Second Sound Measurement for SPL Cavity Diagnostics

K. Liao*, C. Balle, J. Bremer, T. Junginger, W. Vollenberg, W. Weingarten, CERN, Geneva, Switzerland

H. Vennekate#, University of Göttingen, Germany

SRF2011 CHICAGO

OST 1

I. INTRODUCTION

❖ Second sound : a quantum mechanical phenomenon exhibited in superfluids.

❖ The name "second sound" is derived by analogy with first sounds where the former propagates as an entropy (temperature) wave and the latter, a density wave.

❖ Second sound travels at ~ 20 m/s in superfluid Helium near 1.5-1.8K.

❖ Oscillating superleak transducer (OST) contains a flexible porous membrane for transmitting and blocking the movement of the superfluid and normal fluid component of the second sound wave.

❖ Eventually second sound triangulation will be used for SPL cavity (704MHz) quench tests at CERN.

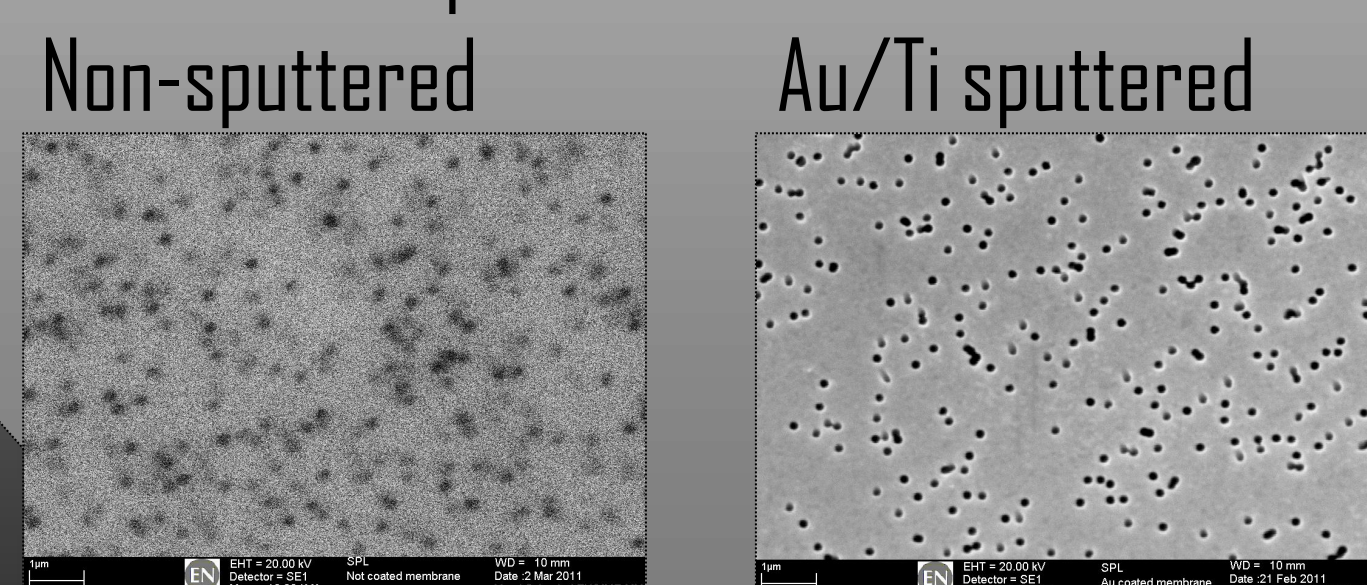❖ Second sound velocity = distance/time-of-flight (measured)
$$= \sqrt{((\rho/\rho_n -1) \cdot T \cdot S^2 / C_v)} \quad \text{(theoretical)}[1]$$

ρ: liquid helium density (g/cm^3)
ρ_n : normal fluid density (g/cm^3)
S: entropy (J/mole · K)   T: temperature (K)
C_v: specific heat (J/mole · K)

IV. OST MANUFACTURING

❖ **Mechanical parts**
 • based on Cornell's design
 • used LEMO connectors instead of SMA ones

