

# **Display Power Characteristics for TV Sets**

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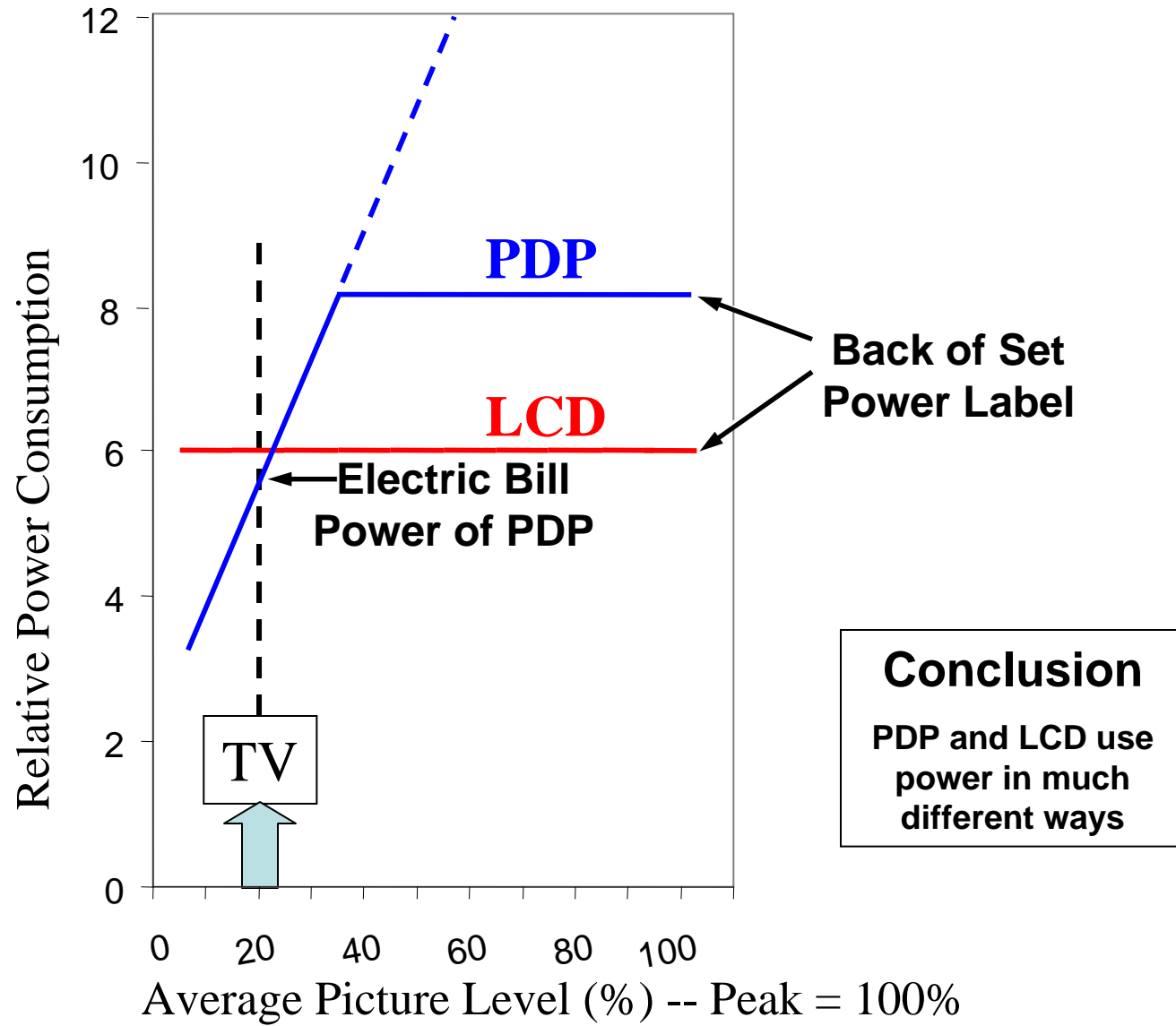
# Display Power Characteristics

## Different Display Types Take Power in Different Ways

- Power-on-Demand
  - Plasma
  - OLED
  - FED/SED
  - LCD/Dynamic backlight
  - Projectors/LED Lamps

