Developing AlMn films for Argonne TES fabrication

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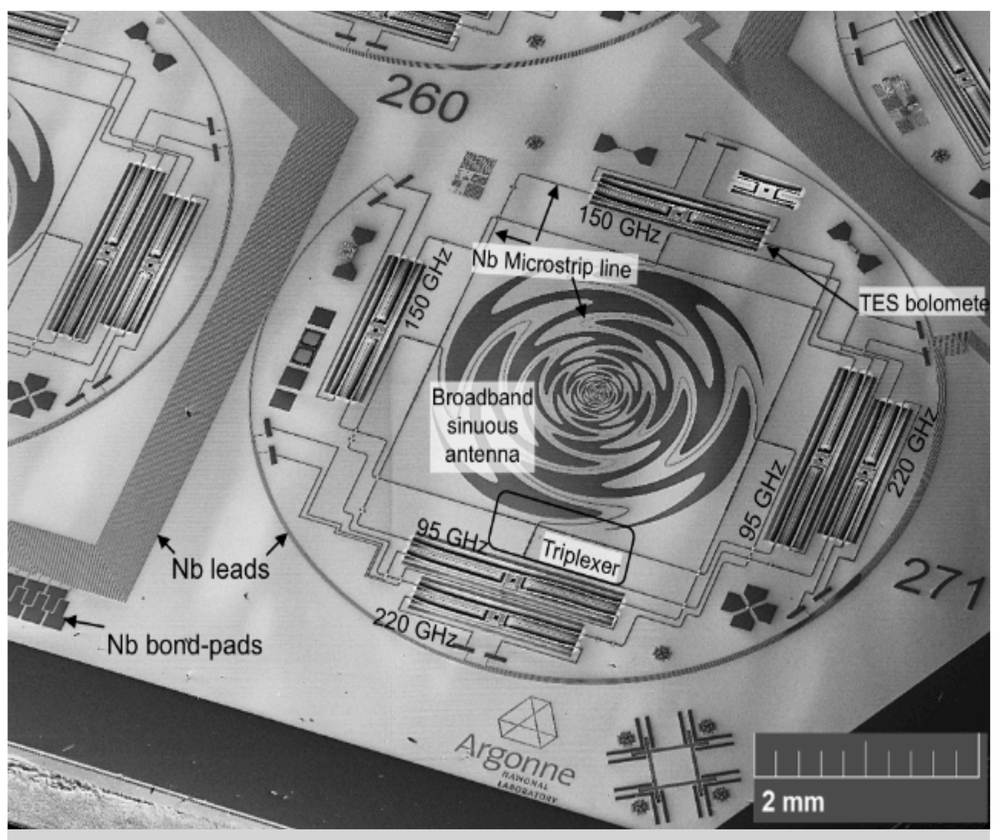
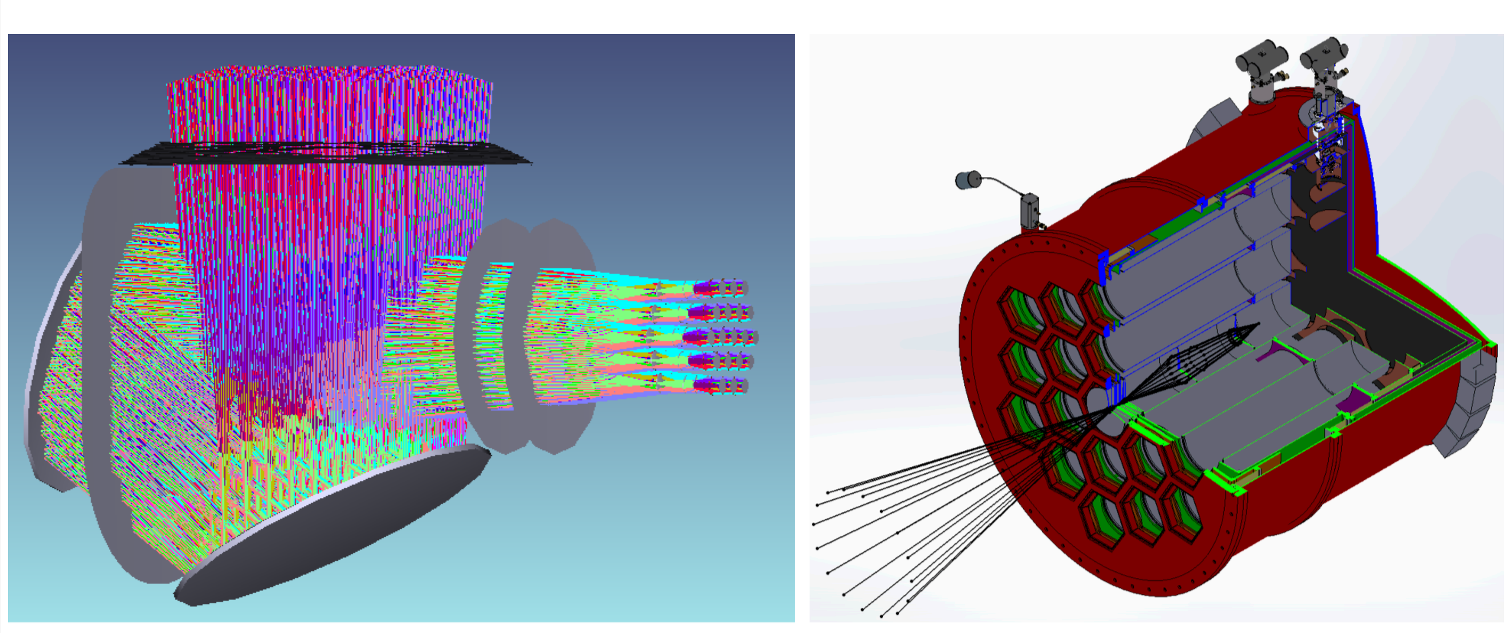


