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Using Quantile-Quantile Plots to Compare Experimental Apples and Oranges in Physics Labs

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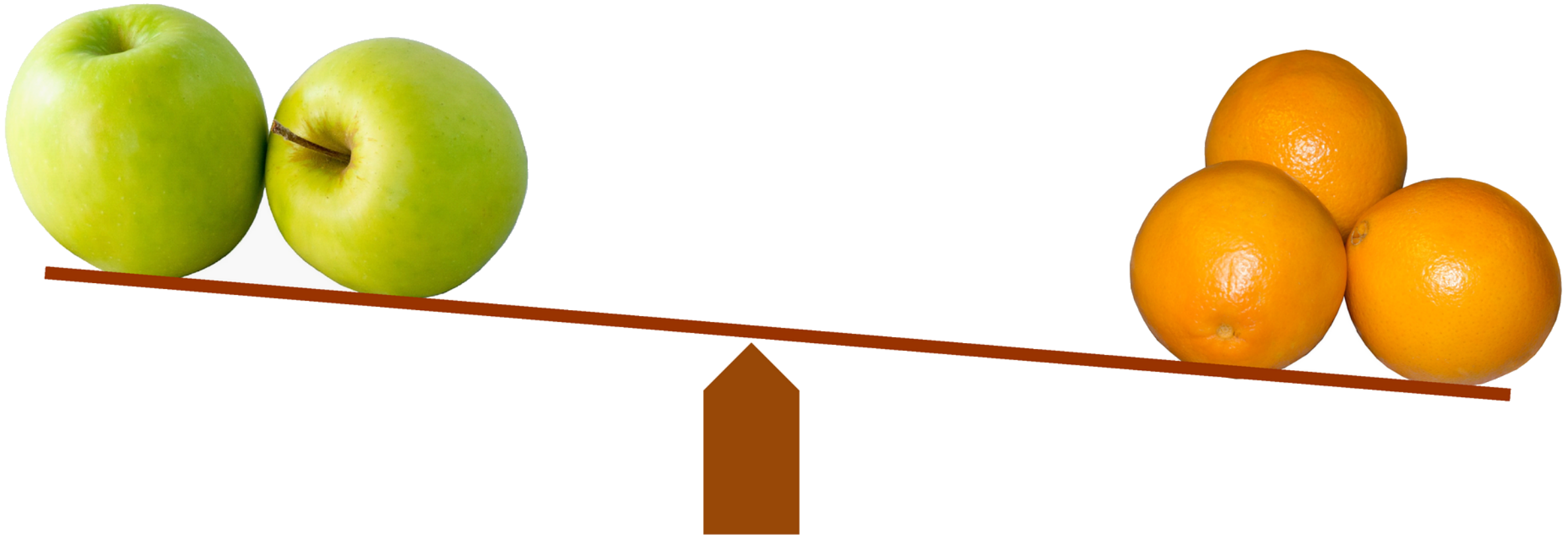
Andersen, Allen and Dennison, JR, "Using Quantile-Quantile Plots to Compare Experimental Apples and Oranges in Physics Labs" (2017). Fall 2018 Four Corner Section Meeting of the American Physical Society. *Presentations*. Paper 191.

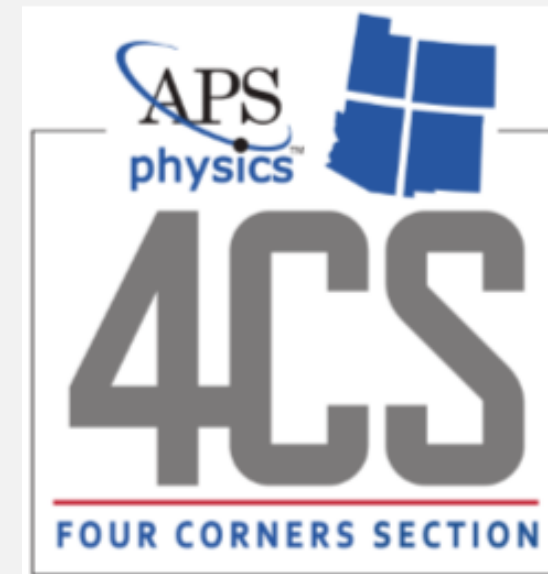
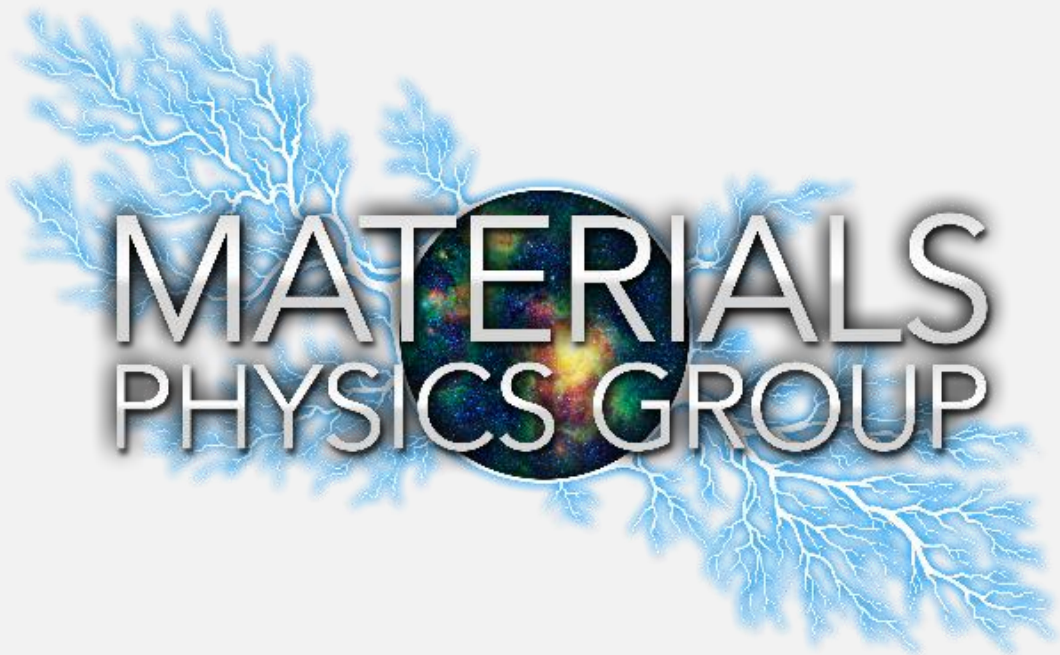
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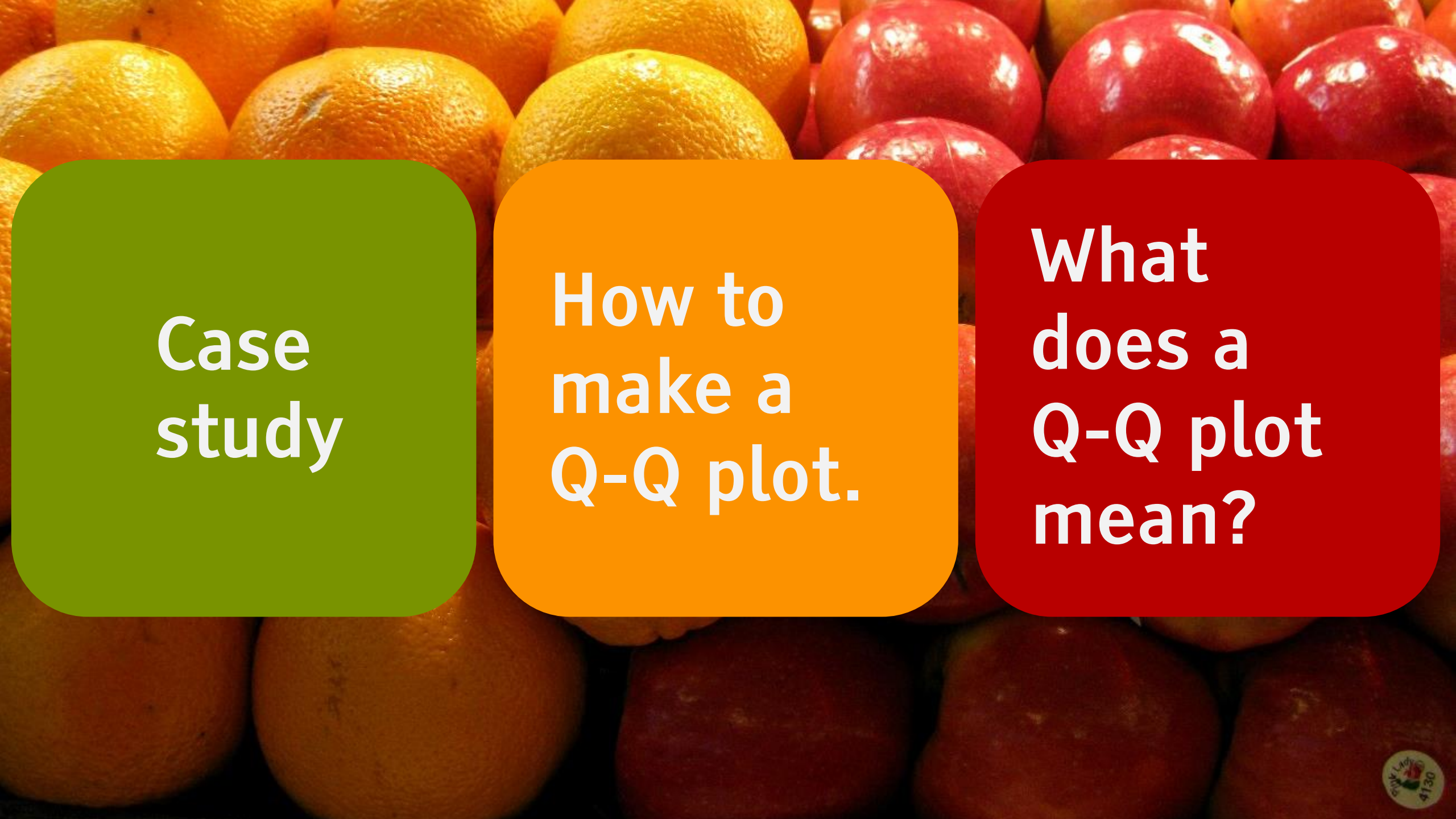
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Comparing Experimental Apples and Orange with Quantile-Quantile Plots







