Dark matter search with superconducting detector

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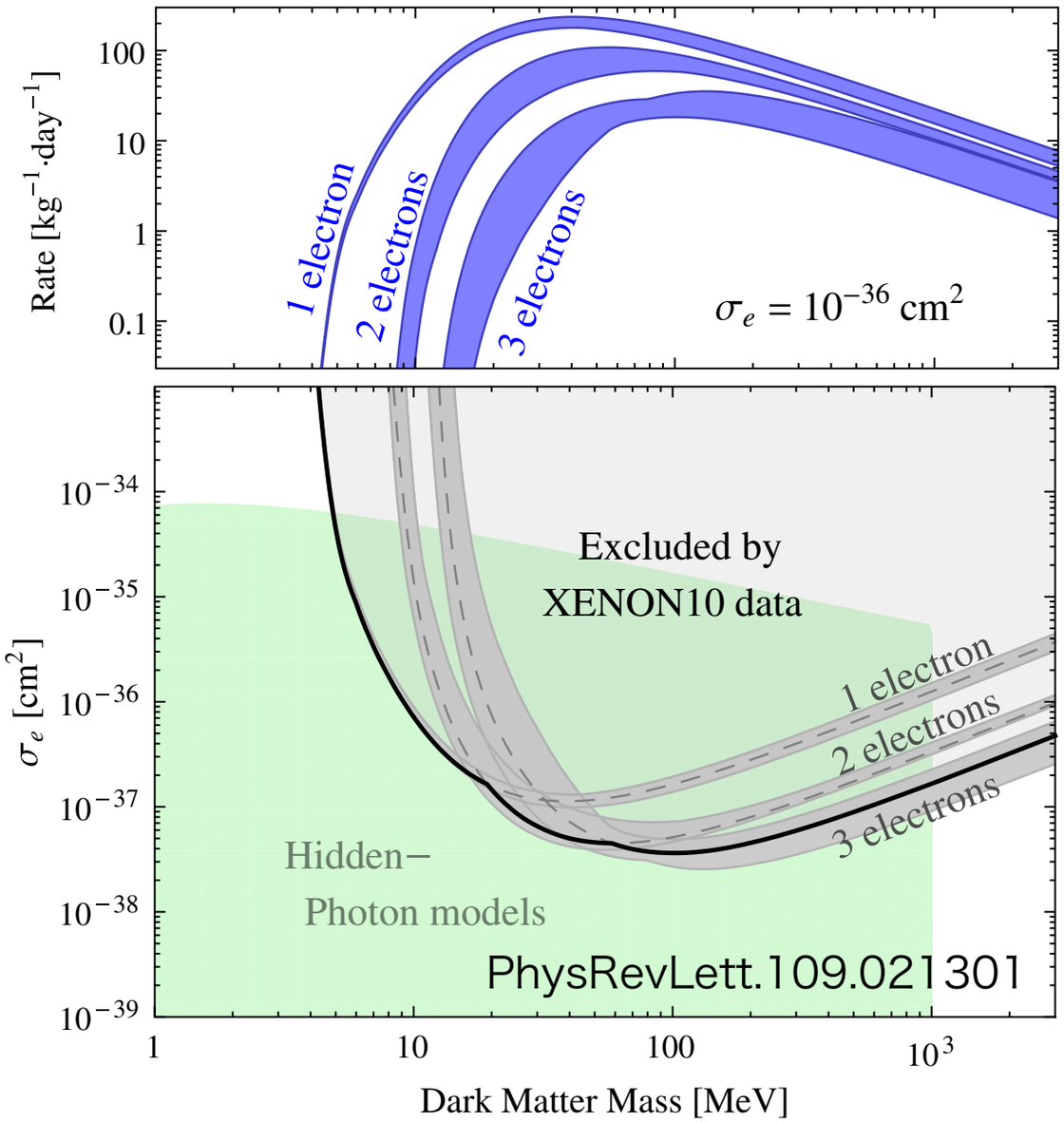
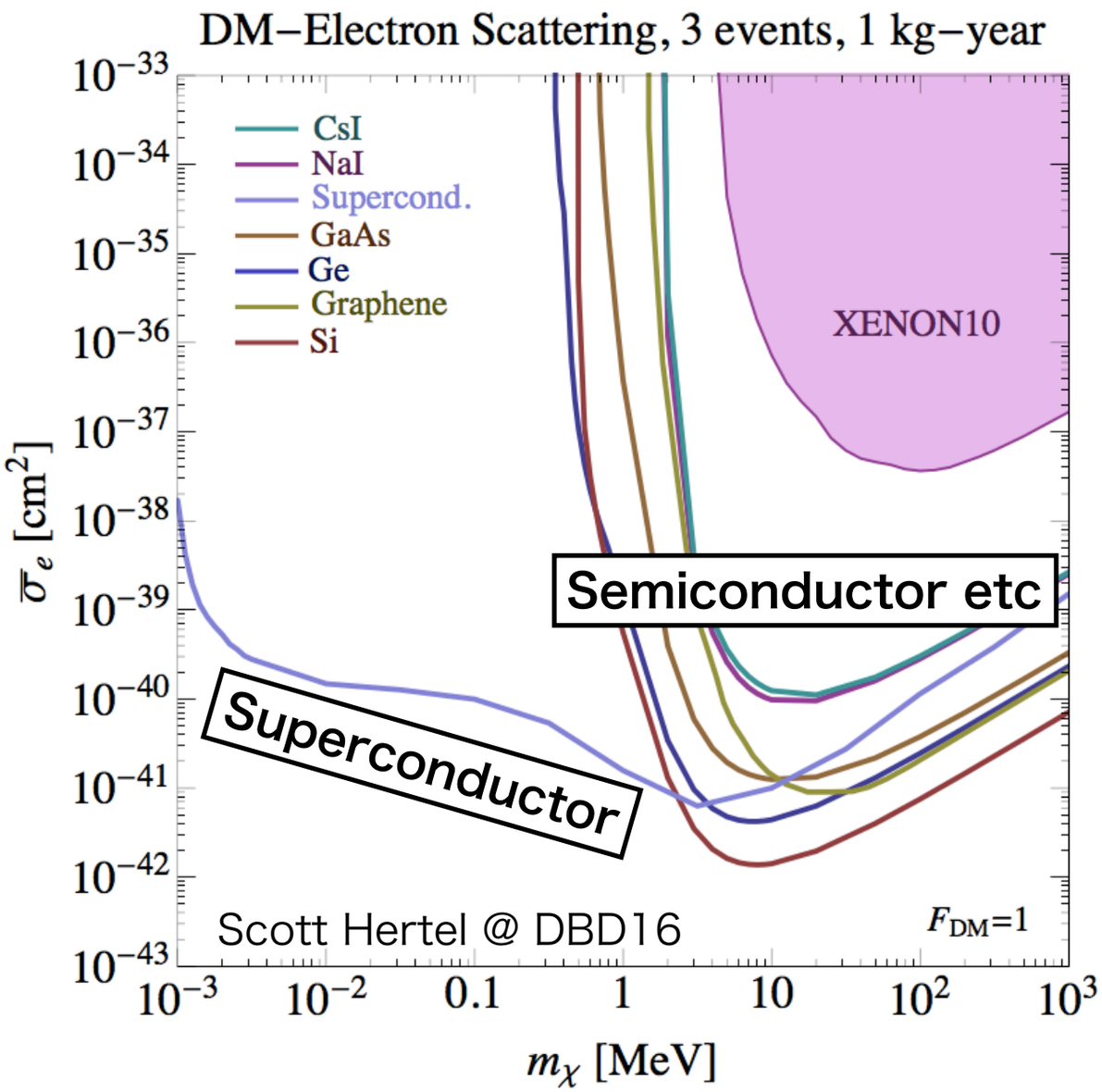
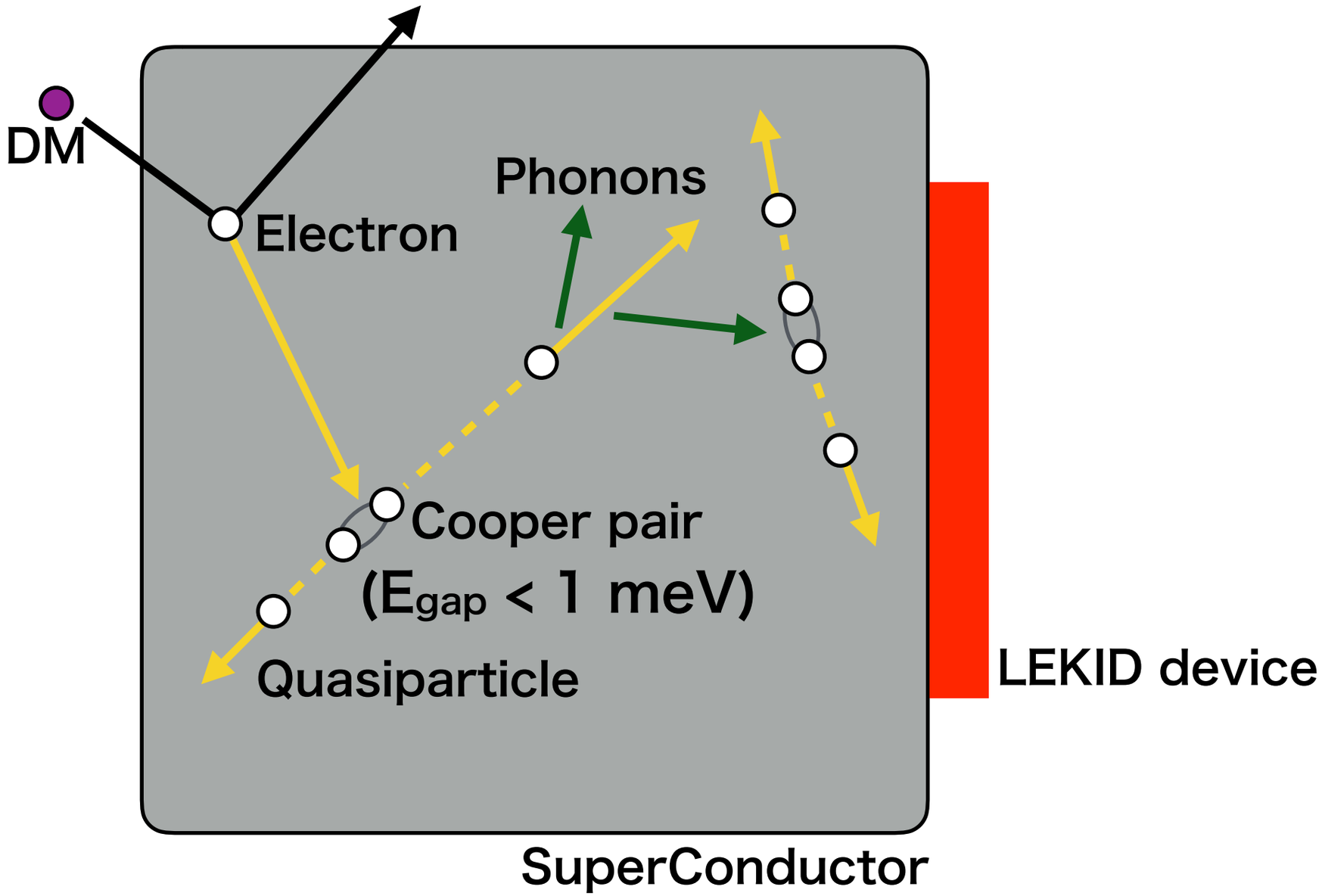
Motivation





