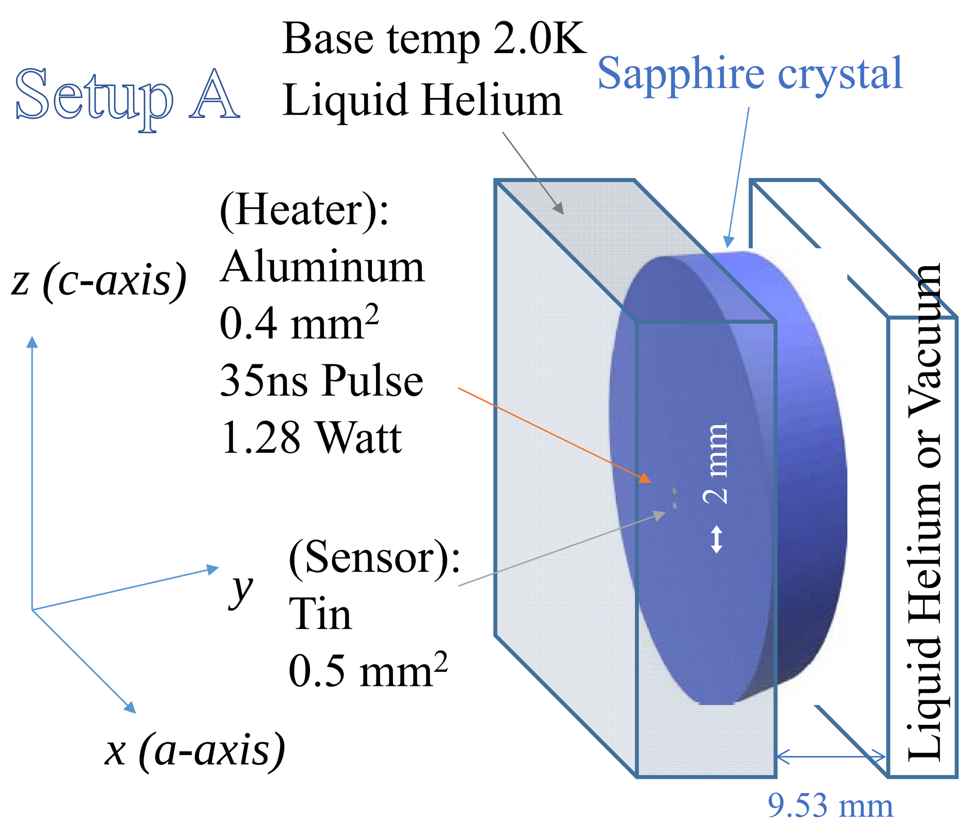
A model on heat signal of crystal detector at low temperature

Jin Li, Inwook Kim

Center for Underground Physics, Institute for Basic Science (IBS), Daejeon, Korea

Contact: lijin1201@gmail.com



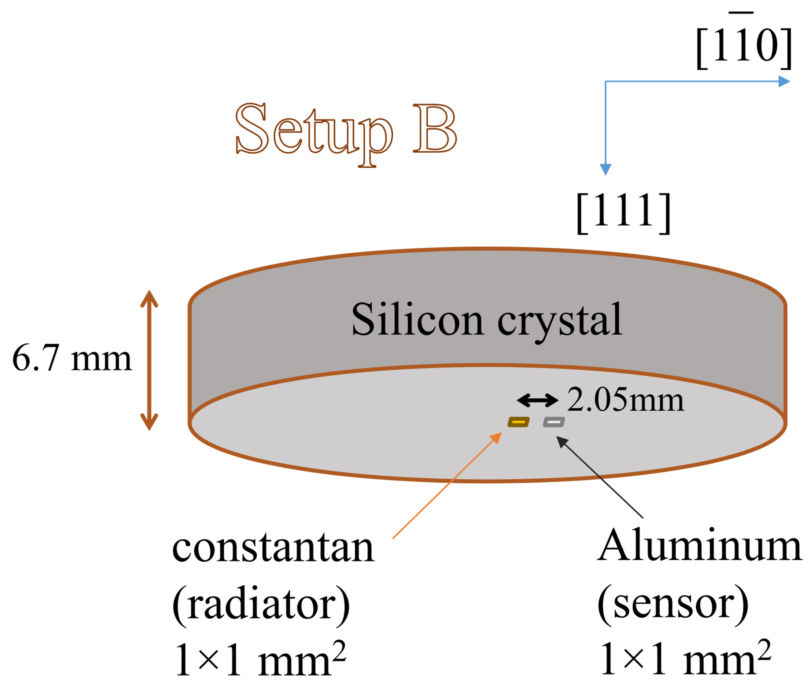
P. Taborek and D. Goodstein, Phys. Rev. B **22**, 1550 (1980)