**Case
study**

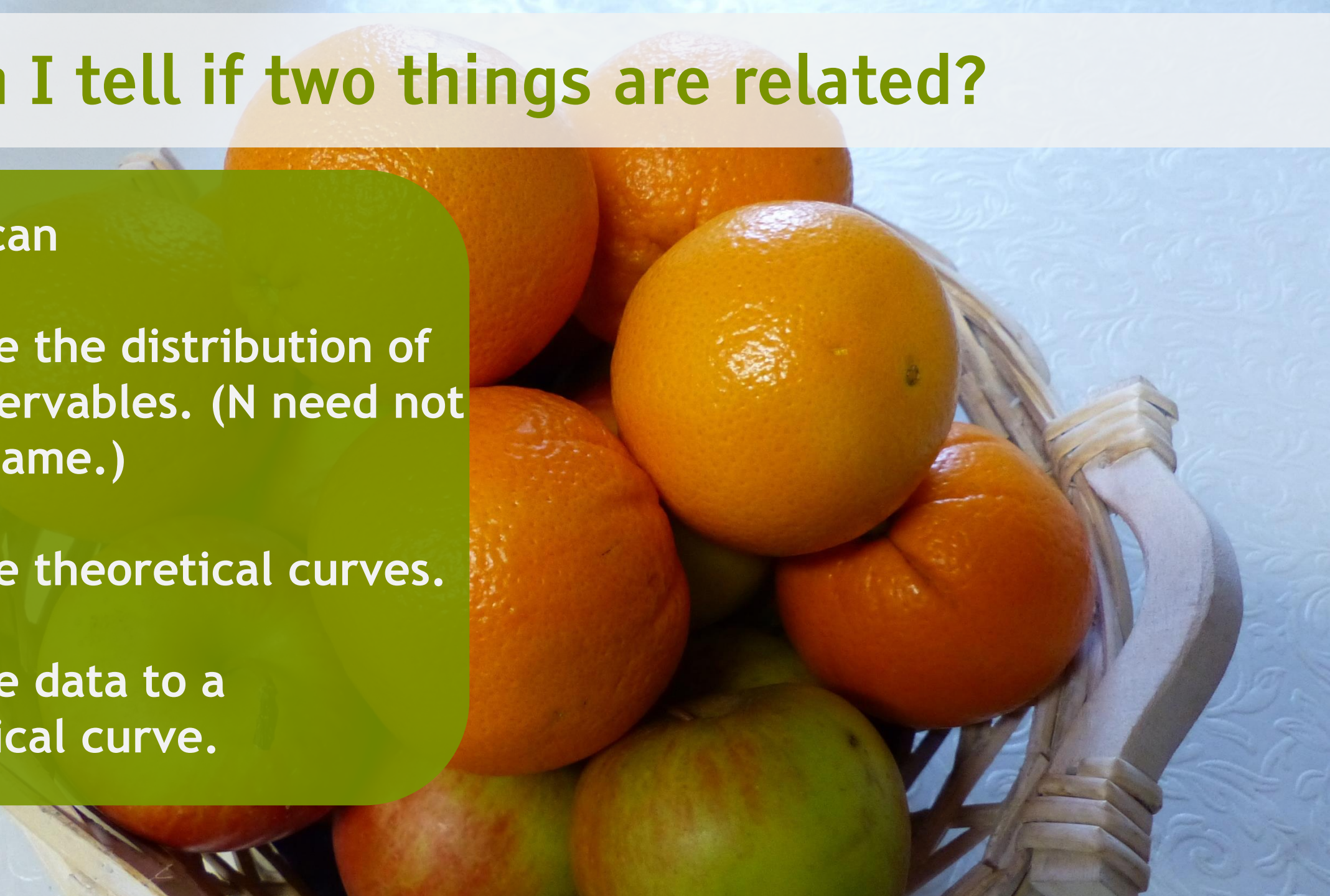
**How to
make a
Q-Q plot.**

**What
does a
Q-Q plot
mean?**

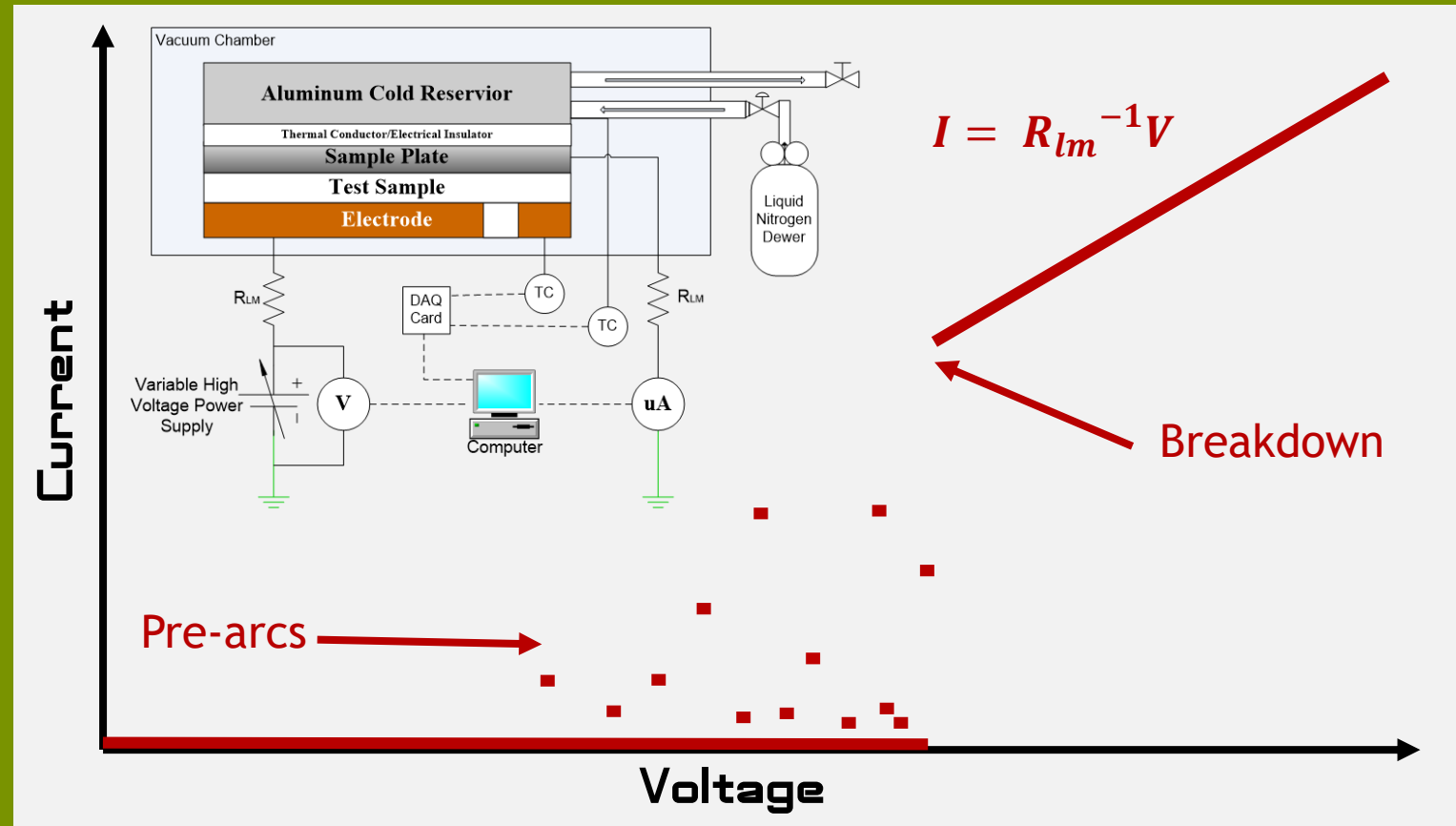
How can I tell if two things are related?

Q-Q plots can

- Compare the distribution of two observables. (N need not be the same.)
- Compare theoretical curves.
- Compare data to a theoretical curve.

