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A Cockcroft-Walton HV-Generator / PMT-Base for NPS

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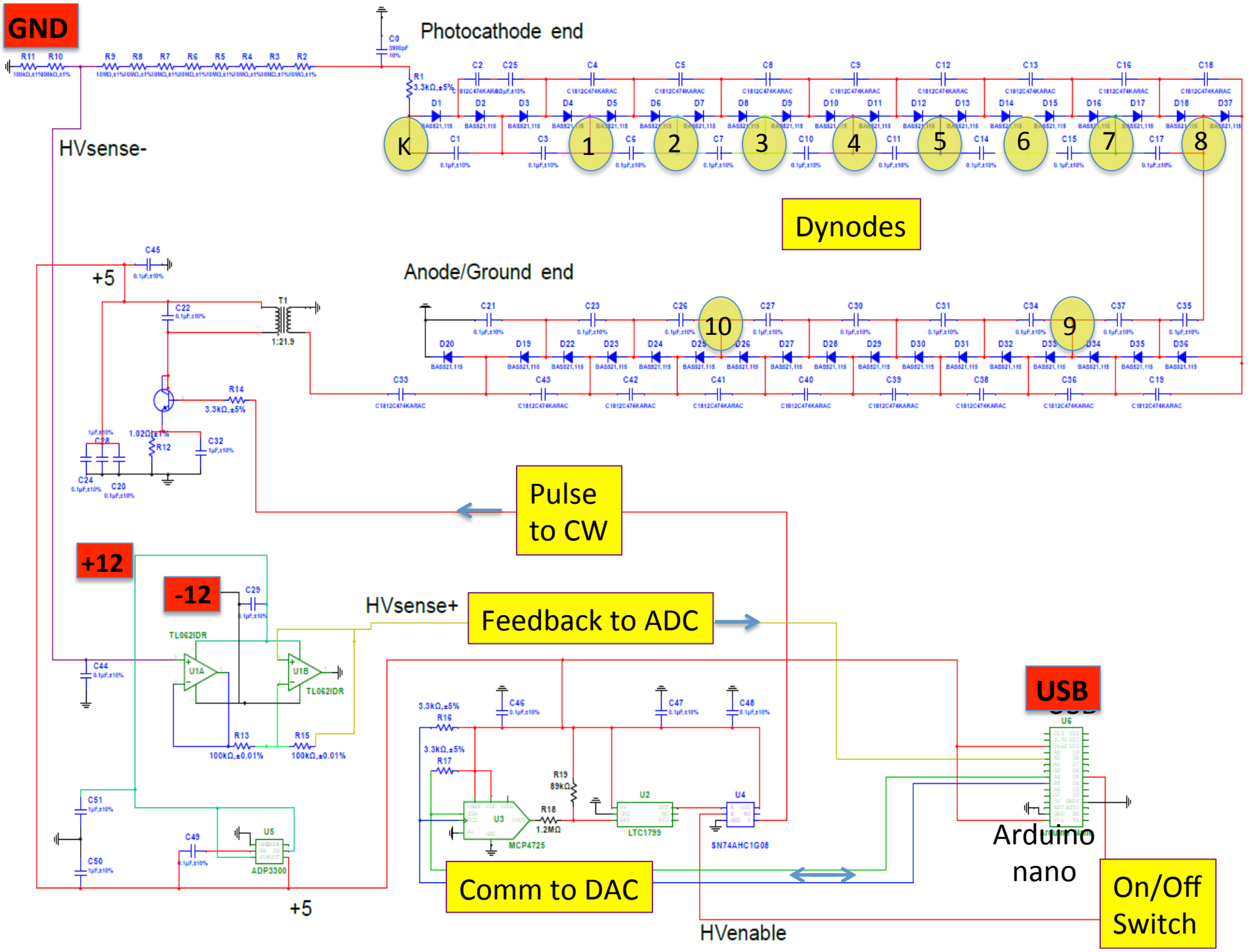
Why C-W Base?

