NASA Atmospheric Effects of Aviation Project

Aerosol Instrument Inter-Comparison Workshop

Bruce Anderson
NASA LaRC
Lead Workshop Scientist

Phase I: Instrument comparisons using particle generators

Phase II: Instrument and inlet comparisons using the T-38 aircraft

Objectives:

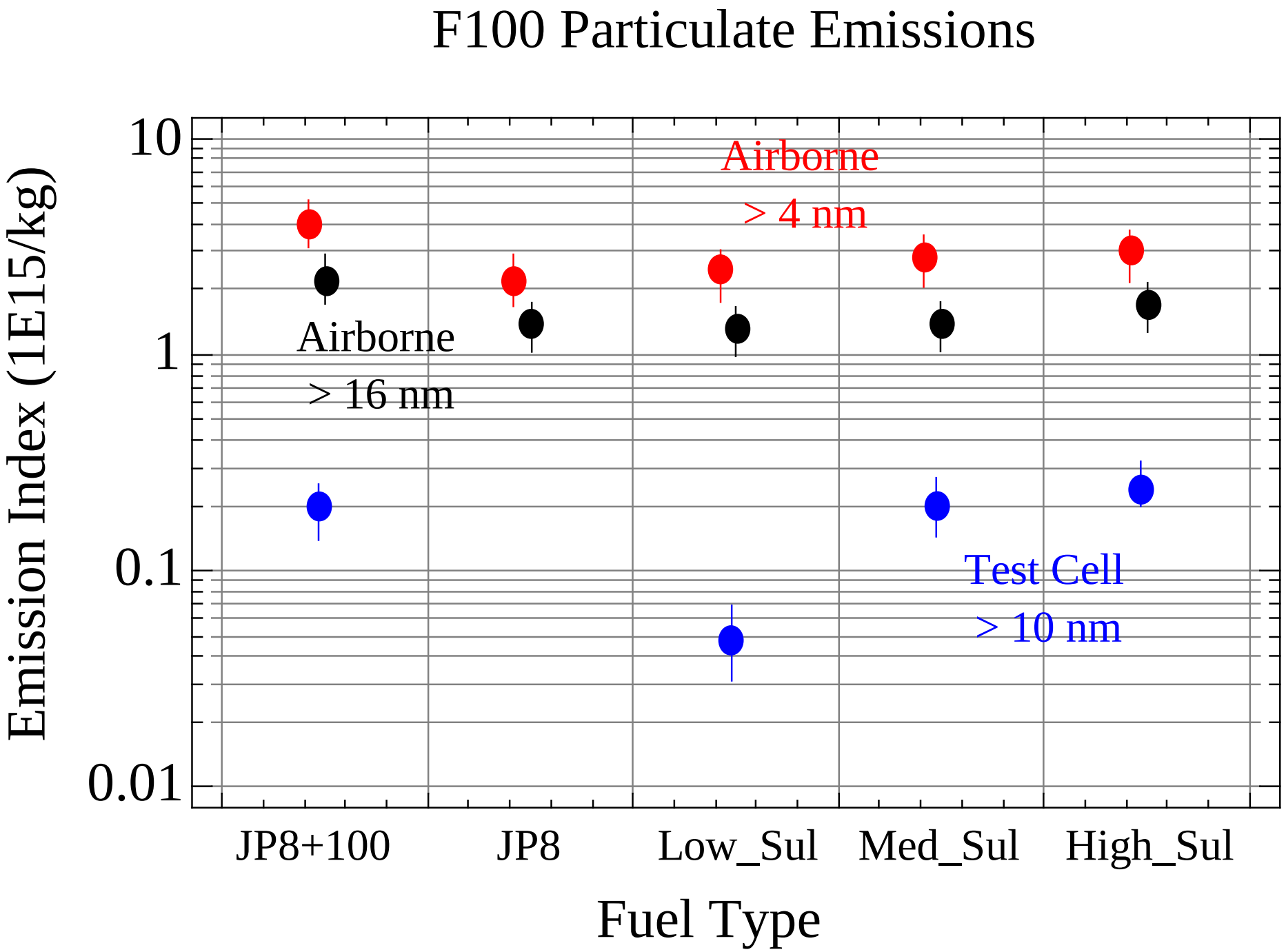
- Investigate the causes of aerosol measurement disparities in the SUCCESS data set
- Investigate differences in aircraft aerosol emission factors determined by different research groups in similar test venues
- Establish standard sampling practices for measuring aircraft particle emissions in airborne and ground-based test venues

