Differential Absorption Light Detection and Ranging

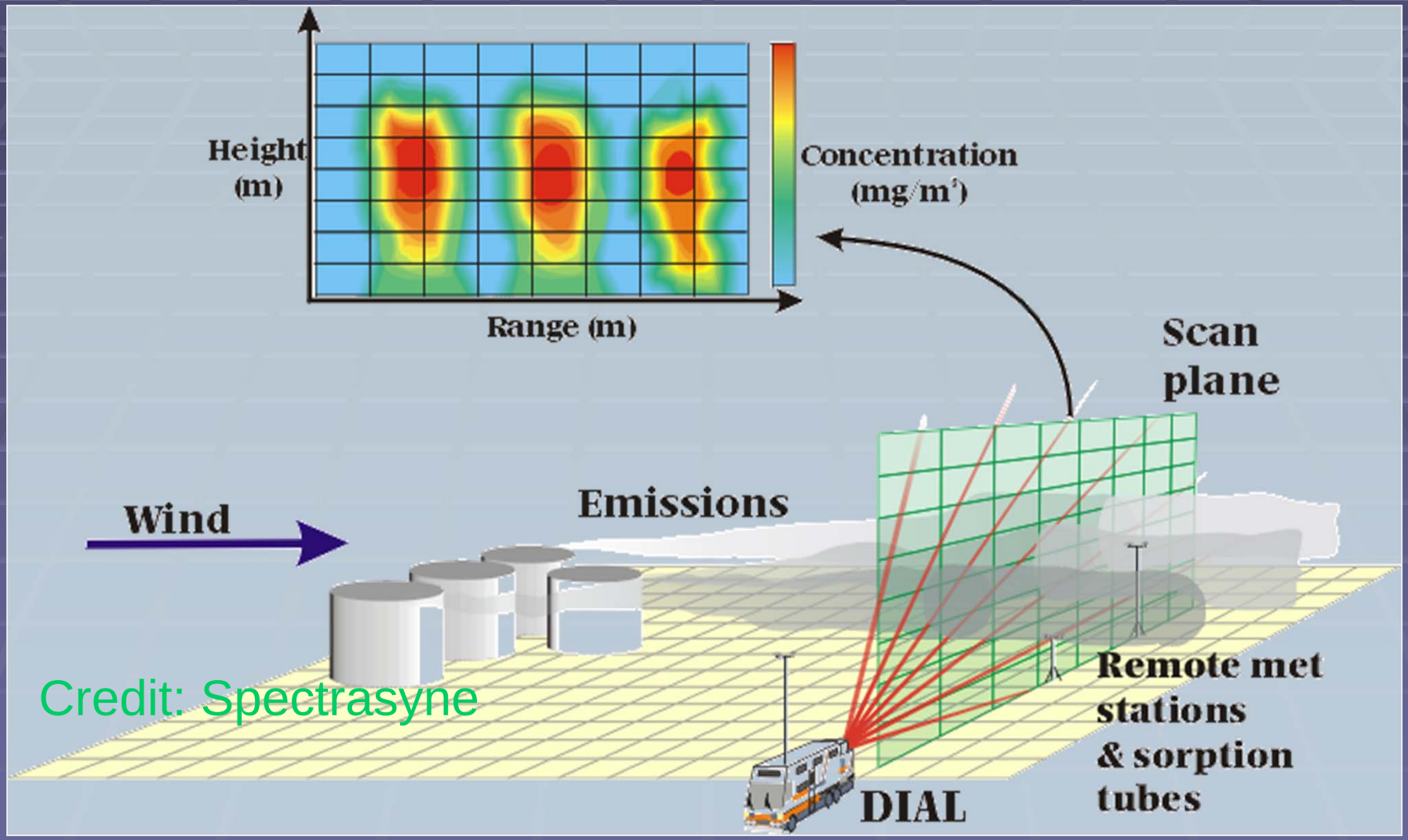
Recent Experiences in Emissions Measurement

