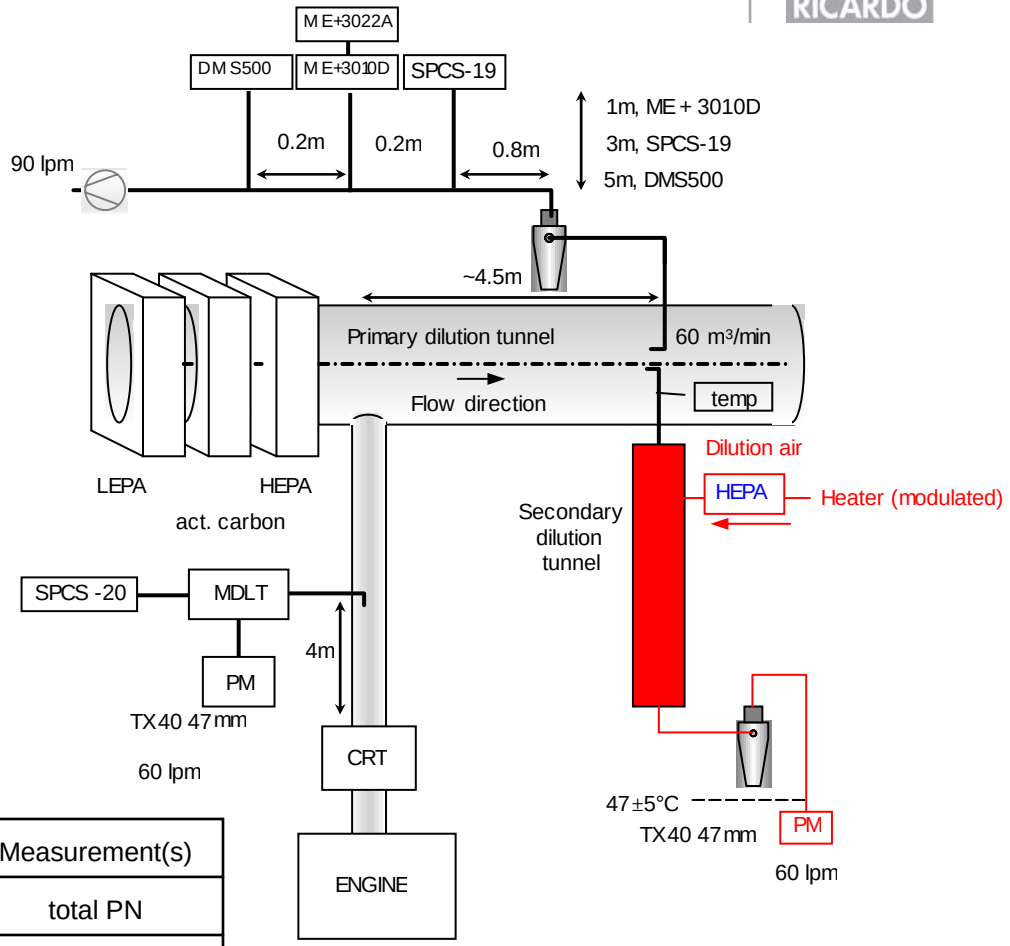
PMP HD_ILCE Informal Meeting at DfT London 30th March 2009

Preliminary results from VE testing of Iveco Cursor 8 at Ricardo

Equipment – Instruments and Configuration

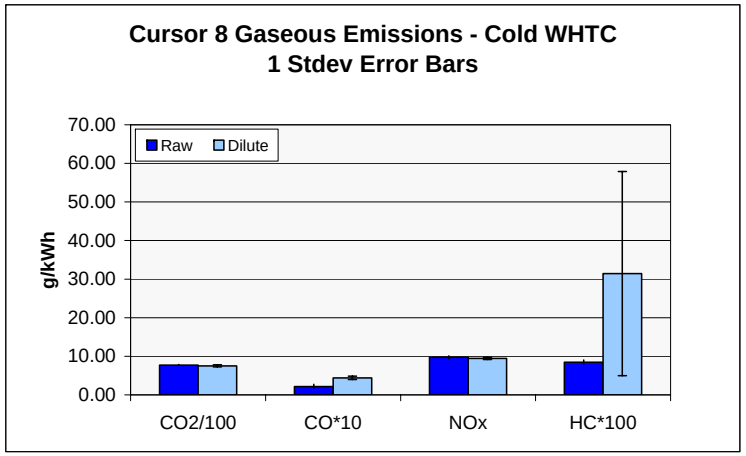
	CVS	MDLT
Flow rate	~56m^3/min	60litres/min
Split ratio	1	1100
Volume (1800s)	1700m^3	1800litres
PM flow	60litres/min	60litres/min
Scaling factor	1	~945

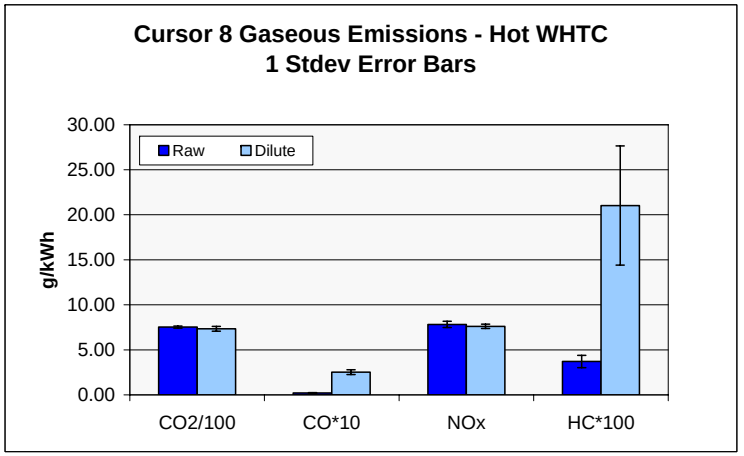


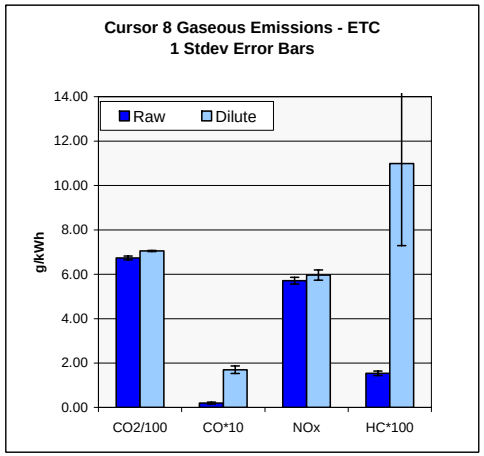
Identifier	Instrument	Particles	Size range	Measurement(s)
SPCS-19	GPMS-CVS	solid	>23nm	total PN
SPCS-20	GPMS-MDLT	solid	>23nm	total PN
ME_3010D	ALT-CVS	solid	>23nm	total PN
ME_3022A	additional	solid	>7nm	total PN
DMS500	additional	Solid & volatile	5nm -1000nm	size dist, total PN

