



All of the wavelengths
All of the times
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Moving Optical MKIDs to Lower Temperature: Preliminary Characterization of Hafnium Resonators

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Motivation

Why lower T_c ?

Sensitivity

$$\delta S_{21} \sim \frac{1}{T_c^2}$$

Energy resolution

$$R \sim \sqrt{\frac{1}{\Delta}} \sim \sqrt{\frac{1}{T_c}}$$

Why Hafnium?

Elemental superconductor \rightarrow ease of fabrication
Bulk $T_c=128\text{mK}$

Hf film characterization

Resistivity:
~80 $\mu\Omega$ cm

Surface inductance:
~40pH/ \square @50nm
~18pH/ \square @125nm

RRR:
~1.4

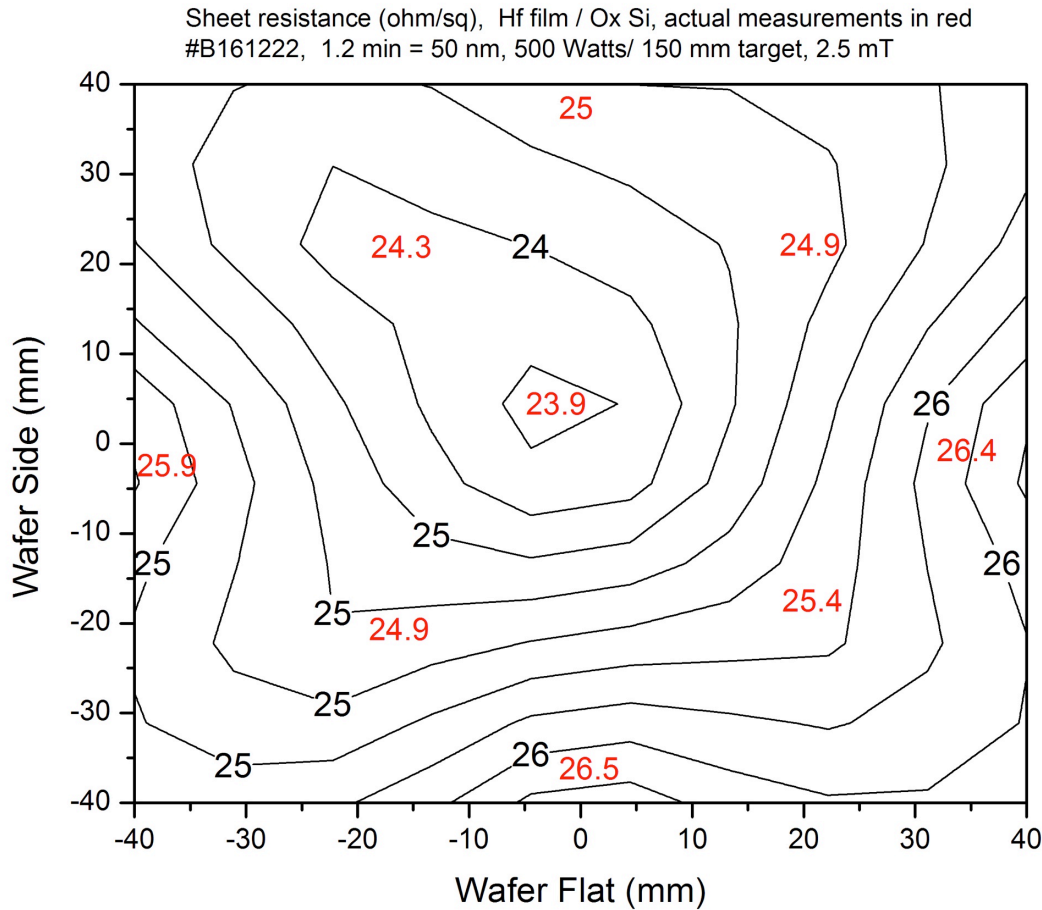
α :
~95%



Measured T_c :
440mK to 480mK
Depends on the film compressive stress

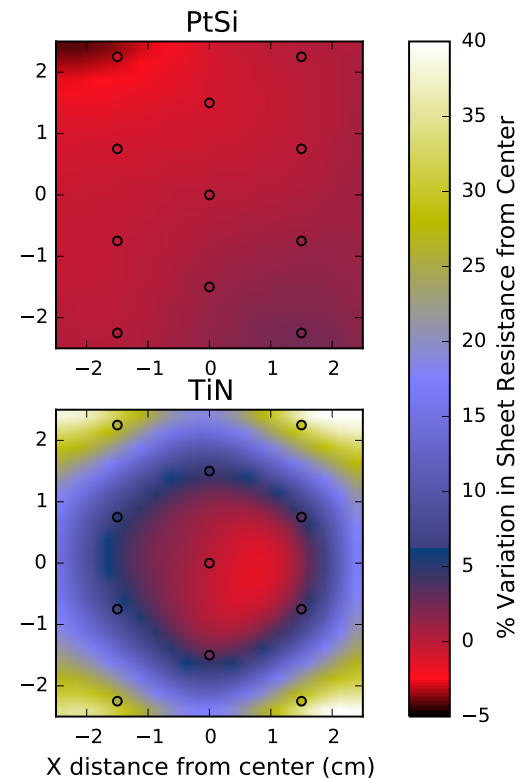
Jonathon Hunacek's talk today at 6:20pm
"Design and Status of TIME, a mm-wavelength spectrometer array for [CII] intensity mapping"