Cary Secrest, US EPA
Office of Civil Enforcement
Air Enforcement Division

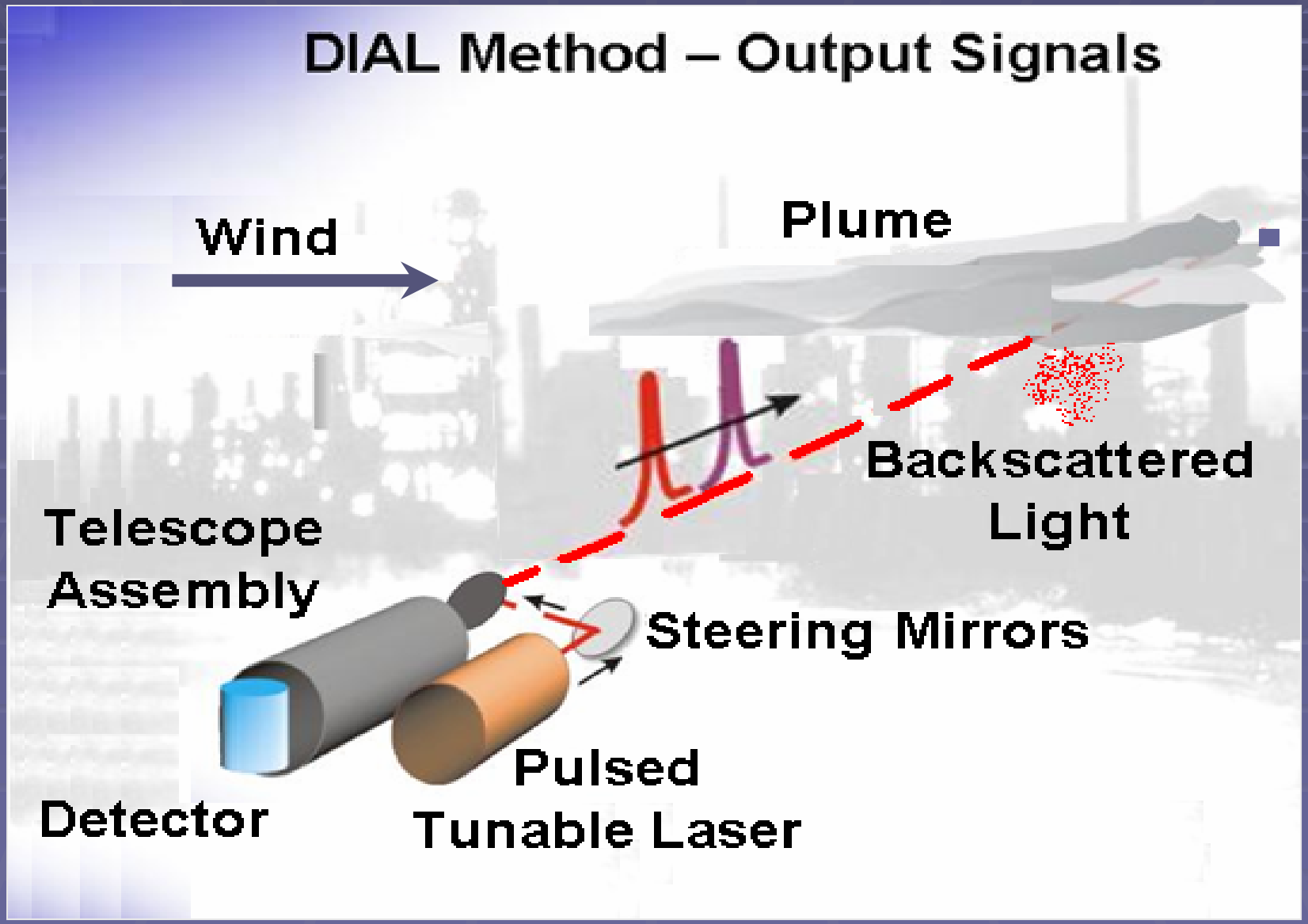
What is DIAL?

- Laser-based method for measuring fugitive emission rates over large areas
  - Measurement principle: Beer's Law
  - Measurement Range: 400 m (uv) – 1 km (ir)
- Developed in the 1980's by petroleum companies and researchers
- Used in Sweden for refinery emissions since 1988
- Applications: refineries, petrochemicals, Hg chlor-alkali plants and mines, steel mills, methane sources, and others

The DIAL Concept



Detection Method



NPL DIAL


NPL
National Physical Laboratory
Environmental Remote Sensing System
NPL
National Physical Laboratory
Environmental Remote Sensing System