- No HV cables – cuts cost
- Less (?) power dissipation.
- Better (?) stability vs pile-up fluctuations.
- Design Example:
  - ZEUS HCal → JLab/IU RadΦ → RHIC AnDY

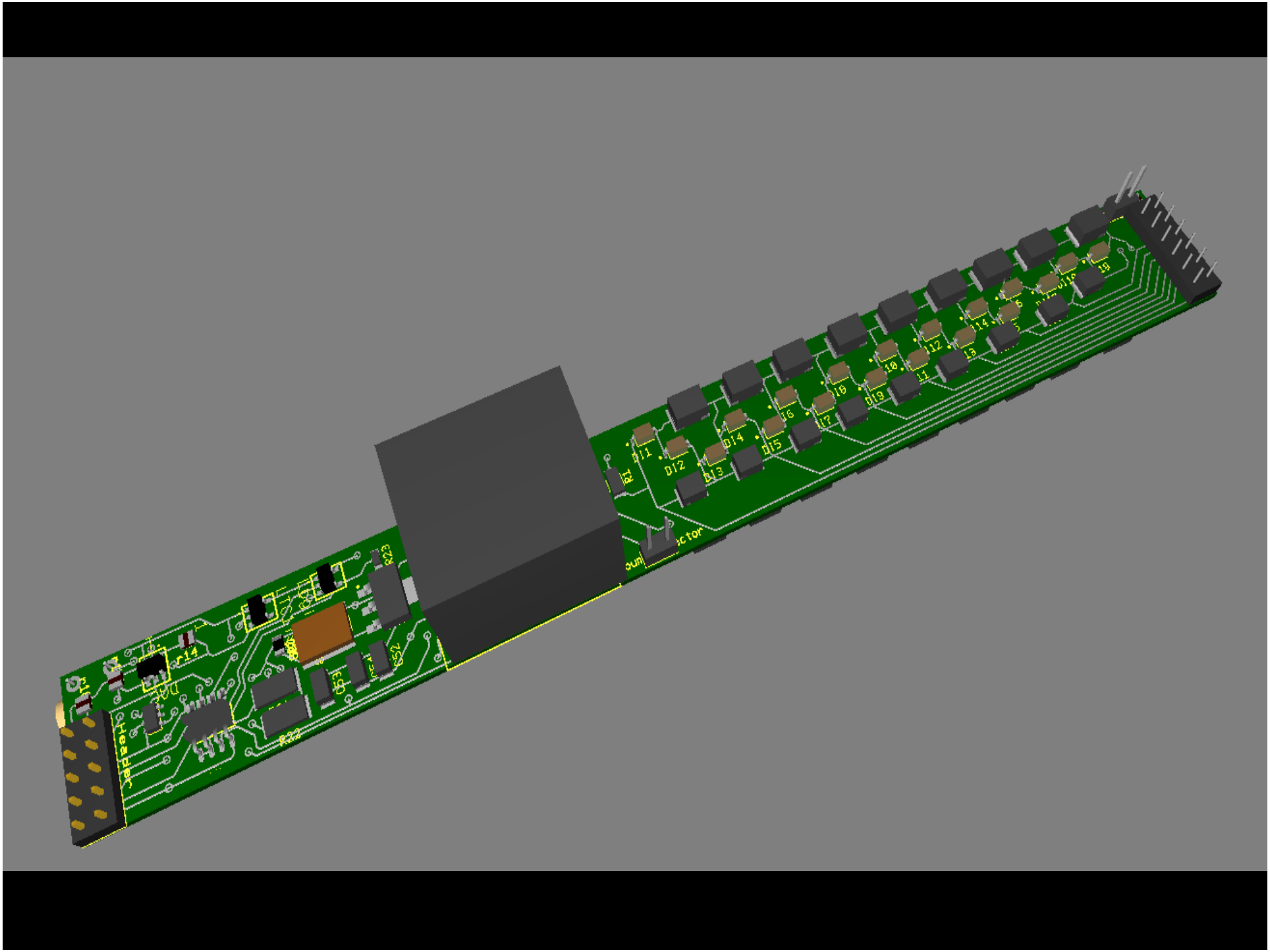
Cockcroft-Walton Concept

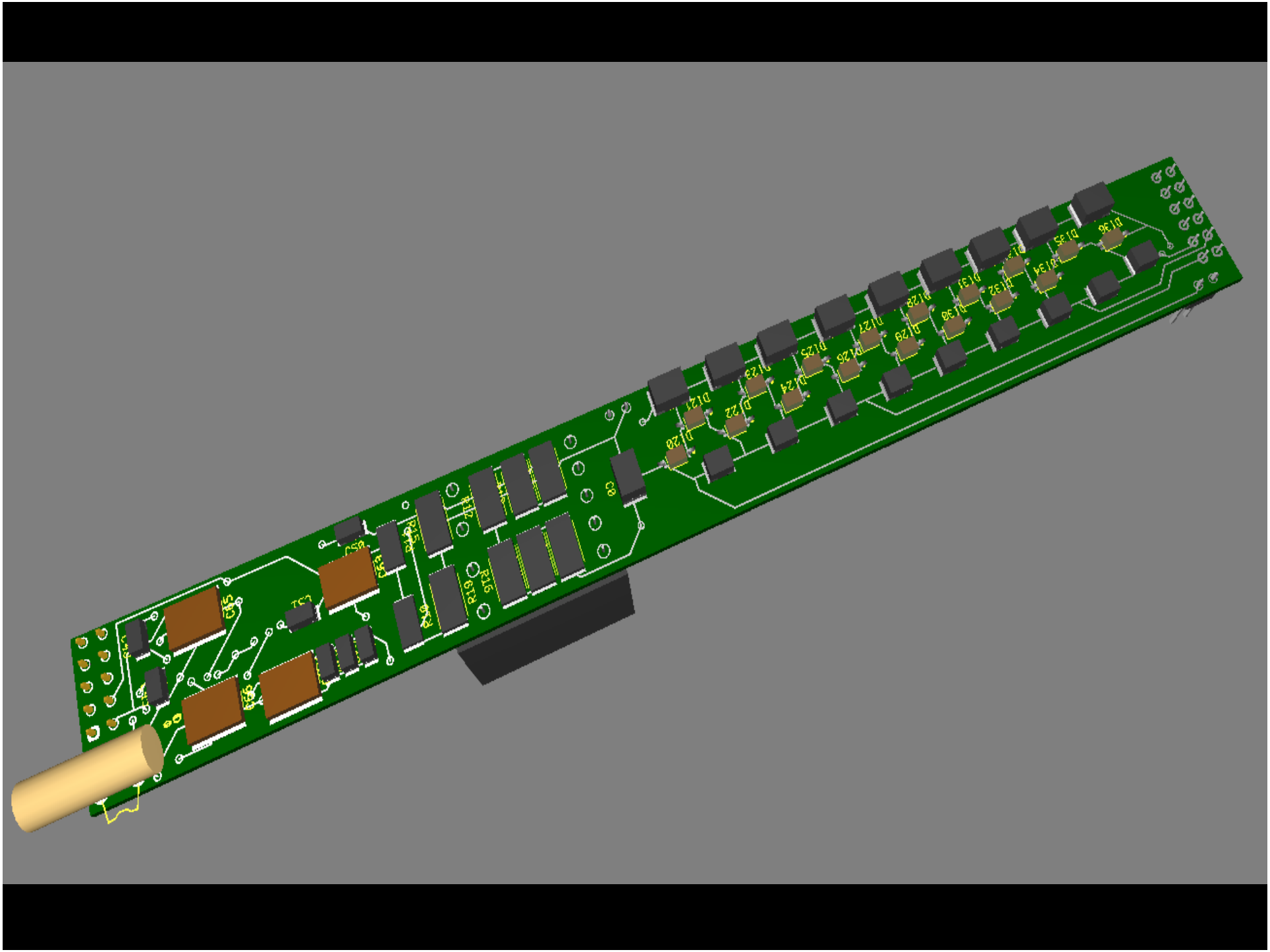
- Generate HV with a DC Transformer
  - High frequency pulse generator drives a capacitor/diode ladder
    - Rectifiers stacked on rectifiers
  - Our version, 0→+5V pulse at 10–40 KHz drives a transformer to ~ 100V
  - Transformer drives ~20 stage ladder

