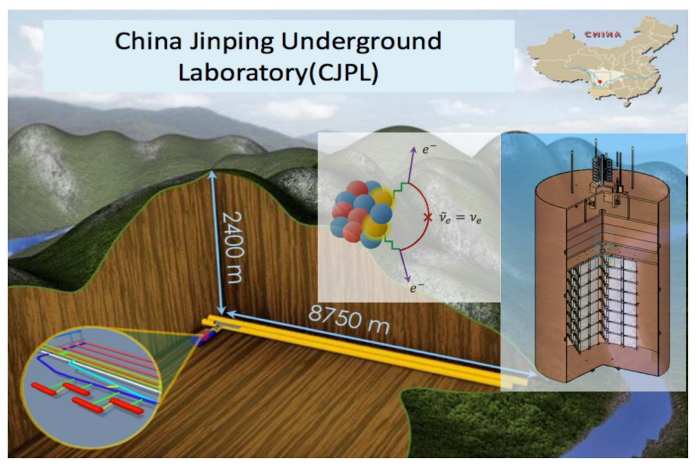
# Recent R&D Progress Towards a Bolometric 0νββ Experiment at China Jinping Underground Laboratory

Huaqi Cao, Jiaxuan Cao, Hao Chen, Shihong Fu, Keyu Shang, Long Ma, Fang Xie*

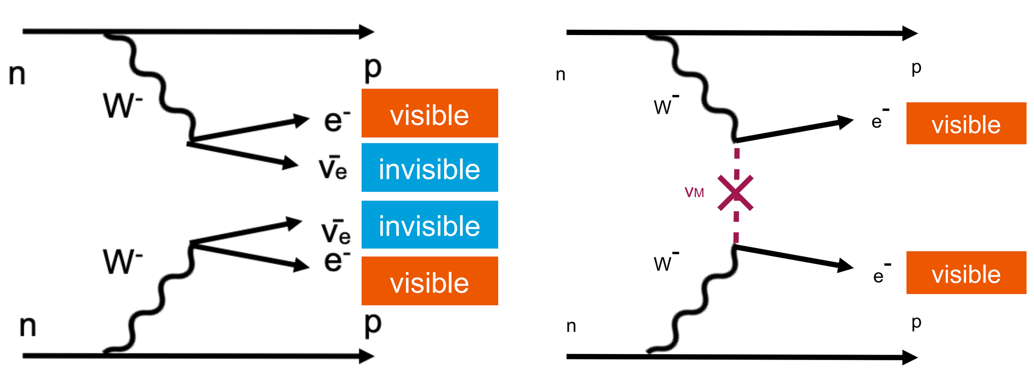
xiefang@fudan.edu.cn Fudan University, 220 Handan Rd., Yangpu Dist., Shanghai, China - 200433

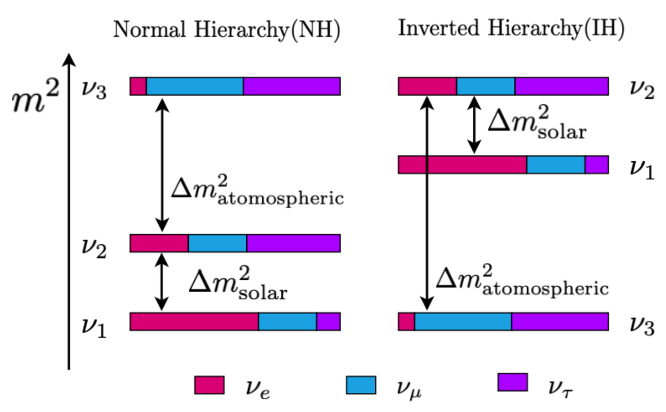
## Introduction

Neutrinoless double-beta decay (0νββ) is a rare nuclear process which observation would demonstrate the Majorana nature of neutrinos and the violation of lepton number conservation, with profound implications for particle physics and cosmology. Next-generation 0νββ searches require detectors with excellent energy resolution, ultra-low background, and the ability to discriminate the type of particles. The China Jinping Underground Laboratory (CJPL), one of the deepest underground facilities in the world, provide extremely low cosmic-ray background environment for such experiment. Here we present recent R&D progress towards scintillating bolometers for future 0νββ searches at CJPL.



