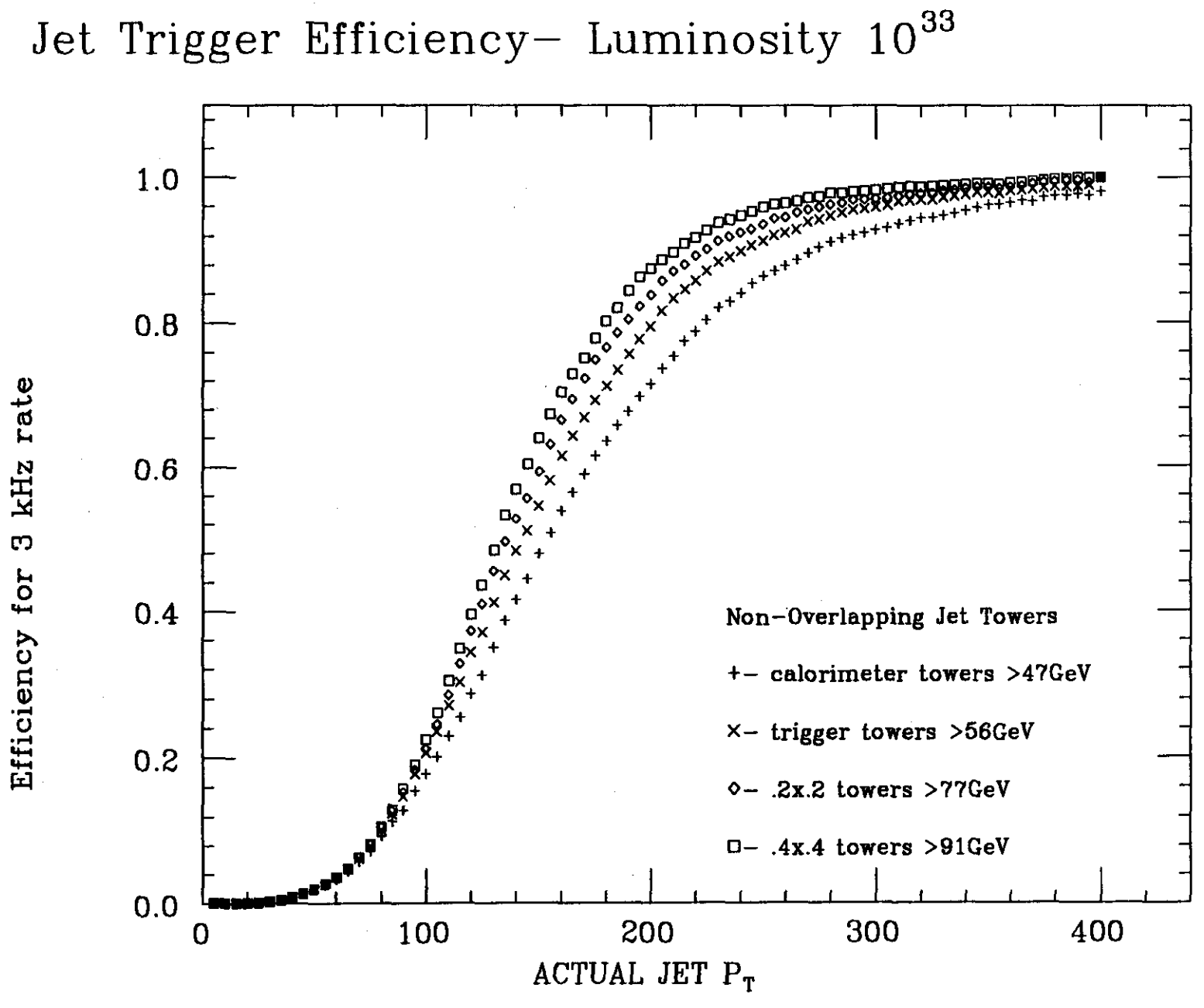
Jet Trigger Efficiency– Luminosity 10^{33}
Efficiency for 3 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
Non–Overlapping Jet Towers
+– calorimeter towers >47GeV
×– trigger towers >56GeV
◇– .2x.2 towers >77GeV
□– .4x.4 towers >91GeV

Figure 29

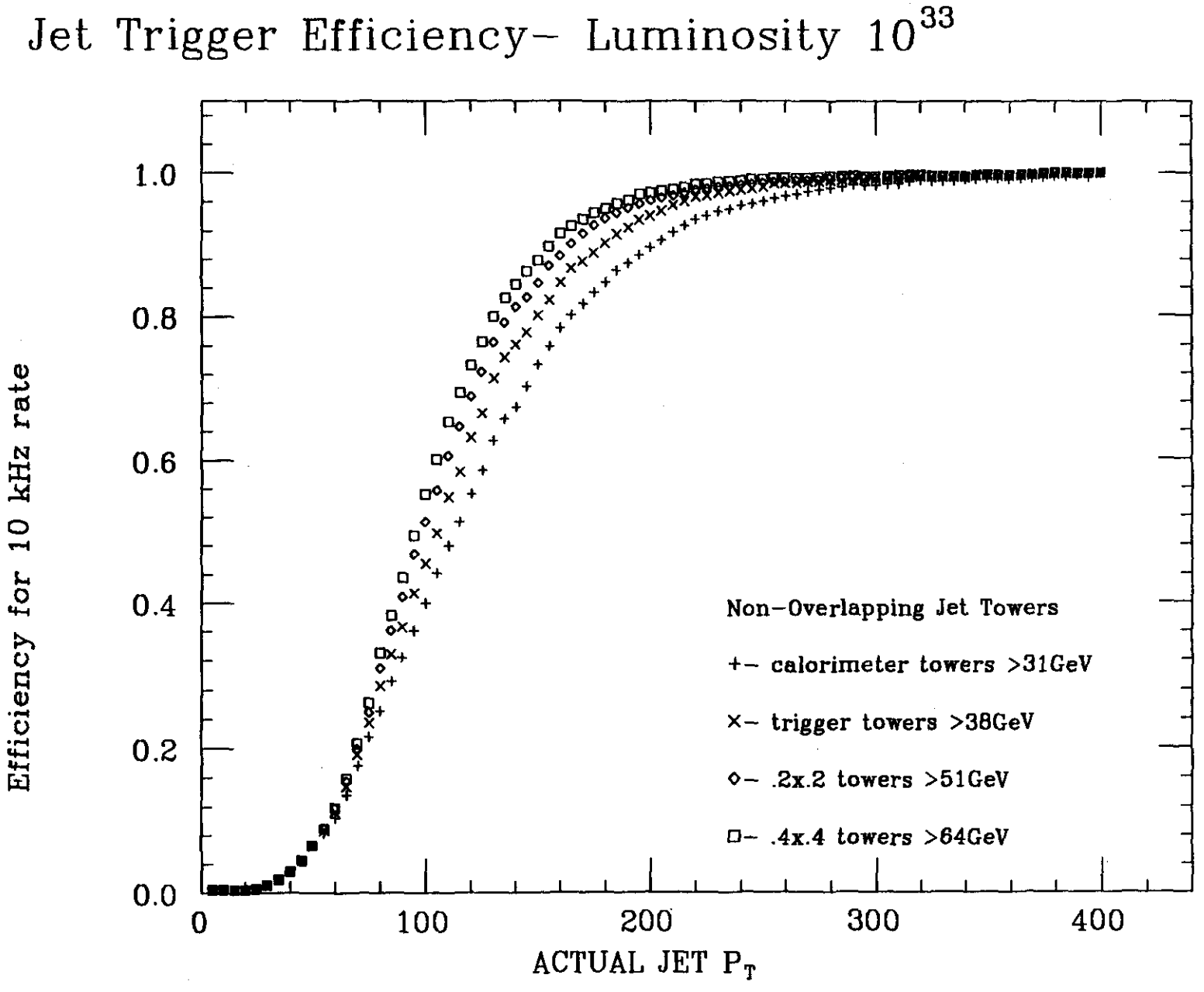
Jet Trigger Efficiency- Luminosity 10^{33}
Efficiency for 10 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
Non-Overlapping Jet Towers
+- calorimeter towers >31GeV
×- trigger towers >38GeV
◇- .2x.2 towers >51GeV
□- .4x.4 towers >64GeV

Figure 30

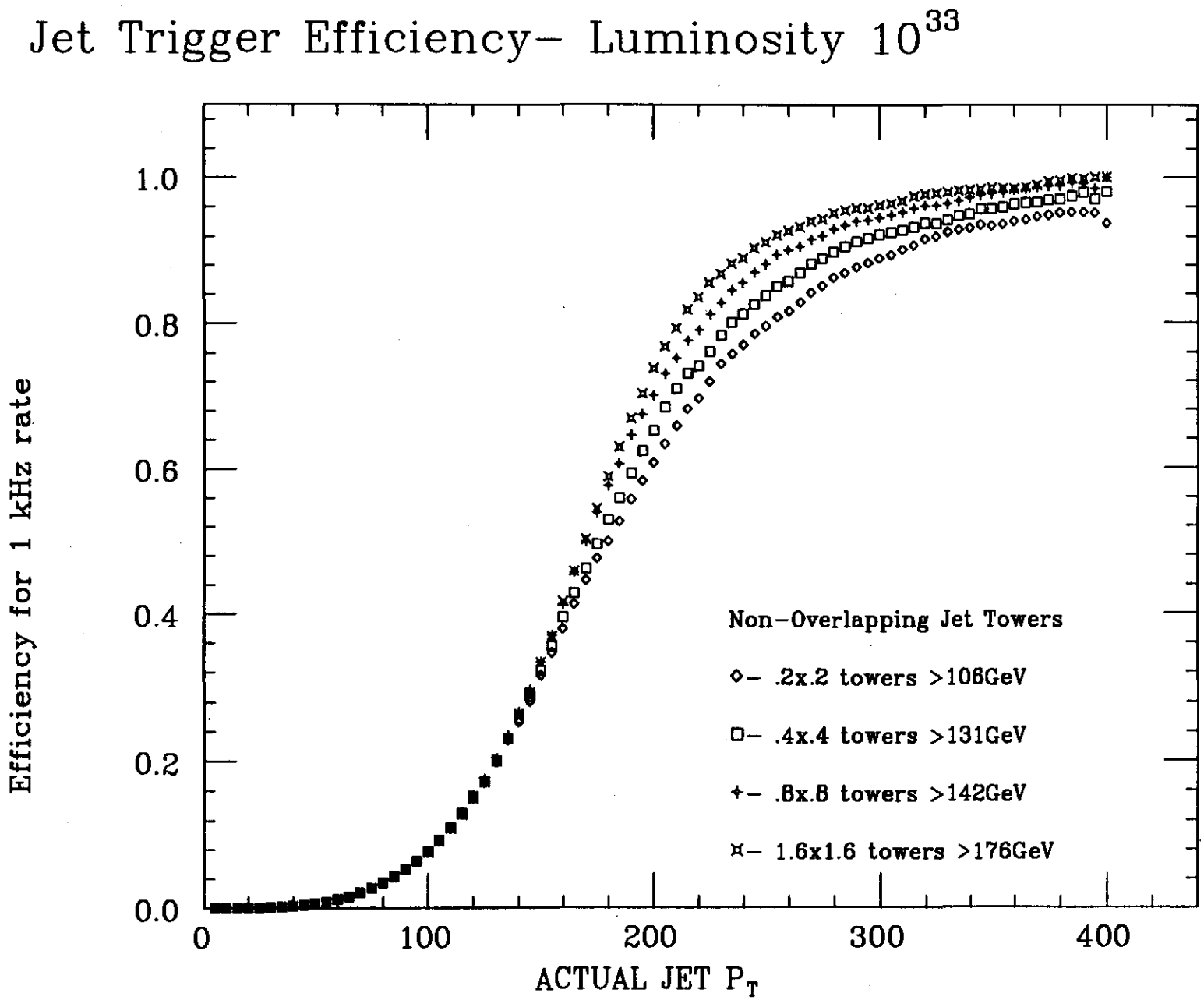
Jet Trigger Efficiency– Luminosity 10^{33}
Efficiency for 1 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
Non–Overlapping Jet Towers
◇– .2x.2 towers >106GeV
□– .4x.4 towers >131GeV
+– .8x.8 towers >142GeV
¤– 1.6x1.6 towers >176GeV

Figure 31

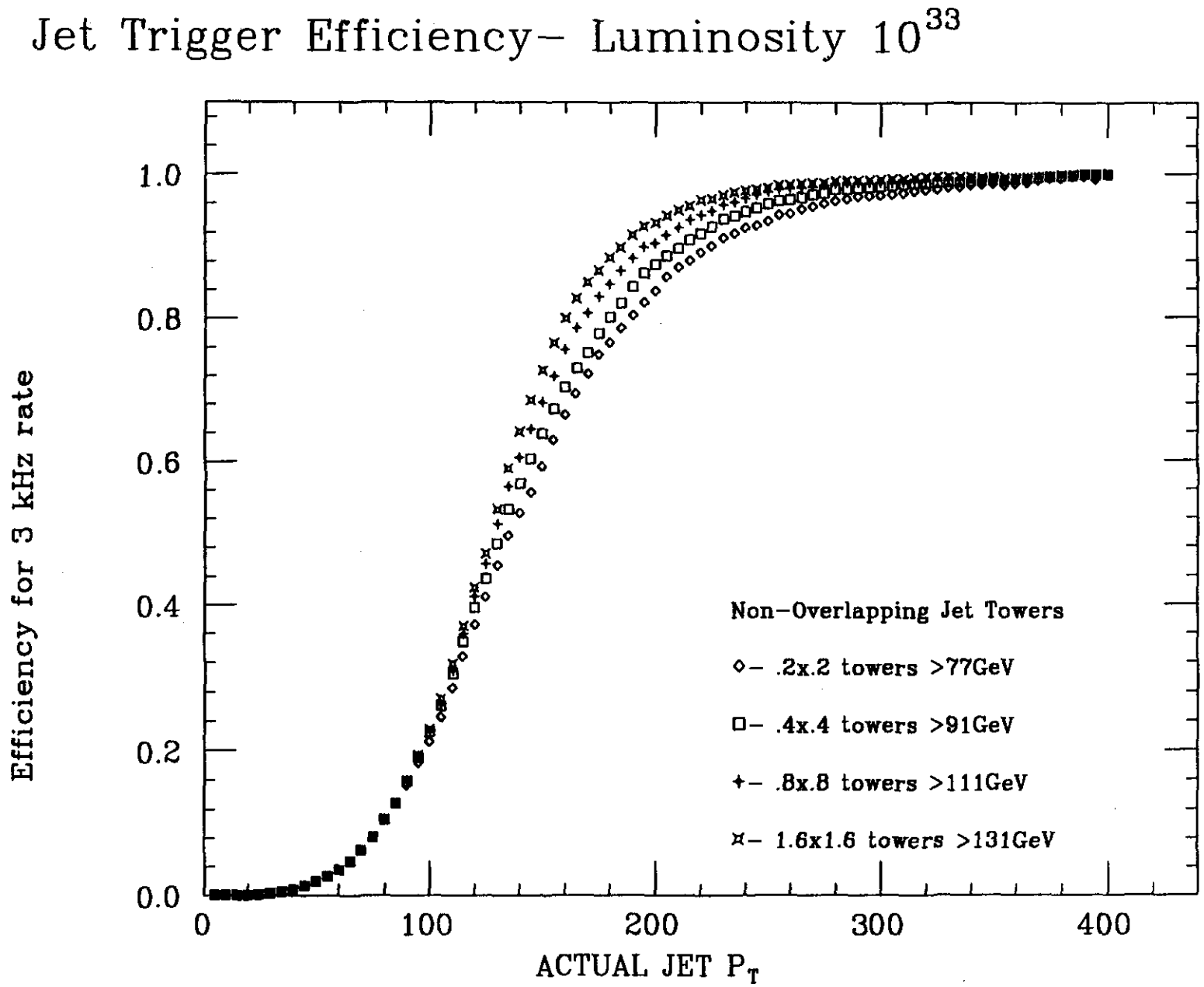
Jet Trigger Efficiency– Luminosity 10^{33}
Efficiency for 3 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
Non–Overlapping Jet Towers
◇– .2x.2 towers >77GeV
□– .4x.4 towers >91GeV
+– .8x.8 towers >111GeV
×– 1.6x1.6 towers >131GeV

Figure 32

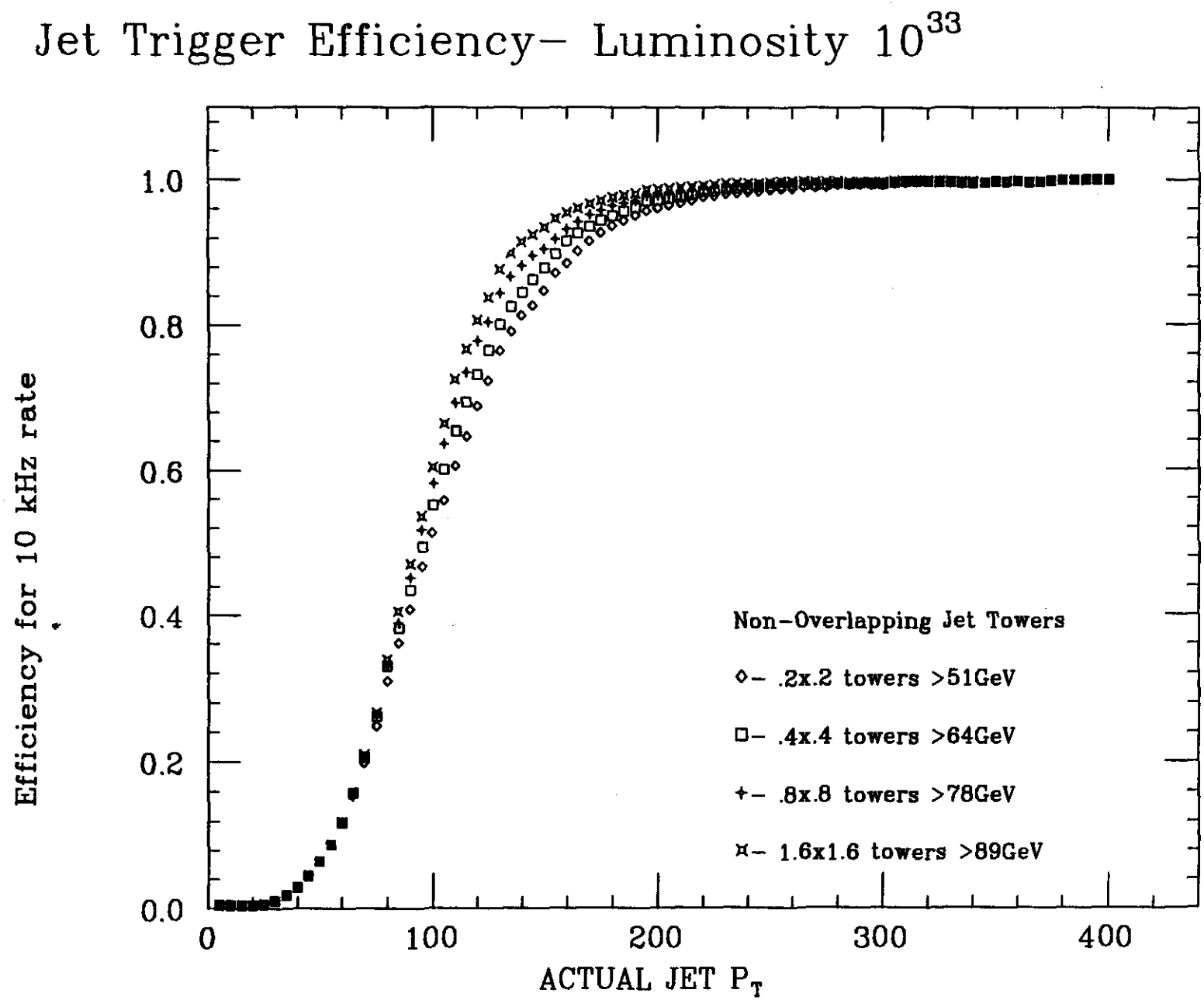
Jet Trigger Efficiency– Luminosity 10^{33}
Efficiency for 10 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
Non–Overlapping Jet Towers
◇– .2x.2 towers >51GeV
□– .4x.4 towers >64GeV
+– .8x.8 towers >78GeV
¤– 1.6x1.6 towers >89GeV

Figure 33

Jet Trigger Efficiency– Luminosity 10^{33}

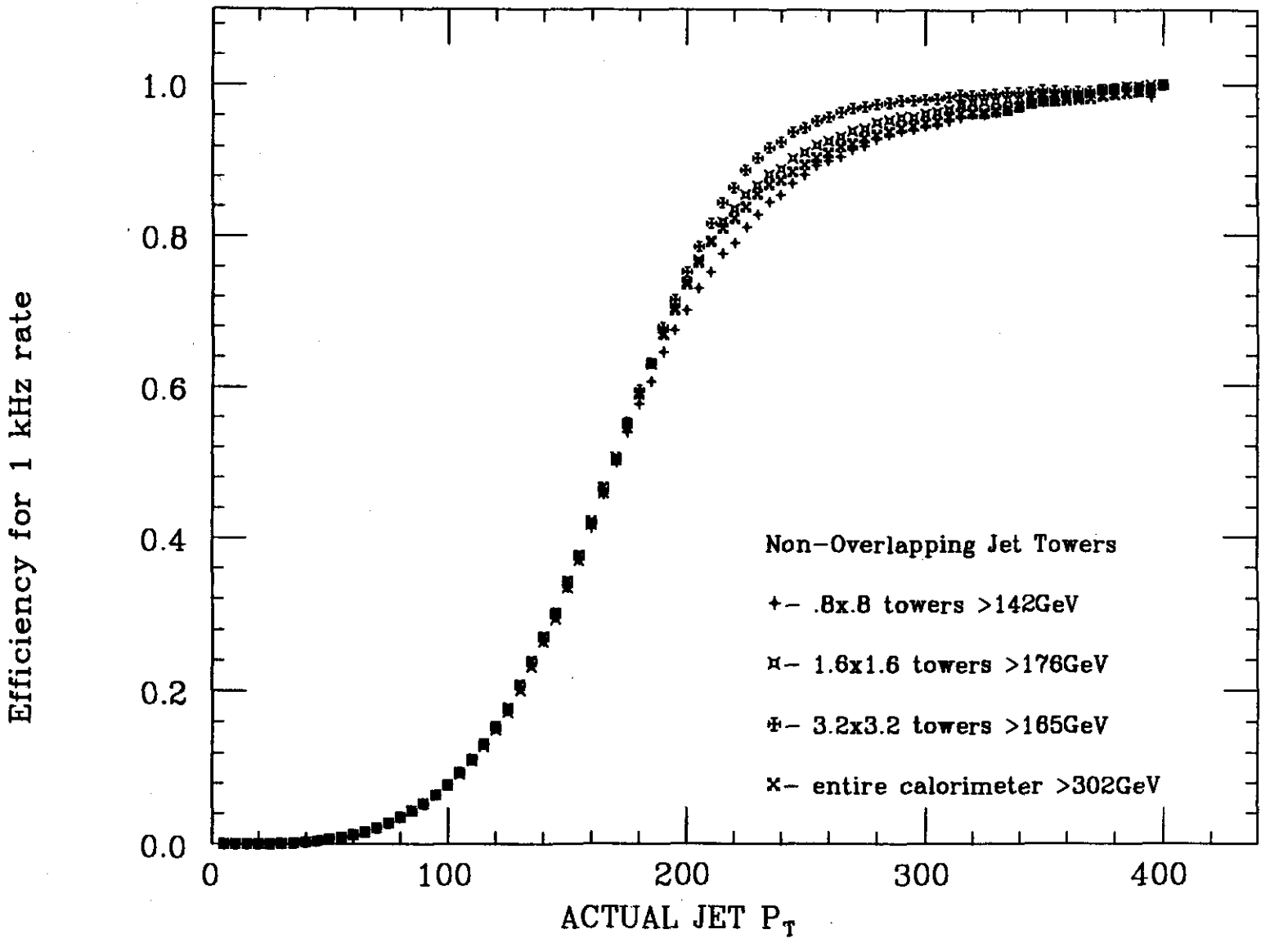

Figure 34

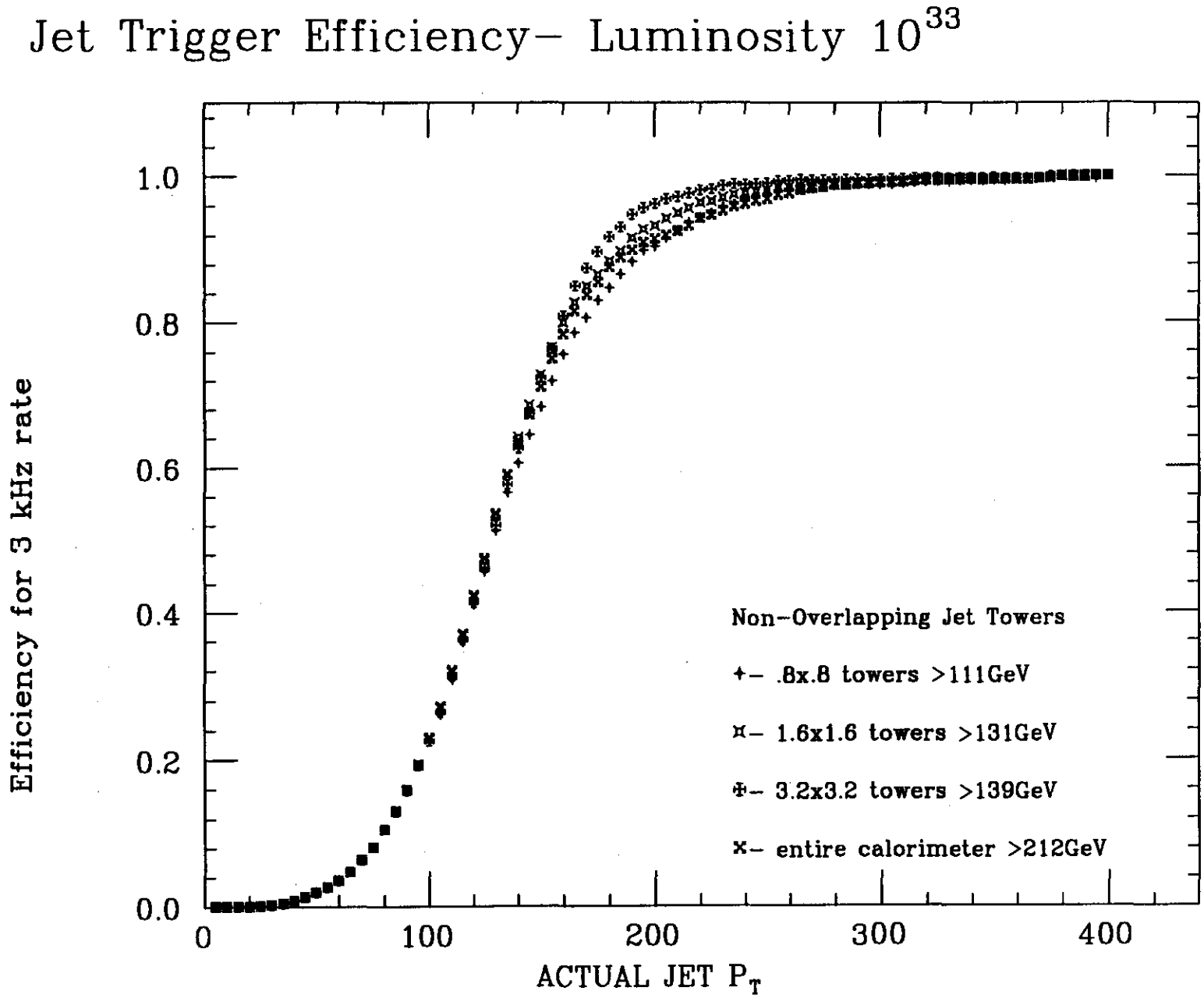
Jet Trigger Efficiency– Luminosity 10^{33}
Efficiency for 3 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
Non-Overlapping Jet Towers
+– .8x.8 towers >111GeV
¤– 1.6x1.6 towers >131GeV
Φ– 3.2x3.2 towers >139GeV
×– entire calorimeter >212GeV

Figure 35

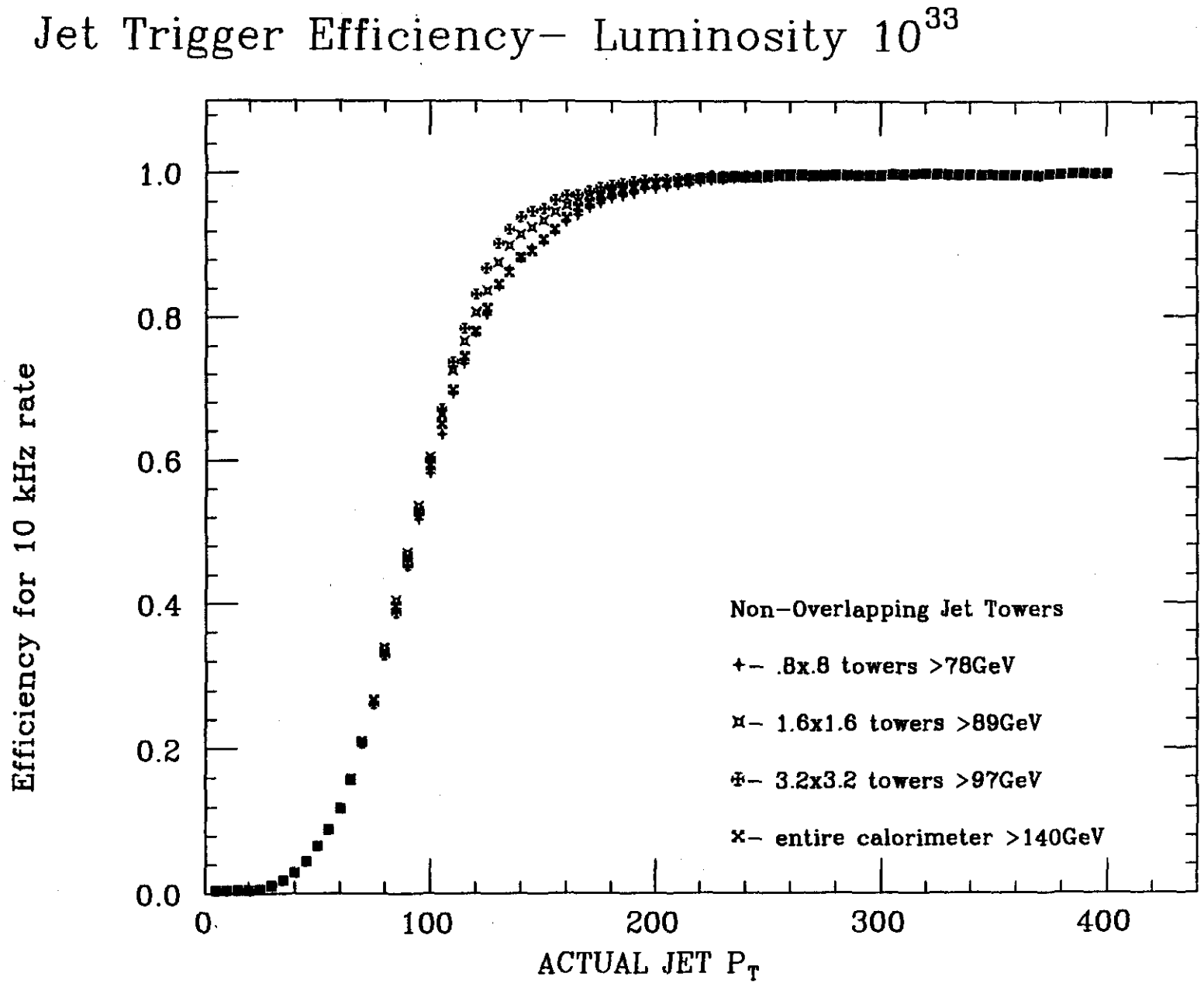
Jet Trigger Efficiency– Luminosity 10^{33}
Efficiency for 10 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
Non–Overlapping Jet Towers
+– .8x.8 towers >78GeV
¤– 1.6x1.6 towers >89GeV
⊕– 3.2x3.2 towers >97GeV
×– entire calorimeter >140GeV

