RD53b bias and current measurements

LBL Weekly Instrumentation Meeting

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ATLAS EXPERIMENT | BERKELEY LAB

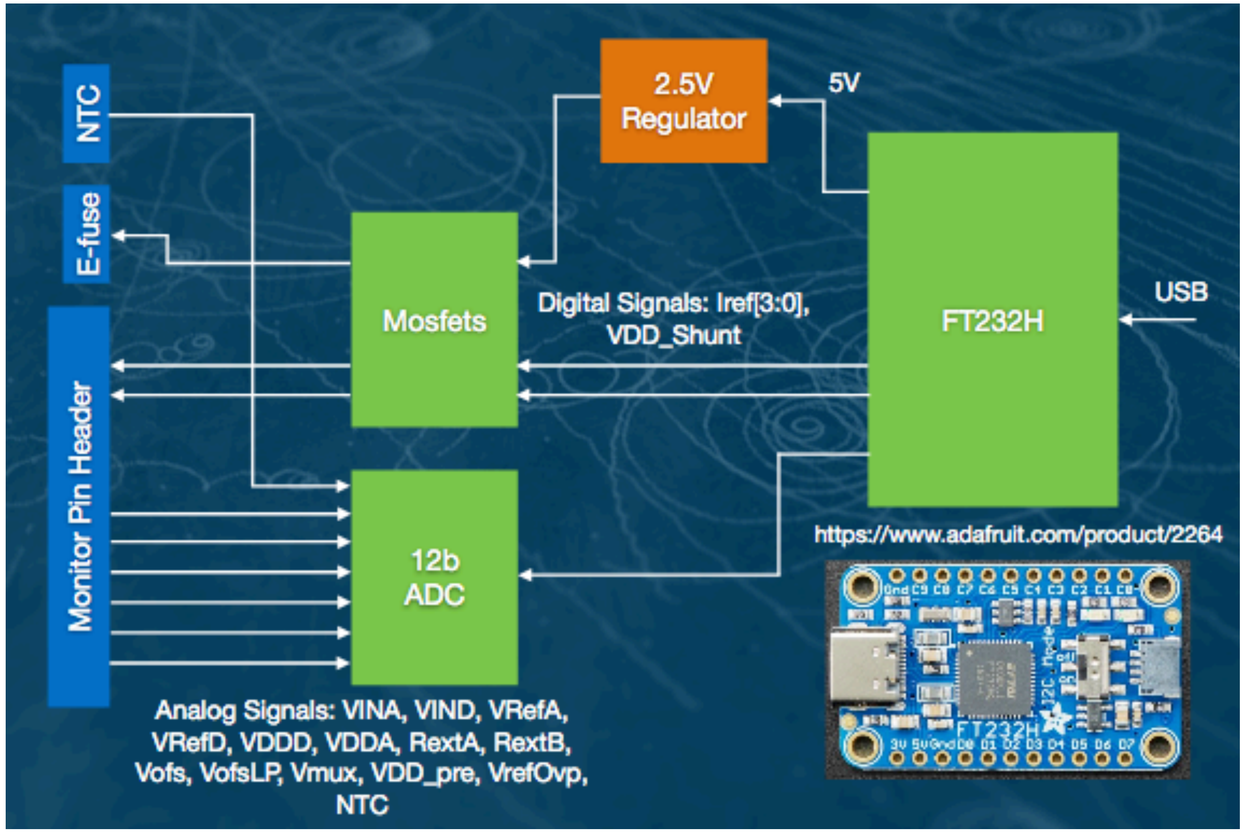
Introduction

- RD53b SCC Analog Monitor Card
- On-going Measurements
  - Setup
  - Power-cycling
  - DAC measurements
- Next steps

Analog Monitor Card

- We've designed and assembled a standalone monitoring card for the RD53b SCC
  - "Standalone" ↔ independent of DAQ, controlled by host PC
  - Design files and schematic are on RD53b testing twiki
- The idea is to:
  - monitor the analog signals broken out by the monitor pin header on the SCC
  - ⊕ monitoring of RD53b temperature via on-board NTC(s)
  - ⊕ e-fuse powering, shunt enable, IREF trim enable, etc…
- I'll introduce the analog monitor card here

Analog Monitor Card



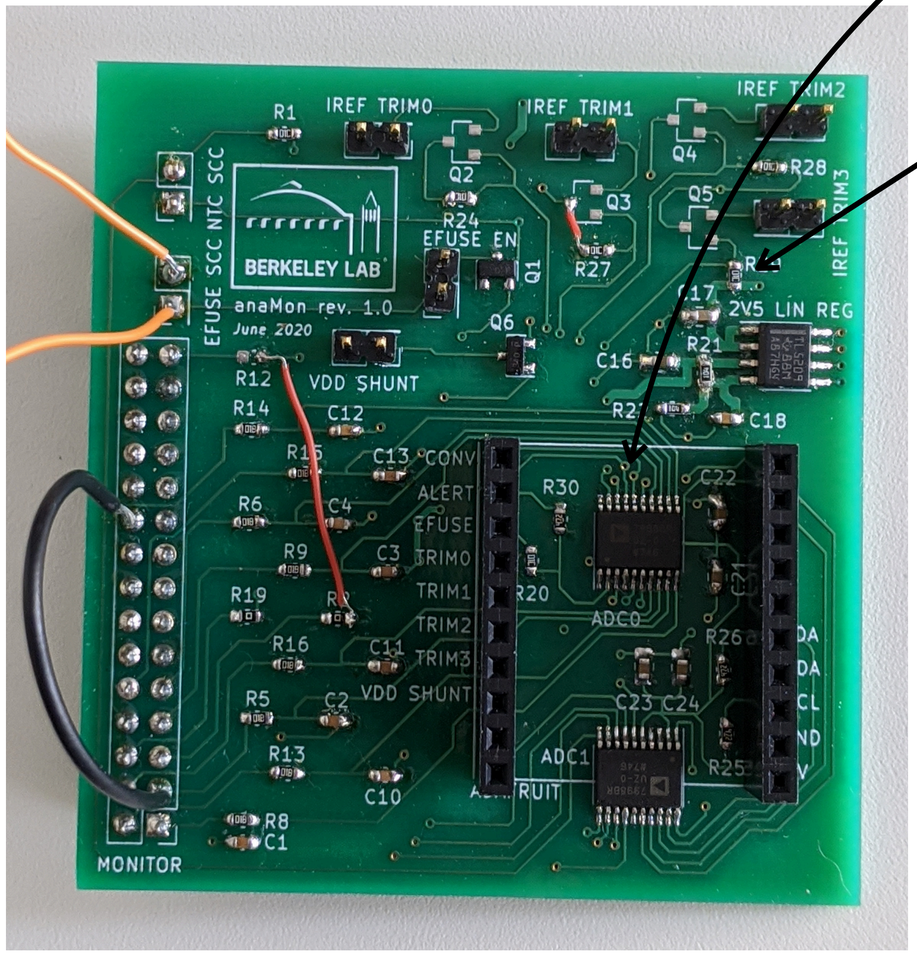
Control/data to/from host PC via USB

SCC

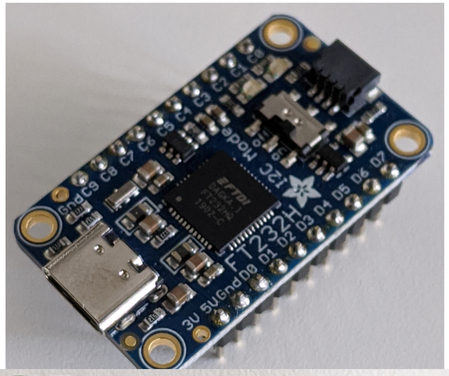
analog monitor card

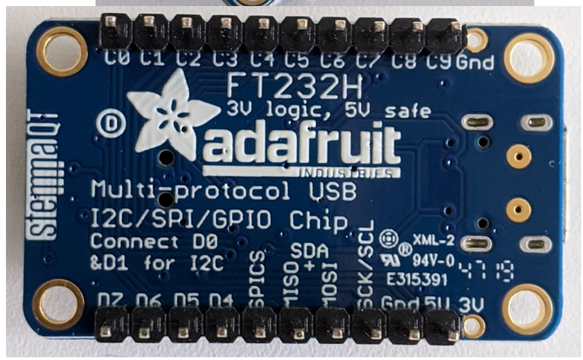
The FT232H enables serial (I2C) communication between the host PC and on-board ADCs (making your computer act as a primary on a serial bus), as well exposing additional GPIOs