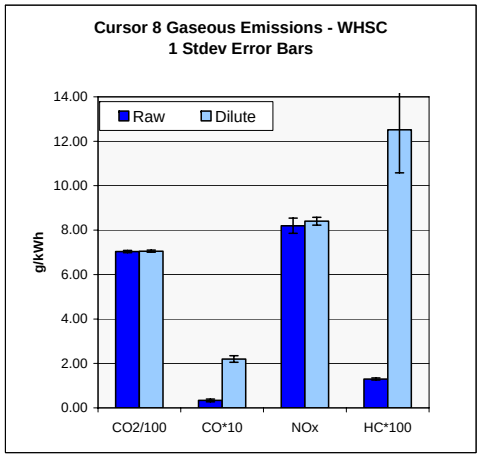
Gaseous Emissions

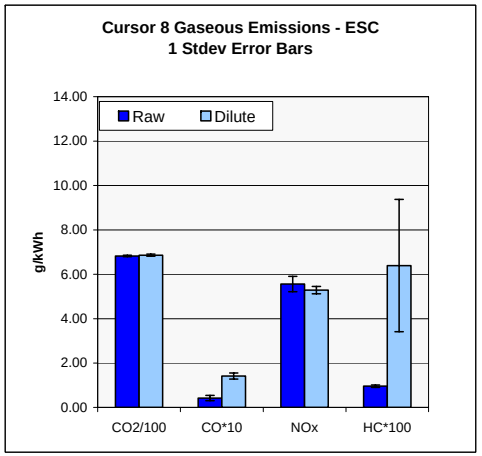
- Similar results from raw and dilute measurements except for HCs and to a lesser extent CO – indicates HC background in CVS