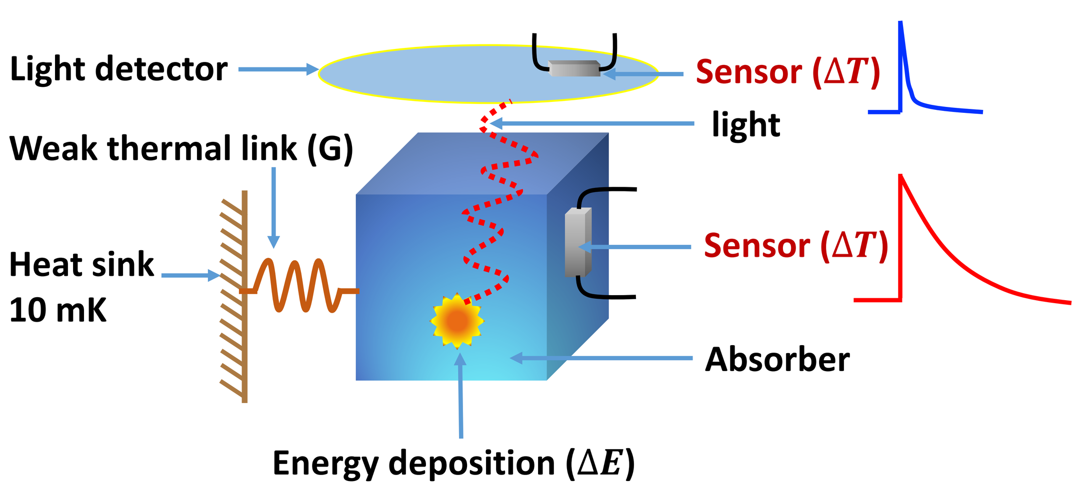

## Neutrinoless Double Beta Decay

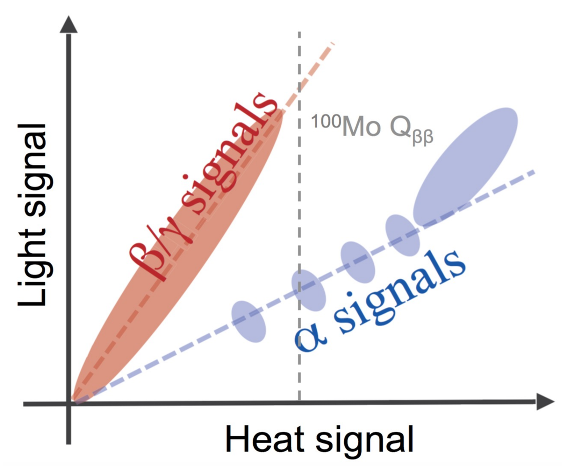



- Hypothetical process: forbidden in the Standard Model
- Violate lepton number (ΔL=2)
- Dirac vs. Majorana test: 0νββ possible only if ν is Majorana particle
- Neutrino mass sensitivity: decay rate $\Gamma \propto |m_\nu|^2$
- $T_{1/2} > 10^{26}$ yr (inverted mass order)
- Experimental require: ultra-low background, high energy resolution

