

Walk-in Cooler:

Understanding the infiltration phenomenon and key contributing factors

Kristina Kamensky: Prismitech, ASHRAE member
ASHRAE 2011 Annual Conference Montreal
June 25-29, 2011

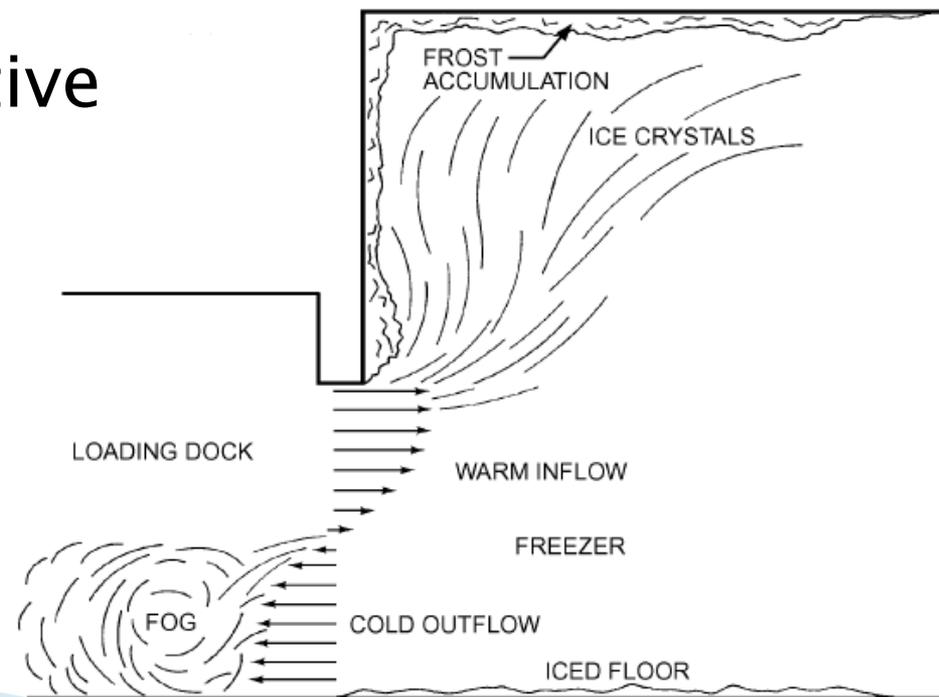
Goals

- ▶ Understanding the infiltration phenomenon
 - ▶ Visualization of the infiltration process
 - PIV technique
 - ▶ Quantification of the infiltration rate
 - Tracer gas method
 - ▶ Determination of key factors
- 