Analog Monitor Card

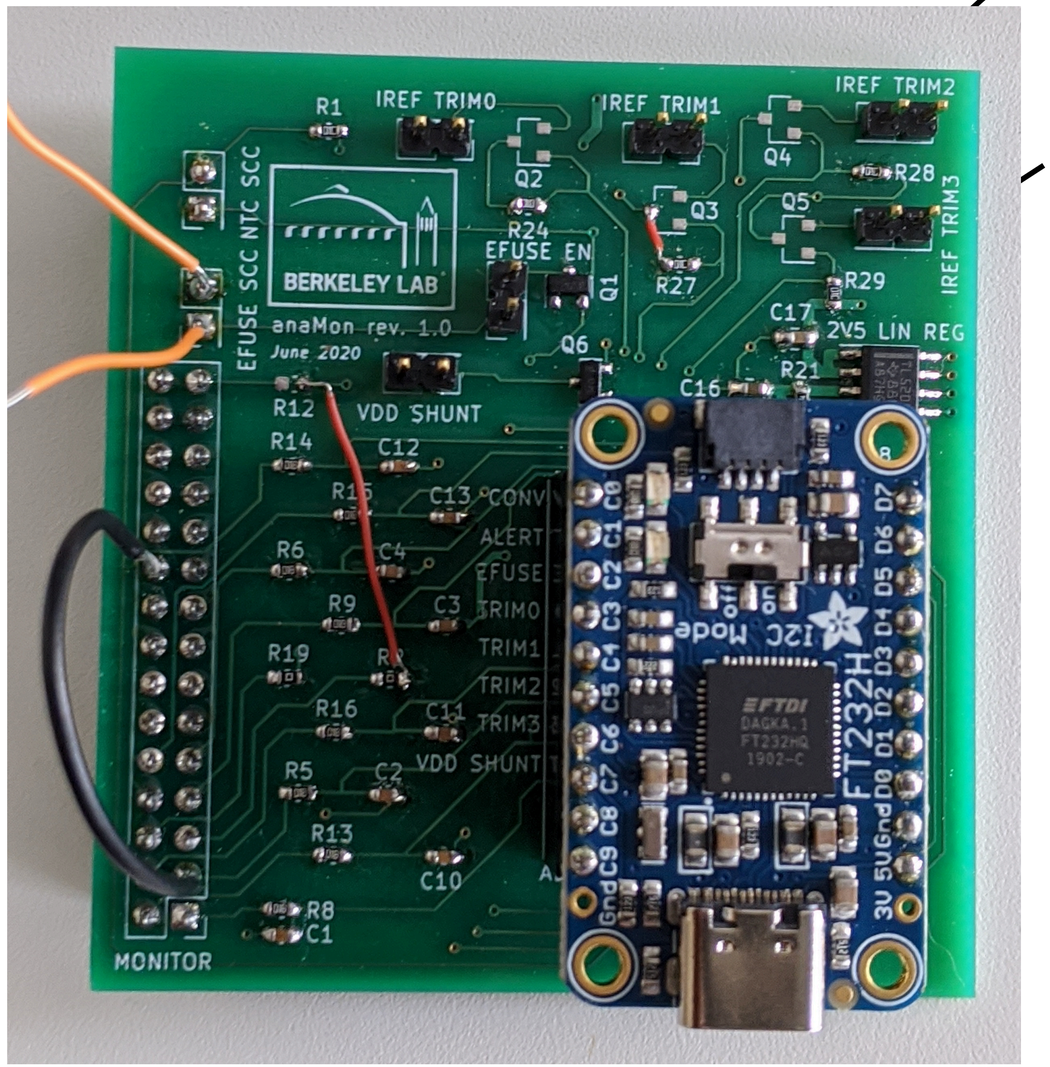


- Two on-board 8-channel 12-bit, low-power ADCs (AD7998)
  - 2.5 V reference generated by 5 V input from USB





Analog Monitor Card



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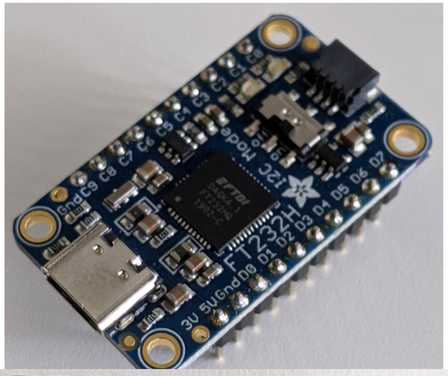

