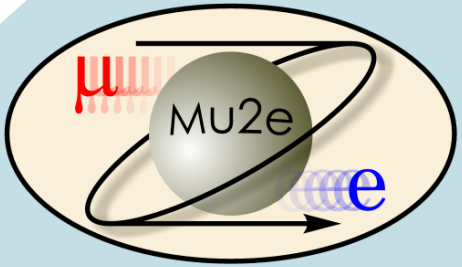

CHARACTERIZATION AND OPTIMIZATION OF PREAMPS FOR THE MU2E TRACKER

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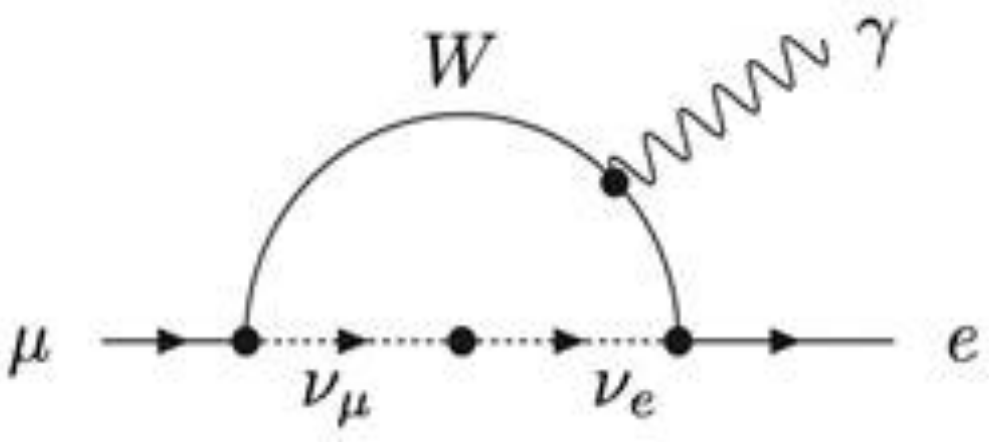
OVERVIEW

- General Background on Mu2e
- Preamp Specifications
- Original Preamp
- Modifications
- New Design
- Future Improvements

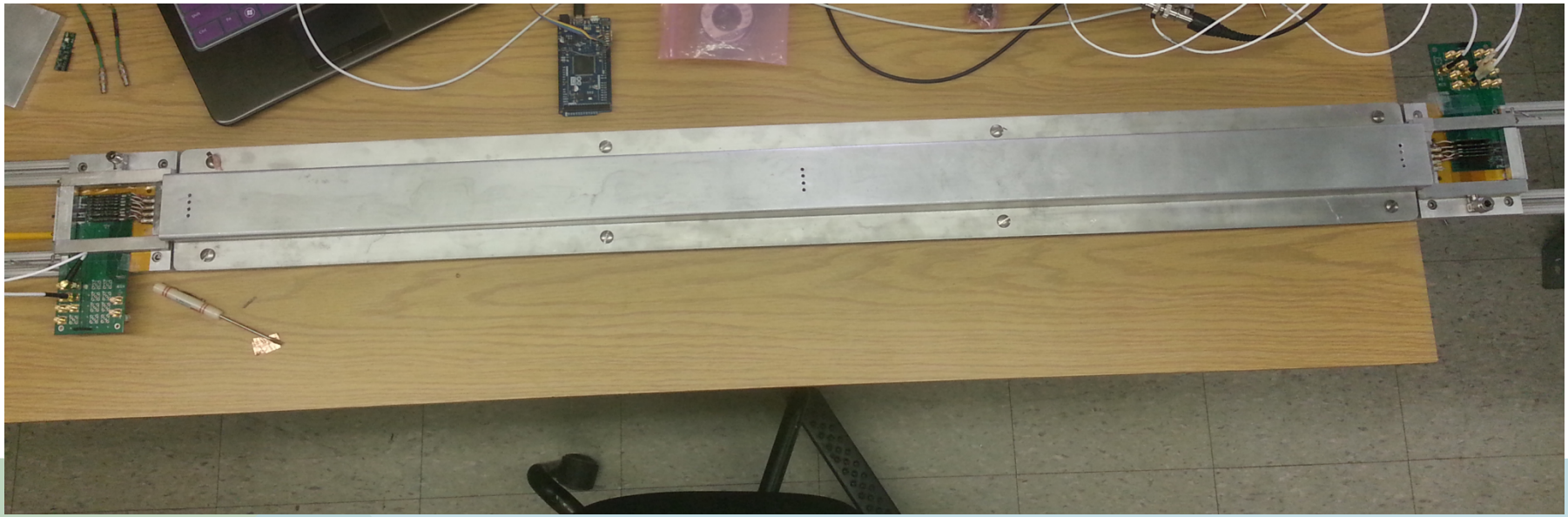
MU2E: CHARGED LEPTON FLAVOR VIOLATION

- Neutrinoless conversion of a muon into an electron
- Rare event – rates predicted by SM theory of $< 10^{-50}$
- Effectively, one event could imply New Physics