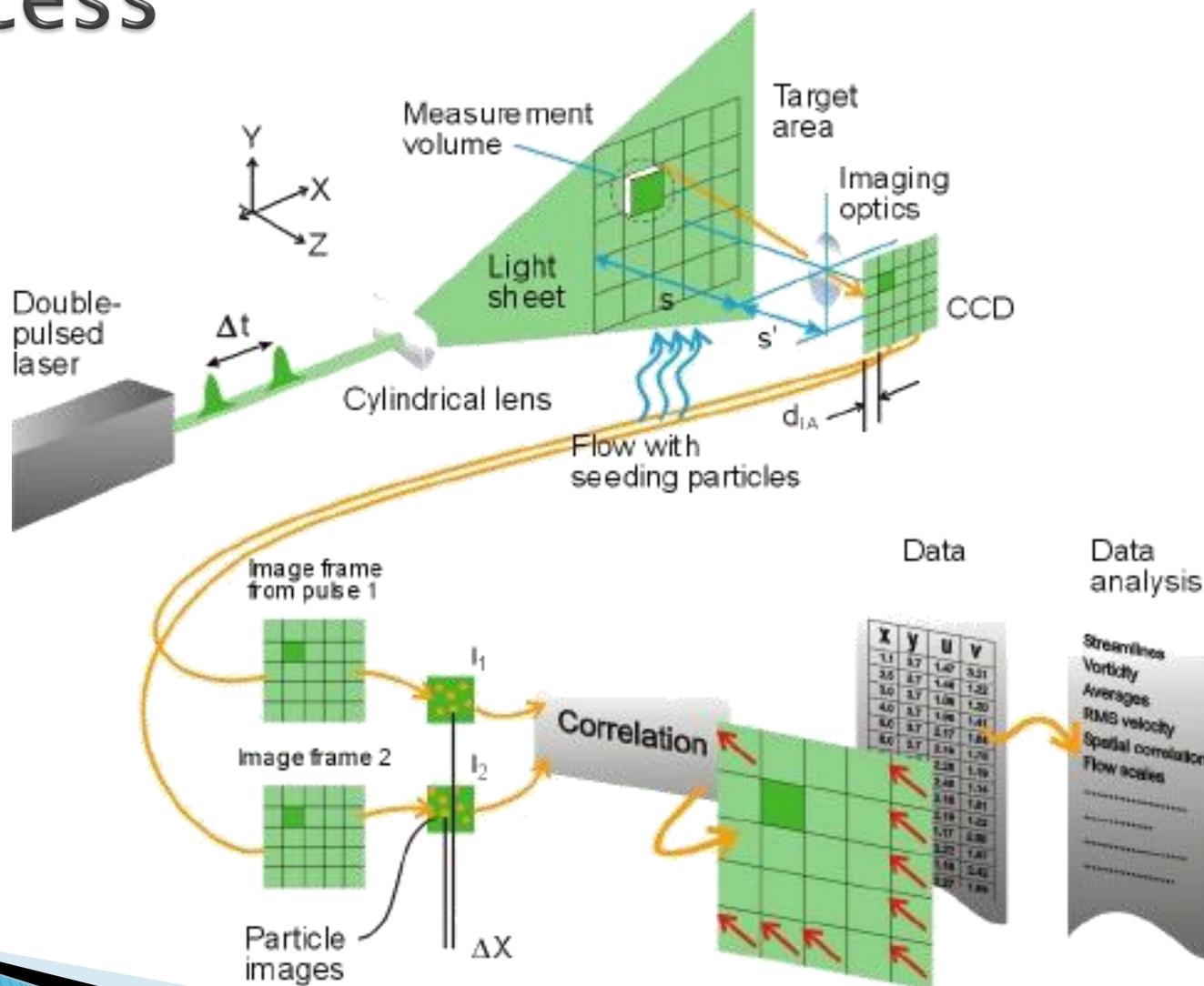
Infiltration Phenomenon

- ▶ The introduction of outside air into an air-conditioned space occurs
 - during door opening periods
 - through not completely sealed cracks and openings
- ▶ Driven mainly by the temperature and relative humidity differential across a doorway