Participants: LaRC aerosol group (Anderson), NCAR aerosols (Twohy), NOAA/DU aerosol group (Brock), U. Missouri Rolla Aerosol and Cloud group (Hagen and Whitefield), U. Minnesota Particle Technology Laboratory (Pui), NASA GRC Pagems group

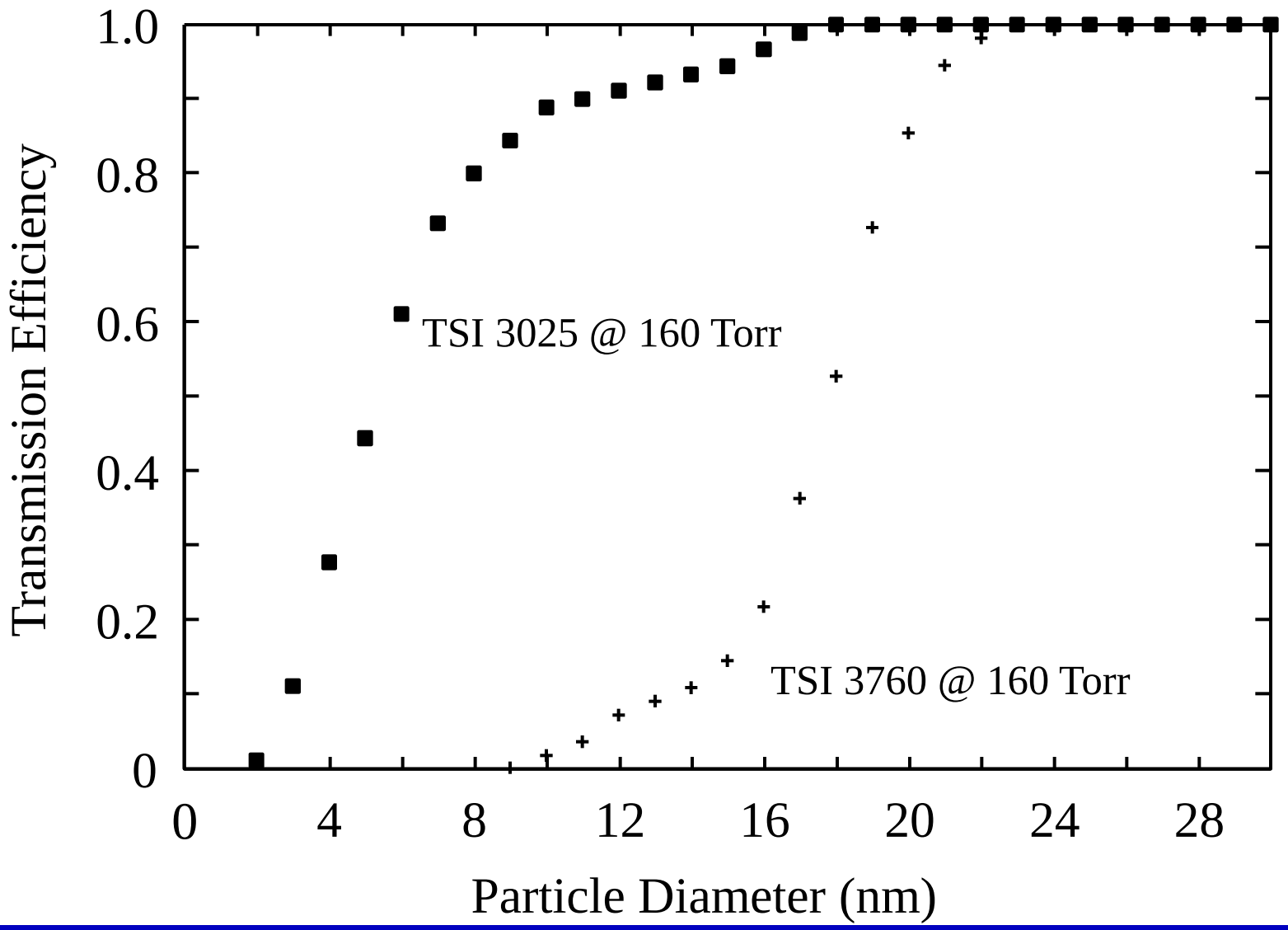
Approach:

1) Test aerosol instrument dynamic ranges and calibrations using particle generated by the U Minn particle generator and by diffusion burners
2) Test relative sampling probe collection efficiencies using the LaRC T-38 as the exhaust source.

