G115 @ SLAC

Noah Kurinsky, Xuji Zhou,
Tsuguo Aramaki, Bruno Serfass, Caleb Fink, Matt Pyle, Paul Brink

Tower Technical Meeting

July 14, 2017

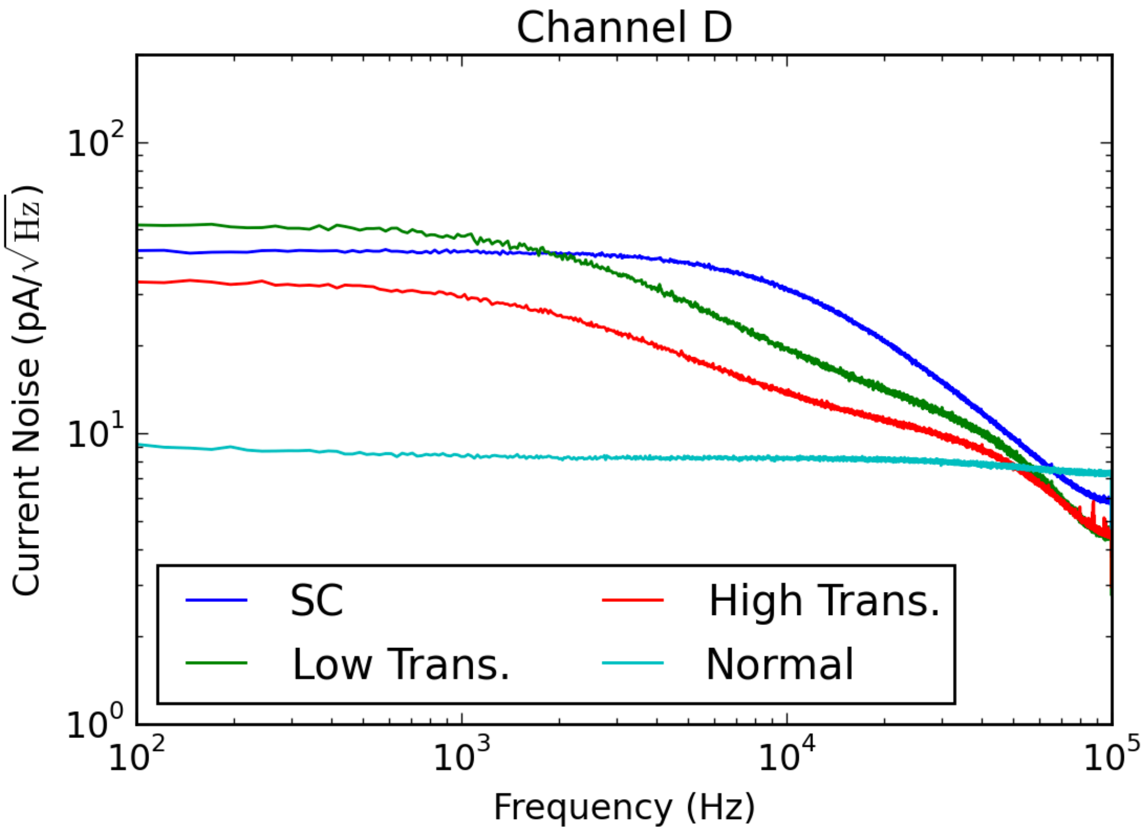
U.S. DEPARTMENT OF ENERGY
Office of Science

SLAC NATIONAL ACCELERATOR LABORATORY

Goal of SLAC Tests

- Demonstrate much lower passive noise than at UCB
  - SNOLAB electronics with smaller Rp/Rsh, less Johnson noise
  - Isothermal tower so more resistors at <30 mK, less Johnson noise
  - Lower bath temperature -> Low TES noise?
- UCB has done a more thorough job of isolating sources of current noise, but there seems to be a source of excess power noise. Is this also present at SLAC?
- Does the complex impedance change when we operate a detector at a bath temperature further from Tc? (It should)

UCB Noise: Normal vs Transition



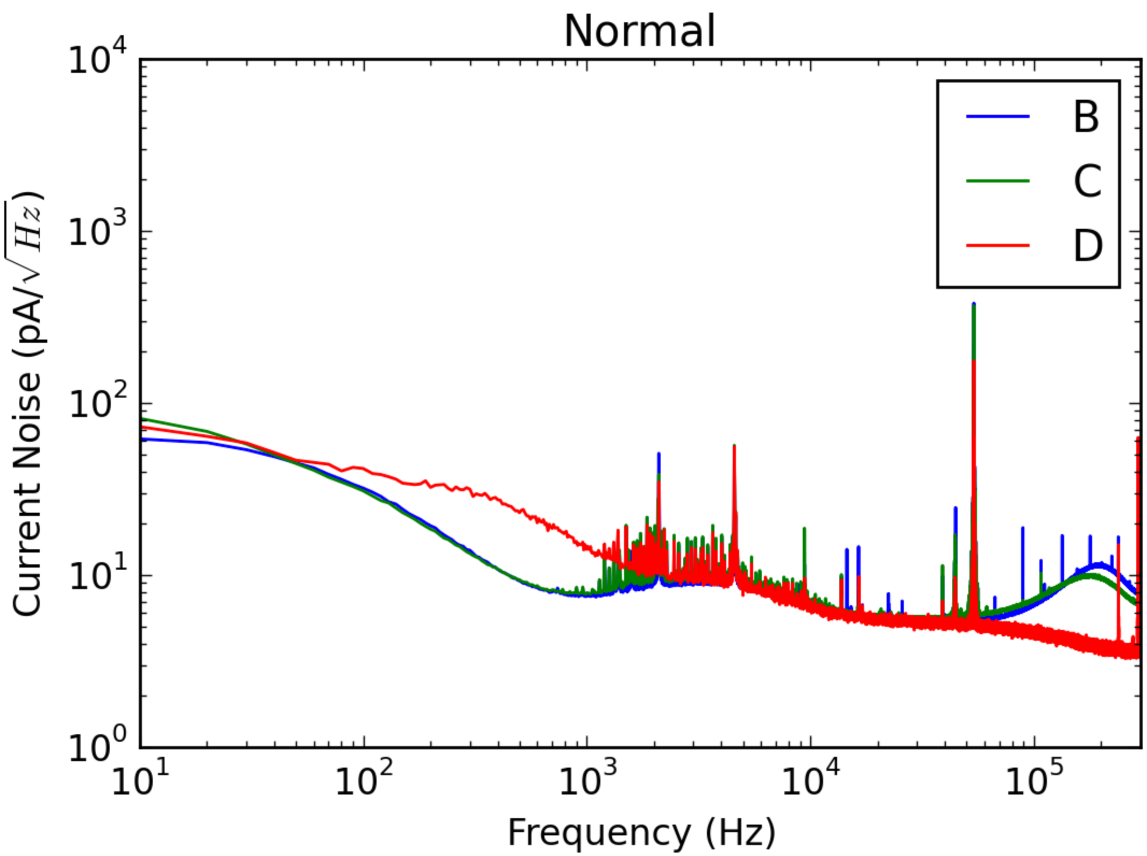
Superconducting noise dominates over high transition noise, but not low transition noise

Mix of extra power noise and high-level of current noise from passive electronics

Tc~45 mK and Tb~40 mK, so some of this could be related to weak bath power

http://titus.stanford.edu/cdms_restricted/detector_physics/HV/ebook/170511a/index.html

