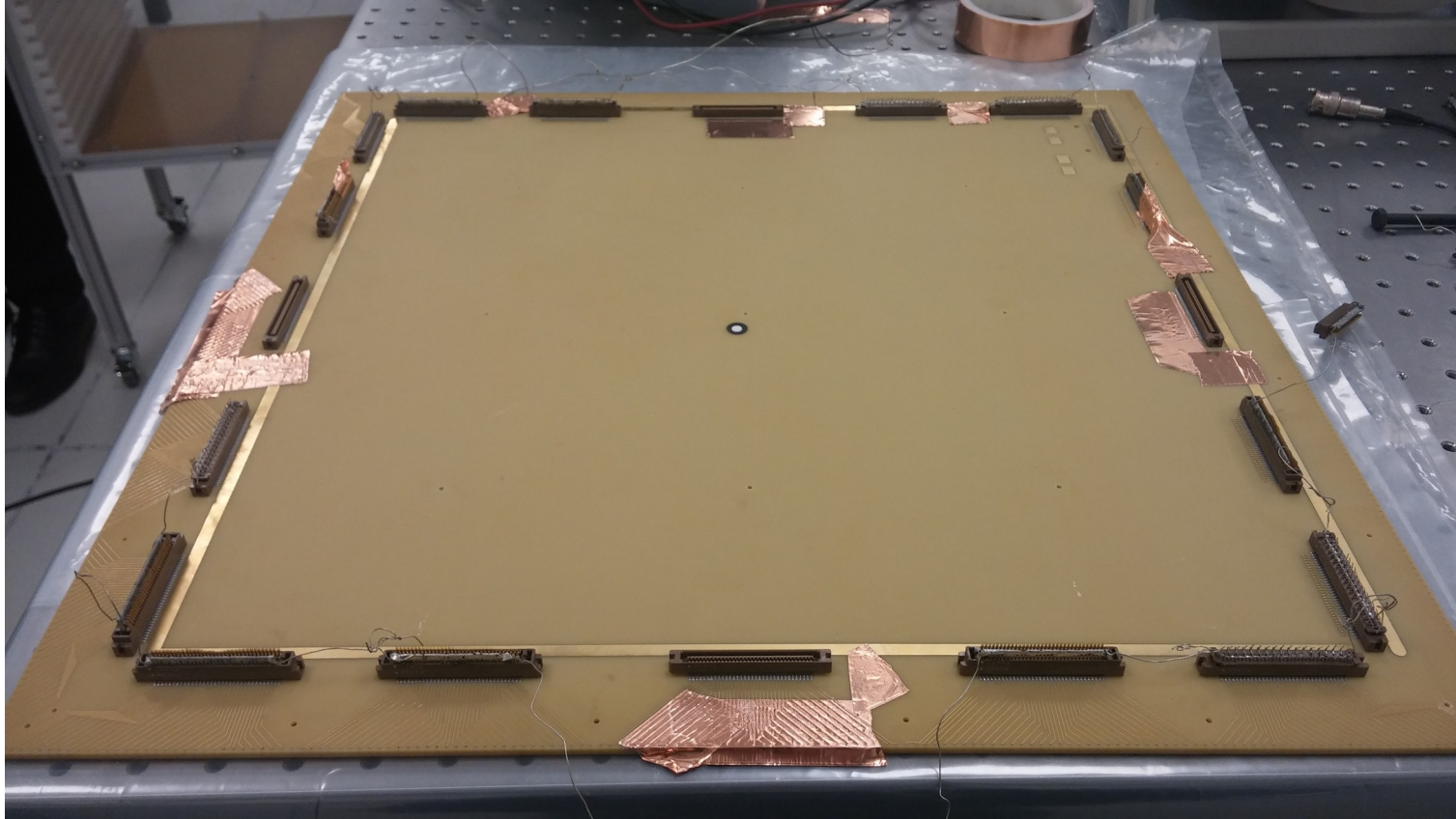


Capacitance Studies on Anode Measurements and Simulations



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WA105 Collaboration Meeting 22/03/2017

Goal

Capacitance studies of the anode:

- Measurements:
capacitance measurements with LCR meter
- Simulations:
capacitance simulations to model the anode and cross check with the results from the measurements