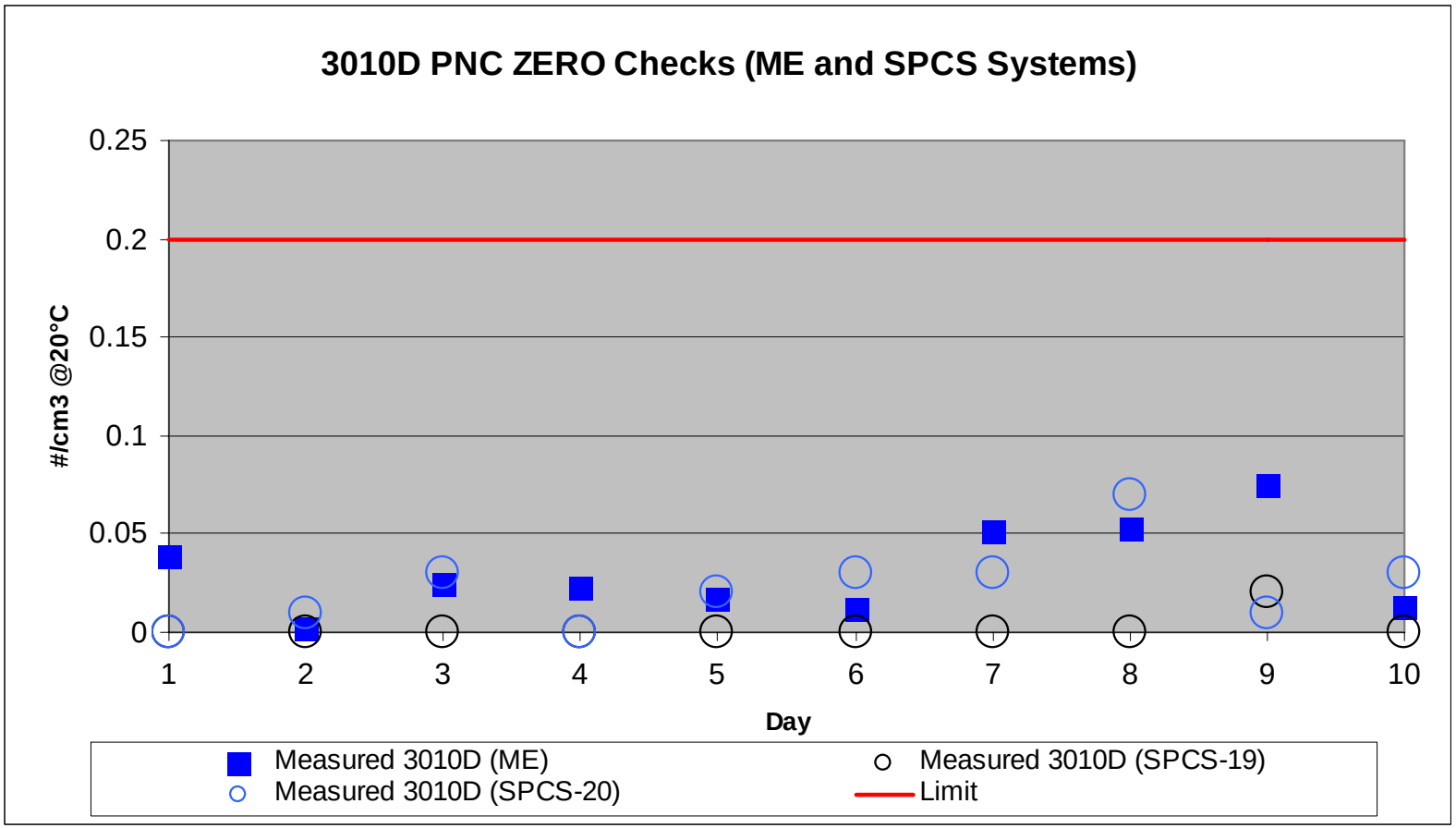






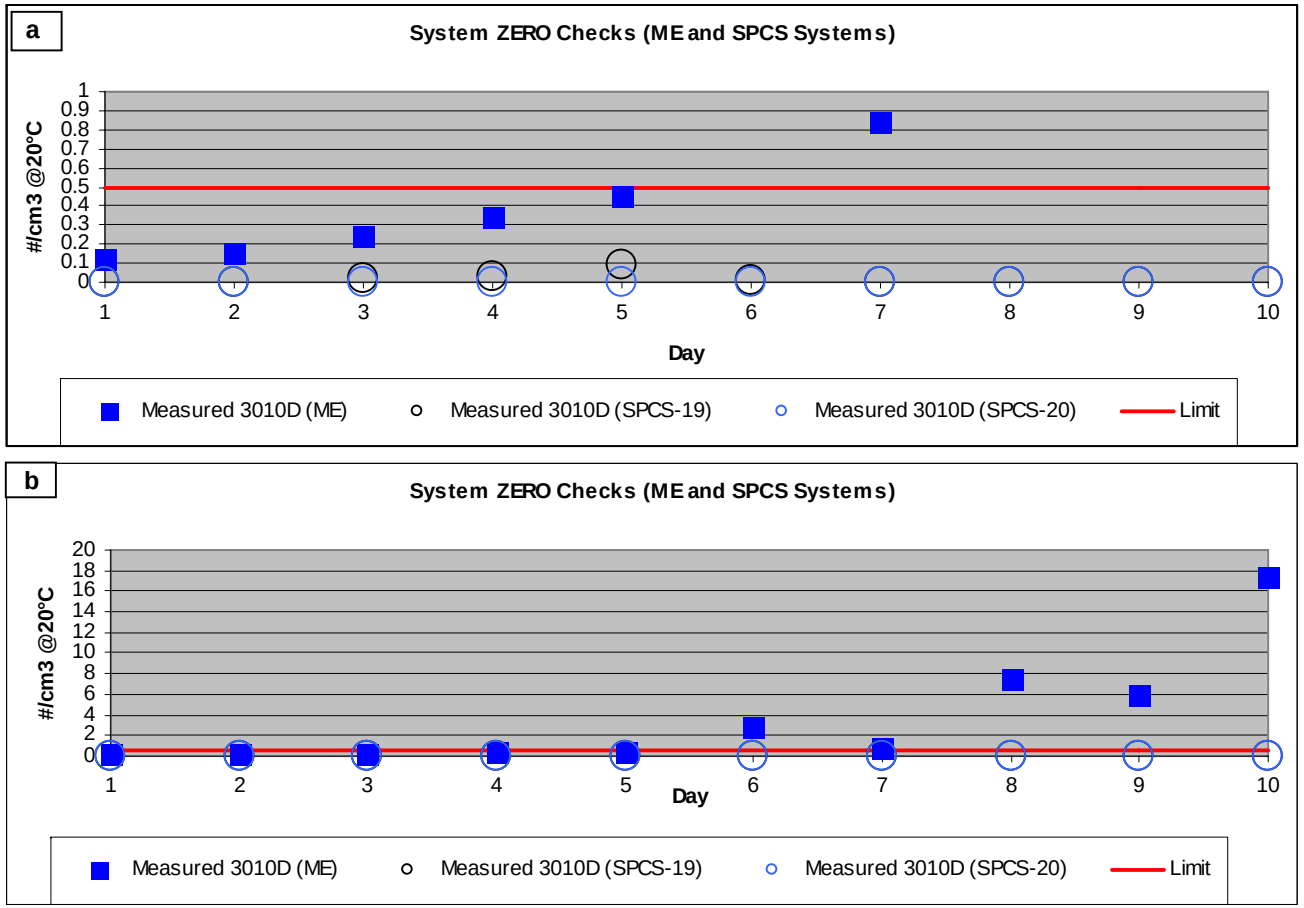
Instrument Validations

- All PNCs easily met zero check criterion



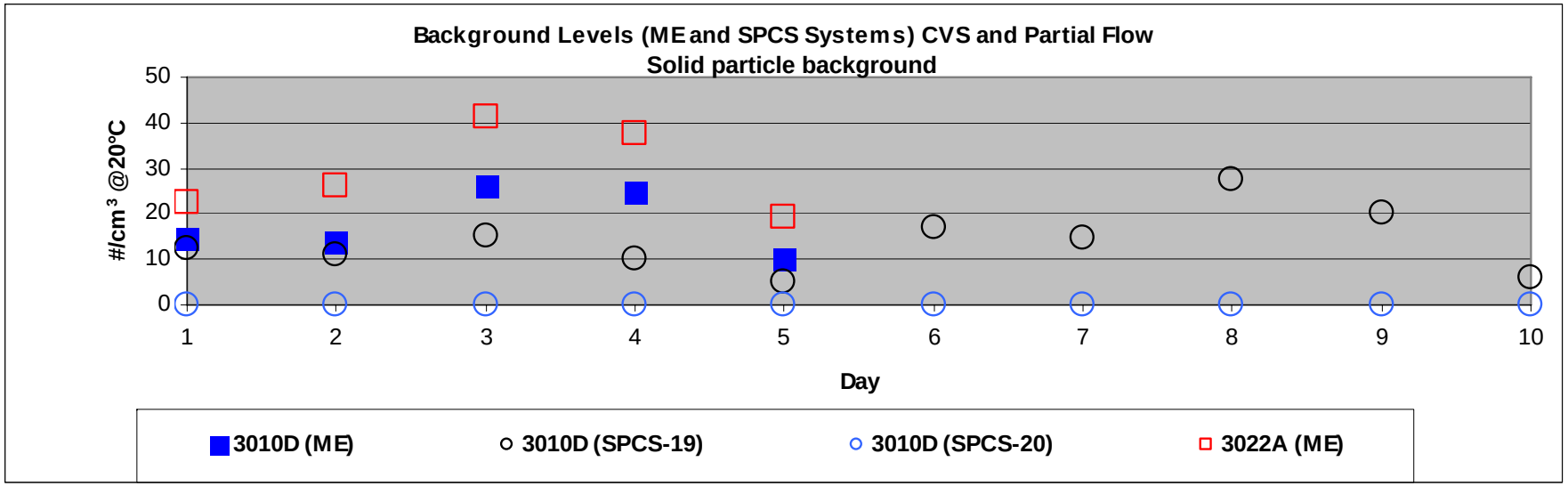
Instrument Validations

- SPCS systems easily met system zero criterion, but Matter system failed after the first few days
  - Disc wear led to high background particle numbers, so later data discarded
  - Matter working on new disc coatings for greater robustness; preliminary results encouraging