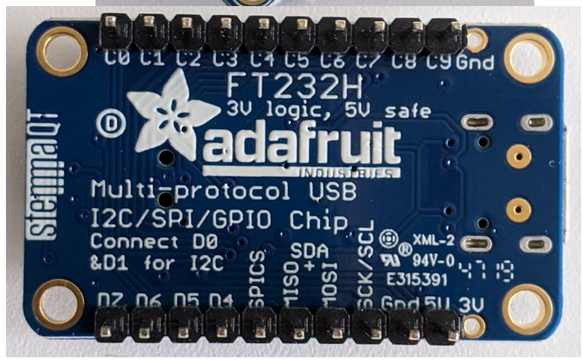

Analog Monitor Card

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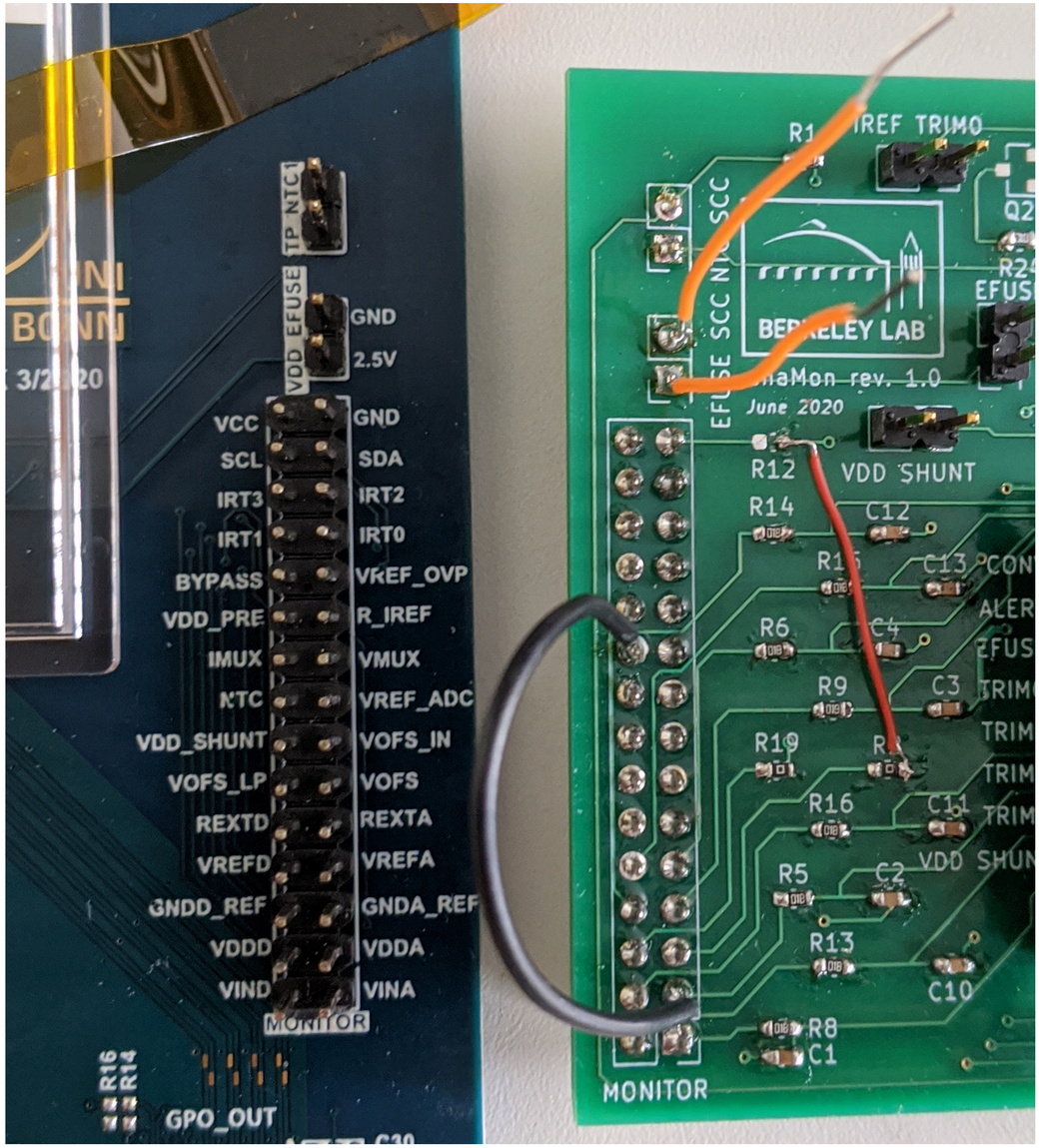
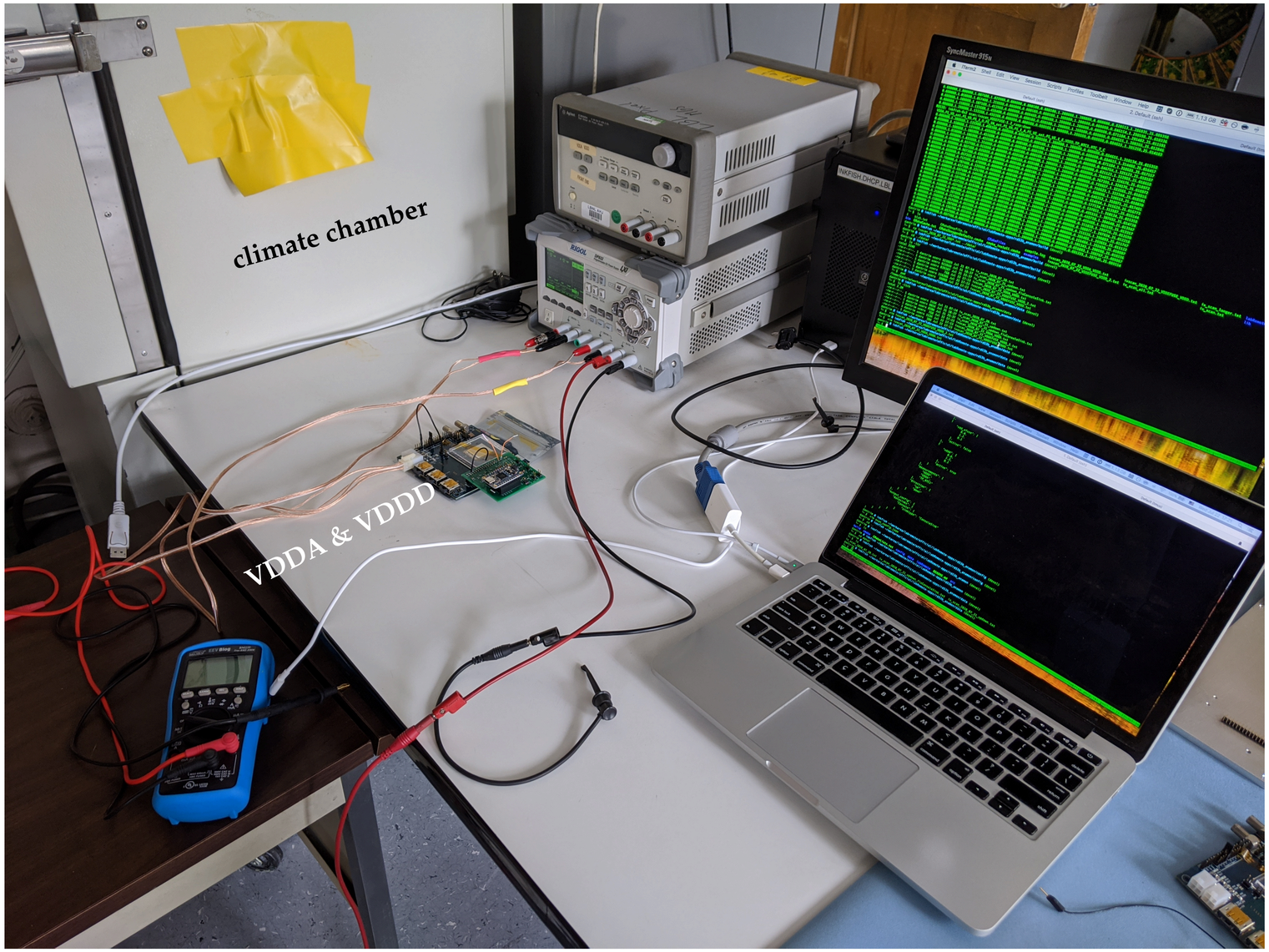
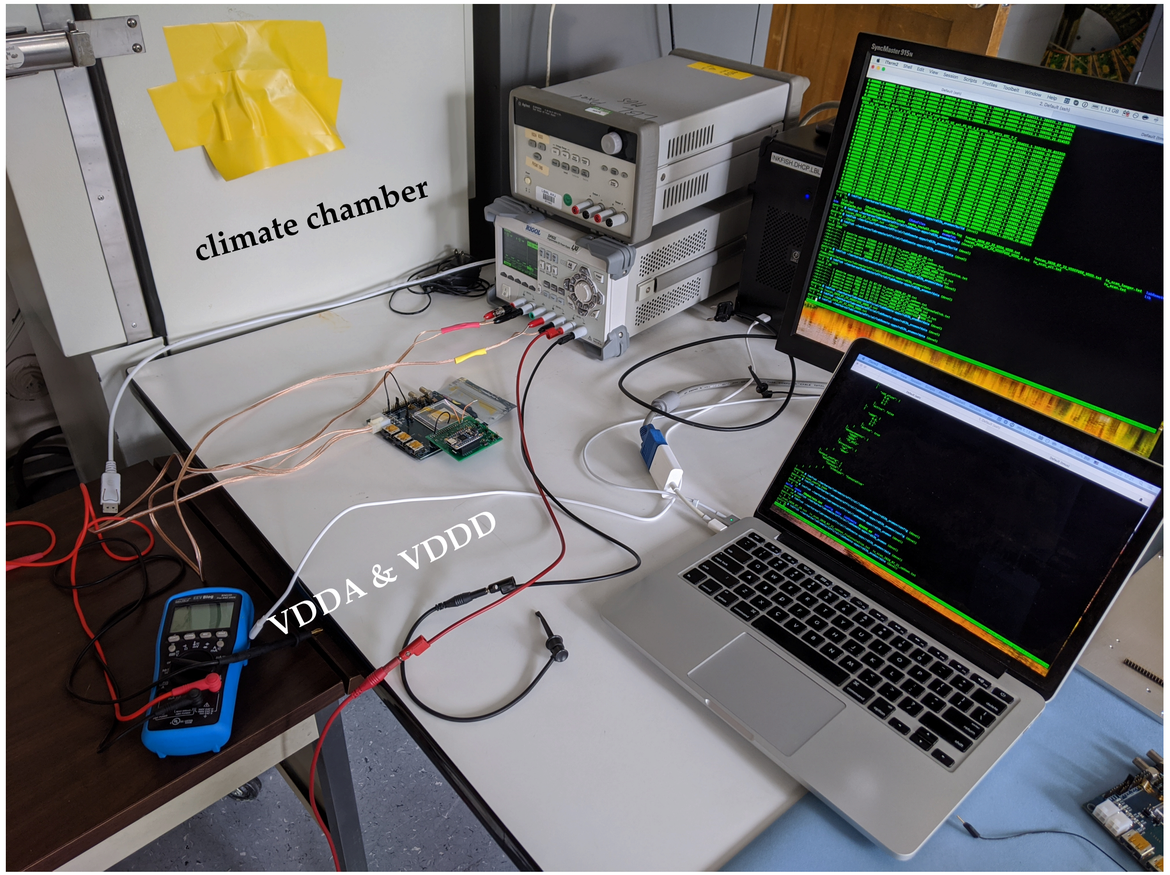


