7th Workshop on Radiation Monitoring for the International Space Station

Preliminary Results of ISS Active Radiation Instruments from 1st ICCHIBAN

(InterComparison for Cosmic-ray with Heavy-Ion Beams At NIRS)

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Introduction

- Introduction to the ISS Tissue Equivalent Proportional Counter (ISS TEPC)
- Brief description of the exposures measured with the ISS TEPC
- Preliminary results of the ISS TEPC measurements
- Introduction to the Intra-Vehicular Charged Particle Directional Spectrometer (IV-CPDS)
- Brief description of the exposures measured with the IV-CPDS
- Preliminary results of the IV-CPDS measurements
- Summary and Conclusions

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First time in Japan…"Let's go find some cold soba!"

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After first Earthquake…"Maybe these helmets are a good idea after all!"

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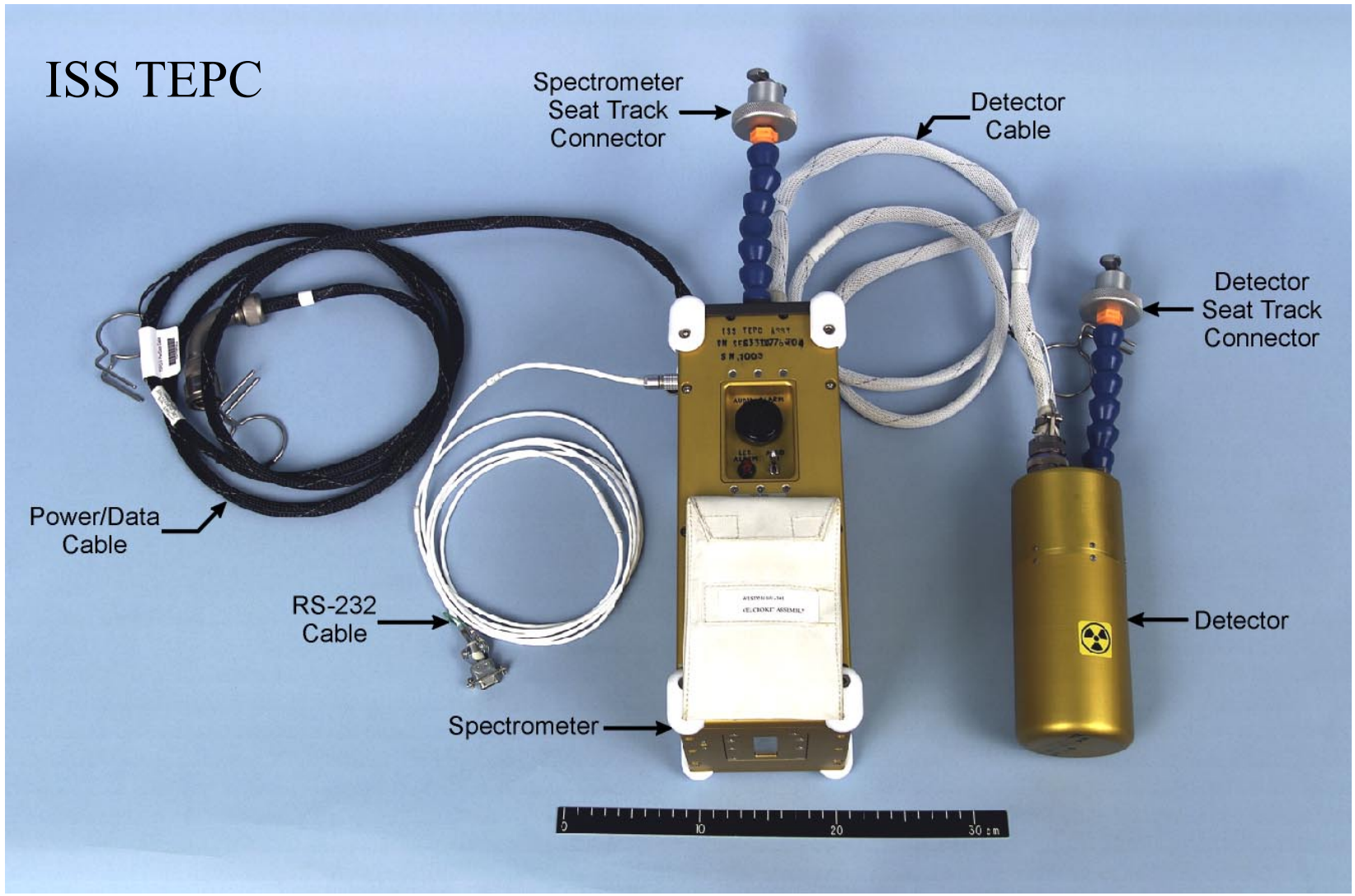
Grand Champion - Guest House B…"Let's Wrestle!"


ISS TEPC
Spectrometer Seat Track Connector
Detector Cable
Detector Seat Track Connector
Power/Data Cable
RS-232 Cable
Detector
Spectrometer
0
10
20
30 cm

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ISS TEPC Spectrometer

Dual Multi-Channel Analyzer Design
- 1024 Channels of Low-Gain Data
- 256 Channels of High-Gain Data

RS-232 and 1553 Communication Ports
120 V or 28 V Power Operation

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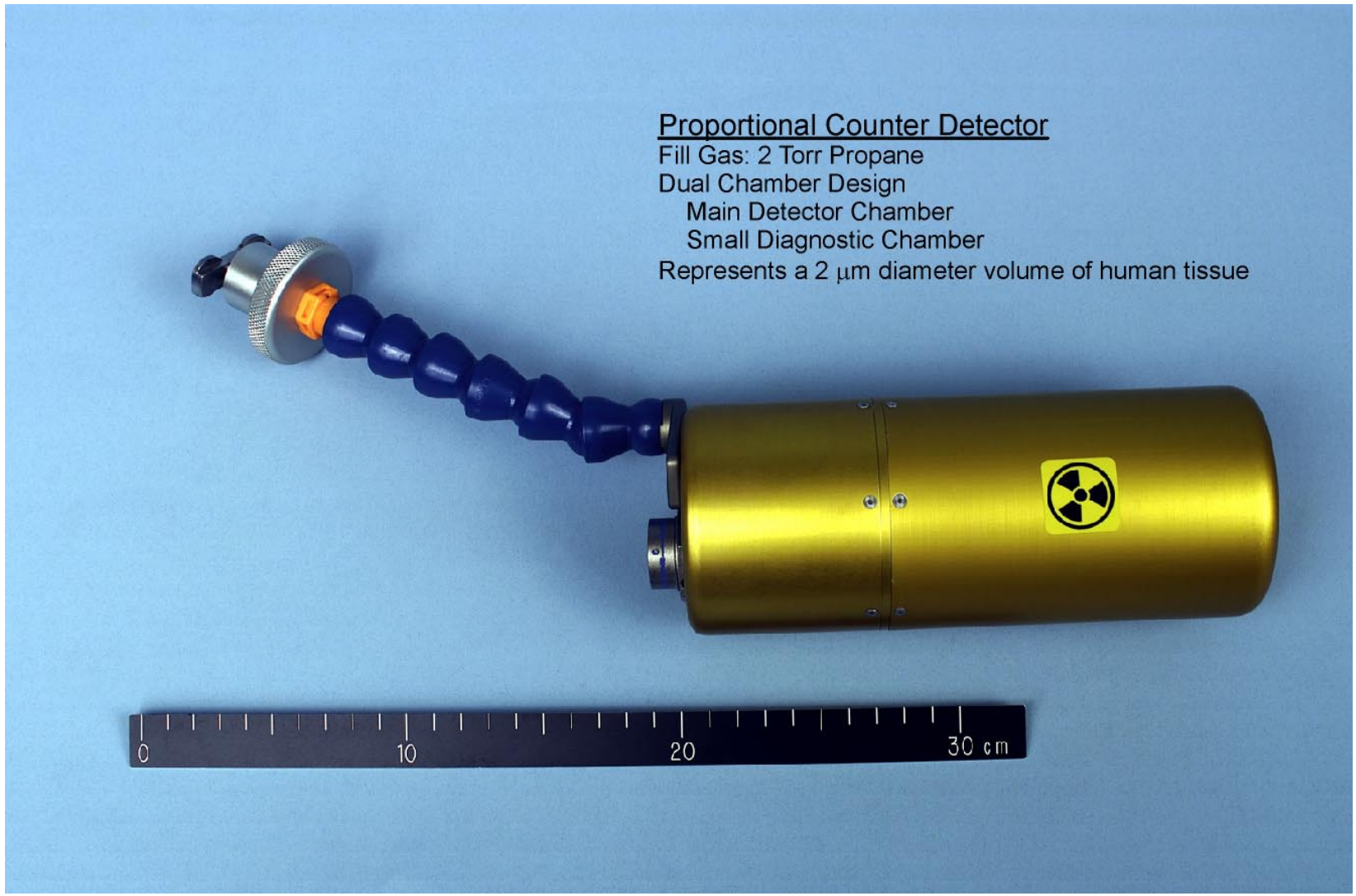

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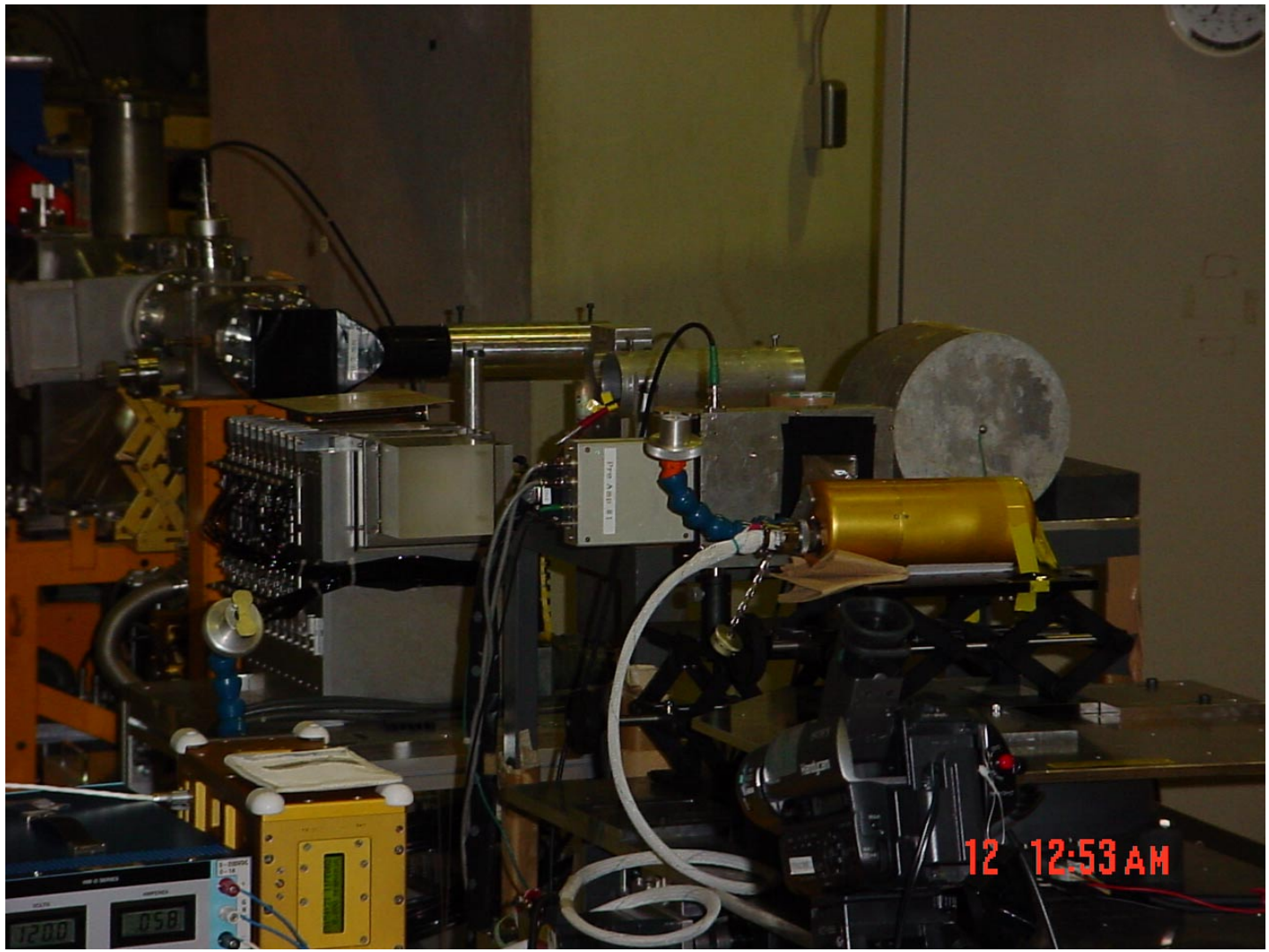
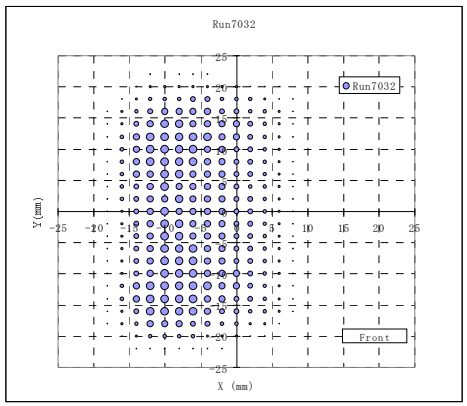
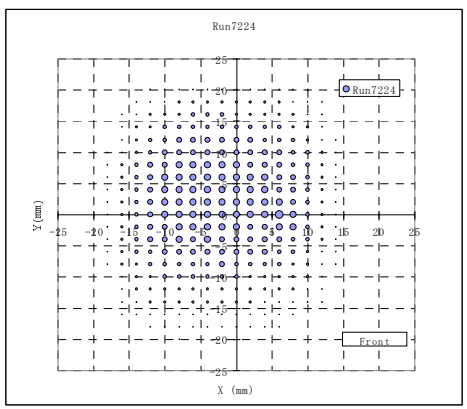


