次世代赤外線天文衛星 SPICA 搭載用 遠赤外線観測装置 SAFARI

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SRON
Netherlands Institute for Space Research
Netherlands Organisation for Scientific Research

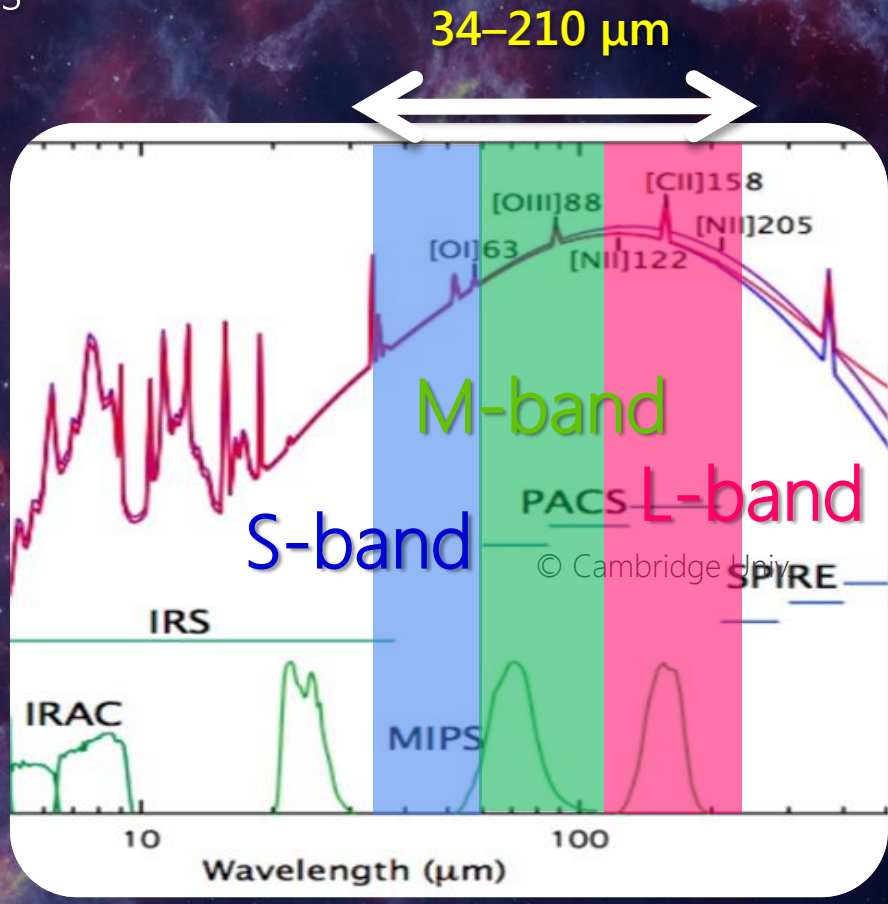
JAXA
Japan Aerospace Exploration Agency

SAFARI

SPICA: space mission for mid-& far-IR astronomy

- Telescope: 2.5 m & <8 K
  - -Natural background limited Infrared (IR) observations
    → Need **ultra-sensitive** IR detectors

- IR instruments
  - -SMI (12-37 μm)
  - -SAFARI (34-210 μm)
  - -Three-band grating spectrometers with **TES bolometer** arrays



Noise Equivalent Power (NEP) required by SPICA/SAFARI

Minimum detectable input power to have S/N=1 with T_{int}=0.5 sec

Higher sensitivity = Lower NEP

ISO-Herschel era

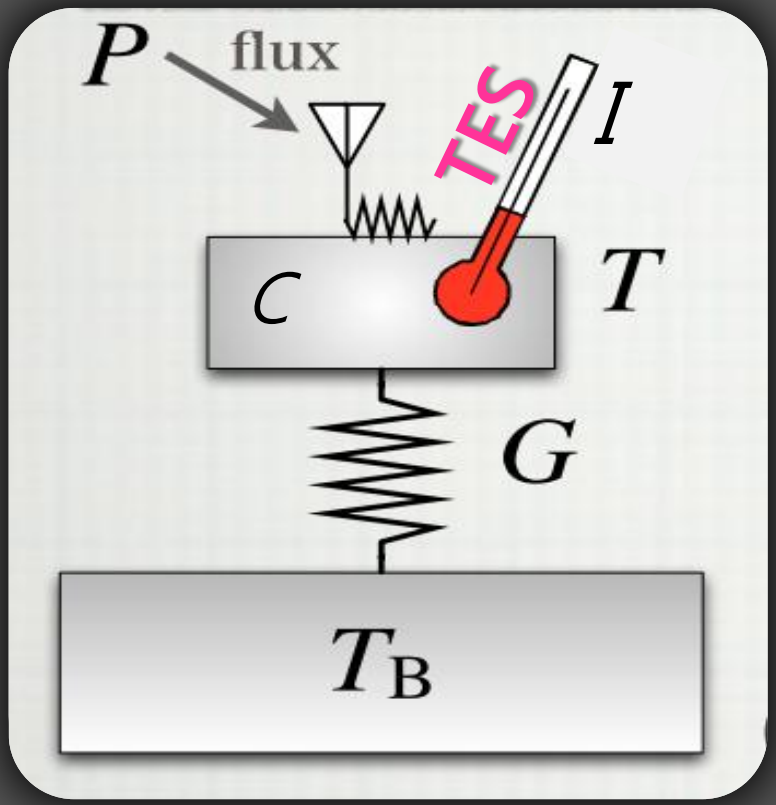
$\sim 10^{-16}$ -10^{-17} W/√Hz

100-1000 times!!