Figure 36

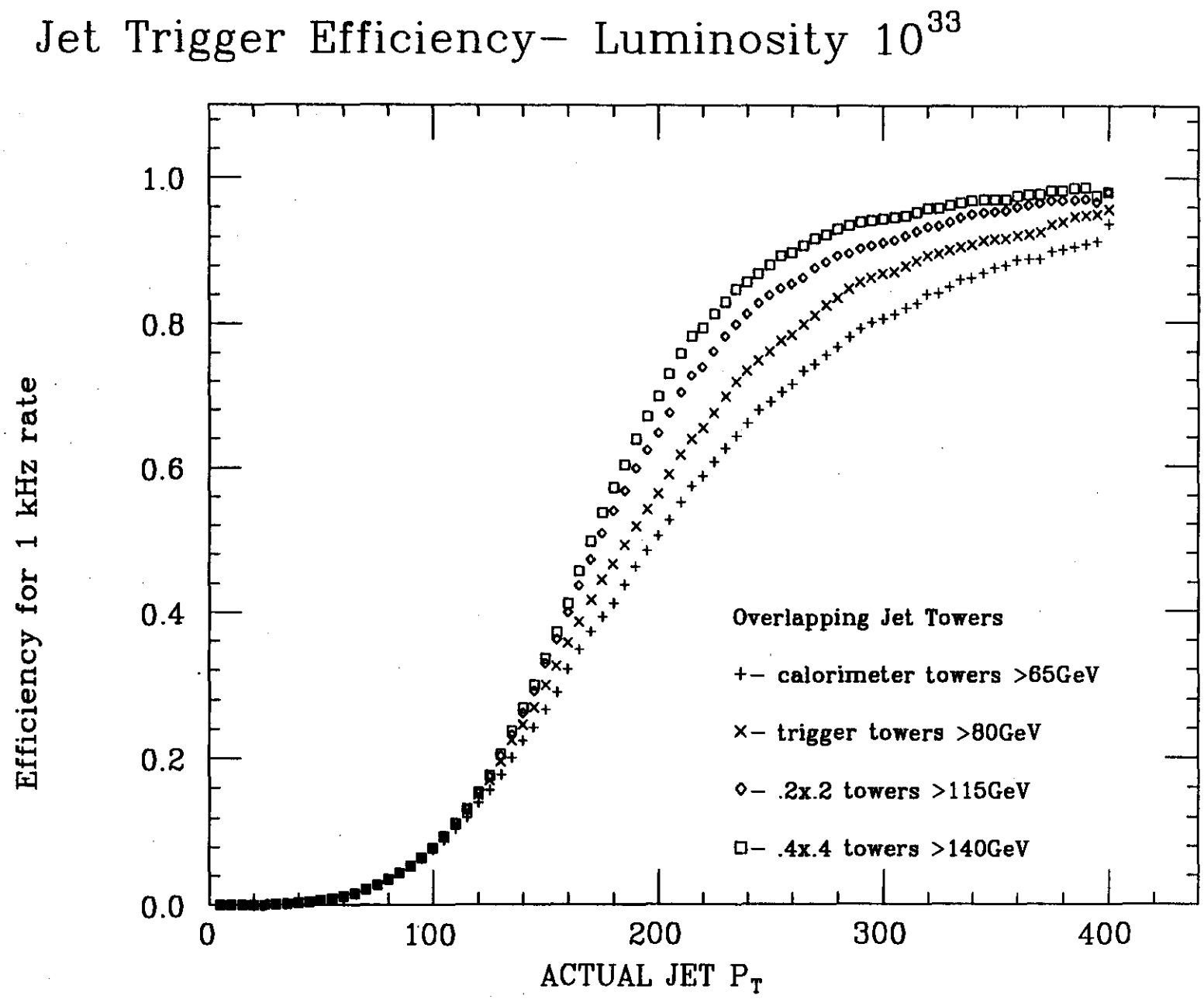
Jet Trigger Efficiency– Luminosity 10^{33}
Efficiency for 1 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
Overlapping Jet Towers
+– calorimeter towers >65GeV
×– trigger towers >80GeV
◇– .2x.2 towers >115GeV
□– .4x.4 towers >140GeV

Figure 37

Type of jet trigger		30 kHz	10 kHz	3 kHz
calorimeter tower		225	296	> 400
trigger tower		201	266	389
$.2 \times .2$	non-overlapping	189	252[2]	351[3]
$.2 \times .2$	overlapping	180	237[3]	327[2]
$.4 \times .4$	non-overlapping	180	236[2]	330[4]
$.4 \times .4$	overlapping	171	223	305[3]
$.8 \times .8$	non-overlapping	170[3]	224[3]	305[3]
$.8 \times .8$	overlapping	164	213	287
1.6×1.6	non-overlapping	165[4]	214[4]	288[4]
1.6×1.6	overlapping	159[3]	206[3]	274[3]
3.2×3.2	non-overlapping	163[4]	214[4]	286[4]
3.2×3.2	overlapping	162[4]	211[4]	284[4]
entire calorimeter		167[5]	219[5]	292[6]
all have low energy cutoff at .1 GeV except as noted [2] – low energy cutoff at .2 GeV [3] – low energy cutoff at .5 GeV [4] – low energy cutoff at 1 GeV [5] – low energy cutoff at 2 GeV [6] – low energy cutoff at 5 GeV				

Luminosity of $10^{34} cm^{-2} sec^{-1}$

Table 5.6: Jet p_T at which 80% efficiency is achieved (GeV)

Type of jet trigger		30 kHz	10 kHz	3 kHz
calorimeter tower		273	379	> 400
trigger tower		242	329	> 400
$.2 \times .2$	non-overlapping	225	310	> 400
$.2 \times .2$	overlapping	211[3]	288[3]	> 400
$.4 \times .4$	non-overlapping	211[2]	281[2]	> 400
$.4 \times .4$	overlapping	199	264	370[4]
$.8 \times .8$	non-overlapping	197[4]	265[3]	368[2]
$.8 \times .8$	overlapping	189	245	333
1.6×1.6	non-overlapping	189[4]	247[3]	335[3]
1.6×1.6	overlapping	179[3]	229[3]	305[3]
3.2×3.2	non-overlapping	181[4]	237[4]	315[4]
3.2×3.2	overlapping	177[4]	232[4]	308[4]
entire calorimeter		193[5]	254[5]	333[5]
all have low energy cutoff at .1 GeV except as noted [2] – low energy cutoff at .2 GeV [3] – low energy cutoff at .5 GeV [4] – low energy cutoff at 1 GeV [5] – low energy cutoff at 2 GeV				

Luminosity of $10^{34} cm^{-2} sec^{-1}$

Table 5.7: Jet p_T at which 90% efficiency is achieved (GeV)

p_T of 305 GeV.

Table 11 shows the actual jet p_T at which 95% efficiency for jets is reached with the various jet triggers considered. The thresholds are set to achieve a 3 kHz, 10 kHz, and 30 kHz rate. To reach 95% efficiency as soon as possible with a 3 kHz rate, therefore, one would use an overlapping grid of 3.2×3.2 towers, and reach 95% efficiency at an actual jet p_T of 330 GeV.

Type of jet trigger		30 kHz	10 kHz	3 kHz
calorimeter tower		334	> 400	> 400
trigger tower		284	387	> 400
$.2 \times .2$	non-overlapping	264[3]	379	> 400
$.2 \times .2$	overlapping	247[3]	339[3]	> 400
$.4 \times .4$	non-overlapping	241[2]	336[2]	> 400
$.4 \times .4$	overlapping	229	313[2]	> 400
$.8 \times .8$	non-overlapping	226[4]	307[3]	> 400
$.8 \times .8$	overlapping	215	278[2]	387
1.6×1.6	non-overlapping	215[3]	281[3]	387[4]
1.6×1.6	overlapping	198[3]	253[3]	344[3]
3.2×3.2	non-overlapping	199[4]	263[4]	349[4]
3.2×3.2	overlapping	193[4]	251[4]	330[4]
entire calorimeter		229[5]	298[5]	386[6]

all have low energy cutoff at .1 GeV except as noted
[2] – low energy cutoff at .2 GeV
[3] – low energy cutoff at .5 GeV
[4] – low energy cutoff at 1 GeV
[5] – low energy cutoff at 2 GeV
[6] – low energy cutoff at 5 GeV

Luminosity of $10^{34} cm^{-2} sec^{-1}$

Table 5.8: Jet p_T at which 95% efficiency is achieved (GeV)

5.2.1 Overlapping vs. Non-Overlapping Grids

In all of the efficiency curves shown, the efficiency plotted for a particular jet p_T value is the efficiency of the trigger in finding jets with p_T above the value.

First the effect of using two overlapping grids rather than one non-overlapping grid was determined. Figure 46 shows the efficiency curve for $.2 \times .2$ jet towers, plotted against the p_T of the highest p_T jet in the event, for both non-overlapping and overlapping jet towers. The threshold here was set to achieve a 3 kHz rate: for overlapping grids of towers, the required threshold was 160 GeV, with a low energy cutoff of .2 GeV. For a non-overlapping grid the threshold was 147 GeV, with a low energy cutoff of .5 GeV. We see that the lower jet threshold used by the non-overlapping jet trigger only results in higher efficiency in a very low p_T range – this is due to the steeply falling distribution of jet energies. Figure 47 shows the efficiency curve for $.2 \times .2$ jet towers, plotted with the threshold set to achieve a 10 kHz rate: for overlapping grids of towers, the required threshold was 116 GeV, with a low energy cutoff of .5 GeV. For a non-overlapping grid the threshold was 107 GeV, with a low energy cutoff of .2 GeV. Figure 48 shows the efficiency curve for $.2 \times .2$ jet towers, plotted with the threshold set to achieve a 30 kHz rate: for overlapping grids of towers, the required threshold was 84 GeV, with a low energy cutoff of .1 GeV. For a non-overlapping grid the threshold was 77 GeV, with a low energy cutoff of .1 GeV. The overlapping grid performs better than the non-overlapping grid.

Figure 49 shows the efficiency curve for $.4 \times .4$ jet towers, plotted against the p_T of the highest p_T jet in the event, for both non-overlapping and overlapping jet towers. The threshold here was set to achieve a 3 kHz rate; for overlapping grids of towers, the required threshold was 188 GeV, with a low energy cutoff of .5 GeV. For a non-overlapping grid the threshold was 171 GeV, with a low energy cutoff of 1 GeV. Figure 50 shows the efficiency curve for $.4 \times .4$ jet towers, plotted with the threshold set to achieve a 10 kHz rate: for overlapping grids of towers, the required threshold was 143 GeV, with a low energy cutoff of .1 GeV. for a non-overlapping grid the threshold was 132 GeV, with a low energy cutoff of .2 GeV. Figure 51 shows the efficiency curve for $.4 \times .4$ jet towers, plotted with the threshold set to achieve a 30 kHz rate: for overlapping grids of towers, the required threshold was 105 GeV, with a low energy cutoff of .1 GeV. For a non-overlapping grid the threshold was 97 GeV, with a low energy cutoff of .1 GeV. The overlapping $.4 \times .4$ grid performs better than the non-overlapping grid at all rates, but the advantage is larger at relatively low rates.

Figure 52 shows the efficiency curve for $.8 \times .8$ jet towers, plotted against the p_T of the highest p_T jet in the event, for both non-overlapping and overlapping jet towers. The threshold here was set to achieve a 3 kHz rate; for overlapping grids of towers, the required threshold was 228 GeV, with a low energy cutoff of .1 GeV. For a non-overlapping grid the threshold was 199 GeV, with a low energy cutoff of .5 GeV. Figure 53 shows the efficiency curve for $.8 \times .8$ jet towers, plotted with the threshold set to achieve a 10 kHz rate: for overlapping grids of towers, the required threshold was 173 GeV, with a low energy cutoff of .1 GeV. For a non-overlapping grid the threshold was 147 GeV, with a low energy cutoff of .5 GeV. Figure 54 shows the efficiency curve for $.8 \times .8$ jet towers, plotted with the threshold set to achieve a 30 kHz rate: for overlapping grids of towers, the required threshold was 131 GeV, with a low energy cutoff of .1 GeV. For a non-overlapping grid the threshold was 108 GeV, with a low energy cutoff of .5 GeV. The overlapping $.8 \times .8$ grid performs better than

the non-overlapping grid at all rates, but the advantage is larger at relatively low rates.

Figure 55 shows the efficiency curve for 1.6×1.6 jet towers, plotted against the p_T of the highest p_T jet in the event, for both non-overlapping and overlapping jet towers. The threshold here was set to achieve a 3 kHz rate; for overlapping grids of towers, the required threshold was 240 GeV, with a low energy cutoff of .5 GeV. For a non-overlapping grid the threshold was 207 GeV, with a low energy cutoff of 1 GeV. Figure 56 shows the efficiency curve for 1.6×1.6 jet towers, with the threshold set to achieve a 10 kHz rate: for overlapping grids of towers, the required threshold was 183 GeV, with a low energy cutoff of .5 GeV. For a non-overlapping grid the threshold was 152 GeV, with a low energy cutoff of 1 GeV. Figure 57 shows the efficiency curve for 1.6×1.6 jet towers, with the threshold set to achieve a 30 kHz rate: for overlapping grids of towers, the required threshold was 139 GeV, with a low energy cutoff of .5 GeV. For a non-overlapping grid the threshold was 110 GeV, with a low energy cutoff of 1 GeV. The overlapping 1.6×1.6 grid performs better than the non-overlapping grid at all rates, but the advantage is larger at relatively low rates.

Figure 58 shows the efficiency curve for 3.2×3.2 jet towers, plotted against the p_T of the highest p_T jet in the event, for both non-overlapping and overlapping jet towers. The threshold here was set to achieve a 3 kHz rate; for overlapping grids of towers, the required threshold was 260 GeV, with a low energy cutoff of 1 GeV. For a non-overlapping grid the threshold was 249 GeV, with a low energy cutoff of 1 GeV. Figure 59 shows the efficiency curve for 3.2×3.2 jet towers, plotted with the threshold set to achieve a 10 kHz rate: for overlapping grids of towers, the required threshold was 194 GeV, with a low energy cutoff of 1 GeV. For a non-overlapping grid the threshold was 187 GeV, with a low energy cutoff of 1 GeV. Figure 60 shows the efficiency curve for 3.2×3.2 jet towers, plotted with the threshold set to achieve a 30 kHz rate: for overlapping grids of towers, the required threshold was 144 GeV, with a low energy cutoff of 1 GeV. For a non-overlapping grid the threshold was 137 GeV, with a low energy cutoff of 1 GeV. The overlapping 3.2×3.2 grid performs better than the non-overlapping grid, but the advantage is smaller than in smaller tower sizes, and nearly disappears at 30 kHz.

Jet Trigger Efficiency– Luminosity 10^{34}

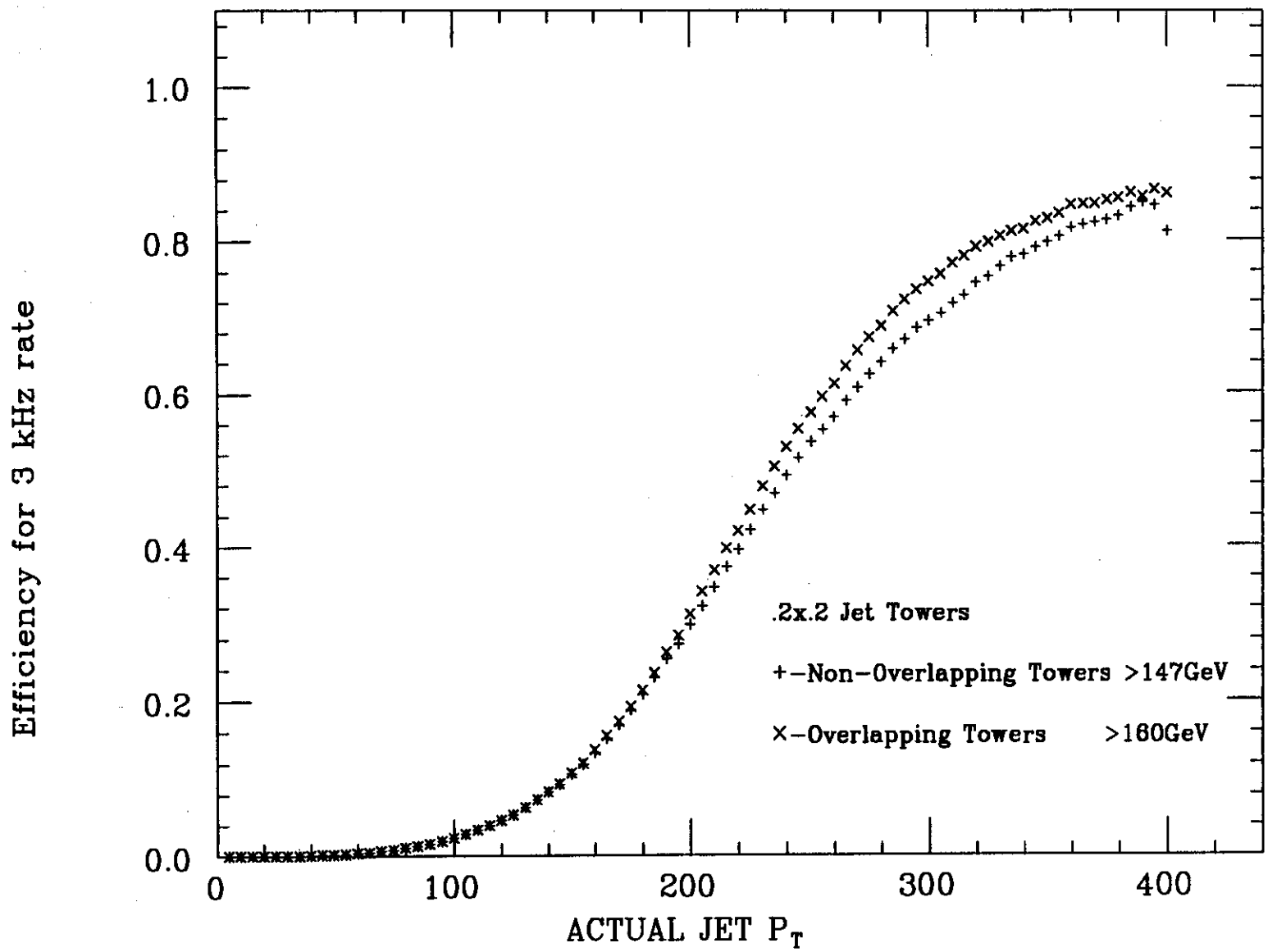

Figure 46

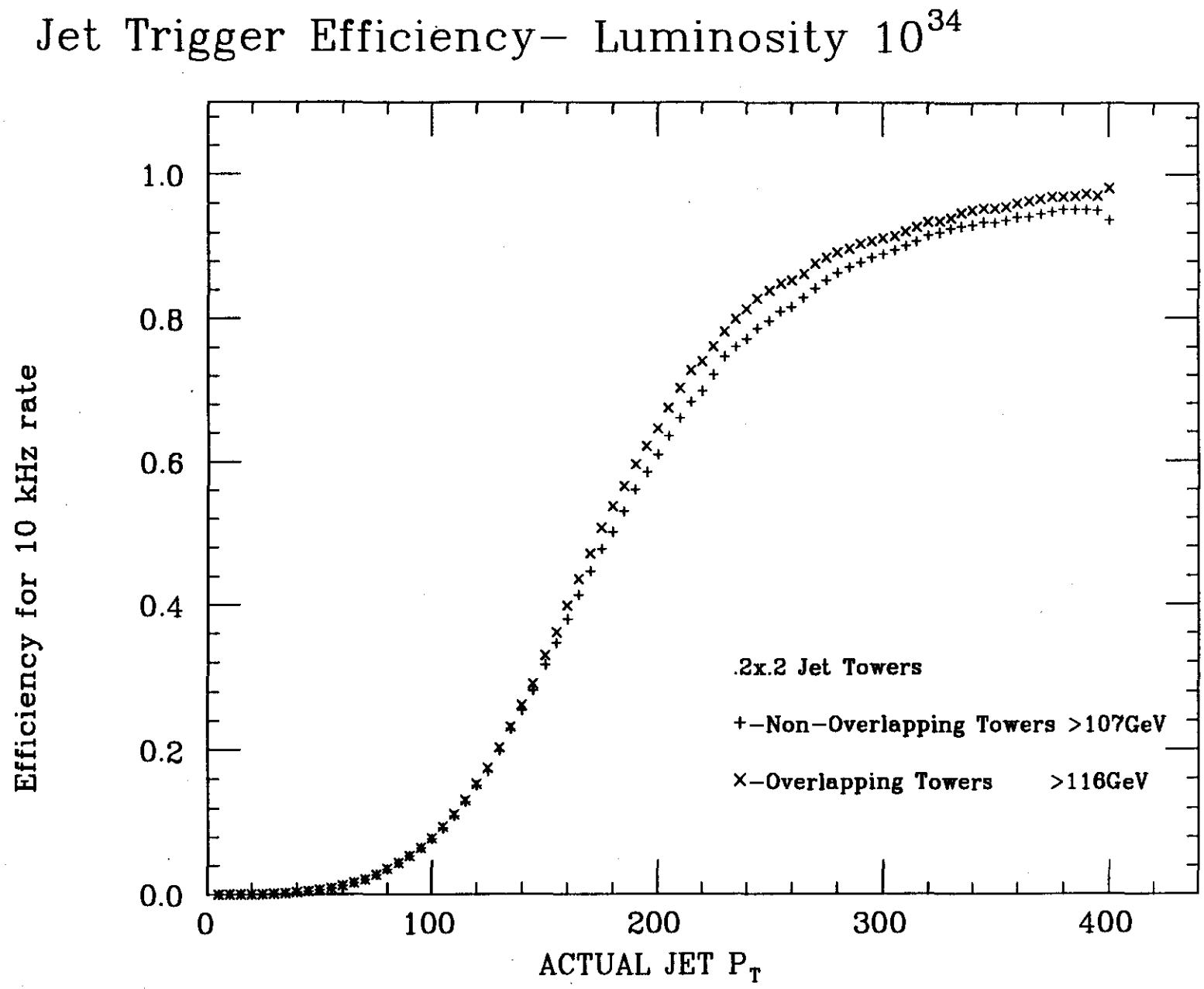
Jet Trigger Efficiency– Luminosity 10^{34}
Efficiency for 10 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
.2x.2 Jet Towers
+–Non–Overlapping Towers >107GeV
×–Overlapping Towers >116GeV

