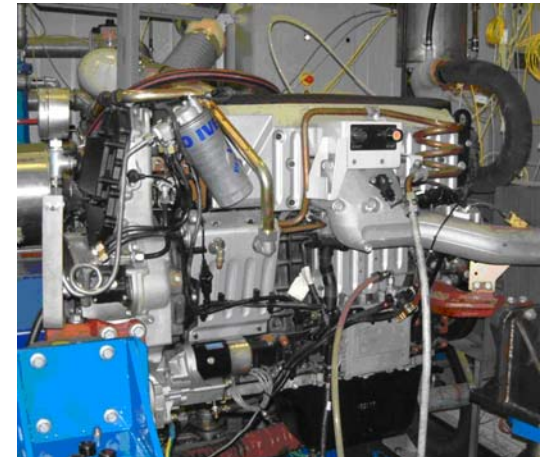


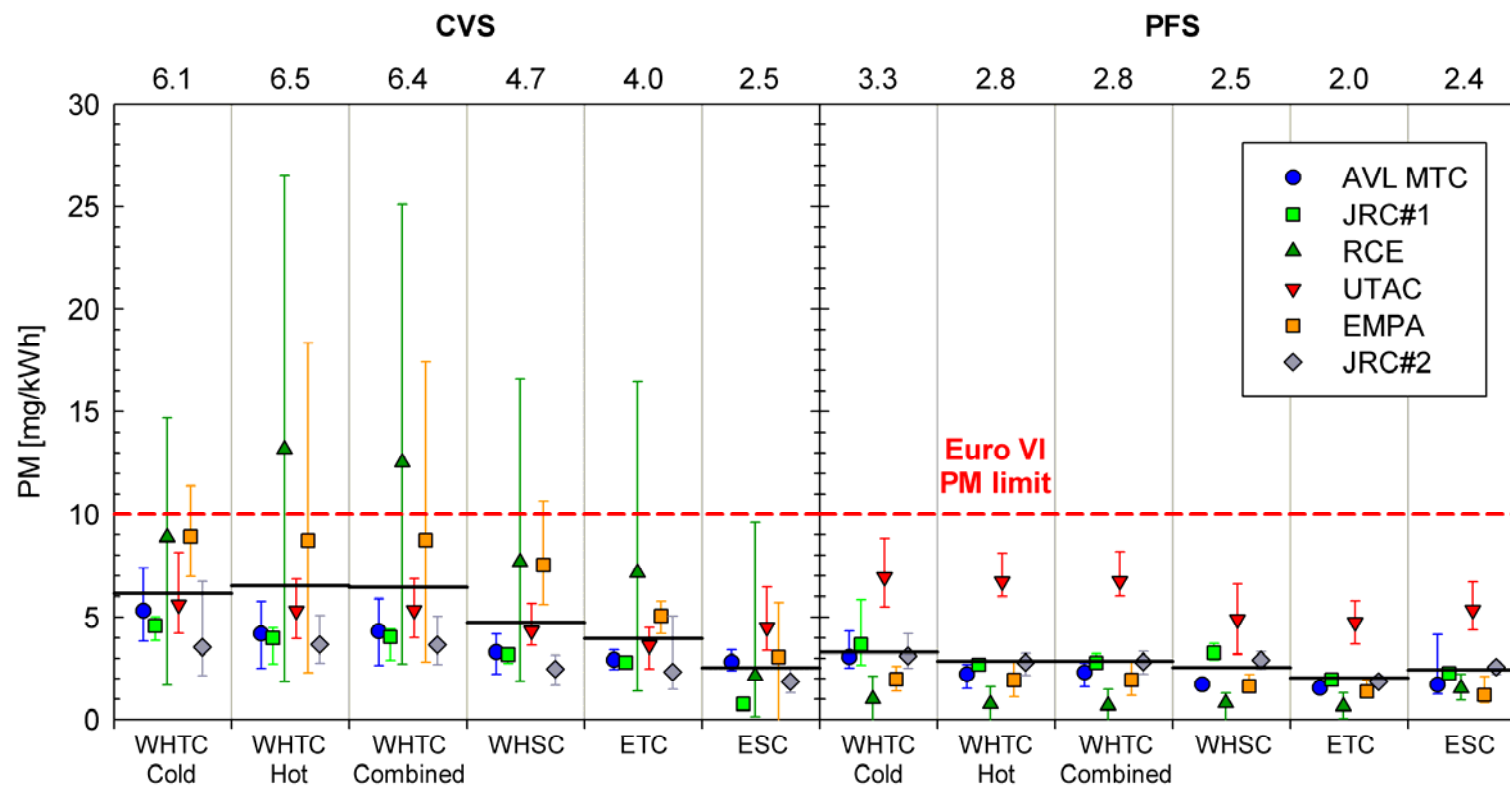
PMP Heavy Duty Validation Exercise

- Inter-laboratory exercise at 5 labs: JRC(x2), AVL-MTC, Ricardo, UTAC, EMPA
- January 2008 – November 2009
- DPF equipped Golden Engine
- 2 Golden Systems (CVS & PFDS)
- Golden Engineer