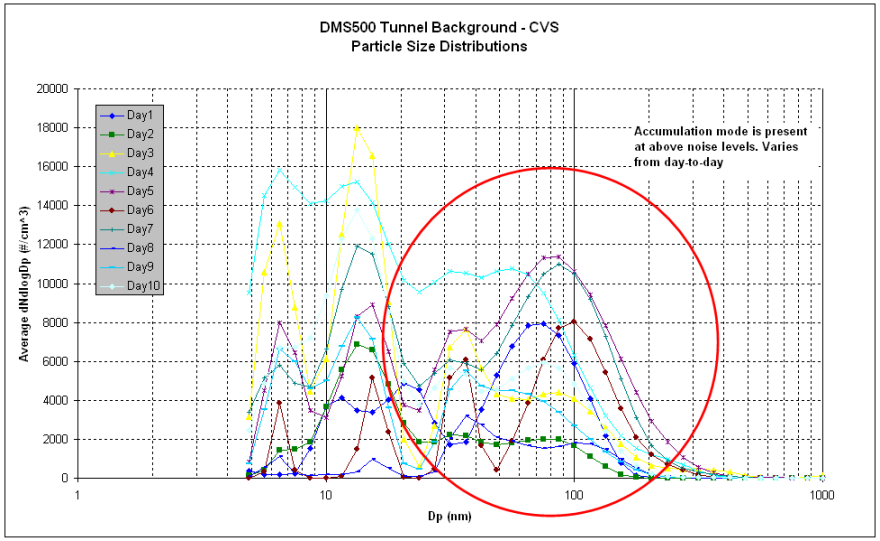


System Backgrounds

- CVS solid particle number backgrounds much higher than partial flow

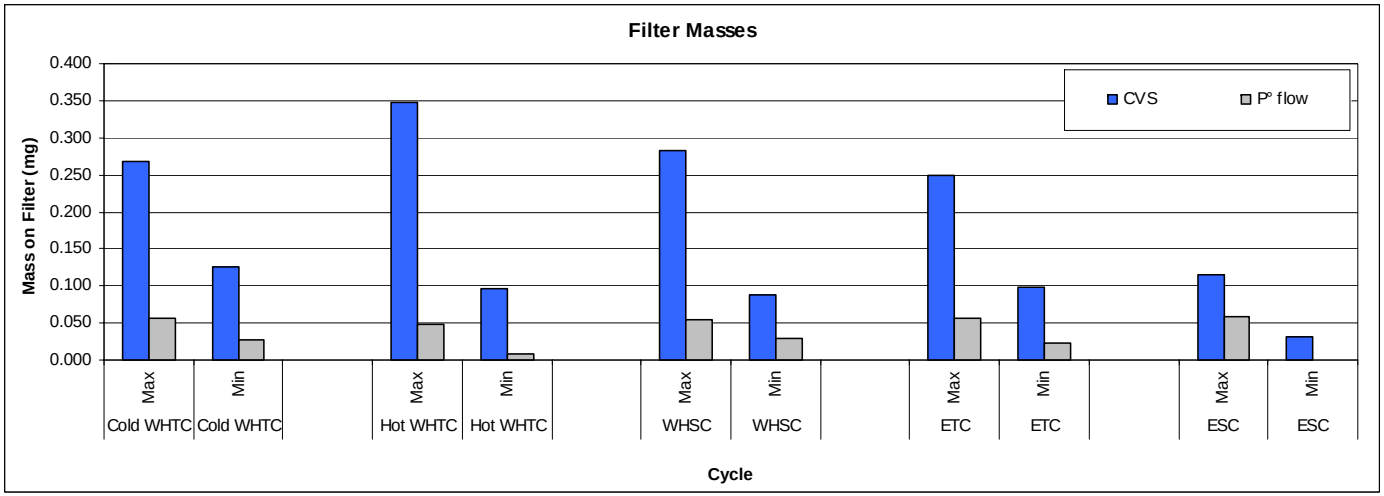


- DMS shows variable accumulation mode to be present
  - Solid particle background probably historic soot and low volatility HCs
    - Mass background also expected
  - Volatile background present as nucleation mode and also associated with accumulation mode



PM Measurements

- General trend that CVS sampled filter masses are higher than partial flow masses

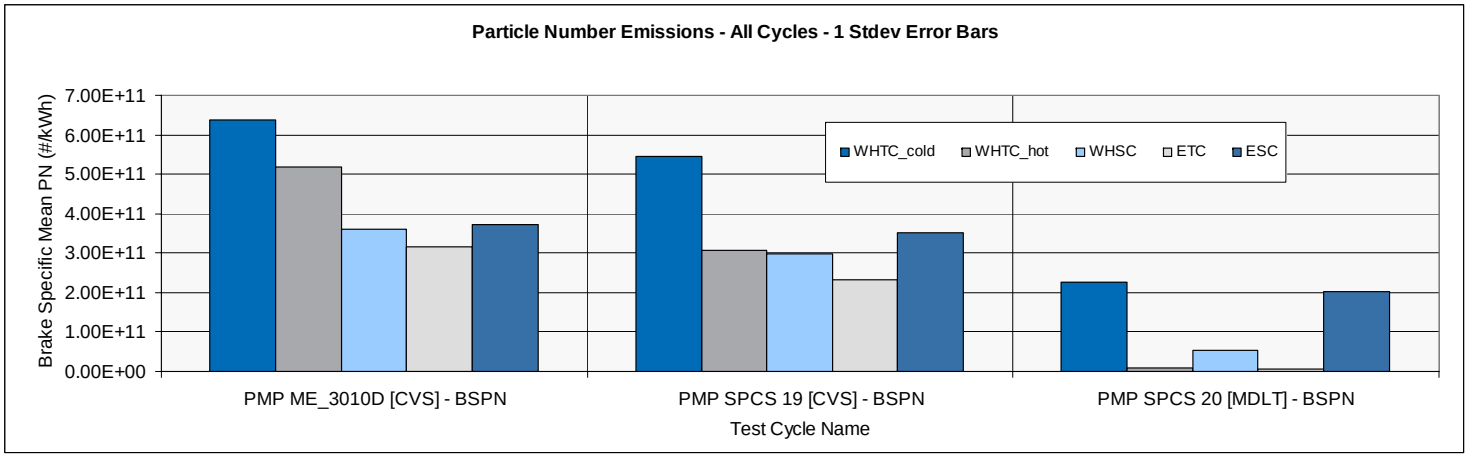


- The LOD can be determined as 3 x standard deviation of the blank measurement.
  - Partial flow mass method LOD: $3s$ = 35µg (equates to **1.1mg/kWh** ETC)
  - Full flow mass method LOD: $3s$ = 108µg (equates to **8.3mg/kWh** ETC)