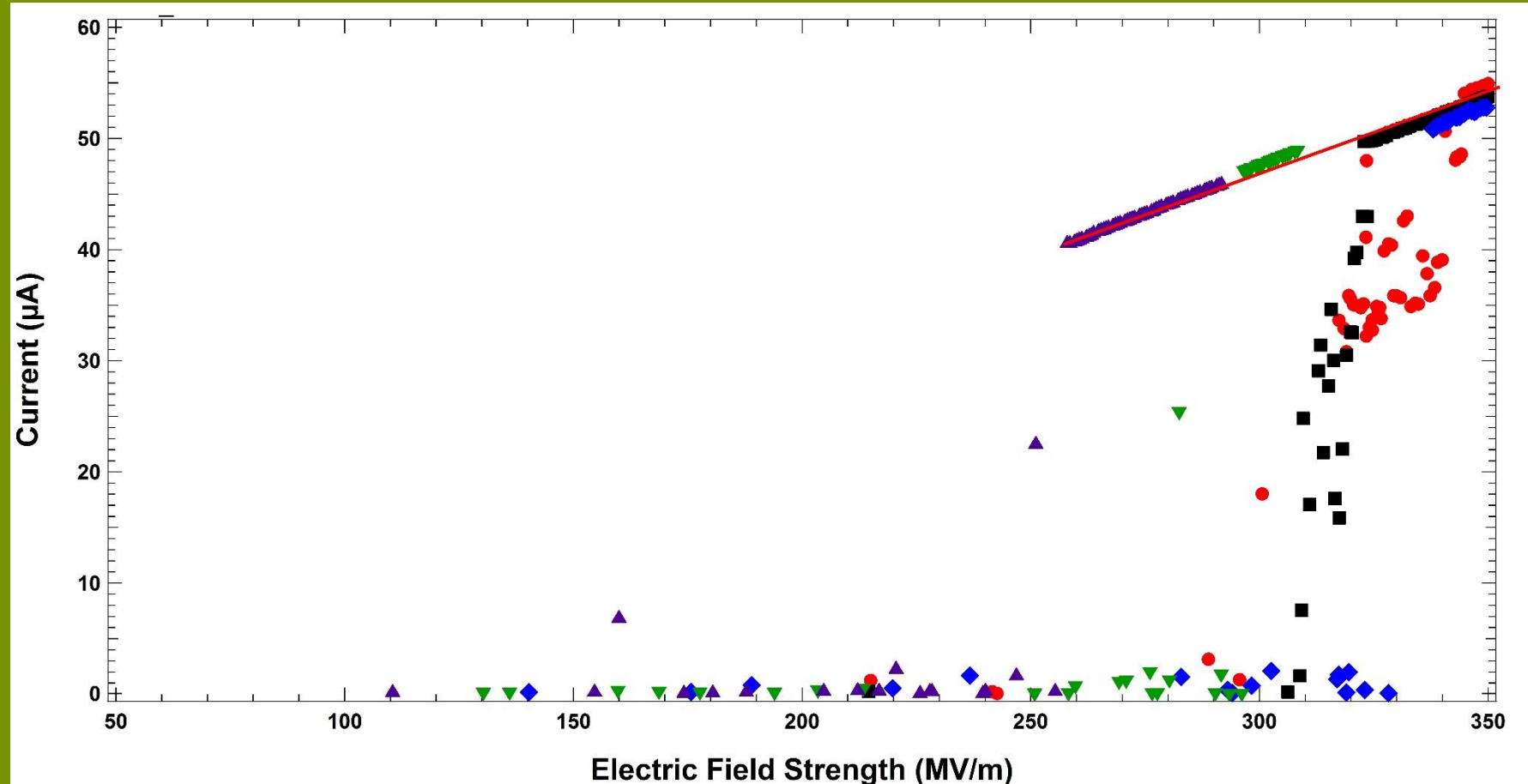


Case Study: Dielectric Breakdown Testing



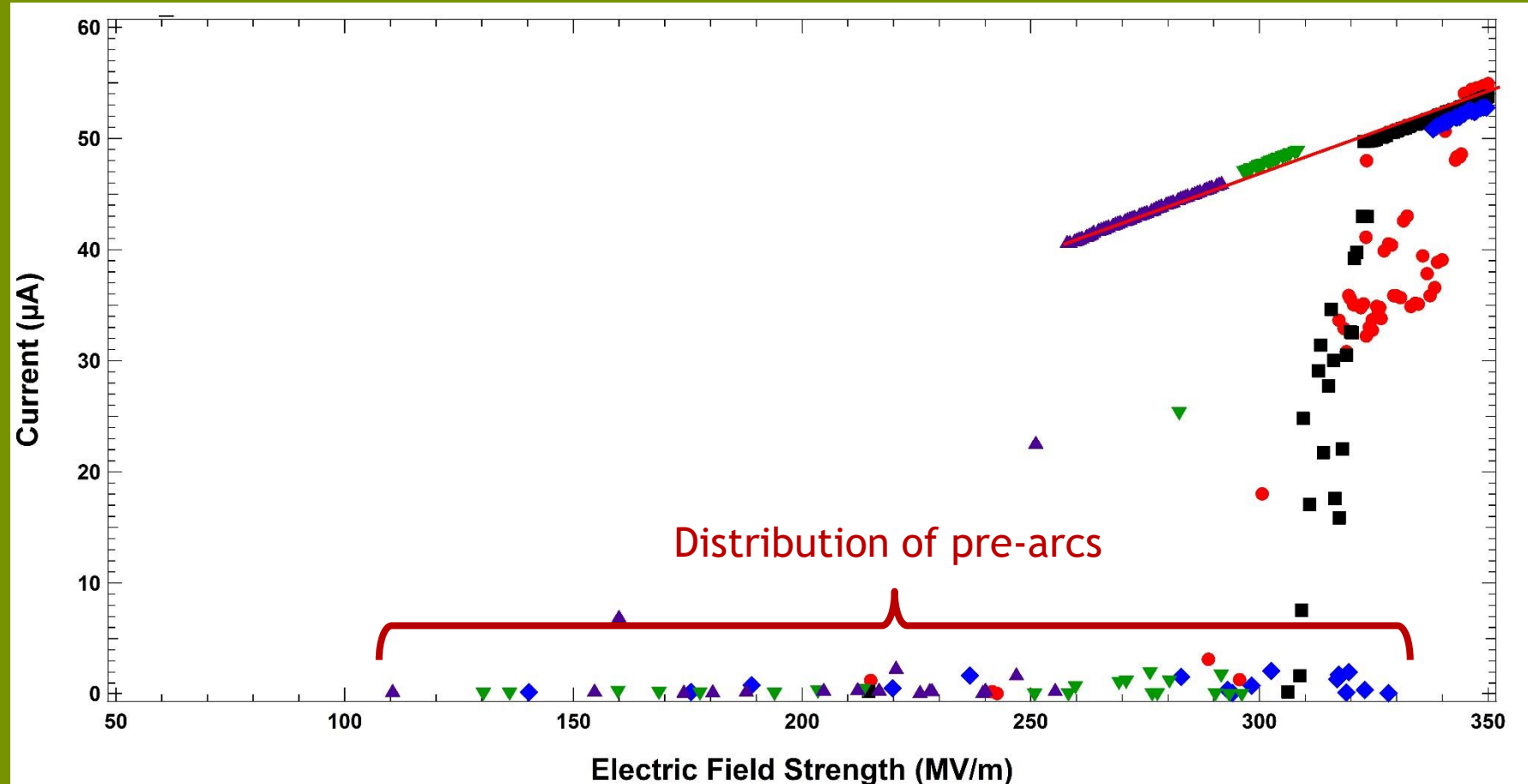
Voltage is increased across a dielectric sample in a parallel-plate capacitor and monitor the leakage current.

Case Study: Dielectric Breakdown Testing



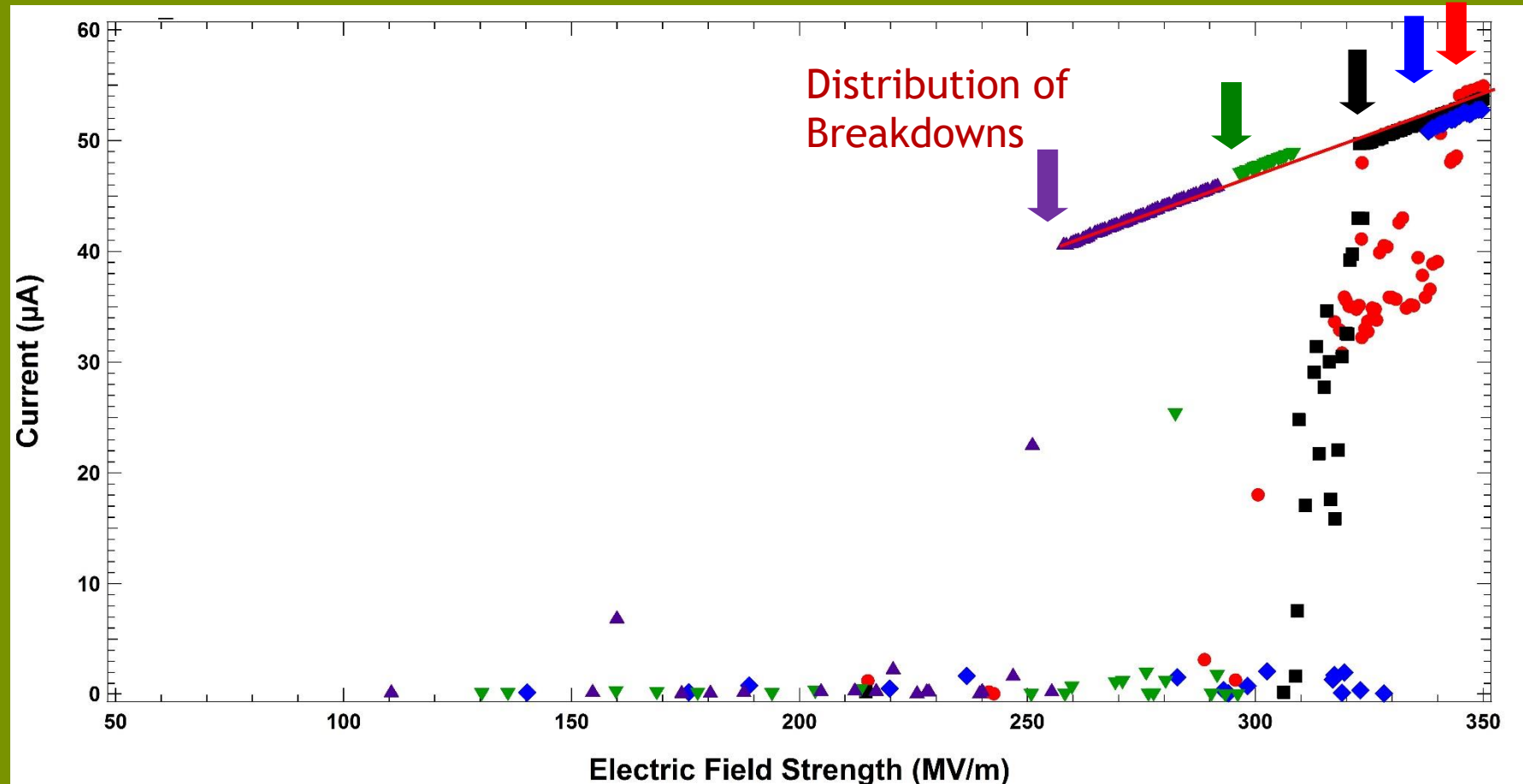
Plot of 5 voltage step-up to breakdown tests on LDPE.

Case Study: Dielectric Breakdown Testing



Plot of 5 voltage step-up to breakdown tests on LDPE.

Case Study: Dielectric Breakdown Testing



Plot of 5 voltage step-up to breakdown tests on LDPE.

Are pre-arcs related to the breakdowns?

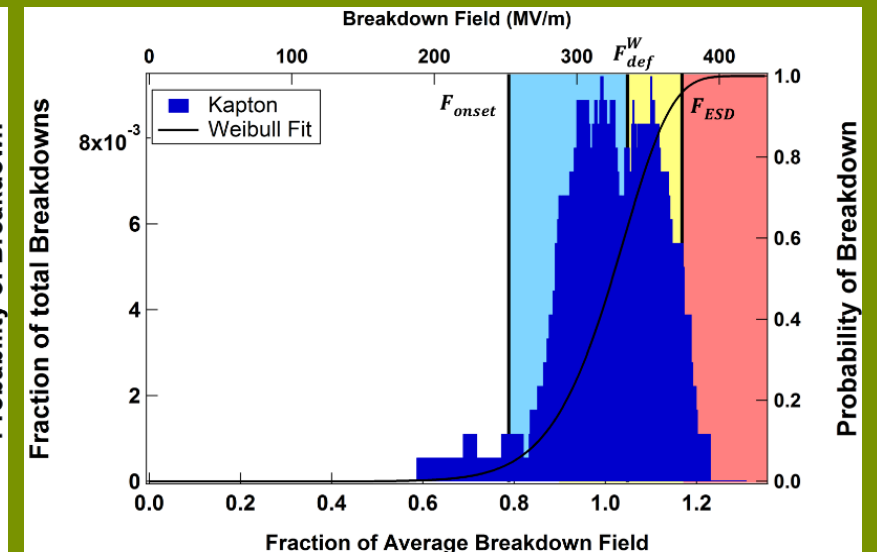
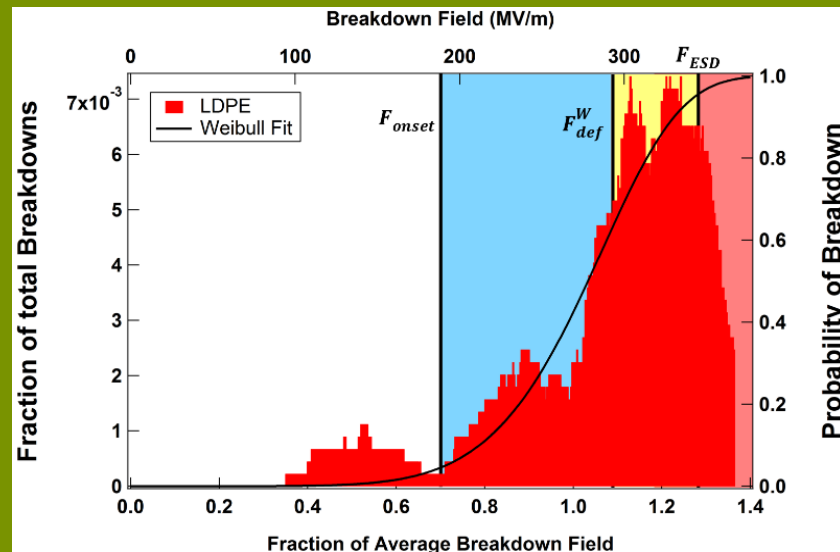
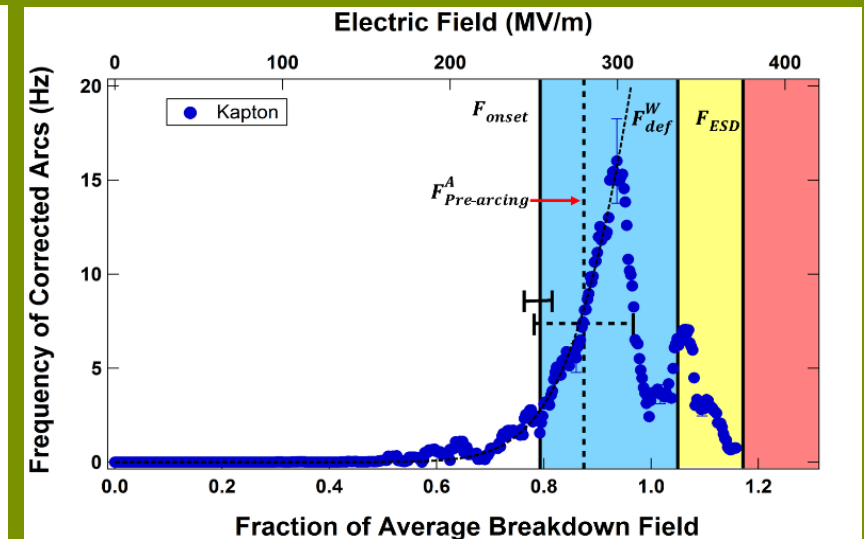
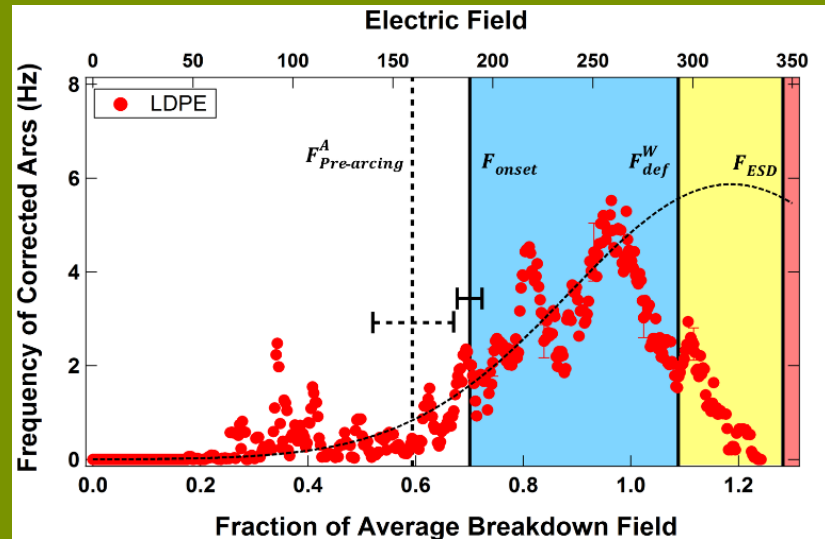
Pre-arcing distributions