- Common fuel & lubricant
- Test matrix included multiple repeat WHTC (cold and hot), WHSC, ETC and ESC cycles



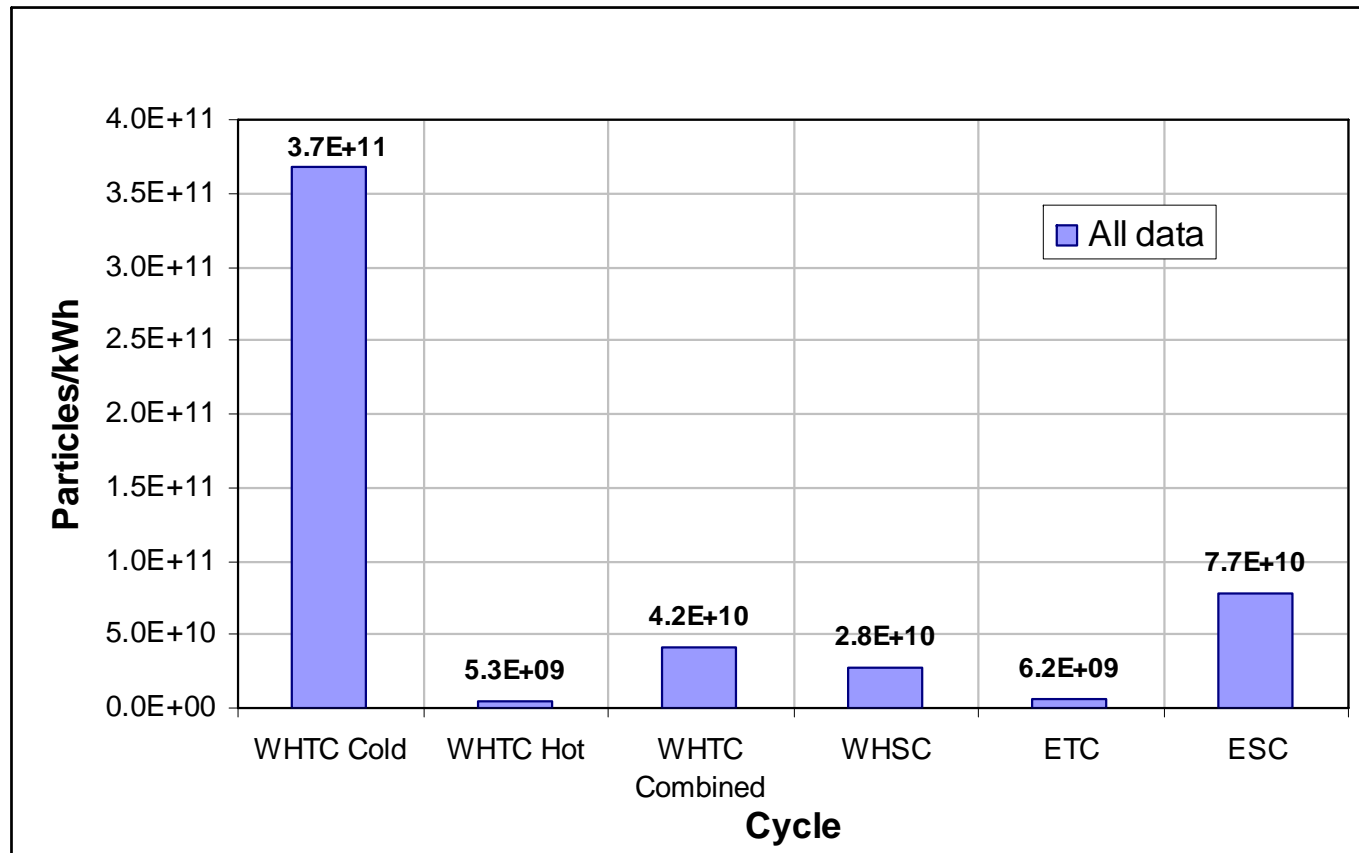
PM Observations

- Generally well below 10mg/kWh
- Minimal cycle dependency
- Some high results due to high tunnel background contribution