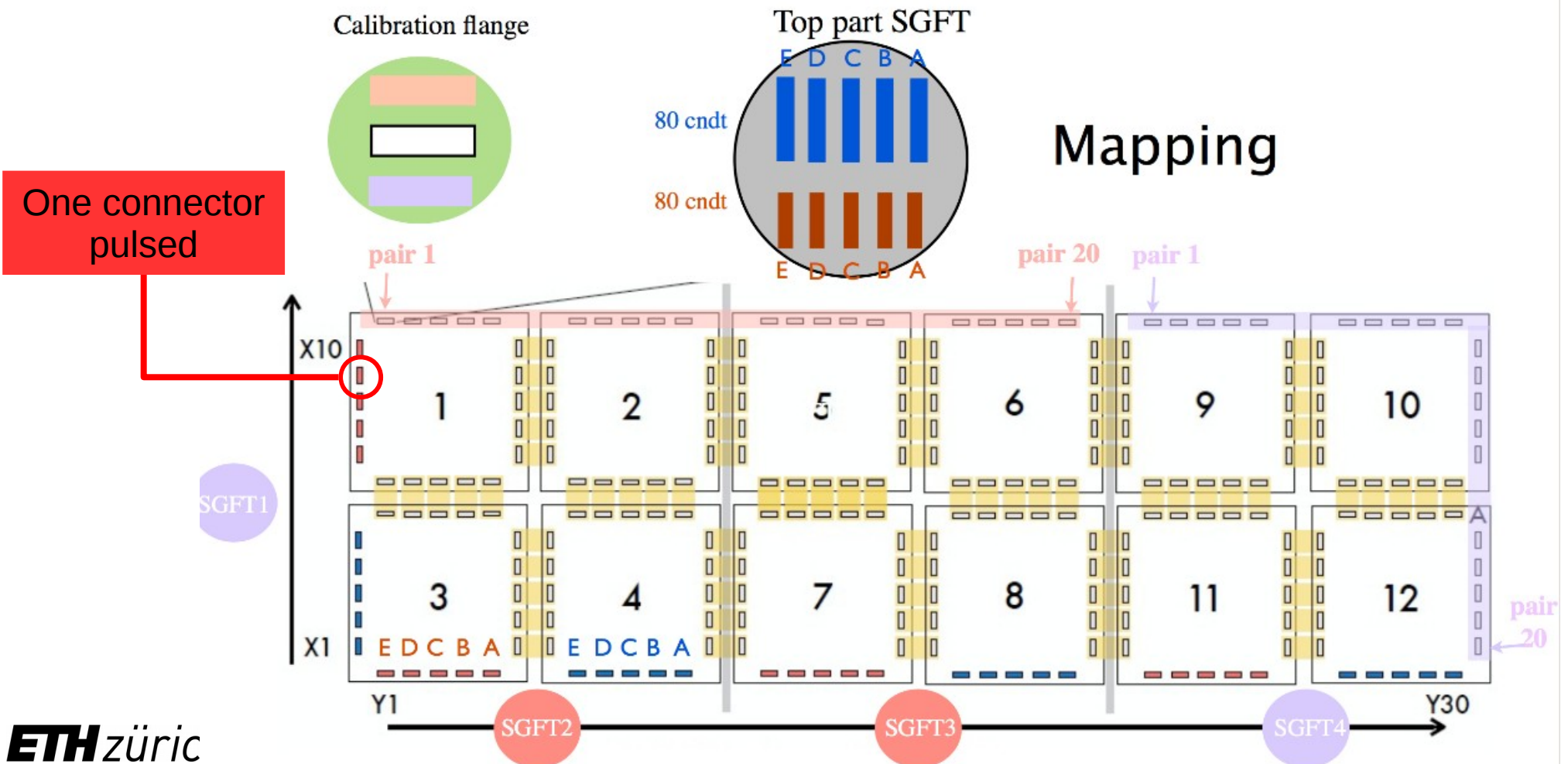
Outline

1. Motivation → Pulsing measurements
2. Measurements with LCR meter
3. Simulations with a simplified model
4. Equivalent circuit studies

Pulsing Measurements

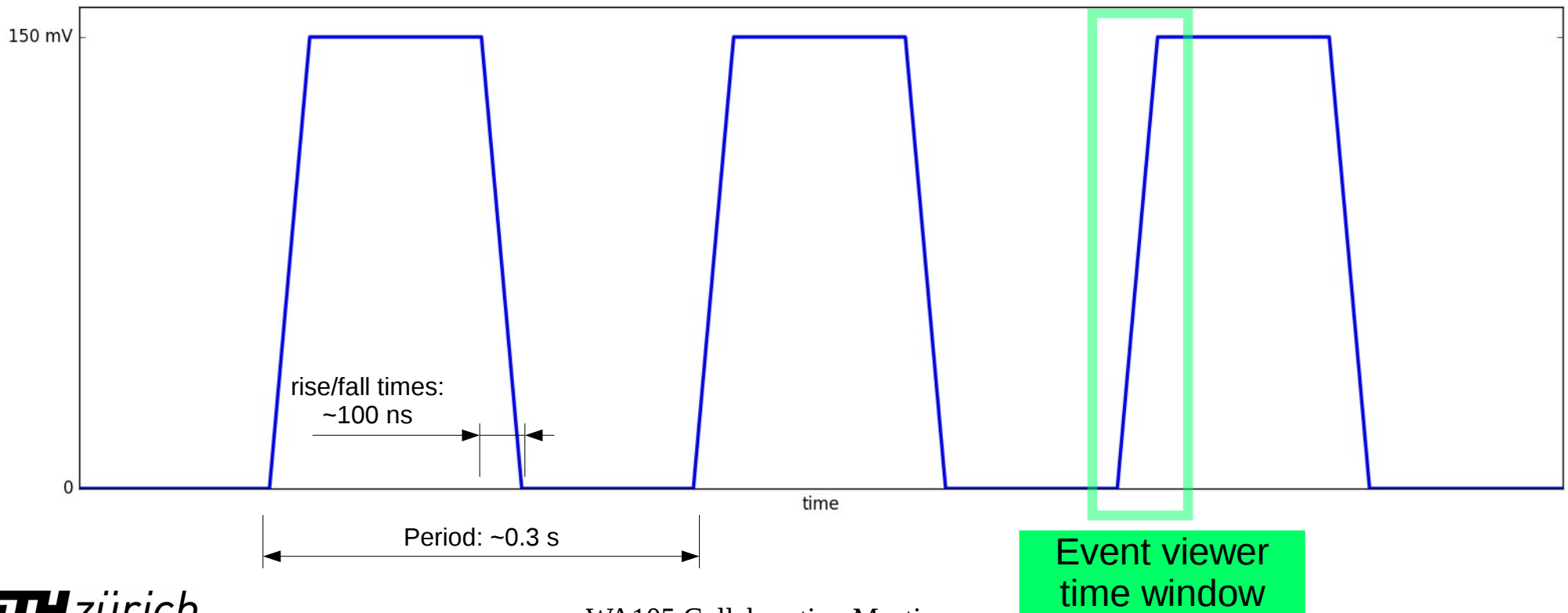
Pulsing measurements

- pulsing took place before Christmas last year
- 32 channels were pulsed simultaneously with 150 mV through a 1 pF capacitor \triangleq 150 pC charge



