Characterization of a microchannel plate photomultiplier tube with a high sensitivity GaAs photocathode

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BURLE INDUSTRIES, INC.

13th Annual International Laser Ranging Workshop

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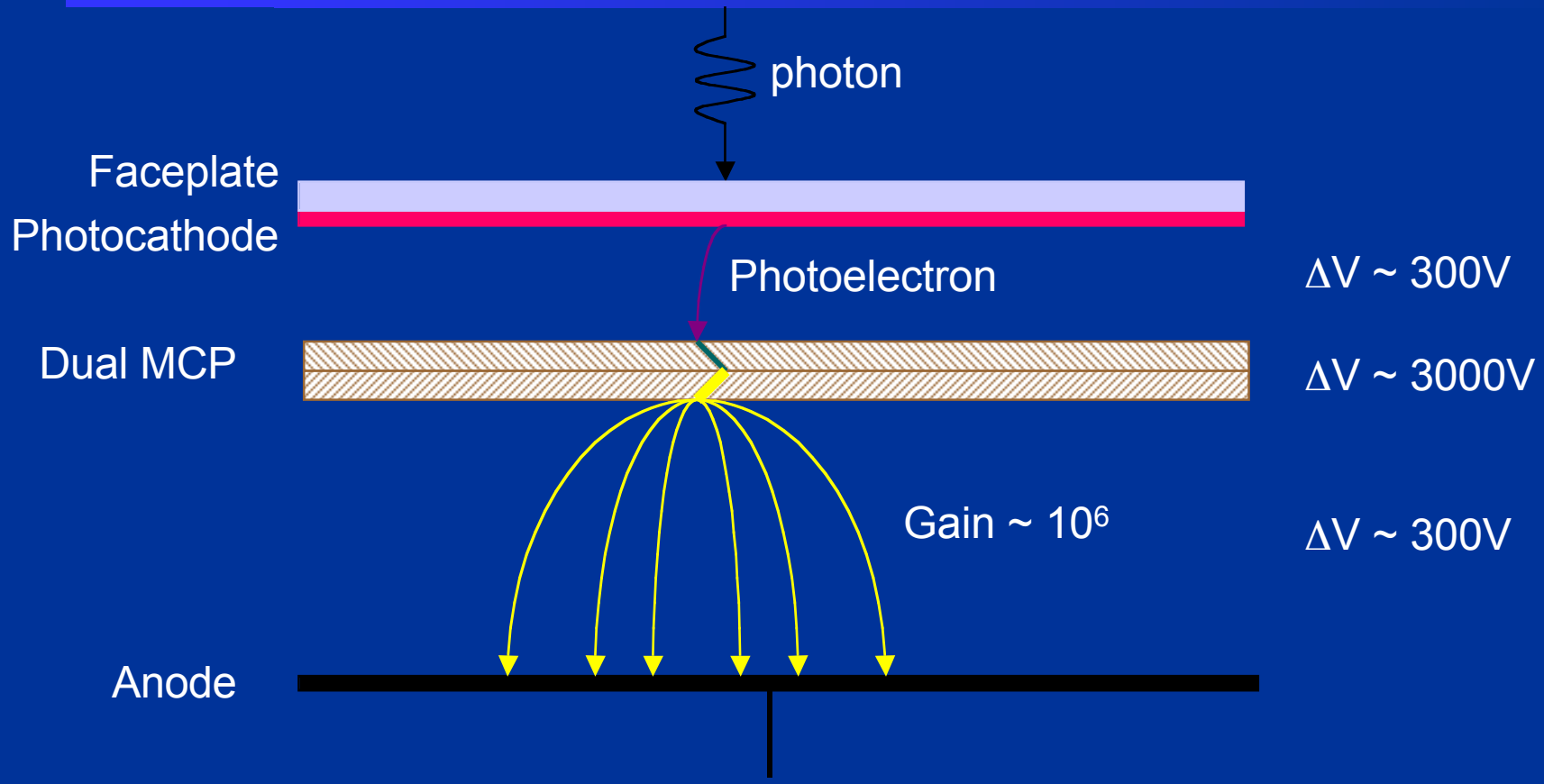
MCP-PMT Developments

- **18mm GaAs MCP-PMT**
  - Very high, broad spectral response with excellent red sensitivity.
  - Very good photon counting properties.
  - Applications include Lidar, flourescence, chemiluminescence, …
- **2” Square Planacon™**
  - Large area MCP-PMT with good photon counting properties.
  - Ideal for tiling applications and good platform for multi-anode configurations.