Example of Differences Seen in Measurements: Air (LaRC) vs. Ground (UMR)

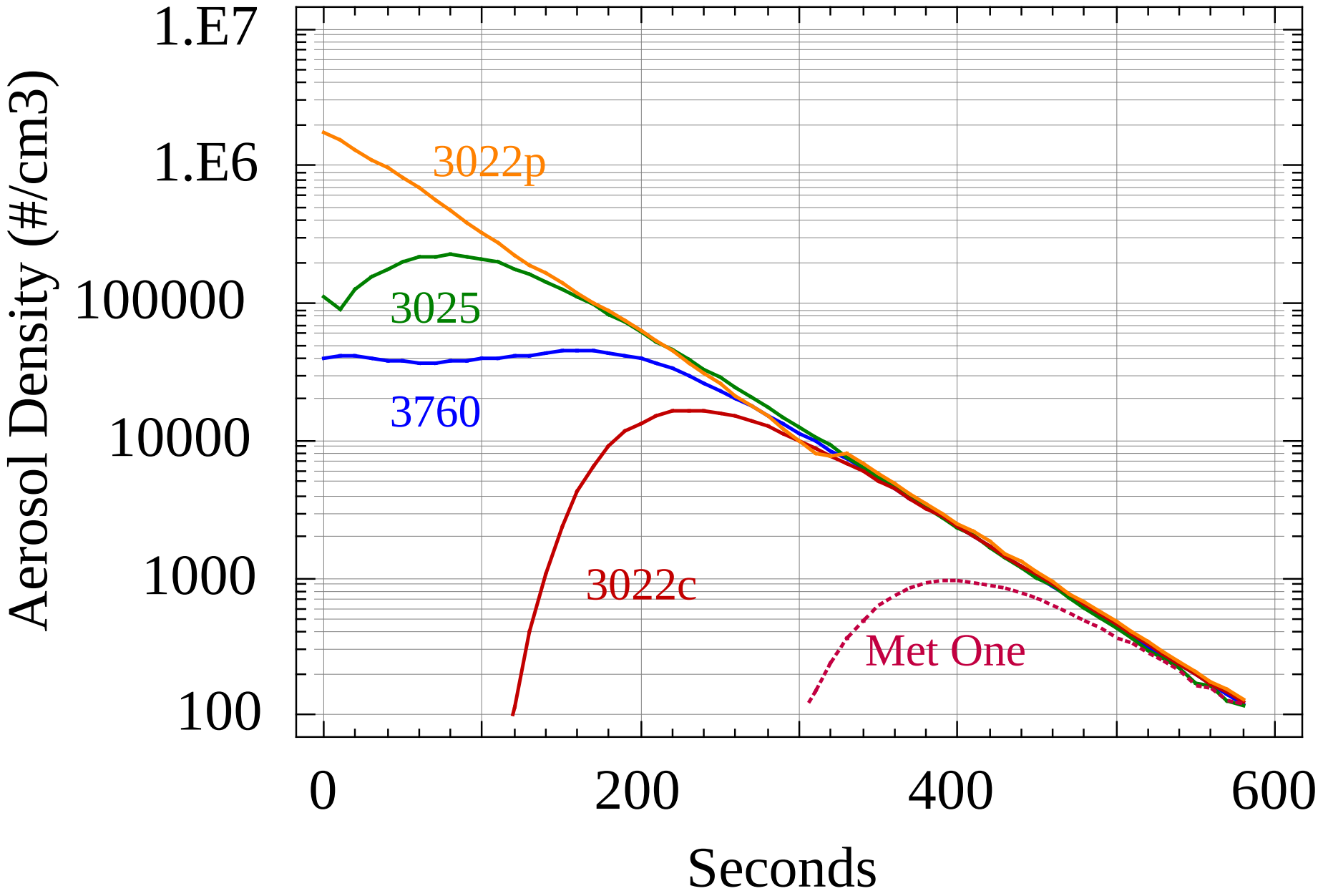


Instrument Detection Efficiency as a Function of Size



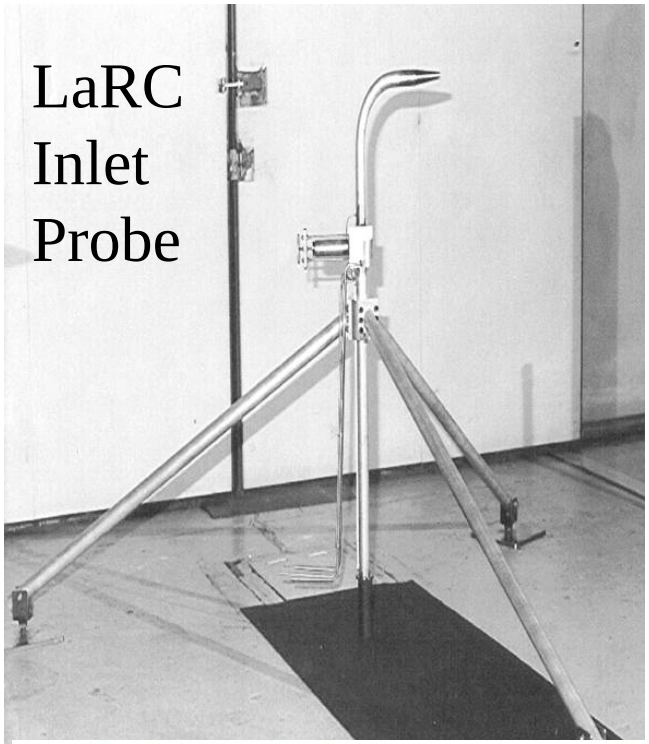
Aircraft PM are small, differences in