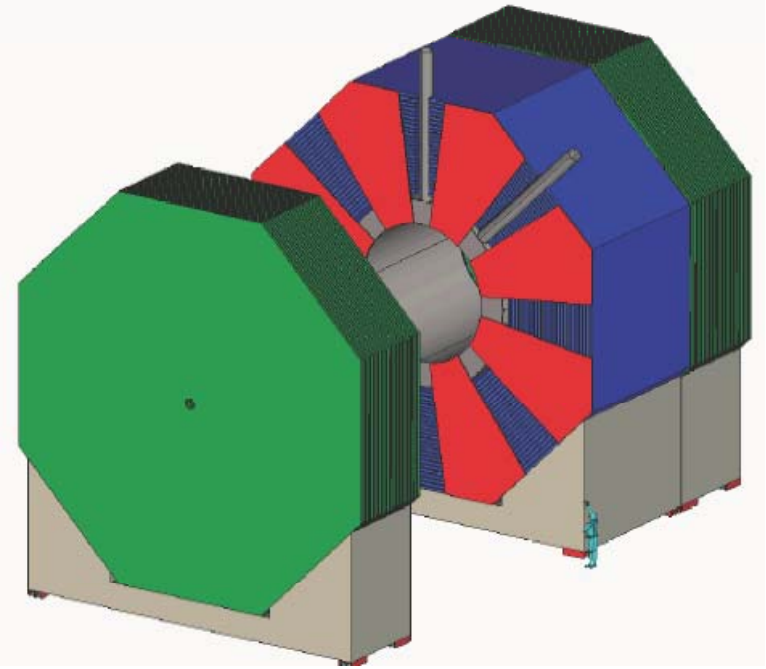
# MAPMTs Anode Output Current Response Study

Alexandre Dyshkant
for NICADD at NIU

# Proposed SiD Muon System/Tail Catcher



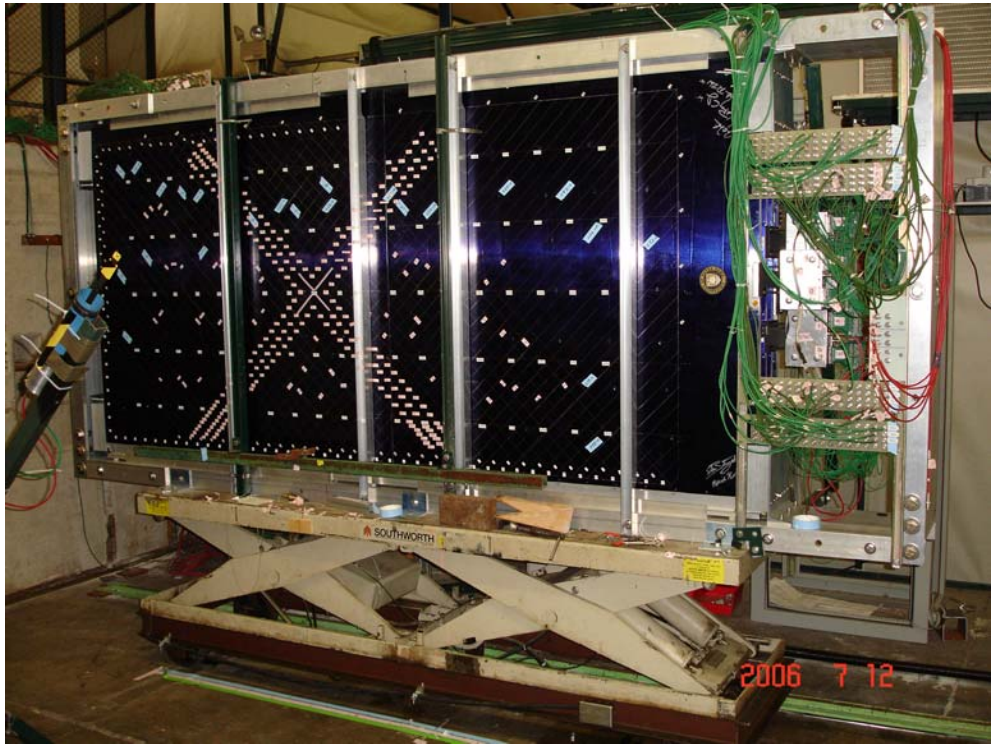
•Central Muon System:
After 4.6 nuclear interaction lengths ($\lambda$)
Of calorimeters and the 5T solenoid coil and cryostat 1.27 $\lambda$ → ~6 inter. Length.
• Installed in the Iron of the 5Tsolenoid flux return ~ 2.30m of Fe:~18 $\lambda$ total.
• Central barrel 5.7 m long, R = 3.5 m.

•Barrel and EndCaps Muon System unit:
10 cm thick Fe; 4 cm gaps

•Total detector area ~6000 $m^2$ for 14 layers.

Candidate detector technologies: RPCs and/or Strip-scintillator

# ILC MuonTest Setups




Prototypes installed in Fermilab Beam Test Facility
256 scintillator strips
384 PMT channels

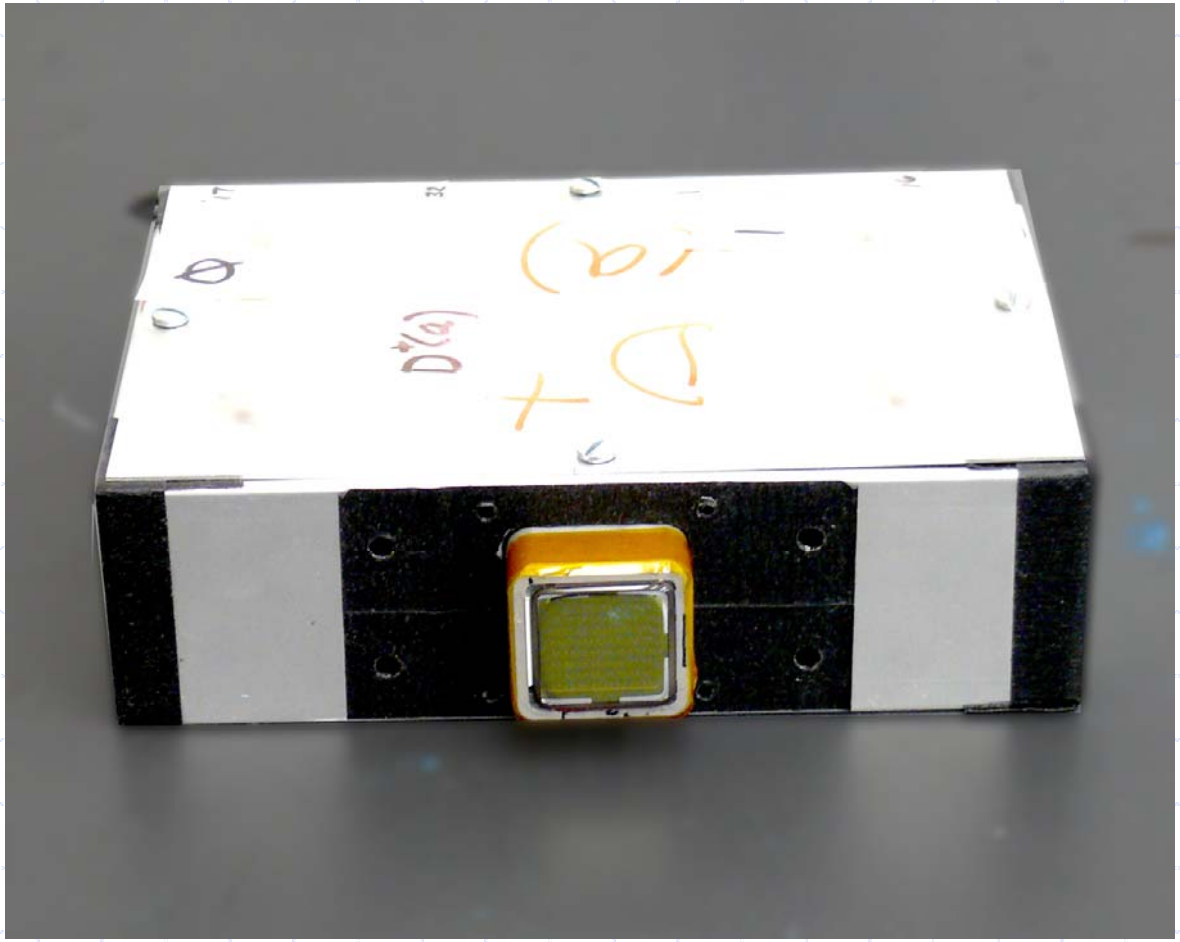
# Goal

- As a possible first step to understand each strip's output, the response of every photomultiplier anode to a given brightness of input light and applied voltage needs to be measured.
- If you know the relative anode responses, the correction to particular strip's output can be applied that removes the effect of PMT itself.
- Such a correction helps clarify a comparison of strip responses to a beam particle.

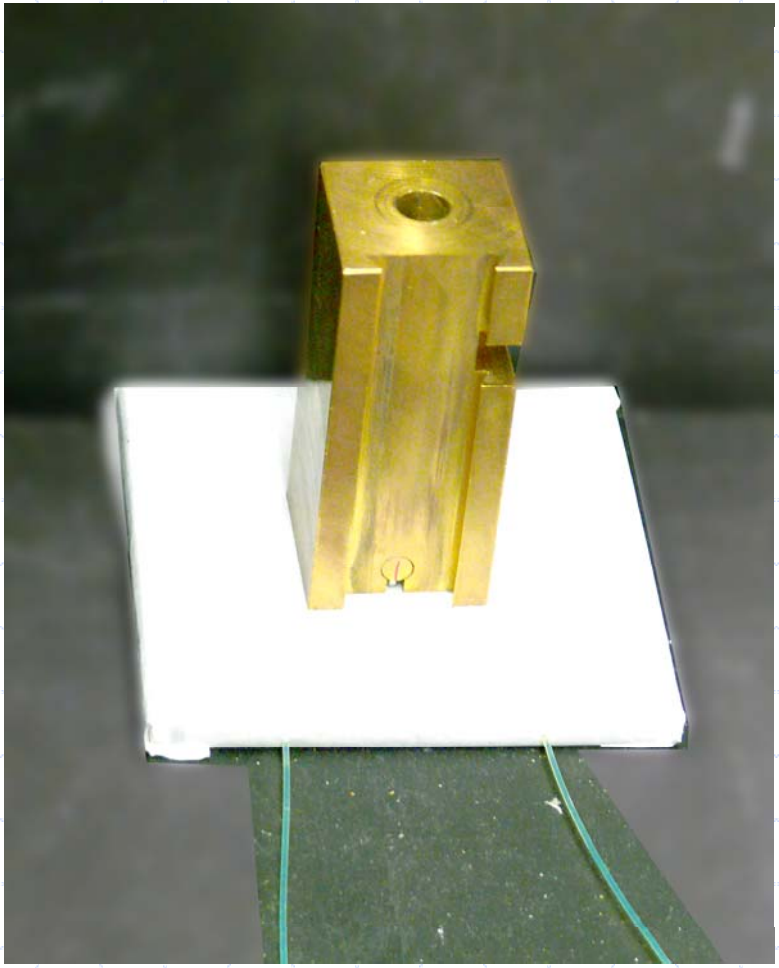
# Current Measurement Problems

- What is MAPMT dark current level?
- What is HV?
- Can custom made source of light saturat a MAPMT?
- How was fiber connected?
- How was interface alignment checked/verified?
- What is a gain? What is a response?
- Do different channels have a different slope in response dependence of voltage?
- How large is cross talk between neighboring channels?
- Can double reference method help keep track of reproducibility and repeatability of the measurements?