Abstract

We present a model to calculate heat signal shapes from low temperature bolometer attached to a crystal. It can be used to understand and predict signals of real detectors. The comparisons between our model and real data show excellent agreement.

Motivation

With the development of low temperature detectors, there is a growing interest in understanding the observed signals from basic physical principles. Previous attempts are either limited in time scale or in type of physics processes considered. Thus a new way to quantitatively describe the observables is needed.

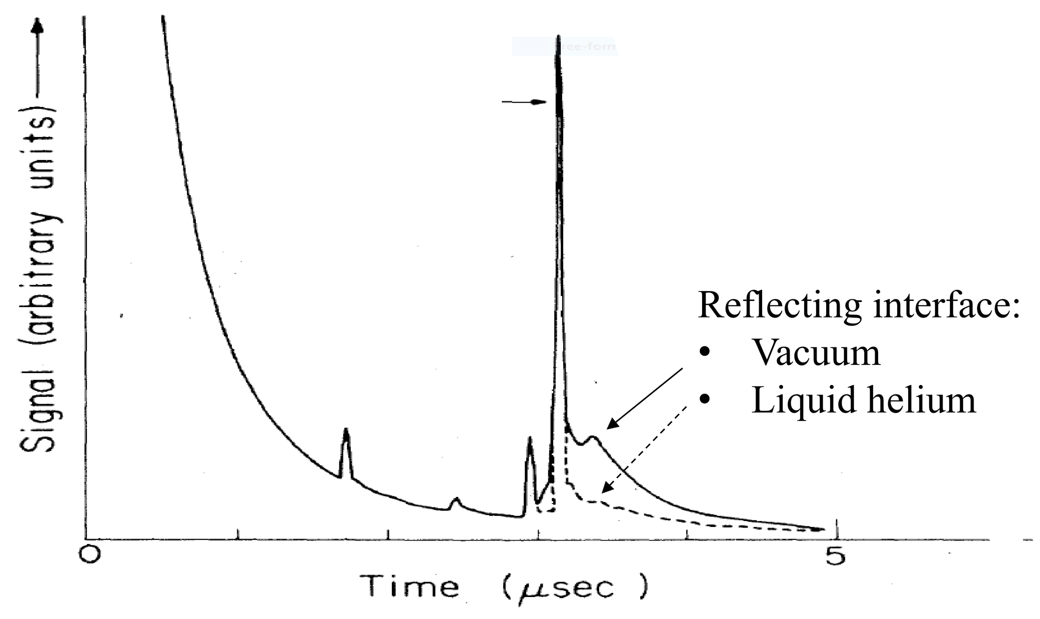


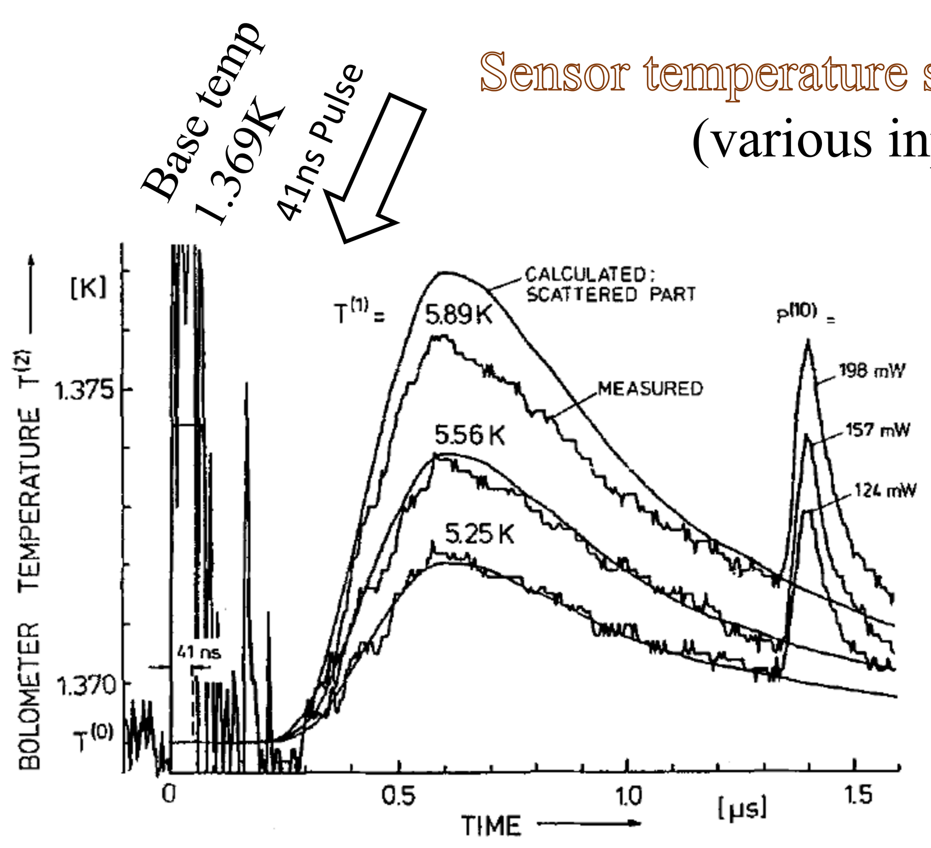
A. Mrzyglod, O. Weis: Z. Phys. B **97**, 103-112 (1995)

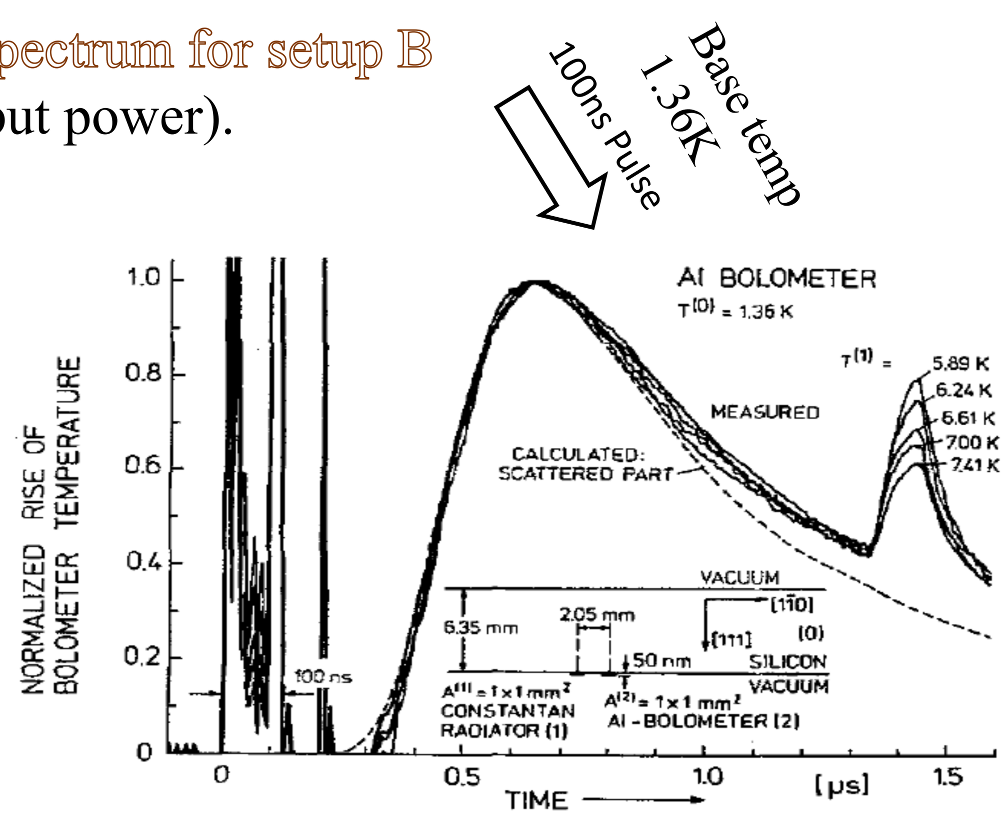
Sensor power input spectrum for setup A

Sensor temperature spectrum for setup B (various input power).