instrument size sensitivity can lead to large differences in measured exhaust plume concentrations

Dynamic Range of Particle Counters



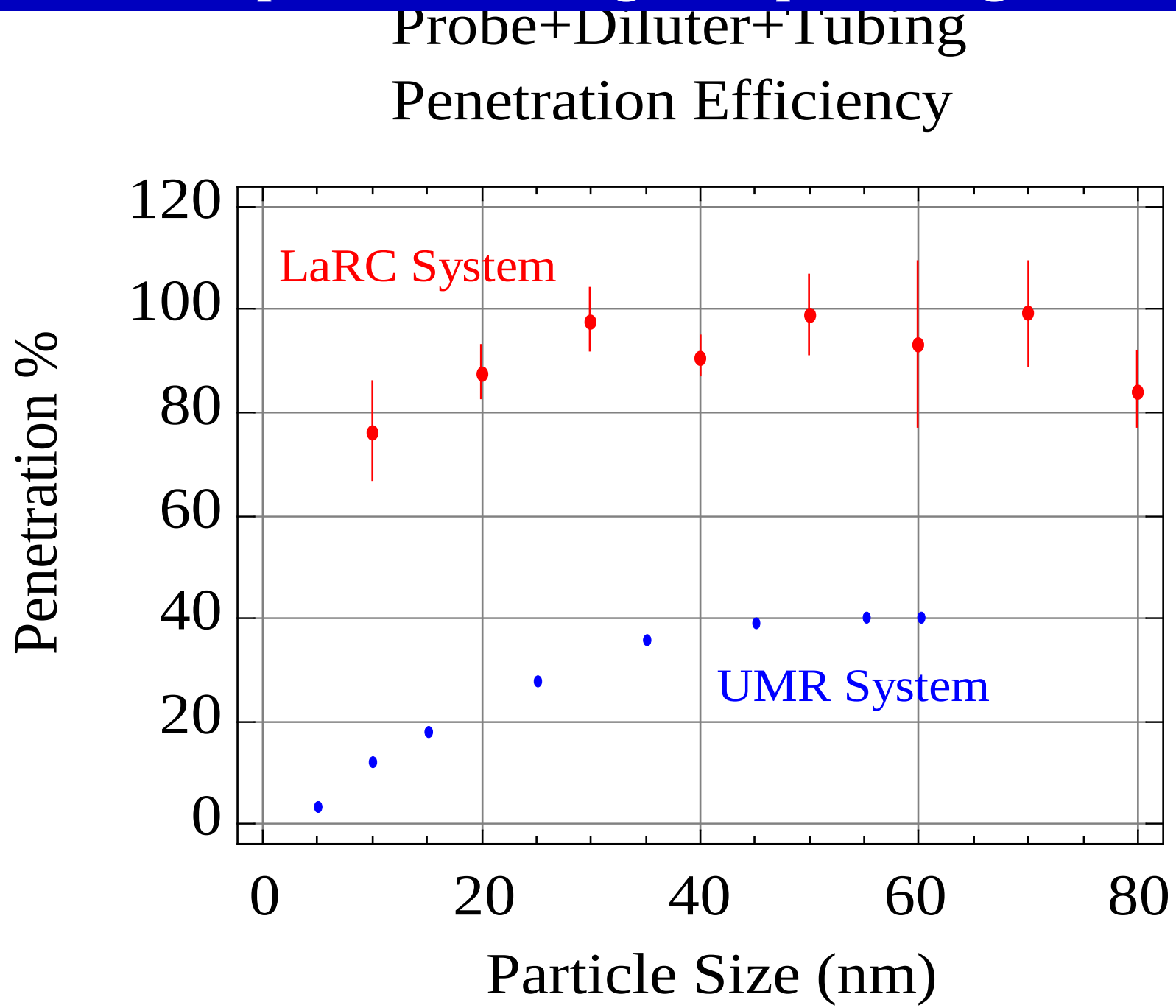
"Clean Room" CPCs often saturate when sampling high particle concentrations