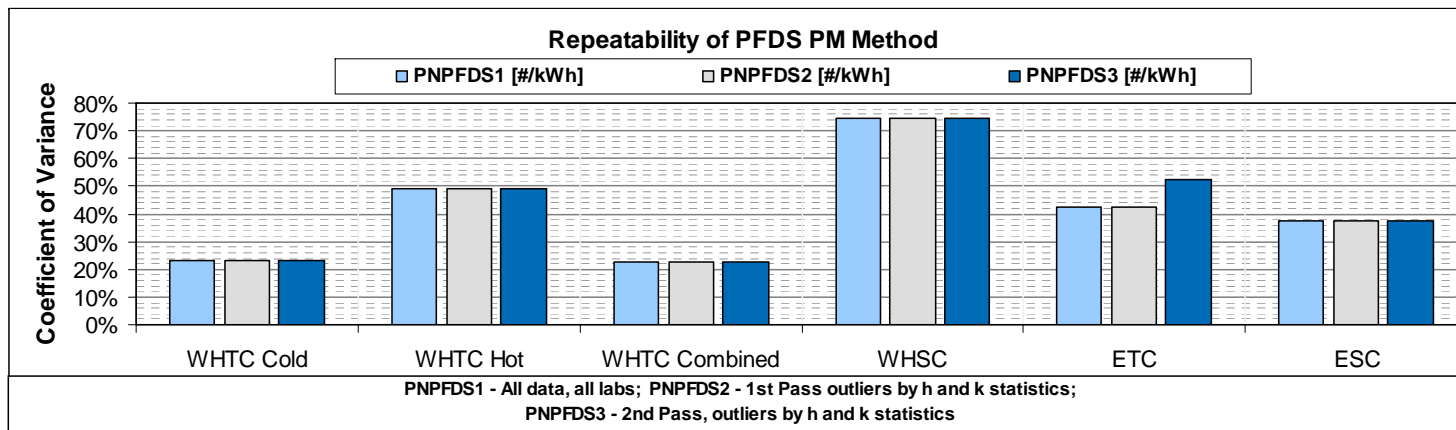
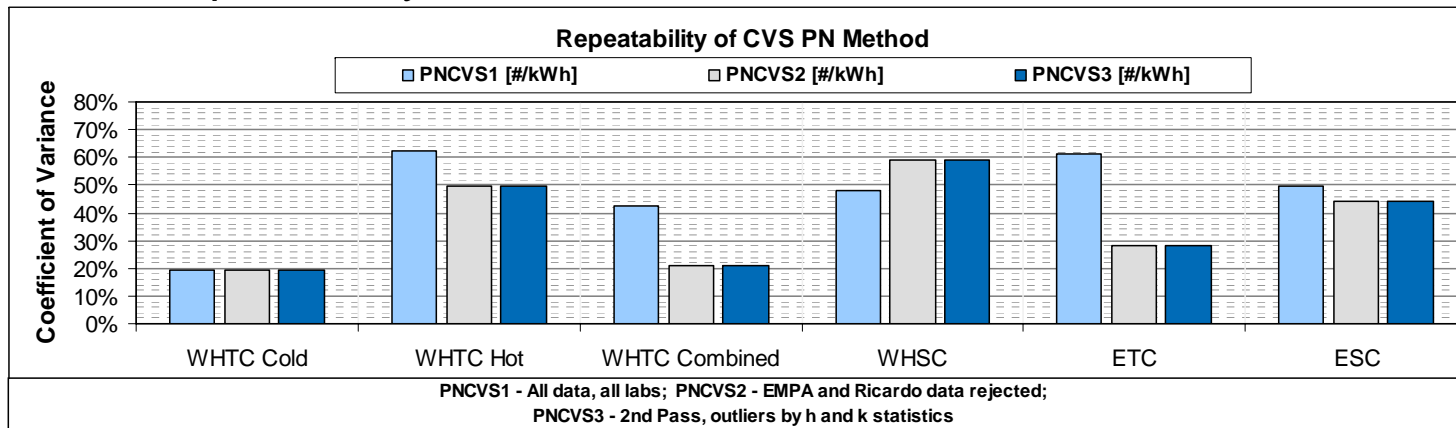
PN Emissions Levels