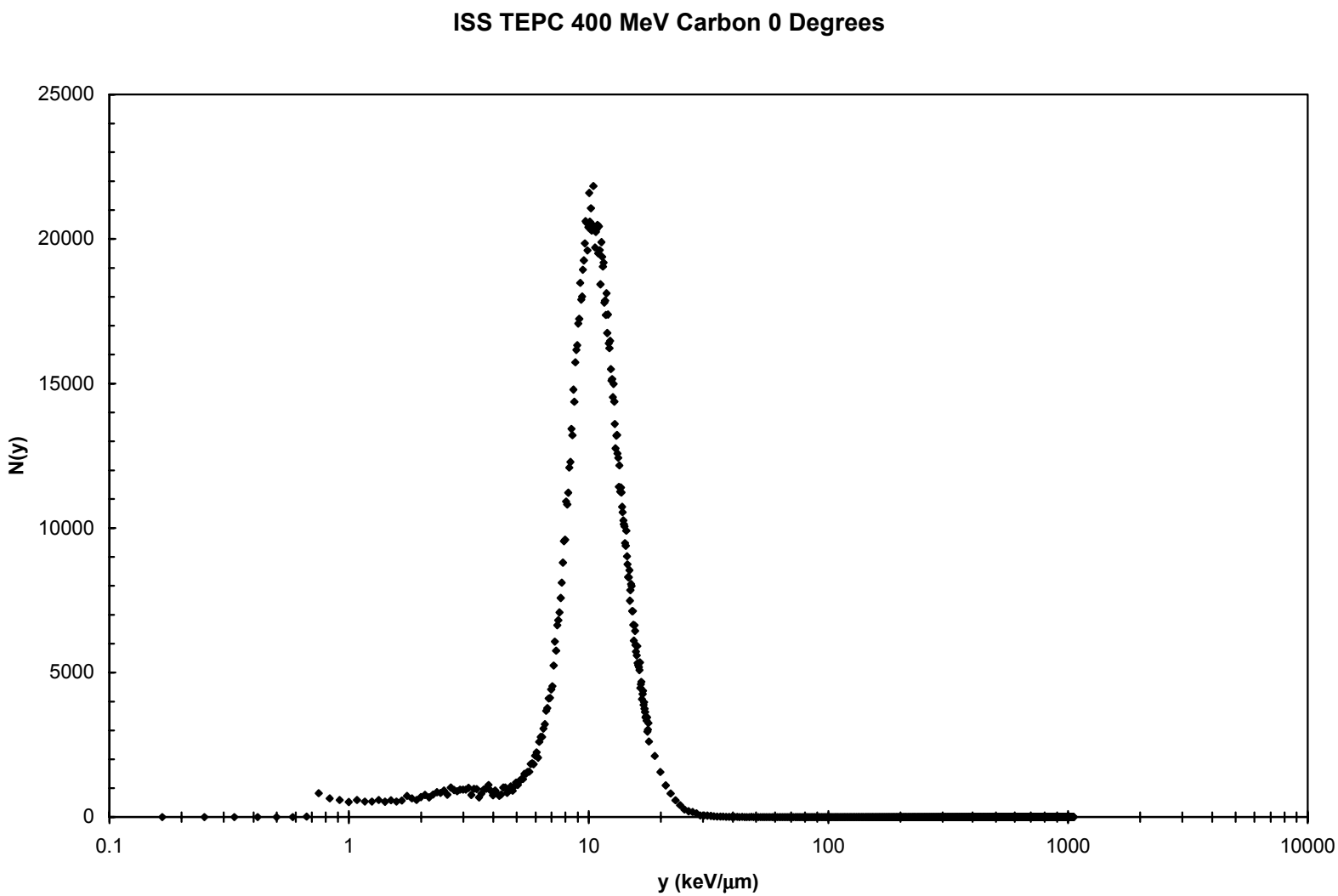
ISS TEPC Exposure Summary

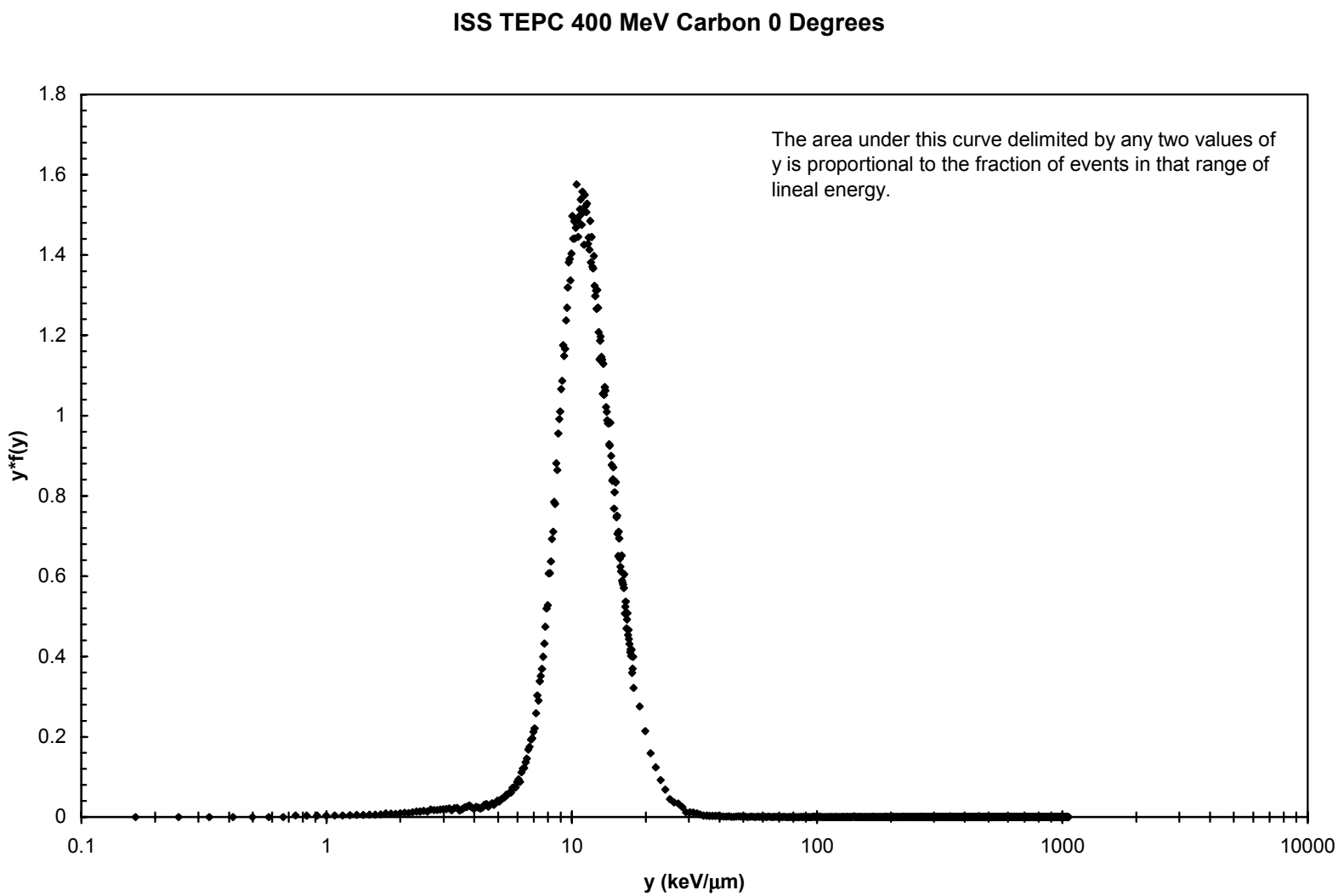


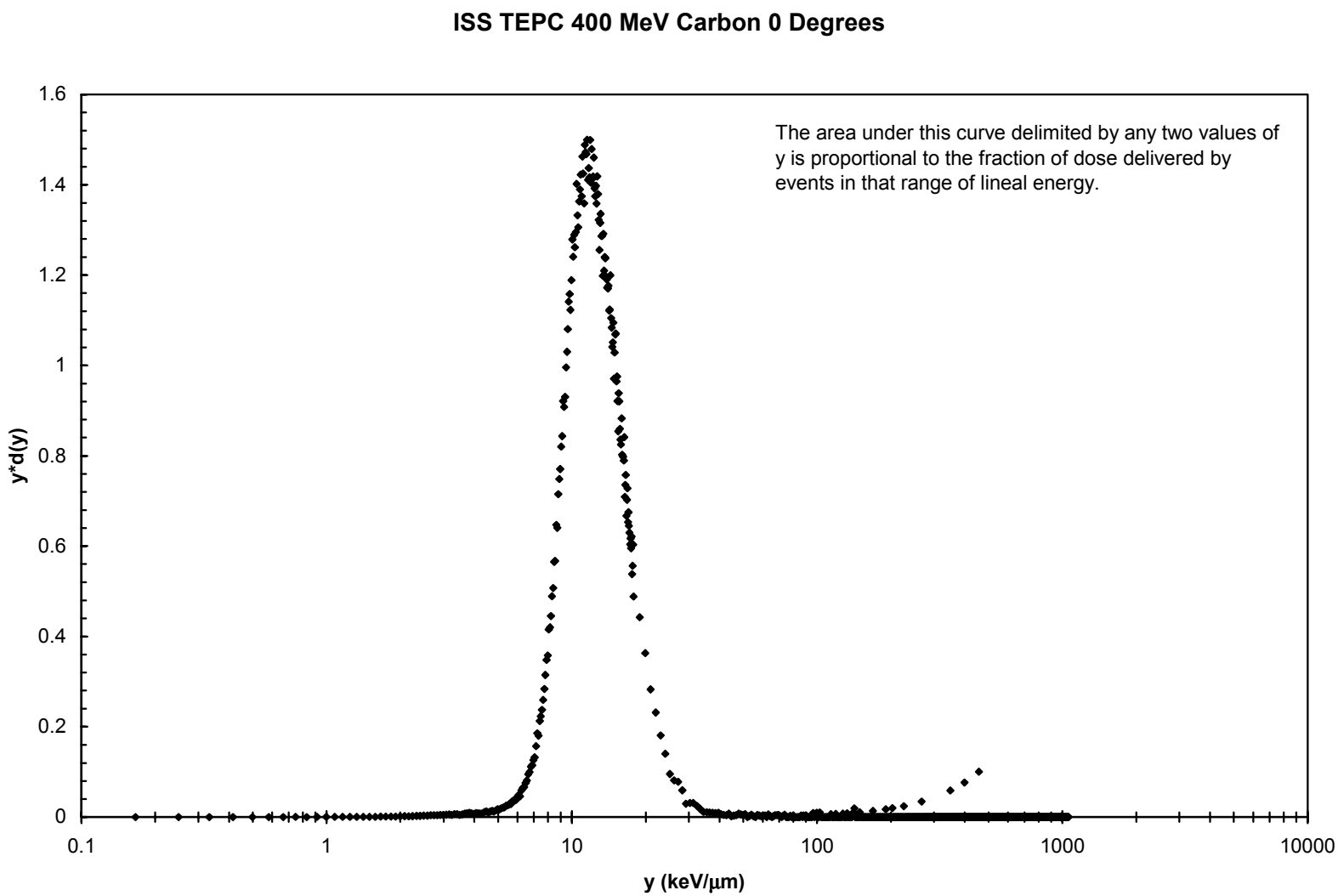
398 MeV Carbon Beam
Run 7032 – 0 Degrees Centered (30 minutes)
Run 7033 – 30 Degrees Centered (30 minutes)
Run 7034 – 90 Degrees Centered (20 minutes)
Run 7035 – 0 Degrees X+15 Z+15 (20 minutes)

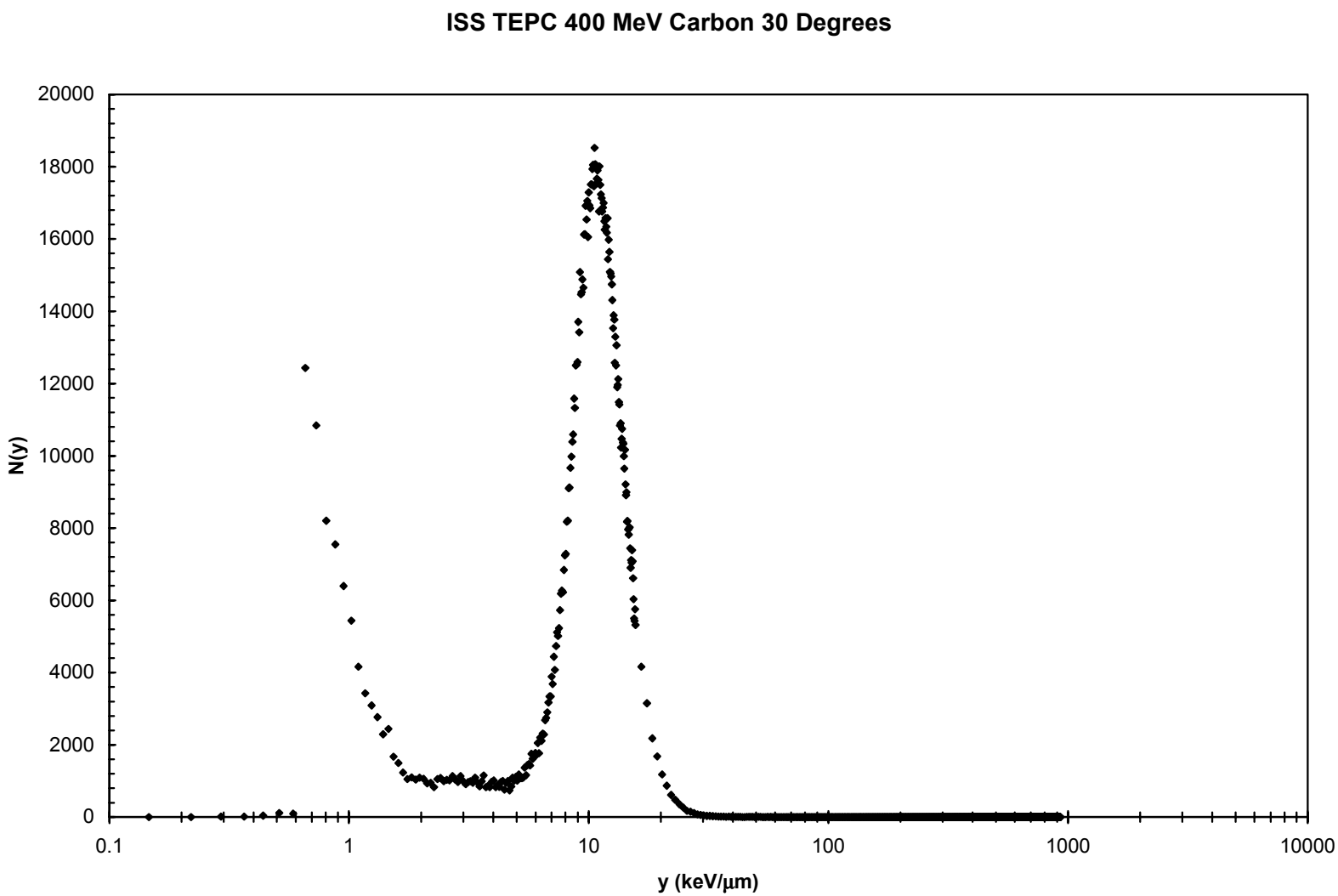


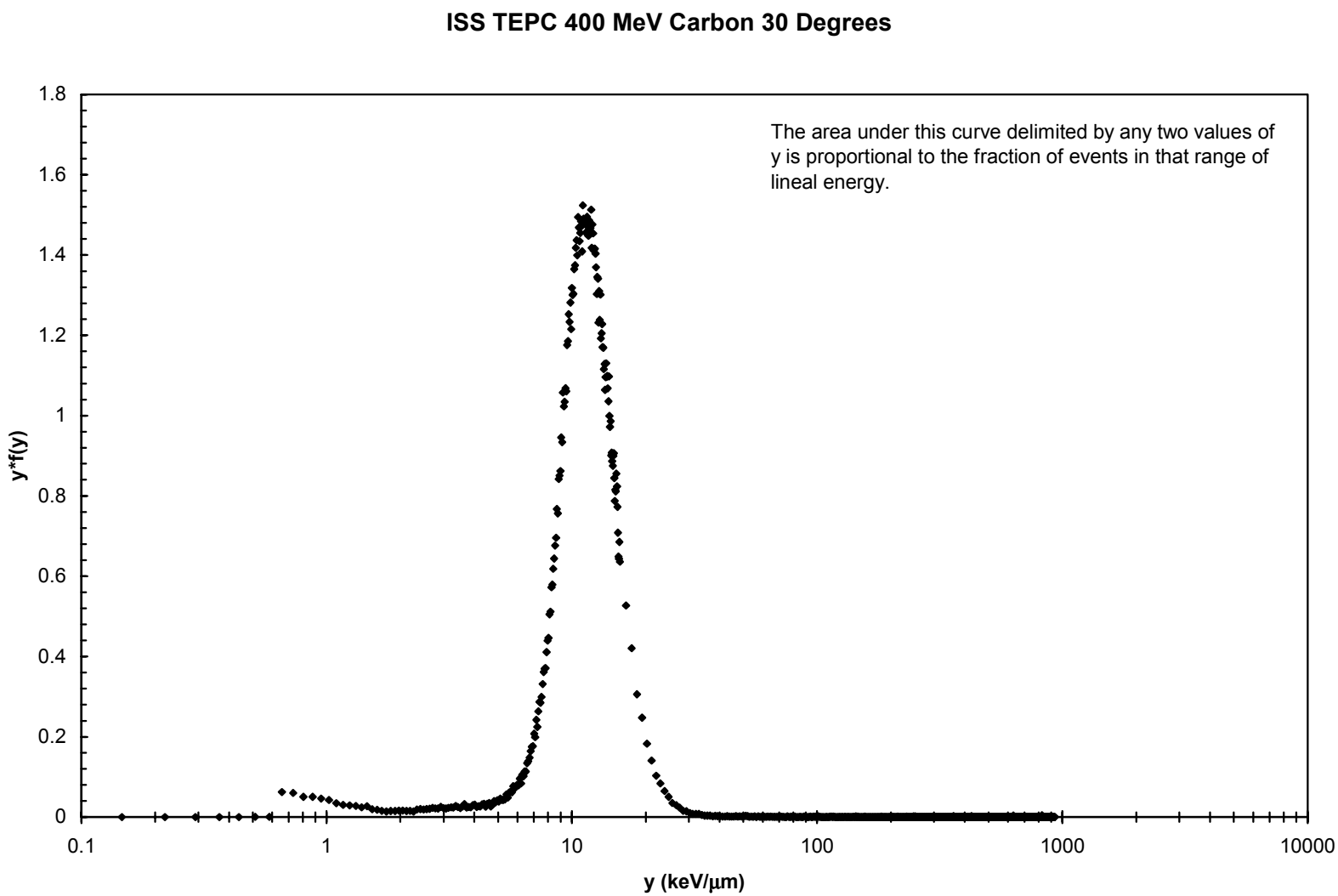
388 MeV Iron Beam
Run 7224 – 0 Degrees Centered (30 minutes)
Run 7225 – 30 Degrees Centered (20 minutes)
Run 7226 – 90 Degrees Centered (15 minutes)
Run 7227 – 0 Degrees X+15 Z+15 (20 minutes)


ISS TEPC 400 MeV Carbon 0 Degrees
25000
20000
15000
10000
5000
0
N(y)
0.1
1
10
100
1000
10000
y (keV/µm)

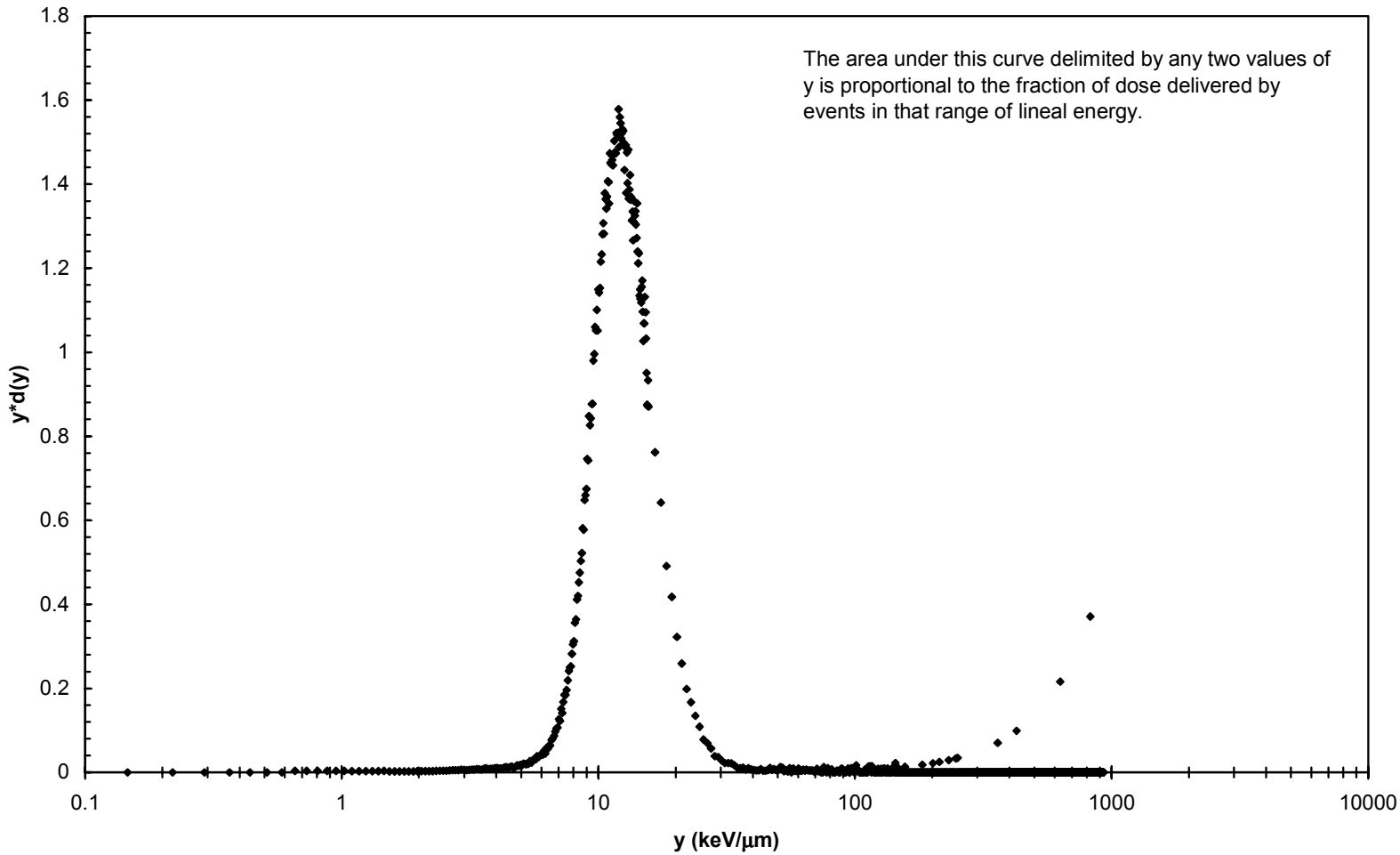

ISS TEPC 400 MeV Carbon 0 Degrees
The area under this curve delimited by any two values of y is proportional to the fraction of events in that range of lineal energy.
y*f(y)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.1
1
10
100
1000
10000
y (keV/µm)

