



A Multi-Faceted Approach to Tackling Hail Losses

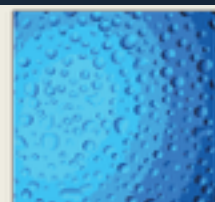
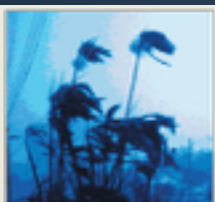
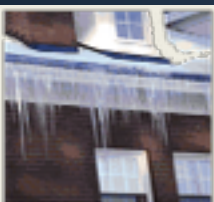
ICLR Friday Forum
December 12, 2014

Tanya M. Brown, PhD

South Carolina Wind and Hail Underwriting Association Junior Chair
Lead Research Engineer & Director of Hail Research



“Where building safety research leads to real-world solutions.”



Accomplishing the Mission

- 1. Conduct building science**
- 2. Identify mitigation solutions for all aspects of building chain**
- 3. Improve public policy**
- 4. Develop voluntary standards and guidance**
- 5. Communicate research findings**

Insurance Operational Implications

- Lower loss exceedance curve
- Better understand vulnerability; how to reduce it (underwriting)
- More accurately assess interaction between weather and built environment (pricing)
- Improve catastrophe models
- Provide new tools for claims adjustment
- Focus on priorities (“getting the roof right”)

Topics for Today

- IBHS Research Center
- Hailstorm Risks—How to Study This with Goal to Reduce Losses?
- Hailstone Characteristics Field Project
 - Measurements
 - Radar Detection
- Asphalt Shingle Impact Resistance Testing
- Full-Scale Laboratory Testing
- Aging
- Roofing and Collaboration

IBHS Research Center



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Laboratory Building for Small Tests



Large Test Chamber



- ✓ 145 ft W x 145 ft L x 70 ft H test chamber
- ✓ 60 ft W x 30 ft H wind inlet
- ✓ 105 fans, each with 350 hp motors



- ✓ Enough power for 9,000 homes
- ✓ Flow volume = 20 X **GREATER** **THAN** Niagara Falls
- ✓ High-definition cameras & TV lighting

WIND



WILDFIRE



HAIL



RAIN



IBHS Research Center Results

Gain a better understanding of:

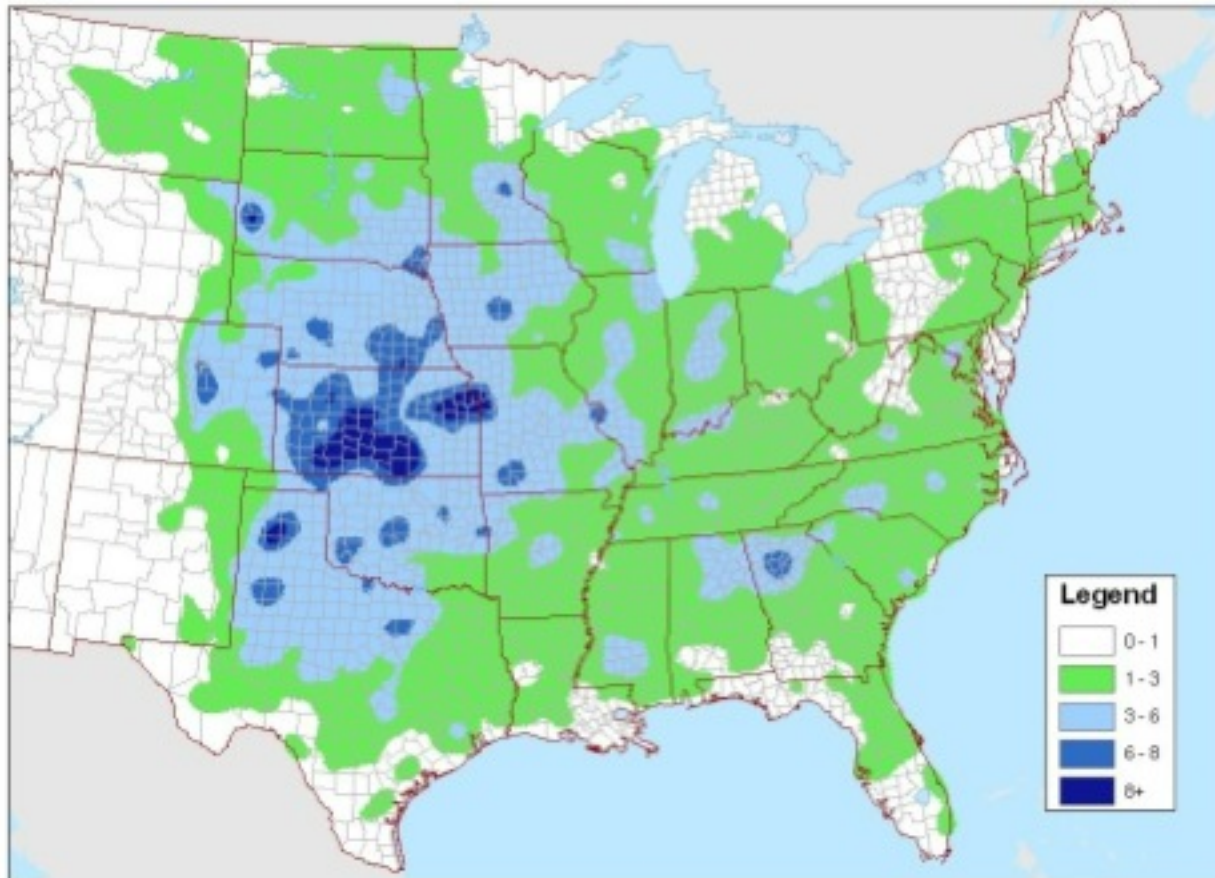
- Risks through field work and environmental analysis
- Realistic impact on buildings through damage surveys; claims analysis
- Existing test methods; true applicability to actual performance
- Cosmetic vs. functional damage through full-scale testing
- Repair methodologies through full-scale testing after aging
- Effects of long-term aging on various materials
- Materials comparisons

Hailstorm Risks

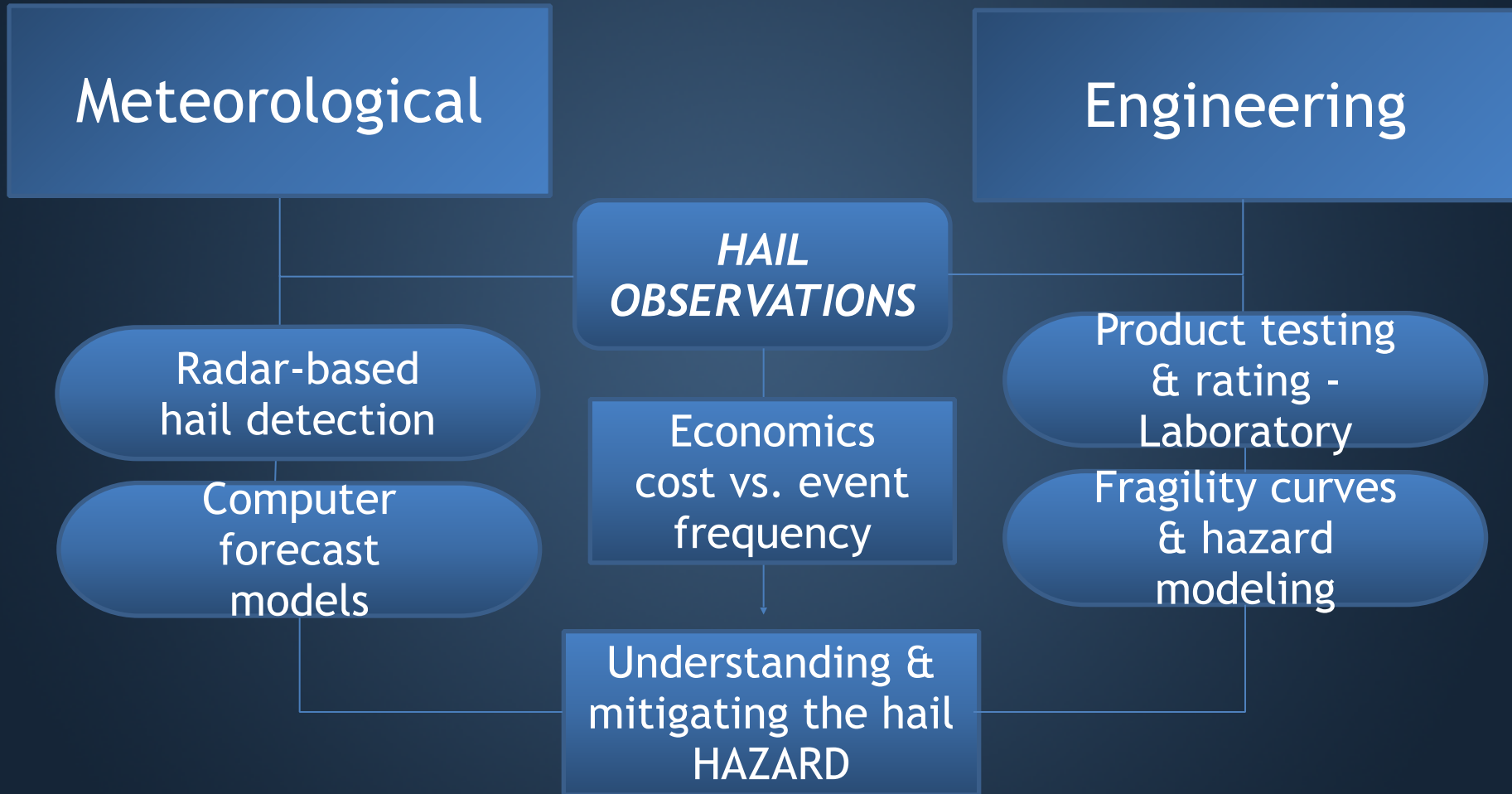
- Severe hail (≥ 1 inch diameter) most commonly occurs in thunderstorms
- Largest hailstones occur in supercell thunderstorms with strong updrafts; tornadoes can also be present
- Risk extends across the US; east of Rocky Mountains
- More than 75% of US cities experience at least one hailstorm a year
- On average, annual hail losses are nearly \$1 billion

Hailstorm Risks

Hail Activity in the United States
Average Number of Hail Reports per 100 Square Miles
2000 - 2009 Reports of Hail 1" or Larger



Multidisciplinary Approach

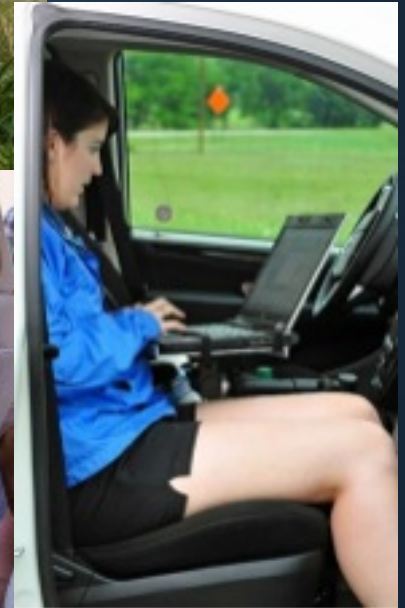


IBHS Hail Research: Pushing the Boundaries of Building Science

- Full-scale hailstorm simulation; three sizes of hailstones
- Small roof and component panel impact testing
- Field work to validate laboratory findings; improve hail forecasting and detection

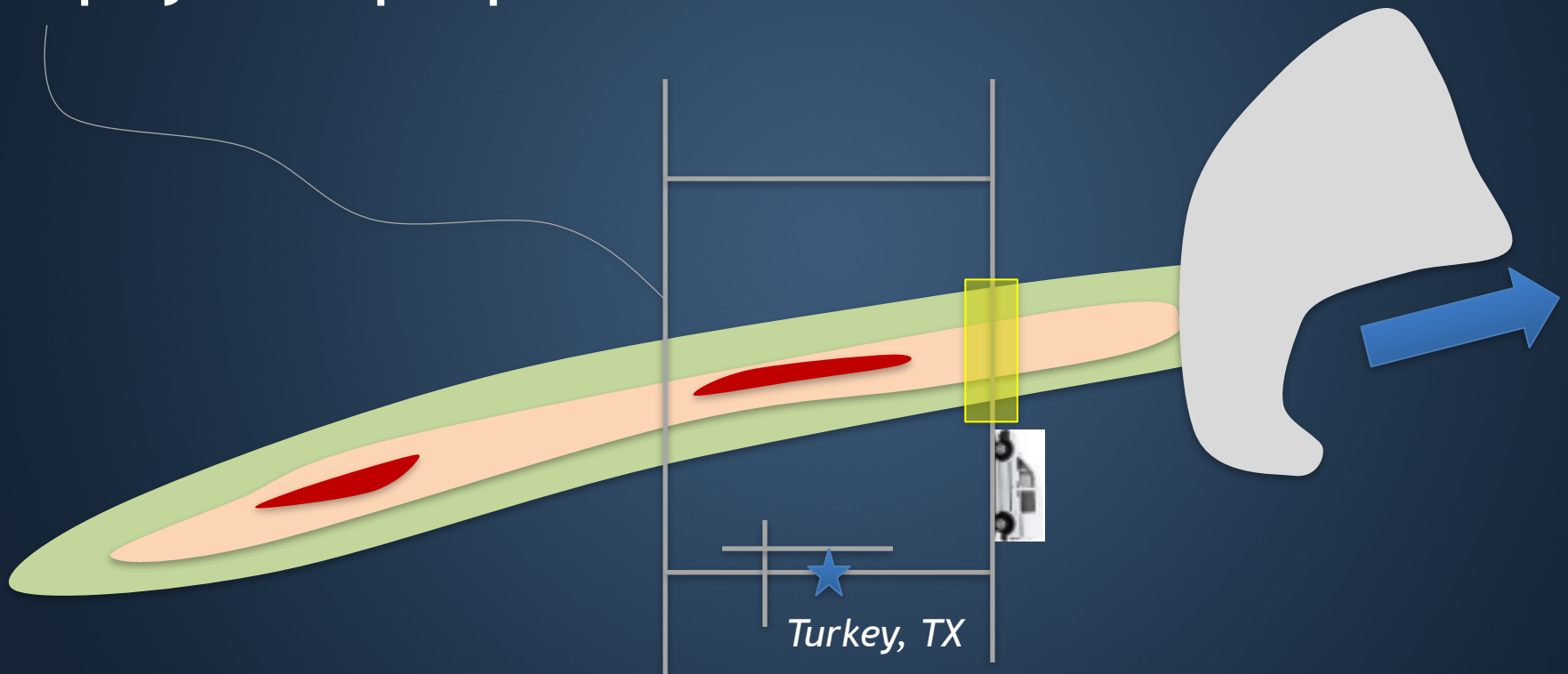


Hailstone Characteristics Field Project



Hailstone Characteristics Field Project

Mission: Safely collect measurements of the physical properties of hail



Hailstone Characteristics Field Project



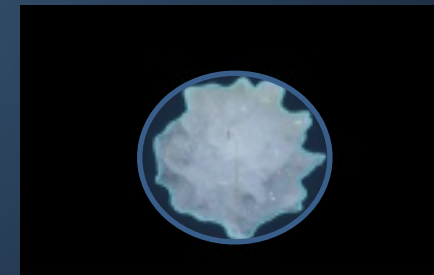
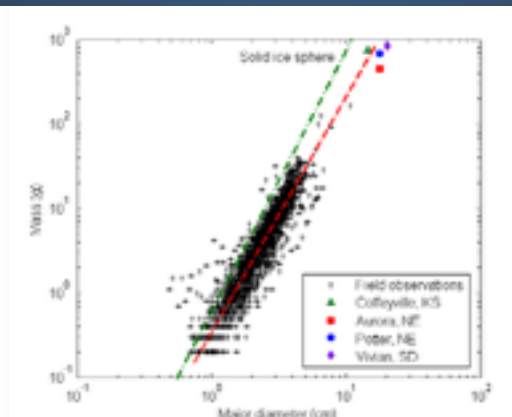
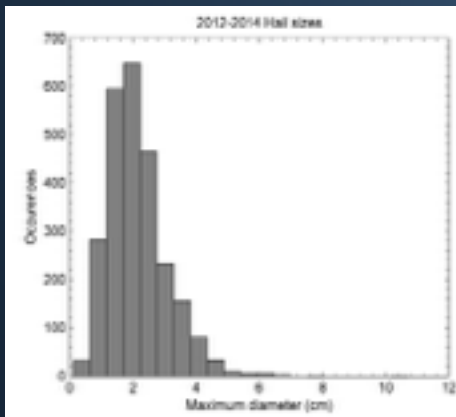
- Develop relationships between hailstone characteristics and environmental/radar data
- Understand spatial and temporal variability in hailfall