❖ **Manufacturing process**

(a) back plate   LEMO   electrode
(b) glue
(c) membrane   upper lid
(d) OST   superfluid   normal fluid
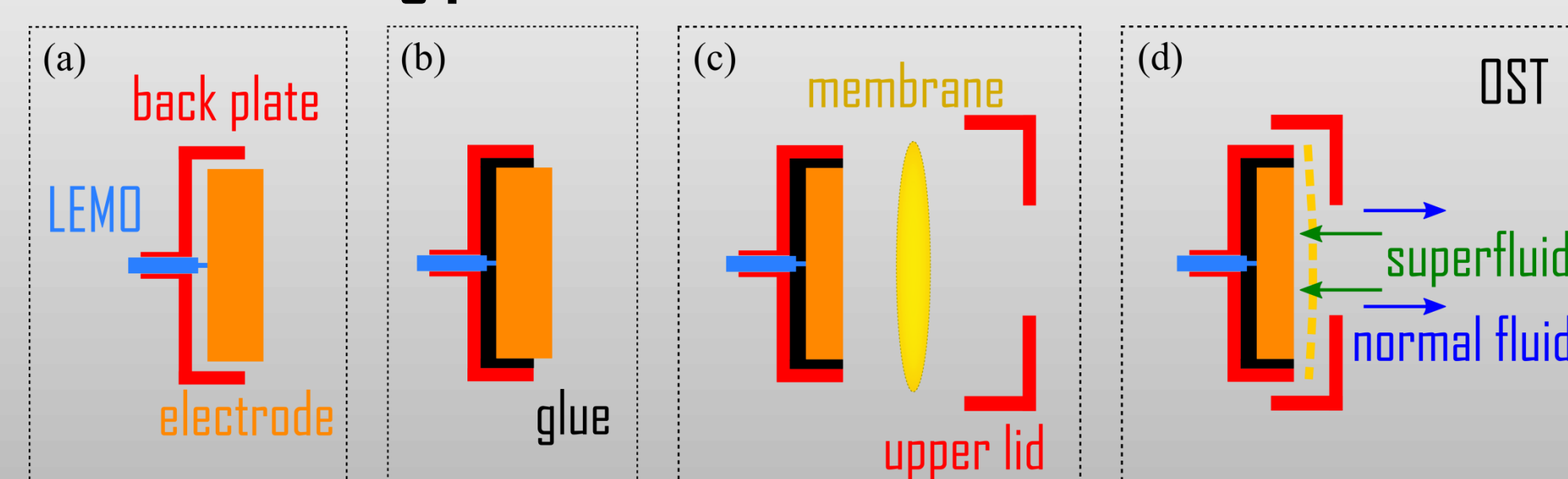
❖ **Membrane (polycarbonate) sputtering**
 • Ti 3 nm + Au 50 nm
 • SEM pictures

