$0\nu\beta\beta$ experiment based on $Li_2{}^{100}MoO_4$ with simultaneous phonon and photon detection using TES

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Outline

1. About Beijing Normal University
2. $0\nu\beta\beta$ experiment using $Li_2{}^{100}MoO_4$+TES
3. Summary

Beijing Normal University

- Features
  - The first national university in China
    - Founded in 1902
    - Research-intensive, Comprehensive
  - Top 1 normal university in China
    - Education, Chinese History, etc.
  - Outstanding Alumni
    - Winner of Nobel Prize in Literature
    - Mr. Yan Mo
- Academic Units
  - 24 Colleges and Schools
  - 36 Research Institutes
  - 168 Research Centers

北京师范大学核科学与技术学院
College of Nuclear Science and Technology,Beijing Normal University

Beijing Normal University

- Academic Faculty
  - Faculties: 1840
    - Professors: 692
    - Associate Professors: 698
    - Member of the National Academy of Sciences and Engineering:19

- Students
  - Full-time: 21964
    - Undergraduate: 8854
    - Graduate: 11261
    - International Students: 1849
  - Part-time: 40178

CJPL-BNU Joint Laboratory

- College of Nuclear Science and Technology
  - Founded in 1958
  - Faculties: 59

- CJPL-BNU Joint Laboratory
  - Founded in 2018
  - Faculties: 8
  - Graduate & Undergraduate: 26
  - Radiation Physics and Detection Technology
    - Background radiation measurement techniques and methods

^{76}Ge-based $0\nu\beta\beta$ from CDEX-1 experiment

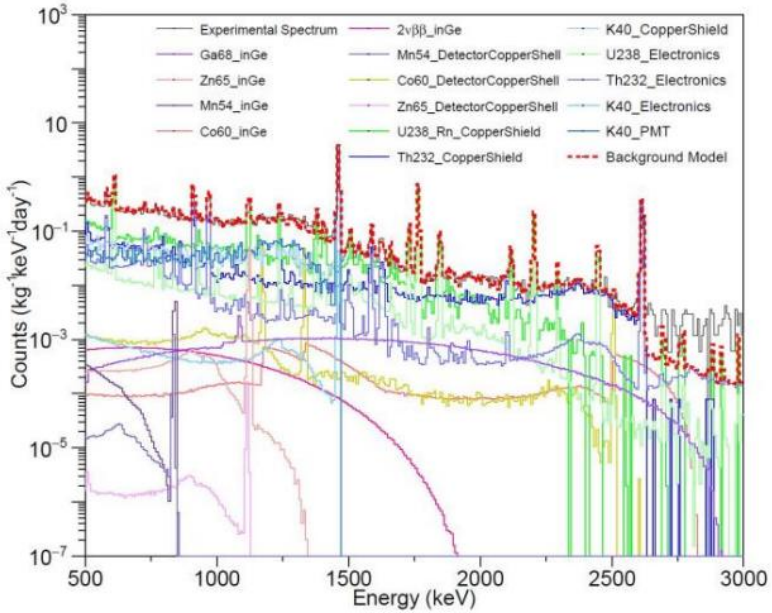


Figure 6 (Color online) The decomposition of the background spectrum of CDEX-1 detector in the high energy of 500 keV to 3 MeV.