# Boxed MAPMT

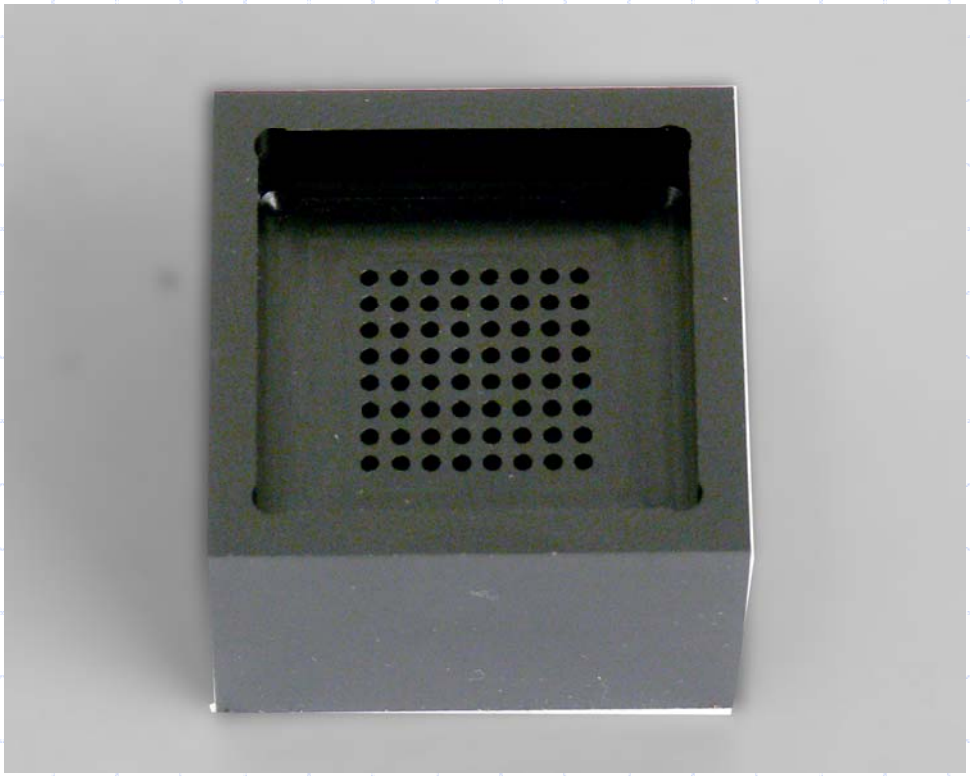


# Custom Made Permanent Source of Light



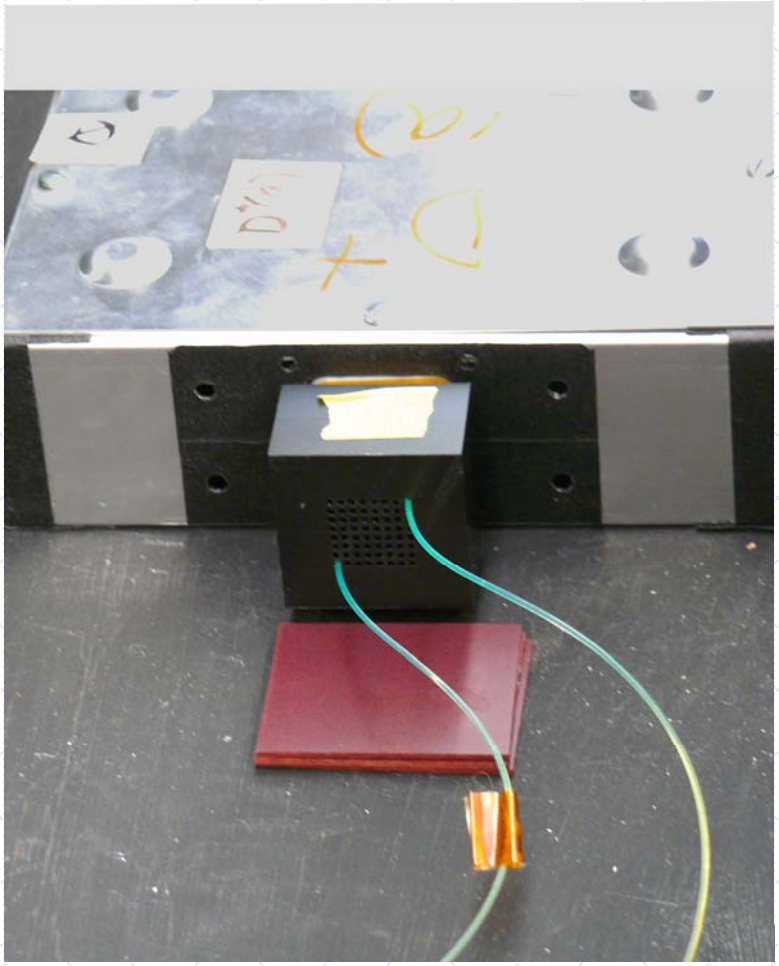
- *Radioactive source Sr-90.*
- *Cast scintillator EJ-200, 10 mm thick with two grooves.*
- *WLS fibers Y-11, 1.2 mm in diameter, 1.01 m long, polished mirrored, UV protected.*
- *Two layers of Tyvek.*
- *Two WLS fibers were used because of the double reference method measurements.*

# Custom Made Interface



64 1.3 mm in diameter holes with 2.3 mm steps following the HAMAMATSU drawing. Made from delrin.

# Boxed MAPMT with Interface and WLS Fibers Connected



Labeled WLS fiber is a reference one that positioned at channel number 57 permanently in each MAPMT.
Control measurements were performed using the second fiber by repeating the measurement in channel number 64

# Major Parts Connections


Each output was measured independently.
Each output has a reference measurement in the same MAPMT.
Each eight output measurements have a control measurement.
For each input a cross talk in each output can be measured.
Measurements were performed in a light tight box.
Measurements were performed at about 800 V and room temperature (without additional controls).

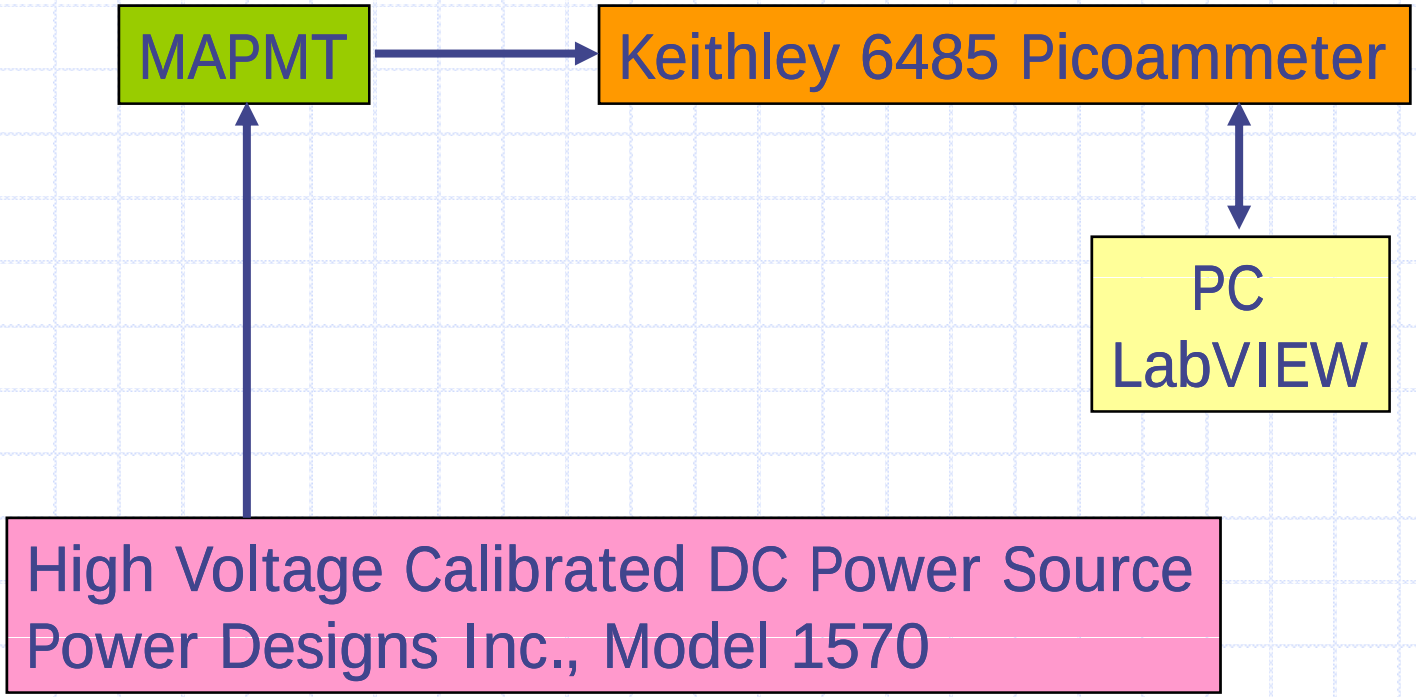
# PC Top View Mapping

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
| 33 | 34 | 35 | 36 | **37** | 38 | 39 | 40 |
| 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 |
| 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 |
| 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 |