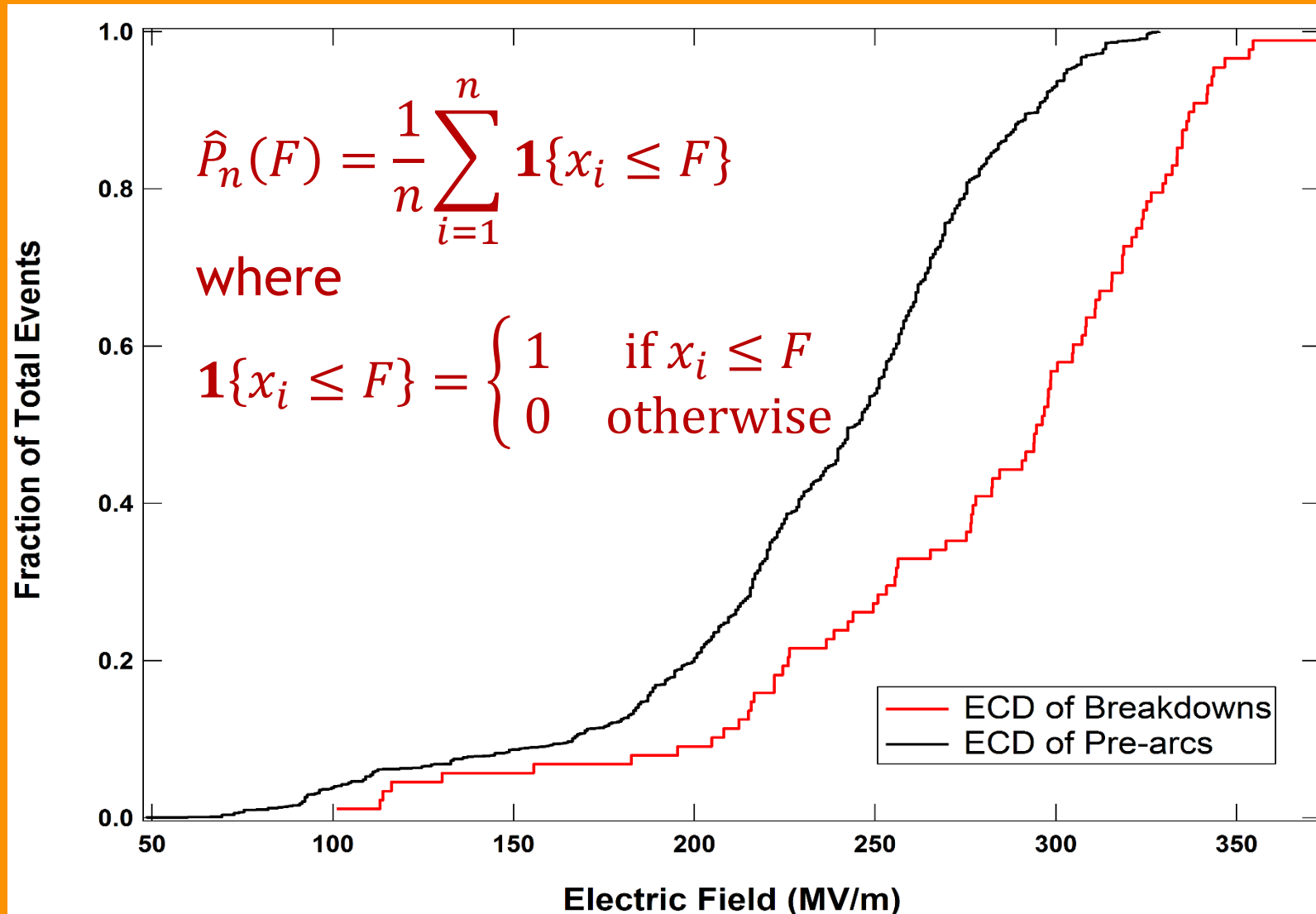
Breakdown distributions

The reviewer for our last paper was not convinced.

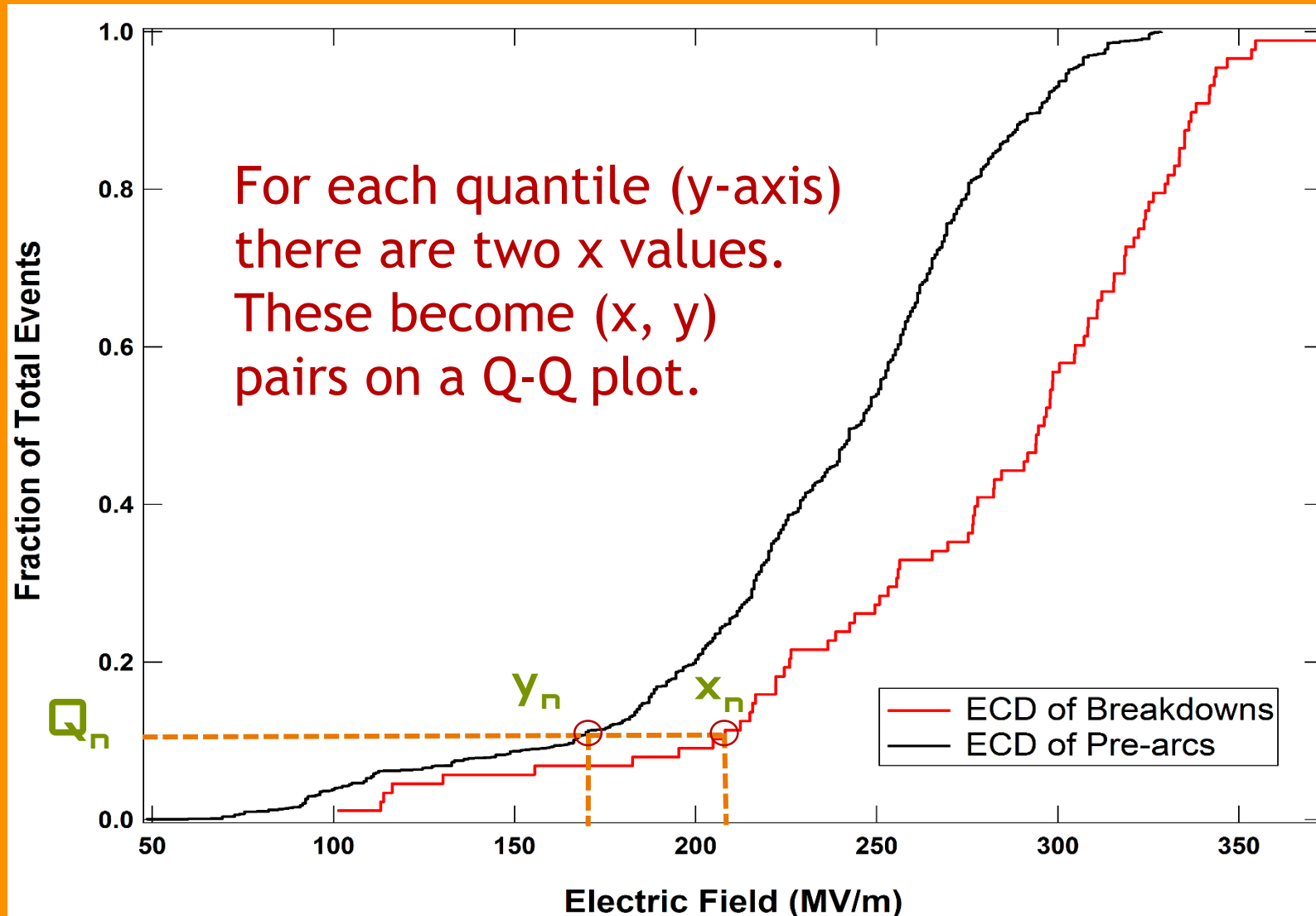
A better method was needed.



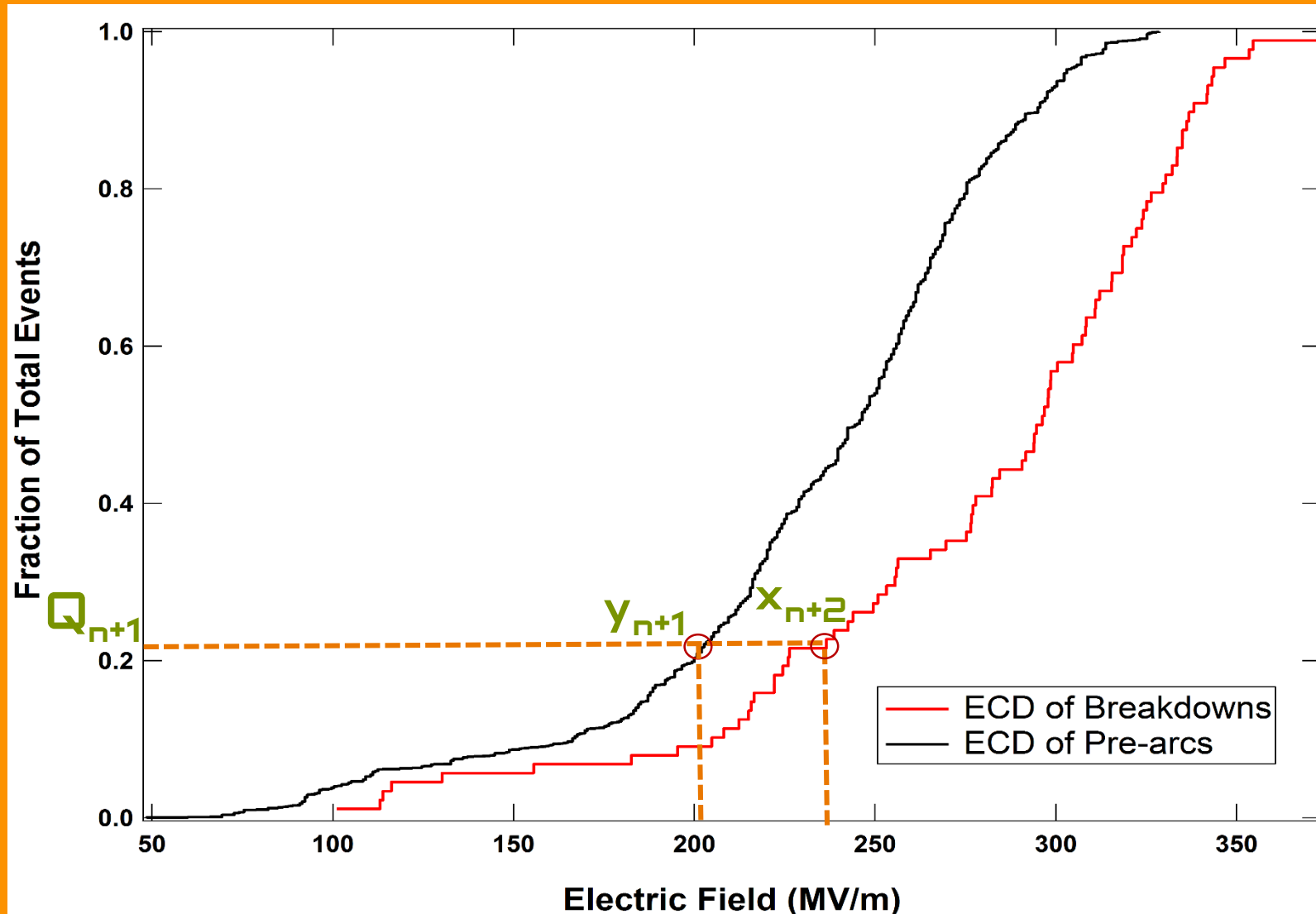
Step 1: Empirical Cumulative Distributions