- Constant Power
  - LCD (current products)
  - Projectors/Arc Lamp

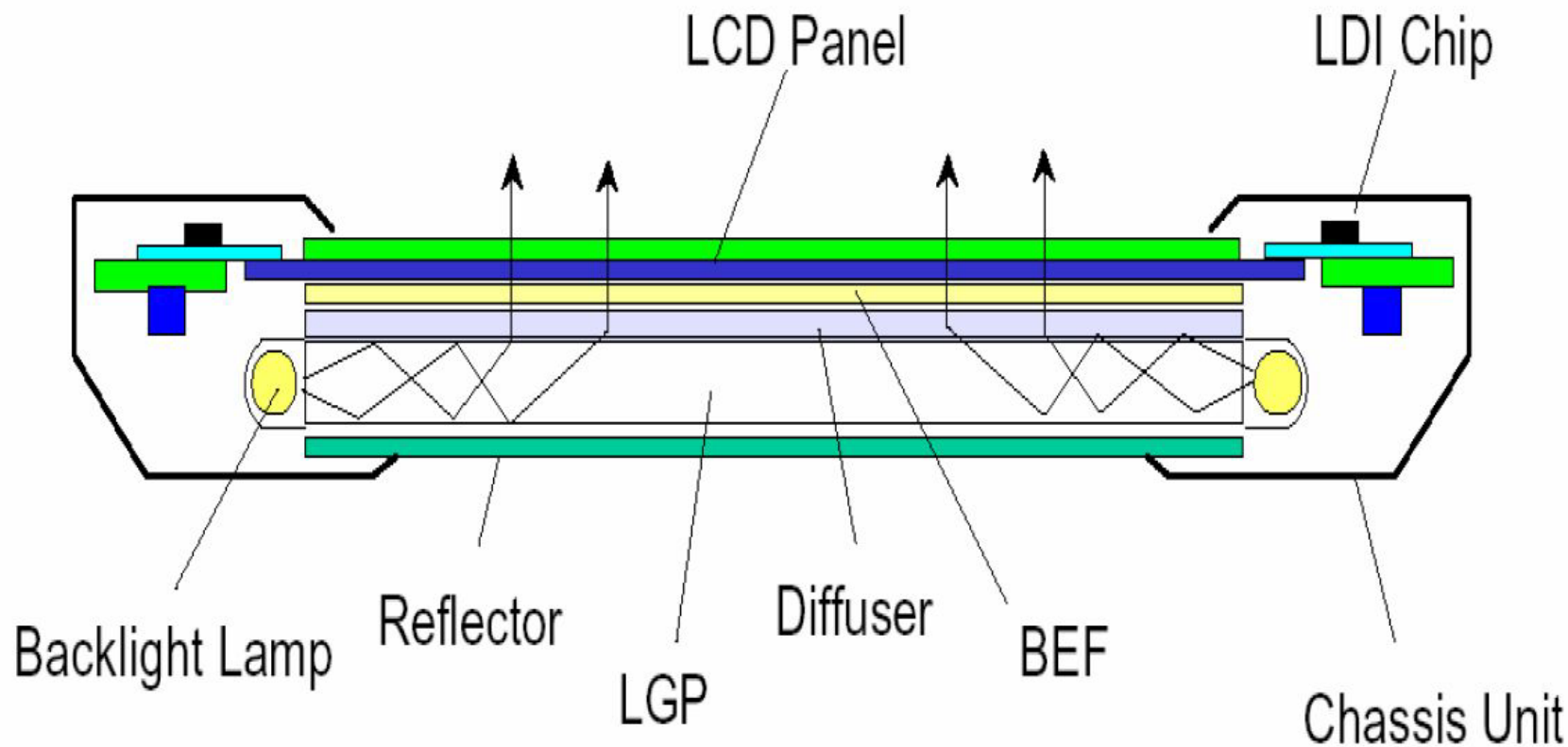
# Power Consumption Dependence on APL



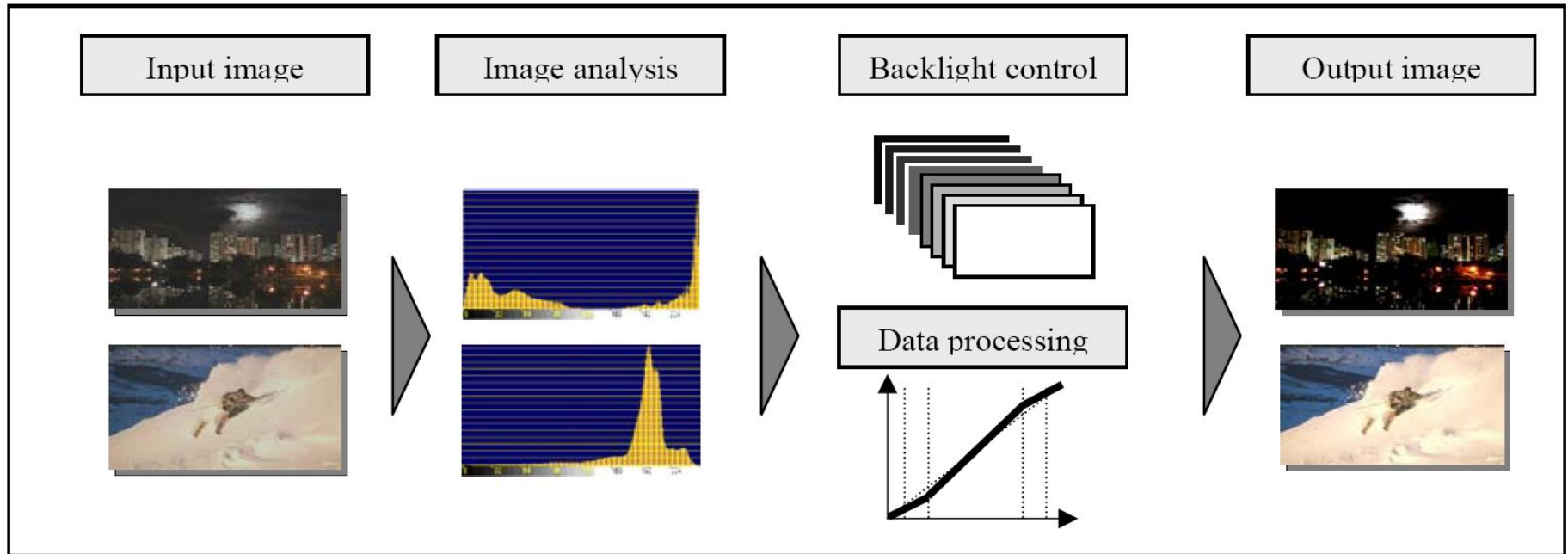
# Future LCDs will be Power-on-Demand

- Increase power efficiency with dynamic backlight designs
- 0D Design
  - Dim entire backlight
- 1D Design
  - Scan 1D backlight tubes
- 2D Design
  - Modulate 2D LED array

# Most of LCD Power is in Backlight



# Dynamically Dim Backlight Depending on TV Signal



- Can get some of 5X Power-on-Demand advantage enjoyed by emissive displays

# Dynamic Backlight 42" IPS LCD

0D Design

		Improved	Normal
Luminance(cd/m <sup>2</sup> )	Black	0.5	1.0
	White	500	500
	Peak	550	-
Contrast ratio	Static	500 : 1	500 : 1
	Dynamic	1100 : 1	-
Power consumption	cumulation	130W	170W
Temperture	front	40 °C	45 °C