Analog Monitor Card



On-going measurements

Setup



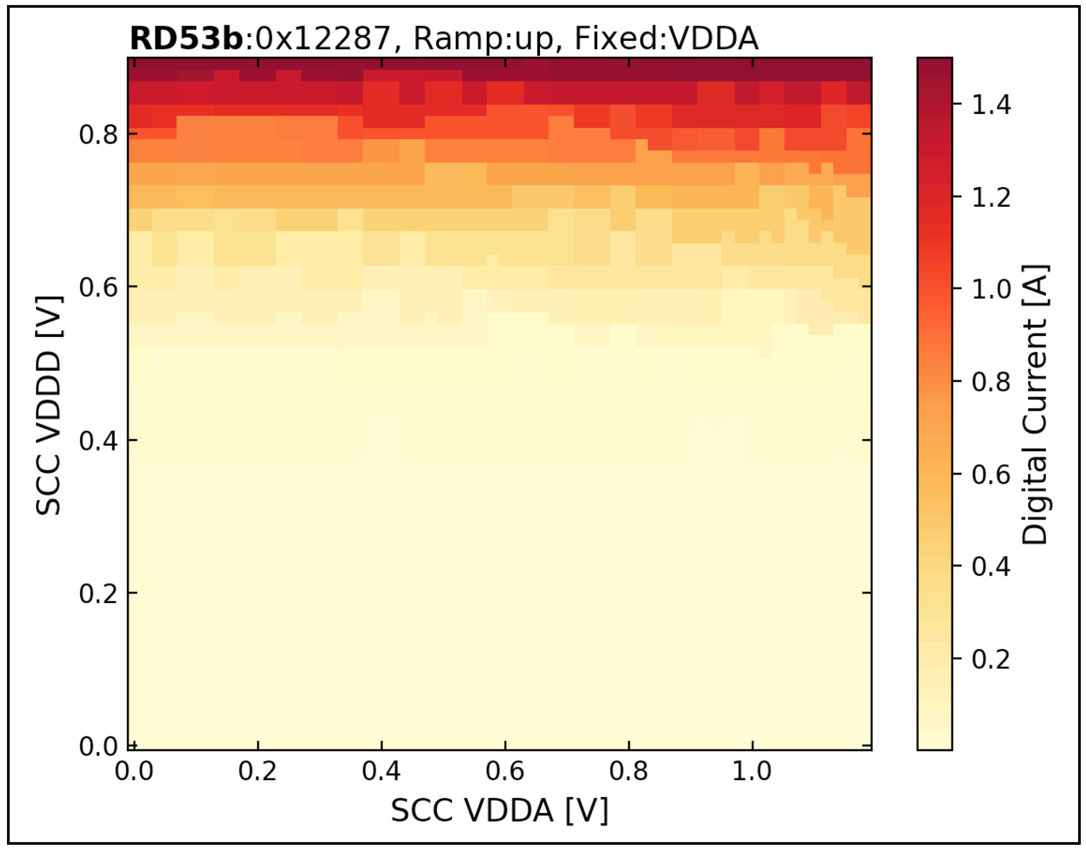
Name
bash
cmake
configs
src
YARR @ 01dc2bae
boost_histogram @ f6563de9
rd53b_anamon @ a36ee448
.gitignore
.gitmodules
CMakeLists.txt
README.md

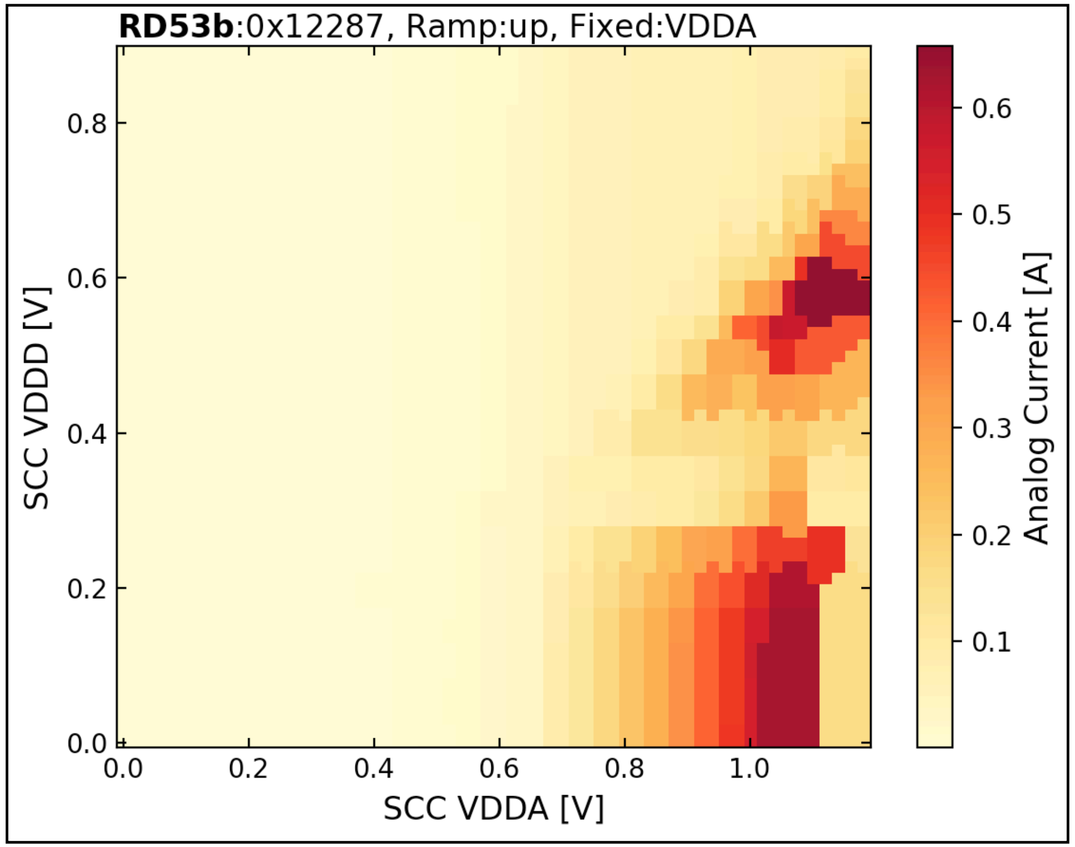
⊕ rd53b_workbench

IV Measurement

- Perform IV scans to get an idea of the power consumption of the chip
  - We know that the digital current issue is caused by the multi-bit latch issue (now)
  - Will want to characterize the IV-curves of the chip as a function of operating temperature

