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

Insurance Institute for Business & Home Safety

“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

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
FORTIFIED


WILDFIRE


HAIL


RAIN
© Insurance Institute for Business & Home Safety

IBHS Research Center Results

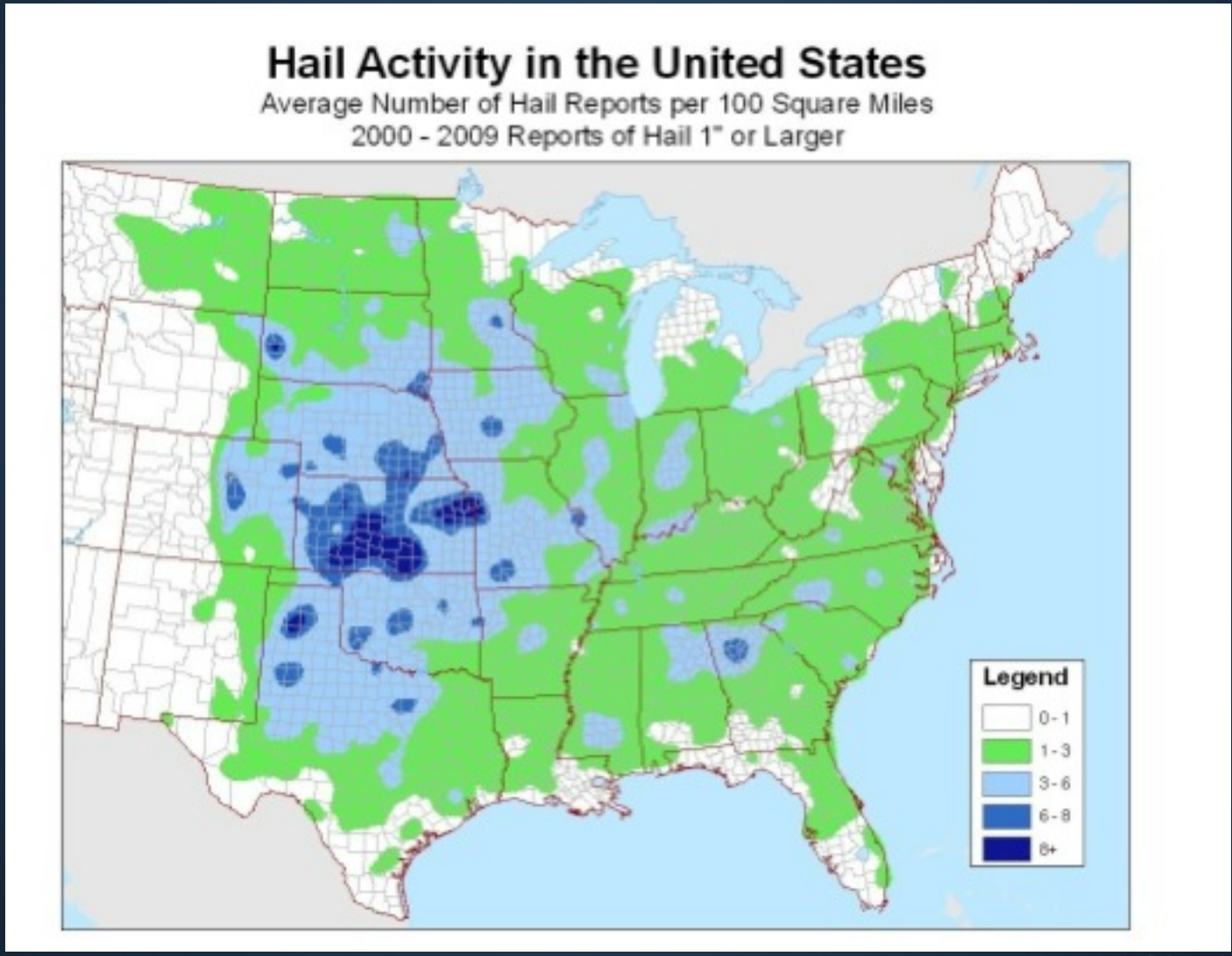
Gain a better understanding of:

- 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

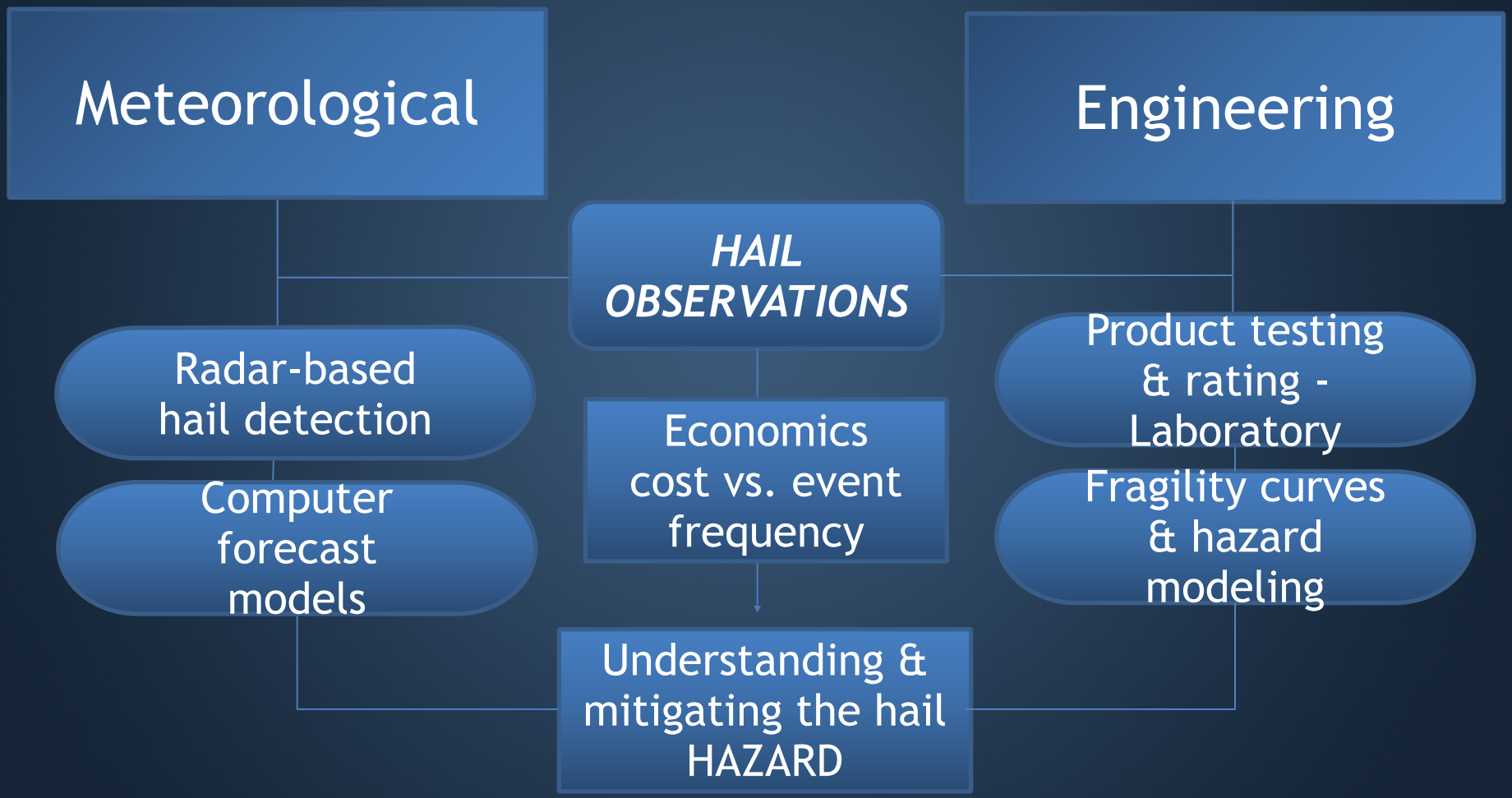
Hailstorm Risks

- 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



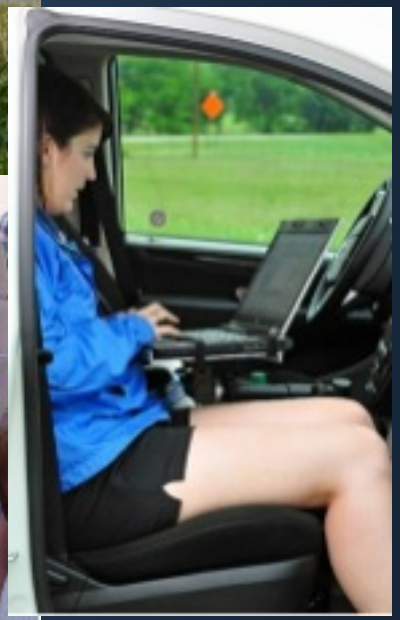
Multidisciplinary Approach



IBHS Hail Research:
Pushing the Boundaries of Building Science

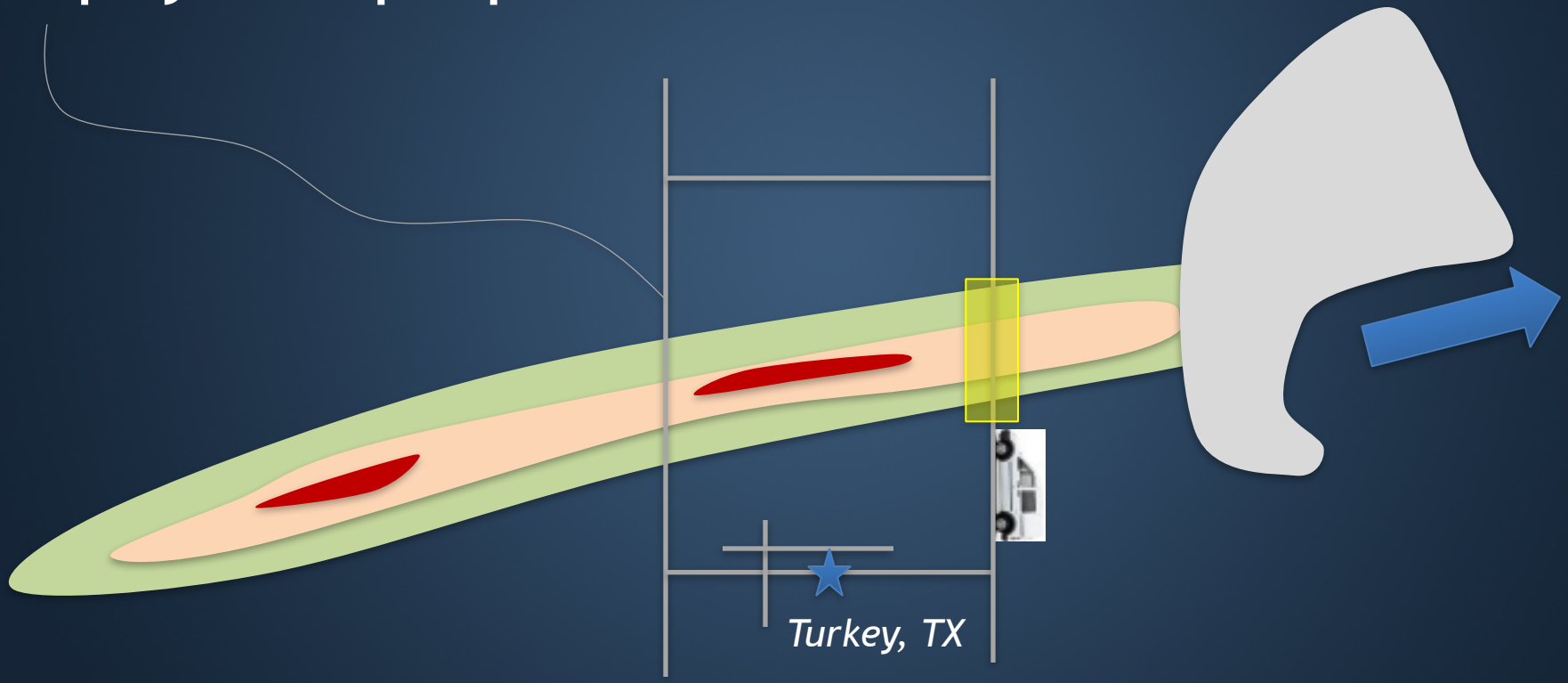
- Full-scale hailstorm simulation; three sizes of hailstones
- Small roof and component panel impact testing
- Field work to validate laboratory findings; improve hail forecasting and detection

Hailstone Characteristics Field Project



Hailstone Characteristics Field Project

Mission: Safely collect measurements of the physical properties of hail



Hailstone Characteristics Field Project

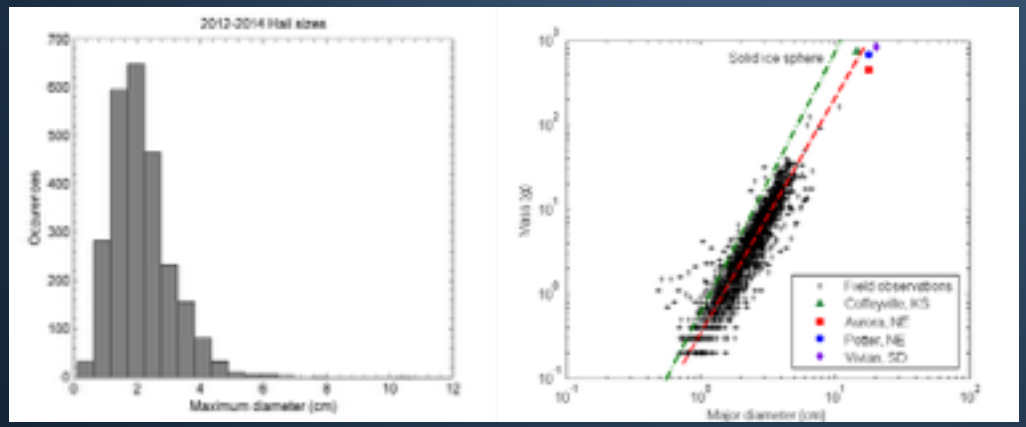
- Develop relationships between hailstone characteristics and environmental/radar data
- Understand spatial and temporal variability in hailfall