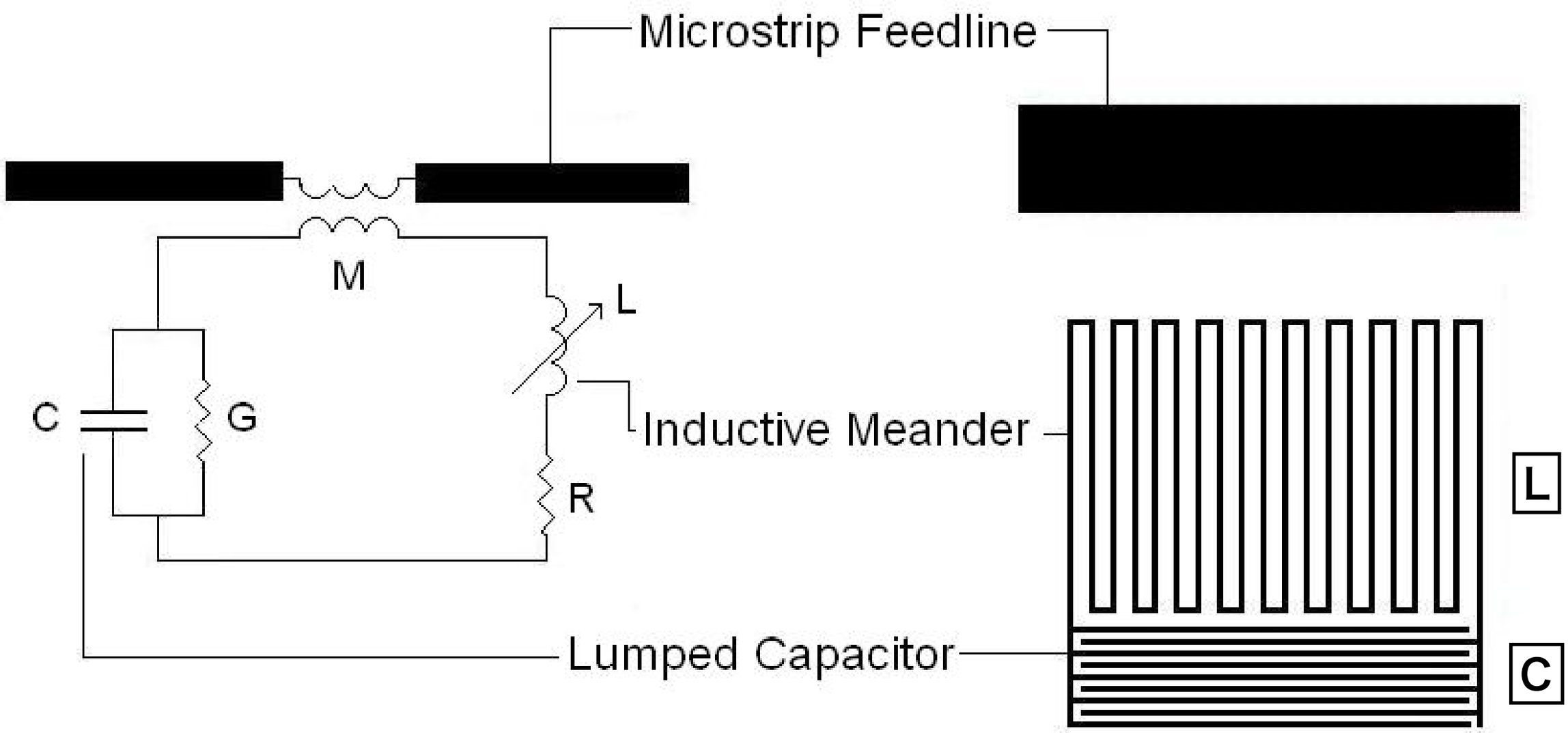
- Search for **DM interacting electrons** (hidden-photon, milli-charged DM etc)
- Aim to achieve **keV mass region** using superconducting target

Detection principle



- Electron recoiled by DM **breaks cooper pairs** in superconductor.
- Gap energy of cooper pairs is **enough low to observe keV mass DM**.

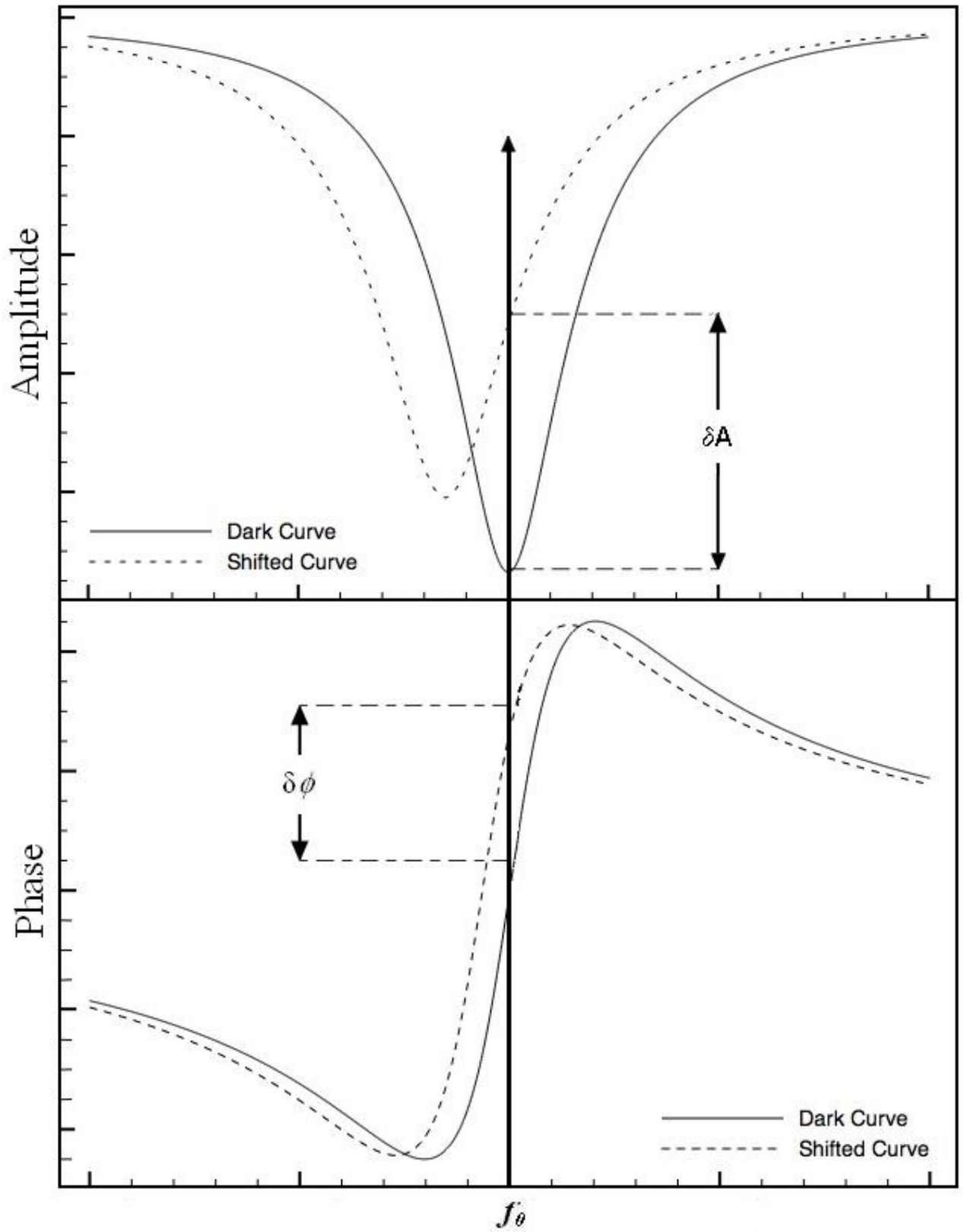
Lumped Element Kinetic Inductance Detector (LEKID)



$$f = \frac{1}{\sqrt{LC}}$$

- Read out “Resonant Frequency” alteration.
  - Phonons/quasi-particles change inductance in KID LC circuit.