Uniformity of Hf film



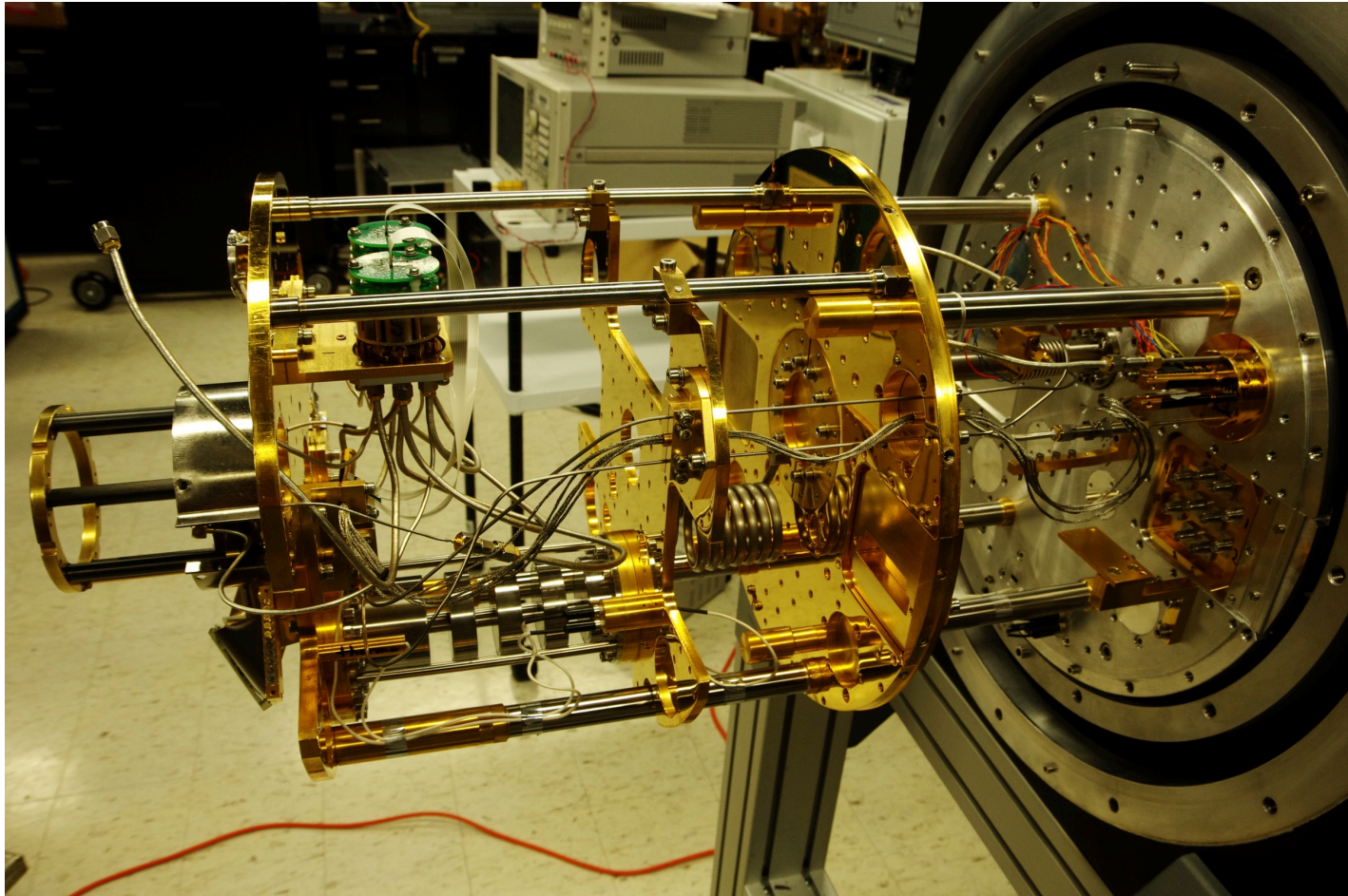
Courtesy Bruce Bumble

Szypryt+ 2016

