Measure the leak rate of CO_2 from Mylar straws

University of Minnesota

Yan Ke

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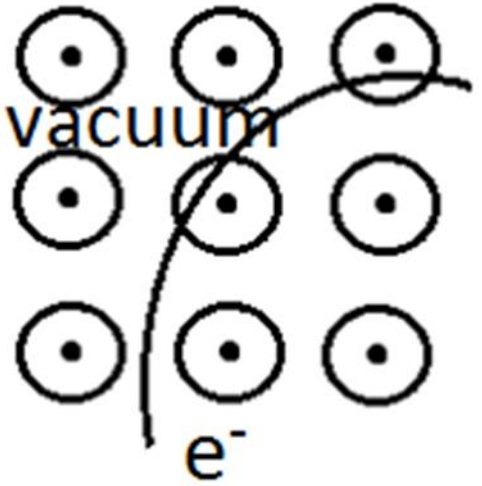
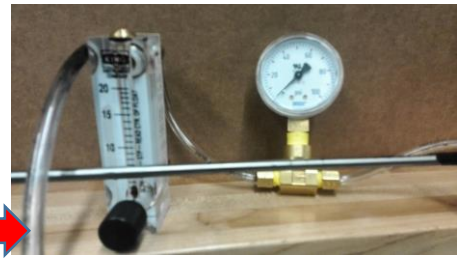
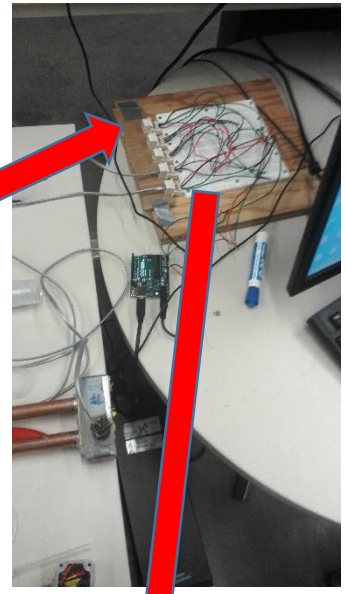
Introduction

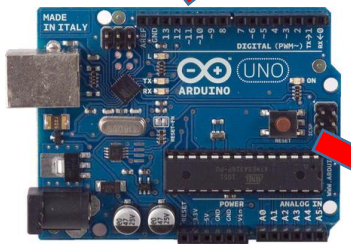
- Straw will be running in vacuum in real Mu2e experiment. ie. It will be vacuum outside the straw and 1 atm $ArCO_2$ kept being flushed inside the straw. Therefore we need 1 atm pressure difference. We need pressurized straw to 2 atm when testing.
- We now have $ArCO_2$ gas, but may use pure CO_2 for testing in the future.
- Win7 computer password: CardBoardTube1972



