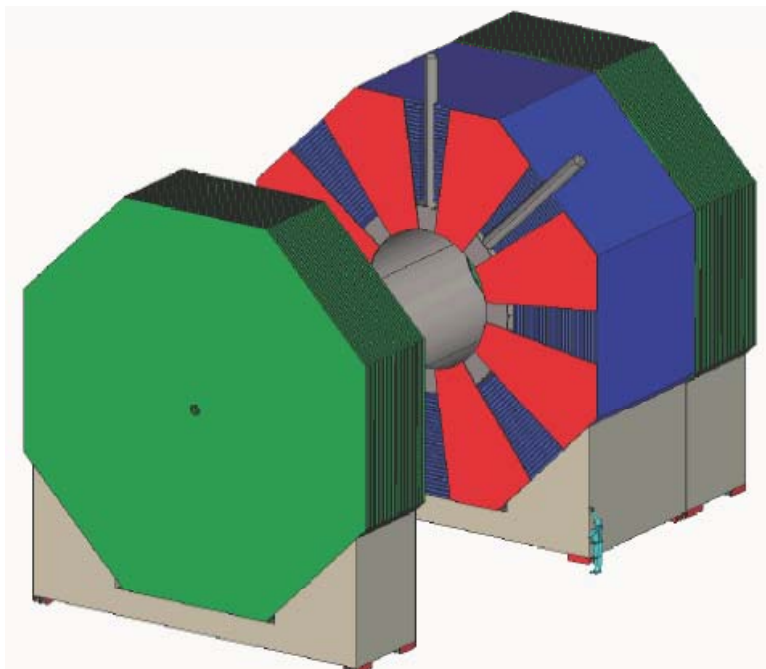




Radioactive Source Calibration of MAPMTs

Alexandre Dyshkant
for NICADD at NIU

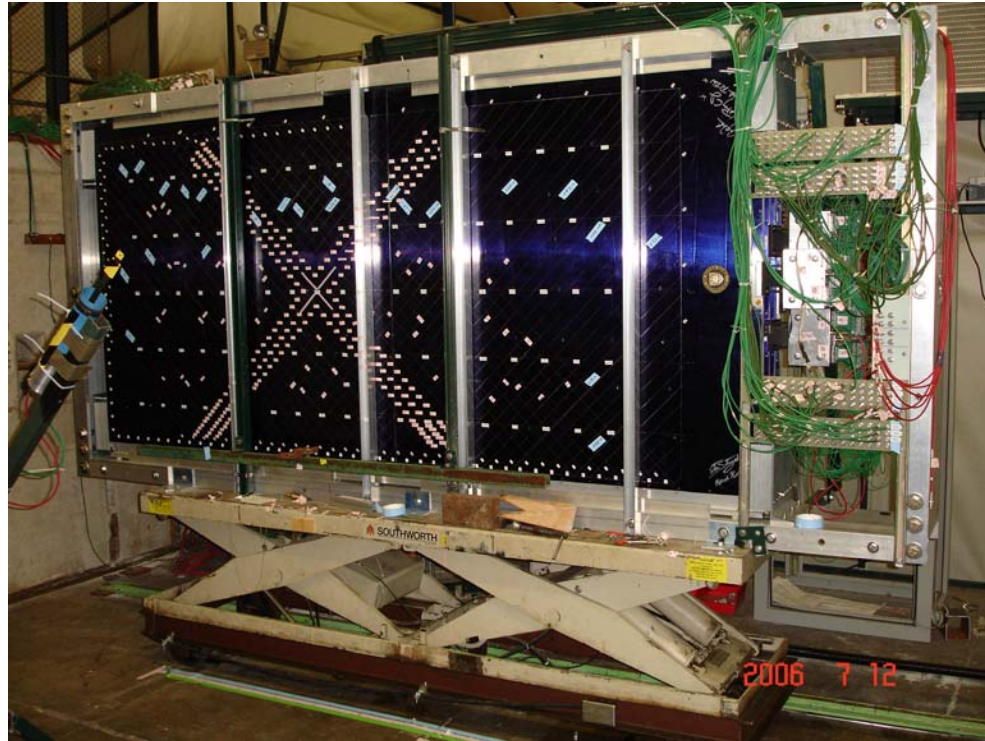
Proposed SiD Muon System/Tail Catcher



- Central Muon System:
 - After 4.6 nuclear interaction lengths (λ) Of calorimeters and the 5T solenoid coil and cryostat $1.27 \lambda \rightarrow \sim 6$ inter. Length.
 - Installed in the Iron of the 5T solenoid flux return $\sim 2.30\text{m}$ of Fe: $\sim 18 \lambda$ 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 $\sim 6000 \text{ m}^2$ 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

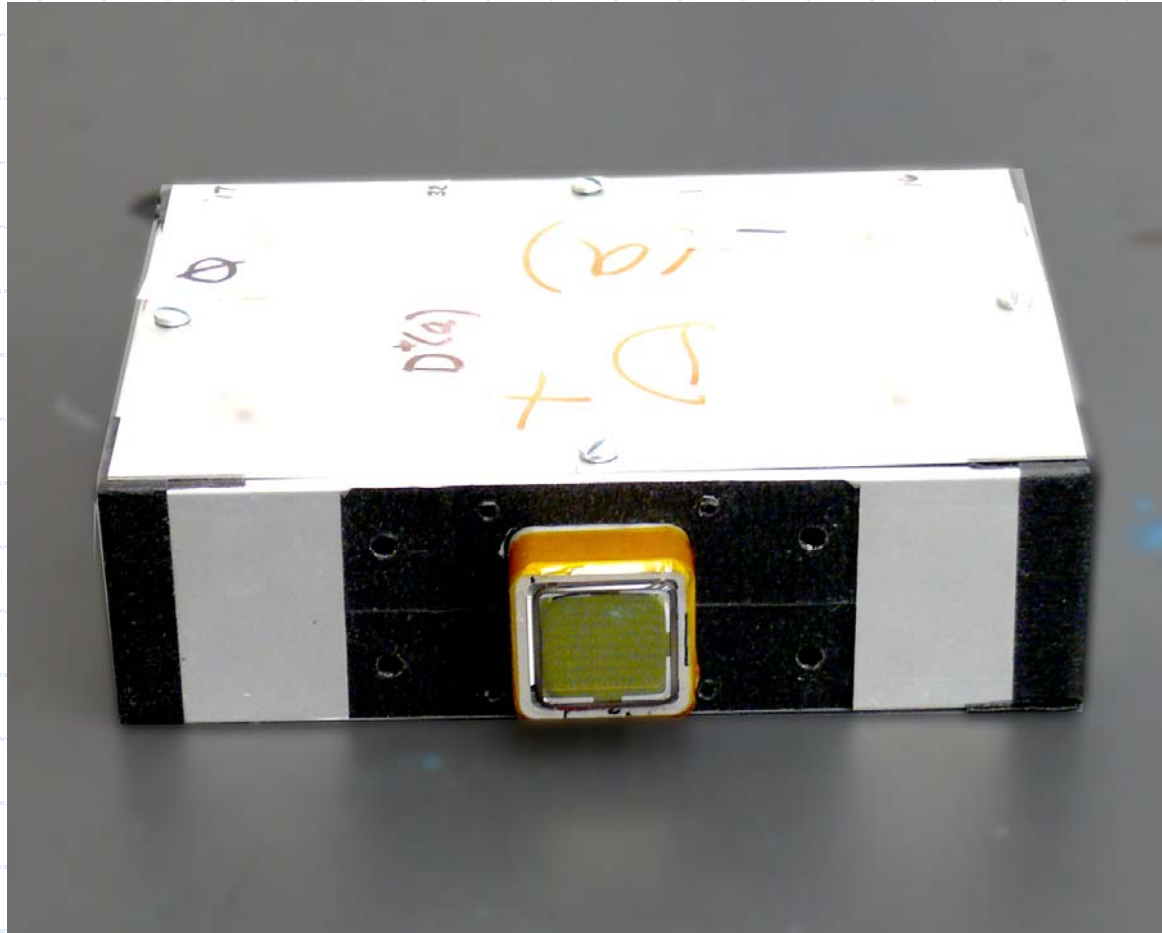
Goal

- ◆ As a possible first step to understand each strip's output, the response of every photomultiplier anode to a given 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.
- ◆ The PMT correction helps clarify a strip response to a beam particle.

