A photoelectron source for electrons on liquid helium

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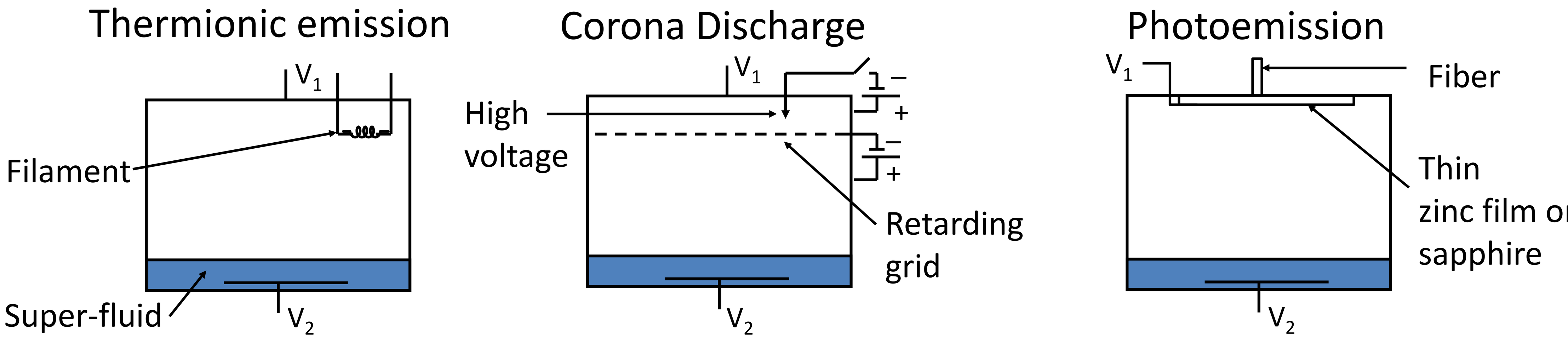
What do we want from an electron source?

Should generate low energy electrons with low input power to avoid heating. Should be reliable and easy to control

Common approaches

Better approach



Heats low T system.
Too many electrons
Unreliable – filament breaks

High energy electrons
High pressure gas ➔ warm up to 1 K from 30 mK

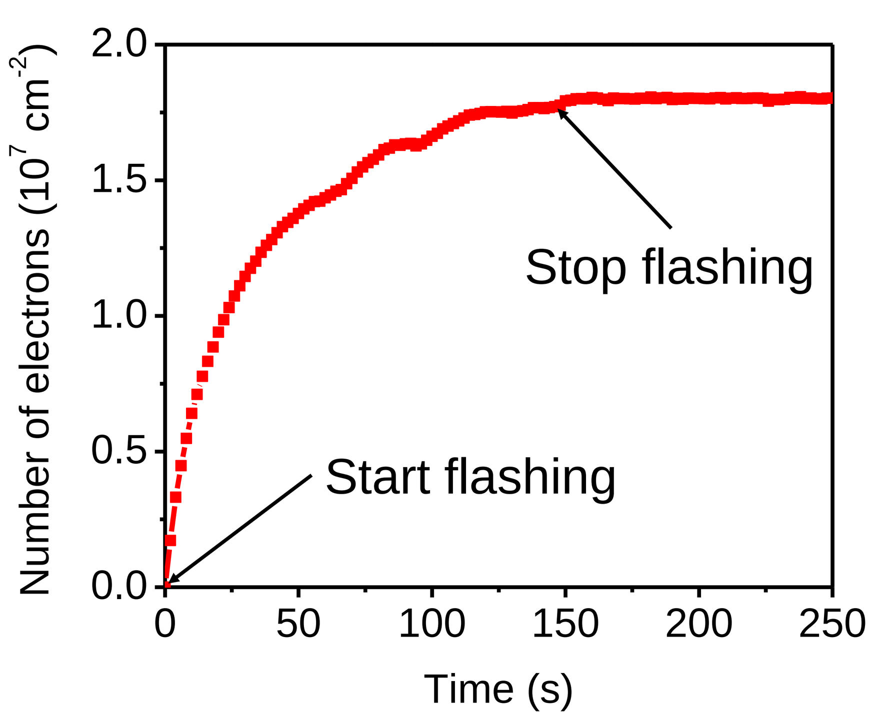
Implemented by Wilen and Gianetta, Rev. Sci. Instr. **56**, 2175 (1985)
Used 1 kW arc lamp focused into fiber
Instead we use low power lamp

How does it work?

Collect electrons at bottom of cell – 3 plate circuit board
Photo-emit into vacuum – get 10^8 electrons per lamp flash

T ~ 1.5 K. ~ 1 mm thick super-fluid helium covering circuit board
Sommer – Tanner measurement

3 plate circuit board on cell bottom



Collect electrons !

~10^3 electrons per lamp flash

Hold zinc few volts repulsive with respect to cell walls and circuit board

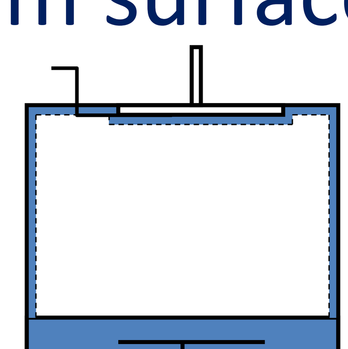
How do electrons reach the bottom helium surface?