Figure 47

Jet Trigger Efficiency– Luminosity 10^{34}

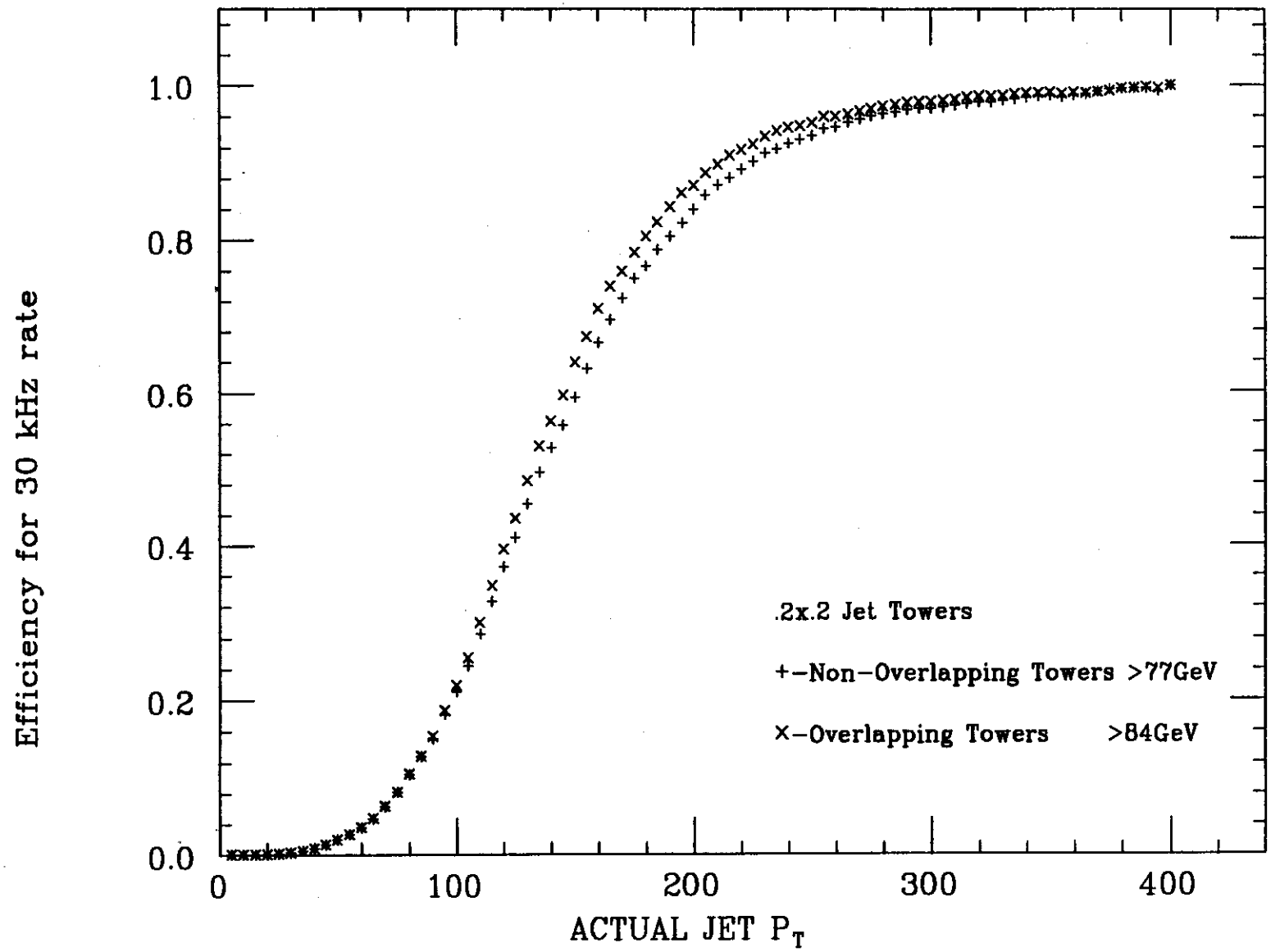

Figure 48

Jet Trigger Efficiency– Luminosity 10^{34}

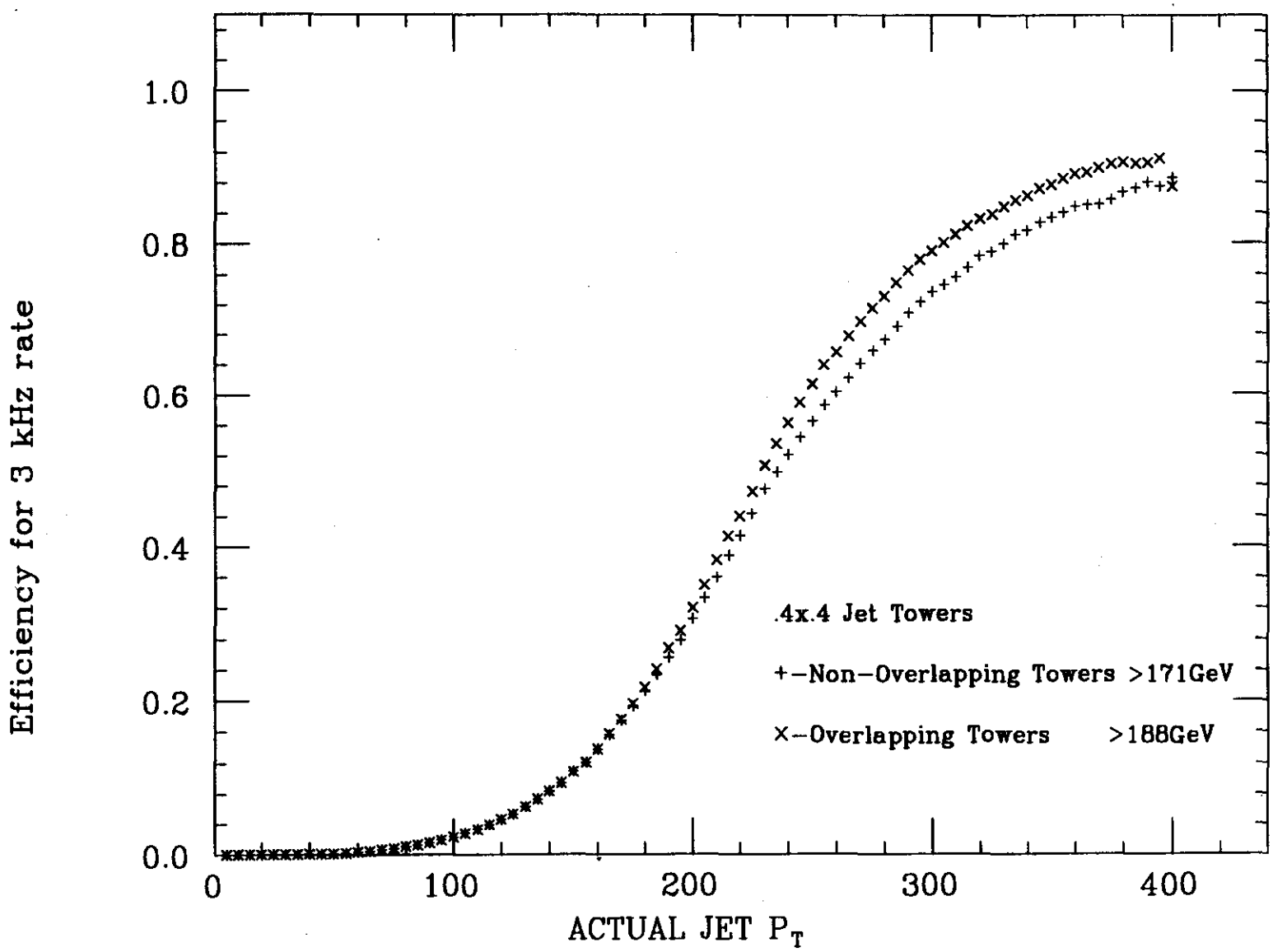

Figure 49

Jet Trigger Efficiency– Luminosity 10^{34}

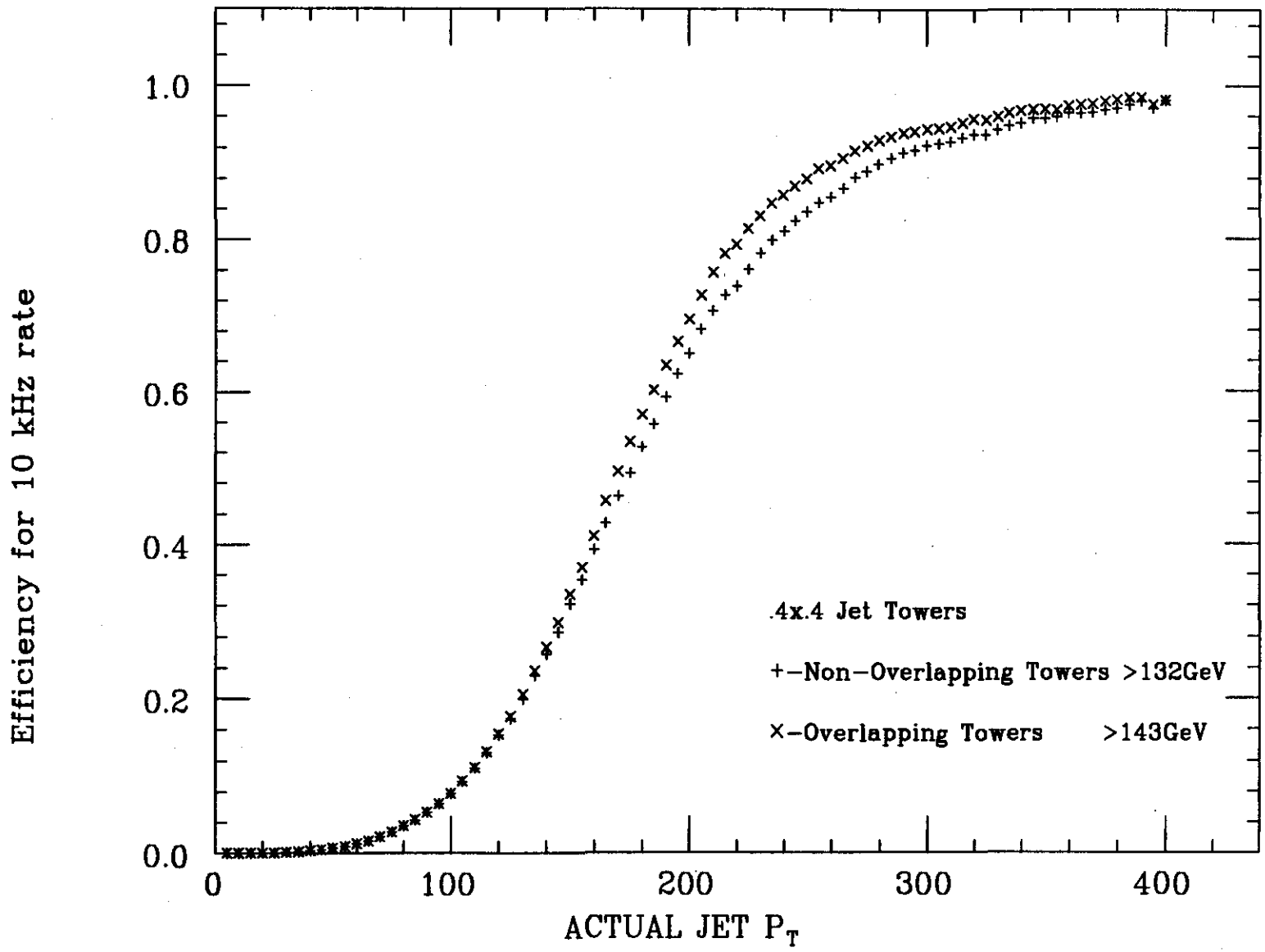

Figure 50

Jet Trigger Efficiency– Luminosity 10^{34}

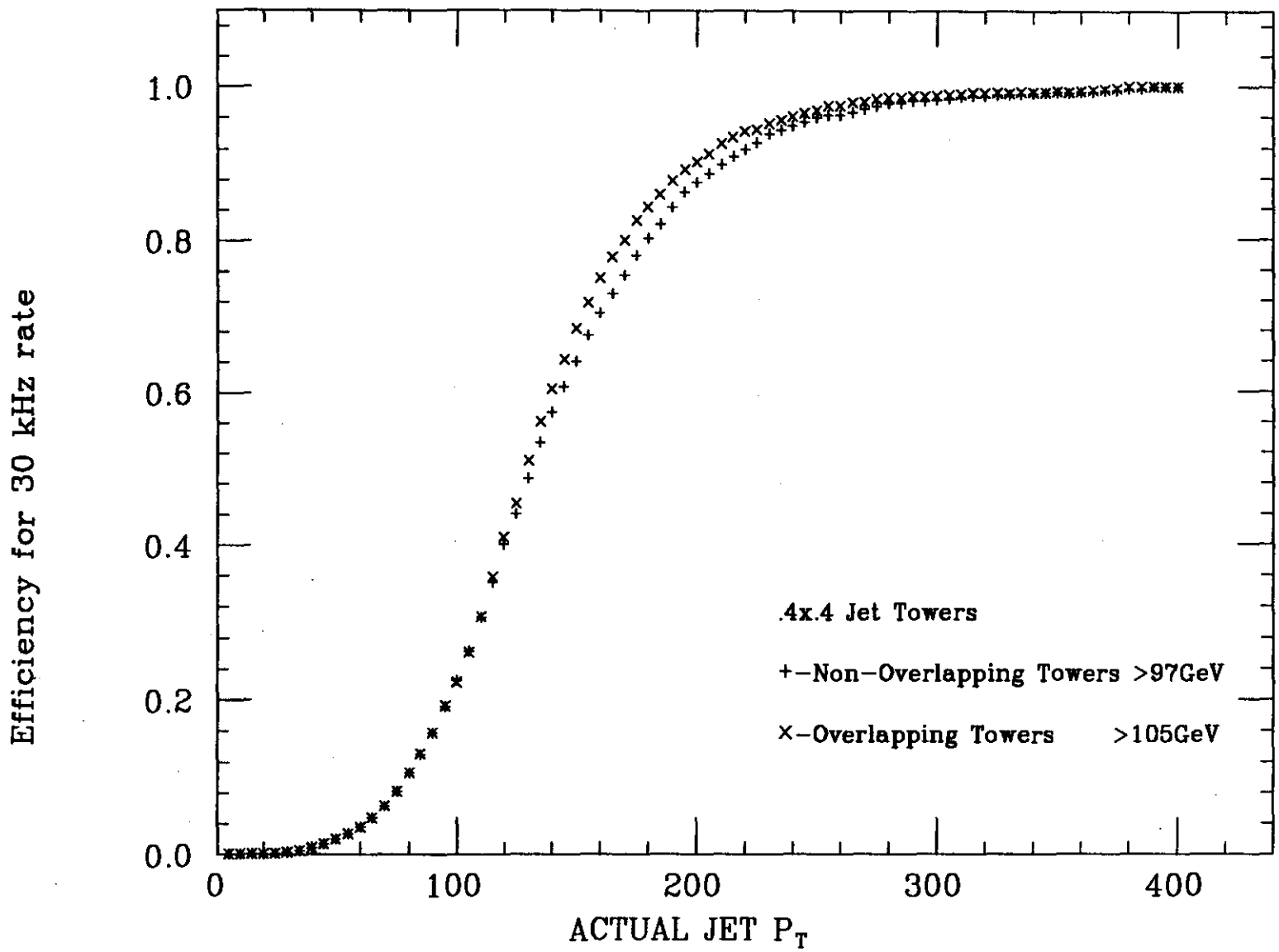

Figure 51

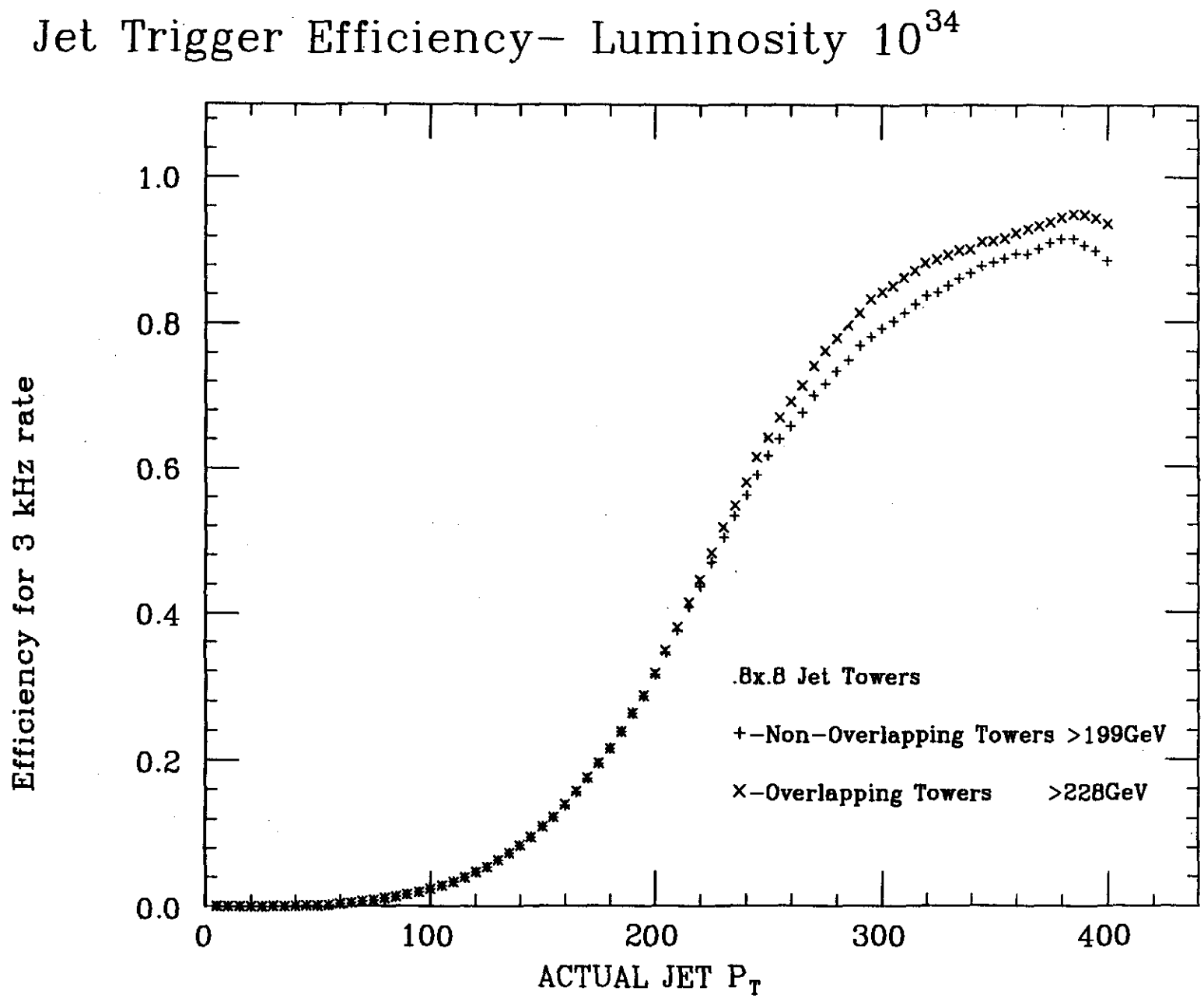
Jet Trigger Efficiency– Luminosity 10^{34}
Efficiency for 3 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
.8x.8 Jet Towers
+–Non–Overlapping Towers >199GeV
×–Overlapping Towers >228GeV

Figure 52

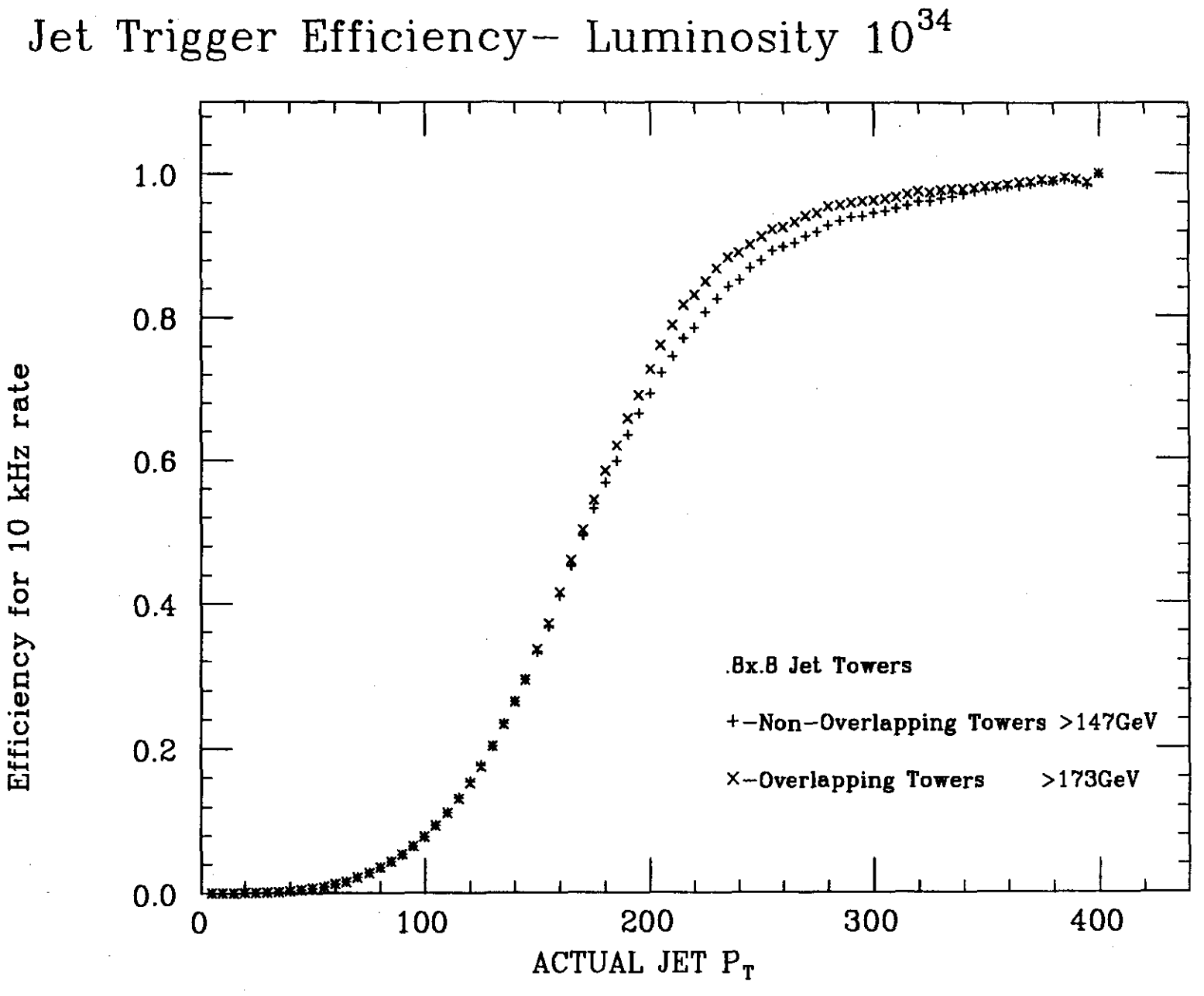
Jet Trigger Efficiency– Luminosity 10^{34}
Efficiency for 10 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
.8x.8 Jet Towers
+–Non–Overlapping Towers >147GeV
×–Overlapping Towers >173GeV

Figure 53

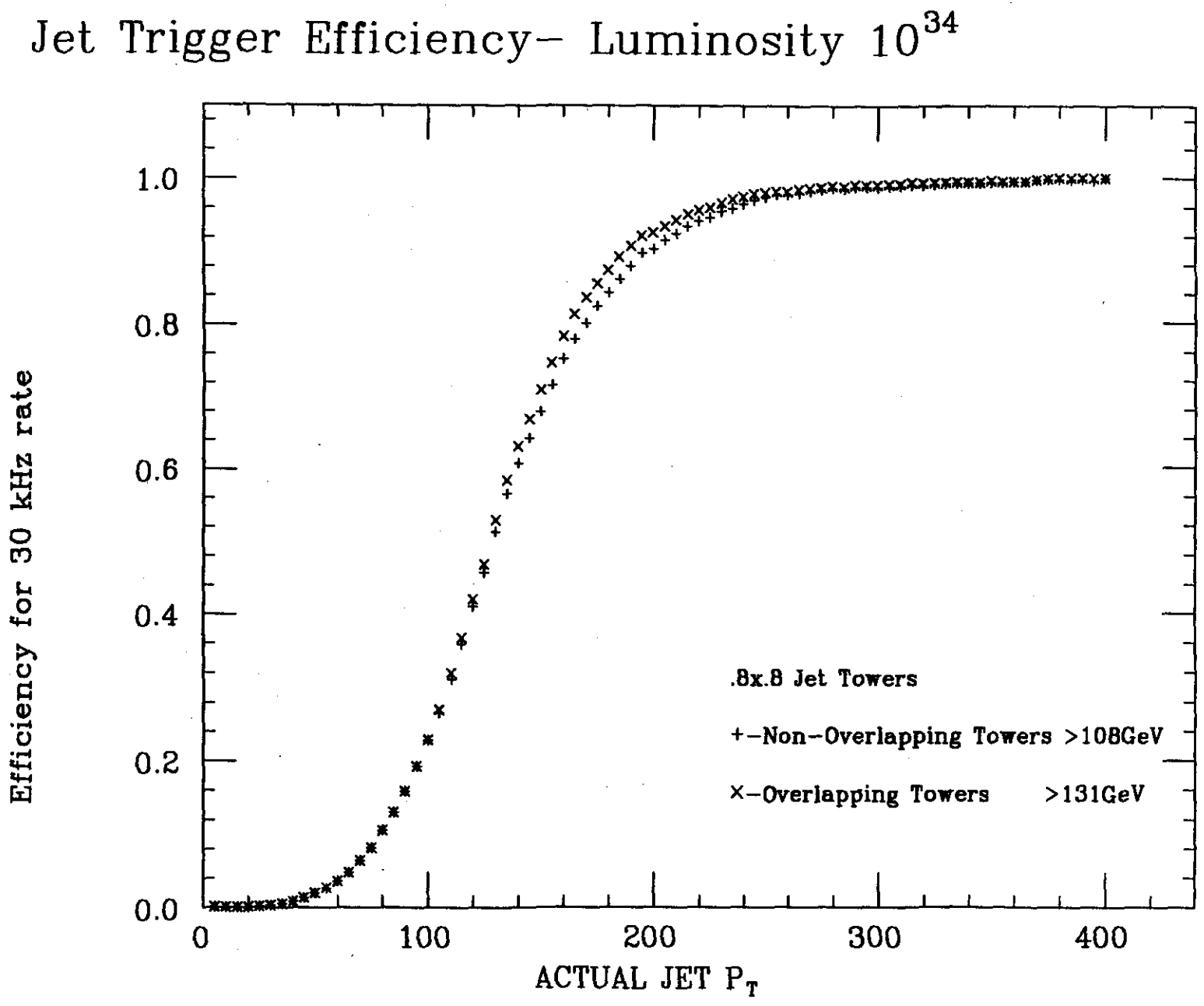
Jet Trigger Efficiency– Luminosity 10^{34}
Efficiency for 30 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
.8x.8 Jet Towers
+–Non–Overlapping Towers >108GeV
×–Overlapping Towers >131GeV

Figure 54

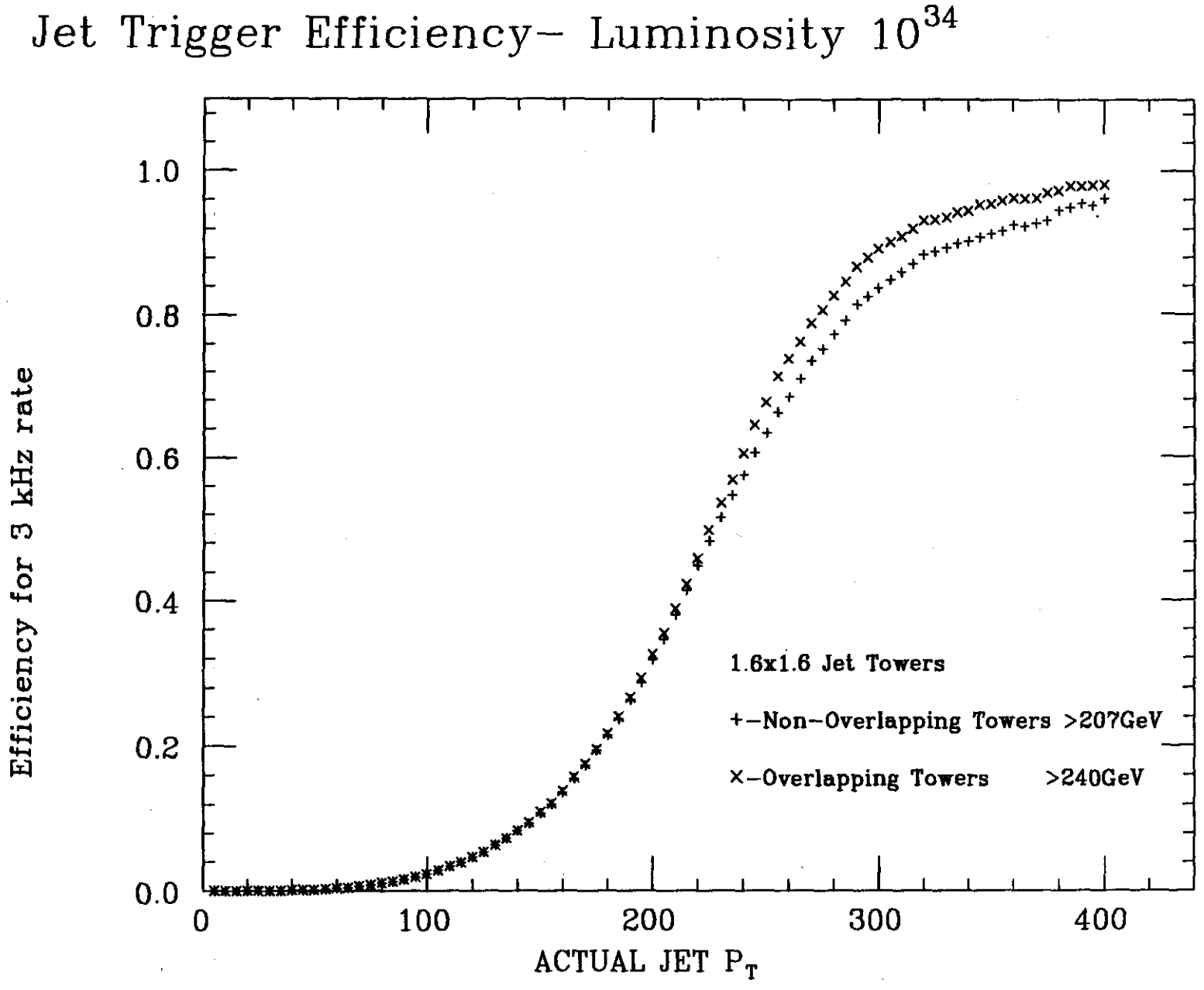
Jet Trigger Efficiency– Luminosity 10^{34}
Efficiency for 3 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
1.6x1.6 Jet Towers
+–Non–Overlapping Towers >207GeV
×–Overlapping Towers >240GeV

Figure 55

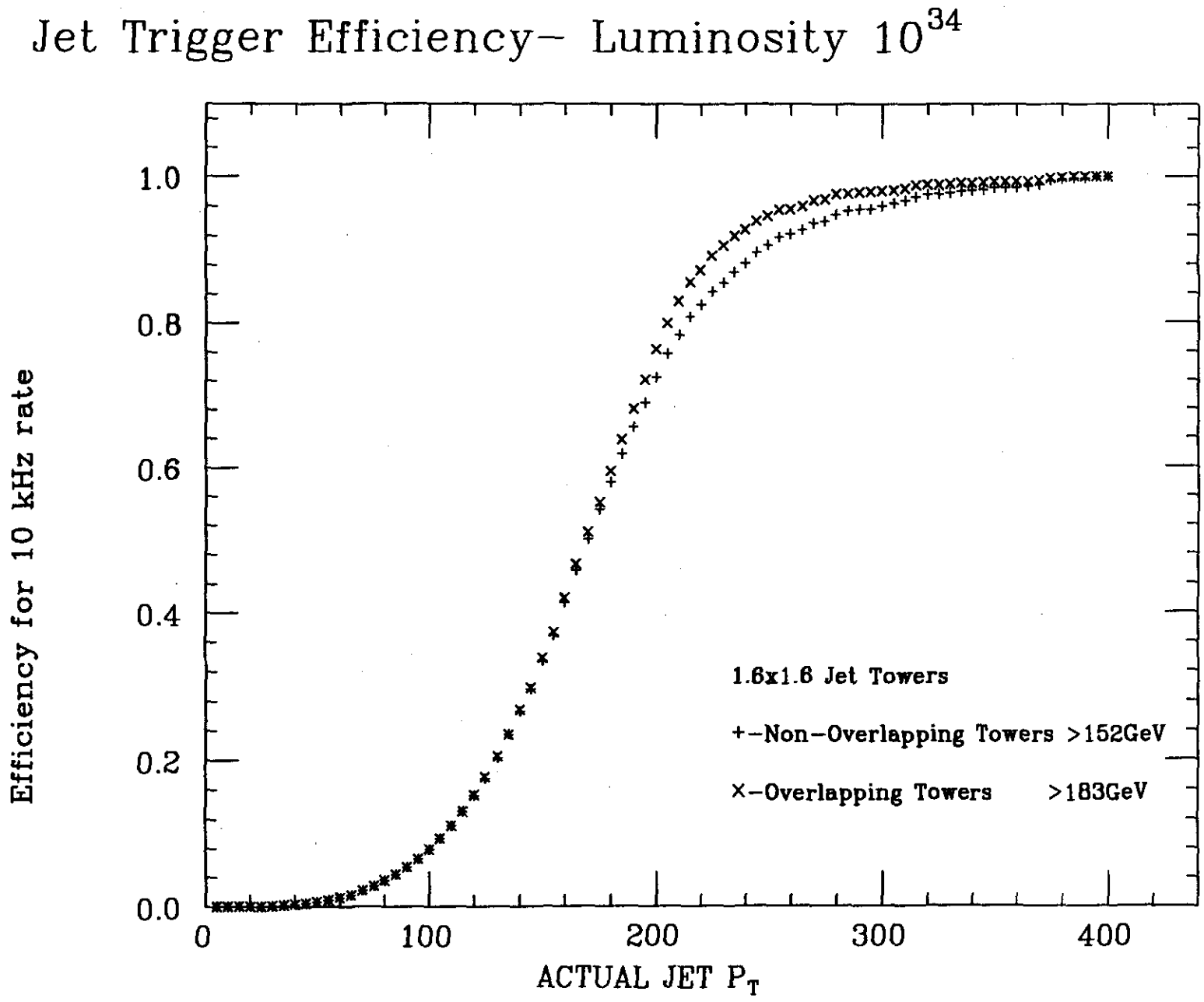
Jet Trigger Efficiency– Luminosity 10^{34}
Efficiency for 10 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
1.6x1.6 Jet Towers
+–Non–Overlapping Towers >152GeV
×–Overlapping Towers >183GeV