Hailstone Characteristics Field Project

Photograph

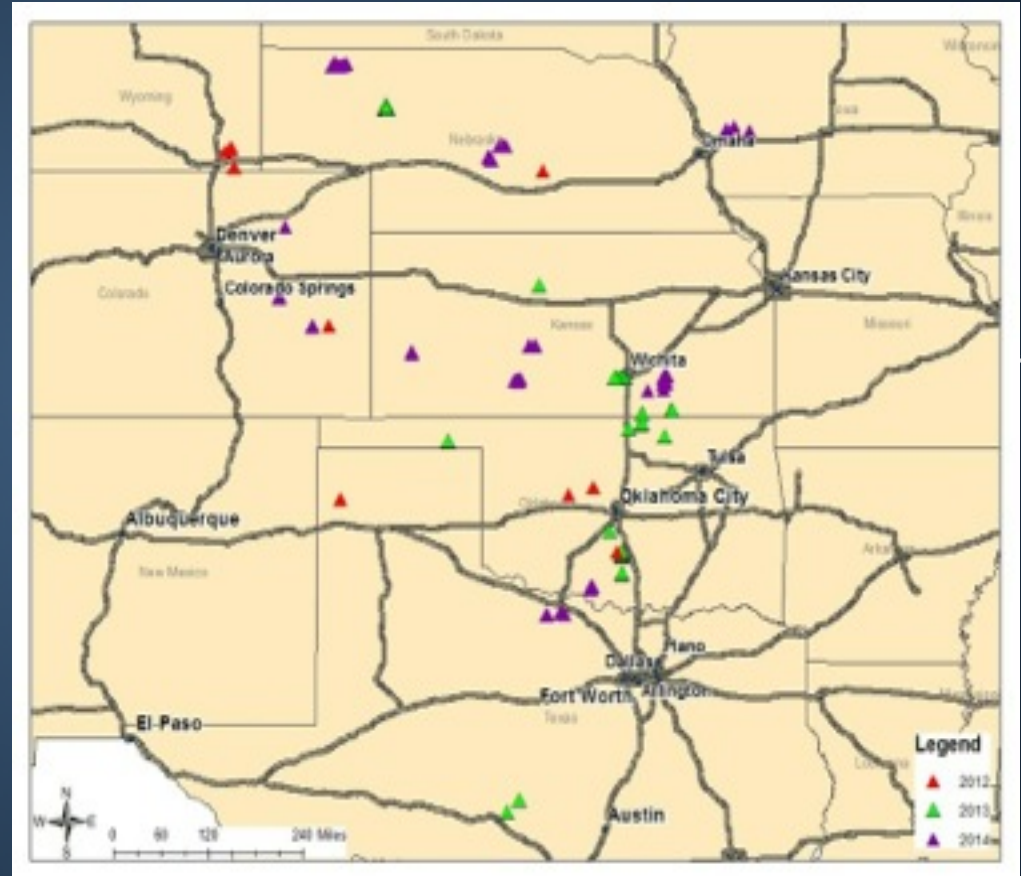
Measure/Weigh

Crush Test

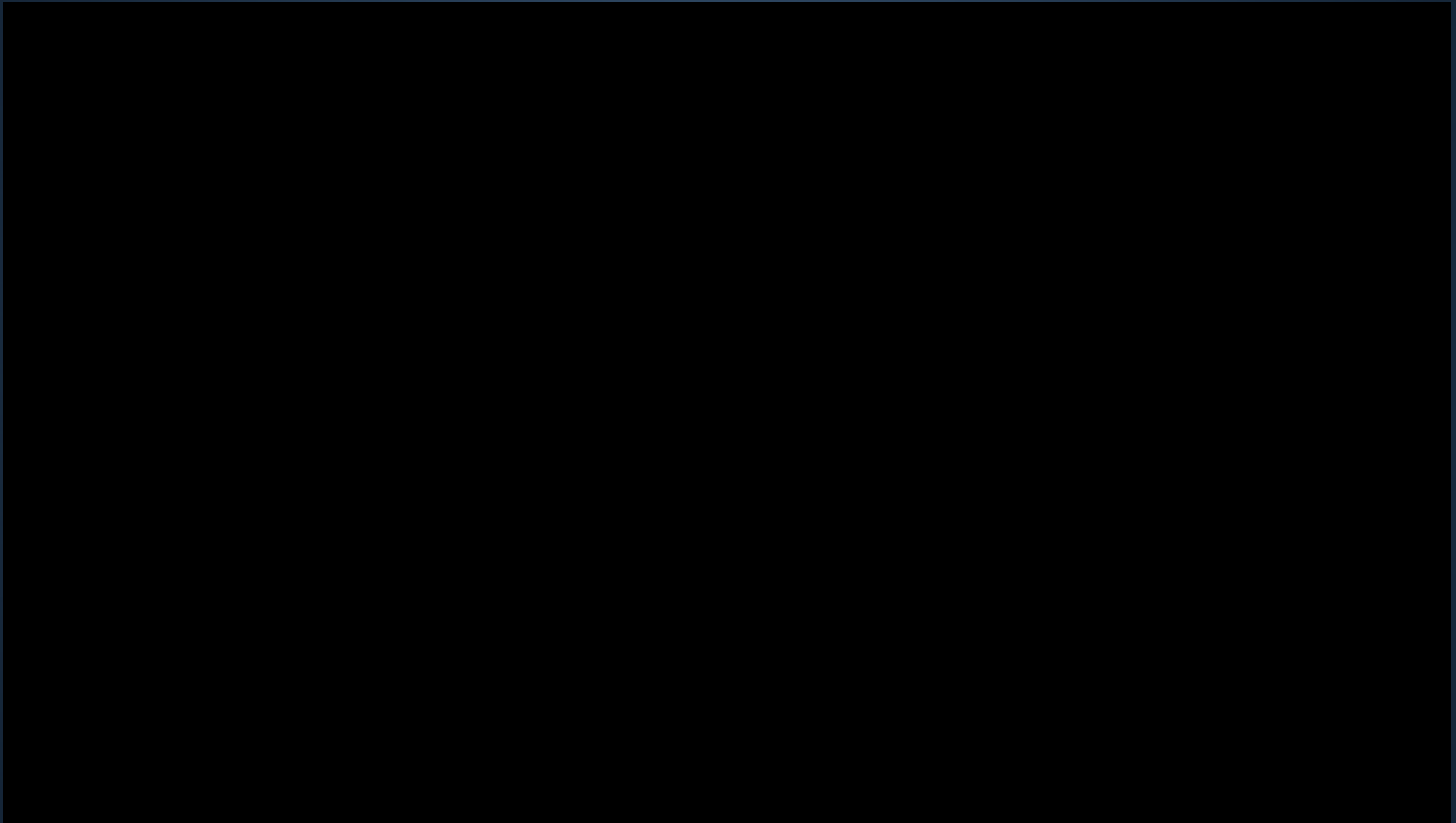


Hailstone Characteristics Field Project

- 2012-2014
- 33 parent thunderstorms
- 2500+ hailstones cataloged
- Multiple dimensions, mass, compressive strength test



Hailstone Characteristics Field Project

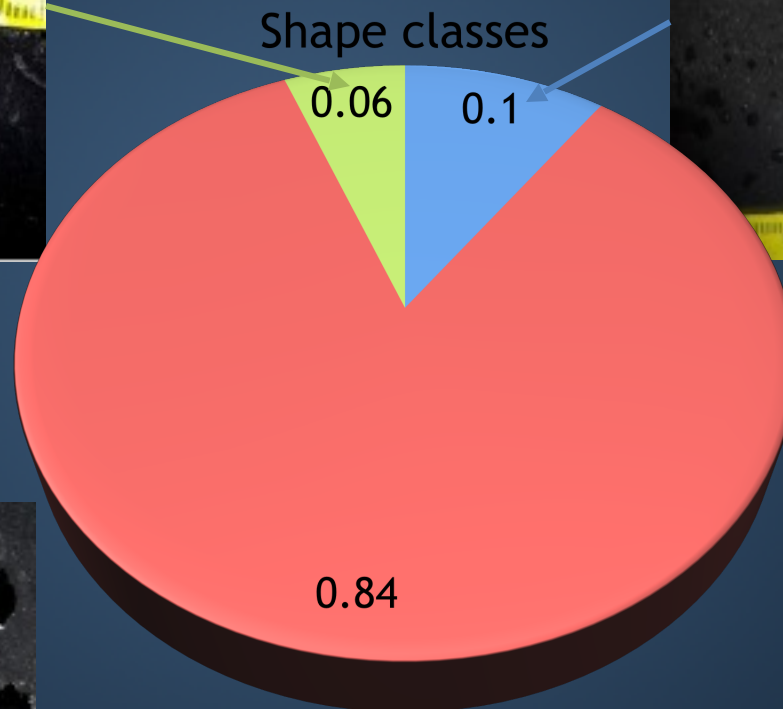


Hailstone Characteristics Field Project

2012	2013	2014
<i>9 storms</i>	<i>12 storms</i>	<i>11 storms</i>
<i>7 days</i>	<i>7 days</i>	<i>7 days</i>
<i>0.16 in. - 3.05 in.</i>	<i>0.04 in. - 4.21 in.</i>	<i>0.05 in.- 2.66 in.</i>
<i>9 psi - 620 psi</i>	<i>1 psi - 1097 psi</i>	<i>0 psi - 2958 psi</i>