Super-fluid helium coats all surfaces in cell. ~ 30 nm covers the zinc.

Presents 1 eV barrier to emission

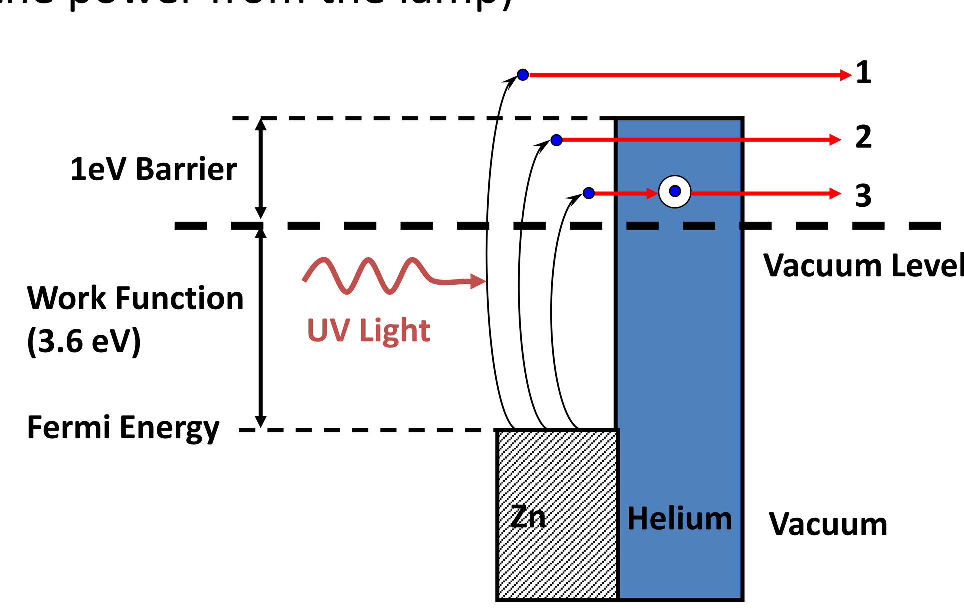
Not boiling off the film, unlike Wilen-Gianetta

(more emission in vacuum; need ~100 nJ, which is all the power from the lamp)



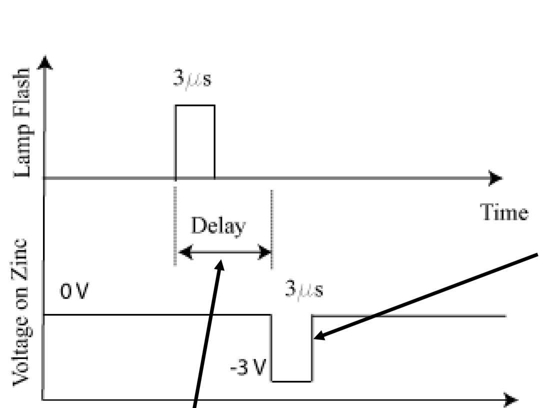
Possibilities

1. Emit over 1 eV barrier
2. Tunnel through 1 eV barrier
3. Form bubbles which escape over ~ milliseconds



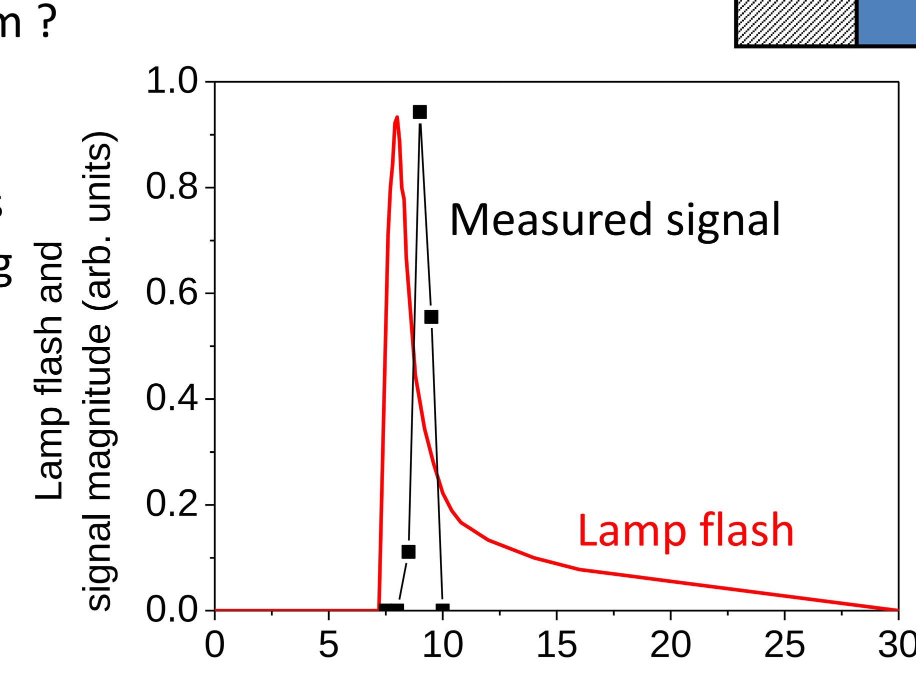
Time resolved emission experiment

– when do the electrons reach the bottom ?