## Scintillating Bolometers

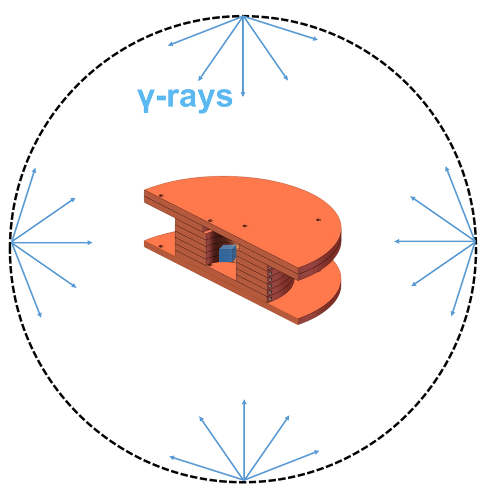


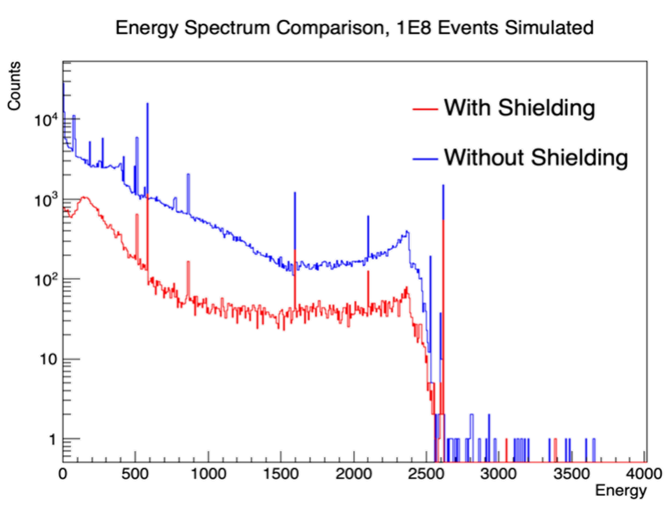



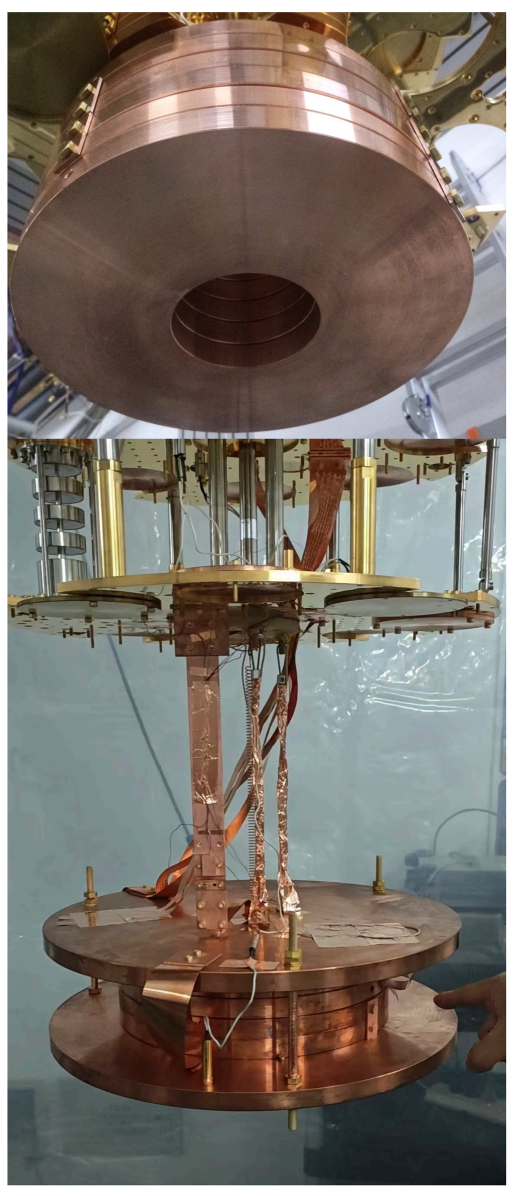

- Cryogenic detectors: ~ 20 mK and below
- Small temperature rise from the deposited energy is measured by a sensitive thermal sensor (e.g. NTD-Ge, TES)
- Scintillation light is collected by a separate light absorber
- Particle identification: α and β/γ discrimination via light/heat signal
- Excellent energy resolution: few keV FWHM at Q-value
- High detection efficiency: detector=source

## Shielding

- **Motivation:** suppress γ-rays, the dominant source of external background.
- **Simulation:** geant4 model of cylindrical Cu shield with end-cap extensions.
- **Prototype:** shielding module fabricated and suspended inside the cryostat.
- **Conclusion:** orders-of-magnitude suppression of external γ-rays.