Non-sputtered   Au/Ti sputtered
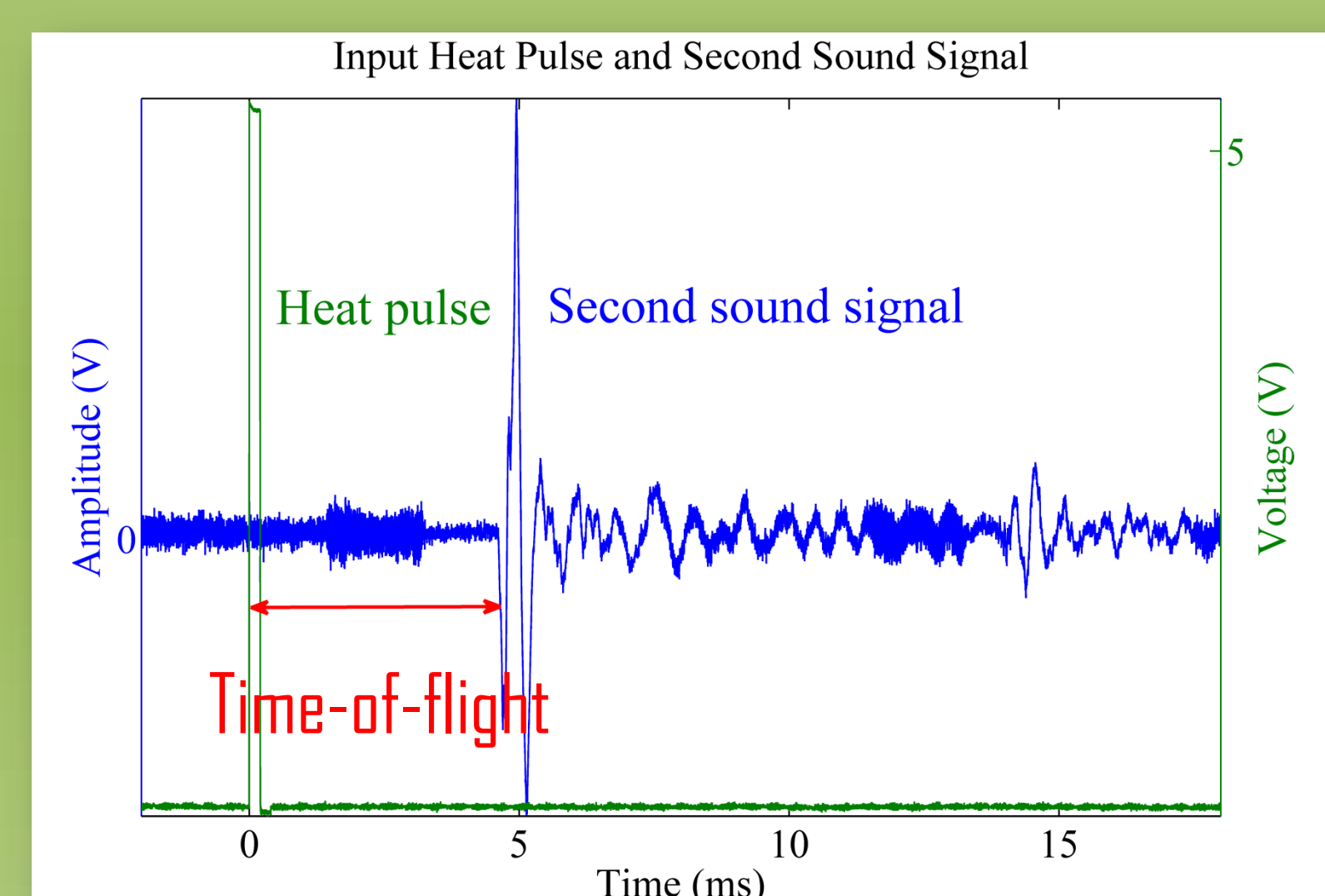
courtesy of Maud Scheubel

OST 3

III. SECOND SOUND RESULTS

SPL Cavity

❖ **Fight against noise!** (1) insulate the building ground and the cryostat,
→ **53% noise reduced** (2) 120V battery charger for OST

