Employing Machine Learning Techniques to Determine Emission Sources at Industrial Facilities Use of Open Path Air Monitoring Systems

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Paper Overview:

Present challenges presenting finding the usefulness of fence-line data.

Provide an overview using machine learning to optimize information gathered by fence-line data.

Present a list of data analysis rules.

Show a case study of the rules in action.

Present work going forward.

Question: What is the actual goal of the fence-line monitoring program?

So What?

- Meeting a regulatory requirement
- Use the data to identify sources and possible mitigate them
- Used to collect data during non-routine emission events
- Worker safety
- Determine health impacts on communities
- Others?

Often the site layout for monitoring equipment is not optimal to meet these goals.

Structural impediments

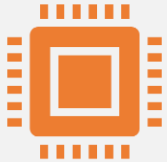
Analyzer limitations

Infrastructure requirements

We should build the fence line first and then install the refinery.

(FYI - This is sarcasm. We know this isn’t practical).

Challenge:



Let’s figure out a way to get the most out of the data with the scenario we’ve been presented (fence line layout, other technologies, refinery support).

Let’s find a way to get the most out of the data as quickly as possible (data importance decreases over time).

Let’s find a way to minimize the cost of getting this information (bottom line is always a high priority).

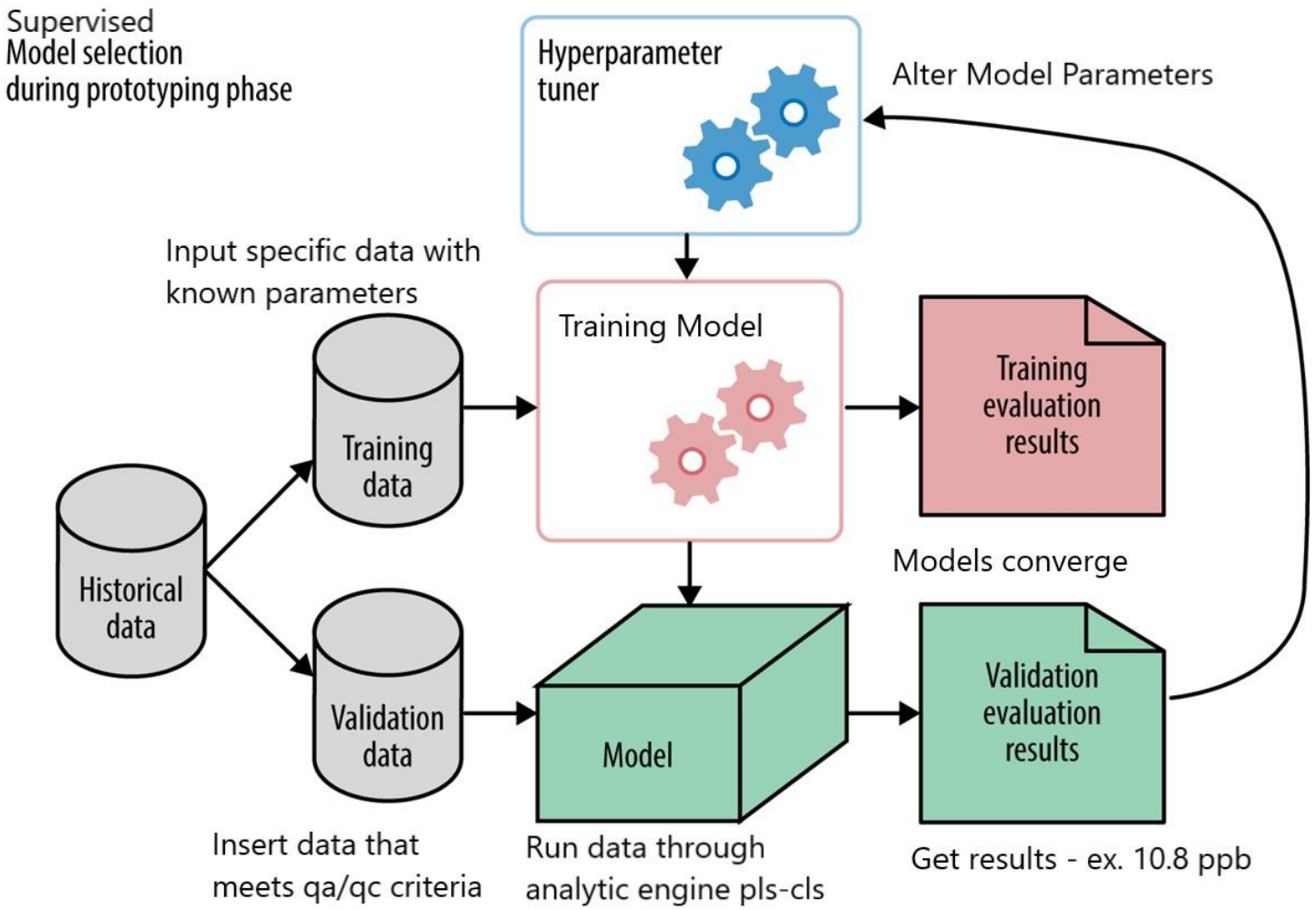
Argos' Solution: Machine Learning

It can be adapted to the resources at hand (equipment and backup support).