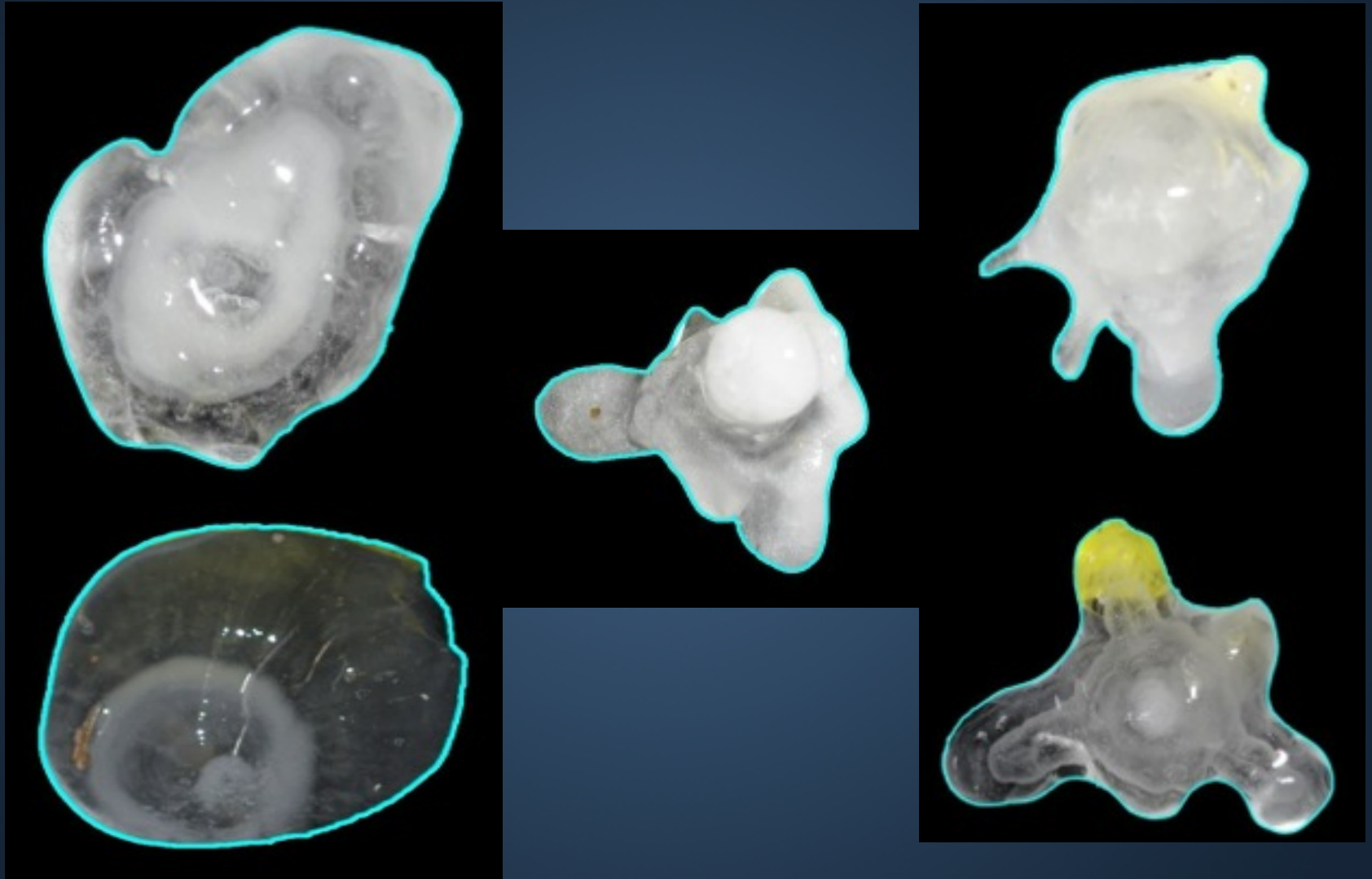


Hail Hazard: Shapes

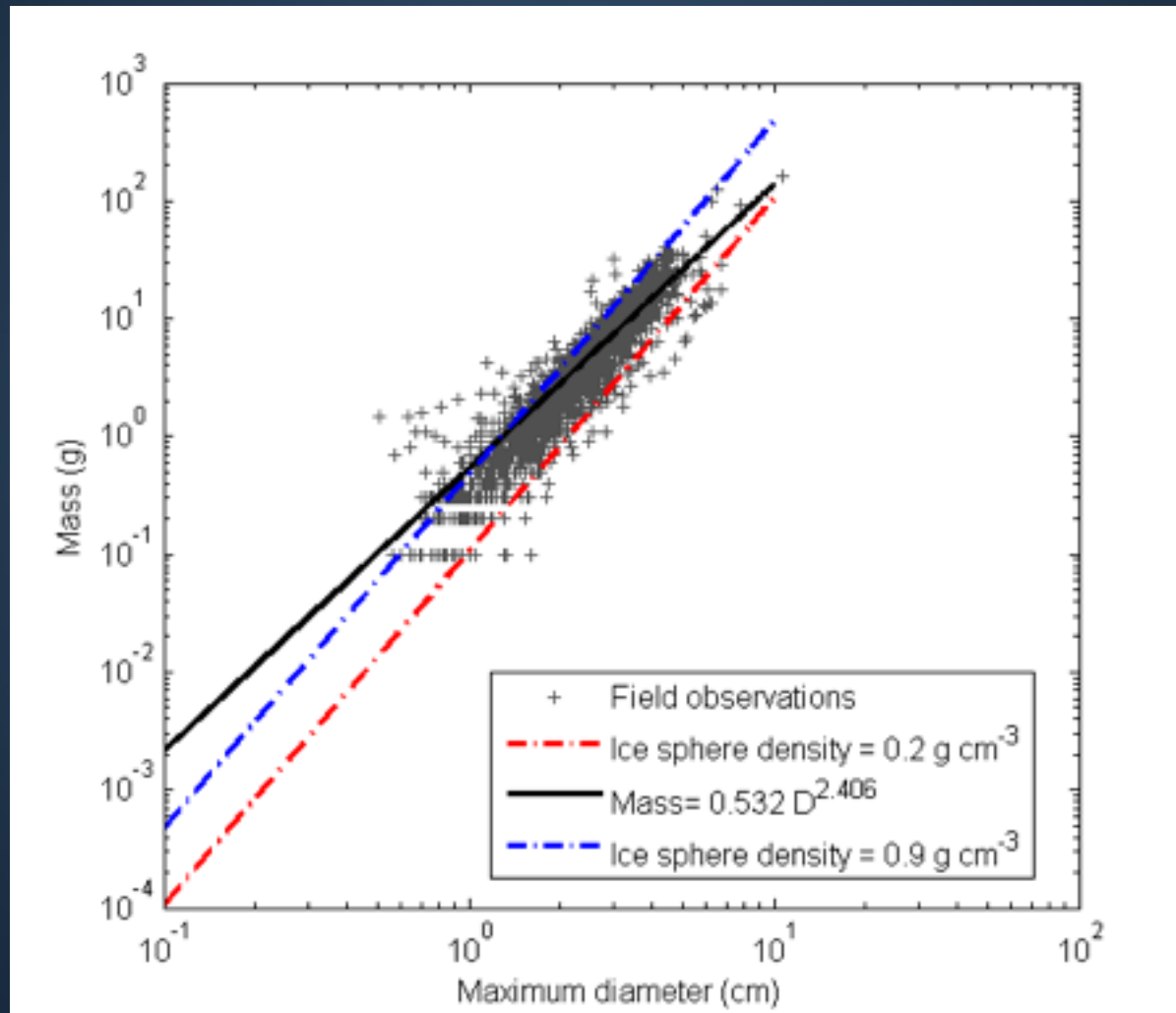


- Conical
- Spheroid
- Irregular

Hail Hazard: Shapes



Hail Hazard: Density



Hail: Field vs. Lab

Density

- Artificial hailstones—varies from 0.45-1.1 g/cm³
- Natural hailstones—varies from 0.1-0.9 g/cm³ (historical studies)

Compressive Stress

- Artificial hailstones—varies from 3-308 psi
- Natural hailstones — 1-8000 psi (limited field dataset)



Hail: Field vs. Lab

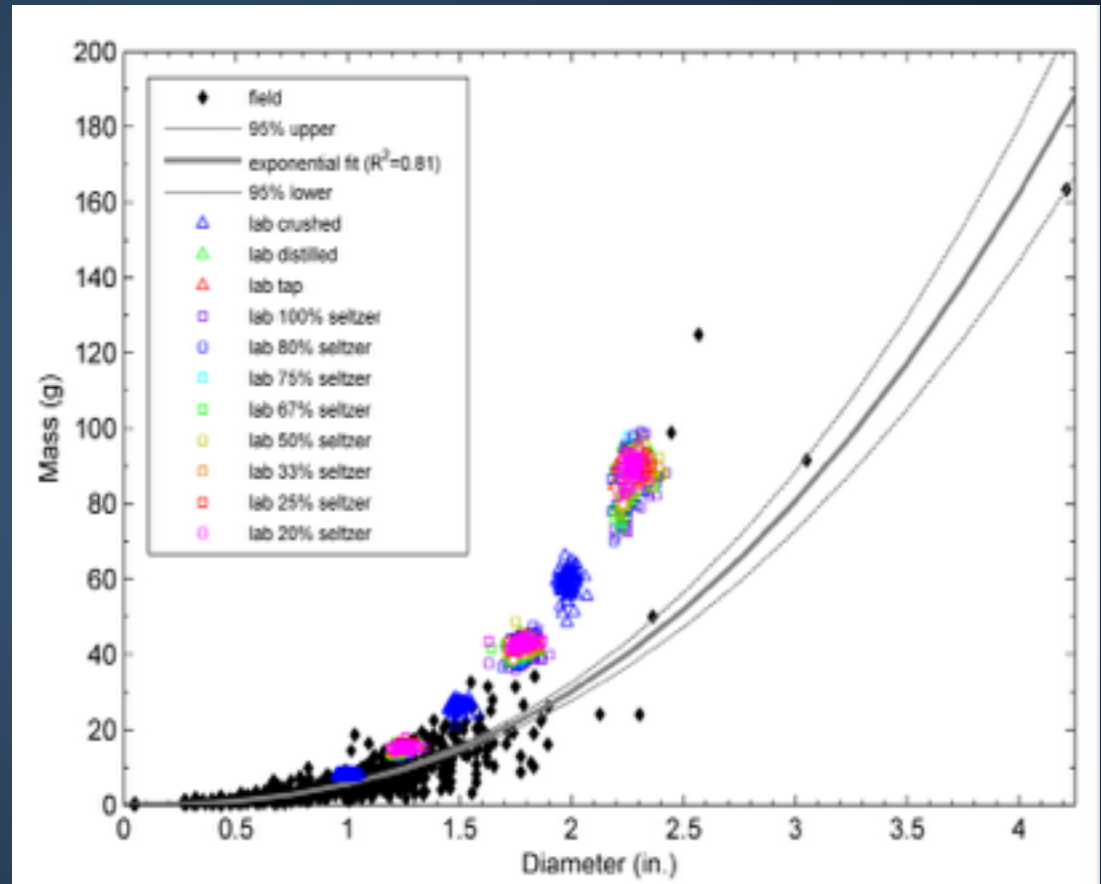
Standardized tests

- UL 2218 - Steel ball
- FM 4473 - Ice ball

“worst case impact”

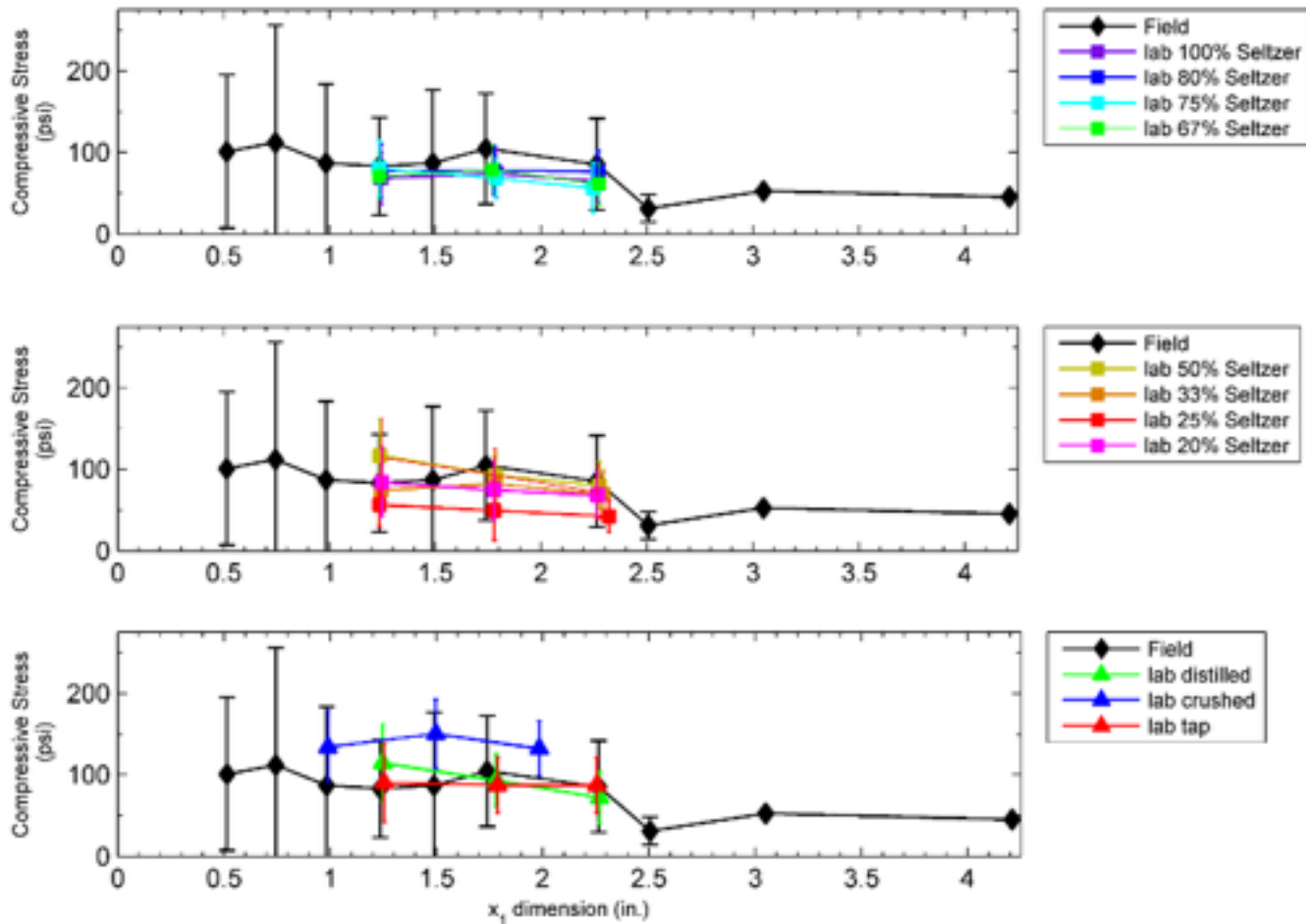
Field observations

- Lab ice sphere will have higher mass than typical natural hailstone of same maximum diameter



Oblate spheroids (e.g. “hamburger bun-ish”), depart from perfect spheres with size

Hail: Field vs. Lab



Hail: Field vs. Lab

Pure ice sphere diameter (in.)	Typical natural hail diameter of the same (in.)
0.5	0.65
0.75	0.68
1.00	1.18
1.25	1.56
1.50	1.90
1.75	2.21
2.00	2.65
2.50	3.40
3.00	4.30
3.50	5.05
4.00	5.90

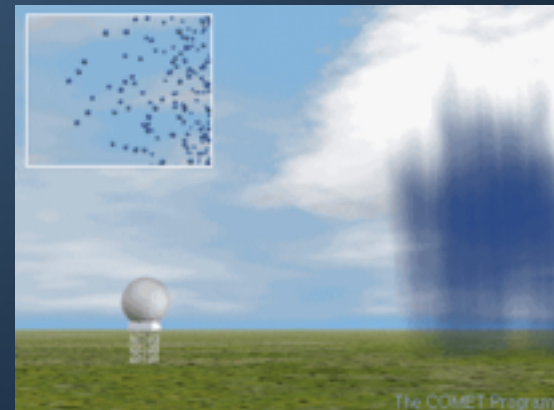
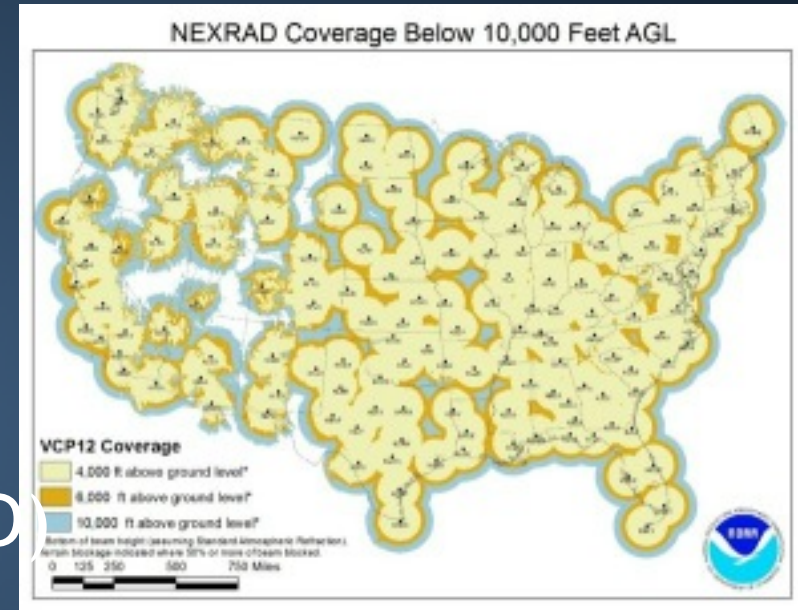
*When we shoot a 2 in. stone, it's really like a typical 2.65 in. hailstone
UL 2218 & FM 4473 kinetic energy all based on spheres*

Hail: Loss Reduction

- Predict which hailstorms are damaging
- Accurately delineate hail swath using improved radar data
- Reduce “neighboritis” and claims at fringe of swath

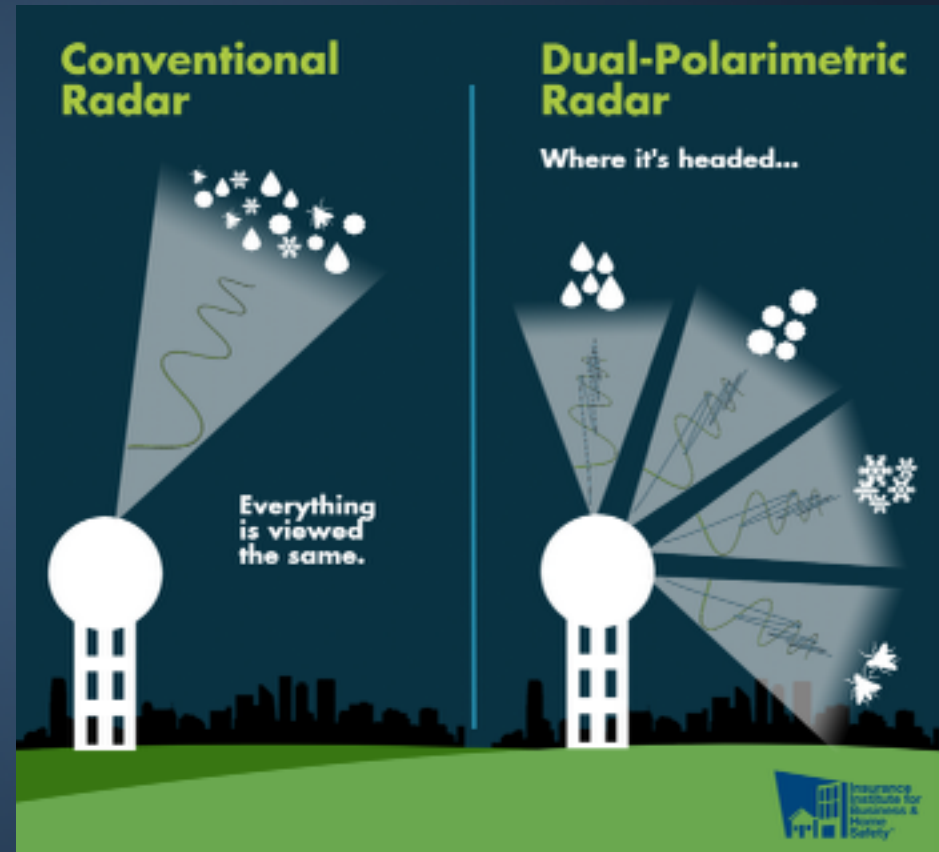
Hail: Radar Detection

- National Weather Service Network of Doppler Radars
- WSR-88D
- First deployed 1988 (NEXRAD)
- Operate continuously
- Data are free