Experimental apparatus





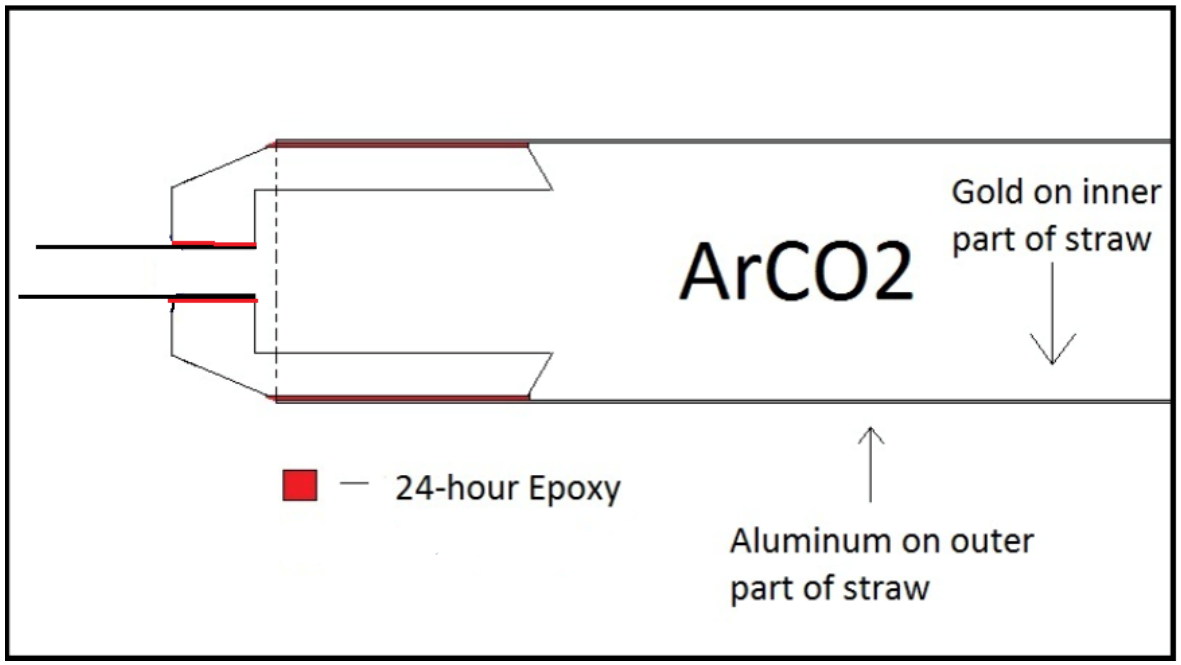


N_2 → Flow meter → Chamber (with CO_2 sensor EE891 & fan) → Microprocessor (Arduino) → Computer (Python code)

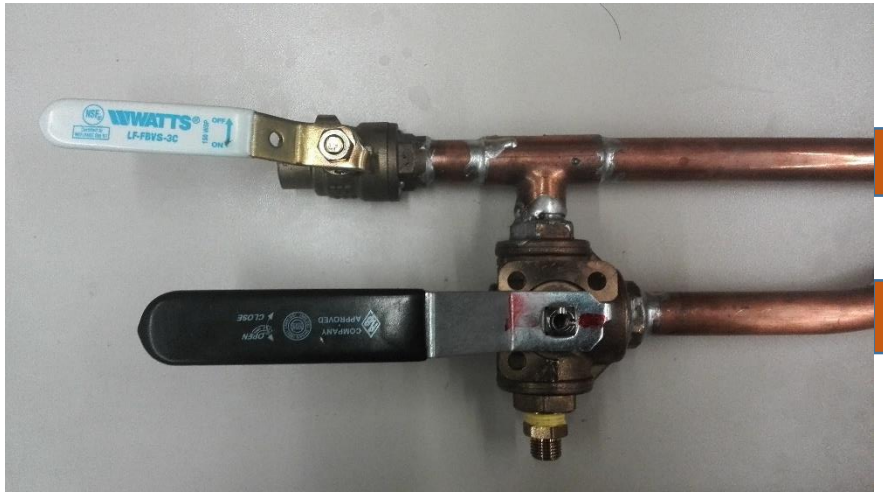
CO_2 mixture → Flow meter → Pressure meter → Straw