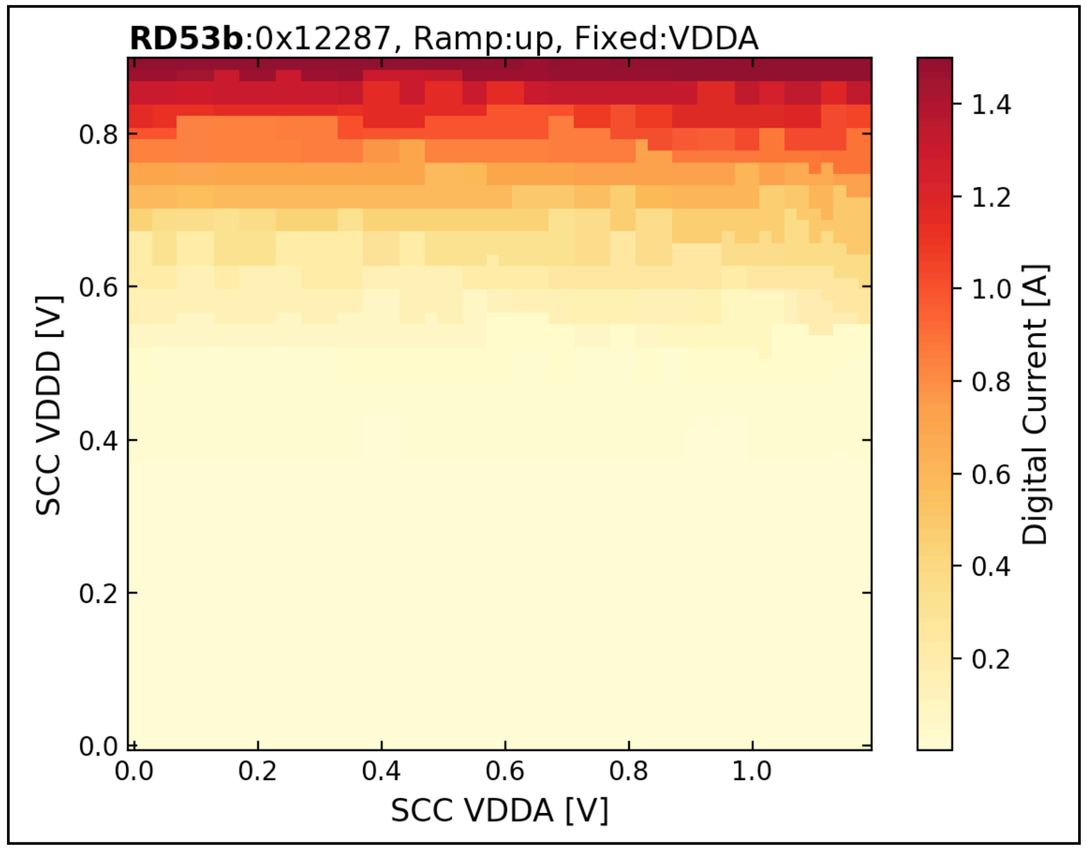
IV Measurement

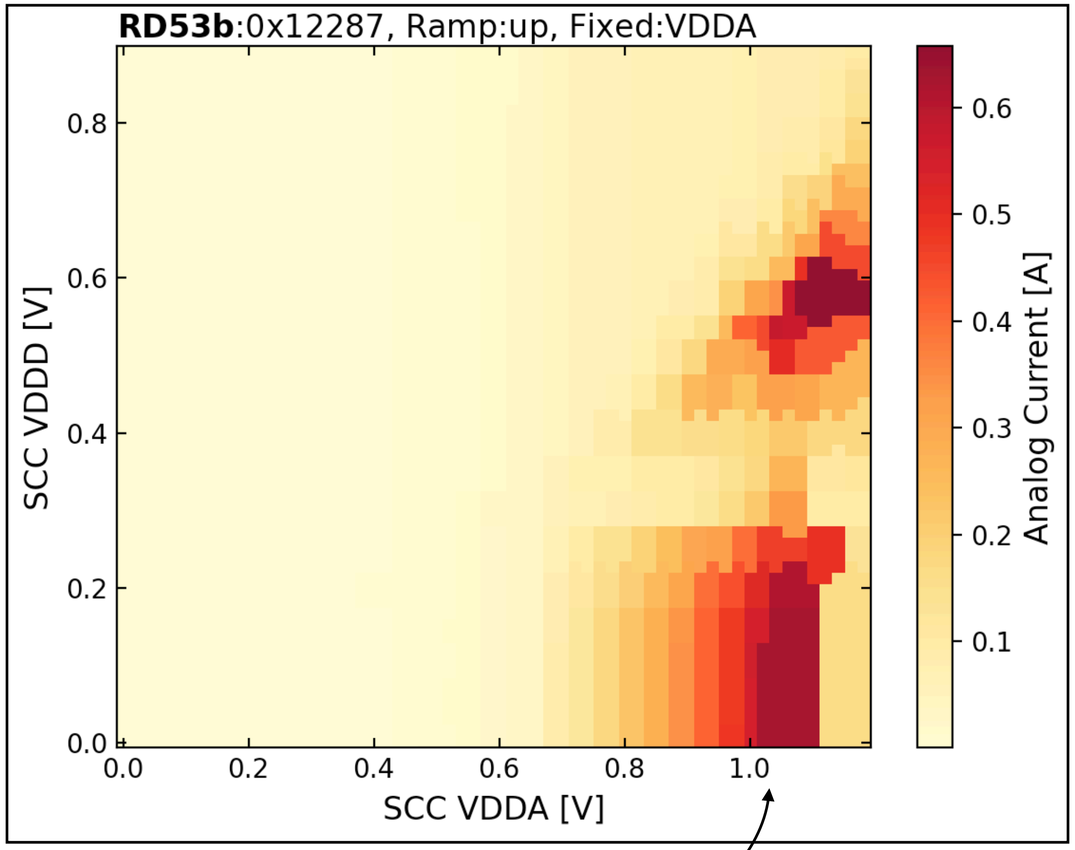




Each vertical column represents an independent scan over the quantity on the y-axis (VDDD) for the set value of the quantity on the x-axis (VDDA), with the specified current measurement on the z-axis