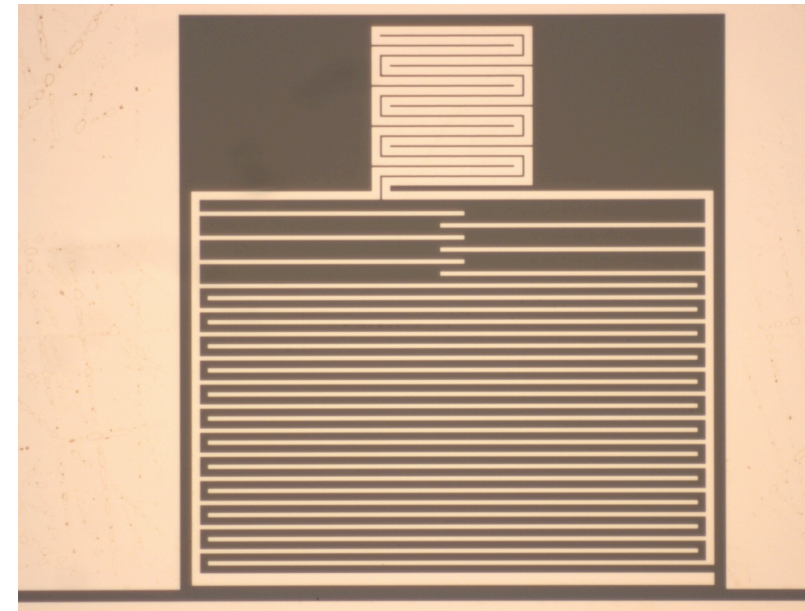
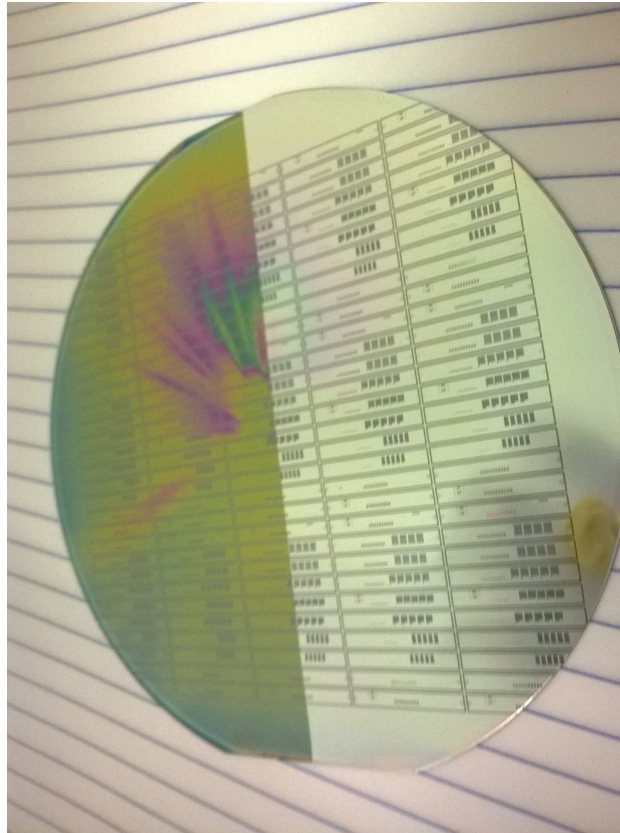
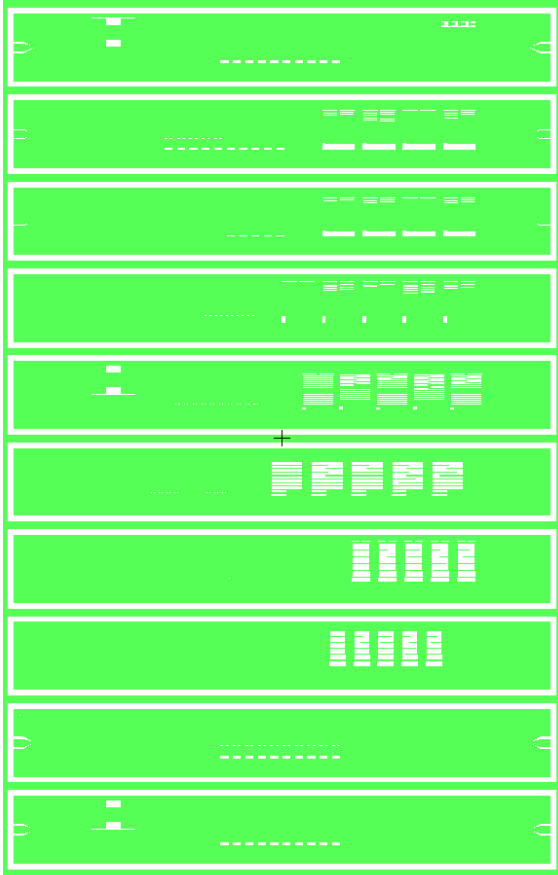


