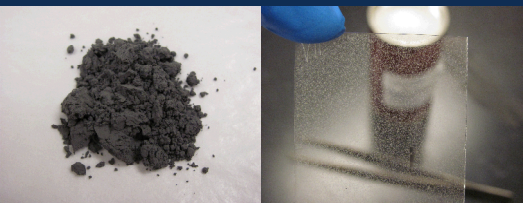

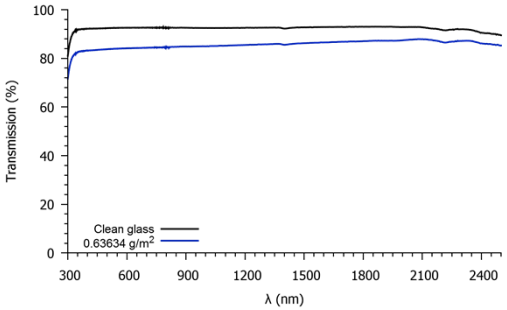

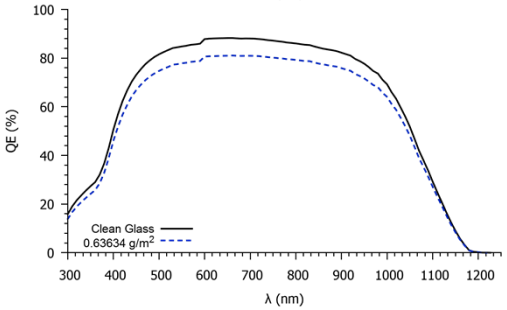

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SAND2014-4476C

Determination of a Minimum Soiling Level to Affect Photovoltaic Devices

Patrick D. Burton, Bruce H. King

40th Photovoltaic Specialists Conference
System Modeling and Energy Predictions Session

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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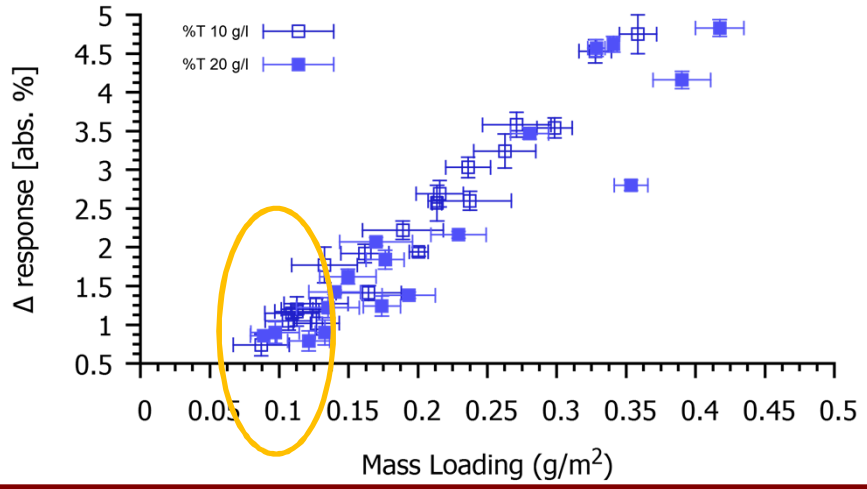
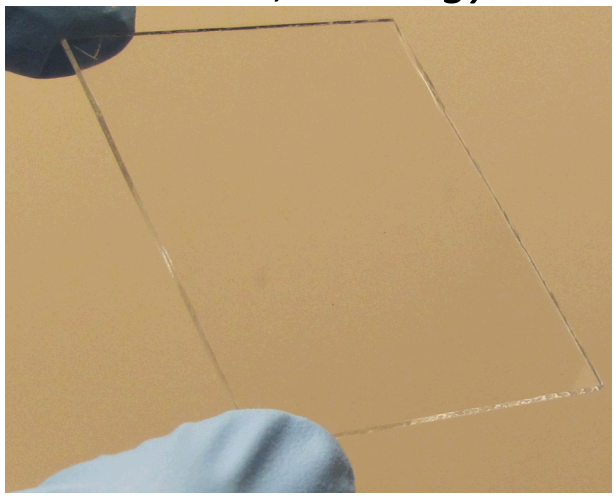
SAND2014-XXXXP