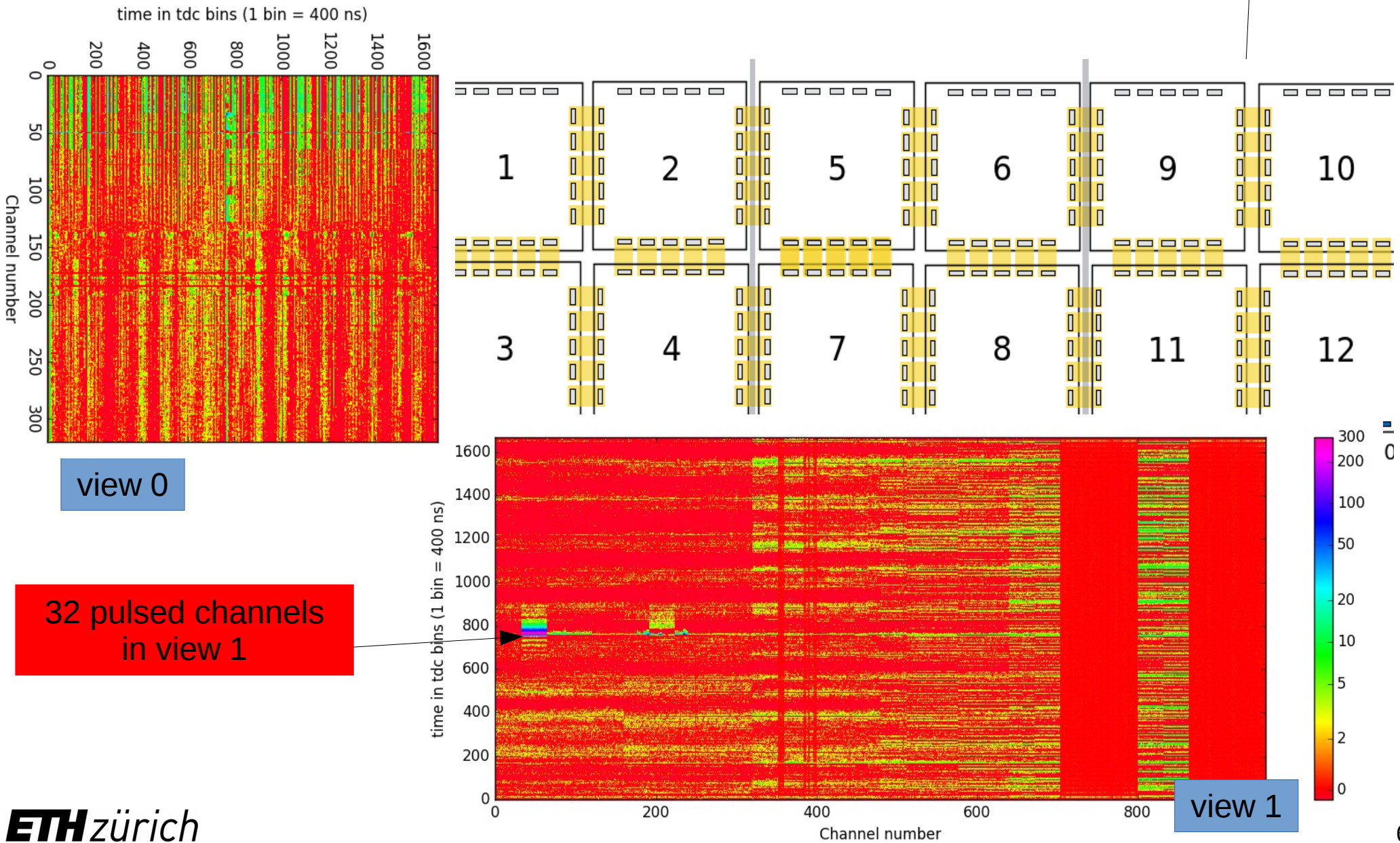
Pulsing measurements

- pulsing took place before Christmas last year
- 32 channels were pulsed simultaneously with 150 mV through a 1 pF capacitor \triangleq 150 pC charge
- pulse shape: square wave with, frequency \sim 3 Hz, 50% duty cycle, rise/fall times \sim 100 ns