Hailstone Characteristics Field Project

Photograph

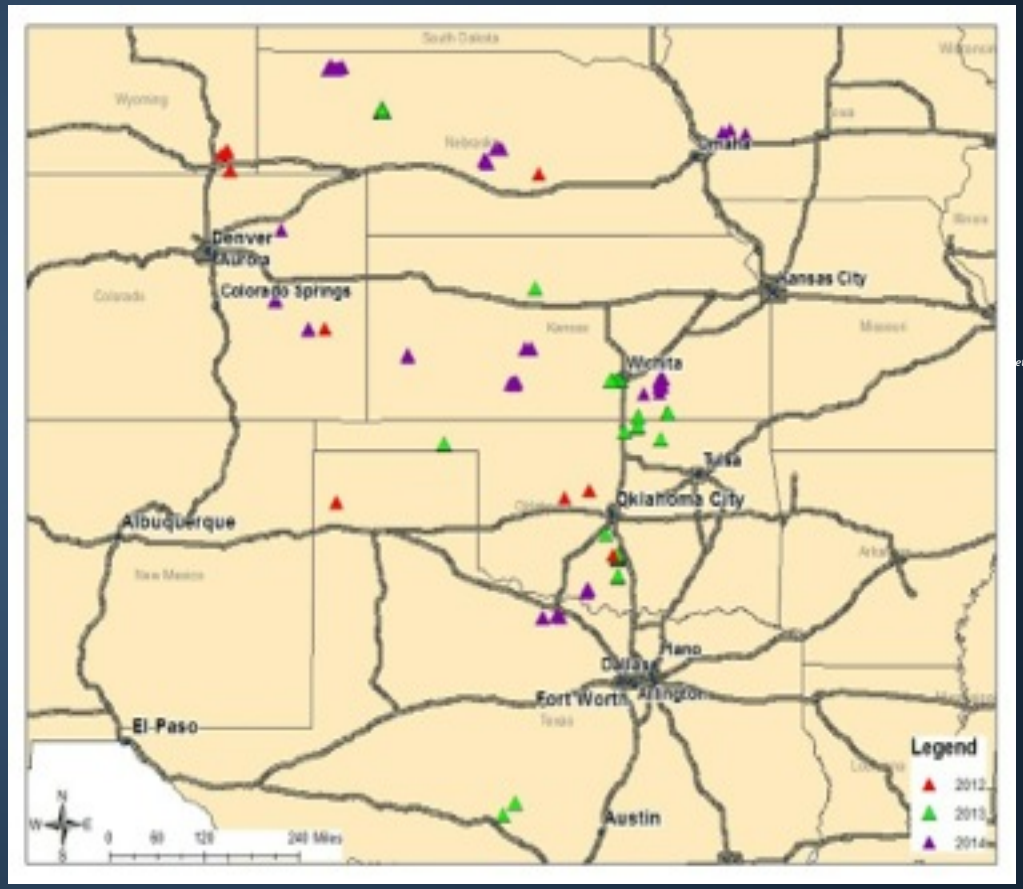
Measure/Weigh

Crush Test

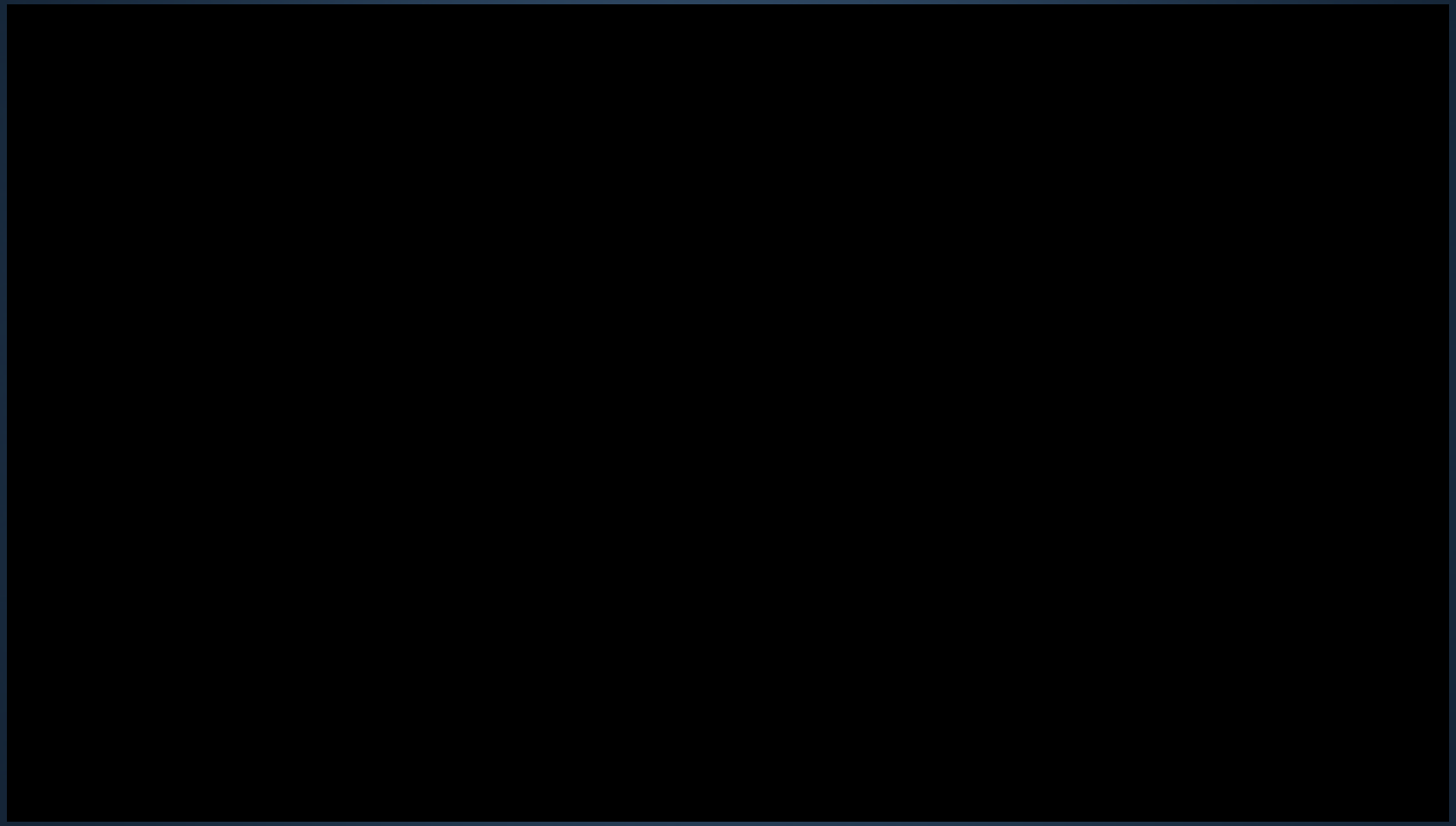


Hailstone Characteristics Field Project

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

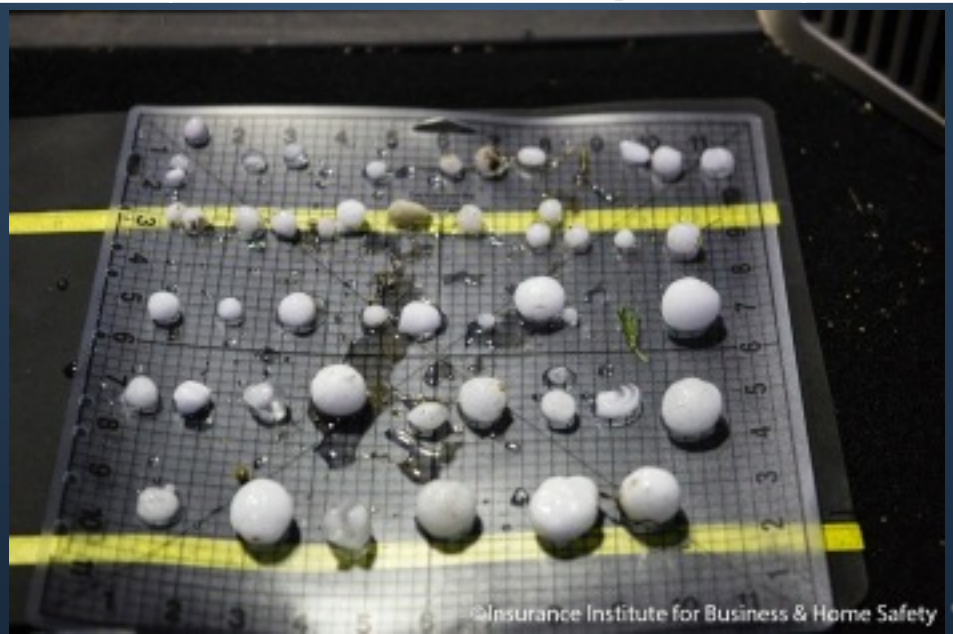


Hailstone Characteristics Field Project



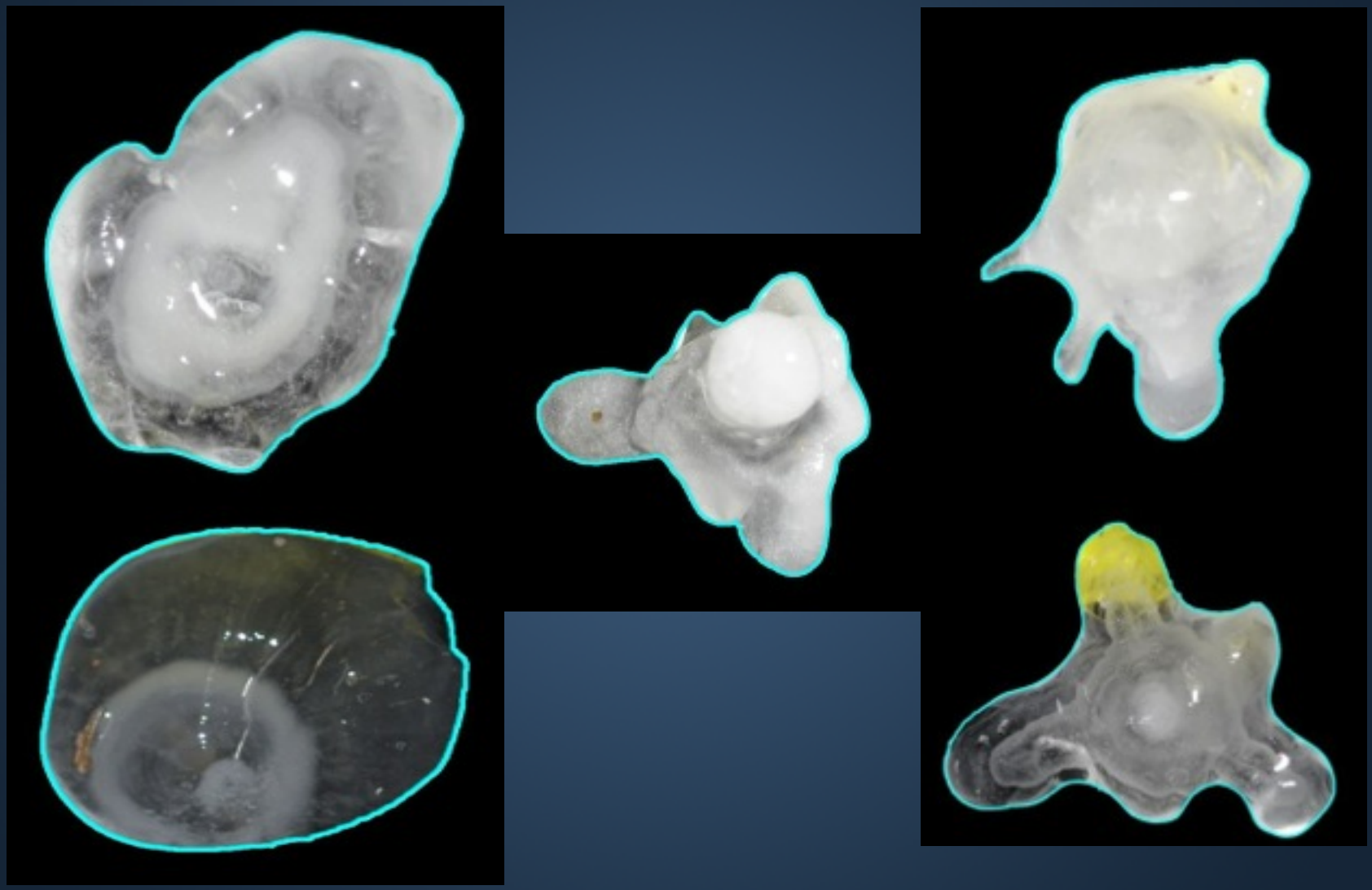
Hailstone Characteristics Field Project

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

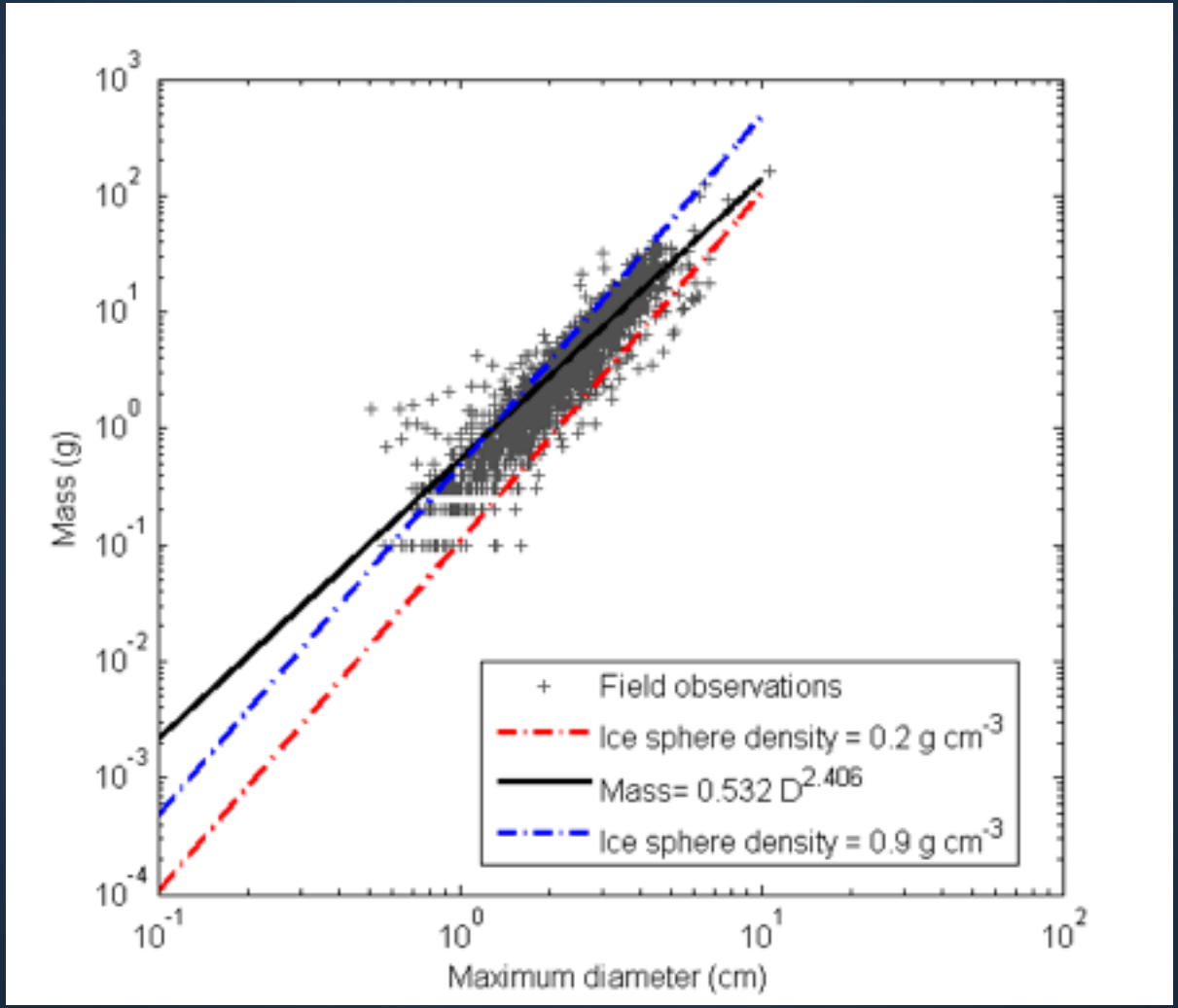


Hail Hazard: Shapes

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

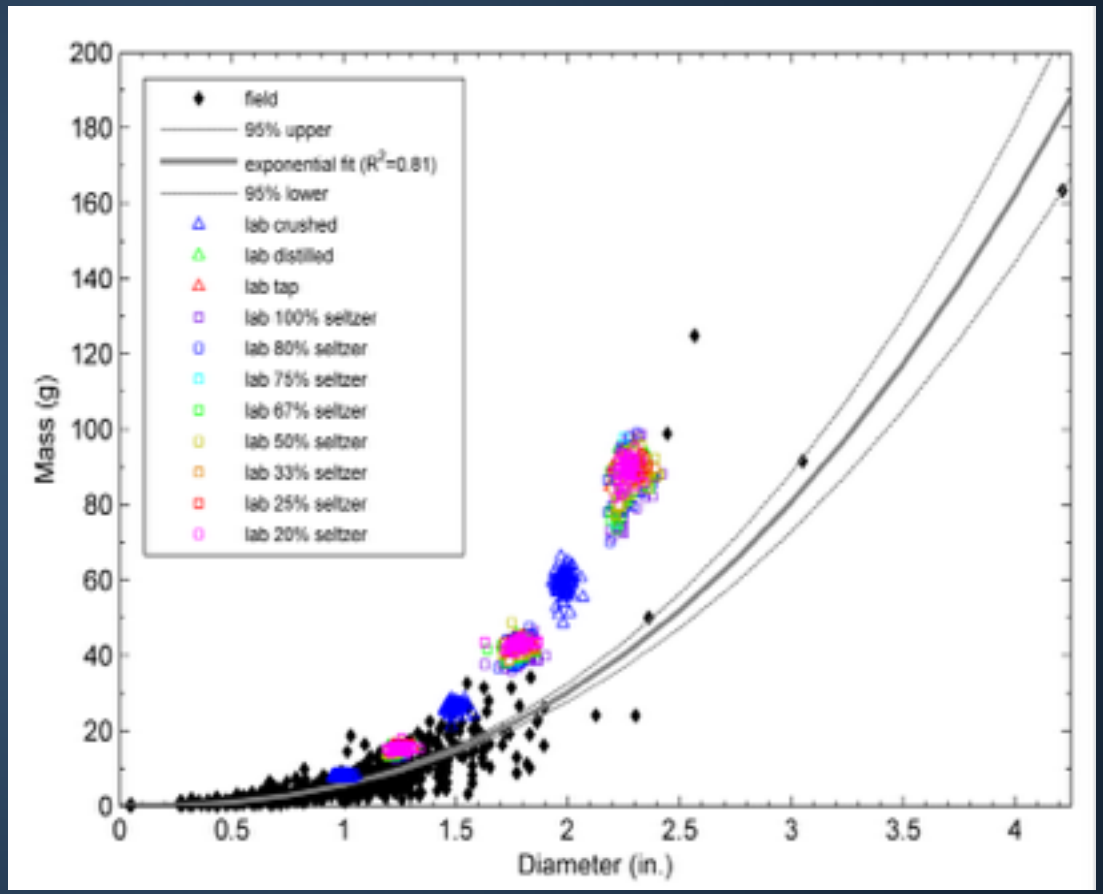
Standardized tests