SLAC Noise: Normal



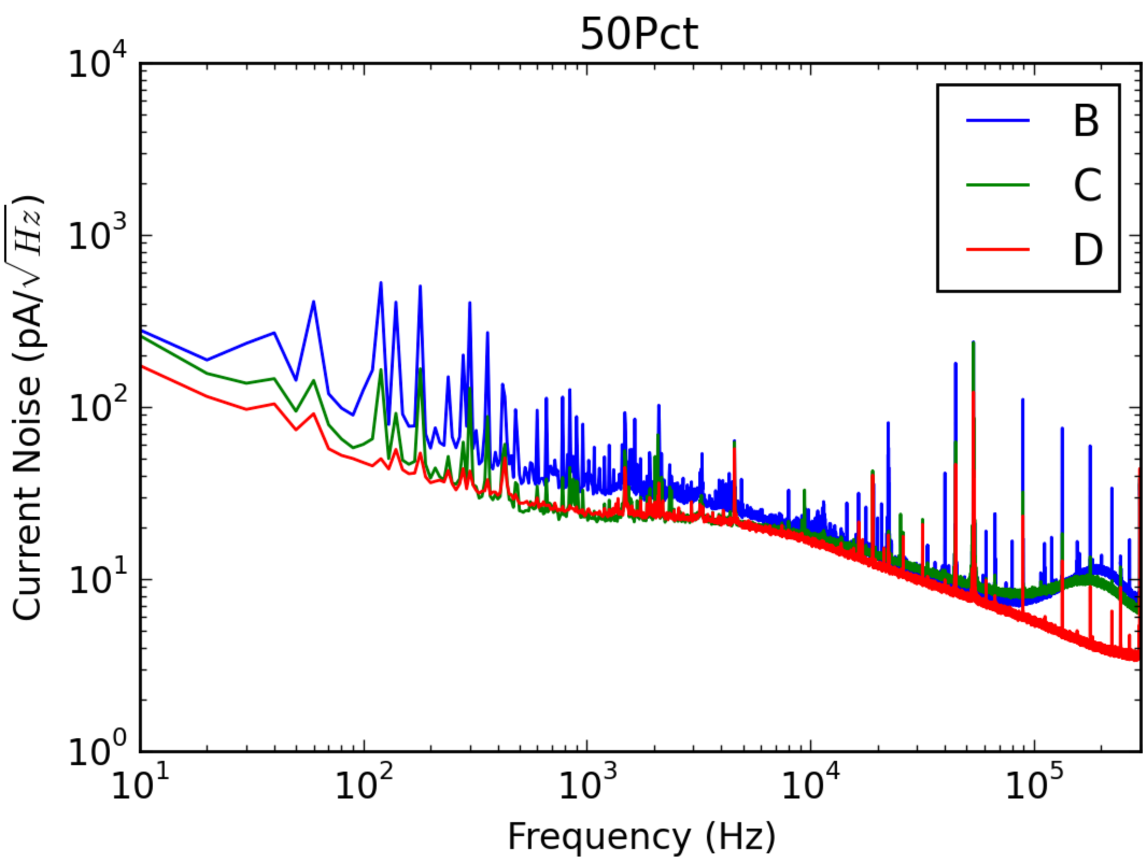
Normal noise from DCRC D.0 at SLAC still much noisier than at UCB

Everything between 1kHz and 100 kHz is environmental - seems to be excess current noise in the zap-switch power supply

Below 1 kHz noise is related to DCRC D.0 noise at driver offset, seen at UCB also - this is a solved problem

https://confluence.slac.stanford.edu/display/CDMS/SLAC+Run+23+DCRC+Noise+on+G115

SLAC Noise: Transition

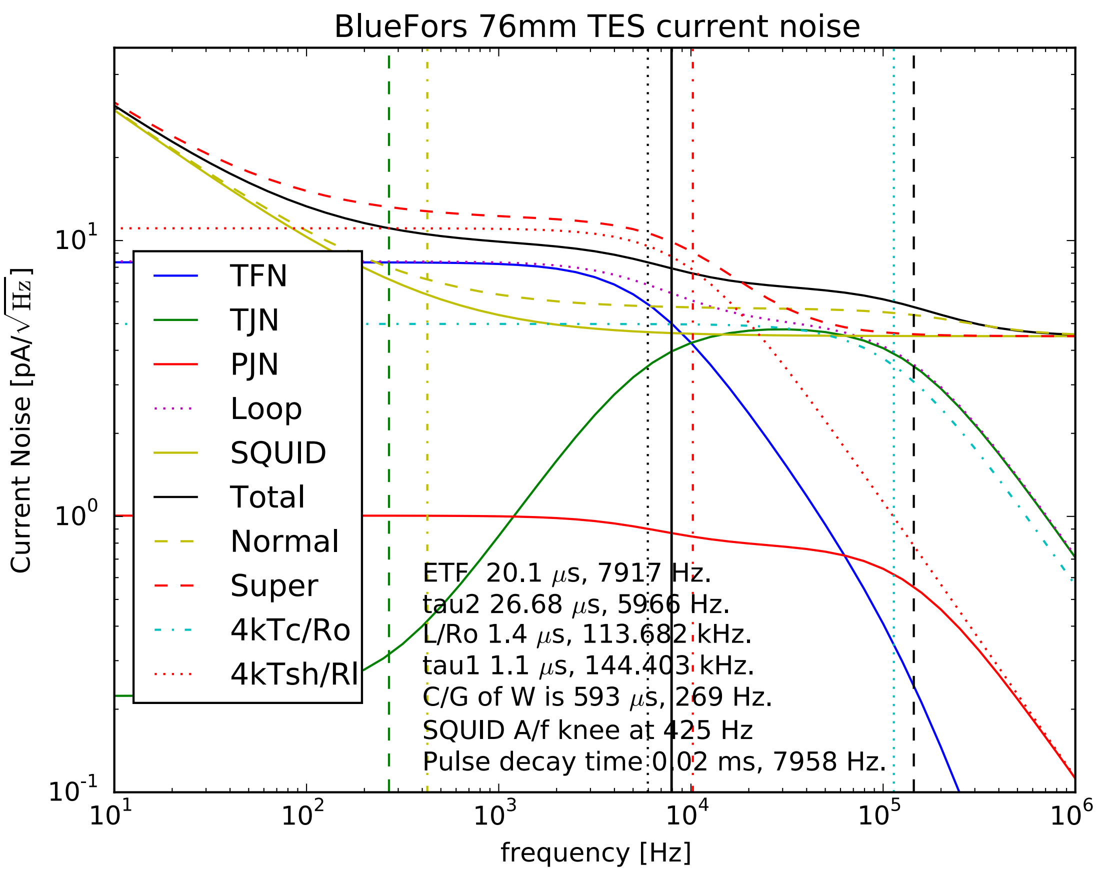


Transition Noise is comparable to UCB above 1 kHz, but spectral shape diverges below 1kHz (mostly DCRC noise)

