Power - Digital

VD-PD

W. Pellico

Digital Power/Arapuca – Assumptions

- Digital Transmitters (2/Box)
  - Current – est. 75 – 100 ma
  - Voltage – est. **5 volts**
  - Bias current 2 ma
- FPGA (1 for 4 Arapucas)
  - Peak current 200 ma/Arapuca
  - Voltage **5 volts**
- Electronics
  - Summing Op amp
    - 30 ma
    - **3 – 5 volts**
  - Clock chip – some number
    - Buffer Amp Chip - fanout
    - <5 ma
    - 5 Volts
- SiPMs
  - Bias Voltage
    - **48-50 Volts**
  - Current (~5ua/SiPM)

Base PoF Concept:

Two PoF systems

One @ 48 volts - low current

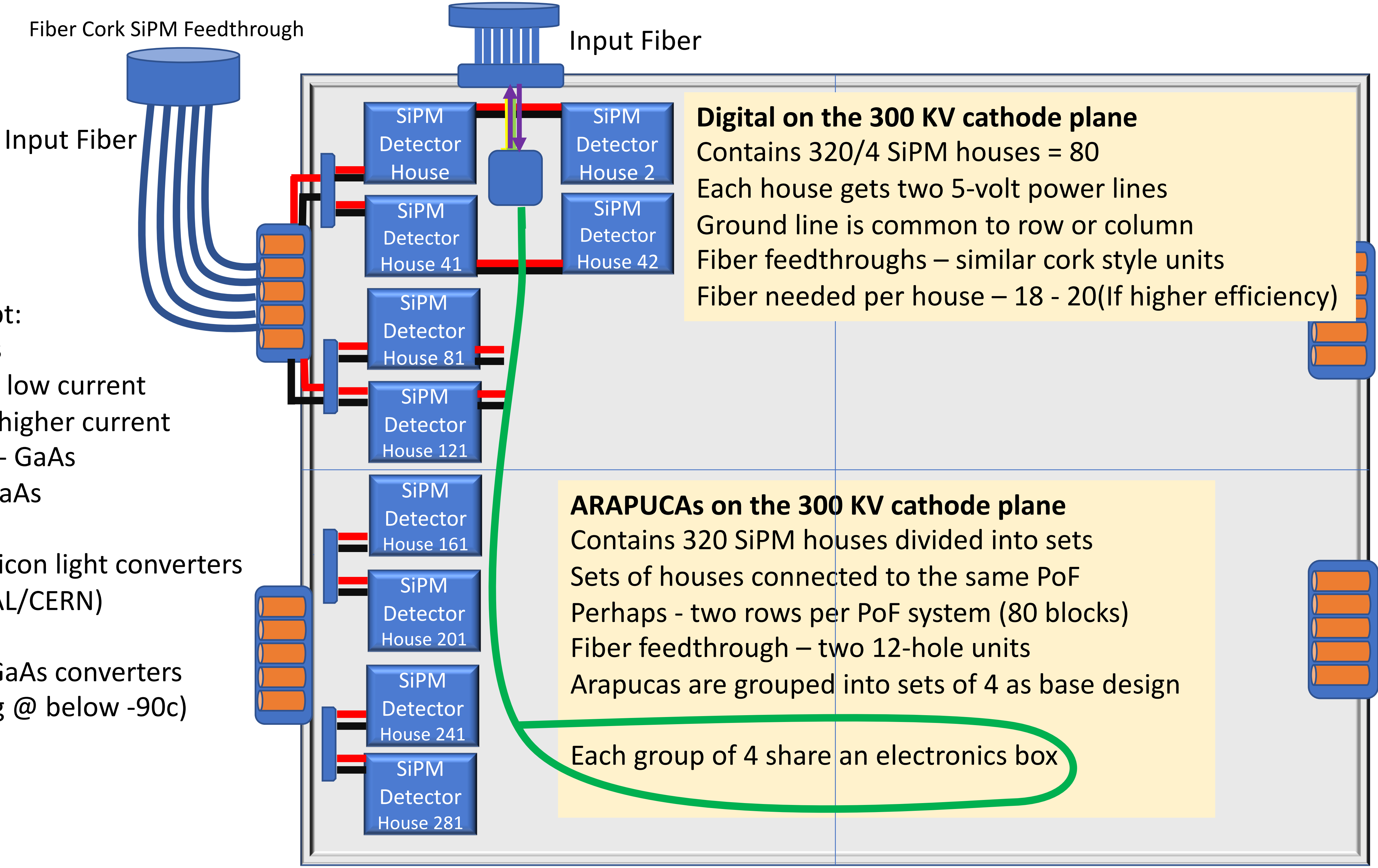
One @ 5 volts – higher current

One @ 3.3 volts - GaAs

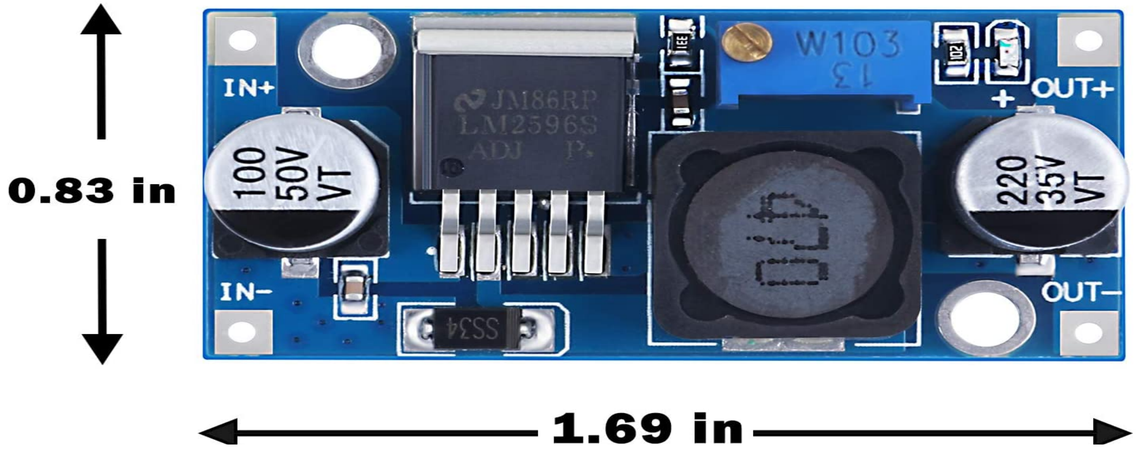
One @ 1 volt - GaAs

The 48 V uses silicon light converters (as tested at FNAL/CERN)

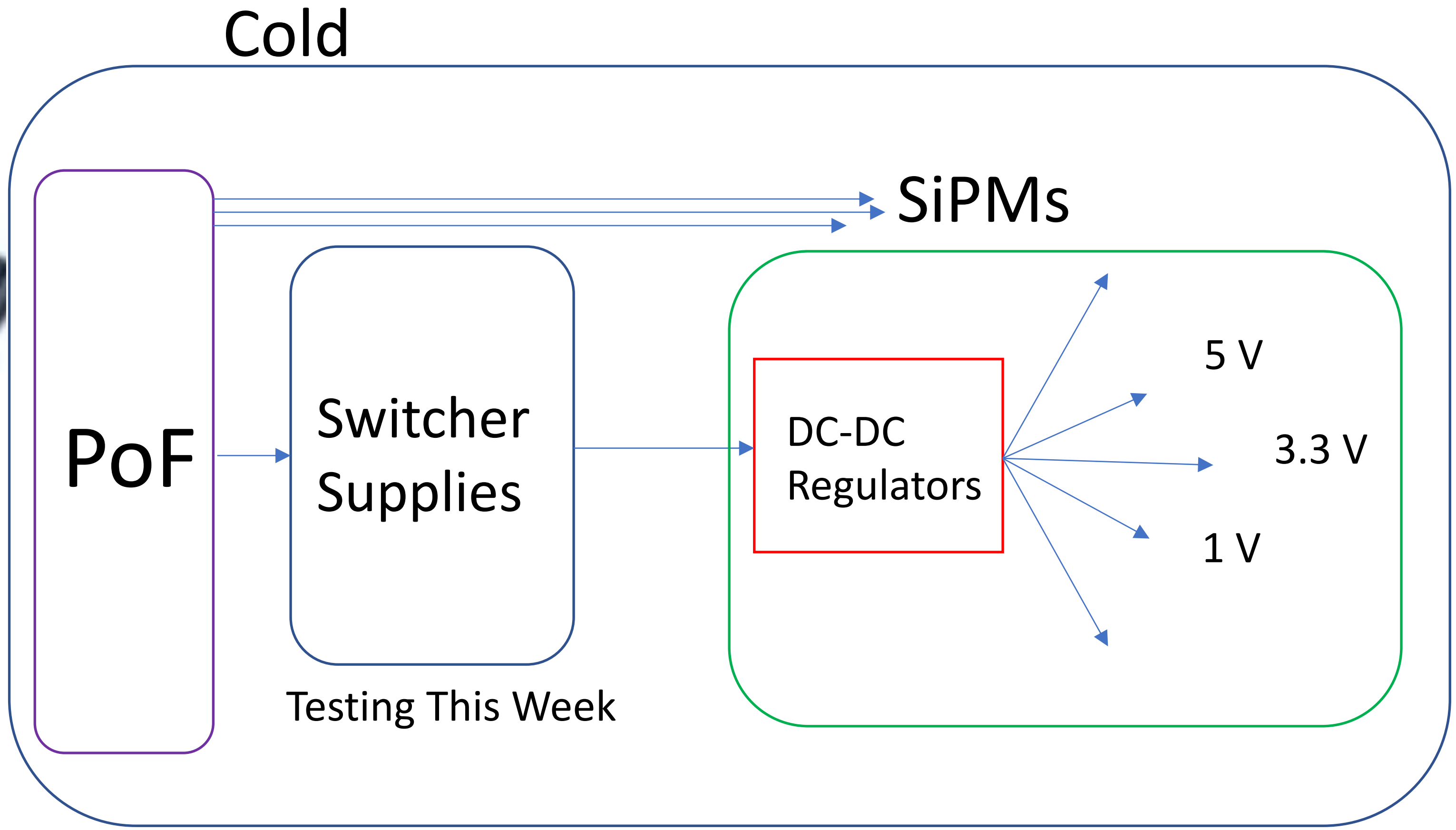
The 5 volt uses GaAs converters (tested at Boeing @ below -90c)