- Highest emissions highest over cold start cycle
- High temperature operation in WHSC and ESC showed some increased emissions due to passive regeneration



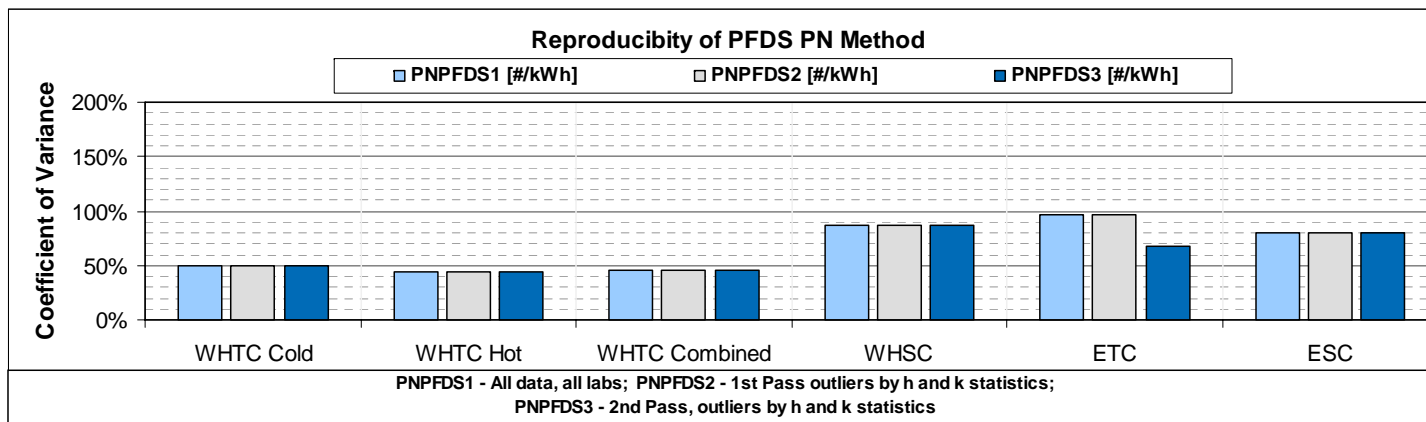
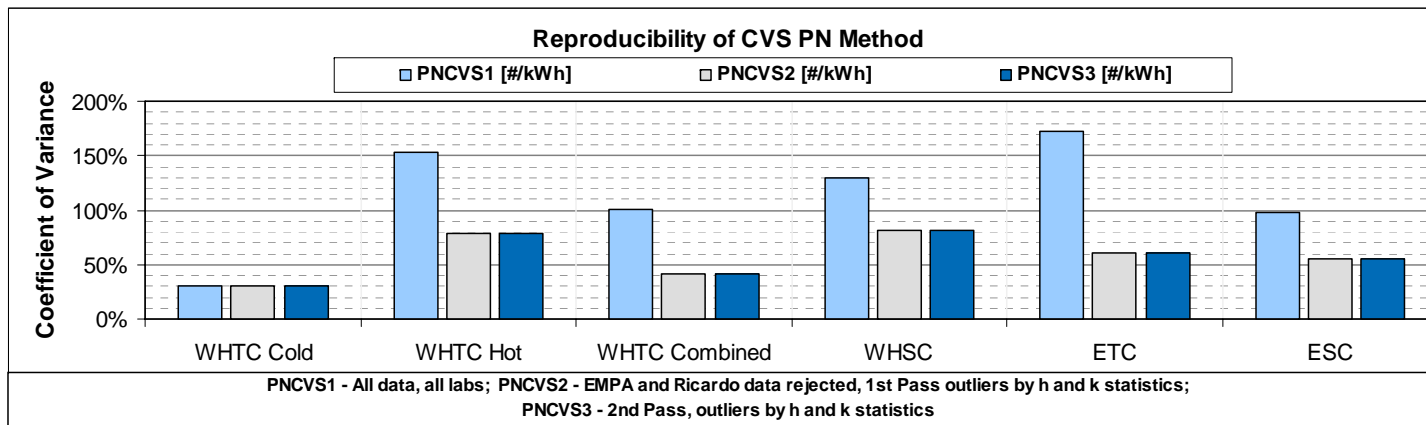
PN Repeatability