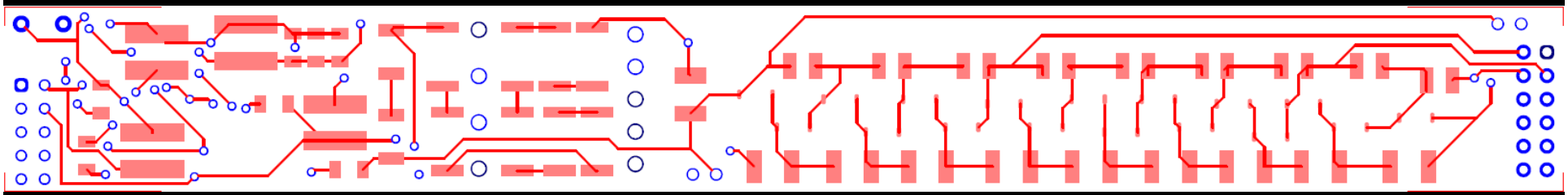

GND
Photocathode end
HVsense-
K
1
2
3
4
5
6
7
8
Dynodes
+5
Anode/Ground end
10
9
Pulse
to CW
+12
-12
HVsense+
Feedback to ADC
TL062IDR
TL062IDR
USB
3.3kΩ,±5%
3.3kΩ,±5%
MCP4725
LTC1799
SN74AHC1G08
ADP3300
Arduino
nano
Comm to DAC
On/Off
Switch
HVenable
+5

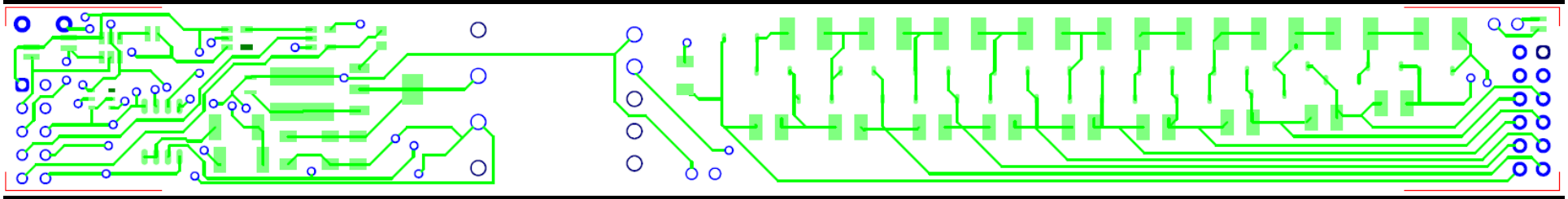
Benefits of Using Arduino

- Easily programmable through the IDE vs ISP
  - This can be done remotely while installed via USB
- Scripts can be written to sequentially program
  - Eliminates manually having to upload code to each board
- Programs can be used/written to monitor & save
  - Save and monitor HV level for stability
- Easily turn HV on/off via logic gate