Before

SMD 2 at 1.71K

After

SMD 2 at 1.71K
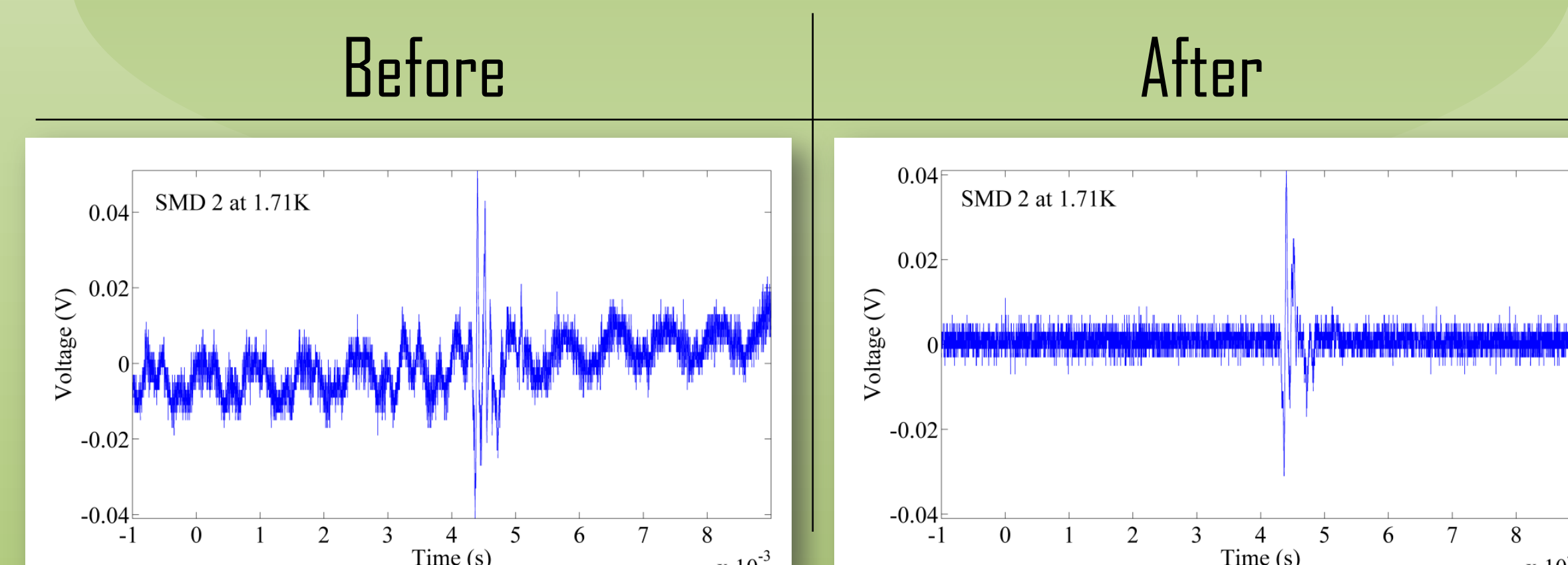
❖ **Measured second sound velocity**
agrees with theoretical value within ±1 % in 1.5~ 2.1K

Input Heat Pulse and Second Sound Signal

Heat pulse   Second sound signal

Time-of-flight