Paul Szypryt's talk: Friday 9:20am
"The DARKNESS array: A 10,000
pixel PtSi MKID array"

Testbed

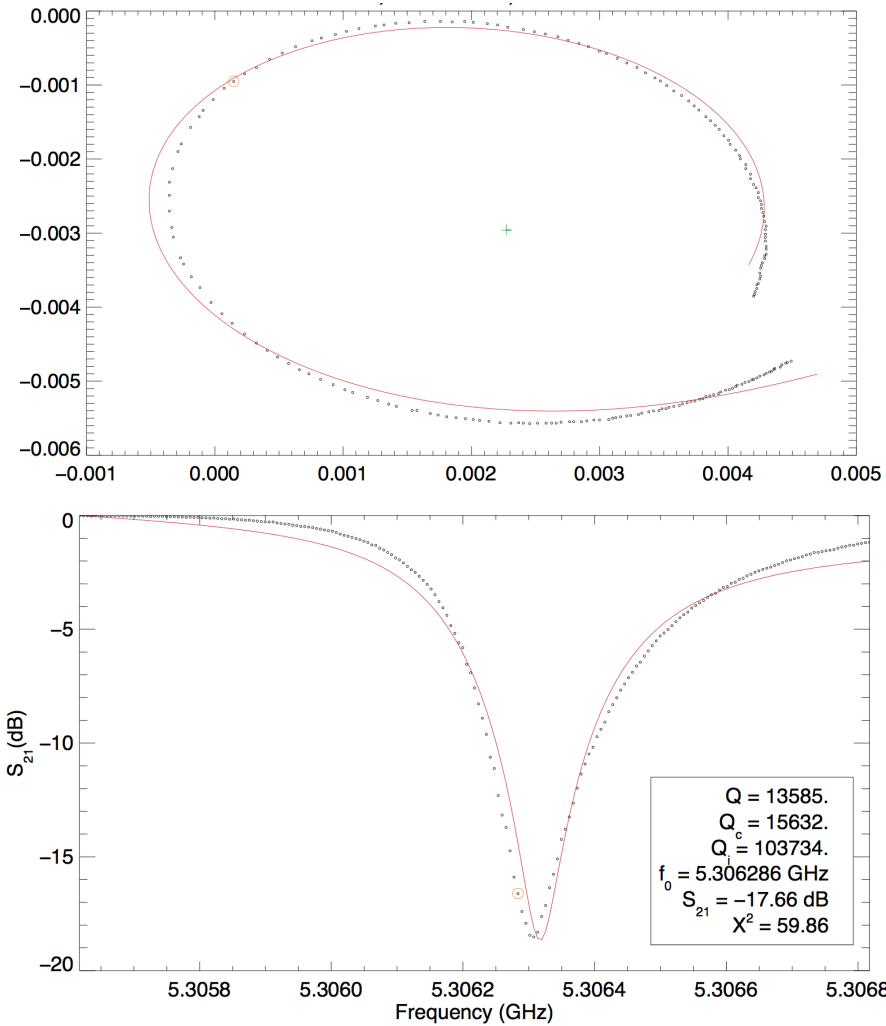


Test Mask Layout

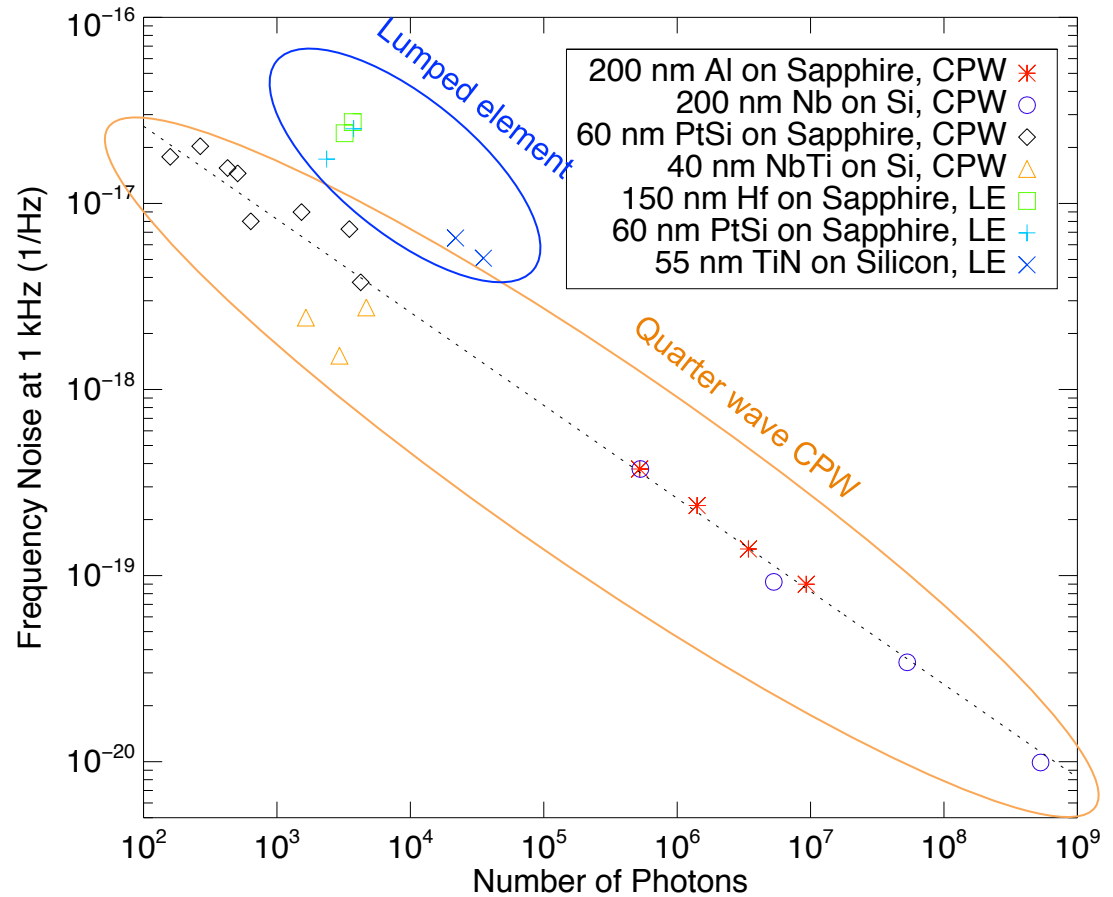


~200 μ m \times 200 μ m