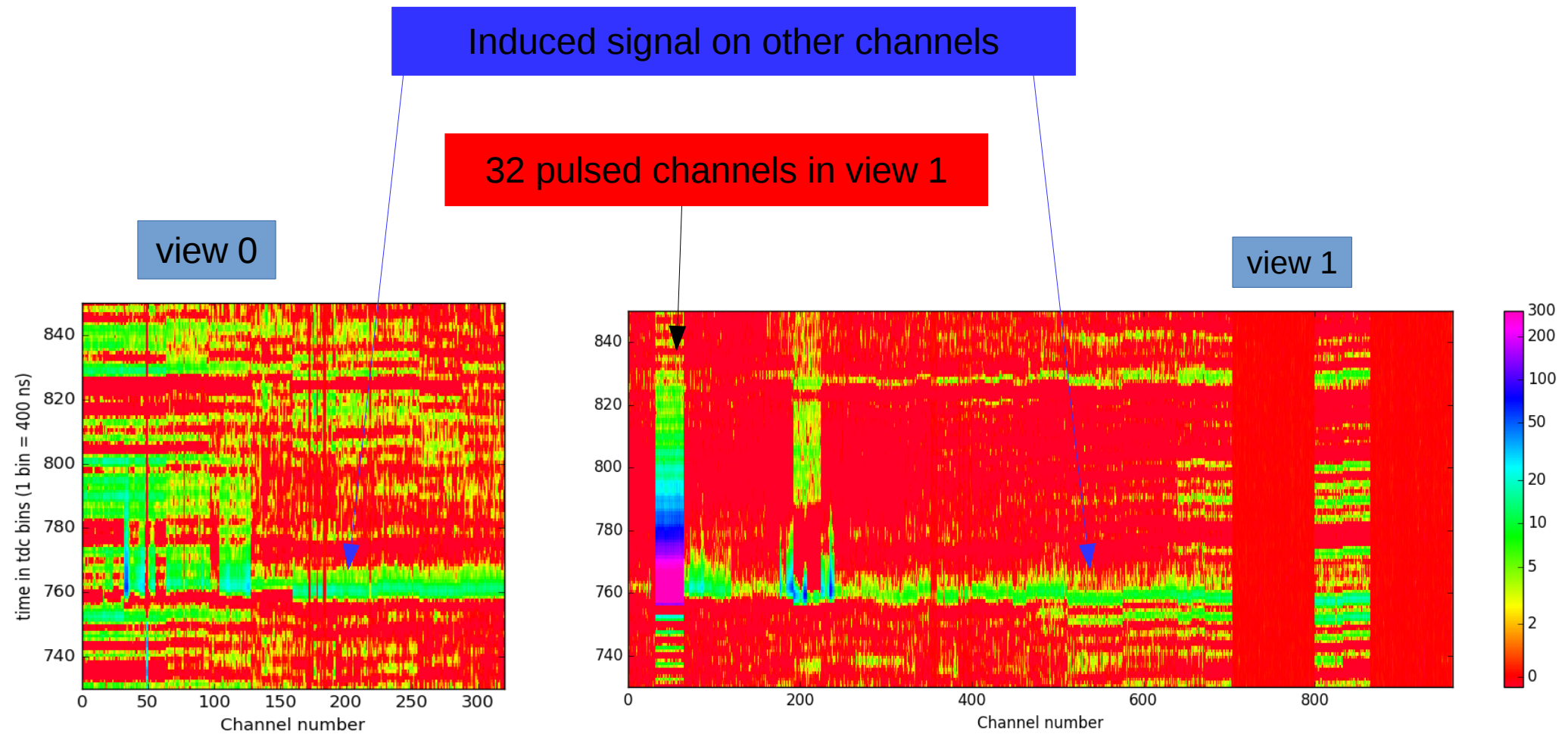


Pulsing measurements

- Noise reduction: cuts in Fourier space for $f > 0.5$ MHz

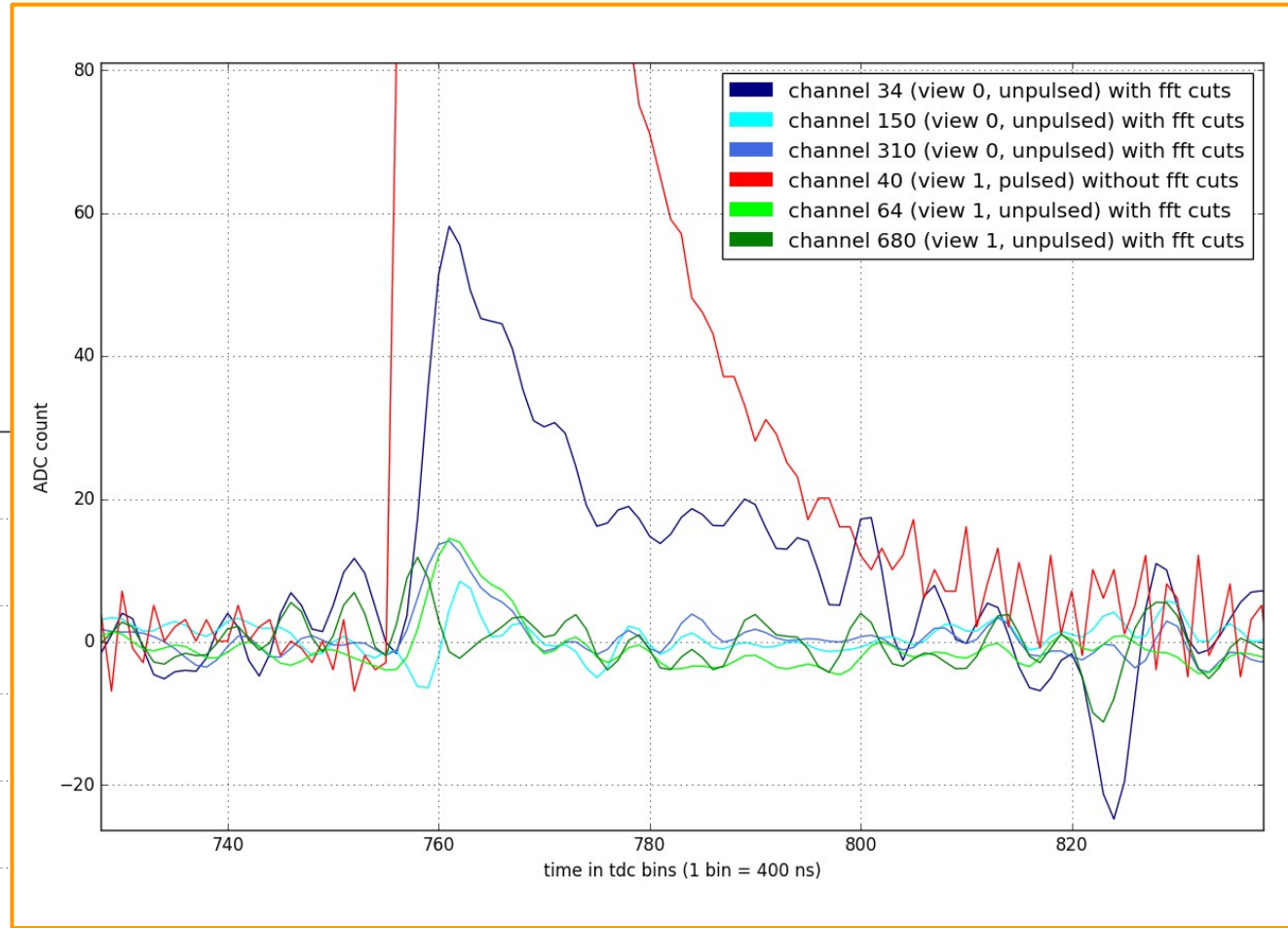
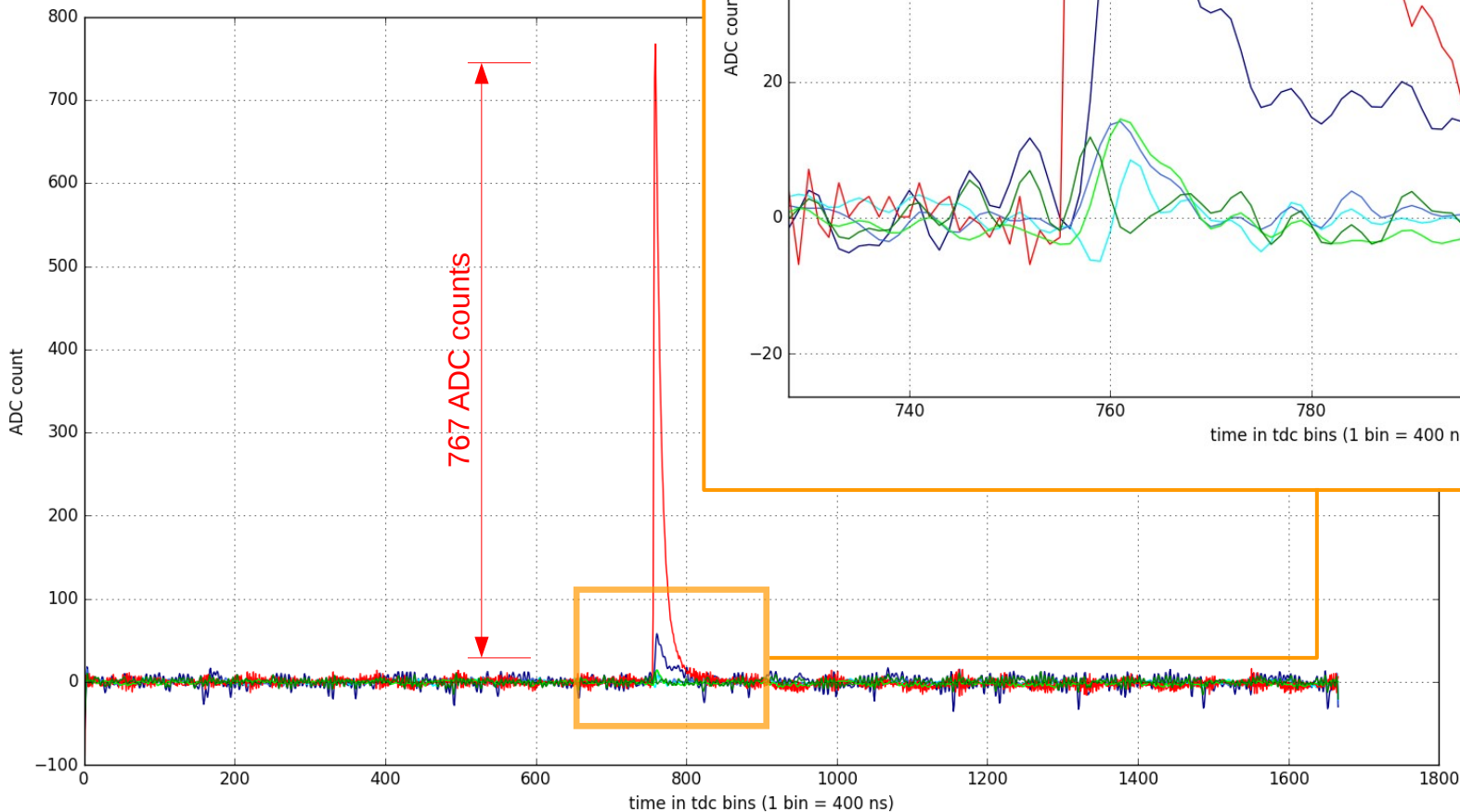