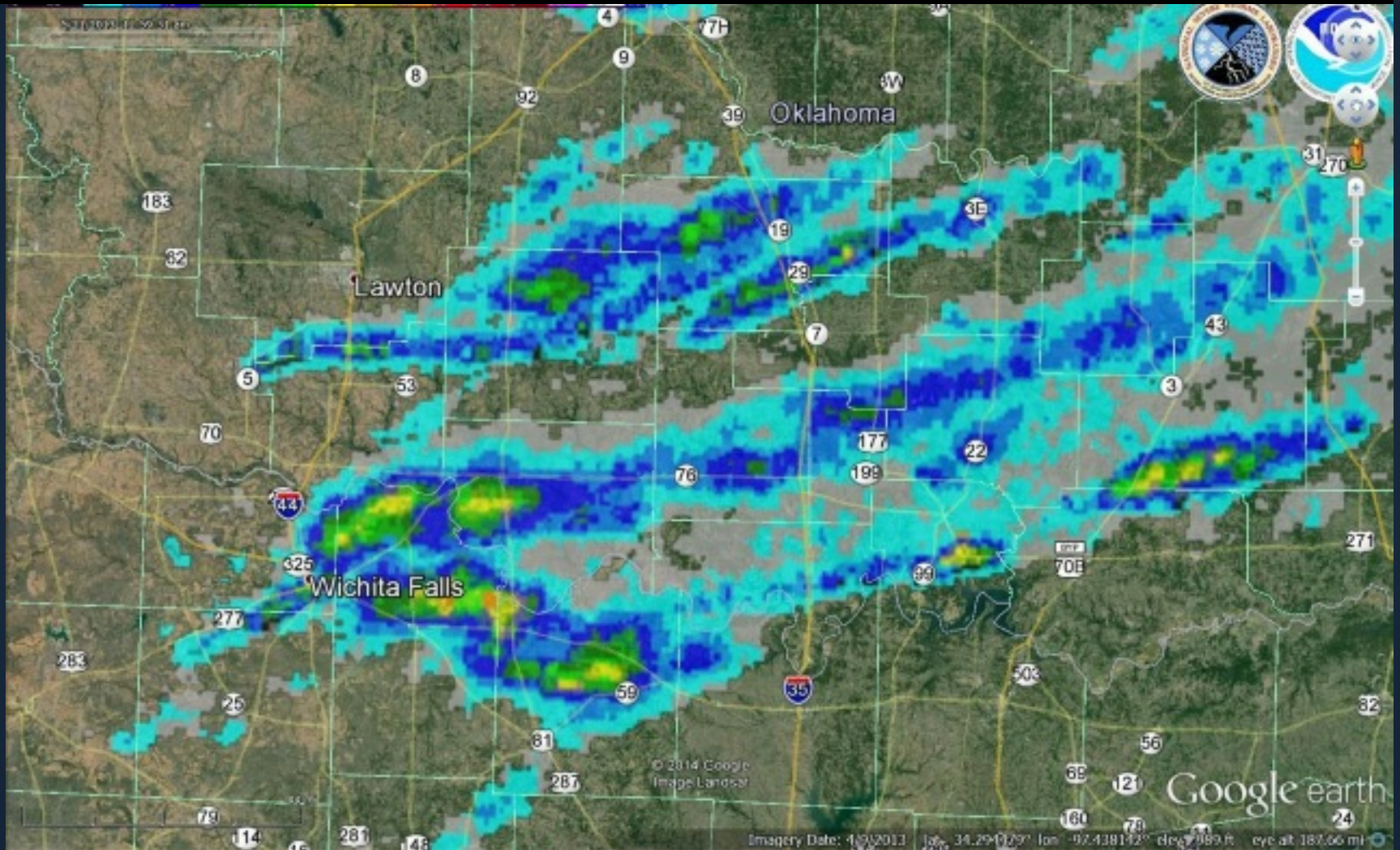


Hail: Radar Detection

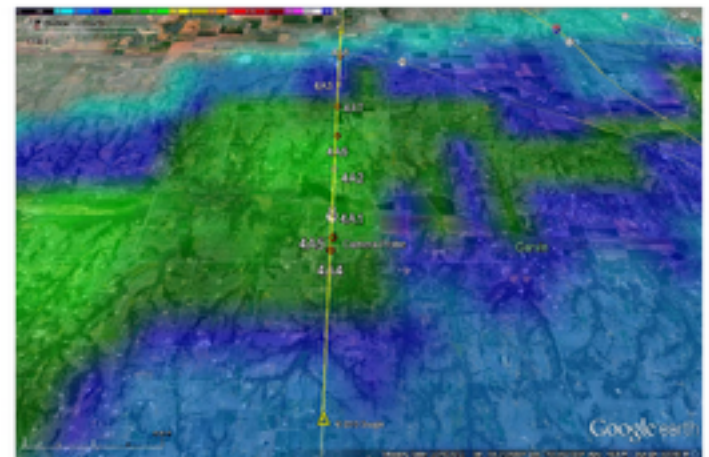
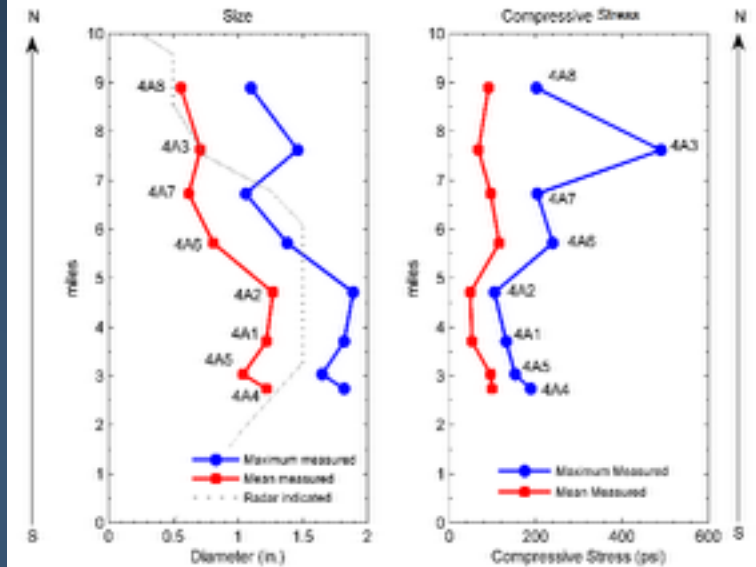
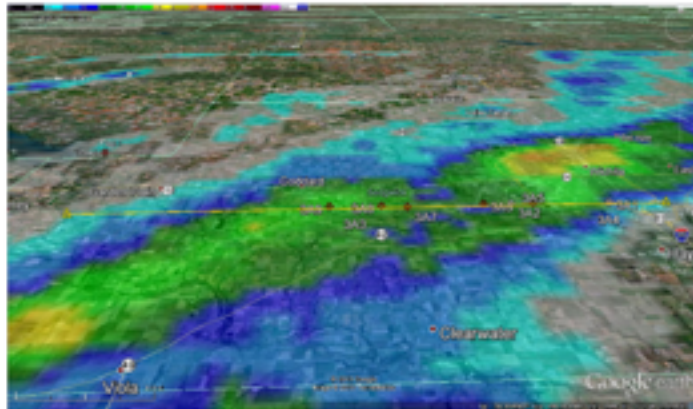
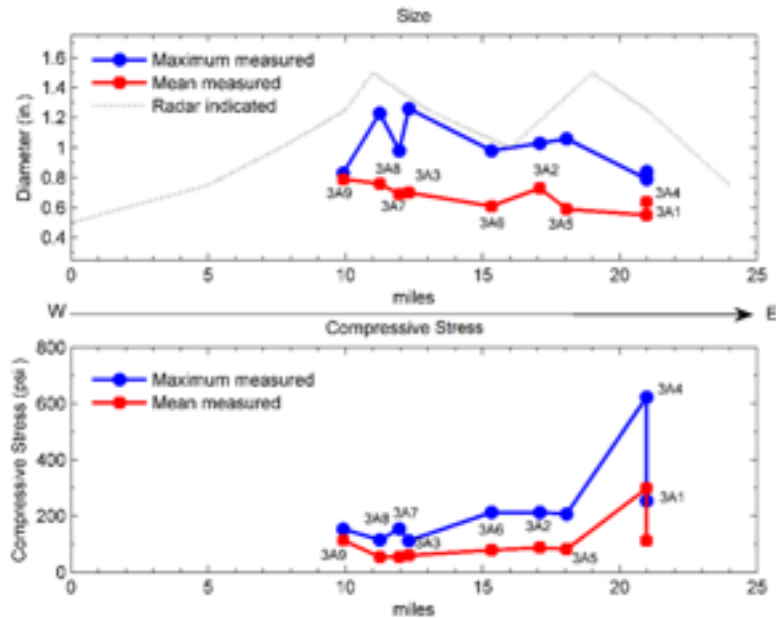
- All NWS radar upgraded to “dual-pol” (2013)
- Collaboration with Dr. Matt Kumjian (Penn State)
- Develop and improve dual-pol hail detection
- No “operational” hail size or concentration algorithm using dual pol information
- Only classification: “HAIL/ HEAVY RAIN”
- Field observations for validation and tuning