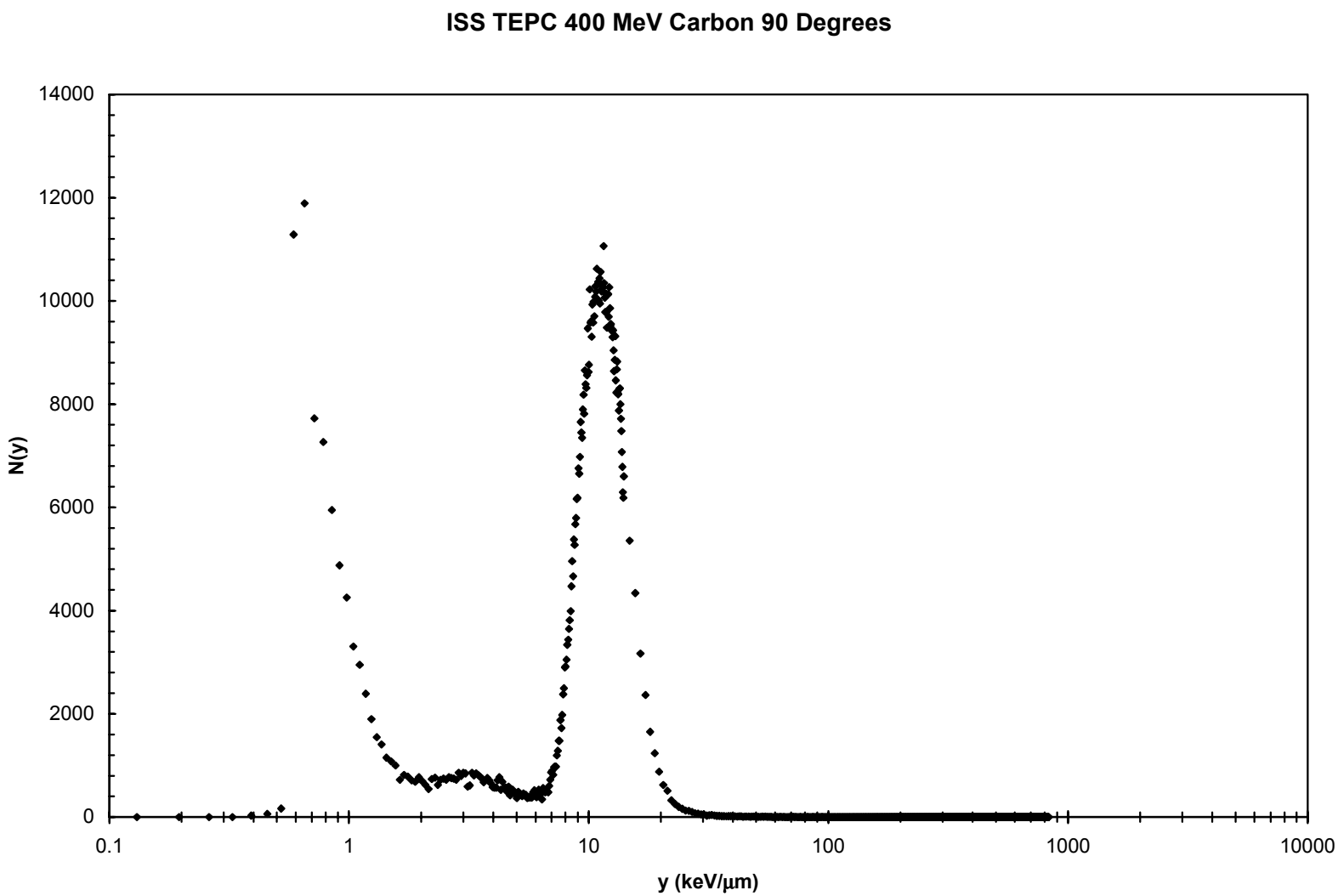

ISS TEPC 400 MeV Carbon 0 Degrees
The area under this curve delimited by any two values of y is proportional to the fraction of dose delivered by events in that range of lineal energy.
y*d(y)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.1
1
10
100
1000
10000
y (keV/µm)

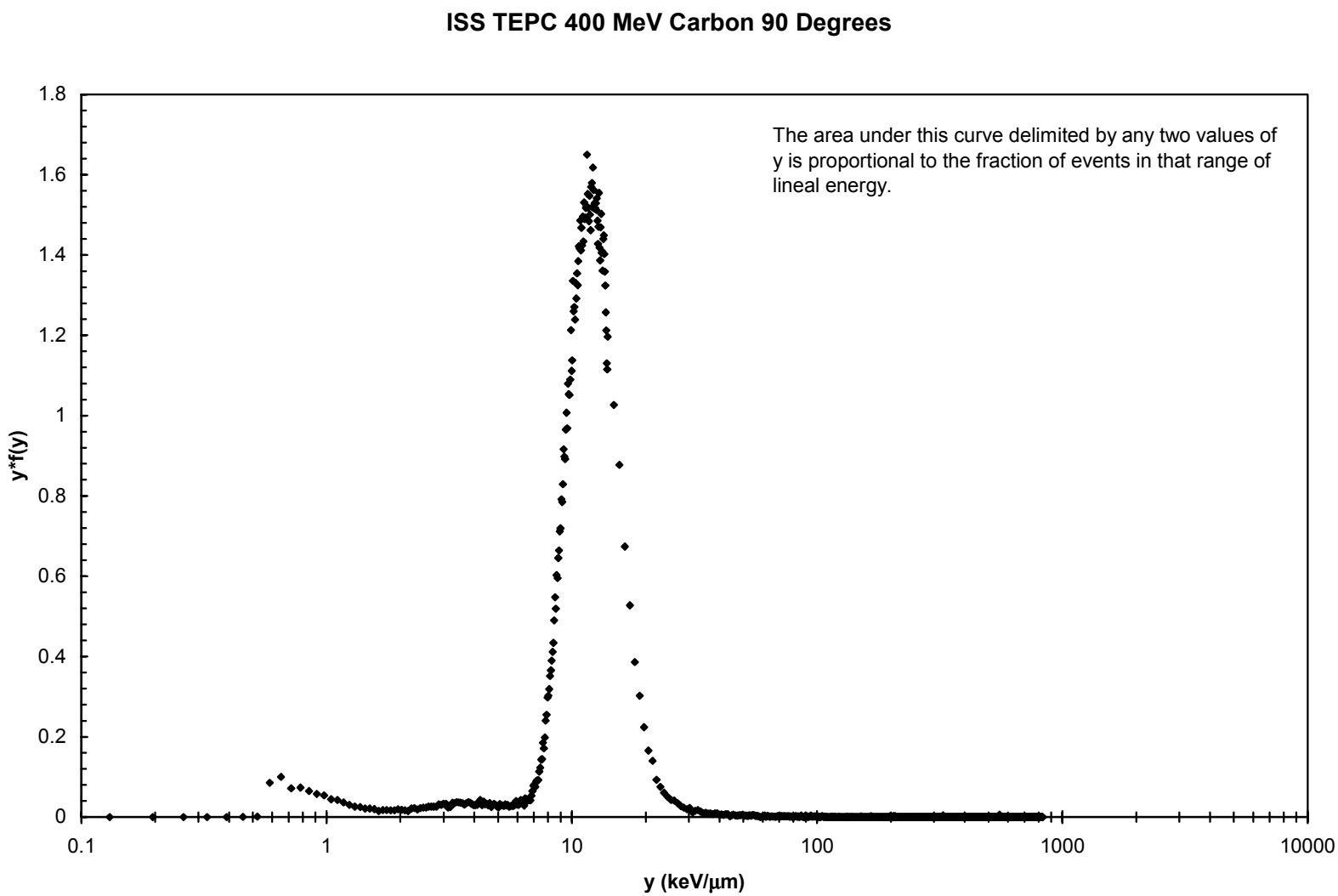

ISS TEPC 400 MeV Carbon 30 Degrees
N(y)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0.1
1
10
100
1000
10000
y (keV/µm)


ISS TEPC 400 MeV Carbon 30 Degrees
The area under this curve delimited by any two values of y is proportional to the fraction of events in that range of lineal energy.
y*f(y)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.1
1
10
100
1000
10000
y (keV/µm)