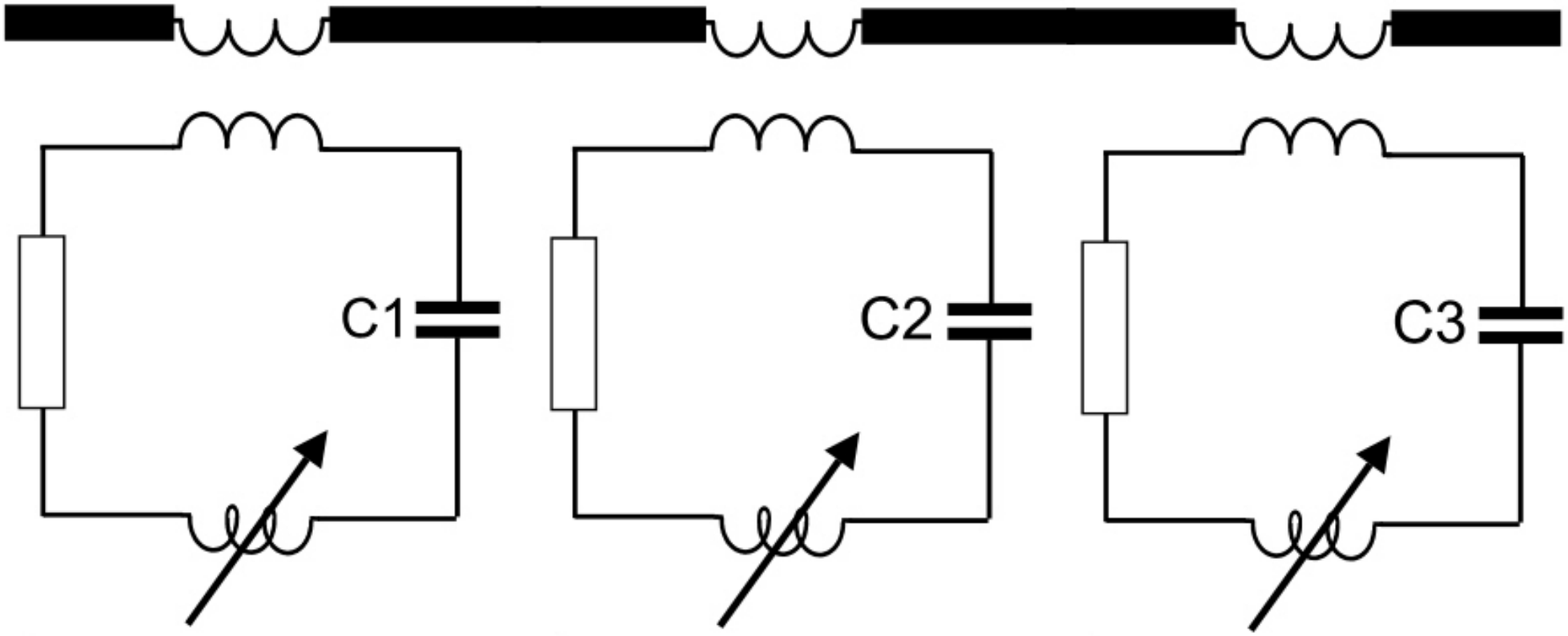
Lumped Element Kinetic Inductance Detector (LEKID)



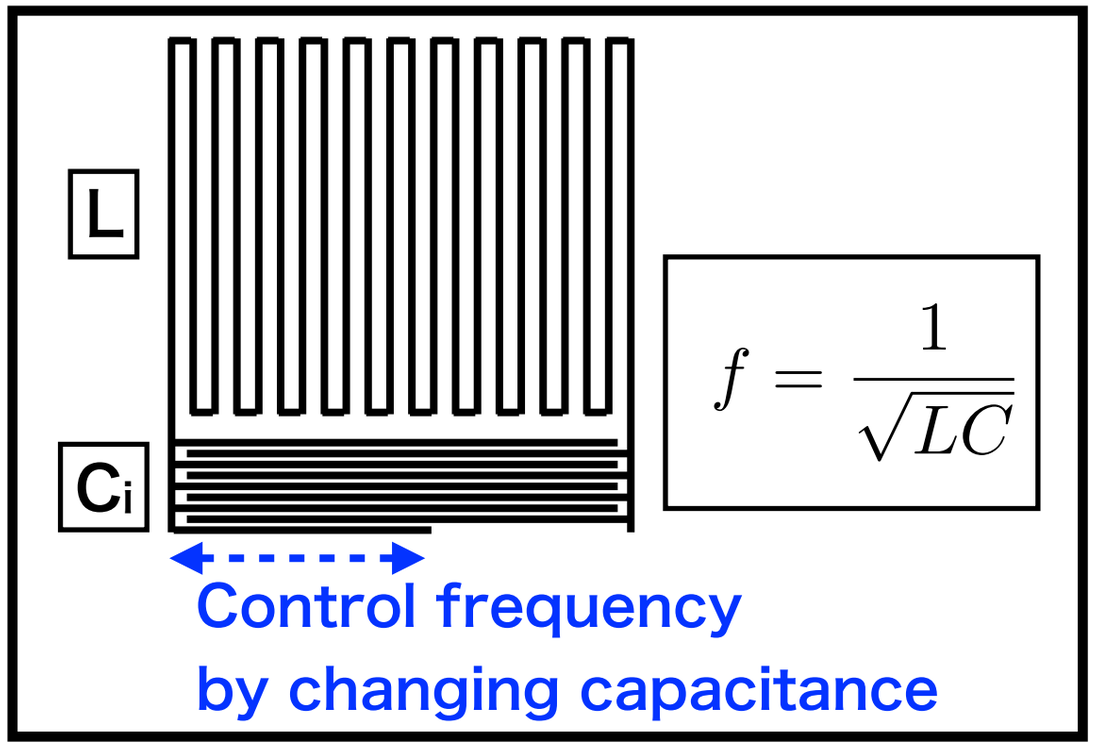
Simon Doyle Ph.D thesis(2008)

LEKID scalability

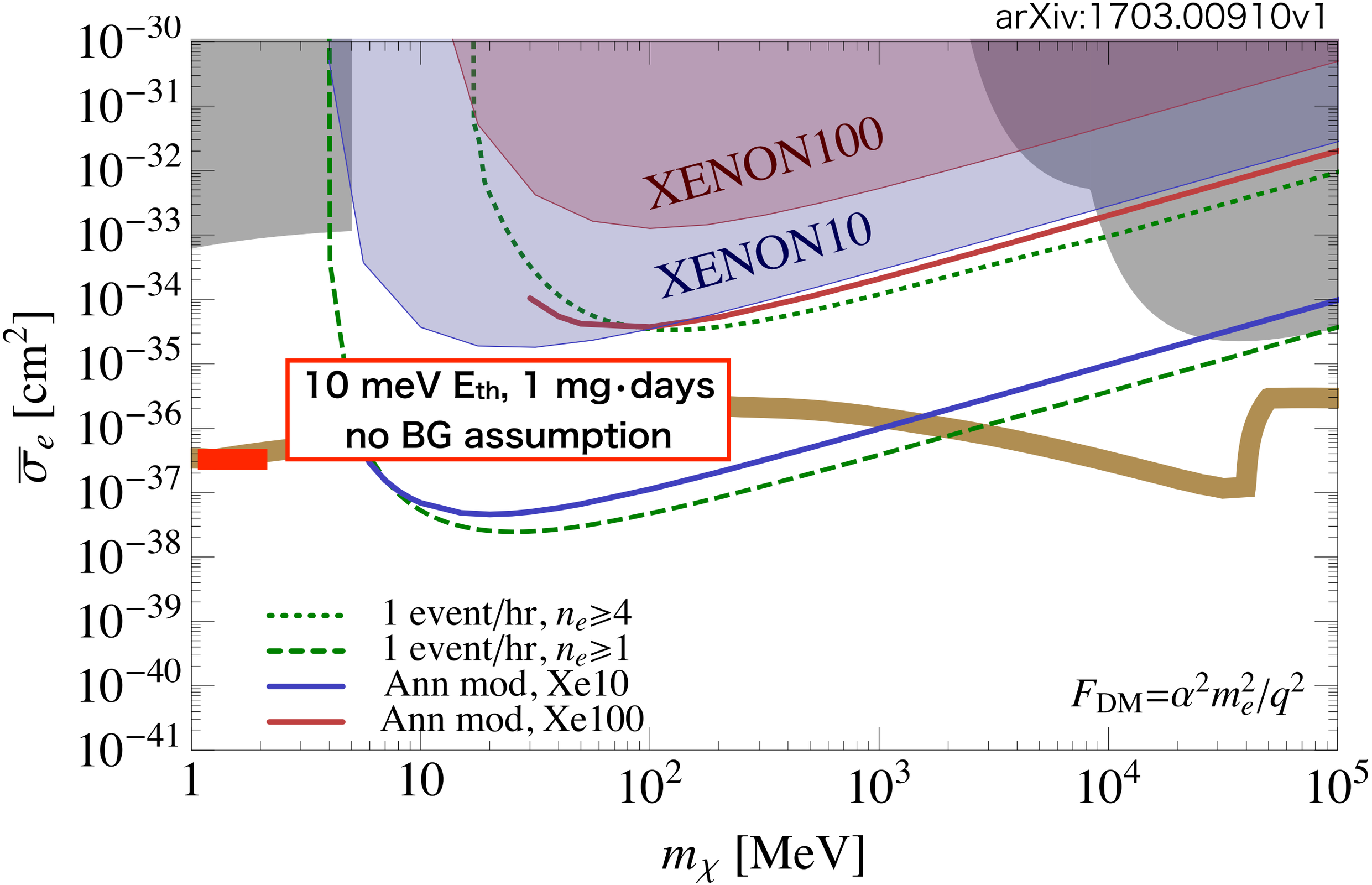
Simon Doyle Ph.D thesis(2008)