Pulsing measurements zoom



Pulsing measurements

- induced signal on other channels: $\sim 1.6\text{-}7.6\%$
- only small dependence on distance of non-pulsed channel to pulsed channel or view (parallel or perpendicular)

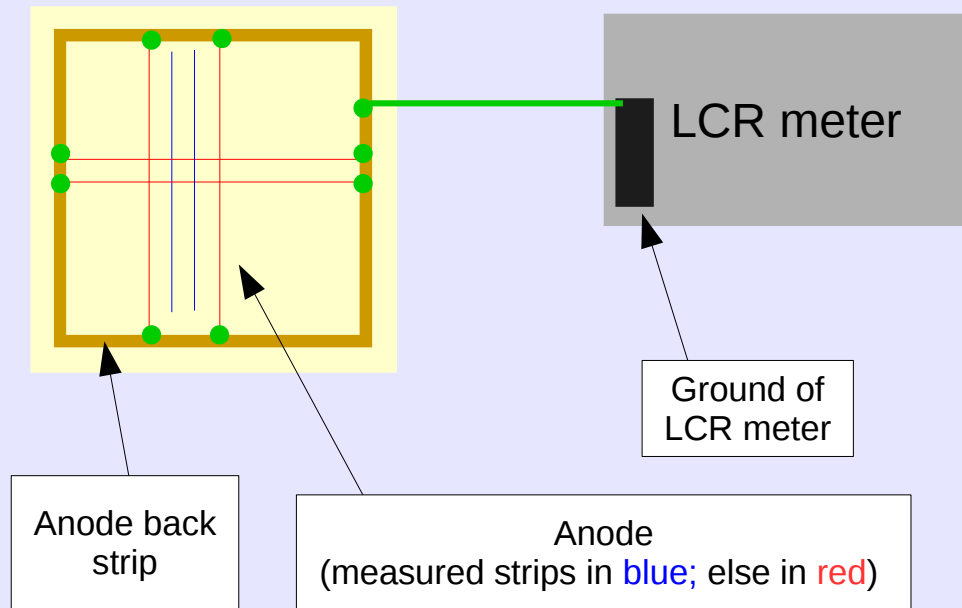


Measurements with LCR meter

Measurement Setup

Cross-Talk Study

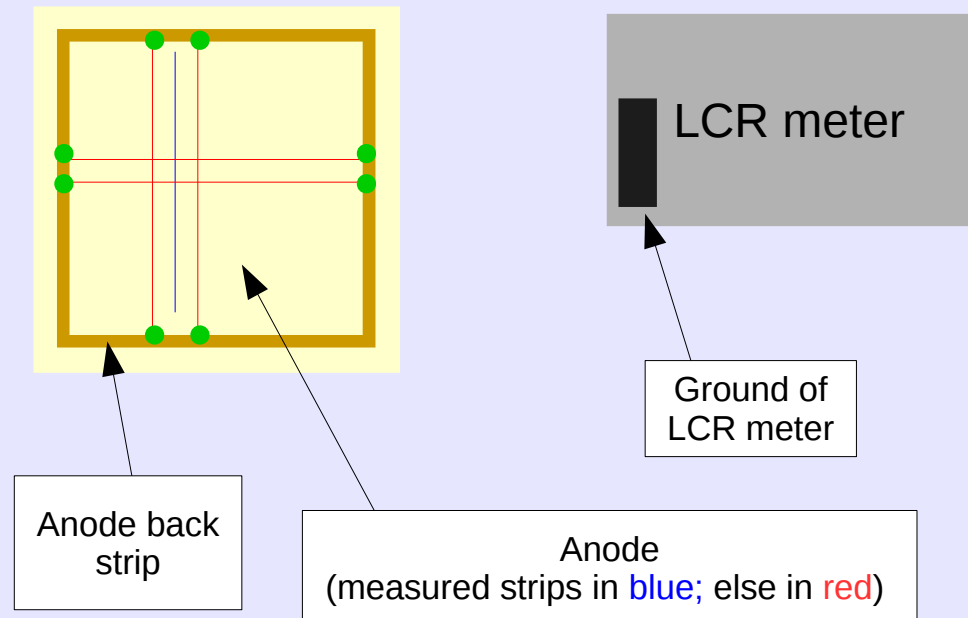
Capacitance between any of the two strips and all the others are connected to ground (ground terminal of the LCR meter for a reference ground).



