



# Hall A Super Big Bite and Big Bite GEM Detector Flow Sensors' Readout Electronics

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# System Flow Requirements

- All GEM modules require 5 vol. exchanges per hour
- (INFN) Forward Tracker module flow for 5 vol. exchanges
  - $2.4 \text{ L/ vol. exchanges} \times 5 \text{ vol. exchanges/hr} = 12 \text{ L/hr}$
  - Each layer gets its own gas line
- (UVA) Back Tracker module flow for 5 vol. exchanges
  - $3.4 \text{ L/ vol. exchanges} \times 5 \text{ vol. exchanges /hr} = 17 \text{ L/hr}$
  - Each module gets its own gas line

# Big Bite Arm

- 4 Forward Tracker Layers (INFN)
  - 12 modules (4 gas lines) each @ 12 L/hr (for 5 vol. exchanges)
  - 144 L/hr (for 5 vol. exchanges/hr)
- 1 Back Tracker Layer (UVA)
  - 4 modules (4 gas lines) ) each @ 17 L/hr (for 5 vol.exchanges)
  - 68 L/hr (5 vol. exchanges/hr)

# Super Big Bite Arm

- 2 Forward Tracker Layers (INFN)
  - 6 modules (2 gas lines) each @ 12 L/hr (for 5 vol. exchanges)
  - 72 L/hr (5 vol. exchanges/hr)
- 10 Back Tracker Layer (UVA)
  - 40 modules (4 gas lines) each @ 17 L/hr (for 5 vol.exchanges)
  - 680 L/h (5 vol. exchanges/hr)

# Total Flow

- Total flow required 964 L/hr
- All module/layer supply lines will be ¼" nylon
- Manifold supply lines will be ½"

# Full Density Flow Detection System

- Super Big Bite and Big Bite GEM detector system
  - requires 50 gas lines to supply the individual layers with an Ar/CO<sub>2</sub> mixture
- **Flow for each gas line must be monitored remotely**
- DSG has developed a cost-effective monitoring system
  - Accuracy (within 1% of the MKS GE50 mass flow meter) for a fraction of the cost of MKS mass flow meters

