Recent HV “Events”, MicroBooNE SPICE Model, and Possible Interpretation

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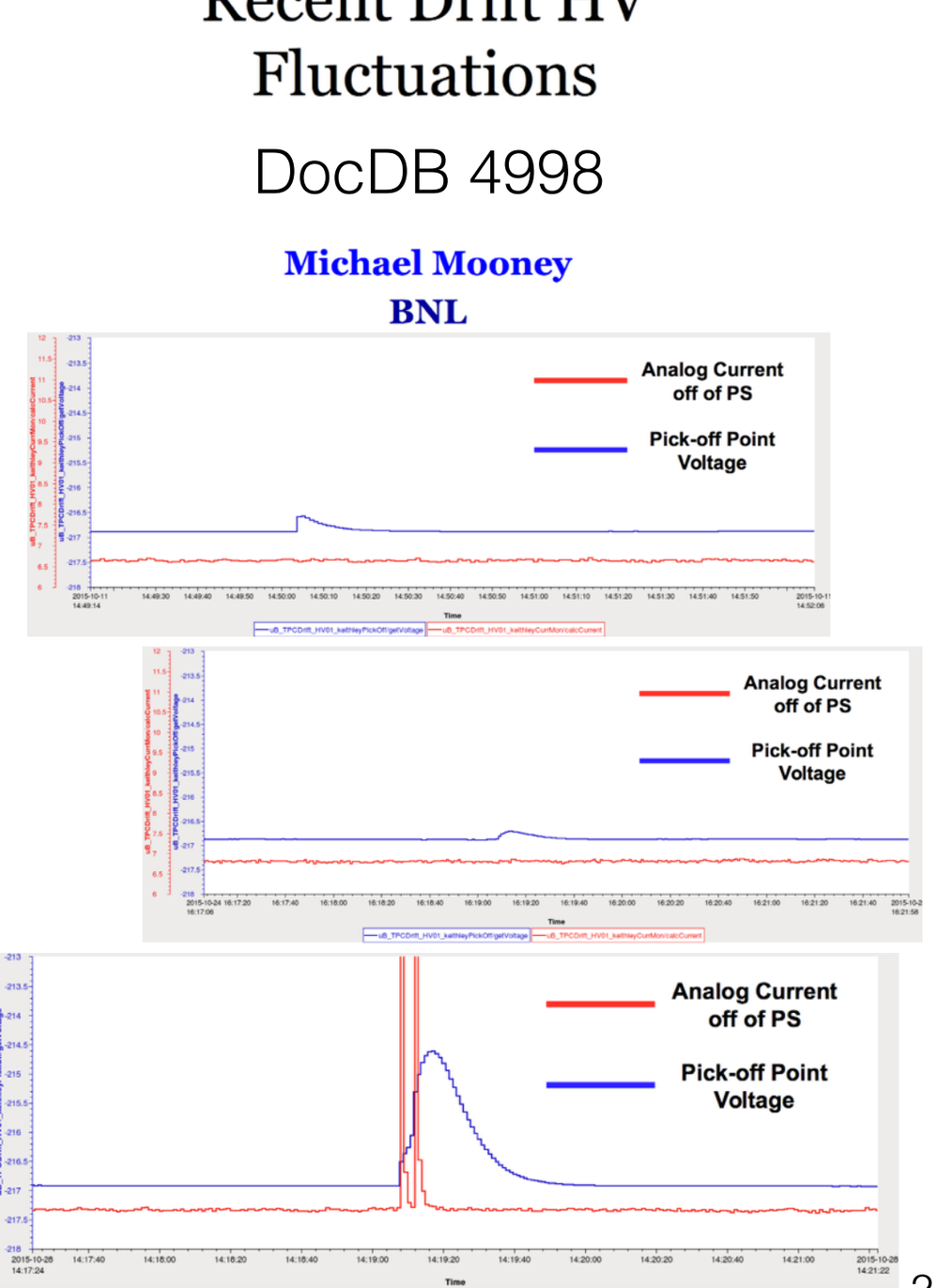
HV “Events”?

- Mike Mooney sent around some slides that pointed out some HV instabilities related to the “pick-off point” voltage and the current draw by the Glassman

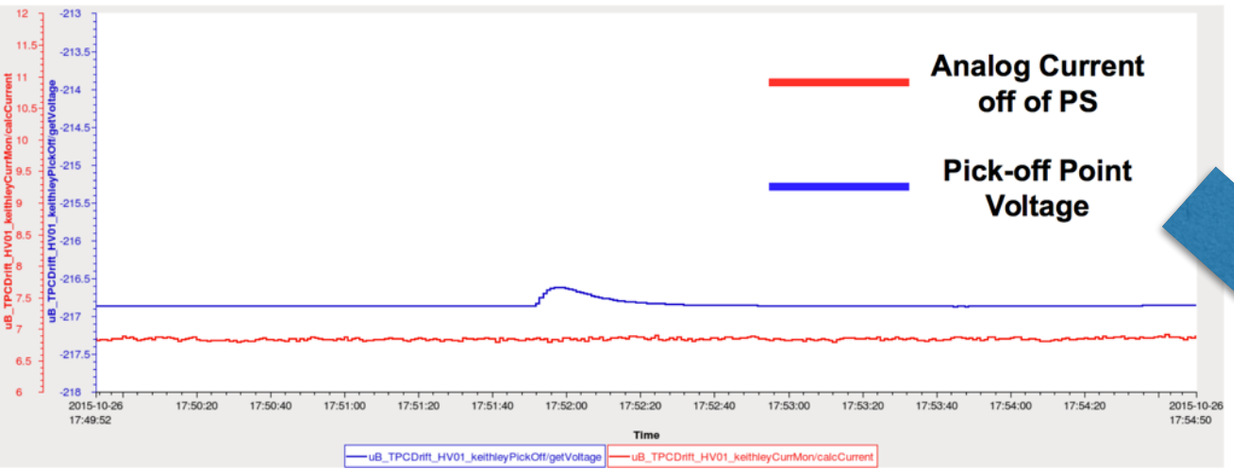
- These caught my eye because the shapes were similar to our SPICE models of the TPC (long RC tails)



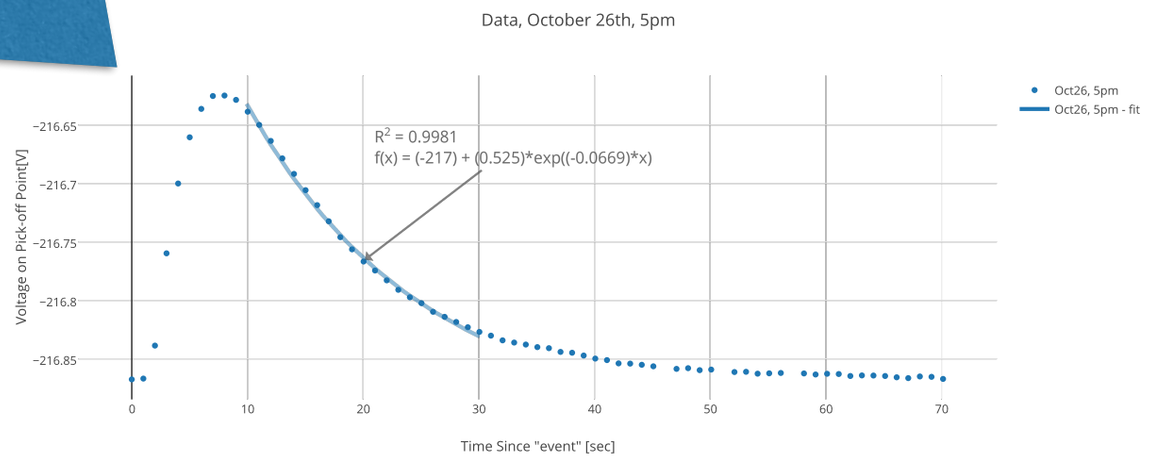
HV “Event” Data, SlowMon

- Using Mike’s slides as a guide I extracted the data about the events from slow-mon and plotted them

- I then fit the exponential tail of the pick-off point voltage as a function of time to see if we could isolate any time constants

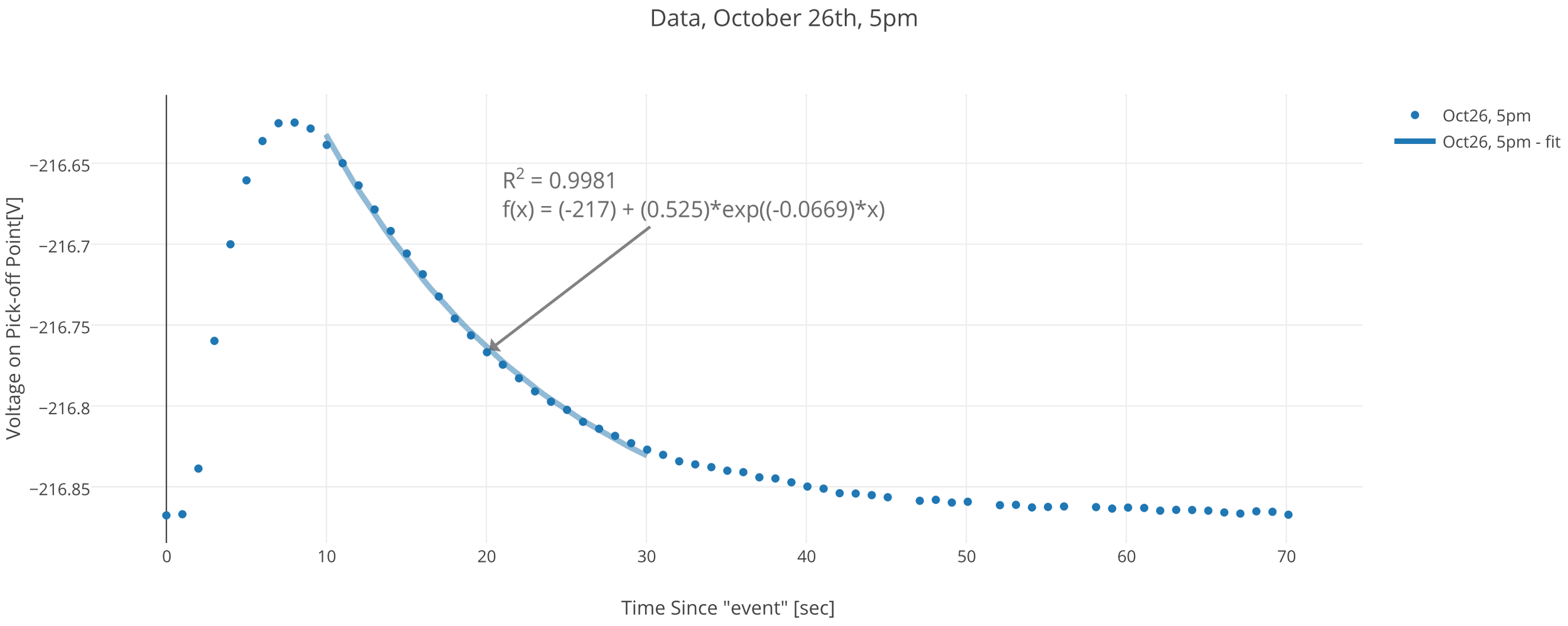


$$V^{\text{tail}}_{\text{pick-off}}(t) = a + be^{ct}$$



Time Constants, Data

- Fitting a number of these curves results in a number of different time constants



