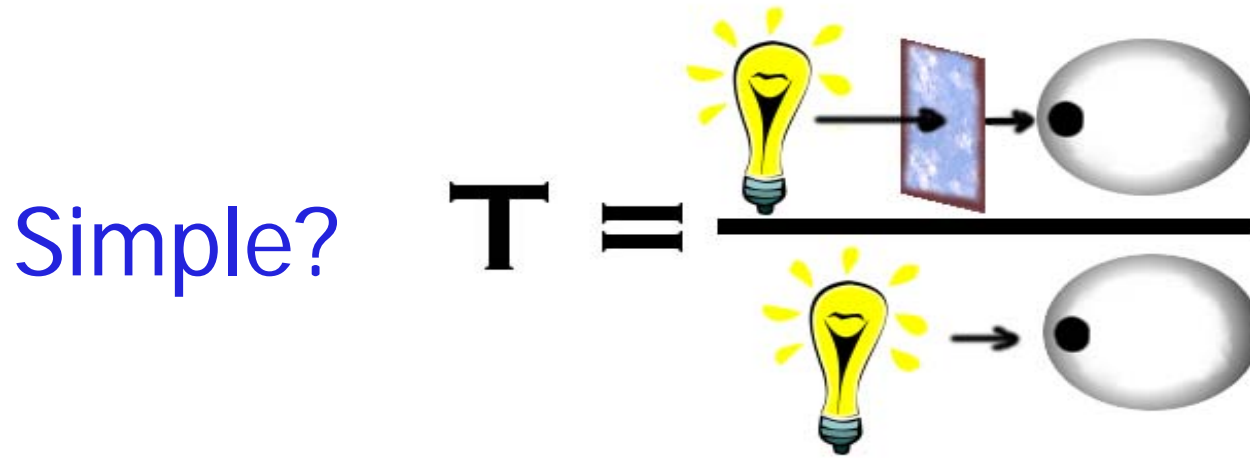


Light-loss when measuring transmittance of thick scattering samples with an integrating sphere

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Measuring transmittance



No, we have systematic errors! Needs investigation

- Sphere response depends on scattering distribution. Physical sphere != ideal sphere.
- Light transmitted through the sample does not enter the sphere
- ...

Who cares?

