DETECTION OF THE SARS-COV-2 USING SPR

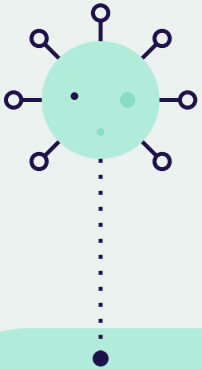
Presenters:

Jasmine

Dan

Dominic

Vinit



OUTLINE

- Surface Plasmonal Resonance (SPR) : (Background)
- SARS-COV-2 : (Background)
- SARS-COV-2 : current detection methods
- Proposal
- Theory: Protein/ antibody binding
- Device Design
- Detection system : magnetic sensing
- Electrical detection system and user readout
- Limitations

SURFACE PLASMONAL RESONANCE (SPR) : (PRINCIPLES)

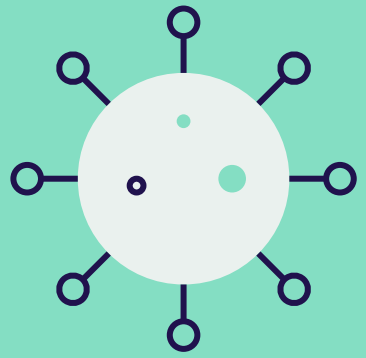
"Polarized light hits a metal surface at the interface of two medias with distinct refractive indices"

Polarized light efficiently propagates electron density waves (plasmons)

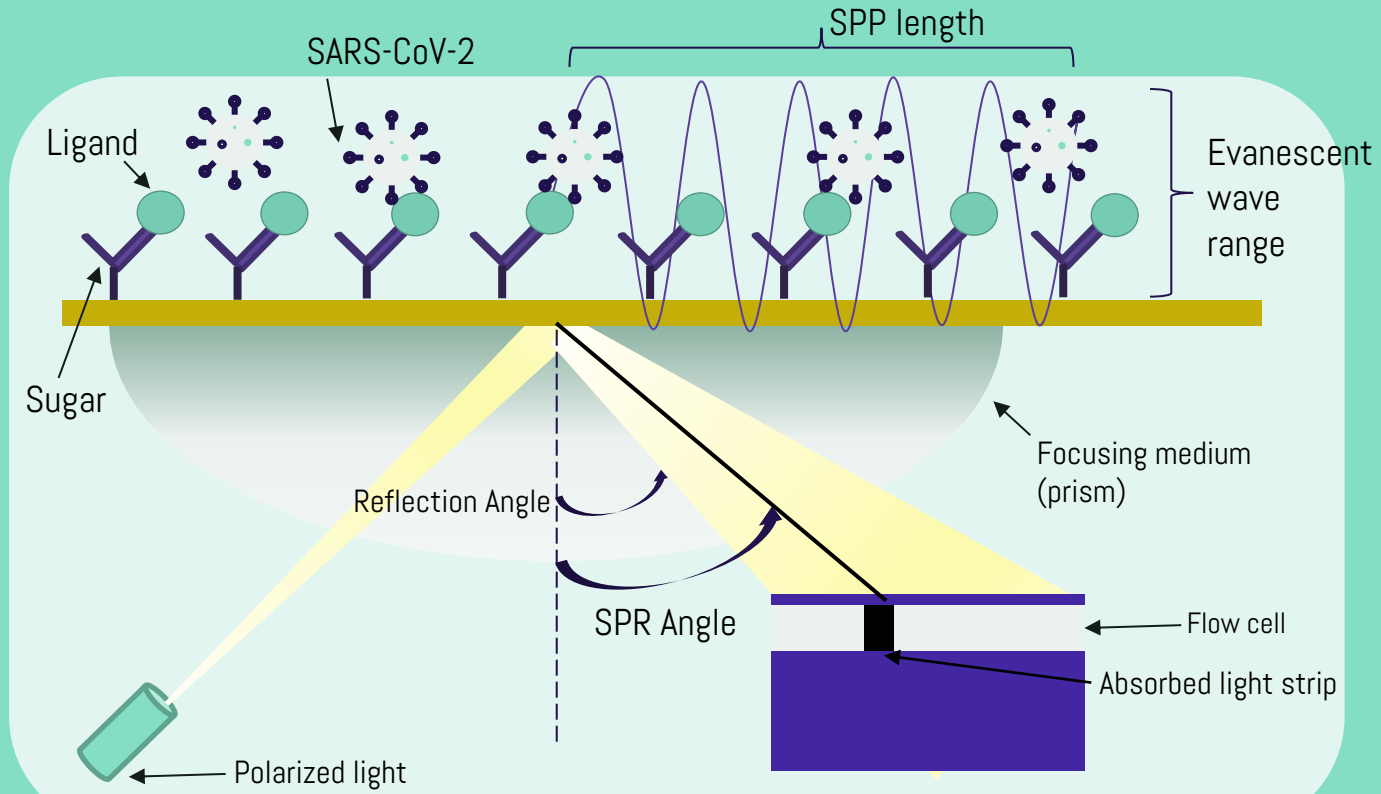
Non-magnetic, thin metal best optimizes the resultant evanescent wave