# Cost Efficiency

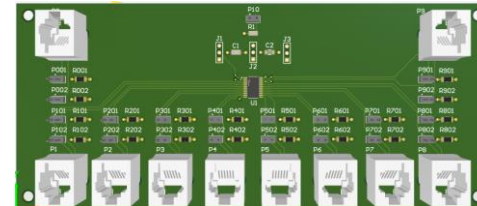


VS



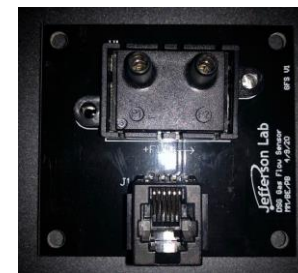
Raspberry Pi

+



I<sup>2</sup>C Mux

+



Gas Flow Sensor  
Version 1

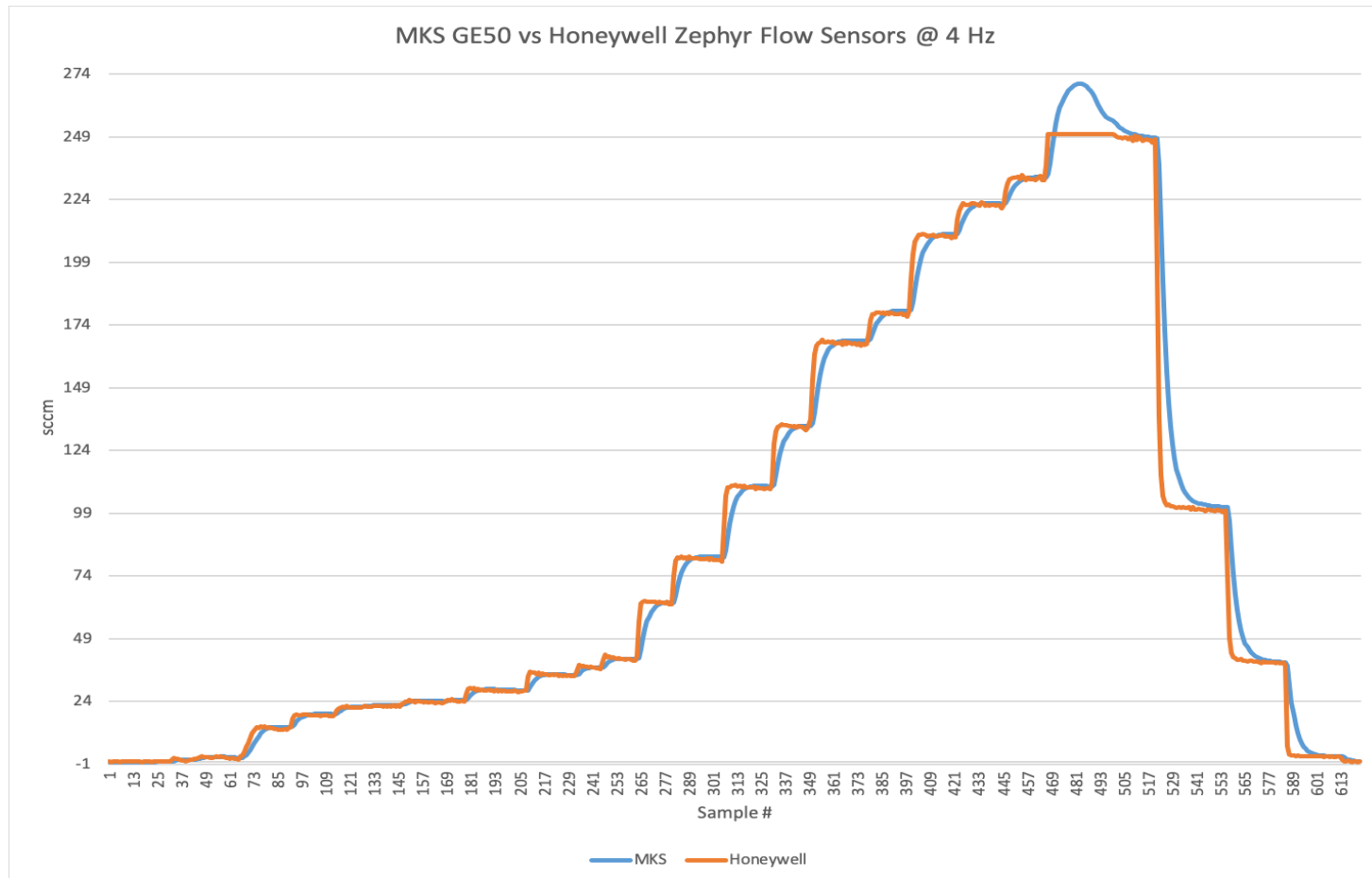
Standard industrial flow meter (MKS 579)  
\$1000 - \$1600 per sensor (1 channel)  
\$50,000 - \$80,000 for 50 channels

**DSG Flow Readout Solution  
for 50 Channels ~\$10000**



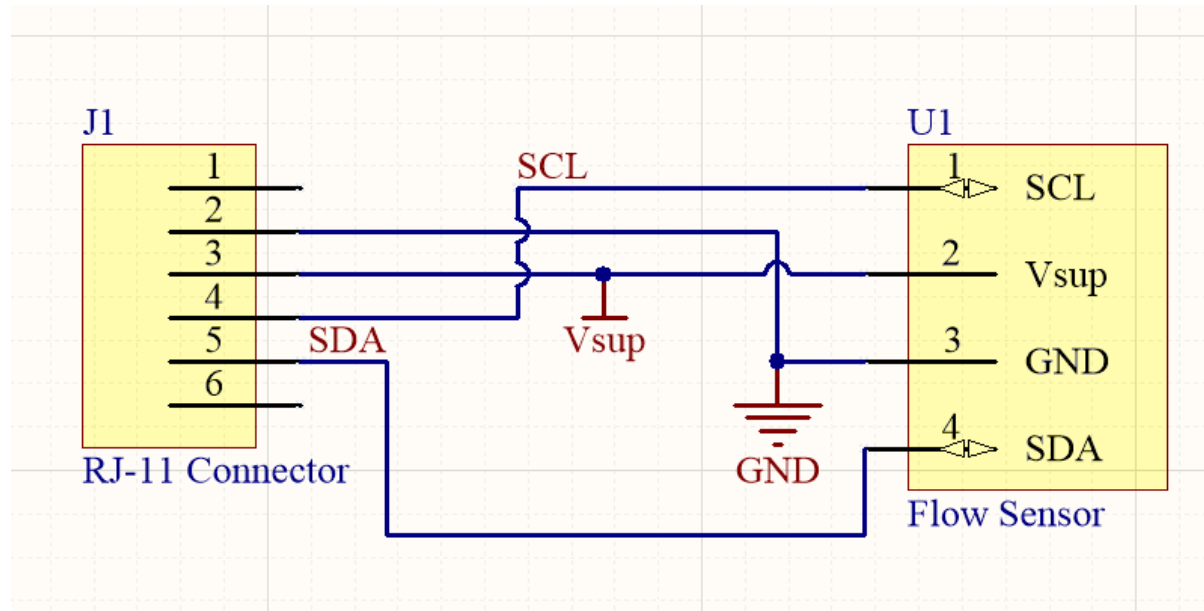
# Honeywell Zephyr Sensor Performance

- Values differ <1% of MKS GE50 MFC/MFM
- Faster response (due to less sensor mass)