Key Findings

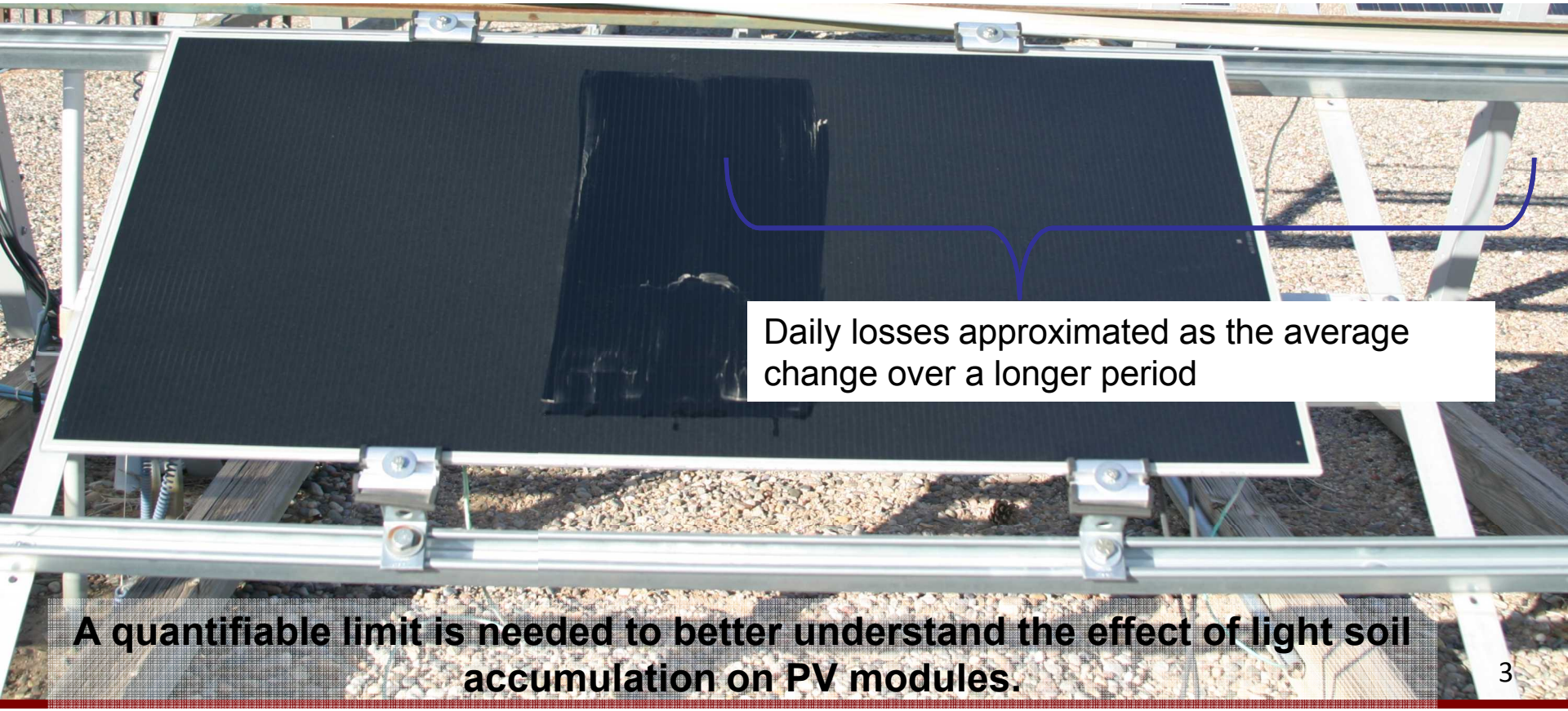
- Artificial soil applied to test coupons can be detected at mass loadings > 0.1 g/m^2, resulting in a transmission loss < 1%
- Reflectance measurements were the most responsive and could be used as a proxy for device response.
- Particle area density influences light transmission.
- ***Soil losses comprise an estimated ~5% uncertainty in a recent performance model*** (Thevenard & Pelland, *Sol. Engy.* 2013).





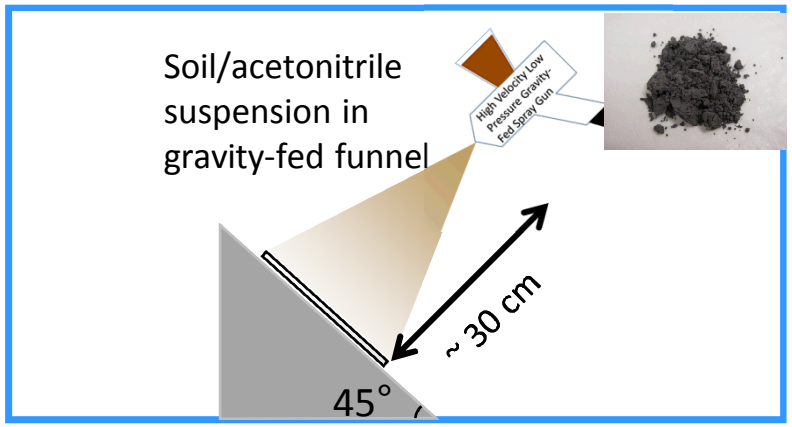
Slow soil accumulation is difficult to predict