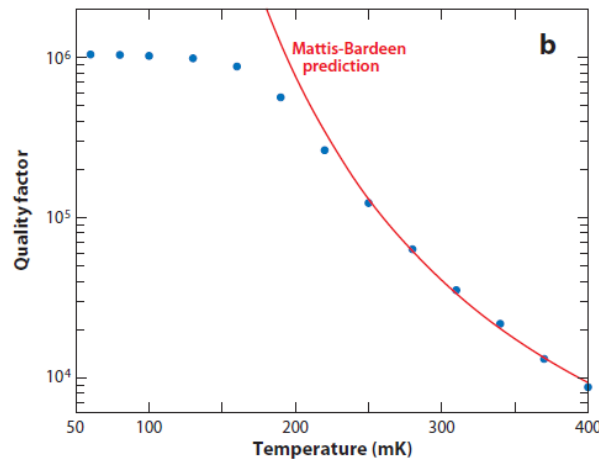
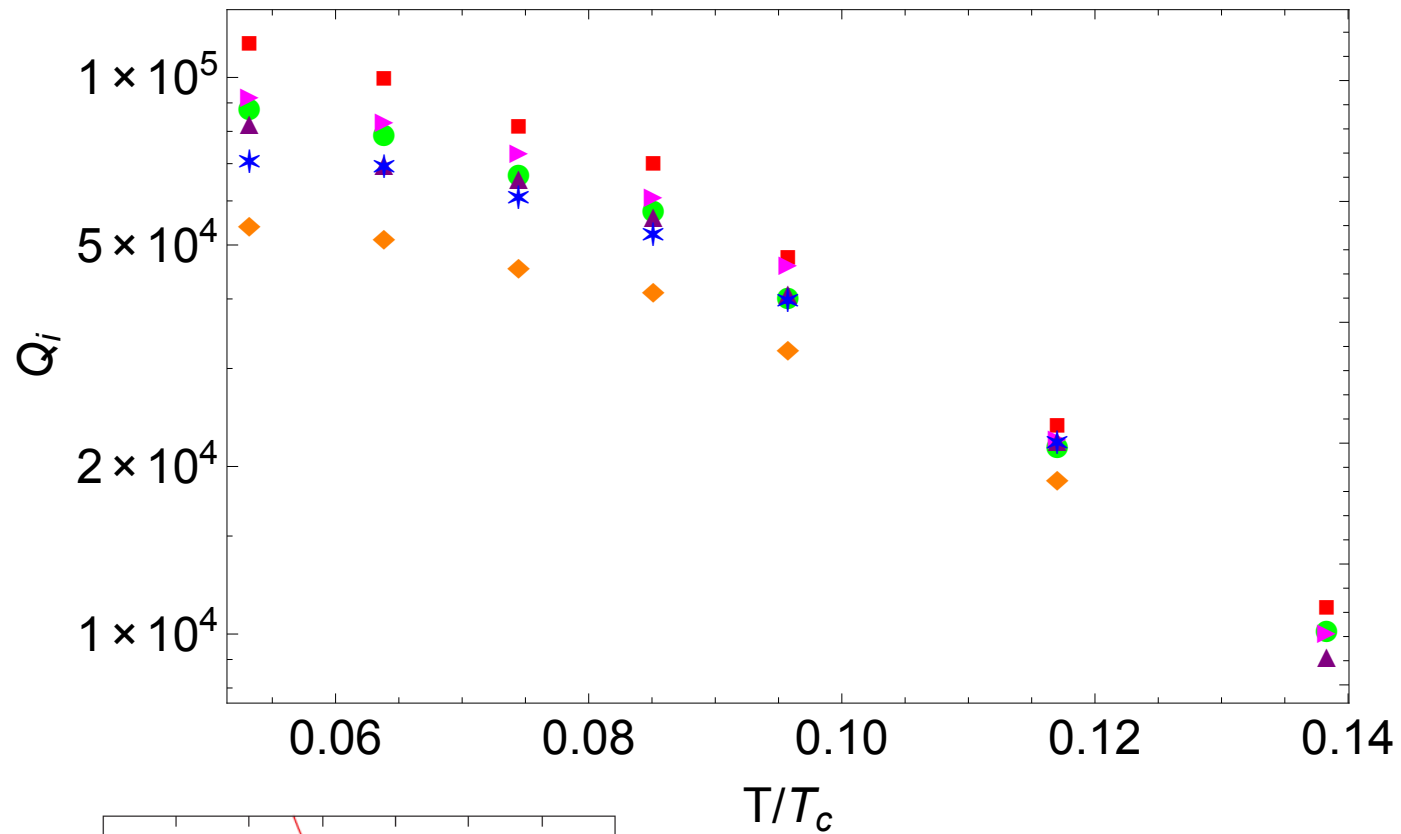
Resonator characterization