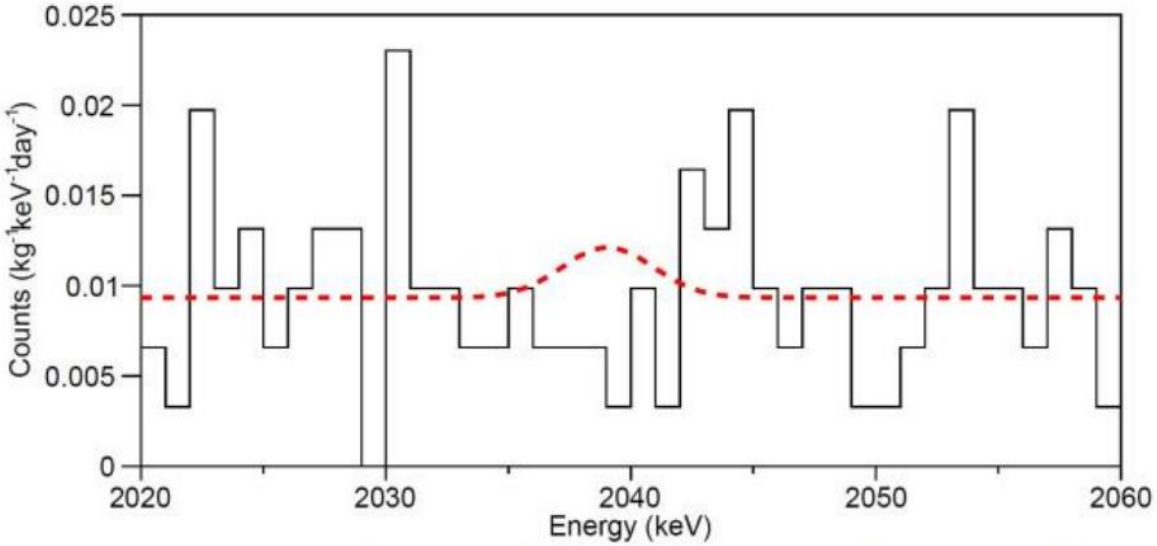


Figure 7 Spectrum without efficiency correction in the region of interest for the 0νββ decay, the red dash line corresponds to 90% C.L. upper limit derived in this work superimposed the fitted background.

- Average event rate at the 2.039 MeV energy range is about **0.012 count per keV per kg per day.**
- The half-life of ^{76}Ge $0\nu\beta\beta$ has been derived as: **T 0v 1/2 > 6.4×1022 yr** (90% C.L.).
- An upper limit on the effective **Majorana-neutrino mass of 5.0 eV** has been achieved

Scintillator based $0\nu\beta\beta$ decay experiment

Cryogenic scintillating bolometers are promising detectors for 0ν2β experiments：

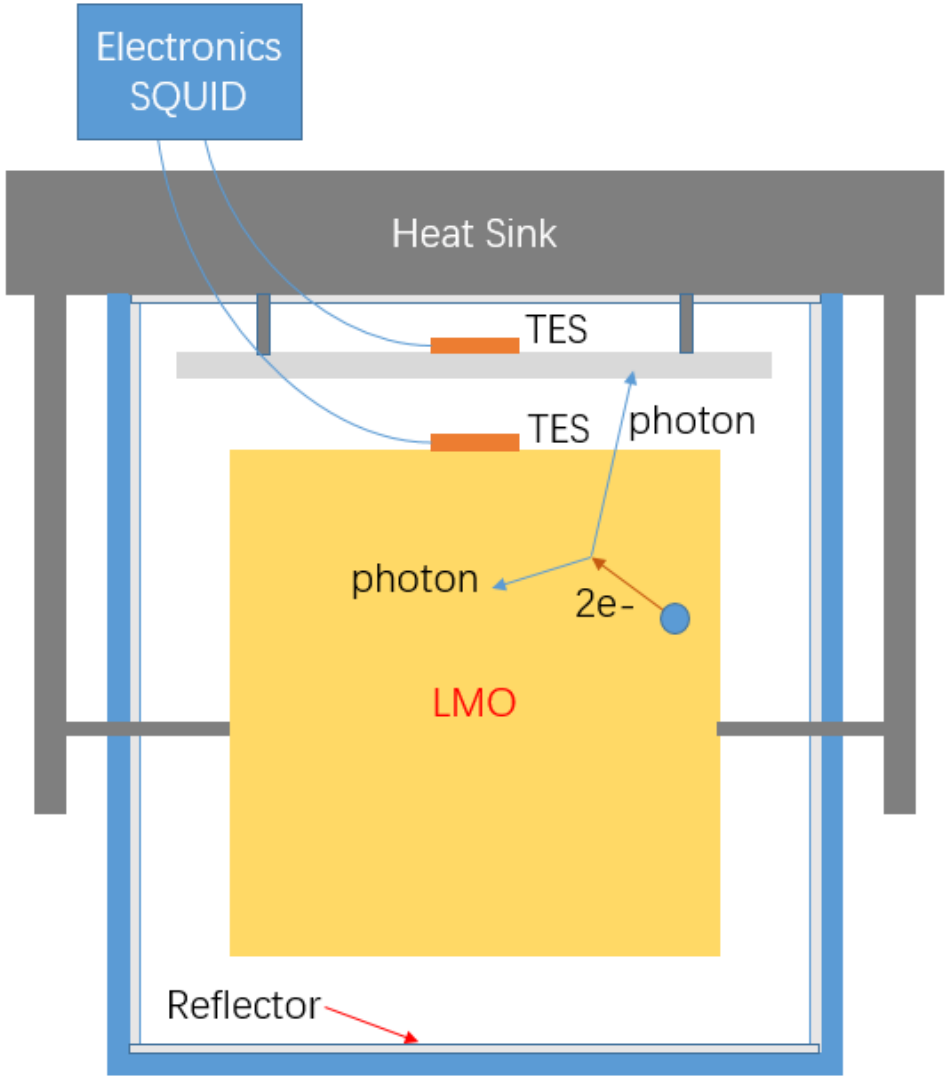
- high energy resolution (a few keV)
- high detection efficiency
- low price