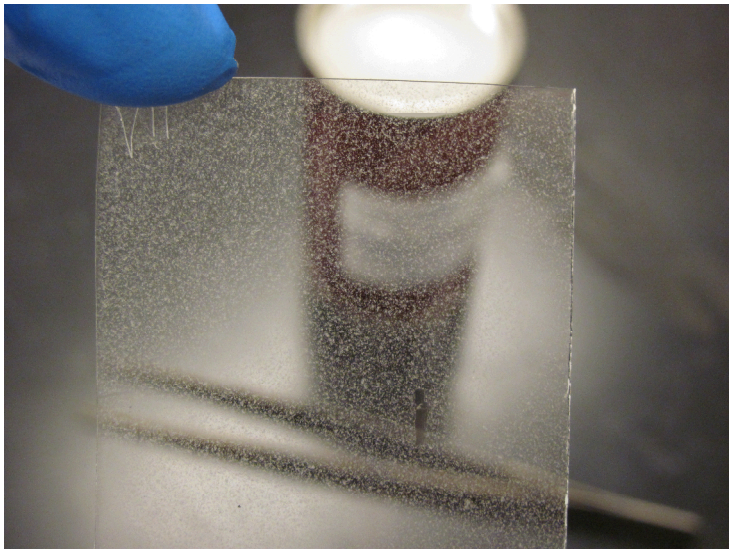
- Performance modeling and validation benefit from accurate estimates of soiling losses
- Losses at low mass loadings are difficult to measure or predict

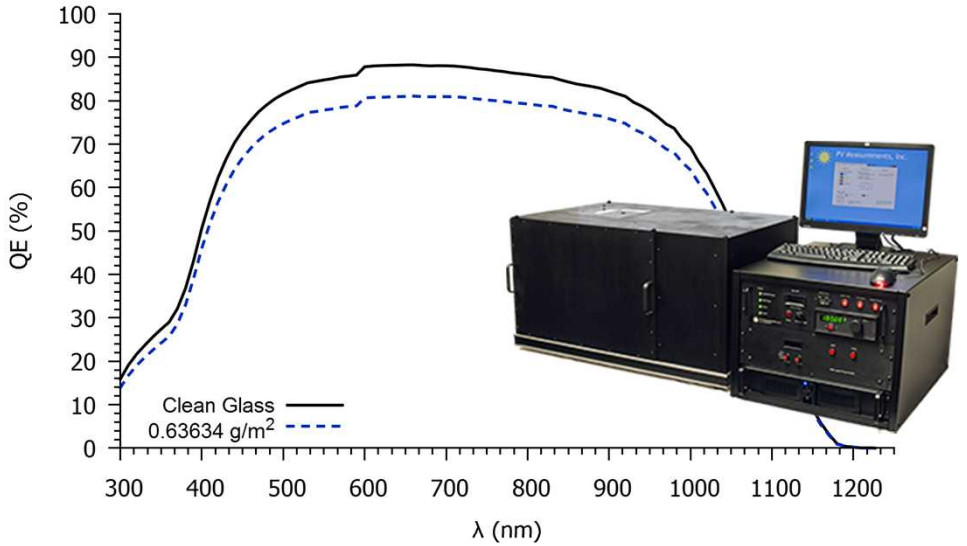


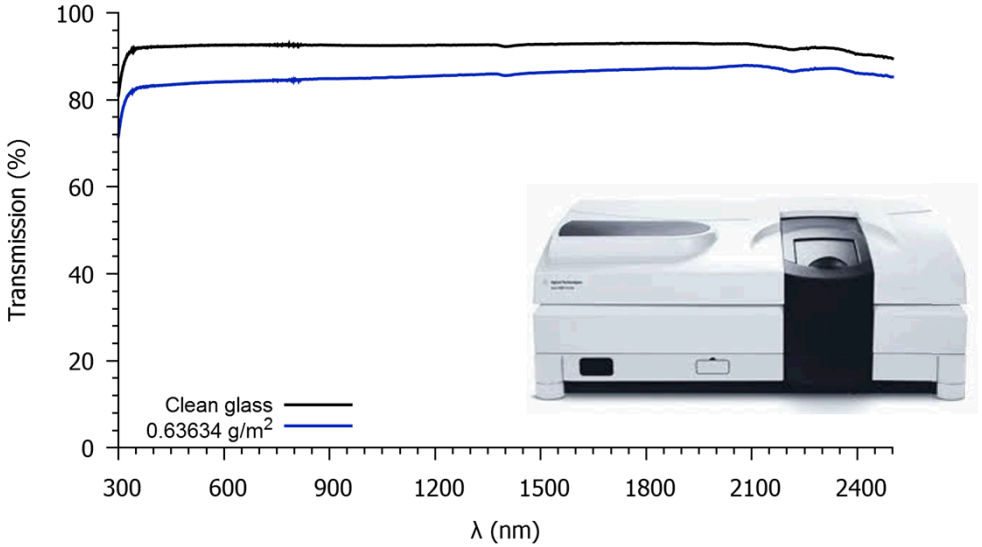
A quantifiable limit is needed to better understand the effect of light soil accumulation on PV modules.