Inlet Probes were tested in the lab for particle transmission efficiency and behind the LaRC T-38 for collection efficiency



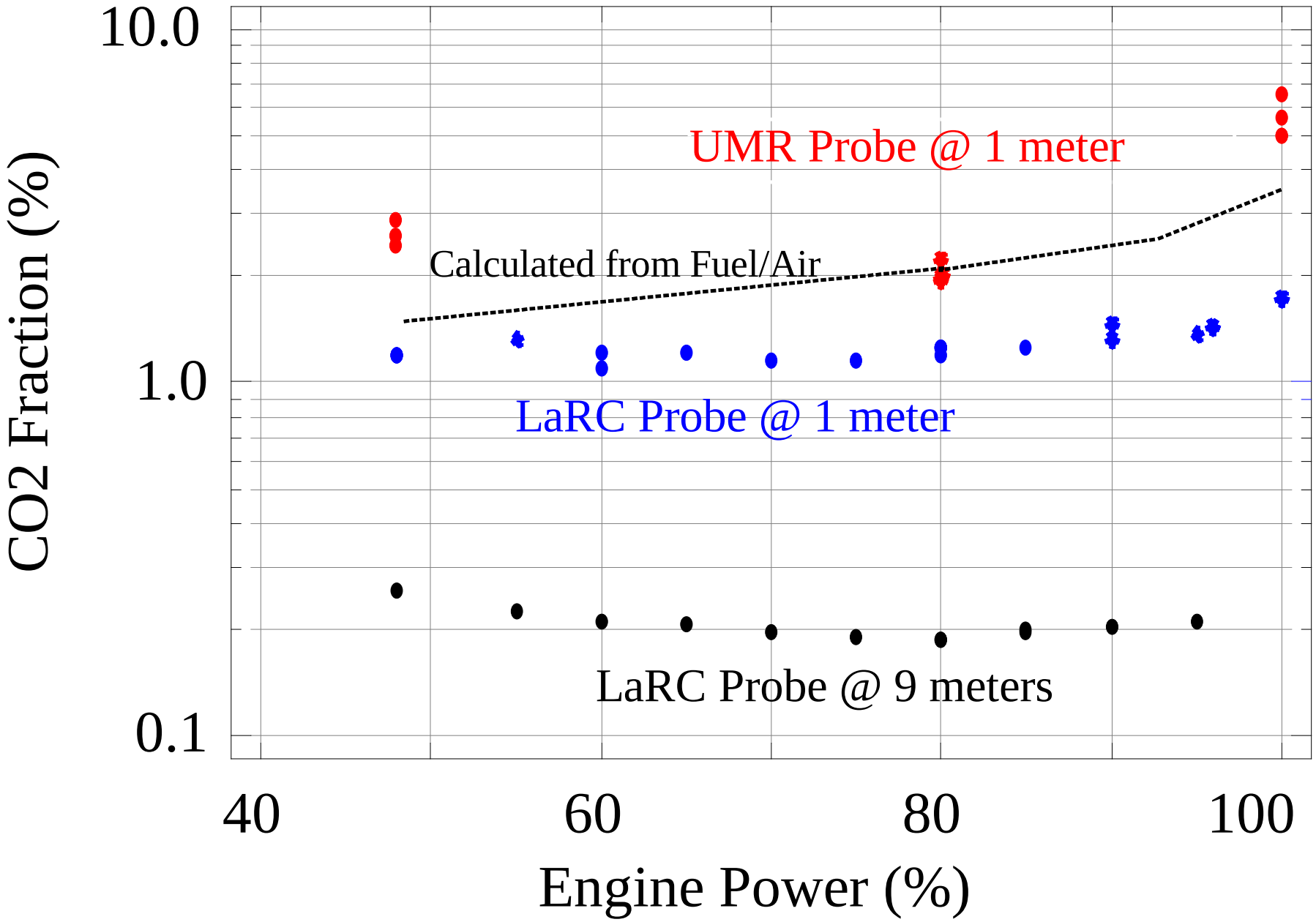
Inlet Probes Positioned 1 m behind LaRC T-38 with J-85GE engines