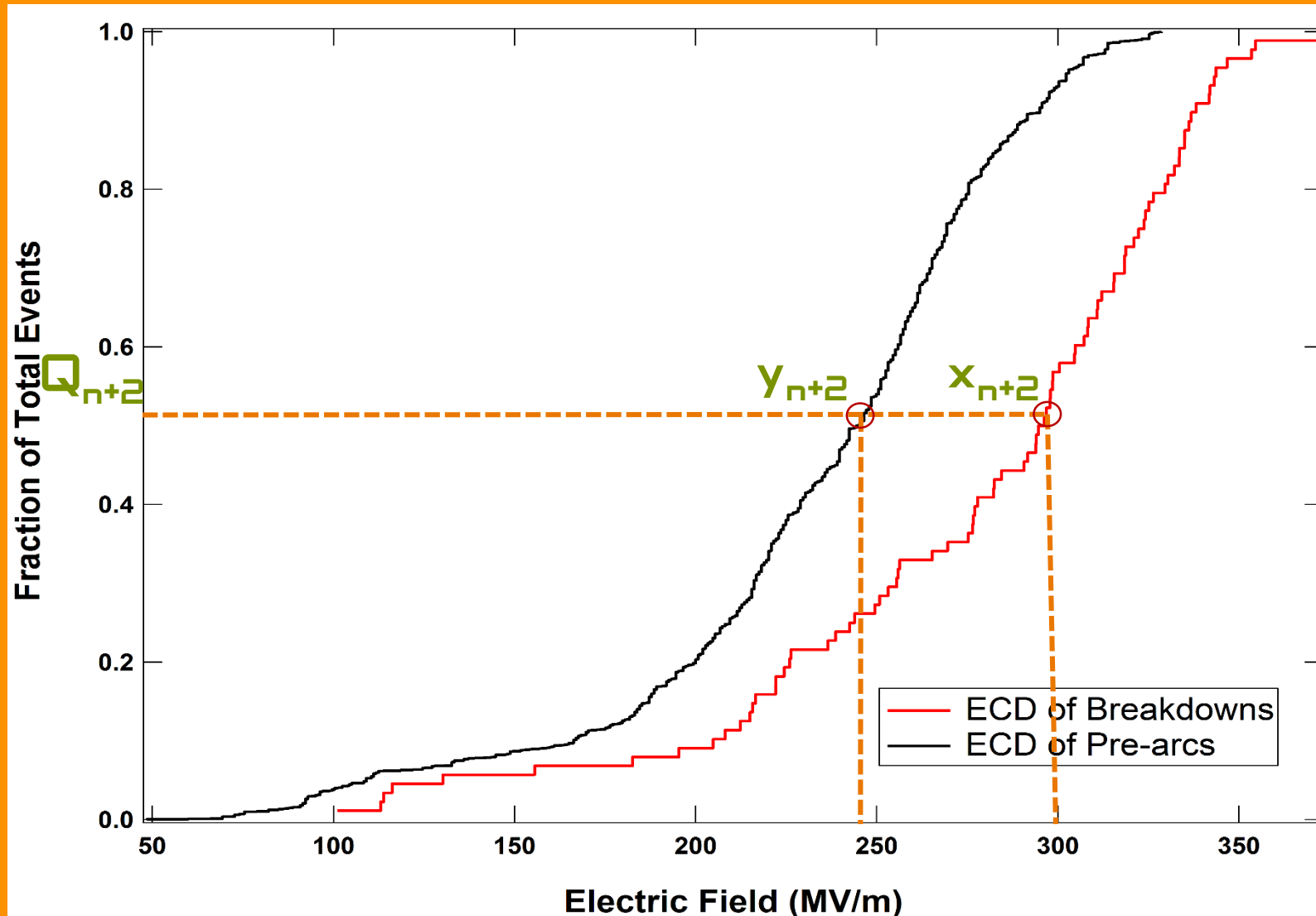
Step 2: Match the quantiles.



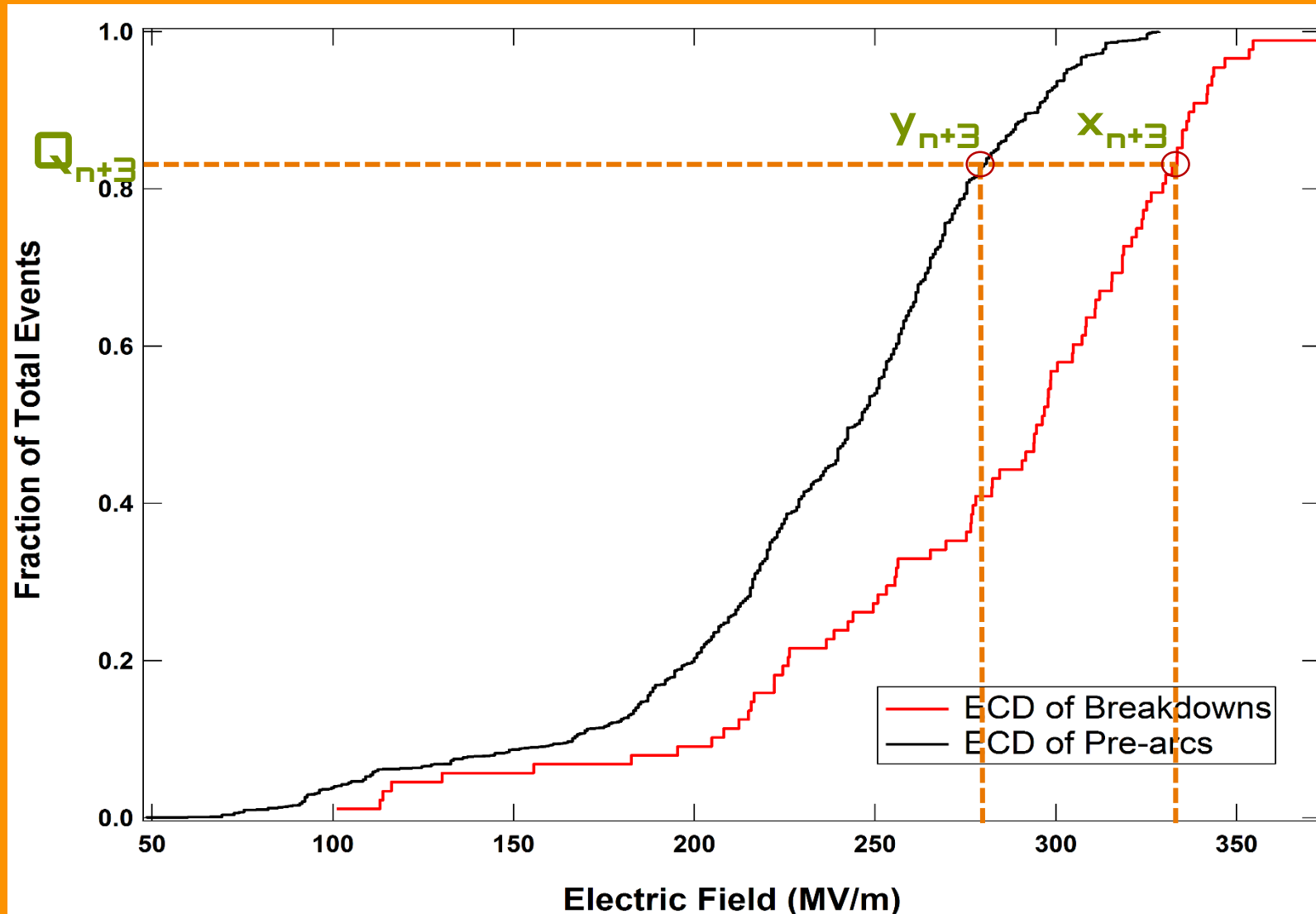
Step 2: Match the quantiles.



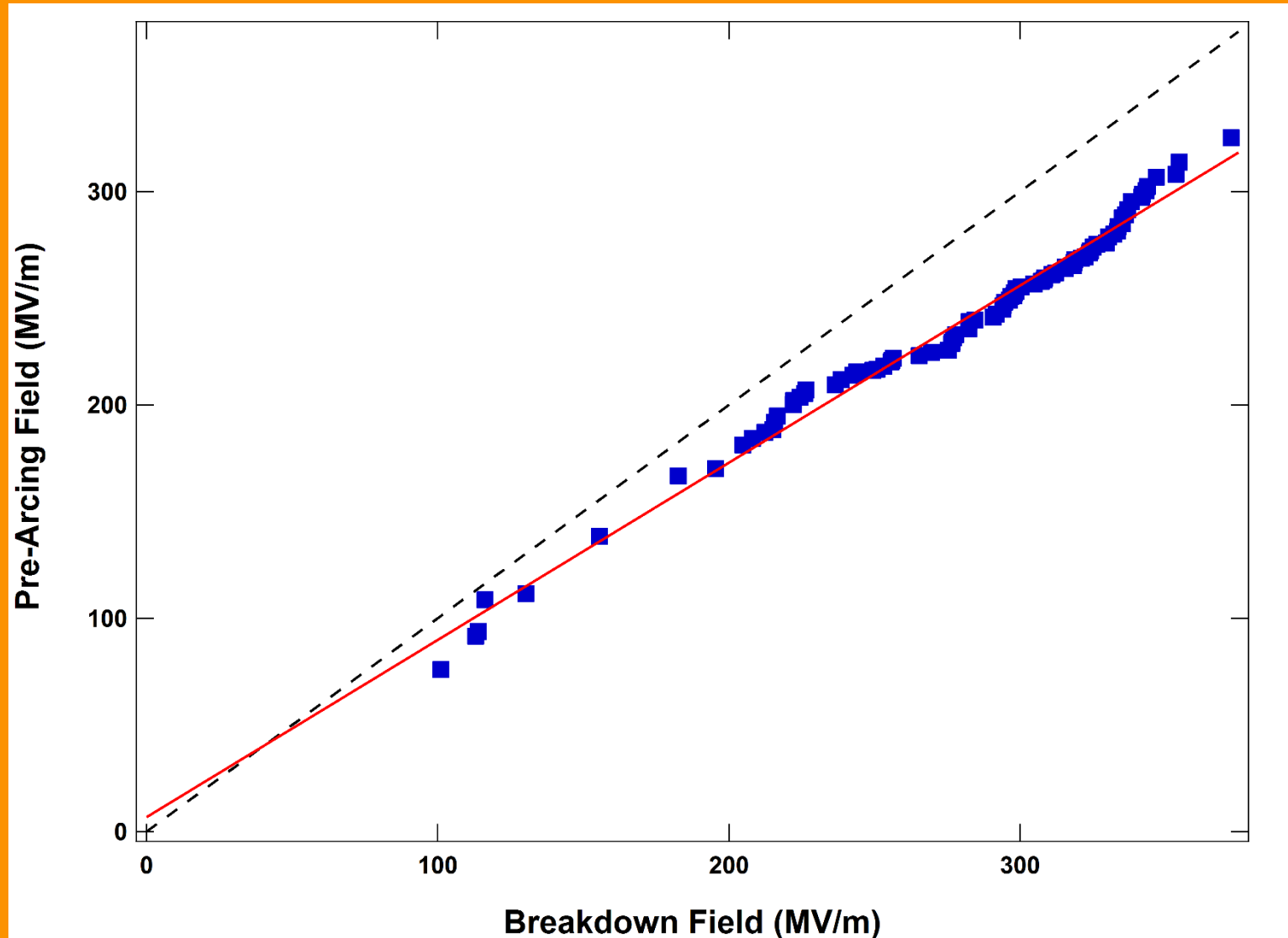
Step 2: Match the quantiles.



Step 2: Match the quantiles.



Step 3: Plot pairs and fit to a line.