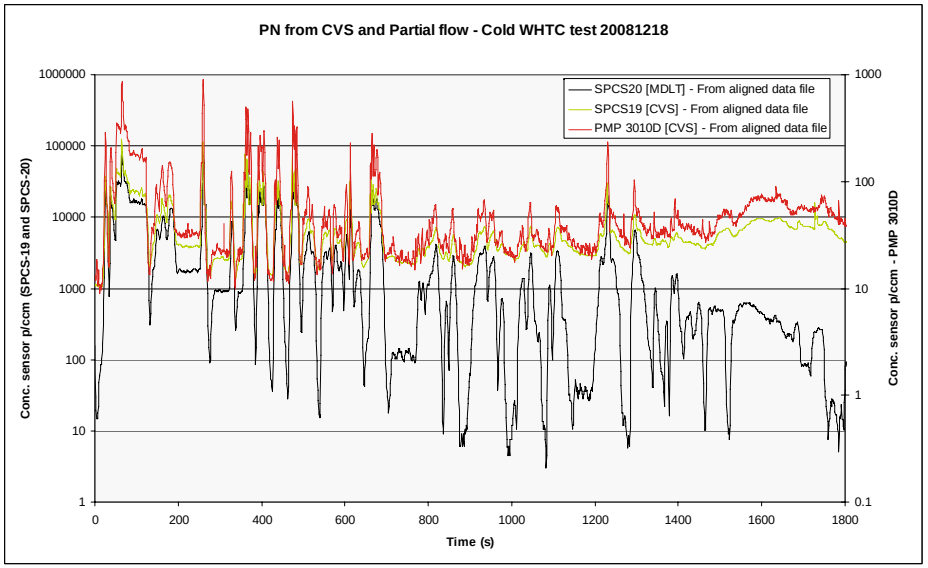
- Partial flow system 7 times more sensitive than full flow for mass measurements

PN Measurements

- PN emissions trends similar between CVS systems, different to partial flow



- CVS PN background much higher than partial flow
- Both systems indicate major transient events
  - C_WHTC