PoF (Testing Regulators)



- LTC3103 – DONE - Failed
- TPS74201RGWR -Today
- TPS74401
- IK0524SA-XP (CERN)
- 2915L18F

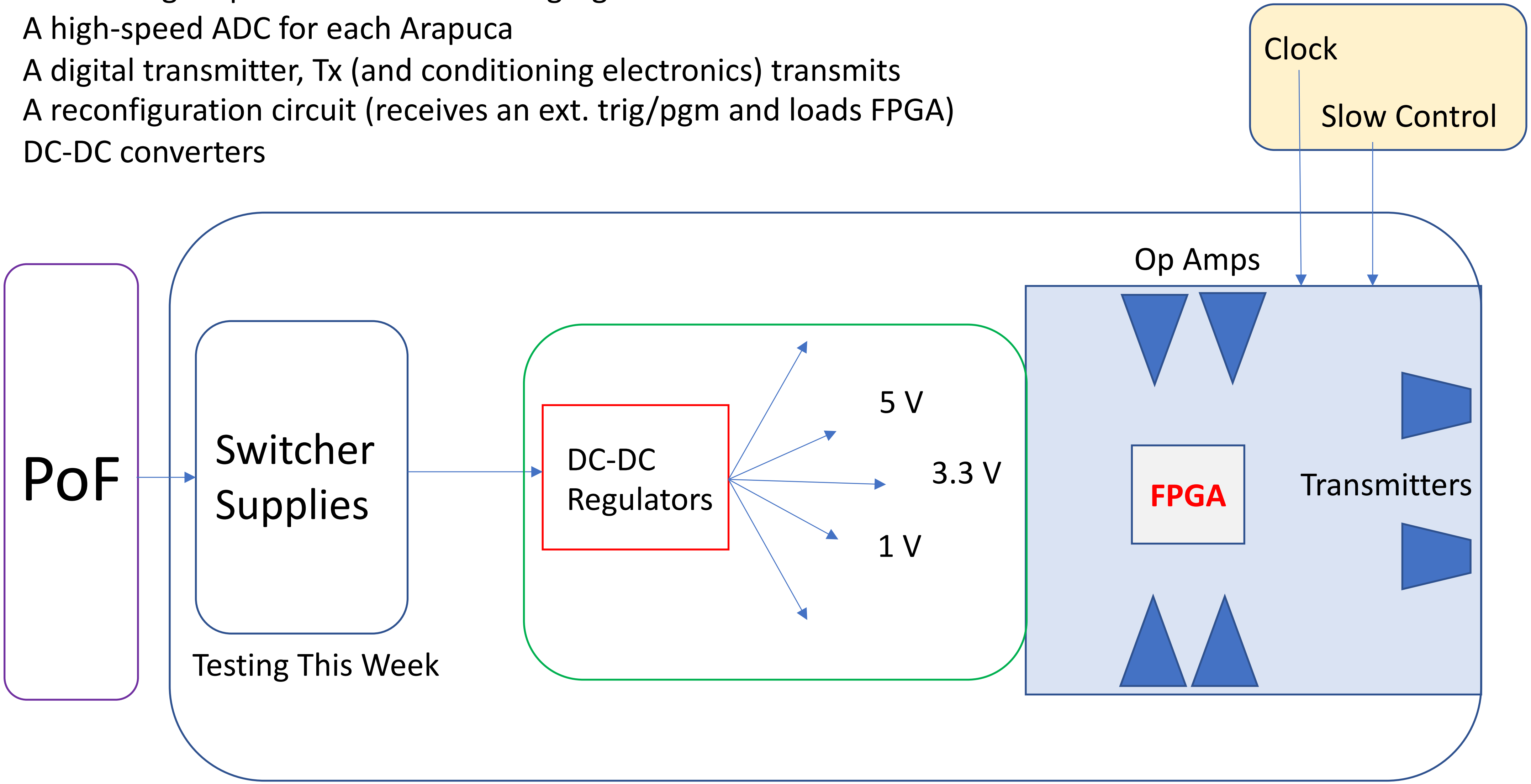


Issues

Some have long delivery times
Each has a unique footprint
Testing only two of each
Need to know loads to fully assess