- **Multi resonators onto a single feedline**
  - Possible to connect
    over 100 LEKIDs by just 2 feedlines
  - Reduce heat inflow from signal line

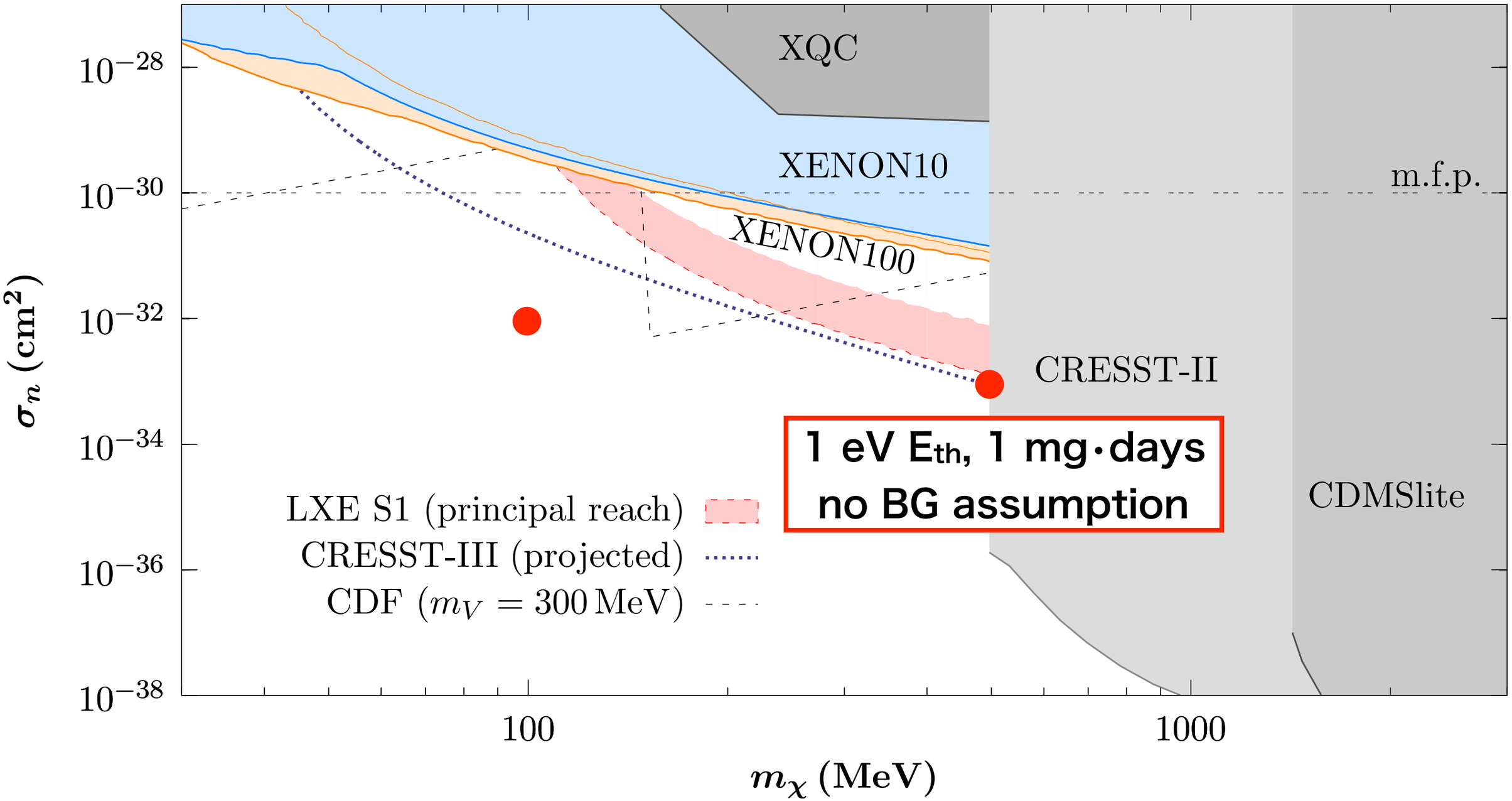


Expected sensitivity

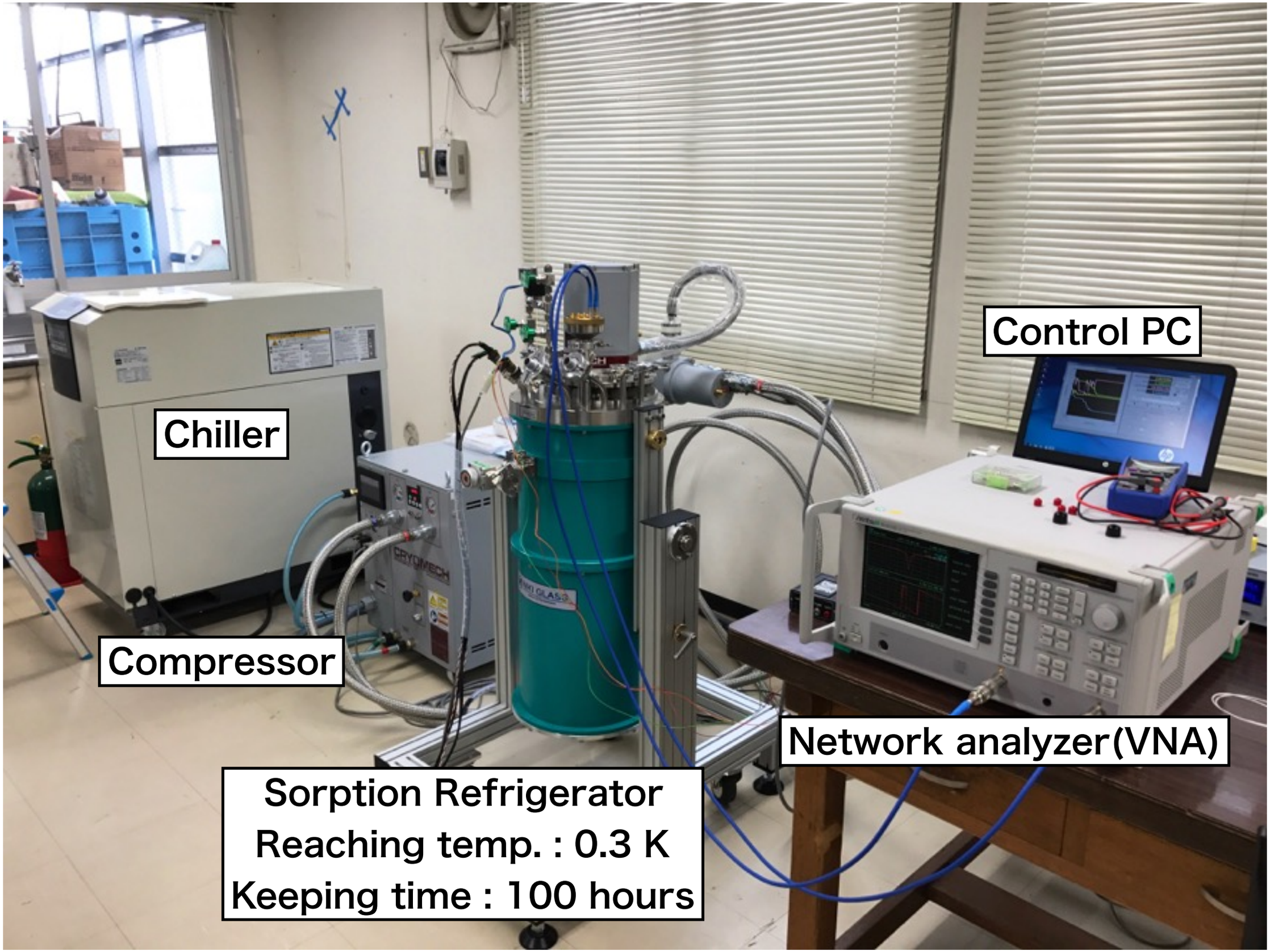


Expected sensitivity (nuclear recoil)