Only electrons emitted during voltage pulse on zinc are collected

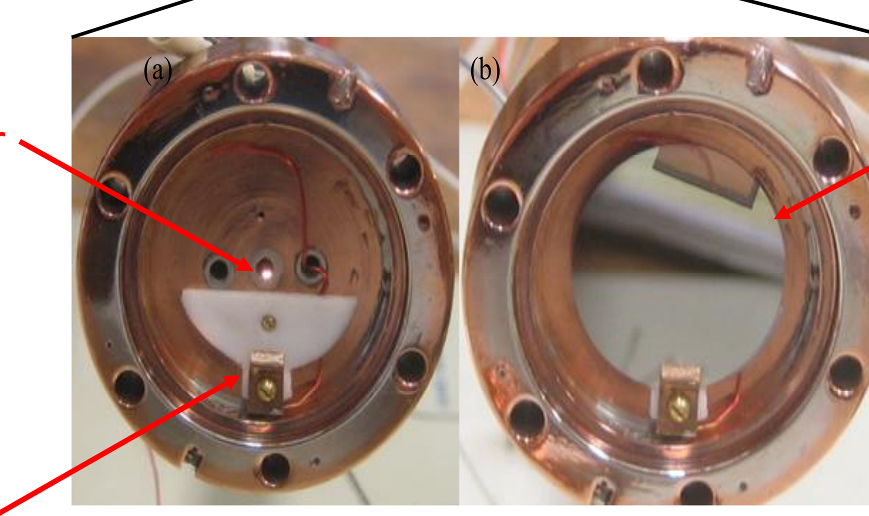
Sweep delay measure Sommer-Tanner signal



No ~ 1 ms tail ➔ no bubbles

~ 1 μs initial delay matches calculated transit time of electrons in helium vapor at 1.5 K

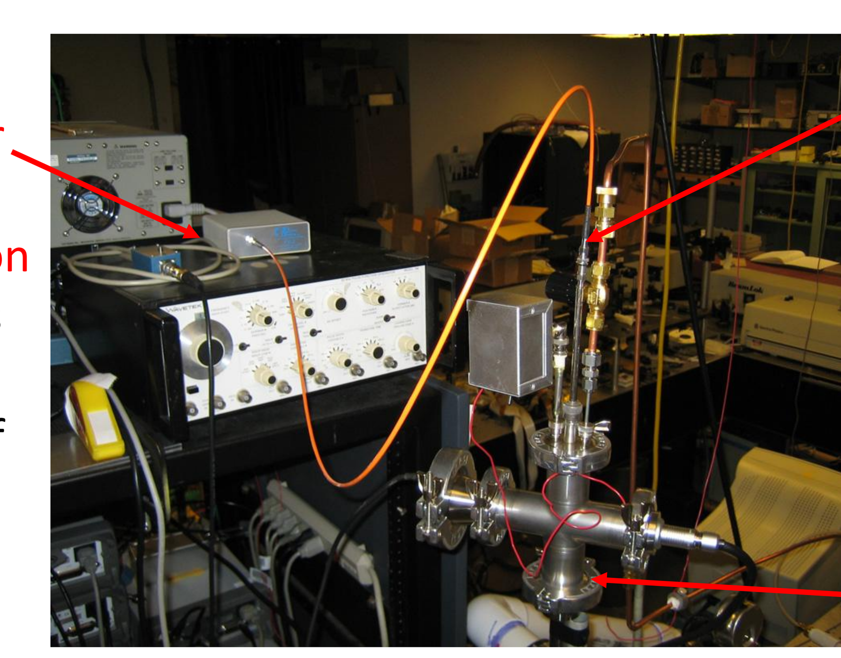
How do we make it?



Thin zinc film
20 nm Zn/10 nm Ti thermally evaporated on 0.02" thick sapphire substrate

photo-current reduces ~10-20% in an hour when exposed to air at room temperature

Small, low power Ocean Optics PX-2 pulsed xenon source. Produces 3 μs pulses at a maximum rate of 200 Hz. ~ 100 nJ energy per pulse



Fiber patch cord into SMA-905 connector

Setup inserted into 1.5 K system

Conclusions

- Implemented photoelectron source for electrons on liquid helium
- ~ 100 nJ per lamp flash, produce ~ 10^3 electrons
- Reliably and controllably produce small numbers of electrons

- Time resolved experiment – electrons arrive at 1 μs after flash ➔ no bubbles in 30 nm helium film covering zinc
- Electrons emit over or tunnel through the 30 nm film covering the zinc, transit in 1 μs through vapor, and reach the bottom helium surface

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