Particles produced using UM particle generator



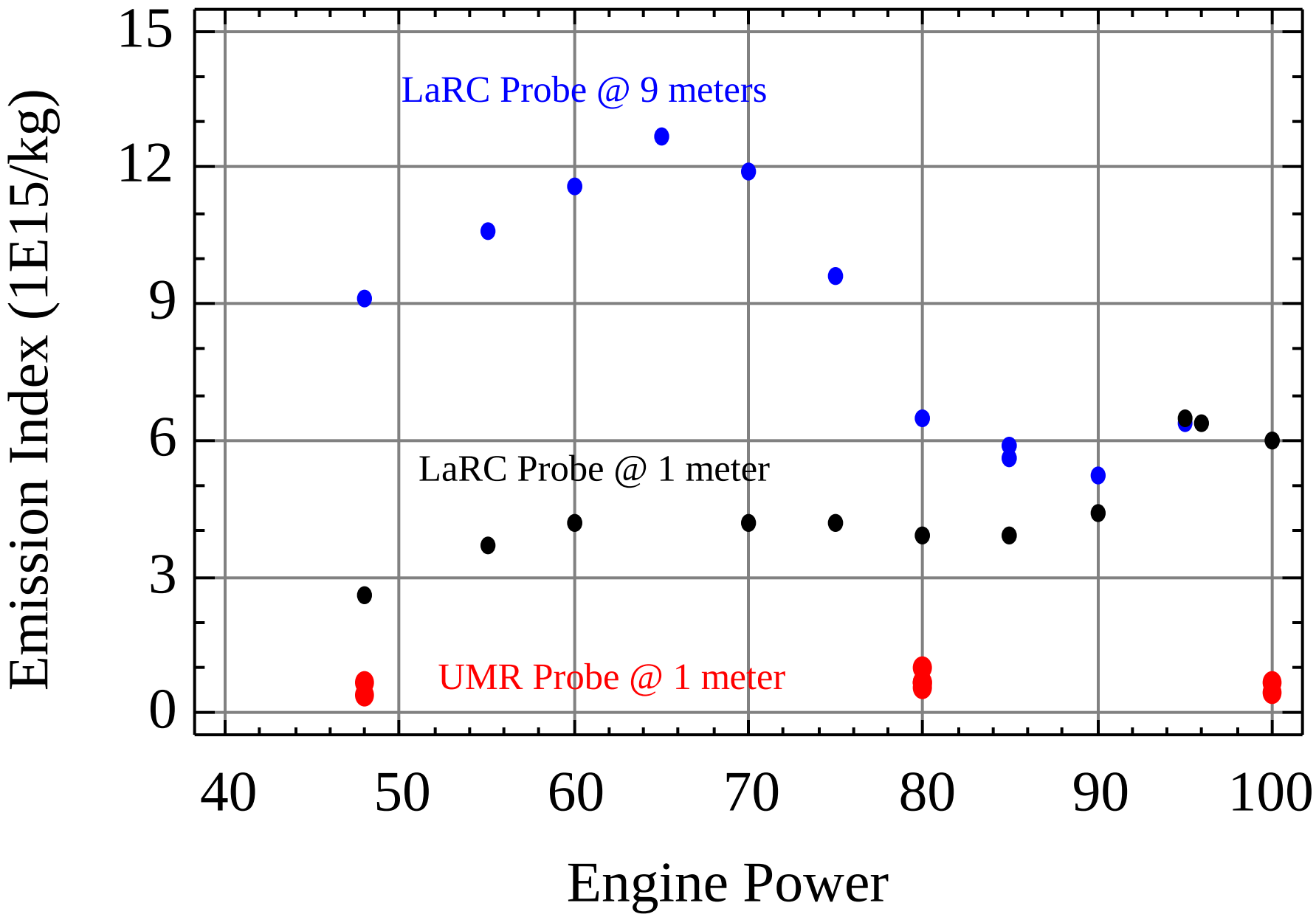
UMR loses partly from poorly conducting tubing