2006 ASHRAE Handbook – Refrigeration,
13.4, Flowing Cold and Warm Air Masses
for Typical Open Freezer Doors



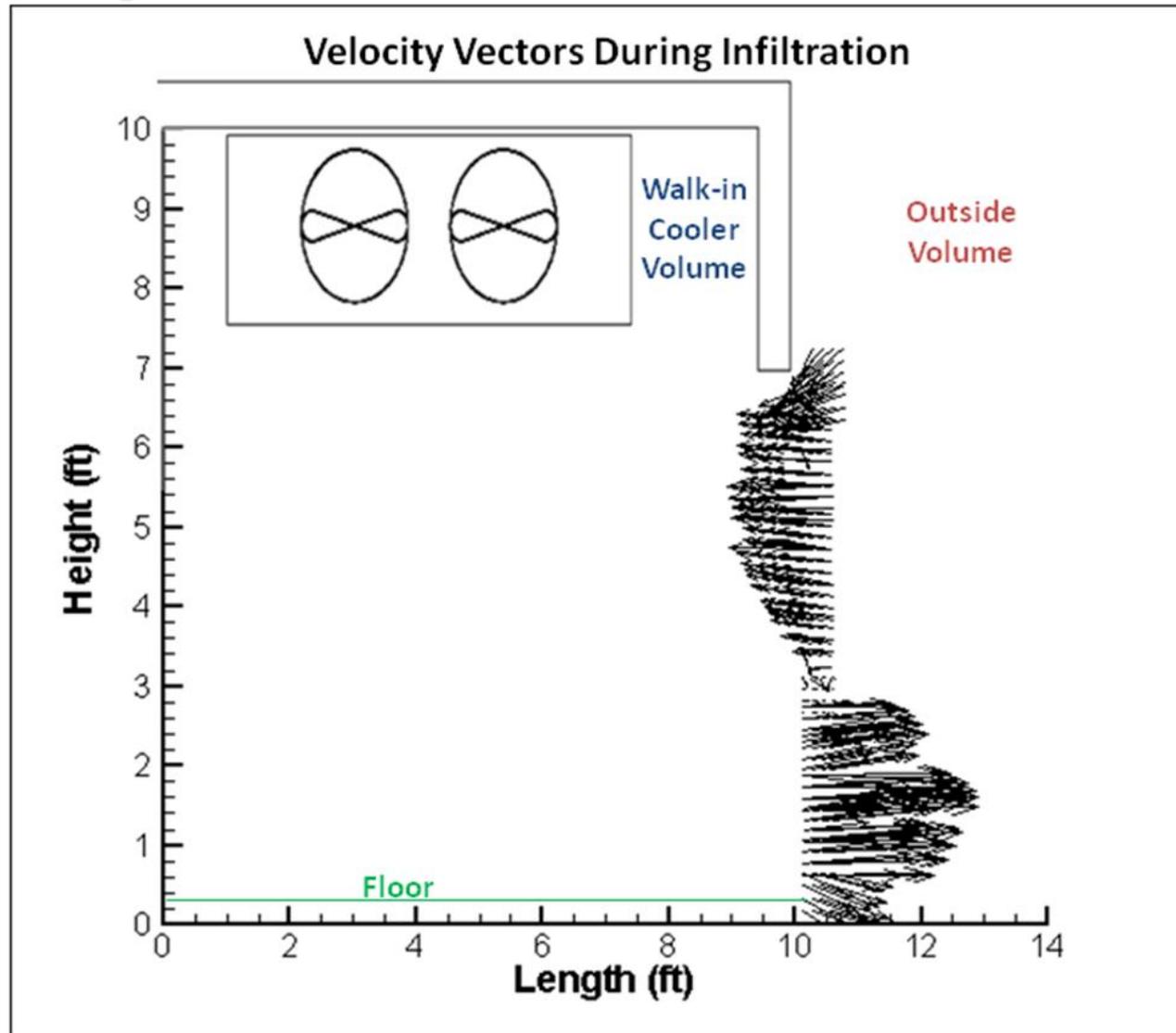
Visualization of the Infiltration Process



Internal & External Conditions during PIV Visualization