Figure 56

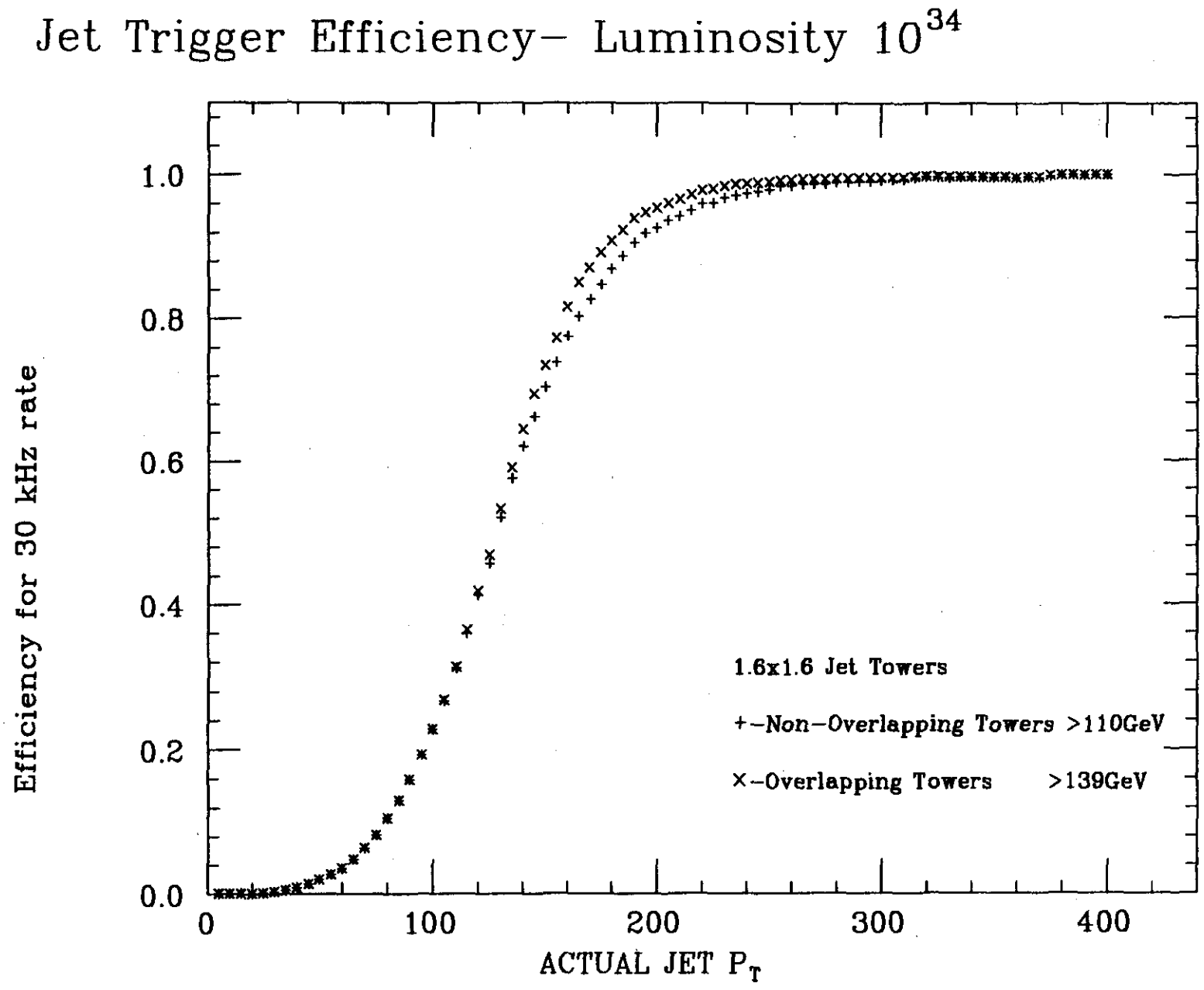
Jet Trigger Efficiency– Luminosity 10^{34}
Efficiency for 30 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
1.6x1.6 Jet Towers
+–Non–Overlapping Towers >110GeV
×–Overlapping Towers >139GeV

Figure 57

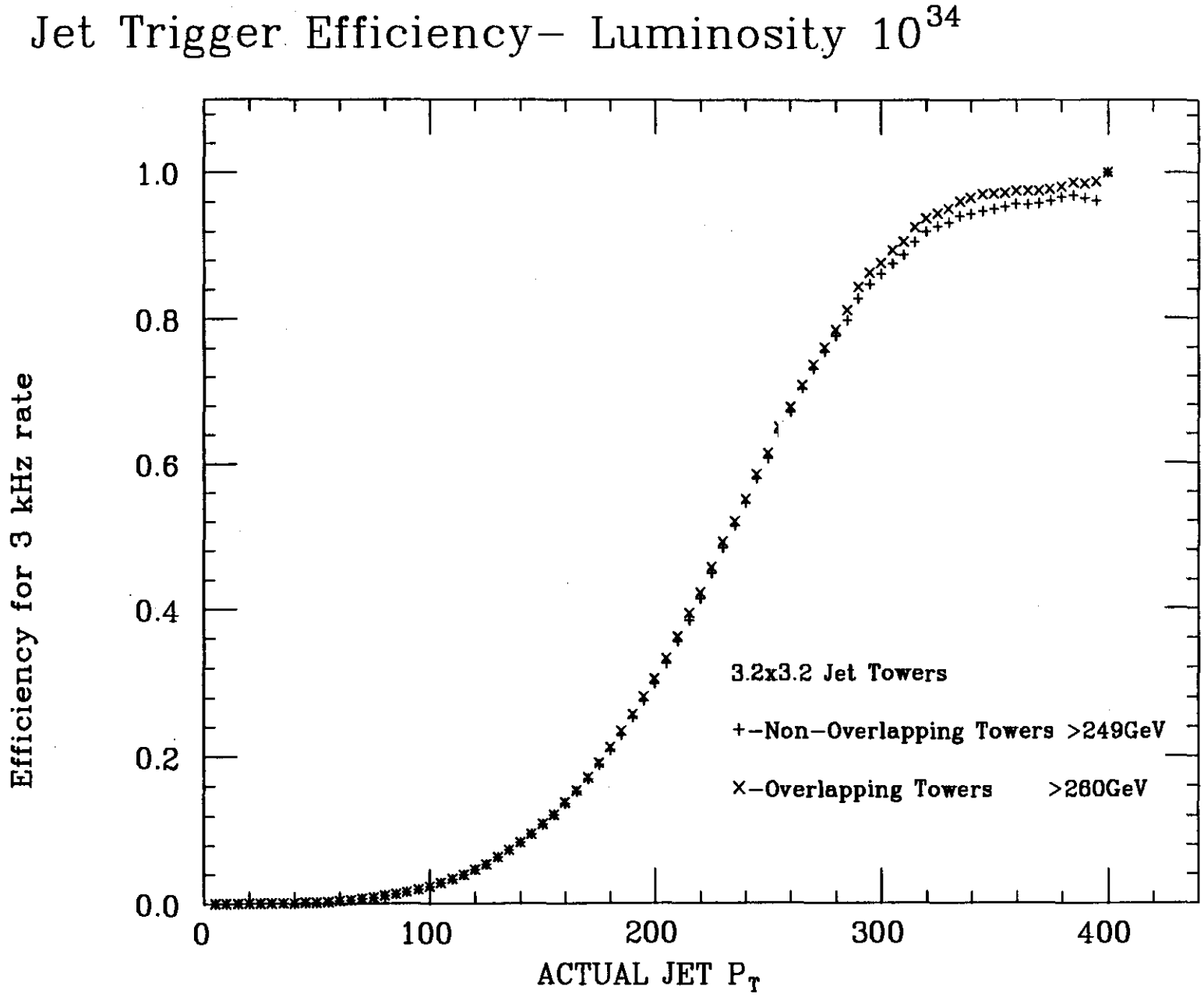
Jet Trigger Efficiency– Luminosity 10^{34}
Efficiency for 3 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
3.2x3.2 Jet Towers
+–Non–Overlapping Towers >249GeV
×–Overlapping Towers >260GeV

Figure 58

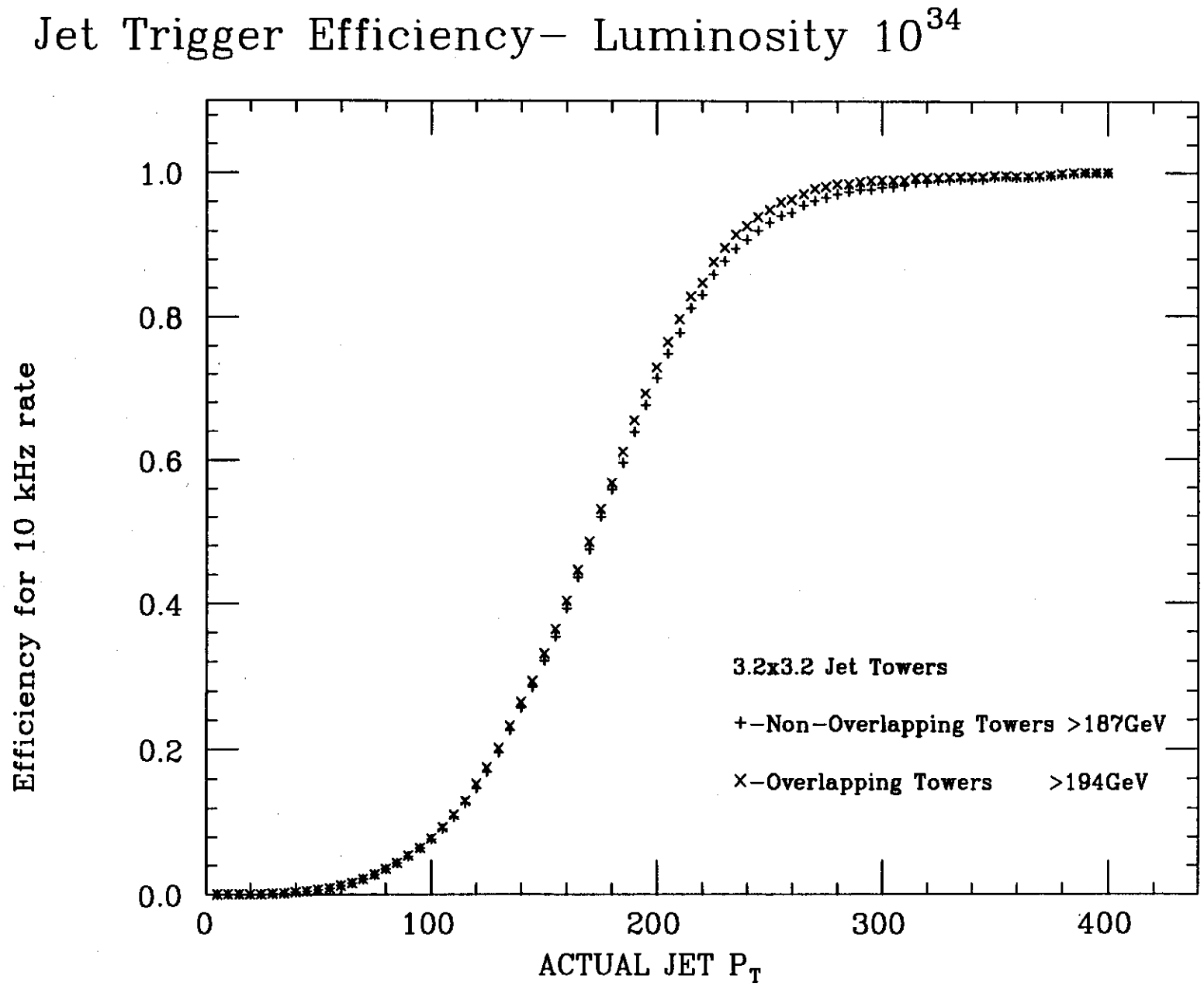
Jet Trigger Efficiency– Luminosity 10^{34}
Efficiency for 10 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
3.2x3.2 Jet Towers
+–Non–Overlapping Towers >187GeV
×–Overlapping Towers >194GeV

Figure 59

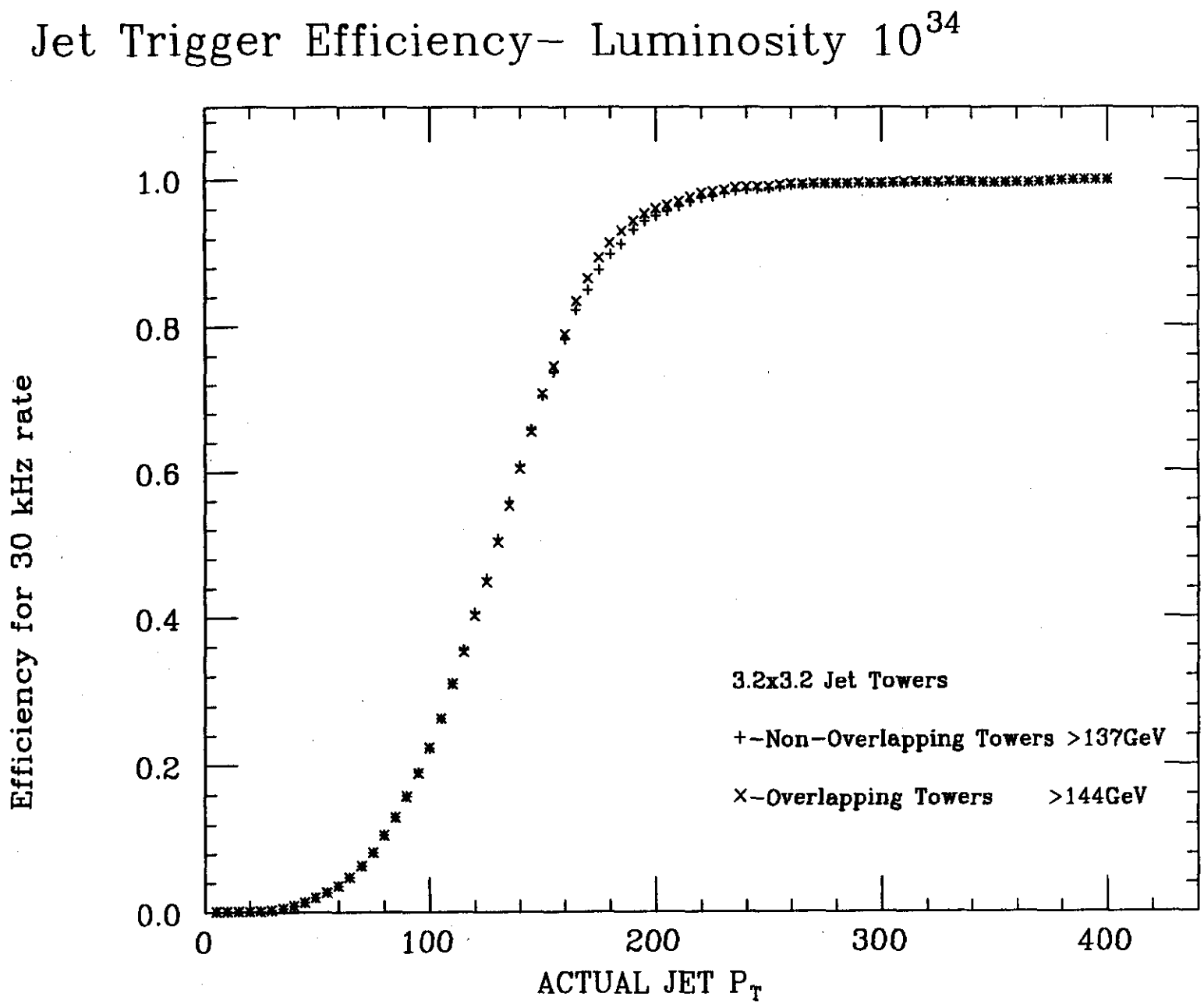
Jet Trigger Efficiency– Luminosity 10^{34}
Efficiency for 30 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
3.2x3.2 Jet Towers
+–Non–Overlapping Towers >137GeV
×–Overlapping Towers >144GeV

Figure 60

5.2.2 Effects of Changing Jet Tower Size

In all of the efficiency curves shown, the efficiency plotted for a particular jet p_T value is the efficiency of the trigger in finding jets with p_T above the value.

Next the effect of changing jet tower size was considered. First we consider it with non-overlapping grids of jet towers. Figure 61 shows the efficiency curves for a single trigger tower jet trigger, a $.2 \times .2$ non-overlapping jet trigger, and a $.4 \times .4$ non-overlapping jet trigger. The thresholds are set for a 3 kHz rate; the single trigger tower trigger requires a threshold of 115 GeV E_T. The $.2 \times .2$ non-overlapping jet trigger requires a threshold of 147 GeV E_T, with a low energy cutoff of .5 GeV. The $.4 \times .4$ non-overlapping jet trigger has a threshold of 171 GeV E_T, with a low energy cutoff of 1 GeV. The calorimeter tower size is not shown on this plot, as the thresholds cannot be set below 400 GeV E_T for a 3 kHz rate to be achieved. None of these tower sizes even approach full efficiency by 400 GeV p_T. Figure 62 shows these efficiency curves for a 10 kHz rate; for a single calorimeter tower jet trigger a threshold of 65 GeV E_T is required. The single trigger tower trigger requires a threshold of 80 GeV E_T. The $.2 \times .2$ non-overlapping jet trigger requires a threshold of 107 GeV E_T, with a low energy cutoff of .2 GeV. The $.4 \times .4$ non-overlapping jet trigger has a threshold of 132 GeV E_T, with a low energy cutoff of .2 GeV. At the 10 kHz rate, the $.4 \times .4$ tower size is approaching full efficiency at 400 GeV, and certainly performs better than the smaller sizes. Figure 63 shows these efficiency curves for a 30 kHz rate; for a single calorimeter tower jet trigger a threshold of 47 GeV E_T is required. The single trigger tower trigger requires a threshold of 57 GeV E_T. The $.2 \times .2$ non-overlapping jet trigger requires a threshold of 77 GeV E_T, with a low energy cutoff of .1 GeV. The $.4 \times .4$ non-overlapping jet trigger has a threshold of 97 GeV E_T, with a low energy cutoff of .1 GeV. We see that even at a 30 kHz rate, the $.2 \times .2$ and smaller tower sizes have not reached full efficiency.

Figure 64 shows the efficiency curves for a $.2 \times .2$ non-overlapping jet trigger, a $.4 \times .4$ non-overlapping jet trigger, a $.8 \times .8$ non-overlapping jet trigger, and a 1.6×1.6 non-overlapping jet trigger. The thresholds are set for a 3 kHz rate; for a $.2 \times .2$ non-overlapping jet trigger a threshold of 147 GeV E_T is required, with a low energy cutoff of .5 GeV. The $.4 \times .4$ non-overlapping trigger requires a threshold of 171 GeV E_T, with a low energy cutoff of 1 GeV. The $.8 \times .8$ non-overlapping jet trigger requires a threshold of 199 GeV E_T, with a low energy cutoff of .5 GeV. The 1.6×1.6 non-overlapping jet trigger has a threshold of 207 GeV E_T, with a low energy cutoff of 1 GeV. The performance of the 1.6×1.6 tower size is much better than that of smaller sizes. Figure 65 shows these efficiency curves for a 10 kHz rate; for a $.2 \times .2$ non-overlapping jet trigger a threshold of 107 GeV E_T is required, with a low energy cutoff of .2 GeV. The $.4 \times .4$ non-overlapping trigger requires a threshold of 132 GeV E_T, with a low energy cutoff of .2 GeV. The $.8 \times .8$ non-overlapping jet trigger requires a threshold of 147 GeV E_T, with a low energy cutoff of .5 GeV. The 1.6×1.6 non-overlapping jet trigger has a threshold of 152 GeV E_T, with a low energy cutoff of 1 GeV. Figure 66 shows these efficiency curves for a 30 kHz rate; for a $.2 \times .2$ non-overlapping jet trigger a threshold of 77 GeV E_T is required, with a low energy cutoff of .1 GeV. The $.4 \times .4$ non-overlapping trigger requires a threshold of 97 GeV E_T, with a low energy cutoff of .1 GeV. The $.8 \times .8$ non-overlapping jet trigger requires a threshold of 108 GeV E_T, with a low energy cutoff of .5 GeV. The 1.6×1.6 non-overlapping jet trigger has a threshold of 110 GeV E_T, with a low energy cutoff of 1 GeV.

Figure 67 shows the efficiency curves for a $.8 \times .8$ non-overlapping jet trigger, a 1.6×1.6 non-overlapping jet trigger, a 3.2×3.2 non-overlapping jet trigger, and a full calorimeter jet trigger. The thresholds are set for a 3 kHz rate; for a $.8 \times .8$ non-overlapping jet trigger a threshold of 199 GeV E_T is required, with a low energy cutoff of .5 GeV. The 1.6×1.6 non-overlapping trigger requires a threshold of 207 GeV E_T, with a low energy cutoff of 1 GeV. The 3.2×3.2 non-overlapping jet trigger requires a threshold of 249 GeV E_T, with a low energy cutoff of 1 GeV. The full calorimeter jet trigger has a threshold of 379 GeV E_T, with a low energy cutoff of 5 GeV. The 3.2×3.2 non-overlapping grid performs best. Figure 68 shows these efficiency curves for a 10 kHz rate; for a $.8 \times .8$ non-overlapping jet trigger a threshold of 147 GeV E_T is required, with a low energy cutoff of .5 GeV. The 1.6×1.6 non-overlapping trigger requires a threshold of 152 GeV E_T, with a low energy cutoff of 1 GeV. The 3.2×3.2 non-overlapping jet trigger requires a threshold of 187 GeV E_T, with a low energy cutoff of 1 GeV. The full calorimeter jet trigger has a threshold of 266 GeV E_T, with a low energy cutoff of 2 GeV. The 3.2×3.2 non-overlapping grid performs best. Figure 69 shows these efficiency curves for a 30 kHz rate; for a $.8 \times .8$ non-overlapping jet trigger a threshold of 108 GeV E_T is required, with a low energy cutoff of .5 GeV. The 1.6×1.6 non-overlapping trigger requires a threshold of 110 GeV E_T, with a low energy cutoff of 1 GeV. The 3.2×3.2 non-overlapping jet trigger requires a threshold of 137 GeV E_T, with a low energy cutoff of 1 GeV. The full calorimeter jet trigger has a threshold of 185 GeV E_T, with a low energy cutoff of 2 GeV. The 3.2×3.2 non-overlapping grid performs best.

Now we consider the effect of changing jet tower size using overlapping grids of jet towers. Figure 70 shows the efficiency curves for a single trigger tower jet trigger, a $.2 \times .2$ overlapping jet trigger, and a $.4 \times .4$ overlapping jet trigger. The thresholds are set for a 3 kHz rate; the single trigger tower trigger requires a threshold of 115 GeV E_T. The $.2 \times .2$ overlapping jet trigger requires a threshold of 160 GeV E_T, with a low energy cutoff of .2 GeV. The $.4 \times .4$ overlapping jet trigger has a threshold of 188 GeV E_T, with a low energy cutoff of .5 GeV. The calorimeter tower size is not shown on this plot, as the thresholds cannot be set below 400 GeV E_T for a 3 kHz rate to be achieved. None of these tower sizes even approach full efficiency by 400 GeV p_T. Figure 71 shows these efficiency curves for a 10 kHz rate; for a single calorimeter tower jet trigger a threshold of 65 GeV E_T is required. The single trigger tower trigger requires a threshold of 80 GeV E_T. The $.2 \times .2$ overlapping jet trigger requires a threshold of 116 GeV E_T, with a low energy cutoff of .5 GeV. The $.4 \times .4$ overlapping jet trigger has a threshold of 143 GeV E_T, with a low energy cutoff of .1 GeV. Figure 72 shows these efficiency curves for a 30 kHz rate; for a single calorimeter tower jet trigger a threshold of 47 GeV E_T is required. The single trigger tower trigger requires a threshold of 57 GeV E_T. The $.2 \times .2$ overlapping jet trigger requires a threshold of 84 GeV E_T, with a low energy cutoff of .1 GeV. The $.4 \times .4$ overlapping jet trigger has a threshold of 105 GeV E_T, with a low energy cutoff of .1 GeV.

Figure 73 shows the efficiency curves for a $.2 \times .2$ overlapping jet trigger, a $.4 \times .4$ overlapping jet trigger, a $.8 \times .8$ overlapping jet trigger, and a 1.6×1.6 overlapping jet trigger. The thresholds are set for a 3 kHz rate; for a $.2 \times .2$ overlapping jet trigger a threshold of 160 GeV E_T is required, with a low energy cutoff of .2 GeV. The $.4 \times .4$ overlapping trigger requires a threshold of 188 GeV E_T, with a low energy cutoff of .5 GeV. The $.8 \times .8$ overlapping jet trigger requires a threshold of 228 GeV E_T, with a low energy cutoff of .1 GeV. The 1.6×1.6 overlapping jet trigger has a threshold of 240 GeV E_T, with a low energy cutoff of .5 GeV. Figure 74 shows these efficiency curves for a 10 kHz rate; for

a $.2 \times .2$ overlapping jet trigger a threshold of 116 GeV E_T is required, with a low energy cutoff of .5 GeV. The $.4 \times .4$ overlapping trigger requires a threshold of 143 GeV E_T, with a low energy cutoff of .1 GeV. The $.8 \times .8$ overlapping jet trigger requires a threshold of 173 GeV E_T, with a low energy cutoff of .1 GeV. The 1.6×1.6 overlapping jet trigger has a threshold of 183 GeV E_T, with a low energy cutoff of .5 GeV. Figure 75 shows these efficiency curves for a 30 kHz rate; for a $.2 \times .2$ overlapping jet trigger a threshold of 84 GeV E_T is required, with a low energy cutoff of .1 GeV. The $.4 \times .4$ overlapping trigger requires a threshold of 105 GeV E_T, with a low energy cutoff of .1 GeV. The $.8 \times .8$ overlapping jet trigger requires a threshold of 131 GeV E_T, with a low energy cutoff of .1 GeV. The 1.6×1.6 overlapping jet trigger has a threshold of 139 GeV E_T, with a low energy cutoff of .5 GeV. The efficiency of overlapping regions improves from the smallest size up to 1.6×1.6 tower sizes.

Figure 76 shows the efficiency curves for a $.8 \times .8$ overlapping jet trigger, a 1.6×1.6 overlapping jet trigger, a 3.2×3.2 overlapping jet trigger, and a full calorimeter jet trigger. The thresholds are set for a 3 kHz rate; for a $.8 \times .8$ overlapping jet trigger a threshold of 228 GeV E_T is required, with a low energy cutoff of .1 GeV. The 1.6×1.6 overlapping trigger requires a threshold of 240 GeV E_T, with a low energy cutoff of .5 GeV. The 3.2×3.2 overlapping jet trigger requires a threshold of 260 GeV E_T, with a low energy cutoff of 1 GeV. The full calorimeter jet trigger has a threshold of 379 GeV E_T, with a low energy cutoff of 5 GeV. Figure 77 shows these efficiency curves for a 10 kHz rate; for a $.8 \times .8$ overlapping jet trigger a threshold of 173 GeV E_T is required, with a low energy cutoff of .1 GeV. The 1.6×1.6 overlapping trigger requires a threshold of 183 GeV E_T, with a low energy cutoff of .5 GeV. The 3.2×3.2 overlapping jet trigger requires a threshold of 194 GeV E_T, with a low energy cutoff of 1 GeV. The full calorimeter jet trigger has a threshold of 266 GeV E_T, with a low energy cutoff of 2 GeV. Figure 78 shows these efficiency curves for a 30 kHz rate; for a $.8 \times .8$ overlapping jet trigger a threshold of 131 GeV E_T is required, with a low energy cutoff of .1 GeV. The 1.6×1.6 overlapping trigger requires a threshold of 139 GeV E_T, with a low energy cutoff of .5 GeV. The 3.2×3.2 overlapping jet trigger requires a threshold of 144 GeV E_T, with a low energy cutoff of 1 GeV. The full calorimeter jet trigger has a threshold of 185 GeV E_T, with a low energy cutoff of 2 GeV. The 3.2×3.2 overlapping tower size still performs best for high efficiency at the higher luminosity. Of the non-overlapping grid sizes, 3.2×3.2 towers are again the best.