The isotope ^{100}Mo is one of the most promising 2β nuclei：

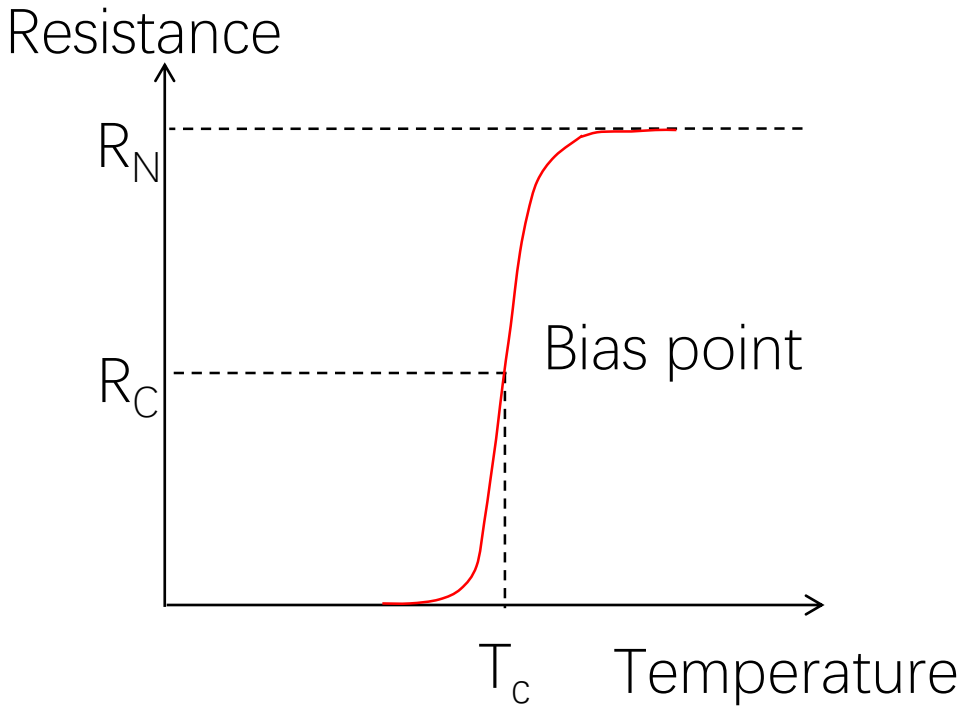
- high energy of the decay (Q2β = 3034.40 keV)
- comparatively high natural isotopic abundance (δ = 9.744(65)%)
- possibility of isotopical separation by centrifugation in a large amount