MU2E: STRAW TRACKER

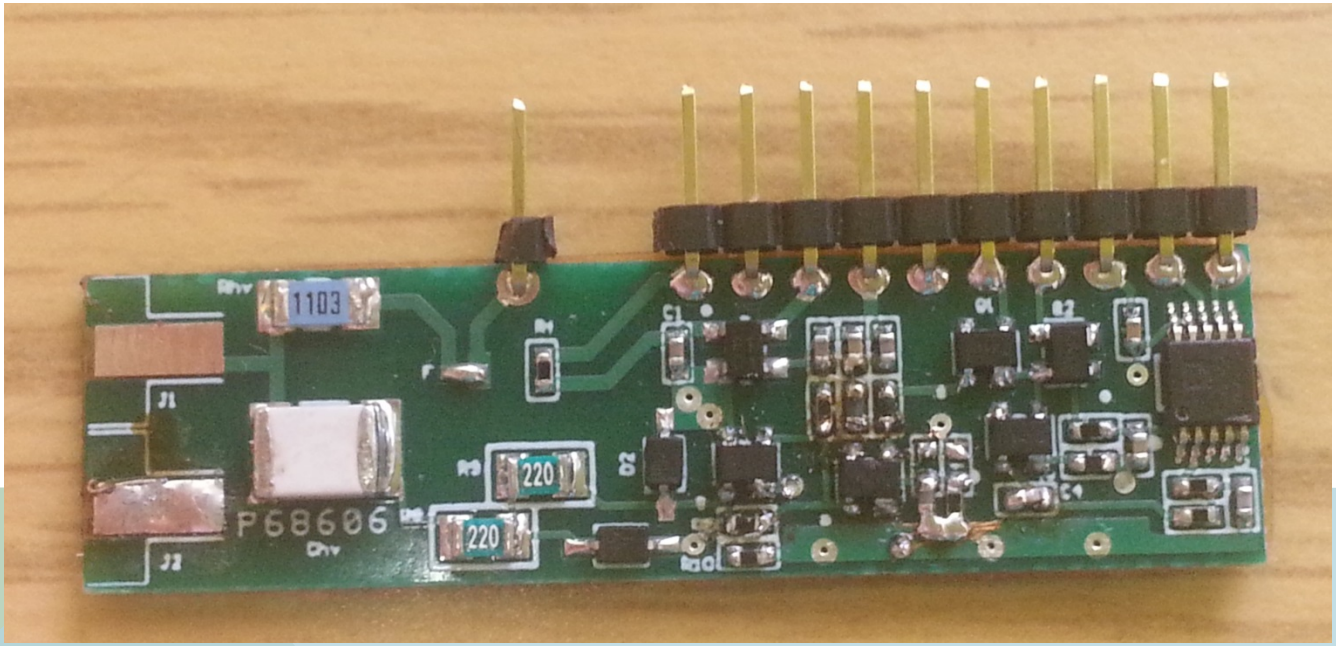
- 5 mm mylar straw with wire running through it, potential difference draws ionized $ArCO_2$ to wire, creating current
- Array tracks path of particles
- Preamp at each end – distance determination