Electronics Box

- Each Arapuca transmits two analog signals to the electronics box
- A summing amp combines both analog signals
- A high-speed ADC for each Arapuca
- A digital transmitter, Tx (and conditioning electronics) transmits
- A reconfiguration circuit (receives an ext. trig/pgm and loads FPGA)
- DC-DC converters



PoF System/Hardware

- ***Cathode SiPMs***
  - 320 ARAPUCAs
  - Divided into sectors (4 – 6)
  - 48 Volts +/- 80 mv
  - 50 ma (DC) / Sector (assuming 5ua/SiPM)
  - Some storage capacitance at housing units

Tested power (FNAL/CERN)

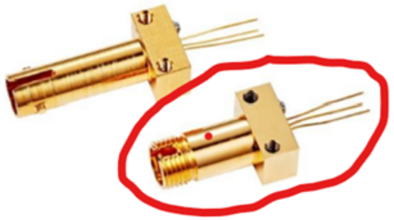
Certified 48 v

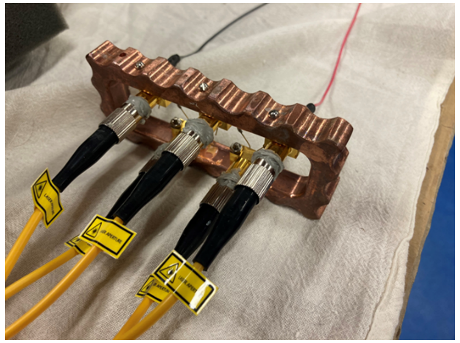
Certified short-term stability

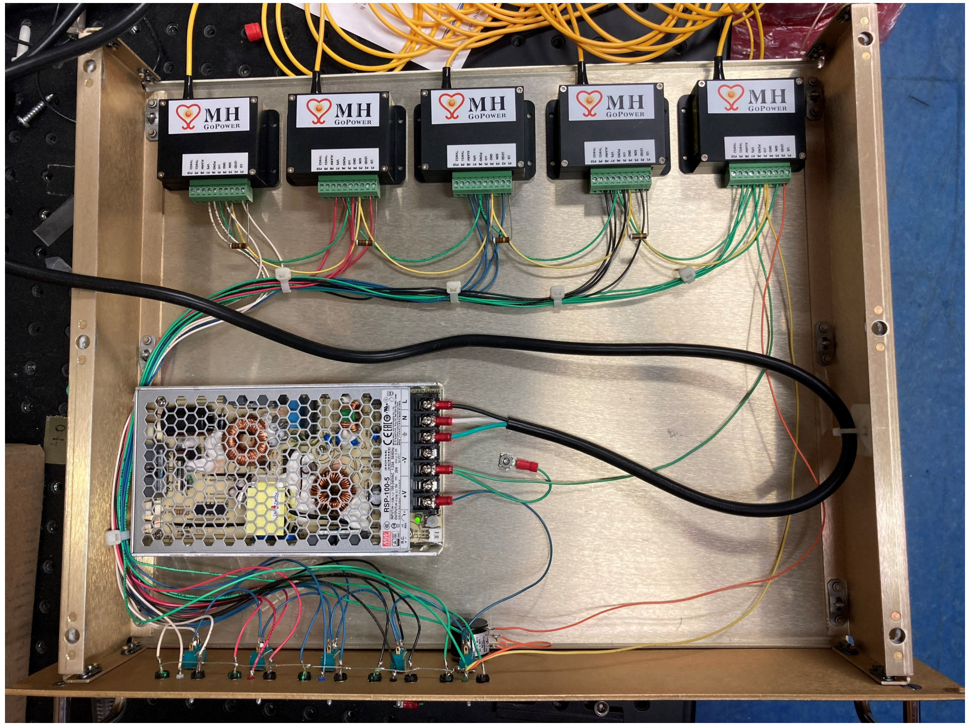
Verified power vs load

<u>Need to verify long term viability</u>

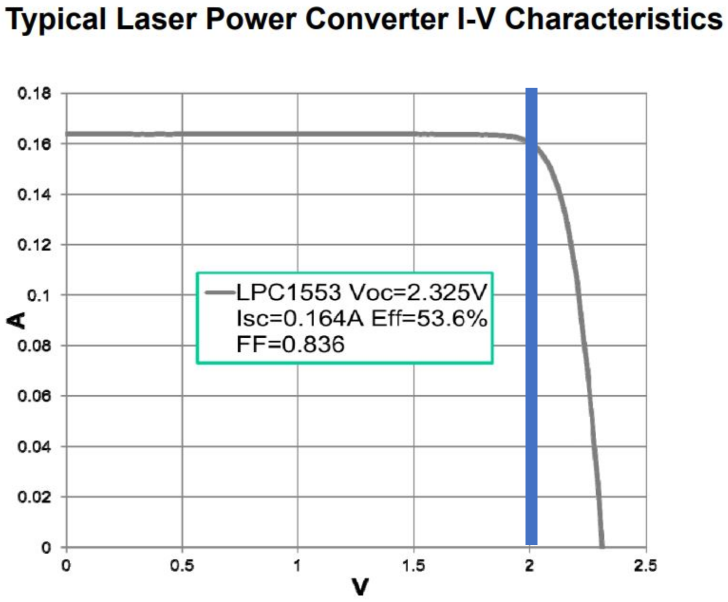
<u>Test DC-DC converter to handle load variations</u>