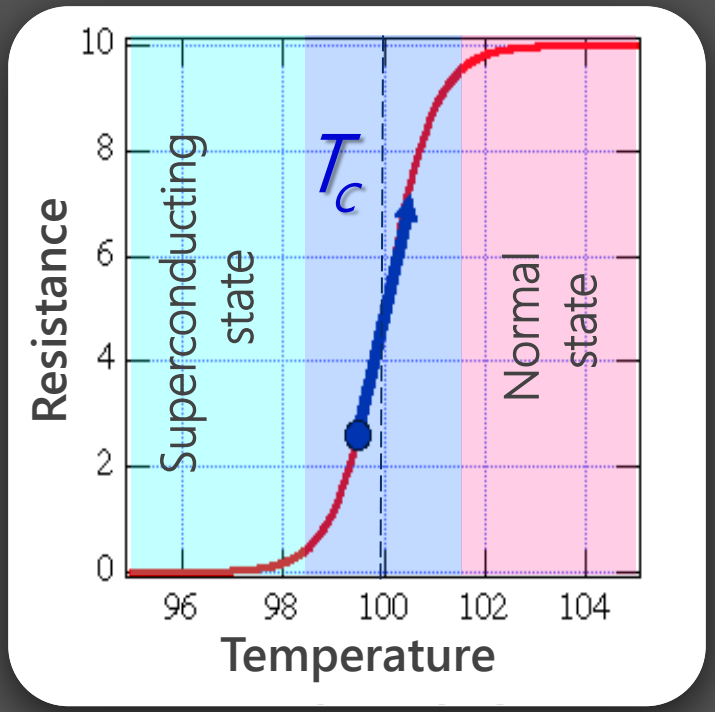
SPICA/SAFARI

2×10^{-19} W/√Hz

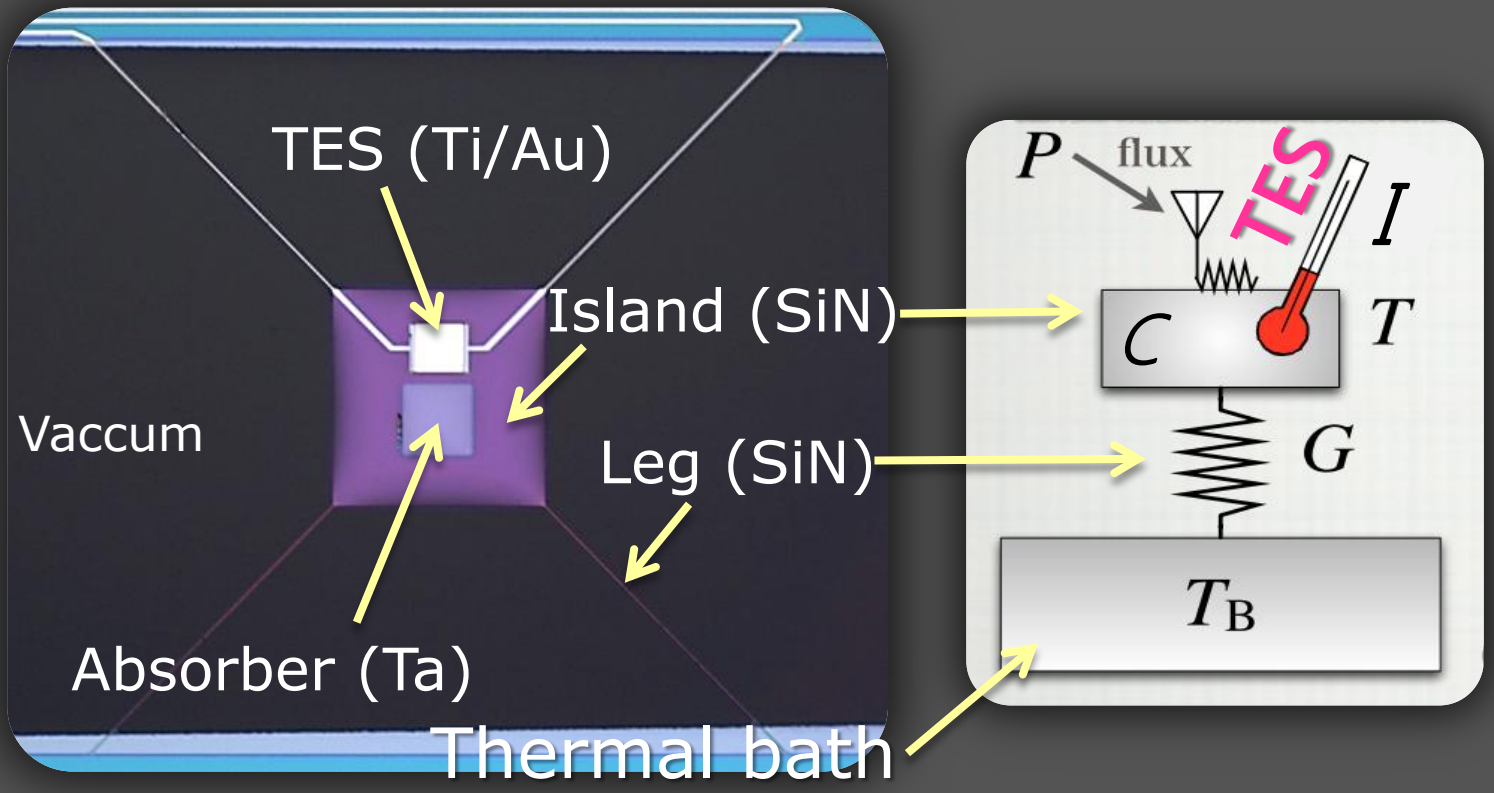
Transition Edge Sensors (TESs)



$\Delta P \rightarrow \Delta T \rightarrow \Delta R$



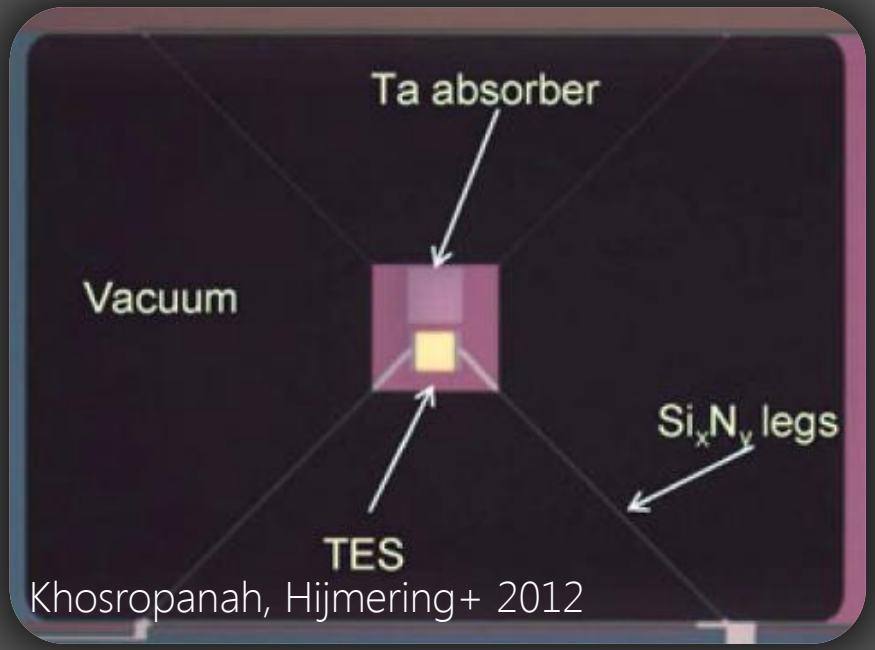
Typical TES pixel for SAFARI/S-band



Intrinsic noise = phonon noise
→Noise Equivalent Power (NEP_{ph})∝ $\sqrt{G}$

Long-standing questions (1)

SRON-TESs fabricated by KOH wet-etching



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SiN legs
-Width (W) = 1 μm
-Thickness (T) = 0.5 μm
-Length (L) = 400 μm