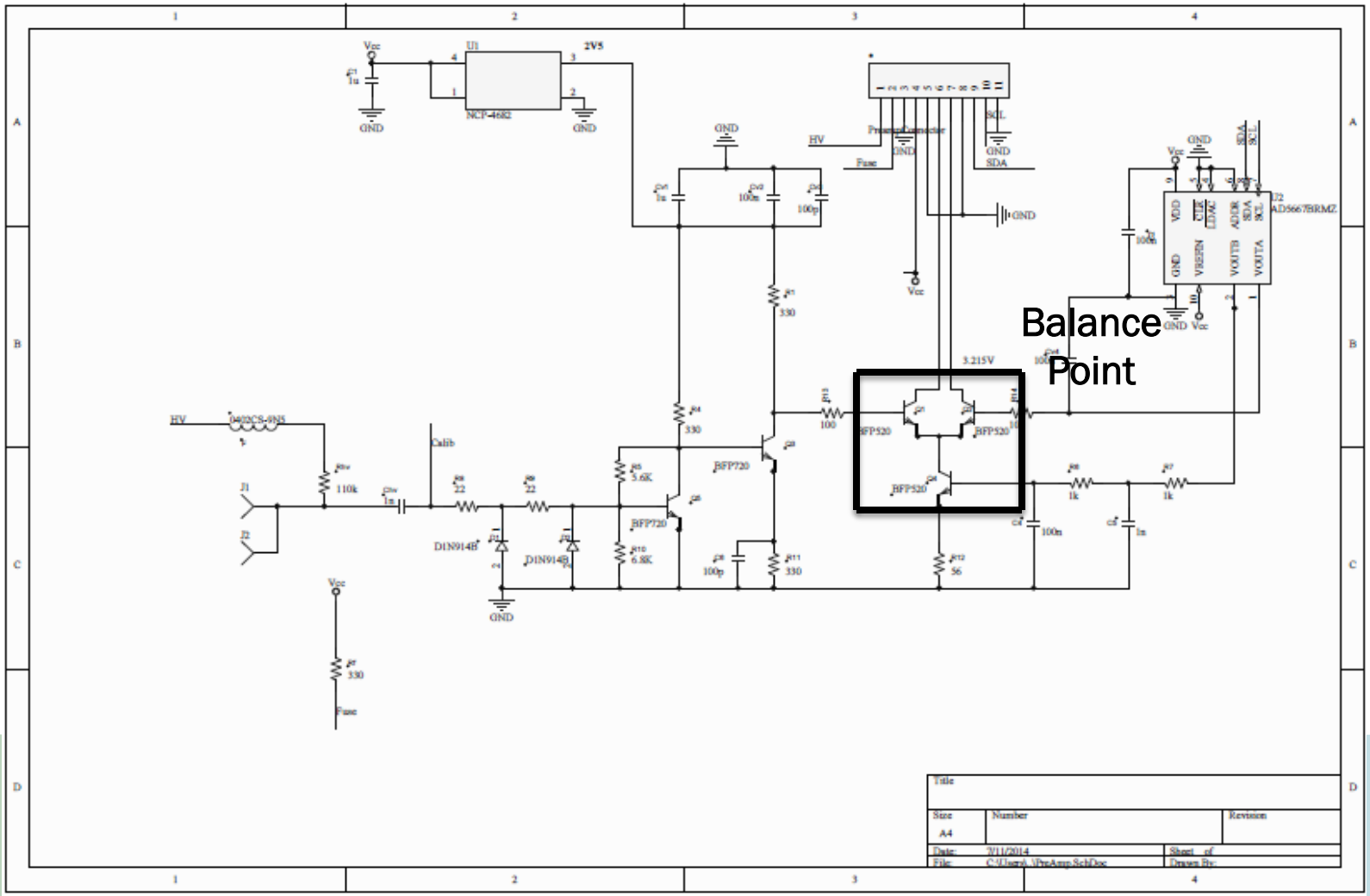
PREAMPS: BASICS

- Small printed circuit board (4.0 by 1.1 cm by 31 mils)
- Amplifies an input signal at an inherent gain