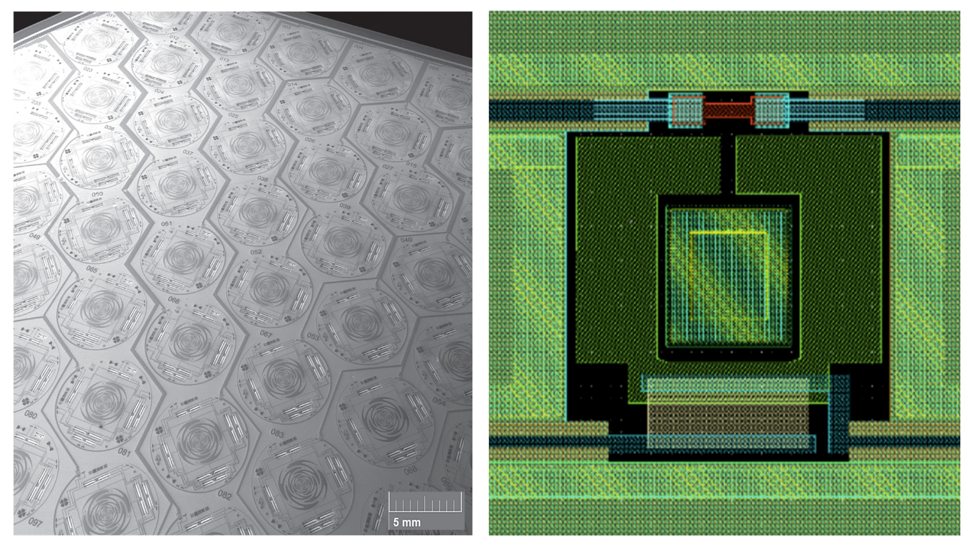
Argonne polarization-sensitive, multichroic array

CMB-S4: Improved measurements for cosmology via cosmic microwave background (CMB) polarization, SZ effects and galaxy clusters, to constrain dark energy, neutrino physics, signatures of inflation



Left: Raytrace of a CMB-S4 19 optics tube 6-m telescope design [1]
Right: Preliminary design for a 19 optics tube cryostat [1,2]

Will use large arrays of transition edge sensor (TES) bolometers coupled to Superconducting Quantum Interference Device (SQUID)-based readout systems. AlMn TESes: simple single layer film manufacturing, highly uniform arrays over large wafers [1]



Left: Fabricated SPT-3G multichroic pixel array [5]
Right: TES geometry can be tuned for desired R_N

We are developing and testing the **fabrication process** for **Argonne AlMn TESes** to be used in **next generation CMB experiments**.