MCP-PMT Operation

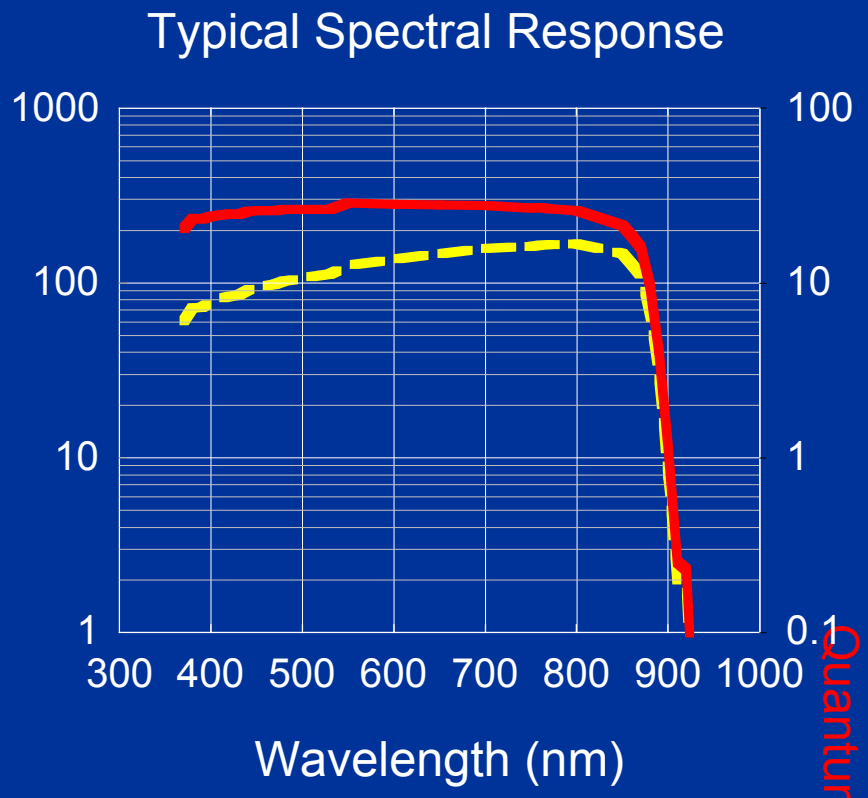


85104 MCP-PMT

- 18 mm dual MCP.
- Very high cathode sensitivity (>1200 μA/lm).
- Excellent red response (>20% QE at 850nm).
- Excellent photon counting properties (peak-valley > 2:1).

Spectral Response

- Very high cathode response, >1200 µA/lm luminous sensitivity, 1500 µA/lm typical.
- Excellent QE
  - ~30% at 600nm
  - > 20% at 850nm
  - > 20% at 370nm



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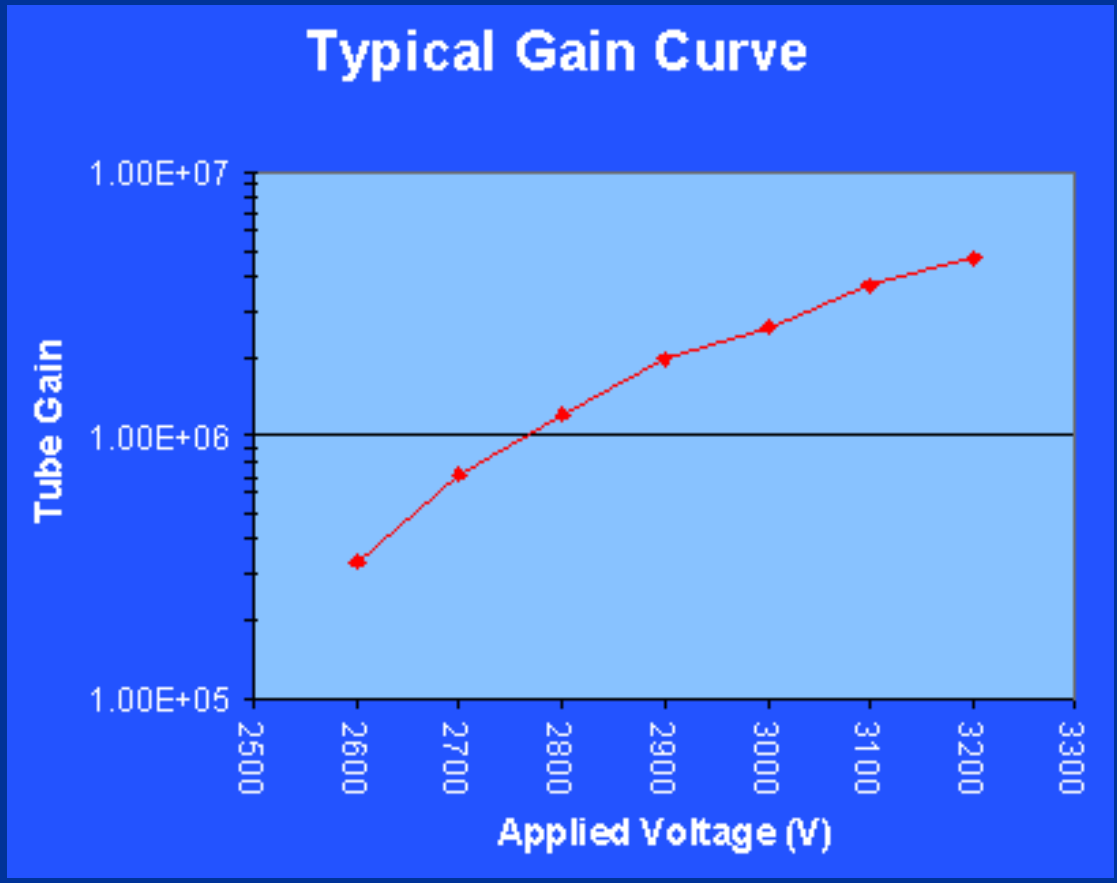
Gain Curve

- High gain devices, typically > 4×10^6.