$$Gain_{dB} = 20\log_{10}\left(A_{out}/A_{in}\right)$$

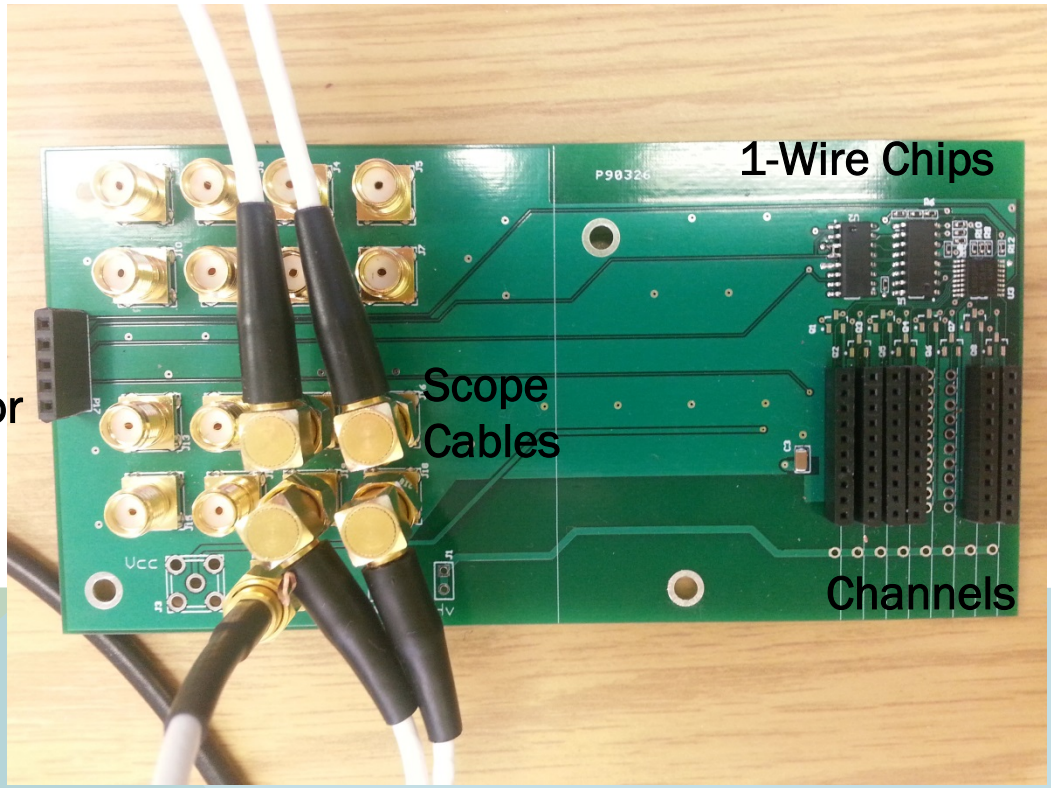


PREAMPS: SCHEMATIC



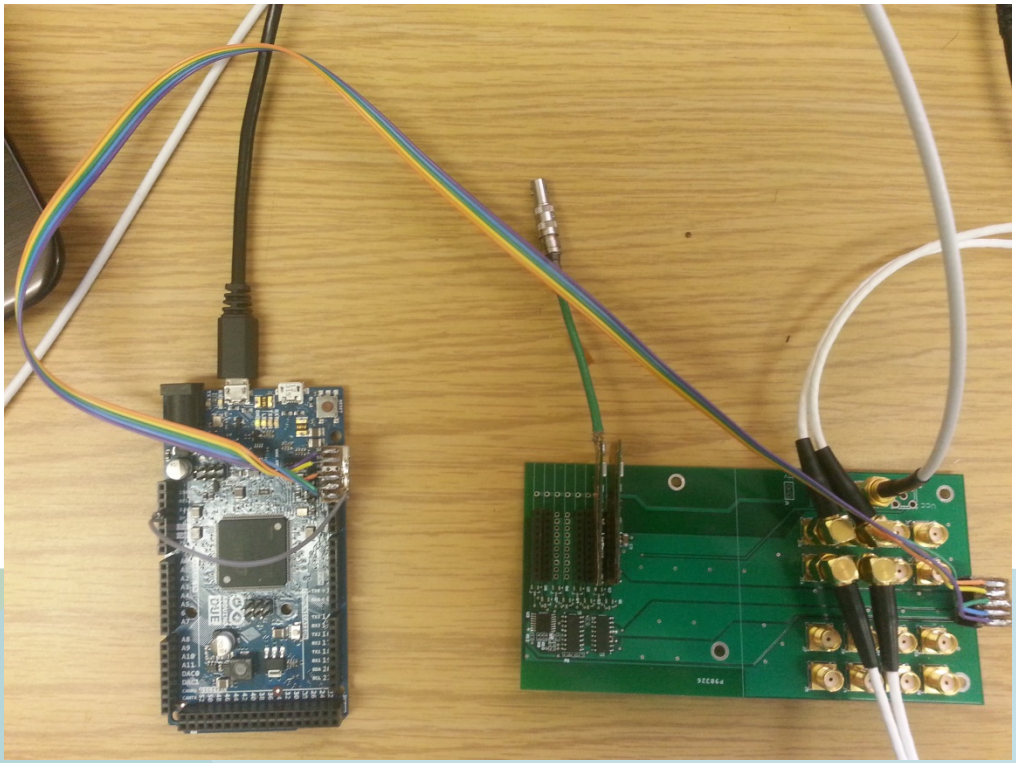
PREAMPS: MOTHERBOARD

- Provides power, programming via 1-Wire, and viewing of output signal for eight preamps
- Mounted very close together – cross talk

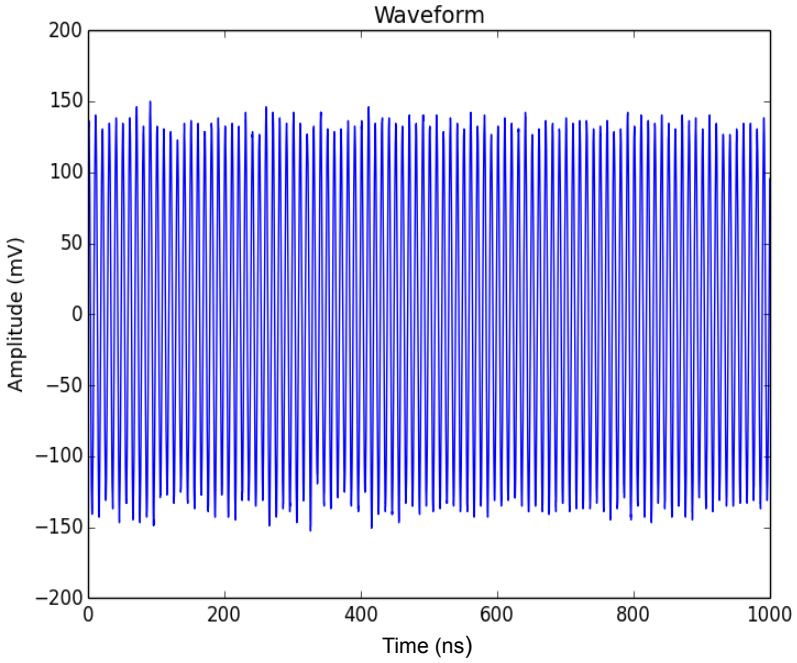


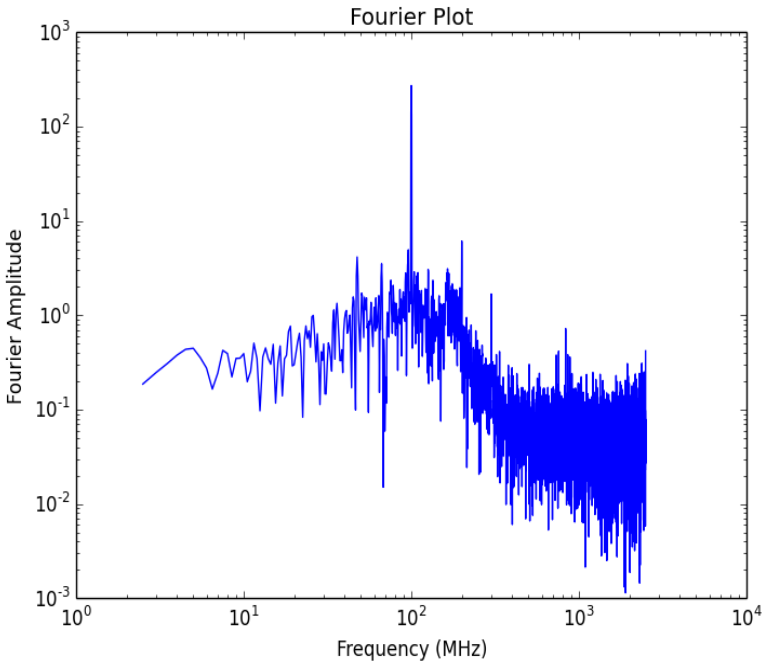
PREAMPS: PROGRAMMING

- One Wire Chip – 8 Channel Addressable Switch
- Arduino Due Microcontroller
- Python