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

"worst case impact"

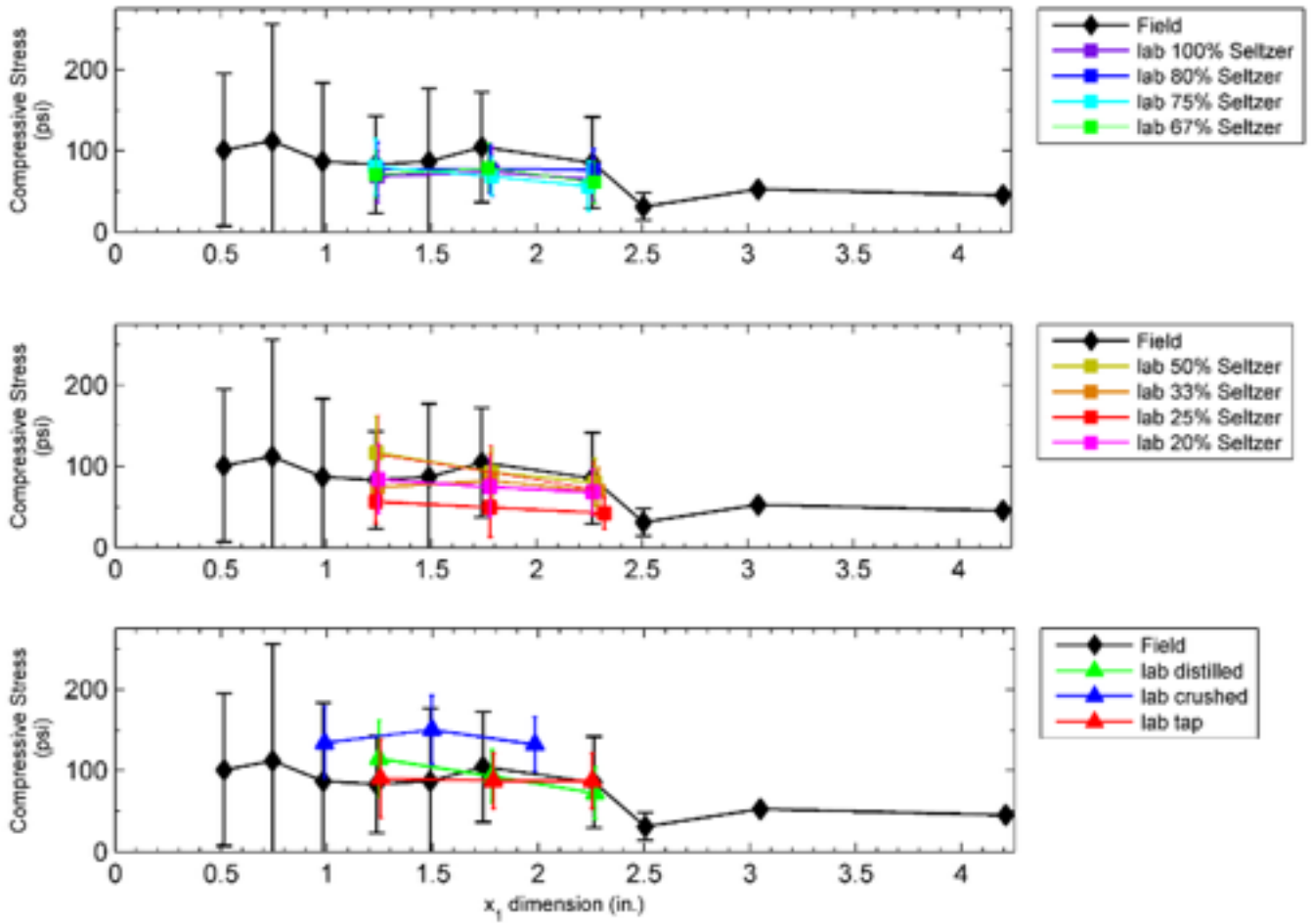
Field observations

- 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

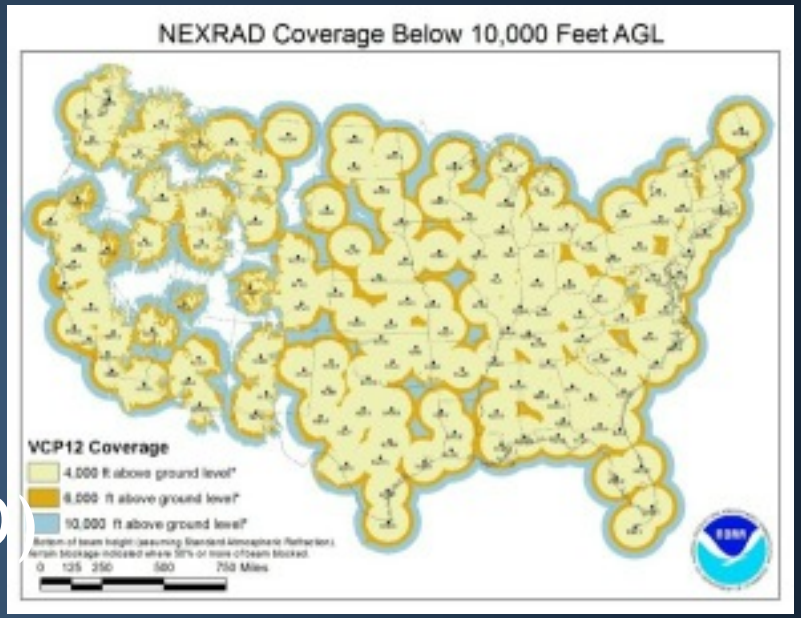
When we shoot a 2 in. stone, it's really like a typical 2.65 in. hailstone
UL 2218 & FM 4473 kinetic energy all based on spheres

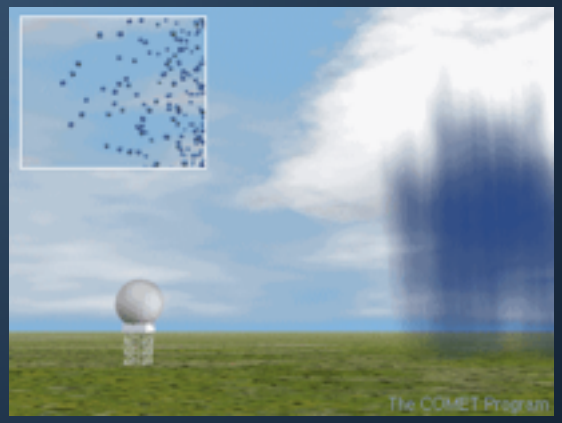
Hail: Loss Reduction

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

Hail: Radar Detection

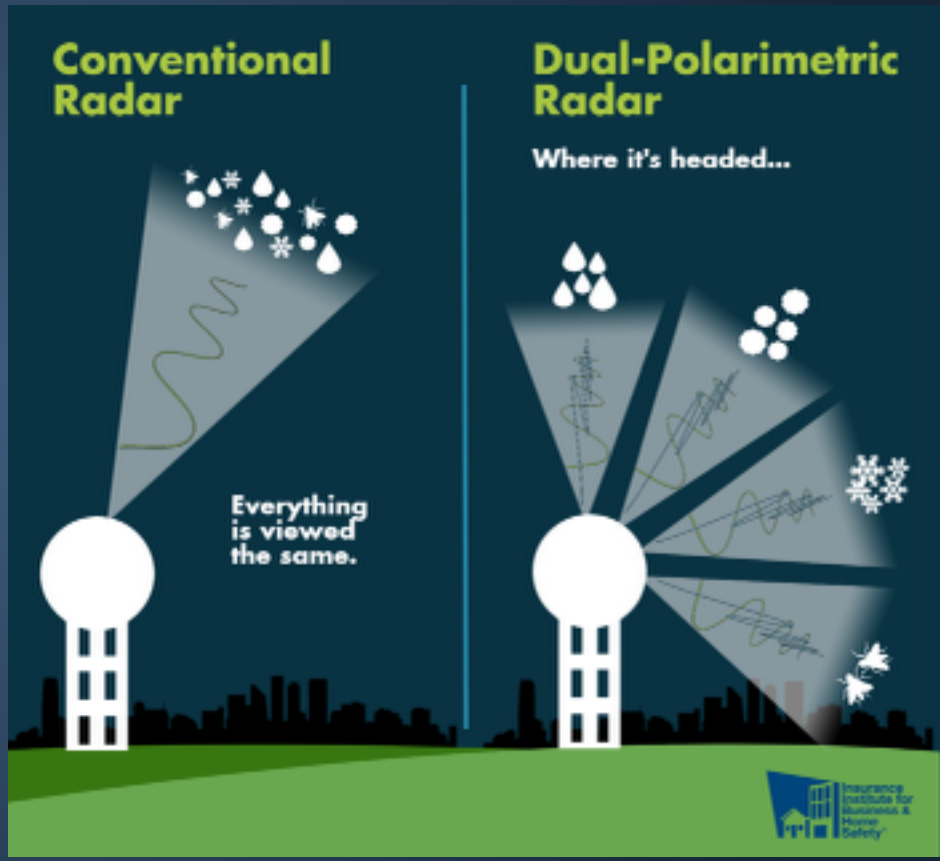
- National Weather Service Network of Doppler Radars
- WSR-88D
- First deployed 1988 (NEXRAD)
- Operate continuously
- Data are free