Single Electron Spectrum

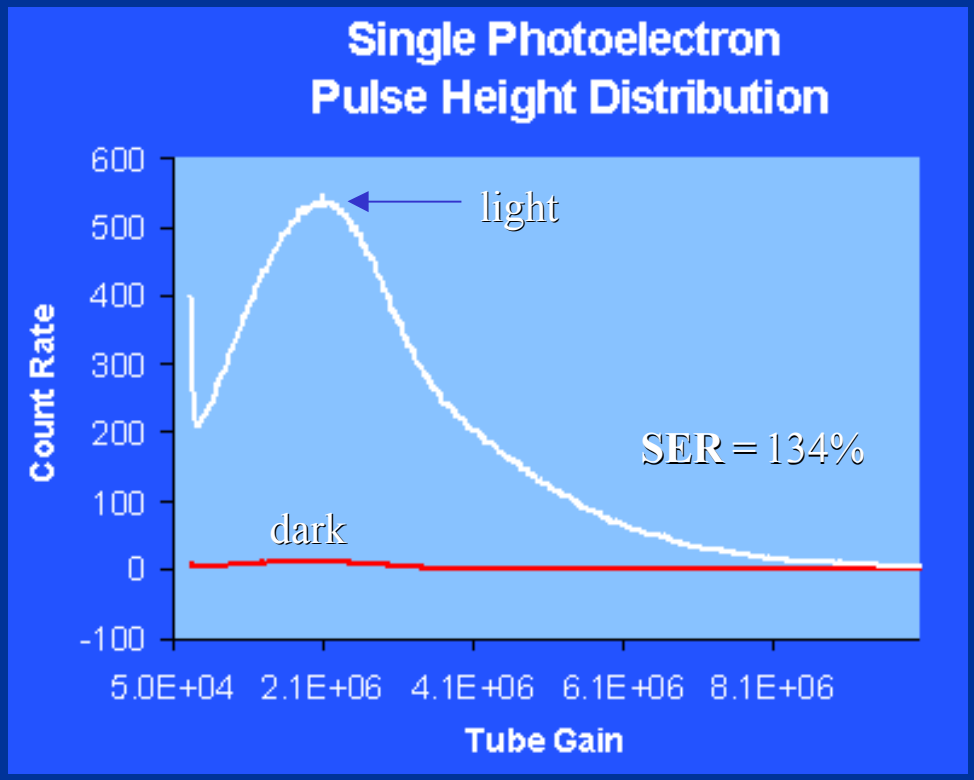
At tube Gain > $5x10^5$

- Peak:Valley > 2:1
- Dark counts < 200 cps.