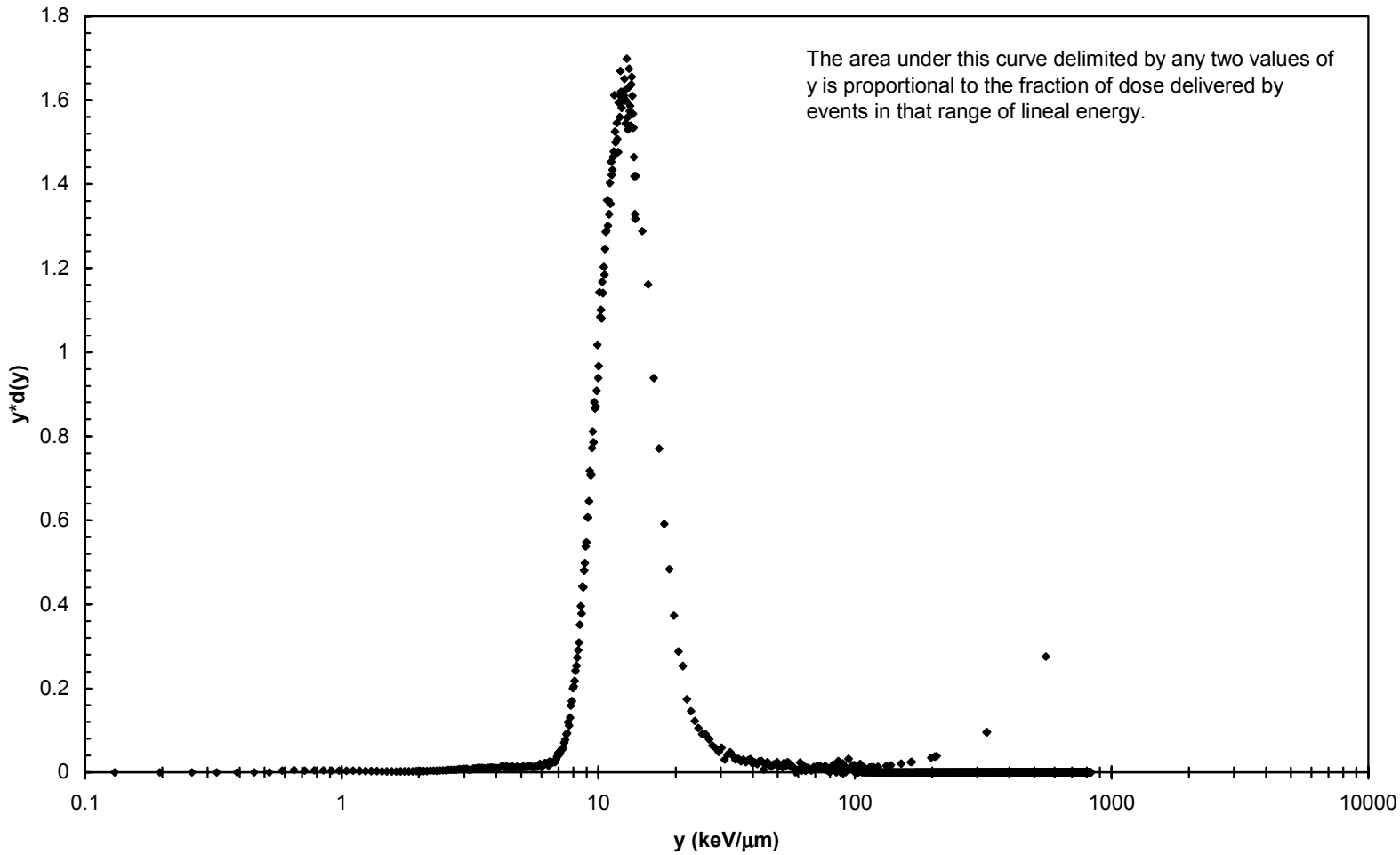
ISS TEPC 400 MeV Carbon 30 Degrees

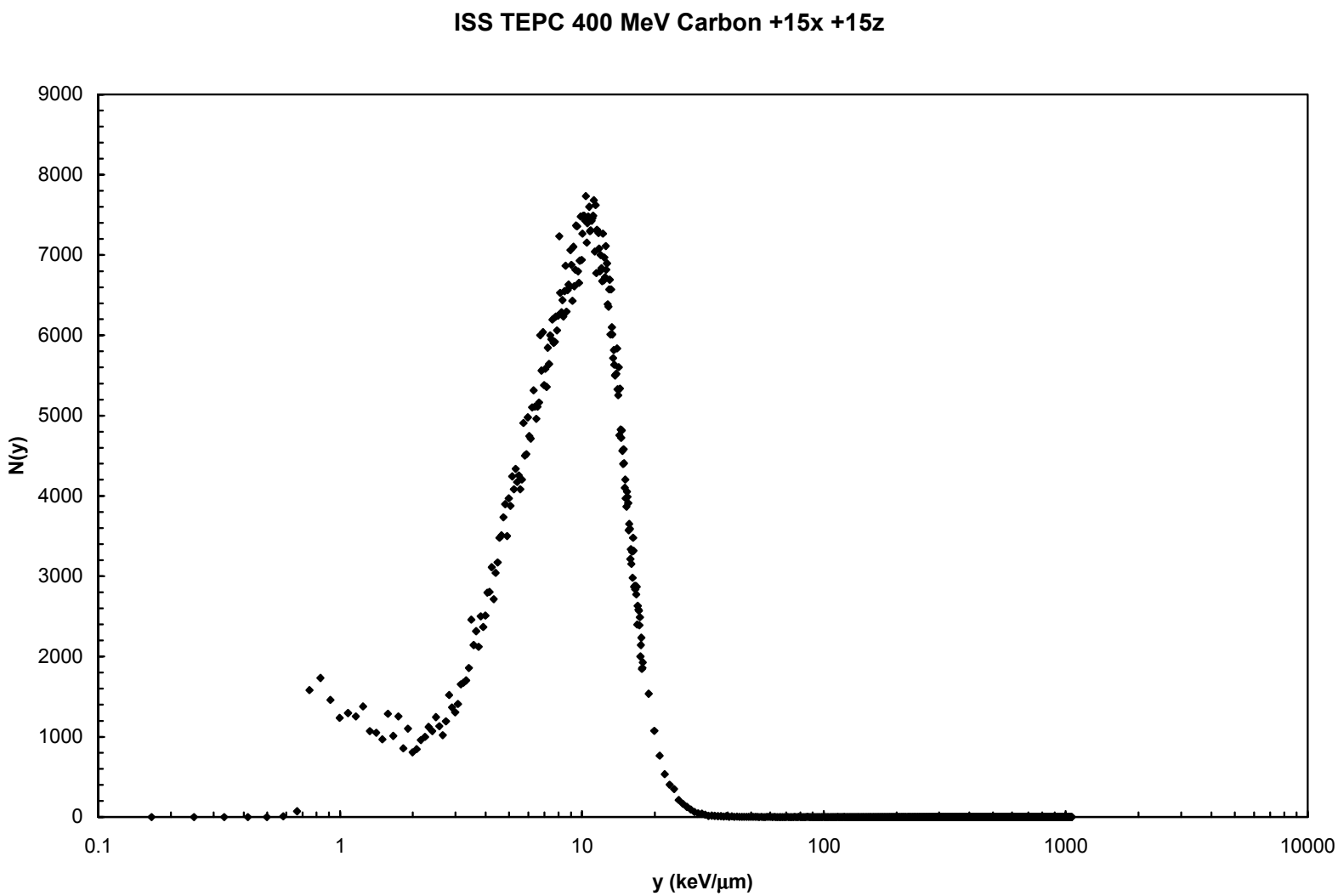


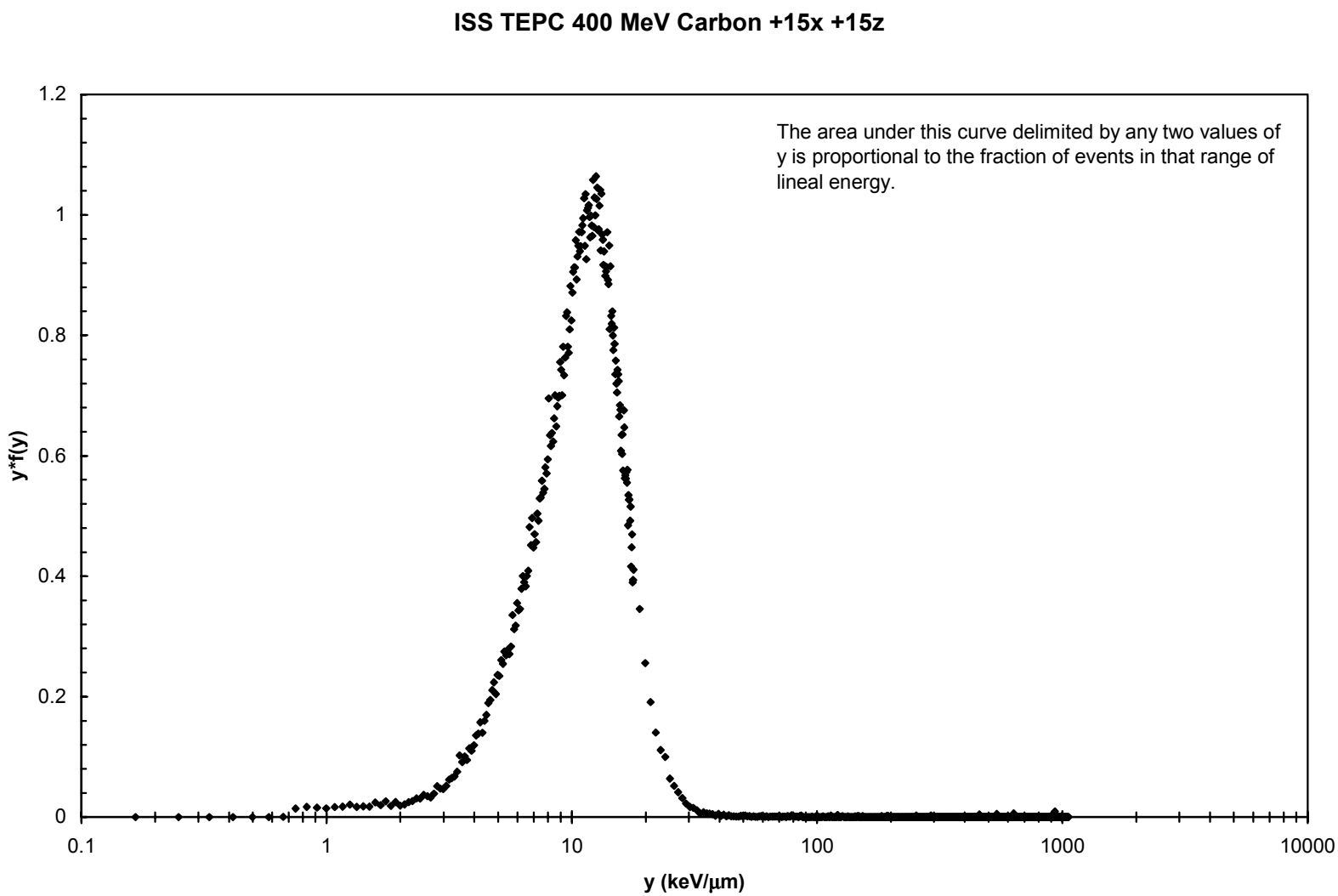

ISS TEPC 400 MeV Carbon 90 Degrees
14000
12000
10000
8000
6000
4000
2000
0
N(y)
0.1
1
10
100
1000
10000
y (keV/µm)


ISS TEPC 400 MeV Carbon 90 Degrees
The area under this curve delimited by any two values of y is proportional to the fraction of events in that range of lineal energy.
y*f(y)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.1
1
10
100
1000
10000
y (keV/µm)

ISS TEPC 400 MeV Carbon 90 Degrees




ISS TEPC 400 MeV Carbon +15x +15z
N(y)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0.1
1
10
100
1000
10000
y (keV/µm)


ISS TEPC 400 MeV Carbon +15x +15z
The area under this curve delimited by any two values of y is proportional to the fraction of events in that range of lineal energy.
y*f(y)
1.2
1
0.8
0.6
0.4
0.2
0
0.1
1
10
100
1000
10000
y (keV/µm)

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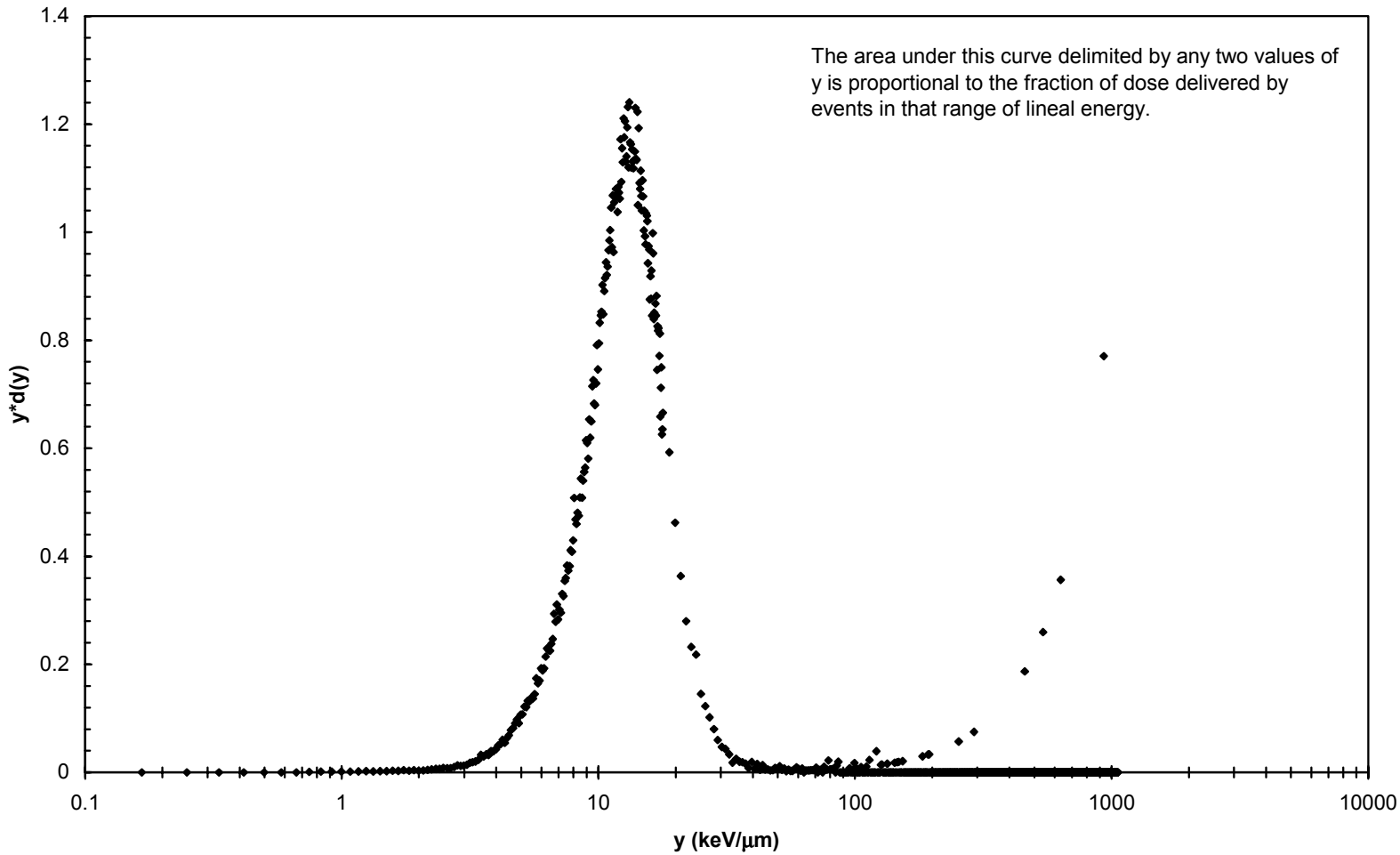
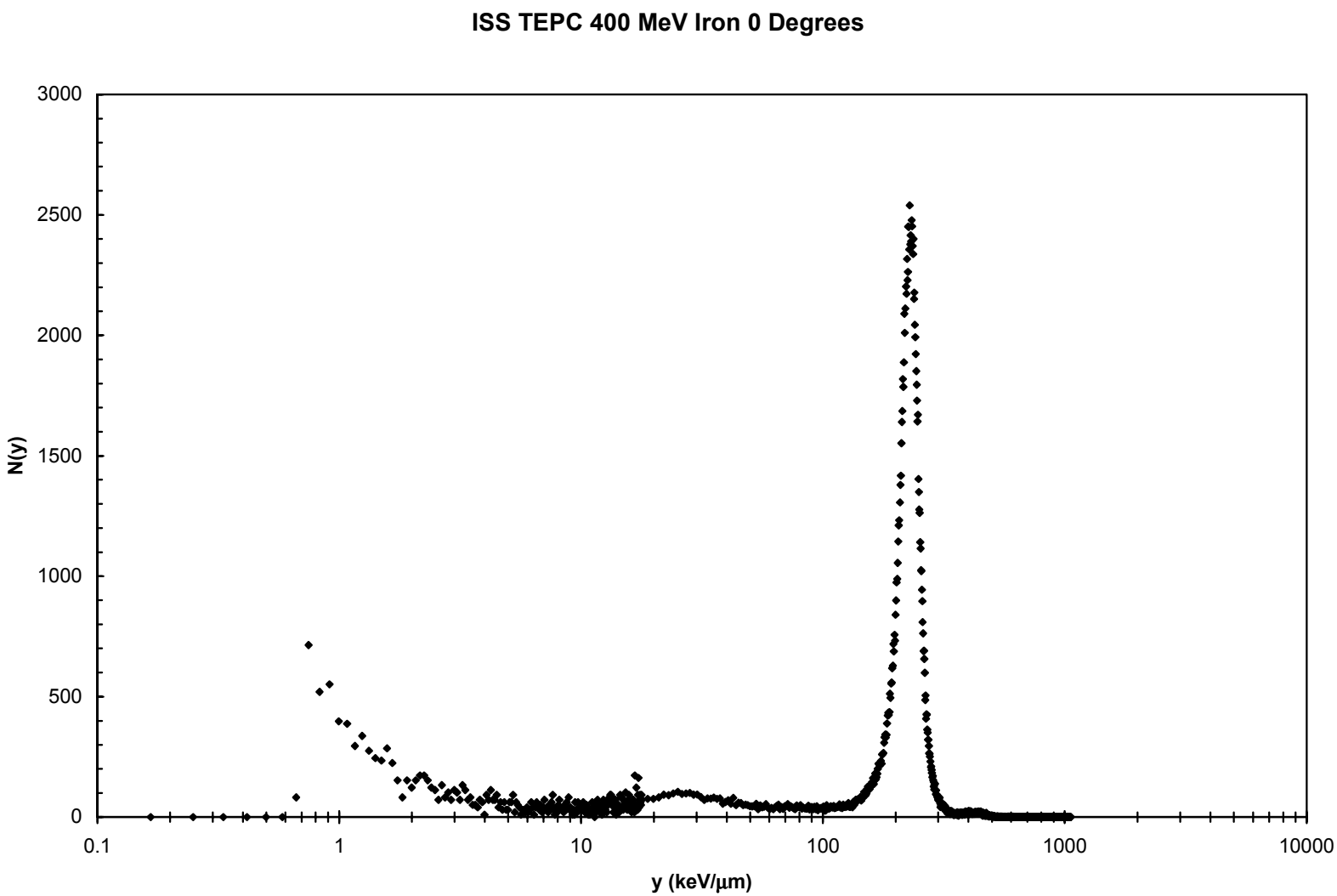
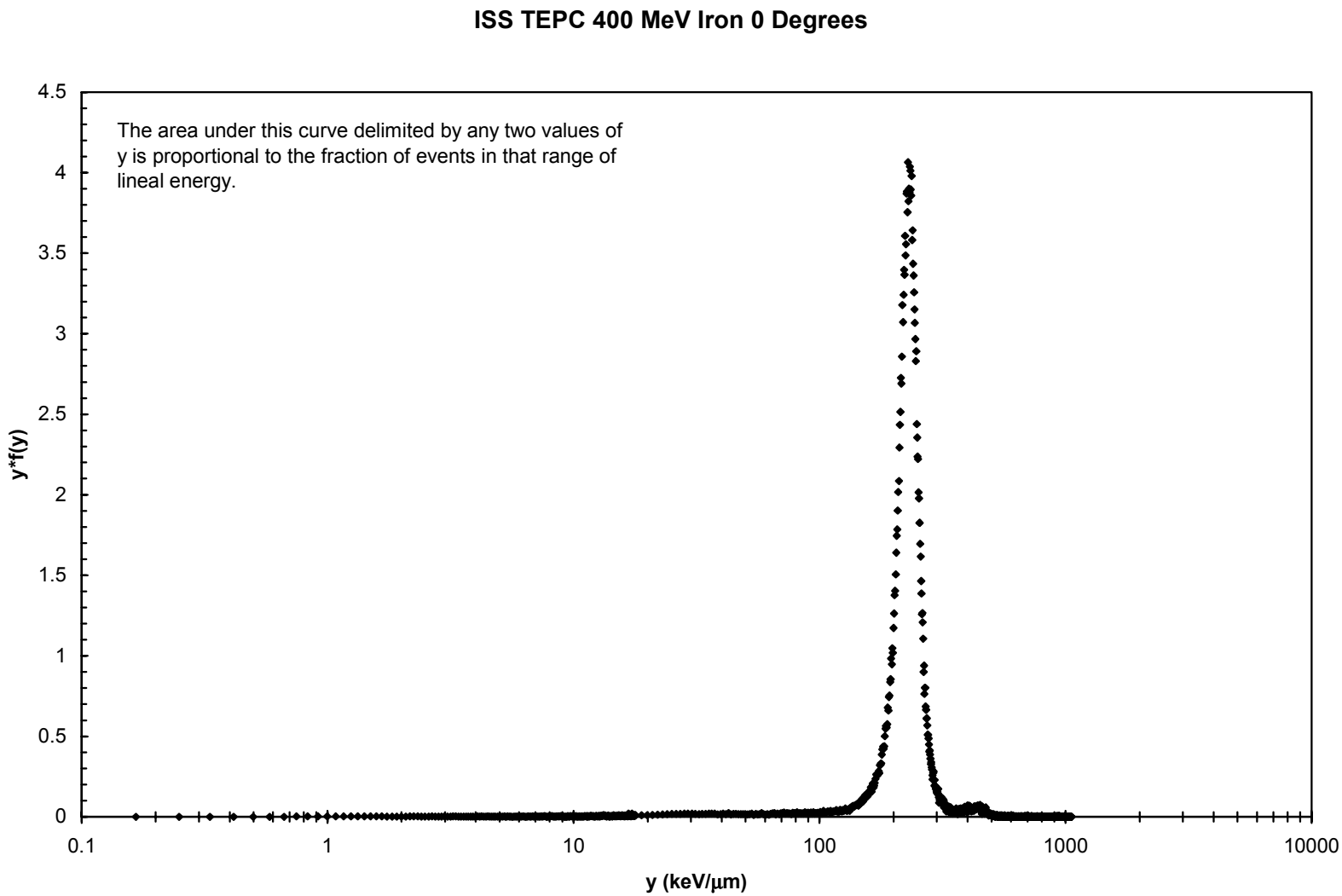
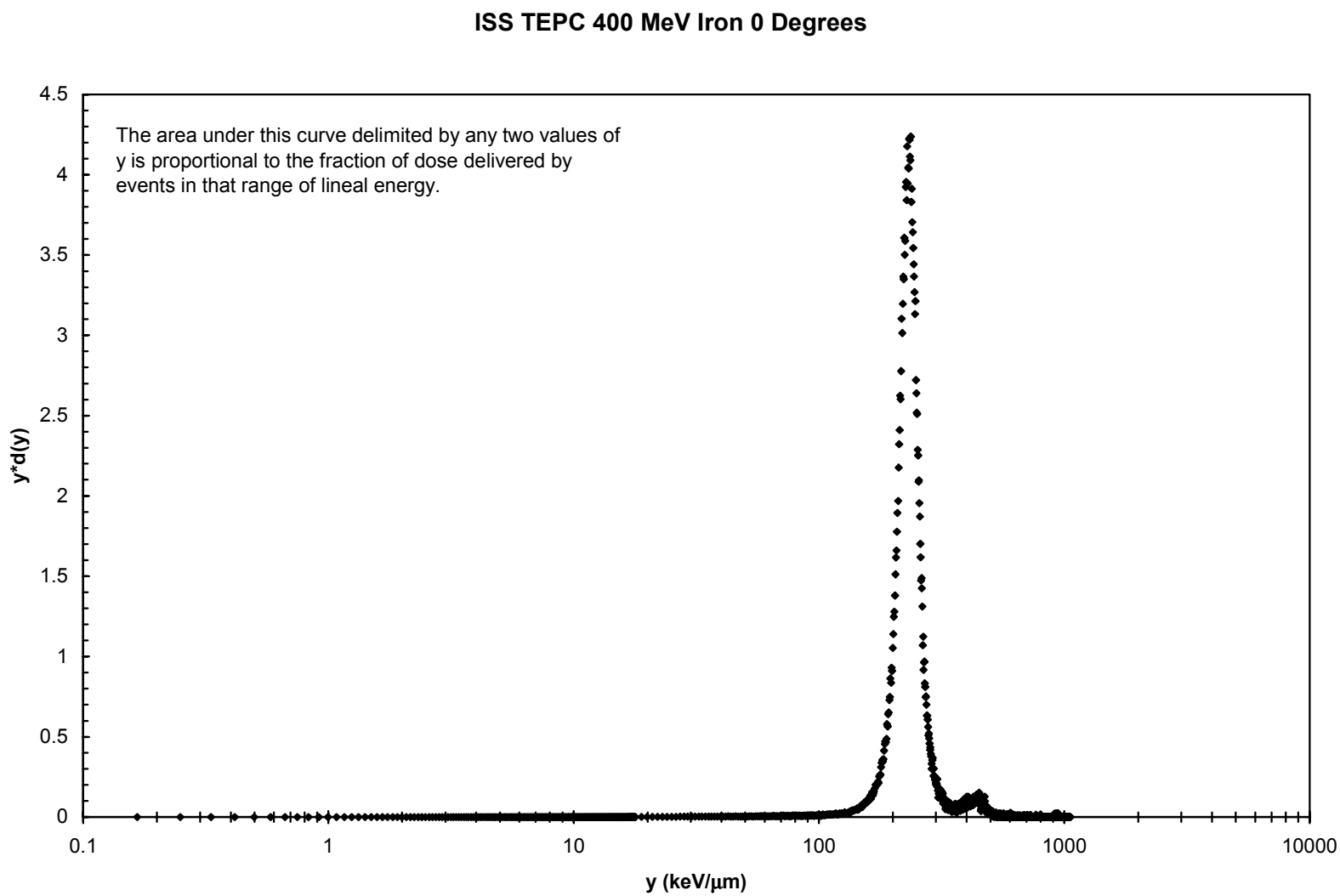
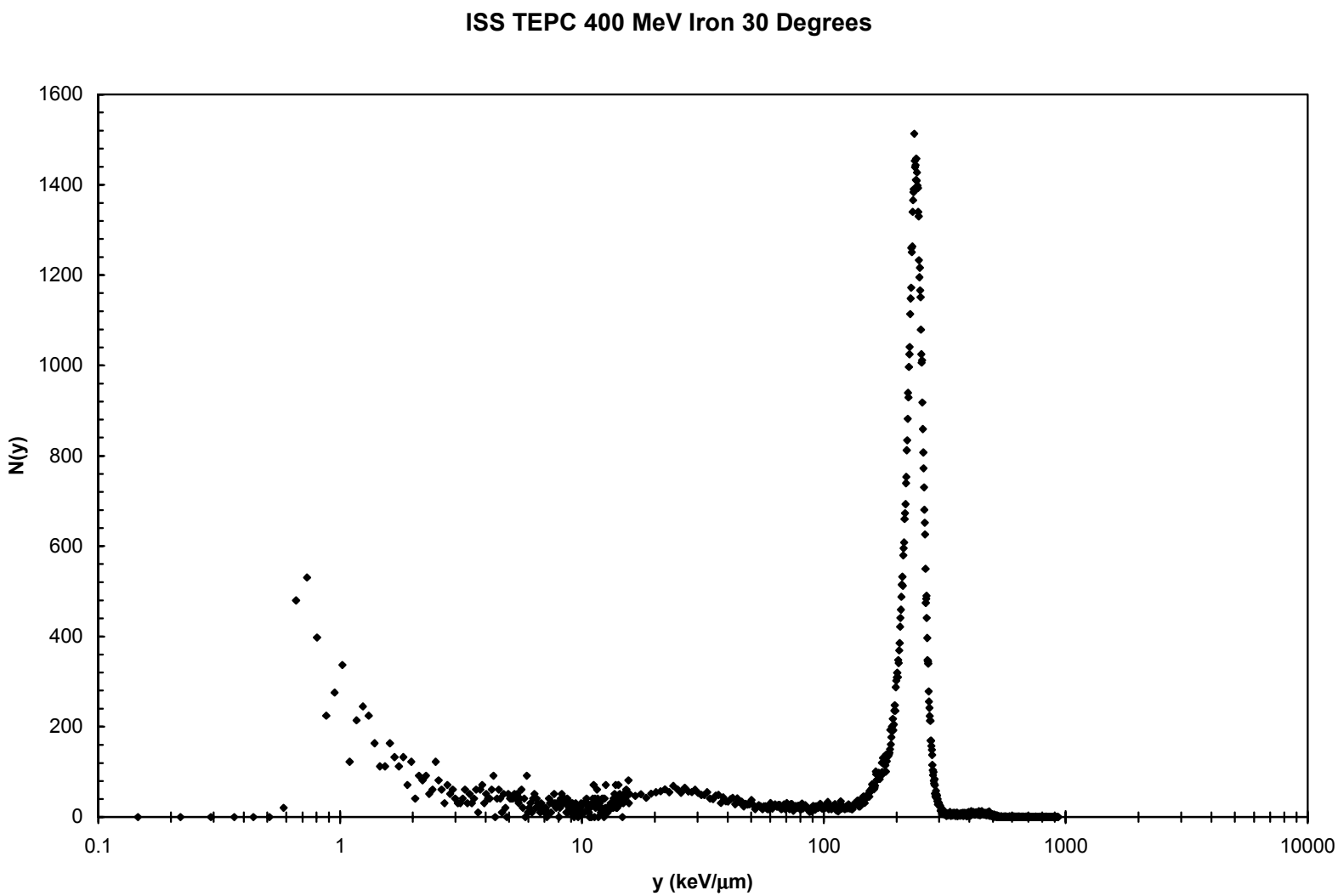
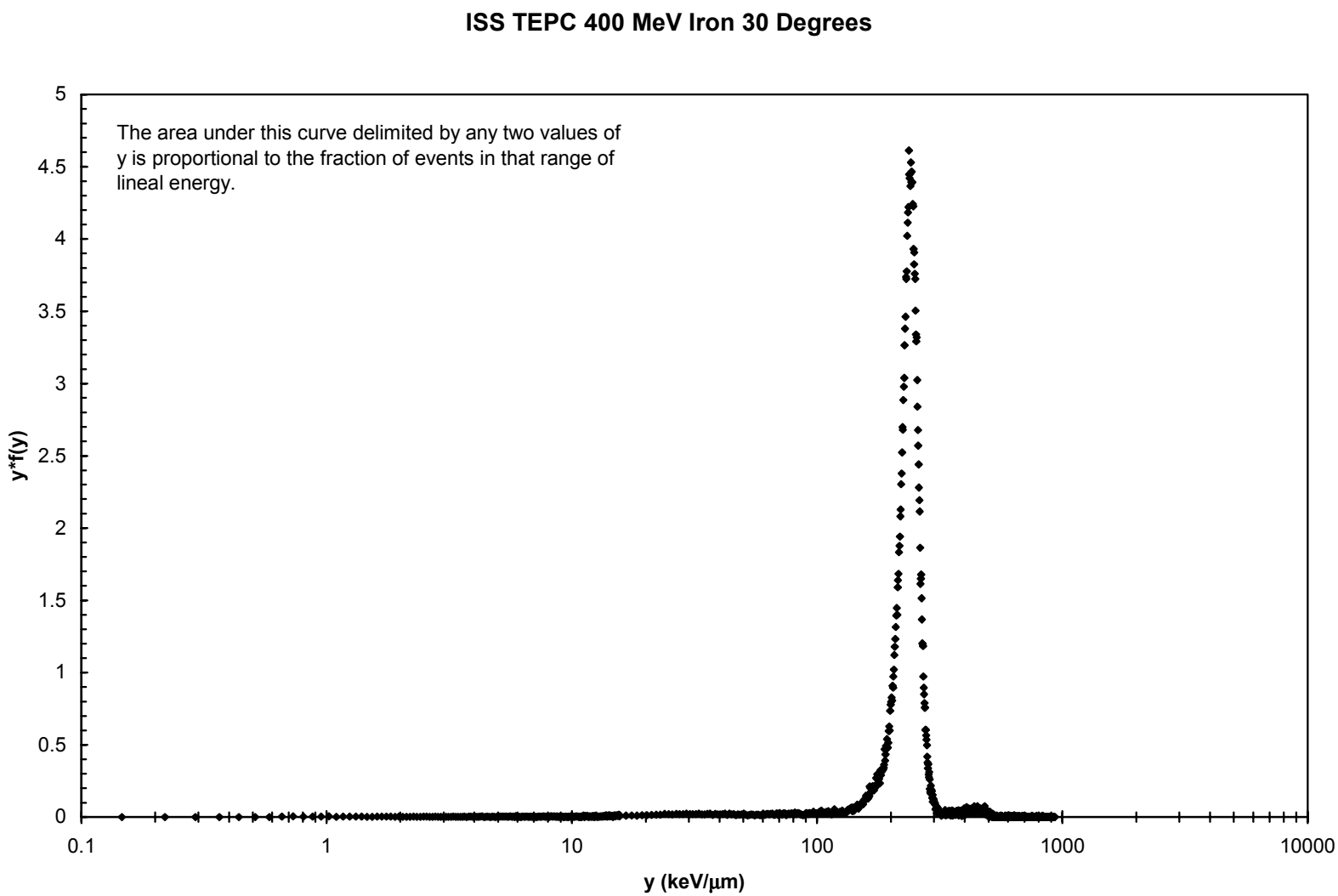