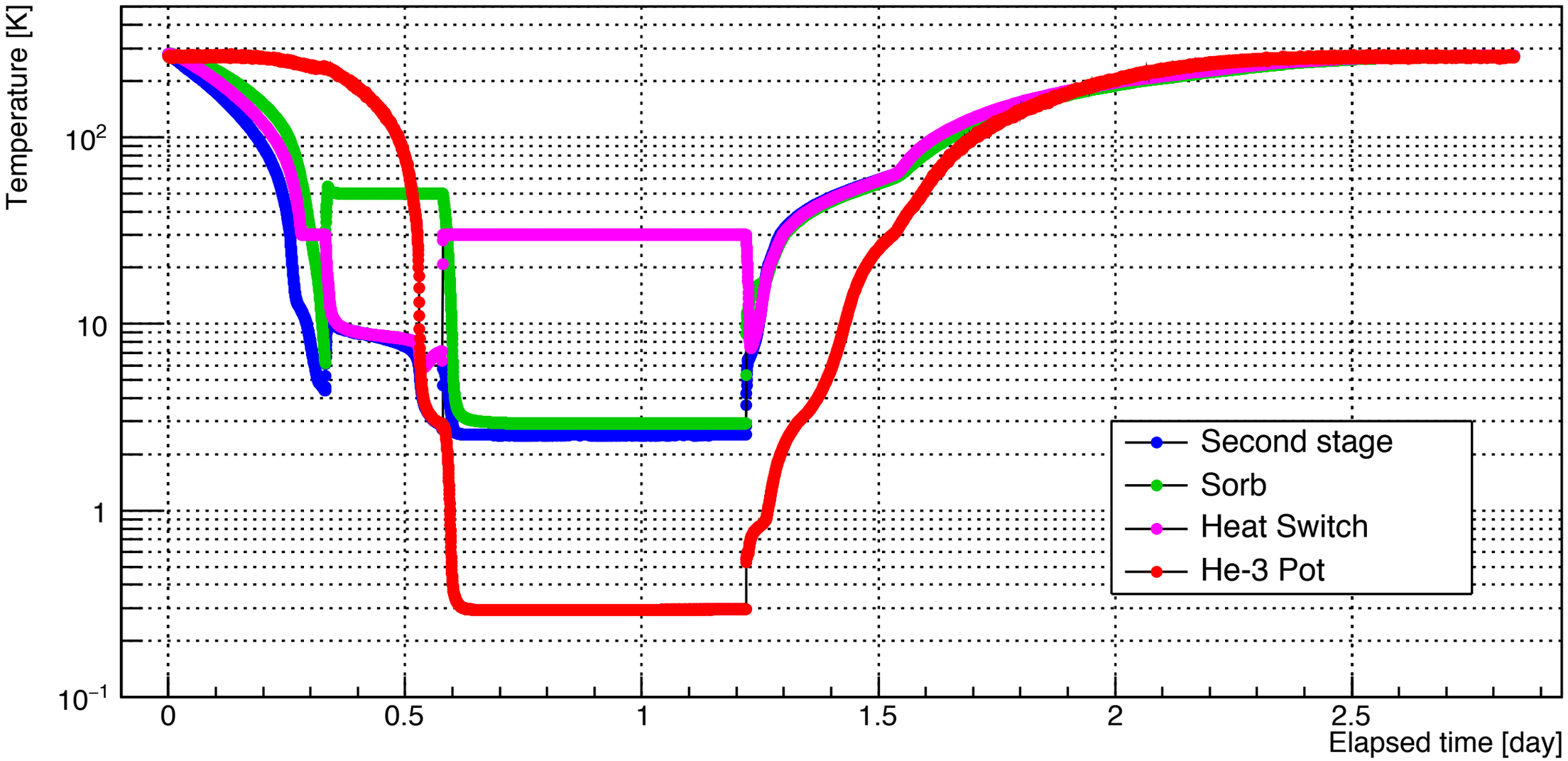
arXiv:1607.01789v2



Sorption refrigerator system

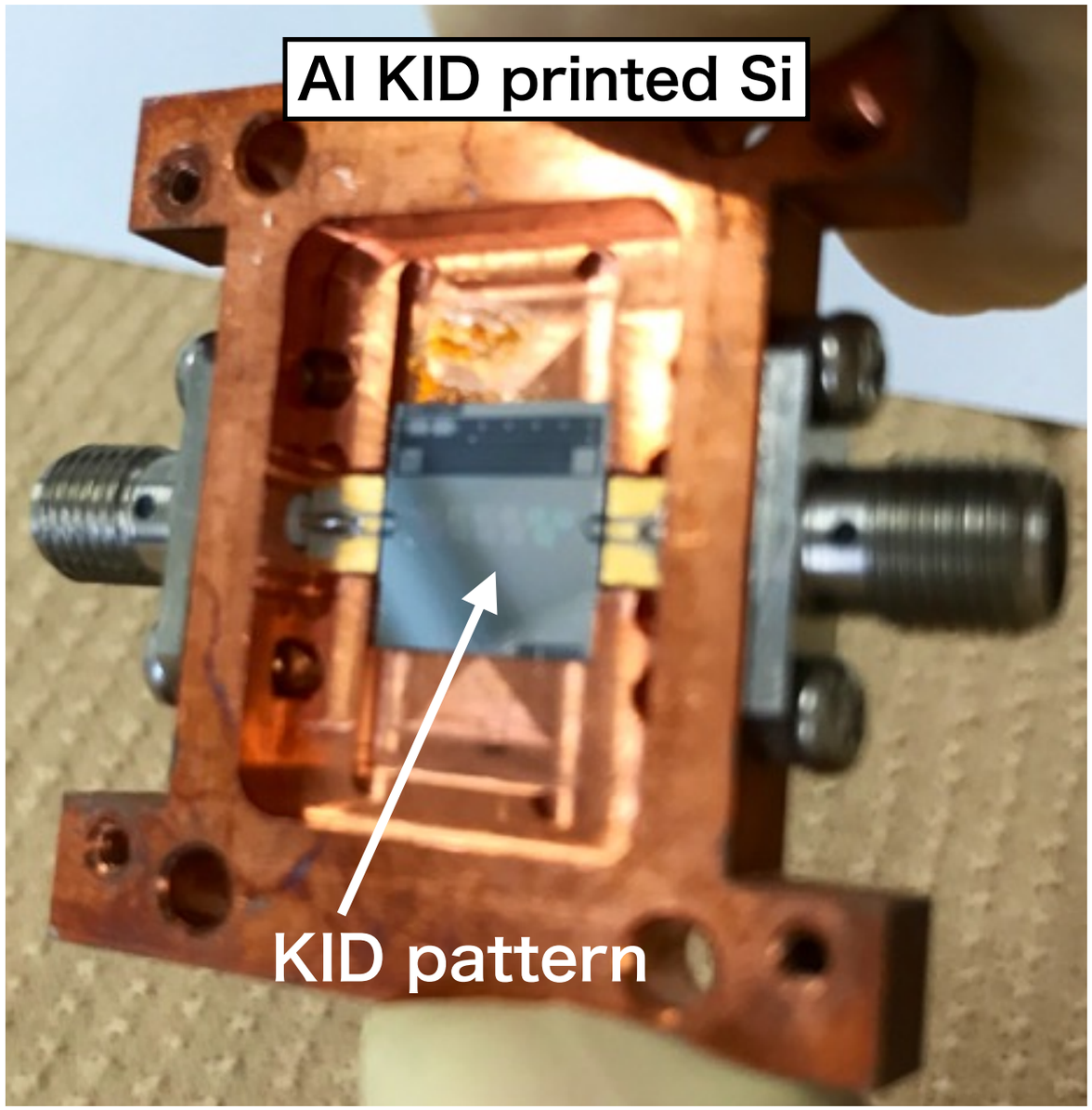


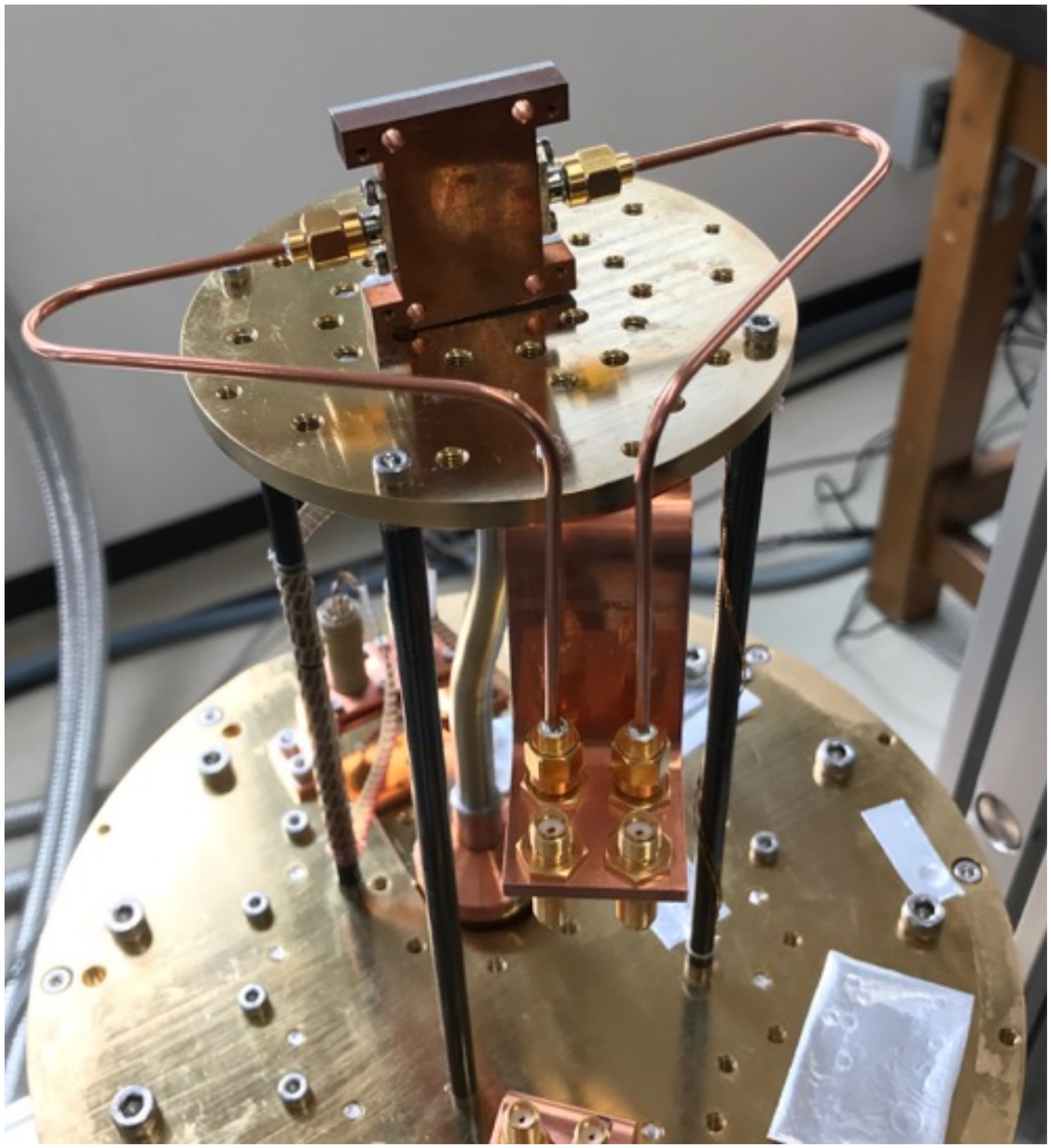
Cooling test



- Achieved 0.3 K by about half day operation. (Tc(Al) = ~1.18K)
- Full automatic!! Keep cooling state over 100 hours.