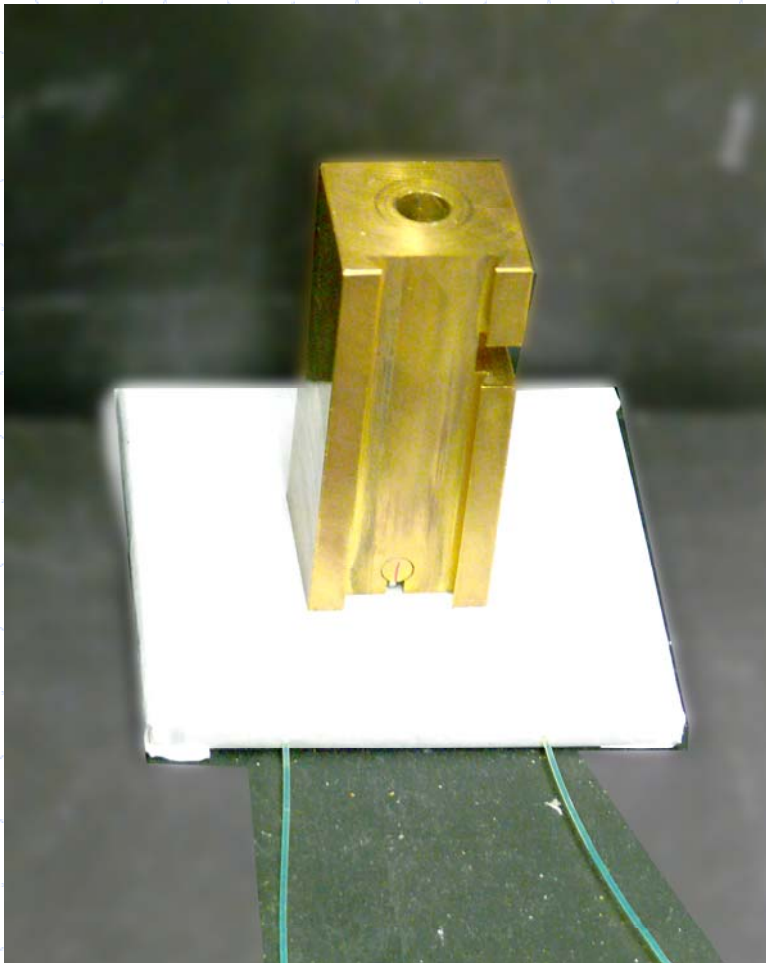
Simple Comparison of Photo Multiplier Tube Response

- ◆ The anode output current per incident light flux on the photo cathode is an important parameter in scintillation detection.
- ◆ This parameter is particularly useful when comparing tubes having the same or similar spectral response range.
- ◆ The light flux and the applied voltage are usually adjusted to an appropriate level.
- ◆ The scintillator usually produces emission in the **blue** region of the spectrum.

Boxed MAPMT

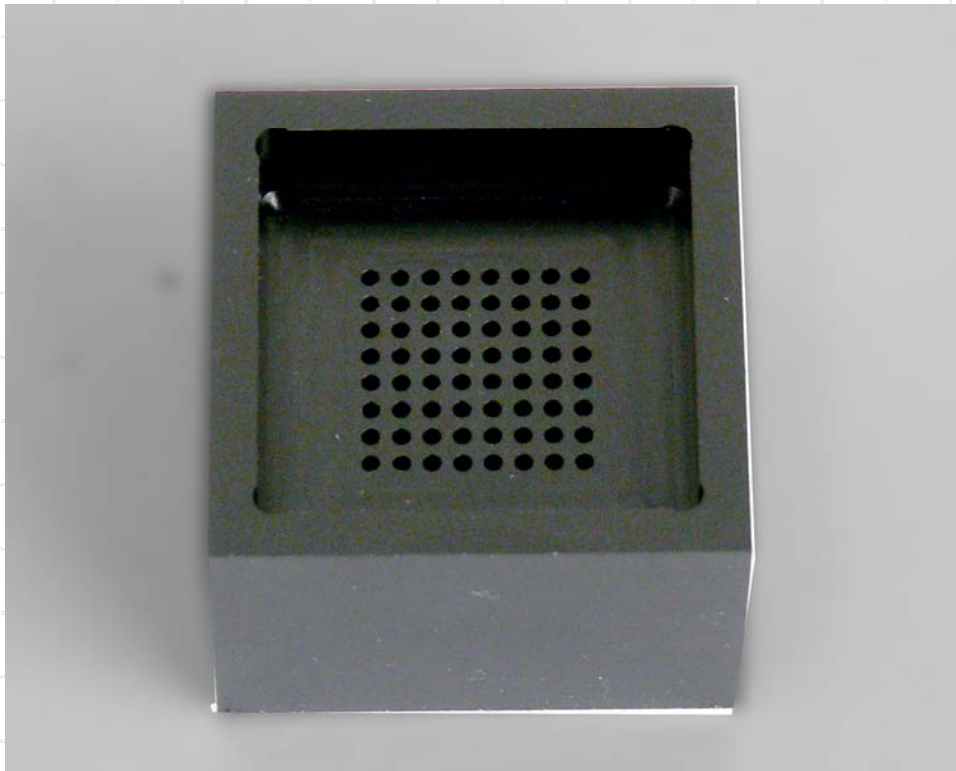


Custom Made Source of Light Mimics **Green** Strip Emission Spectrum



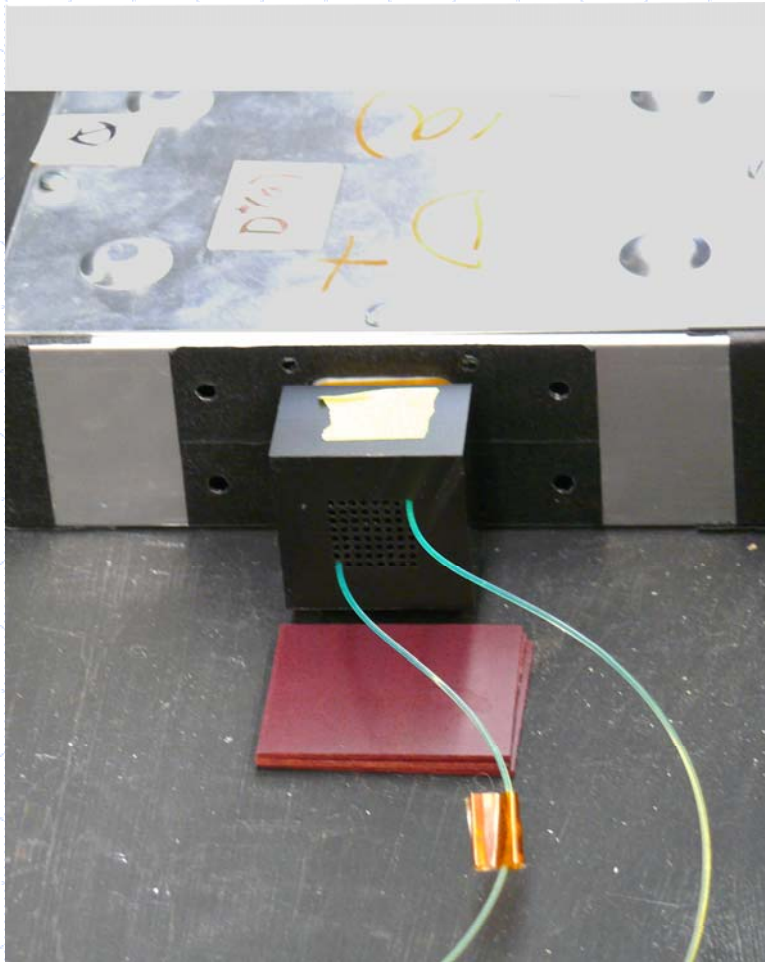
- *Radioactive source Sr-90.*
- *Cast scintillator EJ-200, 10 mm thick with two grooves.*
- *WLS fibers Y-11, 1.2 mm in diameter, 1.01 m long, polished mirrored, UV protected.*
- *Two layers of Tyvek wrapping.*
- *Two WLS fibers were used because of the double reference method measurements.*