PoF Electronics Box

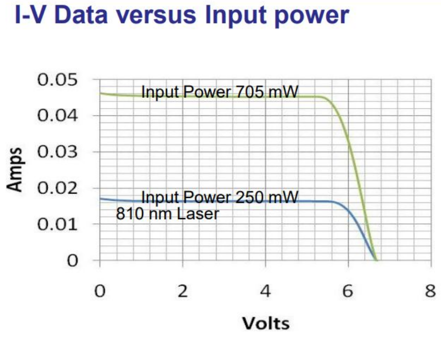


- Two Higher Current / Lower Voltage Options

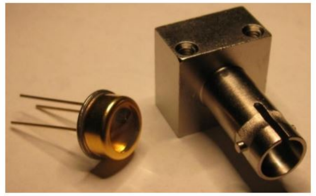
1. Like Arapuca PoF – Silicon based but larger
   - Testing for past five months -
2. GaAs Units: More efficient in cold –

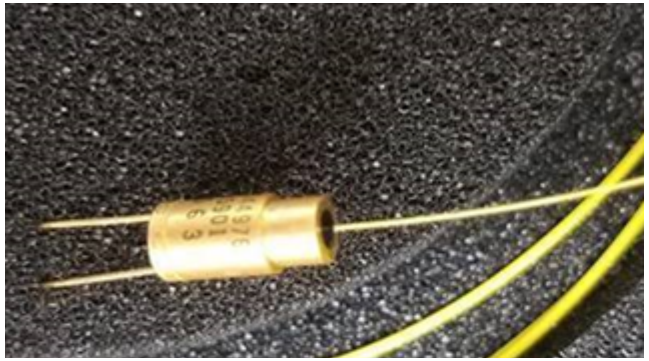
- No electron carrier 'freeze-out'
- Devices are at least 50% efficient and often reach over 60% when tested warm.
- Lower voltage but higher current (off the shelf).
  - Vendor recommends higher power units for testing
  - Can run up to 4 Watts

Temperature Coefficients for		
Dual Junction PV Laser Power Converter		
600mW Illumination		
I_{sc}	-1.04E-04	A/ºC
V_{oc}	-2.87E-03	V/ºC
P_{max}	-6.55E-04	W/ºC
Efficiency	-0.11	%/ºC Abs
V_{pmax}	-2.80E-03	V/ºC



6V LPC Package





Off the Shelf –testing of regulators/misc

LTC3103

Key Features:

- Input Voltage Range: 2.5V to 15V
- Output Voltage Range: 1.3V to 13.8V
- 300mA Output Current
- Efficiency up to 90%

Applications:

- Power over Fiber (PoF)
- Remote Sensors
- Portable Products
- Battery-Operated Devices

Ultralow Quiescent Current: 1.8µA
n Synchronous Rectification: Efficiency Up to 95%
n Wide VIN Range: 2.5V to 15V
n Wide VOUT Range: 0.6V to 13.8V
n 300mA Output Current
n User-Selectable Automatic Burst Mode® or Forced Continuous Operation