Time Constants, Data

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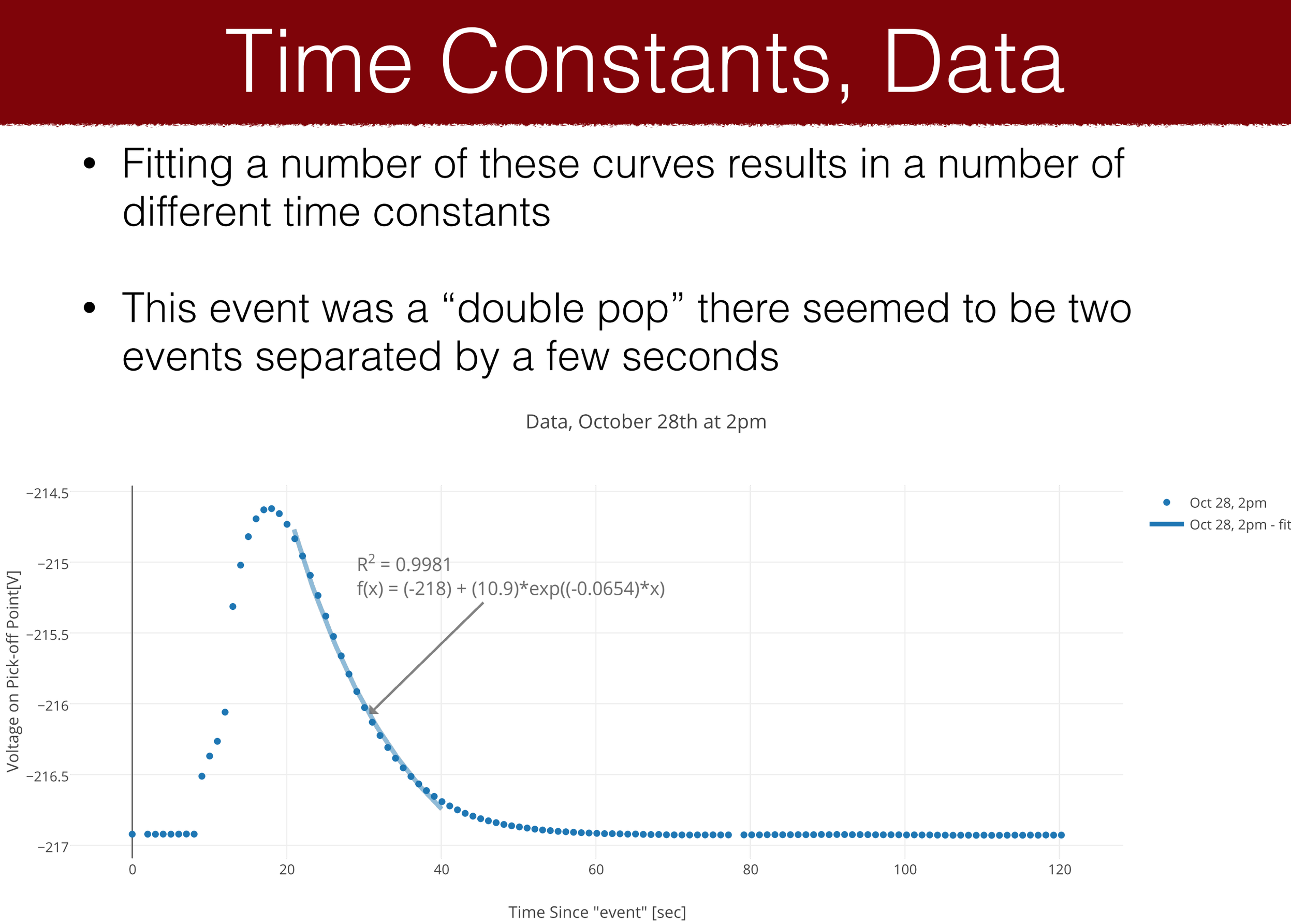
- This event was a “double pop” there seemed to be two events separated by a few seconds



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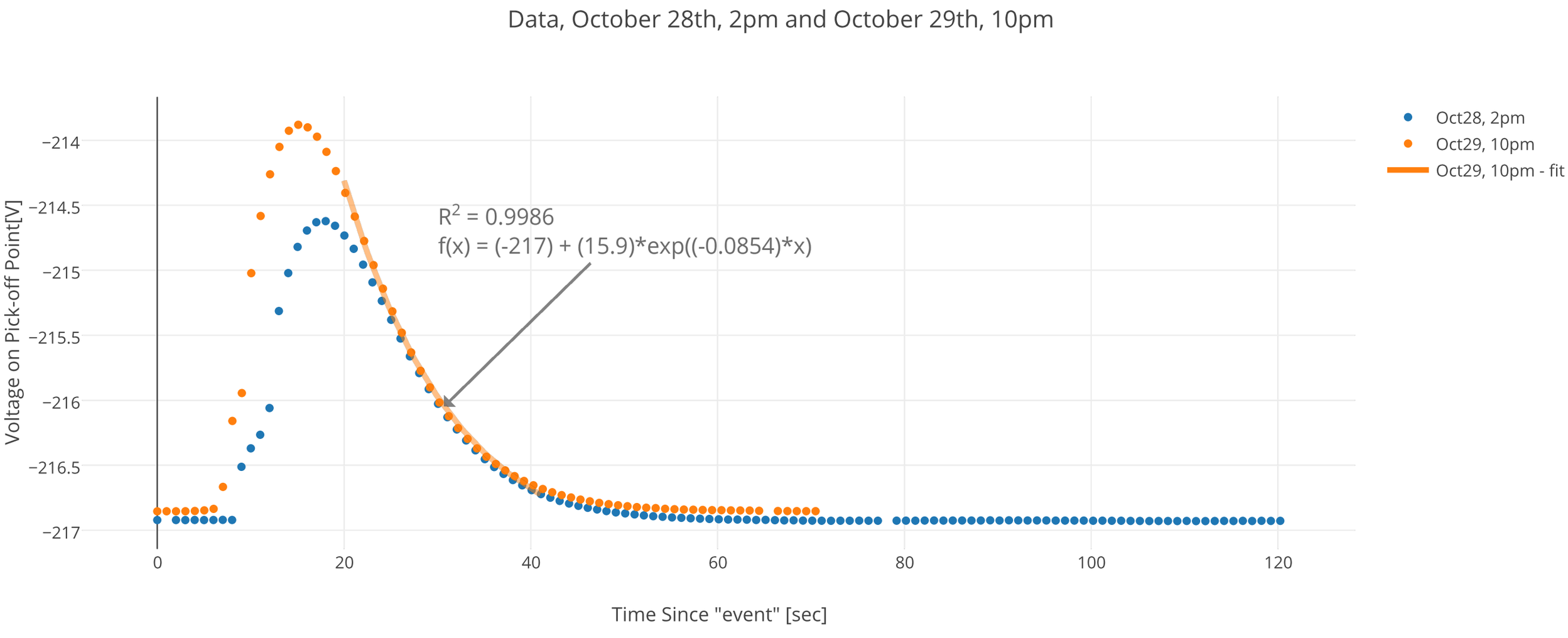
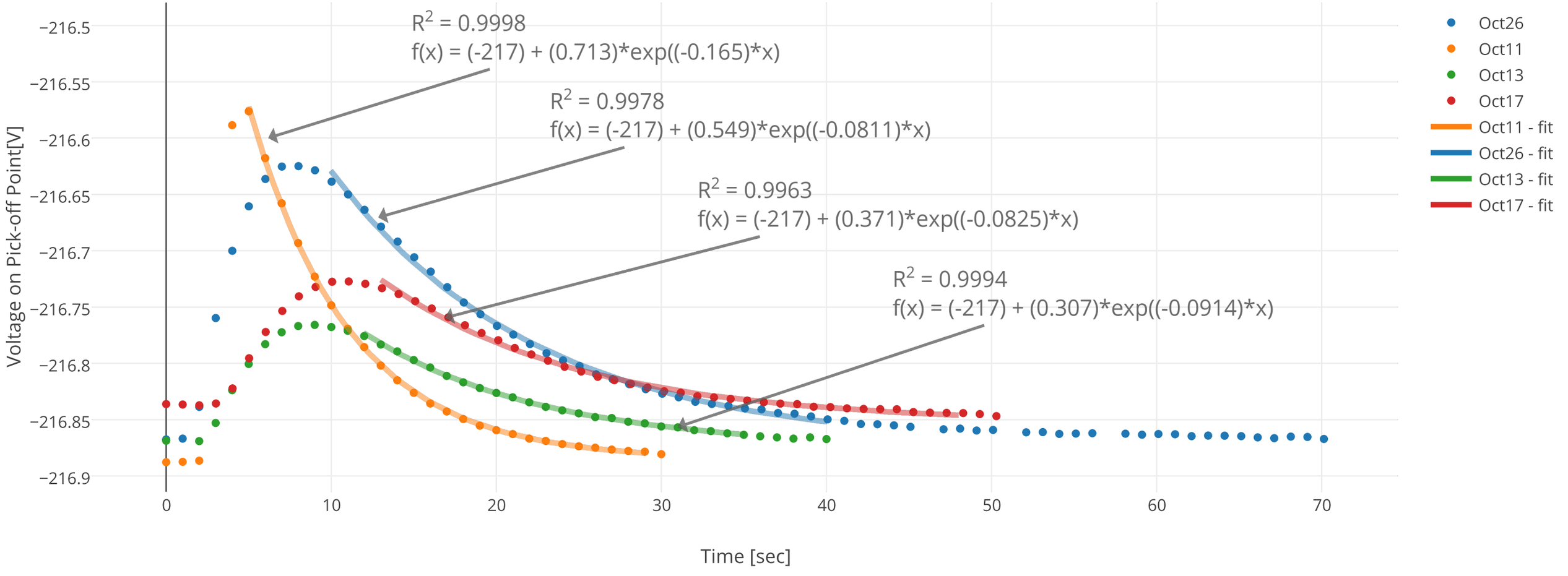


Time Constants, Data

- Fitting a number of these curves results in a number of different time constants

- You will also notice the baseline is a little different for every event,
  - Later we will rescale everything for a shape comparison