It can be automated (impacts the bottom line).

It can be done quickly.

Elements of Machine Learning



Case Study:

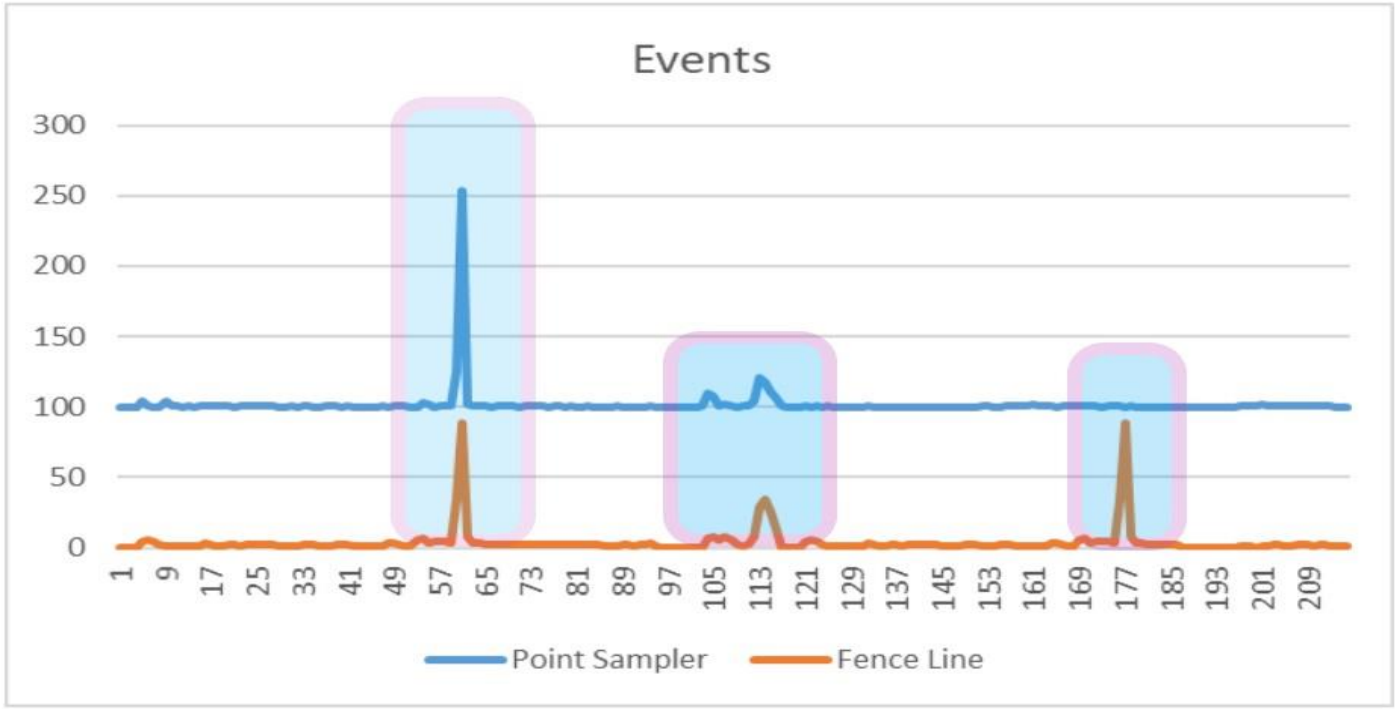
- A facility that has multiple emission sources installed a fence-line network, point samplers and a met station at their facility. Management had a direct buy in to getting the most information out of the technology. Argos developed a program that was used to assist in locating emission sources using the equipment on-hand.

We need the following information to determine source location:

- One sampling system (GC’s, H2S, Ammonia etc.)
- An open-path air monitoring system
- A Met station

Based on the information presented by this equipment and their site locations, we created the following predictive rules to identify emission source locations.