# Gas Flow Sensor Schematic

- Sensor board circuit consist of two components
  - RJ-11 communications connector and the Honeywell Zephyr Flow Sensor



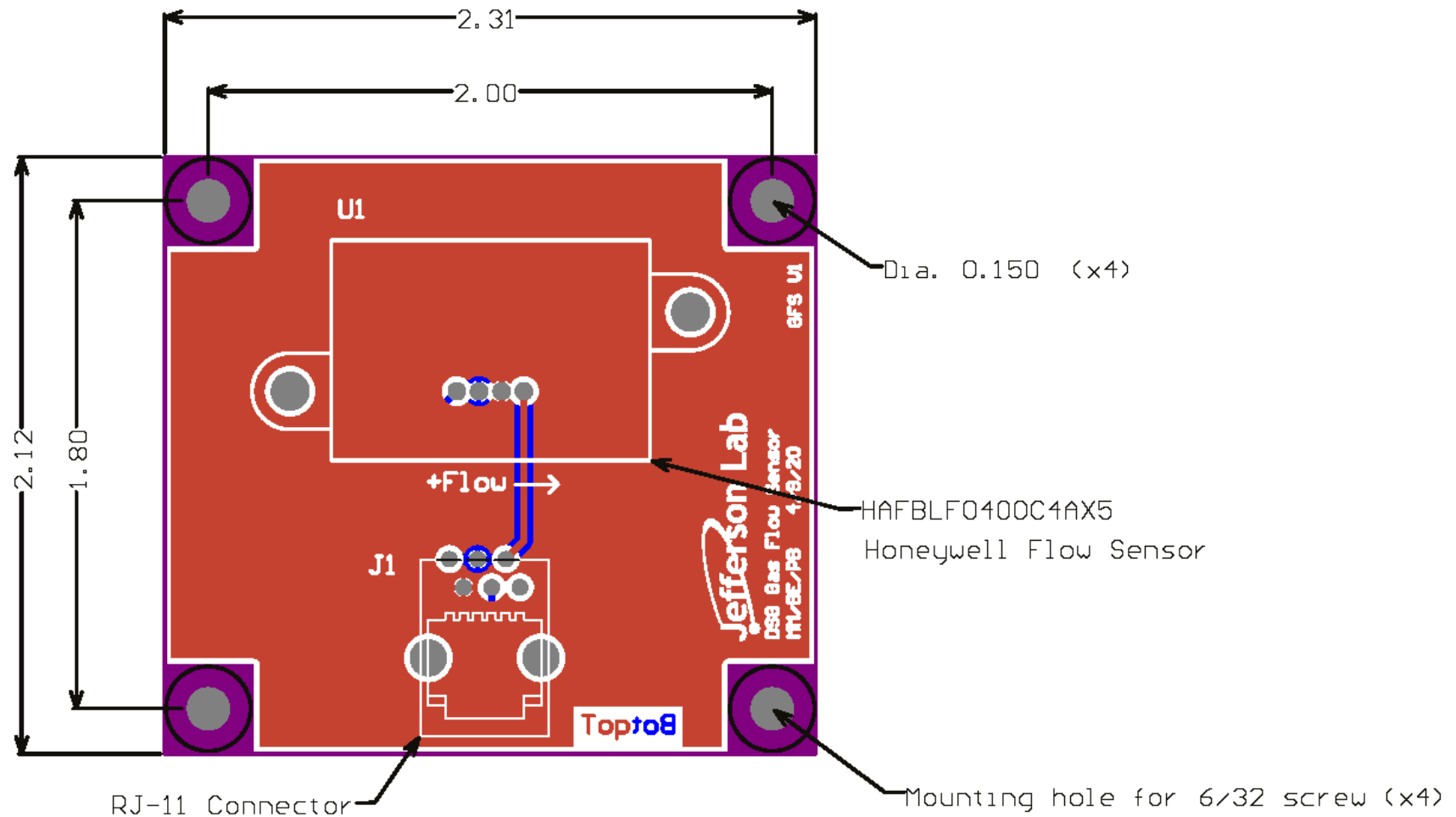
Vsup – 5 volts DC supply power