Second sound velocity vs. T(K)

— theoretical value
— temperature error
— velocity error
• experimental value
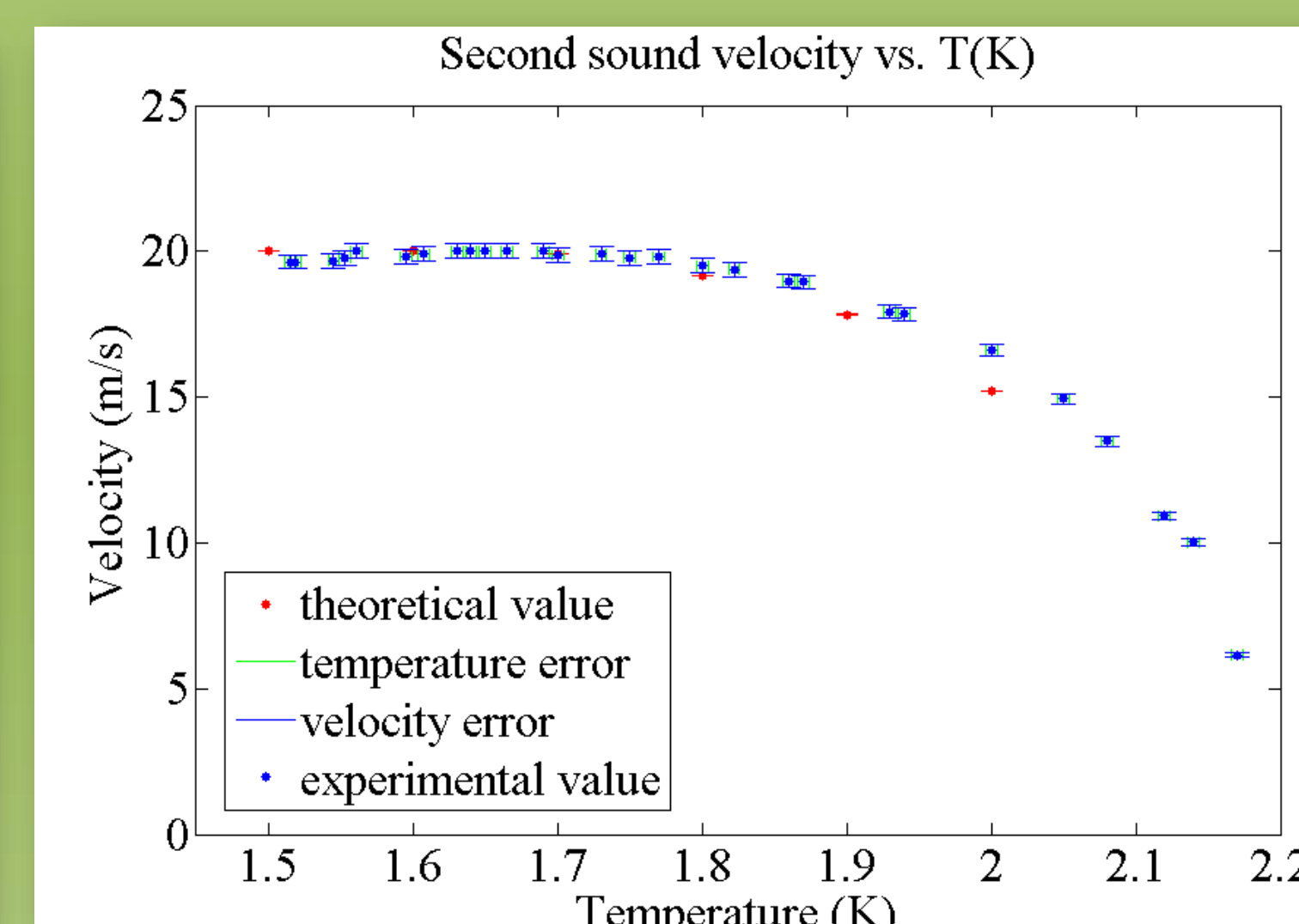
❖ **Heat source distance determination**
measured distance vs. distance derived from measured second sound velocity