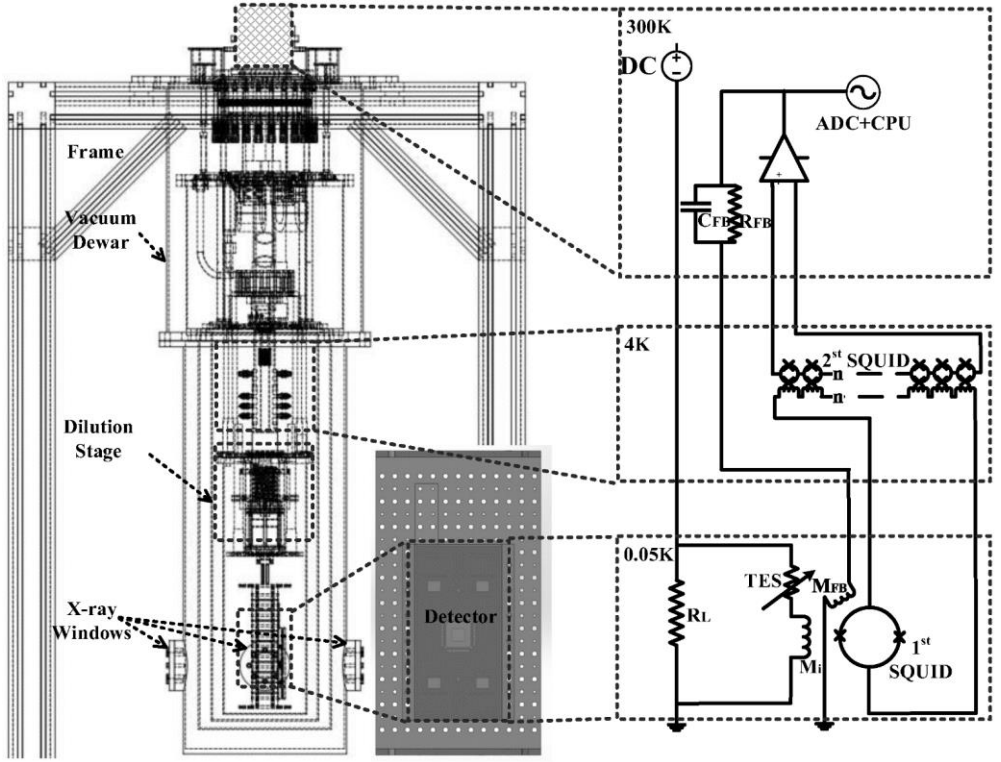
$Li_2{}^{100}MoO_4$ + TES $0\nu\beta\beta$ detector

- Use Mo containing Scintillating Bolometer : $Li_2{}^{100}MoO_4$ + TES
- For Each crystal, phonon sensors made of TES, which is with fast timing resolution and energy resolution, to discriminate pileup events of $2\nu\beta\beta$.
- For Each crystal, phonon and photon sensors made of TES+SQUIDs to separate alphas (background) and betas (signal).