Possible that current noise decreases as DCRC environmental noise decreases

https://confluence.slac.stanford.edu/display/CDMS/SLAC+Run+23+DCRC+Noise+on+G115

SLAC Noise: 50% Transition

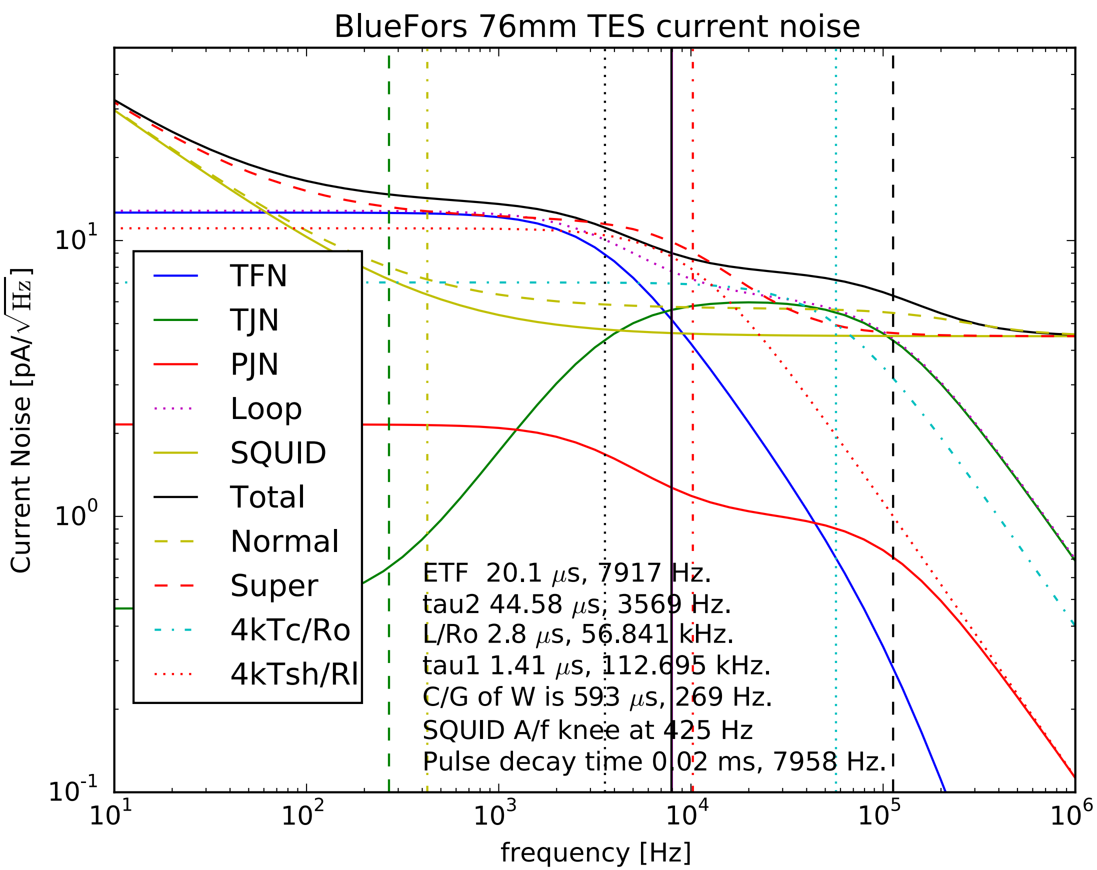


Modeling of current noise for G115 in the SLAC fridge shows what the noise should look like once sources of current noise in the QET/SQUID bias lines are dealt with

Normal and superconducting noise can be fit to PSDs, tell us shunt temperature and SQUID noise profile

Additional noise in transition, coupled with dIdV, tells us about the dIdP and G of the TES, and indicates whether there is additional power-coupled noise in the circuit

SLAC Noise: 25% Transition

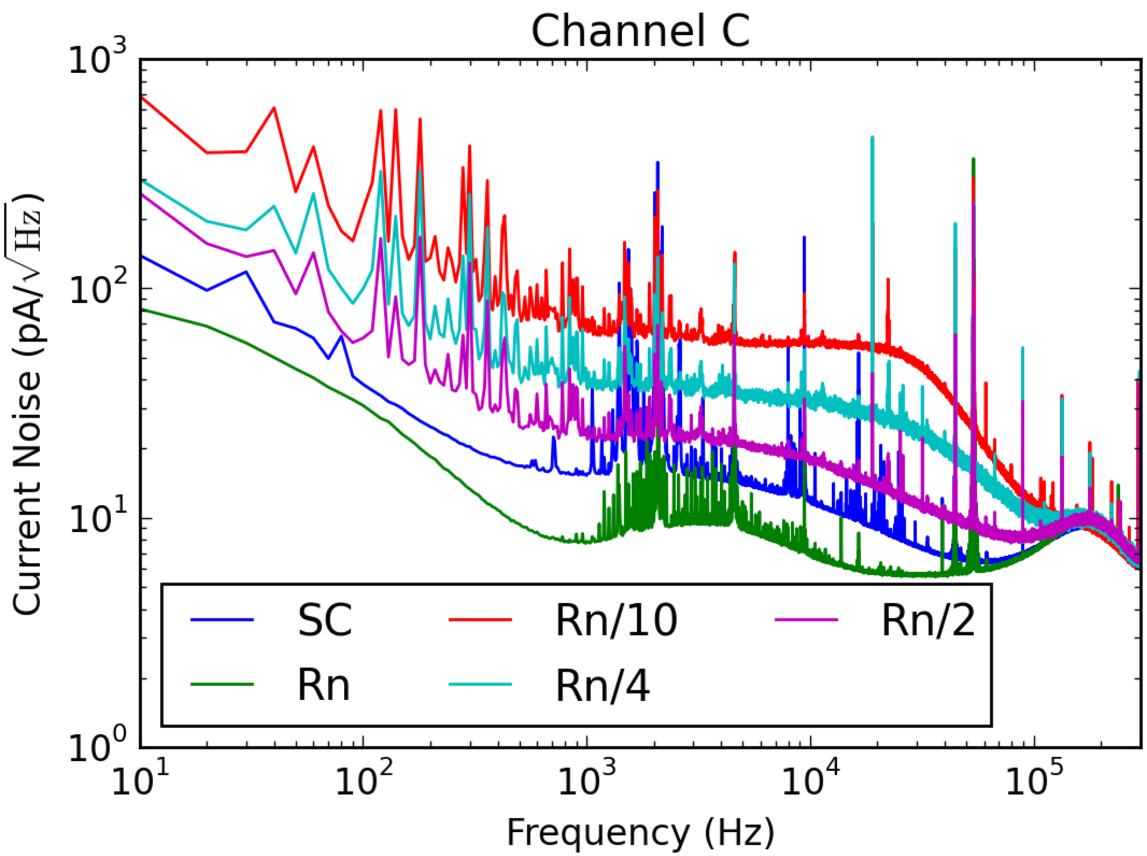


Modeling of current noise for G115 in the SLAC fridge shows what the noise should look like once sources of current noise in the QET/SQUID bias lines are dealt with

Normal and superconducting noise can be fit to PSDs, tell us shunt temperature and SQUID noise profile

Additional noise in transition, coupled with dIdV, tells us about the dIdP and G of the TES, and indicates whether there is additional power-coupled noise in the circuit

SLAC Noise: Transition, Normal & SC



Comparison of normal and SC noise shows that current noise from passive network is much smaller than at UCB (validating design expectation)

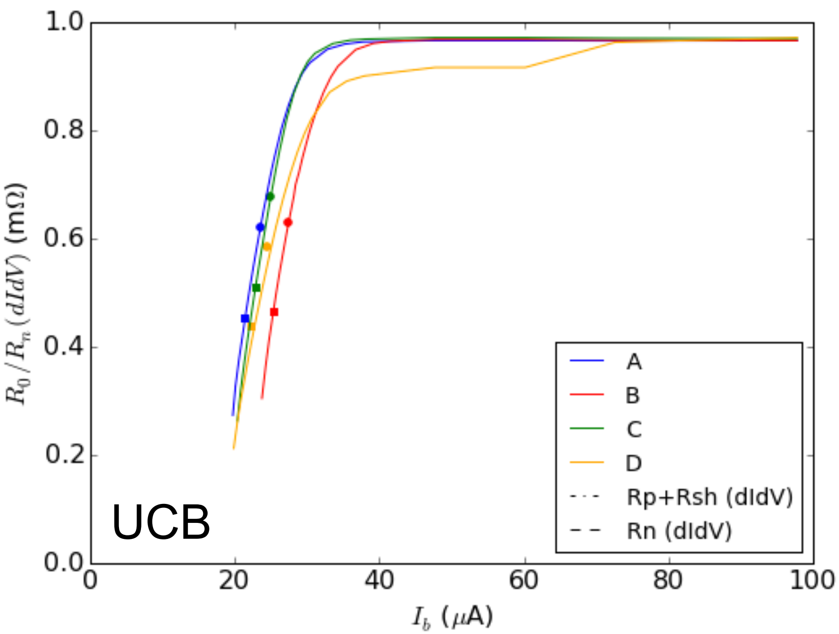
Lowest bias point (which has highest dIdP) has noise most clearly determined by transition