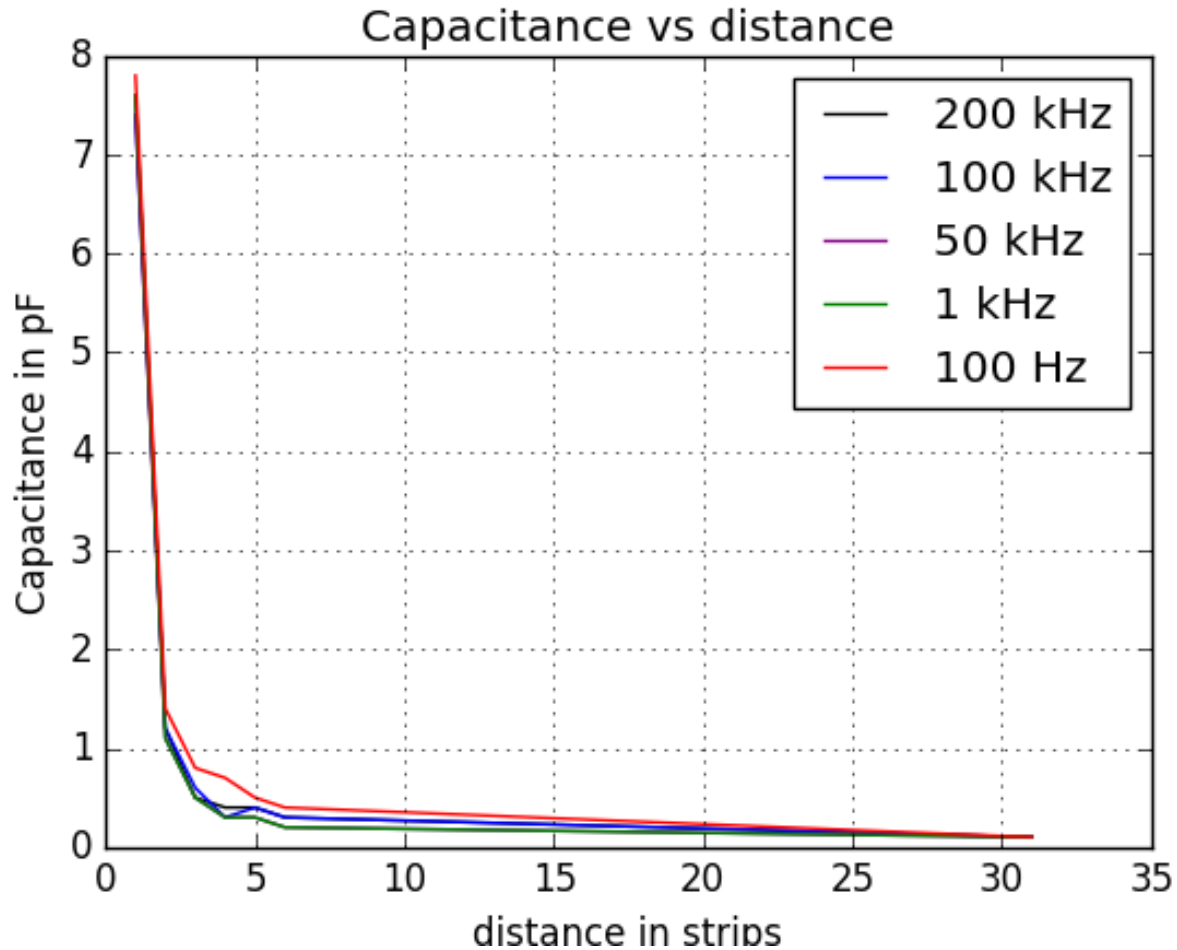
Capacitance to ground

All strips are connected to the anode back strip and the anode back strip is left floating.

Capacitance measured between 1 strip and the ground.



Cross Talk Study – Strip-to-strip parallel capacitance

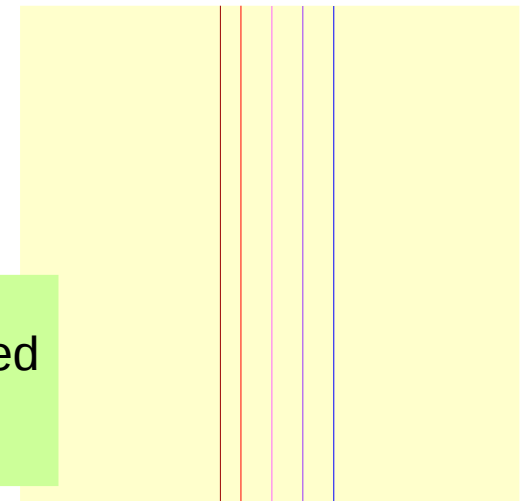


Strip-to-strip parallel capacitance decreases rapidly with distance

Capacitance measured between parallel strips with varying distance

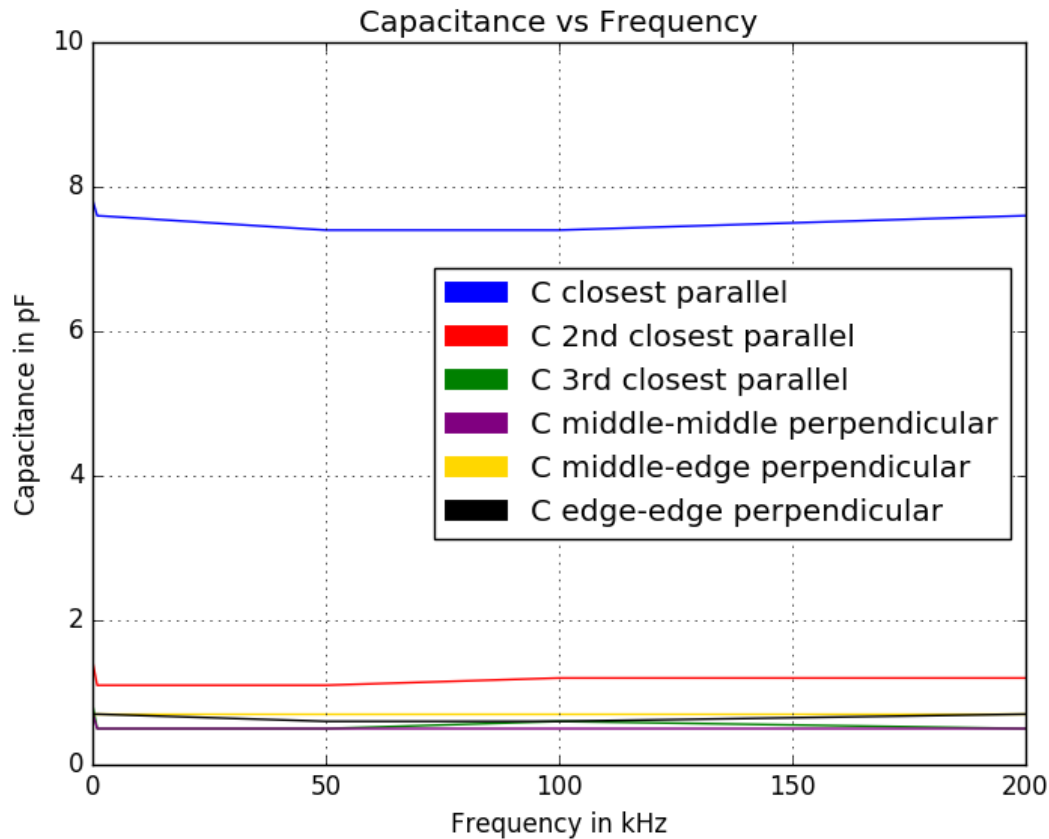
Measurement conditions:
Humidity: 39.8 %
Temperature: 19.4 °C