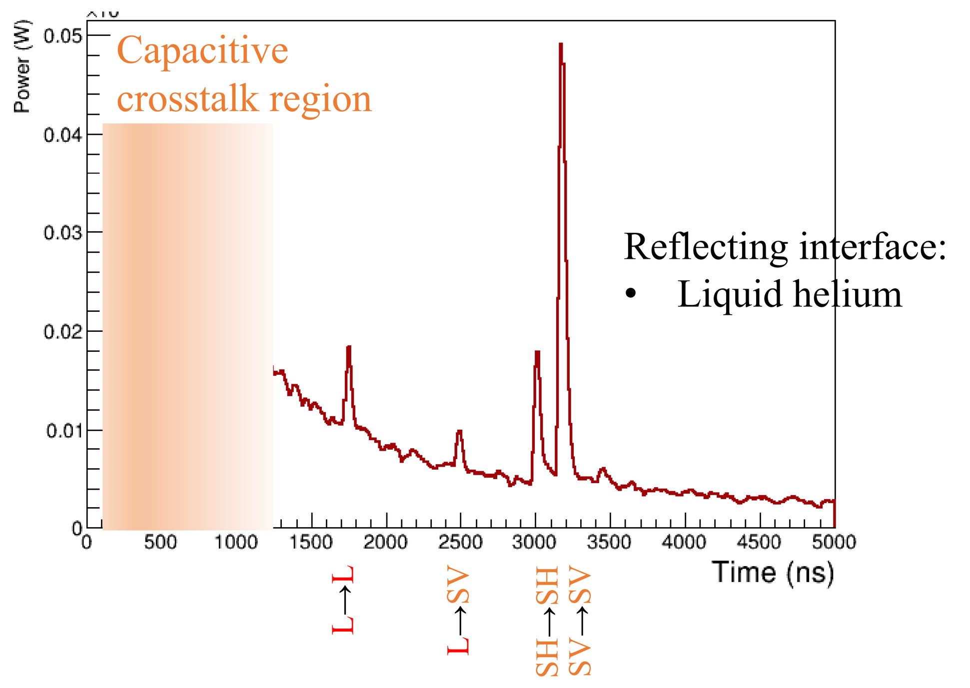
Real Data

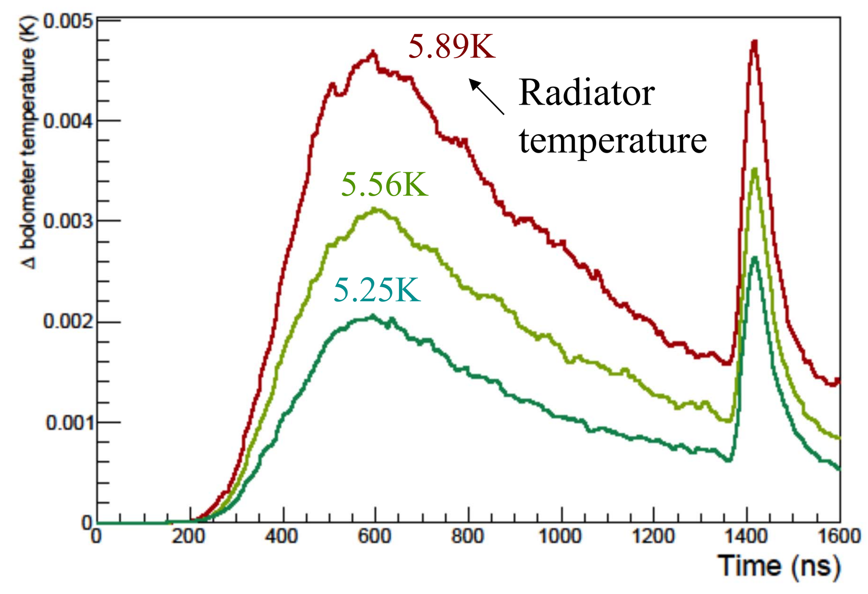


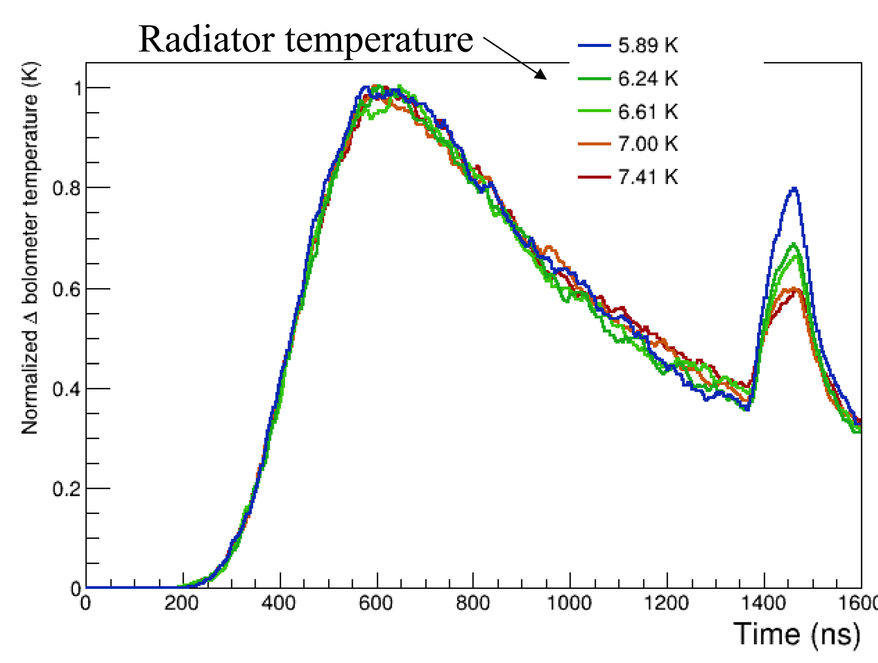




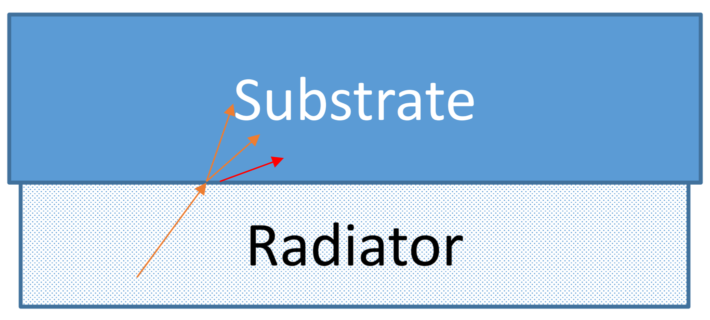
Simulation





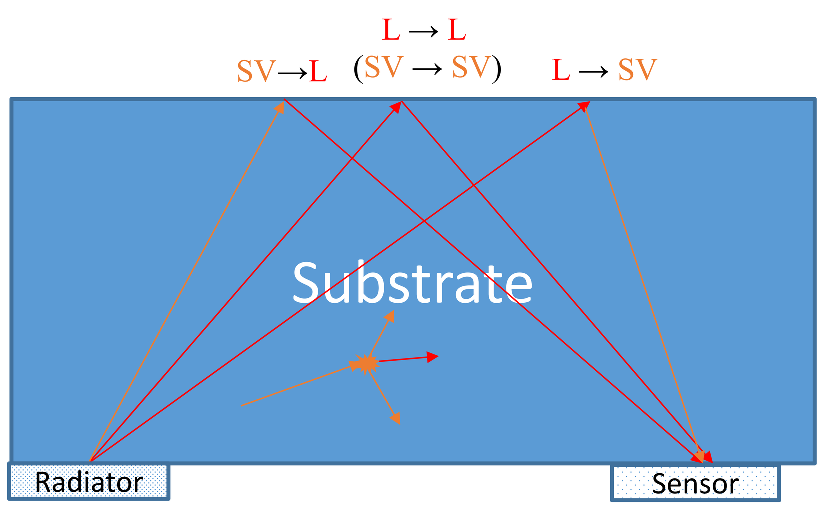


Physical Processes in simulation



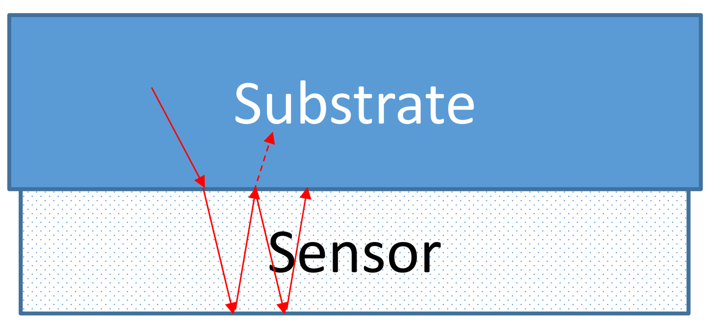
- Spectral Power distribution in Radiator
- Spectral half-space radiation
- $\vec{q}$-space source distribution from differential emissivities