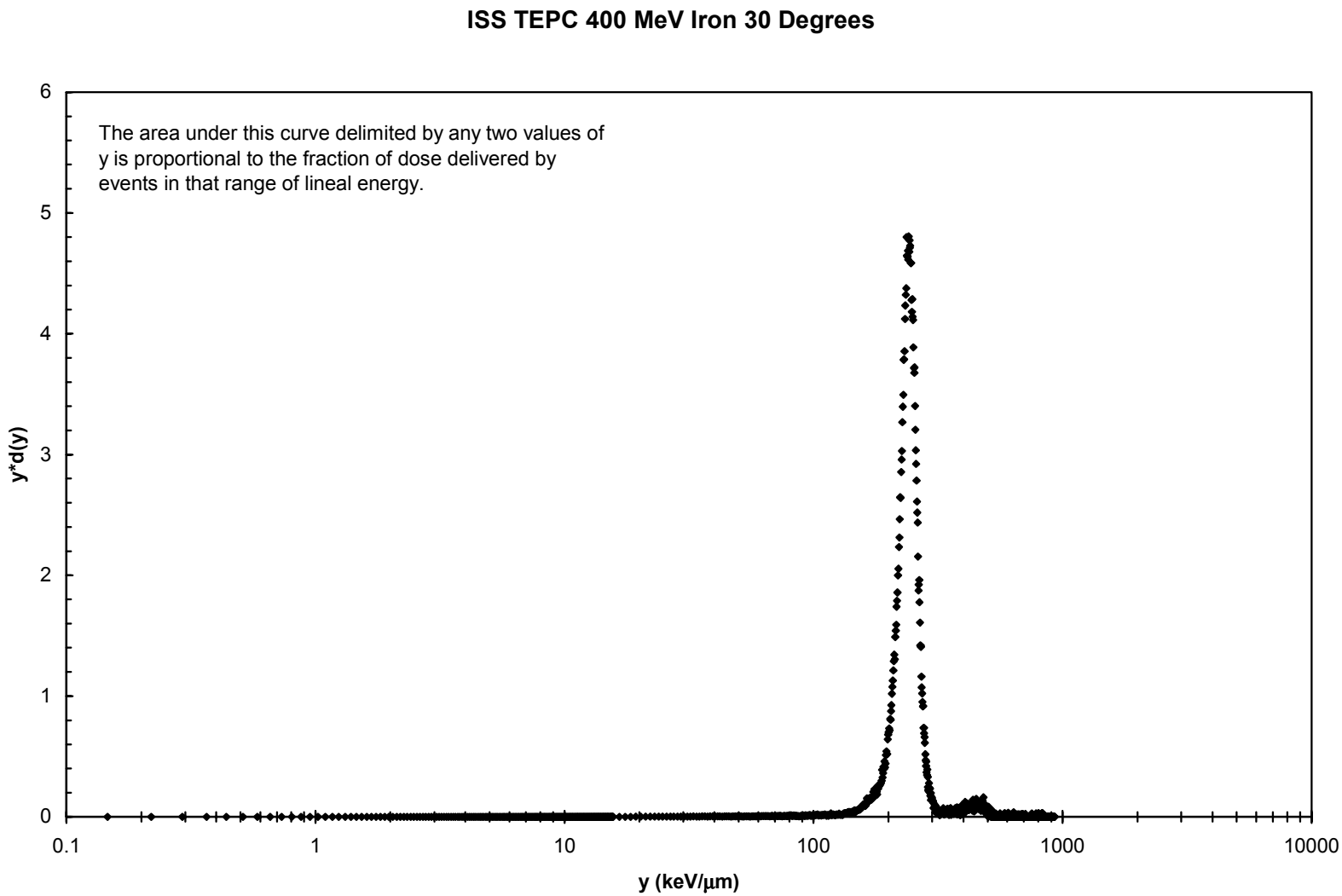

ISS TEPC 400 MeV Iron 0 Degrees
N(y)
3000
2500
2000
1500
1000
500
0
0.1
1
10
100
1000
10000
y (keV/µm)

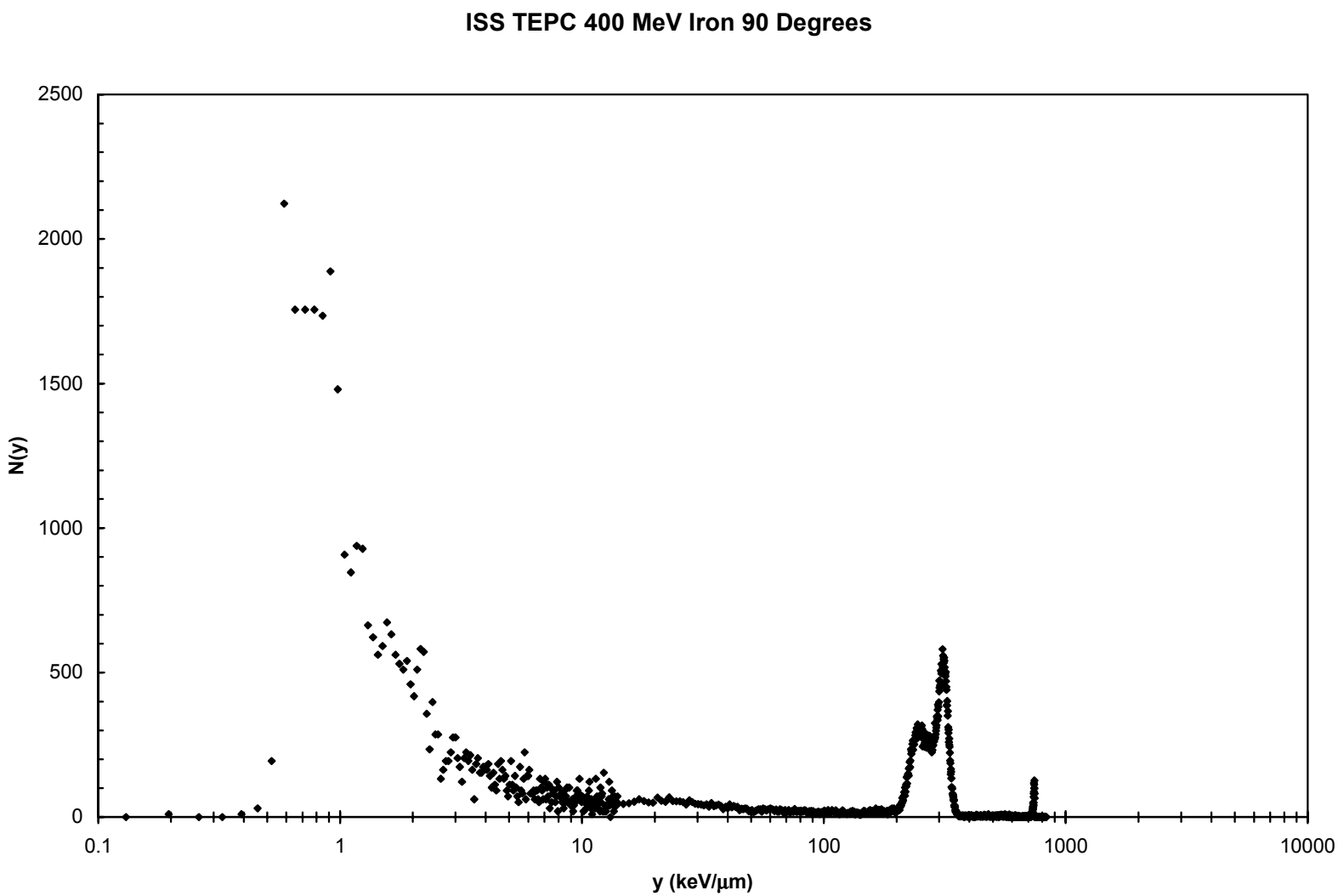

ISS TEPC 400 MeV Iron 0 Degrees
The area under this curve delimited by any two values of y is proportional to the fraction of events in that range of lineal energy.
y*f(y)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0.1
1
10
100
1000
10000
y (keV/µm)