 • fixed OST   • adjustable OST

— Measured distance
• Calculated (using 2nd sound velocity)
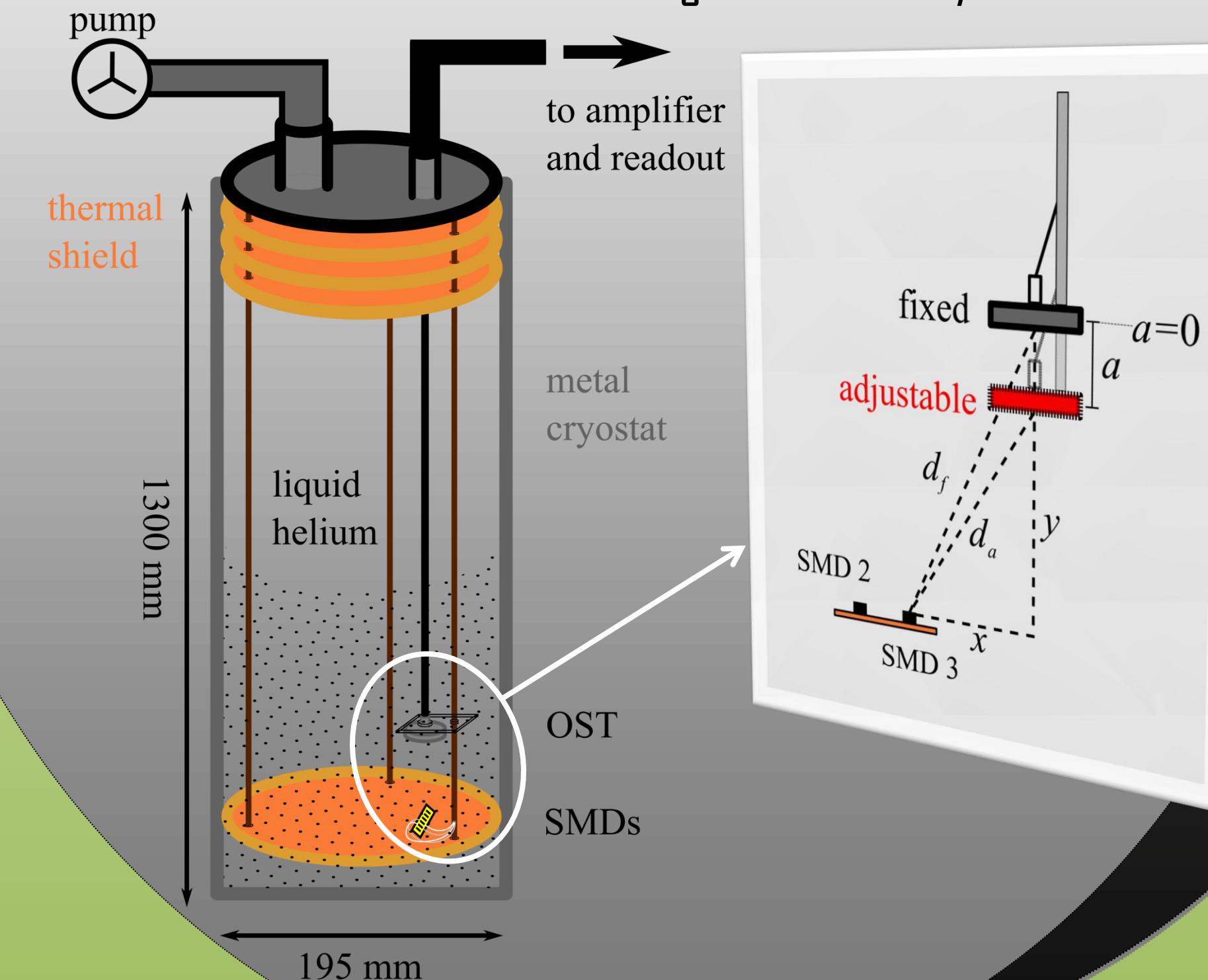