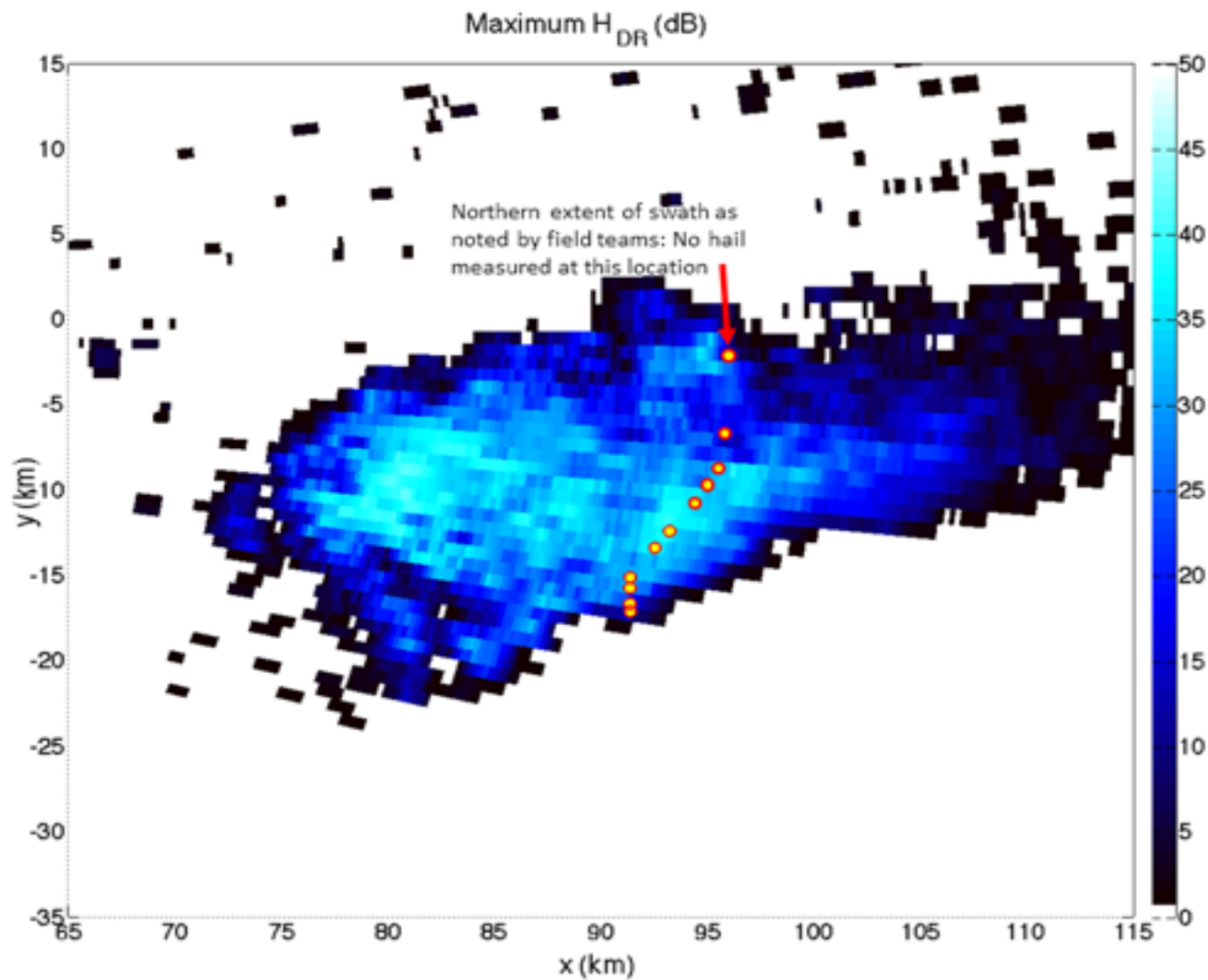
Hail: Conventional Radar Detection



Hail: Conventional Radar Detection

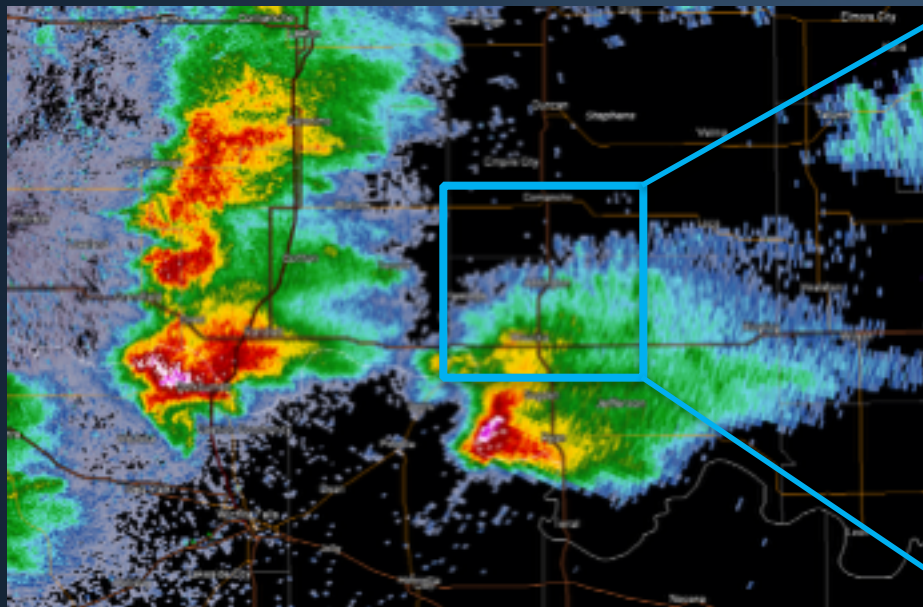


Hail: Emerging Radar Detection



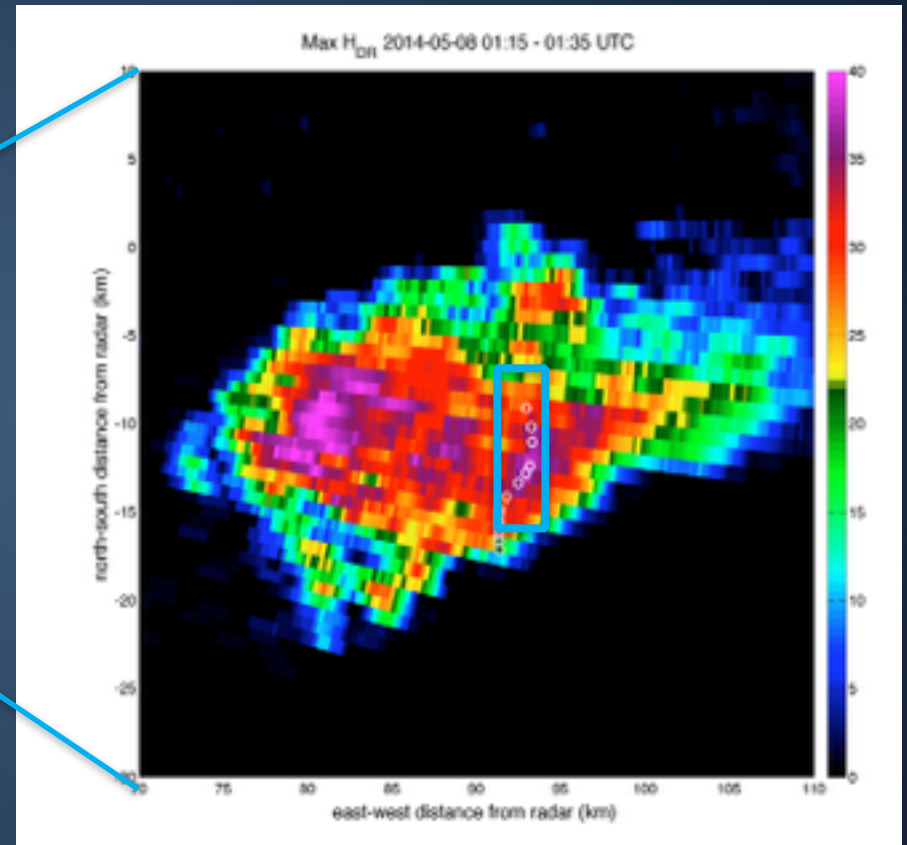
Data courtesy of
Matt Kumjian
(Penn State)

Hail: Emerging Radar Detection



Conventional radar reflectivity

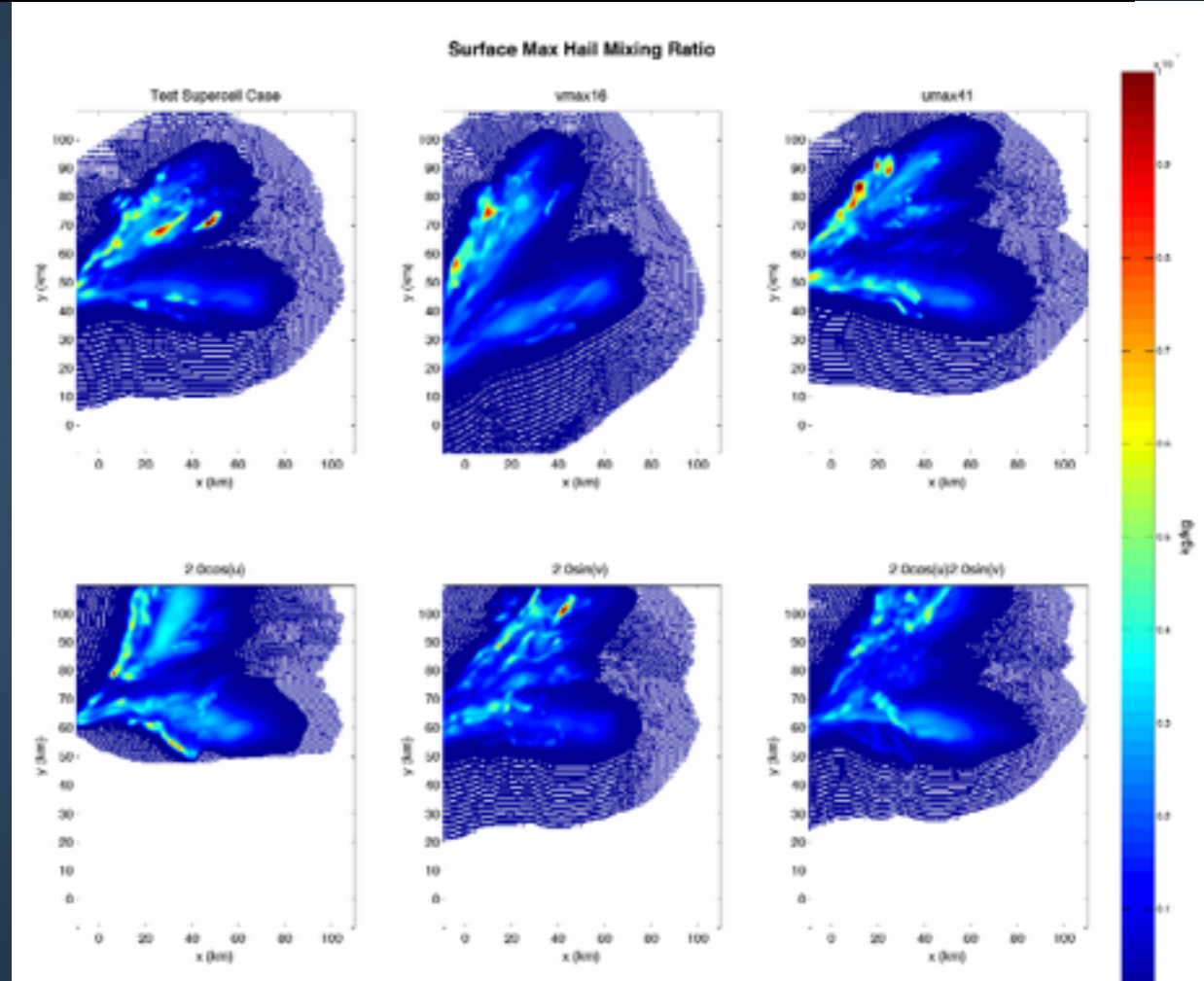
Data courtesy of Matt Kumjian (Penn State)



Dual pol derived swath - contribution of hail to backscattered energy at lowest radar scan

Hail: Future Forecasting

- Numerical model simulation
- 6 different wind profiles
- Can “turn the knobs” on the environment
- Shaded colors represent hail concentration
- Next step: simulations of field events



Hail Impact Disdrometer Probes

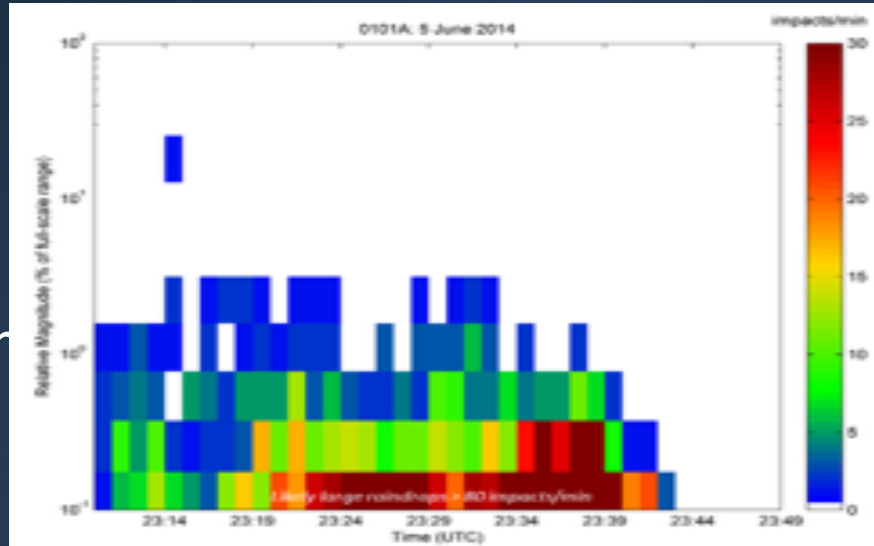
- Rapidly deployable
- Detect hail impacts
- Group into sizes
- Impact energy
- RUGGED!!!

GOAL: Deployable research network (20 or more)
GOAL: Use on fixed observing stations (2015 pilot study)

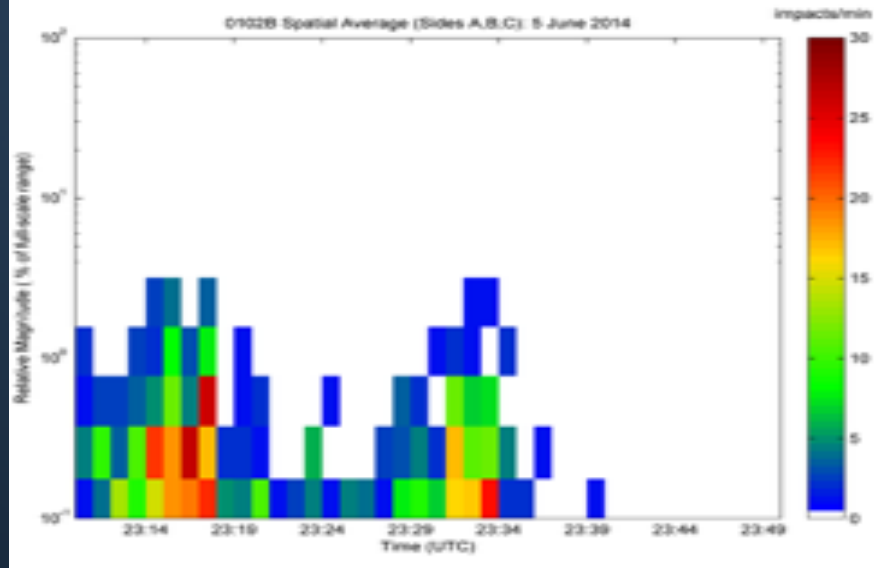


Hail Impact Disdrometer Probe Example

Single piezo-
electric sensor



Three piezo-
electric
sensors



Punkin Center, CO; 5
June 2014

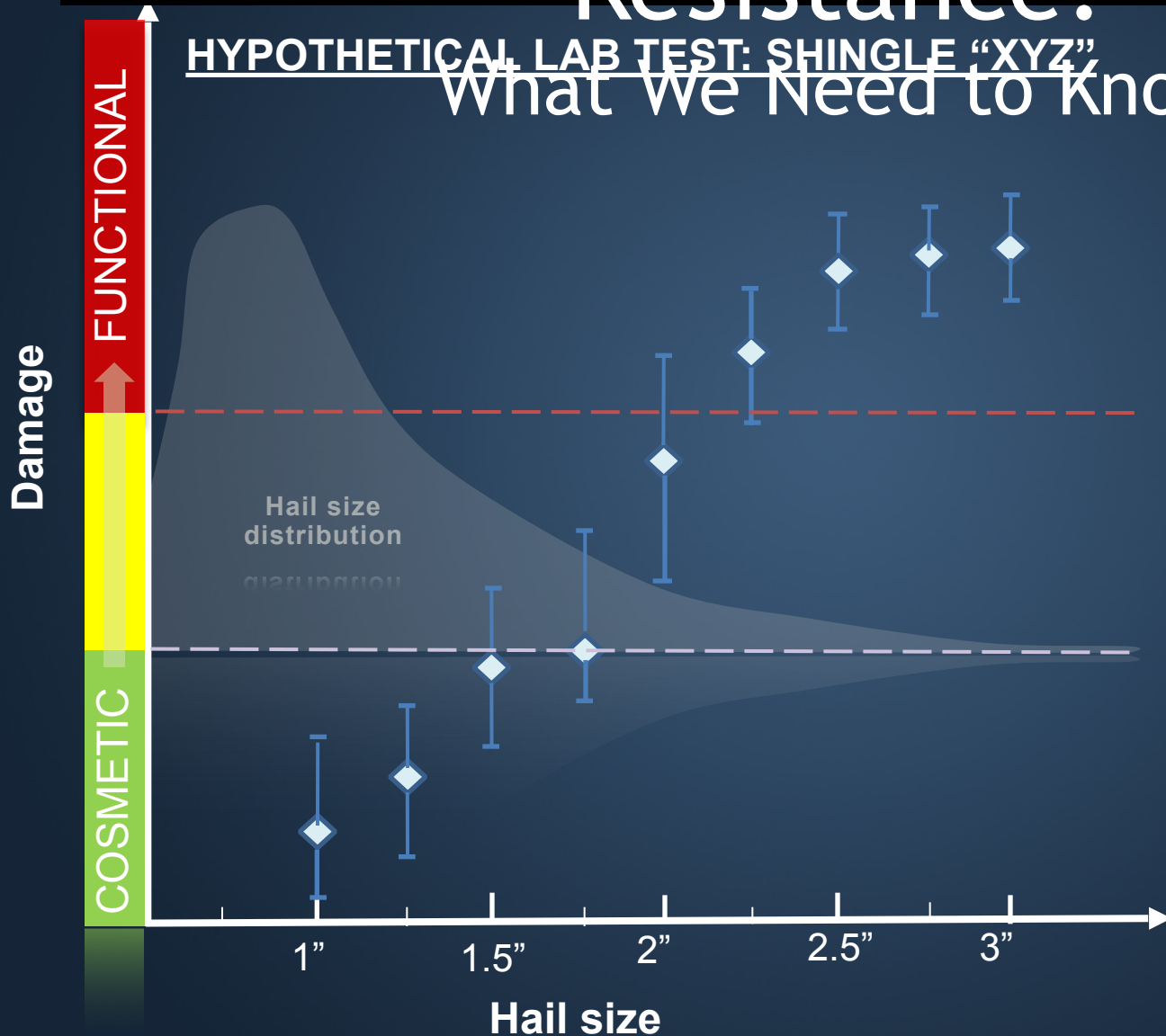
Large volume of
small hail

– 10-20 impacts per
minute

Asphalt Shingle Impact Resistance:

HYPOTHETICAL LAB TEST: SHINGLE "XYZ"

What We Need to Know



At what point does the shingle lose its water shedding ability?

What does the relationship actually look like?

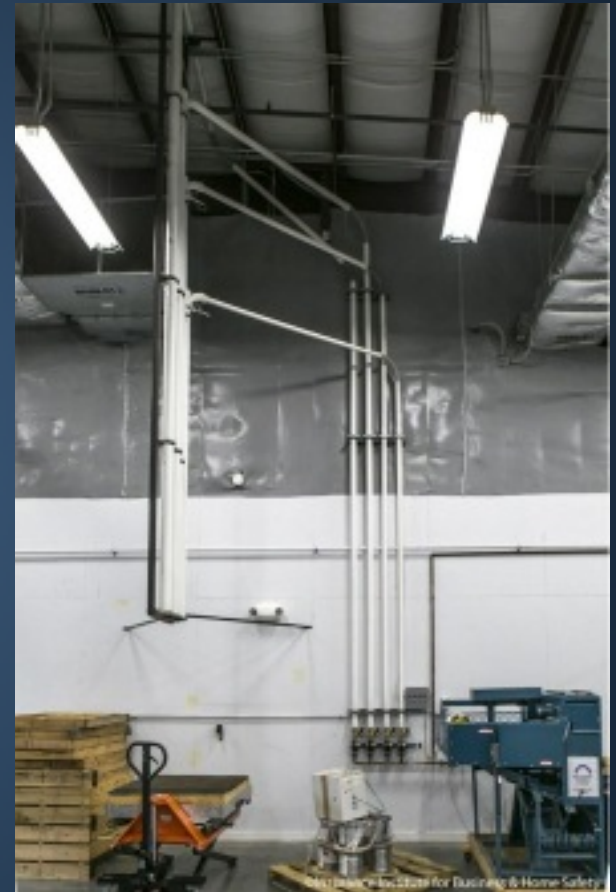
How do the effects of aging play a role?