Simple operation test

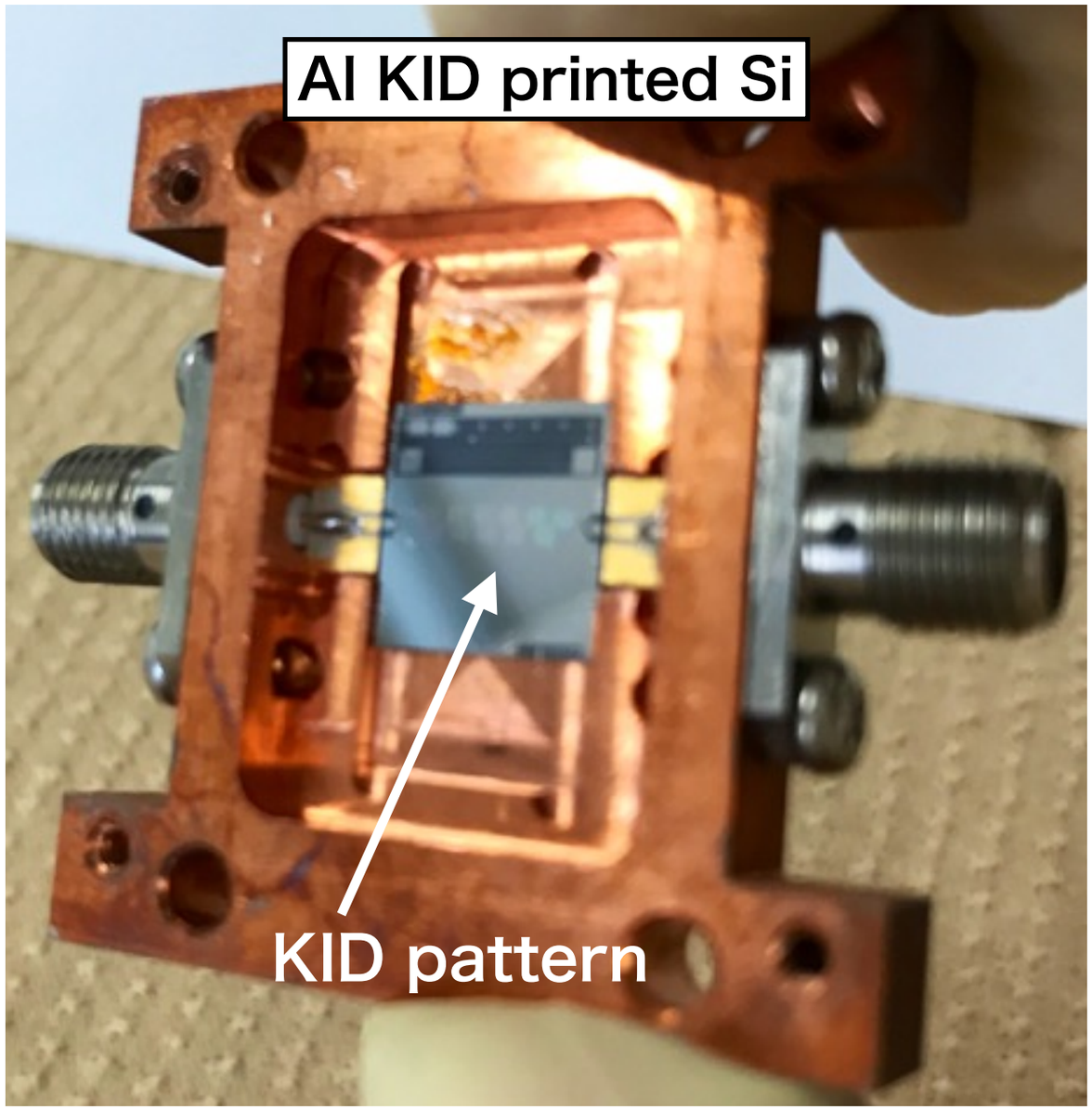


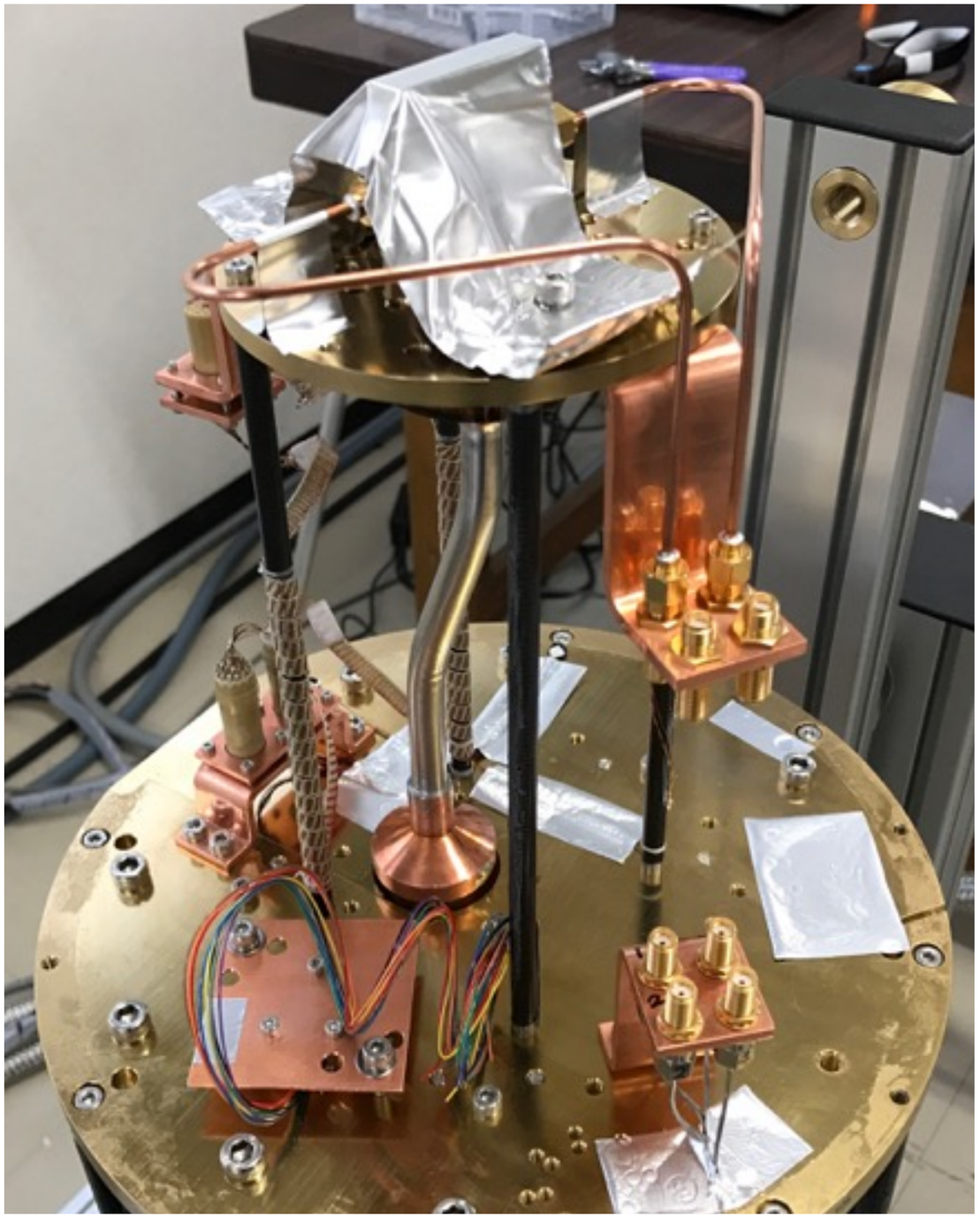


Signal path

VNA → KID → amp → VNA

Simple operation test

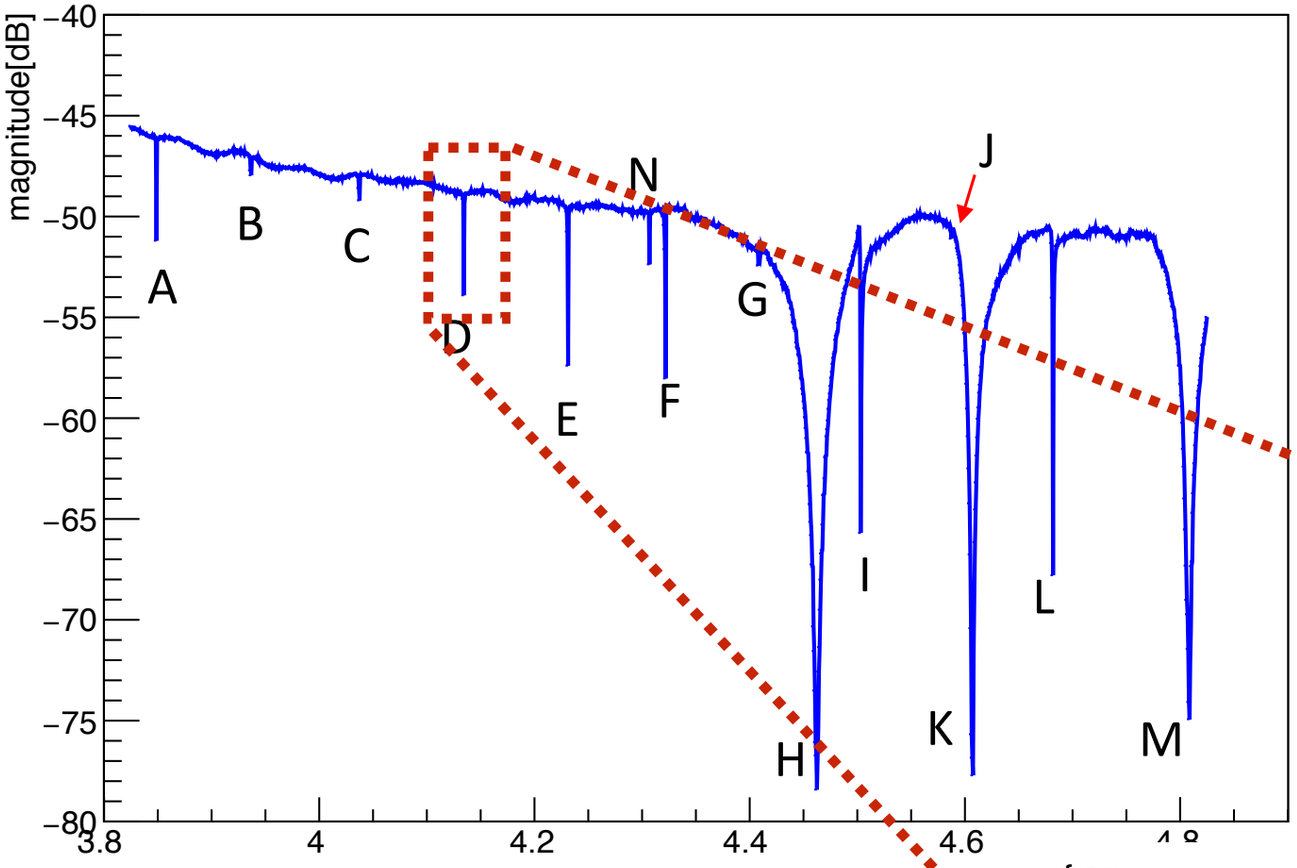


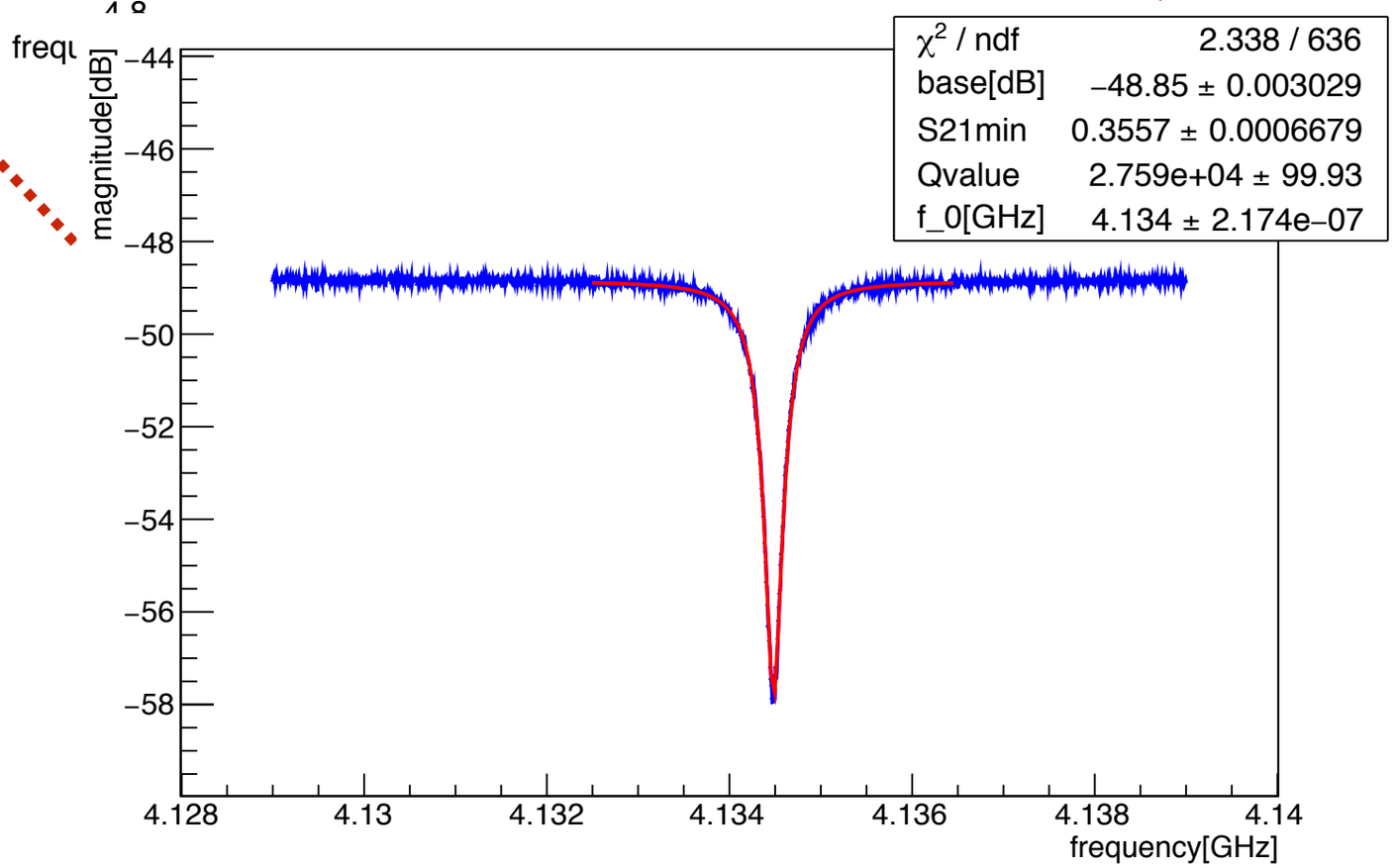


Signal path

VNA → KID → amp → VNA

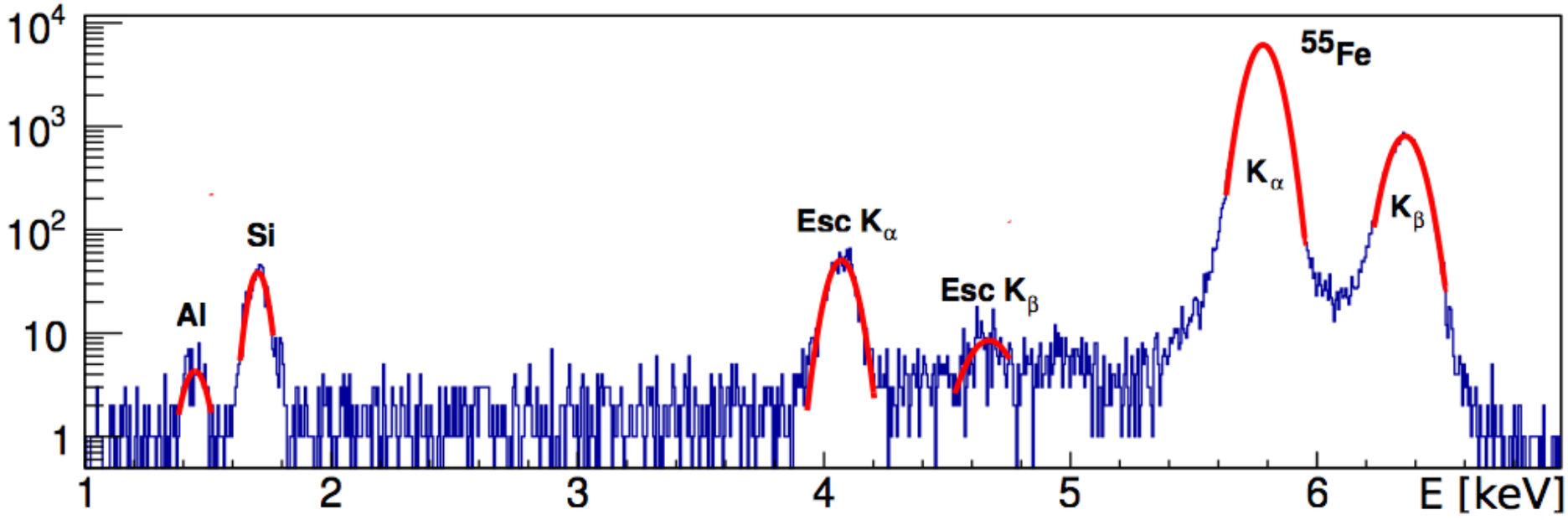
Observed resonance

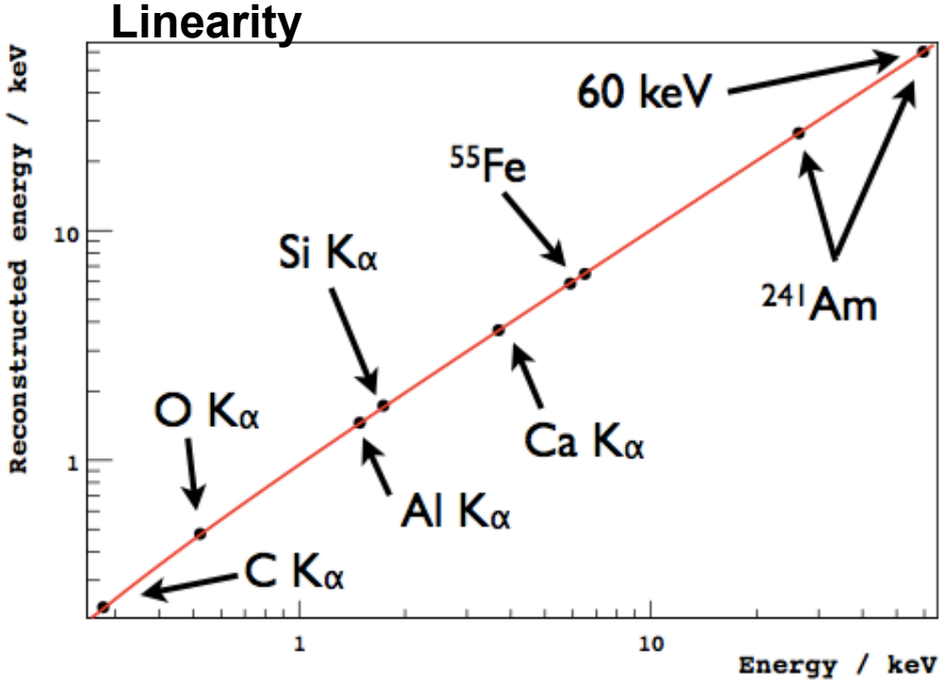