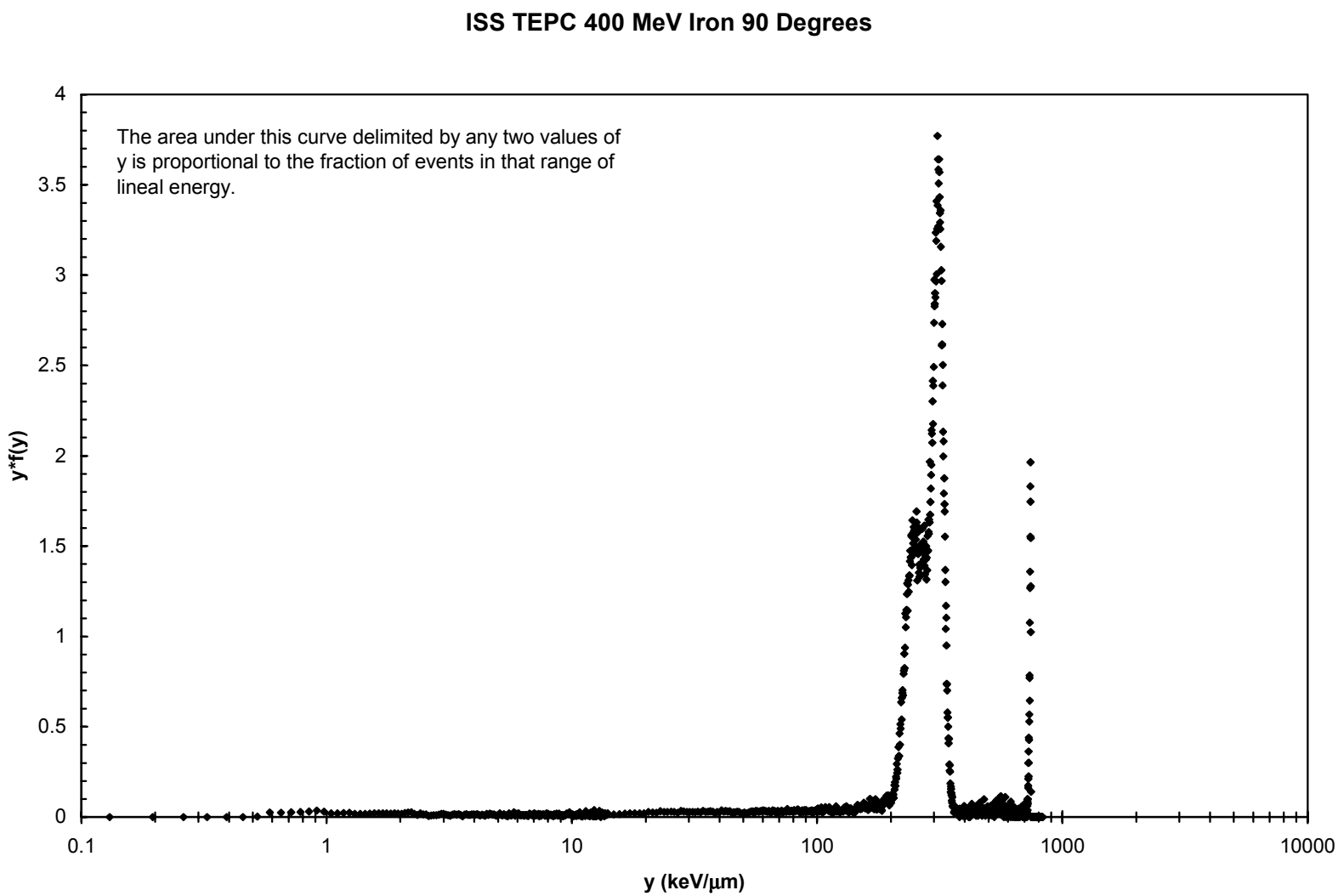

ISS TEPC 400 MeV Iron 0 Degrees
The area under this curve delimited by any two values of y is proportional to the fraction of dose delivered by events in that range of lineal energy.
y*d(y)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0.1
1
10
100
1000
10000
y (keV/µm)

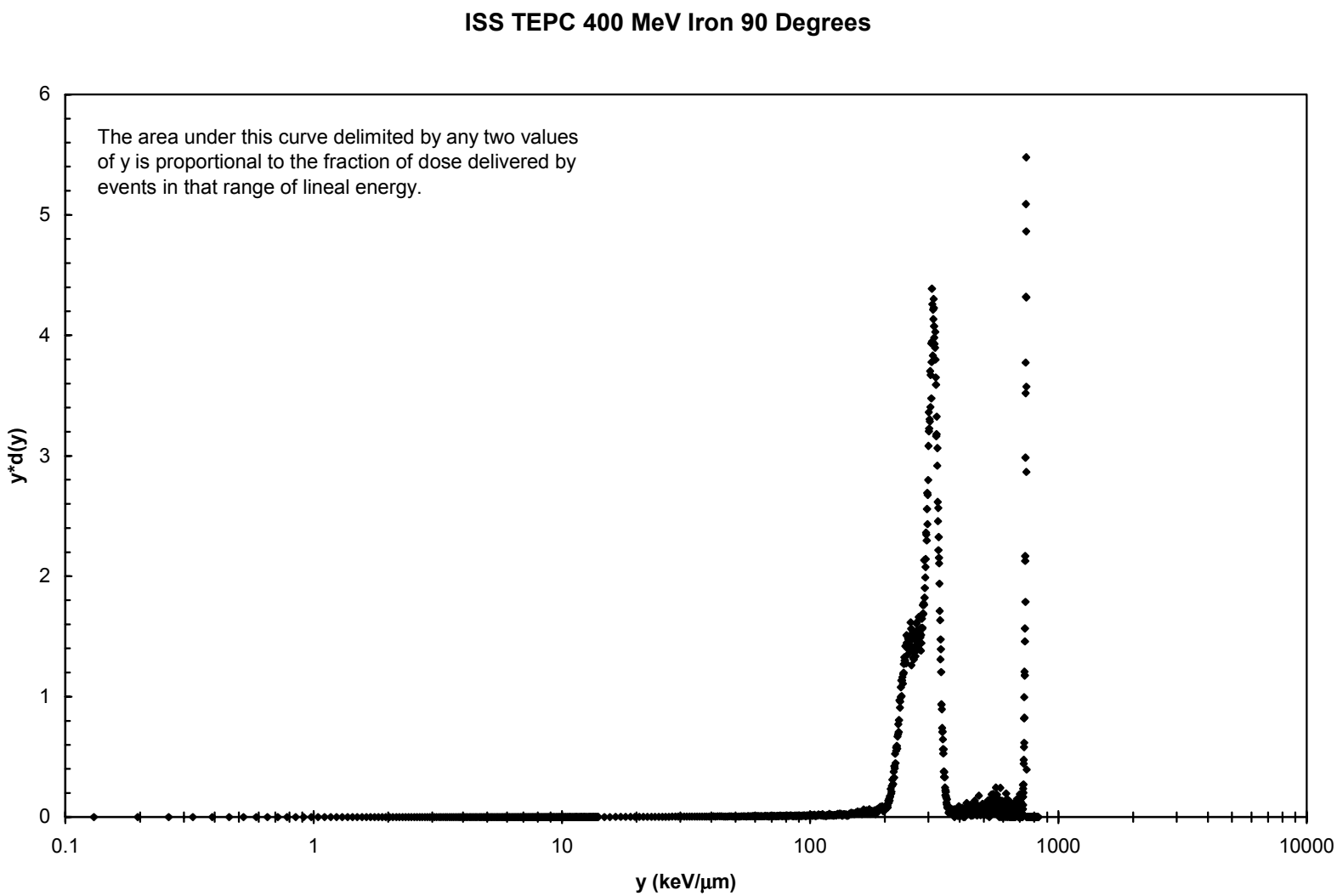

ISS TEPC 400 MeV Iron 30 Degrees
N(y)
1600
1400
1200
1000
800
600
400
200
0
0.1
1
10
100
1000
10000
y (keV/µm)

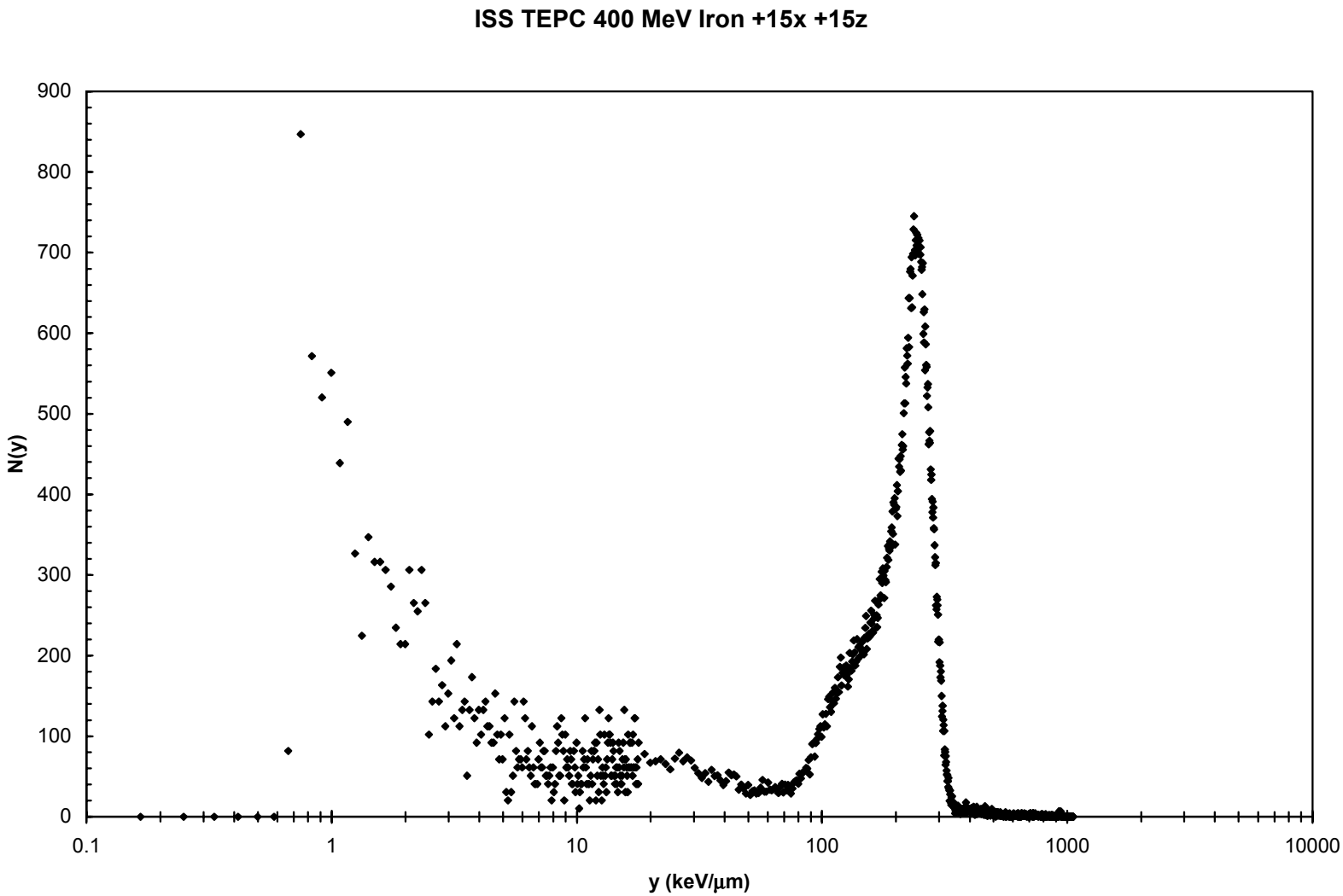

ISS TEPC 400 MeV Iron 30 Degrees
The area under this curve delimited by any two values of y is proportional to the fraction of events in that range of lineal energy.
y*f(y)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0.1
1
10
100
1000
10000
y (keV/µm)

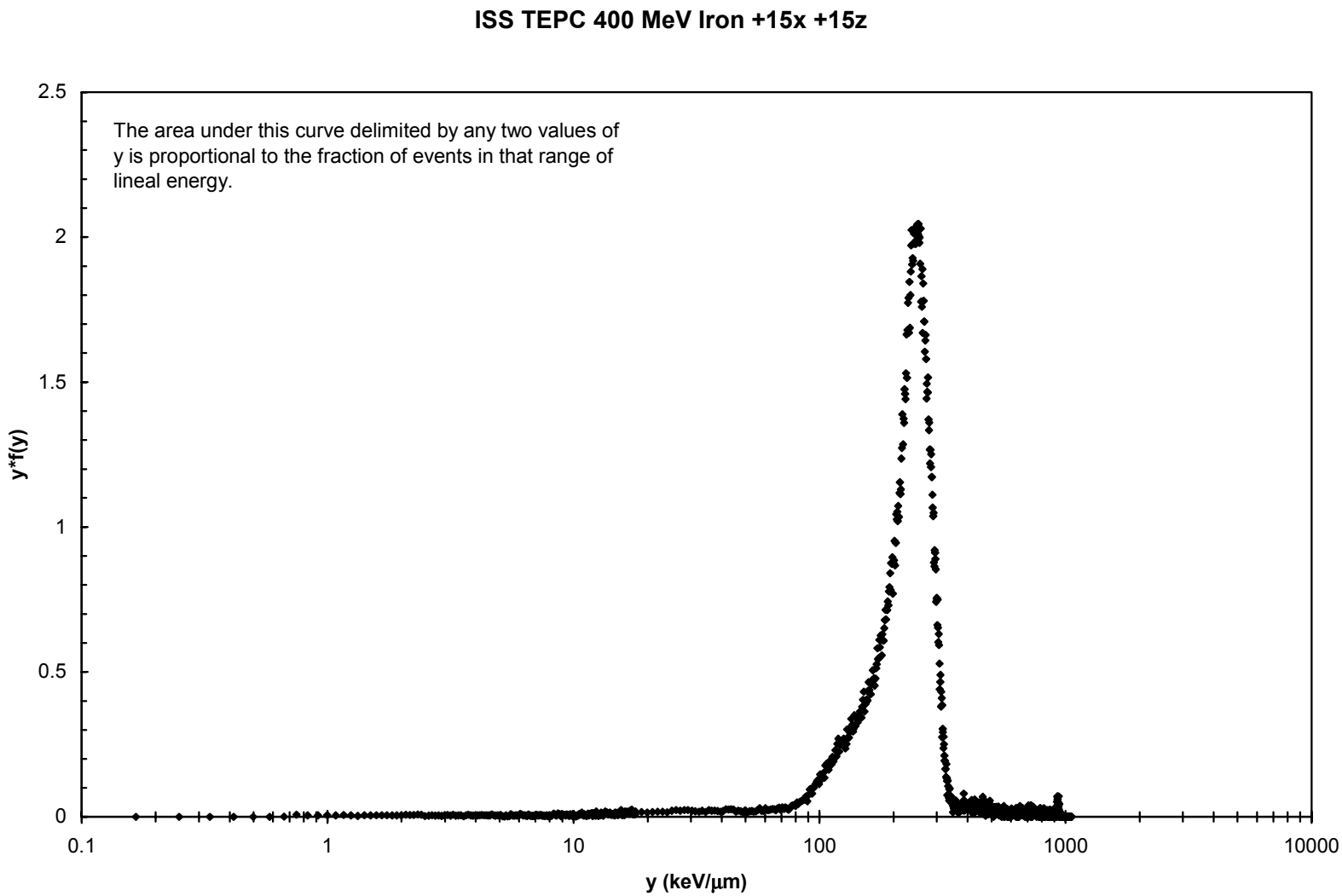

ISS TEPC 400 MeV Iron 30 Degrees
The area under this curve delimited by any two values of y is proportional to the fraction of dose delivered by events in that range of lineal energy.
y*d(y)
0
1
2
3
4
5
6
0.1
1
10
100
1000
10000
y (keV/µm)

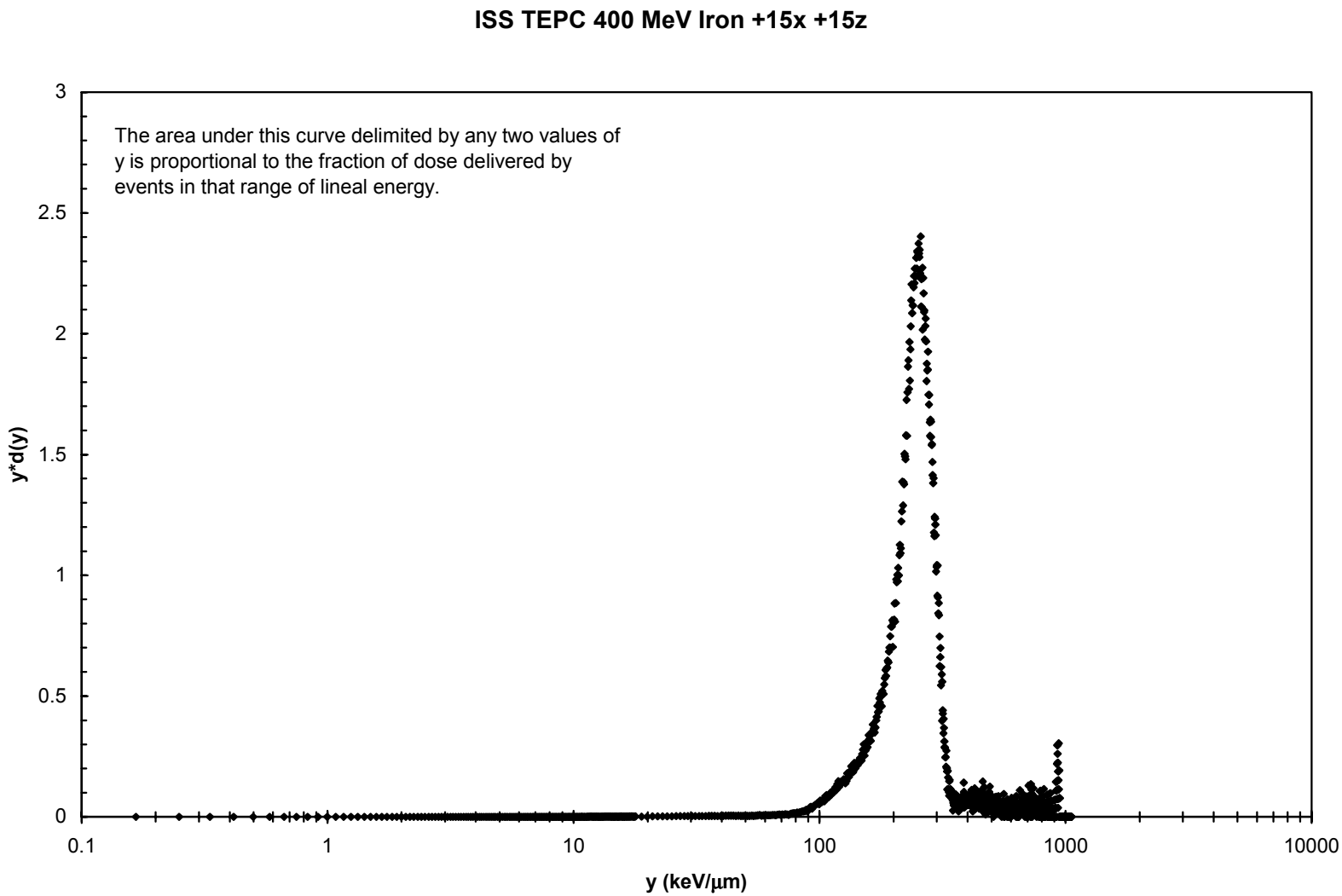

ISS TEPC 400 MeV Iron 90 Degrees
N(y)
2500
2000
1500
1000
500
0
0.1
1
10
100
1000
10000
y (keV/µm)