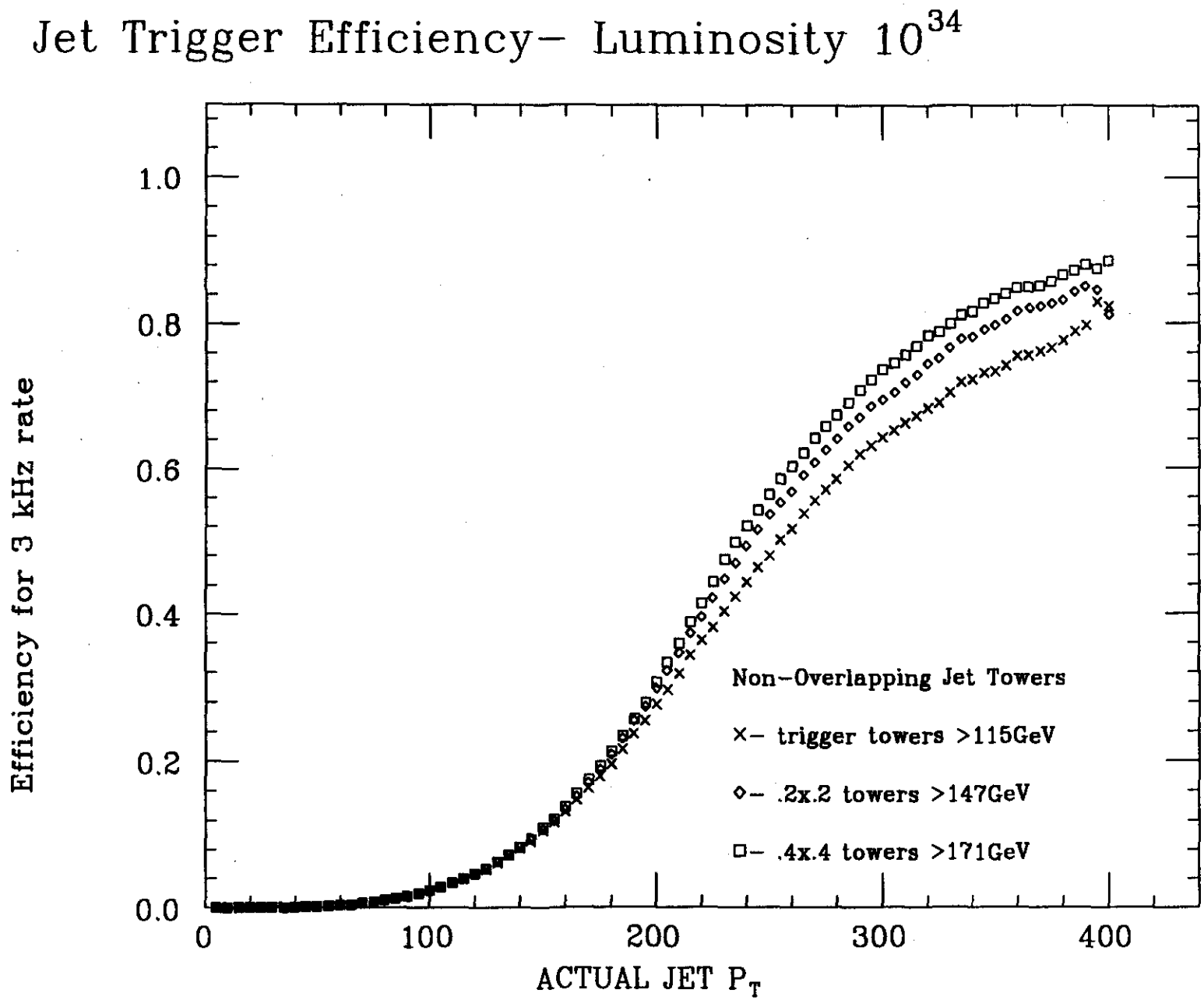
Jet Trigger Efficiency– Luminosity 10^{34}
Efficiency for 3 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
Non–Overlapping Jet Towers
×– trigger towers >115GeV
◇– .2x.2 towers >147GeV
□– .4x.4 towers >171GeV

Figure 61

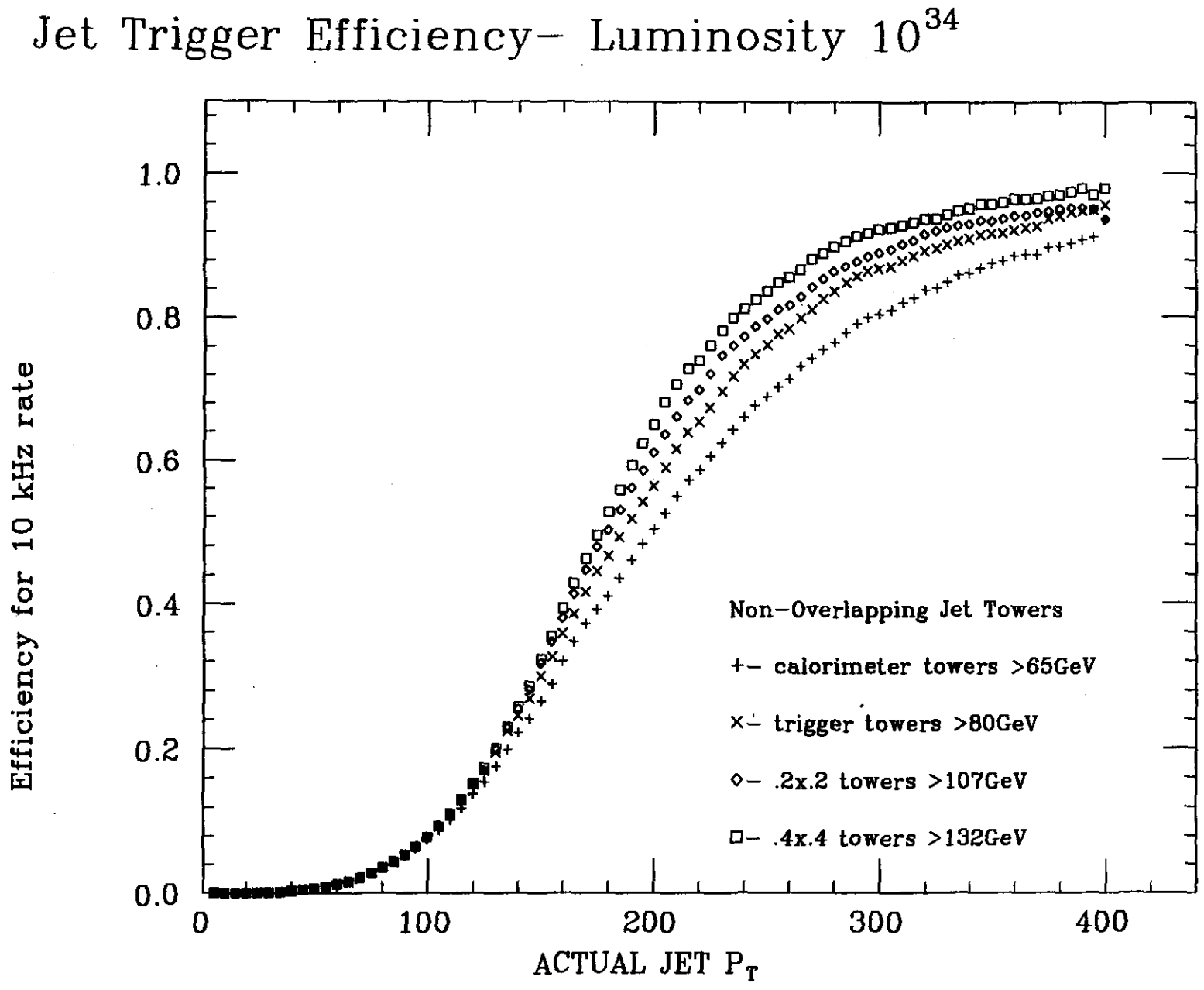
Jet Trigger Efficiency– Luminosity 10^{34}
Efficiency for 10 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
Non–Overlapping Jet Towers
+– calorimeter towers >65GeV
×– trigger towers >80GeV
◇– .2x.2 towers >107GeV
□– .4x.4 towers >132GeV

Figure 62

Jet Trigger Efficiency– Luminosity 10^{34}

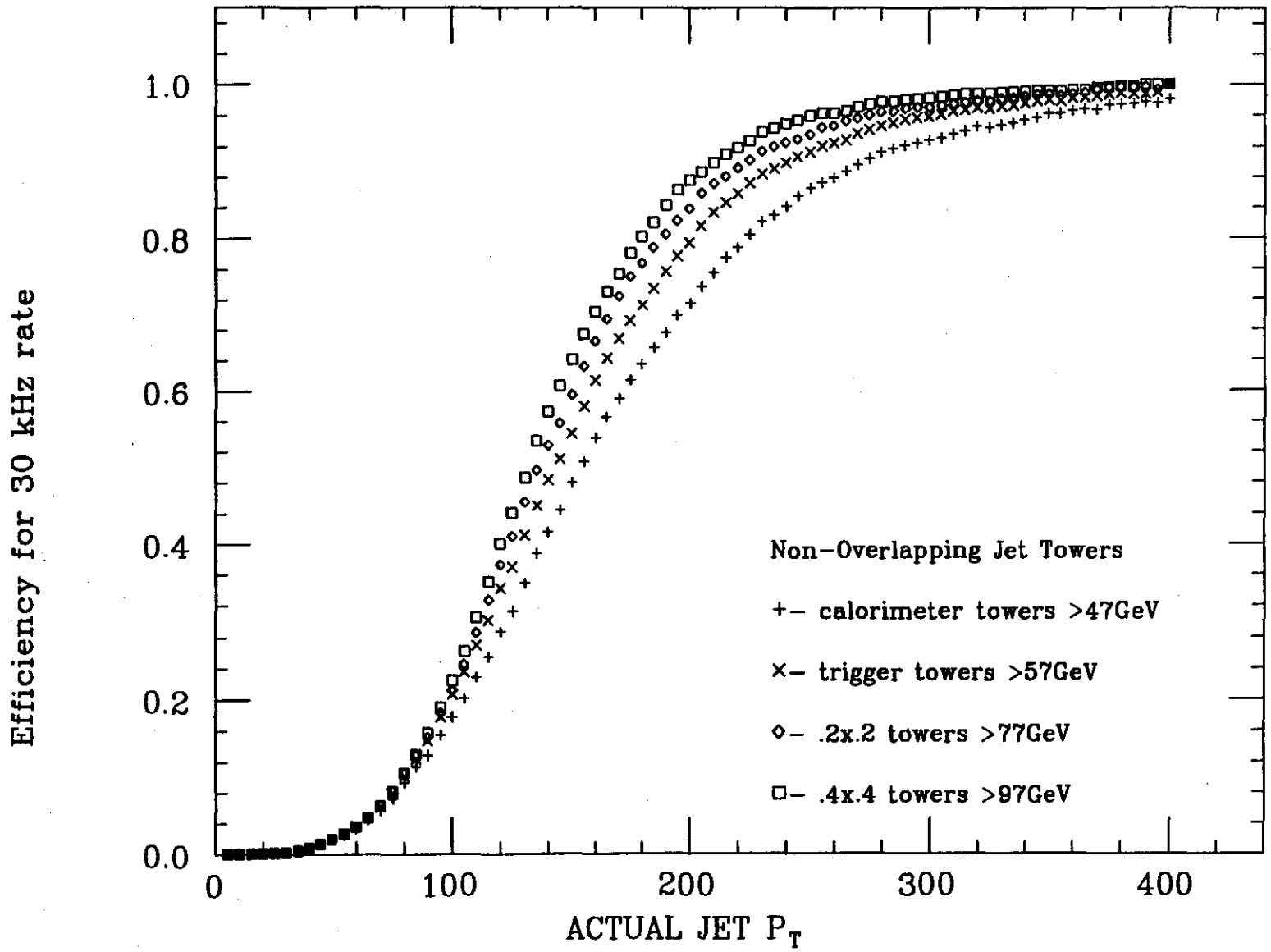

Figure 63

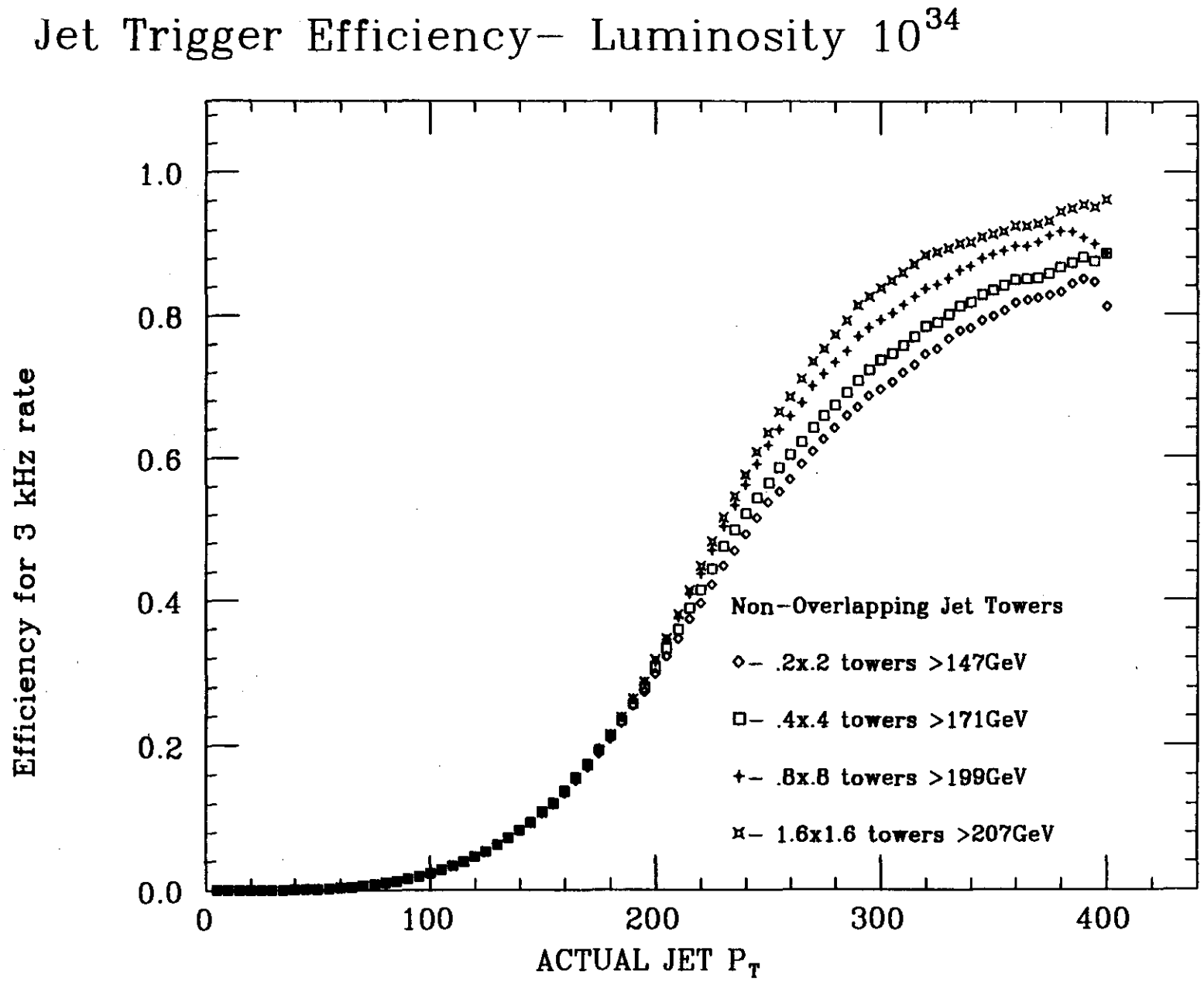
Jet Trigger Efficiency– Luminosity 10^{34}
Efficiency for 3 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
Non–Overlapping Jet Towers
◇– .2x.2 towers >147GeV
□– .4x.4 towers >171GeV
+– .8x.8 towers >199GeV
¤– 1.6x1.6 towers >207GeV

Figure 64

Jet Trigger Efficiency– Luminosity 10^{34}

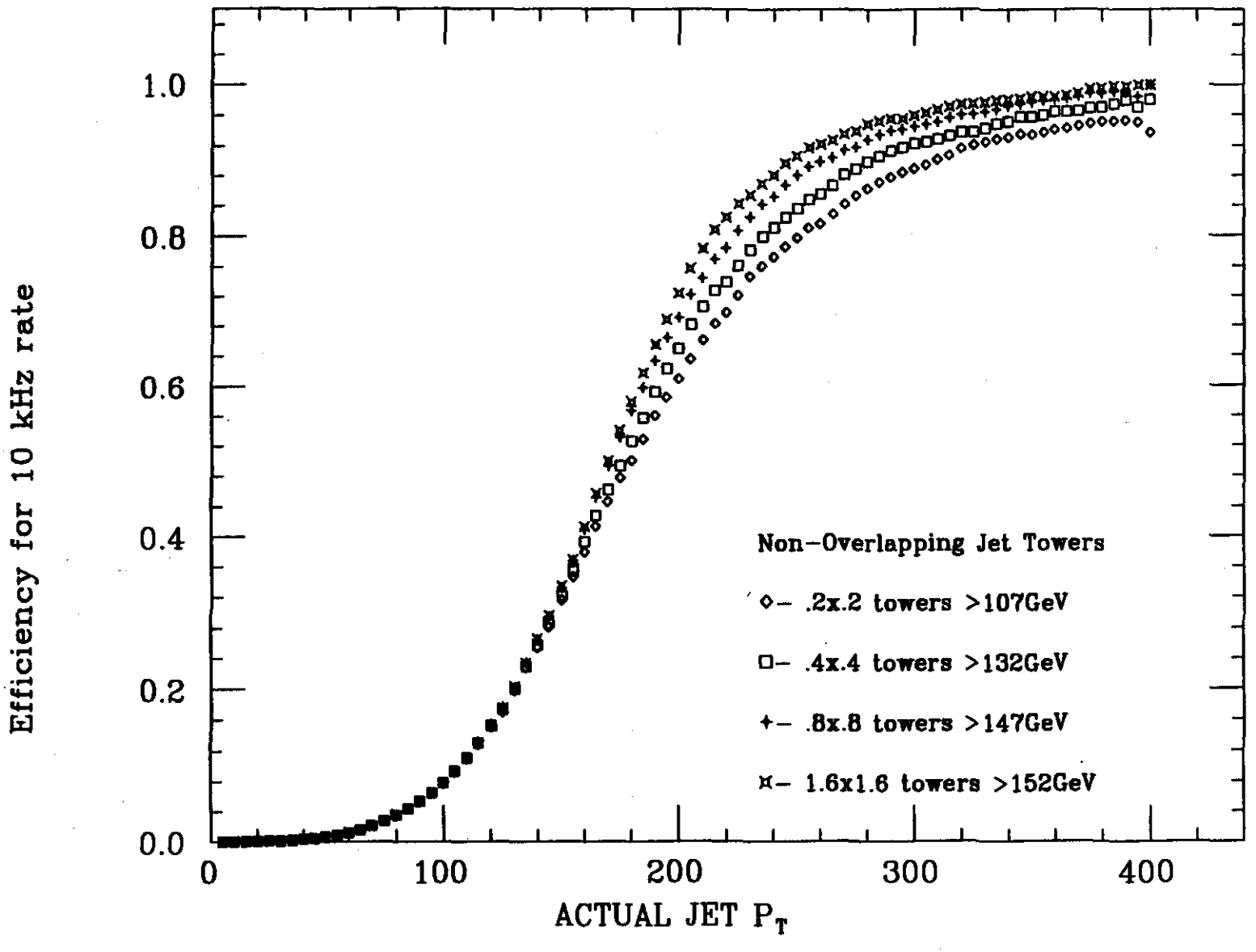

Figure 65

Jet Trigger Efficiency– Luminosity 10^{34}

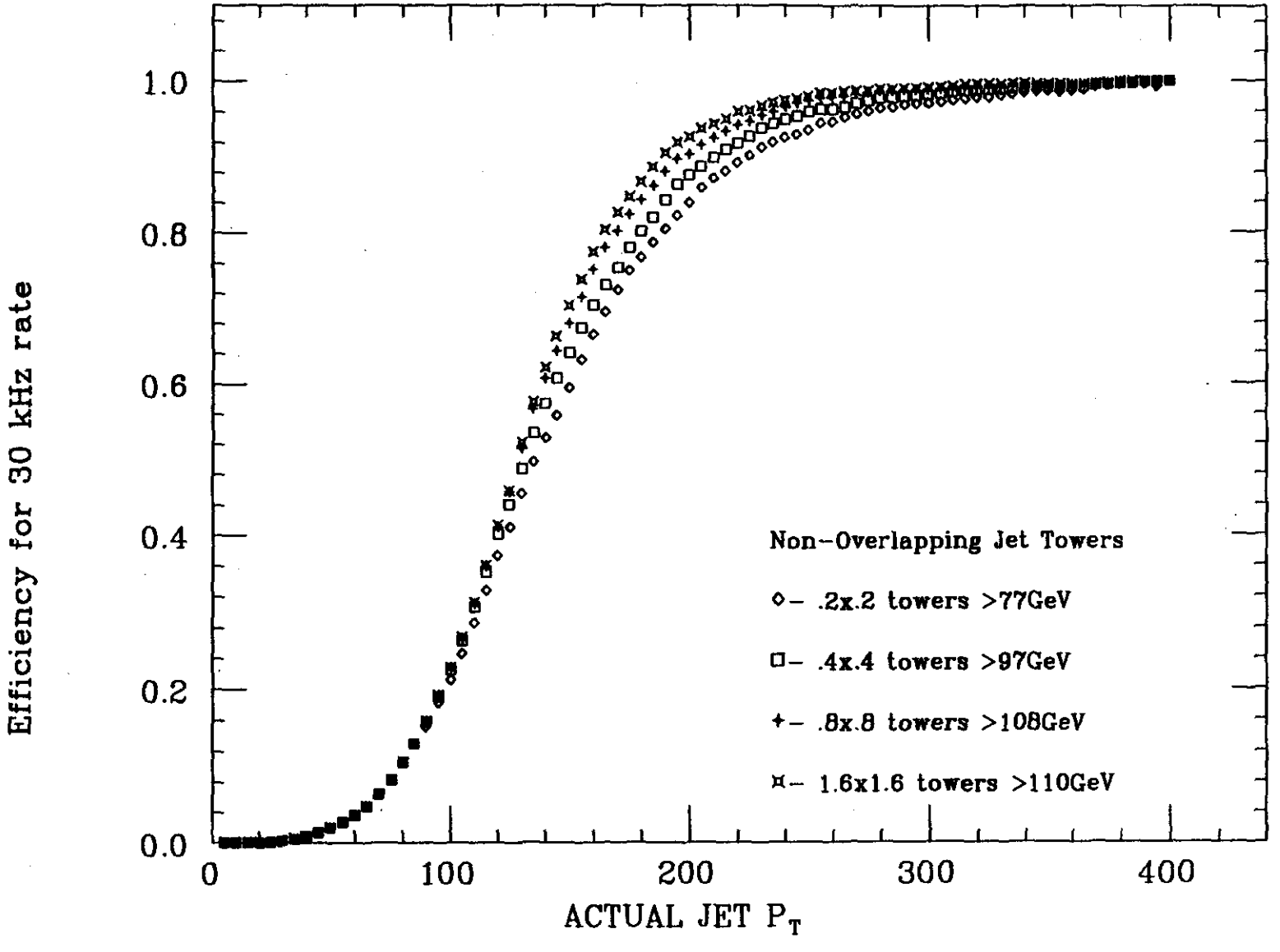

Figure 66

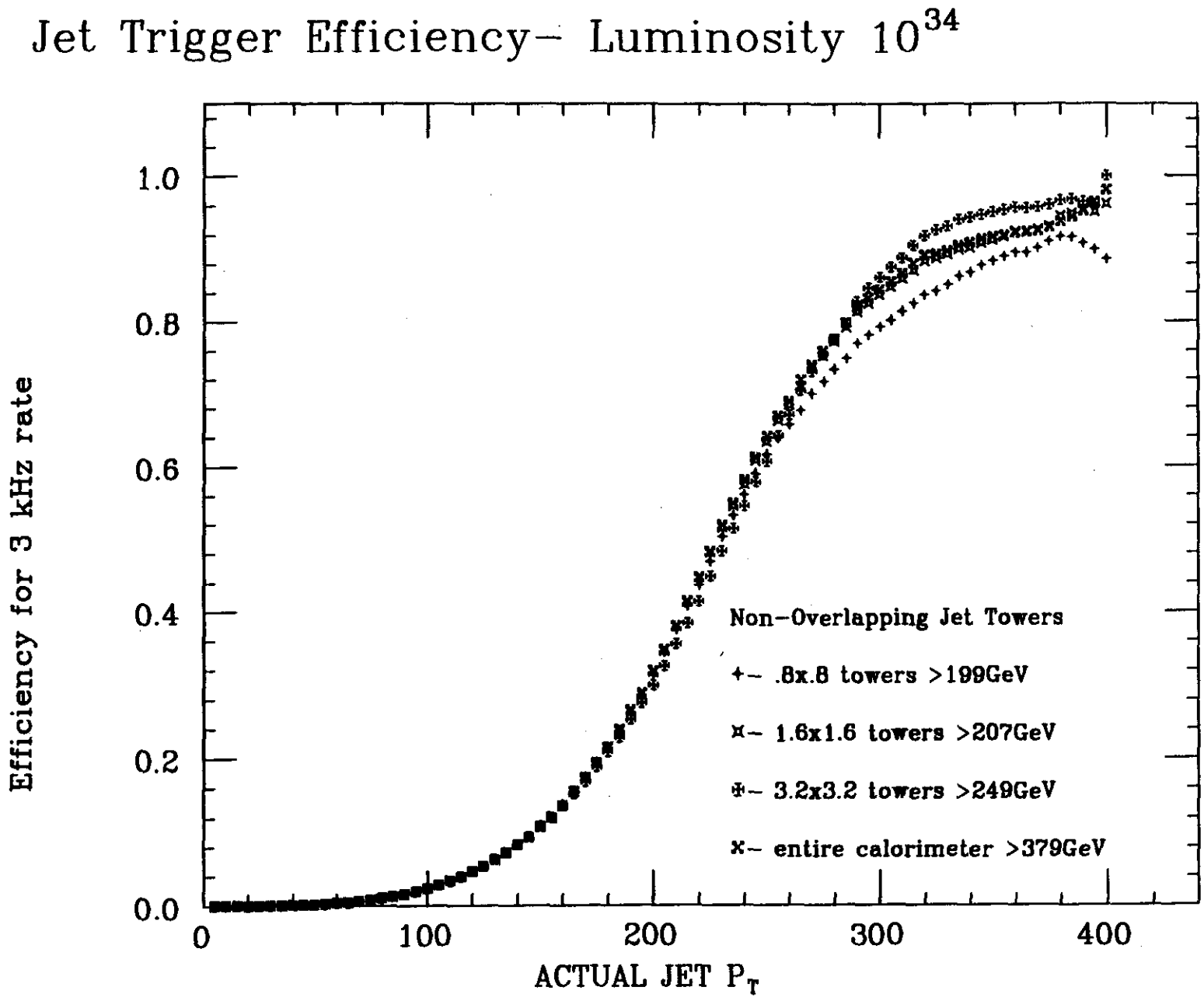
Jet Trigger Efficiency– Luminosity 10^{34}
Efficiency for 3 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
Non–Overlapping Jet Towers
+– .8x.8 towers >199GeV
×– 1.6x1.6 towers >207GeV
✱– 3.2x3.2 towers >249GeV
×– entire calorimeter >379GeV

Figure 67

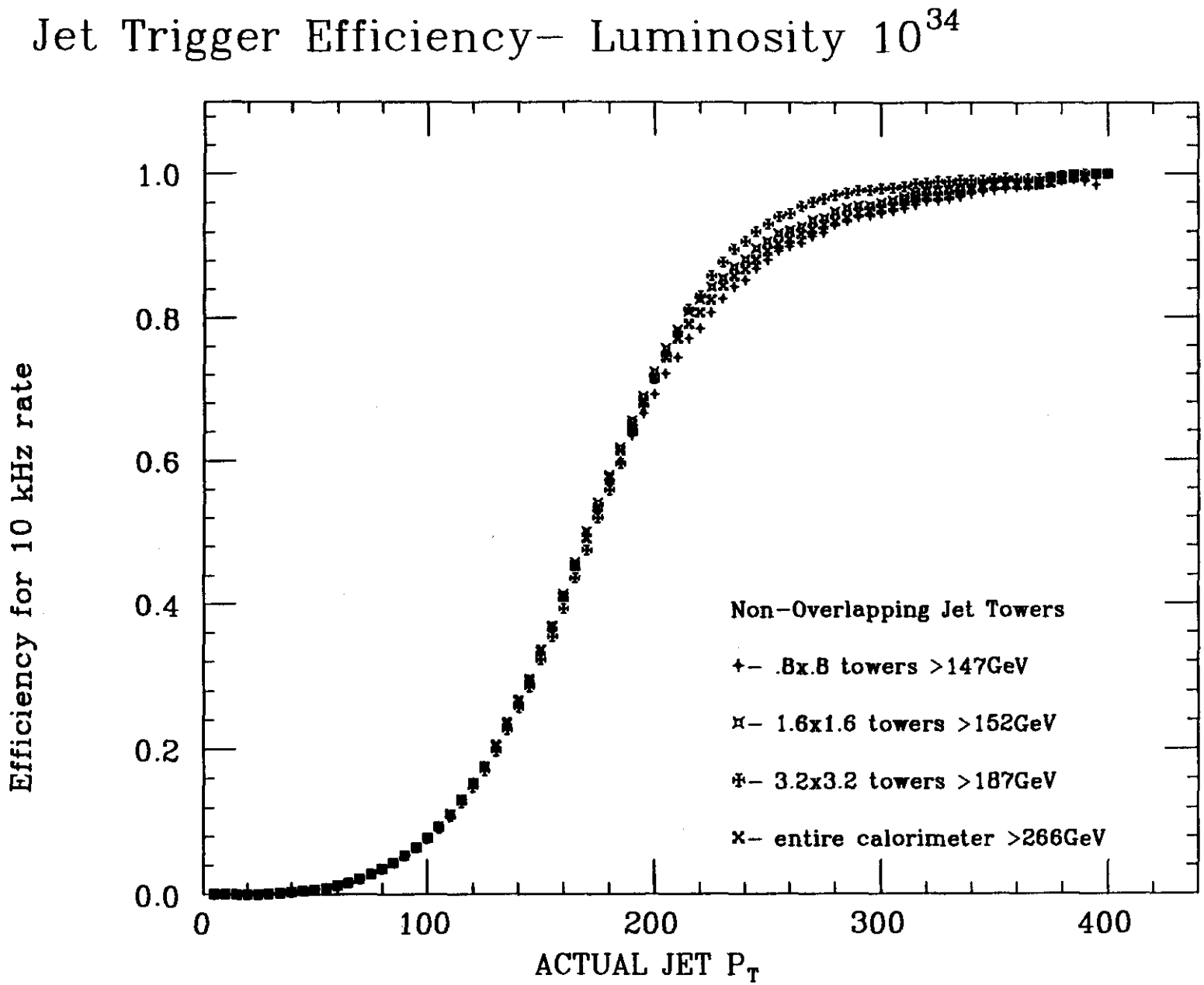
Jet Trigger Efficiency– Luminosity 10^{34}
Efficiency for 10 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
Non–Overlapping Jet Towers
+– .8x.8 towers >147GeV
¤– 1.6x1.6 towers >152GeV
✠– 3.2x3.2 towers >187GeV
×– entire calorimeter >266GeV

Figure 68

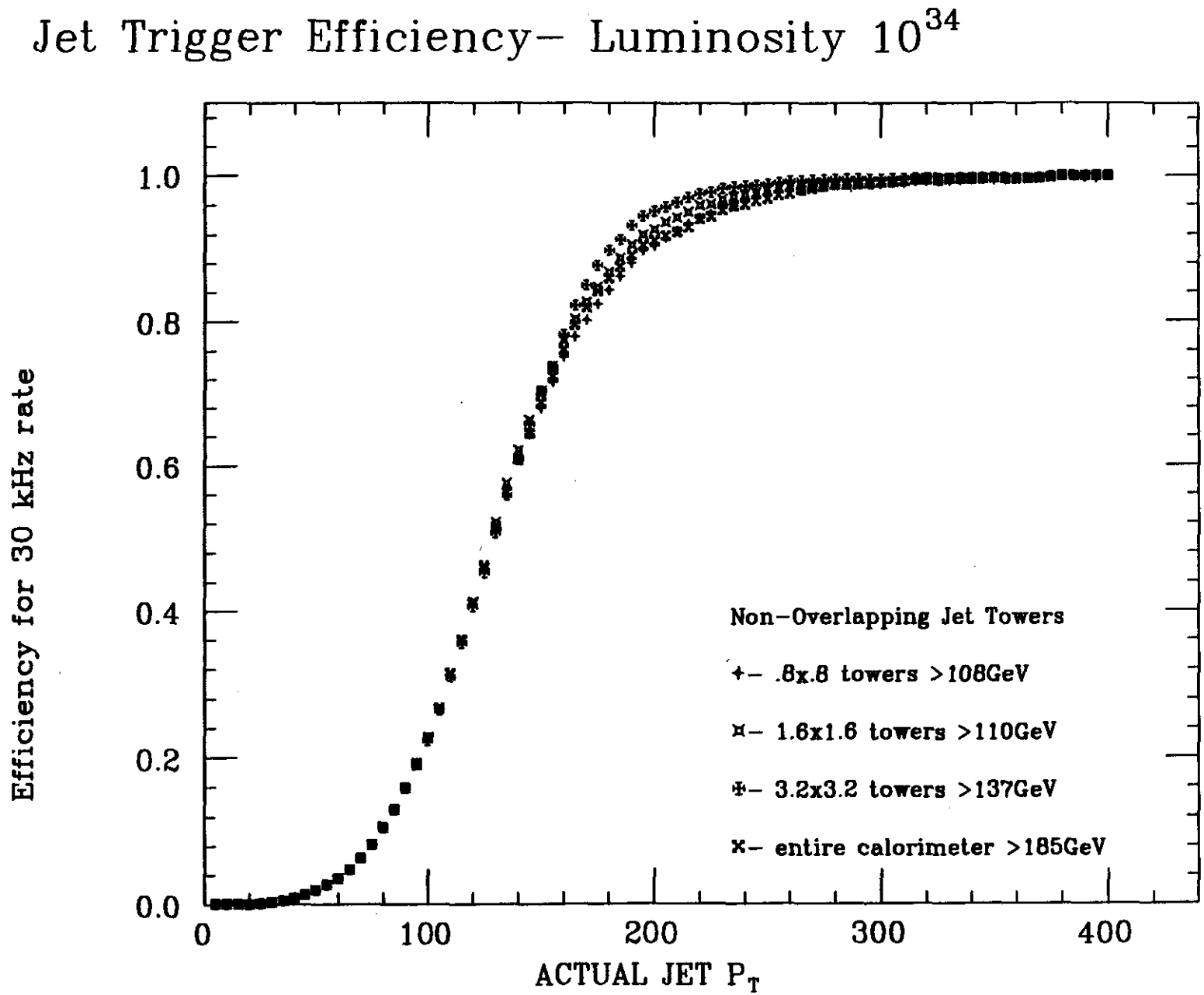
Jet Trigger Efficiency– Luminosity 10^{34}
Efficiency for 30 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
Non–Overlapping Jet Towers
+– .8x.8 towers >108GeV
¤– 1.6x1.6 towers >110GeV
✠– 3.2x3.2 towers >137GeV
×– entire calorimeter >185GeV