The targets are a **critical temperature of 150-200 mK** and a **normal resistance of 10-20 mOhms**.

For **more information**, take a picture

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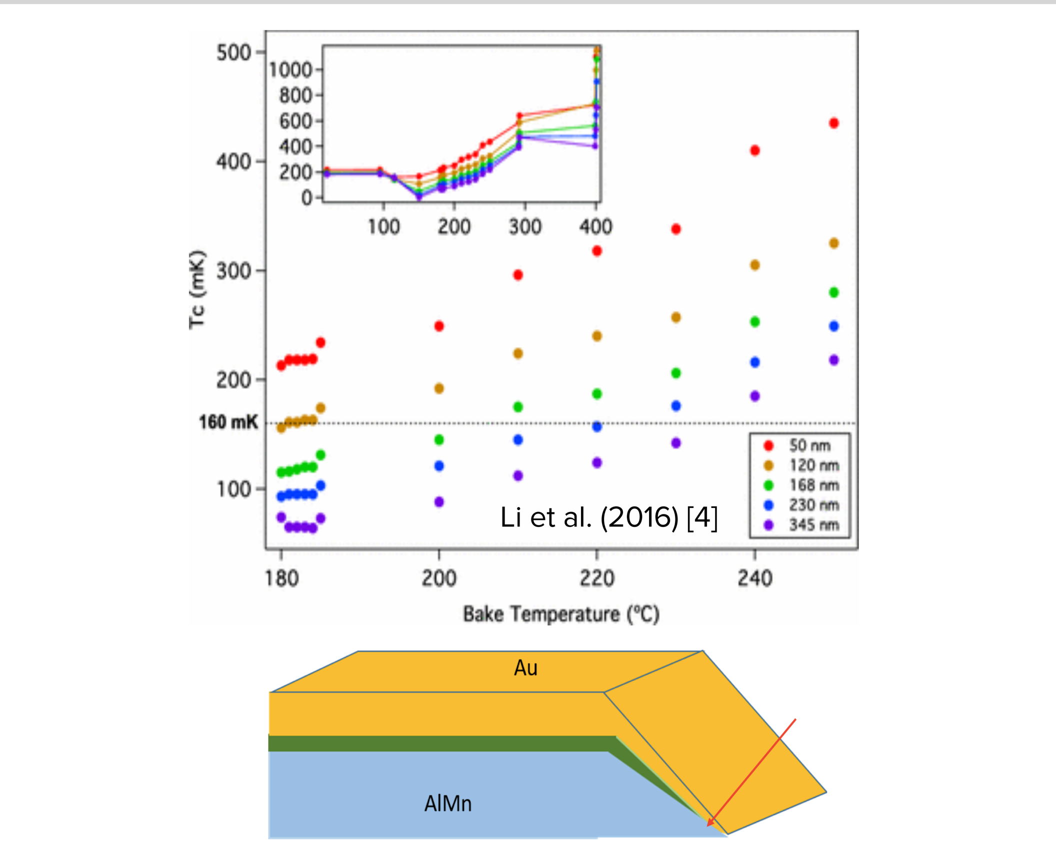
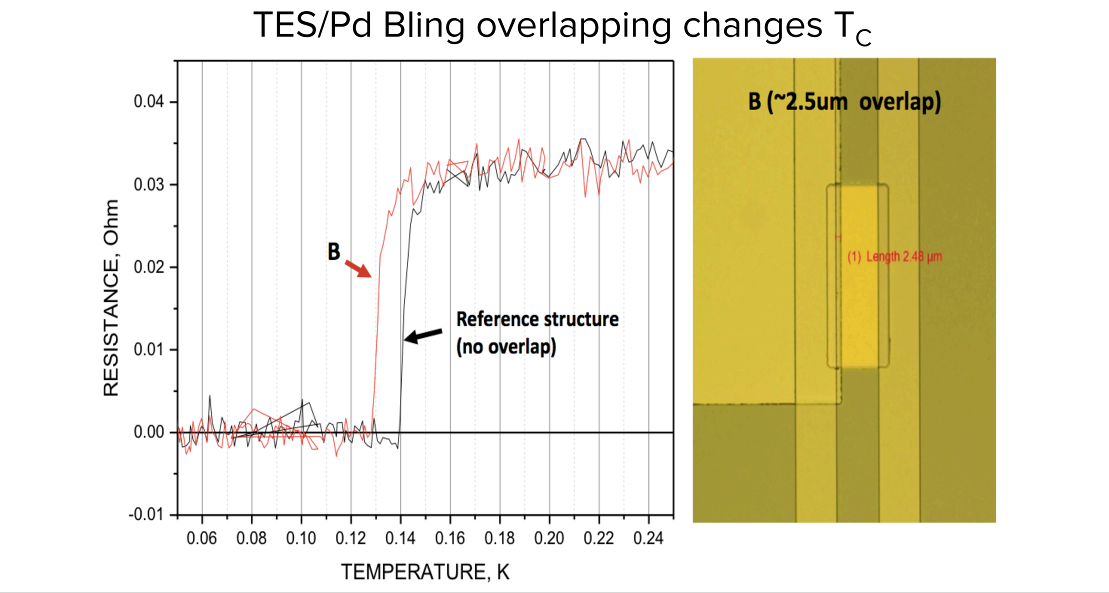
T_C primarily set by Mn concentration and fabrication temperature, as described in Li et al. (2016) [4]