7 Data points at 1.69 K
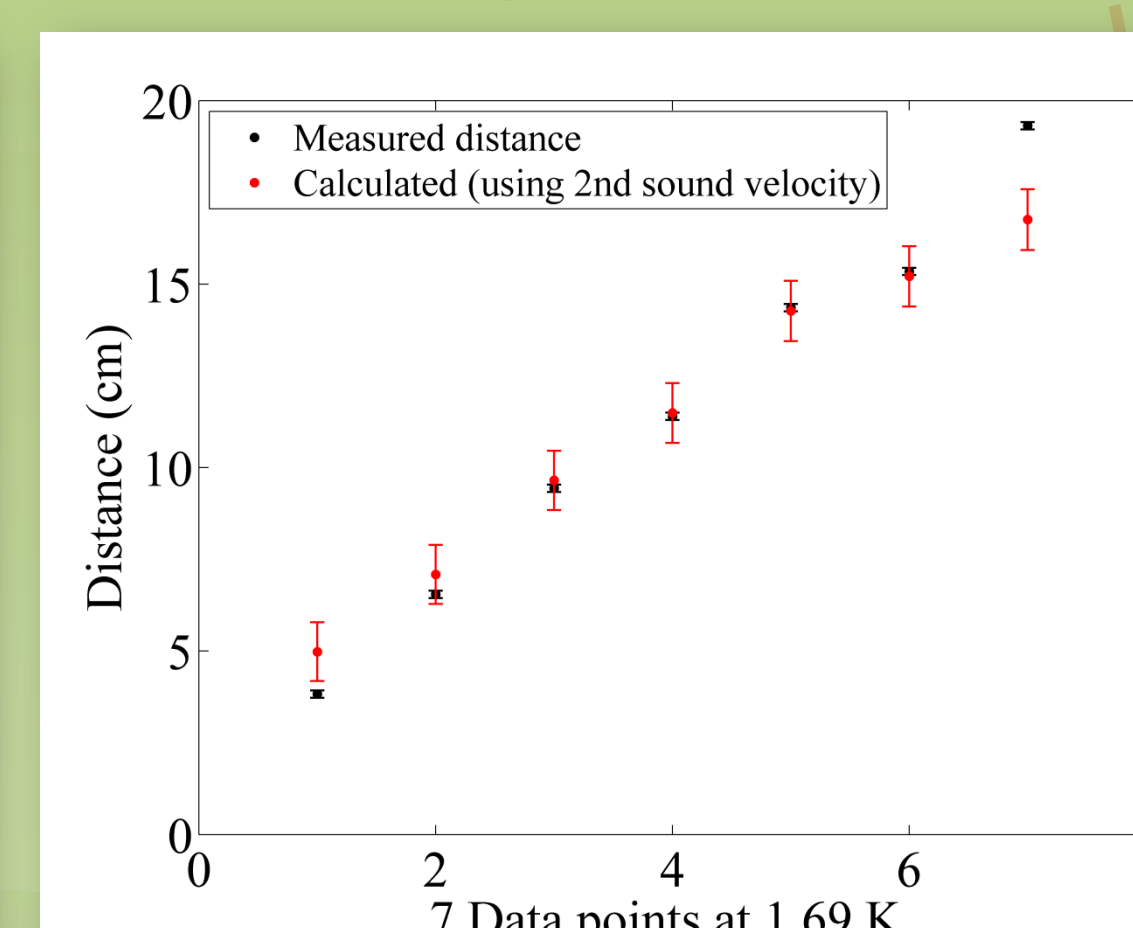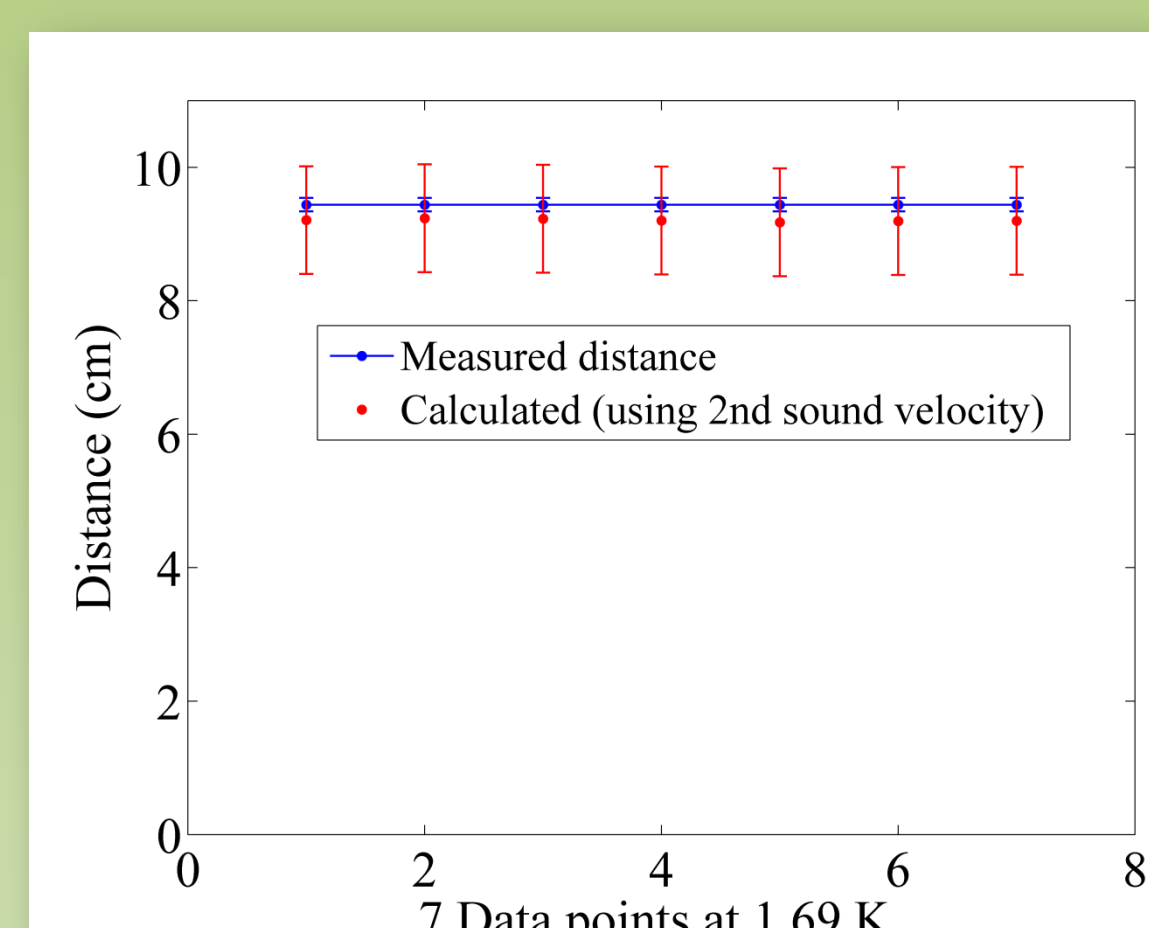
*Kitty.Liao @ CERN.CH
#Technical Student at CERN