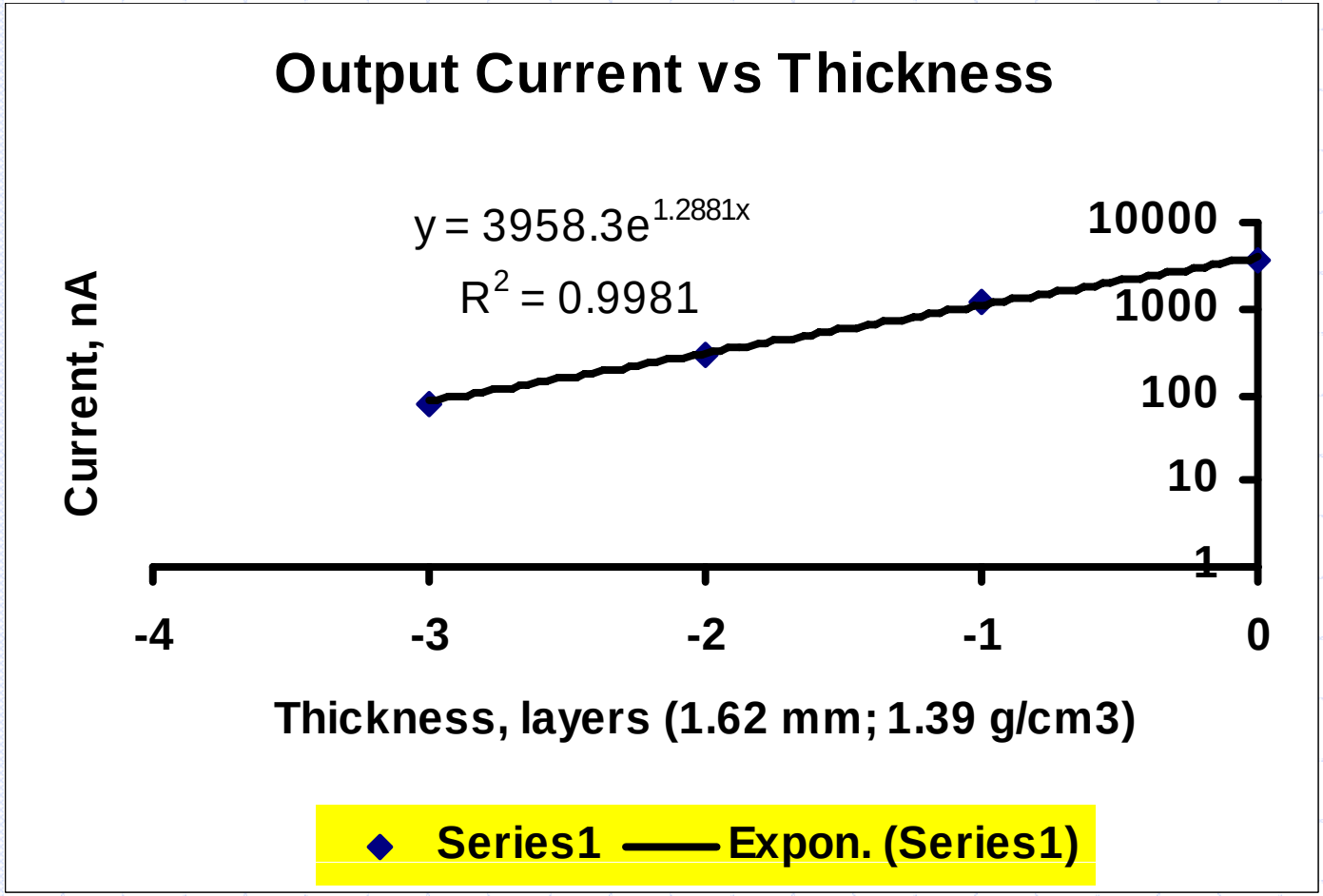
*57 channel input was used for the reference measurements.*
*64 channel input was used for the control measurements.*
*49,50,58 affected (by 57) channels.*