Event Summary - Three different events with different characteristics,

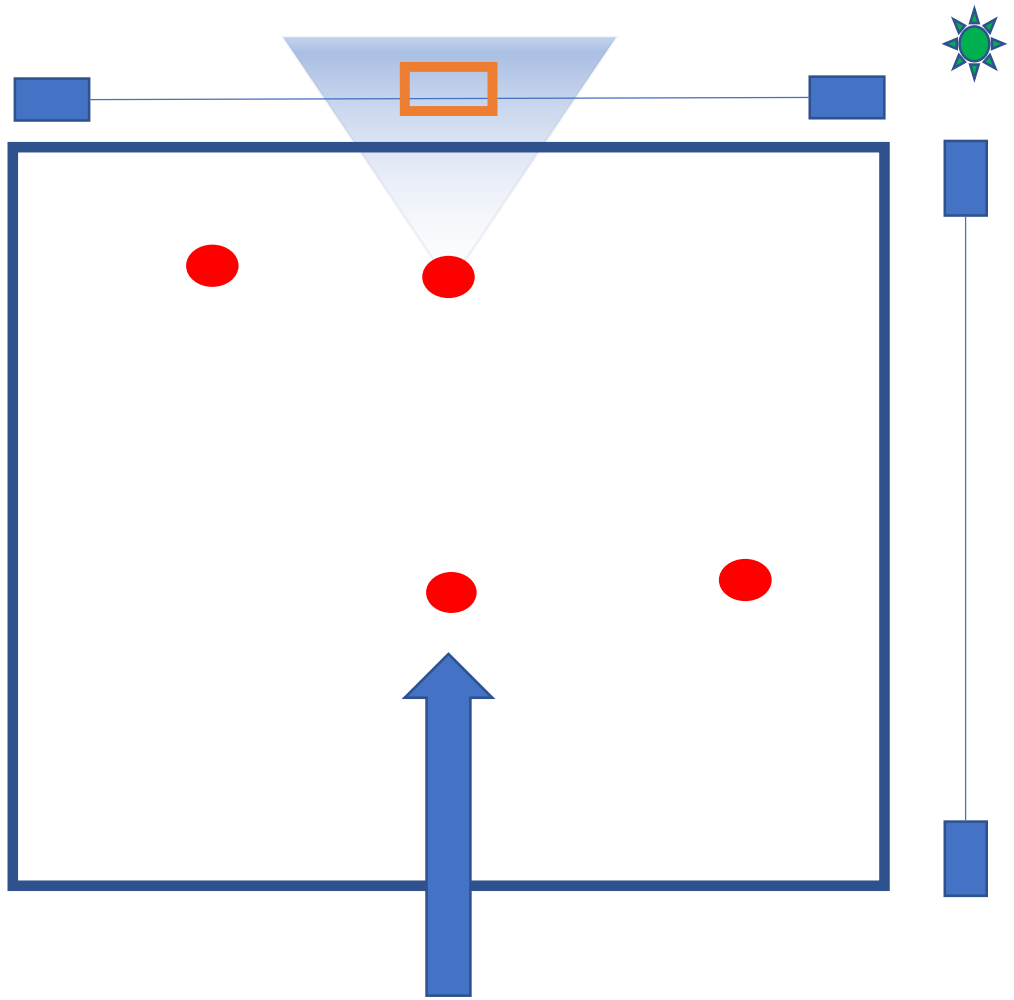


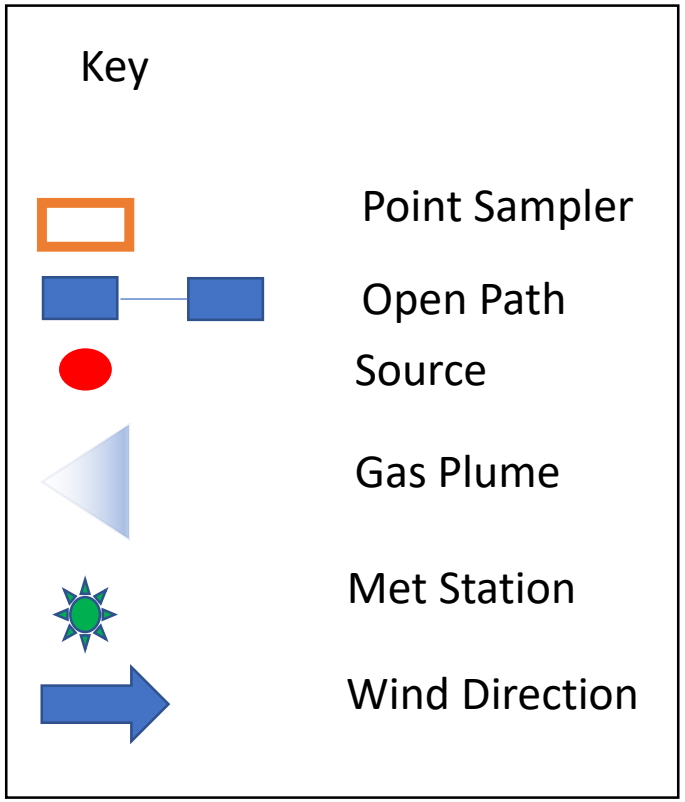
Scenario #1 – Correlated with the Point Sampler Higher than the fence-line.