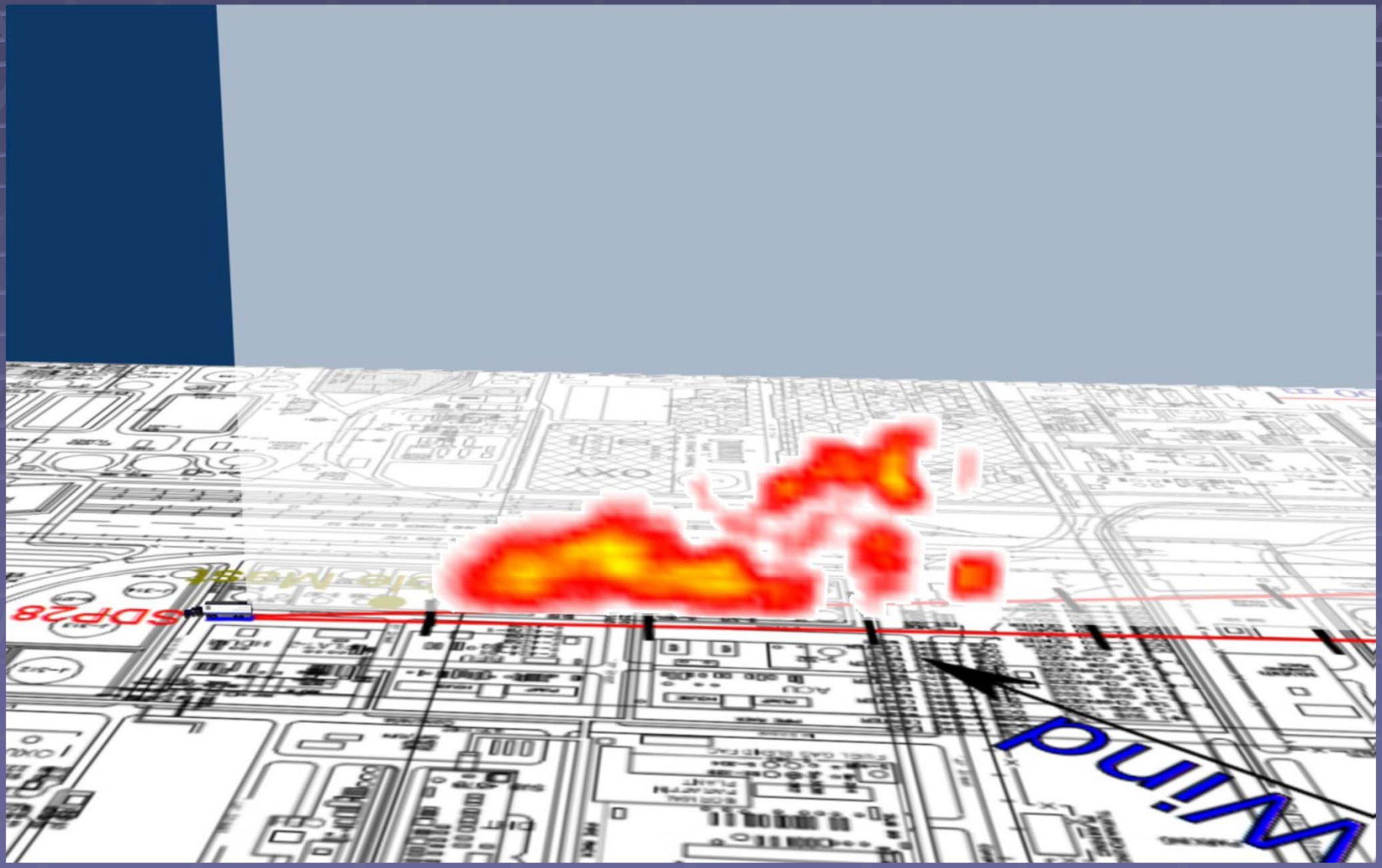
DIAL – Typical Detection Limits

Gas	Region	Detect Limits (ppb)
Nitrogen oxide	UV	5
Benzene	UV	10
Elemental Hg	UV	0.001
Toluene	UV	10
Ozone	UV	5
SO_2	UV	10
NO_2	UV-VIS	50
THC	IR	40
Methane	IR	50
Ethane	IR	20