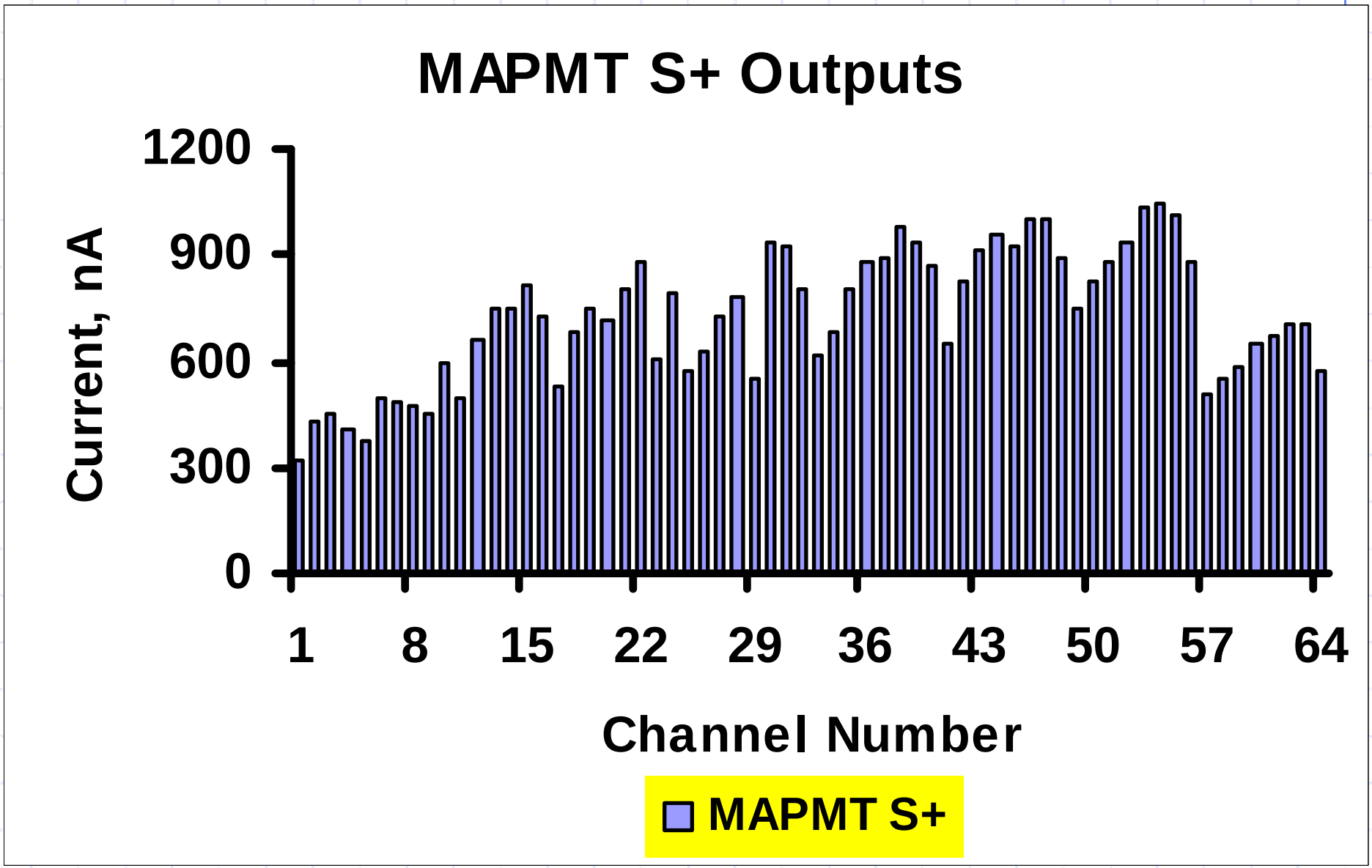
**S+ D+(a) D-(a)**
**S- D+(b) D-(b)**

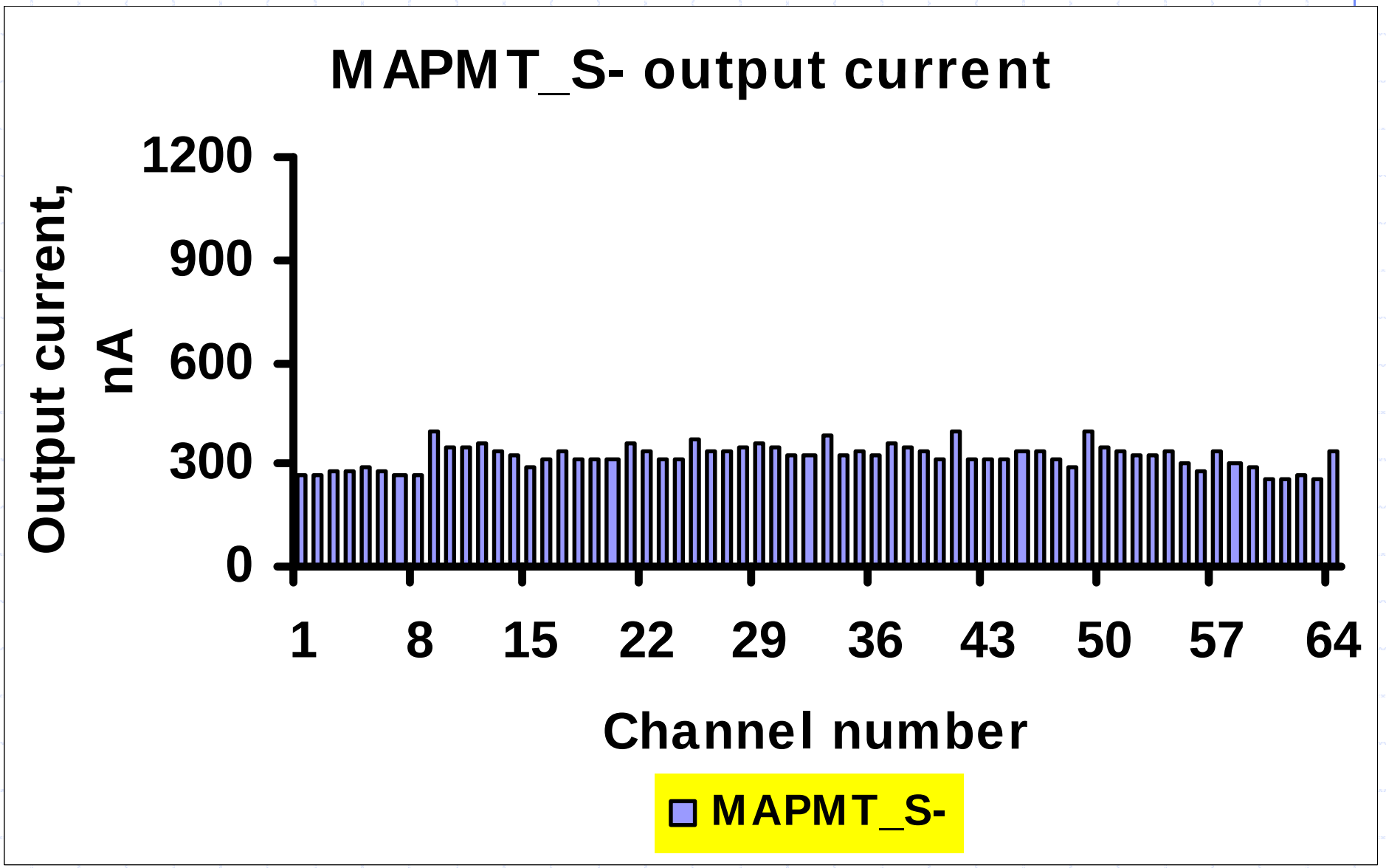
# Measurement Setup

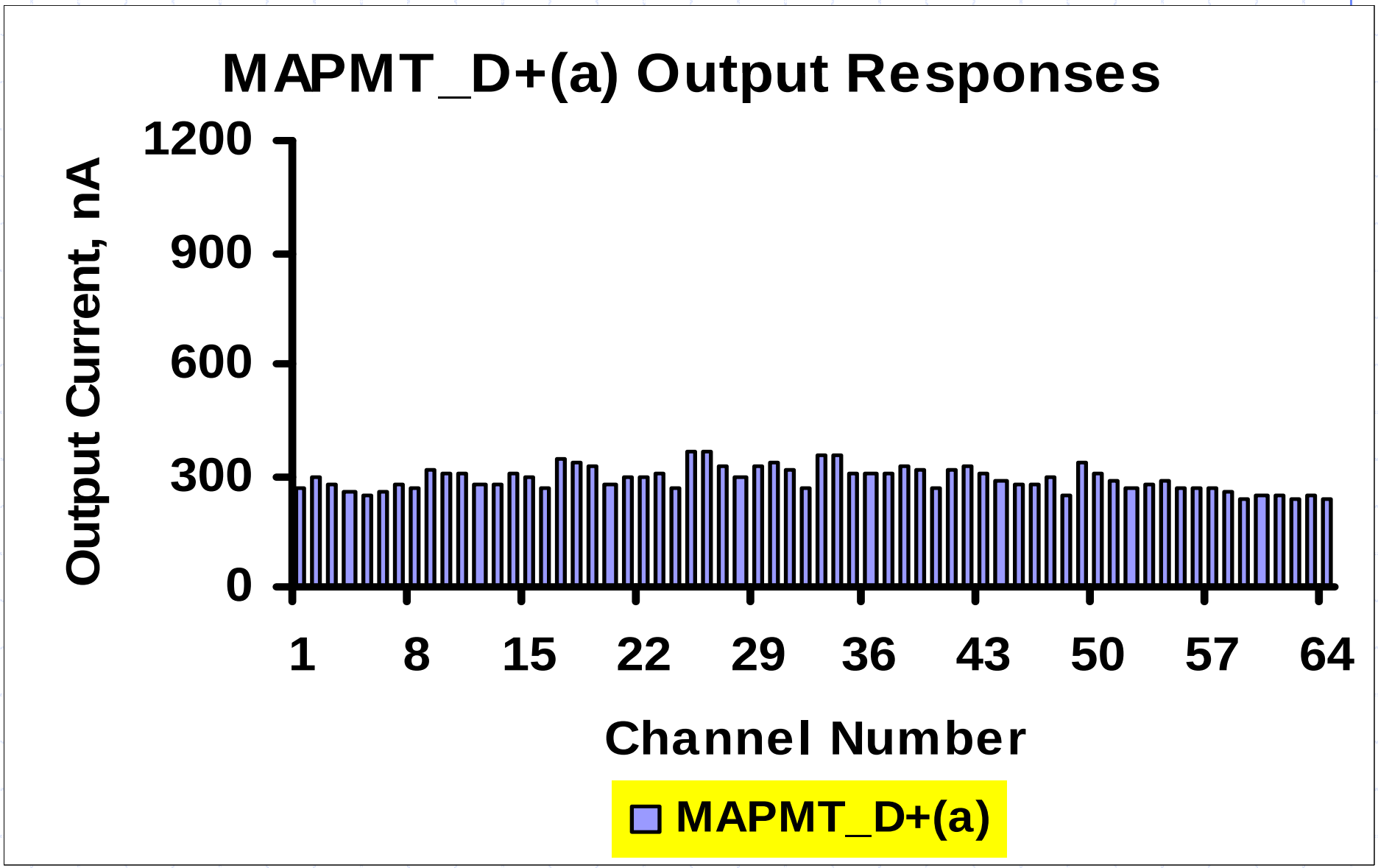


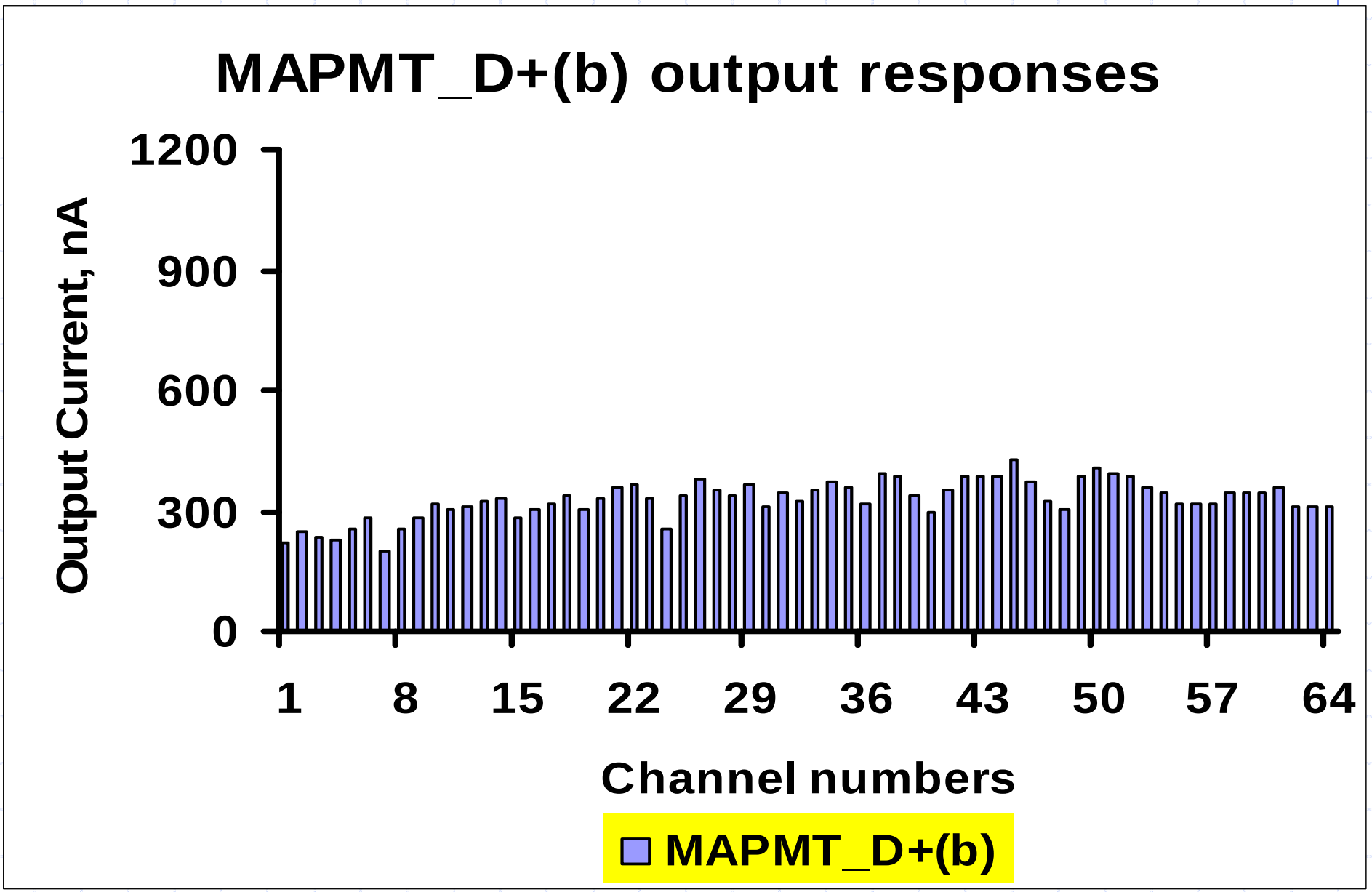
# Is PMT Output Saturated?