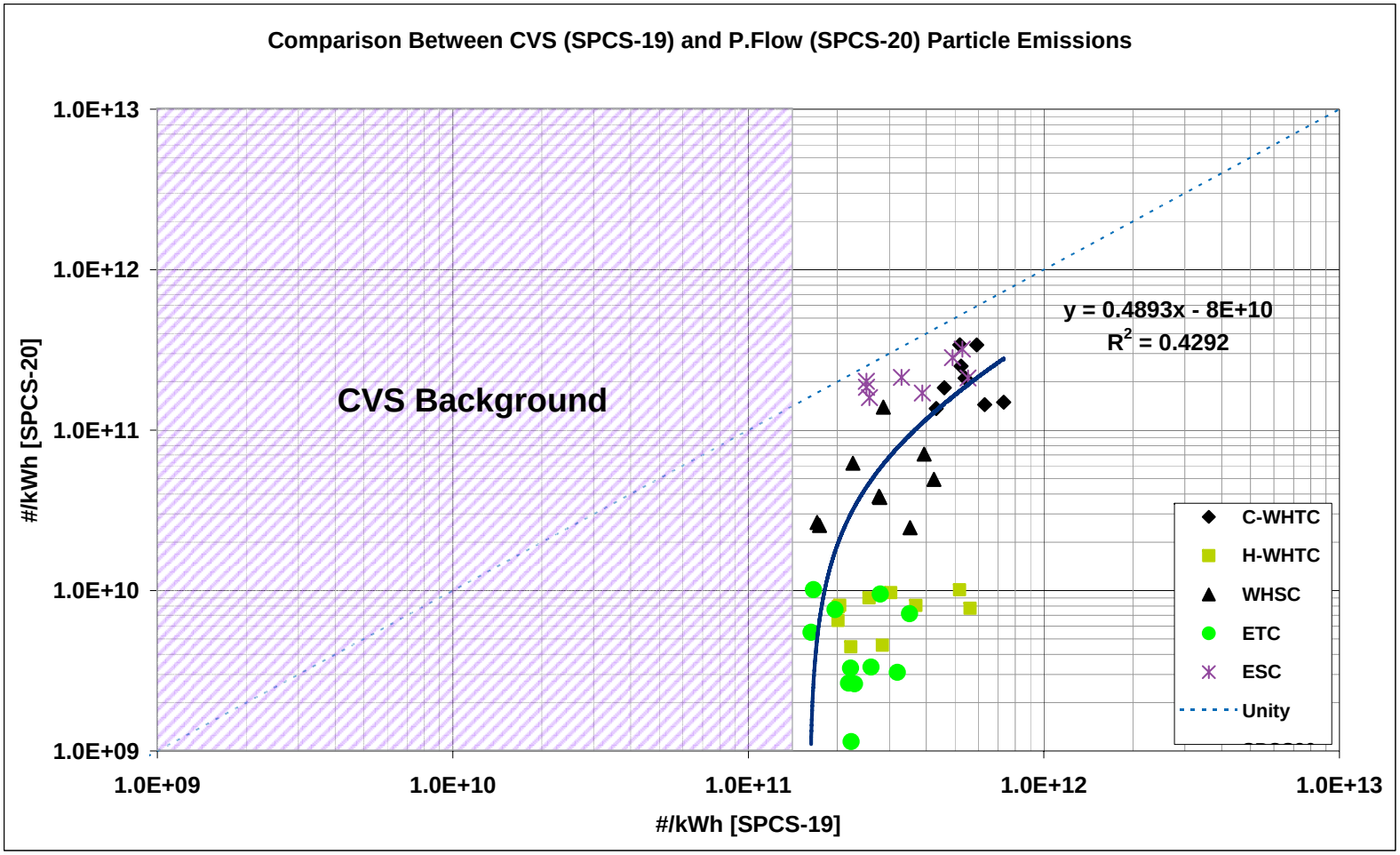


PN Limit of Detection

- The LOD can be determined as 3 x standard deviation of the blank measurement.
- Partial flow + SPCS-20
  - LOD: 3σ = 15 particles/cm^3 in the tunnel (after dilution correction)
  - equates to **~8.7x10^8** particles/kWh over the ETC
- Full flow + SPCS-19
  - LOD: 3σ = 3055 particles/cm^3 in the CVS (after dilution correction)
  - equates to **~1.4x10^{11}** particles/kWh over the ETC
- Based upon these results, the limit of detection for the partial flow system is **160** times lower than for the full-flow system

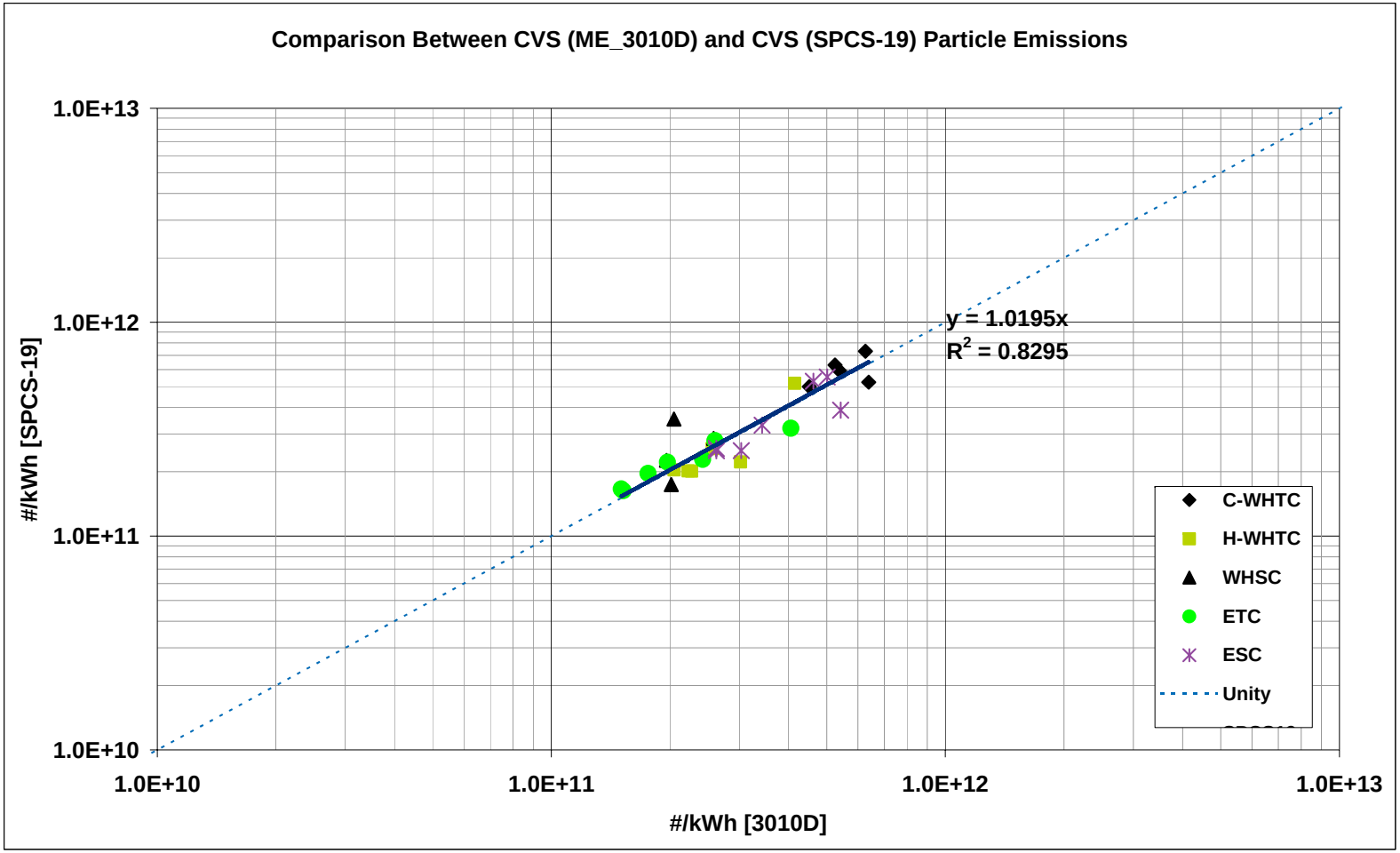
Full flow Vs Partial Flow – Correlation between Number Data

- Results from cycles with highest emissions levels similar between full and partial flow
- Lowest emissions cycles results only discriminated in partial flow system