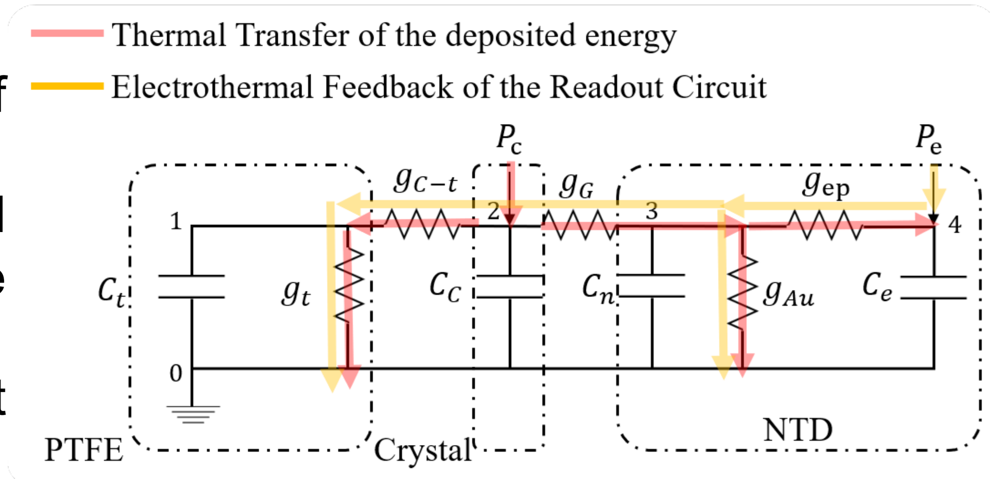
**Simulation Setup**

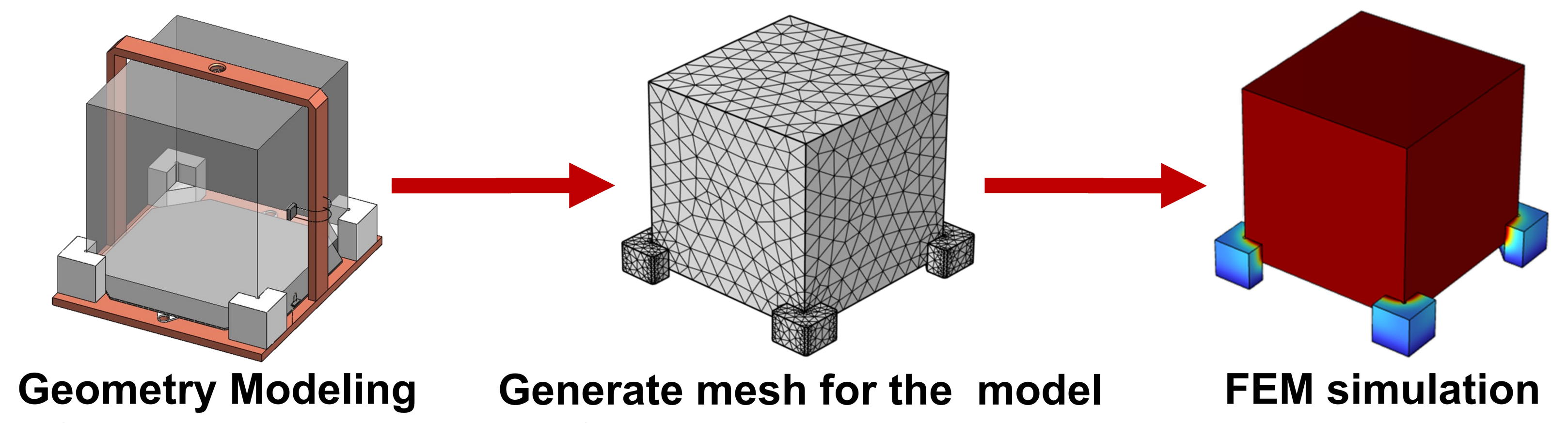
1. Geometry & materials
Cu Shielding: top/bottom caps + donut-shaped rings
LMO Crystal: 4.5 cm cube
2. Source
4π isotropic γ-emitter ($^{208}$Tl result shown here)
Positioned on a sphere centered around the crystal
3. EM Processes:
Standard + Livermore low-E model
4. Statistics:
$10^8$ events simulated, with/without shielding