PART NUMBER	DESCRIPTION	COMMENTS
LTC3104	15V, 300mA Synchronous Step-Down DC/DC Converter with Ultralow Quiescent Current and 10mA LDO	V_{IN}: 2.5V to 15V, $V_{OUT(MIN)}$ = 0.6V, I_Q = 2.8µA, I_{SD} = 1µA, 3mm × 3mm DFN-10, MSOP-10
LTC3642	45V (Transient to 60V) 50mA Synchronous Step-Down DC/DC Converter	V_{IN}: 4.5V to 45V, $V_{OUT(MIN)}$ = 0.8V, I_Q = 12µA, I_{SD} < 1µA, 3mm × 3mm DFN-8, MSOP-8
LTC3631	45V (Transient to 60V) 100mA Synchronous Step-Down DC/DC Converter	V_{IN}: 4.5V to 45V, $V_{OUT(MIN)}$ = 0.8V, I_Q = 12µA, I_{SD} < 1µA, 3mm × 3mm DFN-8, MSOP-8
LTC3632	50V (Transient to 60V) 20mA Synchronous Step-Down DC/DC Converter	V_{IN}: 4.5V to 50V, $V_{OUT(MIN)}$ = 0.8V, I_Q = 12µA, I_{SD} < 1µA, 3mm × 3mm DFN-8, MSOP-8
LTC3388-1/LTC3388-3	20V, 50mA High Efficiency Nano Power Step-Down Regulators	V_{IN}: 2.7V to 20V, $V_{OUT(MIN)}$ Fixed 1.1V to 5.5V, I_Q = 720nA, I_{SD} = 400nA, 3mm × 3mm DFN-10, MSOP-10
LTC3108/LTC3108-1	Ultralow Voltage Step-Up Converter and Power Managers	V_{IN}: 0.02V to 1V, $V_{OUT(MIN)}$ Fixed 2.35V to 5V, I_Q = 6µA, I_{SD} < 1µA, 3mm × 4mm DFN-12, SSOP-16
LTC3109	Auto-Polarity, Ultralow Voltage Step-Up Converter and Power Manager	V_{IN}: 0.03V to 1V, $V_{OUT(MIN)}$ Fixed 2.35V to 5V, I_Q = 7µA, I_{SD} < 1µA, 4mm × 4mm QFN-20, SSOP-20
LTC4071	Li-Ion/Polymer Shunt Battery Charger System with Low Battery Disconnect	Charger Plus Pack Protection in One IC Low Operating Current (550nA), 50mA Internal Shunt Current, Pin Selectable Float Voltages (4.0V, 4.1V, 4.2V), 8-Lead, 2mm × 3mm, DFN and MSOP Packages
LTC4070	Li-Ion/Polymer Low Current Shunt Battery Charger System	Selectable V_{FLOAT} = 4.0V, 4.1V, 4.2V, Max Shunt Current = 50mA, I_{CCQ} = 450nA to 1.04mA, I_{CCQLB} = 300nA, 2mm × 3mm DFN-8, MSOP-8
LTC1877	10V, 600mA High Efficiency Synchronous Step-Down DC/DC Converter	V_{IN}: 2.65V to 10V, $V_{OUT(MIN)}$ = 0.8V, I_Q = 10µA, I_{SD} < 1µA, MSOP-8
LTC3105	5V, 400mA, MPPC Step-Up Converter with 250mV Start-Up	V_{IN}: 0.225V to 5V, $V_{OUT(MAX)}$ = 5.25V, I_Q = 24µA, I_{SD} = 10µA, 3mm × 3mm DFN-10, MSOP-12