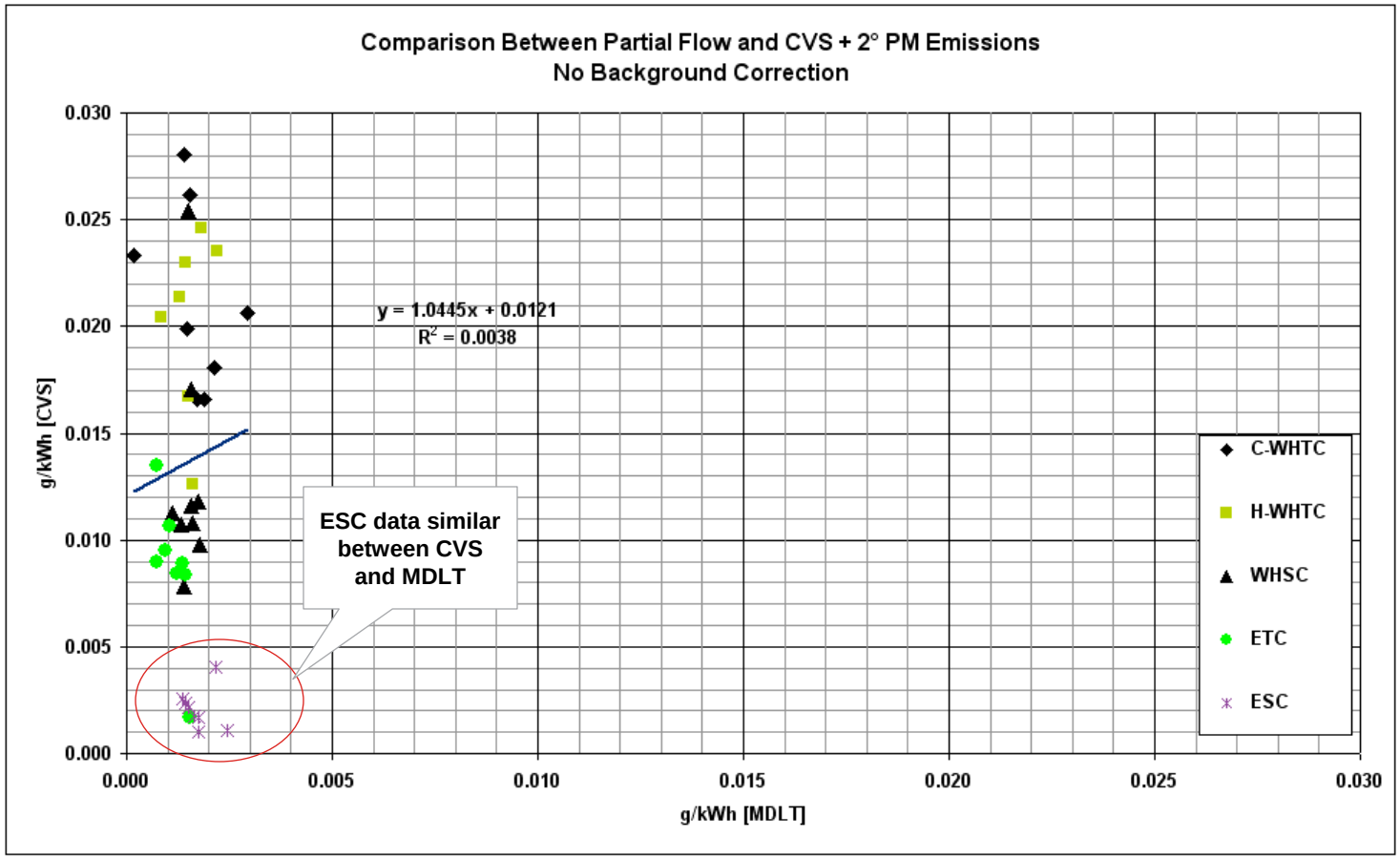
Full flow - Correlation between Different Measurement Systems

- Excellent (2%) agreement between Matter system and SPCS-19, both from CVS
- Dilution factors used for comparison



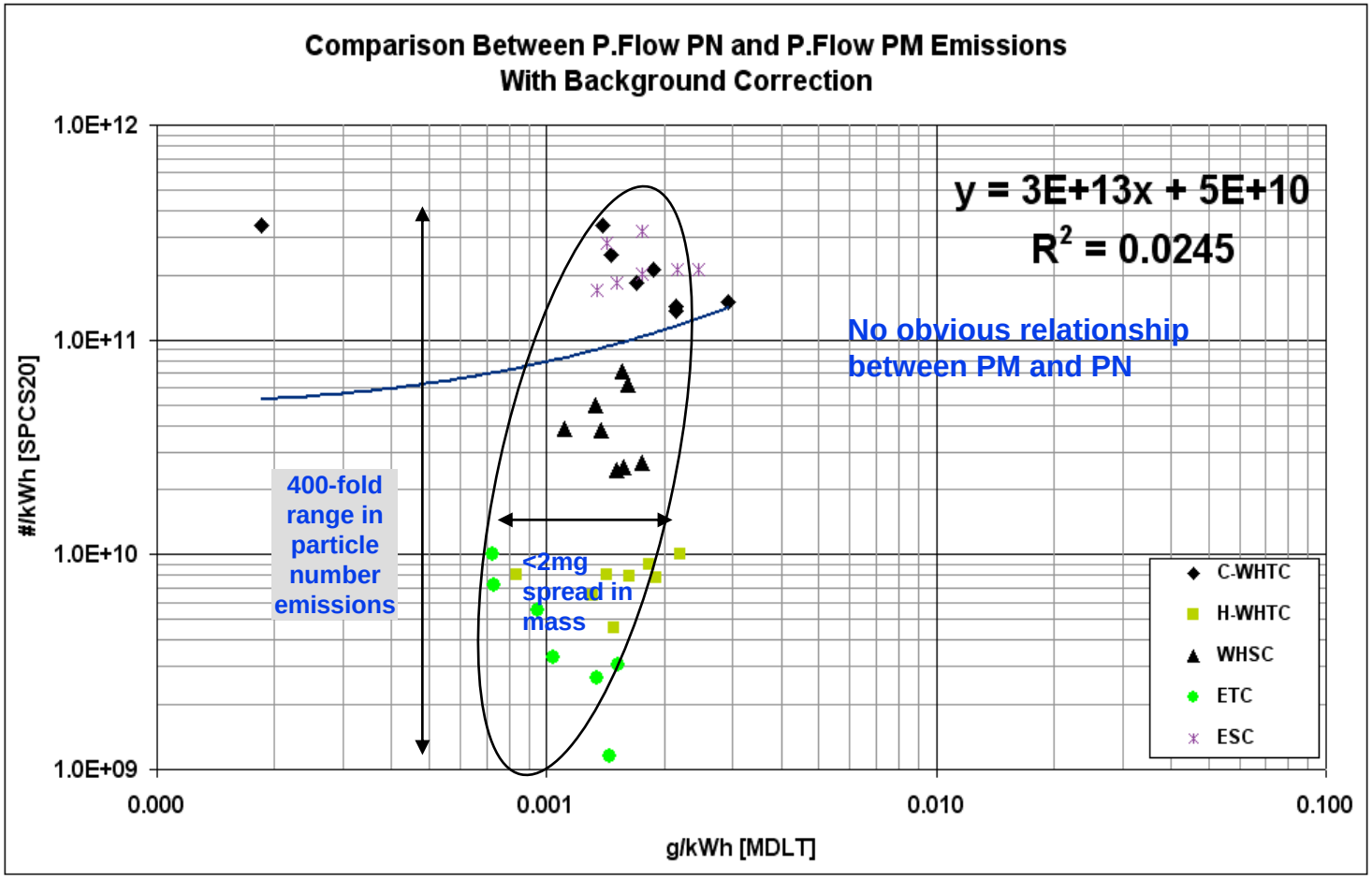
Full flow Vs Partial Flow – Correlation between Mass Data