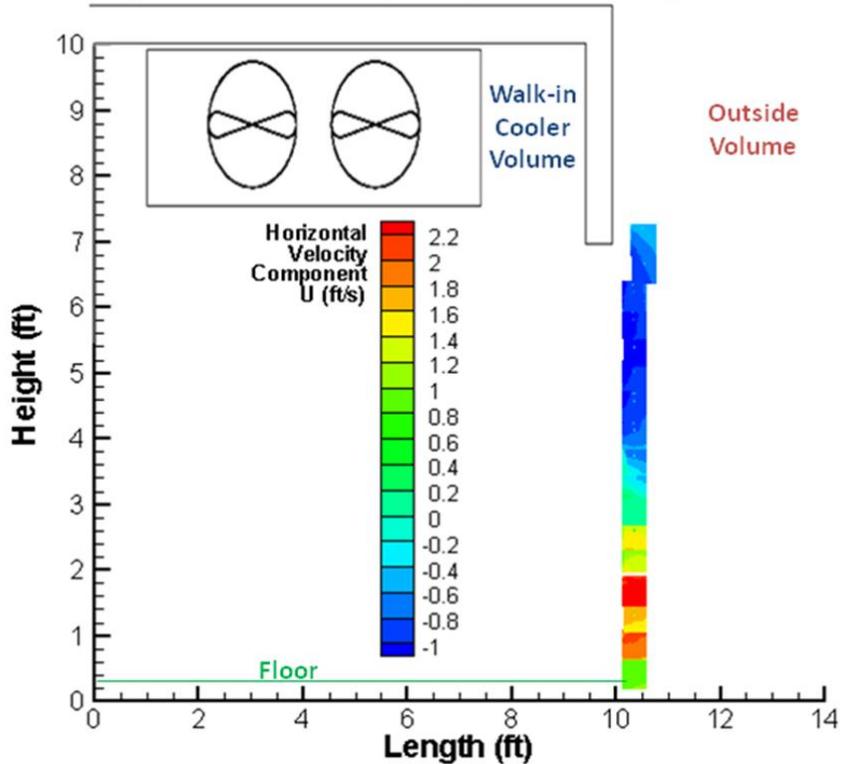
- ▶ Walk-in cooler maintained at about 35 ° F DB
 - Relative humidity (RH) was monitored but not controlled
- ▶ Environmental chamber containing walk-in was maintained at 75 ° F DB with 55% RH
 - ASHRAE testing specs for a “conditioned space”