Transition Edge Superconducting detectors

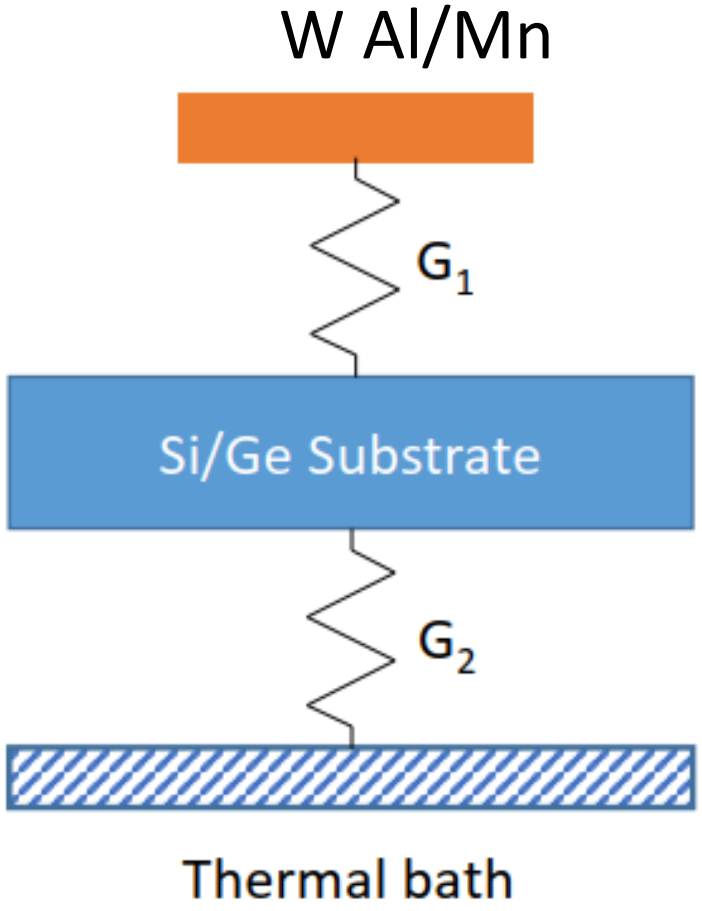




Transition Edge Sensors (TES) LDs are an excellent choice

- High energy resolution → Low T_c
- Fast response time → Negative electrothermal feedback
- Large scale multiplexing

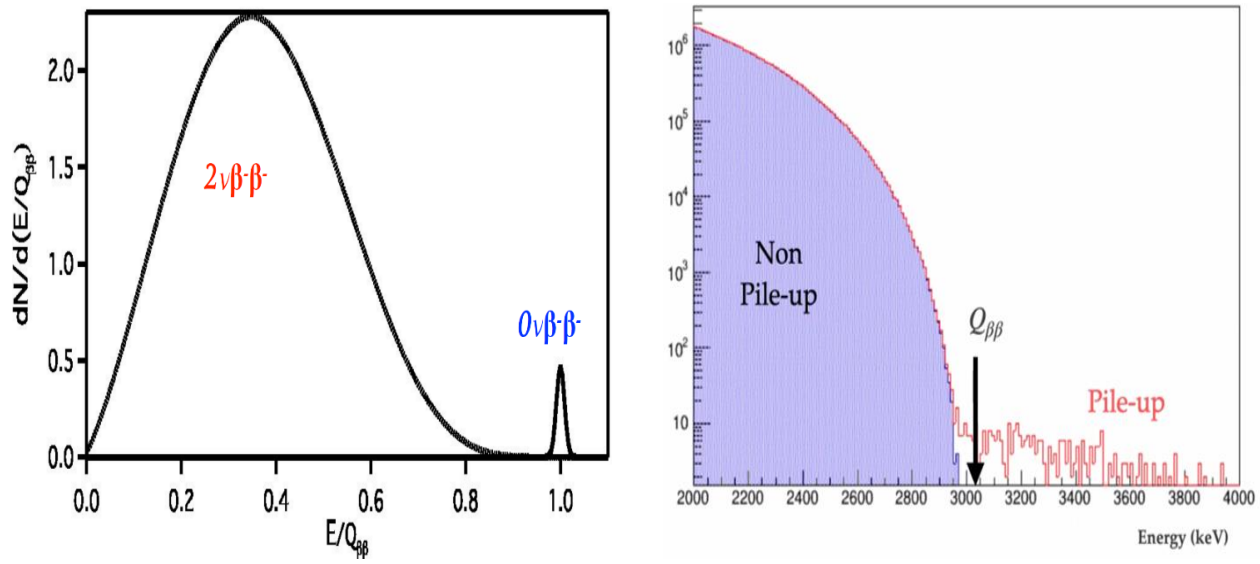
Path to a Low Tc TES Detector



- Low T_c Superconducting films: W or Al/Mn bilayers, T_c tunable between 10-20 mK.
- Light absorber: 2” Si/Ge wafer
- Detector dynamics modeled with TES physics
- Fabrication at IHEP, characterization at IHEP and ShanghaiTech