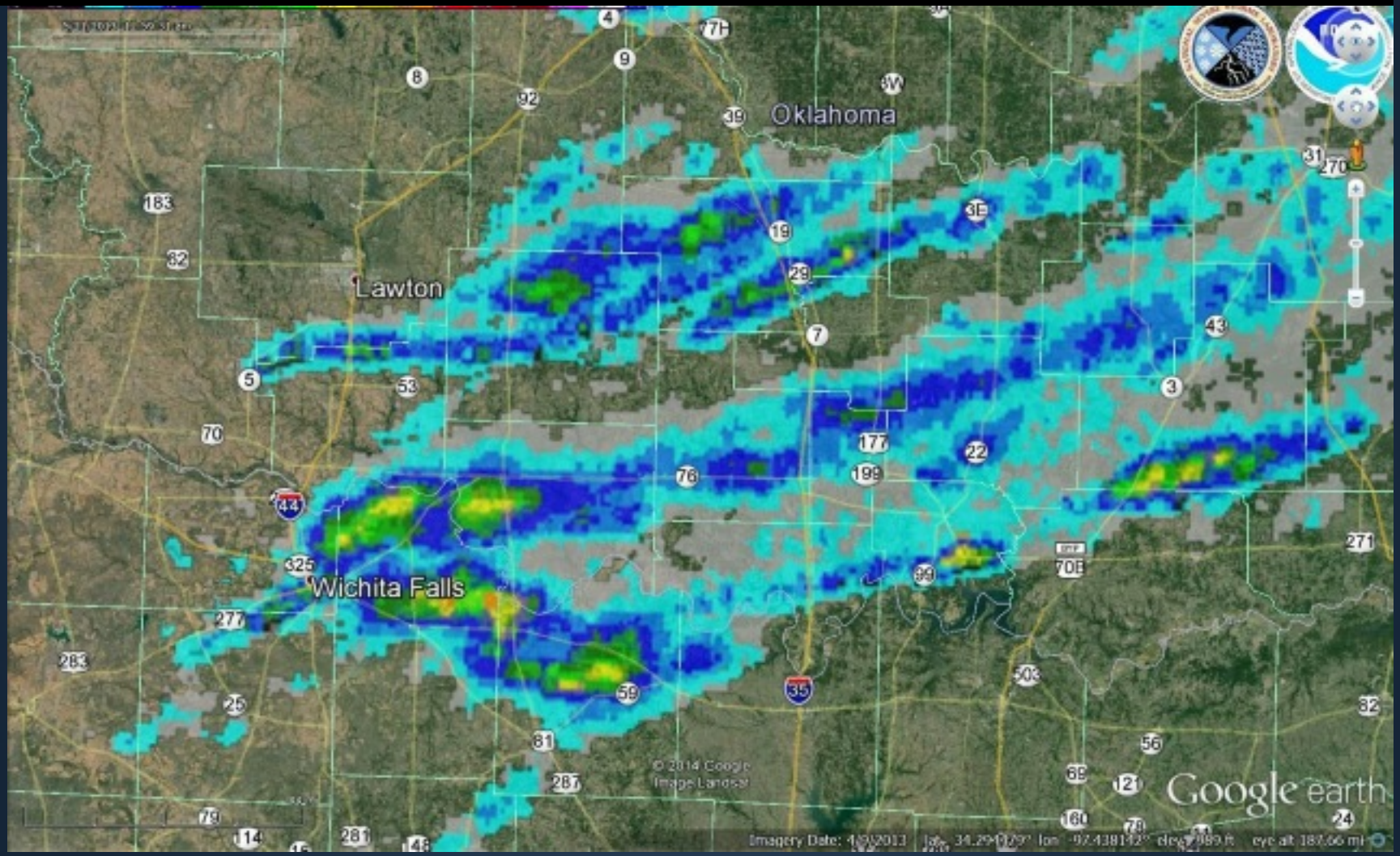


Hail: Radar Detection

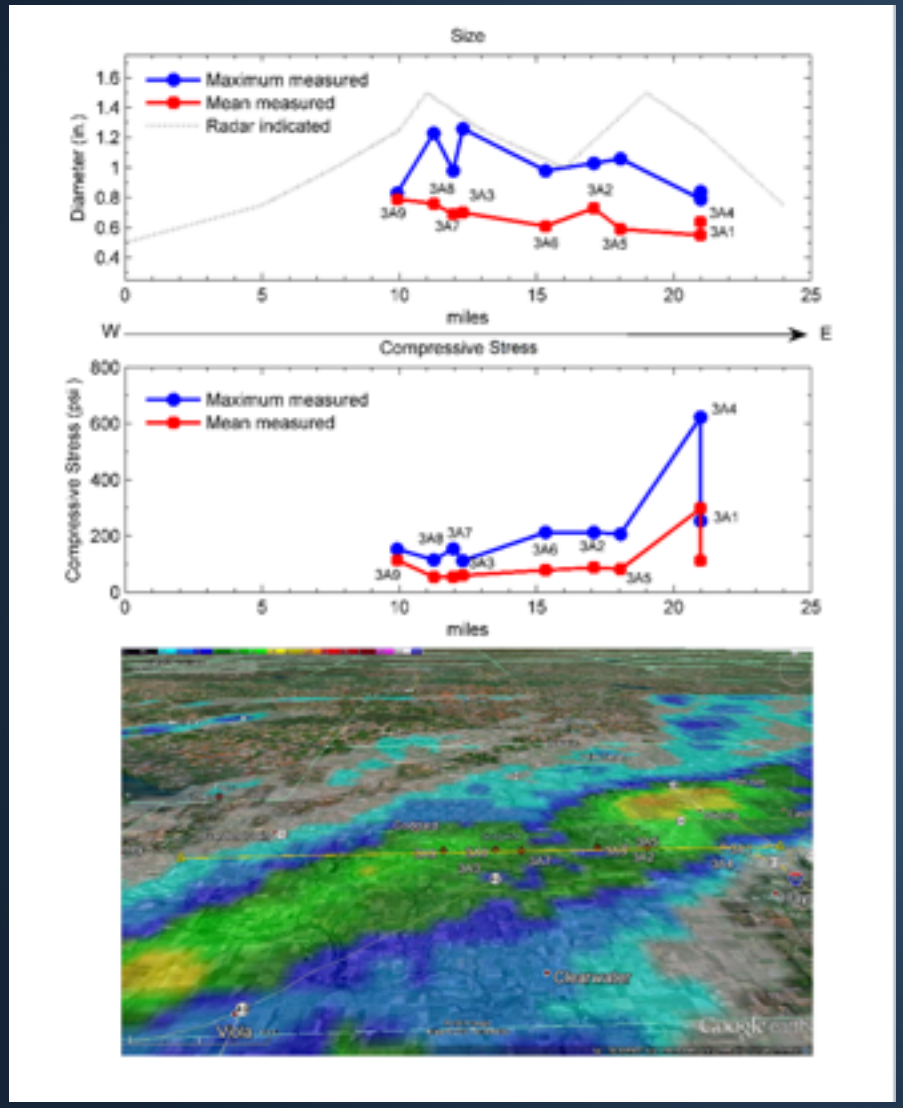
- All NWS radar upgraded to "dual-pol" (2013)
- Collaboration with Dr. Matt Kumjian (Penn State)
- Develop and improve dual-pol hail detection
- No "operational" hail size or concentration algorithm using dual pol information
- Only classification: "HAIL/ HEAVY RAIN"
- Field observations for validation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

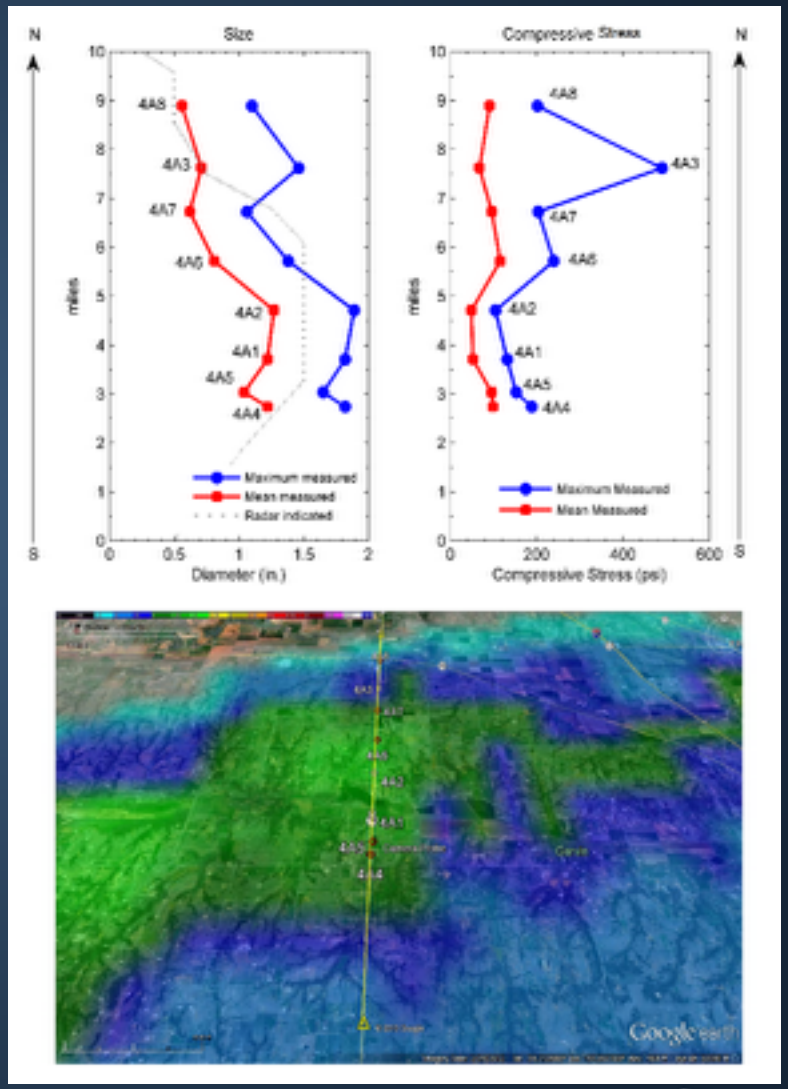


Hail: Conventional Radar Detection

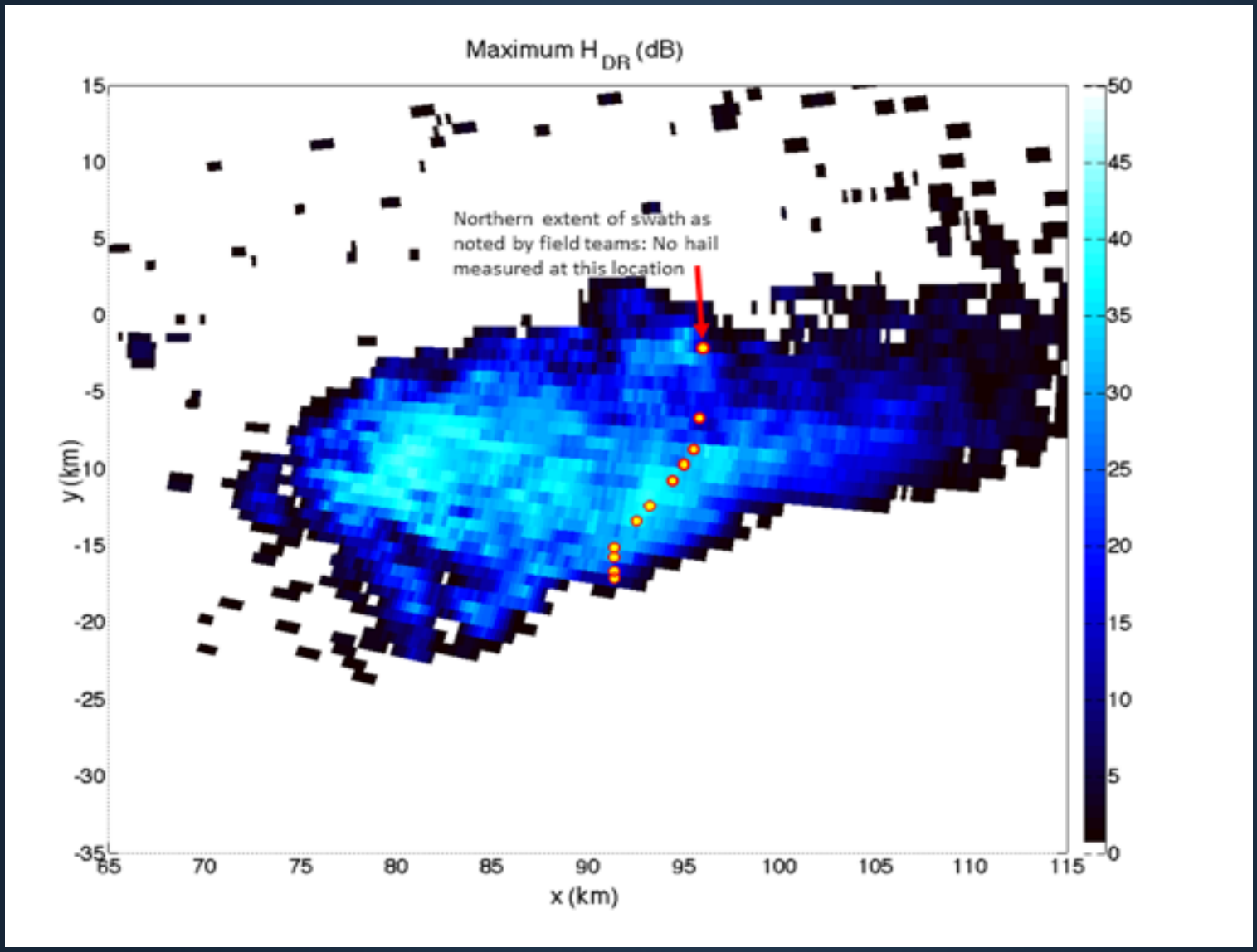


Hail: Conventional Radar Detection



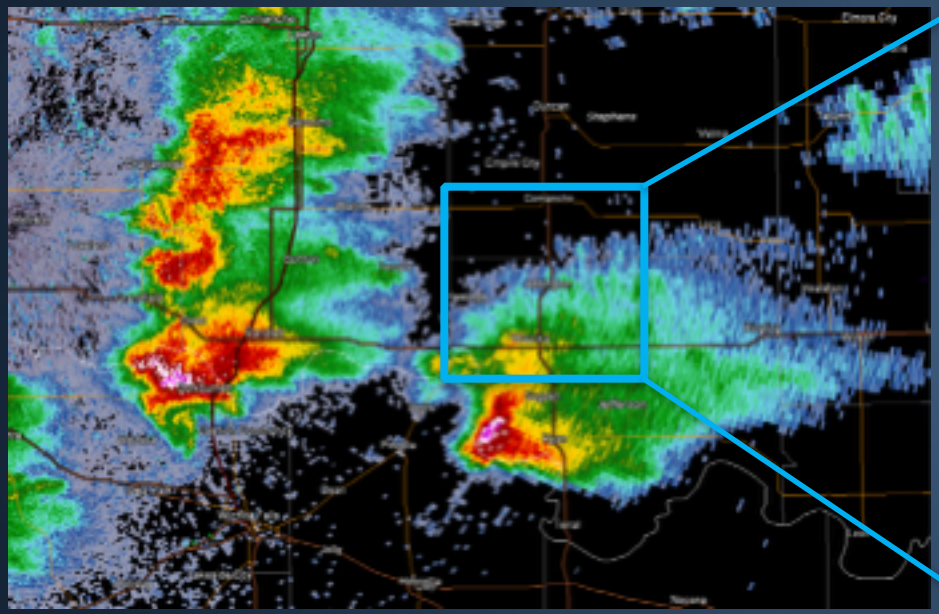


Hail: Emerging Radar Detection

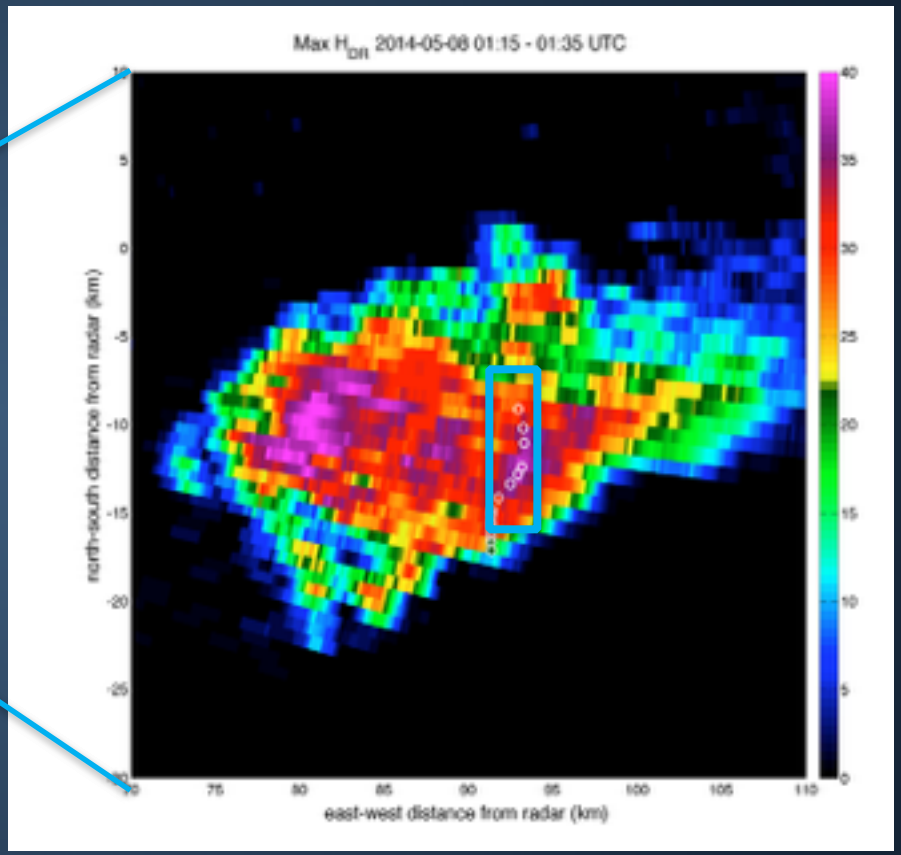


Data courtesy of Matt Kumjian (Penn State)