Uniform coats of soil analogues were applied via aerosol sprayer









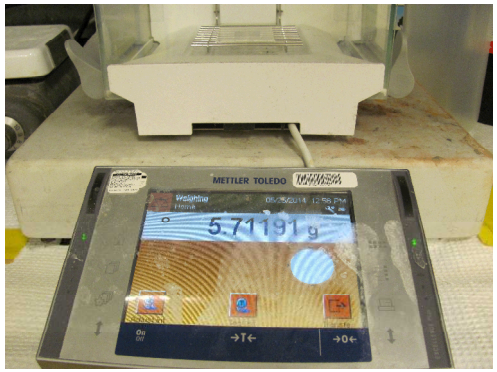
Goal is to apply indoor measurements and artificial soiling technique to determine a minimum detectable level of soil

Precise measurements essential to determining low soiling limit

distribution to glass
tering influences the
exponential function.
e for the observation
st".
conditions [5], it is
e allowed to reach a

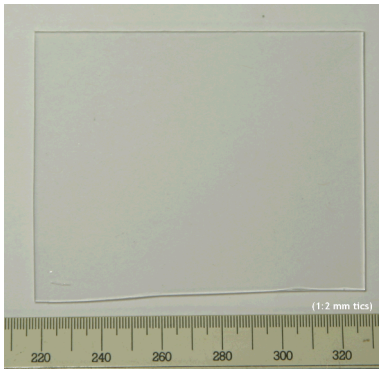
uniform pattern. Previously, the spray
from right to left to apply a uniform,
entire coupon. This step has been mo
work to produce very light coatings. In
applicator, it was held over the center o
cm) coupon while a brief spray (~ 1
acetonitrile carrier solvent evaporated q

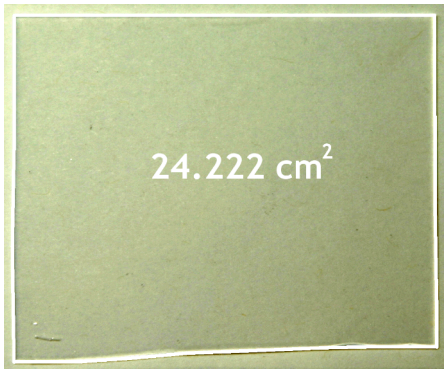
1.15 % loss, 0.10930 g/m^2



Specific area determined by image analysis with calibrated photographs and ImageJ software.