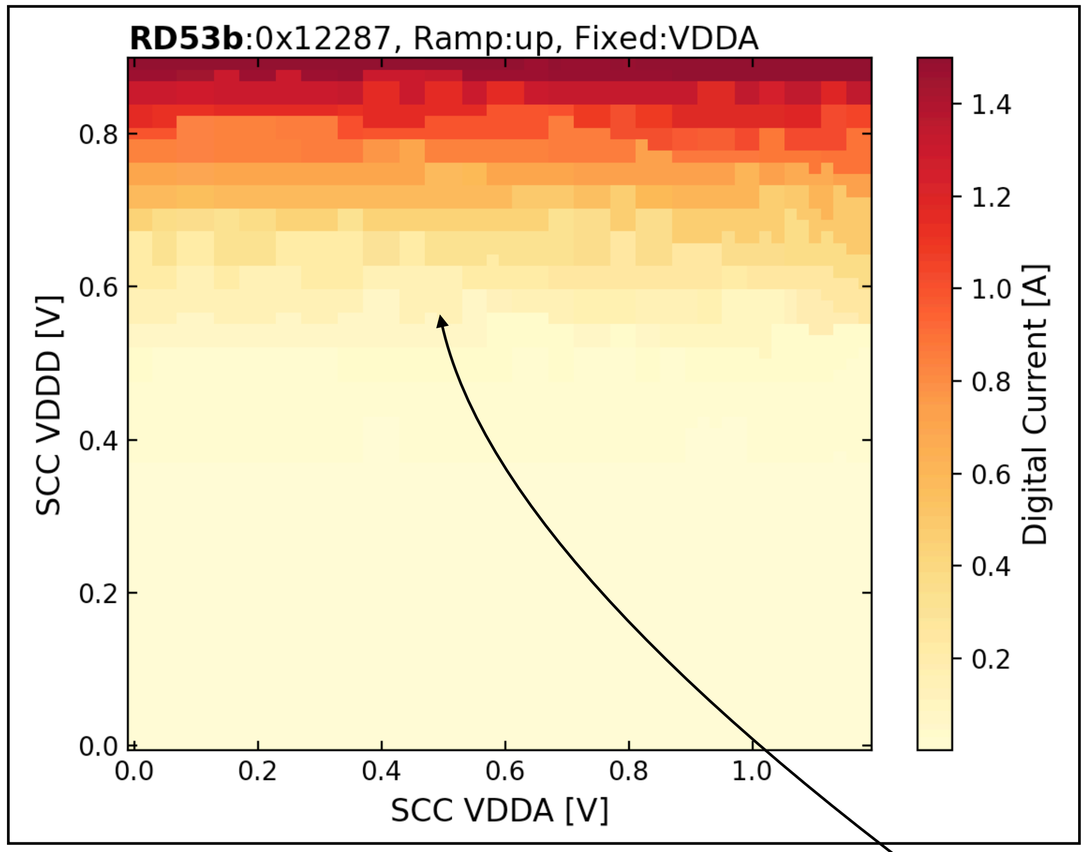
IV Measurement

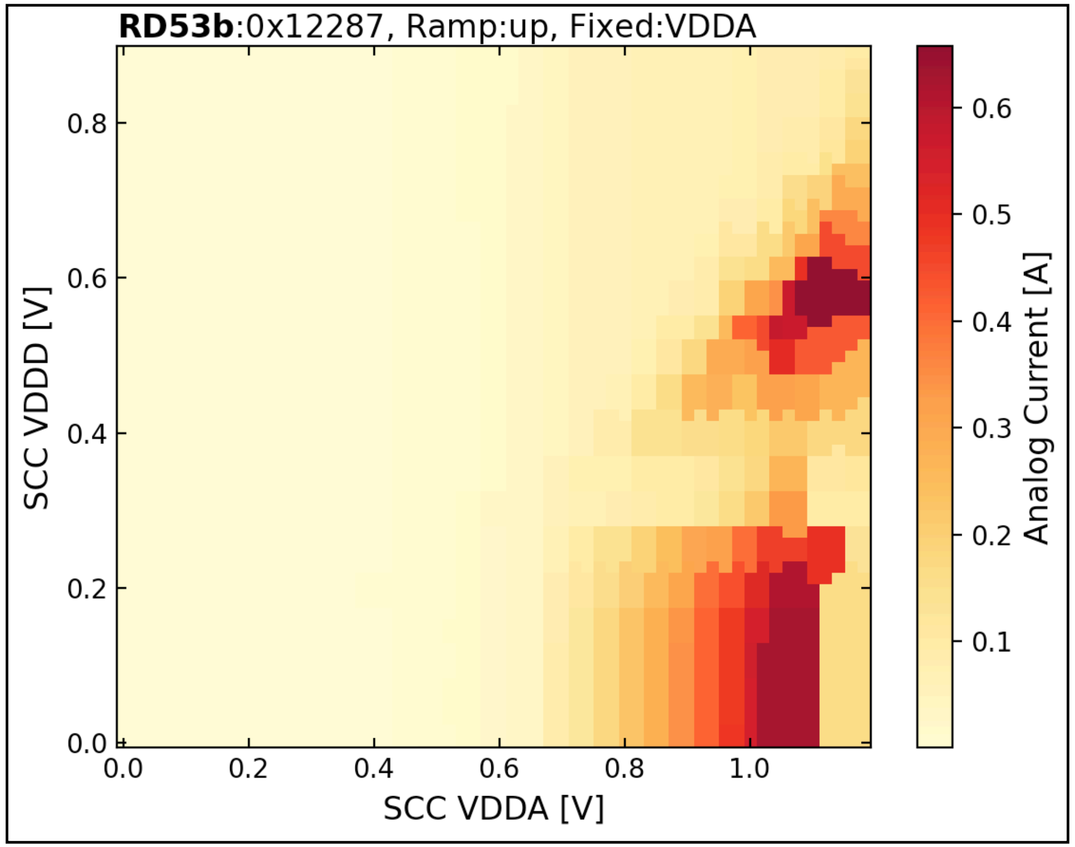




Not sure about the analog current behavior

IV Measurement



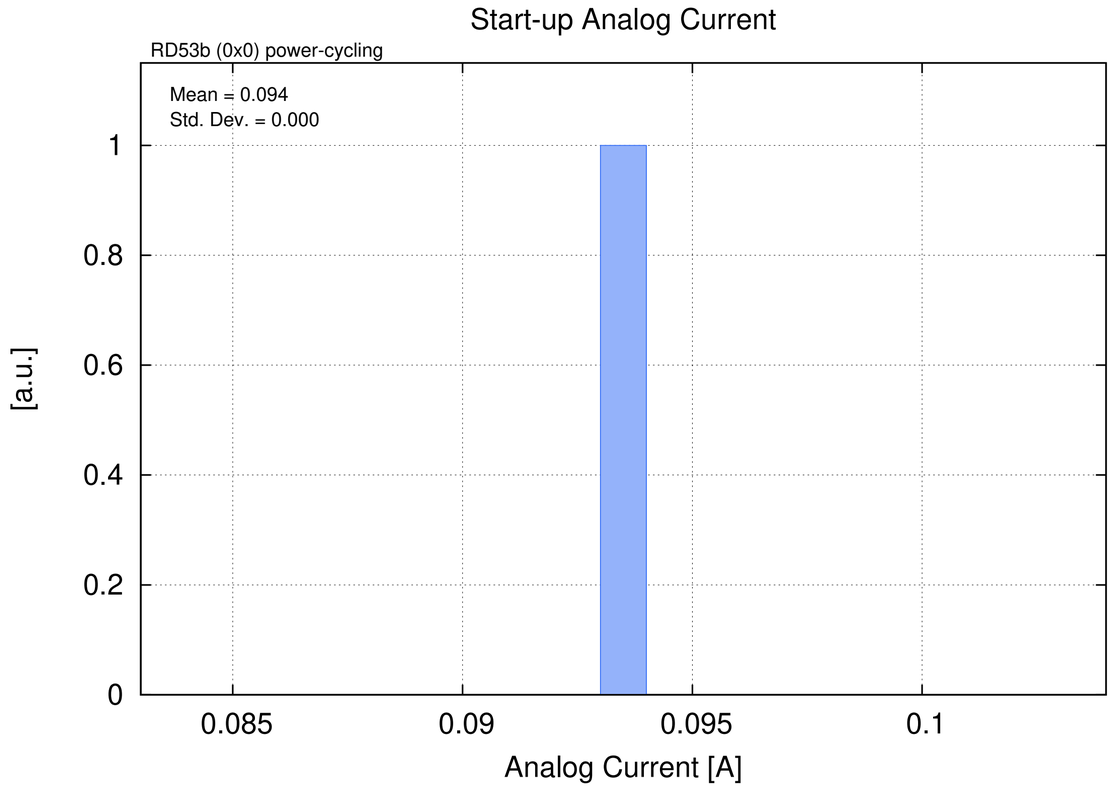


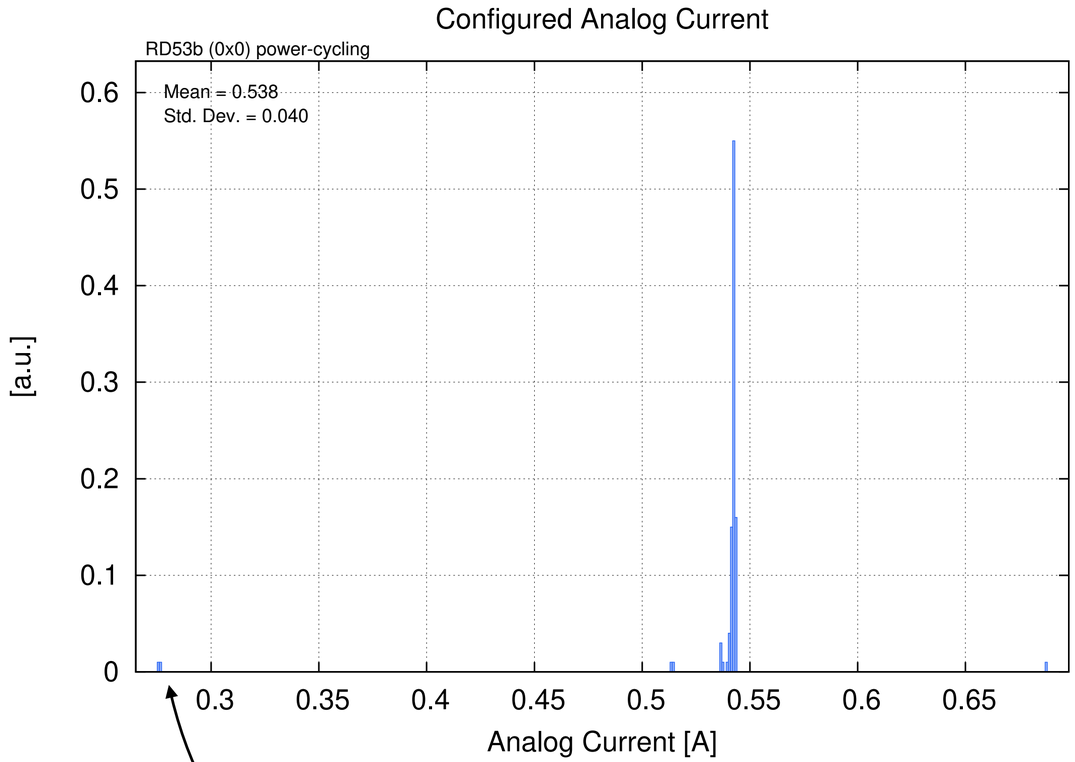
High digital current consumption we know about

Power-cycling Measurements

- Characterizing the current-consumption of the RD53b at power-on/start-up and after configuration
- Given the digital current issues (multi-bit latch issues), only looking at the analog current
- Follow the loop:
  1. Power-on Rd53b
  2. Measure analog current
  3. Configure RD53b with default configuration
  4. Measure current
  5. Remove power from Rd53b
  6. Repeat n-times to get sample

Power-cycling Measurements





Stray points due to insufficient settling time in the loop

DAC Measurements

- The RD53b has many configurable DACs which set things like the threshold levels, transistor biases, etc…