Data, from SlowMon



Time Constants, Data

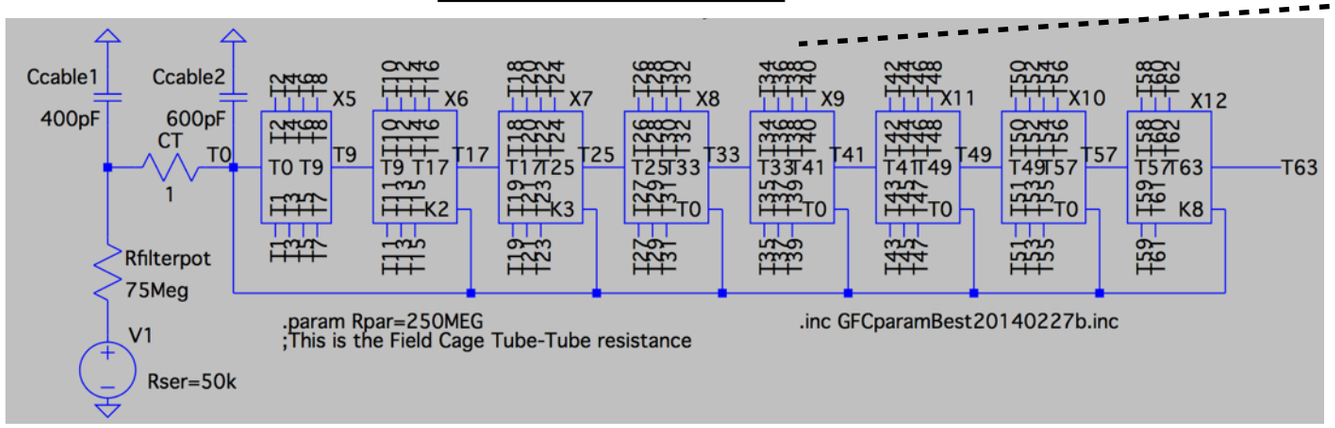
- Basically you get two populations of time-constants:
    - $\tau \approx 12$ sec, or parameter c ≈ 0.082
    - $\tau \approx 15$ sec, or parameter c ≈ 0.065

- We can compare these to what we would expect from the TPC

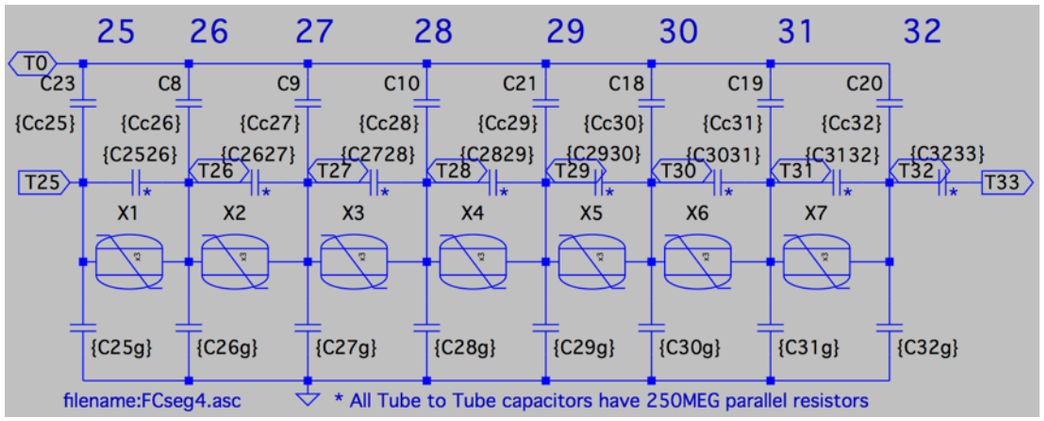
- After trying to do the math in the Control Room Stephen Pordes pointed me towards Dave Huffman who has a full SPICE simulation of the MicroBooNE TPC

MicroBooNE SPICE Model

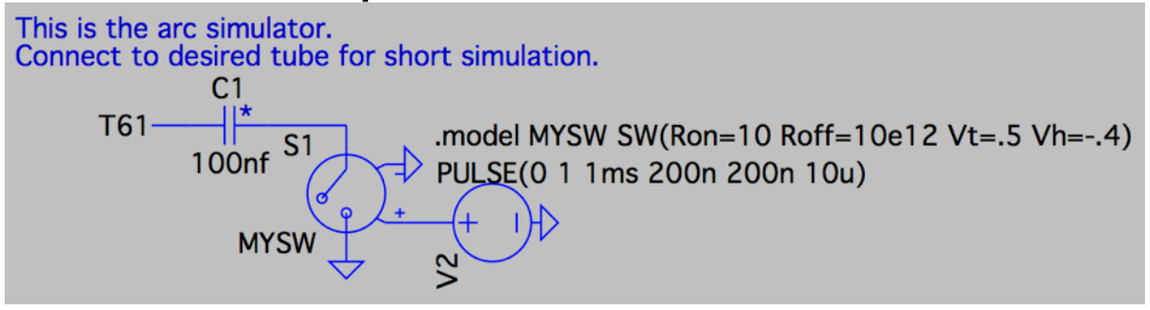
The TPC



The Tubes



A "Spark" Model



A caveat

This model was used when we studied the varistors, the model tracked the data well back then

- Using Dave's SPICE model of the TPC we can simulate a "spark" from any element to ground
- After this we can study the voltage at the "pick-off point" and compare to the data
- **Important to note T0 is the cathode T63 is the anode**

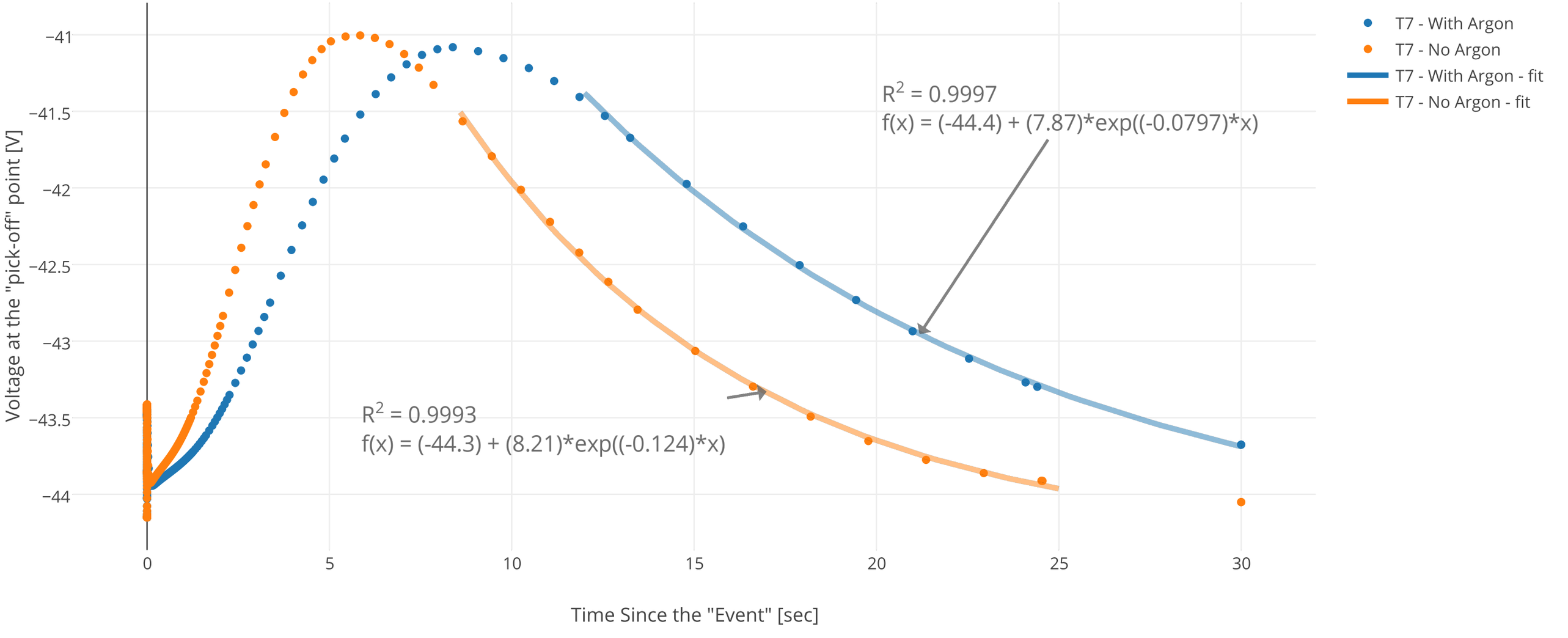
How to Interpret the Simulation

- If we interpret the data “events” as HV breakdowns we wouldn’t know the timing or size of the discharge so the normalization and timing of the simulation can’t be compared
  - The rise time, shape, and time constants that are simulated depend on the fix detector capacitances and resistances
  - So do not necessarily look at the normalization of the simulated plots to follow
    - I test this in a few slides…
- We will only be modeling events with only one apparent “event” (one current spike on the power supply) since we can’t simulate two simultaneous breakdowns
- Dave noticed late in the game that the final resistance of the pick-off point was set to the wrong value, but this will only effect the amplitude and baseline of our model