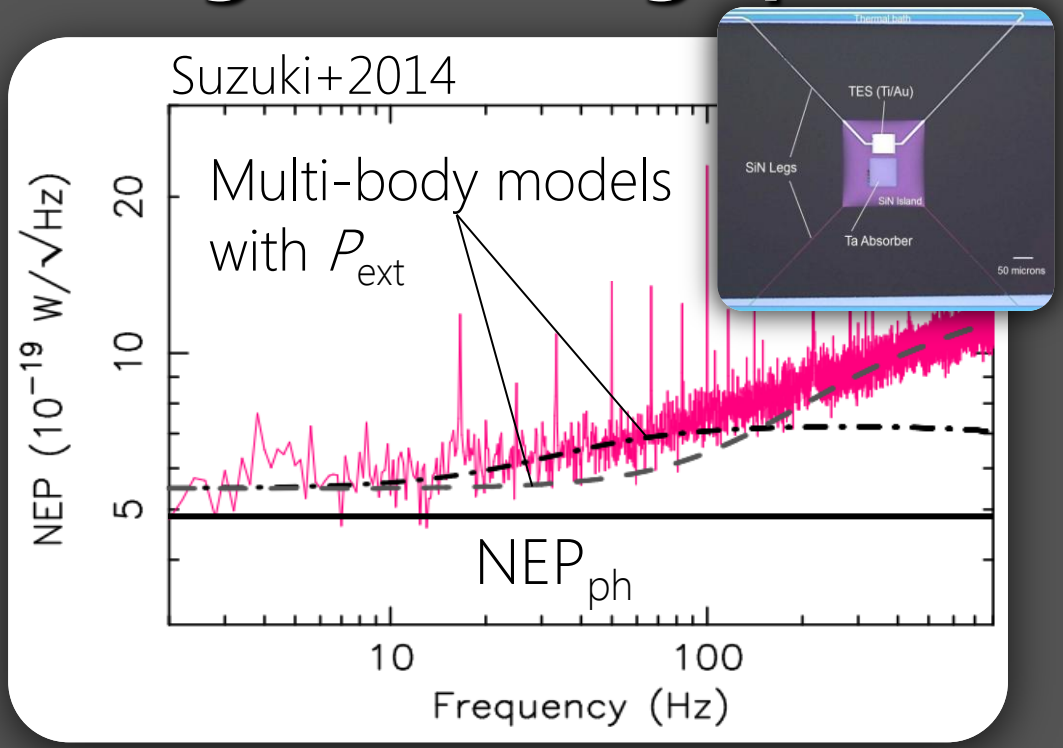
G_{meas} = 330 fW/K

NEP_{meas} = 4.2×10^{-19} W/√Hz (best)

→ Deep Reactive Ion Etching (DRIE)

Q1. Can we achieve lower G and thus NEP values by making narrower and thinner SiN legs??

Long-standing questions (2)



NEP$_{meas}$/NEP$_{ph}$~2-3 (typ.)

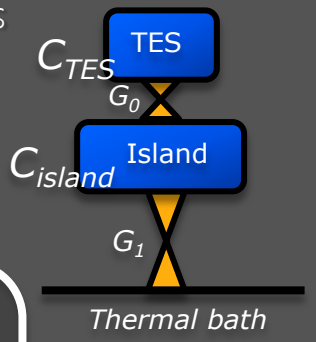
Khosropanah, Hijmering+ 09,10,11,12

Excess noises

1) Extra-phonon noise (f>~10Hz)

C_{tes}~C_{island} & C_{legs}

2) Photon noise

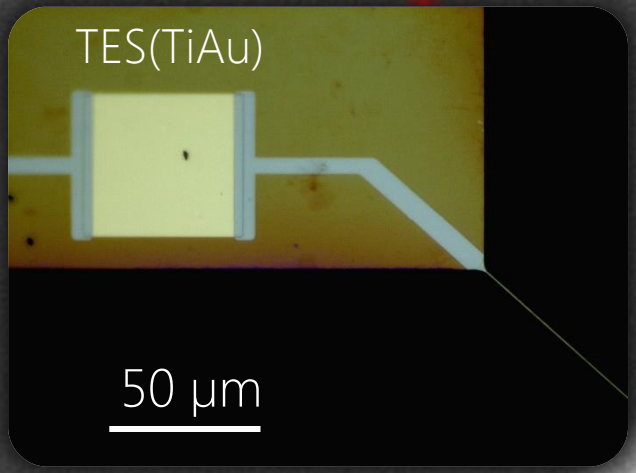


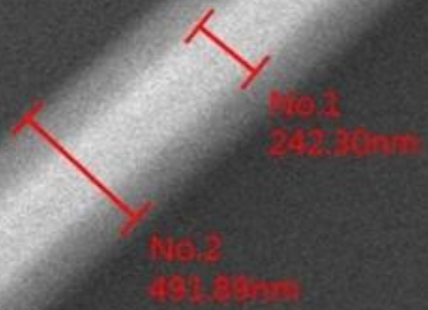
Q2. Can we reduce the extra-phonon noise by making lighter SiN island and SiN legs??

Q3. How dark is our setup??

New TESs fabricated by DRIE

- Deep Reactive Ion Etching (DRIE) process success
- Narrow SiN legs ~0.5-0.7 μm
- Thin SiN legs and island ~0.2 μm





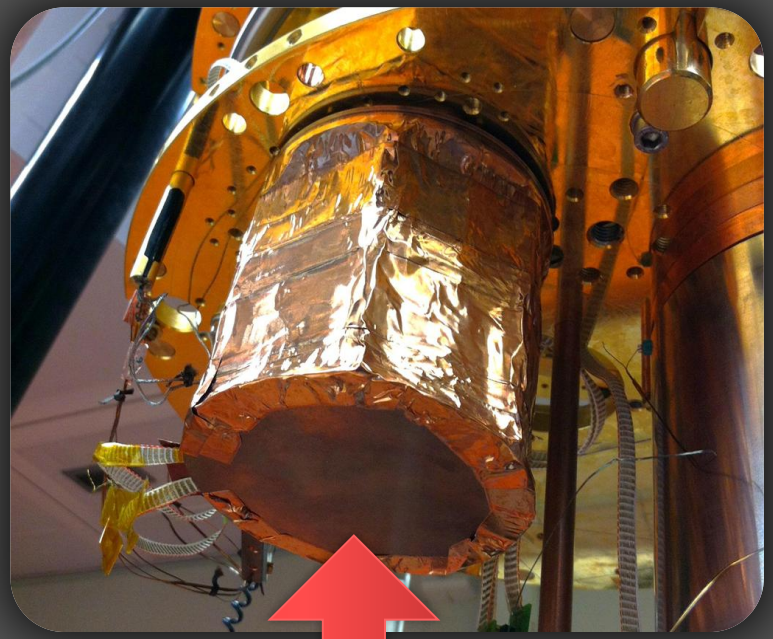
Fabricated by Marcel Ridder (SRON)