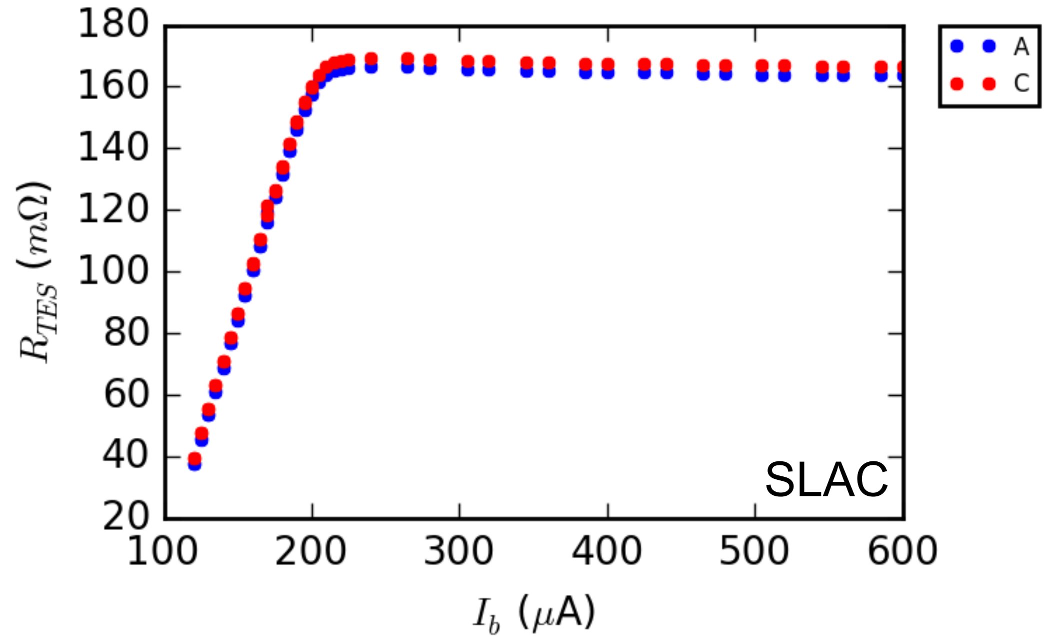
L/R pole decreases as we go lower in transition, demonstrates increased high frequency response (L is constant, R(1+beta) seems to be increasing?)

Very interesting stuff here

https://confluence.slac.stanford.edu/display/CDMS/SLAC+Run+23+DCRC+Noise+on+G115

IBIS at SLAC/UCB



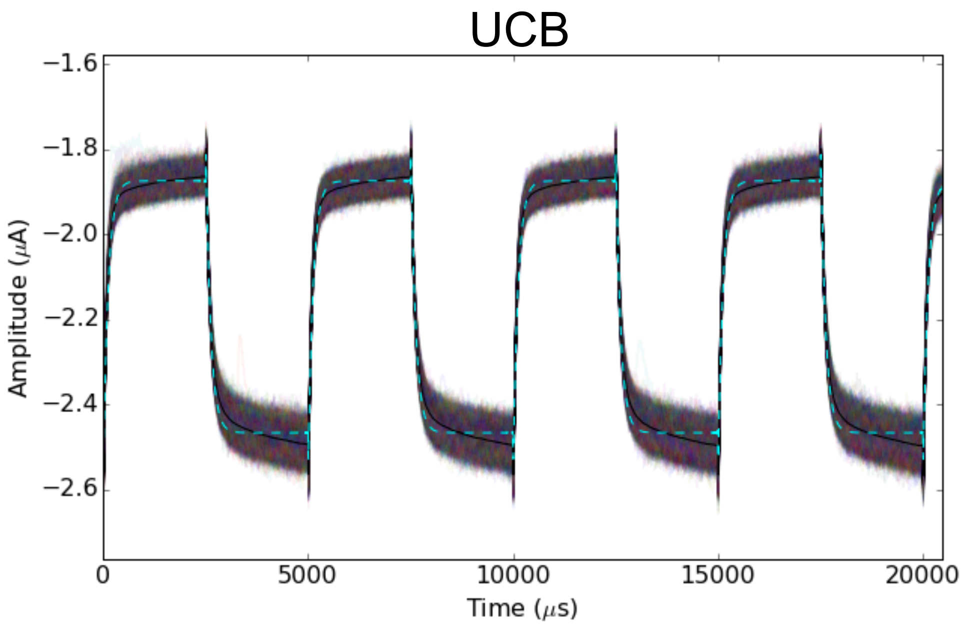


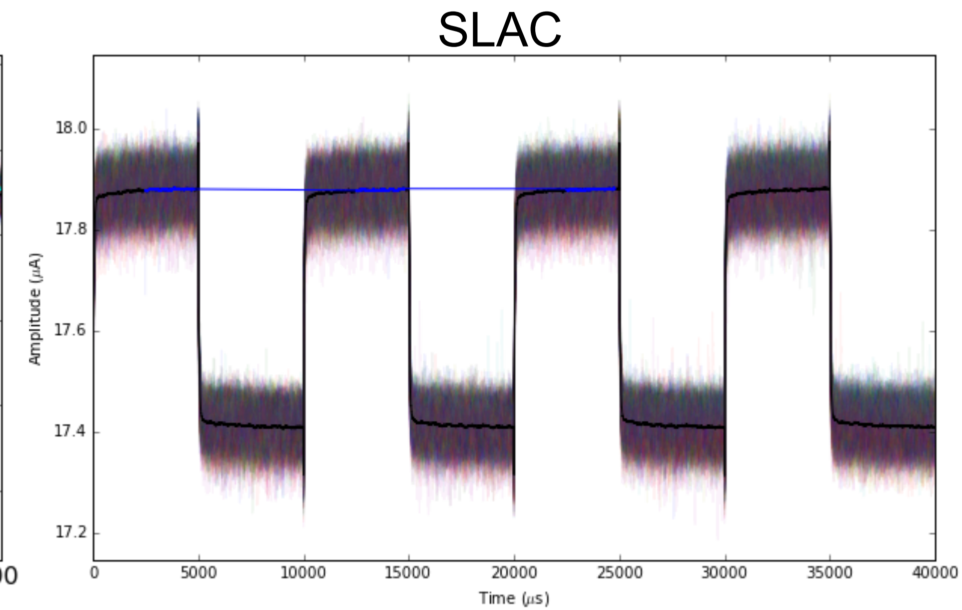
IBIS looks similar, bias power is higher at SLAC due to lower shunt resistor values.