$Q_i \sim 100,000$



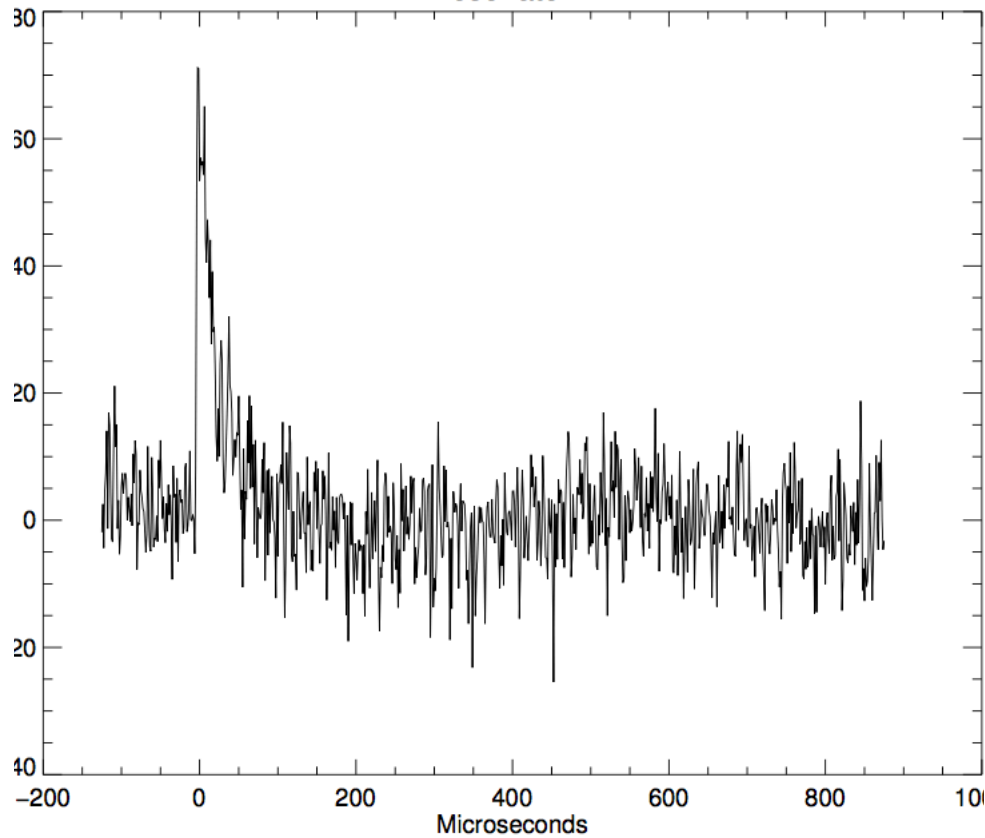
Temperature sweep



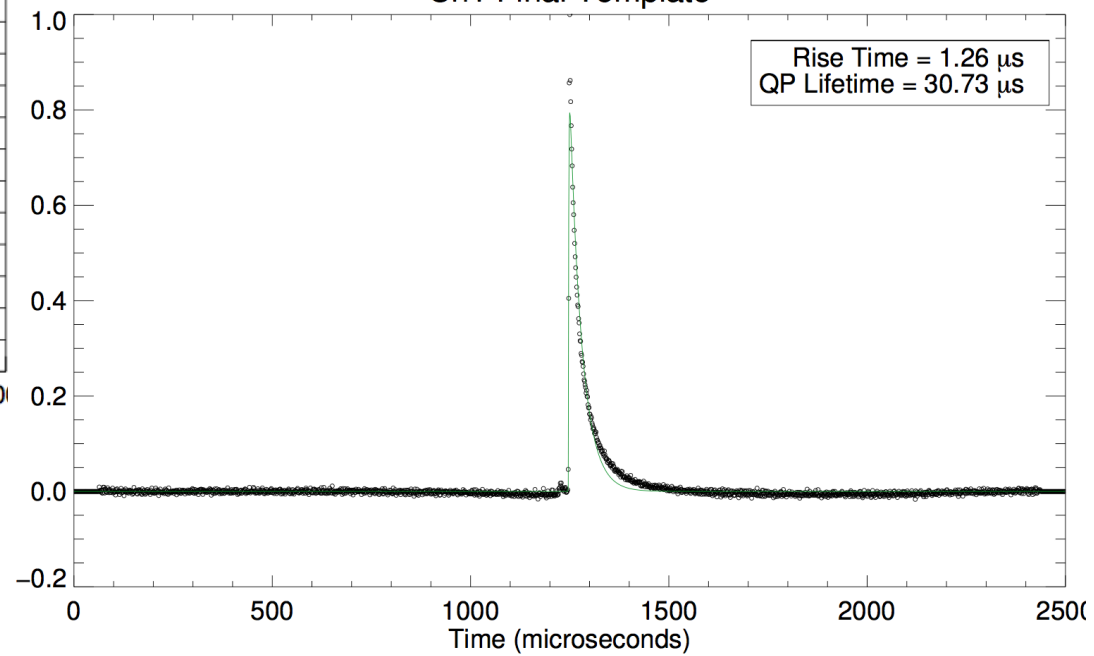
Zmuidzinas 2012
"Annual review of
Condensed Matter Physics"