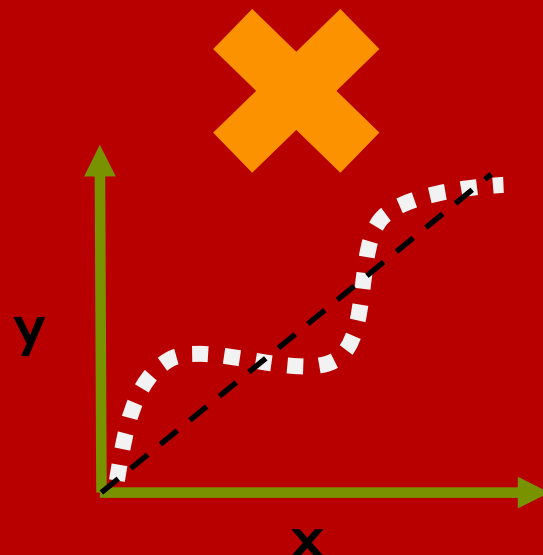
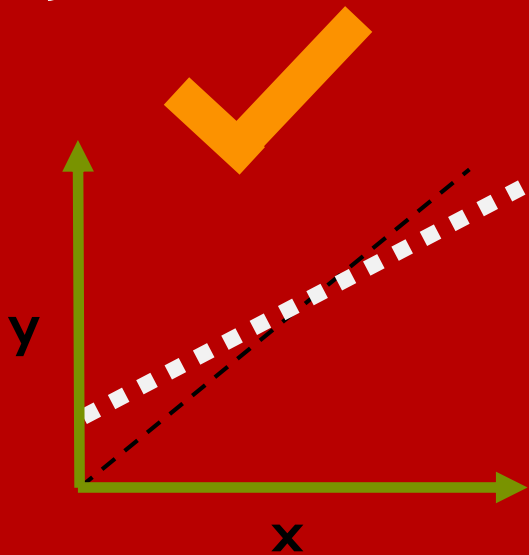


What does it mean?

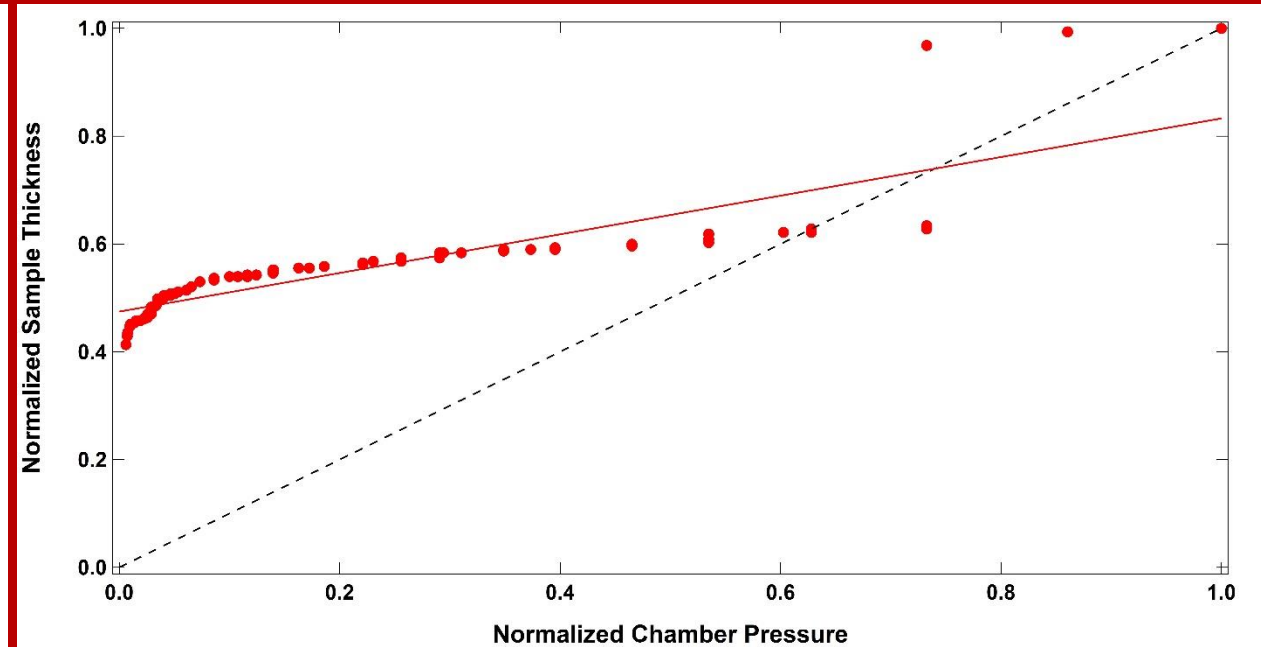
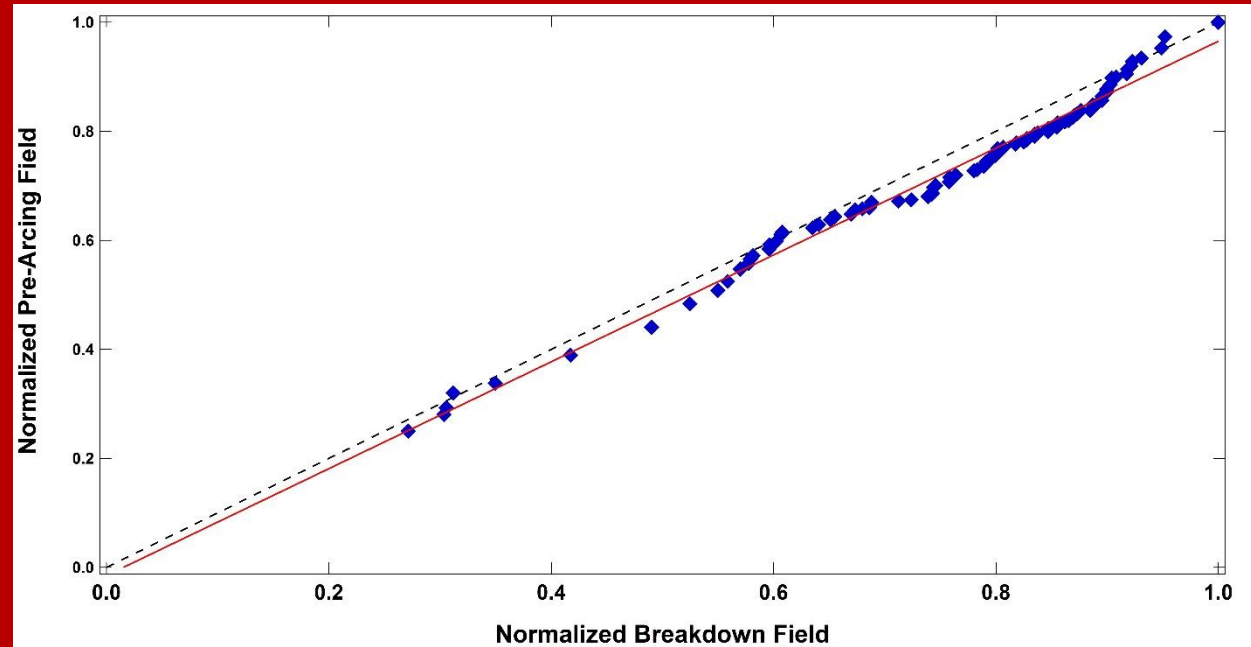
Quantile-Quantile plots compare the distributions of two observables.

If the distributions are related the plot is a linear.

If the fields at each quantile are identical, points will lie on $y=x$.



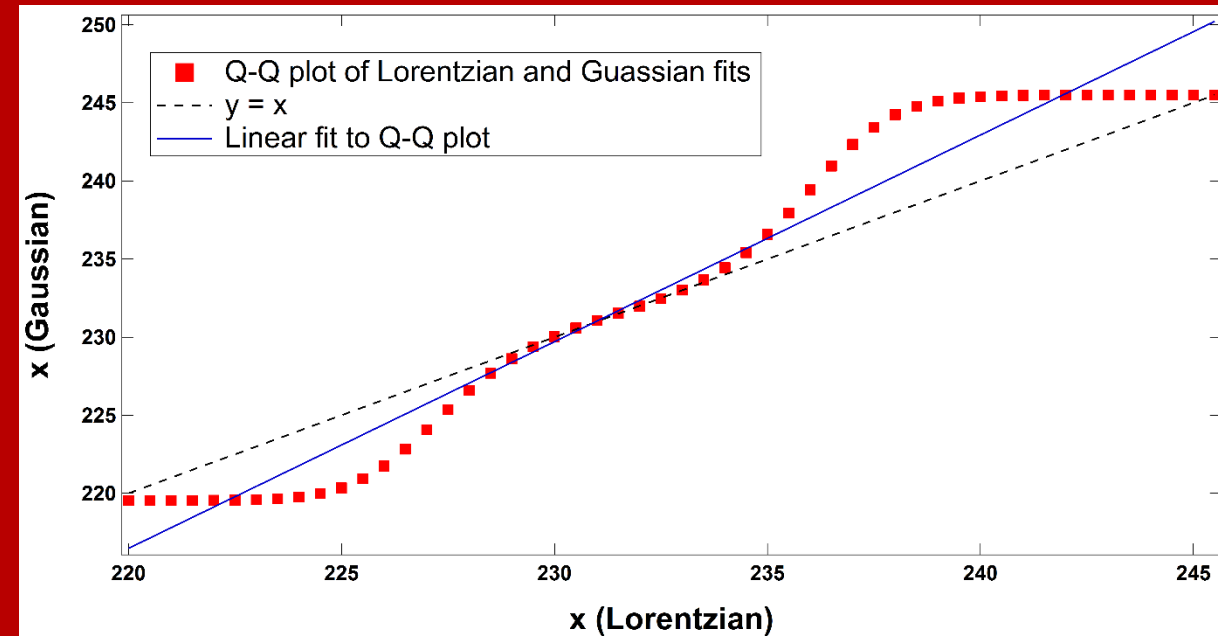
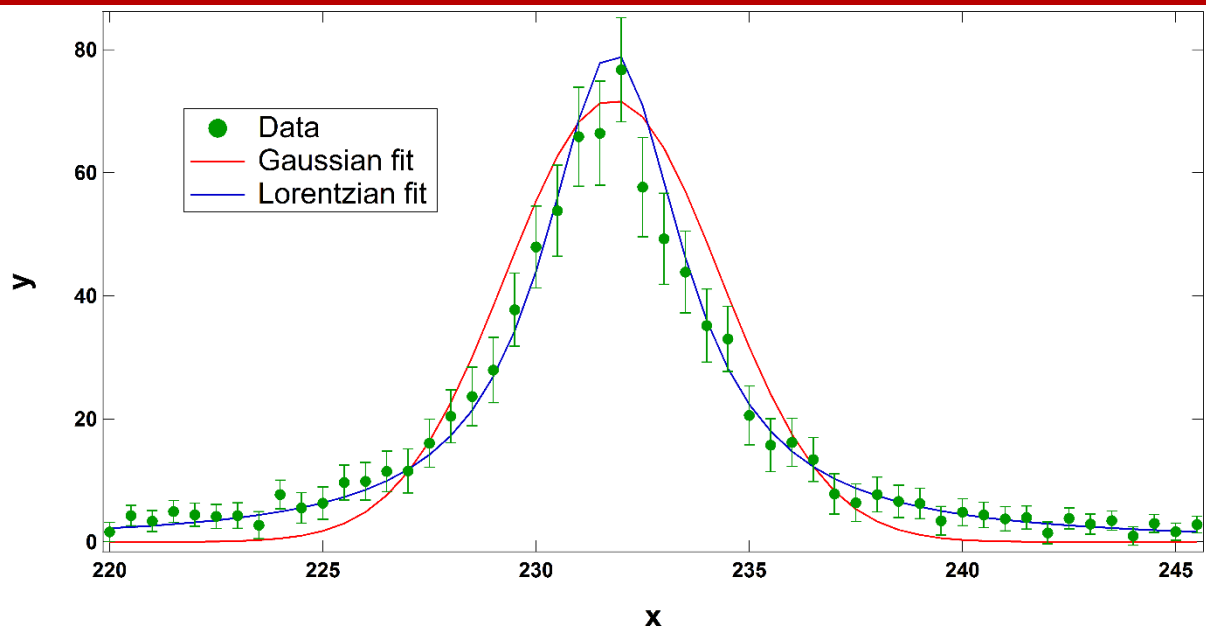
Check the method.