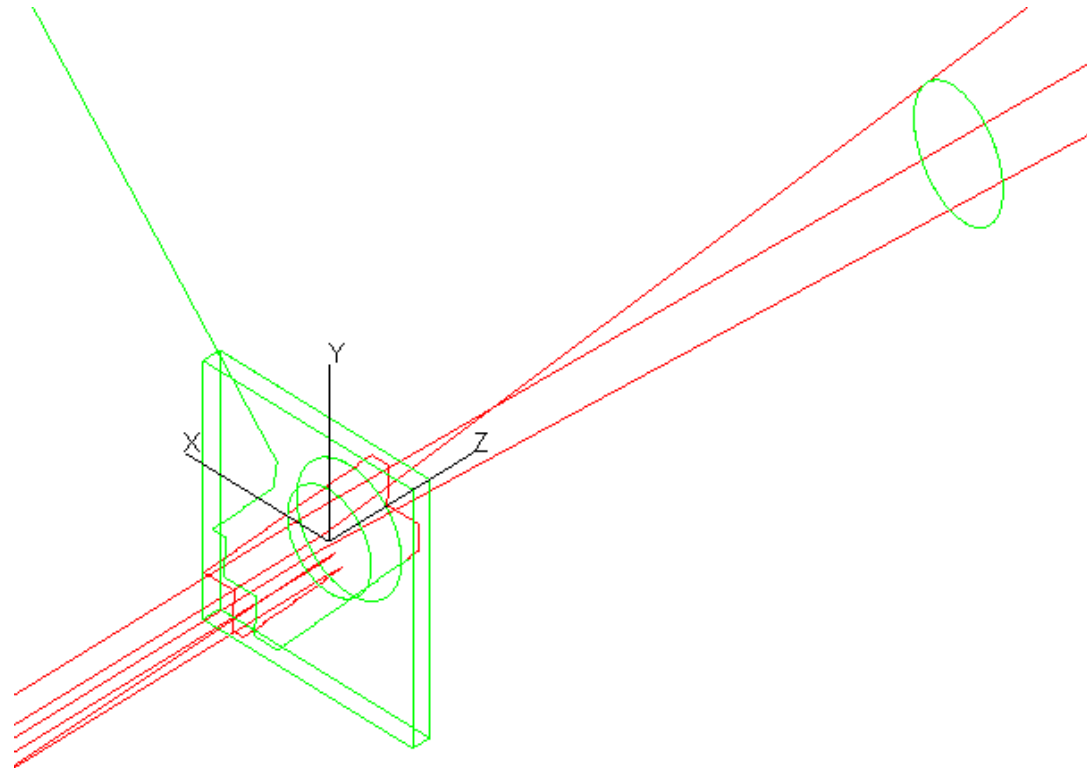


- **National Fenestration Rating Council (NFRC) has been rating non-scattering products forever. Building codes will soon require energy rating on scattering fenestration products.**
- **International Commission on Glass (ICG) is conducting a world-wide inter-laboratory comparison on scattering samples.**
- **“The truth is out there” - *Agent Mulder***

Today: Light not entering the sphere

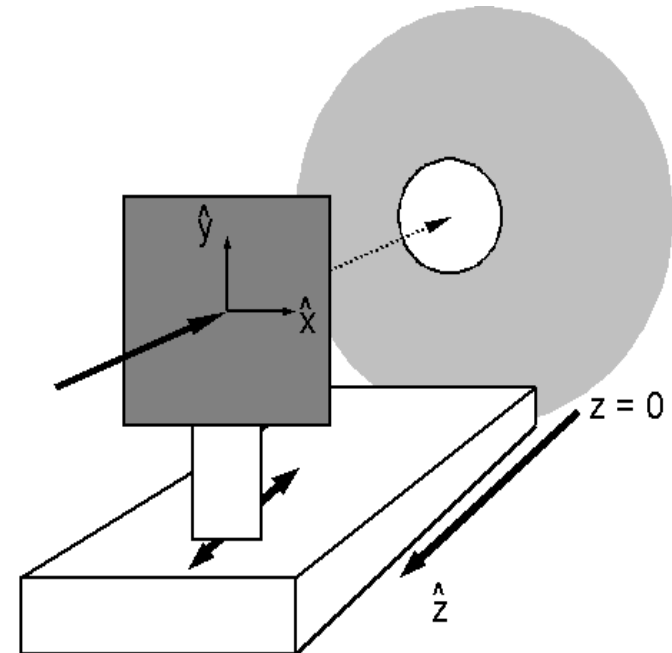
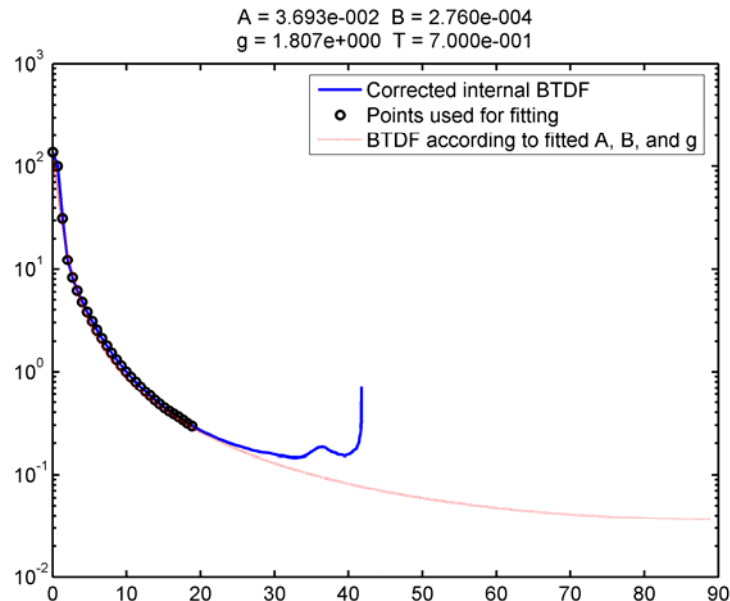


- **Side-loss:** Light exiting the side of the sample
- **Side-shift:** Transmitted light not entering the sphere port
- **Absorption:** Light absorbed in the sample
- **Reflectance:** Light reflected back towards the source