Custom Made Interface



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

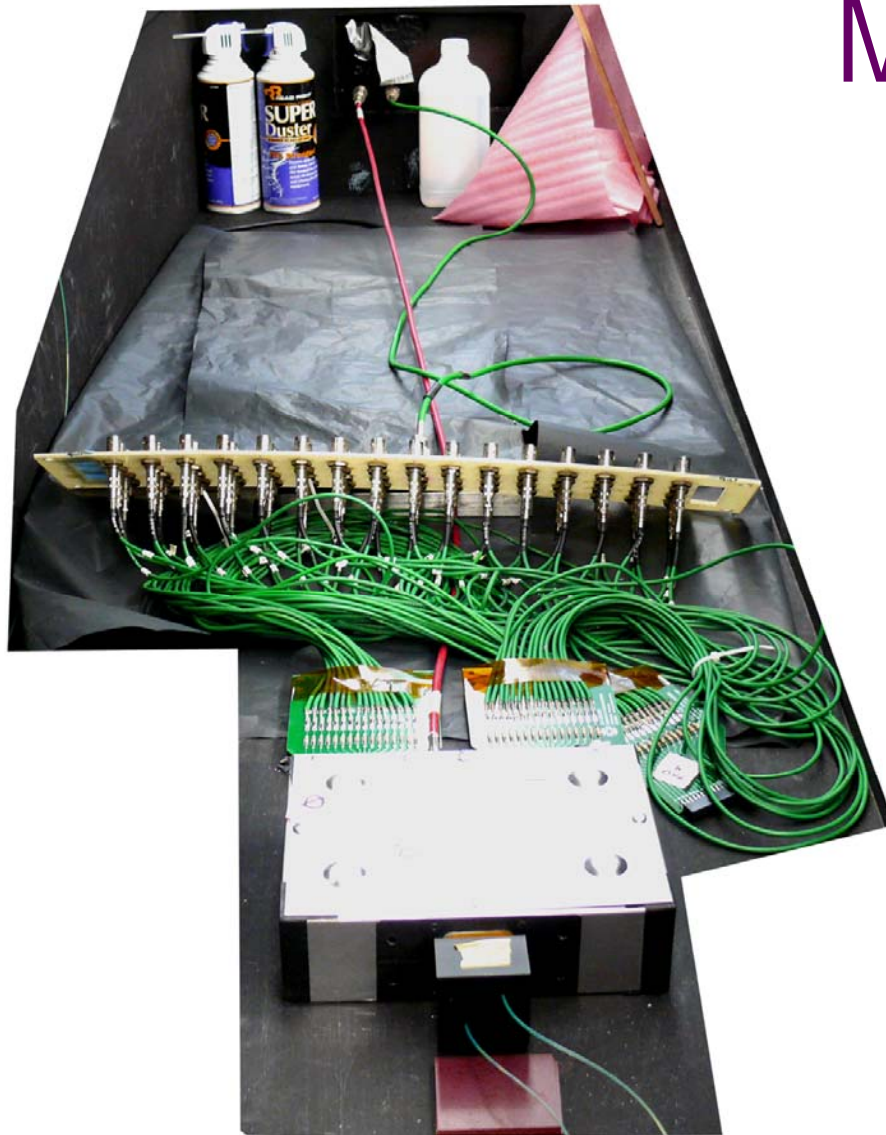
Boxed MAPMT with Interface and WLS Fibers Connected



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 Connections



Each output was measured independently.
Each output has a reference measurement in the same MAPMT.
Each eight output measurements have a control measurement.
Measurements were performed in a light tight box at about 800 V and a room temperature.

Photo Cathode 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

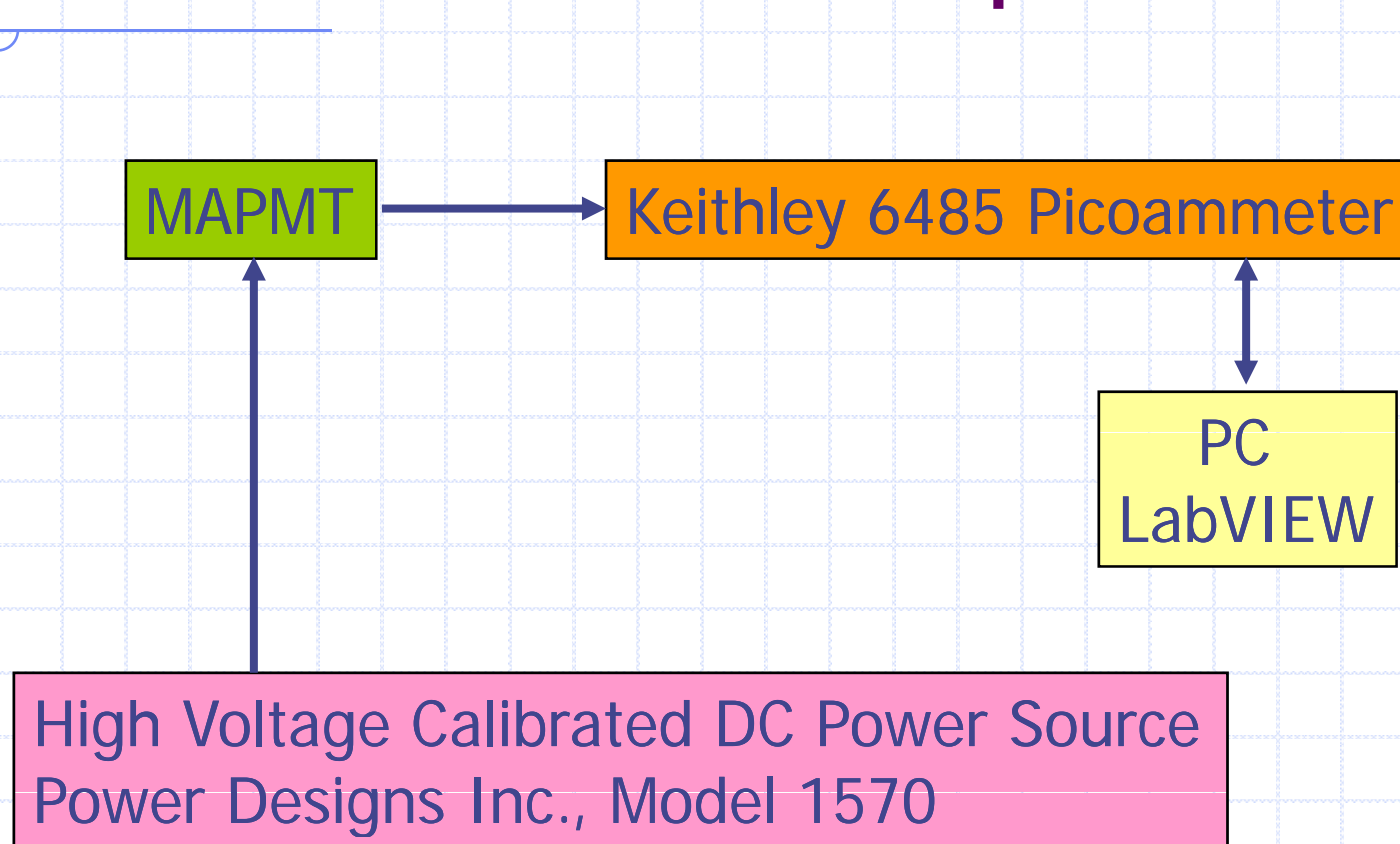
57 channel input was used for the reference measurements.

64 channel input was used for the control measurements.

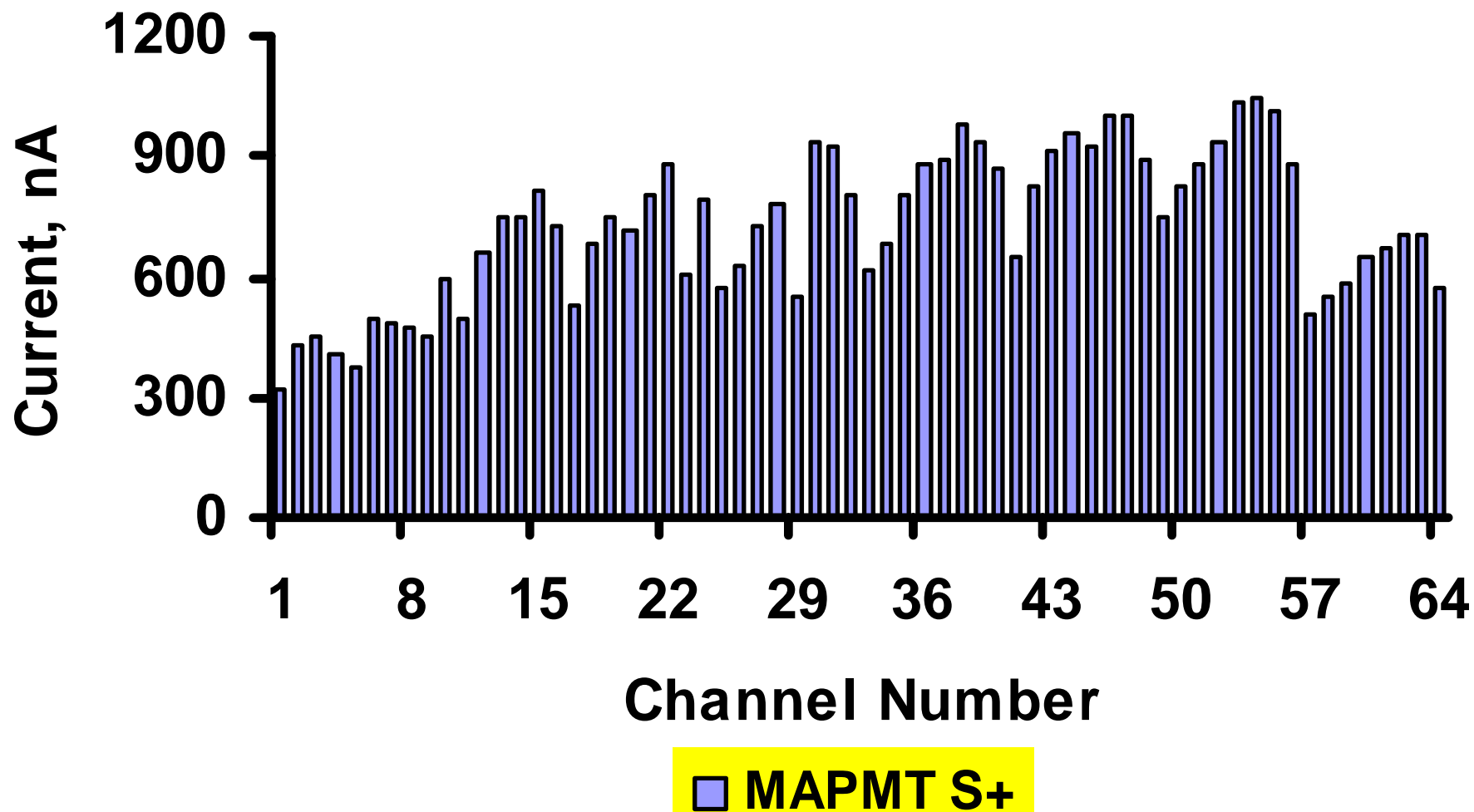
49,50,58 affected (by 57) channels.