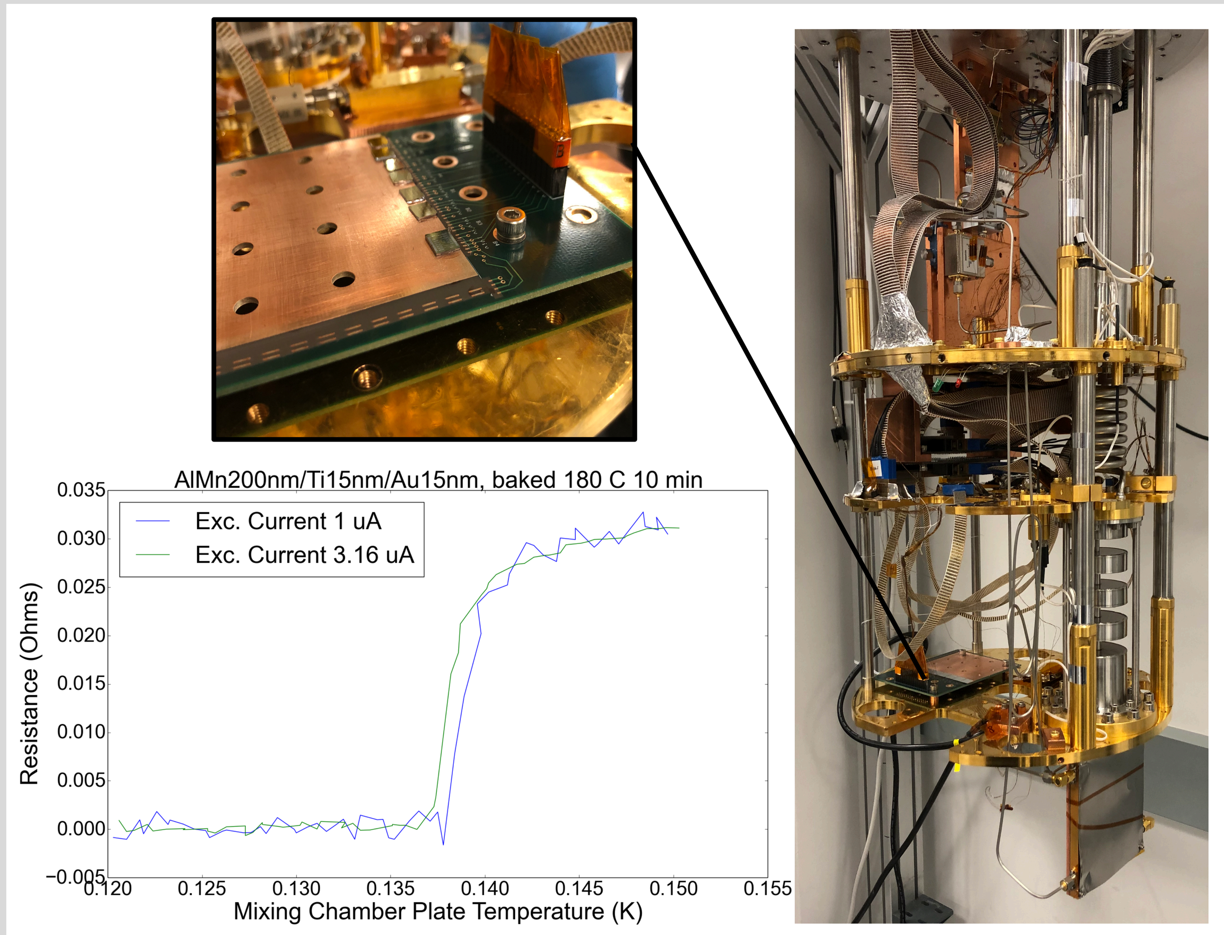
X-section of AlMn/Ti/Au multilayer structure edge after lift-off process. Direct contact of Al, Au (red arrow) causes variation of SC properties.