Importance of the Capacitances

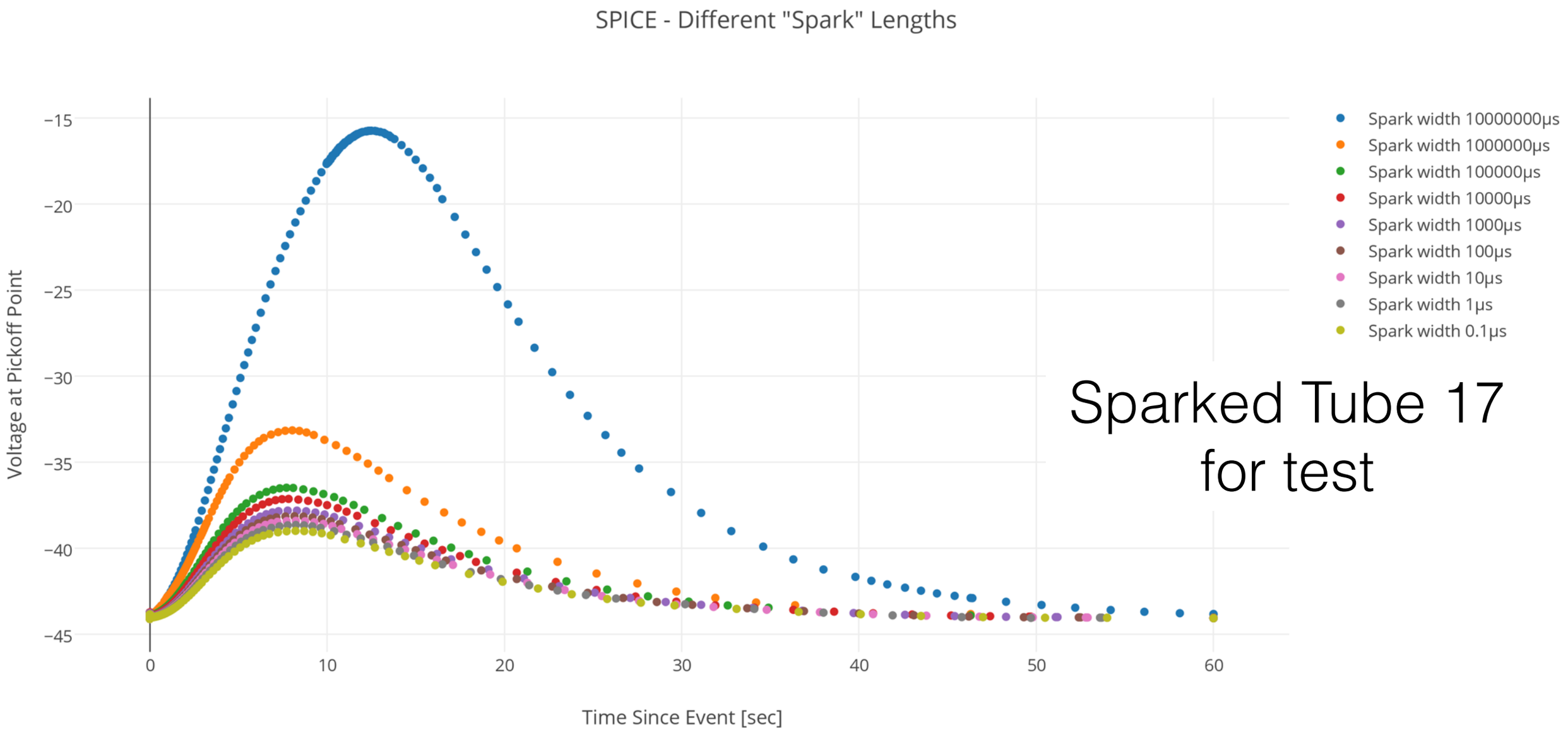
- Initially the model didn't include the effects of the argon in the capacitances but we added it to see what the effect is
  - The answer is quite a bit!
- This was added and all the simulations were rerun

SPICE Model



Spark Simulation Systematics

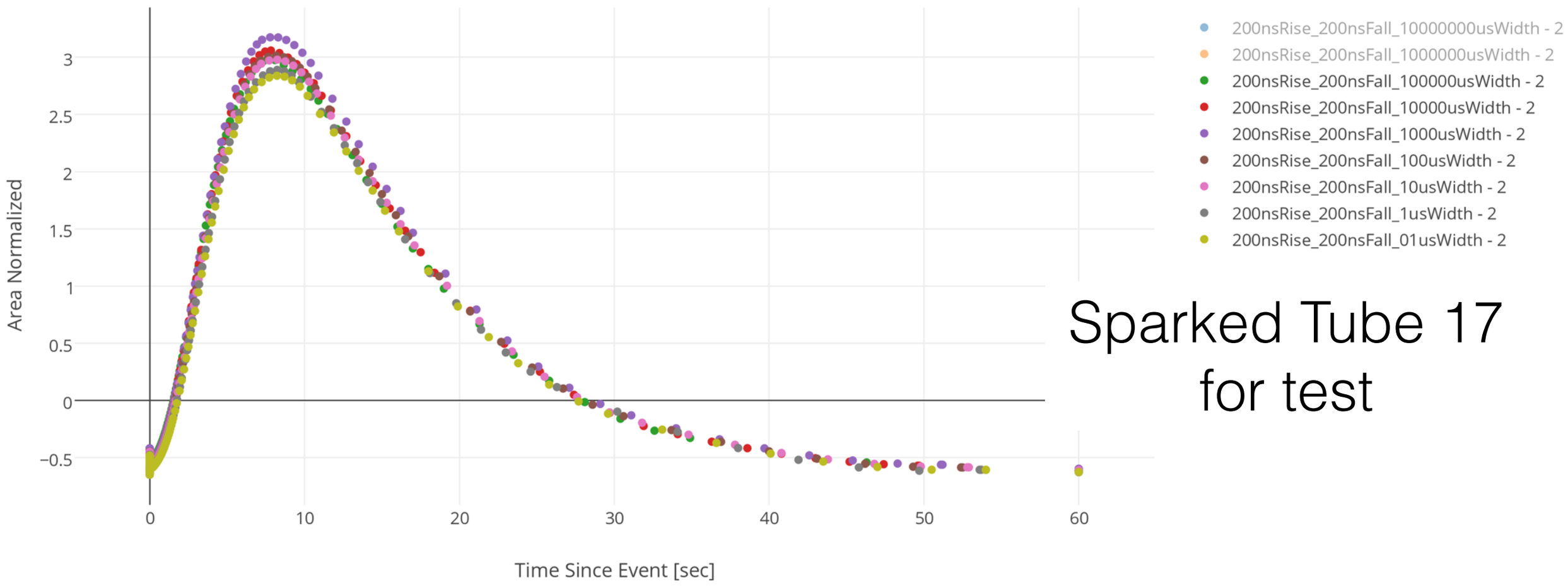
- I wanted to check if changing the length of the “spark” affected the shape of the distribution or just the normalization



Sparked Tube 17 for test

Spark Simulation Systematics

- We removed the two obvious outliers that we will analyze further and then checked the shape of the other distributions
- We can see that there is a little shape difference in the peak but the tail and rise time looks very similar over 7 orders of magnitude



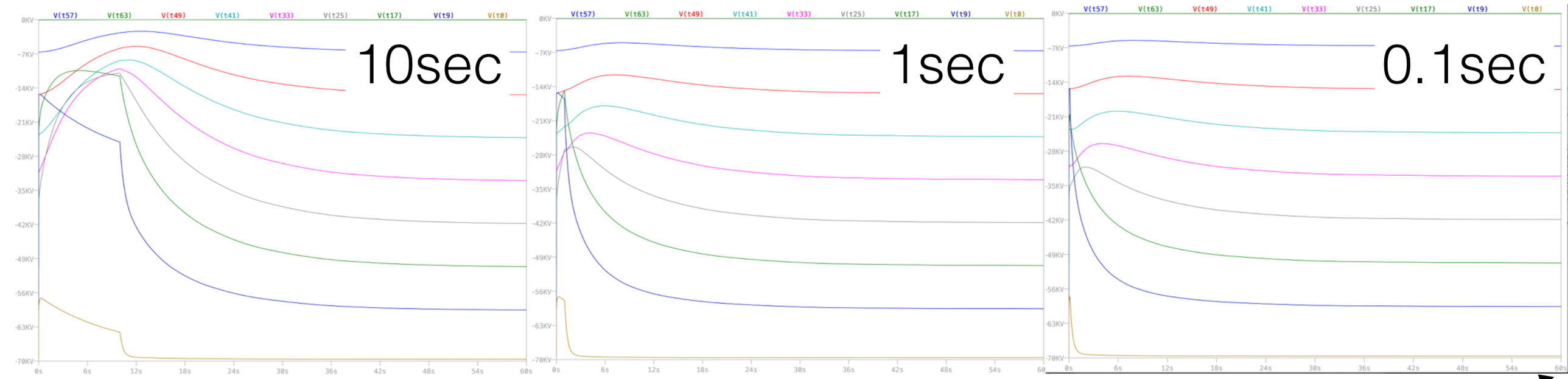
Sparked Tube 17 for test

Very Long Sparks

- We look at the voltages across the field cage for the sparks that last 10seconds and 1second

- We can see slightly different behavior in the 0.1sec spark where the voltage on the tube closest to the grounded behaves more smoothly

- This could imply that we are probing a different phase space than we might be seeing in the detector….?



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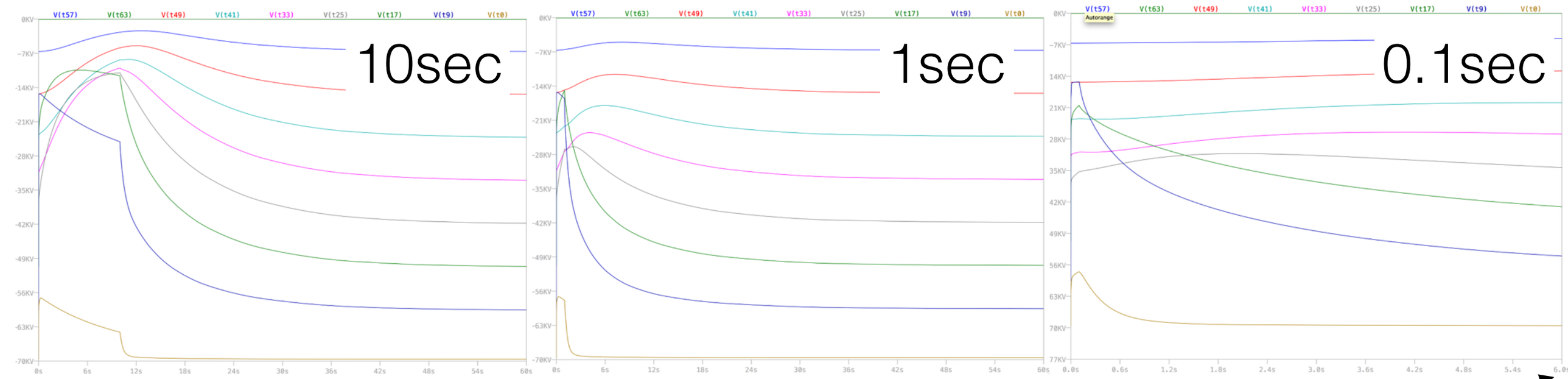

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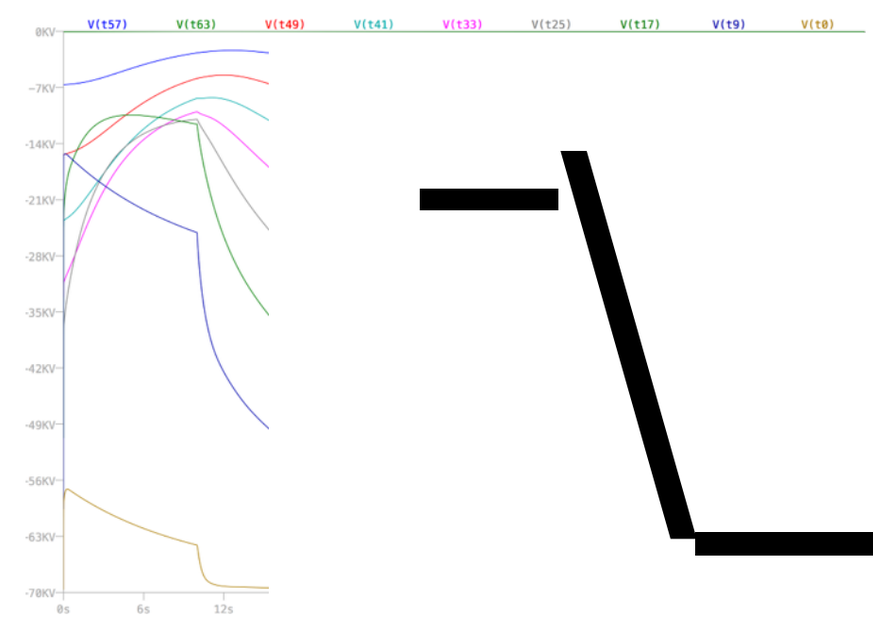