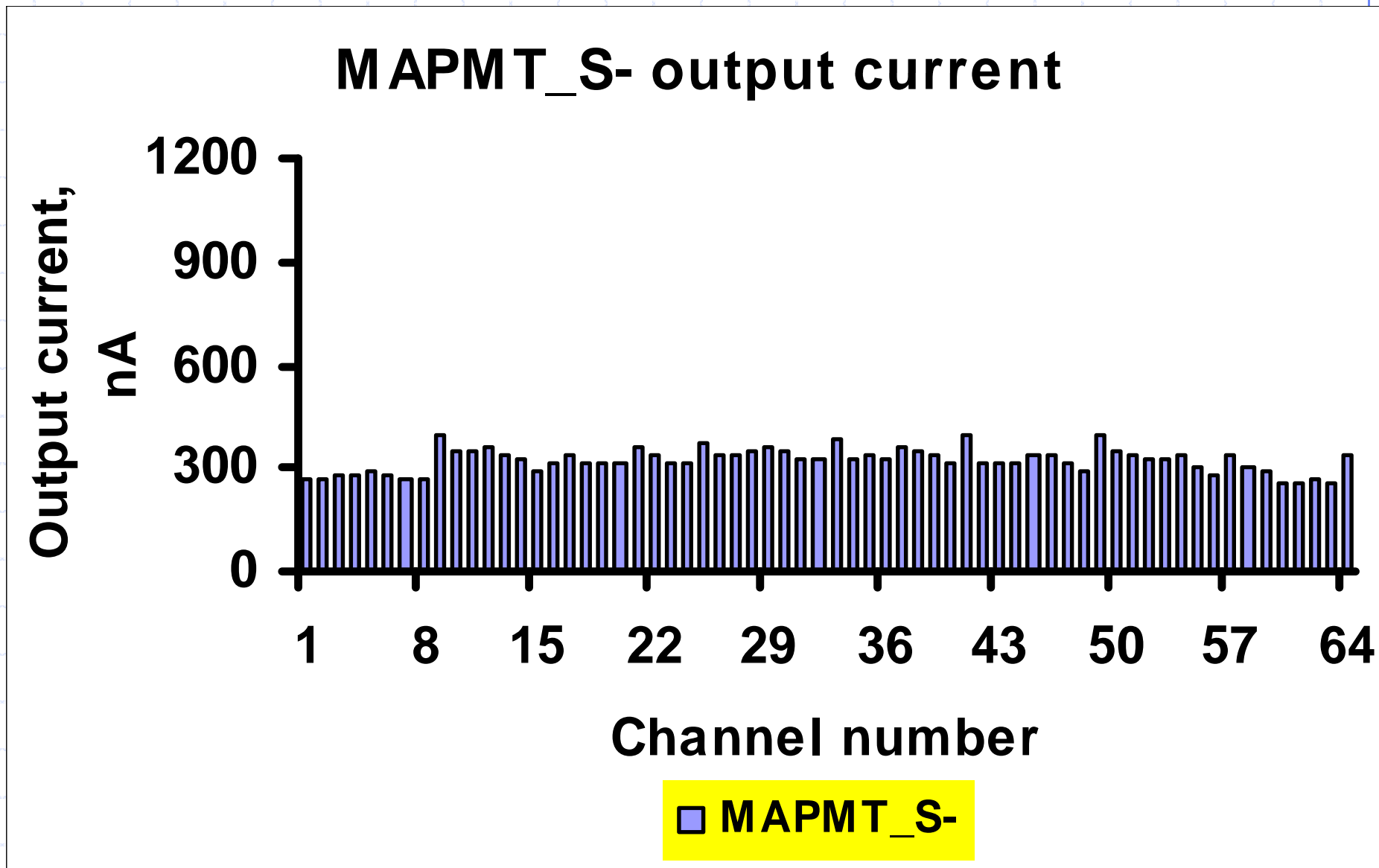
S+ D+ (a) D- (a)
S- D+ (b) D- (b)