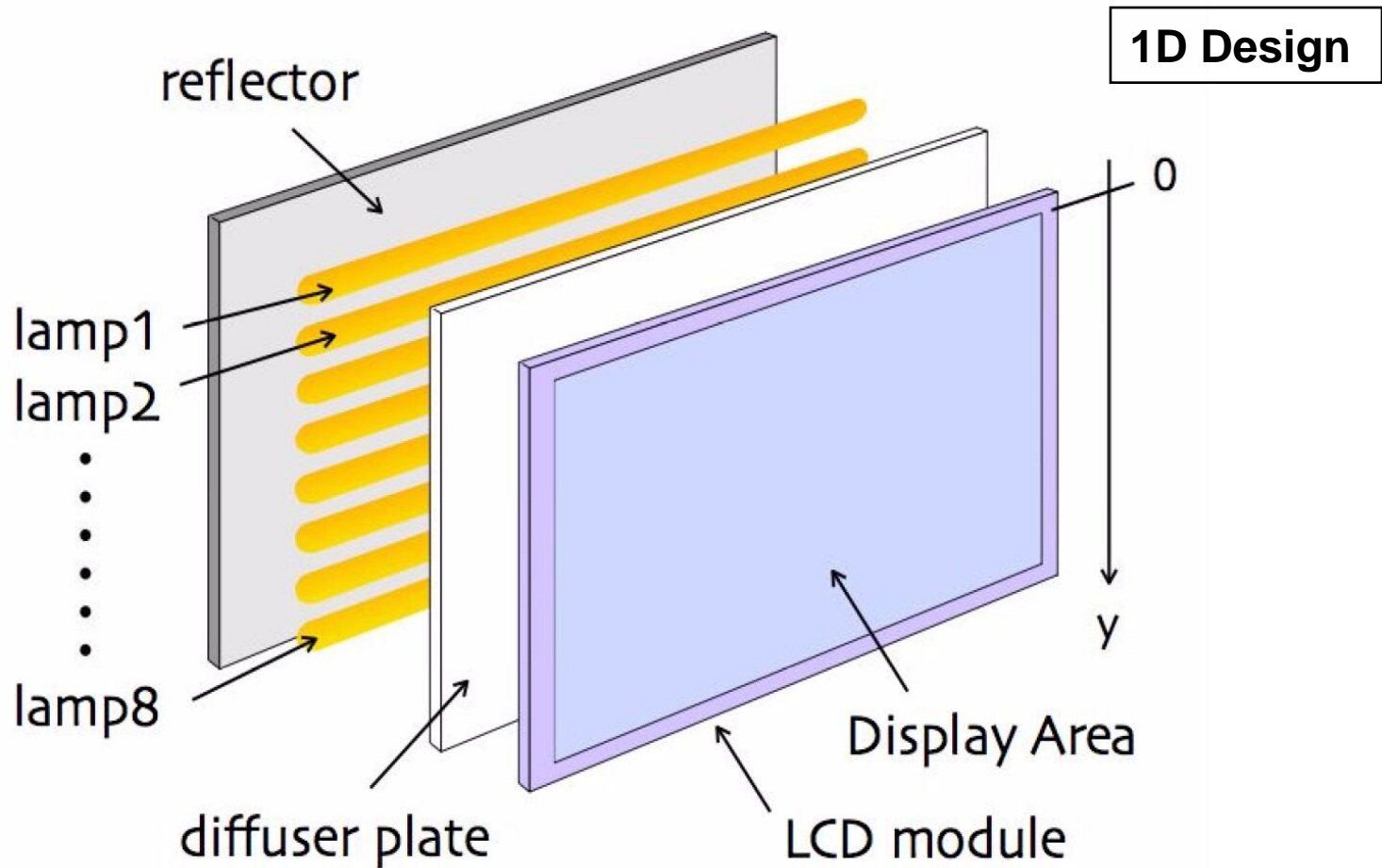
# Set Backlight to Brightest pixels



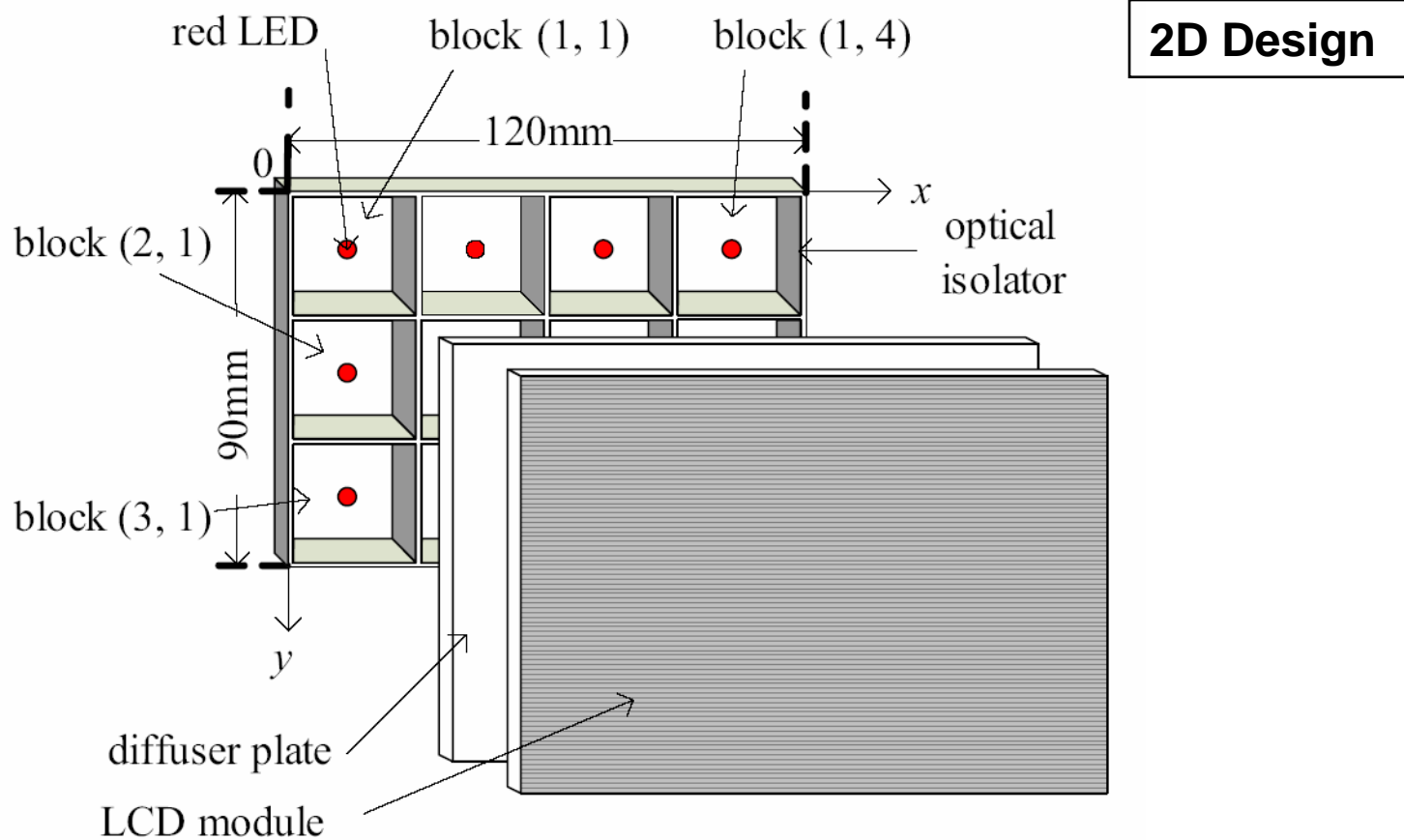
SID '04 Takeo, et al



# Can Also Adjust Each Lamp Independently for Lower Power



# LED Backlight for LCD can Achieve 2X Power Reduction

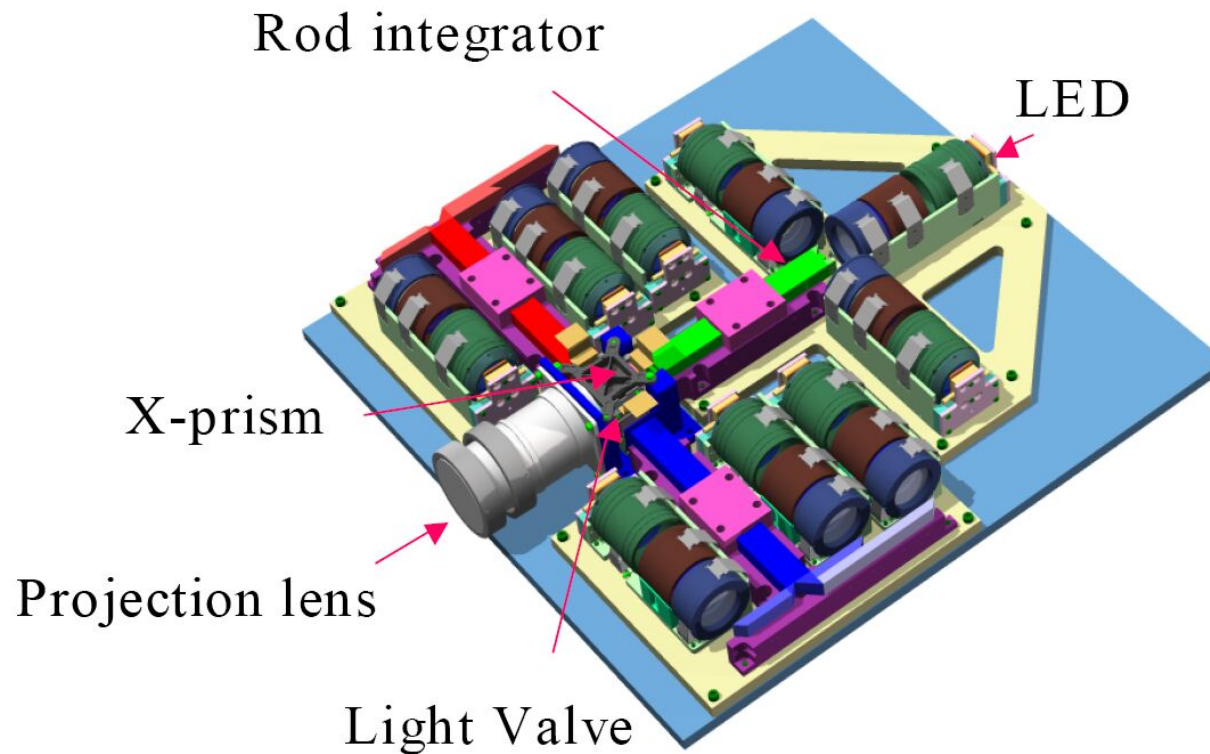


**Figure 1. LED backlight unit and LCD module**

# **Future Projection TVs will use Power on Demand LED Lamps**

- Increase power efficiency with dynamic LED lamp designs
- Can easily reduce intensity and power of LED lamps for dim TV images