Optical Pulses and Quasiparticle Lifetime

Resonator 1

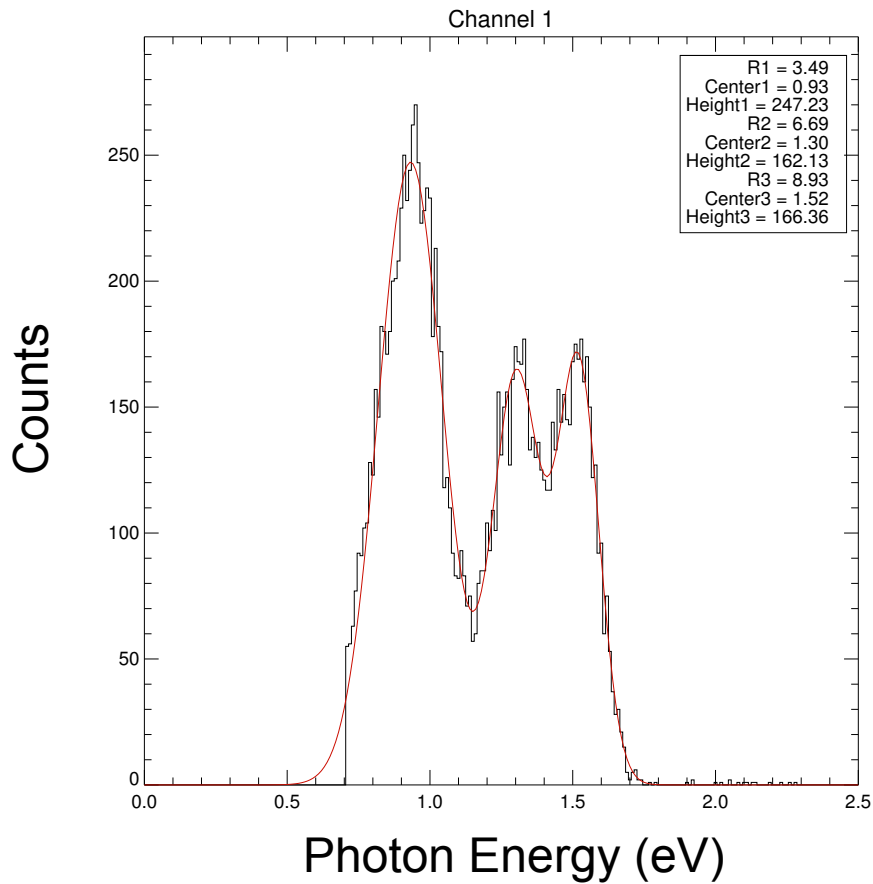


Ch1 Final Template



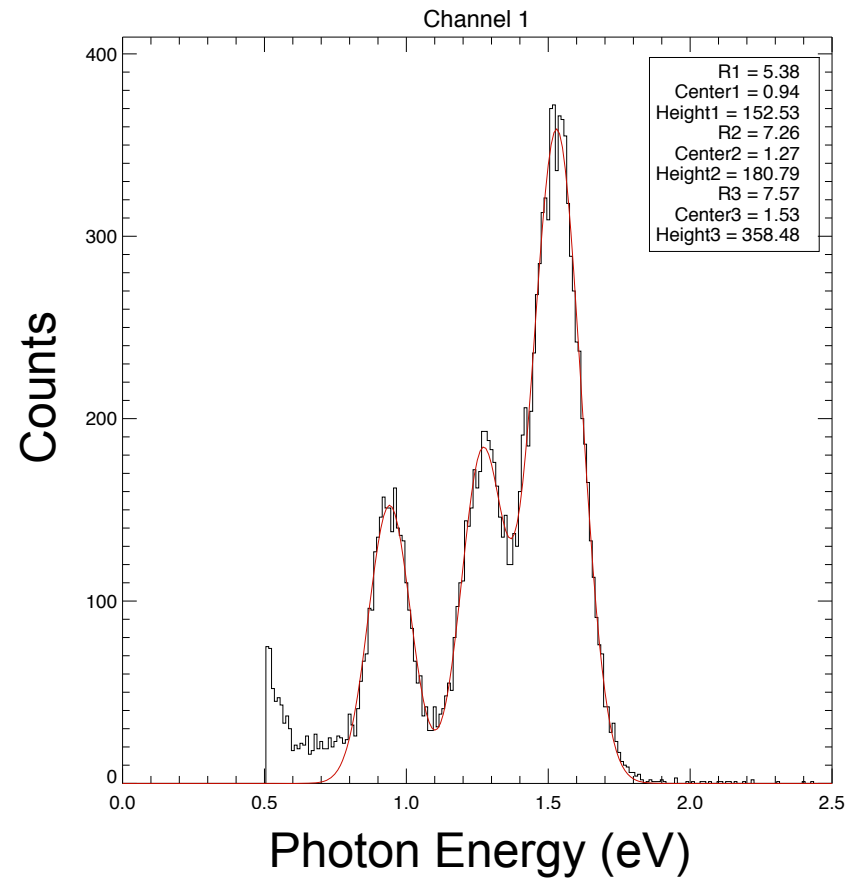
Energy resolution

Hafnium



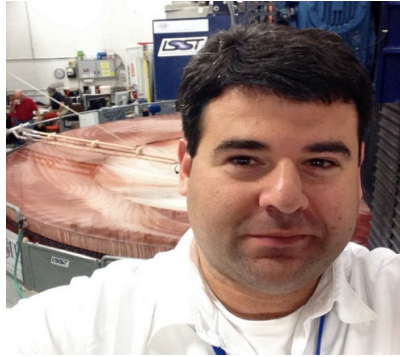
R=8.9@808nm

PtSi



R=7.6@808nm

UCSB



Benjamin A. Mazin



Grégoire Coiffard



Paul Szypryt

JPL

Bruce Bumble

Hafnium MKIDs: Conclusions and Future work

Summary:

Kinetic inductance fraction ~95%

Resistivity ~80 $\mu\Omega$ cm

Uniformity ~5% on a 3" wafer

Noise is comparable to PtSi and TiN lumped element resonators

Q_i~100,000

Quasiparticle lifetime ~30 μ s

R~8.9 at 808nm

Next steps:

Reducing T_c:

- higher sputtering pressure and/or lower sputtering rate to reduce stress
- annealing

Improving uniformity of sputtered film

Improve heat sinking and build a box in a box setup

Optimize film thickness