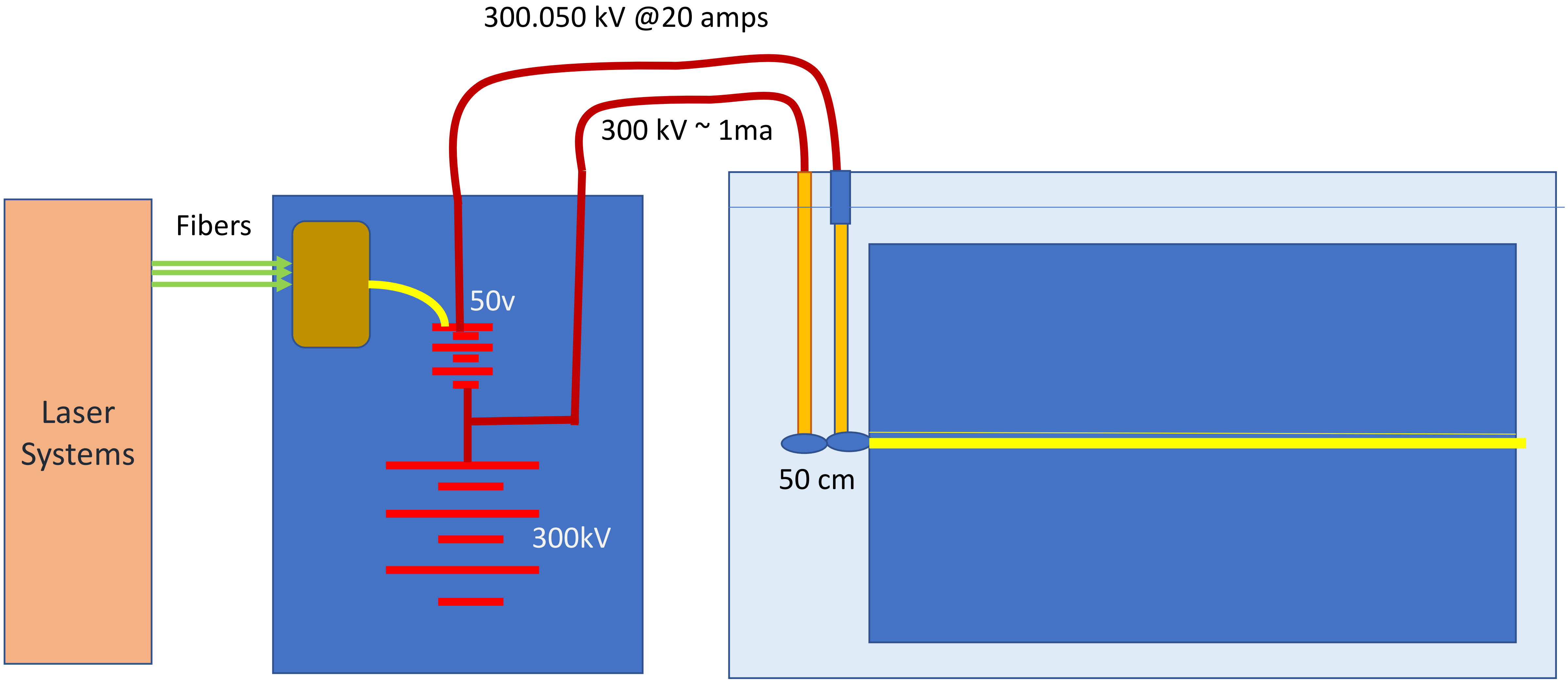
Digital Power Estimates

- Arapuca
  - <1ma (all SiPMs)
  - 48 volts
    - Power per Arapuca = 48*1ma=.048W
  - Op amp (two)
    - 10 – 30 ma @5 volt
    - Power = .1 W - .3 W
  - SiPM total: 320ma@48 Volts ~100 mW
  - Op amps: 320* .1 = **32 W** or **96 W**
- **TOTAL = 100mW + 96 W = 97 W**

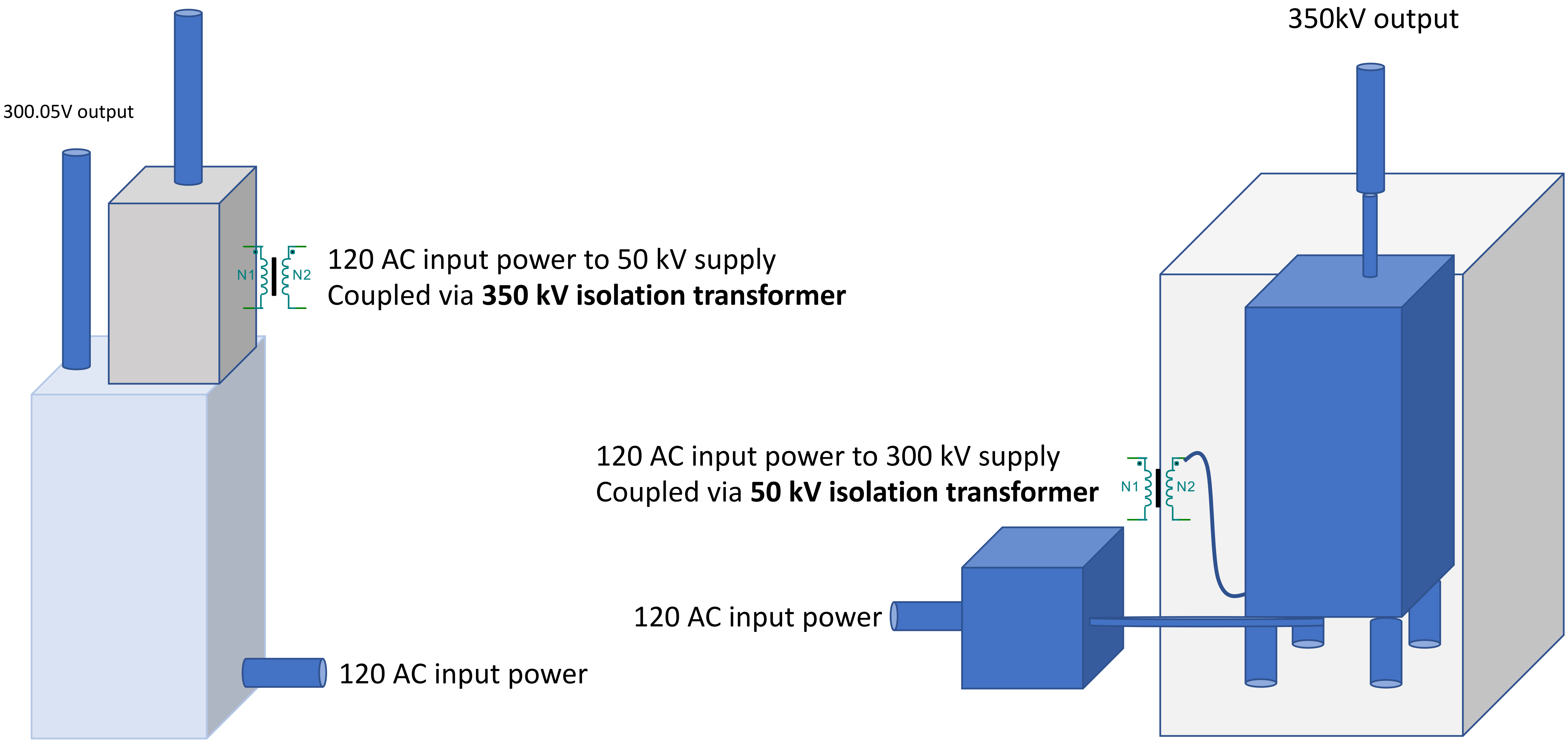
- Electronics Box
  - Transmitters
    - 800 mW each/4 Arapuca
  - Op amp summer/DC-DC converters
    - 4 op amps
      - 5 V @ 10 ma *4 = .4 W
  - FPGA/4 Arapucas:2- 4 W (standby – active)
  - 100 MB ADCs: .250 W / channel: 1 W/Box
  - ***Misc*** (Clock, Boot hardware, Buffers – shared)
- **Box TOTAL = .8 W+ .4W + 1 W + 4 W = 6 W**
- **Electronics Box Total = 6*80 = ~ 500 W**
- **Cathode Total = 500 + 97 + 200 = ~800 W**
- **FC TOTAL = 2600 W (Shared electronics box)**

