**Cannabix Technologies, Inc.**

**Trip Report and Recommendations**

**prepared by Jared J. Boock, PhD 2 Aug 2017**

**I. Experimental Setup.** Data were collected for human breath after consumption of chewing gum, nicotine, and THC using DBD/V2 FAIMS. Analytes of interest were successfully isolated from background; though, they were observed just above baseline. Some work is needed to improve the spectra, which will be discussed below. Data will be presented separately.

There are several variables that can drastically affect the results of this experiment. Considering that two of the major components of the instrument in their current configurations had never been powered up before, last week was a resounding success that reflects the hard work of all involved.

1. Flow rate experiments. Ultimately, we will require regulated flow rate. I conducted some on-the-fly experiments breathing through the DBD and found that a fairly moderate breath is needed in order to see signal.

2. DBD supply. The supply worked well, though it was observed that signal stabilized over time each day when it was run. At first, no plasma was visible and there was erratic ionization, but this changed after running a few hours at a time. The placement of the screen makes a significant difference on signal, though.

3. V2 board. At first, the V2 board did not function and we observed a pulse driver error message and incorrect current readback on the HV power supply. KLN did some rewiring which improved durability and fixed soldering issues on the driver ICs. A pulse driver had also overheated at some point, damaging the processor. The circuit ran solidly after that for the rest of the week. KLN also hard-wired the FAIMS cell to the lower-capacitance cables, which seemed to work well.

4. Mass spectrometer. Most of the issues we observed during the week were related to parts of the V2, possibly the DBD, affecting the TSQ (mass spectrometer) calibration. We have seen this issue in FL before, but not to the same degree. Tuning the instrument with analyte standard will definitely help. I am currently in contact with Mikko to attempt to mitigate these issues, and will look into whether or not shielding for the TSQ is needed.

**II. Recommended Engineering and Research Plan.**

There is a great deal of work to be done, but we now have multiple teams in both BC and FL. To make the best use of skillsets and resources available to us, we should coordinate these efforts, which will speed up our instrument development milestones, and result in a superior product. Open communication and cross-talk should be maintained at all times to reduce duplication of effort and approach problems from as many different perspectives as possible. There should be consultation and cross-talk on all design work between both TTB and KLN.

Tech Toybox (TTB) -- Should take the design lead on circuits involving FAIMS, ionization/DBD, ion optics and trajectories, and ion detection.

KLN -- Should take the design lead on the breath collection module aka "front end." Feedback should be acquired from specialists in this area, as necessary. Should take the lead on fabrication and board population. Further on, they should also take the design lead for circuit durability, packaging, prototyping, and manufacturing.

Mikko, Mike C., and I -- We need to duplicate the experiments already conducted to reduce statistical variance, and note improvements needed, while making use of new ones. We will maintain cross-talk and pass on everything we observe and learn to each other.

Dave Hasman -- Can work with Mikko on the BC instrument and do in-depth data analysis and peak identification of THC and metabolites for data sets collected both in BC and FL.

University of Florida (UF) -- Will conduct basic research that will result in improvements to the instrument. Their work will be carefully guided by our team.

**III. Recommended Action Items.**

1. Detector. I left a working and calibrated detector board behind. KLN should mount this inside the box and power it in parallel using the +/-15V supply already present. They can then rewire the lead connecting the board to the Faraday plate using a longer, more durable lead. This will result in a functioning, stand-alone instrument. KLN will also need to conduct studies in their clean room to correlate changes in frequency in the detector to ion intensity values, while free of electrostatic interference. I suggest that they work with TTB to plan these experiments. Currently, we use a digital multimeter as the readback for the detector. KLN and TTB can design a display to replace the DMM. This will be a temporary measure until we use a processor-based user interface.

2. Ion optics. A Faraday screen allows transmission of ions into the FAIMS cell, but this can be greatly improved. I will work with Mike C., TTB, and UF to look into short-term improvements (many have been discussed) that can be made to the Faraday screen we currently use. UF can conduct basic research to help us understand the field behavior that occurs with and between the DBD and FAIMS. We can then employ optics that will maximize the flow of ions into the FAIMS cell, which will improve our sensitivity. Optics will probably also be needed between the FAIMS cell and detector plate.

3. KLN should manufacture two V2.1 boxes employing the new design, so we are all testing with the same version. To reduce variance, it is absolutely essential that both BC and FL test with the same instrument in the same configuration.

4. Once these boxes are received from KLN, UF should look into comparing data taken with the V1, V2, and V2.1 circuits in order to gain an understanding of how faster high voltage transitions affect FAIMS. These basic studies will help us narrow down the optimal settings for the instrument, and ultimately lead to improvements in sensitivity and resolving power.

5. Deposition/coatings. Any imperfections on the DBD electrodes and dielectric cause apparent plasma distribution issues, loss of ion signal, and, eventually, arcing. Applying uniform coatings to the DBD dielectric to create the outer electrode, as well as the inner electrode will result in a higher, more stable signal which will last longer and be less susceptible to moisture. Research can also be done to coat the FAIMS cell electrodes. Both KLN and TTB have an atomic deposition system that is currently not in use. Both should be brought online. I will work with Mike C., TTB, and UF to look into short-term improvements that can be made, such as different metal foils and use of conductive epoxy.

6. We should plan to have occasional technical conference calls to discuss our instrument design and findings with Rick Yost, Matthew Matyjaszczyk, and Dave Hasman. I suggest that we have one within a week to finalize the detector design and see if they can provide input to help us improve signal/noise.

7. We may need to look into applying shielding to the TSQs in order to prevent further calibration issues. I will discuss with TTB.

8. I will work with Mike C., Matthew, and UF on looking into longer-term improvements, such as different FAIMS cell geometries and designs. As we collect more data, we will be able to gauge and prioritize needs for improvement. This is a low overall priority, but should be considered.

**IV. Recommended Short-term Action Items.**

Jared

- Will work with Mike C., TTB, and UF on improving signal/noise and making high-priority improvements to the instrument. Will attempt to duplicate previous experiments.

- Will assist Mikko as needed and provide feedback for data collected in BC.

Mikko

- Attempt to duplicate previous experiments and note improvements to be made, while making use of new ones. We need to demonstrate repeatability, which is necessary to find exact CV/DV values.

Dave

- Can take deeper dives into data sets collected in BC and FL to look into peak identification and pharmacokinetic studies. Can provide feedback on data sets.

TTB

- Conduct ion trajectory simulations. This will help in many areas to find where signal/noise issues originate.

- We will conduct ion optics experiments to improve signal/noise.

- Internal high voltage power supply -- already designed by Mark.

- Internal DBD circuit. We need to reduce variances in ionization between systems.

- Mounting Rail -- already designed and built by Joaquin.

KLN

- Fabricate V2.1 boxes for FL GTEC lab and UF (one for each).

- Detector mounting and correlation study.

UF

- Help with ion optics experiments. (Different screens, aperture lenses, etc.)

- Help with DBD experiments. (Different materials for electrodes and dielectrics)

- Provide input to characterization of electric field behavior.

**V. Conclusion.** We should be able to produce the video we discussed later this month once we have improved the signal to noise and the detector is mounted. The more that efforts by both BC and FL teams are planned and coordinated, the faster our company will reach our technical milestones. We have successfully demonstrated proof-of-concept with both the V1 and V2, but there is a great deal of work to be done.