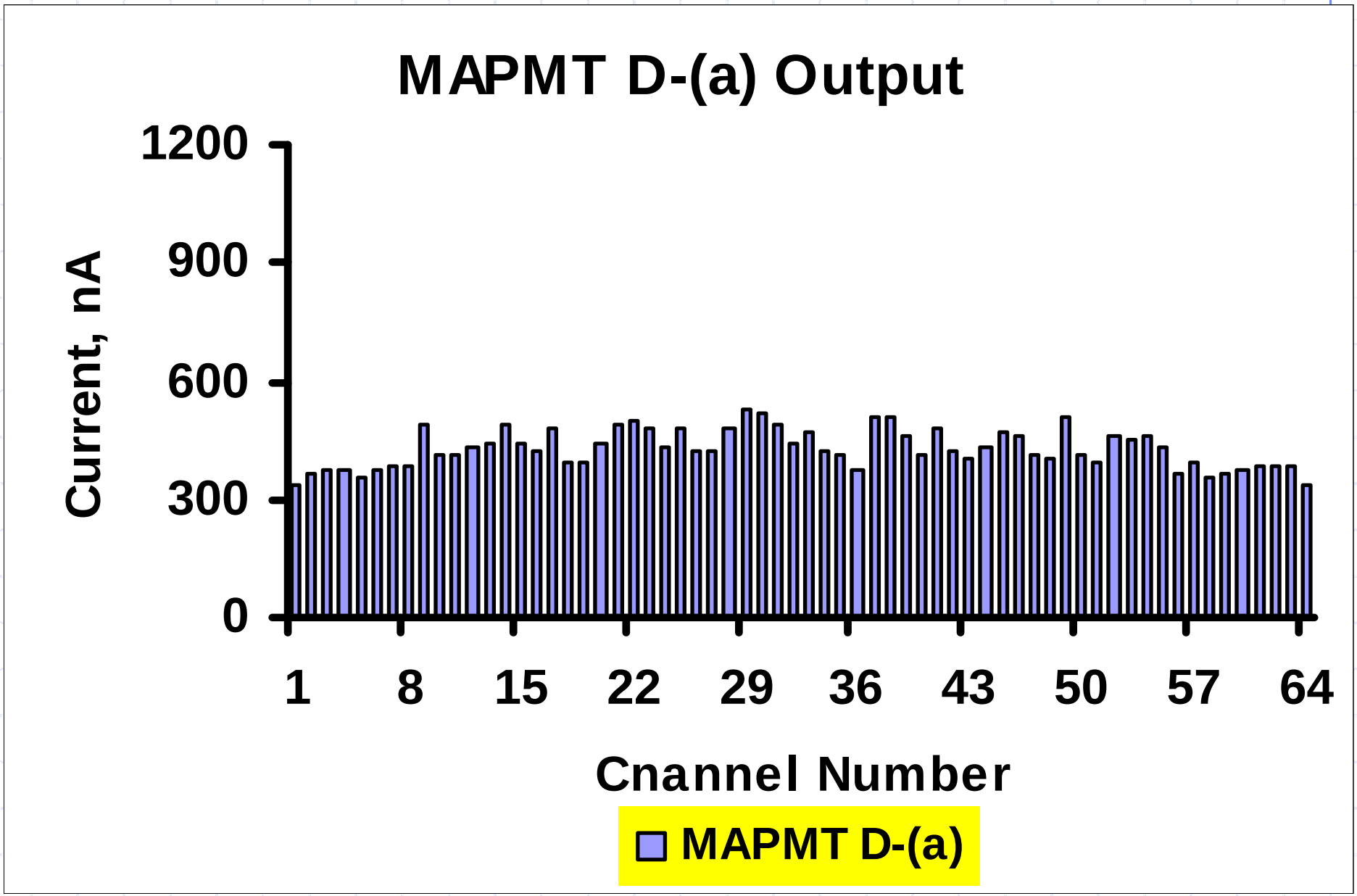


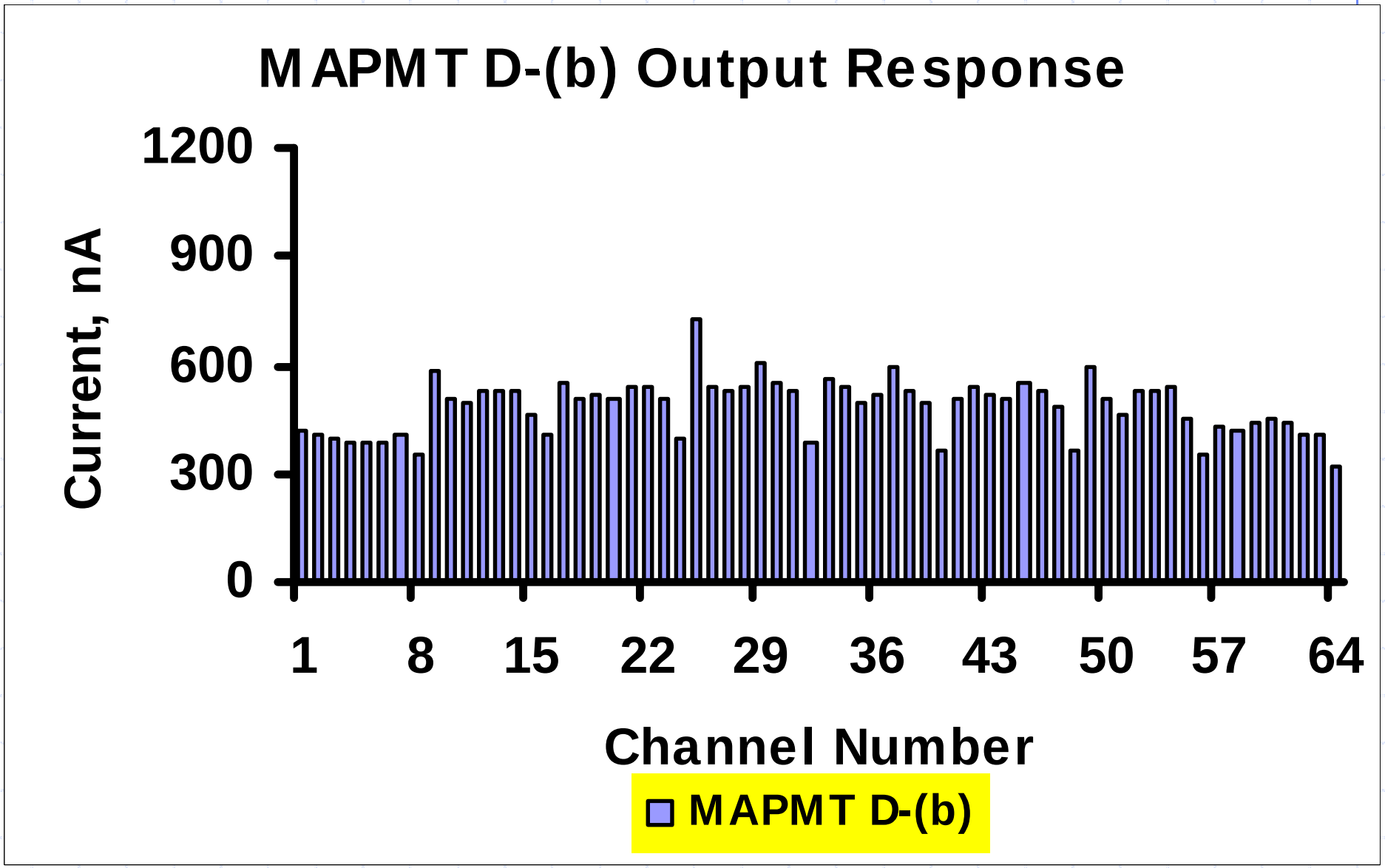

MAPMT S+ Outputs
Current, nA
1200
900
600
300
0
1
8
15
22
29
36
43
50
57
64
Channel Number
MAPMT S+


MAPMT_S- output current
Output current, nA
1200
900
600
300
0
1
8
15
22
29
36
43
50
57
64
Channel number
MAPMT_S-

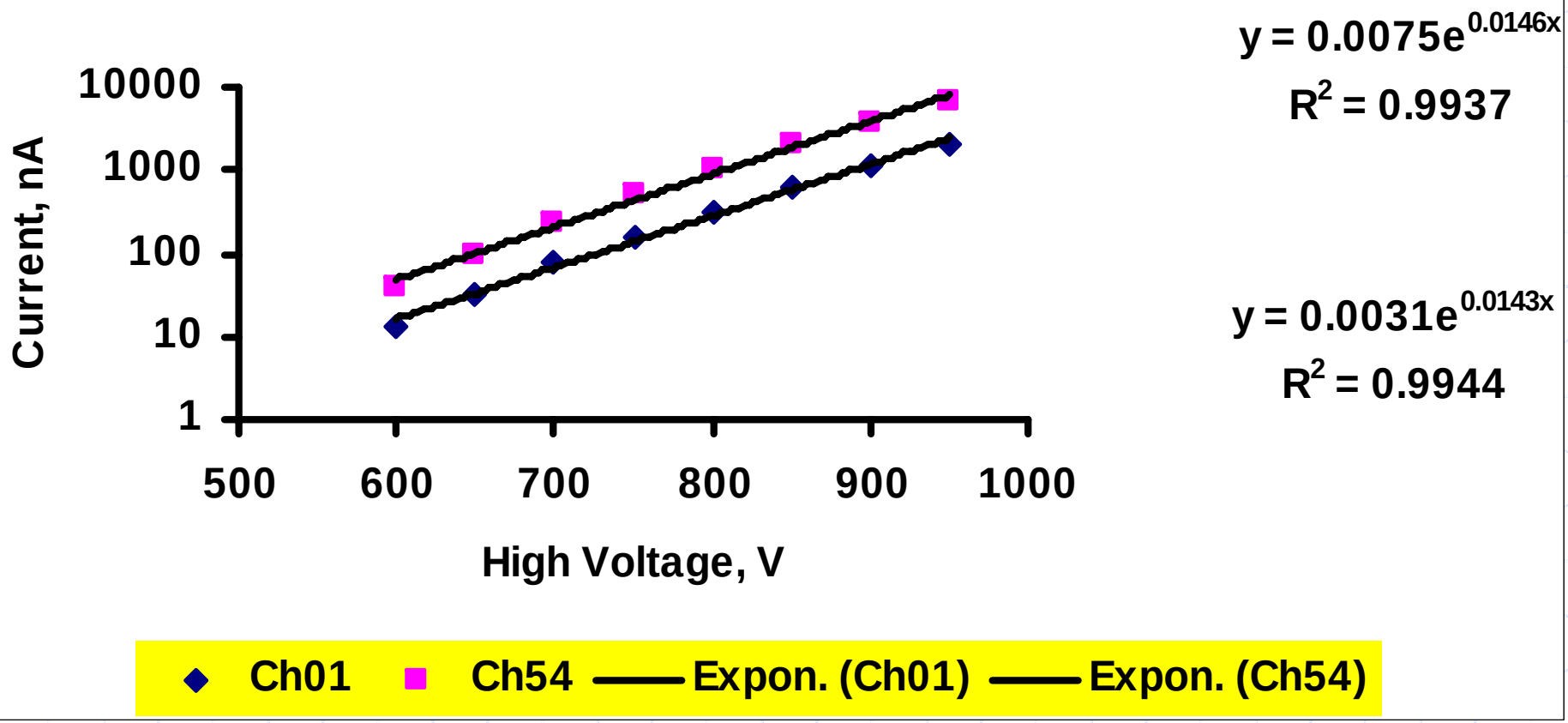

MAPMT_D+(a) Output Responses
Output Current, nA
1200
900
600
300
0
1
8
15
22
29
36
43
50
57
64
Channel Number
MAPMT_D+(a)

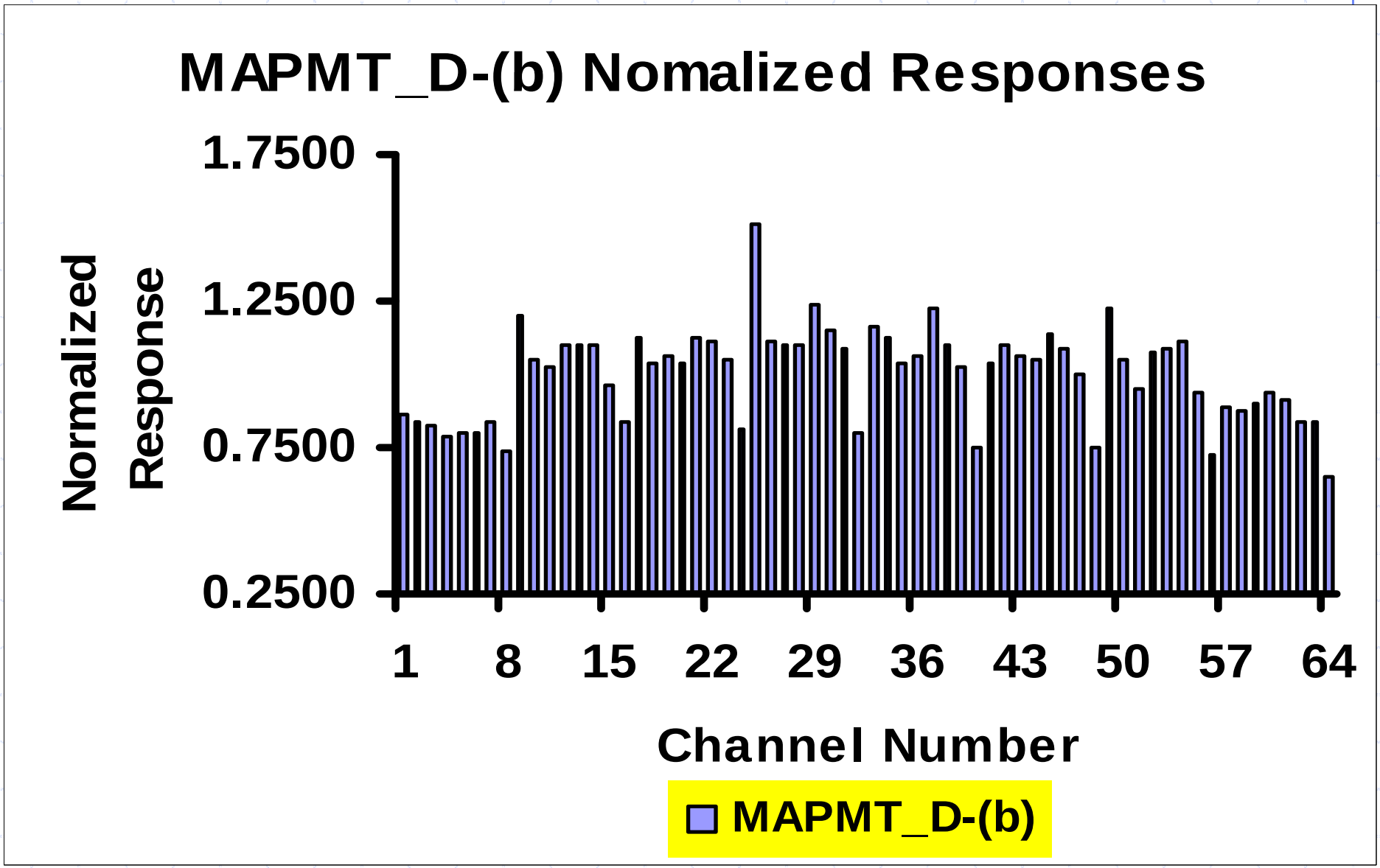

MAPMT_D+(b) output responses
Output Current, nA
1200
900
600
300
0
1
8
15
22
29
36
43
50
57
64
Channel numbers
MAPMT_D+(b)