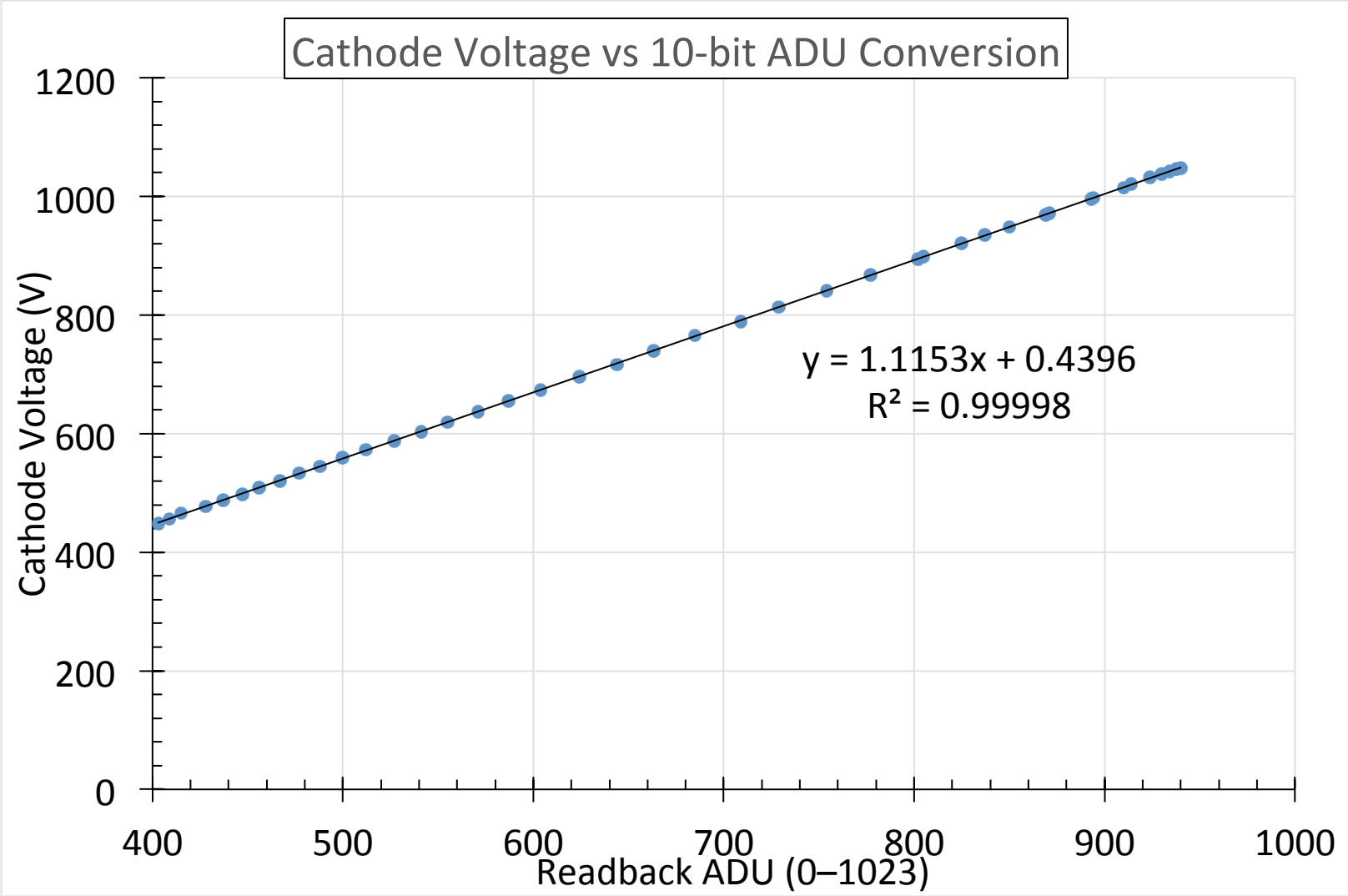

Header
D11
D12
D13
D14
D15
D16
D17
D18
D19
R14
R22
R23


D121
D122
D123
D124
D125
D126
D127
D128
D129
D130
D131
D132
D133
D134
D135
D136
R16
R19
C8

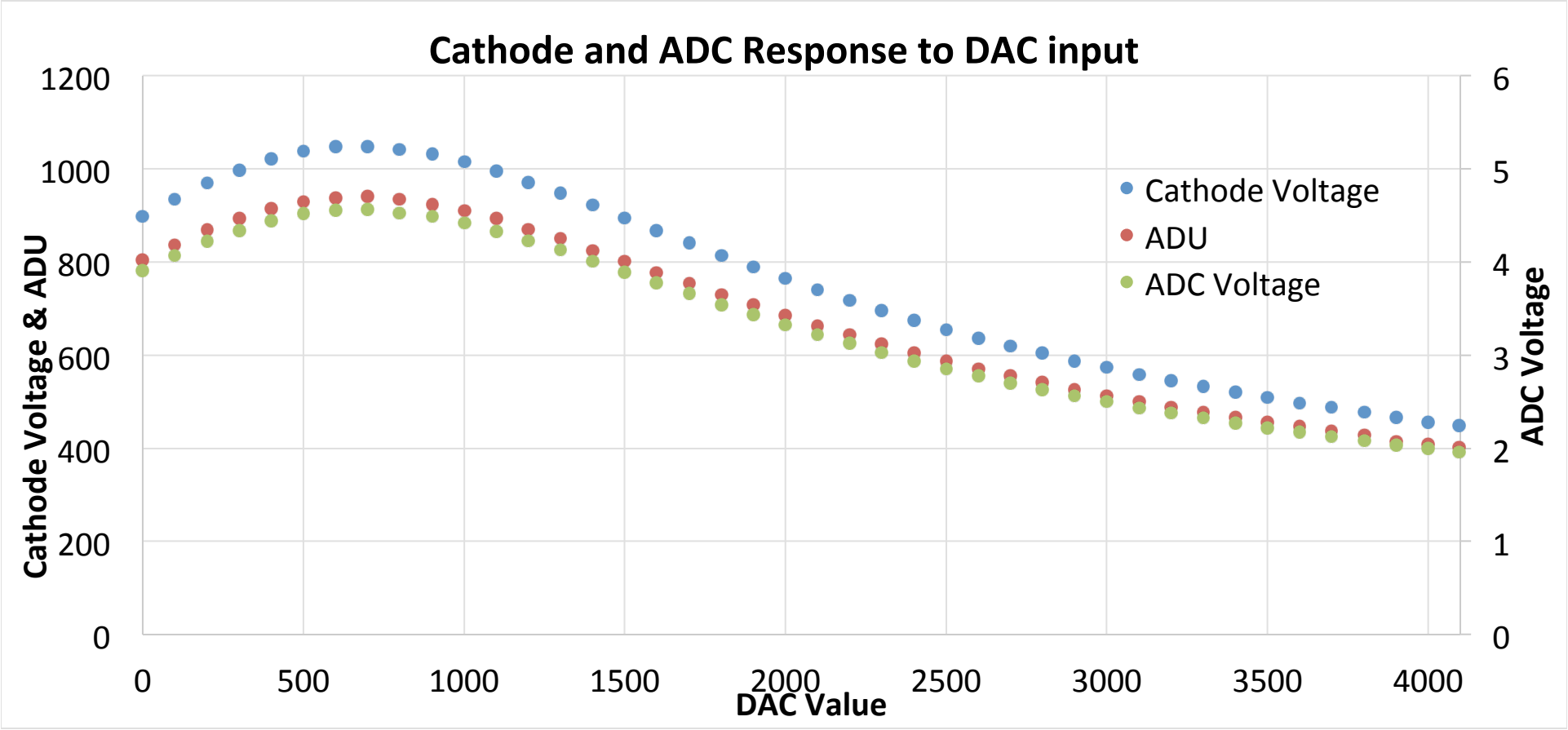




Readback is linear



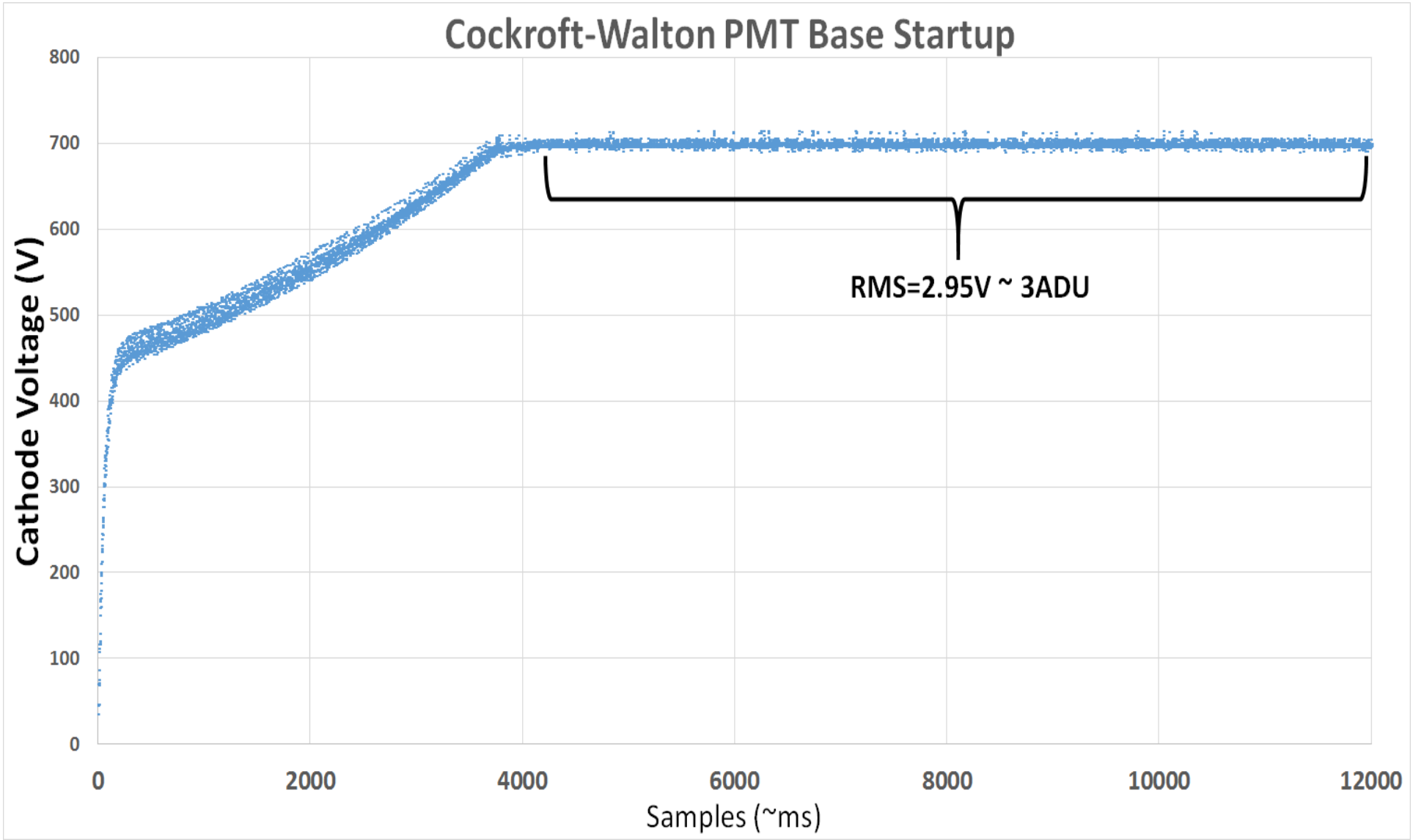
Affect of Resonance on Feedback



Effect of Resonance on Feedback

- Frequency range can be set to exclude resonance
  - Change resistance between Vcc & Set on oscillator
  - Easier control for when Vset < Vresonance
- Creates a non-linearity that is compensated for in code
- Create code so that resonance frequency is not reached

Sample HV Signal: It Works!



Planned Additions

- Mount Arduino on to PCB
- 12bit ADC separate from MCU
  - Allows finer control to match 12bit DAC
- Additional ADP3300 voltage regulator
  - Lower noise supply powering Arduino & transformer