Background Rejection

- **Random Coincidence of $2\nu\beta\beta$ decay events**



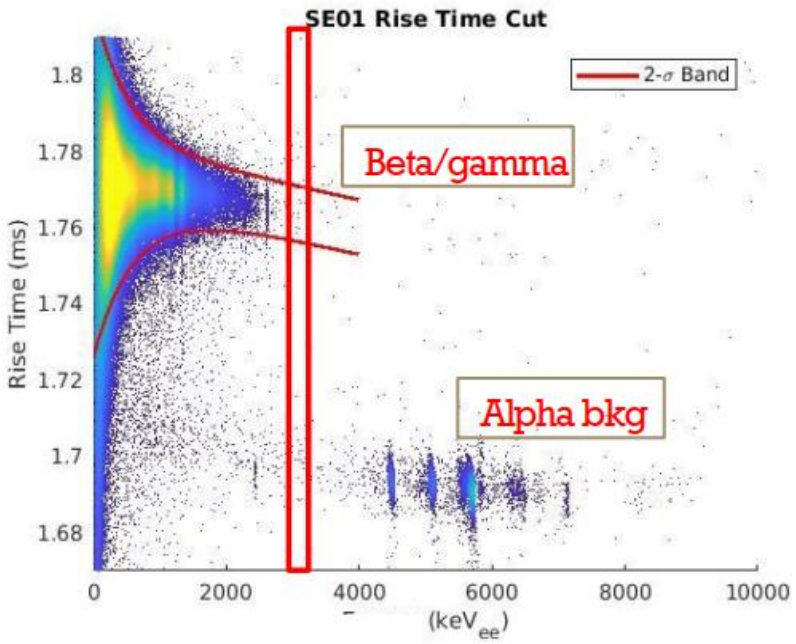
CUPID Group, 2021

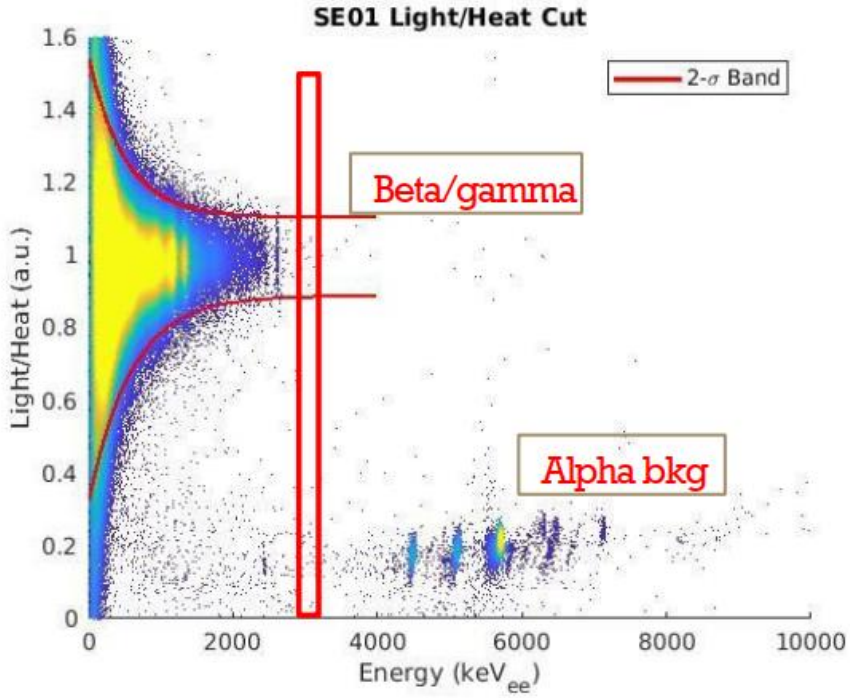
Two-neutrino double β decay can create an irremovable background even in high energy resolution detectors searching for neutrinoless double β decay due to random coincidence of 2ν2β events in the case of poor time resolution.

Background Rejection

- Alphas

  Alpha Backgrounds are effectively rejected with pulse shape discriminator and light-to-heat ratio





arXiv:1903.09483

Summary

- Mo containing Scintillating Bolometer （$Li_2{}^{100}MoO_4$ + TES） to look for $0\nu\beta\beta$ is under development.
- Simultaneous phonon and photon readout are proposed to reject alpha and random $2\nu\beta\beta$ coincidence events
- TES aiming tunable T_c between 10-20 mK