- c.20% WHTC_{cold}, 50% WHTC_{hot}, c.20% WHTC_{combined}, 60-70% WHSC
- Similar repeatability CVS and PFS



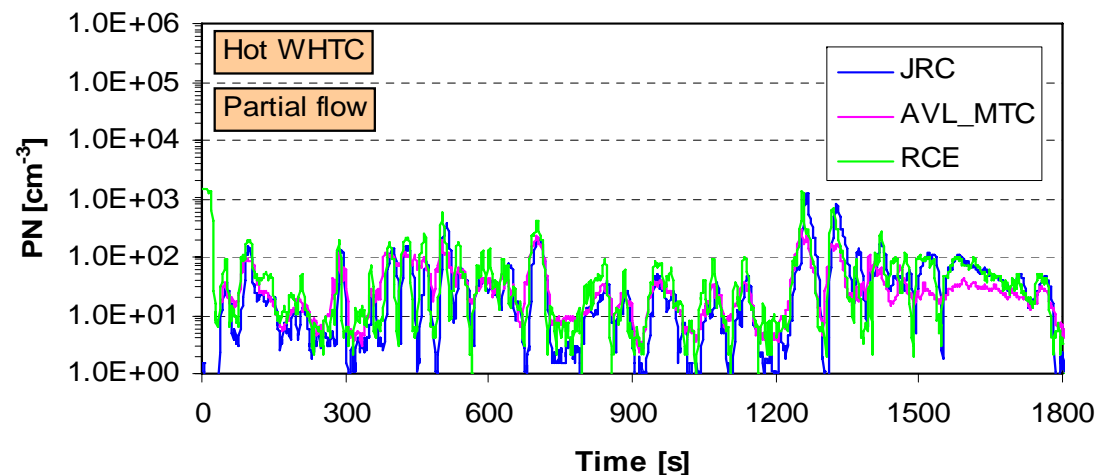
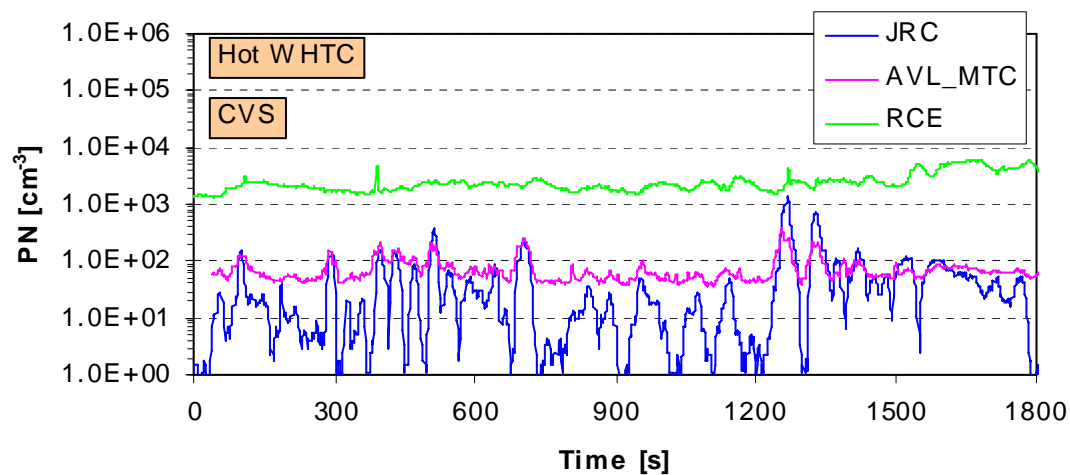
PN Reproducibility