ISS TEPC 400 MeV Iron 90 Degrees
The area under this curve delimited by any two values of y is proportional to the fraction of events in that range of lineal energy.
y*f(y)
y (keV/µm)
0
0.5
1
1.5
2
2.5
3
3.5
4
0.1
1
10
100
1000
10000


ISS TEPC 400 MeV Iron 90 Degrees
The area under this curve delimited by any two values of y is proportional to the fraction of dose delivered by events in that range of lineal energy.
y*d(y)
0
1
2
3
4
5
6
0.1
1
10
100
1000
10000
y (keV/µm)

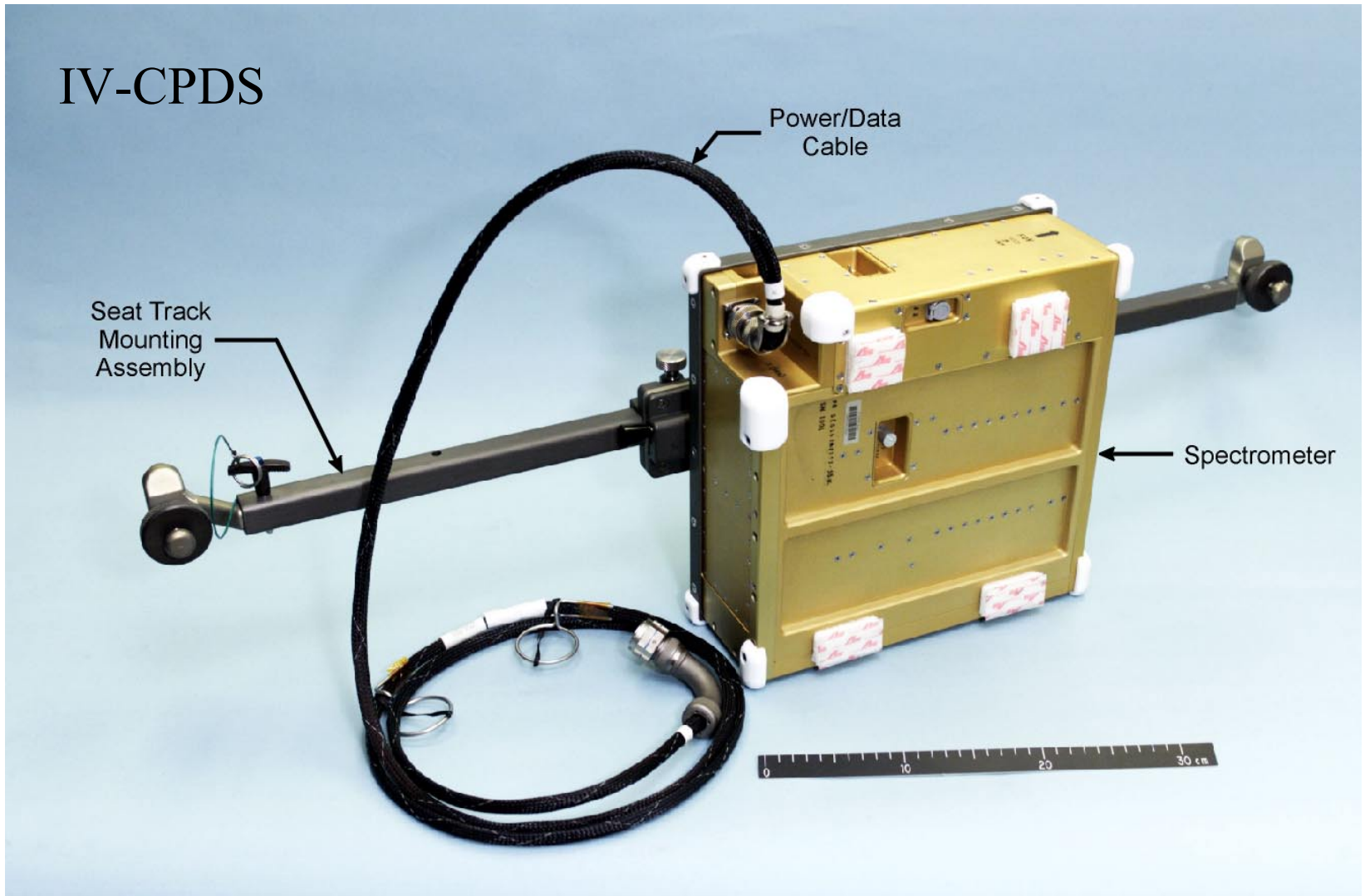

ISS TEPC 400 MeV Iron +15x +15z
N(y)
900
800
700
600
500
400
300
200
100
0
0.1
1
10
100
1000
10000
y (keV/µm)


ISS TEPC 400 MeV Iron +15x +15z
The area under this curve delimited by any two values of y is proportional to the fraction of events in that range of lineal energy.
y*f(y)
2.5
2
1.5
1
0.5
0
0.1
1
10
100
1000
10000
y (keV/µm)


ISS TEPC 400 MeV Iron +15x +15z
The area under this curve delimited by any two values of y is proportional to the fraction of dose delivered by events in that range of lineal energy.
y*d(y)
3
2.5
2
1.5
1
0.5
0
0.1
1
10
100
1000
10000
y (keV/µm)

ISS TEPC 1st ICCHIBAN Summary

1st ICCHIBAN Run	Total Events Recorded	Mean y Frequency	Mean y Dose	Mean Q	Absorbed Dose (Gy)	Absorbed Dose Equivalent (Sy)	Absorbed Dose Per Event (nGy/Event)
ISS TEPC 0 Degree 400 MeV Carbon	172340	11.76	13.49	2.82	1.20E-04	3.37E-04	2.96
ISS TEPC 30 Degree 400 MeV Carbon	178683	11.47	14.19	3.57	1.37E-04	4.48E-04	2.45
ISS TEPC 90 Degree 400 MeV Carbon	119718	11.81	14.72	4.67	1.04E-04	4.86E-04	2.20
ISS TEPC +15x +15z 400 MeV Carbon	99839	11.01	15.31	3.05	6.48E-05	1.97E-04	2.79
ISS TEPC 0 Degree 400 MeV Iron	168646	222.53	235.63	18.34	2.23E-03	4.10E-02	64.29
ISS TEPC 30 Degree 400 MeV Iron	104182	227.25	240.85	16.94	1.60E-03	2.71E-02	55.97
ISS TEPC 90 Degree 400 MeV Iron	71666	265.91	322.89	14.24	1.44E-03	2.06E-02	57.81
ISS TEPC +15x +15z 400 MeV Iron	102918	217.55	250.80	19.11	1.33E-03	2.55E-02	62.88


IV-CPDS
Power/Data
Cable
Seat Track
Mounting
Assembly
Spectrometer
0
10
20
30 cm

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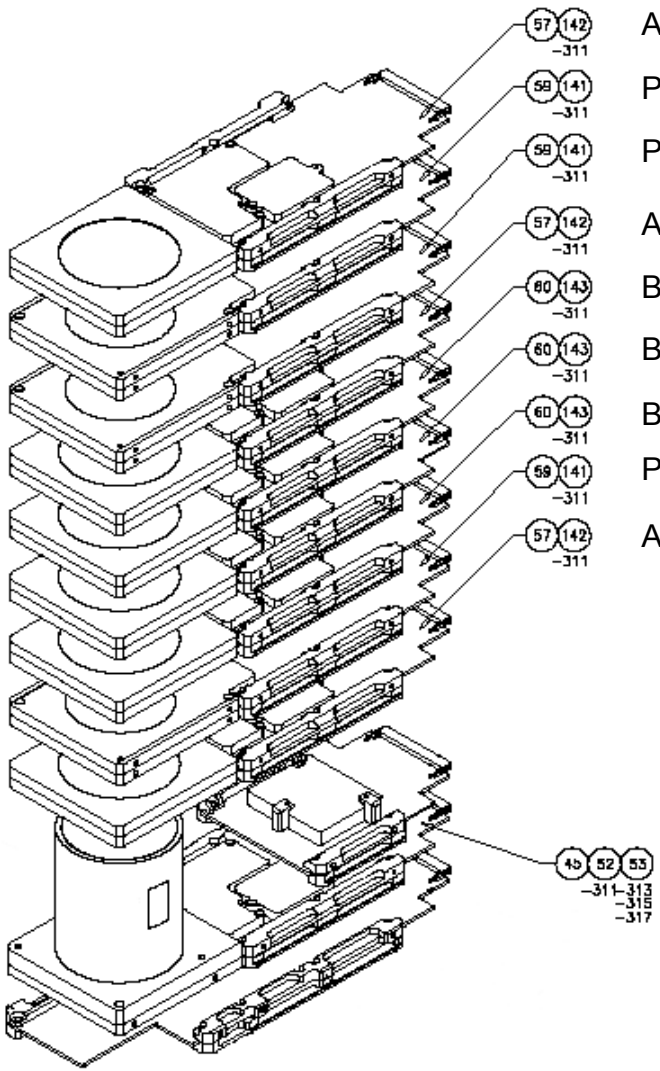


A1 Detector

PSD1 Detector

PSD2 Detector

A2 Detector

B1/B2 Detectors

B3/B4 Detectors

B5/B6 Detectors

PSD3 Detector

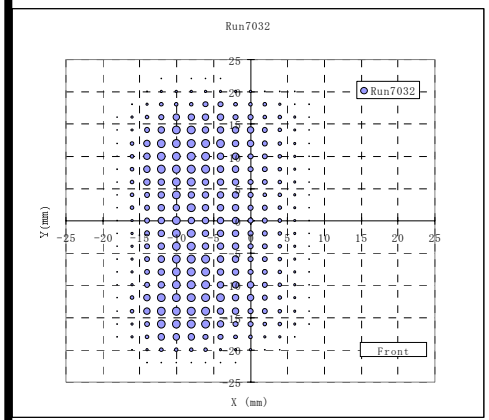
A3 Detector

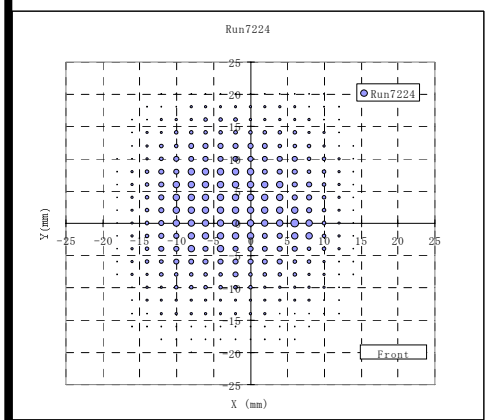
C Detector

<u>Detector Types</u>

A - 1 mm thick Si
B - 5 mm thick Si/Li
C - Cerenkov
PSD - 24 X 24 Cells

IV-CPDS Exposure Summary





398 MeV Carbon Beam

Run 7036 – 0 Degrees Centered (40 minutes)

Run 7037 – 30 Degrees Centered (40 minutes)

388 MeV Iron Beam

Run 7232 – 0 Degrees Centered (10 minutes)

Run 7233 – CH2 Fragmentation (30 minutes)

IV-CPDS X-25mm

CH2 Block 50cm upstream of IV-CPDS

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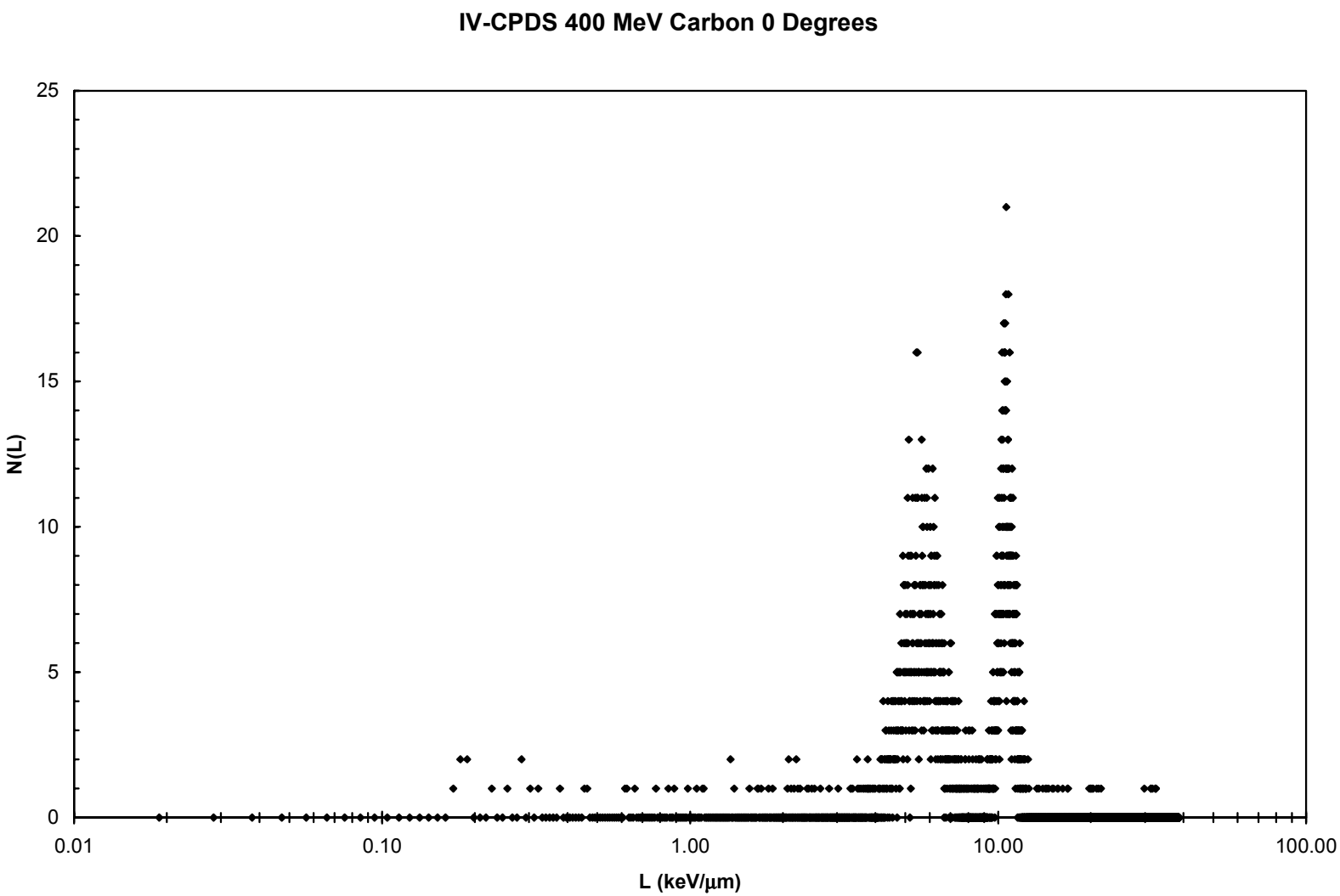
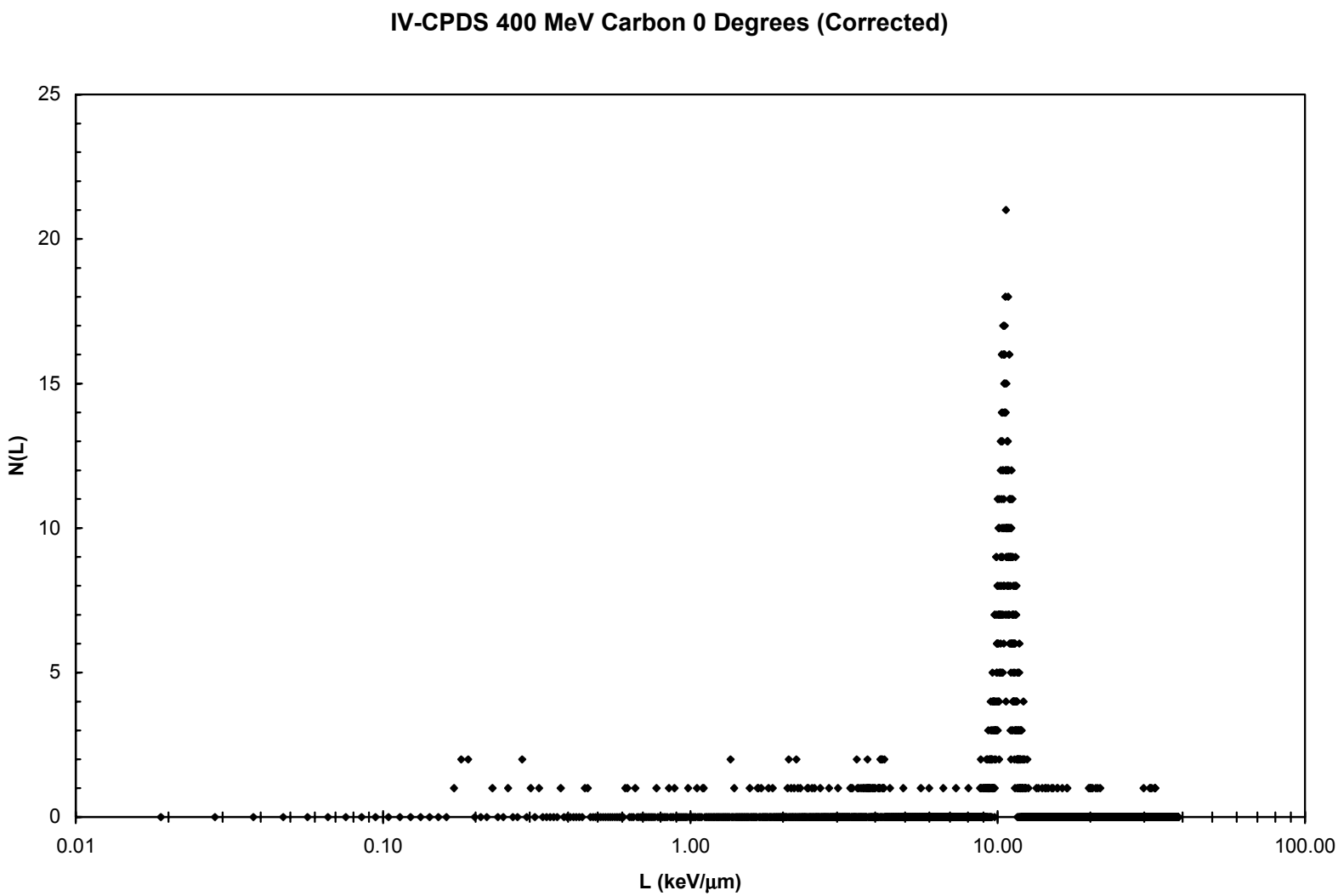