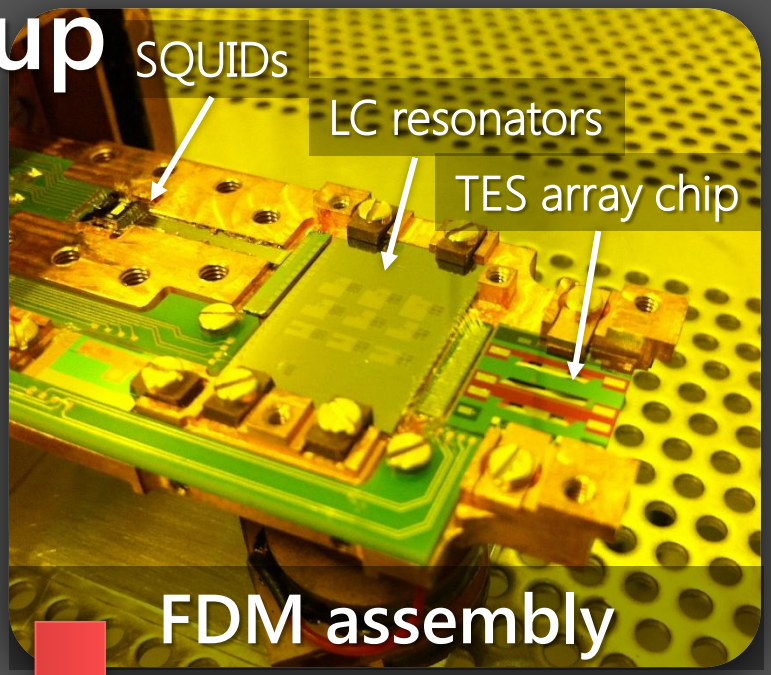
SED 15.0kV WD12.3mm Std.-P.C.43.0 HighVac. x20,000 1um

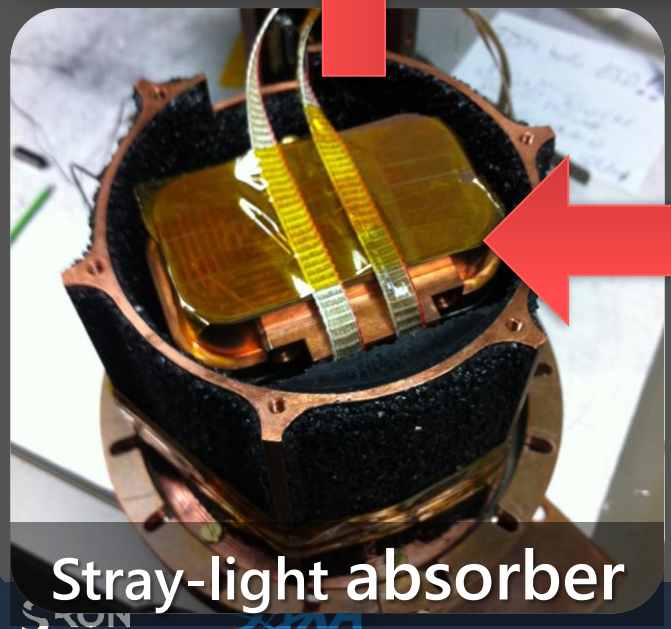
Do not blow a puff of air, please!!

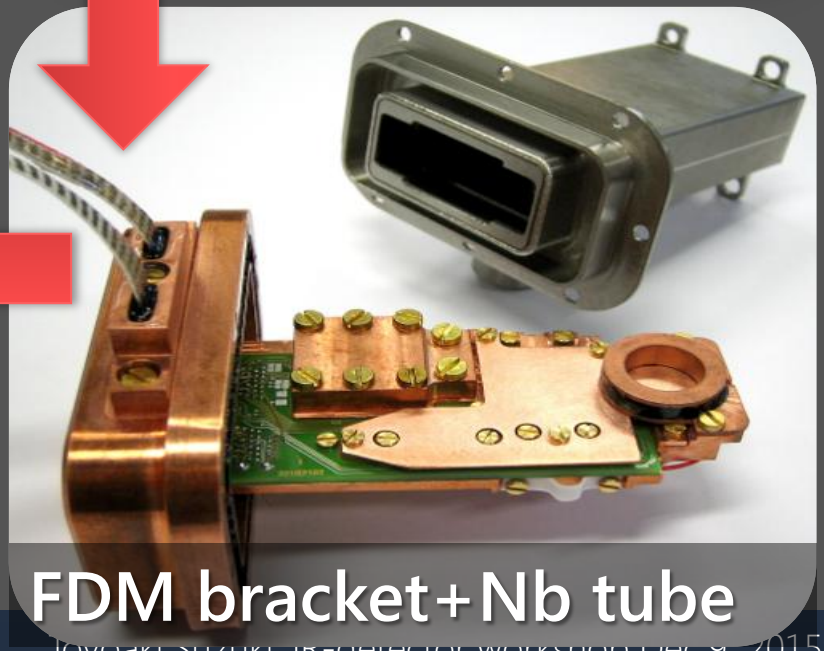
SED 15.0kV WD30.3mm Std.-P.C.26.9 HighVac. x43 500um