Hail: Emerging Radar Detection



Conventional radar reflectivity

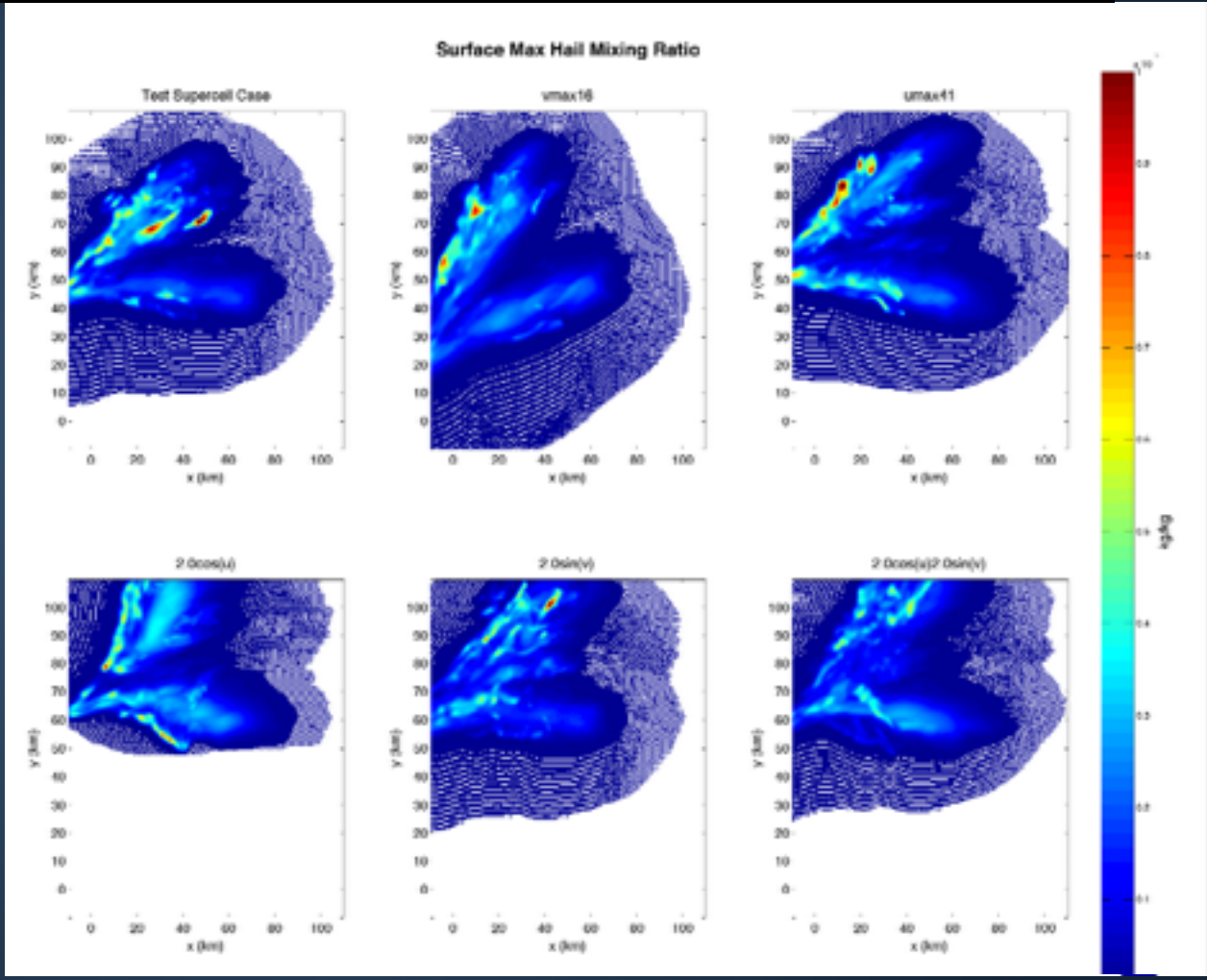


Dual pol derived swath – contribution of hail to backscattered energy at lowest radar scan

Data courtesy of Matt Kumjian (Penn State)

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



Dennis and Kumjian 2014 (Penn State)

Hail Impact Disdrometer Probes

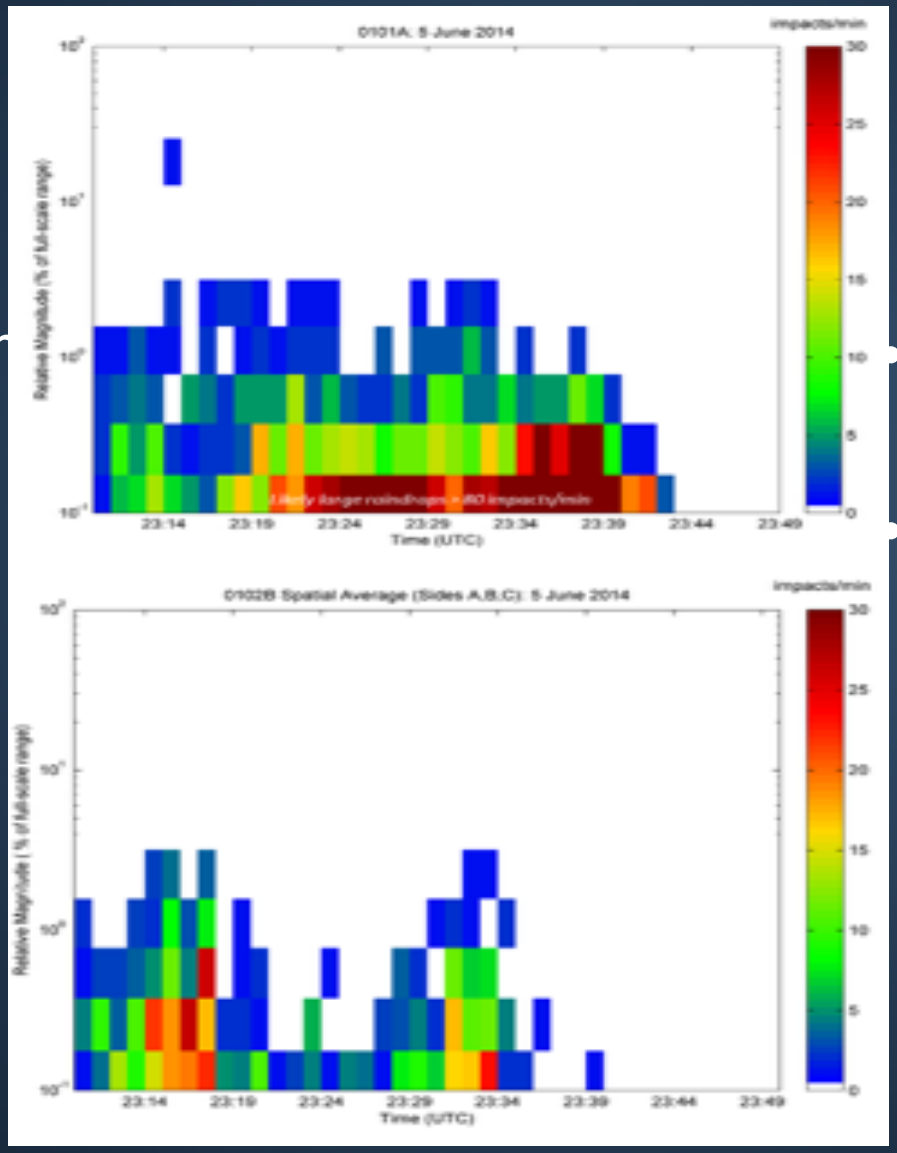
- Rapidly deployable
- Detect hail impacts
- Group into sizes
- Impact energy
- RUGGED!!!

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

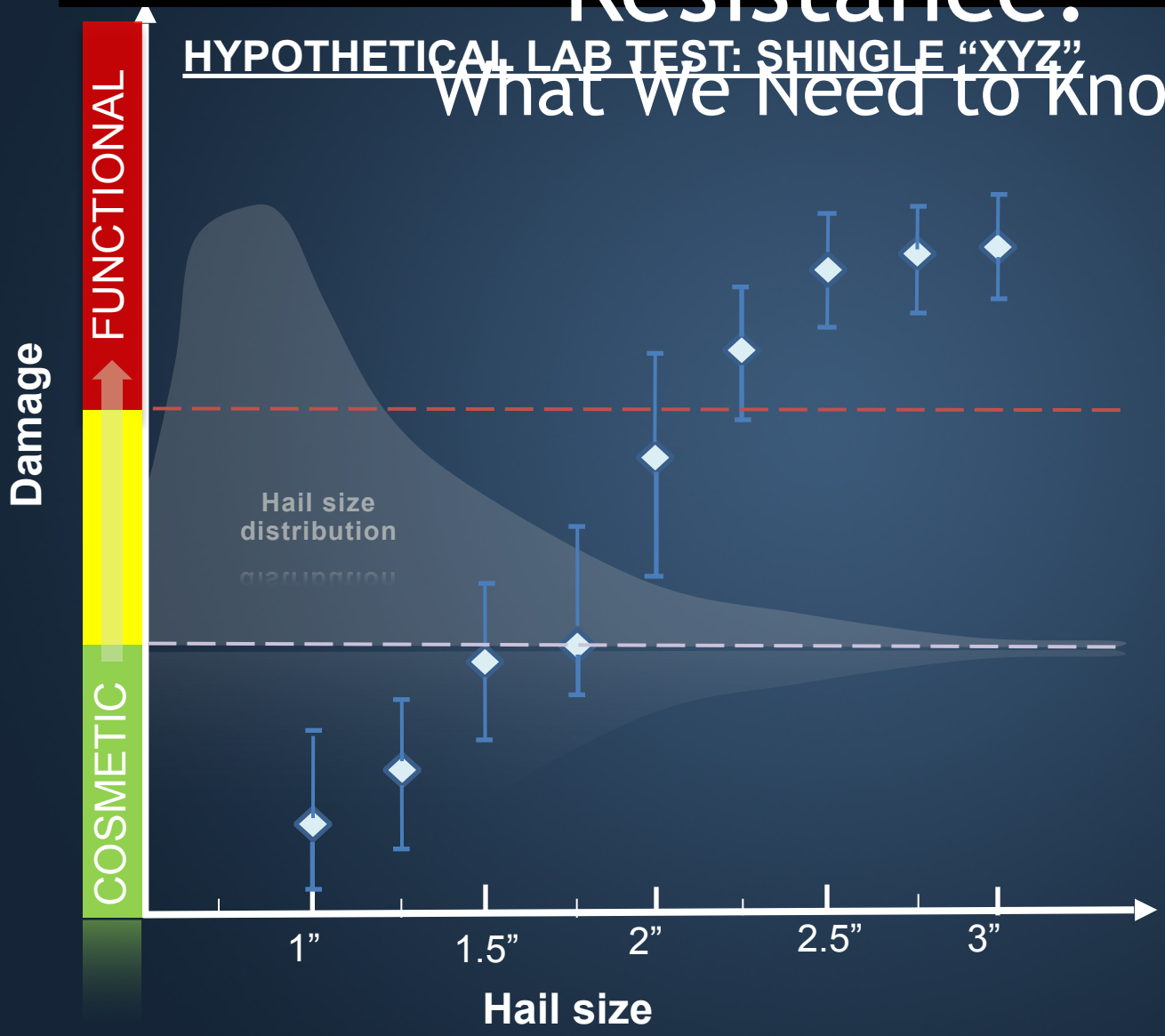
Three piezo-electric sensors



- Punkin Center, CO; 5 June 2014
- Large volume of small hail
  - 10-20 impacts per minute

Asphalt Shingle Impact Resistance:

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

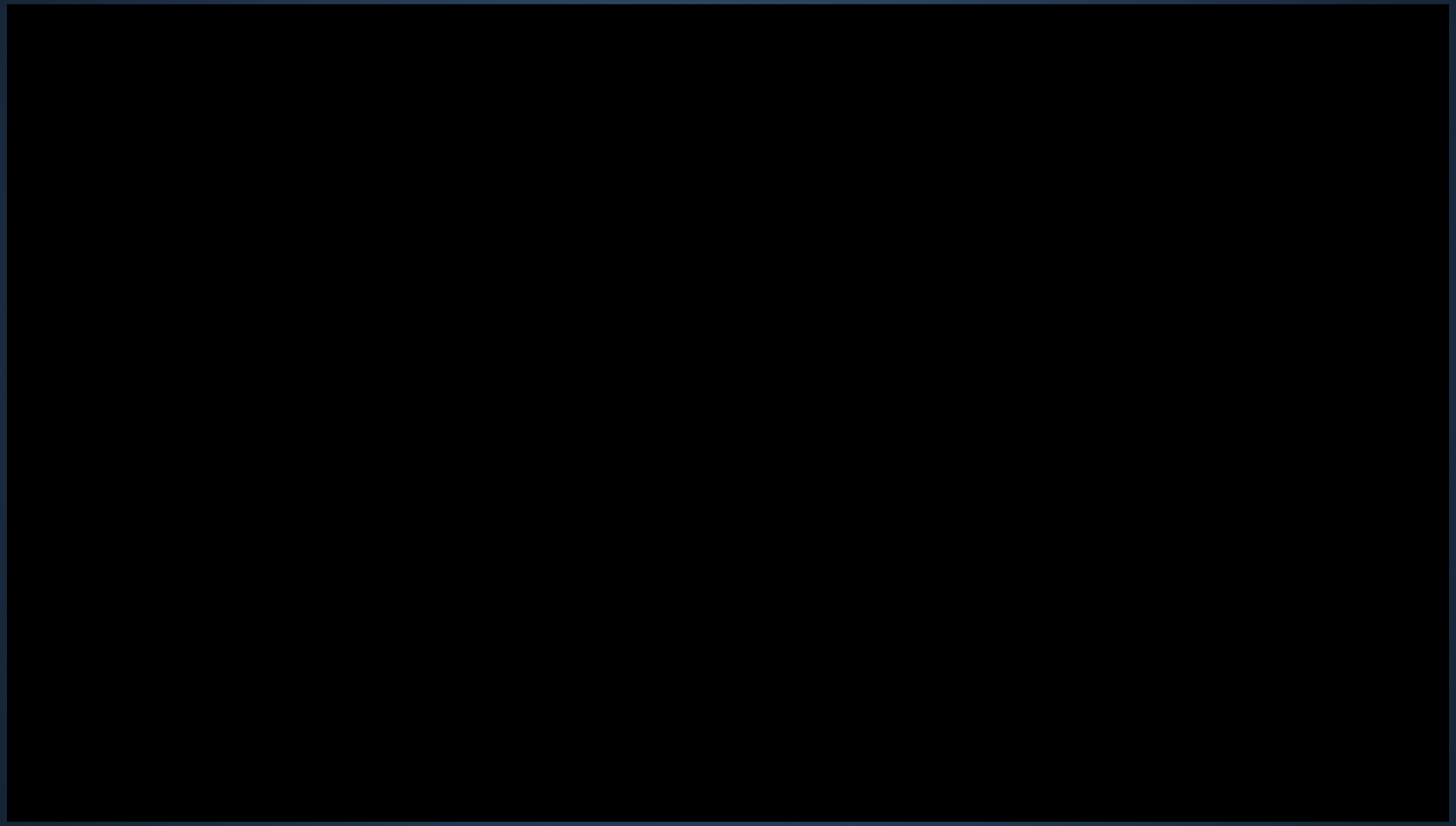
UL 2218 Shingle Impact Test Method

- 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 ºF
- 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

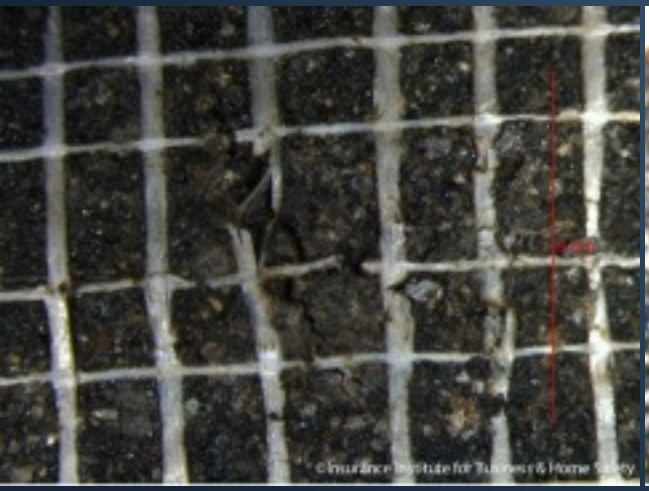


Asphalt Shingle Impact Test Observations

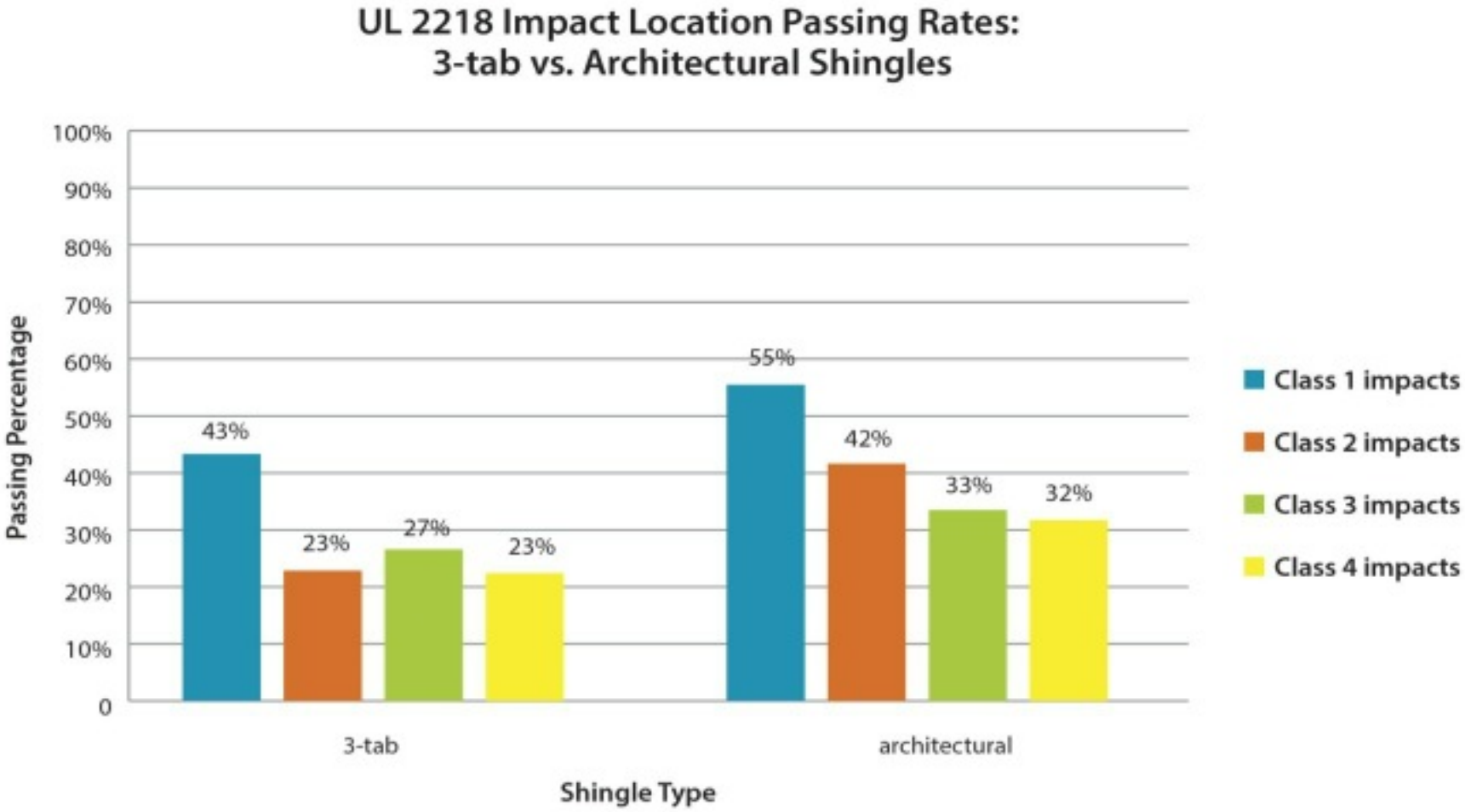
- Common impact marks
  - Crushed granules—visible on all panels, not seen in real-world
  - Dents—most severe at midspan 2 x 4 brace
  - Flattening of shingles—particularly at edges, joints, corners

Asphalt Shingle Impact Test Observations

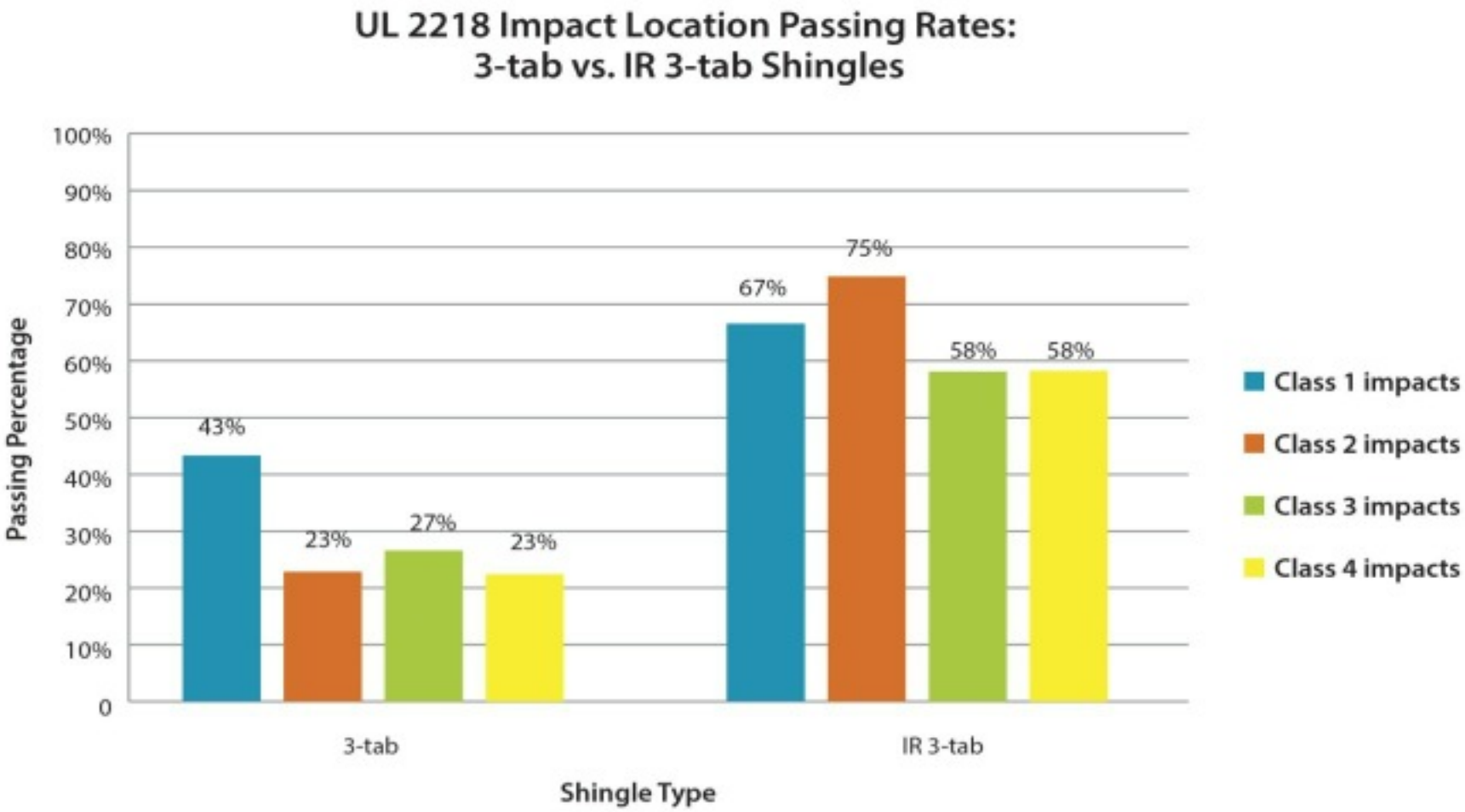
- Common performance criteria failures
  - Cracks—through 3-tab and single-ply ply portion of architectural shingles; both plies of double-ply
  - Tears—at edge of 3-tab and single-ply portion of architectural shingles; both plies of double-ply
  - Unclear if one damage mode is more detrimental



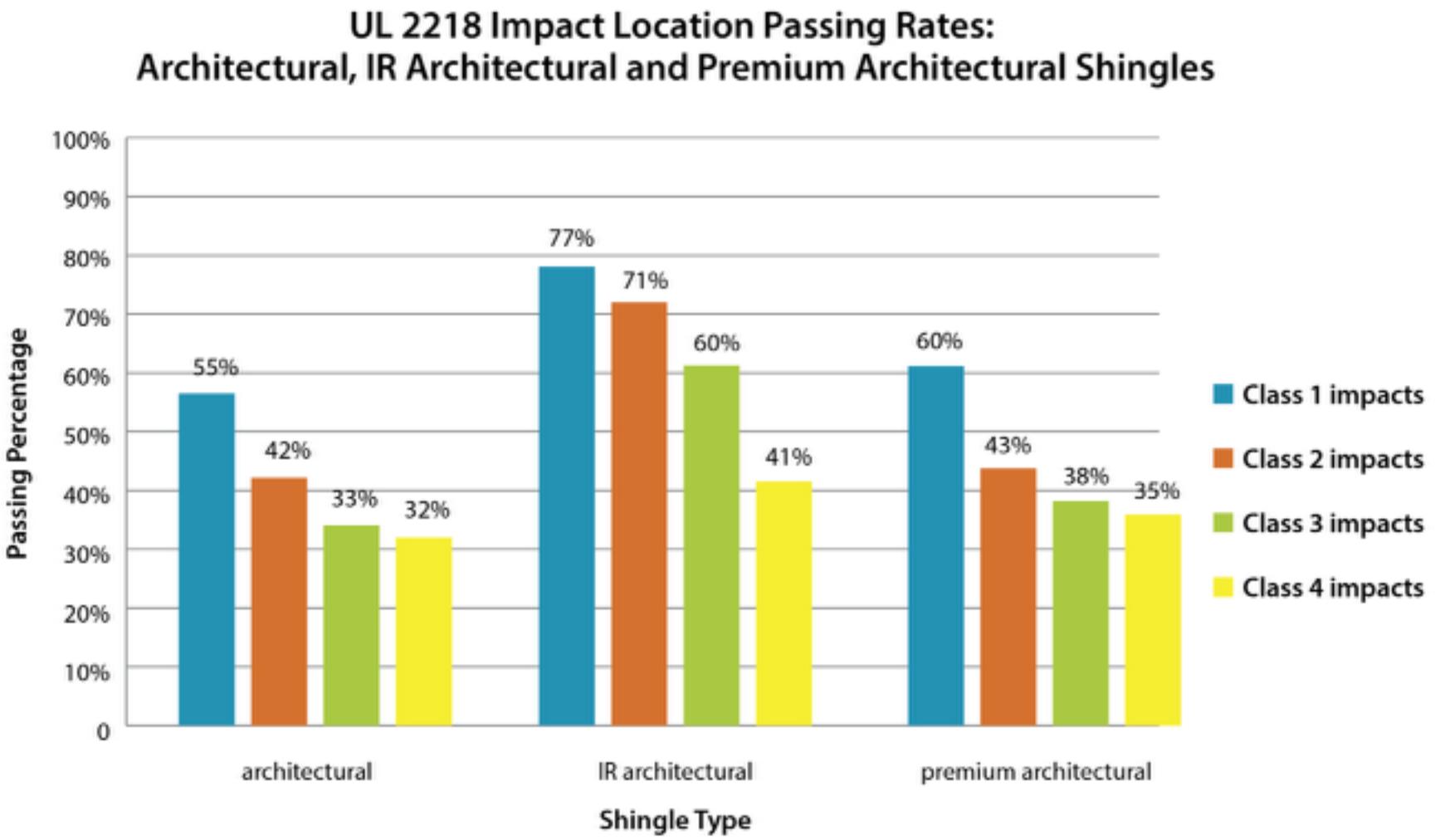
Asphalt Shingle Impact Resistance Testing