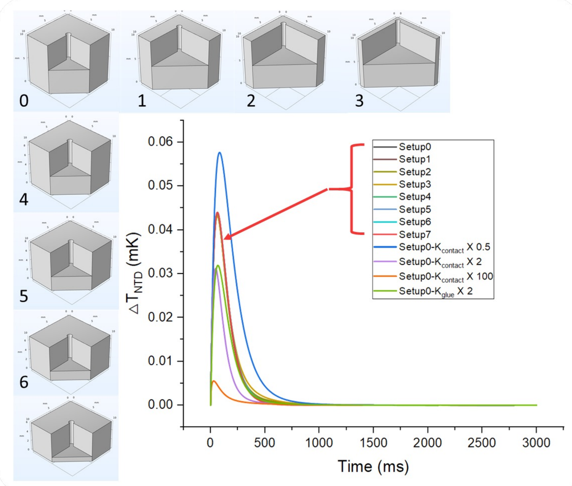
## Thermal Conductivity Simulation

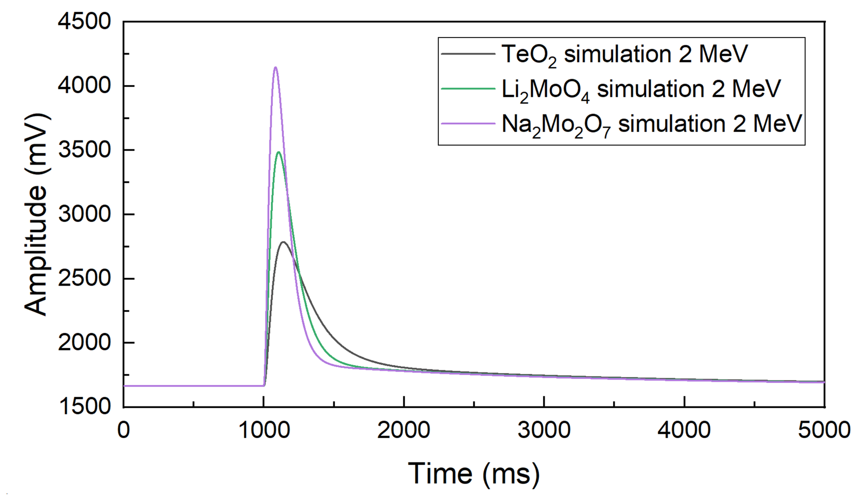
**Thermal Circuit**

- $C_t$, $C_e$ are the heat capacity of PTFE and crystal;
- $g_t$, $g_G$, $g_{Au}$ are the thermal conductance of PTFE, glue and bond wires;
- $g_{c-t}$ represent the contact resistance.