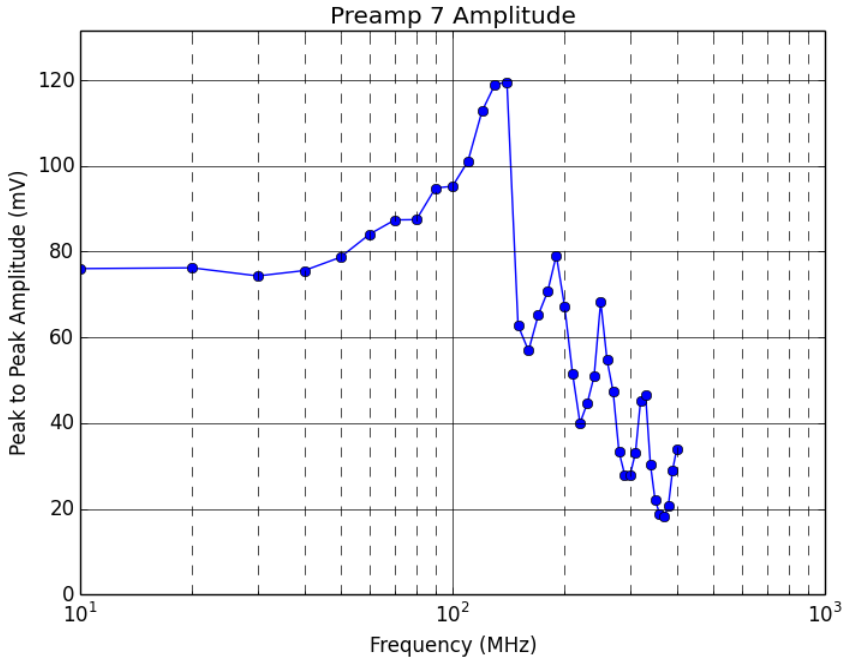
PREAMPS: “READ.PY”





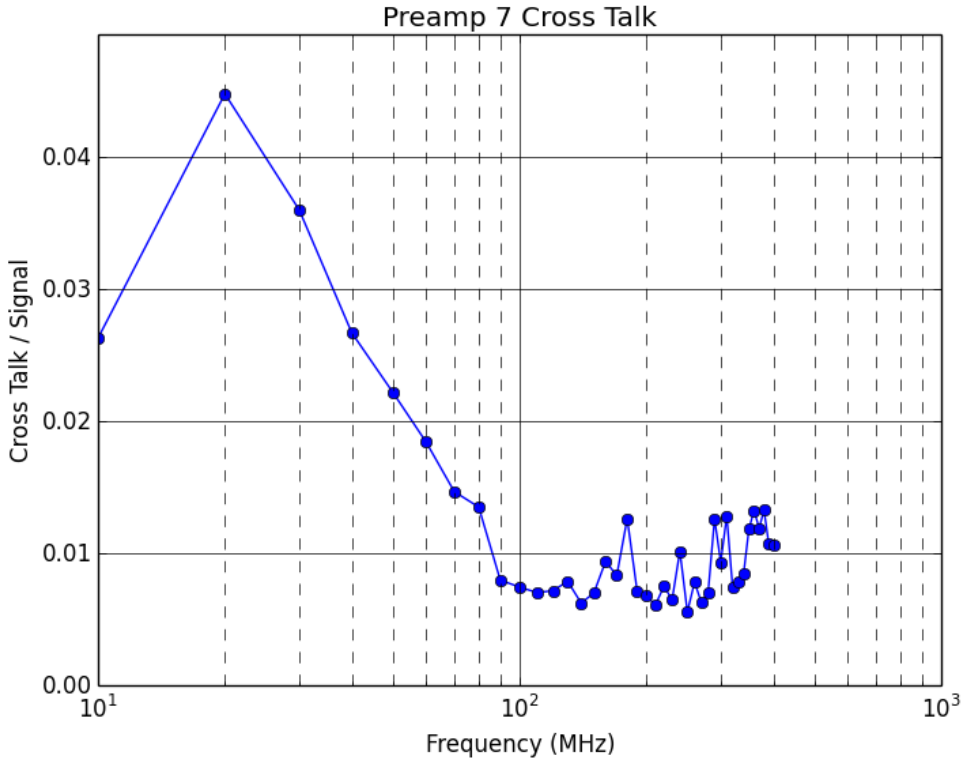
ORIGINAL PREAMPS

- No shaping
- Soldered directly to motherboard
- 2.5 mV input peak-to-peak amplitude from signal generator