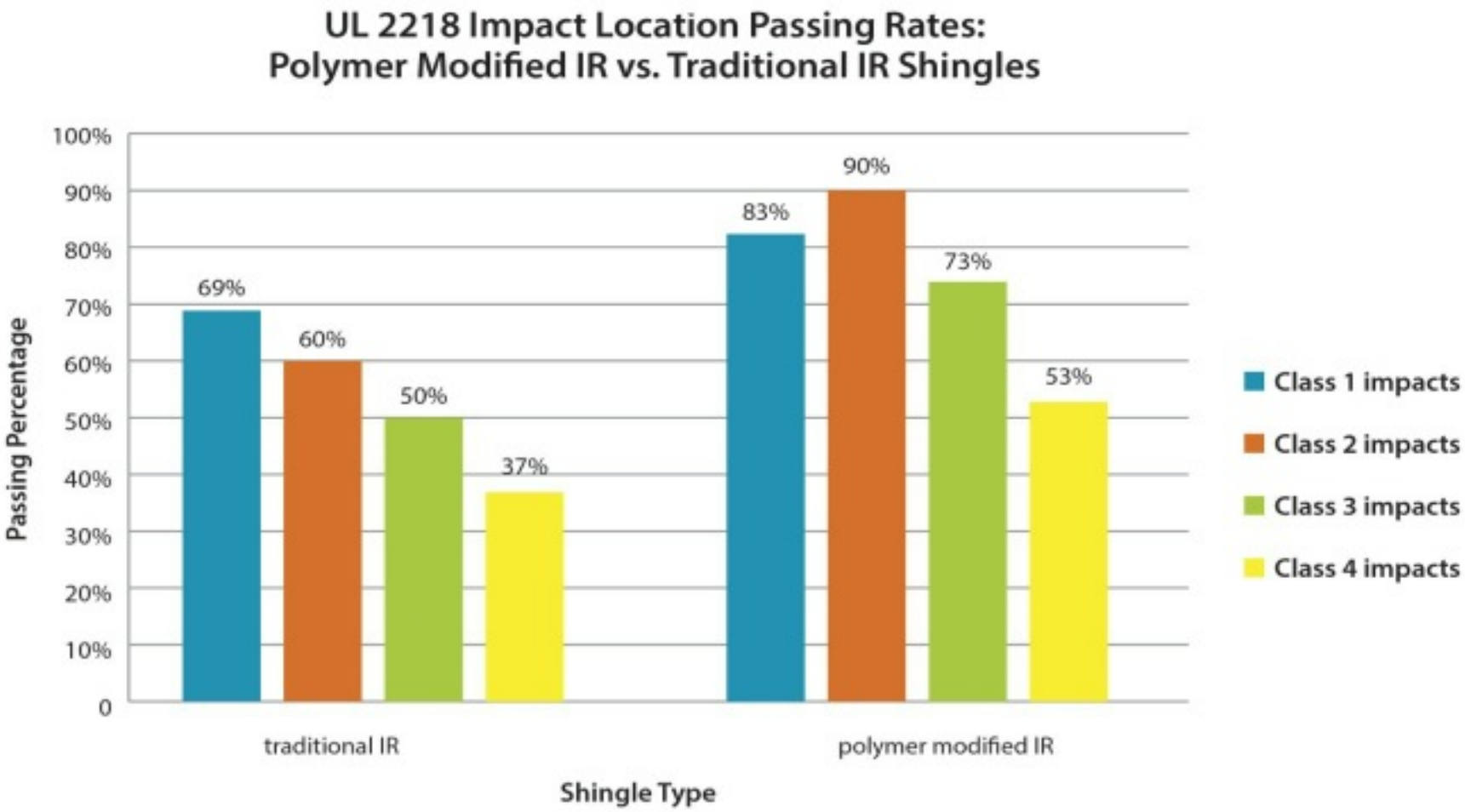
Asphalt Shingle Impact Resistance Testing



Asphalt Shingle Impact Resistance Testing



Asphalt Shingle Impact Resistance Testing



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

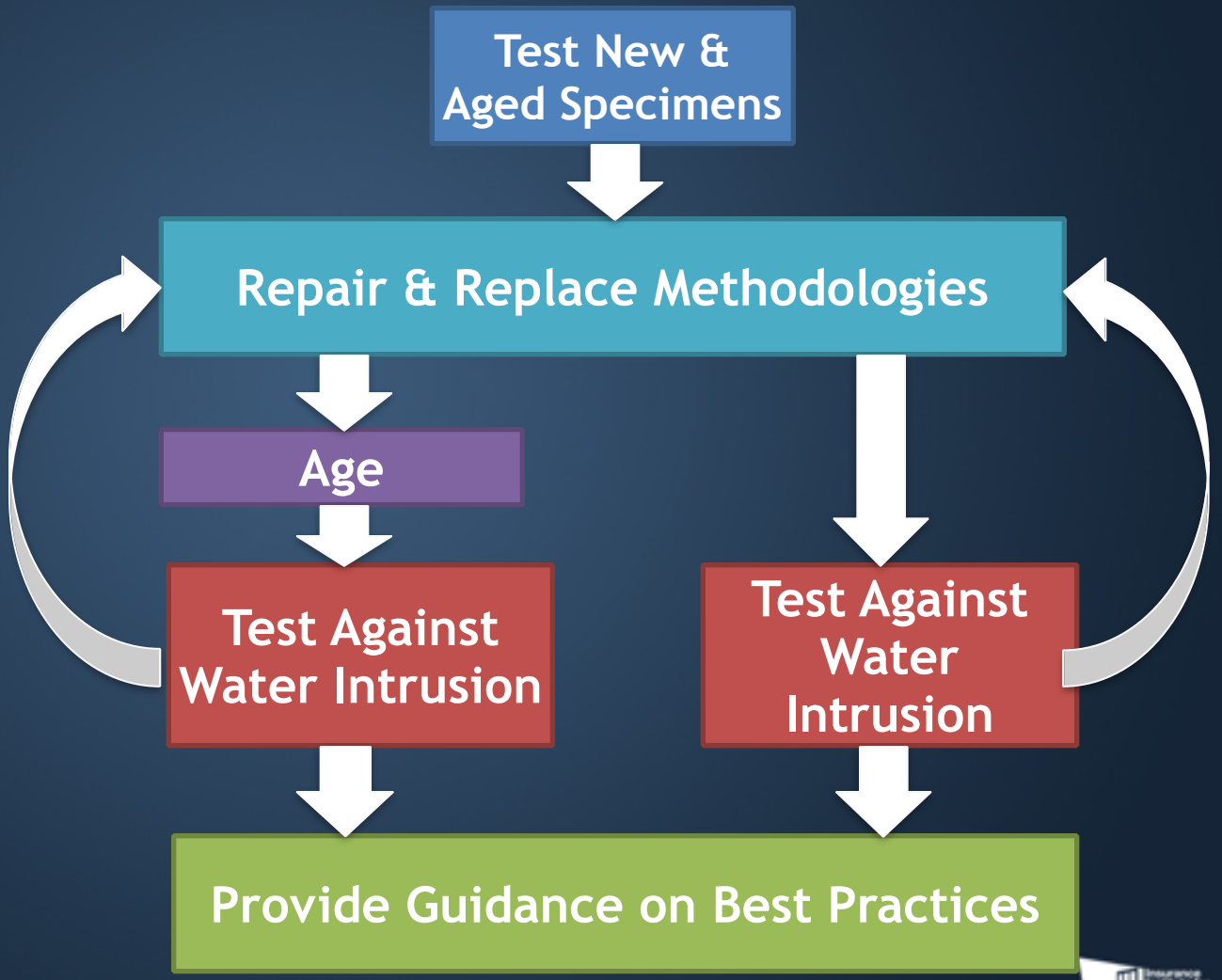
- 3 sizes (1 in., 1.5 in., 2 in.)
- Adaptable for different sizes
- Structural vs. Aesthetic Damage
- Repair vs. Replace Methodologies

Full-Scale Impact Testing

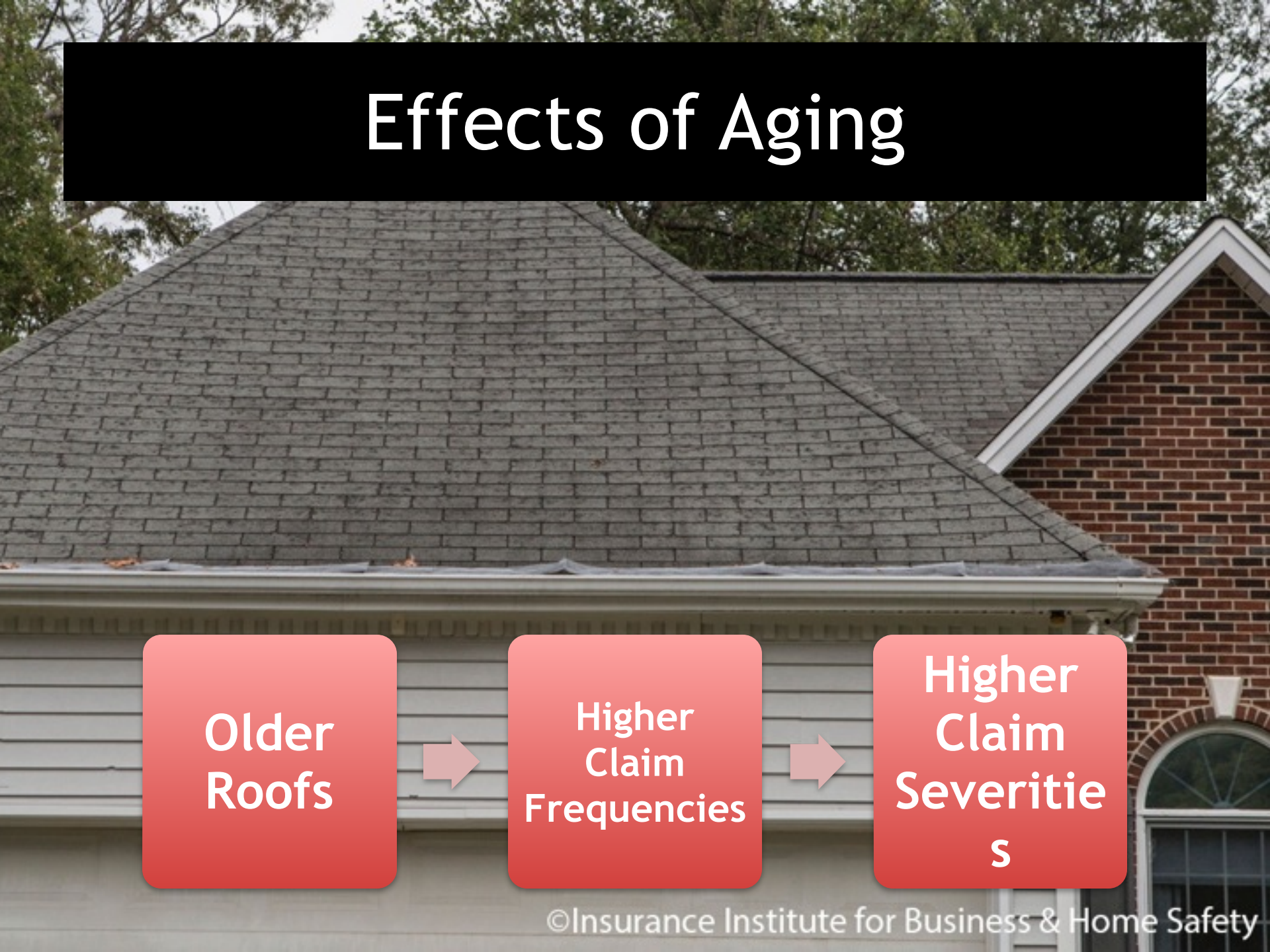
Full-Scale Impact Testing

Full-Scale Impact Testing

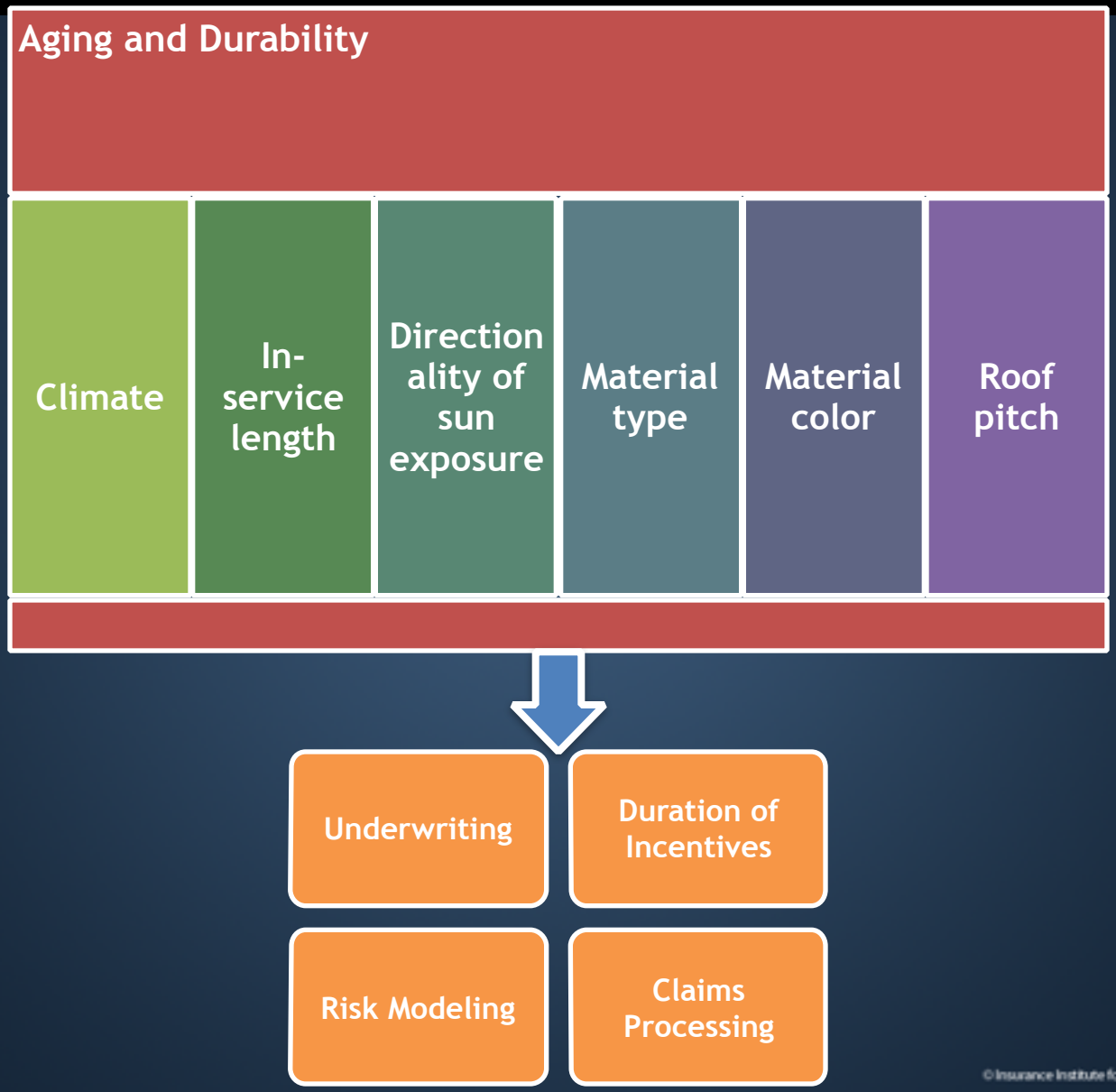
Future Research (after automatic hailstone production)