Minimum bias is similar, lower at SLAC due to lower Rsh+Rp, but Rp is not as low as expected for SNOLAB cables/connectors

High-current pathologies seen at UCB absent at SLAC, curve is more linear in bias current

Complex Impedance



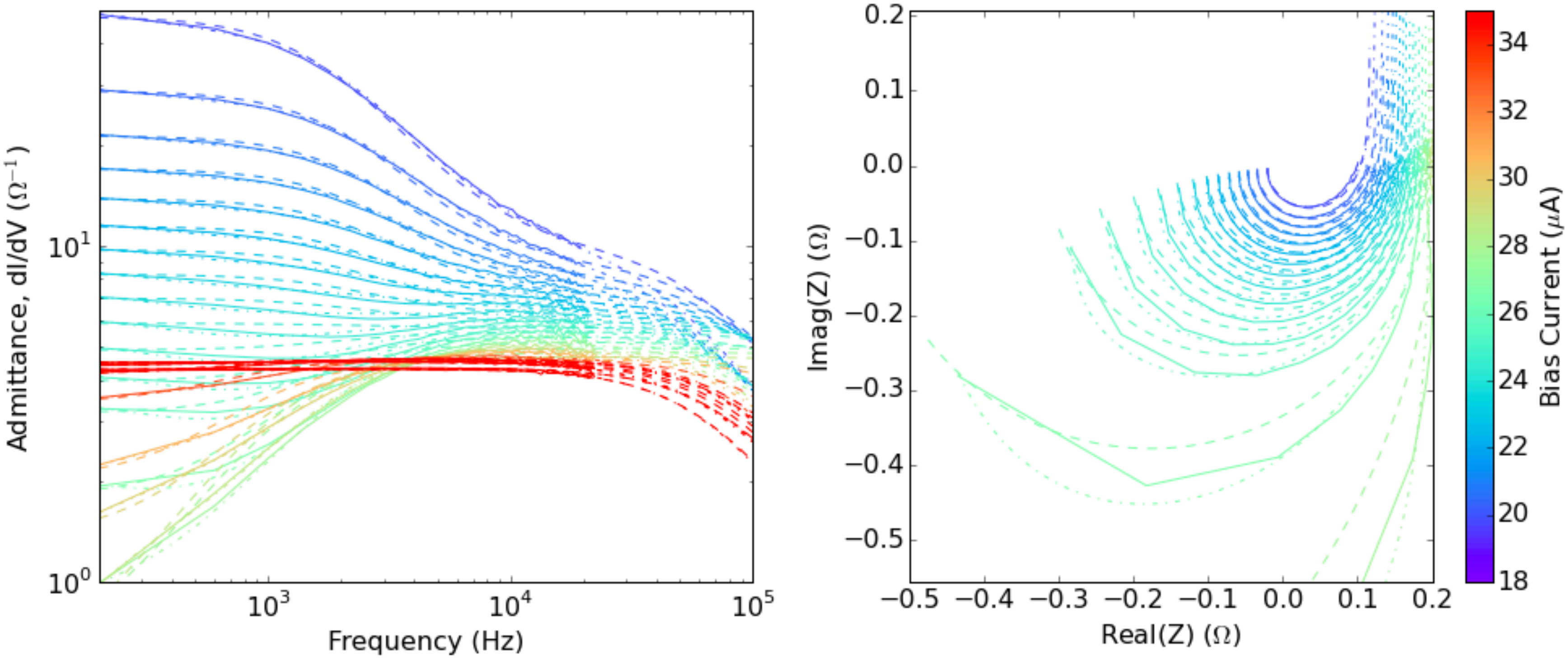


Long tails seen at UCB absent at same bias at SLAC

This is despite the much higher background at SLAC, muon tails disappear much more quickly due to lower bath temperature

Longer traces also allow us to use lower frequency signal generator, reconstruct lower frequency dIdV more completely

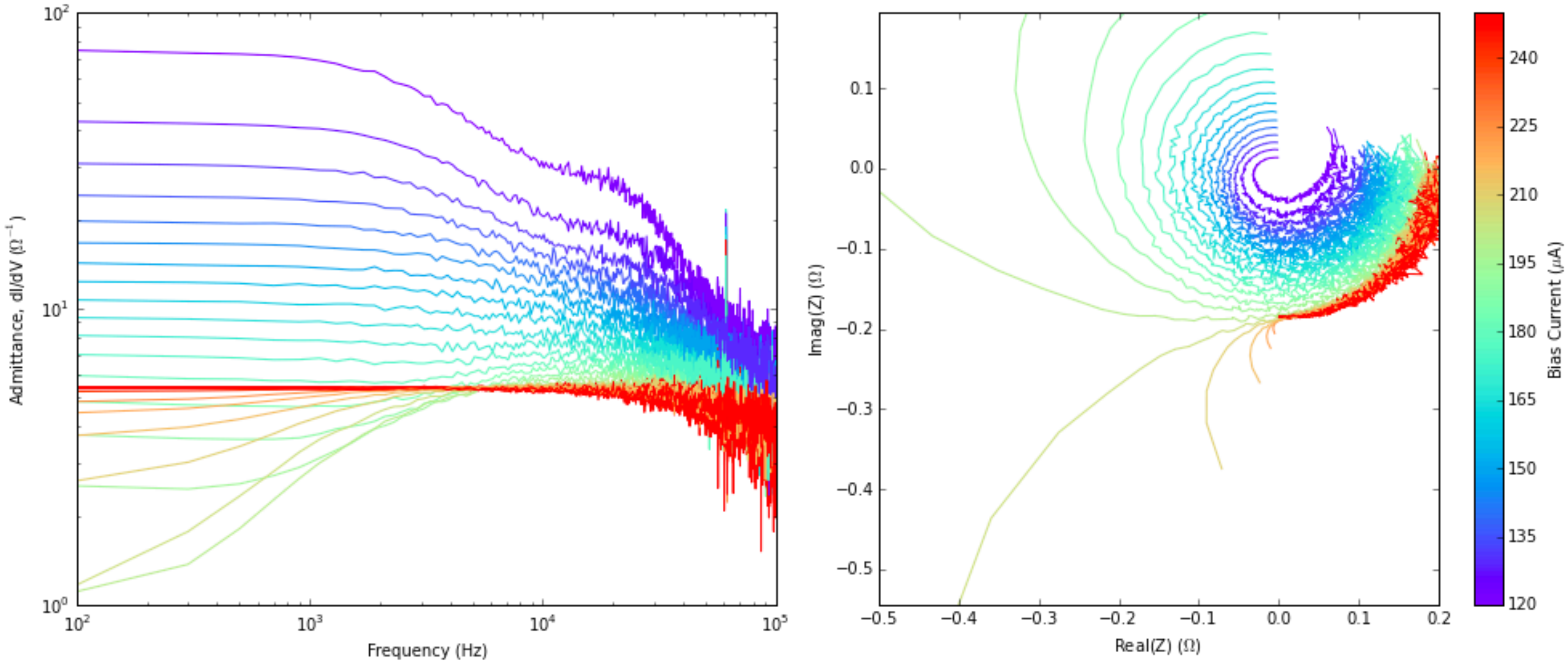
Complex Impedance: UCB



Most dIdV curves increasing at 100 Hz, largest dIdV curve doesn't quite reach 100 S

Dashed lines show fits which are used to back out alpha/beta and TES poles, around 1 kHz and 50 kHz (TES and L/R poles)