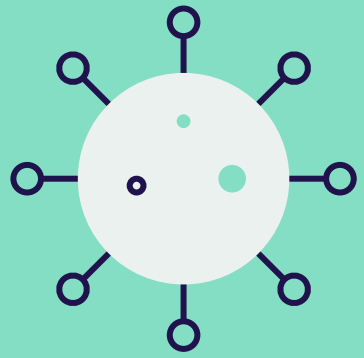
The tight interface directs light at consistent angle toward metal surface

Different refractive indices allow for sensible coupling, inducing oscillation



SURFACE PLASMONAL RESONANCE (SPR) : (APPARATUS)

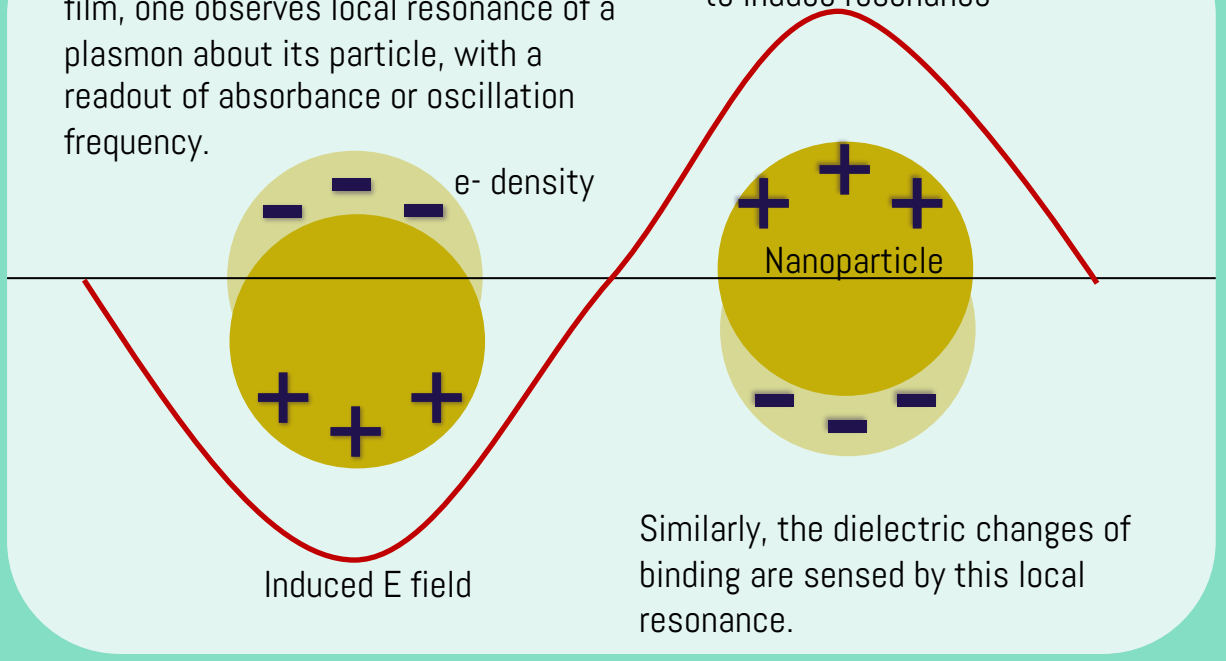




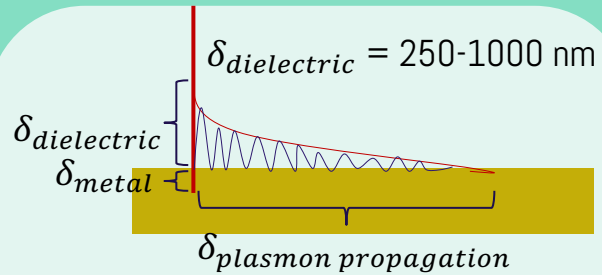
LOCALIZED SURFACE PLASMON RESONANCE

Rather than bulk resonance across a film, one observes local resonance of a plasmon about its particle, with a readout of absorbance or oscillation frequency.