Velocity Vectors (Profile)

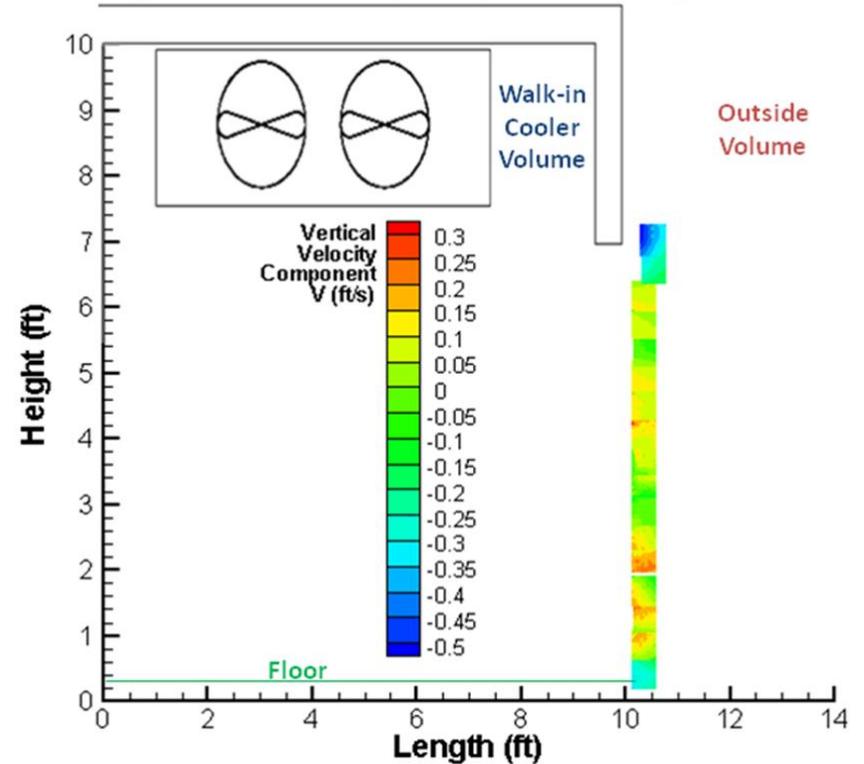


Velocity Contours

Magnitude of Velocity Component During Infiltration



Magnitude of Velocity Component During Infiltration



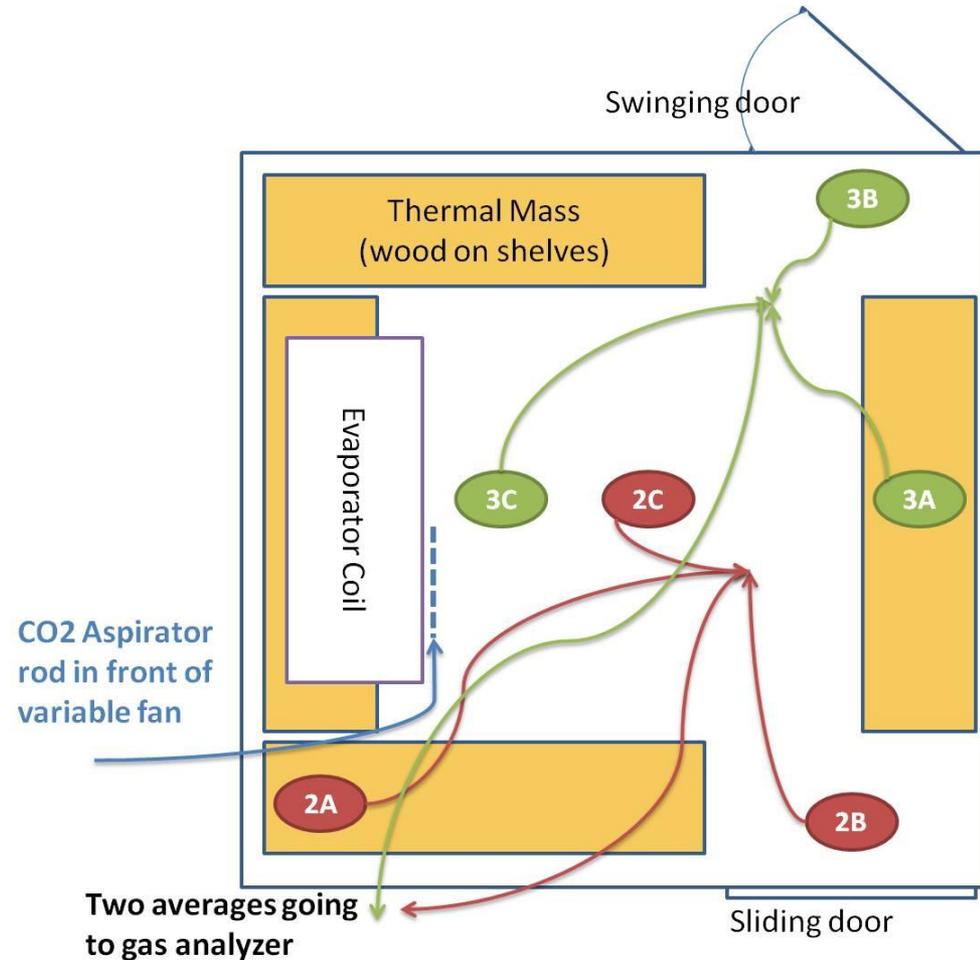
Quantification of the Infiltration Rate

Tracer Gas Method

- ▶ Flooded the cold air with tracer gas (CO_2) when door closed
- ▶ Opened and closed the door at different time intervals
- ▶ The overall change in CO_2 concentration was monitored in time inside and outside the cooler
 - The transient (time varying) infiltration rate is calculated from CO_2 concentrations

Experimental Setup

- ▶ CO₂ injected into the room to reach 2% concentration by volume
- ▶ Gas analyzer with 3 channels
 - 1 channel to probe in the ambient space
 - 2 channels dedicated to sampling inside walk-in cooler concentration