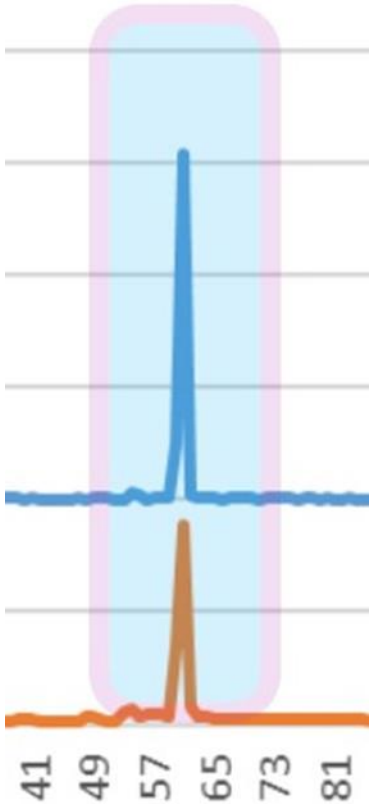
Detection occurs with both systems but the difference between point monitor and fence-line concentrations is significant then:

- Estimate the plume width based on the point sample results (plume is higher concentration near the point monitor).
- Source is close to the fence line
- Use Met data to back-calculate to potential emission sources.
- Report information to refinery personnel to help identify potential sources.

Scenario 1




Key
Point Sampler
Open Path
Source
Gas Plume
Met Station
Wind Direction


41
49
57
65
73
81

Scenario #2

Detection occurs with both the point sample and the open-path system and the data is highly correlated:

If the path average value of the fence-line system matches the concentration of detect by the point analyzer, then the plume is well mixed when it arrives at the fence line across the entire sample path.

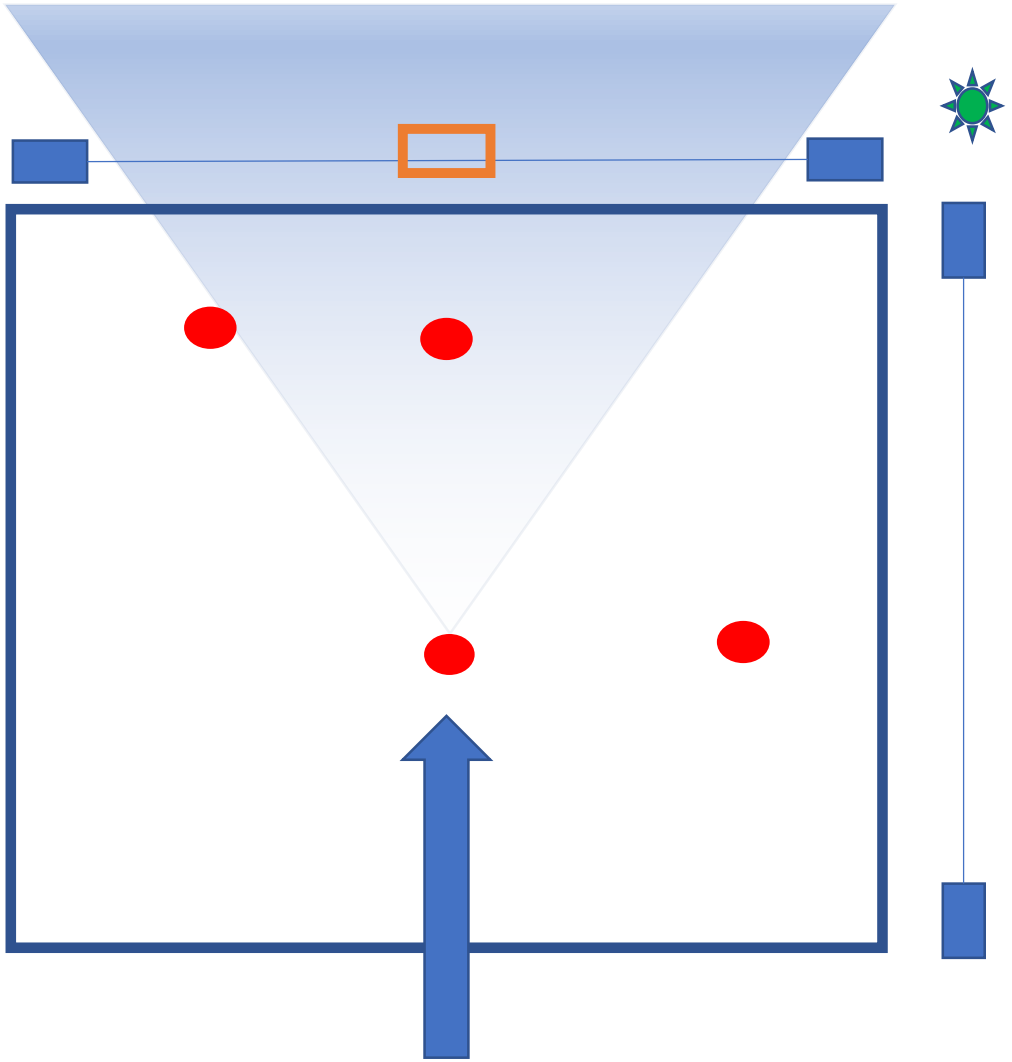
Assume the plume width at the fence line is approximately the same as the sample path.