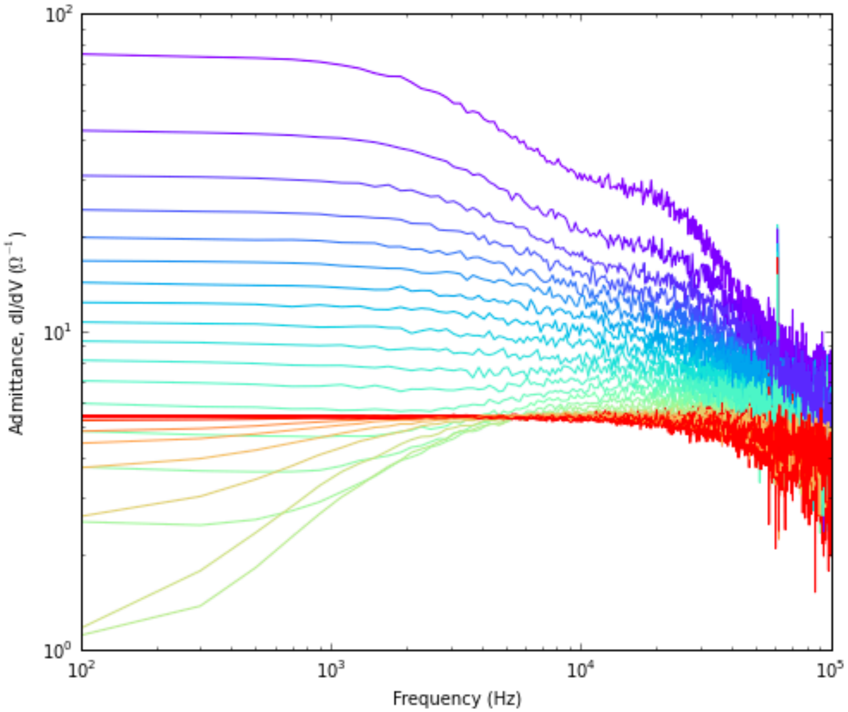
Complex Impedance: SLAC

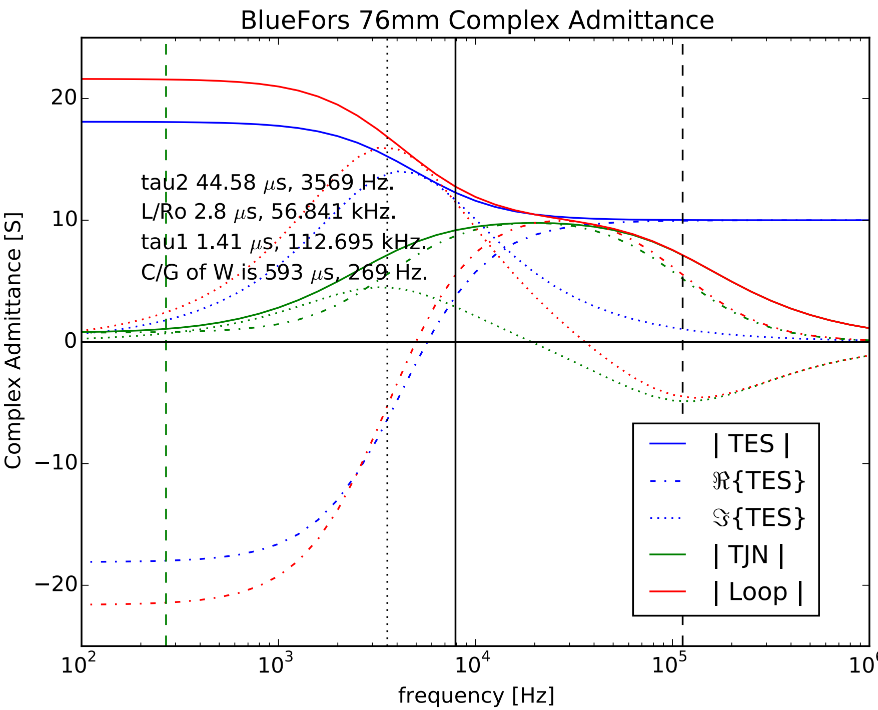


All dIdV curves much flatter by 100Hz, long tail seems to be present a little at the lowest bias settings; may also have to do with nature of parasitic resistance

Fits not yet working for SLAC dIdV unfortunately, results soon

Comparing dIdV between UCB/SLAC

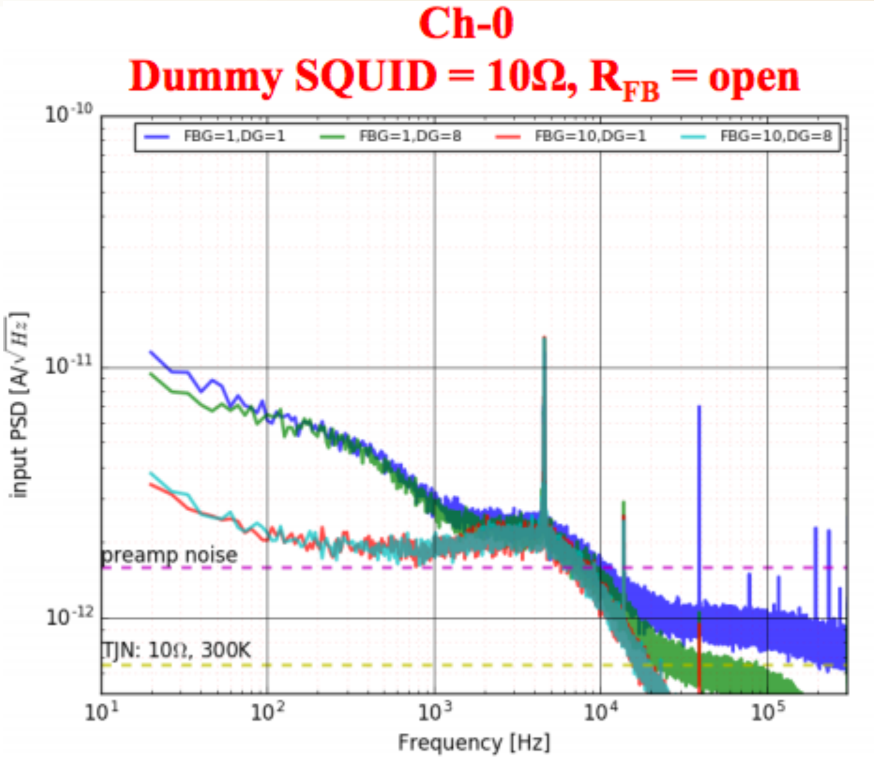


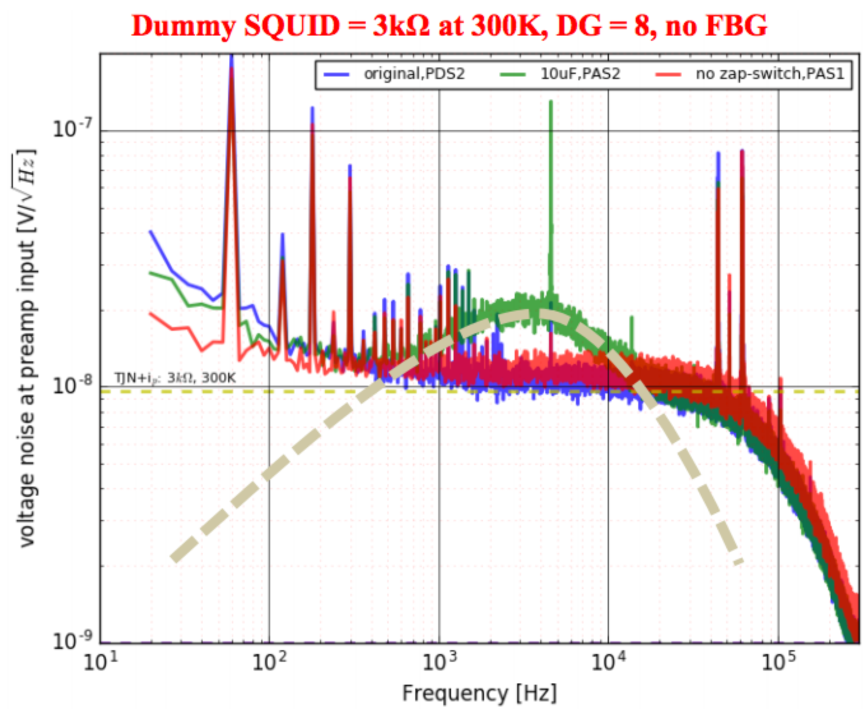


Curves match expectation remarkably well, should allow us to determine all free parameters in TES bias circuit