Measurement Setup

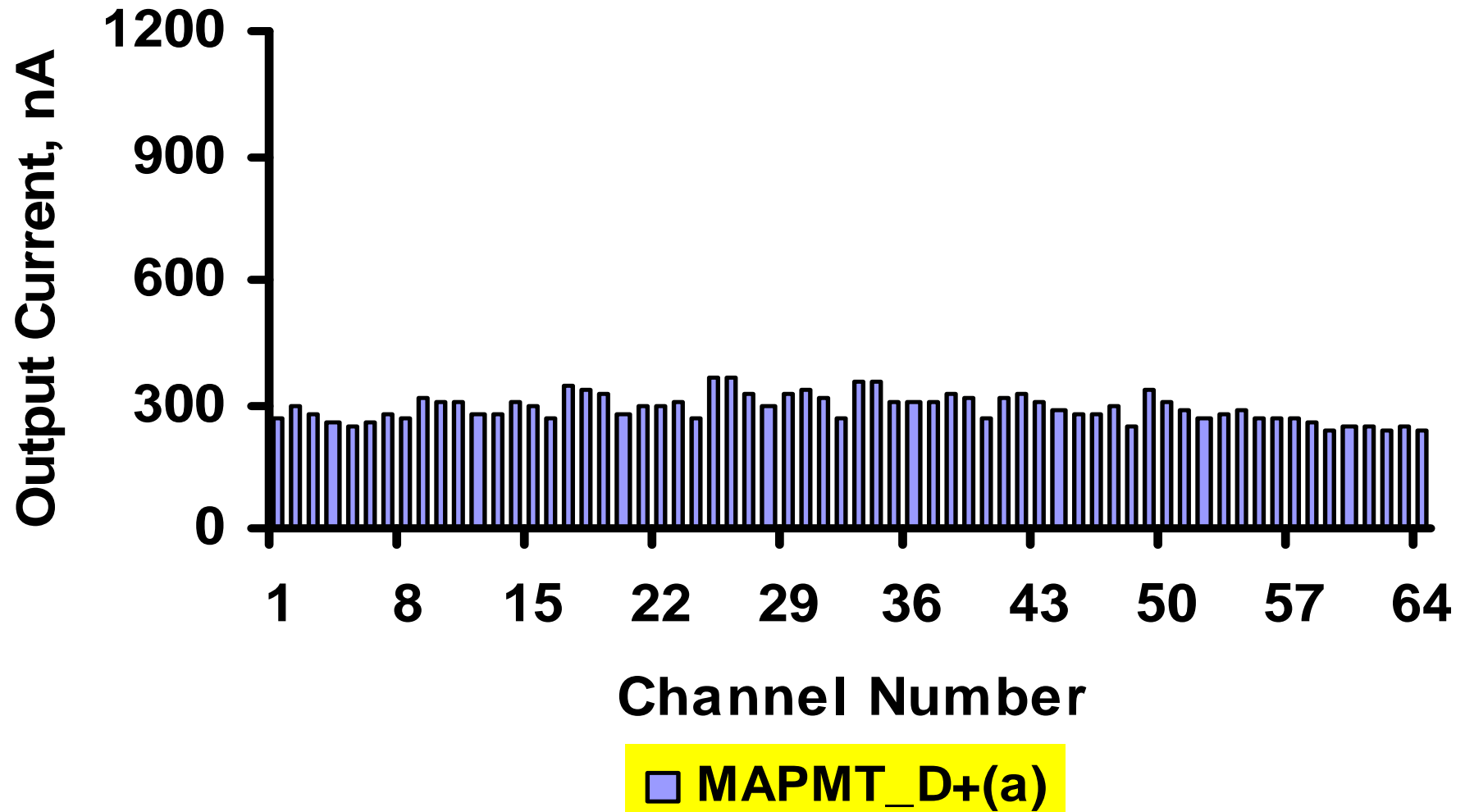


MAPMT S+ Outputs

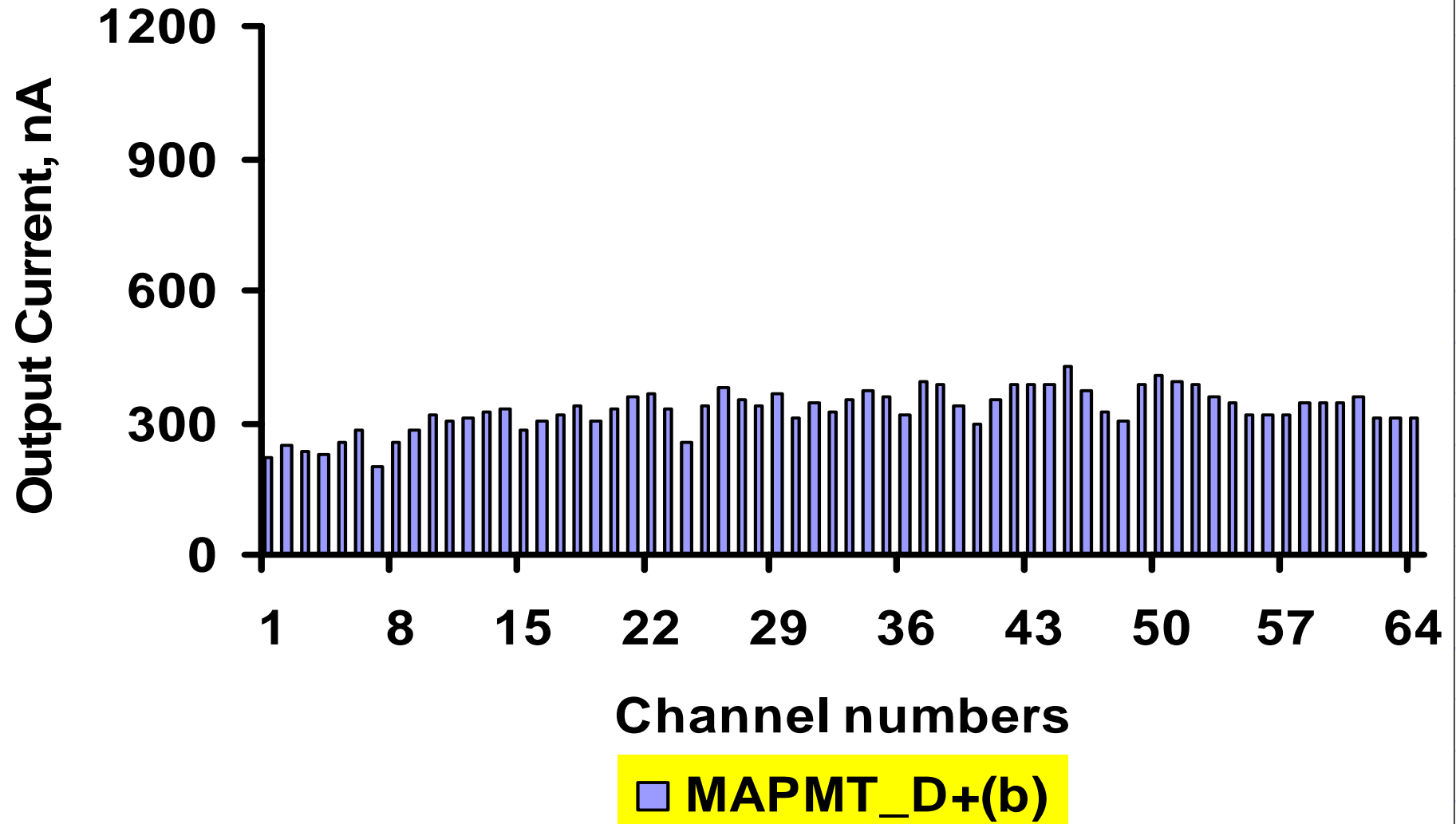




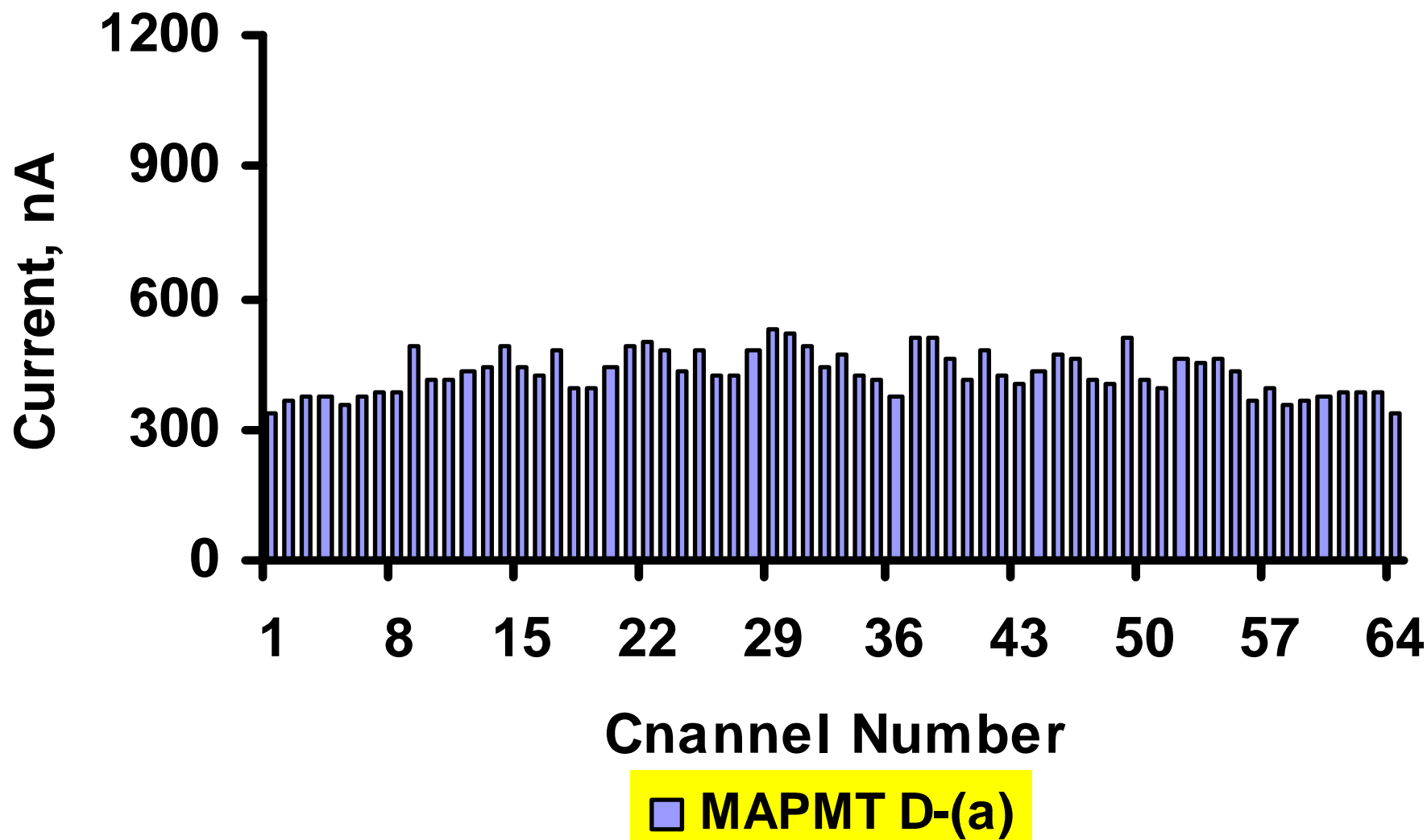
MAPMT_D+(a) Output Responses



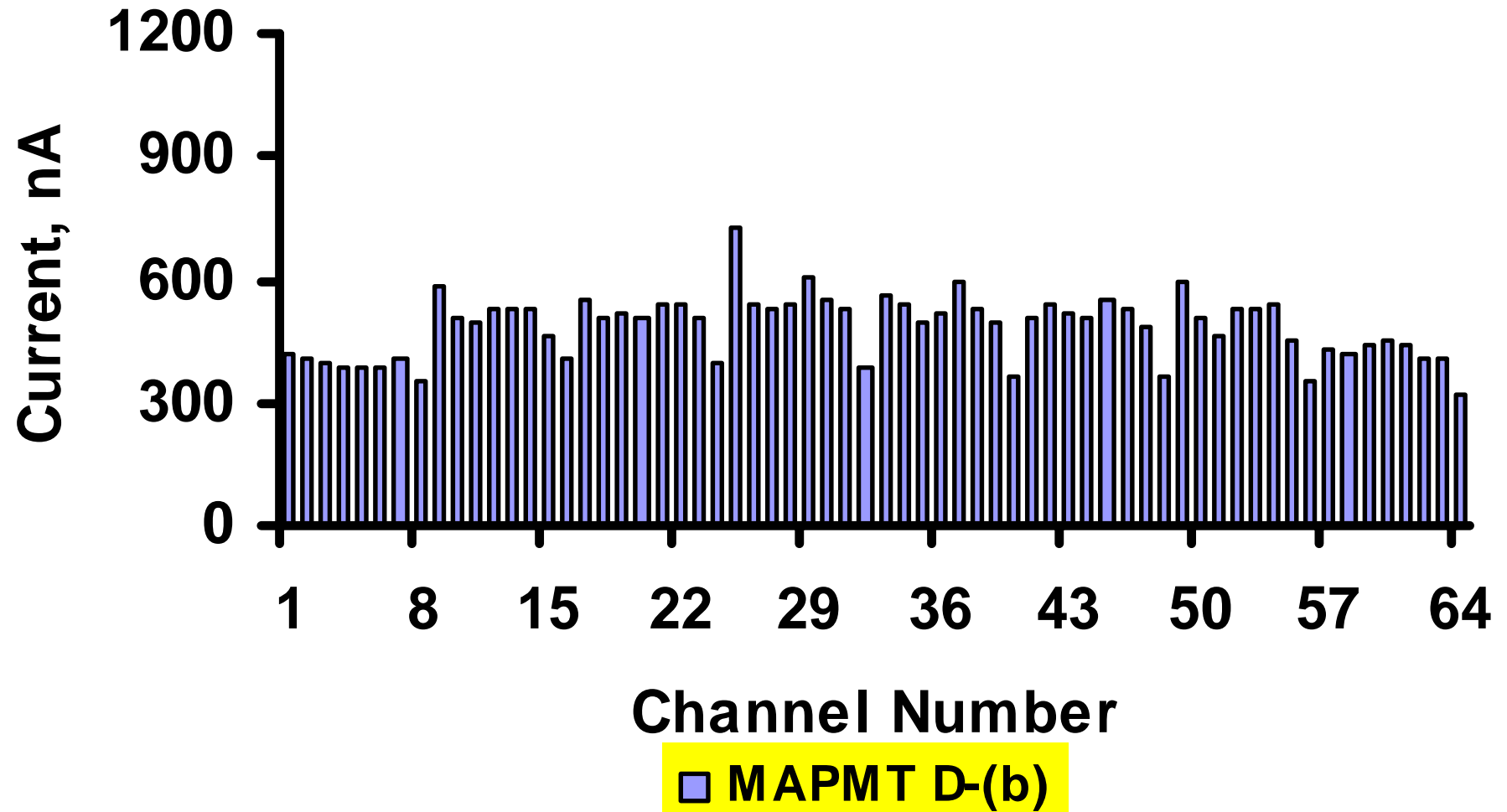
MAPMT_D+(b) output responses



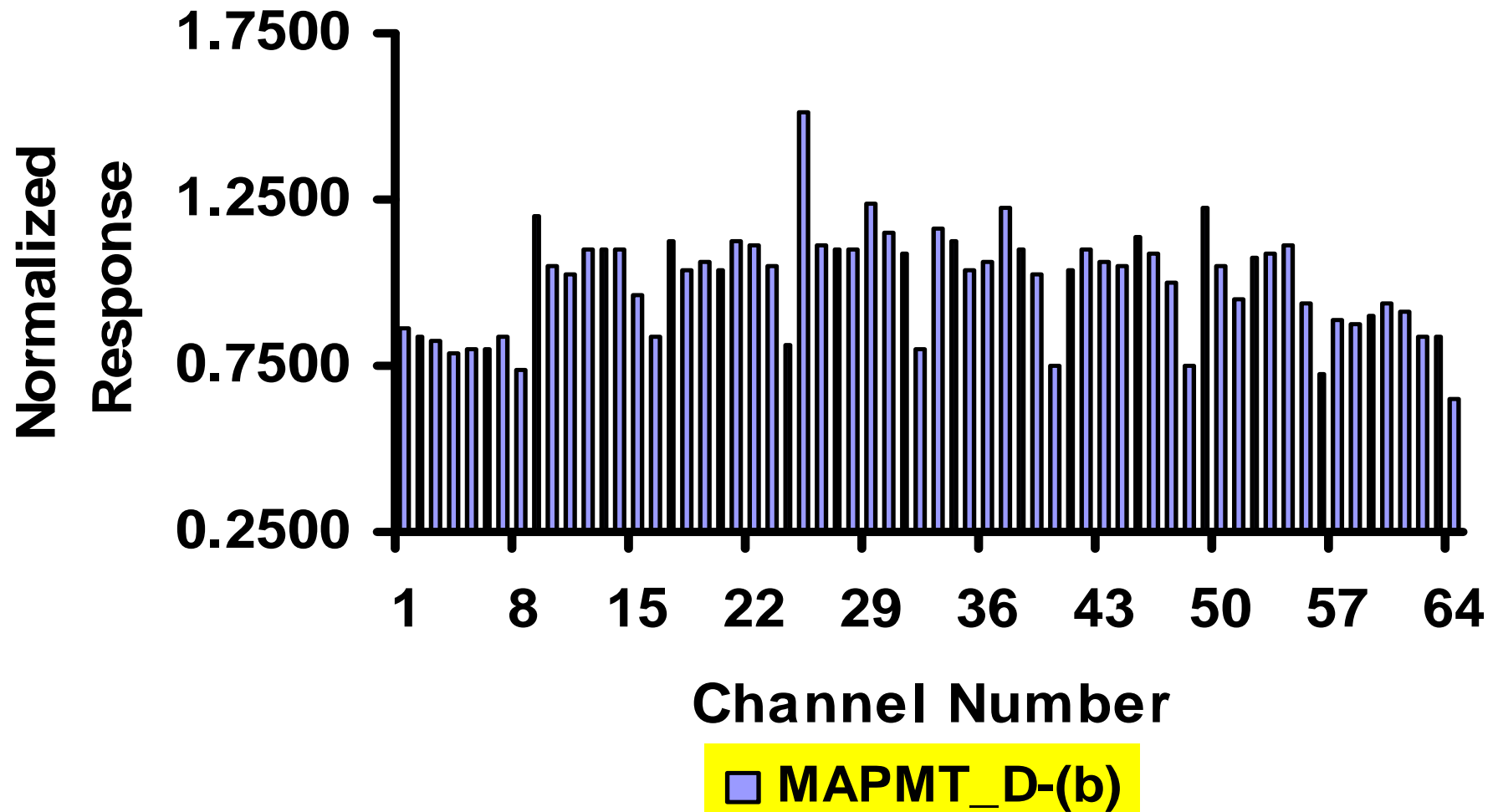
MAPMT D-(a) Output