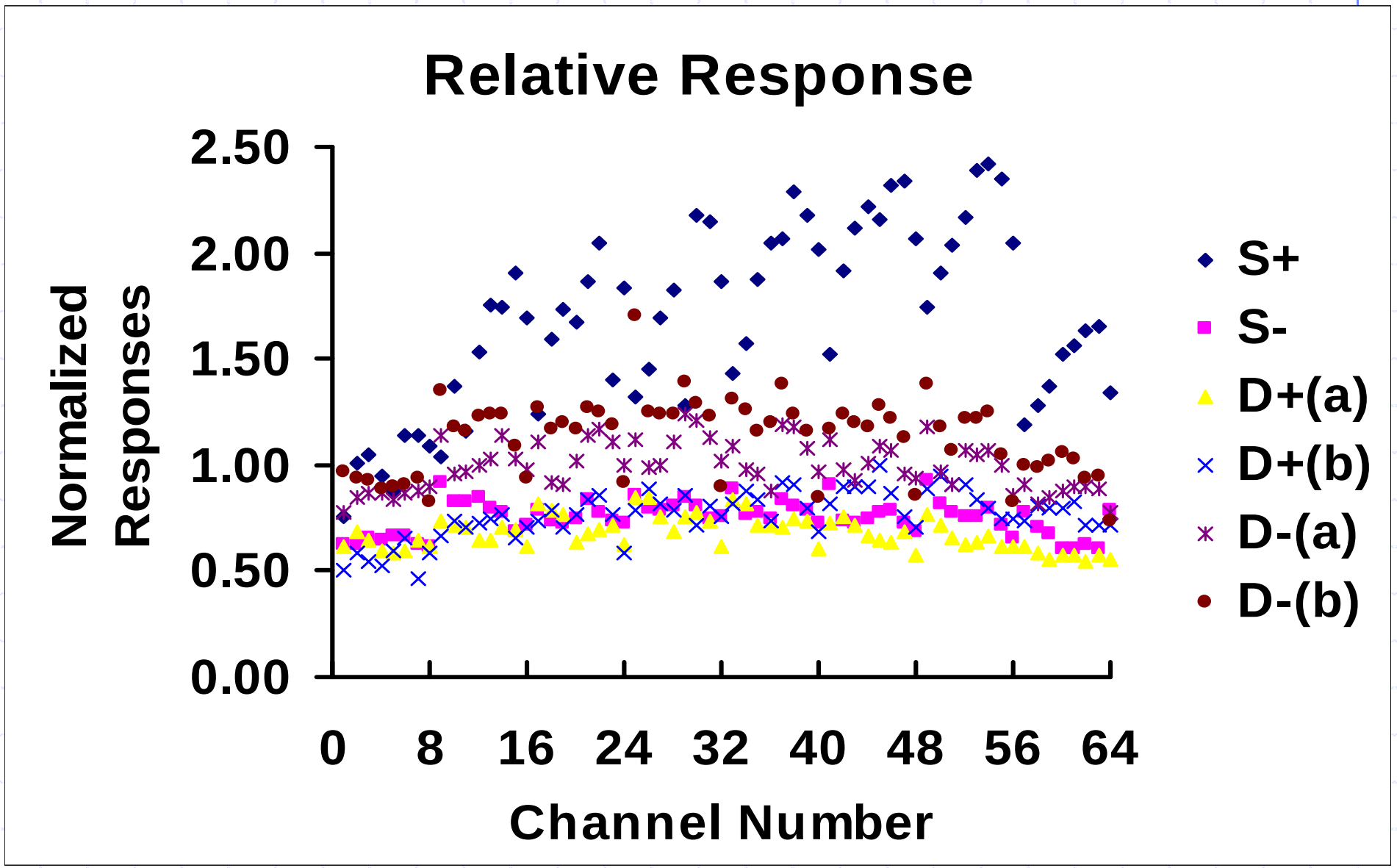

MAPMT D-(a) Output
Current, nA
1200
900
600
300
0
1
8
15
22
29
36
43
50
57
64
Cnannel Number
MAPMT D-(a)

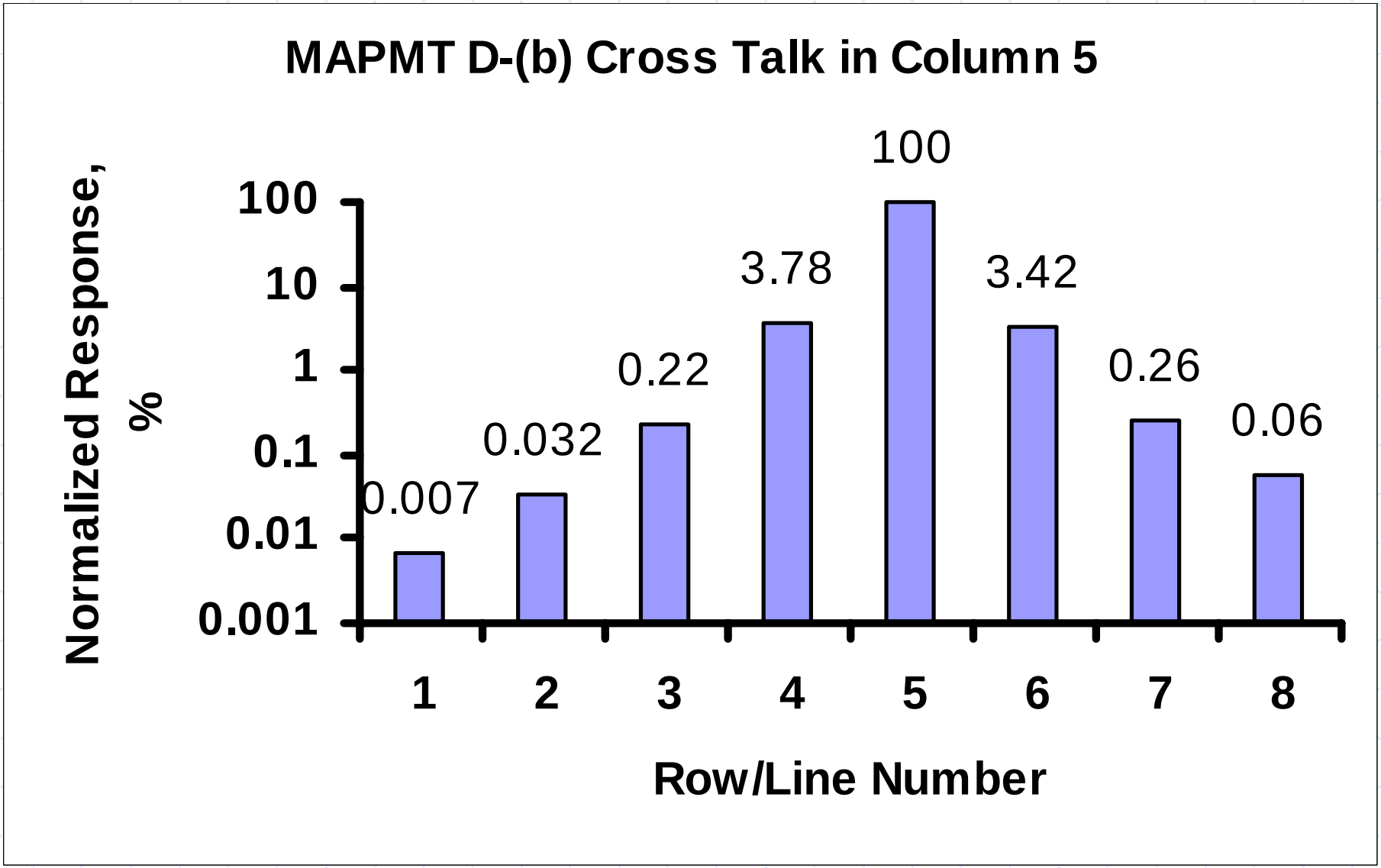

MAPMT D-(b) Output Response
Current, nA
1200
900
600
300
0
1
8
15
22
29
36
43
50
57
64
Channel Number
MAPMT D-(b)

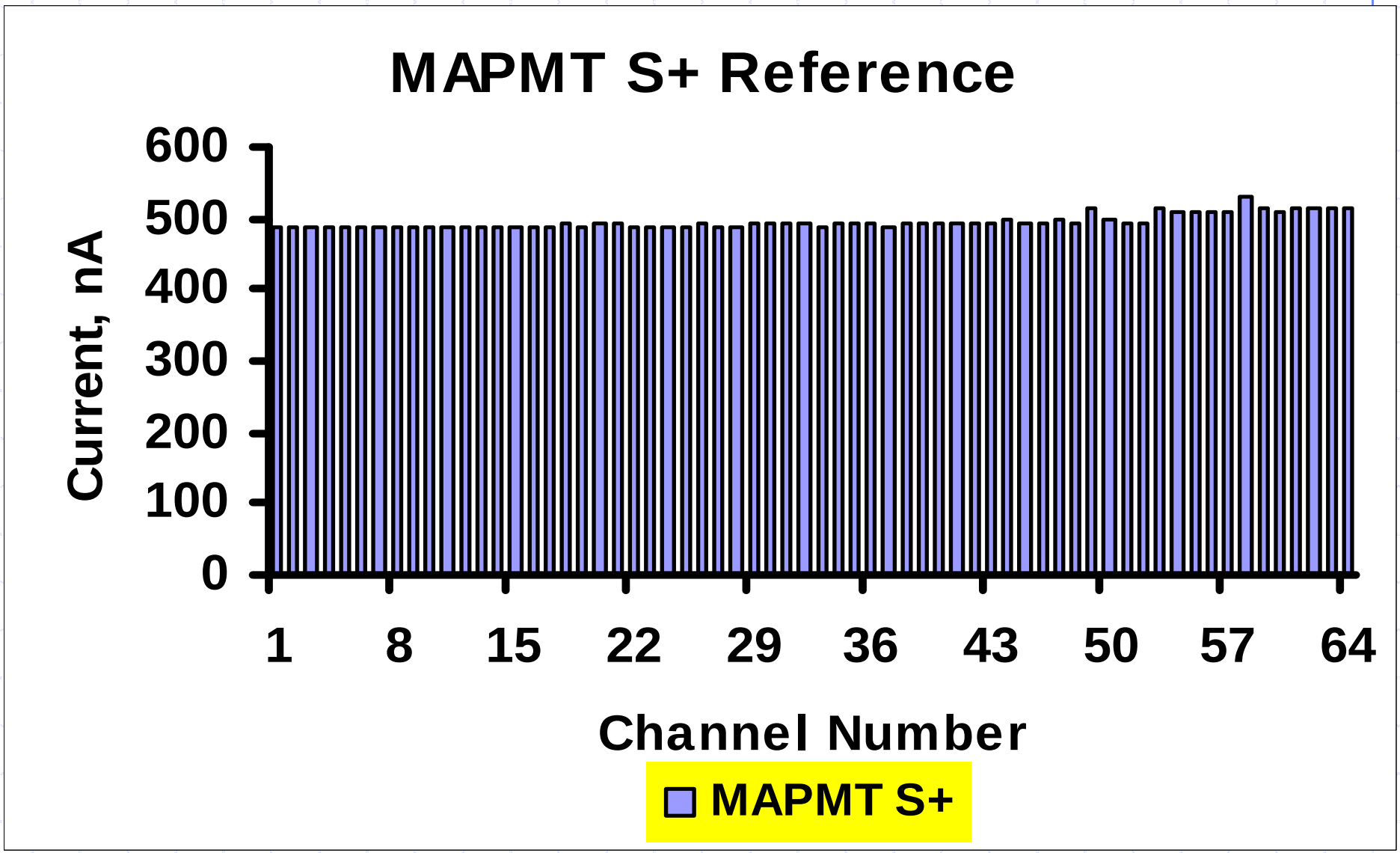
# Output Current for Different MAPMT S+ Channels