- Smaller transformer
  - Isolation transformer to separate HV chain from digital components?

Cost Per Board @1000

Mfr. #	Manufacturer	Desc.	Order Qty.	Price (USD)	Ext.: (USD)
PZT3904	Fairchild Semiconductor	BJT NPN Transistor General Purpose	1000	$0.108	$108.00
750871011	Wurth Electronics	Transformers Audio & Signal 4mH 1.60Ohm	1000	$5.41	$5,410.00
MCP4725A0T-E/CH	Microchip	Digital to Analog Converters - DAC Sngl 12B NV DAC	1000	$0.73	$730.00
SN74AHC1G08DBVR	Texas Instruments	Logic Gates Single 2-Input	1000	$0.103	$103.00
ADP3300ARTZ-5REEL7	Analog Devices Inc.	Linear Voltage Regulators High Acc 50mA LDO	1000	$0.666	$666.00
TL062IDR	Texas Instruments	Op Amps Dual Low-Noise JFET-Input	1000	$0.282	$282.00
CRCW080533R0FKEA	Vishay	1/8watt 33ohms 1% 100ppm	1000	$0.019	$19.00
ERJ-P08J332V	Panasonic	1206 3300ohms 5% Thick Film Resistor	5000	$0.017	$85.00
ERJ-3EKF8872V	Panasonic	0603 88.7Kohms 1% Tol	1000	$0.004	$4.00
CRCW2010100KFKEF	Vishay	3/4watt 100Kohms 1%	3000	$0.07	$210.00
1812HC392KAT1A	AVX	3900 pF 10% 3 KVolts X7R	1000	$0.384	$384.00
C1206C104KARACTU	Kemet	250volts 0.1uF X7R 10%	30000	$0.056	$1,680.00
C1812C474KARACTU	Kemet	250volts 0.47uF X7R 10%	18000	$0.252	$4,536.00
C1825C105KARACTU	Kemet	250volts 1uF X7R 10%	5000	$0.648	$3,240.00
BAV3004WS-7	Diodes Incorporated	Power Switching Diode 200mW 350V	36000	$0.072	$2,592.00
ERJ-8ENF1204V	Panasonic	1206 1.2Mohms 1% Tolerance	1000	$0.01	$10.00
LTC1799HS5#PBF	Linear Technologies	1kHz to 33MHz Resistor set SOT-23 Oscillator	1000	$3.04	$3,040
PCB	Rush PCB		1000	$1.50	$1,500
"Arduino" Nano	Variable	USB controlled Microcontroller	1000	$2.00	$2,000
571-5103309-1	TE Connectivity	HDR VERT DOUBLE 10P low profile	1000	$0.627	$627
				Total (1000)	$27,226.00
				Total (single)	$27.23