MAPMT D-(b) Output Response



MAPMT_D-(b) Normalized Responses



Relative Response

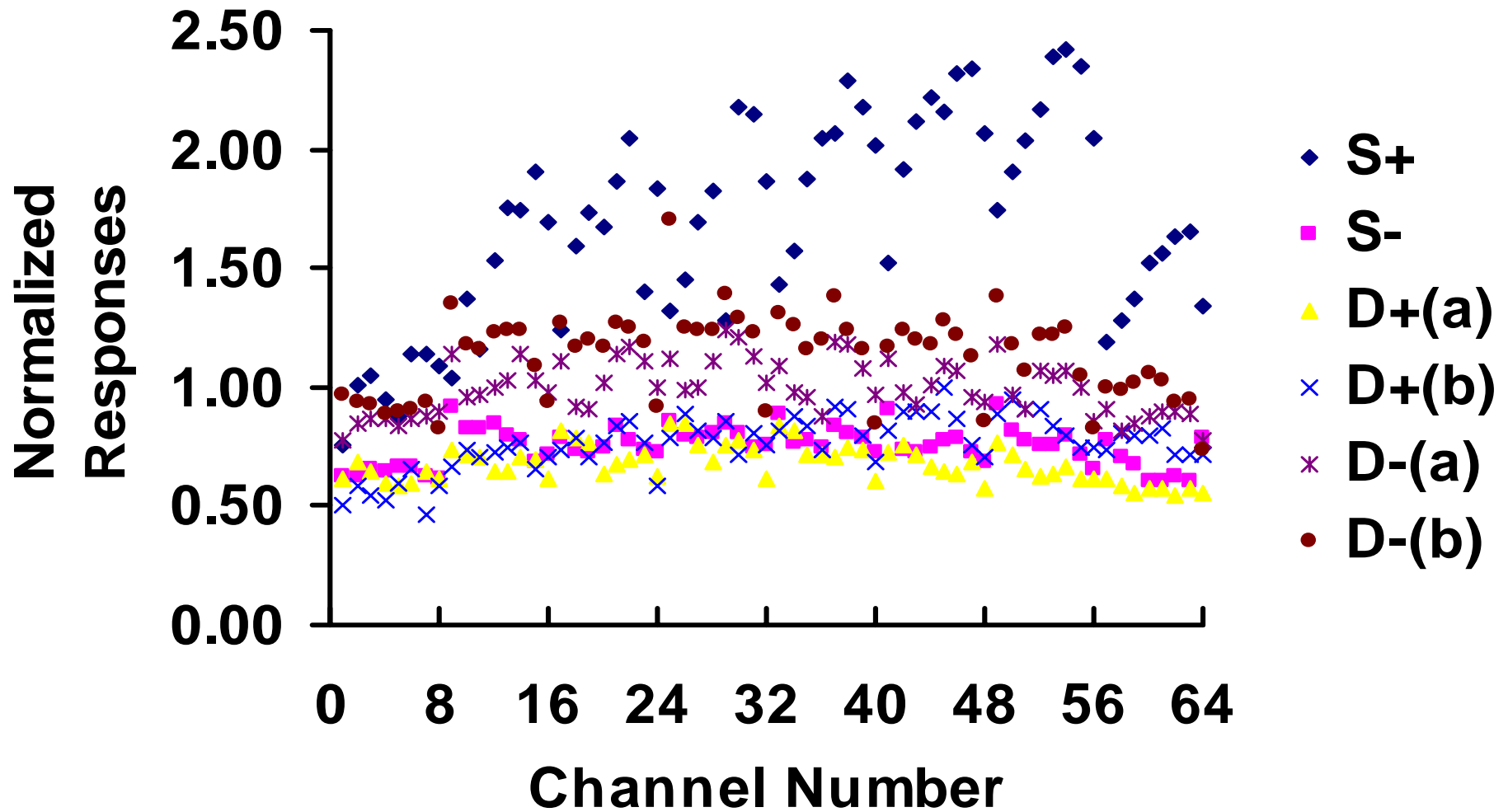


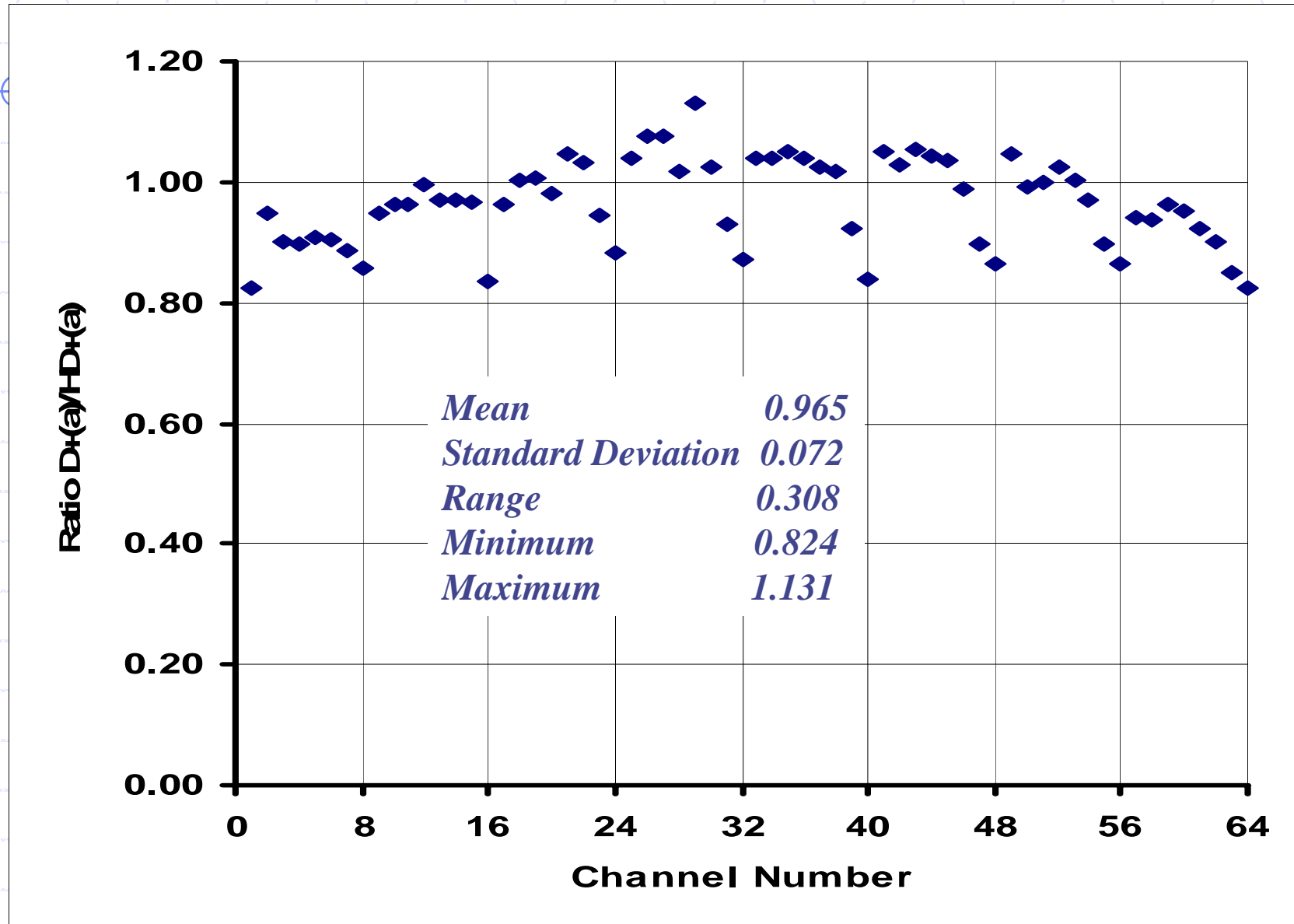
Table of MAPMTs Anode Output Current Parameters (units in nA)

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

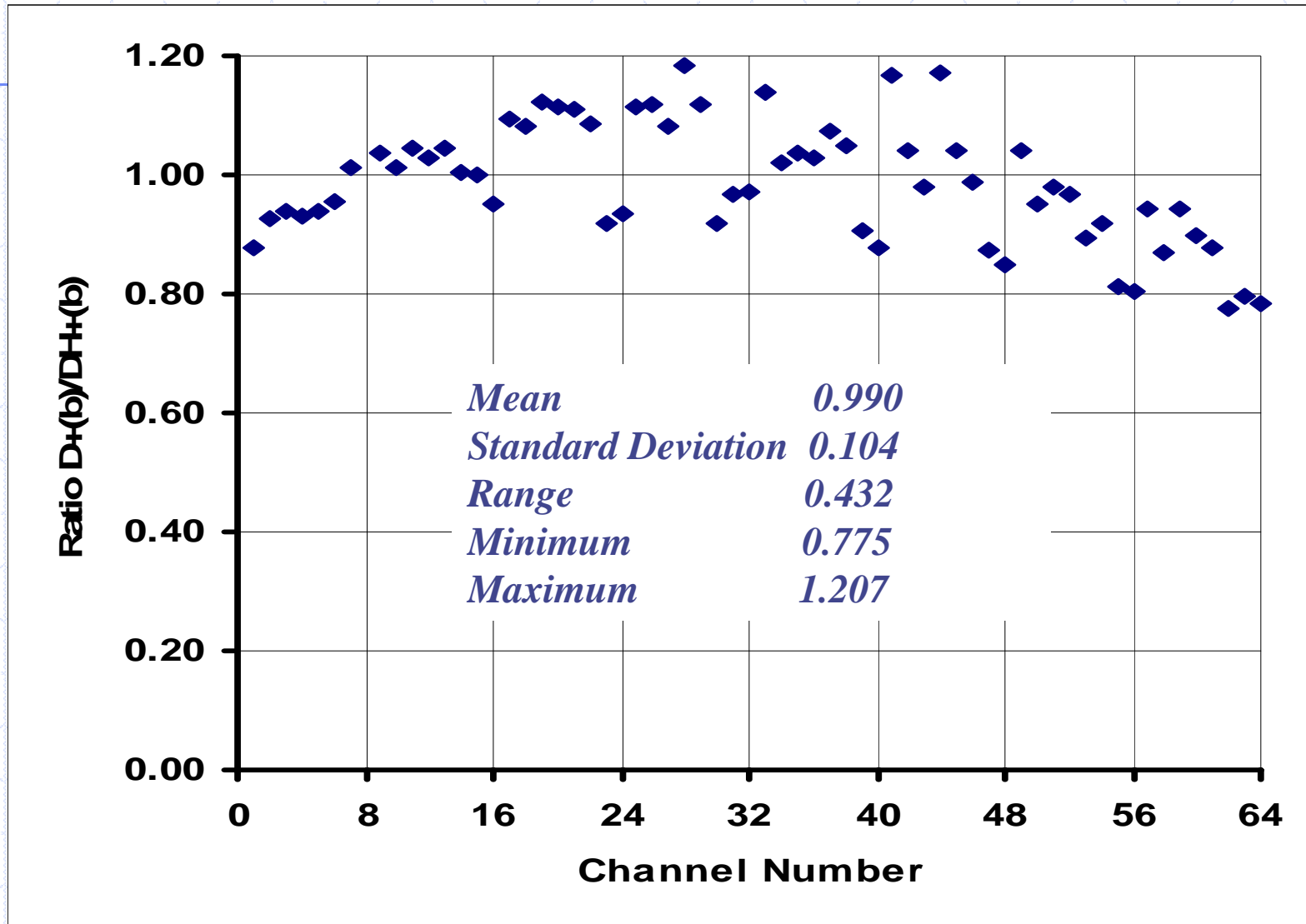
Simple Comparison of Photo Multiplier Tube Spectral Response

- ◆ Hamamatsu final test sheets accompanying the tubes usually indicates relative anode uniformity.
- ◆ The current from the anode produced by a light flux of a tungsten lamp at 2856K passing through a **blue** filter Corning CS 5-58 was measured and normalized to the maximum.