Exhaust CO2

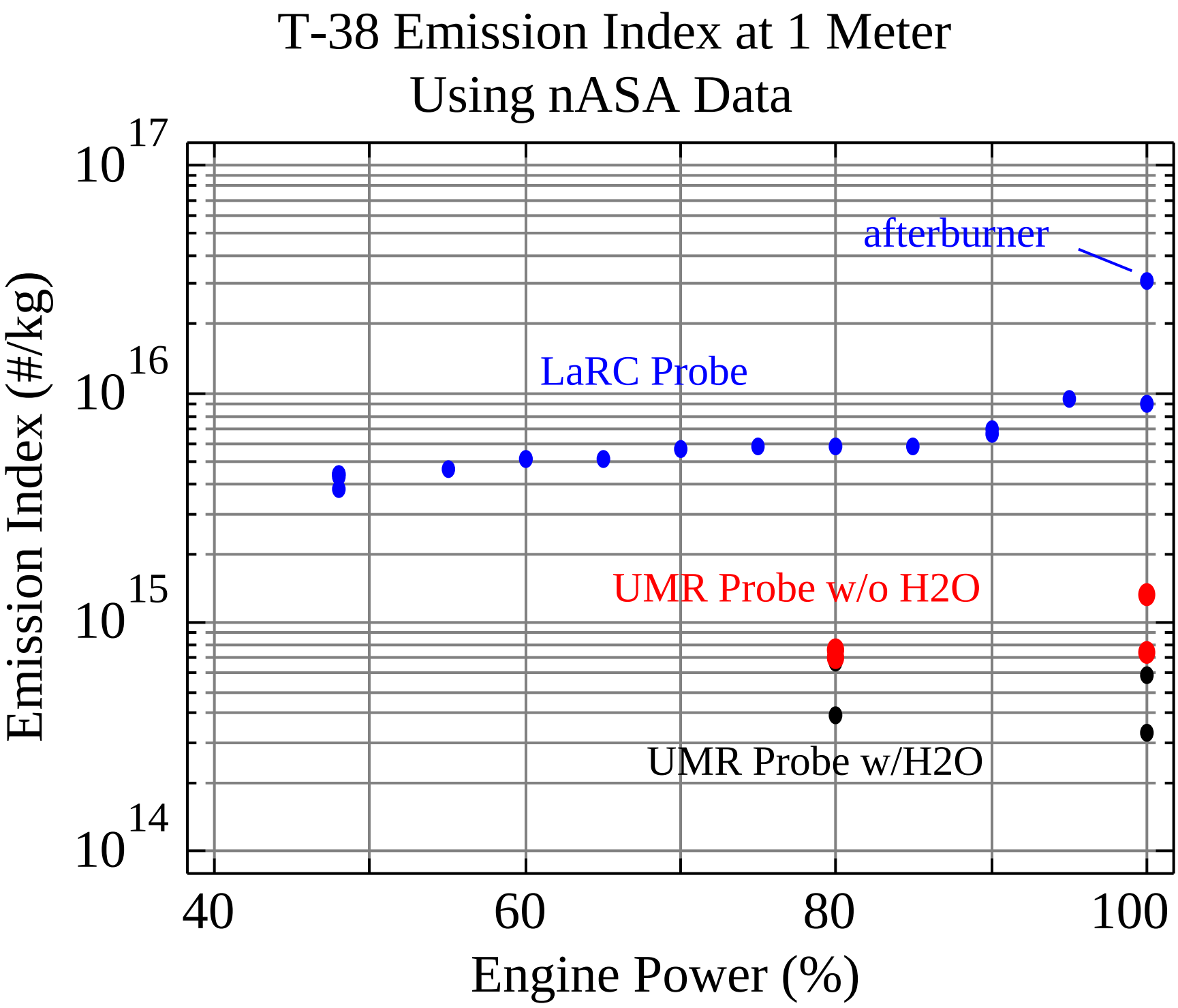


CO2 estimated from stated dilution ratios

T-38 Emissions
Uncorrected TSI 3025



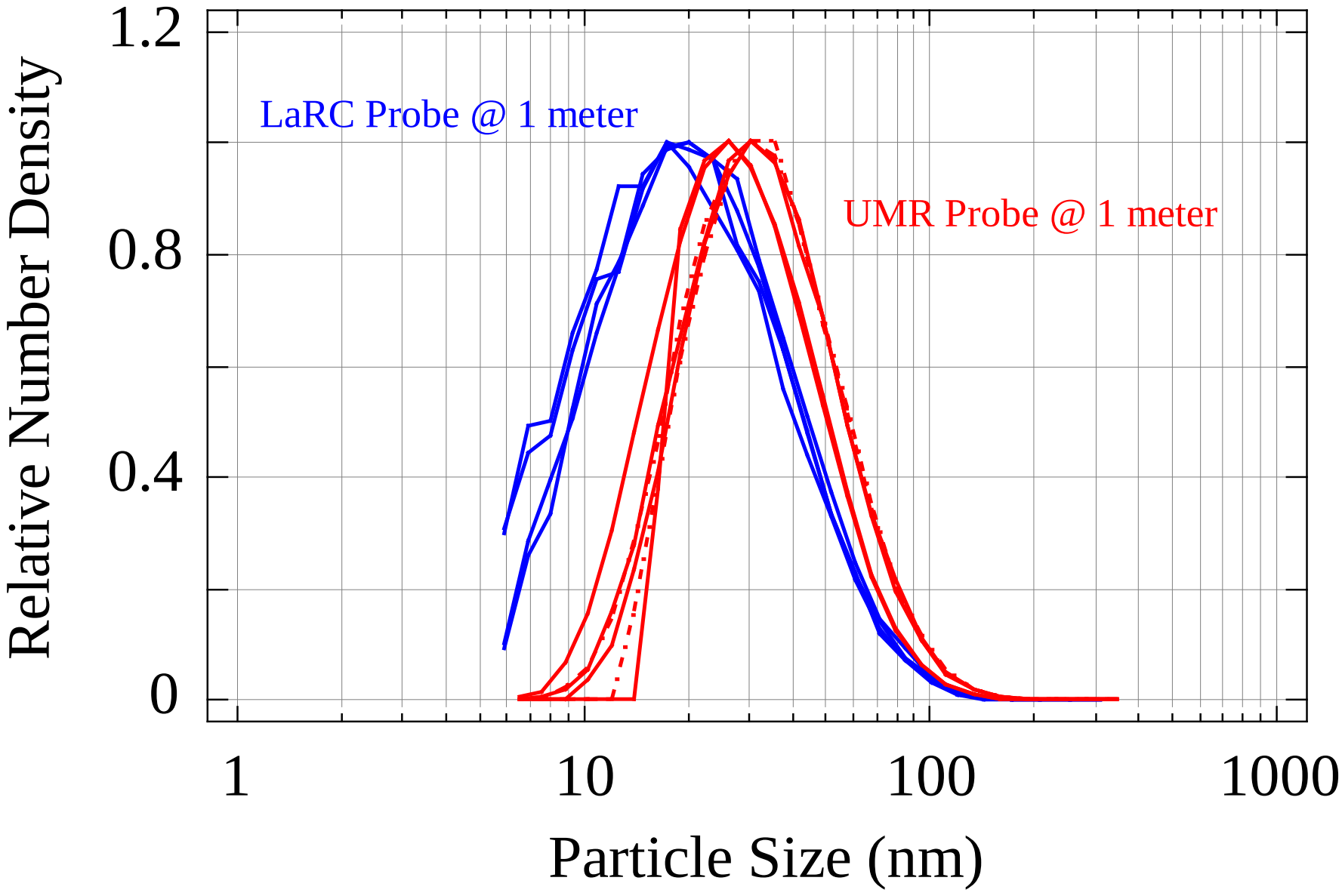
Differences in EIs behind 1-m probes > line loss differences



Water-cooling of UMR probe leads to thermophoretic losses

T-38 Particulate Emissions Characteristics

80% Power



large losses of nanoparticles occur in UMR probe

Summary

- Particle counter efficiency varies with pressure, must be calibrated for anticipated sampling conditions.
- Particle counters have vastly different dynamic ranges; clean-room CPCs easily saturate when sampling combustion plumes
- Aircraft generate large numbers of nanoparticles, which can lead to large differences in measurements between CPC's with different lower size cuts
- Aircraft particle emissions are likely charged, may lead to significant transmission losses in sample tubes that are not sufficiently conductive
- Aircraft exhaust is >300 C at 1 meter, using water-cooled sampling probes can lead to large thermophoretic particle losses
- Aircraft exhaust velocities approach mach 1, sampling probes should be designed to expand flow and add diluent in less turbulent flow