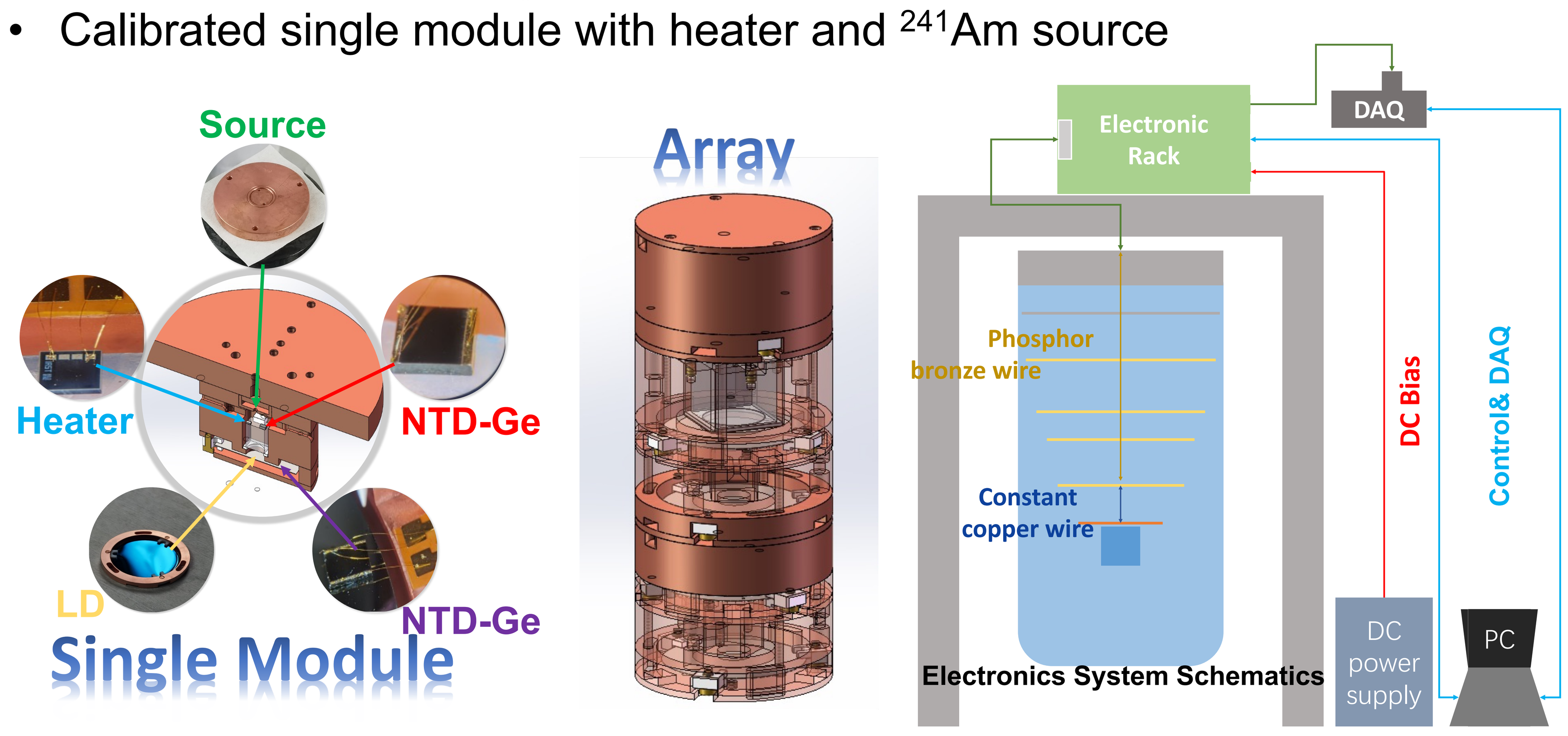



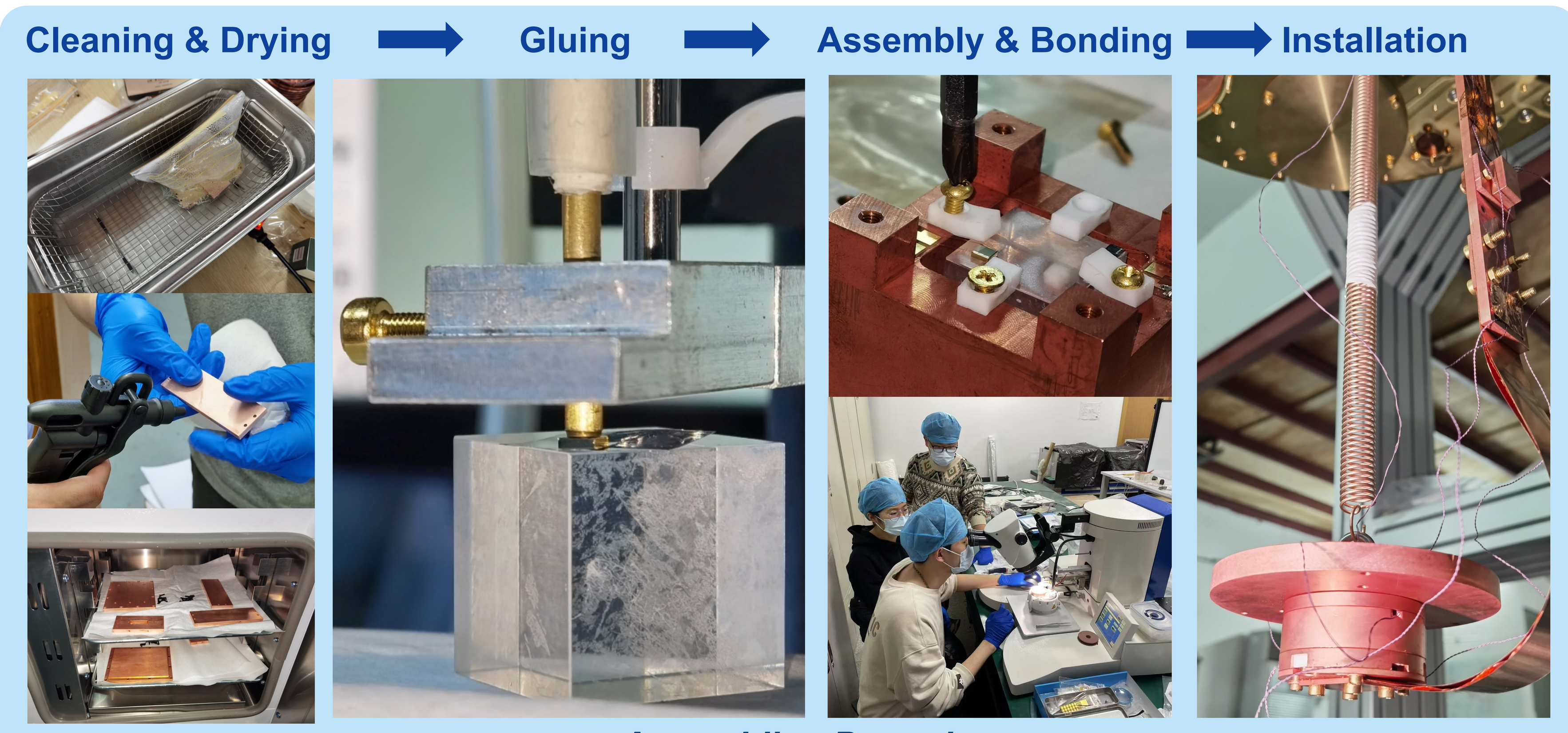



- Can simulate the detector behavior on different model designs;
- And compare the thermal response on different crystals.

## Detector R&D in Ground-level Lab

- Bolometer design: single module & array
- Sensor + Crystal + LD + Electronics: R&D, fabrication & test (collaborate with IJC-Lab, MiB, SICCAS, USTC, BNU etc..)
- Established assembling procedure
- Calibrated single module with heater and $^{241}$Am source




*Assembling Procedure*

## Results

First calibration of bolometer in heat channel with $^{241}$Am source and heater.