[1]P. Bendt et al, "Excitations in liquid Helium: Thermodynamic Calculations (1956)"

II. EXPERIMENTAL SETUP

OST 2

❖ Used 6 different Surface Mount Device (SMD) -- thick film resistors

❖ SMD 2 and 3 with better signals for analysis

pump
to amplifier and readout
thermal shield
metal cryostat
liquid helium
1300 mm
195 mm
OST
SMDs

fixed   a=0
adjustable   a
d_f d_a y
SMD 2   SMD 3   x

❖ **Second sound strength**
indicate the benefit of operating cavities below 1.8K increase the second sound amplitude

Second sound amplitude vs. T(K)

Second sound wave

Quench spot

Time-of-flight
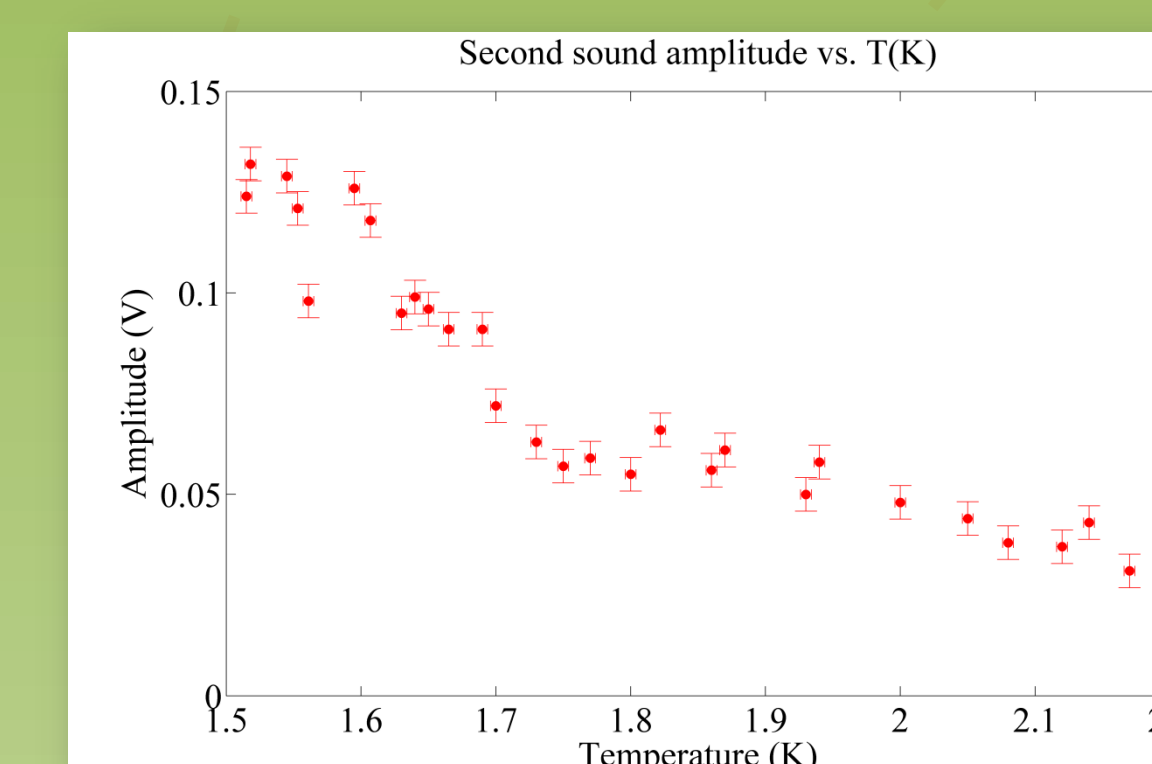
V. CONCLUSION

❖ An efficient noise reduction increases the discernment of the second sound signal to noise level (S/N).

❖ 2nd sound amplitude decreases with the superfluid helium temperature.

❖ The measured second sound speed agreed with the theoretical curve, and the distance derived from which agrees with the measured value within error bars.

❖ The measurements improvement and studies will be continued to enhance the understanding of the characteristics of second sound and the OSTs.

OST 4