In conventional Cavity Ring Down Spectroscopy (CRDS), light is admitted to a high finesse Fabry-Perot cavity and bounces back and forth between its two highly reflecting mirrors. If the light input is terminated, the intensity in the cavity will decay to zero and the rate the intensity decreases (rings-down) depends on the energy losses at each reflection from a mirror and on the absorption of the medium between the mirrors. Although CRDS is a powerful tool for direct absorption spectroscopy of atoms and molecules in the gas phase, it is compromised by the presence of any scattering (including scattering by the molecules themselves). Conventional CRDS cannot distinguish between loss of a photon by scattering and loss of a photon by absorption.

We are introducing a powerful new technique we call Integrating Cavity Ring Down Spectroscopy (ICRDS). Our ICRDS concept does distinguish between scattering and absorption losses; it provides a measurement of absorption that is completely independent of scattering effects in the medium. Basically, the idea is to build a cavity whose wall is made of a diffuse reflecting material whose reflectivity is extremely high. An optical fiber that penetrates the cavity wall provides an input pulse of light to the cavity; this light is diffusely reflected by the walls and bounces around in all directions inside the cavity. Since the light is already diffusely reflected in all directions, scattering by particles in a medium filling the cavity cannot change anything. A second optical fiber that also penetrates the cavity wall samples the optical energy in the cavity. The decay of the latter provides a measure of the energy loss at each reflection by the cavity wall as well as of absorption losses of the medium filling the cavity.

Implementation of ICRDS has only now become possible because we have successfully developed a new diffuse reflector whose reflectivity is substantially greater than that of any previously known diffuse reflecting material. ICRDS will open new research vistas by providing very sensitive and accurate direct absorption measurements on a sample independent of any scattering in the sample.

Examples of ring down data for a spherical cavity whose diffuse reflecting wall has reflectivity $\rho=0.9991$. Three cases are shown: an empty cavity ($\alpha=0$); and two cases with the cavity filled with media whose absorption coefficients are $\alpha=1\times10^{-5}$/cm and $\alpha=5\times10^{-6}$/cm. These are easily distinguished; careful analysis shows capabilities reach $\alpha=1\times10^{-9}$/cm.