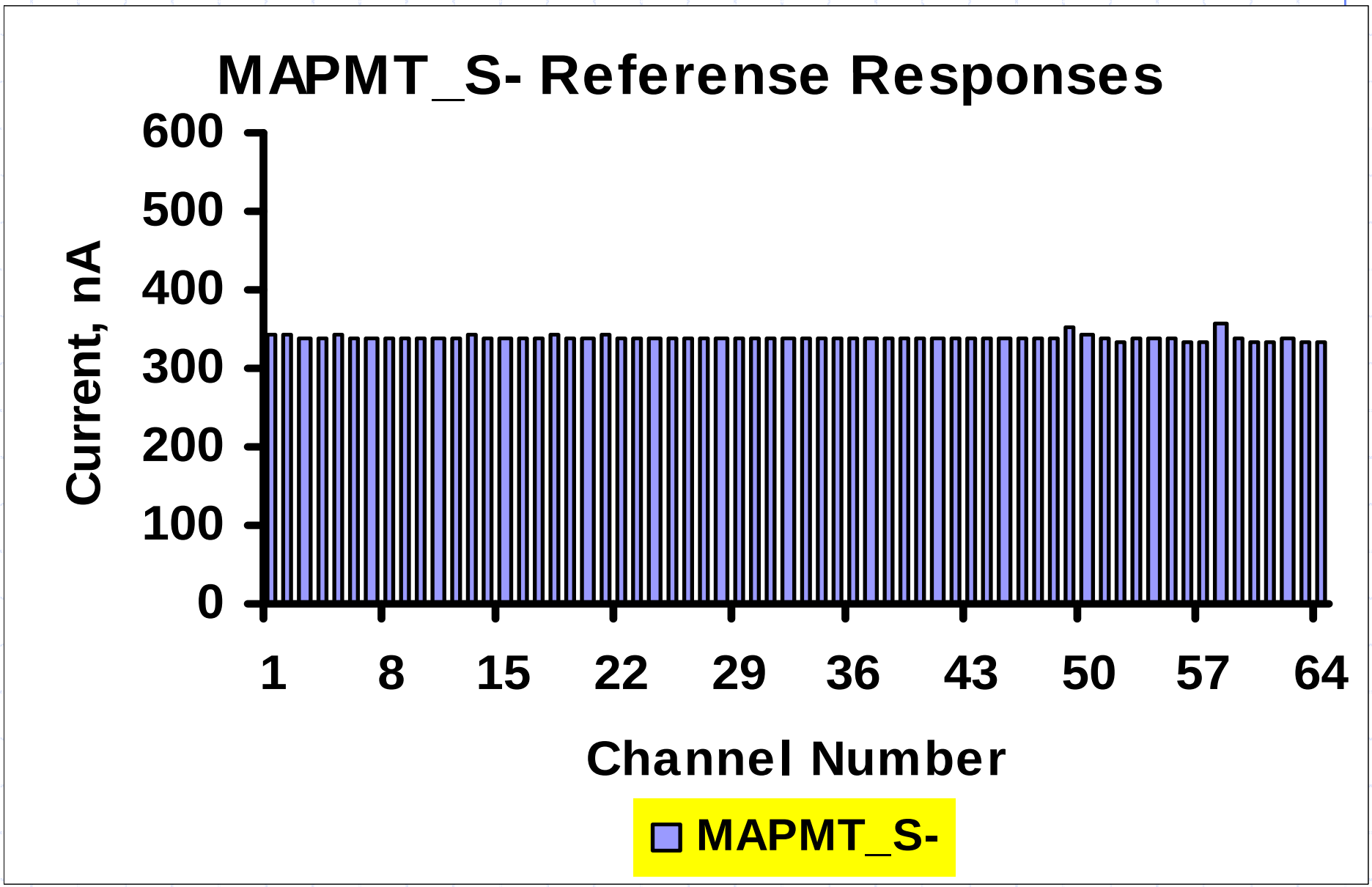


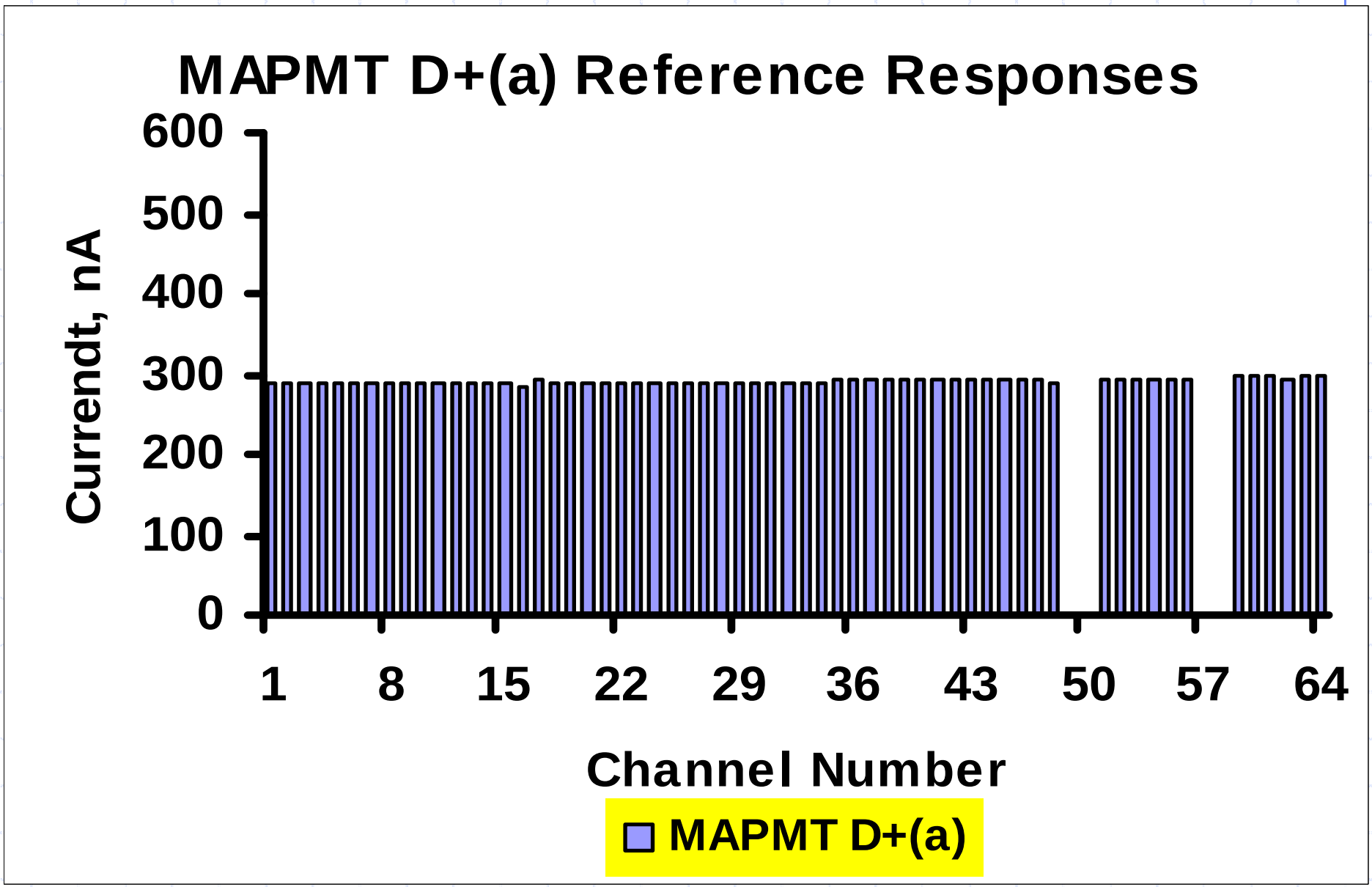

MAPMT_D-(b) Nomalized Responses
Normalized Response
1.7500
1.2500
0.7500
0.2500
1
8
15
22
29
36
43
50
57
64
Channel Number
MAPMT_D-(b)

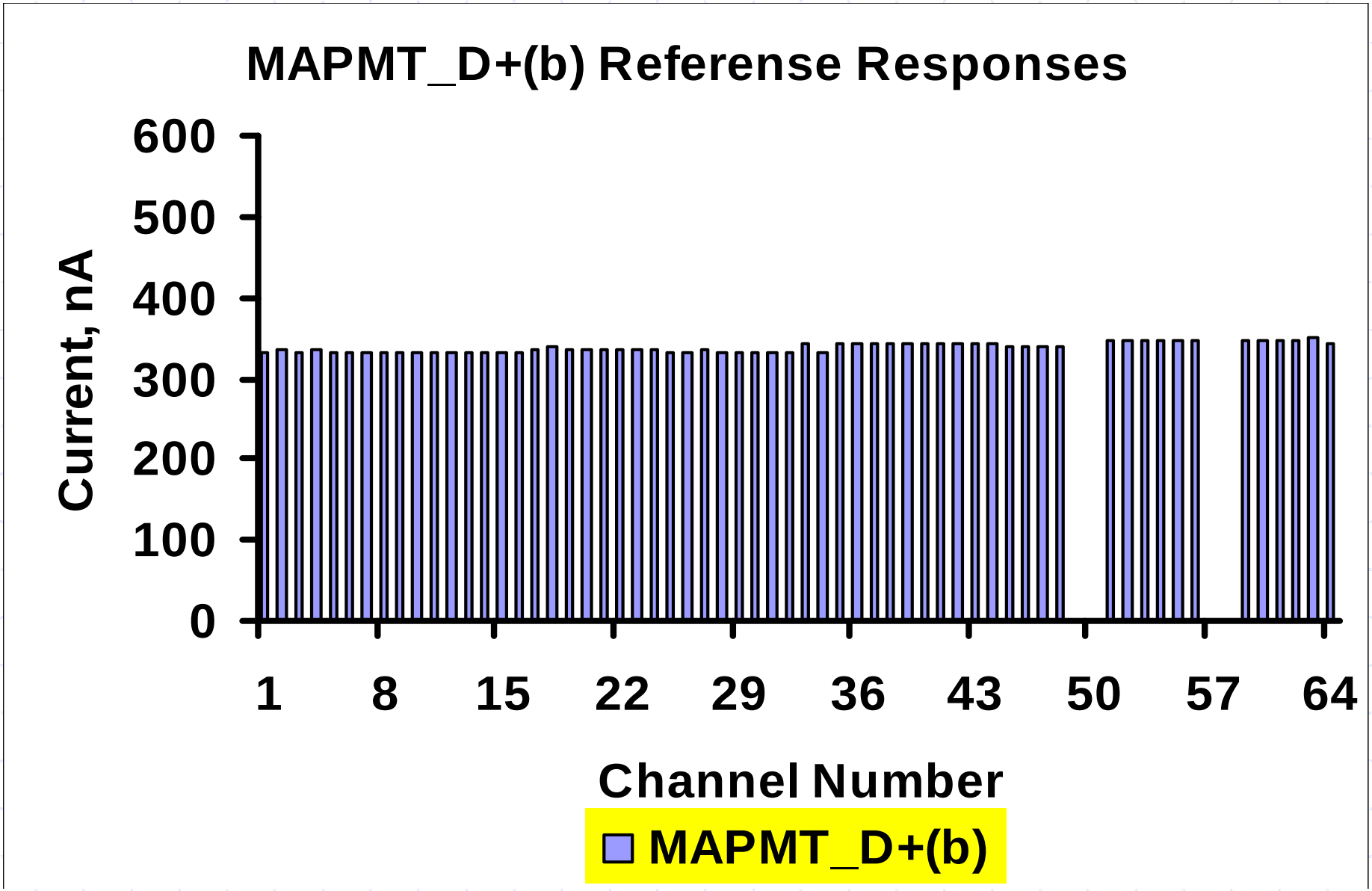

Relative Response
Normalized Responses
2.50
2.00
1.50
1.00
0.50
0.00
0
8
16
24
32
40
48
56
64
Channel Number
S+
S-
D+(a)
D+(b)
D-(a)
D-(b)