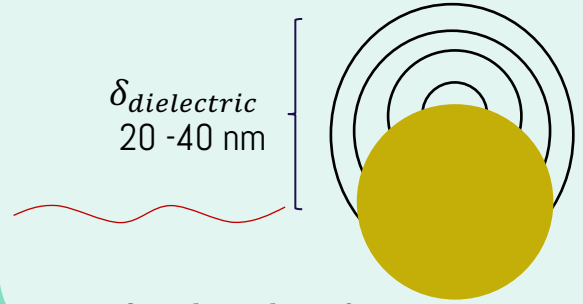
Specific light wavelength to induce resonance



Similarly, the dielectric changes of binding are sensed by this local resonance.



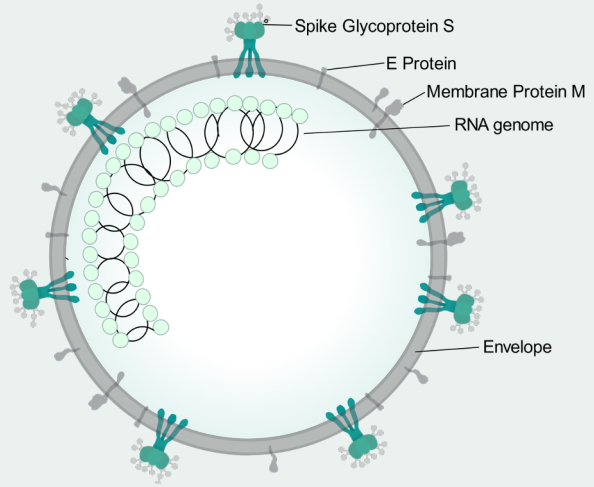
$interface\ length \gg \delta_{plasmon\ propagation}$



$interface\ length \ll \delta_{plasmon\ propagation}$

SARS-COV-2 : (BACKGROUND)

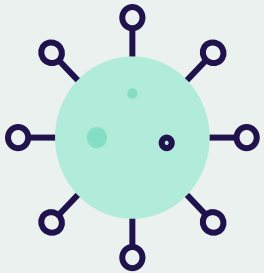
- Severe acute respiratory syndrome coronavirus 2 is the virus strain that causes the global pandemic COVID-19
- 50–200 nanometers in diameter.
- 4 structural proteins: S (spike), E (envelope), M (membrane), and N (nucleocapsid) proteins.
- S-protein of coronavirus is divided into two functional units, S1 and S2. S1 facilitates virus infection by binding to host receptors via the S protein–ACE2 binding pathway.



SARS-COV-2 : (CURRENT TEST METHOD)

REAL TIME – POLYMERASE CHAIN REACTION (RT-PCR)

- Detect and amplify SARS-CoV – 2 viral RNA by thermal cycling
- Result may take up to hours.
- Require Laboratory equipment: Thermo Cycler.
- High sensitivity



ISOTHERMAL NUCLEIC ACID AMPLIFICATION (ABBOTT ID NOW™ COVID-19)

- Detect and amplify SARS-CoV-2 viral RNA by isothermal nucleic amplification method.
- Positive result can be achieved in as little as 5 minutes.
- Performed in small, portable system at point of care.
- Previous testing for influenza with this technology exhibit lower sensitivity (~80%)

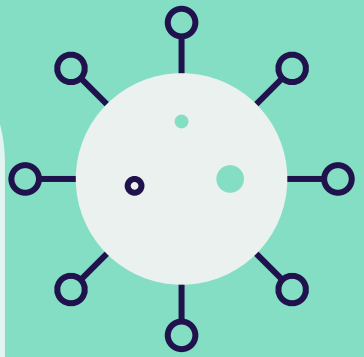
PROPOSAL

The existing solutions for detection of COVID-19 such as has several disadvantages such as:

- Time taken per test (~8-10 hours)
- Labor intensive and High cost
- Low sensitivity
- Non-portability (can only be used in clinical settings by trained personals)