AC measurement setup

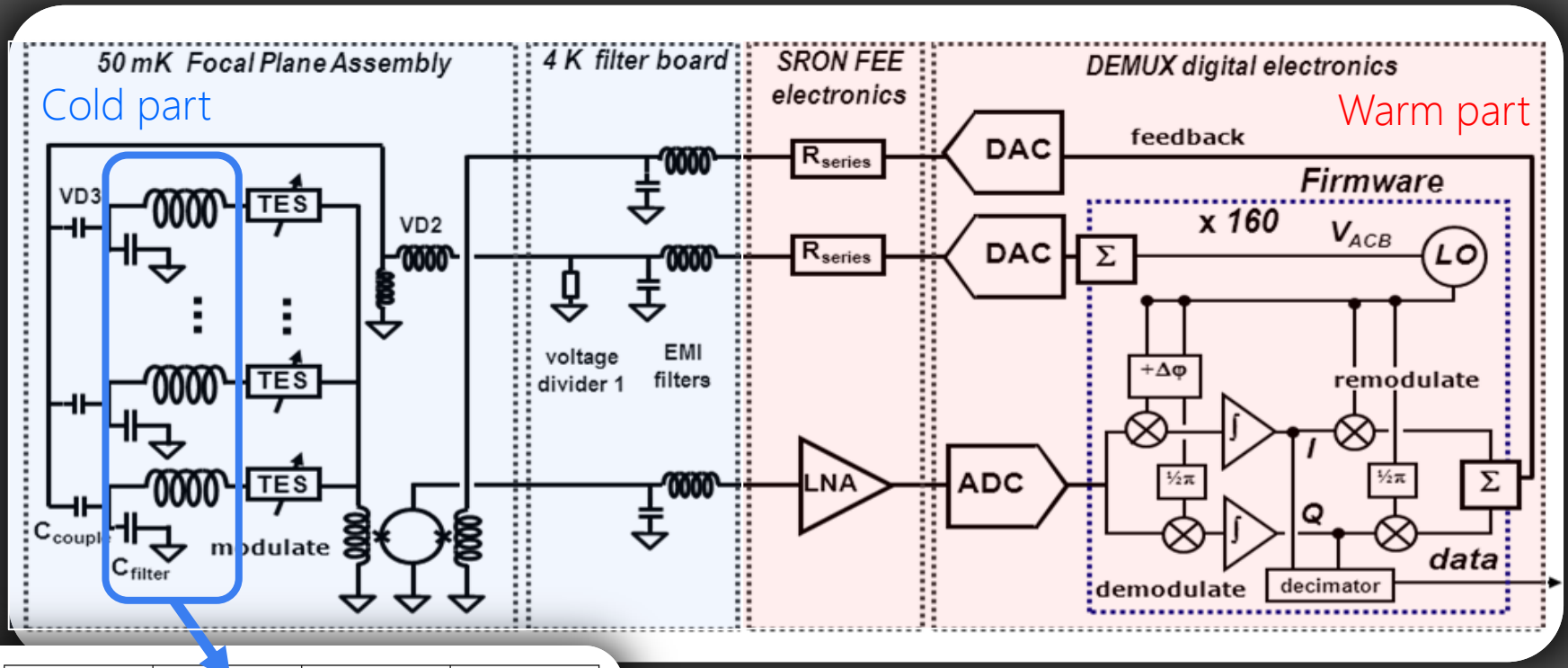


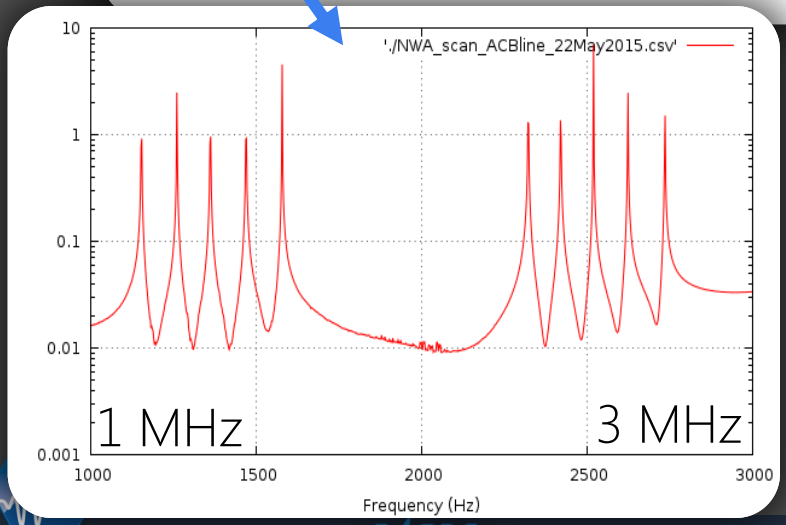






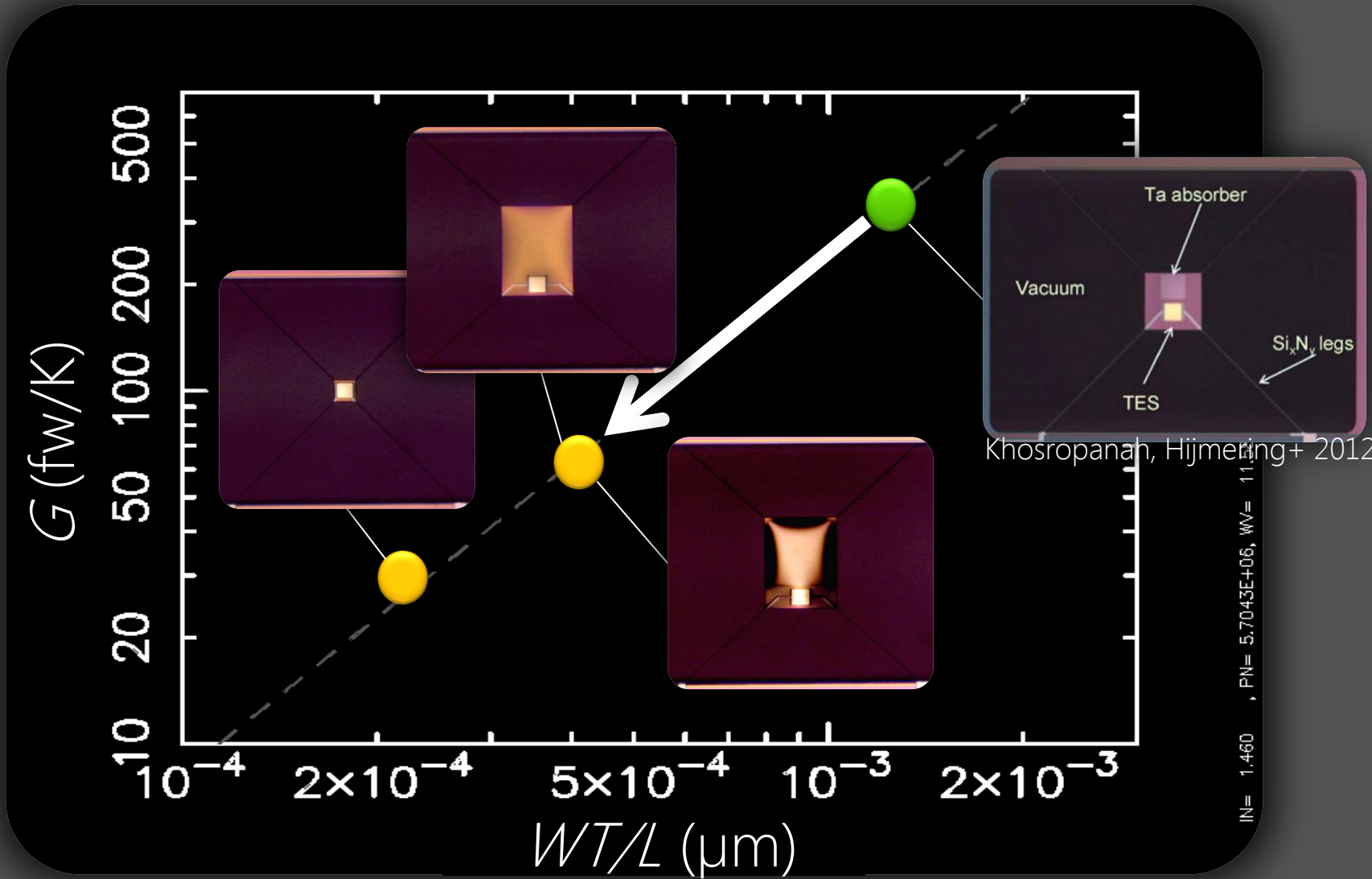