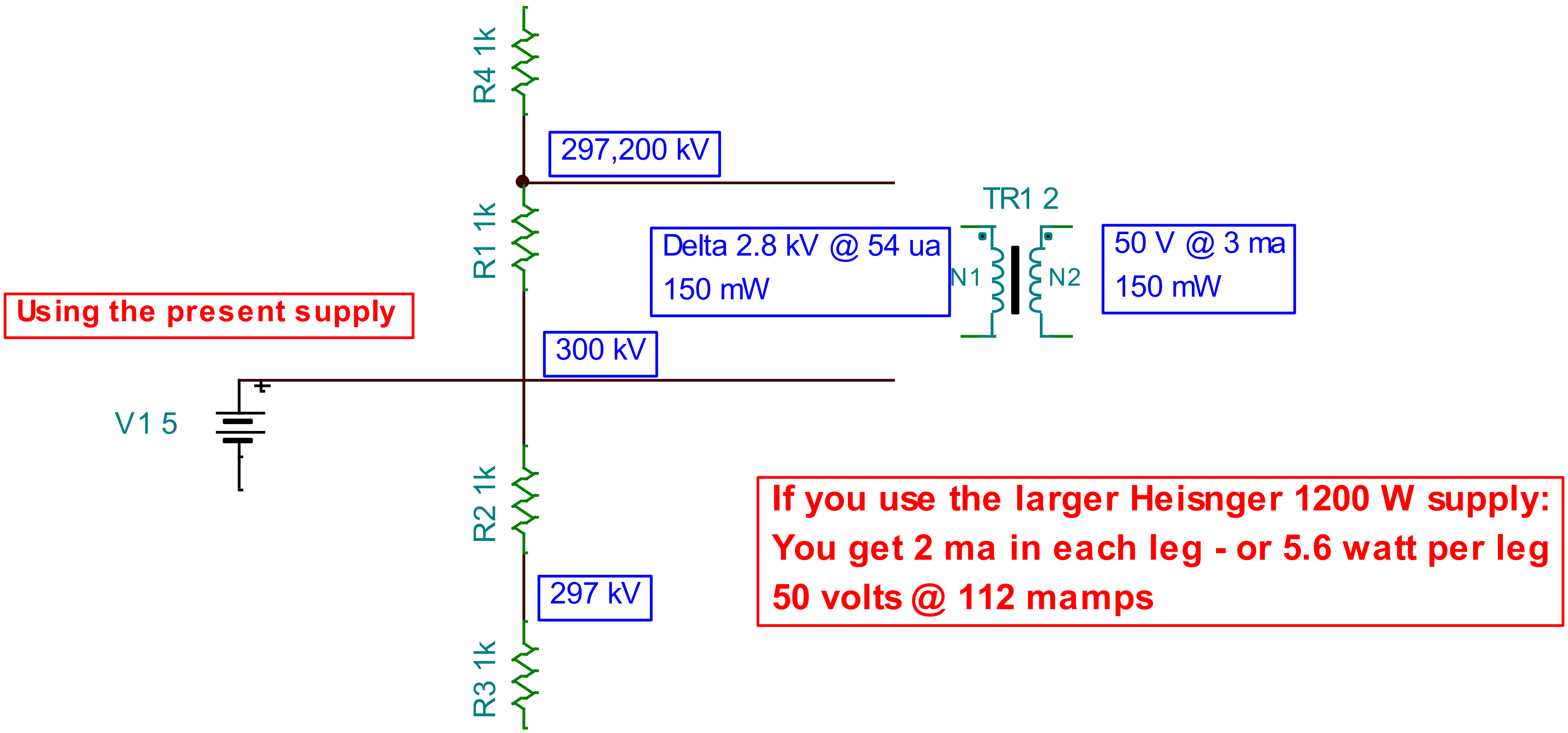
Extra – Power Option

A floating 1000 watts supply floating on the 300 KV Cathode PS



Two options for reaching 350 kV
Float the 50 kV supply and use a larger isolation transformer to power
Float the 300 kV supply at 50kv, use a 50 kV IT but then box up the 300 kV supply




R4 1k
297,200 kV
R1 1k
TR1 2
Delta 2.8 kV @ 54 ua
150 mW
N1
N2
50 V @ 3 ma
150 mW
Using the present supply
300 kV
V1 5
R2 1k
297 kV
R3 1k
If you use the larger Heisnger 1200 W supply:
You get 2 ma in each leg - or 5.6 watt per leg
50 volts @ 112 mamps