All other strips grounded on both ends



Cross Talk Study – Strip-to-strip perpendicular capacitance

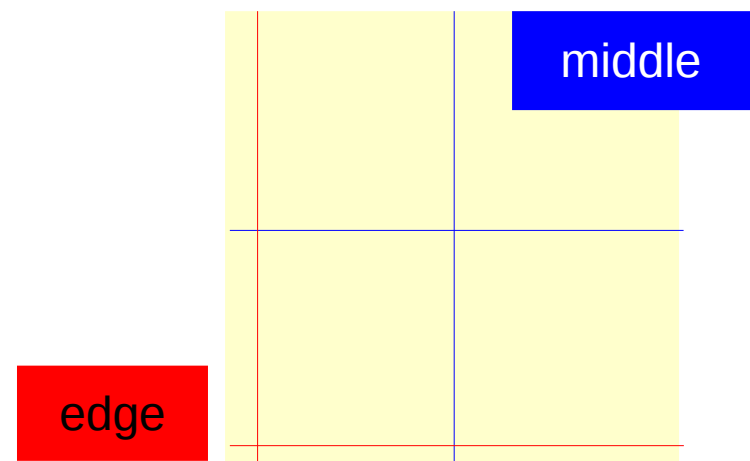
Comparison to capacitance between parallel strips:



Measurement conditions:
Humidity: 39.8 %
Temperature: 19.4 °C

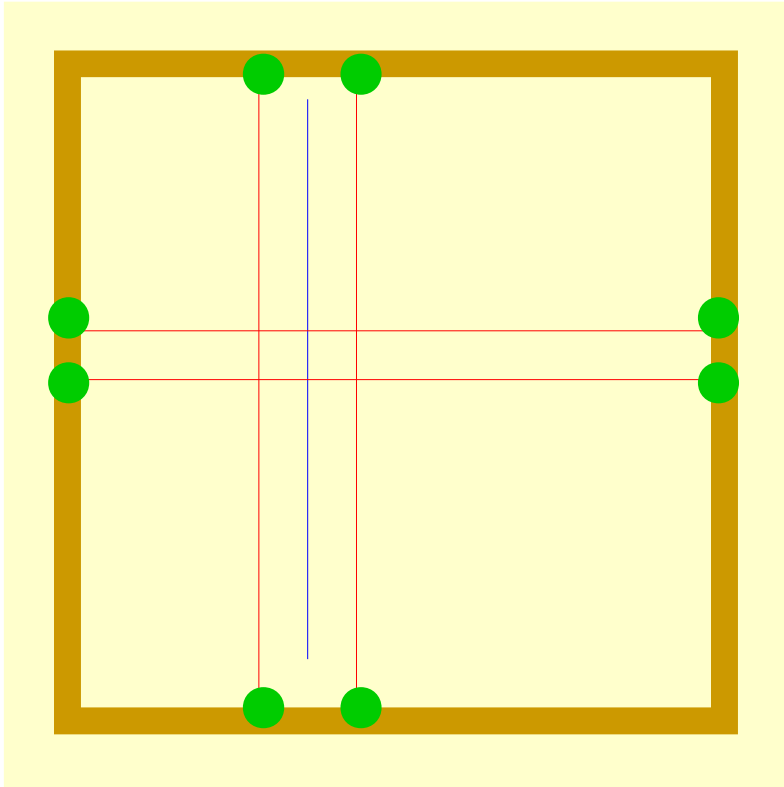
Very similar capacitance measured between all combinations of perpendicular strips

Capacitance measured between perpendicular strips



All other strips grounded on both ends

Capacitance to ground



Capacitance measured
between 1 strip and ground

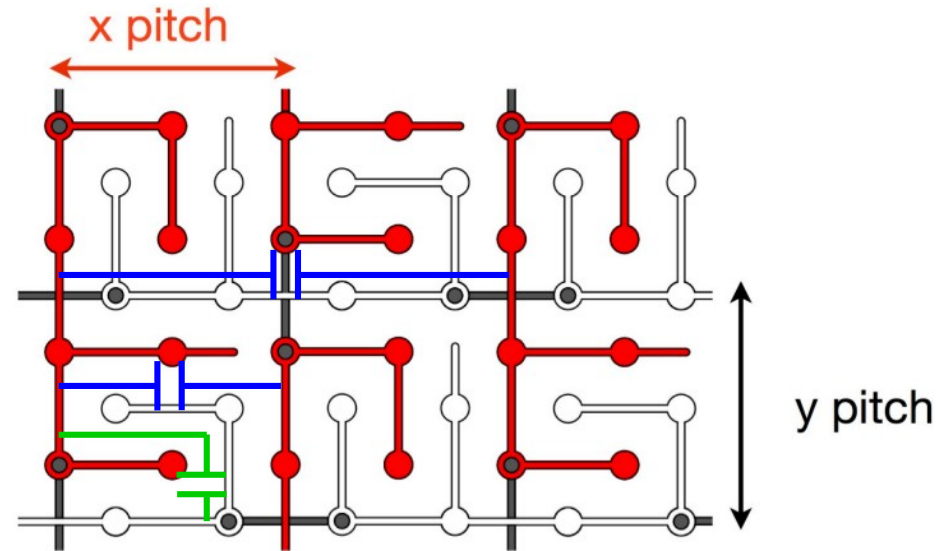
Capacitance to ground ~ 78 pF

All other strips are connected to the anode back
strip and the anode back strip is left floating

Simulations with a Simplified Model

Capacitance Matrix

- Anode consisting of parallel/perpendicular strips acts like a capacitor.
- From the pulsing measurement, ~1.6 – 7.6 % signal on other strips were observed.



- To understand the interference between any of the two strips, the **capacitance matrix** is introduced.
- Diagonal elements: capacitance between one strip and all the others (total capacitance).
- Off-diagonal elements: capacitance between any of the two strips.

$$\begin{bmatrix} Q_1 \\ Q_2 \\ \cdot \\ \cdot \\ \cdot \\ Q_n \end{bmatrix} = \begin{pmatrix} C_{11} & C_{12} & \cdot & \cdot & C_{1n} \\ C_{21} & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ C_{n1} & \cdot & \cdot & \cdot & C_{nn} \end{pmatrix} \begin{bmatrix} V_1 \\ V_2 \\ \cdot \\ \cdot \\ \cdot \\ V_n \end{bmatrix}$$