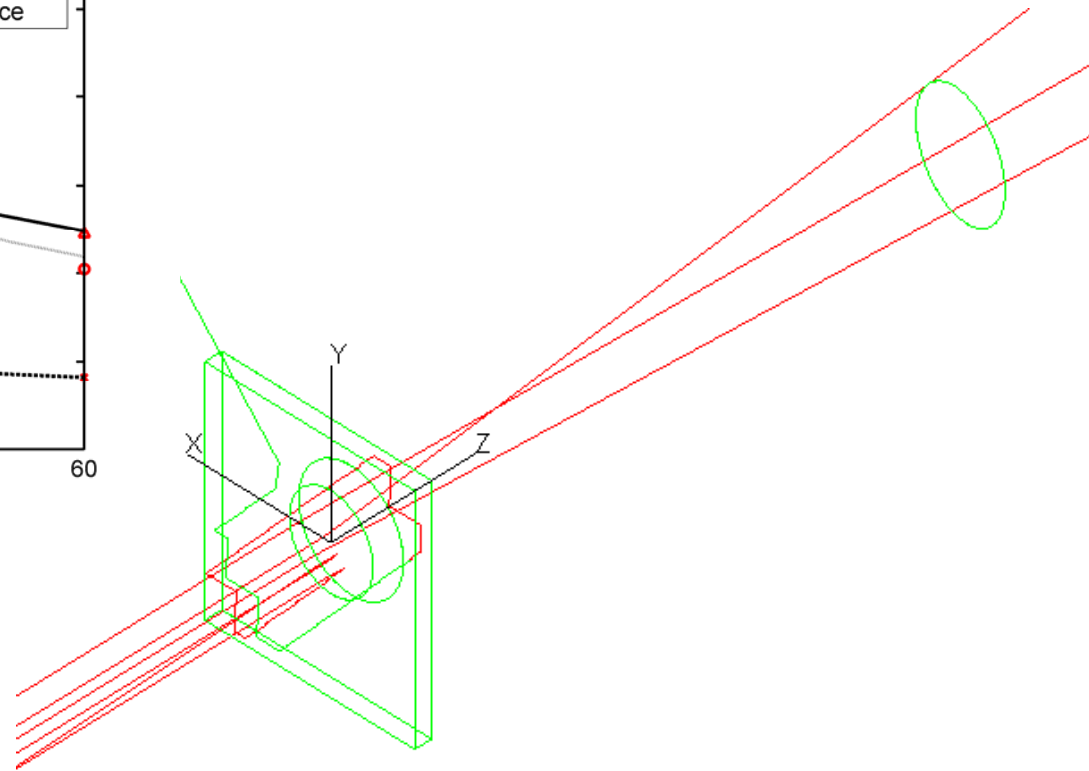
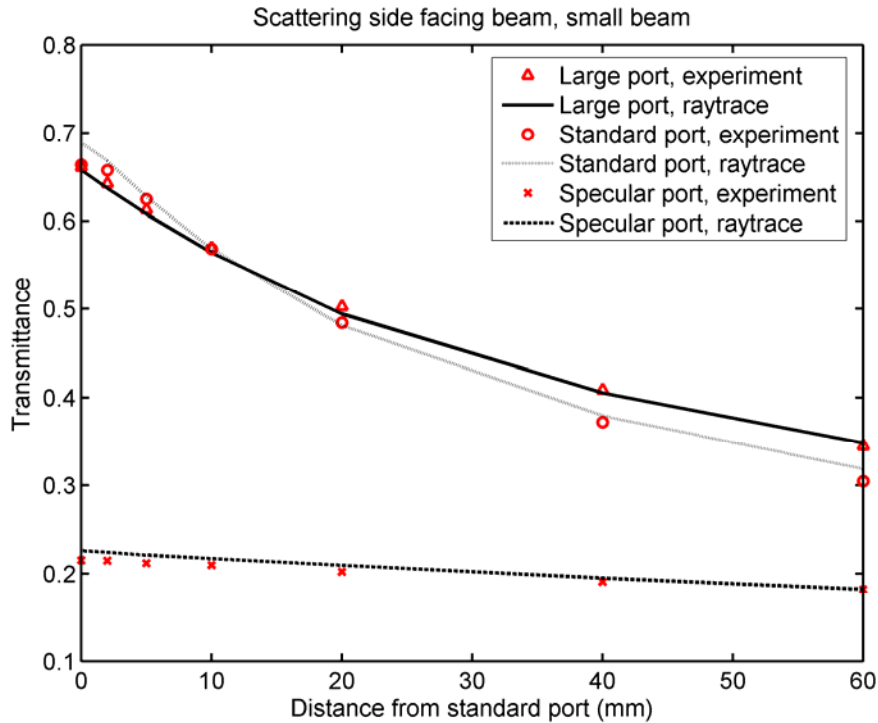