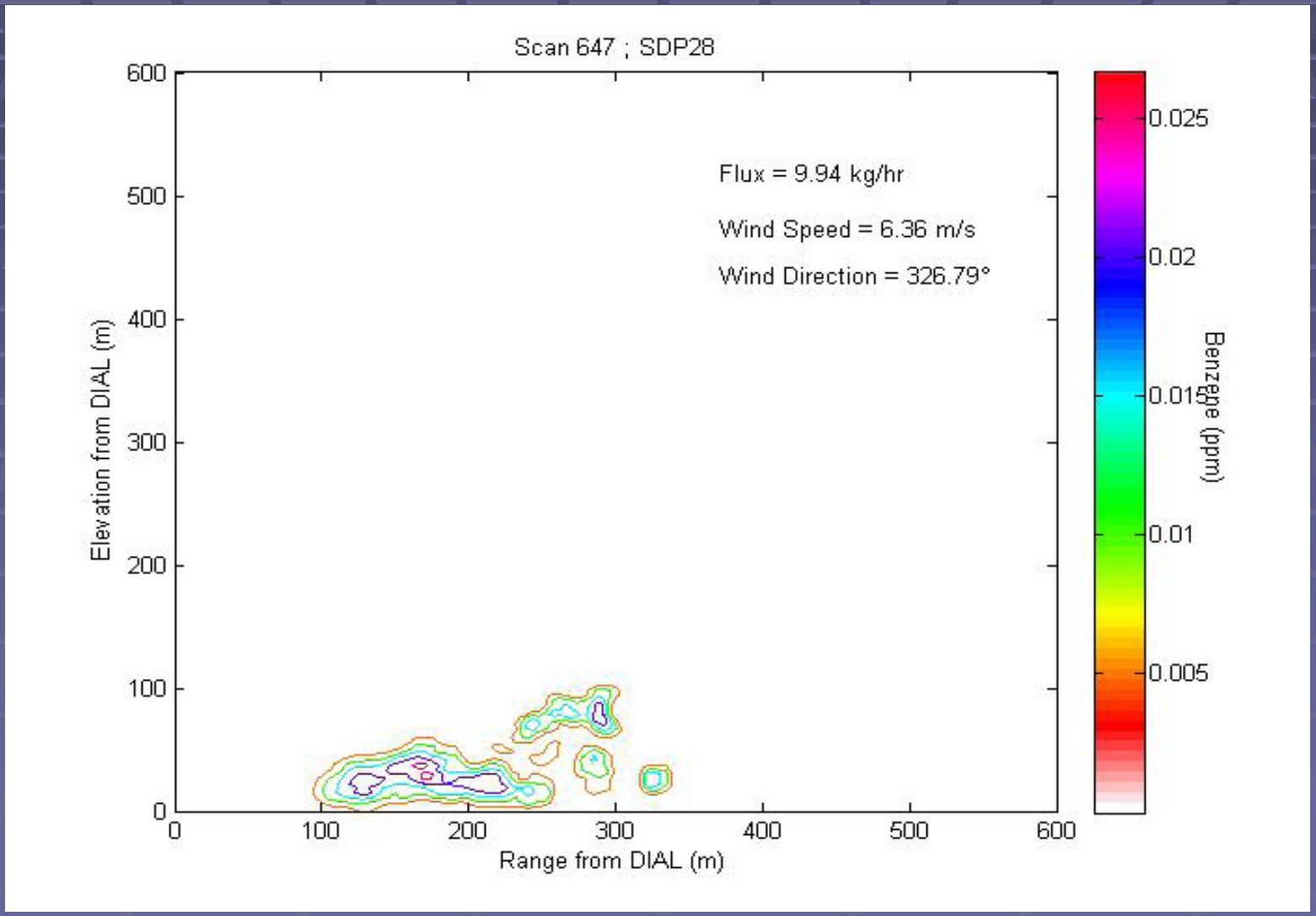
Mass Emission Rate

- Total mass in scan plane x wind speed = total flux of measured gases
- Flux of other gases estimated by compound ratios using sorbent tubes or SUMMA's
- Accuracy 10% to 15% in controlled tracer release and CEMS comparison studies
- Greatest potential measurement uncertainty… wind speed in the scan plane
  - Accuracy may be 35% in complex wind fields
  - AED may require 20 m met tower in scan plane during future measurements

DIAL Scan Plane
Benzene Extraction/Aromatics Concentration



Scan Plane Contour Plot (BEU/ACU 22 lbs/hr benzene)



Texas City Refinery (Summer 2007)

- Crude oil tank VOC emissions measured with DIAL were more than 5 times the hourly tank emissions estimated using AP-42 emission factors
- DIAL measured 1.5 to 2.1 lbs/hr of benzene emissions during the coking process
  - Benzene is not a well-understood delayed coker pollutant
- VOC emissions from a flare were 88 to 326 lbs/hr
  - Flares are assumed to have >98% combustion efficiency!
- VOC emissions from wastewater treatment area were 30 lbs/hr

Houston Area Refinery (Spring 2010)

- Examples of benzene emissions include:
  - Refinery Delayed Coker
    - Measured….3.3 to 48.9 lbs/hr
    - Texas Flexible Permit….0.005 lbs/hr
  - Chemical plant pyrolysis gasoline storage tank
    - Measured….1.2 to 32.5 lbs/hr
    - Texas Flexible Permit….1.83 lbs/hr
    - Benzene emissions also appeared to originate from an unpermitted tank
  - Refinery Wastewater Treatment Basins
    - Measured….2.6 to 10.3 lbs/hr
    - Texas Flexible Permit…0.82 lbs/hr
- The results were consistent with other DIAL campaigns showing that emissions *can* be much greater than permitted or expected

Next Steps

- OAQPS and City of Houston are collaborating to tie DIAL results to process information for emission factors development.
- Elevated wind measurement in scan plane will likely be part of future emissions tests.