We see that pre-arcing correlates very well to breakdowns.

Sample thickness and chamber pressure do not—no surprise.

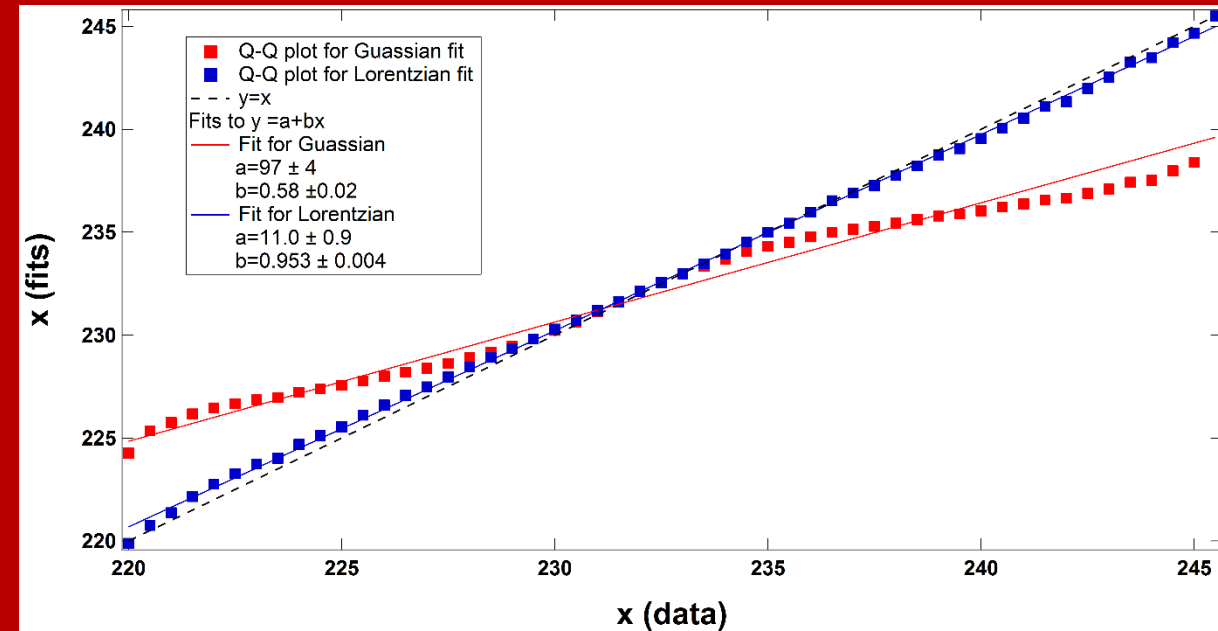
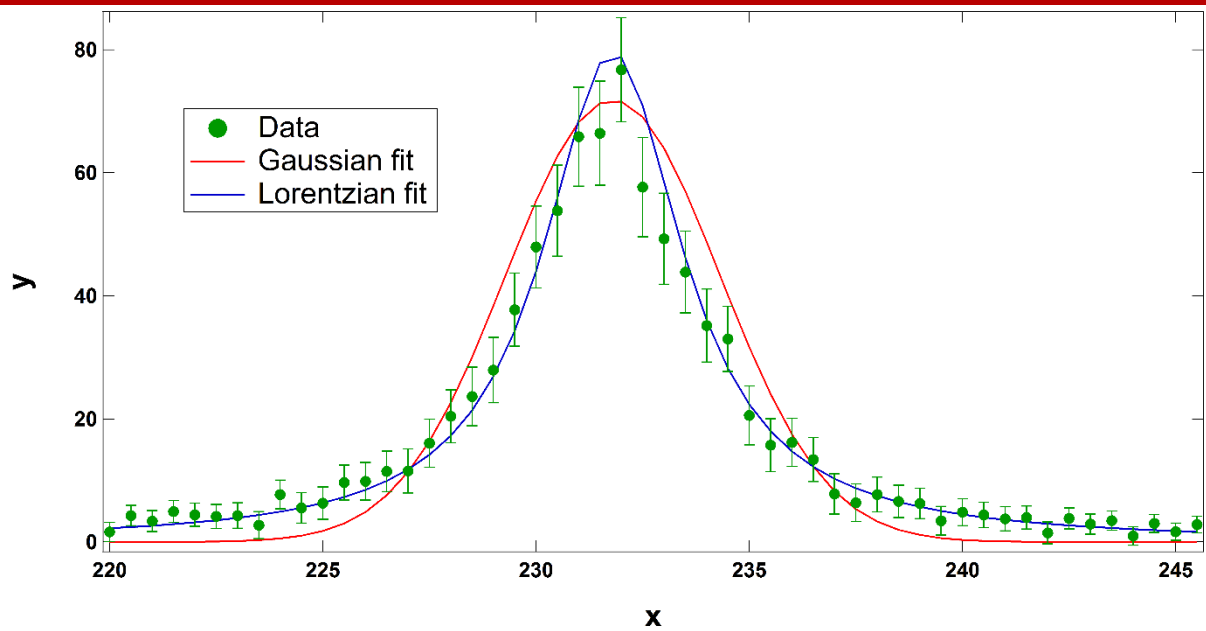
Additional Applications of Q-Q plots.



A Q-Q plot of the two fits shows that the two fits are significantly different.

Q-Q plots can compare mathematical functions.

Additional Applications of Q-Q plots.



Q-Q plots comparing the two fits to the data show that the Lorentzian fit is better in this case.

Q-Q plots can compare data to theoretical fits.

The background of the slide is a close-up photograph of several lemons and limes. The lemons are at the top, showing their bright yellow-orange skin, while the limes are at the bottom, showing their vibrant green skin. The lighting is bright, creating highlights and shadows on the textured surfaces of the fruit.

**Pre-arc
correlates
to
breakdown.**

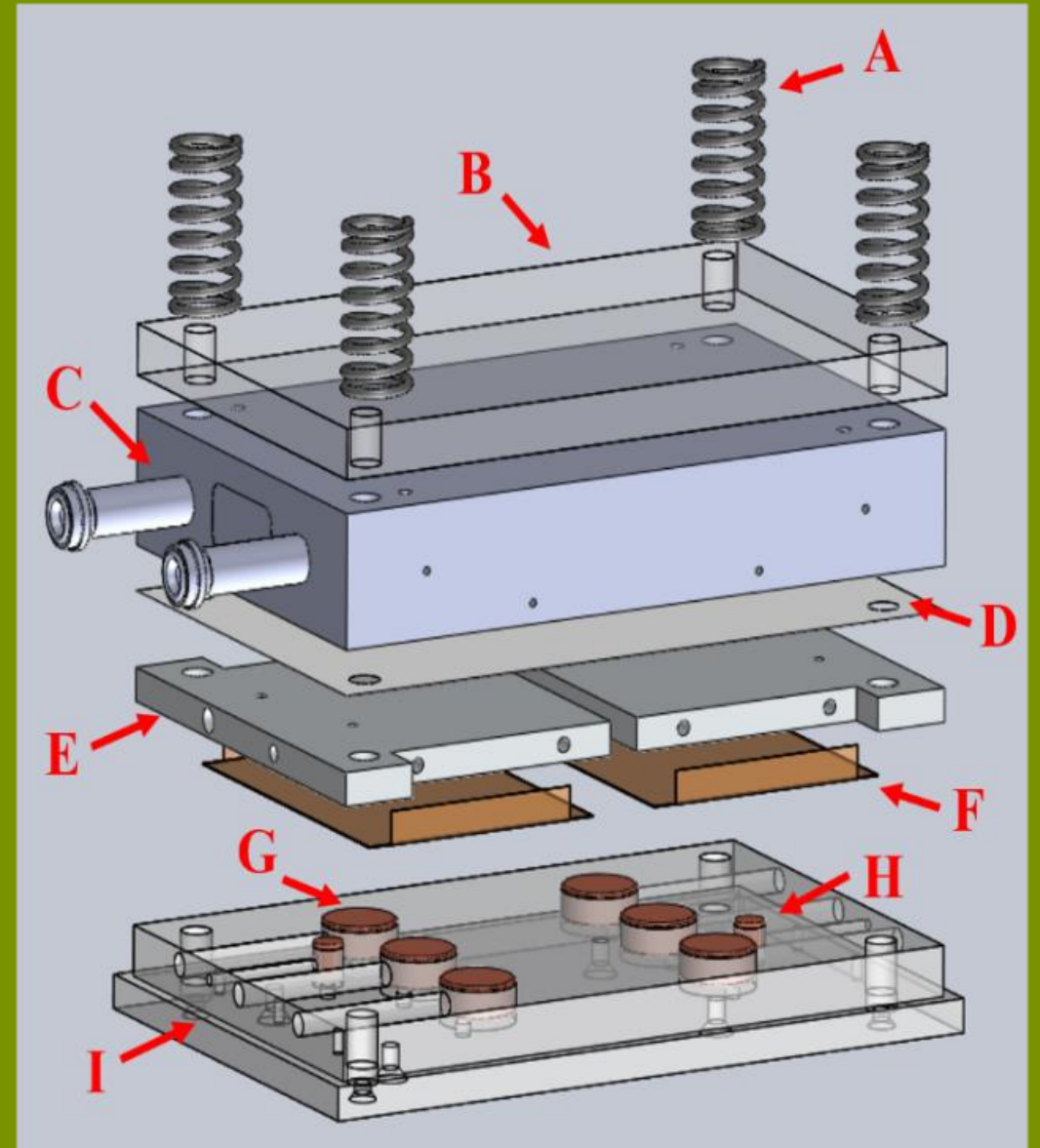
**Q-Q plots
are
versatile
and easy to
make.**