GND – Return for 5V

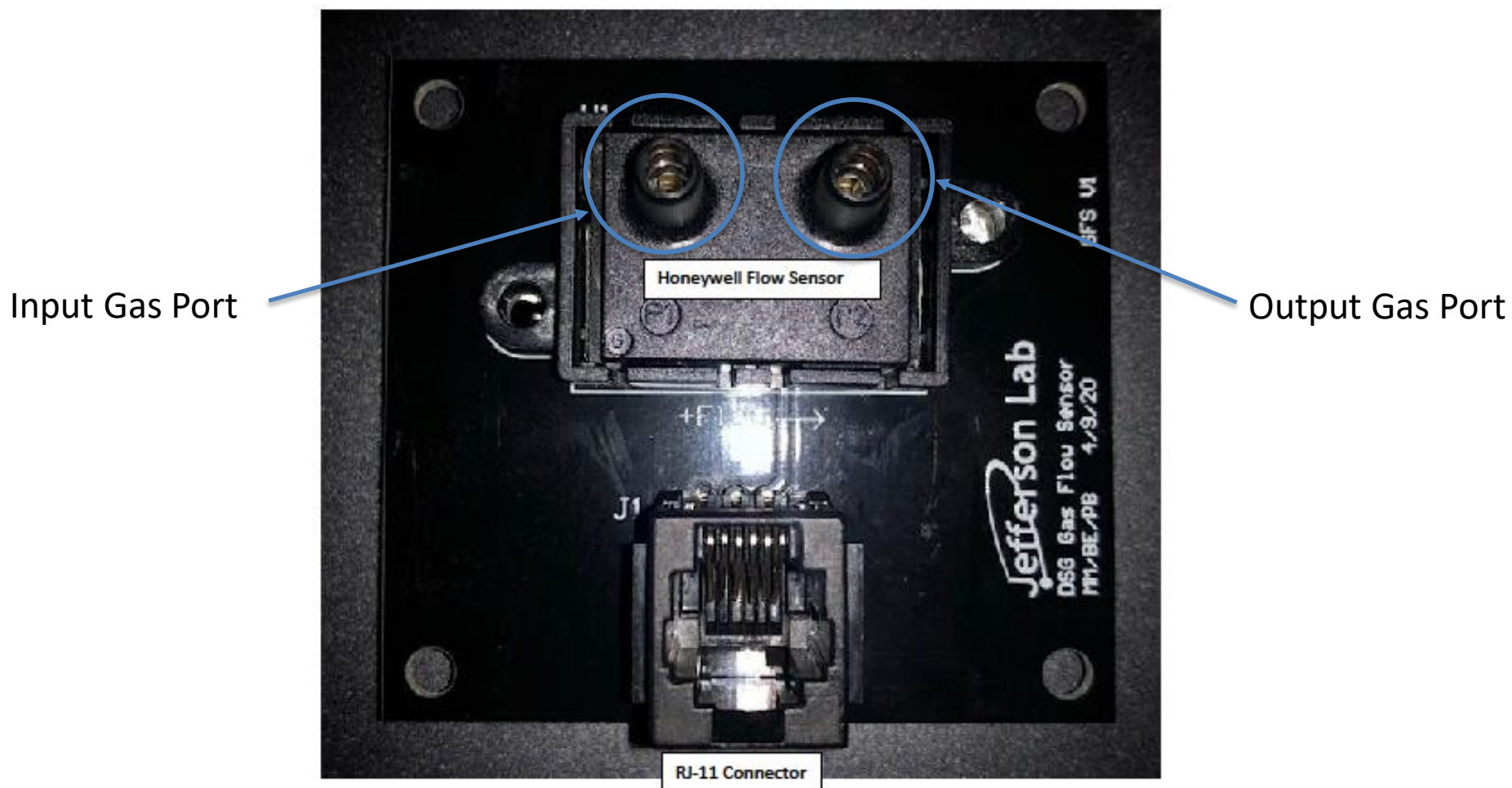
SCL – **S**erial **C**Lock (Synchronization for communication and data)

SDA – **S**erial **D**Ata (I<sup>2</sup>C information transmission)