At tube Gain > $1x10^6$

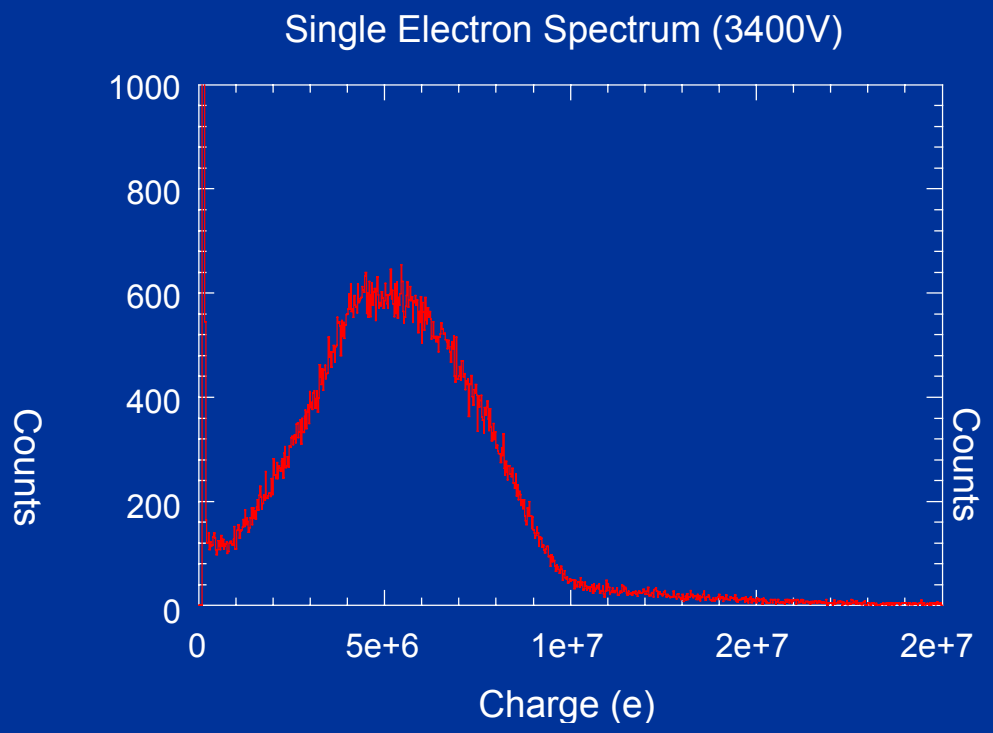
- Typical SER < 150%

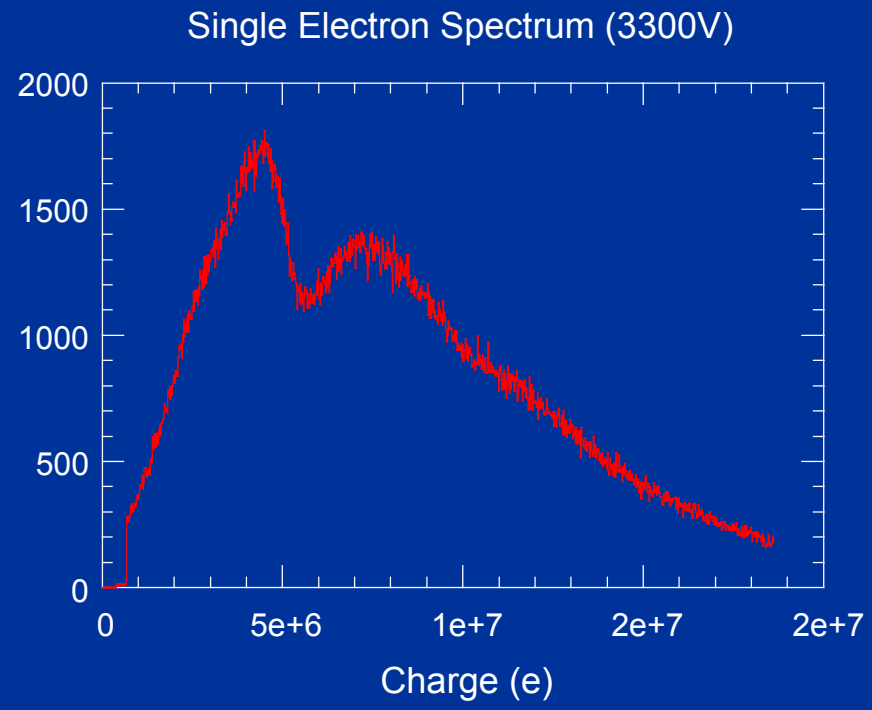
(*SER*= FWHM/Peak)



Single Electron Spectrum

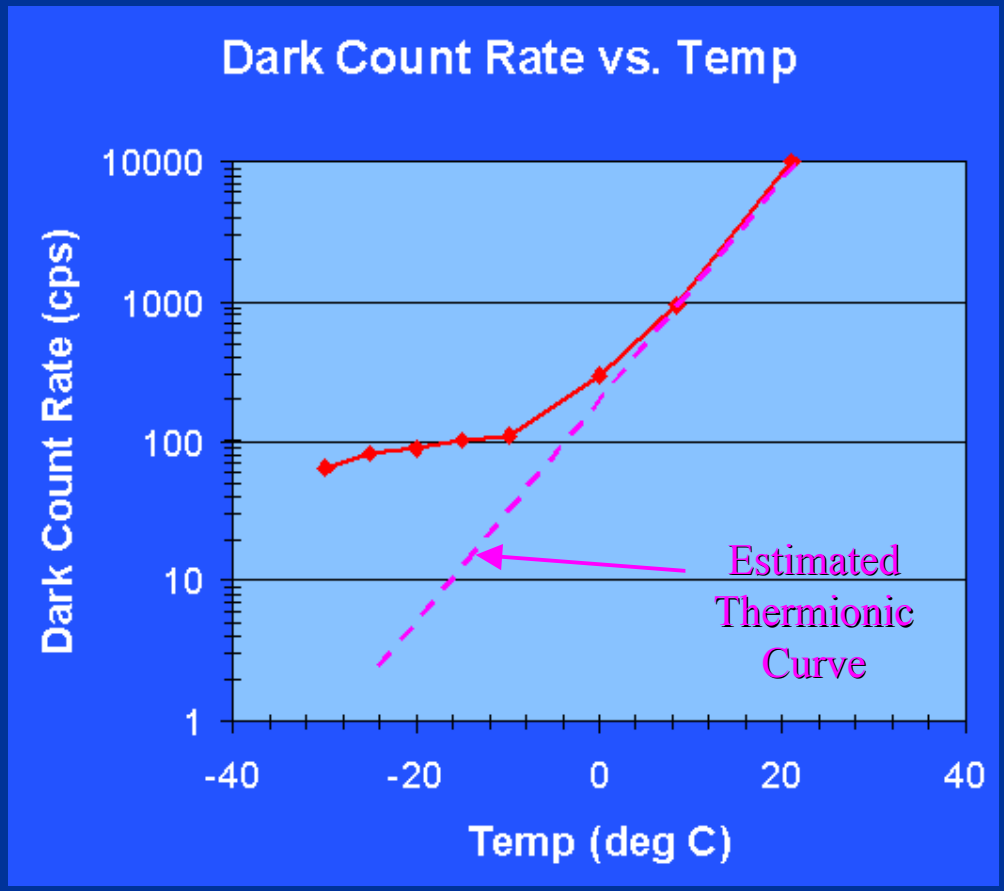
- At higher gains ability to distinguish 1pe and 2pe peaks.





Dark Counts

- ~10,000 cps @ Room Temp.
- < 200 cps at –30°C for operating voltage that gives > 2:1 peak-valley and gain of > $5x10^5$.
- Currently limited by "front-end" noise, not the cathode.
- Slight increase in noise with increasing voltage.