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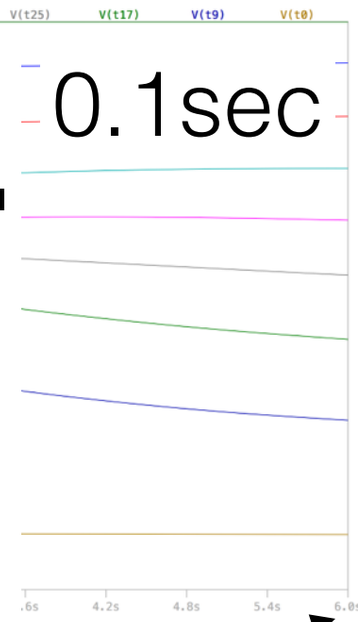


6 sec

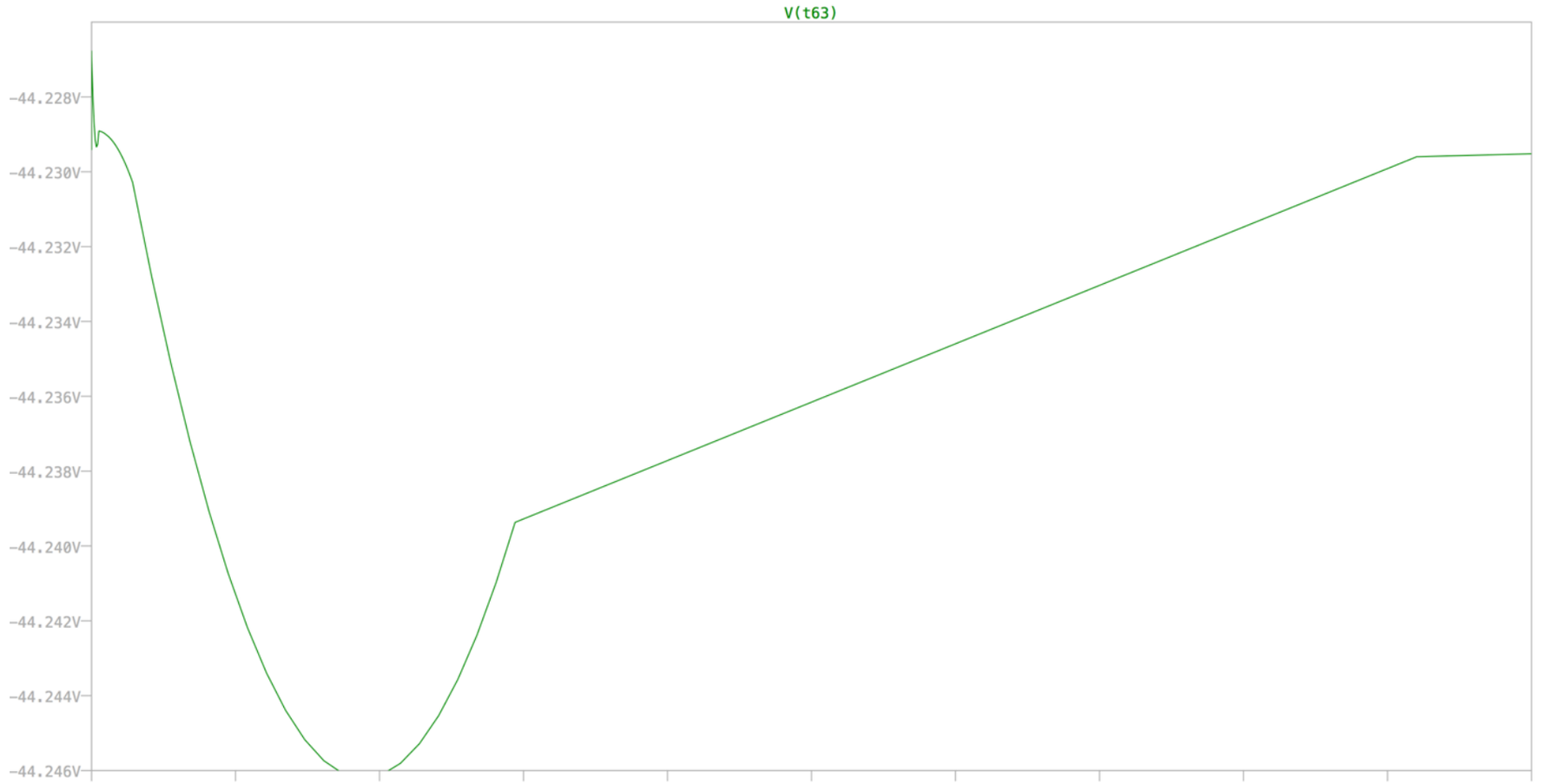
Cathode “Spark”

- The place with the highest potential is an obvious first place to look

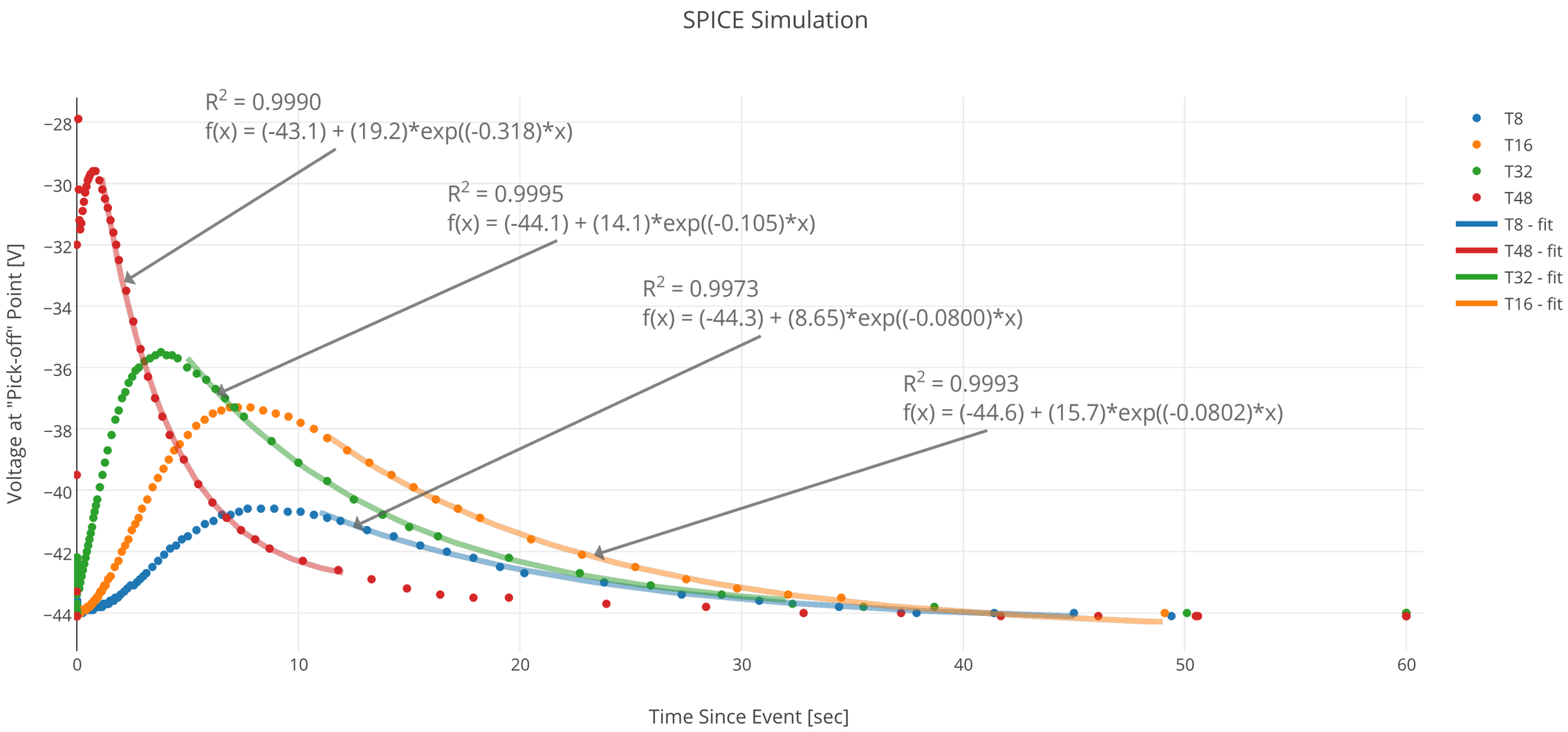
- The pickoff point voltage (green curve below) looks nothing like what we are observing in data which implies that we aren’t seeing discharge from the cathode

Tube-to-tube Breakdowns

- Another possible source of breakdowns are the sharp edges near the resistor chain jumping from one tube to another
- This is unlikely because any breakdown in this style would increase the voltage observed at the end of the resistor chain since we are bypassing one set of resistors
- As we see in the model this shape of the resulting is the opposite which we observe in the data