8.11 % loss, 0.53798 g/m^2





Measured %T, %R, %QE responses show a consistent trend

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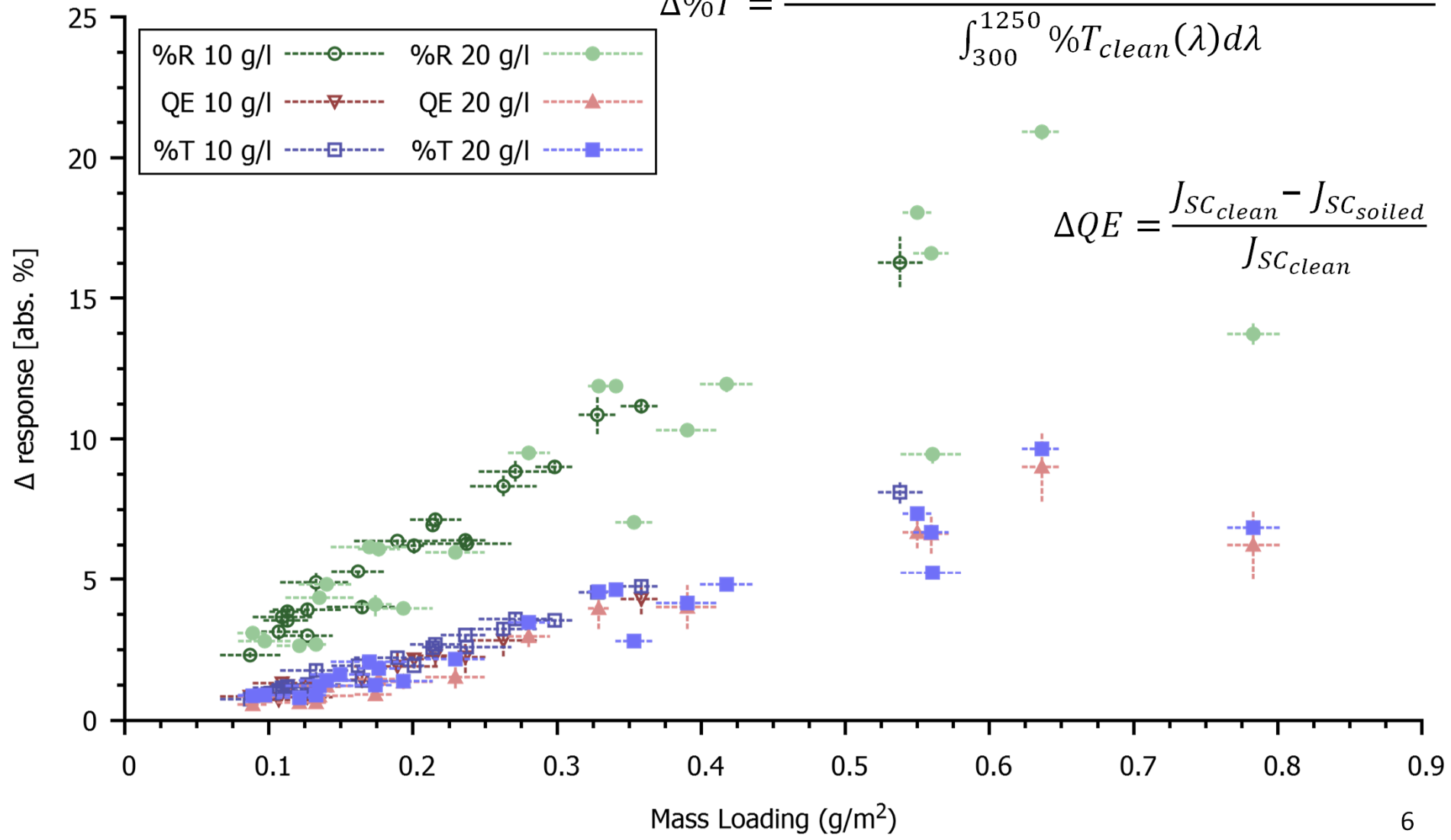
$$\Delta\%T = \frac{\int_{300}^{1250} \%T_{clean}(\lambda)d\lambda - \int_{300}^{1250} \%T_{soiled}(\lambda)d\lambda}{\int_{300}^{1250} \%T_{clean}(\lambda)d\lambda}$$

$$\Delta QE = \frac{J_{SC_{clean}} - J_{SC_{soiled}}}{J_{SC_{clean}}}$$



UV/vis measurements have lower σ than QE due to larger sampling region

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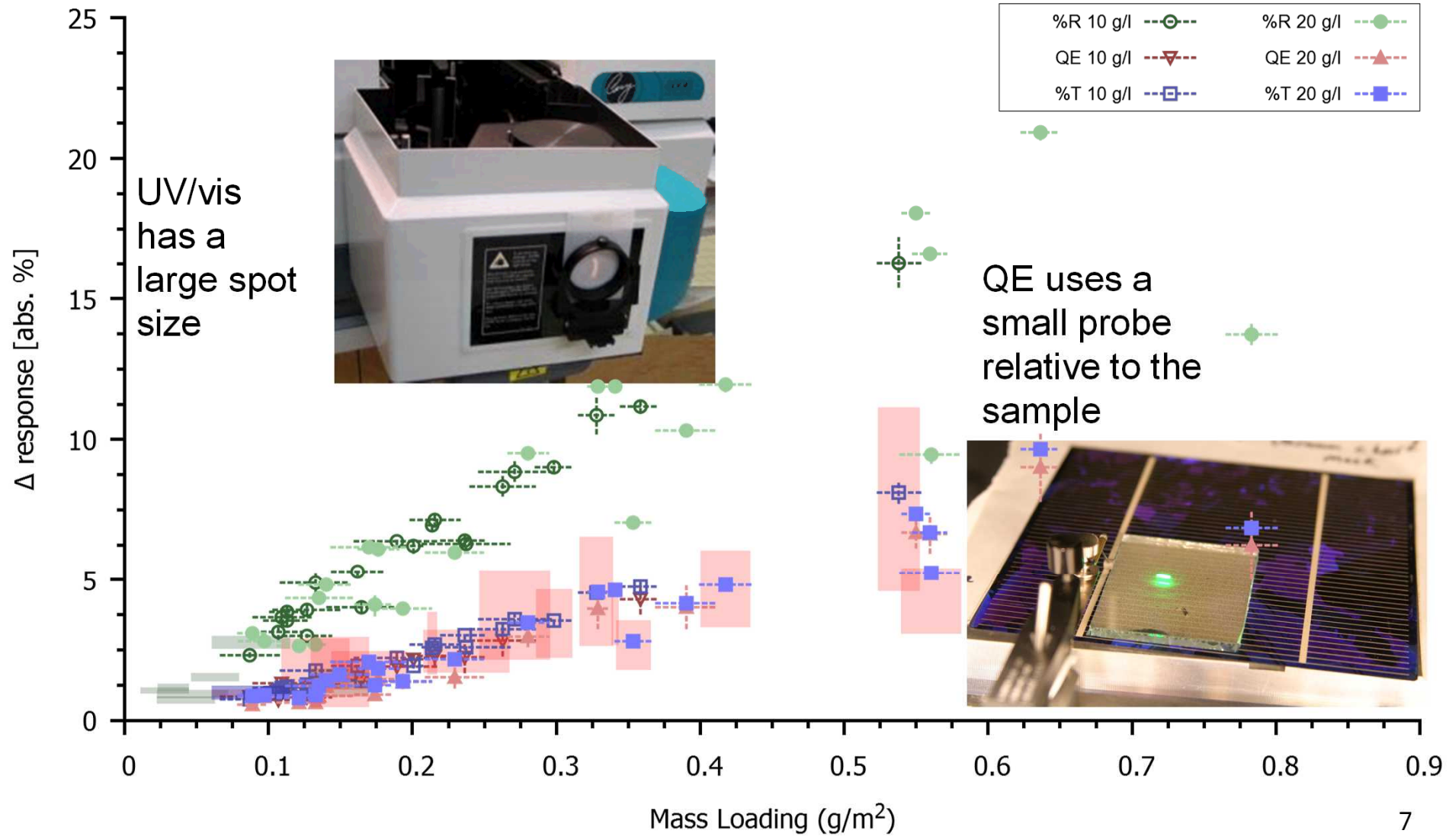