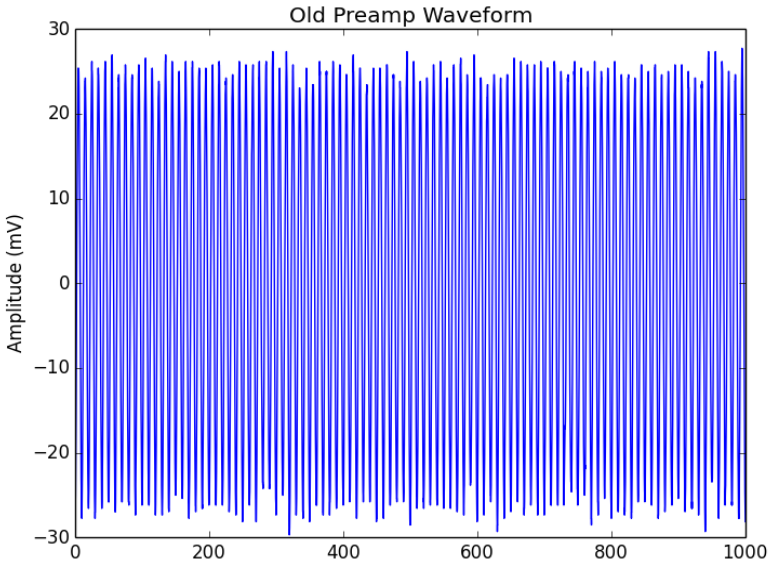
ORIGINAL PREAMPS: CROSS TALK

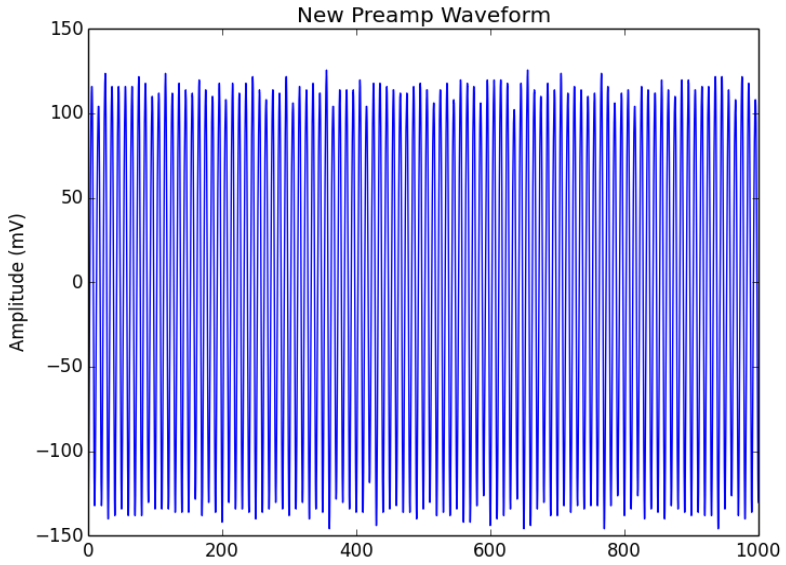
- Unavoidable fact of close mounting
- Mounted second preamp into channel 6 on motherboard
- Two percent limit for final experiment



NEW PREAMPS: SHAPING

- Addition of 100 pF capacitor to shape (“boost”) gain at 100 MHz
- Factor of five increase
- Input Signal: 50 mV attenuated by 38 dB – 0.63 mV





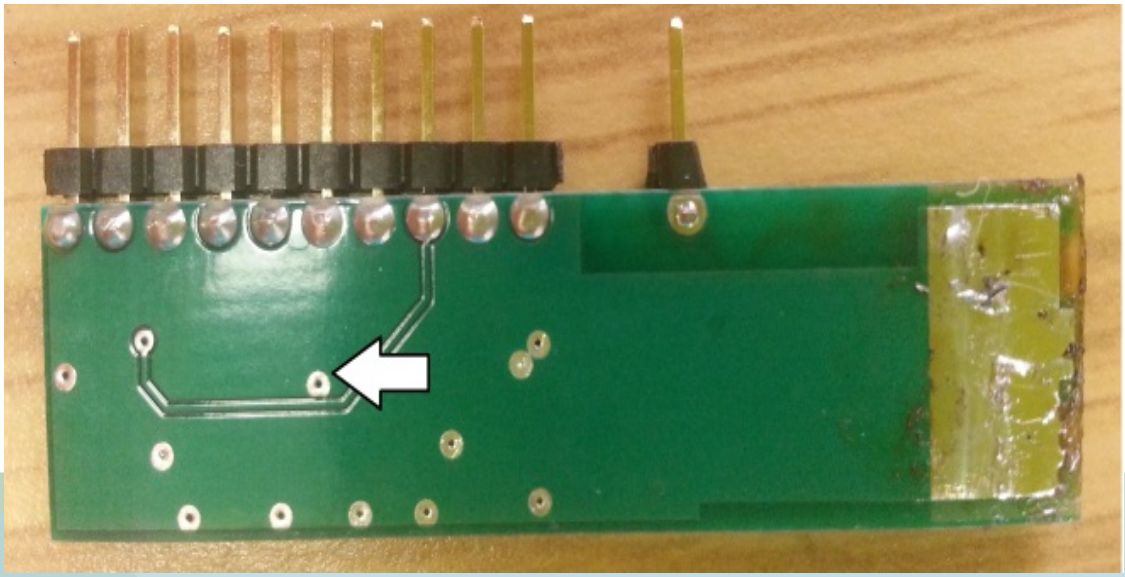
INSTABILITY: REMOVAL OF CAPACITOR

- Boosting made the preamps very sensitive to movement / touching
- Touching preamps adds capacitance where it doesn't belong
- Shaping capacitor was removed from eight preamps