FDM readout





10pix-FDM system
1-3 MHz resonators
df=100 kHz

Measured thermal conductance



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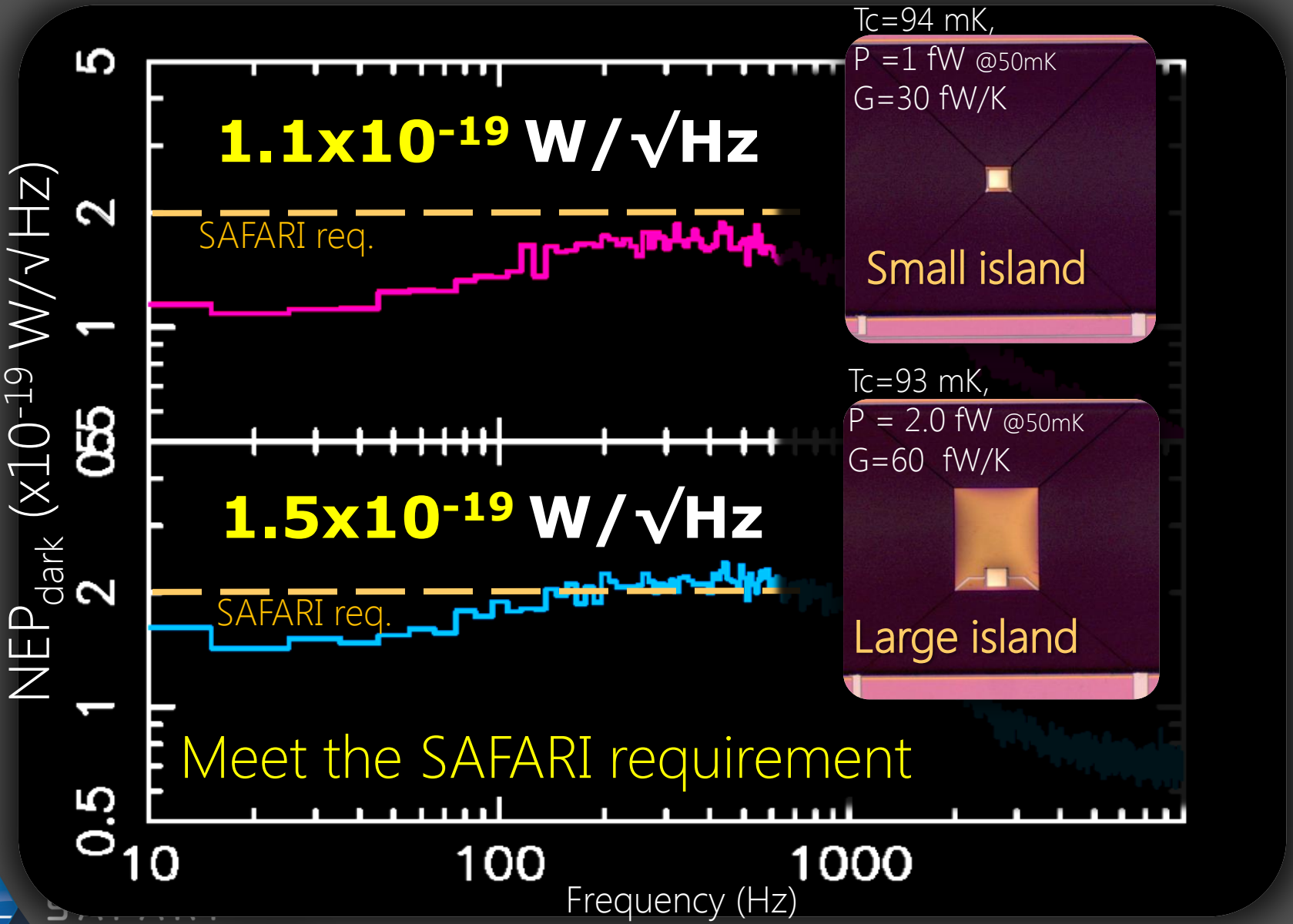
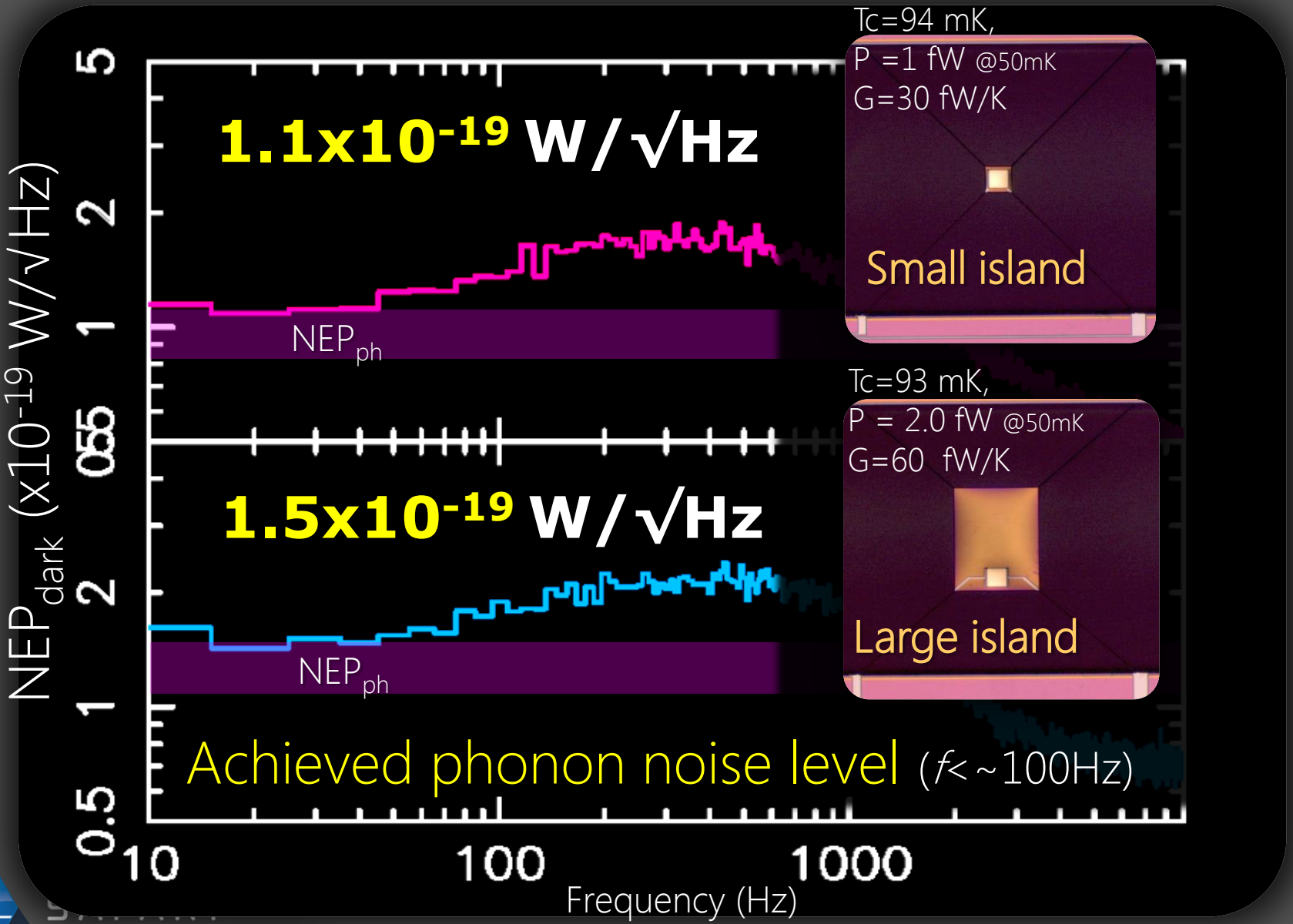
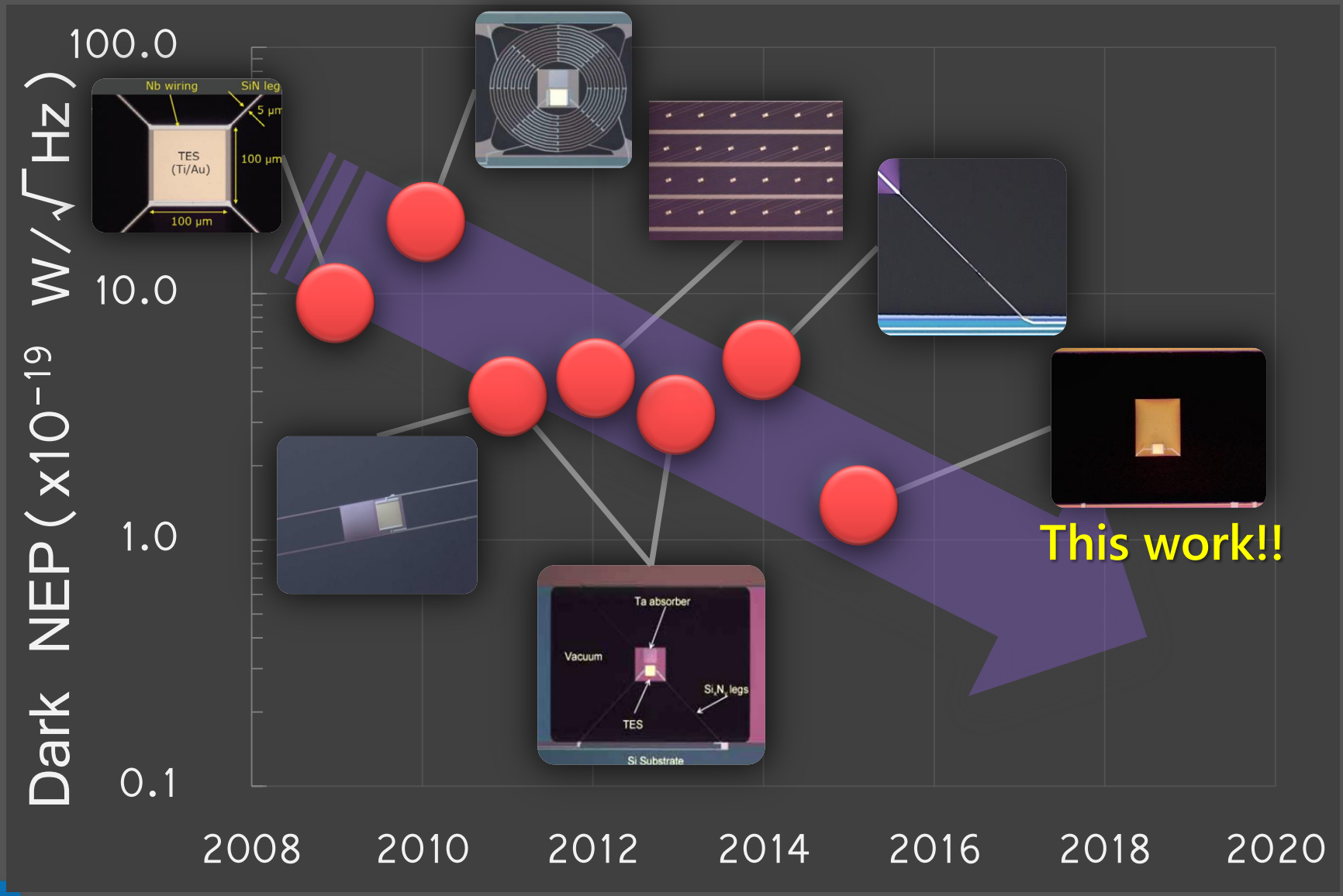
Measured NEPs



