

Motivation

- 1.3 million women and girls are pregnant with HIV yearly [1]
- Up to 32% chance that the mother can spread HIV to their baby through breastfeeding if not on ART [2]
- 420,000 children contracted HIV (2007), usually through mother-to-child transmission (MTCT) [3]
- Most common method of MTCT is breastfeeding [3]
- No options that allow mothers to breastfeed safely
- Many health benefits associated with breastmilk:
 - Delivers antibodies to fight infection [4]
 - Delivers custom nutrition based on baby's needs (i.e. melatonin near bedtime) [4]

Objective

Our team is designing a medical device to be used by HIV-positive, breastfeeding mothers for the prevention of perinatal transmission by deactivating the virus with UV-C light while preserving the taste, nutritional value and immunity aspects of breastmilk.

Sustainability

Milk it's solution aligns with the United Nations Sustainability and Development Goals including: goal 2 – zero hunger, goal 3 – good health and well-being, and goal 5 – gender equality. The device pasteurizes the HIV-infected breastmilk and preserves important nutrients like proteins to deliver safe and healthy milk to the baby. Our solution reduces gender inequality and empowers mothers by giving them safe options concerning the health of themselves and their babies.

UV Dosage Concept

- The D10 is recognized as the industry standard for the radiation dose required to deactivate 90% of a viable microbial population. [6]
- Dosage is dependent on average Fluence [6]:

$$F_{avg} = F_0 \left(\frac{1-10^{-AL}}{AL \ln(10)} \right)$$

- To calculate the dosage, the average fluence is then multiplied by the time in seconds that the solution is exposed to the UVC light. [6]
- The experimental method for determining the D10 of the solution is done through plotting multiple dosages and their respective viral concentration logarithmically. [6]



MILKit

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Design

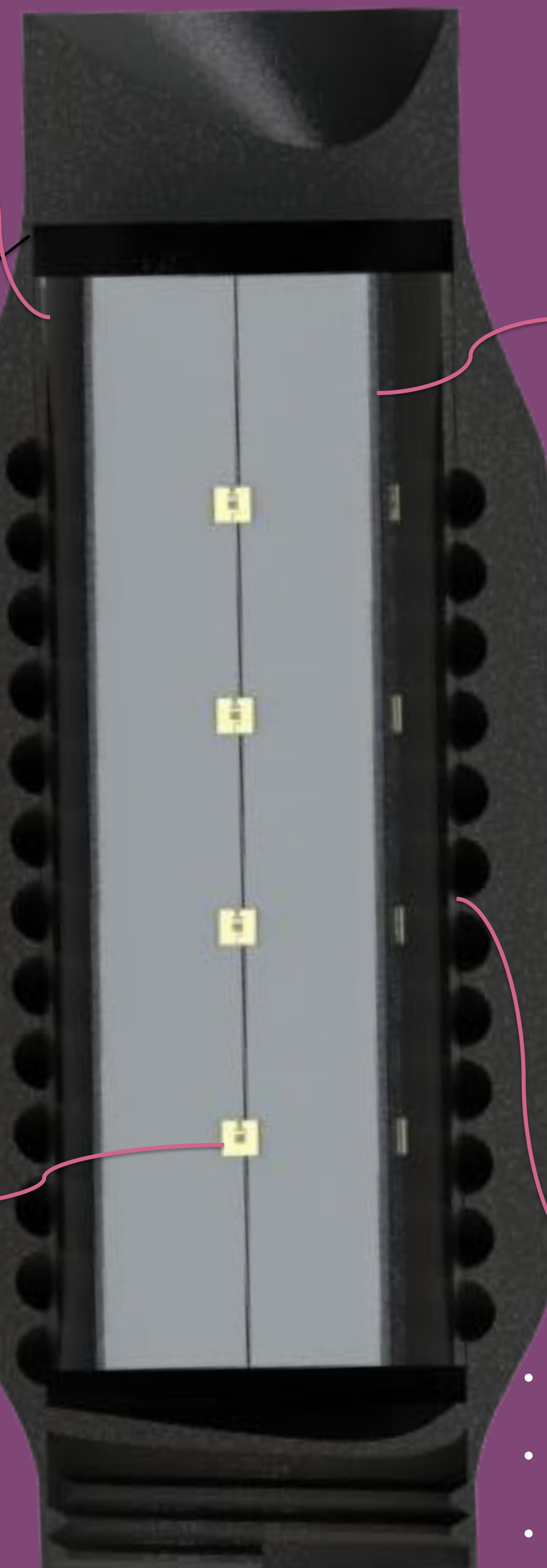
Fused Quartz Tube

- Readily transmits light from 180 – 400 nm
- Made of silicon dioxide



UV LEDs

- 60 mW optical power
- Wavelength of 260-275 nm
- High efficiency
- Best power to cost ratio



Aluminum Rod

- Heatsink that allows heat dissipation from LEDs
- Prevents milk temperatures from exceeding 65 degrees Celsius (temperature of protein denaturation)