Modeling the sample

- 1) Ceramic frit sample studied
- 2) Obtain scattering distribution using goniophotometer
- 3) Verify scattering distribution used in the raytracing with experiments



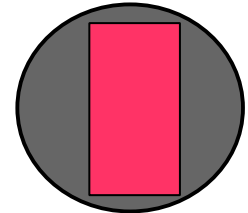
Comparing ray-tracing and experiment



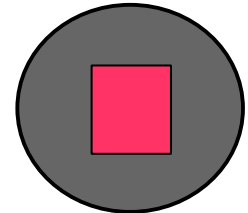
Results



Beam size	Side-loss	Side-shift	Absorption
Large	0.032	0.013	0.156
Small	0.032	0.0013	0.156



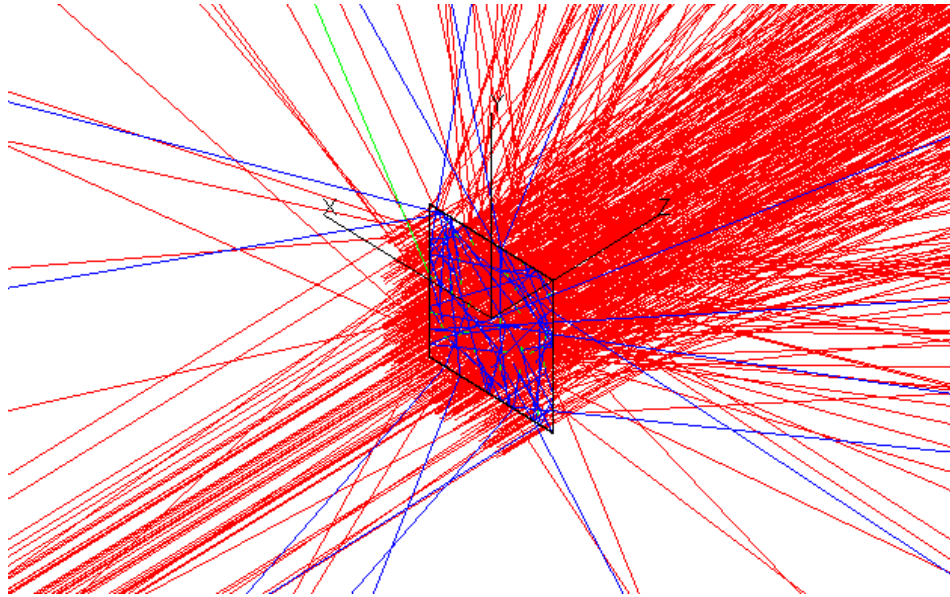
Large



Small

- **Identical side-loss and absorption.**
- **Reducing the beam-size significantly reduces side-shift.**
- **Sample was 6 mm thick, 50 mm x 50 mm, and the entrance port had a 20 mm diameter.**
- **Simulation carried out by Polato et al. indicated that the sample studied should have a side-loss of ~0.2.**

Effects on an installed window



- **Simulating a 1 m x 1 m pane with full illumination.**
- **Absorption + side-loss remains constant with the smaller sample. But side-loss is only 0.002 for the large pane.**

Conclusions



- **Ray-tracing viable for obtaining quantitative numbers of systematic errors resulting in light not entering the sphere.**
- **The errors depends on the sample's scattering profile and sphere geometry.**
- **Samples with high enough absorption are not affected much by side-loss. Bulk-scattering samples could differ.**