- These are all routed to a multiplexed monitoring output `VMUX_OUT` on the RD53b
- Selecting the multiplexer output is done by writing to a specific register on the RD53b
- The measurements of the analog output exposed on `VMUX_OUT` are obtained by the analog monitor card, with it's 12-bit ADCs

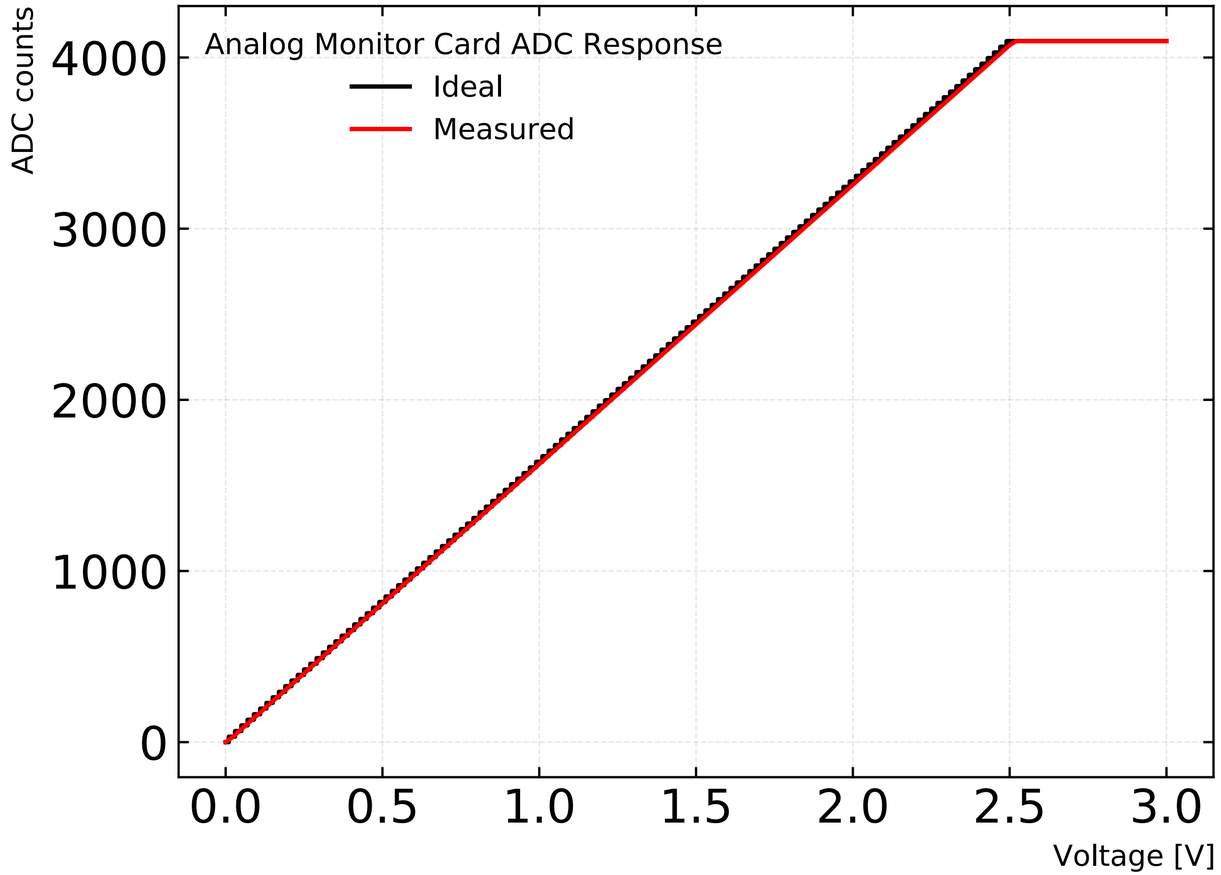
DAC Measurements

Setting	Selected Input	Setting	Selected Input	Setting	Selected Input
0	Vref_ADC (GADC)	10	DIFF FE VTH1 Main array	31	Vref_CORE
1	I_mux pad voltage	11	DIFF FE VTH1 Left	32	Vref_PRE
2	NTC_pad voltage	12	DIFF FE VTH1 Right	33	VINA / 2
3	Vref_ADC (VCAL DAC)	13	RADSENS Ana. SLDO	34	VDDA / 2
4	VDDA/2 from capmeasure	14	TEMPSENS Ana. SLDO	35	VrefA
5	Poly TEMPSENS top	15	RADSENS Dig. SLDO	36	VOFS_Half
6	Poly TEMPSENS bottom	16	TEMPSENS Dig. SLDO	37	VIND / 2
7	VCAL_HI	17	RADSENS center	38	VDDD / 2
8	VCAL_MED	18	TEMPSENS center	39	VrefD
9	DIFF FE VTH2	19-30	Ana. GND	40-63	not used

Table 26: Voltage multiplexer (V_mux) assignments for ATLAS chip.