Spiral Configuration

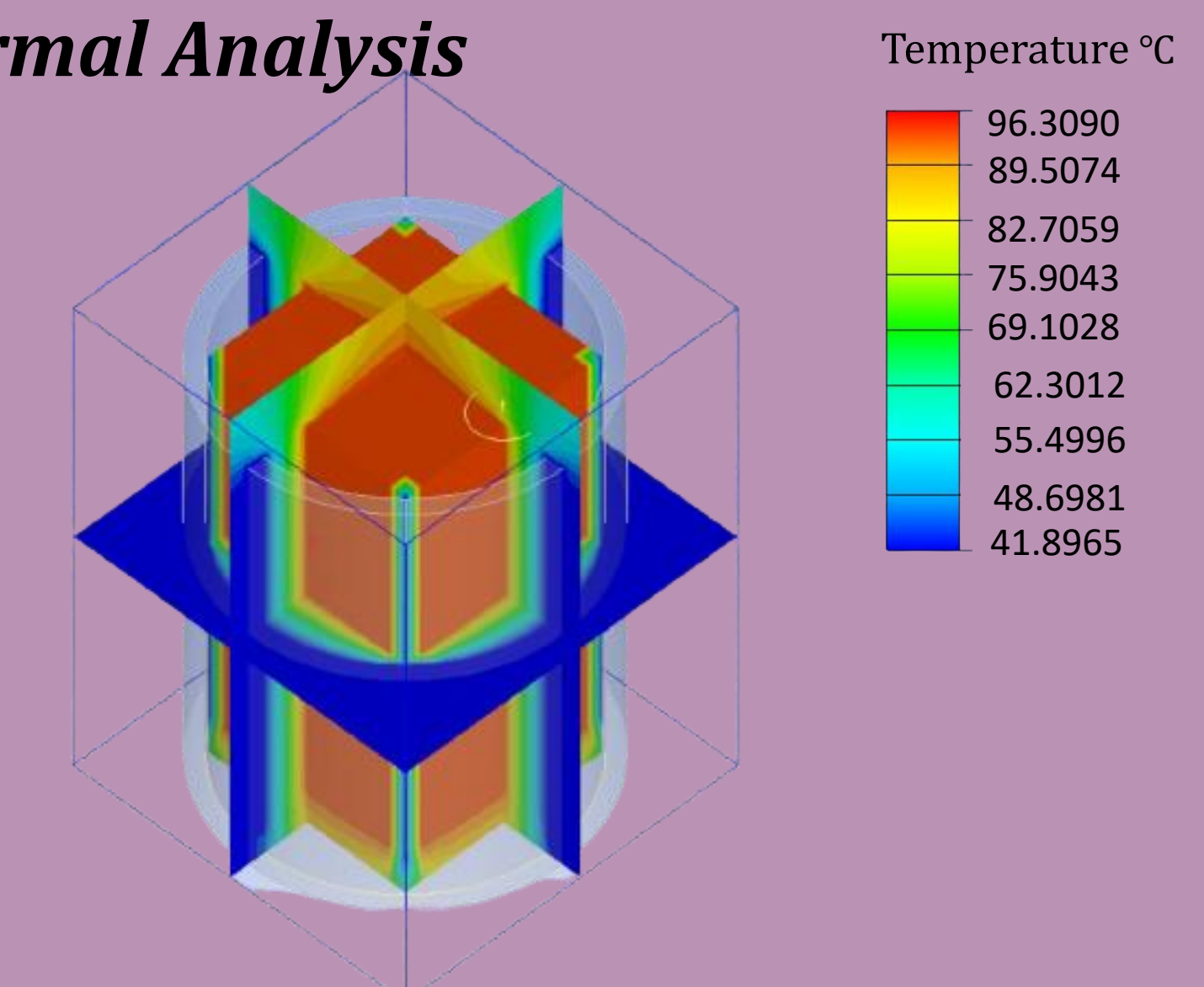
- Milk is a highly opaque fluid which makes it difficult to transmit light
- Flow through a helix ensures thorough mixing of the milk
- Ensures entire volume will be exposed to UV-C light

Experimental Testing

- A series of experiments were done to determine whether the selected LEDs could deliver enough radiation to kill the virus over varying time intervals
- The virus used was recombinant baculovirus ~ has a similar UV dosage as murine leukemia virus which has a similar genetic makeup to HIV
- Tests ran at 1-minute and 5-minute intervals
- Virus concentration quantified via end-point dilution assay
- **Virus was below detection limit of 78.8 MPN/mL for both 1 and 5-minute durations**

Analysis

Thermal Analysis



- Heat dissipation was simulated over the aluminum heatsink contained in the quartz tube using ANSYS Icepack.
- Met the temperature criteria of less than 65 °C
- at the milk-tube interface

User Feedback and Community Outreach

- Conducted a consultation with Breastfeeding Buddies and the Aids Committee of the Cambridge, Kitchener and Waterloo area (ACCKWA)
- Secondary users showed interest and relevancy for a solution like this in the Kitchener-Waterloo area



Next Steps

- Continue experiments with breastmilk and shorter time durations to determine the exact UV dosage required
- Scaling of system and revised thermal management based on exact dosage results
- Collaborate with ARCH clinic and Breastfeeding buddies to carry out testing for primary users
- Pitch the product at Velocity Concept 5K finals

Acknowledgement

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