**A powerful
empirical
tool for
physics
research.**

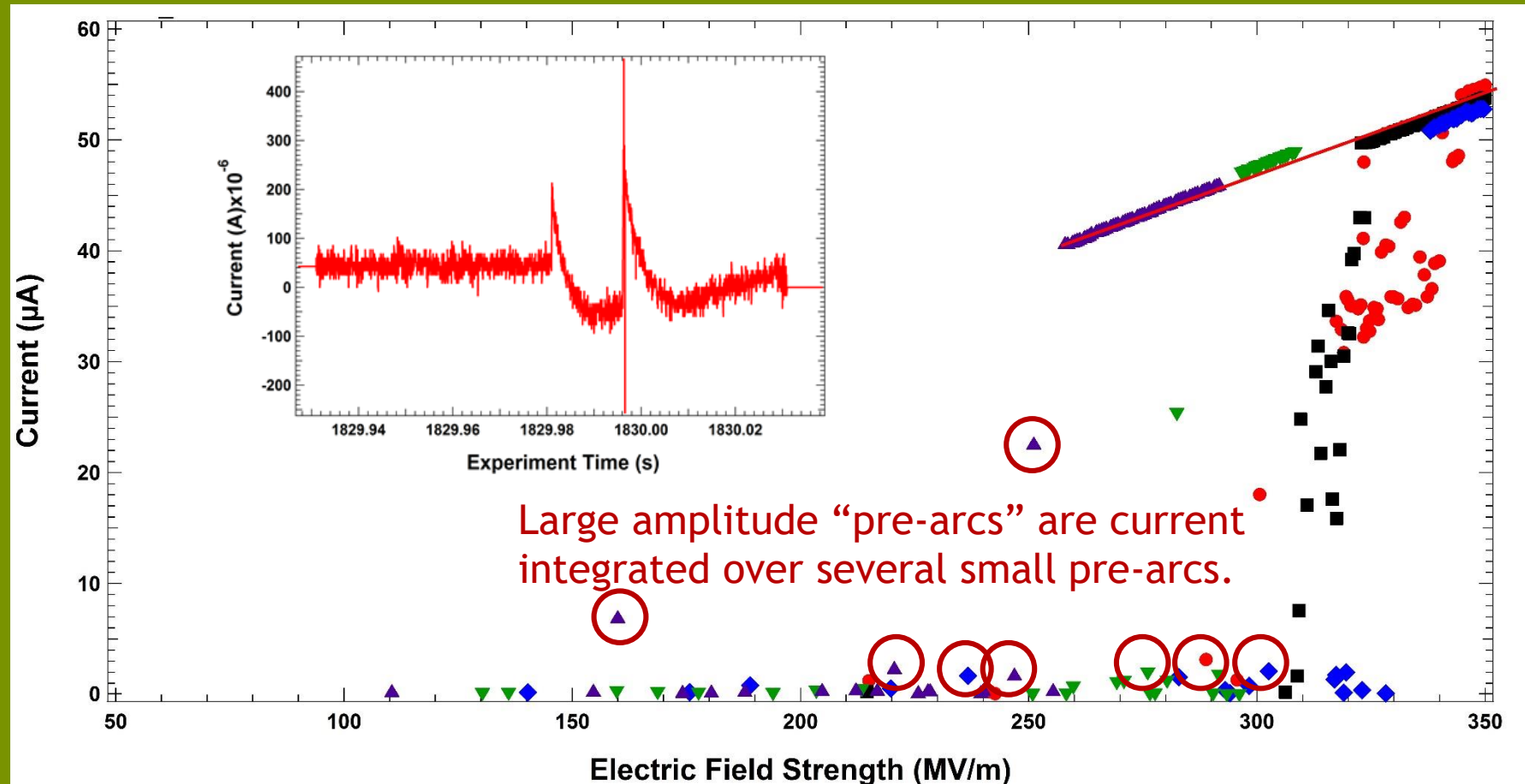
Case Study: Dielectric Breakdown Testing

ESD Test Assembly:

- (A) Adjustable pressure springs,
- (B) Insulating layer
- (C) Cryogen reservoir,
- (D) Thermally conductive, electrically isolating layer,
- (E) Sample and mounting plate,
- (F) Sample
- (G) HV Cu electrode
- (H) Cu thermocouple electrode,
- (I) Insulating base.

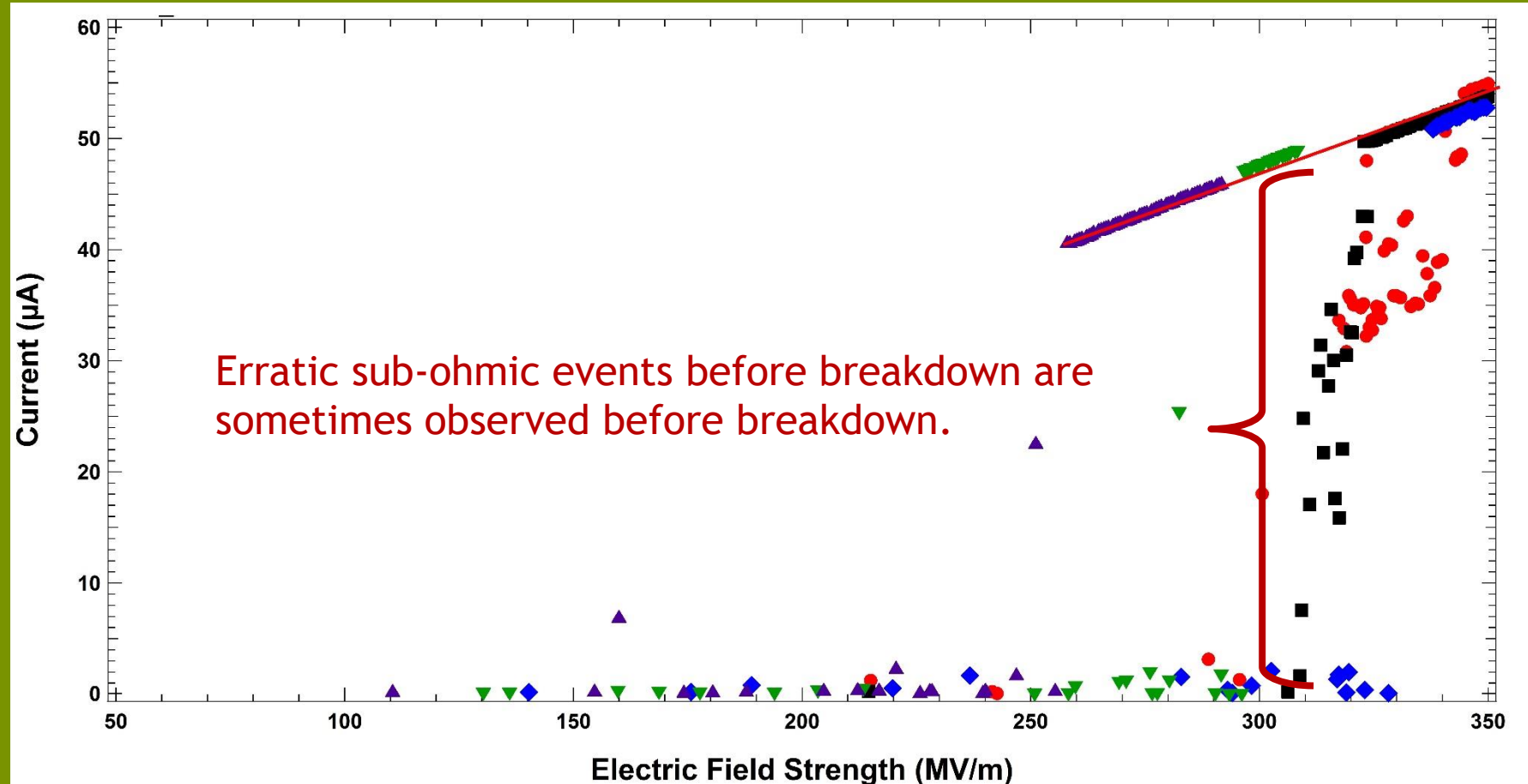


Case Study: Dielectric Breakdown Testing



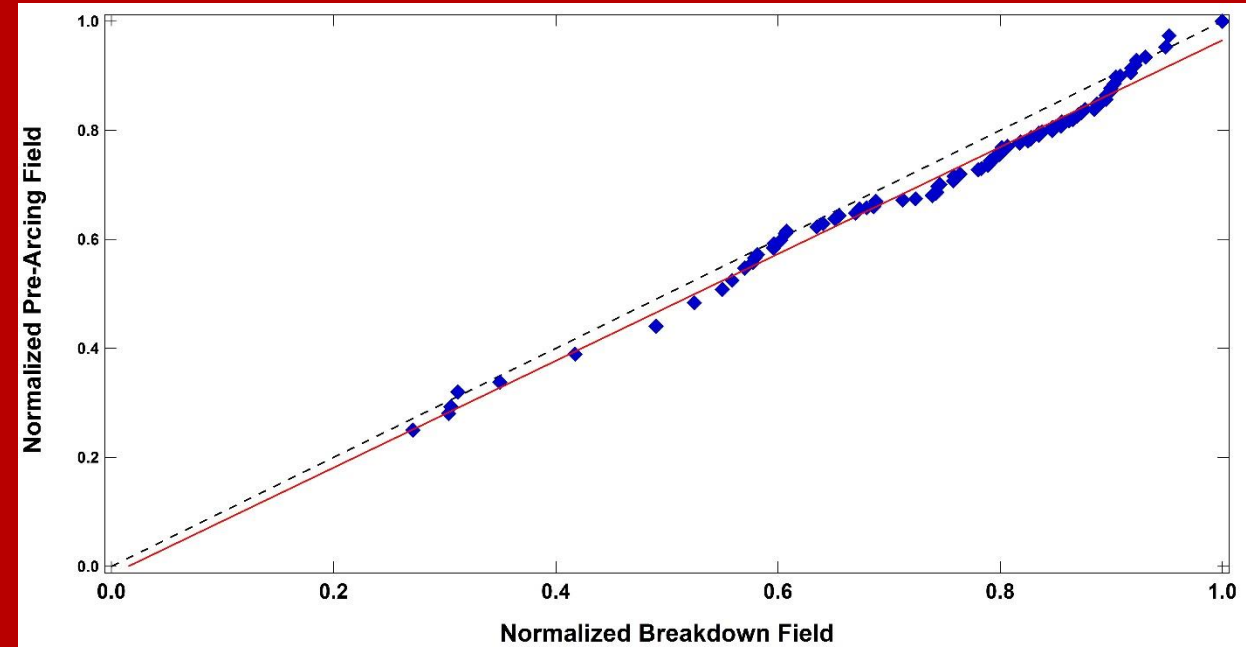
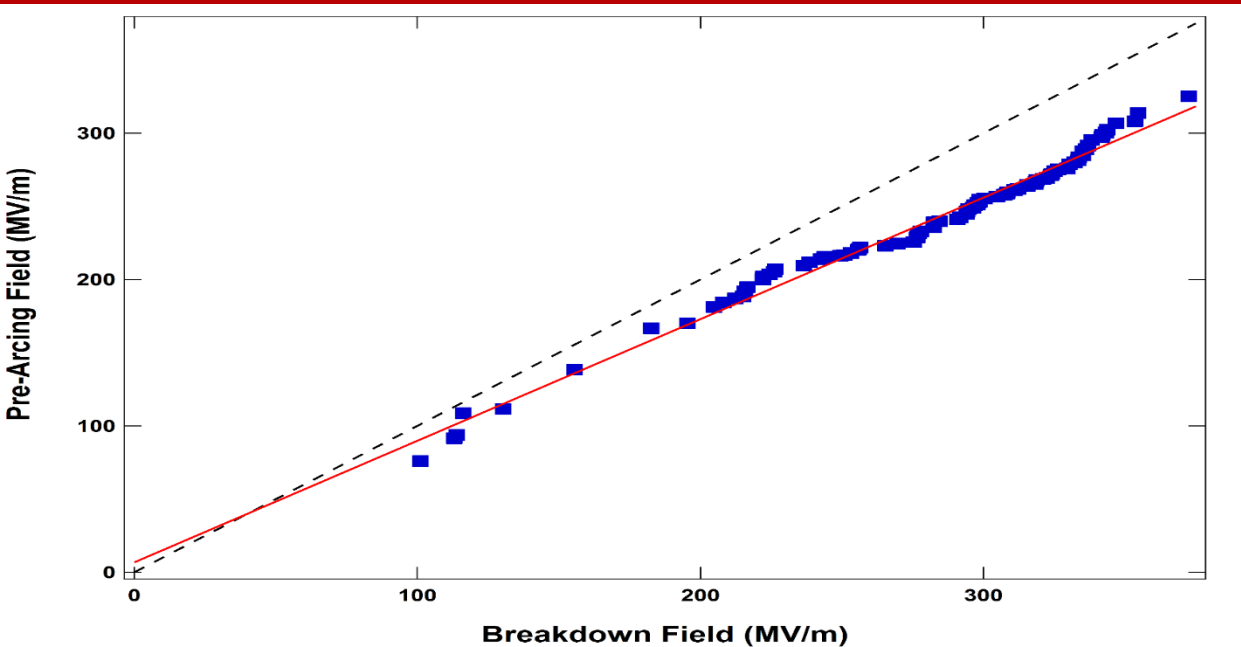
Plot of 5 voltage step-up to breakdown tests on LDPE.

Case Study: Dielectric Breakdown Testing



Plot of 5 voltage step-up to breakdown tests on LDPE.

Effect of scaling on Q-Q plots.



Re-scaling the fields brings the data points in the Q-Q plot closer to $y=x$.