# LED Lamp Projector Design



**Fig. 1** Light engine with LED light sources

# LED Light Source Projection TV

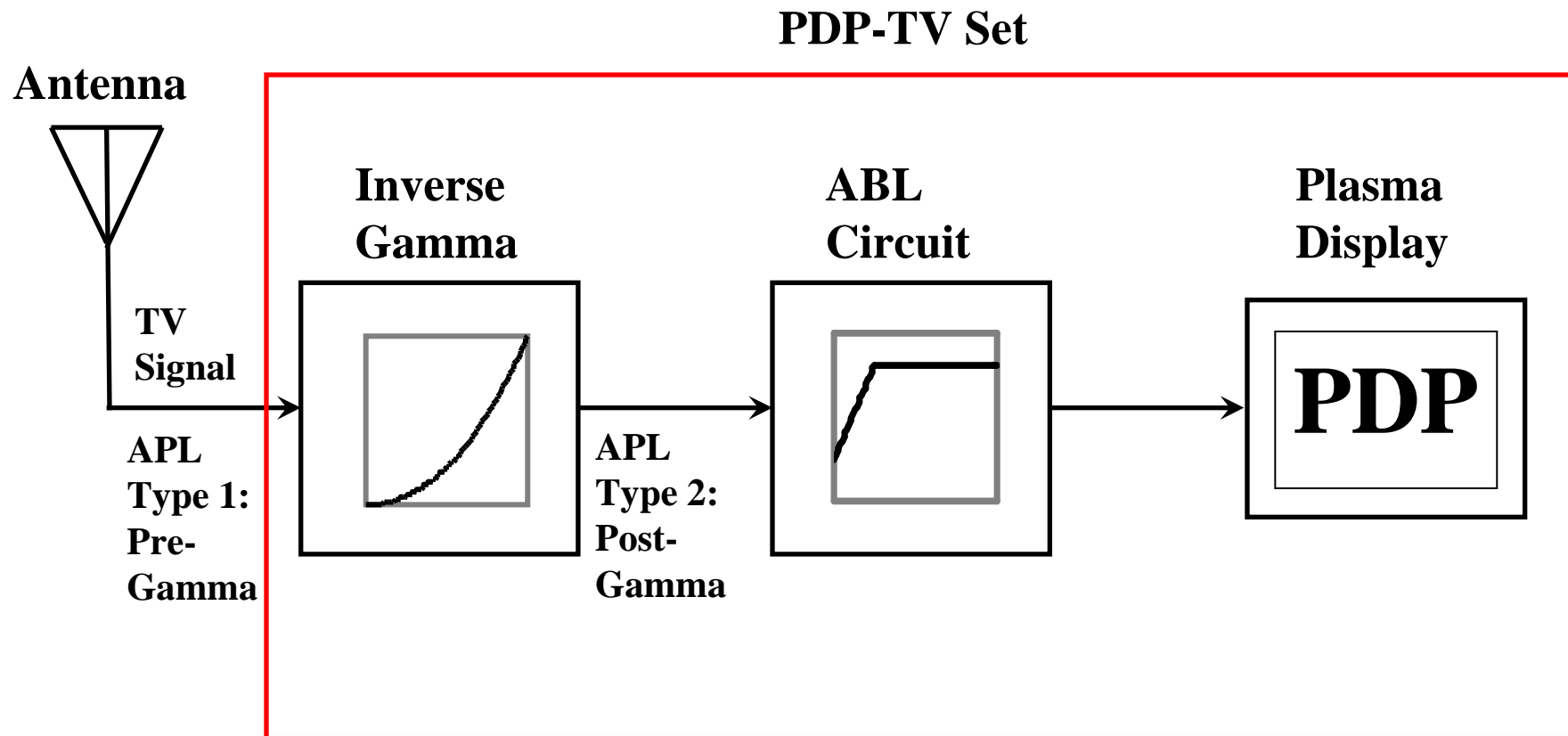


55 inch Projection TV

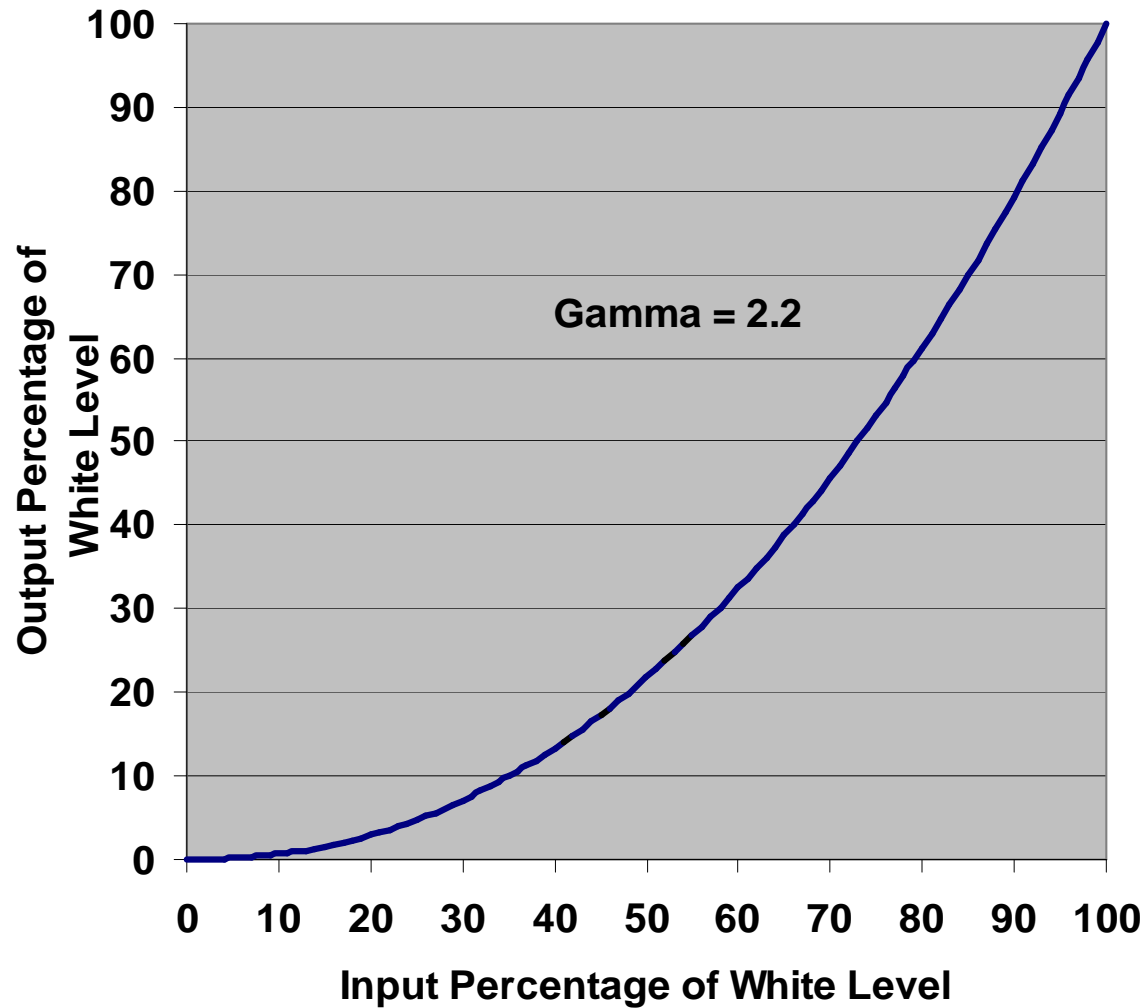
50 inch Plasma TV

Sanyo at CES '06

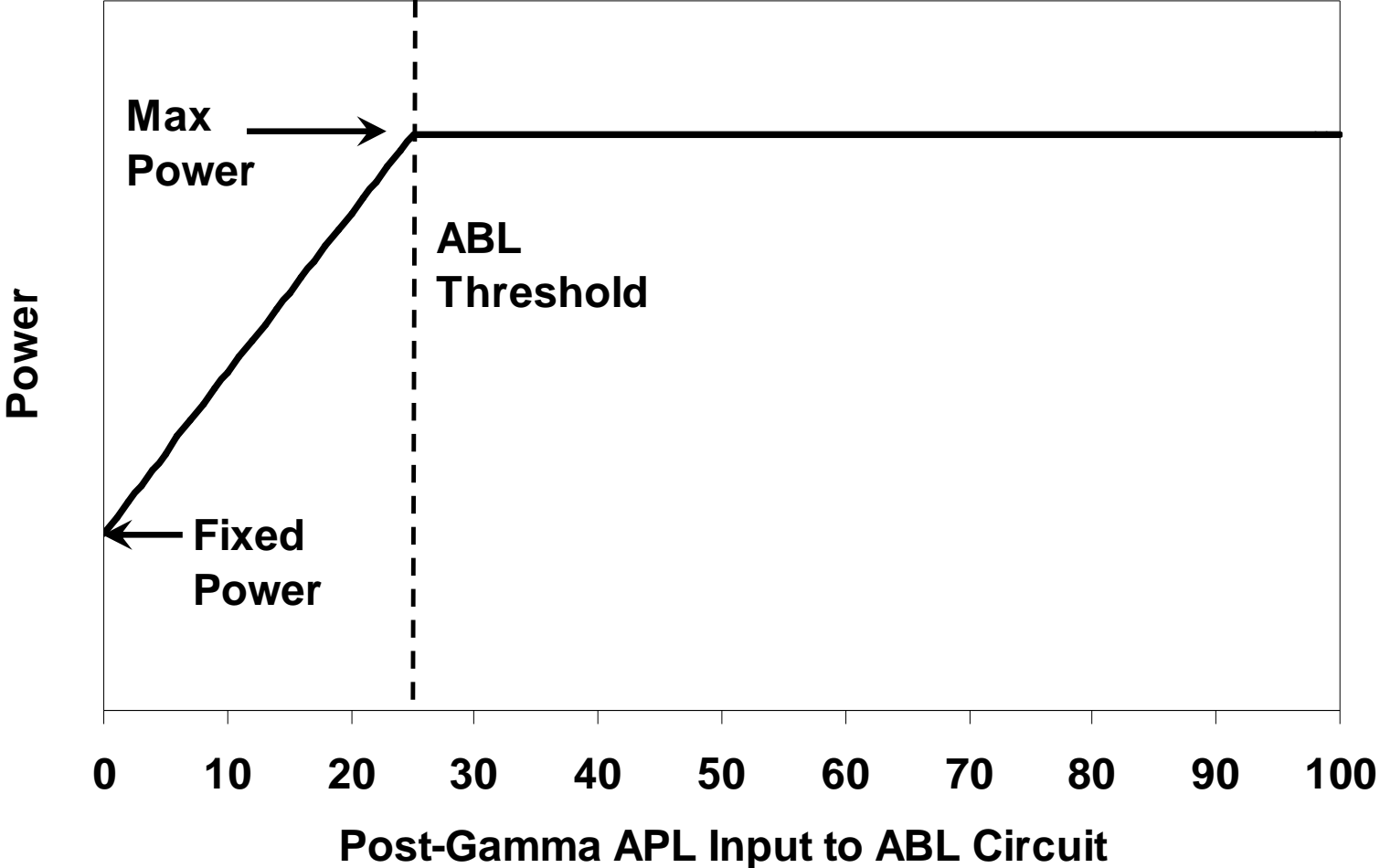
# Power Model for Plasma Display TV Set



# Inverse Gamma Function

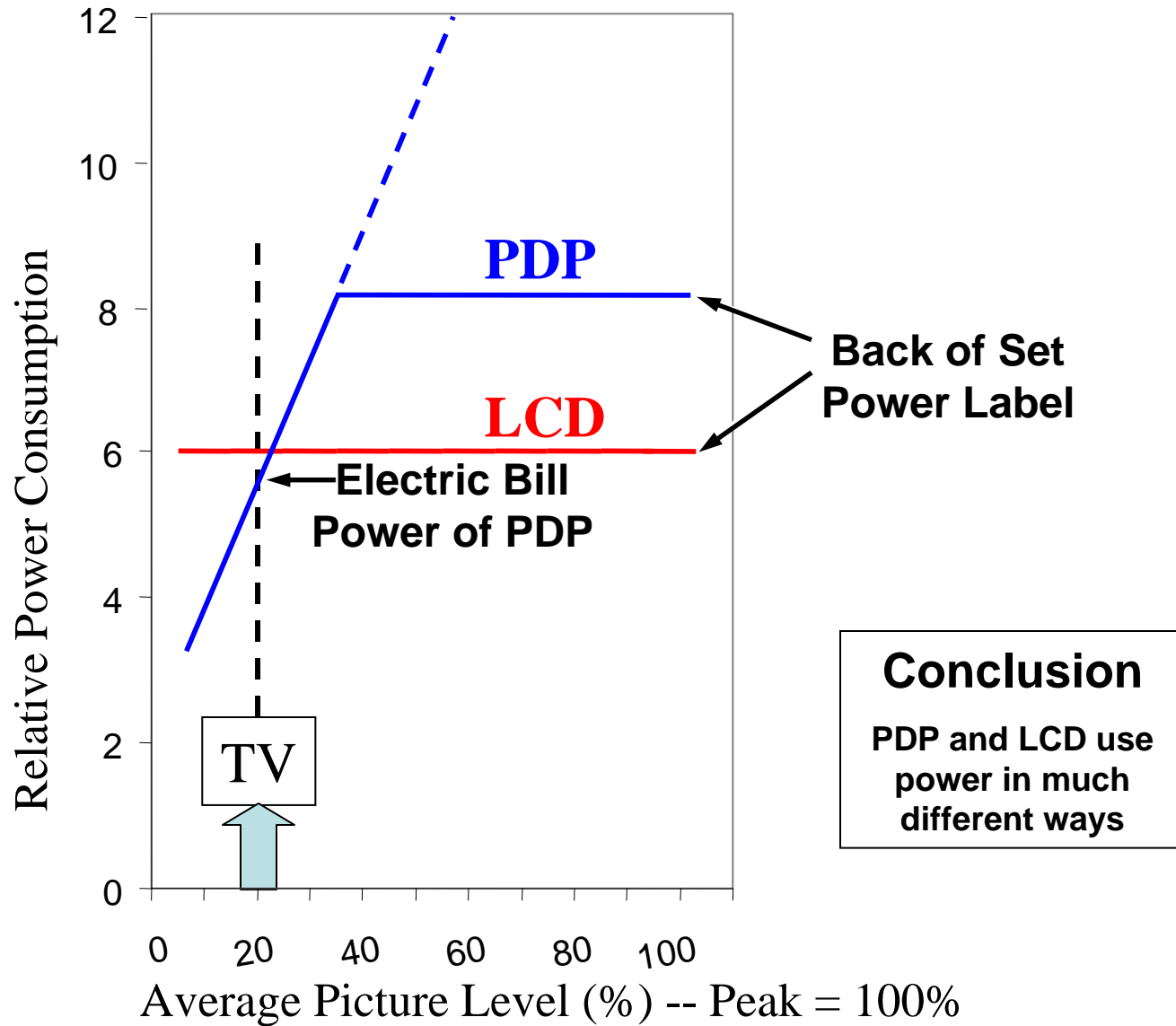


# Plasma TV Power Characteristic





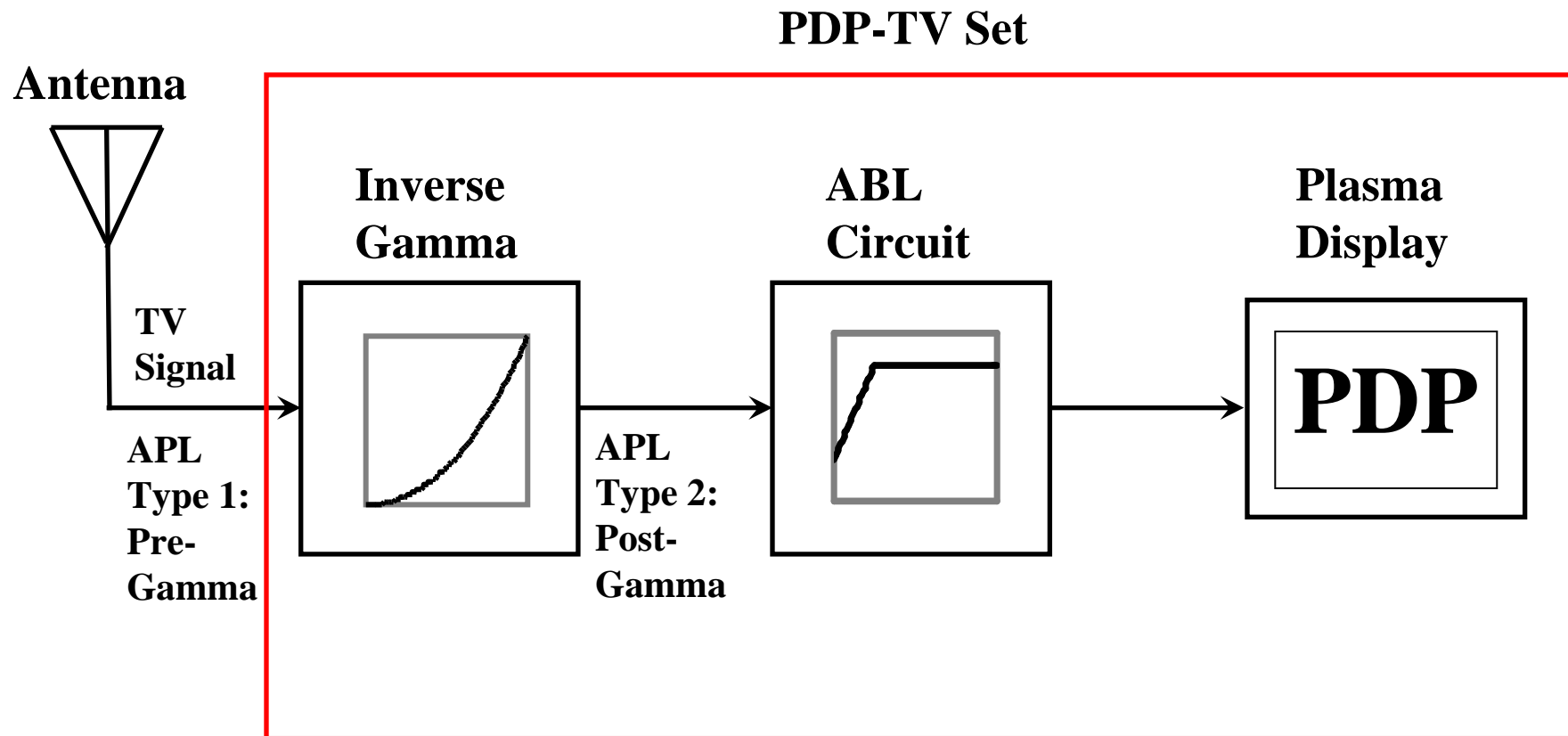