- 30-50% WHTC_{cold}, 50-80% WHTC_{hot}, c.50% WHTC_{combined}, c.80% WHSC



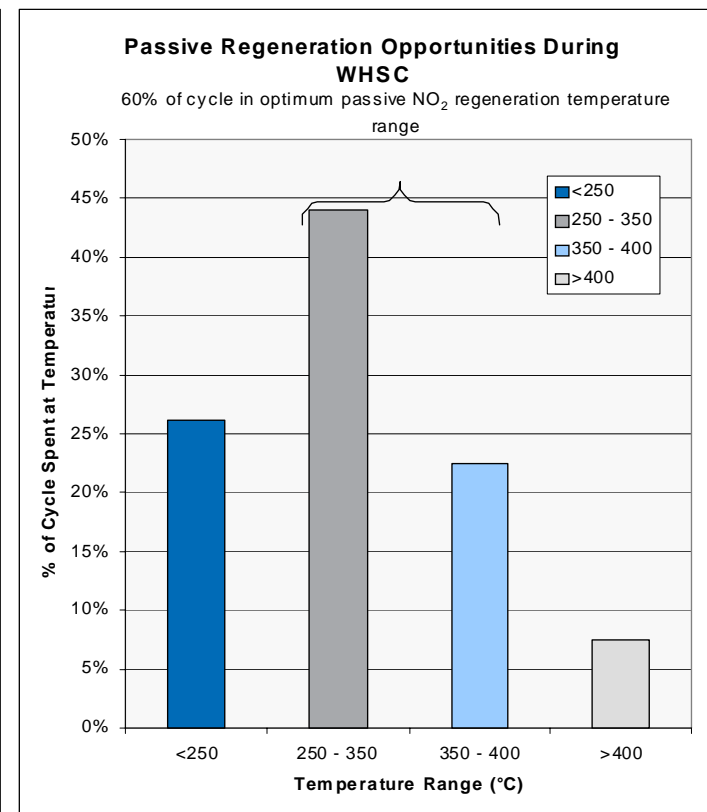
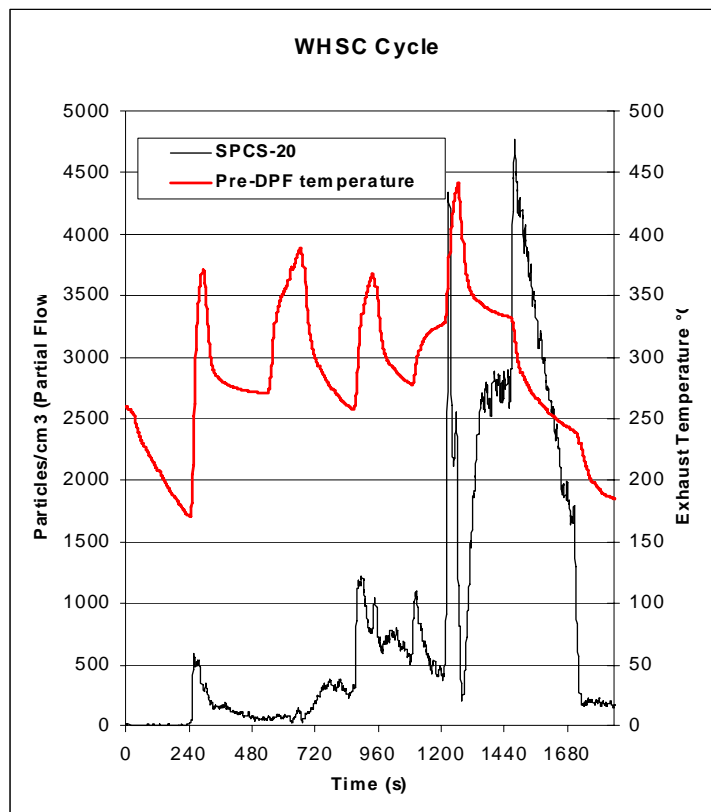
Dilution System Background Influence

- In some labs' CVS dilution systems, background levels were significant over low emission cycles