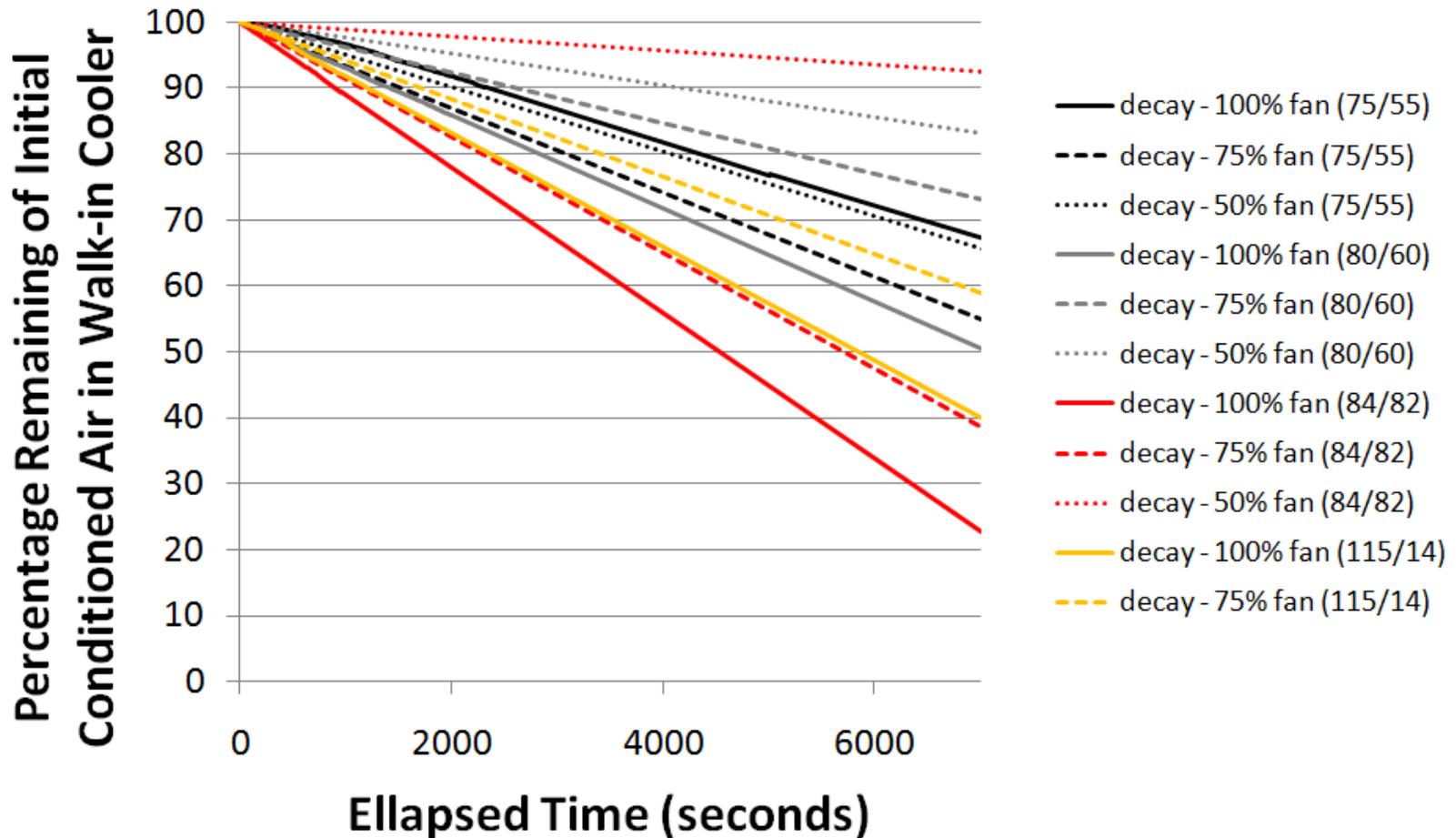
Key Contributing Factors

A	Doorway area – Available area for mass transfer or infiltration
RH	Relative humidity
ΔT	Temperature difference
t	Time duration that door stays open
V	Empty volume inside the cooler (%)
f	Fan speed (When door is opened)
	Strip curtains
	Traffic
	<u>Natural decay</u>

- ▶ Leaks result in “natural” infiltration
 - Small openings and unsealed areas
 - Gaskets wear over time
- ▶ Ambient and internal conditions
- ▶ Percent of walk-in cooler filled
- ▶ Frequent opening and closing of doors, and the duration for which they are left open partially or completely

Natural Infiltration

Infiltration that Occurs Naturally in a Closed and Stabilized System



Conclusions

- ▶ Identified the key factors contributing to infiltration
- ▶ Visualized the flow pattern at the doorway by PIV technique
- ▶ Demonstrated the feasibility of the tracer gas method for:
 - Measuring the infiltration rate directly
 - Taking a systematic approach to create a global model

Questions?