Figure 69

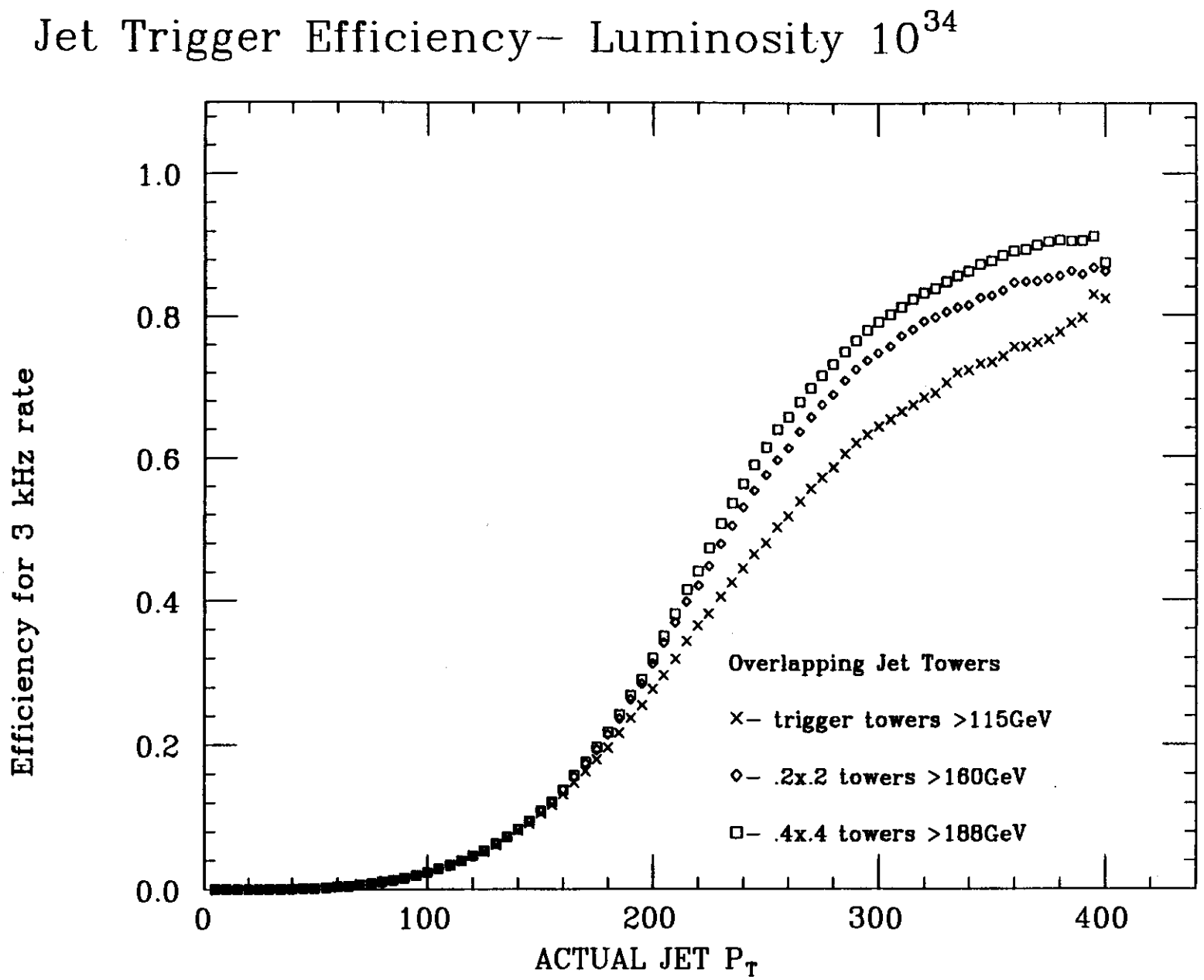
Jet Trigger Efficiency– Luminosity 10^{34}
Efficiency for 3 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
Overlapping Jet Towers
×– trigger towers >115GeV
◇– .2x.2 towers >160GeV
□– .4x.4 towers >188GeV

Figure 70

Jet Trigger Efficiency– Luminosity 10^{34}

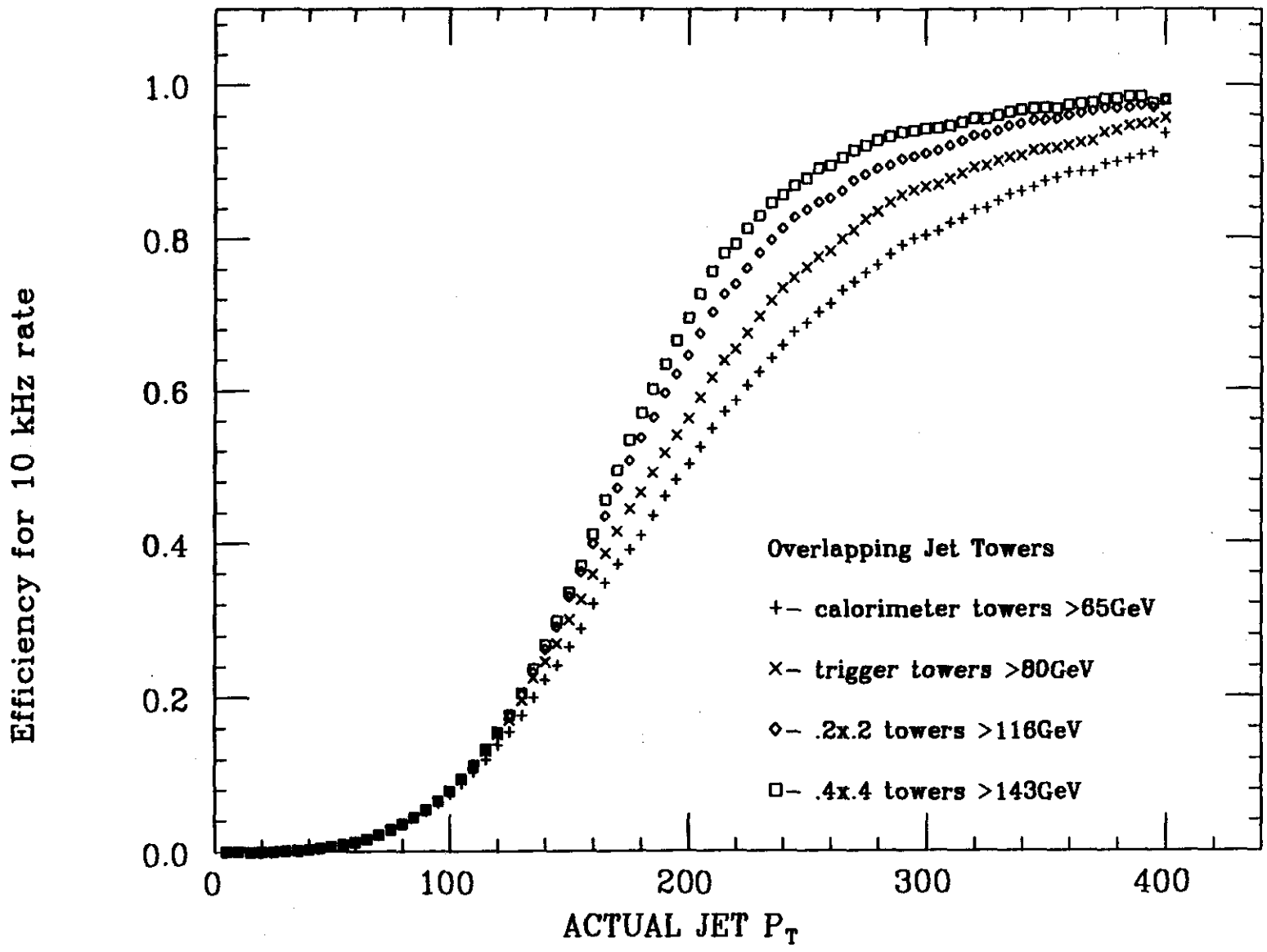

Figure 71

Jet Trigger Efficiency– Luminosity 10^{34}

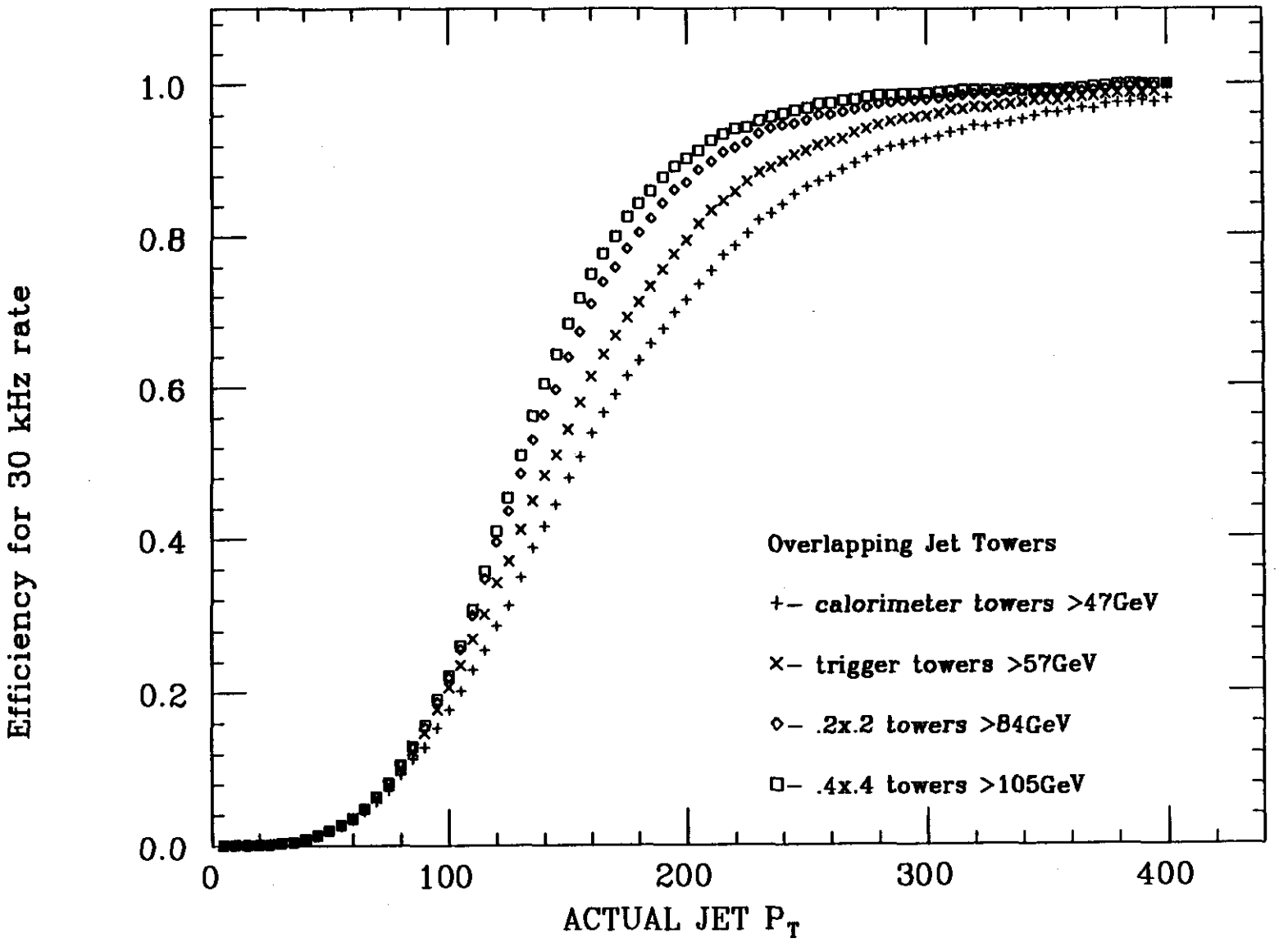

Figure 72

Jet Trigger Efficiency– Luminosity 10^{34}

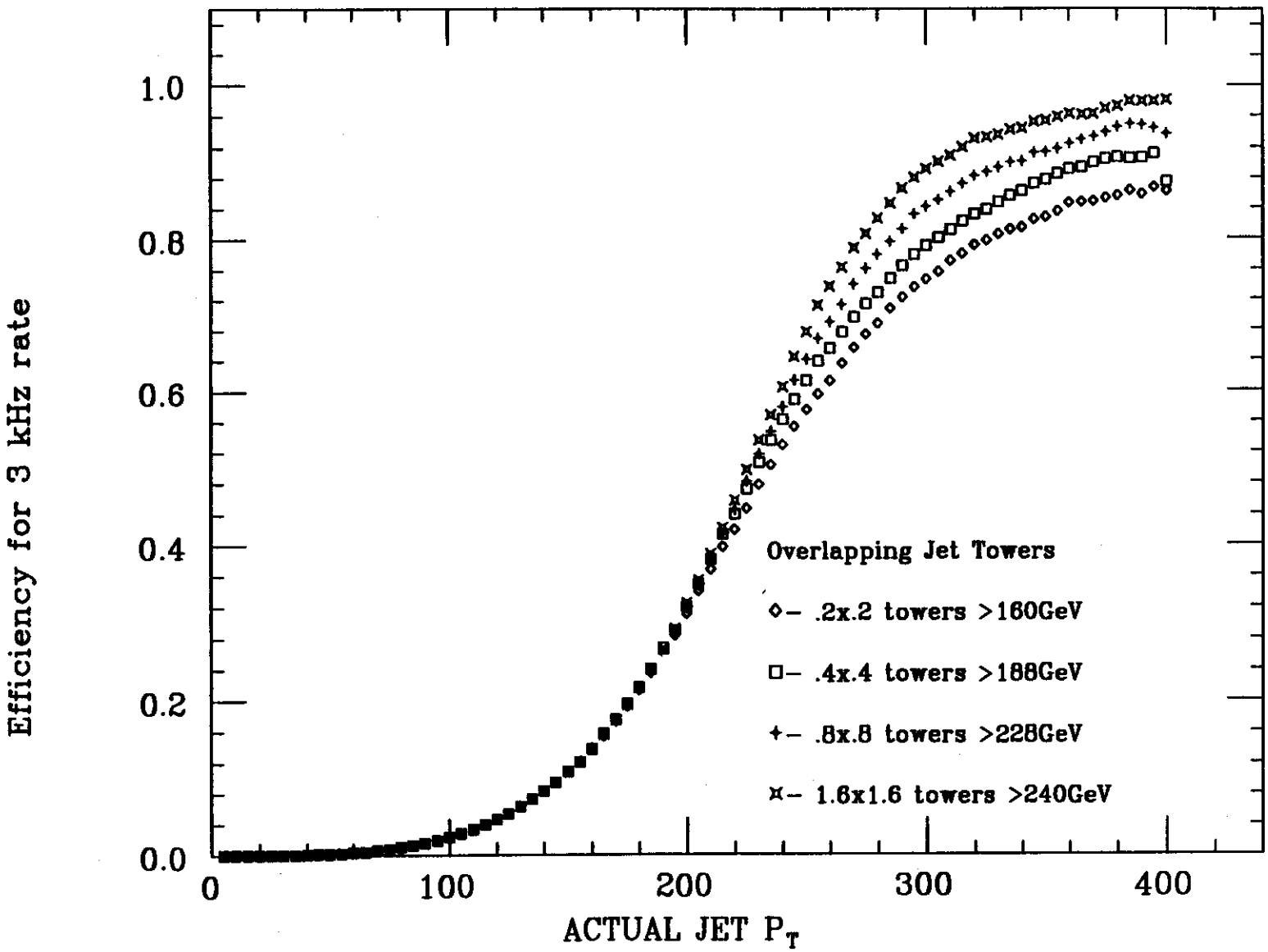

Figure 73

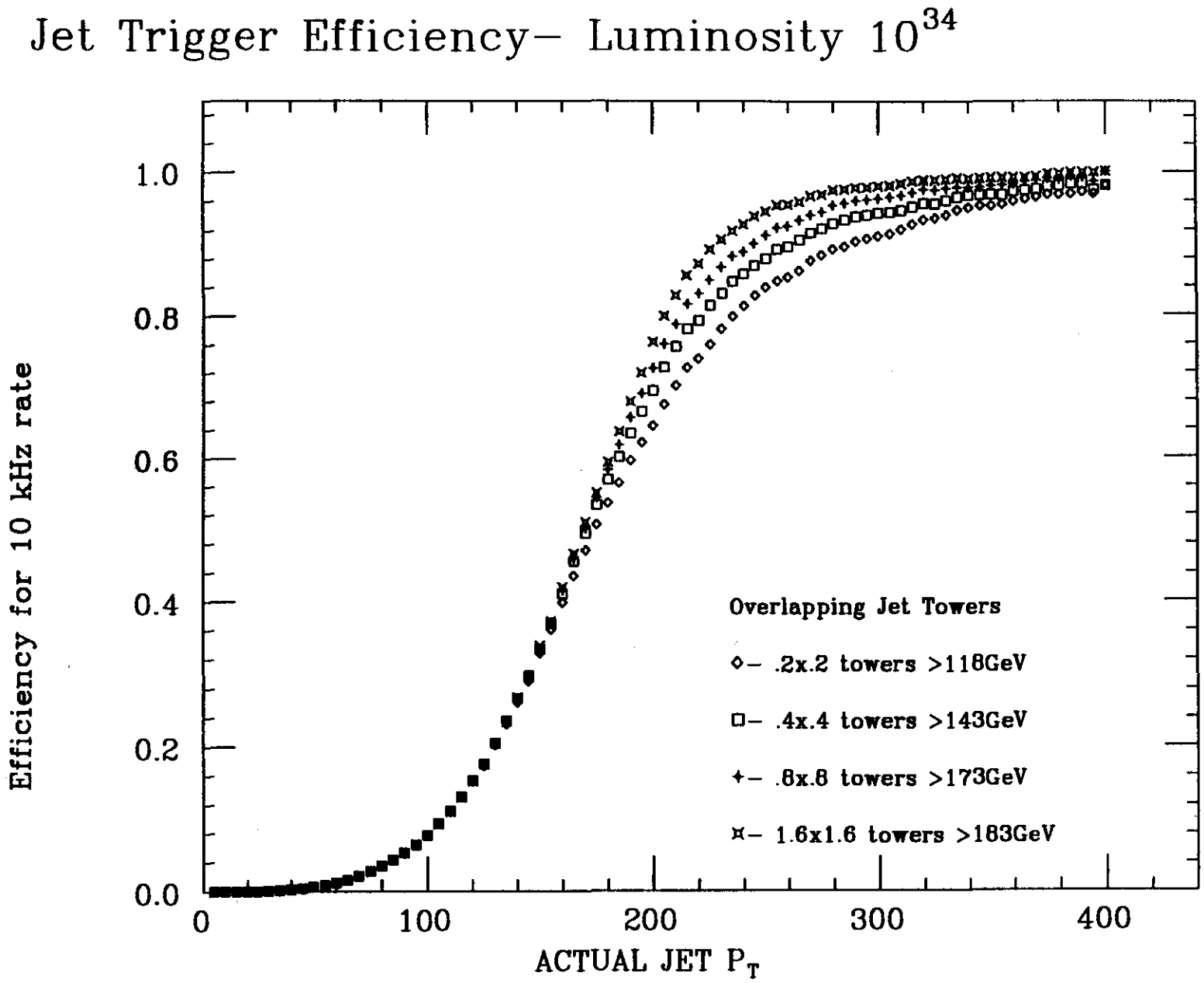
Jet Trigger Efficiency– Luminosity 10^{34}
Efficiency for 10 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
Overlapping Jet Towers
◇– .2x.2 towers >118GeV
□– .4x.4 towers >143GeV
+– .8x.8 towers >173GeV
¤– 1.6x1.6 towers >183GeV

Figure 74

Jet Trigger Efficiency– Luminosity 10^{34}

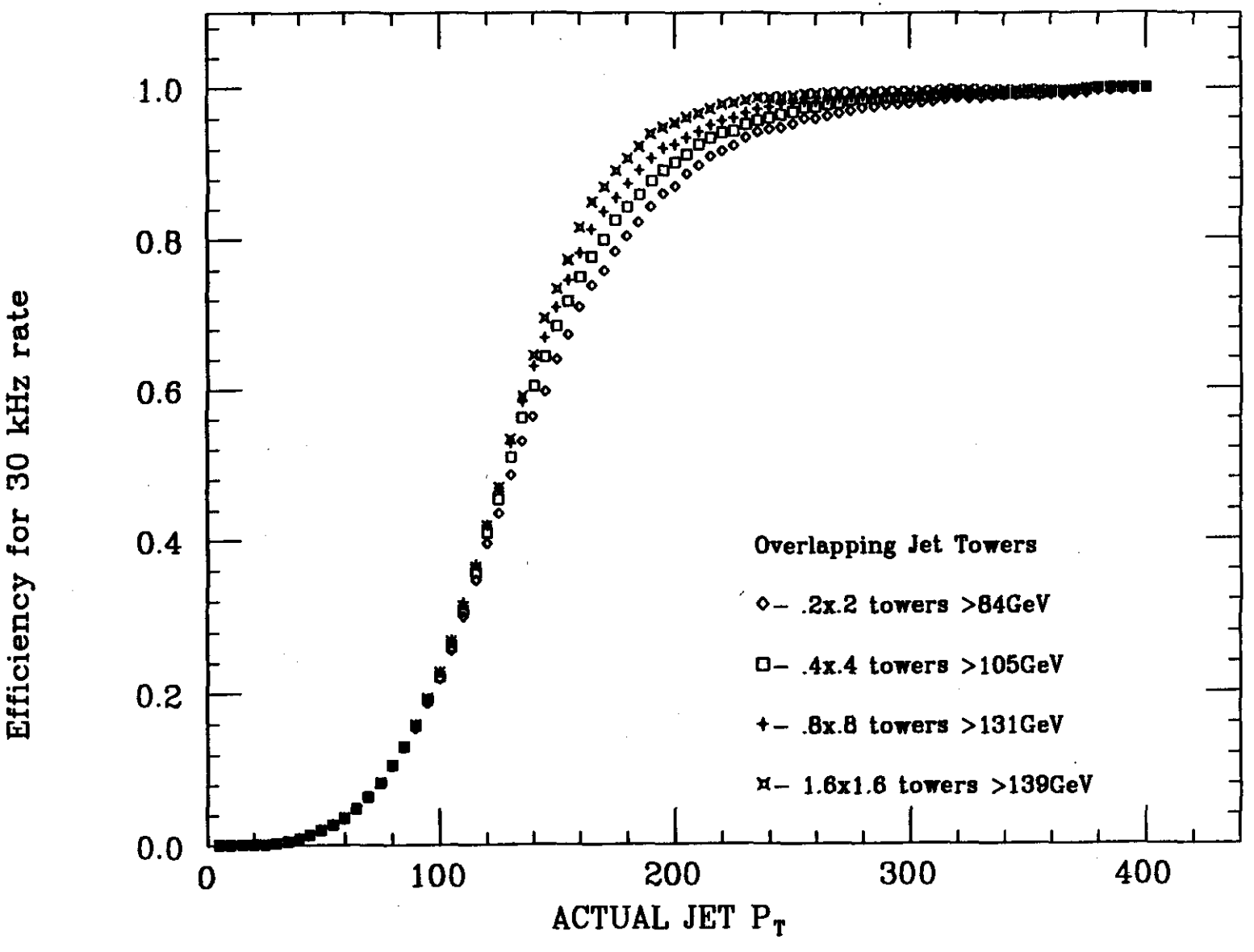

Figure 75

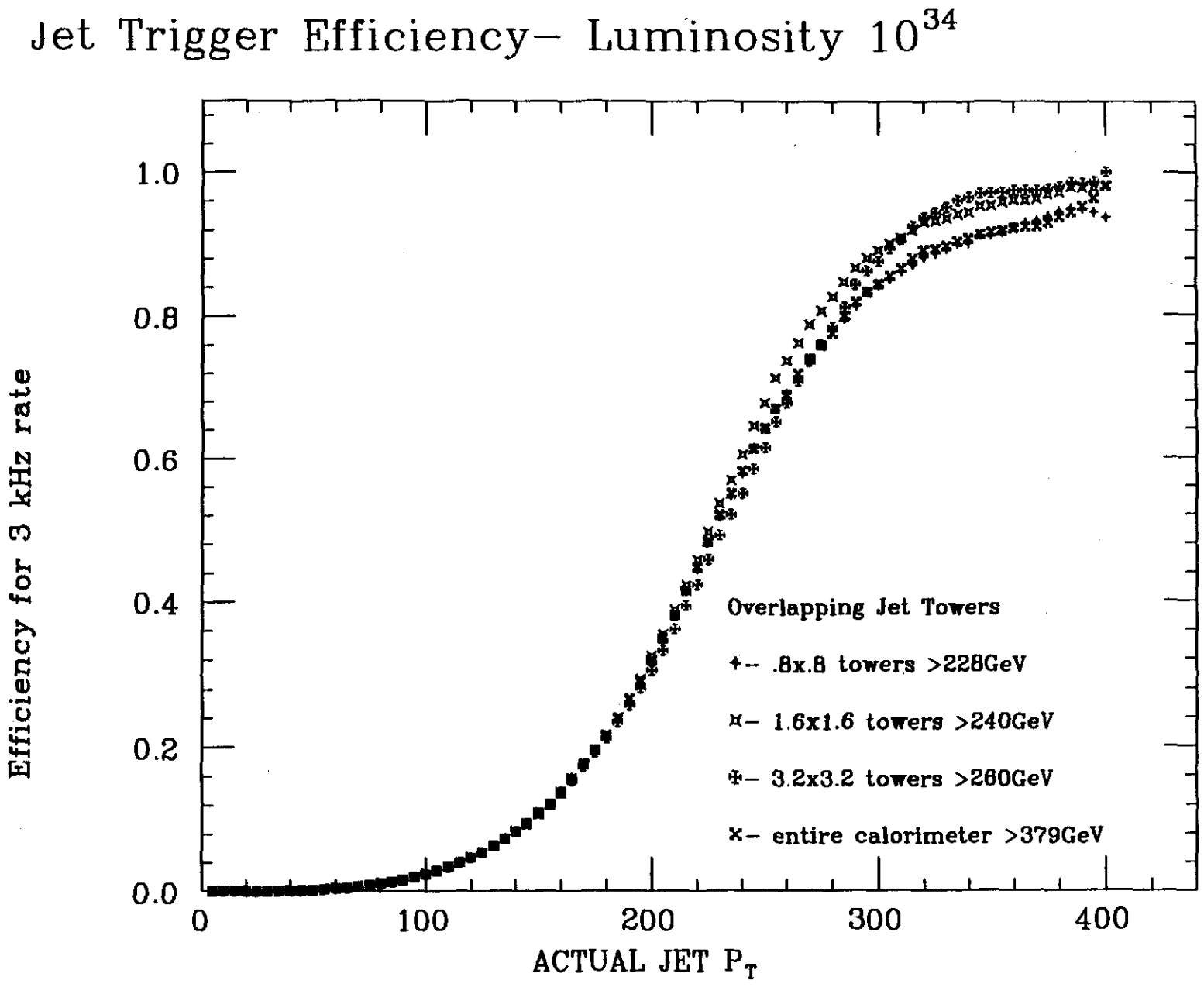
Jet Trigger Efficiency– Luminosity 10^{34}
Efficiency for 3 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
Overlapping Jet Towers
+– .8x.8 towers >228GeV
¤– 1.6x1.6 towers >240GeV
✠– 3.2x3.2 towers >260GeV
×– entire calorimeter >379GeV