Surface reflectance is the most repeatable measurement

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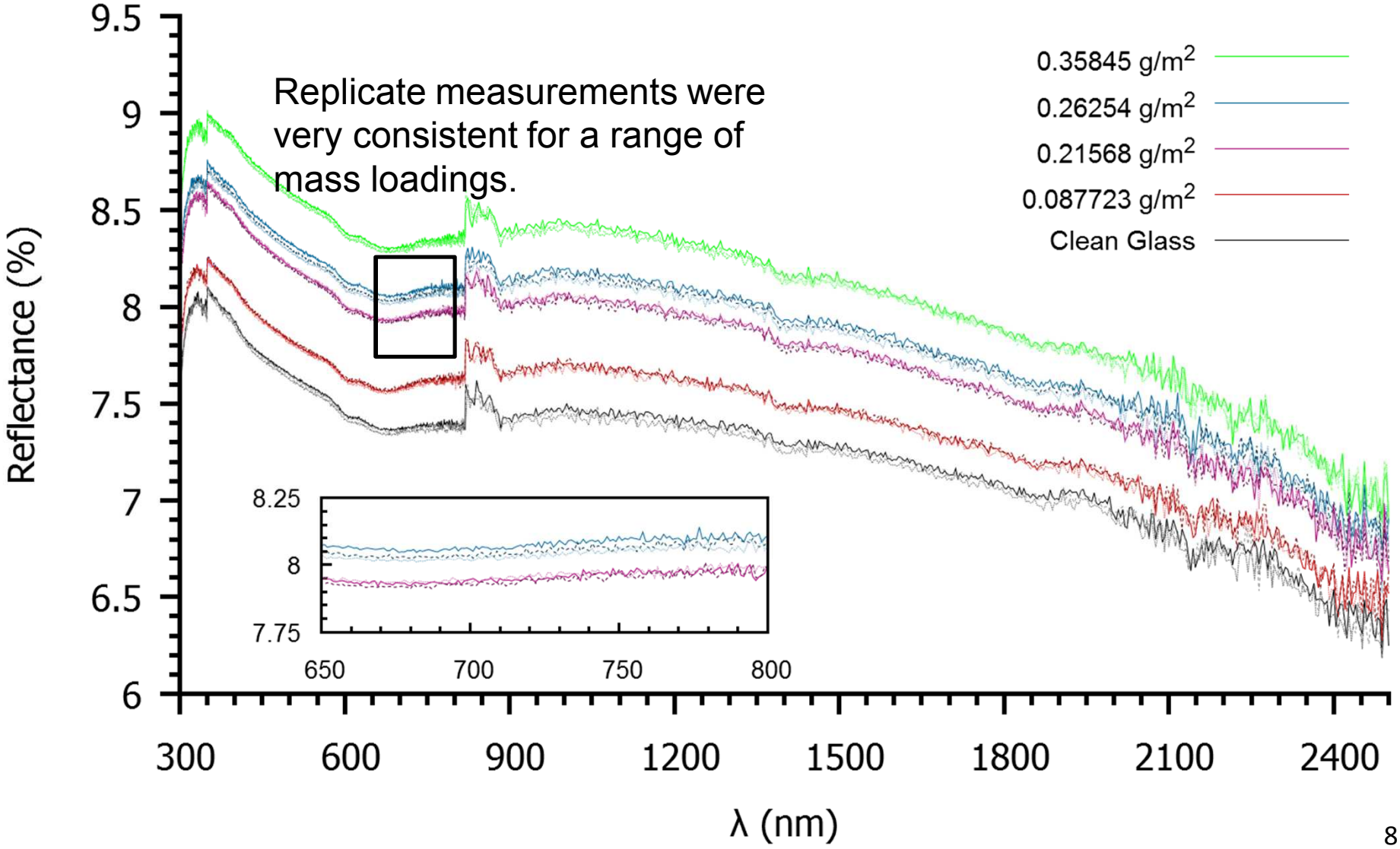
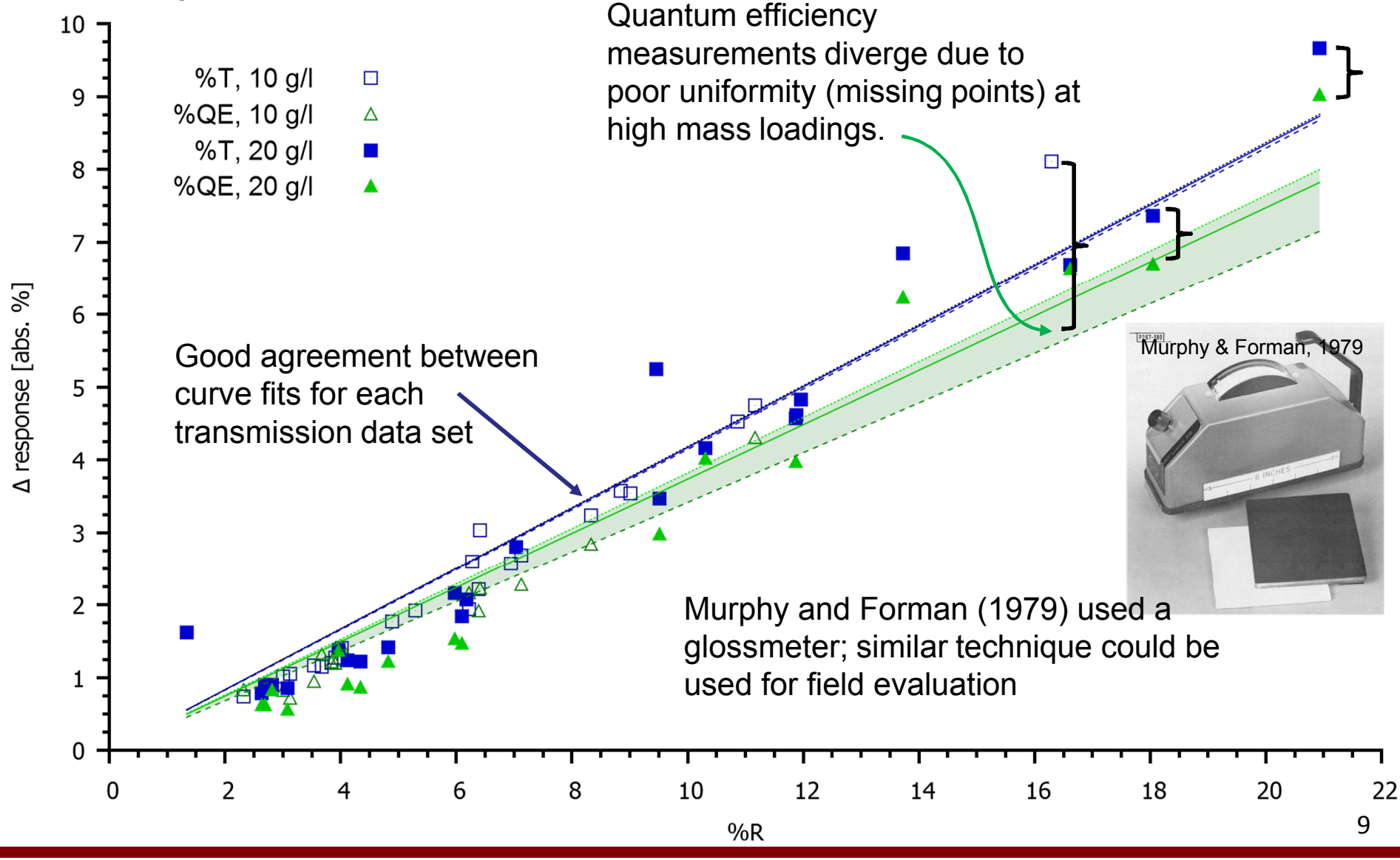
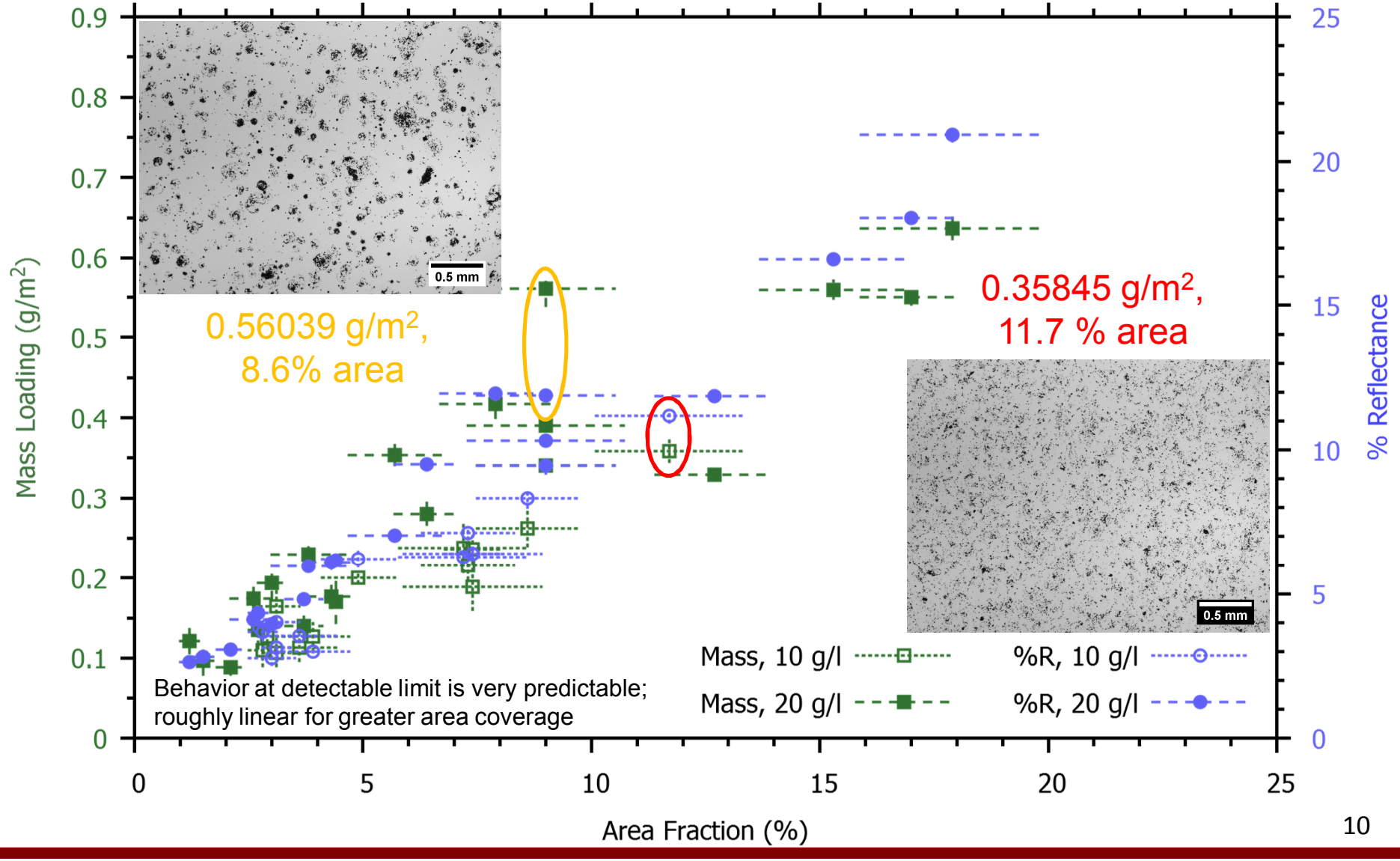


Reflectance correlates to PV device response



Aggregate size & patterning influence light transmission



Summary

- Mass measurement precision and accuracy is the primary limiting factor in determining a minimum level of loss due to soil accumulation.
- Reliable measurements could not be determined < 0.1 g/m^2.
- Reflectance measurements were the most responsive and could be used as a proxy for device response.
- Particle density can be roughly controlled by grime carrier suspension density
- Ongoing work will apply this technique to spectrally responsive grime types.

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For additional questions, please contact pdburto@sandia.gov

THANK YOU!