# Power Consumption Dependence on APL



# Average Pixel Level (APL)

- APL has major impact on TV power usage
- **APL Type 1 ( Pre-Gamma ) Definition:**
  - APL is the time average of the video signal input voltage to the TV set, which is usually expressed as a percentage of the *full white signal level voltage*.
- **APL Type 2 ( Post-Gamma ) Definition:**
  - APL is the time average of the average luminance of all pixels in the TV set, which is usually expressed as a percentage of the *peak white luminance level*.

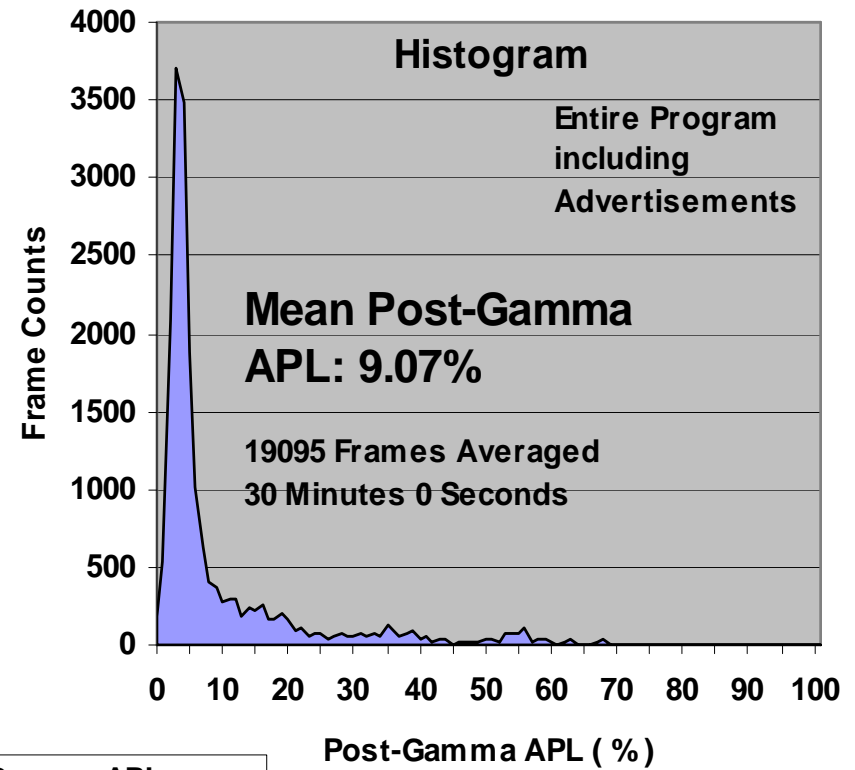
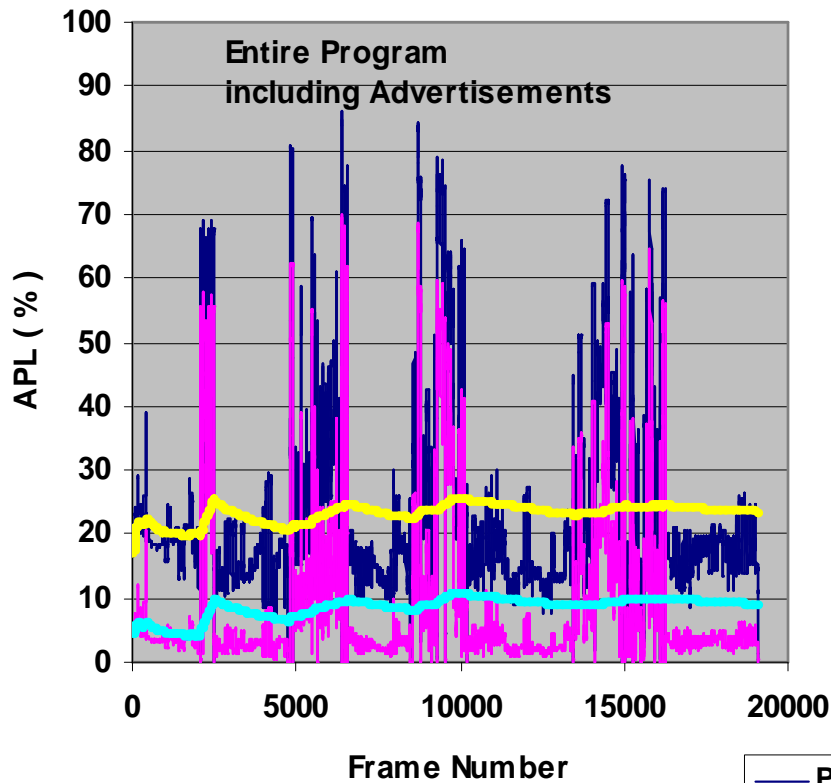
# Power Model for Plasma Display TV Set



# APL of Popular TV Program

The Young and the Restless Soap Opera

The Young and the Restless Soap Opera



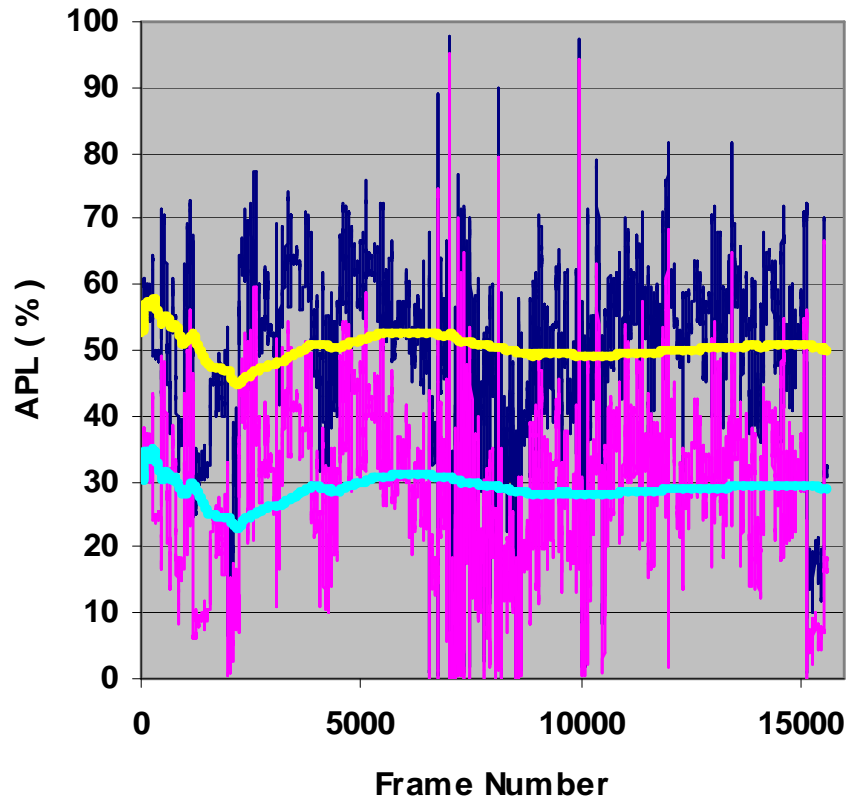
- Pre-Gamma APL
- Post-Gamma APL
- Mean Pre-Gamma APL
- Mean Post-Gamma APL