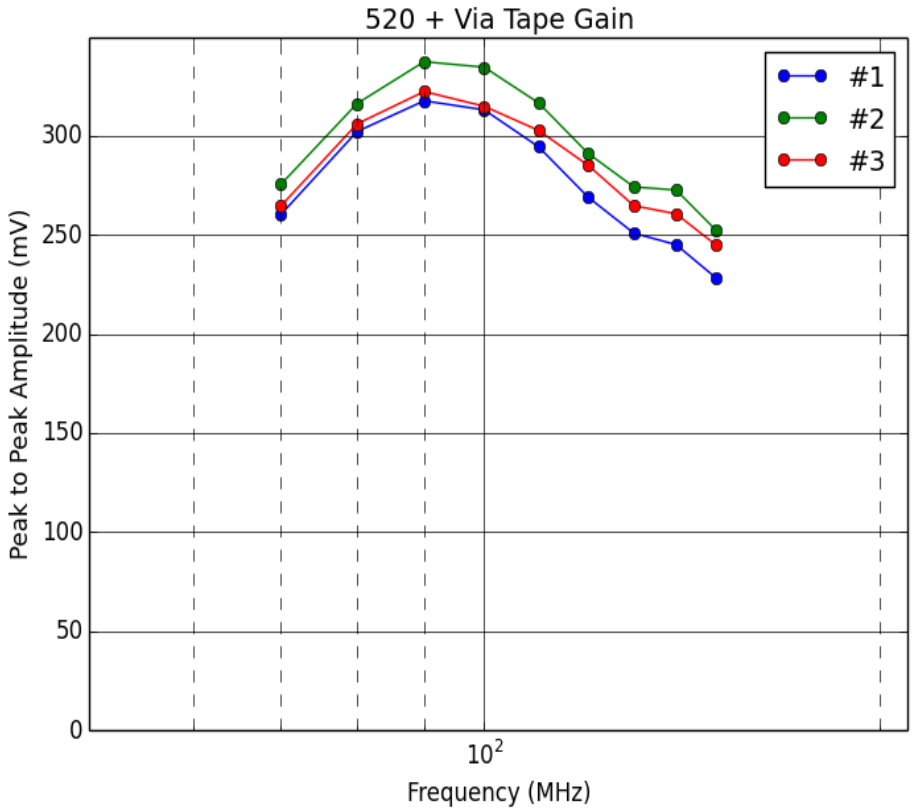
Preamp #	Balance #	Voltage Drop	Output Amplitude (mV)	Noise RMS
0	22800	70	21	0.35
1	22600	74	23	0.38
2	22900	65	48	0.6
3	22400	74	21	0.34
4	22300	75	21	0.36
5	23100	70	24	0.36
6	21800	73	20	0.33
7	22300	71	22	0.35

INSTABILITY: BFP520 VERSUS BFP720

- Originally, two 720s for input and three 520s for output
- BFP720: Si-Ge material allows for faster transition frequency and greater bandwidth
- Via not well grounded – small piece of copper tape