- No correlation between mass from different measurement systems
- PM from ESC cycle similar from both CVS and partial flow

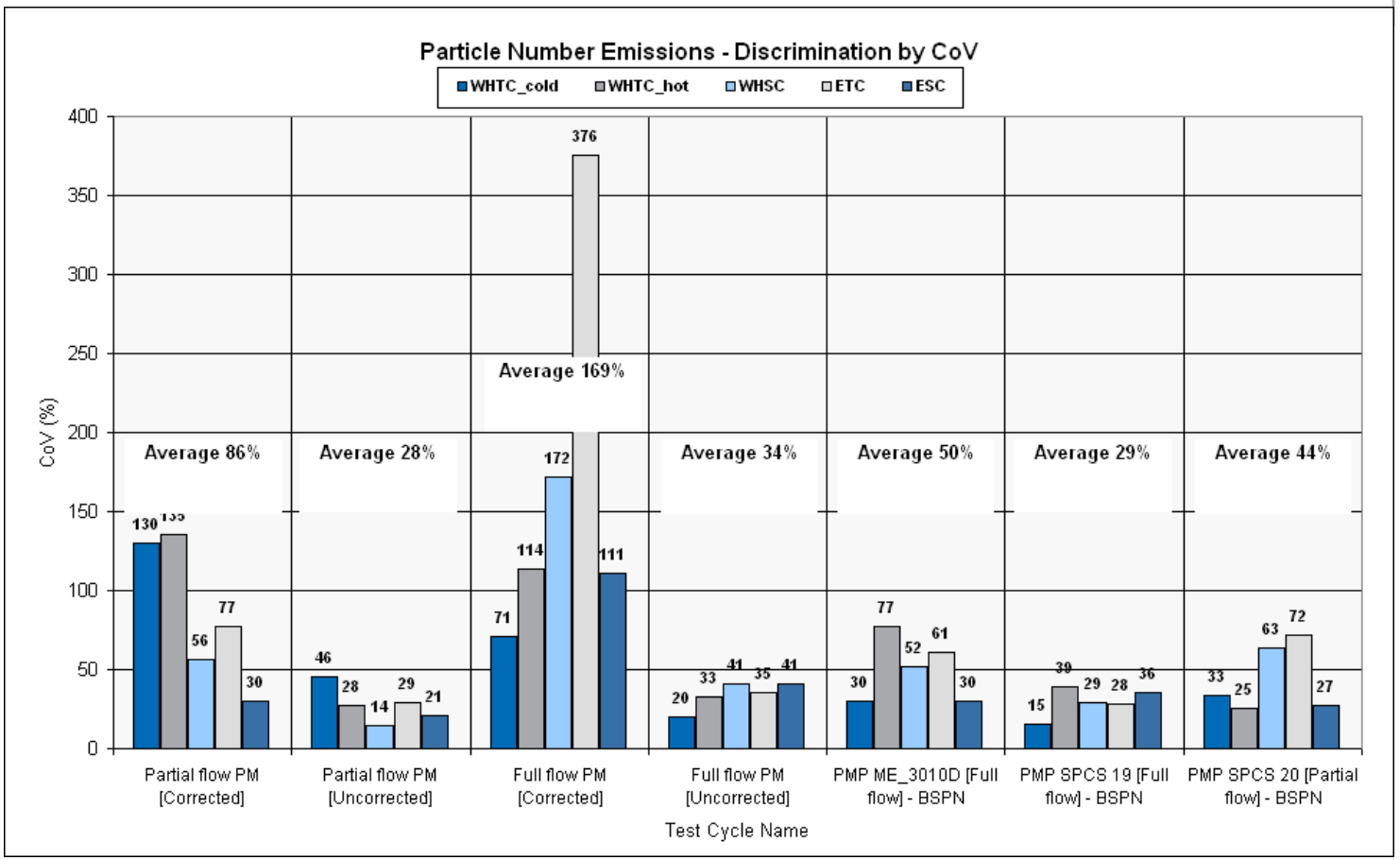


Partial flow Mass Vs Partial Flow Number

- No obvious correlation between mass and number, even with very low background partial flow system: mass method insensitive
- Poor correlation on log-log chart



Which is the 'best' system?



- **Using CoV as the discriminator…**
  - **Background corrected mass should be avoided**
  - **Number is generally better than mass**
- **Partial flow PM has the lowest average CoV**
- **CVS PN has the lowest particle number CoV**

- **But:**
  - **Partial flow mass method lacks sensitivity**
  - **CVS data has high background**
- **Repeatability not a good metric!**
- **Confirmation of observations in the ILCE_LD**

Summary

- Measurements from Ricardo showed high particle and HC background in the CVS, but very low background from partial flow system
  - CVS >20 years old and used for many projects including DPF regeneration
    - DPF calibration work may have contaminated the system leaving particle precursors that were not removed despite the PMP preconditioning
  - Partial flow dilution system new, but also much more practical to clean!
- PN from CVS did not correlate well with partial flow PN except for highest emissions cycles
  - CVS limit of detection for PN was ~ 10^{11}/kWh and ~8mg/kWh for mass
- PM from partial flow tunnel did not correlate with PN from partial flow or PM from full flow
  - Partial flow limit of detection was <10^{9}/kWh and ~1mg/kWh for mass
- CoV not seen as a good metric for assessing particle number or mass systems

For consideration

- If Ricardo CVS is representative of working CVS systems, then a PN limit of 10^{11}/kWh is unfeasible due to high background levels
  - 10^{12}/kWh is possible
    - Both partial and full flow systems could be used at this level
- If partial flow only were permitted, a much lower PN limit could be applied
- DPF regeneration has not been studied, and this could lead to higher backgrounds in all dilution systems