Effects of Aging

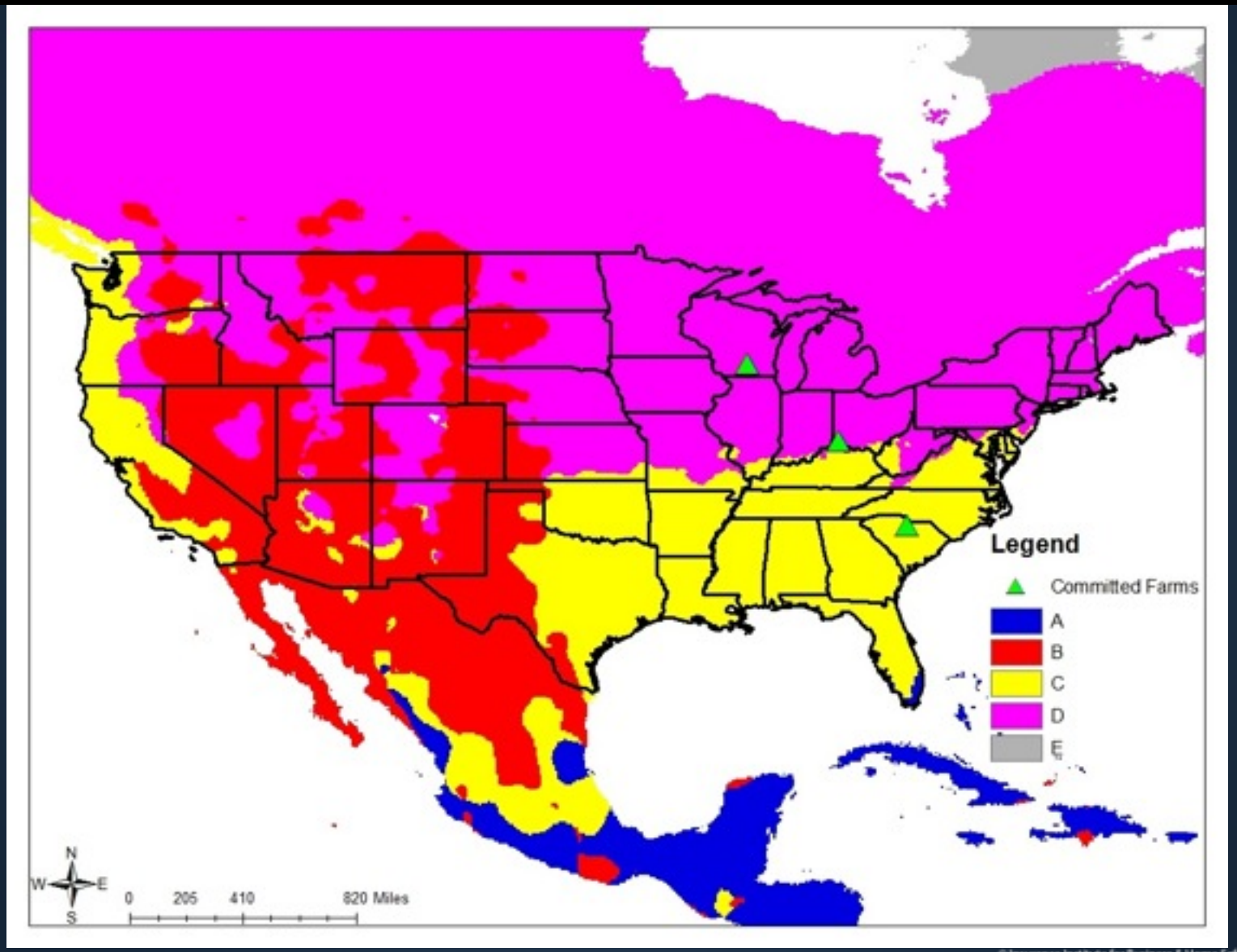


Impact of Aging on Insurance Industry



Roof Aging Farms

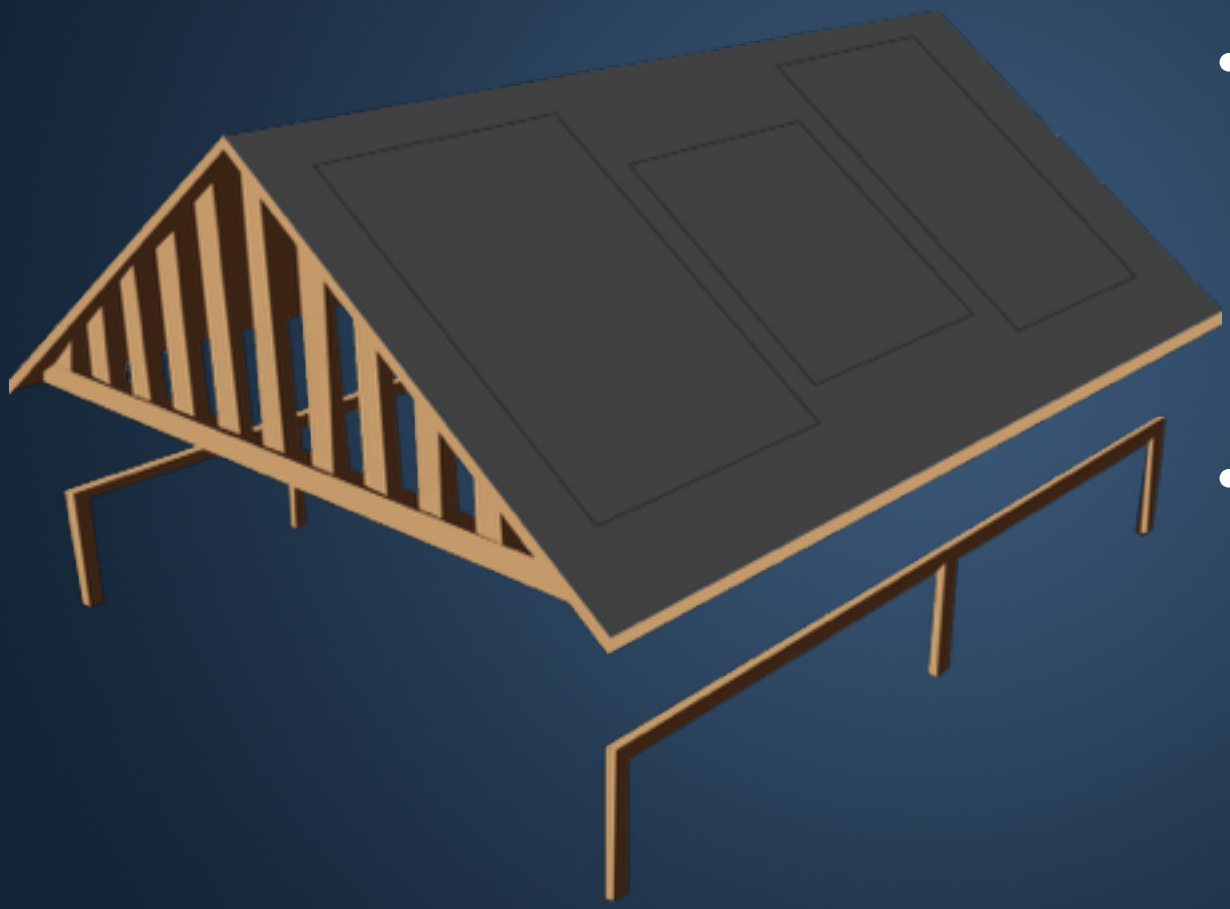
Roof Aging Farms: Climates



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

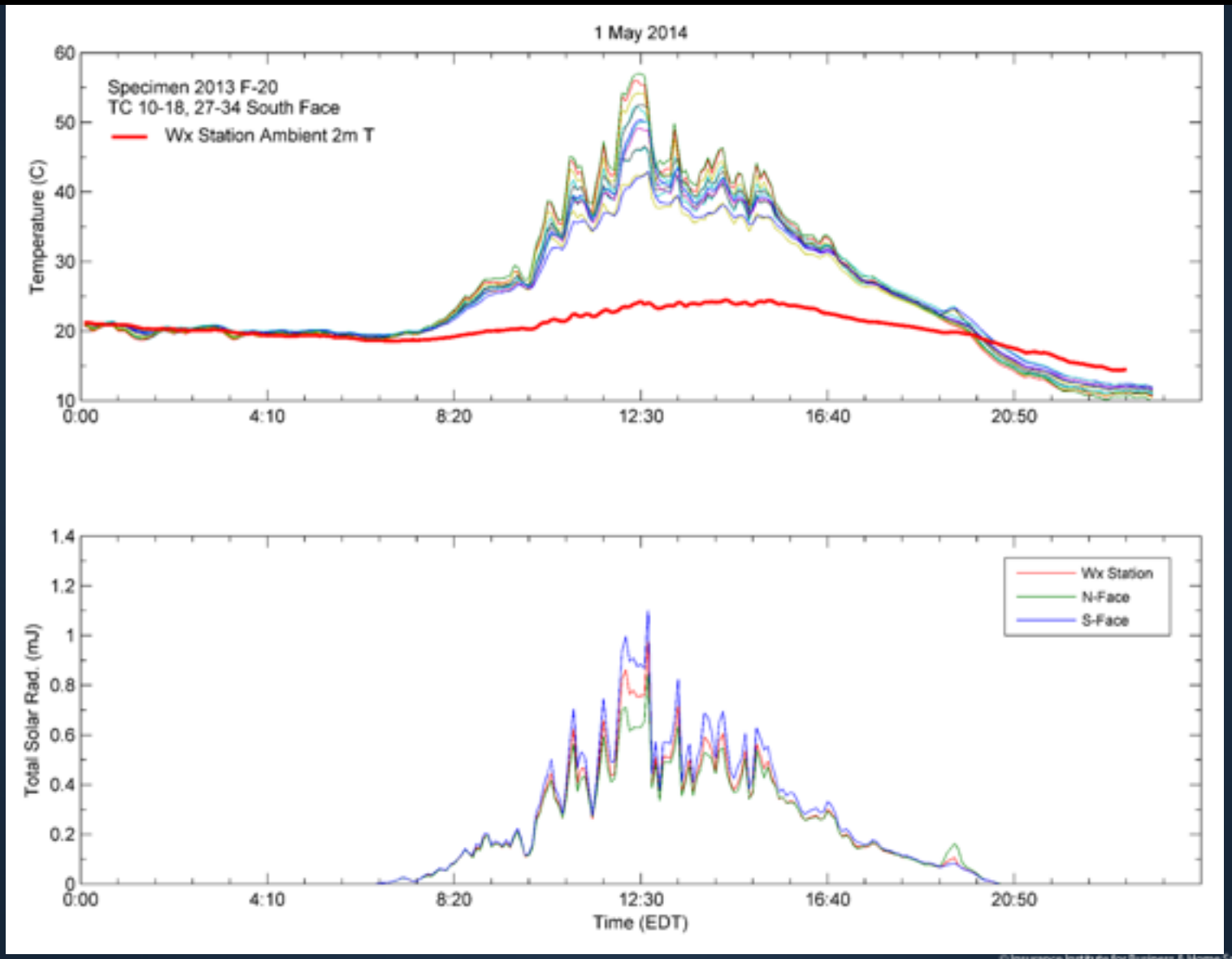
Roof Aging Farms: Areas of Focus

- 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

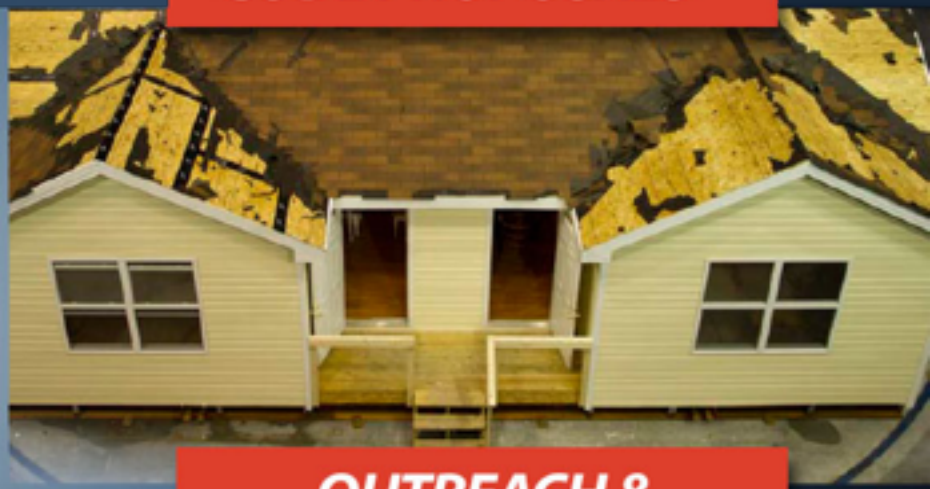
Roof Aging Farms: Data



Protection from the Top:
Focus on the Roof

RESEARCH

CODE PROPOSALS



COMMUNICATIONS

OUTREACH & TRAINING

Roofing Industry

Questions?

Tanya Brown
tbrown@ibhs.org
www.disastersafety.org