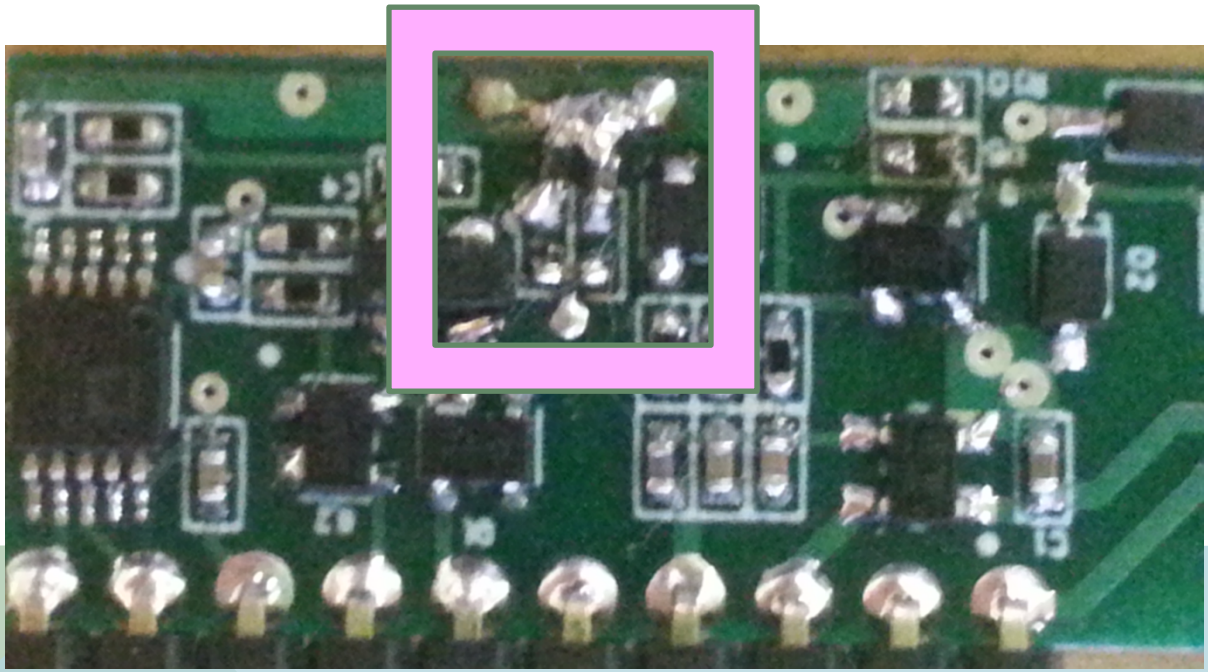


BFP 520 + COPPER TAPE



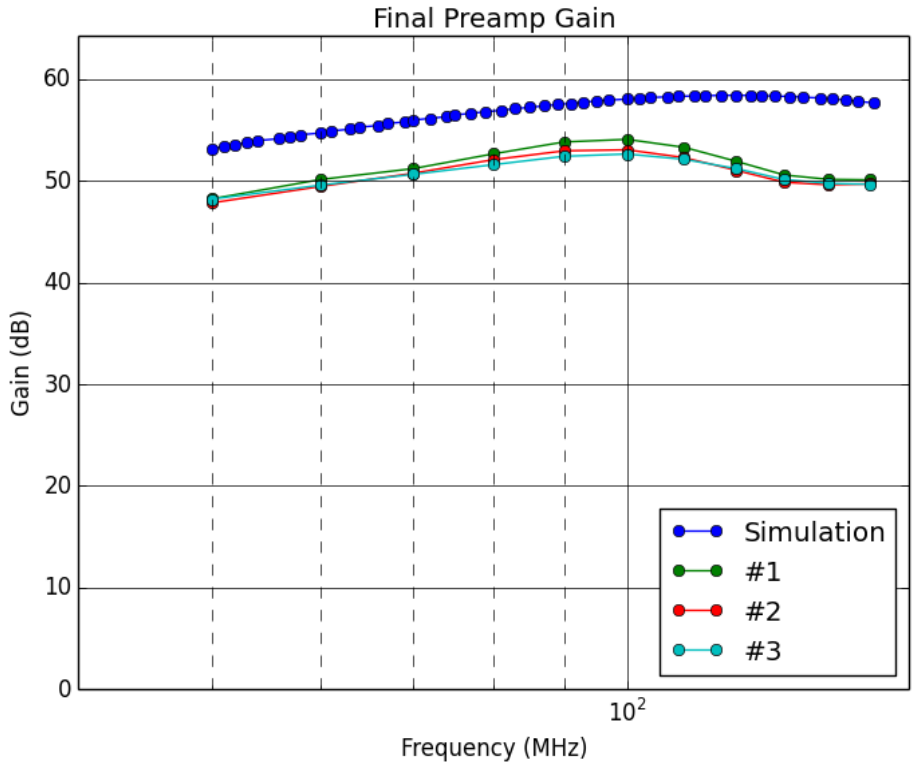
BETTER GROUNDING FOUND

- Large ground plane right by components that rely on via
- Flipped them around and soldered, now well grounded



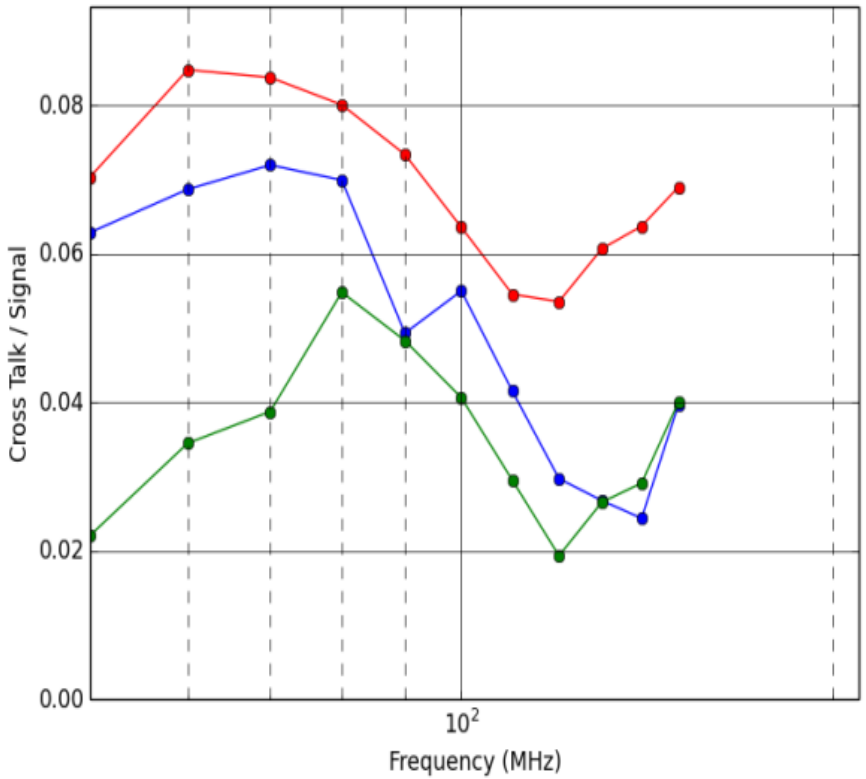
FINAL PREAMPS: GAIN

- All BFP520 transistors, shaping capacitor replaced, components flipped to ground



FINAL PREAMPS: CROSS TALK

- Above the requisite two percent, no further testing done at this point



CONCLUSIONS & FUTURE MODIFICATIONS

- 52 db gain for preamps with:
  - BFP520 transistors throughout
  - Shaping capacitor
  - Better grounding
- Original preamps: gain of 30 dB
- Future Modifications:
  - Better grounding for components built into layout
  - Reduction of cross talk to signal ratio

QUESTIONS?

REFERENCES

DS2408: 1-Wire 8-Channel Addressable Switch

http://www.maximintegrated.com/en/products/digital/memory-products/DS2408.html

Arduino Due Microcontroller

http://arduino.cc/en/Main/ArduinoBoardDue

ACKNOWLEDGEMENTS

Several parties are deserving of recognition for the success of this project and summer internship. I would first like to thank my supervisor, Dr. Vadim Rusu, for providing me with ample guidance and support throughout my project, while also allowing me to learn from my own mistakes. I would also like to thank my assistant supervisor, Aseet Mukherjee, and coworker Angela Yang for always lending her third hand. Finally, I would like to recognize Elliot McCrory, Dianne Engram, Linda Diepholz and the rest of the SIST Committee for selecting me to be a part of this program.