IV-CPDS 400 MeV Carbon 0 Degrees
N(L)
25
20
15
10
5
0
0.01
0.10
1.00
10.00
100.00
L (keV/µm)


IV-CPDS 400 MeV Carbon 0 Degrees (Corrected)
N(L)
25
20
15
10
5
0
0.01
0.10
1.00
10.00
100.00
L (keV/µm)

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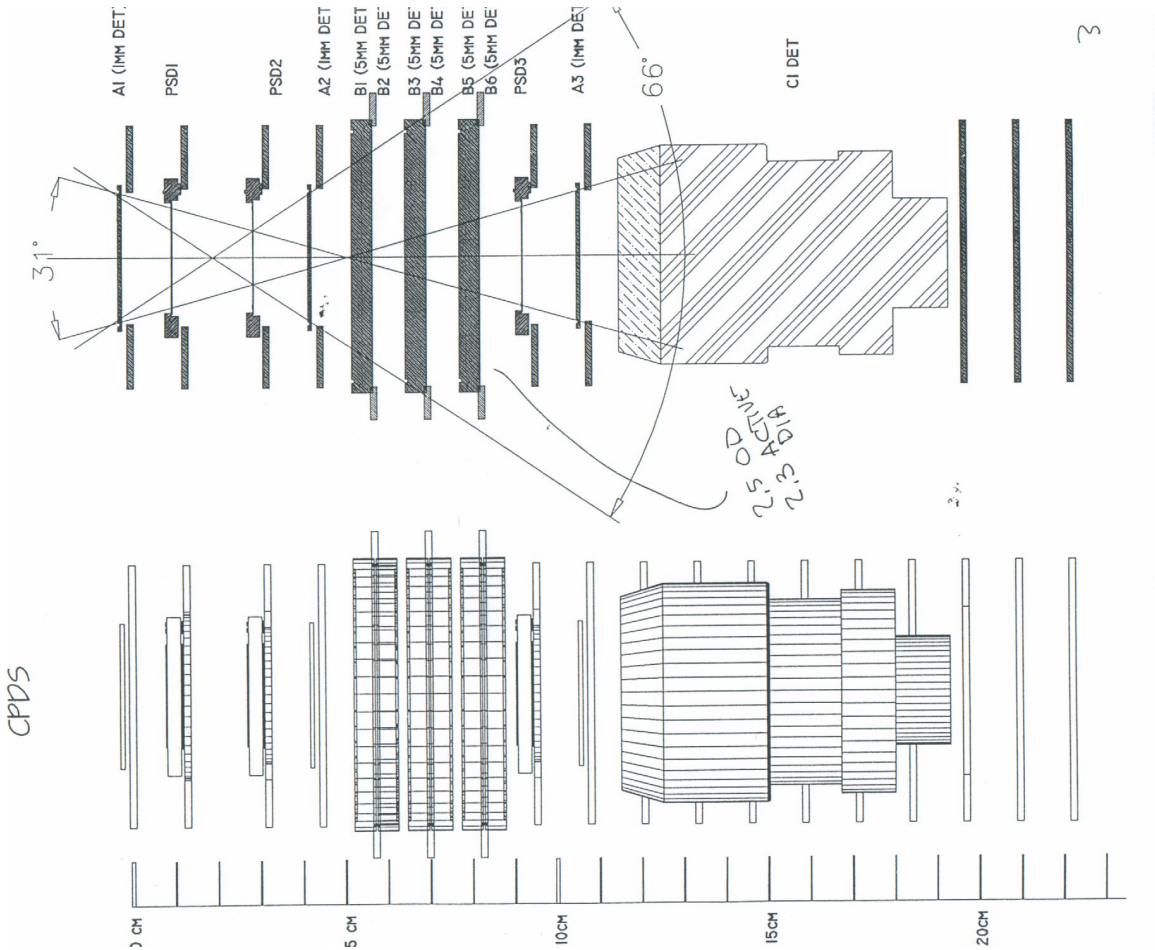
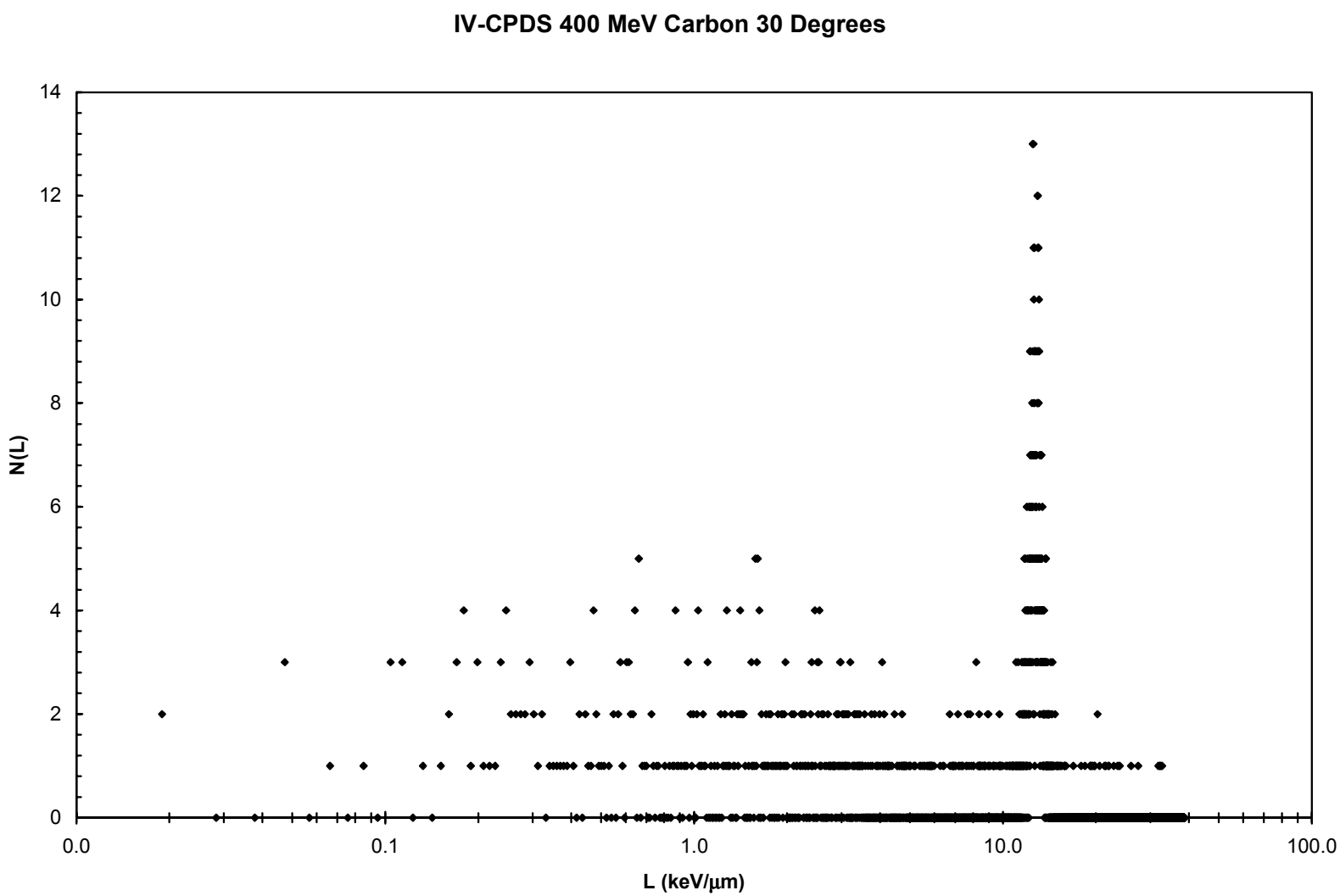
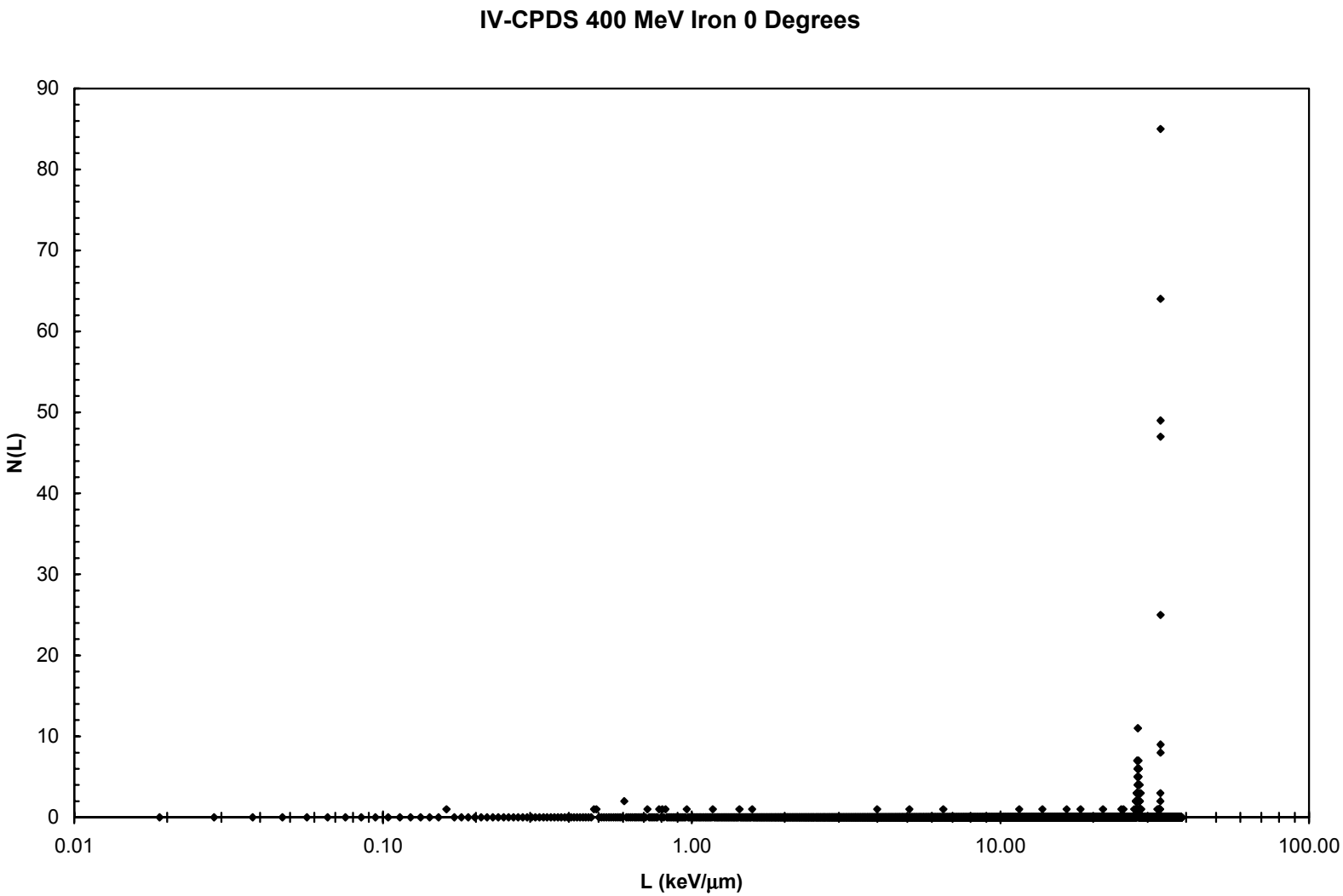
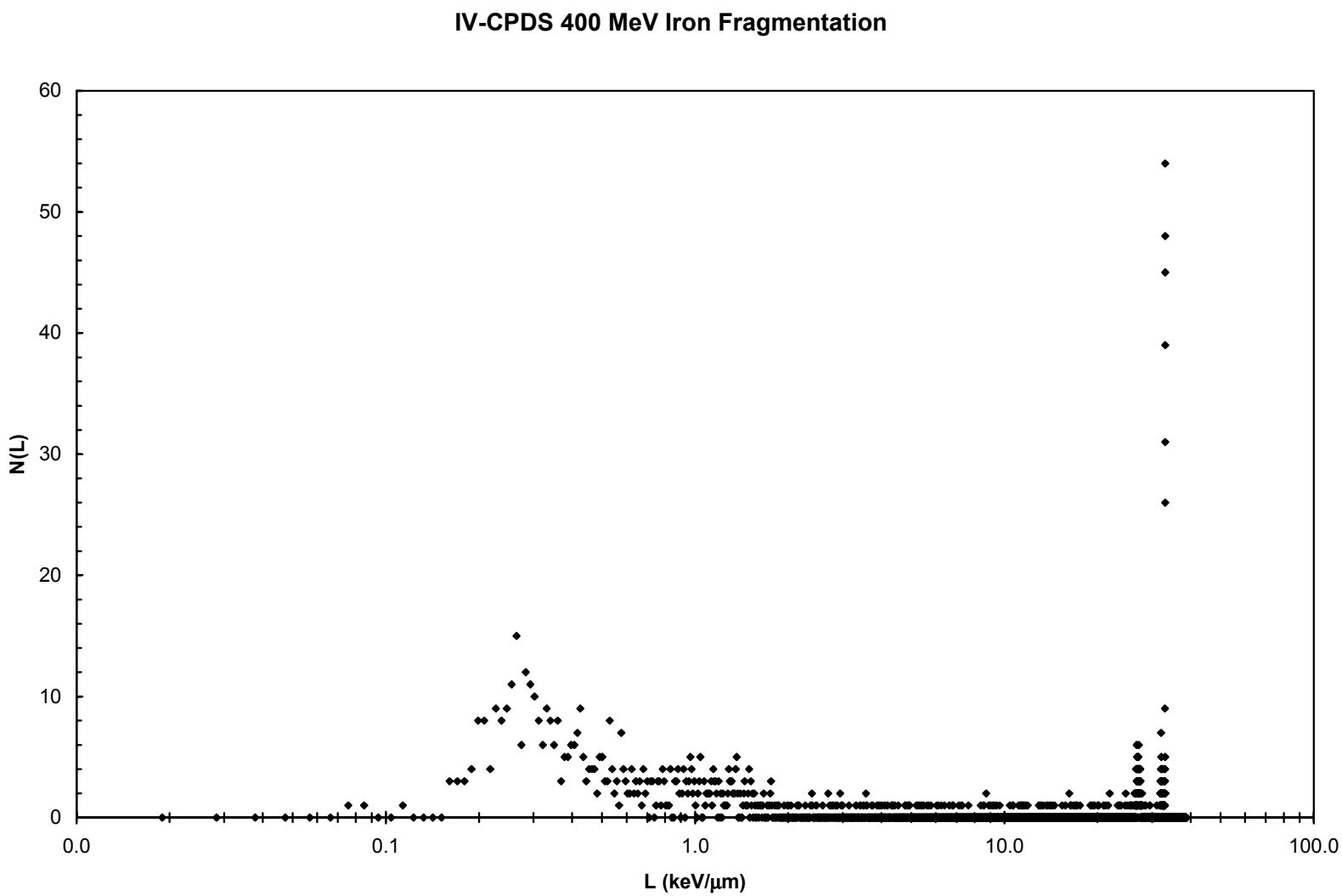



IV-CPDS 400 MeV Carbon 30 Degrees
N(L)
L (keV/µm)
0
2
4
6
8
10
12
14
0.0
0.1
1.0
10.0
100.0


IV-CPDS 400 MeV Iron 0 Degrees
N(L)
90
80
70
60
50
40
30
20
10
0
0.01
0.10
1.00
10.00
100.00
L (keV/µm)


IV-CPDS 400 MeV Iron Fragmentation
N(L)
60
50
40
30
20
10
0
0.0
0.1
1.0
10.0
100.0
L (keV/µm)

IV-CPDS 1st ICCHIBAN Summary

1st ICCHIBAN Run	Total Events Recorded	Absorbed Dose (Gy)	Absorbed Dose Per Event (nGy/Event)
IV-CPDS 0 Degree 400 MeV Carbon	1856	4.03E-06	2.17
IV-CPDS 30 Degree 400 MeV Carbon	1702	3.03E-06	1.78
IV-CPDS 0 Degree 400 MeV Iron	560	3.49E-06	6.23
IV-CPDS 400 MeV Iron Fragment	1356	4.80E-06	3.54

Note: IV-CPDS LET Max = ~38 keV/μm

Summary and Conclusions

ISS TEPC:

- Investigate anomalous reset problem
- Lower detector threshold

IV-CDPS:

- Investigate dead time problem
- Investigate double-peak problem
- Lower detector gain settings

Recommendations for 3rd ICCHIBAN Measurement:

- Larger beam size (Biology room?)
- Proton Beam Run
- Iron Fragment Beam Run

Acknowledgements

- We gratefully acknowledge NIRS for the use of the HIMAC facility in support of the ICCHIBAN investigations.