Figure 76

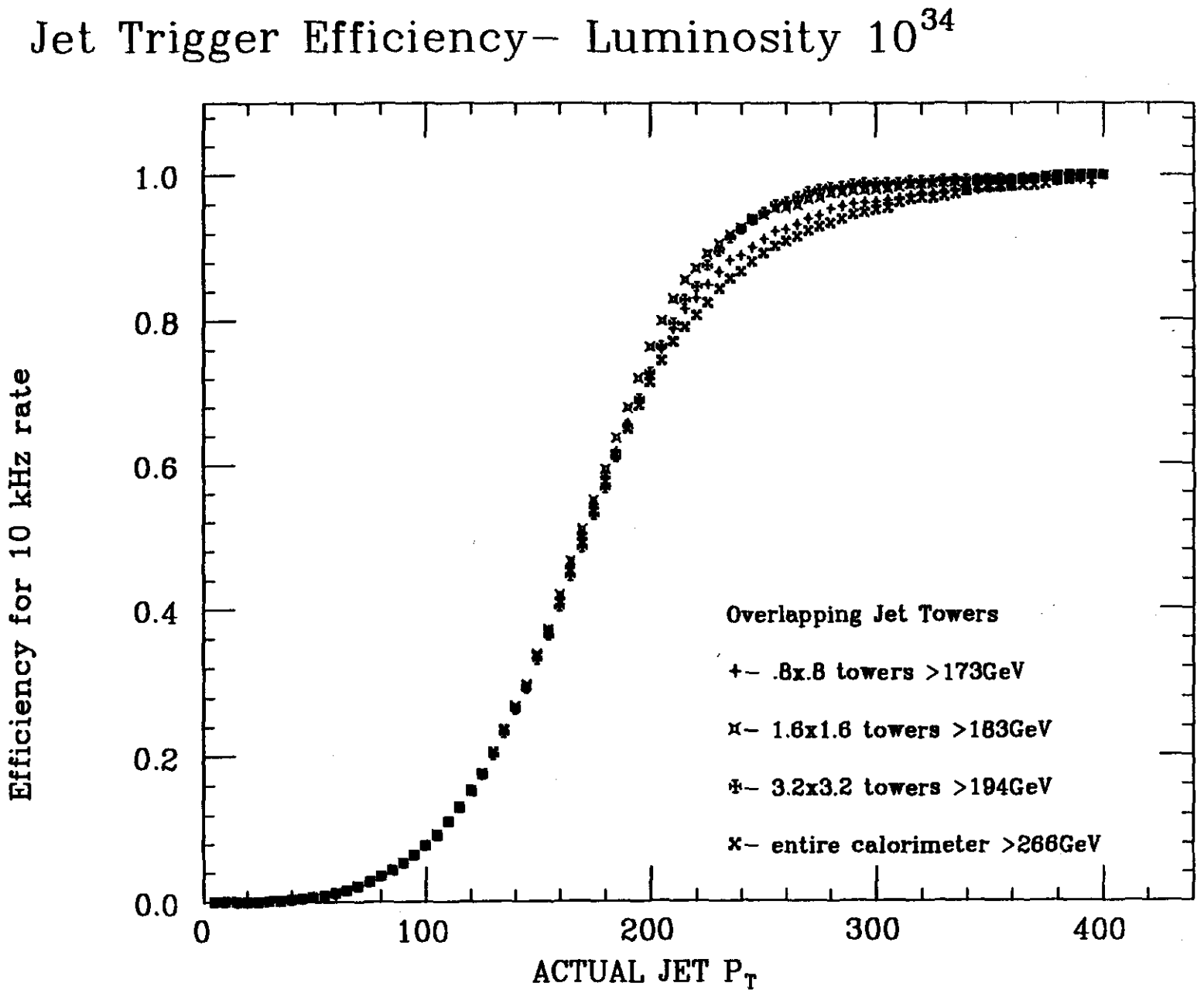
Jet Trigger Efficiency– Luminosity 10^{34}
Efficiency for 10 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
Overlapping Jet Towers
+– .8x.8 towers >173GeV
×– 1.6x1.6 towers >183GeV
✱– 3.2x3.2 towers >194GeV
×– entire calorimeter >266GeV

Figure 77

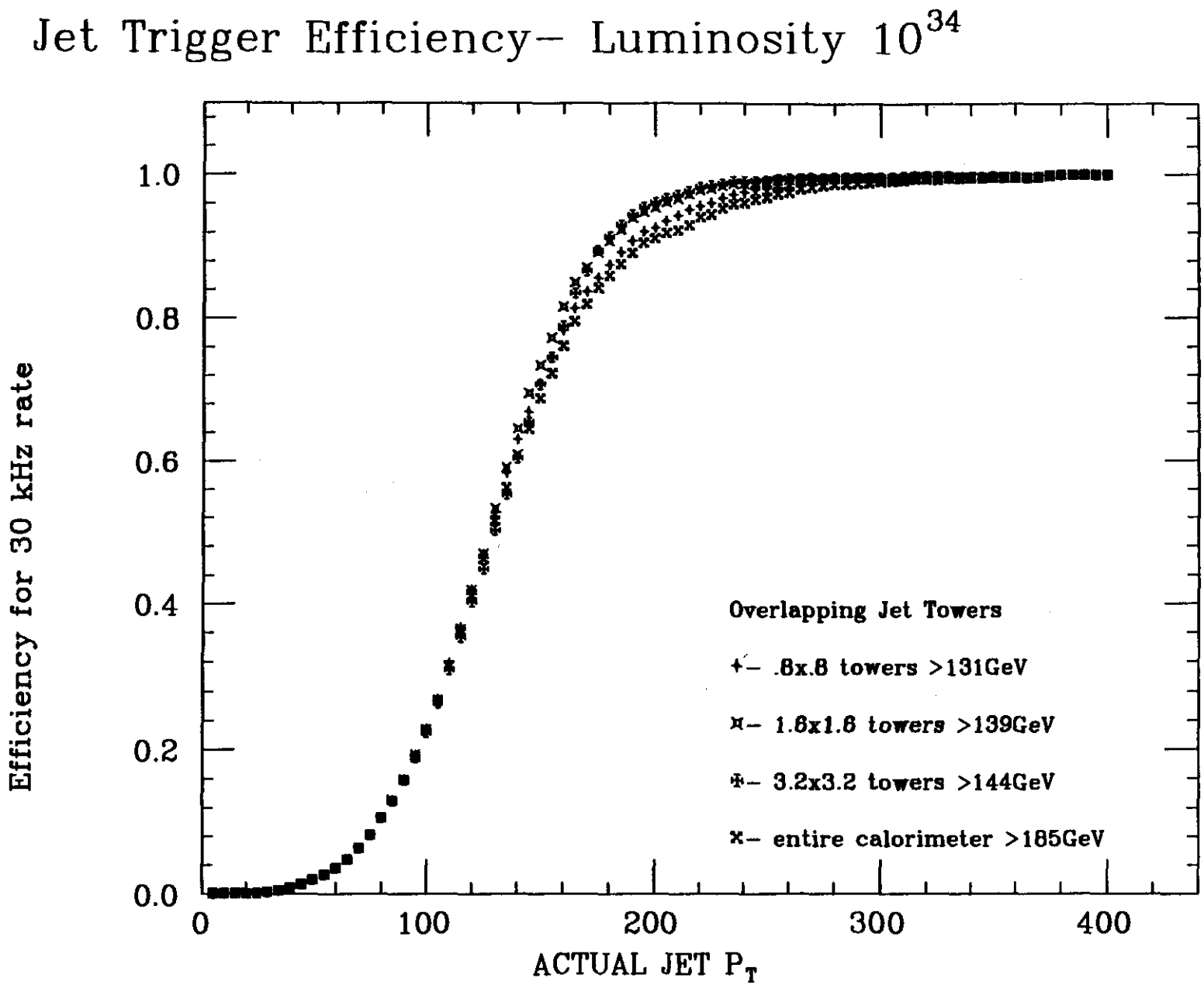
Jet Trigger Efficiency– Luminosity 10^{34}
Efficiency for 30 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
Overlapping Jet Towers
+– .8x.8 towers >131GeV
¤– 1.6x1.6 towers >139GeV
✱– 3.2x3.2 towers >144GeV
×– entire calorimeter >185GeV

Figure 78

Chapter 6

Effect of low energy cutoff on Jet Trigger Efficiencies

In each case considered above, various low energy cutoffs were considered, and the low energy cutoff used was chosen in order to achieve 80% efficiency at the lowest possible jet p_T value for the rate considered. As an illustration of this, Figure 79 shows the efficiency curves for a 3.2×3.2 overlapping jet trigger at a luminosity of $10^{34} cm^{-2} sec^{-1}$, with thresholds set to achieve a 30 kHz rate and low energy cutoffs of .1, 1, and 5 GeV. In this case, to optimize efficiency, a 1 GeV cutoff per tower would be used.

Jet Trigger Efficiency– Luminosity 10^{34}

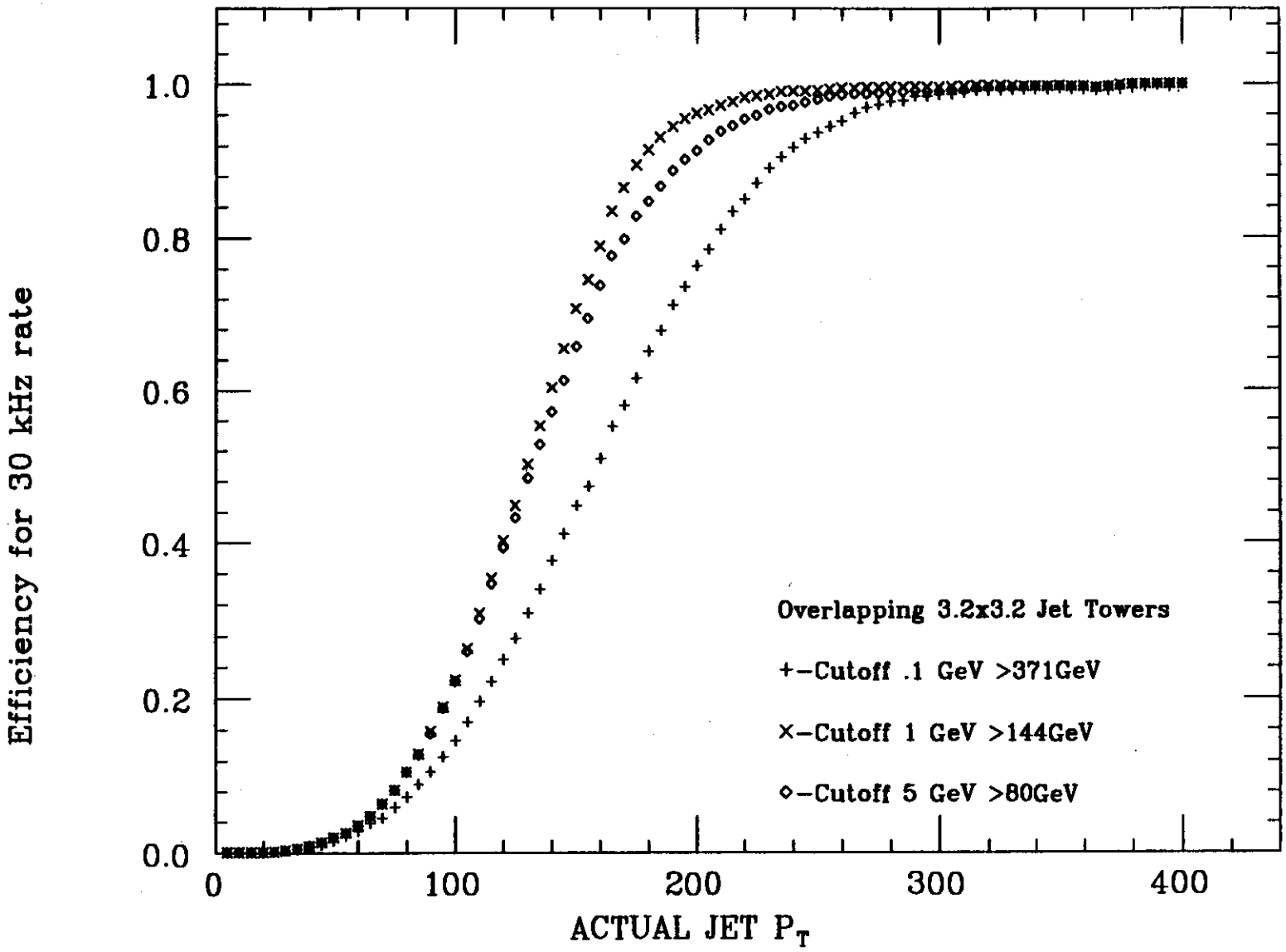

Figure 79

Chapter 7

Effect of Non-linear Scale on Efficiency

We investigated the effect upon efficiency which resulted from using an 8-bit logarithmic scale to transmit energies from the calorimeter to the electronics, followed by a 12-bit linear scale for adding. Figures 80-84 are at the SSC design luminosity of $10^{33} cm^{-2} sec^{-1}$. Figure 80 shows the efficiency curves for a 3 kHz rate for an overlapping grid of $.4 \times .4$ jet towers using an 8-bit logarithmic scale versus a 31-bit linear scale. There is some apparent loss in efficiency, though this is smaller than the difference observed in changing jet tower sizes or changing from overlapping to non-overlapping grids. In Figure 81 we see the efficiencies for a 3 kHz rate with a tower size of $.8 \times .8$. Figure 82 shows the comparison for 1.6×1.6 towers. Figure 83 shows this comparison for non-overlapping 3.2×3.2 grids of towers. Figure 84 shows the effect of different scales on overlapping 3.2×3.2 grids of towers.

Figures 85-89 are at the SSC maximum luminosity of $10^{34} cm^{-2} sec^{-1}$. Figure 85 shows the efficiency curves for a 10 kHz rate for an overlapping grid of $.4 \times .4$ jet towers using an 8-bit logarithmic scale versus a 31-bit linear scale. In Figure 86 we see the efficiencies for a 10 kHz rate with a tower size of $.8 \times .8$. Figure 87 shows the comparison for 1.6×1.6 towers. Figure 88 shows this comparison for non-overlapping 3.2×3.2 grids of towers. Figure 89 shows the effect of different scales on overlapping 3.2×3.2 grids of towers. The effect of the different scale seems to change little with the increase in luminosity.

Figure 90 shows the efficiencies for overlapping grids of 1.6×1.6 and 3.2×3.2 towers. Thresholds are set to achieve a 10 kHz rate, at the SSC maximum luminosity of $10^{34} cm^{-2} sec^{-1}$. Figure 91 shows the efficiencies for overlapping grids of 1.6×1.6 and 3.2×3.2 towers. Thresholds are set to achieve a 3 kHz rate, at the SSC design luminosity of $10^{33} cm^{-2} sec^{-1}$. In neither case does using the 8-bit scale significantly alter the characteristics of the curves.

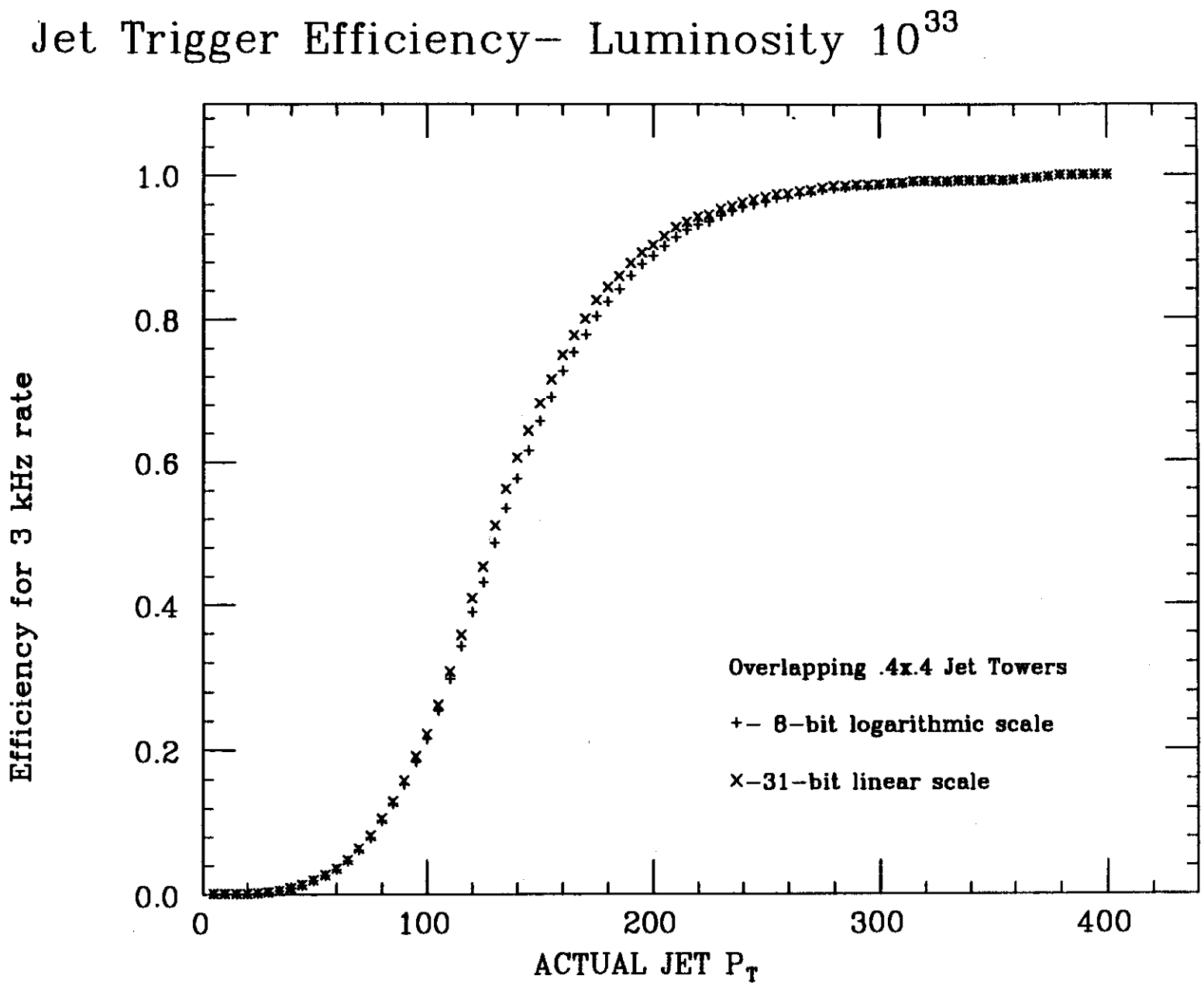
Jet Trigger Efficiency– Luminosity 10^{33}
Efficiency for 3 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
Overlapping .4x.4 Jet Towers
+– 8–bit logarithmic scale
×–31–bit linear scale

Figure 80

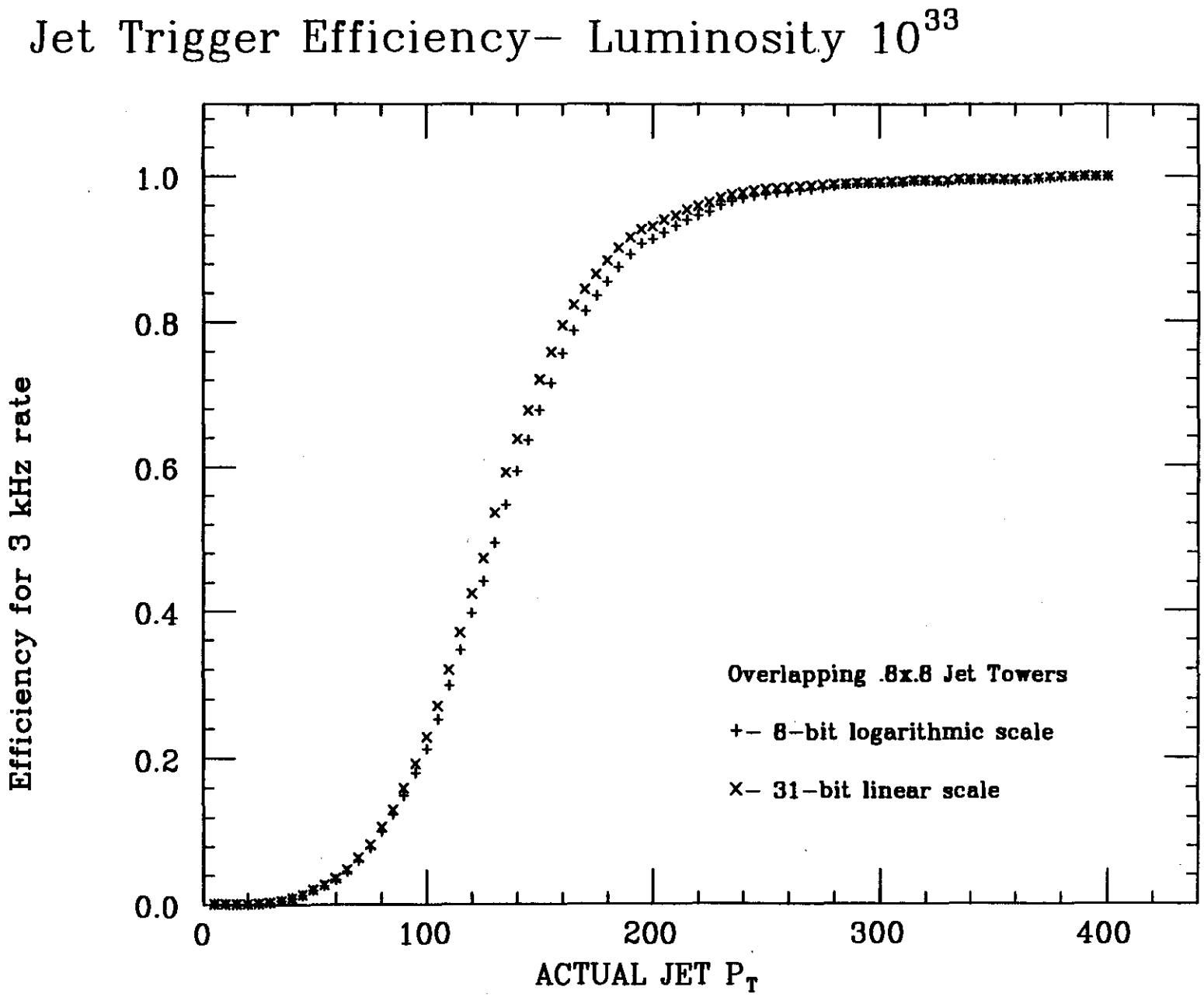
Jet Trigger Efficiency– Luminosity 10^{33}
Efficiency for 3 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
Overlapping .8x.8 Jet Towers
+– 8–bit logarithmic scale
×– 31–bit linear scale

Figure 81

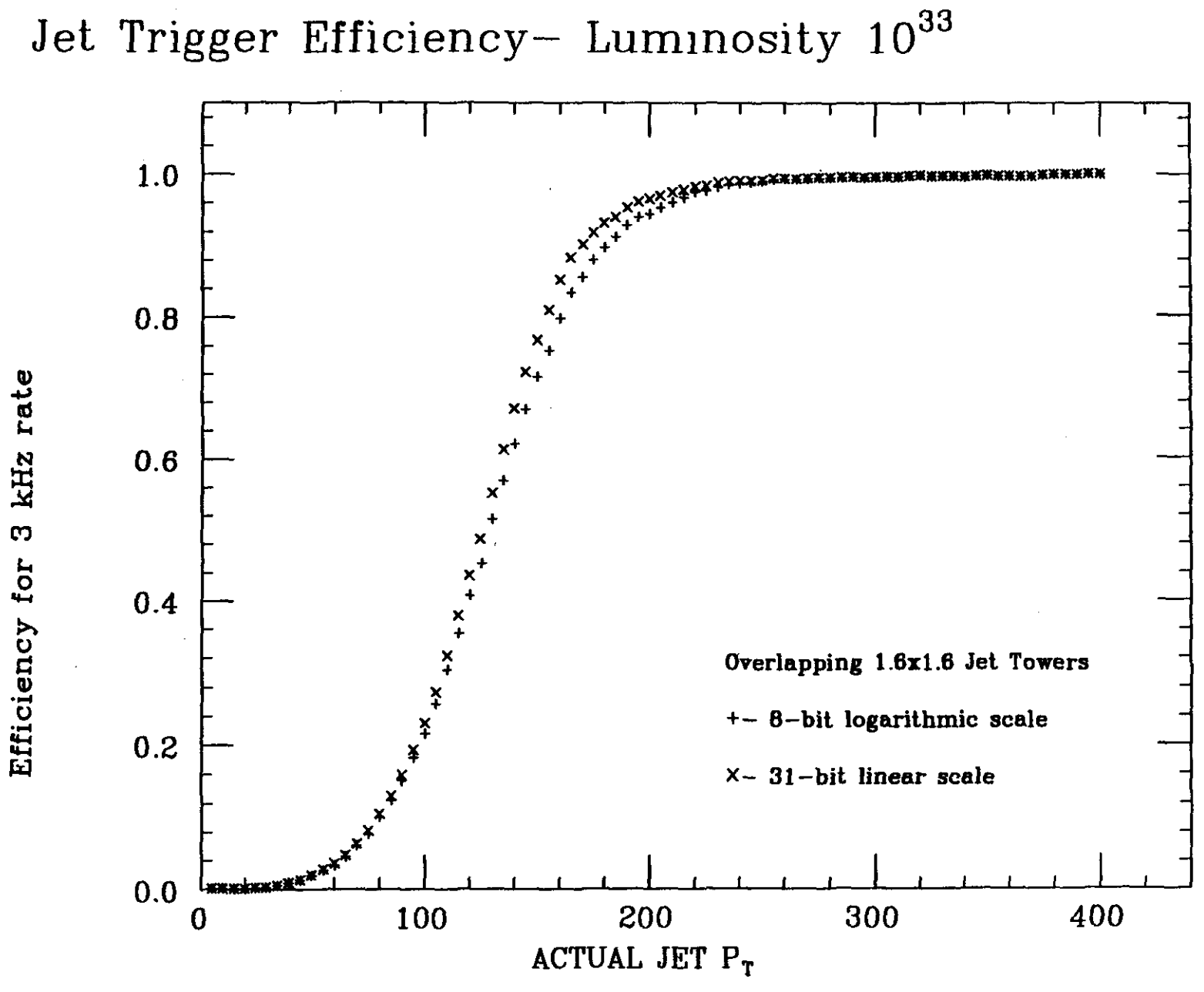
Jet Trigger Efficiency– Luminosity 10^{33}
Efficiency for 3 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
Overlapping 1.6x1.6 Jet Towers
+– 8–bit logarithmic scale
×– 31–bit linear scale

Figure 82

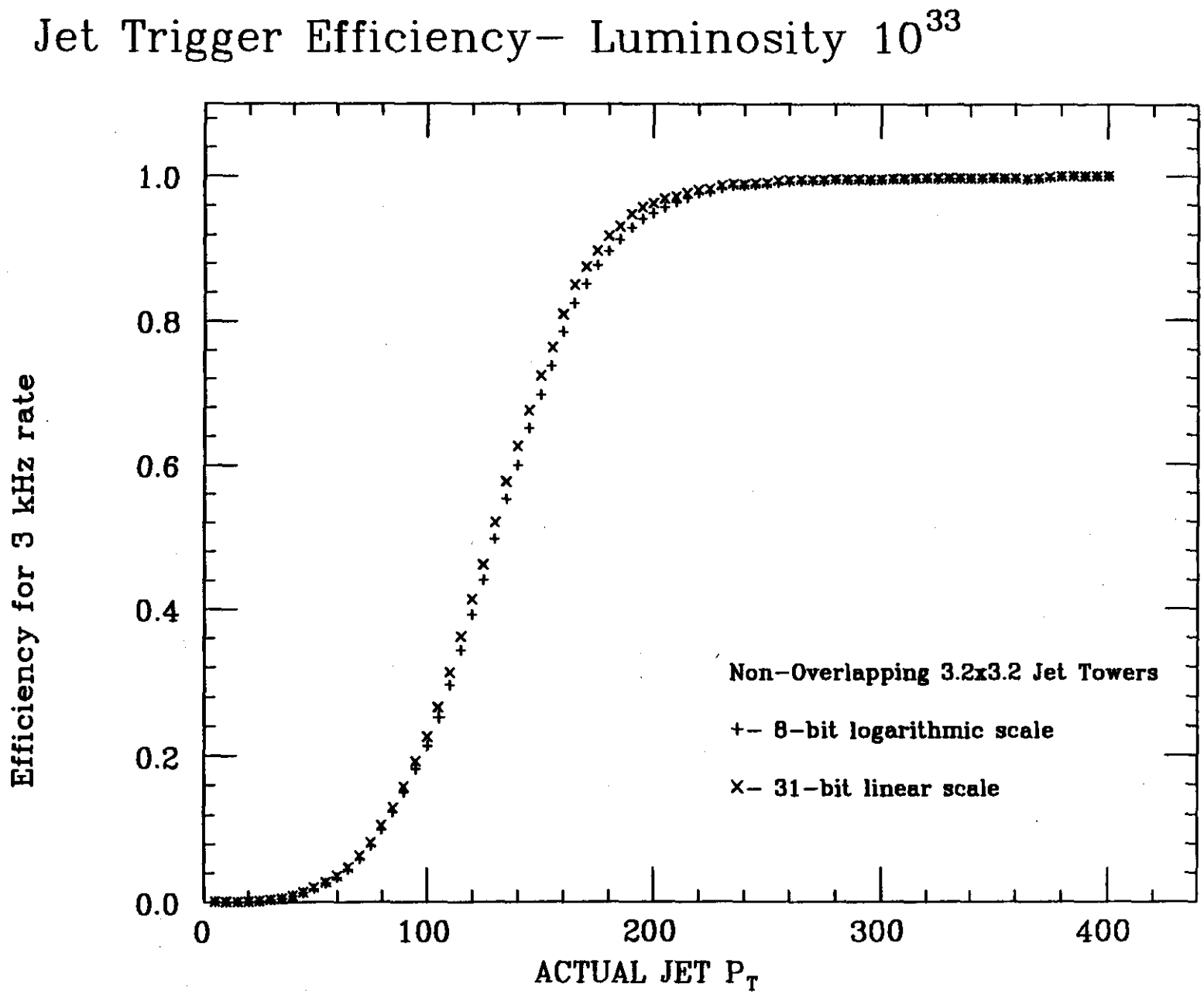
Jet Trigger Efficiency– Luminosity 10^{33}
Efficiency for 3 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
Non–Overlapping 3.2x3.2 Jet Towers
+– 8–bit logarithmic scale
×– 31–bit linear scale