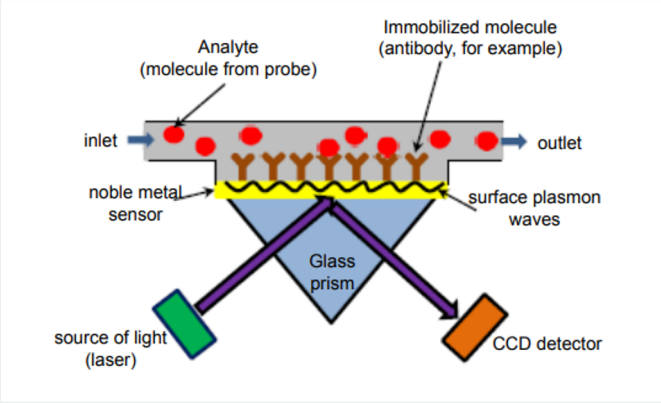
As a focus on reduction of cost and to facilitate the point-of-care testing, we instead propose a detection system based SPR methodology. Below are highlights of the proposed system

- Using bimetallic nanoparticles (utilizing noble and magnetic metals)
- Utilizing magnetic sensing approach to enable development of a hand-held system
- Targeted detection time of ~15 minute



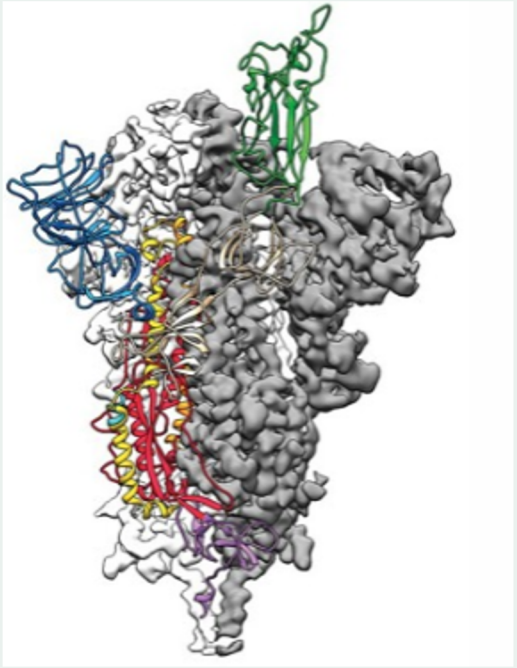
THEORY : ANTIBODY BINDING

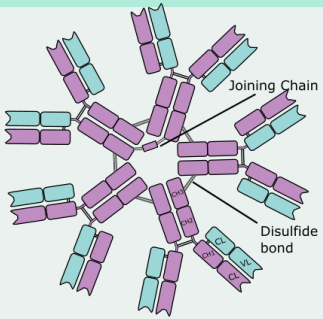
- In order to detect the virus, it must be first immobilized on the sensor chip surface while retaining biological activity. This can be done by antibody binding.
- The binding of the receptor protein leads to its accumulation on the sensor's surface and increases the refractive index near the sensor surface.
- Antibody binding is also called Affinity Capturing Systems .
    - Antibodies immobilized via amine coupling