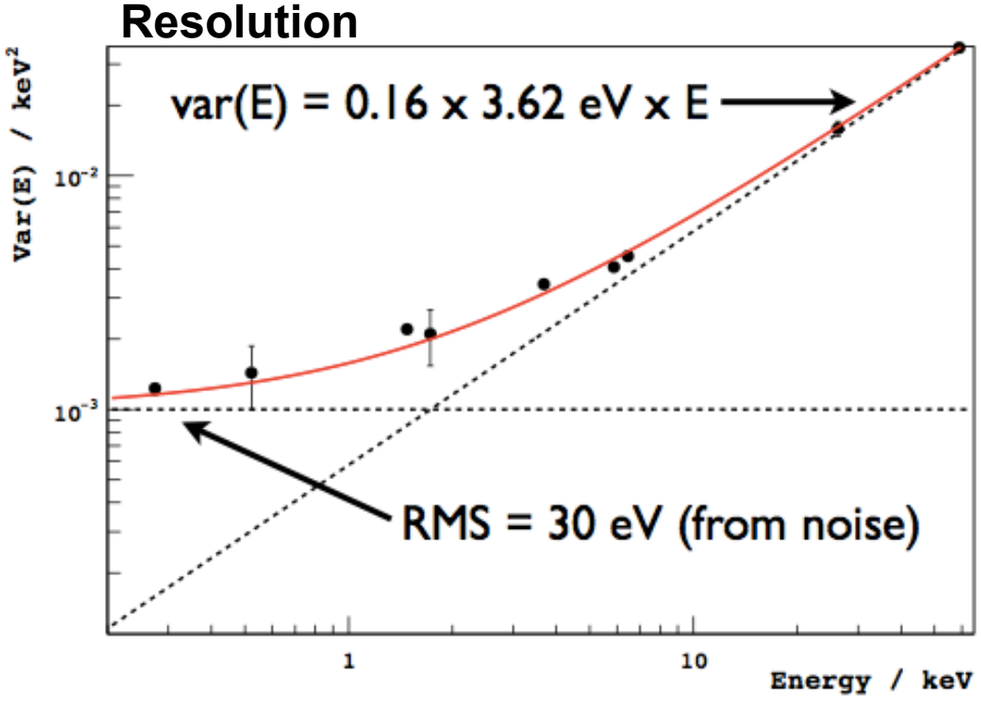


Ideas for calibration

DAMIC calibration (keV_{ee})





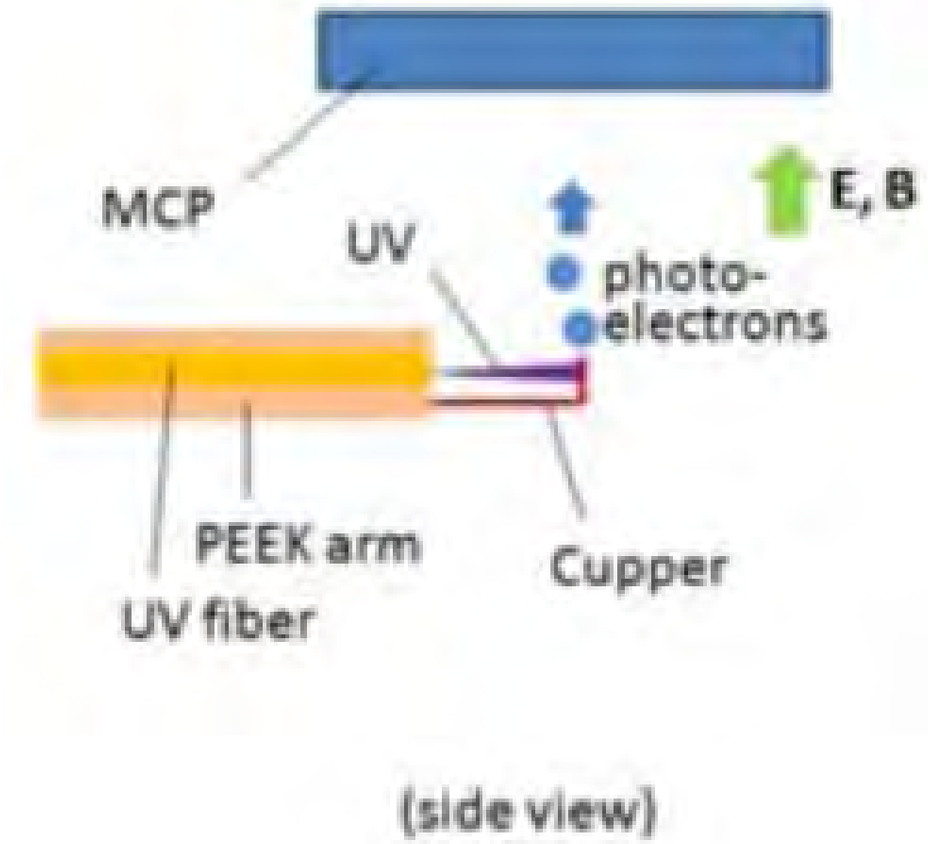


Paolo Privitera @ COSMO 2014 5

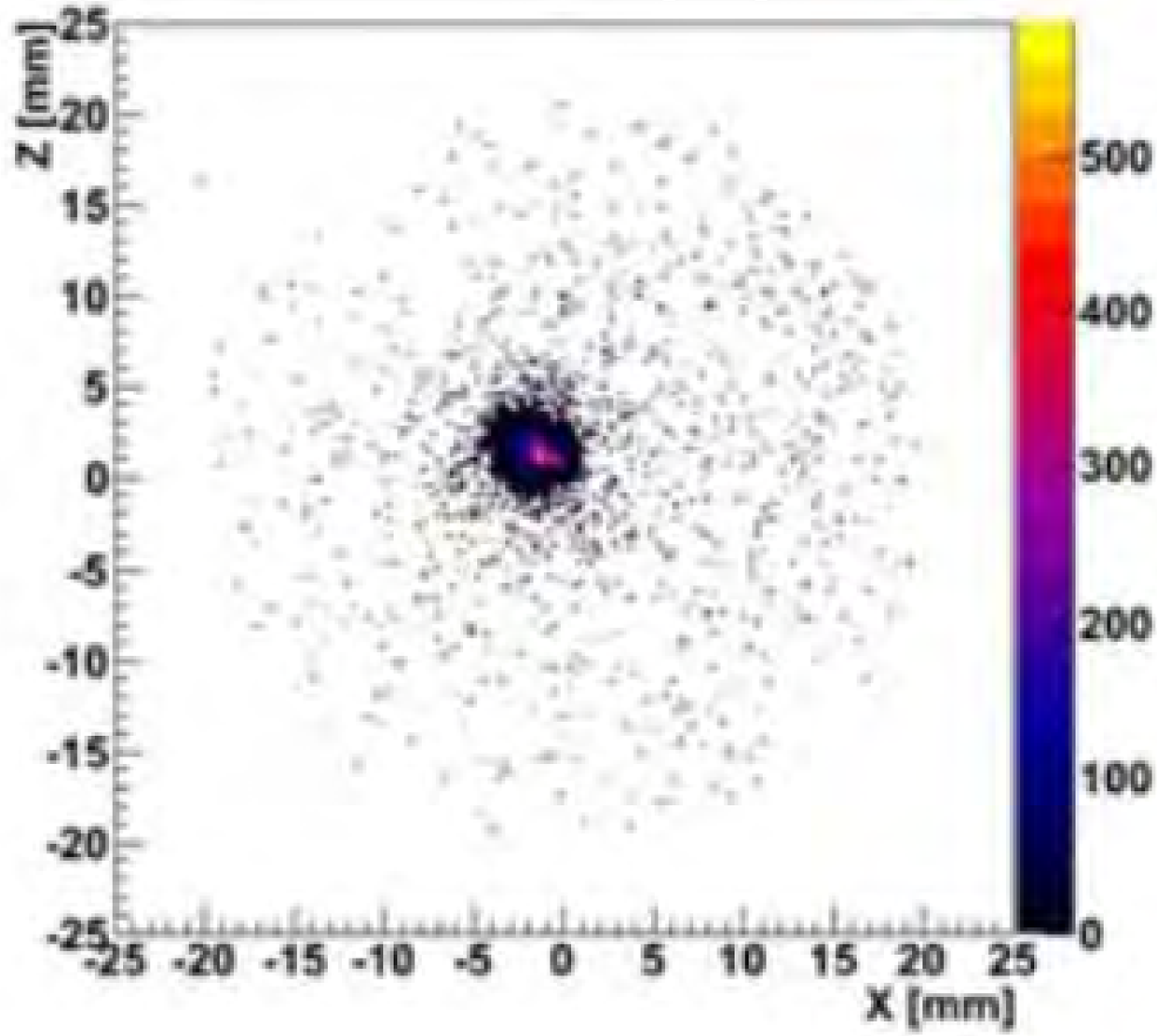
- Energy calibration down to O(100) eV using characteristic X-rays

Ideas for calibration

UV source: Flash lump



Photoelectron imaging with MCP



K. Ueno, KEK (2012)

http://www.icepp.s.u-tokyo.ac.jp/info/sympo/18/torape/20120222_kazuki_ICEPPsympo.pdf

- Energy calibration down to O(1) eV using photoelectrons

Summary

- Aim to search ultra-low mass dark matter with superconductor
- Cooling and operation test using Si - Al KID detector.
  - Observed expected resonance.
- To do
  - Construct our LEKID detector
  - Read out environment
  - Calibration
  - etc...