Simplified Model in Simulation

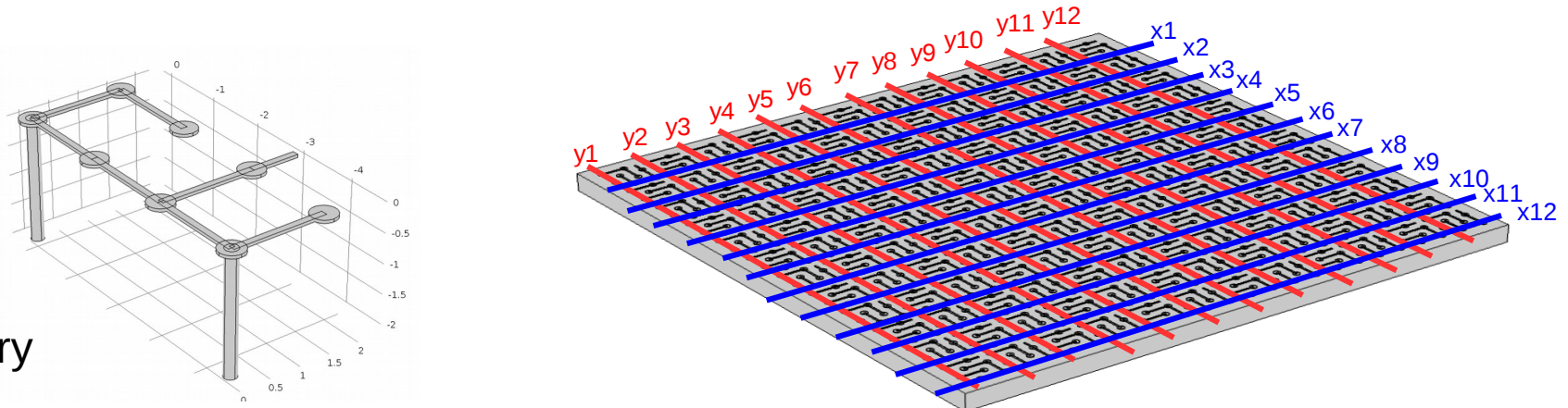
- In the measurement of 50x50 cm² PCB, there are 160 strips in each view.
- For simplicity in simulation, a simplified model with 12 strips were used, and linearly calculated to 160 strips to cross check with the results from the measurement.

$$\begin{matrix}
 & \begin{matrix} y1 & & y12 & x1 & & x12 \end{matrix} \\
 \begin{matrix} y1 \\ \vdots \\ \vdots \\ \vdots \\ \vdots \\ x12 \end{matrix} & \left(\begin{array}{cccccc}
 C_{y1-y1} & \cdots & C_{y1-y12} & C_{y1-x1} & \cdots & C_{y1-x12} \\
 \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\
 \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\
 \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\
 \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\
 C_{x12-y1} & \cdots & \cdots & \cdots & \cdots & C_{x12-x12}
 \end{array} \right)
 \end{matrix}$$

To replicate the measurement, 1V is applied to 1 strip and all the others are set to ground.

Capacitance matrix contains all the 12 strips in x view and the 12 strips in y view. With this matrix, capacitance between parallel and perpendicular strips can be obtained.

3D geometry



Results from Simulations and Measurements

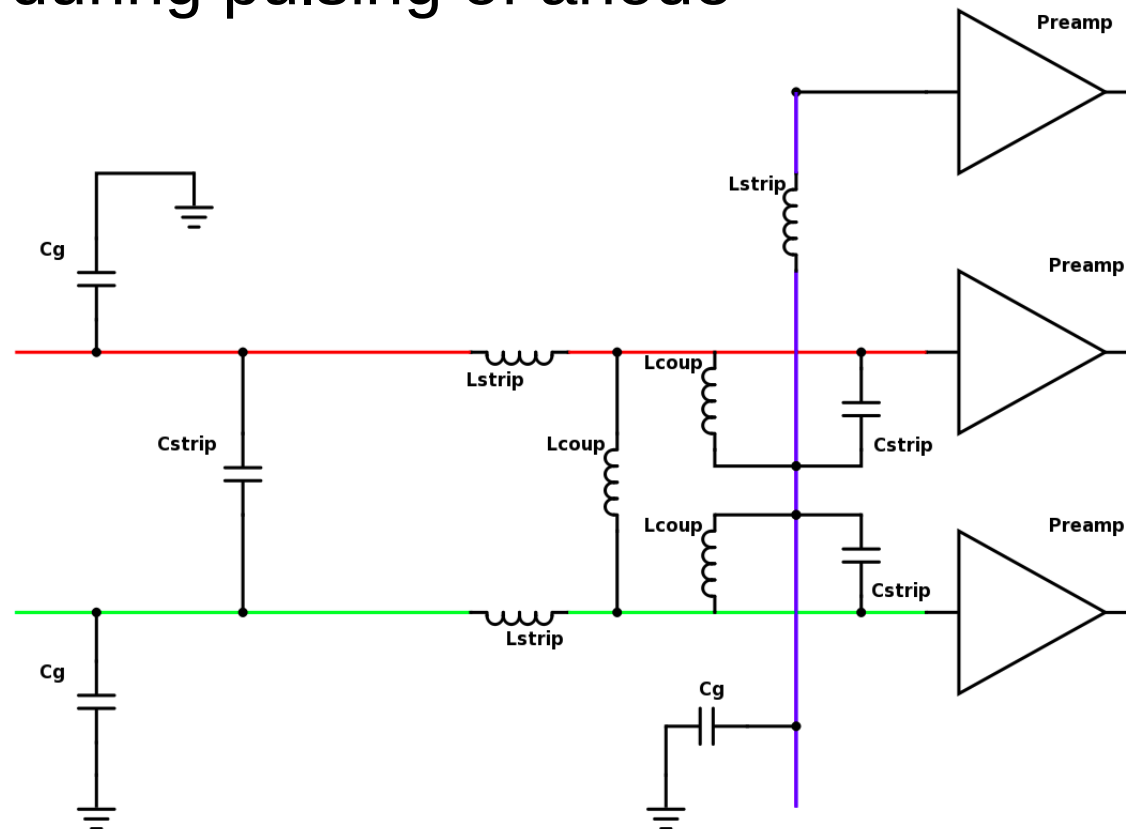
	1 strip and ground	closest parallel strips	perpendicular strips
Result from simulation	41.83 pF	3.34 pF	0.22 pF
Result from measurement	78 pF	7.6 pF	0.5 pF

Simulations with different configurations are in progress, e.g. keep the other strips floating.

Equivalent circuit studies

Equivalent circuit studies

- simulation of equivalent circuit of multiple anode strips ongoing
- Goal: compare simulated induced signals to the ones observed during pulsing of anode



Conclusion

- Capacitance measurements:
 - Capacitance between parallel strips decreases rapidly with distance → capacitance between 3rd closest strips (0.5 pF) less than 10% of closest strips (7.6 pF).
 - Capacitance between perpendicular strips (0.5 pF) ~10% of closest parallel capacitance (7.6 pF). Each strip couples to 160 perpendicular strips.
 - Capacitance to ground ~ 78 pF.
- Capacitance simulations:
 - We were able to model the anode and have a preliminary understanding. Different configurations are in progress.