Deployed SPT-3G array: T_C = 420 mK, R_N = 2 Ω. To use this technology for CMB-S4: T_C ~150-200 mK (decreased T_{bath} reduces thermal fluctuation noise), R_N ~10-20 mΩ (for TDM or uMUX readout). $AlMn_{2000ppm}$ with different thicknesses tested. Repeatable result: $AlMn_{2000ppm}$ 200nm/Ti15nm/Au15nm, modified geometry to get R_N ~20mΩ, Pb bling-TES lateral proximity tested.

TES/Pd Bling overlapping changes T_C

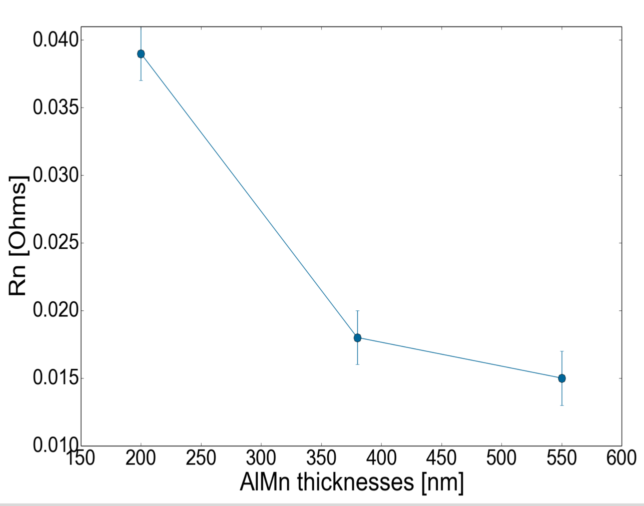


Fabrication process (deposition layers, geometry, baking time and temp., etc.) affect TES T_C, R_N [3]. Argonne devices fabricated in various ways to compare designs and methods.

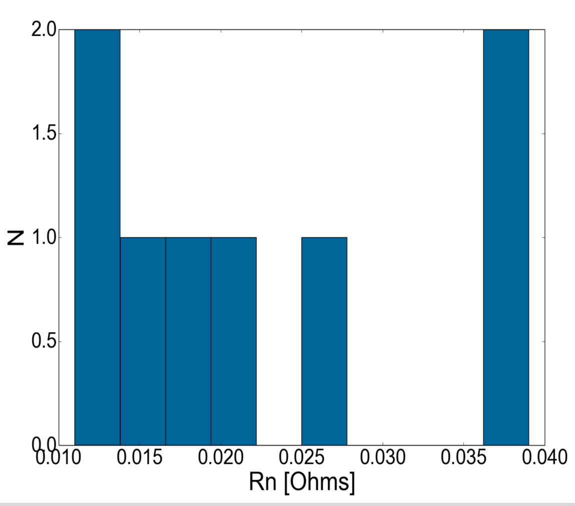


Right: Interior of the Bluefors LD dilution refrigerator test bed at Cornell, with close-up of 4-lead board bonded to Argonne samples.
Left: T_C measurement and variation with excitation current