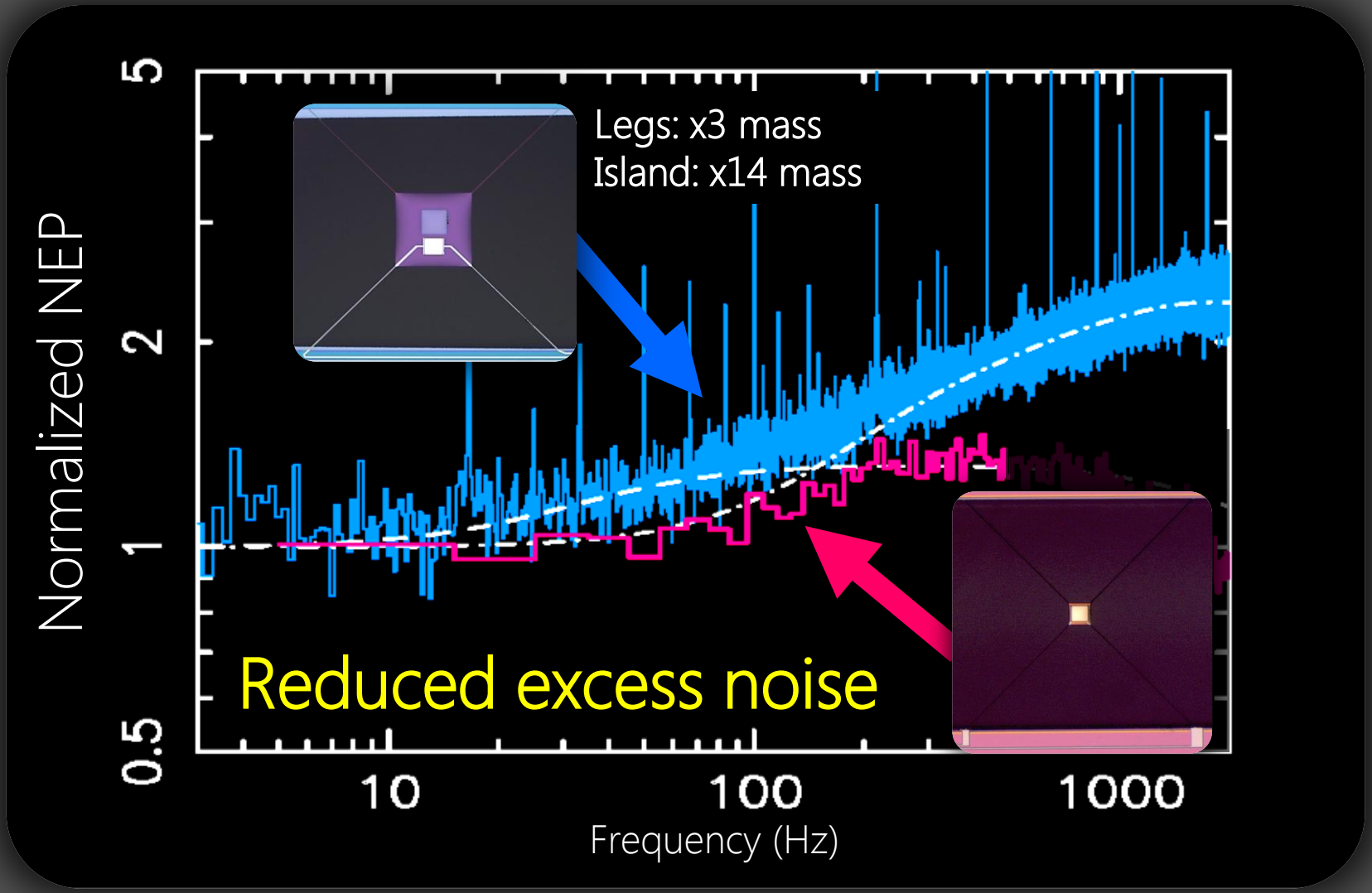
Measured NEPs



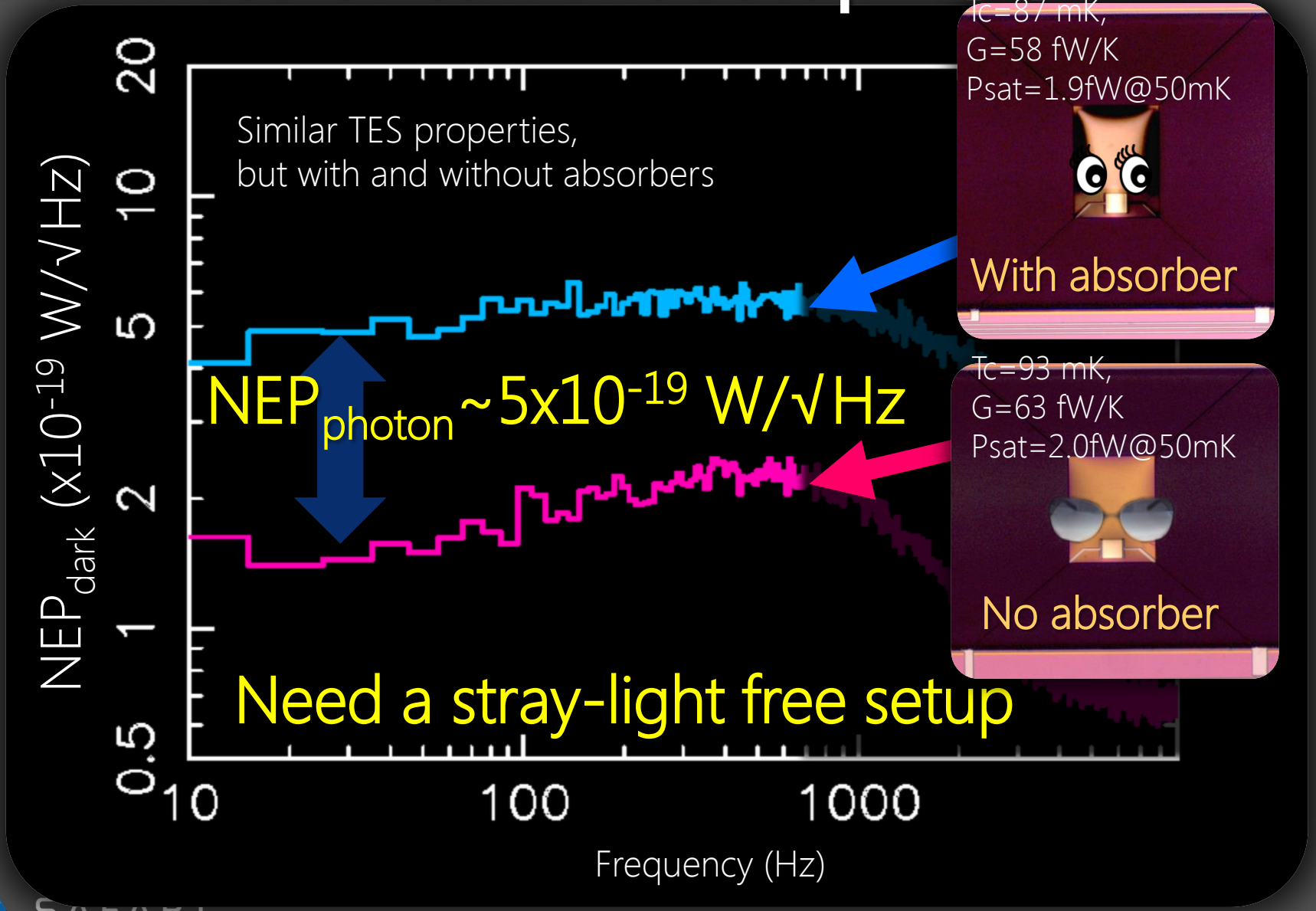
NEP-evolution track of SRON TESs



Excess noise



Darkness of current setup



Summary

Ultra-low *G* TESs were fabricated by DRIE

- ***Without*** **an absorber**

  We measured an electrical NEP as low as **1.1×10^{-19}** W/√Hz, which achieved the **phonon noise limit**, and also a reasonable response speed (**<1 msec**).

- ***With*** **an absorber**

  We confirmed a higher NEP (**~5×10^{-19}**) due to stray light.