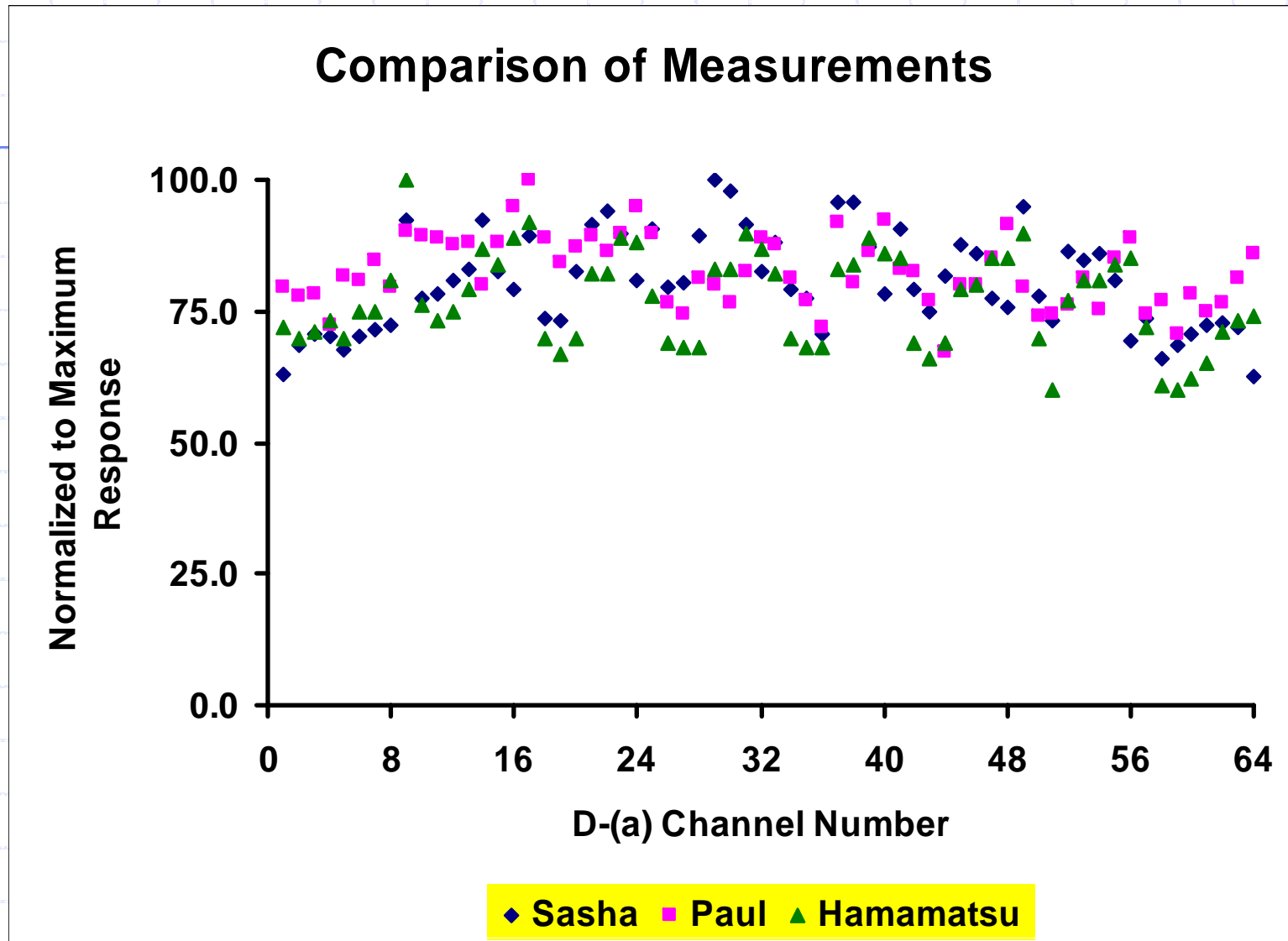
Comparison with Hamamatsu 1



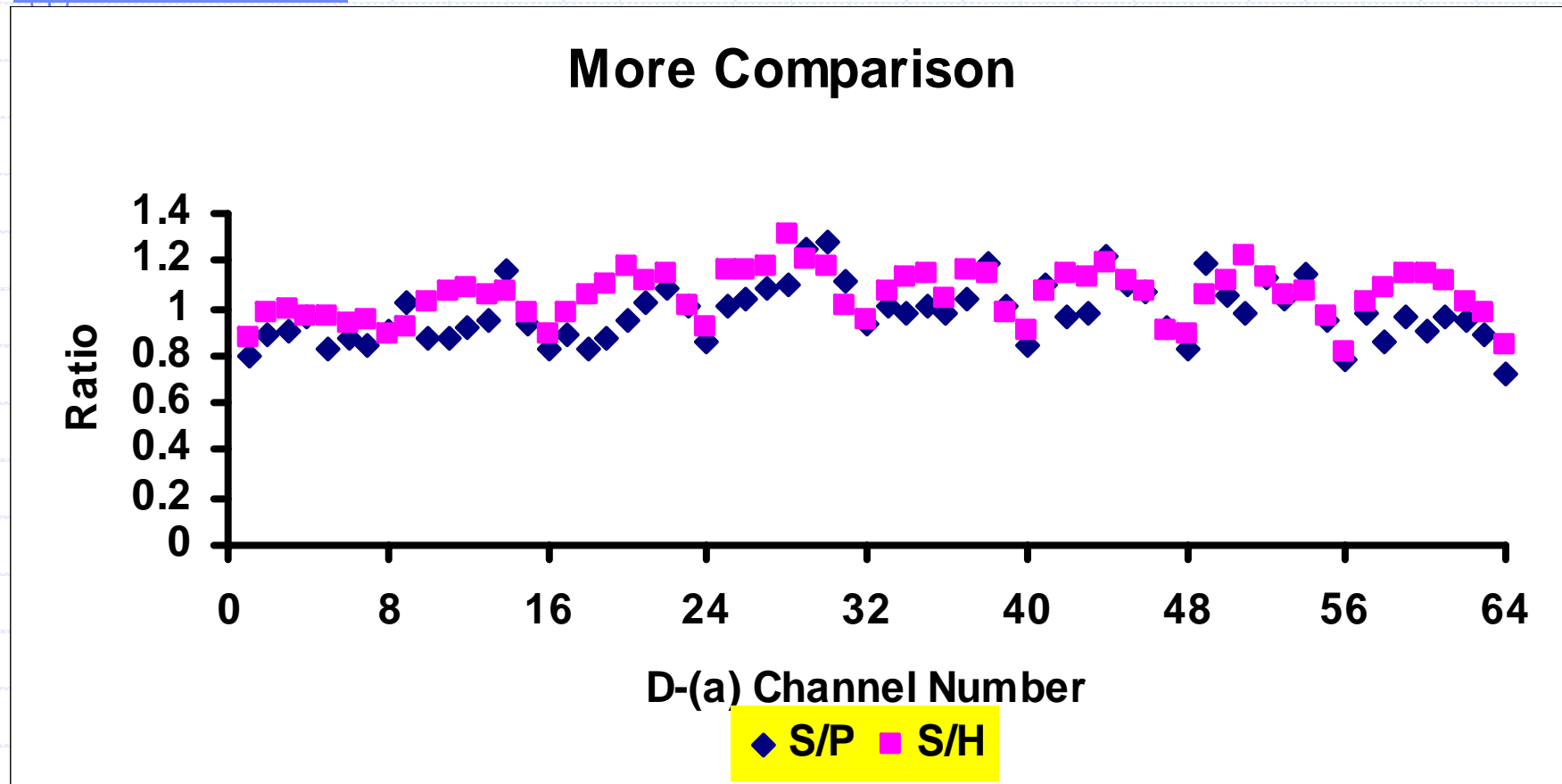
Comparison with Hamamtsu 2



Comparison of Measurements



Discussion



Summary

- ◆ MAPMTs anode responses are measured at *the same brightness* of about 500nm input light at *and* 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.
- ◆ There is a good agreement between NICADD and Hamamatsu factory anode uniformity measurements for MAPMT H7546B.
- ◆ 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 ~ 500 nm input light and 800 V voltage between photo cathode and anode was applied.
- ◆ Because of a few percent deviation in the reference and the control measurements, the measured **anode output current of any channels can be directly compared** .

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.*)
- ◆ MAPMT H7546B Anode Current Response Study for ILC SiD Muon System Prototype. FERMILAB-PUB-07-485-E, September 2007 (Submit to IEEE Trans. Nucl. Sci.)