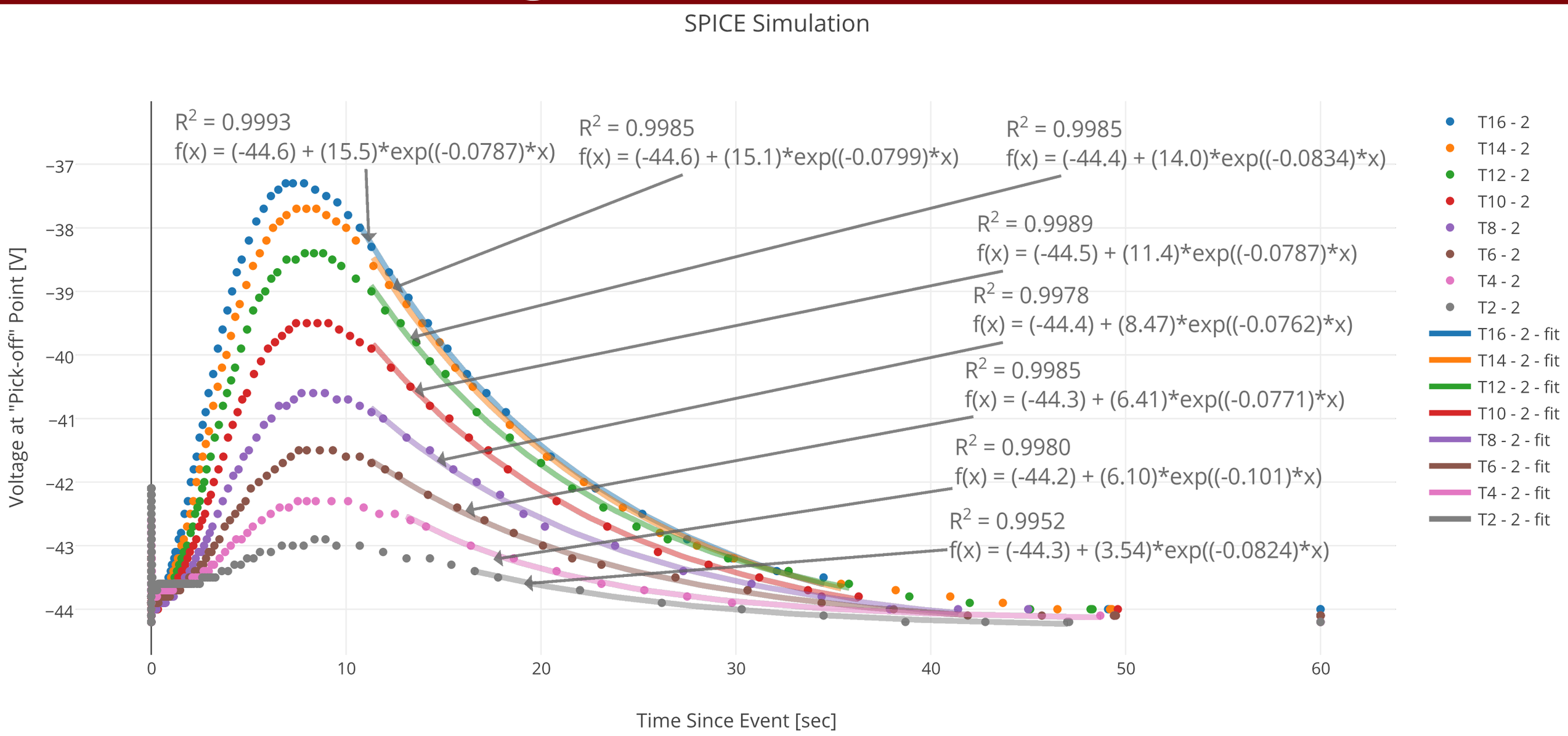
Pick-off Voltage Behavior



- Using this simulation we can do a gross scan of the TPC to see if anything gets close to the time constant we observe

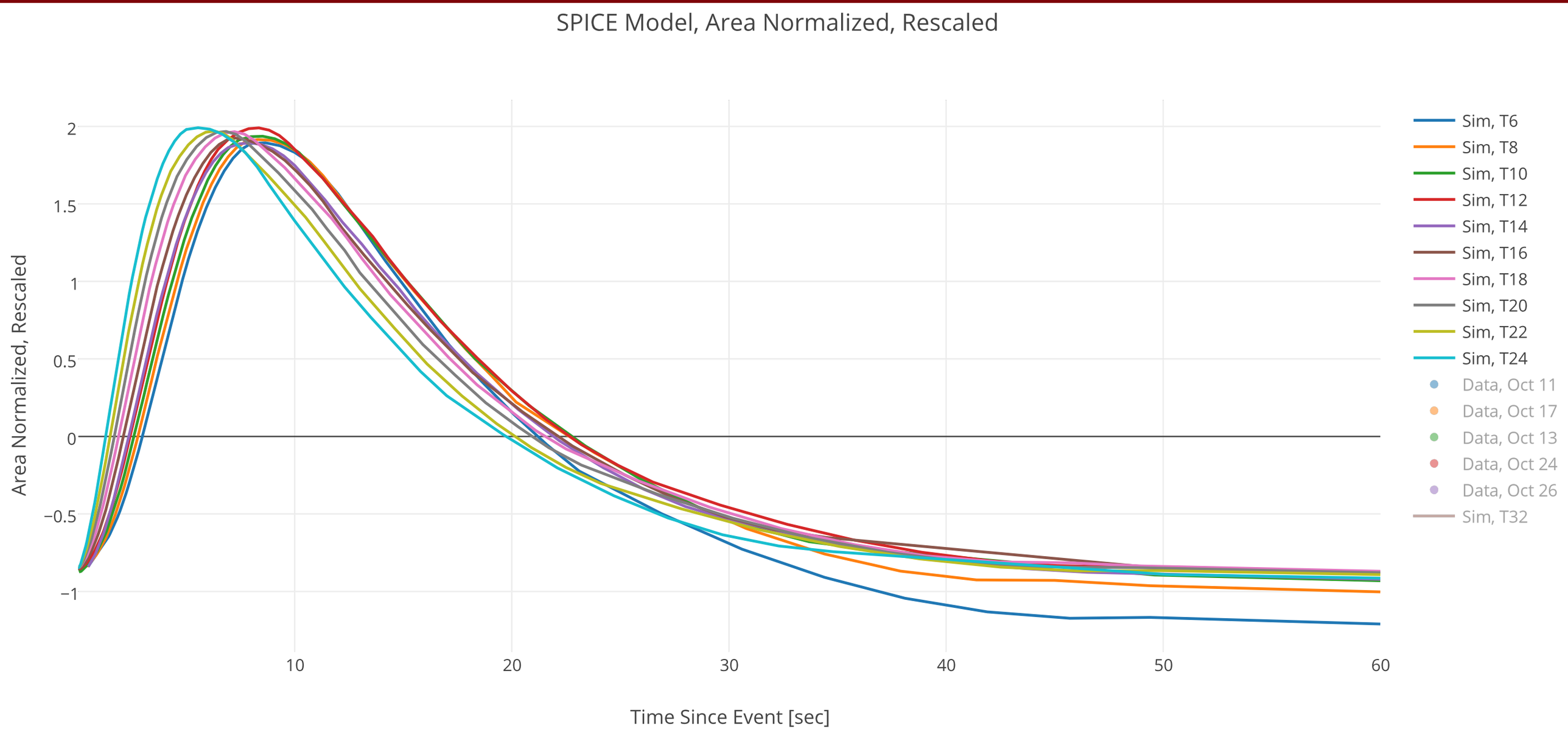
- It appears the if we spark closer to the cathode the time constants (and shape) agree better with the data

Pick-off Voltage Behavior, Near Cathode



- We can then do a fine scan the tubes approaching the cathode
- We can see the time constants are very similar in this region
- Instead we can area normalize these distributions and rescale the baseline and compare the shape

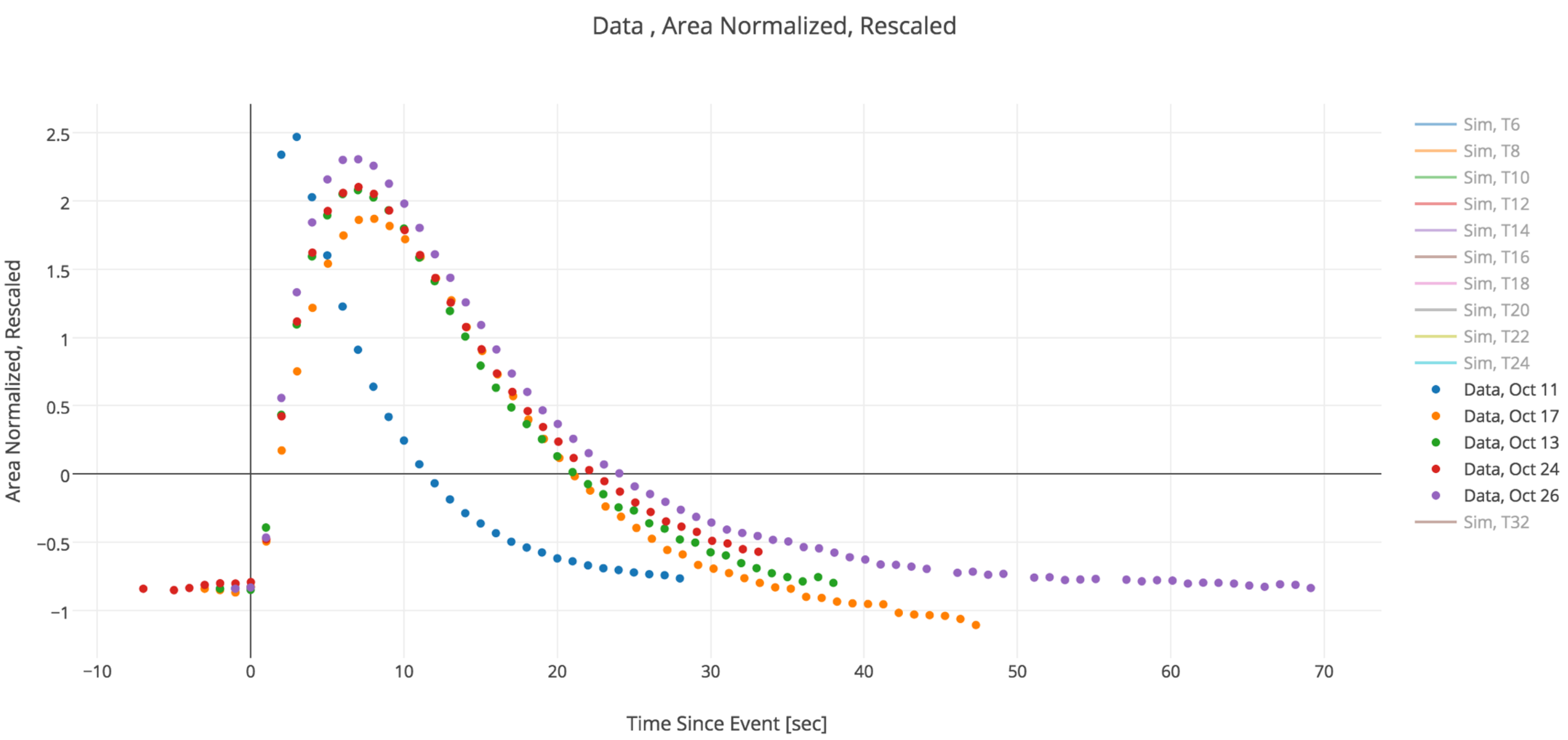
Pick-off Voltage Behavior, Shape Comparison



- We truncate these distributions by cutting off the first 0.5sec this removes some of the prompt fast processes that our monitoring tools wouldn't see
- We can see a pretty good separation between the various tubes