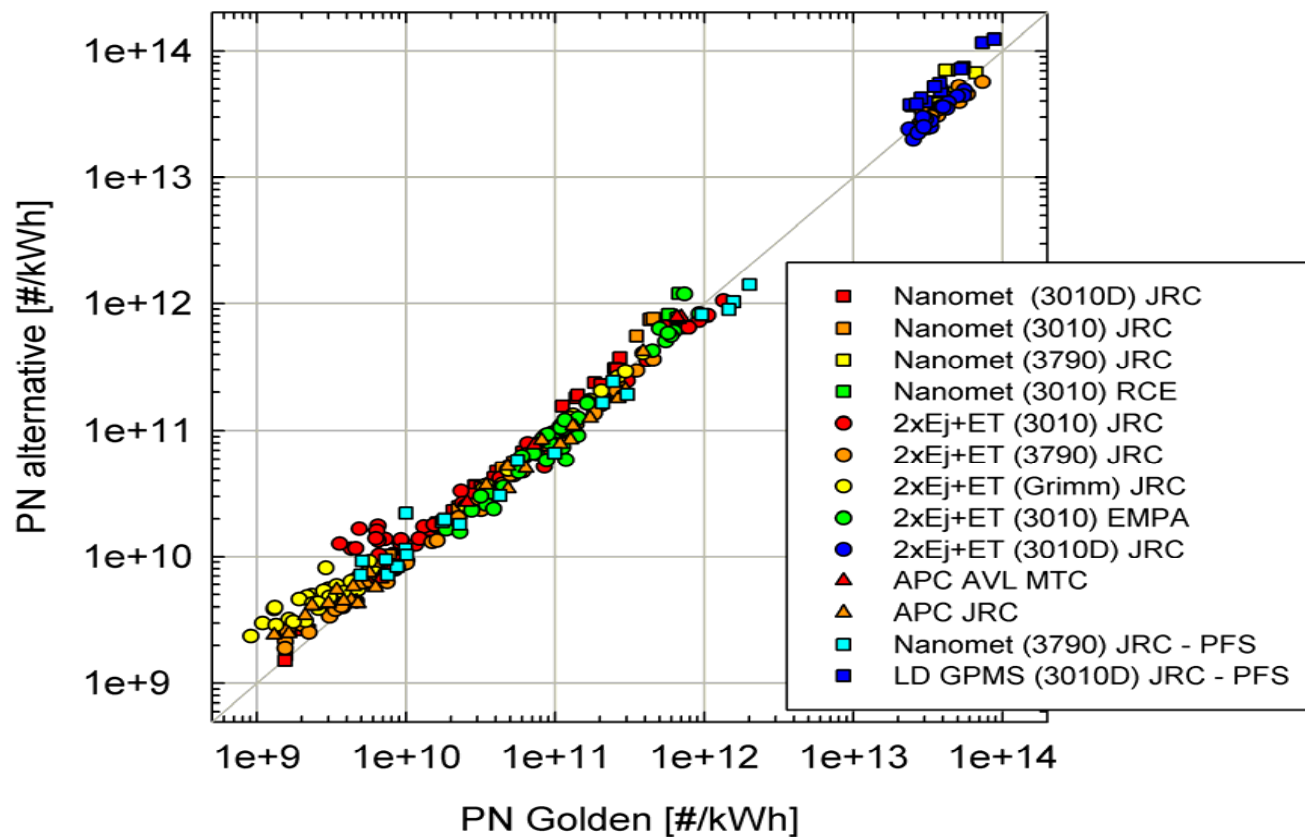
WHSC Passive Regeneration Impacts

- ~65% of cycle in temperature window in which passive regeneration can occur
- Increased emissions and variability



Agreement of Different PN Measurement Systems

- Calibrated systems generally agreed well with Golden System
- High system background on some uncalibrated systems gave higher offsets at lower emissions levels



Conclusions

- PN Measurement System performed reliably with no significant failures
- PN emission levels over cold WHTC were $\sim 4 \times 10^{11}$ #/kWh. At these emission levels, dilution system background is insignificant.
- PN emission levels over hot start WHTC and ETC cycles were $< 2 \times 10^{10}$ #/kWh.
- Passive regeneration occurring over the WHSC and ESC cycles results in an increase of the emissions, up to 6×10^{10} #/kWh, and in variability due to influence of initial DPF fill state
- Background in some labs CVS dilution systems was a substantial influence on their hot start cycle results
- Alternative systems correlated closely with the GPMS
- Repeatability and reproducibility levels were similar for Full and Partial Flow Dilution Systems, ranging from:
 - $\sim 20\%$ and $\sim 40\%$, respectively, over cold WHTC ; to
 - $\sim 70\%$ and $\sim 80\%$, respectively, over WHSC, due to passive regeneration related effects

Recommendations

- Labs should monitor and manage tunnel background e.g. via use and cleaning of PFDS, test scheduling, tunnel pre-conditioning
- Higher variability on WHSC (due to passive regeneration) needs to be allowed for in setting of PN limit values
- PN sample flow extraction should be corrected for in PFDS control & PM measurement (total sampling type)