Asphalt Shingle Impact Resistance Testing

Systematic approach to compare:

1. Different classes of materials
 - a) 3-tab vs. architectural shingles
 - b) standard vs. IR vs. premium
 - c) Traditional IR vs. polymer modified IR
2. Standard test methods: UL 2218 / FM 4473
3. Altered test methods: different density and/or hardness of stones
4. Aging and climate effects

Goal = Develop statistically based damage curves for size, density, and hardness of hailstones



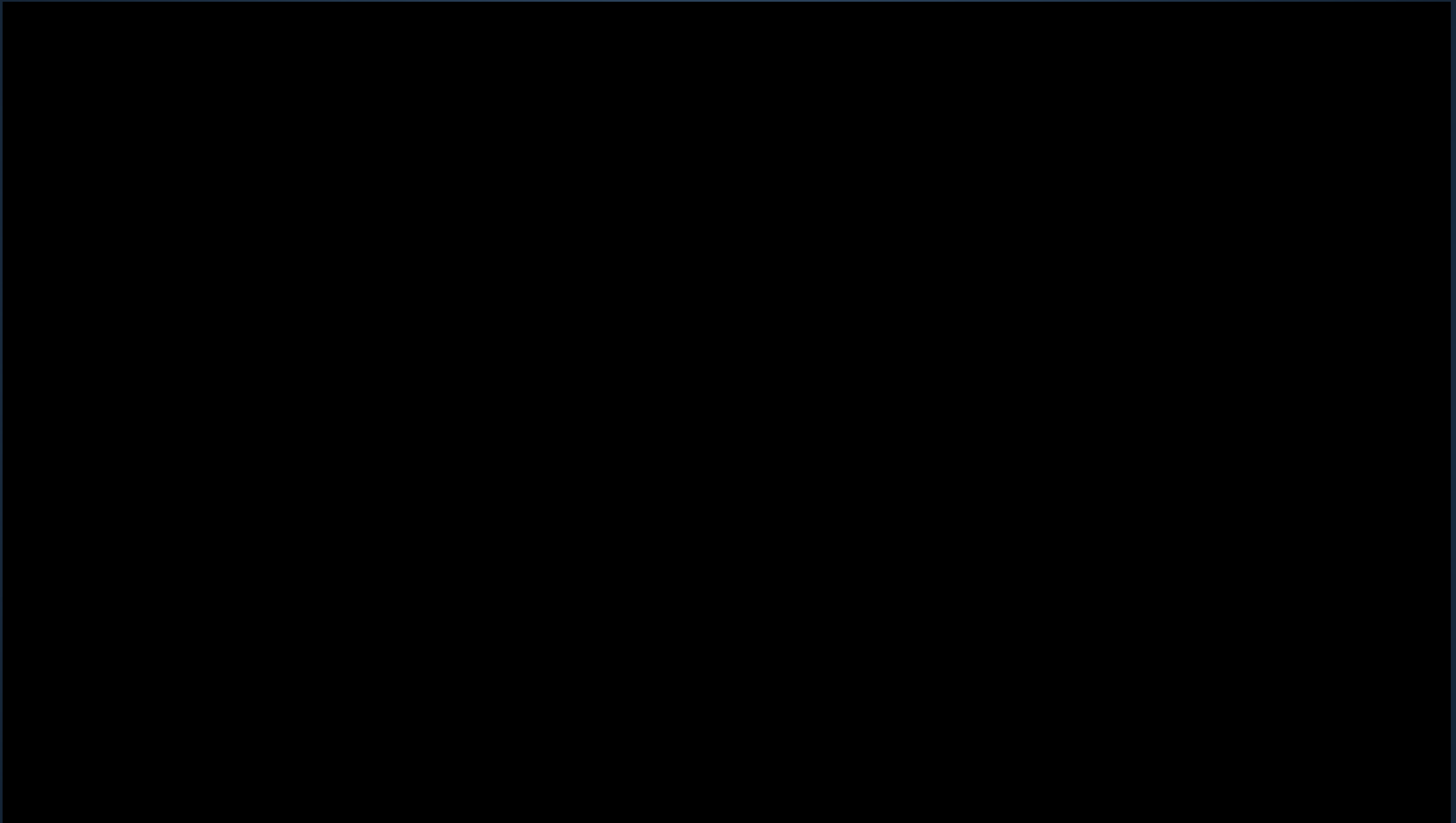
UL 2218 Shingle Impact Test Method

- Official method for rating shingle impact resistance
- 3' x 3' panels constructed with shingles installed by manufacturer's guidelines
- Conditioned for 16 hours @ 135-140 °F
- Steel balls dropped from height necessary to achieve same kinetic energy as similarly-sized hailstone
 - Class 1 ball = 1.25"
 - Class 2 ball = 1.50"
 - Class 3 ball = 1.75"
 - Class 4 ball = 2.00"

UL 2218 Shingle Impact Test Method

- Two impacts at each of six locations on 3' x 3' test panel
- Resultant impact marks inspected under microscope
- Any evidence of opening—tearing, cracking, fracturing, or rupturing—visible on the back of the shingle is considered test failure

UL 2218 Shingle Impact Test Method



Asphalt Shingle Impact Test Observations

- Common impact marks
 - Crushed granules—visible on all panels, not seen in real-world
 - Dents—most severe at midspan 2 x 4 brace
 - Flattening of shingles—particularly at edges, joints, corners



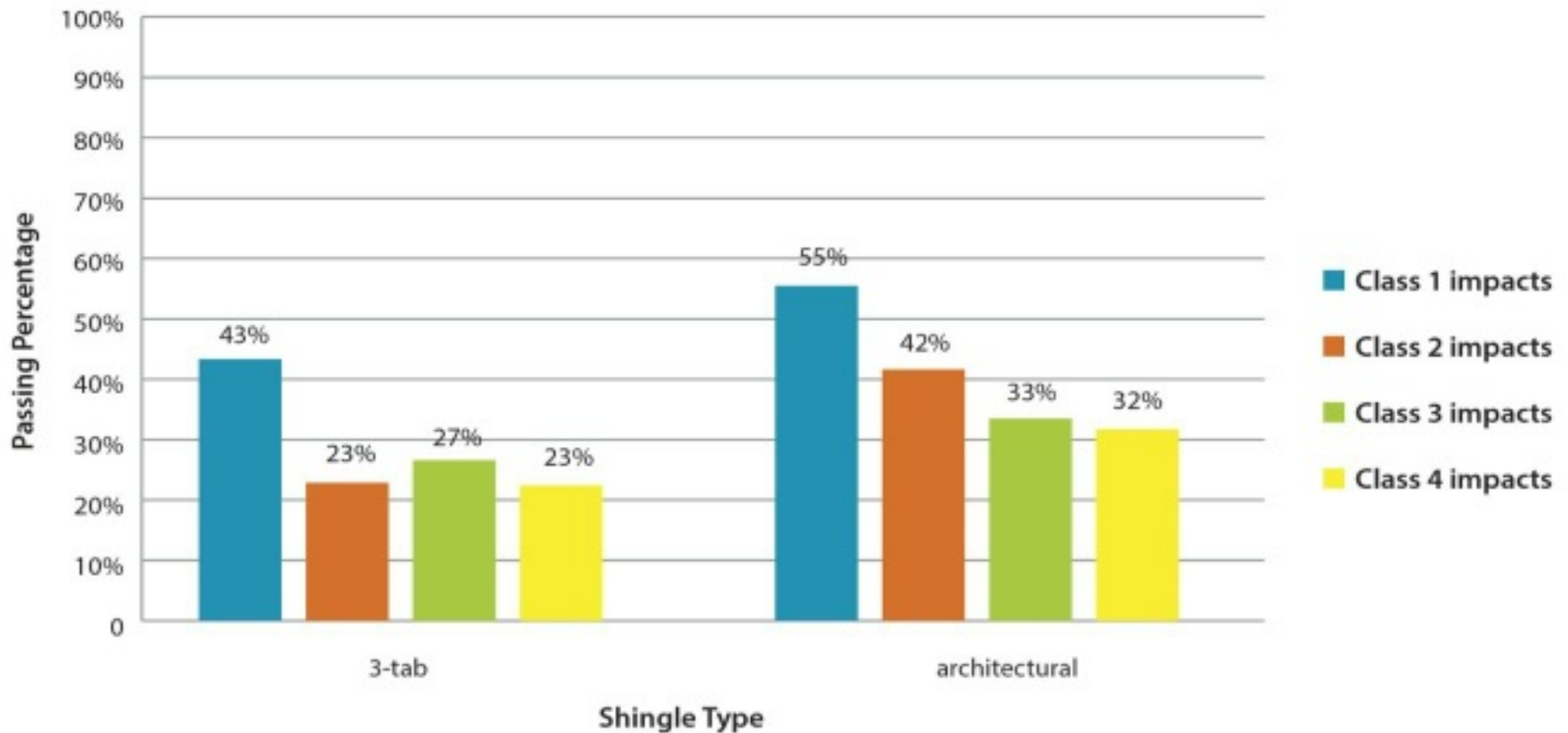
Asphalt Shingle Impact Test Observations

- Common performance criteria failures
 - Cracks—through 3-tab and single-ply ply portion of architectural shingles; both plies of double-ply
 - Tears—at edge of 3-tab and single-ply portion of architectural shingles; both plies of double-ply
 - Unclear if one damage mode is more detrimental



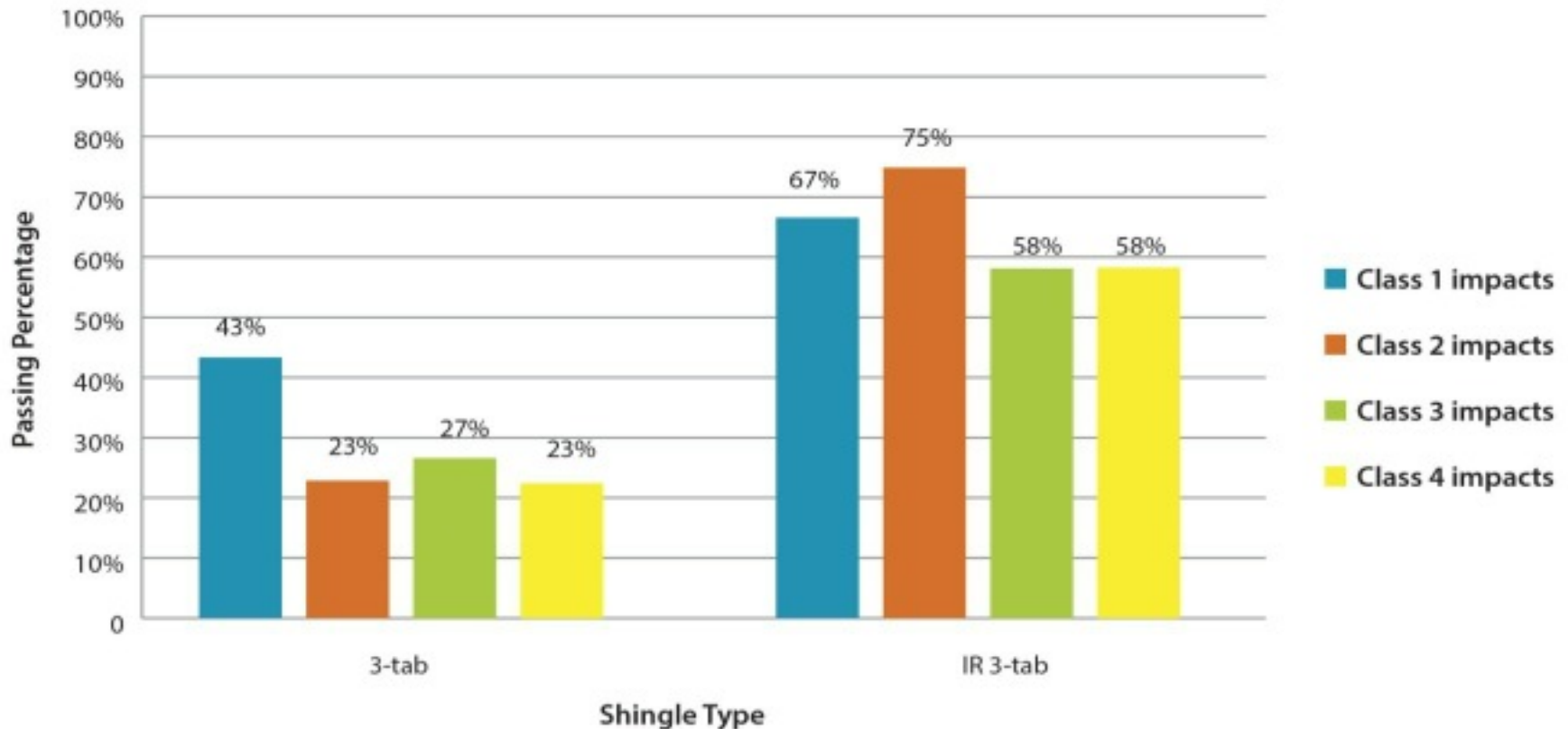
Asphalt Shingle Impact Resistance Testing

UL 2218 Impact Location Passing Rates:
3-tab vs. Architectural Shingles



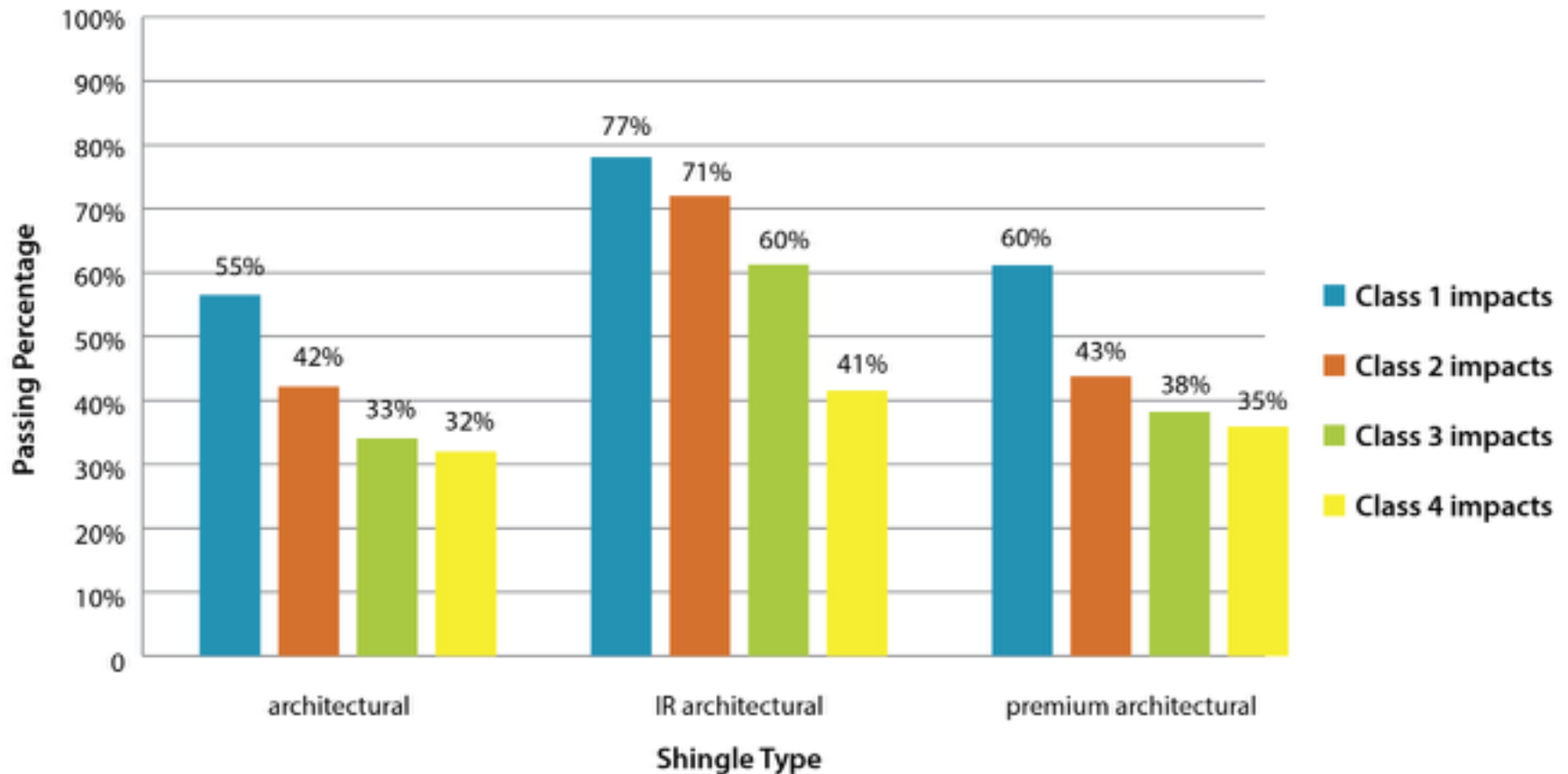
Asphalt Shingle Impact Resistance Testing