Models include parallel inductance, which levels out transfer function above 1MHz

Noise Sources Isolated



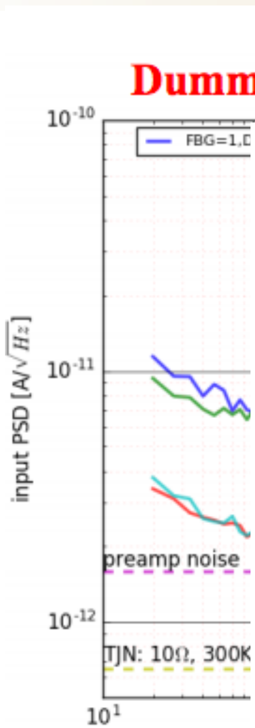


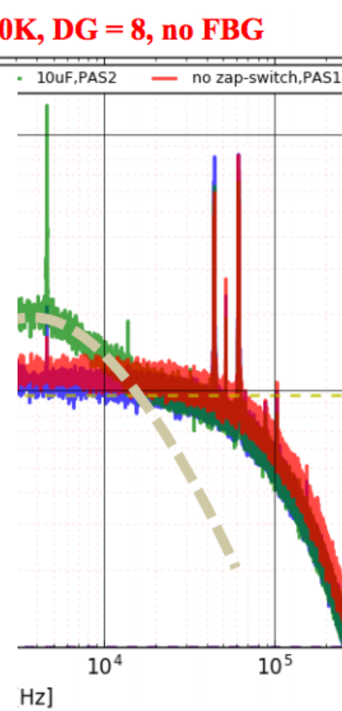
Noise on driver gain input is too large; can be fixed with higher pre-amp gain and better filtering

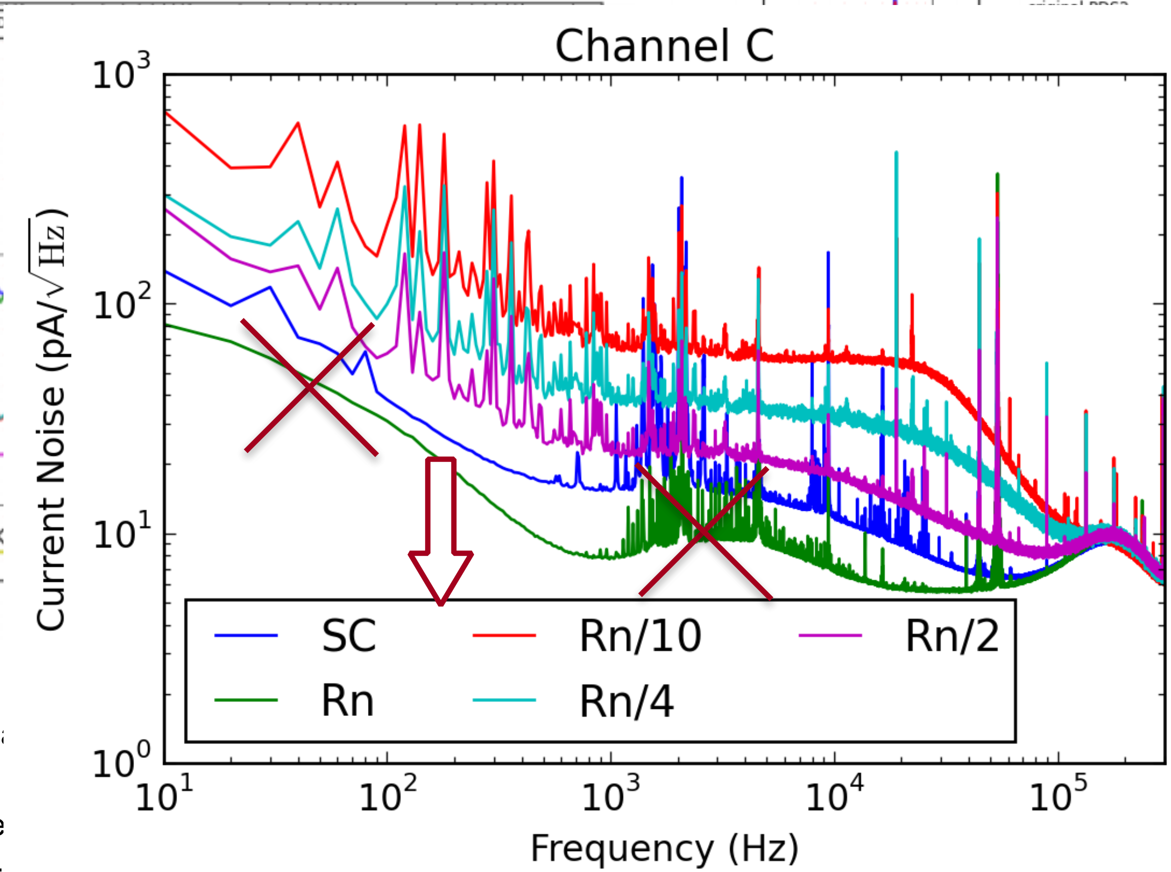
Seems that noise 'hump', caused by ethernet-related voltage noise on the power lines, was leaking in through the zap switch at the pre-amp input; better filtering gets rid of this.