Anode Pulse – Single PE

Anode Rise-Time:

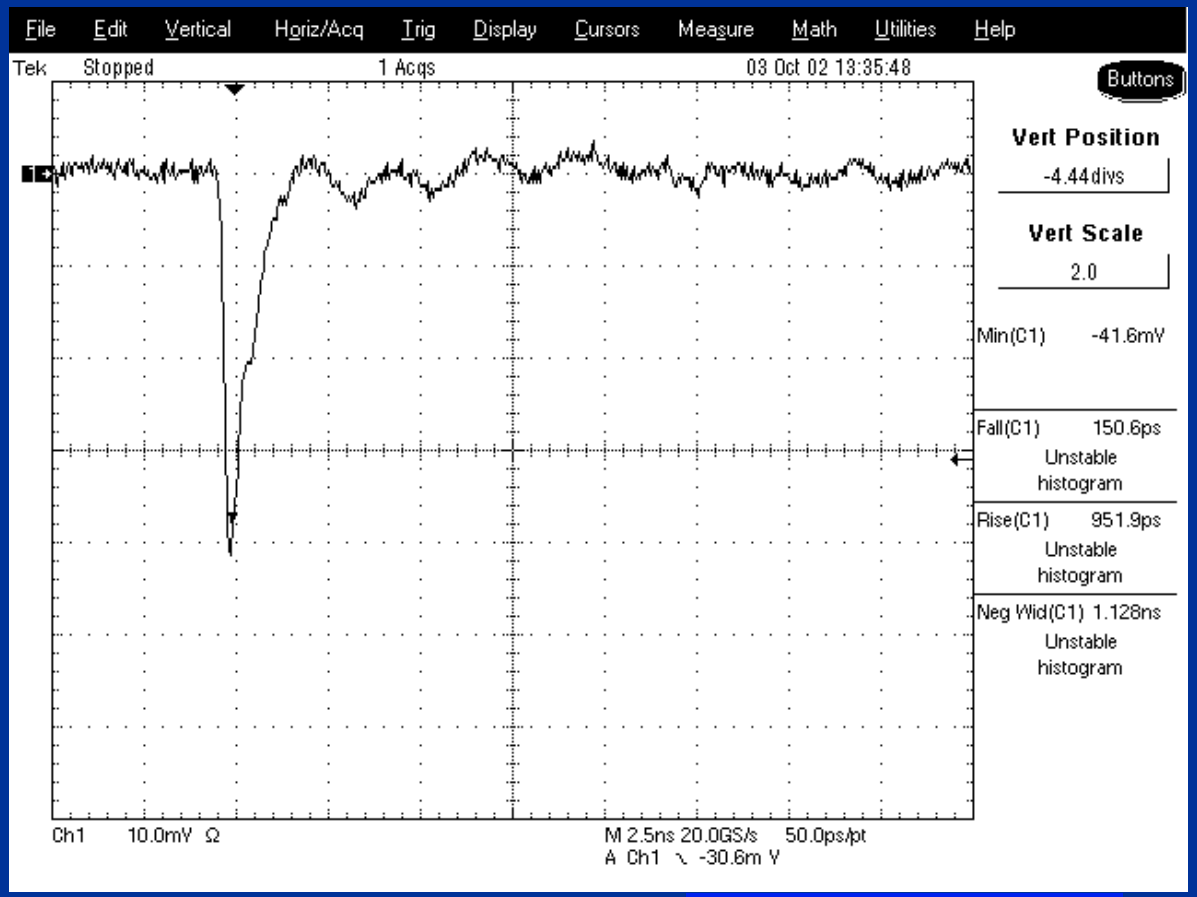
< 200ps

(for single electrons)

Anode Fall-Time:

~ 1ns

(Currently limited by anode design. Re-design is in progress.)



Anode Pulse – Multiple PE

Anode Rise-Time:

~350 ps

(using 28ps rise-time laser pulse @636nm)

Anode Fall-Time:

~ 1.5 ns

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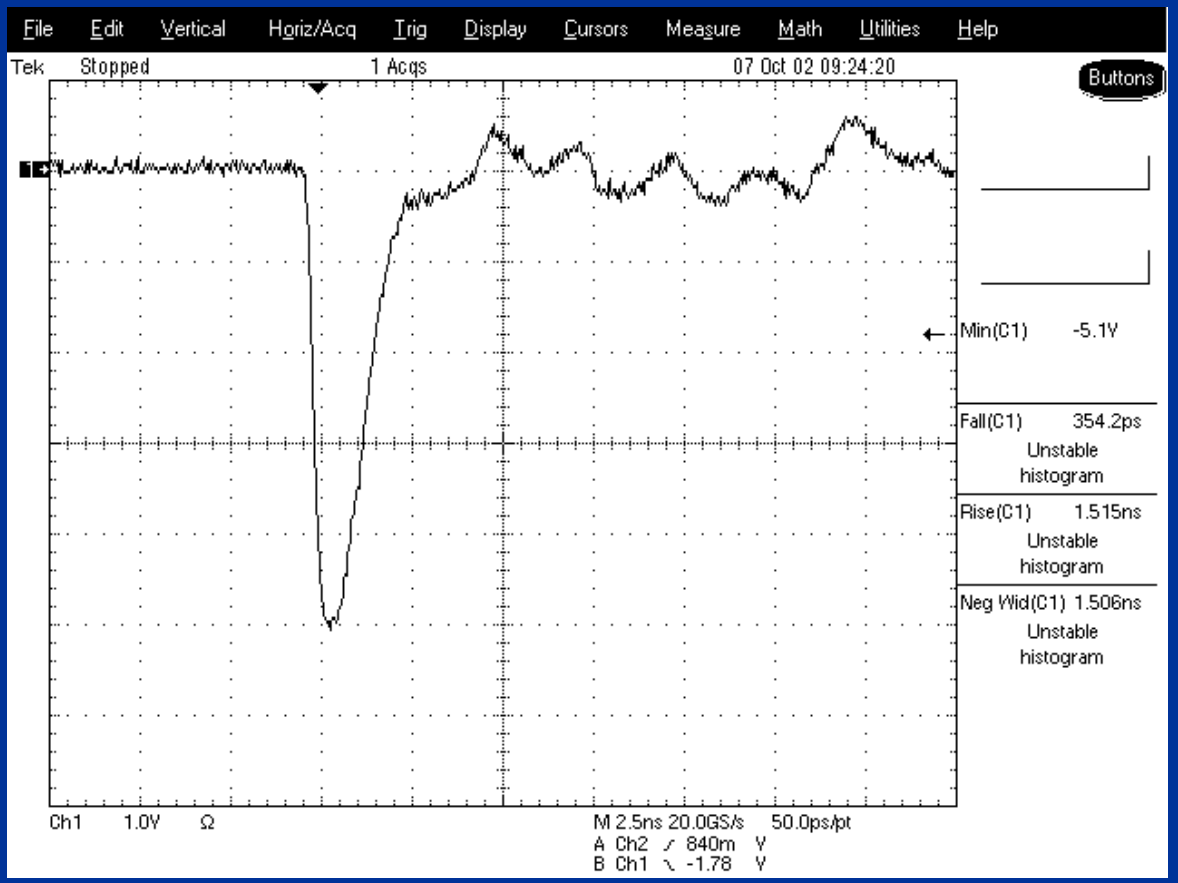
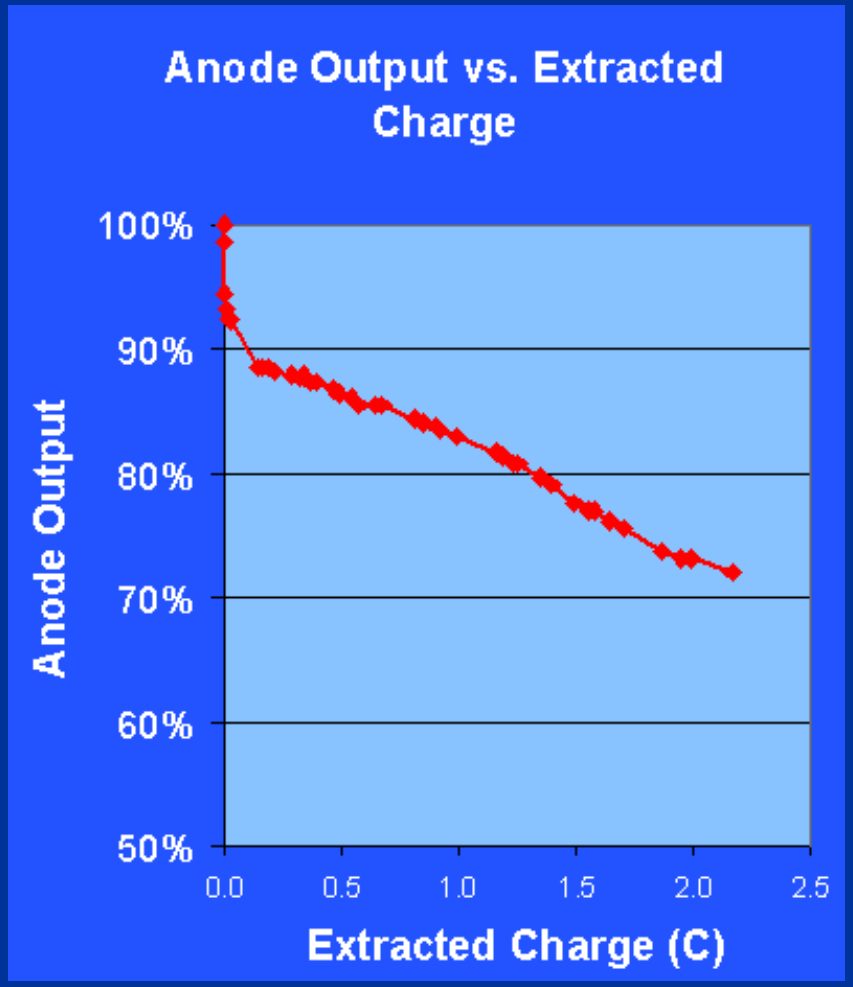
Transit Time Spread (*TTS*):