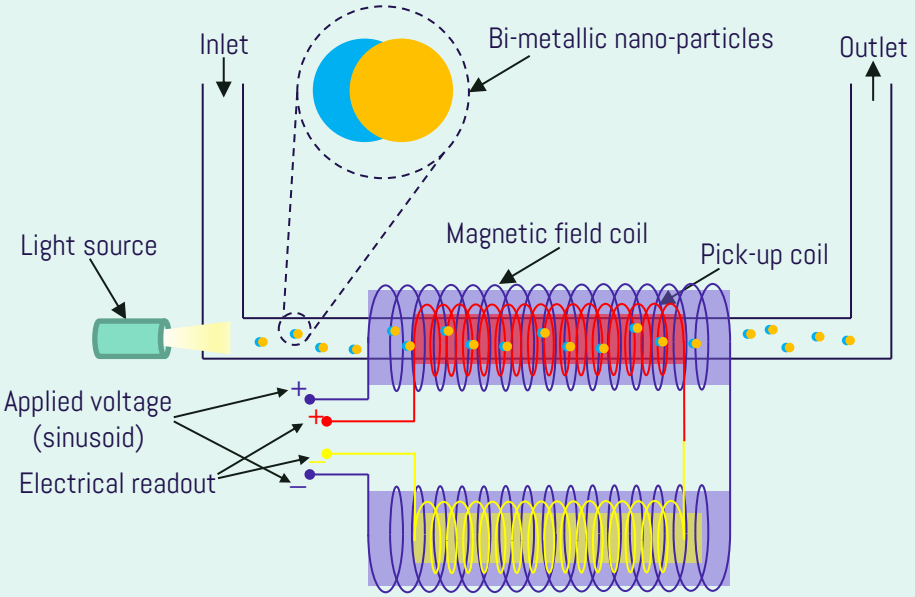
THEORY : ANTIBODY BINDING

- Target the S1 functional group of the SARS-COV-2 Spike glycoprotein
    - This protein allows the virus to attach to and infect human cells
- Spike proteins have different shapes between different coronaviruses, and therefore prevent the chance of false positives
- Target IgM antibody for more acute detection





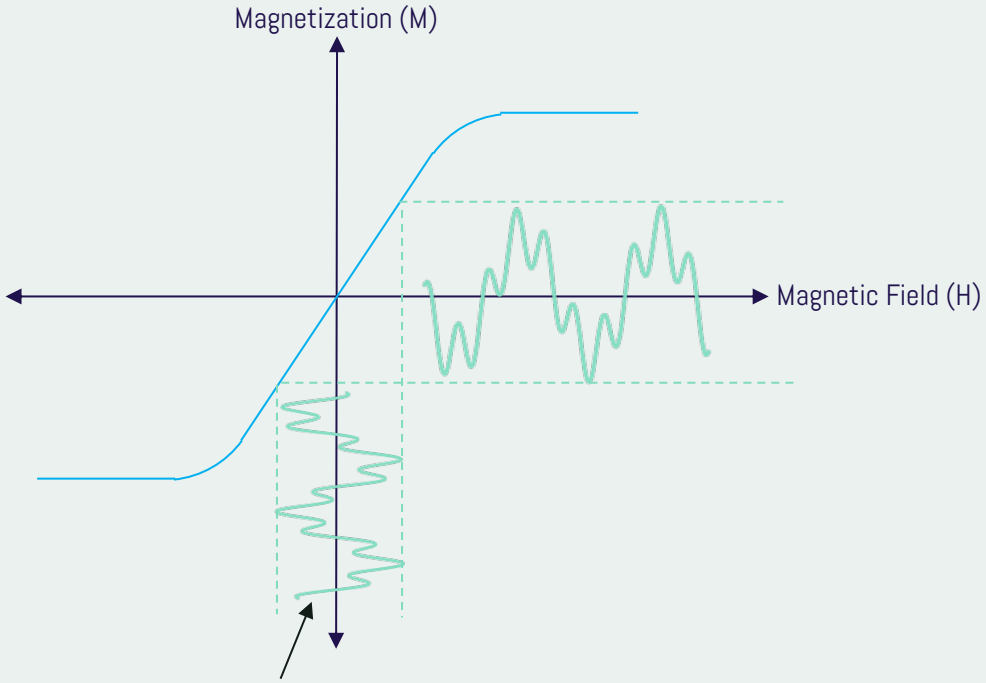
DEVICE DESIGN : SCHEMATIC



Important points:

- Bi-metallic particles consist of magnetic and noble metals
- Second (lower) branch of magnetic and pick-up coils is to cancel out the induced emf due to applied voltage and only capture response of nano-particle movement

DETECTION SYSTEM : MAGNETIC SENSING PRINCIPLE



*Applied field is sinusoid with a single frequency, second harmonic distortion would be due to nano-particle motion due to SPR

According to Faraday's law:

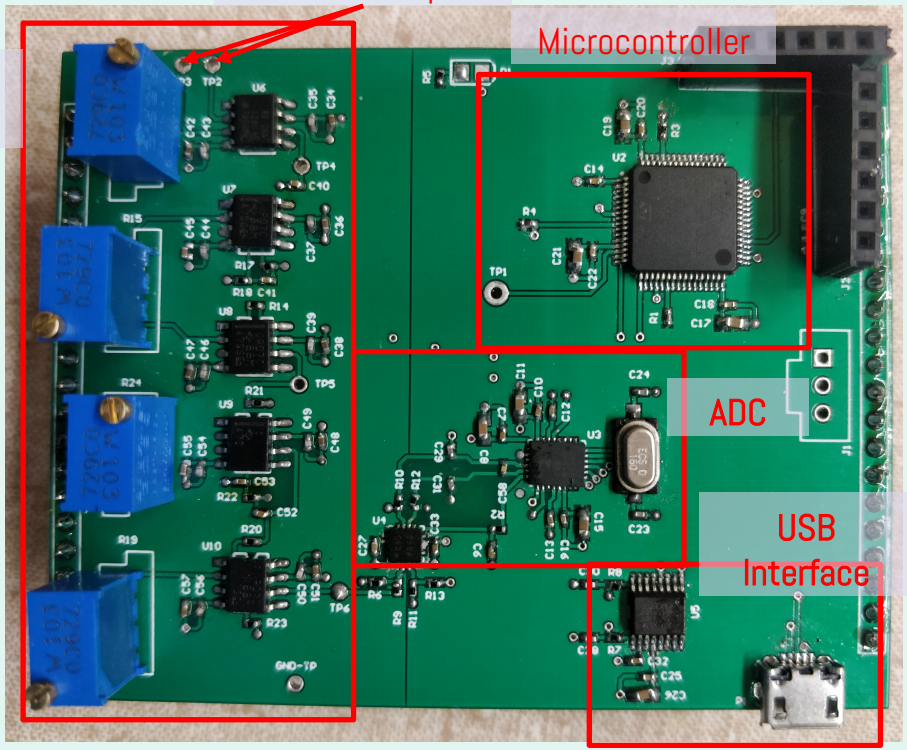
$$EMF = -N\frac{d\boldsymbol{\phi}}{dt}$$

Where:

- N = number of turns in solenoid (pick-up coil)
- $\boldsymbol{\phi}$ = magnetic flux passing through coil area

Change in magnetic flux due to magnetization response of nanoparticle would generate electrical potential readout

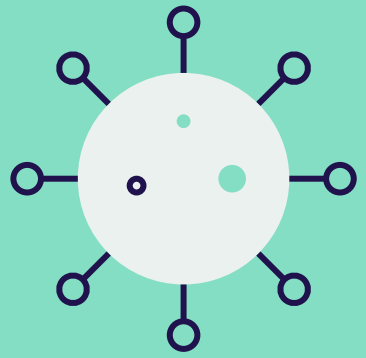
ELECTRICAL DETECTION SYSTEM AND USER READOUT



ADVANTAGES AND LIMITATIONS

SPR Against other Biosensors:

Advantages	Limitations
Real-time data acquisition for P.O.C	Steric hinderance
Label-free	Biochemical incompatibility
Faster than most biosensors	Native ligand configuration
More accurate than most biosensors	Amplification may be required
	Specificity cannot be ensured



LSPR over SPR

Negligible “bulk-effect”

Instrumentally less complex

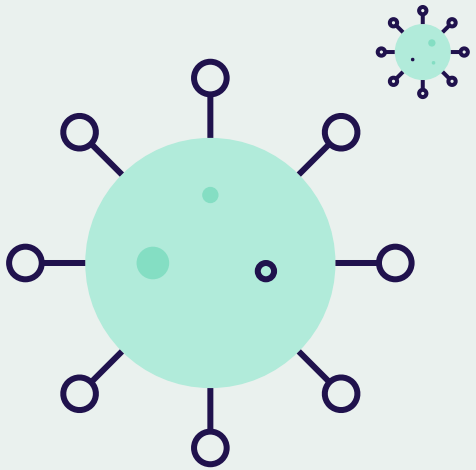
Less sensitive to EMF and temperature noise

Larger tube radii allowed

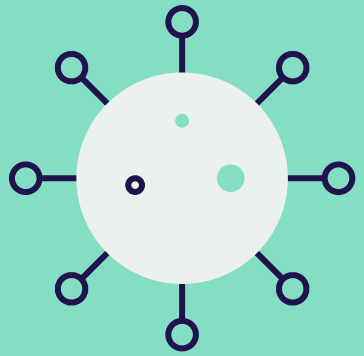
Vastly more scalable

CONCLUSION

- Keys to large-scale implementation
  - Cost-effective system
  - Minute-scale vs hour-scale
  - Instrumental simplicity enables manufacturing simplicity
  - Compact device optimizes point-of-care use



THANKS!



Do you have any questions?