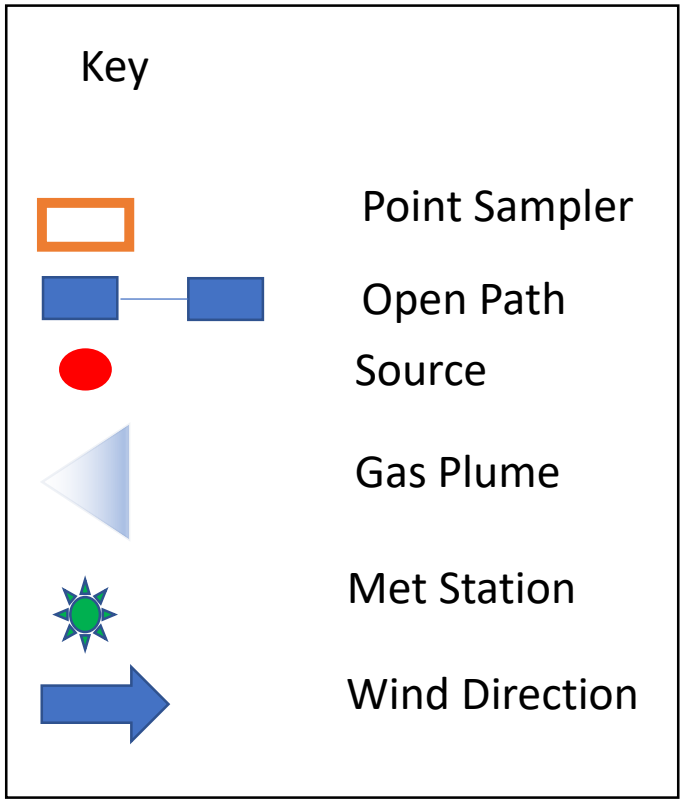
Source is well dispersed and not close to fence line

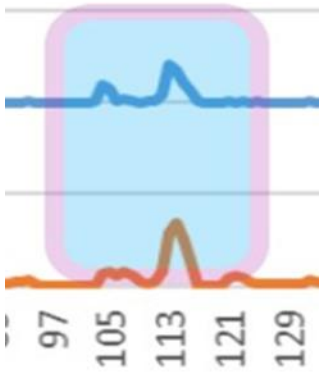
Use Met data back-calculate to potential emission sources.

Report information to refinery personnel to help identify potential sources.

Scenario 2




Key
Point Sampler
Open Path
Source
Gas Plume
Met Station
Wind Direction


97
105
113
121
129

Scenario #3 – Point Sampler Lower than the fence line average.

Detection occurs with fence-line system but not the point sampler:

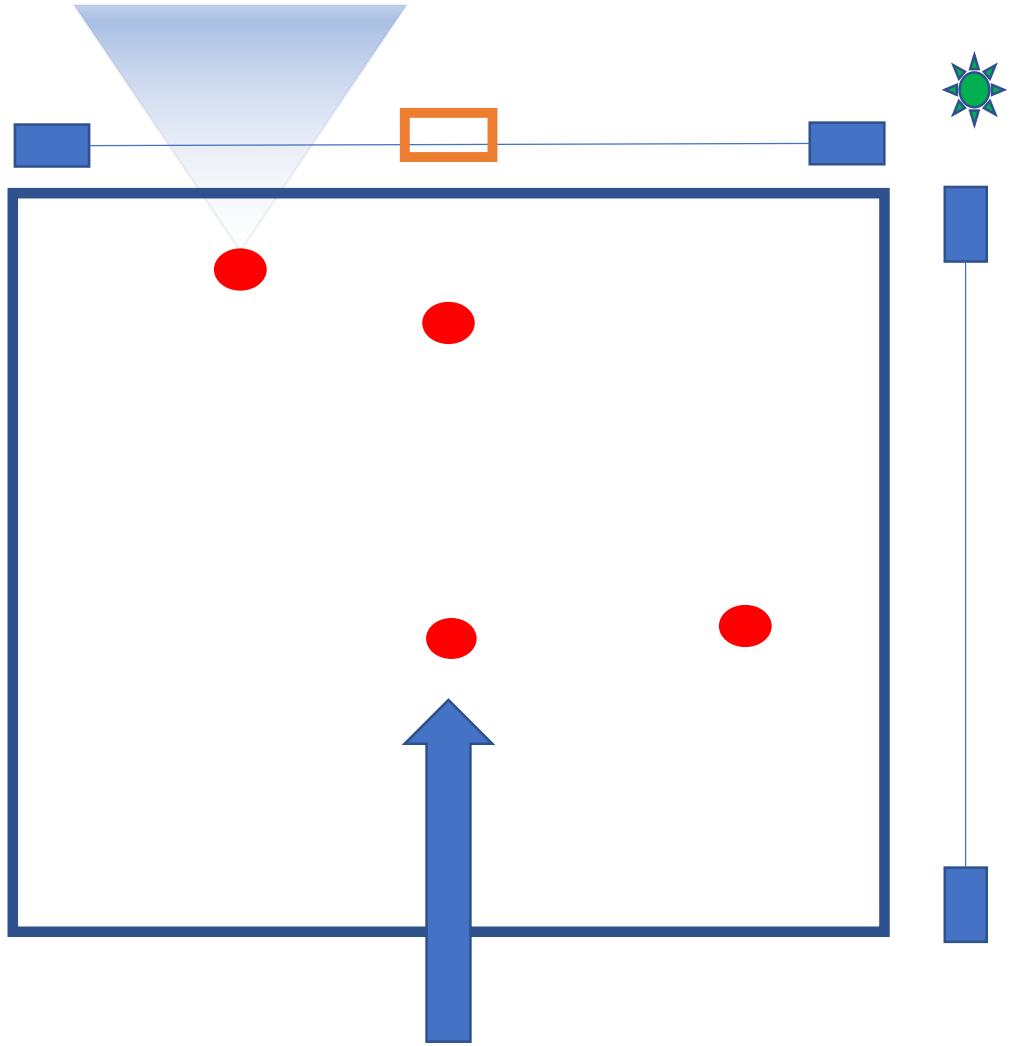
Estimate the plume width based on the fence-line results (concentration is higher away from the point monitor).

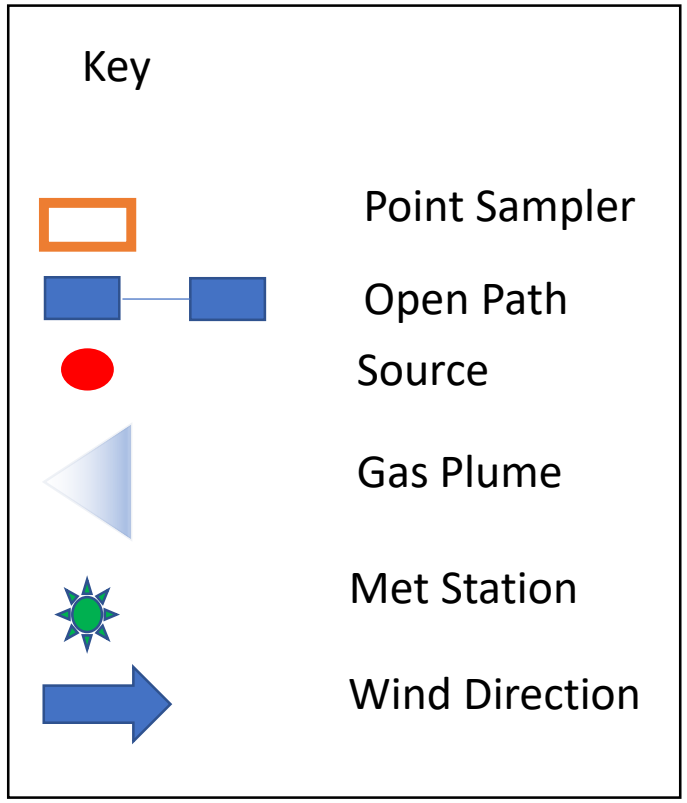
Assuming a rough rule of thumb that over 100 m a gas gets diluted 50 times and that the plume is a cone (without performing dispersion modelling on the data).