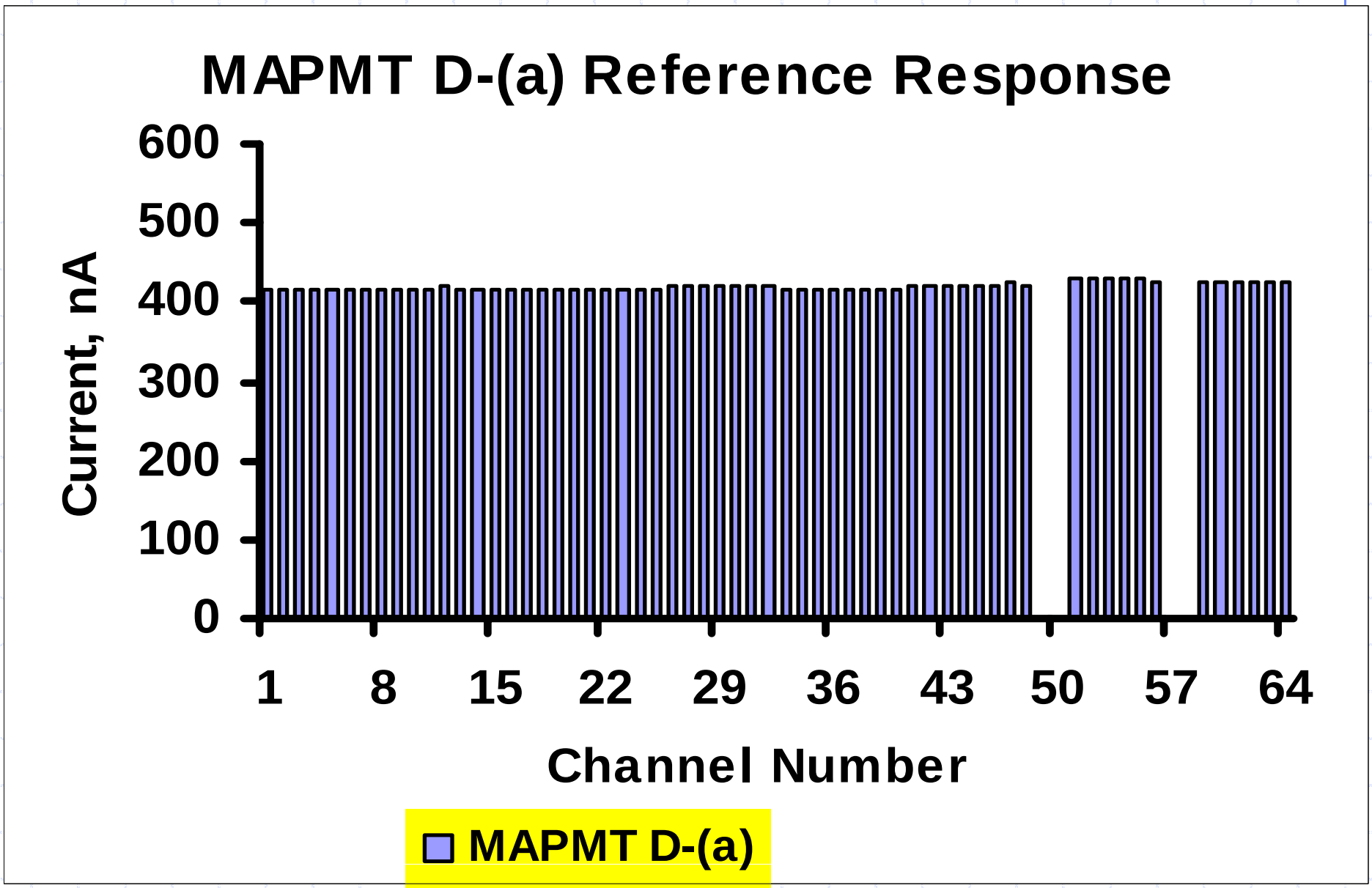

MAPMT D-(b) Cross Talk in Column 5
Normalized Response, %
100
10
1
0.1
0.01
0.001
0.007
0.032
0.22
3.78
100
3.42
0.26
0.06
1
2
3
4
5
6
7
8
Row/Line Number

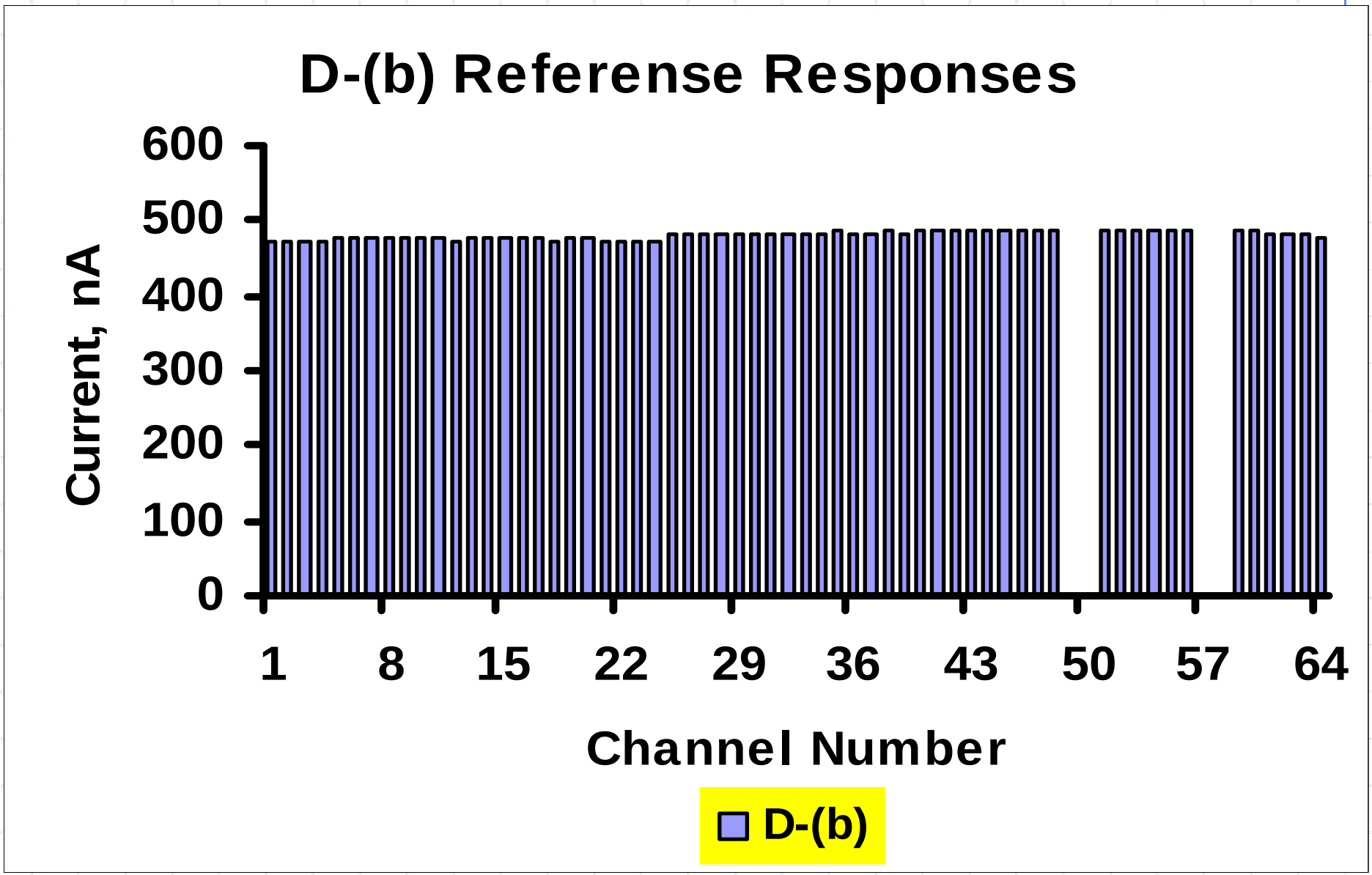

MAPMT S+ Reference
Current, nA
600
500
400
300
200
100
0
1
8
15
22
29
36
43
50
57
64
Channel Number
MAPMT S+


MAPMT_S- Reference Responses
Current, nA
600
500
400
300
200
100
0
1
8
15
22
29
36
43
50
57
64
Channel Number
MAPMT_S-


MAPMT D+(a) Reference Responses
Currendt, nA
600
500
400
300
200
100
0
1
8
15
22
29
36
43
50
57
64
Channel Number
MAPMT D+(a)


MAPMT_D+(b) Reference Responses
Current, nA
600
500
400
300
200
100
0
1
8
15
22
29
36
43
50
57
64
Channel Number
MAPMT_D+(b)


MAPMT D-(a) Reference Response
Current, nA
600
500
400
300
200
100
0
1
8
15
22
29
36
43
50
57
64
Channel Number
MAPMT D-(a)


D-(b) Reference Responses
Current, nA
600
500
400
300
200
100
0
1
8
15
22
29
36
43
50
57
64
Channel Number
D-(b)

# Table of MAPMTs Anode Output Current Parameters (units in nA)

| MAPMT | Mean | St.Dev. | Min | Max | Ratio |
|---|---|---|---|---|---|
| S+ | 726.1 | 184.9 | 323.4 | 1040.5 | 3.22 |
| S- | 322.2 | 34.2 | 258.8 | 400 | 1.55 |
| D+(a) | 291.0 | 33.0 | 235 | 362.7 | 1.54 |
| D+(b) | 328.5 | 48.0 | 198.9 | 427.5 | 2.15 |
| D-(a) | 427.7 | 49.3 | 332.3 | 532.1 | 1.60 |
| D-(b) | 484.6 | 76.3 | 315.4 | 731.3 | 2.32 |
| | | | 198.9 | 1040.5 | 5.23 |

# Summary

- *MAPMTs anode output currents are measured at the constant (green) input light brightness and the same photocathode to anode voltage (800V).*
- *The anode output currents have a wide spread. For all tubes the maximum value is 5.23 time larger than minimum value.*
- *MAPMT D-(b) cross talks were measured for the central input (channel 37). Maximum cross talk value is about 4.89%. Average cross talk for the nearest 4 neighboring channels is 3.91%, for the farther 4 is 0.98%.*
- *To assure the reproducibility and repeatability of the measurements the double reference method was used.*

# Conclusion

- MAPMT anode output current was measured at NICADD/NIU on 64 channels for 6 tubes using constant source of green light as input to each channel. 800 V voltage between photo cathode and anode was applied.
- Because of a few percent deviation in the reference and the control measurements, the **anode output current response of any channels can be directly compared** .
- Database Microsoft Excel file is available.

# Acknowledgments


- The authors would like to thank Phill Stone for excellent mechanical and machining support at NIU.

# References

- Quality control studies of wave length shifting fibers for a scintillator-based tail-catcher muon-tracker linear collider prototype detector. FERMILAB-PUB-06-129-E, May 2006, 10 pp; IEEE Trans. Nucl. Sci. 53: 3944-3948, 2006. *(In this study the double reference method was used.)*