~ 200 ps



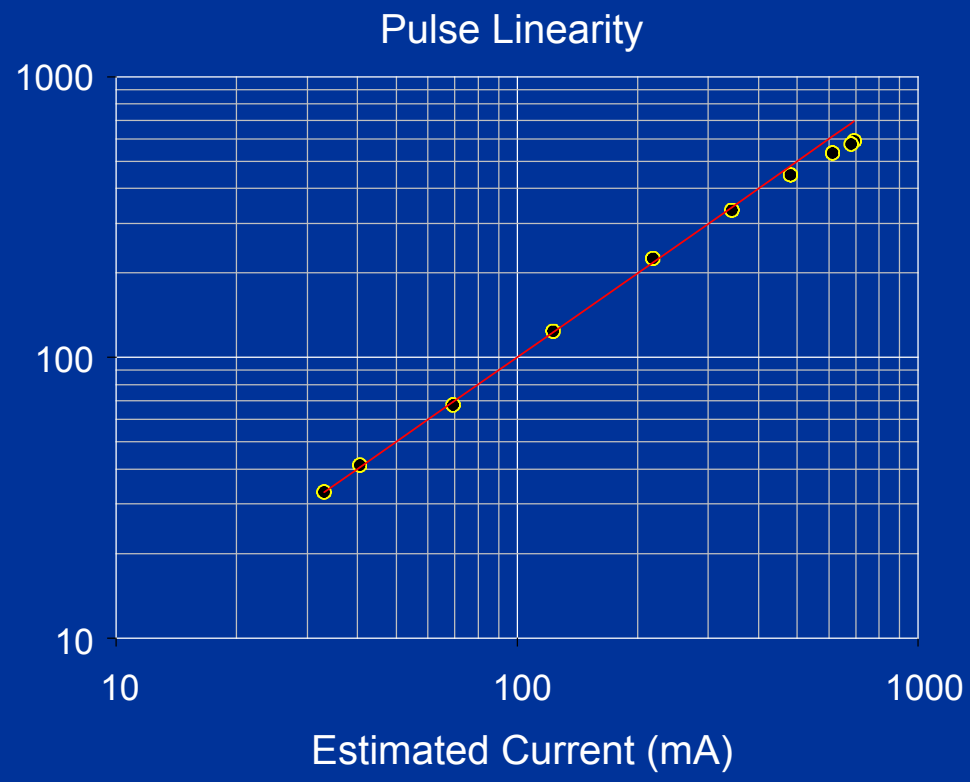
Lifetime of 85104

Tube Operating Conditions…		
Tube Gain	$1x10^6$	Gain
Typical Count Rate	$1x10^5$	Cts/s
Lifetime… ***(@50% Anode Sensitivity Loss)***		
Total Extracted Charge	7.0 $4.4x10^{19}$	Coulombs Electrons
1.2E+05 hrs	**14 years**	$1.5x10^{14}$ photons (@30% QE)



Pulse Linearity

- Very good pulse linearity, ~ 400mA peak pulse current for < 5% linearity
- Average anode current is limited to ~300nA maximum.

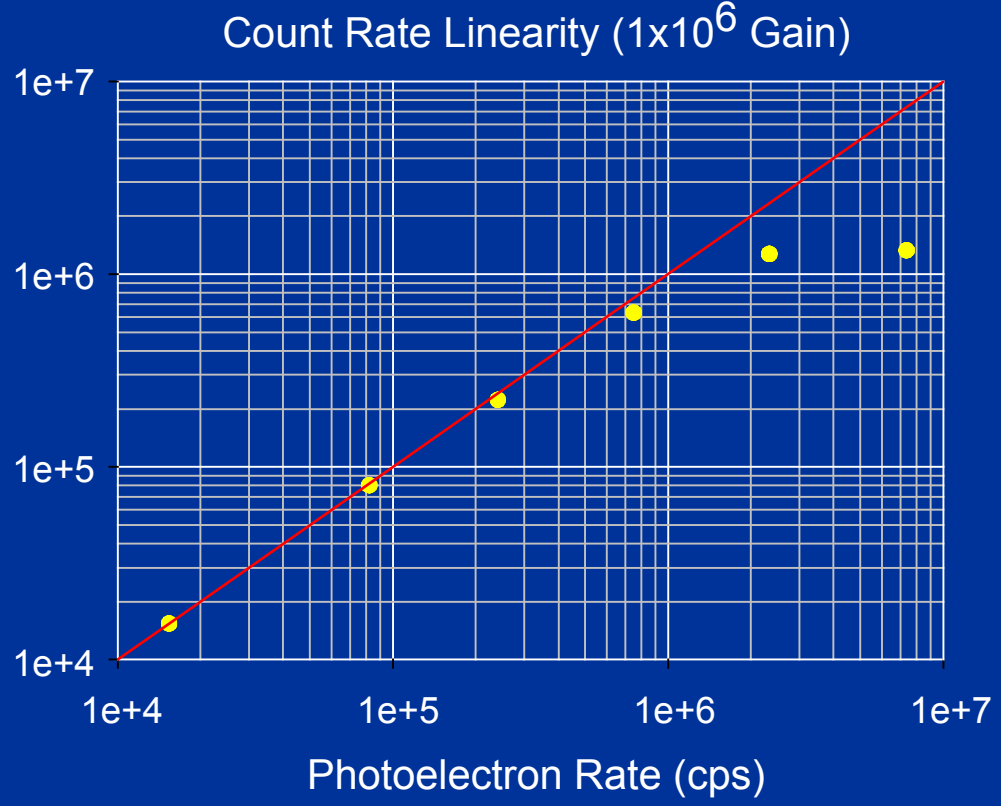


Count Rate Linearity

- Good count rate linearity.
- Within 20% for 10^6 cps at gain of 10^6

(counting pulses > 1/3 pe as defined at low count rates).