Experimental apparatus

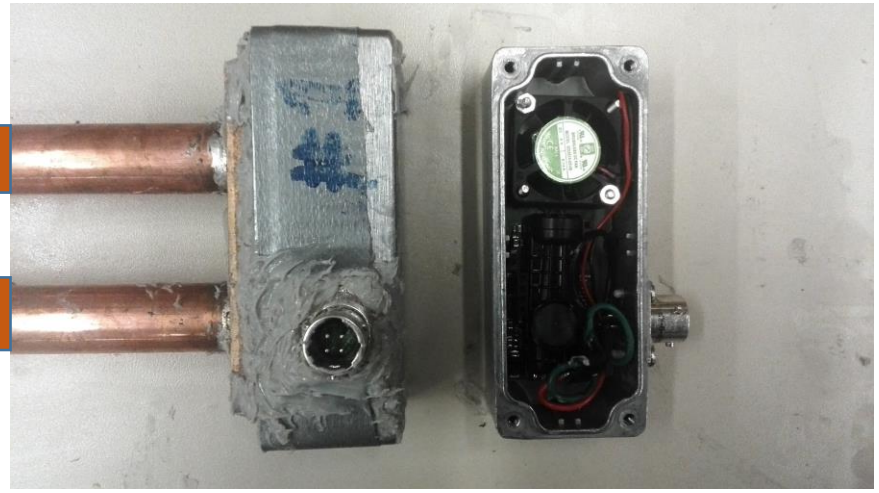
Straw

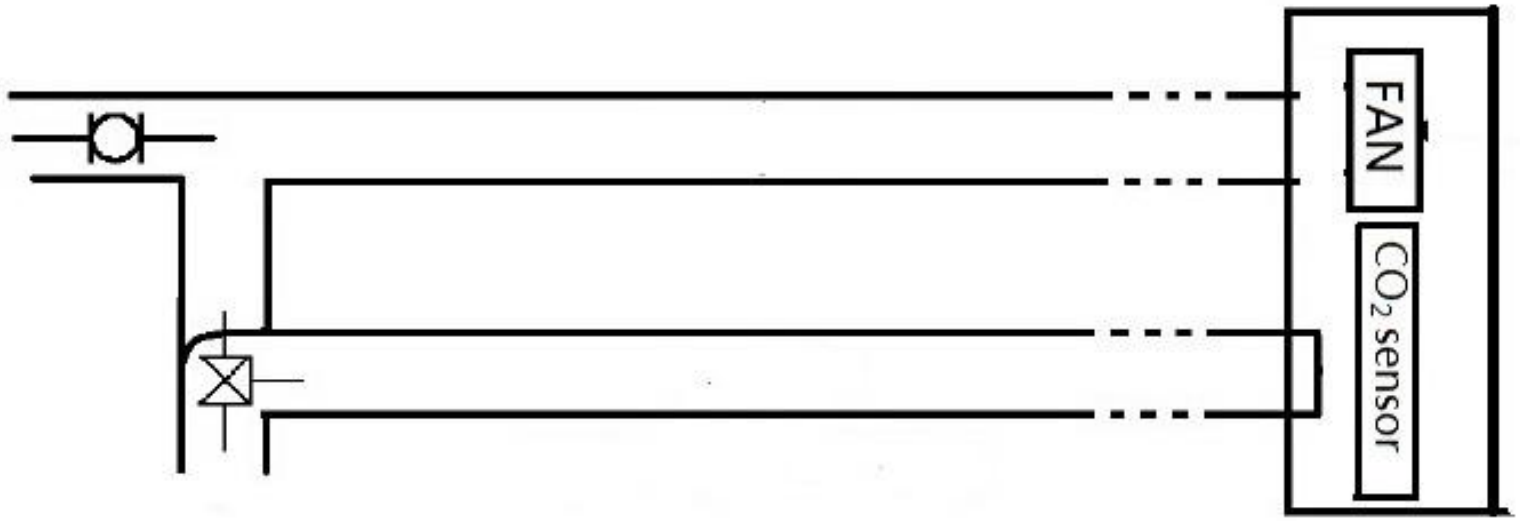


Experimental apparatus



About 1.4m long pipe





Arduino, sensor and leak test code

- The Arduino chip get tested ppm value from CO_2 sensor around every 15 secs.
- Sensors returns an measurement in ppm. The measurement will be in the range of 0~2000ppm
- We will run a python code (by Dan Ambrose) that is used for testing the leak rate. It updates the leak rate in every 15 secs. There will be a test result in pdf format as well.
- Python code -> Arduino code -> E2 interface headerfile code
- Note: Better not to open the pdf file during testing. If pdf file is opened while the python code is trying to update pdf file, it will throw an error and then stop.

Experiment process

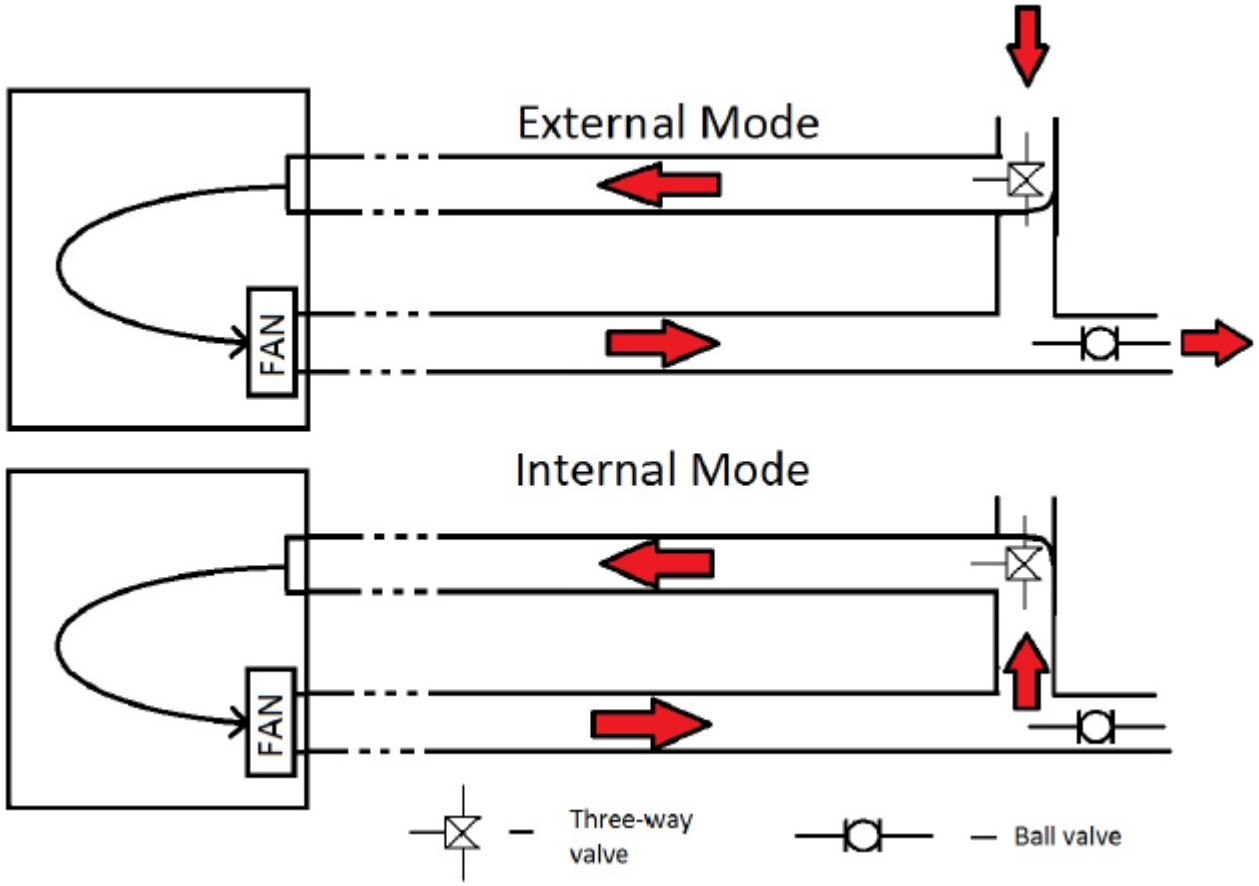
- Background test:

1.The reason why we do this:

To see whether the chamber leaks.

2.The experiment:

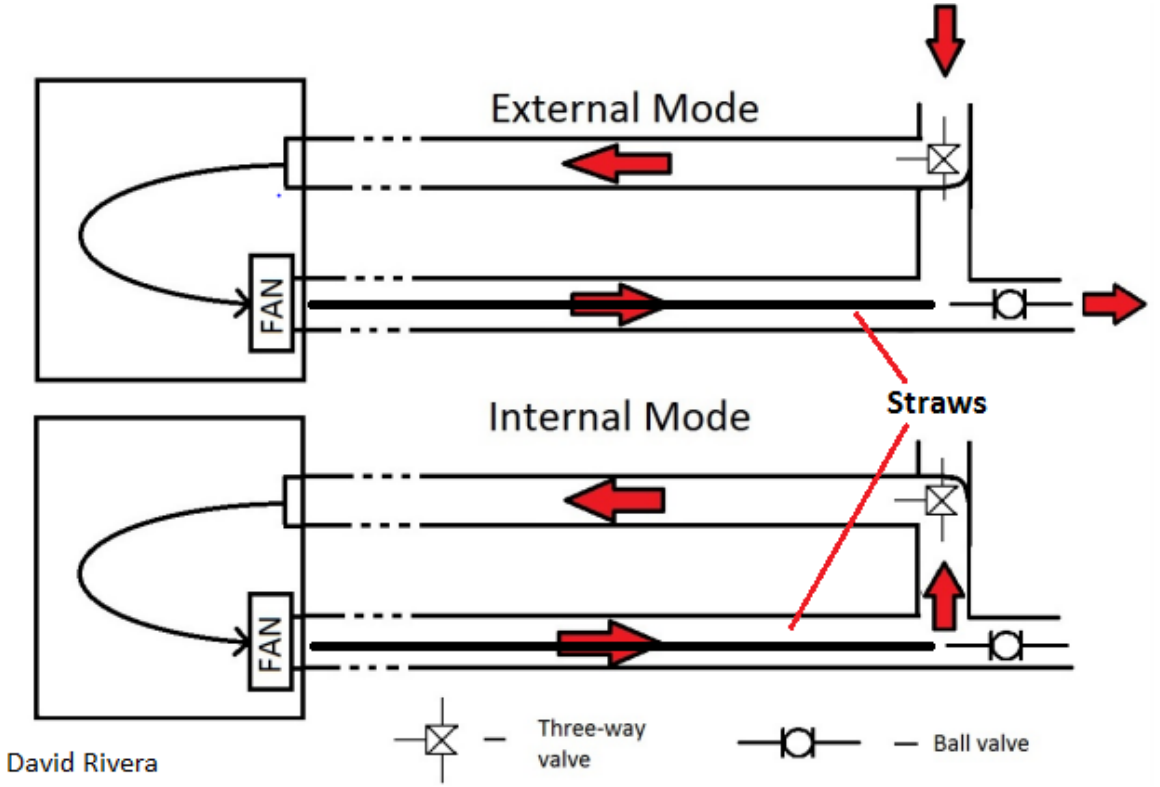
Flush the chamber with nitrogen first and then run the sensor in internal mode.



Note: Air background value is different between sensors. But they should be in the range of 300~500 ppm.

Experiment process

- Test the CO_2 leakage of straws:
  1. Pressurize the straw with CO_2 /Ar gas and seal the straw with end pieces.
  2. Put the straw into the chamber
  3. Flush the chamber with nitrogen gas
  4. Run the chamber in internal mode.
     in real test, we test each straw in ~20mins
  5. After testing, take out the straw.