# PCB Layout (Dimensions in Inches)



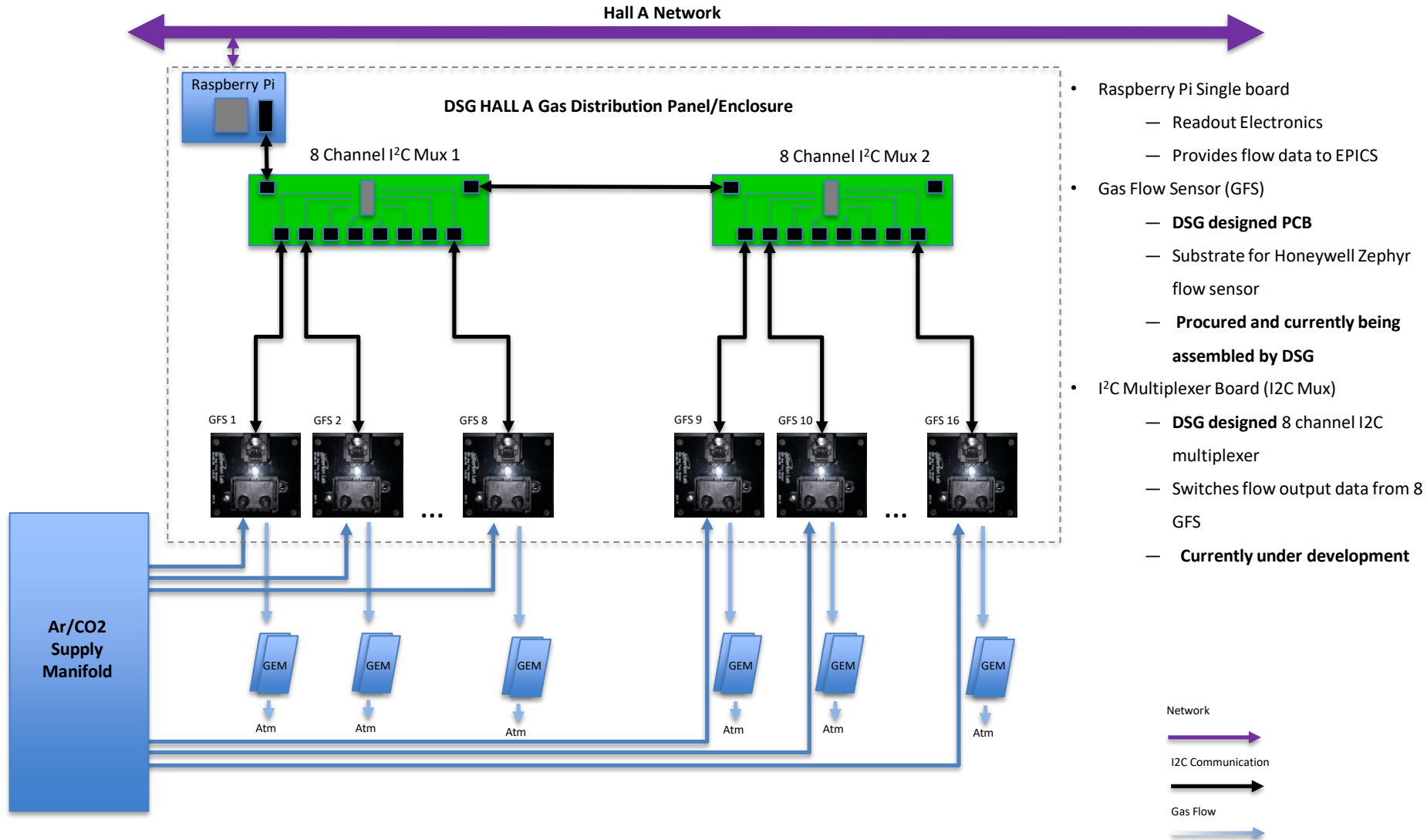
# DSG Gas Flow Sensor Version 1 Assembled



# Honeywell Zephyr Sensor Readout

- Digital output via I<sup>2</sup>C bus
  - No need for external ADC to get flow
- All devices share the same I<sup>2</sup>C address
  - DSG is designing an 8 device multiplexer (I<sup>2</sup>C Multiplexer)
  - Updated IC compared to existing Hall A 4 device multiplexer
- Controller planned to be a single-board computer
  - Currently testing Raspberry Pi 4 Model B

# GFS Data Flow Diagram



# Conclusion

- GEM detector system requires large number of gas lines (50 gas lines)
- Zephyr flow sensors are precise <1% error
- System component designs are underway:
  - Gas Flow Sensor board has been developed and procured
  - Population and testing has started
  - I<sup>2</sup>C Mux board is currently being designed
- DSG has developed a cost-effective solution to provide readback flow data to EPICS

**\$10, 000 Zephyr system v. \$50,000-\$80,000 MKS**

# END



# PCB Layout (Dimensions in Mils)