- Strip Current ~ 3mA.



Gated Operation

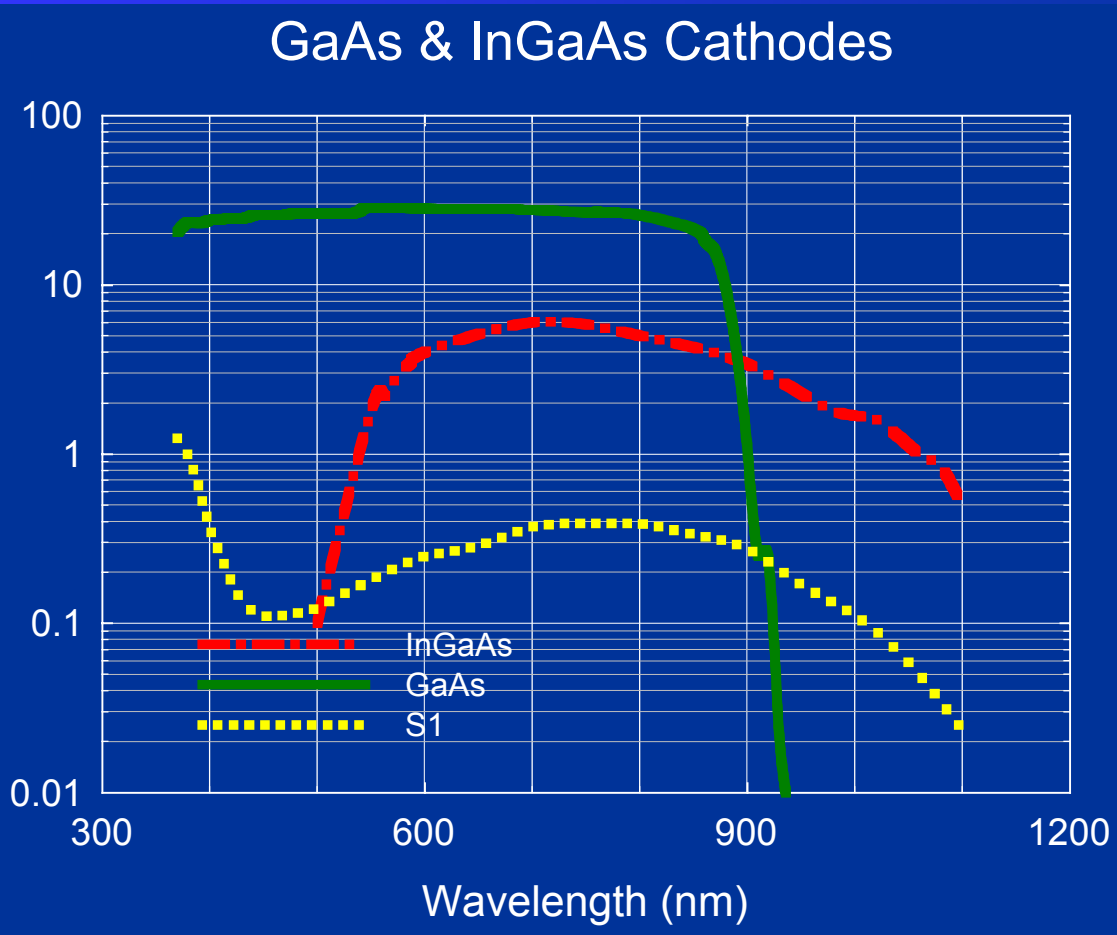
- Gating the photocathode of the 85104 results in > 10^7 reduction in sensitivity for white light.
- Integrated gating circuit and external drive module in development for fast gating of PMT.

Goals: 10ns on/off response.

On times: 100's ns – 10's μs

Normally OFF/Gate ON

InGaAs Spectral Response



Developments

- Improved anode response

  (Goal <200ps rise/fall times).
- Expanded photocathode offering, including InGaAs, Bi-alkali, and Multi-alkali.
- Custom anode designs will be considered.
- Gating (ongoing development!).

Burle Accessories

HV Power Supply

PF1056

- *New November 2002.*
- **Low Noise** (~15mV ripple).
- Neg. 0-5kV.
- 667uA output current.
- Analog programmable.
- Inherent short circuit protection.

•Gating Module

•Cabling

•Thermoelectric Cooler

(Available via *Products for Research*.)

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Comparison with Conventional PMT

Characteristic	MCP-PMT	Conventional
Construction	*Simple Multiplier*	*Complex multiplier*
	Complex Body	*Simple Body*
Processing	*Slow & Complex*	*Fast & Simple*
	"Clean"	*"high alkali"*
Effective QE	*Moderate collection efficiency*	*Good – Excellent Collection efficiency*
	> 20% (370 – 870nm)	*25 – 33% peak QE*

Comparison with Conventional PMT

Characteristic	MCP-PMT	Conventional
Timing Resolution	*Excellent, risetime < 200ps*	*Poor – Very good*
Open Area	*Poor – Moderate with existing designs*	*Good - Excellent*
Linearity	Limited average DC current (<1μA)	Good–Excellent for DC
	Excellent for pulsed light	Moderate – very good for pulsed light