Note: Don't purge CO_2 into the chamber. Since CO_2 could stuck on wall of the chamber and give us a "fake" leak. Also remember to take out the straw after measurement otherwise excessive CO_2 will stuck on the wall just like purging CO_2 inside the chamber.

Pressurize the straws with CO_2 /Ar gas

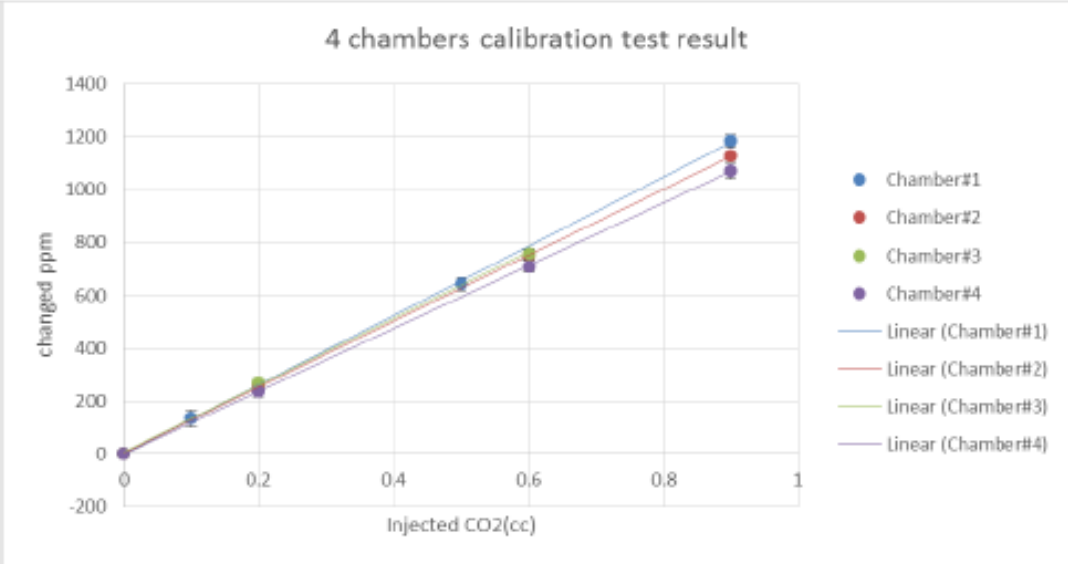
(1)Flush the straw

(2)Use the end piece seal the other end of the straw

(3)Wait till the pressure goes to the value we want and then seal this side

Measure the volume of the chambers by injecting CO2

The injection method



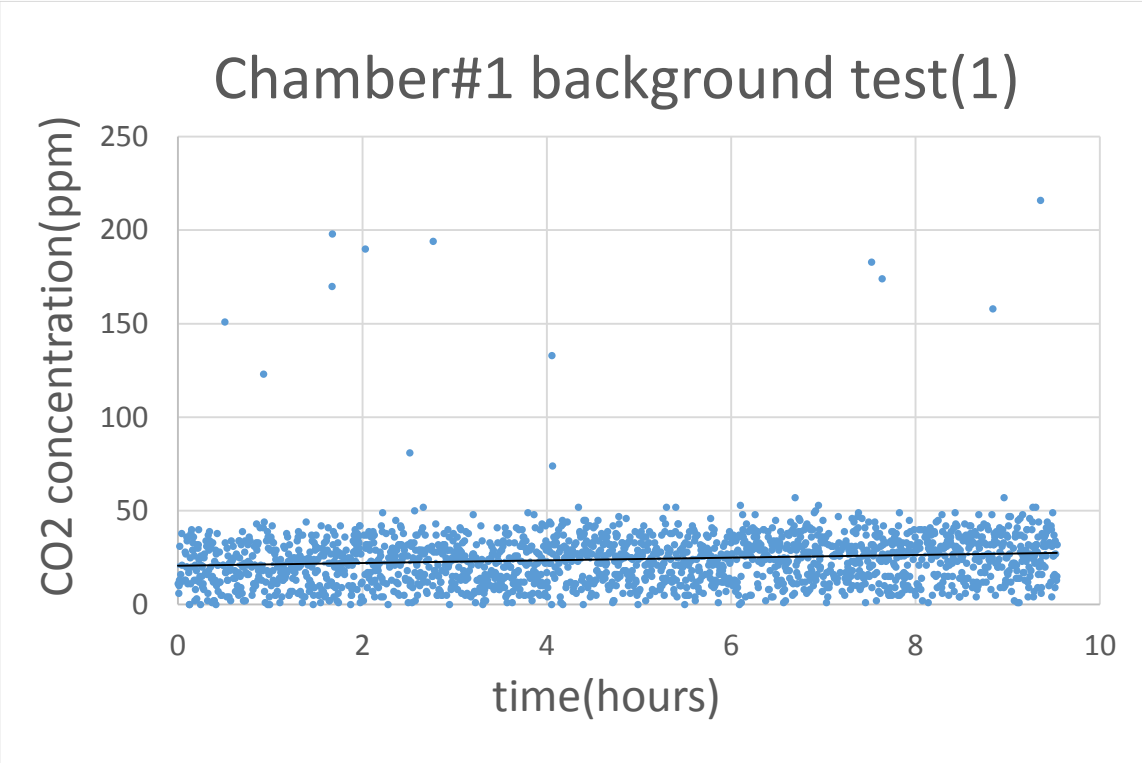
- $V_{geometric} > V_{injection}$. (trend is opposite Fermilab measurements)
- Tried the fits in two ways:
  - (0,1) is the background rate.
  - Just fit (w/o the origin (0,1))
  - With origin (0,1). Δ(ppm) ~ 1 in ~1 hour.