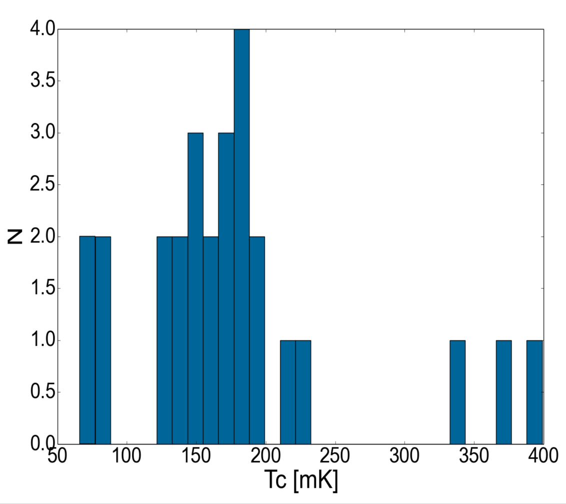
Measured the critical temperature and device parameters of Argonne samples and TESes at Cornell, using 4-lead measurements and SQUID-based TDM readout. T_C was found to vary with baking temperature, materials, and design. Optimization and testing of the Argonne devices for CMB-S4 is ongoing.



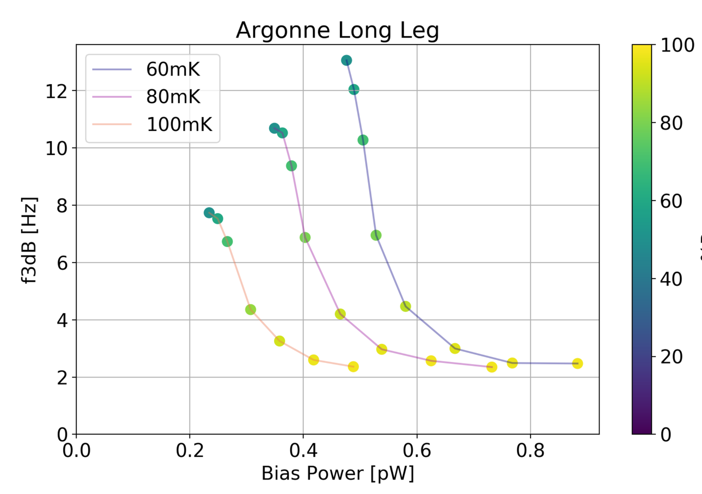
Measured normal resistance vs. AlMn thickness of three TESes



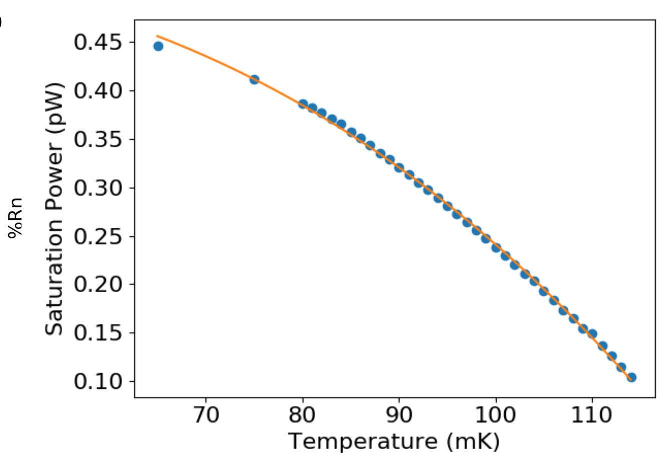
Histogram of measured R_N for TESes



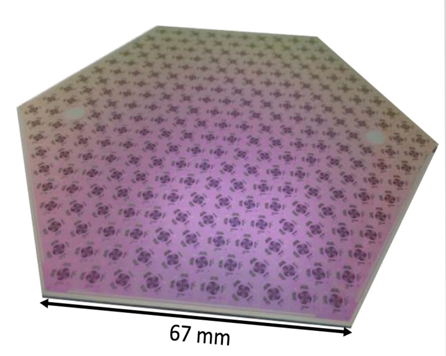
Histogram of measured T_C for films and devices



TES time constant measurements



TES Psat/IV analysis



Future: Test new arrays using 4-lead measurements and IVs

Cornell University · Argonne National Laboratory · The University of Chicago · NSF · U.S. Department of Energy Office of Science

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Acknowledgements
Work at Argonne, including use of the Center for Nanoscale Materials, an Office of Science user facility, was supported by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences and Office of High Energy Physics, under Contract No. DE-AC02-06CH11357. This material is based upon work supported by the National Science Foundation Graduate Research Fellowship Program under Grant No. DGE-1650441 and NSF CAREER award #1454881.