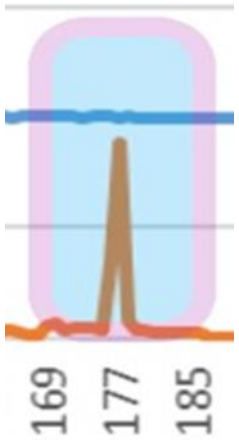
Use Met data back-calculate to potential emission sources.

Report information to refinery personnel to help identify potential sources.

Scenario 3




Key
Point Sampler
Open Path
Source
Gas Plume
Met Station
Wind Direction


169
177
185

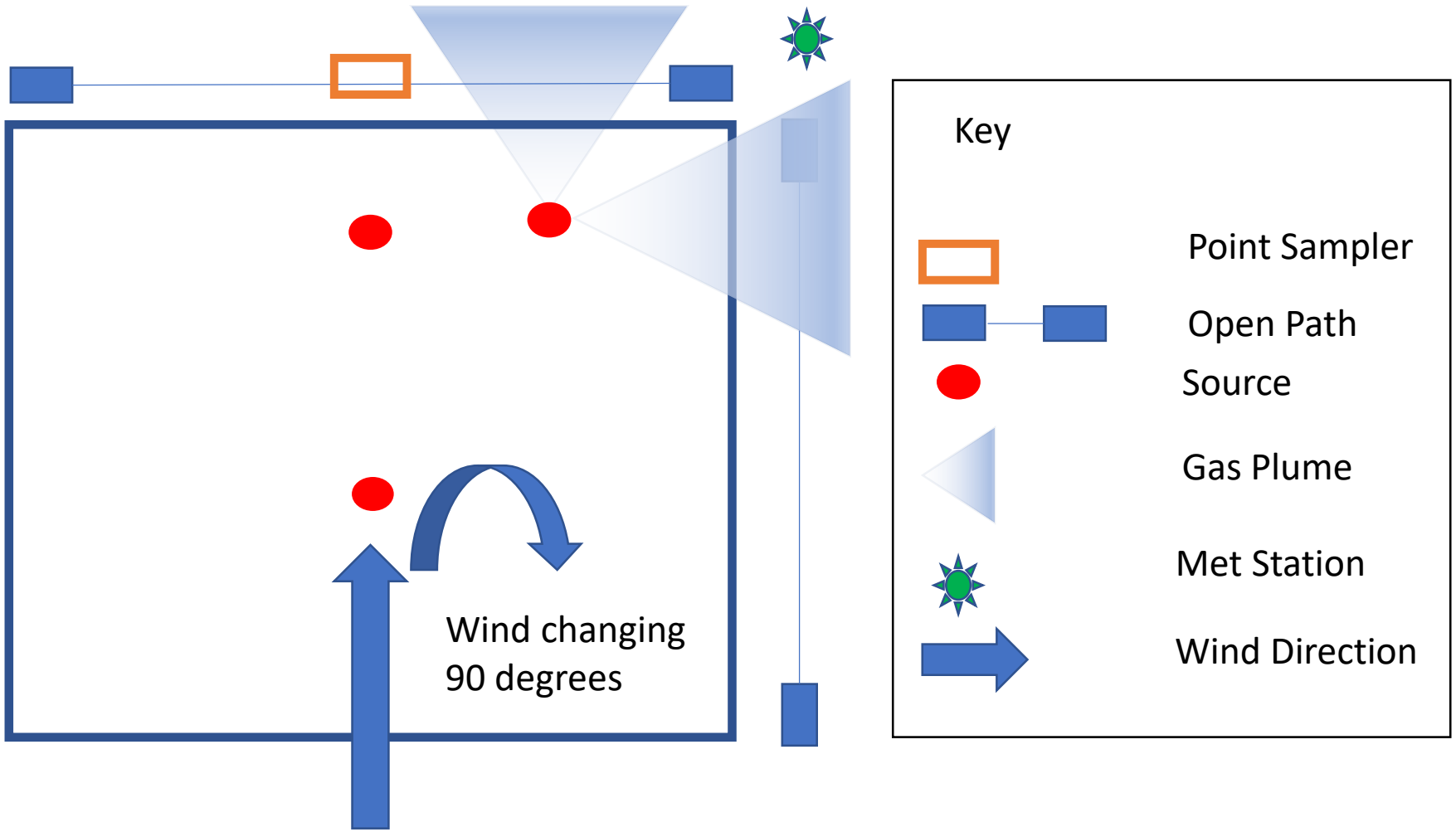
Scenario #4 – Gas is detected by two open-path systems.