See Tsuguo's talk at electronics meeting this afternoon, it's really good work

Noise Sources Isolated







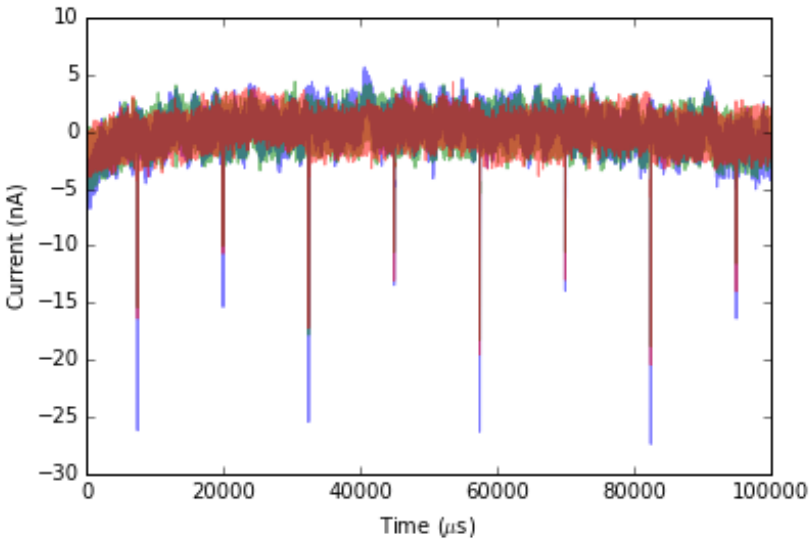
Noise on driver g

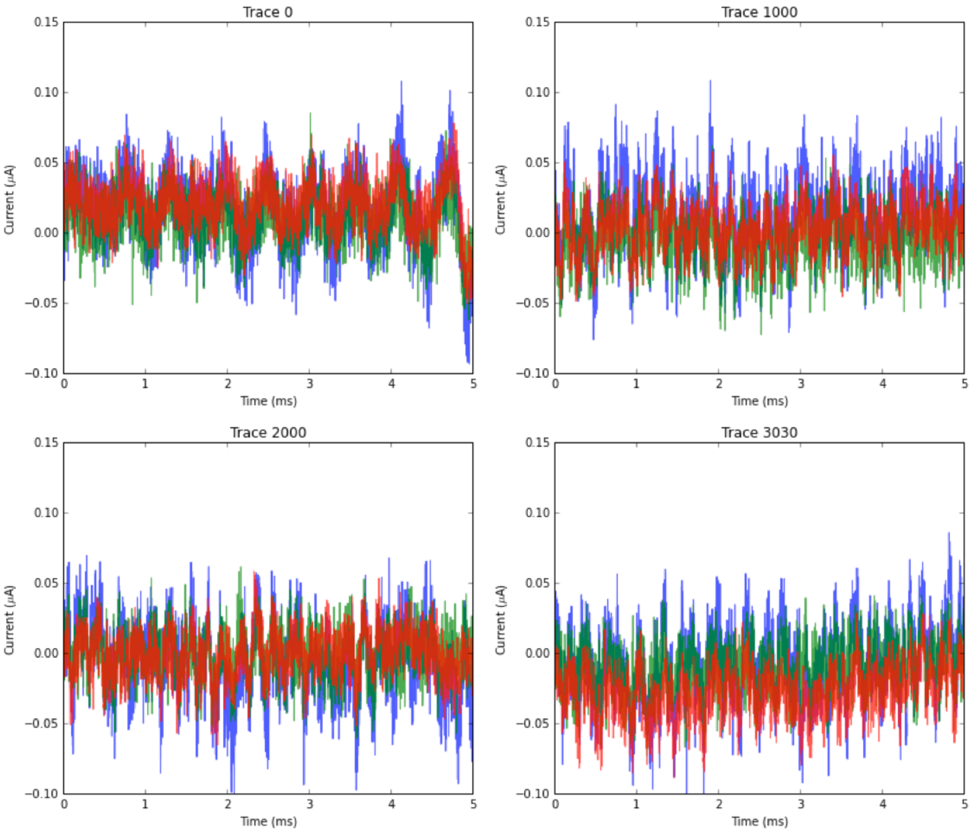
Seems that noise … hrough the zap switch at the pre-

See Tsuguo's talk at electronics meeting this afternoon, it's really good work

Some Issues Remain (D.0)

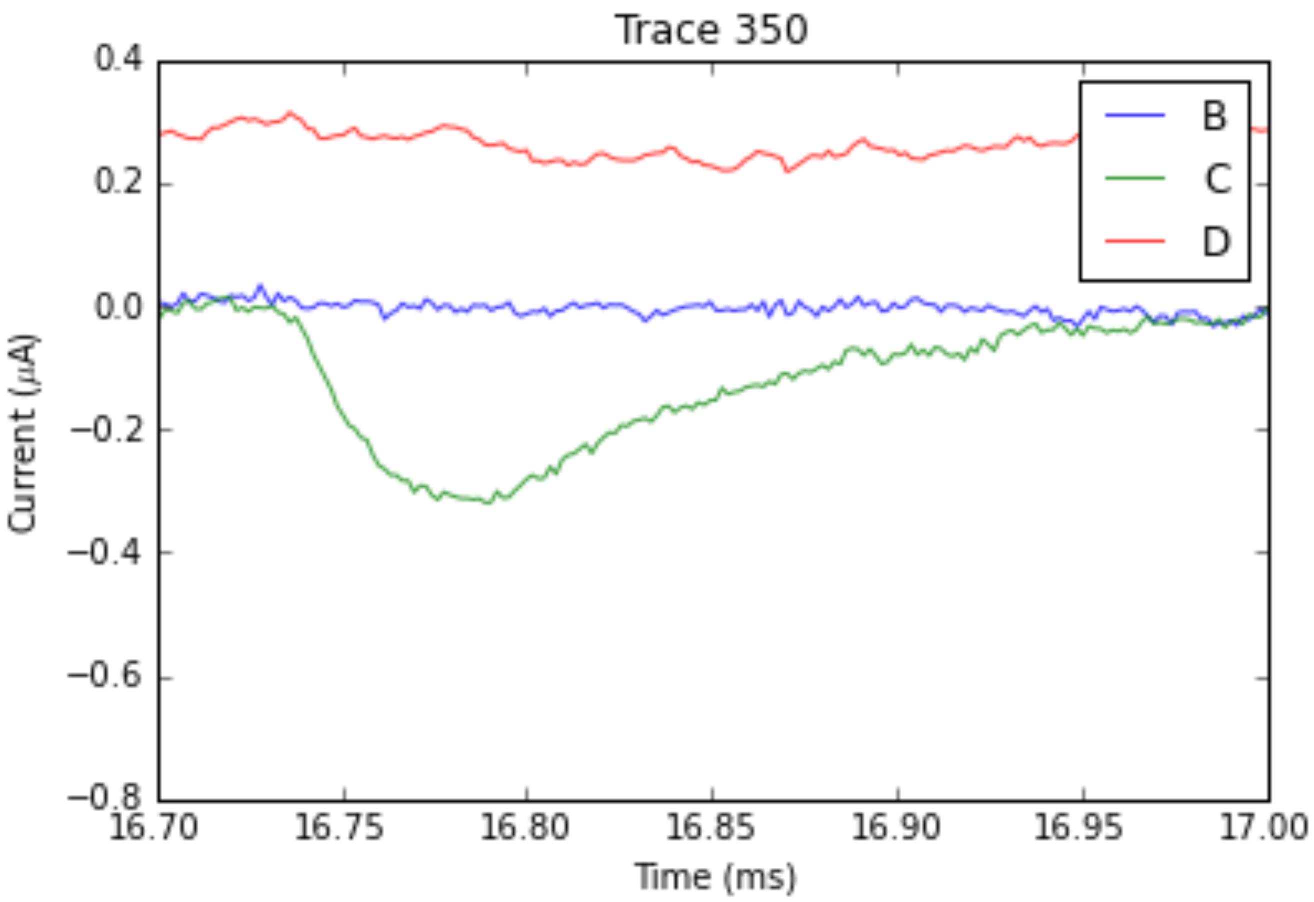
Crosstalk from Signal Generator Trigger





kHz time-varying environmental noise,
generated by compressor and DCRC on power rails

But Fast Pulses!



Lessons Learned, Studies in Progress

SLAC

- Tc measurements between SLAC and UCB were very consistent, both ~45 mK and stable over the course of the run
- Pulses very fast at SLAC, TES fall times of 20 microseconds, faster than expected
  - Lower bath temperature removes second fall-time seen at UCB, showing that this is not a multi-block TES problem
- Overall higher than expected TFN noise somewhat consistent between test facilities, but high dIdP means that when SLAC noise is cleaned up we should get better energy resolution than at UCB. When excess SQUID bias current noise is reduced, the transition noise also seems to be reduced
- Studying complex impedance and eventually efficiency, more updates in coming weeks
  - Fitting complex impedance to determine alpha/beta as a function of R0
  - Calculate OF energy resolution using improved DCRC noise and baseline traces, assuming ~6-8% efficiency
  - Use Am-241 or Fe-55 sources to measure efficiency in SLAC fridge
  - Repeat measurements with copper shield to see how reduced background impacts performance