UL 2218 Impact Location Passing Rates:
3-tab vs. IR 3-tab Shingles



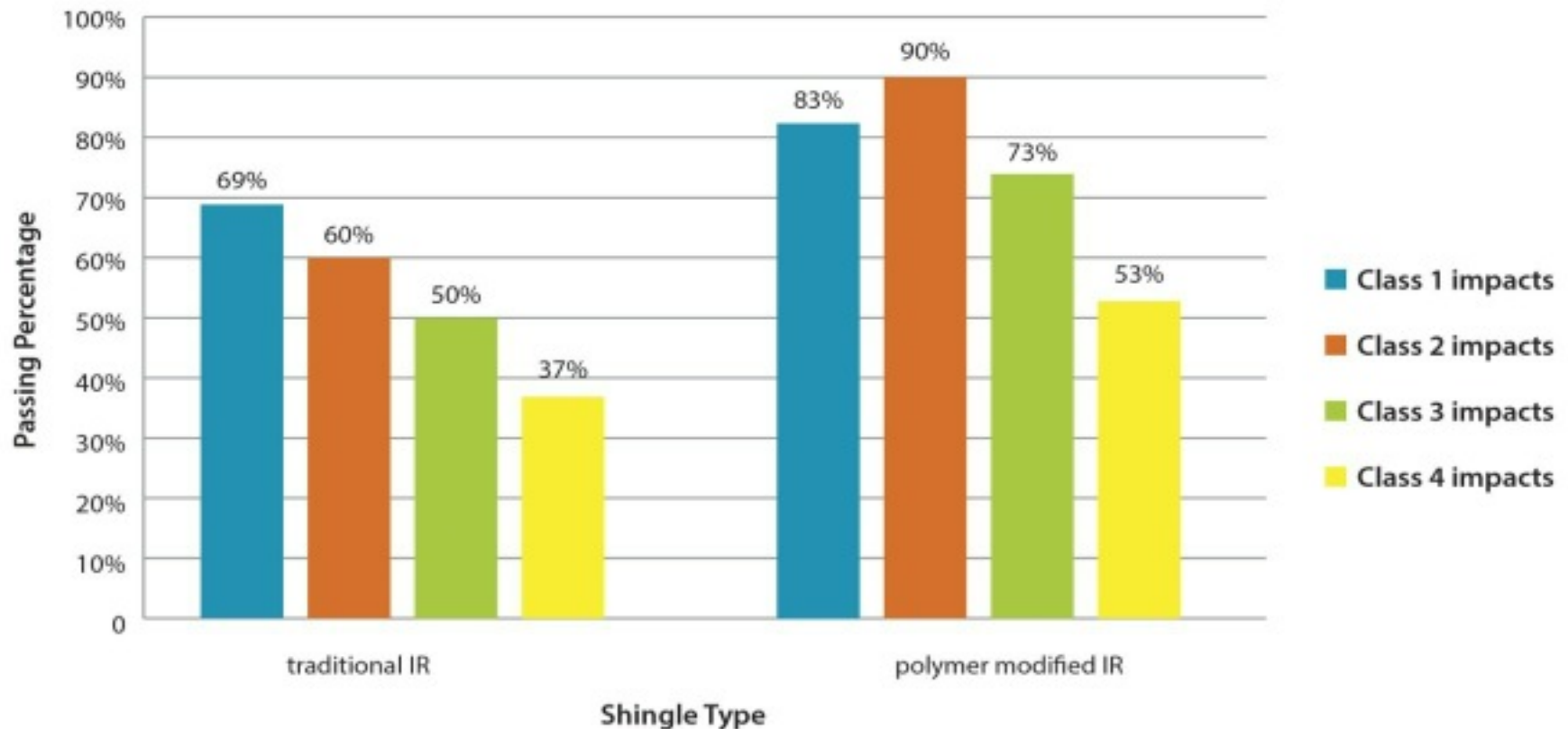
Asphalt Shingle Impact Resistance Testing

UL 2218 Impact Location Passing Rates:
Architectural, IR Architectural and Premium Architectural Shingles



Asphalt Shingle Impact Resistance Testing

UL 2218 Impact Location Passing Rates:
Polymer Modified IR vs. Traditional IR Shingles



Asphalt Shingle Impact Resistance Testing—Next Steps

- Panel variability—increase sample size for select products
- Subjective rating variability—include damage ratings from 4 or 5 independent raters for select products
- Ice testing
 - Limited sample of pure ice (FM 4473)
 - IBHS hailstones replicating natural hail
- Layers/substrates—approved for 2015

Full-Scale Impact Testing



- 12 hail cannons on upper catwalk
 - Computer-controlled firing system
 - Fully-controllable shooting speeds
 - Fully-controllable shooting frequencies

Full-Scale Impact Testing

- 3 sizes (1 in., 1.5 in., 2 in.)
- Adaptable for different sizes
- Structural vs. Aesthetic Damage
- Repair vs. Replace Methodologies



Full-Scale Impact Testing



Full-Scale Impact Testing



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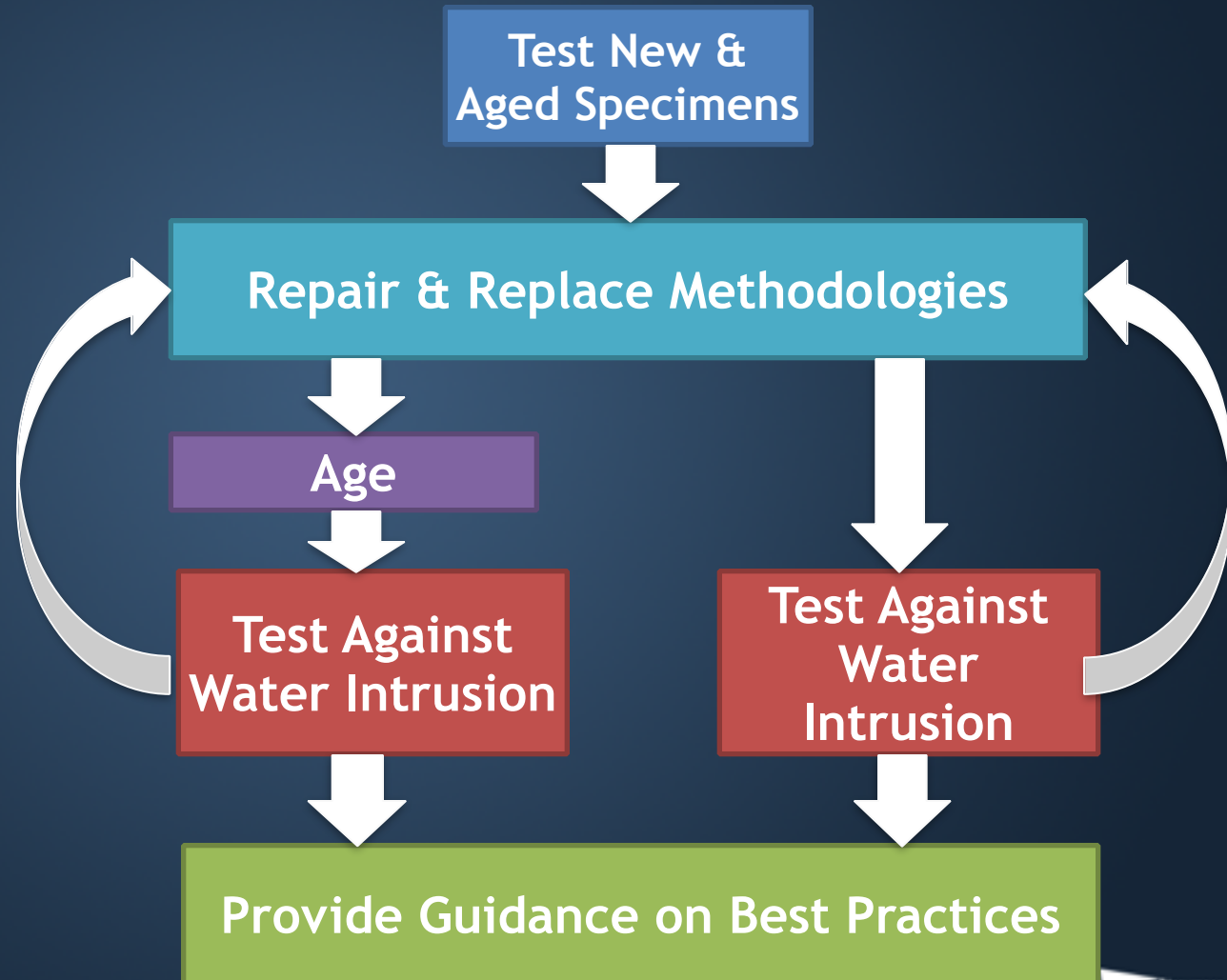
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Full-Scale Impact Testing

Future
Research
(after
automatic
hailstone
production)