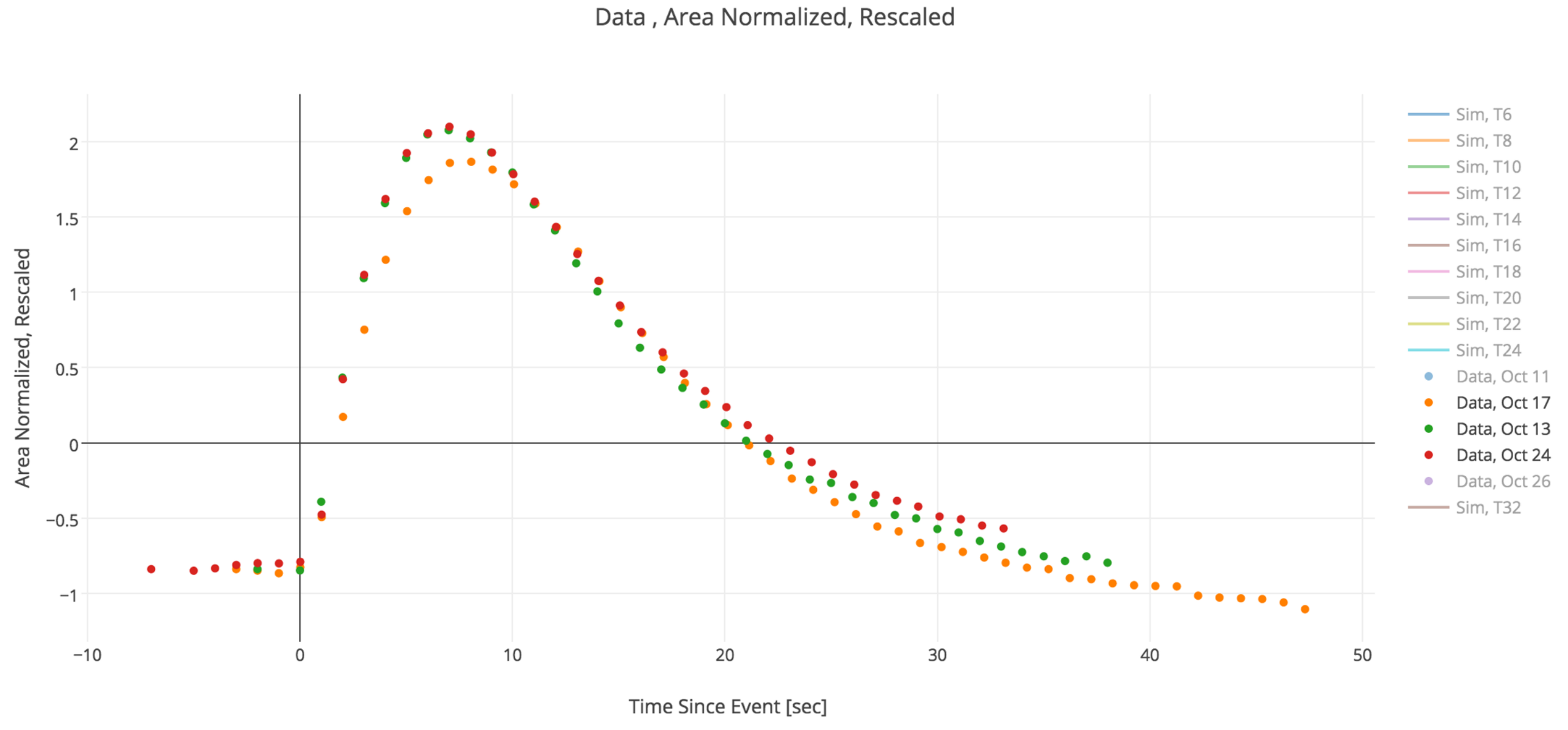
Data “Event” to “Event” Comparison

- We can now compare the shapes of the various events, rescaling “start” time and baseline and then area normalizing all the distributions



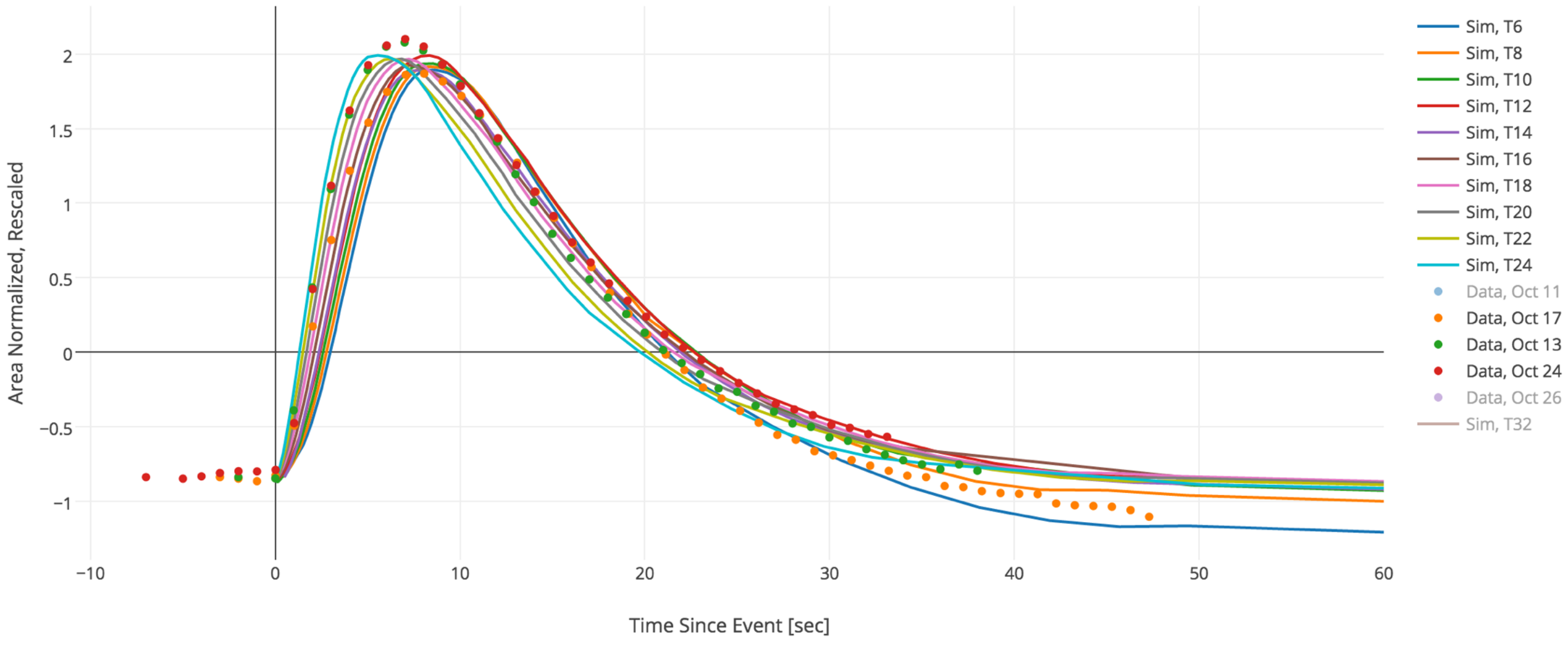
Data “Event” to “Event” Comparison

- We can see that there are two events which form outliers so let’s remove them
- The remaining three events look very similar, we can see how these compare to the simulation



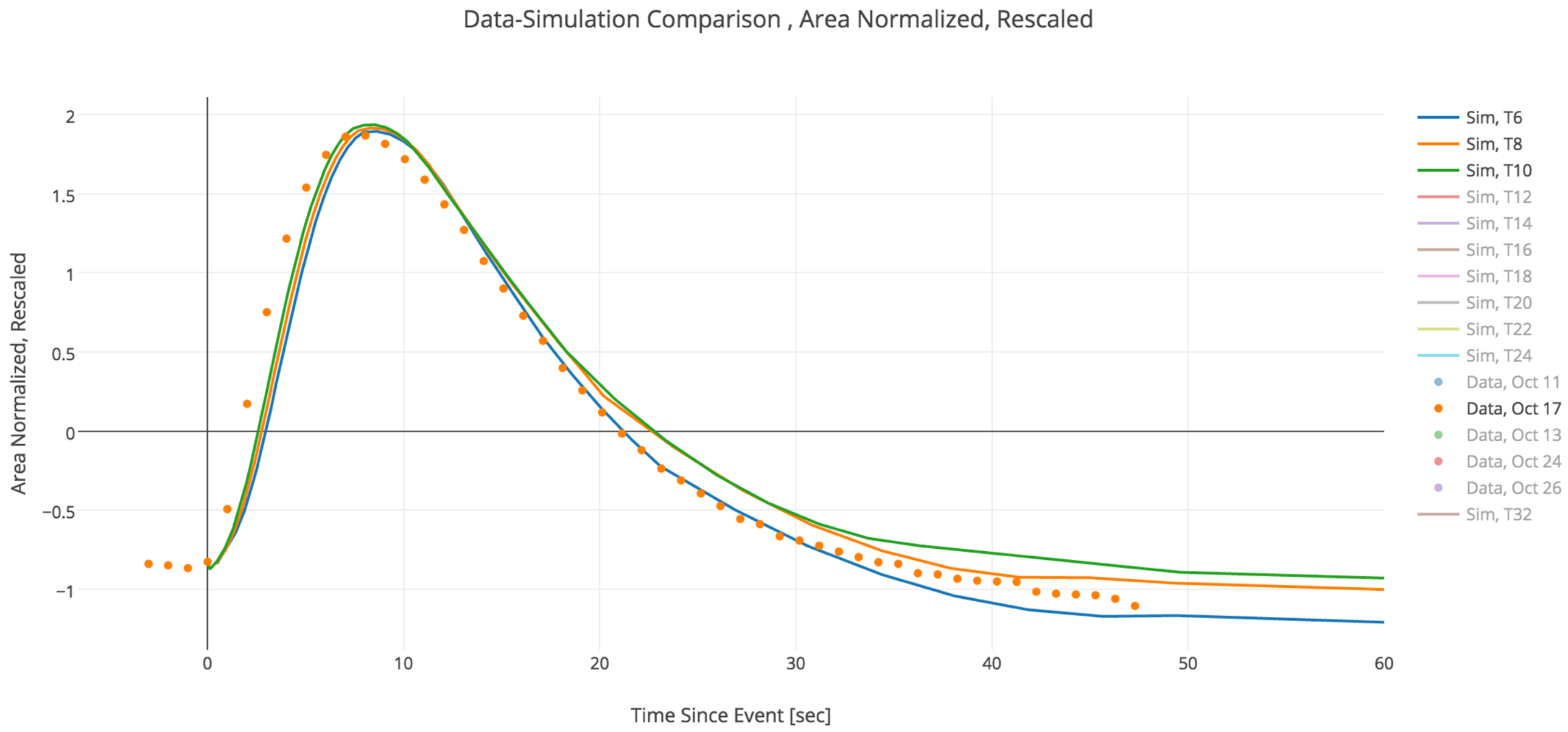
Data-Simulation Shape Comparison

- There is quite a bit of spread
- On the next slide we can slim down the number of models we are comparing to and see if we can hone in