Questions We Have

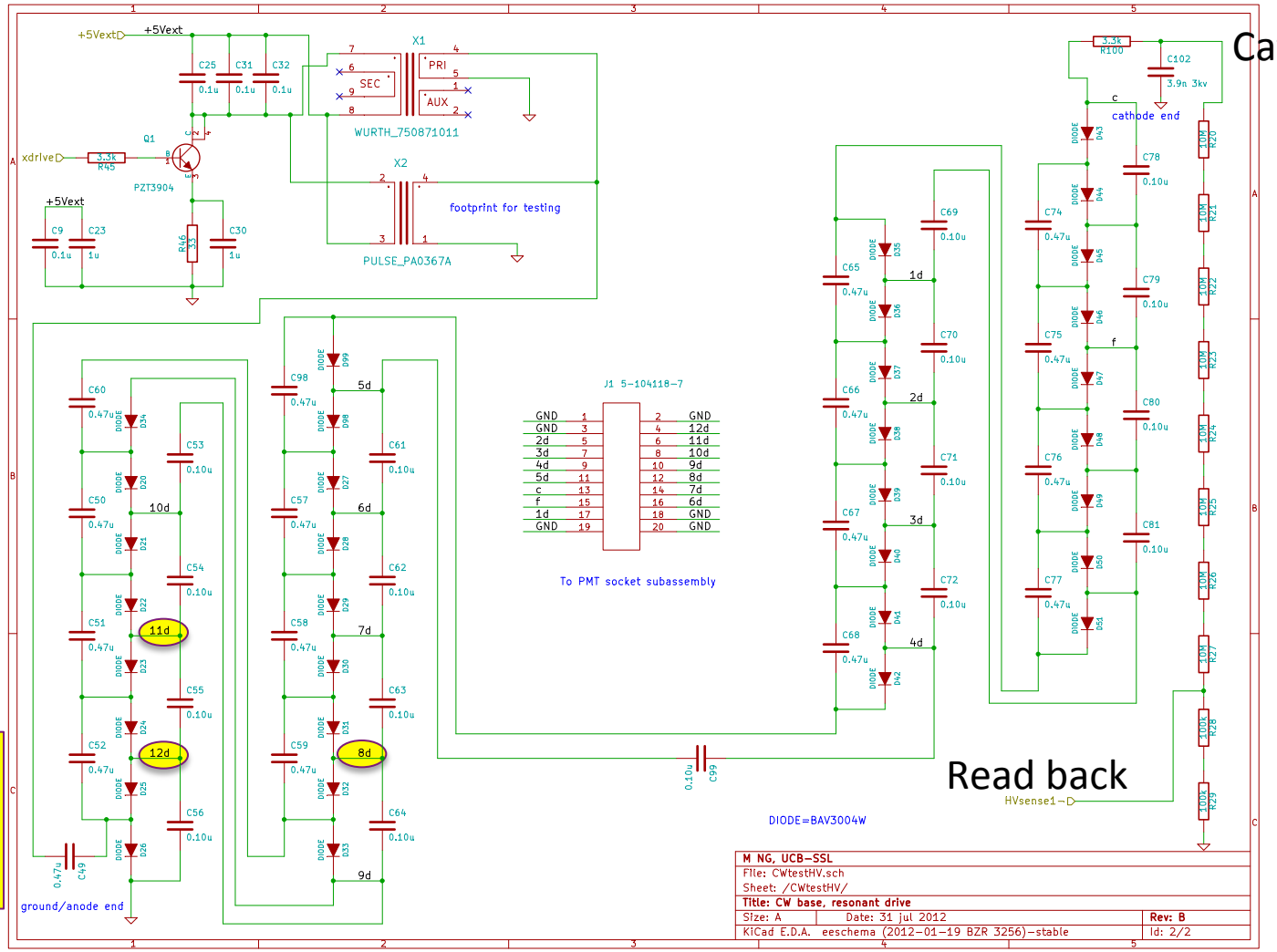
- How will PMT load chance readings?
- What is the Voltage ripple spec (≤ 1V rms ?)
- What is the dynamic range/stability criterion for anode current?
  - 1% at (10 MHz)(10^5 gain)(10 p.e.) = 2 microAmp ??
- When is the deadline for a design choice
  - Yesterday?

Conclusions

- We have proof-of-principle prototype
  - We think we can improve it to meet spec
- We do not yet have a working PMT base.
  - We think we can get there by April (sooner?)
- Provides a digitally controlled, compact, and efficient alternative to resistive base

Starting Design

Pulse in →



Cathode

Dynode HV
(12 for AnDY)
10 for NPS

Feedback & Set-Point/Readback Communications

Power / I-O