1. Weis, O.: Z. Angew. Phys.**26**, 325 (1969).
2. Bayrle, R. & Weis, O. J Low Temp Phys (1989) **76**: 129.
3. Rösch, F. & Weis, O. Z Physik B (1977) **27**: 33.
4. Müller, G. & Weis, O. Z. Physik B - Condensed Matter (1990) **80**: 25.



- Phonon propagation
- Phonon scattering
- Phonon reflection at the boundary

5. J.P. Wolfe, Imaging Phonons, Cambridge Univ. Press, Cambridge, 1998.
6. Weis, O. Z. Physik B - Condensed Matter (1995) **96**: 525.
7. Weis, O. Z Physik B (1979) **34**: 55.



- Spectral Power absorption
- Spectral Power distribution and radiation for temperature rise

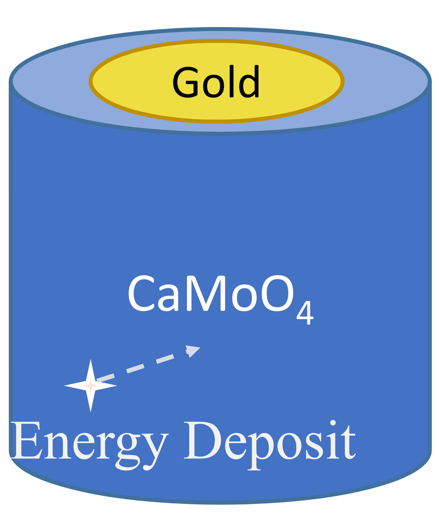
8. Mrzyglod, A. & Weis, O. J Low Temp Phys (1994) **97**: 275.
9. Goetze, M., Nover, M. & Weis, O. Z Physik B (1976) **25**: 1.

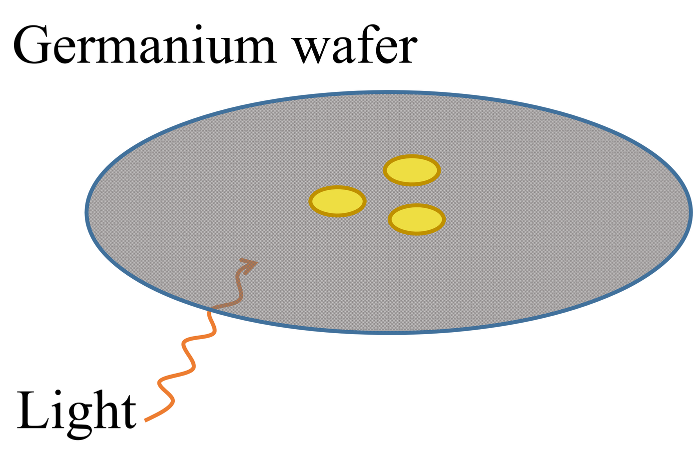
Comparison between existing calculation and our method

	Existing calculation	This work
Method	Numerical iteration	Simulation
Time range	Limited to the first reflection peak	No limit
Multiple scattering	Consider only one scatter (works on weak scattering limit)	No limit
Scalability and Shape	Restricted to thin geometry	No limit
Radiator and Sensor	Should be small compared to the crystal	No limit
Extension	Not straightforward to extend to other energy deposit types	Free to add additional physical process with different energy deposit process, and more …

What's next

Apply to detectors with large size and various shapes. Example @ AMoRE experiment:





Phonon generation from energy deposit by external particles.

Conclusions

A new model has connected the real signals of low temperature crystal and the underlying first principle physical processes. It is a result of combining the evolving computing technology and the basic theory of acoustic waves. Thus, from now, our community has a new tool to explain and predict the full series of data spectrum quantitatively.

This tool is expected to be useful when applying to larger and more complex experimental setups. Here, new questions in phonon physics may appear in the development of phonon-based detectors.

Thank you for your attention at this poster!