# Low Budget Animation

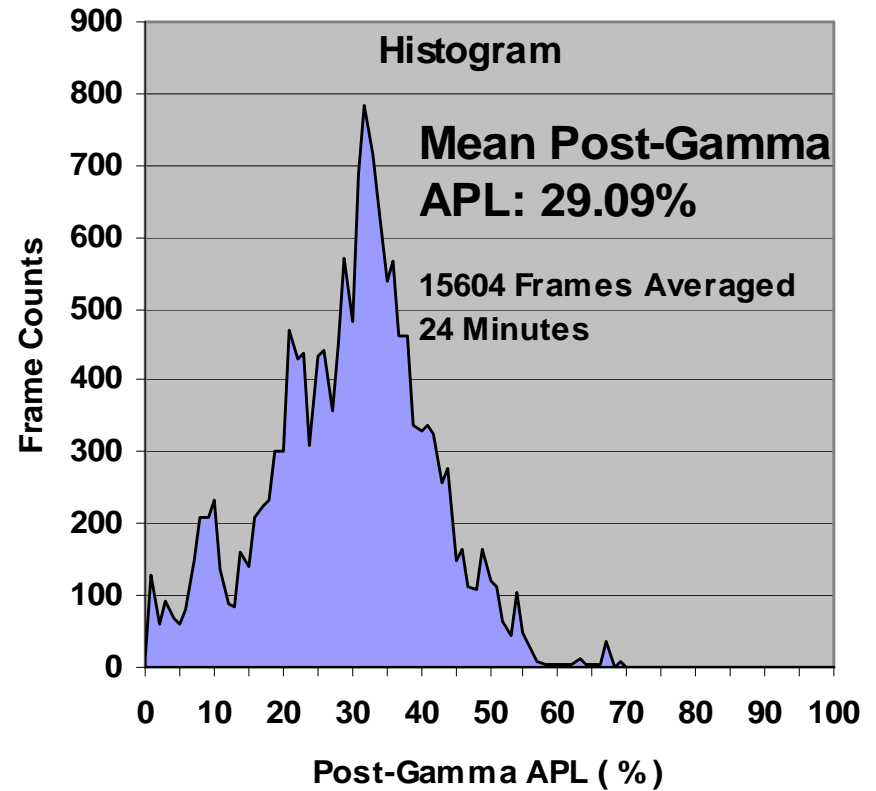


# Low Budget Animation

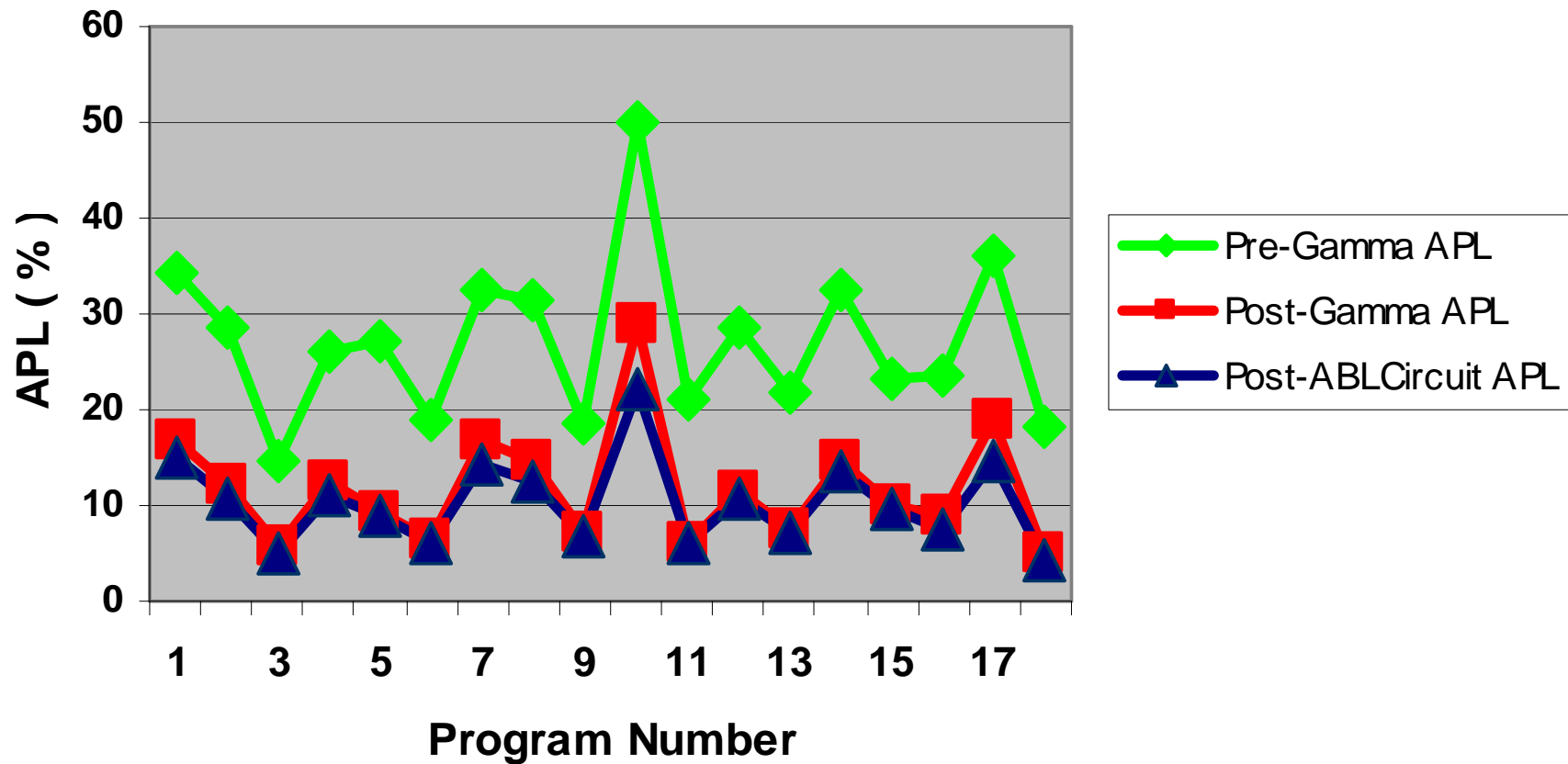
Rug Rats Low Budget Animation



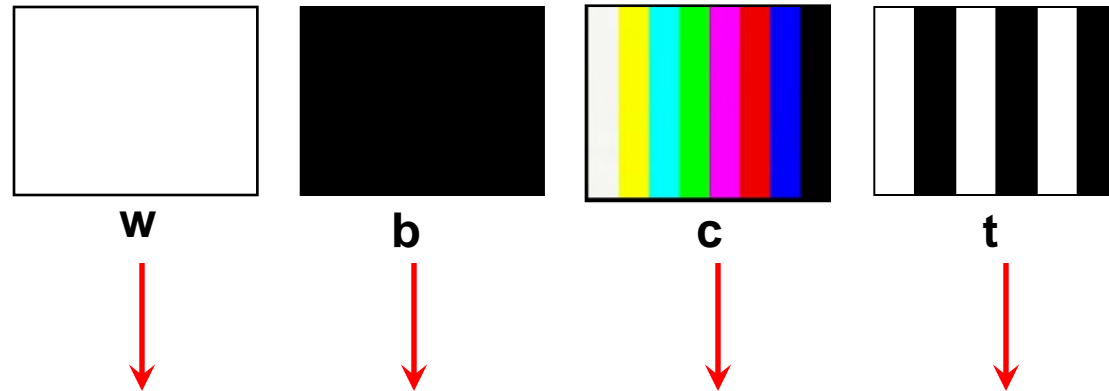
Rug Rats Low Budget Animation



# Summary of Measured APL



# JEITA Proposed TV Set Power Measurement Method



$$P_o = 0.167 \times P_w + 0.167 \times P_b + 0.333 \times P_c + 0.333 \times P_t$$

where:

$P_o$  is the output power value that is used for the final power calculations,

$P_w$  is the measured power of the 100% white pattern,

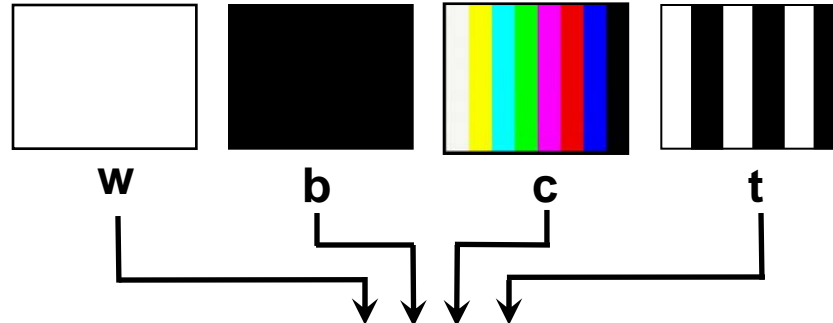
$P_b$  is the measured power of the full black pattern,

$P_c$  is the measured power of the color bar pattern,

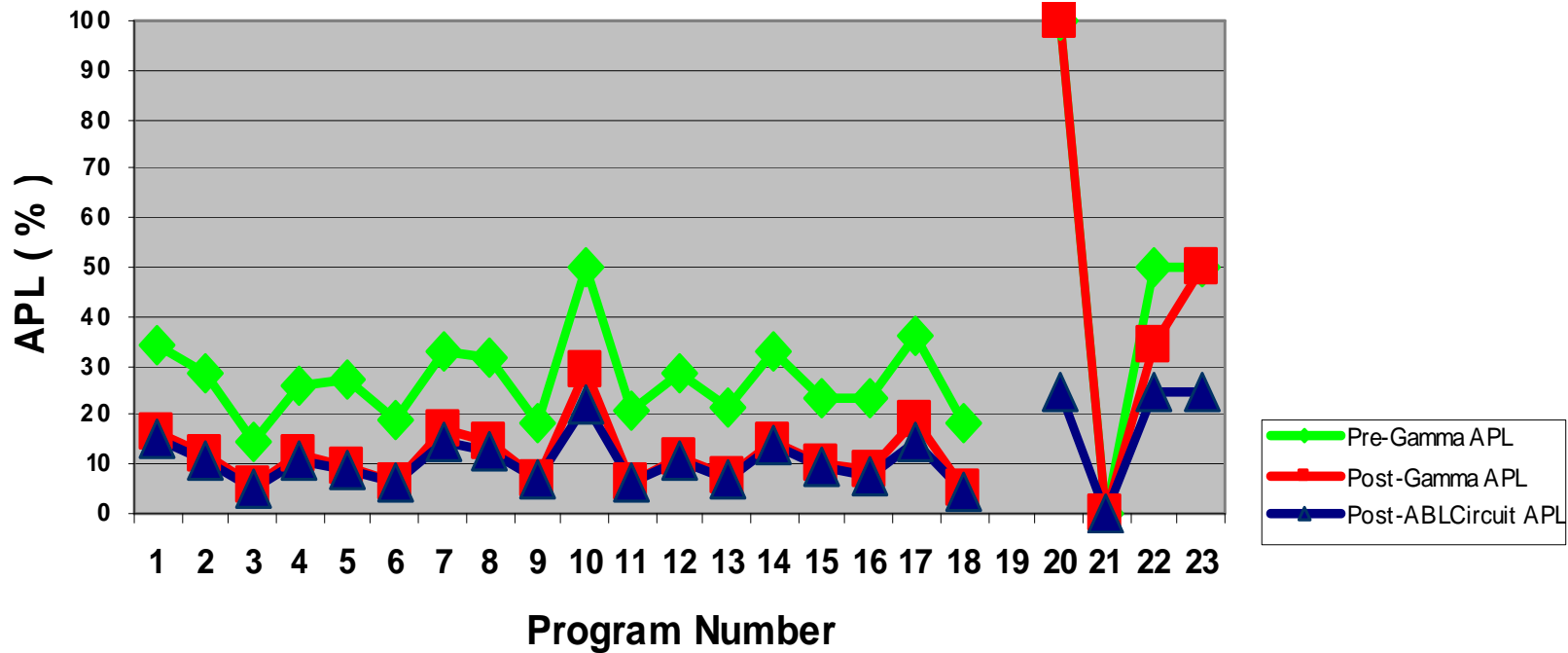
$P_t$  is the measured power of the white and black bar pattern.



# JEITA Proposal APL Comparison



Summary of Measured APL



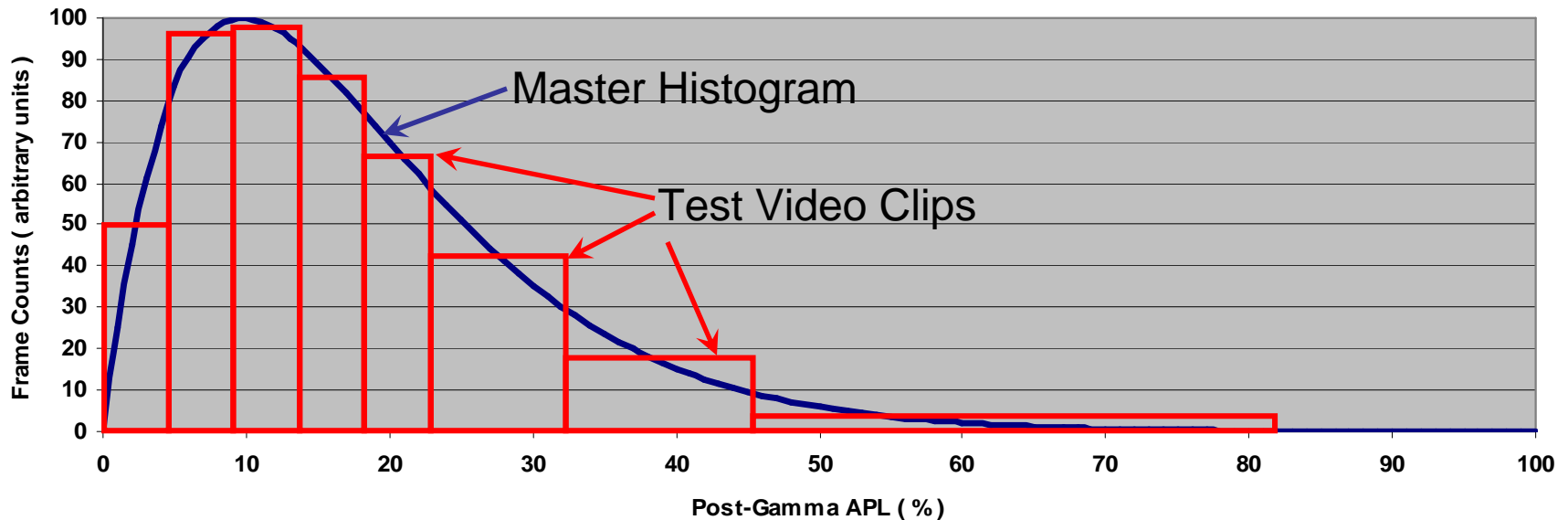
# Proposed New Test Method

- Preserve simplicity of JEITA TV Set test
  - Run test images and measure power
- Modify test images
  - Images must represent real TV signals
- Use special test video disk (tape) for images
  - Must be chosen very carefully in order to be truly representative of real TV signals

# Special Test Video Disk

- Measure APL Histograms of many popular TV programs
  - Big job that will take a few months
- Prepare Master Histogram of all TV programs
  - Weight individual program histograms by Nielsen ratings
  - Master Histogram will represent average TV usage
- Prepare Test Video Disk with various video clips
  - Histogram of final disk will be same as Master Histogram
  - Use available public domain video material

# Master Histogram



$$P_o = W_1 \times P_1 + W_2 \times P_2 + W_3 \times P_3 + W_4 \times P_4 + \dots + W_n \times P_n \quad (3)$$

Where:

$P_o$  is the output power value that is used for the final power calculations,  
 $P_1, P_2, P_3, \dots, P_n$  are the powers that are measured with the various test images,  
 $W_1, W_2, W_3, \dots, W_n$  are fixed numbers or Weights defined by the test method.

# New Measurement Method Standard

- Build on good ideas of JEITA-METI Standard
  - Simple to measure
  - Robust
- Increased accuracy
- Fair to all technologies
  - LCD, PDP, Projection, CRT, OLED , FED/SED
- Accurate for future display innovations
  - Dynamic LCD Backlight, LED Backlight
  - LED Projector Lamps