Wind direction changing

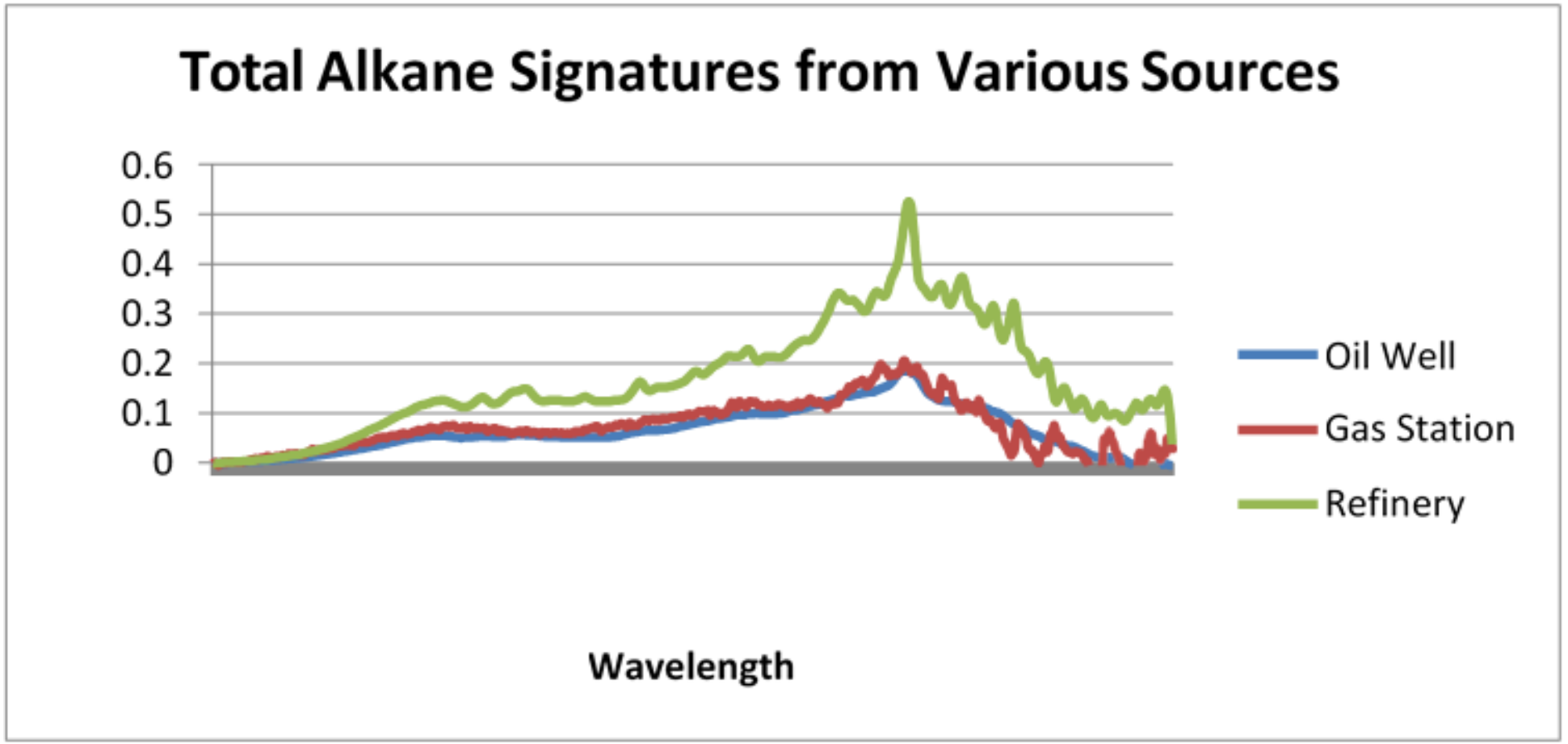
Detections highly correlated with wind direction

Use triangulation to find potential sources

Scenario 4


Wind changing
90 degrees
Key
Point Sampler
Open Path
Source
Gas Plume
Met Station
Wind Direction

Machine Learning – Going Forward



Conclusions

- Machine learning is a valuable tool for fence-line monitoring

- Path average and point monitoring data employed together gives:
  - More information about source proximity
  - More information about source location
  - Adding meteorological data gives more information regarding source direction/location
  - Observing these patterns in data has potential pinpoint sources
  - This data can help operators locate leaks with IR cameras

- We continue to add more technology to enhance the systems set of data input
  - Exploring the use of low-cost point monitoring systems to supplement the systems already in place

- As we incorporate more data into the system, the predictive behavior improves

- The value of the system to the customer has increased with minimal additional investment.