DAC Measurements

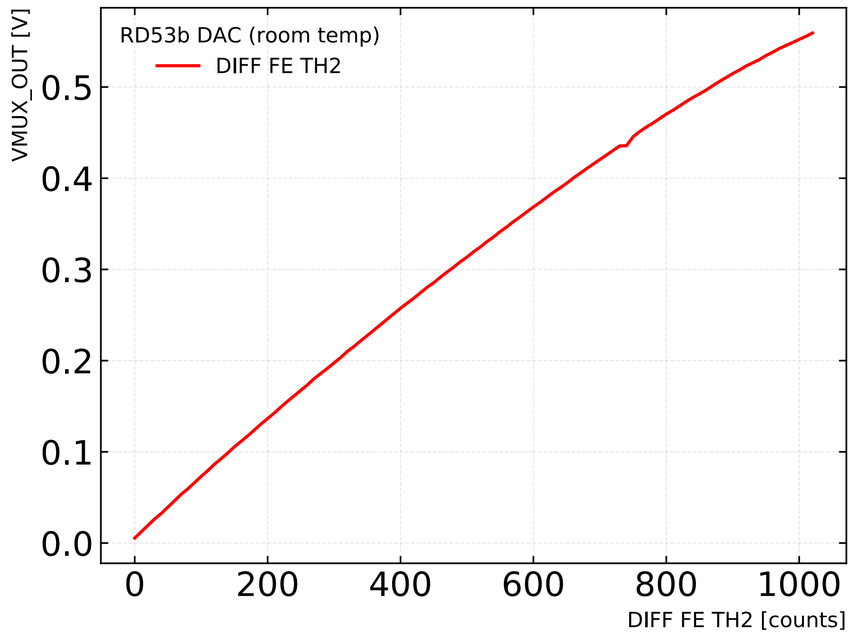
- I assume (so far) an ideal ADC response in the code that reads out the analog monitor card ADCs
- Checking the external ADC response
- This looks to be OK
- The RD53b internal ADC are not yet read out

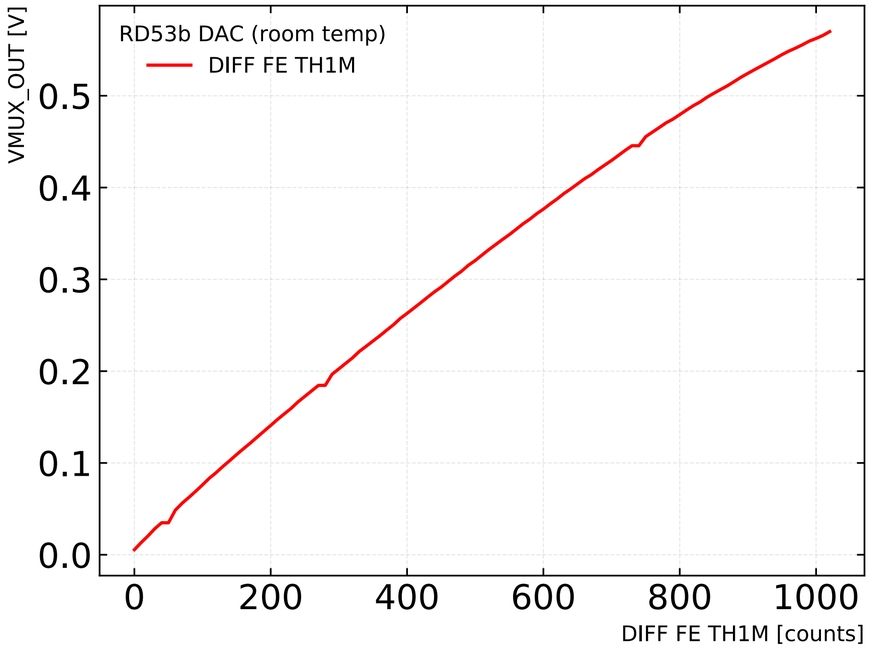


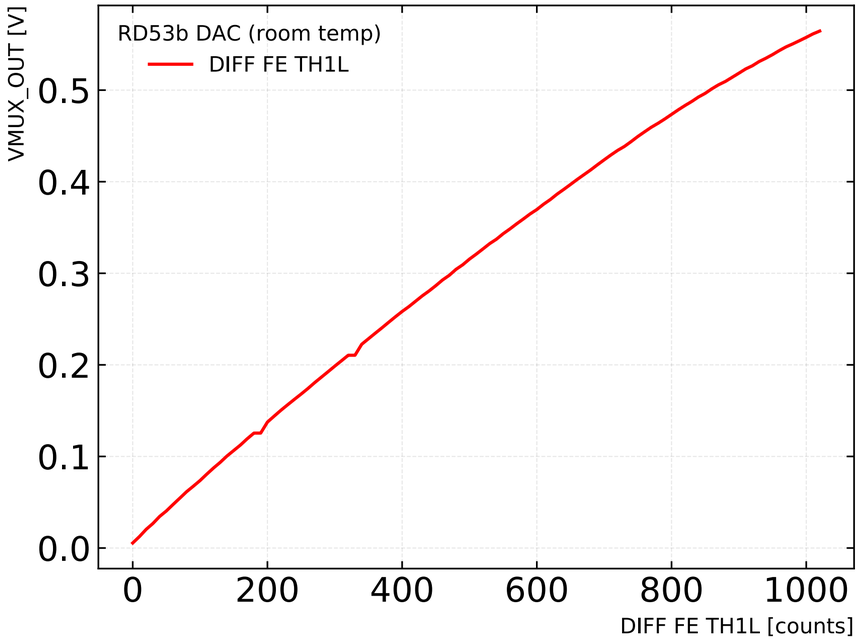
DAC Measurements

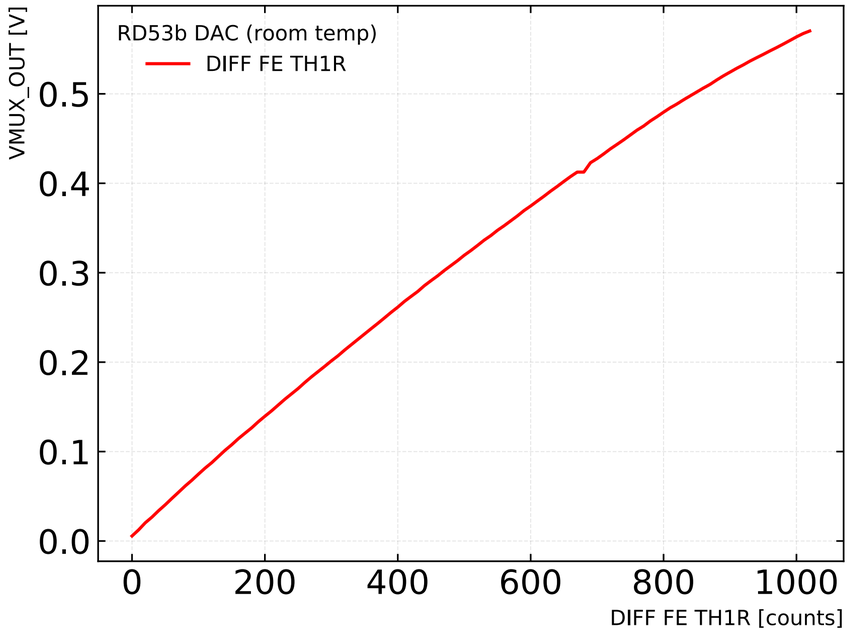
- DAC measurement follows the loop:
  1. Power-on Rd53b
  2. Reset ToT memories (reduce digital current)
  3. Configure RD53b with default configuration
  4. Enable monitoring of VMUX_OUT
  5. Loop over range of DAC (set RD53b DAC register values)
  6. Measure DAC value using analog monitor card's access to VMUX_OUT

DAC Measurements









Next steps

Next Steps

- Everything is now ready to go
  - Putting together the software setup took a few weeks
    - labRemote + YARR
    - rd53b_workbench
- Will now start performing these measurements at different temperatures, using climate chamber in the pixel lab
- E-fuse testing, pulse-shape analysis, etc…