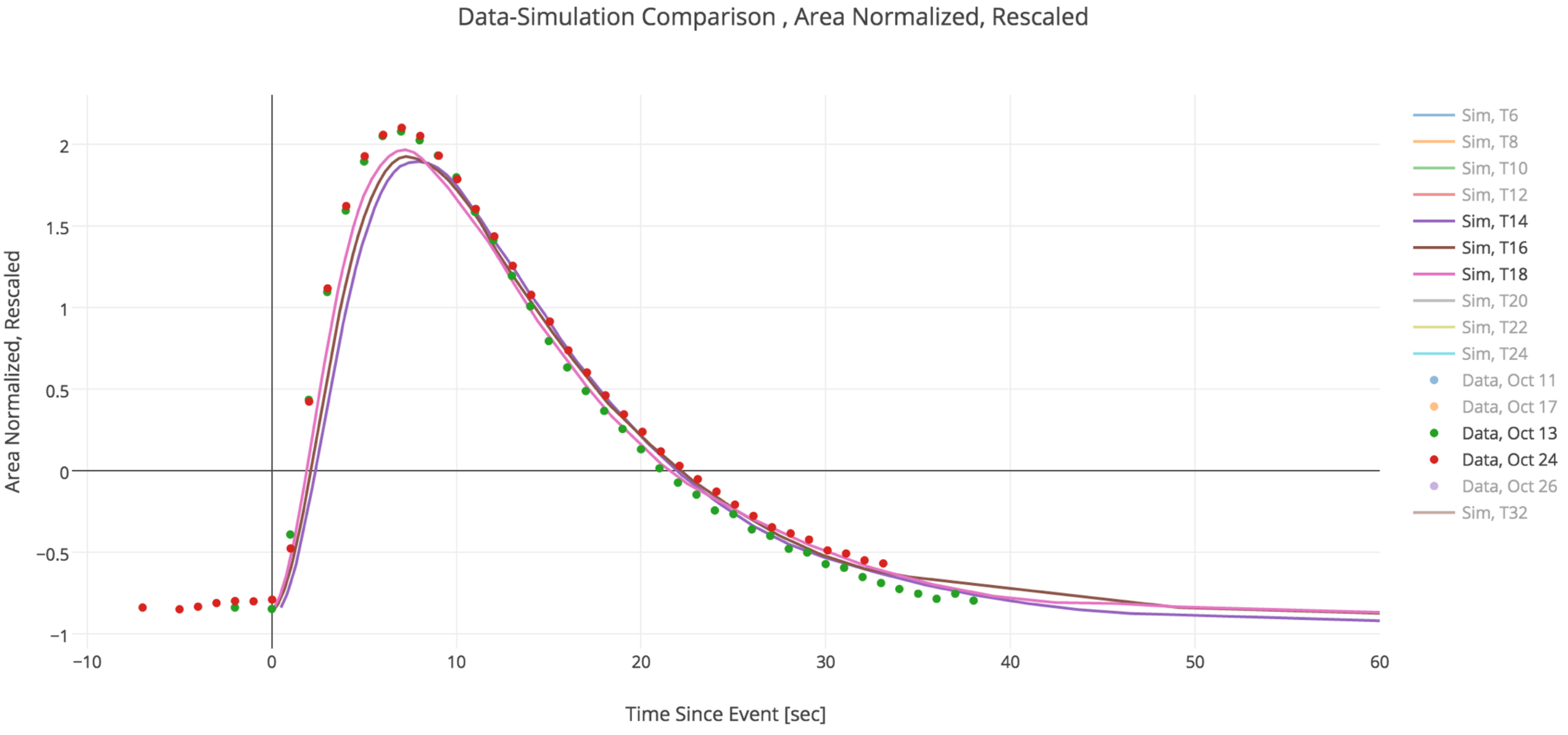
Data-Simulation Shape Comparison

- You can see that these curves reproduced the October 17th “event” well, this would imply that this event could be interpreted as a breakdown from one of the tubes from 6 and 10 to ground



Data-Simulation Shape Comparison

- The other two “events” aren’t as well modeled but you can see that the simulations of breakdowns from tube 14 to ground through tube 18 to ground do trend along with the data

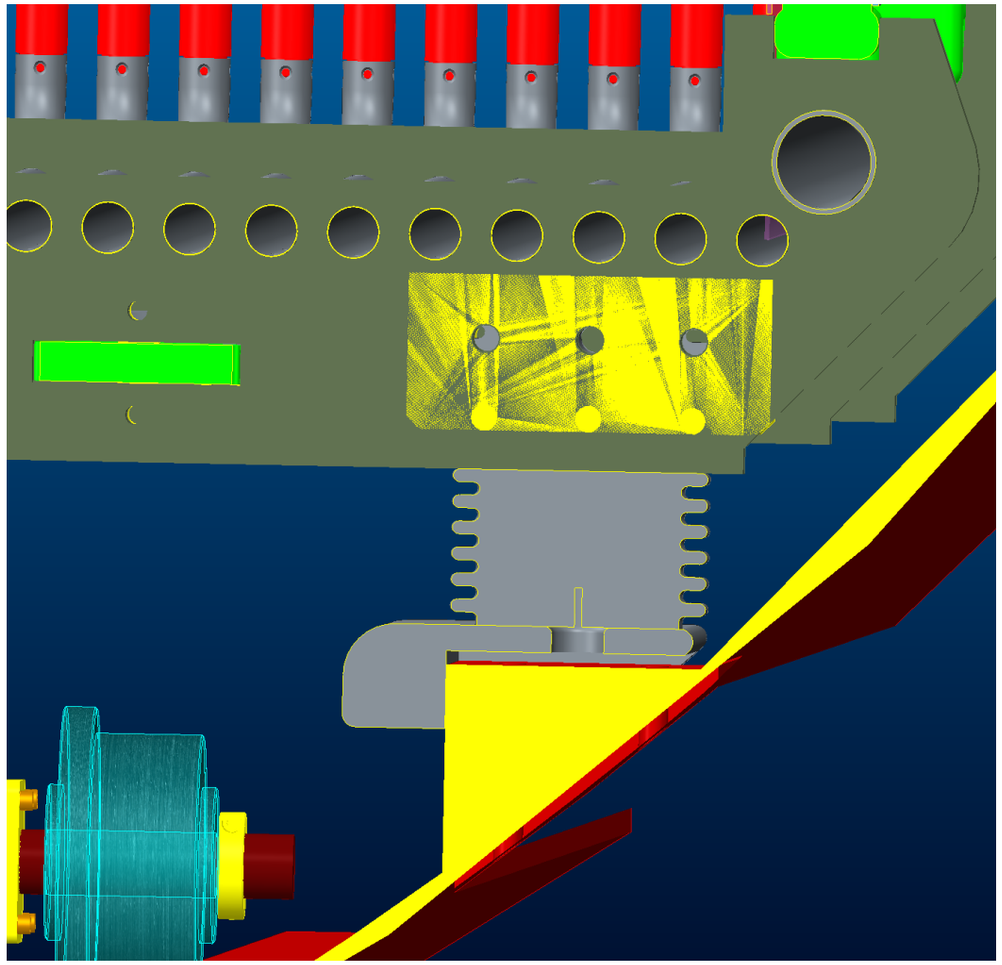


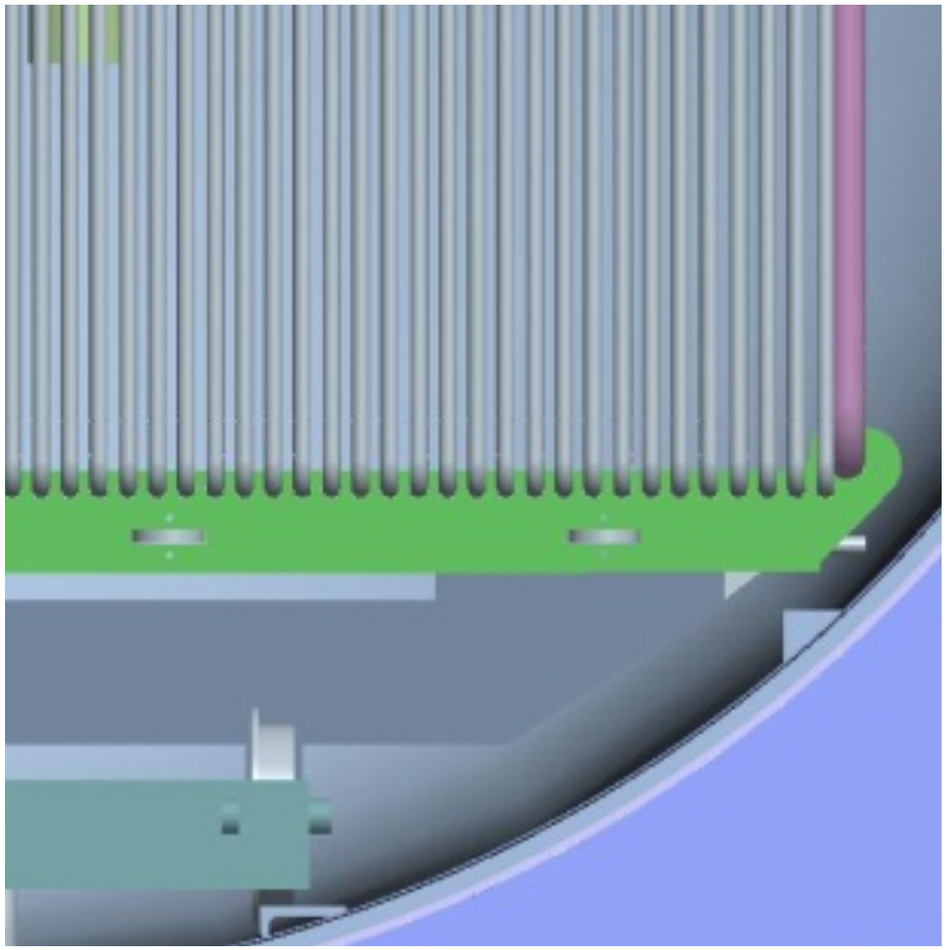
Data “Event”

- After comparing the data “events” to the discharge simulation they seem to trail each other
- One could interpret this as evidence that we are observing breakdowns in the detector

Possible Interpretation, TPC-Cryostat Connection

TPC Cryostat Connection





- From tube 1 to tube 6 we are stilling very close to the feet

Possible Interpretation, Voltage Divider Chain

- From tubes 0 until tube 16 contain the “Zebra resistors” and for an additional 16 tubes after that we have the varistor boards

- Though tube-to-tube breakdowns are disfavored in our models