Effects of Aging

Older
Roofs

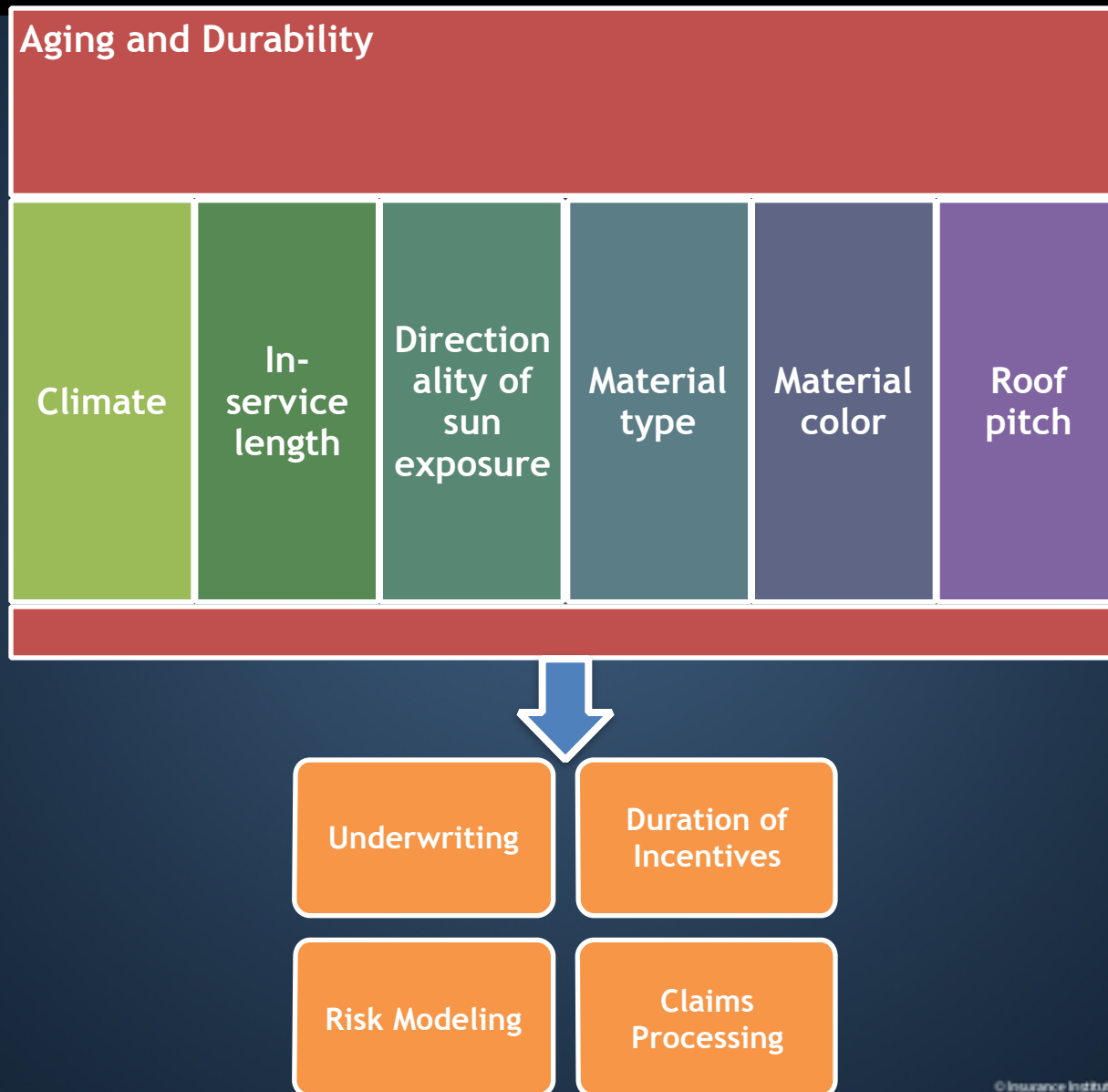


Higher
Claim
Frequencies



Higher
Claim
Severities

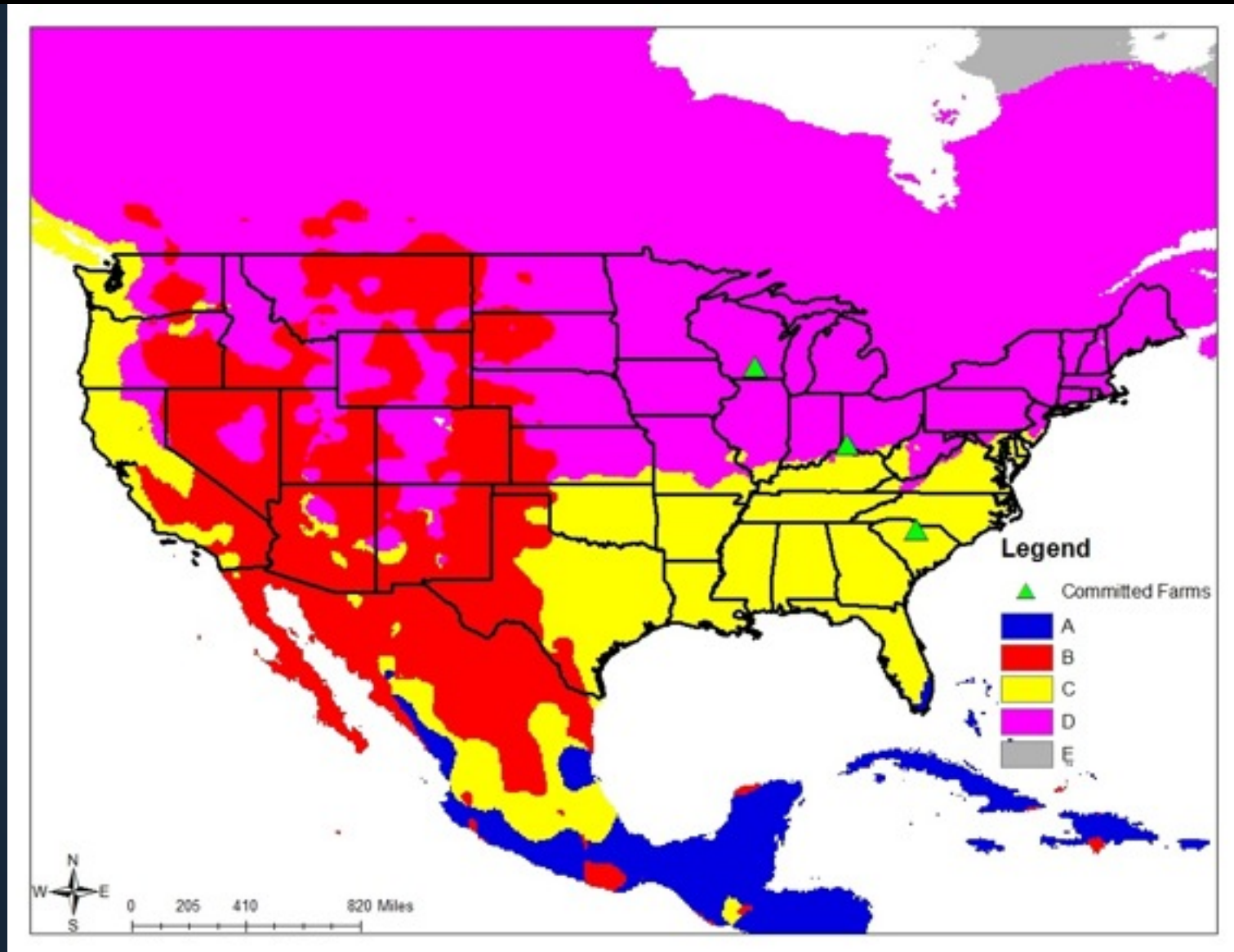
Impact of Aging on Insurance Industry



Roof Aging Farms



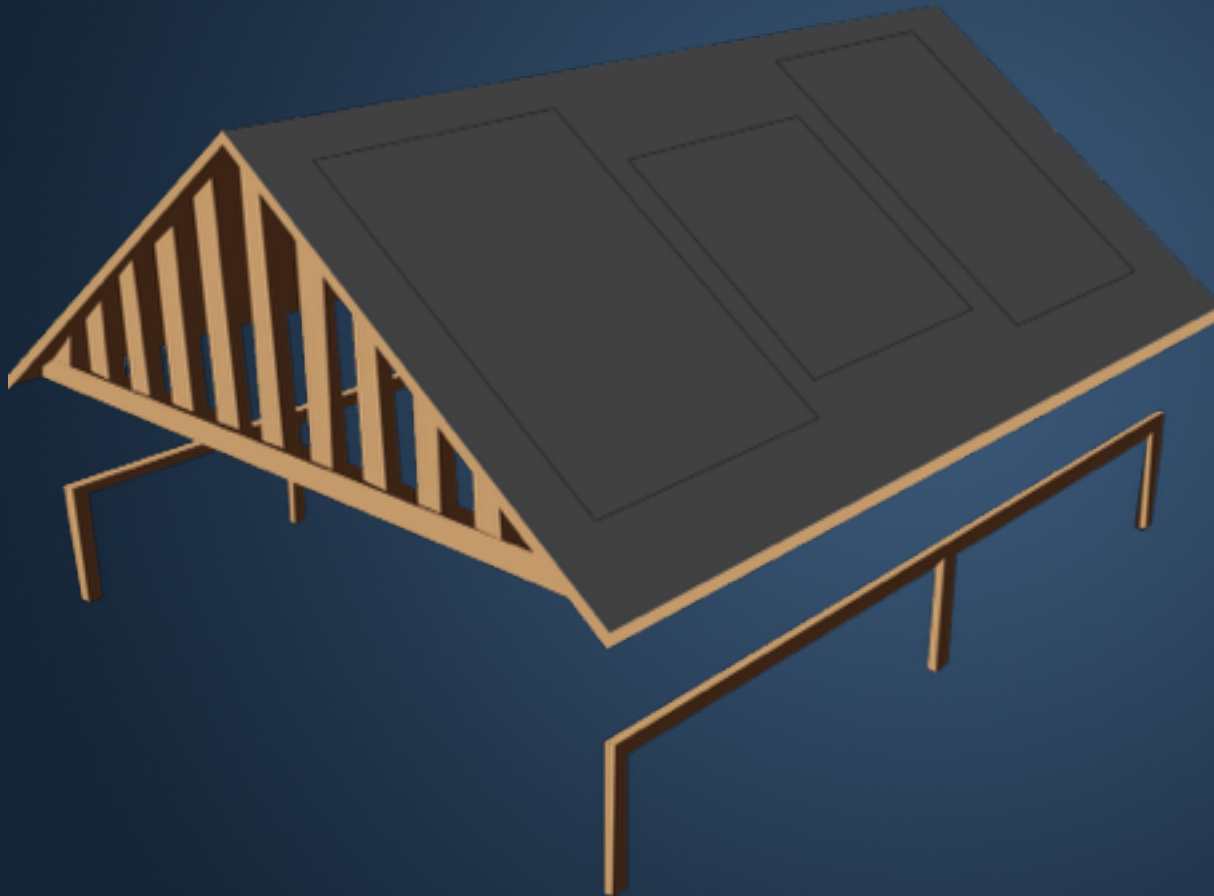
Roof Aging Farms: Climates



Roof Aging Farms

- Naturally age small roof specimens for wind and hail testing up to 20 years
- Test at five-year increments (baseline = new)
- Multiple test panels for each age; north and south facing

Roof Aging Farms



- **50 in. x 66 in. panels**
 - 2 north-facing
 - 2 south-facing
- **36 in. x 36 in. panels**
 - 1 north-facing
 - 1 south-facing

Roof Aging Farms: Areas of Focus

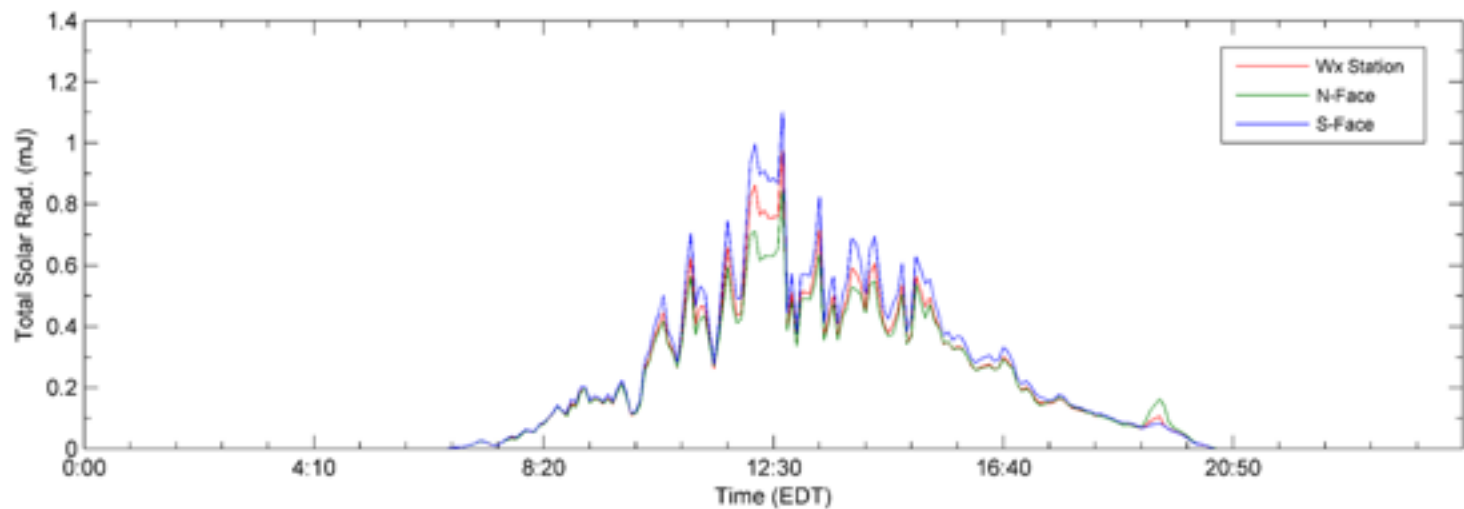
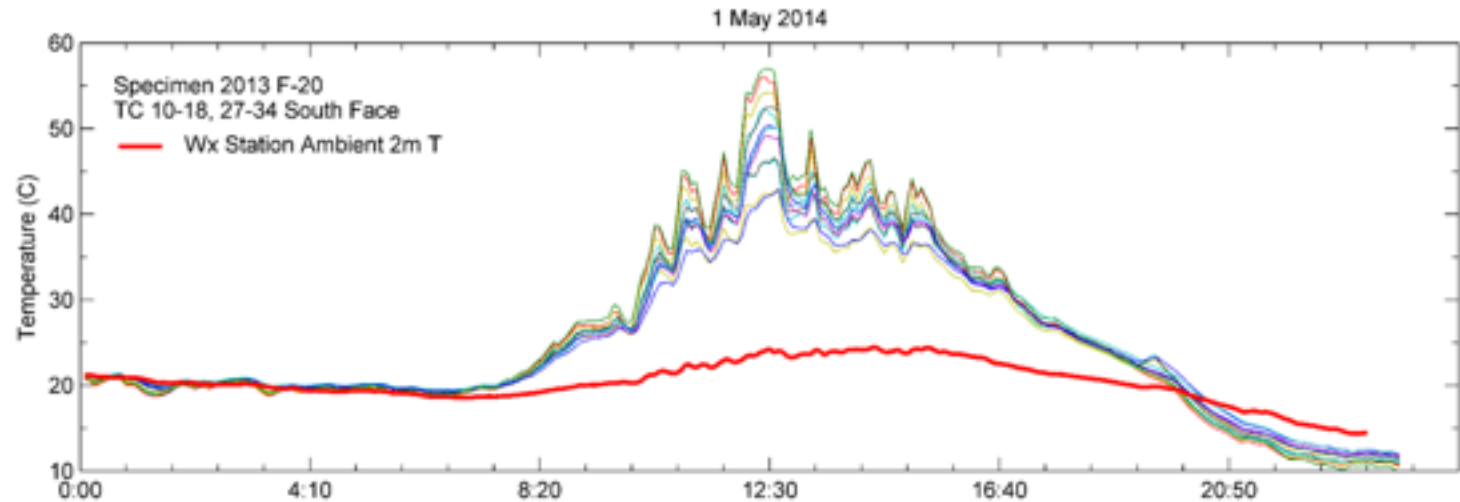
- 6/12 roof slope
- In-Service Length
 - Control (baseline)
 - 5-year
 - 10-year
 - 15-year
 - 20-year
- Similar colors
- Materials
 - 3-tab asphalt
 - Architectural asphalt
 - Traditional IR
 - Polymer Modified

Roof Aging Farms: Construction

- Both roof slopes instrumented with thermocouples
- Adjacent weather station



Roof Aging Farms: Data

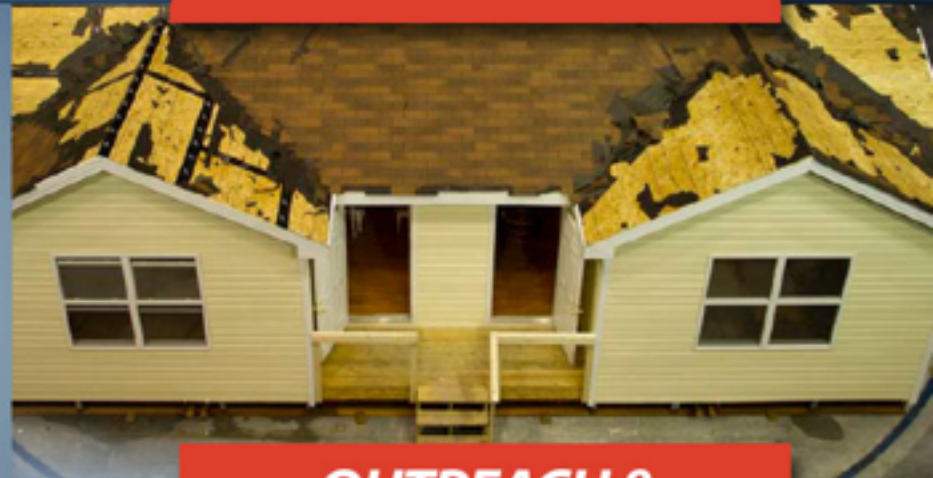


Protection from the Top: Focus on the Roof

RESEARCH



CODE PROPOSALS



COMMUNICATIONS

**OUTREACH &
TRAINING**

Roofing the Right Way
RE-ROOFING THE RIGHT WAY FOR SHINGLE ROOFS IN HURRICANE-PRONE AREAS

When it's time to replace your roof, due to weather-related damage or simply age, follow the advice in this guide to improve the long-term performance of your new roof. When you're ready to get started, find a qualified roofing contractor. Proper installation directly impacts a roof's long-term performance. Take the time to check the contractor's references and their insurance coverage (or "professional liability insurance") and to talk to the contractor about your expectations.

NINE STEPS TO REPAIRING YOUR ROOF THE RIGHT WAY

- REMOVE THE OLD ROOF COVER:** Remove the damaged or aged roof cover and underlying building paper or underlayment to expose a roof deck. The deck should be clean and provide the smooth surface needed to fasten shingles so that the new roof cover achieves its full strength.
- INSPECT FOR DAMAGE:** Look at the roof deck for rotting, deteriorating, warping or other signs of damage. If any of these signs are present, the contractor should be notified as soon as possible.

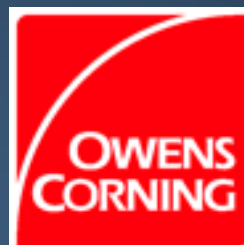
with vertical surfaces, in roof valleys or any location where the roof changes slope, and at eaves and gable ends. Verify that all fasteners are installed in accordance to weather-resistant fasteners. Installation of the deck should be followed by a moisture barrier membrane and underlayment or metal flashing installed in the valleys & eaves.

- All exposures of the roof with vertical surfaces, gullies, eaves and gable ends, flashing should extend up the vertical surface be covered with seal coating and applied over high quality felt.
- A comprehensive checklist should be provided at every stage of the project.

Is your roof FORTIFIED?

A photograph of a house with a red roof, likely a Fortified Roof. The house is white with a red roof and a chimney.

Roofing Industry



Questions?

Tanya Brown

tbrown@ibhs.org

www.disastersafety.org