Figure 83

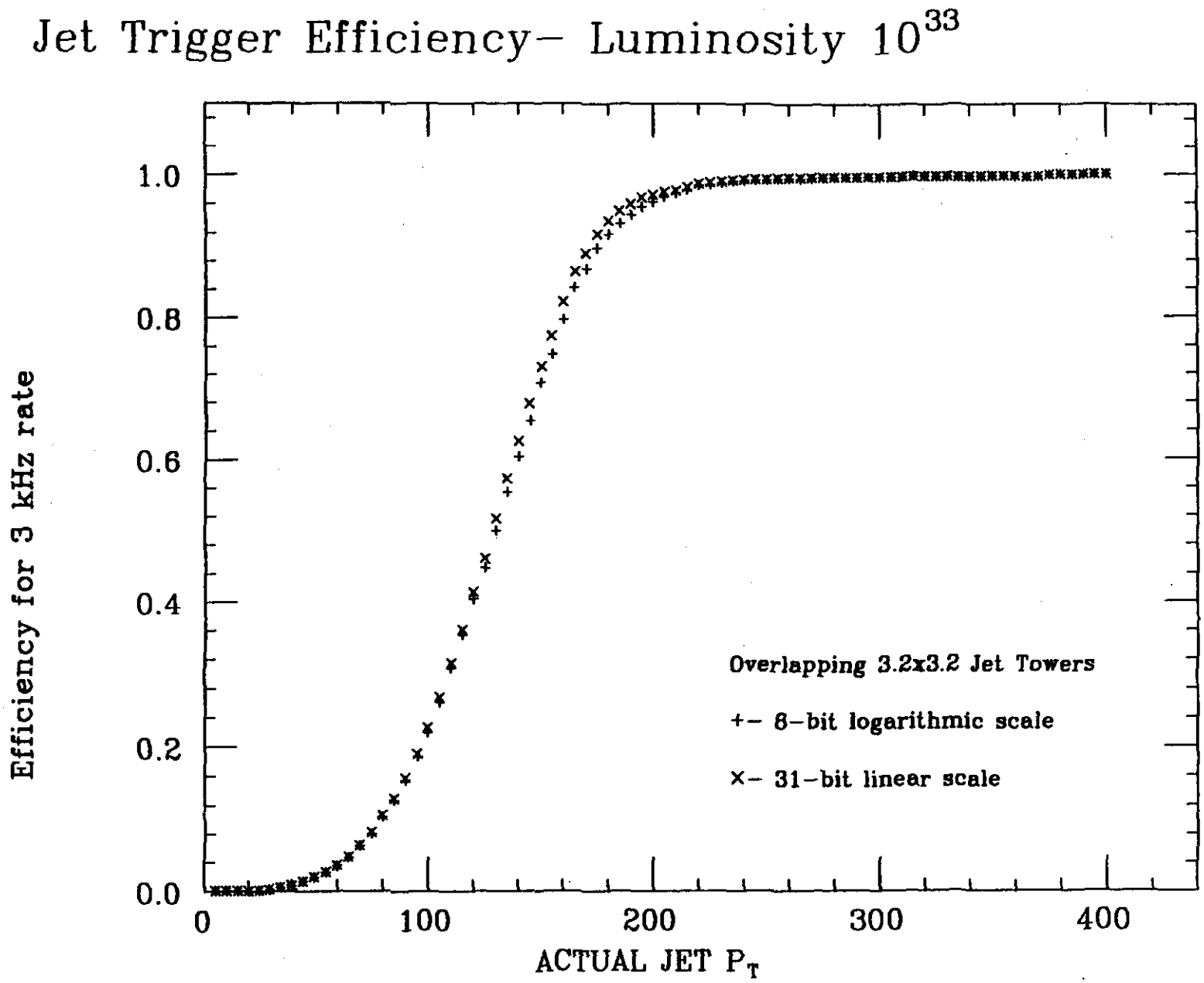
Jet Trigger Efficiency– Luminosity 10^{33}
Efficiency for 3 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
Overlapping 3.2x3.2 Jet Towers
+– 8–bit logarithmic scale
×– 31–bit linear scale

Figure 84

Jet Trigger Efficiency– Luminosity 10^{34}

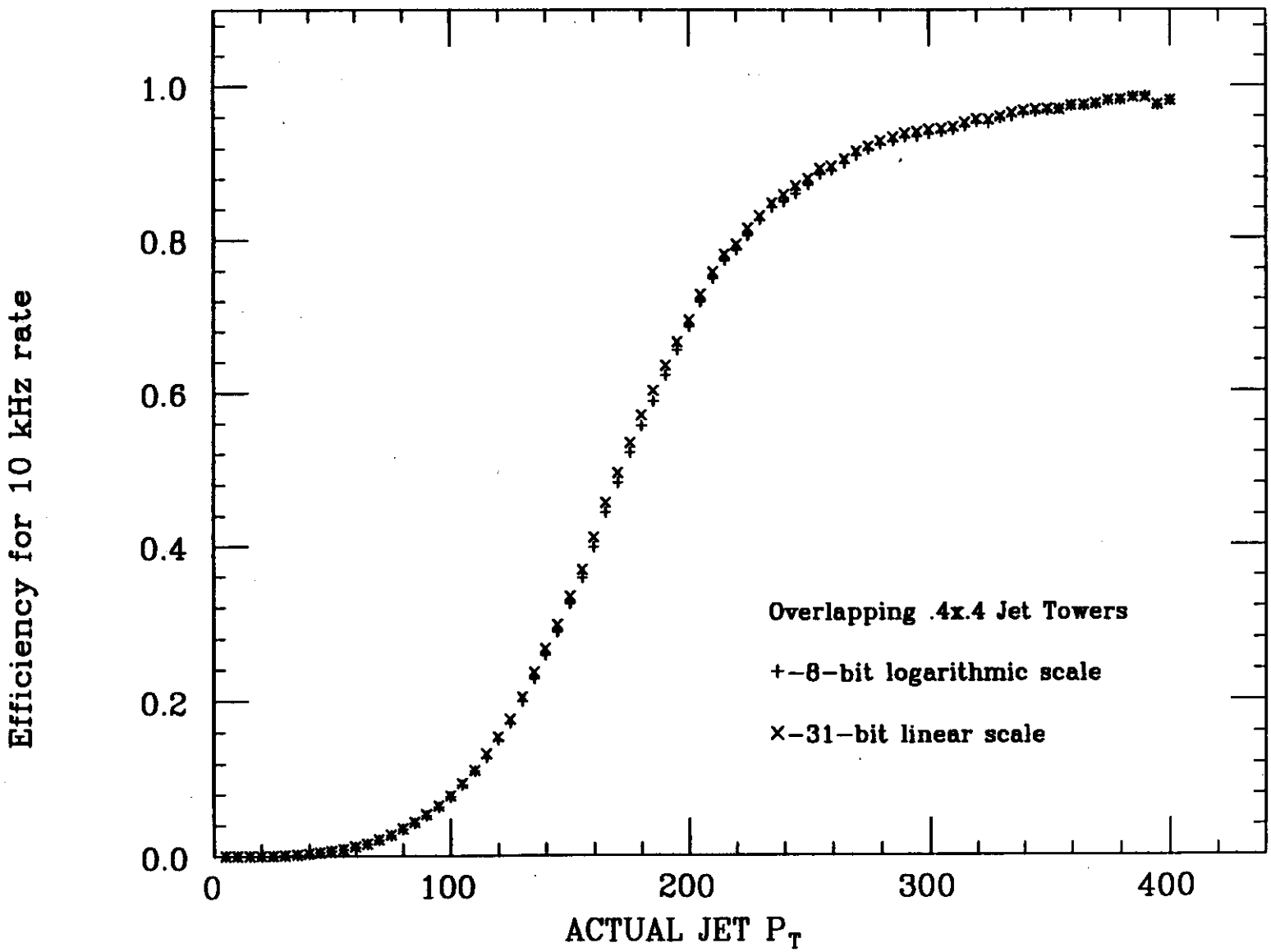

Figure 85

Jet Trigger Efficiency– Luminosity 10^{34}

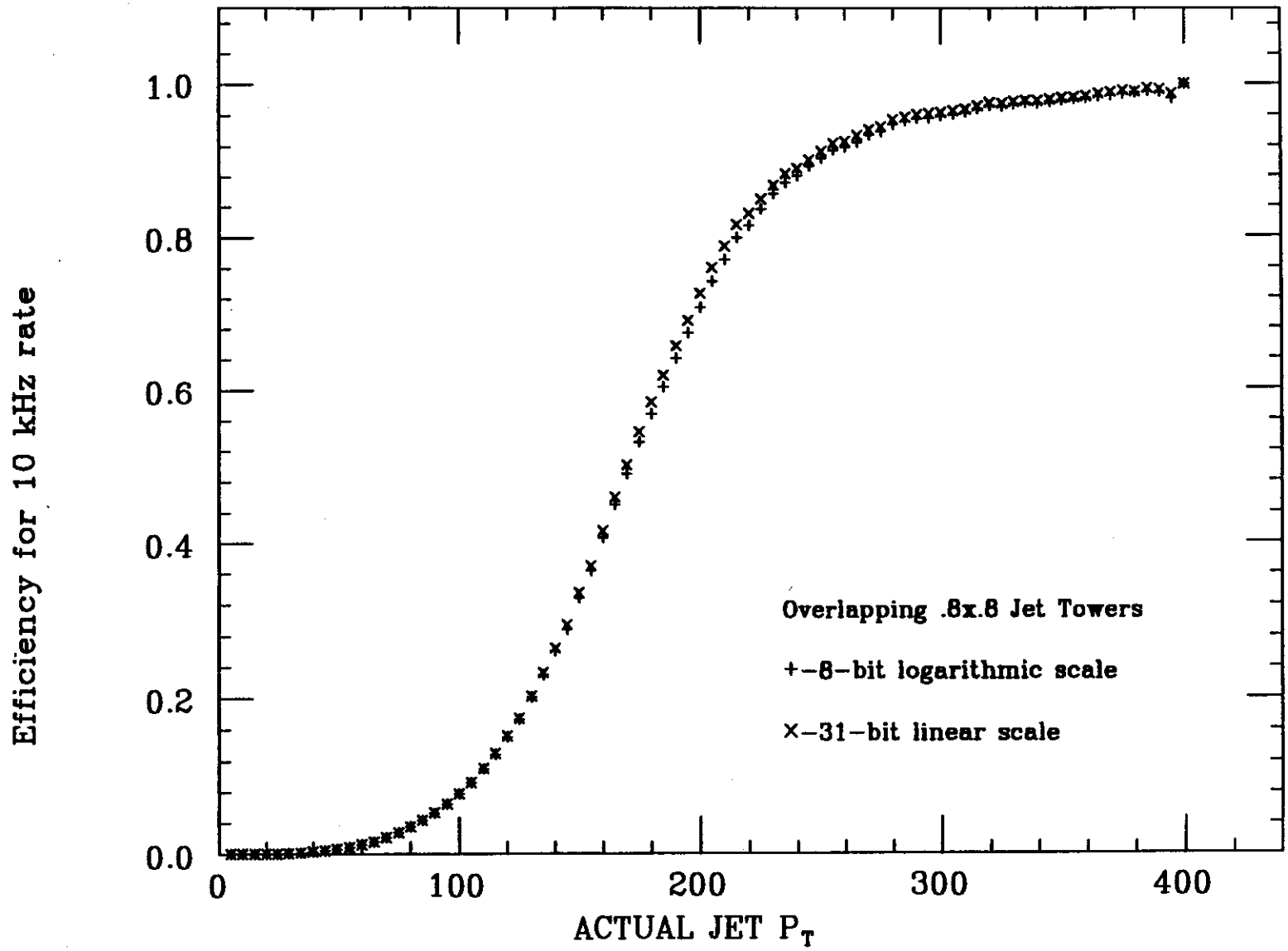

Figure 86

Jet Trigger Efficiency– Luminosity 10^{34}

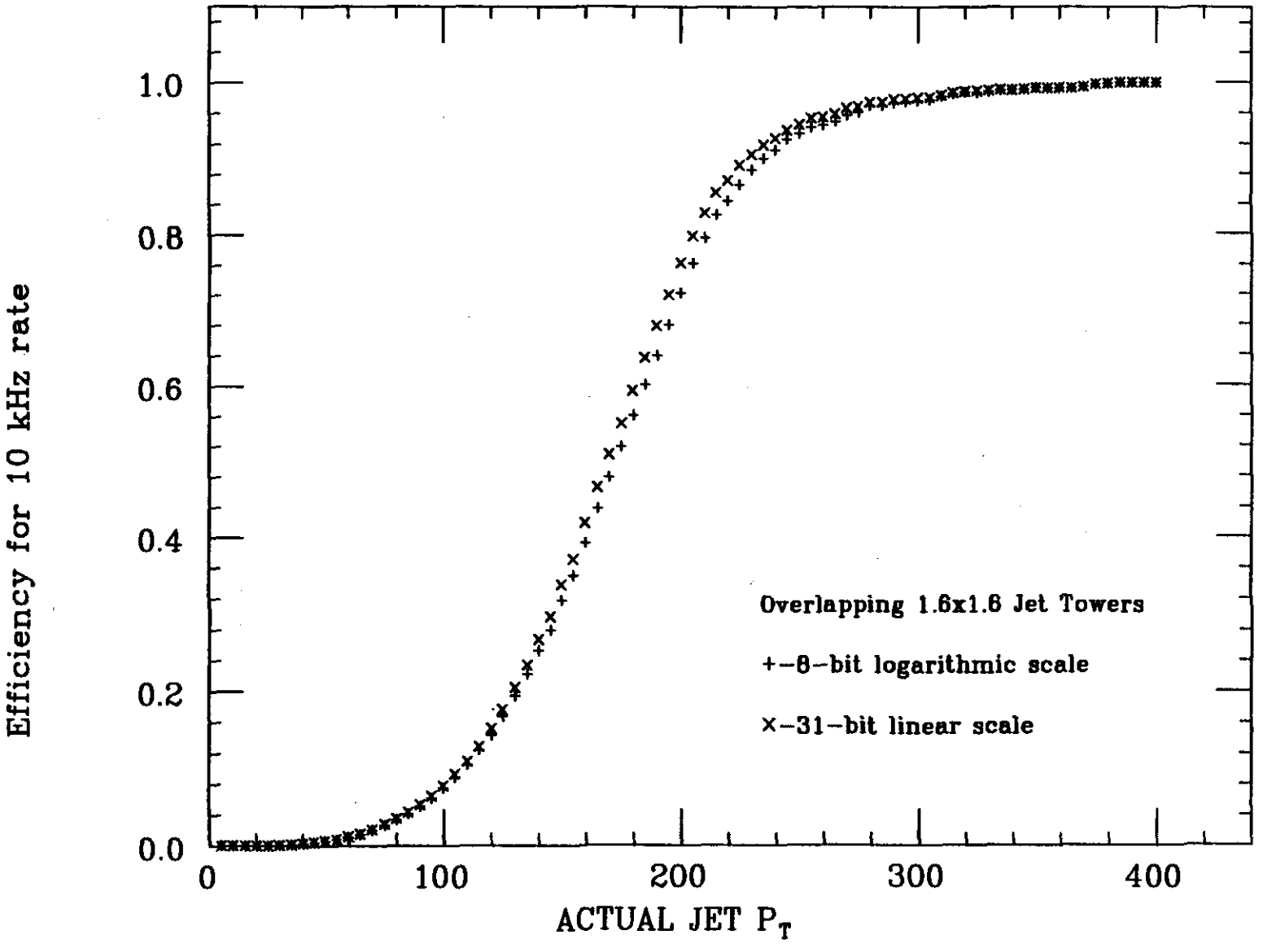

Figure 87

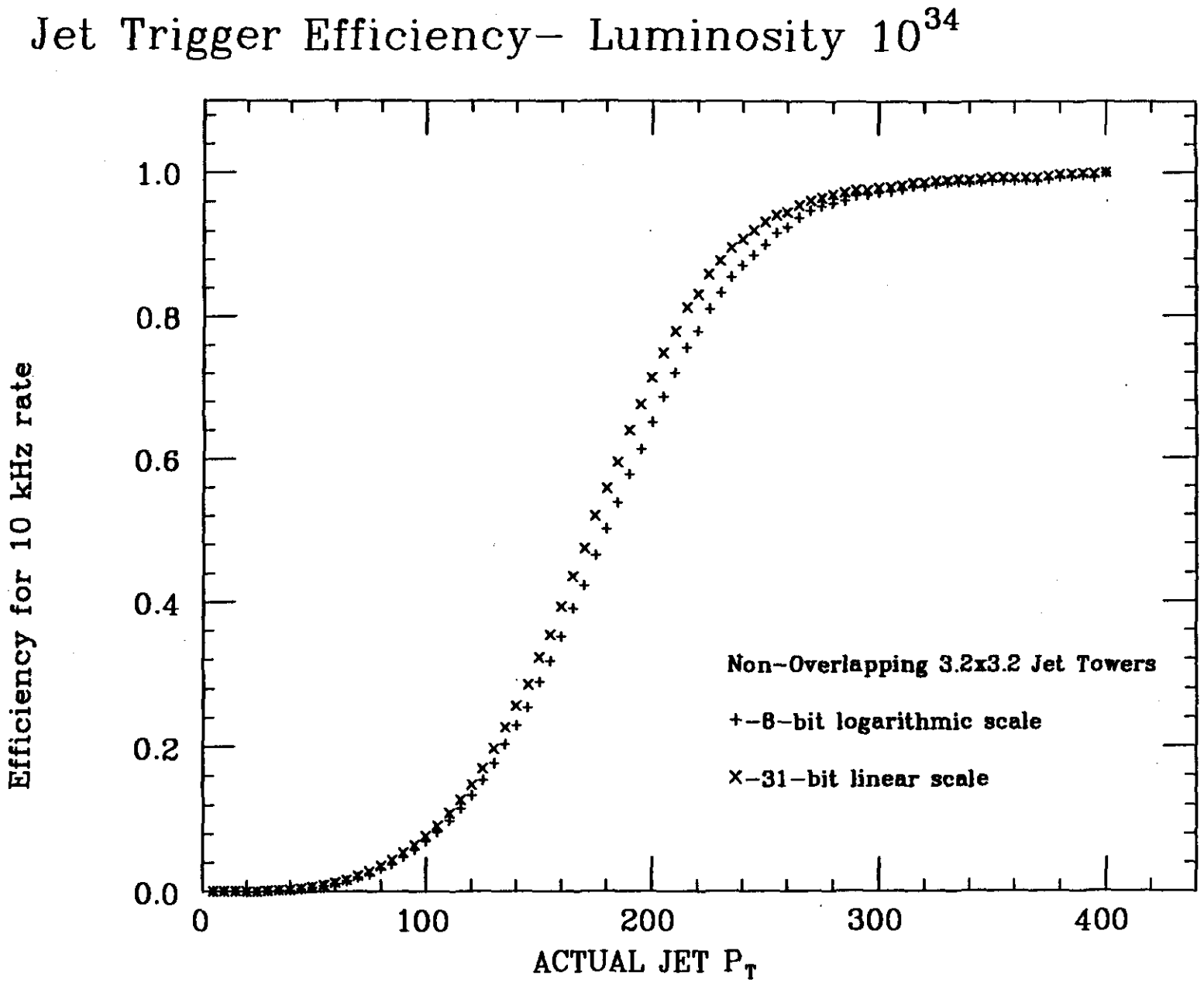
Jet Trigger Efficiency– Luminosity 10^{34}
Efficiency for 10 kHz rate
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
ACTUAL JET P_T
Non–Overlapping 3.2x3.2 Jet Towers
+–8–bit logarithmic scale
×–31–bit linear scale

Figure 88

Jet Trigger Efficiency– Luminosity 10^{34}

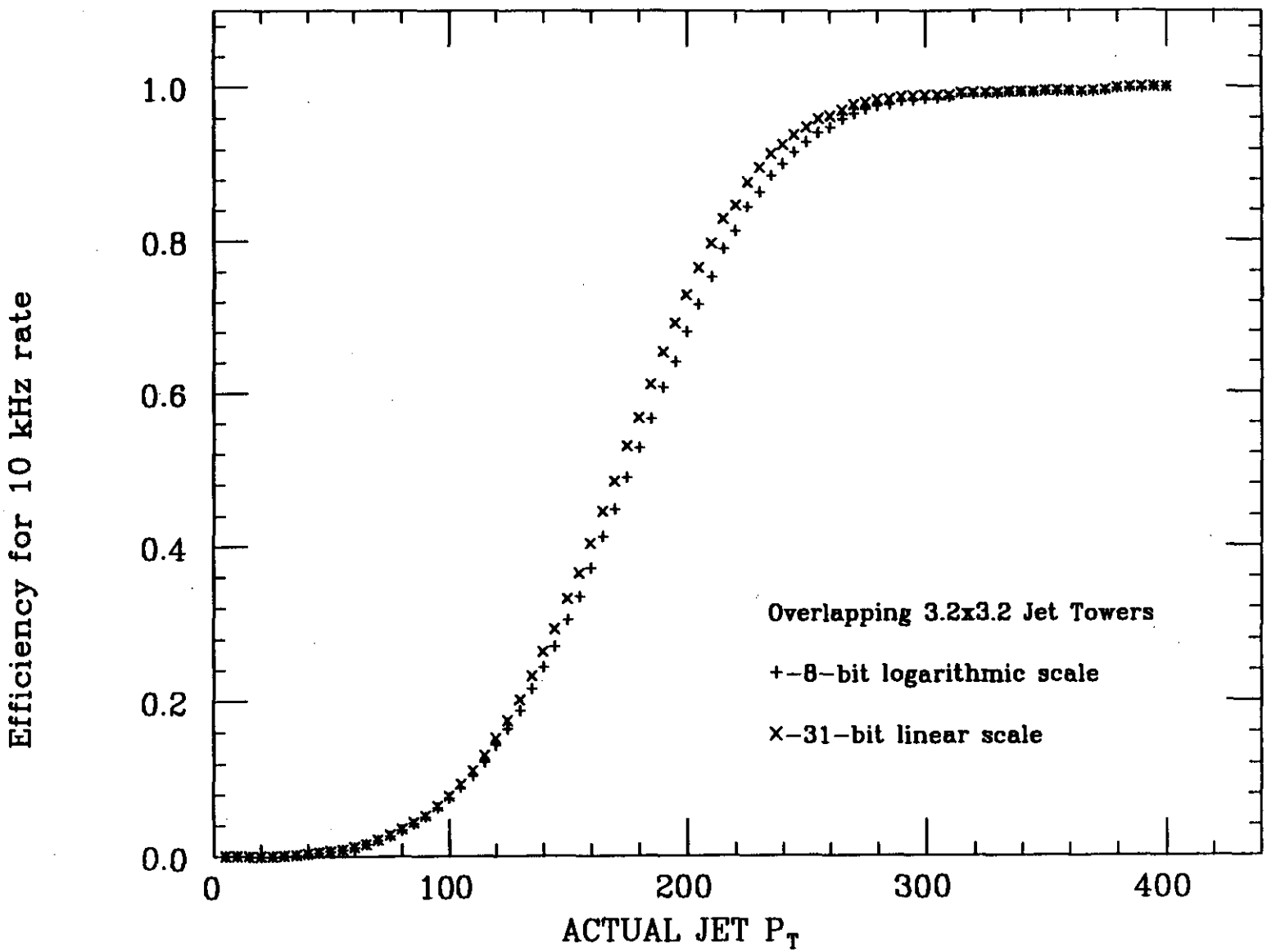

Figure 89

Jet Trigger Efficiency– Luminosity 10^{34}

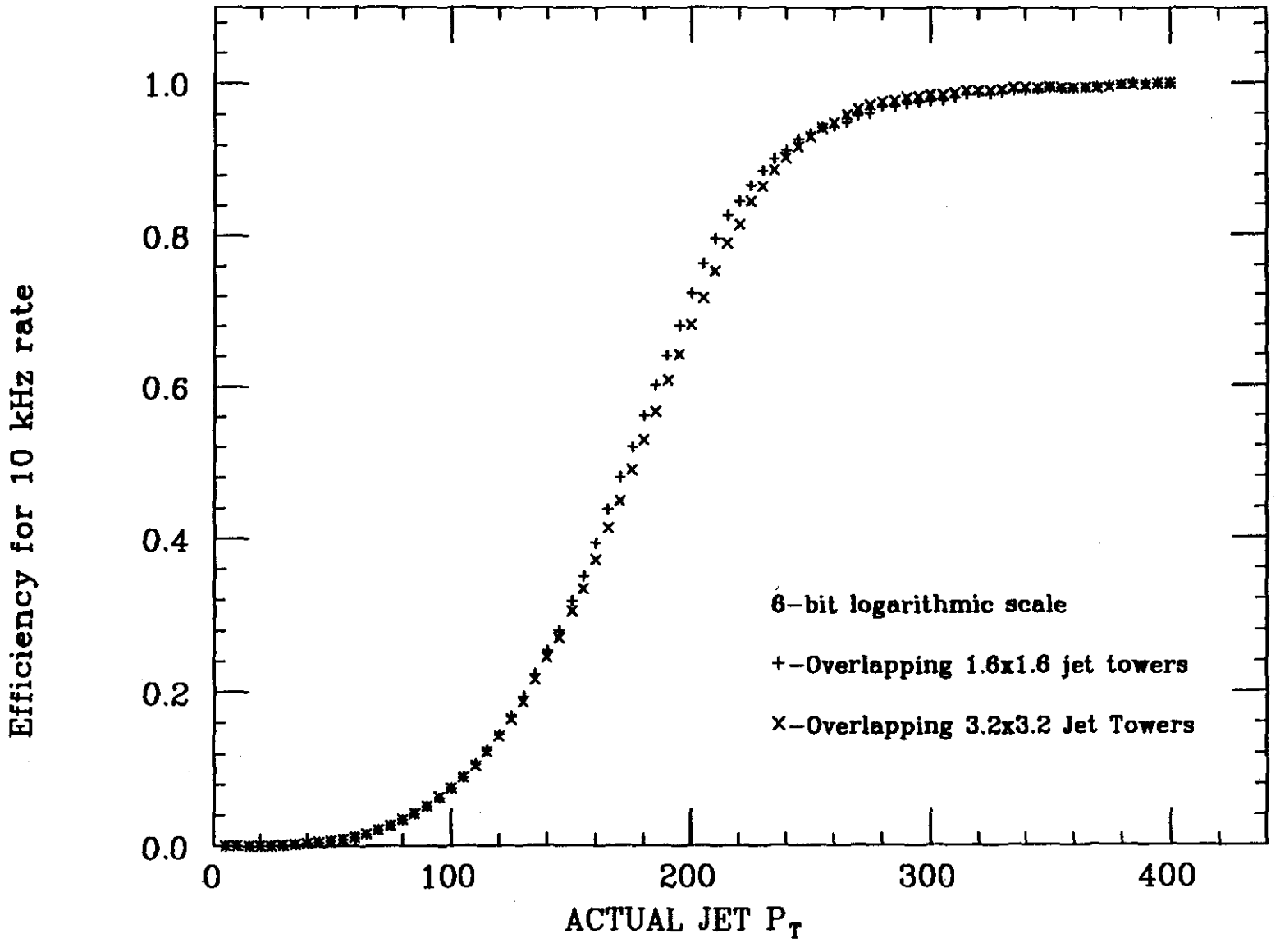

Figure 90

Jet Trigger Efficiency– Luminosity 10^{33}

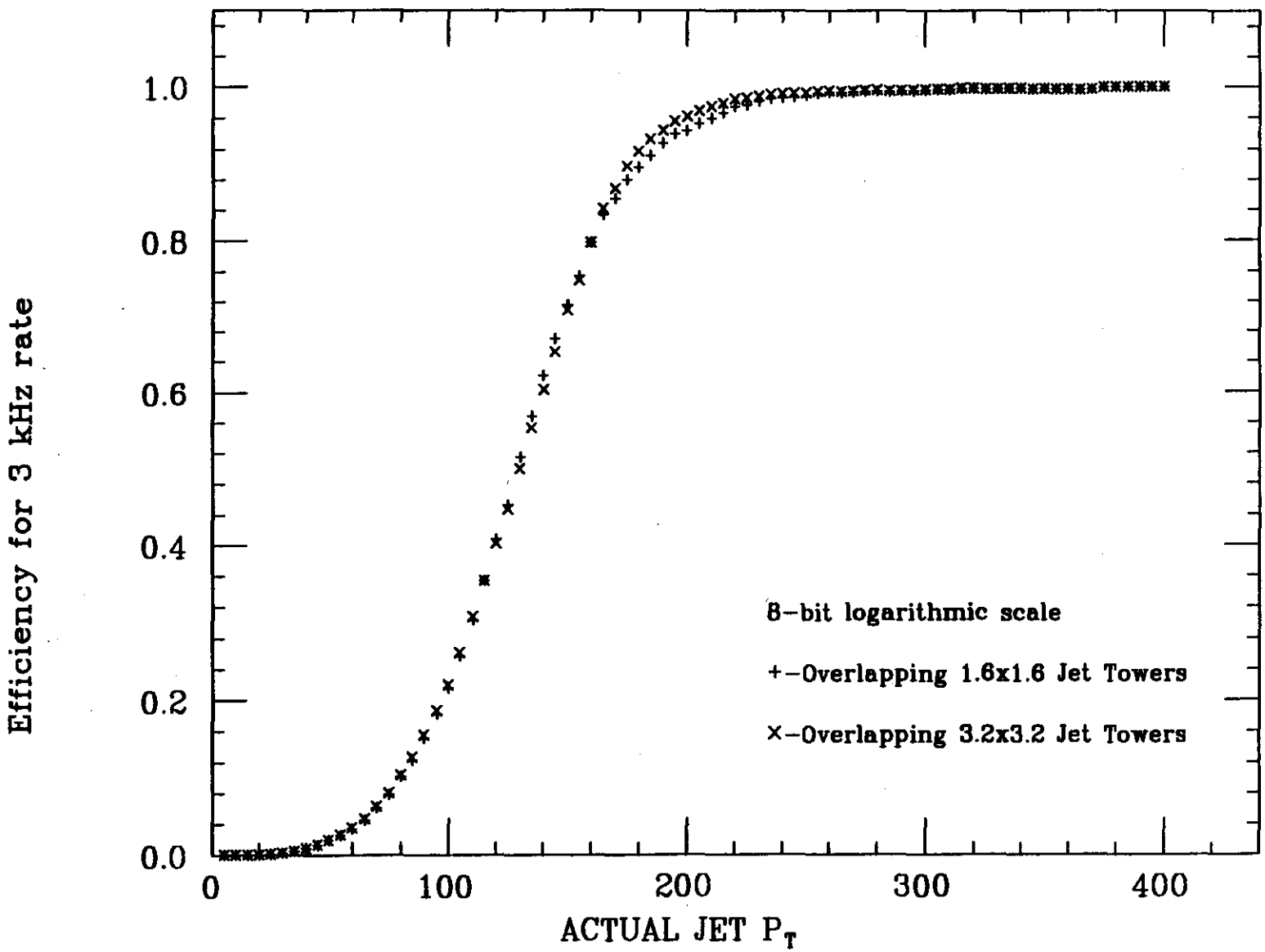

Figure 91

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