Results Without count in (0,1)		Results with(0,1)	geometric method	
Chamber	volume (cc)	volume (cc)	volume (cc)	ΔV
#1	380±14	382±7	466	84
#2	403±11	399±6	461	62
#3	407±19	391±9	454	63
#4	422±19	422±9	455	33

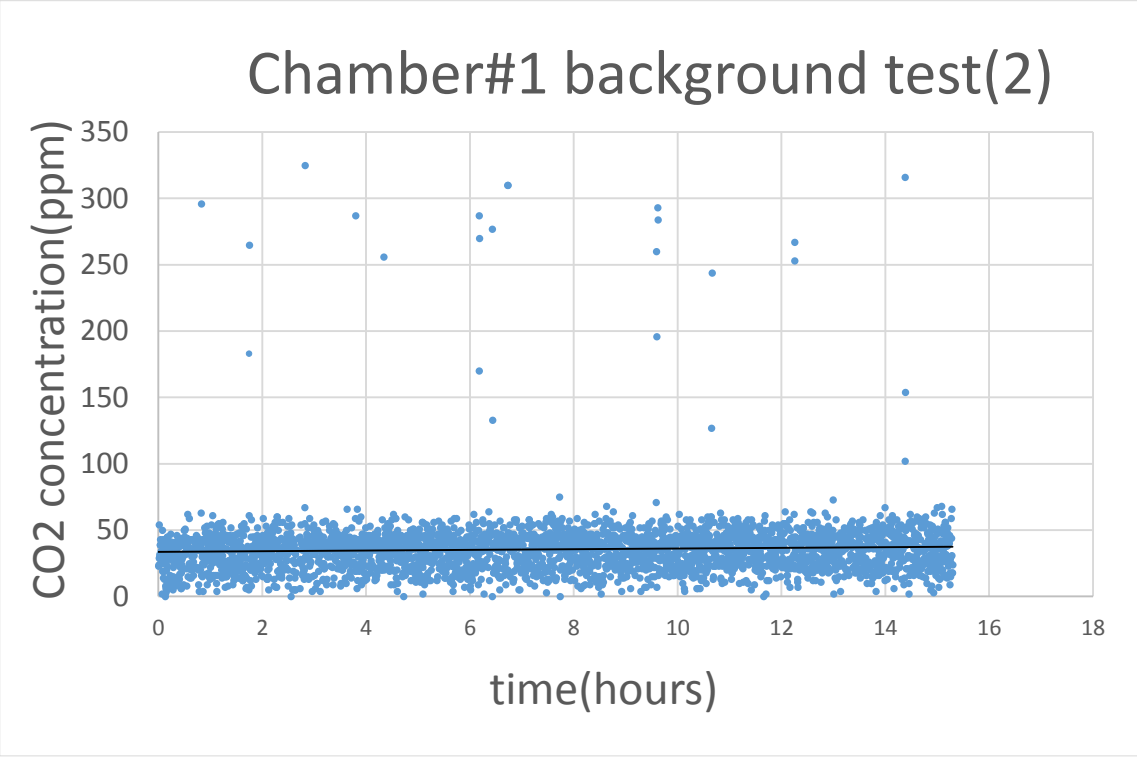
- Will measure mass (weight) to see if pipe used is the same in each case

Result

- Background test result:

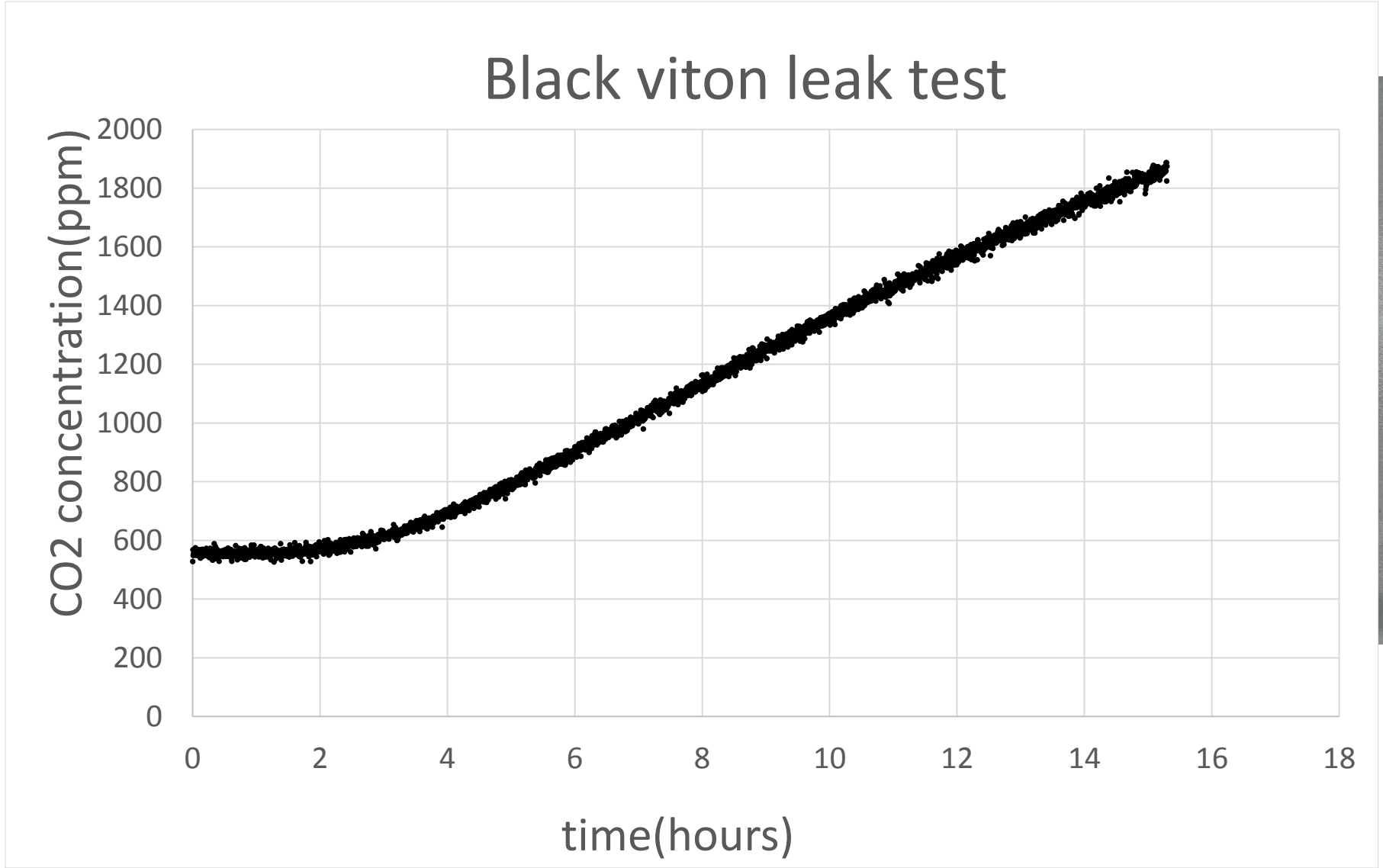


ppm1 = 0.7152t + 20.707

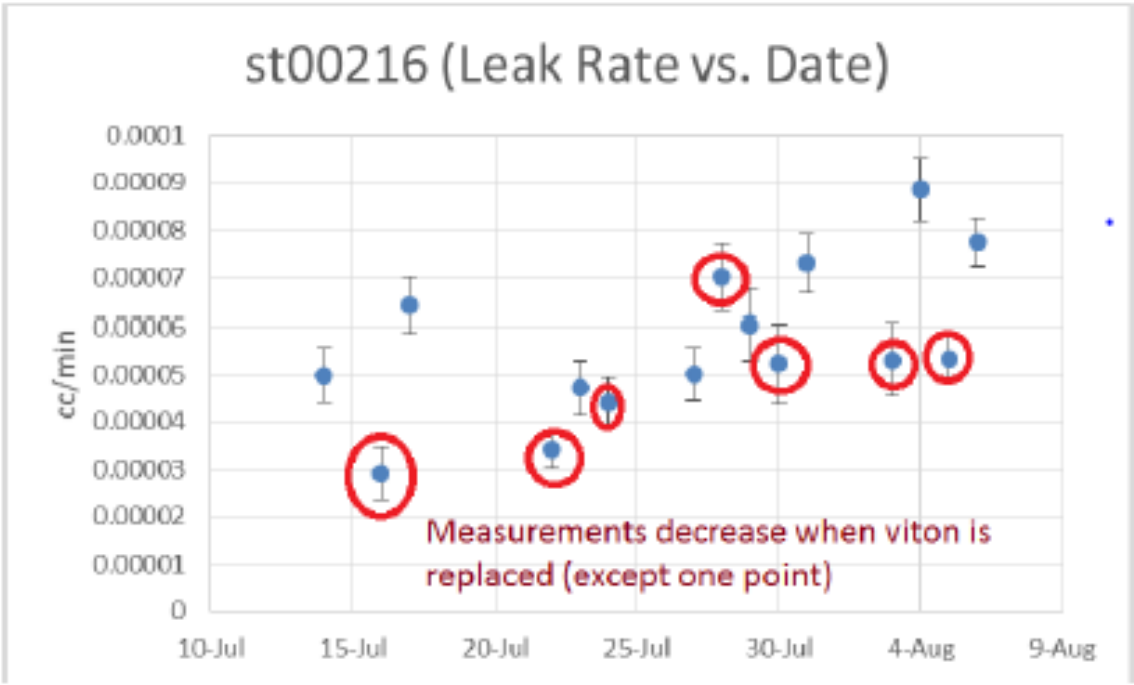


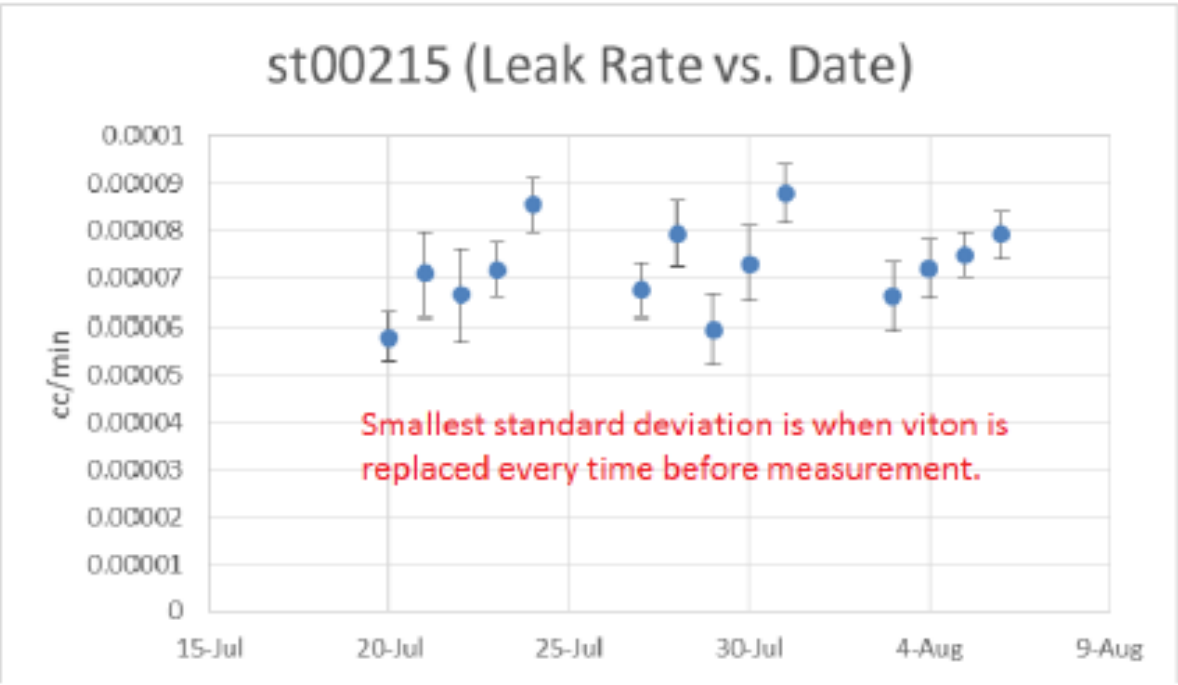
ppm2 = 0.248t + 33.637

The problem comes from the black viton tube



Consistency test by replacing the viton tubes





st00219 standard deviation: 8.7016E-06

- St00215 and st00216 have never been measured before these measurements.
- Viton was left for desaturation for 1~2 days.
  - St00216 : viton tubes were replaced **every other day**.
  - St00215 : viton tubes were replaced **everyday**.
- **The standard deviation of results by replacing viton is comparable to the results by flushing with N_2.**

Thank you!